APPENDIX A.1A: Concordance Table to the Executive Committee's Request for Supplementary Information



CASINO MINING CORPORATION
CASINO PROJECT

CONCORDANCE TABLE TO THE EXECUTIVE COMMITTEE'S REQUEST FOR SUPPLEMENTARY INFORMATION

On January 27, 2015, the Executive Committee requested that Casino Mining Corporation (CMC) provide supplementary information for the Casino Project (YESAB Project No. 2014-0002) to enable the Executive Committee to commence Screening. The Executive Committee considered received comments from various First Nations, Decision Bodies and regulators on the adequacy of the Project Proposal in the preparation of the Adequacy Review Report (ARR). Casino Mining Corporation is providing this Supplementary Information Report (SIR) to comply with the Executive Committee's Adequacy Review Report; CMC anticipates that the information in the SIR and Proposal, when considered together, is adequate to commence Screening.

The Executive Committee has 449 requests for supplementary information related to the Project Proposal submitted on January 3, 2014. Request # refers to the assigned identification number in the ARR. These requests are listed in the concordance table with the corresponding location of the supplementary information withing the SIR. Some responses require detailed technical information, data, and figures. Where necessary, this additional supporting information is provided as appendices to the SIR.

Request #	Request for Supplementary Information	Response
R1	All information and rationale used for the selection of the proposed tailings management facility over alternative disposal methods.	Section A.4.2.1.1 Appendix A.4A Tailings Management Facility Construction Material Alternatives
R2	Alternative dam construction methods to using cyclone sand.	Section A.4.2.1.2 Appendix A.4A Tailings Management Facility Construction Material Alternatives
R3	All information and rationale used to justify the proposed road alignment over alternative alignments.	Section A.4.2.2.1 Appendix A.4B Information on Alternative Access Road Alignments
R4	Identify whether broad-based stakeholder risk assessment processes, such as failure modes and effects analysis, will be completed and/or whether external expert review panels will be used as internal quality controls to guide the project.	Section A.4.3.1
R5	Identify if and how independent regulatory audits will be conducted.	Section A.4.3.2
R6	Describe how best practices, in relation to oversight, will be applied to the Project given the scale and nature of challenges associated with the proposed activities and site.	Section A.4.3.3
R7	A description of all other staging and preparation activities. For example, equipment, fuel, and material staging for the upgrade to the Freegold Road and construction of the Freegold Road Extension.	Section A.4.4.1

Request #	Request for Supplementary Information	Response
R8	Describe the interdependency of and critical path for staging and construction activities.	Section A.4.4.2
R9	Details regarding planned barging activity, including frequency, temporal periods, and types of freight anticipated by barge. Additionally, please describe any ancillary activities associated with barging, such as landing sites and access road.	Section A.4.4.3
R10	The reports that show results of metallurgical testing and sulphur removal performance from 2009 and 2010 bench tests, as well as the 2012 pilot test by G&T.	Section A.4.5.1 Appendix A4.N Scoping Level Assessment of Casino Property Appendix A4.O Advanced Metallurgical Assessment of the Casino Copper Gold Project Appendix A.4P Production of Environmental Tailings Samples for the Casino Deposit
R11	Additional information to support the feasibility of the sulphide removal process. Details should include: a. detailed description of the sulphide removal process; b. how the process will account for variations in the mineral composition of processed ore and the large tonnage of tailings; and c. QA/QC for tailings classification including a detailed schedule for testing.	Section A.4.5.2 Appendix A4.O Advanced Metallurgical Assessment of the Casino Copper Gold Project
R12	Additional information on the NAG tailings, or cyclone sand, produced through the sulphide removal process. Details should include: a. data to show that the sulphide removal will be effective for all ore types; b. sulphide levels required to produce non-acid generating cyclone sand and tailings; c. residual sulphide concentrations; d. how the sulphide removal process will be managed and how the cyclone sand will be monitored and tested during operation to ensure that the required performance limits are consistently achieved; and e. any remedial measures that may be required should the sulphide removal process be shown to be ineffective.	Section A.4.5.3 Appendix A4.N Scoping Level Assessment of Casino Property Appendix A4.O Advanced Metallurgical Assessment of the Casino Copper Gold Project Appendix A.4P Production of Environmental Tailings Samples for the Casino Deposit Appendix A.22H ML/ARD Management Plan

Request #	Request for Supplementary Information	Response
R13	Detailed description of the temporary construction camp including: a. layout of infrastructure such as camp facilities, generators, sewage disposal system, fuel storage, and generators; b. proximity to surface water; c. human-wildlife conflict prevention; and d. fuel storage requirements and capacity of diesel generators.	Section A.4.6.1.1 Appendix A.22A Waste and Hazardous Materials Management Plan Appendix A.12A Wildlife Mitigation and Monitoring Plan
R14	Detailed description of activities required for construction of camp including: a. site preparation such as clearing, grubbing, and disposal of materials; b. construction material volumes and sources (e.g. granular material requirements); and c. anticipated timing and duration of the proposed activities.	Section A.4.6.1.2
R15	Details and information regarding the authorization requirements of the proposed alignment through Settlement Lands.	Section A.4.6.1.3
R16	Discussion of potential impacts to values associated with Settlement Lands and mitigations proposed to address these effects.	Section A.4.6.1.4
R17	Describe progress on the Road Use Agreement and relevant details that informed the Road Management Plan.	Section A.4.6.1.5
R18	A detailed Road Management Plan for the entire Freegold Road. Specific details for the Freegold Road extension should include: a. description of what other users will have access to the Freegold Road extension; and b. description of the legal instruments and measures that will be implemented to control access to the Freegold Road extension.	Section A.4.6.1.6 Appendix A.22E Road Use Plan
R19	Please confirm that the Road Use Plan, the Extension Access Management Plan, and the Traffic Management Plan refer to the same management plan.	Section A.4.6.1.7 Appendix A.22E Road Use Plan
R20	Reconcile the intention to decommission the access road with the need to maintain access in order to monitor and maintain permanent infrastructure. Details should include a detailed discussion of access requirements for on-going monitoring and maintenance of site infrastructure and how these activities will be undertaken if the road is decommissioned.	Section A.4.6.1.8
R21	A breakdown of Project related traffic volumes, by vehicle type, for the Alaska, North Klondike, and South Klondike highways. Provide a comparison against current traffic levels and capacities including seasonal fluctuations.	Section A.4.6.2.1
R22	Implications of projected traffic due to this Project on the Alaska, North Klondike, and South Klondike highways.	Section A.4.6.2.2

Request #	Request for Supplementary Information	Response
R23	Details on fleet management to ensure rapid response to possible accidents or spills.	Section A.4.6.2.3 Appendix A.22B Spill Contingency Management Plan Appendix A.22A Waste and Hazardous Materials Management Plan
R24	Describe if weight restrictions are predicted to interfere with Project logistics including the anticipated frequency for which a special variance permit may be requested.	Section A.4.6.2.4
R25	Describe maximum predicted haulage weights, including maximum anticipated weights for the importation of equipment and infrastructure.	Section A.4.6.2.5
R26	Traffic projections for mine related traffic within Carmacks, detailed by vehicle class and type, prior to the Carmacks by-pass becoming operational.	Section A.4.6.3.1
R27	A traffic management plan for routing traffic through Carmacks prior to the completion of the Carmacks by-pass. Details should include: a. route through Carmacks; b. timing of transportation activities (e.g. daily, weekly and monthly restrictions); c. safety of residents with particular focus given to routes with no pedestrian sidewalks; d. communication with residents within community; and e. congestion aversion.	Section A.4.6.3.2 Appendix A.22E Road Use Plan
R28	Describe the sourcing of primary mine materials, delineating supplies arriving from Skagway from those from British Columbia and elsewhere. Please distinguish between materials such as primary flotation supplies, heap leach supplies, lubricants, fuels, and cyanide.	Section A.4.6.4.1
R29	Confirm that the export plan is, or will be, logistically possible.	Section A.4.6.4.2 Appendix A.4B Information on Alternative Access Road Alignments

Request #	Request for Supplementary Information	Response
R30	Describe, as best as possible (if data are unavailable, please indicate anticipated rates of use), the frequency, weight, size, truck type, and carrying capacity of trucks carrying: a. pebble lime; b. sodium disobutyl dithiophashinate; c. sodium diethyl dithiphoshinate; d. methyl isobutyl caribinol; e. potassium xanthate; f. sodium hydro-sulphide; g. sodium cyanide; h. sodium hydroxide; i. hydrochloric acid; j. sulphuric acid; k. ammonium nitrate; l. diesel; m. lubricants; n. liquefied natural gas; o. ore concentrates; and p. other hazardous materials.	Section A.4.6.5.1
R31	Additional detail in the Water Management Plan that includes all Project components and phases. Details should include: a. appropriate figures and plans illustrating site water management, including flow sheet information such as monthly water volumes; and b. figures, plans, and sections for key collection and conveyance facilities associated with the Project.	Section A.4.7.1
R32	A description of the methodology used to determine flows for storm events including supporting information such as catchment areas, time of concentrations, inclusion of rain and snow melt events, design events, and results.	Section A.4.7.2.1 Appendix A.7A Variability Water Balance Model Report
R33	Detail and describe the methodology and references used to determine the probable maximum precipitation in relation to conveyance channel design and events pond standards.	Section A.4.7.2.2
R34	Typical cross-sections and design drawings of alignments for diversion ditching across the project site with particular focus around the HLF including: a. confining embankment; b. access road section; and c. event ponds area.	Section A.4.7.2.3 Appendix A.4C Feasibility Design of the Heap Leach Facility
R35	A discussion of measures to be taken should one or more sections of the proposed heap leach facility (HLF) diversion ditches be found to be ineffective or should excessive erosion become an issue.	Section A.4.7.2.4

Request #	Request for Supplementary Information	Response
R36	A discussion of alternatives that CMC considered, including justification and rationale for the use of the proposed ditches.	Section A.4.7.2.5 Appendix A.4C Feasibility Design of the Heap Leach Facility
R37	A description of the diversion ditch on the southwest side of the HLF, including a drawing indicating its proximity to the edge of Byrnelson Creek north tributary sub-watershed. Include a discussion of potential effects to and relevant mitigations for this watershed.	Section A.4.7.2.6
R38	Additional information regarding design of channels in the area that will be susceptible to erosion.	Section A.4.7.2.7
R39	Rationale for directing various non-contact water sources into the TMF. Include a discussion of how non-contact water will be managed throughout the life of the Project.	Section A.4.7.2.8
R40	Further rationale for sizing of the water management pond and sedimentation ponds in terms of sediment removal and confirm if the proposed sizes will meet objectives.	Section A.4.7.3.1 Appendix A.4D Report on the Feasibility Design of the TMF
R41	Clarify whether the size of the event pond is for managing return period rainfall events or return period snow melt-rain events.	Section A.4.7.3.2
R42	Details and rationale on the selection of return period design criteria for all the WMP components during all phases of the Project, including long-term closure. Details should include calculation of the failure probabilities.	Section A.4.7.4.1 Appendix A.4C Feasibility Design of the Heap Leach Facility Appendix A.4D Report on the Feasibility Design of the TMF
R43	Detailed information on the sources and quantities of suitable borrow materials.	Section A.4.8.1.1 Appendix A.4C Feasibility Design of the Heap Leach Facility
R44	Clarify whether HLF excavations will be to competent bedrock or weathered bedrock. Provide justification and the criteria used to determine the suitability of the foundation for the HLF.	Section A.4.8.1.2 Appendix A.4C Feasibility Design of the Heap Leach Facility
R45	Details on foundation preparation including drainage management and accommodation of the proposed liner.	Section A.4.8.1.3 Appendix A.4C Feasibility Design of the Heap Leach Facility
R46	Rationale for the sufficiency of a 30 cm thick soil liner.	Section A.4.8.2.1
R47	A description of the composition and potential effects of the overliner on the performance of the liner considering permeability and hydraulic head.	Section A.4.8.2.2

Request #	Request for Supplementary Information	Response
R48	Details on the mitigation and management of leaks from the HLF including during all stages of operations.	Section A.4.8.3.1 Appendix A.4C Feasibility Design of the Heap Leach Facility
R49	Details on the maintenance and repair of the LDRS sump and pumps.	Section A.4.8.3.2
R50	Details on the pipelines, pumps, and related infrastructure connecting the components of the HLF including SART, cyanide, and gold extraction facilities. Include details on pipeline alignments and leak detection measures.	Section A.4.8.4.1 Appendix A.4C Feasibility Design of the Heap Leach Facility
R51	Volumes and sources of water stored in the embankment and the events pond during a 1 in 100 year 24-hour storm event.	Section A.4.8.4.2
R52	Sensitivity analyses for makeup water requirements and water retention requirements for different moisture content values for stacked ore and wetter or dryer climatic conditions. Include a discussion on any implications in relation to HLF and events pond storage capacity.	Section A.4.8.4.3 Appendix A7.A Variability Water Balance Model Report Appendix A7.C Potential Effects of Climate Change on the Variability Water Balance
R53	A description of the HLF solution balance including in wet and dry conditions.	Section A.4.8.4.4 Appendix A7.A Variability Water Balance Model Report Appendix A7.C Potential Effects of Climate Change on the Variability Water Balance
R54	Rationale for the selection of design criteria for HLF events pond and events pond spillway sizing. Include a discussion on potential consequences resulting from larger hydrological events.	Section A.4.8.4.5
R55	Discussion on the potential for the buckling and decreasing efficiency of collection wells for leachate recovery.	Section A.4.8.5.1
R56	Estimates for the approximate tonnage in each ore lift within the HLF.	Section A.4.8.6.1
R57	Clarification on the leach cycle activities and durations.	Section A.4.8.6.2 Appendix A4.C Feasibility Design of the Heap Leach Facility

Request #	Request for Supplementary Information	Response
R58	Identify additional metallurgical test work that has been undertaken or is planned prior to/during construction and operation to improve leach cycle time estimates.	Section A.4.8.6.3 Appendix A.4E Results of Additional Lab Testing of Leach Ore
R59	A discussion on the implications of the following scenarios and provide consideration of options that the mine could implement should the following unforeseen conditions occur during construction and operations: a. leach times that are significantly increased for short or extended times. As an example, if the leach cycle is unexpectedly increased from 60 days to 100 days for an extended time; b. shortages in stockpile capacity for excess oxide ore should the expected HLF stacking rate need to be reduced; c. possible extension of the HLF operation beyond Year 15 due to longer than anticipated leach cycles; and d. requirements for additional gold ore stockpile capacity and/or provisional spare leach pad later during operations since the surface area of the lifts will be reduced as the heap extends upslope.	Section A.4.8.6.4 Appendix A.4F Waste Storage Area and Stockpiles Feasibility Design
R60	Additional details regarding the HLF confining embankment giving consideration to the varying functions of the structure (i.e. HLF stability, leach solution storage, road traffic, and housing services). Details should include: a. construction methods and design of the section of the access road situated between the confining embankment toe and the events pond; b. measures incorporated into its design to protect any buried services and the confining embankment drainage blanket; and c. clarification regarding whether or not the confining embankment drainage blanket will extend under the road and daylight in the tailings management facility area.	Section A.4.8.7.1
R61	A detailed schedule for the works required to construct the HLF and commence leaching operations. Consideration should be given to key QA/QC requirements and contingency planning for scheduling delays.	Section A.4.8.8.1
R62	Implications of scheduling delays or suspension of HLF construction.	Section A.4.8.8.2
R63	Details on the specialized personnel required to construct, operate, maintain, monitor and oversee the HLF.	Section A.4.8.8.3
R64	The missing Section 4.4.4 of the project proposal.	Section A.4.8.8.4
R65	Additional justification and rationale for the “high” hazard classification for the tailings management facility. In addition, provide details on construction and design implications of using an “extreme” hazard classification.	Section A.4.9.1.1
R66	If available, comparisons with other similar sand embankments or compacted sand dams, and/or natural analogs within similar environments. The discussion should include details on permeability, stress, strength, and performance of these structures.	Section A.4.9.1.2 Appendix A.4D Report on the Feasibility Design of the TMF

Request #	Request for Supplementary Information	Response
R67	Detailed rationale for the selection of the factor of safety during dam construction.	Section A.4.9.1.3
R68	Evidence demonstrating that the stability of the proposed TMF dam can be achieved through a post-closure period lasting thousands of years. Include a discussion on technically feasible options for managing the risk to downstream areas in perpetuity.	Section A.4.9.1.4
R69	An explanation on the likelihood and implications of saturation of the TMF dam's foundation, drains, and lower portions.	Section A.4.9.2.1
R70	Justification and rationale for using a factor of 1.5 for ground motion amplification for potential slip surfaces in the embankment foundation.	Section A.4.9.2.2
R71	Clarification if V_{s30} is site specific and how it was derived.	Section A.4.9.2.3
R72	Mean peak ground acceleration values derived from EZ-FRISK.	Section A.4.9.2.4
R73	Explanation of the difference between Natural Resources Canada spectral periods and the spectral periods presented in the report on the feasibility of the TMF.	Section A.4.9.2.5
R74	Explanation on monitoring and remediation activities that may be required during closure including the extent of remediation required in event of an MDE.	Section A.4.9.2.6
R75	Reassess and model the IDF and PMP using modern storm expansion techniques. In addition, provide: a. a full description of the methodology used; and b. rationale for using a 100-year design snowpack.	Section A.4.9.3.1 Appendix A.4D Report on the Feasibility Design of the TMF Appendix A.4G Updated Hydrometeorology Report
R76	Rationale for not constructing an emergency spillway for the TMF during operations.	Section A.4.9.4.1 Appendix A.4D Report on the Feasibility Design of the TMF
R77	A discussion on potential consequences of HLF failure resulting in displacement of water in the TMF.	Section A.4.9.4.2 Appendix A.4C Feasibility Design of the Heap Leach Facility
R78	A discussion and details of the methodology used to determine closure spillway requirements and relevant data such as time distribution of rainfall and relevant hydrographs.	Section A.4.9.4.3
R79	Discussion of the potential for closure spillway blockages and expected extent of maintenance and monitoring the spillway.	Section A.4.9.4.4
R80	Identify mitigations, with appropriate thresholds for implementation, and monitoring activities for closure spillway related erosion, both in the spillway channel and downstream water bodies.	Section A.4.9.4.5

Request #	Request for Supplementary Information	Response
R81	A dam breach analysis with water/tailings inundation modeling consistent with the Canadian Dam Association's dam safety guidelines including: a. probable maximum flood inundation map showing the maximum extent of flooding relating to a sudden full storage embankment breach extending to when expected flooding is within the natural water channels; b. an assessment of environmental and human impacts associated with a release of tailings; c. an assessment of potential impacts to First Nation Settlement Lands; d. an assessment of impacts to downstream infrastructure; e. mitigation measures in the event of a tailings breach; and f. for each proposed breach scenario a cross section of the critical TMF embankment, proposed loading factors, and each scenario's factor of safety.	Section A.4.9.5.1
R82	Rationale for the proposed thickness of the core and downstream filter, considering the dam height and permanent performance requirements.	Section A.4.9.6.1 Appendix A.4D Report on the Feasibility Design of the TMF
R83	Rationale for the ceiling of 12 percent fines in cycloned sand to be used in embankment construction including a discussion of frost susceptibility and drainage characteristics.	Section A.4.9.7.1
R84	Provide testing or analyses to demonstrate that pore pressures, shear strength, angles of friction, and contraction of cyclone sand is acceptable at all pressures found in the TMF embankment.	Section A.4.9.7.2 Appendix A.4R Report on Laboratory Geotechnical Testing of Tailings Materials
R85	Clarification on the specific gravities of cyclone overflow and underflow.	Section A.4.9.7.3 Appendix A.4D Report on the Feasibility Design of the TMF
R86	Justify the upper range of 2.0 m for proposed lift heights of cyclone sand.	Section A.4.9.7.4
R87	Supporting evidence for the absence or presence of faults and fractures within the TMF and embankment areas including their activity.	Section A.4.9.8.1 Appendix A.4D Report on the Feasibility Design of the TMF

Request #	Request for Supplementary Information	Response
R88	Additional drill results, with detailed analysis and discussion, to provide an accurate characterization of the hydraulic conductivity and identification fault/shear zones within the embankment foundation.	Section A.4.9.9.1 Appendix A.4D Report on the Feasibility Design of the TMF Appendix A.4L Report on Revised Tailings Management Facility Seepage Assessment
R89	Details regarding the cut off trench and seepage control for the TMF embankment including: a. clarification on the depth of the cut-off trench and justification based on the depth of overburden and fractured bedrock; b. an updated cross section of the TMF embankment that includes the cut off trench and associated seepage barrier; c. a profile diagram of the cut off trench showing its depth across the dam core, along with available information on the depth of overburden and fractured bedrock; d. a discussion of measures to address fractured bedrock; and e. a discussion on the use of a grout curtain to control seepage	Section A.4.9.9.2 Appendix A.4D Report on the Feasibility Design of the TMF
R90	Further characterization of the dam foundation materials to confirm the presence and distribution of permafrost.	Section A.4.9.10.1
R91	Details regarding plans to ensure embankment foundations do not incorporate frozen and/or frost susceptible soils during construction.	Section A.4.9.10.2
R92	A detailed schedule for the works required to construct the TMF before and during operations. Consideration should be given to key QA/QC requirements and contingency planning for scheduling delays and freezing conditions.	Section A.4.9.11.1
R93	Implications of scheduling delays or suspension of dam construction during the nine month construction period.	Section A.4.9.11.2
R94	A review of relevant examples of sand embankment dams constructed in cold weather environments. This review should identify challenges, potential issues, and solutions surrounding sand placement and QA/QC.	Section A.4.9.11.3
R95	Methods of erosion control during dam construction.	Section A.4.9.11.4
R96	Description of ground surface conditions currently in relation to overburden and vegetation and any modification in preparation for the construction and filling of the TMF.	Section A.4.9.11.5 Appendix A.4D Report on the Feasibility Design of the TMF
R97	Discussion on any hydrological changes expected from changing ground thermal conditions and any monitoring to this effect.	Section A.4.9.11.6 Appendix A.4D Report on the Feasibility Design of the TMF
R98	Confirmation that natural or artificial liners are not included as part of the technical design of the TMF embankment.	Section A.4.9.11.7

Request #	Request for Supplementary Information	Response
R99	Confirmation of the availability of non-frost susceptible materials for the construction of the dam core. Include a discussion that demonstrates that the material with a 20 percent or more fines is not a frost susceptible material.	Section A.4.9.12.1 Appendix A.4D Report on the Feasibility Design of the TMF
R100	Please provide the Mine Site Borrow Materials Assessment Report (VA101-325/16-3). If not part of the assessment report, include detailed information about: a. the locations of borrow sources; b. description of dimensions of borrow source excavations including area and depth of excavations; c. the estimated quantities of suitable borrow material available; d. the quantity of borrow material required for engineered mine components; e. proposed mitigation measures to minimize potential adverse effects associated with the development and use of the proposed borrow sites; and f. alternatives in the event that dam core material cannot be sourced at the site in sufficient quantities.	Section A.4.9.12.2 Appendix A.4Q Mine Site Borrow Materials Assessment Report
R101	A discussion on the thawing and containment of borrow and embankment excavations.	Section A.4.9.12.3
R102	Clarification on the use of filter-graded zones between the waste rock shells (if selected) of the starter dam and the overlying tailings shells (e.g. to prevent possible future deformation of the tailings shells).	Section A.4.9.13.1
R103	The missing information referenced in footnote No. 6 on p. 4-54 of the proposal related to Table 4.3-7 (Inflow Design Flood and Earthquake Design Ground Motion).	Section A.4.9.14.1
R104	For the LNG storage facilities, regasification facilities, and mobile fueling stations, provide: a. a detailed description for all facilities related to LNG including location, design, construction, operation and closure; b. measures for the safety of Project personnel including separation distances from office and living areas; c. design measures and operating procedures to prevent a cascading accident; and d. a list of standards and codes that will apply to design and operation of the each component identified above.	Section A.4.10.1.1 Appendix A.22G LNG Management Plan
R105	Identification of potential hazards to LNG facilities at the Casino Mine site associated with seismic activity, extreme weather events, wildfire, unstable terrain, and degradation of discontinuous permafrost, and a quantitative assessment of the related risk to those facilities.	Section A.4.10.1.2 Appendix A.22G LNG Management Plan

Request #	Request for Supplementary Information	Response
R106	Identification of the potential supplier of LNG from British Columbia and the established supplier of LNG from Alaska. Indicate the nature of any supply agreements that are in place. Indicate the nature of any uncertainties about the LNG facility in British Columbia being operational by the time LNG is required at the Casino Mine site. Provide documentation to confirm that the facility in Alaska will be able to supply LNG in sufficient quantity to meet the needs of the Casino Mine, should LNG not be available from the proposed facility in British Columbia. Describe the Casino Mining Corporation's fallback plan in the event that LNG is unavailable from either identified source, or is not available in sufficient quantity. Indicate whether an alternative source of electrical power might be required in such a case. Assess the effect of the above scenarios on the project's economic feasibility.	Section A.4.10.1.3
R107	The earthquake design basis for the LNG storage tank at the mine site.	Section A.4.10.1.4 Appendix A.22G LNG Management Plan
R108	A description of diesel storage facilities along with anticipated rates of use and storage volumes for each stage of the Project.	Section A.4.10.2.1
R109	A table or tables that summarize the following information for each major mine component: a. where appropriate, dimensions, mass, volume, centroid and elevation; b. reclamation characteristics (slope aspects, cover type and depth, volume required, re-vegetation type); c. source controls (e.g. liners, compacted graded drained foundations, and covers over reclaimed features) and any features associated with fluid management and stabilization and/or water management and treatment; and d. geotechnical protocols and results (e.g. FOS).	Section A.4.11.1.1 Appendix A.4C Feasibility Design of the Heap Leach Facility Appendix A.4D Report on the Feasibility Design of the Tailings Management Facility Appendix A.4F Waste Storage Area and Stockpiles Feasibility Design
R110	Conservative considerations for the long-term operational and maintenance requirements for the site.	Section A.4.11.1.2
R111	Analysis of closure options including long-term and short-term costs, care and maintenance requirements, and long-term environmental risks. The options analysis should include: a. open pit; b. tailings management facility; c. heap leach facility; d. stockpile areas; and e. water management and treatment.	Section A.4.11.2.1 Appendix A.4H Cold Climate Passive Treatment Systems Literature Review
R112	Discuss and if necessary update the conceptual closure plan to take into account the most recent Government of Yukon Reclamation and Closure Planning for Quartz Mining Projects, Plan Requirements and Closure Costing Guidance (Government of Yukon, 2013).	Section A.4.11.2.2

Request #	Request for Supplementary Information	Response
R113	Clarify what is meant by regular or infrequent site presence or what degree of on-site presence is envisioned (e.g. yearly during summer, once every 10 years, or site presence in step with closure stage).	Section A.4.11.2.3
R114	Justification and clarification of the proposed five year post-closure monitoring period given that actual closure conditions will not be established for about 95 years (pit discharge) and other closure conditions are not fully known or presented here (e.g. time for contaminated groundwater sources to report to TMF/seepage).	Section A.4.11.2.4
R115	Examples of successful similar treatment systems with similar contaminant loads, flows and climate.	Section A.4.11.3.1 Appendix A.4H Cold Climate Passive Treatment Systems Literature Review
R116	Initiation of laboratory studies to confirm the effectiveness of the wetlands as a water treatment system for the purpose of closure and to inform future field studies. The Executive Committee expects that results from these studies will be provided throughout the assessment process.	Section A.4.11.3.2 Appendix A.4K Metal Uptake in Northern Constructed Wetland
R117	Detailed plans on field studies to support and refine the effectiveness of the wetland water treatment system. Details should include: a. a preliminary schedule for studies; b. location and sequencing of field scale studies; and c. any required activities, such as earthworks, required for field studies.	Section A.4.11.3.3
R118	Details on any proposed pilot studies for the bioreactor system associated with the HLF.	Section A.4.11.3.4
R119	An assessment of uncertainty associated with the performance of the proposed passive treatment system.	Section A.4.11.3.5
R120	Prediction of a worst case scenario of downstream water quality assuming no treatment system. Predictions should extend as far downstream as necessary to demonstrate no further exceedances of the CCME surface water quality objectives attributed to the mine (or 90th percentile of background for those constituents that naturally exceed CCME).	Section A.4.11.3.6
R121	A discussion of contingency, alternative, or additional treatment options that could achieve water quality objectives should the passive treatment system not be viable or perform as required.	Section A.4.11.3.7
R122	A discussion of the requirements and merits for conventional treatment as the treatment method.	Section A.4.11.3.8 Appendix A.4H Cold Climate Passive Treatment Systems Literature Review

Request #	Request for Supplementary Information	Response
R123	A discussion and rationale on how the design of the north end of the tailings management facility wetlands will accommodate a range of possible flows from the pit lake.	Section A.4.11.3.9 Appendix A.7B Water Quality Predictions Report
R124	Details and design considerations for the remotely operated solar powered decant valves. Details should include: a. infrastructure requirements; b. monitoring and maintenance requirements, including an estimated timeframe; c. contingency planning related to malfunctions, inappropriate feedback and interaction; and d. case studies where such systems are effectively used;	Section A.4.11.3.10
R125	Details and rationale on the proposed storage and disposal of low-grade ore. Details should include: a. detailed geochemical characterization of material in the low-grade ore stockpile; and b. supporting evidence and rationale as to why leaving this material on surface to continue to generate acid and metal contaminants before much later disposal in the pit is any more beneficial than disposing same under water in the TMF when this material is first encountered.	Section A.4.11.4.1
R126	Details and discussion on groundwater collection and/or infiltration suppression to manage seepage through the low grade ore stockpile.	Section A.4.11.4.2
R127	A detailed discussion on lake stratification or mixing in relation to discharge including: a. any evidence or assumptions for lake mixing or stratification; and b. stratifications or mixing impacts to discharge water quality and the tailings management facility wetlands.	Section A.4.11.4.3 Appendix A.7B Water Quality Predictions Report
R128	Additional analysis to inform and update the Conceptual Closure and Reclamation Plan to address potential pit wall instability in post-closure.	Section A.4.11.5.1 Appendix A.4I Open Pit Geotechnical Design
R129	A sensitivity analysis examining the effect of less stable pit walls and show how the additional waste rock would be managed if the wall slopes had to be relaxed.	Section A.4.11.5.2
R130	A description of the barrier to prevent access to pit walls.	Section A.4.11.6.1
R131	Results and analysis of testing of heap leach facility detoxification using samples and conditions similar to an exhausted heap of friable ore approximately 150 m high.	Section A.4.11.7.1
R132	A discussion on alternative mitigation measures that may be required if heap leach facility rinsing and detoxification is not successful. The discussion should include examples of successful heap rinsing at comparable sites where materials of a similar nature, mass and northern location have been encountered.	Section A.4.11.7.2 Appendix A.4J Laboratory Evaluation of the SO2/Air and Peroxide Process
R133	Describe how fluid impoundment behind the HLF embankment will be prevented at closure.	Section A.4.11.7.3

Request #	Request for Supplementary Information	Response
R134	Additional details on the design basis and requirements for cover materials. Details should include: a. cover modeling and assessment including validation of assumed infiltration rates; b. availability and location of sufficient construction materials to meet the design requirements; c. composition of materials to be used for the cover system including mineral soil, topsoil, and vegetation; d. range of expected performance of proposed cover systems; and e. long-term monitoring and maintenance requirements.	Section A.4.11.8.1
R135	Feasibility level design details for the winter seepage mitigation pond cut-off wall and cut-off trench/barrier. Include a discussion of how the structures are to be constructed.	Section A.4.11.9.1
R136	Rationale for the construction of a cut-off barrier only after operations.	Section A.4.11.9.2 Appendix A.7B Water Quality Predictions Report
R137	Additional details about the winter seepage mitigation pond dam should include: a. proposed design standards (e.g. Canadian Dam Association Safety Guidelines); b. cross-sections; c. construction materials; d. consequence of failure classification; e. detailed foundation characterization; and f. monitoring and maintenance requirements.	Section A.4.11.9.3
R138	Demonstrate that the rate of discharge from the proposed winter seepage mitigation pond can be controlled in response to downstream flow rates within Casino Creek in order to meet downstream water quality objectives. Details should include WSMP capacity to handle excess water that is not discharged due to low flow conditions in Casino Creek.	Section A.4.11.9.4 Appendix A.7A Variability Water Balance Report
R139	Detailed plans for establishing vegetation on the downstream slope of the tailings management facility west and main embankments. Details should include: a. examples of successful projects where vegetation was established on similar slopes under similar climatic conditions as supporting rationale for the proposed closure and reclamation plan; b. a conceptual schedule for the site vegetation studies and feasibility level site vegetation designs, including the maintenance expectations; and c. a description of the estimated feasibility level costs of site vegetation upon mine closure account for the site-specific conditions.	Section A.4.11.10.1
R140	Further discussion regarding site infrastructure that may not be conducive to climax vegetation in closure. Include measures that you will implement to ensure long-term integrity of this reclaimed infrastructure.	Section A.4.11.11.1

Request #	Request for Supplementary Information	Response
R141	Additional details in the Conceptual Closure and Reclamation Plan with regard to temporary or early closure. Details should include: a. water and solution management and any requirements for water treatment; b. infrastructure requirements (e.g. ability of heap leach facility or tailings management facility to accommodate temporary or early closure); c. identify critical points in the project life cycle where temporary or early closure is most probable and most challenging; and d. length of time project could remain in temporary closure before discharge would be required.	Section A.4.11.12.1
R142	Contingency measures or alternatives that may be required in the event of early closure if passive treatment system field trials have not been completed or are shown to be unsuccessful.	Section A.4.11.12.2
R143	Update the CCRP and security estimates based on the Government of Yukon's updated guidance document: Reclamation and Closure Planning for Quartz Mining Projects, Plan Requirements and Closure Costing Guidance (Government of Yukon, 2013).	Section A.4.11.13.1
R144	Additional justification and discussion on security estimates. Details should include: a. all major mine components; b. all reclamation and closure stages; c. consideration of temporary or early closure; d. consideration of accidents and malfunctions; and e. consideration of effects of the environment.	Section A.4.11.13.2
R145	The following documents referenced in the Conceptual Closure and Reclamation Plan (Appendix 4A): a. R&C Environmental Services, 2010 b. pers.comm. J. Marsden, 2013	Section A.4.11.14.1 Appendix A.4J Laboratory Evaluation of the SO2/Air and Peroxide Process
R146	A detailed description of waste management for the Project including: a. location and size of all facilities associated with waste management; b. detailed description of waste storage facilities including the waste management facility, landfill, incinerator, land treatment facility, and sewage treatment plant; c. detailed description of waste management at the various facilities; d. anticipated volumes of waste at various stages of the Project; e. details on special waste and hazardous waste handling including anticipated volumes; and f. a more detailed waste management plan.	Section A.4.12.1 Appendix A.22A Solid Waste and Hazardous Materials Management Plan
R147	A detailed discussion on the short and long-term stability of mine infrastructure and surrounding slopes in the upper Casino Creek watershed due to permafrost degradation. Consideration should be given to the effects of permafrost degradation related to site infrastructure and climate change.	Section A.6.2.1.1

Request #	Request for Supplementary Information	Response
R148	Maps and relevant references showing permafrost distribution within the mine site as well as the Freegold Road, the airstrip and the airstrip access road.	Section A.6.2.1.2
R149	A detailed thermal modeling analysis of the proposed TMF and associated infrastructure on foundation conditions to support engineering design (including determination of embankment height, width of right of way, safety margin, etc.) and to assess the effects of the Project on the ground thermal regime. Include a detailed discussion and analysis about potential impacts to mine infrastructure from altered foundation conditions.	Section A.6.3.1.1
R150	An analysis of how climate change has been incorporated into the thermal erosion analysis to support Project design and the impact assessment.	Section A.6.3.1.2
R151	The depths at which ground temperatures have been measured for each cable installed in 1994.	Section A.6.4.1.1
R152	The ground temperature readings for all thermistor cables (from 1994 to 2013) in the same format (graphs of ground temperature with depth at a given time) which will allow an assessment of the impacts of recent climate warming (from 1994 until now) on permafrost.	Section A.6.4.1.2
R153	A discussion of whether ground temperature monitoring is planned for the proposed alignment of the Freegold Road Extension.	Section A.6.4.1.3
R154	Please clarify the assumption that permafrost might have low ice content based on the comparison between depth of permafrost and depth to groundwater.	Section A.6.4.1.4
R155	Clarification of the legends used in the baseline terrain maps as well as a simpler interpretation (label) of the units, especially those with multiple capital letters and integers. This will help establish the baseline surficial geology (terrain).	Section A.6.4.1.4
R156	Develop and present a site-specific terrain hazard classification scheme for the mine site, the Freegold Road, and the airstrip and airstrip access road, consistent with the YESAB draft guidance document titled Geohazards and Risk: A Proponents Guide to Linear Infrastructure (YESAB, 2014).	Section A.6.6.1.1
R157	Clarification of whether an ice-rich permafrost distribution map has been considered in the terrain hazard classification scheme	Section A.6.6.1.2
R158	An assessment of potential water quality under a broader range of hydrologic conditions, including: a. the ability to manage waters during wet, dry and average years; b. the receiving water effects during typical and extreme summer and winter low flows (7Q20 and 7Q10); and c. the water storage and receiving water effects during freshet and event flow.	Section A.7.2.1.1 Appendix A.7A Appendix A.7B
R159	An assessment of the potential effects of climate change on source loadings and receiving water effects.	Section A.7.2.1.2 Appendix A.7A Appendix A.7C

Request #	Request for Supplementary Information	Response
R160	An assessment of potential water quality under a broader range of operating/closure scenarios, including permit limits, atypical operations, accident scenarios, with and without passive treatment.	Section A.7.2.1.3 Appendix A.7B
R161	Additional baseline water quality data for key water sampling locations on a minimum monthly basis for a minimum period of one year to estimate seasonal variability. The Executive Committee expects that results from ongoing water quality data collection will be provided throughout the assessment process.	Section A.7.3.1.1 Appendix A.7D Updated Appendix B5 to Appendix 7A
R162	An analysis regarding dataset robustness, which should at a minimum include additional analysis of central tendency (i.e. standard deviation) and could include better description of data distribution, data variance and other summary statistics where data is not normally distributed to aid in understanding the robustness of the present water quality dataset.	Section A.7.3.1.2 Appendix A.7D Updated Appendix B5 to Appendix 7A
R163	Additional details on water sampling protocols and field sampling methodologies. Details should include: a. filtration protocol/methodology (e.g. field filtered, filtered in lab); b. sample handling and preservatives protocol; and c.analytical hold times, chain of custody, etc.	Section A.7.3.1.3
R164	Clarify whether water quality parameters being monitored and conclusions are being drawn from total metals content, dissolved metals content, or both. Discuss whether elevated metals were a result of additional metals associated with higher suspended sediments.	Section A.7.3.1.4 Appendix A.7D Updated Appendix B5 to Appendix 7A Appendix A.7F The Effect of Acid Rock Drainage on Casino Creek
R165	Further discussion and clarification on baseline data from the existing adit. Details should include: a. rationale as to the limited amount of data from the adit; and b. an analysis for loadings (mass-balance) at additional points along the pathway from the adit to site W4.	Section A.7.3.1.5
R166	Toxicity testing and evaluation on water quality samples using early-life stages of salmonid and non-salmonid fish species, invertebrate species, and aquatic plant species.	Section A.7.3.1.6 Appendix A.7G Toxicity Testing Reports
R167	Clarify and provide further justification for the use of water monitoring stations W18, M18, and H18.	Section A.7.3.1.7 Appendix A.7B Water Quality Predictions Report
R168	Toxicity and bioaccumulation testing and evaluation on sediment quality samples.	Section A.7.3.2.1 Appendix A.7G Toxicity Testing Reports

Request #	Request for Supplementary Information	Response
R169	Baseline hydrological information for streams and rivers downstream of W16 on Dip Creek and the Yukon River (e.g. Klotassin River and White River), inclusive of the Yukon River at the respective point of confluence.	Section A.7.4.1.1
R170	Provide estimates of flow rates for the Yukon River either at the point of confluence with Britannia Creek or at the point of planned water withdrawal from the Yukon River;	Section A.7.4.1.2
R171	Confirm whether on-going hydrometric monitoring will continue to improve the reliability of described baseline flow characteristics.	Section A.7.4.1.3
R172	Survey cross-sections of the stream gauging stations as well as an assessment of the accuracy of the measured peak flows considering the rating curve data.	Section A.7.4.1.4
R173	Confirm whether hydrometric monitoring station W1 that was discontinued in 2011 will be re-established. If not, provide rationale as to chosen approach.	Section A.7.4.1.5
R174	Discuss the use of stage-discharge measurements prior to 2011 (measurements which did not include benchmarks) in developing rating curves. Discuss the implications of only using data from 2013 and onwards in developing rating curves.	Section A.7.4.1.6
R175	A detailed description of the methodology used to select the Big Creek drainage as a regional surrogate watershed to develop the synthetic flow series. Consideration should be given to developing a focussed regional relationship using the larger and more current data set.	A.7Section A.7.4.1.7
R176	Update tables 5.1-2, 5.2-1, and 5.3-1 in Appendix 7B, Hydrology Baseline Report to include discharge estimates (e.g. cubic meters per second or liters per second.	Section A.7.4.1.8
R177	A discussion on, and if necessary reassess, the values identified in Tables 5.2-1 and 5.3-1 of Appendix 7B (Hydrology Baseline Report) given that a comparison with regional hydrometric data suggests that values presented are higher than regional values.	Section A.7.4.1.9
R178	The following referenced report: Knight Piésold Ltd. 2010 Hydrometeorology Report (Ref. No. VA101-325/3-1, June 2010)	Section A.7.4.1.10 Appendix A.4G Updated Hydrometeorology Report
R179	An update and overview of current hydrogeology baseline information. Details should be provided for the following: a. whether additional conductivity studies are being done in the TMF Main Embankment area and rationale for the selected approach; b. characterization of hydrogeology in the open pit area outside the immediate footprint; and c. characterization of hydrogeology in the gold ore, supergene oxide/low grade ore, and low grade ore stockpile areas.	Section A.7.5.1.1 Appendix A.7M 2013-2014 Groundwater Data Report
R180	Additional discussion and supporting rationale on groundwater seepage from the open pit area to the Canadian Creek drainage. The discussion should include implications to base flows during operations and water quality during closure and post-closure.	Section A.7.5.1.2

Request #	Request for Supplementary Information	Response
R181	The following document for review: Knight Piésold Ltd. Revised Tailings Management Facility Seepage Assessment (Ref. No. VA101-325/8-13, December, 2012).	A.7Section A.7.5.1.3 Appendix A.4L Revised Tailings Management Facility Seepage Assessment
R182	Additional detail and rationale to indicate that samples collected for geochemical characterization of ore, waste rock, and tailings, provide a statistically representative dataset. Details should include: a. results of sensitivity analysis and gap analysis of geochemical characterization program; b. summation of geochemical sampling program relative to rock lithology and alteration types; and c. if current sampling is found to be incomplete, please update accordingly with a suitable number of samples for ABA, as well as appropriate kinetic testing.	Section A.7.6.1.1 Appendix A.7H Appendix A2 to Casino Waste Rock and Ore Geochemical Static Test Assessment Report: Cross-Sections
R183	Complete cross-section and long-sectional diagrams of the open pit. Diagrams should include: a. all sample locations; b. all geologic units and lithologies; c. ore body outline; and d. any other data that will increase understanding of the deposit geology.	Section A.7.6.1.2 Appendix A.7H Appendix A2 to Casino Waste Rock and Ore Geochemical Static Test Assessment Report: Cross-Sections
R184	The following referenced reports: a. Lorax Environmental Service Ltd. (2009) Casino Phase I Geochemical Assessment Report prepared for Western Copper Corporation, January, 2009. b. Lorax Environmental Services Ltd. (2010) Casino Phase II Geochemical Assessment Report, prepared for Western Copper Corporation, January 2010.	Section A.7.6.1.3
R185	Describe or otherwise comment upon the added dimension of lithology in their analysis.	Section A.7.6.1.4
R186	Information on and description of the “FZ” lithology listed in Table 3-2 report titled Casino Waste Rock and Ore Geochemical Static Test Assessment (Appendix 7D, Lorax, Dec 3, 2013).	Section A.7.6.1.5
R187	Clarify why there are only about 12 percent of HYP samples included in the shake flask extraction testwork when the HYP type makes up almost 37 percent of the alteration types.	Section A.7.6.1.6 Appendix A.7I Casino Kinetic Testwork 2014 Update for Ore, Waste Rock and Tailings
R188	Rational as to why there are no values presented for uranium and fluoride despite having identified them as parameters of interest.	Section A.7.6.1.7

Request #	Request for Supplementary Information	Response
R189	Details on: mining sequence; production of ore and waste types relative to lithology and alteration; and blending schedule. Details should include: a. an ore/waste production schedule (tables and figures) broken down by lithologic/alteration units and tonnages mined; and b. demonstration that the mixing CAP and SUP material with HYP material could be implemented and will be an effective mitigation.	Section A.7.6.1.8 Appendix A.4F Waste Storage Area and Stockpiles Feasibility Design Appendix A.22H ML/ARD Management Plan
R190	Update and provide a discussion of on-going kinetic testwork. Provide any results and demonstrate how those results may inform the Project. Details should include: a. discussion on whether any of the tests recommended by Knight Piésold have been conducted or initiated; b. any additional laboratory reports that are available; and c. discussion on what experiments/test work will be conducted prior to starting construction of the heap.	Section A.7.6.1.9 Appendix A.7I Casino Kinetic Testwork 2014 Update for Ore, Waste Rock and Tailings
R191	Details demonstrating the ore beneficiation process proposed to produce suitable concentrate. Details should include the process steps, reagents to be used, and resulting concentrates and wastes generated.	Section A.7.6.1.10 Appendix A.4M Processing Flow Sheets Appendix A.22H ML/ARD Management Plan

Request #	Request for Supplementary Information	Response
R192	For the Freegold Road upgrade and extension, access road borrow sources, airstrip, airstrip access road, and mine site borrow sources, provide additional details and information on: a. all geological materials, including estimates of volumes, that will be excavated, exposed or otherwise disturbed; b. geochemical characterization, analysis, and interpretation on representative samples for those geological materials; c. consideration of potential effects and appropriate mitigation measures associated with excavating, exposing, or disturbing those materials.	Section A.7.6.1.11 Appendix A.22H ML/ARD Management Plan Appendix A.7J Preliminary Risk Assessment Metal Leaching and Acid Rock Drainage Appendix A.7K Casino Mine Site Borrow Sites ML/ARD Potential Appendix A.12A Wildlife Mitigation and Monitoring Plan V.1.2 Appendix A.22A Waste and Hazardous Materials Management Plan Appendix A.22C Sediment and Erosion Control Management Plan Appendix A.22D Invasive Species Management Plan
R193	The following referenced report: Lorax Environmental Services Ltd. (2012) Casino Road: Preliminary Risk Assessment Metal Leaching and Acid Rock Drainage.	Section A.7.6.1.12 Appendix A.7J Preliminary Risk Assessment Metal Leaching and Acid Rock Drainage
R194	Details and justification on the depth of reaction and loadings source of 2.0 m for the face of the embankment when the active oxidation zone will initially be over a much deeper zone and will evolve downward over time. Justify the loading rates in the source term as a function of the oxidation zone only.	Section A.7.6.2.1
R195	Clarify the loadings as either runoff on the embankment slope and/or the downward infiltration that will eventually daylight as seepage from the embankment.	Section A.7.6.2.2 Appendix A.7B Water Quality Predictions Report

Request #	Request for Supplementary Information	Response
R196	Justify the depth of oxidation on the tailings beach and show the effect and implications of oxidation on the loadings associated with the infiltrating porewater and tailings seepage.	Section A.7.6.2.3 Appendix A.7B Water Quality Predictions Report
R197	The text on page 4-66 refers to Figure 4.1.4 yet this could not be found, or appears to be mislabelled. Please provide this figure for review.	Section A.7.6.3.1
R198	Casino Cross Sections (Appendix A2 – in LORAX (2013) Casino Geochemical Static Test Assessment, 3-Dec-13, J862-5).	Section A.7.6.3.2 Appendix A.7H Appendix A2 to Casino Waste Rock and Ore Geochemical Static Test Assessment Report: Cross-Sections
R199	Supplemental Unsaturated Kinetic Test Results (Appendix B – LORAX (2013) Casino Geochemical Source Term Development, 4 December, J862-5).	Section A.7.6.3.3 Appendix A.7L Casino Geochemical Source Term Development: Appendix B
R200	The following referenced report: Himmelright, J. R., 1994: The effect of natural acid rock drainage on Casino Creek. Prepared for Pacific Sentinel Gold Corp. August 1994.	Section A.7.6.3.4 Appendix A.7F The Effect of Acid Rock Drainage on Casino Creek
R201	Re-run the numerical groundwater model with updated groundwater baseline data.	Section A.7.7.1.1
R202	A copy of the updated Modflow numerical groundwater model and all input data used in the modeling runs including: a. a copy of all model outputs as summary tables and figures; and b. further discussion of assumptions used in the modeling.	Section A.7.7.1.2
R203	Discuss whether the open pit lake seepage predicted by the numerical model, to Casino Creek after closure, is assessed in the overall loadings to the TMF and the downstream environment. If not, provide rationale for its exclusion.	Section A.7.7.1.3 Appendix A.7B Water Quality Predictions Report
R204	If the majority of the predicted seepage, from the open pit lake, of 12 L/s will report to the upper groundwater system in Casino Creek: a. identify what the predicted magnitude of the remaining seepage will be; and b.identify where the remaining seepage is predicted to report to and what the effect of that seepage will be.	Section A.7.7.1.4

Request #	Request for Supplementary Information	Response
R205	Discuss whether the potential for preferential flow through faults below the TMF were considered and if not, discuss why and if so, discuss what were the results and implications for water quality downstream of the TMF.	Section A.7.7.1.5 Appendix A.4D Report on the Feasibility Design of the Tailings Management Facility Appendix A.4L Revised Tailings Management Facility Seepage Assessment
R206	Clarify whether hydraulic conductivity values of the tailings and embankment materials are estimates or laboratory measured values. If they are estimates, please indicate if, and when laboratory testing will be conducted.	Section A.7.7.1.6 Appendix A.4L Revised Tailings Management Facility Seepage Assessment
R207	Update the numerical groundwater model to specifically include the seepage recovery pond and calculate the seepage recovery pond's efficiency including the flux of untreated water that will bypass the pond.	Section A.7.7.1.7
R208	Justification for using a series of steady state models rather than one transient model to predict groundwater flows.	Section A.7.7.1.8
R209	A description of how the numerical groundwater model is to be used and updated during the mining process in order to improve mine management and predictions for closure. Indicate when any updates would be released during operations.	Section A.7.7.1.9
R210	Groundwater level data between the proposed TMF and the Dip Creek watershed. The area of greatest concern is along the watershed divide just beyond the eastern end of the main embankment.	Section A.7.7.1.10 Appendix A.7M 2013-2014 Groundwater Data Report Appendix A.7N Extension of Numerical Groundwater Modelling to include Dip Creek Watershed
R211	A NW-SE geological cross-section (same approximate orientation as the main embankment) from the TMF to Dip Creek since this could demonstrate potential groundwater flow pathways across the topographic divide.	Section A.7.7.1.11
R212	Numerical groundwater flow modeling that extends into the Dip Creek watershed and eliminates the assumption of a no-flow boundary. Modeling should consider the potential for subpermafrost groundwater flow across the topographic divide. Modeling the seepage from the TMF should consider three dimensional flow from the TMF in order to consider not only vertical flow through or beneath the dam but also horizontal flow around the dam and potentially into Dip Creek tributaries.	Section A.7.7.1.12

Request #	Request for Supplementary Information	Response
R213	Map of the elevation of the base of permafrost and data on deep permafrost conditions east of the proposed tailings management facility.	Section A.7.7.1.13 Appendix A.7N Extension of Numerical Groundwater Modelling to include Dip Creek Watershed
R214	Justification for not including the subsurface distribution of permafrost (in particular lower hydraulic conductivity of frozen ground as a barrier to groundwater flow) in the numerical groundwater flow modeling.	Section A.7.7.1.14
R215	A discussion of the effect of permafrost distribution on the observed and modelled patterns of groundwater flow.	Section A.7.7.1.15
R216	Discussion of hydraulic conductivities of frozen and unfrozen hydrostratigraphic units. Details should include: a. estimates of frozen and unfrozen hydraulic conductivities of all rock materials subject to permafrost; and b. how thermal changes (due to facility construction and climate change) will affect the groundwater regime.	Section A.7.7.1.16
R217	A discussion and consideration of a numerical permafrost model to assess the effects of the mine components on permafrost distribution in the mine footprint.	Section A.7.7.1.17
R218	A discussion on the discrepancies between the Inferred Spatial Distribution of Permafrost (Figure 2.3 of Appendix 7C) and the Groundwater Recharge Zones (Figure 3.4 of Appendix 7E).	Section A.7.7.1.18
R219	A discussion of how recharge distributions were modified and their potential effects on the numerical groundwater flow model.	Section A.7.7.1.19
R220	A new figure combining both the recharge and permafrost distributions so that it is possible to identify where the distributions overlap and differ.	Section A.7.7.1.20
R221	Complete groundwater modeling on the period of time that the TMF is dewatered to allow construction of the TMF wetlands.	Section A.7.7.1.21
R222	Modeling for seepage flow rates from the water management pond if the water level exceeds desired levels.	Section A.7.7.1.22
R223	Verification methods for seepage flow not captured by the water management pond.	Section A.7.7.1.23
R224	An assessment of potential water quantity under a broader range of hydrologic conditions, including: a. the ability to manage waters during wet, dry and average years; b. the receiving water effects during typical and extreme summer and winter low flows (7Q20 and 7Q10); and c. the water storage and receiving water effects during freshet and event flow.	Section A.7.8.1.1 Appendix A.7A Variability Water Balance Model Report

Request #	Request for Supplementary Information	Response
R225	An assessment of the potential effects of climate change on water balance.	Section A.7.8.1.2 Appendix A.7A Variability Water Balance Model Report Appendix A.7C Potential Effects of Climate Change on the Variability Water Balance
R226	An assessment of potential water quantity under a broader range of operating/closure scenarios, including permit limits, atypical operations, and accident scenarios.	Section A.7.8.1.3 Appendix A.7A Variability Water Balance Model Report
R227	Provide sensitivity analysis for the site water balance model identifying: a.the potential impact of variation in assumed values for key water balance model parameters; and b. the potential impact of temporal change in the assumed distribution of precipitation and snowmelt.	Section A.7.8.1.4 Appendix A.7A Variability Water Balance Model Report Appendix A.7B Water Quality Predictions Report
R228	Identify if the results of the sensitivity analysis materially affect the Water Management Plan for the project proposal, and if yes, update the Water Management Plan.	Section A.7.8.1.5 Appendix A.7A Variability Water Balance Model Report
R229	A description of how the water balance model is to be used and updated during the mining process in order to improve mine management and predictions for closure. Indicate when any updates would be released during operations.	Section A.7.8.1.6 Appendix A.7A Variability Water Balance Model Report Appendix A.7C Potential Effects of Climate Change on the Variability Water Balance
R230	Provide the reasoning for selecting Big Creek as the most representative long-term hydrometric station for generating site synthetic stream flow data.	Section A.7.8.1.7
R231	Re-run the water quality model with updated water quality baseline data.	Section A.7.9.1.1
R232	A copy of the GoldSim model and all input data used in the assessment.	Section A.7.9.1.2 Appendix A.7B Water Quality Predictions Report

Request #	Request for Supplementary Information	Response
R233	A copy of all model outputs as summary tables and figures.	Section A.7.9.1.3 Appendix A.7B Water Quality Predictions Report
R234	A discussion of assumptions used in the modeling.	Section A.7.9.1.4 Appendix A.7B Water Quality Predictions Report
R235	Any additional information that the Proponent may have used in their assessment so as to facilitate an independent calculation of potential water quality effects by reviewers.	Section A.7.9.1.5 Appendix A.7A Variability Water Balance Model Report
R236	A description of how the water quality model is to be used and updated during the mining process in order to improve mine management and predictions for closure. Indicate when any updates would be released during operations.	Section A.7.9.1.6
R237	An explanation of how loadings from embankment runoff and embankment seepage relate to the conceptual flow diagram in Figure 7-2 in LORAX (2013) Casino Geochemical Source Term Development, 4 December, J862-5. In addition, please confirm that those loadings were included in the water quality model.	Section A.7.9.2.1 Appendix A.7B Water Quality Predictions Report
R238	Additional details and rationale supporting the use of site specific water quality objectives (SSWQO) for certain contaminants of concern. Details should include: a. justification for not using CCME guidelines to develop SSWQO; b. demonstration that aquatic biota remain protected to the same degree as provided by the CCME guidelines; c. how SSWQO account for chronic/long-term acceptable limits; and d. consideration for the new, hardness-dependent, long-term limit for cadmium now available from CCME.	Appendix A.7A Variability Water Balance Model Report Appendix A.7B Water Quality Predictions Report Appendix A.7E 2008 Environmental Studies Report: Final
R239	Predictions for pH in table 7.4-3 (Water Quality Model Parameters and CCME and BC MOE Guidelines) and Tables 7.4-8 through 7.4-10 (Summary of Predicted Water Quality in Casino Creek at M18 and W4 and Dip Creek at W5).	Section A.7.10.1.2 Appendix A.7B Water Quality Predictions Report
R240	Predictions for toxicity, pH, and radium 226 in the tailings management facility pond and the winter seepage mitigation pond. Provide a discussion on how these parameters address the limits under the Metal Mining Effluent Regulations.	Section A.7.10.2.1 Appendix A.7B Water Quality Predictions Report

Request #	Request for Supplementary Information	Response
R241	An assessment of potential water quality effects extending downstream to include water monitoring station W16 and, if necessary, as far downstream to demonstrate no further exceedances of the CCME surface water quality objectives attributed to the mine (or 90th percentile of background for those constituents that naturally exceed CCME). The assessment should consider scenarios both with and without use of the passive treatment system.	Section A.7.11.1.1
R242	Additional rationale supporting the use of station M18/W18 as the receiving environment for the Project. Consideration should be given to: a. how this site fits within the intent of CCME; and b. to what degree does contribution of water from Brynelson Creek provide a buffer for the project meeting CCME or site specific water quality objectives for the protection of aquatic resources.	Section A.7.11.1.2
R243	Expected length of time PAG materials will be exposed to oxygen and water before submersion in the TMF and any expected resulting acid generation.	Section A.7.12.1.1 Appendix A.7I Casino Kinetic Testwork 2014 Update for Ore, Waste Rock and Tailings
R244	An analysis of scenarios that may cause exposure of PAG materials considering variation of meteorological factors, vegetative interception, and seepage losses. Details should include: a. an analysis of successive dry years on TMF water balance and its implications on PAG tailings and waste rock oxidizing due to low water levels; b. the minimum annual precipitation required to maintain PAG materials below the water table in the TMF; c. scenarios during closure that would cause the water table in the TMF to be low enough to allow oxidation of the PAG materials; and d. the potential effects associated with metals mobilization under these scenarios.	Section A.7.12.1.2 Appendix A.4D Report on the Feasibility Design of the Tailings Management Facility
R245	A plan describing mitigations in case unsuitable (e.g. elevated metal concentrations) water is encountered via pit dewatering (i.e. prior to sufficient storage developed on-site).	Section A.7.13.1.1
R246	Details on the characterization of groundwater and flow patterns near the adit.	Section A.7.14.1.1
R247	A comprehensive description of the adit including: a. physical characteristics (e.g. incline or decline, dimensions, length); and b. extent of fracturing.	Section A.7.14.1.2
R248	How and when the adit will be reclaimed. Describe implications of reclamation on surrounding groundwater and infrastructure such as the HLF.	Section A.7.14.1.3
R249	Reasons for missing data at regional climate stations (i.e. was the station not operated for budget considerations or did an extreme weather event destroy the station).	Section A.8.2.1.1

Request #	Request for Supplementary Information	Response
R250	Rationale for a linear orographic factor at the Project site for 24-hour extreme events considering available data and any terrain effects.	Section A.8.2.1.2
R251	Additional rationale for developing the precipitation return period events (e.g. extreme rainfall). Details should include the methodology for developing the 200 and 1000-year return period events as well as rationale for using the Gumbel distribution.	Section A.8.2.1.3
R252	Discussion of the role of aspect in relation to climate variables at the Project site.	Section A.8.2.1.4
R253	Justify the use of only Pelly Ranch in building climate baseline data at the Project site for periods where data are unavailable for the Project location.	Section A.8.2.1.5
R254	Confirm that on-site meteorological data collection is ongoing. Provide raw and processed data and recalculate precipitation estimates and measures of variability.	Section A.8.2.1.6
R255	Clarification regarding the climate variables that have been utilized as part of project safety and design as well as an explanation for why those climate variables have been chosen.	Section A.8.2.1.7
R256	Clarification regarding the values used when considering climate change projections and their interactions with the project.	Section A.8.2.1.8
R257	Additional information on wind speed/direction sensor position and height.	Section A.8.2.1.9
R258	Develop a more robust estimate of evaporation and evapotranspiration using air temperature, relative humidity, wind speed and solar radiation.	Section A.8.2.1.10
R259	A discussion on how variability and uncertainty associated with the impacts of climate change was considered in Project safety and design and how those impacts will be mitigated, particularly with respect to permafrost thaw and hydrological changes.	Section A.8.3.1.1
R260	In planning the design and construction of the mine, a greater range of potential change should be considered (and not just the mean). For example, if the range of precipitation change is projected to be between 5 and 25 percent, design considerations should not be limited to a mean (15 percent) but should address the potential maximum (25 percent). Please clarify what values were used when considering climate change projections and their interactions with the Project.	Section A.8.3.1.2
R261	Clarification on the calculations related to the projected rate of increase of flow, including details on how historical trends for Big Creek have been taken into consideration in the projection as well as how the potential maximum increase has been addressed.	Section A.8.3.1.3
R262	The CALPUT and CALMET input files such that a recreation of the model is possible.	Section A.8.4.1.1 Appendix A.8A Emissions Inventory for Construction and Operations
R263	Details on the specifications of ambient air monitoring and meteorological equipment.	Section A.8.4.1.2

Request #	Request for Supplementary Information	Response
R264	An analysis of wind directions compared to other regional sites.	Section A.8.4.1.3
R265	A detailed emission inventory for construction and operational activities.	Section A.8.4.1.4 Appendix A.8A Emissions Inventory for Construction and Operations
R266	Clarification if mitigations, such as ultra-low sulphur fuel, proposed for air quality were reflected in model parameters. If not, results of the air quality model with the mitigations reflected in model parameters.	Section A.8.4.2.1
R267	If predicted air quality, after mitigations, results in exceedances, provide mitigations for identified exceedances.	Section A.8.4.2.2
R268	The raster data generated from the CALPUFF model in a standard GIS format.	Section A.8.4.3.1
R269	A description of predicted exceedances including concentrations and predicted frequency.	Section A.8.4.3.2
R270	Details on the compositions of dust generated by the mine and how this is expected to compare with the proposal's baseline data.	Section A.8.5.1.1
R271	Details on volumes of water required for dust management and clarification if this water was accounted for in overall water use requirements.	Section A.8.5.1.2
R272	Update to Table 22.3-2 to include a conclusive list of proposed mitigation measures for potential project effects on air quality.	Section A.8.6.1.1
R273	An updated Section 10 of the proposal which reflects the current *Fisheries Act* (Fisheries Protection Provisions). This updated section should include the identification of project components likely requiring a paragraph 35(2)(b) *Fisheries Act* authorization.	Section A.10.2.1.1 Appendix A.10A Updated Fish Habitat Offsetting Plan
R274	Proposed charge weights to be used for different project activities including the operation of the mine pit, and construction of infrastructure site pads and access roads. Indicate setback distances from fish-bearing waters for each activity and an analysis of potential effects based on this information.	Section A.10.3.1.1 Appendix A.10A Updated Fish Habitat Offsetting Plan Appendix A.10B Fish Habitat Evaluation: Instream Flow and Habitat Evaluation Procedure Study
R275	Baseline data for the creek intersected by the proposed airstrip, Taylor Creek, and other Casino Creek tributaries lacking baseline data including: a. the existing condition, including quality and relative abundance, of the fish habitat; and b. the species and life stages of fish present.	Section A.10.4.1.1
R276	A discussion of fish populations, densities, and diversity in downstream watercourses including lower Dip Creek and the Klotassin River.	Section A.10.4.1.2

Request #	Request for Supplementary Information	Response
R277	Maps demonstrating fish presence, assumed absence, or observed absence by stream segment. Include the stream channel intersected by the proposed airstrip, Casino Creek tributaries such as Taylor Creek, and the Freegold Road. Where fish are assumed as absent, provide rationale.	Section A.10.4.1.3
R278	Maps demonstrating fish habitat quality and fish distribution by species for watercourses including Casino Creek and its tributaries, Dip Creek downstream of its confluence with Casino Creek, and Britannia Creek and its tributaries. Include any seasonal barriers to movement.	Section A.10.4.1.4
R279	A table or other tool identifying the location in the proposal of supporting baseline information for each of the potentially impacted watercourses.	Section A.10.4.1.5
R280	Information on the time of year each of the water bodies potentially affected by the Project are likely to be used by the various life stages of each fish species.	Section A.10.4.1.6
R281	Appendices A through E for Appendix 10 A – Casino Project Fish and Aquatic Resources Baseline Report, November 12, 2013, by Palmer Environmental Consulting Group Inc.	Section A.10.4.2.1
R282	A description of the detailed methods used to calculate the estimated reductions in flow and wetted area from baseline conditions in all watercourses affected. (EcoMetrix)	Section A.10.5.1.1 Appendix A.10B Fish Habitat Evaluation: Instream Flow and Habitat Evaluation Procedure Study
R283	An indication of and rationale for the selected minimum in-stream flow threshold. (EcoMetrix)	Section A.10.5.1.2 Appendix A.10B Fish Habitat Evaluation: Instream Flow and Habitat Evaluation Procedure Study
R284	The full documents cited as KPL 2013 and Normandeau, November 2013. (EcoMetrix)	Section A.10.5.1.3 Appendix A.10B Fish Habitat Evaluation: Instream Flow and Habitat Evaluation Procedure Study

Request #	Request for Supplementary Information	Response
R285	A discussion of the extent to which the identified overwintering and spawning habitat in the affected portion of Casino Creek is actively used by Arctic grayling for these stages, and the potential effects of the Project to this habitat.	Section A.10.5.1.4 Appendix A.10A Updated Fish Habitat Offsetting Plan Appendix A.10B Fish Habitat Evaluation: Instream Flow and Habitat Evaluation Procedure Study
R286	A discussion of the potential fish barrier proposed to be installed above the Casino- Brynelson Creek confluence. This discussion should include: a. a description of the barrier proposed, and details regarding its installation; and b. identification of alternative mitigations to the physical fish barrier in this location to prevent winter kill and fish stranding.	Section A.10.5.2.1
R287	The degree of risk for fish stranding to actually occur in Casino Creek due to low water flow attributed to the operation of the tailings management facility.	Section A.10.5.2.2 Appendix A.10B Fish Habitat Evaluation: Instream Flow and Habitat Evaluation Procedure Study
R288	A discussion of and rationale for the diversion of this drainage around the airstrip. This discussion should consider alternatives, such as allowing the drainage to pass underneath the airstrip.	Section A.10.5.3.1 Appendix A.10A Updated Fish Habitat Offsetting Plan Appendix A.10B Fish Habitat Evaluation: Instream Flow and Habitat Evaluation Procedure Study
R289	A discussion of the potential for seasonal stranding of fish in the lower portion of the dewatered channel.	Section A.10.5.3.2
R290	An updated Fish Habitat Compensation Plan to align with the new requirements of the *Fisheries Protection Provisions* of the new *Fisheries Act*.	Section A.10.5.4.1 Appendix A.10A Updated Fish Habitat Offsetting Plan

Request #	Request for Supplementary Information	Response
R291	A detailed description of the physical habitat simulation model. Details should include: a. data used in the model (habitat and hydrological) and methods for field data collection; b. locations of all transects (of each mesohabitat type - riffle, pool and glide) on each watercourse; c. habitat suitability indices (HSI) curves for Arctic grayling in all life stages which consider site specific conditions; d. species and life stage periodicity chart highlighting the seasonal use of the study area by different life stages of the target species, and a discussion of whether migration patterns were considered in the model; e. discussion of whether seasonal use by life stage requirements of target species was considered in the model; f. target flow velocities for low, mid and high flows, with a comparison to the baseline and projected flows for construction, operation and closure phases, indicating and providing rationale for the selected minimum in-stream threshold; g. discussion of impacts to Britannia Creek from reduced flows in Canadian Creek as flow is redirected to the pit; and h. a comparison of percent reduction in flow for areas affected by reduced stream flows considering natural variability observed in stream.	Section A.10.5.5.1 Appendix A.10B Fish Habitat Evaluation: Instream Flow and Habitat Evaluation Procedure Study
R292	A detailed description of the habitat evaluation procedure. Details should include: a. methods and assumptions for the calculation of habitat lost; b. summary of HSI values for each variable; c. identification of and rationale for habitat types included; and d. data and methods used to calculate habitat gains, including from all proposed compensation options.	Section A.10.5.5.2 Appendix A.10B
R293	Clarification of whether the estimated habitat loss in Dip Creek was accounted for in the total habitat loss calculation for the proposed airstrip tributary diversion channel.	Section A.10.5.6.1
R294	Clarification of, and rationale for, the methods used to calculate the figures in Table 4-5: in-stream habitat impacts and in-stream habitat gains. This clarification should include the calculation of 4753 m^2 as identified in Table 4-5, based on the proposed airstrip diversion channel width of 2.5 m and length of 1 509 m.	Section A.10.5.6.2 Appendix A.10A Updated Fish Habitat Offsetting Plan
R295	Clarification of whether the assumed fish bearing streams (those of less than 20 percent gradient) were included in the habitat evaluation procedure analysis for habitat loss and compensation.	Section A.10.5.7.1
R296	Identification and rationale for the type(s) of habitat created by ford restoration.	Section A.10.5.8.1 Appendix A.10A Updated Fish Habitat Offsetting Plan

Request #	Request for Supplementary Information	Response
R297	Clarification of whether clear-span bridges are proposed for all fish-bearing watercourses. If culverts will be installed on some fish-bearing creeks, please provide rationale, mitigations, and incorporate habitat losses into the habitat compensation plan.	Section A.10.6.1.1
R298	Details on existing crossing structures no longer used for portions of the Freegold Road upgrade once the road is re-aligned.	Section A.10.6.2.1
R299	Details on when and how the Nordenskiold River bridge pier will be constructed.	Section A.10.6.3.1
R300	The quality and type of fish habitat (e.g. highly suitable spawning and/or rearing habitat, confirmed spawning habitat, and migratory channel) potentially affected by the Nordenskiold River bridge. Discussion should include identification of potential effects of the bridge and the pier, focusing on potential long-term morphological changes to the river in contrast to natural morphological changes.	Section A.10.6.3.2
R301	The fish species (and their life stages) present in the area potentially affected by the Nordenskiold River bridge. Discussion should include identification of potential effects of the bridge and the pier.	Section A.10.6.3.3
R302	A list of stream crossings for the Freegold Road including stream name, kilometre marker, crossing properties and the type of crossing, considering DFO's definition of clear-span crossing.	Section A.10.6.4.1
R303	An assessment of the overall erosion and sedimentation risk that will form the basis for designing and ultimately preparing an erosion and sediment control plan for the Freegold Road Upgrade, Airstrip Access Road and Casino Mine site.	Section A.10.6.5.1
R304	Identification of fish-bearing and non fish-bearing reaches of affected watercourses in the Map Series 3 (overall erosion and sedimentation risk) of the Erosion and Sedimentation Risk Assessment Report.	Section A.10.6.5.2
R305	Discussion on the methods of monitoring for erosion and sedimentation during all phases of the Project.	Section A.10.6.5.3 Appendix A.10A Updated Fish Habitat Offsetting Plan Appendix A.22C Sediment and Erosion Control Management Plan
R306	Discussion of and rationale for the exclusion of W16 or other downstream locations from monitoring throughout the life of the Project.	Section A.10.7.1.1
R307	The information related in Section 7.4.5.1 and 7.4.5.2.	Section A.10.8.1.1
R308	Discussion of the potential effects of the construction, operation, and possible decommissioning of other project infrastructure on habitat (such as fens and tors) with elevated potential for rare species.	Section A.11.2.1.1 Appendix A.12A Wildlife Monitoring and Mitigation Plan Appendix A.22C Sediment and Erosion Control Plan

Request #	Request for Supplementary Information	Response
R309	Discussion of the potential effects of the construction, operation, and possible decommissioning of the airstrip and airstrip access road on proximate vegetation and wetlands. In particular, this discussion should identify impacts to downslope wetlands.	Section A.11.2.1.2 Appendix A.12A Wildlife Monitoring and Mitigation Plan Appendix A.22C Sediment and Erosion Control Plan
R310	An update to Figure 3.1 with the ecosystem types identified in the large vegetation polygon overlapping with the centre of the airstrip.	Section A.11.2.1.3
R311	Discussion of the use of “Loss of Vegetation Associations” and “Wetlands and Riparian Vegetation Associations” as indicators for vegetation health.	Section A.11.3.1.1 Appendix A.12A Wildlife Monitoring and Mitigation Plan Appendix A.22C Sediment and Erosion Control Plan
R312	A clear mitigation (buffer zone and avoidance) and management plan (where avoidance cannot be achieved) to support the residual effect assessment, for both the construction and operation of the project components.	Section A.11.3.1.2 Appendix A.10A Fish Habitat Offsetting Plan Appendix A.22C Sediment and Erosion Control Plan
R313	Details on a conceptual integrated management plan for project activities affecting vegetation. Details should include: a. proposed buffer zones around wetlands, valuable vegetation associations or sites, and riparian areas which also consider the needs of wildlife for movement corridors; b. species to be used for re-vegetation; c. timeframe for re-vegetation and reclamation activities; d. measures to monitor success and take corrective actions as necessary; and e. control of invasive species.	Section A.11.4.1.1 Appendix A.10A Fish Habitat Offsetting Plan Appendix A.22C Sediment and Erosion Control Plan Appendix A.22D Invasive Species Management Plan
R314	The correct references for each place in Section 12 that this error text appears.	A.12.2.1.1
R315	Discussion on the effects to wildlife for caribou, wood bison, and Dall sheep, related to predator-prey systems affected by the Freegold Road, airstrip and airstrip access road, through all project phases. This discussion should: a. use the most current data and information available; b. include changes to population dynamics; and c. include areas of wildlife concentration, such as mineral licks.	A.12.3.1.1 Appendix A.12A Wildlife Mitigation and Monitoring Plan

Request #	Request for Supplementary Information	Response
R316	Describe how wildlife crossing areas will be implemented. Details should include: a. the schedule and methods for data collection and analysis regarding the determination of high use wildlife crossing areas along the access roads; and b. how crossing areas may change seasonally and annually.	A.12.3.2.1
R317	Detail on road maintenance activities (e.g. road salt, road margin vegetation management for wildlife, etc.), and other mitigations (such as reducing the frequency of traffic, having periods of time with no traffic, etc.), with a particular emphasis on key wildlife areas. This discussion should include rationale for the effectiveness of mitigations.	A.12.3.3.1 Appendix A.22E Road Use Plan Appendix A.12A Wildlife Mitigation and Monitoring Plan
R318	Wildlife monitoring and adaptive response strategies.	A.12.3.3.2 Appendix A.12A Wildlife Mitigation and Monitoring Plan
R319	Alternative mitigation measures to reduce or eliminate negative effects on wildlife in the event that the Proponent does not have full legal authority to operate and manage the road.	A.12.3.3.3 Appendix A.22E Road Use Plan Appendix A.12A Wildlife Mitigation and Monitoring Plan
R320	Further discussion on the potential indirect effects to wildlife from harvesting.	A.12.3.3.4 Appendix A.12B Wildlife Baseline Report
R321	A discussion of noise associated with the Project in relation to the habitat suitability model using the most recent reference materials available. This discussion should include consideration of noise from all Project activities.	A.12.4.1.1
R322	A discussion of objectives for evaluating model assumptions for caribou disturbance, monitoring movement and potential changes in predation, and setting adaptive management thresholds to support actions which may mitigate adverse effects.	A.12.4.1.2 Appendix A.12A Wildlife Mitigation and Monitoring Plan
R323	A discussion of potential Project effects to the Fortymile caribou herd supported by available data.	A.12.4.1.3
R324	Discussion of the development of the RSF model, including all inputs. Consideration should be given to concerns raised by the Government of Yukon.	A.12.4.1.4
R325	Discuss how the RSF model: a. reflects the distribution of high quality habitat across the Klaza caribou herd's range; and b. accounts for the variability in caribou distribution based on environmental facts and among years.	A.12.4.1.5

Request #	Request for Supplementary Information	Response
R326	Discussion of the potential bias in the estimated winter range.	A.12.4.1.6 Appendix A.12B Wildlife Baseline Report
R327	Winter range map or maps that are representative of caribou use since the late 1980s.	A.12.4.1.7 Appendix A.12B Wildlife Baseline Report
R328	An evaluation of the Klaza caribou herd use of the local study area during summer, using the most recent GPS radio-collar data provided by the Government of Yukon.	A.12.4.1.8 Appendix A.12B Wildlife Baseline Report
R329	A discussion of how the Project may affect (e.g. fire suppression) the Dawson Range's fire regime and its corresponding implications to caribou and caribou habitat.	A.12.4.1.9
R330	Population survey data and demographic models for moose to determine sensitivity to change from potential additional predation or hunting pressure.	A.12.4.2.1
R331	Moose harvest data by sex, including an estimate of First Nations harvest, as well as a population model and sensitivity analysis.	A.12.4.2.2 Appendix A.12B Wildlife Baseline Report
R332	Mitigation measures for displacement/mortality of moose near roads.	A.12.4.2.3 Appendix A.12A Wildlife Mitigation and Monitoring Plan
R333	Detailed design of the pipeline with rationale. If a final design cannot be selected at this stage, please provide detailed design alternatives, and include the potential effects associated with each. In the event that design has not been finalized, please provide the schedule and methods for moose monitoring efforts to inform development of the pipeline.	A.12.4.2.4 Appendix A.12A Wildlife Mitigation and Monitoring Plan Appendix A.12B Wildlife Baseline Report
R334	A discussion of and rationale for the selected model. This discussion should include: a. rationale for the ratings assigned to the subalpine and low boreal zones, as well as the selection of north-facing slopes, which considers the comments made by the Government of Yukon; and b. an explanation of Figure 4.3 in the Wildlife Baseline Report showing habitat quality class, which includes statistical support for each of the bars.	A.12.4.2.5 Appendix A.12C Moose Late Winter Habitat Suitability Report
R335	A discussion of and rationale for a 300 m zone of influence. This discussion should consider increasing the zone to at least 500 m.	A.12.4.2.6 Appendix A.12C Moose Late Winter Habitat Suitability Report

Request #	Request for Supplementary Information	Response
R336	Detail on baselines survey efforts, including den surveys, and including routes taken.	A.12.4.3.1 Appendix A.12B Wildlife Baseline Report
R337	Additional data (one year minimum) on bear den presence and distribution within the project area.	A.12.4.3.2
R338	Discussion regarding the dates provided by the Government of Yukon for grizzly bear denning and how these dates may affect or be affected by project activities.	A.12.4.3.3
R339	Details on the Habitat Suitability and Habitat Effectiveness models, including: a. additional clarification on why habitat types were rated as presented; for example, alpine habitat is rated as 'low' (0) value in the spring. For bears, alpine has high habitat value in spring; b. clarification on traffic projections; c. clarification on the dates used to define the different seasons in the HE model; d. clarification on the coefficients used to develop the HE model; and e. clarification on disturbance events considered in the development of the models.	A.12.4.3.4 Appendix A.12B Wildlife Baseline Report
R340	Details on the Security Areas model, including: a. rationale (including reference if possible) for the selection of the 2300 m asl as the threshold for available security areas, as opposed to 1900 m asl; b. clarification on traffic projections; and c. clarification on disturbance events considered in the development of the model.	A.12.4.3.5 Appendix A.12B Wildlife Baseline Report
R341	A discussion of and rationale for the use of a qualitative assessment, as opposed to quantitative, for grizzly bear mortality.	A.12.4.3.6
R342	Clarification of and rationale for the grizzly bear density estimate for the area.	A.12.4.3.7
R343	More information on Table 8.1 of the grizzly bear effects assessment, including: a. proportion of males and females harvested; b. a discussion of how the numbers relate to the population estimate; and c. a discussion of the population-level effects of direct mortality.	A.12.4.3.8
R344	A discussion on the mortality estimate from the mine site, Freegold Road, and airstrip and airstrip access road. Discussion should include: a. conflict kills and road kills; b. consideration of high traffic roads vs. low traffic trails and different traffic types; c. assumptions used for mortality risk assessment related to the Freegold Road and mine site; and d. clarification of and rationale for the quota identified for annual allowable human- caused mortality.	A.12.4.3.9 Appendix A.12A Wildlife Mitigation and Monitoring Plan

Request #	Request for Supplementary Information	Response
R345	Collared pika colony occupancy data to accurately predict species' current abundance and distribution. If occupancy data is unavailable, proposed methods for collecting such data prior to habitat alteration.	A.12.4.4.1 Appendix A.12B Wildlife Baseline Report
R346	A habitat suitability model and related analyses, which identifies potential denning habitat of wolverines in the local study area and regional study area.	A.12.4.5.1 Appendix A.12B Wildlife Baseline Report
R347	A risk assessment for wolverines which considers the habitat suitability model. The assessment should identify potential effects to natal and maternal den sites and proposed measures for avoiding disturbance of females with kits.	A.12.4.5.2 Appendix A.12A Wildlife Mitigation and Monitoring Plan Appendix A.22A Waste and Hazardous Materials Management Plan
R348	Areas of use by the little brown myotis within the LSA and RSA, particularly for roosting and foraging.	A.12.4.6.1 Appendix A.12B Wildlife Baseline Report
R349	If baseline data is unavailable, proposed mitigation and monitoring efforts for the species.	A.12.4.6.2 Appendix A.12A Wildlife Mitigation and Monitoring Plan Appendix A.12B Wildlife Baseline Report
R350	Baseline information for Dall sheep or, if unavailable, proposed mitigation and monitoring measures, particularly in relation to the Freegold Road.	A.12.4.7.1 Appendix A.12B Wildlife Baseline Report
R351	Discussion of alpine breeders as key indicator species, which considers their associated priority for conservation and the project's potential effects on this group.	A.12.5.1.1
R352	The location of alpine meadows in the local study area and regional study area.	A.12.5.1.2
R353	The results of baseline surveys for short-eared owl, horned grebe, and common nighthawk pre-construction surveys (i.e. dusk call playback surveys) and a description of plans for mitigation and monitoring of potential adverse effects cause by the Project.	A.12.5.2.1
R354	Additional detail on the mortality risk to birds including identifying areas of highest risk.	A.12.5.3.1 Appendix A.12A Wildlife Mitigation and Monitoring Plan

Request #	Request for Supplementary Information	Response
R355	Details on the rusty blackbird model. Details should include model inputs and assumptions and indicate whether and how it accounts for small wetlands.	A.12.5.4.1
R356	Discussion regarding the models for olive-sided flycatcher and short-eared owl, including categorization of high quality habitat types. Consideration should be given to an expanded model for the short-eared owl and olive-sided flycatcher.	A.12.5.4.2
R357	A map showing observation sites and potential breeding locations for horned grebes within the project footprint.	A.12.5.4.3
R358	Rationale behind decreasing habitat quality ratings one class, as opposed to two in some cases.	A.12.5.5.1
R359	Proposed mitigations for effects of chronic noise on bird species.	A.12.5.5.2
R360	Discussion of and rationale for buffer sizes around active bird nests.	A.12.5.5.3 Appendix A.12A Wildlife Mitigation and Monitoring Plan
R361	Confirmation on whether the cliff-nesting raptor survey involved re-visiting previously documented nests.	A.12.5.6.1
R362	A figure showing the aerial route followed during cliff-nesting raptor surveys within the local study area and regional study area.	A.12.5.6.2
R363	Rationale for the size of the proposed buffers around cliff-nesting raptor nests.	A.12.5.7.1 Appendix A.12A Wildlife Mitigation and Monitoring Plan
R364	Methods used to identify wetlands, including open-water wetlands and small ponds.	A.12.5.8.1
R365	Information displaying the locations of these wetlands and ponds, and their distribution across the LSA.	A.12.5.8.2
R366	Discussion of potential effects to these wetlands and ponds, and any associated mitigations.	A.12.5.8.3 Appendix A.12A Wildlife Mitigation and Monitoring Plan
R367	An effects assessment of the TMF wetlands, as they relate to waterfowl.	A.12.5.9.1 Appendix A.12A Wildlife Mitigation and Monitoring Plan
R368	Monitoring and mitigations to prevent waterfowl from utilizing the TMF wetlands and other mine water bodies (events pond, pit lake, etc.). Details should include effectiveness of proposed mitigations.	A.12.5.9.2 Appendix A.12A Wildlife Mitigation and Monitoring Plan

Request #	Request for Supplementary Information	Response
R369	Clarification on the meanings of “unacceptable levels of trace metals” and “limited effects” in relation to waterfowl, and rationale for the statement that despite unacceptable levels of trace metals shown by water quality monitoring, resulting effects to waterfowl will be limited.	A.12.5.9.3
R370	Rationale for how water quality mitigation measures alone will address concerns around waterfowl exposure to elevated levels of trace metals.	A.12.5.9.4 Appendix A.12A Wildlife Mitigation and Monitoring Plan Appendix A.7B Water Quality Model Report
R371	Clarification as to whether Figure 8.2 in Section 12B refers to only passerine bird species or to upland birds in general.	A.12.5.10.1
R372	The potential effects of climate change on key indicator species over the life of the Project.	A.12.6.1.1
R373	Discussion of monitoring and adaptive management measures to be implemented to detect and mitigate potential effects of the Project in the context of climate change.	A.12.6.1.2 Appendix A.12A Wildlife Mitigation and Monitoring Plan
R374	Details on the timing, spatial boundaries, frequency, and general methods of monitoring surveys for caribou, moose, carnivore dens, pika colonies, obligate alpine breeders, waterfowl, and bird species at risk.	A.12.7.1.1 Appendix A.12A Wildlife Mitigation and Monitoring Plan
R375	Discussion and rationale on the Proponent’s position that the boom and bust cycle to be either minimal or acceptable within the context of Yukon. Consideration should be given to the contribution of annual taxes, royalties and GDP to the Yukon economic base and the scale of the Project.	Section A.15.2.1.1 Appendix A.13A Economic Impacts of the Casino Mine Project
R376	A description of what measures will be put in place to reduce the effects of boom and bust cycles.	Section A.15.2.1.2
R377	Identify specific conditions and scenarios where the Project might operate on a reduced scale.	Section A.15.2.1.3
R378	Details regarding any specific methods that the Proponent intends to use to enable local and Yukon businesses to supply or service the Project.	Section A.15.3.1.1 Appendix A.22F Socio-Economic Management Plan
R379	Details regarding any specific methods that the Proponent intends to use to enable First Nation businesses to supply or service the Project.	Section A.15.3.1.2 Appendix A.22F Socio-Economic Management Plan

Request #	Request for Supplementary Information	Response
R380	A detailed plan on how the proponent intends to monitor and manage socio-economic effects. This plan should include: a. objectives, indicators, and monitoring methods; b. thresholds and triggers for action; and c. adaptive management strategies.	Section A.15.4.1.1 Appendix A.22F Socio-Economic Management Plan
R381	The following referenced report: MNP LLP. 2013. Economic Impacts of the Casino Mine Project. March 2013. Casino Mine Corporation.	Section A.13.4.1.1 Appendix A.13A Economic Impacts of the Casino Mine Project
R382	A plan on how the Proponent intends to meet their commitment to hire within Yukon including: a. anticipated training programs; b. a monitoring mechanism including indicators; c. how the plan has or will involve communities and First Nations considering Chapter 22 of the Umbrella Final Agreement; d. implementation timelines; and e. apprenticeship and co-op opportunities.	Section A.14.2.1.1 Appendix A.22F Socio-Economic Management Plan
R383	Transportation alternatives for potential employees in Yukon communities outside of Whitehorse during each Project phase.	Section A.14.3.1.1
R384	Details of the “hiring policy that encourages the employment of workers from Yukon and in particular the rural communities of the LSA” and workforce opportunities for residents in Carmacks and Pelly Crossing and citizens of affected FNs.	Section A.14.3.1.2 Appendix A.22F Socio-Economic Management Plan
R385	Assumptions supporting migration estimates, including between communities in Yukon and how downward population pressures were considered.	Section A.14.4.1.1
R386	A breakdown of direct Project employment projected for each affected community. Please indicate if employees are new, existing, or returning residents or from other communities in Yukon.	Section A.14.4.1.2
R387	Clarify if the flexible rotations, counselling services, and adaptive management are the mitigation strategies for the proposed shift structure as suggested in the proposal. Please elaborate in detail for each mitigation strategy.	Section A.14.5.1.1 Appendix A.22F Socio-Economic Management Plan
R388	Details on how CMC will accommodate cultural and community events, including funerals and potlatches, in its proposed shift structure.	Section A.14.5.1.2 Appendix A.22F Socio-Economic Management Plan
R389	Rationale for the determination of high resilience as the context for possible effects to community vitality. In addition, provide a discussion on the implications of using a more conservative estimate of resiliency.	Section A.16.2.1.1 Appendix A.22F Socio-Economic Management Plan

Request #	Request for Supplementary Information	Response
R390	A plan for of how community well-being will be monitored, including: a. a clear definition of community wellbeing and community vitality, and how the community has been involved in the process of definition; b. indicators to monitor and evaluate the level of community well-being and vitality in each affected community; c. methods of monitoring each indicator; d. how the Proponent will communicate monitoring results; and e. any monitoring efforts outside of Pelly Crossing and Carmacks.	Section A.16.3.1.1 Appendix A.22F Socio-Economic Management Plan
R391	A description of how these suggested valued components can be incorporated into the Project's management, effects monitoring, and community involvement.	Section A.16.4.1.1
R392	A Heritage Management Plan including: a. a description of input from First Nations including Traditional Knowledge; b. a range of mitigation measures; c. heritage resource management framework; d. definitions and objectives; and e. a monitoring and evaluation mechanism.	Section A.18.2.1.1 Appendix A.18A Casino Summary Heritage Report Appendix A.18B Casino Heritage Sites Summary
R393	A table summarizing the number of historical and archaeological sites, their relative location in relation to the mine site, the Freegold Road Upgrade, the Freegold Road Extension, the airstrip location and associated borrow sites. Within that table include additional details such as: a. characterization of predicted disturbance; b. proposed Mitigation; c. description of the site; d. if applicable, the Project component footprint that the site overlaps; and e. site name, date of discovery, general location and traditional territory.	Section A.18.3.1.1 Appendix A.18B Casino Heritage Sites Summary
R394	Clarification regarding whether avoidance is possible for the five historic sites located along the Freegold Road Extension. If not, a description of next steps and proposed mitigations is required.	Section A.18.4.1.1 Appendix A.18B Casino Heritage Sites Summary
R395	Clarification on the specific efforts and processes undertaken by the Proponent to gather TK and TLU in order to inform the proposal. A description of what TK or TLU information the Proponent received for the purposes of drafting the proposal.	Section A.2.2.1.1 Appendix A.2A
R396	A TK and TLU study for the Project.	Section A.2.2.1.2
R397	A review of effects from resource projects and effects on TLU in a northern context.	A.2.2.1.3
R398	A framework for monitoring effects to TLU resulting from the Project.	Section A.2.2.1.3 Appendix A.22F
R399	An assessment of impacts of the Project on traditional economy.	Section A.2.2.1.4

Request #	Request for Supplementary Information	Response
R400	A discussion of the potential effects of the Project to commercial, recreational and Aboriginal fisheries (e.g. Arctic grayling and Chinook salmon). This discussion should include: a. a geographic scope that includes areas downstream of Dip Creek up to and including the White River; b. consideration of the changes in rearing, spawning, and overwintering habitat; c. a consideration of the migratory nature of various fish species; and d. potential fish kills and stranding.	Section A.19.2.1.1
R401	Description of any identified plant species of traditional, cultural, or economic importance within the Project footprint. Include a description of any efforts to engage First Nations or other land users in identifying plants of concern.	Section A.19.3.1.1
R402	Any ground studies that sought to identify and map plants of concern.	Section A.19.3.1.2
R403	If, during consultation with First Nations, any concerns were raised on impacts to important areas of wildlife harvest.	Section A.19.4.1.1
R404	A monitoring plan for induced hunting effects along the Freegold Road, either independently or in conjunction with First Nations.	Section A.19.4.1.2
R405	Description of discussions with and feedback from affected trapline concession holders including how many trapline concession holders were contacted and responded.	Section A.2.3.1.1
R406	Description of discussions with and feedback from affected outfitting concession holders including how many outfitting concession holders were contacted and responded.	Section A.2.3.1.2
R407	A summary of any geographically specific important areas for outfitting or trapping that overlap or may be affected by the Project and the species involved.	Section A.19.5.1.1
R408	A description of any contact or discussions between CMC and mineral rights holders in relation to the road.	Section A.2.4.1.1
R409	A rationale for why tenure No. 334151 is not considered in the effects assessment.	Section A.19.6.1.1
R410	A mitigation strategy for the cabin located at the southern edge of a proposed borrow pit and what if any measures will be in place to ensure continued access. In addition, identify whether the owner has been contacted or not. If so, please provide information regarding the outcome of this contact.	Section A.19.6.1.2
R411	Details regarding how the noise model accounted for seasonal variability.	Section A.9.2.1.1
R412	Details how the collected baseline data informed modeling or if other sources were used.	Section A.9.2.1.2
R413	Rationale on model selection including model limitations.	Section A.9.2.1.3
R414	Rationale on why noise levels in Carmacks and the FGR were not modeled.	Section A.9.2.1.4
R415	Identification of reference equipment used to calculate sound pressure levels.	Section A.9.2.1.5

Request #	Request for Supplementary Information	Response
R416	Confirmation that the noise modeling accounts for air traffic, shovels, cycloning, blasting, the concrete batch plant, and HLF crushing operations and revised predictions if these are not included in the original proposal.	Section A.9.2.1.6
R417	A revision of the section on accidents and malfunctions to address worker and public health and safety.	Section A.21.2.1.1 Appendix A.22B Spill Contingency Management Plan
R418	Clarification of the procedures that will be established in the event of a Level II Emergency Event, as defined in the conceptual Emergency Response Plan, and how these procedures rely on existing infrastructure and services.	Section A.21.3.1.1 Appendix A.22B Spill Contingency Management Plan
R419	For accidents on the Freegold Road, a description of how emergency services will be coordinated, and where these services will come from.	Section A.21.3.1.2 Appendix A.22E Road Use Plan
R420	A description of any discussions between CMC and protective and emergency services regarding increases in traffic and therefore and increase in accidents on the Freegold Road, Alaska Highway or Klondike Highway?	Section A.21.3.1.3 Appendix A.22G LNG Management Plan Appendix A.22A Waste and Hazardous Materials Management Plan Appendix A.22B Spill Contingency Management Plan
R421	Details regarding on-site personnel, equipment, and services that are provided based on anticipated requirements.	Section A.21.3.1.4
R422	Describe and outline how would the mine site be evacuated in different seasons. Details should include: a. length of time an evacuation would require; and b. logistics for transportation.	Section A.21.3.2.1
R423	The rationale for two hours, or 682 m^3, as the minimum capacity for water storage for on- site firefighting capacity.	Section A.21.4.1.1 Appendix A.4M Processing Flow Sheets
R424	Confirmation of where off-site emergency fire services for the Project will come from.	Section A.21.4.1.2
R425	A description of the human element in fire suppression and equipment available including: a. the level of training will be available to workers in fire suppression; b. a description of firefighting infrastructure will be on-site; and c. a description of any equipment available for first responders.	Section A.21.4.1.3
R426	An elaboration on the need or absence of need for non-water jet firefighting methods.	Section A.21.4.1.4

Request #	Request for Supplementary Information	Response
R427	Description of the consideration of fire at the cyanide, LNG, or explosives facilities.	Section A.21.4.1.5 Appendix A. 22G LNG Management Plan
R428	A description of any plans to train and familiarize first responders with the Project and associated hazards, infrastructure, and layout.	Section A.21.4.1.6
R429	Rationale for the statement in Section 20.3.4.4 that wildfire will not cause a shutdown of the mine for more than 24 hours.	Section A.20.2.1.1
R430	Implications to the Project if a wildfire results in a mine shutdown, or access road closure, for more than 24 hours.	Section A.20.2.1.2
R431	A description of any medical infrastructure that will be in place on-site regarding medical emergencies, and the depth of nursing, pharmaceutical, and first aid services that CMC forecasts as being available on-site.	Section A.21.5.1.1
R432	Details on the capacity to provide medical treatment planned in event of a potential delay to emergency response. Please describe this in terms of both the ability to provide emergency medical care for multiple casualties concurrently as well as in terms of overall duration and level of care.	Section A.21.5.1.2
R433	Considering the remote nature of the Freegold Road, a description of medical and communication capacity along the Freegold Road and its extension including the need or absence of need for any helipads.	Section A.21.5.1.3
R434	A description of how a destination medical facility will be chosen and the threshold for medevac.	Section A.21.5.1.4
R435	Details of a Human Health Monitoring Plan.	Section A.22.2.1.1
R436	Any description of spill infrastructure along public highways or the Freegold Road upgrade and extension.	Section A.22.3.1.1 Appendix A.22B Spill Contingency Management Plan
R437	A complete list of floatation circuit and heap leach chemicals with their anticipated on-site storage capacities and rates of use.	Section A.22.3.2.1 Appendix A.4M Processing Flow Sheets Appendix A.22B Spill Contingency Management Plan
R438	A detailed Cyanide Transportation Management Plan. Details should be Yukon-focused, and in particular the Freegold Road to the Project site.	Section A.22.3.3.1 Appendix A.22B Spill Contingency Management Plan

Request #	Request for Supplementary Information	Response
R439	Clarification regarding handling, storage, and use of cyanide at the Project site. Details should include: a. description of unloading process and area for solid sodium cyanide (NaCN); b. details on storage of solid NaCN in bulk bags; c. the process for moving: the solid NaCN from the unloading area to the storage area in the adsorption, desorption and recovery building; the solid NaCN from the storage area to the NaCN mix tank; and the NaCN from the mix tank to the liquid NaCN storage tank; d. use of level indicators and high-level alarms for the liquid NaCN mix and storage tanks; e. ventilation requirements for the solid NaCN in the cyanide storage area within the adsorption, desorption and recovery building; and f. ambient air monitoring requirements within the solid NaCN storage area, liquid NaCN mixing area and liquid NaCN storage area to protect workers.	Section A.22.3.3.2 Appendix A.4M Processing Flow Sheets
R440	A detailed management plan for LNG.	Section A.22.3.3.3 Appendix A.22G LNG Management Plan
R441	A detailed management plan for explosives and its constituents.	Section A.22.3.3.4 Appendix A.22A Waste and Hazardous Materials Management Plan
R442	An assessment of risk for the transportation of LNG, cyanide, ammonium nitrate, and other hazardous materials with focus on sensitive areas such as major bridge and culvert crossings.	Section A.22.3.3.5 Appendix A.22C Sediment and Erosion Control Plan Appendix A.22B Spill Contingency Management Plan
R443	A more detailed description of what will be included in the Emergency Response Plan for emergencies related to cyanide. Details should include: a. potential cyanide failure scenarios appropriate for the site-specific environmental and operating circumstances; b. specific response actions such as clearing site personnel and advising potentially-affected communities; c. use of cyanide antidotes and first aid measures for cyanide exposure; and d. control of releases at their source and containment, assessment, mitigation and future prevention of releases.	Section A.22.3.3.
R444	A comprehensive Human Health Risk Assessment for each stage of the Project.	Section A.22.4.1.1

Request #	Request for Supplementary Information	Response
R445	Add a valued component and assessment for worker health and safety to the Project proposal.	Section A.5.2.1.1
R446	Describe how emergency and non-emergency services in Carmacks were factored into Project plans and design. Consideration should be given to health, law enforcement, conservation, and other government services.	Section A.21.6.1.1
R447	A detailed characterization of potential major mine infrastructure failures and proposed response measures to these events.	Section A.21.7.1.1
R448	An updated discussion regarding the likelihood and consequence of a TMF embankment failure considering the entire lifetime of the facility (i.e. in perpetuity) in light of updated site condition characterization and dam break/inundation analysis as outlined in other sections of the Adequacy Review Report.	Section A.21.7.1.2
R449	A Mine Infrastructure Failure Response Plan that includes consideration of updated site condition characterization and dam break/inundation analysis as outlined in other sections of the Adequacy Review Report.	Section A.22.5.1.1

APPENDIX A.2A: Traditional Knowledge Bibliography



MEMORANDUM

Date:	December 1 2014
To:	CMC
From:	Hemmera
Re:	Casino: Bibliography of Reviewed Traditional Knowledge (TK) Literature

This document lists the traditional knowledge literature reviewed by the Hemmera team in order to prepare specific content excerpts for Casino's technical team as they prepare supplementary information for the project proposal. The listing reflects suggestions provided through comments on the YESAB On-line Registry, Hemmera's suggested documents and other sources uncovered through the exercise of retrieving these sources. The focus was first on Northern Tutchone specific information, then on Yukon information and lastly approaches for North of 60. The documents listed below were each reviewed for relevant information as it relates to the topics of vegetation, wildlife, birds and fish, as well as more holistically as they related to traditional ecological knowledge or traditional land use.

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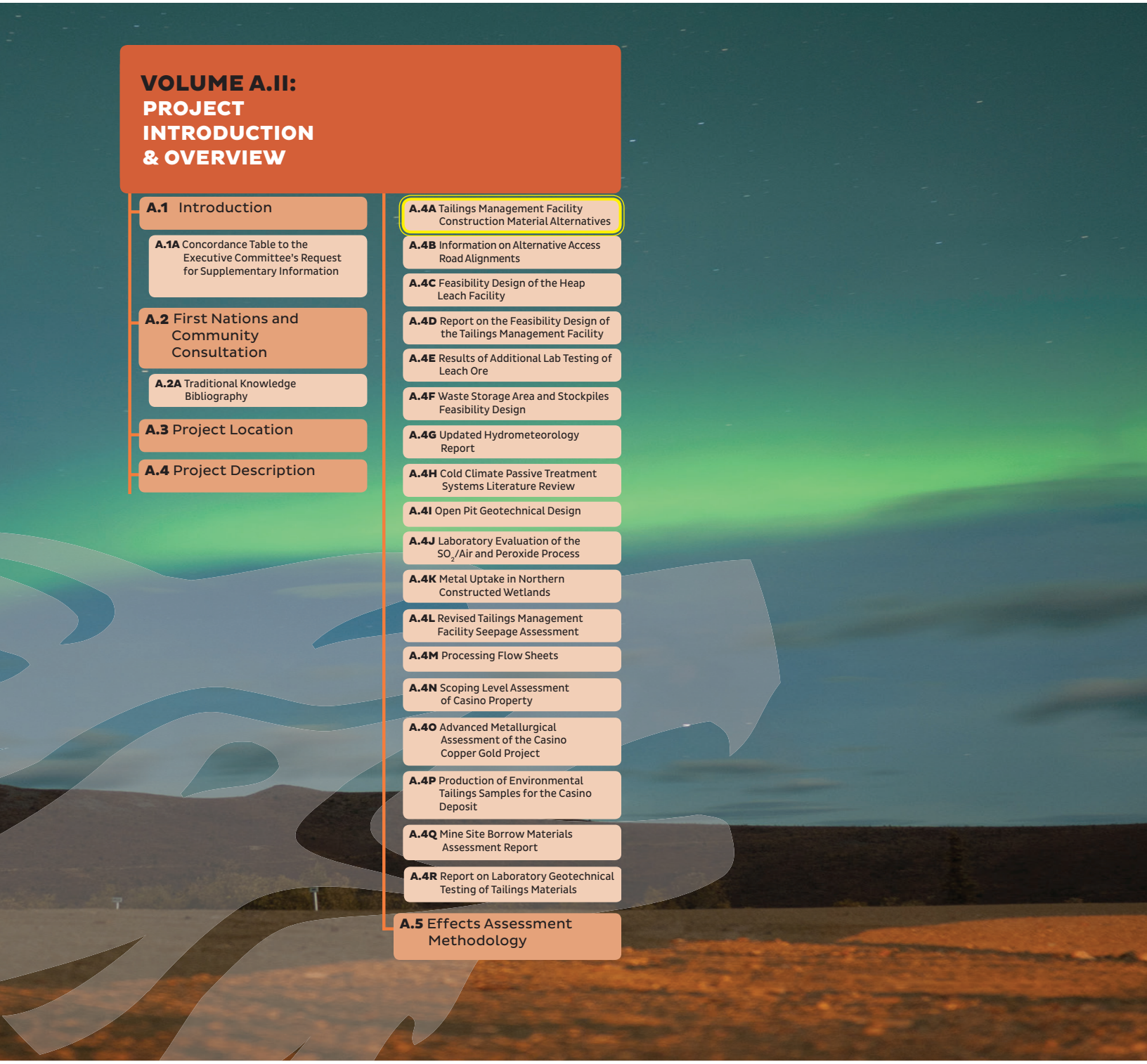
APPENDIX A.4A: Tailings Management Facility Construction Material Alternatives



Knight Piésold

WESTERN COPPER CORPORATION
CASINO COPPER-GOLD PROJECT

TAILINGS MANAGEMENT FACILITY CONSTRUCTION MATERIAL ALTERNATIVES







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VA101-325/3-2
Rev 0
June 15, 2010

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ISO 9001, ISO 14001
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WESTERN COPPER CORPORATION
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TAILINGS MANAGEMENT FACILITY CONSTRUCTION MATERIAL ALTERNATIVES (REF. NO. VA101-325/3-2)

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TAILINGS MANAGEMENT FACILITY CONSTRUCTION MATERIAL ALTERNATIVES (REF. NO. VA101-325/3-2)

EXECUTIVE SUMMARY

The Casino Copper-Gold Project is a venture by Western Copper Corporation to develop an Open Pit copper-gold-molybdenum mine in the Yukon Territory. The project is located in the Dawson Range Mountains of the Klondike Plateau approximately 300 km northwest of Whitehorse, Yukon Territory, Canada.

Pre-feasibility design studies completed in 2008 for the Tailings Management Facility (TMF) utilised Non Acid Generating (NAG) mine waste rock for embankment construction. However, recent geochemical characterisation of the mine waste indicates there is potential for the large majority of the NAG material to have metal (copper) leaching potential, and is therefore likely not suitable for embankment construction. Consequently, a study has been carried out to evaluate alternative embankment construction options and alternative tailings disposal technologies for the TMF. The evaluation is based on conceptual designs and preliminary cost estimates developed to provide a comparative cost assessment only.

The following three options have been considered for dam construction and/or tailings disposal and management:

- Use of local borrow materials to replace mine waste rock for construction of the tailings embankment,
- Cyclone sand construction of the tailings embankment, and
- Development of a dewatered tailings (dry stack) facility.

The design basis for the TMF is to provide secure storage of approximately 974 million tonnes of tailings and 838 million tonnes of potentially acid generating and metal leaching waste rock and overburden. The expansion potential of each TMF option has also been examined, to accommodate a potential increase in total mined ore production to approximately 1.2 billion tonnes.

The comparative evaluation of the three TMF options has included consideration of the potential advantages and short-comings of each option. Economic, environmental, design and operating factors have been assessed, including consideration of TMF construction and operation in cold climate conditions. The findings of the comparative assessment indicate that the use of cyclone sand for embankment construction is the preferred option and provides the most efficient and cost effective design concept for the TMF. However, it may be necessary to utilize earth/rockfill materials in the initial years of operations to accommodate any shortfall of cyclone sand availability for construction of staged embankment expansions. Embankment staging, sand cell construction sequencing and integration with rockfill placement schedules (if required) will need to be examined in more detail for future design studies. Suitable earth/rockfill materials may also be required to provide erosion protection for the cyclone sand embankment, and to satisfy embankment stability requirements.

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(REF. NO. VA101-325/3-2)

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SECTION 1.0 - INTRODUCTION

1.1 BACKGROUND

The Casino Copper-Gold Project is a venture by Western Copper Corporation to develop an Open Pit copper-gold-molybdenum mine in the Yukon Territory. The project is located in the Dawson Range Mountains of the Klondike Plateau, approximately 300 km northwest of Whitehorse, Yukon Territory, Canada, as shown on Figure 1.1. This area is somewhat unique in that the region was not glaciated during the Wisconsin Advance. The deposit is hosted by the Casino Complex, a suite of igneous intrusive rocks, with an intense hydrothermal alteration overprint. The deposit will be mined using Open Pit methods with a nominal mill throughput of 100,000 tonnes/day (tpd) of ore.

Pre-feasibility design studies completed in 2008 for the Tailings Management Facility (TMF) utilised Non Acid Generating (NAG) mine waste rock for embankment construction. However, recent geochemical characterization of the mine waste indicates that there is potential for the large majority of the NAG material to be metal (copper) leaching, and therefore likely not suitable for embankment construction. Consequently, a study has been carried out to evaluate alternative embankment construction options and alternative tailings disposal technologies for the TMF.

The primary objective of this study is to determine the preferred design concept for mine waste management (waste rock and tailings) and construction of tailings embankments.

1.2 SCOPE OF WORK & DESIGN BASIS

Following discussions with Western Copper Corporation, the following three options have been considered for dam construction and/or tailings disposal and management:

- Use of local borrow materials to replace mine waste rock for construction of the tailings embankment
- Cyclone sand construction of the tailings embankment, and
- Development of a dewatered tailings (dry stack) facility.

Development of the design concept for each TMF option considers construction material availability, tailings production rates and embankment material requirements over the operating life of the TMF. Consideration has also been given to development of the TMF, using a combination of cycloned sand construction and local borrow materials.

The conceptual design for each TMF option has been developed using the design basis and criteria defined for the Pre-Feasibility study completed in 2008 (974.4 million tonnes of tailings over an operating life of 28 years). However, it is now assumed that no mine waste rock will be suitable for embankment

construction other than waste material from the oxide cap zone in the Open Pit (approximately 8.5 million tonnes). All other waste rock is assumed to require subaqueous disposal within the TMF, comprising approximately 837.6 million tonnes of Potentially Acid Generating (PAG) and Metal Leaching (ML) waste rock and overburden. It is assumed that suitable processing of the tailings stream will be provided (pyrite separation) to ensure that the majority of the tailings are non-reactive (geochemically innocuous), and suitable to produce cyclone sand for embankment fill, or for placement as filtered (unsaturated) tailings within a "dry stack" tailings facility. All potentially reactive tailings and waste rock materials are to be accommodated by subaqueous disposal within the TMF.

This report presents a comparative scoping level evaluation for staged development of the TMF for each of the three options. The potential advantages and short-comings of each TMF option are highlighted, including consideration of construction and operation in cold climate conditions. Preliminary order of magnitude initial capital, sustaining capital and operating costs, including costs for material preparation, transport and placement, have been prepared to facilitate a comparative assessment of the economics of the three TMF options.

The expansion potential of each TMF option has also be examined, up to a potential total mine production of approximately 1.2 billion tonnes of ore (resulting in approximately 1.2 billion tonnes of tailings and 1 billion tonnes of waste rock).

A summary of the design basis and operating criteria adopted for the three TMF options is summarized in Table 1.1. The conceptual design for each of the three options, presentation of the potential issues which influence the selection of these options and a comparative assessment (with consideration of environmental, design, operating and economic factors) are provided in the following sections.

SECTION 2.0 - LOCAL BORROW MATERIALS

2.1 DESIGN CONCEPT

The design concept for this option is the same as that developed previously for the pre-feasibility design study completed in 2008, with the exception that the majority of waste rock from Open Pit development is assumed to be not suitable for use as embankment fill due to its acid generating or metal leaching potential.

Embankment construction for this option is assumed to be primarily from rockfill. Suitable waste rock from the Open Pit is assumed to be available to construct the Stage I (starter) dam using NAG material from the oxide cap. Embankment construction to facilitate staged expansion of the TMF will be carried out using suitable rockfill materials sourced from local quarrying. A schematic arrangement of the TMF for this option is illustrated on Figure 2.1.

The embankments will be constructed as water-retaining zoned structures with a low permeability core zone and appropriate filter and transition zones to prevent downstream migration of fines. The core zone will include a seepage cut-off keyed into competent rock in the foundation. Information from previous geotechnical investigations at the site indicates that residual soils in the area may provide suitable low permeability borrow fill for use in construction of the embankment core zone and seepage cut-off.

The embankments are designed as full section embankments, with 2H:1V upstream and downstream slopes. Staged expansions of the embankments will utilize the centreline method of construction. A typical section through the Main Embankment is shown on Figure 2.2. An embankment height of approximately 303 m (Elevation 1,008 m) is required at the deepest section for storage of 974.4 million tonnes of tailings (including approximately 49 million tonnes of pyritic tailings) and 837.6 million tonnes of PAG and ML waste rock. The depth-area-capacity (storage) relationship for this facility is given on Figure 2.3.

Tailings slurry will be discharged from the mill circuits at about 55% solids by total mass of slurry. It is assumed that approximately 95% of the tailings will be delivered to the TMF as geochemically innocuous material following pyrite separation. The remaining 5% of the total tailings comprises potentially reactive pyritic tailings discharged by a separate pipeline into a cell contained within the northern end of the TMF, remote from the embankment. Given the elevation difference between the mill and the TMF, the tailings will flow by gravity through a single pipeline, with provision for energy dissipation as required. The slurry is typically discharged through one or several off-takes, from header pipes situated around the periphery of the TMF and its confining embankments. The tailings solids settle out of the slurry and released water accumulates in a surface water (supernatant pond). Clear water from this pond is pumped back to the mill for re-use in the process.

Specific overall features of this TMF option are listed below:

- Two earth-rockfill, zoned embankments, referred to as the Main and West Embankments
- Tailings distribution system
- Reclaim water system
- PAG/ML waste storage area

- Pyritic tailings storage area
- Supernatant (surface water) pond, and
- Seepage collection ditches and ponds/sumps.

A summary of the design basis and operating criteria for this TMF option is included in Table 1.1.

Expansion of the TMF to provide additional storage capacity for tailings and PAG/ML waste rock is possible. An embankment height of approximately 320 metres is required to accommodate an increase in mine production to 1.2 billion tonnes of ore (approximately 1,193 million tonnes of tailings and 1,036 million tonnes of waste rock). This increase in embankment height requires approximately 5 million m^3 of additional embankment fill. The relatively minor increase in embankment height (5% increase in height for a 20% increase in storage capacity) is due to the favourable storage efficiency of the TMF in the later years of operations.

2.2 DESIGN AND OPERATING CONSIDERATIONS

Key design considerations that need to be included in the evaluation of use of local borrow materials for dam construction include the following:

- Availability of borrow materials. The quantity of shell zone material required for the Main and West Embankments (excluding the Stage I dam) is approximately 105 million m^3. The source of this material has yet to be defined. For this study, it is assumed that this material will be sourced from a quarry operation within 5 km of the Main Embankment.
- The geochemical characteristics of rockfill borrow materials would need to be assessed to confirm that they are not potentially acid generating or have metal leaching potential.
- Site investigations and testing will be required to characterize the availability and suitability of potential rockfill quarry locations.
- Any NAG waste rock material determined to have no metal leaching potential can be used to supplement local borrow materials in embankment construction. The unit cost for mine waste rock will likely be less than that associated with rockfill sourced by local quarrying.
- Placement of a buttress against the downstream shell of the Main Embankment may be required to ensure long-term stability and integrity of the TMF due to the height of the final dam (exceeding 300 m). Embankment stability analyses will need to consider the condition of underlying foundation soils and the impact of high confining stresses on the shear strength of the rockfill materials (with consideration of rock type, distribution of rockfill particle sizes, density and durability).

2.3 CAPITAL AND OPERATING COSTS

Capital and operating costs associated with this TMF option, including the use of local borrow materials for embankment construction is presented in Table 2.1. The following assumptions have been made in developing the cost estimate:

- The estimated unit rate for the clearing, stripping and grubbing of the TMF Embankment footprint is \$0.40/m^3 (based on 2008 Pre-Feasibility Design Study).
- Capital, operating and power costs associated with the tailings distribution and water reclaim systems are based on the cost estimate developed for the 2008 Pre-Feasibility Design Study.

- The capital costs for the tailings distribution and water reclaim systems include a bulk thickened tailings pipeline (pipe, energy dissipation, anchoring, valves), a pyritic tailings pipeline (pipe, pipeline flotation and anchoring), and a water reclaim system comprised of a floating pump-station with piping and anchors.
- The equipment and maintenance cost per year for the tailings distribution and reclaim systems is approximated as 15% of the initial capital cost.
- The estimated unit rate for haulage, placement and compaction of rockfill material from the Open Pit used in the Stage I (starter) dam is $\$3.00/m^3$ (based on the 2008 Pre-Feasibility Design Study).
- The estimated unit rate for haulage, placement and compaction of core (low permeability fill material) and filter zone material in the embankments is $\$11.80/m^3$ (based on the 2008 Pre-Feasibility Design Study).
- The estimated all-in capital and operating cost for the use of local borrow (rockfill) materials in embankment construction (shell zones) is $\$8.60/m^3$ (pro-rated from other projects of similar size). On a per tonne of shell zone material basis, the overall cost is estimated at $4.30/tonne (based on an assumed compacted fill density of 2.0 tonne/m^3).

A summary and comparative assessment of the estimated costs for this TMF option with the other two options is provided in Section 5.0.

SECTION 3.0 - CYCLONE SAND EMBANKMENT

3.1 DESIGN CONCEPT

Embankment construction for this option is assumed to be primarily from cyclone sand material. The sand fraction of the bulk tailings is extracted by cycloning the tailings slurry. The resulting sandy underflow product can be used as a construction material provided that it can be placed, drained and compacted sufficiently to ensure embankment stability and preclude potential for liquefaction during seismic shaking. Suitable waste rock from the Open Pit is assumed to be available to construct the Stage I (starter) dam using NAG material from the oxide cap. Embankment construction to facilitate staged expansion of the TMF will be carried out primarily using cyclone sand material. A general arrangement of the TMF for this design option is illustrated on Figure 3.1.

There is ample precedent in North America for tailings dam construction using cyclone sand, but this technique has not been used for large tailings dams in the Yukon. Examples of mine operations in British Columbia, where cyclone sand is used to construct the tailings dams include the Kemess, Gibraltar and Highland Valley mines. To accommodate cold operating conditions in the winter months the construction season at Gibraltar is typically from March to October. Longer cycloning operations for sand fill construction have apparently been possible at the Kemess mine. Dam construction typically runs 6 to 10 months of the year at Highland Valley. During the remainder of the year, tailings are used to construct an upstream beach between the dam and the tailings supernatant pond. Numerous cyclone sand embankments are utilized at mining operations in other regions of the world, including Anglo's Los Bronces mine, Southern Peru Copper's Quebrada Honda mine, and the Los Quillayes tailings impoundment operated by Minera Los Pelambres in Chile (constructed with cyclone sand to a maximum height of approximately 175 m). Several large cyclone sand dams have been constructed to dam heights in the range of approximately 150 m to 200m and are often located in seismically active areas.

The particle size distribution of the Casino mill tailings is a key consideration for determining the suitability of the bulk tailings to provide cyclone sand fill material of suitable quality and sufficient quantity. Coarser tailings are preferred, as a higher sand fraction or 'split' can be realized. A low percentage of fines is also preferred, in order to promote rapid drainage and to facilitate compaction. Two stage cycloning will be required to achieve the desired sand product (low fines content).

Similar to the TMF option utilizing only local borrow materials, the embankments will be constructed as water-retaining zoned structures with a low permeability core zone, appropriate filter and transition zones to prevent downstream migration of fines, and a seepage cut-off keyed into competent rock in the foundation. Information from previous geotechnical investigations at the site indicates that residual soils in the area may provide suitable low permeability borrow fill for use in construction of the embankment core zone and seepage cut-off. Staged expansions of the embankments will utilize the centreline method of construction with a minimum downstream slope of 3H:1V. A typical section through the Main Embankment is shown on Figure 3.2. An embankment height of approximately 290 metres (Elevation 990 m) is required at the deepest section for storage of 755.7 million tonnes of tailings (including approximately 49 million tonnes of pyritic tailings) and 837.6 million tonnes of PAG and ML waste rock. Approximately 219 million tonnes of the stored tailings will be utilized as cyclone sand fill for embankment construction. The depth-area-capacity (storage) relationship for this facility is given on Figure 3.3.

Cell construction using narrow sand deposition panels will be required for raising the downstream shell of the embankments. The panel method involves the construction and maintenance of long, narrow cells along the face of the embankment. A schematic of the panel construction sequence is shown on Figure 3.4. Selected photographs from an operating mine, where dozers are used to place and compact cyclone sand in cells, are included with this report.

The amount of sand that can practically be placed in the TMF embankment fill zones is dependent on a number of factors. If a coarse mill grind is assumed (approximately 45% sand fraction), this suggests that a recovery of about 35% to 38% of the feed can be practically split out for use as sand fill. However, seasonal factors may limit operations to about 9 months of the year, reducing cyclone sand production by about 25%. This results in about 25% of the total mill feed being available annually as suitable sand fill material for embankment construction. For this study, it is assumed that the cyclone sand plant would operate at 90% availability. Also, other water management and environmental factors may tend to further reduce the volume of material that is available to be placed in embankment fill zones.

It is assumed that approximately 95% of the tailings will be geochemically innocuous material following pyrite separation. The remaining 5% of the total tailings comprises potentially reactive pyritic tailings discharged by a separate pipeline into a cell contained within the northern end of the TMF, remote from the embankment. A summary of the design basis and operating criteria for this TMF option is included in Table 1.1.

It is estimated that approximately 5.1 million m^3 (8.1 million tonnes) of cyclone sand fill material can be produced annually using the production factors presented in Table 1.1. This volume may be less than the annual fill volumes required for staged expansions in the early years of operations. Any shortfall of embankment fill material would need to be made up with rockfill from Open Pit stripping (if available and geochemically innocuous) and/or suitable fill material from local borrow sources or quarries. It is estimated that in each of the first five years of operations, approximately 0.7 million m^3 of rockfill will be required to supplement the shortfall in cyclone sand production.

Significant features of the cyclone sand design concept required for the TMF include the following:

- A two stage cyclone sand plant.
- The cyclone sand plant will be located at an elevation such that discharge of sand and combined cyclone overflow can be achieved by gravity. Relocation of the cyclone plant may be required later in the project life.
- The cyclone sand plant will be fed directly from the mill using off-take connections from and to the existing bulk tailings pipelines. This arrangement will maintain the operational ability to bypass the cyclone plant and continue to deposit bulk tailings directly into the TMF when required.
- An additional water inflow of approximately 5,000 m^3/hr is required at the cyclone sand plant during operations. This will be used to reduce the solids content of the primary and secondary cyclone feeds and to fluidize the sand to enhance gravity transport, reduce pipeline pressures and minimize sand pumping costs. Supply of the additional water will come from a dedicated floating reclaim pump-station located within the TMF. A single dedicated pipeline will connect this floating pump-station to the cyclone sand plant.
- The cyclone underflow (sand fraction) will be pumped as required and discharged by gravity from the cyclone sand plant as a slurry of approximately 55% solids by weight, through one of several steel

pipelines laid from the cyclone station. These lines will be laid across a downstream bench below the crest of the TMF confining embankment and extended at intervals down the downstream face for deposition of sand into confining "cells" for use as construction material. The provision of several lines enables the relocation of discharge points, on-going pipeline maintenance and the continuous placement of sand, allowing zones of previously deposited sand material to drain and be compacted by earthmoving equipment.

- The fine cyclone overflow material (fine tailings) will be returned back into the existing bulk tailings discharge pipelines, immediately downstream of the cyclone sand plant, and discharged directly into the TMF from existing off-takes in pipelines laid along the upstream embankment crest and around the periphery of the TMF. Additional pumping will be provided as required.
- Additional solids collection and water recovery measures will be required at the downstream embankment toe. These include sediment collection ponds, drainage recovery pumping and pipeworks systems, plus a seepage recovery pond and pump-back system. These components are required to collect fine sediments and water recovered from the draining sand fill. The sediments will need to be removed by dredging or excavation on at least an annual basis and all water will be pumped back into the TMF through dedicated pipelines. Back-up pumping and power will be required.
- During the winter months and at other times when the cyclone sand plant is not operating, bulk tailings discharge will be rotated sequentially into the TMF from offtakes in the bulk tailings pipelines.

Expansion of the TMF to provide additional storage capacity for tailings and waste rock is possible. An embankment height of approximately 310 metres is required to accommodate an increase in mine production to 1.2 billion tonnes of ore. Assuming full production (100,000 tpd), approximately 5 million m^3 of cycloned sand can be produced annually. This volume may exceed the additional volume of cycloned sand required for expansion due to the favourable storage efficiency of the TMF in the later years of operations.

3.2 DESIGN AND OPERATING CONSIDERATIONS

Key design and operating considerations that need to be included in the evaluation of cyclone sand material for embankment construction include the following:

- Embankment height, stability and seismic resistance. This limits the sand placement options and would likely necessitate construction using sand cells, where additional vibratory compaction would be required to ensure a sufficiently dense, high strength and liquefaction resistant material.
- Cold winter conditions that will reduce the construction period, partly due to the potential for freezing and ice entrainment in the sand fill and partly because of snow drifting in the sand cells.
- Tailings particle size distribution. The tailings grind is fundamental in determining the 'split' that can be achieved by cycloning (i.e. the percentage of the tailings stream that can be separated and used as sand fill for construction). Clean sand, with a low fines content, will be required for placement in the sand cells, in order to facilitate rapid drainage and subsequent compaction. It is anticipated that the fines content (% passing a #200 sieve) of the cyclone sand will need to be less than 15%, in order to maximize fill placement rates and to ensure adequate compaction and drainage.
- The availability of cyclone sand needs to be matched with the filling schedule for the TMF, to ensure adequate embankment heights are provided well in advance of the rising tailings surface. The Stage 1 (starter) embankment must be high enough to allow sufficient quantities of sand to be produced and

placed to facilitate subsequent embankment raises. A hybrid approach (combination of rockfill and cyclone sand) may be necessary to offset any shortfall of cyclone sand available for construction during the operating life of the TMF. The sequencing of sand cell construction in relation to the requirements for embankment crest raising and the associated rockfill placement schedules will need to be carefully evaluated in subsequent design studies. Similarly, the timing, logistics and operating requirements for pipeline management and relocations will also need to be evaluated for future design studies.

- If a combination of cyclone sand and rockfill is utilised for embankment construction, additional filter and drainage layers will be required at the base of sand zones to prevent the migration of tailings sand into underlying rockfill and to provide drainage for the transport of water released from the sand.
- The possibility of windy conditions at the site must be considered. The problem can be exacerbated during cold winter conditions as a 'freeze drying' process tends to destroy capillary tensions in partially saturated sand, making it more susceptible to dusting. This will be a significant environmental consideration. Appropriate provisions will need to be incorporated to prevent wind blown dusting. This will most likely mean that the cyclone sand material will have to be capped with erosion resistant fill material, particularly during the cold winter months, when it may be impractical and/or impossible to continue with active sand placement.
- Only clean (geochemically innocuous) bulk tailings can be cycloned to produce sand fill material for embankment construction. No potentially acid generating or metal leaching materials can be used for embankment construction. Management of the potentially reactive pyritic tailings stream during system maintenance or breakdown needs to be coordinated to ensure that total tailings that include the pyrite stream are not directed to the cyclone sand plant.
- Water management is a major consideration, as protection of downstream fisheries resources is a fundamental requirement. Downstream cyclone water recovery systems will need to include appropriate provisions for containment of fines washed out of the cyclone sand fill, along with additional water collection ponds and water recovery systems. The provision of back-up pumps and a standby power supply must be considered for pump-back systems. The water management aspects of the cyclone sand systems will be major environmental considerations. These will need to be carefully considered to ensure appropriate levels of environmental protection are maintained, both during operations and after closure.
- The requirement for a very large embankment may warrant the installation of multiple or movable sand plants, particularly if the use of cyclone sand as a construction material is to be maximized.
- To accommodate cyclone sand plant maintenance or downtime (primarily during the winter months), valves and pipeworks will need to allow bulk tailings to be delivered directly to the TMF for discharge.
- Placement of a buttress against the downstream shell of the Main Embankment, or an overall flattening of the slope, may be required to ensure long-term stability and integrity of the TMF due to the height of the final dam (280+ metres). Embankment stability analyses will need to consider the condition of underlying foundation soils and the impact of high confining stresses on the shear strength of the cyclone sand material.

3.3 CAPITAL AND OPERATING COSTS

Capital and operating costs associated with the cyclone sand TMF option are presented in Table 3.1. The following assumptions have been made in developing this cost estimate:

- The estimated unit rate for the clearing, stripping and grubbing of the TMF Embankment footprint is $0.40/m^3 (based on 2008 Pre-Feasibility Design Study).
- Capital, operating and power costs associated with the tailings distribution and water reclaim systems are based on the cost estimate developed for the 2008 Pre-Feasibility Design Study.
- The capital costs for the tailings distribution and water reclaim systems include a bulk thickened tailings pipeline (pipe, energy dissipation, anchoring, valves), a pyritic tailings pipeline (pipe, pipeline flotation and anchoring), a water reclaim system comprised of a floating pump-station with piping and anchors, and a water reclaim system for the cyclone plant comprised of a floating pump-station, piping, and head tank.
- The equipment and maintenance cost per year for the tailings distribution and reclaim systems, cyclone plant and associated items is approximated as 15% of the initial capital cost.
- The estimated unit rate for the haulage, placement and compaction of rockfill material from the Open Pit used in the Stage I (starter) dam is $3.00/m^3 (based on 2008 Pre-Feasibility Design Study).
- The estimated unit rate for the haulage, placement and compaction of core and filter zone material in the embankments is $11.80/m^3 (based on 2008 Pre-Feasibility Design Study).
- The estimated all-in capital and operating cost for local borrow materials in the embankments is $8.60/m^3 (pro-rated from other projects of similar size). On a per tonne of shell zone material basis, the overall cost is estimated at $4.30/tonne (based on an assumed compacted fill density of 2.0 tonne/m^3).
- The estimated all-in capital and operating cost for cycloned sand placement for embankment construction is $3.60/m^3 (pro-rated from information provided by other projects). On a per tonne of sand basis, the overall cost is estimated at $2.25/tonne (based on an assumed compacted dry density of 1.6 tonne/m^3)
- Capital costs for cyclone plant and associated infrastructure have been based on information provided by other projects. The capital costs for the cyclone plant and associate infrastructure comprise cyclone clusters, booster pump-stations, valves, pipeworks, cyclone plant earthworks/concrete/steel, electrical, and offtakes.

A summary and comparative assessment of the estimated costs for this TMF option with the other two options is provided in Section 5.0.

SECTION 4.0 - DEWATERED TAILINGS 'DRY STACK'

4.1 DESIGN CONCEPT

This option considers the use of dewatered (filtered) tailings for storage within a "dry stack" facility. A dry stack facility can be used to store the majority of the tailings and would require significantly less material for the confining embankments, compared to disposal by conventional tailings slurry discharge. However, a separate facility is still required to provide subaqueous storage and confinement of potentially reactive waste rock (PAG and ML) and pyritic tailings, and to provide a facility for water management (including recovery to the mill) and contingency storage for those periods when the dry stack facility or dewatering plant is not operational.

Filtered tailings are produced using pressure or vacuum forces in presses, drums or belt filtration units. The tailings are typically dewatered to a moist, cake-like consistency, with water contents sufficiently low to achieve an unsaturated tailings material. The dewatered tailings are transported by conveyors or trucks to a 'dry stack' where they can be compacted in lifts to improve density and stability and enable the ability for machinery to work on the impoundment surface to facilitate on-going expansion.

Pyritic tailings (assumed to be approximately 5% of the total tailings) and all PAG and ML waste rock from open pit stripping will be deposited within a Potentially Reactive (PR) waste facility located in the Casino Creek valley south-east from the Open Pit. The dry stack facility accommodating all non-reactive tailings will be located immediately downstream of this impoundment.

A general arrangement of the dry stack facility and adjacent PR waste facility is shown on Figure 4.1. Specific features of the mine waste facilities are listed below:

- One earth-rockfill, zoned embankment
- Non-reactive tailings distribution system
- Pyritic tailings distribution system
- Dewatered tailings distribution system
- Reclaim water system
- Reactive waste storage area
- Pyritic tailings storage area
- Supernatant (surface water) pond, and
- Seepage collection ditches and ponds/sumps.

It is assumed that the dry stack tailings facility will accommodate approximately 90% of the total tailings stream. The dewatered tailings will be placed and compacted in conjunction with a perimeter berm constructed from waste rock and/or local borrow materials. Filtered tailings will be produced at a dewatering plant, likely established in the area west of the dry stack facility, where the proposed plant site is currently situated. It is assumed that the dewatered tailings will be delivered to the dry stack either by truck or by conveyor. A typical section through the dry stack facility is shown on Figure 4.2. The depth-capacity (storage) relationship for the dry stack tailings facility is given on Figure 4.3. The final height of the dry stack facility required for storage of 487.2 million m^3 (876.9 million tonnes) of dewatered tailings is approximately 226 metres (Elevation 991 m). This is based on an assumed in situ average tailings dry

density of 1.8 tonnes/m^3. It is likely that an underdrain system will be required to ensure drainage and maintain unsaturated conditions within the filtered tailings pile.

The PR waste facility is required for storage of all pyritic tailings (assumed to be 5% of the total tailings stream) and all mine waste rock identified as Potentially Acid Generating (PAG) or with Metal Leaching (ML) potential. Additionally, it is assumed that approximately 5% of the non-reactive tailings will be discharged into this facility. This will be required during periods when the tailings dewatering plant is not operating (e.g. due to maintenance or unscheduled shutdown) or due to unfavourable weather conditions inhibiting tailings placement in the dry stack facility. The confining embankment for the PR waste facility will have a similar design concept to that described for the local borrow embankment option. The facility has been designed to permanently store 97.4 million tonnes of pyritic and bulk tailings (69.6 million m^3 at an assumed average dry density of 1.4 t/m^3) and approximately 837.6 million tonnes of PAG and ML waste rock which will be stored in the Reactive Waste Storage Area contained within the PR waste facility. The final embankment height is approximately 280 m (Elevation 1,025 m). The depth-area-capacity relationship for the PR waste facility is shown on Figure 4.4.

Expansion of the PR waste facility and dry stack facility to provide additional storage capacity is possible. However, expansion of the PR waste facility would encroach on the proposed location of the low grade ore stockpiles east of the mill site. For the dry stack facility a final tailings elevation of approximately 940 m is required to accommodate an increase in mine production to 1.2 billion tonnes of ore (approximately1,074 million tonnes of tailings assuming 90% of the total tailings). For the PR waste facility an embankment height of approximately 305 metres is required to store approximately 119 million tonnes of tailings (pyritic tailings and 5% of the non-reactive tailings) and 1,036 million tonnes of waste rock. This increase in embankment height requires approximately 2 to 3 million m^3 of additional embankment fill.

The overall configuration of the dry stack tailings facility and adjacent PR waste facility has been developed to minimize disturbed area (impoundment footprint), minimize the contributing catchment area (to simplify water management requirements), and to enable the non-reactive tailings dry stack to provide an additional seepage barrier between the PR waste facility and downstream receiving waters.

Embankment slope revegetation and reclamation could occur incrementally during staged expansion of the dry stack facility. Reclamation at closure would consist of revegetating the final surface of the impoundment. Decommissioning of ancillary facilities such as the tailings filtering and dewatering plant would occur at the time other project facilities were dismantled.

A summary of the design basis and operating criteria for the dry stack facility and PR waste facility is included in Table 1.1.

4.2 DESIGN AND OPERATING CONSIDERATIONS

Tailings physical characteristics, such as particle size distribution (percent fines), strongly influence the ability to dewater the tailings solids sufficiently for them to be handled and placed in a compacted dry stack. The presence of excessive fines in the tailings may make it impractical to achieve a workable “dry” tailings product.

The storage of dry tailings can be beneficial, but it is not a method that can be applied in all circumstances. Operational problems may occur as a result of filtering equipment breakdown or a failure of filters to achieve performance requirements, resulting in a variable product. The filtering and transport of dry tailings to the storage area can be very costly in comparison to conventional pumping of tailings slurry, particularly if the slurry can flow under gravity, without pumping. Handling and placement of dewatered tailings in the dry stack facility will add to labour and equipment costs. In an environment with a potential water surplus, such as Casino, water management and water balance requirements may be challenging with a dry stack facility.

In the event of a planned (maintenance) or unplanned halt to operations at the dewatering plant or delivery system, it will be necessary to provide an alternative method for tailings discharge to avoid mill shut-down. This can be achieved by installing a backup pipeline system to the PR waste facility.

Dry stack tailings facilities by nature are expected to have little seepage, but this may not be the experience in practice. Seepage controls have been required at La Coipa Mine in Chile, the Mineral Hill Mine in Montana and the Raglan Mine in Quebec. At Greens Creek Mine in Alaska, a continuous addition of organic carbon to the tailings is required to assure their long-term chemical stability in order to meet water quality requirements.

The cold climate at the Casino site will present challenges during winter operations, including the need to prevent snow or ice accumulations on the tailings dry stack. Dust emissions from the dewatered tailings surface will be difficult to manage during dry spells, particularly if there is strong wind exposure. Wind blown dusting can worsen in winter months, as freeze-drying and other frost processes can loosen the tailings surface. The moderately wet climate may cause problems during the summer months, as excessive moisture addition can result in rapid degradation of trafficability and prevent adequate compaction.

The filtered tailings stack would be susceptible to instability, due to any residual ice lenses or localized liquefaction, if the pile becomes saturated due to rainfall, snow entrainment or percolation from runoff. The risk of embankment stability issues is also high for the PR waste facility due to the need to provide subaqueous storage for the entire impoundment surface, resulting in a water pond immediately upstream of the embankment (no tailings beach).

The above issues will be exacerbated by the need to produce a consistent dewatered tailings product that satisfies performance requirements for a large tonnage, high production rate (100,000 tpd) operation.

4.3 CAPITAL AND OPERATING COSTS

The filter plant required to dewater the bulk tailings stream at Casino would be a very large, expensive structure, due to the high production rate (100,000 tpd). Operating requirements and costs would also be substantial. Filter plants of comparable size are currently unprecedented. The requirement for any backup or bypass system would add significantly to capital costs.

Capital and operating costs for the incremental costs associated with filtered tailings are presented in Table 4.1. The following assumptions have been made in developing this cost estimate:

- The estimated unit rate for the clearing, stripping and grubbing of the TMF Embankment footprint is $\$0.40/m^3$ (based on 2008 Pre-Feasibility Design Study).
- Capital, operating and power costs associated with the tailings distribution and water reclaim systems are based on the cost estimate developed for the 2008 Pre-Feasibility Design Study.
- The capital costs for the tailings distribution and water reclaim systems include a bulk thickened tailings pipeline (pipe, energy dissipation, anchoring, valves), a pyritic tailings pipeline (pipe, pipeline flotation and anchoring), and a water reclaim system comprised of a floating pump-station with piping and anchors.
- The equipment and maintenance cost per year for the tailings distribution and reclaim systems, filtration plant and conveyor system is approximated as 15% of the initial capital cost.
- The estimated unit rate for the haulage, placement and compaction of rockfill material from the Open Pit used in the Stage I (starter) dam is $\$3.00/m^3$ (based on 2008 Pre-Feasibility Design Study).
- The estimated unit rate for the haulage, placement and compaction of core and filter zone material in the PR waste facility Main Embankment is $\$11.80/m^3$ (based on 2008 Pre-Feasibility Design Study).
- The estimated all-in capital and operating cost for local borrow materials in the PR waste facility Main Embankment is $\$8.60/m^3$ (pro-rated from other projects of similar size). On a per tonne of shell zone material basis, the overall cost is estimated at $4.30/tonne. (This is based on an assumed compacted fill density of 2.0 tonne/m^3).
- The estimated all-in capital and operating cost for the placement and compaction of filtered tailings is $\$2.70/m^3$ (pro-rated from other projects of similar size). On a per tonne of shell zone material basis, the overall cost is estimated at $1.50/tonne. (This is based on an assumed compacted dry density of 1.8 tonne/m^3).
- The estimated unit rate for the haulage, placement and compaction of the underdrain material throughout the dry stack facility foundation is $\$11.80/m^3$ (based on 2008 Pre-Feasibility Design Study).
- Capital costs for filtration plant, conveyor system and associated infrastructure have been based on information provided by other projects.

A summary and comparative assessment of the estimated costs for this option with the other two TMF options is provided in Section 5.0.

SECTION 5.0 - TMF ALTERNATIVES ASSESSMENT

5.1 GENERAL

A comparative scoping level evaluation has been carried out for the three TMF options described in the preceding sections. The potential advantages and short-comings of each TMF option have been examined, including consideration of construction and operating factors for a large scale mine waste management plan in cold climate conditions. The preferred TMF option will be that which is best suited to the site-specific circumstances and requirements. No “one size fits all” solution is available to address every particular and unique environmental, design and operational issue. The chosen option will aim to apply the best available and most appropriate technology, with a commitment to best management practices and cost effectiveness.

Primary design and operating, environmental, and economic considerations for the three TMF options are discussed in the following sections.

5.2 DESIGN AND OPERATING CONSIDERATIONS

Design and operating considerations include adapting to inevitable changes and variability in the mill throughput (production rate and material composition); embankment stability requirements, construction material availability and suitability, TMF seepage control, tailings handling and delivery, pipeline and pumping systems reliability, flexibility and redundancy, tailings deposition and reclaim water management, water management, and closure requirements.

The water management system for the cycloned sand and dry stack options will be more complex than that required for a conventional tailings management system as utilised for the option using local borrow materials for embankment construction. Two reclaim water systems are required to provide mill process water and feed water for the cycloned sand plant. Also, two mine waste facilities (dry stack and PR waste facility) with very different design and operating requirements are required for the dewatered tailings option.

A TMF that utilises local borrow materials for embankment construction will require a significant quantity of suitable rock/earthfill material that is characterised as non-potentially acid generating and does not exhibit metal leaching potential. Potential locations to source this material are currently not defined.

Placement of embankment fill during the winter months using local borrow (rockfill) materials will be less challenging compared to the other two TMF options. Embankment construction using local borrow materials can be performed year round, although the efficiency of construction operations will likely be less during the winter months. Cyclone sand production and placement may be limited to about 9 months of the year, due to the cold winter climate at the Casino site. Bulk tailings discharge into the TMF will be required during any cessation in cyclone sand production. The availability of cyclone sand for embankment construction is dependent on a number of factors and may not meet embankment construction material requirements at certain times during operations. However, shortfalls in sand production can be balanced with suitable (geochemically innocuous) rockfill from open pit stripping and/or from local borrow sources or quarry.

The dewatered tailings option requires two individually managed facilities, both of which will have their own operating requirements and challenges. The need to operate two facilities will only add to the complexity of the mine waste management plan. All of the design and operating issues identified with the use of local borrow materials for embankment construction will also apply to the PR waste facility. The dewatered tailings option incorporates filtered tailings production technologies and delivery systems that are without precedent for the scale of operation anticipated for the Casino project, particularly for the cold winter conditions experienced at the site. Therefore, there are inherent risks in proceeding with this technology for the Casino project, unless appropriate contingency measures are incorporated in the mine waste management plan.

The static and seismic stability of the confining embankments is an important consideration for each of the TMF options, due to the large dam heights required. The TMF option that utilises local borrow for embankment construction requires a final embankment exceeding 300 m in height. A final embankment height of 290 m is required for the cyclone sand option. Although the dewatered tailings option requires a lower final embankment height (about 280 m), the stability and integrity of the dry stack and PR waste facilities will likely have a higher risk of potential issues associated with embankment stability and integrity, as discussed in Section 4.2.

The use of cyclone sand fill in embankment construction provides a corresponding reduction in impoundment storage requirements, resulting in a reduced embankment height. The final embankment for the cyclone sand option is approximately 18 metres lower than the TMF option using only local borrow (rockfill) materials. This is relatively minor given the large quantity of sand tailings that will be utilised in embankment construction, but is due to the storage characteristics of the TMF in the later years of operations (large storage capacity increase for a small increase in TMF height).

A review of the design and operating considerations suggests that a mine waste management plan that utilises local borrow materials or cyclone sand for embankment construction are the preferred options. However, both options have specific design and operating issues that will need to be examined in more detail for future design studies.

5.3 ENVIRONMENTAL CONSIDERATIONS

Selection of a preferred TMF option requires consideration of several environmental factors. These include the following potential key factors:

- Impact to fisheries resources
- Stream flow impacts and mitigation opportunities
- Wildlife considerations
- Dusting
- Geochemical considerations (oxidation of reactive materials)
- Biological and social impacts
- Impacts to ground and surface waters, and
- Opportunities for concurrent reclamation and closure requirements.

For the three TMF options presented in this study, the cyclone sand option has the smallest footprint within the Casino Creek valley. The TMF embankment constructed of local borrow materials will create an impoundment only slightly larger than the cyclone sand option. However, it will also include a large disturbance area outside of the TMF associated with the large borrow area(s) required to provide sufficient rockfill material. The dewatered tailings dry stack facility and adjacent PR waste facility will create the largest disturbance area. This TMF option also has the largest direct catchment area and will likely have the largest impact on water resources.

Impacts to air quality related to dusting due to construction traffic and wind blown sand from the tailings embankments will be higher for the cyclone sand and tailings dry stack facilities. Appropriate provisions to manage dusting will be required for these two options.

The review of environmental factors and considerations indicates that the dewatered tailings option will have the largest environmental impact.

5.4 ECONOMIC CONSIDERATIONS

Preliminary order of magnitude initial capital, sustaining capital and operating costs, including costs for material preparation, transport and placement, have been prepared to facilitate a comparative economic assessment of the three TMF options. The economic evaluation considers capital and operating costs associated with storage of tailings and waste rock for the full mine life. A summary of the estimated capital and operating costs for the three TMF options is provided in Table 5.1. Additional details of the estimated capital and operating costs for each of the three TMF options are presented in Tables 2.1, 3.1 and 4.1.

The cycloned sand and dewatered tailings (dry stack) options have larger initial capital costs compared to the option using only local borrow material for embankment construction. The initial capital cost for the cyclone sand option is approximately $20 million more than the local borrow materials option. This is primarily due to the high initial capital costs associated with construction of a cyclone sand plant and associated infrastructure. The initial capital cost for the dewatered tailings option is approximately three times greater than the local borrow materials option and cyclone sand option. High initial capital costs for the dewatered tailings option are associated with the tailings dewatering (filtration) plant, tailings transportation (conveyor/truck delivery system) and provision of a PR waste facility to accommodate subaqueous disposal of PAG and ML waste material and pyritic tailings.

The local borrow materials and dewatered tailings options have significantly larger sustaining capital costs compared to the cyclone sand option. The sustaining capital cost for the cyclone sand option is approximately $410 million less than the local borrow materials option and approximately $1,225 million less than the dry stack option. This is primarily due to the lower unit rate of fill material used for embankment construction. The local borrow materials option has the smallest operating cost of the three options due to lower power requirements.

The use of cyclone sand for TMF embankment construction has the potential to utilize approximately 220 million tonnes of tailings sand which will displace 275 million tonnes of rockfill from within the

embankments. The total savings associated with the use of cyclone sand over locally quarried rockfill is in the order of $270 million over the operating life of the facility.

A review of the economic considerations suggests that the mine waste management plan that is the most economical over the life of the project is the cyclone sand option.

SECTION 6.0 - SUMMARY AND CONCLUSIONS

The following three options have been considered for dam construction and/or tailings disposal and management:

- Use of local borrow materials to replace mine waste rock for construction of the tailings embankment
- Cyclone sand construction of the tailings embankment, and
- Development of a dewatered tailings (dry stack) facility.

In addition to development of a dry stack facility, the dewatered tailings design concept requires provision of a second facility to accommodate subaqueous disposal of all potentially reactive waste rock and tailings materials. This potentially reactive waste facility is also needed to provide contingency storage for water management, and for time periods when the dewatering plant is not operational or dewatered tailings placement is not possible due to adverse climatic conditions.

A comparative evaluation of the three TMF options has included consideration of the potential advantages and short-comings of each option. Economic, environmental, design and operating factors have been assessed, including consideration of TMF construction and operation of a large scale mine waste management plan in cold climate conditions.

The findings of the comparative assessment indicate that the use of cyclone sand for embankment construction is the preferred option and provides the most efficient and cost effective design concept for the TMF. However, it may be necessary to utilize earth/rockfill materials in the initial years of operations to accommodate any shortfall of cyclone sand availability for construction of staged embankment expansions. Embankment staging, sand cell construction sequencing and integration with rockfill placement schedules (if required) will need to be examined in more detail for future design studies. Suitable earth/rockfill materials may also be required to provide erosion protection and minimise dusting for the cyclone sand embankment, and to satisfy embankment stability requirements. Use of cyclone sand as embankment fill reduces the amount of solids that are stored within the TMF by a volume roughly equivalent to the volume of sand used for construction. This allows for either additional storage capacity or a reduced embankment height.

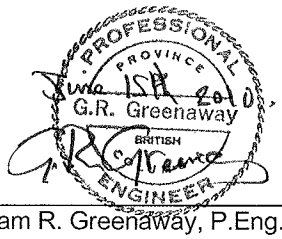
It is noted that the potential cost advantage for cyclone sand is sensitive to assumptions relating to the cost of using local borrow (rockfill) material as an alternative embankment construction material. In particular, if rockfill haulage costs are reduced by implementation of efficient material delivery systems and/or borrow locations that shorten the overhaul distance to the TMF embankment, then the cost advantage for the cyclone sand construction method may be less. It will be important to evaluate potential local borrow alternatives in conjunction with the cyclone sand option.

SECTION 7.0 - CERTIFICATION

This report was prepared, reviewed and approved by the undersigned.

Prepared: G.R. Greenaway

for André C. Gagnon, E.I.T.
Staff Engineer



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Approved:

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Managing Director

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TABLE 1.1

WESTERN COPPER CORPORATION
CASINO COPPER-GOLD PROJECT

SUMMARY OF DESIGN BASIS AND CRITERIA

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ITEM	DESIGN CRITERIA
1 MINE PRODUCTION	
Ore Production	• Total Ore Milled = 980.3 Million tonnes (Mt) • Total Ore Milled - Expansion Case = 1,200 Million tonnes (Mt) • Throughput = 100,000 tpd • Mine Life = 28 years • % Concentrate = 0.6
2 WASTE ROCK	
Waste Rock Production	• PAG & ML waste rock produced from Year -1 to Year 23 • Subaqueous disposal within TMF • Total PAG & ML material produced = 837.6 Mt • Total PAG & ML material produced - Expansion Case = 1,035.7 Mt • Total non-PAG & non-ML material produced from oxide cap (used in starter embankment shell zone) = 8.6 Mt • 2.0 t/m^3 - in situ average density (estimated)
3 TAILINGS	
Local Borrow Materials and Cyclone Sand Options	• 974.4 Mt tailings storage • 1,192.8 Mt tailings storage - Expansion Case • Two tailings streams ◦ 95% bulk tailings (non-reactive) ◦ 5% pyritic tailings (discharged separately) • 1.2 t/m^3 - in situ average dry density for Years 1 to 2 (estimated) • 1.3 t/m^3 - in situ average dry density for Year 3 (estimated) • 1.4 t/m^3 - in situ average dry density for Years 4 to 28 (estimated)
Dewatered Tailings Option	• 90% of tailings dewatered and placed in Dry Stack facility ◦ 1.8 t/m^3 - in situ average dry density for Years 1 to 28 (estimated) • 10% of tailings stored in Potentially Reactive waste facility (5% pyritic tailings, 5% filtered tailings) ◦ 1.4 t/m^3 - in situ average dry density for Years 1 to 28 (estimated)
4 CYCLONE SAND	
Cyclone Sand Option	• 35% of bulk tailings solids assumed produced by cyclone sand plant as sand fill suitable for embankment construction (based on expected tailings particle size distribution) • Cyclone sand production begins in Year 1. • Cyclone sand production for average 9 months per year. • Cyclone sand plant availability is 90%, during 9 month period. • Compacted cyclone sand dry density = 1.6 t/m^3.

M:\1\01\00325\03\A\Report\2-TMF Construction Material Alternatives\Rev 0\Tables\[Table 1.1 - TMF Design Basis Criteria.xls]Table

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	10JUN'10	ISSUED WITH REPORT VA101-325/3-2	AG	GRG	KJB

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TABLE 2.1

WESTERN COPPER CORPORATION
CASINO COPPER-GOLD PROJECT

LOCAL BORROW OPTION
INITIAL CAPITAL, SUSTAINING CAPITAL AND OPERATING COSTS

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Item Number	Description	Unit	Unit Rate	INITIAL CAPITAL		SUSTAINING CAPITAL		OPERATING COSTS		TOTAL	
				Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost
1	**EARTHWORKS**										
1.1	**Clearing TMF Embankment Foundation Footprint**	m^2	$0.40	244,200	$97,700	940,800	$376,300	0	$0	1,185,000	$474,000
1.2	**Stripping and Grubbing TMF Embankment Foundation Footprint - 1 m average**	m^3	$0.40	244,200	$97,700	940,800	$376,300	0	$0	1,185,000	$474,000
1.3	**TMF Embankment Construction**										
a	Starter: haul, place and compact core zone	m^3	$11.80	3,946,300	$46,566,300	0	$0	0	$0	3,946,300	$46,566,300
b	Starter: haul, place and compact filter zone	m^3	$11.80	160,500	$1,893,900	0	$0	0	$0	160,500	$1,893,900
c	Starter: haul, place and compact shell zone from Open Pit	m^3	$3.00	5,327,200	$15,981,600	0	$0	0	$0	5,327,200	$15,981,600
d	Final: haul, place and compact core zone - Ongoing	m^3	$11.80	0	$0	7,324,000	$86,423,200	0	$0	7,324,000	$86,423,200
e	Final: haul, place and compact filter zone - Ongoing	m^3	$11.80	0	$0	1,439,200	$16,982,600	0	$0	1,439,200	$16,982,600
f	Final: haul, place and compact shell zone - Ongoing from quarry source	m^3	$8.60	0	$0	105,061,600	$903,529,800	0	$0	105,061,600	$903,529,800
2	**TAILINGS DISTRIBUTION AND RECLAIM SYSTEMS**										
2.1	**Bulk thickened rougher tailings pipeline, 32" std. wt. steel pipe, energy dissipation and anchoring, valves (Mill to TMF)**	LS	$7,750,000	1	$7,750,000	0.16	$1,260,000	0	$0	1	$9,010,000
2.2	**Pyrite tailings pipeline, 10" DR9 HDPE pipe, pipeline flotation and anchoring (Mill to TMF)**	LS	$180,000	1	$180,000	0	$0	0	$0	1	$180,000
2.3	**Reclaim System, floating pumpstation with anchors and MCC, 36" steel pipe with anchors as required (TMF to Mill)**	LS	$9,100,000	1	$9,100,000	0	$0	0	$0	1	$9,100,000
2.4	**Equipment maintenance and replacement (Note 3)**	LS	$2,554,500	0	$0	0	$0	28	$71,526,000	28	$71,526,000
3	**POWER (OPERATING COST)**										
3.1	**Reclaim Barge power usuage per annum**	MWhr	$94.00	0	$0	0	$0	720,000	$67,680,000	720,000	$67,680,000
TOTALS					$81,667,200		$1,008,948,200		$139,206,000		$1,229,821,400

M:\1\01\00325\03\A\Report\2-TMF Construction Material Alternatives\Rev 0\Tables\[Table 2.1 - Local Borrow Costs.xls]Table 2.1

NOTES:

1. INDICATED DESIGN DETAILS ARE PRELIMINARY ESTIMATES ONLY AND REQUIRE REFINING.
2. 2008 PRE-FEASIBILITY UNIT RATES FOR ITEMS 1.1 TO 1.3 HAVE BEEN ADJUSTED TO 2010 DOLLARS.
3. ANNUAL EQUIPMENT MAINTENANCE AND REPLACEMENT COST ESTIMATED AS 15% OF THE PRE-PRODUCTION TAILINGS AND RECLAIM SYSTEMS COSTS.

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TABLE 3.1

WESTERN COPPER CORPORATION
CASINO COPPER-GOLD PROJECT

CYCLONE SAND OPTION
INITIAL CAPITAL, SUSTAINING CAPITAL AND OPERATING COSTS

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Item Number	Description	Unit	Unit Cost	INITIAL CAPITAL		SUSTAINING CAPITAL		OPERATING COSTS		TOTAL	
				Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost
1	**EARTHWORKS**										
1.1	**Clearing TMF Embankment Foundation Footprint**	m^2	$0.40	243,800	$97,500	1,153,600	$461,400	0	$0	1,397,400	$558,900
1.2	**Stripping and Grubbing TMF Embankment Foundation Footprint - 1 m average**	m^3	$0.40	243,800	$97,500	1,153,600	$461,400	0	$0	1,397,400	$558,900
1.3	**TMF Embankment Construction**										
a	Starter: haul, place and compact core zone	m^3	$11.80	4,072,100	$48,050,800	0	$0	0	$0	4,072,100	$48,050,800
b	Starter: haul, place and compact filter zone	m^3	$11.80	170,400	$2,010,700	0	$0	0	$0	170,400	$2,010,700
c	Starter: haul, place and compact shell zone from Open Pit	m^3	$3.00	5,658,100	$16,974,300	0	$0	0	$0	5,658,100	$16,974,300
d	Final: haul, place and compact core zone - Ongoing	m^3	$11.80	0	$0	8,516,000	$100,488,800	0	$0	8,516,000	$100,488,800
e	Final: haul, place and compact filter zone - Ongoing	m^3	$11.80	0	$0	1,682,800	$19,857,000	0	$0	1,682,800	$19,857,000
f	Final: haul, place and compact shell zone - First five years from quarry source	m^3	$8.60	0	$0	3,378,500	$29,055,100	0	$0	3,378,500	$29,055,100
g	Final: haul, place and compact cycloned sand - Ongoing	m^3	$3.60	0	$0	122,750,300	$441,901,100	0	$0	122,750,300	$441,901,100
2	**CYCLONE PLANT**										
2.1	**Cyclone clusters, booster pumps stations (primary and secondary feed), valves and pipeworks, underflow pumpstation as required, cyclone plant earthworks/concrete/steel, cyclone plant electrical and MCC**	LS	$6,660,000	1	$6,660,000	0.08	$500,000	0	$0	1	$7,160,000
2.2	**Cyclone combined overflow pipeworks, pumpstation, 36" DR13.5 HDPE offtakes, 36" DR11 HDPE offtakes, valves**	LS	$3,980,000	1	$3,980,000	0.65	$2,580,000	0	$0	2	$6,560,000
2.3	**Equipment maintenance and replacement (Note 3)**	LS	$1,596,000	0	$0	0	$0	28	$44,688,000	28	$44,688,000
3	**TAILINGS DISTRIBUTION AND RECLAIM SYSTEMS**										
3.1	**Bulk thickened rougher tailings pipeline, 32" std. wt. steel pipe, energy dissipation and anchoring, valves (Mill to TMF)**	LS	$7,750,000	1	$7,750,000	0.16	$1,260,000	0	$0	1	$9,010,000
3.2	**Pyrite tailings pipeline, 10" DR9 HDPE pipe, pipeline flotation and anchoring (Mill to TMF)**	LS	$180,000	1	$180,000	0	$0	0	$0	1	$180,000
3.3	**Reclaim System, floating pumpstation with anchors and MCC, 36" steel pipe with anchors as required (TMF to Mill)**	LS	$9,100,000	1	$9,100,000	0	$0	0	$0	1	$9,100,000
3.4	**Reclaim System, floating pumpstation, 36" steel pipe, head tank as required (TMF to Cyclone Plant Head Tank)**	LS	$6,200,000	1	$6,200,000	0	$0	0	$0	1	$6,200,000
3.5	**Equipment maintenance and replacement (Note 4)**	LS	$3,484,500	0	$0	0	$0	28	$97,566,000	28	$97,566,000
4	**POWER (OPERATING COST)**										
4.1	**Reclaim to TMF power usuage per annum**	MWhr	$94.00	0	$0	0	$0	705,000	$66,270,000	705,000	$66,270,000
4.2	**Reclaim to Cyclone Plant power usuage per annum**	MWhr	$94.00	0	$0	0	$0	371,720	$34,941,700	371,720	$34,941,700
4.3	**Pumping cyclone overflow into TMF**	MWhr	$94.00	0	$0	0	$0	212,500	$19,975,000	212,500	$19,975,000
TOTALS					$101,100,800		$596,564,800		$263,440,700		$961,106,300

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NOTES:

1. INDICATED DESIGN DETAILS ARE PRELIMINARY ESTIMATES ONLY AND REQUIRE REFINING.
2. 2008 PRE-FEASIBILITY UNIT RATES FOR ITEMS 1.1 TO 1.3 HAVE BEEN ADJUSTED TO 2010 DOLLARS.
3. ANNUAL EQUIPMENT MAINTENANCE AND REPLACEMENT COST ESTIMATED AS 15% OF THE PRE-PRODUCTION CYCLONE PLANT COSTS.
4. ANNUAL EQUIPMENT MAINTENANCE AND REPLACEMENT COST ESTIMATED AS 15% OF THE PRE-PRODUCTION TAILINGS AND RECLAIM SYSTEMS COSTS.

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TABLE 4.1

WESTERN COPPER CORPORATION
CASINO COPPER-GOLD PROJECT

DEWATERED TAILINGS OPTION
INITIAL CAPITAL, SUSTAINING CAPITAL AND OPERATING COSTS

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Item Number	Description	Unit	Unit Rate	INITIAL CAPITAL		SUSTAINING CAPITAL		OPERATING COSTS		TOTAL	
				Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost
1	**EARTHWORKS**										
1.1	**Clearing Main Embankment Foundation Footprint**	m^2	$0.40	251,200	$100,500	487,200	$194,900	0	$0	738,400	$295,400
1.2	**Clearing Dry Stack Facility Foundation Footprint**	m^2	$0.40	211,300	$84,500	5,916,400	$2,366,600	0	$0	6,127,700	$2,451,100
1.3	**Stripping and Grubbing Main Embankment Foundation Footprint - 1 m average**	m^3	$0.40	251,200	$100,500	487,200	$194,900	0	$0	738,400	$295,400
1.4	**Stripping and Grubbing Dry Stack Facility Foundation Footprint - 1 m average**	m^3	$0.40	211,300	$84,500	5,916,400	$2,366,600	0	$0	6,127,700	$2,451,100
1.5	**Main Embankment Construction**										
a	Starter: haul, place and compact core zone	m^3	$11.80	4,191,400	$49,458,500	0	$0	0	$0	4,191,400	$49,458,500
b	Starter: haul, place and compact filter zone	m^3	$11.80	188,800	$2,227,800	0	$0	0	$0	188,800	$2,227,800
c	Starter: haul, place and compact shell zone from Open Pit	m^3	$3.00	6,267,100	$18,801,300	0	$0	0	$0	6,267,100	$18,801,300
d	Final: haul, place and compact core zone - Ongoing	m^3	$11.80	0	$0	3,043,600	$35,914,500	0	$0	3,043,600	$35,914,500
e	Final: haul, place and compact filter zone - Ongoing	m^3	$11.80	0	$0	593,600	$7,004,500	0	$0	593,600	$7,004,500
f	Final: haul, place and compact shell zone - Ongoing from quarry source	m^3	$8.60	0	$0	44,228,800	$380,367,700	0	$0	44,228,800	$380,367,700
1.6	**Dry Stack Facility**										
a	Starter toe berm: haul, place and compact shell zone from Open Pit	m^3	$3.00	179,100	$537,300	0	$0	0	$0	179,100	$537,300
b	Place and compact filtered tailings - Ongoing	m^3	$2.70	0	$0	487,191,705	$1,315,417,600	0	$0	487,191,705	$1,315,417,600
c	Haul, place and compact foundation underdrain - Ongoing	m^3	$11.80	211,300	$2,493,300	5,916,400	$69,813,500	0	$0	6,127,700	$72,306,800
2	**CONVEYOR SYSTEM**										
2.1	**Conveyor**	LS	$43,800,000	1	$43,800,000	0.17	$7,300,000	0	$0	1	$51,100,000
2.2	**Equipment maintenance and replacement (Note 3)**	LS	$6,570,000	0	$0	0	$0	28	$183,960,000	28	$183,960,000
3	**DEWATERING PLANT**										
3.1	**Filtration Plant**	LS	$130,000,000	1	$130,000,000	0.00	$0	0	$0	1	$130,000,000
3.2	**Equipment maintenance and replacement (Note 4)**	LS	$19,500,000	0	$0	0	$0	28	$546,000,000	28	$546,000,000
4	**TAILINGS DISTRIBUTION AND RECLAIM SYSTEMS**										
4.1	**Bulk thickened rougher tailings pipeline, 32" std. wt. steel pipe, energy dissipation and anchoring, valves (Mill to Potentially Reactive Waste Facility)**	LS	$7,750,000	1	$7,750,000	0.16	$1,260,000	0	$0	1	$9,010,000
4.2	**Pyrite tailings pipeline, 10" DR9 HDPE pipe, pipeline flotation and anchoring (Mill to Potentially Reactive Waste Facility)**	LS	$180,000	1	$180,000	0.00	$0	0	$0	1	$180,000
4.3	**Reclaim System, floating pumpstation with anchors and MCC, 36" steel pipe with anchors as required (Potentially Reactive Waste Facility to Mill)**	LS	$9,100,000	1	$9,100,000	0.00	$0	0	$0	1	$9,100,000
4.4	**Equipment maintenance and replacement (Note 5)**	LS	$2,554,500	0	$0	0	$0	28	$71,526,000	28	$71,526,000
5	**POWER (OPERATING COST)**										
5.1	**Conveyor System (20,000 MWhr per annum 9 months of the year)**	MWhr	$94.00	0	$0	0	$0	560,000	$52,640,000	560,000	$52,640,000
5.2	**Reclaim Barge power usage per annum (70% of thickened tailings option)**	MWhr	$94.00	0	$0	0	$0	504,000	$47,376,000	504,000	$47,376,000
TOTALS					$264,718,200		$1,822,200,800		$901,502,000		$2,988,421,000

M:\1\01\00325\03\A\Report\2-TMF Construction Material Alternatives\Rev 0\Tables\[Table 4.1 - Dry Stack Costs.xls]A.3

NOTES:

1. INDICATED DESIGN DETAILS ARE PRELIMINARY ESTIMATES ONLY AND REQUIRE REFINING.
2. 2008 PRE-FEASIBILITY UNIT RATES FOR ITEMS 1.1 TO 1.6 HAVE BEEN ADJUSTED TO 2010 DOLLARS.
3. ANNUAL EQUIPMENT MAINTENANCE AND REPLACEMENT COST ESTIMATED AS 15% OF THE PRE-PRODUCTION CONVEYOR SYSTEM COST.
4. ANNUAL EQUIPMENT MAINTENANCE AND REPLACEMENT COST ESTIMATED AS 15% OF THE PRE-PRODUCTION FILTRATION PLANT COST.
5. ANNUAL EQUIPMENT MAINTENANCE AND REPLACEMENT COST ESTIMATED AS 15% OF THE PRE-PRODUCTION TAILINGS AND RECLAIM SYSTEMS COSTS.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	14JUN'10	ISSUED WITH REPORT VA101-325/3-2	AG	HPD	KJB

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TABLE 5.1

WESTERN COPPER CORPORATION
CASINO COPPER-GOLD PROJECT

SUMMARY OF INITIAL CAPITAL, SUSTAINING CAPITAL AND OPERATING COSTS

Print Jun/15/10 12:07:27

TMF Option	Initial Capital Cost (Million CAD)	Sustaining Capital Cost (Million CAD)	Operating Cost (Million CAD)	Total Cost (Million CAD)
Local Borrow	82	1,009	139	1,230
Cyclone Sand	101	597	263	961
Dewatered Tailings	265	1,822	902	2,988

M:\1\01\00325\03\A\Report\2-TMF Construction Material Alternatives\Rev 0\Tables\[Table 5.1 - Cost Summary.xls]Table 2.2

NOTES:

1. THIS IS A COMPARATIVE COST ESTIMATE ONLY AND HAS BEEN ONLY BASED PRIMARILY ON COMPARATIVE QUANTITIES AND COSTS FOR EARTHWORKS AND PIPEWORKS SYSTEMS. IT EXCLUDES VARIOUS INFRASTRUCTURE COMPONENTS, INDIRECTS, OPERATING COSTS, ETC.
2. OPERATING COSTS ARE FOR TAILINGS, RECLAIM AND FRESHWATER PIPEWORKS AND PUMPING/INFRASTRUCTURE SYSTEMS OVER A 28 YEAR PERIOD.

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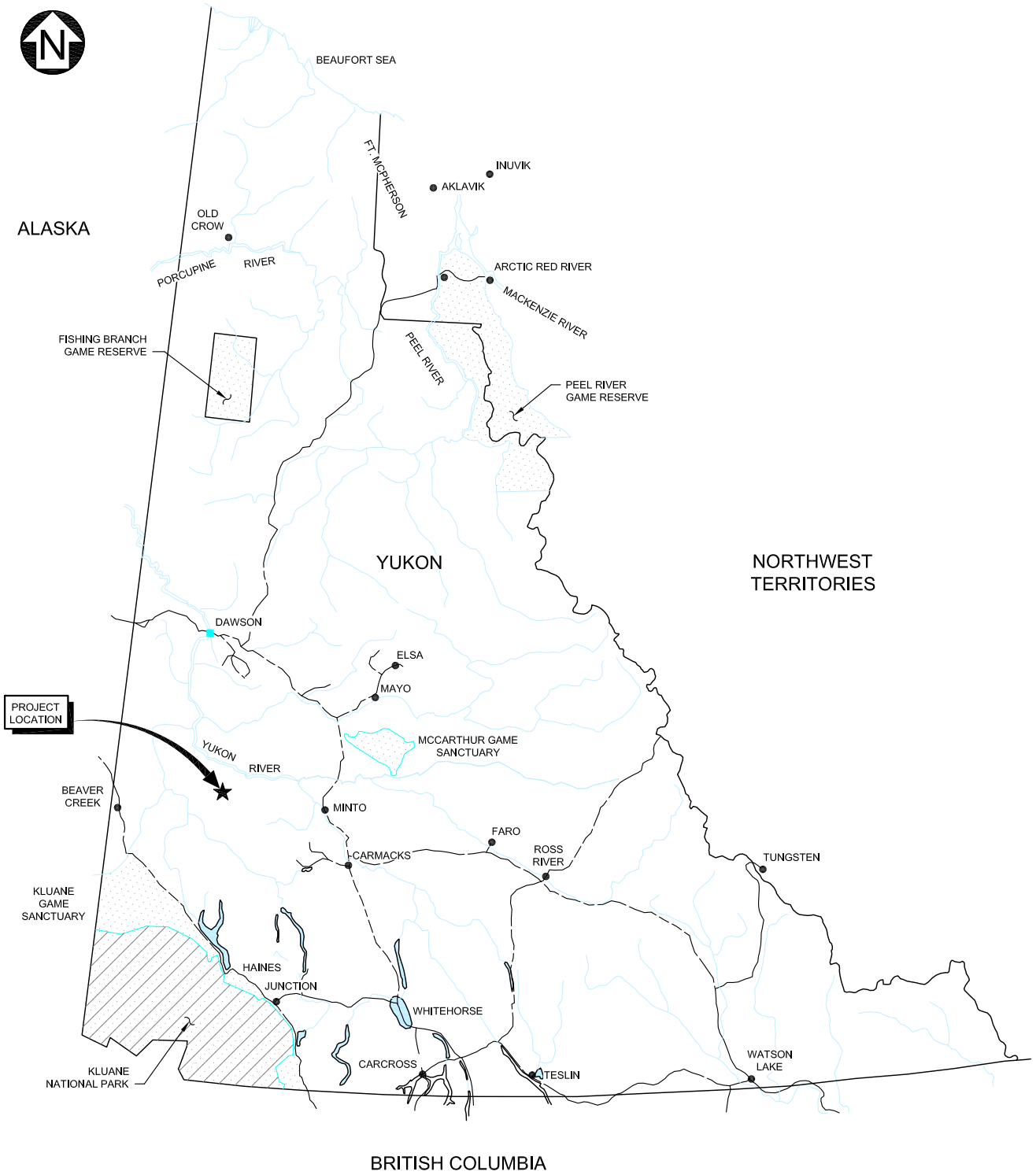

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	16APR'10	ISSUED FOR REPORT	AG	SC	GRG	KJB

WESTERN COPPER CORPORATION

CASINO COPPER-GOLD PROJECT

PROJECT LOCATION MAP

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P/A NO. VA101-325/3

REF NO. 2

FIGURE 1.1

REV 0

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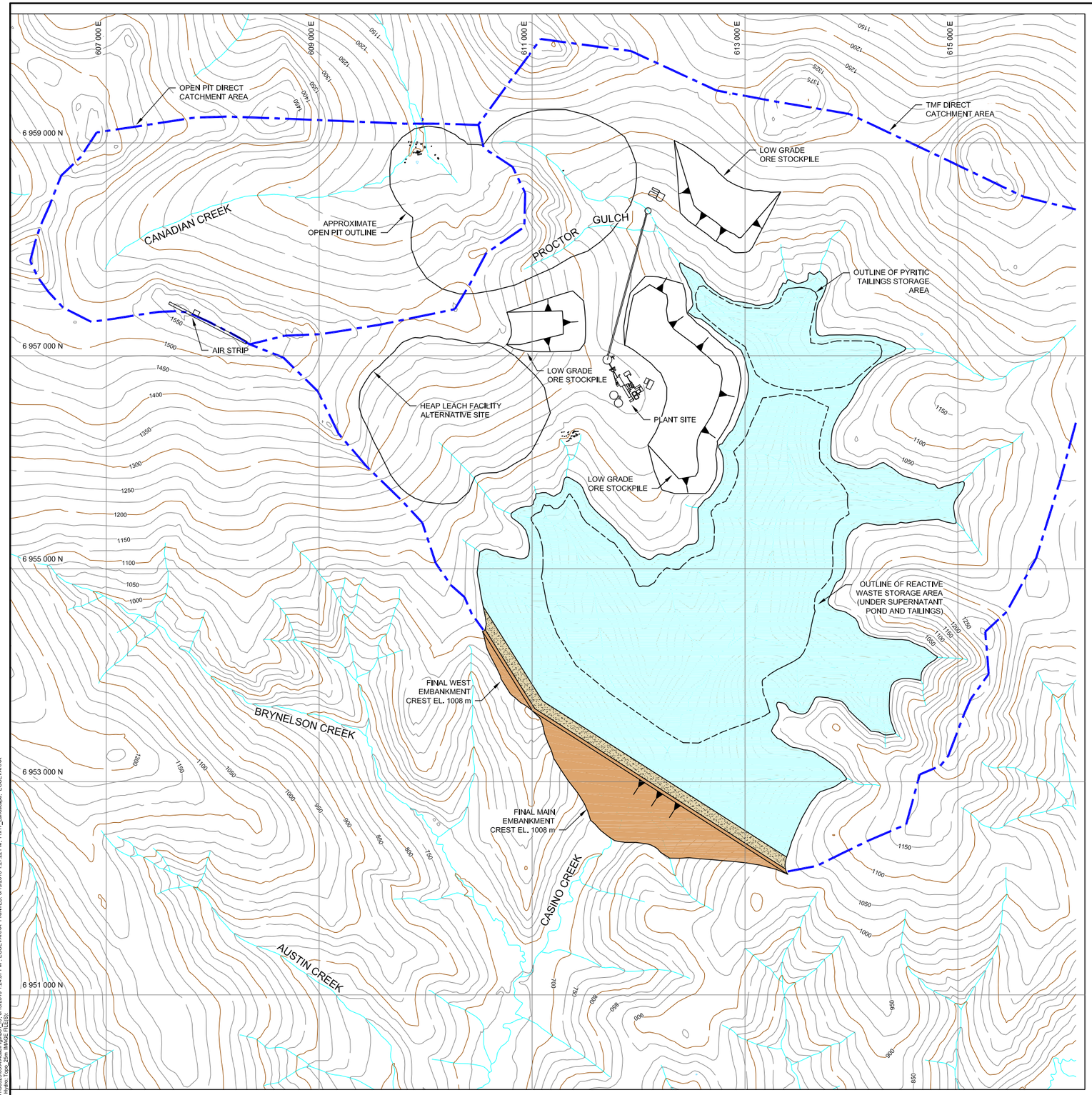

NOTES:

1. COORDINATE GRID IS UTM (WGS84/NAD83) ZONE 7 (m).
2. CONTOUR INTERVAL IS 25 METRES.
3. DIMENSIONS ARE IN METRES UNLESS NOTED.
4. PLANT SITE AND CRUSHER LAYOUT PROVIDED BY M3ENGINEERING AND TECHNOLOGY CORPORATION (APRIL 9, 2008).

SCALE A 400 200 0 400 800 1200 1600 2000 m

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	16APR'10	ISSUED WITH REPORT	AG	SC	GRG	KJB

WESTERN COPPER CORPORATION

CASINO COPPER-GOLD PROJECT

LOCAL BORROW MATERIALS OPTION GENERAL ARRANGEMENT

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P/A NO. VA101-325/3

REF NO. 2

FIGURE 2.1

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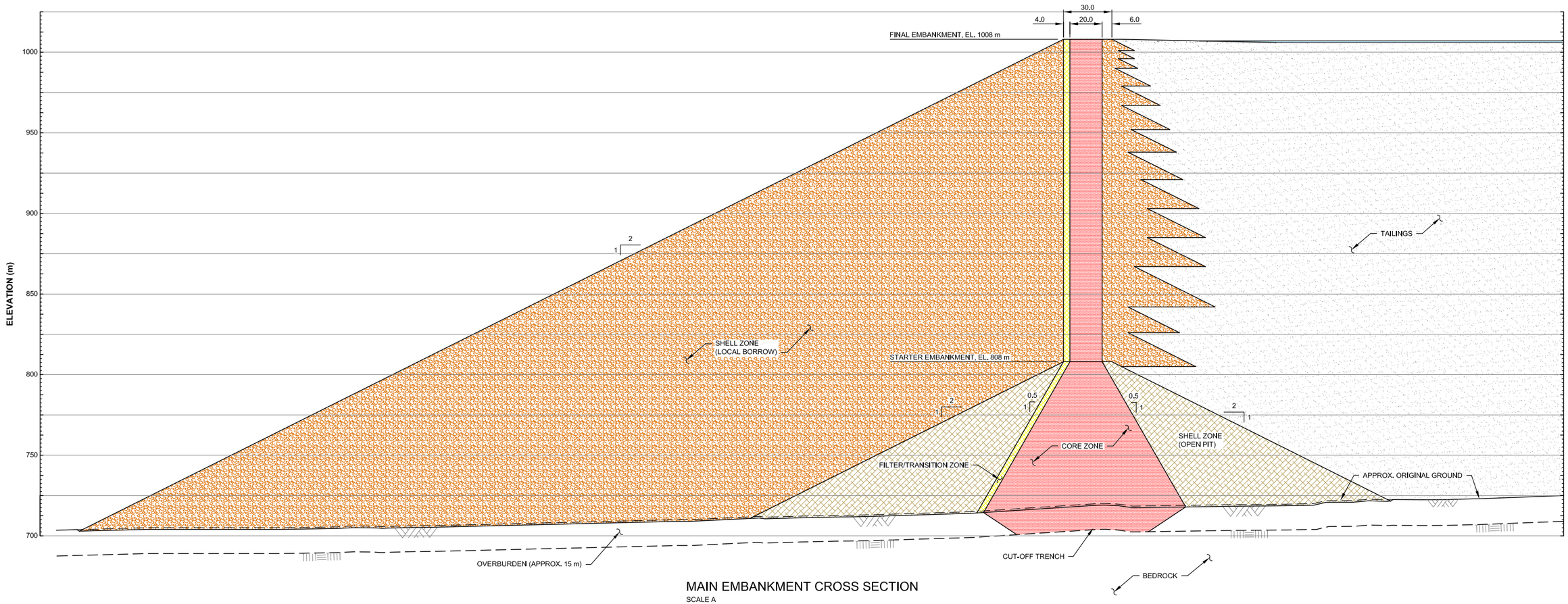
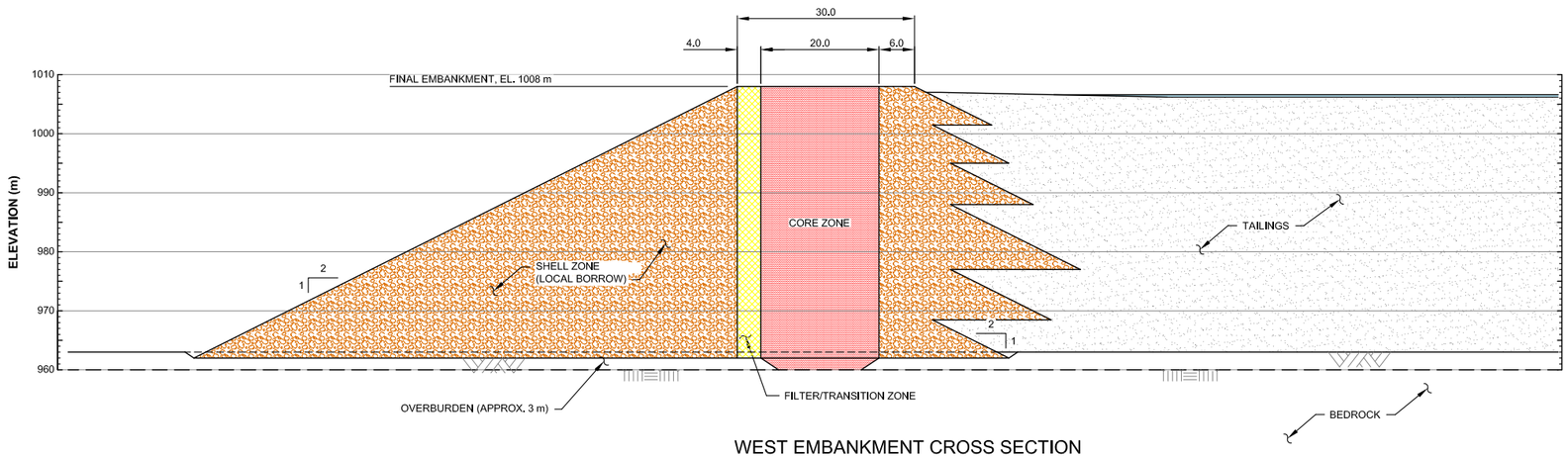


MAIN EMBANKMENT CROSS SECTION
SCALE A



WEST EMBANKMENT CROSS SECTION
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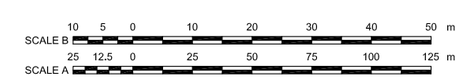

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WESTERN COPPER CORPORATION

CASINO COPPER-GOLD PROJECT

LOCAL BORROW MATERIALS OPTION
TYPICAL EMBANKMENT SECTIONS

Knight Piésold CONSULTING

P/A NO. VA101-325/3 | REF NO. 2

FIGURE 2.2 | REV 0

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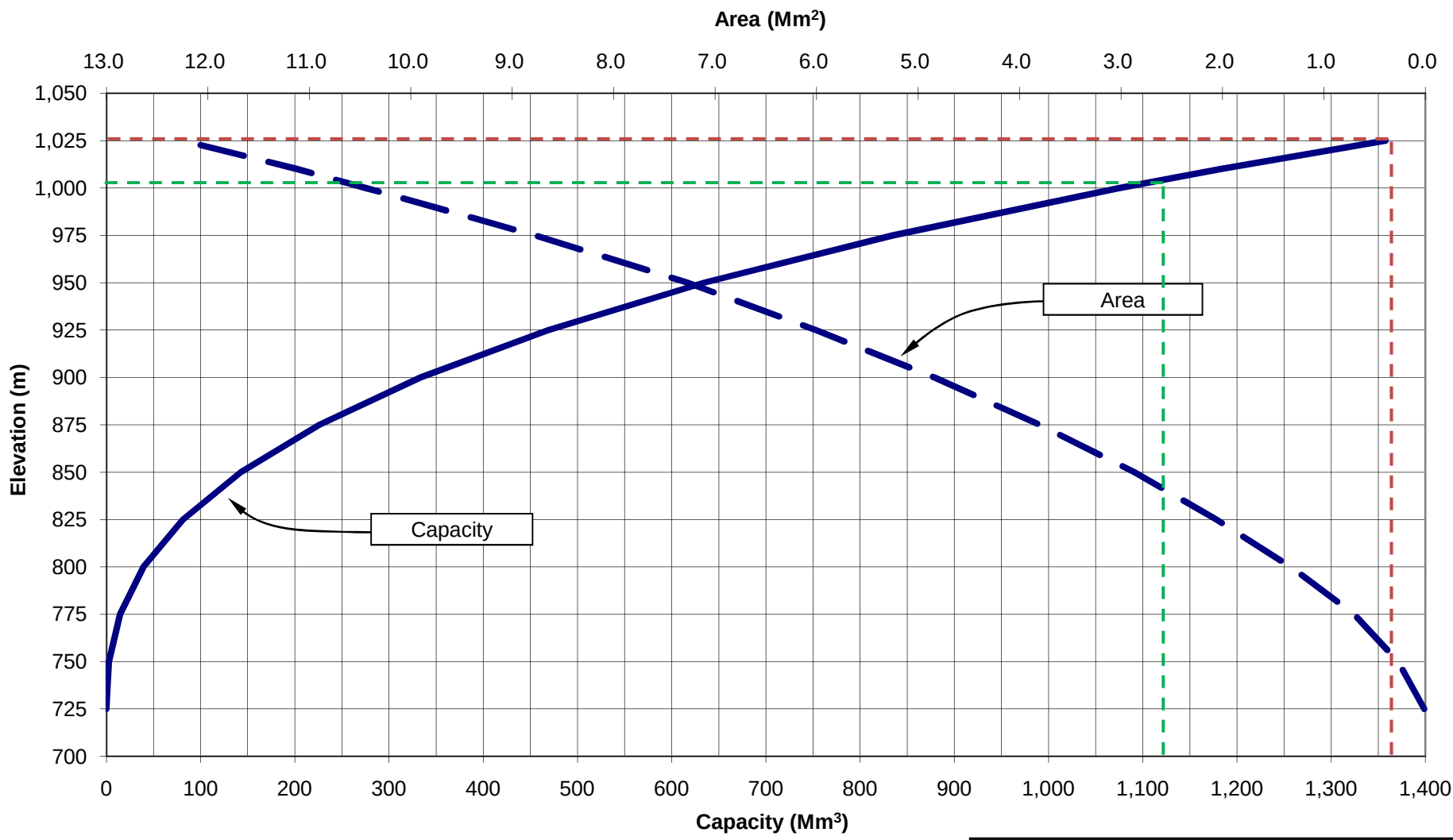

NOTES:

1. TAILINGS PLUS PAG AND ML WASTE MATERIAL STORAGE VOLUME = 1,119 Mm³.
2. EXPANDED CASE: TAILINGS PLUS PAG AND ML WASTE MATERIAL STORAGE VOLUME = 1,369.9 Mm³.

WESTERN COPPER CORPORATION

CASINO COPPER-GOLD PROJECT

LOCAL BORROW MATERIALS OPTION
DEPTH-AREA-CAPACITY RELATIONSHIP

Knight Piésold CONSULTING

PROJECT / ASSIGNMENT NO. VA101-325/3

REF NO. 2

FIGURE 2.3

REV. 0

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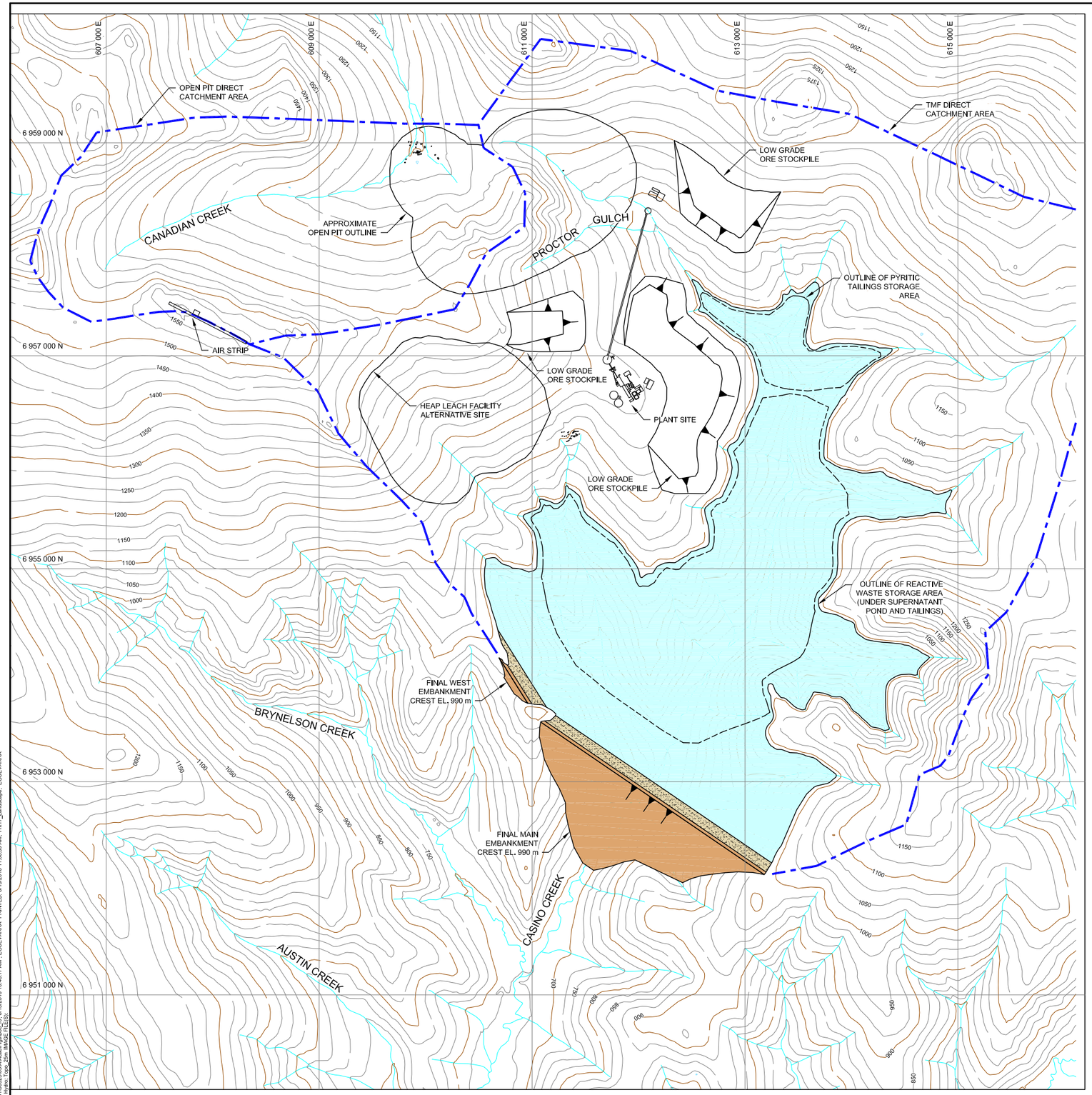

NOTES:

1. COORDINATE GRID IS UTM (WGS84/NAD83) ZONE 7 (m).
2. CONTOUR INTERVAL IS 25 METRES.
3. DIMENSIONS ARE IN METRES UNLESS NOTED.
4. PLANT SITE AND CRUSHER LAYOUT PROVIDED BY M3ENGINEERING AND TECHNOLOGY CORPORATION (APRIL 9, 2008).

SCALE A 400 200 0 400 800 1200 1600 2000 m

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	16APR'10	ISSUED WITH REPORT	AG	SC	GRG	KJB

WESTERN COPPER CORPORATION

CASINO COPPER-GOLD PROJECT

CYCLONE SAND EMBANKMENT OPTION GENERAL ARRANGEMENT

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P/A NO. VA101-325/3

REF NO. 2

FIGURE 3.1

REV 0

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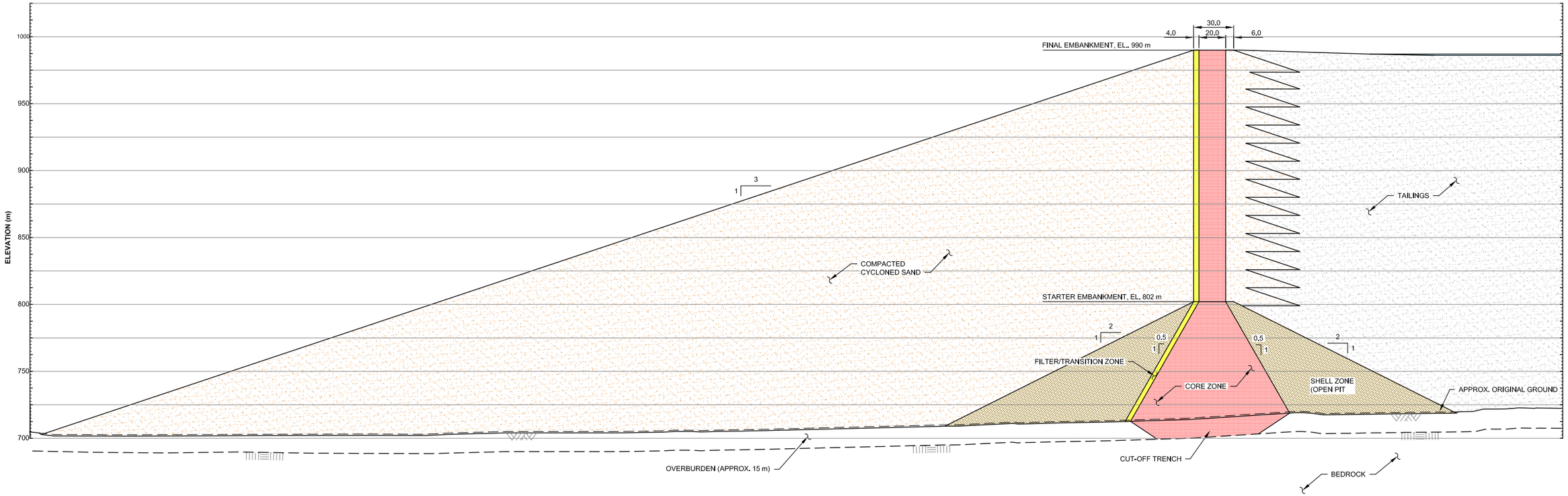
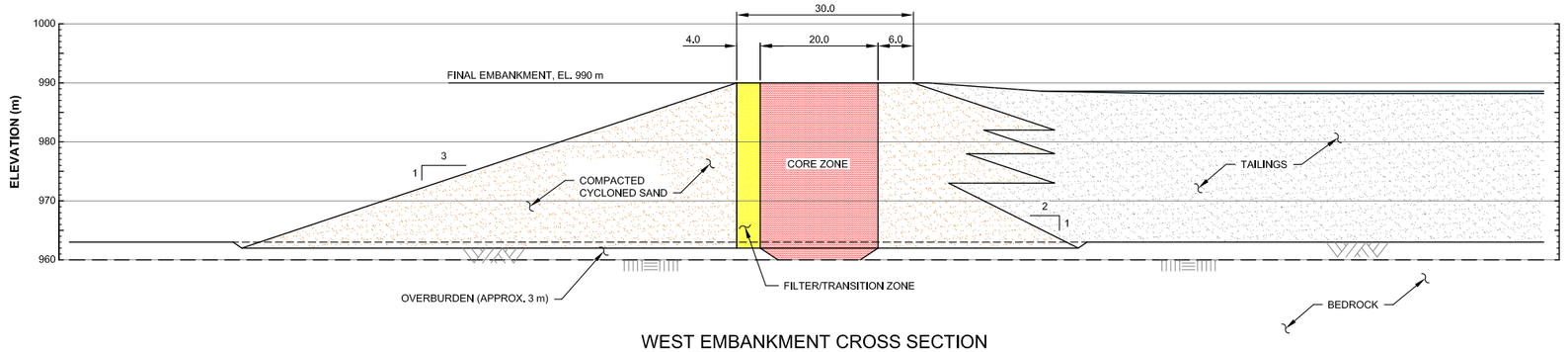


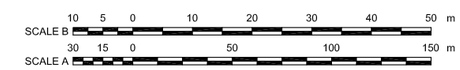
MAIN EMBANKMENT CROSS SECTION

SCALE A



WEST EMBANKMENT CROSS SECTION

SCALE B



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WESTERN COPPER CORPORATION

CASINO COPPER-GOLD PROJECT

CYCLONE SAND EMBANKMENT OPTION
TYPICAL EMBANKMENT SECTIONS

Knight Piésold CONSULTING

P/A NO. VA101-325/3

REF NO. 2

FIGURE 3.2

REV 0

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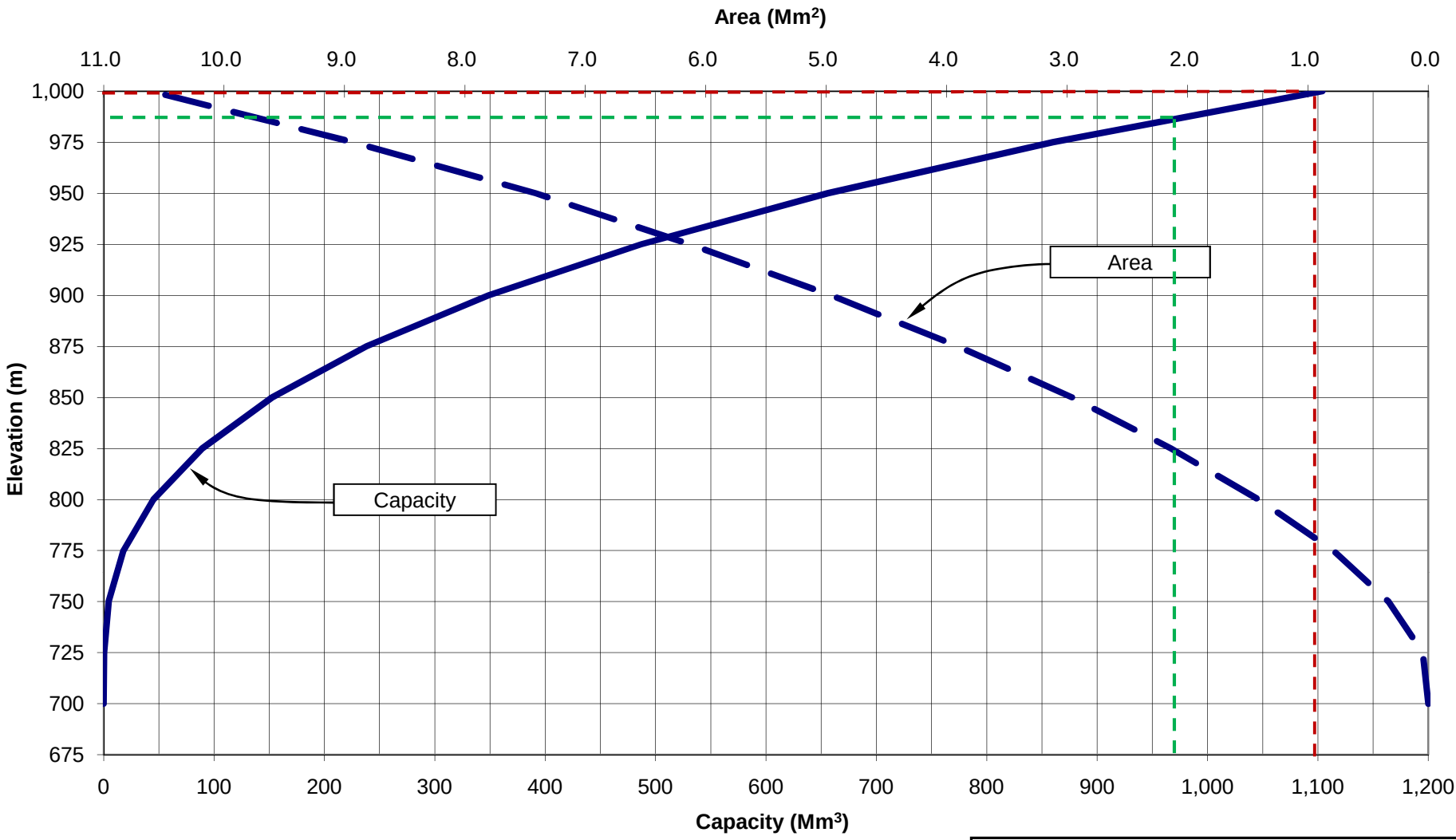

NOTES:

1. TAILINGS PLUS PAG AND ML WASTE MATERIAL STORAGE VOLUME = 962.8 Mm³.
2. EXPANDED CASE: TAILINGS PLUS PAG AND ML WASTE MATERIAL STORAGE VOLUME = 1,096.1 Mm³.

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CASINO COPPER-GOLD PROJECT

CYCLONE SAND EMBANKMENT OPTION
DEPTH-AREA-CAPACITY RELATIONSHIP

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REF NO. 2

FIGURE 3.3

REV. 0

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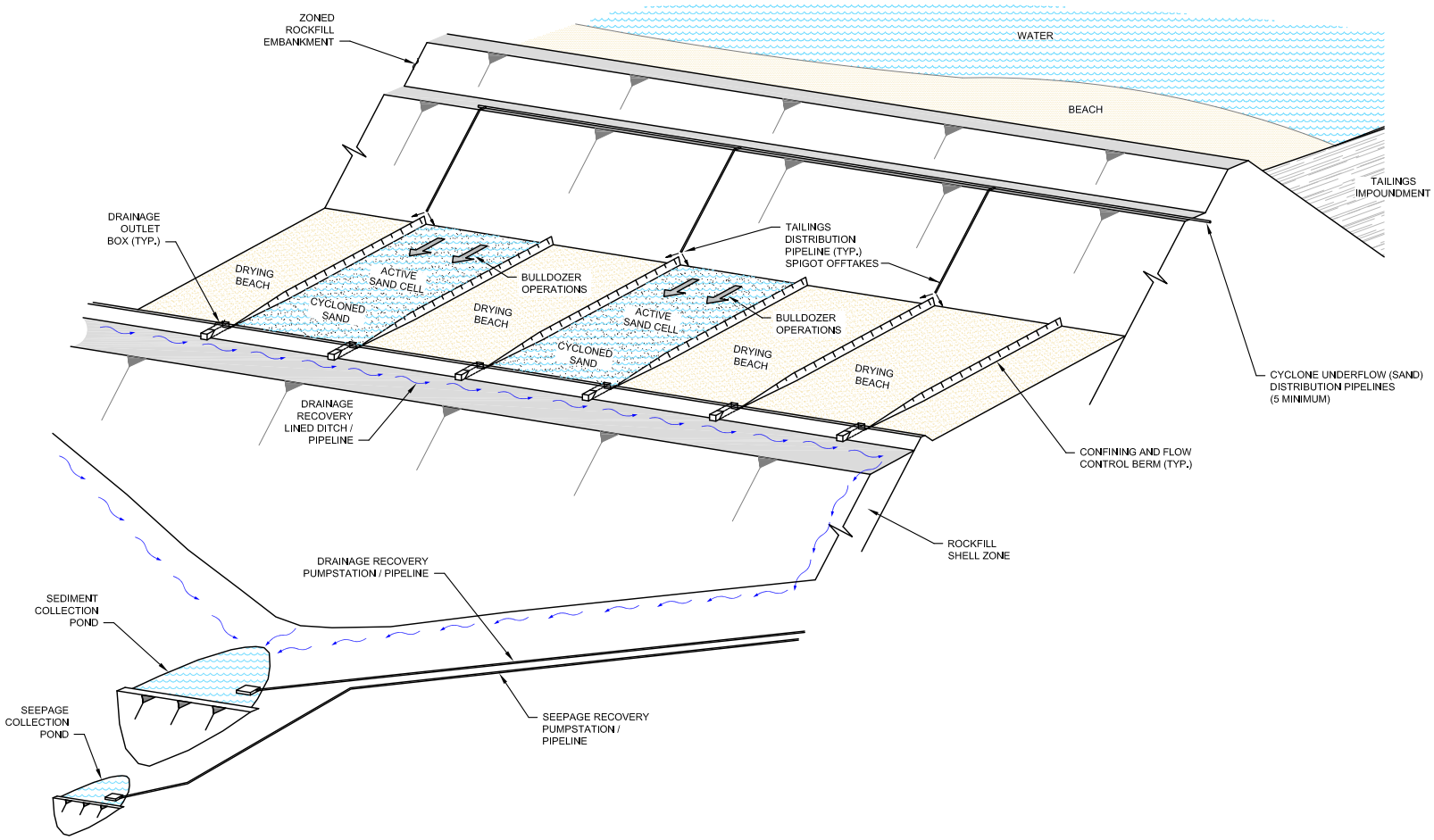

NOTES:

1. SAND CELL PLACEMENT OPERATIONS OCCUR SIMULATANEOUSLY IN TWO OR THREE CELLS.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	19MAY'10	ISSUED WITH REPORT	AG	RP	GRG	KJB

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CASINO COPPER -GOLD PROJECT

CYCLONE SAND DEPOSITION SCHEMATIC

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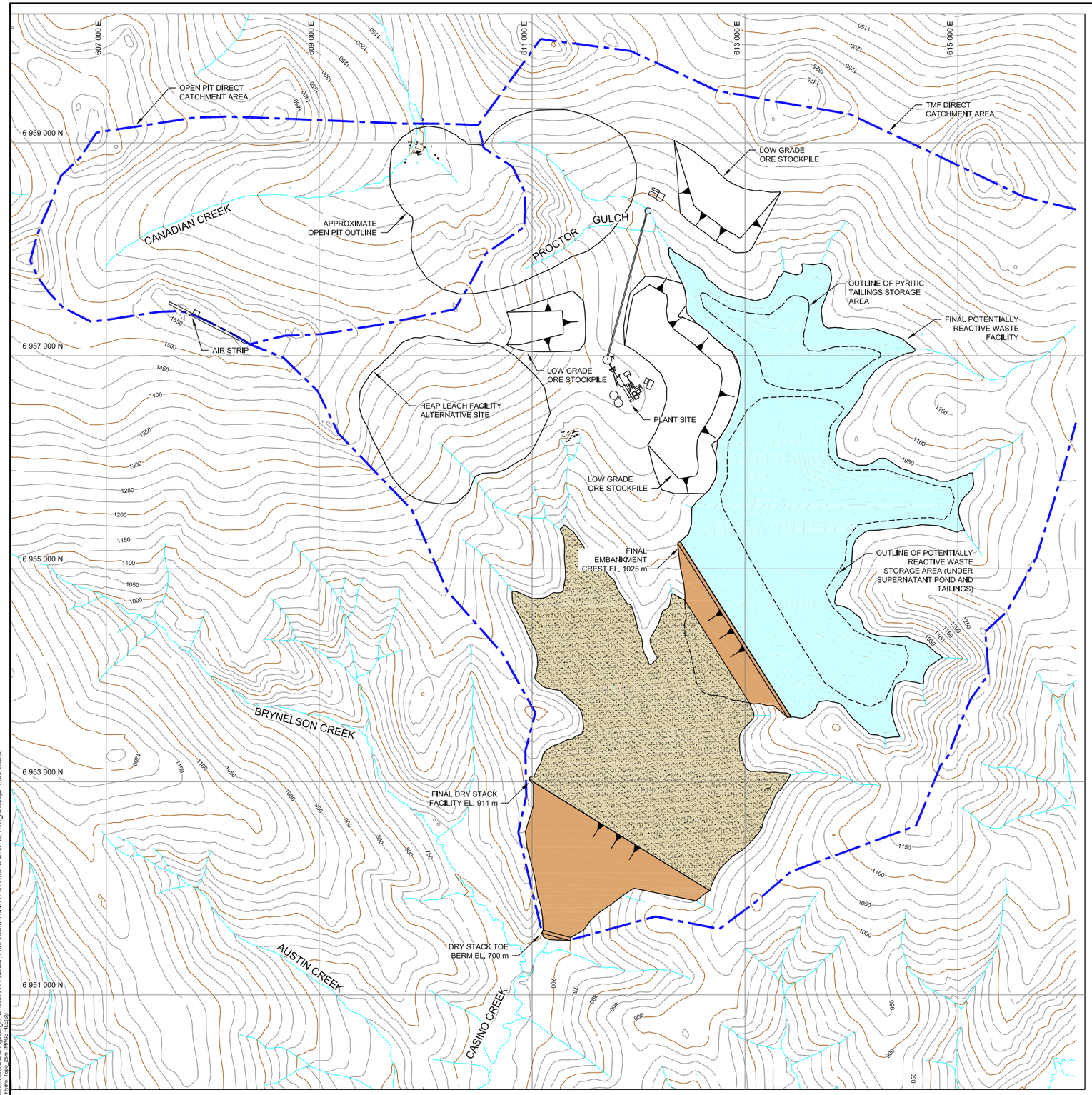
REF NO. 2

FIGURE 3.4

REV 0



NOTES:

1. COORDINATE GRID IS UTM (WGS84/NAD83) ZONE 7 (m).
2. CONTOUR INTERVAL IS 25 METRES.
3. DIMENSIONS ARE IN METRES UNLESS NOTED.
4. PLANT SITE AND CRUSHER LAYOUT PROVIDED BY M3ENGINEERING AND TECHNOLOGY CORPORATION (APRIL 9, 2008).

SCALE A 400 200 0 400 800 1200 1600 2000 m

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	16APR'10	ISSUED WITH REPORT	AG	SC	GRG	KJB

WESTERN COPPER CORPORATION

CASINO COPPER-GOLD PROJECT

DEWATERED TAILINGS OPTION GENERAL ARRANGEMENT

Knight Piésold CONSULTING

P/A NO.	REF NO.
VA101-325/3	2

FIGURE 4.1 REV 0

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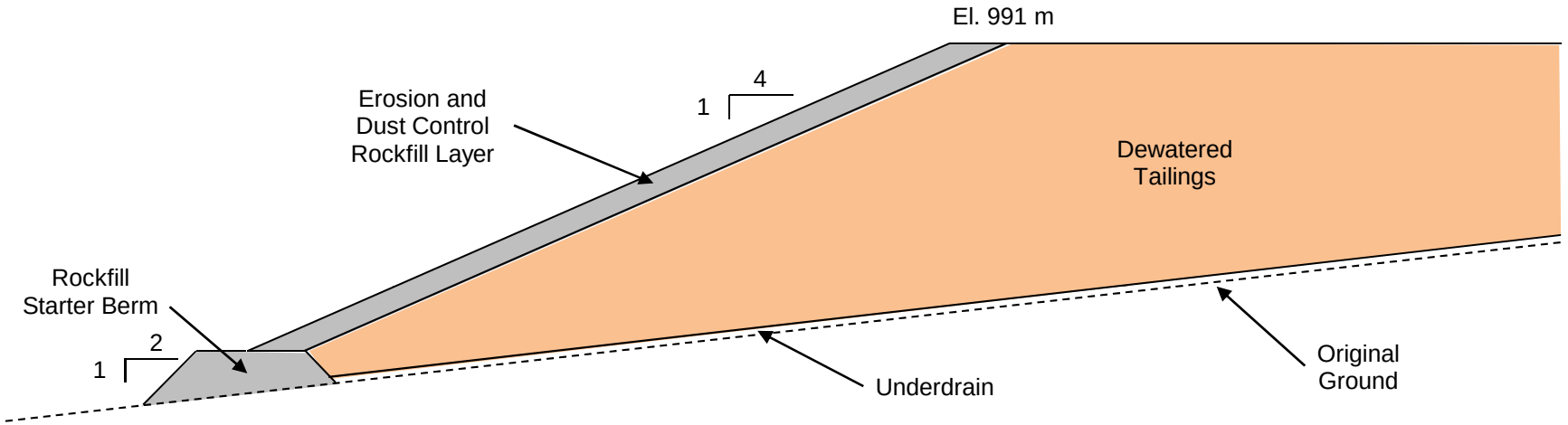

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WESTERN COPPER CORPORATION

CASINO COPPER-GOLD PROJECT

DEWATERED TAILINGS OPTION
DRY STACK FACILITY
TYPICAL SECTION

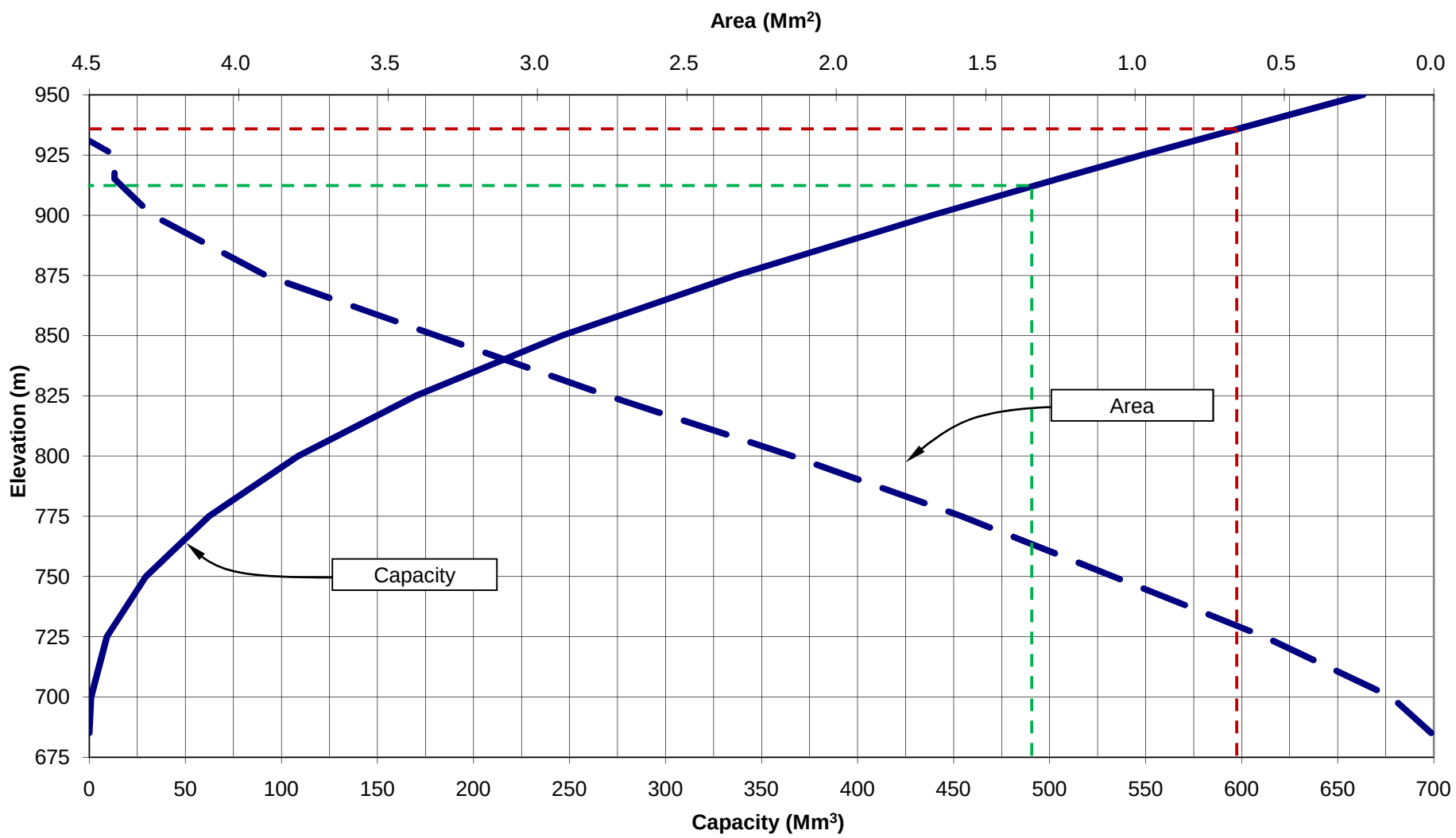
Knight Piésold CONSULTING

P/A NO. VA101-325/3

REF. NO. 2

FIGURE 4.2

REV 0



NOTES:

1. TAILINGS STORAGE VOLUME = 487.2 Mm³.
2. EXPANDED CASE: TAILINGS STORAGE VOLUME = 596.4 Mm³.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	03MAY'10	ISSUED WITH REPORT	AG	GRG	KJB

WESTERN COPPER CORPORATION

CASINO COPPER-GOLD PROJECT

DEWATERED TAILINGS OPTION
DRY STACK FACILITY
DEPTH-AREA-CAPACITY RELATIONSHIP

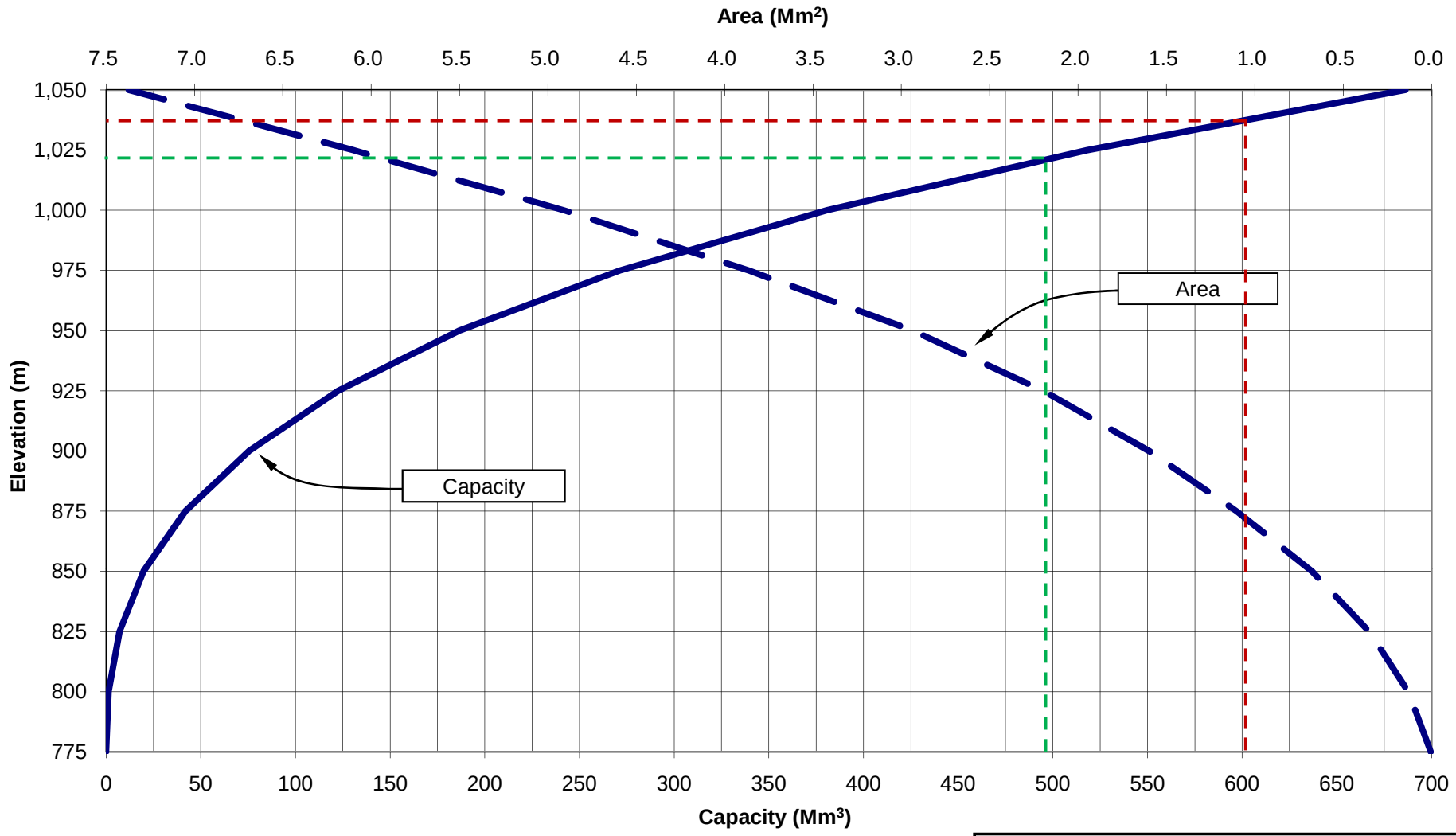
Knight Piésold CONSULTING

PROJECT / ASSIGNMENT NO. VA101-325/3

REF NO. 2

FIGURE 4.3

REV. 0



NOTES:

1. TAILINGS PLUS PAG AND ML WASTE MATERIAL STORAGE VOLUME = 492.7 Mm³.
2. EXPANDED CASE: TAILINGS PLUS PAG AND ML WASTE MATERIAL STORAGE VOLUME = 603.9 Mm³.

WESTERN COPPER CORPORATION

CASINO COPPER-GOLD PROJECT

DEWATERED TAILINGS OPTION
POTENTIALLY REACTIVE WASTE FACILITY
DEPTH-AREA-CAPACITY RELATIONSHIP

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PROJECT / ASSIGNMENT NO. VA101-325/3

REF NO. 2

FIGURE 4.4

REV. 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	19MAY'10	ISSUED WITH REPORT	AG	GRG	KJB



PHOTO 1 – Typical sand cell construction showing tailings stream entering sand cell.
Note tailings sand discharging into cell with dozer spreading and compacting deposited sand.

WESTERN COPPER CORPORATION
CASINO COPPER-GOLD PROJECT



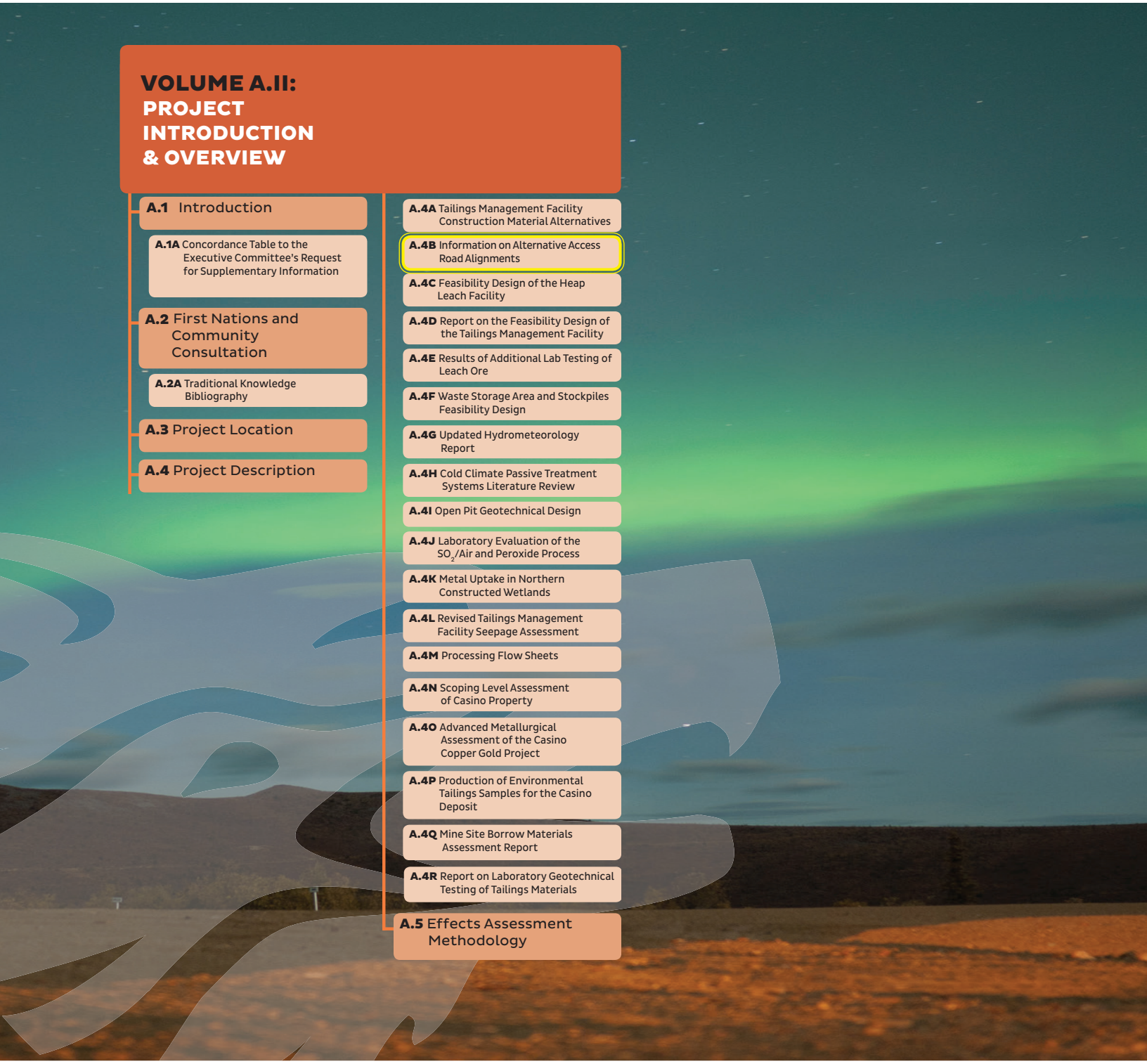
PHOTO 2 – Typical sand cell construction showing re-distribution of deposited sand in active sand cell. Note excess water decanted out of cell through moveable discharge box.

WESTERN COPPER CORPORATION
CASINO COPPER-GOLD PROJECT



PHOTO 3 – Typical sand cell construction with decant box.

APPENDIX A.4B: Information on Alternative Access Road Alignments



Report

Associated Engineering

GLOBAL PERSPECTIVE. LOCAL FOCUS.

Casino Mine Project

Project Transportation Scoping Study

Prepared for:
M3 Engineering and
Western Copper Corporation

March 2008



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Prepared by:

Associated Engineering (B.C.) Ltd.

Collings Johnston Inc.

Lauga & Associates Consulting Ltd.

Executive Summary

1 OVERALL FINDINGS

This report is a scoping and pre-feasibility study to examine transportation options for concentrate from the proposed Casino Mine in the Central Yukon to a deep-sea port. The Mine expects to produce about 250,000 tonnes of dry copper concentrate per annum during its 25 years of expected life. It is also expected that about 75,000 tonnes of supplies will need to be hauled into the Mine each year. The distance from the Mine to tide water is approximately 600 km, depending on the chosen route and port site.

A review was done of five transportation modes which showed that trucking will provide the most convenient and cost-effective modes for transportation.

An analysis has been undertaken of seven alternative routes for an all-weather road access to the Mine capable of operation throughout the year. The analysis included consideration of the Ports of Skagway and Haines as sea-water ports for the Mine.

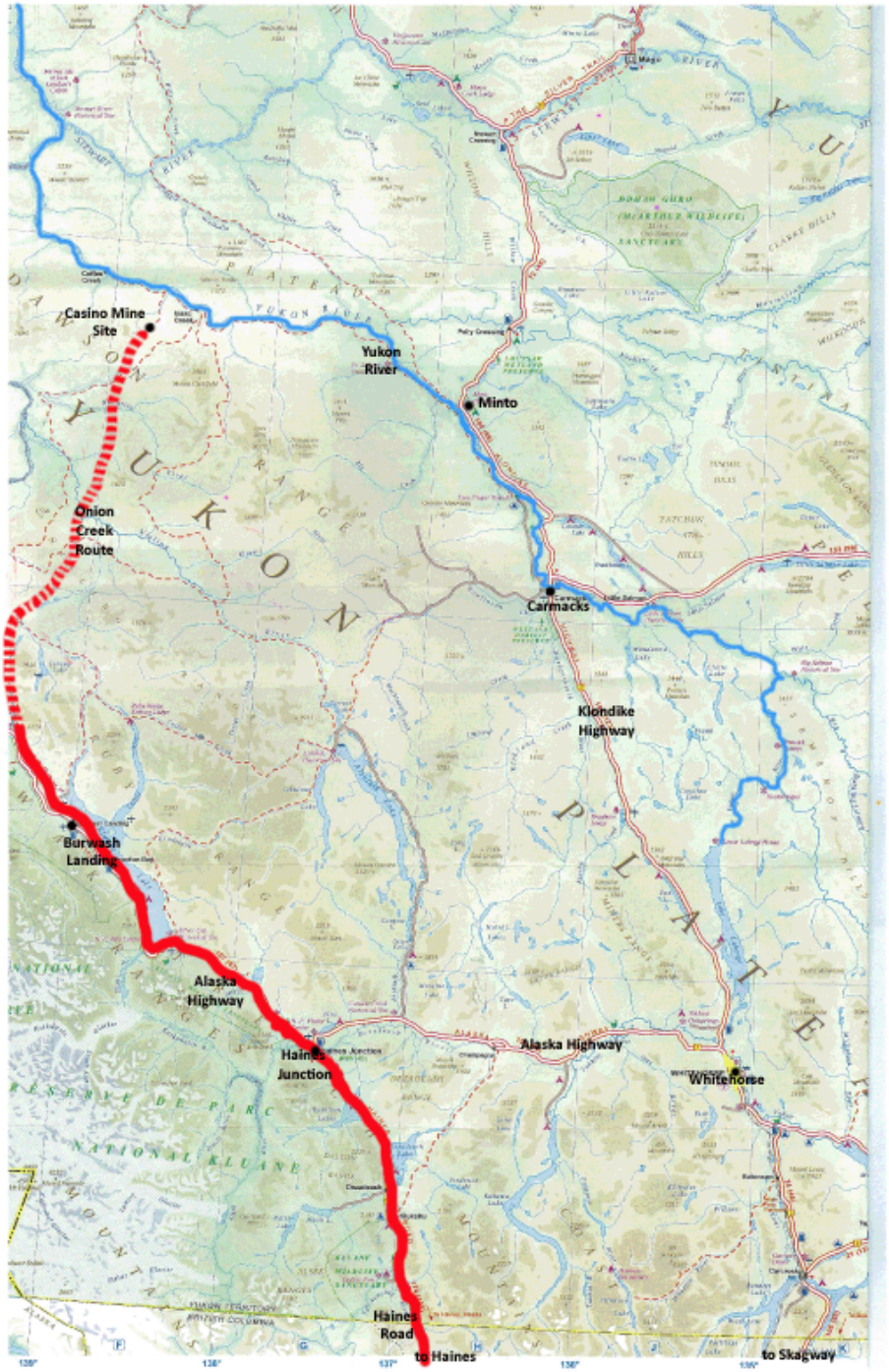
It has been concluded that Haines will likely to provide the most advantageous port for both concentrate exports and mine supply imports. A trucking route using Onion Creek and the Haines Road will provide the most economic alignment in terms of haul distance, road construction costs and terrain traveled.

The recommended route, shown in Figure ES 1, will follow the existing winter road south of the Mine, across the Nisling River Valley and the south along Onion Creek to the Alaska Highway north of Burwash Landing. This will require construction of 187 km of new mine haul road. The route would then follow south on the paved Alaska Highway and Haines Road for 408 km to Haines.

It is expected that the cost of construction of the mine haul road will be $91M in year 2007 dollars and that it will cost about $2.5 M per annum to maintain. The land transportation costs of transporting concentrate out from the Mine to the Port of Haines and transporting supplies from the Port into the Mine will be $156/tonne in net present value terms. For purposes of this evaluation it was assumed that B-train dump trucks would be used to haul concentrate outbound and standard Tridem trucks would be used to haul supplies inbound. This cost will fall to $114/tonne if coal is added as a backhaul to the transportation logistics.

The economic cost of hauling concentrate to the Port of Haines on the Onion Creek Route was further analyzed with a back haul of coal. This analysis, along with other economic assessments and major assumptions, are discussed in Chapters 6 and 7. No consideration at this time has been made of the shipment from the Port of Haines to an oversees smelter, likely to be located in east Asia.

Figure ES-1
Recommended Onion Creek Route from Casino Mine to the Alaska Highway and then south on the Haines Road to Haines



2 ALTERNATIVE TRANSPORTATION MODES

Chapter 2 of this study considers five modes of transportation:

- Barge
- Pipeline
- Rail
- Air
- Truck

It was concluded that trucking presents the most reliable means of transporting concentrate and supplies to and from the Mine. All the modes noted above would require some form of road access. Trucks can operate in all seasons and in extremely cold conditions that can be expected at the Casino Mine and on the Klondike Plateau. The main focus of this report therefore has been on trucking and truck routing.

3 TRUCKING CONSIDERATIONS

North America's large trucking industry has developed the ability to function in extreme weather and terrain conditions. Concentrate can be transported by several different haulage methods:

- Side –dumps trailers (b-trains or tridems)
- Bulk tank trailers
- Standard Containers on high-boy trailer
- Heavy-duty plastic bags on high-boy trailers

Chapter 3 of the report addresses a number of trucking considerations and reports on the existing Yukon Infrastructure, including construction and maintenance requirements. An all-weather road with a properly designed gravel surface can be maintained for a high level of operation throughout the year, except with the possibility of load restrictions during spring thaw. Winter operations will require a strict program of road maintenance, including stockpiling of sand in order to maintain optimum truck turn-around times. Routes through mountainous conditions will require more road maintenance, and may have to be closed during extreme weather conditions when truck haulage may not be possible.

4 CANDIDATE TRUCK TRANSPORTATION ROUTES

The alternative truck transportation routes are shown in Figure ES 3, the map titled "Road Transportation Corridor Options" and further detailed in Chapter 4. They are based primarily on 1:50,000 contour mapping with 50 m contour intervals and an understanding of the terrain gained from a brief over-flight of the routes. The road corridors where plotted on the map taking into consideration the observed soil conditions and road gradients. This data can be seen on the spreadsheets entitled "Estimated Site Conditions" in Appendix B. The "Estimated Site Condition" data sheets also give assumed road gradients for both favourable and adverse hauls. The truck haul times (Truck Turn Around times) was based on this information.

The road and earthwork quantities together with the construction cost estimates are shown in Appendix C. They were based on the terrain information and typical road cross sections shown in Appendix D.

Seven candidate routes have been studied for possible access of an all-weather road from the mine site to the Yukon highway system. Chapter 4 describes these corridors in more detail. These routes are illustrated on Figure ES-4 and Figure 4.1 and are shown in more detail in Appendix 1. Each route was considered with a port destination of Skagway and Haines; the “a” routes are to Skagway and the “b” routes are to Haines.

- Route 1 - Onion Creek
- Route 2 - Aishihik Lake
- Route 3 - East Route
- Route 4 - Wolverine Creek
- Route 5 - Klaza River
- Route 6 - Yukon River
- Route 7 - Hayes Creek

The overall transportation characteristics of each route are summarized in the Figure ES-2 below. This table does not take into account the backhaul of coal. Figure ES-2 is further expanded in Figure ES-3 which shows the transportation costs for concentrate haul to the port and the costs of backhauling both coal and mine supplies. The truck operating considerations and the trucking cost analysis are described in Chapters 5 and 6.

Based on available information, Route 1,Onion Creek Route, appears to provide the lowest road construction costs, and the lowest over all transportation costs to both the port of Haines and Skagway. This route along with the Route 4, the Wolverine Cr Route is reported as likely to present the least difficulties in permitting.

The present value cost of the Onion Creek to Haines route is $53 million less than the next best option, the Onion to Skagway route. The other candidate routes have significantly higher costs.

Figure ES 2
Summary of the Costs of Mine Road Routes and Truck Haulage without Coal Back Haul

Route #	Route Name	Distance of New and Upgraded Road (km)	Estimated Cost of Construction ($M)	Land Transportation Cost per tonne of haulage to HAINES ($)	Land Transportation Cost per tonne of haulage to SKAGWAY ($)
1	Onion Creek	187	91	156	173
2	Aishihik Lake	323	106	170	174
3	East Route	280	107	216	174
4	Wolverine Creek	138	154	221	177
5	Klaza River	273	169	228	186
6	Yukon River	205	189	246	202
7	Haines Creek	210	193	273	193

5 PORT CONSIDERATIONS AT HAINES AND SKAGWAY

Skagway or Haines are the only practical terminals for concentrate shipments from Casino Mine. The characteristics of these two ports are analyzed in Chapter 7. Skagway offers an existing operating concentrate terminal albeit with shared use capacity limitations. The land cost transportation to Skagway is estimated to be $53 million higher than to Haines. Pilotage, tug assistance, and ship operating costs are likely to be similar at Skagway and Haines. Haines offers the possibility of a dedicated terminal and upland areas although these will have to be developed for use by the Mine.

Both Skagway and Haines appear to have facilities able to receive and ship both inbound mine supplies and outbound concentrate shipments. Haines appears to offer the closest port and the best flexibility for port development by the Mine for their terminal requirements.

6 RECOMMENDATION

The results of this scoping study show that the Onion Creek route to the Port of Haines provides the most economical and flexible options for truck routing and port facilities.

In order to confirm the suitability of the Onion Creek routes, road construction and land transportation cost assumptions will need to be confirmed. Similarly a terminal facility at Haines will require further investigation. This will include conceptual site development plans, order of magnitude development costs and capacity assessments for bulk shipping. Further investigations will also be required to confirm the location of the overseas smelter as the destination for the concentrate. This will allow the cost of shipping to be included in the overall transportation costs. Similarly, if coal is to be transported inbound to the Mine, an understanding of the origin

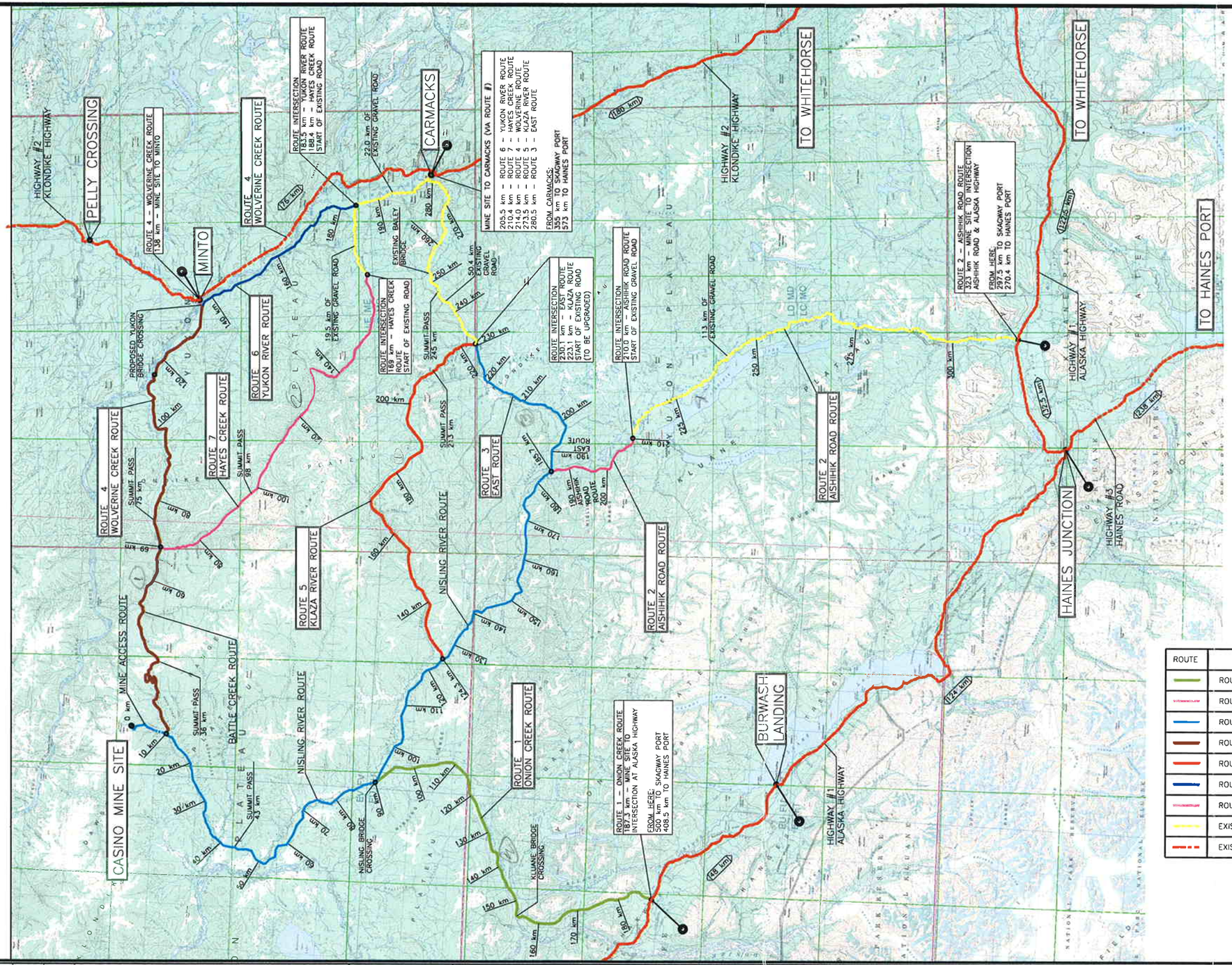
Figure ES-3
Summary of Transport Costs

Description	Side Dump Trucking $/Year Concentrate	Side Dump Trucking $/Year Coal	Tridem Trucking Supplies $/Year	Road Maintenance $/Year	Concentrate Terminal Charges $/Year	Coal Terminal Charges $/Year	Total $/Year
1. 275,000 Tonnes Wet Concentrate	$25,286,250			$2,511,387	$2,750,000		$30,547,637
2. 275,000 Tonnes Wet Concentrate plus back haul coal	$13,772,000	$13,772,000		$3,139,234	$2,750,000		$33,433,234
3. 75,000 Tonnes from Haines incremental cost			$7,902,750				$7,902,750
4. 75,000 Tones of supplies from Whitehorse incremental cost			$6,621,000				$6,621,000

Note: The shaded portion of the table provides costs for the Onion Creek Route for both concentrate hauling to the Ports of Skagway and Haines using B-Train Side Dump Trucks, and backhauling of coal to the mine. All the other route costs do not include the backhauling of coal.

Figure ES-4
Road Transportation Corridor
(next page)

This Drawing Is For The Use Of The Client And Project Indicated
No Representations Of Any Kind Are Made To Other Parties





KEY MAP
N.T.S.

ROUTE	MINE SITE – TO PORT	DISTANCE to SKAGWAY PORT (km)	DISTANCE to HAINES PORT (km)
	ROUTE 1 – ONION CREEK ROUTE	687.3	595.8
	ROUTE 2 – AISHIHIK ROAD ROUTE	620.5	593.4
	ROUTE 3 – EAST ROUTE	635.5	853.5
	ROUTE 4 – WOLVERINE CREEK ROUTE	569.0	787.0
	ROUTE 5 – KLAZA RIVER ROUTE	628.5	846.5
	ROUTE 6 – YUKON RIVER ROUTE	560.5	778.5
	ROUTE 7 – HAYES CREEK ROUTE	565.4	783.4
	EXISTING ROADS TO BE UPGRADED	–	–
	EXISTING HIGHWAYS	–	–

PRELIMINARY
NOT FOR CONSTRUCTION

REV.	DATE	ENG.	BY	SUBJECT
3	07/11/21	R.K.	W.R.	ADD WOLVERINE–MINTO DISTANCES IN TABLE
2	07/11/19	R.K.	W.R.	GENERAL REVISION
1	07/11/05	R.K.	W.R.	ADD ALTERNATE ROUTES VIA CARMACKS & TABLE
0	07/10/05	R.K.	W.R.	PRELIMINARY

REVISIONS

VERIFY SCALES

BAR IS 10mm ON ORIGINAL DRAWING
0 —— 10mm
IF NOT 10mm ON THIS SHEET, ADJUST SCALES ACCORDINGLY

Associated Engineering
GLOBAL PERSPECTIVE. LOCAL FOCUS.

		INITIAL	DATE
PROJECT No.	20072115		
SCALE	1 : 1 000 000		
DRAWN BY:	WAYNE RILEY		07/11/14
DESIGNED BY:	RAY KORPELA		07/11/14
CHECKED BY:	MARTIN JOBKE		07/11/14
APPROVED BY:			

CLIENT: M3 ENGINEERING & TECHNOLOGY CORPORATION
OWNER: WESTERN COPPER CORPORATION

DRAWING TITLE: ROAD TRANSPORTATION CORRIDOR OPTIONS

PROJECT: CASINO GOLD PROJECT
CONCENTRATE HANDLING & HAULAGE TO PORT

DRAWING NUMBER	REV. NO.	SHEET
20072115-00-110	3	1/1

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Appendix D - Preliminary Road Construction Details

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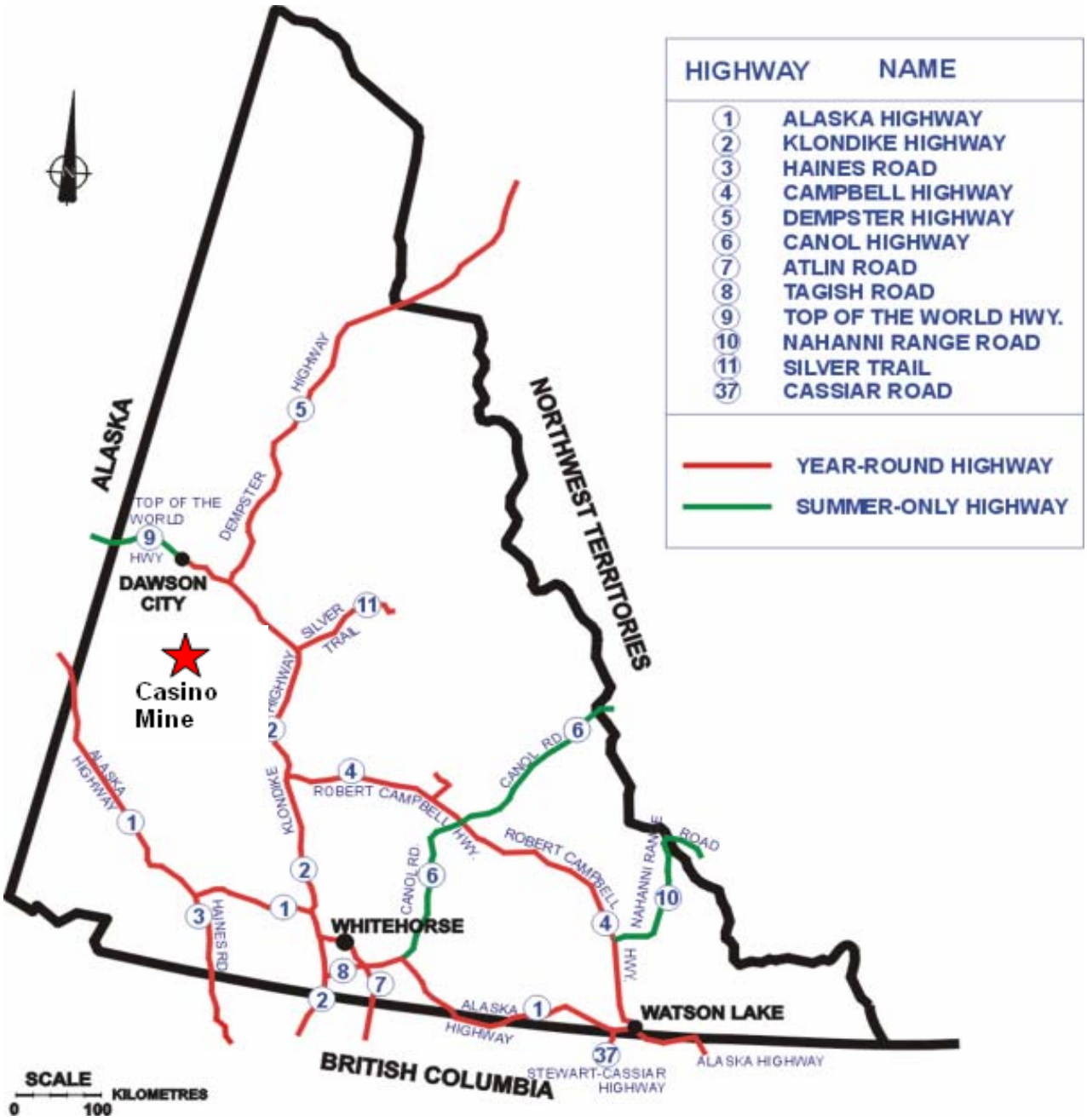
1 Transportation Requirements for the Casino Mine Project

The Casino Mine expects to produce about 250,000 tonnes of dry concentrate per annum over an expected Mine life of 25 years. If this was to be increased by 10% to allow for the bulking of moist concentrate, this will result in an annual haul of 275,000 tonnes and a daily shipment of 820 tonnes per day, which will have to be moved from the Casino Mine site. It is estimated that approximately 75,000 tonnes of mining supplies and provisions will have to be hauled into the Mine every year.

The Mine site is about 190 km west of Minto along the Yukon River. The approximate elevation of the Mine is 1,400 m and is on the west side of the Dawson Range. The Dawson Range, with peaks above 2,000 m, runs NW to SE, west of the Yukon River.

Figure 1-1
Yukon Highway System



2 Methods of Transporting Concentrate

There are five possible methods of transporting concentrate to a tidal port.

- By barge along the Yukon River;
- By concentrate pipeline to a trans-shipment point;
- By rail if the Alaska-Canada Rail Link is built;
- By air using heavy-duty transport aircraft; and
- By truck along a specially prepared gravel mining road and paved Yukon highways.

The following is a description of each method and its application to the transportation requirements of the Casino Mine. The first three methods present logistical challenges and are costly to implement and to operate. Trucking would provide the Mine with the flexibility and versatility, despite the long length of the haul to the port.

2.1 CONVENTIONAL TUG-AND-BARGE OR SELF-PROPELLED BARGE ON THE YUKON RIVER

The Yukon River was used as a transportation route by steam paddle-wheelers during the 1890s and the early part of the 20th century. There were more than 20 steamers operating this route in the late 1890s. The reported travel time was 36 hours from Bennett Lake to Dawson City, a distance of 600 km. The return journey against the fast-flowing Yukon River current took nearly 5 days. The Yukon River, in the late summer and early fall, flows at approximately 60 m/s (in excess of 10 knots). This is a strong current even for modern barge traffic.

The Yukon River, over the section between Bennett Lake and Minto, had two tricky rapids to negotiate. The first was at Whitehorse, where travelers had to walk while the ferry captains negotiated the rapid. A hydro-electric dam has been built at this location, thus blocking the river for navigation between Bennett Lake and Whitehorse. The second set of rapids, the “Five Finger” Rapids, is between Carmacks and Minto, and was the site of a number of steam paddlewheel ferry mishaps in the early 1900s. There are unconfirmed reports that some of the rocks in the rapid have been removed by dynamiting but there remains a steep drop in the river at this point.

The River flows ice-free for four months between June and October. It is often possible to build an ice bridge across the River from late November until March. The ability to build an ice bridge varies from year to year and this appears to have been the case from the 1890s until the present. Severe ice flows are often present in the River in April and May, preventing River traffic.

If barges are to be used to transport concentrate, there are a number of restrictions:

- The River is only open to barge traffic for four months – June to October;
- The River current is very strong and tugs would require large engines;
- The Five Finger Rapids and other rapids may still present an obstacle; and
- Sandbars and shallow channels, especially in reaches of the River downstream from the Mine.

It is conceivable that barges could be used to transport concentrate along the Yukon River for 160 km, from Britannia Creek (approximately 20 km north of the Mine) upstream to Minto, where it could be transferred to trucks for transport along the Klondike Highway to Skagway. The River between Britannia Creek and Minto appears to be deep enough for barge traffic and there are no known rapids. Barges could also travel to a truck trans-shipment point at Carmacks or Whitehorse.

Barges can be pulled by tugs that require up to 4 metres of draft. Barges can also be self-powered and can operate in water depths of 3 metres. Utility barges can hold up to 1,000 or 2,000 tonnes and one tug could pull several barges at the same time.

It is also conceivable that barges could be used to transport concentrate from Britannia Creek downstream to Dawson City or to further transhipment points. It may also be possible to barge to the mouth of the Yukon River and beyond. Barging to Dawson City or further west and then transferring to a truck would involve a very long truck haul to a seaport. Barging to the mouth of the Yukon River would be difficult due to sandbars in the river and due to the shallow seabed at this point in the Gulf of Alaska. The shallow seabed will make it difficult for access to concentrate carriers. The possibility may also exist of barging all the way to the location of a smelter in Eastern Asia but utility barges of 1000 to 2000 tonnes are small for ocean travel..

Concentrate could be carried to a Britannia Creek barge port by pipeline or truck. It is likely that a slurry pipeline would be a preferred means of transportation since a winter road along Britannia Creek would be extremely steep, with grades in excess of 15%. A concentrate shed would have to be built at the barge port to store concentrate for at least 8 months of the year. This shed will have to store up to 250,000 m3 of concentrate, and would be susceptible to contamination. Furthermore, by this method, a large fleet of barges and trucks would only be operational for 4 months of the year.

Operational supplies would still have to be transported to the Mine by some means – either by a winter road or by air. Both these operations are costly and dependent on weather. This would limit the flexibility of the mining operation and would add to the costs of transportation.

Barging is not considered a feasible option for Casino Mine, owing primarily to the limited barging season and the difficulties of operating on the Yukon River. One of the advantages of using barges is that their means of travel does not need infrastructure. However, for Casino Mine, barging will always have to be undertaken in conjunction with road, pipeline or air transportation which will offset any cost advantages of barging.

2.2 HOVER BARGE

Hover barges have been used in the past on the Yukon River. Two hover barges pulled by a cable, with a payload capacity of 160 tons, provided round the clock, roll-on, roll-off, ferry crossing services during the construction of the Trans Alaskan pipeline project in the late1970s. Operating in sub-zero temperatures, over 100,000 tons of equipment was shipped per month. The two "Yukon Princesses" (illustrated on Figure 2.1 below ferried trucks across the Yukon River to support construction of the pipeline. The barges were prefabricated and assembled on site in 10 weeks. At the location needed for the pipeline, high current speeds, winter ice and fluctuating water levels precluded the use of a conventional cable ferry. Each barge had two 700 hp engines driving air fans. Pulled by a cable, a crossing of 1.6 km took 20 to 30 minutes.

Hover barges do present an alternative to a bridge over the Yukon River but to operate along the River for any distance presents propulsion challenges. Owing to their weight, size and shape, hover barges are not able to navigate themselves. They require a cable in order to cross rivers or inlets. Redfern Mine in Northern BC is proposing to use an amphibious tug to tow a hover barge. This tug cannot operate in winter and has a crawler arrangement to travel over sandbars and stretches of shallow water which raises environmental concerns. The hovering mechanisms are known to be mechanically unpredictable and fuel consumptive.

For the same reasons as described above for conventional barging, hover barging is not considered a feasible option for Casino Mine. The main rationale for considering a hovercraft is that it can navigate over ice, sand and swift flowing rivers. The need to propel the hover barge by some conventional means limits its year-round usefulness and negates its hovering properties.

Figure 2-1



2.3 CONCENTRATE PIPELINE

Concentrate pipelines are becoming more common in the mining industry, and their operating characteristics are becoming better understood by mining companies. The constitution of the slurry depends on the type of rock that is milled, together with its abrasive properties. Most slurry pipelines operate under gravity, with pump stations only for emergency use. Problems are reported with pipelines operating in extremely cold conditions, but this can be overcome by heating the slurry.

It is conceivable that a slurry pipeline could be built from the Mine due north to a barge port on the Yukon River at Britannia Creek, a distance of about 20 km, as discussed above.

The second concept would be to carry concentrate in a pipeline to Minto or Carmacks, a distance of 200 or 300 km, and then trans-ship to a truck for transportation to Skagway along the Klondike Highway. This could be a year-round operation. It would be susceptible to freezing, and would require a holding shed and a pipe bridge across the Yukon River.

The construction of a concentrate pipeline also involves the construction of a road for purposes of pipe and pump station supply, pipe assembly and regular maintenance. Concentrate pipelines usually require an additional water pipeline for the return of slurry water to the mill. A Typical concentrate pipeline costs about $1 million/km and the return water pipeline about $0.5 million/km. Storage tanks would be required at both the mill and the end of the pipeline, and a de-watering tank would also be required at the end of the pipeline. As a rule of thumb, the capital cost of a pipeline is twice the cost of a mine haul road. However, the operation of a pipeline is half the cost of maintaining a truck haul fleet.

2.4 RAIL TRANSPORTATION

Rail is usually the preferred method of transporting bulk cargos over long distances. Rail costs for coal, which is transported across British Columbia, is five times cheaper than by truck. The problem is that a rail line is five to ten times more expensive to build and to maintain. The State of Alaska has recently been studying an Alaska-Canada rail link between Fairbanks and the North American rail network in northern British Columbia. One of the potential corridors for this rail link is the Nisling River between Beaver Creek and Carmacks. This potential project is in the early pre-feasibility planning stage and cannot yet be justified commercially. If such a project was to proceed immediately, it would take eight to ten years to complete.

Construction of the Alaska-Canada Rail Link is not likely to happen immediately, and the possibility of a rail link for future transportation of Casino Mine concentrate is unlikely to materialize during the first part of the Mine’s life.

2.5 HEAVY-DUTY TRANSPORT AIRCRAFT

Heavy-duty cargo aircraft can carry approximately 50 tonnes, which is the same as a highway truck. Concentrate could be shipped in containers or sacks directly from the landing strip at the Mine to a port such as Haines or to an alternative port in Alaska or British Columbia. While this option is feasible, it is expensive. A truck costs approximately $100 an hour to operate, while a Hercules transport plane costs approximately $9,000 an hour. A round trip for a truck to the Mine site is approximately 36 hours, while a round trip for a plane would be closer to 4 hours. Air transportation would be an order of magnitude greater than truck travel. If concentrate was to be carried by aircraft, there would still be a need for a road to transport supplies into the Mine site.

Air transport is unlikely to be feasible for Casino Mine, due primarily to the cost.

Figure 2-2
Existing Runway at the Casino Mine Site



2.6 TRUCK TRANSPORTATION

Trucking presents the most reliable means of transporting concentrate in the Yukon and has been made the focus of this report.

A number of options were investigated for the location of an all-weather road from the Mine site to the Yukon Territory Highway network that would permit truck transportation to either the ports of Skagway or Haines. Truck transportation is flexible and can be undertaken year-round. Concentrate can be carried by truck in a number of different kinds of containers. Different truck/trailer combinations can also be used for standard highway and private mining roads. Road transportation presents challenges in the form of road construction, operation and maintenance.

Overall, North America has a large trucking industry that has learned to adapt to transportation in extreme weather and terrain conditions.

3 Trucking Considerations

A number of possibilities need to be addressed in considering truck transportation.

- How is the concentrate to be carried?
- How is it to be loaded and unloaded?
- Existing Yukon highway infrastructure
- What truck and trailer combinations should be considered?
- What kind of road pavement should be considered?
- Should hauling be undertaken in one stage or several stages?
- What kind of road construction should be considered – winter only or all-season roads?
- What geometry of road should be considered – one-way only or two-way?
- Should the Mine be considering a private or a public road and the likelihood of future reclamation of this road?

Figure 3-1



3.1 HOW IS THE CONCENTRATE TO BE CARRIED BY TRUCK?

There are four haulage methods commonly used by mining companies to transport concentrate by truck:

- By side-dump trailers;
- By bulk tank trailers;
- By standard containers on flat trailers;
- By heavy-duty plastic bags or sacks (tote bags) on flat trailers.

Each of the above methods can carry concentrate so as to prevent any spillage of mineral or potential contaminants. Concentrate shipping companies and smelting companies usually require concentrate to be delivered with a maximum moisture content of 8%. This concentrate texture appears to be almost dry and cannot be pumped as a slurry, so any trans-shipment requires either transferring with loading equipment or adding additional water. Water is bulky and heavy to transport, so the drier the concentrate, the more economical it is to haul. Water mixed with concentrate is often heavily contaminated.

Trucks can operate throughout most weather conditions. In the summer, roads have to be treated with a road salt such as calcium chloride to suppress dust. During winter months, roads need to be kept gravelled to ensure traction. The operating costs for a truck are higher in extremely cold conditions. During the spring break-up, load restrictions apply on all roads and trucks normally can only carry up to 80% of their regulation weight.

The common method of transporting concentrate in North America is with side-dump, B-train truck/trailers. These trailers can be loaded by a conveyor belt or by front-end loader and can be easily dumped within a concentrate storage shed. Trailers can also be fitted to carry containers for the return transportation of supplies to the Mine. The maximum payload for a B-train is 41 tonnes.

Transport by standard steel container can be environmentally secure and is easy to trans-ship. Containers can be transported from a mine and loaded onto a ship and only emptied at the smelter. If the concentrate needs to be trans-shipped to the concentrate carrier ship at a North American port, it can be tipped into the vessel. Container handling has become a highly specialized activity and containers of various sizes can be easily manoeuvred by fork-lifters, intermediate-sized cranes, or derrick cranes. The problem with containers is that each weighs two or more tonnes and this adds to the gross weight of transportation.

A standard container (a TEU or 20-foot equivalent unit) weighs 2.2 tonnes and has approximate dimensions of 8-foot wide, 8-foot high and 20-foot long. It can be easily loaded onto a flatbed truck in a Tridem or B-train combination. It can take a payload of up to 21.6 tonnes. A double container, which is 40-foot long, weighs 3.8 tonnes, and can take a payload up to 26.5 tonnes.

Transportation by plastic bags weighing one or two tonnes is becoming a more common form of trans-shipment. No extra weight has to be carried, as in the case of containers, and the bags can be easily handled by fork-lifters and cranes. The problem with concentrate bags is that they are known to leak and can be punctured during transportation or trans-shipment.

3.2 HOW WILL THE CONCENTRATE BE LOADED AND UNLOADED?

Most spillage and contamination of concentrate occurs at the point of its loading and unloading. The fewer points at which concentrate is handled in its raw state will provide better quality control and environmental compliance.

If concentrate is to be transported by pipeline or a tanker trailer it can be pumped directly from the mill to the pipeline or trailer and then again pumped to a ship or barge. Concentrate in this form generally has a high water content and has to be de-watered before conveyance to an ocean-going ship. This water is often highly contaminated and needs to be specifically treated or returned to the mill.

Loading and unloading of concentrate with a maximum moisture content of 8%, required by concentrate ships, can be handled by loaders, forklift or derrick cranes if it is conveyed loose in a container or in plastic bags.

3.3 EXISTING YUKON HIGHWAY INFRASTRUCTURE

The Yukon is well served with surfaced roads, which traverse the more populated South-Western part of the Territory and provide access to ports in Southeast Alaska. Figure 3-2 shows the road infrastructure of the Yukon in relation to the continental road network. Figure 3-3 illustrates the location of various focal points for the export of commodities in the Yukon, Alaska and Northern B.C. Exhibit 3-4 gives an indication of distances from Whitehorse to ports and centres in the Yukon and Alaska.

Figure 3-2
Infrastructure in Western Canada and Alaska

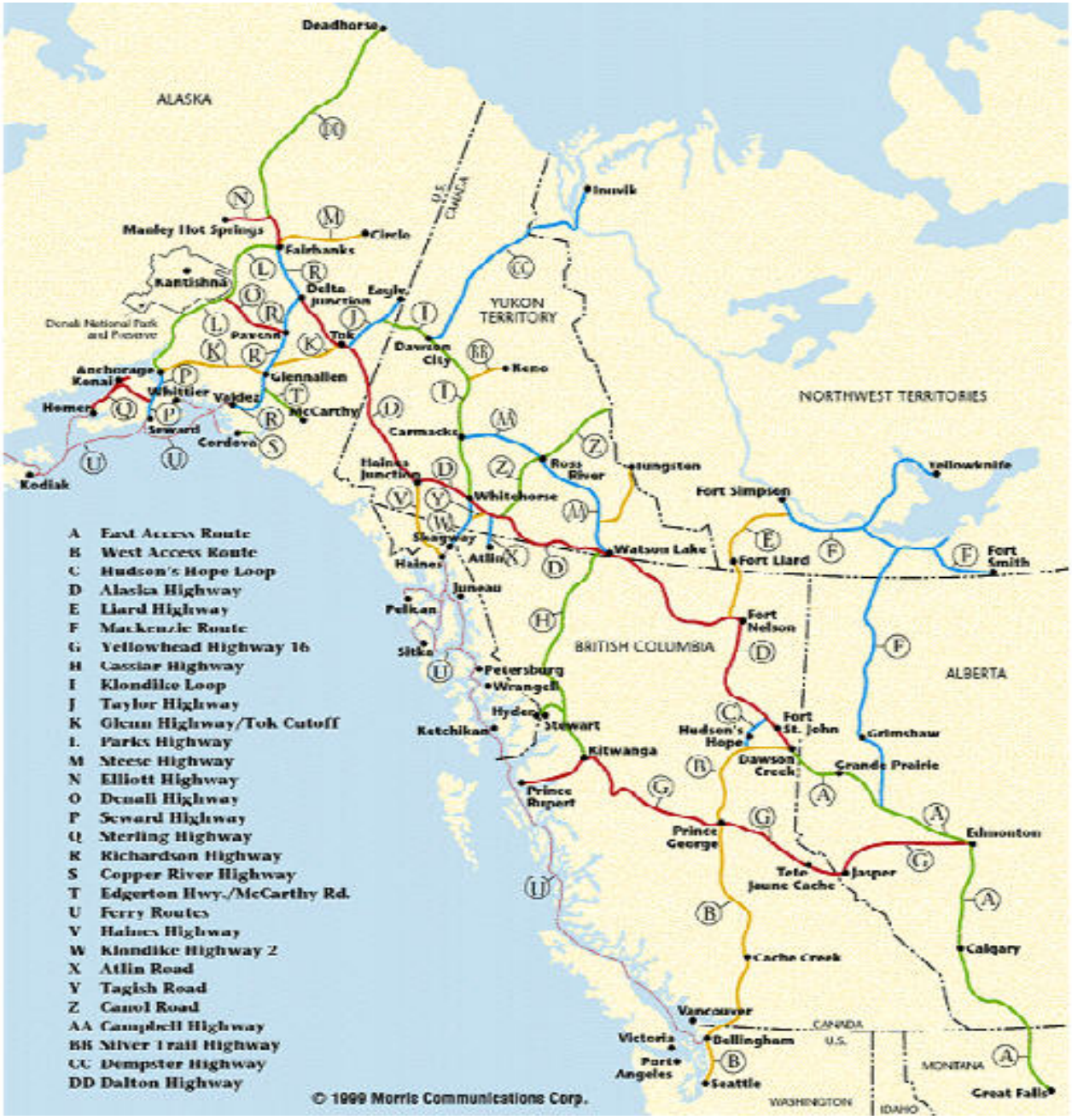


Figure 3-3
Focal Points for the Export of Commodities



The main highway across the Yukon is the Alaska Highway, which originates in Dawson Creek, BC and runs for 909 km through the Yukon from the BC border east of Watson Lake to the interior Alaska border at Beaver Creek. The Klondike Highway follows the old gold-rush trail from Skagway through Whitehorse to Dawson City. Whitehorse is the centre of travel in the Yukon. The following table summarizes distances to the nearest ports and centres from Whitehorse1, indicating the remote nature of the Yukon.

Figure 3-4
Distances from Whitehorse

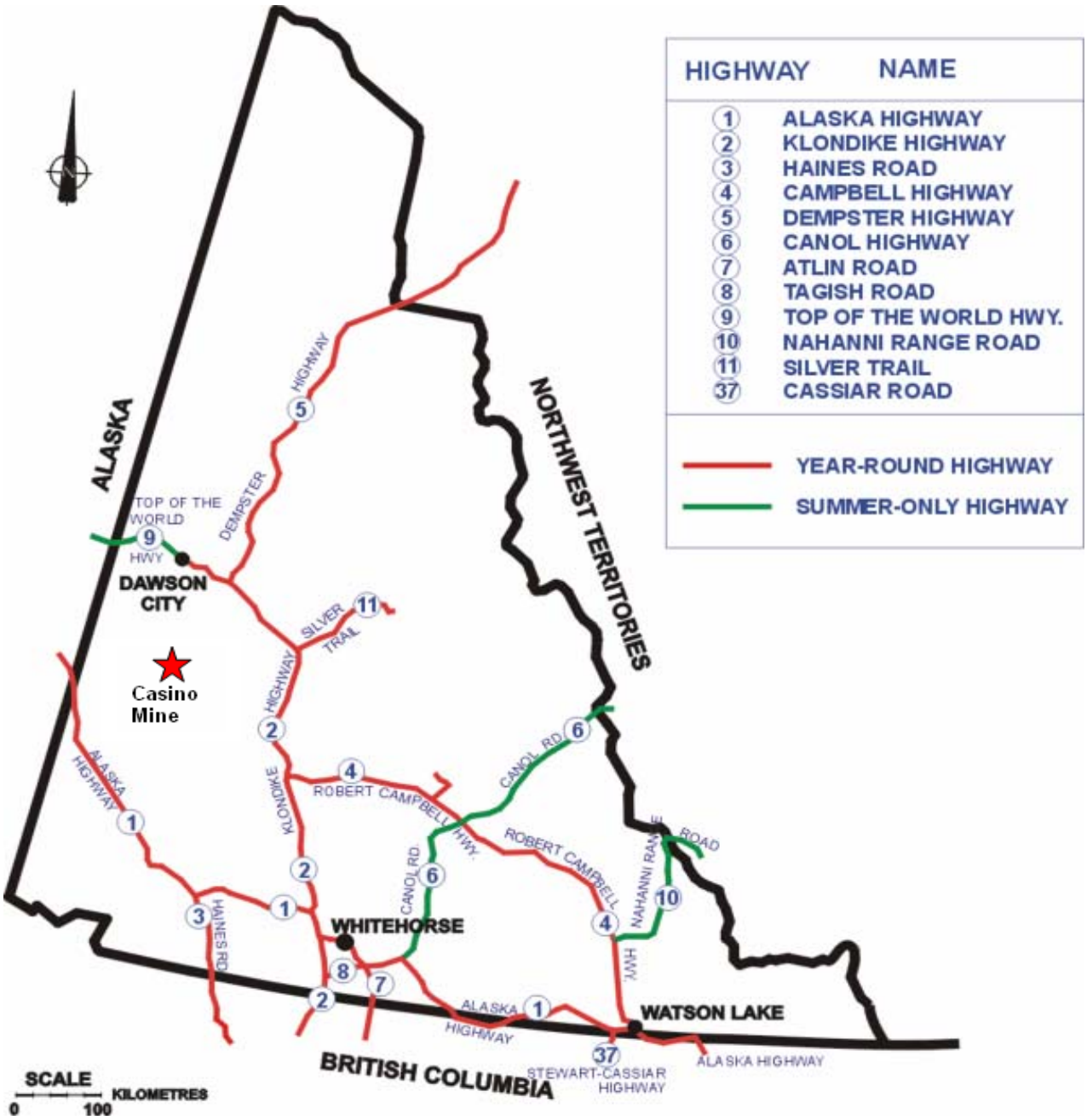
Principal Ports	Distance (km)
Skagway, AK	177
Haines, AK	396
Stewart, BC	1,050
Prince Rupert, BC	1,438
Seward, AK	1,234
To Other Northern Centres	
Fairbanks, AK	951
Beaver Creek, Alaska Border	456
Haines Junction	156
Dawson City	536
Carmacks	176
Watson Lake	453
Dawson Creek	1,426
Prince George	1,622
Inuvik	1,222

3.4 TRAFFIC LEVELS ON YUKON HIGHWAYS

Yukon Highways are illustrated on Figure 3-5. The Alaska Highway and the Haines Highway were built in 1943 as military pioneer roads. They were improved as gravel roads during the 1950s and substantially upgraded in the 1980s. These two principal highways are well-paved and well-maintained. They carry a small amount of traffic compared with provincial highways in BC and Alberta. The highest vehicle movements are within the Whitehorse area, between Whitehorse and Skagway and between Whitehorse and Haines Junction. In 2005 the annual average daily traffic (AADT) on the Alaska Highway was approximately 500 vehicles per day, rising to 800 during summer months (SADT). This compares with AADT of 1350 and an SADT of 1820 on BC Highway 16 at the Highway 37 junction.

The highway from Haines to Interior Alaska is the main connection from Fairbanks to Juneau and Seattle by way of the Alaska ferry service (the Alaska Marine Highway). Relatively few vehicles use this highway, which in 2005 averaged 188 vehicles per day during the summer and 112 vehicles per day over the rest of the year.

Figure 3-5
Yukon Highways



The Klondike Highway between Skagway, Whitehorse and Dawson City, is built to the same standards as the Alaska Highway and Haines Road. South of Minto it carried an average of between 200 and 400 vehicles per day in 2005, with 400 to 600 per day during summer months. The Dempster Highway, a gravel highway of over 1,000 km, carries only 100 vehicles per day on average, and 180 vehicles per day during summer months.

The capacity of a rural highway varies with its distance from major cities and the desired speed. A Yukon highway with an operating speed of 110 km/h would have a capacity of approximately 8,000 to 10,000 vehicles per day for a Level of Service C. This would indicate the consistent presence of short convoys of vehicles at any given point and the continuous need for overtaking.

The traffic on most highways in Canada has been growing at 2% per annum over the last 20 years. In the Yukon, traffic was declining at the turn of the century due to decreased economic activity and decreased tourism. Traffic in 2005 was between 5 and 10% less than in the year 2000. This may have reversed between 2000 and 2007 with renewed mineral activity.

3.5 PAVEMENT STRENGTH OF EXISTING HIGHWAYS

All principal roads in the Yukon have been designed to withstand standard highway loading based on approximately 2000 standard truck movements per day. A standard highway truck illustrated in Figures 3-6 and 3-7 is a semi-trailer with three axles and gross vehicle weight of 40 tonnes with a wheel base of 22.7m. At present, approximately 5% of the traffic on Yukon Highways (approximately 60 trucks) use the Alaska Highway per day. Most of these trucks are carrying goods for the re-supply of Yukon and Interior Alaska communities.

A representative pavement section on the Haines Highway is reported in “Status of Reconstruction” – Public Works Canada 1992, and consists of:

- Bituminous surface treatment
- 150mm base course
- 250mm sub-case

This section of the Highway, which was reconstructed in 1989/1990, was assumed the start of the current design life. On assessment the design life of the Highway compared the number of Equivalent Standard Axle Loads (ESALs) with the number to which the pavement is assumed to have actually been subjected based on the traffic volumes estimated to have used the road. The conclusion reached is that In fact, the Government of the Yukon is planning to repave both the Alaska and the Haines Highways in the next 5-10 years.

All Yukon highways are subject to load restrictions during the spring thaw period, when the surface layers of a highway do not have the same strength as when they are either frozen or completely thawed. This period can last for six to eight weeks between April and June, and most trucks are only allowed a gross vehicle weight of 20% of the maximum axel loading.

There is evidently sufficient capacity on Yukon highways to accommodate three to five times more vehicles than the current traffic levels. If the number of trucks using these highways is to increase substantially, or if this load class of truck is to increase, the pavements will have to be strengthened and climbing lanes added on steep gradients.

3.6 WHAT TRUCK AND TRAILER COMBINATION CAN BE CONSIDERED?

For reference, the following diagrams of standard highway trucks have been taken from the Geometric Design Guide of Canadian Roads by the Transportation Association of Canada. The maximum truck axle loading is 80 kN (18,000 lbs) and its allowable gross vehicle weight (GVW) is 63 tonnes.
A semi-trailer (or tridem) combination, the most common configuration on North American roads, is illustrated on Figure 3-6. It is a versatile transporter for carrying all kinds of commodities including bulk cargoes and supply components. Due to axel load considerations, it can carry a maximum payload of up to 32 tonnes.

Figure 3-6
Dimensions of a WB-20 Tractor-Semi-Trailer (or a 3-Axle Tridem Truck)

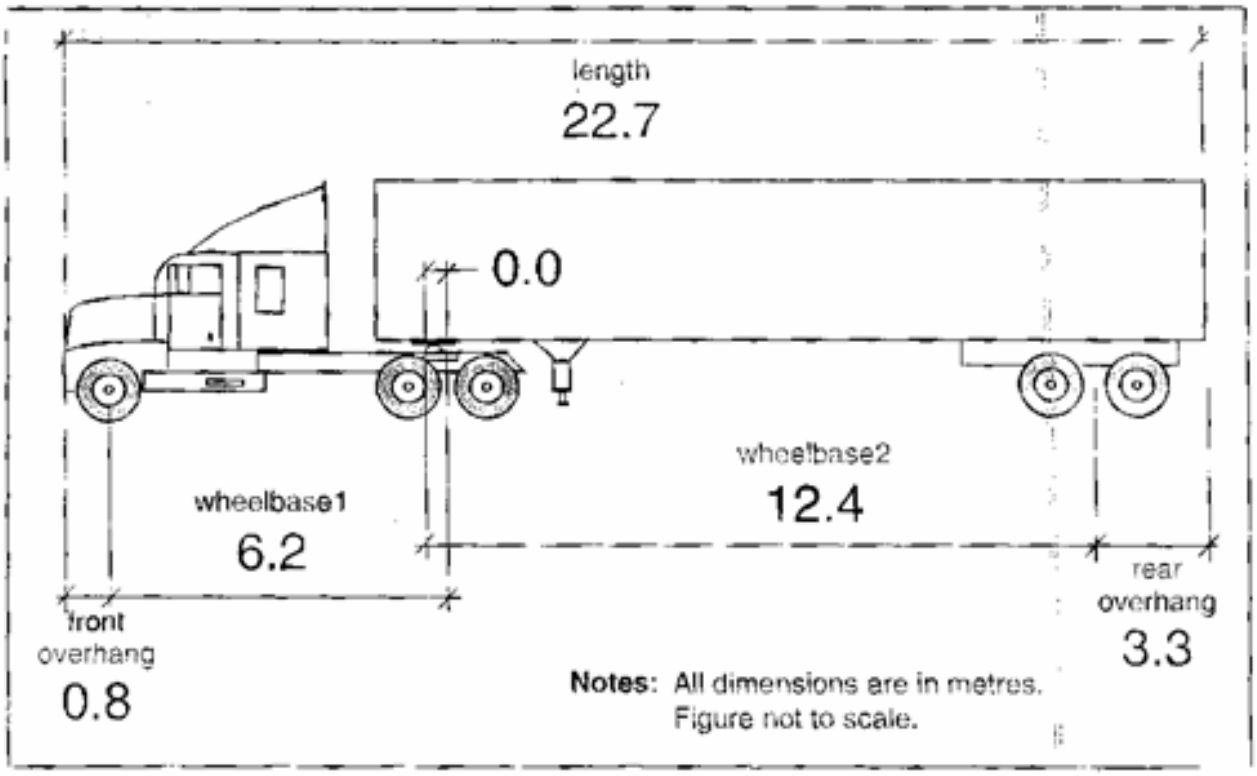
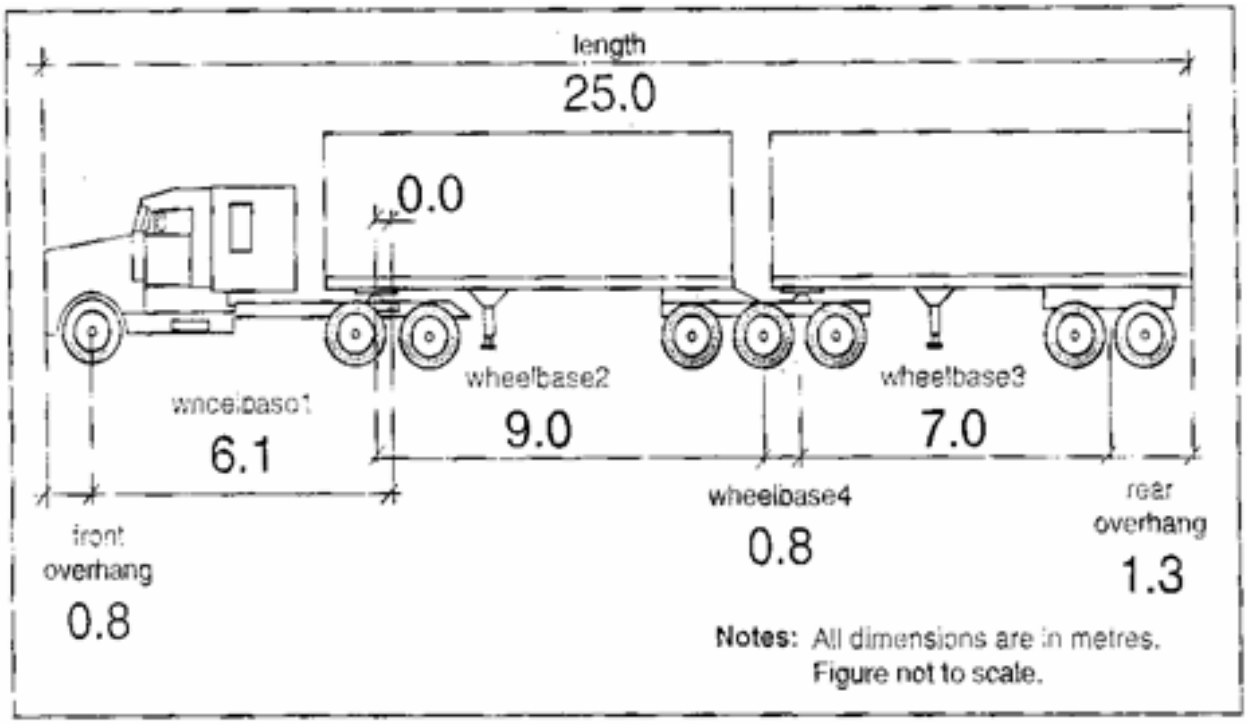


Figure 3-7
B-Train Double (BTD) Dimensions

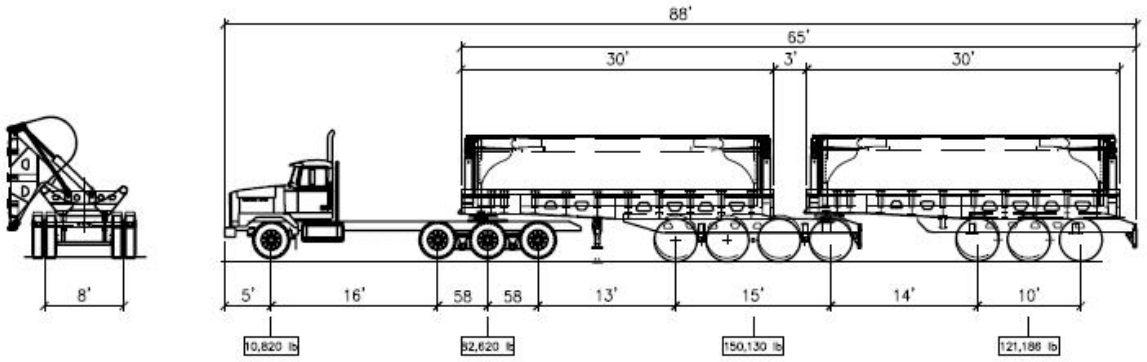


Note: Fifth wheel offset set to zero to yield the maximum swept path in a turn.

A B-Train combination is illustrated on Figure 3-7. This configuration, with flatbed cargo compartment or side-dump trailers, is similar to a typical ore-bearing truck design vehicle used in Northern Canada and in the State of Alaska. It is subject to the same GVW and axle loading on public highways as the semi-trailer. Its additional axle allows it to carry up to 41 tonnes of payload depending on its tire arrangements.

On off-highway conditions, as on private mining roads, the B-Train, illustrated on Figure 3-8, can carry up to 150 tonnes (200 US tons) of concentrate. The problem with operating such large trucks is that they are usually purpose-made by only a few suppliers. It would usually require a mining company to purchase these trucks or require an operating company to purchase them as part of a long-term trucking contract. Trucks that are permitted for Yukon and Alaska Highway use are easily available in a competitive trucking industry and truckers can be readily hired to undertake the transportation needs of mines.

Figure 3-8
Typical Ore Bearing Vehicle



The B-train arrangement that has been used on the Red Dog Mine since 2004 is illustrated on Figure 3-9. It is reported to operate with gross vehicle weights of 160-180 tonnes and a specially-designed gravel pavement to carry these loads.

For purposes of this scoping study, it has been concluded that the Mine will use trucks that can be licensed on public highways in both the Yukon and Alaska. The economic assessment undertaken in Chapters 6 and 7 has assumed that outbound concentrate trucks will be standard B-train doubles with side-dumping capability and that inbound supplies will be hauled on a standard tractor-semi-trailer truck combination. Oversized trucks were not considered in this study.

Figure 3-9
2004 Red Dog Side-Dump Concentrate Carrier



An illustration of the layout of the Red Dog Haul Road in north-west Alaska is shown on Figure 3-10 below. It is reported to be a two-lane, 9.0m wide gravel road and has been in operation for 15 years. Most of the road is in level terrain but the northern part of the road is mountainous with some fairly sharp curvature and 5% to 6% grades. Much of the terrain south of the Casino Mine is similar to the Red Dog terrain, indicating that similar heavy-haul vehicles could be considered for use as off-highway vehicles.

Figure 3-10
The Red Dog Road and Terrain



3.7 WHAT KIND OF ROAD PAVEMENT SHOULD BE CONSIDERED FOR A MINE ROAD?

The three highways of interest to Casino Mine, the Alaska Highway, the Haines Highway and the Klondike Highway, have all been constructed to full highway strength for vehicles licensed under the Canadian Motor Vehicle Act and licensed in the State of Alaska.

Off-highway trucks can operate on private roads such as mine access roads with a pavement structure consisting of a gravel sub-grade with 1.0 to 1.5 metres of graded gravel surface. The surface is applied with a solution of magnesium chloride to reduce dust.

3.8 WHAT KIND OF ROAD GEOMETRY SHOULD BE CONSIDERED: ONE WAY ONLY OR TWO-WAY?

The construction of mine access roads is a large overhead to a new mine undertaking and has a significant impact on the operation of the mine and on the cost of the mineral.

A mine access road can be built for operating speeds up to 80 kph. This will determine the curvature to be designed for the horizontal and vertical alignment. The width of the road could be 5.0 metres for a one-way operation, which would need to be closely controlled for safety. It could be up to 8.0 metres for a two-way operation.

3.9 WHAT KIND OF ROAD CONSTRUCTION SHOULD BE CONSIDERED?

The Casino Mine could consider an all-weather road or a winter-only road. A winter road would operate for 3 to 4 months (December to March) under freezing conditions. An all-weather road provides a mine with operating flexibility for incoming supplies and outgoing concentrate haulage. An all-weather road with a properly designed gravel surface can be maintained for a high level of operation throughout the year, with only a requirement for load restrictions (80% of regulated load) during the spring thaw. A winter road could only be used for 3-4 months and may be inoperable during periods of temporary winter thaw.

Winter maintenance requires a strict program of weather monitoring, clearing, salting and sanding. Under such protocol, trucks can operate at summer speeds even in extremely cold conditions.

A strictly private road could be developed on the Onion Route or Wolverine Route (see Chapter 4 below) and would be subject to the Mine's de-commissioning plan. A route along Aishikik Lake or along the Nisling River would follow the historic Dalton Trail and could be developed with the Yukon government because of its heritage interest.

The Mine should consider developing an all-season road capable of operating trucks throughout the year and using the most economical route for this purpose. Such a route can be designed for an operating life the same as the proposed life of the Mine and would be de-commissioned when the Mine is closed.

3.10 SHOULD THE ROAD BE PRIVATE OR PUBLIC?

Casino Mine could consider a private or a public road from either the Klondike or the Alaska Highways. A public road could attract public funding for capital and maintenance works but the road would have to be open to the public and to other mineral interests. A private road would be operated only by the Mine and could be gated and used only by Mine vehicles. Such a road would be subject to the same permitting requirements as a public road and may bring greater risk to the transportation operations.

The Mine should pursue an access road in conjunction with the Yukon government. This may provide a cost advantage to the Mine involving shared costs or construction and annual maintenance. If the government wishes to maintain the road beyond the Mine's life, it could assume full ownership at that time.

3.11 SHOULD HAULING BE UNDERTAKEN IN ONE STAGE OR SEVERAL STAGES?

The Mine could consider a single truck haul from the Mine site to the port. The Mine could also operate a 2-stage operation using heavy ore carriers between the Mine site and the Yukon highway system and then transfer loads or trailers to a highway carrier. It could also consider a 2-stage operation involving a standard B-Train truck combination with two trailers on public highways and a C-Train combination with three trailers off-highway. Chilean and Australian companies are known to operate up to five trailers on flat, open terrain.

For purposes of this study, it has been assumed that a one-stage operation will be used and that highway permitted trucks will operate on both the Mine road and public highways.

4 Alternative Mine Road Routes

Exploration mining activities at the proposed Casino Mine Site are shown in Figure 4-1. Seven candidate routes were considered for an all-weather Casino Mine access road. These routes are described briefly below and are illustrated on Figure 4-2. They are summarized with the total haul distances on the table in Figure 4-12. A summary of the estimated construction cost for each route is shown in Figure 4-13. A tabulated description of the physical conditions and gradients of the alternative routes is provided in Appendix B. Preliminary cost estimates for the construction of each of the alternative routes is shown in Appendix C. Typical cross-sections for the Mine access road in various conditions are shown in Appendix D and a socio-environmental map of the central Yukon is shown together with the alternative routes in Appendix E.

It has been noted that the Dawson Range is a major wildlife habitat and that animal migrations will affect the final road alignment. Several First Nations Bands have formed defined relationships with certain mining companies and have established binding agreements. These precedents can be used as reference for future agreements.

Figure 4-1
Present Casino Mine Exploration Site



4.1 ROUTE 1 - ONION CREEK ROUTE

There is an existing 190 km winter road from the Casino Mine site to the north of Kluane Lake on the Alaska Highway. This route has been used by Casino Mine for earlier transportation of exploration equipment. It follows a route through the wetland north of the Nisling River Valley. The terrain is mainly flat below the mine site and crosses the large flat valleys of the Nisling and Donjek Rivers before crossing the Nisling Range and the Kluane River.

Much of this route is extremely swampy in the summer and fall, with evidence of large volumes of peat underlying the surface. Such a route makes a good winter road when frozen. It would require excavation of unsuitable material and significant quantities of gravel to create a summer road.

A number of winter roads connect to Casino Creek and to the proposed Mine site. These are shown on Figure 4-3. A modification of the south-west bound winter road was investigated following the higher ground on the east of Casino Creek, south of the Mine. The same alignments were used on Routes 2 and 3 – the Aishihik Lake and East Routes. Where these routes cross the Nisling River, Route 1 would follow Onion Creek in a south-westerly direction to a crossing of the Kluane River, and then south on the east slopes of the Donjek River to the Alaska Highway.

Figure 4-2
Illustration of Candidate Routes from Casino Mine (Not to Scale)

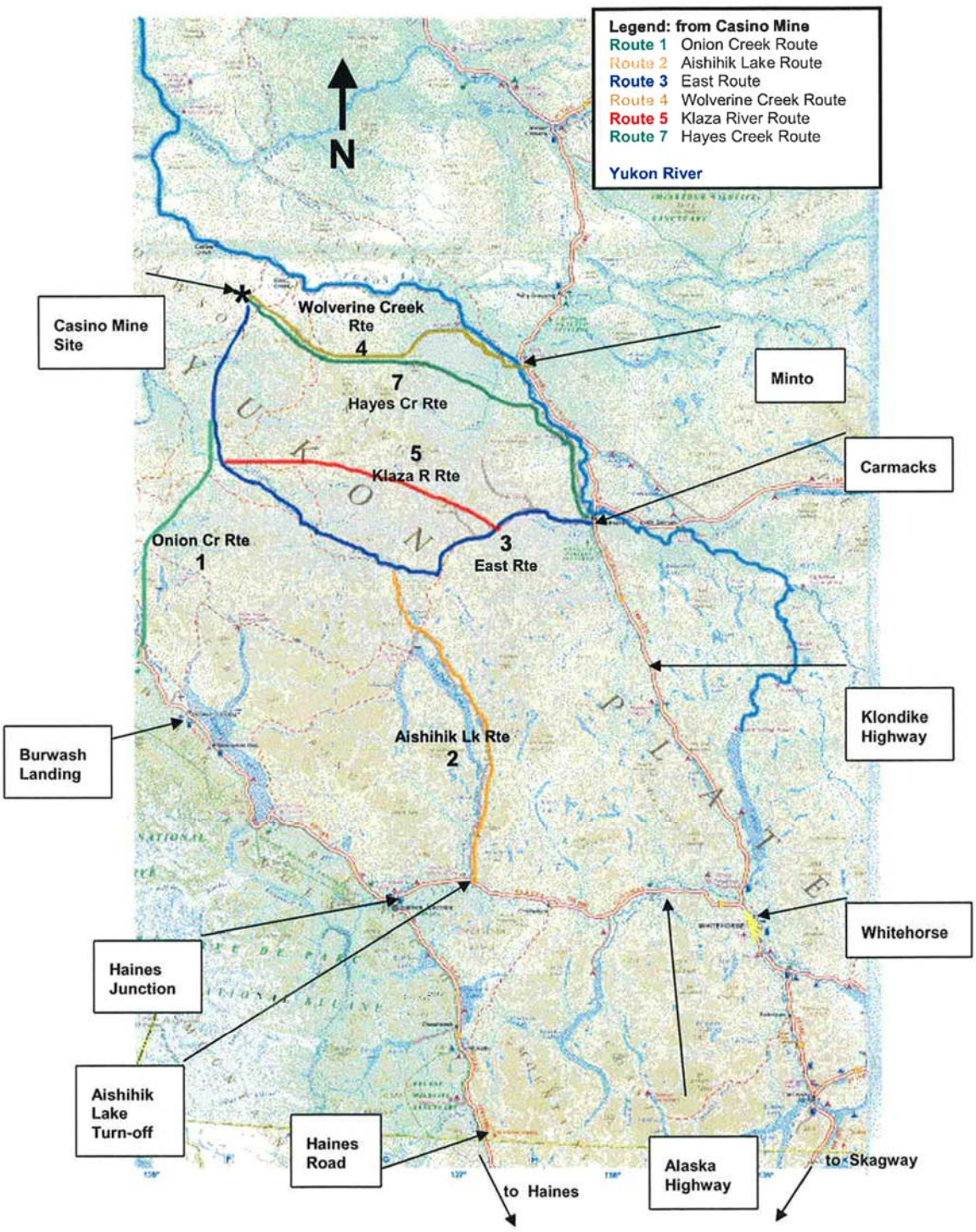
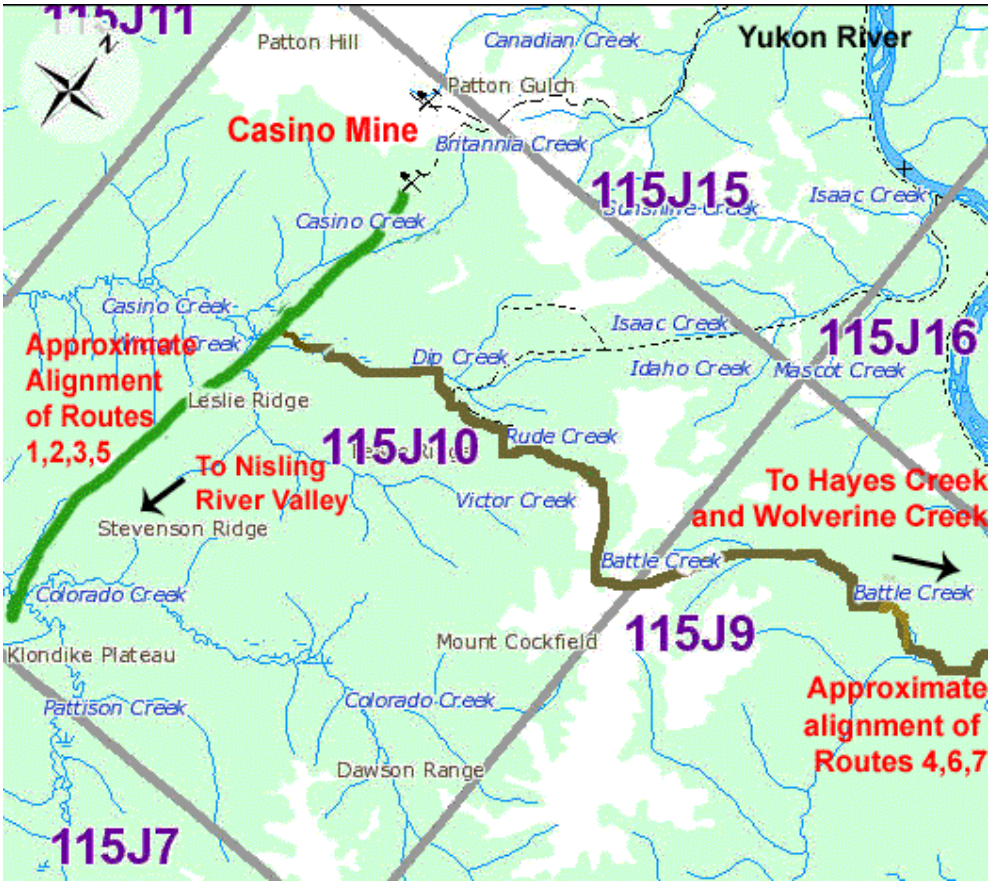


Figure 4-3
Indication of Alternative Alignments at Casino Mine



A preliminary assessment of the Onion Creek alignment showed an even profile following higher terrain where possible above the wetlands of the Casino and Nisling Rivers for 187 km from the Mine to the Alaska Highway. The feasibility of the Onion Creek Route will need more geotechnical assessment to investigate the availability of gravel deposits and to assess the foundation conditions of the preferred alignment and extent of peat deposits. Much of the route across the Nisling River valley will have to be on an embankment. A major river structure is likely to be required at the crossing of the Kluane River. This route would favour haulage route 1b to the Port of Haines.

The Onion Creek route appears to avoid much of the sensitive wildlife and First Nations areas and appears to be relatively straightforward for permitting. 85 to 95 km from the Mine un-surveyed First Nations lands highlight areas that are traditional fishing and spawning grounds. Further south, First Nations timber and quartz mine claims are located.

Burwash Caribou and Grizzly habitats are wildlife concerns along Onion Creek. These may require mitigation during the route development and further study will be required to determine their significance.

Figure 4-4
Onion Creek leading out of the flat Nisling River Valley



Figure 4-5
Nisling River Valley South of Casino Mine



4.2 ROUTE 2 - AISHIHIK LAKE ROUTE

This route would follow the same alignment as Route 1 from the Mine and east of the wetland to a crossing of the Nisling River close to Onion Creek. It would then follow the south slopes of the Nisling River Valley, before turning south to follow along the existing, summer-only Aishihik Lake Road to the Alaska Highway.

Approximately 210 km of new road will be required across level terrain and a further 113 km on the existing recreational road on the east side of Aishihik Lake would need to be upgraded. No major river structures would be required. This route also has historic significance, since it follows the Dalton Trail, which was the original route in gold rush times to Dawson City from Haines.

This route appears to be feasible. It will have the same concerns as Route 1 about wetland in the Nisling Valley but follows southern slopes and an established road to the Alaska Highway, 33 km east of Haines Junction. This route could allow haulage on Routes 2a or 2b to ports at either Skagway or Haines.

Nisling River Valley Area, which is common to both the East and Aishihik routes, is currently only accessible by air or boat during the summer months. Due to its remoteness, the area supports a healthy population of wood bison. There is also evidence of wild sheep and moose. The presence of these species may cause concerns when trying to permit a route along the Nisling River. There may be considerable resistance to permitting along the Nisling River. Up-grading the existing Aishihik Road would require agreements from both the Champagne and Aishihik First Nations.

Figure 4-6
The North End of Aishihik Lake



4.3 ROUTE 3 - EAST ROUTE

This route would start at Casino Mine and, as with Routes 1 and 2, would follow the same eastern slopes of Casino Creek to a crossing of the Nisling River close to Onion Creek, then follow along the southern slopes of the Nisling River valley. Before the headwaters of the Nisling River, it would join the existing Mansen Mine Road, which is an existing Yukon secondary highway to Carmacks and the Klondike Highway.

This route appears to be relatively flat and feasible. It will contain sections of wet, peat terrain, but it mostly follows sloping ground with the potential of surface gravel. It would require construction of 230 km of new road and upgrading of 50 km of existing secondary road. No major river structures will be required. The same permitting considerations apply to the East Route as they do to the Aishikik Lake Route. This route would favour haulage on route 3a to the Port of Skagway.

Figure 4-7
Nisling River Valley



Figure 4-8
Mansen Mine Road West of Carmacks



4.4 ROUTE 4 - WOLVERINE CREEK ROUTE

The Wolverine Creek Route is the most northern route from the Casino Mine to the Yukon Highway system, as illustrated in Figure 4-2. It would follow the steep Rude Creek from Casino Creek east to a pass over the high point of the Dawson Range as illustrated in Figure 4-3. It would then continue over extremely steep and rugged mountainous terrain along Battle Creek to the headwaters of Hayes Creek. The route then follows more moderate terrain to the headwaters of Wolverine Creek which leads down to the Yukon River and the existing Minto Mine Road. Minto Mine maintains a barge ferry crossing across the Yukon River to Minto, which is on the Klondike Highway.

The section over mountainous terrain is approximately 69 km and will involve switch-backs and steep grades (10 – 14%). It will also require expensive maintenance for operations in the winter. The more moderate section between Hayes Creek and the Minto Mine Road is about 45 km. The existing road from the Wolverine Creek to the barge is 24 km. A new bridge would have to be built across the Yukon River to enable all-season access.

The total length of new and upgraded road from Minto to the Casino Mine will be about 140 km in mostly steep terrain. This compares with 180 km of new road on the Onion Creek Route in flat terrain. This Wolverine Creek would favour haulage on Route 3a to the Port of Skagway.

The major portion of this route is on the edge of key wildlife areas, and is unlikely to present significant opposition to permitting. Bridging the Yukon River at Minto will present environmental impacts to recreational groups and the Federal Department of Fisheries and Oceans.

Figure 4-9
Steep Terrain looking up Battle Creek in the Dawson Range



Figure 4-10
Minto Mine Road and the Barge Crossing at Minto





4.5 ROUTE 5 - KLAZA RIVER ROUTE

This route is similar to Route 3 but instead of following the Nisling River east to the Mansen Mine Road it would follow the more mountainous route of Klaza Creek. The purpose of pursuing this route was to avoid the wetland of the Nisling River. It would be a slightly shorter section of new road than the East Route, 223 km instead of 230 km, and is likely to be more costly to build and to operate. This route would favour haulage on Route 4a to the Port of Skagway.

It is anticipated that the route along the Klaza River and Hayes Creek (Route 7) may receive environmental resistance to their development. These areas are a caribou winter range and are considered necessary for sustaining First Nations hunting traditions. Wildlife studies will be needed to support approval of both these routes.

4.6 ROUTE 6 - YUKON RIVER WEST ROUTE

This is an extension of the Wolverine Creek Route (Route 4). Instead of crossing the Yukon River at Minto, the road would connect with the Klondike Highway at Carmacks. It would add 76 km of new road but would not require a bridge across the Yukon River. This route would favour haulage on Route 6a to the Port of Skagway.

The environmental issues here are similar to the Wolverine Creek route, except more objections can be expected from wildlife, tourist and sport-fishing interest groups due to its proximity to the Yukon River.

4.7 ROUTE 7 - HAYES CREEK ROUTE

This route, also illustrated in Figure 4-2, would take the same alignment as Route 4 east of the Casino Mine and over the Dawson Range to Hayes Creek. It would then descend southward down Hayes Creek to the existing Yukon secondary road, known as the Freegold Road, which would be followed to Carmacks and the Klondike Highway. No crossing of the Yukon River is necessary for this route.

The total length of new and upgraded road from the Mine to Carmacks on this Hayes Creek Route is 210 km, compared to 135 km from the Mine to Minto on Route 4. It would follow much of the same terrain as the Wolverine Creek Route. This Hayes Creek Route would favour haulage on Route 7a to the Port of Skagway.

The environmental concerns of this route are the same as the Klaza River route since it follows known wildlife habitat.

Figure 4-11
Freegold Road Northwest of Carmacks



Figure 4-12
Summary of Alternative Mine Road Routes between a Port and Casino Mine

Route	From Port	Via	Distance on Yukon Main Roads	Upgrade of Yukon Secondary Roads	Build New Mine Access Road in moderate terrain	Build New Mine Access Road in steep terrain	Total Haul Distance to Mine from a Port
	(km)	(km)	(km)	(km)	(km)	(km)	(km)
1a Skagway via Onion Cr	Skagway – Haines Junction	Haines Jct - Turnoff	Total Main Road	n/a	Turn-off - Mine	n/a	
Distance	350	172	502		187		688
1b Haines via Onion Cr	Haines – Haines Junction	Haines Jct – Turn-off	Total Main Road	n/a	Turn-off - Mine	n/a	
Distance	238	172	410		187		596
2a Skagway via Aishihik Lk	Skagway – Whitehorse	Whitehorse – Aishihik Lk Turn-off	Total Main Road	Aishihik Lake Turn-off - Aishihik	Aishihik - Mine	n/a	
Distance	175	123	298	113	210		621
2b Haines via Aishihik Lk	Haines – Haines Jct	Haines Jct - Aishihik Lk Turn-off	Total Main Road	Aishihik Lake Turn-off - Aishihik	Aishihik - Mine	n/a	
Distance	238	33	271	113	210		594
3a Skagway via East Road	Skagway – Carmacks	n/a	Total Main Road	Carmacks – Mt. Mansen Road	Mt. Mansen Road - Mine		
Distance	355		355	50	230		635
3b Haines via East Road	Haines – Whitehorse	Whitehorse – Carmacks	Total Main Road	Carmacks – Mt. Mansen Road	Mt. Mansen Road to Mine		
Distance	393	180	573	50	230		853

Route	From Port	Via	Distance on Yukon Main Roads	Upgrade of Yukon Secondary Roads	Build New Mine Access Road in moderate terrain	Build New Mine Access Road in steep terrain	Total Haul Distance to Mine from a Port
	(km)	(km)	(km)	(km)	(km)	(km)	(km)
4a Skagway via Wolverine Cr	Skagway – Carmacks	Carmacks – Minto	Total Main Road	Minto – Minto Mine turn-off	Minto Mine turn-off – Hayes Cr	Hayes Creek – Battle Creek - Mine	
Distance	355	76	431	24	45	69	569
5a Skagway via Klaza River	Skagway – Carmacks	n/a	Total Main Road	Carmacks – Mt Mansen Rd	Klaza River to Mine	Mt. Mansen Road along Klaza River	
Distance	355		355	50	124	99	628
6a Skagway via Yukon River	Skagway – Carmacks	Total Main Road	Total Main Road	n/a	Carmacks – Hayes Creek	Hayes Cr – Battle Cr - Minto	
Distance	355		355		136	69	560
7a Skagway via Hayes Cr	Skagway – Carmacks	n/a	Total Main Road	Carmacks – end of Freegold Road	End of Freegold Road – Hayes Cr	Hayes Creek – Battle Creek - Mine	
Distance	355		355	42	99	69	565

Figure 4-13
Summary of Approximate Construction Costs for Alternative Mine Road Routes from Casino Mine to the Yukon Highway System

Route	Length of New and Upgraded Road			From Mine to	Est Direct Costs $M	Est Indirect Costs $M	Total Est Cost $M
	Upgrade	New	Total				
1. Onion Creek Route	-	187	187	Alaska Hwy N of Burwash Landing including Kluane River Bridge	76.6	12.6	91.2
2. Aishihik Lake Route	113	210	323	Alaska Hwy between Whitehorse and Haines Junction	91.3	14.6	105.9
3. East Route	50	230	280	Klondike Hwy at Carmacks via Nisling River	92.2	14.8	107.0
4. Wolverine Creek Route	24	114	138	Klondike Hwy at Minto (Including Yukon River Bridge)	132.9	21.3	154.2
5. Klaza River Route	50	223	273	Klondike Hwy at Carmacks via Klaza River	146.3	23.4	169.7
6. Yukon River Route	-	205	205	Klondike Hwy at Carmacks via Wolverine Creek	162.9	26.1	189.0
7. Hayes Creek Route	42	168	210	Klondike Hwy at Carmacks via Freegold Rd	166.2	26.6	192.8

5 Truck Operational Considerations and Assumptions

A fleet of trucks and trailers would be purchased or leased by the Mine. This fleet would conform to the operating requirements and trailer combinations discussed in Section 3.5. It is likely that a B-Train truck combination will be required for concentrate hauling and a semi-trailer (Tridem) combination will be required for supply haulage.

Major Assumptions
Figure 5-2 Major Assumptions

Major Assumptions (other details available on request)	
Total of overheads as % of total trucking cost (profit, ins, admin, working capital)	20.7%
Cost of capital based on current prime rate	5.25%
Assumed grade of dry concentrate	25%
Winter operations cost adjustment factor	1.06
% of time for winter operations	50%
Bulk terminal charge per wet tonne	$10.00
Ship cost to Orient per wet tonne	$60.00
Tonnes of dry concentrate shipped per year	250,000
Assumed moisture content of concentrate	10%
Tonnes of trucked mine supplies per year	75,000
Cost of diesel fuel for trucks	$1.215
Base wages for truck drivers per hour	$22.25
Base wages for truck mechanic per hour	$28.00
Wage burden	1.3
Lump sum overnight allowance per truck trip to marine terminal	$150.00
Estimated cost of B-train set	$313,767
Estimated cost of Tridem set	$239,206
Cost of a tire	$460.00
Assumed tractor life in years	5
Assumed trailer life in years	8
Assumed payload of B-train trucks in tonnes	40.5
Assumed payload of Tridem trucks in tonnes	32.0
Average payload for B-trains allowing for spring load limits	38.13
Average payload for Tridems allowing for spring load limits	30.13
Assumed equipment spares	20%
Assumed speed on paved roads in km/h, on moderate grades	80

Major Assumptions (other details available on request)	
Assumed speed on paved roads in km/h, flat and moderate grades	70
Assumed days of operations on Wolverine and Hayes routes	320
Assumed days of operations on Onion, Aishihik, East and Klaza routes	335
Assumed days of year when 75% GVW loading applies (variable)	50
Assumed mine life in years	25

5.1 SUPPORTING INFRASTRUCTURE

In addition to the haul fleet, supporting infrastructure will be required for the handling of the concentrate. This will include the following components:

- A concentrate storage shed at the Mine and the Port sites to handle approximately 1 month's supply of concentrate or 40,000 tonnes; a storage shed can cost $5.0m and would be designed for negative air pressure to contain concentrate dust;
- Truck loading and wash-down facilities at both the Mine and the Port site;
- Truck fuelling facilities at both the Mine and the Port site;
- Haul fleet maintenance shops and administration offices at a convenient location at either the Mine or the Port site;
- A conveyor system at the Mine for the loading of concentrate from the Mill;
- A conveyor system at the Port to load concentrate from the concentrate shed to the concentrate ship carrier
- The cost of fueling, conveying and wash-down infrastructure at both the Mine and the Port is likely to exceed $10 M.

5.2 TRUCK PERFORMANCE MODELS

Several truck suppliers, such as Cummins and Caterpillar, provide performance characteristics for their standard truck fleets. The Society for Automobile Engineers (SAE) publishes procedures for the charting of vehicle performance but these are confined to standard tractor/trailer units operating on paved highways. The Forest Engineering Research Institute of Canada (FERIC) has developed a truck simulation model for off-highway truck operations on unpaved roads. This model is reported to simulate performance of logging trucks and estimates fuel consumption, travel speeds, and driver characteristics for typical forestry roads. This model is restricted to members of FERIC.

At a more detailed stage of the Mine development, it would be advisable to procure one of the above models for a precise analysis of the truck performances on the selected route. At this stage, a more simplified approach based on Exhibit 3.6.6 has been used to estimate truck haul speeds based on reports of trucking operations in northern British Columbia. This method has used the following assumptions for a standard fully-loaded typical side-dump B-train truck/trailer arrangement operating uphill or downhill:

- Average speed on the paved Alaska Highway, Haines Road and Klondike Highway = 60 - 80kph
- For assumed specifics on the variables route, see tables in Appendix B.

5.3 TYPICAL TRUCK SUPPLIERS

For purposes of this assessment, it has been assumed that the Mine will use side-dump B-train 7-axle tractor/trailer units with gross vehicle weights of 63 tonnes. These vehicles provide a payload capacity of approximately 41 tonnes and a combination currently retails for approximately $313,000. A Tridem set currently retails for $240,000.
Suppliers of these trucks include Kenworth, Peterbilt and Western Star. All these suppliers have operations in Northern British Columbia and the Yukon.

5.4 A POSSIBLE LOGISTICS PLAN

The following is an outline of a possible Casino Mine logistics plan. It is intended as a template upon which a more detailed plan can build with more information as it becomes available.

- The Mine is expected to produce 250,000 tonnes per year (t/y)
- The Mine will require a reverse haul of supplies of approximately 75,000 t/y or 250 t/day in the form of grinding balls, lime, reagents, lines explosives and living requirements.
- An all-season road will allow trucking all year round and likely 320 days/year
- The haul of concentrate to a port site is likely to have a bulking factor of 10% requiring 250,000 x 1.1 = 275,000 t/y or 900 t/day of transportation
- Yukon Highway regulations allow gross vehicle weight of 63 t
- Nominally each highway truck combination can carry 41 t of concentrate or supplies
- Hence Casino Mine would require 900 t/day = 22 standard truck loads/day - 41 t/truck
- If the Mine used containers, each container can only carry 18 – 20 t/load, requiring 22 – 25 trucks will be needed.
- Average distance from the Mine to Skagway is approximately 600 km
- Assume 22 truck + 3 spares for a probably fleet of 25 trucks
- The estimated volume of Casino trucks on a public highway will be approximately 2 trucks/h in each direction. This is equivalent to about 10 passenger vehicles/h in each direction

6 Trucking Cost Analyses

6.1 SUMMARY OF TRUCKING COST ANALYSIS

A total of 14 route options for the transportation of concentrate from the Mine to the Ports of Skagway and Haines were analyzed, along with the reverse haul of mine supplies and coal. Trucking costs were estimated by an explicit analysis that took into account variables about: grades, road surface types, distances, varying seasonal payloads, cycle time analyses, current estimated prices for labour, fuel and equipment and many other factors. Further analysis taking into account the different costs of new road construction and maintenance was carried out. Rough allowances for terminal costs and ship costs were added to arrive at a total transport cost estimate.

The analysis combined the capital cost of road construction, road maintenance costs, truck purchase costs, truck operating costs and supplies shipment amounts by means of discounted cash flow analysis in various forms and allocations to arrive at the figures shown in the tables and graphs that follow. The analysis was based on the use of B-Train trucks (40.5 tonne maximum payload) for the haul of concentrate on the four southern routes (routes 1, 2, 3 and 5). Tridem trucks (32 tonne maximum payload) were assumed for use on the three northern, mountainous routes (routes 4, 6 and 7).

Figure 6-1 summarizes the total costs of transportation in terms of dollars per wet tonne of concentrate. Note that the comparison of routes assumes no coal backhaul. The Onion Creek Route, which is the recommended route, has the coal backhaul shown at the top of this table. Figure 6-2 shows the same table as Figure 6-1 converted to dollars per/lb. of copper.

Figure 6-3 is a bar charge showing the total land transportation costs and Figure 6-4 shows the make-up of these costs. Figure 6-5 shows only the costs of trucking mine supplies from a Port to the Mine.

Appendix A provides the detail of the net present value analysis for each of the candidate routes. The analysis also provides a breakdown of the cycle times used to calculate the return trip time and the number of trucks that will be required for both the portage of concentrate and mine supplies.

6.2 TRUCKING OF CONCENTRATES

Options for the transport of concentrates include bulk or containerized shipments through Skagway or Haines. In bulk, the lowest cost route is through Haines with an estimated FAS cost of $226 per tonne delivered to an oriental smelter port. This figure includes: trucking to Haines [$92 per tonne], allocated road capital and maintenance [$36 per tonne], allocated supply trucking [$29 per tonne], an allowance for port charges [$10 per tonne] and allowance for sea freight [up to $60 per tonne]. Skagway has an existing small scale bulk terminal for shipping concentrates. Investments to expand storage and materials handling capacity would be required to handle Casino concentrates. At Haines, no bulk materials handling facilities exist, but space for facilities exist in at least two sites. Both Skagway and Haines have existing under-used RORO barge facilities that can probably be used to store and transfer containers. Container capacity assessments and logistical investigations have not been carried out.

Trucking of Mine Supplies

Both Skagway and Haines have existing under-used RORO barge facilities that could be used to transport inbound mine supplies. At this stage, the capacity to handle the necessary volume of mine supplies appears to be available. However, the capacity to add outgoing shipments of concentrate in containers as a back haul requires further investigation. Using the lowest cost route, mine supplies brought in through Haines and along the Onion Creek route, have a trucking cost estimated at $105 per tonne. Other components of the total transport cost of supplies have not been estimated and the logistics of mines supplies transport have not been investigated.

6.3 TRUCKING OF INBOUND COAL FOR POWER GENERATION

Working with the assumption that the volumes of inbound coal and outbound concentrates are similar, the back haul of coal using the returning concentrate trucks offers reduced trucking costs to both commodities. On the lowest cost route and, based on an equal cost allocation, the cost of trucking drops to $50 per tonne from $92 per tonne for each of concentrates and coal. The ability to handle inbound coal at Skagway is not obvious. However, at Haines, at least two port sites may lend themselves to the purpose of coal handling. The ability to handle both concentrates and coal at Haines probably exists, but determining a workable arrangement for costing purposes requires further study.

How the coal should arrive at Haines and in what shipment sizes, also requires examination to arrive at an estimate for the cost of coal. With an estimate for the cost of imported coal, it would be possible to evaluate the option of sourcing coal from Yukon's Division Mountain mine site near Breaburn. To estimate the cost of Division Mountain coal, it will necessary to estimate the coal trucking cost and assume that the East Route will be selected. To estimate the cost of imported coal, it is necessary to combine the: FOB loading port cost of coal, shipping cost, receiving terminal capital and operating costs, and back haul trucking cost to the Casino Mine. One potential advantage of sourcing coal from Division Mountain is the commercial reality that the Division Mountain's coal deposit is, for practical purposes, isolated from currently volatile and relatively high international steam coal prices. In short, it may be possible to negotiate a long term price agreement for Division Mountain coal that is lower than current international prices.

Lowest Cost Land Route

The lowest cost land transport route, the Onion Creek route to Haines has a total land transport cost of $156 per wet tonne of concentrate when concentrate trucking, road costs and supplies trucking are combined and allocated. For the Onion Creek route, concentrate trucking is $92 per tonne and supplies trucking is $105 per tonne, when costed alone. Although two other routes have concentrate trucking costs almost almost as low (namely, $93 per tonne and $96 per tonne on Rt#2, the Aishihik Route), the allocated cost of highway construction and maintenance is far lower on the Onion Creek route. The Onion Creek route's road cost of $36 per tonne is the deciding factor in the selection of this route. For example, the next lowest road costs are $48 per tonne on the Aishihik Route and $45 per tonne on Rt#3, the East route. The East route concentrate trucking cost and supplies trucking costs are higher as well, $98 per tonne and $148 per tonne respectively.

6.4 PORT TERMINAL COSTS

The port terminal handling costs at Skagway and Haines cannot be distinguished without a conceptual layout and order of magnitude capital cost estimate. That said, there are significant operational and capacity differences between the two ports. These differences are discussed in the sections describing the ports of Skagway and Haines. The terminal charge of about $10 per wet tonne of concentrate in the estimate is slightly higher than typical Vancouver market rates for concentrate terminal handling. The Western Copper's capital and operations obligations at Haines and Skagway are unknown at this time.

6.5 SHIPPING COST

An explicit calculation based on the costs of ships and their operation is likely to result in a ship cost in the order of $30 per wet tonne of concentrate. However, shipping markets are currently highly volatile. Ship costs as high as $60 per wet tonne of concentrate have been reported recently. The higher figure was used in the estimate.

6.6 OTHER LOGISTICAL ISSUES

Adding inbound coal to the transport system, opens a wide range of potentially advantageous logistical opportunities. In addition, to reducing the allocated cost of concentrate trucking, the logistical implications of inbound coal have the potential to reduce: capital costs of port development at Haines, overall environmental protection costs, smelting costs, and, marine transport costs for concentrate and for mine supplies. (Refer to Further Work Required on page 2 for a list of logistical options.) Furthermore, as discussed above, sourcing coal from Division Mountain mine site also re-opens the land route selection question.

Figure 6-1
Transportation Costs in $ per Tonne of Concentrate Hauled

		Transportation Costs in $ per Tonne of Concentrate Hauled										
Rt#	Route Options: (new roads) + (existing roads)	Concentrate Trucking	Supply Trucking	Road Cost	Land Transport Cost	Terminal Charge	Ship Cost (highly variable)	Total Transport Cost	Rank	PV Land Variance $ mil	% of Lowest	Back Haul
1	(Nisling R + Onion Ck) to (Alaska Hwy + Klondike Hwy to Skagway	$113.40	$32.48	$35.53	$181.41	$10	$60	$251.41	n/a	n/a	n/a	coal backhaul
1	(Nisling R + Onion Ck) to (Alaska Hwy + Haines Rd to Haines)	$100.16	$28.74	$35.53	$164.43	$10	$60	$234.43	n/a	n/a	n/a	coal backhaul
1	(Nisling + Onion Ck) to (Alaska Hwy + Klondike Hwy to Skagway)	$104.57	$32.48	$35.53	$172.58	$10	$60	$242.58	3	$62	110.50%	no backhaul
1	(Nisling + Onion Ck) to (Alaska Hwy + Haines Rd to Haines)	$91.95	$28.74	$35.53	$156.22	$10	$60	$226.22	1	$0	100.00%	no backhaul
2	(Nisling + Aishihik Rd) to (Alaska Hwy. + Klondike Hwy. to Skagway)	$96.23	$29.96	$47.69	$173.88	$10	$60	$243.88	4	$67	111.30%	no backhaul
2	(Nisling + Aishihik Rd) to (Alaska Hwy. + Haines Rd to Haines)	$93.29	$29.16	$47.69	$170.14	$10	$60	$240.14	2	$53	108.90%	no backhaul
3	(Nisling R + East Route) to (Carmacks to Skagway)	$98.16	$30.74	$45.39	$174.29	$10	$60	$244.69	5	$68	111.60%	no backhaul
3	(Nisling R + East Route) to (Carmacks to Haines)	$130.66	$40.38	$45.39	$216.43	$10	$60	$286.43	10	$228	138.50%	no backhaul
4	(Battle Ck + Wolverine Ck) to (Minto to Skagway)	$97.99	$27.17	$52.68	$177.84	$10	$60	$247.84	6	$82	113.80%	no backhaul
4	(Battle Ck + Wolverine Ck) to (Minto to Haines)	$132.41	$36.47	$52.68	$221.55	$10	$60	$291.55	11	$247	141.80%	no backhaul
5	(Nisling R + Klaza R) to (Carmacks to Skagway)	$97.33	$30.51	$58.21	$186.06	$10	$60	$256.06	7	$113	119.10%	no backhaul
5	(Nisling R + Klaza R) to (Carmacks to Haines)	$129.77	$40.13	$58.21	$228.11	$10	$60	$298.11	12	$272	146.00%	no backhaul
6	(Battle Ck + WolverineCk + Yukon R) to (Carmacks to Skagway)	$102.06	$28.22	$72.16	$202.44	$10	$60	$272.44	9	$175	129.60%	no backhaul
6	(Battle Ck + WolverineCk + Yukon R) to (Carmacks to Haines)	$136.54	$37.74	$72.16	$246.44	$10	$60	$316.44	14	$341	157.70%	no backhaul
7	(Battle Ck + Hayes Ck) to (Klondike Hwy.) near Carmacks to Skagway)	$102.06	$28.34	$62.91	$193.32	$10	$60	$263.32	8	$140	123.70%	no backhaul
7	(Battle Ck + Hayes Ck) to (Klondike Hwy.) near Carmacks to Haines)	$136.54	$37.88	$62.91	$237.33	$10	$60	$307.33	13	$307	151.90%	no backhaul

Note 1: The highlighted rows in the table above are for the Onion Creek Route only and include coal backhaul.

Note 2: The total land transportation costs are shown in the highlighted column, and relate only to the costs of hauling and mine roads.

Note 3: Calculations for $ per wet tonne of concentrate assume a 10% moisture content and shipping in bulk. Costs for shipping by container have not been estimated.

Figure 6-2
Costs in $ per lb. of copper with no coal backhaul

		Costs in $ per lb of Cu										
Rt#	**Route Options: (new roads) + (existing roads)**	concentrate trucking	Supply trucking	Road Cost	Land Transport Cost	Terminal Charge	Ship Cost (highly variable)	Total Transport Cost	Rank	PV land variance $ mill	% of Lowest	back haul
1	(Nisling R + Onion Ck) to (Alaska Hwy + Klondike Hwy to Skagway)	$0.113	$0.06	$0.07	$0.25	$0.02	$0.11	$0.38	n/a	n/a	n/a	coal back haul
1	(Nisling R + Onion Ck) to (Alaska Hwy + Haines Rd to Haines)	$0.100	$0.06	$0.07	$0.23	$0.02	$0.11	$0.36	n/a	n/a	n/a	coal back haul
1	(Nisling R + Onion Ck) to (Alaska Hwy + Klondike Hwy to Skagway)	$0.209	$0.06	$0.07	$0.34	$0.02	$0.11	$0.47	3	$62	110.5%	no back haul
1	(Nisling R + Onion Ck) to (Alaska Hwy + Haines Rd to Haines)	$0.183	$0.06	$0.07	$0.31	$0.02	$0.11	$0.44	1	$0	100.0%	no back haul
2	(Nisling R + Aishihik Rd) to (Alaska Hwy + Klondike Hwy to Skagway)	$0.192	$0.060	$0.095	$0.347	$0.018	$0.109	$0.474	4	$67	111.3%	no back haul
2	(Nisling R + Aishihik Rd) to (Alaska Hwy + Haines Rd to Haines)	$0.186	$0.058	$0.095	$0.340	$0.018	$0.109	$0.467	2	$53	108.9%	no back haul
3	(Nisling R + East Route) to (Carmacks to Skagway)	$0.196	$0.061	$0.091	$0.348	$0.018	$0.109	$0.475	5	$68	111.6%	no back haul
3	(Nisling R + East Route) to (Carmacks to Haines)	$0.261	$0.081	$0.091	$0.432	$0.018	$0.109	$0.559	10	$228	138.5%	no back haul
4	(Battle Ck + Wolverine Ck) to (Minto to Skagway)	$0.196	$0.054	$0.105	$0.355	$0.018	$0.109	$0.482	6	$82	113.8%	no back haul
4	(Battle Ck + Wolverine Ck) to (Minto to Haines)	$0.264	$0.073	$0.105	$0.442	$0.018	$0.109	$0.569	11	$247	141.8%	no back haul
5	(Nisling R + Klaza R) to (Carmacks to Skagway)	$0.194	$0.061	$0.116	$0.371	$0.018	$0.109	$0.498	7	$113	119.1%	no back haul
5	(Nisling R + Klaza R) to (Carmacks to Haines)	$0.259	$0.080	$0.116	$0.455	$0.018	$0.109	$0.582	12	$272	146.0%	no back haul
6	(Battle Ck + Wolverine Ck + Yukon R) to (Carmacks to Skagway)	$0.204	$0.056	$0.144	$0.404	$0.018	$0.109	$0.531	9	$175	129.6%	no back haul
6	(Battle Ck + Wolverine Ck + Yukon R) to (Carmacks to Haines)	$0.272	$0.075	$0.144	$0.492	$0.018	$0.109	$0.619	14	$341	157.7%	no back haul
7	(Battle Ck + Hayes Ck) to (Klondike Hwy near Carmacks to Skagway)	$0.205	$0.057	$0.126	$0.387	$0.018	$0.109	$0.514	8	$142	124.0%	no back haul
7	(Battle Ck + Hayes Ck) to (Klondike Hwy near Carmacks to Haines)	$0.273	$0.076	$0.126	$0.475	$0.018	$0.109	$0.602	13	$309	152.2%	no back haul

Note: Calculations for $ per lb of Cu assume a concentrate grade of 25%.

Figure 6-3
Summary of Total Land Transportation Costs

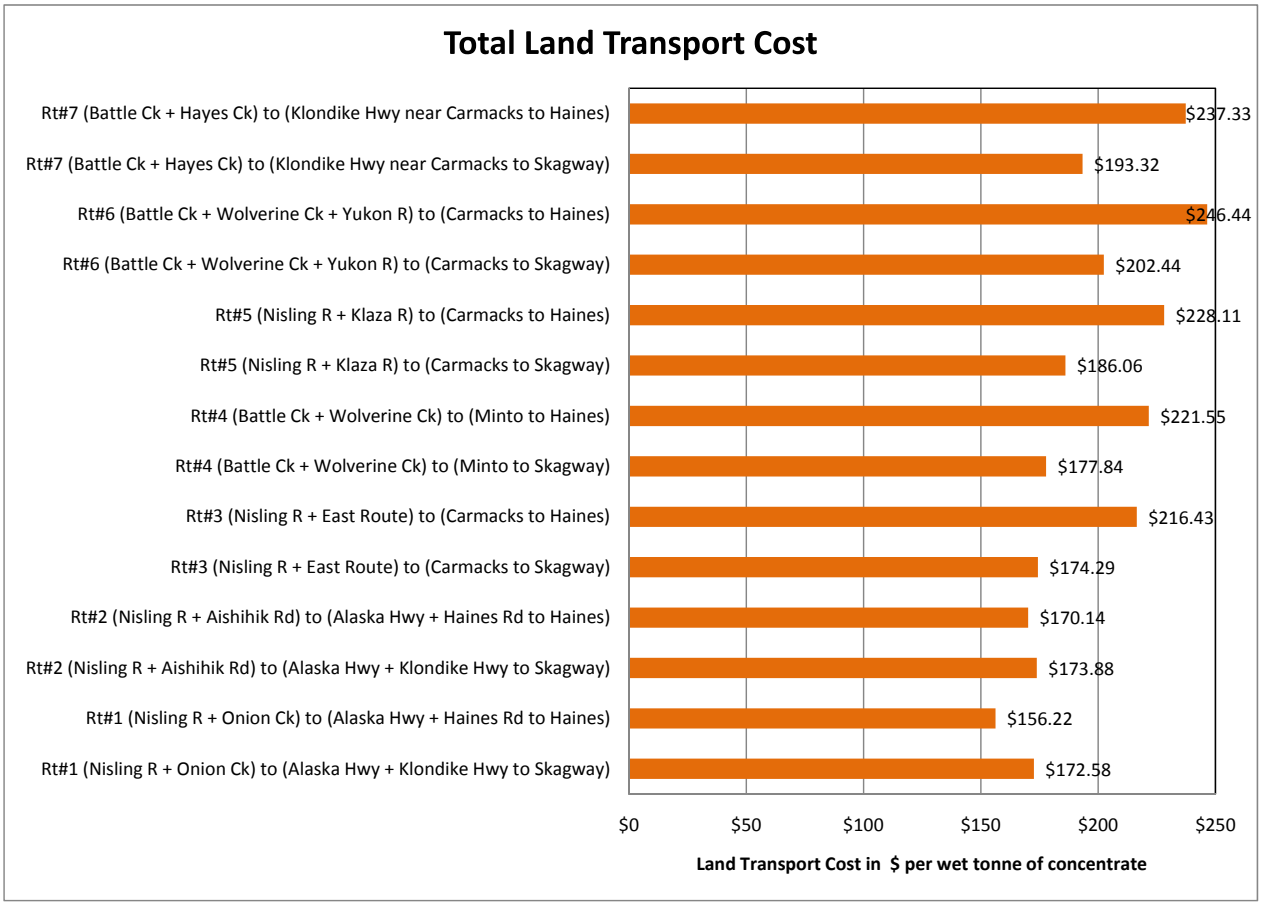
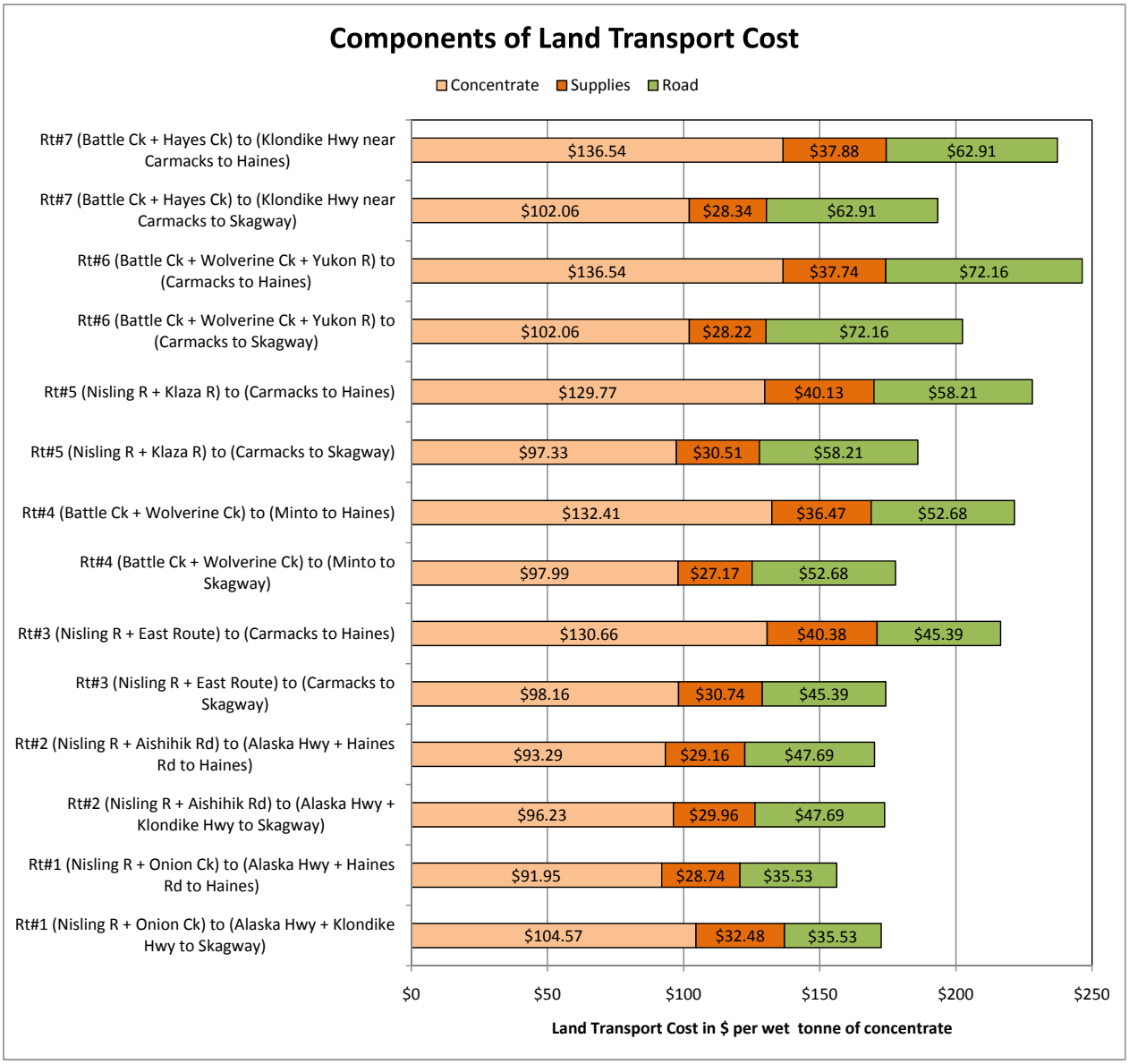
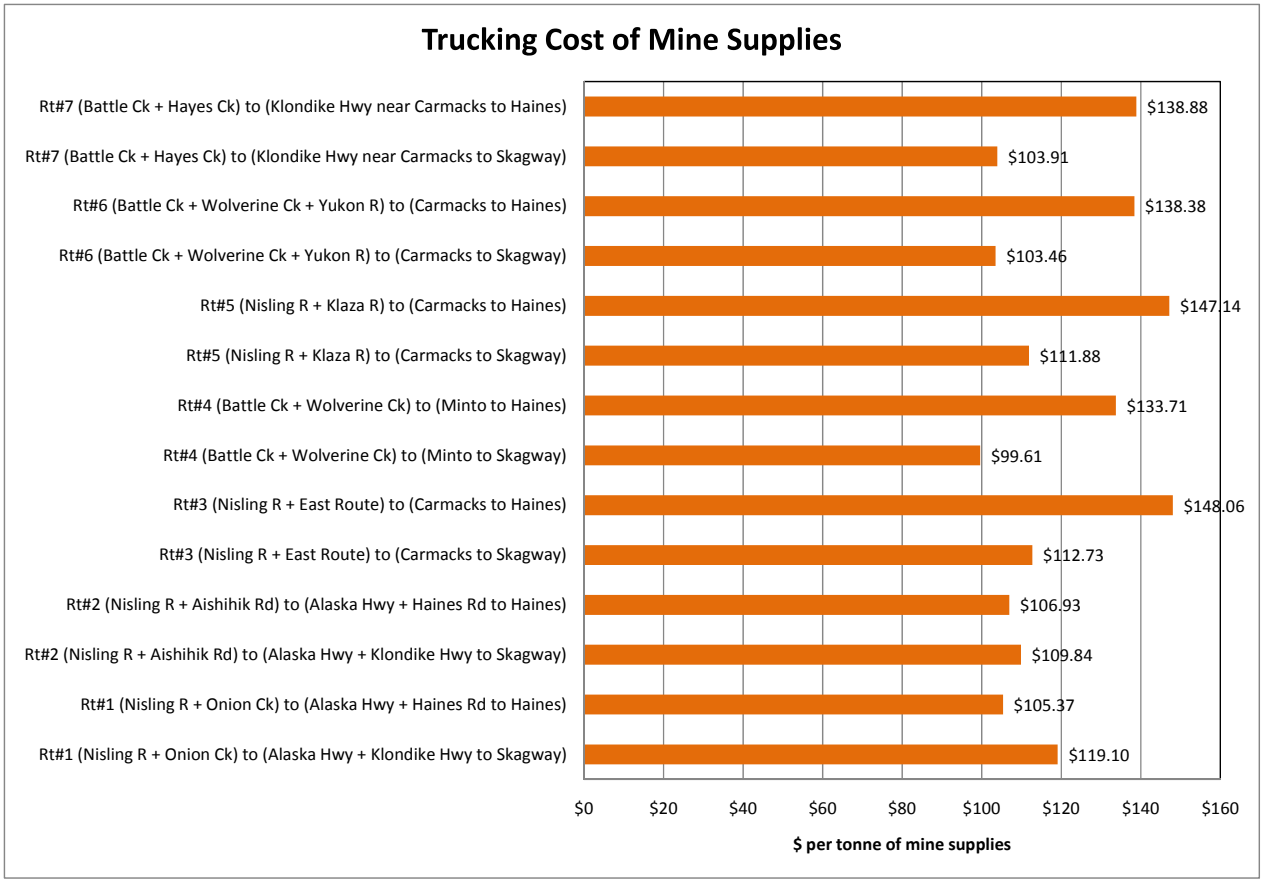


Figure 6-4
Summary of the Components of Land Transportation Costs



Note: The cost of mine supplies has been allocated to the total transport cost of concentrates. Similarly, the road capital and maintenance component of total transport cost has been allocated to the total transport cost. The option to return haul coal in the concentrate trucks is not included in the table above.

Figure 6-5
Trucking Costs of Mine Supplies using a fleet of Tridem Trucks



7 Overview of Port Conditions at Haines and Skagway

7.1 OVERVIEW

For more than 100 years, Skagway has been the Yukon's main port outlet. The port has a demonstrated capacity to handle hundreds of thousands of tonnes of concentrates and similar quantities of general cargoes. The existing narrow gauge White Pass Railway formerly delivered mineral concentrates from the Yukon's Faro Mine to Skagway's bulk concentrate terminal. Skagway's mostly containerized general cargoes arrive by barge to a floating barge ramp which leads to an inter-modal yard. The general cargoes are carried by truck to the Yukon and Alaska.

The main issue at Skagway is capacity. The potential for expansion is very limited. Since the end of large scale concentrate exports in the 1980's, the cruise trade has expanded to take up much of the berthing capacity at Skagway, including the concentrate dock.

7.1.1 Ship Berths

All of the existing and potential ship berthing positions are taken up by cruise ships in summer during day hours. In summer, concentrate loading would have to take place at night. To completely free the concentrate dock for bulk handling, it would be necessary to re-construct the existing Alaska State Ferry terminal to be a dual purpose cruise and ferry facility. It also may be possible construct a separate dedicated bulk barge berth at the seaward end of the concentrate deep sea berth.

7.1.2 Anchorages

There are no deep sea vessel anchorages at Skagway in Taiya Inlet. The nearest anchorages are near Haines, about 24 km to the south in Lutak Inlet. At higher throughput levels, the shuttling to and from distant anchorages will add to the overall cost of shipping concentrate through Skagway. In summer, cruise ships will occupy the concentrate dock in the day time leaving free time for concentrate ships at night. Concentrate ships, depending of the size of their shipments and the number of mines using Skagway, may have to fill partial loads and then shift off to an anchorage before returning the next night to Skagway to complete their loading plan. Additional costs to shippers for: tug assist, pilotage, port charges, lines charges and ship idle time could occur.

7.1.3 Cargo Storage Areas

The concentrate terminal and adjacent vacant lands provide a potential maximum development area of about 2.7 ha. More area could be available if the existing helicopter terminal were re-located. However, finding a suitable new location near the helicopter terminal's cruise ship customers will be difficult in the confined port areas of Skagway. Finding space for bulk storage for concentrates is also complicated by the need to have separate stockpiles for each mineral and each mineral shipper. There does not appear to be space for coal storage as well as concentrates.

7.1.4 Multi-Lateral Agreements

Use of the Skagway concentrate terminal will require a series of multi-lateral agreements with AIDEA, the owner of the terminal site, White Pass, the owner of the concentrate dock, and Sherwood Copper, the current user of the facility.

7.1.5 Advantages and Disadvantage of using the Port of Skagway

Advantages:

- Skagway's concentrate terminal has an existing dock, ship loader and newly constructed materials handling infrastructure created for Sherwood Copper's new shipments copper concentrates from its Minto project. The facility upgrade costs to accommodate the Minto shipments are about $10 million. To some extent, the client will benefit from this investment by others. As well, to some extent, the existing wharf and shiploader and concrete storage pad may be available for shared use at lower costs than for new dedicated facilities.
- As a new shipper, the client's Casino project would be able share in the costs of existing services infrastructure.
- The elapsed time to begin shipping through the concentrate terminal in Skagway is likely to be less than for a new dedicated terminal to be built elsewhere.

Disadvantages:

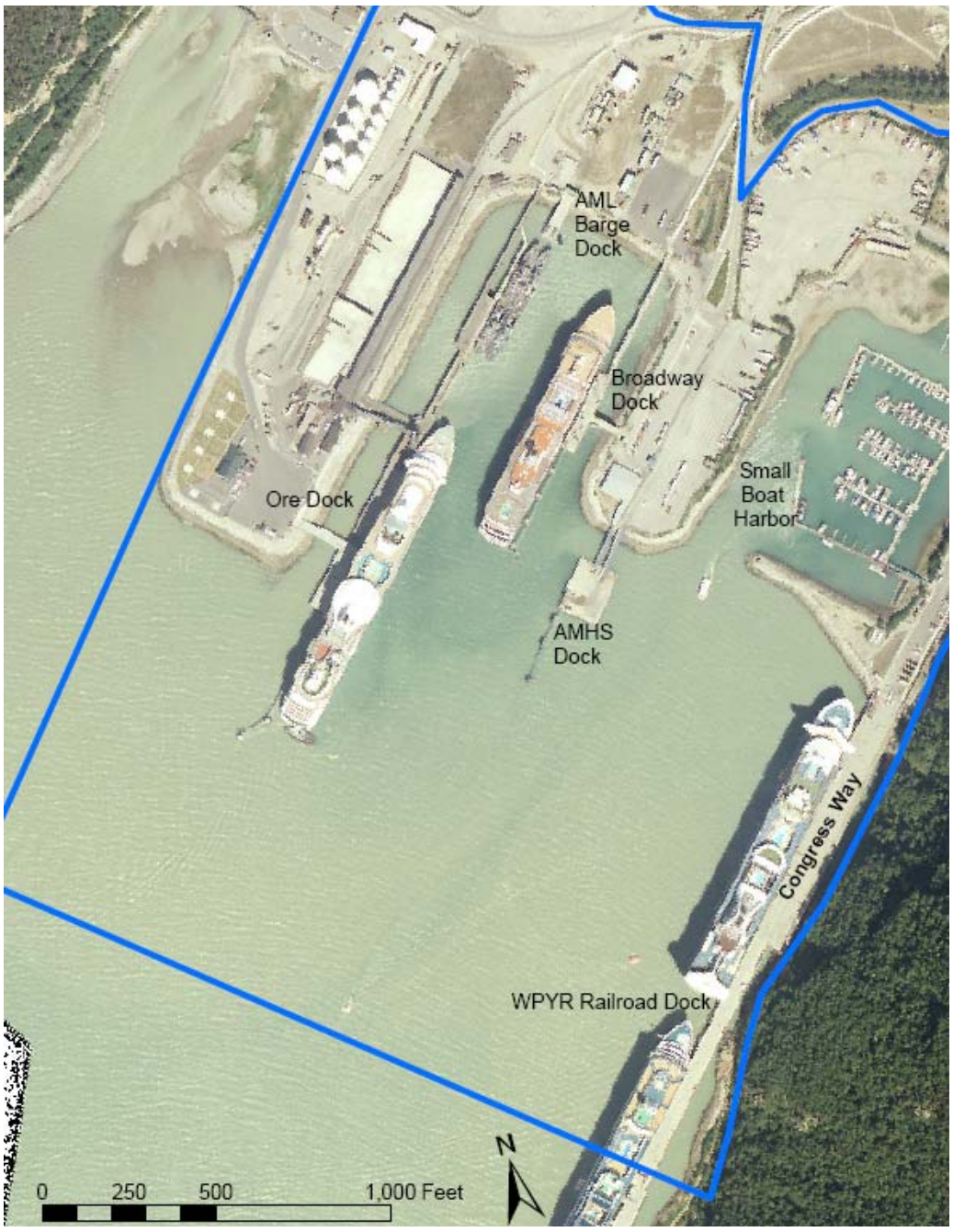
- The existing wharf and shiploader are low capacity assets. In summer, the wharf must be shared with daytime visits by cruise ships. Structurally, the wharf itself may be sufficient for perhaps handy-max sized bulk vessels at most. Further investigations are needed to determine whether lower cost larger bulk vessels can use the wharf. The shiploader is reported to have a maximum capacity of 900 tonnes per hour, with a continuous average capacity that is less than this figure. For modern bulk shipping, this is a relatively low handling rate. Given the limitations concerning berthing space and the current high idle time cost of bulk carriers, a 900 tonnes per hour maximum rate may prove to be costly and/or insufficient. Furthermore, the ship loader is fixed in its position; ships must be warped along the dock to reach next hold in their loading plans. Typically, a ship loading plan requires five holds to be loaded in two or three stages for a total of 12 or more loading passes. Allowing 20 to 30 minutes to warp the ship and slew the loader into position for each pass, a considerable amount of berth time would be lost.
- There are no anchorages at Skagway. In summer, concentrate ships would have to seek anchorage in Lutak Inlet (near Haines) and would sometimes have to interrupt night time loading to make way for cruise ships arriving in the morning. (Cruise ships have priority at the dock.) There would be additional costs for tug assistance, pilotage and lines charges.
- The limited expansion space for product storage, the low capacity ship loader, the limited amount available berth time, and the need for concentrate trucks to travel through the main tourist area of Skagway raise questions about the maximum practical throughput capacity of the concentrate terminal. If the client joins the terminal as the third or fourth shipper through Skagway, there may be some capacity risks. Further investigation, to assess Skagway's concentrate terminal capacity is recommended.
- There does not appear to be space for the storage and receiving of coal. While a self-discharging coal barge could conceivably moor at the concentrate dock, finding space for cargo storage would be difficult. Furthermore, in summer, the already crowded berth schedule would add to the difficulties described above for concentrate ships.

Figure 7.1.1
Skagway, Alaska



The concentrate terminal is to the left. Space for expansion is limited.
The white line ellipse shows the location of bulk facilities.

Figure 7.1.2
Skagway in Summer



In summer, cruise ships take up all available deep sea berths during the day. Note the cruise ship moored at the concentrate terminal.

Figure 7.1.3
Skagway Concentrate Dock



The fixed ship loader slows ship loading considerably.

Figure 7.1.4
Skagway RORO Terminal



Skagway has the capacity to handle container shipments by barge. Mine supplies and/or containerized concentrates could be handled.

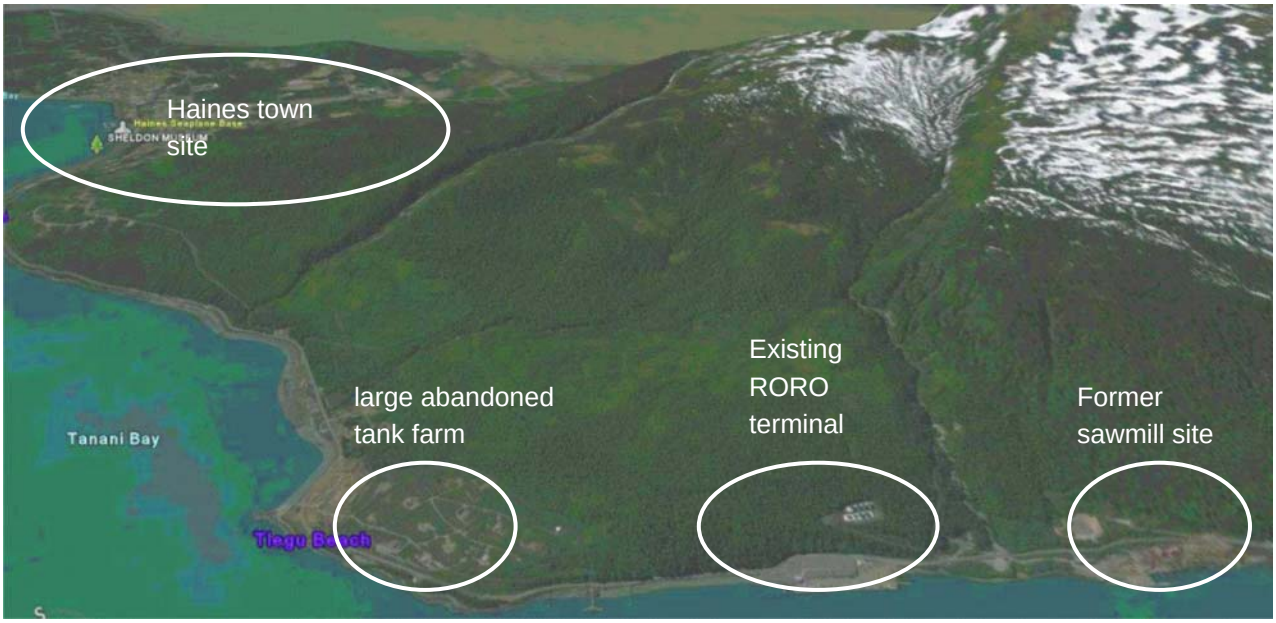
7.2 PORT OF HAINES

7.2.1 Overview

Haines was established as a supply port for the construction of the Alaska Highway and oil pipeline by the US Military in 1943. The Borough of Haines has established port industrial areas on the shores of Lutak inlet, about 4 kilometres north of the town. Potential terminal sites include: part of a multi-modal terminal of about 6 hectares, an abandoned tank farm of about 34 hectares and a former saw mill site of about 8 hectares.

Conversations with the Borough of Haines indicate strong interest in having a concentrate terminal in this area. At this time, there are no known obvious major social issues that would preclude development on the industrial shores of Lutak Inlet. The Borough appears to be flexible about ownership and operations management.

Figure 7.2.1



7.2.2 Advantages and Disadvantages of using the Port of Haines

Advantages:

- The complexities and risks associated with multi-lateral agreements required at Skagway would be avoided.
- The ship berth could be dedicated to the client thereby reducing some port costs.

- Site development could be optimized to suit the client's requirements. At Skagway adjustments and compromises connected with the small site area and working with an existing user could be avoided.
- Road grades approaching Haines are slightly less onerous than at Skagway.
- There is a greater potential for expansion at Haines and also the possibility of profitable sharing of infrastructure costs from future mineral shippers.
- Social issues at Haines may be less complex than at Skagway where port operations and truck transport mixes closely with tourism and tourists. At Haines, the townsite, tourist activity and its residential areas are four kilometres away from the potential port sites.
- The land transport costs to Haines are expected to be lower than for the other routes to Skagway. The present value of the estimated land transport cost advantage for using the Onion Creek route to Haines instead of the next best route is $41 million. Applying some of this cost advantage towards the higher capital cost of a terminal at Haines may be appropriate.
- There appears to be space for the receiving and storage of: mine supplies, concentrates and coal.
- Marine conditions, topography and site development do not appear to present obvious difficulties.
- There is a fuel tank farm near to the existing RORO terminal. There does not appear to be any obvious impediment to expanding the tank farm.

Disadvantages

- The capital cost to develop terminal facilities at Haines is likely to be higher than at Skagway.
- It will probably take longer to develop a new terminal at Haines than to become an additional user at Skagway.

Figure 7.2.2
Port Sites at Haines



Port Sites at Haines, Alaska – Haines has three port sites about 50 metres wide by 300 metres long bordering a quiet bay that offers anchorage for deep sea vessels. Increasing the size of these sites is possible with cuts into the hillsides. The port sites are away from the town and options for by-pass road and rail alignments are probably feasible. The favourable sea conditions will probably allow the option of floating bulk barge-to-ship transfer terminals. For receiving mine supplies, the existing RORO container and truck/trailer could be expanded.

One option for overcoming site development problems at Haines would be to use floating bulk transfer terminals.

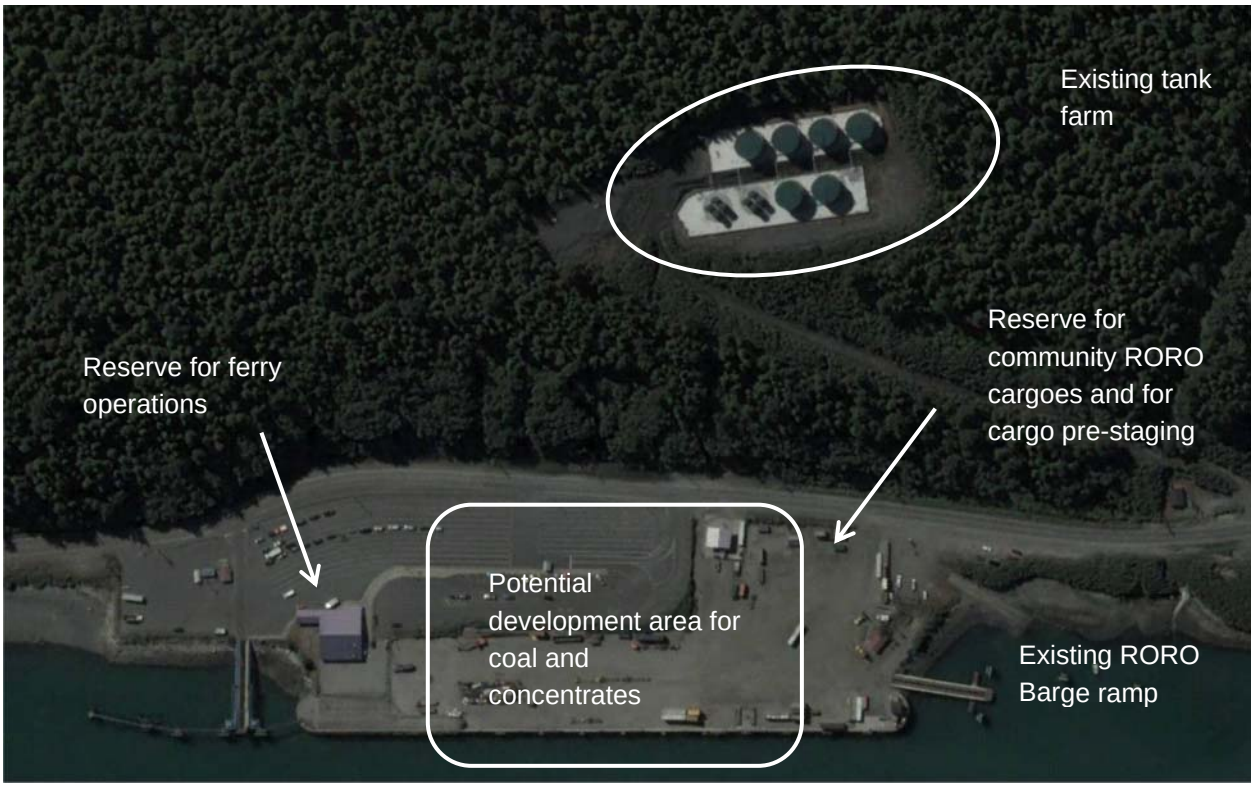
Figure 7.2.3
SeaBulk Cape Size Transfer System



Figure 7.2.4
SeaBulk Transshipper



Figure 7.2.5
Haines' RORO Terminal



This RORO Terminal, called Lutak City Dock, is used by Alaska Ferries and by RORO barge services; the space for both functions is under utilized. The nearby tank farm provides fuel storage and may have expansion potential.

7.2.3 Possible Development at Haines's RORO Terminal

With the addition of Casino mine project cargoes, four cargo handling areas would be active: the ferry operations area, the coal storage and handling system, the concentrates storage and handling system and the RORO cargo area. In the RORO cargo area, Casino cargoes would mix with community cargoes. The addition of Casino cargoes to RORO operations may be an advantage to the town if it encourages a more frequent and higher level of service. Either containerized concentrate handling or bulk handling may be feasible. For coal deliveries, barge delivery rather than deep sea ship delivery would probably be required. The large deep sea shipment sizes common in the coal trades could not handled at the RORO terminal. If concentrates are to be shipped in bulk in deep sea vessels, deep sea berthing structures would have to be constructed. The Haines RORO terminal is owned by the Borough of Haines.

The following are details of the existing Haines RORO Termina:

- Name – Lutak City Dock
- Site area – 6.4 ha including 2 used by Alaska State Ferry Terminal; part paved, part gravel
- Berth Face – 305 metres
- Water depth – 11 metres
- Activity – AML weekly container container barge and general cargo service; Delta Western inbound petroleum tanker barge and outbound truck distribution
- Status – owned by the Borough of Haines

Figure 7.2.6
Former Sawmill Site
Potential Terminal Site at Haines for a coal port.



7.2.4 Possible Development at the former Sawmill Site as a Coal Terminal

The former sawmill site is large enough to accommodate bulk coal received from deep sea vessels and bulk concentrates. However, the cost of site development and the necessarily larger scale materials handling and storage requirements would result in higher development costs than at the RORO site, Lutak City Dock. Extensive site leveling, demolitions and filling would be required. This site is privately held. There is an existing timber wharf but it is in poor condition and is probably unsalvagable. Similarly, it is unlikely that any of the derilict mill structures on the site can re-used.

The following are the details of the potential Site:

- Name – Chilkoot Lumber Property
- Site Area – 8 ha
- Water depth – 11 metres
- Status – private and for sale; industrial zoned

Figure 7.2.7
Example of a Coal Terminal – Middle Point at Campbell River





The Middle Point Coal Terminal near Campbell River on Vancouver Island is a potential model for coal and/or concentrate operations at Haines. The terminal has an enclosed truck receiving building, a completely enclosed coal storage building and covered conveyors leading to the barge loader. These dust control measures will probably be required at the Haines RORO terminal to ensure compatibility with ferry and community RORO operations. The storage capacity is 15,000 tonnes and the loading rates in 2,000 tonnes per hour. The Middle Point barge terminal is also a potential source of coal to be delivered to Haines. The smaller scale of coal operations from this terminal may be a good match for the Casino mine project's requirements. Barge back hauls of containerized concentrates to reach Vancouver area container terminals may be logistically and economically convenient.

Figure 7.2.9
Example of Gravel Loading Terminal – Port McNeill, BC



The gravel trades operating on Vancouver Island and in other locations in the waters between Vancouver Island and the mainland are a potential opportunity for low cost coal transport to Haines. Self-discharging bulk vessels similar to the vessel shown in Figure 9 may be available to bring coal to Haines as a backhaul for gravel shipments. These self-discharging vessels would be essential if coal were to be received at Haines at the former saw mill site. The long booms on these vessels allow high speed discharge to sites with minimal port facilities. Suitably placed mooring dolphins would be sufficient for this vessel; the vessel's boom swings overland to discharge the coal.

7.3 FURTHER WORK REQUIRED

This brief analyses of the Ports of Skagway and Haines together with the potential use as a terminal facility by Casino Mine requires further substantiation. The following is a indication of further work that the Mine may wish to undertake to select the port that will best satisfy the needs of the projected mining operations.

- Further analysis is needed to substantiate the selection between the Onion Creek routes, to Skagway and to Haines. Further work is also required to substantiate the selection of Haines as the optimal port for the purposes of Casino Mine. Conceptual site development plans and order of magnitude development costs are needed. Capacity assessments for bulk shipping out of Skagway and Haines are needed. If further analysis confirms that the land transport route to Haines via the proposed Onion Creek mine road is the lowest cost option, the higher expected capital investment at Haines may be justified.
- Given their current market volatility, ship costs require further investigation to assess the likely range of ship transport costs.
- The transport logistics of incoming coal and supplies and, outgoing concentrates requires further investigation. The outcomes of the investigations are likely to have a material affect on costs. Logistical options recommended for study would include:
- Barge transport of coal from Middle Point (on Vancouver Island) to Haines or Skagway and, possibly, the backhaul of containerized concentrate to Vancouver container terminals;
- Barge transport of coal from Ridley Terminals (near Prince Rupert) to Haines or Skagway and, possibly, the backhaul of containerized concentrate to Prince Rupert's container terminal;
- Deep sea transport of offshore or locally sourced coal in self-discharging vessels to Haines. Such a service may include coal supply as a low cost back haul for the gravel trades now operating in south coast B.C.;
- Direct truck haul of Division Mountain coal (near Breaburn, Yukon) 310 km to the Casino on an eastern road route passing near to Western Copper's Carmacks property;
- Coal imports at Haines may favour the logistics for containerized concentrates out and containerized back hauls of mine supplies in. A coal receiving facility at Haines may take up the limited land available for bulk storage and handling. Since some port land must reserved for the community's RORO truck-trailer/container storage needs, adding concentrate and mine supplies containers to Haines' existing RORO transport system may be logistically convenient. At the port terminal, container handling and environmental protection capital investment costs are likely to be much lower than for bulk handling.
- The commercial advantages and disadvantages of containerized concentrate with respect to smelting services should be examined. Containerization and use of water and rail links, may provide Western Copper with a greater range of smelting options, both in Canada and, in Asia.

A Appendix A - Net Present Value and Cycle Time Analyses

Figure A-1
Net Present Value Analyses for Route 1

			Route Number	1					
			new mine road	Nisling R + Onion Ck to Alaska Hwy					
			paved roads used	Alaska Hwy + Klondike Hwy	Alaska Hwy + Haines Rd	Alaska Hwy + Klondike Hwy	Alaska Hwy + Haines Rd	Alaska Hwy + Klondike Hwy	Alaska Hwy + Haines Rd
			select truck type	tridem	tridem	b-train	b-train	b-train	b-train
			select logistics option	loaded in + empty out	loaded in + empty out	empty in + loaded out	empty in + loaded out	loaded in + loaded out	loaded in + loaded out
			select terminal	Skagway	Haines	Skagway	Haines	Skagway	Haines
			distance, km	693.3	604.3	693.3	604.3	693.3	604.3
			trips per year	2,489	2,489	7,212	7,212	7,212	7,212
			Road Cost + Maintenance	Supply Trucking		Bulk Trucking			
		$/hr	n/a	$153.89	$149.41	$178.61	$173.14	$90.75	$87.79
		$/lb Cu	$0.071	$0.065	$0.057	$0.209	$0.183	$0.113	$0.100
		$/t	$27.92	$119.10	$105.37	$104.57	$91.95	$56.70	$50.08
Concentrate tonnage	Supply Tonnage	$/km	$717,208	$5.18	$5.25	$5.75	$5.80	$3.12	$3.16
		$/t-km	$0.15	$0.17	$0.17	$0.15	$0.15	$0.08	$0.08
3,780,554	1,031,060	PV	$134,332,990	$122,801,637	$108,639,373	$395,319,743	$347,637,322	$428,697,444	$378,673,031
		Year 0	$91,176,476	$3,109,676	$2,870,471	$10,981,851	$10,040,549	$11,295,618	$10,668,083
275,000	75,000	1	$3,139,233	$7,164,720	$6,391,563	$22,310,756	$19,813,832	$24,852,596	$22,093,434
275,000	75,000	2	$3,139,233	$7,640,334	$6,776,855	$24,028,398	$21,208,142	$26,494,063	$23,421,875
275,000	75,000	3	$3,139,233	$8,115,948	$7,162,146	$25,746,041	$22,602,452	$28,135,531	$24,750,315
275,000	75,000	4	$3,139,233	$8,591,561	$7,547,438	$27,463,683	$23,996,763	$29,776,998	$26,078,755
275,000	75,000	5	$3,139,233	$10,879,365	$9,605,521	$34,261,910	$30,036,179	$36,644,209	$32,342,620
275,000	75,000	6	$3,139,233	$7,828,722	$6,929,467	$25,572,986	$22,461,974	$27,970,150	$24,616,473
275,000	75,000	7	$3,139,233	$8,304,336	$7,314,758	$27,290,628	$23,856,284	$29,611,618	$25,944,913
275,000	75,000	8	$3,139,233	$10,198,999	$9,009,942	$35,338,840	$31,038,543	$37,764,528	$33,423,049
275,000	75,000	9	$3,139,233	$8,193,160	$7,224,696	$25,506,345	$22,407,878	$27,906,465	$24,564,932
275,000	75,000	10	$3,139,233	$10,480,964	$9,282,778	$32,304,572	$28,447,294	$34,773,677	$30,828,797
275,000	75,000	11	$3,139,233	$7,430,321	$6,606,725	$23,615,648	$20,873,089	$26,099,618	$23,102,650
275,000	75,000	12	$3,139,233	$7,905,935	$6,992,016	$25,333,290	$22,267,399	$27,741,085	$24,431,090
275,000	75,000	13	$3,139,233	$8,381,548	$7,377,308	$27,050,933	$23,661,709	$29,382,552	$25,759,530
275,000	75,000	14	$3,139,233	$8,857,162	$7,762,599	$28,768,575	$25,056,019	$31,024,020	$27,087,971
275,000	75,000	15	$3,139,233	$11,144,966	$9,820,682	$35,566,802	$31,095,435	$37,891,231	$33,351,836
275,000	75,000	16	$3,139,233	$9,513,372	$8,454,520	$33,208,447	$29,309,179	$35,728,615	$31,775,384
275,000	75,000	17	$3,139,233	$7,507,533	$6,669,274	$23,375,952	$20,678,514	$25,870,553	$22,917,267
275,000	75,000	18	$3,139,233	$7,983,147	$7,054,566	$25,093,595	$22,072,824	$27,512,020	$24,245,707
275,000	75,000	19	$3,139,233	$8,458,761	$7,439,857	$26,811,237	$23,467,134	$29,153,487	$25,574,148
275,000	75,000	20	$3,139,233	$10,746,565	$9,497,940	$33,609,464	$29,506,550	$36,020,698	$31,838,013
275,000	75,000	21	$3,139,233	$7,695,921	$6,821,886	$24,920,540	$21,932,345	$27,346,639	$24,111,865
275,000	75,000	22	$3,139,233	$8,171,535	$7,207,178	$26,638,182	$23,326,655	$28,988,107	$25,440,305
275,000	75,000	23	$3,139,233	$8,647,149	$7,592,469	$28,355,825	$24,720,966	$30,629,574	$26,768,746
275,000	75,000	24	$3,139,233	$10,541,813	$9,287,653	$36,404,036	$31,903,225	$38,782,484	$34,246,882
275,000	75,000	25	$3,139,233	$10,348,164	$9,175,198	$31,652,126	$27,917,665	$34,150,166	$30,324,190

Notes:

- The left most column of costs shows year by year road maintenance for grading and sanding.
- The six truck cost columns on the right show the year by year sum of costs for: fuel, lub/oil, tires, driver wages, truck maintenance, overheads, licensing, and the periodic end of life purchases of new trucks and trailers. The variation of truck costs year by year reflects age related truck maintenance and purchases of replacement tractors and trailers.
- The two columns on the far right show the costs for bulk trucking, loaded in and loaded out. These columns contain the costs that would be relevant if coal were the back haul for concentrates shipped out.

Figure A-2
Net Present Value Analyses for Route 2

	Route Number	2					
	new mine road	Nisling R + Aishihik Rd to Alaska Hwy					
	paved roads used	Alaska Hwy + Klondike Hwy	Alaska Hwy + Haines Rd	Alaska Hwy + Klondike Hwy	Alaska Hwy + Haines Rd	Alaska Hwy + Klondike Hwy	Alaska Hwy + Haines Rd
	select truck type	tridem	tridem	b-train	b-train	b-train	b-train
	select logistics option	loaded in + empty out	loaded in + empty out	empty in + loaded out	empty in + loaded out	loaded in + loaded out	loaded in + loaded out
	select terminal	Skagway	Haines	Skagway	Haines	Skagway	Haines
	distance, km	622.5	601.5	622.5	601.5	622.5	601.5
	trips per year	2,489	2,489	7,212	7,212	7,212	7,212
	Road Cost + Maintenance	Supply Trucking		Bulk Trucking			
$/hr	n/a	$146.46	$144.96	$169.87	$167.57	$86.17	$85.16
$/lb Cu	$0.095	$0.060	$0.058	$0.192	$0.186	$0.104	$0.101
$/t	$37.47	$109.84	$106.93	$96.23	$93.29	$52.21	$50.76
$/km	$558,162	$5.32	$5.36	$5.89	$5.91	$3.20	$3.22
$/t-km	$0.12	$0.18	$0.18	$0.15	$0.16	$0.08	$0.08
PV	$180,286,306	$113,256,191	$110,253,283	$363,802,966	$352,699,694	$394,732,180	$383,827,440
Year 0	$105,862,633	$2,870,471	$2,870,471	$10,668,083	$10,354,316	$10,981,851	$10,981,851
1	$5,413,627	$6,712,433	$6,543,051	$20,802,421	$20,248,273	$23,137,629	$22,523,769
2	$5,413,627	$7,104,368	$6,913,205	$22,218,833	$21,586,462	$24,489,854	$23,800,627
3	$5,413,627	$7,496,302	$7,283,359	$23,635,246	$22,924,651	$25,842,079	$25,077,484
4	$5,413,627	$7,888,237	$7,653,513	$25,051,659	$24,262,840	$27,194,305	$26,354,342
5	$5,413,627	$9,952,962	$9,696,459	$31,403,497	$30,391,293	$33,627,114	$32,711,784
6	$5,413,627	$7,259,611	$7,059,821	$23,492,541	$22,789,826	$25,705,840	$24,948,839
7	$5,413,627	$7,651,545	$7,429,975	$24,908,953	$24,128,015	$27,058,066	$26,225,697
8	$5,413,627	$9,353,372	$9,110,022	$32,475,062	$31,435,026	$34,740,860	$33,833,124
9	$5,413,627	$7,559,930	$7,343,451	$23,437,587	$22,737,908	$25,653,377	$24,899,300
10	$5,413,627	$9,624,656	$9,386,396	$29,789,425	$28,866,362	$32,086,187	$31,256,742
11	$5,413,627	$6,931,304	$6,749,759	$21,878,469	$21,264,895	$24,164,913	$23,493,797
12	$5,413,627	$7,323,239	$7,119,913	$23,294,881	$22,603,083	$25,517,139	$24,770,655
13	$5,413,627	$7,715,173	$7,490,067	$24,711,294	$23,941,272	$26,869,364	$26,047,512
14	$5,413,627	$8,107,108	$7,860,221	$26,127,707	$25,279,461	$28,221,589	$27,324,370
15	$5,413,627	$10,171,833	$9,903,167	$32,479,545	$31,407,915	$34,654,399	$33,681,812
16	$5,413,627	$8,788,374	$8,576,421	$30,718,285	$29,775,270	$33,063,694	$32,249,436
17	$5,413,627	$6,994,932	$6,809,851	$21,680,810	$21,078,152	$23,976,212	$23,315,613
18	$5,413,627	$7,386,867	$7,180,005	$23,097,222	$22,416,340	$25,328,437	$24,592,470
19	$5,413,627	$7,778,801	$7,550,159	$24,513,635	$23,754,529	$26,680,662	$25,869,328
20	$5,413,627	$9,843,527	$9,593,105	$30,865,473	$29,882,983	$33,113,472	$32,226,770
21	$5,413,627	$7,150,175	$6,956,467	$22,954,517	$22,281,516	$25,192,198	$24,463,825
22	$5,413,627	$7,542,110	$7,326,621	$24,370,929	$23,619,704	$26,544,423	$25,740,683
23	$5,413,627	$7,934,044	$7,696,775	$25,787,342	$24,957,893	$27,896,649	$27,017,540
24	$5,413,627	$9,635,871	$9,376,822	$33,353,451	$32,264,904	$35,579,443	$34,624,968
25	$5,413,627	$9,515,220	$9,283,042	$29,251,401	$28,358,051	$31,572,545	$30,771,728

Figure A-3
Net Present Value Analyses for Route 3

	Route Number	3					
	new mine road	Nisling R + East Route to Carmacks					
	paved roads used	Klondike Hwy	Klondike Hwy + Alaska Hwy + Haines Rd	Klondike Hwy	Klondike Hwy + Alaska Hwy + Haines Rd	Klondike Hwy	Klondike Hwy + Alaska Hwy + Haines Rd
	select truck type	tridem	tridem	b-train	b-train	b-train	b-train
	select logistics option	loaded in + empty out	loaded in + empty out	empty in + loaded out	empty in + loaded out	loaded in + loaded out	loaded in + loaded out
	select terminal	Skagway	Haines	Skagway	Haines	Skagway	Haines
	distance, km	638.5	865.5	638.5	865.5	638.5	865.5
	trips per year	2,489	2,489	7,212	7,212	7,212	7,212
	Road Cost + Maintenance	Supply Trucking		Bulk Trucking			
$/hr	n/a	$146.75	$153.98	$169.00	$178.09	$86.07	$91.39
$/lb Cu	$0.091	$0.061	$0.081	$0.196	$0.261	$0.107	$0.141
$/t	$35.66	$112.73	$148.06	$98.16	$130.66	$53.38	$70.65
$/km	$611,752	$5.32	$5.15	$5.86	$5.76	$3.19	$3.11
$/t-km	$0.13	$0.18	$0.17	$0.15	$0.15	$0.08	$0.08
PV	$171,596,385	$116,226,731	$152,656,633	$371,102,253	$493,982,664	$403,616,227	$534,187,162
Year 0	$106,965,300	$3,109,676	$3,588,088	$10,668,083	$12,864,454	$11,295,618	$13,178,221
1	$4,701,308	$6,844,285	$8,873,139	$21,218,246	$27,749,009	$23,604,023	$30,812,180
2	$4,701,308	$7,249,818	$9,506,850	$22,683,037	$30,027,383	$25,003,514	$33,003,981
3	$4,701,308	$7,655,351	$10,140,561	$24,147,828	$32,305,757	$26,403,004	$35,195,782
4	$4,701,308	$8,060,884	$10,774,272	$25,612,619	$34,584,131	$27,802,495	$37,387,583
5	$4,701,308	$10,278,607	$13,498,971	$32,012,835	$42,814,047	$34,427,730	$45,676,085
6	$4,701,308	$7,410,448	$9,757,860	$24,000,248	$32,076,207	$26,262,004	$34,974,954
7	$4,701,308	$7,815,981	$10,391,570	$25,465,039	$34,354,582	$27,661,494	$37,166,755
8	$4,701,308	$9,640,563	$12,662,646	$33,079,526	$44,048,766	$35,572,428	$46,955,240
9	$4,701,308	$7,721,187	$10,243,440	$23,943,418	$31,987,812	$26,207,707	$34,889,918
10	$4,701,308	$9,938,910	$12,968,139	$30,343,634	$40,217,728	$32,832,941	$43,178,420
11	$4,701,308	$7,070,750	$9,227,027	$22,331,047	$29,479,888	$24,667,215	$32,477,290
12	$4,701,308	$7,476,283	$9,860,738	$23,795,838	$31,758,262	$26,066,706	$34,669,091
13	$4,701,308	$7,881,816	$10,494,449	$25,260,629	$34,036,637	$27,466,197	$36,860,892
14	$4,701,308	$8,287,349	$11,128,160	$26,725,420	$36,315,011	$28,865,688	$39,052,693
15	$4,701,308	$10,505,072	$13,852,860	$33,125,636	$44,544,927	$35,490,922	$47,341,195
16	$4,701,308	$9,055,962	$11,749,113	$31,262,745	$41,222,897	$33,836,639	$44,236,748
17	$4,701,308	$7,136,586	$9,329,906	$22,126,637	$29,161,943	$24,471,917	$32,171,426
18	$4,701,308	$7,542,119	$9,963,617	$23,591,428	$31,440,317	$25,871,408	$34,363,227
19	$4,701,308	$7,947,652	$10,597,328	$25,056,219	$33,718,692	$27,270,899	$36,555,028
20	$4,701,308	$10,165,375	$13,322,027	$31,456,435	$41,948,607	$33,896,134	$44,843,530
21	$4,701,308	$7,297,215	$9,580,916	$23,443,848	$31,210,768	$25,730,407	$34,142,399
22	$4,701,308	$7,702,748	$10,214,626	$24,908,639	$33,489,142	$27,129,898	$36,334,201
23	$4,701,308	$8,108,281	$10,848,337	$26,373,430	$35,767,516	$28,529,389	$38,526,002
24	$4,701,308	$9,932,864	$13,119,413	$33,987,917	$45,461,700	$36,440,323	$48,314,486
25	$4,701,308	$9,825,677	$12,791,195	$29,787,233	$39,352,288	$32,301,345	$42,345,865

Figure A-4
Net Present Value Analyses for Route 4

	Route Number	4					
	new mine road	Battle Ck + Wolverine Ck to Minto					
	paved roads used	Klondike Hwy	Klondike Hwy + Alaska Hwy + Haines Rd	Klondike Hwy	Klondike Hwy + Alaska Hwy + Haines Rd	Klondike Hwy	Klondike Hwy + Alaska Hwy + Haines Rd
	select truck type	tridem	tridem	tridem	tridem	tridem	tridem
	select logistics option	loaded in + empty out	loaded in + empty out	empty in + loaded out	empty in + loaded out	loaded in + loaded out	loaded in + loaded out
	select terminal	Skagway	Haines	Skagway	Haines	Skagway	Haines
	distance, km	541.5	768.5	541.5	768.5	541.5	768.5
	trips per year	2,489	2,489	9,126	9,126	9,126	9,126
	Road Cost + Maintenance	Supply Trucking		Bulk Trucking			
$/hr	n/a	$131.52	$140.63	$135.31	$144.29	$71.37	$77.00
$/lb Cu	$0.105	$0.054	$0.073	$0.196	$0.264	$0.110	$0.149
$/t	$41.39	$99.61	$133.71	$97.99	$132.41	$55.24	$74.49
$/km	$1,443,147	$5.54	$5.24	$5.45	$5.19	$3.07	$2.92
$/t-km	$0.30	$0.18	$0.17	$0.18	$0.17	$0.10	$0.10
PV	$199,154,348	$102,702,868	$137,868,045	$370,470,350	$500,567,366	$417,644,702	$563,202,737
Year 0	$154,131,384	$3,109,676	$3,588,088	$10,764,265	$12,677,912	$11,242,676	$13,156,323
1	$3,275,000	$6,140,180	$8,140,746	$22,139,707	$29,491,079	$25,571,869	$34,096,312
2	$3,275,000	$6,421,548	$8,622,003	$23,203,810	$31,302,557	$26,588,073	$35,838,388
3	$3,275,000	$6,702,917	$9,103,261	$24,267,913	$33,114,034	$27,604,277	$37,580,464
4	$3,275,000	$6,984,285	$9,584,519	$25,332,016	$34,925,512	$28,620,481	$39,322,539
5	$3,275,000	$9,077,844	$12,156,765	$32,669,086	$44,125,150	$36,188,450	$48,731,574
6	$3,275,000	$6,532,997	$8,812,627	$23,625,295	$32,020,073	$26,990,586	$36,528,415
7	$3,275,000	$6,814,365	$9,293,885	$24,689,398	$33,831,551	$28,006,790	$38,270,490
8	$3,275,000	$8,514,783	$11,412,507	$30,665,597	$41,428,386	$34,153,405	$46,016,238
9	$3,275,000	$6,748,595	$9,181,390	$24,440,663	$33,408,115	$27,769,251	$37,863,278
10	$3,275,000	$8,842,154	$11,753,636	$31,777,732	$42,607,754	$35,337,219	$47,272,312
11	$3,275,000	$6,297,307	$8,409,498	$22,733,942	$30,502,677	$26,139,356	$35,069,153
12	$3,275,000	$6,578,675	$8,890,756	$23,798,045	$32,314,154	$27,155,560	$36,811,229
13	$3,275,000	$6,860,043	$9,372,013	$24,862,148	$34,125,632	$28,171,764	$38,553,305
14	$3,275,000	$7,141,412	$9,853,271	$25,926,252	$35,937,110	$29,187,967	$40,295,380
15	$3,275,000	$9,234,970	$12,425,517	$33,263,321	$45,136,748	$36,755,936	$49,704,415
16	$3,275,000	$8,109,173	$10,718,745	$29,131,626	$38,817,028	$32,688,483	$43,504,928
17	$3,275,000	$6,342,985	$8,487,627	$22,906,692	$30,796,758	$26,304,329	$35,351,967
18	$3,275,000	$6,624,353	$8,968,885	$23,970,795	$32,608,235	$27,320,533	$37,094,043
19	$3,275,000	$6,905,722	$9,450,142	$25,034,898	$34,419,713	$28,336,737	$38,836,119
20	$3,275,000	$8,999,280	$12,022,389	$32,371,968	$43,619,351	$35,904,706	$48,245,153
21	$3,275,000	$6,454,434	$8,678,251	$23,328,178	$31,514,274	$26,706,842	$36,041,994
22	$3,275,000	$6,735,802	$9,159,508	$24,392,281	$33,325,752	$27,723,046	$37,784,070
23	$3,275,000	$7,017,170	$9,640,766	$25,456,384	$35,137,230	$28,739,250	$39,526,146
24	$3,275,000	$8,717,588	$11,759,389	$31,432,583	$42,734,065	$34,885,865	$47,271,894
25	$3,275,000	$8,763,590	$11,619,260	$31,480,615	$42,101,955	$35,053,476	$46,785,892

Note: All routes using the Battle Creek section are assumed to use tridem trucks because of steep grades.

Figure A-5
Net Present Value Analyses for Route 5

	Route Number	5					
	new mine road	Nisling R + Klaza R to Carmacks					
	paved roads used	Klondike Hwy	Klondike Hwy + Alaska Hwy + Haines Rd	Klondike Hwy	Klondike Hwy + Alaska Hwy + Haines Rd	Klondike Hwy	Klondike Hwy + Alaska Hwy + Haines Rd
	select truck type	tridem	tridem	b-train	b-train	b-train	b-train
	select logistics option	loaded in + empty out	loaded in + empty out	empty in + loaded out	empty in + loaded out	loaded in + loaded out	loaded in + loaded out
	select terminal	Skagway	Haines	Skagway	Haines	Skagway	Haines
	distance, km	631.5	858.5	631.5	858.5	631.5	858.5
	trips per year	2,489	2,489	7,212	7,212	7,212	7,212
	Road Cost + Maintenance	Supply Trucking		Bulk Trucking			
$/hr	n/a	$145.30	$152.74	$167.17	$176.53	$85.17	$90.61
$/lb Cu	$0.116	$0.061	$0.080	$0.194	$0.259	$0.106	$0.140
$/t	$45.74	$111.88	$147.14	$97.33	$129.77	$52.94	$70.17
$/km	$804,652	$5.34	$5.16	$5.88	$5.76	$3.20	$3.12
$/t-km	$0.17	$0.18	$0.17	$0.15	$0.15	$0.08	$0.08
PV	$220,072,418	$115,349,895	$151,709,006	$367,976,192	$490,599,043	$400,268,896	$530,582,204
Year 0	$169,657,868	$3,109,676	$3,588,088	$10,668,083	$12,864,454	$11,295,618	$13,178,221
1	$3,667,188	$6,801,871	$8,829,142	$21,072,583	$27,597,802	$23,438,378	$30,640,990
2	$3,667,188	$7,197,916	$9,451,781	$22,503,031	$29,836,290	$24,805,159	$32,794,537
3	$3,667,188	$7,593,961	$10,074,421	$23,933,479	$32,074,778	$26,171,940	$34,948,083
4	$3,667,188	$7,990,006	$10,697,060	$25,363,927	$34,313,266	$27,538,721	$37,101,630
5	$3,667,188	$10,198,242	$13,410,689	$31,729,800	$42,503,296	$34,131,246	$45,351,877
6	$3,667,188	$7,354,787	$9,698,406	$23,789,359	$31,849,247	$26,034,235	$34,731,110
7	$3,667,188	$7,750,833	$10,321,045	$25,219,808	$34,087,735	$27,401,016	$36,884,656
8	$3,667,188	$9,565,927	$12,581,050	$32,799,952	$43,742,033	$35,279,239	$46,634,886
9	$3,667,188	$7,658,256	$10,175,502	$23,733,862	$31,762,399	$25,981,207	$34,647,558
10	$3,667,188	$9,866,492	$12,889,130	$30,099,735	$39,952,429	$32,573,732	$42,897,805
11	$3,667,188	$7,023,038	$9,176,847	$22,159,294	$29,298,380	$24,476,721	$32,277,038
12	$3,667,188	$7,419,083	$9,799,487	$23,589,742	$31,536,868	$25,843,502	$34,430,585
13	$3,667,188	$7,815,128	$10,422,126	$25,020,190	$33,775,356	$27,210,283	$36,584,131
14	$3,667,188	$8,211,173	$11,044,766	$26,450,638	$36,013,844	$28,577,064	$38,737,678
15	$3,667,188	$10,419,408	$13,758,394	$32,816,511	$44,203,874	$35,169,588	$46,987,925
16	$3,667,188	$8,995,004	$11,683,476	$31,025,766	$40,965,635	$33,584,020	$43,963,841
17	$3,667,188	$7,087,333	$9,277,929	$21,959,676	$28,986,001	$24,285,988	$31,976,513
18	$3,667,188	$7,483,378	$9,900,568	$23,390,124	$31,224,489	$25,652,769	$34,130,059
19	$3,667,188	$7,879,423	$10,523,208	$24,820,572	$33,462,977	$27,019,550	$36,283,606
20	$3,667,188	$10,087,658	$13,236,836	$31,186,445	$41,653,007	$33,612,074	$44,533,853
21	$3,667,188	$7,244,204	$9,524,553	$23,246,004	$30,998,958	$25,515,063	$33,913,086
22	$3,667,188	$7,640,249	$10,147,192	$24,676,452	$33,237,446	$26,881,844	$36,066,632
23	$3,667,188	$8,036,294	$10,769,832	$26,106,900	$35,475,934	$28,248,625	$38,220,179
24	$3,667,188	$9,851,389	$13,029,836	$33,687,045	$45,130,232	$36,126,849	$47,970,409
25	$3,667,188	$9,755,909	$12,715,278	$29,556,379	$39,102,140	$32,054,560	$42,079,781

Figure A-6
Net Present Value Analyses for Route 6

	Route Number	6					
	new mine road	Battle Ck + Wolverine Ck + Yukon R to Carmacks					
	paved roads used	Klondike Hwy	Klondike Hwy + Alaska Hwy + Haines Rd	Klondike Hwy	Klondike Hwy + Alaska Hwy + Haines Rd	Klondike Hwy	Klondike Hwy + Alaska Hwy + Haines Rd
	select truck type	tridem	tridem	tridem	tridem	tridem	tridem
	select logistics option	loaded in + empty out	loaded in + empty out	empty in + loaded out	empty in + loaded out	loaded in + loaded out	loaded in + loaded out
	select terminal	Skagway	Haines	Skagway	Haines	Skagway	Haines
	distance, km	563.5	790.5	563.5	790.5	563.5	790.5
	trips per year	2,489	2,489	9,126	9,126	9,126	9,126
	Road Cost + Maintenance	Supply Trucking		Bulk Trucking			
$/hr	n/a	$132.03	$141.63	$136.00	$144.66	$71.85	$77.27
$/lb Cu	$0.144	$0.056	$0.075	$0.204	$0.272	$0.115	$0.153
$/t	$56.70	$103.46	$138.38	$102.06	$136.54	$57.49	$76.78
$/km	$844,583	$5.53	$5.28	$5.46	$5.21	$3.07	$2.93
$/t-km	$0.18	$0.18	$0.18	$0.18	$0.17	$0.10	$0.10
PV	$272,800,179	$106,678,201	$142,682,160	$385,860,803	$516,203,157	$434,725,644	$580,548,886
Year 0	$188,993,846	$3,109,676	$3,827,294	$11,003,471	$12,917,118	$11,481,882	$13,395,529
1	$6,096,128	$6,392,962	$8,397,383	$23,069,881	$30,426,740	$26,628,477	$35,158,852
2	$6,096,128	$6,690,487	$8,896,376	$24,194,255	$32,303,977	$27,703,413	$36,965,592
3	$6,096,128	$6,988,012	$9,395,370	$25,318,629	$34,181,213	$28,778,348	$38,772,331
4	$6,096,128	$7,285,537	$9,894,363	$26,443,003	$36,058,449	$29,853,284	$40,579,070
5	$6,096,128	$9,395,252	$12,623,745	$33,979,743	$45,463,245	$37,619,383	$50,192,167
6	$6,096,128	$6,808,335	$9,094,025	$24,639,613	$33,047,540	$28,129,189	$37,681,231
7	$6,096,128	$7,105,860	$9,593,018	$25,763,987	$34,924,776	$29,204,124	$39,487,970
8	$6,096,128	$8,822,435	$11,838,535	$31,909,615	$42,696,527	$35,518,628	$47,407,540
9	$6,096,128	$7,036,313	$9,476,378	$25,501,163	$34,485,970	$28,952,857	$39,065,643
10	$6,096,128	$9,146,029	$12,205,759	$33,037,903	$43,890,766	$36,718,956	$48,678,740
11	$6,096,128	$6,559,112	$8,676,040	$23,697,774	$31,475,060	$27,228,762	$36,167,804
12	$6,096,128	$6,856,636	$9,175,033	$24,822,148	$33,352,297	$28,303,697	$37,974,543
13	$6,096,128	$7,154,161	$9,674,026	$25,946,522	$35,229,533	$29,378,633	$39,781,282
14	$6,096,128	$7,451,686	$10,173,020	$27,070,896	$37,106,769	$30,453,568	$41,588,022
15	$6,096,128	$9,561,402	$12,902,401	$34,607,636	$46,511,565	$38,219,668	$51,201,119
16	$6,096,128	$8,393,534	$11,119,205	$30,288,760	$39,990,374	$33,969,042	$44,803,013
17	$6,096,128	$6,607,413	$8,757,048	$23,880,308	$31,779,817	$27,403,270	$36,461,116
18	$6,096,128	$6,904,938	$9,256,041	$25,004,682	$33,657,053	$28,478,206	$38,267,855
19	$6,096,128	$7,202,463	$9,755,035	$26,129,056	$35,534,289	$29,553,141	$40,074,594
20	$6,096,128	$9,312,178	$12,484,416	$33,665,796	$44,939,085	$37,319,241	$49,687,692
21	$6,096,128	$6,725,261	$8,954,697	$24,325,667	$32,523,380	$27,829,046	$37,176,755
22	$6,096,128	$7,022,786	$9,453,690	$25,450,041	$34,400,616	$28,903,982	$38,983,495
23	$6,096,128	$7,320,311	$9,952,683	$26,574,415	$36,277,853	$29,978,917	$40,790,234
24	$6,096,128	$9,036,885	$12,198,200	$32,720,042	$44,049,604	$36,293,421	$48,709,803
25	$6,096,128	$9,062,954	$12,066,431	$32,723,957	$43,366,606	$36,418,814	$48,174,264

Note: All routes using the Battle Creek section are assumed to use tridem trucks because of steep grades.

Figure A-7
Net Present Value Analyses for Route 7

	Route Number	7					
	new mine road	Battle Ck + Hayes Ck to Minto					
	paved roads used	Klondike Hwy	Klondike Hwy + Alaska Hwy + Haines Rd	Klondike Hwy	Klondike Hwy + Alaska Hwy + Haines Rd	Klondike Hwy	Klondike Hwy + Alaska Hwy + Haines Rd
	select truck type	tridem	tridem	tridem	tridem	tridem	tridem
	select logistics option	loaded in + empty out	loaded in + empty out	empty in + loaded out	empty in + loaded out	loaded in + loaded out	loaded in + loaded out
	select terminal	Skagway	Haines	Skagway	Haines	Skagway	Haines
	distance, km	568.4	795.4	568.4	795.4	568.4	795.4
	trips per year	2,489	2,489	9,126	9,126	9,126	9,126
	Road Cost + Maintenance	Supply Trucking		Bulk Trucking			
$/hr	n/a	$132.75	$142.26	$136.77	$145.33	$72.26	$77.63
$/lb Cu	$0.126	$0.057	$0.076	$0.205	$0.273	$0.115	$0.154
$/t	$49.43	$103.91	$138.88	$102.52	$137.04	$57.76	$77.07
$/km	$1,130,449	$5.51	$5.26	$5.44	$5.19	$3.06	$2.92
$/t-km	$0.23	$0.18	$0.17	$0.18	$0.17	$0.10	$0.10
PV	$237,846,525	$107,138,623	$143,192,040	$387,577,501	$518,102,028	$436,766,929	$582,771,037
Year 0	$192,823,561	$3,109,676	$3,827,294	$11,003,471	$12,917,118	$11,481,882	$13,395,529
1	$3,275,000	$6,414,228	$8,419,755	$23,148,492	$30,509,426	$26,732,819	$35,267,239
2	$3,275,000	$6,717,182	$8,925,283	$24,293,408	$32,411,280	$27,827,355	$37,097,625
3	$3,275,000	$7,020,135	$9,430,811	$25,438,324	$34,313,133	$28,921,891	$38,928,011
4	$3,275,000	$7,323,089	$9,936,340	$26,583,240	$36,214,986	$30,016,428	$40,758,396
5	$3,275,000	$9,438,232	$12,672,256	$34,140,522	$45,644,398	$37,802,128	$50,395,140
6	$3,275,000	$6,837,180	$9,125,520	$24,746,903	$33,164,593	$28,260,895	$37,822,631
7	$3,275,000	$7,140,133	$9,631,048	$25,891,819	$35,066,446	$29,355,431	$39,653,016
8	$3,275,000	$8,862,137	$11,883,100	$32,057,989	$42,862,814	$35,689,536	$47,596,232
9	$3,275,000	$7,069,318	$9,512,880	$25,624,194	$34,621,886	$29,099,582	$39,225,161
10	$3,275,000	$9,184,461	$12,248,797	$33,181,475	$44,051,298	$36,885,282	$48,861,905
11	$3,275,000	$6,583,409	$8,702,061	$23,787,857	$31,571,493	$27,344,049	$36,289,396
12	$3,275,000	$6,886,362	$9,207,589	$24,932,773	$33,473,346	$28,438,586	$38,119,782
13	$3,275,000	$7,189,316	$9,713,118	$26,077,689	$35,375,199	$29,533,122	$39,950,167
14	$3,275,000	$7,492,269	$10,218,646	$27,222,605	$37,277,052	$30,627,658	$41,780,553
15	$3,275,000	$9,607,413	$12,954,562	$34,779,887	$46,706,465	$38,413,359	$51,417,296
16	$3,275,000	$8,425,410	$11,154,349	$30,407,521	$40,121,175	$34,111,694	$44,957,617
17	$3,275,000	$6,632,591	$8,784,130	$23,973,726	$31,880,246	$27,521,740	$36,586,547
18	$3,275,000	$6,935,545	$9,289,658	$25,118,642	$33,782,099	$28,616,276	$38,416,932
19	$3,275,000	$7,238,498	$9,795,187	$26,263,558	$35,683,952	$29,710,812	$40,247,318
20	$3,275,000	$9,353,642	$12,531,103	$33,820,840	$45,113,365	$37,496,513	$49,884,061
21	$3,275,000	$6,752,589	$8,984,367	$24,427,221	$32,633,560	$27,955,280	$37,311,553
22	$3,275,000	$7,055,543	$9,489,895	$25,572,137	$34,535,413	$29,049,816	$39,141,938
23	$3,275,000	$7,358,497	$9,995,424	$26,717,053	$36,437,266	$30,144,352	$40,972,324
24	$3,275,000	$9,080,500	$12,247,475	$32,883,223	$44,233,634	$36,478,457	$48,915,539
25	$3,275,000	$9,099,871	$12,107,644	$32,861,793	$43,520,265	$36,579,667	$48,350,827

Note: All routes using the Battle Creek section are assumed to use tridem trucks because of steep grades.

Figure A-8
Cycle Time Analyses, Part 1

Cycle Time Analysis by Road Link Descriptions	One way distance in km	Drive to Terminal	Driving Break	Unload + Fuel + Inspect	back haul: wash + load	Overnight rest	Drive to Mine	Driving Break	Load + Fuel + Inspect	back haul: unload + wash	truck cycle time	back haul: truck cycle time	Driver duty hours per trip	back haul: Driver duty hours per trip
Route Description for Concentrate Shipments														
(Nisling R + Onion Ck) to (Alaska Hwy + Klondike Hwy to Skagway)	693.3	9.16	0.50	1.50	0.75	10.00	9.16	0.50	1.50	0.75	32.32	33.82	22.32	23.82
(Nisling R + Onion Ck) to (Alaska Hwy + Haines Rd to Haines)	604.3	8.13	0.50	1.50	0.75	10.00	8.13	0.50	1.50	0.75	30.25	31.75	20.25	21.75
(Nisling R + Aishihik Rd) to (Alaska Hwy + Klondike Hwy to Skagway)	622.5	8.80	0.50	1.50	0.75	10.00	8.80	0.50	1.50	0.75	31.60	33.10	21.60	23.10
(Nisling R + Aishihik Rd) to (Alaska Hwy + Haines Rd to Haines)	601.5	8.61	0.50	1.50	0.75	10.00	8.61	0.50	1.50	0.75	31.23	32.73	21.23	22.73
(Battle Ck + Wolverine Ck + Yukon R) to (Carmacks to Skagway)	563.5	9.31	0.50	1.50	0.75	10.00	9.31	0.50	1.50	0.75	32.61	34.11	22.61	24.11
(Battle Ck + Wolverine Ck + Yukon R) to (Carmacks to Haines)	790.5	12.22	0.50	1.50	0.75	10.00	12.22	0.50	1.50	0.75	38.44	39.94	28.44	29.94
(Battle Ck + Wolverine Ck) to (Minto to Skagway)	541.5	8.91	0.50	1.50	0.75	10.00	8.91	0.50	1.50	0.75	31.82	33.32	21.82	23.32
(Battle Ck + Wolverine Ck) to (Minto to Haines)	768.5	11.83	0.50	1.50	0.75	10.00	11.83	0.50	1.50	0.75	37.65	39.15	27.65	29.15
(Battle Ck + Hayes Ck) to (Klondike Hwy near Carmacks to Skagway)	568.4	9.29	0.50	1.50	0.75	10.00	9.29	0.50	1.50	0.75	32.59	34.09	22.59	24.09
(Battle Ck + Hayes Ck) to (Klondike Hwy near Carmacks to Haines)	795.4	12.21	0.50	1.50	0.75	10.00	12.21	0.50	1.50	0.75	38.42	39.92	28.42	29.92
(Nisling R + Klaza R) to (Carmacks to Skagway)	631.5	9.10	0.50	1.50	0.75	10.00	9.10	0.50	1.50	0.75	32.20	33.70	22.20	23.70
(Nisling R + Klaza R) to (Carmacks to Haines)	858.5	12.01	0.50	1.50	0.75	10.00	12.01	0.50	1.50	0.75	38.03	39.53	28.03	29.53
(Nisling R + East Route) to (Carmacks to Skagway)	638.5	9.07	0.50	1.50	0.75	10.00	9.07	0.50	1.50	0.75	32.15	33.65	22.15	23.65
(Nisling R + East Route) to (Carmacks to Haines)	865.5	11.99	0.50	1.50	0.75	10.00	11.99	0.50	1.50	0.75	37.98	39.48	27.98	29.48
Route Description for Supply Shipments from Haines														
Nisling R + Onion Ck to Alaska Hwy to Haines	604.3	8.13	0.50	2.00	0.50	10.00	8.13	0.50	2.00	0.50	31.25	32.25	21.25	22.25
Nisling R + Aishihik Rd to Alaska Hwy to Haines	601.5	8.61	0.50	2.00	0.50	10.00	8.61	0.50	2.00	0.50	32.23	33.23	22.23	23.23
Battle Ck + Wolverine Ck + Yukon R to Carmacks to Haines	790.5	12.22	0.50	2.00	0.50	10.00	12.22	0.50	2.00	0.50	39.44	40.44	29.44	30.44
Battle Ck + Wolverine Ck to Minto to Haines	768.5	11.83	0.50	2.00	0.50	10.00	11.83	0.50	2.00	0.50	38.65	39.65	28.65	29.65
Battle Ck + Hayes Ck to Minto to Haines	795.4	12.21	0.50	2.00	0.50	10.00	12.21	0.50	2.00	0.50	39.42	40.42	29.42	30.42
Nisling R + Klaza R to Carmacks to Haines	858.5	12.01	0.50	2.00	0.50	10.00	12.01	0.50	2.00	0.50	39.03	40.03	29.03	30.03
Nisling R + East Route to Carmacks to Haines	865.5	11.99	0.50	2.00	0.50	10.00	11.99	0.50	2.00	0.50	38.98	39.98	28.98	29.98
Route Description for Supply Shipments from Skagway														
Nisling R + Onion Ck to Alaska Hwy to Skagway	693.3	9.16	0.50	2.00	0.50	10.00	9.16	0.50	2.00	0.50	33.32	34.32	23.32	24.32
Nisling R + Aishihik Rd to Alaska Hwy to Skagway	622.5	8.80	0.50	2.00	0.50	10.00	8.80	0.50	2.00	0.50	32.60	33.60	22.60	23.60
Battle Ck + Wolverine Ck + Yukon R to Carmacks to Skagway	563.5	9.31	0.50	2.00	0.50	10.00	9.31	0.50	2.00	0.50	33.61	34.61	23.61	24.61
Battle Ck + Wolverine Ck to Minto to Skagway	541.5	8.91	0.50	2.00	0.50	10.00	8.91	0.50	2.00	0.50	32.82	33.82	22.82	23.82
Battle Ck + Hayes Ck to Minto to Skagway	568.4	9.29	0.50	2.00	0.50	10.00	9.29	0.50	2.00	0.50	33.59	34.59	23.59	24.59
Nisling R + Klaza R to Carmacks to Skagway	631.5	9.10	0.50	2.00	0.50	10.00	9.10	0.50	2.00	0.50	33.20	34.20	23.20	24.20
Nisling R + East Route to Carmacks to Skagway	638.5	9.07	0.50	2.00	0.50	10.00	9.07	0.50	2.00	0.50	33.15	34.15	23.15	24.15

Figure A-9
Cycle Time Analyses, Part 2

Cycle Time Analysis by Road Link Descriptions	back haul: Driver duty hours per trip	Driver Cost per trip	back haul: Driver Cost per trip	Driver Cost per Tonne B-train	Driver Cost per Tonne tridem	Kms per truck per year	back haul: kms per truck per year	B-train units in fleet	tridem units in fleet	back haul: B-train units in fleet	back haul: tridem units in fleet	Op Days per year	B-train licensing cost/yr	tridem licensing cost/yr	back haul: B-train licensing cost/yr	back haul: tridem licensing cost/yr
Route Description for Concentrate Shipments																
(Nisling R + Onion Ck) to (Alaska Hwy + Klondike Hwy to Skagway)	23.82	$904.51	$955.21	$23.72	$30.02	146,584	140,083	35	44	36	46	335	$61,320	$77,088	$63,072	$80,592
(Nisling R + Onion Ck) to (Alaska Hwy + Haines Rd to Haines)	21.75	$834.50	$885.20	$21.89	$27.69	136,515	130,066	32	41	34	43	335	$56,064	$71,832	$59,568	$75,336
(Nisling R + Aishihik Rd) to (Alaska Hwy + Klondike Hwy to Skagway)	23.10	$880.08	$930.78	$23.08	$29.21	134,625	128,524	34	43	35	45	335	$59,568	$75,336	$61,320	$78,840
(Nisling R + Aishihik Rd) to (Alaska Hwy + Haines Rd to Haines)	22.73	$867.53	$918.23	$22.75	$28.79	131,631	125,598	33	42	35	44	335	$57,816	$73,584	$61,320	$77,088
(Battle Ck + Wolverine Ck + Yukon R) to (Carmacks to Skagway)	24.11	$914.36	$965.06	$23.98	$30.34	112,789	107,830	37	46	38	48	320	$64,824	$80,592	$66,576	$84,096
(Battle Ck + Wolverine Ck + Yukon R) to (Carmacks to Haines)	29.94	$1,111.37	$1,162.07	$29.15	$36.88	134,235	129,194	43	54	45	56	320	$75,336	$94,608	$78,840	$98,112
(Battle Ck + Wolverine Ck) to (Minto to Skagway)	23.32	$887.62	$938.32	$23.28	$29.46	111,080	106,080	36	45	37	47	320	$63,072	$78,840	$64,824	$82,344
(Battle Ck + Wolverine Ck) to (Minto to Haines)	29.15	$1,084.63	$1,135.33	$28.45	$35.99	133,241	128,136	42	53	44	55	320	$73,584	$92,856	$77,088	$96,360
(Battle Ck + Hayes Ck) to (Klondike Hwy near Carmacks to Skagway)	24.09	$913.49	$964.19	$23.96	$30.31	113,859	108,849	37	46	38	48	320	$64,824	$80,592	$66,576	$84,096
(Battle Ck + Hayes Ck) to (Klondike Hwy near Carmacks to Haines)	29.92	$1,110.50	$1,161.20	$29.12	$36.85	135,158	130,079	43	54	45	56	320	$75,336	$94,608	$78,840	$98,112
(Nisling R + Klaza R) to (Carmacks to Skagway)	23.70	$900.41	$951.11	$23.61	$29.88	134,021	128,056	34	44	36	46	335	$59,568	$77,088	$63,072	$80,592
(Nisling R + Klaza R) to (Carmacks to Haines)	29.53	$1,097.41	$1,148.11	$28.78	$36.42	154,273	148,419	41	51	42	53	335	$71,832	$89,352	$73,584	$92,856
(Nisling R + East Route) to (Carmacks to Skagway)	23.65	$898.58	$949.28	$23.57	$29.82	135,734	129,683	34	43	36	45	335	$59,568	$75,336	$63,072	$78,840
(Nisling R + East Route) to (Carmacks to Haines)	29.48	$1,095.59	$1,146.29	$28.73	$36.36	155,752	149,833	41	51	42	53	335	$71,832	$89,352	$73,584	$92,856
Route Description for Supply Shipments from Haines																
Nisling R + Onion Ck to Alaska Hwy to Haines	22.25	$868.30	$902.10	$22.77	$28.81	132,147	128,050	9	12	10	12	335	$15,768	$21,024	$17,520	$21,024
Nisling R + Aishihik Rd to Alaska Hwy to Haines	23.23	$901.33	$935.13	$23.64	$29.91	127,546	123,708	10	12	10	13	335	$17,520	$21,024	$17,520	$22,776
Battle Ck + Wolverine Ck + Yukon R to Carmacks to Haines	30.44	$1,145.17	$1,178.97	$30.03	$38.00	130,832	127,597	12	16	13	16	320	$21,024	$28,032	$22,776	$28,032
Battle Ck + Wolverine Ck to Minto to Haines	29.65	$1,118.43	$1,152.23	$29.33	$37.11	129,794	126,521	12	15	12	16	320	$21,024	$26,280	$21,024	$28,032
Battle Ck + Hayes Ck to Minto to Haines	30.42	$1,144.30	$1,178.10	$30.01	$37.97	131,729	128,470	12	16	13	16	320	$21,024	$28,032	$22,776	$28,032
Nisling R + Klaza R to Carmacks to Haines	30.03	$1,131.21	$1,165.01	$29.67	$37.54	150,320	146,565	12	15	12	15	335	$21,024	$26,280	$21,024	$26,280
Nisling R + East Route to Carmacks to Haines	29.98	$1,129.39	$1,163.19	$29.62	$37.48	151,756	147,959	12	15	12	15	335	$21,024	$26,280	$21,024	$26,280
Route Description for Supply Shipments from Skagway																
Nisling R + Onion Ck to Alaska Hwy to Skagway	24.32	$938.31	$972.11	$24.61	$31.14	142,185	138,042	10	13	10	13	335	$17,520	$22,776	$17,520	$22,776
Nisling R + Aishihik Rd to Alaska Hwy to Skagway	23.60	$913.88	$947.68	$23.97	$30.33	130,495	126,612	10	12	10	13	335	$17,520	$21,024	$17,520	$22,776
Battle Ck + Wolverine Ck + Yukon R to Carmacks to Skagway	24.61	$948.16	$981.96	$24.87	$31.46	109,433	106,272	11	13	11	14	320	$19,272	$22,776	$19,272	$24,528
Battle Ck + Wolverine Ck to Minto to Skagway	23.82	$921.42	$955.22	$24.16	$30.58	107,695	104,511	10	13	11	13	320	$17,520	$22,776	$19,272	$22,776
Battle Ck + Hayes Ck to Minto to Skagway	24.59	$947.29	$981.09	$24.84	$31.44	110,470	107,276	11	13	11	14	320	$19,272	$22,776	$19,272	$24,528
Nisling R + Klaza R to Carmacks to Skagway	24.20	$934.21	$968.01	$24.50	$31.00	129,985	126,184	10	13	10	13	335	$17,520	$22,776	$17,520	$22,776
Nisling R + East Route to Carmacks to Skagway	24.15	$932.38	$966.18	$24.45	$30.94	131,639	127,784	10	13	10	13	335	$17,520	$22,776	$17,520	$22,776

Note: Truck fleet requirements are shown highlighted.

B Appendix B - Physical Conditions and Grades of Alternative Mine Road Routes

WESTERN COPPER CORPORATION

CASINO GOLD PROJECT - CONCENTRATE HANDLING & HAULAGE TO PORT

ROUTE 1

ESTIMATED SITE CONDITIONS - CASINO MINE SITE TO ALASKAN HIGHWAY INTERSECTION
(MINE ACCESS - NISLING RIVER - ONION CREEK ROUTES)

KM MARKER	km SECTION	ADVERSE ROAD GRADES (%)	FAVORABLE ROAD GRADES (%)	ESTIMATED SPEED (km / hr)	SOIL CONDITION (km) DRY	SOIL CONDITION (km) WET	TIMBER	ROAD WORKS APPROX. SIDE SLOPE (%)	ROAD WORKS APPROX. AREA (sq. m.)	ROAD WORKS EST. ROCK VOLUME (cu. m.)	ROAD WORKS EST. O.M. VOLUME (cu. m.)	CREEK CROSSINGS NUMBER	CREEK CROSSINGS REQD SPAN (m)	CREEK CROSSINGS TOTAL LENGTH (m)	COMMENTS & NOTES
MINE SITE															Edit Date:
TO															November 22, 2007
ALASKAN HWY															
															START OF MINE ACCESS ROUTE
0 - 10	0 - 4		8-12	35	4.0		4.0					0			
	4 - 10		2-4	35	6.0		6.0					3	12	36	START OF PROPOSED ROAD
SUB-TOTAL (kms)	10														END OF MINE ACCESS ROUTE
EXISTING ROAD															
UPGRADE															
															START OF NISLING RIVER ROUTE
10 - 20	10 - 10.5		2-4	70	0.5		0.5				2,160	1	24	24	DIP CREEK CROSSING AT CASINO CREEK TRIBUTARY
	10.5 - 11.0		2-4	70		0.5									
	11.0 - 20		2-4	70	9.0		9.0				38,880	7	12	84	
20 - 30	20 - 30		2-4	70	10.0		10.0				43,200	11	12	132	
30 - 40	30 - 35		2-4	70	5.0		5.0				21,600	1	24	24	DIP CREEK CROSSING
												1	12	12	
	35 - 38.5		2-4	70		3.5						2	12	24	
	38.5 - 40		2-4	70	1.5		1.5				6,480	1	24	24	DIP CREEK CROSSING
												1	24	24	KLOTASSIN RIVER CROSSING
40 - 50	40 - 41		2-4	70		1.0						1	12	12	
	41 - 43.5	2-4		70	2.5		2.5				10,800				
	43.5	2-4		70											SUMMIT PASS AT 43.5 km MARKER - ELEV. 625 m
	43.5 - 50		2-4	70	6.5		6.5				28,080	1	12	12	
50 - 60	50 - 51	2-4		70		1.0		45	50	24,500		1	50	50	NISLING RIVER CROSSING
												3	12	36	NISLING RIVER TRIBUTARIES
	51 - 60	2-4		70	9.0		9.0				38,880	2	12	24	
60 - 70	60 - 69	2-4		70	9.0		9.0				38,880				
	69 - 69.5	-		70		0.5						1	12	12	
	69.5 - 70	2-4		70	0.5		0.5				2,160				
70 - 80	70 - 76	2-4		70	6.0		6.0				25,920	2	50	100	NISLING RIVER CROSSINGS
												2	12	24	
	76 - 80	2-4		70		4.0									
80 - 90	80 - 90	2-4		70	10.0		10.0				43,200	1	12	12	
												2	50	100	NILSING RIVER CROSSINGS
															END OF NISLING RIVER ROUTE
SUB-TOTAL	90				69.5	10.5	69.5			24,500	300,240	39		630	SUB TOTALS
															START OF ONION CREEK ROUTE
90 - 100	90 - 100	2-4		70	10.0		10.0				43,200	3	12	36	
100 - 110	100 - 104	2-4		70	4.0		4.0	10	25		100,000	3	12	36	
	104 - 109.5	2-4		70	5.5		5.5	20	40		220,000				
	109.5 - 110	2-4		70	0.5		0.5	50	60	21,000					
110 - 120	110 - 110.5	2-4		70	0.5		0.5	50	60	21,000					
	110.5 - 120	2-4		70	9.5		9.5				41,040	4	12	48	
120 - 130	120 - 130	2-4		70	10.0		10.0	20	40		400,000	3	12	36	
130 - 140	130 - 140	2-4		70	10.0		10.0	25	50		500,000	4	12	48	
140 - 150	140 - 150	2-4		70	10.0		10.0	10	25		250,000	4	24	96	
150 - 160	150 - 160	2-4		70	10.0		10.0	10	25		250,000	1	200	200	KLUANE RIVER CROSSING
160 - 170	160 - 170	2-4		70	10.0		10.0	20	40		400,000	3	12	36	
												1	24	24	MARKER 161.5 km
170 - 180	170 - 180	2-4		70	10.0		10.0	20	40		400,000	4	12	48	
												1	24	24	MARKER 169.5 km
180 - 187.3	180 - 187.3	2-4		70	7.3		7.3	10	25		182,500	1	24	24	MARKER 171.0 km
															END OF ONION CREEK ROUTE
SUB-TOTAL	187.3				97.3	0.0	97.3			42,000	2,786,740	111		656	SUB TOTALS
TOTAL	177.3				166.8	10.5	166.8			66,500	3,086,980	150		1,286	TOTAL
NEW ROAD CONSTRUCTION															
										3,153,480					TOTAL EXCAVATION (EST.)
TOTAL (kms)	187.3														ROUTE 1 - ONION CREEK ROUTE TO THE INTERSECTION OF ALASKAN HIGHWAY

PRELIMINARY

WESTERN COPPER CORPORATION

CASINO GOLD PROJECT - CONCENTRATE HANDLING & HAULAGE TO PORT

ROUTE 2

ESTIMATED SITE CONDITIONS - CASINO MINE SITE TO ALASKAN HIGHWAY & AISHIHIK ROAD INTERSECTION
(MINE ACCESS - NISLING RIVER - AISHIHIK ROAD ROUTES)

KM MARKER	km SECTION	ADVERSE ROAD GRADES (%)	FAVORABLE ROAD GRADES (%)	ESTIMATED SPEED (km / hr)	SOIL CONDITION (km) DRY	SOIL CONDITION (km) WET	TIMBER	CREEK CROSSINGS NUMBER	CREEK CROSSINGS REQ'D SPAN (m)	CREEK CROSSINGS TOTAL LENGTH (m)	COMMENTS & NOTES
MINE SITE											Edit Date
TO											November 22, 2007
ALASKAN HWY											
		>									
0 - 10	0 - 4		9-12	35	4.0		4.0	0			START OF MINE ACCESS ROUTE
	4 - 10		0-4	35	6.0		6.0	3	12	36	START OF PROPOSED ROAD
SUB-TOTAL (kms)	10										END OF MINE ACCESS ROUTE
EXISTING ROAD UPGRADE											
											START OF NISLING RIVER ROUTE
10 - 20	10 - 10.5		2-4	70	0.5		0.5	1	24	24	DIP CREEK CROSSING AT CASINO CREEK TRIBUTARY
	10.5 - 11.0		2-4	70		0.5					
	11.0 - 20		2-4	70	9.0		9.0	7	12	84	
20 - 30	20 - 30		2-4	70	10.0		10.0	11	12	132	
30 - 40	30 - 35		2-4	70	5.0		5.0	1	24	24	DIP CREEK CROSSING
								1	12	12	
	35 - 38.5		2-4	70		3.5		2	12	24	
	38.5 - 40		2-4	70	1.5		1.5	1	24	24	DIP CREEK CROSSING
								1	24	24	KLOTASSIN RIVER CROSSING
40 - 50	40 - 41		2-4	70		1.0		1	12	12	
	41 - 43.5	2-4		70	2.5		2.5				
	43.5	2-4		70							SUMMIT PASS AT 43.5 km MARKER - ELEV. 825 m
	43.5 - 50		2-4	70	6.5		6.5	1	12	12	
50 - 60	50 - 51	2-4		70		1.0		1	50	50	NISLING RIVER CROSSING
								3	12	36	NISLING RIVER TRIBUTARIES
	51 - 60	2-4		70	9.0		9.0	2	12	24	
60 - 70	60 - 69	2-4		70	9.0		9.0				
	69 - 69.5	2-4		70		0.5		1	12	12	
	69.5 - 70	2-4		70	0.5		0.5				
70 - 80	70 - 76	2-4		70	6.0		6.0	2	50	100	NISLING RIVER CROSSINGS
								2	12	24	
	76 - 80	2-4		70		4.0					
80 - 90	80 - 90	2-4		70	10.0		10.0	1	12	12	
								2	50	100	NILSING RIVER CROSSINGS
90 - 100	90 - 100	2-4		70	10.0		10.0	3	12	36	
								1	24	24	ONION CREEK CROSSING
100 - 110	100 - 107	2-4		70	7.0		7.0	2	12	24	
	107 - 109.5	2-4		70		2.5					
	109.5 - 110	2-4		70	0.5		0.5	1	12	12	
110 - 120	110 - 117.5	2-4		70	7.5		7.5	1	12	12	
	117.5 - 119	2-4		70		1.5					
	119 - 120	2-4		70	1.0		1.0	2	12	24	
120 - 124.3	120 - 124.3	2-4		70	4.3		4.3	2	12	24	
	124.3										ROUTE INTERSECTION
124.3 - 130	124.3 - 130	2-4		70	5.7		5.7	5	12	60	
130 - 140	130 - 133	2-4		70	3.0		3.0	1	12	12	
	133 - 133.5	2-4		70		0.5					
	133.5 - 138	2-4		70	4.5		4.5	1	12	12	
	138 - 140	2-4		70		2.0		1	24	24	NISLING RIVER CROSSING
140 - 150	140 - 142	2-4		70		2.0		1	24	24	NISLING RIVER CROSSING
	142 - 143	2-4		70	1.0		1.0				
	143 - 143.5	2-4		70		0.5		2	12	24	
	143.5 - 150	2-4		70	6.5		6.5				
150 - 160	150 - 152	4-8		70	2.0		2.0	1	12	12	
								1	24	24	BIRCH CREEK CROSSING
	152 - 160	2-4		70	8.0		8.0	3	12	36	
								1	24	24	TYRELL CREEK CROSSING
160 - 170	160 - 170	2-4		70	10.0		10.0	5	12	60	
170 - 180	170 - 180	2-4		70	10.0		10.0	2	12	24	
180 - 185.7	180 - 185.7	2-4		70	5.7		5.7	3	12	36	
											END OF NISLING RIVER ROUTE
SUB-TOTAL	175.7				156.2	19.5	156.2	89		1,258	SUB TOTALS
											START OF AISHIHIK ROAD ROUTE
185.7 - 190	185.7 - 190	2-4		70	4.3		4.3	2	12	24	
190 - 200	190 - 196	2-4		70	6.0		6.0	2	12	24	
	196 - 197	2-4		70		1.0					
	197 - 200	2-4		70	3.0		3.0	4	12	48	
200 - 210 (INTERSECTION)	200 - 210	2-4		70	10.0		10.0	6	12	72	END OF AISHIHIK ROAD ROUTE
SUB-TOTAL	24.3				23.3	1.0	23.3	14		168	SUB TOTALS
TOTAL NEW ROAD CONSTRUCTION	200.0				179.5	20.5	179.5	94		1426	TOTAL
											TOTAL EXCAVATION (EST.)
											START OF EXISTING AISHIHIK ROAD
210 - 323 (EXISITNG ROAD)	210 - 323	+	2-6	65	113.0		113.0				GRAVEL ROAD TO BE UPGRADED
SUB-TOTAL (kms) EXISTING ROAD UPGRADE	113										END OF EXISTING AISHIHIK ROAD (INTERSECTION TO ALASKAN HIGHWAY)
TOTAL (kms)	323										ROUTE 2 - AISHIHIK ROAD ROUTE TO INTERSECTION OF AISHIHIK ROAD & ALASKAN HIGHWAY

PRELIMINARY

WESTERN COPPER CORPORATION

CASINO GOLD PROJECT - CONCENTRATE HANDLING & HAULAGE TO PORT

ROUTE 3

ESTIMATED SITE CONDITIONS - CASINO MINE SITE TO CARMACKS - EAST ROUTE
(MINE ACCESS - NISLING RIVER - EAST ROUTES)

KM MARKER	km SECTION	ADVERSE ROAD GRADES (%)	FAVORABLE ROAD GRADES (%)	ESTIMATED SPEED (km / hr)	SOIL CONDITION (km) DRY	WET	TIMBER	CREEK CROSSINGS NUMBER	REQ'D SPAN (m)	TOTAL LENGTH (m)	COMMENTS & NOTES
											Edit Date: November 22, 2007
MINE TO CARMACKS											
											START OF MINE ACCESS ROUTE
0 - 10	0 - 4		8-12	35	4.0		4.0	0			
	4 - 10		2-4	35	6.0		6.0	3	12	36	START OF PROPOSED ROAD
											END OF MINE ACCESS ROUTE
SUB-TOTAL (kms)	10										
EXISTING ROAD UPGRADE											
											START OF NISLING RIVER ROUTE
10 - 20	10 - 10.5		2-4	70	0.5		0.5	1	24	24	DIP CREEK CROSSING AT CASINO CREEK TRIBUTARY
	10.5 - 11.0		2-4	70		0.5					
	11.0 - 20		2-4	70	9.0		9.0	7	12	84	
20 - 30	20 - 30		2-4	70	10.0		10.0	11	12	132	
30 - 40	30 - 35		2-4	70	5.0		5.0	1	24	24	DIP CREEK CROSSING
								1	12	12	
	35 - 38.5		2-4	70		3.5		2	12	24	
	38.5 - 40		2-4	70	1.5		1.5	1	24	24	DIP CREEK CROSSING
								1	24	24	KLOTASSIN RIVER CROSSING
40 - 50	40 - 41		2-4	70		1.0		1	12	12	
	41 - 43.5	2-4		70	2.5		2.5				
	43.5	2-4		70							SUMMIT PASS AT 43.5 km MARKER - ELEV. 625 m
	43.5 - 50		2-4	70	6.5		6.5	1	12	12	
50 - 60	50 - 51	2-4		70		1.0		1	50	50	NISLING RIVER CROSSING
								3	12	36	NISLING RIVER TRIBUTARIES
	51 - 60	2-4		70	9.0		9.0	2	12	24	
60 - 70	60 - 69	2-4		70	9.0		9.0				
	69 - 69.5	2-4		70		0.5		1	12	12	
	69.5 - 70	2-4		70	0.5		0.5				
70 - 80	70 - 76	2-4		70	6.0		6.0	2	50	100	NISLING RIVER CROSSINGS
								2	12	24	
	76 - 80	2-4		70		4.0					
80 - 90	80 - 90	2-4		70	10.0		10.0	1	12	12	
								1	50	50	NILSING RIVER CROSSING
90 - 100	90 - 100	2-4		70	10.0		10.0	3	12	36	
								1	24	24	ONION CREEK CROSSING
100 - 110	100 - 107	2-4		70	7.0		7.0	2	12	24	
	107 - 109.5	2-4		70		2.5					
	109.5 - 110	2-4		70	0.5		0.5	1	12	12	
110 - 120	110 - 117.5	2-4		70	7.5		7.5	1	12	12	
	117.5 - 119	2-4		70		1.5					
	119 - 120	2-4		70	1.0		1.0	2	12	24	
120 - 124.3	120 - 124.3	2-4		70	4.3		4.3	2	12	24	
	124.3									836	ROUTE INTERSECTION
124.3 - 130	124.3 - 130	2-4		70	5.7		5.7	5	12	60	
130 - 140	130 - 133	2-4		70	3.0		3.0	1	12	12	
	133 - 133.5	2-4		70		0.5					
	133.5 - 138	2-4		70	4.5		4.5	1	12	12	
	138 - 140	2-4		70		2.0		1	24	24	NISLING RIVER CROSSING
140 - 150	140 - 142	2-4		70		2.0		1	24	24	NISLING RIVER CROSSING
	142 - 143	2-4		70	1.0		1.0				
	143 - 143.5	2-4		70		0.5		2	12	24	
	143.5 -150	2-4		70	6.5		6.5				
150 - 160	150 - 152	4-8		70	2.0		2.0	1	12	12	
								1	24	24	BIRCH CREEK CROSSING
	152 - 160	2-4		70	8.0		8.0	3	12	36	
								1	24	24	TYRELL CREEK CROSSING
160 - 170	160 - 170	2-4		70	10.0		10.0	5	12	60	
170 - 180	170 - 180	2-4		70	10.0		10.0	2	12	24	
180 - 185.7	180 - 185.7	2-4		70	5.7		5.7	3	12	36	
											END OF NISLING RIVER ROUTE
SUB-TOTAL	175.7				155.2	19.5	156.2	79		2,044	SUB TOTALS
											START OF EAST ROUTE
185.7 - 190	185.7 - 190	2-4		70	4.3		4.3	5	12	60	
190 - 200	190 - 196.5	2-4		70	6.5		6.5	1	12	12	
	196.5 - 197	2-4		70		0.5					
	197 - 200	2-4		70	3.0		3.0	1	12	12	
200 - 210	200 - 210	2-4		70	10.0		10.0	2	12	24	
210 - 220	210 - 212	2-4		70	2.0		2.0	2	12	24	
	212 - 213	2-4		70		1.0					
	213 - 216	2-4		70	3.0		3.0	1	12	12	
	216 - 220	2-4		70		4.0					
220 - 230.1	220 - 221	2-4		70		1.0					
	221 - 225.5	2-4		70	4.5		4.5	1	12	12	
	225.5 - 226	2-4		70		0.5					
	226 - 230.1	2-4		70	4.1		4.1	2	12	24	
											END OF EAST ROUTE
SUB-TOTAL	44.4				37.4	7.0	37.4	15		180	SUB TOTAL
TOTAL	220.1				192.6	26.5	193.6	94		2,224	TOTAL
NEW ROAD CONSTRUCTION											
											TOTAL EXCAVATION (EST.)
											START OF EXISTING ROAD
230.1 - 280.5 (CARMACKS)	230.1 - 280.5	2-6		50	50.4		50.4	19	0	0	EXISTING CREEK CROSSINGS
SUB-TOTAL (kms)	50.4										END OF EXISTING ROAD
EXISTING ROAD UPGRADE											
TOTAL (kms)	280.5										ROUTE 3 - EAST ROUTE TO CARMACKS

PRELIMINARY

WESTERN COPPER CORPORATION

CASINO GOLD PROJECT - CONCENTRATE HANDLING & HAULAGE TO PORT

ROUTE 4

ESTIMATED SITE CONDITIONS - CASINO MINE SITE TO MINTO - WOLVERINE CREEK ROUTE
(MINE ACCESS - BATTLE CREEK - WOLVERINE CREEK ROUTES)

KM MARKER	km SECTION	ADVERSE ROAD GRADES (%)	FAVORABLE ROAD GRADES (%)	ESTIMATED SPEED (km / hr)	SOIL CONDITION (km) DRY	SOIL CONDITION (km) WET	TIMBER	ROAD WORKS APPROX. SIDE SLOPE (%)	ROAD WORKS APPROX. AREA (sq. m.)	ROAD WORKS EST. ROCK VOLUME (cu. m.)	ROAD WORKS EST. O.M. VOLUME (cu. m.)	CREEK CROSSINGS NUMBER	CREEK CROSSINGS REQ'D SPAN (m)	CREEK CROSSINGS TOTAL LENGTH (m)	COMMENTS & NOTES Edit Date: November 22, 2007
MINE TO CARMACKS															
															START OF MINE ACCESS ROUTE
0 - 10	0 - 4		8-12	35	4.0		4.0					0			EXISTING MINE ACCESS ROAD FROM CASINO CREEK
	4 - 10		2-4	35	6.0		6.0					3	12	36	
															END OF MINE ACCESS ROUTE
SUB-TOTAL (kms)	10														
EXISTING ROAD UPGRADE															
															START OF BATTLE CREEK ROUTE
10 - 20	10 - 18	2-4		70		8.0						3	12	36	
												1	24	24	CASINO CREEK CROSSING
	18 - 20	2-4		70	2.0		2.0	45	50	70,000		1	12	12	ENVIRONMENTAL ISSUES MAY ARISE
												1	24	24	DIP CREEK CROSSING AT CASINO CREEK TRIBUTARY
20 - 30	20 - 21	8-12		10	1.0		1.0	45	50	35,000		1	24	24	RUDE CREEK CROSSING
	21 - 25	10-12		10	4.0		4.0	55	75	210,000		1	24	24	JENS CREEK CROSSING
	25 - 28	10-12		10	3.0		3.0	55	75	157,500					NUMEROUS SWITCHBACKS REQ'D TO ASCEND SUMMIT PASS
												1	24	24	TROMSLEY CREEK CROSSING
	28 - 30	10-12		10	2.0		2.0	55	75	105,000					
30 - 40	30 - 36	10-12		10	6.0		6.0	55	75	309,750					
	36	12-14		10				40	280	156,800					SUMMIT PASS (800m LONG) AT 36 km MARKER - ELEV. 1400 m
	36 - 40		10-12	35	4.0		4.0	50	60	147,000					
40 - 50	40 - 42		10-12	35	2.0		2.0	50	60	84,000					BATTLE CREEK RAVINE TO SELWYN RIVER BASIN
												1	24	24	BATTLE CREEK CROSSING
	42 - 46		12-14	35	4.0		4.0	50	60	168,000		1	12	12	STEEP, NARROW TERRAIN
	46 - 48		10-12	35	2.0		2.0	50	60	84,000		1	42	42	SELWYN CREEK CROSSING
	48 - 50		6-10	35	2.0		2.0	60	95	133,000					
50 - 60	50 - 51.5		4-8	35	1.5		1.5	60	95	99,750					
	51.5 - 52		2-4	70		0.5						1	12	12	RIVER MEANDERS THROUGH NARROW VALLEY
	52 - 56	2-4		70		4.0						5	12	60	ENVIRONMENTAL ISSUES MAY ARISE
	56 - 60	2-4		70		4.0						2	24	48	HAYES CREEK CROSSINGS
60 - 70	60 - 65	2-4		70		5.0						8	12	96	RIVER MEANDERS THROUGH NARROW VALLEY
	65 - 69	2-4		70		4.0									ENVIRONMENTAL ISSUES MAY ARISE
												3	24	72	HAYES CREEK CROSSINGS
												1	42	42	HAYES CREEK CROSSING - MAIN
															END OF BATTLE CREEK ROUTE
SUB-TOTAL	69.0				33.5	25.5	33.5			1,759,800	0	28		462	SUB TOTALS
															START OF WOLVERINE CREEK ROUTE
	69 - 70	2-4		70	1.0		1.0	60	95	66,500					SELKIRK CREEK RUNS INTO HAYES CREEK
70 - 80	70 - 80	2-4		70	10.0		10.0				43,200	5	12	60	SELKIRK CREEK VALLEY BASIN - MODERATE GRADES EXPECTED
															SUMMIT PASS AT 75 km MARKER - ELEV. 730 m
80 - 90	80 - 85	2-4		70	5.0		5.0				21,600	2	12	24	
	85 - 89	2-4		70		4.0						1	42	42	WOLVERINE CREEK CROSSING
	89 - 90	2-4		70	1.0		1.0				4,320				ENTERING WOLVERINE CREEK VALLEY BASIN
90 - 100	90 - 96	2-4		70	6.0		6.0				25,920	2	12	24	
	96 - 98			70		2.0						1	20	20	
	98 - 100	2-4		70	2.0		2.0				8,640	1	30	30	
100 - 110	100 - 108	2-4		70	8.0		8.0				34,560	5	12	60	
	108 - 110	2-4		70	2.0		2.0	45	50	70,000		1	12	12	
110 - 120	110 - 114		4-6	70	4.0		4.0	45	50	140,000		2	30	60	
												1	60	60	
	114 - 120		2-4	70	6.0		6.0	45	50	210,000		3	12	36	WOLVERINE CREEK RUNS INTO YUKON RIVER
120 - 130	120 - 125		2-4	70	5.0		5.0	45	50	175,000					YUKON RIVER DELTA - POTENTAIL WETTED AREAS
	125 - 130	2-4		70	5.0		5.0				21,600	1	120	120	BIG CREEK CROSSING
130 - 140	130 - 138	2-4		70	8.0		8.0				34,560				YUKON RIVER DELTA - POTENTIAL WETTED AREAS
															TURN-OFF TO MINTO - YUKON RIVER CROSSING REQ'D
															END OF WOLVERINE CREEK ROUTE
SUB-TOTAL	128.0				63.0	6.0	63.0			661,500	194,400	23		548	SUB TOTALS
TOTAL	138.0				96.5	31.5	96.5			2,421,300	194,400	51		1,010	TOTAL
NEW ROAD CONSTRUCTION															
										2,615,700					TOTAL EXCAVATION (EST.)
TOTAL (kms)	138.0														ROUTE 4 - WOLVERINE CREEK ROUTE TO MINTO

PRELIMINARY

WESTERN COPPER CORPORATION

CASINO GOLD PROJECT - CONCENTRATE HANDLING & HAULAGE TO PORT

ROUTE 5

ESTIMATED SITE CONDITIONS - CASINO MINE SITE TO CARMACKS - KLAZA RIVER ROUTE
(MINE ACCESS - NISLING RIVER - KLAZA RIVER ROUTES)

KM MARKER	km SECTION	ADVERSE ROAD GRADES (%)	FAVORABLE ROAD GRADES (%)	ESTIMATED SPEED (km / hr)	SOIL CONDITION (km) DRY	SOIL CONDITION (km) WET	TIMBER	ROAD WORKS APPROX. SIDE SLOPE (%)	ROAD WORKS APPROX. AREA (sq. m.)	ROAD WORKS EST. ROCK VOLUME (cu. m.)	ROAD WORKS EST. O.M. VOLUME (cu. m.)	CREEK CROSSINGS NUMBER	CREEK CROSSINGS REQ'D SPAN (m)	CREEK CROSSINGS TOTAL LENGTH (m)	COMMENTS & NOTES
															Edit Date:
MINE TO CARMACKS															November 22, 2007
0 - 10	0 - 4		8-12	35	4.0		4.0					0			START OF MINE ACCESS ROUTE
	4 - 10		2-4	35	6.0		6.0					3	12	36	START OF PROPOSED ROAD
SUB-TOTAL (kms)	10														END OF MINE ACCESS ROUTE
EXISTING ROAD UPGRADE															
															START OF NISLING RIVER ROUTE
10 - 20	10 - 10.5		2-4	70	0.5		0.5				2,160	1	24	24	DIP CREEK CROSSING AT CASINO CREEK TRIBUTARY
	10.5 - 11.0		2-4	70		0.5									
	11.0 - 20		2-4	70	9.0		9.0				38,880	7	12	84	
20 - 30	20 - 30		2-4	70	10.0		10.0				43,200	11	12	132	
30 - 40	30 - 35		2-4	70	5.0		5.0				21,600	1	24	24	DIP CREEK CROSSING
												1	12	12	
	35 - 38.5		2-4	70		3.5						2	12	24	
	38.5 - 40		2-4	70	1.5		1.5				6,480	1	24	24	DIP CREEK CROSSING
												1	24	24	KLOTASSIN RIVER CROSSING
40 - 50	40 - 41		2-4	70		1.0						1	12	12	
	41 - 43.5	2-4		70	2.5		2.5				10,800				
	43.5	2-4		70											SUMMIT PASS AT 43.5 km MARKER - ELEV. 825 m
	43.5 - 50		2-4	70	6.5		6.5				28,080	1	12	12	
50 - 60	50 - 51	2-4		70		1.0		45	50	24,500		1	50	50	NISLING RIVER CROSSING
												3	12	36	NISLING RIVER TRIBUTARIES
	51 - 60	2-4		70	9.0		9.0				38,880	2	12	24	
60 - 70	60 - 69	2-4		70	9.0		9.0				38,880				
	69 - 69.5	2-4		70		0.5						1	12	12	
	69.5 - 70	2-4		70	0.5		0.5				2,160				
70 - 80	70 - 76	2-4		70	6.0		6.0				25,920	2	50	100	NISLING RIVER CROSSINGS
												2	12	24	
	76 - 80	2-4		70		4.0									
80 - 90	80 - 90	2-4		70	10.0		10.0				43,200	1	12	12	
												2	50	100	NILSING RIVER CROSSINGS
90 - 100	90 - 100	2-4		70	10.0		10.0				43,200	3	12	36	
												1	24	24	ONION CREEK CROSSING
100 - 110	100 - 107	2-4		70	7.0		7.0				30,240	2	12	24	
	107 - 109.5	2-4		70		2.5		45	50	35,000					
	109.5 - 110	2-4		70	0.5		0.5				2,160	1	12	12	
110 - 120	110 - 117.5	2-4		70	7.5		7.5				32,400	1	12	12	
	117.5 - 119	2-4		70		1.5									
	119 - 120	2-4		70	1.0		1.0				4,320	2	12	24	
120 - 124.3	120 - 124.3	2-4		70	4.3		4.3				18,576	2	12	24	
															END OF NISLING RIVER ROUTE
SUB-TOTAL	124.3				99.8	14.5	99.8			59,500	431,136	53		866	SUB TOTALS
															START OF KLAZA RIVER ROUTE
124.3 - 130	124.3 - 130	2-4		70		5.7						1	60	60	NISLING RIVER CROSSING
												2	12	24	
130 - 140	130 - 138	2-4		70	8.0		8.0				34,560	3	12	36	
	138 - 140	2-4		70	2.0		2.0				8,640				
140 - 150	140 - 148	2-4		70		8.0						3	30	90	KLAZA RIVER CROSSINGS
												1	12	12	RIVER MEANDERS THROUGH NARROW VALLEY
															ENVIRONMENTAL ISSUES MAY ARISE
	148 - 150	2-4		70	2.0		2.0				8,640	1	12	12	
150 - 160	150 - 153	2-4		70	3.0		3.0	60	95	199,500		1	30	30	KLAZA RIVER CROSSINGS
	153 - 159	2-4		70		6.0						2	12	24	RIVER MEANDERS THROUGH NARROW VALLEY
	159 - 160	2-4		70	1.0		1.0	60	95	66,500					ENVIRONMENTAL ISSUES MAY ARISE
160 - 170	160 - 162	2-4		70		2.0						1	24	24	RIVER MEANDERS THROUGH NARROW VALLEY
	162 - 169	2-4		70	7.0		7.0	60	95	399,000		5	12	60	ENVIRONMENTAL ISSUES MAY ARISE
	169 - 170	2-4		70		1.0						1	30	30	KLAZA RIVER CROSSING
170 - 180	170 - 179	2-4		70		9.0						4	12	48	NARROW VALLEY
	179 - 180	2-4		70		1.0									
180 - 190	180 - 187	2-4		70	7.0		7.0	40	40	196,000		2	12	24	
	187 - 190	2-4				3.0						1	20	20	
190 - 200	190 - 19.5	2-4		70		0.5						1	12	12	
	19.5 - 196	2-4		70	5.5		5.5	30	30	115,500		2	12	24	
	197 - 200	2-4		70	4.0		4.0	40	40	112,000		1	12	12	
200 - 210	200 - 201	2-4				1.0									
	201 - 205	2-4		70	4.0		4.0	40	40	112,000		3	12	36	
	205 - 209	4-6		40	4.0		4.0	40	40	112,000		1	12	12	
	209 - 210	6-8		40	1.0		1.0	40	40	28,000		1	12	12	
210 - 220	210 - 213	8-10		40	3.0		3.0	40	40	84,000					
	213	10-12		40						42,000					SUMMIT PASS AT 213 km MARKER - ELEV. 1420 m
	213 - 216		8-10	45	3.0		3.0	30	30	63,000					
	216 - 219		6-8	45	3.0		3.0	30	30	63,000		1	12	12	
	219 - 220		4-6	45	1.0		1.0	30	30	21,000		1	12	12	
220 - 223.1	220 - 223.1		2-4	70	3.1		3.1	30	30	65,100					END OF PROPOSED ROUTE
															END OF KLAZA RIVER ROUTE
SUB-TOTAL	223.1				61.6	37.2	61.6			1,675,800	51,840	39		626	SUB TOTALS
TOTAL	213.1				161.4	51.7	161.4			1,735,100	482,976	92		1,512	TOTAL
NEW ROAD CONSTRUCTION															
										2,221,076					TOTAL EXCAVATION VOLUME (EST.)
															START OF EXISTING ROAD
223.1 - 273.5 (CARMACKS)	223.1 - 273.5	2-6		50	50.4		50.4					19	0	0	EXISTING CREEK CROSSINGS
SUB-TOTAL (kms)	50.4														END OF EXISTING ROAD
EXISTING ROAD UPGRADE															
TOTAL (kms)	273.5														ROUTE 5 - KLAZA RIVER ROUTE TO CARMACKS

PRELIMINARY

WESTERN COPPER CORPORATION

CASINO GOLD PROJECT - CONCENTRATE HANDLING & HAULAGE TO PORT

ROUTE 6

ESTIMATED SITE CONDITIONS - CASINO MINE SITE TO CARMACKS - YUKON ROVER ROUTE
(MINE ACCESS - BATTLE CREEK - WOLVERINE CREEK - YUKON RIVER ROUTES)

KM MARKER	km SECTION	ADVERSE ROAD GRADES (%)	FAVORABLE ROAD GRADES (%)	ESTIMATED SPEED (km/hr)	SOIL CONDITION (km) DRY	SOIL CONDITION (km) WET	TIMBER	ROAD WORKS APPROX. SIDE SLOPE (%)	ROAD WORKS APPROX. AREA (sq. m.)	ROAD WORKS EST. ROCK VOLUME (cu. m.)	ROAD WORKS EST. O.M. VOLUME (cu. m.)	CREEK CROSSINGS NUMBER	CREEK CROSSINGS REQ'D SPAN (m)	CREEK CROSSINGS TOTAL LENGTH (m)	COMMENTS & NOTES
															Edit Date: November 22, 2007
MINE TO CARMACKS															
															START OF MINE ACCESS ROUTE
0 - 10	0 - 4		8-12	35	4.0		4.0					0			EXISTING MINE ACCESS ROAD FROM CASINO CREEK
	4 - 10		2-4	35	6.0		6.0					3	12	36	
SUB-TOTAL (kms)	10														END OF MINE ACCESS ROUTE
EXISTING ROAD UPGRADE															
															START OF BATTLE CREEK ROUTE
10 - 20	10 - 18	2-4		70		8.0						3	12	36	
												1	24	24	CASINO CREEK CROSSING
	18 - 20	2-4		70	2.0		2.0	45	50	70,000		1	12	12	ENVIRONMENTAL ISSUES MAY ARISE
												1	24	24	DIP CREEK CROSSING AT CASINO CREEK TRIBUTARY
20 - 30	20 - 21	8-12		10	1.0		1.0	45	50	35,000		1	24	24	RUDE CREEK CROSSING
	21 - 25	10-12		10	4.0		4.0	55	75	210,000		1	24	24	JENS CREEK CROSSING
	25 - 28	10-12		10	3.0		3.0	55	75	157,500					NUMEROUS SWITCHBACKS REQ'D TO ASCEND SUMMIT PASS
												1	24	24	TROMBLEY CREEK CROSSING
	28 - 30	10-12		10	2.0		2.0	55	75	105,000					
30 - 40	30 - 36	10-12		10	6.0		6.0	55	75	309,750					
	36	12-14		10				40	280	156,800					SUMMIT PASS (800m LONG) AT 36 km MARKER - ELEV. 1400 m
	36 - 40		10-12	35	4.0		4.0	50	60	147,000					
40 - 50	40 - 42		10-12	35	2.0		2.0	50	60	84,000					BATTLE CREEK RAVINE TO SELWYN RIVER BASIN
												1	24	24	BATTLE CREEK CROSSING
	42 - 46		12-14	35	4.0		4.0	50	60	168,000		1	12	12	STEEP, NARROW TERRAIN
	46 - 48		10-12	35	2.0		2.0	50	60	84,000		1	42	42	SELWYN CREEK CROSSING
	48 - 50		6-10	35	2.0		2.0	60	95	133,000					
50 - 60	50 - 51.5		4-8	35	1.5		1.5	60	95	99,750					
	51.5 - 52		2-4	70		0.5						1	12	12	RIVER MEANDERS THROUGH NARROW VALLEY
	52 - 56	2-4		70		4.0						5	12	60	ENVIRONMENTAL ISSUES MAY ARISE
	56 - 60	2-4		70		4.0						2	24	48	HAYES CREEK CROSSINGS
60 - 70	60 - 65	2-4		70		5.0						8	12	96	RIVER MEANDERS THROUGH NARROW VALLEY
	65 - 69	2-4		70		4.0									ENVIRONMENTAL ISSUES MAY ARISE
												3	24	72	HAYES CREEK CROSSINGS
												1	42	42	HAYES CREEK CROSSING - MAIN
															END OF BATTLE CREEK ROUTE
SUB-TOTAL	69.0				33.5	25.5	33.5			1,759,800	0	28		462	SUB TOTALS
															START OF WOLVERINE CREEK ROUTE
	69 - 70	2-4		70	1.0		1.0	60	95	66,500					SELKIRK CREEK RUNS INTO HAYES CREEK
70 - 80	70 - 80	2-4		70	10.0		10.0				43,200	5	12	60	SELKIRK CREEK VALLEY BASIN - MODERATE GRADES EXPECTED
															SUMMIT PASS AT 75 km MARKER - ELEV. 730 m
80 - 90	80 - 85	2-4		70	5.0		5.0				21,600	2	12	24	
	85 - 89	2-4		70		4.0						1	42	42	WOLVERINE CREEK CROSSING
	89 - 90	2-4		70	1.0		1.0				4,320				ENTERING WOLVERINE CREEK VALLEY BASIN
90 - 100	90 - 96	2-4		70	6.0		6.0				25,920	2	12	24	
	96 - 98			70		2.0						1	20	20	
	98 - 100	2-4		70	2.0		2.0				8,640	1	30	30	
100 - 110	100 - 108	2-4		70	8.0		8.0				34,560	5	12	60	
	108 - 110	2-4		70	2.0		2.0	45	50	70,000		1	12	12	
110 - 120	110 - 114		4-6	70	4.0		4.0	45	50	140,000		2	30	60	
												1	60	60	
	114 - 120		2-4	70	6.0		6.0	45	50	210,000		3	12	36	WOLVERINE CREEK RUNS INTO YUKON RIVER
120 - 130	120 - 125		2-4	70	5.0		5.0	45	50	175,000					YUKON RIVER DELTA - POTENTAIL WETTED AREAS
	125 - 130	2-4		70	5.0		5.0				21,600	1	120	120	BIG CREEK CROSSING
130 - 140	130 - 138	2-4		70	8.0		8.0				34,560				YUKON RIVER DELTA - POTENTIAL WETTED AREAS
															TURN-OFF TO MINTO - YUKON RIVER CROSSING REQ'D
															END OF WOLVERINE CREEK ROUTE
SUB-TOTAL	138.0				63.0	6.0	63.0			661,500	194,400	23		548	SUB TOTALS
															START OF YUKON RIVER ROUTE
	138 - 140	2-4		70	2.0		2.0				8,640				
140 - 150	140 - 142	2-4		70	2.0		2.0				8,640	1	20	20	
	142 - 148	2-4		70	6.0		6.0	45	50	210,000					
	148 - 150	2-4		70	2.0		2.0				8,640				
150 - 160	150 - 152	2-4		70	2.0		2.0				8,640	1	20	20	
												1	60	60	HOOCHOKOO CREEK CROSSING
	152 - 160	2-4		70	8.0		8.0	40	40	224,000					
160 - 170	160 - 161	2-4		70	1.0		1.0	40	40	28,000					
	161 - 163	2-4		70	2.0		2.0	40	40	56,000					STEEP EMBANKMENTS
	163 - 170	2-4		70	7.0		7.0	40	40	196,000		1	60	60	WILLIAMS CREEK CROSSING
												1	60	60	MERRICE CREEK CROSSING
170 - 180	170 - 173	2-4		70	3.0		3.0	40	40	84,000		1	20	20	
	173 - 174		2-4	70	1.0		1.0	40	40	28,000					
	174 - 180	2-4		70	6.0		6.0	40	40	168,000		1	30	30	CROSSING CREEK CROSSING
180 - 183.5	180 - 183.5	2-4		70	3.5		3.5	40	40	98,000					INTERSECTION AT EXISTING ROAD
															END OF YUKON RIVER ROUTE
SUB-TOTAL	183.5				45.5	0	45.5			1,092,000	34,560	6		270	SUB TOTALS
TOTAL	173.5				142.0	31.5	142.0			3,513,300	228,960	57		1,280	TOTAL
NEW ROAD CONSTRUCTION															
										3,742,260					TOTAL EXCAVATION (EST.)
															START OF EXISTING ROAD
183.5 - 205.5 (CARMACKS)	183.5 - 205.5	2-6		70	22.0		22.0					3	0	0	EXISTING CREEK CROSSINGS
SUB-TOTAL (kms)	22														END OF EXISTING ROAD
EXISTING ROAD UPGRADE															
TOTAL (kms)	205.5														ROUTE 6 - YUKON RIVER ROUTE TO CARMACKS

PRELIMINARY

WESTERN COPPER CORPORATION

CASINO GOLD PROJECT - CONCENTRATE HANDLING & HAULAGE TO PORT

ROUTE 7

ESTIMATED SITE CONDITIONS - CASINO MINE SITE TO CARMACKS - HAYES CREEK ROUTE
(MINE ACCESS - BATTLE CREEK - HAYES CREEK ROUTES)

KM MARKER	km SECTION	ADVERSE ROAD GRADES (%)	FAVORABLE ROAD GRADES (%)	ESTIMATED SPEED (km / hr)	SOIL CONDITION (km) DRY	SOIL CONDITION (km) WET	TIMBER	ROAD WORKS APPROX. SIDE SLOPE (%)	ROAD WORKS APPROX. AREA (sq. m.)	ROAD WORKS EST. ROCK VOLUME (cu. m.)	ROAD WORKS EST. O.M. VOLUME (cu. m.)	CREEK CROSSINGS NUMBER	CREEK CROSSINGS REQ'D SPAN (m)	CREEK CROSSINGS TOTAL LENGTH (m)	COMMENTS & NOTES
															Edit Date: November 22, 2007
MINE TO CARMACKS															
															START OF MINE ACCESS ROUTE
0 - 10	0 - 4		8-12	35	4.0		4.0								
	4 - 10		2-4	35	6.0		6.0					3	12	36	START OF PROPOSED ROAD
															END OF MINE ACCESS ROUTE
SUB-TOTAL (kms)	10														
EXISTING ROAD UPGRADE															
															START OF BATTLE CREEK ROUTE
10 - 20	10 - 18	2-4		70		8.0						3	12	36	
												1	24	24	CASINO CREEK CROSSING
	18 - 20	2-4		70	2.0		2.0	45	50	70,000		1	12	12	ENVIRONMENTAL ISSUES MAY ARISE
												1	24	24	DIP CREEK CROSSING AT CASINO CREEK TRIBUTARY
20 - 30	20 - 21	8-12		10	1.0		1.0	45	50	35,000		1	24	24	RUDE CREEK CROSSING
	21 - 25	10-12		10	4.0		4.0	55	75	210,000		1	24	24	JENS CREEK CROSSING
	25 - 28	10-12		10	3.0		3.0	55	75	157,500					NUMEROUS SWITCHBACKS REQ'D TO ASCEND SUMMIT PASS
												1	24	24	TROMBLEY CREEK CROSSING
	28 - 30	10-12		10	2.0		2.0	55	75	105,000					
30 - 40	30 - 36	10-12		10	6.0		6.0	55	75	309,750					
	36	12-14		10				40	280	156,800					SUMMIT PASS (800m LONG) AT 36 km MARKER - ELEV. 1400 m
	36 - 40		10-12	35	4.0		4.0	50	60	147,000					
40 - 50	40 - 42		10-12	35	2.0		2.0	50	60	84,000					BATTLE CREEK RAVINE TO SELWYN RIVER BASIN
												1	24	24	BATTLE CREEK CROSSING
	42 - 46		12-14	35	4.0		4.0	50	60	168,000		1	12	12	STEEP, NARROW TERRAIN
	46 - 48		10-12	35	2.0		2.0	50	60	84,000		1	42	42	SELWYN CREEK CROSSING
	48 - 50		8-10	35	2.0		2.0	60	95	133,000					
50 - 60	50 - 51.5		4-8	35	1.5		1.5	60	95	99,750					
	51.5 - 52		2-4	70		0.5						1	12	12	RIVER MEANDERS THROUGH NARROW VALLEY
	52 - 56	2-4		70		4.0						5	12	60	ENVIRONMENTAL ISSUES MAY ARISE
	56 - 60	2-4		70		4.0						2	24	48	HAYES CREEK CROSSINGS
60 - 70	60 - 65	2-4		70		5.0						8	12	96	RIVER MEANDERS THROUGH NARROW VALLEY
	65 - 69	2-4		70		4.0									ENVIRONMENTAL ISSUES MAY ARISE
												3	24	72	HAYES CREEK CROSSINGS
												1	42	42	HAYES CREEK CROSSING - MAIN
															END OF BATTLE CREEK ROUTE
SUB-TOTAL	69.0				33.5	25.5	33.5			1,759,800	0	28		462	SUB TOTALS
															START OF HAYES CREEK ROUTE
															HAYES CREEK VALLEY BASIN STARTS
69 - 70	69 - 70	2-4		70	1.0		1.0				4,320	1	42	42	HAYES CREEK CROSSING - MAIN
70 - 80	70 - 71	2-4		70	1.0		1.0				4,320	2	12	24	
	71 - 79	2-4		70	8.0		8.0	60	95	380,000					RIVER MEANDERS THROUGH NARROW VALLEY
															ENVIRONMENTAL ISSUES MAY ARISE
												1	24	24	KLINES GULCH CROSSING
												1	24	24	BATTLEFIELD CREEK CROSSING
												1	30	30	FOURMILE CREEK CROSSING
	79 - 80	2-4		70	1.0		1.0				4,320	2	12	24	
80 - 90	80 - 81	2-4		70	1.0		1.0				4,320	2	20	40	
	81 - 83	2-4		70		2.0						1	30	30	HAYES CREEK CROSSING - BRANCHES OFF
	83 - 90	2-4		70	7.0		7.0	35	35	245,000		3	12	36	START ASCENDING TO SUMMIT PASS
90 - 100	90 - 98	2-4		70	8.0		8.0				34,560	6	12	72	
	98			70											SUMMIT PASS AT 98 km MARKER - ELEV. 1090 m
	98 - 100		4-6	70	2.0		2.0	40	40	40,000					
100 - 110	100 - 101		6-8	50	1.0		1.0				4,320	1	12	12	
	101 - 103		4-6	50	2.0		2.0				8,640	3	12	36	
	103 - 109		2-4	70	6.0		6.0				25,920	2	12	24	INTERSECTION OF BIG CREEK VALLEY BASIN
	109 - 110		2-4	70		1.0						1	12	12	
110 - 120	110 - 113		2-4	70		3.0						3	12	36	
												1	30	30	BIG CREEK CROSSING
	113 - 120		2-4	70	7.0		7.0				30,240	6	12	72	
120 - 130	120 - 129		2-4	70	9.0		9.0				38,880	6	12	72	
	129 - 130		2-4	70		1.0						1	12	12	
130 - 140	130 - 131		2-4	70		1.0						1	12	12	
	131 - 132		2-4	70		1.0									
	132 - 139	2-4		70	7.0		7.0	60	95	332,500		3	12	36	START OF SEYMOUR CREEK VALLEY BASIN
															RIVER MEANDERS THROUGH NARROW VALLEY
															ENVIRONMENTAL ISSUES MAY ARISE
	139 - 140	2-4		70	1.0		1.0	60	95	47,500		1	30	30	BOW CREEK CROSSING
140 - 150	140 - 142	2-4		70	2.0		2.0	60	95	95,000		2	12	24	RIVER MEANDERS THROUGH NARROW VALLEY
	142 - 146	2-4		70	4.0		4.0	60	95	190,000		2	12	24	ENVIRONMENTAL ISSUES MAY ARISE
	146 - 150	2-4		70	4.0		4.0	60	95	190,000		2	12	24	
150 - 160	150 - 155	2-4		70	5.0		5.0	60	95	237,500		2	12	24	
	155 - 160	2-4		70	5.0		5.0				21,600	1	12	12	
160 - 169	160 - 169	2-4		70	9.0		9.0				38,880	3	12	36	END OF PROPOSED ROUTE
															END OF HAYES CREEK ROUTE
SUB-TOTAL	169				91.0	9.0	91.0			1,757,500	220,320	53		874	SUB TOTAL
TOTAL NEW ROAD CONSTRUCTION	159				124.5	34.5	124.5			3,517,300	220,320	81		1336	TOTAL
										3,737,620					TOTAL EXCAVATION (EST.)
															START OF EXISTING ROAD
169 - 188.4 (INTERSECTION)	169 - 188.4	2-4		70	19.4		19.4					6	0	0	EXISTING CREEK CROSSINGS
188.4 - 210.4 (CARMACKS)	188.4 - 210.4	2-4		70	22.0		22.0					3	0	0	EXISTING CREEK CROSSINGS
															END OF EXISTING ROAD
SUB-TOTAL (kms)	41.4														
EXISTING ROAD UPGRADE															
TOTAL (kms)	210.4														ROUTE 7 - HAYES CREEK ROUTE TO CARMACKS

PRELIMINARY

C Appendix C - Preliminary Estimates of Construction Costs of Alternative Mine Road Routes

WESTERN COPPER CORPORATION

CASINO GOLD PROJECT - CONCENTRATE HANDLING & HAULAGE TO PORT

SUMMARY OF DIRECT & INDIRECT ROAD CONSTRUCTION COSTS

PRELIMINARY

	CASINO MINE SITE TO ALASKAN HIGHWAY ROUTE 1 ONION CREEK ROUTE Total Route Length (kms) 187.3	CASINO MINE SITE TO ALASKAN HIGHWAY ROUTE 2 AISHIHIK ROAD ROUTE Total Route Length (kms) 323.0	CASINO MINE SITE TO CARMACKS ROUTE 3 EAST ROUTE Total Route Length (kms) 280.5	CASINO MINE SITE TO MINTO ROUTE 4 WOLVERINE CREEK ROUTE Total Route Length (kms) 138.0	CASINO MINE SITE TO CARMACKS ROUTE 5 KLAZA RIVER ROUTE Total Route Length (kms) 273.5	CASINO MINE SITE TO CARMACKS ROUTE 6 YUKON RIVER ROUTE Total Route Length (kms) 205.5	CASINO MINE SITE TO CARMACKS ROUTE 7 HAYES CREEK ROUTE Total Route Length (kms) 210.4
Estimated Direct Costs	$78,600,411	$91,260,890	$92,211,466	$132,871,883	$146,256,783	$162,925,728	$166,227,208
	See Page 1	See Page 2	See Page 3	See Page 4	See Page 5	See Page 6	See Page 7
Engineering Fees 10%	$7,860,041	$9,126,089	$9,221,147	$13,287,188	$14,625,678	$16,292,573	$16,622,721
Environmental Assessment 5%	$3,930,021	$4,563,045	$4,610,573	$6,643,594	$7,312,839	$8,146,286	$8,311,360
Permitting 1%	$786,004	$912,609	$922,115	$1,328,719	$1,462,568	$1,629,257	$1,662,272
Estimated Indirect Costs	$12,576,066	$14,601,742	$14,753,834	$21,259,501	$23,401,085	$26,068,117	$26,596,353
Total	$91,176,476	$105,862,633	$106,965,300	$154,131,384	$169,657,868	$188,993,846	$192,823,561
DISTANCE - MINE TO SKAGWAY PORT	687.3	620.5	635.5	589.0	628.5	660.5	665.4
DISTANCE- MINE TO HAINES PORT	595.8	593.4	853.5	787.0	846.5	778.5	783.4
						Edit Date:	November 22, 2007

WESTERN COPPER CORPORATION

CASINO GOLD PROJECT - CONCENTRATE HANDLING & HAULAGE TO PORT

PRELIMINARY ESTIMATE OF ROAD CONSTRUCTION COSTS

ROUTE 1

CASINO MINE SITE TO ALASKAN HIGHWAY INTERSECTION - ONION CREEK ROUTE
(MINE ACCESS - NISLING RIVER - ONION ROUTES)

ITEM	UNIT	QUANTITY	UNIT COST	TOTAL
EXISTING ROAD UPGRADE	km	10	$30,000.00	$300,000
		SUB - TOTAL		**$300,000**
NEW ROAD CONSTRUCTION	km	177.3		
CLEARING R.O.W.	Ha	532	$4,000.00	$2,127,600
STRIPPING	cu. m.	1,851,900	$1.80	$3,333,420
OTHER MATERIAL (O.M.) + 20%	cu. m.	3,086,980	$5.25	$16,206,645
ROCK EXCAVATION	cu. m.	66,500	$24.45	$1,625,925
FILTER FABRIC (PER 4m x 100m ROLL)	roll	509	$800.00	$407,400
PIT RUN GRAVEL (ASSUME 10km HAULAGE)	cu. m.	891,420	$18.45	$16,446,699
SURFACING	cu. m.	193,930	$25.00	$4,848,250
BRIDGES	ln. m.	1,286	$14,500.00	$18,647,000
CULVERTS (600 DIA. INCL. INSTALLATION)	ln. m.	8,652	$180.00	$1,557,403
Total Route Length (km)	187.3	SUB - TOTAL		$65,200,342
Cost Per Kilometer for Existing Road Upgrade	$30,000	TOTAL		$65,500,342
Cost Per Kilometer for New Road Construction	$441,288	CONTINGENCY (20%)		$13,100,068
Road Cost Per Kilometer for Entire Route	$419,650	DIRECT COSTS		$78,600,411

PRELIMINARY

Edit Date: November 22, 2007

NOTES:

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3. Cost estimates are based on limited information & are intended only to provide comparitive cost estimates for each Transportation Route Corridor.
4. Route feasibility to be field confirmed.
5. Rock excavation quantities are estimated from side slope information derived from mapping. See Note 1.
6. Pit run gravel cost based on 10 km haul distance.
7. Culvert quantity based on average 12 m (40') length. Cost includes installation.
8. Assumed 4 x 600 dia. CSP Culverts per Kilometer with Road Grades less than 6%
9. Assumed 8 X 600 dia. CSP Culverts per Kilometer with Road Grades greater than 6%

WESTERN COPPER CORPORATION

CASINO GOLD PROJECT - CONCENTRATE HANDLING & HAULAGE TO PORT

PRELIMINARY ESTIMATE OF ROAD CONSTRUCTION COSTS

ROUTE 2

CASINO MINE SITE TO ALASKAN HIGHWAY & AISHIHIK ROAD INTERSECTION (AISHIHIK ROAD ROUTE TO HAINES JUNCTION)

(MINE ACCESS - NISLING RIVER - AISHIHIK ROAD ROUTES)

ITEM	UNIT	QUANTITY	UNIT COST	TOTAL
EXISTING ROAD UPGRADE (MINE ACCESS ROUTE	km	10	$30,000.00	$300,000
EXISTING ROAD UPGRADE (AISHIHIK ROAD)	km	113	$75,000.00	$8,475,000
		SUB TOTAL		**$8,775,000**
NEW ROAD CONSTRUCTION	km	200		
CLEARING R.O.W.	Ha	600	$4,000.00	$2,400,000
STRIPPING	cu. m.	1,992,600	$1.80	$3,586,680
OTHER MATERIAL (O.M.) + 20%	cu. m.	956,448	$5.25	$5,021,352
ROCK EXCAVATION	cu. m.	59,500	$24.45	$1,454,775
FILTER FABRIC (PER 4m x 100m ROLL)	roll	994	$800.00	$795,400
PIT RUN GRAVEL (ASSUME 10km HAULAGE)	cu. m.	1,406,300	$18.45	$25,946,235
SURFACING	cu. m.	225,500	$25.00	$5,637,500
BRIDGES	ln. m.	1,426	$14,500.00	$20,677,000
CULVERTS (600 DIA. INCL. INSTALLATION)	ln. m.	9,760	$180.00	$1,756,800
Total Route Length (km)	**323.0**	SUB TOTAL		**$67,275,742**
Cost Per Kilometer for Existing Road Upgrade (average of the above road upgrade costs)	**$52,500**	TOTAL		**$76,050,742**
Cost Per Kilometer for New Road Construction	**$403,654**	CONTINGENCY (20%)		**$15,210,148**
Road Cost Per Kilometer for Entire Route	**$434,576**	TOTAL DIRECT COSTS		**$91,260,890**

PRELIMINARY

Edit Date: **November 22, 2007**

NOTES:

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4. Route feasibility to be field confirmed.
5. Rock excavation quantities are estimated from side slope information derived from mapping. See Note 1.
6. Pit run gravel cost based on 10 km haul distance.
7. Culvert quantity based on average 12 m (40') length. Cost includes installation.
8. Assumed 4 x 600 dia. CSP Culverts per Kilometer with Road Grades less than 6%
9. Assumed 8 X 600 dia. CSP Culverts per Kilometer with Road Grades greater than 6%

WESTERN COPPER CORPORATION

CASINO GOLD PROJECT - CONCENTRATE HANDLING & HAULAGE TO PORT

PRELIMINARY ESTIMATE OF ROAD CONSTRUCTION COSTS

ROUTE 3

CASINO MINE SITE TO CARMACKS (EAST ROUTE)

(MINE ACCESS - NISLING RIVER - EAST ROUTES)

ITEM	UNIT	QUANTITY	UNIT COST	TOTAL
EXISTING ROAD UPGRADE	km	60.4	$30,000.00	$1,812,000
		SUB - TOTAL		$1,812,000
NEW ROAD CONSTRUCTION	km	220.1		
CLEARING R.O.W.	Ha	660	$4,000.00	$2,641,200
STRIPPING	cu. m.	2,360,280	$1.80	$4,248,504
OTHER MATERIAL (O.M.) + 20%	cu. m.	1,003,622	$5.25	$5,269,018
ROCK EXCAVATION	cu. m.	59,500	$24.45	$1,454,775
FILTER FABRIC (PER 4m x 100m ROLL)	roll	1,285	$800.00	$1,028,200
PIT RUN GRAVEL (ASSUME 10km HAULAGE)	cu. m.	1,710,140	$18.45	$31,552,083
SURFACING	cu. m.	242,110	$25.00	$6,052,750
BRIDGES	ln. m.	1,438	$14,500.00	$20,851,000
CULVERTS (600 DIA. INCL. INSTALLATION)	ln. m.	10,741	$180.00	$1,933,358
Total Route Length (km)	280.5	SUB - TOTAL		$75,030,888
Cost Per Kilometer for Existing Road Upgrade	$30,000	TOTAL		$76,842,888
Cost Per Kilometer for New Road Construction	$409,073	CONTINGENCY (20%)		$15,368,578
Road Cost Per Kilometer for Entire Route	$328,740	DIRECT COSTS		$92,211,466

PRELIMINARY

Edit Date: November 22, 2007

NOTES:

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3. Cost estimates are based on limited information & are intended only to provide comparitive cost estimates for each Transportation Route Corridor.
4. Route feasibility to be field confirmed.
5. Rock excavation quantities are estimated from side slope information derived from mapping. See Note 1.
6. Pit run gravel cost based on 10 km haul distance.
7. Culvert quantity based on average 12 m (40') length. Cost includes installation.
8. Assumed 4 x 600 dia. CSP Culverts per Kilometer with Road Grades less than 6%
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WESTERN COPPER CORPORATION

CASINO GOLD PROJECT - CONCENTRATE HANDLING & HAULAGE TO PORT

PRELIMINARY ESTIMATE OF ROAD CONSTRUCTION COSTS

ROUTE 4

CASINO MINE SITE TO MINTO - WOLVERINE CREEK ROUTE (YUKON RIVER CROSSING)

(MINE ACCESS - BATTLE CREEK - WOLVERINE CREEK ROUTES)

ITEM	UNIT	QUANTITY	UNIT COST	TOTAL
EXISTING ROAD UPGRADE	km	10	$30,000.00	$300,000
		SUB - TOTAL		**$300,000**
NEW ROAD CONSTRUCTION	km	128		
CLEARING R.O.W.	Ha	384	$4,000.00	$1,536,000
STRIPPING	cu. m.	1,098,000	$1.80	$1,976,400
OTHER MATERIAL (O.M.) + 20%	cu. m.	194,400	$5.25	$1,020,600
ROCK EXCAVATION	cu. m.	2,421,300	$24.45	$59,200,785
FILTER FABRIC (PER 4m x 100m ROLL)	roll	1,213	$800.00	$970,200
PIT RUN GRAVEL (ASSUME 10km HAULAGE)	cu. m.	1,053,000	$18.45	$19,427,850
SURFACING	cu. m.	84,150	$25.00	$2,103,750
BRIDGES	ln. m.	1,010	$14,500.00	$14,645,000
YUKON RIVER BRIDGE (TO MINTO)	L.S.	350 m length	$8,000,000	$8,000,000
CULVERTS (600 DIA. INCL. INSTALLATION)	ln. m.	8,589	$180.00	$1,545,984
Total Route Length (km)	**138.0**	SUB - TOTAL		**$110,426,569**
Cost Per Kilometer for Existing Road Upgrade	**$30,000**	TOTAL		**$110,726,569**
Cost Per Kilometer for New Road Construction	**$1,035,249**	CONTINGENCY (20%)		**$22,145,314**
Road Cost Per Kilometer for Entire Route	**$962,840**	DIRECT COSTS		**$132,871,883**

PRELIMINARY

Edit Date: November 22, 2007

NOTES:

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4. Route feasibility to be field confirmed.
5. Rock excavation quantities are estimated from side slope information derived from mapping. See Note 1.
6. Pit run gravel cost based on 10 km haul distance.
7. Culvert quantity based on average 12 m (40') length. Cost includes installation.
8. Assumed 4 x 600 dia. CSP Culverts per Kilometer with Road Grades less than 6%
9. Assumed 8 X 600 dia. CSP Culverts per Kilometer with Road Grades greater than 6%

WESTERN COPPER CORPORATION

CASINO GOLD PROJECT - CONCENTRATE HANDLING & HAULAGE TO PORT

PRELIMINARY ESTIMATE OF ROAD CONSTRUCTION COSTS

ROUTE 5

CASINO MINE SITE TO CARMACKS - KLAZA RIVER ROUTE
(MINE ACCESS - NISLING RIVER - KLAZA RIVER ROUTES)

ITEM	UNIT	QUANTITY	UNIT COST	TOTAL
EXISTING ROAD UPGRADE	km	60.4	$30,000.00	$1,812,000
		SUB - TOTAL		**$1,812,000**
NEW ROAD CONSTRUCTION	km	213.1		
CLEARING R.O.W.	Ha	639	$4,000.00	$2,557,200
STRIPPING	cu. m.	2,361,240	$1.80	$4,250,232
OTHER MATERIAL (O.M.) + 20%	cu. m.	482,976	$5.25	$2,535,624
ROCK EXCAVATION	cu. m.	1,738,100	$24.45	$42,496,545
FILTER FABRIC (PER 4m x 100m ROLL)	roll	2,135	$800.00	$1,708,360
PIT RUN GRAVEL (ASSUME 10km HAULAGE)	cu. m.	2,065,820	$18.45	$38,114,379
SURFACING	cu. m.	179,850	$25.00	$4,496,250
BRIDGES	ln. m.	1,512	$14,500.00	$21,924,000
CULVERTS (600 DIA. INCL. INSTALLATION)	ln. m.	11,034	$180.00	$1,986,062
Total Route Length (km)	**273.5**	SUB - TOTAL		**$120,068,652**
Cost Per Kilometer for Existing Road Upgrade	**$30,000**	TOTAL		**$121,880,652**
Cost Per Kilometer for New Road Construction	**$676,126**	CONTINGENCY (20%)		**$24,376,130**
Road Cost Per Kilometer for Entire Route	**$534,760**	DIRECT COSTS		**$146,256,783**

PRELIMINARY

Edit Date: **November 22, 2007**

NOTES:

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4. Route feasibility to be field confirmed.
5. Rock excavation quantities are estimated from side slope information derived from mapping. See Note 1.
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WESTERN COPPER CORPORATION

CASINO GOLD PROJECT - CONCENTRATE HANDLING & HAULAGE TO PORT

PRELIMINARY ESTIMATE OF ROAD CONSTRUCTION COSTS

ROUTE 6

CASINO MINE SITE TO CARMACKS - YUKON RIVER ROUTE
(MINE ACCESS - BATTLE CREEK - WOLVERINE CREEK - YUKON RIVER ROUTES)

ITEM	UNIT	QUANTITY	UNIT COST	TOTAL
EXISTING ROAD UPGRADE	km	32	$30,000.00	$960,000
		SUB - TOTAL		**$960,000**
NEW ROAD CONSTRUCTION	km	173.5		
CLEARING R.O.W.	Ha	521	$4,000.00	$2,082,000
STRIPPING	cu. m.	1,136,400	$1.80	$2,045,520
OTHER MATERIAL (O.M.) + 20%	cu. m.	228,960	$5.25	$1,202,040
ROCK EXCAVATION	cu. m.	3,513,300	$24.45	$85,900,185
FILTER FABRIC (PER 4m x 100m ROLL)	roll	1,213	$800.00	$970,200
PIT RUN GRAVEL (ASSUME 10km HAULAGE)	cu. m.	1,072,200	$18.45	$19,782,090
SURFACING	cu. m.	92,950	$25.00	$2,323,750
BRIDGES	ln. m.	1,280	$14,500.00	$18,560,000
CULVERTS (600 DIA. INCL. INSTALLATION)	ln. m.	10,809	$180.00	$1,945,656
Total Route Length (km)	**205.5**	SUB - TOTAL		**$134,811,441**
Cost Per Kilometer for Existing Road Upgrade	**$30,000**	TOTAL		**$135,771,441**
Cost Per Kilometer for New Road Construction	**$932,413**	CONTINGENCY (20%)		**$27,154,288**
Road Cost Per Kilometer for Entire Route	**$792,826**	DIRECT COSTS		**$162,925,729**

PRELIMINARY

Edit Date: **November 22, 2007**

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WESTERN COPPER CORPORATION

CASINO GOLD PROJECT - CONCENTRATE HANDLING & HAULAGE TO PORT

PRELIMINARY ESTIMATE OF ROAD CONSTRUCTION COSTS

ROUTE 7

CASINO MINE SITE TO CARMACKS - HAYES CREEK ROUTE
(MINE ACCESS - BATTLE CREEK - HAYES CREEK ROUTES)

ITEM	UNIT	QUANTITY	UNIT COST	TOTAL
EXISTING ROAD UPGRADE	km	51.4	$30,000.00	$1,542,000
		SUB-TOTAL		**$1,542,000**
NEW ROAD CONSTRUCTION	km	159		
CLEARING R.O.W.	Ha	477	$4,000.00	$1,908,000
STRIPPING	cu. m.	1,210,800	$1.80	$2,179,440
OTHER MATERIAL (O.M.) + 20%	cu. m.	220,320	$5.25	$1,156,680
ROCK EXCAVATION	cu. m.	3,517,300	$24.45	$85,997,985
FILTER FABRIC (PER 4m x 100m ROLL)	roll	1,328	$800.00	$1,062,600
PIT RUN GRAVEL (ASSUME 10km HAULAGE)	cu. m.	1,157,400	$18.45	$21,354,030
SURFACING	cu. m.	94,050	$25.00	$2,351,250
BRIDGES	ln. m.	1,336	$14,500.00	$19,372,000
CULVERTS (600 DIA. INCL. INSTALLATION)	ln. m.	8,882	$180.00	$1,598,688
Total Route Length (km)	210.4	SUB-TOTAL		$136,980,673
Cost Per Kilometer for Existing Road Upgrade	$30,000	TOTAL		$138,522,673
Cost Per Kilometer for New Road Construction	$1,033,816	CONTINGENCY (20%)		$27,704,535
Road Cost Per Kilometer for Entire Route	$790,053	DIRECT COSTS		$166,227,208

PRELIMINARY

Edit Date: November 22, 2007

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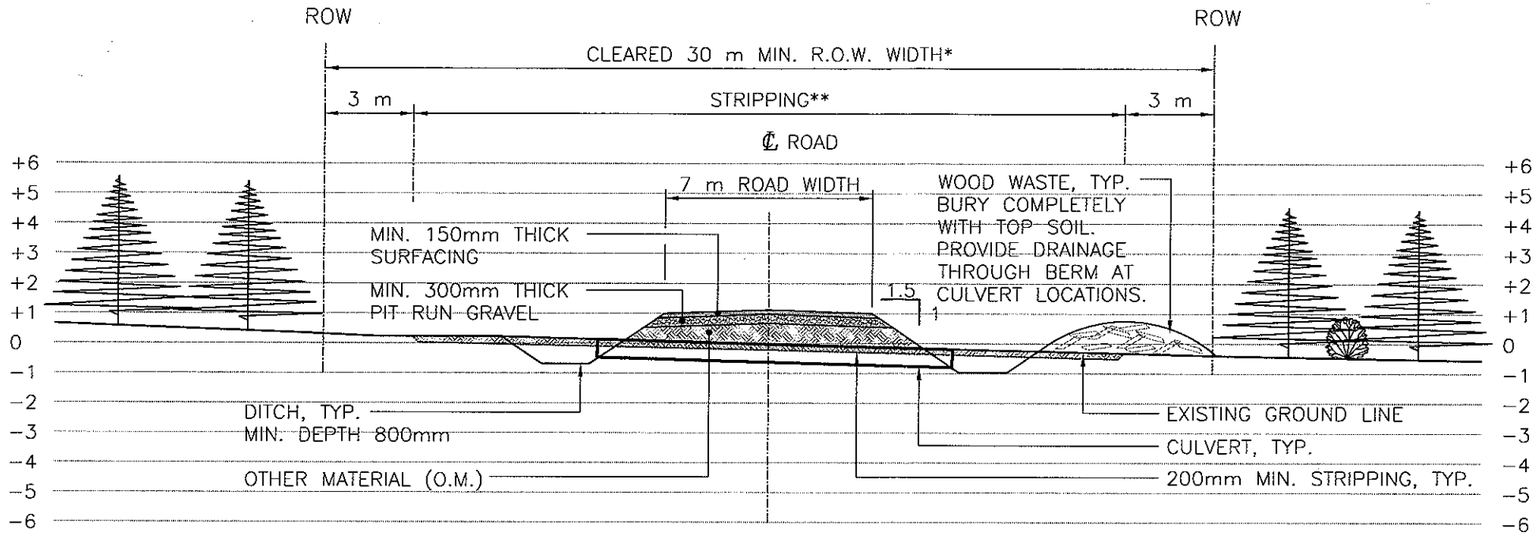
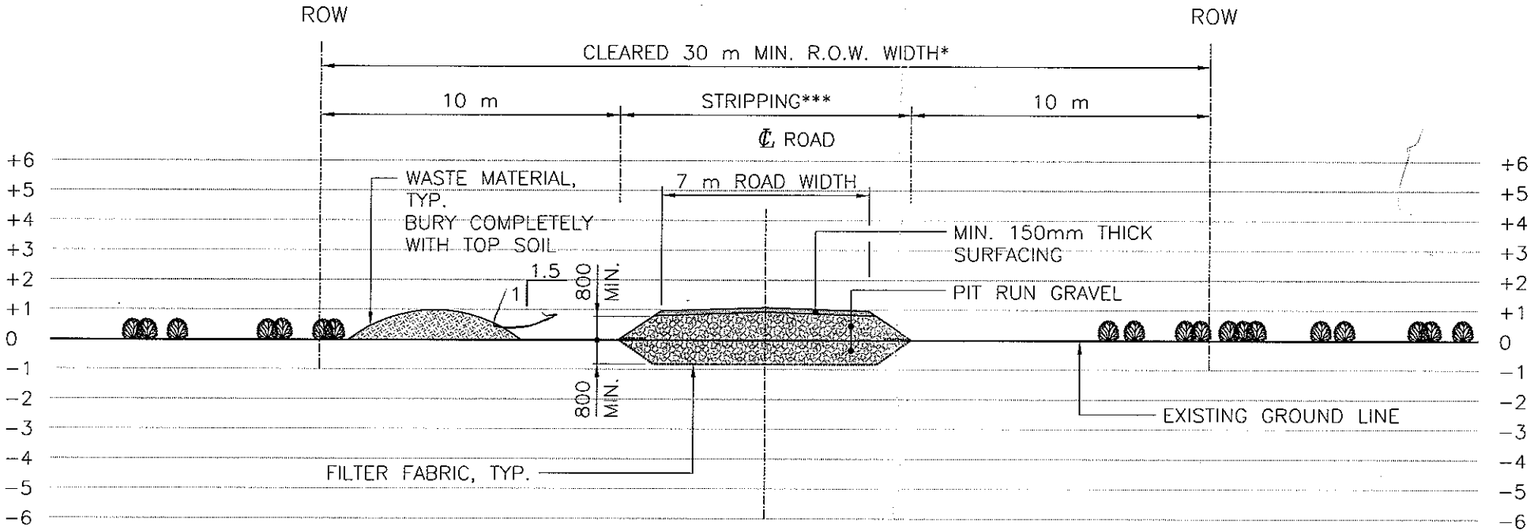
9. Assumed 8 X 600 dia. CSP Culverts per Kilometer with Road Grades greater than 6%

D Appendix D - Preliminary Road Construction Details

This Drawing Is For The Use Of The Client And Project Indicated
No Representations Of Any Kind Are Made To Other Parties



TYPICAL ROAD CROSS SECTION
1:200



TYPICAL ROAD CROSS SECTION THROUGH "WET" TERRAIN
1:200

PRELIMINARY
NOT FOR CONSTRUCTION

NOTES:

* R.O.W. WIDTH WILL VARY DUE TO TERRAIN CHARACTERISTICS AT EACH ROAD STATION CROSS SECTION.

REV.	DATE	ENG.	BY	SUBJECT
0	07/10/05	R.K.	W.R.	PRELIMINARY

REVISIONS

VERIFY SCALES

BAR IS 10mm ON ORIGINAL DRAWING

0 ——— 10mm

IF NOT 10mm ON THIS SHEET, ADJUST SCALES ACCORDINGLY

Associated Engineering

GLOBAL PERSPECTIVE. LOCAL FOCUS.

		INITIAL	DATE
PROJECT No.	20072115		
SCALE	AS SHOWN		
DRAWN BY:	WAYNE RILEY		07/10/05
DESIGNED BY:	RAY KORPELA		07/10/05
CHECKED BY:	MARTIN JOBKE		07/10/05
APPROVED BY:			

CLIENT: M3 ENGINEERING & TECHNOLOGY CORPORATION
OWNER: WESTERN COPPER CORPORATION

DRAWING TITLE: PRELIMINARY ROAD CONSTRUCTION DETAILS

PROJECT: CASINO GOLD PROJECT
CONCENTRATE HANDLING & HAULAGE TO PORT

DRAWING NUMBER	REV. NO.	SHEET
20072115-00-113	0	1/1

This Drawing Is For The Use Of The Client And Project Indicated
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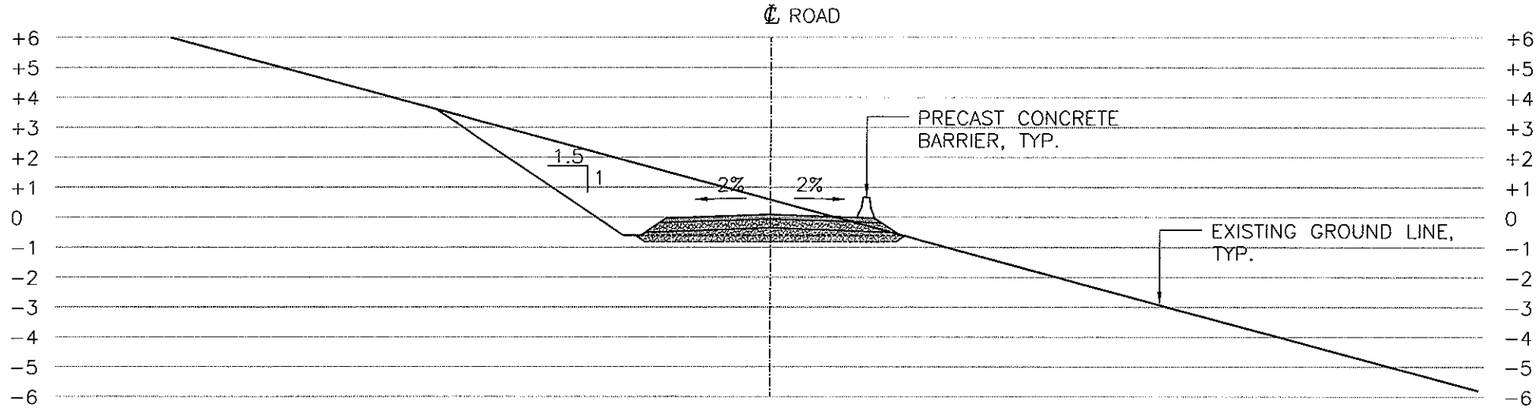
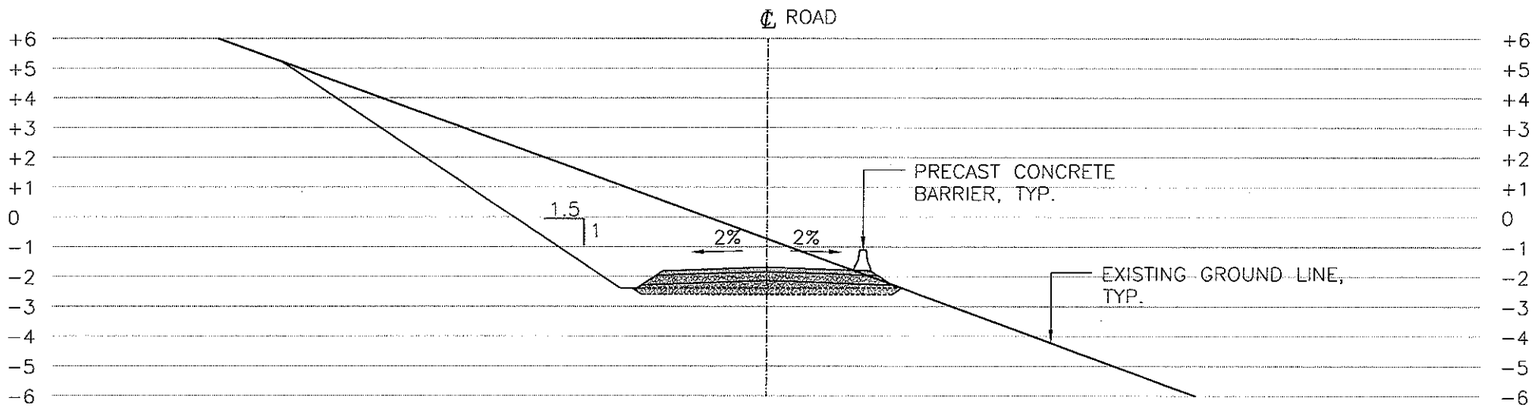


TYPICAL ROAD CROSS SECTION W/ 10% SLOPE

1:200



TYPICAL ROAD CROSS SECTION w/ 20% SLOPE

1:200

NOTES:

PRELIMINARY
NOT FOR CONSTRUCTION

REV.	DATE	ENG.	BY	SUBJECT
0	07/10/05	R.K.	W.R.	PRELIMINARY

REVISIONS

VERIFY SCALES

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0 10mm

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Associated Engineering

GLOBAL PERSPECTIVE. LOCAL FOCUS.

		INITIAL	DATE
PROJECT No.	20072115		
SCALE	AS SHOWN		
DRAWN BY:	WAYNE RILEY		07/11/14
DESIGNED BY:	RAY KORPELA		07/11/14
CHECKED BY:	MARTIN JOBKE		07/11/14
APPROVED BY:			

CLIENT:
M3 ENGINEERING & TECHNOLOGY CORPORATION
OWNER:
WESTERN COPPER CORPORATION

DRAWING TITLE:
TYPICAL ROAD CROSS SECTION DETAILS – SHEET 1

PROJECT:
CASINO GOLD PROJECT
CONCENTRATE HANDLING & HAULAGE TO PORT

DRAWING NUMBER	REV. NO.	SHEET
20072115-00-116	0	1/1

This Drawing Is For The Use Of The Client And Project Indicated
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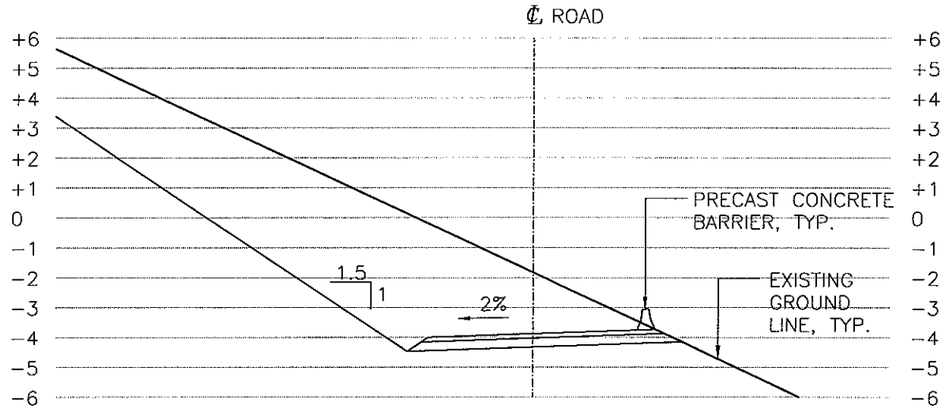
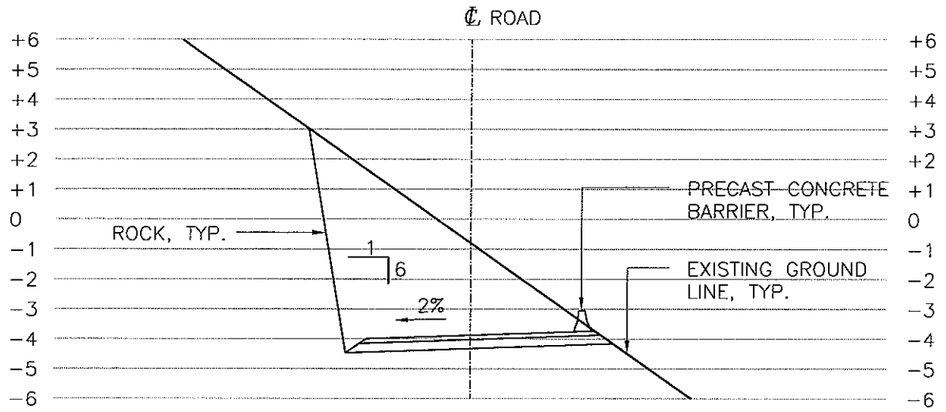
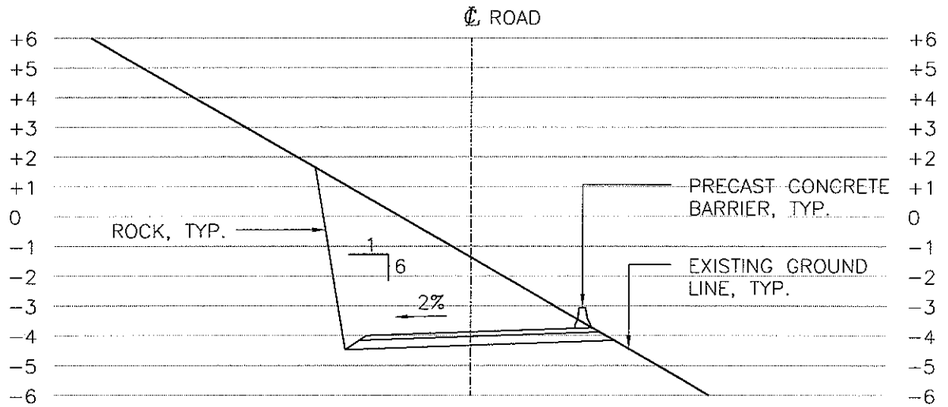


TYPICAL ROAD CROSS SECTION w/ 25% SLOPE
1:200



TYPICAL ROAD CROSS SECTION w/ 35% SLOPE
1:200



TYPICAL ROAD CROSS SECTION w/ 30% SLOPE
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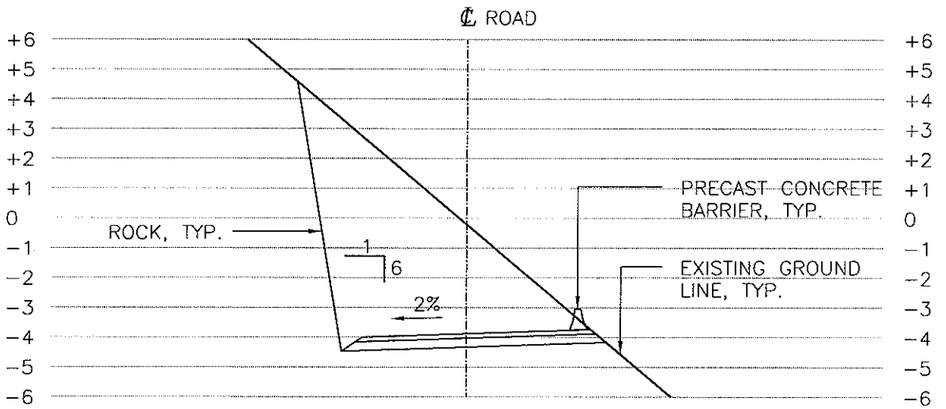

TYPICAL ROAD CROSS SECTION w/ 40% SLOPE
1:200

NOTES:

PRELIMINARY
NOT FOR CONSTRUCTION

REV.	DATE	ENG.	BY	SUBJECT
0	07/10/05	R.K.	W.R.	PRELIMINARY

REVISIONS

VERIFY SCALES

BAR IS 10mm ON ORIGINAL DRAWING

0 10mm

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Associated Engineering

GLOBAL PERSPECTIVE. LOCAL FOCUS.

		INITIAL	DATE
PROJECT No.	20072115		
SCALE	AS SHOWN		
DRAWN BY:	WAYNE RILEY		07/11/14
DESIGNED BY:	RAY KORPELA		07/11/14
CHECKED BY:	MARTIN JOBKE		07/11/14
APPROVED BY:			

CLIENT:
M3 ENGINEERING & TECHNOLOGY CORPORATION
OWNER:
WESTERN COPPER CORPORATION

DRAWING TITLE:
TYPICAL ROAD CROSS SECTION DETAILS – SHEET 2

PROJECT:
CASINO GOLD PROJECT
CONCENTRATE HANDLING & HAULAGE TO PORT

DRAWING NUMBER	REV. NO.	SHEET
20072115-00-117	0	1/1

This Drawing Is For The Use Of The Client And Project Indicated
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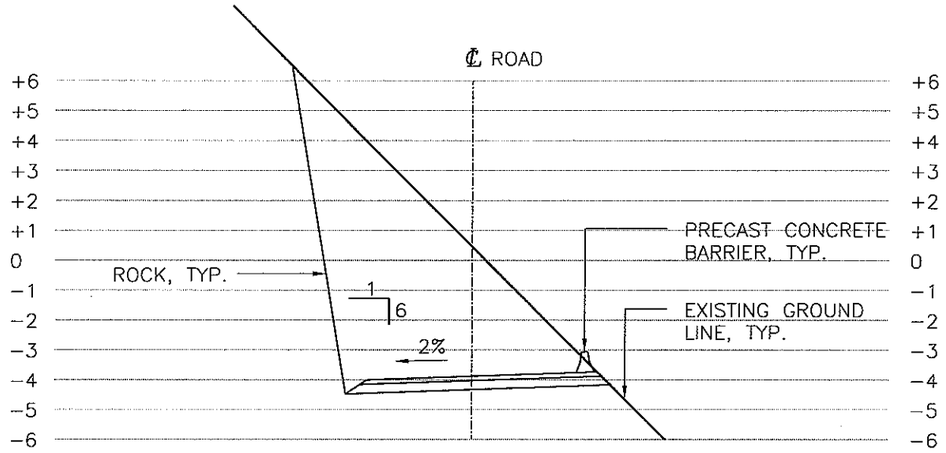
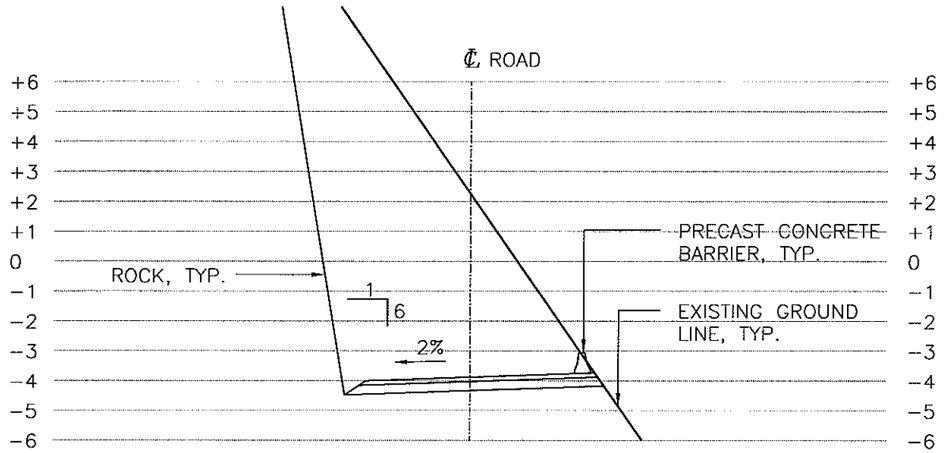


TYPICAL ROAD CROSS SECTION w/ 45% SLOPE
1:200



TYPICAL ROAD CROSS SECTION w/ 55% SLOPE
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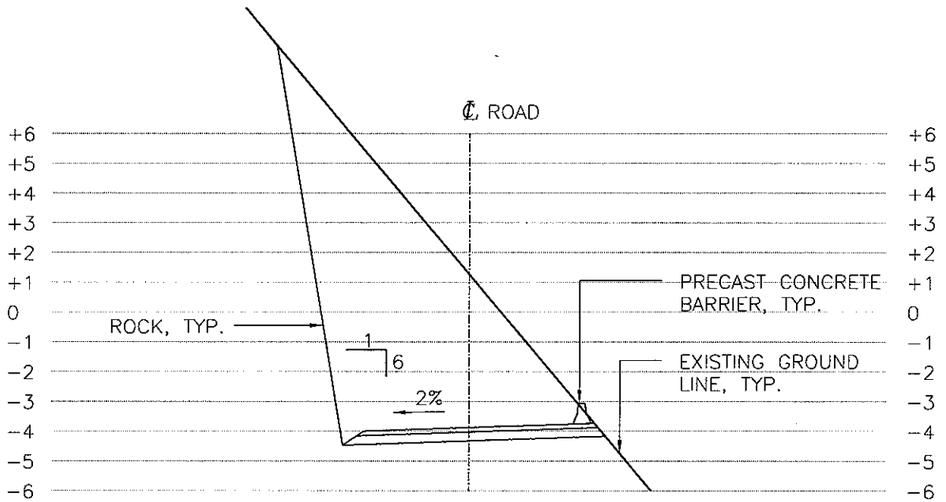

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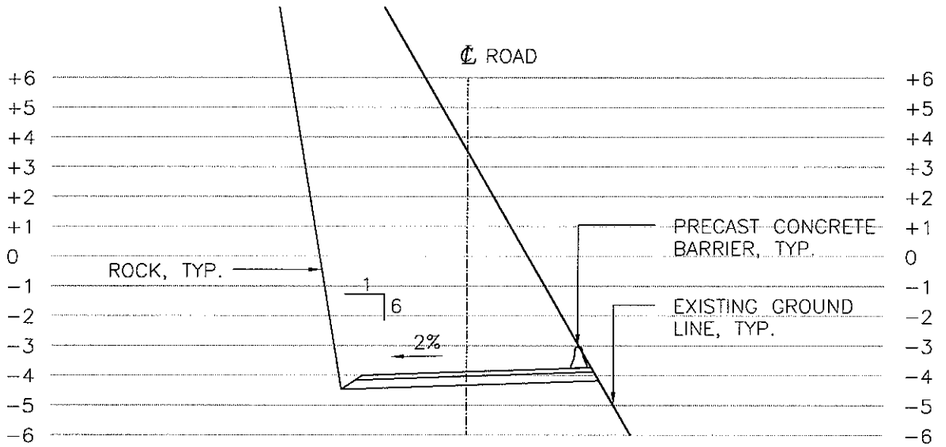

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NOTES:

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0	07/10/05	R.K.	W.R.	PRELIMINARY

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SCALE	AS SHOWN		
DRAWN BY:	WAYNE RILEY		07/11/14
DESIGNED BY:	RAY KORPELA		07/11/14
CHECKED BY:	MARTIN JOBKE		07/11/14
APPROVED BY:			

CLIENT: M3 ENGINEERING & TECHNOLOGY CORPORATION
OWNER: WESTERN COPPER CORPORATION

DRAWING TITLE: TYPICAL ROAD CROSS SECTION DETAILS – SHEET 3

PROJECT: CASINO GOLD PROJECT
CONCENTRATE HANDLING & HAULAGE TO PORT

DRAWING NUMBER	REV. NO.	SHEET
20072115-00-118	0	1/1

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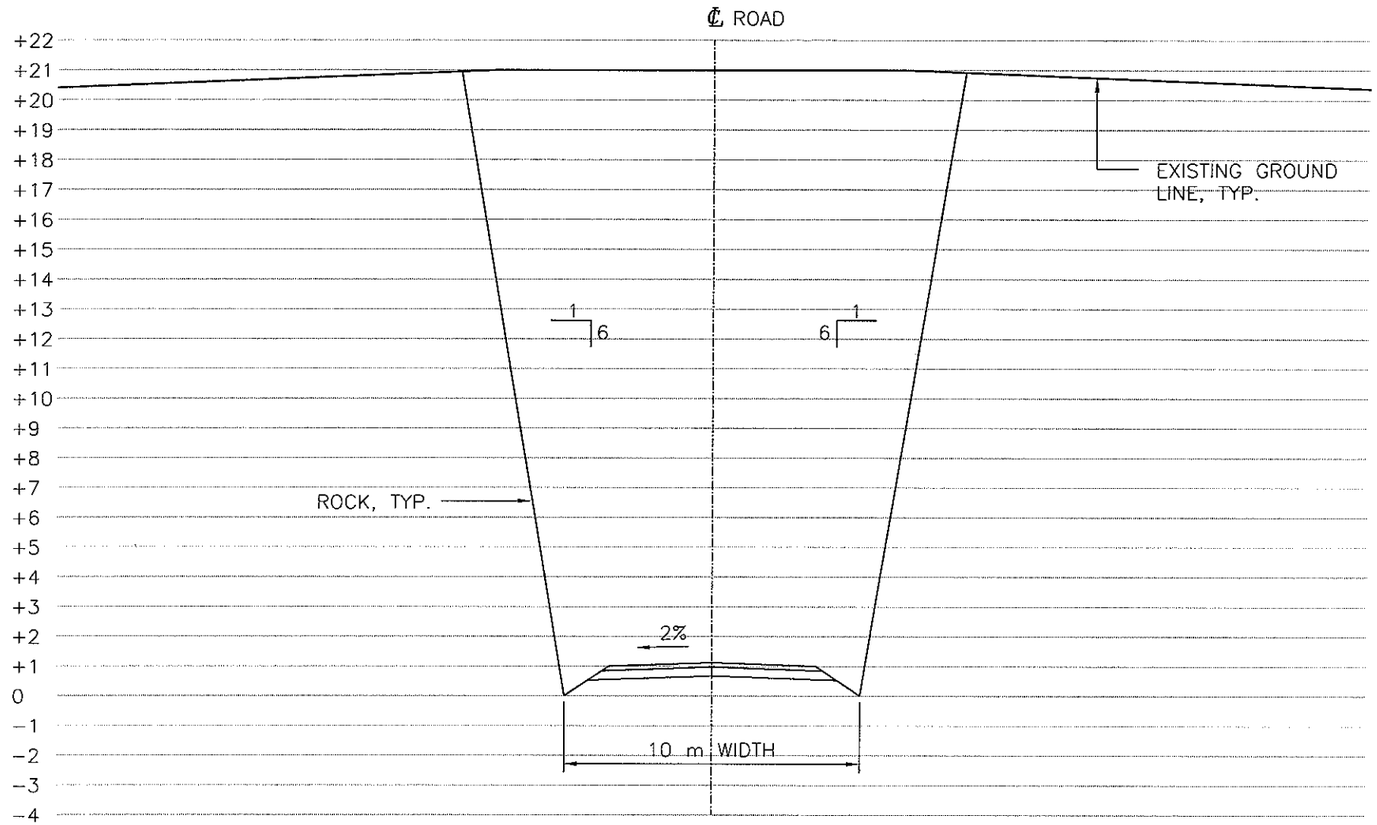

TYPICAL ROAD CROSS SECTION AT PASS SUMMIT
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NOTES:

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REV.	DATE	ENG.	BY	SUBJECT
0	07/10/05	R.K.	W.R.	PRELIMINARY

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		INITIAL	DATE
PROJECT No.	20072115		
SCALE	AS SHOWN		
DRAWN BY:	WAYNE RILEY		07/11/14
DESIGNED BY:	RAY KORPELA		07/11/14
CHECKED BY:	MARTIN JOBKE		07/11/14
APPROVED BY:			

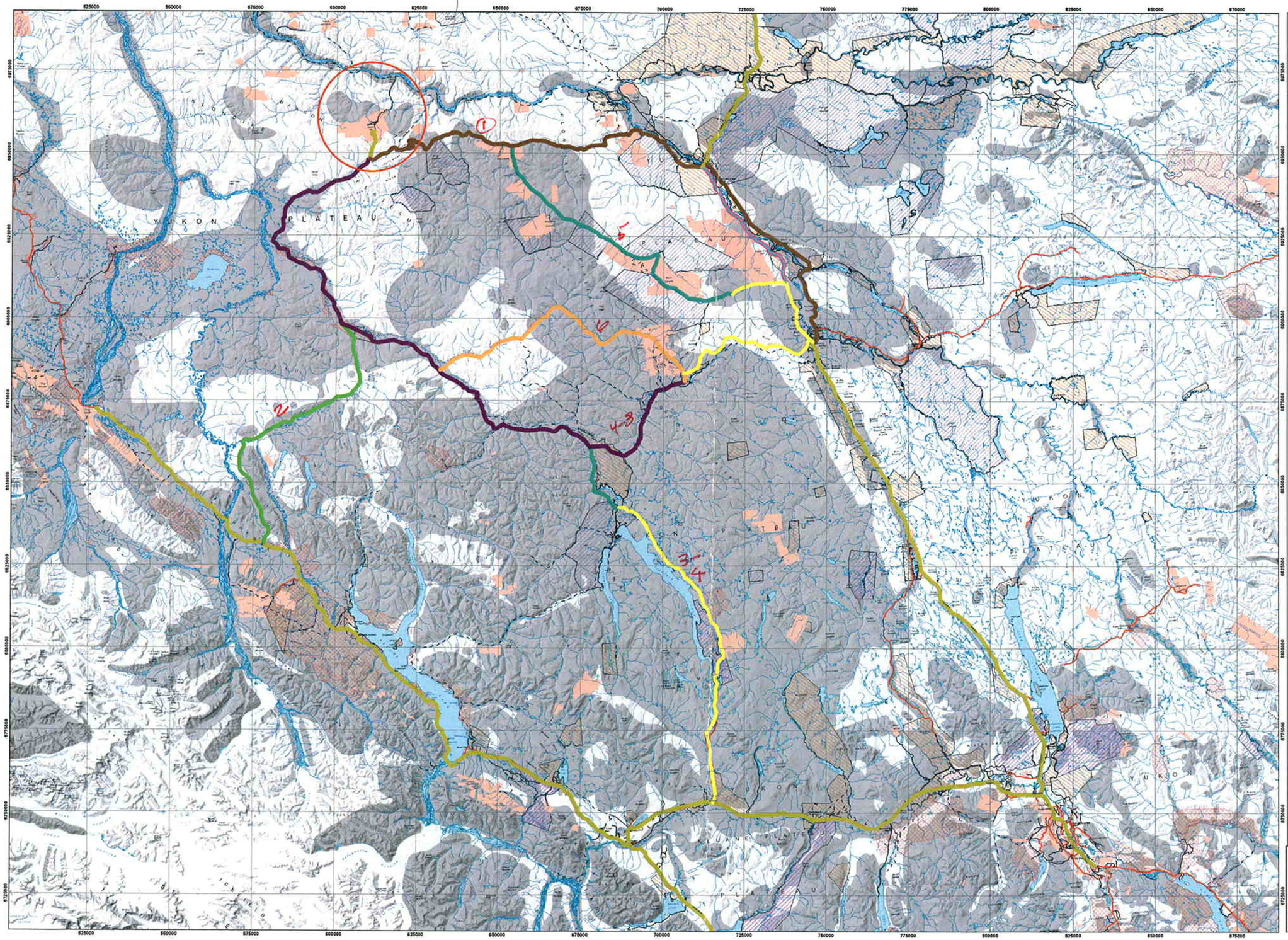
CLIENT: M3 ENGINEERING & TECHNOLOGY CORPORATION
OWNER: WESTERN COPPER CORPORATION

DRAWING TITLE: TYPICAL ROAD CROSS SECTION DETAILS – SHEET 4

PROJECT: CASINO GOLD PROJECT
CONCENTRATE HANDLING & HAULAGE TO PORT

DRAWING NUMBER	REV. NO.	SHEET
20072115-00-119	0	1/1

E Appendix E - Map of NRCAN FH Lands from Gartner Lee



Legend

Corridors

- Existing Route to be Upgraded
- Route 1 - Onion Creek Route
- Route 3 - East Route
- Route 4 - Wolverine Creek Route
- Route 5 - Klaza River Route
- Route 6 - Yukon River Route
- Route 7 - Hayes Creek Route

Transportation

- Road
- Limited-used road
- Trail

Mineral Claims

- Active

NRCAN FN Lands

Category

- A
- B
- FS
- Unsurveyed
- Wildlife Key Area

DRAFT

N W E S

20 0 20 Km

1:500,000

Casino

5 December, 2007

Gartner Lee

Figure 1

DRAFT for DISCUSSION

CASINO
COPPER AND GOLD

Review of Access Road Alternatives

Presented to Yukon Government
Department of Environment
Fish and Wildlife Branch
22 November, 2012

CASINO
COPPER AND GOLD

Agenda

1. Introduction/Overview
2. History of the "Casino Trail"
3. Route Alternatives
4. Studies Underway
5. Current Status/Next Steps

2

CASINO COPPER AND GOLD

Overview

History of the Property



- First mineral claims on the property filed as early as 1917
- Since that time, there have been periods of exploration and development by various owners

Location of the Property

- West central Yukon in Dawson Range Mountains
- On Crown Land administered by Yukon Government
- 300 km northwest of Whitehorse, 115 km west of Pelly Crossing
- Mine located within traditional territory of Selkirk First Nation
- Road access will fall within traditional territories of Selkirk and Little Salmon/Carmacks First Nations



3

CASINO COPPER AND GOLD

Casino Trail History

- **Interest in the Casino Trail started around 1960**
- **First official road proposal of the Casino Trail was in 1985**
- **Road construction began in 1986**
- **Casino Trail Local Resource Group formed in 1987**
- **By 1988, 40 km of the Casino Trail had been built**
- **Local Resource Group submitted recommendations in 1989**

4

CASINO COPPER AND GOLD

Casino Trail History

Casino Trail Local Resource Group

Objectives: review existing information, identify environmental and socio-economic concerns

Recommendations (1989):

- Archeological Studies
- Terrain Analysis and Geotechnical Studies
- Wildlife and Fisheries Studies
- Environmental Protection Plan
- Access Control
- Spur Roads Networking Plan
- Wildlife Management Plan
- Maximize local opportunities
- Review of compensation by governments

5

CASINO COPPER AND GOLD

Casino Trail History

Casino Trail baseline studies completed include:

- Socio-economic impact review (1988)
- Terrain Analysis (1986)
- Moose population inventory (1987)
- Raptor nest survey (1988)
- Caribou inventory (1991)

Casino Trail Wildlife Management Plan (1989)

- Key strategies:
  1. Harvest management
  2. Habitat management
  3. Population monitoring
  4. Community participation in wildlife management

6

Current Status

- Developing a Project Proposal for review under YESAA, including access road
- Extensive environmental, engineering and geotechnical studies have been completed over the last 4 years along the route that follows the originally proposed "Casino Trail"
- Discussions continue with Yukon Government about upgrades that will be required along the existing Freegold Road

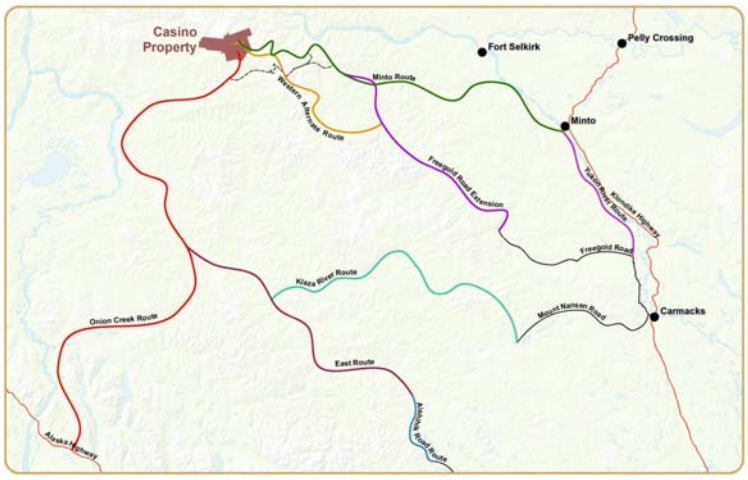
7

Route Alternatives

- **Seven route alternatives were identified in 2008**
  - Based solely on engineering and cost
- **Each route was assessed based on potential environmental and socio-economics effects, three routes were given further consideration**
  1. Onion Creek
  2. Minto
  3. Casino Trail

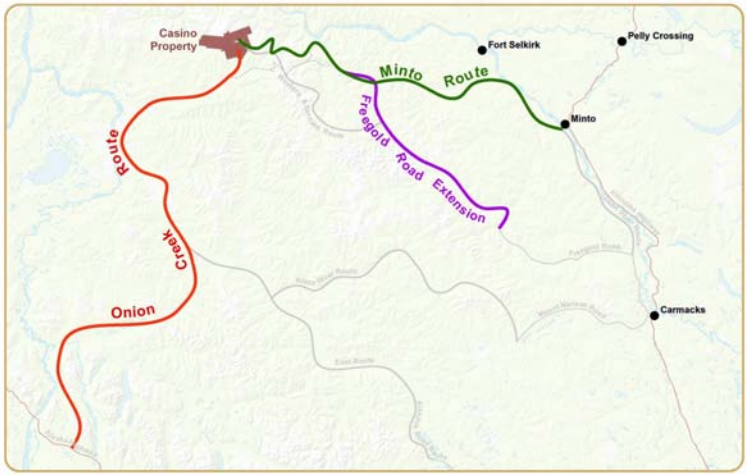
8

2008 Route Considerations



9

2008 Preferred Route Candidates



10

Onion Creek Route

Used in 2008 Pre-Feasibility Study



Pros:

- Fewer river crossings
- Lowest cost

Cons:

- Unsettled land claims (crosses withdrawn areas)
- Wildlife sensitive areas (e.g. Kluane Caribou Herd winter range, moose, salmon, outfitting activities)
- Potential to open new access to wilderness areas

Status: No longer considered

11

Minto



Pros:

- Reasonable alternative based on cost and engineering
- Uses some existing road and trails

Cons:

- Crosses settlement land
- Requires bridge across Yukon River
- Potential to open new access to wilderness areas

Status: Not preferred route

12

Freegold Road Extension

Used in 2011 Pre-Feasibility Study Update



Pros:

- Minimizes new disturbance – follows impacted corridor along metal-rich belt
- Reasonable cost
- Long history of engineering, studies and planning dating back 45 years

Cons:

- Potential to open new access to wilderness areas
- Potential impacts to wintering caribou

Status: Preferred route

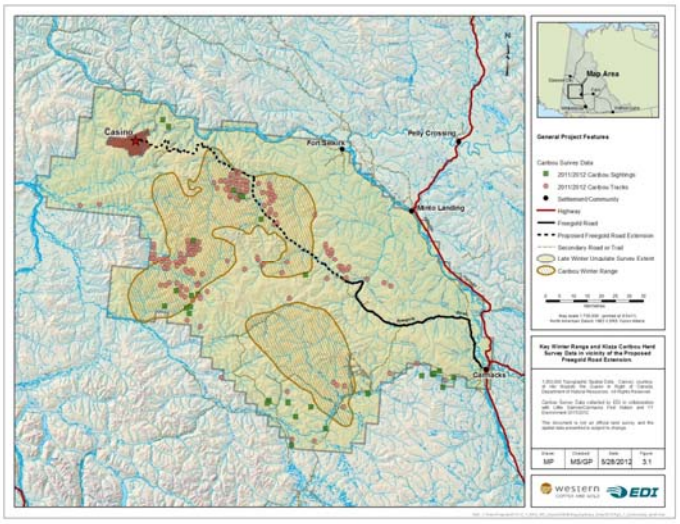
13

Freegold Road – Key Issue

- **Crosses the Klaza Caribou Herd winter range**
  - Similar winter distribution in 1987-90 and 2011/12 studies
    - Hayes Creek and Klotassin River
- **Klaza Caribou Herd**
  - Composed of at least 650 animals (2003), today _____
  - Use higher elevation habitats during winter
  - Experience relatively minimal harvest pressure
  - Listed on the *Species at Risk Act*

14

Caribou Winter Distribution



15

Freegold Road Extension
Current Environmental Studies

Caribou studies completed:

- Regional moose and caribou winter distribution surveys (2011/2012)
  - Collaboration with Yukon Government and First Nations governments
- Klaza caribou collaring program and population inventory (2012)
  - Providing support to Yukon Government study

Other studies completed:

- Fish inventory of streams crossing the road (2010/2011)
- Bear den survey (2012)
- Bird surveys (2010/2011)
- Vegetation surveys (2011)
- Rare plant surveys (2010/2012)
- Terrain assessments (2010)

Freegold Road Extension
Engineering Studies

- 2008 – Preliminary examination of route options and analysis
- 2009 – Continued refinement of options
- 2010 – Identification of preferred route, preliminary engineering, and initiation of environmental baseline studies
- 2011 – Continued geotechnical and baseline studies
- 2012 – Completion of engineering feasibility study; Re-examination and analysis of initial access route alternatives

Freegold Road Extension
Community and Government Engagement

- 2008 – Introduction to the project and presentation of route options to Selkirk First Nation
- 2009 – Engagement on baselines studies for Freegold Road extension
- 2010 – Information provided at various meetings, including community meeting in Pelly Crossing
- 2011 – Discuss baseline studies with regulators; presentation of preferred route to Selkirk First Nation
- 2012 – Increased engagement with communities, RRCs, and governments; Issue scoping; Currently seeking resolution to identified issues and concerns (e.g. Klaza Caribou)

Freegold Road Extension Next Steps

Examine options to address caribou concerns

- Seek additional input/advice from stakeholders
- Identify mitigation options
  - New information will inform detailed mitigation
- Follow-up dialog with First Nation governments, Yukon Government, Renewable Resource Councils and others

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Freegold Road Extension Wildlife Mitigation Options

- Control access
  - Gate the road to control access?
  - No hunting allowed from road?
- Time construction and maintenance to occur when caribou are not present along the road
- Minimize new disturbance in the KCH winter range
  - Place construction camps and borrow pits outside of the winter range
- Reduce speed limits within the winter range
- Hire a local wildlife observer to monitor caribou near the road
- Communicate to drivers when caribou are observed along road
- Trucks will travel in convoys to reduce frequency of disturbance
- Snowbank management to allow wildlife movement across roads

20

Freegold Road Extension Mitigation Actions

- **CMC can work with governments and stakeholders to cooperatively:**
  - Conduct technical/scoping workshop?
  - Update Wildlife Management Plan?
  - Develop Access Management Plan?
  - Monitor licensed and unlicensed wildlife harvest?
  - Work with local trappers to support sustainable management of regional wolf population?
  - Continue support of regional wildlife monitoring
  - Establish environmental working group to review and recommend adaptive mitigation?

21

Next Steps?

22

CASINO
COPPER AND GOLD

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Vancouver, BC, Canada
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www.ae.ca

May 2, 2013
File: 20092374.00.E.03.00

Jonathan Clegg, P.Eng.
Western Copper and Gold Corporation
2050 - 1111 West Georgia Street
Vancouver, BC V6E 4M3

Re: YUKON RIVER CROSSING AND MINTO ROUTE RECONNAISSANCE

Dear Mr. Clegg:

The following letter discusses findings from the Casino Mine Access route alternatives reconnaissance trip that took place on Thursday August 9th, 2012. The reconnaissance was completed via helicopter and the team consisted of Patrick Stancombe and Evan Johnson from Associated Engineering and James Hayley from Knight Piesold.

The objective of the trip was to investigate alternative corridors to the Casino Mine that avoid the Woodland Caribou wintering grounds in the Dawson Range. The alternative corridor investigations included the following three elements:

- **Yukon River Bridge** - Yukon River crossing locations and connecting roads near Minto, YT
- **The Minto Route Corridors** - east-west route from Yukon River near Minto west to Hayes Creek.
- **The Wolverine Route Corridor** - Big Creek north to Wolverine Creek and west to Hayes Creek.

Based on available wildlife information, these route alternatives avoid passing through the middle of the Woodland Caribou Wintering Grounds area; however, they all still pass through the northern extents of the Woodland Caribou key Wintering Grounds area.

1 YUKON RIVER BRIDGE

Prior to the trip, Associated Engineering completed a brief desktop study and identified ten potential horizontal crossing locations along the Yukon River. The crossing locations were identified using only high level aerial photography as terrain mapping was not available. The study covered an area from 33 km south of Minto to 26 km north of Minto.

During the field investigation flight, crossing locations further than 5 km south of Minto were eliminated from consideration due to steep terrain found to the west and north of the river. These locations are unsuitable for bridge crossings due to the difficulty of abutment and approach road design. Navigating the steep terrain would likely require road narrowing, speed reductions, retaining walls, and high road construction costs. As the trip continued it became evident that crossing sites closer to Minto and to the north of Minto had narrower river sections and more favourable bank conditions than those of the southern sites. The southern crossing locations do not appear to have any advantages that warrant the additional length of new road required to access them. This eliminated seven crossings.

The three remaining crossings under consideration are:

- Site 1 located 3 km south of Minto,
- Site 2 immediately adjacent to Minto, and
- Site 3 located 26 km north of Minto near the Hell's Gate Rapids.

Crossing Sites 1 and 2 are close to Minto and the Klondike Highway to the east. Crossing Site 3 is approximately 27 km from the Klondike Highway to the east. Photos of the crossing locations can be found in Figure 1, Figure 2, and Figure 3 respectively. The approximate width of the Yukon River from bank to bank is 229 m at Site 1, 288 m at Site 2, and 216 m at Site 3. Required bridge lengths will be considerably longer than the Yukon River widths and will vary depending on the grades and bank conditions of each site. Bridge costs could also vary considerably due to geotechnical considerations. For locations refer to sketches SK012 and SK013.

2 THE MINTO ROUTE CORRIDORS

Two corridor options from the Yukon River to Hayes Creek were investigated: The Minto Landing option using crossing Site 2, and the Hells Gate option using crossing Site 3.

The Minto Landing option requires 24 km of the existing Minto Mine Road West of the Yukon River and 25km of new road through some steep terrain and drainages to reach the Wolverine Creek Valley. There is also steep terrain on the final decent into the Wolverine Creek valley.

The Hells Gate option requires approximately 27 km of new road to connect with the Klondike Highway to the east. To the west, another 25 km of new road climbing steeply away from the Yukon River is required to reach the Wolverine Creek Valley. There is steep terrain located near the banks of the Yukon River and on the final decent into the Wolverine Creek Valley. The steep terrain presents major challenges to locating a road alignment with suitable curves and grades for haul truck operations. For locations refer to sketches SK012 and SK013.

Both corridors eventually connect at the Wolverine Creek Valley approximately 25 km directly west of the Yukon River and start following the valley to the west. Once the road enters the Wolverine Creek valley, the terrain flattens out and it should be possible to locate a road alignment with gentle grades and curves. We anticipate that both options will require a minimum of 4 major bridge crossings on Wolverine and Selkirk Creeks before arriving at the Hayes Creek Valley and joining with the current Freegold Road Extension alignment. It was also noted that sources for borrow material could be scarce near Wolverine Creek and Selkirk Creek. If sufficient material cannot be located near the alignment at regular intervals it will result in longer haul distances and increased road construction costs.

3 THE WOLVERINE ROUTE CORRIDOR

The day prior to our scheduled reconnaissance trip, Jesse Duke, P.Geo. in charge of Western Copper and Gold Corporation's government and community relations, proposed an additional corridor referred to as the Wolverine Route for the team to investigate. The Wolverine Route is a potential route alternative for the Freegold Road Extension that bypasses a portion of the Woodland Caribou winter range. The route would branch to the north off of the Big Creek section of the Freegold Road Extension and follow the Wolverine Creek Valley to Selkirk Creek where it would turn to the west and follow the Selkirk Creek Valley until it rejoined the Freegold Road Extension at Hayes Creek.

Visual field investigation of this route from the helicopter revealed steep terrain and narrow drainage valleys between Big Creek and the southern tip of the Wolverine Creek valley. We were unable to locate a suitable route over the height of land between the two creek valleys during our helicopter flight. Figure 4 shows a photo of some typical steep terrain in this area. It is anticipated that the road grades required along this route would present challenges for winter operations and that even in summer operations reduced speed sections would likely be required along with sections of one-lane road, retaining walls, and reinforced slopes. This route would have high capital and operating costs and would likely have some safety concerns. Further north in the Wolverine Creek Valley, it appeared that a route could be located. The route would require several crossings of the Wolverine Creek before reaching the final stretch along Selkirk Creek west to Hayes Creek.

A debrief meeting with Jesse Duke was held the day following the field investigation along with the environmental team of Michael Setterington and Matt Power of Environmental Dynamics Inc. (EDI) at EDI's offices in Whitehorse. At this meeting we discussed our observations of the Wolverine Route and presented photos of the steep terrain and narrow valleys. Jesse Duke decided that based on our observations, this route would not be investigated further at this time.

4 ADDITIONAL AFTER TRIP DESKTOP STUDY FINDINGS

Subsequent to the field investigation, Associated Engineering acquired 1:50,000 scale mapping and 40 m contour data from Geomatics Yukon. We then prepared conceptual horizontal and vertical alignments for each of the Minto Route corridor options. There are two route alternatives for the Hells Gate corridor option and three route alternatives for the Minto Landing corridor option. All route alternatives follow a common alignment from the Wolverine Creek Valley to the Hayes Creek Valley located mainly along the toe of the south facing valley slopes. The route alternatives are shown in attached sketches SK012 and SK013.

Road lengths from the Casino Mine to the port of Skagway for the roads associated with all the route alternatives and the Freegold Road Extension are shown in the attached Table 1. The table shows that the Minto Landing option routes are 2-4 km longer than the Freegold Road Extension while the Hells Gate option routes are 11-14 km longer.

The Hells Gate option routes have the advantage of avoiding Minto Mine property and First Nations settlement lands, but they are longer, require more new road construction, have more steep terrain sections, and they reduce the likelihood of cost sharing agreements with other road and bridge users. These routes should only be considered if First Nations and private property conflicts arise and cannot be resolved.

Minto Landing option routes are shorter, make use of 24 km of the existing Minto Mine road, and have a higher potential for cost sharing agreements with other road and bridge users. These routes pass through Minto Mine property and First Nations settlement lands.

While it appears that a feasible route from Minto to Hayes Creek can be located, a preferred route has not yet been selected. More detailed mapping is required to identify a preferred route option, confirm the alignment, and estimate cut and fill volumes for cost estimating. We will also need to better understand the environmental, First Nations, private property and geotechnical issues in the area.

5 CONCLUSIONS AND RECOMMENDATIONS

In order to advance the Minto Route corridor options and Yukon River bridge design we recommend the following tasks be completed as a Desktop study. Tasks are listed in the order in which they should be completed.

1. Obtain and Review aerial photos and terrain mapping for the Minto Route study area. Possible mapping sources include PhotoSat Satellite photo terrain mapping data (higher quality and available in spring or summer), LIDAR (higher quality and available in spring or summer), and digitised air photos from Yukon EMR library catalogue (lower quality and available any time).

2. Prepare functional designs of alternative routes using new terrain mapping and building upon initial conceptual alignments and field reconnaissance routes. Includes horizontal and vertical alignment design, cross-sections, identifying stream crossings, preliminary bridge concepts (including Yukon River crossing), and calculating preliminary costs and quantities.

3. Identify constraints and issues including private property, cost sharing possibilities, first nations, environmental, drainage, archaeological, borrow sources, terrain stability, and other potential risks.

4. Preliminary geotechnical testing.

5. Select preferred Minto route option and preferred Yukon River bridge crossing location based on functional designs and alignment issues.

6. Complete a written report discussing route options, alignment issues, selection criteria, and preliminary cost estimates.

Completion of these desktop study tasks will provide the information necessary to move forward with more detailed field investigations and additional engineering work. This will provide the basis to eventually achieve the same design level currently achieved for the Freegold Road extension. These tasks should preferably be completed prior to the spring of 2013 in order to provide sufficient lead time to organise field investigations during the 2013 field season.

Should you have any questions, please contact Ray Korpela or me.

Yours truly,

Prepared by:

PROFESSIONAL ENGINEER
YUKON TERRITORY
PATRICK T. STANCOMBE

Patrick Stancombe, P.Eng.
Project Engineer

Reviewed by:

Ray Korpela, AScT
Project Manager

PS/RK/af

Attachments:

- Figures 1, 2, 3, and 4
- Table 1, SK012 and SK013

cc: Jesse Duke



Figure 1
Potential Yukon River Crossing Site #1
Located 3 km South of Minto
Looking South



Figure 2
Potential Yukon River Crossing Site #2
Located Immediately South of Minto Landing
Looking North



Figure 3
Potential Yukon River Crossing Site #3
Located 26 km North of Minto near the Hell's Gate Rapids
Looking North



Figure 4
Steep Big Creek Valley Slopes
Between the Big Creek Valley and the Wolverine Creek Valley Beyond
Looking North

Table 1 - Road Distances

Highway Distance From Minto To Skagway	425 km

Distance From Hayes Creek Tie-in To Mine	61.5 km

Minto Route - Minto Landing Corridor - Crossing #2					
Option	Road Lengths (km)				
	Built Paved Highway	Built Gravel Road	New Construction	Hayes Tie in to Minto Total	Mine to Skagway Total
1	0	23.7	48.8	72.5	559
2	0	23.7	50.8	74.5	561
3	0	23.7	50.8	74.5	561

Minto Route - Hells Gate Corridor - Crossing Site #3					
Option	Road Lengths (km)				
	Built Paved Highway	Built Gravel Road	New Construction	Hayes Tie in to Minto Total	Mine to Skagway Total
1	7.4	0	73.6	81.0	568
2	7.4	0	77.1	84.5	571

Current Route - Freegold Road Extension				
Road Lengths (km)				
New Construction	Maintained Freegold Road	Unmaintained Freegold Road	Highway Distance Carmacks to Skagway	Mine to Skagway Total
133	61	9	354	557

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FORT SELKIRK

YUKON RIVER

19.8 km

HELLS GATE OPT. 2

YUKON RIVER
CROSSING SITE #3

HELLS GATE OPT. 1

16.3 km

21.8 km

WOLVERINE
CREEK

THE MINTO
ROUTE CORRIDOR

5.6 km

2.5 km

HAYES
CREEK

12.3 km

MINTO LANDING OPT. 1

2.2 km

SELKIRK
CREEK

TO CASINO
MINE SITE

6.8 km

MINTO LANDING OPT. 2

FREEGOLD ROAD EXTENSION
AT HAYES CREEK
APPROXIMATE TIE IN
STATION = 71+100

THE WOLVERINE
ROUTE CORRIDOR

MINTO LANDING OPT. 3

11.5 km

7.5 km

WOLVERINE
CREEK

TO BIG CREEK

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NO.	DATE	ENG.	BY	SUBJECT

REVISIONS

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DESIGNED	PATRICK STANCOMBE		2013/05/01
CHECKED			
APPROVED			
DATE		INITIAL	

WESTERN COPPER AND GOLD CORPORATION

50 m CONTOUR INTERVAL

CASINO MINE ACCESS
MINTO ROUTES

DRAWING NUMBER	REV. NO.	SHEET
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No Representations Of Any Kind Are Made To Other Parties

FORT SELKIRK
YUKON RIVER
19.8 km
HELLS GATE OPT. 2
YUKON RIVER
CROSSING SITE #3
HELLS GATE
RAPIDS
27.4 km
HELLS GATE OPT. 1
YUKON RIVER
16.3 km
THE MINTO ROUTE - HELLS GATE
CORRIDOR
WOLVERINE
CREEK
10.0 km
12.3 km
THE MINTO ROUTE - MINTO LANDING
CORRIDOR
MINTO LANDING OPT. 1
MINTO LANDING OPT. 2
6.8 km
MINTO BARGE SITE
7.4 km
HIGHWAY 2
MINTO LANDING OPT. 3
7.5 km
23.7 km
EXISTING MINTO MINE ROAD
YUKON RIVER
CROSSING SITE #2
APPROXIMATE MINTO
MINE SITE BOUNDARY
HIGHWAY 2
TO CARMACKS
YUKON RIVER
CROSSING SITE #1

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APPROVED			
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50 m CONTOUR INTERVAL

CASINO MINE ACCESS
MINTO ROUTES

DRAWING NUMBER	REV. NO.	SHEET
20092374-00-SK013		

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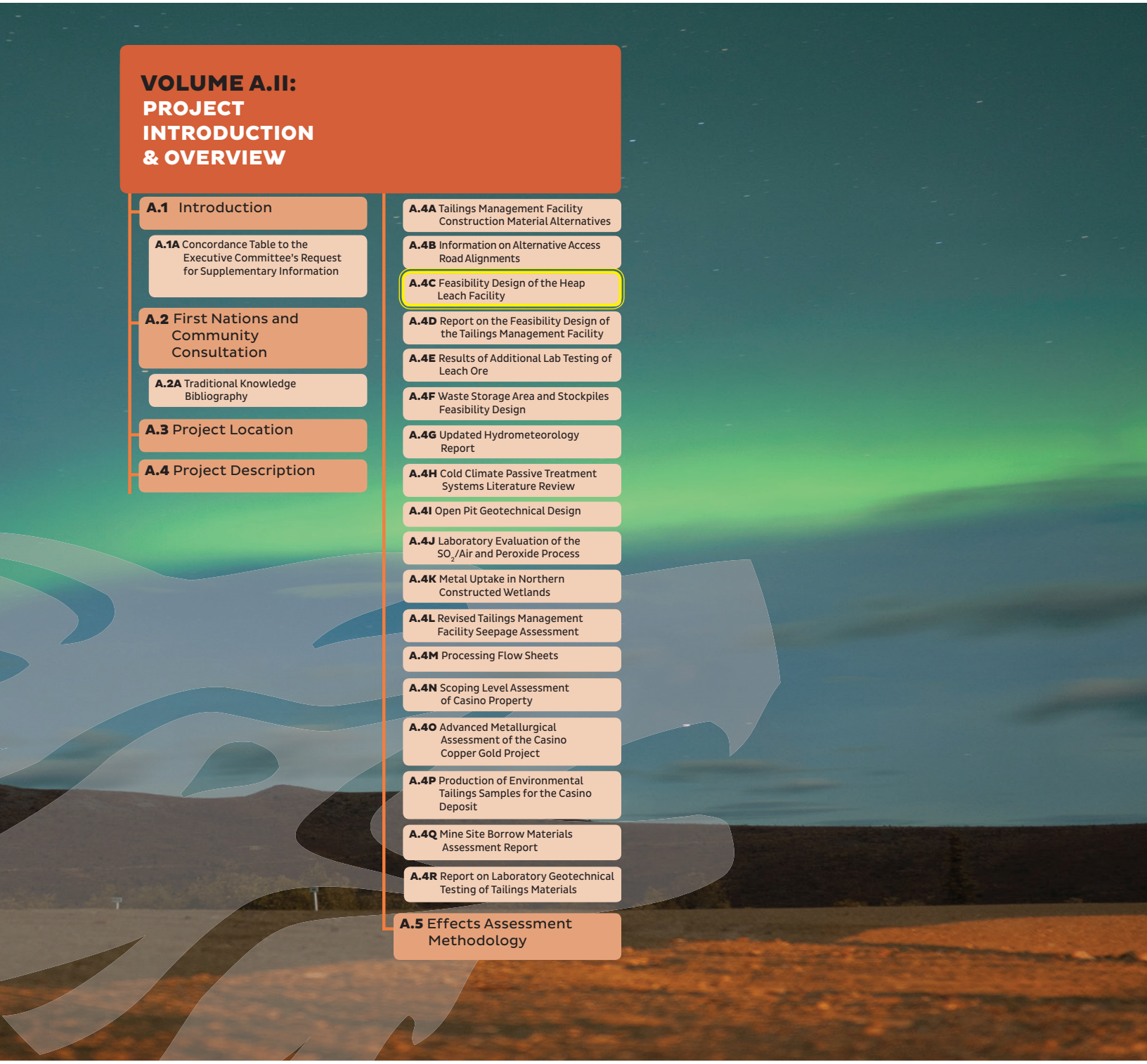
APPENDIX A.4C: Feasibility Design of the Heap Leach Facility



CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT





FEASIBILITY DESIGN OF THE HEAP LEACH FACILITY

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VA101-325/8-9
Rev 0
December 19, 2012

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ISO 9001 - FS 64925
ISO 14001 - EMS 550121
OHSAS 18001 - OHS 550122

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

FEASIBILITY DESIGN OF THE HEAP LEACH FACILITY
VA101-325/8-9

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0	Issued in Final	December 19, 2012	KVB

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EXECUTIVE SUMMARY

A Feasibility design has been undertaken for a Heap Leach Facility (HLF) at the Casino Copper-Gold Project. The proposed facility is located on a southeast facing hill-slope approximately one kilometre south of the deposit area. HLF operations will commence during pre-production stripping of the open pit. The design was carried out for an ore tonnage of 157.5 million tonnes. The heap leach pad will be stacked with ore and leached from Year -3 through Year 15 of mine operations. The ore will be leached at a nominal rate of 9.125 million tonnes per year. There is potential for stacking of additional ore if the mine production schedule is revised and additional leach ore is identified.

The Feasibility design includes an assessment of the following:

- Geotechnical site conditions
- Design basis and design requirements
- Design of heap leach pad and liner system
- Design of leachate collection system and events pond
- Water management and water balance
- Construction requirements and operational strategy
- Quantities and information for capital cost estimation
- Preliminary monitoring and reclamation requirements, and
- Recommendations for additional site investigations and design studies.

Information provided by site investigations and design studies indicate that the construction and operation of a HLF is possible at this site. However, the cold climate and presence of extensive permafrost requires special design and operational considerations.

The following is a summary of the design features, operational requirements and construction methods which will be required for the proposed facility:

- Pumping of pregnant solution to a gold extraction plant, located southwest of the plant site area.
- Excavation of the pad foundation down to competent bedrock in areas with permafrost to eliminate potential settlement and instability resulting from thawing of ice-rich overburden. These materials will require containment and sediment control upon thawing. The extent of ice-rich overburden throughout the heap leach pad area has been estimated as approximately two metres deep
- An events pond for temporary storage of storm runoff and pregnant solution overflow during shut down will be constructed at the foot of the HLF confining embankment. The events pond will be included as part of the pre-production schedule.
- A composite liner system comprising a LLDPE liner, compacted soil liner and leak detection and recovery system to maximize leachate collection and minimize seepage losses will be constructed over the upper portion of the leach pad. A double composite liner system comprising two LLDPE liners, a compacted soil liner and a geotextile layer will also be constructed in the lower portion of the leach pad (potential ponding area) and events pond and will include a leak detection and recovery system for intercepting and collecting any leakage through the inner liner.
- Borrow materials for the confining embankment, events pond and soil liner construction may utilize suitable overburden (residual and colluvial soils) and weathered bedrock along well

drained, non-frozen, south-facing slopes east or west of the HLF. Suitable non-reactive mine waste rock may also be used for HLF construction.

- The heap leach pad will be developed in five stages by loading in successive lifts upslope from the confining embankment. This will provide initial stability and minimize initial capital costs. The pad will be developed in eight metre lifts constructed at repose bench face angles of approximately 1.4H:1V. Bench widths approximately nine metre wide will be left at the toe of each lift to establish a final overall slope angle of 2.5H:1V.
- Operations will involve the irrigation of a weak cyanide solution over the ore lift and the recovery of pregnant solution by means of solution collection pipes and pumps. The solution will be pumped to the gold extraction plant for metal extraction and recycled for re-use in the leaching process. The irrigation lines will be buried to prevent freezing during winter conditions.

The final heap leach pad required for an ore tonnage of 157.5 million tonnes will have a surface area of approximately 1,501,000 m^2. An events pond will provide storage for excess leachate and storm water runoff. The heap leach pad confining embankment and events pond will require approximately 1,067,000 m^3 of embankment and drainage fill for construction. The required storage capacity for the events pond is approximately 110,000 m^3. The total quantity of geosynthetic liner required for the heap leach pad and confining embankment is approximately 1,587,000 m^2. The total quantity of geosynthetic liner for the events pond is approximately 50,300 m^2.

On-going costs will include foundation preparation and liner installation for expansion of the leach pad up the slope. Other costs associated with the HLF include operational costs and capital costs for leaching services. It is assumed that capital and operating cost estimates will be developed by Others.

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Appendix A Water Balance

1 – INTRODUCTION

1.1 PROJECT DESCRIPTION

The Casino Copper-Gold Project is a venture by Casino Mining Corporation (CMC) to develop an open pit copper-gold-molybdenum mine located in west central Yukon, Canada. The project is located in the Dawson Range Mountains of the Klondike Plateau approximately 300 km northwest of Whitehorse, Yukon, Canada, as shown on Figure 1.1. The deposit will be mined using open pit methods with a nominal mill throughput of 125,000 tonnes per day (TPD) of ore. Approximately 157.5 Mt of additional mined ore will be processed at the Heap Leach Facility (HLF) located south of the open pit. HLF operations will commence during pre-production stripping of the open pit. The heap leach pad will be stacked with ore and leached simultaneously from Year -3 through Year 15 of mine operations. The ore will be leached at a nominal rate of 9.125 million tonnes per year. The proposed facility is located on a southeast facing hill-slope approximately one kilometre south of the deposit area.

1.2 SCOPE OF WORK

This report presents the Feasibility design of the proposed HLF. The leach pad will comprise a fully contained gold ore treatment facility. The leaching process will involve the irrigation of weak cyanide solution over successive lifts of heaped ore. A total of 157.5 million tonnes (Mt) of ore was assumed for the design (based on the mining schedule issued by CMC on November 7, 2012), with consideration for potential expansion. This report discusses general site conditions, geotechnical implications, design requirements and design aspects for the heap leach pad.

Geotechnical site investigations in the current HLF area were carried out in 1993, 1994, 2011 and 2012. Additional site investigations, design studies and ore characterization will be required to confirm design assumptions and details.

1.3 PREVIOUS STUDIES

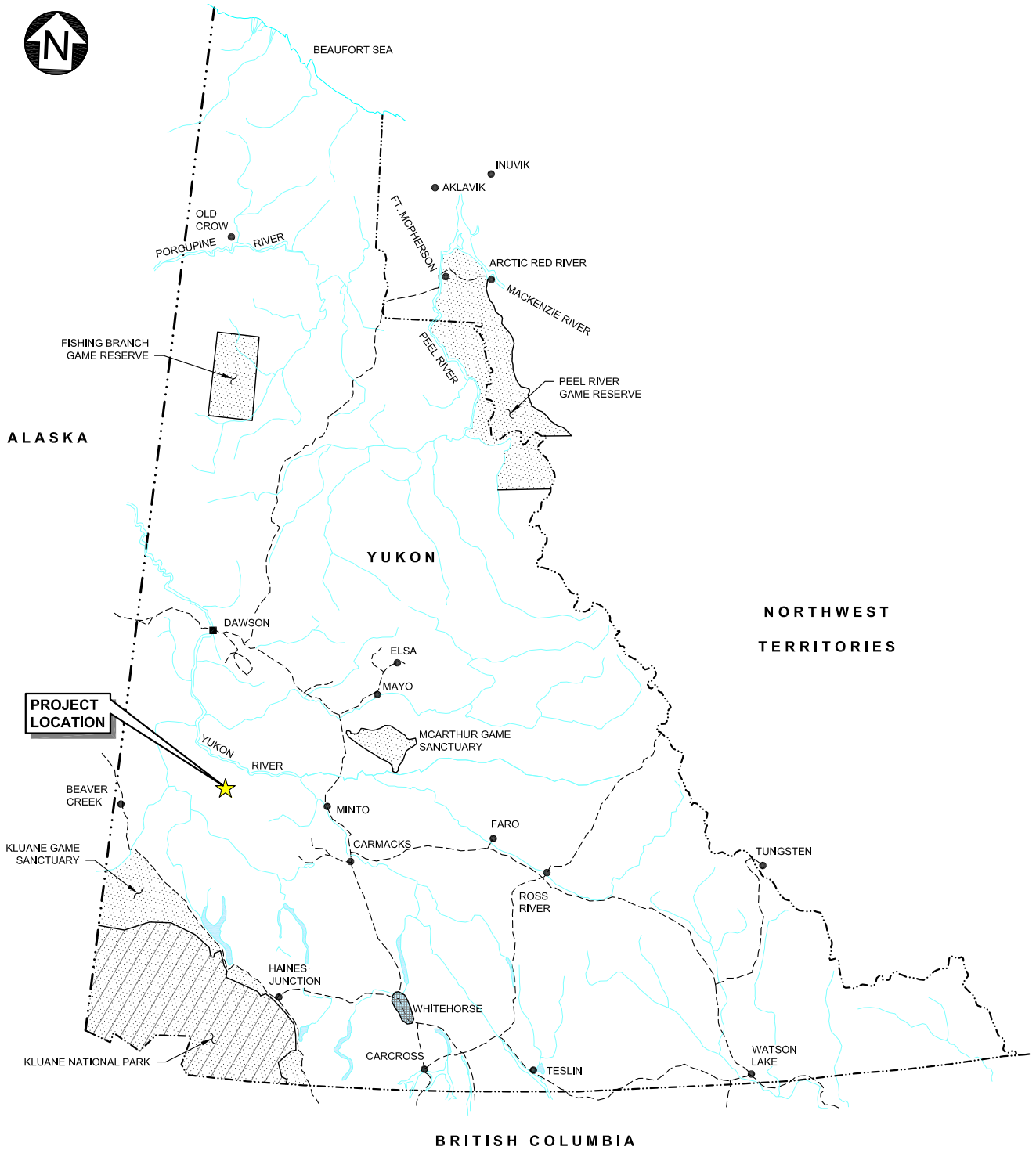
A conceptual design for a HLF was conducted by Knight Piésold Ltd. (KPL) in 1994 to 1995 and presented in the “Report on Conceptual Design of Heap Leach Facility” (Ref No. 1833/1, January 24, 1995). This facility was located immediately south of the deposit area and sized to accommodate 36.5 million tonnes of ore, with provision for expansion up to 50 million tonnes. This site was later ruled out due to an increased capacity requirement of leach ore.

A Pre-Feasibility design for a 75 Mt HLF was undertaken by KPL in 2008. The selected facility location was immediately north of the Tailings Management Facility (TMF). Details of this design are presented in KPL report “Pre-Feasibility Design of the Heap Leach Facility” (Ref. No. VA101-325/1-1, April 23, 2008).

A revised Pre-Feasibility design for an 81.6 Mt HLF was carried out by KPL in 2011. This revised Pre-Feasibility design located the HLF in a position deemed more favourable because of its topography and proximity to the deposit area and plant site. The site was located south of the deposit area as shown on Figure 1.2, in an area previously designated but no longer required for storage of Non-Acid Generating (NAG) mine waste rock and overburden. This site is located

upstream and within the same catchment area as the TMF, thereby simplifying water management and minimizing potential environmental impact.

This Feasibility design report further develops the 2011 revised pre-feasibility HLF design. The HLF pad has been expanded to accommodate a total capacity of 157.5 Mt of ore (an additional 75.9 Mt). Further expansion of the site to accommodate additional leach ore within the HLF is also possible if the mine production schedule is revised and additional leach ore is identified.



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PROJECT LOCATION MAP

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FIGURE 1.1

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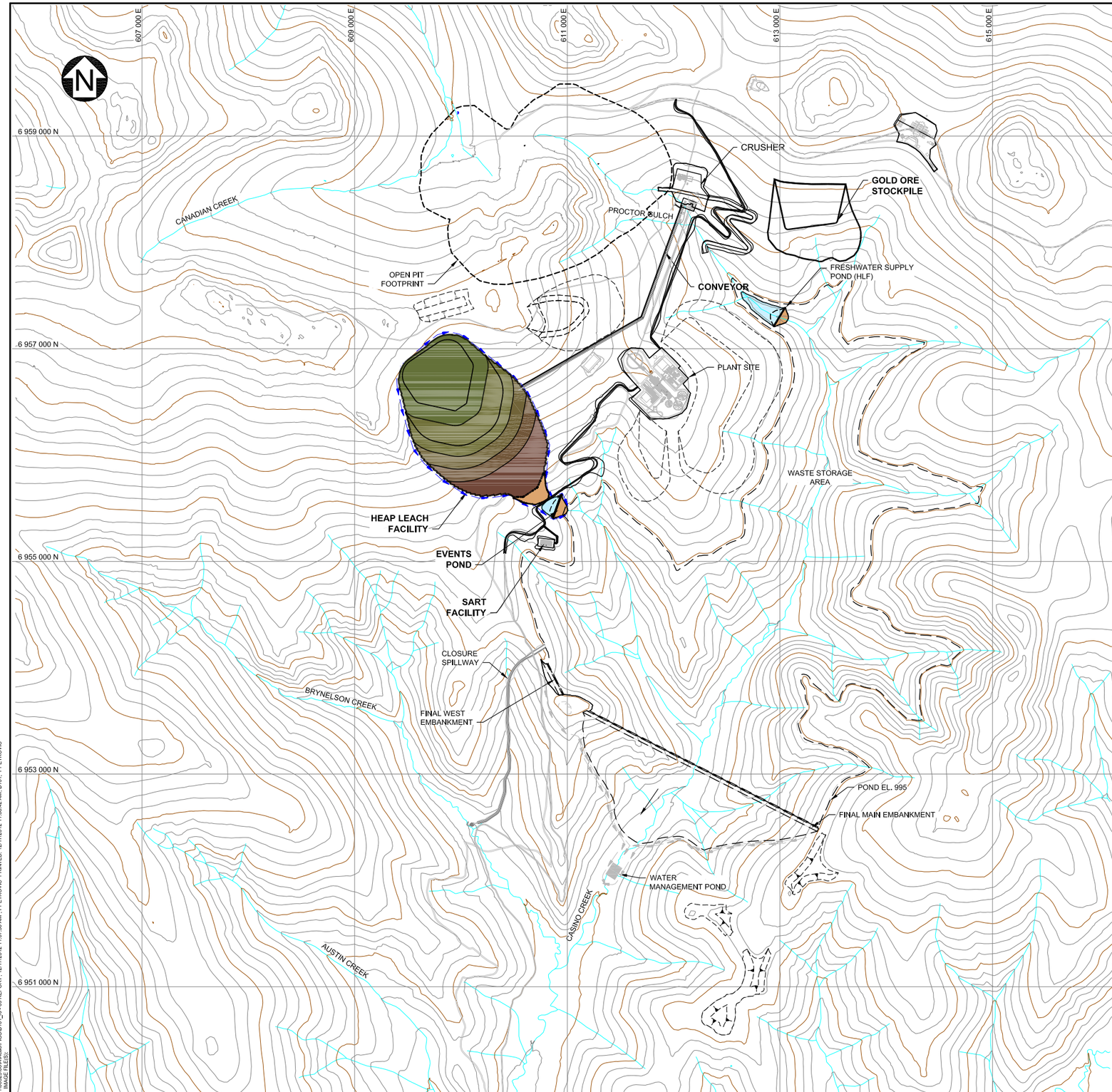

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PROJECT GENERAL ARRANGEMENT

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FIGURE 1.2

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2 – SITE CHARACTERISTICS

2.1 PHYSIOGRAPHIC SETTING

The project is located in the Dawson Range Mountains of the Klondike Plateau. The area is somewhat unique in that the region was not glaciated during the Wisconsin Advance. The characteristic terrain features are smooth, rolling topography, with moderate to deeply incised valleys. Major drainage channels extend below 1,000 m elevation. Most of the terrain lies between 1,000 m and 1,500 m elevation.

The proposed heap leach facility is located west of the plant site and south of the open pit area. The leach pad is situated on a relatively uniform southeast-facing hillside. The existing topography slopes at approximately 20% (11.5 degrees). The site was chosen for its proximity to the proposed open pit to minimize haul road and ore transport conveyor distances, and to include the leach pad within the same catchment area as the TMF.

A natural drainage channel exists along the middle of the leach pad, where the main leachate collection pipes will be located. The location of the heap leach pad in relation to the overall site and other project components is shown on Figure 1.2.

2.2 HYDROMETEOROLOGY

2.2.1 General

The climate at the Casino Project area is characterized by long, cold, dry winters and short, warm, wet summers, with conditions varying according to altitude and aspect. Streamflow in the region is typically highest in May due to melting of the winter snowpack. Annual peak instantaneous flows commonly occur in this freshet period on larger rivers, but on smaller streams they may also occur in summer or early autumn due to intense rain or rain on snow events. Flows decrease throughout the winter and minimum flows typically occur in March or April.

The climate and hydrology at the Casino Project site have been assessed based on both short-term site data and longer-term regional data. Climatic data were collected on-site at the Project climate station located in the upper Casino Creek sub-watershed at an elevation of 1200 m. The period of site record extends from 1993 to 1994 and from 2008 to 2011. Preliminary streamflow data were collected by Hallam Knight Piésold in 1993 and 1994. A new data streamflow collection program was initiated by AECOM in 2008, with the installation of ten streamflow gauging stations. As of 2012, nine streamflow gauging stations are considered to be in active operation and continue to be operated at present by Knight Piésold Ltd. (KPL). A summary of the hydrometeorological parameters is described below and the detailed analyses are presented in KPL report “Updated Hydrometeorology Report” (Ref. No. VA101-325/8-11, July 9, 2012).

2.2.2 Temperature

The mean annual temperature for the Casino Project area is estimated to be -3 °C, with minimum and maximum mean monthly temperatures of -17 °C and 12 °C occurring in January and July, respectively.

The mean monthly temperature values are presented in Table 2.1.

Table 2.1 Mean Monthly Temperature and Precipitation Values

Location	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Casino Project Station (El. 1200 m)	Rainfall est.	0	0	0	8	37	62	91	67	47	18	0	0	**330**
	Snowfall est.	32	24	19	9	0	0	0	0	0	20	43	33	**180**
	Precipitation (mm)	32	24	19	17	37	62	91	67	47	38	43	33	**510**
	Temperature (°C)	-16.1	-14.9	-9.5	-0.6	6.5	9.8	12.3	10.3	4.6	-3.6	-12.0	-14.0	**-2.2**

2.2.3 Precipitation and Evaporation

The Mean Annual Precipitation (MAP) for the Casino Project area is estimated to be 510 mm, with 65% falling as rain and 35% falling as snow. The mean monthly values are presented in Table 2.1.

The annual potential evapotranspiration (PET) value for the Casino Project area is estimated to be 300 mm, based on measured temperatures at the Project site climate station, and long-term regional temperature records. Potential evapotranspiration values generally provide reasonable estimates of lake evaporation rates, and are assumed to be appropriate for estimating evaporation from lakes and ponds in the Project area.

2.2.4 Annual Snowfall and Snowmelt

Based on the estimated MAP of 510 mm and a rain/snow ratio of 0.65/0.35, the annual snowfall value for Casino was estimated to be 179 mm. This is generally consistent with the 141 mm mean annual maximum snowpack value (snow water equivalent, SWE), taking into account approximately 40 mm lost to sublimation, recorded in the Project area at the Casino Creek snow course station (09CD-SC01) operated by the Yukon Department of Environment (1977-2011), Water Resources Branch.

Based on the complete years of snowpack data, the average monthly snowmelt distribution for the Casino Project area was estimated to be approximately 20% in April and the remaining 80% in May, although there is considerable variation from year to year.

2.3 SEISMICITY

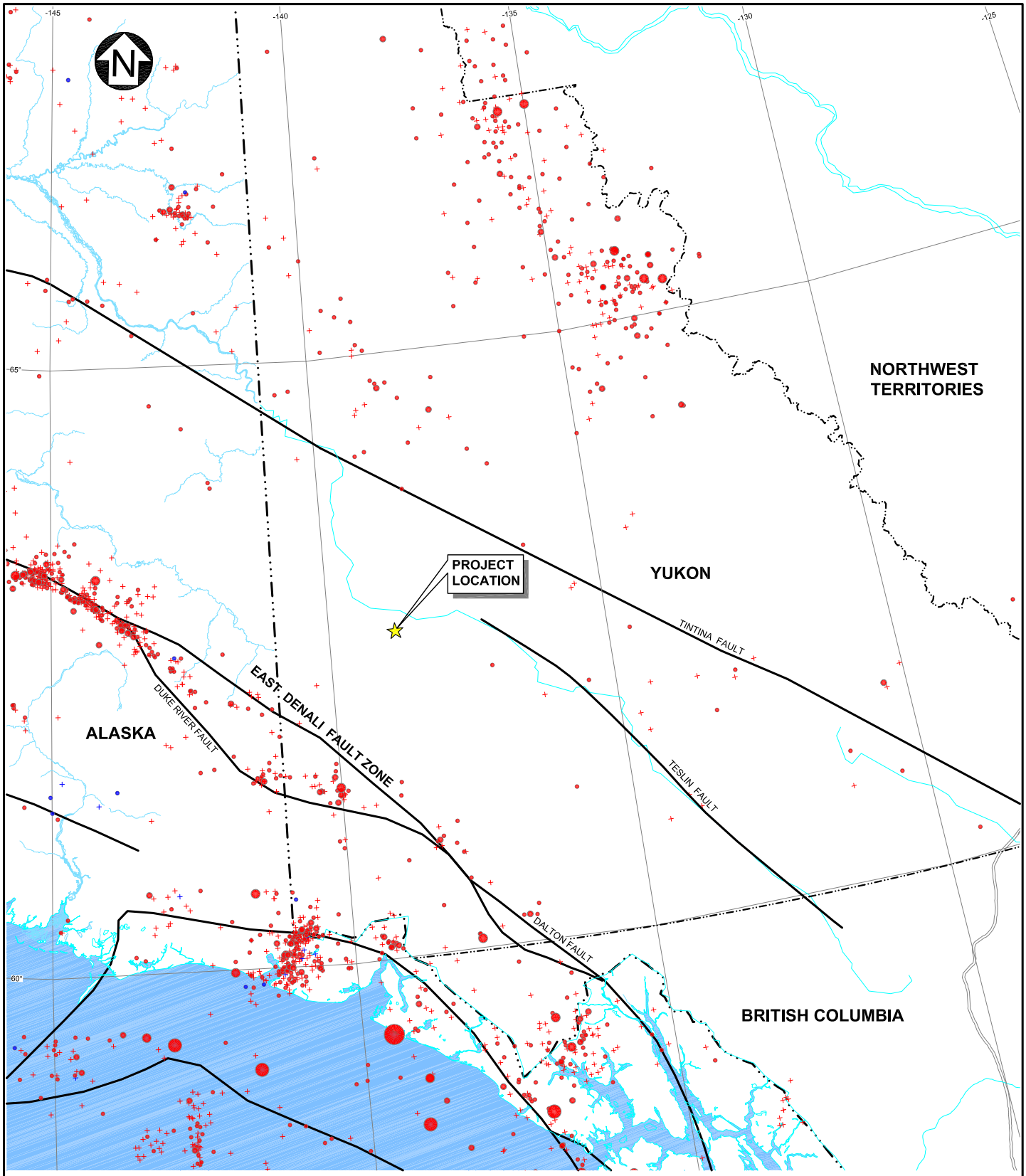
A review of the regional seismicity has been carried out to enable selection of an appropriate design earthquake event for seismic stability assessment of the HLF.

The region of the southwest Yukon Territory and northwest British Columbia is one of the most seismically active areas in Canada. The seismic hazard in the region is also influenced by the seismically active region of southeast Alaska. The coastal region has experienced many large earthquakes, including events with magnitudes in the range of magnitude 7.0 to 8.0. In 1958 a magnitude 7.9 earthquake occurred along the Fairweather fault (the northern extension of the Queen Charlotte transform fault). The most significant inland zone of seismicity follows the Dalton and Duke River segments of the Denali fault zone through the southwest Yukon. Farther inland there is only

minor seismicity between the Denali and Tintina fault systems, including the region of the Casino Project site.

A probabilistic seismic hazard assessment has been carried out for the Casino project site to provide seismic parameters for design of project facilities. Details and results of the seismic hazard analysis are provided in the KPL report "Feasibility Design of the Tailings Management Facility" (Ref. No. VA101-325/8-10, November, 2012).

Figure 2.1 shows the regional tectonics and historical seismicity of the Yukon and surrounding regions. Review of historical earthquake records and regional tectonics indicates that the Casino Project site is situated in a region of low seismicity and moderate seismic hazard.



SYMBOL SIZE PROPORTIONAL TO MAGNITUDE

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- 4.0 - 4.9
- 5.0 - 5.9
- 6.0 - 6.9
- 7.0 - 7.9
- 8.0 - 8.9
- 9.0 +

NOTES:

1. GLOBAL COORDINATE SYSTEM IS UTM WITH NAD83 DATUM, ZONE 10 m, CENTRAL MERIDIAN.
2. HISTORICAL EARTHQUAKE DATA FROM NRCAN, USGS, AND NGDC DATABASES.
3. INCLUDES RECORDED EARTHQUAKES FROM 1600 TO 1973 (MAGNITUDE > 6.0) AND FROM 1973 TO SEPTEMBER 2012 (MAGNITUDE > 3.5).

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REGIONAL TECTONICS AND HISTORICAL SEISMICITY

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FIGURE 2.1 | REV 0

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3 – DESIGN REQUIREMENTS AND PARAMETERS

3.1 DESIGN OBJECTIVES

The primary design objectives for the proposed heap leach pad are as follows:

- Provide a stable and cost effective configuration for staged heap development
- Effectively collect and convey leachate solutions to the process plant or the events pond while ensuring maximum recovery
- Provide for secure containment of events solutions while monitoring and minimizing losses due to leakage
- Minimize surface runoff entering the leach pad area while providing for the collection of direct runoff from the heap area
- Sequential, staged development and leaching operations with particular emphasis on winter operations, and
- Effective decommissioning and reclamation of all heap leach facility components.

The following sections discuss the storage requirements and design assumptions and parameters for the proposed leach pad. Design features for each component are discussed in Section 5.0.

3.2 DESIGN BASIS AND ASSUMPTIONS

The design storage for the heap leach pad has been based on a requirement for 157.5 million tonnes capacity with the potential for further expansion if required.

Various design assumptions and parameters were used in this Feasibility design and configuration layout of the heap leach pad. The assumptions and parameters used to develop the design are listed below:

- Total ore tonnage: 157.5 Mt
- Ore stacking schedule: 300 days/year
- Ore leaching schedule: 365 days/year
- Annual stacking tonnage: 9,125,000 tonnes/year (max); 6,580,000 tonnes/year (min)
- Mine-run Ore specific gravity (estimate): 2.65
- Constant average depth to bedrock: 2 metres
- Lift thickness: 8 metres
- Dry density of ore heap (estimate): 1.75 t/m^3
- Mine-run ore moisture content: 2%
- Leach pile ore operating moisture content: 12%
- Leach pile ore retained moisture content: 10%
- Ore irrigation rate: 0.29 $m^3/day/m^2$ (12 $L/h/m^2$)
- HLF Irrigation capacity: 1312 m^3/day
- Runoff on heap leach pad: 98.25 %
- Design Storm: 1 in 100 year 24-hour: 53 mm
- Design Storm: 1 in 200 year 24-hour: 56 mm

The Water Management System is designed to accommodate the 1 in 100 year storm event. Spillways are designed for the 1 in 200 year storm event.

Leach ore testing (to determine ore moisture contents and densities) will be required to confirm assumptions for future design studies.

The pad will be constructed in five stages commencing in Year -3 (pre-production stage of the project). It will be loaded in successive eight metre thick lifts for 300 days a year while the leaching process will operate year round. A drip-type irrigation system will be implemented which enables year round leaching operation due to being insulated by the placement of subsequent ore lifts overtop.

Gold ore to feed the HLF will be located in a temporary stockpile east of the open pit, close to the crusher. The ore will be crushed and transported to the pad by conveyor. The locations of the proposed gold ore stockpile, crusher and conveyor alignment are included on Figure 1.2.

4 – GEOTECHNICAL CHARACTERISTICS

4.1 GEOTECHNICAL CONDITIONS

Geotechnical and hydrogeological information in the vicinity of the HLF is derived from the interpretation of KPL drill hole and test pit data within both the HLF and surrounding areas. Several geotechnical site investigation programs were conducted in the area of the HLF in 1993 and 1994 and in 2011 and 2012. Details and results of the site investigations are presented in the following KPL reports:

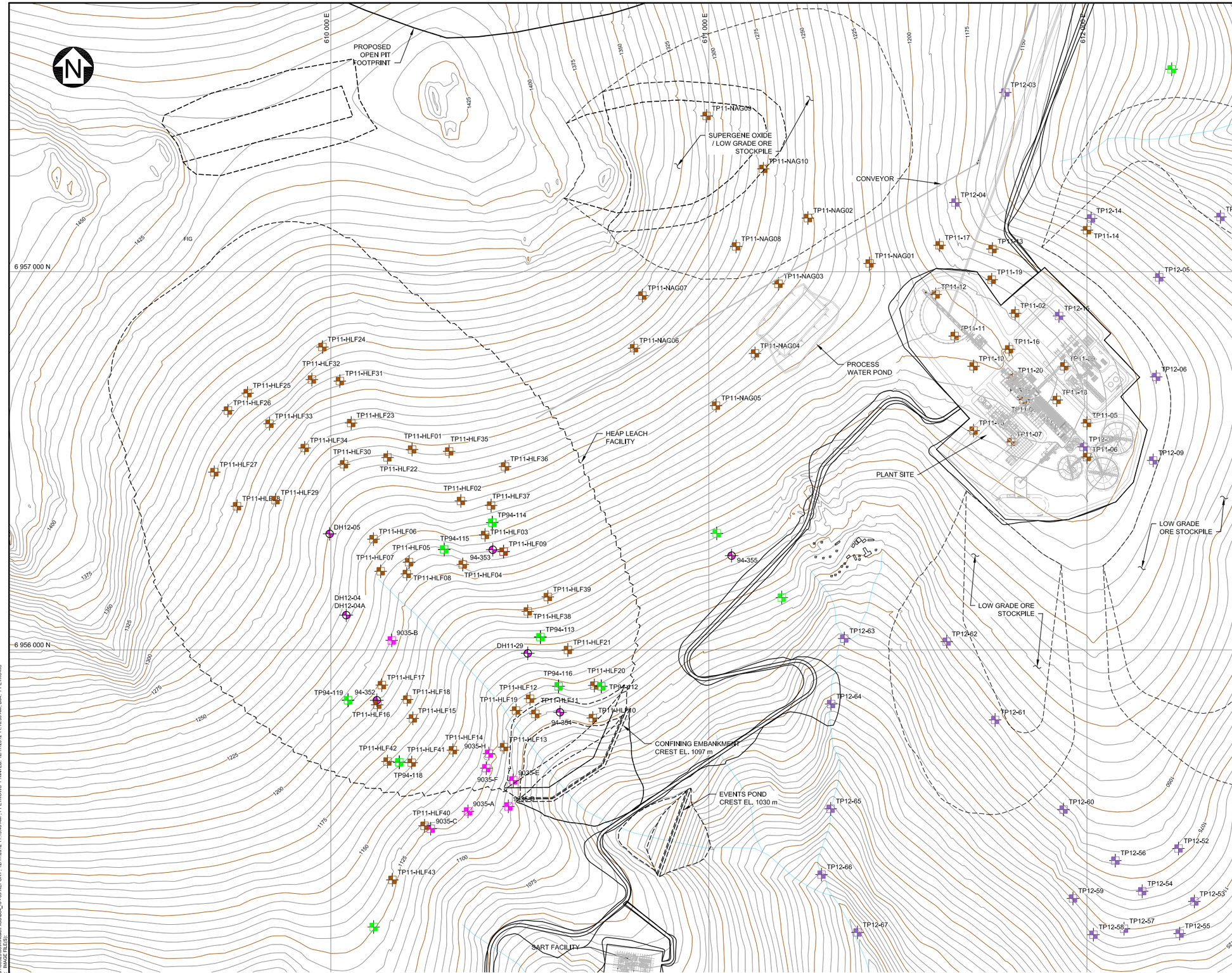
- Report on Preliminary Surficial Geotechnical Investigations (Ref. No. 1831/1, March, 1994)
- Data Compilation Report on 1994 Geotechnical/Hydrogeological Investigations (Ref. No. 1832/1, February 22, 1995)
- 2011 Geotechnical Site Investigation Data Report Waste Management Facilities (Ref. No. VA101-325/8-5, May 18, 2012), and
- 2012 Geotechnical Site Investigation Data Report (Ref. No., VA101-325/8-14, December, 2012).

The locations of drill holes, test pits, and test trenches excavated in the vicinity of the proposed heap leach facility are shown on Figure 4.1. The majority of the test pits conducted in 2011 were ended due to refusal on frozen ground or boulders.

The HLF is situated on a southeast-facing slope south of the deposit area. Vegetation is comprised primarily of deciduous black spruce with thin moss and forest litter cover. Soil profiles throughout the proposed heap leach pad area typically comprise a thin veneer of organic-rich topsoil and colluvium overlying in situ weathered residual soils or granodiorite bedrock.

The subsurface conditions in the area of the HLF are based on the findings of the geotechnical investigations, and are generally summarized below:

- Topsoil comprises a moist organic-rich silty layer. Coarse talus blocks (boulders) are also common. Topsoil thicknesses vary from approximately 0.1 to 1.0 m.
- Silty sand containing some gravel and cobbles, trace boulders and clay (residual soil and colluvium). Residual soils generally comprise moderately to highly weathered silts and sands with some gravel and trace clay. Ice lenses were found in some test pits which could result in high water contents upon thawing.
- Dawson Range Batholith (Mid-Cretaceous) is the main country rock in the HLF area and is dominantly granodiorite in composition. Aplite was found in 94-352 and a Patton Porphyry Dyke (Upper Cretaceous) was noted in DH11-29. The depth to bedrock varies from 1 to 7.6 m, with an average depth of approximately 2.5 m. The greatest depth to bedrock was encountered at the bottom (southern) end of the HLF area (DH94-453). Weathered Granodiorite has been found to extend to 41 m depth in recent site investigations, but earlier investigations indicated the presence of slightly weathered, competent bedrock.



LEGEND:

- 1993 AND 1994 TEST PIT
- 2010 TEST PIT
- 2011 TEST PIT
- 2012 TEST PIT
- 2012 GEOTECHNICAL DRILLHOLE
- 1994 GEOTECHNICAL DRILLHOLE

NOTES:

1. COORDINATE GRID IS UTM (WGS84/NAD83) ZONE 7 (m).
2. CONTOUR INTERVAL IS 5 METRES.
3. DIMENSIONS ARE IN METRES UNLESS NOTED.
4. ONLY SELECT TEST PITS AND DRILL HOLES ARE SHOWN FROM PREVIOUS SITE INVESTIGATION PROGRAMS.
5. ORE AND TOPSOIL STOCKPILES ARE SHOWN AT THEIR MAXIMUM SIZE DURING OPERATIONS.

CASINO MINING CORPORATION

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HEAP LEACH FACILITY SITE INVESTIGATION PLAN

Knight Piésold CONSULTING

P/A NO.	REF NO.
VA101-325/8	9

FIGURE 4.1 REV 0

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4.2 HYDROGEOLOGICAL CONDITIONS

The interpreted baseline groundwater conditions are based on piezometric levels in standpipe piezometers throughout the study area. Permeability results are based on packer tests and falling head tests performed in the drill holes and piezometers in the different geological units.

Water level readings were recorded for piezometers 94-352, 94-353, 94-354 (between September and December of 1994) and in DH11-29. The depth from ground surface to water varies from approximately 3 metres in the southwest area of the HLF to 20 metres in the southeast area. The water level in DH11-29 was measured at 12.2 m below ground surface in 2011.

In situ packer and falling head permeability tests were carried out in a number of drill holes within the HLF area during the 1994 and 2011 geotechnical/hydrogeological investigations. Estimates of in situ permeability values, along with supporting hydrogeologic observations are summarized as follows:

- One falling head test was performed in overburden soils in drill hole 94-354 with an estimated permeability of 8×10^{-5} cm/s.
- 14 permeability (slug) tests performed in 1994 in rock ranged from 5×10^{-6} cm/s to 1×10^{-3} cm/s, with a geometric mean value of 1×10^{-4} cm/s.
- Three packer tests and one falling head test performed in rock at DH11-29 indicated permeability values ranging from 3×10^{-6} cm/s to 6×10^{-5} cm/s.

Permafrost has an important effect on groundwater flow. Saturated frozen soil and rock have a much lower permeability when frozen compared to a thawed or unfrozen state.

Water well level elevations in the HLF area range from approximately 1080 to 1230 meters. The highest water levels are located in the upper part of the HLF, which indicates groundwater is flowing southeast and downgradient towards the Meloy Creek valley bottom.

4.3 PERMAFROST

Permafrost, or perennially frozen ground, is discontinuous along Casino Creek valley and is restricted primarily to valley bottoms, north-facing slopes and local shaded areas. Although permafrost was recorded in some areas of the HLF, the area is typically characterized by well-drained colluvial and/or residual sandy soils supporting stands of tall spruce and poplar. Permafrost was most extensive in the upper part of the HLF area, where vegetation consists of shrubs and a few stunted trees. It is less prominent in the more densely forested southeast part of the area. The permafrost table varies from 0.2 to 3 m depth, with an average depth of 1.5 m.

The estimated frost penetration depth for the Casino Project site is estimated to be approximately 5.5 metres in sand and gravel soils (granular) and decomposed/weathered bedrock. A thermistor was installed in DH12-05 during the 2012 site investigation to provide a better understanding of the thermal regime in the bedrock.

Disturbance or removal of the vegetative cover for foundation preparation may result in the melting of permafrost and the development of unstable conditions. It is therefore recommended that all ice-rich overburden encountered during construction be removed along the entire foundation of the HLF. Ground ice is not expected to be significant in bedrock which will likely provide a stable foundation for the pad and other components of the HLF.

4.4 GEOTECHNICAL IMPLICATIONS FOR DESIGN

The information provided by the site investigations has been used to determine geotechnical implications for this Feasibility design. Additional subsurface investigations will be required to confirm foundation conditions for future design studies.

The geotechnical implications for design are as follows:

- Initial foundation preparation for the heap leach pad will involve stripping of thick moss and shrub vegetation and removal of coarse talus blocks along the slope. Topsoil from stripping will be stockpiled for reclamation, as required.
- Frozen, organic and ice-rich colluvium and residual soils may require ripping or blasting to competent, non-frost susceptible bedrock for subgrade preparation. All ice-rich overburden and heavily weathered rock must be removed to prevent potential thaw-settlement resulting from melting permafrost. The bedrock will provide a thaw-stable foundation for the leach pad.
- Depths to competent bedrock over the leach pad area are expected to vary from approximately 1 to 8 metres, based on available information. An average depth of 2.5 m has been assumed for estimating the quantity of foundation excavation required.
- Spoil from excavated ice-rich overburden will require containment and sediment control during thawing.
- Colluvium and residual soils along south-facing slopes east and west of the HLF may provide excellent borrow materials for initial leach pad construction. The finer grained residual silty sands near surface may be utilized as soil liner for embankment and leach pad construction. Coarser grained colluvium, gravelly residual sands and broken, weathered bedrock at depth may be used as general backfill for the leach pad foundation or as fill in embankment construction.
- Foundation drains may be required to relieve groundwater pressures under the pad liners and/or if significant natural seeps are intersected. The drains will likely comprise perforated drain pipe surrounded by drain gravel and filter fabric. The drain gravel may be obtained from crushed borrow quarry rock or alluvial soils from creek beds.
- Diversion and runoff collection ditches constructed around the HLF will likely be founded in overburden. Therefore in order to prevent degradation from thawing permafrost riprap or other erosion protection will be required.

The proposed gold extraction facilities may be sited on competent, hard granodiorite bedrock at shallow depths adjacent to the HLF.

5 – ENGINEERING ANALYSES AND DESIGN

The Heap Leach Facility (HLF) consists of the following system components:

- Heap leach pad
- Liner System
- Leachate collection system
- Events pond
- Stormwater management system, and
- Freshwater supply.

The ore stacking schedule for the heap leach pad has been designed as 'development' stages, with each stage requiring advance expansion of the pad footprint. The HLF will be constructed in five 'pad development' stages, with the pad foundation preparation, liner installation and leachate collection piping developed as the footprint of the leach pad expands upslope to accommodate additional ore lifts. The duration for each stacking stages ranges from three to four years.

The initial HLF development (Stage 1) will also include the complete development of the confining embankment, events pond and perimeter diversion ditches prior to commencing ore stacking and leaching. Table 5.1 presents the stacking schedule, the respective development footprints and ore volume capacities. Figure 5.1 presents the plan and typical section of the final HLF pad, confining embankment and events pond. Figures 5.2 to 5.4 present the staging and the development progress and Figure 5.5 presents the Elevation - Capacity curve for the pad.

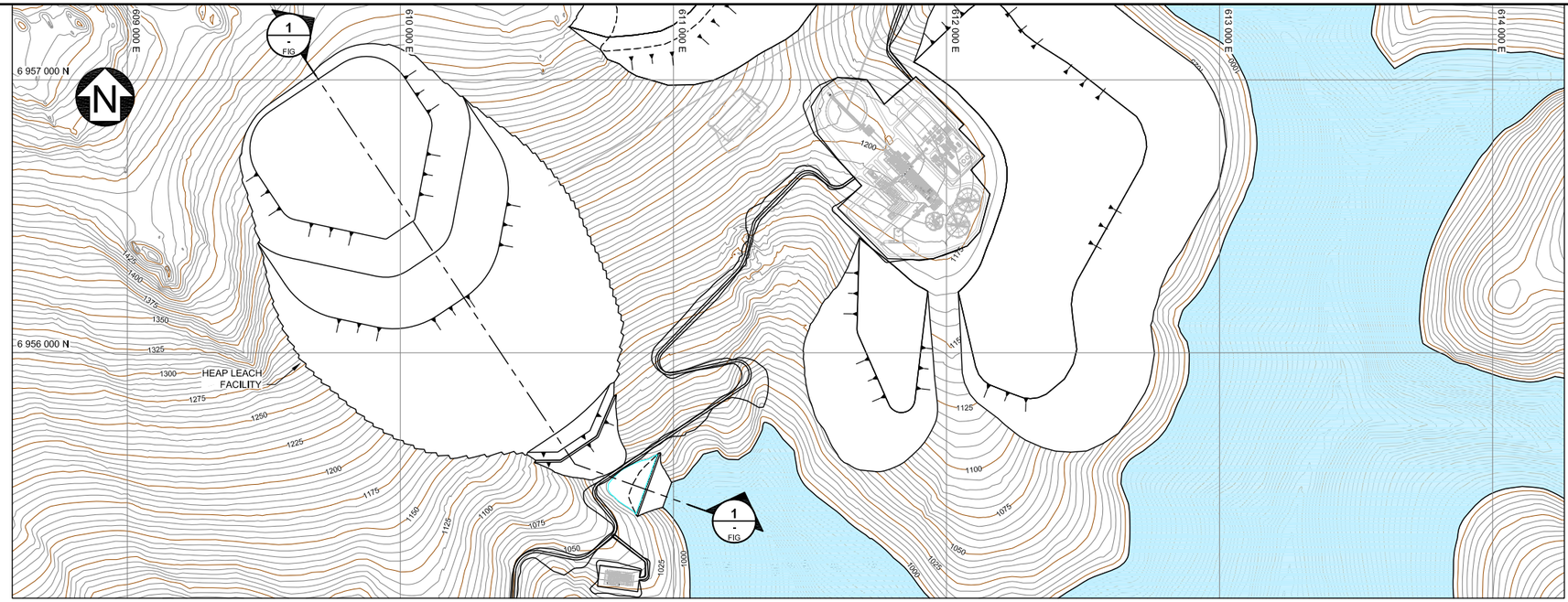
Design details for each of the HLF components are discussed further in the following sections.

Table 5.1 Heap Leach Stacking Schedule

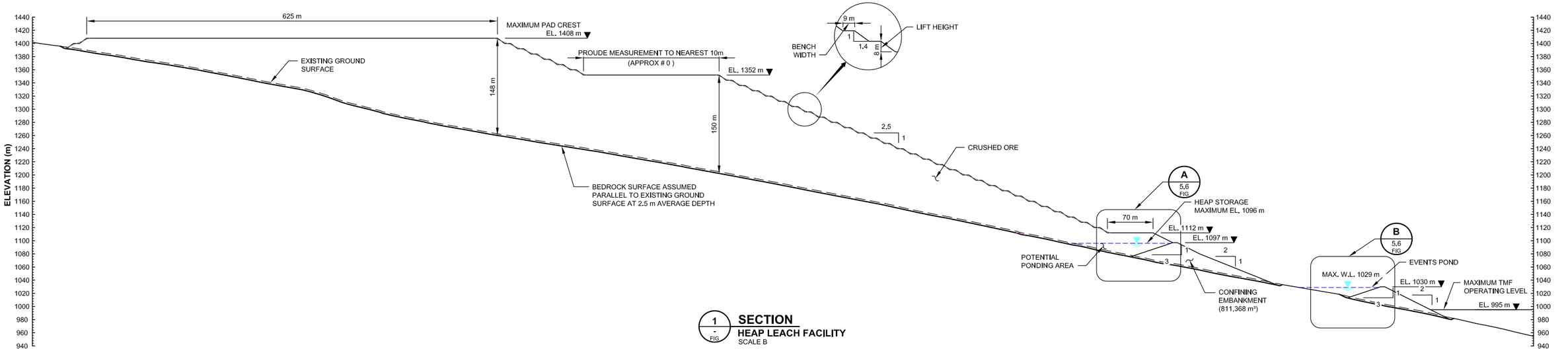
YEAR	DEVELOPMENT STAGE	HEAP LEACH FACILITY			
		Liner footprint (expansion area)	Stacked Ore Mass [1]	Stacked Ore Volume [1]	Cummulative Stacked Ore Volume
		m^2	Tonnes	m^3	m^3
-3	1	498,456	6,580,000	3,760,000	3,760,000
-2			9,125,000	5,214,286	8,974,286
-1			9,125,000	5,214,286	14,188,571
1	2	292,660	9,125,000	5,214,286	19,402,857
2			9,125,000	5,214,286	24,617,143
3			9,125,000	5,214,286	29,831,429
4	3	299,680	9,125,000	5,214,286	35,045,714
5			9,125,000	5,214,286	40,260,000
6			9,125,000	5,214,286	45,474,286
7			9,125,000	5,214,286	50,688,571
8	4	220,610	9,125,000	5,214,286	55,902,857
9			9,125,000	5,214,286	61,117,143
10			9,125,000	5,214,286	66,331,429
11			9,125,000	5,214,286	71,545,714
12	5	189,542	9,125,000	5,214,286	76,760,000
13			9,125,000	5,214,286	81,974,286
14			9,125,000	5,214,286	87,188,571
15			4,874,000	2,785,143	89,973,714

NOTES:

1. Mine schedule provided by Casino Mining Corporation November 7, 2012.
2. Assumes ‘stacked’ gold ore density of 1.75 t/m3



PLAN
HEAP LEACH
SCALE A



1 / - FIG **SECTION**
HEAP LEACH FACILITY
SCALE B

NOTES:

1. CONTOUR INTERVAL IS 5 METRES.
2. DIMENSIONS ARE IN MILLIMETRES AND ELEVATIONS ARE IN METRES, UNLESS NOTED OTHERWISE.

SCALE B: 60 30 0 100 200 300 m
SCALE A: 200 100 0 200 400 600 800 1000 m

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HEAP LEACH FACILITY
PLAN, TYPICAL SECTION AND DETAIL

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P/A NO.	REF NO.
VA101-325/8	9

FIGURE 5.1 REV 0

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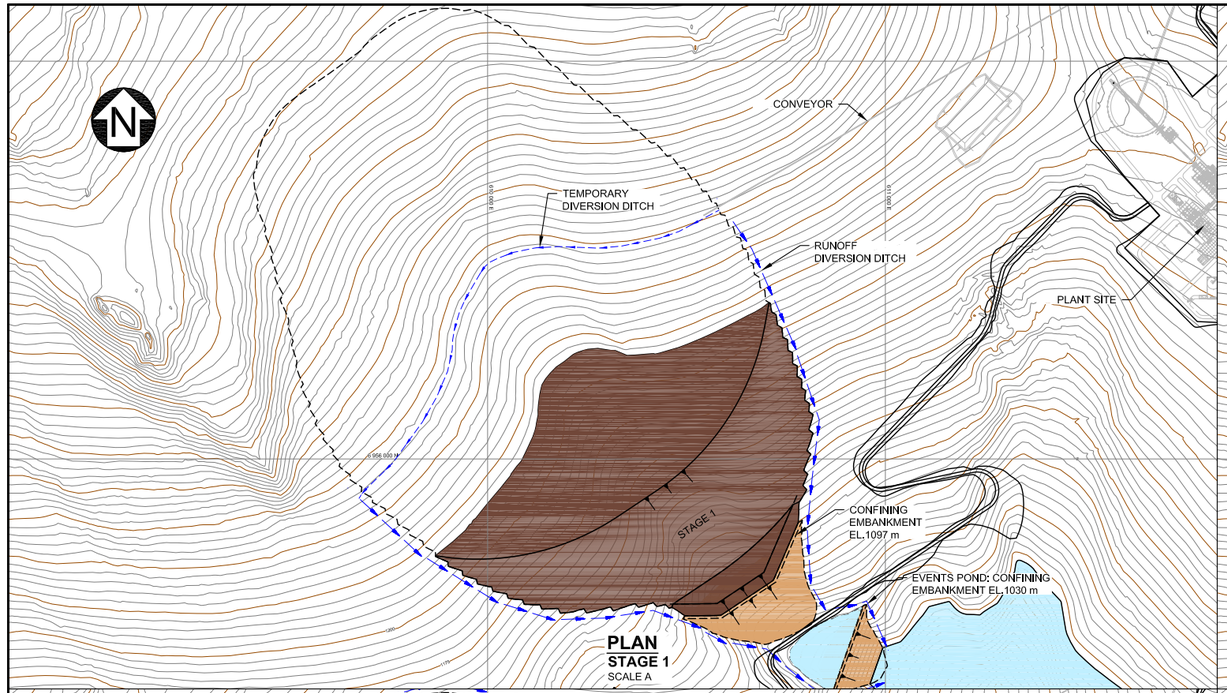
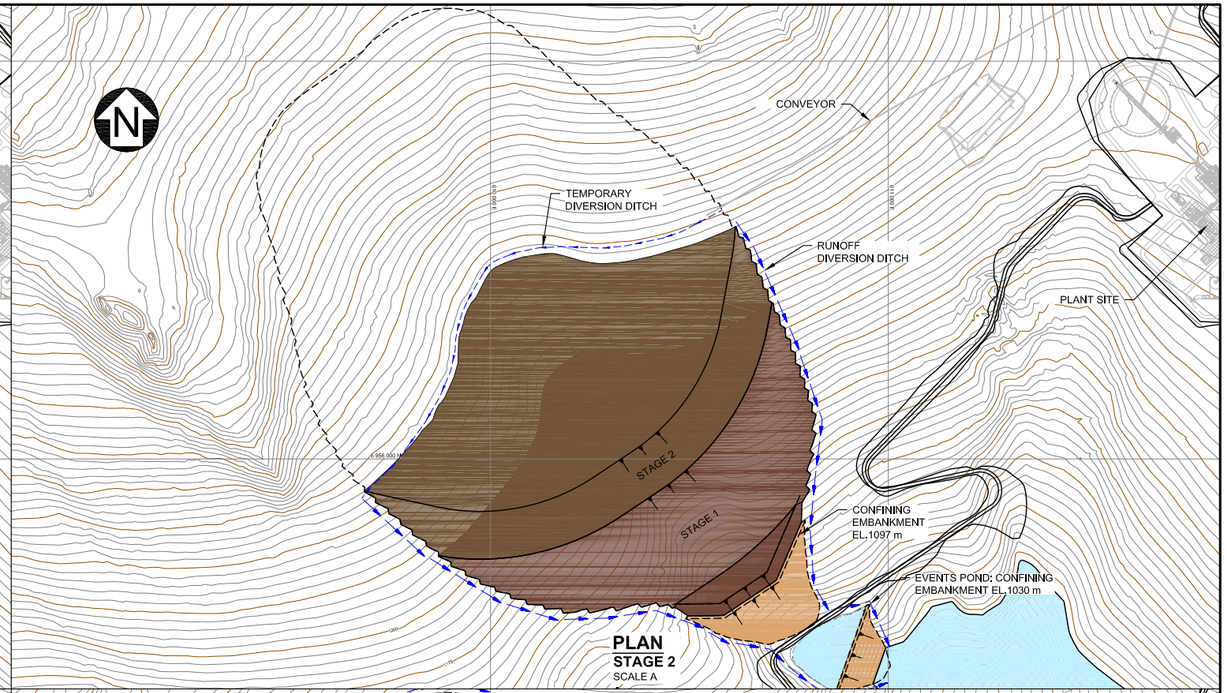
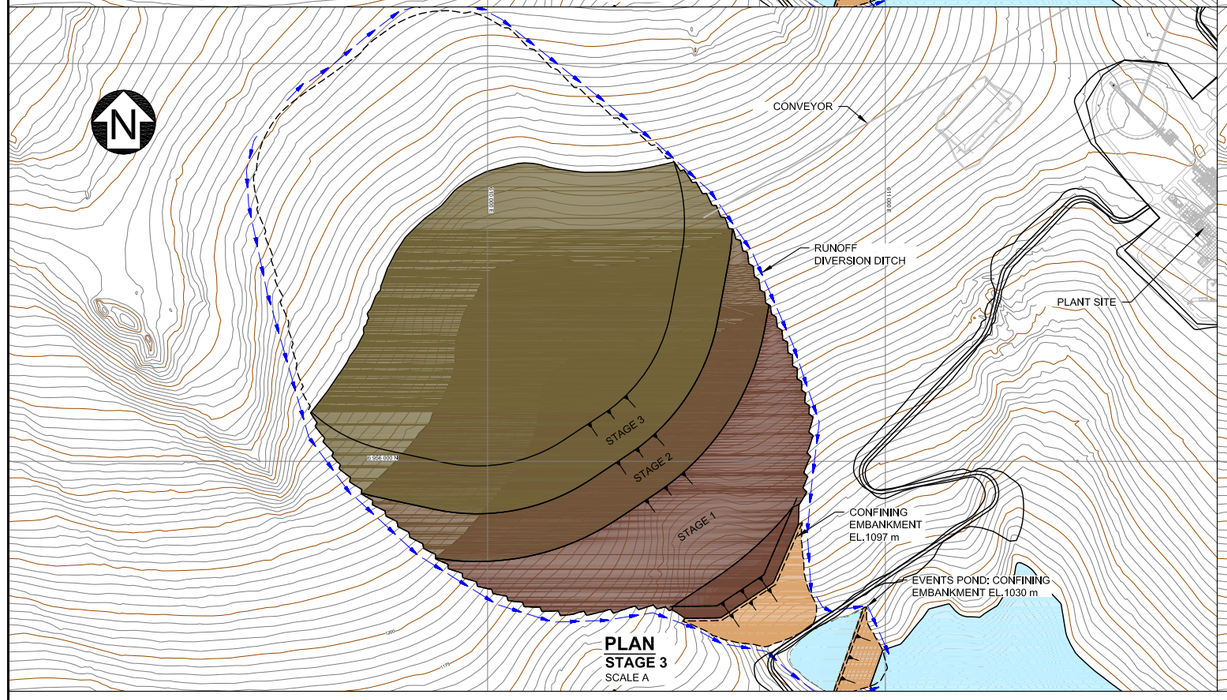


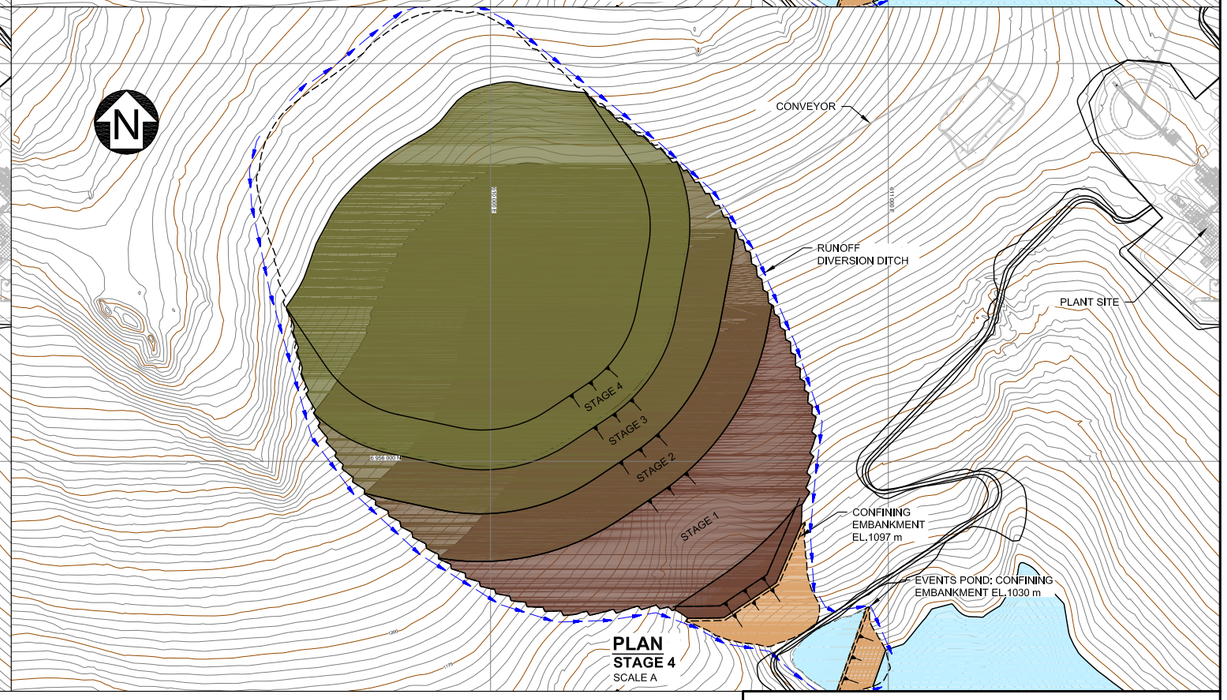
PLAN
STAGE 1
SCALE A



PLAN
STAGE 2
SCALE A



PLAN
STAGE 3
SCALE A



PLAN
STAGE 4
SCALE A

NOTES:

1. CONTOUR INTERVAL IS 5 METRES.

SCALE A 80 40 0 100 200 300 400 m

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CASINO COPPER-GOLD PROJECT

HEAP LEACH FACILITY
STAGE 1, 2, 3 & 4 PLAN

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P/A NO. VA101-325/8

REF NO. 9

FIGURE 5.2

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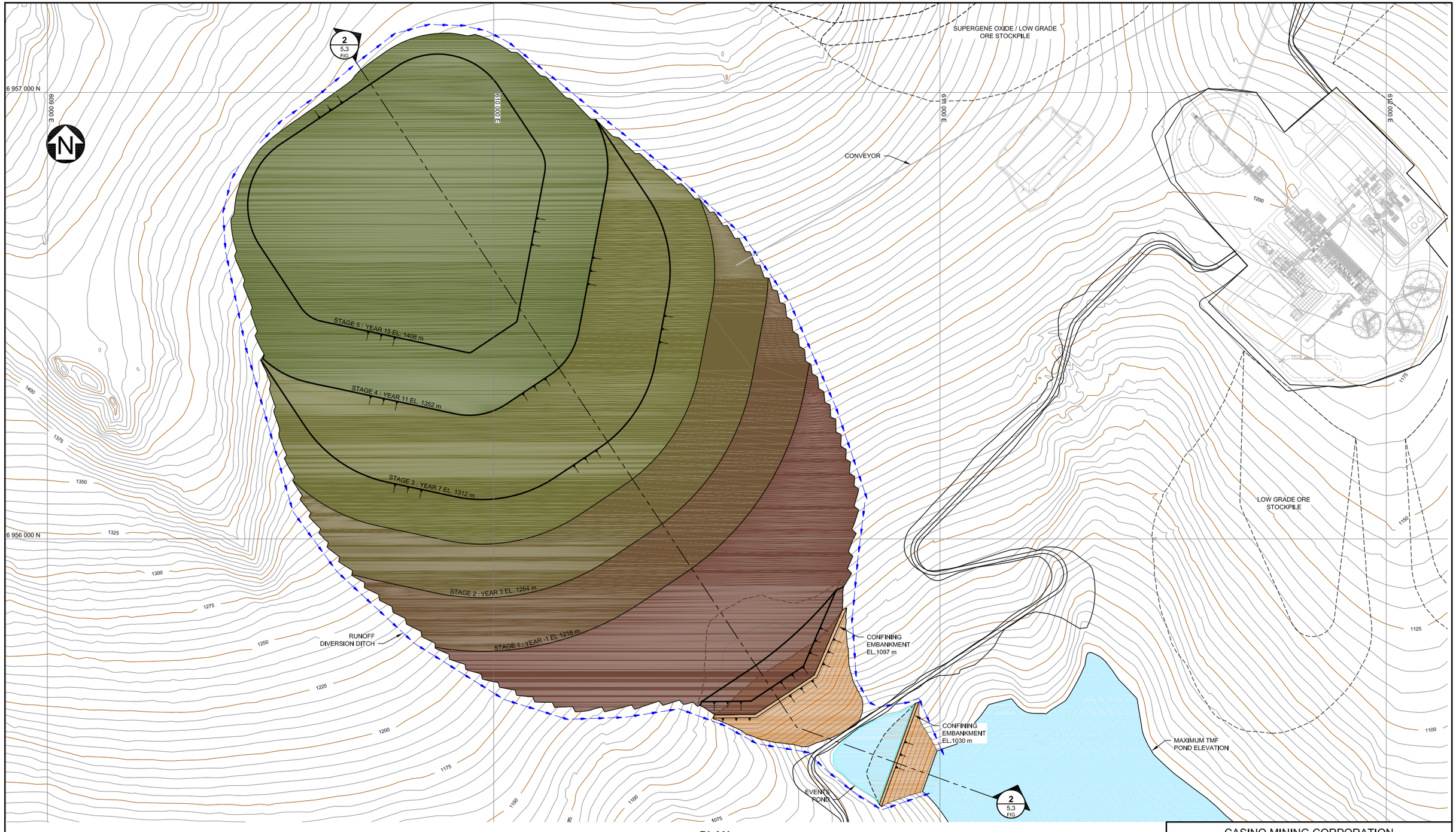

LEGEND:

PERMANENT DIVERSION CHANNEL

PLAN
HEAP LEACH
SCALE A

NOTES:

1. CONTOUR INTERVAL IS 5 METRES.
2. DIMENSIONS ARE IN MILLIMETRES AND ELEVATIONS ARE IN METRES, UNLESS NOTED OTHERWISE.
3. THE STAGING ELEVATIONS ARE APPROXIMATE.
4. ORE STOCKPILES ARE SHOWN AT THEIR MAXIMUM SIZE DURING OPERATIONS.

SCALE A 80 40 0 100 200 300 400 m

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CASINO COPPER-GOLD PROJECT

HEAP LEACH FACILITY
LOADING STAGING PLAN

Knight Piésold CONSULTING

P/A NO. VA101-325/8

REF NO. 9

FIGURE 5.3

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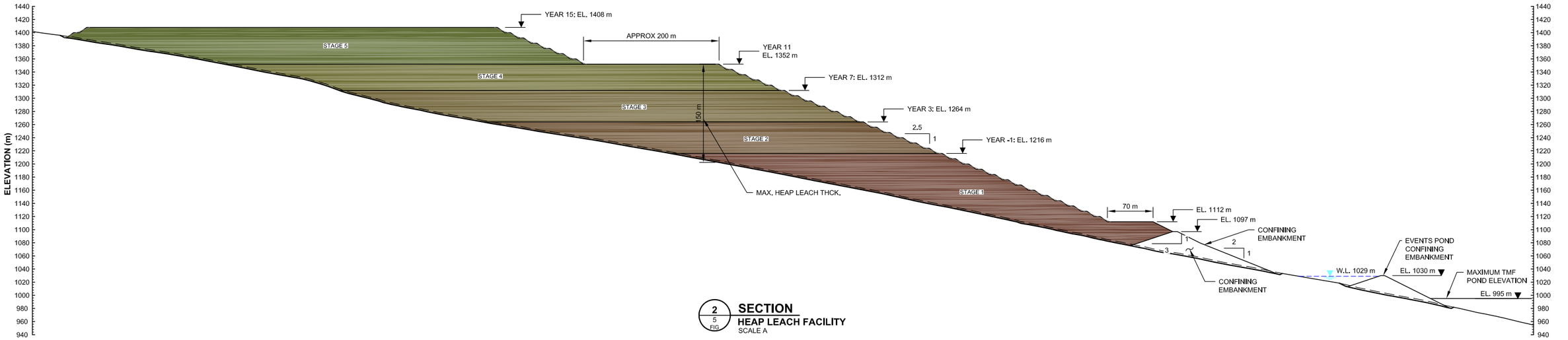

2
5
FIG

SECTION
HEAP LEACH FACILITY
SCALE A

LINER DEVELOPMENT STAGE	YEAR	HEAP LEACH FACILITY			
		GOLD ORE TO HLF (STACKING SCHEDULE)	GOLD ORE TO HLF (VOLUME) (STACKING SCHEDULE) ASSUMING 1.75t/m³ ORE HEAP DENSITY	GOLD ORE (CUMMULATIVE STACKED VOLUME)	LINER FOOTPRINT (EXPANSION AREA)
		Tonnes	m³	m³	m²
1	-3	6,580,000	3,760,000	3,760,000	498,500
	-2	9,125,000	5,214,286	8,974,286	
	-1	9,125,000	5,214,286	14,188,571	
2	1	9,125,000	5,214,286	19,402,857	292,700
	2	9,125,000	5,214,286	24,617,143	
	3	9,125,000	5,214,286	29,831,429	
3	4	9,125,000	5,214,286	35,045,714	299,700
	5	9,125,000	5,214,286	40,260,000	
	6	9,125,000	5,214,286	45,474,286	
	7	9,125,000	5,214,286	50,688,571	
4	8	9,125,000	5,214,286	55,902,857	220,600
	9	9,125,000	5,214,286	61,117,143	
	10	9,125,000	5,214,286	66,331,429	
	11	9,125,000	5,214,286	71,545,714	
5	12	9,125,000	5,214,286	76,760,000	189,500
	13	9,125,000	5,214,286	81,974,286	
	14	9,125,000	5,214,286	87,188,571	
	15	4,874,000	2,785,143	89,973,714	
	TOTAL	157,454,000	89,973,714	89,973,714	1,501,000

NOTES:

1. DIMENSIONS ARE IN MILLIMETRES AND ELEVATIONS ARE IN METRES, UNLESS NOTED OTHERWISE.
2. THE STAGING ELEVATIONS ARE APPROXIMATE.
3. VOLUMES ASSUMES ORE DENSITY =1.75 t/m³

60 30 0 100 200 300 m
SCALE A

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HEAP LEACH FACILITY
LOADING STAGING PLAN
TYPICAL SECTION

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P/A NO. VA101-325/8

REF NO. 9

FIGURE 5.4

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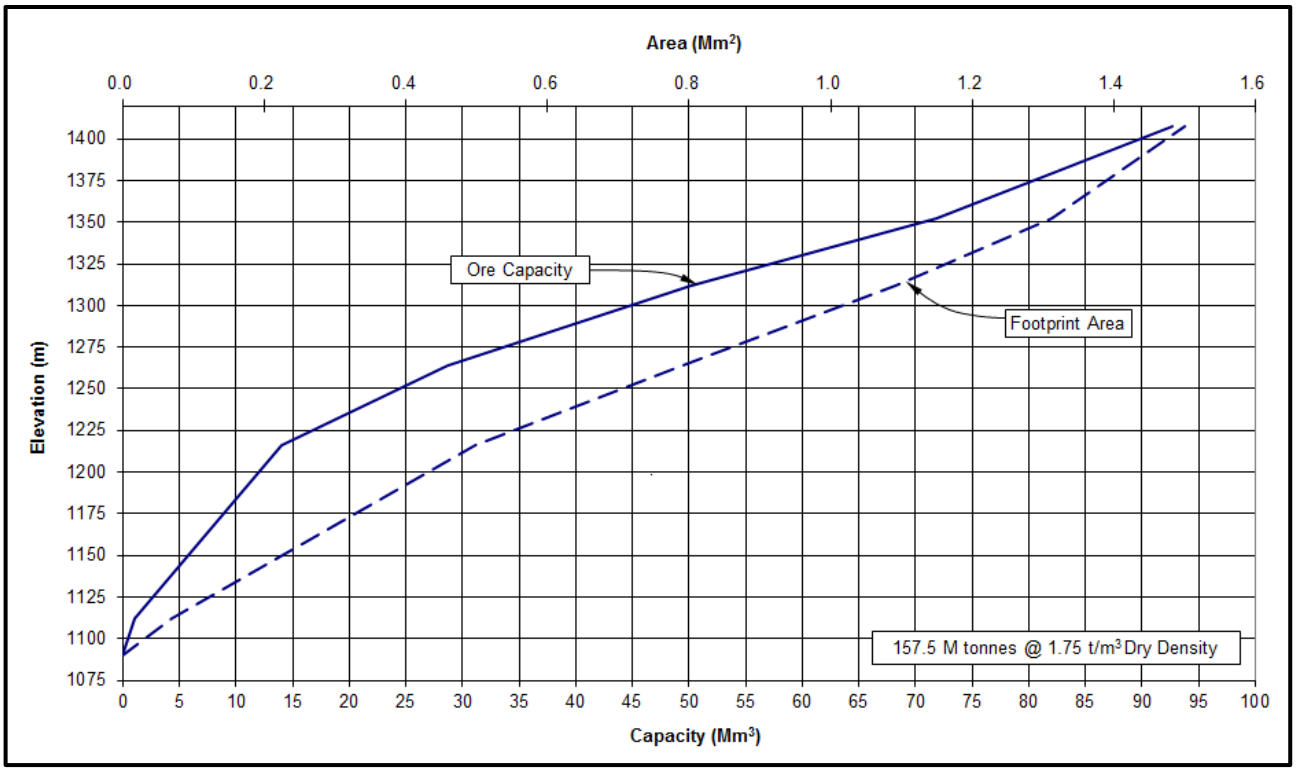


Figure 5.5 Heap Leach Facility: Elevation - Capacity Curve

5.1 HEAP LEACH PAD

The heap leach pad consists of a confining embankment, pad liner system and leachate collection system to collect and convey the leachate solution to the gold extraction plant, which is located to the southeast of the HLF.

The pad is located on a uniformly sloping sidehill with a slope of approximately 5H:1V (20%) and has an approximate footprint area of 1,501,000 m^2. The heap leach pad is designed to be operated predominantly as a dry heap-leach facility with minimal leachate storage to occur behind the confining HLF embankment.

The following sections outline the general design features and construction aspects for each of the main components of the heap leach pad.

5.1.1 Foundation

At the start of each of the development stages preparation of the pad foundation is required. Foundation preparation entails the stripping of approximately 0.5 metres of topsoil and vegetation and the removal of any talus boulders. The topsoil will be stockpiled at a location north of the HLF (see Figure 1.2) and used for reclamation of the HLF at closure.

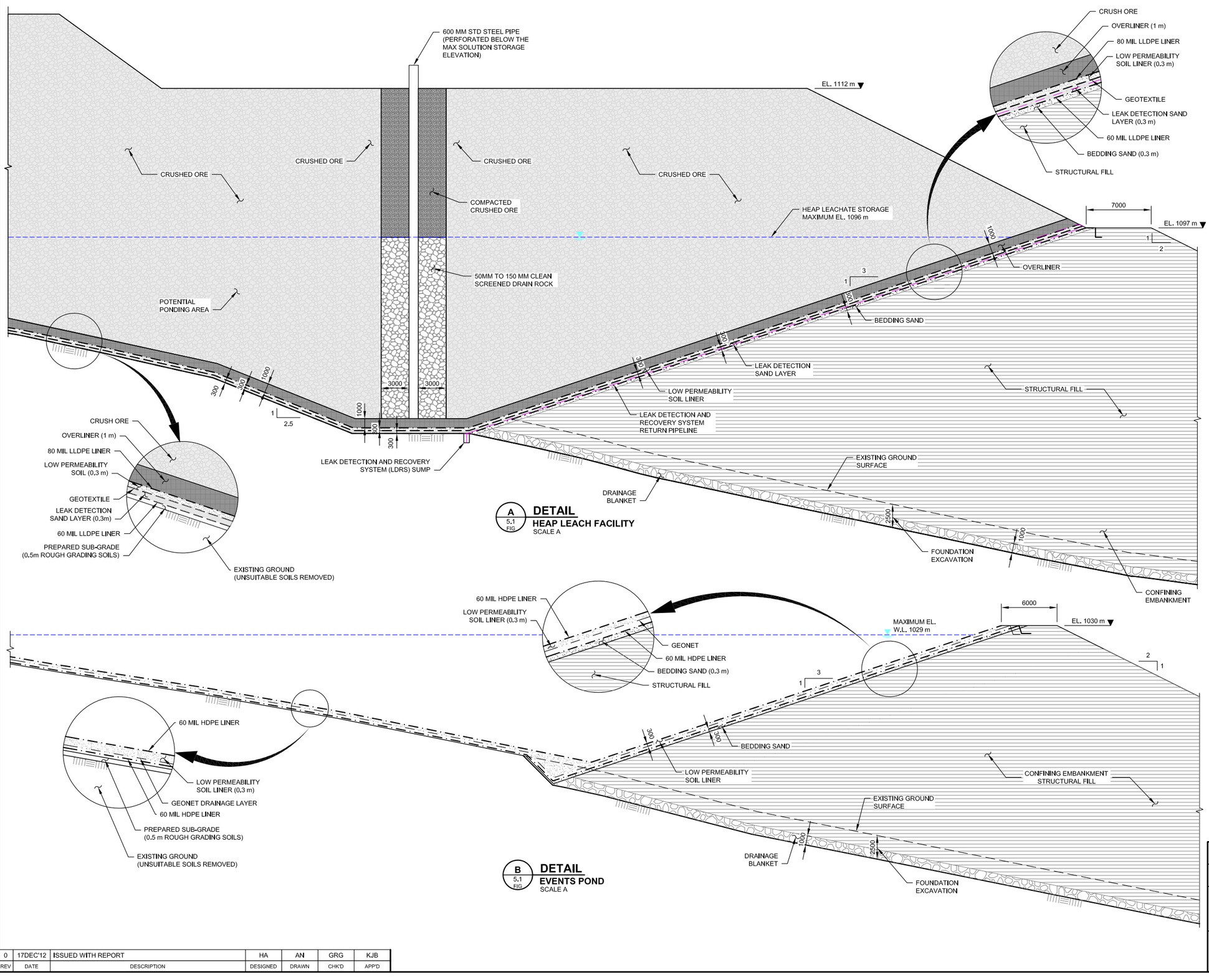
The underlying frozen colluvial and residual soils will be excavated down to a competent, stable bedrock foundation. Any ice-rich materials will not be suitable for use as borrow in embankment construction and therefore will be transported to the TMF for disposal. A two metre excavation depth has been estimated in Table 9.1 for foundation preparation to competent ground. In order to provide

a uniformly and positively graded surface to place the pad liner system, rough grading and backfill will be used to level the naturally undulating bedrock surface and to ensure that the pad grading will promote leachate flow to be positively draining towards the leachate collection piping system and sump located at the centre of the embankment upstream toe. A minimum pad grade of 2% is required.

5.1.2 Confining Embankment and Construction

The HLF embankment constructed at the toe of the proposed pad will provide stability to the heap leach pad and provide in-heap storage for solution. As presented on Figure 5.1, the embankment will have a final crest elevation of 1097 m and a crest width of seven metres. The embankment will be constructed with an upstream slope of 3H:1V and downstream slope of 2H:1V. While storage of leachate behind the confining embankment will not normally occur, after significant periods of rainfall or during a process shut-down in-heap storage will be utilized. The confining embankment has been designed with an in-heap storage capacity of approximately 61,000 m^3 (approximately two days irrigation volume). If the storage requirement is greater than this, excess solution will pass over the confining embankment spillway (invert elevation 1096 m) into the Events Pond (see Section 5.4).

Preparation of the embankment foundation will be undertaken in the same manner as the foundation preparation for the Heap Leach pad and will involve stripping the topsoil and excavating the underlying frozen colluvial and residual soils down to component, stable bedrock. The main embankment body will be constructed from structural fill which will consist primarily of locally sourced rock and earth fill. The embankment will be constructed by placing the fill in lifts and compacting to a specified density. It is proposed that the earthfill will be sourced from borrow areas along the south facing slopes adjacent to the HLF and the rockfill will be obtained from talus deposits and new local rock quarries. Suitable non-reactive mine waste rock may also be used if available. A 0.3 metre thick bedding sand layer will be placed over the final upstream slope of the embankment in preparation for installation of the liner system. Details of the liner system is outlined in the following Section and is presented on Figure 5.6.



NOTES:

1. DIMENSIONS ARE IN MILLIMETRES AND ELEVATIONS ARE IN METRES, UNLESS NOTED OTHERWISE.

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HEAP LEACH FACILITY
LINER AND EMBANKMENT DETAIL

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P/A NO. VA101-325/8

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FIGURE 5.6

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5.2 LINER SYSTEM

A liner system is used to maximize pregnant solution recovery and minimize environmental operational impacts by minimizing leakage losses of pregnant solution through the bottom and sides of the leach heap pad. The composite liner consists of 'barrier' and 'drainage' layers using a combination of synthetic and natural materials to provide leachate solution containment which meets the required 'accepted standards' for leach pad design. While the Heap Leach Pad is designed to operate as a 'dry' pad with minimal solution storage occurring in-heap storage during normal operating conditions, the liner system was designed to still meet the required performance standards assuming fully saturated solution storage conditions behind the confining embankment.

5.2.1 Liner Design

Two liner systems have been developed for the Heap Leach pad, an engineered single liner design for the upper portion of the leach pad (above the in-heap leachate solution storage elevation) and a composite double liner design for the lower portion of the leach pad which will potentially have leachate solution storage.

The 'Upper' or single liner system, is designed to be installed on the heap leach pad's upper sloped surfaces which positively drain towards the leachate collection pipes and sump. The liner system consists of the following components:

- 1 metre thick overliner (38 mm minus with less than 10% fines content)
- 80 mil (2 mm) linear low-density polyethylene (LLDPE) geomembrane, and
- 0.3 metre thick compacted low permeability soil liner.

The portions of liner that are located directly below the leachate collection pipes will also have Leak Detection and Recovery System (LDRS) layers which consist of the following:

- Non-woven, needle punched geotextile layer, and
- Leak Detection and Recovery System (LDRS)

The 'Ponded' or double liner system is designed to be installed on the heap leach pad's lower slopes which may experience hydraulic loading from in-heap solution storage. Whilst still positively draining towards the leachate collection pipes and sump, the surface grades under the double lined portion may be as low as 2%. The double liner system consists of the following components:

- 1 metre thick overliner (38 mm minus with less than 10% fines content)
- 80 mil (2 mm) linear low-density polyethylene (LLDPE) geomembrane
- 0.3 metre thick compacted low permeability soil liner
- Non-woven, needle punched geotextile layer
- Leak Detection and Recovery System (LDRS), and
- 60 mil (1.5 mm) linear low-density polyethylene (LLDPE) geomembrane.

Figure 5.6 the locations and detailed cross-sections of the two liner systems.

Linear low-density polyethylene (LLDPE) was used for the geomembrane liner systems for the heap leach pad as it has the following benefits (Lupo and Morrison, 2005):

- Generally higher interface friction values, compared to other geomembrane materials
- Ease of installation in cold climates due to added flexibility,
- Good performance under high confining stresses (large heap height), and

- Higher allowable strain for projects where moderate settlement may become an issue.

Laboratory direct shear testing is recommended prior to detailed design to determine the interface shear strength of the liner materials and to confirm strengths are sufficient to provide long-term stability of the HLF. Representative samples of the geomembrane materials should be used for the testing, provided by the project supplier.

5.2.2 Construction

Development of the heap leach liner will be constructed in five development stages, with liner expansions proposed every three to four years to meet ore stacking requirements.

The liner system will be constructed with both the synthetic and natural layers extending to the top of the confining embankment and perimeter berms to provide full containment. The synthetic liners and geotextiles will be anchored and backfilled in a trench along the heap leach pad perimeter and confining embankment crest to ensure that ore loading does not compromise the liners coverage of the heap leach pad footprint by pulling the liner into the pad. Along the embankment toe, all liners will be tied into their corresponding liner layer along the foundation of the pad to provide a continuous liner seal and drainage connection.

A small perimeter berm will also be constructed as part of the liner tie-in around the perimeter of the pad footprint to ensure that heap solution is contained within the pad footprint and to also prevent surface runoff from the adjacent slopes entering the pad collection system.

As noted in Section 5.1.2, a 0.3 metre thick bedding sand layer will be placed on the upslope face of the confining embankment directly underneath the second (bottom) geomembrane liner to provide additional integrity protection to the liner.

5.2.3 Overliner

A protective layer approximately one metre thick of coarse crushed ore will be placed over the entire liner system footprint to protect the liner's integrity from damage during ore placement. The overliner will also double as a drainage layer, promoting leachate solution drainage into the piped leachate collection system, therefore reducing head loading on the liner and maximizing solution recovery.

5.3 LEACHATE COLLECTION SYSTEM

Collection and recovery of the pregnant solution is undertaken by the leachate collection system which works in conjunction with the heap leach liner, overliner and leak detection and recovery systems. The collection system consists of the following pipe and sump components:

- Lateral Collection pipes
- Collection Header pipes
- Main Header Collection pipes, and
- Leachate Collection Sumps.

The leachate collection system is designed to streamline solution collection and facilitate solution conveyance off the pad as quickly as possible thereby reducing the potential risk of leachate solution losses through liner system. The entire piping system is constructed from perforated CPT pipe which is embedded within the one metre thick overliner layer.

The Lateral Collection pipes, which are spaced approximately six metres apart under the entire pad footprint, feed directly into the Collection Header pipes which then flow into the Main Header Collection Pipe. The Main Header Collection pipes are positioned along the centerline of the Heap Leach Pad and terminate at the upstream toe of the confining embankment at the Leachate Collection Sump.

Three Leachate Collection Sumps are located at the toe of the confining embankment, spaced equally across the base width of the heap leach pad. The sumps consist of two sections, the lower 'collection zone' and the upper zone. The lower zone consists of a three-metre thick zone of clean screened gravel (approximate gravel diameter 50 mm to 150 mm) placed around a 600 mm diameter perforated steel vertical riser pipe. The upper zone consists of a three-metre thick zone of compacted crushed ore placed around a 600 mm diameter non-perforated steel vertical riser pipe. The compaction of the crushed ore is critical to ensure that settlement around the vertical riser does not occur and damage the collection system.

As detailed in Section 5.2, the Heap leach pad liner system is designed to be operated as a dry-operation with pregnant leachate solution being pumped out as soon as it collects in the sump thereby reducing the hydraulic head on the liner system. If required however, solution storage in the ore-pore volume behind the confining embankment is possible up to elevation 1096 m before discharging over the confining embankment spillway.

5.3.1 Leak Detection and Recovery System

The Leak Detection and Recovery System (LDRS) is designed to capture and convey any solution which leaks through the overlying geomembrane and low permeability soil layers. As presented in the detail on Figure 5.7, there are two components to the LDRS, the LDRS under the double lined area and the LDRS under the single lined area.

The LDRS under the double lined area consists of a 0.3 metre thick sand layer which is embedded with 100 mm diameter perforated CPT collection pipes. A non-woven needle punched geotextile overlies the LDRS sand layer to prevent particles from the above low permeability soil layer from entering the LDRS, clogging the sand and impeding drainage flow.

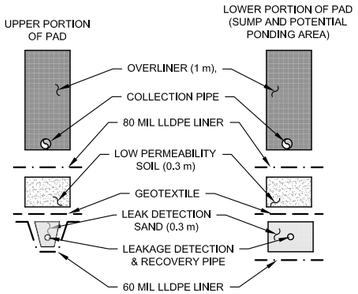
The LDRS under the single lined area consists of a network of drainage 'trenches' which contain 100 mm diameter perforated CPT collection pipes surrounded by drainage sand. The trenches are aligned underneath the 'Collection Header' and 'Main Collection Header' pipes which are part of the Leachate Collection system embedded in the above overliner layer. These drainage trenches 'feed' into the LDRS layer underlying the double lined area in the lower heap leach portion.

Any leakage recovered by the LDRS will be conveyed into the LDRS sump at the toe of the confining embankment. A level-switch controlled submersible sump pump will transfer the recovered solution up the embankment slope via a pipe installed within the LDRS sand layer and connect into the main solution recovery line for processing, (refer to Figure 5.6). Monitoring of the leakage recovery will be undertaken through continuous monitoring of the pump hour records.

5.3.2 Leakage Detection Cells

In order to facilitate advanced leak detection source identification, the entire heap leach pad leachate collection system is sub-divided into 16 independently monitored areas or “cells” separated by small cell division berms. Each of these cells has a dedicated leakage detection collection system comprising a drain gravel layer beneath the inner composite liner system which conveys the leakage to a 100 mm diameter perforated collection pipe within the LDRS collection trench. The LDRS ditches flow by gravity at a minimum 0.5 % slope towards the LDRS collection sump structures, located along the right and left sides of the leach pad. The flow rates from the dedicated collection pipes are continuously monitored and measured prior to discharging into a sump. A float switch within the sump triggers a submersible pump which pumps the accumulated solution via a pipeline (located between the two liners on the confining embankment) back onto the heap pad. LDRS collection sumps are shown on Figure 5.7.

609 000 E
610 000 E
611 000 E
6 957 000 N
6 956 000 N
CONVEYOR
COLLECTION HEADER PIPES (PERFORATED HDPE) EMBEDDED IN OVERLINER LAYER (LDRS COLLECTION PIPES PLACED IN LDRS DRAINAGE LAYER UNDER GEOMEMBRANE AND SOIL LINER, REFER TO TYPICAL SECTION DETAIL)
PLANT SITE
HEAP LEACH FACILITY FOOTPRINT
MAIN COLLECTION HEADER PIPES (PERFORATED HDPE) (LDRS COLLECTION PIPES PLACED IN LDRS DRAINAGE LAYER UNDER GEOMEMBRANE AND SOIL LINER, REFER TO DETAILS, FIGURE 5.1)
HEAP SOLUTION STORAGE MAXIMUM ELEVATION 1096m
LEACHATE COLLECTION SUMP
SART FACILITY
MAXIMUM T
POND ELEV
1425
1400
1375
1350
1325
1300
1275
1250
1225
1200
1175
1150
1125
1100
1075
1050
1025
1000



TYPICAL SECTION
SHOWING LINER ARRANGEMENT WITH COLLECTION PIPING AND LEAKAGE DETECTION AND RECOVERY SYSTEM PIPING
NTS

NOTES:

1. CONTOUR INTERVAL IS 5 METRES.
2. DIMENSIONS ARE IN MILLIMETRES AND ELEVATIONS ARE IN METRES, UNLESS NOTED OTHERWISE.

SCALE A 100 50 0 100 200 300 400 500 m

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	17DEC'12	ISSUED WITH REPORT	RSS	AN/PP	LM	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

HEAP LEACH FACILITY
LEACHATE COLLECTION SYSTEM

Knight Piésold CONSULTING

P/A NO. VA101-325/8 | REF NO. 9

FIGURE 5.7 | REV 0

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5.4 EVENTS POND

The events pond is designed to provide storage for excess leachate and runoff which is generated as a result of rainfall events that cannot be accommodated by the in-heap storage capacity of the HLF. The pond is situated immediately down gradient of the HLF embankment and pond flows are conveyed via the HLF spillway. The plan layout of the Events Pond is included on Figure 5.1. A typical cross-section through the events pond and embankment is included on Figure 5.6.

The events pond is designed to meet the following design criteria:

- Storage capacity to contain the excess HLF leachate and surface runoff from the 1 in 100 year 24-hour storm event without discharge to the TMF
- Spillway designed to discharge the 1 in 200 year 24-hour storm event with a minimum embankment crest freeboard of 0.3 metres.

5.4.1 Storage Requirements

The storage requirement for the Events Pond was established based on containment of the entire estimated surface runoff generated from the HLF during the 1 in 100 year 24-hour storm event. Evaluation of the HFL embankment identified that storage for approximately two days irrigation volume was provided within the in-heap void volume capacity behind the embankment and therefore solution storage within the Events Pond was not required.

Modeling of the HLF storm runoff was undertaken using the Hydrologic Modeling System (HEC-HMS) which was designed by the Hydrologic Engineering Centre (U.S. Army Corps of Engineers) to simulate precipitation-runoff processes of dendritic drainage basins. The model uses site specific data to accurately capture the specific climate and catchment conditions at Site, including storm precipitation intensity distribution, snowmelt, catchment slope, drainage and precipitation losses.

Based on the surface runoff results generated by the model, the following storage requirements for the events pond were identified:

- Total runoff estimate for 1 in 100 year 24- hour storm event 98,600 m^3
- 15% additional capacity buffer 14,300 m^3, and
- Total Events Pond Storage Capacity 112,900 m^3.

Solution stored in the Events Pond will be pumped back to the Heap Leach Pad using the Events Pond pump station. The pump station is designed to be able to empty the 1 in 10 year storm runoff volume (approximately 79,900 m^3) over ten days, and the 1 in 100 year volume (98,600 m^3) over 12.5 days. Depending on the solution processing rate of the gold extraction plant and the available solution storage capacity behind the confining embankment, the actual pump rate will likely need to vary.

5.4.2 Liner System

The engineered double liner system designed for the Events Pond (as shown on Figure 5.6) uses the same design principles as the 'ponded' HLF pad liner system. The liner consists of the following layer configuration:

- 60 mil (1.5 mm) high-density polyethylene (HDPE) geomembrane
- 0.3 metre thick low permeability soil liner

- Geosynthetic 'geonet' drainage layer, and
- 60 mil HDPE geomembrane.

Careful preparation of the existing ground interfacing the lower geomembrane layer is required to ensure that the ground surface conditions are acceptable to install the geomembrane liner without compromising the liner integrity. The liner system installed on the upslope of the Events Pond embankment will have an additional 0.3 metre thick bedding sand layer which will interface with the lower geomembrane layer to protect the integrity of the liner.

Installation of a Leak Detection and Recovery System (LDRS) is not required for the Events Pond as the pond is operated as a dry-facility and will only receive and store runoff water during significant storm events. In the event that leakage does occur through the double liner system, this water will conveyed via the geonet layer to a 1 metre thick drainage blanket which underlies the Events Pond embankment. This drainage blanket discharges directly to the Tailings Management Facility (TMF).

It is recommended that HDPE geomembrane is used for the Events Pond liner system rather than LLDPE. Unlike the heap leach pad, the Events Pond liner system will not be subjected to high confining stresses from ore stacking. Also, HDPE has a higher ultraviolet resistance which is critical for exposed surfaces like that of the Events Pond.

Typical sections showing the location and extent of the Events Pond liner system are shown on Figure 5.6.

5.4.3 Embankment

The embankment will likely be constructed of colluvial and residual soil borrow materials, quarried rockfill, and potentially non-reactive mine waste rock from open pit development. Finer grained residual soils will be selectively utilized on the upstream face to provide a seal zone and an acceptable surface for geosynthetic liner installation.

The embankment is designed with a 2H:1V downstream slope and a 3H:1V upstream slope. These slopes ensure embankment stability. The embankment will be underlain with a 1 metre thick drainage blanket layer to promote and facilitate drainage of any 'leakage' out of the embankment and to discharge into the TMF.

5.4.4 Construction and Operation

The Events Pond will be constructed to full size prior to commencing HLF operations. Construction of the earthfill embankment for the Events Pond involves stripping approximately 0.5 metres of topsoil and 2 metres of overburden beneath the embankment and ponding footprint. The earthfill embankment, pond liner and LDRS system will be constructed directly on competent rock. A solution return pump station will be constructed adjacent to the Events Pond embankment to pump solution back to the HLF in-heap storage for gold-extraction processing or re-use in leaching.

Under typical operating conditions the Events Pond will be operated as a dry pond to ensure that the maximum pond capacity is available for storage of excess HLF surface runoff from storm events. During a storm event leachate and runoff exceeding the HLF in-heap storage capacity will flow into the Events Pond via the HLF spillway to be stored in the Events Pond. This water will then be transferred back to the HLF in-heap storage as required. During storm events greater than 1 in

200 year 24-hour, water volumes exceeding the Events Pond storage capacity will be conveyed to the TMF pond via the Events Pond Spillway.

5.5 DIVERSION AND RUNOFF COLLECTION

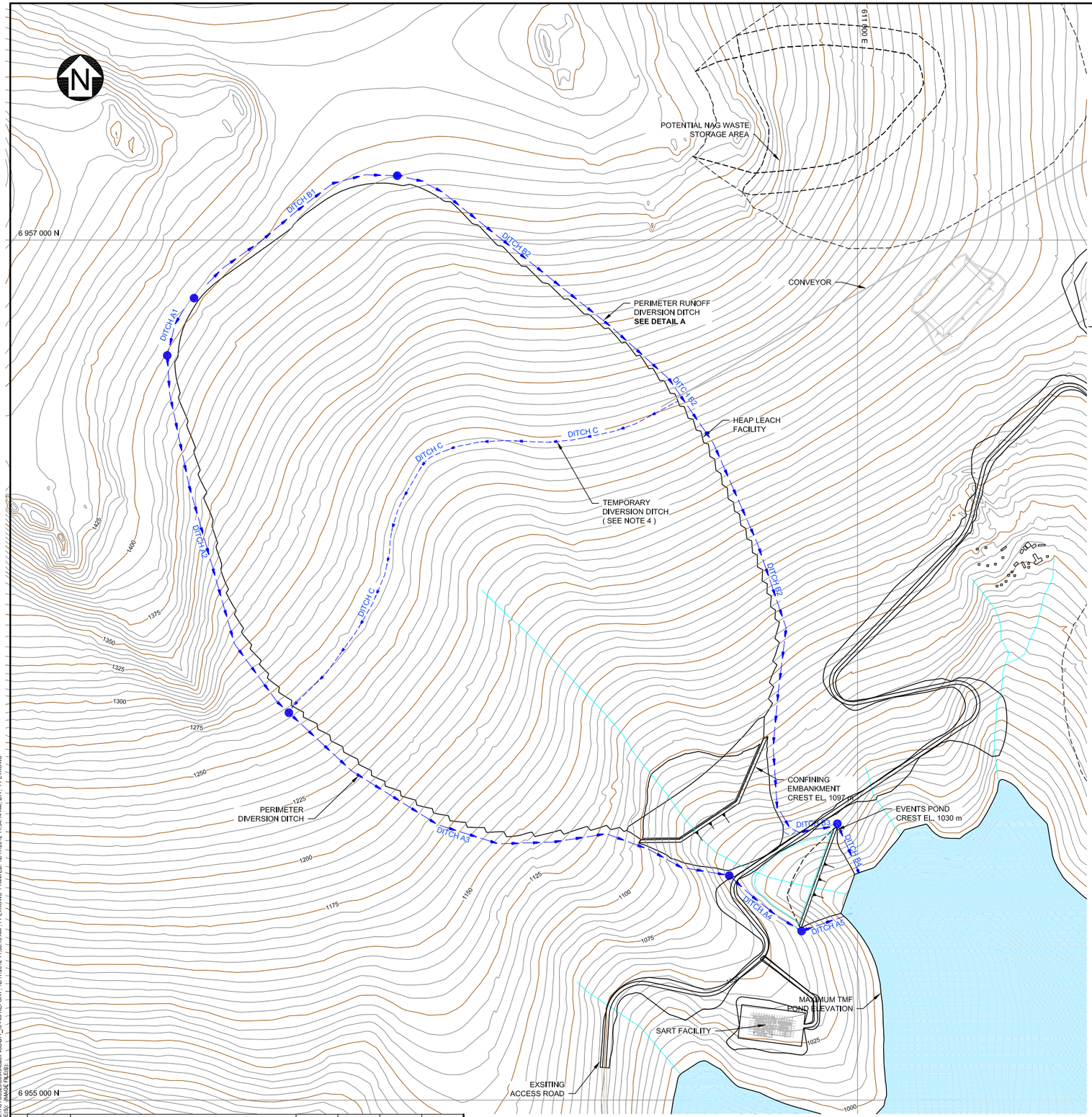
The surface water management system for the site, as presented on Figure 5.8, consists of a series of ditches constructed around the perimeter of the HLF to intercept overland surface runoff around the HLF pad and to convey flows to the TMF. The ditches are designed to meet the following design criteria:

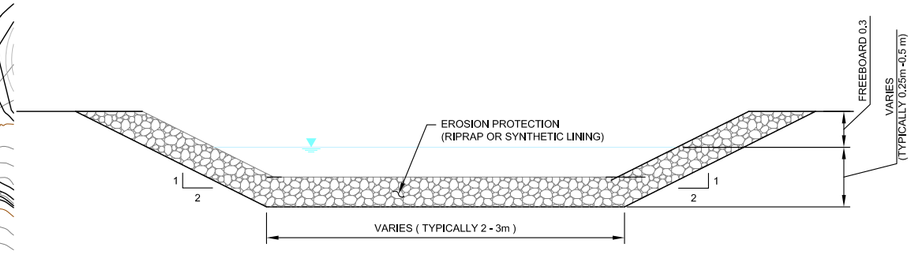
- Conveys the 1 in 100 24-hour duration storm event
- Minimum freeboard = 0.3 m
- Minimum ditch grade = 0.01 m/m
- Side slopes = 2H:1V, and
- Channel shape = trapezoidal.

Lining and protection of the ditch channels from erosion and scouring is required for all permanent ditches due to the steep ditch grades associated with the natural topography and the anticipated high runoff flowrates. The alignments of the HLF diversion ditches are shown on Figure 5.8. Diversion ditch requirements and dimensions are provided in Table 5.2. At start-up, (Year -3), a temporary ditch (Ditch C) approximately six metres wide will be constructed which will divert surface runoff from the upper portion of the final HLF pad footprint. This temporary ditch will be decommissioned in Year 3 when the footprint of the HLF extends beyond El 1264 m.

Table 5.2 Diversion Ditch Requirements

Ditch Name:	Length (m)	Water Depth: 100 yr event (m)	Total Ditch Width (m)	Velocity (m/s)	Flow capacity (m3/s)
Ditch A1	350	0.43	5.9	1.64	2.73
Ditch A2	930	0.27	4.3	4.04	2.77
Ditch A3	1110	0.37	4.7	5.29	5.36
Ditch A4	210	0.47	6.1	3.15	5.83
Ditch A5	110	0.32	4.5	6.77	5.72
Ditch B1	350	0.47	5.1	2.85	3.93
Ditch B2	1910	0.32	4.5	4.80	4.05
Ditch B3	120	0.48	5.1	2.90	4.13
Ditch B4	130	0.28	4.3	5.85	4.19
Ditch C	1250	0.49	6.2	1.51	2.95





A - **DETAIL**
TYPICAL DITCH
SCALE B

LEGEND:

TEMPORARY DIVERSION CHANNEL

PERMANENT DIVERSION CHANNEL

NOTES:

1. COORDINATE GRID IS UTM (WGS84/NAD83) ZONE 7 (m).
2. CONTOUR INTERVAL IS 5 METRES.
3. DIMENSIONS ARE IN METRES UNLESS NOTED.
4. TEMPORARY DIVERSION DITCH TO CONTROL DRAINAGE, TO BE CONSTRUCTED AT START OF HEAP LEACH FACILITY CONSTRUCTION AND PRIOR TO ORE LOADING.
5. REFER TO TABLE IN REPORT FOR MINIMUM DITCH DIMENSIONS

SCALE A 100 50 0 100 200 300 400 500 m

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0	17DEC'12	ISSUED WITH REPORT	RSS	PP	LM	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

HEAP LEACH FACILITY
WATER MANAGEMENT PLAN

Knight Piésold CONSULTING

P/A NO. VA101-325/8

REF NO. 9

FIGURE 5.8

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5.6 OPERATIONAL WATER SUPPLY

Operation of the HLF requires a water supply with an approximate average flowrate of 104 m^3/h. In order to meet this demand two water sources will be used during the life of the HLF facility, a purpose built fresh water supply pond from Year -3 through Year -1, and the TMF from Year 1 through Year 15. To meet the HLF water demand prior to construction and commissioning of the TMF construction of an embankment and associated collection ditch system is proposed as shown on Figure 1.2. The earthfill embankment, which will be located in a northern reach of the final TMF footprint, will be approximately 21 metres high and have a storage capacity of approximately 460,000 m3 of water (six months' supply for the HLF operations) and requires a catchment area of approximately 430 ha. Water collection for storage behind the embankment will be undertaken through a diversion ditch system.

In Year 1, once the TMF embankment is constructed and commissioned, HLF water will be sourced from the water stored in the TMF. Alternatively, water may also be sourced from the Mill make-up water pipeline from the Yukon River which will be constructed for the start of Mill operations in Year 1.

5.7 WATER BALANCE

An operational average monthly water balance analysis was undertaken for the HLF. The intent of the modelling was to estimate the magnitude and extent of any water surplus or deficit conditions in the HLF based on annual average climatic conditions. The modelling timeline was for 19 years of HLF operations (covering 3 pre-production years and 16 years of mill operations, consistent with the project mine production schedule). The model incorporates the following major project components:

- Open Pit
- Heap Leach Pad
- Ore Stockpile
- Fresh Water Supply Pond (Makeup Water supply Years -3 to -1 only), and
- Events Pond Storage (50,000 m^3 Years -3 to -1 only).

The findings of the water balance were that the HLF will operate in a water deficit. The deficit is most pronounced in the early years and diminishes later in operations as water stored within the ore is released from the earlier leaching stages. The total make up required by the HLF is 4.3 million m^3 over the life of the facility. The HLF water requirement ranges from 50,000 m^3 to 670,000 m^3 annually, and during the final years the Site is in surplus.

The water balance was based on assumed moisture content values for the stacked ore. The model is sensitive to these values and they should be reviewed and confirmed for future design studies.

Details of the HLF water balance are included in Appendix A.

5.8 STABILITY ASSESSMENT

Analyses have been carried out to examine the stability of the HLF to a final ore heap elevation of 1,408 m. The stability analyses were carried out using the limit equilibrium computer program SLOPE/W. In this program a systematic search is performed to obtain the minimum factor of safety from a number of potential slip surfaces. Factors of safety were calculated using the rigorous Morgenstern-Price method of analysis.

Analyses have been performed to investigate the stability of the final heap leach pad under both static and seismic conditions. A typical cross-section of the heap leach pad used in the analyses is shown on Figure 5.9 The minimum acceptable factor of safety for the heap leach pad under static conditions is 1.3 for short-term operating conditions and 1.5 for long-term (post-closure) of the HLF. The consequences of failure of the HLF during an earthquake event are likely to be minimal and restricted to some displacement of the heap leach pad slopes. There would be negligible impact on the integrity of the HLF and little, if any, impact on other Mine site facilities. However, for design of the HLF a conservative design earthquake corresponding to the 1 in 500 year return period event has been adopted, consistent with the Operating Basis Earthquake (OBE) defined for the TMF. The corresponding mean peak ground acceleration is 0.08g. A design earthquake magnitude of 8.0 has been selected based on a review of regional tectonics, potential seismic source zones in the region and historical seismicity. The seismic stability assessment of the heap leach pad has included estimation of seismically induced deformations of the pad from the design earthquake.

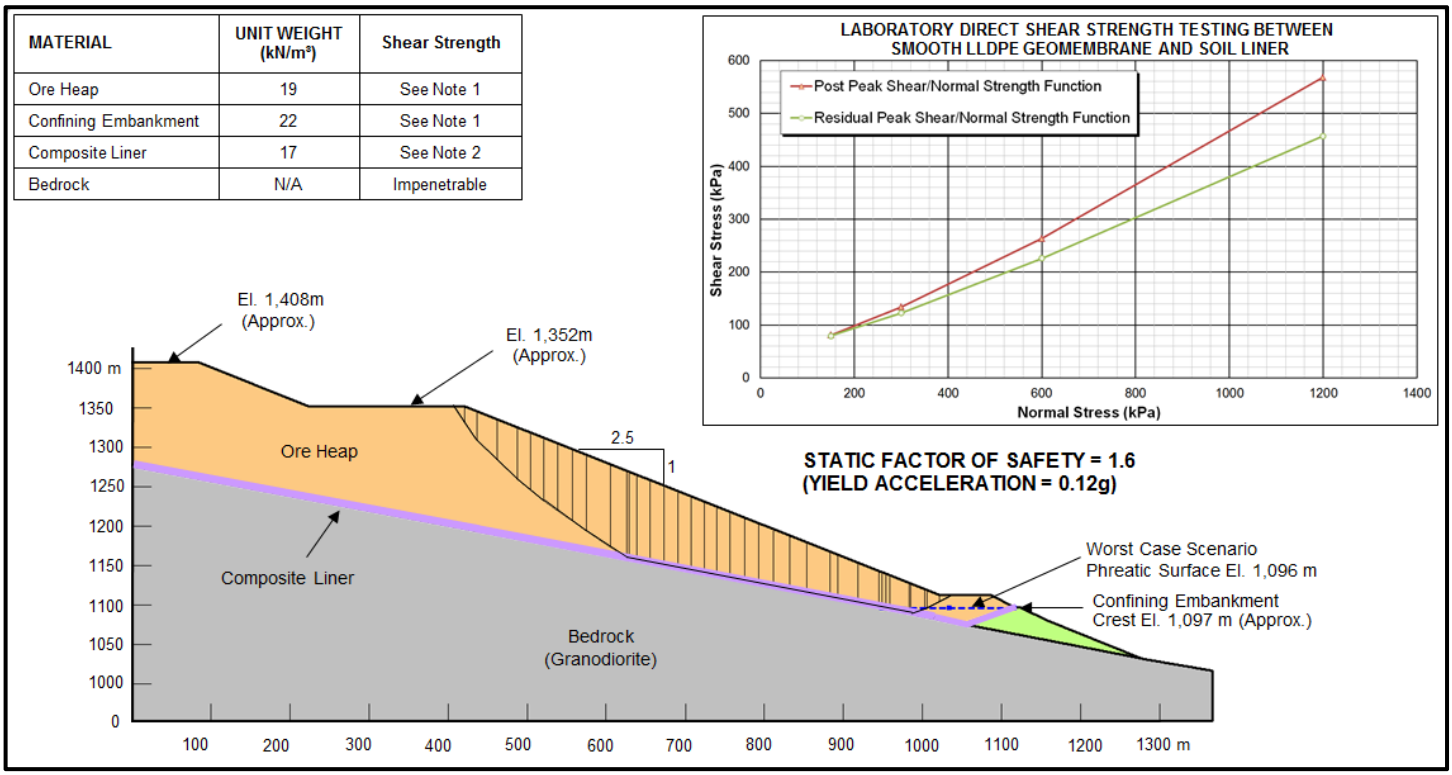

Figure 5.9 Heap Leach Facility: Leach Pad Stability Assessment

NOTES:

1. A relationship for friction angle and effective stress was developed for the ore heap and confining embankment material, based on LEPS (1970).
2. The liner interface with the lowest shear strength and therefore controlling the heap stability is the interface between the smooth LLDPE geomembrane and soil liner direct shear strength test results for LLDPE geomembrane and soil liner are shown on this figure. Post peak shear/normal strength function was used for static analyses. Residual shear/normal strength function was used for seismic analyses.

5.8.1 Material Parameters and Assumptions

The following parameters and assumptions were incorporated into the stability analyses:

- Unit weights for the heap leach pad and foundation materials were based on typical values for similar materials. Adopted values are included on Figure 5.9
- The shear strength for the ore heap and rockfill material in the confining embankment has been defined using a conservative (lower bound) strength function that defines the variation of shear strength with normal stress. This strength function is based on published information on the shear strength properties of granular rockfill materials (Leps, 1970).
- A phreatic surface within the lower portion of the leach pad was modelled with a constant head at elevation 1,096 m to represent maximum potential solution storage during shut-down. No water or phreatic surface was modelled in the upper portion of the leach pad. This is a reasonable assumption since adequate drainage will be provided at the base of the heap to minimize the build-up of pore water pressures within the heap.
- There are no excess pore pressures generated by thawing of foundation materials. It is assumed that appropriate foundation preparation and/or excavation have been conducted in any areas with frozen soil.

The stability of the heap leach pad is controlled by the interface shear strength between the various components of the liner system (overliner, geomembrane liners, soil liner, leak detection/bedding sand layers and geotextile), as shown on Figure 5.6. It is anticipated that the liner interface with the lowest shear strength and therefore controlling heap stability is the interface between the Smooth LLDPE geomembrane and Soil Liner.

The interface shear strength between the Smooth LLDPE geomembrane and soil liner has been defined using the results of laboratory direct shear strength testing. Direct shear strength testing was conducted using a suitable sample of smooth LLDPE geomembrane material and a composite sample of low permeability residual soil, provided by test pit samples and representing potential borrow material for the soil liner. The soil sample was prepared to the anticipated compaction specifications for the soil liner material (95% Standard Proctor density). Laboratory test results (stress-strain plots) were used to define relationships between interface shear strength and normal confining stress for peak, post-peak (15mm strain) and residual (> 60mm strain) strength conditions. The post-peak relationship was used for static stability conditions, as it is recognized that some relative displacement between the layers may occur during construction or operation of the pad. The residual strength value was used for seismic loading conditions from the design earthquake. The adopted relationships between interface shear strength and normal confining stress for the post-peak and residual strengths are included on Figure 5.9

5.8.2 Results of Stability Analyses

Results of the stability analyses indicate that the leach pad is stable with a minimum static factor of safety of 1.6. The potential slip surface and calculated static factor of safety is shown on Figure 5.9.

Stability of the HLF during earthquake loading has been assessed by performing a pseudo-static analysis, whereby a horizontal force (seismic coefficient) is applied to the heap to simulate earthquake loading to determine the critical acceleration required to reduce the factor of safety to 1.0. Deformation is predicted to occur if the critical acceleration is lower than the predicted average maximum ground acceleration along the potential slope surface from the design earthquake.

Potential deformations under earthquake loading have been estimated using the semi-empirical simplified methods of Newmark (1965), Makdisi-Seed (1977) and Bray (2007). These methods estimate displacement of the potential sliding mass based on the average maximum ground acceleration and the yield acceleration. The yield acceleration corresponds to the seismic coefficient required to initiate movement of the sliding mass. The yield acceleration was determined by iterative stability analyses. For the final heap leach pad configuration, the estimated yield acceleration is 0.12g. To account for the possible amplification of ground accelerations as seismic waves propagate through the heap leach pad, an amplification factor of 1.5 was assumed, resulting in an estimated average maximum acceleration of 0.12g. Predicted heap leach pad deformations calculated for the design earthquake are negligible, if any, and would not impact operations at the HLF.

The stability of the HLF is sensitive to the interface shear strengths associated with the liner system. It is recommended that laboratory shear strength tests for each of the liner interfaces within the composite liner systems are tested for detailed design studies, once all material sources have been confirmed.

6 – CONSTRUCTION AND OPERATIONS

6.1 STAGED CONSTRUCTION

The proposed heap leach pad will be developed in five stages. This will minimize initial capital costs while allowing monitoring to maximize the efficiency and recovery during leaching. The general operational strategy will involve placing the ore in successive lifts followed by irrigation with leach solutions. The lifts will be placed by conveyor and spread with dozers. The ore will then be placed in strips parallel to the confining embankment and loaded upslope to ensure on-going stability and to prevent trafficking over the liner. Proposed bench lifts of eight metres will be constructed at bench face angles of approximately 1.4H:1V. Berm widths of nine metres will be left at the toe of each lift resulting in an overall slope of 2.5H:1V. On-going pad development` will involve extending the composite liner upslope to allow for continued lift placement.

6.2 LIFT PLACEMENT AND LEACHING

Leachate solution will be collected by a series of drainage pipes within the coarse drainage layer at the base of the pad. The drain pipes will connect to main leachate collector pipes for transport to the vertical riser pipe within the potential ponding area.

The sequence of lift placement and leaching will likely be as follows:

- Place 38 mm minus overliner material on the surface of the geomembrane liner to provide liner protection and base drainage.
- Place eight metre lift of ore, as required, by moveable ore transport conveyors or haul trucks. Spread with dozers to establish an evenly graded surface for leaching.
- Layout irrigation lines for drip leaching. Sprinkler leaching may also be possible during summer months as part of a rotational, cell-type leach operation.
- Cover irrigation lines with ore having a thickness greater than the depth-of-freeze in the fall to prevent freezing during winter operations.
- Leach the lift of ore above the irrigation lines prior to loading with the next eight metre lift.

6.3 BORROW MATERIALS

Borrow materials will be required for the construction of the leach pad foundation, confining embankment and events pond. Random fill may also be required for foundation earthworks prior to soil liner placement. Borrow for overliner material may be obtained by screening ore at the crusher plant. Rockfill for embankment construction may be obtained from local rock excavation, remote quarry sources or suitable non-reactive (leah cap) mine waste rock, if available.

Materials for the soil liner and random fill may be obtained from borrow areas along south-facing slopes, upslope and east or west of the HLF. Additional test pits and laboratory testwork will be required in these areas to confirm the suitability, availability and quantity of borrow materials for earthworks construction. The borrow areas will be developed by dozing and ripping material down-slope to refusal. Finer grained residual silty sands near surface will be stockpiled for use as soil liner material. Coarser grained material at depth will be utilized as random fill in the construction of the confining embankment and the events pond dam. The material may also be used as general backfill over bedrock for the leach pad foundation. Ripping or blasting in rock may provide rockfill for the shell zones of the confining embankment and events pond, as required.

6.4 COLD WEATHER CONSIDERATIONS

As detailed in Section 2.2.2 the Casino Project area's mean minimum monthly temperature in January is -17 °C, extreme temperature events however produce temperatures significantly colder. In order to enable year-round operation of the HLF the Site's winter conditions (snowfall and cold temperatures) were considered during the preparation of the design.

As noted in Section 3.2, ore stacking will be conducted 300 days/year and leaching 365 days/year. Seasonal stacking of the ore reduces the risks and challenges of stacking during winter e.g. heavy snowfall and reduced day light hours. Challenges of leaching during winter include reduced leaching efficiency, freezing solution and leachate lines and freezing ponds. In order to overcome the risk of freezing ponds during winter, all leachate collection will be conducted within the heap leach pad behind the confining embankment within the ore voids rather than in an external free-surface pond. The events pond was designed as a dry-pond to ensure that freezing and associated ice-damage to the pond liner does not occur. Winterization of the leachate and solution lines will also be required and may include heat tracing and insulation. Winter operations for the HLF will also likely be modified during extreme cold events to include 'ripping' the frozen ore stacks to promote improved infiltration through the ore bed.

7 – INSTRUMENTATION AND MONITORING

Instrumentation and monitoring will be carried out on an on-going basis to ensure the safe and effective operation of the HLF. Recommendations for instrumentation and monitoring are summarized below:

Instrumentation

Geotechnical instrumentation will be installed to monitor the performance of the HLF during the construction stage and throughout the life of the facility. The purpose of the instrumentation will be to provide data to assess the stability of the heap leach pad and to evaluate the effectiveness and performance of the overliner and foundation drains.

The following instrumentation is recommended for installation at the HLF:

- Piezometers will be installed to allow measurement of phreatic levels and pore water pressures within the HLF and foundations. Vibrating wire piezometers will be installed in the following locations:
  - The leach pad and events pond embankment fill materials and foundation
  - The leach pad and events pond foundation drains; and
  - The overliner.

Monitoring

Preliminary recommendations for monitoring are summarized below:

- Surface water quality sampling at selected locations downstream of the HLF.
- Installation of monitoring wells around the facility to monitor groundwater quality during operations and at closure. These wells would be installed prior to development to obtain baseline information for comparative assessment.
- Installation of an LDRS to monitor and recover any leakage through the liner systems within the heap leach pad area and events pond.
- Slope movement monuments and survey control points installed and monitored to ensure the integrity and stability of the ore heap.
- The installation of flow monitoring devices in diversion ditches and creeks to confirm design flows.
- Review of thermistor data to confirm the thermal regime at the site.

Details of the instrumentation and monitoring plan will be developed in conjunction with the appropriate regulatory authorities.

8 – CLOSURE AND RECLAMATION

Reclamation will be carried out to minimize potential impacts to the surrounding environment. Preliminary recommendations for closure and reclamation are summarized below:

- Grading, covering and revegetation of final heap slopes to provide adequate drainage and erosion protection from surface runoff. This may be carried out during operations as the final slope of the heap is developed.
- Rinsing and drain-down of the ore and cyanide destruction at the end of HLF operations.
- Removal of geosynthetic liners from the overflow spillway and the events pond, as required.
- Decommissioning of the pregnant solution recovery system.
- Removal of pregnant solution and events pond pumps and pipeworks.

A preliminary closure and reclamation plan has been prepared by Others, and will continue to be developed in conjunction with the appropriate regulatory authorities.

9 – ESTIMATED QUANTITIES AND CAPITAL COST INFORMATION

Preliminary cost items and estimated quantities have been developed for the proposed leach pad, events pond and solution recovery components of the facility for pre-production and 157.5 million tonne configuration. The cost items and associated quantities have been summarized in Table 9.1. Appropriate unit rates and the capital cost estimate will be compiled by Others.

Initial capital costs will likely include the foundation works, embankment construction and ancillary works required for the leach pad, confining embankment, events pond and solution recovery systems. On-going capital costs will need to include for staged expansion of the leach pad up the slope.

Other costs associated with the HLF include operational costs and capital costs for leaching services.

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TABLE 9.1

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FEASIBILITY DESIGN OF THE HEAP LEACH FACILITY
SCHEDULE OF QUANTITIES

Item No.	Description	Unit	Estimated Quantity				
			Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
			Year -3	Year -1	Year 3	Year 7	Year 11
1.0	**Leach Pad**						
	Approximate 3D Area: total new footprint area (ponded and non-ponded)	m^2	*419,000*	*387,000*	*306,000*	*266,000*	*153,000*
	1.1 Stripping and removal of unsuitable materials[1]						
	1.1a Topsoil stripping	m^3	209,000	193,500	153,000	133,000	76,500
	1.1b Excavation of unsuitable materials (2 metres thick)	m^3	838,000	774,000	612,000	532,000	306,000
	1.2 Rough grading (general backfill - 0.5 m)	m^3	209,000	193,500	153,000	133,000	76,500
	1.3 Liner System - ponded area	m^2	23,000	-	-	-	-
	1.3a Overliner (1.0 m thick, placed and compacted, 38 mm minus)	m^3	23,000	-	-	-	-
	1.3b Primary Geomembrane: 80 mil (2 mm) smooth LLDPE	m^2	23,000	-	-	-	-
	1.3c Soil liner, 0.3 m thick (supply, place and compact)	m^3	7,000	-	-	-	-
	1.3d Geotextile	m^2	23,000	-	-	-	-
	1.3e Leak detection sand layer, (0.3 m thick)	m^3	7,000	-	-	-	-
	1.3f Secondary Geomembrane: 60 mil (2 mm) smooth LLDPE	m^2	23,000	-	-	-	-
	1.4 Liner System - non-ponded area	m^2	396,000	387,000	306,000	266,000	153,000
	1.4a Overliner (1.0 m thick, placed and compacted, 38 mm minus)	m^3	396,000	387,000	306,000	266,000	153,000
	1.4b Primary Geomembrane: 80 mil (2 mm) smooth LLDPE	m^2	396,000	387,000	306,000	266,000	153,000
	1.4c Soil liner, 0.3 m thick (supply, place and compact)	m^3	119,000	116,000	92,000	80,000	46,000
	1.4d Leak detection gravel layer (0.3 m thick, 0.3m wide under collection pipe system)	m^3	460	250	200	440	430
	1.4d Leak detection pipes (100 mm dia. perforated HDPE)	m	5,000	3,000	2,000	5,000	5,000
	1.4e Geotextile (allow 10% of total area, under collection pipes)	m^2	40,000	39,000	31,000	27,000	15,000
	1.5 Solution Collection System						
	1.5a Lateral Collection pipes (perforated HDPE)	m	70,000	65,000	51,000	44,000	25,000
	1.5b Collection Header pipes (perforated HDPE)	m	2,000	1,000	1,000	3,000	3,000
	1.5c Main Header Collection pipes (perforated HDPE)	m	3,000	2,000	1,000	2,000	2,000
2.0	**Confining Embankment**						
	Approximate Area under the embankment footprint	m^2	58,000	-	-	-	-
	2.1 Stripping and removal of unsuitable materials[1]						
	2.1a Topsoil stripping	m^3	29,000	-	-	-	-
	2.1b Excavation of unsuitable materials (2 metres thick)	m^3	115,000	-	-	-	-
	2.2 Rough grading (general backfill, 0.5 m thick)	m^3	29,000	-	-	-	-
	2.3 Embankment fill (supply, place and compact)						
	2.3a Structural fill (minus filter sand liner and drainage blanket)	m^3	749,000	-	-	-	-
	2.3b Drainage blanket (1m)	m^3	58,000	-	-	-	-
	Upstream slope surface area of confining embankment	m^2	17,000	-	-	-	-
	2.4 Liner System						
	2.4a Overliner (1.0 m thick, placed and compacted, 38 mm minus)	m^3	17,000	-	-	-	-
	2.4b Primary Geomembrane: 80 mil (1.5 mm) smooth LLDPE	m^2	17,000	-	-	-	-
	2.4c Soil liner, 0.3 m thick (supply, place and compact)	m^3	5,000	-	-	-	-
	2.4d Geotextile	m^2	17,000	-	-	-	-
	2.4e Leak detection layer (supply, place and compact)	m^3	5,000	-	-	-	-
	2.4f Secondary Geomembrane: 60 mil (1.5 mm) smooth LLDPE	m^2	17,000	-	-	-	-
	2.4g Bedding layer, 0.3 m thick (supply, place and compact)	m^3	5,000	-	-	-	-
	2.5 Access Road	m	450	-	-	-	-
3.0	**Events Pond**						
	Approximate Areas	m^2	42,000	-	-	-	-
	- Embankment Area (downslope)	m^2	16,000	-	-	-	-
	- Embankment Area (upslope)	m^2	9,000	-	-	-	-
	- Area behind embankment (elev. 1030m)	m^2	17,000	-	-	-	-
	3.1 Stripping and removal of unsuitable materials[1]						
	3.1a Topsoil stripping	m^3	21,000	-	-	-	-
	3.1b Excavation of unsuitable materials (2 metres thick)	m^3	83,000	-	-	-	-
	3.2 Rough grading (general backfill - 0.5 m)	m^3	21,000	-	-	-	-
	3.3 Embankment fill (supply, place and compact)						
	3.3a Structural fill (minus soil, bedding and drainage blanket layers)	m^3	235,000	-	-	-	-
	3.3b Drainage blanket (1m)	m^3	25,000	-	-	-	-
	3.4 Liner System - embankment area (downslope)						
	3.4a Primary Geomembrane: 60 mil (1.5 mm) smooth HDPE	m^2	9,000	-	-	-	-
	3.4b Soil liner, 0.3 m thick (supply, place and compact)	m^3	3,000	-	-	-	-
	3.4c Geonet	m^2	9,000	-	-	-	-
	3.4d Secondary Geomembrane: 60 mil (1.5 mm) smooth HDPE	m^2	9,000	-	-	-	-
	3.4e Bedding layer, 0.3 m thick (supply, place and compact)	m^3	3,000	-	-	-	-
	3.5 Liner System - ponded area						
	3.5a Primary Geomembrane: 60 mil (1.5 mm) smooth HDPE	m^2	17,000	-	-	-	-
	3.5b Soil liner, 0.3 m thick (supply, place and compact)	m^3	5,000	-	-	-	-
	3.5c Geonet	m^2	17,000	-	-	-	-
	3.5d Secondary Geomembrane: 60 mil (1.5 mm) smooth HDPE	m^2	17,000	-	-	-	-
	3.5e Bedding layer, 0.3 m thick (supply, place and compact)	m^3	5,000	-	-	-	-
	3.6 Solution recovery pipeline	m	450	-	-	-	-
	3.7 Pumps	PS	2	-	-	-	-
	3.8 Access Road	m	80	-	-	-	-
	3.9 Diversion ditching (construction, lining and energy dissipation)	m	6,000	-	-	-	-
4.0	**Fresh Water Supply Pond**						
	4.1 Foundation stripping and removal of unsuitable materials[1]	m^3	52,000	-	-	-	-
	4.2 Rough grading (general backfill - 0.5 m)	m^3	10,000	-	-	-	-
	4.3 Embankment fill (supply, place and compact)						
	4.3a Structural fill	m^3	258,000	-	-	-	-
	4.3b Drainage blanket (1m)	m^3	21,000	-	-	-	-
	4.4 Diversion ditching (construction, lining and energy dissipation)	m	9,000	-	-	-	-

NOTES:
1. A TOTAL DEPTH OF 2.5 m HAS BEEN ASSUMED FOR 'STRIPPING AND REMOVAL OF UNSUITABLE MATERIALS' UNDER THE HLF PAD CONFINING, EVENTS POND AND FRESH WATER SUPPLY POND EMBANKMENTS.
2. THE LLDPE LINER THICKNESS MAY BE REVISED AFTER ADDITIONAL LABORATORY TESTING.

10 – SUMMARY AND RECOMMENDATIONS

A Feasibility design for the HLF has been carried out for the Casino Project. The proposed leach pad is located on a uniform southeast-facing slope south of the deposit area. Preparation of layouts and sections of the various project components including the leach pad, confining embankment, liner systems and events pond have been completed. The leach pad will provide safe containment and storage for up to 157.5 million tonnes of leach ore and pregnant solution. There is capacity for additional leach ore placement, if required.

The following is a summary list of the main advantages for the proposed HLF:

- The leach pad is located near the deposit area thus minimizing haul and/or ore transport conveyor distances.
- Nearby potential borrow sources on well drained slopes east or west of the HLF may provide relatively short haul distances for leach pad foundation and embankment construction.
- Generally a shallow depth of bedrock throughout much of the HLF area, resulting in reduced foundation excavation requirements.

Design features include the following:

- Pumping of pregnant solution to a gold extraction plant, located southwest of the plant site.
- Excavation of overburden materials to competent bedrock, to eliminate potential settlement and instability resulting from thawing ice-rich overburden. These materials will require containment and sediment control upon thawing.
- Utilize suitable overburden (residual and colluvial soils) and weathered bedrock along well drained, non-frozen, south-facing slopes in the leach pad area as potential borrow for soil liner and embankment construction.
- A single composite liner system comprising an 80 mil (2 mm) smooth LLDPE geomembrane, compacted soil liner and leachate detection and recovery system to maximize leachate collection and minimize seepage losses will be constructed over the upper portion of the heap leach pad.
- A double composite liner system comprising of an 80 mil and a 60 mil (1.5 mm) smooth LLDPE geomembrane liner, a compacted soil liner and geotextile will be constructed over the lower portion of the leach pad and will include a leachate detection and recovery system for intercepting and collecting any leakage through the inner liner.
- A double composite liner system comprising of an 60 mil and a 60 mil (1.5 mm) smooth HDPE geomembrane liner, a compacted soil liner and geonet drainage layer will be constructed over the events pond.A one metre overliner layer comprising 38 mm minus crushed ore over the composite liner to protect the geomembrane and to provide free drainage at the base of the heap. A network of perforated, corrugated polyethylene tubing, or similar, to maximize leachate solution recovery.
- Pregnant solution recovery by means of a submersible pump and pipeline.
- An events pond to provide temporary storage of overflow from the potential ponding area and storm runoff over the leach pad.
- Diversion ditches around the facility to intercept and divert surface runoff.

The heap leach pad will be developed in five stages by loading in successive lifts upslope from the confining embankment. Bench lift heights of approximately eight metres will be constructed at repose bench face angles of 1.4H:1V. Benches approximately nine metres wide will be left at the toe

of each lift to establish a final overall slope angle of approximately 2.5H:1V. This will provide stability of the heap and allow for on-going reclamation during operations.

The following is a list of recommendations for additional site investigations, testwork and design studies required to carry the project through to final design and construction:

Geotechnical Investigations and Testwork:

- Additional test pits /drill holes to prove up suitability, availability and quantity of borrow materials for earthworks construction.
- Laboratory testing of potential borrow materials for pad foundation (overliner and low permeability soil layer) and embankment construction (including particle size distribution, Atterberg limits, specific gravity, moisture-density relationship, permeability and shear strength tests).
- Laboratory direct shear testing of liner interfaces, to determine the interface shear strength relationships for heap stability assessment. It is recommended that the shear strength tests are carried out for each of the liner interfaces within the composite liner systems, once all material sources have been confirmed.
- Ore testing (including particle size distribution, specific gravity, permeability under load, load-percolation, and direct shear/triaxial shear strength tests).

Design Studies and Analyses:

- Leach testing (by Others) to determine optimal ore densities, leaching rates and resulting in-heap moisture contents.
- Detailed water balance analyses, based on results of hydrology and leach testing, to estimate solution storage area water volumes, peak storm flows for ditch design, and to confirm sizing of pump and pipework systems.
- Heap stability assessment based on results of laboratory shear strength and liner interface strength testing.
- Seepage analyses to predict seepage flow patterns and solution losses for the design of the LDRS.
- Detailed design of all civil and mechanical works, including sumps, intakes, outlets, pumps, pipe systems etc.
- Advanced studies on the staging configuration of the heap leach pad.

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12 – CERTIFICATION

This report was prepared, reviewed and approved by the undersigned.



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APPENDIX A

WATER BALANCE

(Pages A-1 to A-7)

APPENDIX A

WESTERN COPPER CORPORATION
CASINO COPPER-GOLD PROJECT

OPERATIONAL AVERAGE MONTHLY WATER BALANCE MODEL

A.1. GENERAL

An operational average monthly water balance analysis was undertaken for the Heap Leach Facility (HLF) at the Casino Copper-Gold project site using Excel and annual average precipitation. The intent of the modelling was to estimate the magnitude and extent of any water surplus or deficit conditions in the HLF based on annual average climatic conditions. The modelling timeline included three pre-production years (Year -3 to Year -1), and 16 years of operation (Year 1 to 16). The model is shown schematically on Figure D.1 and incorporates the following major project components:

- Open Pit
- Heap Leach Pad
- Ore Stockpile
- Fresh Water Supply Pond (Makeup Water supply Years -3 to -1 only)
- Events Pond Storage (50,000 m^3 Years -3 to -1 only)

The model assumptions and parameters are discussed in the following sections the design inputs are summarized in Table D.1.

Table A.1 Heap Leach Facility Design Water Balance Inputs

Heap Leach Facility Stacking and Leaching		
Stacking Days	300	M3 Design Criteria
Leaching Cycle (days)	60	M3 Design Criteria
Leaching Days per Year	365	M3 Design Criteria
Leachate application Rate (m^3/hr/m2)	0.012	M3 Design Criteria
Leachate Maximum Flow (m^3/hr)	1,312	M3 Design Criteria
Maximum Leaching area	109,000	
Dry Density of Heap (t/m^3)	1.75	M3 Design Criteria
Moisture Contents by Mass		
Initial Moisture Content	2%	M3 Design Criteria
Leaching Moisture Content	12%	M3 Design Criteria
Residual Moisture Content	10%	M3 Design Criteria

A.2. MODEL ASSUMPTIONS

A.2.1 Average Hydrometeorological Conditions

The base case monthly operational water balance model was developed using average estimated values for precipitation and runoff. Complete details of the derivation of the climate and hydrology inputs for the project site are outlined in the Updated Hydrometeorology Report (Knight Piésold, 2012a). The values used for modelling are summarized in Table D.2.

The available runoff from the undisturbed catchment areas within the HLF catchment were modelled on the basis of the long-term runoff estimates for Casino Creek at hydrology station W4, as summarized in Table D.2. Natural runoff values however, are not applicable for mine disturbed areas because altering the ground cover changes the runoff. Therefore, the water (runoff/infiltration) generated from the mine affected areas was estimated based on rainfall and snowmelt. The available precipitation is summarized in Table D.2 and the runoff coefficients are given in Table D.3.

Table A.2 Average Hydrometeorological Inputs

Parameter	Monthly Value (mm)												Annual
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	(mm)
Precipitation	32	24	19	17	37	62	91	67	47	38	43	33	**510**
Rainfall	0	0	0	8	37	62	91	67	47	18	0	0	**330**
Snowfall	32	24	19	9	0	0	0	0	0	20	43	33	**180**
Sublimation	5	5	5	5	0	0	0	0	0	5	5	5	**40**
Snowmelt	0	0	0	25	115	0	0	0	0	0	0	0	**140**
Available Precipitation	0	0	0	33	152	62	91	67	47	18	0	0	**470**
Lake Evaporation	0	0	0	0	49	69	75	66	41	0	0	0	**300**
Available Runoff	0.5	0.3	0.3	3	45	25	33	31	27	15	2	1	**183**

NOTES:

1. THE PRECIPITATION VALUES WERE ESTIMATED FOR ELEVATION 1200 m.
2. THE MONTHLY RUNOFF VALUES ARE SUMMARIZED FOR LOWER CASINO CREEK AT HYDROLOGY STATION W4.
3. MEAN ANNUAL RUNOFF (MAUR)

A.2.2 Heap Leach Facility

The ore will be stacked on a composite geotextile liner in eight meter lifts. Ore will be stacked on the heap 300 days per year and leaching will occur year round in 2 month cycles. The HLF inputs are detailed below:

- HLF Stacking is modelled at a steady rate over ten months each year. The annual stacking rate in Year –3 is 6.6 Mt per year, and increases to 9.1 Mt per year in Years -2 to 14, in Year 15 the rate drops to 4.9 Mt per year.
- HLF leaching is modelled as two month blocks. The leaching process will consist of applying leaching solution to the stacked ore thereby raising the moisture content of the ore from its initial level to the optimum level as shown on Table D.1. The hydration process is assumed to take place within the first month of the leaching cycle and in months where drawdown of the heap occurs (see below) the drawdown is recycled onto the heap. The first leaching cycle in the model occurs during freshet of Year -3. Approximately 30 k m^3 of makeup water will need to be supplied from external sources to fully hydrate the first block of ore.
- The heap pad has been designed to direct all infiltration to the solution sump at the base of the heap, as such available runoff from the active heap pad and composite liner catchments has been modelled as 98% recovered. Evaporation of moisture from the heap surface has been modelled as 50% of the lake evaporation.
- Drawdown occurs when solution is no longer applied to the ore and the moisture content of the leach block drops from the leaching moisture content to the residual moisture content. Solution will continue to flow through the lower heap layers, when actively leaching the upper ore lifts, therefore the model assumes that drawdown will occur once the active leaching process has been completed for that slice of the heap footprint. The tonnage of ore that is available to release drawdown water has been calculated on an annual basis and this has been applied uniformly over the year.
- The HLF Events Pond has been designed to attenuate the 1 in 100 year storm event on the full HLF footprint. During years -3 to -1 the undeveloped portion of the heap pad catchment is diverted. As a result approximately 50,000 m^3 of storm capacity id available to store excess runoff from the heap pad for recycling until the Tailings Management Facility (TMF) is constructed. The model draws water from the HLF Events Pond first and it is completely pumped out at the start of each new leaching cycle. Evaporation from this pond has not been calculated as the losses would be small and the surface area is to variable to accurately calculate on a monthly basis. The HLF Events pond is modelled as constructed prior to freshet Year -3. In years 1 through 16 excess runoff is assumed to be routed to the TMF.
- A fresh water supply pond is required to supply water to the HLF in years -3 to -1 prior to construction of the Yukon Water Supply Pipeline. The Fresh Water Supply Pond will be constructed prior to Year -3, and is able supply all makeup water requirements to the HLF in Years -3 to -1, with the exception of the first leaching block as noted above. Starting in Year 1 the Fresh Water Supply Pond and its associated catchments are incorporated in the TMF water balance. Evaporation has not been considered from this pond as the pond is at its maximum volume and spilling in all months when evaporation would occur and therefore all loses would be replaced by inflows.
- Water Storage within the heap has been modelled as zero. It has been assumed that the storage available in the pore spaces at the pump vertical riser will amount to approximately 1 day of pumping and will have a negligible effect on a monthly time step model. As there is no in heap storage, in months that inflows exceed the leaching requirements of the HLF all excess water is discharged and

routed to the TMF. Conversely in months where leaching requirements exceed inflows, makeup water is added to the HLF. As stated above, water supply is modelled to come from the Events and Fresh Water Supply ponds in Years -3 to -1. In Years 1 to 16 the makeup water is modelled as coming from an alternative water source (either the pipeline or TMF supernatant pond).

A.2.3 Ore Stockpile

The production rate of leachable ore from the Open Pit is highly variable from one year to the next, while leaching operations are limited by the available equipment to a certain range of annual production rates. The ore stockpile attenuates the variability of the Open Pit production, in years when an excess of ore is produced all excess is placed in the stockpile, in years when Open Pit production is lower than the design HLF stacking rate the remaining ore demand is sourced from the stockpile. The model inputs for the ore stockpile are detailed below:

- The initial water content of the ore is shown on Table D.1.
- Runoff infiltration and evaporation are calculated in the same way as infiltration and evaporation from the HLF. 98% of runoff is captured and evaporation from the heap is 50% of lake evaporation.
- The cumulative mass of water in the heap is tracked and is modelled to not exceed the residual moisture content shown in Table D1.
- Ore supplied from the stockpile has a higher water content than that of the Open Pit production due to hydration while stockpiled and the water required to fully hydrate stockpile ore to the leaching moisture content is calculated separately from the water required to hydrate Open Pit ore.

A.2.4 Catchment Areas

The HLF catchment areas and corresponding runoff coefficients used in the eater balance are summarized in table D.5

Table A.3 Facility Catchment Areas

Facility	Catchment Area (km^2)						Runoff coefficient
	Year -3	Year -1	Year 3	Year 11	Year 13	Year 15	
HLF Ore Stack	0.45	0.8	0.8	1.5	1.5	1.5	0.98
Undisturbed area in HLF catchment	0.35	0.0	0.7	0.007	0.0	0.0	-
Ore Stockpile	0	0.28	0.55	0.55	0.28	0	0.98
Events Pond	0.06	0.06	0.06	0.06	0.06	0.06	0.98
Freshwater Supply Pond	5.8	5.8	-	-	-	-	-

NOTES:

1. HLF = HEAP LEACH FACILITY.
2. THE ESTIMATED RUNOFF FOR ALL FACILITY FOOTPRINTS WITH THE EXCEPTION OF UNDISTURBED AREAS AND SOIL STOCKPILES IS CALCULATED BY MULTIPLYING THE MONTHLY AVAILABLE PRECIPITATION VALUE BY THE RUNOFF COEFFICIENT.
3. UNDISTURBED AND SOIL STOCKPILE RUNOFF IS ESTIMATED BASED ON THE MONTHLY AVAILABLE RUNOFF VALUES, WHICH IS A DIRECT INPUT TO THE MODEL.

A.3. RESULTS AND RECOMMENDATIONS

A.3.1 Model Results

The model results are summarized in Table D.4 below. It can be seen from this table that the makeup water requirements are highest at the start of the operation and discharge is lowest. By the end of the HLF production life the makeup water requirements have diminished to less than the discharge requirements.

Table A.4 Annual Make up and Discharge Requirements

Mine Year	Makeup Water (m^3)	Discharge (m^3)
-3	522,000	0
-2	669,000	0
-1	666,000	0
1	666,000	167,000
2	666,000	167,000
3	596,000	234,000
4	579,000	237,000
5	450,000	263,000
6	418,000	269,000
7	571,000	282,000
8	581,000	280,000
9	581,000	280,000
10	290,000	688,000
11	357,000	318,000
12	299,000	329,000
13	273,000	340,000
14	210,000	372,000
15	58,000	479,000
16	0	269,000
Sub-total Years -3 to -1	1,857,000	0
Sub-total Years 1 to 16	6,595,000	4,974,000
Total	8,452,000	4,974,000

NOTES:

1. YEARS -3 TO -1 - MAKEUP WATER IS SOURCED FROM THE FRESH WATER SUPPLY POND.
2. YEARS 1 TO 15 - MAKEUP WATER IS SOURCED FROM THE YUKON WATER SUPPLY PIPELINE

A.3.2 Recommendations

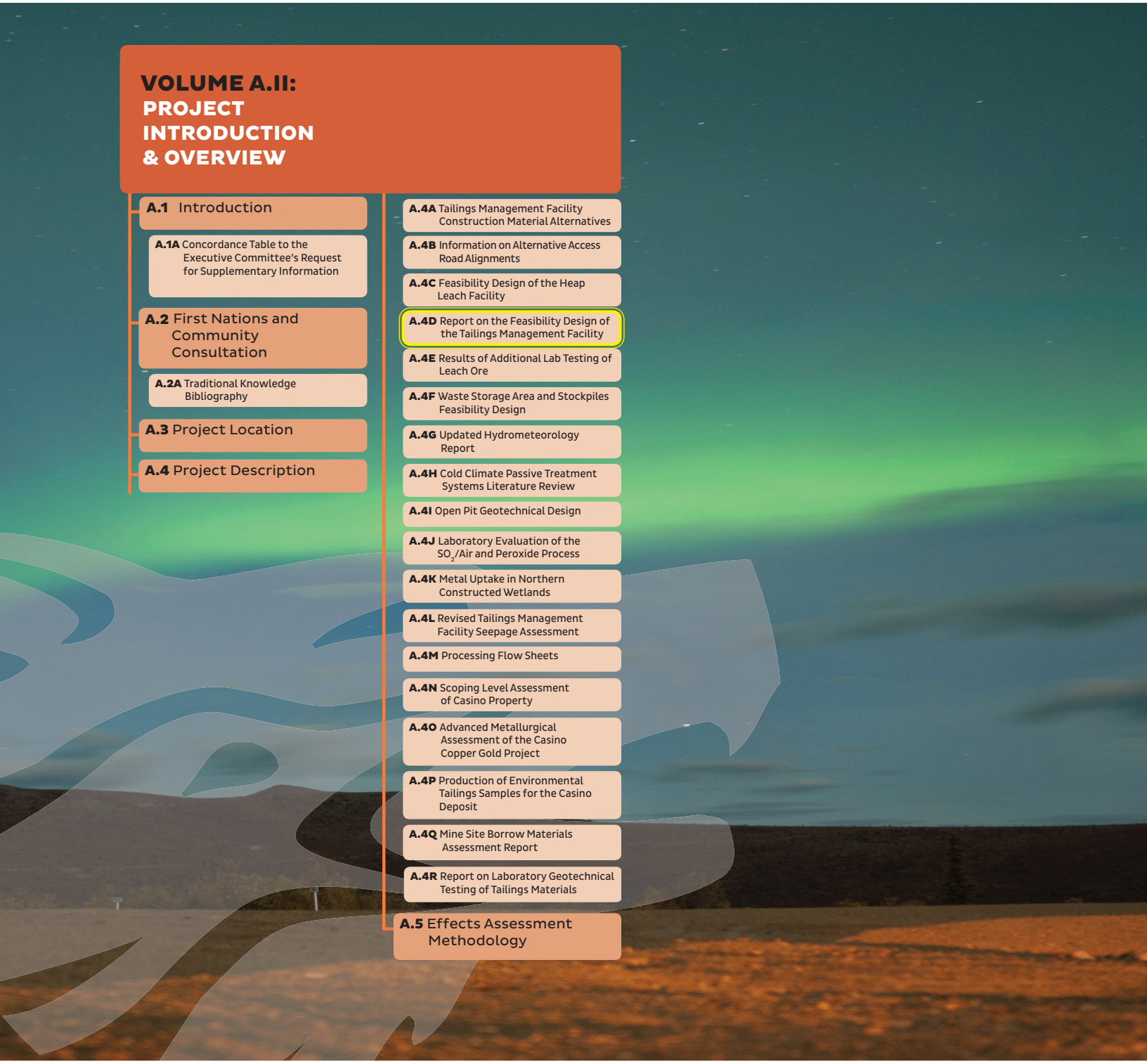
The first leaching cycle in Year -3 was modelled as an equal portion of the annual tonnage, this will require an input of approximately 32 k m^3 of water to fully hydrate the ore. If the first block is reduced in size to approximately 80% there is sufficient water to fully hydrate. The remaining 20% from the first cycle can be distributed over the remaining months so that the annual target is met. The model has been calculated such that freshet flow occur at the beginning of a leaching cycle this allows close to 100% recycle of the runoff to hydrate a new block of ore. If this is not possible on an operational basis then there will be an increase in both the makeup and discharge requirements shown above.

A.4. REFERENCES

Knight Piésold Ltd. (2012a). Hydrometeorology Report (Ref. No. VA101-325/8-11, Rev 0). July 9, 2012.

Knight Piésold Ltd. (2012b). Feasibility Design of the Heap Leach Facility (Ref. No. VA101-325/8-9, Rev A). November 2012.

APPENDIX A.4D: Report on the Feasibility Design of the Tailings Management Facility



CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT






REPORT ON FEASIBILITY DESIGN OF THE TAILINGS MANAGEMENT FACILITY

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VA101-325/8-10
Rev 0
December 20, 2012

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ISO 9001 - FS 64926
ISO 14001 - EMS 550121
OHSAS 18001 - OHS 550122

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

REPORT ON FEASIBILITY DESIGN OF THE TAILINGS MANAGEMENT FACILITY
VA101-325/8-10

Rev	Description	Date	Approved
0	Issued in Final	December 20, 2012	KJB

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EXECUTIVE SUMMARY

The Casino Copper-Gold Project is a large copper-gold deposit located in the Dawson Range Mountains of the Yukon Territory, approximately 300 km northwest of Whitehorse. The deposit will be mined using open pit methods with a nominal mill throughput of approximately 125,000 tonnes/day of ore over a 22 year operating life. Knight Piésold Ltd. has been engaged to prepare a Feasibility design of the Tailings Management Facility (TMF) to accommodate all tailings and potentially reactive mine waste rock and overburden materials. The total mined ore reporting to the mill is approximately 965 million tonnes. Approximately 157.5 Mt of additional mined ore will be processed at a Heap Leach Facility (HLF) located south of the open pit.

The TMF will be used for safe, secure and environmentally secure disposal of mine tailings and all potentially acid generating and metal leaching waste rock and overburden. The TMF is located within Casino Creek valley. The embankments that confine the TMF are the Main Embankment to the south and the West Saddle Embankment to the west. The embankments have been designed in accordance to the Canadian Dam Association (CDA) “Dam Safety Guidelines” (2007).

Since the completion of the revised Pre-Feasibility design in 2011, additional geotechnical site investigations and laboratory testing have been completed in 2011 and 2012 to obtain additional geotechnical and hydrogeological information in the area of the TMF embankments. The information collected has been reviewed and incorporated into this Feasibility design. The findings of previous site investigation programs at the site in 1993, 1994, 2010 and 2011 were also used to support the Feasibility design.

The TMF has been sized to provide sufficient capacity to store approximately 956 million tonnes of tailings (including cyclone sand tailings used as embankment fill) and co-disposal of up to 658 million tonnes of potentially reactive waste rock and overburden materials. Potentially reactive waste rock and overburden will be hauled to the TMF for co-disposal with tailings and submergence by tailings and the supernatant pond. A Waste Storage Area (WSA) will be developed in the northern section of the TMF impoundment area.

Approximately 80% of the total tailings will be geochemically innocuous NAG material, following the removal of the pyrite component. These tailings will be used for the production of cyclone sand for construction of the Main Embankment. It is assumed that the NAG tailings will be passed through the cyclone plant for approximately nine months of each year. Cyclone operations will likely not be possible for a portion of the year due to freezing temperatures in the winter months. In addition to cyclone sand the cyclone plant will produce a high volume low solids content stream, containing the fines fraction of the tailings (cyclone overflow). This material will be discharged into the TMF. The discharge of bulk NAG tailings and cyclone overflow will be from valved offtakes located along the Main Embankment and from the West Saddle Embankment.

Approximately 20% of the total tailings will be PAG tailings which are delivered to the TMF in a separate pipeline. The PAG tailings deposit will be developed in a separate central region of the TMF by discharging the tailings from the north-western side of the TMF, close to the WSA. Deposition in this area will keep the PAG tailings remote from the confining embankments. This will minimise seepage from the PAG tailings and ensure that they remain in a subaqueous state.

The TMF embankments will be constructed as water-retaining zoned structures with a low permeability core zone and appropriate filter and transition zones to prevent downstream migration of fines. The core zone will include a seepage cut-off into competent rock in the foundation. The Main Embankment Starter dam is designed to store runoff as a source for mill start-up water and accommodate tailings and potentially reactive waste rock and overburden production for approximately one year of initial operations. The embankment shell zones for the Starter dam will be constructed with random fill comprising suitable rockfill from local borrow sources, supplemented by available non-reactive (leach cap) waste rock material from pre-production stripping. Cyclone sand production in Year 1 of operations will be used to extend the downstream shell of the Main Embankment, allowing the dam crest and core zone to be raised after about 1 year. Ongoing raises will comprise centreline raises with a vertical low permeability core zone and adjacent downstream filter zones. Cyclone sand will be produced from bulk NAG tailings at the Cyclone Plant and discharged into the cyclone sand shell zones (upstream and downstream of the core zone) where it will be spread in cells and compacted using bulldozers. Bulk tailings that bypass the Cyclone Plant and cyclone overflow (fines) produced during cycloning operations will be discharged into the impoundment. The final Main Embankment will be approximately 286 meters high at the deepest section of Casino Creek valley.

The West Saddle Embankment will be constructed at the south-western corner of the TMF and is required at the start of operations to provide a pipeline corridor at a suitable grade for tailings delivery to the cyclone sand plant and TMF. The embankment will comprise an earth-rockfill dam, constructed from local borrow materials to a maximum height of approximately 21 metres.

The TMF will be used to assist with site water management. The supernatant pond within the TMF will provide a large water storage capacity that will be used to both store water for later use and to attenuate inflows. The TMF supernatant pond will provide a water source for milling operations. The supply of reclaim water to the mill will be by a reclaim barge equipped with a pumping system and a reclaim water pipeline to connect the barge and mill.

A revised seepage assessment for the TMF has also been completed and the results incorporated into the Feasibility design. A detailed monthly operational water balance model has been developed for the TMF to assess the various flows to and from the facility, to predict the variation in supernatant pond volume during operations and to estimate makeup water requirements. The water balance includes consideration of Heap Leach Facility operations, cyclone sand operations, tailings consolidation and the co-disposal of potentially reactive waste materials within the TMF. The water balance indicates that the mine site will likely be in a deficit condition over the operating life of the TMF, except for the last 1 to 2 years.

A spillway and downstream channel will be required at closure to facilitate control and discharge of excess water accumulation within the TMF and to provide safe passage of storm water volumes from the TMF. The water balance model developed for the TMF indicates that there will be a water surplus at closure. The closure spillway will be located close to the right abutment of the West Saddle Embankment to provide long term protection against overtopping of the TMF during the post closure years.

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Appendix B Seismic Hazard Assessment
Appendix C Embankment Stability Analyses
Appendix D Operational Monthly Stochastic Water Balance Model
Appendix E Cyclone Sand Design (Paterson and Cooke)

1 – INTRODUCTION

1.1 PROJECT DESCRIPTION

The Casino Copper-Gold Project is a venture by Casino Mining Corporation (CMC) to develop an open pit copper-gold-molybdenum mine in the Yukon Territory. The project is located in the Dawson Range Mountains of the Klondike Plateau approximately 300 km northwest of Whitehorse, Yukon, Canada, as shown on Figure 1.1. This area is somewhat unique in that the region was not glaciated during the Wisconsin Advance. The deposit is hosted by the Prospector Mountain Suite, a suite of igneous intrusive rocks with an intense hydrothermal alteration overprint. The deposit will be mined using open pit methods with a nominal mill throughput of approximately 125,000 tonnes/day (tpd) of ore over a 22 year operating life.

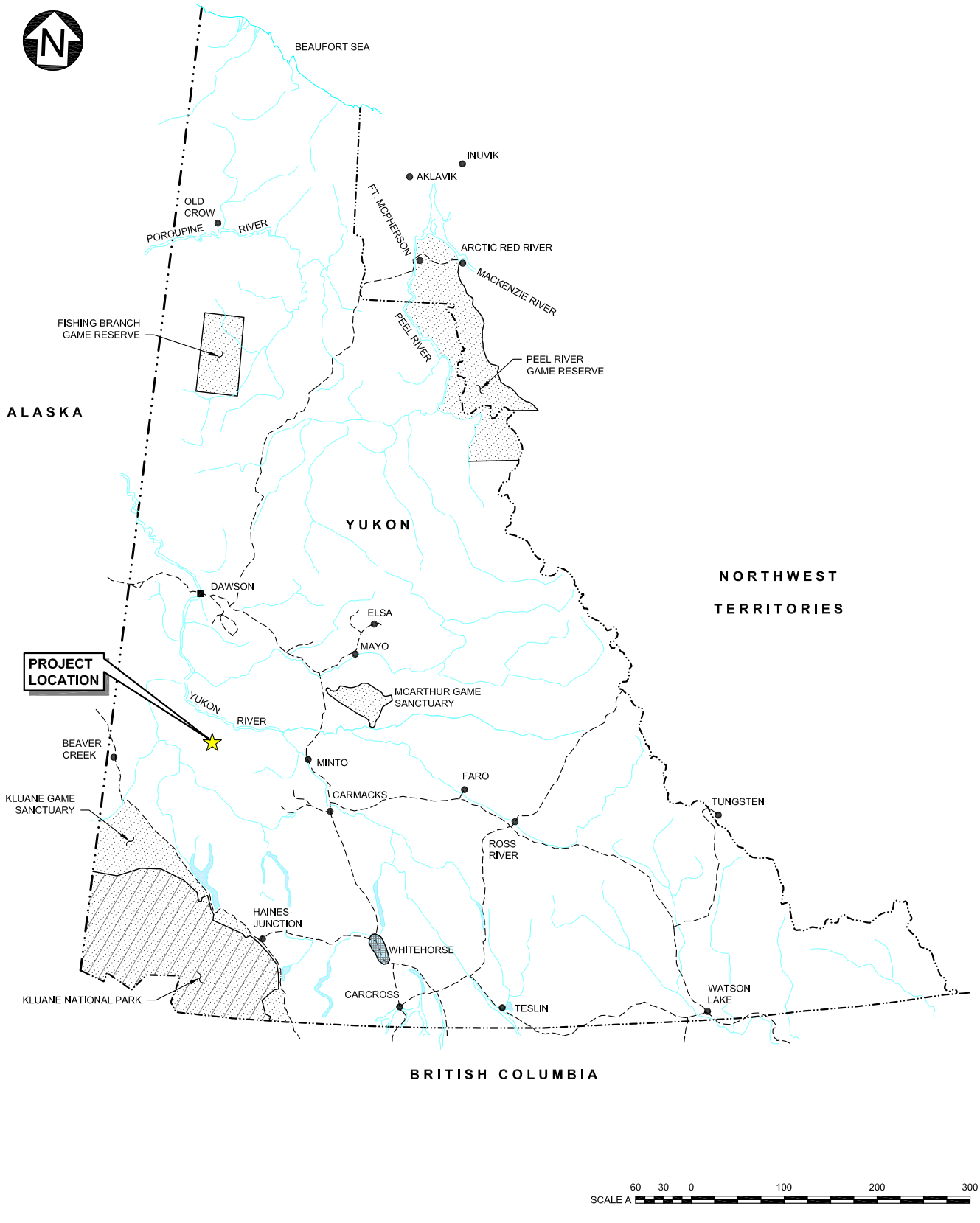
A general layout of the project site is shown on Figure 1.2. The proposed components of the project facilities include an open pit up to 600 meters deep containing a mineable reserve of approximately 965 million tonnes of mill ore. The Tailings Management Facility (TMF) has been sized to provide sufficient capacity to store approximately 956 million tonnes of tailings (including cyclone sand tailings used as embankment fill) and co-disposal of up to 658 million tonnes of potentially reactive waste rock and overburden materials.

Approximately 157.5 Mt of additional mined ore will be processed at a Heap Leach Facility (HLF) located south of the open pit. Details of the Feasibility design of the HLF are presented in Knight Piésold Ltd. (KPL) report “Feasibility Design of the Heap Leach Facility” (Ref. No. VA101-325/8-9, December, 2012). HLF operations will commence during pre-production stripping of the open pit.

Since the completion of the revised Pre-Feasibility design in 2011, additional geotechnical site investigations and laboratory testing have been completed at the TMF, HLF, plant site, ore stockpile areas and open pit. The information collected has been reviewed and incorporated into the applicable project design components. A revised seepage assessment for the TMF has also been completed in 2012. The results of the seepage assessment have been incorporated into the Feasibility design. A detailed operational water balance model has been developed for the TMF and includes consideration of HLF operations, cyclone sand operations and the co-disposal of potentially reactive waste rock within the TMF.

Approximately 80% of the total tailings will be Non-Acid Generating (NAG) material, following the removal of the pyrite component. The NAG tailings will be passed through a cyclone station to produce suitable cycloned sand for embankment construction. The quantity of cyclone sand used in embankment construction is approximately 221 million tonnes. It is estimated that 50% of the NAG tailings can be recovered as cyclone sand when the cyclone station is operating. This amounts to approximately 7.2 to 7.5 million m^3 (12 to 12.5 million tonnes) of cyclone sand fill material produced annually, except for Years 1 and 22. Approximately 20% of the total tailings will be Potentially Acid Generating (PAG) tailings which are delivered to a central region of the TMF in a separate pipeline.

Any non-reactive waste rock and overburden materials produced from mining activities can be used in embankment construction. It is anticipated that approximately 2 to 3 million tonnes of non-reactive leach cap material will be available during pre-production and will be used to provide some of the fill requirements for the Stage IA (starter) embankment.



CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

PROJECT LOCATION MAP

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FIGURE 1.1 | REV 0

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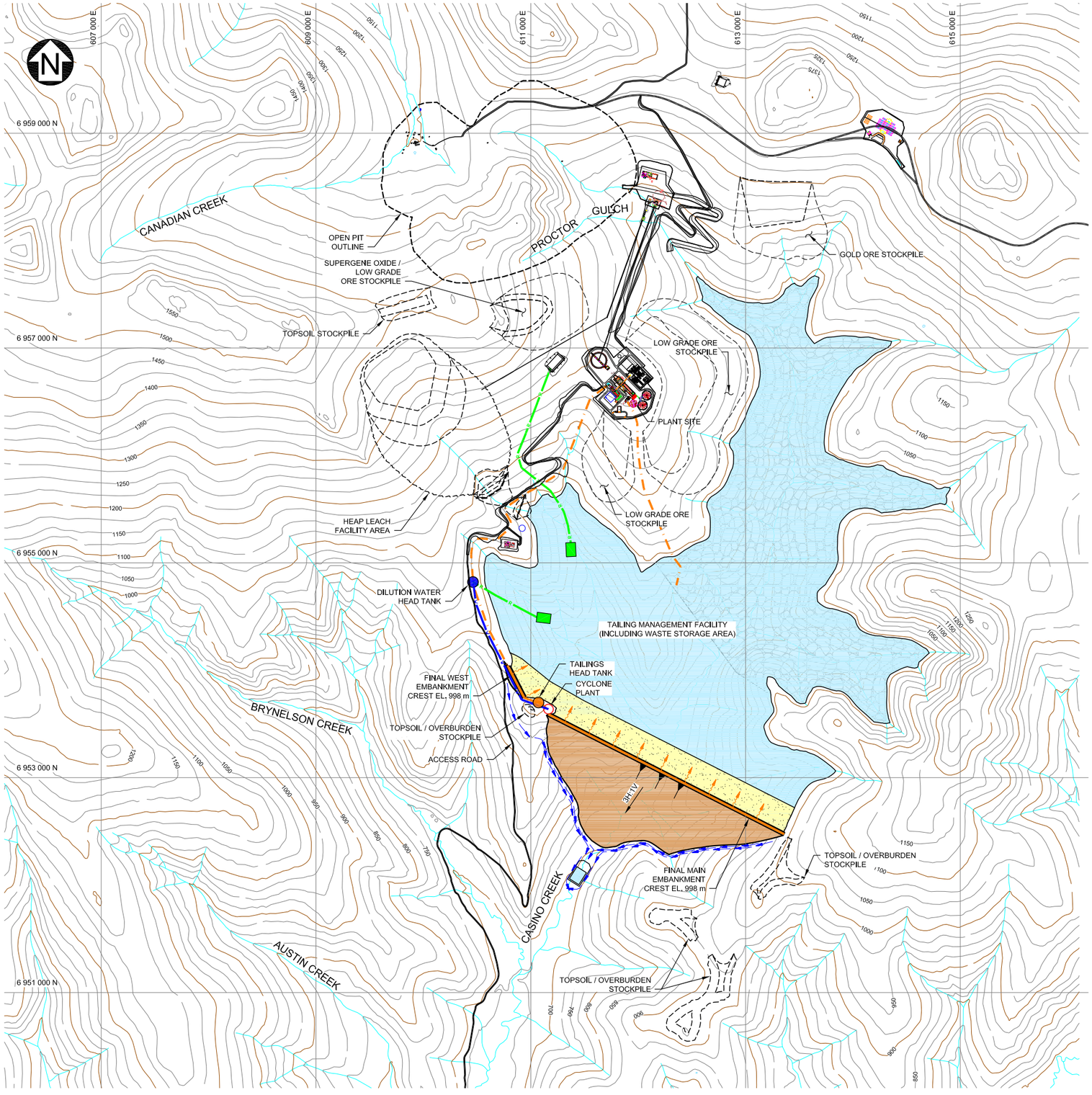

LEGEND:

- TAILINGS
- EMBANKMENT (CYCLONE SAND)
- EMBANKMENT (ROCKFILL)
- POND
- TAILINGS PIPELINES
- RECLAIM PIPELINES
- WATER PIPELINES
- TAILINGS HEAD TANK
- DILUTION WATER HEAD TANK
- CYCLONE PLANT
- DIVERSION DITCHES

NOTES:

1. COORDINATE GRID IS UTM (WGS84/NAD83) ZONE 7 (m).
2. CONTOUR INTERVAL IS 25 METRES.
3. DIMENSIONS ARE IN METRES UNLESS NOTED.
4. OPEN PIT AT ITS FINAL OUTLINE AS PROVIDED BY CASINO MINING CORPORATION (NOVEMBER 2012).
5. PLANT SITE AND CRUSHER LAYOUT PROVIDED BY M3 ENGINEERING AND TECHNOLOGY CORPORATION (OCTOBER 4, 2012).
6. ORE AND TOPSOIL STOCKPILES ARE SHOWN AT THEIR MAXIMUM SIZE DURING OPERATIONS.

SCALE A 400 200 0 400 800 1200 1600 2000 m

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PROJECT GENERAL ARRANGEMENT

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P/A NO.	REF NO.
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FIGURE 1.2 REV 0

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1.2 PREVIOUS STUDIES

Knight Piésold Ltd. (KPL) was retained in 1993 by Pacific Sentinel Gold Corp. to prepare a scoping level study of the open pit, heap leach facility, mine tailings and waste rock management options for the proposed Casino open pit mine development. A number of engineering and environmental reports have been submitted by KPL and Hallam Knight Piésold since the beginning of the project. A list of the reports to date is included in Appendix A.

Several geotechnical site investigation programs were conducted by KPL in the Casino Project area from 1993 to 1994. Preliminary surficial geotechnical investigations were carried out at the site over the period of June 4 to October 1, 1993. The investigations were carried out as part of the Placer Lease Agreement Program to provide a preliminary overview of the surficial materials and foundation conditions for the various potential mine site components (including the open pit, plant site, heap leach facility, waste rock storage and potential tailings impoundment sites). The site investigation program included the excavation of geotechnical trenches for visual description and characterization of surficial materials, and for the collection of representative samples for laboratory testing. The laboratory testwork was carried out on site by KPL and included particle size analyses, natural moisture contents, Atterberg limits (plasticity), compaction tests and permeability tests. The results of the investigations are included in the KPL report "Report on Preliminary Surficial Geotechnical Investigations" (Ref. No. 1831/1, March, 1994).

Geotechnical and hydrogeological investigations conducted in 1994 resulted in fifteen drillholes throughout the Casino Project area. The investigation program also included the excavation of test pits for visual inspection and characterization of surficial materials. Representative rock core and test pit samples were collected for laboratory testwork. The laboratory testwork included particle size analyses, natural moisture contents, Atterberg limits, and compaction tests. In situ packer and falling head permeability tests and shut-in pressure tests were conducted within the drillholes and groundwater monitoring wells and thermistors were installed. Point load testing was conducted on site by KPL for select rock core samples. The results of the investigations are included in KPL report "Data Compilation Report on 1994 Geotechnical and Hydrogeotechnical Investigations" (Ref. No. 1832/2, February 22, 1995).

Alternative waste management sites were short listed for consideration during these previous studies. Preliminary studies identified Site No. 2 as the preferred option, and a scoping level conceptual design of the tailings facility was completed, and presented in the KPL letter report "230 Million Tonne Tailings Storage Facility Study" (Ref. No. 5/2115, September 14, 1995).

Initial scoping studies for a mine production rate of 100,000 tpd were completed in January 2008. This included a preliminary mine waste management alternatives assessment, comprising the following:

- Evaluation of potential TMF options, taking into consideration the recommendations of the previous studies on the conceptual layout for a 230 million tonne tailings storage facility completed by KPL in September 1995
- Determination of storage and embankment volume requirements for each potential TMF
- Consideration of the incorporation of potentially reactive waste rock within the tailings impoundment for flooded co-disposal with the tailings, and
- Selection of the most appropriate TMF option, considering a number of factors.

The TMF options were assessed using a number of criteria including:

- Ability to meet storage capacity requirements
- Minimal footprint and catchment area
- Water management, and
- Minimal infrastructure requirements, including consideration of tailings and reclaim pipelines, ease of road construction, embankment fill volume and construction requirements and location relative to the plant site and open pit.

Consideration was given to minimizing the overall project footprint, placing mine site facilities within one catchment, reducing the contributing catchment areas (simplifying site water management) and mitigating environmental impact.

This study also included a preliminary review and assessment of the potential use of dewatered (thickened/paste) tailings for surface disposal and an initial review of operating considerations for tailings and reclaim systems in freezing conditions. The results of the study were presented in the KPL letter report "Mine Waste Management Assessment" (Ref. No. VA07-01593, January 18, 2008).

The conceptual design for the selected TMF (Option 2) was used as a basis for development of the Pre-Feasibility level design completed in May 2008 and presented in KPL report "Report on the Pre-Feasibility Design of the Tailings Management Facility" (Ref. No. VA101-325/1, May 30, 2008).

Pre-Feasibility design studies completed in 2008 for the TMF utilized Non-Acid Generating (NAG) mine waste rock for embankment construction. However, subsequent geochemical characterization of the mine waste indicated that almost all of the mine waste material may have acid generating or metal (copper) leaching potential, and therefore not suitable for embankment construction. Consequently, a study was carried out to evaluate alternative embankment construction options and alternative tailings disposal technologies for the TMF. The findings of the study indicated that the use of cyclone sand for embankment construction is the preferred option and provides the most efficient and cost effective design concept for the TMF.

Consequently a revised Pre-feasibility design for the TMF completed in early 2011 incorporated the use of cycloned sand in embankment construction. A site investigation program was carried out between May and August of 2010 to obtain geotechnical and hydrogeological information in the TMF embankment area. This information was used to support the revised Pre-Feasibility Study. Geotechnical conditions were also investigated at the current locations of the Plant Site and Open Pit to assess the geotechnical factors affecting design. The results of the investigations are included in KPL report "2010 Geotechnical Site Investigation Data Report" (Ref. No. VA101-325/3-4, November 2, 2010).

1.3 FEASIBILITY DESIGN SCOPE OF WORK

This report presents the Feasibility design of the TMF. Specific design items which are addressed in the report include:

- Review of site characteristics including hydrometeorology, regional geology, hydrogeology and seismicity.
- Tailings physical characteristics.
- Review and evaluation of the results of previous geotechnical investigations carried out at the project site.

- Development of a suitable TMF layout and operating strategy.
- Evaluation of the TMF foundations and preliminary identification of potential borrow sources for construction materials.
- Development of a filling schedule for the TMF to determine initial and on-going staged embankment construction requirements.
- Design of TMF embankments, including static and seismic stability assessment.
- Development of a monthly operational water balance for the TMF to provide a running total of the inputs and outputs from the facility and water availability for reclaim.
- Examination of surface drainage and diversion requirements.
- Seepage analyses and consideration of seepage recovery and control systems.
- Consideration of the operating requirements for the tailings delivery, cyclone sand production and water reclaim systems.
- Preliminary consideration for TMF closure and reclamation requirements, including a closure spillway, and
- Estimation of TMF construction quantities (costing to be carried out by Others).

Additional site investigations to support the Feasibility design of the TMF and other project facilities (including the Waste Storage Area (WSA), stockpile areas and HLF) have been carried out in 2011 and 2012. A primary focus of the 2011 and 2012 site investigation programs was to confirm foundation conditions (including permeability of overburden and rock), refine the characterisation of geotechnical and hydrogeological conditions and to delineate and characterize the low permeability soil materials required for construction of the TMF and HLF. Thermistors were installed in the TMF and HLF areas to provide additional information on the subsurface thermal regime.

A summary of the geotechnical information provided by the site investigations is included in Section 4.0. Details and findings of the 2011 and 2012 site investigation programs for the waste management facilities are provided in KPL reports “2011 Geotechnical Site Investigation Data Report – Waste Management Facilities” (Ref. No., VA101-325/8-5, December, 2012), and “2012 Geotechnical Site Investigation Data Report” (Ref. No., VA101-325/8-14, December, 2012).

2 – TAILINGS CHARACTERISTICS

2.1 GENERAL

The tailings from the Casino Project operation will be produced from the conventional milling of copper and gold ore. The anticipated tailings stream from the mill will be at a typical solids throughput of approximately 45 to 46 million tonnes per year (approximately 34.5 million tonnes in Year 1 and 22.9 million tonnes in Year 22 of operations). The tailings will be transported from the mill at a thickened slurry solids content of about 55 percent by weight.

The tailings stream will be split into a PAG stream (20% by mass) and NAG tailings (80% by mass). Bulk NAG tailings will be passed through a cyclone station for approximately nine months of the year. The sand fraction (underflow) will be recovered and made available for embankment construction. The cyclone overflow (fine tailings) will report to the TMF for disposal. Bulk tailings will also report to the TMF when cycloning operations are suspended (assumed to be for approximately three months of the year) when freezing climatic conditions likely preclude sand placement in the embankments, and when the cyclone station is unavailable due to maintenance or downtime.

2.2 PHYSICAL CHARACTERISTICS

A laboratory testing program has been conducted in 2012 to determine the geotechnical characteristics of the Casino tailings materials. A tailings sample representing Non Acid Generating (NAG) Whole Tailings was provided by Casino Mining Corporation for testing. This sample was used to generate representative samples of tailings Cyclone Overflow (fine tailings) and Cyclone Underflow (sand) materials. A sample of Potentially Acid Generating (PAG) tailings was not available for testing at this time.

The test program included index testing to enable geotechnical classification of each of the materials. The Whole Tailings material can generally be described as non-plastic sand and silt with trace clay. The particle size distribution of the Whole Tailings sample comprises approximately 58% fine sand, 35% silt and 7% clay. The Cyclone Overflow sample was generated to a target particle size distribution with approximately 75% fines (silt and clay fractions). Similarly, the Cyclone Underflow sample was generated for a target particle size distribution with a maximum of 15% fines.

The specific gravity of the tailings solids was determined to be 2.70 for the Whole Tailings sample, 2.71 for the Cyclone Overflow sample, and 2.80 for the Cyclone Underflow sample.

A particle size distribution and specific gravity value for the PAG tailings material was provided by Casino Mining Corporation (based on test results conducted for laboratory metallurgical testing). The particle size distribution for the PAG tailings is included on Figure 2.1. The specific gravity of solids for the PAG tailings sample is 3.0. It is recommended that laboratory testing is also carried out on a representative sample of PAG tailings for future design studies.

Slurry settling (undrained and drained), air drying, consolidation and permeability tests were conducted to determine the characteristics of the Whole Tailings and Cyclone Overflow following deposition and for a range of conditions (representative of expected field conditions). Compaction, strength and permeability tests were carried out on the Cyclone Underflow sample to provide

information on the characteristics of the material as sand fill material over a range of stress conditions.

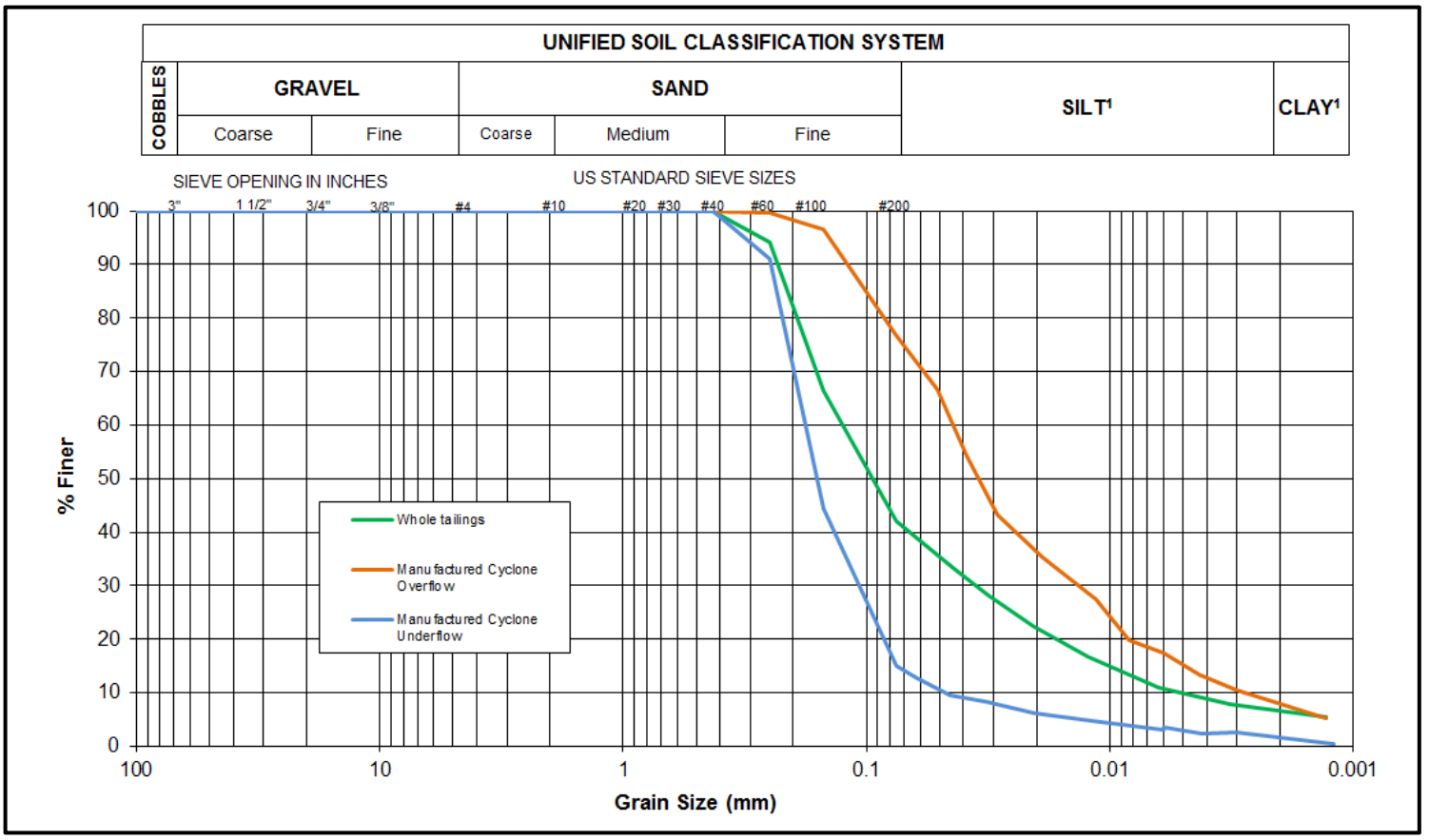


Figure 2.1 Particle Size Distribution for Tailings Samples

NOTES:

1. Silt and clay limits from the US Department of Agriculture definition. The Unified Soil Classification System defines all particles with diameters <0.075 mm as fines with silt and clay defined only by plasticity.

The methodology and complete results of the laboratory testwork are included in KPL report "Report on Laboratory Geotechnical Testing of Tailings Materials" (Ref. No. VA101-325/8-1, December, 2012). A summary of the laboratory testing and results is provided below.

2.2.1 Whole Tailings and Cyclone Overflow

The following is a list of the geotechnical tests conducted on the Whole Tailings and Cyclone Overflow samples:

- Undrained Settling
- Drained Settling (with Falling Head permeability measurement)
- Air drying
- Slurry Consolidometer Test (with permeability measurement), and
- Low Stress Slurry Consolidation (Burette) Test.

The slurry settling (sedimentation) tests provide an estimate of the density to which the tailings slurry will settle in a sub-aqueous environment, under undrained and drained conditions. These tests provide an estimate of expected tailings density in a storage facility after settling and before any significant consolidation or air drying occurs. The air drying test provides the geotechnical characteristics of the tailings for expected conditions on exposed beaches following deposition. The effect of air drying on moisture loss and tailings density is determined by this test.

The slurry consolidometer test is used to determine the consolidation, compressibility and permeability characteristics of the tailings over a wide range of confining pressures (typically corresponding to expected conditions in the field). These parameters are used to determine the amount and rate of consolidation, seepage rates, settlement and density increase for the tailings. The slurry consolidation cylinder test provides a measure of the consolidation characteristics of the tailings at very low effective stresses (representing freshly deposited tailings immediately following settling).

The following points summarize the pertinent findings of the tailings tests:

- For an initial slurry solids content of 55% the settled dry density of the Whole Tailings is approximately 1.0 tonnes/m^3 for undrained settling conditions and 1.09 tonnes/m^3 for drained settling conditions.
- For an initial slurry solids content of about 25% the settled dry density of the Cyclone Overflow is approximately 0.8 tonnes/m^3 for undrained settling conditions, and 0.95 tonnes/m^3 for drained settling conditions.
- Air drying of the tailings materials produces a significant increase in dry density over those from the undrained and drained settling tests. For the Whole Tailings with an initial slurry solids content of 55% a dry density of approximately 1.35 tonnes/m^3 is achieved under air drying conditions. For the Cyclone Overflow with an initial slurry solids content of 25% a dry density of 1.29 tonnes/m^3 is achieved.
- Relationships between coefficient of consolidation, void ratio and vertical coefficient of permeability to effective stress have been developed for the Whole Tailings and Cyclone Overflow material. The coefficients of consolidation generally increase with increasing effective stress, with calculated coefficients of consolidation for the Whole Tailings ranging from 100 m^2/year at very low stresses to over 1000 m^2/year at high stresses. Calculated coefficients of consolidation for the Cyclone Overflow range from 25 m^2/year at very low stresses to over 1000 m^2/year at high stresses.
- The dry density of the Whole Tailings and Cyclone Overflow increases with increasing effective stress (due to consolidation), with a value of approximately 1.6 tonne/m^3 achieved under effective stress conditions greater than about 500 kPa.
- Measured vertical permeability values for the Whole Tailings and Cyclone Overflow decrease with increasing effective stress. The permeability of the Whole Tailings ranges from approximately 1 x 10^{-4} cm/sec at low stresses (representing unconsolidated or fresher tailings near surface) to about 1 x 10^{-6} cm/sec at high stresses, corresponding to a reduction in void ratio (representing more consolidated or deeper tailings within the deposit). Similarly, the permeability of the Cyclone Overflow ranges from approximately 5 x 10^{-5} cm/sec at low stresses to about 1 x 10^{-6} cm/sec at high stresses.

2.2.2 Cyclone Underflow (Cyclone Sand)

The following is a list of the geotechnical tests conducted on the Cyclone Underflow sample:

- Compaction (Proctor) Test
- Tri-axial Shear Strength, and
- Flexible Wall Permeability.

The compaction test provides information on the expected density of the cyclone sand following placement as compacted sand fill for embankment construction. The optimum moisture content of the Cyclone Underflow sample was determined to be 16.7% and the maximum dry density was 1,559 kg/m^3.

The shear strength test provides information on the strength of the compacted sand over a range of confining stresses, and is used for embankment stability assessment. Similarly, the permeability test provides information on the expected permeability of the cyclone sand fill over a range of confining stresses. The permeability characteristics of the cyclone sand are an important consideration in the design of free-draining cyclone sand embankment dams. The shear strength and permeability tests were carried out over a large range of confining stresses to examine the influence of high confining stresses (corresponding to a large dam height) on the strength and permeability values.

The shear strength of the cyclone sand is defined by an average effective friction angle of 36 degrees and zero cohesion. The potential strength characteristics of the cyclone sand over a large stress range was examined by comparison of the laboratory test data to published information on the non-linear strength characteristics of similar granular materials (angular sands). This information suggests that the effective friction angle of the cyclone sand may be greater than 36 degrees at low confining stresses but potentially lower at very high stresses. However, the laboratory test results for the Cyclone Underflow sample suggest that there is no apparent loss of strength at the higher stresses, over the stress range tested (up to about 3000 kPa).

Permeability values determined for the Cyclone Underflow show a general trend of reducing permeability with increasing confining stress. This decrease is the result of the decrease in material density and potentially from the generation of finer particles due to particle crushing. However, the results do not appear to indicate a dramatic decrease in permeability at high stresses, which would be indicative of significant particle crushing and changes to the fines content of the material. The permeability of the Cyclone Underflow ranges from approximately 2×10^{-3} cm/sec at lower stresses to about 5×10^{-4} cm/sec at high stresses (approximately 3000 kPa). Extrapolation of these results suggests that the permeability of the Cyclone Underflow will remain greater than 1×10^{-4} cm/sec at very high stresses of about 4000 to 5000 kPa.

2.3 GEOCHEMICAL CHARACTERISTICS

Detailed laboratory testing and chemical analysis of the tailings (solids and process solutions) has been conducted by Others to determine their geochemical characteristics under saturated and unsaturated conditions. CMC has indicated that approximately 20% of the total tailings will comprise potentially acid generating material.

The PAG tailings are assumed to require complete subaqueous disposal in the TMF, to maintain the tailings deposit in a saturated state and inhibit their oxidation and potential reactivity.

The NAG tailings stream (80% of the tailings total) is assumed to be suitable for production of cyclone sand fill material for embankment construction.

3 – SITE CHARACTERISTICS

3.1 PHYSIOGRAPHIC SETTING

The project is located in the Dawson Range Mountains of the Klondike Plateau. The area is somewhat unique in that the region was not glaciated during the Wisconsin Advance. The characteristic terrain features are smooth, rolling topography, with moderate to deeply incised valleys. Major drainage channels extend below 1,000 m elevation. Most of the terrain lies between 1,000 m and 1,500 m elevation.

The tailings basin area is sited within the Casino Creek valley. The valley bottoms throughout the project area, with impeded drainage, have prominent permafrost features such as peat plateaus, palsas, hummocky tussock fields and polygons.

3.2 HYDROMETEOROLOGY

3.2.1 General

The climate at the Casino Project area is characterized by long, cold, dry winters and short, warm, wet summers, with conditions varying according to altitude and aspect. Streamflow in the region is typically highest in May due to melting of the winter snowpack. Annual peak instantaneous flows commonly occur in this freshet period on larger rivers, but on smaller streams they may also occur in summer or early autumn due to intense rain or rain on snow events. Flows decrease throughout the winter and minimum flows typically occur in March or April.

The climate and hydrology at the Casino Project site have been assessed based on both short-term site data and longer-term regional data. Climatic data were collected on-site at the Project climate station located in the upper Casino Creek sub-watershed at an elevation of 1200 m. The period of site record extends from 1993 to 1994 and from 2008 to 2011. Preliminary streamflow data were collected by Hallam Knight Piésold in 1993 and 1994. A new data streamflow collection program was initiated by AECOM in 2008, with the installation of ten streamflow gauging stations. As of 2012, nine streamflow gauging stations are considered to be in active operation and continue to be operated at present by Knight Piésold Ltd. (KPL). A summary of the hydrometeorological parameters is described below and the detailed analyses are presented in KPL report “Updated Hydrometeorology Report” (Ref. No. VA101-325/8-11, July 9, 2012).

3.2.2 Temperature

The mean annual temperature for the Casino Project area is estimated to be -3 °C, with minimum and maximum mean monthly temperatures of -17 °C and 12 °C occurring in January and July, respectively.

The mean monthly temperature values are presented in Table 3.1.

Table 3.1 Mean Monthly Temperature and Precipitation Values

Location	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Casino Project Station (El. 1200 m)	Precipitation (mm)	32	24	19	17	37	62	91	67	47	38	43	33	**510**
	Temperature (°C)	-16.8	-14.0	-10.2	-1.9	5.0	10.0	11.6	9.2	3.8	-4.5	-12.1	-15.3	**-2.9**

3.2.3 Precipitation and Evaporation

The Mean Annual Precipitation (MAP) for the Casino Project area is estimated to be 510 mm, with 65% falling as rain and 35% falling as snow. The mean monthly values are presented in Table 3.1.

The annual potential evapotranspiration (PET) value for the Casino Project area is estimated to be 300 mm, based on measured temperatures at the Project site climate station, and long-term regional temperature records. Potential evapotranspiration values generally provide reasonable estimates of lake evaporation rates, and are assumed to be appropriate for estimating evaporation from lakes and ponds in the Project area.

3.2.4 Annual Snowfall and Snowmelt

Based on the estimated MAP of 510 mm and a rain/snow ratio of 0.65/0.35, the annual snowfall value for Casino was estimated to be 179 mm. This is generally consistent with the 141 mm mean annual maximum snowpack value (snow water equivalent, SWE), taking into account approximately 40 mm lost to sublimation, recorded in the Project area at the Casino Creek snow course station (09CD-SC01) operated by the Yukon Department of Environment (1977-2011), Water Resources Branch.

Based on the complete years of snowpack data, the average monthly snowmelt distribution for the Casino Project area was estimated to be approximately 20% in April and the remaining 80% in May, although there is considerable variation from year to year.

3.3 REGIONAL GEOLOGY

Regional geological information in the vicinity of the TMF is derived from the interpretation of KPL drillhole and test pit data within both the TMF and surrounding areas. Several geotechnical site investigation programs were conducted in the area of the TMF in 1993 and 1994 and in 2010, 2011 and 2012. Details and results of the site investigations and the foundation conditions defined for the TMF basin are presented in the following KPL reports:

- "Report on Preliminary Surficial Geotechnical Investigations" (Ref. No. 1831/1, March, 1994),
- "Data Compilation Report on 1994 Geotechnical/Hydrogeological Investigations" (Ref. No. 1832/2, February 22, 1995),
- "2010 Geotechnical Site Investigation Data Report" (Ref. No. VA101-325/3-4, November 2, 2010),
- "2011 Geotechnical Site Investigation Data Report – Waste Management Facilities" (Ref. No., VA101-325/8-5, December, 2012), and
- "2012 Geotechnical Site Investigation Data Report" (Ref. No., VA101-325/8-14, December, 2012).

The TMF is underlain by the following geotechnical units:

- Overburden
  - Topsoil
  - Silty SAND to GRAVEL with some cobbles, trace clay (residual soil and colluvial veneer) along valley ridges and upper slopes
  - SILT and SAND with some gravel and cobbles, trace clay (colluvial apron) and interbedded SAND and gravelly SAND with some cobbles (alluvium) along the lower slopes and valley bottom
- Weathered Bedrock, and
- Fresh Bedrock.

The bedrock primarily comprises Dawson Range Batholith Granodiorite throughout the TMF Main Embankment and impoundment area, and Yukon Metamorphic Group Gneiss and Quartzite in the West Saddle Embankment area. Dawson Range Batholith (Mid-Cretaceous) is the main country rock in the TMF area and is dominantly granodiorite in composition. Quartz monzonite and diorite are less abundant. Yukon Metamorphic Group (Paleozoic) is found at depth within drillholes 94-345, 94-346, DH10-01, DH10-02 and DH10-04. The Yukon Metamorphic group was also encountered in test pits near the west embankment. It consists primarily of mafic gneiss, with less abundant meta-diorite/amphibolite, quartz-rich and intermediate gneiss, and quartzite. The Yukon Group represents an older suite of metamorphic rocks which were intruded by the Dawson Range intrusives. Along slopes and ridges in Casino Creek valley the depth to bedrock varies from about 0.5 to 7.5 meters, with an average overburden thickness of between 2 and 3 metres. Depths to bedrock in the Casino Creek valley bottom vary from approximately 2 to 23 metres.

3.4 HYDROGEOLOGY

The interpreted baseline groundwater conditions are based on piezometric levels in standpipes throughout the study area, in addition to shut-in pressure tests performed during drilling in 1994. Permeability results are based on packer tests and falling head tests performed in the drillholes and piezometer standpipes in the different geotechnical units.

Estimates of in situ permeability values, along with supporting hydrogeologic observations are summarized as follows:

- In situ packer and falling head permeability tests were carried out in various drillholes within the TMF basin and Main and West Embankment areas during the 1994, 2010 and 2011 geotechnical/hydrogeological investigations. One packer test and two falling head tests were conducted in the overburden soils near the bottom of the Casino Creek valley in drillholes 94-345 and DH10-04. Permeabilities within the overburden soils ranged from 3×10^{-6} cm/s to 3×10^{-5} cm/s, with a geometric mean value of approximately 7×10^{-6} cm/s. These permeabilities are lower than expected possibly due to a high percentage of fines and/or frozen ground conditions in the vicinity of the tests.
- Permeabilities within Highly Fractured bedrock ranged from 2×10^{-3} cm/s to 2×10^{-7} cm/s, with a geometric mean value of approximately 5×10^{-5} cm/s.
- Permeabilities within Slightly to Moderately Fractured bedrock ranged from 6×10^{-4} cm/s to 2×10^{-7} cm/s, with a geometric mean value of approximately 1×10^{-5} cm/s.

- Permafrost has an important effect on hydrogeology. Saturated frozen soil and rock have a much lower permeability when frozen compared to a thawed or unfrozen state. In situ hydraulic conductivity test results showing very low hydraulic conductivities potentially indicate frozen soil or rock. Thermistors were installed during the 2011 and 2012 site investigations to provide a better understanding of the thermal regime in the subsurface. The permafrost conditions at the TMF site are discussed in detail in Section 4.0.

Well water level elevations in the TMF impoundment area within Casino Creek valley range from approximately 720 to 970 metres. The highest water levels are located at the West Saddle Embankment and the lowest at the Main Embankment, which indicates southeast moving groundwater flow from the West Saddle Embankment to the Main Embankment.

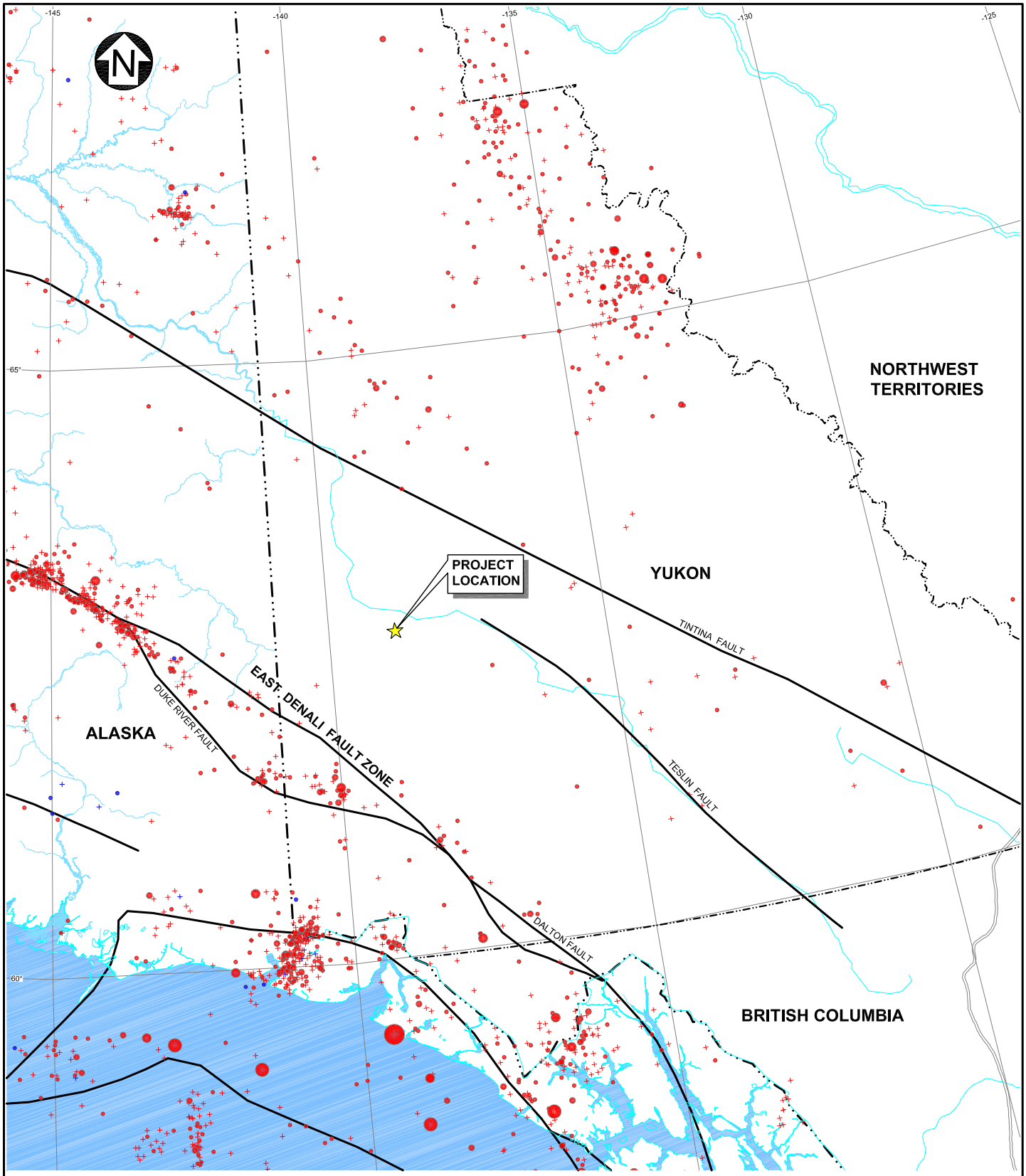
3.5 SEISMICITY

3.5.1 Regional Tectonics and Seismicity

A review of the regional tectonics and historical seismicity has been carried out to enable selection of appropriate design earthquake events for the TMF for use in seismic stability assessment.

The region of the southwest Yukon Territory and northwest British Columbia is one of the most seismically active areas in Canada. The seismic hazard in the region is also influenced by the seismically active region of southeast Alaska. The coastal region has experienced many large earthquakes, including events with magnitudes in the range of magnitude 7.0 to 8.0. In 1958 a magnitude 7.9 earthquake occurred along the Fairweather fault (the northern extension of the Queen Charlotte transform fault). The most significant inland zone of seismicity follows the Dalton and Duke River segments of the East Denali fault zone through the southwest Yukon. Farther inland there is only minor seismicity between the Denali and Tintina fault systems, including the region of the Casino Project site.

Figure 3.1 shows the regional tectonics and historical seismicity of the Yukon and surrounding regions and the location of the Casino project. Review of historical earthquake records and regional tectonics indicates that the Casino Project site is situated in a region of low seismicity.



SYMBOL SIZE PROPORTIONAL TO MAGNITUDE

- 3.5 - 3.9
- 4.0 - 4.9
- 5.0 - 5.9
- 6.0 - 6.9
- 7.0 - 7.9
- 8.0 - 8.9
- 9.0 +

NOTES:

1. GLOBAL COORDINATE SYSTEM IS UTM WITH NAD83 DATUM, ZONE 10 m, CENTRAL MERIDIAN.
2. HISTORICAL EARTHQUAKE DATA FROM NRCAN, USGS, AND NGDC DATABASES.
3. INCLUDES RECORDED EARTHQUAKES FROM 1600 TO 1973 (MAGNITUDE > 6.0) AND FROM 1973 TO SEPTEMBER 2012 (MAGNITUDE > 3.5).

SCALE A: 50 25 0 50 100 150 200 250 km

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

REGIONAL TECTONICS AND HISTORICAL SEISMICITY

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	19DEC'12	ISSUED WITH REPORT	GRG	NSD	GRG	KJB

Knight Piésold CONSULTING

P/A NO. VA101-325/8 | REF NO. 10

FIGURE 3.1 | REV 0

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3.5.2 Seismic Hazard Analysis

The seismic hazard for the Casino project has been defined using probabilistic methods of analysis. Design ground motion parameters have been determined for the project site using information provided by the probabilistic seismic hazard database of Natural Resources Canada (NRC) (http://earthquakescanada.nrcan.gc.ca/hazard-alea/zoning/haz-eng.php). The results are summarized in Table 3.2 in terms of earthquake return period, probability of exceedance (for a 22 year design operating life) and the corresponding peak ground acceleration (median and mean hazard values). For a return period of 500 years the corresponding median peak ground acceleration is 0.07g, indicating a low to moderate seismic hazard for the site.

Table 3.2 Summary of Probabilistic Seismic Hazard Analysis

Return Period (Years)	Probability of Exceedance[1] (%)	Peak Ground Acceleration (PGA)[2]	
		Median PGA[3,4] (g)	Estimate Mean PGA[5] (g)
100	20	0.04	0.05
500	4	0.07	0.08
1,000	2	0.08	0.10
2,500	1	0.11	0.13
5,000	0.4	0.14	0.17
10,000	0.2	0.18	0.22

NOTES:

1. Probability of exceedance calculated for a design life of 22 years:
   $q = 1-\exp(-L/T)$
   Where: q = probability of exceedance
   L = design life in years
   T = return period in years
2. Peak ground accelerations are for soft rock/very dense soil (Vs_{30} = 360 to 760 m/sec) .
3. Median peak accelerations for return period up to 2,500 years obtained from the seismic hazard database of Natural Resources Canada.
4. Median peak ground accelerations for return periods of 5,000 and 10,000 years obtained from site-specific analysis using EZ-FRISK.
5. Mean PGA values estimated as 1.2 x median values.

However, the NRC database only provides ground motion parameters up to a return period of approximately 2,500 years (corresponding to a 2% probability of exceedance in 50 years). Therefore, a probabilistic seismic hazard analysis was conducted to provide ground motion parameters beyond 2,500 years, specifically for return periods of 5,000 and 10,000 years.

The computer program EZ-FRISK (Risk Engineering, Inc., 2008) was used to develop a seismic hazard model for the Yukon and the surrounding regions. The seismic hazard analysis module available with EZ-FRISK includes a database provided by Risk Engineering Inc. of faults and areal seismic sources for the pertinent regions of western Canada. Seismic sources defined in the hazard model include the regions of the southern Yukon Territory, southeastern Alaska, and the Denali and Fairweather fault systems. The seismic hazard model was used to determine the relationship between peak ground acceleration and annual frequency of occurrence for the project site. Predicted values for the project site are included in Table 3.2 for return periods of 5,000 and 10,000 years. Predicted values for lower return periods were very similar to those provided by the NRC seismic hazard database.

The seismic hazard for the project site is predominantly from shallow crustal earthquakes (magnitudes up to M7) in the region of the southern Yukon, but it is also influenced by the potential for larger magnitude earthquakes (approximately M7.5 to 8.0) occurring farther from the site on the East Denali fault zone.

Details of the probabilistic seismic hazard assessment are provided in Appendix B.

4 – SITE GEOTECHNICAL CONDITIONS

4.1 SITE INVESTIGATIONS

Geotechnical site investigation programs were conducted by KPL in the area of the TMF in 1993 and 1994 and more recently in 2010, 2011 and 2012. The programs included drillholes and test pits to investigate the geotechnical characteristics and foundation conditions. Geophysical surveys were carried out by Frontier Geosciences Inc. as part of the 2011 site investigations, and included seismic refraction surveys, Ground Penetrating Radar (GPR) surveys and an EM31 conductivity survey. The geotechnical data has been used to evaluate the tailings basin and embankment foundation conditions, and to evaluate the geological factors affecting design of the TMF.

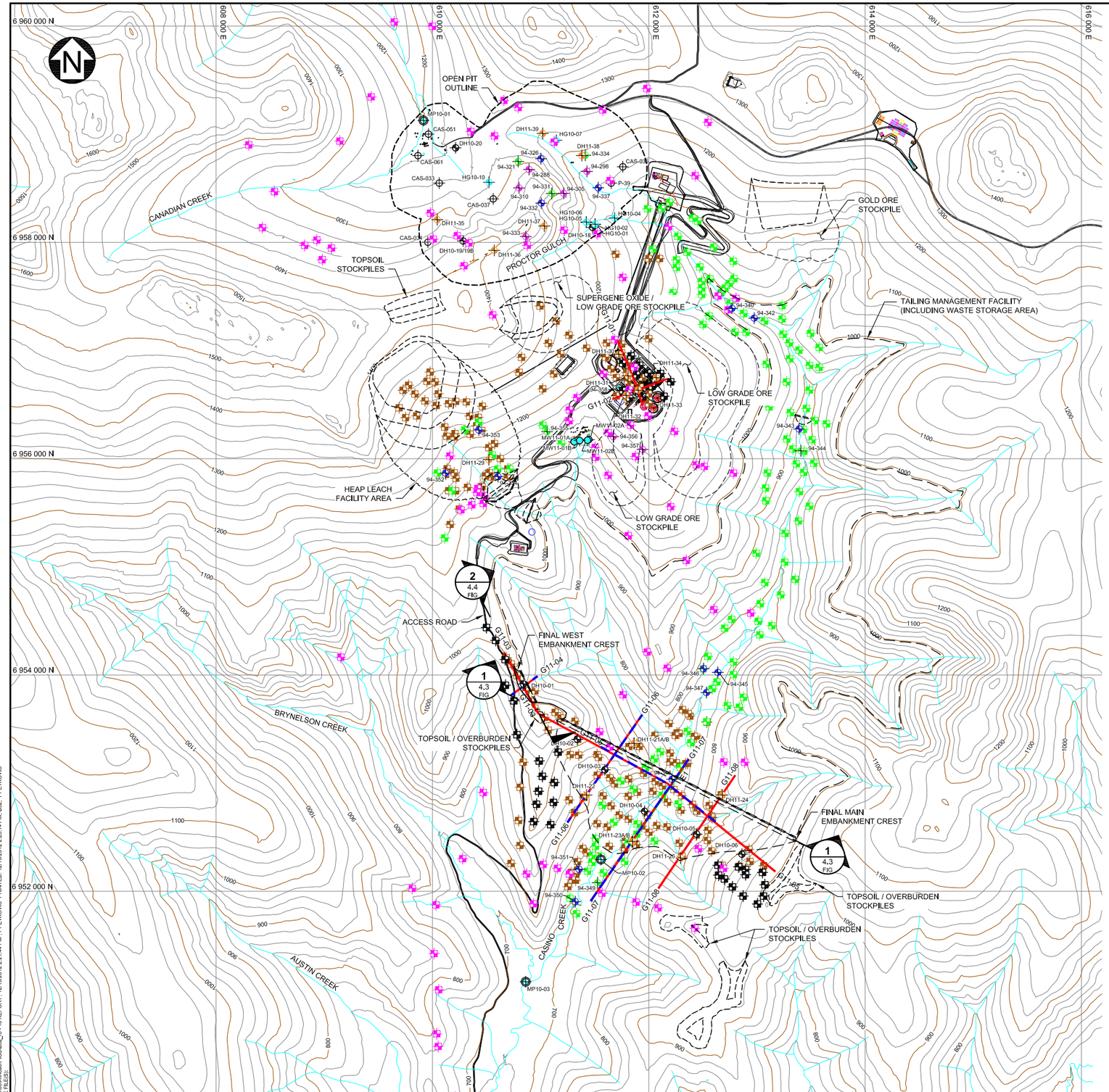
The site investigations conducted in the area of the proposed TMF site included the following:

- Preliminary surficial geotechnical investigations were carried out in 1993 at the Casino project area. The investigations were carried out as part of the Placer Lease Agreement Program to provide a preliminary overview of the surficial materials and foundation conditions for the various potential mine-site components, including the Open Pit, Plant site, Heap Leach Pad, Waste Rock Storage and Tailings Impoundment sites. The exposed surficial materials were described and characterized, and representative samples were selected for laboratory testing. The laboratory testwork was carried out on site by KPL and included particle size analyses, natural moisture contents, Atterberg limits (plasticity), compaction tests and permeability tests. The results of the investigations are included in KPL report “Report on Preliminary Surficial Geotechnical Investigations” (Ref. No. 1831/1, March, 1994).
- Eleven drillholes were completed in 1994 near the proposed TMF embankment and impoundment areas. Groundwater monitoring wells were installed in nine of these drillholes, and thermistors were installed in two other holes. In situ packer, falling head permeability tests, and shut-in pressure tests were conducted within the drillholes. The investigation program also included the excavation of test pits for visual inspection and characterization of surficial materials. Representative test pit samples were collected for laboratory testing. The laboratory testwork included particle size analyses, natural moisture contents, Atterberg limits and compaction tests. The results of the investigations are included in KPL report “Data Compilation Report on 1994 Geotechnical and Hydrogeotechnical Investigations” (Ref. No. 1832/2, February 22, 1995).
- The 2010 Site Investigation program included six geotechnical drillholes, all near the crest of the proposed TMF Main Embankment. In situ packer and falling head permeability tests were conducted within the drillholes and piezometers. A test pit investigation was performed around the TMF embankment area to determine the suitability and availability of potential embankment construction materials. Representative test pit samples were collected for laboratory test work. The soil samples were subjected to particle size analysis, natural moisture content, Atterberg limit, specific gravity, flexible wall permeability, triaxial shear and compaction tests. Additionally, AECOM installed mini piezometer MP-02 downstream of the proposed TMF and a water level logger in drillhole 94-352 at the HLF area. The results of the investigations performed by KPL are included in KPL report “2010 Geotechnical Site Investigation Data Report” (Ref. No. VA101-325/3-4, November 2, 2010). The hydrogeological investigations by AECOM are summarized in

the report “Casino Project – Hydrogeological Technical Report – DRAFT” (Ref. No. 60146995-9, March 2011).

- A total of seven KPL geotechnical drillholes were completed in 2011 in the TMF area. Standpipe piezometers were installed in five of these drillholes, and thermistors were installed in two other holes. In situ packer and falling head permeability tests were conducted within the drillholes, as well as Standard Penetration Tests (SPT). More than 100 test pits were excavated for visual inspection and characterization of surficial materials. Laboratory testing on representative samples included particle size analyses, natural moisture content, organic content, Atterberg limit, specific gravity, flexible wall permeability, and compaction tests. Geophysical investigations comprised seismic refraction surveys along six sections, Ground Penetrating Radar (GPR) surveys along five sections, and an EM31 conductivity survey along one section across the TMF area. The results of the investigations are included in KPL report “2011 Geotechnical Site Investigation Data Report - Waste Management Facilities” (Ref. No. VA101-325/8-5, December 2012).
- Three drillholes were drilled in the TMF area during the 2012 site investigations. Thermistors were installed in all three drillholes. The investigation program also included the excavation of test pits for visual inspection and characterization of surficial materials, and to obtain representative test pit samples for laboratory testing. The laboratory testwork included particle size analyses, natural moisture content, organic content, soluble salts, Atterberg limit, flexible wall permeability, and compaction tests. The results of the investigations are included in KPL report “2012 Geotechnical Site Investigation Data Report” (Ref. No. VA101-325/8-14, December 2012).

Geological sections have been prepared with the site investigation results along the embankment crest. Figure 4.1 shows the locations of drillholes, test pits and geophysical survey lines from previous site investigations, and includes the locations of the geological sections. The site investigation plan for the 2012 site investigation is shown on Figure 4.2, and includes the outline of the colluvial apron under the embankment footprint. The geological section along the Main Embankment is shown on Figure 4.3 and the section along the West Saddle Embankment on Figure 4.4.



LEGEND:

- DH11-30 — 2011 GEOTECHNICAL DRILLHOLE
- MW11-01A — 2011 MONITORING WELL
- MP10-01 — MINI PIEZOMETER
- HG10-01 — 2010 HYDROGEOLOGICAL DRILLHOLE
- DH10-01 — 2010 GEOTECHNICAL DRILLHOLE
- CAS-033 — EXPLORATION DRILLHOLE WITH PIEZOMETER OR THERMISTOR
- 94-305 — 1994 GEOTECHNICAL DRILLHOLE
- 94-344 — 1994 GEOTECHNICAL DRILLHOLE WITH THERMISTOR
- 94-350 — 1994 GEOTECHNICAL DRILLHOLE WITH 50 mm DIA. WELL
- 2011 TEST PIT LOCATION
- 2010 TEST PIT LOCATION
- 1994 TEST PIT LOCATION
- 1993 TEST TRENCH LOCATION
- 2011 SEISMIC REFRACTION LINE
- 2011 GROUND PENETRATING RADAR (GPR) LINE
- 2011 EM31 LINE

NOTES:

1. COORDINATE GRID IS UTM (WGS84/NAD83) ZONE 7 (m).
2. CONTOUR INTERVAL IS 25 METRES.
3. DIMENSIONS ARE IN METRES UNLESS NOTED.
4. OPEN PIT IS SHOWN AT ITS FINAL OUTLINE AS PROVIDED BY CASINO MINING CORPORATION (NOVEMBER 2012).
5. PLANT SITE AND CRUSHER LAYOUT PROVIDED BY M3 ENGINEERING AND TECHNOLOGY CORPORATION (OCTOBER 4, 2012).
6. HEAP LEACH PAD IS SHOWN AT ITS MAXIMUM SIZE.
7. ORE AND TOPSOIL STOCKPILES ARE SHOWN AT THEIR MAXIMUM SIZE DURING OPERATIONS.
8. TEST PITS ID'S ARE NOT SHOWN ON FIGURE TO IMPROVE CLARITY

SCALE A: 400 200 0 400 800 1200 1600 2000 m

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	19DEC'12	ISSUED WITH REPORT	SB	DP/PP	LM	KJB

CASINO MINING CORPORATION

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PREVIOUS SITE INVESTIGATIONS

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FIGURE 4.1 | REV 0

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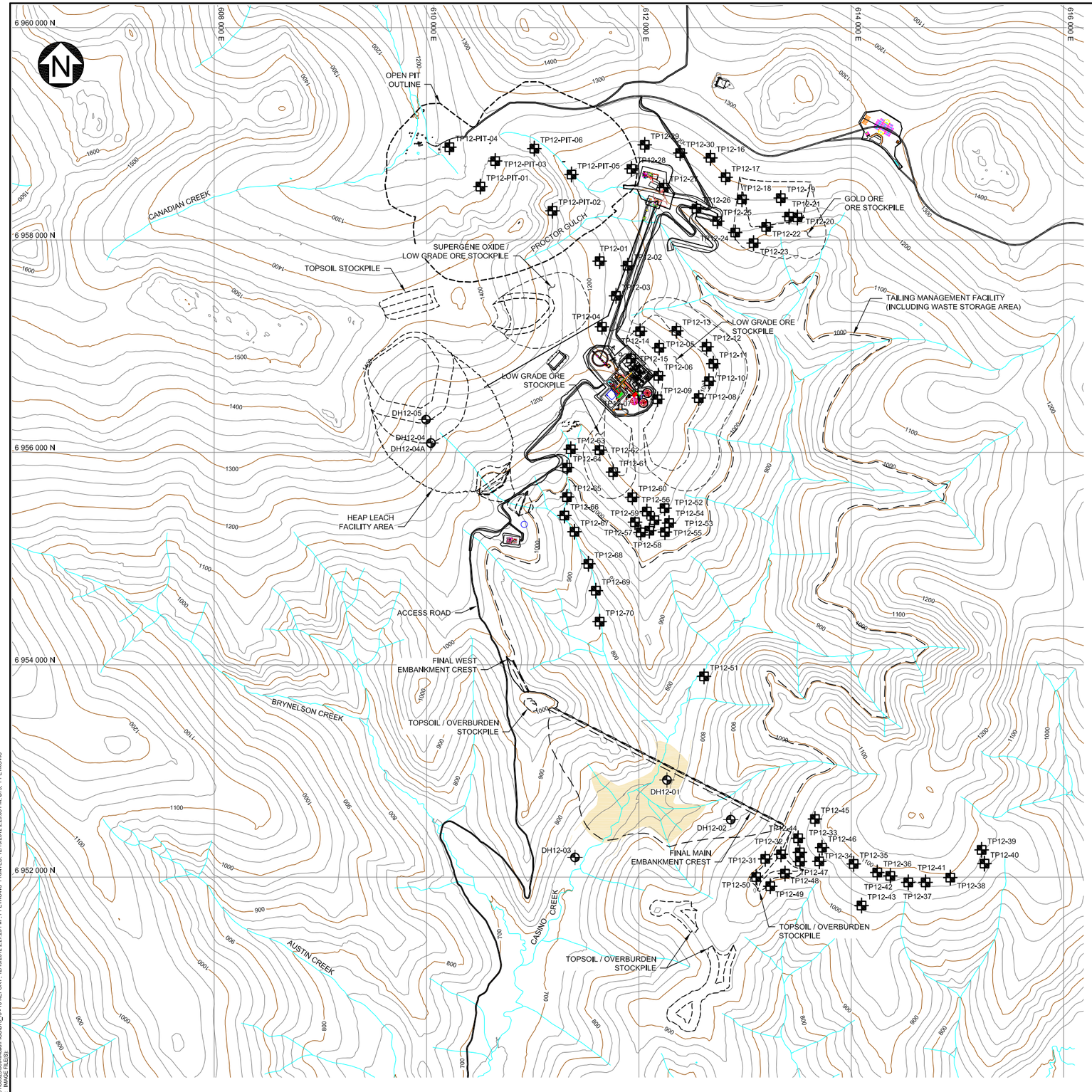

LEGEND:

DH12-01 2012 GEOTECHNICAL DRILLHOLE

TP12-39 2012 TEST PIT

APPROXIMATE EXTENT OF COLLUVIAL APRON

NOTES:

1. COORDINATE GRID IS UTM (WGS84/NAD83) ZONE 7 (m).
2. CONTOUR INTERVAL IS 25 METRES.
3. DIMENSIONS ARE IN METRES UNLESS NOTED.
4. OPEN PIT IS SHOWN AT ITS FINAL OUTLINE AS PROVIDED BY CASINO MINING CORPORATION (NOVEMBER 2012).
5. PLANT SITE AND CRUSHER LAYOUT PROVIDED BY M3 ENGINEERING AND TECHNOLOGY CORPORATION (OCTOBER 4, 2012).
6. HEAP LEACH PAD IS SHOWN AT ITS MAXIMUM SIZE.
7. ORE AND TOPSOIL STOCKPILES ARE SHOWN AT THEIR MAXIMUM SIZE DURING OPERATIONS.

SCALE A 400 200 0 400 800 1200 1600 2000 m

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

2012 SITE INVESTIGATION

Knight Piésold CONSULTING

P/A NO.	REF NO.
VA101-325/8	10

FIGURE 4.2 REV 0

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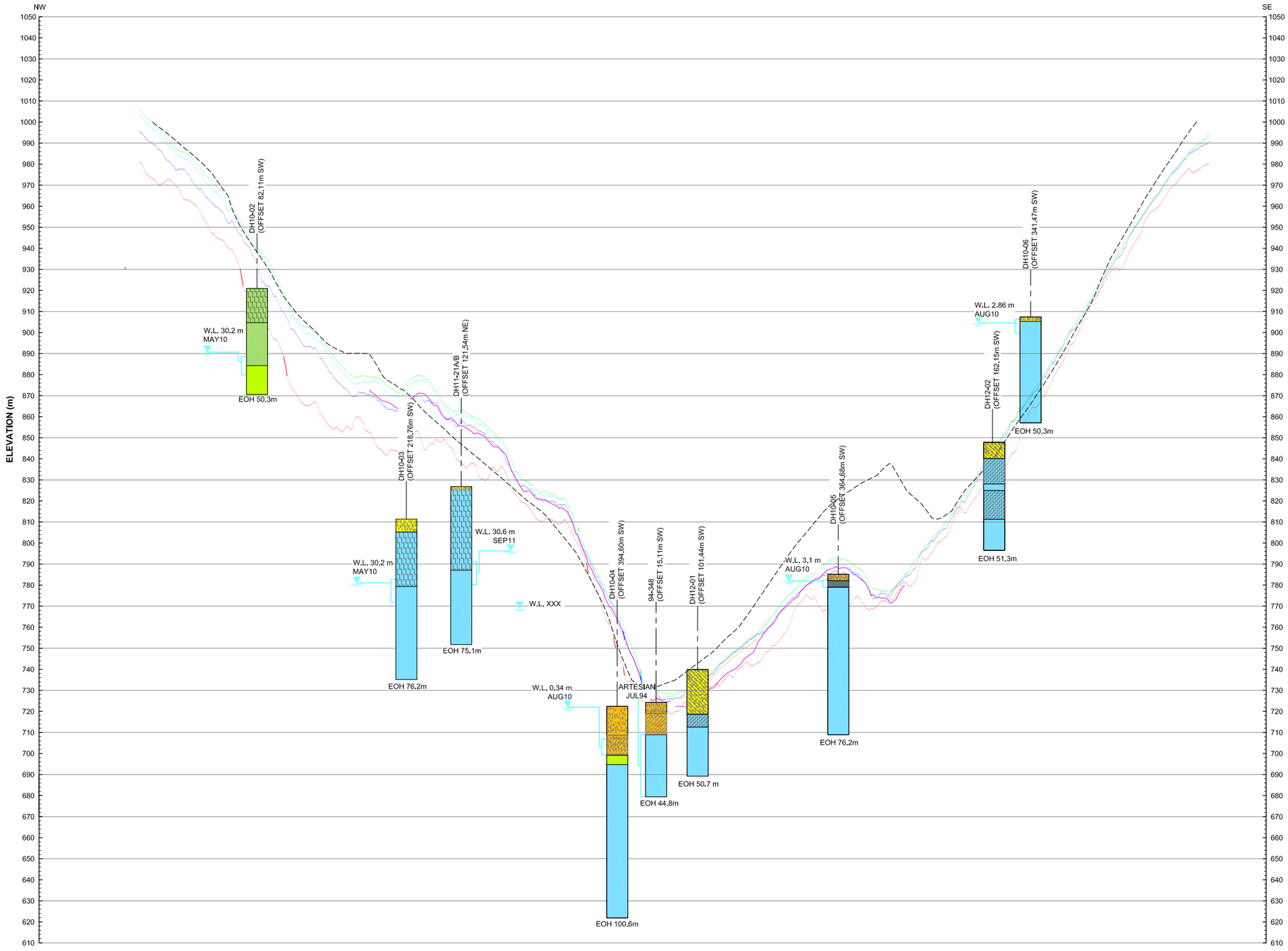

LEGEND:

- WEATHERED YMQT
- YUKON METAMORPHIC COMPLEX - QUARTZITE (YMQT)
- YUKON METAMORPHIC COMPLEX - GNEISS (YMGN)
- WEATHERED WRGD
- DAWSON RANGE BATHOLITH - GRANODIORITE (WRGD)
- COLLUVIAL VENEER
- COLLUVIAL VENEER FROZEN
- COLLUVIAL APRON
- COLLUVIAL APRON FROZEN
- GROUND SURFACE ALONG GEOPHYSICS LINE
- SEISMIC SURFICIAL LAYER
- SEISMIC INTERMEDIATE LAYER
- SEISMIC BASAL LAYER
- GPR REFLECTOR
- GPR ICE BOTTOM REFLECTOR
- GROUND SURFACE

NOTES:

LOCATION OF DRILLHOLES DH12-01 AND DH12-02 PRESENTED ON FIGURE 4.2.

SCALE B: 20 10 0 20 40 60 80 100 m

SCALE A: 100 50 0 100 200 300 400 500 m

1 / 4.1 FIG **SECTION**
HORIZONTAL: SCALE A
VERTICAL: SCALE B

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CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

TAILING MANAGEMENT FACILITY
GEOLOGICAL SECTION
MAIN EMBANKMENT

Knight Piésold CONSULTING

P/A NO. VA101-325/8 | REF NO. 10

FIGURE 4.3 | REV 0

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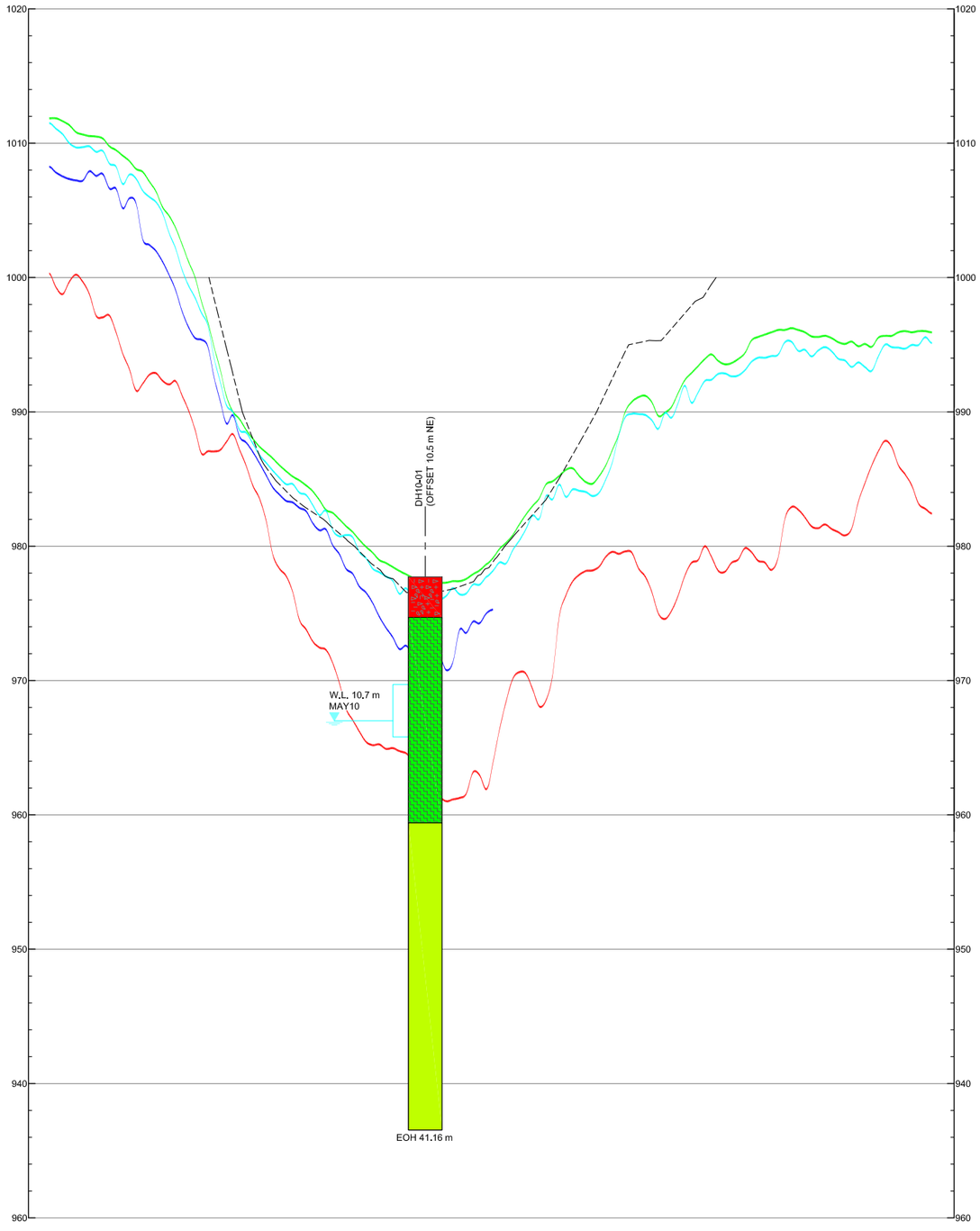

2
4.1
FIG

SECTION
HORIZONTAL: SCALE A
VERTICAL: SCALE B

LEGEND:

- RESIDUAL SOIL
- WEATHERED YMGN
- YUKON METAMORPHIC COMPLEX - GNEISS (YMGN)
- GROUND SURFACE ALONG GEOPHYSICS LINE
- SEISMIC SURFICIAL LAYER
- SEISMIC INTERMEDIATE LAYER
- SEISMIC BASAL LAYER
- GROUND SURFACE

PROGRESS PRINT
DEC. 19, 2012 (2:36 PM)

SCALE B 4 2 0 4 8 12 16 20 m

SCALE A 40 20 0 40 80 120 160 200 m

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

TAILING MANAGEMENT FACILITY
GEOLOGICAL SECTION
WEST SADDLE EMBANKMENT

Knight Piésold CONSULTING

P/A NO.	REF NO.
VA101-325/08	10

FIGURE 4.4 REV 0

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4.2 EMBANKMENT FOUNDATION

4.2.1 General

This section discusses in detail the geotechnical conditions encountered throughout the embankment area of the TMF in previous site investigation programs. Permafrost considerations and foundation preparation requirements are also discussed.

4.2.2 Geotechnical Conditions

Overburden

The results from site investigations show that overburden is generally shallow along the ridges and upper slopes of Casino Creek valley. The overburden depth in this area varies from 0.5 to 7.5 m, with an average thickness between 2 and 3 m. The overburden consists of residual soil and colluvial veneer, overlain by approximately 0.3 m of silty, mossy topsoil.

Residual soils are mainly present along ridges at higher elevations and along the upper parts of slopes. The residual soil is generally comprised of loose to compact silty sand and gravel with some cobbles and trace clay. The material is derived from in situ weathering of host bedrock. Weathering is dominated by frost action rather than chemical weathering, and as a result little clay is present. The material is locally silt-rich due to windblown loess enrichment. The residual soils coarsen with depth to fractured rock as the influence of frost action decreases.

The ridges and upper slopes are characterized by well drained colluvial and residual sandy soils, supporting stands of tall spruce and poplar. The colluvial veneer is locally overlying residual soils near the top of the slopes. The colluvial soils have been transported down-slope by gravity, causing variations in composition and intermixing of organic material. The colluvium is relatively thin along the upper part of particularly south facing slopes, and generally absent on ridges where residual soils predominate.

The colluvial veneer along the slopes of Casino Creek valley is comprised of a fine to medium grained sand with some silt, supporting coarse gravel and cobble sized broken rock fragments. The thickness and organic content generally increase down-slope. On north-facing slopes, the colluvial veneer is mostly frozen.

The depth to bedrock is considerably larger near the valley bottom, where slopes are gentler. The overburden thickness in the Casino Creek valley bottom varies from approximately 2 to 23 m. This material is classified as colluvial apron, which has a higher fines and organic content than the colluvial veneer. The colluvial apron is mostly frozen, with excess ice and massive ice layers, as recovered in DH11-23A. The colluvial apron is underlain by alluvium close to Casino Creek. The alluvium is coarse grained and comprised of interbedded sands and gravelly sands with cobbles. It is typically overlain by frozen, organic-rich colluvial apron, except near the creek where the alluvium is non-frozen and at surface. The alluvium is generally at surface in tributary valleys, and consists of highly saturated, ice rich, fine grained sands and clayey silts.

It is not always possible to differentiate residual soils from colluvial soils, as colluvial soils are essentially residual soils that have migrated down-slope. The gradations of residual and colluvial soils are often similar and range from sandy silt to gravel with many cobbles, depending on the

degree of weathering with depth, localized windblown silt enrichment and down-slope transportation processes.

Bedrock

Bedrock is considered "weathered" if weathering processes have considerably weakened the rock and penetrative discoloration has occurred. Geotechnical logging of drillholes revealed weathered bedrock (Granodiorite) up to 38 m thick. The average thickness of the weathered bedrock zone is approximately 17.5 m. The average RMR for weathered bedrock is approximately 40, indicating a rock mass quality of POOR to FAIR (Bieniawski, 1989).

Dawson Range Batholith Granodiorite was encountered in all 2011 and 2012 drillholes in the TMF Main Embankment area. The fresh bedrock is strong with an average unconfined compressive strength (UCS) field estimate of 70 MPa. The average RMR for fresh bedrock is approximately 60, and is considered FAIR to GOOD rock mass quality.

Drillholes from the 1994 and 2010 site investigations also indicate that Dawson Range Batholith Granodiorite is the primary lithology in the embankment area. The bedrock underlying the proposed West Embankment and the topographical knob between the West Embankment and the Main Embankment consist of Yukon Metamorphic Complex Gneiss and Quartzite. These lithologies were also encountered in the 2011 test pits near the proposed West Embankment. The 1994 drillholes that were drilled in the TMF impoundment area indicate the presence of Dawson Range Batholith Granodiorite, Yukon Metamorphic Complex Gneiss and Patton Porphyry.

Two narrow zones of low velocity within the competent bedrock were encountered in the seismic refraction data at chainage 40 NE on line G11-08 (on the east abutment of the Main Embankment) and at chainage 600 NE on line G11-06 (near drillhole DH10-03 on the west abutment). These low velocities are consistent with zones of highly fractured and weathered granodiorite, and likely indicate shear or fault zones in the bedrock. Confirmation and detailed mapping of these fault zones will require additional investigations.

4.2.3 Permafrost

Permafrost is discontinuous over the TMF embankment area, and is primarily present at the valley bottom, north-facing slopes and shaded areas. The ridges at higher elevations and upper slopes on the west abutment are southeast-facing, and are generally free of permafrost except for some local shaded areas.

Permafrost is common in the northwest-facing east abutment area, where test pits were terminated at shallow depths in frozen colluvium and residual soils. Permafrost occurs here as thin ice lenses in fine grained soils and as small ice wedges in broken rock.

Permafrost is abundant in the organic, silty colluvial apron of the Casino Creek and tributary valley bottoms. The overburden is generally saturated and frozen in these areas, with high ice contents. Massive ice layers were encountered in the colluvial apron in DH11-23A. The massive ice was also identified in the GPR data in more than half of the survey line length along the valley bottom. The GPR data also indicated ground ice close to tributaries leading to Casino Creek.

Alluvium lies at surface in very close proximity to Casino Creek, where it is not frozen due to the presence of a talik (permanently unfrozen ground). Permafrost is also absent in localized areas

along Casino valley as indicated by the presence of tall grasses and willows, and the absence of thick mosses. These areas are discontinuous and likely result from the historic shifting of the creek channel which acts to maintain a thawed region under the creek.

Thawing of ice-rich soils may lead to excessive settlements, and loss of strength. The ice-rich soils typically exhibit very low strengths when thawed, and flow even under very flat slopes. Two gelifluction lobes that were observed within the colluvial apron in the TMF embankment area are evidence of this potential for instability. Ice-rich soils also have the potential for long term creep displacements.

Disturbance or removal of the vegetative cover may result in the melting of permafrost and the development of unstable conditions. Frozen overburden and bedrock that are underlying part of the tailings impoundment and embankments are expected to thaw over time, as the tailings and water stored in the TMF will act as a heat source. It is therefore recommended that all ice-rich overburden encountered during construction be removed along the entire foundation of the TMF embankments. Ground ice is not expected to be significant in bedrock which will likely provide a stable foundation for the embankments. Preferential seepage paths may develop when ice filled discontinuities thaw. Bedrock may have to be steamed and grouted if this is the case.

Thermistors were installed during the 2011 and 2012 site investigations to provide a better understanding of the thermal regime in the bedrock. Additional site investigations will be required to confirm the characteristics of the overburden and bedrock, and the extent of permafrost within the TMF embankment area. Thermal modelling may also be required to predict the effect of the proposed TMF on foundation conditions.

4.2.4 Foundation Preparation

Foundation preparation for the TMF embankments will involve the stripping of topsoil and vegetation and the removal of all talus boulders. The topsoil will be stockpiled for reclamation purposes. The underlying frozen soils will be excavated down to a competent, stable bedrock or non-frost susceptible overburden foundation. Ice-rich and frost-susceptible materials will be removed to spoil and are expected to be unsuitable for use as borrow in embankment construction. The quantity of spoil will be significant and may require special measures such as dams or berms to provide containment of the thaw-saturated materials. The ice-rich spoil material will be placed in the TMF impoundment to satisfy this requirement.

The embankment footprint area that covers colluvial apron or other ice-rich overburden will be excavated to competent foundation, absent of frost susceptible soil. The removed material will be replaced with core, filter or shell zone material, depending on the location relative to the embankment. The average thickness of the colluvial apron is expected to be approximately 10 metres based on the findings of the site investigations.

A low permeability cut-off is required beneath the core zone of the Main Embankment and West Saddle Embankment at locations where no colluvial apron or other ice rich soil is present, to provide an effective seepage control barrier. The seepage cut-off trench will extend through the foundation soils and key into competent bedrock, at an average depth of about three meters for both the Main and West Embankment.

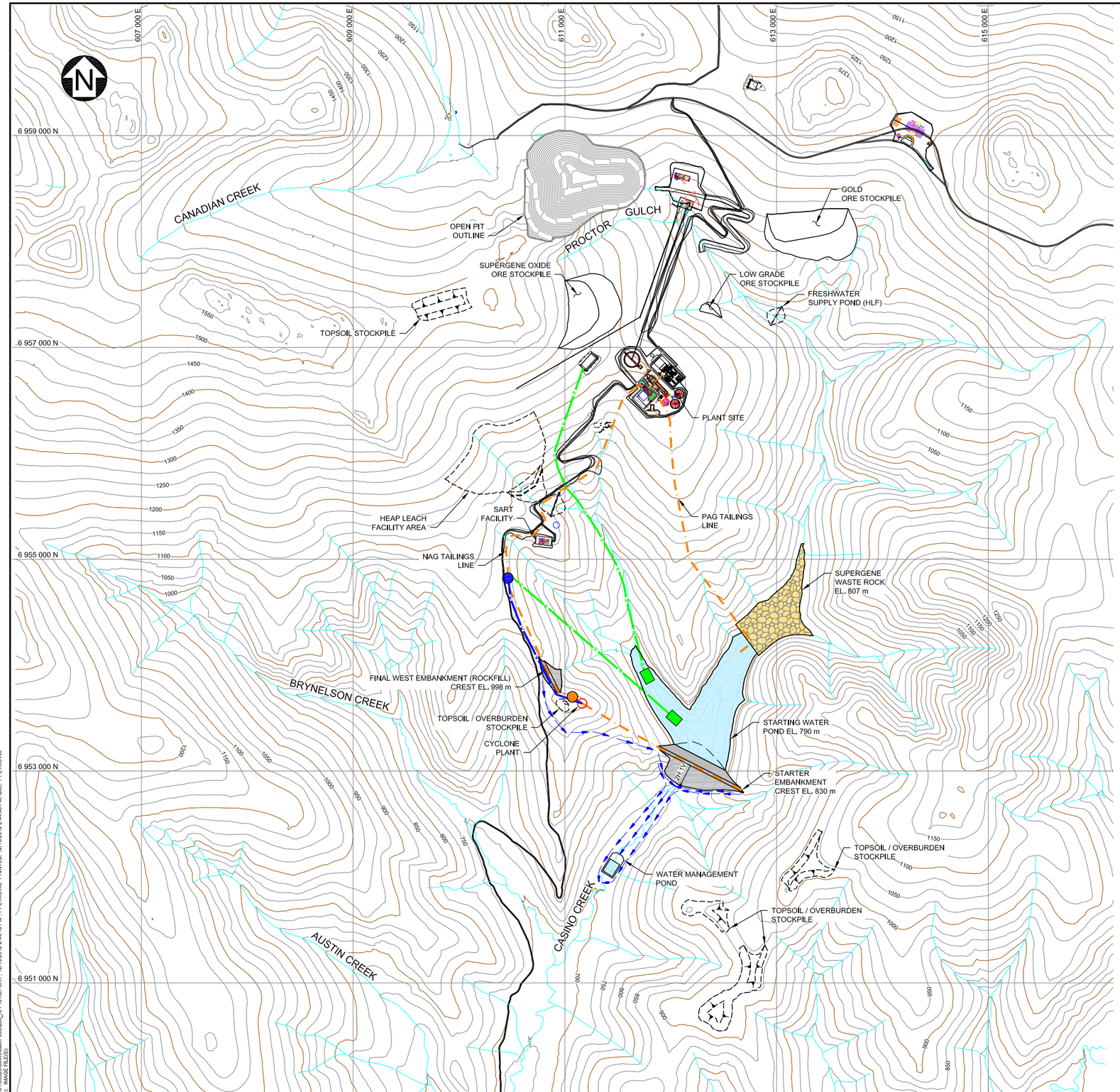
5 – TAILINGS MANAGEMENT FACILITY DESIGN

5.1 GENERAL

The principal objectives of the Feasibility design for the Tailings Management Facility (TMF) are to ensure protection of the regional groundwater and surface waters both during operations and in the long-term (post-closure), and to achieve effective reclamation at mine closure. The Feasibility design of the TMF has taken into account the following requirements:

- Permanent, secure and total confinement of all solid waste materials within an engineered disposal facility.
- Control, collection and removal of free draining liquids from the tailings during operations for recycling as process water to the maximum practical extent.
- The use of cyclones to generate clean sand, from the bulk Non-Acid Generating (NAG) tailings, for embankment construction.
- The inclusion of monitoring features for all aspects of the facility to ensure performance goals are achieved and design criteria and assumptions are met.
- Staged development of the facility over the life of the project.

The overall project general arrangement of the TMF is shown on Figure 1.2. General arrangements illustrating the development at the end of pre-production (Year -1), at interim stages (Years 1, 4 and 10), and the final arrangement (Year 22) are shown on Figures 5.1 to 5.5, respectively. Typical sections showing the development of the TMF and WSA during mine operations (Years 1, 4, 10 and 22) are provided on Figure 5.6.



NOTES:

1. COORDINATE GRID IS UTM (WGS84/NAD83) ZONE 7 (m).
2. CONTOUR INTERVAL IS 25 METRES.
3. DIMENSIONS ARE IN METRES UNLESS NOTED.
4. OPEN PIT AS PROVIDED BY CASINO MINING CORPORATION (NOVEMBER 2012).
5. PLANT SITE AND CRUSHER LAYOUT PROVIDED BY M3 ENGINEERING AND TECHNOLOGY CORPORATION (OCTOBER 4, 2012).
6. TOPSOIL / OVERBURDEN STOCKPILES ARE SHOWN AT THEIR MAXIMUM SIZE.

LEGEND:

- WASTE ROCK
- EMBANKMENT (ROCKFILL)
- POND
- TAILINGS PIPELINES
- RECLAIM PIPELINES
- WATER PIPELINES
- TAILINGS HEAD TANK
- DILUTION WATER HEAD TANK
- CYCLONE PLANT
- DIVERSION DITCHES

SCALE A: 400 200 0 400 800 1200 1600 2000 m

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CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

TAILINGS MANAGEMENT FACILITY GENERAL ARRANGEMENT STARTER (PRE-PRODUCTION)

Knight Piésold CONSULTING

P/A NO. VA101-325/8

REF NO. 10

FIGURE 5.1

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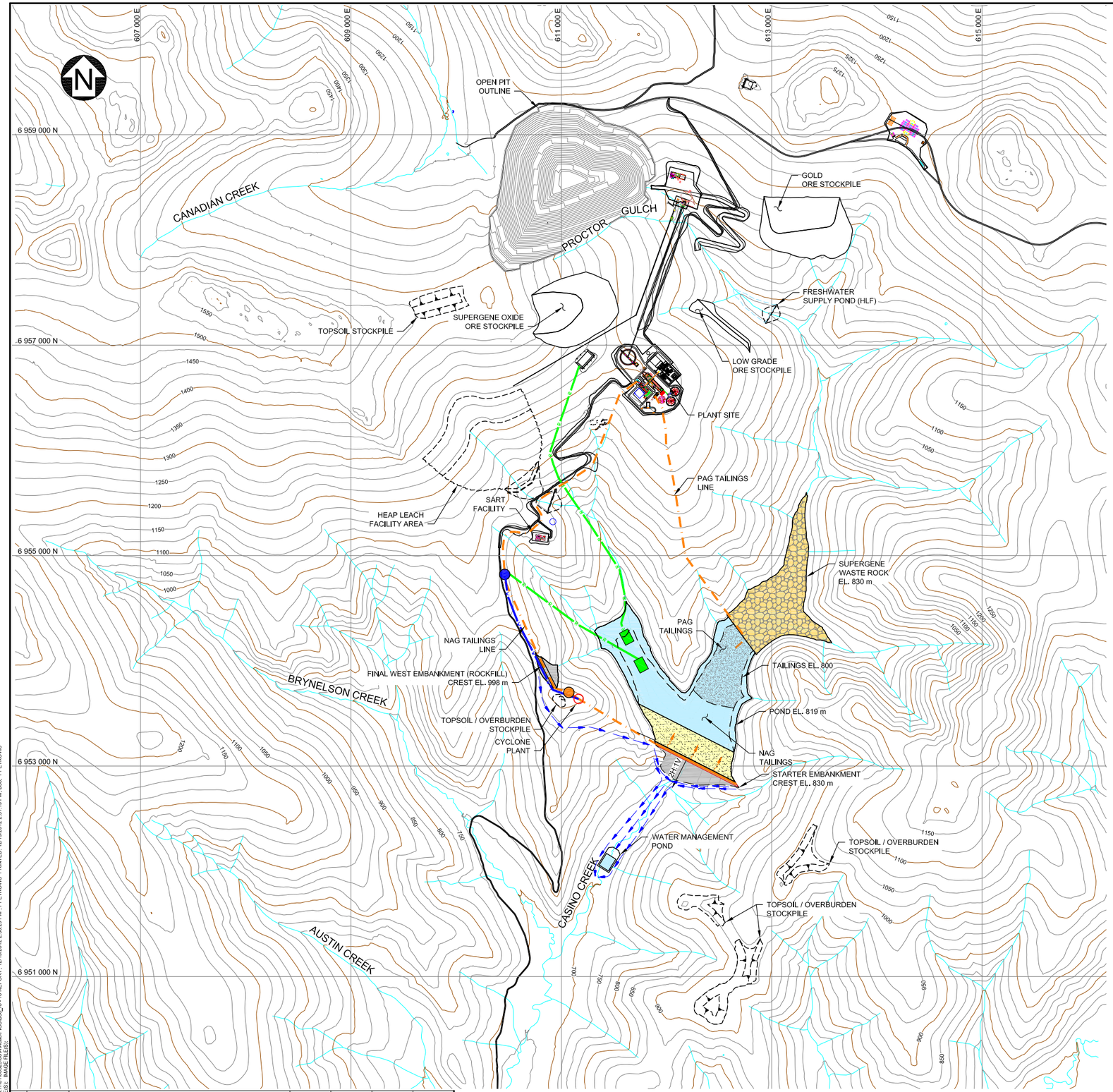

NOTES:

1. COORDINATE GRID IS UTM (WGS84/NAD83) ZONE 7 (m).
2. CONTOUR INTERVAL IS 25 METRES.
3. DIMENSIONS ARE IN METRES UNLESS NOTED.
4. EXCESS CYCLONE SAND THAT WILL BE DEPOSITED AT EMBANKMENT TOE IS NOT SHOWN ON DRAWING.
5. OPEN PIT AS PROVIDED BY CASINO MINING CORPORATION (NOVEMBER 2012).
6. PLANT SITE AND CRUSHER LAYOUT PROVIDED BY M3 ENGINEERING AND TECHNOLOGY CORPORATION (OCTOBER 4, 2012).
7. TOPSOIL / OVERBURDEN STOCKPILES ARE SHOWN AT THEIR MAXIMUM SIZE.

LEGEND:

- WASTE ROCK
- TAILINGS
- EMBANKMENT (ROCKFILL)
- POND
- TAILINGS PIPELINES
- RECLAIM PIPELINES
- WATER PIPELINES
- TAILINGS HEAD TANK
- DILUTION WATER HEAD TANK
- CYCLONE PLANT
- DIVERSION DITCHES

SCALE A 400 200 0 400 800 1200 1600 2000 m

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CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

TAILINGS MANAGEMENT FACILITY GENERAL ARRANGEMENT YEAR 1

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P/A NO. VA101-325/8 | REF NO. 10

FIGURE 5.2 | REV 0

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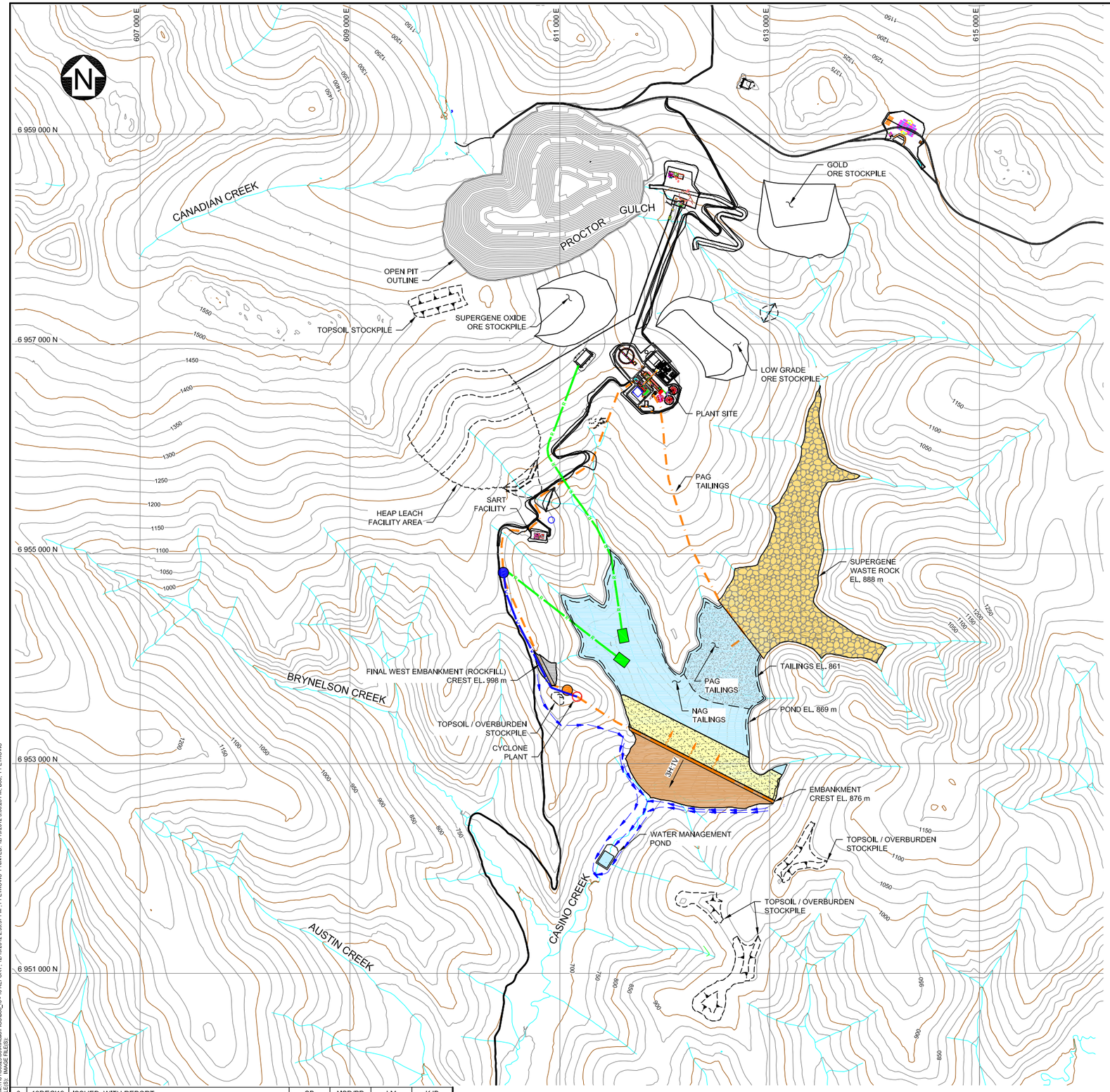

NOTES:

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5. OPEN PIT AS PROVIDED BY CASINO MINING CORPORATION (NOVEMBER 2012).
6. PLANT SITE AND CRUSHER LAYOUT PROVIDED BY M3 ENGINEERING AND TECHNOLOGY CORPORATION (OCTOBER 4, 2012).
7. TOPSOIL / OVERBURDEN STOCKPILES ARE SHOWN AT THEIR MAXIMUM SIZE.

LEGEND:

- WASTE ROCK
- TAILINGS
- EMBANKMENT (CYCLONE SAND)
- EMBANKMENT (ROCKFILL)
- POND
- TAILINGS PIPELINES
- RECLAIM PIPELINES
- WATER PIPELINES
- TAILINGS HEAD TANK
- DILUTION WATER HEAD TANK
- CYCLONE PLANT
- DIVERSION DITCHES

SCALE A 400 200 0 400 800 1200 1600 2000 m

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

TAILINGS MANAGEMENT FACILITY GENERAL ARRANGEMENT INTERIM (YEAR 4)

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VA101-325/8	10

FIGURE 5.3 REV 0

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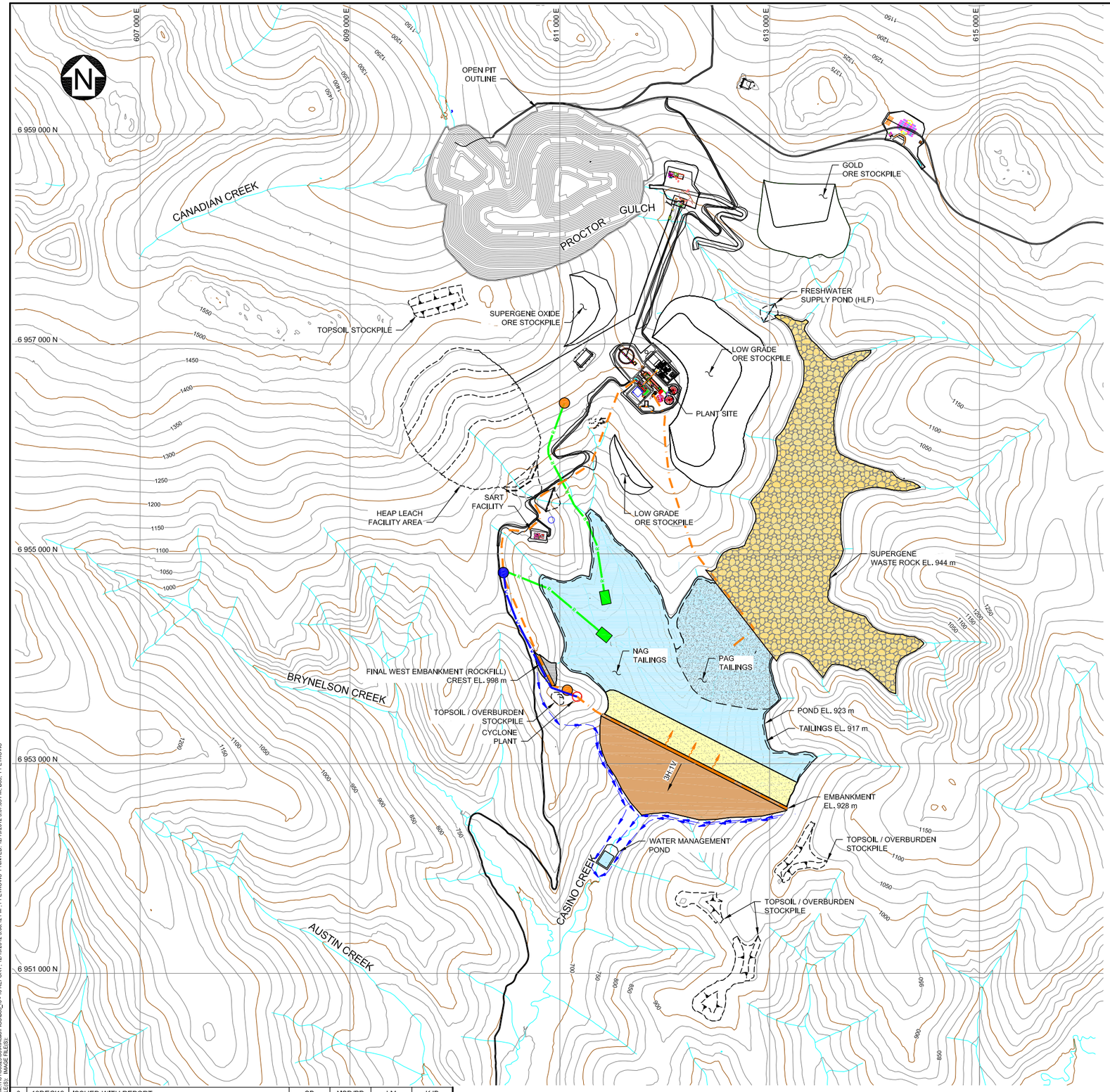

NOTES:

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6. PLANT SITE AND CRUSHER LAYOUT PROVIDED BY M3 ENGINEERING AND TECHNOLOGY CORPORATION (OCTOBER 4, 2012).
7. TOPSOIL / OVERBURDEN STOCKPILES ARE SHOWN AT THEIR MAXIMUM SIZE.

LEGEND:

- WASTE ROCK
- TAILINGS
- EMBANKMENT (CYCLONE SAND)
- EMBANKMENT (ROCKFILL)
- POND
- TAILINGS PIPELINES
- RECLAIM PIPELINES
- WATER PIPELINES
- TAILINGS HEAD TANK
- DILUTION WATER HEAD TANK
- CYCLONE PLANT
- DIVERSION DITCHES

SCALE A 400 200 0 400 800 1200 1600 2000 m

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

TAILINGS MANAGEMENT FACILITY GENERAL ARRANGEMENT INTERIM (YEAR 10)

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FIGURE 5.4 REV 0

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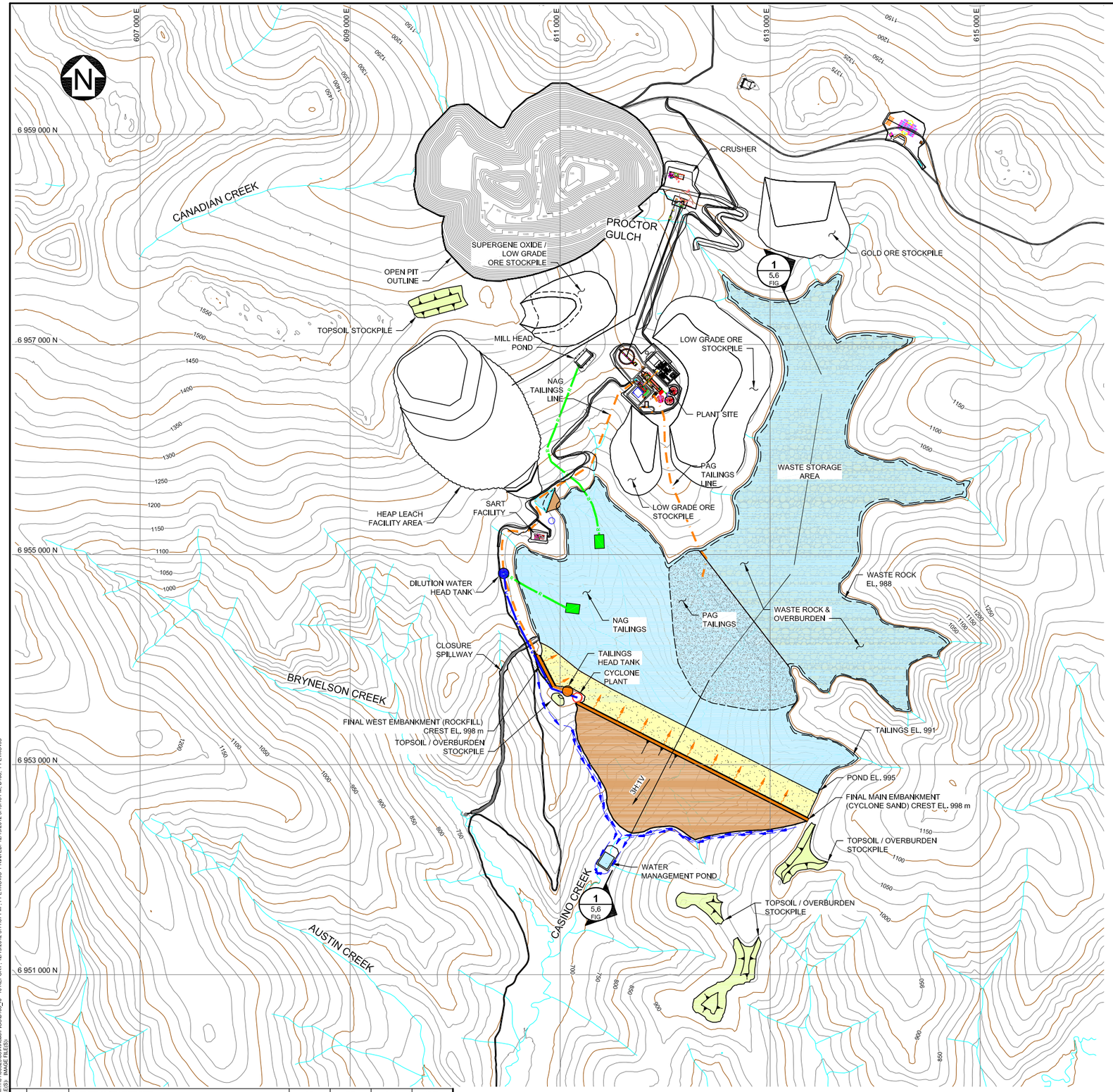

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5. PLANT SITE AND CRUSHER LAYOUT PROVIDED BY M3 ENGINEERING AND TECHNOLOGY CORPORATION (OCTOBER 4, 2012).
6. ORE AND TOPSOIL STOCKPILES ARE SHOWN AT THEIR MAXIMUM SIZE DURING OPERATIONS.

LEGEND:

- TOPSOIL / OVERBURDEN
- TAILINGS
- EMBANKMENT (CYCLONE SAND)
- EMBANKMENT (ROCKFILL)
- POND
- TAILINGS PIPELINES
- RECLAIM PIPELINES
- WATER PIPELINES
- TAILINGS HEAD TANK
- DILUTION WATER HEAD TANK
- CYCLONE PLANT
- DIVERSION DITCHES

SCALE A: 400 200 0 400 800 1200 1600 2000 m

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
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CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

TAILINGS MANAGEMENT FACILITY GENERAL ARRANGEMENT FINAL (YEAR 22)

Knight Piésold CONSULTING

P/A NO. VA101-325/8 | REF NO. 10

FIGURE 5.5 | REV 0

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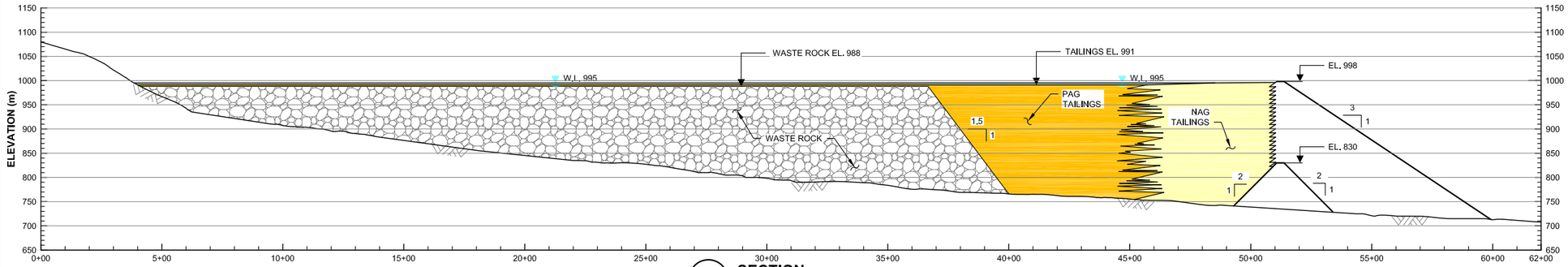
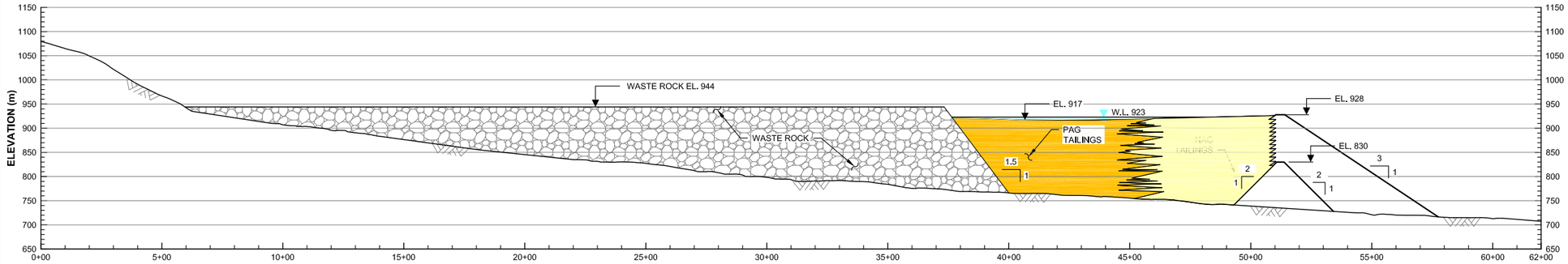
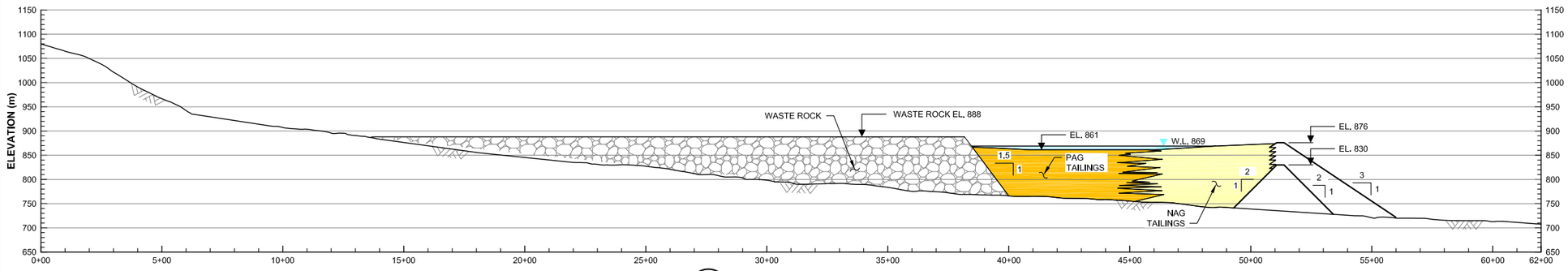


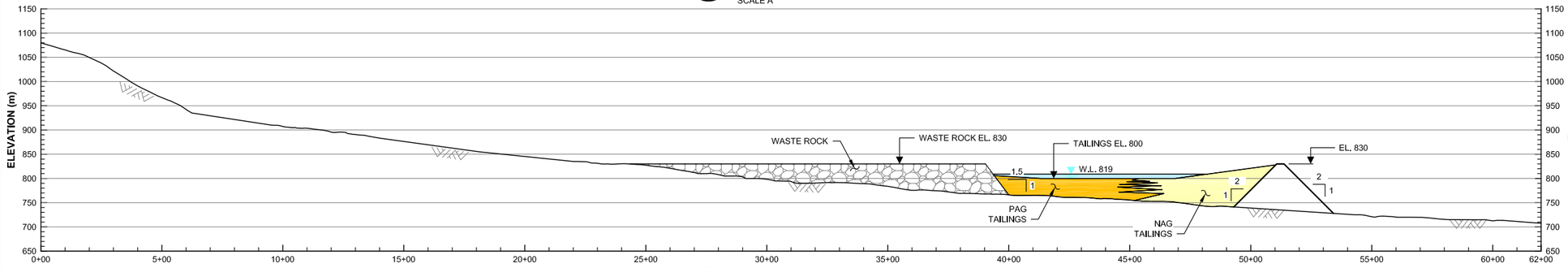
1 5.5 FIG **SECTION**
YEAR 22
SCALE A



1 5.5 FIG **SECTION**
YEAR 10
SCALE A



1 5.5 FIG **SECTION**
YEAR 4
SCALE A



1 5.5 FIG **SECTION**
YEAR 1
SCALE A

NOTES:

1. DIMENSIONS ARE IN METRES UNLESS NOTED.

VERT. SCALE 100 50 0 100 200 300 400 500 m

HORIZ. SCALE 200 100 0 200 400 600 800 1000 m

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

TAILINGS MANAGEMENT FACILITY
WASTE DEPOSITION STRATEGY
TYPICAL SECTIONS (YEARS 1, 4, 10 and 22)

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P/A NO.	REF NO.
VA101-325/8	10

FIGURE 5.6 REV 0

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	19DEC'12	ISSUED WITH REPORT	SB	PP	LM	KJB

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5.2 DESIGN BASIS AND ASSUMPTIONS

Mining of the open pit will yield approximately 965 million tonnes of ore (789 million tonnes of direct feed mill ore, 32 million tonnes of Supergene Oxide ore and 144 million tonnes of Low Grade ore). The mill will operate at a nominal mill throughput of approximately 125,000 tonnes per day of ore. The total estimated tonnage of tailings solids over the 22 year operating life of the mine is approximately 956 million tonnes, assuming an average one percent concentrate recovery during ore processing. Approximately 20% of the mill tailings will consist of PAG material and will be managed separately.

It is assumed that the NAG tailings (80% of the tailings total) will be passed through a cyclone station for approximately nine months of each year (on average) to produce suitable cycloned sand for embankment construction. Cyclone operations will likely not be possible for a portion of the year due to freezing temperatures in the winter. The cyclone sand plant is assumed to have 90% availability over the 9 month period. A required design criterion for the cyclone plant sand product is that the fines content (% passing a #200 sieve) must be 12% or less. The quantity of cyclone sand used in embankment construction is approximately 221 million tonnes. It is estimated that 50% of the NAG tailings can be recovered as cyclone sand when the cyclone station is operating. This amounts to approximately 7.2 to 7.5 million m^3 (12 to 12.5 million tonnes) of cyclone sand fill material produced annually, except for Years 1 and 22. For estimating cyclone sand fill requirements for embankment construction a conservative average in situ dry density of 1.65 tonne/m^3 was assumed for compacted fill. Typical values for compacted cyclone sand fill are in the range of 1.6 to 1.65 tonne/m^3.

A total of 658 million tonnes of mine waste materials will be mined from the open pit. The results of waste characterization studies completed by Others indicate that almost all of the waste rock is potentially reactive material (based on the mining schedule issued by CMC on November 1, 2012). This potentially reactive material made up of PAG and Metal Leaching (ML) waste rock and overburden will be stored subaqueously within the proposed TMF in a Waste Storage Area located in the upper (northern) region of the TMF basin.

The TMF has been sized to provide sufficient capacity to store approximately 956 Mt of tailings (including cyclone sand tailings used as embankment fill) and co-disposal of up to 658 million tonnes of potentially reactive waste rock and overburden materials. Approximately 221 million tonnes of NAG tailings will be used as cyclone sand fill for embankment construction. The remaining 735 million tonnes of tailings (544 million tonnes of bulk NAG tailings and NAG cyclone overflow, plus 191 million tonnes of PAG tailings) will report to the TMF as slurry for permanent storage.

For development of the TMF filling schedule, a tailings dry density of 1.2 t/m³ was assumed during the first three years of production, 1.3 t/m³ in Year 4 and 1.4 t/m³ for Years 5 to 22 (end of operations). These values were based on predicted average dry density values provided by tailings consolidation modelling incorporating the consolidation characteristics of the tailings (see Section 5.9). The average dry density is predicted to increase gradually to approximately 1.5 tonne/m^3 by the end of operations. However, a conservative lower value of 1.4 tonne/m^3 was adopted for determining the capacity requirements of the TMF. The depth-area-capacity relationship and filling schedule for the TMF are shown on Figures 5.7 and 5.8, respectively.

Each stage of TMF development has been sized to store tailings (based on the mine production schedule), together with potentially reactive waste rock from the open pit and a supernatant water

pond. Additional capacity is also provided for storm water storage for the inflow design flood event (see Section 5.3.1) and an allowance of two additional metres of embankment freeboard for wave run-up protection.

A summary of the design basis and operating criteria for the TMF is given in Table 5.1.

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TABLE 5.1

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

FEASIBILITY DESIGN OF THE TAILINGS MANAGEMENT FACILITY
SUMMARY OF DESIGN BASIS AND OPERATING CRITERIA

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ITEM	DESIGN CRITERIA
1.0 GENERAL	
Site Coordinates	613,000 E 6,955,000 N (WGS84/NAD83) Zone 7
Climate	• Estimated Mean Annual Precipitation = 510 mm • Estimated Effective Runoff Coefficient = 0.4 • Estimated Mean Annual Temperature = -2.9 °C at 1200 m elevation. • Average Annual Lake Evaporation = 300 mm
Hazard Classification Consequence Category	• **HIGH**, as defined by the Canadian Dam Association (CDA) "Dam Safety Guidelines" (2007)
Design Flood	• Inflow Design Flood (IDF) up to and including Year 1 = 1,000 years event for 72 hour storm duration. • Inflow Design Flood (IDF) during operations = "one third between 1,000 years and the Probable Maximum Flood (PMF) event for 72 hour storm duration" • Inflow Design Flood (IDF) for closure = Probable Maximum Flood (PMF) event for 24 hour storm duration
Seismic Design[(2)]	• Operating Basis Earthquake (OBE) = 1/500 ◦ Mean maximum firm ground acceleration = 0.08 g, Magnitude = 8.0 • Maximum Design Earthquake (MDE) = 1/2,500 ◦ Mean maximum firm ground acceleration = 0.13 g, Magnitude = 8.0
2.0 PRODUCTION	
Mine Production	• Total Ore Milled = 965.2 Million tonnes (Mt) • Nominal Throughput = Approximately 125,000 tpd • Mine Life = 22 years • Average Stripping Ratio = 0.7 (Waste:Ore) • Concentrate = 1.0 %
Tailings	• Total tailings = 955.6 Mt • Bulk tailings specific gravity = 2.70 t/m^3 • Two tailings streams (55% solids by weight) ◦ 80% Non Acid Generating (NAG) tailings (764.5 Mt) ◦ 20% Potentially Acid Generating (PAG) tailings (191.1 Mt) • Tailings stored in impoundment = 734.3 Mt • NAG tailings specific gravity = 2.7 t/m^3 • PAG tailings specific gravity = 3.0 t/m^3 • 1.2 t/m^3 - in situ average dry density for Years 1, 2 and 3 • 1.3 t/m^3 - in situ average dry density for Year 4 • 1.4 t/m^3 - in situ average dry density for Years 5 to 22
Cyclone Sand	• Cycloning of NAG tailings only. • Approximately 50% of NAG tailings solids assumed to be produced by cyclone plant as sand fill suitable for embankment construction (based on expected tailings particle size distribution). • Cyclone sand production for average 9 months per year. • Cyclone sand production begins at start of Year 1. • Cyclone plant availability is 90%, during 9 months per year. • Cyclone sand material produced = 221.3 Mt • Cyclone sand product has no more than 12% fines (silt/clay fraction) • Compacted cyclone sand average dry density = 1.65 t/m^3 • Cyclone Overflow solids content = 24% • Cyclone Underflow solids content (undiluted) = 74% • Cyclone Underflow solids content (diluted for discharge) = 65%
Mine Waste Rock and Overburden	• Total waste material = 657.9 Mt (stored in TMF impoundment) • Total Hypogene waste material produced = 241.9 Mt • Total Supergene waste material produced (overburden, leach cap, supergene sulfide and supergene oxide) = 414.7 Mt • Total Unclassified waste material produced = 1.3 Mt • Waste material produced from Pre-Production to Year 19 • Subaqueous disposal within TMF • 2.0 t/m^3 - in situ average density (estimated) • Approximately 2 Mt of non reactive waste material available during pre-production.

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TABLE 5.1

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

FEASIBILITY DESIGN OF THE TAILINGS MANAGEMENT FACILITY
SUMMARY OF DESIGN BASIS AND OPERATING CRITERIA

3.0 WATER MANAGEMENT	
Site Water Management Priorities During Operations	• Maximum recycle to mill circuit. • Collect and recycle runoff from mine affected areas including open pit, plant site, heap leach facility, ore stockpiles, and tailings management facility. • Minimum TMF pond volume of 15 Mm^3 required (3 months of process water supply). • Project water supply (design by Others)
4.1 TAILINGS FACILITY EMBANKMENTS	
Embankment Crest Width	• 30 m
Design Freeboard	• Sufficient freeboard to accommodate Inflow Design Flood above maximum supernatant pond level at each stage plus 2 m allowance for wave run-up.
Construction Schedule	• Staged centreline construction ◦ Starter Embankment for 1 year of tailings storage and waste rock storage ◦ Final Embankment for 22 years of tailings and reactive waste rock storage
Construction Materials	• Overburden and/or non-reactive waste rock from open pit and borrow sources, and cyclone sand.
Water Management System & Monitoring Measures	• Embankment keyed into native overburden foundation • Seepage collection systems include: ◦ Embankment under-drains; ◦ Surface ditching system; ◦ Water management pond; and ◦ Groundwater monitoring wells (if required).
Stability Analyses	• The minimum acceptable factors of safety based on the CDA "Dam Safety Guidelines" (2007) are as follows: ◦ During construction 1.3 ◦ Long term (post closure) 1.5 ◦ Post-earthquake (full liquefaction of tailings assumed) 1.2
4.2 TAILINGS BASIN	
Geological and Geotechnical Conditions	• Previous data reports
Surface Soil Salvage and Stockpiles	• Topsoil from embankment foundation preparation will be stockpiled for reclamation. • Low grade ore stockpiled during operations ◦ Maximum size = 143.8 Mt • Supergene Oxide ore stockpiled during operations ◦ Maximum size = 32.4 Mt • Gold Ore stockpiled during operations (to Heap Leach Facility) ◦ Maximum size = 39.4 Mt
5.0 CLOSURE REQUIREMENTS	
General	• Saturated storage of potentially reactive mine waste rock and overburden. • Concurrent reclamation of disturbed areas conducted where possible. • TMF reclamation to include for revegetation of exposed embankments. • Remove all pipeworks, pump stations and surface structures. • Decommission and reclaim all non-essential access roads and diversion ditches. • Stockpiles topsoil and overburden required for reclamation of the tailings beach and downstream slope of the TMF embankment. • Closure spillway to pass 24 hr PMF event.

\\VAN11\Prj_file\1\01\00325\08\A\Report\10 - TMF Feasibility Design Report\Rev 0\Tables\[Table 5.1 Rev 0 - TMF Design Basis.xlsx]Table 5.1

NOTES:

1. MINE SCHEDULE PROVIDED BY CASINO MINING CORPORATION (VERSION SCHED01NOV2012).
2. FOR A MEASURE OF ROBUSTNESS, ADDITIONAL STABILITY CALCULATIONS HAVE BEEN PERFORMED USING THE 1/10,000 EARTHQUAKE WITH MEAN MAXIMUM FIRM GROUND ACCELERATION OF 0.22g.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
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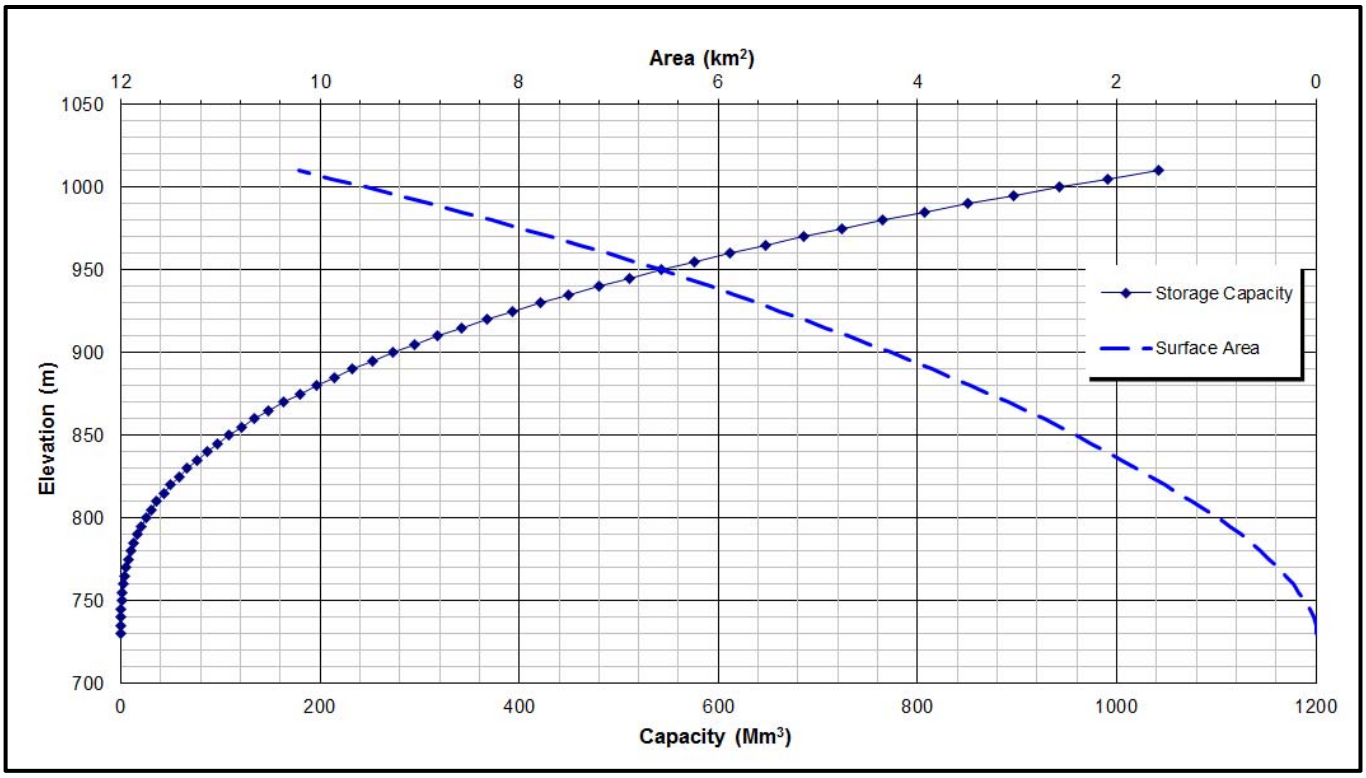

Figure 5.7 Tailings Management Facility – Depth-Area-Capacity Curves

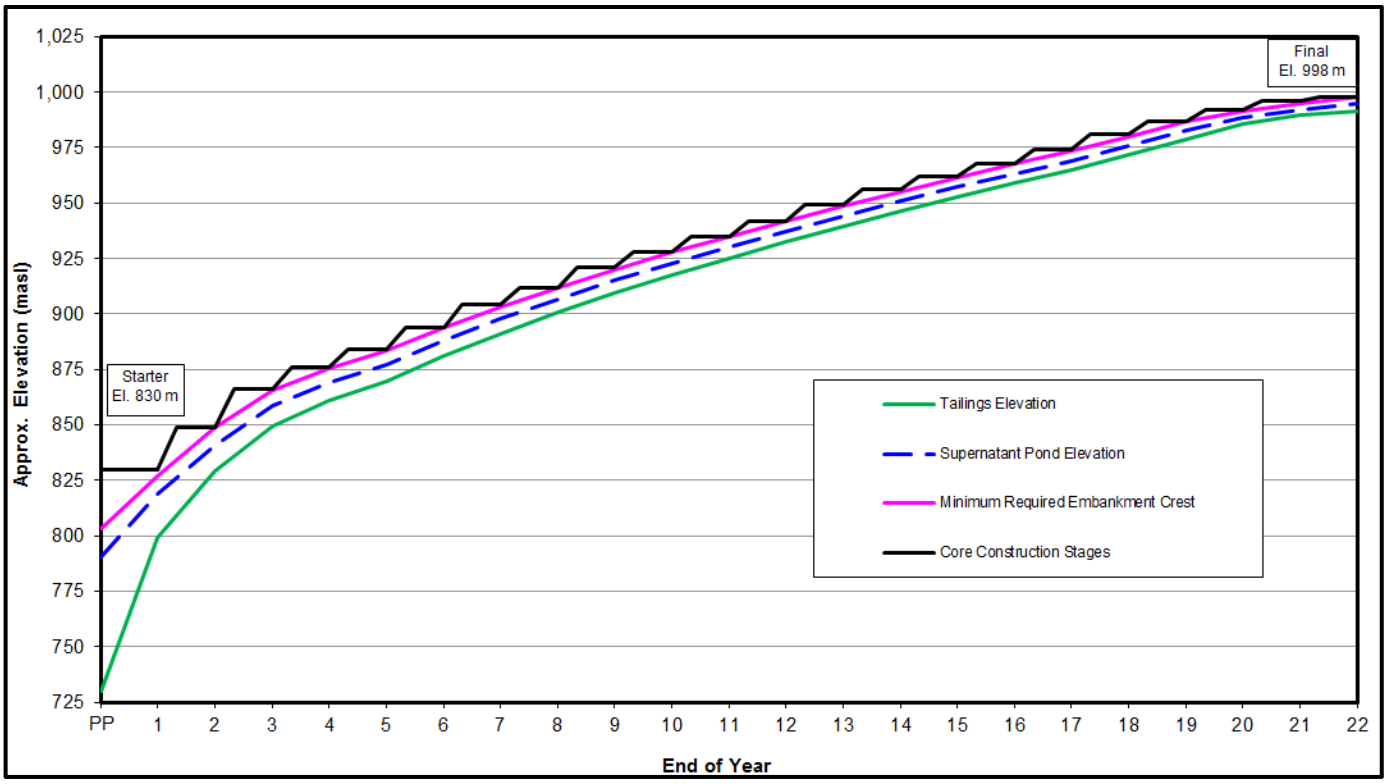

Figure 5.8 Tailings Management Facility – Production and Filling Schedule Curves

NOTES:

1. The filling schedule accounts for 734.3 Mt of tailings and 657.9 Mt of waste rock.
2. The average dry density of the tailings is assumed to be 1.2 t/m^3 in the first three years of production, 1.3 t/m^3 in Year 4 and 1.4 t/m^3 from Year 5 to end of mine life.
3. Compacted cycloned sand dry density assumed to be 1.65 t/m^3.
3. Nominal ore production is approximately 125,000 tpd.
4. Minimum required embankment crest includes freeboard to accommodate Inflow Design Flood (IDF) and two metres for wave run-up protection.
5. Tailings and waste rock modelled as a horizontal surface.
6. Waste rock average dry density assumed to be 2.0 t/m^3.
7. Core zone construction period assumed to be 4 months per year.

5.3 DAM CLASSIFICATION

A preliminary dam classification has been carried out to enable appropriate design earthquake and flood events to be determined for the TMF. The selection of appropriate design earthquake and flood events has been based on classification of the tailings dam using criteria provided by the Canadian Dam Association's (CDA) "Dam Safety Guidelines" (2007), shown in Table 5.2.

Table 5.2 Dam Classification

Dam Class	Population at Risk[1]	Incremental Losses		
		Loss of Life[2]	Environmental and Cultural Values	Infrastructure and Economics
Low	None	Zero	Minimal short-term loss No long-term loss	Low economic losses; area contains limited infrastructure or services
Significant	Temporary only	Unspecified	No significant loss or deterioration of fish or wildlife habitat Loss of marginal habitat only Restoration or compensation in kind highly possible	Losses to recreational facilities; seasonal workplaces, and infrequently used for transportation services
High	Permanent	10 or fewer	Significant loss or deterioration of *important* fish or wildlife habitat Restoration or compensation in kind highly possible	High economic losses affecting infrastructure, public transportation, and commercial facilities
Very High	Permanent	100 or fewer	Significant loss or deterioration of *critical* fish or wildlife habitat Restoration or compensation in kind possible but impractical	Very high economic losses affecting important infrastructure or services (e.g., highway, industrial facility, storage facilities for dangerous substances)
Extreme	Permanent	More than 100	Major loss of critical fish or wildlife habitat Restoration or compensation in kind impossible	Extreme losses affecting critical infrastructure or services (e.g., hospital, major industrial complex, major storage facilities for dangerous substances)

NOTES:

1. Definitions for population risk:
   None – There is no identifiable population at risk, so there is no possibility of loss of life other than through unforeseeable misadventure.
   Temporary – People are only temporarily in the dam-breach inundation zone (e.g. seasonal cottage use, passing through on transportation routes, participating in recreational activities).
   Permanent – The population at risk is ordinarily located in the dam-breach inundation zone (e.g. as permanent residents); three consequence classes (high, very high, extreme) are proposed to allow for more detailed estimates of potential loss of life (to assist in decision-making if the appropriate analysis is carried out).
2. Implications for loss of life:
   Unspecified – The appropriate level of safety required at a dam where people are temporarily at risk depends on the number of people, the exposure time, the nature of their activity, and other conditions. A higher class could be appropriate, depending on the requirements. However, the design flood requirement, for example, might not be higher if the temporary population is not likely to be present during the flood season.

Classification of a tailings dam is carried out by considering the potential incremental consequences of a failure. The incremental consequences of failure are defined by the CDA as *"the total damage from an event with dam failure minus the damage that would have resulted from the same event had*

the dam not failed." The consequences of failure considered include loss of life, environmental and cultural impacts and losses, and economic loss.

There is no permanent population at risk downstream of the TMF. The potential for loss of life from a dam failure is likely minor but cannot be discounted, particularly during operations when there will be work activities in the waste storage area and intermittently in areas downstream of the TMF. The economic consequences (including clean-up, repair and remedial works) would also be high.

The environmental impact on downstream watercourses has the potential to be significant if a failure resulted in the release of tailings and/or process water into Casino Creek. An uncontrolled release into Casino Creek may flow into Dip Creek and potentially to the Yukon River by way of the Klotassin, Donjek and White Rivers. Fish species present in Casino Creek include Arctic Grayling, Burbot, and Slimy Sculpin. In addition to these species, Round Whitefish have been observed, and Chinook Salmon are likely present in Dip Creek. The fish species present are all currently listed as 'Unthreatened' under the Species at Risk Act and are widespread in the region, as is rearing habitat. Based on the methodology presented by Eagen and Greenaway (2010, 2011) and the results of environmental baseline studies, the environmental consequences of a dam failure would be defined as HIGH, based on the classification criteria provided by the CDA Guidelines.

Consequently, a HIGH dam classification has been assigned to the TMF. This dam classification should be reviewed for future design studies and revised if appropriate.

5.3.1 Design Flood Event

Selection of an appropriate Inflow Design Flood (IDF) is required to carry out a safety assessment of the TMF and to determine storm storage requirements. The size of the IDF is dependent on the dam classification, as shown in Table 5.3. Based on the HIGH dam classification assigned to the TMF, an appropriate IDF is an event equal to "one third between 1,000 years and the Probable Maximum Flood (PMF)" event. For closure of the TMF the IDF has been defined as the PMF.

During operations there is no spillway to pass flood waters from the TMF. Therefore, the IDF has been defined using 72-hour 1:1,000 and PMF events. However, for the short-term Stage I TMF (pre-production and Year 1 of operations) the 72-hour 1:1,000 year event was adopted. This reduced IDF has been implemented in the TMF design so that it remains sufficiently large, but not so conservative that it would result in a Stage I embankment that is excessively oversized. A spillway will be constructed at the end of operations for closure water management. Accordingly, the IDF for closure has been defined as the PMF associated with the 24-hour maximum precipitation event.

The Hershfield (1977) method was used to estimate the probable maximum precipitation (PMP) and 1:1,000 year return period rainfall event values based on the 24-hour maximum precipitation data available in the Rainfall Frequency Atlas for Canada (RFAC) (Hogg and Carr, 1985). The 72-hour PMP and 1:1,000 year rainfall depths were estimated by scaling the 24-hour values by ratios of 1.6 and 1.3, respectively, based on measured depth-duration values developed by the National Oceanic and Atmospheric Administration (NOAA, 1999). The resulting 24-hour and 72-hour rainfall depths for the project area are summarized below:

- 24-hour 1:1,000 year rainfall depth = 66 mm
- 72-hour 1:1,000 year rainfall depth = 85 mm
- 24-hour PMP depth = 159 mm, and

- 72- hour PMP depth = 255 mm.

Potential snowmelt during an extreme rainfall event has to be taken into consideration when estimating the resulting flood event. The snowpack present during the IDF was assumed to be equivalent to a 1:100 year snowpack of 256 mm, based on fitting the annual average maximum snowpack (140 mm) and standard deviation (36.9 mm) to a Gumbel distribution. The derivation of the annual average snowpack and 24-hour rainfall depths are presented in KPL report "Updated Hydrometeorology Report" (Ref. No. VA101-325/8-11, July 9, 2012).

The potential snowmelt that could occur in conjunction with the 24-hour 1:1,000 year rainfall or PMP event was then estimated by applying a formula that considered how much snow would melt given a maximum daily temperature of 15 degrees Celsius and a wind speed of 8 m/s (Coulson, 1991). The highest potential snowmelt for the 24-hour rainfall events, assuming a clear catchment with no trees, is:

- 24-hour PMP snowmelt = 156 mm, and
- 24-hour 1:1,000 year snowmelt = 138 mm.

The additional snowmelt that would occur over the subsequent 24 hour periods for a 72-hour event was estimated based on the proportion of rain that is assumed to fall in the second and third 24-hour periods of a 72-hour event. For the 72-hour 1:1,000 year rainfall and PMP events, the total potential snowmelt was predicted to be 393 mm and 425 mm, respectively. However, the snowmelt is limited by the assumed available snowpack of 256 mm (equivalent to the 1:100 year snowpack); accordingly it was assumed that all of the available snowpack would melt during the IDF event. Furthermore, the IDF volume is typically applied to the maximum TMF pond volume in a given year, which generally occurs during the freshet months when the snowpack is melting. Since the maximum TMF pond volume already accounts for snowmelt of the average annual maximum snowpack (140 mm), this depth was then subtracted from estimated potential snowmelt of 256 mm, resulting in an estimated 116 mm of snowmelt contributing to the IDF storage volume requirements.

The resulting total potential runoff depth from a combined return period rainfall event and snowmelt for the 24-hour and 72-hour events are:

- 72-hour 1:1,000 year total runoff depth = 201 mm
- 24-hour PMP total runoff depth = 175 mm, and
- 72-hour PMP total runoff depth = 371 mm.

The total runoff depths were applied to the inflow catchment area of the TMF of 35 km^2. This results in an IDF flood volume of 7.0 million m^3 for the 72-hour 1,000 year event used for Stage I (Pre-production and Year 1), 9.0 million m^3 for the 72-hour one third value between the 1,000 year and PMF event used for the remainder of TMF operations, and 6.1 million m^3 for the 24-hour PMF event used for the TMF at closure, once the spillway is operational.

The design of the TMF embankments includes storm storage volume requirements for the IDF above the operating supernatant pond elevation, plus an additional two metres for wave run-up protection.

5.3.2 Design Earthquakes

Consistent with the current design philosophy for geotechnical structures such as dams, two levels of design earthquake have been considered: the Operating Basis Earthquake (OBE) for normal operations, and the Maximum Design Earthquake (MDE) for extreme conditions (ICOLD, 1995).

Values of Peak Ground Acceleration (PGA) and design earthquake magnitude have been determined for both the OBE and MDE.

The OBE is usually selected from the results of a probabilistic hazard evaluation. The hazard level selected for the OBE is often chosen as the earthquake with a 10% probability of exceedance in 50 years (with a corresponding return period of about 500 years). For design of the TMF, the OBE has been taken as the 1 in 500 year return period event. The probability of exceedance for this event is only 4% for a 22 year operating period. The corresponding median PGA for this event is 0.07g. However, for geotechnical structures it is recommended that the mean average PGA value be used for design (CDA Dam Safety Guidelines, 2007). The mean PGA is likely to be approximately 15 to 20 percent greater than the median value, giving an estimated value of 0.08g. A design earthquake magnitude of 8.0 has been selected for the OBE, based on a review of regional tectonics and historical seismicity. The TMF would be expected to function in a normal manner after the OBE.

An appropriate MDE for embankment design has been selected, based on the HIGH dam classification defined for the TMF and the criteria for design earthquakes provided by the Canadian Dam Association's (CDA) "Dam Safety Guidelines" (2007), and presented in Table 5.3. The CDA Guidelines require that a HIGH dam classification be designed for a probabilistically derived event (defined as the Earthquake Design Ground Motion) having an annual exceedance probability (AEP) of 1/2,500. Consequently, the MDE selected for the TMF is the 1 in 2,500 year earthquake. The median PGA is 0.11g for the 1 in 2,500 year earthquake. The corresponding mean average PGA used for design is estimated to be 0.13g. A design earthquake magnitude of 8.0 has been selected for the MDE, based on a review of regional tectonics and historical seismicity. Limited deformation of the tailings embankment is acceptable under seismic loading from the MDE, provided that the overall stability and integrity of the TMF is maintained and that there is no release of stored tailings or water (ICOLD, 1995).

To demonstrate the robustness of the embankment design to seismic loading the 1 in 10,000 year earthquake has also been considered. The mean PGA for the 1 in 10,000 year event is 0.22g.

Table 5.3 Suggested Design Flood and Earthquake Levels

Dam Class	Annual Exceedance Probability (AEP)	
	Inflow Design Flood (IDF)[1]	Earthquake Design Ground Motion (EDGM)[3]
Low	1/100	1/500
Significant	Between 1/100 and 1/1,000[4]	1/1,000
High	1/3 between 1/1,000 and Probable Maximum Flood[5]	1/2,500[6]
Very High	2/3 between 1/1,000 and Probable Maximum Flood[5]	1/5,000[6]
Extreme	Probable Maximum Flood (PMF)[6]	1/10,000

NOTES:

1. As defined in Table 5.2 – Dam Classification.
2. Extrapolation of flood statistics beyond 1/1,000 year flood (10^{-3} AEP) is discouraged.
3. AEP levels for EDGM are to be used for mean rather than median estimates for the hazard.
4. Selected on the basis of incremental flood analysis, exposure, and consequence of failure.
5. PMF has no associated AEP. The flood defined as "1/3 between 1/1,000 year and PMF" or "2/3 between 1/1,000 year and PMF" has no defined AEP.
6. The EDGM value must be adjusted to demonstrate conformance to societal norms of acceptable risk. Justification can be provided with the help of failure modes analysis focused on the particular modes that can contribute to failure initiated by a seismic event. If justification cannot be provided, the EDGM should be 1/10,000.

5.4 LAYOUT AND OPERATING STRATEGY

5.4.1 General

Tailings and potentially reactive waste rock and overburden will be deposited in an impoundment located in the Casino Creek valley southeast from the open pit. Specific overall features of the TMF are illustrated on Figures 5.1 to 5.6 and are listed below:

- Two earth-rockfill-cyclone sand, zoned embankments, referred to as the Main Embankment and West Saddle Embankment
- Cyclone sand plant
- Tailings distribution pipelines – bulk NAG tailings, PAG tailings, cyclone sand, cyclone overflow (fines)
- Two separate reclaim water systems – mill and cyclone plant
- Waste Storage Area – for potentially reactive waste rock and overburden
- Supernatant (surface water) pond, and
- Water Management system – seepage collection ditches and pond, and seepage recycle system.

5.4.2 Confining Embankments

The Main Embankment will be developed in stages throughout the life of the TMF using a combination of suitable non-reactive earth and rock fill borrow materials and cyclone sand.

The Main Embankment will be expanded in stages across the Casino Creek valley. The Stage IA (Starter) embankment is designed to store runoff as a source for mill start-up water and accommodate tailings and potentially reactive waste rock and overburden production for approximately one year of initial operations. Cyclone sand production in Year 1 of operations will be used to extend the downstream shell of the Main Embankment (Stage IB), allowing the dam crest

and core zone to be raised after about 1 year. Ongoing raises will comprise centreline raises with a vertical low permeability core zone and adjacent downstream filter zones. Cyclone sand will be produced from bulk NAG tailings at the Cyclone Plant and discharged into the cyclone sand shell zones (upstream and downstream of the core zone) where it will be spread in cells and compacted using bulldozers. Bulk tailings that bypass the Cyclone Plant and cyclone overflow (fines) produced during cycloning operations will be discharged into the impoundment.

The alignment of the Main Embankment has been revised since previous studies to take advantage of topographic features (based on the latest site topographic data). The alignment has been revised to minimize the size of the Stage I embankment, reduce seepage flows from the TMF and minimize the volume of colluvial apron material requiring excavation in the embankment footprint.

The West Saddle Embankment will be constructed at the south-western corner of the TMF (as shown on Figures 5.1 to 5.5), and is required at the start of operations to provide a pipeline corridor at a suitable grade for tailings delivery to the cyclone sand plant and the TMF. The embankment will be developed in pre-production years using suitable non-reactive earth and rockfill from local borrow sources.

5.4.3 Water Management

The Stage IA (Starter) Main Embankment will be constructed in pre-production years, with construction scheduled to provide enough time to impound sufficient surface water runoff for mill start-up. It is assumed that a start-up water pond of approximately 15 million m^3 is required, corresponding to about 3 months of mill water requirements. Mill process water for ongoing operations and water for cyclone plant operations will be reclaimed from the TMF supernatant pond.

A monthly operational mine site water balance, incorporating stochastic analysis for climate conditions, indicates that the TMF will be in a water deficit condition for the majority of the mine operating life. To satisfy mill requirements a make-up water supply system will be required, and has been design by Others.

Design provisions to minimize seepage losses from the TMF include the installation of a seepage cut-off beneath the Main Embankment and West Saddle Embankment, a low permeability blanket beneath the Stage I embankment, a seepage interception and recovery system and contingency measures for groundwater recovery and recycle.

Seepage water from the TMF will be collected by a Water Management System, which consists of an under-drain system and a surface ditch system which both discharge into a water management pond located downstream of the Main Embankment. Seepage collected in the pond will be pumped back into the TMF. The Water Management System has been designed to accommodate seepage through the TMF embankments, water recovered from cyclone sand embankment construction and surface runoff.

The water balance model developed for the TMF indicates that there will be a water surplus at closure. A spillway will be provided at closure to facilitate control and discharge of excess water accumulation within the TMF and to provide safe passage of storm water volumes from the TMF.

5.4.4 Tailings Distribution

Three distinct tailings streams will discharge into the TMF:

- PAG tailings – 12 months of the year,
- Bulk NAG tailings – approximately three months of the year plus any periods when the cyclone plant is not operating, and
- Cyclone overflow (fine fraction of bulk NAG tailings) – approximately nine months of the year.

It is assumed that approximately 80% of the tailings will be geochemically innocuous NAG material, following the removal of the pyrite component. The discharge of bulk NAG tailings and cyclone overflow will be from valved offtakes located along the Main Embankment and from the West Saddle Embankment. The coarser fraction of the discharged tailings will settle rapidly, tending to accumulate closer to the discharge points and forming a beach slope. Finer tailings particles will travel farther and settle at a flatter slope beneath the supernatant pond. Deposition will be developed and managed, with the intent to maximize storage efficiency in the TMF and to maintain the deeper, cleaner locations of the supernatant pond in the vicinity of the reclaim barges. Schematic development plans for tailings discharge are included on Figures 5.2 to 5.5, for Years 1, 4, 10 and 22 of operations respectively.

Approximately 20% of the total tailings will be PAG tailings. The PAG tailings deposit will be developed in a separate central region of the TMF by discharging the tailings from the north-western side of the TMF, close to the WSA. The discharge point will be relocated frequently throughout operations to manage the deposition of the PAG tailings and to accommodate raises of the WSA. Deposition in this area will keep the PAG tailings between the WSA and NAG tailings deposit, remote from the confining embankments. This will minimise seepage from the PAG tailings and ensure that they remain in a subaqueous state.

Unsuitable colluvial apron material excavated from the footprint of the Main Embankment will be placed upstream within the TMF basin. This material can be placed in a location to provide a simple barrier between the initial zones of PAG and NAG tailings deposition. This will ensure PAG tailings deposited in the initial months of TMF operations will not flow towards the Main Embankment prior to establishment of a NAG tailings beach area.

A flat surface profile for deposited tailings solids has been assumed for capacity considerations. Detailed design studies should evaluate the potential impact of sloping sub-aerial and sub-aqueous beach areas. Consideration of tailings beach configurations may result in modifications to staged embankment heights and the tailings deposition strategy.

5.4.5 Waste Storage Area

Potentially reactive waste rock and overburden will be hauled to the TMF for co-disposal with tailings and submergence by tailings and the supernatant pond. The Waste Storage Area (WSA) will be developed in the northern section of the TMF impoundment area, upstream of the PAG tailings deposit. Development of the waste storage area has been designed in step with the mine production schedule presented in Table 5.4. It will be developed at the same or similar rate of rise as the tailings but will be several meters higher to provide a dry, stable placement surface. The ongoing maximum elevation of the WSA will be maintained at an elevation above the flood level of the supernatant pond (defined by the IDF event).

Waste rock delivery to the WSA is complete in Year 19. By the end of operations the WSA will be submerged below tailings (from the processing of Low Grade ore) and supernatant pond water,

ensuring long-term subaqueous containment for closure. The operational water balance developed for the TMF (see Section 6.0 and Appendix D) indicates that the WSA will be completely covered by the supernatant pond in Year 20, approximately one year following the end of waste rock deposition. Based on the present mine production schedule and development strategy, approximately three years of tailings deposition will occur after final placement of potentially reactive waste rock. This will result in a thin layer of tailings over the top of the WSA (approximately 3 metres thick). The depth of the final supernatant pond overlying the WSA and tailings is estimated to be approximately 4 metres deep.

Schematic development of the WSA during TMF operations is included on Figures 5.1 to 5.5, for Years -1 (pre-production), 1, 4, 10 and 22 of operations respectively.

In the case of a premature mine closure, a portion of the WSA may need to be excavated to an elevation below the natural pond elevation in the TMF. This would be required to ensure potentially reactive waste materials will be maintained in a saturated state with a sufficient minimum pond cover (2 metres).

Additional information on the development and operation of the WSA and a stability assessment are provided in the KPL report ““Waste Storage Area and Stockpiles Feasibility Design” (Ref. No. VA101-325/8-12, December, 2012).

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TABLE 5.4

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

FEASIBILITY DESIGN OF THE TAILINGS MANAGEMENT FACILITY
TAILINGS AND WASTE PRODUCTION SCHEDULE

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YEAR	ORE TO MILL				CONCENTRATE	TAILINGS		WASTE MATERIAL			
	Direct Feed	Ore Stockpiles		Total	Concentrate	NAG	PAG	Hypogene	Supergene	Unclassified Waste	Total Waste
		Low Grade	Supergene Oxide								
	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes
PP	0	0	0	0	0	0	0	0	9,470,000	210,000	9,680,000
1	34,500,000	0	0	34,500,000	345,000	27,324,000	6,831,000	5,000	22,429,000	78,000	22,512,000
2	45,928,000	0	0	45,928,000	459,280	36,374,976	9,093,744	159,000	29,031,000	116,000	29,306,000
3	45,814,000	0	0	45,814,000	458,140	36,284,688	9,071,172	943,000	36,757,000	211,000	37,911,000
4	42,056,000	0	3,600,000	45,656,000	456,560	36,159,552	9,039,888	573,000	38,759,000	31,000	39,363,000
5	41,653,000	0	3,600,000	45,253,000	452,530	35,840,376	8,960,094	10,690,000	30,585,000	64,000	41,339,000
6	41,605,000	0	3,600,000	45,205,000	452,050	35,802,360	8,950,590	14,096,000	20,972,000	21,000	35,089,000
7	41,576,000	0	3,600,000	45,176,000	451,760	35,779,392	8,944,848	10,579,000	27,036,000	64,000	37,679,000
8	42,145,000	0	3,600,000	45,745,000	457,450	36,230,040	9,057,510	12,401,000	25,529,000	39,000	37,969,000
9	42,491,000	0	3,600,000	46,091,000	460,910	36,504,072	9,126,018	8,952,000	26,680,000	226,000	35,858,000
10	41,175,000	0	3,600,000	44,775,000	447,750	35,461,800	8,865,450	6,369,000	28,591,000	55,000	35,015,000
11	41,095,000	0	3,600,000	44,695,000	446,950	35,398,440	8,849,610	7,931,000	44,635,000	132,000	52,698,000
12	42,251,000	0	3,610,000	45,861,000	458,610	36,321,912	9,080,478	15,273,000	32,380,000	10,000	47,663,000
13	46,249,000	0	0	46,249,000	462,490	36,629,208	9,157,302	20,341,000	23,455,000	1,000	43,797,000
14	45,798,000	0	0	45,798,000	457,980	36,272,016	9,068,004	31,372,000	11,413,000	0	42,785,000
15	45,187,000	0	0	45,187,000	451,870	35,788,104	8,947,026	31,379,000	6,445,000	5,000	37,829,000
16	45,064,000	0	0	45,064,000	450,640	35,690,688	8,922,672	37,370,000	563,000	1,000	37,934,000
17	44,772,000	0	0	44,772,000	447,720	35,459,424	8,864,856	20,242,000	0	0	20,242,000
18	44,934,000	0	0	44,934,000	449,340	35,587,728	8,896,932	8,266,000	0	0	8,266,000
19	14,676,000	30,915,000	0	45,591,000	455,910	36,108,072	9,027,018	4,932,000	0	0	4,932,000
20	0	45,053,000	0	45,053,000	450,530	35,681,976	8,920,494	0	0	0	0
21	0	44,985,000	0	44,985,000	449,850	35,628,120	8,907,030	0	0	0	0
22	0	22,875,000	0	22,875,000	228,750	18,117,000	4,529,250	0	0	0	0
TOTALS	788,969,000	143,828,000	32,410,000	965,207,000	9,652,070	764,443,944	191,110,986	241,873,000	414,730,000	1,264,000	657,867,000

\\VAN11\Prj_file\1\01\00325\08\A\Report\10 - TMF Feasibility Design Report\Rev 0\Tables\[Table 5.4 Rev 0 - Tailings and Waste Production Schedule.xlsx]Table 5.4

NOTES:

1. MINE SCHEDULE PROVIDED BY CASINO MINING CORPORATION (NOVEMBER 01, 2012).
2. PP = PRE-PRODUCTION YEARS -3, -2 AND -1.
3. CONCENTRATE ASSUMED TO BE 1% OF MILL FEED.
4. POTENTIALLY ACID GENERATING (PAG) TAILINGS ASSUMED TO BE 20% OF TOTAL TAILING; NON-ACID GENERATING (NAG) TAILINGS ASSUMED TO BE 80% OF TOTAL TAILINGS.
5. APPROXIMATELY 2 Million Tonnes OF WASTE MATERIAL IS NON-ACID GENERATING AND BECOMES AVAILABLE DURING PRE-PRODUCTION.

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5.5 CYCLONE SAND DESIGN CONSIDERATIONS

Numerous large cyclone sand embankments are utilized at mining operations in many regions of the world, including Anglo's Los Bronces mine, Southern Peru Copper's Quebrada Honda mine, and the Los Quillayes tailings impoundment operated by Minera Los Pelambres in Chile. Several large cyclone sand dams have been constructed to dam heights in the range of approximately 150 m to 200+ m and are often located in seismically active areas. The Los Quillayes tailings dam was constructed with cyclone sand to a maximum height of 198 m. The Mauro cyclone sand dam at the Los Pelambres mine was constructed to a height of 248 m in a region of high seismicity.

The particle size distribution of the Casino mill tailings is a key consideration for determining the suitability of the bulk NAG tailings to provide cyclone sand of suitable quality and in sufficient quantity. Coarser tailings are preferred, as a higher sand fraction or 'split' can be realized. Clean sand with sufficiently low fines content (% passing a #200 sieve) will be required for placement, in order to facilitate rapid drainage and subsequent compaction. The anticipated particle size distribution of the Casino tailings (see Section 2.2 and Figure 2.1) is well within the range of tailings particle size distributions that have been successfully cycloned at other tailings operations.

Experience from existing cyclone sand dams indicates that the sand fill should have an in situ permeability equal to or greater than 2×10^{-4} cm/s (Barrera, Valenzuela and Campana, 2011). This will ensure the rapid drainage of construction water (following cyclone sand placement), seepage water and direct precipitation. It is typical to present specifications limiting the fines content of the cyclone sand. For copper tailings a fines content in the range of 15 and 20 percent typically provides sufficient permeability for sand drainage. This criterion continues to be valid provided the sand grain size is not significantly changed by particle crushing, due to very large confining pressures imposed by dams of large height. Chilean experience for large copper cyclone sand tailings dams indicates that large confining pressures do not significantly affect the sand grain size. However, this may not be valid for tailings with a different mineralogy. Therefore, for large cyclone sand dams it is prudent to conduct permeability tests at large confining pressures to simulate the behavior of the material.

Permeability testing has been conducted on a laboratory generated sample of cyclone underflow (cyclone sand), as discussed in Section 2.2. The results of the permeability tests did not indicate any evidence of particle crushing and measured permeability values were greater than 2×10^{-4} cm/s, even at very high confining pressures.

From consideration of the large height and size of the Main Embankment it is recommended that the fines content of the cyclone sand be less than 15%, in order to maximize fill placement rates and to ensure adequate compaction, strength and drainage. A maximum fines content of 12% has been adopted for the Feasibility design. There may be an opportunity to increase the fines content a few percent to allow increased sand quantities, based on actual performance during operations and material characteristics (permeability and strength) of the cyclone sand. The potential to provide more sand fill material will allow increased operating flexibility related to construction activities.

The large embankment height associated with the Main Embankment limits the sand placement options and likely necessitates construction using sand cells, where additional vibratory compaction will be required to ensure a sufficiently dense, high strength material. It is important to provide a cyclone sand fill material that is sufficiently dense to provide adequate strength for embankment stability (with consideration of the high confining stresses) and to ensure the material is not

susceptible to cyclic softening or flow liquefaction under seismic loading. A requirement of the cyclone sand placement will be to achieve a dry density of 95% Standard Proctor compaction.

It is recommended that future studies include examination of the influence of cyclone underflow solids content on the compaction characteristics of in situ cyclone sand fill. This will enable determination of the optimum solids content of the cyclone underflow to achieve good compaction of the sand fill.

There is ample precedent in North America for tailings dam construction using cyclone sand, but this technique has not been used for large tailings dams in the Yukon. There is potential for cold winter conditions to reduce the construction period for cyclone sand placement, partly due to the potential for freezing and ice entrainment in the sand fill and partly because of snow drifting into sand cells. Examples of mine operations in British Columbia, where cyclone sand is used to construct the tailings dams, include the Kemess, Gibraltar and Highland Valley mines. To accommodate cold operating conditions in the winter months, the construction season at Gibraltar is typically from March to October. Longer cycloning operations for sand fill construction have apparently been possible at the Kemess mine, with operations possible at temperatures as low as -25°C. Dam construction typically runs 6 to 10 months of the year at Highland Valley. During the remainder of the year, tailings are used to construct an upstream beach between the dam and the tailings supernatant pond. For this Feasibility design the cyclone plant and cyclone sand placement activities are assumed to be operational for an average 9 months of the year (with a 90% sand plant availability to account for maintenance and other downtime).

5.6 EMBANKMENT CONSTRUCTION

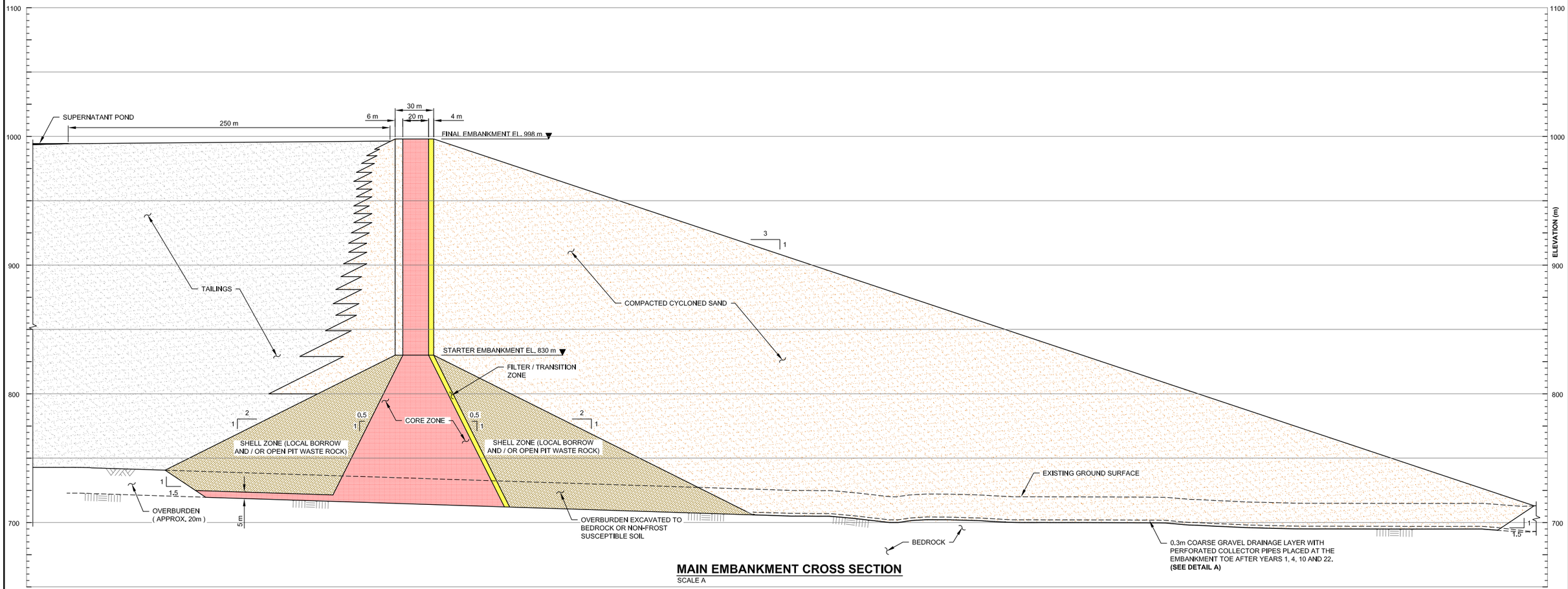
The embankments will be constructed as water-retaining zoned structures with a low permeability core zone and appropriate filter and transition zones to prevent downstream migration of fines. The core zone will include a seepage cut-off keyed into competent rock in the foundation.

5.6.1 Main Embankment

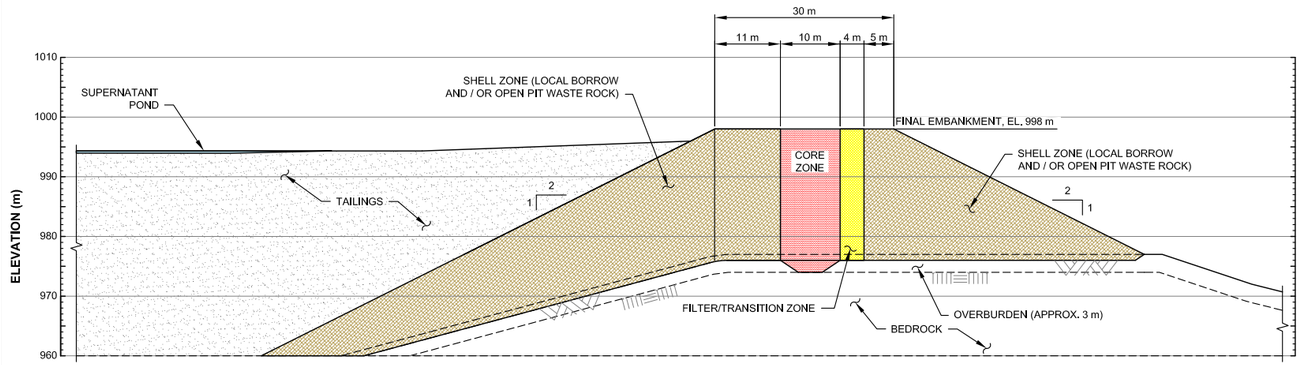
The Main Embankment required for the TMF has been designed to be constructed in several stages over the operating life of the mine. It will consist of an initial starter (Stage IA) embankment, an extension of the downstream shell during the first year of operations (Stage IB), and staged raises thereafter over the life of the project using the centreline method of construction. The filling schedule for the TMF is included on Figure 5.8. On-going raises of the embankment crest and core zone to support the staged expansion will be carried out annually, during the summer months of operations.

The Stage I embankment will comprise an approximately 105 metres high dam (crest to downstream toe) constructed to El. 830 m. A cofferdam will be required in order to drain and prepare the foundation prior to Stage I embankment construction in the pre-production years. The cofferdam will be constructed upstream of the Main Embankment footprint to capture upstream surface water flows and route it around the construction work area and back into Casino Creek in a surface pipeline. The embankment shell zones for the Stage IA (Starter) dam will be constructed with random fill comprising suitable rockfill from local borrow sources, supplemented by available non-reactive waste rock. Approximately 2 to 3 million tonnes of non-reactive waste rock (leach cap) material is available from initial open pit stripping operations.

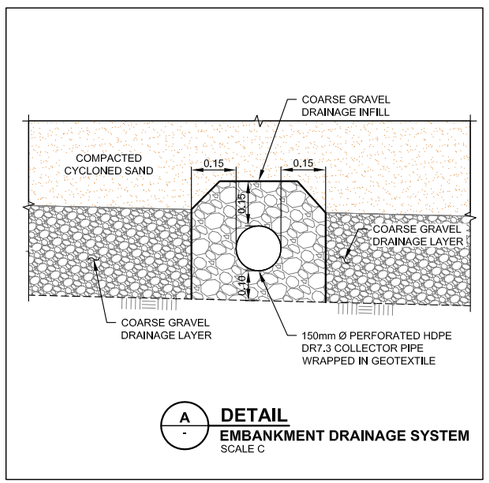
The crest of the final embankment will reach an elevation of 998 m, providing storage capacity for 22 years of tailings and potentially reactive waste rock and overburden production. A typical section through the final Main Embankment is shown on Figure 5.9. The maximum height of the final embankment (crest to downstream toe) will be approximately 286 metres. Construction of each of the embankment stages will be scheduled to correspond with material availability for cyclone sand (produced from NAG tailings), local borrow sources and the tailings impoundment filling rate.



MAIN EMBANKMENT CROSS SECTION
SCALE A



WEST EMBANKMENT CROSS SECTION
SCALE B



A
-
DETAIL
EMBANKMENT DRAINAGE SYSTEM
SCALE C

NOTES:

1. COORDINATE GRID IS UTM (WGS84/NAD83) ZONE 7 (m).
2. DIMENSIONS AND ELEVATIONS ARE IN METRES UNLESS NOTED.
3. GENERALIZED TOPOGRAPHY SHOWN.

SCALE C: 0.2 0.1 0 0.2 0.4 0.6 0.8 1 m
SCALE B: 10 5 0 10 20 30 40 50 m
SCALE A: 30 15 0 50 100 150 m

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CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

TAILINGS MANAGEMENT FACILITY
TYPICAL EMBANKMENT SECTIONS

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P/A NO. VA101-325/8 | REF NO. 10

FIGURE 5.9 | REV 0

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For each stage of embankment construction the foundations will require clearing and stripping preparation for fill placement. An average stripping depth of one meter has been assumed within the embankment footprint. For the embankment footprint area that covers colluvial apron or other ice-rich overburden, all unsuitable material will be excavated to competent foundation, absent of frost susceptible soil. The average thickness of the colluvial apron is expected to be approximately 10 metres based on the findings of site investigations. The removed material will be replaced with core, filter or shell zone material, depending on the location relative to the embankment. A 5 metre thick low permeability upstream blanket is also included to reduce seepage from the TMF, as shown on Figure 5.9.

A low permeability cut-off is required beneath the core zone of the Main Embankment and West Saddle Embankment at locations where no colluvial apron or other ice rich soil is present, to provide an effective seepage control barrier. The seepage cut-off trench will extend through the foundation soils and key into competent bedrock, at an average depth of about three meters for both the Main and West Embankment.

Ongoing embankment stages will comprise centreline raises with a vertical low permeability core zone (20 metres wide) and adjacent downstream filter and transition zones. The development of sufficient tailings beach area will be required between the supernatant pond and the embankment to provide a stable upstream construction surface for the centreline embankment raises. The upstream and downstream shell zones will be constructed from compacted cyclone sand.

The embankment filter zone will prevent piping of the core zone material and will reduce pore pressures within the embankment. The transition zone will prevent the migration of fines from the dam core zone and filter zone into the pervious downstream shell zone (rockfill and cyclone sand). The filter and transitions zones will consist of suitable crushed and screened rock or local borrow materials.

Cyclone sand will be produced from bulk NAG tailings at the Cyclone Plant and discharged into the cyclone sand shell zones where it will be spread in cells and compacted using bulldozers. Cyclone sand slurry will be discharged into each construction cell to depths of 0.5 m to 2.0 m, and will be heavily track packed by dozers. Water expelled from the sand by the track packing will drain from the cells for collection in the downgradient water management pond at the toe of the embankment. The draining and track packing will provide compacted zones of cyclone sand that meet 95% Standard Proctor compaction density specification. The in situ density, moisture content, and fines content will be obtained from within 48 hours of sand placement. The embankment design relies on maintaining a free-draining downstream sand embankment for static and seismic stability.

Cell construction using narrow sand deposition panels will be required for raising the downstream shell of the Main Embankment. The panel method involves the construction and maintenance of long, narrow cells (typically approximately 100 m by 20 m) along the face of the embankment. A schematic of the panel construction sequence is shown on Figure 5.10.

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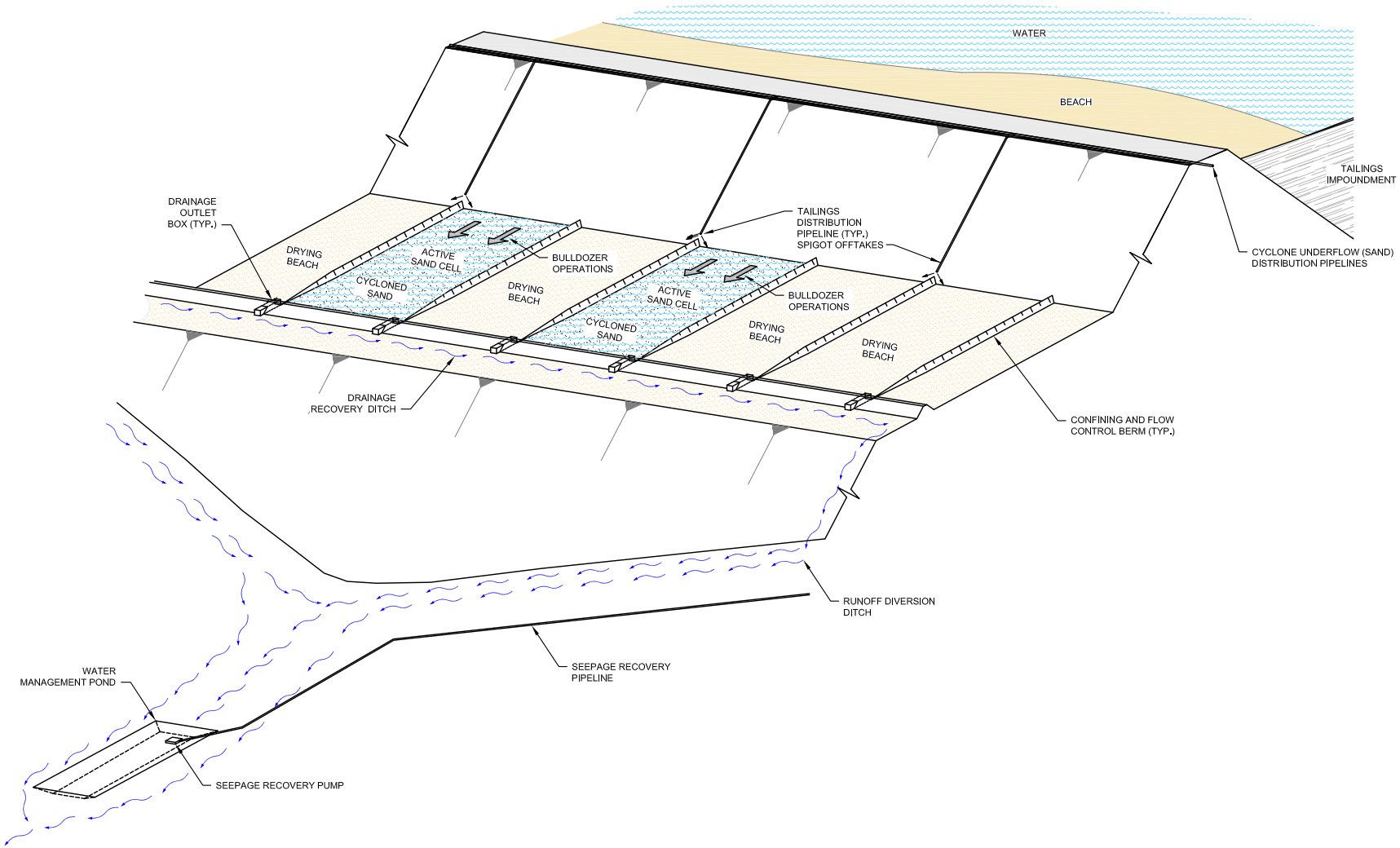

NOTES:

1. SAND CELL PLACEMENT OPERATIONS OCCUR SIMULTANEOUSLY IN TWO OR THREE CELLS.

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CASINO COPPER -GOLD PROJECT

CYCLONE SAND DEPOSITION SCHEMATIC

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P/A NO. VA101-325/8

REF NO. 10

FIGURE 5.10

REV 0

Cyclone sand production commencing in Year 1 of operations will be used to extend the downstream shell of the Main Embankment (Stage IB), allowing the dam crest and core zone to be raised after about one year. The availability of cyclone sand needs to be matched with the filling schedule for the TMF, to ensure adequate embankment heights are provided well in advance of the rising tailings surface. The Stage IA (Starter) embankment must be high enough to allow sufficient quantities of sand to be produced and placed to facilitate subsequent embankment raises.

It is estimated that approximately 7.2 to 7.5 million m^3 (12 to 12.5 million tonnes at an in situ dry density of 1.65 tonne/m^3) of cyclone sand fill material can be produced annually, except for Year 1, using the production values presented in Table 5.5. Approximately 5.6 million m^3 of cyclone sand can be produced in Year 1 as the mill ramps up to full production. This volume is less than the fill volume required for embankment construction in Year 1. The annual shortfall of embankment fill material will need to be made up with suitable fill material from a local borrow source or quarry. It is estimated that approximately 1.2 million m^3 of rockfill will be required to supplement the shortfall in cyclone sand production in Year 1. This rockfill can be preferentially placed in the bottom area of the downstream shell to further promote drainage of the cyclone sand. Additional filter and transition layers will be required between the cyclone sand and rockfill to prevent the migration of sands into the rockfill and to provide drainage for the transport of water released from the sand.

The current material balance indicates that sufficient cyclone sand material is available to meet embankment fill requirements for Years 2 to 22. Table 5.5 provides a detailed summary of embankment fill quantities for each of the zones by year.

The materials balance for construction requirements is sensitive to the factors assumed for cyclone sand production (including cold weather operations). Therefore, additional local borrow may be required for embankment construction in the event that cyclone sand production does not meet targets in any given year during operations.

The Stage IA Main Embankment requires approximately 9.3 million m³ of total fill material. The total fill requirement for the final Main Embankment (including the seepage cut-off) is 152 million m³.

The sequencing of sand cell construction in relation to the requirements for embankment crest raising will need to be carefully evaluated for detailed design studies.

Placement of additional rockfill against the downstream shell of the Main Embankment can be used to provide additional structural support, if required. However, stability assessment (see Section 5.10) indicates that the embankment satisfies operating and long-term (post-closure) stability requirements without downstream buttressing.

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TABLE 5.5

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

FEASIBILITY DESIGN OF THE TAILINGS MANAGEMENT FACILITY
EMBANKMENT FILL VOLUME REQUIREMENTS

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Stage	End of Year	Min. Crest Elevation	Main Embankment						West Saddle Embankment				Total Core Volume [1]	Total Filter and Transition Volume	Total Shell Volume	Total Volume
			Core Zone[1]	Filter and Transition Zone	Shell Zone			Stage Volume	Core Zone	Filter and Transition Zone	Shell Zone Local Borrow	Stage Volume				
					Local Borrow	Open Pit Waste Rock	Cycloned Sand									
		(m)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)
IA	PP	830	2,975,000	201,000	5,118,000	1,000,000	0	9,294,000	53,000	18,000	284,000	355,000	3,028,000	219,000	6,402,000	9,649,000
IB	1	830	0	0	1,200,000	0	5,589,000	6,789,000	0	0	0	0	0	0	6,789,000	6,789,000
II	2	849	433,000	86,000	0	0	7,440,000	7,959,000	0	0	0	0	433,000	86,000	7,440,000	7,959,000
III	3	866	441,000	87,000	0	0	7,422,000	7,950,000	0	0	0	0	441,000	87,000	7,422,000	7,950,000
IV	4	876	331,000	65,000	0	0	7,396,000	7,792,000	0	0	0	0	331,000	65,000	7,396,000	7,792,000
V	5	884	256,000	50,000	0	0	7,331,000	7,637,000	0	0	0	0	256,000	50,000	7,331,000	7,637,000
VI	6	894	371,000	73,000	0	0	7,323,000	7,767,000	0	0	0	0	371,000	73,000	7,323,000	7,767,000
VII	7	904	363,000	72,000	0	0	7,319,000	7,754,000	0	0	0	0	363,000	72,000	7,319,000	7,754,000
VIII	8	912	303,000	60,000	0	0	7,411,000	7,774,000	0	0	0	0	303,000	60,000	7,411,000	7,774,000
IX	9	921	350,000	69,000	0	0	7,467,000	7,886,000	0	0	0	0	350,000	69,000	7,467,000	7,886,000
X	10	928	318,000	63,000	0	0	7,254,000	7,635,000	0	0	0	0	318,000	63,000	7,254,000	7,635,000
XI	11	935	285,000	56,000	0	0	7,241,000	7,582,000	0	0	0	0	285,000	56,000	7,241,000	7,582,000
XII	12	942	290,000	57,000	0	0	7,429,000	7,776,000	0	0	0	0	290,000	57,000	7,429,000	7,776,000
XIII	13	949	339,000	67,000	0	0	7,492,000	7,898,000	0	0	0	0	339,000	67,000	7,492,000	7,898,000
XIV	14	956	260,000	51,000	0	0	7,419,000	7,730,000	0	0	0	0	260,000	51,000	7,419,000	7,730,000
XV	15	962	263,000	52,000	0	0	7,320,000	7,635,000	0	0	0	0	263,000	52,000	7,320,000	7,635,000
XVI	16	968	311,000	61,000	0	0	7,300,000	7,672,000	0	0	0	0	311,000	61,000	7,300,000	7,672,000
XVII	17	974	272,000	54,000	0	0	7,253,000	7,579,000	0	0	0	0	272,000	54,000	7,253,000	7,579,000
XVIII	18	981	278,000	55,000	0	0	2,569,000	2,902,000	0	0	0	0	278,000	55,000	2,569,000	2,902,000
XIX	19	987	284,000	56,000	0	0	2,569,000	2,909,000	0	0	0	0	284,000	56,000	2,569,000	2,909,000
XX	20	992	194,000	38,000	0	0	2,569,000	2,801,000	0	0	0	0	194,000	38,000	2,569,000	2,801,000
XXI	21	996	149,000	29,000	0	0	2,000,000	2,178,000	0	0	0	0	149,000	29,000	2,000,000	2,178,000
XXII	22	998	151,000	29,000	0	0	1,000,000	1,180,000	0	0	0	0	151,000	29,000	1,000,000	1,180,000
TOTALS			9,217,000	1,431,000	6,318,000	1,000,000	134,113,000	152,079,000	53,000	18,000	284,000	355,000	**9,270,000**	**1,449,000**	**141,715,000**	**152,434,000**

\\VAN11\Prj_file\1\01\00325\08\A\Report\10 - TMF Feasibility Design Report\Rev 0\Tables\[Table 5.5 Rev 0 - TMF Staged Embankment Volumes.xlsx]Volumes Rounded

NOTE:

1. CORE VOLUME INCLUDES LOW PERMEABILITY UPSTREAM BLANKET (206,000 m³)
2. NEAT LINE VOLUMES (NO OVERBUILD ALLOWANCE INCLUDED).

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5.6.2 West Saddle Embankment

The West Saddle Embankment will comprise an earth-rockfill dam, constructed from local borrow materials. This embankment is not required for tailings and supernatant pond confinement until about Year 18 of operations. However, the embankment will be constructed for the start of operations to provide a pipeline corridor at a suitable grade for tailings delivery to the cyclone sand plant and the TMF. The embankment is required to a maximum height of approximately 21 m at El. 998 m.

Information collected during the site investigation programs in the West Embankment area indicated that the depth to bedrock throughout the area is likely to be less than three meters and the shallow overburden will likely comprise residual and colluvial soils.

The embankment includes a vertical low permeability core zone (10 metres wide) and adjacent downstream filter and transition zones. A cut-off trench will likely be required beneath the core of the dam to provide an effective seepage control barrier within the underlying permeable foundation soils. The seepage cut-off trench will extend through the permeable soils and key into competent rock, at an average depth of about three meters.

A typical section through the West Saddle Embankment is included on Figure 5.9.

The total fill required for construction of the West Saddle Embankment is approximately 0.36 million m^3.

5.6.3 Borrow Materials

Local borrow sources are required to provide the following materials for embankment construction:

- Core zone – locally sourced low permeability overburden.
- Filter and transition zones – required gradation depends on the gradation of the core zone material. Local borrow is likely the main source for this material.
- Rockfill Shell Zones – partly sourced from non-reactive open pit waste, the remainder will be sourced from local borrow (quarries).

All embankment construction materials will need to be non-reactive. Rockfill is expected to be sourced relatively easily on site, including use of excavated material from preparation of the plant site foundations. The borrow sources for the filter and transition zones have not been identified at this stage as this depends on the gradation of the core zone material. An effort has been made to identify potential borrow sources for low permeability core zone material and the upstream blanket.

- Laboratory permeability test results on compacted residual and colluvial soil from 1993, 2010, 2011 and 2012 test pit samples indicate that permeabilities range from approximately 1×10^{-5} cm/s to 1×10^{-9} cm/s, depending on material gradation, moisture content, compactive effort and confining pressure. The more recent testing carried out in 2011 and 2012 indicates that permeability values in the range of approximately 1×10^{-6} cm/s to 1×10^{-5} cm/s are typically achievable for the finer grained soils (with more than 20% fines) present at the project site. The laboratory testing also suggests that the permeability will reduce at higher confining stresses, with a permeability decrease from 1×10^{-5} cm/s to 1×10^{-6} cm/s reported for an increase in confining stress from 200 kPa to 600 kPa. Confining stresses will exceed 600 kPa in the majority of the embankment core zone for the TMF Main Embankment (from about 30 metres below the dam crest). Therefore, it is expected that a permeability of about 1×10^{-6} cm/s, and

perhaps less, will be achieved in the majority of the core material. Additional testing is required to confirm the suitability of core materials.

The criteria that have been used to determine suitability of the material for use as low permeability core zone borrow material are:

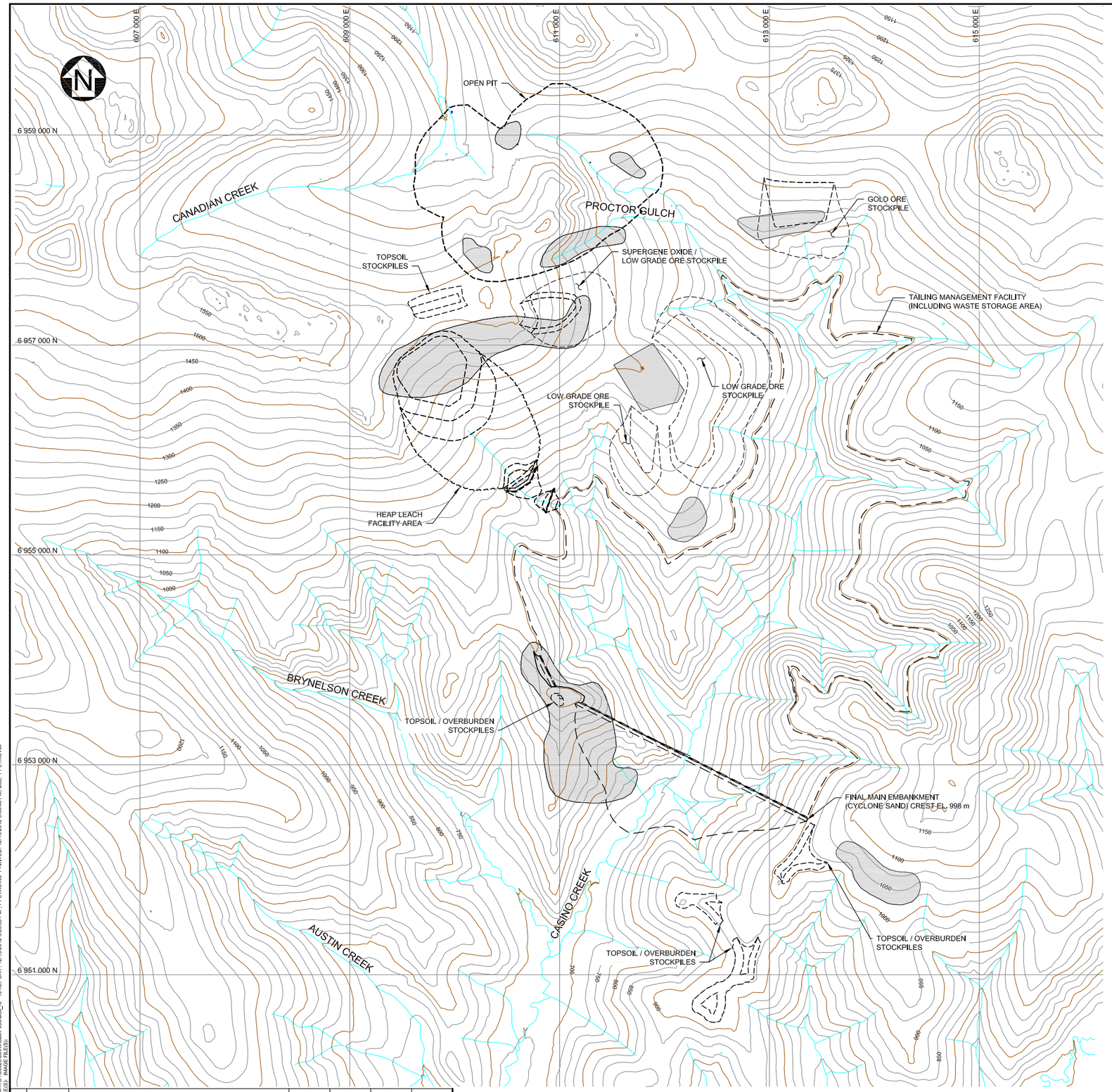
- ≥ 20% fines. Material with ≥ 20% fines is expected to have a sufficiently low permeability for use as core zone material, based on available laboratory testing and experience with other projects.
- No organic content. Where the presence of organic material is indicated by laboratory testing or geotechnical logging, the material is considered unsuitable for use as core material. Organic material can oxidize over time, potentially causing settlements and leading to preferential seepage paths.
- Non frost susceptible. Ice rich soils are considered unsuitable as these are difficult to excavate when frozen. Thawing of ice rich soils will cause excess water to be released, which causes the soil to flow and makes it very difficult to handle and compact.

The residual soil and colluvial veneer materials identified at the site are potentially suitable core zone borrow materials. The colluvial apron in Casino Valley is typically organic-rich, saturated and frozen, and is not suitable for use as core zone construction material.

Residual soils are locally silt rich due to windblown loess enrichment. Residual soils at the site are mainly present along ridges at higher elevations and along the upper parts of some slopes. In the open pit and Gold Ore stockpile areas, residual soils are locally thick and clay-rich due to the presence of alteration zones and preferential weathering along shear and fault structures.

Colluvial veneer is found along valley slopes. The nature of colluvium, i.e. material that has been transported down slopes, causes local variations in the composition. The downslope migration also causes organic material to be included in the deposit at some locations. The organic content generally increases down-slope. On north facing slopes, the colluvial veneer is mostly frozen and not considered to be a suitable borrow source.

Several potential core zone borrow source areas have been identified at the project site and are shown on Figure 5.11.



NOTES:

1. COORDINATE GRID IS UTM (WGS84/NAD83) ZONE 7 (m).
2. CONTOUR INTERVAL IS 25 METRES.
3. DIMENSIONS ARE IN METRES UNLESS NOTED.
4. OPEN PIT IS SHOWN AT ITS FINAL OUTLINE AS PROVIDED BY CASINO MINING CORPORATION (NOVEMBER 2012).
5. PLANT SITE AND CRUSHER LAYOUT PROVIDED BY M3 ENGINEERING AND TECHNOLOGY CORPORATION (OCTOBER 4, 2012).
6. HEAP LEACH PAD IS SHOWN AT ITS MAXIMUM SIZE.
7. ORE AND TOPSOIL STOCKPILES ARE SHOWN AT THEIR MAXIMUM SIZE DURING OPERATIONS.

LEGEND:

POTENTIAL CORE ZONE BORROW AREA

SCALE A 400 200 0 400 800 1200 1600 2000 m

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0	19DEC'12	ISSUED WITH REPORT	SB	PP	LM	KJB

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POTENTIAL CORE ZONE BORROW MATERIAL

Knight Piésold CONSULTING

P/A NO. VA101-325/8 | REF NO. 10 | REV 0

FIGURE 5.11

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The main challenges to be considered in the sourcing of suitable core zone borrow materials are as follows:

- Colluvial veneer has a variable composition and has the potential of intermixed organics.
- The layer of suitable material is typically only between 1 and 2 meter thick, underlying an unsuitable (topsoil) layer of 0.3 m or more. This may lead to large spoil piles and disturbance areas.
- Topsoil overlying potential borrow sources should be carefully stripped in order to avoid contamination of the borrow materials with organic material.
- Permafrost and frost susceptible materials should be avoided.

Specific materials will be required at specific times from the borrow areas. For example, large quantities of free draining, possibly processed material will be required to construct the downstream filter and transition zones. This material will be prepared in advance and stockpiled near the work area. Alluvial soil deposits in the area may provide suitable free draining material for construction of the embankment filter and transition zones. Additional site investigations and laboratory testing will be required for future design studies to confirm the suitability of local borrow sources and provide sufficient material characterization to enable fill placement specifications to be defined (including lift thickness, particle size distribution and compaction requirements).

These investigations will also be required to confirm the extent and availability of sufficient suitable borrow materials for embankment core zone construction throughout the life of the facility. Future studies may also need to consider alternative core zone materials and options, if additional characterisation and delineation of borrow sources indicates a potential shortfall of suitable low permeability material.

Future studies should also confirm specific borrow sources for filter zone and quarried rockfill materials required for embankment construction.

5.7 TMF OPERATIONS UNDER FREEZING CONDITIONS

Numerous mines have operated or currently operate tailings facilities under severe winter (freezing) conditions. In many instances a frozen layer forms over the TMF supernatant pond, which is maintained and operated under the ice.

Design and operating considerations, developed from mine operating experiences under freezing conditions, which may be considered for winter operations at Casino, include the following:

- Shape the tailings impoundment surface (during summer tailings deposition) to provide a winter pond that can be maintained "localized" in one or specific areas of the facility.
- Concentrate winter tailings discharge from a single, relocateable, point. This will tend to channelize the flow and move it through and under the ice cover where the solid/liquid separation occurs. This prevents sheet tailings flow over the ice.
- Commence winter tailings discharge from a more remote location and retreat the deposition point closer to the source/pond/recovery point, in steps, as winter progresses.
- Store sufficient water in the tailings facility prior to freezing, to provide for all anticipated ice and pore water losses during winter (i.e. develop and maintain a good water/ice balance).
- The potential for dusting can be exacerbated during cold winter conditions as a 'freeze drying' process tends to destroy capillary tensions in partially saturated sand materials, making it more

susceptible to dusting. Appropriate provisions will be required to prevent dusting of cyclone sand fill. This may mean that the cyclone sand will need capping with erosion resistant fill material, particularly during the cold winter months, when it may be impractical to continue with active sand placement.

5.8 WATER MANAGEMENT SYSTEM

The Water Management System for the TMF has been designed to accommodate seepage through the TMF embankment, water recovered from the cyclone sand embankment construction and surface runoff from the 1 in 10 year 24-hour design storm event.

Seepage from the TMF will result from infiltration of ponded water directly through the embankment fill and the natural ground and from expulsion of pore water as the tailings mass consolidates. The seepage will largely be controlled by the low permeability core zone of the embankments, the seepage cut-off provided beneath the core of the dams, the upstream low permeability blanket provided for the Main Embankment and the tailings deposit.

Cyclone sand embankment construction will be undertaken for approximately nine months of the year and it is expected that there will be significant water recovery as a by-product of the construction process. The majority of water recovered will be collected as surface runoff, with a portion also collected as infiltration and drainage through the cyclone sands placed as embankment fill.

The 1 in 10 year 24-hour design storm event is anticipated to generate periodic high flow surface runoff events.

The Water Management System consists of an under-drain system and a surface ditch system which both discharge into a water management pond located downstream of the Main Embankment. The under drain system, which is installed beneath the Main Embankment, incorporates a 0.3 metre thick gravel drainage blanket with perforated collection pipes to convey collected water away from under the embankment (see Figure 5.9). The layout of the collection pipes has been designed with pipes installed at four phases during development, Year 1, Year 4, Year 10 and Year 22. The collection pipes will be spaced approximately every 230 metres as the footprint of the embankment increases with staged expansions. As the embankment height increases, it is expected that the perforated pipes will deform and likely collapse due to the embankment loading, however the majority of infiltration drainage from the cyclone sand operation is anticipated to be complete at this stage and any remaining drainage will still infiltrate through the gravel drainage blanket.

The surface ditch system has been configured as a dual-ditch design (two parallel ditches, one ‘clean’ and one ‘dirty’), with the upslope ditch (constructed along the toe of the embankment) collecting surface runoff from the embankment (generated by either precipitation or cyclone sand placement), and the downslope ditch diverting ‘clean’ surface runoff. The dual-ditch system was adopted to reduce the quantity of water that requires storage in the water management pond and pumping back to the TMF. Lining and scour protection of the ditching will be required to prevent erosion of the ditch channels. Similar to the underdrain system, the ditch system has been designed to be constructed with four development phases to accommodate staged embankment expansions. The ditch alignments through the four development phases are included on Figures 5.2 to 5.5.

The water management pond (see Figures 5.1 to 5.5) has been designed as a dry-pond and is sized to manage the 1 in 10 year 24-hour storm event. Any storm events greater than the 1 in 10 year will discharge through the pond discharge channel. A pump station to return the water stored in the pond back to the TMF will be controlled through level controls. Supplemental booster pump stations will be required as the TMF embankment height increases.

Groundwater will be monitored in wells situated downstream of the Main Embankment and West Saddle Embankment. If deemed necessary, groundwater recovery wells may be installed in the same locations, with water being pumped back to the TMF.

On-going water quality monitoring will be required to assess the effectiveness of the Water Management System. In the unlikely event that the Water Management System is found to not effectively collect and recover seepage, it will be necessary to install additional seepage control provisions.

5.9 TAILINGS CONSOLIDATION ANALYSES

On-going consolidation of the tailings deposit is an important consideration for the design and construction of the TMF during operations and after closure. Consolidation occurs continuously within the tailings deposit during deposition and will continue after completion of operations until all excess pore pressures have dissipated. Expulsion of pore fluids during consolidation produces settlement of the tailings surface and a corresponding increase in the average density of the deposit.

KPL have developed a one-dimensional finite difference computer model which predicts the magnitude and rate of tailings consolidation and the corresponding average density of the deposit. This model incorporates the consolidation characteristics of the tailings, the tailings deposition rate and large strain consolidation theory.

Analyses were performed to predict average tailings dry densities and consolidation seepage rates during operations and after closure of the TMF. The effect of co-disposal of waste rock within the TMF on the tailings rate of rise was accounted for in the analysis.

An average tailings dry density of approximately 1.2 tonne/m^3 was predicted during the initial three years of operations, increasing to 1.3 tonne/m^3 in Year 4. Thereafter, the average dry density is predicted to increase gradually to approximately 1.5 tonne/m^3 by the end of operations when tailings deposition ceases. The density of the deposit will increase once tailings deposition ceases at closure and self-weight consolidation continues, assisted by surface desiccation due to evaporation from exposed tailings beach areas. Following the end of operations the average dry density of the tailings deposit is predicted to increase to approximately 1.55 to 1.6 tonne/m^3 once fully consolidated conditions are achieved.

The large majority of consolidation seepage from the tailings deposit (typically about 80% to 90%) flows upwards and towards the supernatant pond. Most of the remaining consolidation seepage will likely flow toward the more free-draining tailings beach areas, confining embankments and Waste Storage Area. The low quantity of downward consolidation seepage is due to the increasing drainage path length during operations (between freshly deposited tailings and the base of the TMF) and the low permeability of deeper, more consolidated, tailings at the base of the facility.

The tailings will remain partially consolidated during operations and for a period of time after closure until all excess pore water pressures have dissipated. The actual time taken for complete consolidation will be dependent on the in situ consolidation characteristics of the tailings material.

The methodology, assumptions and results of the tailings consolidation analysis are included in the KPL document "Report on Revised Tailings Management Facility Seepage Assessment" (Ref. No. VA101-325/8-13, December, 2012).

5.10 SEEPAGE ANALYSES

Steady-state seepage analyses for the TMF were carried out to estimate the amount of seepage through the embankments and foundation materials. The analyses were completed using the finite element computer program SEEP/W. Seepage rates through the Main Embankment, West Saddle Embankment and tailings basin were examined.

The seepage rate through foundation materials and embankment fill zones is influenced by the following factors:

- Permeability of the embankment zones
- Permeability of the foundation materials
- The thickness and permeability of the tailings stored within the TMF
- Distribution of waste rock within the TMF
- Seepage gradients in the embankment and foundation zones, and
- The seepage area available (increases with time during operations).

The seepage flow rate will vary over the life of the TMF as it gradually fills with tailings, potentially reactive mine waste rock and supernatant water. During operation of the TMF the tailings deposit will increase in thickness and decrease in permeability due to on-going consolidation. The seepage analyses have been performed to predict seepage flows from the TMF for the embankments at various stages throughout operations (Year 1, Year 10 and Final).

The seepage analyses have been based on typical cross-sections through the TMF, as shown on Figures 5.6 and 5.9. Foundation conditions incorporated into the seepage analyses were based on information provided by the geotechnical site investigation programs (described in Section 4.0).

Material permeabilities were determined for each of the embankment fill zones, tailings deposit and foundation materials. All foundation permeability values are based on the results of in situ testing performed during the 1994, 2010 and 2011 geotechnical site investigation programs. The permeability of core zone and cyclone sand fill zones in the Main Embankment were based on the results of laboratory testing. Permeability values adopted for the tailings deposit were estimated using the results of laboratory testing and consolidation modelling.

Flow rates for seepage components passing through the TMF embankments and passing directly into the TMF foundation (from the tailings and Waste Storage Area) were estimated. The predicted total seepage rate from the TMF is approximately 5 l/sec for Year 1 (Stage I Embankment), increasing to about 20 l/sec by Year 10 and approximately 40 l/sec for the final embankment arrangement (El. 998 m). Approximately 70% of the total seepage is estimated to flow directly into original ground and about 30% through the Main Embankment and West Saddle Embankment. For the final TMF arrangement approximately 97 % of the total seepage through the embankments is estimated to flow through the Main Embankment and 3 % through the West Saddle Embankment.

Long-term (post-closure) seepage rates from the TMF are expected to be similar or less than the predicted values for the final embankment arrangement at the end of operations, but will be dependent on the reclamation and closure plan developed for the facility.

Details of the material permeabilities, modelling assumptions and results of the steady-state seepage analyses provided by the SEEP/W models are presented in the KPL report "Revised Tailings Management Facility Seepage Assessment" (Ref. No. VA101-325/8-13, December, 2012).

Water quality studies and environmental effects assessment are on-going and take into account the quantity and quality of seepage from the TMF, including any seepage that will not be recovered by the Water Management System. The findings of this assessment will dictate if additional seepage collection and recovery systems will be required, such as groundwater recovery wells.

5.11 EMBANKMENT STABILITY ANALYSES

Stability analyses were carried out to investigate the stability of the Main Embankment under both static and seismic loading conditions. These comprised checking the stability of the embankment arrangement for each of the following cases:

- Static conditions during operations and post-closure
- Earthquake loading from the Operating Basis Earthquake (OBE) and the Maximum Design Earthquake (MDE), and
- Post-earthquake conditions using residual (post-liquefaction) tailings strengths.

The stability analyses were based on a typical cross-section through the Main Embankment for the final TMF with a supernatant pond elevation of 995 m and an embankment crest elevation of 998 m.

The stability analyses were carried out using the limit equilibrium computer program SLOPE/W. In this program a systematic search is performed to obtain the minimum factor of safety from a number of potential slip surfaces. Factors of safety have been computed using the Morgenstern-Price method.

In accordance with international recommendations (ICOLD, 1995) and standard industry practice, the minimum acceptable factor of safety for the tailings embankment under static conditions is 1.3 for short-term operating conditions and 1.5 for long-term (post-closure) of the TMF. A factor of safety of less than 1.0 is acceptable under earthquake loading conditions provided that calculated embankment deformations resulting from seismic loading are not significant and that the post earthquake stability of the embankment maintains a factor of safety greater than 1.2, implying there is no flow slide potential. For the post earthquake case the tailings deposit was conservatively assumed to be fully liquefied, and an appropriate low residual strength was applied.

The results of the stability analyses satisfy the minimum requirements for factors of safety and indicate that the proposed design is adequate to maintain both short term (operational) and long term (post-closure) stability. The seismic analyses indicate that any embankment deformations during earthquake loading from the OBE or MDE would be minor, and would not have any significant impact on embankment freeboard or result in any loss of embankment integrity. The results also indicate that the embankment is not dependent on tailings strength to maintain overall stability and integrity.

Details of the embankment stability analyses, including the adopted material strength parameters are presented in Appendix C.

6 – SITE WATER MANAGEMENT

6.1 GENERAL

The main objective of the site water management plan is to effectively control all water that originates within the project area, or is brought into the project area, in an environmentally responsible manner. This includes optimizing the use of available water sources to supply the water requirements of the milling process and related mining activities, thereby reducing the demand for external make-up water. Water sources that will be controlled include surface water runoff, groundwater from the open pit, process water, tailings consolidation seepage, TMF seepage and bleed water from cyclone sand placement.

Freshwater is required to supplement process water requirements at start-up and to provide makeup water to the mill throughout operations. Freshwater for use during mill start-up will be supplied by constructing the starter (Stage IA) embankment in pre-production years concurrent with open pit stripping, with construction scheduled to provide enough time to capture sufficient surface water runoff for mill start-up. It is anticipated that approximately 3 months of mill water requirements will be available in the start-up water pond prior to commencement of mill operations. Provisions for makeup water to the mill have been included in the TMF water balance. The freshwater source is assumed to be the Yukon River and/or a groundwater well field.

A monthly water balance model was developed for the TMF to assess the various flows to and from the facility, to predict the variation in supernatant pond volume during operations and to estimate makeup water requirements. The determination of an accurate water balance for the operating facility is a key part of the TMF design process.

6.2 WATER BALANCE MODEL

A stochastic analysis was carried out on the base case monthly operational mine site water balance using the GoldSim© software package. The intent of the modelling is to estimate the magnitude and extent of any water surplus and/or deficit conditions in the TMF based on a range of possible climatic conditions. The modelling timeline includes two pre-production years (Year -2 and Year -1), and 22 years of operation (Years 1 to 22), based on the mine production schedule. The TMF pond is assumed to have a minimum pond volume of 15 million m^3 (approximately 3 months of slurry water requirements) in all months throughout operations. Therefore, a deficit condition is defined as when the TMF pond volume is at the minimum volume of 15 million m^3 and that the system (including the TMF, open pit, and contributing catchments) is not able to supply enough water to meet the mill process water requirements, thereby indicating the need for make-up water. Details of the water balance model including a schematic of the model and a summary table of input values are included in Appendix D.

The water balance indicates that the mine site will likely be in a deficit condition over the operating life of the TMF, except for the last 1 to 2 years. The maximum annual volume of makeup water required occurs in Year 3 for all climate scenarios. The 95th percentile wet and dry values are defined as having a 5% and 95% chance of being equalled or exceeded in any year, respectively. The range of monthly TMF pond volumes from Years -2 to 22, for the 95th percentile dry, median and 95th percentile wet scenarios is included in Appendix D.

It should be noted that the water balance results are very sensitive to the input values, which are best estimates based on currently available information, so changes to the inputs could result in substantial changes to the results.

7 – TAILINGS DISTRIBUTION AND RECLAIM WATER SYSTEMS

7.1 GENERAL

There will be two separate tailings slurry streams from the mill. The principal (rougher) stream (80%) will consist of bulk Non-Acid Generating (NAG) tailings. The minor stream (20%) will be Potentially Acid Generating (PAG) material that will be handled and stored separately and maintained under water. Both of these tailings streams will leave the mill at a solids content of approximately 55%. For approximately nine months of each year on average the NAG tailings will be passed through a cyclone plant to produce clean sand for embankment construction. The cyclone plant will also produce a high volume low solids content stream, containing the fines fraction of the tailings (cyclone overflow). This material will be discharged into the TMF at a solids content of approximately 24%. A flow diagram of the tailings handling process is shown on Figure 7.1.

Only clean (geochemically innocuous) bulk NAG tailings may be cycloned to produce sand fill material for embankment construction. No potentially reactive materials can be used for embankment construction. Management of the PAG tailings stream during system maintenance or breakdown needs to be coordinated, to ensure that any combined tailings that includes the PAG stream is not directed to the cyclone sand plant.

On this basis the design must consider four separate tailings streams:

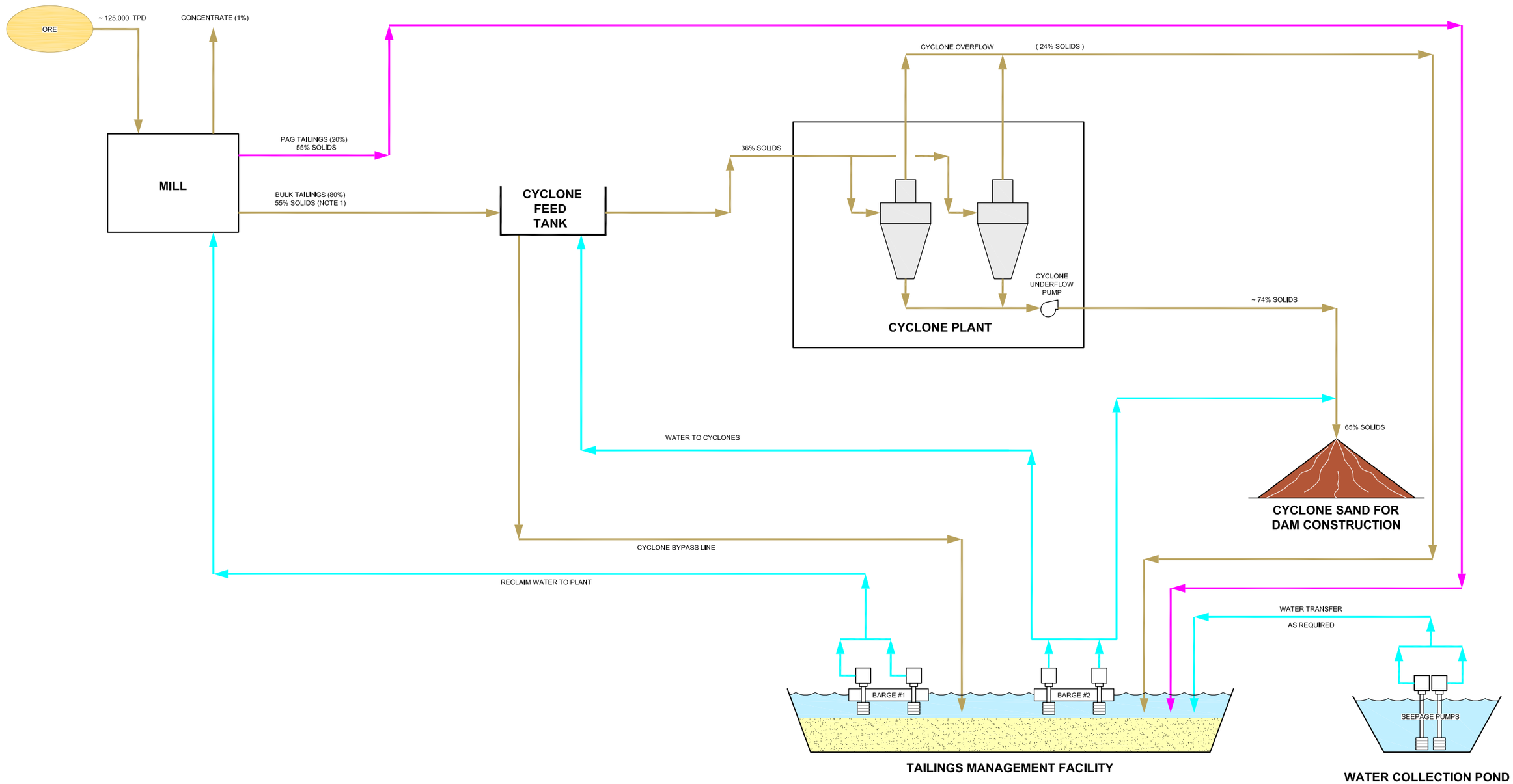
- PAG tailings
- Bulk NAG tailings
- Cyclone sand (underflow), and
- Cyclone overflow.

The higher elevation of the mill relative to the TMF will enable gravity discharge for the tailings streams, including cyclone sand products for most, if not the entire project life.

Water will be reclaimed from the tailings supernatant pond by two floating, barge mounted, pump-stations. One reclaim barge reports to the process water settlement pond located above the mill terrace for mill water and the other to a dilution water head tank to provide gravity flow to the cyclone feed tank.

General locations for the tailings delivery lines, cyclone plant and reclaim system over the operating life of the TMF are included on Figure 5.1 for pre-production conditions (start of operations) and Figures 5.2 to 5.5 for operating years 1, 4, 10 and 22 (Final) respectively.

Summaries of the tailings distribution, cyclone sand production and reclaim water systems are provided in the following sections.



NOTES:

1. BULK NAG TAILINGS AT 55% SOLIDS ARE DIRECTED TO CYCLONE PLANT FOR APPROXIMATELY 9 MONTHS PER YEAR OTHERWISE DISCHARGE IS DIRECTLY INTO TMF.

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TAILINGS HANDLING PROCESS FLOW DIAGRAM

Knight Piésold CONSULTING

P/A NO. VA101-325/8

REF NO. 10

FIGURE 7.1

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7.2 PAG TAILINGS DISTRIBUTION

A single PAG tailings line will be laid heading approximately east from the mill, between low grade ore stockpiles, down to the TMF. Valved tees located at intervals in the line will enable subaqueous deposition of the PAG tailings into the TMF. This can be accomplished using a floating HDPE pipeline with submerged exit holes. The line will be moored to shore to allow its location to be managed. Floatation will be provided to ensure that the line remains at surface. Consideration will be given in future design studies to the possibility of the floating line freezing during winter conditions.

The design of the PAG tailings delivery system from the mill to the TMF has been designed by Others.

7.3 BULK NAG TAILINGS DISTRIBUTION

Bulk NAG tailings will be delivered to the southwest end of the TMF, either for the production of sand via the cyclone plant (for approximately nine months per year) or for direct deposition into the TMF.

The design of the NAG tailings delivery system from the mill to the tailings head tank (feeding the cyclone plant) has been designed by Others. The design of the tailings delivery systems from the tailings head tank onwards have been designed by Paterson and Cooke (details are provided in Appendix E).

The same pipe system used to deliver the cyclone overflow stream to the TMF can also be used for the undiluted Bulk NAG tailings stream when the cyclone station is by-passed (see Section 7.4.2). Tailings discharge into the TMF will be from a selected valved off-take along a pipeline on the embankment crest. Valves will be spaced at approximately 100 meter intervals. Normally only one off-take will be open to manage the tailings discharge. Discharge into the TMF will not be continuous from any one location in the pipeline. It will be rotated between off-takes as appropriate for tailings distribution within the TMF. This will ensure adequate beach development adjacent to the embankments and maximize the ability of the reclaim system to recover clean water.

Discharge from the line will be enabled at appropriately located tees, each provided with a downstream isolation valve and an off-take valve. The off-take will typically include a downstream section of pipeline to allow single point tailings out-flow to be delivered into the surface water pond or beach, with minimum erosion of the confining embankment face.

7.4 CYCLONE SAND PRODUCTION

The design of the Cyclone Sand Plant and delivery systems from the sand plant to the TMF have been designed by Paterson and Cooke of Vancouver, B.C. Details of the design of the cyclone sand plant, cyclone underflow (sand) distribution system, cyclone overflow (fines) distribution system (including the bulk NAG tailings by-pass system) and associated water systems are provided in the Paterson Cooke report “Casino Project Tailings Cyclone and Transport Study – Feasibility Study Report, December, 2012). This document is included as Appendix E.

A required design criterion for the cyclone plant sand product is that the fines content (% passing a #200 sieve) must be 12% or less. The current particle size distribution of the bulk NAG tailings (approximately 58% sand fraction) and information provided by cyclone suppliers indicates that single-stage cycloning will be sufficient to achieve a clean sand product with 12% fines or less and a

sand recovery of approximately 50% by weight from the bulk tailings stream. The cyclone feed will require water addition to reduce the cyclone feed solids content to 36%. The sand (cyclone underflow) product will be produced at approximately 74% solids by weight. This will require water addition and mixing to a solids content of approximately 65% for distribution to discharge points along the embankment crest.

7.4.1 Cyclone Sand Discharge to Main Embankment

Cyclone sand will be delivered through a piping system on the downstream side of the embankment.

The pipe system consists of four sections:

- 18" downhill pipe
- 18" horizontal pipe on the sand jacking header
- 14" downhill pipes – from jacking header, and
- 14" downhill pipe – jacking header bypass for high turn down throughput requirements.

The 18" cyclone sand pipeline initially follows the 15% site gradient down towards the dam. At the Main Embankment the pipeline continues on a jacking header. 14" take off valves are provided every 100 metres from the main pipeline for sand deposition. Each take-off valve is connected to a mobile 14" HDPE DR 11 pipe, running downhill on the embankment to sand deposition cells (approximately 100 m by 20 m in size). Each 14" individual branch pipe is capable of transporting the full sand plant production to fill a cell at a time.

7.4.2 Cyclone Overflow Discharge

In conjunction with the production of the cyclone sand, the cyclone plant produces a large volume of tailings fines (combined cyclone overflow), at a low solids content (approximately 24%). This material is discharged into the TMF from points upstream of the Main Embankment, generally over the same locations as the bulk NAG tailings.

This system handles the cyclone overflow stream as well as the undiluted Bulk NAG tailings stream when the cyclone station is by-passed.

The system consists of three sections:

- 36" HDPE DR 11 downhill pipe
- 32" CS Std Sch horizontal pipe on jacking header, and
- 16" HDPE DR 17 take-off pipes from the jacking header.

The cyclone overflow pipeline initially follows the 15% site gradient down to the Main Embankment. On the embankment the pipe is laid on a hydraulically raised jacking header, which is a separate structure from the sand jacking header. 16" take-offs with valves are placed every 100 metres. Each take-off valve is connected to a 16" HDPE DR 17 pipe running down from the jacking header onto the beach of the TMF.

7.5 RECLAIM WATER SYSTEM

Water will be reclaimed from the tailings supernatant pond by two floating, barge mounted, pump-stations. One reclaim barge reports to the process water settlement pond located above the mill terrace for mill water and the other to a dilution water head tank to provide gravity flow to the cyclone

feed tank. The floating pump-stations will be located in the general southwest corner of the TMF at the start of operations.

Additional pump-stations in series are currently envisaged for the mill reclaim system, due to the significant elevation difference between the initial supernatant pond in the TMF and the mill, coupled with the possibility of a shallow supernatant pond increasing the risk of barge grounding.

The design of the reclaim water system from the TMF to the mill and from the TMF to the dilution water head tank has been completed by Others.

Water reclaimed from the TMF consists of supernatant from the settled tailings, as well as run-off from precipitation, snowmelt and ice melt, from within the TMF catchment area. Dedicated pipelines will convey reclaimed water to the settlement pond located up-gradient of the mill and a water head tank up-gradient of the cyclone plant. The initial mill reclaim discharge pipeline will run approximately northwest and relatively directly to the mill head tank. The cyclone plant water line will run approximately west from the TMF.

Water reclaim from the surface water pond begins with two shallow draft, barge mounted, reclaim pump-stations, that float within the TMF. These will be installed at locations remote from the point of normal tailings discharge to ensure clean water recovery. A shallow draft maximizes the potential for year round recovery of water of acceptable clarity. Relocation of the barges is required to accommodate ongoing development of the TMF, changes in the elevation of the surface water pond and encroachment of the tailings discharge plume into the vicinity of the barge.

The barges will be fitted with vertical turbine pumps, including standby pumping capacity and all necessary control, check, drainage and isolation valves. One pump will normally be operated on the mill reclaim barge at all times during winter, to reduce the potential for water freezing in the reclaim pipeline. The cyclone reclaim system will be drained and the barge winterized appropriately.

8 – INSTRUMENTATION AND MONITORING

8.1 GENERAL

Geotechnical instrumentation will be installed in the tailings embankment and foundation during construction and over the life of the project. The instrumentation will be monitored during the construction and operation of the TMF to assess embankment performance and to identify any conditions different to those assumed during design and analysis. Amendments to the on-going designs and/or remediation work can be implemented to respond to the changed conditions, should the need arise.

Geotechnical instrumentation, comprising vibrating wire piezometers, thermistors, slope inclinometers and movement (survey) monuments will be installed at selected planes along the Main Embankment and West Saddle Embankment. Groundwater wells will be installed at suitable locations downstream of the embankment.

Monitoring of civil and mechanical operational components will be a daily/shift requirement, to ensure that systems are functioning correctly. Excess noise/wear/movement/leakage/spillage etc. may indicate problems with pipelines or valves. In particular, during winter operations, ice formation may impact reclaim barge stability and operation or result in blockage of pipelines.

8.2 INSTRUMENTATION

Vibrating wire type piezometers will be installed in the embankment fill, foundations and tailings deposit to measure pore water pressures during initial placement, throughout operations and post-closure. The piezometers will be distributed throughout the various foundation and fill zones to provide a spectrum of monitoring data. Thermistors may be required to determine the temperature profile to supplement piezometer data. The piezometer and thermistor leads will be appropriately routed to read-out panels for ease of monitoring.

Movement monuments will be installed on the embankment crest following the completion of selective embankment raises to monitor deflections along the slope and crest of the embankment. Periodic surveying of the monument locations will provide early warning of movements and possible acceleration of movement which often occurs prior to failure

Groundwater monitoring/recovery wells will be installed at appropriate locations along the downstream toe of the Main Embankment. The wells will be used to recover samples for water quality monitoring.

8.3 MONITORING PROGRAM

Monitoring should be done routinely both during construction and operations. Following initial installation of the geotechnical instrumentation, measurements should be taken and analyzed on a daily basis to monitor the response of the earthfill and foundation from fill loading.

The frequency of monitoring for piezometers and inclinometers may be decreased to bi-monthly readings once the effects of initial construction have dissipated. Surface movement monuments should be surveyed twice per year during operations. Water quality and flow monitoring of the seepage through the embankment and foundation shall be monitored monthly during operations.

Pipeline and pump-station flow, wear and pressure monitoring, pump-power consumption and vibration monitoring will be ongoing requirements. During winter, heating, insulation and de-icing measures must be checked on a shift by shift basis. For all pipelines, any components required for emergency use, such as drainage, must be scheduled for inspection.

8.4 INSPECTION AND REVIEW

In addition to the routine inspections carried out by mine personnel on a shift/daily/weekly and monthly basis, the TMF should be regularly audited by a suitably qualified Geotechnical Engineer to ensure it is operating in a safe and efficient manner. Such audits should be conducted annually. Additionally, a formal dam safety review should be conducted every 5 to 10 years, depending on the dam classification assigned to the TMF embankments. For a HIGH dam classification, the frequency suggested by the CDA “Dam Safety Guidelines” (2007) is seven years. The dam classification is reviewed during the dam safety review process and should also be routinely reviewed as part of the annual audit.

9 – CLOSURE AND RECLAMATION

9.1 GENERAL

The primary objective of the closure and reclamation initiatives will be to eventually return the TMF site to a self-sustaining facility with pre-mining usage and capability. The TMF will be required to maintain long-term stability, protect the downstream environment and manage surface water. Activities that will be carried out during operations and at closure to achieve these objectives are discussed in the following sections.

The closure plan for the project is being developed by Others.

9.2 DECOMMISSIONING AND CLOSURE

Upon mine closure, surface facilities will be removed in stages and full reclamation of the TMF will be initiated. General aspects of the closure plan include:

- Selective discharge of tailings around the facility during the final years of operations to establish a final tailings surface and water pond that will facilitate post closure surface water management and reclamation (including full coverage by the water pond to ensure all PAG tailings and reactive (PAG/ML) waste rock remain in a fully saturated state).
- Dismantling and removal of the tailings and reclaim delivery systems, cyclone plant and all pipelines, structures and equipment not required beyond mine closure.
- Removal of the seepage collection system at such time that suitable water quality for direct release is achieved.
- Construction of an overflow spillway and channel to allow surface water discharge downstream of the TMF.
- Removal and regrading of all access roads, ponds, ditches and borrow areas not required beyond mine closure.
- Long-term stabilization of all exposed erodible materials.
- During the closure phase of the project, suitable topsoil and seeding will be placed on the beach surface after tailings deposition ends to promote revegetation and minimise dusting potential.

9.3 CLOSURE SPILLWAY

A spillway and downstream channel will be required at closure to facilitate control and discharge of excess water accumulation within the TMF and to provide safe passage of storm water volumes from the TMF. The water balance model developed for the TMF indicates that there will be a water surplus at closure.

The closure spillway will be located close to the west abutment of the West Saddle Embankment to provide long term protection against overtopping of the TMF during the post closure years. The spillway will be routed from the TMF to the south, ultimately terminating at a plunge pool prior to discharging to Brynelson Creek, as shown on Figure 9.1.

The spillway design flow (SDF) for the closure spillway was calculated by routing the Probable Maximum Flood (PMF) storm hydrograph through the TMF supernatant pond assuming the facility is at capacity at the time the storm occurs. Diversion ditches were assumed to have been damaged

and not functioning in this storm flood routing evaluation. The routing exercise determined the IDF hydrograph for the TMF to be 854 m^3/s. Modelling of the closure spillway indicated that a 20 meter wide spillway sill, with 2 horizontal to 1 vertical side slopes will result in a peak outflow (SDF) from the pond of approximately 45 m^3/s, with a peak water elevation of 1.1 m above the closure spillway invert.

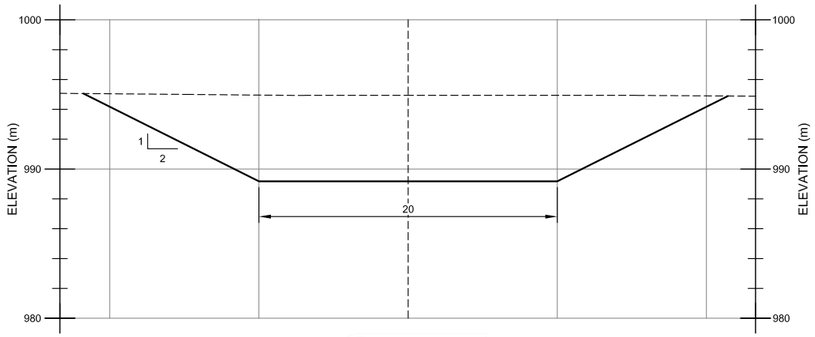
The spillway will be comprised of a 20 meter wide side sill, with 2 horizontal to 1 vertical side slopes, excavated in bedrock to an invert elevation of 3 m below the crest of the dam. The sill of the spillway will convey the SDF downstream to a discharge channel that will be aligned along an existing tributary for Brynelson Creek. This tributary will be modified to provide a channel having a minimum base width of 5 meters, and 1 (or greater) horizontal to 1 vertical side slopes. The spillway channel will ultimately terminate at an adequately sized and erosion protected plunge pool at the confluence of Brynelson Creek. Flow depths through the spillway channel have been calculated to range between 0.6 m in the steeper upper regions and 1 m in the shallower lower regions.

To satisfy post-closure water quality requirements and objectives a concrete “stop-log” system may be installed in the spillway structure to facilitate impounding of the supernatant pond. This allows downstream seepage water to be collected and returned to the pond during the winter months, and released during the summer months.

9.4 ON-GOING MONITORING REQUIREMENTS

The seepage collection ponds/sumps and recycle pumps will be retained until monitoring results indicate that any seepage from the TMF is of suitable quality for direct release to downstream waters. The groundwater monitoring wells and all other geotechnical instrumentation will be retained for use as long term monitoring devices.

Post-closure requirements will also include an annual inspection of the TMF and an on-going evaluation of water quality, flow rates and instrumentation records to confirm design assumptions for closure.



1 - FIG **SECTION**
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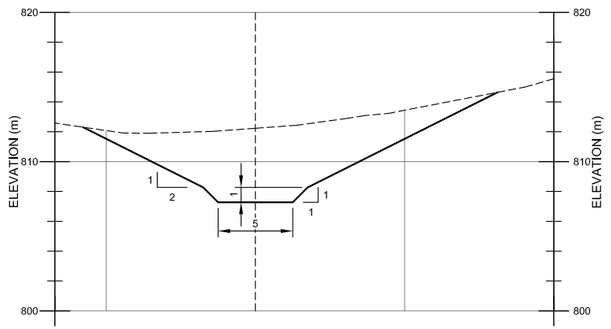

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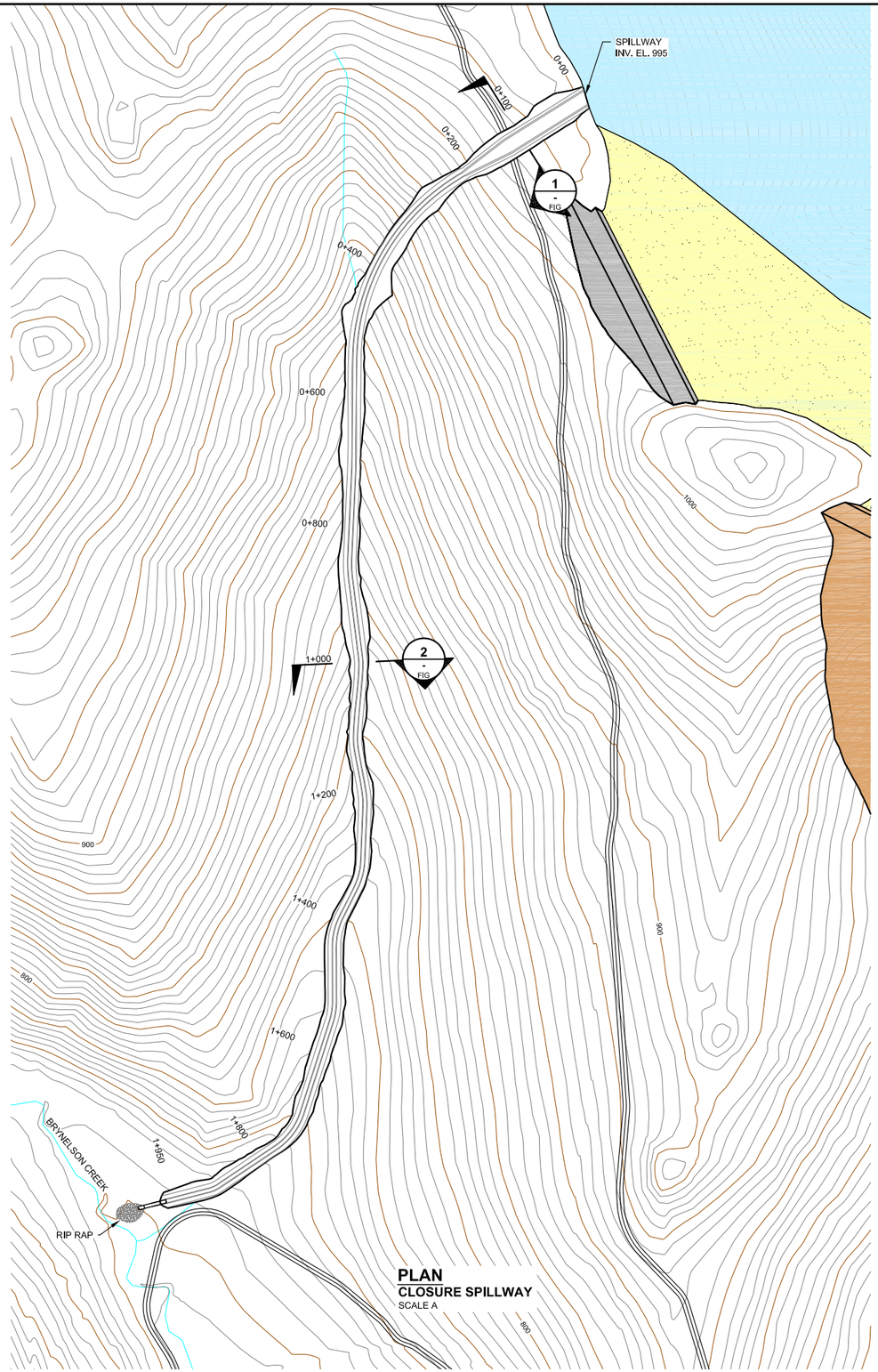
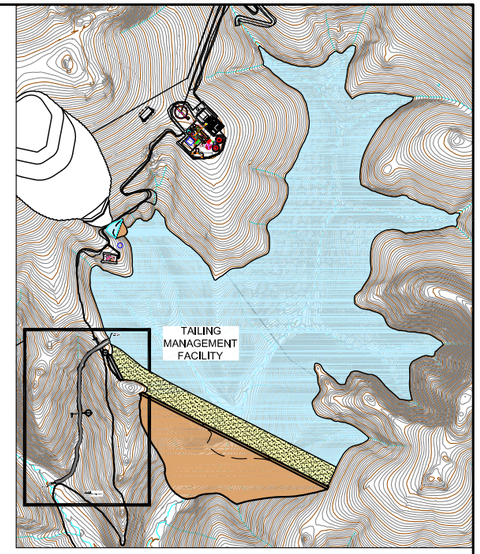


PLAN
CLOSURE SPILLWAY
SCALE A



KEY PLAN

NOTES:

1. COORDINATE GRID IS UTM (WGS84/NAD83) ZONE 7 (m).
2. CONTOUR INTERVAL IS 5 METRES.
3. DIMENSIONS AND ELEVATIONS ARE IN METRES, UNLESS NOTED OTHERWISE
4. PLANT SITE AND CRUSHER LAYOUT PROVIDED BY M3 ENGINEERING AND TECHNOLOGY CORPORATION.(OCTOBER 4, 2012)

SCALE B 4 2 0 4 8 12 16 20 m

SCALE A 80 40 0 100 200 300 400 mm

CASINO MINING CORPORATION

CASINO COPPER GOLD PROJECT

TAILINGS MANAGEMENT FACILITY
CLOSURE SPILLWAY

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FIGURE 9.1 REV 0

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10 – SCHEDULE OF QUANTITIES

Quantity estimates for the materials and work items required for initial construction and for ongoing expansion and operation of the TMF are presented in Table 10.1.

Quantities have been estimated for the following components of the TMF:

- Topsoil/overburden stripping
- Foundation preparation within the embankment footprints (including excavation of unsuitable materials)
- Embankment fill placement, including seepage cut-off
- Seepage interception and collection system
- Instrumentation and monitoring, and
- Closure Spillway

The Feasibility level quantities were measured on the basis of the designs and dimensions shown on the relevant Figures of this report. These quantities have been developed to enable costing to be conducted to a level of accuracy of ± 15 percent. It is understood that the all initial and sustaining capital costs and operating costs will be carried out by Others.

The cost estimate will also need to include the following items:

- Hauling of all embankment fill materials to the embankment
- Hauling of topsoil/overburden materials to stockpiles
- Hauling of unsuitable foundation soils for disposal within TMF
- Hauling potentially reactive waste rock and overburden to the TMF, and
- Electrical power supply, instrumentation and control.

Equipment lists and quantities (material take-off lists) for the cyclone sand plant, cyclone underflow (sand) distribution system, cyclone overflow (fines) distribution system (including the bulk NAG tailings by-pass system) and associated water systems are provided in the Paterson Cooke report "Casino Project Tailings Cyclone and Transport Study – Feasibility Study Report, December, 2012). This document is included as Appendix E.

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TABLE 10.1

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

FEASIBILITY DESIGN OF THE TAILINGS MANAGEMENT FACILITY
TAILINGS MANAGEMENT FACILITY SCHEDULE OF QUANTITIES

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Item Number		Description	Unit	PP Quantity	Year 1 Quantity	Year 2 Quantity	Year 3 Quantity	Year 4 Quantity	Year 5 Quantity	Year 6 Quantity	Year 7 Quantity	Year 8 Quantity	Year 9 Quantity	Year 10 Quantity	Year 11 Quantity
1		**TAILINGS MANAGEMENT FACILITY EARTHWORKS**													
		MAIN EMBANKMENT													
1.1		**Clearing and Grubbing TMF Main Embankment Foundation Footprint**	m^2	242,000	176,000	154,000	132,000	110,000	88,000	88,000	77,000	66,000	66,000	55,000	55,000
1.2		**Topsoil Stripping of TMF Main Embankment Foundation Footprint - 1 m Average**	m^3	242,000	176,000	154,000	132,000	110,000	88,000	88,000	77,000	66,000	66,000	55,000	55,000
1.3		**Excavation of Colluvial Apron under TMF Main Embankment Foundation Footprint (10 m Average)**	m^3	1,315,000	317,000	317,000	317,000	317,000	317,000	317,000	317,000	317,000	317,000	317,000	317,000
1.4		**Excavation of Core Trench in Overburden Other Than Colluvial Apron**	m^3	104,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000
1.5		**Construction Dewatering - Upstream Cofferdam and Pumping**	PS	1	0	0	0	0	0	0	0	0	0	0	0
1.6		**TMF Main Embankment Construction**													
	a	Haul, Place and Compact Upstream Blanket	m^3	226,000	0	0	0	0	0	0	0	0	0	0	0
	b	Haul, Place and Compact Core Zone (Excluding Upstream Blanket)	m^3	3,046,000	0	477,000	486,000	364,000	282,000	408,000	400,000	333,000	385,000	350,000	313,000
	c	Haul, Place and Compact Filter Zone	m^3	221,000	0	94,000	96,000	72,000	55,000	81,000	79,000	66,000	76,000	69,000	62,000
	d	Haul, Place and Compact Shell Zone from Local Borrow	m^3	5,630,000	1,320,000	0	0	0	0	0	0	0	0	0	0
	e	Haul, Place and Compact Shell Zone from Open Pit	m^3	1,100,000	0	0	0	0	0	0	0	0	0	0	0
	f	Haul, Place and Compact Cycloned Sand	m^3	0	5,589,000	7,440,000	7,422,000	7,396,000	7,331,000	7,323,000	7,319,000	7,411,000	7,467,000	7,254,000	7,241,000
		WEST EMBANKMENT													
1.7		**Clearing TMF West Embankment Foundation Footprint**	m^2	41,000	0	0	0	0	0	0	0	0	0	0	0
1.8		**Stripping and Grubbing TMF West Embankment Foundation Footprint - 1 m Average**	m^3	41,000	0	0	0	0	0	0	0	0	0	0	0
1.9		**Excavation of Core Trench in Overburden**	m^3	9,000	0	0	0	0	0	0	0	0	0	0	0
1.10		**TMF West Embankment Construction**													
	a	Haul, Place and Compact Core Zone	m^3	58,000	0	0	0	0	0	0	0	0	0	0	0
	b	Haul, Place and Compact Filter Zone	m^3	19,000	0	0	0	0	0	0	0	0	0	0	0
	c	Haul, Place and Compact Shell Zone from Local Borrow	m^3	313,000	0	0	0	0	0	0	0	0	0	0	0
2		**SEEPAGE AND SURFACE WATER MANAGEMENT SYSTEM**													
		WATER MANAGEMENT POND													
2.1		**Excavation of Unsuitable Materials (Average 20 m Depth)**	m^3	591,000	0	0	0	0	0	0	0	0	0	0	0
2.2		**Backfilling/Pond Slope Construction**	m^3	33,000	0	0	0	0	0	0	0	0	0	0	0
2.3		**Liner System**													
	a	Primary Geomembrane: 60 mil (1.5 mm) LLDPE	m^2	50,000	0	0	0	0	0	0	0	0	0	0	0
	b	Leak Detection Layer/ Drainage Gravel Layer (0.3 m thick)	m^3	9,400	0	0	0	0	0	0	0	0	0	0	0
	c	Bedding Layer, 300 mm Thick (Supply, Place and Compact)	m^3	9,400	0	0	0	0	0	0	0	0	0	0	0
2.4		**Return Pipeline from WMP to TMF (HDPE DR9 700 mm)**	m	1,600	0	0	0	0	0	0	0	0	0	0	0
2.5		**Pond Spillway and Discharge Channel (Approx. 472 m Length) (Excavation and Erosion Protection)**	m^3	22,000	0	0	0	0	0	0	0	0	0	0	0
2.6		**Pump Station (313 m Head, 972 m3/hr)**	LS	1	0	0	0	0	0	0	0	0	0	0	0
2.7		**Access Road**	m	1,700	0	0	0	0	0	0	0	0	0	0	0
2.8		**Construction and Engineered Lining/Energy Dissapation (Width = 2.5 to 6 m)**	m	6,100	0	0	0	0	0	0	0	0	0	0	0
2.8		**Drainage Ditching**													
	a	Construction and Engineered Lining/Energy Dissapation (Width = 2.5 to 6 m)	m	6,100	0	0	0	5,400	0	0	0	0	0	6,900	0
	b	Upgrade to existing (widening)	m	0	0	0	0	1,300	0	0	0	0	0	800	0
		SEEPAGE COLLECTION SYSTEM													
2.9		**Gravel Collection Drainage Mat (300 mm Thickness)**	m^3	34,000	0	0	0	117,000	0	0	0	0	0	111,000	0
2.10		**Sub-Collector Header Pipes (HDPE DR7.3 150 mm)**	m	1,200	0	0	0	2,100	0	0	0	0	0	2,700	0
2.11		**Collector Header Pipes (HDPE DR7.3 150 mm)**	m	760	0	0	0	0	0	0	0	0	0	0	0
2.12		**Deep-trench Seepage Connection Pipe to Pond (HDPE DR7.3 150 mm)**	m	210	0	0	0	0	0	0	0	0	0	0	0
3		**CLOSURE SPILLWAY**													
3.1		**Stripping and Grubbing**	m^2	0	0	0	0	0	0	0	0	0	0	0	0
3.2		**Excavation of Overburden**	m^3	0	0	0	0	0	0	0	0	0	0	0	0
3.3		**Spillway Excavation - Drill and Blast Rock**													
	a	Spillway Channel	m^3	0	0	0	0	0	0	0	0	0	0	0	0
	b	Plunge Pool	m^3	0	0	0	0	0	0	0	0	0	0	0	0
3.4		**Erosion Protection at Spillway Outlet**													
	a	Erosion Protection at Spillway Outlet - Rip Rap	m^3	0	0	0	0	0	0	0	0	0	0	0	0
	b	Erosion Protection at Spillway Outlet - Geotextile Liner	m^2	0	0	0	0	0	0	0	0	0	0	0	0
3.5		**Hydroseeding of Erodible Exposed Overburden Faces**	m^2	0	0	0	0	0	0	0	0	0	0	0	0
3.6		**Spillway Surface Foundation Treatment**													
	a	Concrete	m^3	0	0	0	0	0	0	0	0	0	0	0	0
	b	Mesh	m^2	0	0	0	0	0	0	0	0	0	0	0	0
	c	Anchor Bolts #5 or #6 Rebar	m	0	0	0	0	0	0	0	0	0	0	0	0
	d	Rebar Face Plates	ea	0	0	0	0	0	0	0	0	0	0	0	0
4		**INSTRUMENTATION AND MONITORING**	PS	1	0	0	0	0	0	0	0	0	0	0	0
5		**SEDIMENT AND EROSION CONTROL BMP'S ALLOWANCE**	PS	1	0	0	0	0	0	0	0	0	0	0	0

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TABLE 10.1

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CASINO COPPER-GOLD PROJECT

FEASIBILITY DESIGN OF THE TAILINGS MANAGEMENT FACILITY
TAILINGS MANAGEMENT FACILITY SCHEDULE OF QUANTITIES

Item Number	Description	Unit	Year 12 Quantity	Year 13 Quantity	Year 14 Quantity	Year 15 Quantity	Year 16 Quantity	Year 17 Quantity	Year 18 Quantity	Year 19 Quantity	Year 20 Quantity	Year 21 Quantity	Year 22 Quantity
1	**TAILINGS MANAGEMENT FACILITY EARTHWORKS**												
	MAIN EMBANKMENT												
1.1	**Clearing and Grubbing TMF Main Embankment Foundation Footprint**	m^2	55,000	55,000	55,000	55,000	0	0	0	0	0	0	0
1.2	**Topsoil Stripping of TMF Main Embankment Foundation Footprint - 1 m Average**	m^3	55,000	55,000	55,000	55,000	0	0	0	0	0	0	0
1.3	**Excavation of Colluvial Apron under TMF Main Embankment Foundation Footprint (10 m Average)**	m^3	317,000	317,000	317,000	317,000	0	0	0	0	0	0	0
1.4	**Excavation of Core Trench in Overburden Other Than Colluvial Apron**	m^3	7,000	7,000	7,000	7,000	0	0	0	0	0	0	0
1.5	**Construction Dewatering - Upstream Cofferdam and Pumping**	PS	0	0	0	0	0	0	0	0	0	0	0
1.6	**TMF Main Embankment Construction**												
a	Haul, Place and Compact Upstream Blanket	m^3	0	0	0	0	0	0	0	0	0	0	0
b	Haul, Place and Compact Core Zone (Excluding Upstream Blanket)	m^3	319,000	372,000	286,000	290,000	342,000	300,000	306,000	313,000	214,000	164,000	166,000
c	Haul, Place and Compact Filter Zone	m^3	63,000	74,000	56,000	57,000	67,000	59,000	60,000	62,000	42,000	32,000	32,000
d	Haul, Place and Compact Shell Zone from Local Borrow	m^3	0	0	0	0	0	0	0	0	0	0	0
e	Haul, Place and Compact Shell Zone from Open Pit	m^3	0	0	0	0	0	0	0	0	0	0	0
f	Haul, Place and Compact Cycloned Sand	m^3	7,429,000	7,492,000	7,419,000	7,320,000	7,300,000	7,253,000	2,569,000	2,569,000	2,569,000	2,000,000	1,000,000
	WEST EMBANKMENT												
1.7	**Clearing TMF West Embankment Foundation Footprint**	m^2	0	0	0	0	0	0	0	0	0	0	0
1.8	**Stripping and Grubbing TMF West Embankment Foundation Footprint - 1 m Average**	m^3	0	0	0	0	0	0	0	0	0	0	0
1.9	**Excavation of Core Trench in Overburden**	m^3	0	0	0	0	0	0	0	0	0	0	0
1.10	**TMF West Embankment Construction**												
a	Haul, Place and Compact Core Zone	m^3	0	0	0	0	0	0	0	0	0	0	0
b	Haul, Place and Compact Filter Zone	m^3	0	0	0	0	0	0	0	0	0	0	0
c	Haul, Place and Compact Shell Zone from Local Borrow	m^3	0	0	0	0	0	0	0	0	0	0	0
2	**SEEPAGE AND SURFACE WATER MANAGEMENT SYSTEM**												
	WATER MANAGEMENT POND												
2.1	**Excavation of Unsuitable Materials (Average 20 m Depth)**	m^3	0	0	0	0	0	0	0	0	0	0	0
2.2	**Backfilling/Pond Slope Construction**	m^3	0	0	0	0	0	0	0	0	0	0	0
2.3	**Liner System**												
a	Primary Geomembrane: 60 mil (1.5 mm) LLDPE	m^2	0	0	0	0	0	0	0	0	0	0	0
b	Leak Detection Layer/ Drainage Gravel Layer (0.3 m thick)	m^3	0	0	0	0	0	0	0	0	0	0	0
c	Bedding Layer, 300 mm Thick (Supply, Place and Compact)	m^3	0	0	0	0	0	0	0	0	0	0	0
2.4	**Return Pipeline from WMP to TMF (HDPE DR9 700 mm)**	m	0	0	0	0	0	0	0	0	0	0	0
2.5	**Pond Spillway and Discharge Channel (Approx. 472 m Length) (Excavation and Erosion Protection)**	m^3	0	0	0	0	0	0	0	0	0	0	0
2.6	**Pump Station (313 m Head, 972 m3/hr)**	LS	0	0	0	0	0	0	0	0	0	0	0
2.7	**Access Road**	m	0	0	0	0	0	0	0	0	0	0	0
2.8	**Drainage Ditching**	m	0	0	0	0	0	0	0	0	0	0	0
a	Construction and Engineered Lining/Energy Dissapation (Width = 2.5 to 6 m)	m	0	0	0	0	0	0	0	0	0	0	0
b	Upgrade to existing (widening)	m	0	0	0	0	0	0	0	0	0	0	0
	SEEPAGE COLLECTION SYSTEM												
2.9	**Gravel Collection Drainage Mat (300 mm Thickness)**	m^3	0	0	0	0	0	0	0	0	0	0	143,000
2.10	**Sub-Collector Header Pipes (HDPE DR7.3 150 mm)**	m	0	0	0	0	0	0	0	0	0	0	3,500
2.11	**Collector Header Pipes (HDPE DR7.3 150 mm)**	m	0	0	0	0	0	0	0	0	0	0	0
2.12	**Deep-trench Seepage Connection Pipe to Pond (HDPE DR7.3 150 mm)**	m	0	0	0	0	0	0	0	0	0	0	0
3	**CLOSURE SPILLWAY**												
3.1	**Stripping and Grubbing**	m^2	0	0	0	0	0	0	0	0	0	0	67,000
3.2	**Excavation of Overburden**	m^3	0	0	0	0	0	0	0	0	0	0	187,000
3.3	**Spillway Excavation - Drill and Blast Rock**												
a	Spillway Channel	m^3	0	0	0	0	0	0	0	0	0	0	39,000
b	Plunge Pool	m^3	0	0	0	0	0	0	0	0	0	0	1,100
3.4	**Erosion Protection at Spillway Outlet**												
a	Erosion Protection at Spillway Outlet - Rip Rap	m^3	0	0	0	0	0	0	0	0	0	0	5,500
b	Erosion Protection at Spillway Outlet - Geotextile Liner	m^2	0	0	0	0	0	0	0	0	0	0	2,800
3.5	**Hydroseeding of Erodible Exposed Overburden Faces**	m^2	0	0	0	0	0	0	0	0	0	0	55,000
3.6	**Spillway Surface Foundation Treatment**												
a	Concrete	m^3	0	0	0	0	0	0	0	0	0	0	4,400
b	Mesh	m^2	0	0	0	0	0	0	0	0	0	0	23,700
c	Anchor Bolts #5 or #6 Rebar	m	0	0	0	0	0	0	0	0	0	0	23,700
d	Rebar Face Plates	ea	0	0	0	0	0	0	0	0	0	0	23,700
4	**INSTRUMENTATION AND MONITORING**	PS	0	0	0	0	0	0	0	0	0	0	0
5	**SEDIMENT AND EROSION CONTROL BMP'S ALLOWANCE**	PS	0	0	0	0	0	0	0	0	0	0	0

\\VAN11\Prj_file\1\01\00325\08\A\Report\10 - TMF Feasibility Design Report\Rev 0\Tables\[Table 10.1 Rev 0 - Earthworks Schedule of Quantities.xlsx]Table 10.1

NOTE:

1. PS = PROVISIONAL SUM.
2. QUANTITIES INCLUDE 10% OVERBUILD ALLOWANCE.
3. ALL VOLUME ARE IN PLACE -> BCM / CCM / LCM
4. NO CONTINGENCY ADDED TO QUANTITIES.
5. ALL ROCKFILL IS ASSUMED TO BE SOURCED FROM LOCAL BORROW SOURCES.
6. COLLUVIAL APRON IS ICE-RICH SOIL AND MORE DIFFICULT TO EXCAVATE THAN OTHER OVERBURDEN.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	07DEC'12	ISSUED WITH REPORT VA101-325/8-10	SB	LM	KJB

11 – RECOMMENDATIONS FOR FUTURE STUDIES

The following is a list of recommendations for additional geotechnical site investigations, laboratory testing and design studies required to carry the TMF design through to final design and construction:

Geotechnical Investigations and Laboratory Testwork

- Additional geotechnical drilling and test pits in the TMF area to investigate and confirm foundation conditions (specifically the extent of the colluvial apron), permafrost characteristics and depth to bedrock.
- Additional test pits and drilling to confirm suitability and quantity of borrow materials for embankment construction (specifically low permeability soils for embankment core zone).
- Additional laboratory index testing (including compaction tests) and strength and permeability tests on potential borrow materials for embankment construction.
- Laboratory testing to confirm the physical characteristics of the cyclone sand (material classification, strength and permeability tests). This should include strength and permeability tests at very high confining stresses, representative of the large height of the Main Embankment, and testing to examine the influence of cyclone sand fines content on available percentage of sand recovery and the impact on permeability.
- Examination of the influence of cyclone underflow solids content on the compaction characteristics of in situ cyclone sand fill.
- Laboratory testing to determine the physical characteristics of the PAG tailings (material classification, slurry settling, consolidation and permeability tests).

Large scale generation of a cyclone sand sample (using a laboratory cyclone device) is recommended to provide sufficient quantity of representative sand material for laboratory testing.

Design Studies and Analyses

- Review and updates to hydrometeorological and hydrology information, incorporating on-going site data collection.
- Review and confirmation of the thermal regime in the TMF foundation using site thermistor data. Thermal modelling may also be required to predict the effect of the TMF on foundation conditions.
- Confirmation of geochemical characterisation and potential reactivity of tailings and waste rock from on-going waste characterisation studies.
- Review and confirmation of TMF seepage predictions and seepage control measures and requirements
- Development of a tailings and waste rock deposition strategy to optimize material handling, and tailings discharge line and reclaim barge locations throughout operations.
- Consideration of alternative core zone materials and options if additional characterisation and delineation of borrow sources indicates a potential shortfall of suitable low permeability material.
- Assessment of the sequencing of sand cell construction in relation to embankment raising requirements to optimise material demand and placement strategies.
- Evaluation of the potential impact of sloping sub-aerial and sub-aqueous tailings beach areas. Consideration of tailings beach configurations may result in modifications to staged embankment heights and the tailings deposition strategy.

- Review and reassessment of trade-off study for embankment construction material options (cyclone sand versus local borrow material) based on the most current design requirements and cost estimate information.

12 – REFERENCES

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13 – CERTIFICATION

This report was prepared, reviewed and approved by the undersigned.

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APPENDIX A

LIST OF PREVIOUS KNIGHT PIÉSOLD LTD. AND HALLAM KNIGHT PIÉSOLD REPORTS

(Pages A-1 to A-3)

Knight Piésold CONSULTING

APPENDIX A

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

LIST OF KNIGHT PIÉSOLD LTD. REPORTS AND HALLAM KNIGHT PIESOLD LTD. REPORTS

1. Knight Piésold Ltd., December, 2012, 2012 Geotechnical Site Investigation Data Report Waste Management Facilities (Ref. No. VA101-325/8-14, Rev 0).

2. Knight Piésold Ltd., December, 2012, Feasibility Design of Heap Leach Facility (Ref. No. VA101-325/8-9, Rev 0).

3. Knight Piésold Ltd., December, 2012, Waste Storage Area and Stockpiles Feasibility Design (Ref. No. VA101-325/8-12, Rev A).

4. Knight Piésold Ltd., December, 2012, Report on Revised Tailings Management Facility Seepage Assessment (Ref. No. VA101-325/8-13, Rev 0).

5. Knight Piésold Ltd., December, 2012, Report on Laboratory Geotechnical Testing of Tailings Materials (Ref. No. VA101-325/8-1, Rev 0).

6. Knight Piésold Ltd., July 9, 2012, Updated Hydrometeorology Report (Ref. No. VA101-325/8-11, Rev 0).

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8. Knight Piésold Ltd., April 13, 2012, Terrain Hazards Assessment for Proposed Mine Site (Ref. No. VA101-325/8-3, Rev 0).

9. Knight Piésold Ltd., February 23, 2011, Revised Pre-Feasibility Design of the Heap Leach Facility (Ref. No. VA101-325/3-6, Rev A).

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12. Knight Piésold Ltd., February 4, 2011, Waste Storage Area and Ore Stockpiles (Ref. No. VA10-01746, Rev A).

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18. Knight Piésold Ltd., June 15, 2010, Hydrometeorology Report (Ref. No. VA101-325/3-1, Rev 0).

19. Knight Piésold Ltd., May 16, 2010, May 2010 Casino Site Visit (Ref. No. VA10-00863).

20. Knight Piésold Ltd., March 21, 2010, March 2010 Winter Low-Flow Site Visit (Ref. No. VA10-00568).

21. Knight Piésold Ltd., November 17, 2008, Heap Leach Facility Alternative Site (Ref. No. VA08-02009).

22. Knight Piésold Ltd., October 6, 2008, Geotechnical Laboratory Testing of Tailings (Ref. No. VA101-325/2-1, Rev 0).

23. Knight Piésold Ltd., August 25, 2008, Chapter 4 – Geotechnical Pre-Feasibility Design (Ref. No. VA101-325/1-3, Rev 1).

24. Knight Piésold Ltd., April 23, 2008, Pre-Feasibility Design of the Heap Leach Facility (Ref. No. VA101-325/1-1, Rev 0).

25. Knight Piésold Ltd., April 22, 2008, Conceptual Water Intake at Yukon River (Ref. No. VA08-00809).

26. Knight Piésold Ltd., April 16, 2008, Waste Storage Area and Low Grade Ore Stockpiles (Ref. No. VA08-00818).

27. Knight Piésold Ltd., March 14, 2008, Potable Water Study (Ref. No. VA08-00317).

28. Knight Piésold Ltd., February 15, 2008, Preliminary Plant Site Foundation Assessment (Ref. No. VA07-01669).

29. Knight Piésold Ltd., January 24, 2008, Preliminary Open Pit Slope Design (Ref. No. VA07-01637).

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39. Hallam Knight Piesold Ltd., March, 1994, Data Report 1993.

40. Hallam Knight Piesold Ltd., November 18, 1993, Environmental Monitoring Program – Baseline Environmental and Socioeconomic Studies.

APPENDIX B

SEISMIC HAZARD ASSESSMENT

(Pages B-1 to B-8)

APPENDIX B

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

SEISMIC HAZARD ASSESSMENT

B.1 INTRODUCTION

A seismicity assessment has been carried out for the Casino Copper-Gold Project, including a review of the regional seismicity and a seismic hazard analysis. The results of the seismic hazard analysis are required to provide seismic design parameters for the design of the Tailings Management Facility and for other facilities at the project site, including the Heap Leach Facility and ore stockpiles. Design ground motion parameters provided by the seismic hazard analysis include peak ground acceleration, spectral acceleration (defining the uniform hazard spectrum) and design earthquake magnitude.

The findings of the seismicity review and the methodology and results of the seismic hazard analysis are presented in the following sections.

B.2 REGIONAL TECTONICS AND SEISMICITY

The region of the southwest Yukon Territory and northwest British Columbia is one of the most seismically active areas in Canada. The seismic hazard in the region is also influenced by the seismically active region of southeast Alaska. The coastal region has experienced many large earthquakes, including events with magnitudes in the range of magnitude 7.0 to 8.0. In 1958 a magnitude 7.9 earthquake occurred along the Fairweather fault (the northern extension of the Queen Charlotte transform fault). The most significant inland zone of seismicity follows the Dalton and Duke River segments of the Denali fault zone through the southwest Yukon. Farther inland there is only minor seismicity between the Denali and Tintina fault systems, including the region of the Casino Project site.

The southern coast of Alaska is a region of high seismicity and high seismic hazard, where earthquakes are generated by the Pacific (oceanic) plate subducting under the North American plate at an average rate of approximately 5 to 8 cm per year. Evidence shows that these tectonic plates are locking as they pass each other, building up tremendous pressure that can sometimes be released as large Magnitude 8 to 9+ earthquakes. These large interface subduction (thrust) earthquakes typically occur at shallow depths of 15 to 35 km. This seismic source region, known as the Alaska-Aleutian Megathrust, has been responsible for several of the largest earthquakes recorded globally, including the 1964 Prince William Sound Magnitude 9.2 (M9.2) earthquake. There is potential for future large interface subduction earthquakes (M8 to M9+) along the southern coast of Alaska. However, these earthquakes would occur at too great a distance from the Casino project to have any significant influence on the seismic hazard at the site, due to attenuation of ground motions over the large distance (over 400 km).

Figure B.1 shows the regional tectonics and historical seismicity of the Yukon and surrounding regions and the location of the Casino project.

B.3 SEISMIC HAZARD ANALYSIS

The seismic hazard for the Casino project has been defined using probabilistic methods of analysis. This method requires an examination of historical earthquake data and the regional tectonics to identify potential seismic sources and to determine the maximum earthquake magnitude for each seismic source. Appropriate relationships defining the attenuation of earthquake ground motion with distance are also required.

Design ground motion parameters have been determined for the project site using information provided by the probabilistic seismic hazard database of Natural Resources Canada (NRC) (http://earthquakescanada.nrcan.gc.ca/hazard-alea/zoning/haz-eng.php). The results are summarized in Table B.1 in terms of earthquake return period, probability of exceedance (for a 22 year design operating life) and the corresponding peak ground acceleration (median and mean hazard values). However, the NRC database only provides ground motion parameters up to a return period of approximately 2500 years (corresponding to a 2% probability of exceedance in 50 years). Higher return periods will need to be considered for dam design if the classification is defined as Very High or Extreme (based on the requirements of the Canadian Dam Safety Guidelines). Therefore, a probabilistic seismic hazard analysis has been conducted to provide ground motion parameters beyond 2500 years, specifically for return periods of 5000 and 10,000 years.

The methodology used to complete the site-specific probabilistic seismic hazard analysis and the results of the analysis are described in the following sections.

B.3.1 Ground Motion Attenuation

Appropriate attenuation models defining the relationship between earthquake magnitude, source to site distance and peak ground motion (acceleration) are required to carry out a probabilistic seismic hazard analysis. The ground motions experienced at the project site are dependent on the regional ground motion attenuation characteristics and the earthquake source mechanism.

For shallow crustal earthquakes a set of four ground motion attenuation models, known as the New Generation Attenuation (NGA) relations was used (Earthquake Spectra, 2008). These include the ground motion relationships of Abrahamson and Silva, Boore and Atkinson, Campbell and Bozorgnia and Chiou and Youngs. These ground motion attenuation relationships are applicable to shallow crustal earthquakes in western North American and similar tectonic regions of the world. The predicted peak ground accelerations for shallow crustal earthquakes are average values calculated using the four attenuation relationships (equal weighting).

The peak ground accelerations and spectral accelerations predicted using the attenuation relationships are for soft rock/very dense soil site conditions, assuming an average shear wave velocity in the upper 30 meters (defined as the Vs30 value) of 560 m/sec (range of 360 to 760 m/sec). This corresponds to Site Class C, as defined by the National Building Code of Canada (NBCC 2010).

B.3.2 Probabilistic Analysis

A probabilistic seismic hazard analysis is carried out to define a unique probability of occurrence for each possible level of ground acceleration experienced at a site. The methodology used for the probabilistic

analysis is based on that presented by Cornell (1968). The likelihood of occurrence of earthquakes within defined seismic source zones is determined by examining seismicity data. Using historical earthquake records for the region, magnitude-frequency recurrence relationships are established for potential earthquake source zones. The magnitude recurrence relationships are of the form derived by Gutenberg-Richter (1944):

$$\log(N) = a - b(M)$$

where, M = Earthquake magnitude
N =Annual frequency of occurrence for earthquakes exceeding magnitude M
(1/N = Return Period)

The computer program EZ-FRISK (Risk Engineering, Inc., 2008) was used to develop a seismic hazard model for the southern Yukon and the surrounding regions. The seismic hazard analysis module available with EZ-FRISK includes a database provided by Risk Engineering Inc. of faults and areal seismic sources for the pertinent regions of western Canada. Seismic sources defined in the hazard model include the regions of the southern Yukon Territory, southeastern Alaska, and the Denali and Fairweather fault systems. The project site is located within an areal seismic source that defines the seismicity in the southern Yukon. A maximum earthquake of Magnitude 7.0 was assigned to this source zone, which is characterized by shallow crustal earthquakes.

Magnitude-frequency recurrence relationships and the corresponding maximum earthquake magnitude for each seismic source are prepared by Risk Engineering from consideration of historical seismicity, fault characteristics and the regional tectonics, using information obtained from the Geological Survey of Canada and proprietary studies. For calculation of peak ground accelerations a minimum magnitude of 5.0 was used in the analysis for all seismic source zones. Earthquakes of lower magnitude are not considered to be a risk to engineered facilities. Appropriate ground motion attenuation relationships were assigned to each seismic source, as discussed in Section 2.1 above.

The seismic hazard model developed using EZ-FRISK was used to determine the relationship between peak ground acceleration and annual frequency of occurrence for the project site. Median hazard values of peak ground acceleration have been determined for return periods up to 10,000 years. Predicted values for the project site are included in Table B.1 for return periods of 5000 and 10,000 years. Predicted values for lower return periods were very similar to those provided by the NRC seismic hazard database.

The probabilistic seismic hazard analysis has also been used to calculate spectral acceleration values (5% damping). These have been used to develop site-specific uniform hazard spectra corresponding to return periods of 500, 2500 and 10,000 years. The uniform hazard spectra are shown on Figure B.2. Tabulated values of these uniform hazard spectra are provided in Table B.2.

Deaggregation of the probabilistic seismic hazard results has been carried out to provide the relative contributions of all potential seismic sources, and to more accurately define the characteristics of potential earthquakes contributing to the seismic hazard. The findings indicate that the seismic hazard for the

project site is predominantly from shallow crustal earthquakes associated with the southern Yukon region, but also from the Denali fault system.

A design earthquake magnitude of 8.0 has been selected, based on the review of regional tectonics and historical seismicity, and the findings of deaggregation off the probabilistic seismic hazard.

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TABLE B.1

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

FEASIBILITY DESIGN OF THE TAILINGS MANAGEMENT FACILITY
SUMMARY OF PROBABILISTIC SEISMIC HAZARD ANALYSIS

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Return Period (Years)	Probability of Exceedance[1] (%)	Peak Ground Acceleration (PGA)[2]	
		Median PGA[3,4] (g)	Estimated Mean PGA[5] (g)
100	20	0.04	0.05
500	4	0.07	0.08
1,000	2	0.08	0.10
2,500	1	0.11	0.13
5,000	0.4	0.14	0.17
10,000	0.2	0.18	0.22

\\VAN11\Prj_file\1\01\00325\08\A\Report\10 - TMF Feasibility Design Report\Rev 0\APP B Rev 0 - Seismic Hazard Assessment\[Table B.1 - Table B.2 - Figure B.2 - Rev 0.xlsx]Deaggregation Data

NOTES:

1. PROBABILITY OF EXCEEDANCE CALCULATED FOR A DESIGN LIFE OF 22 YEARS.

   $q = 1-EXP(-L/T)$

   WHERE: q = PROBABILITY OF EXCEEDANCE
   L = DESIGN LIFE IN YEARS
   T = RETURN PERIOD IN YEARS

2. PEAK GROUND ACCELERATIONS ARE FOR SOFT ROCK/VERY DENSE SOIL (Vs_{30} = 360 - 760 M/SEC)
3. MEDIAN PEAK GROUND ACCELERATIONS FOR RETURN PERIOD UP TO 2,500 YEARS OBTAINED FROM THE SEISMIC HAZARD DATABASE OF N
4. MEDIAN PEAK GROUND ACCELERATIONS FOR RETURN PERIODS OF 5,000 AND 10,000 YEARS OBTAINED FROM SITE-SPECIFIC ANALYSIS US
5. MEAN PGA VALUES ESTIMATED AS 1.2 X MEDIAN VALUES.

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TABLE B.2

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

UNIFORM HAZARD SPECTRA FOR 1/500, 1/2,500 AND 1/10,000 YEAR EARTHQUAKES

Spectral Period (seconds)	Spectral Accelerations for 1/500 Year Earthquake		Spectral Accelerations for 1/2,500 Year Earthquake		Spectral Accelerations for 1/10,000 Year Earthquake	
	Median (g)	Estimated Mean (g)	Median (g)	Estimated Mean (g)	Median (g)	Estimated Mean (g)
PGA	0.07	0.08	0.11	0.13	0.18	0.22
0.02	0.07	0.08	0.11	0.13	0.18	0.22
0.03	0.07	0.08	0.11	0.13	0.18	0.22
0.05	0.08	0.10	0.14	0.16	0.23	0.28
0.1	0.11	0.13	0.19	0.23	0.36	0.43
0.2	0.16	0.19	0.26	0.31	0.43	0.52
0.3	0.19	0.23	0.30	0.36	0.43	0.52
0.4	0.21	0.25	0.32	0.39	0.45	0.54
0.5	0.23	0.27	0.35	0.42	0.49	0.58
0.75	0.30	0.35	0.46	0.55	0.61	0.73
1.0	0.24	0.28	0.36	0.44	0.49	0.59
2.0	0.11	0.13	0.16	0.19	0.22	0.26
3.0	0.06	0.08	0.10	0.12	0.13	0.15
4.0	0.04	0.05	0.07	0.08	0.09	0.11

\\VAN11\Prj_file\1\01\00325\08\A\Report\10 - TMF Feasibility Design Report\Rev 0\APP B Rev 0 - Seismic Hazard Assessment\[Table B.1 - Table B.2 - Figure B.2 - Rev 0.xlsx]UHS Table B.2

NOTES:

1. SPECTRAL ACCELERATIONS ARE MEAN HAZARD VALUES FOR SOFT ROCK/ VERY DENSE SOIL SITE CONDITIONS (Vs_{30} = 360 - 760 m/sec).
2. ESTIMATED MEAN VALUES ESTIMATED AS 1.2 X MEDIAN VALUES.

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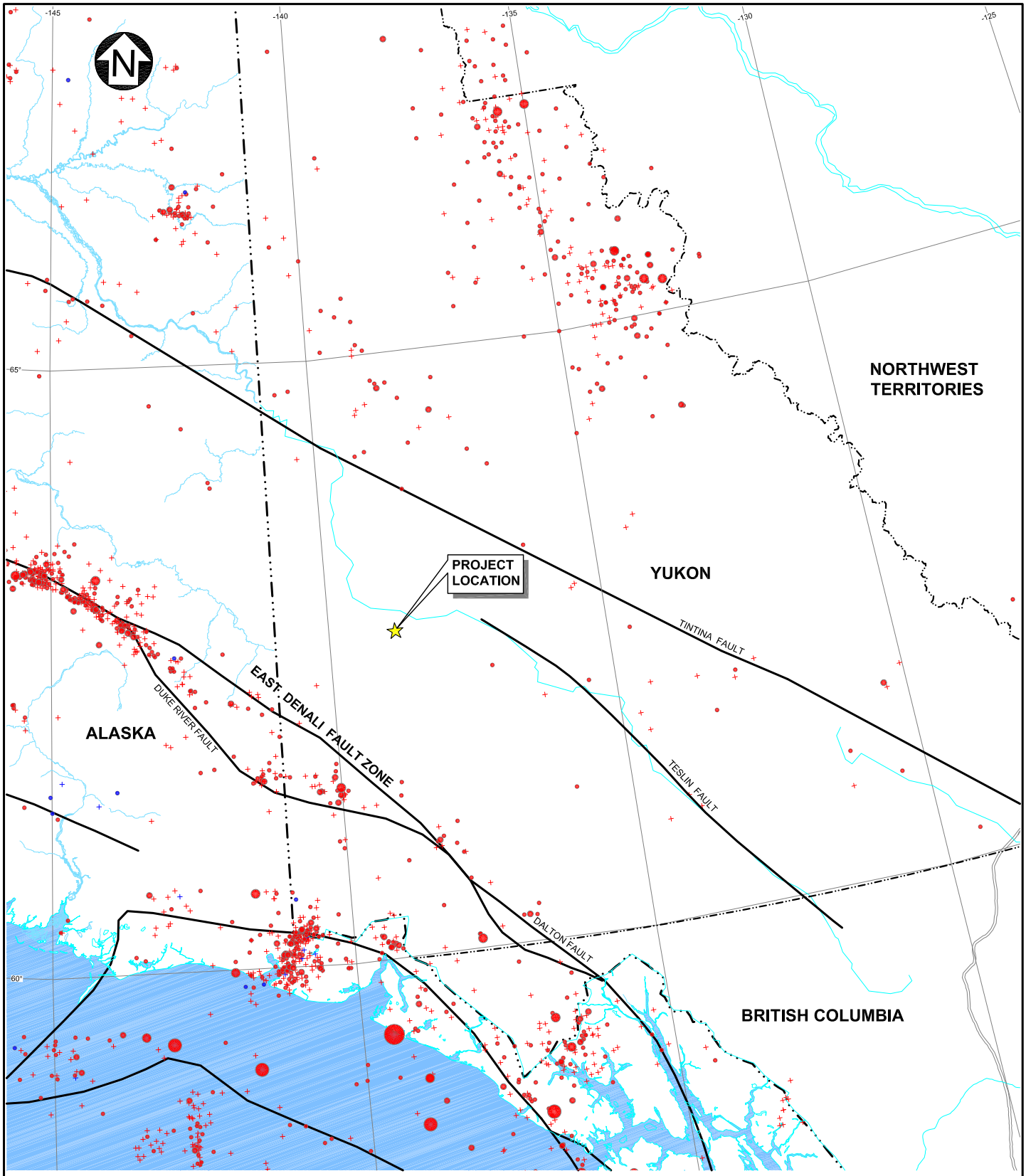

SYMBOL SIZE PROPORTIONAL TO MAGNITUDE

- 3.5 - 3.9
- 4.0 - 4.9
- 5.0 - 5.9
- 6.0 - 6.9
- 7.0 - 7.9
- 8.0 - 8.9
- 9.0 +

NOTES:

1. GLOBAL COORDINATE SYSTEM IS UTM WITH NAD83 DATUM, ZONE 10 m, CENTRAL MERIDIAN.
2. HISTORICAL EARTHQUAKE DATA FROM NRCAN, USGS, AND NGDC DATABASES.
3. INCLUDES RECORDED EARTHQUAKES FROM 1600 TO 1973 (MAGNITUDE > 6.0) AND FROM 1973 TO SEPTEMBER 2012 (MAGNITUDE > 3.5).

SCALE A: 50 25 0 50 100 150 200 250 km

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REGIONAL TECTONICS AND HISTORICAL SEISMICITY

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FIGURE B.1

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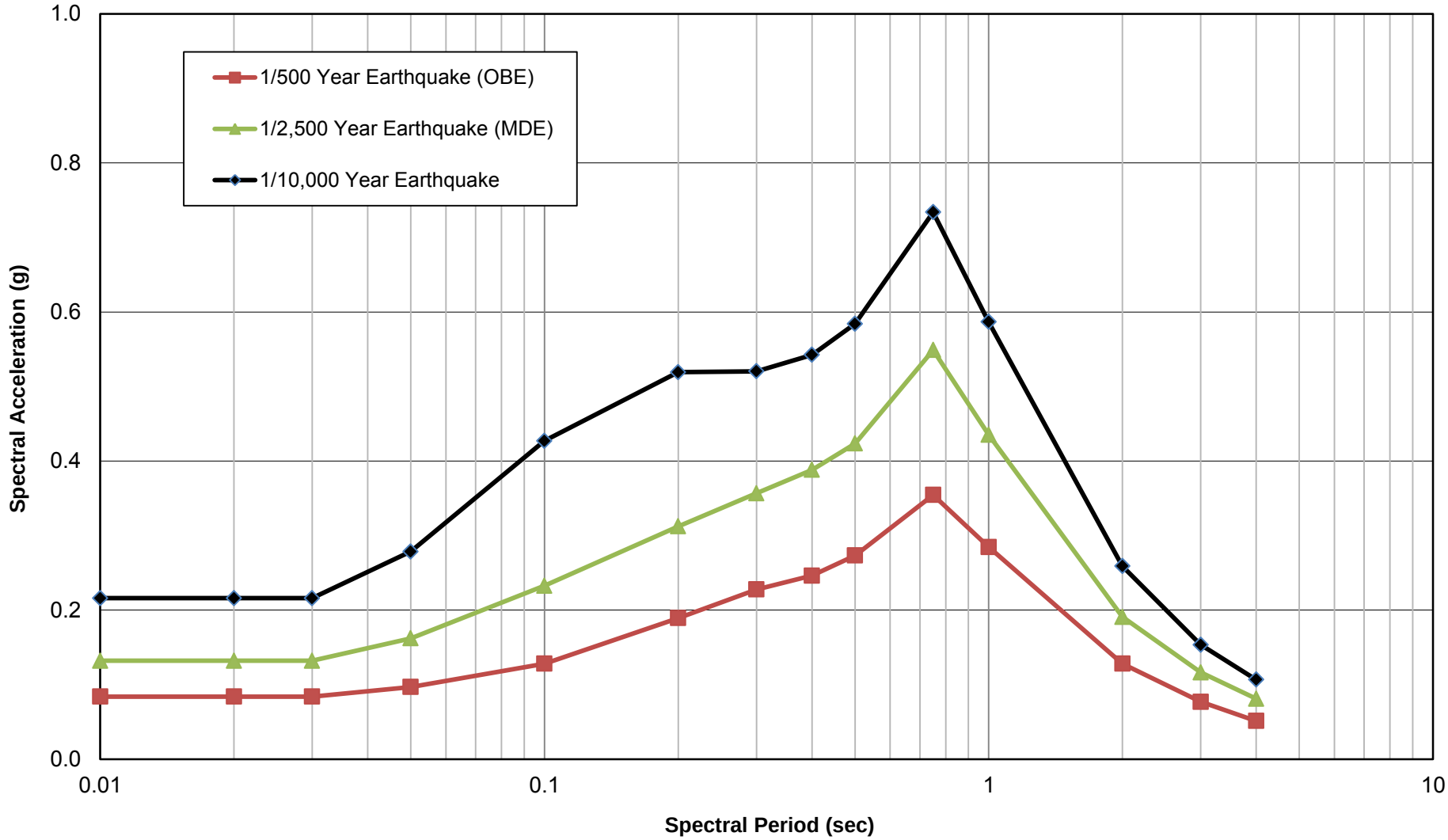

NOTES:
1. SPECTRAL ACCELERATIONS ARE MEAN HAZARD VALUES FOR SOFT ROCK/ VERY DENSE SOIL SITE CONDITIONS (Vs30 = 360 - 760 m/sec).

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CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

UNIFORM HAZARD SPECTRA FOR 1/500, 1/2,500 AND 1/10,000 YEAR EARTHQUAKES

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FIGURE B.2

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APPENDIX C

EMBANKMENT STABILITY ANALYSES

(Pages C-1 to C-7)

APPENDIX C

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

EMBANKMENT STABILITY ANALYSES

C.1 GENERAL

Embankment stability analyses were carried out to investigate the stability of the Main Embankment under both static and seismic loading conditions. These comprised checking the stability of the embankment arrangement for each of the following cases:

- Static conditions during operations and post-closure;
- Earthquake loading from the Operating Basis Earthquake (OBE) and the Maximum Design Earthquake (MDE); and
- Post-earthquake conditions using residual (post-liquefaction) tailings strengths.

The stability analyses were based on the maximum cross-section through the Main Embankment for the final TMF with a supernatant pond elevation of 995 m and an embankment crest elevation of 998 m.

The stability analyses were carried out using the limit equilibrium computer program SLOPE/W. In this program a systematic search is performed to obtain the minimum factor of safety from a number of potential slip surfaces. Factors of safety have been computed using the Morgenstern-Price method.

In accordance with international recommendations (ICOLD, 1995) and standard industry practice, the minimum acceptable factor of safety for the tailings embankment under static conditions is 1.3 for short-term operating conditions and 1.5 for long-term (steady-state and post-closure) of the TMF. A factor of safety of less than 1.0 is acceptable under earthquake loading conditions provided that calculated embankment deformations resulting from seismic loading are not significant and that the post earthquake stability of the embankment maintains a factor of safety greater than 1.2, implying there is no flow slide potential. The TMF would be expected to function in a normal manner after the OBE. Limited deformation of the tailings embankment is acceptable under seismic loading from the MDE, provided that the overall stability and integrity of the TMF is maintained and that there is no release of stored tailings or water (ICOLD, 1995). Some remediation of the embankment may be required following the MDE.

The seismic stability assessment of the TMF has included estimation of seismically induced deformations of the dam from the OBE and MDE events. The OBE has been defined as the 1 in 500 year earthquake with a mean Peak Ground Acceleration (PGA) of 0.08g and design earthquake magnitude of 8.0. The MDE corresponds to the 1 in 2,500 year earthquake with a mean PGA of 0.13g and design earthquake magnitude of 8.0. To demonstrate the robustness of the embankment design to seismic loading the 1 in 10,000 year earthquake has also been considered. The PGA for the 1 in 10,000 year event is 0.22g.

The design PGA values are for very dense soils and soft (weathered) rock ground conditions. This is consistent with the foundation conditions beneath the Main Embankment. To account for the potential

amplification of ground motions as seismic waves propagate through the foundation soils and embankment, an amplification factor of 1.5 has been assumed to estimate the average PGA along a potential slip surface through the embankment. This amplification factor is based on consideration of the expected embankment foundation conditions and fill materials (density and stiffness). This results in an estimated average PGA within the embankment of 0.13g for the OBE, 0.2g for the MDE and 0.32g for the 1 in 10,000 year earthquake.

C.2 MATERIAL PARAMETERS AND ASSUMPTIONS

The following parameters and assumptions were incorporated into the stability analyses:

- Bulk unit weights for the Stage 1 embankment materials, low permeability core zone, and foundation materials were based on typical values for similar materials and the results of laboratory testing. The unit weights are listed in Figure C.1.
- A bulk unit weight of 18 kN/m^3 was used for the cyclone sand embankment fill, based on the results of compaction and triaxial testing of a laboratory prepared sample (representing cyclone underflow) and report density values for existing large cyclone sand dams.
- An undrained shear strength was adopted to represent the tailings material strength for the static, seismic and post-earthquake cases, as described by the following relation:

  Su/p' = 0.20 (static and seismic loading)

  Su/p' = 0.10 (post liquefaction residual strength)

  where, Su = undrained shear strength

  p' = effective vertical stress;
- An average effective friction angle of 35 degrees was adopted for the sand-gravel foundation soils based on laboratory test results conducted in 2010;
- Effective strength parameters for the embankment core zone material and low permeability upstream blanket were estimated based on typical values for similar materials. An average effective friction angle of 33 degrees was used;
- The shear strength for rockfill (Stage 1 dam shell zones) was defined using a conservative strength function that defines the variation with shear strength with normal stress. This strength function is based on published information on the shear strength properties of rockfill (Leps, 1970);
- Cyclone sand fill is assumed to remain well drained (unsaturated and therefore not potentially liquefiable);
- A strength function for angular sand (Leps, 1970), similar to that for rockfill, was adopted for the cyclone sand embankment fill, based on the results of shear strength testing of a laboratory prepared sample. The results of the testing are shown on Figure C.2. Details of the shear strength testing and results are provided in the KPL document ""Report on Laboratory Geotechnical Testing of Tailings Materials" (Ref. No. VA101-325/8-1, December, 2012); and
- The predicted phreatic surface from TMF seepage modelling (see Section 5.10) was used in the stability analysis for the Main Embankment.

The stability model developed for the Main Embankment is shown on Figure C.1.

C.3 RESULTS OF STABILITY ANALYSES

The potential slip surface through the final Main Embankment (Crest El. 998 m) is shown on Figure C.1.

For static stability conditions, the minimum factor of safety calculated is 2.2. This exceeds the minimum factor of safety for short-term operating conditions and for long-term (post-closure) conditions.

Embankment stability during earthquake loading has been assessed by performing a pseudo-static analysis, whereby a horizontal force (seismic coefficient) is applied to the embankment to simulate earthquake loading to determine the critical acceleration required to reduce the factor of safety to 1.0. Deformation of the embankment is predicted to occur if the critical acceleration is lower than the predicted average PGA along the potential slip surface from the design earthquake.

Potential deformations under earthquake loading have been estimated using the simplified methods of Newmark (1965) and Makdisi-Seed (1977). These two methods estimate displacement of the potential sliding mass based on the average maximum ground acceleration and the yield acceleration. The yield acceleration corresponds to the seismic coefficient required to initiate movement of the sliding mass. The yield acceleration was determined by iterative stability analyses. For the Main Embankment, the estimated yield acceleration is approximately 0.3g. Predicted embankment deformations from the OBE and MDE are negligible, as the calculated yield acceleration exceeds the estimated average PGA for these events. Calculated average embankment displacements are also minor (approximately 0.01 m) for the 1 in 10,000 year earthquake.

The more recently published method of Bray (2007) was also used to predict seismically induced slide displacement of the embankment. In addition to the yield acceleration, this method considers the predominant period of response (T_s) of the embankment under seismic loading and the corresponding spectral ground acceleration (Sa). The predominant period is related to the stiffness characteristics of the embankment fill and to the height of the embankment. Spectral acceleration values were provided by the uniform hazard spectrum defined for each design earthquake event. The uniform hazard spectra for the 1 in 500 (OBE), 1 in 2,500 (MDE) and 1 in 10,000 year earthquakes were defined from the results of a site specific probabilistic seismic hazard analysis (see Section 3.5) and are provided on Figure C.3. Maximum displacements of approximately 0.02 m and 0.01 m were predicted for the 1 in 10,000 year earthquake and MDE respectively, based on the stiffness of the embankment fill and predominant period of the embankment under seismic loading (estimated to be in the range of about 1.5 seconds). Predicted embankment displacement for the OBE is negligible (< 0.01 m). The predominant period of the embankment is long due to the embankment height (maximum of approximately 286 m). Spectral accelerations from the design earthquakes are lower in the longer period range. This results in the predicted displacement being lower than would typically be calculated for a lower height dam with the same yield acceleration.

Some deformation of the embankment is expected to result from settlement of the fill materials during earthquake shaking. Potential settlement of the embankment crest has been estimated using the empirical relationship provided by Swaisgood (2003). This relationship was developed from an extensive review of case histories of embankment dam behaviour due to earthquake loading. Required inputs to the relationship are the earthquake magnitude, the peak ground acceleration on rock at the site, the depth

to rock (overburden thickness) and the embankment height. The predicted maximum crest settlements for the Main Embankment section are approximately 0.2 m for the OBE, 0.25 m for the MDE and less than 0.4 m for the 1 in 10,000 year earthquake.

Maximum embankment deformations and settlements calculated for the design earthquakes are less than 0.5 m and do not have a significant impact on the available embankment freeboard (minimum of 3.0 m) or result in any loss of embankment integrity. Predicted embankment deformations from the OBE are negligible and would not impact on-going operations at the TMF.

The post earthquake condition that conservatively assumes complete liquefaction of the tailings deposit was also analysed, using a post-liquefaction residual tailings strength. The calculated factor of safety is the same as the static factor of safety as the critical potential slip surface does not pass through the liquefied tailings deposit. This indicates that the embankment is not dependent on tailings strength for downstream stability and is not susceptible to a flow slide or large deformations resulting from earthquake-induced liquefaction of the tailings deposit.

The stability of the Main Embankment can be increased further by placement of non-reactive waste rock, or suitable borrow material against the downstream face of the dam. However, this is not a requirement in providing appropriate embankment stability and minimum factors of safety, based on the strength parameters adopted for this study.

The on-going increase in tailings strength and reduction in pore water pressures as the tailings consolidate will only improve the overall stability and integrity of the embankment after closure.

C.4 REFERENCES

Bray, J.D.& Travasarou, T., 2007, Simplified Procedure for Estimating Earthquake-induced Deviatoric Slope Displacement, doi 10.1061/(ASCE)1090-0241(2007)133:4(381).

ICOLD - International Commission on Large Dams, 1995, Tailings Dams and Seismicity: Review and Recommendations, Bulletin 98.

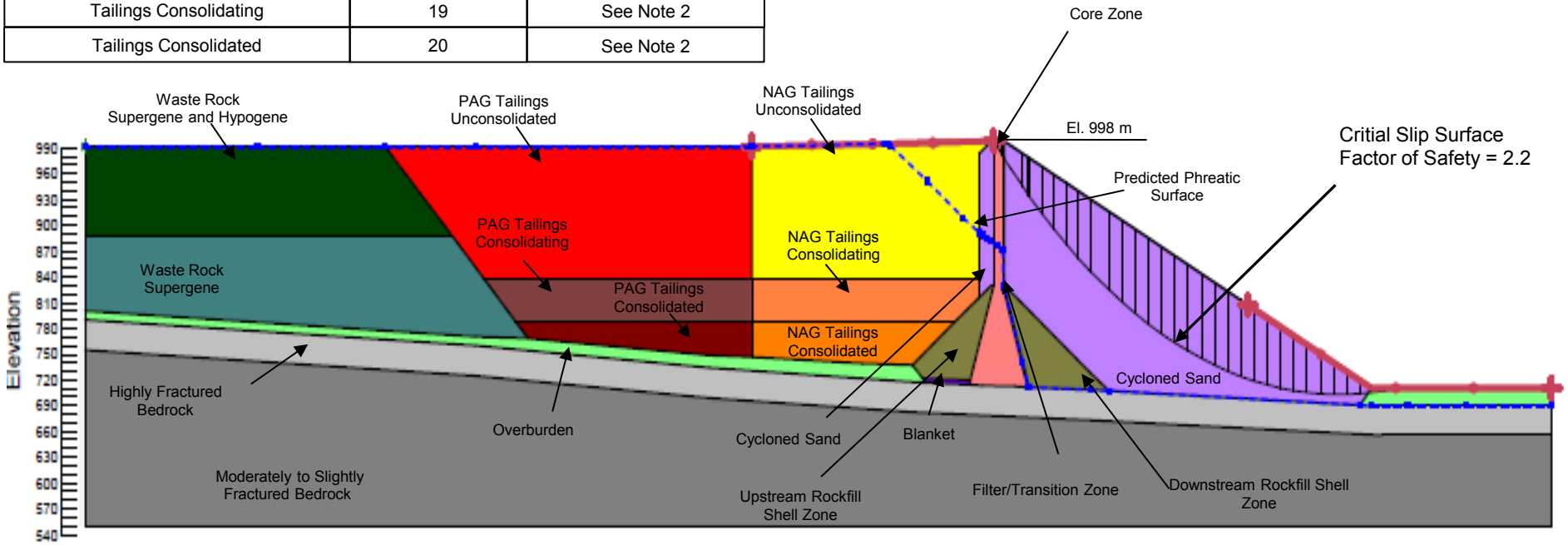
Leps, T.M., 1970, Review of Shearing Strength of Rockfill, Journal of the Soil Mechanics and Foundations Division, Vol. 96 pp 1159 – 1170.

Makdisi, F.I., and Seed, B.H., 1977, A Simplified Procedure for Estimating Earthquake-Induced Deformations in Dams and Embankments, Earthquake Engineering Research Center Report No. UCB/EERC-77/19, University of California, Berkeley, California.

Newmark, N.M., 1965, Effects of Earthquakes on Dams and Embankments, Vol. 15 No. 2 pp 139 – 159.

Swaisgood, J.R., 2003, Embankment Dam Deformations Caused by Earthquakes, 2003 Pacific.

Material	Unit Weight (kN/m^3)	Effective Friction Angle (deg)
Cycloned Sand & Blanket	18	See Note 3
Rockfill Shell Zones	22	See Note 3
Core Zone	21	33
Filter/Transition Zone	21	33
Overburden	20	35
Bedrock	N/A	Impenetrable
Tailings Unconsolidated	17	See Note 2
Tailings Consolidating	19	See Note 2
Tailings Consolidated	20	See Note 2



NOTES:

1. LOCATION OF PHREATIC SURFACE PREDICTED FROM STEADY STATE SEEPAGE ANALYSIS.
2. A RELATIONSHIP FOR SHEAR STRESS AND EFFECTIVE NORMAL STRESS (SU/P') WAS USED TO MODEL THE TAILINGS STRENGTH.
3. RELATIONSHIPS FOR FRICTION ANGLES AND EFFECTIVE STRESS WERE DEVELOPED BASED ON LEPS (1970).

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CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

TAILINGS MANAGEMENT FACILITY
MAIN EMBANKMENT
STABILITY ASSESSMENT

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REF NO. 10

FIGURE C.1

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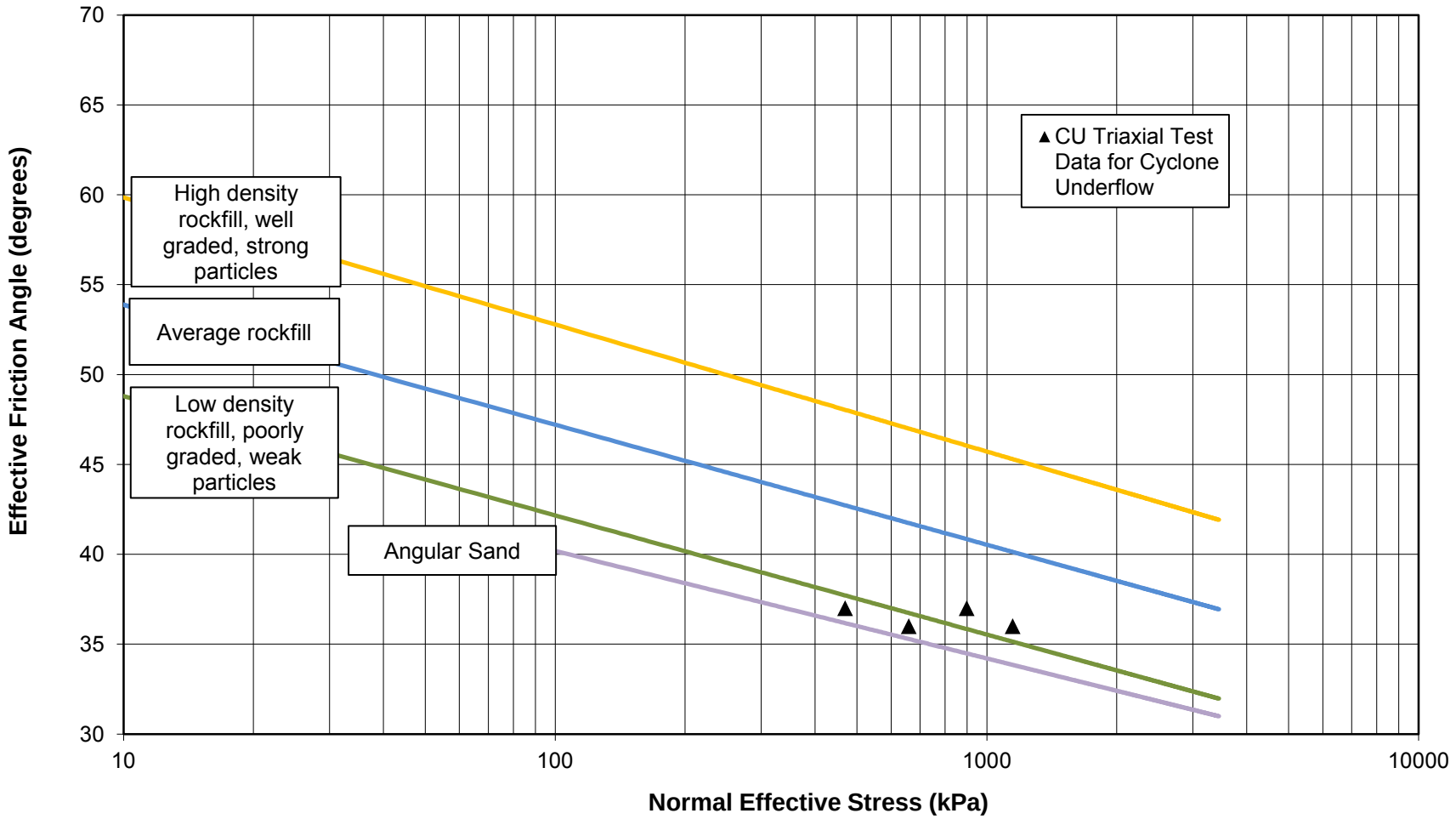

NOTE:
1. RESULTS PRESENTED WITH THE RELATIONSHIP BETWEEN NORMAL STRESS ACROSS THE FAILURE PLANE OF ROCKFILL AND FRICTION ANGLE (SHOWN AS FOUR RELATIONSHIPS FOR 1) HIGH DENSITY, WELL GRADED, STRONG PARTICLES; 2) AVERAGE ROCKFILL; 3) LOW DENSITY, POORLY GRADED, WEAK PARTICLES; AND 4) ANGULAR SAND) AFTER LEPS, 1970.

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

RELATIONSHIP BETWEEN EFFECTIVE FRICTION ANGLE AND NORMAL EFFECTIVE STRESS FOR MANUFACTURED CYCLONE UNDERFLOW

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FIGURE C.2

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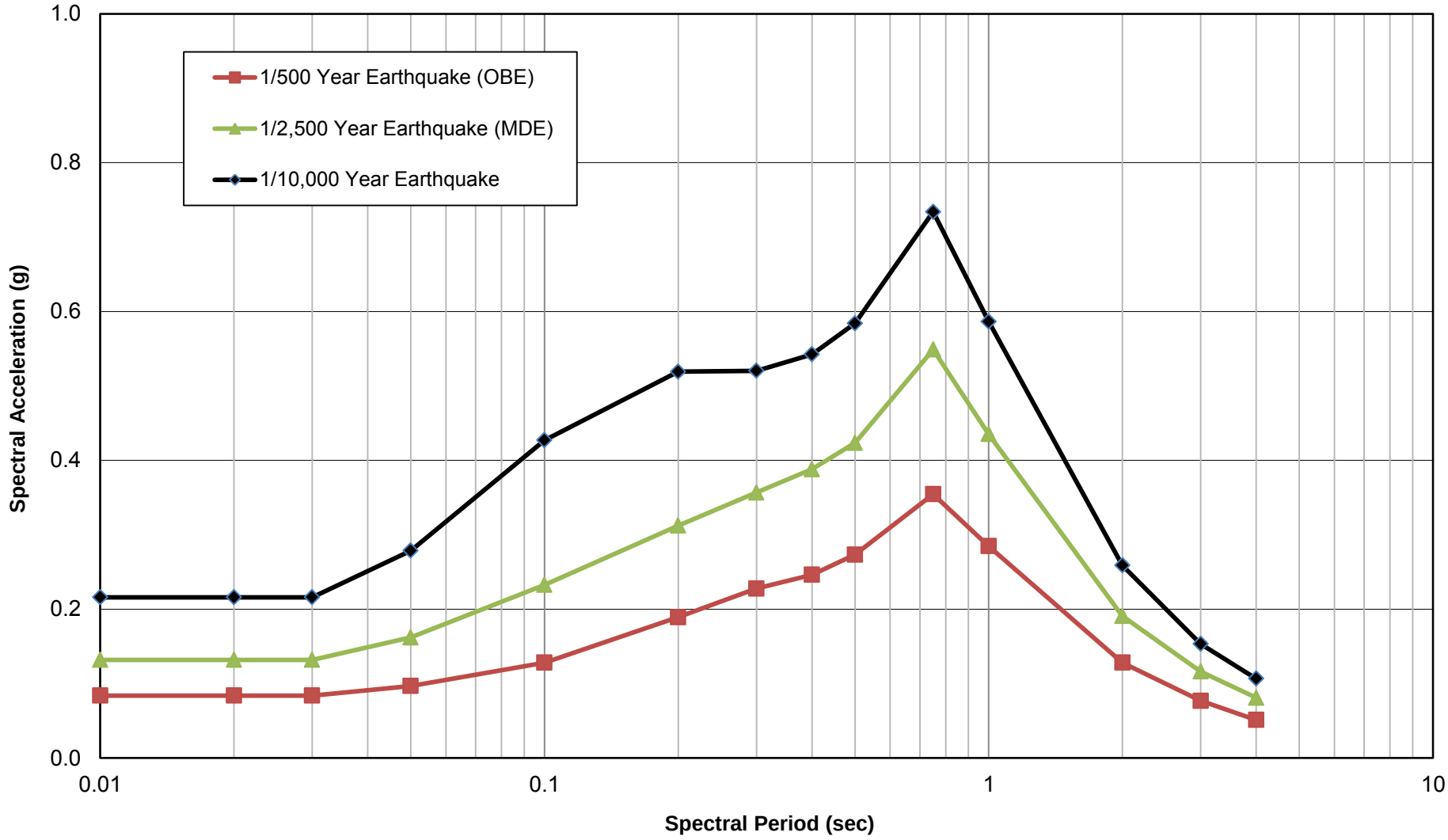

NOTES:
1. SPECTRAL ACCELERATIONS ARE MEAN HAZARD VALUES FOR SOFT ROCK/ VERY DENSE SOIL SITE CONDITIONS (Vs30 = 360 - 760 m/sec).

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CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

UNIFORM HAZARD SPECTRA FOR 1/500, 1/2,500 AND 1/10,000 YEAR EARTHQUAKES

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REF NO. 10

FIGURE C.3

REV 0

APPENDIX D

OPERATIONAL MONTHLY STOCHASTIC WATER BALANCE MODEL

(Pages D-1 to D-4)

APPENDIX D

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

OPERATIONAL MONTHLY STOCHASTIC WATER BALANCE MODEL

D.1 GENERAL

A stochastic analysis was carried out on the base case monthly operational mine site water balance using the GoldSim© software package. The intent of the modelling was to estimate the magnitude and extent of any water surplus and/or deficit conditions in the Tailings Management Facility (TMF), based on a range of possible climatic conditions. The modelling timeline included two pre-production years (Year -2 and Year -1), and 22 years of operation (Year 1 to 22) at a nominal rate of 125,000 dry metric tonnes per day. The model is shown schematically on Figure D.1 and incorporates the following major project components:

- Open Pit
- Mill Site
- Tailings Management Facility (TMF)
- Cyclone Sand Plant, and
- Low Grade Ore Stockpiles.

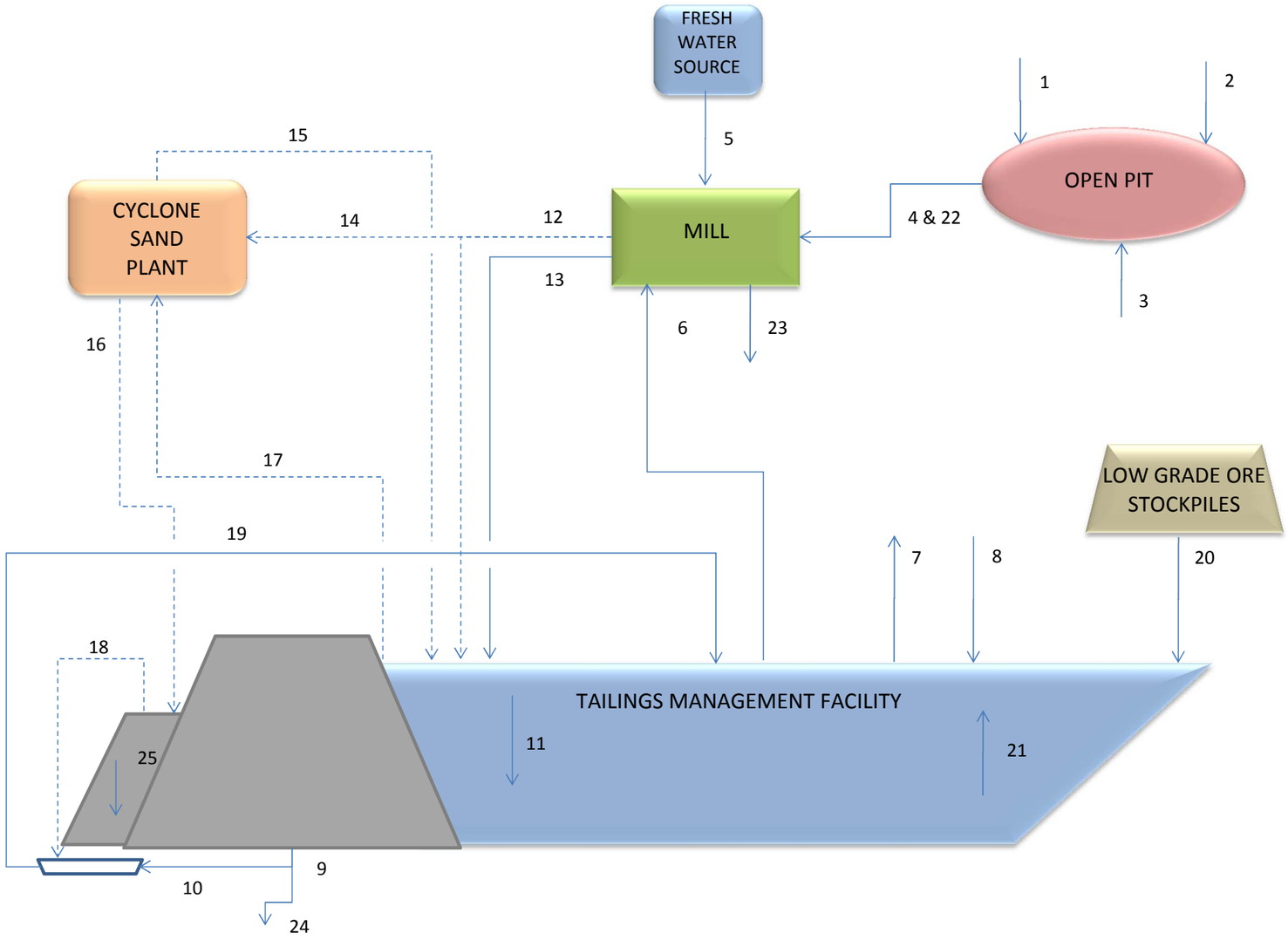
The model assumptions and parameters are discussed in the following sections and summarized in Table D.1.

D.2 MODEL ASSUMPTIONS

D.2.1 Average Hydrometeorological Conditions

The base case monthly operational water balance model was developed using average estimated values for runoff and precipitation. The mean annual unit runoff (MAUR) for undisturbed basins in the project area was estimated to be approximately 183 mm and the mean annual precipitation was estimated to be 510 mm. The annual average long-term potential evapotranspiration for the project site was estimated to be 300 mm. The mean monthly values for precipitation, runoff, and lake evaporation are summarized in Table D.2. Complete details of the derivation of the climate and hydrology inputs for the project site are outlined in the Hydrometeorology Report (Knight Piésold, 2012a).

The available runoff from the undisturbed catchment areas and ore stockpiles (within the TMF catchment) were modelled on the basis of the long-term runoff estimates for Casino Creek at hydrology station W4, as summarized in Table D.2. Natural runoff values are not directly applicable for mine disturbed areas because of the substantial changes in runoff caused by altering the ground cover. Therefore, the water (runoff/infiltration) generated from the mine affected areas and open water (TMF supernatant pond) was estimated on the basis of rainfall and snowmelt estimates. The available precipitation is summarized in Table D.2 and the runoff coefficients are given in Table D.5.



Number	Description
1	Direct Precipition on the Open Pit
2	Open Pit Catchment Runoff
3	Groundwater Inflows to Open Pit
4	Pit Dewatering
5	Fresh Water Make-up
6	Reclaim Water from TMF
7	TMF Pond Evaporation
8	TMF Catchment Runoff and Direct Precipitation
9	TMF Embankment Seepage
10	TMF Seepage Embankment Collection in Seepage Ponds
11	Water trapped in the Tailings and Waste Rock Voids
12	NAG Tailings Slurry Water from Mill
13	PAG Tailings Slurry Water to TMF (All year-round)
14	NAG Tailings Slurry Water to Sand Plant
15	Cyclone Overflow Slurry Water to TMF pond
16	Cyclone Sand Underflow Slurry Water to TMF embankment
17	Process Water to Sand Plant
18	Water Recovered from Sand Cells
19	TMF Seepage Pond Recycle to TMF pond
20	Ore Stockpile Runoff
21	Tailings Consolidation Seepage Recovery
22	Water in Ore
23	Water retained in Concentrate
24	TSF Embankment Seepage lost to deep groundwater
25	Water retained in Sand Cells

NOTES:

1. DASHED LINES ILLUSTRATE WATER FLOW PATHS DURING SAND PLANT OPERATION.
2. DURING THE MONTHS WHEN ALL THE TAILINGS ARE DIRECTED TO THE TMF, THERE ARE DEPOSITED AS 80% BULK TAILINGS AND 20% PYRITIC TAILINGS.

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CASINO COPPER-GOLD PROJECT

TAILINGS MANAGEMENT FACILITY WATER BALANCE SCHEMATIC

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REF NO. 10

FIGURE D.1

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TABLE D.1

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

WATER BALANCE INPUT PARAMETERS

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Component	Assumption
Mean Annual Unit Runoff (mm) - undisturbed areas	183
Mean Annual Precipitation (mm)	510
Mean Annual Lake Evaporation (mm)	300
Total Tailings production (million tonnes)	955.6
Nominal Daily Ore Production (dry metric tonnes)	125,000
Mine Life (years)	22
Mill Fresh water requirement (m^3/hr)[1]	134
Tailings initial settled dry density (tonnes/m^3)	1.1
NAG tailings (80% by weight)	
NAG tailings solids content (% by weight)	55%
NAG tailings specifc gravity	2.7
Cyclone Sand (NAG tailings)	
Inflow Cylone sand slurry solids content (% by weight)	55%
Sand fraction (cyclone underflow) used for embankment construction (65% solids content by weight)	50%
Fine Tailings fraction (cyclone overflow) to TMF (25% solids content by weight)	50%
Sand cells water recovery (recycled to TMF pond)	90%
PAG tailings (20% by weight)	
PAG tailings solids content (% by weight)	55%
PAG tailings specific gravity	3.0
Waste Rock (PAG deposited in TMF Year -1 to 19)	
Waste Rock dry density (tonnes/m^3)	2.0
Waste Rock specific gravity	2.8
Main Embankment Seepage (L/s)	
Year 1	5
Year 10	20
Year 22	39
West Embankment Seepage (L/s)	
Year 22	1
Embankment Seepage Recycle rate	90%
Tailings mass consolidation seepage (L/s) (contributes to TMF pond)	
Year 1	140
Year 2-22	140-400
Groundwater inflows to Open Pit (L/s)	
Year -1	2
Year 4	20
Year 11	30
Year 17	36

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NOTES:

1. THE MILL FRESH WATER REQUIREMENT WAS ASSUMED TO BE SUPPLIED FROM AN OUTSIDE SOURCE AND WILL BE DIRECTED TO THE TMF ONCE IT HAS BEEN USED IN THE MILL PROCESS.
2. THE TAILINGS MASS CONSOLIDATION SEEPAGE RATE FOR YEARS 2 TO 22 WAS LINEARLY INTERPOLATED BETWEEN 140 L/S (YEAR 1) TO 400 L/S (YEAR 22)

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Table D.2 Average Hydrometeorological Inputs

Parameter	Monthly Value (mm)												Annual
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	(mm)
Precipitation	32	24	19	17	37	62	91	67	47	38	43	33	**510**
Rainfall	0	0	0	8	37	62	91	67	47	18	0	0	**330**
Snowfall	32	24	19	9	0	0	0	0	0	20	43	33	**180**
Sublimation	5	5	5	5	0	0	0	0	0	5	5	5	**40**
Snowmelt	0	0	0	25	115	0	0	0	0	0	0	0	**140**
Available Precipitation	0	0	0	33	152	62	91	67	47	18	0	0	**470**
Lake Evaporation	0	0	0	0	49	69	75	66	41	0	0	0	**300**
Available Runoff	0.5	0.3	0.3	3	45	25	33	31	27	15	2	1	**183**

NOTES:
1. THE PRECIPITATION VALUES WERE ESTIMATED FOR ELEVATION 1200 m.
2. THE MONTHLY RUNOFF VALUES ARE SUMMARIZED FOR LOWER CASINO CREEK AT HYDROLOGY STATION W4.

D.2.2 Stochastic Inputs

The potential variability of surface water runoff was addressed with a stochastic version of the water balance model that uses Monte Carlo simulation techniques. Monthly runoff parameters were modelled as probability distributions rather than mean values. The year-to-year variability of monthly runoff was quantified using coefficient of variation (C_v) values that were derived using the long-term regional stream flow record for the Water Survey of Canada (WSC) station at Big Creek (station ID 09AH003). The monthly C_v values for runoff, along with the monthly mean and corresponding standard deviation values are listed in Table D.3. The monthly mean and standard deviation values were used to develop the monthly probability distributions required for a Monte Carlo simulation. The Monte Carlo simulations were run with 10,000 iterations enabling nearly every conceivable combination of wet, dry and average months and years of runoff to be considered. Each iteration resulted in distributions of possible results for each month in each year, from which probabilities of occurrence were assessed.

Table D.3 Stochastic Monthly Inputs

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Runoff (mm)	0.5	0.3	0.3	3	45	25	33	31	27	15	2	1
Std. Dev. (mm)	0.4	0.2	0.2	6	29	4	21	18	17	7	1	0.8
Coefficient of Variation (C_v)	1.0	0.9	0.9	2.0	0.7	0.5	0.6	0.6	0.6	0.5	0.6	0.9

NOTES:
1. COEFFICIENT OF VARIATION = STANDARD DEVIATION / MEAN

D.2.3 Tailings

The TMF design is based on the assumption that approximately 80% of the tailings will be Non-Acid Generating material (NAG) following pyrite separation and removal. The remaining 20% of the tailings comprises Potentially Acid Generating (PAG) tailings that will be discharged by a separate pipeline and contained within the central region of the TMF, remote from the embankments.

D.2.4 Cyclone Sand Plant

The NAG tailings (80% of total tailings by weight) will be used to produce cyclone sand for embankment fill, over a period of approximately 9 months each year (typically from about February to November). Cycloning operations are assumed to be suspended or significantly reduced during the coldest winter months (in particular December and January). Cyclone sand production can reduce during the last few years of TMF operations, when the demand for sand fill for embankment construction reduces.

The NAG tailings will be directed to the cyclone sand plant as a slurry at 55% solids by weight. The cyclone underflow (sand fraction) will be discharged from the sand plant as a slurry at 65% solids (by weight) to construction cells along the upstream and downstream shells of the TMF embankment. The cyclone overflow material (fine fraction) will be discharged directly to the TMF impoundment as slurry at approximately 25% solids by weight. Water will be recovered from the sand cells to the extent possible and pumped back to the TMF pond. Residual moisture draining from the fill in the sand construction cells will be collected in the downstream seepage collection system and pumped back to the TMF pond. Water required for operation of the sand plant will be supplied from the TMF pond. The sand plant is assumed to operate for 90% of the time during the period when it is active. Bulk NAG tailings will be

directed to the TMF impoundment when the sand plant is not in operation. The assumed months of sand plant operation during each year of the mine life are summarized in Table D.4.

Table D.4 Cyclone Sand Plant Operation

Year	Operating Months
1 to 17	9 months: February to October
18 to 20	4 months: May to September
21 to 22	3 months: June to August

D.2.5 Mill Water Requirements

Water requirements at the mill are calculated based on the specified mill production rate and the expected solids content (% by weight) of the tailings. The mine production rate used in the water balance model is approximately 125,000 tpd (less for Years 1 and 22). PAG) and Metal eaching (ML) waste rock will be placed into the TMF, starting in Year -1 (pre-production) and continuing until Year 19. The waste rock will be stored in the upper (northern) area of the TMF. The water balance indicates that the waste rock will become partially submerged by the TMF supernatant pond as of Year 1 and fully submerged by Year 20, approximately one year following the end of waste rock placement in the TMF.

The majority of the process water will be supplied by the TMF reclaim system and open pit dewatering. The mill requires 134 m^3/hr of fresh water in addition to the process water reclaimed from the TMF.

D.2.6 Open Pit Dewatering System

The water pumped from the open pit by the dewatering system includes pit wall runoff, undisturbed pit catchment runoff, and groundwater inflows. This water will be pumped to the mill for use as process water make-up.

D.2.7 Catchment Areas

The TMF catchment areas and corresponding runoff coefficients used in the water balance are summarized in Table D.5. The ore stockpile areas are included in the TMF undisturbed area, as summarized in Table D.5.

Table D.5 Facility Catchment Areas

Facility	Catchment Area (km^2)						Runoff coefficient
	Year 1	Year 5	Year 10	Year 15	Year 20	Year 23	
Open pit footprint	0.3	0.8	1.4	2.0	2.5	2.8	0.9
Undisturbed area in OP catchment	7.7	7.5	7.2	7.0	6.7	6.6	-
LG ore stockpile	0.1	0.6	1.2	1.7	2.2	0.0	0.8
HLF footprint	0.9	1.2	1.2	1.2	1.2	1.2	-
TMF beach	0.1	0.3	0.5	0.7	0.9	0.9	0.7
TMF pond	1.3	3.1	4.8	6.4	8.0	8.3	1.0
TMF undisturbed area	34	31	28	25	23	24	-

NOTES:
1. OP = OPEN PIT; HLF = HEAP LEACH FACILITY; LG = LOW GRADE; TMF = TAILINGS MANAGEMENT FACILITY
2. THE ESTIMATED RUNOFF FOR ALL FACILITY FOOTPRINTS WITH THE EXCEPTION OF UNDISTURBED AREAS AND SOIL STOCKPILES IS CALCULATED BY MULTIPLYING THE MONTHLY AVAILABLE PRECIPITATION VALUE BY THE RUNOFF COEFFICIENT.
3. UNDISTURBED AND SOIL STOCKPILE RUNOFF IS ESTIMATED BASED ON THE MONTHLY AVAILABLE RUNOFF VALUES, WHICH IS A DIRECT INPUT TO THE MODEL.

D.2.8 Heap Leach Facility

The Heap Leach Facility (HLF) will be constructed prior to mill operations (during Year -3) and will operate until approximately Year 15. For the purpose of the TMF water balance model, it was assumed that all water needed for the heap leach process is managed separately from the TMF water balance. Water supplied to the HLF will come from direct precipitation on the HLF footprint and recycled water from the HLF process, with make-up water sourced from a freshwater reservoir until Year 1. As of Year 1, the freshwater reservoir will be decommissioned and a pipeline from the Yukon River will supply the makeup water requirements from both for both the HLF and TMF. Details of the water balance model for the HLF are outlined in the Feasibility Design of the Heap Leach Facility report (Knight Piésold, 2012b).

D.2.9 Water Retained in Tailings and Waste Rock Voids

The amount of water retained in the tailings and potentially reactive waste rock (PAG and ML) voids is a function of the mine production schedule and the dry density and specific gravity of both the tailings and waste rock. The initial settled dry density values for the tailings and waste rock were assumed to be 1.1 t/m^3 and 2.0 t/m^3, respectively, as shown in Table D.1. Water released due to consolidation of the tailings mass was estimated based on tailings consolidation modelling. The resulting tailings consolidation water release rates are:

- 140 L/s in Year 1
- Increasing linearly each year up to a maximum of 400 L/s in Year 22

D.2.10 Reclaim Water

The volume of water available for reclaim to the mill was estimated using the TMF water balance.

The primary TMF inflows are:

- Water being pumped to the TMF from the mill as part of the tailings slurry
- Pit dewatering
- Direct precipitation on and runoff to the TMF, which includes runoff from the upslope catchments and ore stockpiles
- Tailings settling and consolidation seepage
- Cyclone sand cell water recovery, and
- Embankment seepage recycle.

The primary TMF outflows, excluding reclaim to the mill, are:

- Water retained in the tailings and waste rock voids
- Evaporation, and
- Seepage not intercepted by the embankment seepage collection and recycle system.

The water available for process use is assumed to be 100% of the difference between these inflows and outflows.

D.2.11 Fresh Water Requirements

The assumed total fresh water requirements at the project site are:

- Mill (operations) – 134 m^3/hr
- Potable water for the camp – 5 m^3/hr during operations

D.3 RESULTS

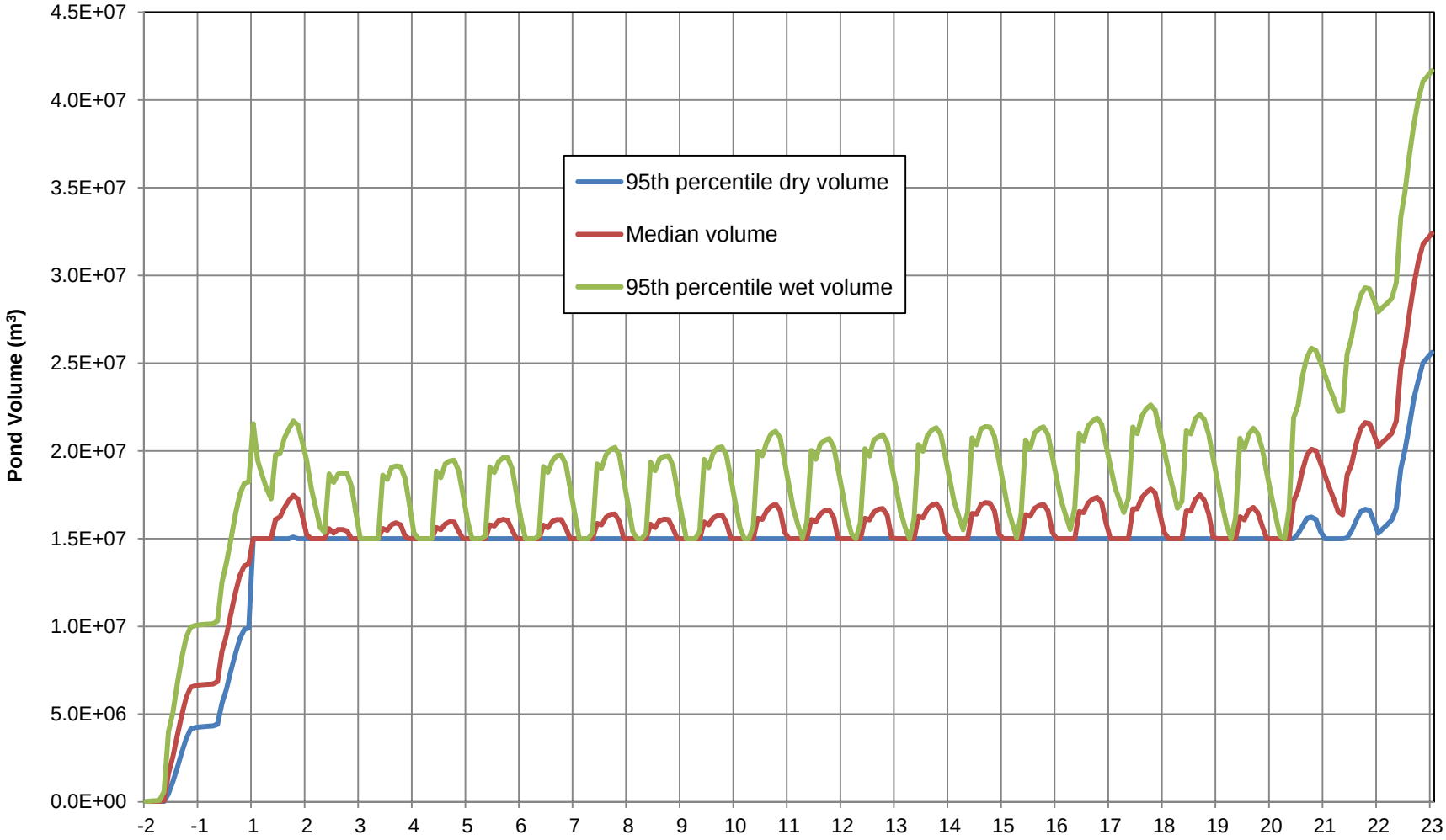
D.3.1 Model Results

The model results were used to determine the likelihood of having a surplus or deficit for the mine site, as illustrated on Figure D.2. The TMF pond is assumed to have a minimum pond volume of 15 million m^3 (approximately 3 months of slurry water requirements) in all months throughout operations. Therefore, a deficit condition is defined as when the TMF pond volume is at the minimum volume of 15 million m^3 and that the system (including the TMF, open pit, and contributing catchments) is not able to supply enough water to meet the mill process water requirements, thereby indicating the need for make-up water. Figure D.2 presents the range of possible cumulative pond volumes that in the TMF over the life of the mine, as defined by the 95th percentile wet and dry values (5% and 95% chance of being equalled or exceeded in any year, respectively). This range of volumes can also be thought of as the required active, or “live”, storage capacity of the TMF pond for a reasonably large range of anticipated climatic conditions. It was

assumed that a TMF start-up pond would be allowed to accumulate over two freshet seasons rather than one, thereby increasing the potential start-up water volume.

The TMF is able to accumulate a start-up pond volume of at least 15 million m^3 by the start of Year 1 for all climatic conditions. The stored water in the pond from Year 1 onward is slowly consumed by void spaces in the tailings and waste rock and the TMF pond volume is at the minimum of 15 million m^3 during some months in each year. During these months, the system operates in a deficit condition and requires additional makeup water, under the range of climatic conditions represented in the modelling. The process make-up water requirements from an outside source, for the range of modelled scenarios, are presented in Table D.6. The 5th percentile and 95th percentile scenarios shown correspond to the 95th percentile wet and dry scenarios on Figure D.2, respectively. The maximum annual makeup water requirement occurs in Year 3. This is due to an increase in the volume of waste rock saturated by the TMF pond in that year, resulting in more water being lost to the waste rock voids.

It should be noted that the water balance results are very sensitive to the input values, which are best estimates based on the currently available information.



NOTES:
1. TMF MINIMUM POND VOLUME IS ASSUMED TO BE 15 MILLION m³ (3 MONTHS PROCESS WATER REQUIREMENT).

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	07DEC'12	ISSUED FOR REPORT	ER	DF	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

TAILINGS MANAGEMENT FACILITY
POND VOLUME
STOCHASTIC RESULTS

Knight Piésold CONSULTING

P/A NO. VA101-325/8

REF NO 10

FIGURE D.2

REV 0

Knight Piésold CONSULTING

TABLE D.6

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

PROCESS MAKE UP WATER REQUIREMENTS
STOCHASTIC WATER BALANCE MODEL RESULTS

Print Dec/21/12 9:37:25

Year	95th percentile dry (m^3/yr)	Median (m^3/yr)	95th percentile wet (m^3/yr)
-2	0	0	0
-1	0	0	0
1	10,222,442	6,112,242	2,724,257
2	11,855,399	8,282,767	3,127,817
3	11,883,946	8,844,134	5,496,621
4	11,368,726	8,221,608	5,327,931
5	10,640,326	7,478,545	4,471,525
6	10,861,930	7,563,539	4,547,847
7	9,774,109	6,501,697	3,889,269
8	11,057,015	7,594,240	4,244,122
9	10,350,310	6,913,418	4,095,385
10	8,768,455	5,237,647	2,729,210
11	9,457,520	5,660,757	1,912,569
12	9,473,898	5,785,776	2,435,046
13	8,761,706	5,007,519	1,687,382
14	8,541,347	4,697,132	923,048
15	9,057,148	5,136,426	1,230,971
16	7,979,760	4,559,087	634,911
17	6,716,788	3,802,565	0
18	9,366,564	5,176,772	0
19	11,643,677	7,416,224	2,640,693
20	5,704,723	5,158,938	1,480,843
21	2,722,223	0	0
22	0	0	0

\\VAN11\Prj_file\1\01\00325\08\A\Report\10 - TMF Feasibility Design Report\Rev 0\APP D Rev 0 - WBM\[Fig D.1-Fig D.2-Tab D.1-Tab D.6-Rev 0 - Casino WBM_20_FS_rev A.xlsx]Tab D.6-Stochastic_ta

NOTES:

1. TMF MINIMUM OPERATING POND ASSUMED TO BE 15 MILLION m^3 (3 MONTHS PROCESS WATER REQUIREMENT).

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	07DEC'12	ISSUED FOR REPORT VA101-325/8-10	ER	DF	KJB

APPENDIX E

CYCLONE SAND DESIGN (PATERSON AND COOKE)

(Pages E-1 to E-153)

Knight Piésold CONSULTING

Knight Piésold

Casino Project Tailings Cyclone and Transport Study

Feasibility Study Report

Report Number: KPV-5277 R02 Rev 0

December, 2012

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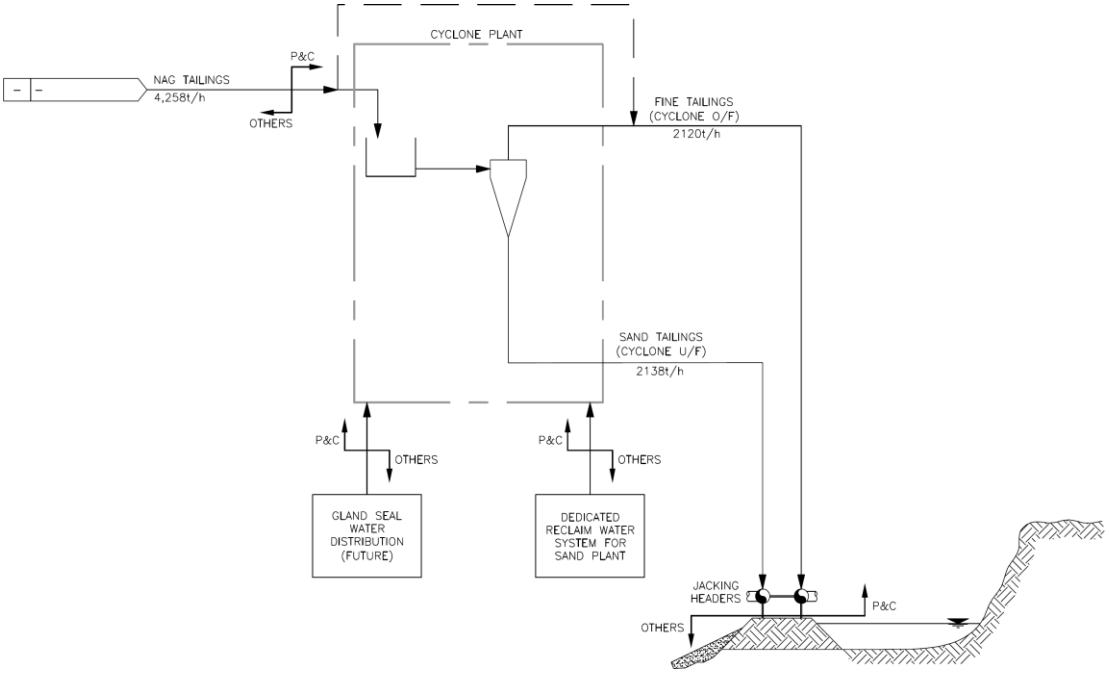
EXECUTIVE SUMMARY

This document presents the feasibility study (FS) design for tailings cyclone and transport developed for Knight Piésold (KP) for the Casino mine project. The design has been prepared to a level appropriate for the development of capital costs to an accuracy of +15/-15%.

Paterson & Cooke (P&C) compiled aterial take-offs (MTOs) and power consumption estimates to support the development of the capital and operating cost estimates by others. The MTOs and power consumption estimates are presented in Appendix E and Appendix F respectively of this document.

Overall schematic of the proposed system is presented on the diagram.



Sand recovery in the cyclone plant is 50.2%, which was agreed with a cyclone vendor. The cyclone plant will be generating 2,138t/h (42,950tpd) or 11,75mln t/y of sand. This is based on:

- 120,000tpd run of mine (ROM)
- 1% of ROM as concentrate
- 80% of all tailings are NAG tailings feeding the cyclone plant
- 9 out 12 months of the cyclone plant operation
- 93% process plant availability
- 90% cyclone plant availability.

At a late stage of the study, a new production schedule was issued. The new throughput (46,249,000 tpy or 126,700tpd) is approximately 5% (5.6%) higher than the old throughput used by P&C (43,800,000 tpy or 120,000tpd). The new production rate is within the design factor of 15%. Consequently the cyclone plant design is capable of handling the new throughput.

High level summary for the system is presented in the following table.

TAILINGS CYCLONE AND TRANSPORT SYSTEM	
System overview	The thickened non-acid generating (NAG) tailings (nominal process values: 4,258 tph, 5,064 m^3/h, 55%m) flow by gravity from the mill to the cyclone plant. For approximately nine months of each year, the NAG tailings are processed in a single stage of cyclones to produce sand as cyclone underflow for the Tailings Storage Facility (TMF) embankment construction. The cyclone overflow material (fine tailings) is discharged directly into TMF on the upstream impoundment side of the dam. During the three winter months (and when the cyclone station is offline), the tailings bypass the cyclone plant and are deposited directly into TMF through the cyclone overflow pipeline. In order to feed the cyclones at optimum solids concentration for solids separation, dilution water is required at the cyclone plant. This dilution water is pumped directly from the TMF pond by barge and intermediate pumps (by others) to a water header tank located at the cyclone feed tank. Two jacking headers are provided; one for the cyclone underflow and the second for the cyclone overflow pipe line to match the piping lift rate with the rise rate of the dam crest. In the beginning of operation both sand and fines flow under gravity from the cyclone plant to the jacking header on the dam. Ten (10) ceramic orifices are required to slow down sand slurry in the downhill pipe. Orifices are gradually removed with the dam build up. As the dam further rises, centrifugal pumps are progressively added for pumping sand and fines to the dam.
Sand (Cyclone U/F) distribution	Year 1 to 5 – no pumps, gravity flow, pipe with ceramic orifices for energy dissipation Year 6 to 11 – 1 stage pumping Year 12 to 18 – 2 stage pumping Year 19 to 22 – 3 stage pumping.
Fines (Cyclone O/F) distribution	Year 1 to 12 – no pumps, gravity flow, no ceramic orifices Year 13 to 22 – 1 stage pumping.
Major equipment	Cyclones: Weir Cavex or similar One cyclone cluster with 10 operating plus 2 standby 800mm diameter cyclones Pumps Cyclone U/F: Warman 16x14 AHP or similar with 671kW motors and VFDs Operating/standby sets Pumps Cyclone O/F: Warman 650L or similar with 2000kW motors and VFDs Operating/standby set Orifices: 10pcs, cyclone U/F distribution in year 1 to 5 ID=254 mm (10”) on 18” pipe, 8m head loss per orifice
Pipelines	Cyclone U/F: 18” CS with ceramic liner for first 250m of pipe (slack flow conditions) 18” CS sch 80 for reminder pipe section (full pipe flow conditions) Cyclone O/F: 36” HDPE DR 11 for first 850m of pipe on the sloped section 32” CS std sch for jacking header section This pipe carries also the cyclone bypass during the three winter months in each year and during times when the cyclone plant is by-passed.
Key assumptions and considerations	▪ The mass balance was developed based on nominal process plant feed of 120,000 metric tons per day

TAILINGS CYCLONE AND TRANSPORT SYSTEM	
	▪ Design factors are +15/-10% from nominal plant feed ▪ Life of Mine (LOM) is 22 years ▪ NAG tailings solids concentration: 55%m ▪ The turn down requirement is 60% of nominal throughput ▪ Weather conditions, stringent sand quality and sand yield specifications necessitated the use of a central cyclone station instead of mobile cyclone rigs on the crest ▪ Due to high cost, cyclone plant is not considered to be relocated over LOM ▪ The cyclones are fed by gravity from an elevated feed tank to eliminate pumping ▪ The cyclone underflow pipes special protection (lined pipe, ceramic orifices) ▪ The slurry pipelines are not insulated and are to be drained to prevent freezing ▪ The high crest rise rate and high flow rates necessitates the use of jacking headers across the crest. ▪ Dam construction is by cell fill and mechanical compaction.
Risks and mitigation plans	▪ Lack of slurry rheology data. This was mitigated using conservative safety factors and historical data from similar copper operations. ▪ High pipeline wear in sloped sections (slack flow). This was resolved through the use of ceramic orifices to dissipate energy and reduce slack flow section lengths and ceramic lined pipes on remaining slack flow pipe section. ▪ Maximized plant availability; standby pumps provided, standby cells for sand deposition ▪ Sanding of the cyclone underflow pipeline. Mitigated through proper design and flush water availability along the whole sand pipe ▪ Large turn down ratio requirement to 60% of nominal plant throughput. This risk was eliminated through the use of a smaller diameter sand pipeline to the midslope ▪ Freezing of pipeline contest. Water pipelines are fitted with heat tracing and insulation. Slurry pipelines must be drained for shutdowns longer than two hours ▪ Valve malfunction due to freezing. Mitigated through insulation and heat tracing ▪ Pipeline failure. Drainage construction to ensure that all spillage are directed to the tailings pond.
Alternatives investigated	▪ Single versus two stage cycloning ▪ Various pipes materials for cyclone overflow and underflow to reduce wear ▪ Relocation of the cyclone plant over life of mine to higher elevation ▪ Location of the cyclone plant upstream of the saddle dam.
Future work	▪ Slurry testing is required to confirm hydraulic performance, particularly for cyclone underflow system ▪ Pipeline support analysis (including a seismic stress analysis)

TERMS OF REFERENCE

This work has been conducted by Paterson & Cooke for Knight Piésold under Order Number #9063. The proposal for this work was presented in P&C Proposal KPV-5277 C01 rev B dated June 14th 2012 and change notices CN01 Rev A dated June 26th and CN02 Rev A dated July 13th, 2012.

DOCUMENT DISTRIBUTION, REVISION AND APPROVAL HISTORY

Rev	Date	Distribution / Revisions	Prepared	Reviewed	Client Approval
A	Nov. 1st, 2012	For Review	YK	CK	SB
0	Dec 10th, 2012	Final FS Report	YK		

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1. INTRODUCTION

1.1 Background

The Knight Piésold (KP) from Vancouver office commissioned Paterson&Cooke (P&C) to prepare feasibility study (FS) level designs for Tailings Cyclone and Transport for the Casino Project. The designs have been prepared to a level appropriate for the development of capital and operating expenditure estimates to an accuracy of +15/-15%.

Paterson & Cooke compiled material take-offs (MTOs) and power consumption estimates to support the development of the capital and operating cost estimates by others. The MTOs and power consumption estimates are presented respectively in Appendix F and Appendix G of this document.

This report presents a technical description of the designed system.

1.2 Reference Documents

Document	Abbreviation
P&C Design Criteria Document, R01 Rev C, November 1, 2012.	P&C R01

1.3 Scope of Work

The design scope of work is shown in the table below.

Discipline	Description
Mechanical	The specification of mechanical equipment within the process battery limits is **included.**
Piping	The specification of piping within the process battery limits is **included.**
Tanks & Platework	The specification of tanks and plate work within the process battery limits is **included.**
Civil & Structural	Civil design (grading) for cyclone plant building and tanks benches is **included**. Jacking header structural design is **included**. *Note: P&C uses a sub-contractor in the compilation of the structural component MTOs.* Structural steel design and concrete for cyclone plant building and tanks is **excluded**.
HVAC, fire protection	Heating, ventilation and fire protection is **excluded**. Diesel or propane (non-electrical system) is used for cyclone plant heating.
Electrical	All electrical work within the process battery limits is **excluded.**

Discipline	Description
	Power consumption (kWh) for the cyclone plant and tailings distribution systems is **included**.
Control and instrumentation	Instrumentation requirements within the process battery limits are indicated on P&ID drawings. Higher level control (connection, programming) at the overall plant control system is **excluded.**
Costing	Costing is **excluded** for all items within the scope of work described above. The operating costing is **excluded.** Power consumption is **included**. Labor costing is **excluded**. *Note: P&C provided Material Take-Offs (MTOs) for the cost estimate.*
Services	Services (dilution water, clean water) outside battery limit are **excluded**.
Compressed Air	Compressed air system for cyclone plant operation is **included**.

The process battery limits are detailed in the table below:

Stream	Battery Limits
NAG Tailings Feed	At the inlet to the cyclone feed tank.
Cyclone U/F	At the discharge points on the tailing storage facility.
Cyclone O/F	At the discharge points on the tailing storage facility.
Dilution/Flush water (Reclaim water)	At the discharge of the reclaim water into the dilution water head tank. Reclaim water pumping and piping is the scope by others.

1.4 Appendices

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1.5 Units

Metric units are used for this project. Pipes and valves sizes are reported in inches.

1.6 Abbreviations

The following abbreviations are used in this report:

amsl	above mean sea level
CS	carbon steel
FS	feasibility study
HDPE	high density polyethylene
KP	Knight Piésold
LOM	life of mine
m^3/h	cubic meters per hour
MTOs	material take-offs
NPV	net positive value
NAG	Non-acid generating (tailings)
O/F	overflow
P&C	Paterson & Cooke
PD	positive displacement
PSD	particle size distribution
RL	rubber lined
Sch	schedule
Std	standard
TMF	tailings storage facility
U/F	underflow
t/h	metric tons per hour
VFD	variable frequency drive
%m	solids percentage by mass.

2. CYCLONE FEED

2.1 Overview

Thickened NAG tailings from processing plant at solids concentration of 55%m report to the cyclone feed tank, which also receives pond reclaim water to dilute the slurry feed stream to an optimum solids concentration of 36%m for classification in the cyclones. Tailings after dilution flow under gravity from the tank to the cyclones for processing.

The baffles and valving arrangements around the cyclone feed tank allow bypassing of the cyclones and discharging of undiluted NAG tailings upstream of the dam through the cyclone O/F

distribution system. The tank has an emergency overflow into the emergency spillage pipeline to the nearest point of the TMF.

In case of upset condition in the concentrator, which could result in a turndown to 60% of nominal NAG tailings production, the tailings are diluted to 36%m at the process plant. As a result no dilution in the cyclone feed tank is required.

2.2 Key Assumptions and Consideration

The following considerations played a role in the design:

- The feed tank is elevated above the cyclone plant to allow feed the cyclones by static head from the cyclone feed tank therefore eliminating pumping of the high volume cyclone feed stream.

2.3 System Description and Operation

2.3.1 Cyclone Feed Tank

The tank is presented in Appendix A on P&C's Drawing #5277-1-304, "Cyclone Feed Tank General Arrangement". The tank elevation was established based on hydraulic calculations for the cyclone feed pipe, which operates under static head from the tank and the required cyclone feed pressure. Hydraulic performance of the system is presented in Appendix C on P&C's Drawing #5277-1-201, "Cyclone Feed Hydraulic Grade Line Plot".
The concrete tank has four compartments. The NAG tailing stream and dilution water report to the first compartment, where mixing, stilling and de-aeration occur. The diluted slurry flow over a baffle to feed the cyclone cluster through a rubber lined 38" carbon steel pipe. The overflow compartment has a total height of 6.0m, or 5.0m above the top of the feed pipe. As a result, 5 meter is available for level fluctuation for slurry feeding the cyclones.

Should the cyclones have to be bypassed, the 38" cyclone feed pipe can be isolated with a knife gate valve. The slurry level increases in the overflow compartment, until it reaches an overflow weir. Slurry overflows this weir to a bypass compartment piped through the cyclone plant to the cyclone overflow distribution system for deposition on the upstream side of the tailings dam. In addition, a 24" gate, flush with the cyclone feed tank bottom, provides a connection between the main and bypass tank compartments. The gate is opened during the bypass operation, allowing settling solids to report to the bypass, as the overflow weir is 6 m above the tank bottom.

The tank has also another overflow weir, 1 m above the first one, which takes all tank overflows and spillage in emergency situations to the fourth overflow compartment. The emergency

overflow feeds into the 42" emergency spillage line, which takes the spillage to the nearest location of the tailings pond.

2.3.2 Pipelines

The following piping is used for cyclones feed:

38" CS pipe std schedule with 6mm rubber lining, 100m long.

2.3.3 Valves

All slurry valves are knife gate slurry Clarkson KGD, KGA or equivalent. Valves 8" and above are fitted with air actuators.

2.4 Risks and Mitigation Plans

- All valves located outdoors are insulated and heat traced.
- The cyclone feed pipe is insulated. A drain valve, located within the cyclone plant, is provided to allow drainage of the cyclone feed line.
- Any spillage is carried to the tailings pond through a 42"emergency spillage pipe.

2.5 Alternatives Considered

P&C considered locating the feed tank at the same location as the cyclone plant, using a feed pump instead static head for feeding the cyclones. This option was discarded as more costly and complex.

2.6 Future Work

More detailed hydraulic calculations should be done for cyclone feed system, when slurry rheology data is available.

3. CYCLONE PLANT

3.1 Overview

The NAG tailings are diluted to 36%m before classification by single stage cycloning. Cyclone U/F (sand) is collected in the U/F tank and reports to the sand distribution system on the tailings dam. The cyclone O/F (fines) reports to the O/F tank and are further carried to the fines distribution system on the tailings dam.

The cyclone U/F solids concentration is around 74%m. This sand material is diluted to 65%m for ease of hydraulic transportation. As a result, dilution water is added the cyclone cluster U/F collection launder to control solids concentration for the sand. The water addition control valve is in control loop with a sand slurry density meter, located on a sample circulation loop.

Cyclone O/F is disposed through its piping to the dam as is.

During winter months (3 months/year) the sand construction activities cease. The cyclone section is by-passed entirely during that time. The undiluted whole stream NAG tailings report to the cyclone O/F tank and are discharged to the TMF through the same piping used for cyclone O/F distribution. The cyclone section is also by-passed during planned and unplanned non-availability of the cyclone section or lack of sand demand.

As the dam grows over LOM, slurry pumps for cyclone U/F and O/F are added, when required. The pumps are located in the cyclone plant building.

In addition, the cyclone plant is provided with a sand sampling system, gland water for slurry pumps, compressed air system and HVAC system.

3.2 Key Design Assumptions and Considerations

The following considerations played a role in the design:

- Early calculations showed that the sand quality and sand yield required for the sand construction can be achieved in a single cyclone stage. This reduces the capital and operating cost of a cyclone sand construction options significantly.
- A central cyclone station was chosen to ensure sand product quality and yield even during adverse weather conditions.
- The cyclone section is placed in a building to promote reliable and consistent cyclone control even during poor weather conditions, thus promoting an extended sand construction season.
- Due to the high cost of relocation of a complete building in a remote location the option of staged locations for the cyclone feed tank and cyclone plant was not considered.
- Sand recovery in the cyclone plant was verified with the cyclone vendor and is used throughout the design as 50.2%.
- Cyclone plant availability is assumed to be 90%.

3.3 System Description and Operation

3.3.1 Building

A pre-engineered building is provided for the cyclone plant.

The building is constructed in two phases. In the first phase the building is of LxWxH of 34x26x20m. In year 5, when the first set of sand pumps are added, the building to be expanded by 2 bays and the total length to be 46m.

The building contains the following features:

- A 15 metric ton overhead crane, sufficient for maintenance of the large slurry pumps
- A drive through maintenance bay within the building
- A 5% sloped floor to a sump to contain spillage
- Diesel (propane) heating, ventilation (out of P&C's scope, to be sized and selected by others)
- A leveled pad, filled with gravel, around the building for storage, trucks and maintenance equipment maneuvering.

It is anticipated that electrical rooms are in separate structures attached to the cyclone plant building (out of P&C's scope, to be sized and selected by others).

3.3.2 Cyclone Cluster

The relatively coarse grind makes possible the use of large diameter cyclones. The advantage of larger diameter cyclones is that a single cluster is sufficient which results in a smaller building. The cyclone cluster consists of twelve 800mm diameter Weir CAVEX cyclones. Ten cyclones are required to handle the design tailing tonnage of 4,258t/h. Two spare cyclones have been provided for maintenance and surge flows.

Through automatic control the cyclones can be switched into and out of operation. This and the ability to vary are the primary control parameters to ensure that a correct cyclone feed pressure are maintained.

The plant turn down to 60% of capacity is achieved by switching off cyclones to maintain the necessary feed pressure to the remaining operating cyclones.

3.3.3 Process Tanks

Cyclone U/F Tank.

Features	Description
Function	Collecting classified sand from cyclone U/F launder, 45deg sloped floor, feed tank for pumps
Material	Concrete
Location	Inside the cyclone plant building
Dimensions	LxWxH of 4.0x3.2x4.0m
Insulation	None
Retention time	40 seconds for nominal conditions.

Cyclone O/F Tank.

Features	Description
Function	Collecting fines from cyclone O/F launder, 45deg sloped floor, feed tank for pumps
Material	Concrete
Location	Inside the cyclone plant building
Dimensions	LxWxH of 6.2x5.5x5.0m
Insulation	None
Retention time	40 seconds for nominal conditions.

3.3.4 Slurry Process Pumps

During the initial years of operation, the elevation difference between the cyclone plant and the dam, there is enough static head to push by gravity cyclone U/F and O/F to the deposition points. Starting in year 5, due to dam development, pumps are gradually added to transfer sand and fines to the deposition points.

The pumps are described in the tables below:

Description	Cyclone U/F (sand)
Model	Warman 16x14AHP or similar heavy duty centrifugal pump with gland seal water
Duty point	2,236m^3/h @ 43m (flow sheet flow rate x 1.15)

Description	Cyclone U/F (sand)
Motor	671kW with VFD
Installation schedule	year 1 to 5 no pumps, gravity flow year 6 to 11 1 stage pumping year 12 to 18 2 stage pumping year 19 to 22 3 stage pumping
Standby	One operating train + standby train

Description	Cyclone O/F (fines) or thickened NAG tailings
Model	Warman 650L or similar heavy duty centrifugal pump with gland water
Duty point	8.748m^3/h @ 60m (flow sheet flow rate x 1.15)
Motor	2,000kW with VFD
Installation schedule	year 1 to 12 no pumps, gravity flow year 13 to 22 1 stage pumping
Standby	One operating pump + standby pump

3.3.5 Sand Sampling

The cyclones generate U/F with a solids concentration of 74%m. Dilution water is added at a controlled rate to keep target solids concentration of 65%m for deposition. A nuclear density meter installed on cyclone U/F sample circulation pipe is used to control the dilution water.

The sand sample pump draws sand slurry from the bottom of cyclone U/F tank and pump back to the top of the same tank. A density meter is installed on the 2" pump discharge piping. In addition, a sand sample port is available.

An air operated 1 ½" diaphragm pump is envisaged as sand sample pump.

3.3.6 Compressed Air System

Compressed air is used for instrumentation and the running of the sand sample pump. The air is dried in a desiccant air type dryer to prevent freezing of moisture in the compressed air system.

The compressed air package consists of:

- 11kW compressor providing 100m^3/h of air at 780kPa (110psig)
- Desiccant air dryer sized for 100m^3/h
- An air receiver.

3.3.7 Piping

The table below describes main pipes used in the cyclone plant:

Description	Pipe Size	Pipe Spec	Notes
Cyclone O/F to O/F tank	40”	CS std, 6mm RL	Partially filled pipe
Cyclone U/F to U/F tank	32”	CS std, 6mm RL	Partially filled pipe
Cyclone bypass (undiluted tailings)	32”	CS std, 6mm RL	Full pipe flow
Main spillage header from the cyclone plant	42”	HDPE DR 17	Partially filled pipe
Cyclone U/F to tailings dam	See section 4.0 of this document		
Cyclone O/F to tailings dam	See section 5.0 of this document		
Sand sample	2”	CS std sch, 6mm RL	-
Water distribution piping	See section 6.0 of this document		
Gland water piping	See section 6.0 of this document		
Compressed air piping	1” to 2” SS316 welded		

3.3.8 Valves

The following valves are used in the cyclone plant.

Slurry:

All slurry valves are knife gate slurry Clarkson KGD or KGA or equivalent. All valves 8” and above are air actuated.

Water:

See Section 6 of this document.

3.4 Risks and Mitigation Plans

- Spillage in the plant - 5% sloped floor, large sump and 42” spillage pipe to TMF
- Pipe plugging – flow velocities above deposition conditions, flushing water system available, wash stations
- Arctic conditions – heated building, dried compressed air
- Equipment failure – standby cyclones and pumps provided to keep the plant running
- Components wear – rubber lined piping, standby equipment, heavy duty pumps and valves.

4. CYCLONE U/F (SAND) DISTRIBUTION SYSTEM

4.1 Overview

Sand, at 65%m solids concentration, is to be deposited through a piping system on the downstream embankment side of the tailings dam. The system consists of four sections:

- A 18" downhill pipe
- A 18" horizontal pipe on the sand jacking header
- 14" downhill pipes – from jacking header
- 14" downhill pipe – jacking header bypass for high turn down throughput requirements.

The 18" sand pipeline initially follows the 15% site gradient down towards the dam. At the tailings dam the pipe continues on a jacking header. 14" take off valves every 100m from the main pipeline for deposition. Each take-off valve is connected to a mobile 14" HDPE DR 11 pipe, running downhill on the dam to 100 m by 20 m sand deposition cells. Each 14" individual branch pipe is capable of transporting the full sand plant production to fill a cell at a time.

4.2 Key Assumptions and Considerations

The following considerations played a role in the design:

- Slurry piping is not insulated. Only flush water pipe is insulated and heat traced.
- The cyclone U/F piping will experience high wear. P&C scaled wear rates for carbon steel piping from similar copper tailings applications and the summary is presented in the table below.

Description	Average slurry velocity, m/s	Estimate wear mm/1000h
Cyclone U/F in slack flow	11.0	9.16
Cyclone U/F in full pipe flow	3.7	1.5

4.3 System Description and Operation

The hydraulic performance for the sand distribution system for years 1, 3, 6, 12, 19 and 22 is shown in the Appendix C.

4.3.1 Downhill Pipeline

In the first years of operation, due to high elevation difference between the cyclone plant and the dam, the static head pushes the cyclone U/F to the deposition points. The upper section of the

pipe, with a slope of 15%, operates in slack flow (partially filled pipe) regime. For example, in the first year of the project the slack flow section is estimated to be on the first 600m of the sand pipe. In the following years, slack flow section is shortened, as backpressure builds up due to the dam growth. Eventually, by year 5, all extra head and associated slack flow disappears. Pumps are added to transfer sand to the deposition points.

Slack flow and associated high sand slurry velocities, up to 11m/s, creates very high wear in the sand piping. P&C estimates that 18" carbon steel pipe of Schedule 80 has to be rotated roughly every 100 days and replaced once a year. A value engineering trade off study for optimum pipe material selection was done. The full trade-off study is presented in the Appendix H.

The main findings from the trade-off study are presented in the table below:

Option for sand pipe material on the sloped section	**NPV**
Option 1: CS Sch 80 pipe, no orifices, no ceramic lining	$4,1mln
Option 2: CS Sch 80 pipe, orifices, no ceramic lining	$2.0mln
Option 3: no orifices, ceramic lined pipe	$1,3mln
Option 4: orifices, ceramic lined pipe	**$0.8mln**

P&C selected option 4, as it represents lowest cost for the project.

In the trade-off study P&C did not consider HDPE pipe, as CS outperforms HDPE for slurries with coarse particles.

Overall the recommended sand pipe configuration on the downhill section is as follows:

- Ceramic orifices.
  Orifices keep backpressure in the pipe to minimise the slack flow. Initially, 10 orifices are installed, one every 50m, on the downhill section of the pipe. Each orifice provides a head dissipation of 8m, which is equivalent of 55 m pipe on 15% slope. As the dam rises, one orifice should be removed from the system for every 8m of dam build up, to maintain the hydraulic performance of the system. All orifices are selected with openings of 254mm in 450mm (18") pipe and all of them should be removed from the pipe by year 5.
- Ceramic lined CS pipe.
  P&C recommends using ceramic lined CS pipe in the top section (250m) of the 15% sloped sand pipeline. This is the section, which by design has to be exposed to slack flow and high wear. This pipe section provides a safe margin preventing the sand slurry pipeline from backing up and overflowing to the cyclone plant. Pressure transmitters along the sloped pipe monitor the location of the transition between the slack flow and full bore flow. Once the sand pipe is backing up too close to the cyclone plant an orifice is removed from the pipe.

- CS pipe Sch 80
  The lower section of the sloped pipe is not exposed to slack flow and associated high wear. As a result a schedule 80 carbon steel pipe is sufficient. The same pipe schedule is used on the jacking header.

After year 5, when all orifices have been removed and sand pumps have to be installed progressively, the downhill pipe operates at full flow regime with velocity of around 4 m/s. Pipe wear is not be substantial, but of course should still be monitored. The pipe needs to be rotated to extend its life.

The downhill pipe on the ground is gradually lifted and placed on the expanding dam and jacking header.

4.3.2 Pipe on Jacking Header

A flexible slurry hose serves as transition piece between the downhill pipeline and pipeline on the jacking header. The sand pipeline on the jacking header is 18" CS Sch 80, non-insulated pipe. P&C evaluated using CS sch 40 pipe or ceramic lined pipe, but in both cases the NPV was higher than for CS Sch 80 pipe.

Overall, the sand pipe on the jacking header is provided with:

- 14" take-off valves, every 100m for individual deposition pipes
- 10" flush water connections with 10" water valves
- 18" shut-off valves to isolate sand pipe sections and be able to flush them with water
- Pressure gauges to monitor sand pipe performance
- 300# flanges to provide better pipe stiffness during jacking header lifting.

The pipe and jacking header is expanding over LOM, as the dam length grows.

The table below shows jacking header lengths for some typical years:

End of Year	Crest/Jacking Header Length (m)
Initial (-1)	868
1	868
3	1,450
5	1,610
7	1,832
12	2,061

End of Year	Crest/Jacking Header Length (m)
19	2,363
22	2,460

The sand pipeline on the jacking header is configured to run to the middle of the dam without any tees, further from the dam center, it branches to the two opposite directions of the dam ends. The take-off valves to the sand deposition cells are located after the main splitting tee. As a result, the sand pipe is longer, but because the system is symmetric, has more stable hydraulic performance. This scheme is indicated on P&ID #5277-2-103, "Cyclone Sand Distribution" in the Appendix A.

4.3.3 Downhill Piping off the Jacking Header

Sand deposition to individual cells is through pipes branching off the 18" main pipe on the jacking header. The branches are every 100 m with 14" knife gate valves hydraulically actuated. A manual pinch valve is located downstream of the knife gate valve to allow the adjustment of the flow.

Each 14" take-off pipe is capable of handling the full cyclone plant sand production. These pipes are laid at the same slope of the dam (3:1). Consequently the pipes are exposed to high wear. The pipes are constantly relocated, to suit sand deposition requirements. It is recommended that at all time, at least one pipe/cell set is kept available as standby to maintain a high system availability. After every sand placement campaign, the downhill pipe should be flushed with water.

4.3.4 Downhill Pipe – Jacking Header Bypass for Upset Conditions

In case of a concentrator upset condition, which could result in a throughput turn down to 60% of nominal NAG tailings production, the jacking header pipe cannot be used, as the horizontal pipe would plug because of low flow velocities. In such a case the sand tailings are diverted, before jacking header, to a 14" HDPE DR 11mid slope pipe. Solids deposition does not occur; as the pipe is continuously sloped, running downhill to the embankment's mid slope areas. This downhill pipe is capable of transporting the normal sand production to the mid slope, when the jacking header is down. This means that sand is conserved, even in upset conditions.

4.3.5 Structure for Sand Tailings Jacking Header

The jacking header is a structure on piles, which is hydraulically lifted as the dam rises. Lifting is achieved with hydraulic power packs, which are connected to hydraulic jacks located on each pair of piles. Jacking header piles is spaced every 15m.

The jacking header consists of:

- 12" carbon steel pipe piles on concrete foundation

- 18" sand pipe
- 12" flush water pipe
- Supporting structure
- 1m wide walkway with handrails
- Power cable tray
- Lights
- Hydraulic jacks, on each pair of piles, spaced every 15 m
- Take-off valves, every 100m typically.

5 mobile power packs provide lifting capacity for 5 hydraulic jacks (5 towers, or 60m of pipe) at any time. Each hydraulics pack has a lifting capacity up to 30 metric tons. The hydraulic power packs are moved and shared with the O/F jacking header.

As the dam expands the jacking header is expanded too; new piles (pipes) with support structure are added. Vertical pipes are extended by welding on of new sections. Materials for the header expansion are captured in MTOs.

The jacking header was designed by SMRC Structural Engineers, who were sub-contracted to P&C. More detailed description for the jacking header, drawings and MTOs are presented in the Appendix G.

4.4 Risks and Mitigation Plans

- Freezing of valves - all valves located outdoors are insulated and heat traced
- Plugging of the sand pipe – provision of a flush water pipe on the jacking header
- Freezing of the flush water pipe – provision of insulation and heat tracing
- Horizontal sand pipe plugging on the jacking header during process plant upset conditions (lower throughput) – provision of bypass piping, continuously sloping to prevent solids settling.

4.5 Alternatives Considered

Various pipe materials were considered for sand piping, see Appendix H for details.

4.6 Future Work

- More detailed hydraulic calculations.
- More detailed operation strategy should be evaluated, which may affect features of the pipeline.
- Weather enclosure may be considered for jacking header.

5. CYCLONE O/F (FINES) DISTRIBUTION SYSTEM

5.1 Overview

This system handles the cyclone O/F stream as well as the undiluted NAG tailings stream when the cyclone station is by-passed.

The system consists of three sections:

- A 36" HDPE DR 11 downhill pipe
- A 32" CS Std Sch horizontal pipe on jacking header
- 16" HDPE DR 17 take-off pipes from the jacking header.

The cyclone O/F pipeline initially follows the 15% site gradient down to the dam. On the tailings dam the pipe is laid on a hydraulically raised jacking header, which is a separate structure from the sand jacking header. 16" take-offs with valves are placed every 100m. Each take-off valve is connected to a 16" HDPE DR 17 pipe running down from the jacking header onto the beach of the impoundment of the tailings storage facility.

In case of a concentrator upset condition, which could result in a throughput turn down to 60% of nominal tailings production, this piping system can still handle the cyclone O/F. Fine solids are not as sensitive to settling, even at lower velocities. However, when the cyclones are bypassed, it is recommended that either the cyclone plant emergency spillage system is used to dump the undiluted NAG tailings at the nearest point of the tailings pond, or the NAG tailings are diluted in the overflow box to eliminate risk of plugging of 32" CS pipe on the horizontal jacking header with undiluted NAG tailings.

5.2 Key Assumptions and Considerations

The following considerations played a role in the design:

- The slurry piping is not insulated.
- P&C scaled wear rates for carbon steel piping from similar copper tailings applications and the summary is presented in the table below.

Description	Average slurry velocity, m/s	Estimated CS pipe wear mm/1000h of operation
Cyclone O/F in slack flow	12.6	N/A, thick wall HDPE pipe used on project

Description	Average slurry velocity, m/s	Estimated CS pipe wear mm/1000h of operation
Cyclone O/F in full pipe flow	4.2	0.01
Cyclone bypass in slack flow	11.0	N/A, Thick wall HDPE pipe used on project
Cyclone bypass in full pipe flow	2.8	0.1

5.3 System Description and Operation

Hydraulic performance for the system handling cyclone O/F for years 1, 13, and 22 are shown in the Appendix C.
Hydraulic performance for the system handling cyclone bypass for years 1, and 22 are also shown in the Appendix C.

5.3.1 Downhill Pipeline

In the first 12 years of operation, due to elevation difference between the cyclone plant and the dam, there is enough head for gravity flow. It is estimated that slack flow occurs on the first 750m of the downhill pipe in the first year of operation. Gradually, by year 13, all extra head and slack flow disappears, and at that point a pump is required to transfer fines and/or bypass to the deposition points.

Slack flow and associated high velocities, up to 10 to 12m/s, create high pipe wear of the pipe. The wear is not that substantial, as in the sand system however. 36" HDPE DR 11 pipe, which has wall thickness of 83mm, is recommended therefore for the downhill section. Thick wall combined with frequent pipe rotation is the most economical solution. The pipe wall thickness should be monitored however.

The downhill section of the pipeline gradually reduces and is replaced by expanding jacking header during LOM.

5.3.2 Pipe on Jacking Header

A flexible hose provides the transition between the downhill pipe section and pipe on the jacking header. The pipe on the jacking header is 32" carbon steel standard schedule and non-insulated. Low wear rates do not justify using thicker wall piping. HDPE cannot be used on the jacking header, as the carbon steel flanged piping provides the jacking heading rigidity. Flush water piping for the cyclone O/F system is not required.

The cyclone O/F pipe on the jacking header is be provided with:

- 16" take-off valves, every 100m for individual deposition pipes
- 32" shut-off valves on the main pipe to isolate sections and redirect the flow to the spigots
- Pressure gauges to monitor pipeline performance
- 300# flanges to ensure stiffness

The pipe and jacking header is expanded over LOMs as the dam grows.

The table below shows the jacking header lengths for some typical years.

End of Year	Dam/Jacking Header Length (m)
Initial (-1)	868
1	868
3	1,450
5	1,610
7	1,832
12	2,061
19	2,363
22	2,460

The piping on the cyclone O/F jacking header is routed as "run through" with the take-off valves and tees. The schematic is given on P&ID #5277-3-103, "Cyclone Overflow Distribution" in the Appendix A.

5.3.3 Deposition Piping off the Jacking Header

The cyclone O/F and cyclone bypass deposition is through 16" HDPE DR 17 pipes from the 32" pipe on the jacking header. Branching is every 100m with 16" hydraulically actuated knife gate isolation valves.

During normal operation 2 to 3 take off valves are open at a time. Each 16" take off valve/pipe set is capable of transporting 50% of cyclone O/F production or 50% of undiluted NAG tailings during the cyclone bypass.

5.3.4 Cyclone O/F Tailings Jacking Header

The jacking header is a structure on piles which is hydraulically lifted as the dam rises. Lifting is achieved with mobile hydraulic power packs which are connected to hydraulic jacks located on

each pair of piles. Jacking header piles are spaced every 15m. The cyclone O/F jacking header is a separate structure from the sand system jacking header.

The cyclone O/F jacking header consists of:

- 10" steel pipe piles on concrete foundation
- 32" CS overflow pipe
- A power cable tray
- Hydraulic jacks, spaced every 15m on each pair of piles
- Valves where required, every 100m typically.

No walkway is provided on the cyclone O/F jacking header. Access to the take off valves is through a manlift.

As the dam expands the jacking header is extended; new piles (pipes) with support structure are added. Vertical pipes are extended by welding. Materials for the header expansion are captured in MTOs.

The jacking header was designed by SMRC structural engineers, who were sub-contracted to P&C. More detailed description for the jacking header, drawings and MTOs are presented in the Appendix G.

5.4 Risks and Mitigation Plans

- All valves located outdoors are insulated and heat traced.

5.5 Alternatives Considered

Various pipe materials were considered for cyclone O/F piping.

5.6 Future Work

- More detailed hydraulic calculations.
- More detailed operation strategy should be evaluated, which may affect features of the pipeline.

6. WATER SYSTEMS

6.1 Overview

Water is used in the following applications:

- Dilution, to control the cyclone feed solids concentration for optimum cyclones performance.
- Dilution, to control solids concentration of the sand for deposition.
- Gland seal for process pumps, after year 6.
- Flushing for sanded pipes, housekeeping, etcetera.

Water supply is by others to the battery limits of P&C scope of work. The battery limit is defined as the top of the dilution water head tank. Distribution system downstream of this point is scope of this study.

Table below shows water system main features:

Main function	**Nominal/Maximum Water Flow (m^3/h)**	**Notes**
Dilution water for cyclone operation	4,088/4,699	• Feed by gravity from dilution water head tank • Dilution NAG tailings from 55%m to 36%m
Dilution water for sand slurry placed on the dam	400/460	• Feed by gravity from water buffer tank • Dilution sand from 74%m to 65%m
Gland water supply	7.2	• Gland water tank in the cyclone plant • PD gland water pumps • One gland water pump for each slurry pump
Flush water	525	• Feed by gravity from water buffer tank • Flow based on 2m/s in 12" delivery pipe
Total water demand @ battery limit	4,493/5,166[1]	

Note 1: Water for flushing is excluded from this number; storage tanks provide capacity for flushing.

6.2 Key Assumptions and Considerations

The following considerations played a role in the design:

- Available water quality is assumed to be as "reclaim water from a typical copper mine", that contains some fine particles.

6.3 System Description and Operation

6.3.1 Dilution Water for Cyclone Operation

It is necessary to dilute the plant NAG tailings from 55%m to 36%m, which is optimum solids concentration for the cycloning process. Water is supplied by gravity from the dilution water header tank to the cyclone feed tank. The water addition is controlled according to nuclear density measurement on the cyclone feed pipe.

Dilution Water Head Tank
The dilution water header tank is located around 1,300 m from the cyclone feed tank on a leveled pad at elevation of 1,035 meter above mean sea level. The tank location/elevation was established based on minimum elevation required to provide gravity flow from this tank to the cyclone feed tank.

Tank features are presented in the table below:

Description	**Water buffer tank**
Material	CS plate, 8 and 6mm
Location	Outdoor, P&C dwg #5277-0-301, "Cyclone Feed and Plant, Site Plan"
Dimensions	DxH 12.5x12.5m
Insulation	50mm polyurethane
Volume	1,530m^3
Retention time	20min for nominal conditions.

6.3.2 Dilution Water for Sand

The cyclone U/F is generated at a solids concentration of 74%m. This stream has to be diluted to 65%m, which is required solids concentration for sand deposition on the dam. Dilution water for the sand deposition is supplied by gravity from the water buffer tank. The water addition is controlled according to the nuclear density measurement on the sand sampling loop.

6.3.3 Flush Water System

This system provides water for housekeeping, flushing plugged slurry pipes, sand jacking header, washing tanks, pumps etcetera. Water is supplied from the water buffer tank. The water pressure is boosted to 500kPa (75psig) by a flush water pump. The tank is located next to the cyclone feed tank. The pump is located in the cyclone plant building.
Tank features are presented in the table below:

Description	Water buffer tank
Material	CS plat, 6mm
Location	Outdoor, P&C dwg #5277-0-301, "Cyclone Feed and Plant, Site Plan"
Dimensions	DxH, 6.1x9.0m
Insulation	50mm polyurethane
Volume	263m^3
Retention time	20min for full capacity of flushing pump.

Flush water pump description is presented in the table below:

Description	Flush water pump
Model	8x10 centrifugal pump with mechanical seal
Duty point	525m^3/h @ 40m
Motor	80kW, no VFD
Installation schedule	year 1
Location	Inside the cyclone plant building
Standby	No standby required.

6.3.4 Gland Water System

The process slurry pumps require clean gland seal water. The gland water system is installed in year 6, along with installation of the first pair of slurry pumps. Each process slurry pump is paired with a dedicated gland seal water pump. In this configuration, the system availability is maximized. Water for the gland seal water service comes from the dilution water system.

The system consists of:

- Filters
  The water is filtered to remove particles larger than 25 microns from dilution water feeding gland water system. The filters are two stage, double basket type with differential pressure transmitters to switch over between dirty and clean filter.
- Gland water tank
  The gland water tank has the following features:

Description	Water buffer tank
Material	CS plate, 6mm
Location	In the cyclone plant building
Dimensions	DxH 3.5x9.6m
Insulation	None
Volume	$92m^3$
Retention time	12h for supplying gland water for all operating slurry pumps (4 in total).

- Gland water pumps

Gland water pump description is presented in the table below:

Feature	Description
Type	Positive displacement, plunger type (similar are used in pressure washers), FMC or equivalent
Duty point	$1.8m^3/h$ @ 2,100kPa ($213mH_20$)
Motor	5kW fixed speed
Installation schedule	year 1 to 5 no pumps year 6 to 11 2 pumps year 12 to 13 4 pumps year 12 to 18 6 pumps year 19 to 22 8 pumps.

6.3.5 Piping

The following piping is required for the water system:

Description	Pipe Size	Pipe Specification	Length (m)	Notes
Dilution water for cyclone feed	36”	HDPE DR 11	1,300	By gravity
Dilution water for cyclone U/f (Sand)	8”	HDPER DR 11	100	By gravity
Gland seal water	1”	CS	~50m in total	Pressure
Flush water	Vary, 12” and	CS	Vary, following	Pressure

Description	Pipe Size	Pipe Specification	Length (m)	Notes
	down		jacking header over LOM	

6.3.6 Valves

The following valves are used for water:

2" and below: manual ball valves

3" to 8": manual butterfly valves

10" and above air actuated butterfly valves.

6.4 Risks and Mitigation Plans

- All valves located outdoors are insulated and heat traced.
- The 12" flush water pipe for the sand distribution system is insulated and heat traced.

6.5 Alternatives Considered

None.

6.6 Future Work

Overall more detailed design for all water systems.

Yarek Koziura, PEng, PE
Project Manager
December 10th, 2012

Christian Kujawa
Manager Process

APPENDIX A – DESIGN CRITERIA

Knight Piésold CONSULTING

Knight Piésold

Casino Project Tailings Cyclone and Transport Study

Design Criteria Document

Report Number: KPV-5277 R01 Rev 0

December 10, 2012

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TERMS OF REFERENCE

This work has been conducted by Paterson & Cooke for the Knight Piésold under Order Number #9063. The proposal for this work was presented in P&C Proposal KPV-5277 C01 Rev B dated June 14, 2012 and Change Notices: CN01 Rev A dated June 26, 2012 and CN02 Rev A dated July 13, 2012.

DOCUMENT DISTRIBUTION, REVISION AND APPROVAL HISTORY

Rev	Date	Distribution / Revisions	Prepared	Reviewed	Client Approval
A	July 4, 2012	For Client Review	MJ/YK	CK	
B	September 11, 2012	For Client Review	MJ/YK	CK/RC	SB
C	November 1st, 2012	For FS Report	YK		
0	December 10, 2012	For FS Report	YK		SB

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1. INTRODUCTION

1.1 Background

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Mr. Graham Greenaway of Knight Piésold Vancouver (KPV) requested that Paterson & Cooke (P&C) to carry out a study for the tailings cyclone and transportation system feasibility level design for Casino Mining Corporation for their Casino Project in the Yukon Territory, Canada.

This report presents the design criteria used in this project.

1.2 Reference Documents

Document	Abbreviation
P&C Project Proposal, C01 Rev B, June 14, 2012.	P&C C01
P&C Change Notice CN01 Rev A, June 26, 2012.	P&C CN01
P&C Change Notice CN02 Rev A, July 13, 2012.	P&C CN02
Updated TMF Pre-Feasibility Design Rev 0 (reduced for P&C review)	KP-01
Casino Particle Size Distribution Report	KP-02
TMF - Waste Deposition Strategy - Year 1	KP-03
TMF - Waste Deposition Strategy - Year 23	KP-04
TMF – Production and Filling Schedule Curves dated Sept 28, 2012	KP-05
TMF – Summary of Design Basis and Operating Criteria	KP-06
"Casino-Process Plant", Email dated June 28, 2012 by Graham Greenaway.	KP-07
"RE: Casino-Process Plant design info", Email dated June 29, 2012 by Graham Greenaway.	KP-08
"Re: Casino – updated basis of design." Email dated July 30, 2012 by Sanne Brinkman	KP-09
"Re: Casino - required cyclone sand recovery" Email dated August 8, 2012 by Sanne Brinkman	KP-10
Minutes for Project meeting #6, August 29th 2012	KP-11
RE: Casino: comments on Design Basis and updated Filling Schedule, *Email dated September 28, 2012 by Sanne Brinkman*	KP-12

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1.3 Units

The main inputs and outputs of the project are in customary SI metric units.

1.4 Abbreviations

USD	United States of America Dollar
CAD	Canadian Dollar
FS	feasibility study
LOM	life-of-mine
U/F	cyclone underflow
O/F	cyclone overflow
PSD	particle size distribution
PAG	potentially acid generating
NAG	non-acid generating
TMF	tailings management facility
t/h	metric tonne per hour
t/d	metric tonne per day
t/m^3	metric tonne per cubic metre
m^3/h	cubic metres per hour
%m	solids percentage by mass
%v	solids percentage by volume
μ_{mf}	carrier fluid viscosity
amsl	above mean sea level
cP	centipoise

2. GENERAL

2.1 Process Description

The tailings from the process are split into two dedicated streams: potentially acid generating (PAG) stream (20% by distribution) and non-acid generating (NAG) stream (80% by distribution). This design criteria document applies only to the NAG tailings.

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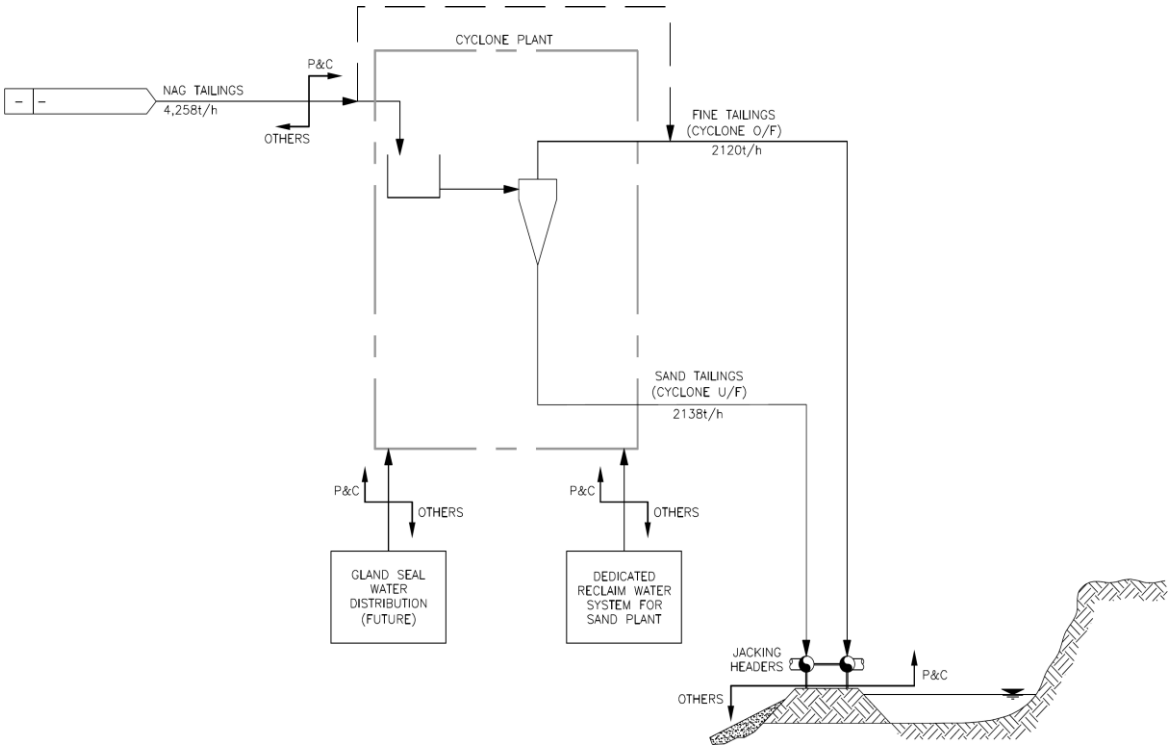
The NAG tailings from the milling process will be delivered from the mill to the Cyclone Plant. For approximately nine months of each year, the NAG tailings will be processed in one stage of cyclones to produce sand for the Tailings Management Facility (TMF) embankment construction. The cyclone overflow material (fine tailings) will be discharged directly into TMF impoundment on upstream side of the dam. During the three winter months (and when the cyclone station is offline), the tailings will bypass the Cyclone Plant and be deposited directly into TMF impoundment through the combined cyclone overflow pipeline. In order to feed the cyclones at optimum solids concentration for solids separation, dilution water is required at the Cyclone Plant.

Jacking headers are required for the cyclone underflow and the combined cyclone overflow pipelines to match the piping lift rate with the rise rate of the dam crest.

Rev 0



2.2 Study Level

The design is prepared at the feasibility study level of ±15% accuracy.

2.3 System List

System Name	System Description
Cyclone plant	Consists of cyclone feed box(es), cyclone feed pump(s), 1 stage cyclones, feed conditioning, water dilution system and interconnecting piping
Sand tailings	Consists of collection box, pump(s) and sand distribution pipelines
Fine tailings	Consists of collection box, fine tailings distribution piping and cyclones bypass arrangement.

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2.4 Process Battery Limits

The process battery limits are detailed in the table below:

Stream	Battery Limits
NAG Tailings Feed	At the inlet to the cyclone station feed box
Cyclone U/F	At the discharge point on the tailings storage facility
Cyclone O/F	At the discharge point on the tailings storage facility
Process water	Top of the dilution water head tank (Process water may be required for flushing, gland seal water or control aspects, such as dilution)

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3. SITE AND ENVIRONMENTAL

Item	Value / Description	Source / Comments
Location	Dawson Range Mountains of Yukon Territory, approximately 300 km northwest of Whitehorse 613,000 E 6,955,000 N	KP-1
Elevation	Sand plant elevation ~1,006 m amsl Crest elevation (year 1) 830 m amsl Crest elevation (year 23) 998 m amsl	P&C estimate KP-12 KP-12
Mean Annual Precipitation	510 mm	KP-12
Site Temperature	-50 ºC minimum	KP-012

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Item	Value / Description	Source / Comments
	+30 ºC maximum	
Seismic conditions	Operating Basis Earthquake (OBE)=1/500 - Mean maximum firm ground acceleration = 0.08g, magnitude = 8.0 Maximum Design Earthquake (MDE)=1/2,500 - Mean maximum firm ground acceleration = 0.13g, magnitude = 8.0	KP-01

4. PROCESS REQUIREMENTS

4.1 Mine

Item	Value / Description	Source / Comments
Total ore milled	975.8 Million tonne	KP-09
Normal throughput	120,000 tpd	KP-09
Mine life	22 year	KP-01
Cyclone plant operation	9 months in each year	KP-01

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4.2 Whole NAG Tailings

Item	Value / Description	Source / Comments
Medium description	Copper/gold flotation tailings	KP-01
Mill total tailings production	120,000*(1-0.01)=118,800 t/d where 0.01 is concentrate production	KP-06
NAG tailings fraction	80% of total tailings	KP-06
Concentrator availability	93%	KP-07
NAG tailings production	118,800*0.8=95,040t/d 95,040/0.93/24=4,258t/h	KP-06
NAG tailings concentration	Nominal 55%m Maximum 60%m Minimum 50%m	KP-06, KP-08

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Item	Value / Description	Source / Comments
Design factor	+15%, -10% 60% of nominal tonnage expected occasionally	KP-08
TR tailings tonnage	Nominal 4,258 t/h @ 55%m Maximum (+15%) 4,258*1.15=4,896 t/h @ 55%m Minimum (-10%) 4,258*0.90=3,832 t/h @ 55%m	KP-06, KP-08

4.3 Cyclone Plant

4.3.1 Cyclone Station Feed

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Item	Value / Description	Source / Comments
Cyclone station capacity	100% of NAG tailings production, 9 months of each year	KP-01
Design Factor	+15%, -10% 40% of nominal tonnage expected occasionally	KP-06, KP-08
Cyclone station feed rate	Normal 95,040t/d or 4,258 t/h at 55%m Maximum (+15%) 4,896 t/h at 55%m Minimum (-10%) 3,832 t/h at 55%m	KP-06, KP-08
Cyclone station location	Cyclone station in a heated building (by others), at a location to be determined by P&C. Cyclone Plant relocation during LOM will be minimized.	P&C design
Cyclone station availability	90% during 9 month period	KP-09
Solids density	2,695 kg/m^3	KP-02
Liquid density	1,000 kg/m^3 (water)	Assumption

4.3.2 Cyclone Station

Item	Value / Description	Source / Comments
Cyclone type	Conventional	P&C design
Feed concentration	36% (diluted from 55% as supplied by process plant)	P&C design
Dilution water source	Reclaim water provided by others	P&C design
Cyclone feed pressure requirement	72.4 kPa	P&C design

Item	Value / Description	Source / Comments
Feed mix box retention time	40 seconds	P&C design
O/F box retention time	40 seconds, cyclone O/F piped directly to TMF	P&C design
U/F box retention time	40 seconds	P&C design
Number of spare cyclones	2	P&C design

4.3.3 Dilution Water Head Tank

Item	Value / Description	Source / Comments
Tank bottom elevation	1035m asl	P&C design
Tank height	12.5m	P&C design
Tank diameter	12.5m	P&C design
Tank retention Time	20 minutes	P&C design

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4.4 Cyclone Overflow

Item	Value / Description	Source / Comments
Medium description	Cyclone overflow	
Design concentration	23.7%m	P&C design
Pipeline route	As defined in P&C corridor drawings	KP-03 and KP-04
Pipeline design factor for friction losses	10% above calculated to cover minor losses and slurry model accuracy	P&C assumption

4.5 Sand (Cyclone Underflow)

Item	Value / Description	Source / Comments
Medium description	Cyclone underflow	

Cyclone plant sand recovery	50.2%	P&C design and KP-10
Cyclone sand production	Nominal 4,258t/d*0.502=2,138t/d 2,138t/d*0.93*0.9*(9/12)*24*365=11.76mln t/year	P&C calculation
Cyclone sand (U/F) quality	12% passing 74 µm	KP-10
Cyclone U/F solids mass concentration (before dilution)	74%	P&C simulation
Solids mass concentration after dilution for dam construction	65%	KP-09
Pipeline route	As defined on site corridor drawings	KP-03 and KP-04
Design factor for friction losses	15% above calculated to cover minor losses and slurry model accuracy	P&C assumption

Rev 0

5. SLURRY PROPERTIES

5.1 NAG Bulk Tailings – Sand Plant Feed

Item	Value / Description		Source / Comments
Size distribution	**Size (µm)**	**Percent passing**	KP-02
	853	100.0%	
	422	99.9%	
	251	94.1%	
	152	66.4%	
	75	42.0%	
	43.5	33.2%	
	31.7	28.1%	
	20.7	22.4%	
	12.3	16.7%	
	6.3	11.0%	
	3.2	7.9%	

Item	Value / Description		Source / Comments
	1.3	5.4%	
Slurry class	Class 3		ANSI/HI 12.1 -12. 6 Service Duty Chart
Solids specific gravity	2,695 kg/m^3		KP-02
d_{50}	100 µm		From PSD
Percent fines (-44µm)	33.3%		From PSD
d_{85} coarse (+74 µm)	241 µm		From PSD
d_{50} coarse (+74 µm)	168 µm		From PSD
C_{bmax}	52 %v		P&C data base
Flocculants or reagents added to medium	n/a		KP-01
Medium temperature	5 to 10ºC		P&C assumption
Slurry flow behavior	NAG tailings and corresponding carrier fluid (-44 µm fraction) are mixed regime (combination of settling and non-settling characteristics.		P&C design
Slurry rheology @ C=55%m	τ_y (Pa)	8.7	P&C assumption based on similar tailings
	K_B (mPa.s)	16	
Carrier fluid rheology @ C=55%m	τ_y (Pa)	0.5	P&C assumption based on similar tailings
	K_B (mPa.s)	4.4	

5.2 Cyclone Overflow (Fine Tailings)

Item	Value / Description		Source / Comments
Size distribution	**Size (µm)**	**Percent passing**	P&C simulation
	2000	100.0	
	1000	100.0	
	850	100.0	

Item	Value / Description		Source / Comments
	600	100.0	
	420	100.0	
	300	100.0	
	212	99.9	
	150	96.8	
	100	85.8	
	75	73.2	
	53	64.4	
	45	60.1	
	38	55.5	
	20	39.6	
	15	34.0	
	10	27.0	
	7	21.5	
Slurry class	Class 2		ANSI/HI 12.1 -12. 6 Service Duty Chart
Solids specific gravity	2,695 kg/m^3		KP-02
d_{50}	30 µm		From PSD
Percent fines (-44µm)	60.1 %		From PSD
C_{bmax}	45%		P&C assumption
Flocculants or reagents added to medium	n/a		KP-01
Medium temperature	5 to 10 ºC		P&C assumption
Slurry flow	The fine tailings are assumed to be non-settling slurry.		P&C assumption

Item	Value / Description	Source / Comments
behavior		
Slurry carrier fluid viscosity	μ_{mf}=1.4cP for solids concentration by weight C_w=23.7% and fines concentration by weight C_{mf}=23.7%	P&C assumption

5.3 Cyclone Underflow (Sand Tailings)

Item	Value / Description		Source / Comments
Size distribution	**Size (µm)**	**Percent passing**	P&C simulation
	2000	100.0	
	1000	100.0	
	850	100.0	
	600	99.9	
	420	99.7	
	300	92.2	
	212	69.8	
	150	35.2	
	100	18.4	
	75	11.1	
	53	8.6	
	45	7.6	
	38	6.8	
	20	4.6	
	15	3.9	
	10	3.0	
	7	2.4	
	3	1.5	
Slurry class	Class 3		ANSI/HI 12.1 -12. 6 Service Duty Chart

Item	Value / Description	Source / Comments
Solids specific gravity	2,695 kg/m^3	KP-02
d_{50}	174 µm	From PSD
Percent fines (-44µm)	7.6%	From PSD
C_{bmax}	50%	P&C assumption
Flocculants or reagents added to medium	n/a	KP-01
Medium temperature	5 to 10ºC	P&C assumption
Slurry flow behavior	The sand tailings are assumed to be fast settling slurry with small carrier fluid component.	P&C assumption
Slurry carrier fluid viscosity	μ_{mf}=1.3cP for solids concentration by weight C_w=65% and fines concentration by weight C_{mf}=18.2%	P&C assumption

6. EMBANKMENT DATA

Item	Value / Description				Source / Comments
Operation	100% of sand production, 9month per year, continuous 24 hour per day				KP-01
Construction mode	Cell construction with compaction				KP-01
Availability	90%, matching sand plant availability				P&C design
Embankment crest width	30 m				KP-09
Dam Elevations & Sand Requirements	**Year**	**Crest Elevation**	**Crest Length (m)**	**Required Sand mt/y**	KP-12
	-1	830 amsl	868	0	
	1	830 amsl	868	9.2	
	2	849 amsl	1,308	12.3	
	3	865 amsl	1,450	12.2	
	4	876 amsl	1550	12.2	
	5	884 amsl	1,610	12.1	
	6	894 amsl	1,754	12.1	
	7	904 amsl	1,832	12.1	
	12	942 amsl	2,061	12.3	
	13	950 amsl	2,109	12.4	
	19	988 amsl	2,363	4.6	
	20	992 amsl	2,400	4.6	
	22	998 amsl	2,460 Main 333 West Dam	1.7	
Pond Elevation Below Crest	11m in year 1 5 to 6m in years 3 to 13 4 to 3m in years 14 to 22				KP-12

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General update of the table

7. IMPOUNDMENT

The NAG whole tailings, sand plant by-pass and combined cyclone overflow use the same pipeline and jacking header across the dam crest.

7.1.1 Non-Reactive Tailings Disposal (Sand Plant Bypass)

Item	Value / Description	Source / Comments
Operation	Continuous for 3 months per year, 24 hours per day, 100% of NAG flotation tailings during winter months, also when cyclone station is by-passed	KP-01
Discharge	Take off valves at 100 m spacing. One take off valve open at any time. Each take off valve/pipe branch set sized to carry 100% of full cyclone u/f.	P&C assumption
Availability	90%, matching sand plant availability	P&C assumption

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7.1.2 Combined Cyclone Overflow Disposal

Item	Value / Description	Source / Comments
Operation	Continuous for 9 months per year, 24hours per day, 100% of combined cyclone overflow	KP-01
Discharge	Take off valves every 100 m spacing. 2 to 3 valves open at any time. Each take off valve/pipe branch set sized to carry 50% of full cyclone O/f or bypass.	P&C assumption
Availability	90%, matching sand plant availability	P&C assumption

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8. MECHANICAL

Item	Value / Description	Source / Comments
Equipment size/types	Only equipment proven on similar operation will be considered	P&C assumption

8.1 Pumps

Item	Value / Description	Source / Comments
Standby	All pumps to be in operating/standby sets to maximize sand plant availability	P&C assumption

Item	Value / Description	Source / Comments
Centrifugal slurry pump lining material	High-head pumps: metal lining Low-head, low-duty slurry pumps: rubber lining	P&C assumption
Centrifugal slurry pump – seal arrangement	All slurry pumps equipped with gland flush seal arrangement	P&C assumption
Centrifugal slurry pump efficiency	Pump efficiency: from pump curve and duty point Variable frequency direct gearbox drive efficiency: 95%	P&C assumption
Centrifugal slurry pump – maximum impeller tip speed	Class 2 slurry with rubber lining: 28 m/s Class 2 slurry with metal lining: 38 m/s Class 3 slurry with rubber lining: 33 m/s Class 3 slurry with metal lining: 26 m/s	P&C assumption, ANSI/HI 12.1 -12. 6 slurry design code

8.2 Jacking Headers

Item	Value / Description	Source / Comments
Header type	Hydraulically operated 1 header for cyclone overflow and/or NAG whole stream tailings 1 header for sand stream	Industry standard
Average rate of rise	8 m per year	KP-02
Jack load	Sand tailings (cyclone u/f): 269kN (27 tonnes) Fine tailings (cyclone o/f): 169kN (19 tonnes)	P&C design
Wind load	Not available	

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9. PIPING

9.1.1 Steel piping

Steel piping used for all main pipelines.

Item	Value / Description	Source / Comments
Dimensional standard	ASME B31.10	P&C assumption
Steel grade	ASTM A53, API 5L X42 or higher	P&C assumption
Flange/couplings	Victaulic type preferred	P&C assumption

Item	Value / Description	Source / Comments
Internal lining	6 mm rubber lining within cyclone plant	P&C assumption
External coating	Painted, epoxy coating to provide life for pipes ~23 years	P&C assumption
Corrosion / wear allowance	2.1mm/1000h for NAG bulk tailings in slack flow 0.1mm/1000h for NAG bulk tailings in full pipe flow 0.1mm/1000h for cyclone O/F in slack flow 0.01mm/1000h for cyclone O/F in full pipe flow 9.1mm/1000h for cyclone U/F in slack flow 1.5mm/1000h for cyclone U/F in full pipe flow	P&C assumption
Support system	Above ground on sleepers, plinths	P&C assumption

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9.1.2 High Density Polyethylene Piping

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HDPE piping used for cyclone o/f on the ground and branch piping off jacking header to deposition points.

Item	Value / Description	Source / Comments
Dimensional standard	ASTM F714	P&C assumption
Material grade	PE4710	P&C assumption
Flange/couplings	Victaulic style 995 or similar	P&C assumption

10. CIVIL

By others.

11. STRUCTURAL

By others.

12. ELECTRICAL AND INSTRUMENTATION

By others.

13. DESIGN CODES AND STANDARDS

Item	Value / Description	Source / Comments
Pipeline design	ANSI/ASME Code for Pressure Piping B31.11 Slurry	Industry standard

Item	Value / Description	Source / Comments
	Transportation Piping Systems	
Cyclone plant piping	ANSI/ASME Process Plant Piping B31.3	Industry standard
Slurry pumps	ANSI/HI 12.1-12.6 2011	Industry standard

14. COSTING

Costing will be done by others. P&C will provide MTOs to support a cost estimate of ±15% accuracy level.

15. KEY DESIGN ISSUES AND DECISIONS

None.

16. UNAGESOLVED ISSUES

16.1 None.

Mazyar Jalayer
Project Engineer
November 1st, 2012

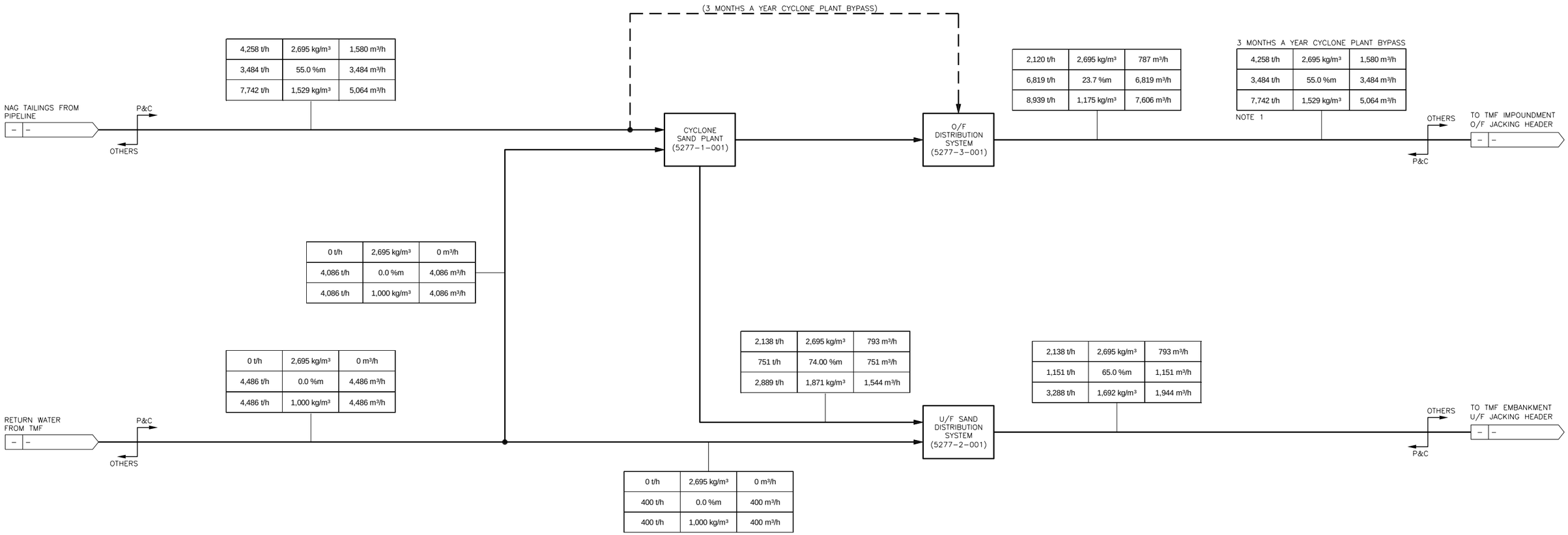
Yarek Koziura
Project Manager

Christian Kujawa
Manager Process

APPENDIX B – PATERSON&COOKE DRAWINGS

SOLIDS t/h	SOLIDS SG	SOLIDS m³/h
LIQUID t/h	%m SOLIDS	LIQUID m³/h
SLURRY t/h	SLURRY SG	SLURRY m³/h

NOMINAL TONNAGE



NOTES

1. NAG TAILINGS TO BYPASS CYCLONE SAND PLANT AND BE TRANSPORTED THROUGH CYCLONE OVERFLOW PIPELINE THREE MONTHS OF THE YEAR.

PRELIMINARY

REVISIONS					
REV	DATE	DESCRIPTION	DESG	DRWN	CHKD
A	27 AUG 12	ISSUED FOR REVIEW	MJ	TF	YK
B	25 OCT 12	ISSUEDFOR APPROVAL	MJ	TF	YK
C	01 NOV 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK
0	10 DEC 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK

REFERENCE DRAWINGS	
DRG No.	DESCRIPTION

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Knight Piésold CONSULTING

CASINO PROJECT
TAILINGS CYCLONE AND TRANSPORTATION STUDY

SHEET ###

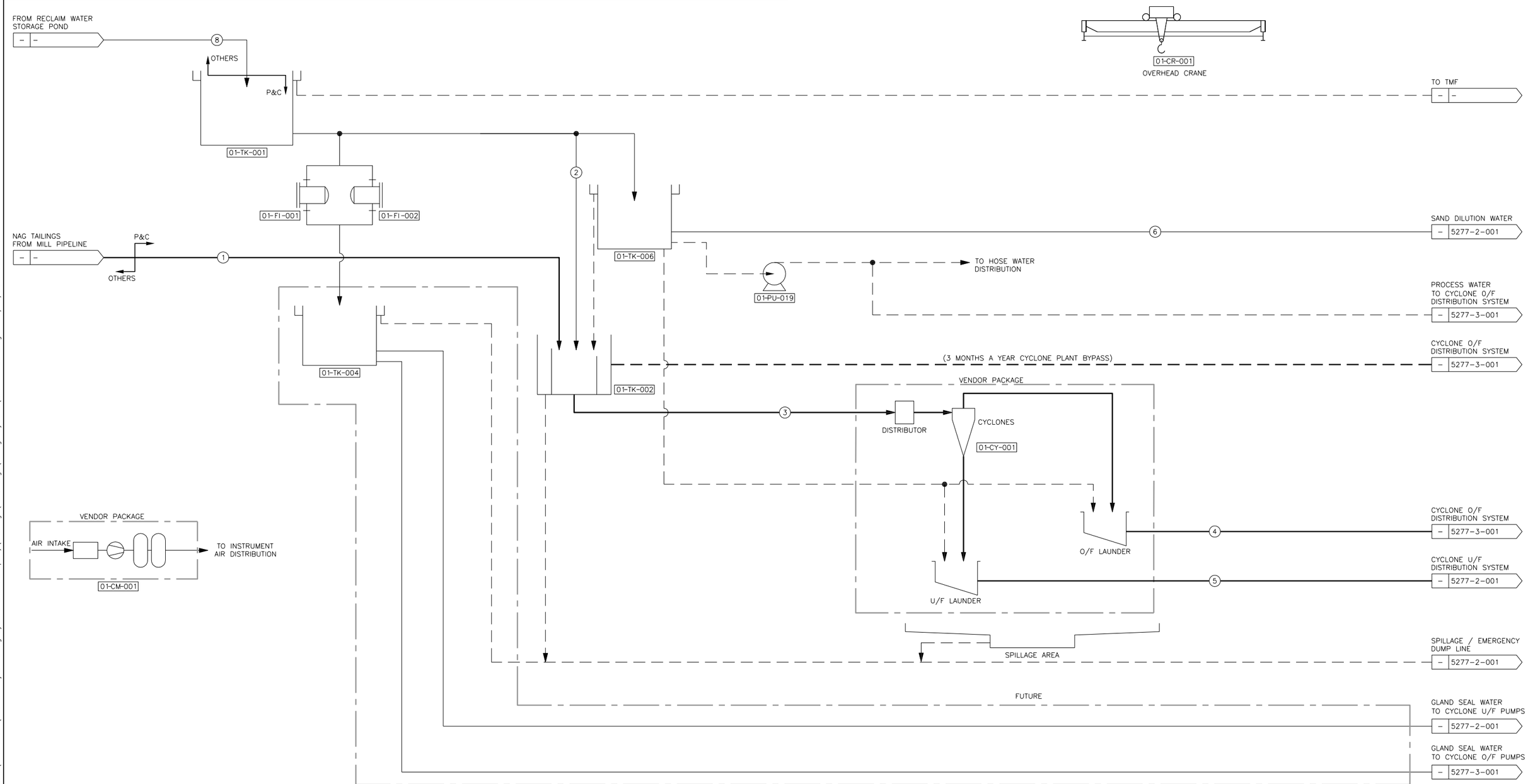
BLOCK PROCESS FLOW DIAGRAM

SCALE			PROJECT NUMBER	SIZE
N.T.S.			KPV-5277	D
DESIGNED	MJ	27-AUG-12	DRAWING NUMBER	REV
DRAWN	TF	27-AUG-12	5277-0-001	0

Tom Figas – P:\3 – Projects\KPV-5277 (Casino Project Tailing Cyclone and Transport)\Drawings\P&C Dwgs\Tailings Cyclone\5277-0-001.dwg – 12/10/2012 2:57 PM

STREAM NUMBER	1		2		3		4		5		6		8	
DESCRIPTION	NR TAILINGS		Dilution Water		Cyclone Feed		Cyclone Overflow		Cyclone Underflow		Sand Dilution Water		Combined Cyclone Dilution Water	
SCENARIO	MAX	NOMINAL	MAX	NOMINAL	MAX	NOMINAL	MAX	NOMINAL	MAX	NOMINAL	MAX	NOMINAL	MAX	NOMINAL
SOLIDS (t/h)	4 897	4 258	-	-	4 897	4 258	2 439	2 120	2 458	2 138	-	-	-	-
WATER (m^3/h)	4 006	3 484	4 699	4 086	8 705	7 570	7 842	6 819	864	751	460	400	5 159	4 486
TOTAL MIXTURE (m^3/h)	5 823	5 064	4 699	4 086	10 522	9 150	8 746	7 606	1 776	1 544	460	400	5 159	4 486
MIXTURE DENSITY (t/m^3)	1.53	1.53	-	-	1.29	1.29	1.18	1.18	1.87	1.87	-	-	-	-
VOLUME CONCENTRATION (%)	31.2%	31.2%	-	-	17.3%	17.3%	10.3%	10.3%	51.4%	51.4%	-	-	-	-
MASS CONCENTRATION (%)	55.0%	55.0%	-	-	36.0%	36.0%	23.7%	23.7%	74.0%	74.0%	-	-	-	-
SOLIDS DENSITY (t/m^3)	2.70	2.70	-	-	2.70	2.70	2.70	2.70	2.70	2.70	-	-	-	-
COMMENT														

TAG NO.	DESCRIPTION	CAPACITY/ DUTY	INSTALLED POWER	COMMENT	INSTALLATION YEAR	DATA SHEET
01-TK-001	DILUTION WATER HEAD TANK	DxH, 12.5 m x 12.5 m			INSTALLED YEAR -1	
01-TK-002	CYCLONE FEED TANK	HxWxL, 8m x 7.7m x 8m			INSTALLED YEAR -1	
01-TK-004	GLAND SEAL WATER TANK	DxH, 3.5m x 9.6m			INSTALLED YEAR 6	
01-TK-006	WATER BUFFER TANK	DxH, 6.1m x 9m			INSTALLED YEAR -1	
01-CY-001	CYCLONE CLUSTER(S)	CLUSTER OF 12 x 800mm Dia., CAVEX CYCLONE			INSTALLED YEAR -1	
01-CR-001	OVERHEAD CRANE	15tonne	20kW		INSTALLED YEAR -1	
01-PU-019	FLUSH WATER PUMP	525 m^3/hr @ 40m	80 kW	8x10	INSTALLED YEAR -1	
01-CM-001	AIR COMPRESSOR PACKAGE	106 m^3/hr at 780 kPa	11kW	ATLAS COPCO GA11-8.5 W/DESICCANT AIR DRYER	INSTALLED YEAR -1	
01-FI-001	GSW FILTER - STANDBY	28.8 m^3/hr			INSTALLED YEAR -1	
01-FI-002	GSW FILTER - STANDBY	28.8 m^3/hr			INSTALLED YEAR -1	



PRELIMINARY

REVISIONS						REFERENCE DRAWINGS	
REV	DATE	DESCRIPTION	DESG	DRWN	CHKD	DRG No.	DESCRIPTION
A	26 SEP 12	ISSUED FOR REVIEW	MJ	TF	YK/CK	5277-0-001	BLOCK PROCESS FLOW DIAGRAM
B	25 OCT 12	ISSUED FOR APPROVAL	MJ	TF	YK	5277-2-001	CYCLONE SAND DISTRIBUTION, PROCESS FLOW DIAGRAM, CYCLONE U/F DISTRIBUTION
C	01 NOV 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK	5277-3-001	CYCLONE OVERFLOW DISTRIBUTION, PROCESS FLOW DIAGRAM, CYCLONE O/F DISTRIBUTION
0	10 DEC 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK		

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CASINO PROJECT
TAILINGS CYCLONE AND TRANSPORTATION STUDY

SHEET 1 ###

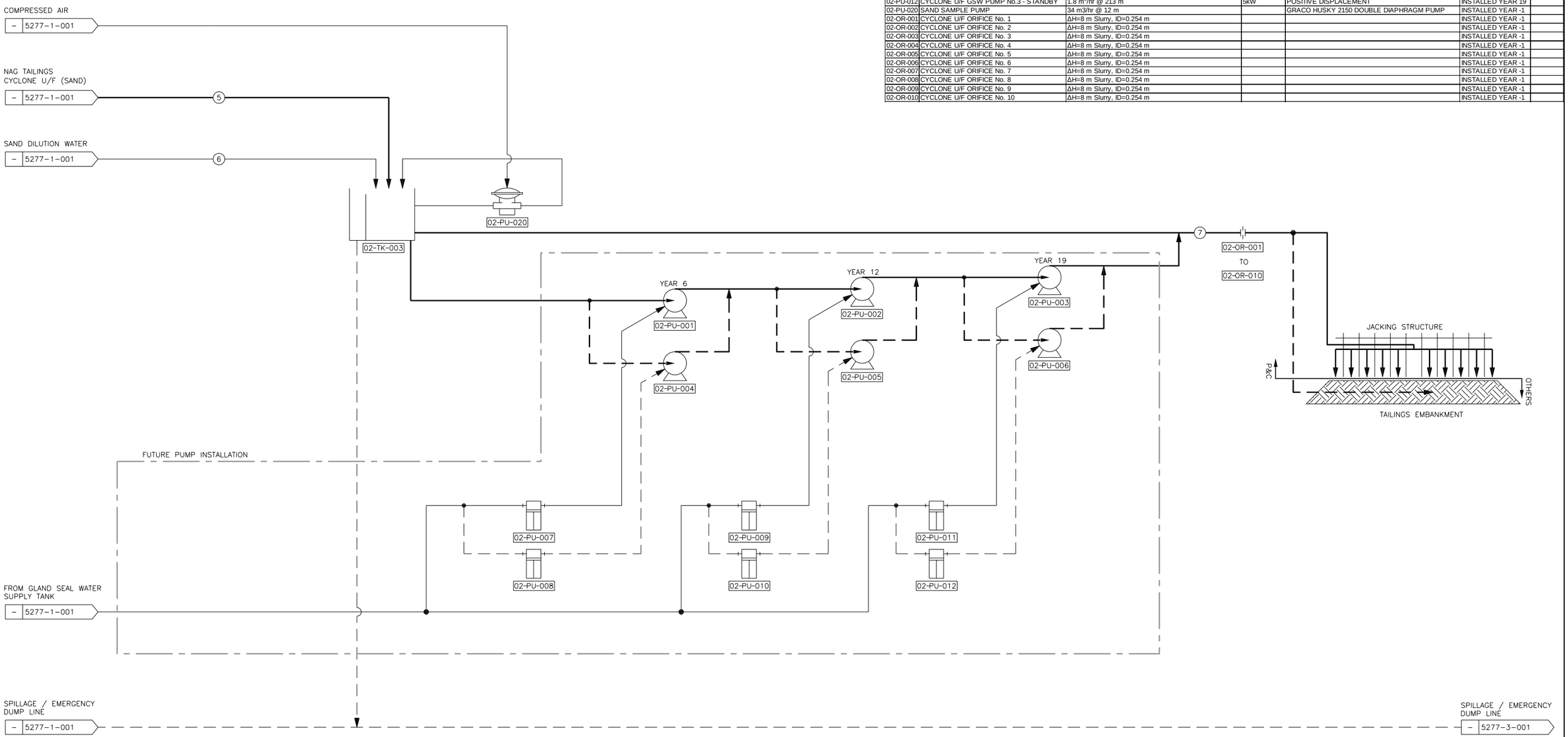
CYCLONE PLANT
PROCESS FLOW DIAGRAM

SCALE			PROJECT NUMBER	SIZE
N.T.S.			KPV-5277	D
DESIGNED	MJ	27-AUG-12	DRAWING NUMBER	REV
DRAWN	TF	27-AUG-12	5277-1-001	0

Tom Figas - P:\3 - Projects\KPV-5277 (Casino Project Tailing Cyclone and Transport)\Drawings\P&C Dwgs\Tailings Cyclone\5277-1-001.dwg - 12/10/2012 2:59 PM

STREAM NUMBER	5		6		7	
DESCRIPTION	Cyclone Underflow		Sand Dilution Water		Final Sand	
SCENARIO	MAX	NOMINAL	MAX	NOMINAL	MAX	NOMINAL
SOLIDS (t/h)	2 458	2 138	-	-	2 458	2 138
WATER (m^3/h)	864	751	460	400	1 324	1 151
TOTAL MIXTURE (m^3/h)	1 776	1 544	460	400	2 236	1 944
MIXTURE DENSITY (t/m^3)	1.87	1.87	-	-	1.69	1.69
VOLUME CONCENTRATION (%)	51.4%	51.4%	-	-	40.8%	40.8%
MASS CONCENTRATION (%)	74.0%	74.0%	-	-	65.0%	65.0%
SOLIDS DENSITY (t/m^3)	2.70	2.70	-	-	2.70	2.70
COMMENT						

TAG NO.	DESCRIPTION	CAPACITY/ DUTY	INSTALLED POWER	COMMENT	INSTALLATION YEAR	DATA SHEET
02-TK-003	CYCLONE U/F TANK	HxLxW, 4 m x 3.2 m x 4 m			INSTALLED YEAR -1	
02-PU-001	CYCLONE U/F PUMP No. 1	2,236 m^3/hr @ 43 m	671kW VFD	WEIR 16/14 AHP	INSTALLED YEAR 6	
02-PU-002	CYCLONE U/F PUMP No. 2	2,236 m^3/hr @ 43 m	671kW VFD	WEIR 16/14 AHP	INSTALLED YEAR 12	
02-PU-003	CYCLONE U/F PUMP No. 3	2,236 m^3/hr @ 43 m	671kW VFD	WEIR 16/14 AHP	INSTALLED YEAR 19	
02-PU-004	CYCLONE U/F PUMP No. 1 - STANDBY	2,236 m^3/hr @ 43 m	671kW VFD	WEIR 16/14 AHP	INSTALLED YEAR 6	
02-PU-005	CYCLONE U/F PUMP No. 2 - STANDBY	2,236 m^3/hr @ 43 m	671kW VFD	WEIR 16/14 AHP	INSTALLED YEAR 12	
02-PU-006	CYCLONE U/F PUMP No. 3 - STANDBY	2,236 m^3/hr @ 43 m	671kW VFD	WEIR 16/14 AHP	INSTALLED YEAR 19	
02-PU-007	CYCLONE U/F GSW PUMP No.1	1.8 m^3/hr @ 213 m	5kW	POSITIVE DISPLACEMENT	INSTALLED YEAR 6	
02-PU-008	CYCLONE U/F GSW PUMP No.1 - STANDBY	1.8 m^3/hr @ 213 m	5kW	POSITIVE DISPLACEMENT	INSTALLED YEAR 6	
02-PU-009	CYCLONE U/F GSW PUMP No.2	1.8 m^3/hr @ 213 m	5kW	POSITIVE DISPLACEMENT	INSTALLED YEAR 12	
02-PU-010	CYCLONE U/F GSW PUMP No.2 - STANDBY	1.8 m^3/hr @ 213 m	5kW	POSITIVE DISPLACEMENT	INSTALLED YEAR 12	
02-PU-011	CYCLONE U/F GSW PUMP No.3	1.8 m^3/hr @ 213 m	5kW	POSITIVE DISPLACEMENT	INSTALLED YEAR 19	
02-PU-012	CYCLONE U/F GSW PUMP No.3 - STANDBY	1.8 m^3/hr @ 213 m	5kW	POSITIVE DISPLACEMENT	INSTALLED YEAR 19	
02-PU-020	SAND SAMPLE PUMP	34 m3/hr @ 12 m		GRACO HUSKY 2150 DOUBLE DIAPHRAGM PUMP	INSTALLED YEAR -1	
02-OR-001	CYCLONE U/F ORIFICE No. 1	ΔH=8 m Slurry, ID=0.254 m			INSTALLED YEAR -1	
02-OR-002	CYCLONE U/F ORIFICE No. 2	ΔH=8 m Slurry, ID=0.254 m			INSTALLED YEAR -1	
02-OR-003	CYCLONE U/F ORIFICE No. 3	ΔH=8 m Slurry, ID=0.254 m			INSTALLED YEAR -1	
02-OR-004	CYCLONE U/F ORIFICE No. 4	ΔH=8 m Slurry, ID=0.254 m			INSTALLED YEAR -1	
02-OR-005	CYCLONE U/F ORIFICE No. 5	ΔH=8 m Slurry, ID=0.254 m			INSTALLED YEAR -1	
02-OR-006	CYCLONE U/F ORIFICE No. 6	ΔH=8 m Slurry, ID=0.254 m			INSTALLED YEAR -1	
02-OR-007	CYCLONE U/F ORIFICE No. 7	ΔH=8 m Slurry, ID=0.254 m			INSTALLED YEAR -1	
02-OR-008	CYCLONE U/F ORIFICE No. 8	ΔH=8 m Slurry, ID=0.254 m			INSTALLED YEAR -1	
02-OR-009	CYCLONE U/F ORIFICE No. 9	ΔH=8 m Slurry, ID=0.254 m			INSTALLED YEAR -1	
02-OR-010	CYCLONE U/F ORIFICE No. 10	ΔH=8 m Slurry, ID=0.254 m			INSTALLED YEAR -1	



PRELIMINARY

REVISIONS						REFERENCE DRAWINGS	
REV	DATE	DESCRIPTION	DESG	DRWN	CHKD	DRG No.	DESCRIPTION
A	26 SEP 12	ISSUED FOR REVIEW	MJ	TF	YK/CK	5277-0-001	BLOCK PROCESS FLOW DIAGRAM
B	25 OCT 12	ISSUED FOR APPROVAL	MJ	TF	YK	5277-1-001	CYCLONE PLANT, PROCESS FLOW DIAGRAM, CYCLONE STATION
C	01 NOV 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK	5277-3-001	CYCLONE OVERFLOW DISTRIBUTION, PROCESS FLOW DIAGRAM, CYCLONE O/F DISTRIBUTION
0	10 DEC 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK		

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CASINO PROJECT
TAILINGS CYCLONE AND TRANSPORTATION STUDY
SHEET 1 ###

CYCLONE SAND DISTRIBUTION
PROCESS FLOW DIAGRAM

SCALE N.T.S. | PROJECT NUMBER KPV-5277 | SIZE D
DESIGNED MJ 27-AUG-12 | DRAWING NUMBER 5277-2-001 | REV 0
DRAWN TF 27-AUG-12

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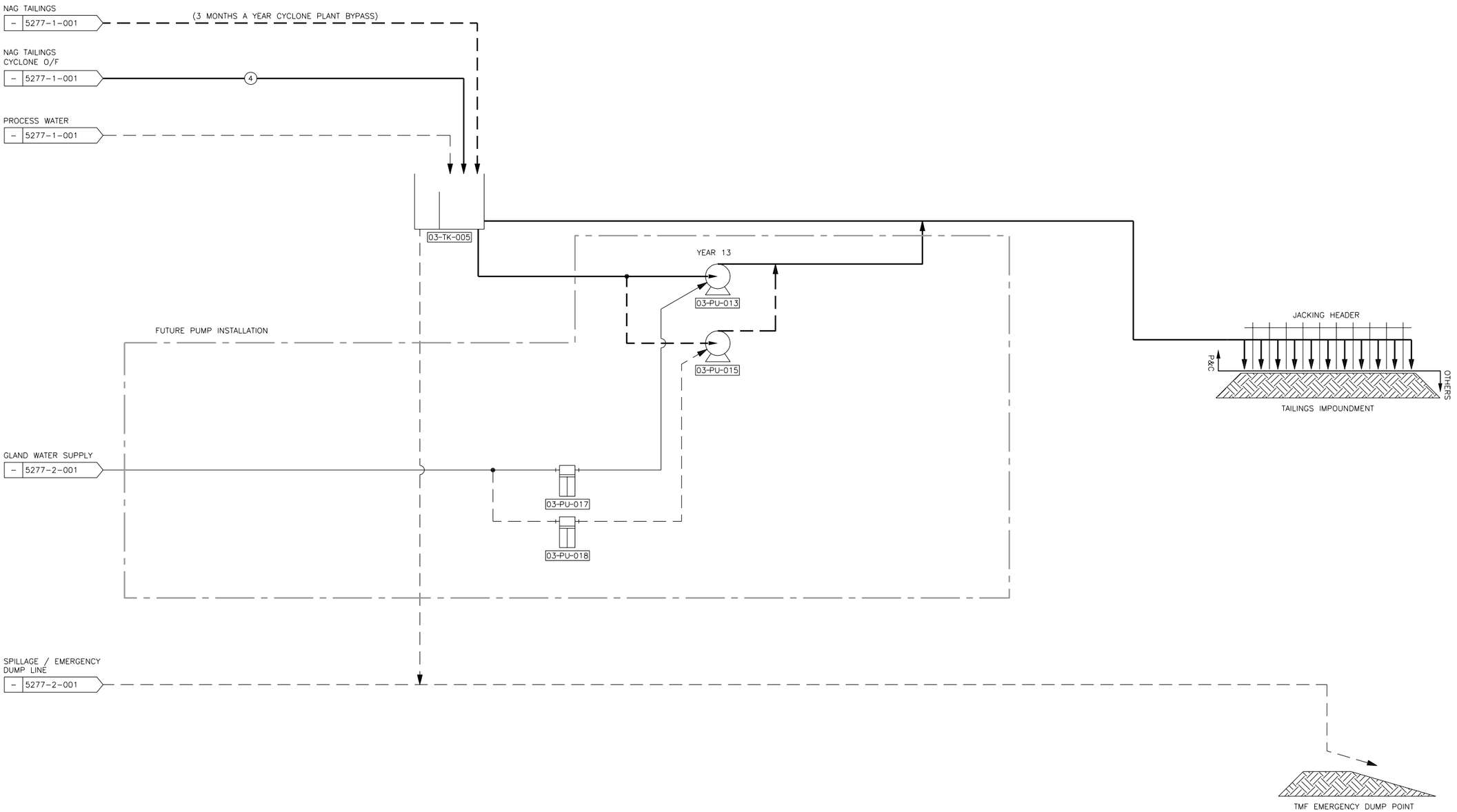
STREAM NUMBER	4	
DESCRIPTION	Cyclone Overflow	
SCENARIO	MAX	NOMINAL
SOLIDS (t/h)	2 439	2 120
WATER (m³/h)	7 842	6 819
TOTAL MIXTURE (m³/h)	8 746	7 606
MIXTURE DENSITY (t/m³)	1.18	1.18
VOLUME CONCENTRATION (%)	10.3%	10.3%
MASS CONCENTRATION (%)	23.7%	23.7%
SOLIDS DENSITY (t/m³)	2.70	2.70
COMMENT		

TAG NO.	DESCRIPTION	CAPACITY/ DUTY	INSTALLED POWER	COMMENT	INSTALLATION YEAR	DATA SHEET
03-TK-005	CYCLONE O/F TANK	HxWxL, 5 m x 5.5 m x 6.2 m			INSTALLED YEAR -1	
03-PU-013	CYCLONE O/F PUMP	8,746 m^3/hr @ 60 m	2000kW VFD	WEIR 650L	INSTALLED YEAR 13	
03-PU-015	CYCLONE O/F PUMP - STANDBY	8,746 m^3/hr @ 60 m	2000kW VFD	WEIR 650L	INSTALLED YEAR 13	
03-PU-017	CYCLONE O/F GSW PUMP	1.8 m^3/hr @ 75 m	5kW	POSITIVE DISPLACEMENT	INSTALLED YEAR 13	
03-PU-018	CYCLONE O/F GSW PUMP - STANDBY	1.8 m^3/hr @ 75 m	5kW	POSITIVE DISPLACEMENT	INSTALLED YEAR 13	



PRELIMINARY

REVISIONS						REFERENCE DRAWINGS	
REV	DATE	DESCRIPTION	DESG	DRWN	CHKD	DRG No.	DESCRIPTION
A	26 SEP 12	ISSUED FOR INTERNAL REVIEW	MJ	TF	YK/CK	5277-0-001	BLOCK PROCESS FLOW DIAGRAM
B	25 OCT 12	ISSUED FOR APPROVAL	MJ	TF	YK	5277-1-001	CYCLONE PLANT, PROCESS FLOW DIAGRAM, CYCLONE STATION
C	01 NOV 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK	5277-2-001	CYCLONE SAND DISTRIBUTION, PROCESS FLOW DIAGRAM, CYCLONE U/F DISTRIBUTION
0	10 DEC 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK		

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CASINO PROJECT
TAILINGS CYCLONE AND TRANSPORTATION STUDY
SHEET 1 ###

CYCLONE OVERFLOW DISTRIBUTION
PROCESS FLOW DIAGRAM

SCALE			PROJECT NUMBER	SIZE
N.T.S.			KPV-5277	D
DESIGNED	MJ	27-AUG-12	DRAWING NUMBER	REV
DRAWN	TF	27-AUG-12	5277-3-001	0

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DILUTION WATER FROM DILUTION WATER HEAD TANK
– | 5277-1-102
HDPE(DR11)-PW
(1.3km)

NAG TAILINGS
– | –
P&C
OTHERS
32"-CS(STD)6mmRL-PS

O/F FROM 01-TK-006
– | 5277-1-102
18"-HDPE(DR17)-PW

36"-CS(STD)-PW
26"
FE
FI
8"-CS(STD)-PW
LI
LE
HS
12"-CS(STD)-PW
6"
FIC
HS
ZIC
ZIO
HS
ZIC
ZIO
NOTE 2 TYP.
EL. 1013.3m
O/F
24" N.C.
N.C.
01-TK-002
CYCLONE FEED TANK

4"-CS(STD)-PW
(INSULATED & HEAT TRACED OUTDOORS)
TO GLAND SEAL WATER SYSTEM
– | 5277-1-103

01-CR-001
OVERHEAD CRANE

32"-CS(STD)6mmRL-PS
NAG TAILINGS BYPASS TO 03-TK-005
– | 5277-3-101

DENSITY SIGNAL FROM SAMPLER OR INLINE DENSITY METER (YEAR 6)
– | 5277-2-101/102

HS
DIC
FI
DI
PI
PI
PI
PIT
LC
HS
VENDOR PACKAGE
FQI
FI
FIC
FE
DE
M
40"-CS(10)-PS
38"-CS(STD)6mmRL-PS
01-CY-001
12 CYCLONE CLUSTER
TO CYCLONE O/F TANK 03-TK-005
40"-CS(10)6mmRL-PS
– | 5277-3-101/102
HS
16" N.C.
DILUTION WATER
– | 5277-1-102
8"-CS(STD)-PW
M
6"
8"
TO CYCLONE U/F TANK 02-TK-003
32"-CS(10)6mmRL-PS
– | 5277-2-101/102
6"
6"
FLUSH WATER FOR CYCLONE U/F & O/F LAUNDER
– | 5277-2-102
6"-CS(STD)-PW
O/F FROM GSW TANK 01-TK-004
– | 5277-1-103
12"-CS(STD)-PW
22"-CS(STD)-PW
SPILLAGE AREA
SPILLAGE / EMERGENCY DUMP LINE
– | 5277-2-101/102
42"-HDPE(DR17)-PW

NOTE:
1. ALL ACTUATED KNIFE GATE VALVES TO BE SUPPLIED WITH OPEN/CLOSE POSITION SWITCH AND DCS INDICATION.

PRELIMINARY

REVISIONS					
REV	DATE	DESCRIPTION	DESG	DRWN	CHKD
A	25 OCT 12	ISSUED FOR APPROVAL	MJ	TF	YK
B	01 NOV 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK
0	10 DEC 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK

REFERENCE DRAWINGS	
DRG No.	DESCRIPTION

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CASINO PROJECT
TAILINGS CYCLONE AND TRANSPORTATION STUDY
SHEET 1 ###
CYCLONE STATION
PIPING AND INSTRUMENT DIAGRAMS (P&ID)
SHEET 1 OF 3

SCALE			PROJECT NUMBER	SIZE
N.T.S.			KPV-5277	D
DESIGNED	MJ	16-AUG-12	DRAWING NUMBER	REV
DRAWN	TF	16-AUG-12	5277-1-101	0

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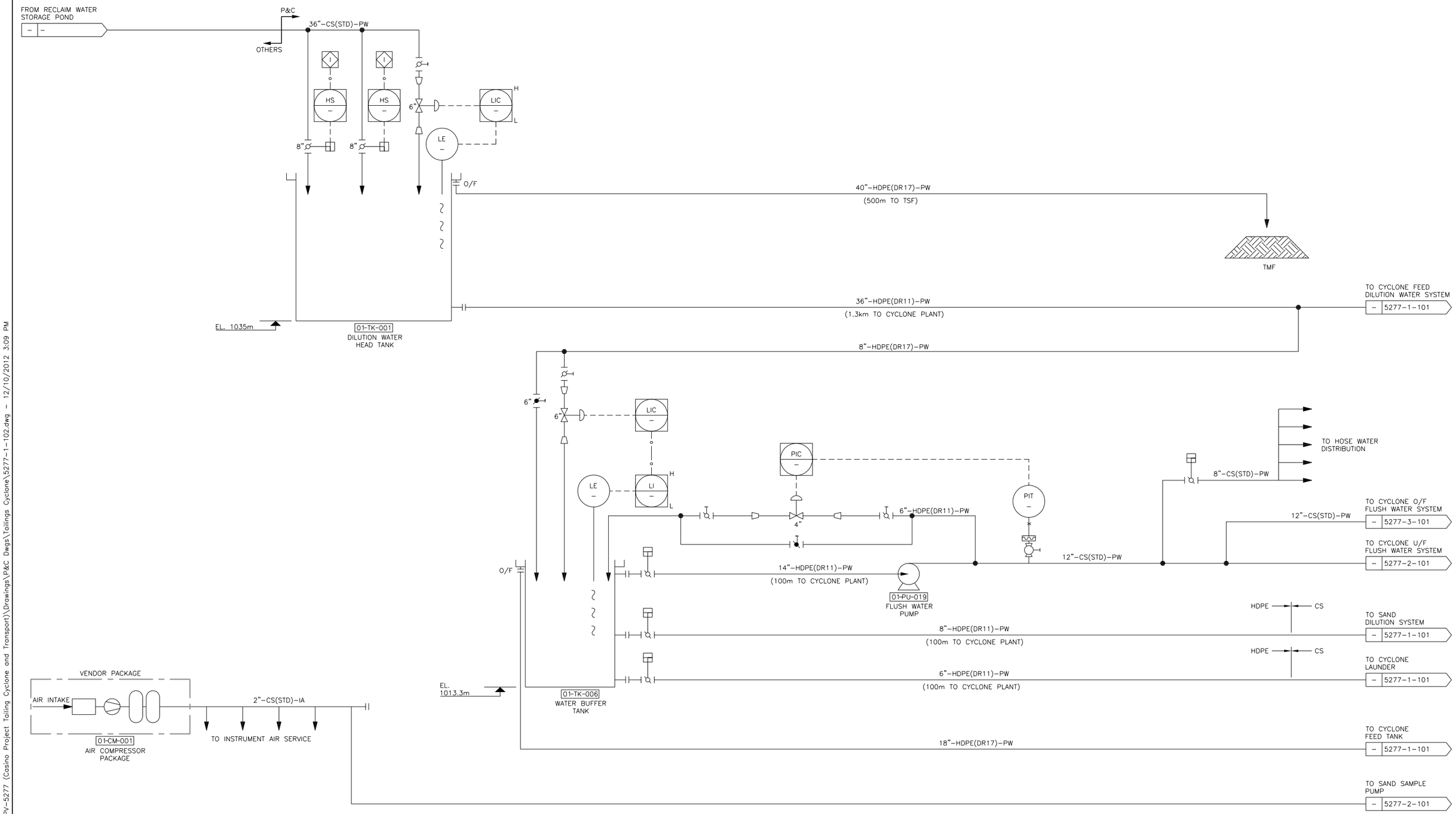

PRELIMINARY

REVISIONS						REFERENCE DRAWINGS	
REV	DATE	DESCRIPTION	DESG	DRWN	CHKD	DRG No.	DESCRIPTION
A	25 OCT 12	ISSUED FOR APPROVAL	MJ	TF	YK		
B	01 NOV 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK		
0	10 DEC 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK		

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CASINO PROJECT
TAILINGS CYCLONE AND TRANSPORTATION STUDY
SHEET 1 ###

CYCLONE STATION
PIPING AND INSTRUMENT DIAGRAMS (P&ID)
SHEET 2 OF 3

SCALE			PROJECT NUMBER	SIZE
N.T.S.			KPV-5277	D
DESIGNED	MJ	16-AUG-12	DRAWING NUMBER	REV
DRAWN	TF	16-AUG-12	5277-1-102	0

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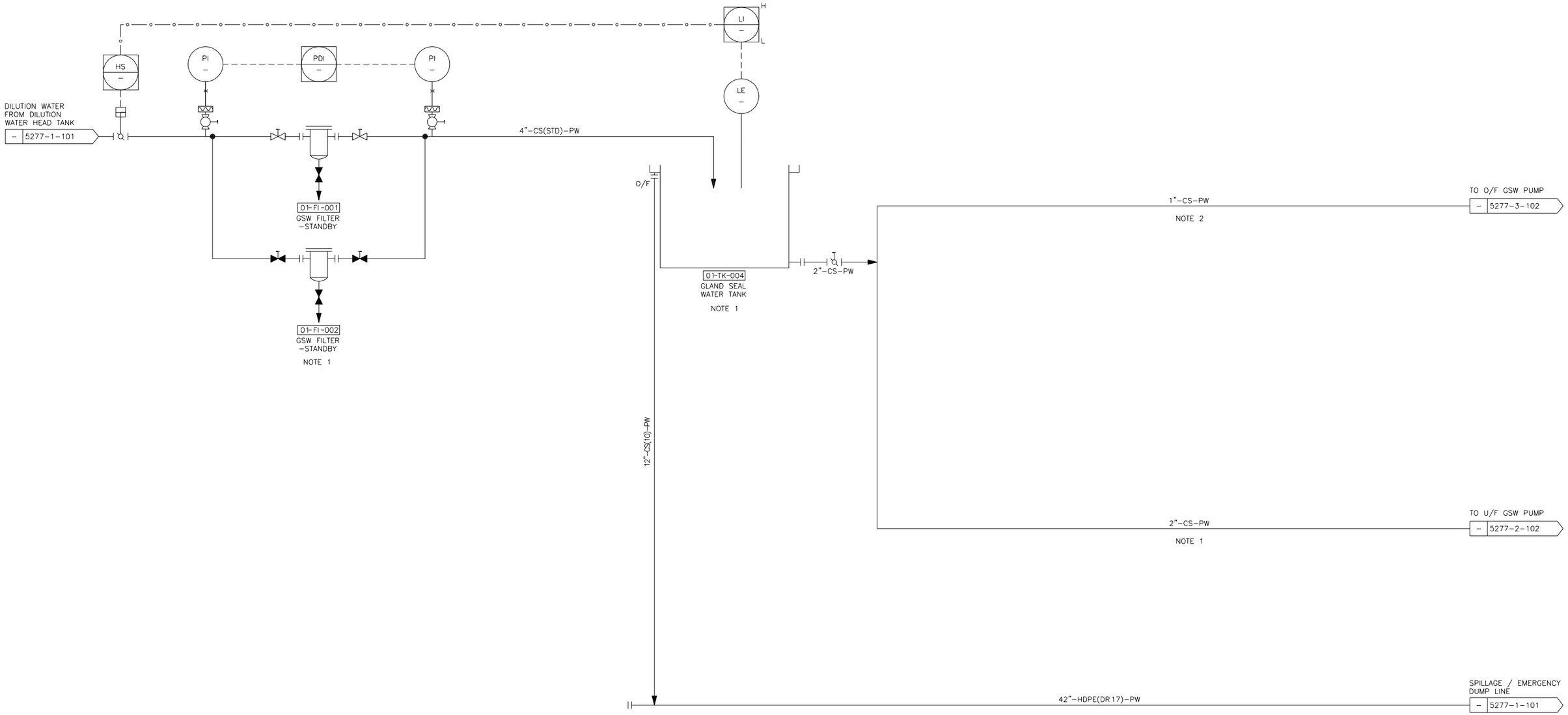

NOTES:
1. GSW FILTER & TANK TO BE INSTALLED IN YEAR 6 WHEN GSW PUMP FOR CYCLONE U/F WILL BE INSTALLED.

PRELIMINARY

REVISIONS						REFERENCE DRAWINGS	
REV	DATE	DESCRIPTION	DESG	DRWN	CHKD	DRG No.	DESCRIPTION
A	25 OCT 12	ISSUED FOR APPROVAL	MJ	TF	YK	5277-2-101	CYCLONE SAND DISTRIBUTION P&ID, CYCLONE U/F DISTRIBUTION
B	01 NOV 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK	5277-3-101	CYCLONE OVERFLOW DISTRIBUTION P&ID, CYCLONE O/F DIAGRAM
0	10 DEC 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK		

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CASINO PROJECT
TAILINGS CYCLONE AND TRANSPORTATION STUDY
SHEET ###
CYCLONE STATION
PIPING AND INSTRUMENT DIAGRAM (P&ID)
SHEET 3 OF 3 (YEAR 6 TO 22)

SCALE		PROJECT NUMBER	SIZE
N.T.S.		KPV-5277	D
DESIGNED	CS	06 JUN 12	REV
DRAWN	TF	11 JUN 12	0

DRAWING NUMBER 5277-1-103

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COMPRESSED AIR
– 5277-1-102

1"-CS

NAG TAILINGS
CYCLONE U/F (SAND)
– 5277-1-101

32"-CS(10)6mmRL-PS

LI –

LIT –

HS –

I

20" N.C.

02-TK-003
CYCLONE
U/F TANK

12"

8" N.C.

02-PU-020
SAND SAMPLE
PUMP

2"-CS(STD)6mmRL-PS

DI –

DIC –

DE –

SAMPLE PORT

TO CYCLONE U/F
DILUTION WATER
CONTROLER
– 5277-1-101

18"-CS(10)6mmCL-PS

CYCLONE UNDERFLOW
JACKING STRUCTURE
– 5277-2-103

FLUSH WATER
– 5277-1-102

12"-CS(STD)-PW

24"-CS(10)-PW

12"-CS(STD)-PW

JACKING STRUCTURE
FLUSHING WATER
– 5277-2-102

SPILLAGE / EMERGENCY
DUMP LINE
– 5277-1-101

42"-HDPE(DR17)-PW

SPILLAGE / EMERGENCY
DUMP LINE
– 5277-3-101/102

PRELIMINARY

REVISIONS						REFERENCE DRAWINGS	
REV	DATE	DESCRIPTION	DESG	DRWN	CHKD	DRG No.	DESCRIPTION
A	25 OCT 12	ISSUED FOR APPROVAL	MJ	TF	YK	5277-1-101	CYCLONE SAND PLANT P&ID, CYCLONE STATION
B	01 NOV 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK	2577-2-102	CYCLONE OVERFLOW DISTRIBUTION P&ID, CYCLONE U/F JACKING HEADER
0	10 DEC 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK	5277-2-103	CYCLONE SAND DISTRIBUTION P&ID, GLAND SEAL WATER SYSTEM
						5277-3-101	CYCLONE OVERFLOW DISTRIBUTION P&ID, CYCLONE O/F DISTRIBUTION

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CASINO PROJECT
TAILINGS CYCLONE AND TRANSPORTATION STUDY
CYCLONE SAND DISTRIBUTION
PIPING AND INSTRUMENT DIAGRAMS (P&ID)
SHEET 1 OF 3 (YEAR 1 TO 5)

SHEET ###

SCALE		PROJECT NUMBER	SIZE
N.T.S.		KPV-5277	D
DESIGNED	CS	06 JUN 12	REV
DRAWN	TF	11 JUN 12	0

DRAWING NUMBER 5277-2-101

Tom Figas – P:\3 – Projects\KPV-5277 (Casino Project Tailing Cyclone and Transport)\Drawings\P&C Dwgs\Tailings Cyclone\5277-2-101.dwg – 12/10/2012 3:13 PM

NAG TAILINGS
CYCLONE U/F (SAND)
– 5277-1-101

32"-CS(10)6mmRL-PS

FLUSH WATER
– 5277-1-102

12"-CS(STD)-PW

– 5277-1-103

12"

HS

LI
LIT

20" N.C.

02-TK-003
CYCLONE
U/F TANK

20"-CS(STD)6mmRL-PS

8" N.C.

8" N.C.

HS

6" N.C.
DRAIN

VFD

02-PU-001
CYCLONE
U/F PUMP
No.1

6" N.C.
DRAIN

FROM
GSW PUMP
02-PU-007

YEAR 6

VFD

02-PU-002
CYCLONE
U/F PUMP
No.2

FROM
GSW PUMP
02-PU-009

YEAR 12

VFD

02-PU-003
CYCLONE
U/F PUMP
No.3

FROM
GSW PUMP
02-PU-011

YEAR 19

PI
PIT

HS

FI
FIT

DIC
DI
DE

TO CYCLONE U/F
DILUTION WATER
CONTROLER
– 5277-1-101

CYCLONE UNDERFLOW
JACKING STRUCTURE
– 5277-2-103

M

18"-CS(80)-PS

FSAL

PI

HS

FS

TO PUMP
No.1

02-PU-007
CYCLONE U/F
GSW PUMP No.1

FSAL

PI

HS

FS

TO PUMP
No.4

02-PU-008
CYCLONE U/F
GSW PUMP No.1
–STANDBY

TYPICAL GSW PUMP ARRANGEMENT

02-PU-009 TYPICAL GSW PUMP ARRANGEMENT TO PUMP No.2

02-PU-010 TYPICAL GSW PUMP ARRANGEMENT TO PUMP No.5

02-PU-011 TYPICAL GSW PUMP ARRANGEMENT TO PUMP No.3

02-PU-012 TYPICAL GSW PUMP ARRANGEMENT TO PUMP No.6

24"-CS(10)-PW

HS

8" N.C.

8" N.C.

N.C.

20"-CS(STD)6mmRL-PS

6" N.C.
DRAIN

VFD

02-PU-004
CYCLONE
U/F PUMP
No.1-STANDBY

6" N.C.
DRAIN

FROM
GSW PUMP
02-PU-008

YEAR 6

VFD

02-PU-005
CYCLONE
U/F PUMP
No.2-STANDBY

FROM
GSW PUMP
02-PU-010

YEAR 12

VFD

02-PU-006
CYCLONE
U/F PUMP
No.3-STANDBY

FROM
GSW PUMP
02-PU-012

YEAR 19

PI
PIT

HS

N.C.

SEE NOTE 1

12"-CS(STD)-PW

JACKING STRUCTURE
FLUSHING WATER
– 5277-2-102

SPILLAGE / EMERGENCY
DUMP LINE
– 5277-1-101

42"-HDPE(DR17)-PW

SPILLAGE / EMERGENCY
DUMP LINE
– 5277-3-101/102

NOTE:
1. THIS DRAWING SHOWS GENERAL ARRANGEMENTS FOR YEAR 6 TO YEAR 19. PUMPS WILL BE INSTALLED IN STAGES @ YEAR 6, 12 AND 19

PRELIMINARY

REVISIONS					
REV	DATE	DESCRIPTION	DESG	DRWN	CHKD
A	25 OCT 12	ISSUED FOR APPROVAL	MJ	TF	YK
B	01 NOV 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK
0	10 DEC 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK

REFERENCE DRAWINGS	
DRG No.	DESCRIPTION
5277-1-101	CYCLONE SAND PLANT P&ID, CYCLONE STATION
2577-2-102	CYCLONE OVERFLOW DISTRIBUTION P&ID, CYCLONE U/F JACKING HEADER
5277-2-103	CYCLONE SAND DISTRIBUTION P&ID, GLAND SEAL WATER SYSTEM
5277-3-101	CYCLONE OVERFLOW DISTRIBUTION P&ID, CYCLONE O/F DISTRIBUTION

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CASINO PROJECT
TAILINGS CYCLONE AND TRANSPORTATION STUDY
SHEET ###
CYCLONE SAND DISTRIBUTION
PIPING AND INSTRUMENT DIAGRAMS (P&ID)
SHEET 2 OF 3 (YEAR 6 TO 22)

SCALE		PROJECT NUMBER	SIZE
N.T.S.		KPV-5277	D
DESIGNED	CS 06 JUN 12	DRAWING NUMBER	REV
DRAWN	TF 11 JUN 12	5277-2-102	0

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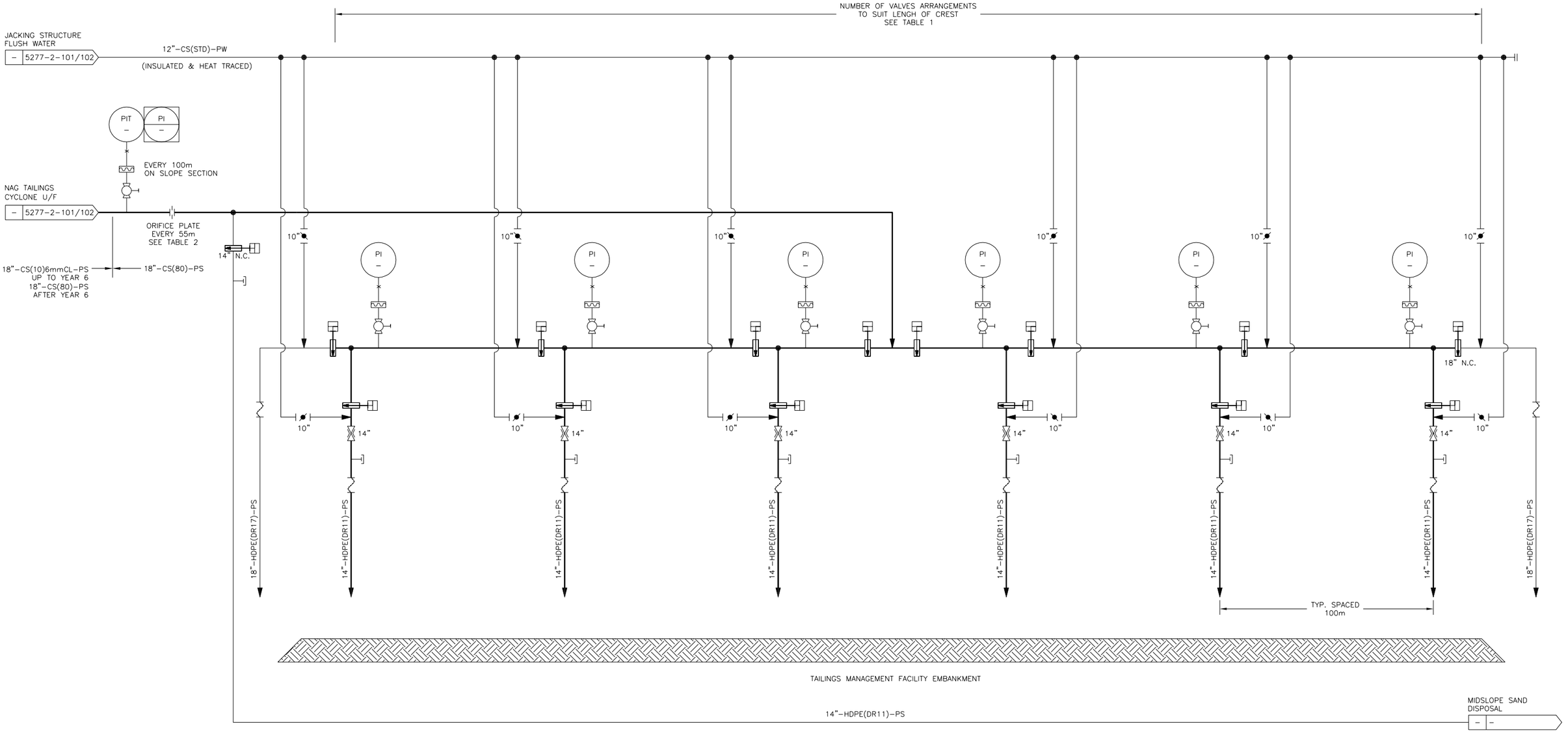
VALVE ARRANGEMENT		
YEARS	DAMM LENGTH (m)	NO. VALVES ARRANGEMENT
1	864	9
2	1308	14
4	1550	16
5	1610	17
6	1754	18
13	2109	22
20	2400	24
22	2460	25

TABLE 1

ORIFICE PLATES	
YEARS	No. OF ORIFICES
0	10
1	7
2	5
3	4
4	2
5	1
6	0

TABLE 2



NOTE:
1. ALL VALVES ON JACKING STRUCTURE TO BE INSULATED & HEAT TRACED

PRELIMINARY

REVISIONS						REFERENCE DRAWINGS	
REV	DATE	DESCRIPTION	DESG	DRWN	CHKD	DRG No.	DESCRIPTION
A	25 OCT 12	ISSUED FOR APPROVAL	MJ	TF	YK	5277-2-101	CYCLONE SAND DISTRIBUTION P&ID, CYCLONE U/F DISTRIBUTION
B	01 NOV 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK		
0	10 DEC 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK		

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SHEET ###

CYCLONE SAND DISTRIBUTION
PIPING AND INSTRUMENT DIAGRAMS (P&ID)
SHEET 3 OF 3

SCALE			PROJECT NUMBER	SIZE
N.T.S.			KPV-5277	D
DESIGNED	MJ	13 SEP 12	DRAWING NUMBER	REV
DRAWN	TF	13 SEP 12	5277-2-103	0

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NAG TAILINGS BYPASS
– 5277–1–101

32"–CS(STD)6mmRL–PS

NAG TAILINGS
CYCLONE O/F
– 5277–1–101

40"–CS(10)6mmRL–PS

LI H – L

LIT –

6"

12" N.C.

03–TK–005
CYCLONE
O/F TANK

I

HS –

10" N.C.

FI –

FIT –

36"–HDPE(DR11)–PS

M

CYCLONE OVERFLOW
JACKING HEADER
– 5277–3–103

FLUSH WATER
– 5277–1–102

12"–CS(STD)–PW

36"–CS(STD)–PW

SPILLAGE / EMERGENCY
DUMP LINE
– 5277–2–101/102

42"–HDPE(DR17)–PW

EMERGENCY DUMP LOCATION
AT TAILINGS MANAGEMENT FACILITY

PRELIMINARY

REVISIONS						REFERENCE DRAWINGS	
REV	DATE	DESCRIPTION	DESG	DRWN	CHKD	DRG No.	DESCRIPTION
A	25 OCT 12	ISSUED FOR APPROVAL	MJ	TF	YK	5277–1–101	CYCLONE PLANT P&ID, CYCLONE STATION
B	01 NOV 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK	5277–2–101	CYCLONE SAND DISTRIBUTION P&ID, CYCLONE U/F JACKING HEADER
0	10 DEC 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK	5277–2–103	CYCLONE SAND DISTRIBUTION P&ID, GLAND SEAL WATER SYSTEM
						5277–3–102	CYCLONE OVERFLOW DISTRIBUTION P&ID, CYCLONE O/F JACKING HEADER

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CYCLONE OVERFLOW DISTRIBUTION
PIPING AND INSTRUMENT DIAGRAMS (P&ID)
SHEET 1 OF 3 (YEAR 1 TO 12)

SHEET ###

SCALE			PROJECT NUMBER	SIZE
N.T.S.			KPV–5277	D
DESIGNED	MJ	13 SEP 12	DRAWING NUMBER	REV
DRAWN	TF	13 SEP 12	5277–3–101	0

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NAG TAILINGS BYPASS
– | 5277-1-101
32"-CS(STD)6mmRL-PS

NAG TAILINGS CYCLONE O/F
– | 5277-1-101
40"-CS(10)6mmRL-PS

LI – H L
LIT –
6"
12" N.C.
03-TK-005
CYCLONE O/F TANK

HS –
10" N.C.
38"-CS(STD)6mmRL-PS
12" N.C.
DRAIN

VFD
03-PU-013
CYCLONE O/F PUMP
12" N.C.
DRAIN
FROM GSW PUMP 02-PU-017
YEAR 13

PI –
PIT –
FI –
FIT –
M
CYCLONE OVERFLOW JACKING HEADER
– | 5277-3-103
36"-HDPE(DR11)-PS

FLUSH WATER
– | 5277-1-102
12"-CS(STD)-PW

– | 5277-1-103

FSAL –
FS
TO PUMP No.13
02-PU-017
CYCLONE O/F GSW PUMP

TO PUMP No.15
02-PU-018
CYCLONE O/F GSW PUMP –STANDBY

36"-CS(STD)-PW

N.C.
38"-CS(STD)6mmRL-PS
12" N.C.
DRAIN
03-PU-015
CYCLONE O/F PUMP –STANDBY
12" N.C.
DRAIN
FROM GSW PUMP 02-PU-018
YEAR 13

SPILLAGE / EMERGENCY DUMP LINE
– | 5277-2-101/102
42"-HDPE(DR17)-PW
(900m TO TSF)

EMERGENCY DUMP LOCATION AT TAILINGS MANAGEMENT FACILITY

PRELIMINARY

REVISIONS						REFERENCE DRAWINGS	
REV	DATE	DESCRIPTION	DESG	DRWN	CHKD	DRG No.	DESCRIPTION
A	25 OCT 12	ISSUED FOR APPROVAL	MJ	TF	YK	5277-1-101	CYCLONE PLANT P&ID, CYCLONE STATION
B	01 NOV 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK	5277-2-101	CYCLONE SAND DISTRIBUTION P&ID, CYCLONE U/F JACKING HEADER
0	10 DEC 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK	5277-2-103	CYCLONE SAND DISTRIBUTION P&ID, GLAND SEAL WATER SYSTEM
						5277-3-102	CYCLONE OVERFLOW DISTRIBUTION P&ID, CYCLONE O/F JACKING HEADER

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SHEET ###
CYCLONE OVERFLOW DISTRIBUTION PIPING AND INSTRUMENT DIAGRAMS (P&ID) SHEET 2 OF 3 (YEAR 13 TO 22)

SCALE		PROJECT NUMBER	SIZE
N.T.S.		KPV-5277	D
DESIGNED	MJ	13 SEP 12	DRAWING NUMBER 5277-3-102 / REV 0
DRAWN	TF	13 SEP 12	

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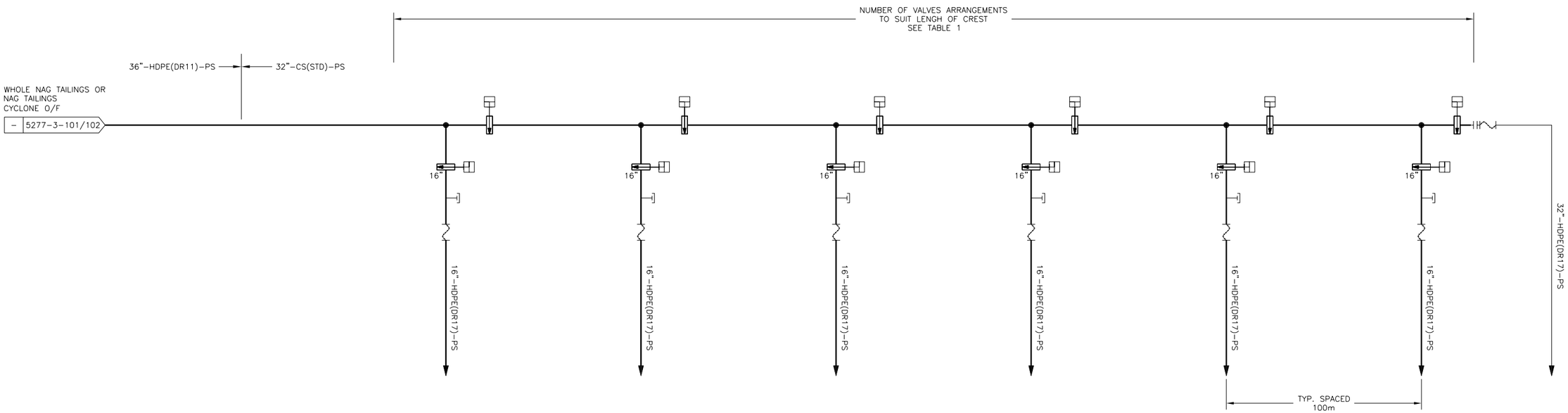
VALVE ARRANGEMENT		
YEARS	DAMM LENGTH (m)	NO. VALVES ARRANGEMENT
0	864	9
2	1308	14
4	1550	16
5	1610	17
6	1754	18
13	2109	22
20	2400	24
22	2460	25

TABLE 1



NOTE:
1. ALL VALVES ON JACKING HEADER TO BE INSULATED & HEAT TRACED

PRELIMINARY

REVISIONS						REFERENCE DRAWINGS	
REV	DATE	DESCRIPTION	DESG	DRWN	CHKD	DRG No.	DESCRIPTION
A	25 OCT 12	ISSUED FOR APPROVAL	MJ	TF	YK	5277-3-101	CYCLONE OVERFLOW DISTRIBUTION P&ID, CYCLONE O/F DIAGRAM
B	01 NOV 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK		
0	10 DEC 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK		

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SHEET ###

CYCLONE OVERFLOW DISTRIBUTION
PIPING AND INSTRUMENT DIAGRAM (P&ID)
SHEET 3 OF 3

SCALE			PROJECT NUMBER	SIZE
N.T.S.			KPV-5277	D
DESIGNED	MJ	13 SEP 12	DRAWING NUMBER	REV
DRAWN	TF	13 SEP 12	5277-3-103	0

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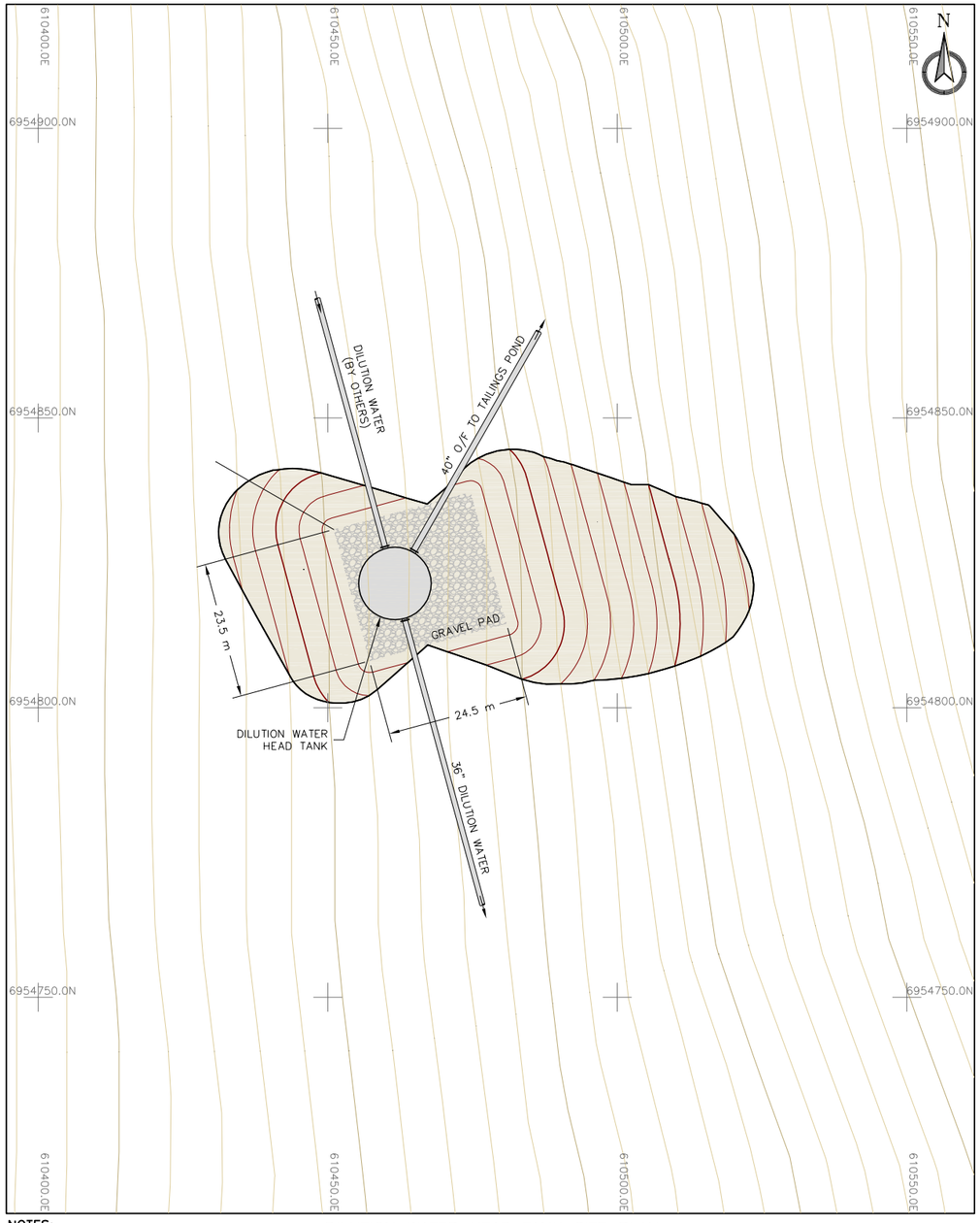
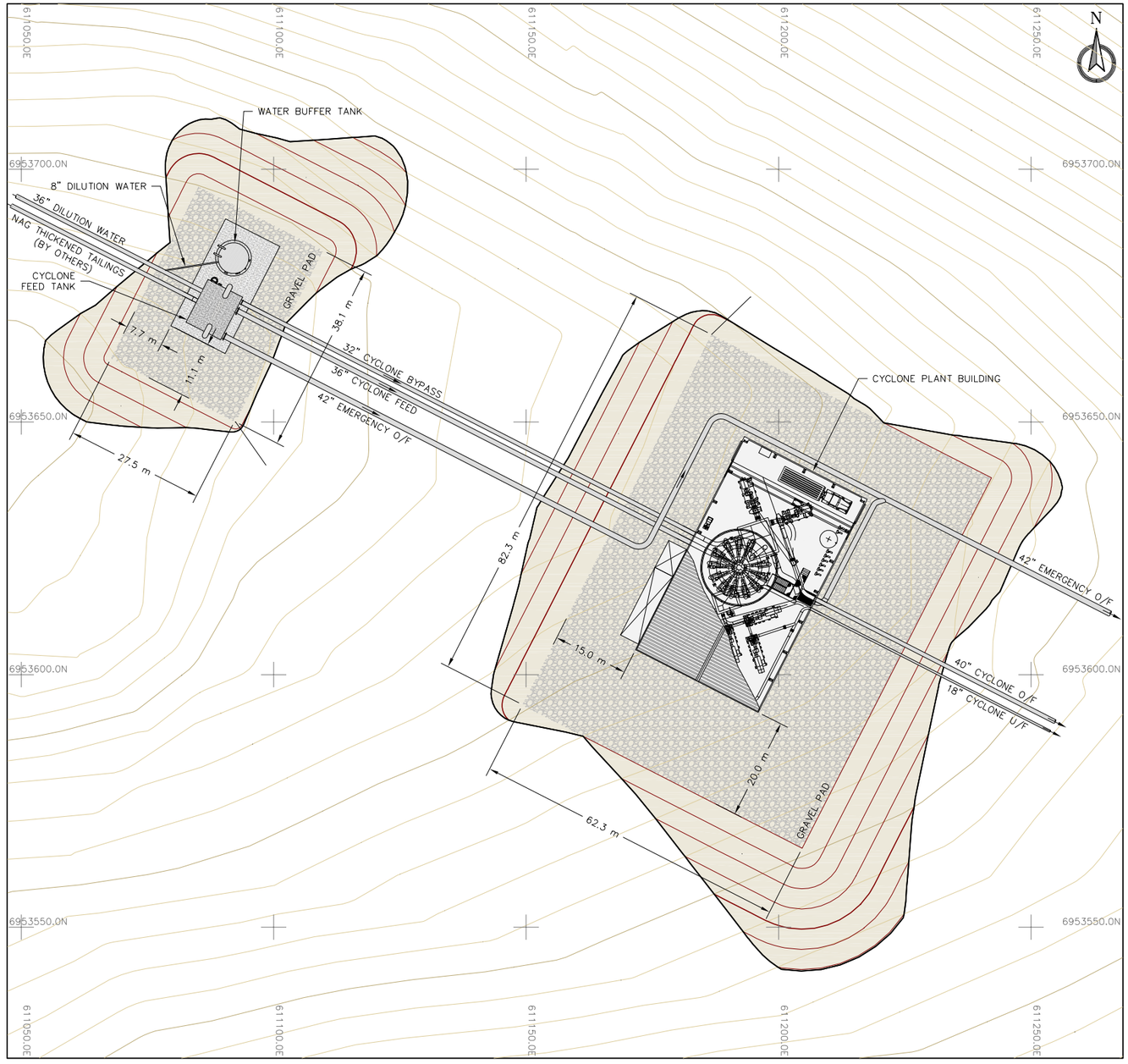


DILUTION WATER HEAD TANK SITE PLAN

SCALE
5m 0 10m
SCALE IN METERS
CONTOUR INTERVAL 2



CYCLONE FEED & CYCLONE PLANT SITE PLAN

SCALE
5m 0 10m
SCALE IN METERS
CONTOUR INTERVAL 2

NOTES:
1. ACCESS ROADS – BY OTHERS.
2. ONLY MAIN PIPES SHOWN.

REVISIONS						REFERENCE DRAWINGS	
REV	DATE	DESCRIPTION	DESG	DRWN	CHKD	DRG No.	DESCRIPTION
A	26–OCT–12	ISSUED FOR APPROVAL	M.J.	T.H.	Y.K.		
B	01–NOV–12	ISSUED FOR FEASIBILITY STUDY REPORT	M.J.	T.H.	Y.K.		
0	10–DEC–12	ISSUED FOR FEASIBILITY STUDY REPORT	M.J.	T.H.	Y.K.		

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CASINO PROJECT
TAILINGS CYCLONE AND TRANSPORTATION STUDY

SHEET ###

CYCLONE FEED & PLANT SITE PLAN

SCALE			PROJECT NUMBER	SIZE
N/A			KPV–5277	D
DESIGNED	M.J.	26–OCT–12	DRAWING NUMBER	REV
DRAWN	T.H.	26–OCT–12	5277–0–301	0

Tom Figos – P:\3 – Projects\KPV–5277 (Casino Project Tailing Cyclone and Transport)\Drawings\P&C Dwgs\Tailings Cyclone\5277–0–301.dwg – 12/10/2012 3:27 PM

ULTIMATE BUILDING
46000

PHASE I BUILDING
5 BAYS @ 6800 = 34000

6000

6000

4"-CS(STD)-PW
FROM WATER HEAD TANK

32"-CS(STD)-PS O/F
TO JACKING HEADER

18"-CS(10)-PS U/F
TO JACKING STRUCTURE

DRAIN

63°

03-PU-017/018
CYCLONE O/F
GSW PUMPS

02-PU-007-012
CYCLONE U/F
GSW PUMPS

SPILLAGE SUMP

01-TK-004
GSW TANK ø3500

02-PU-003
CYCLONE U/F
PUMP#3

02-PU-002
CYCLONE U/F
PUMP#2

40"-CS(STD)-PW
03-TK-005 O/F

24"-CS(10)-PW
02-TK-003 O/F

2400 TYP.

02-PU-001
CYCLONE U/F
PUMP#1

1800 TYP.

5370 TYP.

03-PU-013
CYCLONE O/F PUMP

02-PU-019
SAND SAMPLER
PUMP

02-PU-005
CYCLONE U/F
PUMP#2
-STANDBY

42"-HDPE(DR17)-PW
SPILLAGE/EMERGENCY DUMP LINE

4 BAYS @ 6500 = 26000

5600 TYP.

HVAC

03-TK-005
CYCLONE O/F TANK
5500 x 6200 5000 DEPTH

01-CY-001
CYCLONE CLUSTER(S)

02-TK-003
CYCLONE U/F TANK
3200 x 4000 4000 DEPTH

A
1-302

2700 TYP.

03-PU-015
CYCLONE O/F PUMP
-STANDBY

01-PU-019
FLUSH WATER PUMP

01-CM-001
AIR COMPRESSOR PACKAGE

02-PU-004
CYCLONE U/F PUMP
#1-STANDBY

02-PU-006
CYCLONE U/F PUMP
#3-STANDBY

32"-CS(STD)-PS
TAILINGS BYPASS

38"-CS(STD)-PS
CYCLONE FEED

PHASE I
ELECTRICAL ROOM
6000 x 4000

ULTIMATE
ELECTRICAL ROOM
15000 x 4000

SCALE 1:75

1 0 1 3 5m

B
1-303

REVISIONS					
REV	DATE	DESCRIPTION	DESG	DRWN	CHKD
A	25 OCT 12	ISSUED FOR APPROVAL	MJ	TF	YK
B	01 NOV 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK
0	10 DEC 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK

REFERENCE DRAWINGS	
DRG No.	DESCRIPTION

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CASINO PROJECT
TAILINGS CYCLONE AND TRANSPORTATION STUDY

SHEET 1 ###

CYCLONE PLANT
GENERAL ARRANGEMENT
CYCLONE PLANT BUILDING PLAN

SCALE			PROJECT NUMBER	SIZE
1:75			KPV-5277	D
DESIGNED	MJ	02 OCT 12	DRAWING NUMBER	REV
DRAWN	TF	02 OCT 12	5277-1-301	0

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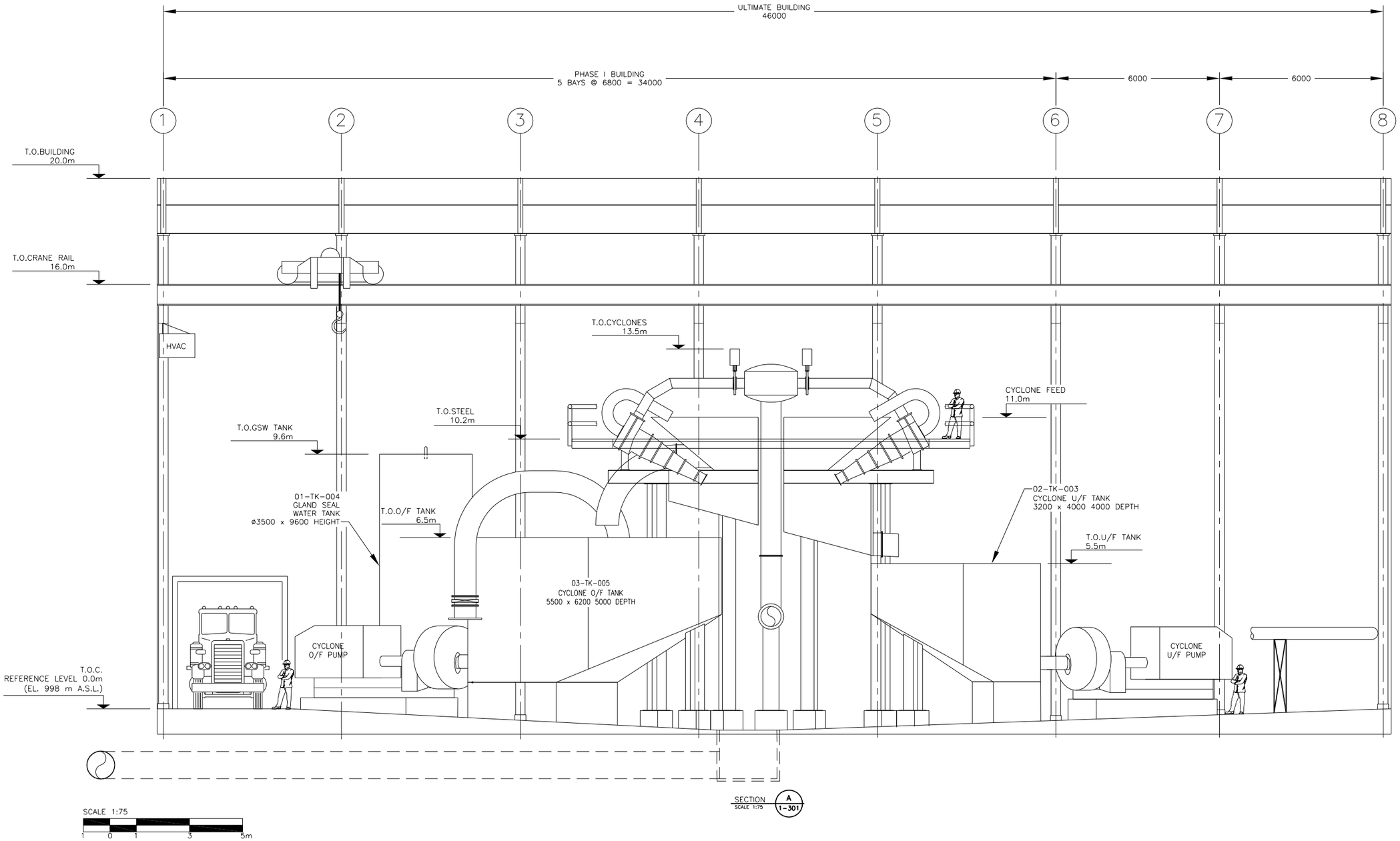

REVISIONS					
REV	DATE	DESCRIPTION	DESG	DRWN	CHKD
A	25 OCT 12	ISSUED FOR APPROVAL	MJ	TF	YK
B	01 NOV 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK
0	10 DEC 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK

REFERENCE DRAWINGS	
DRG No.	DESCRIPTION

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CASINO PROJECT
TAILINGS CYCLONE AND TRANSPORTATION STUDY

SHEET 1 ###

CYCLONE PLANT
GENERAL ARRANGEMENT
CYCLONE PLANT BUILDING SECTION A

SCALE		PROJECT NUMBER	SIZE
1:75		KPV-5277	D
DESIGNED	MJ	02 OCT 12	DRAWING NUMBER 5277-1-302
DRAWN	TF	02 OCT 12	REV 0

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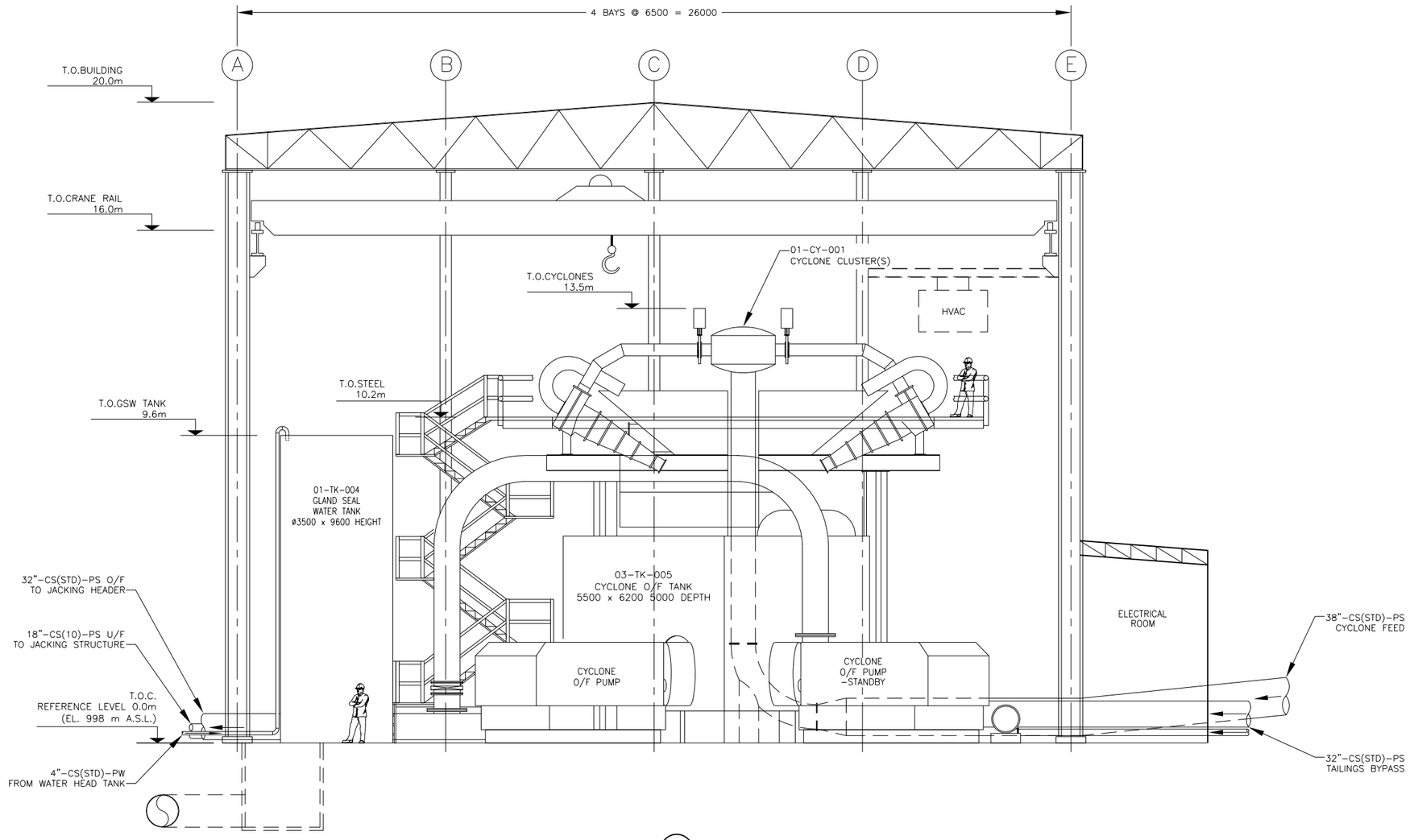

SECTION B
SCALE 1:75
1-301

SCALE 1:75

1 0 1 3 5m

NOTE:
- ALL DIMENSIONS ARE IN MILLIMETERS UNLESS NOTED OTHERWISE

REVISIONS					
REV	DATE	DESCRIPTION	DESG	DRWN	CHKD
A	25 OCT 12	ISSUED FOR APPROVAL	MJ	TF	YK
B	01 NOV 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK
0	10 DEC 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK

REFERENCE DRAWINGS	
DRG No.	DESCRIPTION

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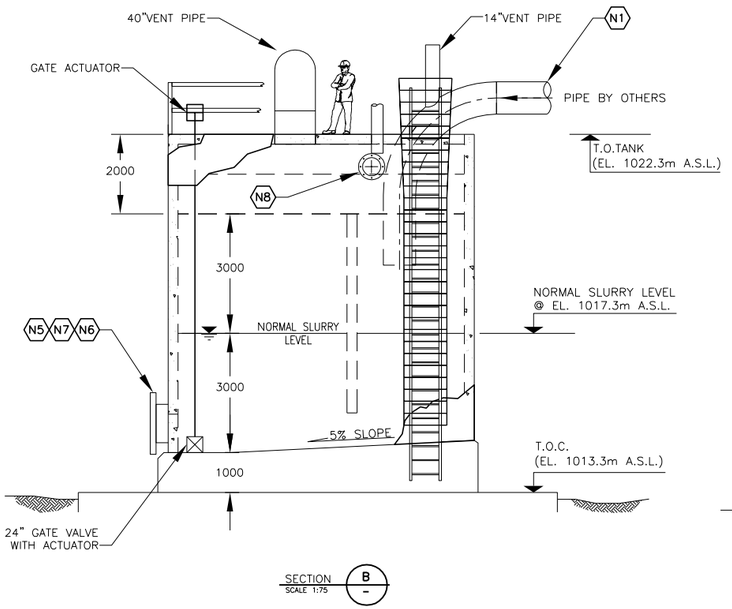
CASINO PROJECT
TAILINGS CYCLONE AND TRANSPORTATION STUDY
SHEET 1 ###

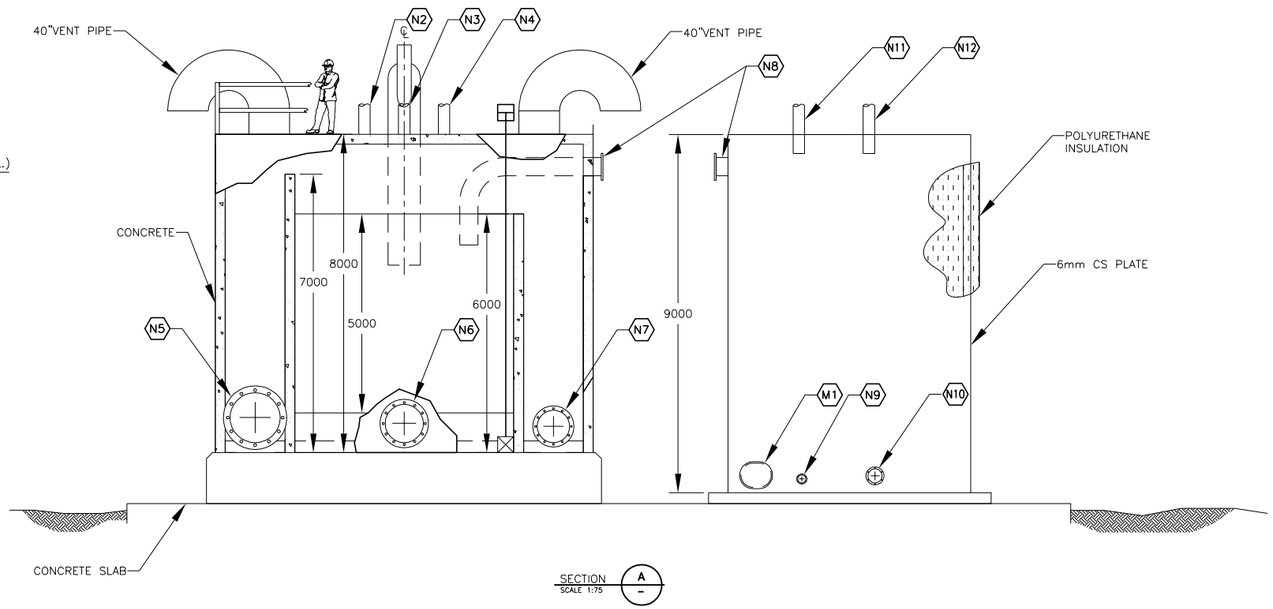
CYCLONE PLANT
GENERAL ARRANGEMENT
CYCLONE PLANT BUILDING SECTION B

SCALE			PROJECT NUMBER	SIZE
1:75			KPV-5277	D
DESIGNED	MJ	02 OCT 12	DRAWING NUMBER	REV
DRAWN	TF	02 OCT 12	5277-1-303	0

Tom Figas - P:\3 - Projects\KPV-5277 (Casino Project Tailing Cyclone and Transport)\Drawings\P&C Dwgs\Tailings Cyclone\5277-1-303.dwg - 12/11/2012 7:28 AM

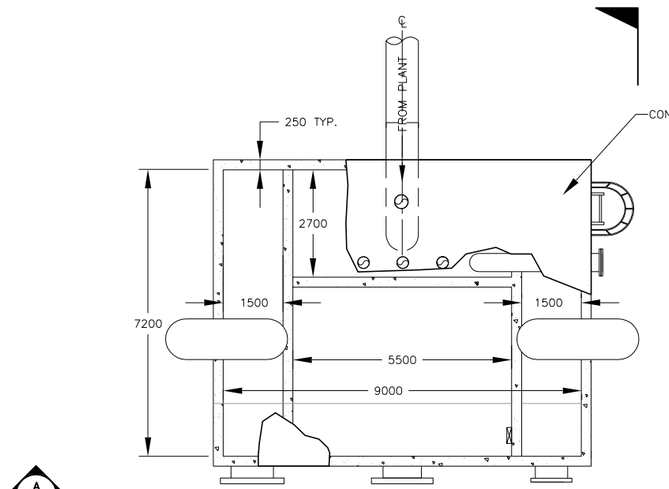


SECTION B
SCALE 1:75

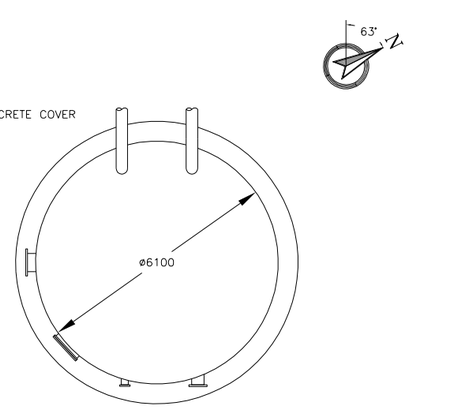


SECTION A
SCALE 1:75

Nozzle Number	Size	Description
N1	By Others	NAG Tailings (By Others)
N2	12"	Dilution Water
N3	12"	Dilution Water
N4	6"	Dilution Water
N5	42"	O/F from Feed Tank
N6	38"	Cyclone Feed
N7	32"	Cyclone By-pass
N8	18"	O/F from Water Buffer Tank
N9	8"	Water for Sand Dilution
N10	14"	Flush Water Pump Suction
N11	6"	Flush Water Return
N12	8"	Dilution Water Feed
M1	24"x30"	Manway for Flush Water Tank



01-TK-002
CYCLONE FEED TANK
PLAN VIEW



01-TK-006
WATER BUFFER TANK
PLAN VIEW

SCALE 1:75

1 0 1 3 5m

REVISIONS					
REV	DATE	DESCRIPTION	DESG	DRWN	CHKD
A	25 OCT 12	ISSUED FOR APPROVAL	MJ	TF	YK
B	01 NOV 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK
0	10 DEC 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK

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DRG No.	DESCRIPTION

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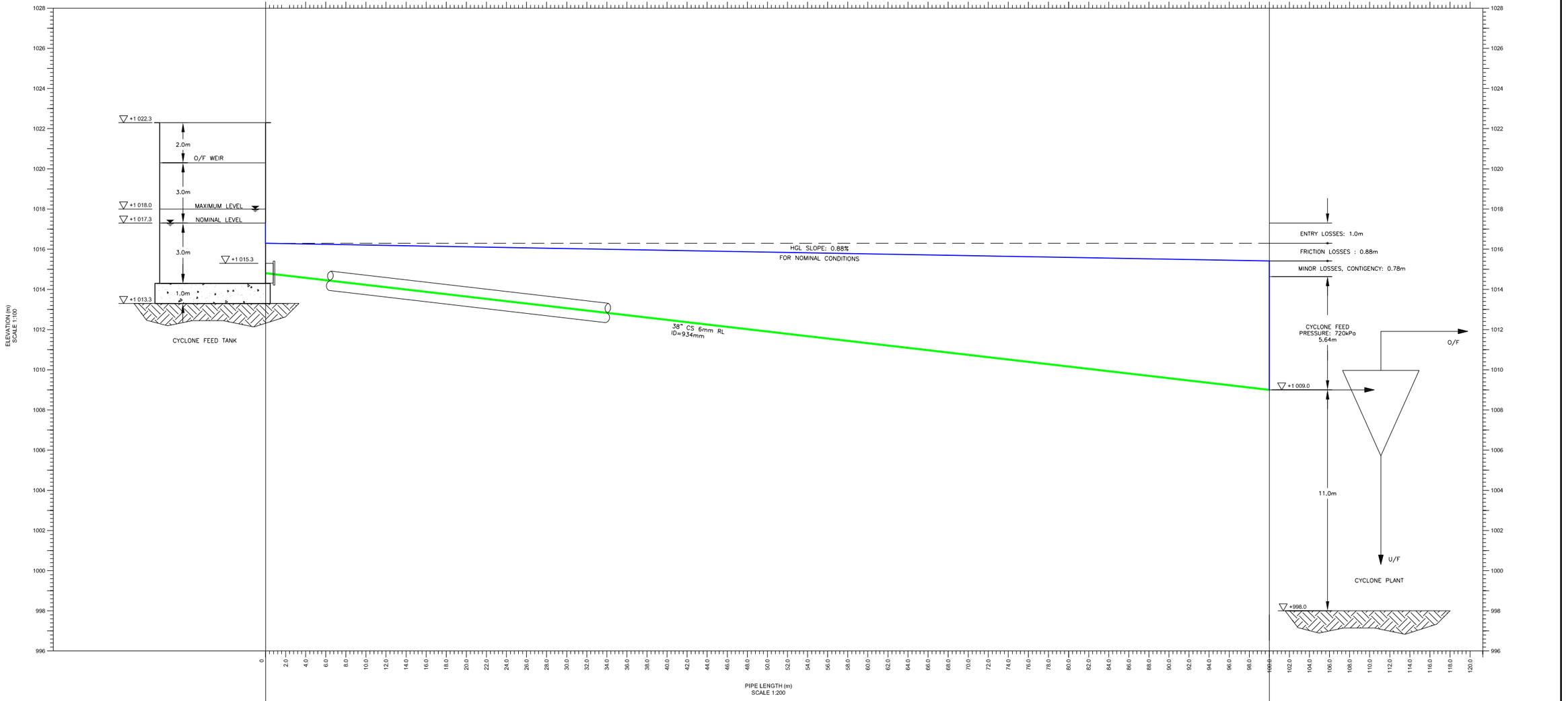
SHEET 1 ###

CYCLONE PLANT
GENERAL ARRANGEMENT
CYCLONE FEED TANK

SCALE			PROJECT NUMBER	SIZE
1:75			KPV-5277	D
DESIGNED	MJ	02 OCT 12	DRAWING NUMBER	REV
DRAWN	TF	02 OCT 12	5277-1-304	0

Tom Figas - P:\3 - Projects\KPV-5277 (Casino Project Tailing Cyclone and Transport)\Drawings\P&C Dwgs\Tailings Cyclone\5277-1-304.dwg - 12/10/2012 3:35 PM

APPENDIX C – HYDRAULIC GRADE LINE PLOTS



NOTES	CYCLONE FEED TANK DISCHARGE	DISCHARGE POINT
PIPELINE ELEVATION (m)	115.3	1 009.0
PIPE NOMINAL DIAMETER / WALL THK	38"CS 6mm RL	
PIPE SPECIFICATION / MATERIAL GRADE	ASME B36.10 / A106 Gr.B, 6mm RL	
LINING TYPE / THICKNESS	RUBBER LINED	
PIPE INTERNAL DIAMETER	934mm	
PIPE PRESSURE RATING	13 990 kPa	
FLANGE SPECIFICATION / MATERIAL	ASME B16.5 / ASTM A105	
FLANGE SIZE / PRESSURE RATING	36" / CLASS 150	
MAX ALLOWABLE WORKING PRESSURE	1 965 kPa	

PRELIMINARY

REVISIONS

REV	DATE	DESCRIPTION	DESG	DRWN	CHKD
A	01 NOV 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK
0	10 DEC 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK

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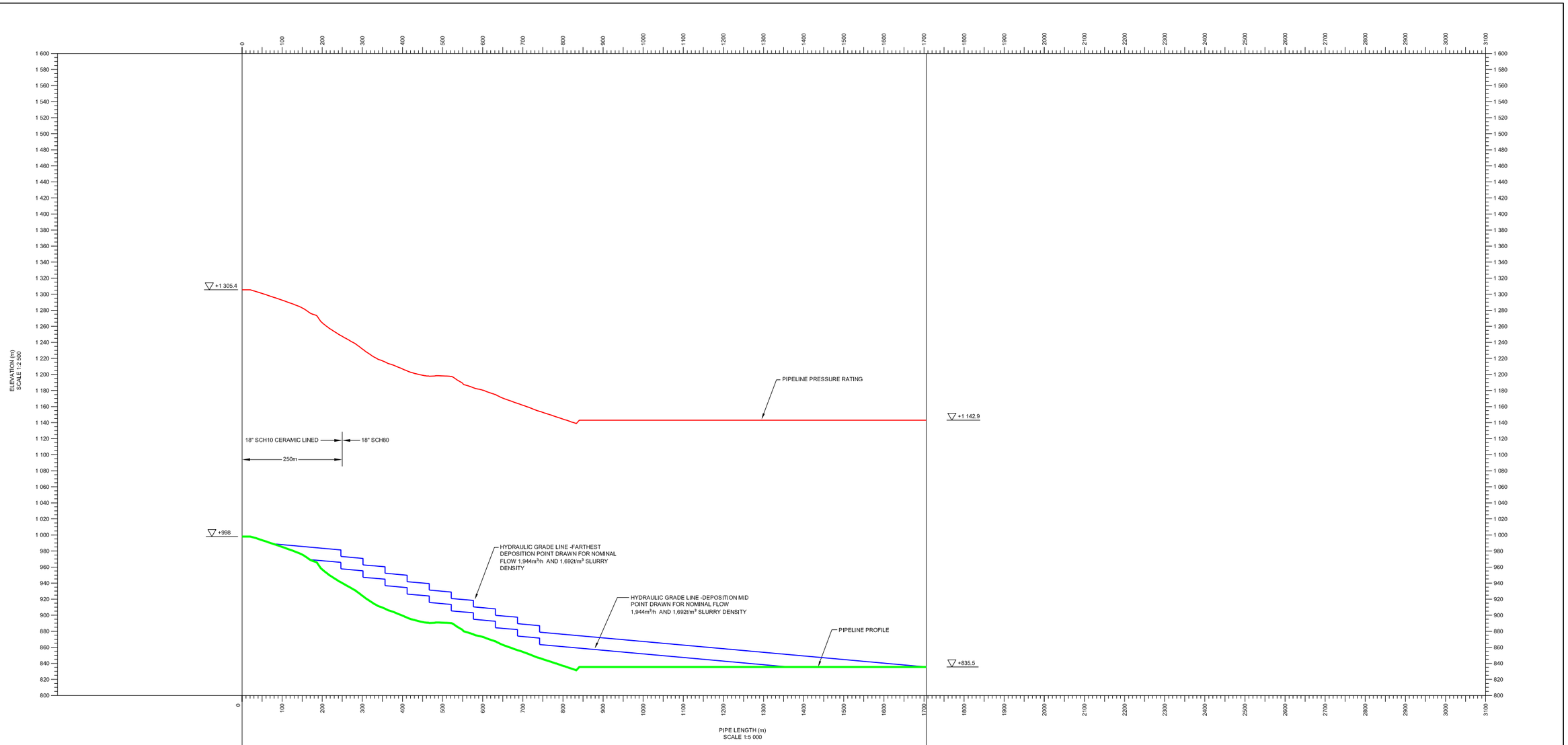
SHEET ###

CYCLONE SAND DISTRIBUTION
HYDRAULIC GRADE LINE PLOT
CYCLONE FEED

SCALE AS NOTED			PROJECT NUMBER KPV-5277	SIZE D
DESIGNED	MJ	12-OCT-12	DRAWING NUMBER 5277-1-201	REV 0
DRAWN	TF	12-OCT-12		

Tom Figos - P:\3 - Projects\KPV-5277 (Casino Project Tailing Cyclone and Transport)\Drawings\P&C Dwgs\Tailings Cyclone\HGL\5277-1-201.dwg - 12/11/2012 7:43 AM



NOTES	CYCLONE STATION DISCHARGE	DISCHARGE POINT
PIPELINE ELEVATION (m)	998	835.5
PIPE NOMINAL DIAMETER / WALL THK	18" / 6.3mm CL 6mm FIRST 250m, 18" / 23.8mm REMAINING	
PIPE SPECIFICATION / MATERIAL GRADE	ASME B36.10 / A106 Gr.B	
LINING TYPE / THICKNESS	N/A	
PIPE INTERNAL DIAMETER	433 mm / 409mm	
PIPE PRESSURE RATING	5 640 kPa	
FLANGE SPECIFICATION / MATERIAL	ASME B16.5 / ASTM A105	
FLANGE SIZE / PRESSURE RATING	18" / CLASS 300	
MAX ALLOWABLE WORKING PRESSURE	5 102 kPa	

PRELIMINARY

REVISIONS

REV	DATE	DESCRIPTION	DESG	DRWN	CHKD
A	01 NOV 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK
0	10 DEC 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK

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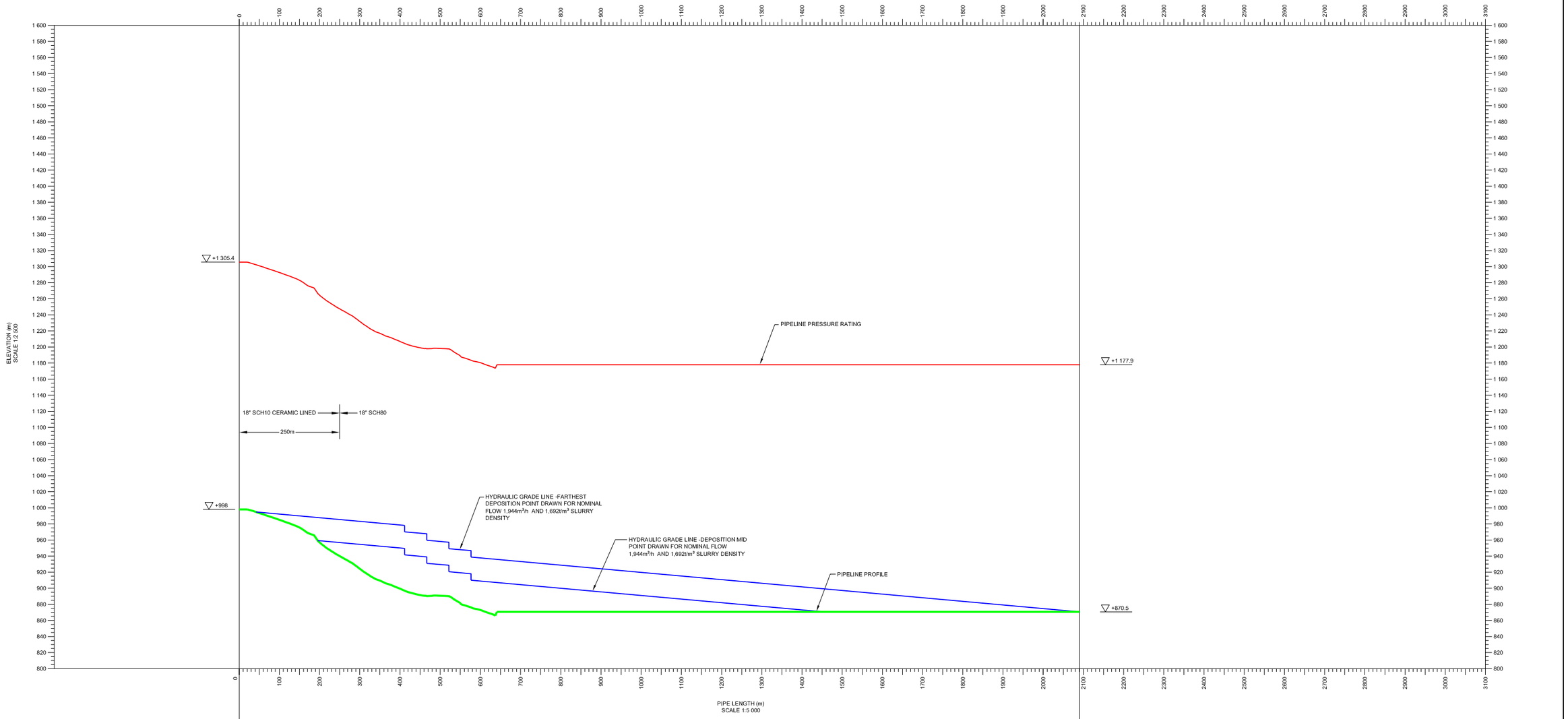
SHEET ###

CYCLONE SAND DISTRIBUTION
HYDRAULIC GRADE LINE PLOT
YEAR -1 AND 1

SCALE			PROJECT NUMBER	SIZE
AS NOTED			KPV-5277	D
DESIGNED	MJ	12-OCT-12	DRAWING NUMBER	REV
DRAWN	TF	12-OCT-12	5277-2-201	0

Tom Figas - P:\3 - Projects\KPV-5277 (Casino Project Tailing Cyclone and Transport)\Drawings\P&C Dwgs\Tailings Cyclone\HGL\5277-2-201.dwg - 12/11/2012 7:45 AM



NOTES	CYCLONE STATION DISCHARGE	DISCHARGE POINT
PIPELINE ELEVATION (m)	998	870.5
PIPE NOMINAL DIAMETER / WALL THK	18" / 6.3mm CL 6mm FIRST 250m, 18" / 23.8mm REMAINING	
PIPE SPECIFICATION / MATERIAL GRADE	ASME B36.10 / A106 Gr.B	
LINING TYPE / THICKNESS	N/A	
PIPE INTERNAL DIAMETER	433 mm / 409mm	
PIPE PRESSURE RATING	5 640 kPa	
FLANGE SPECIFICATION / MATERIAL	ASME B16.5 / ASTM A105	
FLANGE SIZE / PRESSURE RATING	18" / CLASS 300	
MAX ALLOWABLE WORKING PRESSURE	5 102 kPa	

PRELIMINARY

REVISIONS

REV	DATE	DESCRIPTION	DESG	DRWN	CHKD
A	01 NOV 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK
0	10 DEC 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK

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SHEET ###

CYCLONE SAND DISTRIBUTION
HYDRAULIC GRADE LINE PLOT
YEAR 3

SCALE		PROJECT NUMBER	SIZE
AS NOTED		KPV–5277	D
DESIGNED MJ	12–OCT–12	DRAWING NUMBER	REV
DRAWN TF	12–OCT–12	5277–2–202	0

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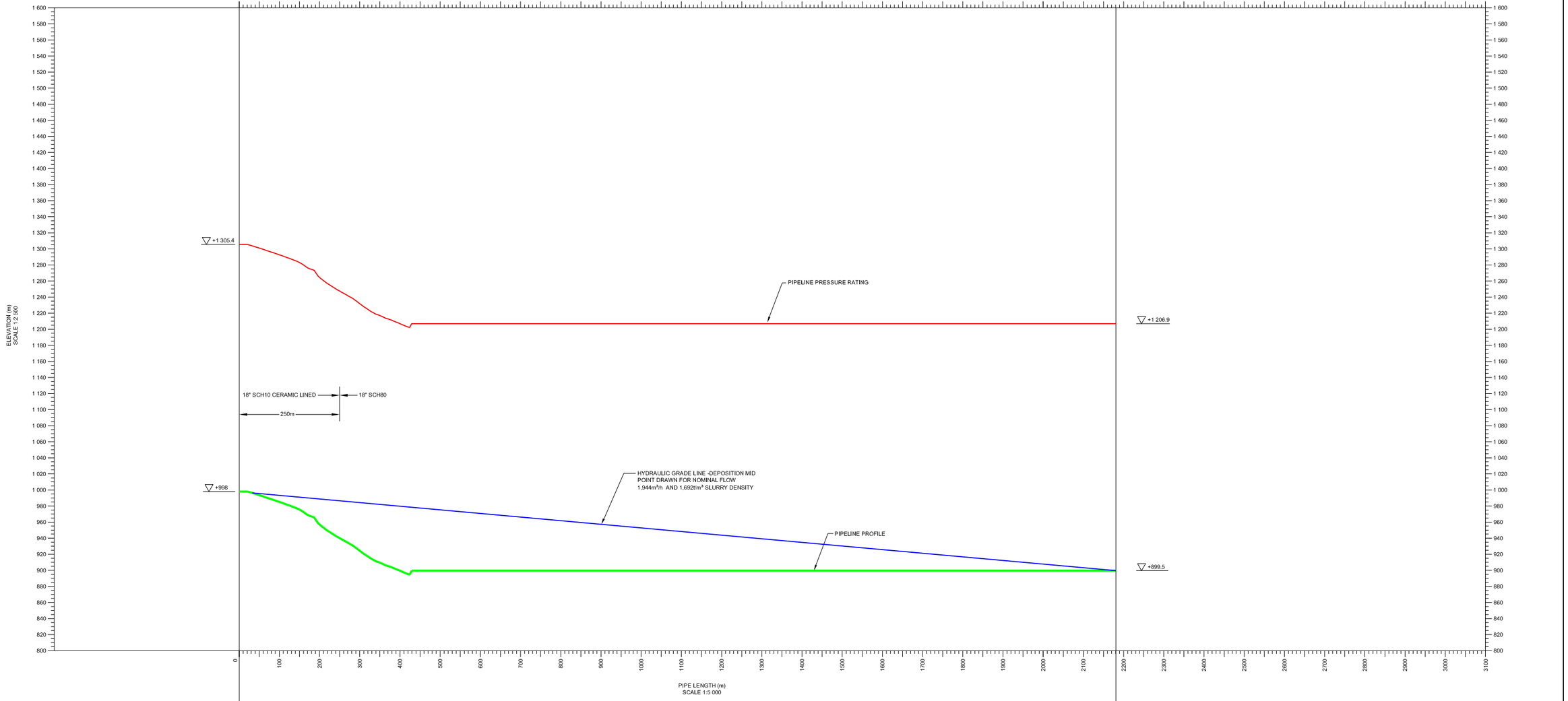

NOTES	CYCLONE STATION DISCHARGE		DISCHARGE POINT
PIPELINE ELEVATION (m)	998		899.5
PIPE NOMINAL DIAMETER / WALL THK	18" / 6.3mm CL 6mm FIRST 250m, 18" / 23.8mm REMAINING		
PIPE SPECIFICATION / MATERIAL GRADE	ASME B36.10 / A106 Gr.B		
LINING TYPE / THICKNESS	N/A		
PIPE INTERNAL DIAMETER	433 mm / 409mm		
PIPE PRESSURE RATING	5 640 kPa		
FLANGE SPECIFICATION / MATERIAL	ASME B16.5 / ASTM A105		
FLANGE SIZE / PRESSURE RATING	18" / CLASS 300		
MAX ALLOWABLE WORKING PRESSURE	5 102 kPa		

PRELIMINARY

REVISIONS

REV	DATE	DESCRIPTION	DESG	DRWN	CHKD
A	01 NOV 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK
0	10 DEC 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK

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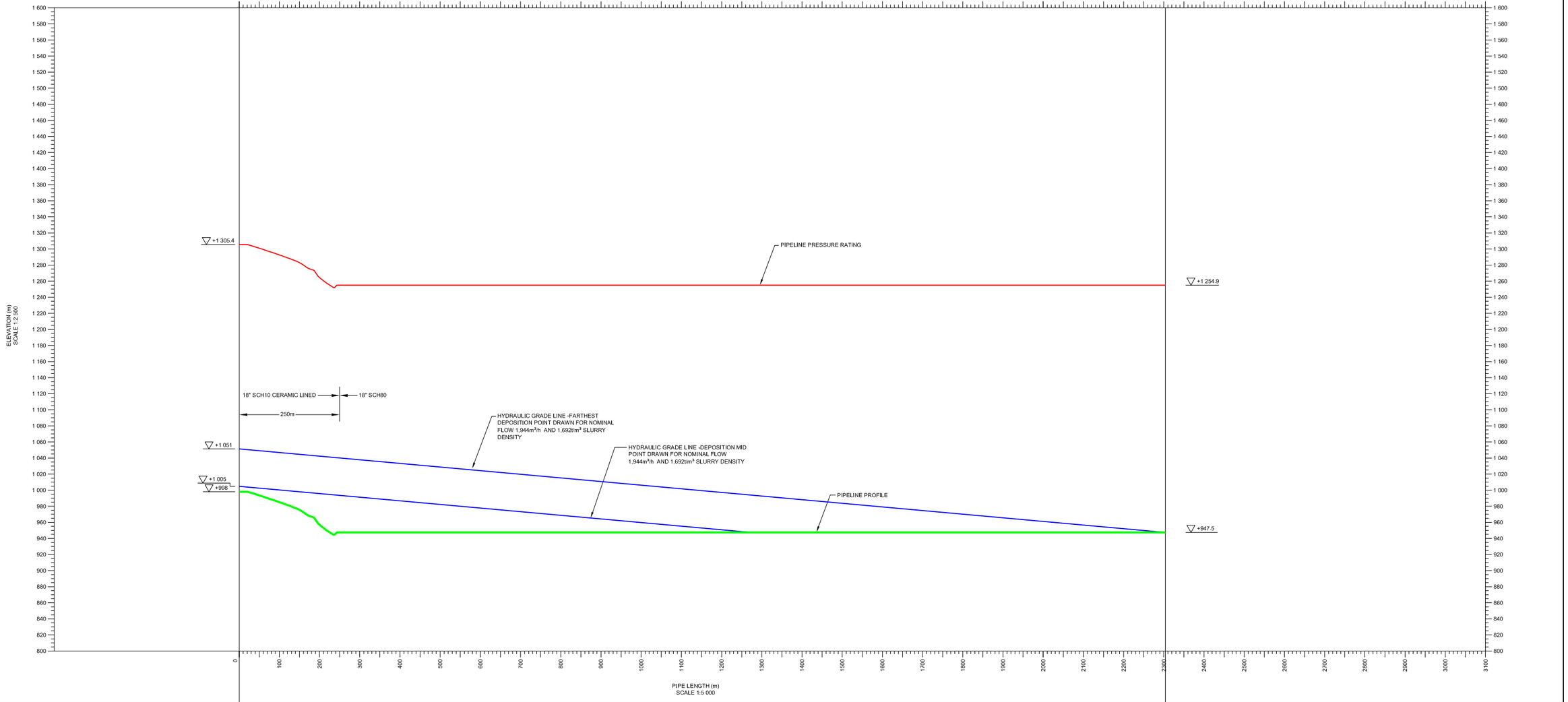
SHEET ###

CYCLONE SAND DISTRIBUTION
HYDRAULIC GRADE LINE PLOT
YEAR 6

SCALE			PROJECT NUMBER	SIZE
AS NOTED			KPV–5277	D
DESIGNED	MJ	12–OCT–12	DRAWING NUMBER	REV
DRAWN	TF	12–OCT–12	5277–2–203	0

Tom Figos – P:\3 – Projects\KPV–5277 (Casino Project Tailing Cyclone and Transport)\Drawings\P&C Dwgs\Tailings Cyclone\HGL\5277–2–203.dwg – 12/11/2012 7:49 AM



	CYCLONE STATION DISCHARGE	DISCHARGE POINT
NOTES		
PIPELINE ELEVATION (m)	998	947.5
PIPE NOMINAL DIAMETER / WALL THK	18" / 6.3mm CL 6mm FIRST 250m, 18" / 23.8mm REMAINING	
PIPE SPECIFICATION / MATERIAL GRADE	ASME B36.10 / A106 Gr.B	
LINING TYPE / THICKNESS	N/A	
PIPE INTERNAL DIAMETER	433 mm / 409mm	
PIPE PRESSURE RATING	5 640 kPa	
FLANGE SPECIFICATION / MATERIAL	ASME B16.5 / ASTM A105	
FLANGE SIZE / PRESSURE RATING	18" / CLASS 300	
MAX ALLOWABLE WORKING PRESSURE	5 102 kPa	

PRELIMINARY

REVISIONS

REV	DATE	DESCRIPTION	DESG	DRWN	CHKD
A	01 NOV 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK
0	10 DEC 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK

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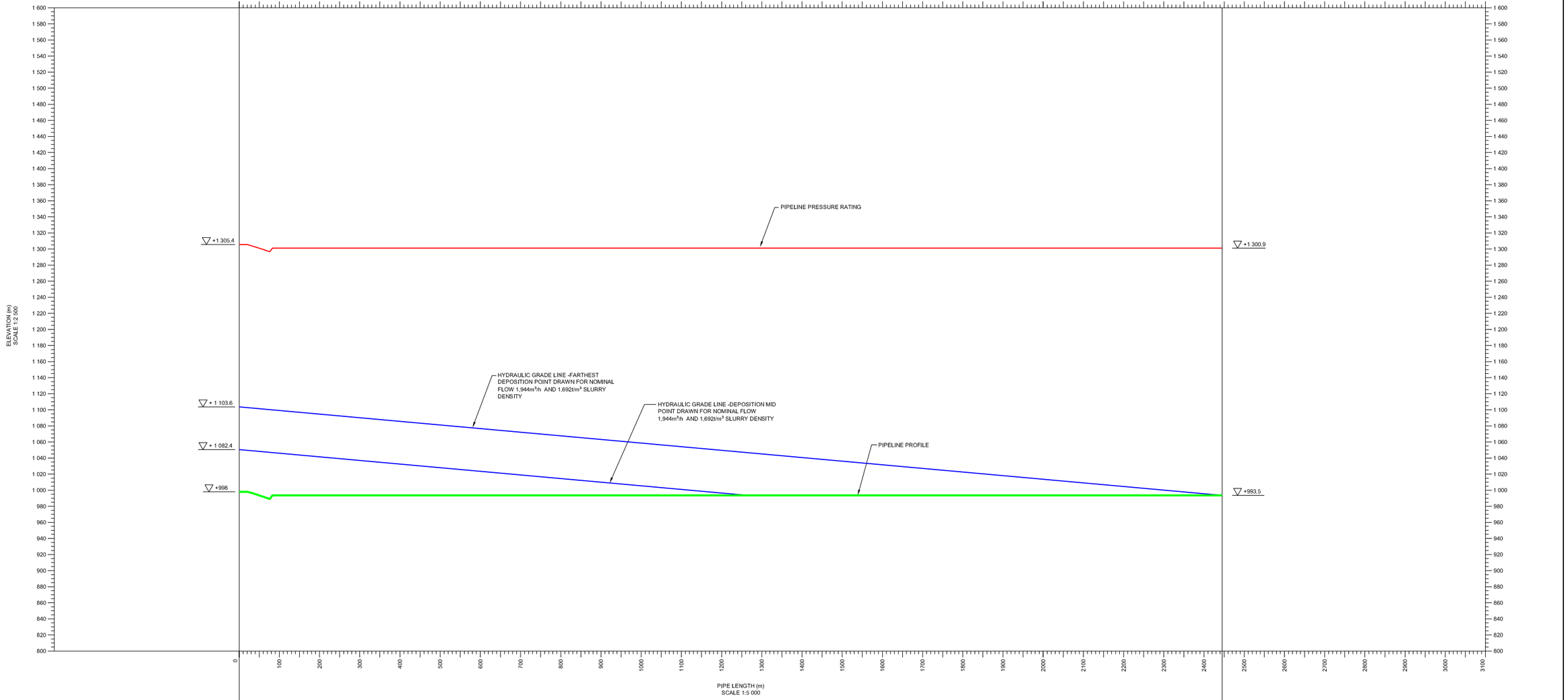
CYCLONE SAND DISTRIBUTION
HYDRAULIC GRADE LINE PLOT
YEAR 12

SHEET ###

SCALE		PROJECT NUMBER	SIZE
AS NOTED		KPV-5277	D
DESIGNED MJ	12-OCT-12	DRAWING NUMBER	REV
DRAWN TF	12-OCT-12	5277-2-204	0

Tom Figas - P:\3 - Projects\KPV-5277 (Casino Project Tailing Cyclone and Transport)\Drawings\P&C Dwgs\Tailings Cyclone\HGL\5277-2-204.dwg - 12/11/2012 7:50 AM



NOTES	CYCLONE STATION DISCHARGE	DISCHARGE POINT
PIPELINE ELEVATION (m)	998	993.5
PIPE NOMINAL DIAMETER / WALL THK	18" / 23.8mm	
PIPE SPECIFICATION / MATERIAL GRADE	ASME B36.10 / A106 Gr.B	
LINING TYPE / THICKNESS	N/A	
PIPE INTERNAL DIAMETER	409mm	
PIPE PRESSURE RATING	24 000 kPa	
FLANGE SPECIFICATION / MATERIAL	ASME B16.5 / ASTM A105	
FLANGE SIZE / PRESSURE RATING	18" / CLASS 300	
MAX ALLOWABLE WORKING PRESSURE	5 102 kPa	

PRELIMINARY

REVISIONS

REV	DATE	DESCRIPTION	DESG	DRWN	CHKD
A	01 NOV 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK
0	10 DEC 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK

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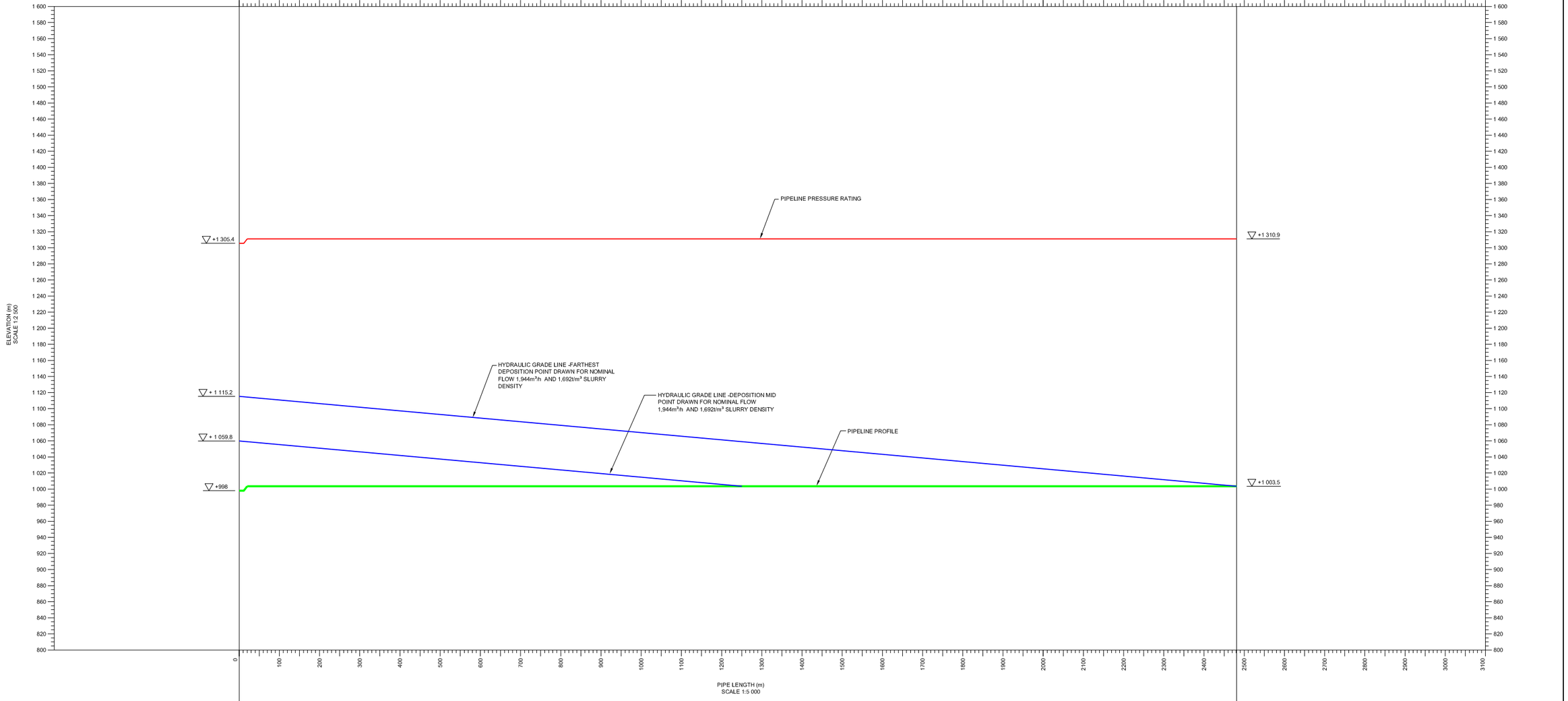
CASINO PROJECT
TAILINGS CYCLONE AND TRANSPORTATION STUDY
SHEET ###

CYCLONE SAND DISTRIBUTION
HYDRAULIC GRADE LINE PLOT
YEAR 19

SCALE			PROJECT NUMBER	SIZE
AS NOTED			KPV-5277	D
DESIGNED	MJ	12-OCT-12	DRAWING NUMBER	REV
DRAWN	TF	12-OCT-12	5277-2-205	0

Tom Figas - P:\3 - Projects\KPV-5277 (Casino Project Tailing Cyclone and Transport)\Drawings\P&C Dwgs\Tailings Cyclone\HGL\5277-2-205.dwg - 12/11/2012 7:51 AM



NOTES	CYCLONE STATION DISCHARGE	DISCHARGE POINT
PIPELINE ELEVATION (m)	998	1 003.5
PIPE NOMINAL DIAMETER / WALL THK	18" / 23.8mm	
PIPE SPECIFICATION / MATERIAL GRADE	ASME B36.10 / A106 Gr.B	
LINING TYPE / THICKNESS	N/A	
PIPE INTERNAL DIAMETER	409mm	
PIPE PRESSURE RATING	24 000 kPa	
FLANGE SPECIFICATION / MATERIAL	ASME B16.5 / ASTM A105	
FLANGE SIZE / PRESSURE RATING	18" / CLASS 300	
MAX ALLOWABLE WORKING PRESSURE	5 102 kPa	

PRELIMINARY

REVISIONS

REV	DATE	DESCRIPTION	DESG	DRWN	CHKD
A	01 NOV 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK
0	10 DEC 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK

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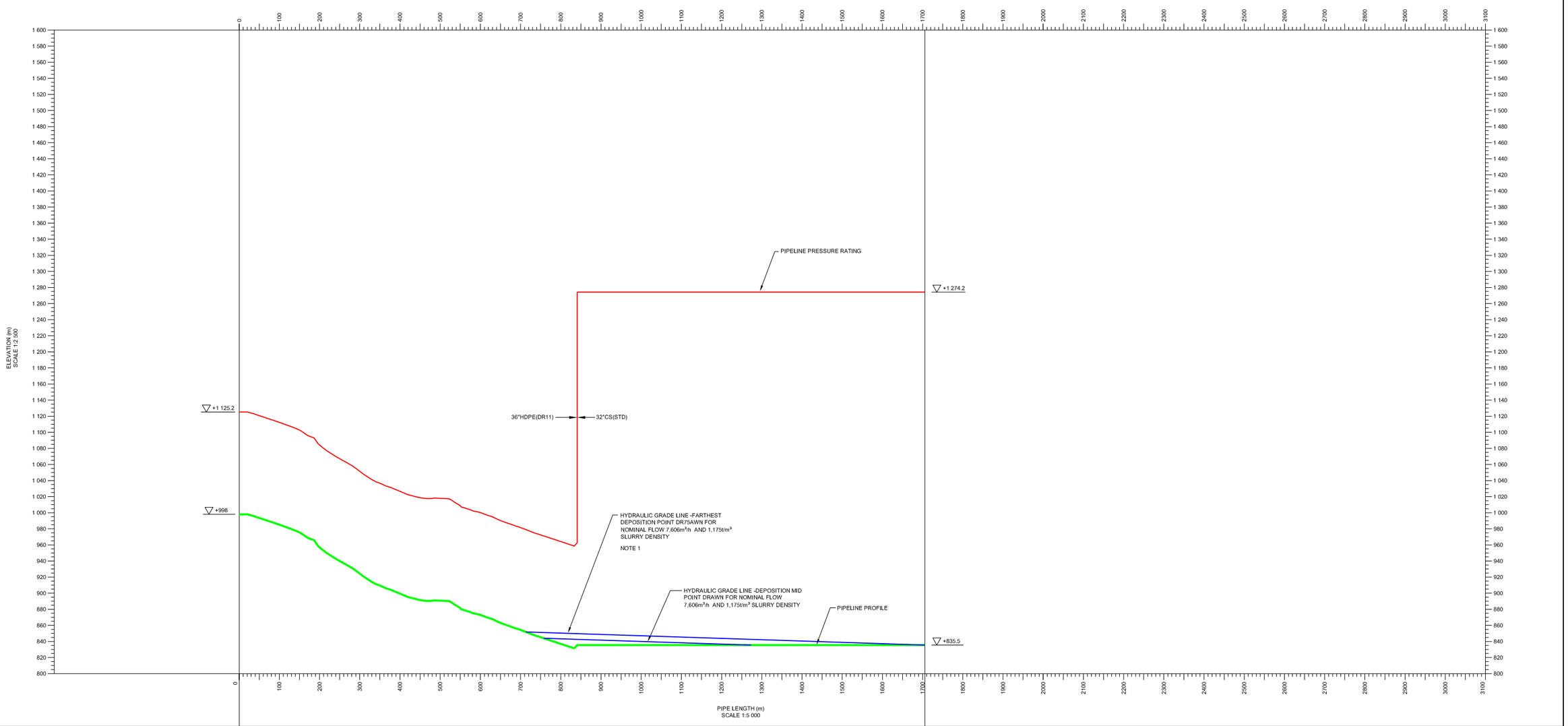
SHEET ###

CYCLONE SAND DISTRIBUTION
HYDRAULIC GRADE LINE PLOT
YEAR 22

SCALE AS NOTED			PROJECT NUMBER KPV-5277		SIZE D
DESIGNED	MJ	12-OCT-12	DRAWING NUMBER 5277-2-206		REV 0
DRAWN	TF	12-OCT-12			

Tom Figas - P:\3 - Projects\KPV-5277 (Casino Project Tailing Cyclone and Transport)\Drawings\P&C Dwgs\Tailings Cyclone\HGL\5277-2-206.dwg - 12/11/2012 7:52 AM



NOTE
1. FOR SIMPLICITY HGL SLOPE FOR CS(STD) PIPE SHOWN. HDPE PIPE IS USED ONLY ON SLACK FLOW SECTION OF PIPE AND WILL BE REPLACED WITH CS PIPE AS THE LENGTH OF DAM PROGRESSES.

	CYCLONE STATION DISCHARGE	DISCHARGE POINT
PIPELINE ELEVATION (m)	998	835.5
PIPE NOMINAL DIAMETER / WALL THK	36"HDPE/83mm, 32"CS / 9.53mm	
PIPE SPECIFICATION / MATERIAL GRADE	ASME B36.10 / A106 Gr.B	
LINING TYPE / THICKNESS	N/A	
PIPE INTERNAL DIAMETER	738mm, 794mm	
PIPE PRESSURE RATING	1 466 kPa, 5 057 kPa	
FLANGE SPECIFICATION / MATERIAL	ASME B16.5 / ASTM A105	
FLANGE SIZE / PRESSURE RATING	36"/CLASS 150, 32" / CLASS 300	
MAX ALLOWABLE WORKING PRESSURE	1 466 kPa	

PRELIMINARY

REVISIONS

REV	DATE	DESCRIPTION	DESG	DRWN	CHKD
A	01 NOV 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK
0	10 DEC 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK

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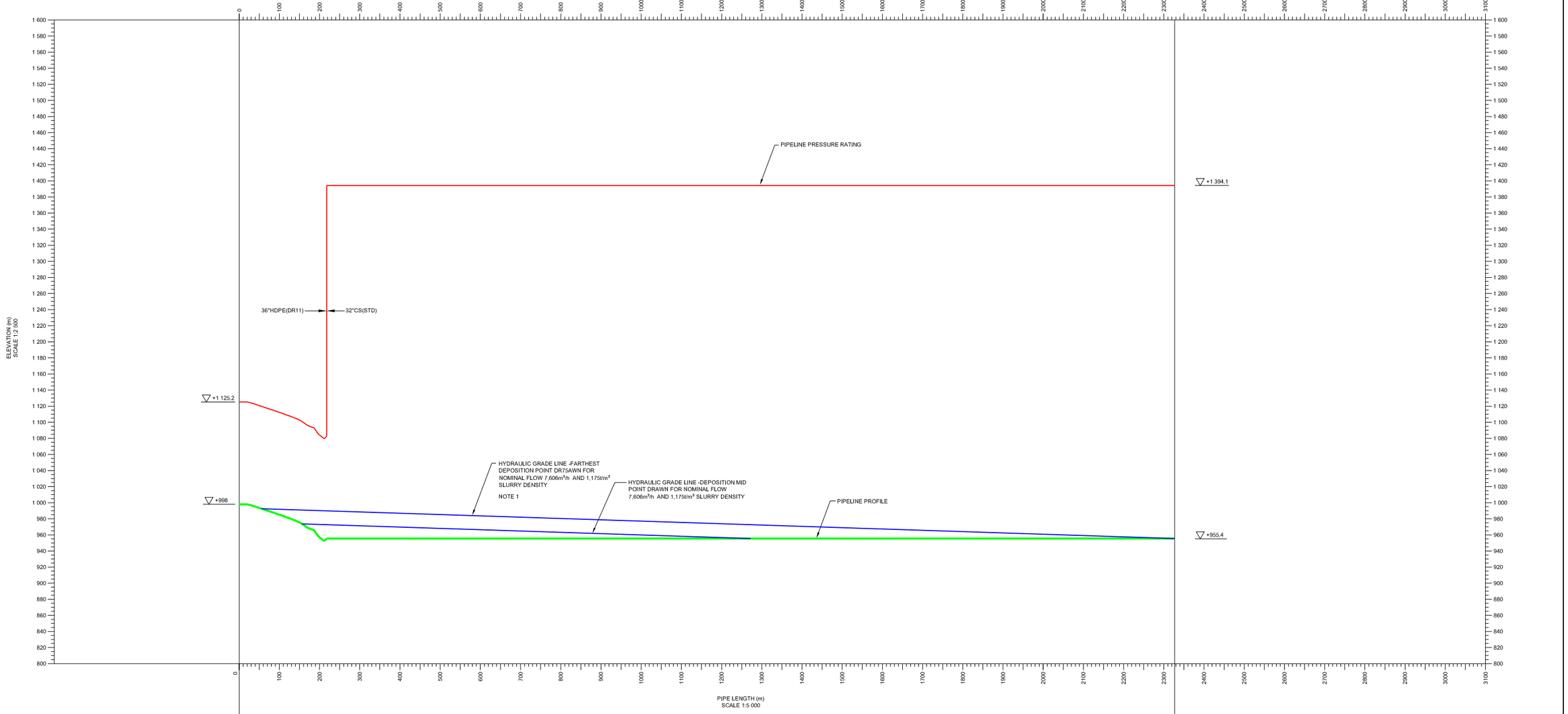
CYCLONE OVERFLOW DISTRIBUTION
HYDRAULIC GRADE LINE PLOT
YEAR -1 (O/F STREAM)

SHEET ###

SCALE		PROJECT NUMBER	SIZE
AS NOTED		KPV-5277	D
DESIGNED MJ	12-OCT-12	DRAWING NUMBER	REV
DRAWN TF	12-OCT-12	5277-3-201	0

Tom Figas - P:\3 - Projects\KPV-5277 (Casino Project Tailing Cyclone and Transport)\Drawings\P&C Dwgs\Tailings Cyclone\HGL\5277-3-201.dwg - 12/11/2012 7:54 AM



NOTES
1. FOR SIMPLICITY HGL SLOPE FOR CS(STD) PIPE SHOWN. HDPE PIPE IS USED ONLY ON SLACK FLOW SECTION OF PIPE AND WILL BE REPLACED WITH CS PIPE AS THE LENGTH OF DAM PROGRESSES.

	CYCLONE STATION DISCHARGE	DISCHARGE POINT
PIPELINE ELEVATION (m)	998	955.4
PIPE NOMINAL DIAMETER / WALL THK	36"HDPE/83mm, 32"CS / 9.53mm	
PIPE SPECIFICATION / MATERIAL GRADE	ASME B36.10 / A106 Gr.B	
LINING TYPE / THICKNESS	N/A	
PIPE INTERNAL DIAMETER	738mm, 794mm	
PIPE PRESSURE RATING	1 466 kPa, 5 057 kPa	
FLANGE SPECIFICATION / MATERIAL	ASME B16.5 / ASTM A105	
FLANGE SIZE / PRESSURE RATING	36"/CLASS 150, 32" / CLASS 300	
MAX ALLOWABLE WORKING PRESSURE	1 466 kPa	

PRELIMINARY

REVISIONS

REV	DATE	DESCRIPTION	DESG	DRWN	CHKD
A	01 NOV 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK
0	10 DEC 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK

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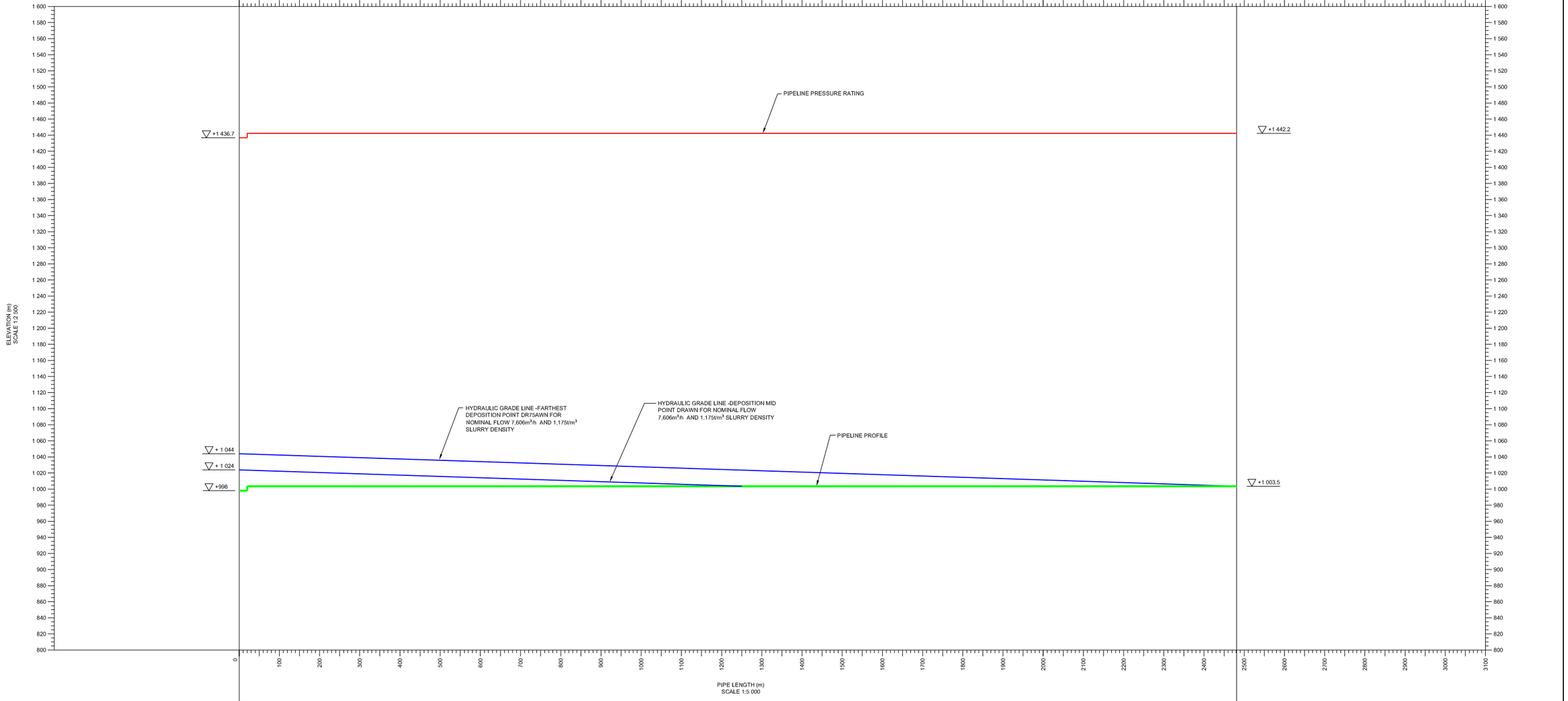
CASINO PROJECT
TAILINGS CYCLONE AND TRANSPORTATION STUDY
CYCLONE OVERFLOW DISTRIBUTION
HYDRAULIC GRADE LINE PLOT
YEAR 13 (O/F STREAM)

SHEET ###

SCALE		PROJECT NUMBER	SIZE
AS NOTED		KPV-5277	D
DESIGNED	MJ	12-OCT-12	DRAWING NUMBER 5277-3-202 / REV 0
DRAWN	TF	12-OCT-12	

Tom Figos - P:\3 - Projects\KPV-5277 (Casino Project Tailing Cyclone and Transport)\Drawings\P&C Dwgs\Tailings Cyclone\HGL\5277-3-202.dwg - 12/11/2012 7:55 AM



NOTES	CYCLONE STATION DISCHARGE	DISCHARGE POINT
PIPELINE ELEVATION (m)	998	1 003.5
PIPE NOMINAL DIAMETER / WALL THK	32" / 9.53mm	
PIPE SPECIFICATION / MATERIAL GRADE	ASME B36.10 / A106 Gr.B	
LINING TYPE / THICKNESS	N/A	
PIPE INTERNAL DIAMETER	794mm	
PIPE PRESSURE RATING	5 057 kPa	
FLANGE SPECIFICATION / MATERIAL	ASME B16.5 / ASTM A105	
FLANGE SIZE / PRESSURE RATING	32" / CLASS 300	
MAX ALLOWABLE WORKING PRESSURE	5 057 kPa	

PRELIMINARY

REVISIONS

REV	DATE	DESCRIPTION	DESG	DRWN	CHKD
A	01 NOV 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK
0	10 DEC 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK

REFERENCE DRAWINGS

DRG No.	DESCRIPTION

PATERSON & COOKE
306-595 HOWE STREET
VANCOUVER, BC CANADA
TEL : 604-687-7704
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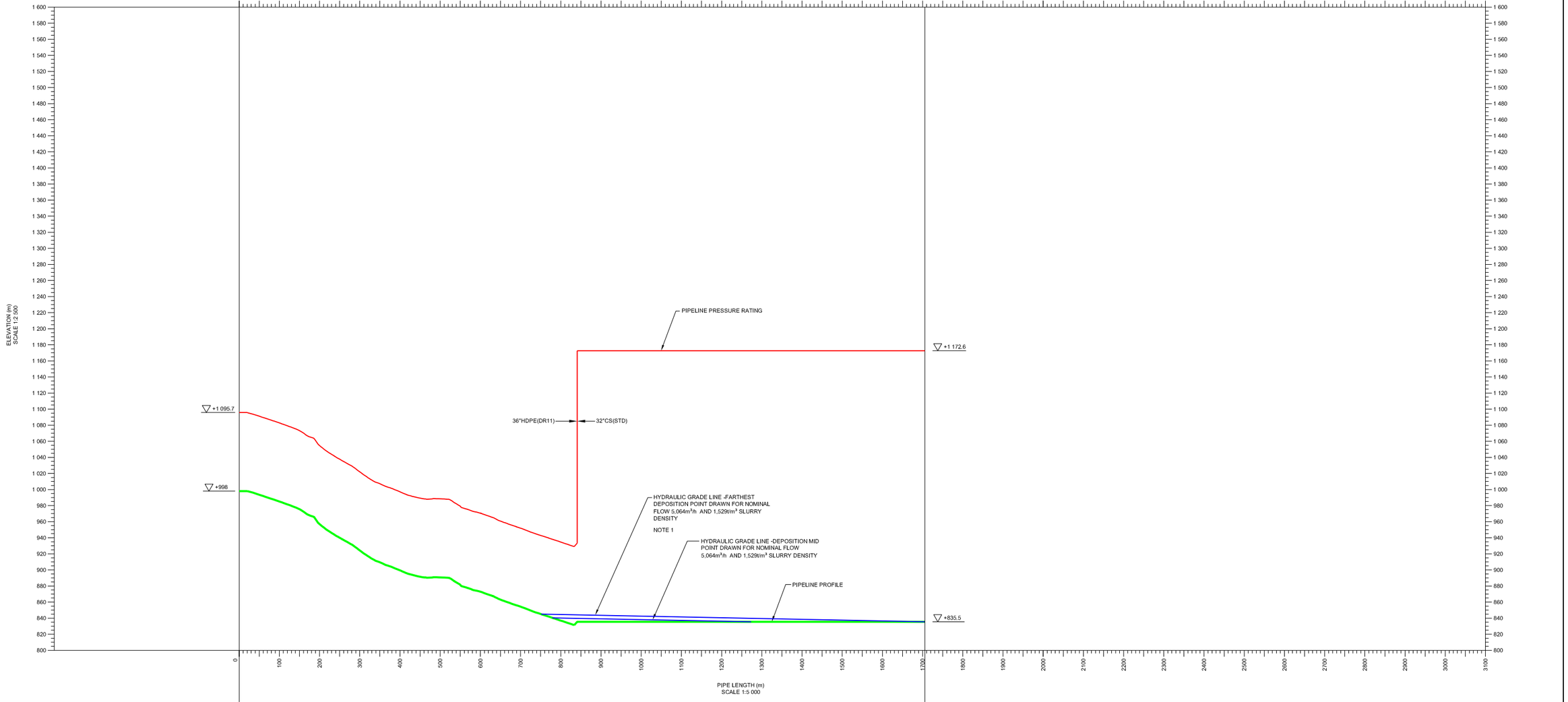
CASINO PROJECT
TAILINGS CYCLONE AND TRANSPORTATION STUDY
CYCLONE OVERFLOW DISTRIBUTION
HYDRAULIC GRADE LINE PLOT
YEAR 22 (O/F STREAM)

SCALE		PROJECT NUMBER	SIZE
AS NOTED		KPV-5277	D
DESIGNED	MJ	12-OCT-12	REV
DRAWN	TF	12-OCT-12	0

SHEET ###
DRAWING NUMBER 5277-3-203

Tom Figas - P:\3 - Projects\KPV-5277 (Casino Project Tailing Cyclone and Transport)\Drawings\P&C Dwgs\Tailings Cyclone\HGL\5277-3-203.dwg - 12/11/2012 7:56 AM



NOTES
1. FOR SIMPLICITY HGL SLOPE FOR CS(STD) PIPE SHOWN. HDPE PIPE IS USED ONLY ON SLACK FLOW SECTION OF PIPE AND WILL BE REPLACED WITH CS PIPE AS THE LENGTH OF DAM PROGRESSES.

	CYCLONE STATION DISCHARGE	DISCHARGE POINT
PIPELINE ELEVATION (m)	998	835.5
PIPE NOMINAL DIAMETER / WALL THK	36"HDPE/83mm, 32"CS / 9.53mm	
PIPE SPECIFICATION / MATERIAL GRADE	ASME B36.10 / A106 Gr.B	
LINING TYPE / THICKNESS	N/A	
PIPE INTERNAL DIAMETER	738mm, 794mm	
PIPE PRESSURE RATING	1 466 kPa, 5 057 kPa	
FLANGE SPECIFICATION / MATERIAL	ASME B16.5 / ASTM A105	
FLANGE SIZE / PRESSURE RATING	36"/CLASS 150, 32" / CLASS 300	
MAX ALLOWABLE WORKING PRESSURE	1 466 kPa	

PRELIMINARY

REVISIONS

REV	DATE	DESCRIPTION	DESG	DRWN	CHKD
A	01 NOV 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK
0	10 DEC 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK

REFERENCE DRAWINGS

DRG No.	DESCRIPTION

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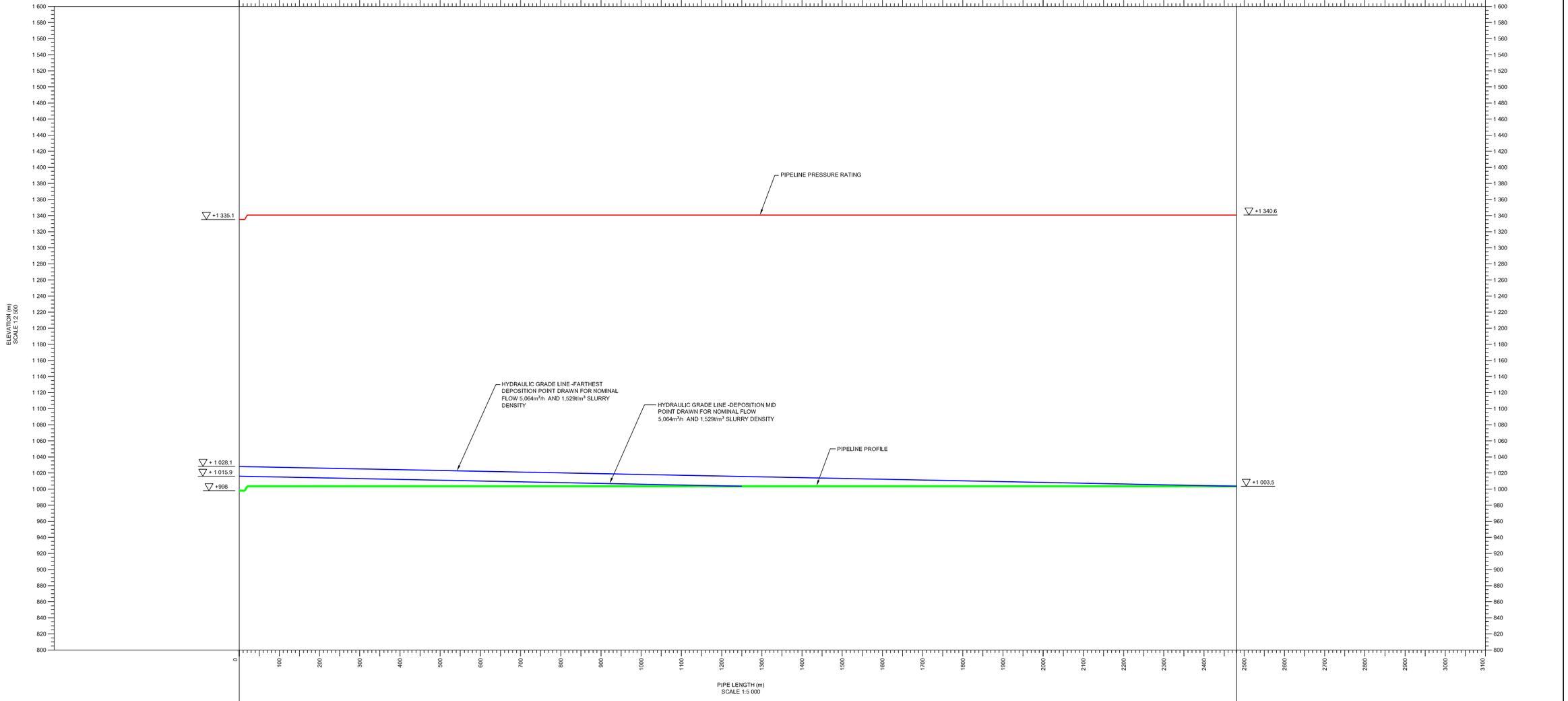
CASINO PROJECT
TAILINGS CYCLONE AND TRANSPORTATION STUDY
CYCLONE OVERFLOW DISTRIBUTION
HYDRAULIC GRADE LINE PLOT
YEAR -1 (NR TAILINGS STREAM)

SHEET ###

SCALE	AS NOTED		PROJECT NUMBER	SIZE
DESIGNED	MJ	12-OCT-12	KPV-5277	D
DRAWN	TF	12-OCT-12	DRAWING NUMBER 5277-3-204	REV 0

Tom Figos - P:\3 - Projects\KPV-5277 (Casino Project Tailing Cyclone and Transport)\Drawings\P&C Dwgs\Tailings Cyclone\HGL\5277-3-204.dwg - 12/11/2012 7:58 AM



NOTES	CYCLONE STATION DISCHARGE	DISCHARGE POINT
PIPELINE ELEVATION (m)	998	1 003.5
PIPE NOMINAL DIAMETER / WALL THK	32" / 9.53mm	
PIPE SPECIFICATION / MATERIAL GRADE	ASME B36.10 / A106 Gr.B	
LINING TYPE / THICKNESS	N/A	
PIPE INTERNAL DIAMETER	794mm	
PIPE PRESSURE RATING	5 057 kPa	
FLANGE SPECIFICATION / MATERIAL	ASME B16.5 / ASTM A105	
FLANGE SIZE / PRESSURE RATING	32" / CLASS 300	
MAX ALLOWABLE WORKING PRESSURE	5 057 kPa	

PRELIMINARY

REVISIONS

REV	DATE	DESCRIPTION	DESG	DRWN	CHKD
A	01 NOV 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK
0	10 DEC 12	ISSUED FOR FEASIBILITY STUDY REPORT	MJ	TF	YK

REFERENCE DRAWINGS

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CASINO PROJECT
TAILINGS CYCLONE AND TRANSPORTATION STUDY
CYCLONE OVERFLOW DISTRIBUTION
HYDRAULIC GRADE LINE PLOT
YEAR 22 (NR TAILINGS STREAM)

SHEET ###

SCALE		PROJECT NUMBER	SIZE
AS NOTED		KPV-5277	D
DESIGNED	MJ	12-OCT-12	DRAWING NUMBER 5277-3-205 REV 0
DRAWN	TF	12-OCT-12	

P:\3 - Projects\KPV-5277 (Casino Project Tailing Cyclone and Transport)\Drawings\P&C Dwgs\Tailings Cyclone\HGL\5277-3-205.dwg - 12/11/2012 8:00 AM
Tom Figas

APPENDIX D – EQUIPMENT LIST

TAG NO.	DESCRIPTION	CAPACITY/ DUTY	INSTALLED POWER	COMMENT	INSTALLATION YEAR	DATA SHEET	DWG No.
01-TK-001	DILUTION WATER HEAD TANK	DxH, 12.5 m x 12.5 m			INSTALLED YEAR -1		5277-1-001
01-TK-002	CYCLONE FEED TANK	HxWxL, 8m x 7.7m x 8m			INSTALLED YEAR -1		
01-TK-004	GLAND SEAL WATER TANK	DxH, 3.5m x 9.6m			INSTALLED YEAR 6		
01-TK-006	WATER BUFFER TANK	DxH, 6.1m x 9m			INSTALLED YEAR -1		
01-CY-001	CYCLONE CLUSTER(S)	CLUSTER OF 12 x 800mm Dia., CAVEX CYCLONE			INSTALLED YEAR -1		
01-CR-001	OVERHEAD CRANE	15tonne	20kW		INSTALLED YEAR -1		
01-PU-019	FLUSH WATER PUMP	525 m^3/hr @ 40m	80 kW	8x10	INSTALLED YEAR -1		
01-CM-001	AIR COMPRESSOR PACKAGE	106 m^3/hr at 780 kPa	11kW	ATLAS COPCO GA11-8.5 W/DESICCANT AIR DRYER	INSTALLED YEAR -1		
01-FI-001	GSW FILTER - STANDBY	28.8 m^3/hr			INSTALLED YEAR -1		
01-FI-002	GSW FILTER - STANDBY	28.8 m^3/hr			INSTALLED YEAR -1		

TAG NO.	DESCRIPTION	CAPACITY/ DUTY	INSTALLED POWER	COMMENT	INSTALLATION YEAR	DATA SHEET	DWG No.
02-TK-003	CYCLONE U/F TANK	HxLxW, 4 m x 3.2 m x 4 m			INSTALLED YEAR -1		5277-2-001
02-PU-001	CYCLONE U/F PUMP No. 1	2,236 m^3/hr @ 43 m	671kW VFD	WEIR 16/14 AHP	INSTALLED YEAR 6		
02-PU-002	CYCLONE U/F PUMP No. 2	2,236 m^3/hr @ 43 m	671kW VFD	WEIR 16/14 AHP	INSTALLED YEAR 12		
02-PU-003	CYCLONE U/F PUMP No. 3	2,236 m^3/hr @ 43 m	671kW VFD	WEIR 16/14 AHP	INSTALLED YEAR 19		
02-PU-004	CYCLONE U/F PUMP No. 1 - STANDBY	2,236 m^3/hr @ 43 m	671kW VFD	WEIR 16/14 AHP	INSTALLED YEAR 6		
02-PU-005	CYCLONE U/F PUMP No. 2 - STANDBY	2,236 m^3/hr @ 43 m	671kW VFD	WEIR 16/14 AHP	INSTALLED YEAR 12		
02-PU-006	CYCLONE U/F PUMP No. 3 - STANDBY	2,236 m^3/hr @ 43 m	671kW VFD	WEIR 16/14 AHP	INSTALLED YEAR 19		
02-PU-007	CYCLONE U/F GSW PUMP No.1	1.8 m^3/hr @ 213 m	5kW	POSITIVE DISPLACEMENT	INSTALLED YEAR 6		
02-PU-008	CYCLONE U/F GSW PUMP No.1 - STANDBY	1.8 m^3/hr @ 213 m	5kW	POSITIVE DISPLACEMENT	INSTALLED YEAR 6		
02-PU-009	CYCLONE U/F GSW PUMP No.2	1.8 m^3/hr @ 213 m	5kW	POSITIVE DISPLACEMENT	INSTALLED YEAR 12		
02-PU-010	CYCLONE U/F GSW PUMP No.2 - STANDBY	1.8 m^3/hr @ 213 m	5kW	POSITIVE DISPLACEMENT	INSTALLED YEAR 12		
02-PU-011	CYCLONE U/F GSW PUMP No.3	1.8 m^3/hr @ 213 m	5kW	POSITIVE DISPLACEMENT	INSTALLED YEAR 19		
02-PU-012	CYCLONE U/F GSW PUMP No.3 - STANDBY	1.8 m^3/hr @ 213 m	5kW	POSITIVE DISPLACEMENT	INSTALLED YEAR 19		
02-PU-019	SAND SAMPLER PUMP	34 m3/hr @ 12 m		GRACO HUSKY 2150 DOUBLE DIAPHRAGM PUMP	INSTALLED YEAR -1		
02-OR-001	CYCLONE U/F ORIFICE No. 1	ΔH=8 m Slurry, ID=0.254 m			INSTALLED YEAR -1		
02-OR-002	CYCLONE U/F ORIFICE No. 2	ΔH=8 m Slurry, ID=0.254 m			INSTALLED YEAR -1		
02-OR-003	CYCLONE U/F ORIFICE No. 3	ΔH=8 m Slurry, ID=0.254 m			INSTALLED YEAR -1		
02-OR-004	CYCLONE U/F ORIFICE No. 4	ΔH=8 m Slurry, ID=0.254 m			INSTALLED YEAR -1		
02-OR-005	CYCLONE U/F ORIFICE No. 5	ΔH=8 m Slurry, ID=0.254 m			INSTALLED YEAR -1		
02-OR-006	CYCLONE U/F ORIFICE No. 6	ΔH=8 m Slurry, ID=0.254 m			INSTALLED YEAR -1		
02-OR-007	CYCLONE U/F ORIFICE No. 7	ΔH=8 m Slurry, ID=0.254 m			INSTALLED YEAR -1		
02-OR-008	CYCLONE U/F ORIFICE No. 8	ΔH=8 m Slurry, ID=0.254 m			INSTALLED YEAR -1		
02-OR-009	CYCLONE U/F ORIFICE No. 9	ΔH=8 m Slurry, ID=0.254 m			INSTALLED YEAR -1		
02-OR-010	CYCLONE U/F ORIFICE No. 10	ΔH=8 m Slurry, ID=0.254 m			INSTALLED YEAR -1		

TAG NO.	DESCRIPTION	CAPACITY/ DUTY	INSTALLED POWER	COMMENT	INSTALLATION YEAR	DATA SHEET	DWG No.
03-TK-005	CYCLONE O/F TANK	HxWxL, 5 m x 5.5 m x 6.2 m			INSTALLED YEAR -1		5277-3-001
03-PU-013	CYCLONE O/F PUMP	8,746 m^3/hr @ 60 m	2000kW VFD	WEIR 650L	INSTALLED YEAR 13		
03-PU-015	CYCLONE O/F PUMP - STANDBY	8,746 m^3/hr @ 60 m	2000kW VFD	WEIR 650L	INSTALLED YEAR 13		
03-PU-017	CYCLONE O/F GSW PUMP	1.8 m^3/hr @ 75 m	5kW	POSITIVE DISPLACEMENT	INSTALLED YEAR 13		
03-PU-018	CYCLONE O/F GSW PUMP - STANDBY	1.8 m^3/hr @ 75 m	5kW	POSITIVE DISPLACEMENT	INSTALLED YEAR 13		

APPENDIX E – MATERIAL TAKE-OFF LISTS

TABLE 10.2
CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

FEASIBILITY DESIGN OF THE TAILINGS MANAGEMENT FACILITY
SCHEDULE OF QUANTITIES

Print Nov/1/12 8:10:25

				INSTALLATION YEAR																					REV
Item Type	Item No.	Description	Unit	-1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
Equipment	5	CYCLONE CLUSTER(S) CLUSTER OF 12 x 800mm Dia., CAVEX CYCLONE	No.	1																						B
		GLAND SEAL WATER TANK, STEEL TANK DxH, 3.5m x 9.6m	t steel							6																B
		OVERHEAD CRANE 15tonne Span 26m, Run 47m	No.	1																						B
		AIR COMPRESSOR PACKAGE, ATLAS COPCO GA11-8.5 W/DESICCANT AIR DRYER & RECEIVER	No.	1																						B
		CYCLONE U/F TANK, CONCRETE TANK HxLxW, 4 m x 3.2 m x 4 m	m3	26																						B
		CYCLONE O/F TANK, CONCRETE TANK HxWxL, 5 m x 5.5 m x 6.2 m	m3	55																						B
		CYCLONE FEED TANK, CONCRETE TANK HxWxL, 8m x 7.7m x 8m	m3	140																						B
		GLAND SEAL WATER PUMP, POSITIVE DISPLACEMENT PUMP 5kW	No.							2					2	2						2				B
		FLUSH WATER PUMP, 8x10 centrifugal pump 80 kW	No.	1																						B
		GLAND SEAL WATER FILTER 28.8 m3/hr	No.							2																B
		DILUTION WATER HEAD TANK, STEEL TANK INSULATED DxH, 12.5 m x 12.5 m	t steel	53																						B
		WATER BUFFER TANK, STEEL TANK INSULATED DxH, 6.1m x 9m	t steel	12																						B
		CERAMIC ORIFICE 18" PIPE ID=0.254 m @ $20,000/PIECE	No.	10																						B
		Cyclone U/F Pump, Warman 16/14 AHP Slurry Pump 671kW	No.							2					2							2				B
		Cyclone O/F Pump Warman 650L Slurry Pump 2000kW	No.													2										B
		SAND SAMPLER PUMP, GRACO HUSKY 2150 DOUBLE DIAPHRAGM PUMP 5kW	No.	1																						B
		O/F Jacking header hydraulic piston (19t)	No.	58		29	10	6	4	10	5	4	3	3	2	3	4	2	2	2	3	3	4	3	2	1	B
		U/F Jacking header hydraulic piston (27t)	No.	58		29	10	6	4	10	5	4	3	3	2	3	4	2	2	2	3	3	4	3	2	1	B
		Mobile Hydraulic Powerpacks (6000psi) for U/F and O/F jacking headers	No.	5																						B
PIPE	3	38"-CS(STD) 6mm RL OVERLAND PIPELINE	m	120																						B
		32"-CS(STD) 6mm RL OVERLAND PIPELINE	m	120																						B
		32"-CS(10) 6mm RL	m	8																						B
		40"-CS(10) 6mm RL	m	8																						B
		36"-HDPE(DR 11) OVERLAND PIPELINE	m	2200																						B
		8"-CS(STD)		147																						B
		12"-CS(STD)	m	64																						B
		18"-HDPE(DR 17) OVERLAND PIPELINE	m	120																						B
		40"-HDPE(DR 17) OVERLAND PIPELINE	m	500																						B
		12"-CS(10)	m	40																						B
		40"-CS(10)	m	20																						B
		24"-CS(10)	m	25																						B
		36"-CS(STD)	m	35																						B
		4"-CS(STD)	m	100																						B
		8"-HDPE(DR 17)	m	50																						B
		8"-HDPE(DR 11) OVERLAND PIPELINE	m	100																						B
		14"-HDPE(DR 11) OVERLAND PIPELINE	m	120																						B
		6"-HDPE(DR 11)	m	15																						B
		12"-CS(STD) OVERLAND PIPELINE	m	50																						B
		2"-CS(STD)	m	115																						B
		1"-CS(STD)	m	40																						B
		20"-CS(STD) 6mm RL	m							8																B
		14"-CS(STD) 6mm RL	m													4						4				B
		18"-CS(10) 6mm Ceramic Lined for Slack flow section CAN $2185 per meter OVERLAND PIPELINE	m	250																						B
		38"-CS(STD) 6mm RL	m														8									B
		42"-HDPE(DR 17) OVERLAND PIPELINE	m	900																						B
		1.5"-CS(STD) Allow. for small bore piping in Cyclone Plant	m	300																						B
		18"-CS(80) OVERLAND PIPELINE	m	900																						B
		6"-CS(STD)	m	40																						B
		6"-HDPE(DR 11) OVERLAND PIPELINE	m	100																						B
		32-HDPE(DR 17) OVERLAND PIPELINE	m	200																						B
		18-HDPE(DR 17) OVERLAND PIPELINE	m	100																						B
		14-HDPE(DR 11) OVERLAND PIPELINE	m	500																						B
		12"-CS(STD) PIPELINE ON JACKING HEADER INSULATED AND HEAT TRACED	m	900			250			250			250			250			250			250			250		B
		18"-CS(80) ON JACKING HEADER	m	1290			250			250			250			250			250			250			250		B
		32"-CS(STD) ON JACKING HEADER	m	860			250			250			250			250			250			250			250		B
		16"-HDPE(DR 17) OFF JACKING HEADER	m	1700		200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	B
		14"-HDPE(DR 11) OFF JACKING HEADER	m	1700		200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	B
Valve	4	18 - #150 - Knife Gate	No.	10																						B
		32" - #150 - Knife Gate	No.	10		5		2	1	1							5						2		1	B
		16" - #150 - Knife Gate	No.	11		5		2	1	1							3						2		1	B
		6" - #150 - Butterfly	No.	9																						B
		10" - #150 - Knife Gate	No.	1													3									B
		18" - #150 - Knife Gate	No.	3		5		2	1	3							4						2		1	B
		38" - #150 - Knife Gate	No.	1													2									B
		12" - #150 - Knife Gate	No.														4									B
		12" - #151 - Knife Gate	No.	1																						B
		4" - #150 - Butterfly	No.							1																B
		4" - #150 - Ball Valve	No.							4																B
		6" - #150 - Knife Gate	No.							4																B
		8" - #150 - Knife Gate	No.	1						4																B
		20" - #150 - Knife Gate	No.	1						2																B
		6" - #150 - Control Valve	No.	4																						B
		4" - #150 - Control Valve	No.	1																						B
		8" - #150 - Butterfly	No.	7																						B
		14" - #150 - Butterfly	No.	1																						B
		12" - #150 - Butterfly	No.	4																						B
		36" - #150 - Butterfly	No.	1																						B
		1.5" - #150 - Allowance for small bore valves	No.	100																						B
		10" - #150 - Butterfly	No.	18		10		4	2	2							8						4		2	B
		14" - #150 - Pinch Valve	No.	9		5		2	1	1							4						2		1	B

TABLE 10.2
CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

FEASIBILITY DESIGN OF THE TAILINGS MANAGEMENT FACILITY
SCHEDULE OF QUANTITIES

Print Nov/1/12 8:10:25

				INSTALLATION YEAR																					REV
Item Type	Item No.	Description	Unit	-1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
Valve	4	14" - #150 - Knife Gate	No.	10		5		2	1	1							4							2		1	B
		24" - #150 - Square GateWATER WORKS TYPE	No.	1																							B
Instrument	6	26" Magnetic Flow Meter	No.	1																							B
		38" Magnetic Flow Meter	No.	1																							B
		Radar Level Meter	No.	7																							B
		18" Ultrasonic Flow Meter	No.	1																							B
		Ceramic Orifices (Included in Equipment Section)	No.	0																							B
		8" Magnetic Flow Meter	No.	1																							B
		700kW VFD FOR SAND PUMPS	No.							2						2							2				B
		2000kW VFD FOR CYCLONE O/F PUMPS	No.														2										B
		Capacitive Level Meter	No.	1																							B
		36" Magnetic Flow Meter	No.	1																							B
		38" Nuclear Density Meter	No.	2																							B
		2" Nuclear Density Meter	No.	1																							B
U/F Jacking Structure	10	Concrete Footings (59 Footings per Header) Reinforced Concrete Footing	m3	266																							B
		Pipe 300x12.7 Pipe	m	1770	2360	2080	1972	2060	2188	2268	2532						10216							11536		3586	B
		Holes in Pipe Piles Used for Raises 22 mm Diameter Holes Each Side	No.	23600	7980	2128	1064	1596	1064	3192	1064						4256							5320		2128	B
		Base Plate for Piles 500mm x 500mm x 30mm	No.	118																							B
		Anchor Bolts 25 mm diameter x 450 mm long	No.	472																							B
		Drift Pins 19 mm Headed Pin x 400 mm Long	No.	236	120	32	16	24	16	48	16						64							80		32	B
		Round Hollow Steel Section (HSS) HS355x9.5 x 450 mm long	m	106	54	14	7	11	7	22	7						29							36		14	B
		Patterned Holes 22 mm Diameter Hole in Spiral Pattern	No.	9440	4800	1280	640	960	640	1920	640						2560							3200		1280	B
		Flange 12.5 mm thick flange x 50 mm projection	No.	236	120	32	16	24	16	48	16						64							80		32	B
		3 Keeper Bolts 12.5mm Dia Bolt X 75 mm Long With Nut & 2 Washers	No.	708	360	96	48	72	48	144	48						192							240		96	B
		Keeper Ring Plate 6mm thick plate x 100mm wide Ring Plate	No.	236	120	32	16	24	16	48	16						64							64		32	B
		Square Hollow Steel Section (HSS) HS355x355x9.5 - 300mm Long	m	71	36	10	5	7	5	14	5						19							24		10	B
		Flange 12.5 mm thick flange x 100 mm projection	No.	236	120	32	16	24	16	48	16						64							80		32	B
		Upper Jacking Beam W250x67	m	118	60	16		12	8	24	8						32							40		16	B
		Lower Jacking Beam W250x67	m	118	60	16	8	12	8	24	8						32							40		16	B
		Girder W610x101	m	1740																							B
		Beam W200x19	m	943																							B
		Diagonal L130x130x9	m	1109																							B
		Steel Connections Add 15% to Member Weights For Connections	kg	39877	20573	5486	2743	4115	2743	8229	2743						10972							13715		5486	B
		Grip Strut Grating 2" plank grip strut grating	m2	1547	800	213	107	160	107	320	107						427							533		213	B
		Guardrail Painted steel - 2 rail with kickplate	m	1926	996	266	133	199	133	398	133						531							664		266	B
		Steel Channels C200x 75	m	2857	1478	394	197	296	197	591	197						788							985		394	B
		Support Columns L75X75x6	m	696	360	96	48	72	48	144	48						192							240		96	B
		Pipe Supports for Piping - Angles/Saddles Add 10% of Pipe Weight for Supports	kg	67048	15000	4000	2000	3000	2000	6000	2000						8000							10000		4000	B
		Ladders at Platforms Ladder with Folding or Sliding Bottom	m	50	22	6	6	6	6	11	6						11							17		6	B
		Jacking Frame Epoxy Paint	m2	522	270	72	36	54	36	108	36						144							180		72	B
		Framing for Walkway and Platform Epoxy Paint	m2	7540	3900	1040	520	780	520	1560	520						2080							2600		1040	B
		Pipe Piles Epoxy Paint	m2	3328																							B
		Holes in Pipe Piles Used for Raises 22 mm Diameter Holes Each Side @150 mm on center	No.		31388	27634	26218	27394	29086	30158	33654						135864							153400		46944	B
		Pipe Piles Epoxy Paint (inside and outside of pile)	m2		1692	451	226	338	226	677	226						902							1128		451	B
		Weld 12.5 mm x 940 mm long	m	111																							B
		Weld 12.5 mm x 1115 mm long	m	262	133	36	18	27	18	53	18						71							89		36	B
		Weld 12.5 mm x1420 mm long	m	335	170	45	23	34	23	68	23						91							114		45	B
		Weld to Square Collar 6 mm x500 mm long	m	118	60	16	8	12	8	24	8						32							40		16	B
		Weld Full Penetration Groove Weld All Arnd Circumference of Pipe	m		222	224	197	197	201	8	254						955							1075		306	B
		Pipe - Material Cost 300x12.7 Pipe	m		900	240	120	180	120	360	120						480							600		240	B
		Pipe - Installation Cost Install 300mm Pipe By Driving It 5 Meters Below Grade	m		300	80	40	60	40	120	40						160							200		80	B
		Girder (2 Per Bay) W610x101	m		900	240	120	180	120	360	120						480							600		240	B
		Beam (5 Per Bay) W200x19	m		488	130	65	98	65	195	65						260							325		130	B
		Diagonal (4 Per Bay) L130x130x9	m		574	153	76	115	76	229	76						306							382		153	B
		Pipe Pile Raises Epoxy Paint (inside and outside of pile)	m2		4437	3346	3647	3798	4023	4174	4625						19101							21507		6755	B
		Makeup Piles Epoxy Paint (inside and outside of pile)	m2			565	60	75	90	90	136						106							181			B
Cyclone Building	7	Allowance for HVAC, Building H=22m, L=47m, W=26m (By others)	No.	1																							B
		Allowance for Electrical Building H=22m, L=47m, W=26m (By others)	No.	1																							B
		Allowance for Lighting Building H=22m, L=47m, W=26m (By others)	No.	1																							B
		Allowance for Concrete foundation Building H=22m, L=47m, W=26m (By others)	No.	1																							B
		Allowance for Plantforms Building H=22m, L=47m, W=26m (By others)	No.	1																							B
		Allowance for Structural Steel Building H=22m, L=47m, W=26m (By others)	No.	1																							B
		Cyclone Plant Building Phase I H=22m L=34m, W=26m (By Others)	No.	1																							B
		Cyclone Plant Building Ultimate Phase 12m Expansion (By Others)	No.						1																		B
Earth Work	8	Dilution Water Head Tank Pad (Cut)	m3 cut	1938																							B
		Dilution Water Head Tank Pad (Fill)	m3 fill	2227																							B
		Dilution Water Head Tank Pad (Net)	m3 fill	290																							B
		Cyclone Feed Tank Pad (Cut)	m3 cut	2369																							B
		Cyclone Feed Tank Pad (Fill)	m3 fill	1610																							B
		Cyclone Feed Tank Pad (Net)	m3 cut	760																							B
		Cyclone Plant Pad (Cut)	m3 cut	10755																							B
		Cyclone Plant Pad (Fill)	m3 fill	9989																							B
		Cyclone Plant Pad (Net)	m3 cut	766																							B
Gravel	8	Dilution Water Head Tank Pad Gravel	m3	68																							B
		Cyclone Feed Tank Pad Gravel	m3	116																							B
		Cyclone Plant Pad Gravel	m3	3837																							B
O/F Jacking Header	11	Anchor Bolts 25 mm diameter x 450 mm long	No.	472																							B
		Drift Pins 19 mm Headed Pin x 400 mm Long	No.	236	120	32	16	24	16	48	16						64							80		32	B
		Patterned Holes 22 mm Diameter Hole in Spiral Pattern	No.	9440	4800	1280	640	960	640	1920	640						2560							3200		1280	B

TABLE 10.2
CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

FEASIBILITY DESIGN OF THE TAILINGS MANAGEMENT FACILITY
SCHEDULE OF QUANTITIES

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				INSTALLATION YEAR																					REV
Item Type	Item No.	Description	Unit	-1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	B
O/F Jacking Header	11	Flange 12.5 mm thick flange x 50 mm projection	No.	236	120	32	16	24	16	48	16						64							80		32	B
		3 Keeper Bolts 12.5mm Dia Bolt X 75 mm Long With Nut & 2 Washers	No.	708	360	96	48	72	48	144	48						192							240		96	B
		Keeper Ring Plate 6mm thick plate x 100mm wide Ring Plate	No.	236	120	32	16	24	16	48	16						64							80		32	B
		Flange 12.5 mm thick flange x 100 mm projection	No.	236	120	32	16	24	16	48	16						64							80		32	B
		Upper Jacking Beam W250x67	m	118	60		8	12	8	24	8						32							40		16	B
		Lower Jacking Beam W250x67	m	118	60	16	8	12	8	24	8						32							40		16	B
		Grip Strut Grating 2" plank grip strut grating	m2	13	6	1	1	1	1	3	1						3							4		1	B
		Guardrail Painted steel - 2 rail with kickplate	m	36	16	4	4	4	4	8	4						8							12		4	B
		Ladders at Platforms Ladder with Folding or Sliding Bottom	m	50	22	6	6	6	6	11	6						11							17		6	B
		Pipe 250x12.7 Pipe	m	1770	2360	2080	1972	2060	2188	2268	2532						10216							11536		3586	B
		Holes in Pipe Piles Used for Raises 22 mm Diameter Holes Each Side @150 mm on center	No.	23600	39368	29762	27282	28990	30150	33350	34718						140120							158720		49072	B
		Base Plate for Piles 450mmx450mmx30mm	No.	118																							B
		Pipe 300x9.3 Pipe x 450 mm long	m	106	54	14	7	11	7	22	7						29							36		14	B
		Square Hollow Steel Section (HSS) HS305x305x9.5 - 300mm Long	m	71	36	10	5	7	5	14	5						19							24		10	B
		Sliding Bearing Pad - 150 mmx 150 mm Pad has Teflon Sheet, Neoprene and 2 Stl Plates	No.	59	30	8	4	6	4	12	4						16							20		8	B
		Pipe Supports for Pipe Add 10% of Pipe Weight for Supports	kg	29000	15000	4000	2000	3000	2000	6000	2000						8000							10000		4000	B
		Steel Framing L75X75x6	m	81	36	9	9	9	9	18	9						18							27		9	B
		Jacking Frames Epoxy Paint	m2	476	255	68	34	51	34	102	34													170		68	B
		Pipe Piles Epoxy Paint (inside and outside of pile)	m2	2785	1416	378	189	283	189	566	189						755							944		378	B
		Weld to Square Collar 6 mm x500 mm long	m	118	60	16	8	12	8	24	8						32							40		16	B
		Weld Full Penetration Groove Weld All Arnd Circumference of Pipe	m				13		9	6	19						6							25			B
		Pipe Pile Raises Epoxy Paint (inside and outside of pile)	m2		3705	2795	3046	3171	3360	3485	3862						15951							17961		5630	
		Makeup Piles Epoxy Paint (inside and outside of pile)	m2			471	50	63	75	75	113						88							151			
		Weld 12.5 mm x 785 mm long	m	93																							
		Weld 12.5 mm x 960 mm long	m	227	115	31	15	23	15	46	15						61							77		31	
		Weld 12.5 mm x1200 mm long	m	283	144	38	19	29	19	58	19						77							96		38	
		Weld Full Penetration Groove Weld All Around Circumference of Pipe	m		185	140	152	159	168	174	193						798							898			
		Pipe - Material Cost 250x12.7 Pipe	m		900	240	120	180	120	360	120						480							600		240	
		Pipe - Installation Cost Install 250mm Pipe By Driving It 5 Meters Below Grade	m		300	80	40	60	40	120	40						160							200		80	

NOTE:
1. NO CONTINGENCY ADDED TO QUANTITIES

P:\3 - Projects\KPV-5277 (Casino Project Tailing Cyclone and Transport)\Costing & Enquiries\MTOs\[Casino MTOs by P&C Rev B Oct 31.xlsx]KP format

APPENDIX F – POWER CONSUMPTION

Casino Project, Tailings Cyclone and Transport Study

Power Consumption for Cylone Plant and Tailings Transport System

Sum of Annual Electrical Power (MW.h)	
Year	Total
-1	922.9 MWh
1	922.9 MWh
2	944.8 MWh
3	966.7 MWh
4	988.6 MWh
5	1,010.5 MWh
6	2,024.6 MWh
7	2,927.7 MWh
8	3,653.5 MWh
9	4,541.1 MWh
10	5,323.9 MWh
11	5,851.5 MWh
12	6,492.6 MWh
13	7,218.4 MWh
14	8,119.6 MWh
15	10,018.1 MWh
16	11,891.1 MWh
17	13,787.1 MWh
18	18,256.2 MWh
19	21,781.7 MWh
20	23,786.8 MWh
21	25,311.8 MWh
22	26,827.4 MWh

APPENDIX G – JACKING HEADER STRUCTURAL DESIGN REPORT

Casino Project
Jacking Header
Feasibility Design Study





Prepared for
Paterson Cooke
October 2012

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1. Summary Pages 1-2
2. Preliminary Load List Pages 3-5
3. Material Take Off (MTO) Pages 6-10
4. Drawings Pages 11-16
5. Sketches Pages 17-20

Casino Jacking Header
Summary

1. General

The proposed project will consist of two jacking headers that will support slurry piping for discharge onto a tailings embankment. The fines tailings header consists of a 32" (813 mm) pipe that will span between jacking frames. The sand tailings header consists of 3 pipes with a walkway platform. Each header will be approximately 870 meters long and be supported by steel piling. The project is located in the Dawson Mountains of the province of Yukon in Canada. The feasibility study analyzed start up conditions only and did not consider subsequent yearly operations.

The following present the findings of our study.

2. General Arrangement

The electrical cable tray for both headers was placed above the piping instead of below it. This will avoid possible water leakage from the piping coming in contact with the electrical conduits.

Platforms were provided to operate piping valves and egress ladders down to the embankment were provided at the sand tailings header at 100 meters on center.

3. Steel Framing

At the sand tailings header, heavy steel wide flange members were used to support the piping at the walkway platform instead of prefabricated steel trusses. While the weight of the wide flange beam will be comparable to that of a prefabricated truss, using a wide flange beam will simplify the framing and connection details.

A Teflon bearing pad is recommended to accommodate thermal movement at the fines tailing header. Because of the long length of both headers, significant thermal growth will be encountered and appropriate engineering details will need to be provided to accommodate loads and movement from thermal changes.

4. Foundation

The jacking structures will be founded initially on concrete footings located at the crest of an embankment dam. It has been reported that footings near the edge of the dam can rotate causing maintenance problems with future pipe pile raises. Providing additional compaction and careful construction observation during the installation of the footings and embankment should prevent rotation of the footings in the future.

At the startup of the header operations the pipe piles will be founded on concrete footings. As tailings are deposited the mechanism for resisting structural loads will change. Lateral loads will change from being resisted by the concrete footings to being resisted by compacted tailings.

Stronger piles may be needed initially during this transition phase until the sufficient tailings are built up around the piles. It is possible that the size of the piles can be reduced for future raises, but further analysis is required.

Preliminary Structural Load List
Casino Jacking Header

1. General

The proposed jacking structures will be required to withstand the loads listed below including anticipated jacking loads.

2. Design Loads

The following describes the structural loads considered in the preliminary design of the jacking header. These loads include the following types of loads.

1. Dead Loads
2. Live Loads
3. Snow Loads
4. Wind Loads
5. Seismic Loads
6. Jacking Loads
7. Geotechnical Information

2.1 Dead loads

Dead loads acting on the structure or a portion thereof shall consist of the weight of all permanent construction, including platforms, ladders, piping, lights and all fixed equipment.

2.2 Live Loads

Live loads shall consist of uniform surface loads or equivalent point loads developed to represent loading effects due to the movement of materials, equipment or personnel on a temporary basis. Loads will be identified as live loads when the item imposing the load is not permanent or rigidly fixed to the structure. The platform of the jacking header shall be designed for a minimum live load of 4.8 kPa (100 psf). A weight of 0.22 kN/m (15 plf) along the length of the header shall be used for electrical conduits. The weights of lights will be covered by a weight of 0.07 kN/m (5 plf) along the edge of the walkway platform at the sand tailings header.

2.3 Snow Loads

A snow load of 2.26 kPa (47 psf) will be used on the horizontal surfaces of the header for snow loads. It is our understanding that the slurry header will not be operational during the winter months. Therefore, possible ice loads from the buildup of frozen slurry were not considered.

2.4 Wind Loads

Wind loads shall be 1.78 kPa (37.2 psf) on flat areas such as steel framing members and 1.23 kPa (25.6 psf) on round areas such as the steel piling and the elevated pipes.

2.5 Seismic Loads

The following parameters shall be used in the design.

Sa (0.2 sec) = 0.544g
Sa (0.5 sec) = 0.336g
Sa (1.0 sec) = 0.168g
Sa (2.0 sec) = 0.094g
PGA = 0.250g

Soil Conditions – A stiff soil was assumed for use in the seismic design.

2.6 Jacking Loads

The slurry header will need to be raised periodically as slurry is deposited. Raises will be performed by hydraulic jacks. Jacking loads will be calculated to size jacks and structural steel members.

The jacking loads for the two headers were analyzed. During jacking it was assumed that the slurry piping was full and that there was a live load on any access platforms or walkways of 15psf. The following jacking loads were determined. The loads do not include a safety factor.

Fines Tailings Jacking Structure – 169 kN (19 tons).

Sand Tailings Jacking Structure – 269 kN (27 tons)

2.7 Geotechnical Information

The following geotechnical information was used in the feasibility study.

1. Soil will consist of hydraulic fill sand with 12% fines.
2. Net allowable bearing pressure = 143.6 kN/m^2 (3000 psf)
3. Modulus of subgrade reaction = 27.13 MN/m^3 (100 pci)

3. Materials

3.1 Structural Concrete

The minimum ultimate compressive strength of structural concrete shall be 31.0 MPa (4500 psi) at 28 days.

3.2 Reinforcement

Reinforcing steel bars shall be grade 60. All bars shall conform to the specifications for deformed billet bars for concrete reinforcement (ASTM A615).

3.3 Structural Steel

All structural steel shall be ASTM A992, Grade 50 unless otherwise specified. Structural steel pipe shall be ASTM A53, grade B.

4. Unit Weights

The following unit weights will be used.

1. Unit weight of concrete shall be assumed equal to 2403 kg/m^3 (150 lbs/ft^3) for design purposes.
2. Unit weight of water shall be assumed equal to 1000 kg/m^3 (62.4 lbs/ft^3).
3. The weight of the slurry shall be assumed to equal 1602 kg/m^3 (100 lbs/ft^3).

MATERIAL TAKE OFF (MTO)

Casino Project
Tailings Jacking Structure
Summary of Modifications Per Year

Increase in Header Length Per Year (1)

Years	Length of Header	Length of Header	Increase in Header Length			
	Calculated	Adjusted for 15 Meter Bays	Number of Added Bays	Added Length	Running Total	
			Each Bay has a Length of 15 Meters	Added Bays x 15 Meters		
Year -1	865	870			870	
Year 1	1,316	1,320	30	450	1320	
Year 2	1,434	1,440	8	120	1440	
Year 3	1,492	1,500	4	60	1500	
Year 4	1,592	1,590	6	90	1590	
Year 5	1,640	1,650	4	60	1650	
Year 6	1,816	1,830	12	180	1830	
Year 7	1,865	1,890	4	60	1890	
Year 13	2,120	2,130	16	240	2130	
Year 20	2,428	2,430	20	300	2430	
Year 22	2,542	2,550	8	120	2550	

Vertical Tailing Raises Per Year

Years	Elevation of Tailings	Raise Height
	(Meters)	(Meters)
Year -1	830	
Year 1	850	20
Year 2	863	13
Year 3	870	7
Year 4	881	11
Year 5	889	8
Year 6	902	13
Year 7	908	6
Year 13	952	44
Year 20	995	43
Year 22	1006	11

Vertical Piles Raises Per Year (2)

Years	Pile Extension on Constructed Header Structure			Makeup Pile Extension on New Added Section of Header (3)		
	Number of Bays Needing Pile Extension	Number of Piles Needing Extension	Length of Added Pile	Number of Bays Affected	Number of Piles Affected	Length of Added Pile
			(Meters Per Pile)			(Meters Per Pile)
Year -1						
Year 1	58	118	20			
Year 2	88	178	10	30	60	5
Year 3	96	194	10	8	16	2
Year 4	100	202	10	4	8	5
Year 5	106	214	10	6	12	4
Year 6	110	222	10	4	8	6
Year 7	122	246	10	12	24	3
Year 13	126	254	40	4	8	7
Year 20	142	286	40	16	32	3
Year 22	162	326	11			

Footnotes:
1. The Length of the Jacking Structures will Increase During Depostion of Tailings
2. Depostion of Tailings Will Require That Piles Be Added to The Top of the Constructed Piles to Allow For Vertical Raises of The Jacking Structure
3. As tailings are deposited, the length of the jacking structure will increase.
   The elevation of the piles in the new expanded sections will be on a different elevation than the rest of the jacking structure.
   A makeup length of pile will be required so that the top of all of the piles are on the same elevation.
   This will allow future raises for all piles to be the same.

Casino Project
Sand Tailings Jacking Structure
Material Take Off - MTO (Year -1)
(Sheet 1 of 2)

Item	Description	Number of Items	Unit Measure	Unit Measure Per Item	Total
Division 3 - Concrete					
Concrete Footings (59 Footings per Header)	Reinforced Concrete Footing	59	Cubic Meters	4.50	265.5
Division 5					
Pipe Piles (118 Piles Per Jacking Structure)					
Pipe	300x12.7 Pipe	118	Length - Meters	15.00	1770.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side	118	Number of Holes	200.00	23600.0
Base Plate for Piles	500mm x 500mm x 30mm	118	Number of Base Plates	1.00	118.0
Anchor Bolts	25 mm diameter x 450 mm long	118	Number of Anchor Bolts	4.00	472.0
Weld	12.5 mm x 940 mm long	118	Length of Weld - Meters	0.94	110.9
	(1/2" weld around perimeter of pile)				
Jacking Frame (Sheet 1) 236 Collars Per Header					
Drift Pins	19 mm Headed Pin x 400 mm Long	236	Number of Pins	1.00	236.0
Circular Collar					
Round Hollow Steel Section (HSS)	HS355x9.5 x 450 mm long	236	Length - Meters	0.45	106.2
Patterned Holes	22 mm Diameter Hole in Spiral Pattern	236	Number of Holes	40.00	9440.0
Flange	12.5 mm thick flange x 50 mm projection	236	Number of Flanges	1.00	236.0
Weld	12.5 mm x 1115 mm long	236	Length of Weld - Meters	1.11	262.0
	(1/2" weld around perimeter of pile)				
Keeper					
3 Keeper Bolts	12.5mm Dia Bolt X 75 mm Long With Nut & 2 Washers	236	Number of Bolts	3.00	708.0
Keeper Ring Plate	6mm thick plate x 100mm wide Ring Plate	236	Number of Plates	1.00	236.0
Square Collar					
Square Hollow Steel Section (HSS)	HS355x355x9.5 - 300mm Long	236	Length - Meters	0.30	70.8
Flange	12.5 mm thick flange x 100 mm projection	236	Number of Flanges	1.00	236.0
Weld	12.5 mm x1420 mm long	236	Length of Weld - Meters	1.42	335.1
	(1/2" weld around perimeter of collar)				
Upper Jacking Beam	W250x67	59	Length - Meters	2.00	118.0
Weld to Square Collar	6 mm x500 mm long	118	Length - Meters	0.50	59.0
	(1/4" weld around perimeter of beam web)				
Lower Jacking Beam	W250x67	59	Length - Meters	2.00	118.0
Weld to Square Collar	6 mm x500 mm long	118	Length - Meters	0.50	59.0
	(1/4" weld around perimeter of beam web)				

Jacking Header Consists of 58 bays. Each bay is 15 meters long

Casino Project
Sand Tailings Jacking Structure
Material Take Off - MTO (Year -1)
(Sheet 2 of 2)

Item	Description	Number of Items	Unit Measure	Unit Measure Per Item	Total
Division 5 Cont'd					
Platform Framing (Sheet 2)					
Girder	W610x101	116	Length - Meters	15.00	1740.0
Beam	W200x19	290	Length - Meters	3.25	942.5
Diagonal	L130x130x9	232	Length - Meters	4.78	1109.0
Steel Connections	Add 15% to Member Weights For Connections		15% Total Weight - kg		31765.0
Walkway Platform (Sheet 3)					
Grip Strut Grating	2" plank grip strut grating	58	Square meters	26.67	1546.9
Guardrail	Painted steel - 2 rail with kickplate	58	Length - Meters	33.20	1925.6
Steel Channels	C200x 75	58	Length - Meters	49.25	2856.5
Support Columns	L75X75x6	58	Length - Meters	12.00	696.0
Steel Connections	Add 15% to Member Weights For Connections		15% Total Weight - kg		8112.0
Misc					
Pipe Supports for Piping - Angles/Saddles	Add 10% of Pipe Weight for Supports	58	10% Total Pipe Weight - kg	1156.00	67048.0
Ladders at Platforms	Ladder with Folding or Sliding Bottom	9	Length - Meters	5.50	49.5
Division 9					
Painting					
Jacking Frame	Epoxy Paint	58	Square meters	9.00	522.0
Framing for Walkway and Platform	Epoxy Paint	58	Square meters	130.00	7540.0
Pipe Piles	Epoxy Paint	118	Square meters	28.20	3327.6

Jacking Header Consists of 58 bays. Each bay is 15 meters long

Casino Project
Fines Tailings Jacking Structure
Material Take Off - MTO (Year -1)

Item	Description	Number of Items	Unit Measure	Unit Measure Per Item	Total
Division 3 - Concrete					
Concrete Footings (59 Footings per Header)	Reinforced Concrete Footing	59	Cubic Meters	3.04	179.4
Division 5 - Metals					
Pipe Piles (118 Piles Per Jacking Structure)					
Pipe	250x12.7 Pipe	118	Length - Meters	15.00	1770.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	118	Number of Holes	200.00	23600.0
Base Plate for Piles	450mmx450mmx30mm	118	Number of Base Plates	1.00	118.0
Anchor Bolts	25 mm diameter x 450 mm long	118	Number of Anchor Bolts	4.00	472.0
Weld	12.5 mm x 785 mm long	118	Length of Weld - Meters	0.79	92.6
	(1/2" weld around perimeter of pile)				
Jacking Frame (Sheet 1) 236 Collars Per Header					
Drift Pins	19 mm Headed Pin x 400 mm Long	236	Number of Pins	1.00	236.0
Circular Collar					
Pipe	300x9.3 Pipe x 450 mm long	236	Length - Meters	0.45	106.2
Patterned Holes	22 mm Diameter Hole in Spiral Pattern	236	Number of Holes	40.00	9440.0
Flange	12.5 mm thick flange x 50 mm projection	236	Number of Flanges	1.00	236.0
Weld	12.5 mm x 960 mm long	236	Length of Weld - Meters	0.96	226.6
	(1/2" weld around perimeter of pile)				
Keeper					
3 Keeper Bolts	12.5mm Dia Bolt X 75 mm Long With Nut & 2 Washers	236	Number of Bolts	3.00	708.0
Keeper Ring Plate	6mm thick plate x 100mm wide Ring Plate	236	Number of Plates	1.00	236.0
Square Collar					
Square Hollow Steel Section (HSS)	HS305x305x9.5 - 300mm Long	236	Length - Meters	0.30	70.8
Flange	12.5 mm thick flange x 100 mm projection	236	Number of Flanges	1.00	236.0
Weld	12.5 mm x1200 mm long	236	Length of Weld - Meters	1.20	283.2
	(1/2" weld around perimeter of collar)				
Upper Jacking Beam	W250x67	59	Length - Meters	2.00	118.0
Weld to Square Collar	6 mm x500 mm long	118	Length - Meters	0.50	59.0
	(1/4" weld around perimeter of beam web)				
Lower Jacking Beam	W250x67	59	Length - Meters	2.00	118.0
Weld to Square Collar	6 mm x500 mm long	118	Length - Meters	0.50	59.0
	(1/4" weld around perimeter of beam web)				
Misc					
Sliding Bearing Pad - 150 mmx 150 mm	Pad has Teflon Sheet, Neoprene and 2 Stl Plates	59	Number of Pads	1.00	59.0
Pipe Supports for Pipe	Add 10% of Pipe Weight for Supports	58	10% Total Pipe Weight - kg	500.00	29000.0
Platform for Valves (9 Total per Header)					
Grip Strut Grating	2" plank grip strut grating	9	Square meters	1.44	13.0
Guardrail	Painted steel - 2 rail with kickplate	9	Length - Meters	4.00	36.0
Steel Framing	L75X75x6	9	Length - Meters	9.00	81.0
Ladders at Platforms	Ladder with Folding or Sliding Bottom	9	Length - Meters	5.50	49.5
Division 9					
Painting					
Jacking Frames	Epoxy Paint	56	Square meters	8.50	476.0
Pipe Piles	Epoxy Paint (inside and outside of pile)	118	Square meters	23.60	2784.8

Jacking Header Consists of 58 bays. Each bay is 15 meters long

Casino Project
Sand Tailings Jacking Structure
Material Take Off - MTO (Year 1)
(Sheet 1 of 2)

Item	Description	Number of Items	Unit Measure	Unit Measure Per Item	Total
Modification Summary for Year 1					
Length Increase of Header	**Addition of 30 Bays @ 15 Meters Per Bay = 450 Meters**				
Vertical Pile Raise	**118 Piles Raised Up by Welding New Pipes to End of Constructed Piles (2 Pile Raises of 10 Meters Each)**				
	(236 New Piles x 10 Meters Long)				
Access to Grade	**4 Ladders**				
Division 5					
Vertical Pile Raises					
Pipe	300x12.7 Pipe	236	Length - Meters	10.00	2360.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	236	Number of Holes	133.00	31388.0
Weld	Full Penetration Groove Weld All Arnd Circumference of Pipe	236	Length of Weld - Meters	0.94	221.8
Length Increase in Header					
Pipe Piles (60 Piles Per Jacking Structure)					
Pipe - Material Cost	300x12.7 Pipe	60	Length - Meters	15.00	900.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side	60	Number of Holes	133.00	7980.0
Pipe - Installation Cost	Install 300mm Pipe By Driving It 5 Meters Below Grade	60	Length - Meters	5.00	300.0
	(Pipe 5 Meters Below Grade, 10 Meters Above Grade)				
Jacking Frame (Sheet 1) 120 Collars Per Header					
Drift Pins	19 mm Headed Pin x 400 mm Long	120	Number of Pins	1.00	120.0
Circular Collar					
Round Hollow Steel Section (HSS)	HS355x9.5 x 450 mm long	120	Length - Meters	0.45	54.0
Patterned Holes	22 mm Diameter Hole in Spiral Pattern	120	Number of Holes	40.00	4800.0
Flange	12.5 mm thick flange x 50 mm projection	120	Number of Flanges	1.00	120.0
Weld	12.5 mm x 1115 mm long	120	Length of Weld - Meters	1.11	133.2
	(1/2" weld around perimeter of pile)				
Keeper					
3 Keeper Bolts	12.5mm Dia Bolt X 75 mm Long With Nut & 2 Washers	120	Number of Bolts	3.00	360.0
Keeper Ring Plate	6mm thick plate x 100mm wide Ring Plate	120	Number of Plates	1.00	120.0
Square Collar					
Square Hollow Steel Section (HSS)	HS355x355x9.5 - 300mm Long	120	Length - Meters	0.30	36.0
Flange	12.5 mm thick flange x 100 mm projection	120	Number of Flanges	1.00	120.0
Weld	12.5 mm x1420 mm long	120	Length of Weld - Meters	1.42	170.4
	(1/2" weld around perimeter of collar)				
Upper Jacking Beam	W250x67	30	Length - Meters	2.00	60.0
Weld to Square Collar	6 mm x500 mm long	60	Length - Meters	0.50	30.0
	(1/4" weld around perimeter of beam web)				
Lower Jacking Beam	W250x67	30	Length - Meters	2.00	60.0
Weld to Square Collar	6 mm x500 mm long	60	Length - Meters	0.50	30.0
	(1/4" weld around perimeter of beam web)				

Casino Project
Sand Tailings Jacking Structure
Material Take Off - MTO (Year 1)
(Sheet 2 of 2)

Item	Description	Number of Items	Unit Measure	Unit Measure Per Item	Total
Division 5 Cont'd					
Platform Framing (Sheet 2)					
Girder (2 Per Bay)	W610x101	60	Length - Meters	15.00	900.0
Beam (5 Per Bay)	W200x19	150	Length - Meters	3.25	487.5
Diagonal (4 Per Bay)	L130x130x9	120	Length - Meters	4.78	573.6
Steel Connections	Add 15% to Member Weights For Connections		15% Total Weight - kg		16389.7
Walkway Platform (Sheet 3)					
Grip Strut Grating	2" plank grip strut grating	30	Square meters	26.67	800.1
Guardrail	Painted steel - 2 rail with kickplate	30	Length - Meters	33.20	996.0
Steel Channels	C200x 75	30	Length - Meters	49.25	1477.5
Support Columns	L75X75x6	30	Length - Meters	12.00	360.0
Steel Connections	Add 15% to Member Weights For Connections		15% Total Weight - kg		4183.4
Misc					
Pipe Supports for Piping - Angles/Saddles	Add 10% of Pipe Weight for Supports	30	10% Total Pipe Weight - kg	500.00	15000.0
Ladders at Platforms	Ladder with Folding or Sliding Bottom	4	Length - Meters	5.50	22.0
Division 9					
Painting					
Jacking Frame	Epoxy Paint	30	Square meters	9.00	270.0
Framing for Walkway and Platform	Epoxy Paint	30	Square meters	130.00	3900.0
Pipe Piles	Epoxy Paint (inside and outside of pile)	60	Square meters	28.20	1692.0
Pipe Pile Raises	Epoxy Paint (inside and outside of pile)	236	Square meters	18.80	4436.8

Casino Project
Fines Tailings Jacking Structure
Material Take Off - MTO (Year 1)

Item	Description	Number of Items	Unit Measure	Unit Measure Per Item	Total
Modification Summary for Year 1					
Length Increase of Header	**Addition of 30 Bays @ 15 Meters Per Bay = 450 Meters**				
Vertical Pile Raise	**118 Piles Raised Up by Welding New Pipes to End of Constructed Piles (2 Pile Raises of 10 Meters Each)**				
	(236 New Piles x 10 Meters Long)				
Platforms	**4 Valve Platforms**				
Division 5 - Metals					
Vertical Pile Raises					
Pipe	250x12.7 Pipe	236	Length - Meters	10.00	2360.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	236	Number of Holes	133.00	31388.0
Weld	Full Penetration Groove Weld All Around Circumference of Pipe	236	Length of Weld - Meters	0.79	185.3
Length Increase in Header					
Pipe Piles (60 Piles Per Jacking Structure)					
Pipe - Material Cost	250x12.7 Pipe	60	Length - Meters	15.00	900.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	60	Number of Holes	133.00	7980.0
Pipe - Installation Cost	Install 250mm Pipe By Driving It 5 Meters Below Grade	60	Length - Meters	5.00	300.0
	(Pipe 5 Meters Below Grade, 10 Meters Above Grade)				
Jacking Frame (Sheet 1) 120 Collars Per Header					
Drift Pins	19 mm Headed Pin x 400 mm Long	120	Number of Pins	1.00	120.0
Circular Collar					
Pipe	300x9.3 Pipe x 450 mm long	120	Length - Meters	0.45	54.0
Patterned Holes	22 mm Diameter Hole in Spiral Pattern	120	Number of Holes	40.00	4800.0
Flange	12.5 mm thick flange x 50 mm projection	120	Number of Flanges	1.00	120.0
Weld	12.5 mm x 960 mm long	120	Length of Weld - Meters	0.96	115.2
	(1/2" weld around perimeter of pile)				
Keeper					
3 Keeper Bolts	12.5mm Dia Bolt X 75 mm Long With Nut & 2 Washers	120	Number of Bolts	3.00	360.0
Keeper Ring Plate	6mm thick plate x 100mm wide Ring Plate	120	Number of Plates	1.00	120.0
Square Collar					
Square Hollow Steel Section (HSS)	HS305x305x9.5 - 300mm Long	120	Length - Meters	0.30	36.0
Flange	12.5 mm thick flange x 100 mm projection	120	Number of Flanges	1.00	120.0
Weld	12.5 mm x1200 mm long	120	Length of Weld - Meters	1.20	144.0
	(1/2" weld around perimeter of collar)				
Upper Jacking Beam	W250x67	30	Length - Meters	2.00	60.0
Weld to Square Collar	6 mm x500 mm long	60	Length - Meters	0.50	30.0
	(1/4" weld around perimeter of beam web)				
Lower Jacking Beam	W250x67	30	Length - Meters	2.00	60.0
Weld to Square Collar	6 mm x500 mm long	60	Length - Meters	0.50	30.0
	(1/4" weld around perimeter of beam web)				
Misc					
Sliding Bearing Pad - 150 mmx 150 mm	Pad has Teflon Sheet, Neoprene and 2 Stl Plates	30	Number of Pads	1.00	30.0
Pipe Supports for Pipe	Add 10% of Pipe Weight for Supports	30	10% Total Pipe Weight - kg	500.00	15000.0
Platform for Valves (4 Total per Header)					
Grip Strut Grating	2" plank grip strut grating	4	Square meters	1.44	5.8
Guardrail	Painted steel - 2 rail with kickplate	4	Length - Meters	4.00	16.0
Steel Framing	L75X75x6	4	Length - Meters	9.00	36.0
Ladders at Platforms	Ladder with Folding or Sliding Bottom	4	Length - Meters	5.50	22.0
Division 9					
Painting					
Jacking Frames	Epoxy Paint	30	Square meters	8.50	255.0
Pipe Piles	Epoxy Paint (inside and outside of pile)	60	Square meters	23.60	1416.0
Pipe Pile Raises	Epoxy Paint (inside and outside of pile)	236	Square meters	15.70	3705.2

Casino Project
Sand Tailings Jacking Structure
Material Take Off - MTO (Year 2)
(Sheet 1 of 2)

Item	Description	Number of Items	Unit Measure	Unit Measure Per Item	Total
Modification Summary for Year 2					
Length Increase of Header	**Addition of 8 Bays @ 15 Meters Per Bay = 120 Meters**				
Vertical Pile Raise	**178 Piles Raised Up by Welding New Pipes to End of Constructed Piles (1 Pile Raise of 10 Meters)**				
	(178 New Piles x 10 Meters Long)				
	60 Piles x 5 Meters Makeup Piles Added				
Access to Grade	**1 Ladders**				
Division 5					
Vertical Pile Raises					
Pipe	300x12.7 Pipe	178	Length - Meters	10.00	1780.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	178	Number of Holes	133.00	23674.0
Weld	Full Penetration Groove Weld All Arnd Circumference of Pipe	178	Length of Weld - Meters	0.94	167.3
Makeup Piles					
Pipe	300x12.7 Pipe	60	Length - Meters	5.00	300.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	60	Number of Holes	66.00	3960.0
Weld	Full Penetration Groove Weld All Arnd Circumference of Pipe	60	Length of Weld - Meters	0.94	56.4
Length Increase in Header					
Pipe Piles (16 Piles Per Jacking Structure)					
Pipe - Material Cost	300x12.7 Pipe	16	Length - Meters	15.00	240.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side	16	Number of Holes	133.00	2128.0
Pipe - Installation Cost	Install 300mm Pipe By Driving It 5 Meters Below Grade	16	Length - Meters	5.00	80.0
	(Pipe 5 Meters Below Grade, 10 Meters Above Grade)				
Jacking Frame (Sheet 1) 32 Collars Per Header					
Drift Pins	19 mm Headed Pin x 400 mm Long	32	Number of Pins	1.00	32.0
Circular Collar					
Round Hollow Steel Section (HSS)	HS355x9.5 x 450 mm long	32	Length - Meters	0.45	14.4
Patterned Holes	22 mm Diameter Hole in Spiral Pattern	32	Number of Holes	40.00	1280.0
Flange	12.5 mm thick flange x 50 mm projection	32	Number of Flanges	1.00	32.0
Weld	12.5 mm x 1115 mm long	32	Length of Weld - Meters	1.11	35.5
	(1/2" weld around perimeter of pile)				
Keeper					
3 Keeper Bolts	12.5mm Dia Bolt X 75 mm Long With Nut & 2 Washers	32	Number of Bolts	3.00	96.0
Keeper Ring Plate	6mm thick plate x 100mm wide Ring Plate	32	Number of Plates	1.00	32.0
Square Collar					
Square Hollow Steel Section (HSS)	HS355x355x9.5 - 300mm Long	32	Length - Meters	0.30	9.6
Flange	12.5 mm thick flange x 100 mm projection	32	Number of Flanges	1.00	32.0
Weld	12.5 mm x1420 mm long	32	Length of Weld - Meters	1.42	45.4
	(1/2" weld around perimeter of collar)				
Upper Jacking Beam	W250x67	8	Length - Meters	2.00	16.0
Weld to Square Collar	6 mm x500 mm long	16	Length - Meters	0.50	8.0
	(1/4" weld around perimeter of beam web)				
Lower Jacking Beam	W250x67	8	Length - Meters	2.00	16.0
Weld to Square Collar	6 mm x500 mm long	16	Length - Meters	0.50	8.0
	(1/4" weld around perimeter of beam web)				

Casino Project
Sand Tailings Jacking Structure
Material Take Off - MTO (Year 2)
(Sheet 2 of 2)

Item	Description	Number of Items	Unit Measure	Unit Measure Per Item	Total
Division 5 Cont'd					
Platform Framing (Sheet 2)					
Girder (2 Per Bay)	W610x101	16	Length - Meters	15.00	240.0
Beam (5 Per Bay)	W200x19	40	Length - Meters	3.25	130.0
Diagonal (4 Per Bay)	L130x130x9	32	Length - Meters	4.78	153.0
Steel Connections	Add 15% to Member Weights For Connections		15% Total Weight - kg		4370.6
Walkway Platform (Sheet 3)					
Grip Strut Grating	2" plank grip strut grating	8	Square meters	26.67	213.4
Guardrail	Painted steel - 2 rail with kickplate	8	Length - Meters	33.20	265.6
Steel Channels	C200x 75	8	Length - Meters	49.25	394.0
Support Columns	L75X75x6	8	Length - Meters	12.00	96.0
Steel Connections	Add 15% to Member Weights For Connections		15% Total Weight - kg		1115.6
Misc					
Pipe Supports for Piping - Angles/Saddles	Add 10% of Pipe Weight for Supports	8	10% Total Pipe Weight - kg	500.00	4000.0
Ladders at Platforms	Ladder with Folding or Sliding Bottom	1	Length - Meters	5.50	5.5
Division 9					
Painting					
Jacking Frame	Epoxy Paint	8	Square meters	9.00	72.0
Framing for Walkway and Platform	Epoxy Paint	8	Square meters	130.00	1040.0
Pipe Piles	Epoxy Paint (inside and outside of pile)	16	Square meters	28.20	451.2
Pipe Pile Raises	Epoxy Paint (inside and outside of pile)	178	Square meters	18.80	3346.4
Makeup Piles	Epoxy Paint (inside and outside of pile)	60	Square meters	9.42	565.2

Casino Project
Fines Tailings Jacking Structure
Material Take Off - MTO (Year 2)

Item	Description	Number of Items	Unit Measure	Unit Measure Per Item	Total
Modification Summary for Year 2					
Length Increase of Header	**Addition of 8 Bays @ 15 Meters Per Bay = 120 Meters**				
Vertical Pile Raise	**178 Piles Raised Up by Welding New Pipes to End of Constructed Piles (1 Pile Raise of 10 Meters Each)**				
	(178 New Piles x 10 Meters Long)				
	60 Piles x 5 Meters Makeup Piles Added				
Platforms	**1 Valve Platforms**				
Division 5 - Metals					
Vertical Pile Raises					
Pipe	250x12.7 Pipe	178	Length - Meters	10.00	1780.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	178	Number of Holes	133.00	23674.0
Weld	Full Penetration Groove Weld All Around Circumference of Pipe	178	Length of Weld - Meters	0.79	139.7
Makeup Piles					
Pipe	250x12.7 Pipe	60	Length - Meters	5.00	300.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	60	Number of Holes	66.00	3960.0
Weld	Full Penetration Groove Weld All Arnd Circumference of Pipe	60	Length of Weld - Meters	0.79	47.4
Length Increase in Header					
Pipe Piles (16 Piles Per Jacking Structure)					
Pipe - Material Cost	250x12.7 Pipe	16	Length - Meters	15.00	240.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	16	Number of Holes	133.00	2128.0
Pipe - Installation Cost	Install 250mm Pipe By Driving It 5 Meters Below Grade	16	Length - Meters	5.00	80.0
	(Pipe 5 Meters Below Grade, 10 Meters Above Grade)				
Jacking Frame (Sheet 1) 32 Collars Per Header					
Drift Pins	19 mm Headed Pin x 400 mm Long	32	Number of Pins	1.00	32.0
Circular Collar					
Pipe	300x9.3 Pipe x 450 mm long	32	Length - Meters	0.45	14.4
Patterned Holes	22 mm Diameter Hole in Spiral Pattern	32	Number of Holes	40.00	1280.0
Flange	12.5 mm thick flange x 50 mm projection	32	Number of Flanges	1.00	32.0
Weld	12.5 mm x 960 mm long	32	Length of Weld - Meters	0.96	30.7
	(1/2" weld around perimeter of pile)				
Keeper					
3 Keeper Bolts	12.5mm Dia Bolt X 75 mm Long With Nut & 2 Washers	32	Number of Bolts	3.00	96.0
Keeper Ring Plate	6mm thick plate x 100mm wide Ring Plate	32	Number of Plates	1.00	32.0
Square Collar					
Square Hollow Steel Section (HSS)	HS305x305x9.5 - 300mm Long	32	Length - Meters	0.30	9.6
Flange	12.5 mm thick flange x 100 mm projection	32	Number of Flanges	1.00	32.0
Weld	12.5 mm x1200 mm long	32	Length of Weld - Meters	1.20	38.4
	(1/2" weld around perimeter of collar)				
Upper Jacking Beam	W250x67	8	Length - Meters	2.00	16.0
Weld to Square Collar	6 mm x500 mm long	16	Length - Meters	0.50	8.0
	(1/4" weld around perimeter of beam web)				
Lower Jacking Beam	W250x67	8	Length - Meters	2.00	16.0
Weld to Square Collar	6 mm x500 mm long	16	Length - Meters	0.50	8.0
	(1/4" weld around perimeter of beam web)				
Misc					
Sliding Bearing Pad - 150 mmx 150 mm	Pad has Teflon Sheet, Neoprene and 2 Stl Plates	8	Number of Pads	1.00	8.0
Pipe Supports for Pipe	Add 10% of Pipe Weight for Supports	8	10% Total Pipe Weight - kg	500.00	4000.0
Platform for Valves (1 Total per Header)					
Grip Strut Grating	2" plank grip strut grating	1	Square meters	1.44	1.4
Guardrail	Painted steel - 2 rail with kickplate	1	Length - Meters	4.00	4.0
Steel Framing	L75X75x6	1	Length - Meters	9.00	9.0
Ladders at Platforms	Ladder with Folding or Sliding Bottom	1	Length - Meters	5.50	5.5
Division 9					
Painting					
Jacking Frames	Epoxy Paint	8	Square meters	8.50	68.0
Pipe Piles	Epoxy Paint (inside and outside of pile)	16	Square meters	23.60	377.6
Pipe Pile Raises	Epoxy Paint (inside and outside of pile)	178	Square meters	15.70	2794.6
Makeup Piles	Epoxy Paint (inside and outside of pile)	60	Square meters	7.85	471.0

Casino Project
Sand Tailings Jacking Structure
Material Take Off - MTO (Year 3)
(Sheet 1 of 2)

Item	Description	Number of Items	Unit Measure	Unit Measure Per Item	Total
Modification Summary for Year 3					
Length Increase of Header	**Addition of 4 Bays @ 15 Meters Per Bay = 60 Meters**				
Vertical Pile Raise	**194 Piles Raised Up by Welding New Pipes to End of Constructed Piles (1 Pile Raise of 10 Meters)**				
	(194 New Piles x 10 Meters Long)				
	16 Piles x 2 Meters Makeup Piles Added				
Access to Grade	**1 Ladders**				
Division 5					
Vertical Pile Raises					
Pipe	300x12.7 Pipe	194	Length - Meters	10.00	1940.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	194	Number of Holes	133.00	25802.0
Weld	Full Penetration Groove Weld All Arnd Circumference of Pipe	194	Length of Weld - Meters	0.94	182.4
Makeup Piles					
Pipe	300x12.7 Pipe	16	Length - Meters	2.00	32.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	16	Number of Holes	26.00	416.0
Weld	Full Penetration Groove Weld All Arnd Circumference of Pipe	16	Length of Weld - Meters	0.94	15.0
Length Increase in Header					
Pipe Piles (8 Piles Per Jacking Structure)					
Pipe - Material Cost	300x12.7 Pipe	8	Length - Meters	15.00	120.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side	8	Number of Holes	133.00	1064.0
Pipe - Installation Cost	Install 300mm Pipe By Driving It 5 Meters Below Grade	8	Length - Meters	5.00	40.0
	(Pipe 5 Meters Below Grade, 10 Meters Above Grade)				
Jacking Frame (Sheet 1) 16 Collars Per Header					
Drift Pins	19 mm Headed Pin x 400 mm Long	16	Number of Pins	1.00	16.0
Circular Collar					
Round Hollow Steel Section (HSS)	HS355x9.5 x 450 mm long	16	Length - Meters	0.45	7.2
Patterned Holes	22 mm Diameter Hole in Spiral Pattern	16	Number of Holes	40.00	640.0
Flange	12.5 mm thick flange x 50 mm projection	16	Number of Flanges	1.00	16.0
Weld	12.5 mm x 1115 mm long	16	Length of Weld - Meters	1.11	17.8
	(1/2" weld around perimeter of pile)				
Keeper					
3 Keeper Bolts	12.5mm Dia Bolt X 75 mm Long With Nut & 2 Washers	16	Number of Bolts	3.00	48.0
Keeper Ring Plate	6mm thick plate x 100mm wide Ring Plate	16	Number of Plates	1.00	16.0
Square Collar					
Square Hollow Steel Section (HSS)	HS355x355x9.5 - 300mm Long	16	Length - Meters	0.30	4.8
Flange	12.5 mm thick flange x 100 mm projection	16	Number of Flanges	1.00	16.0
Weld	12.5 mm x1420 mm long	16	Length of Weld - Meters	1.42	22.7
	(1/2" weld around perimeter of collar)				
Upper Jacking Beam	W250x67	4	Length - Meters	2.00	8.0
Weld to Square Collar	6 mm x500 mm long	8	Length - Meters	0.50	4.0
	(1/4" weld around perimeter of beam web)				
Lower Jacking Beam	W250x67	4	Length - Meters	2.00	8.0
Weld to Square Collar	6 mm x500 mm long	8	Length - Meters	0.50	4.0
	(1/4" weld around perimeter of beam web)				

Casino Project
Sand Tailings Jacking Structure
Material Take Off - MTO (Year 3)
(Sheet 2 of 2)

Item	Description	Number of Items	Unit Measure	Unit Measure Per Item	Total
Division 5 Cont'd					
Platform Framing (Sheet 2)					
Girder (2 Per Bay)	W610x101	8	Length - Meters	15.00	120.0
Beam (5 Per Bay)	W200x19	20	Length - Meters	3.25	65.0
Diagonal (4 Per Bay)	L130x130x9	16	Length - Meters	4.78	76.5
Steel Connections	Add 15% to Member Weights For Connections		15% Total Weight - kg		2185.3
Walkway Platform (Sheet 3)					
Grip Strut Grating	2" plank grip strut grating	4	Square meters	26.67	106.7
Guardrail	Painted steel - 2 rail with kickplate	4	Length - Meters	33.20	132.8
Steel Channels	C200x 75	4	Length - Meters	49.25	197.0
Support Columns	L75X75x6	4	Length - Meters	12.00	48.0
Steel Connections	Add 15% to Member Weights For Connections		15% Total Weight - kg		557.8
Misc					
Pipe Supports for Piping - Angles/Saddles	Add 10% of Pipe Weight for Supports	4	10% Total Pipe Weight - kg	500.00	2000.0
Ladders at Platforms	Ladder with Folding or Sliding Bottom	1	Length - Meters	5.50	5.5
Division 9					
Painting					
Jacking Frame	Epoxy Paint	4	Square meters	9.00	36.0
Framing for Walkway and Platform	Epoxy Paint	4	Square meters	130.00	520.0
Pipe Piles	Epoxy Paint (inside and outside of pile)	8	Square meters	28.20	225.6
Pipe Pile Raises	Epoxy Paint (inside and outside of pile)	194	Square meters	18.80	3647.2
Makeup Piles	Epoxy Paint (inside and outside of pile)	16	Square meters	3.77	60.3

Casino Project
Fines Tailings Jacking Structure
Material Take Off - MTO (Year 3)

Item	Description	Number of Items	Unit Measure	Unit Measure Per Item	Total
Modification Summary for Year 3					
Length Increase of Header	**Addition of 4 Bays @ 15 Meters Per Bay = 60 Meters**				
Vertical Pile Raise	**194 Piles Raised Up by Welding New Pipes to End of Constructed Piles (1 Pile Raise of 10 Meters)**				
	(194 New Piles x 10 Meters Long)				
	16 Piles x 2 Meters Makeup Piles Added				
Platforms	**1 Valve Platforms**				
Division 5 - Metals					
Vertical Pile Raises					
Pipe	250x12.7 Pipe	194	Length - Meters	10.00	1940.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	194	Number of Holes	133.00	25802.0
Weld	Full Penetration Groove Weld All Around Circumference of Pipe	194	Length of Weld - Meters	0.79	152.3
Makeup Piles					
Pipe	250x12.7 Pipe	16	Length - Meters	2.00	32.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	16	Number of Holes	26.00	416.0
Weld	Full Penetration Groove Weld All Arnd Circumference of Pipe	16	Length of Weld - Meters	0.79	12.6
Length Increase in Header					
Pipe Piles (8 Piles Per Jacking Structure)					
Pipe - Material Cost	250x12.7 Pipe	8	Length - Meters	15.00	120.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	8	Number of Holes	133.00	1064.0
Pipe - Installation Cost	Install 250mm Pipe By Driving It 5 Meters Below Grade	8	Length - Meters	5.00	40.0
	(Pipe 5 Meters Below Grade, 10 Meters Above Grade)				
Jacking Frame (Sheet 1) 16 Collars Per Header					
Drift Pins	19 mm Headed Pin x 400 mm Long	16	Number of Pins	1.00	16.0
Circular Collar					
Pipe	300x9.3 Pipe x 450 mm long	16	Length - Meters	0.45	7.2
Patterned Holes	22 mm Diameter Hole in Spiral Pattern	16	Number of Holes	40.00	640.0
Flange	12.5 mm thick flange x 50 mm projection	16	Number of Flanges	1.00	16.0
Weld	12.5 mm x 960 mm long	16	Length of Weld - Meters	0.96	15.4
	(1/2" weld around perimeter of pile)				
Keeper					
3 Keeper Bolts	12.5mm Dia Bolt X 75 mm Long With Nut & 2 Washers	16	Number of Bolts	3.00	48.0
Keeper Ring Plate	6mm thick plate x 100mm wide Ring Plate	16	Number of Plates	1.00	16.0
Square Collar					
Square Hollow Steel Section (HSS)	HS305x305x9.5 - 300mm Long	16	Length - Meters	0.30	4.8
Flange	12.5 mm thick flange x 100 mm projection	16	Number of Flanges	1.00	16.0
Weld	12.5 mm x1200 mm long	16	Length of Weld - Meters	1.20	19.2
	(1/2" weld around perimeter of collar)				
Upper Jacking Beam	W250x67	4	Length - Meters	2.00	8.0
Weld to Square Collar	6 mm x500 mm long	8	Length - Meters	0.50	4.0
	(1/4" weld around perimeter of beam web)				
Lower Jacking Beam	W250x67	4	Length - Meters	2.00	8.0
Weld to Square Collar	6 mm x500 mm long	8	Length - Meters	0.50	4.0
	(1/4" weld around perimeter of beam web)				
Misc					
Sliding Bearing Pad - 150 mmx 150 mm	Pad has Teflon Sheet, Neoprene and 2 Stl Plates	4	Number of Pads	1.00	4.0
Pipe Supports for Pipe	Add 10% of Pipe Weight for Supports	4	10% Total Pipe Weight - kg	500.00	2000.0
Platform for Valves (1 Total per Header)					
Grip Strut Grating	2" plank grip strut grating	1	Square meters	1.44	1.4
Guardrail	Painted steel - 2 rail with kickplate	1	Length - Meters	4.00	4.0
Steel Framing	L75X75x6	1	Length - Meters	9.00	9.0
Ladders at Platforms	Ladder with Folding or Sliding Bottom	1	Length - Meters	5.50	5.5
Division 9					
Painting					
Jacking Frames	Epoxy Paint	4	Square meters	8.50	34.0
Pipe Piles	Epoxy Paint (inside and outside of pile)	8	Square meters	23.60	188.8
Pipe Pile Raises	Epoxy Paint (inside and outside of pile)	194	Square meters	15.70	3045.8
Makeup Piles	Epoxy Paint (inside and outside of pile)	16	Square meters	3.14	50.2

Casino Project
Sand Tailings Jacking Structure
Material Take Off - MTO (Year 4)
(Sheet 1 of 2)

Item	Description	Number of Items	Unit Measure	Unit Measure Per Item	Total
Modification Summary for Year 4					
Length Increase of Header	**Addition of 6 Bays @ 15 Meters Per Bay = 90 Meters**				
Vertical Pile Raise	**202 Piles Raised Up by Welding New Pipes to End of Constructed Piles (1 Pile Raise of 10 Meters)**				
	(202 New Piles x 10 Meters Long)				
	8 Piles x 5 Meters Makeup Piles Added				
Access to Grade	**1 Ladders**				
Division 5					
Vertical Pile Raises					
Pipe	300x12.7 Pipe	202	Length - Meters	10.00	2020.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	202	Number of Holes	133.00	26866.0
Weld	Full Penetration Groove Weld All Arnd Circumference of Pipe	202	Length of Weld - Meters	0.94	189.9
Makeup Piles					
Pipe	300x12.7 Pipe	8	Length - Meters	5.00	40.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	8	Number of Holes	66.00	528.0
Weld	Full Penetration Groove Weld All Arnd Circumference of Pipe	8	Length of Weld - Meters	0.94	7.5
Length Increase in Header					
Pipe Piles (12 Piles Per Jacking Structure)					
Pipe - Material Cost	300x12.7 Pipe	12	Length - Meters	15.00	180.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side	12	Number of Holes	133.00	1596.0
Pipe - Installation Cost	Install 300mm Pipe By Driving It 5 Meters Below Grade	12	Length - Meters	5.00	60.0
	(Pipe 5 Meters Below Grade, 10 Meters Above Grade)				
Jacking Frame (Sheet 1) 24 Collars Per Header					
Drift Pins	19 mm Headed Pin x 400 mm Long	24	Number of Pins	1.00	24.0
Circular Collar					
Round Hollow Steel Section (HSS)	HS355x9.5 x 450 mm long	24	Length - Meters	0.45	10.8
Patterned Holes	22 mm Diameter Hole in Spiral Pattern	24	Number of Holes	40.00	960.0
Flange	12.5 mm thick flange x 50 mm projection	24	Number of Flanges	1.00	24.0
Weld	12.5 mm x 1115 mm long	24	Length of Weld - Meters	1.11	26.6
	(1/2" weld around perimeter of pile)				
Keeper					
3 Keeper Bolts	12.5mm Dia Bolt X 75 mm Long With Nut & 2 Washers	24	Number of Bolts	3.00	72.0
Keeper Ring Plate	6mm thick plate x 100mm wide Ring Plate	24	Number of Plates	1.00	24.0
Square Collar					
Square Hollow Steel Section (HSS)	HS355x355x9.5 - 300mm Long	24	Length - Meters	0.30	7.2
Flange	12.5 mm thick flange x 100 mm projection	24	Number of Flanges	1.00	24.0
Weld	12.5 mm x1420 mm long	24	Length of Weld - Meters	1.42	34.1
	(1/2" weld around perimeter of collar)				
Upper Jacking Beam	W250x67	6	Length - Meters	2.00	12.0
Weld to Square Collar	6 mm x500 mm long	12	Length - Meters	0.50	6.0
	(1/4" weld around perimeter of beam web)				
Lower Jacking Beam	W250x67	6	Length - Meters	2.00	12.0
Weld to Square Collar	6 mm x500 mm long	12	Length - Meters	0.50	6.0
	(1/4" weld around perimeter of beam web)				

Casino Project
Sand Tailings Jacking Structure
Material Take Off - MTO (Year 4)
(Sheet 2 of 2)

Item	Description	Number of Items	Unit Measure	Unit Measure Per Item	Total
Division 5 Cont'd					
Platform Framing (Sheet 2)					
Girder (2 Per Bay)	W610x101	12	Length - Meters	15.00	180.0
Beam (5 Per Bay)	W200x19	30	Length - Meters	3.25	97.5
Diagonal (4 Per Bay)	L130x130x9	24	Length - Meters	4.78	114.7
Steel Connections	Add 15% to Member Weights For Connections		15% Total Weight - kg		3277.9
Walkway Platform (Sheet 3)					
Grip Strut Grating	2" plank grip strut grating	6	Square meters	26.67	160.0
Guardrail	Painted steel - 2 rail with kickplate	6	Length - Meters	33.20	199.2
Steel Channels	C200x 75	6	Length - Meters	49.25	295.5
Support Columns	L75X75x6	6	Length - Meters	12.00	72.0
Steel Connections	Add 15% to Member Weights For Connections		15% Total Weight - kg		836.7
Misc					
Pipe Supports for Piping - Angles/Saddles	Add 10% of Pipe Weight for Supports	6	10% Total Pipe Weight - kg	500.00	3000.0
Ladders at Platforms	Ladder with Folding or Sliding Bottom	1	Length - Meters	5.50	5.5
Division 9					
Painting					
Jacking Frame	Epoxy Paint	6	Square meters	9.00	54.0
Framing for Walkway and Platform	Epoxy Paint	6	Square meters	130.00	780.0
Pipe Piles	Epoxy Paint (inside and outside of pile)	12	Square meters	28.20	338.4
Pipe Pile Raises	Epoxy Paint (inside and outside of pile)	202	Square meters	18.80	3797.6
Makeup Piles	Epoxy Paint (inside and outside of pile)	8	Square meters	9.42	75.4

Casino Project
Fines Tailings Jacking Structure
Material Take Off - MTO (Year 4)

Item	Description	Number of Items	Unit Measure	Unit Measure Per Item	Total
Modification Summary for Year 4					
Length Increase of Header	**Addition of 6 Bays @ 15 Meters Per Bay = 90 Meters**				
Vertical Pile Raise	**202 Piles Raised Up by Welding New Pipes to End of Constructed Piles (1 Pile Raise of 10 Meters)**				
	(202 New Piles x 10 Meters Long)				
	8 Piles x 5 Meters Makeup Piles Added				
Platforms	**1 Valve Platforms**				
Division 5 - Metals					
Vertical Pile Raises					
Pipe	250x12.7 Pipe	202	Length - Meters	10.00	2020.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	202	Number of Holes	133.00	26866.0
Weld	Full Penetration Groove Weld All Around Circumference of Pipe	202	Length of Weld - Meters	0.79	158.6
Makeup Piles					
Pipe	250x12.7 Pipe	8	Length - Meters	5.00	40.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	8	Number of Holes	66.00	528.0
Weld	Full Penetration Groove Weld All Arnd Circumference of Pipe	8	Length of Weld - Meters	0.79	6.3
Length Increase in Header					
Pipe Piles (12 Piles Per Jacking Structure)					
Pipe - Material Cost	250x12.7 Pipe	12	Length - Meters	15.00	180.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	12	Number of Holes	133.00	1596.0
Pipe - Installation Cost	Install 250mm Pipe By Driving It 5 Meters Below Grade	12	Length - Meters	5.00	60.0
	(Pipe 5 Meters Below Grade, 10 Meters Above Grade)				
Jacking Frame (Sheet 1) 24 Collars Per Header					
Drift Pins	19 mm Headed Pin x 400 mm Long	24	Number of Pins	1.00	24.0
Circular Collar					
Pipe	300x9.3 Pipe x 450 mm long	24	Length - Meters	0.45	10.8
Patterned Holes	22 mm Diameter Hole in Spiral Pattern	24	Number of Holes	40.00	960.0
Flange	12.5 mm thick flange x 50 mm projection	24	Number of Flanges	1.00	24.0
Weld	12.5 mm x 960 mm long	24	Length of Weld - Meters	0.96	23.0
	(1/2" weld around perimeter of pile)				
Keeper					
3 Keeper Bolts	12.5mm Dia Bolt X 75 mm Long With Nut & 2 Washers	24	Number of Bolts	3.00	72.0
Keeper Ring Plate	6mm thick plate x 100mm wide Ring Plate	24	Number of Plates	1.00	24.0
Square Collar					
Square Hollow Steel Section (HSS)	HS305x305x9.5 - 300mm Long	24	Length - Meters	0.30	7.2
Flange	12.5 mm thick flange x 100 mm projection	24	Number of Flanges	1.00	24.0
Weld	12.5 mm x1200 mm long	24	Length of Weld - Meters	1.20	28.8
	(1/2" weld around perimeter of collar)				
Upper Jacking Beam	W250x67	6	Length - Meters	2.00	12.0
Weld to Square Collar	6 mm x500 mm long	12	Length - Meters	0.50	6.0
	(1/4" weld around perimeter of beam web)				
Lower Jacking Beam	W250x67	6	Length - Meters	2.00	12.0
Weld to Square Collar	6 mm x500 mm long	12	Length - Meters	0.50	6.0
	(1/4" weld around perimeter of beam web)				
Misc					
Sliding Bearing Pad - 150 mmx 150 mm	Pad has Teflon Sheet, Neoprene and 2 Stl Plates	6	Number of Pads	1.00	6.0
Pipe Supports for Pipe	Add 10% of Pipe Weight for Supports	6	10% Total Pipe Weight - kg	500.00	3000.0
Platform for Valves (1 Total per Header)					
Grip Strut Grating	2" plank grip strut grating	1	Square meters	1.44	1.4
Guardrail	Painted steel - 2 rail with kickplate	1	Length - Meters	4.00	4.0
Steel Framing	L75X75x6	1	Length - Meters	9.00	9.0
Ladders at Platforms	Ladder with Folding or Sliding Bottom	1	Length - Meters	5.50	5.5
Division 9					
Painting					
Jacking Frames	Epoxy Paint	6	Square meters	8.50	51.0
Pipe Piles	Epoxy Paint (inside and outside of pile)	12	Square meters	23.60	283.2
Pipe Pile Raises	Epoxy Paint (inside and outside of pile)	202	Square meters	15.70	3171.4
Makeup Piles	Epoxy Paint (inside and outside of pile)	8	Square meters	7.85	62.8

Casino Project
Sand Tailings Jacking Structure
Material Take Off - MTO (Year 5)
(Sheet 1 of 2)

Item	Description	Number of Items	Unit Measure	Unit Measure Per Item	Total
Modification Summary for Year 5					
Length Increase of Header	**Addition of 4 Bays @ 15 Meters Per Bay = 60 Meters**				
Vertical Pile Raise	**214 Piles Raised Up by Welding New Pipes to End of Constructed Piles (1 Pile Raise of 10 Meters)**				
	(214 New Piles x 10 Meters Long)				
	12 Piles x 4 Meters Makeup Piles Added				
Access to Grade	**1 Ladders**				
Division 5					
Vertical Pile Raises					
Pipe	300x12.7 Pipe	214	Length - Meters	10.00	2140.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	214	Number of Holes	133.00	28462.0
Weld	Full Penetration Groove Weld All Arnd Circumference of Pipe	214	Length of Weld - Meters	0.94	201.2
Makeup Piles					
Pipe	300x12.7 Pipe	12	Length - Meters	4.00	48.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	12	Number of Holes	52.00	624.0
Weld	Full Penetration Groove Weld All Arnd Circumference of Pipe	12	Length of Weld - Meters	0.94	11.3
Length Increase in Header					
Pipe Piles (8 Piles Per Jacking Structure)					
Pipe - Material Cost	300x12.7 Pipe	8	Length - Meters	15.00	120.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side	8	Number of Holes	133.00	1064.0
Pipe - Installation Cost	Install 300mm Pipe By Driving It 5 Meters Below Grade	8	Length - Meters	5.00	40.0
	(Pipe 5 Meters Below Grade, 10 Meters Above Grade)				
Jacking Frame (Sheet 1) 16 Collars Per Header					
Drift Pins	19 mm Headed Pin x 400 mm Long	16	Number of Pins	1.00	16.0
Circular Collar					
Round Hollow Steel Section (HSS)	HS355x9.5 x 450 mm long	16	Length - Meters	0.45	7.2
Patterned Holes	22 mm Diameter Hole in Spiral Pattern	16	Number of Holes	40.00	640.0
Flange	12.5 mm thick flange x 50 mm projection	16	Number of Flanges	1.00	16.0
Weld	12.5 mm x 1115 mm long	16	Length of Weld - Meters	1.11	17.8
	(1/2" weld around perimeter of pile)				
Keeper					
3 Keeper Bolts	12.5mm Dia Bolt X 75 mm Long With Nut & 2 Washers	16	Number of Bolts	3.00	48.0
Keeper Ring Plate	6mm thick plate x 100mm wide Ring Plate	16	Number of Plates	1.00	16.0
Square Collar					
Square Hollow Steel Section (HSS)	HS355x355x9.5 - 300mm Long	16	Length - Meters	0.30	4.8
Flange	12.5 mm thick flange x 100 mm projection	16	Number of Flanges	1.00	16.0
Weld	12.5 mm x1420 mm long	16	Length of Weld - Meters	1.42	22.7
	(1/2" weld around perimeter of collar)				
Upper Jacking Beam	W250x67	4	Length - Meters	2.00	8.0
Weld to Square Collar	6 mm x500 mm long	8	Length - Meters	0.50	4.0
	(1/4" weld around perimeter of beam web)				
Lower Jacking Beam	W250x67	4	Length - Meters	2.00	8.0
Weld to Square Collar	6 mm x500 mm long	8	Length - Meters	0.50	4.0
	(1/4" weld around perimeter of beam web)				

Casino Project
Sand Tailings Jacking Structure
Material Take Off - MTO (Year 5)
(Sheet 2 of 2)

Item	Description	Number of Items	Unit Measure	Unit Measure Per Item	Total
Division 5 Cont'd					
Platform Framing (Sheet 2)					
Girder (2 Per Bay)	W610x101	8	Length - Meters	15.00	120.0
Beam (5 Per Bay)	W200x19	20	Length - Meters	3.25	65.0
Diagonal (4 Per Bay)	L130x130x9	16	Length - Meters	4.78	76.5
Steel Connections	Add 15% to Member Weights For Connections		15% Total Weight - kg		2185.3
Walkway Platform (Sheet 3)					
Grip Strut Grating	2" plank grip strut grating	4	Square meters	26.67	106.7
Guardrail	Painted steel - 2 rail with kickplate	4	Length - Meters	33.20	132.8
Steel Channels	C200x 75	4	Length - Meters	49.25	197.0
Support Columns	L75X75x6	4	Length - Meters	12.00	48.0
Steel Connections	Add 15% to Member Weights For Connections		15% Total Weight - kg		557.8
Misc					
Pipe Supports for Piping - Angles/Saddles	Add 10% of Pipe Weight for Supports	4	10% Total Pipe Weight - kg	500.00	2000.0
Ladders at Platforms	Ladder with Folding or Sliding Bottom	1	Length - Meters	5.50	5.5
Division 9					
Painting					
Jacking Frame	Epoxy Paint	4	Square meters	9.00	36.0
Framing for Walkway and Platform	Epoxy Paint	4	Square meters	130.00	520.0
Pipe Piles	Epoxy Paint (inside and outside of pile)	8	Square meters	28.20	225.6
Pipe Pile Raises	Epoxy Paint (inside and outside of pile)	214	Square meters	18.80	4023.2
Makeup Piles	Epoxy Paint (inside and outside of pile)	12	Square meters	7.54	90.5

Casino Project
Fines Tailings Jacking Structure
Material Take Off - MTO (Year 5)

Item	Description	Number of Items	Unit Measure	Unit Measure Per Item	Total
Modification Summary for Year 5					
Length Increase of Header	**Addition of 4 Bays @ 15 Meters Per Bay = 60 Meters**				
Vertical Pile Raise	**214 Piles Raised Up by Welding New Pipes to End of Constructed Piles (1 Pile Raise of 10 Meters)**				
	(214 New Piles x 10 Meters Long)				
	12 Piles x 4 Meters Makeup Piles Added				
Platforms	**1 Valve Platforms**				
Division 5 - Metals					
Vertical Pile Raises					
Pipe	250x12.7 Pipe	214	Length - Meters	10.00	2140.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	214	Number of Holes	133.00	28462.0
Weld	Full Penetration Groove Weld All Around Circumference of Pipe	214	Length of Weld - Meters	0.79	168.0
Makeup Piles					
Pipe	250x12.7 Pipe	12	Length - Meters	4.00	48.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	12	Number of Holes	52.00	624.0
Weld	Full Penetration Groove Weld All Arnd Circumference of Pipe	12	Length of Weld - Meters	0.79	9.5
Length Increase in Header					
Pipe Piles (8 Piles Per Jacking Structure)					
Pipe - Material Cost	250x12.7 Pipe	8	Length - Meters	15.00	120.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	8	Number of Holes	133.00	1064.0
Pipe - Installation Cost	Install 250mm Pipe By Driving It 5 Meters Below Grade	8	Length - Meters	5.00	40.0
	(Pipe 5 Meters Below Grade, 10 Meters Above Grade)				
Jacking Frame (Sheet 1)16 Collars Per Header					
Drift Pins	19 mm Headed Pin x 400 mm Long	16	Number of Pins	1.00	16.0
Circular Collar					
Pipe	300x9.3 Pipe x 450 mm long	16	Length - Meters	0.45	7.2
Patterned Holes	22 mm Diameter Hole in Spiral Pattern	16	Number of Holes	40.00	640.0
Flange	12.5 mm thick flange x 50 mm projection	16	Number of Flanges	1.00	16.0
Weld	12.5 mm x 960 mm long	16	Length of Weld - Meters	0.96	15.4
	(1/2" weld around perimeter of pile)				
Keeper					
3 Keeper Bolts	12.5mm Dia Bolt X 75 mm Long With Nut & 2 Washers	16	Number of Bolts	3.00	48.0
Keeper Ring Plate	6mm thick plate x 100mm wide Ring Plate	16	Number of Plates	1.00	16.0
Square Collar					
Square Hollow Steel Section (HSS)	HS305x305x9.5 - 300mm Long	16	Length - Meters	0.30	4.8
Flange	12.5 mm thick flange x 100 mm projection	16	Number of Flanges	1.00	16.0
Weld	12.5 mm x1200 mm long	16	Length of Weld - Meters	1.20	19.2
	(1/2" weld around perimeter of collar)				
Upper Jacking Beam	W250x67	4	Length - Meters	2.00	8.0
Weld to Square Collar	6 mm x500 mm long	8	Length - Meters	0.50	4.0
	(1/4" weld around perimeter of beam web)				
Lower Jacking Beam	W250x67	4	Length - Meters	2.00	8.0
Weld to Square Collar	6 mm x500 mm long	8	Length - Meters	0.50	4.0
	(1/4" weld around perimeter of beam web)				
Misc					
Sliding Bearing Pad - 150 mmx 150 mm	Pad has Teflon Sheet, Neoprene and 2 Stl Plates	4	Number of Pads	1.00	4.0
Pipe Supports for Pipe	Add 10% of Pipe Weight for Supports	4	10% Total Pipe Weight - kg	500.00	2000.0
Platform for Valves (1 Total per Header)					
Grip Strut Grating	2" plank grip strut grating	1	Square meters	1.44	1.4
Guardrail	Painted steel - 2 rail with kickplate	1	Length - Meters	4.00	4.0
Steel Framing	L75X75x6	1	Length - Meters	9.00	9.0
Ladders at Platforms	Ladder with Folding or Sliding Bottom	1	Length - Meters	5.50	5.5
Division 9					
Painting					
Jacking Frames	Epoxy Paint	4	Square meters	8.50	34.0
Pipe Piles	Epoxy Paint (inside and outside of pile)	8	Square meters	23.60	188.8
Pipe Pile Raises	Epoxy Paint (inside and outside of pile)	214	Square meters	15.70	3359.8
Makeup Piles	Epoxy Paint (inside and outside of pile)	12	Square meters	6.28	75.4

Casino Project
Sand Tailings Jacking Structure
Material Take Off - MTO (Year 6)
(Sheet 1 of 2)

Item	Description	Number of Items	Unit Measure	Unit Measure Per Item	Total
Modification Summary for Year 6					
Length Increase of Header	**Addition of 12 Bays @ 15 Meters Per Bay = 180 Meters**				
Vertical Pile Raise	**222 Piles Raised Up by Welding New Pipes to End of Constructed Piles (1 Pile Raise of 10 Meters)**				
	(222 New Piles x 10 Meters Long)				
	8 Piles x 6 Meters Makeup Piles Added				
Access to Grade	**2 Ladders**				
Division 5					
Vertical Pile Raises					
Pipe	300x12.7 Pipe	222	Length - Meters	10.00	2220.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	222	Number of Holes	133.00	29526.0
Weld	Full Penetration Groove Weld All Arnd Circumference of Pipe	222	Length of Weld - Meters	0.94	208.7
Makeup Piles					
Pipe	300x12.7 Pipe	8	Length - Meters	6.00	48.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	8	Number of Holes	79.00	632.0
Weld	Full Penetration Groove Weld All Arnd Circumference of Pipe	8	Length of Weld - Meters	0.94	7.5
Length Increase in Header					
Pipe Piles (24 Piles Per Jacking Structure)					
Pipe - Material Cost	300x12.7 Pipe	24	Length - Meters	15.00	360.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side	24	Number of Holes	133.00	3192.0
Pipe - Installation Cost	Install 300mm Pipe By Driving It 5 Meters Below Grade	24	Length - Meters	5.00	120.0
	(Pipe 5 Meters Below Grade, 10 Meters Above Grade)				
Jacking Frame (Sheet 1) 48 Collars Per Header					
Drift Pins	19 mm Headed Pin x 400 mm Long	48	Number of Pins	1.00	48.0
Circular Collar					
Round Hollow Steel Section (HSS)	HS355x9.5 x 450 mm long	48	Length - Meters	0.45	21.6
Patterned Holes	22 mm Diameter Hole in Spiral Pattern	48	Number of Holes	40.00	1920.0
Flange	12.5 mm thick flange x 50 mm projection	48	Number of Flanges	1.00	48.0
Weld	12.5 mm x 1115 mm long	48	Length of Weld - Meters	1.11	53.3
	(1/2" weld around perimeter of pile)				
Keeper					
3 Keeper Bolts	12.5mm Dia Bolt X 75 mm Long With Nut & 2 Washers	48	Number of Bolts	3.00	144.0
Keeper Ring Plate	6mm thick plate x 100mm wide Ring Plate	48	Number of Plates	1.00	48.0
Square Collar					
Square Hollow Steel Section (HSS)	HS355x355x9.5 - 300mm Long	48	Length - Meters	0.30	14.4
Flange	12.5 mm thick flange x 100 mm projection	48	Number of Flanges	1.00	48.0
Weld	12.5 mm x1420 mm long	48	Length of Weld - Meters	1.42	68.2
	(1/2" weld around perimeter of collar)				
Upper Jacking Beam	W250x67	12	Length - Meters	2.00	24.0
Weld to Square Collar	6 mm x500 mm long	24	Length - Meters	0.50	12.0
	(1/4" weld around perimeter of beam web)				
Lower Jacking Beam	W250x67	12	Length - Meters	2.00	24.0
Weld to Square Collar	6 mm x500 mm long	24	Length - Meters	0.50	12.0
	(1/4" weld around perimeter of beam web)				

Casino Project
Sand Tailings Jacking Structure
Material Take Off - MTO (Year 6)
(Sheet 2 of 2)

Item	Description	Number of Items	Unit Measure	Unit Measure Per Item	Total
Division 5 Cont'd					
Platform Framing (Sheet 2)					
Girder (2 Per Bay)	W610x101	24	Length - Meters	15.00	360.0
Beam (5 Per Bay)	W200x19	60	Length - Meters	3.25	195.0
Diagonal (4 Per Bay)	L130x130x9	48	Length - Meters	4.78	229.4
Steel Connections	Add 15% to Member Weights For Connections		15% Total Weight - kg		6555.9
Walkway Platform (Sheet 3)					
Grip Strut Grating	2" plank grip strut grating	12	Square meters	26.67	320.0
Guardrail	Painted steel - 2 rail with kickplate	12	Length - Meters	33.20	398.4
Steel Channels	C200x 75	12	Length - Meters	49.25	591.0
Support Columns	L75X75x6	12	Length - Meters	12.00	144.0
Steel Connections	Add 15% to Member Weights For Connections		15% Total Weight - kg		1673.4
Misc					
Pipe Supports for Piping - Angles/Saddles	Add 10% of Pipe Weight for Supports	12	10% Total Pipe Weight - kg	500.00	6000.0
Ladders at Platforms	Ladder with Folding or Sliding Bottom	2	Length - Meters	5.50	11.0
Division 9					
Painting					
Jacking Frame	Epoxy Paint	12	Square meters	9.00	108.0
Framing for Walkway and Platform	Epoxy Paint	12	Square meters	130.00	1560.0
Pipe Piles	Epoxy Paint (inside and outside of pile)	24	Square meters	28.20	676.8
Pipe Pile Raises	Epoxy Paint (inside and outside of pile)	222	Square meters	18.80	4173.6
Makeup Piles	Epoxy Paint (inside and outside of pile)	8	Square meters	11.30	90.4

Casino Project
Fines Tailings Jacking Structure
Material Take Off - MTO (Year 6)

Item	Description	Number of Items	Unit Measure	Unit Measure Per Item	Total
Modification Summary for Year 6					
Length Increase of Header	**Addition of 12 Bays @ 15 Meters Per Bay = 180 Meters**				
Vertical Pile Raise	**222 Piles Raised Up by Welding New Pipes to End of Constructed Piles (1 Pile Raise of 10 Meters)**				
	(222 New Piles x 10 Meters Long)				
	8 Piles x 6 Meters Makeup Piles Added				
Platforms	**2 Valve Platforms**				
Division 5 - Metals					
Vertical Pile Raises					
Pipe	250x12.7 Pipe	222	Length - Meters	10.00	2220.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	222	Number of Holes	133.00	29526.0
Weld	Full Penetration Groove Weld All Around Circumference of Pipe	222	Length of Weld - Meters	0.79	174.3
Makeup Piles					
Pipe	250x12.7 Pipe	8	Length - Meters	6.00	48.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	8	Number of Holes	79.00	632.0
Weld	Full Penetration Groove Weld All Arnd Circumference of Pipe	8	Length of Weld - Meters	0.79	6.3
Length Increase in Header					
Pipe Piles (24 Piles Per Jacking Structure)					
Pipe - Material Cost	250x12.7 Pipe	24	Length - Meters	15.00	360.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	24	Number of Holes	133.00	3192.0
Pipe - Installation Cost	Install 250mm Pipe By Driving It 5 Meters Below Grade	24	Length - Meters	5.00	120.0
	(Pipe 5 Meters Below Grade, 10 Meters Above Grade)				
Jacking Frame (Sheet 1) 48 Collars Per Header					
Drift Pins	19 mm Headed Pin x 400 mm Long	48	Number of Pins	1.00	48.0
Circular Collar					
Pipe	300x9.3 Pipe x 450 mm long	48	Length - Meters	0.45	21.6
Patterned Holes	22 mm Diameter Hole in Spiral Pattern	48	Number of Holes	40.00	1920.0
Flange	12.5 mm thick flange x 50 mm projection	48	Number of Flanges	1.00	48.0
Weld	12.5 mm x 960 mm long	48	Length of Weld - Meters	0.96	46.1
	(1/2" weld around perimeter of pile)				
Keeper					
3 Keeper Bolts	12.5mm Dia Bolt X 75 mm Long With Nut & 2 Washers	48	Number of Bolts	3.00	144.0
Keeper Ring Plate	6mm thick plate x 100mm wide Ring Plate	48	Number of Plates	1.00	48.0
Square Collar					
Square Hollow Steel Section (HSS)	HS305x305x9.5 - 300mm Long	48	Length - Meters	0.30	14.4
Flange	12.5 mm thick flange x 100 mm projection	48	Number of Flanges	1.00	48.0
Weld	12.5 mm x1200 mm long	48	Length of Weld - Meters	1.20	57.6
	(1/2" weld around perimeter of collar)				
Upper Jacking Beam	W250x67	12	Length - Meters	2.00	24.0
Weld to Square Collar	6 mm x500 mm long	24	Length - Meters	0.50	12.0
	(1/4" weld around perimeter of beam web)				
Lower Jacking Beam	W250x67	12	Length - Meters	2.00	24.0
Weld to Square Collar	6 mm x500 mm long	24	Length - Meters	0.50	12.0
	(1/4" weld around perimeter of beam web)				
Misc					
Sliding Bearing Pad - 150 mmx 150 mm	Pad has Teflon Sheet, Neoprene and 2 Stl Plates	12	Number of Pads	1.00	12.0
Pipe Supports for Pipe	Add 10% of Pipe Weight for Supports	12	10% Total Pipe Weight - kg	500.00	6000.0
Platform for Valves (2 Total per Header)					
Grip Strut Grating	2" plank grip strut grating	2	Square meters	1.44	2.9
Guardrail	Painted steel - 2 rail with kickplate	2	Length - Meters	4.00	8.0
Steel Framing	L75X75x6	2	Length - Meters	9.00	18.0
Ladders at Platforms	Ladder with Folding or Sliding Bottom	2	Length - Meters	5.50	11.0
Division 9					
Painting					
Jacking Frames	Epoxy Paint	12	Square meters	8.50	102.0
Pipe Piles	Epoxy Paint (inside and outside of pile)	24	Square meters	23.60	566.4
Pipe Pile Raises	Epoxy Paint (inside and outside of pile)	222	Square meters	15.70	3485.4
Makeup Piles	Epoxy Paint (inside and outside of pile)	8	Square meters	9.42	75.4

Casino Project
Sand Tailings Jacking Structure
Material Take Off - MTO (Year 7)
(Sheet 1 of 2)

Item	Description	Number of Items	Unit Measure	Unit Measure Per Item	Total
Modification Summary for Year 7					
Length Increase of Header	**Addition of 4 Bays @ 15 Meters Per Bay = 60 Meters**				
Vertical Pile Raise	**246 Piles Raised Up by Welding New Pipes to End of Constructed Piles (1 Pile Raise of 10 Meters)**				
	(246 New Piles x 10 Meters Long)				
	24 Piles x 3 Meters Makeup Piles Added				
Access to Grade	**1 Ladder**				
Division 5					
Vertical Pile Raises					
Pipe	300x12.7 Pipe	246	Length - Meters	10.00	2460.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	246	Number of Holes	133.00	32718.0
Weld	Full Penetration Groove Weld All Arnd Circumference of Pipe	246	Length of Weld - Meters	0.94	231.2
Makeup Piles					
Pipe	300x12.7 Pipe	24	Length - Meters	3.00	72.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	24	Number of Holes	39.00	936.0
Weld	Full Penetration Groove Weld All Arnd Circumference of Pipe	24	Length of Weld - Meters	0.94	22.6
Length Increase in Header					
Pipe Piles (8 Piles Per Jacking Structure)					
Pipe - Material Cost	300x12.7 Pipe	8	Length - Meters	15.00	120.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side	8	Number of Holes	133.00	1064.0
Pipe - Installation Cost	Install 300mm Pipe By Driving It 5 Meters Below Grade	8	Length - Meters	5.00	40.0
	(Pipe 5 Meters Below Grade, 10 Meters Above Grade)				
Jacking Frame (Sheet 1) 16 Collars Per Header					
Drift Pins	19 mm Headed Pin x 400 mm Long	16	Number of Pins	1.00	16.0
Circular Collar					
Round Hollow Steel Section (HSS)	HS355x9.5 x 450 mm long	16	Length - Meters	0.45	7.2
Patterned Holes	22 mm Diameter Hole in Spiral Pattern	16	Number of Holes	40.00	640.0
Flange	12.5 mm thick flange x 50 mm projection	16	Number of Flanges	1.00	16.0
Weld	12.5 mm x 1115 mm long	16	Length of Weld - Meters	1.11	17.8
	(1/2" weld around perimeter of pile)				
Keeper					
3 Keeper Bolts	12.5mm Dia Bolt X 75 mm Long With Nut & 2 Washers	16	Number of Bolts	3.00	48.0
Keeper Ring Plate	6mm thick plate x 100mm wide Ring Plate	16	Number of Plates	1.00	16.0
Square Collar					
Square Hollow Steel Section (HSS)	HS355x355x9.5 - 300mm Long	16	Length - Meters	0.30	4.8
Flange	12.5 mm thick flange x 100 mm projection	16	Number of Flanges	1.00	16.0
Weld	12.5 mm x1420 mm long	16	Length of Weld - Meters	1.42	22.7
	(1/2" weld around perimeter of collar)				
Upper Jacking Beam	W250x67	4	Length - Meters	2.00	8.0
Weld to Square Collar	6 mm x500 mm long	8	Length - Meters	0.50	4.0
	(1/4" weld around perimeter of beam web)				
Lower Jacking Beam	W250x67	4	Length - Meters	2.00	8.0
Weld to Square Collar	6 mm x500 mm long	8	Length - Meters	0.50	4.0
	(1/4" weld around perimeter of beam web)				

Casino Project
Sand Tailings Jacking Structure
Material Take Off - MTO (Year 7)
(Sheet 2 of 2)

Item	Description	Number of Items	Unit Measure	Unit Measure Per Item	Total
Division 5 Cont'd					
Platform Framing (Sheet 2)					
Girder (2 Per Bay)	W610x101	8	Length - Meters	15.00	120.0
Beam (5 Per Bay)	W200x19	20	Length - Meters	3.25	65.0
Diagonal (4 Per Bay)	L130x130x9	16	Length - Meters	4.78	76.5
Steel Connections	Add 15% to Member Weights For Connections		15% Total Weight - kg		2185.3
Walkway Platform (Sheet 3)					
Grip Strut Grating	2" plank grip strut grating	4	Square meters	26.67	106.7
Guardrail	Painted steel - 2 rail with kickplate	4	Length - Meters	33.20	132.8
Steel Channels	C200x 75	4	Length - Meters	49.25	197.0
Support Columns	L75X75x6	4	Length - Meters	12.00	48.0
Steel Connections	Add 15% to Member Weights For Connections		15% Total Weight - kg		557.8
Misc					
Pipe Supports for Piping - Angles/Saddles	Add 10% of Pipe Weight for Supports	4	10% Total Pipe Weight - kg	500.00	2000.0
Ladders at Platforms	Ladder with Folding or Sliding Bottom	1	Length - Meters	5.50	5.5
Division 9					
Painting					
Jacking Frame	Epoxy Paint	4	Square meters	9.00	36.0
Framing for Walkway and Platform	Epoxy Paint	4	Square meters	130.00	520.0
Pipe Piles	Epoxy Paint (inside and outside of pile)	8	Square meters	28.20	225.6
Pipe Pile Raises	Epoxy Paint (inside and outside of pile)	246	Square meters	18.80	4624.8
Makeup Piles	Epoxy Paint (inside and outside of pile)	24	Square meters	5.65	135.6

Casino Project
Fines Tailings Jacking Structure
Material Take Off - MTO (Year 7)

Item	Description	Number of Items	Unit Measure	Unit Measure Per Item	Total
Modification Summary for Year 7					
Length Increase of Header	**Addition of 4 Bays @ 15 Meters Per Bay = 60 Meters**				
Vertical Pile Raise	**246 Piles Raised Up by Welding New Pipes to End of Constructed Piles (1 Pile Raise of 10 Meters)**				
	(246 New Piles x 10 Meters Long)				
	24 Piles x 3 Meters Makeup Piles Added				
Platforms	**1 Valve Platforms**				
Division 5 - Metals					
Vertical Pile Raises					
Pipe	250x12.7 Pipe	246	Length - Meters	10.00	2460.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	246	Number of Holes	133.00	32718.0
Weld	Full Penetration Groove Weld All Around Circumference of Pipe	246	Length of Weld - Meters	0.79	193.1
Makeup Piles					
Pipe	250x12.7 Pipe	24	Length - Meters	3.00	72.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	24	Number of Holes	39.00	936.0
Weld	Full Penetration Groove Weld All Arnd Circumference of Pipe	24	Length of Weld - Meters	0.79	19.0
Length Increase in Header					
Pipe Piles (8 Piles Per Jacking Structure)					
Pipe - Material Cost	250x12.7 Pipe	8	Length - Meters	15.00	120.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	8	Number of Holes	133.00	1064.0
Pipe - Installation Cost	Install 250mm Pipe By Driving It 5 Meters Below Grade	8	Length - Meters	5.00	40.0
	(Pipe 5 Meters Below Grade, 10 Meters Above Grade)				
Jacking Frame (Sheet 1) 16 Collars Per Header					
Drift Pins	19 mm Headed Pin x 400 mm Long	16	Number of Pins	1.00	16.0
Circular Collar					
Pipe	300x9.3 Pipe x 450 mm long	16	Length - Meters	0.45	7.2
Patterned Holes	22 mm Diameter Hole in Spiral Pattern	16	Number of Holes	40.00	640.0
Flange	12.5 mm thick flange x 50 mm projection	16	Number of Flanges	1.00	16.0
Weld	12.5 mm x 960 mm long	16	Length of Weld - Meters	0.96	15.4
	(1/2" weld around perimeter of pile)				
Keeper					
3 Keeper Bolts	12.5mm Dia Bolt X 75 mm Long With Nut & 2 Washers	16	Number of Bolts	3.00	48.0
Keeper Ring Plate	6mm thick plate x 100mm wide Ring Plate	16	Number of Plates	1.00	16.0
Square Collar					
Square Hollow Steel Section (HSS)	HS305x305x9.5 - 300mm Long	16	Length - Meters	0.30	4.8
Flange	12.5 mm thick flange x 100 mm projection	16	Number of Flanges	1.00	16.0
Weld	12.5 mm x1200 mm long	16	Length of Weld - Meters	1.20	19.2
	(1/2" weld around perimeter of collar)				
Upper Jacking Beam	W250x67	4	Length - Meters	2.00	8.0
Weld to Square Collar	6 mm x500 mm long	8	Length - Meters	0.50	4.0
	(1/4" weld around perimeter of beam web)				
Lower Jacking Beam	W250x67	4	Length - Meters	2.00	8.0
Weld to Square Collar	6 mm x500 mm long	8	Length - Meters	0.50	4.0
	(1/4" weld around perimeter of beam web)				
Misc					
Sliding Bearing Pad - 150 mmx 150 mm	Pad has Teflon Sheet, Neoprene and 2 Stl Plates	4	Number of Pads	1.00	4.0
Pipe Supports for Pipe	Add 10% of Pipe Weight for Supports	4	10% Total Pipe Weight - kg	500.00	2000.0
Platform for Valves (2 Total per Header)					
Grip Strut Grating	2" plank grip strut grating	1	Square meters	1.44	1.4
Guardrail	Painted steel - 2 rail with kickplate	1	Length - Meters	4.00	4.0
Steel Framing	L75X75x6	1	Length - Meters	9.00	9.0
Ladders at Platforms	Ladder with Folding or Sliding Bottom	1	Length - Meters	5.50	5.5
Division 9					
Painting					
Jacking Frames	Epoxy Paint	4	Square meters	8.50	34.0
Pipe Piles	Epoxy Paint (inside and outside of pile)	8	Square meters	23.60	188.8
Pipe Pile Raises	Epoxy Paint (inside and outside of pile)	246	Square meters	15.70	3862.2
Makeup Piles	Epoxy Paint (inside and outside of pile)	24	Square meters	4.71	113.0

Casino Project
Sand Tailings Jacking Structure
Material Take Off - MTO (Year 13)
(Sheet 1 of 2)

Item	Description	Number of Items	Unit Measure	Unit Measure Per Item	Total
Modification Summary for Year 13					
Length Increase of Header	**Addition of 16 Bays @ 15 Meters Per Bay = 240 Meters**				
Vertical Pile Raise	**254 Piles Raised Up by Welding New Pipes to End of Constructed Piles (4 Pile Raises of 10 Meters Each)**				
	(1016 New Piles x 10 Meters Long)				
	8 Piles x 7 Meters Makeup Piles Added				
Access to Grade	**2 Ladders**				
Division 5					
Vertical Pile Raises					
Pipe	300x12.7 Pipe	1016	Length - Meters	10.00	10160.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	1016	Number of Holes	133.00	135128.0
Weld	Full Penetration Groove Weld All Arnd Circumference of Pipe	1016	Length of Weld - Meters	0.94	955.0
Makeup Piles					
Pipe	300x12.7 Pipe	8	Length - Meters	7.00	56.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	8	Number of Holes	92.00	736.0
Weld	Full Penetration Groove Weld All Arnd Circumference of Pipe	8	Length of Weld - Meters	0.94	7.5
Length Increase in Header					
Pipe Piles (32 Piles Per Jacking Structure)					
Pipe - Material Cost	300x12.7 Pipe	32	Length - Meters	15.00	480.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side	32	Number of Holes	133.00	4256.0
Pipe - Installation Cost	Install 300mm Pipe By Driving It 5 Meters Below Grade	32	Length - Meters	5.00	160.0
	(Pipe 5 Meters Below Grade, 10 Meters Above Grade)				
Jacking Frame (Sheet 1) 64 Collars Per Header					
Drift Pins	19 mm Headed Pin x 400 mm Long	64	Number of Pins	1.00	64.0
Circular Collar					
Round Hollow Steel Section (HSS)	HS355x9.5 x 450 mm long	64	Length - Meters	0.45	28.8
Patterned Holes	22 mm Diameter Hole in Spiral Pattern	64	Number of Holes	40.00	2560.0
Flange	12.5 mm thick flange x 50 mm projection	64	Number of Flanges	1.00	64.0
Weld	12.5 mm x 1115 mm long	64	Length of Weld - Meters	1.11	71.0
	(1/2" weld around perimeter of pile)				
Keeper					
3 Keeper Bolts	12.5mm Dia Bolt X 75 mm Long With Nut & 2 Washers	64	Number of Bolts	3.00	192.0
Keeper Ring Plate	6mm thick plate x 100mm wide Ring Plate	64	Number of Plates	1.00	64.0
Square Collar					
Square Hollow Steel Section (HSS)	HS355x355x9.5 - 300mm Long	64	Length - Meters	0.30	19.2
Flange	12.5 mm thick flange x 100 mm projection	64	Number of Flanges	1.00	64.0
Weld	12.5 mm x1420 mm long	64	Length of Weld - Meters	1.42	90.9
	(1/2" weld around perimeter of collar)				
Upper Jacking Beam	W250x67	16	Length - Meters	2.00	32.0
Weld to Square Collar	6 mm x500 mm long	32	Length - Meters	0.50	16.0
	(1/4" weld around perimeter of beam web)				
Lower Jacking Beam	W250x67	16	Length - Meters	2.00	32.0
Weld to Square Collar	6 mm x500 mm long	32	Length - Meters	0.50	16.0
	(1/4" weld around perimeter of beam web)				

Casino Project
Sand Tailings Jacking Structure
Material Take Off - MTO (Year 13)
(Sheet 2 of 2)

Item	Description	Number of Items	Unit Measure	Unit Measure Per Item	Total
Division 5 Cont'd					
Platform Framing (Sheet 2)					
Girder (2 Per Bay)	W610x101	32	Length - Meters	15.00	480.0
Beam (5 Per Bay)	W200x19	80	Length - Meters	3.25	260.0
Diagonal (4 Per Bay)	L130x130x9	64	Length - Meters	4.78	305.9
Steel Connections	Add 15% to Member Weights For Connections		15% Total Weight - kg		8741.2
Walkway Platform (Sheet 3)					
Grip Strut Grating	2" plank grip strut grating	16	Square meters	26.67	426.7
Guardrail	Painted steel - 2 rail with kickplate	16	Length - Meters	33.20	531.2
Steel Channels	C200x 75	16	Length - Meters	49.25	788.0
Support Columns	L75X75x6	16	Length - Meters	12.00	192.0
Steel Connections	Add 15% to Member Weights For Connections		15% Total Weight - kg		2231.2
Misc					
Pipe Supports for Piping - Angles/Saddles	Add 10% of Pipe Weight for Supports	16	10% Total Pipe Weight - kg	500.00	8000.0
Ladders at Platforms	Ladder with Folding or Sliding Bottom	2	Length - Meters	5.50	11.0
Division 9					
Painting					
Jacking Frame	Epoxy Paint	16	Square meters	9.00	144.0
Framing for Walkway and Platform	Epoxy Paint	16	Square meters	130.00	2080.0
Pipe Piles	Epoxy Paint (inside and outside of pile)	32	Square meters	28.20	902.4
Pipe Pile Raises	Epoxy Paint (inside and outside of pile)	1016	Square meters	18.80	19100.8
Makeup Piles	Epoxy Paint (inside and outside of pile)	8	Square meters	13.19	105.5

Casino Project
Fines Tailings Jacking Structure
Material Take Off - MTO (Year 13)

Item	Description	Number of Items	Unit Measure	Unit Measure Per Item	Total
Modification Summary for Year 13					
Length Increase of Header	**Addition of 16 Bays @ 15 Meters Per Bay = 240 Meters**				
Vertical Pile Raise	**254 Piles Raised Up by Welding New Pipes to End of Constructed Piles (4 Pile Raises of 10 Meters Each)**				
	(1016 New Piles x 10 Meters Long)				
	8 Piles x 7 Meters Makeup Piles Added				
Platforms	**2 Valve Platforms**				
Division 5 - Metals					
Vertical Pile Raises					
Pipe	250x12.7 Pipe	1016	Length - Meters	10.00	10160.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	1016	Number of Holes	133.00	135128.0
Weld	Full Penetration Groove Weld All Around Circumference of Pipe	1016	Length of Weld - Meters	0.79	797.6
Makeup Piles					
Pipe	250x12.7 Pipe	8	Length - Meters	7.00	56.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	8	Number of Holes	92.00	736.0
Weld	Full Penetration Groove Weld All Arnd Circumference of Pipe	8	Length of Weld - Meters	0.79	6.3
Length Increase in Header					
Pipe Piles (32 Piles Per Jacking Structure)					
Pipe - Material Cost	250x12.7 Pipe	32	Length - Meters	15.00	480.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	32	Number of Holes	133.00	4256.0
Pipe - Installation Cost	Install 250mm Pipe By Driving It 5 Meters Below Grade	32	Length - Meters	5.00	160.0
	(Pipe 5 Meters Below Grade, 10 Meters Above Grade)				
Jacking Frame (Sheet 1) 64 Collars Per Header					
Drift Pins	19 mm Headed Pin x 400 mm Long	64	Number of Pins	1.00	64.0
Circular Collar					
Pipe	300x9.3 Pipe x 450 mm long	64	Length - Meters	0.45	28.8
Patterned Holes	22 mm Diameter Hole in Spiral Pattern	64	Number of Holes	40.00	2560.0
Flange	12.5 mm thick flange x 50 mm projection	64	Number of Flanges	1.00	64.0
Weld	12.5 mm x 960 mm long	64	Length of Weld - Meters	0.96	61.4
	(1/2" weld around perimeter of pile)				
Keeper					
3 Keeper Bolts	12.5mm Dia Bolt X 75 mm Long With Nut & 2 Washers	64	Number of Bolts	3.00	192.0
Keeper Ring Plate	6mm thick plate x 100mm wide Ring Plate	64	Number of Plates	1.00	64.0
Square Collar					
Square Hollow Steel Section (HSS)	HS305x305x9.5 - 300mm Long	64	Length - Meters	0.30	19.2
Flange	12.5 mm thick flange x 100 mm projection	64	Number of Flanges	1.00	64.0
Weld	12.5 mm x1200 mm long	64	Length of Weld - Meters	1.20	76.8
	(1/2" weld around perimeter of collar)				
Upper Jacking Beam	W250x67	16	Length - Meters	2.00	32.0
Weld to Square Collar	6 mm x500 mm long	32	Length - Meters	0.50	16.0
	(1/4" weld around perimeter of beam web)				
Lower Jacking Beam	W250x67	16	Length - Meters	2.00	32.0
Weld to Square Collar	6 mm x500 mm long	32	Length - Meters	0.50	16.0
	(1/4" weld around perimeter of beam web)				
Misc					
Sliding Bearing Pad - 150 mmx 150 mm	Pad has Teflon Sheet, Neoprene and 2 Stl Plates	16	Number of Pads	1.00	16.0
Pipe Supports for Pipe	Add 10% of Pipe Weight for Supports	16	10% Total Pipe Weight - kg	500.00	8000.0
Platform for Valves (2 Total per Header)					
Grip Strut Grating	2" plank grip strut grating	2	Square meters	1.44	2.9
Guardrail	Painted steel - 2 rail with kickplate	2	Length - Meters	4.00	8.0
Steel Framing	L75X75x6	2	Length - Meters	9.00	18.0
Ladders at Platforms	Ladder with Folding or Sliding Bottom	2	Length - Meters	5.50	11.0
Division 9					
Painting					
Jacking Frames	Epoxy Paint	16	Square meters	8.50	136.0
Pipe Piles	Epoxy Paint (inside and outside of pile)	32	Square meters	23.60	755.2
Pipe Pile Raises	Epoxy Paint (inside and outside of pile)	1016	Square meters	15.70	15951.2
Makeup Piles	Epoxy Paint (inside and outside of pile)	8	Square meters	10.99	87.9

Casino Project
Sand Tailings Jacking Structure
Material Take Off - MTO (Year 20)
(Sheet 1 of 2)

Item	Description	Number of Items	Unit Measure	Unit Measure Per Item	Total
Modification Summary for Year 20					
Length Increase of Header	**Addition of 20 Bays @ 15 Meters Per Bay = 300 Meters**				
Vertical Pile Raise	**286 Piles Raised Up by Welding New Pipes to End of Constructed Piles (4 Pile Raises of 10 Meters Each)**				
	(1144 New Piles x 10 Meters Long)				
	32 Piles x 3 Meters Makeup Piles Added				
Access to Grade	**3 Ladders**				
Division 5					
Vertical Pile Raises					
Pipe	300x12.7 Pipe	1144	Length - Meters	10.00	11440.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	1144	Number of Holes	133.00	152152.0
Weld	Full Penetration Groove Weld All Arnd Circumference of Pipe	1144	Length of Weld - Meters	0.94	1075.4
Makeup Piles					
Pipe	300x12.7 Pipe	32	Length - Meters	3.00	96.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	32	Number of Holes	39.00	1248.0
Weld	Full Penetration Groove Weld All Arnd Circumference of Pipe	32	Length of Weld - Meters	0.94	30.1
Length Increase in Header					
Pipe Piles (40 Piles Per Jacking Structure)					
Pipe - Material Cost	300x12.7 Pipe	40	Length - Meters	15.00	600.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side	40	Number of Holes	133.00	5320.0
Pipe - Installation Cost	Install 300mm Pipe By Driving It 5 Meters Below Grade	40	Length - Meters	5.00	200.0
	(Pipe 5 Meters Below Grade, 10 Meters Above Grade)				
Jacking Frame (Sheet 1) 80 Collars Per Header					
Drift Pins	19 mm Headed Pin x 400 mm Long	80	Number of Pins	1.00	80.0
Circular Collar					
Round Hollow Steel Section (HSS)	HS355x9.5 x 450 mm long	80	Length - Meters	0.45	36.0
Patterned Holes	22 mm Diameter Hole in Spiral Pattern	80	Number of Holes	40.00	3200.0
Flange	12.5 mm thick flange x 50 mm projection	80	Number of Flanges	1.00	80.0
Weld	12.5 mm x 1115 mm long	80	Length of Weld - Meters	1.11	88.8
	(1/2" weld around perimeter of pile)				
Keeper					
3 Keeper Bolts	12.5mm Dia Bolt X 75 mm Long With Nut & 2 Washers	80	Number of Bolts	3.00	240.0
Keeper Ring Plate	6mm thick plate x 100mm wide Ring Plate	64	Number of Plates	1.00	64.0
Square Collar					
Square Hollow Steel Section (HSS)	HS355x355x9.5 - 300mm Long	80	Length - Meters	0.30	24.0
Flange	12.5 mm thick flange x 100 mm projection	80	Number of Flanges	1.00	80.0
Weld	12.5 mm x1420 mm long	80	Length of Weld - Meters	1.42	113.6
	(1/2" weld around perimeter of collar)				
Upper Jacking Beam	W250x67	20	Length - Meters	2.00	40.0
Weld to Square Collar	6 mm x500 mm long	40	Length - Meters	0.50	20.0
	(1/4" weld around perimeter of beam web)				
Lower Jacking Beam	W250x67	20	Length - Meters	2.00	40.0
Weld to Square Collar	6 mm x500 mm long	40	Length - Meters	0.50	20.0
	(1/4" weld around perimeter of beam web)				

Casino Project
Sand Tailings Jacking Structure
Material Take Off - MTO (Year 20)
(Sheet 2 of 2)

Item	Description	Number of Items	Unit Measure	Unit Measure Per Item	Total
Division 5 Cont'd					
Platform Framing (Sheet 2)					
Girder (2 Per Bay)	W610x101	40	Length - Meters	15.00	600.0
Beam (5 Per Bay)	W200x19	100	Length - Meters	3.25	325.0
Diagonal (4 Per Bay)	L130x130x9	80	Length - Meters	4.78	382.4
Steel Connections	Add 15% to Member Weights For Connections		15% Total Weight - kg		10926.5
Walkway Platform (Sheet 3)					
Grip Strut Grating	2" plank grip strut grating	20	Square meters	26.67	533.4
Guardrail	Painted steel - 2 rail with kickplate	20	Length - Meters	33.20	664.0
Steel Channels	C200x 75	20	Length - Meters	49.25	985.0
Support Columns	L75X75x6	20	Length - Meters	12.00	240.0
Steel Connections	Add 15% to Member Weights For Connections		15% Total Weight - kg		2789.0
Misc					
Pipe Supports for Piping - Angles/Saddles	Add 10% of Pipe Weight for Supports	20	10% Total Pipe Weight - kg	500.00	10000.0
Ladders at Platforms	Ladder with Folding or Sliding Bottom	3	Length - Meters	5.50	16.5
Division 9					
Painting					
Jacking Frame	Epoxy Paint	20	Square meters	9.00	180.0
Framing for Walkway and Platform	Epoxy Paint	20	Square meters	130.00	2600.0
Pipe Piles	Epoxy Paint (inside and outside of pile)	40	Square meters	28.20	1128.0
Pipe Pile Raises	Epoxy Paint (inside and outside of pile)	1144	Square meters	18.80	21507.2
Makeup Piles	Epoxy Paint (inside and outside of pile)	32	Square meters	5.65	180.8

Casino Project
Fines Tailings Jacking Structure
Material Take Off - MTO (Year 20)

Item	Description	Number of Items	Unit Measure	Unit Measure Per Item	Total
Modification Summary for Year 20					
Length Increase of Header	**Addition of 20 Bays @ 15 Meters Per Bay = 300 Meters**				
Vertical Pile Raise	**286 Piles Raised Up by Welding New Pipes to End of Constructed Piles (4 Pile Raises of 10 Meters Each)**				
	(1144 New Piles x 10 Meters Long)				
	32 Piles x 3 Meters Makeup Piles Added				
Platforms	**3 Valve Platforms**				
Division 5 - Metals					
Vertical Pile Raises					
Pipe	250x12.7 Pipe	1144	Length - Meters	10.00	11440.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	1144	Number of Holes	133.00	152152.0
Weld	Full Penetration Groove Weld All Around Circumference of Pipe	1144	Length of Weld - Meters	0.79	898.0
Makeup Piles					
Pipe	250x12.7 Pipe	32	Length - Meters	3.00	96.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	32	Number of Holes	39.00	1248.0
Weld	Full Penetration Groove Weld All Arnd Circumference of Pipe	32	Length of Weld - Meters	0.79	25.3
Length Increase in Header					
Pipe Piles (40 Piles Per Jacking Structure)					
Pipe - Material Cost	250x12.7 Pipe	40	Length - Meters	15.00	600.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	40	Number of Holes	133.00	5320.0
Pipe - Installation Cost	Install 250mm Pipe By Driving It 5 Meters Below Grade	40	Length - Meters	5.00	200.0
	(Pipe 5 Meters Below Grade, 10 Meters Above Grade)				
Jacking Frame (Sheet 1) 80 Collars Per Header					
Drift Pins	19 mm Headed Pin x 400 mm Long	80	Number of Pins	1.00	80.0
Circular Collar					
Pipe	300x9.3 Pipe x 450 mm long	80	Length - Meters	0.45	36.0
Patterned Holes	22 mm Diameter Hole in Spiral Pattern	80	Number of Holes	40.00	3200.0
Flange	12.5 mm thick flange x 50 mm projection	80	Number of Flanges	1.00	80.0
Weld	12.5 mm x 960 mm long	80	Length of Weld - Meters	0.96	76.8
	(1/2" weld around perimeter of pile)				
Keeper					
3 Keeper Bolts	12.5mm Dia Bolt X 75 mm Long With Nut & 2 Washers	80	Number of Bolts	3.00	240.0
Keeper Ring Plate	6mm thick plate x 100mm wide Ring Plate	80	Number of Plates	1.00	80.0
Square Collar					
Square Hollow Steel Section (HSS)	HS305x305x9.5 - 300mm Long	80	Length - Meters	0.30	24.0
Flange	12.5 mm thick flange x 100 mm projection	80	Number of Flanges	1.00	80.0
Weld	12.5 mm x1200 mm long	80	Length of Weld - Meters	1.20	96.0
	(1/2" weld around perimeter of collar)				
Upper Jacking Beam	W250x67	20	Length - Meters	2.00	40.0
Weld to Square Collar	6 mm x500 mm long	40	Length - Meters	0.50	20.0
	(1/4" weld around perimeter of beam web)				
Lower Jacking Beam	W250x67	20	Length - Meters	2.00	40.0
Weld to Square Collar	6 mm x500 mm long	40	Length - Meters	0.50	20.0
	(1/4" weld around perimeter of beam web)				
Misc					
Sliding Bearing Pad - 150 mmx 150 mm	Pad has Teflon Sheet, Neoprene and 2 Stl Plates	20	Number of Pads	1.00	20.0
Pipe Supports for Pipe	Add 10% of Pipe Weight for Supports	20	10% Total Pipe Weight - kg	500.00	10000.0
Platform for Valves (2 Total per Header)					
Grip Strut Grating	2" plank grip strut grating	3	Square meters	1.44	4.3
Guardrail	Painted steel - 2 rail with kickplate	3	Length - Meters	4.00	12.0
Steel Framing	L75X75x6	3	Length - Meters	9.00	27.0
Ladders at Platforms	Ladder with Folding or Sliding Bottom	3	Length - Meters	5.50	16.5
Division 9					
Painting					
Jacking Frames	Epoxy Paint	20	Square meters	8.50	170.0
Pipe Piles	Epoxy Paint (inside and outside of pile)	40	Square meters	23.60	944.0
Pipe Pile Raises	Epoxy Paint (inside and outside of pile)	1144	Square meters	15.70	17960.8
Makeup Piles	Epoxy Paint (inside and outside of pile)	32	Square meters	4.71	150.7

Casino Project
Sand Tailings Jacking Structure
Material Take Off - MTO (Year 22)
(Sheet 1 of 2)

Item	Description	Number of Items	Unit Measure	Unit Measure Per Item	Total
Modification Summary for Year 23					
Length Increase of Header	**Addition of 8 Bays @ 15 Meters Per Bay = 120 Meters**				
Vertical Pile Raise	**326 Piles Raised Up by Welding New Pipes to End of Constructed Piles (1 Pile Raises of 11 Meters)**				
	(326 New Piles x 11 Meters Long)				
Access to Grade	**1 Ladders**				
Division 5					
Vertical Pile Raises					
Pipe	300x12.7 Pipe	326	Length - Meters	11.00	3586.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	326	Number of Holes	144.00	46944.0
Weld	Full Penetration Groove Weld All Arnd Circumference of Pipe	326	Length of Weld - Meters	0.94	306.4
Length Increase in Header					
Pipe Piles (16 Piles Per Jacking Structure)					
Pipe - Material Cost	300x12.7 Pipe	16	Length - Meters	15.00	240.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side	16	Number of Holes	133.00	2128.0
Pipe - Installation Cost	Install 300mm Pipe By Driving It 5 Meters Below Grade	16	Length - Meters	5.00	80.0
	(Pipe 5 Meters Below Grade, 10 Meters Above Grade)				
Jacking Frame (Sheet 1) 32 Collars Per Header					
Drift Pins	19 mm Headed Pin x 400 mm Long	32	Number of Pins	1.00	32.0
Circular Collar					
Round Hollow Steel Section (HSS)	HS355x9.5 x 450 mm long	32	Length - Meters	0.45	14.4
Patterned Holes	22 mm Diameter Hole in Spiral Pattern	32	Number of Holes	40.00	1280.0
Flange	12.5 mm thick flange x 50 mm projection	32	Number of Flanges	1.00	32.0
Weld	12.5 mm x 1115 mm long	32	Length of Weld - Meters	1.11	35.5
	(1/2" weld around perimeter of pile)				
Keeper					
3 Keeper Bolts	12.5mm Dia Bolt X 75 mm Long With Nut & 2 Washers	32	Number of Bolts	3.00	96.0
Keeper Ring Plate	6mm thick plate x 100mm wide Ring Plate	32	Number of Plates	1.00	32.0
Square Collar					
Square Hollow Steel Section (HSS)	HS355x355x9.5 - 300mm Long	32	Length - Meters	0.30	9.6
Flange	12.5 mm thick flange x 100 mm projection	32	Number of Flanges	1.00	32.0
Weld	12.5 mm x1420 mm long	32	Length of Weld - Meters	1.42	45.4
	(1/2" weld around perimeter of collar)				
Upper Jacking Beam	W250x67	8	Length - Meters	2.00	16.0
Weld to Square Collar	6 mm x500 mm long	16	Length - Meters	0.50	8.0
	(1/4" weld around perimeter of beam web)				
Lower Jacking Beam	W250x67	8	Length - Meters	2.00	16.0
Weld to Square Collar	6 mm x500 mm long	16	Length - Meters	0.50	8.0
	(1/4" weld around perimeter of beam web)				

Casino Project
Sand Tailings Jacking Structure
Material Take Off - MTO (Year 22)
(Sheet 2 of 2)

Item	Description	Number of Items	Unit Measure	Unit Measure Per Item	Total
Division 5 Cont'd					
Platform Framing (Sheet 2)					
Girder (2 Per Bay)	W610x101	16	Length - Meters	15.00	240.0
Beam (5 Per Bay)	W200x19	40	Length - Meters	3.25	130.0
Diagonal (4 Per Bay)	L130x130x9	32	Length - Meters	4.78	153.0
Steel Connections	Add 15% to Member Weights For Connections		15% Total Weight - kg		4370.6
Walkway Platform (Sheet 3)					
Grip Strut Grating	2" plank grip strut grating	8	Square meters	26.67	213.4
Guardrail	Painted steel - 2 rail with kickplate	8	Length - Meters	33.20	265.6
Steel Channels	C200x 75	8	Length - Meters	49.25	394.0
Support Columns	L75X75x6	8	Length - Meters	12.00	96.0
Steel Connections	Add 15% to Member Weights For Connections		15% Total Weight - kg		1115.6
Misc					
Pipe Supports for Piping - Angles/Saddles	Add 10% of Pipe Weight for Supports	8	10% Total Pipe Weight - kg	500.00	4000.0
Ladders at Platforms	Ladder with Folding or Sliding Bottom	1	Length - Meters	5.50	5.5
Division 9					
Painting					
Jacking Frame	Epoxy Paint	8	Square meters	9.00	72.0
Framing for Walkway and Platform	Epoxy Paint	8	Square meters	130.00	1040.0
Pipe Piles	Epoxy Paint (inside and outside of pile)	16	Square meters	28.20	451.2
Pipe Pile Raises	Epoxy Paint (inside and outside of pile)	326	Square meters	20.72	6754.7

Casino Project
Fines Tailings Jacking Structure
Material Take Off - MTO (Year 22)

Item	Description	Number of Items	Unit Measure	Unit Measure Per Item	Total
Modification Summary for Year 23					
Length Increase of Header	**Addition of 8 Bays @ 15 Meters Per Bay = 120 Meters**				
Vertical Pile Raise	**326 Piles Raised Up by Welding New Pipes to End of Constructed Piles (1 Pile Raises of 11 Meters)**				
	(326 New Piles x 11 Meters Long)				
Platforms	**1 Valve Platforms**				
Division 5 - Metals					
Vertical Pile Raises					
Pipe	250x12.7 Pipe	326	Length - Meters	11.00	3586.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	326	Number of Holes	144.00	46944.0
Weld	Full Penetration Groove Weld All Around Circumference of Pipe	326	Length of Weld - Meters	0.79	255.9
Length Increase in Header					
Pipe Piles (16 Piles Per Jacking Structure)					
Pipe - Material Cost	250x12.7 Pipe	16	Length - Meters	15.00	240.0
Holes in Pipe Piles Used for Raises	22 mm Diameter Holes Each Side @150 mm on center	16	Number of Holes	133.00	2128.0
Pipe - Installation Cost	Install 250mm Pipe By Driving It 5 Meters Below Grade	16	Length - Meters	5.00	80.0
	(Pipe 5 Meters Below Grade, 10 Meters Above Grade)				
Jacking Frame (Sheet 1) 32 Collars Per Header					
Drift Pins	19 mm Headed Pin x 400 mm Long	32	Number of Pins	1.00	32.0
Circular Collar					
Pipe	300x9.3 Pipe x 450 mm long	32	Length - Meters	0.45	14.4
Patterned Holes	22 mm Diameter Hole in Spiral Pattern	32	Number of Holes	40.00	1280.0
Flange	12.5 mm thick flange x 50 mm projection	32	Number of Flanges	1.00	32.0
Weld	12.5 mm x 960 mm long	32	Length of Weld - Meters	0.96	30.7
	(1/2" weld around perimeter of pile)				
Keeper					
3 Keeper Bolts	12.5mm Dia Bolt X 75 mm Long With Nut & 2 Washers	32	Number of Bolts	3.00	96.0
Keeper Ring Plate	6mm thick plate x 100mm wide Ring Plate	32	Number of Plates	1.00	32.0
Square Collar					
Square Hollow Steel Section (HSS)	HS305x305x9.5 - 300mm Long	32	Length - Meters	0.30	9.6
Flange	12.5 mm thick flange x 100 mm projection	32	Number of Flanges	1.00	32.0
Weld	12.5 mm x1200 mm long	32	Length of Weld - Meters	1.20	38.4
	(1/2" weld around perimeter of collar)				
Upper Jacking Beam	W250x67	8	Length - Meters	2.00	16.0
Weld to Square Collar	6 mm x500 mm long	16	Length - Meters	0.50	8.0
	(1/4" weld around perimeter of beam web)				
Lower Jacking Beam	W250x67	8	Length - Meters	2.00	16.0
Weld to Square Collar	6 mm x500 mm long	16	Length - Meters	0.50	8.0
	(1/4" weld around perimeter of beam web)				
Misc					
Sliding Bearing Pad - 150 mmx 150 mm	Pad has Teflon Sheet, Neoprene and 2 Stl Plates	8	Number of Pads	1.00	8.0
Pipe Supports for Pipe	Add 10% of Pipe Weight for Supports	8	10% Total Pipe Weight - kg	500.00	4000.0
Platform for Valves (4 Total per Header)					
Grip Strut Grating	2" plank grip strut grating	1	Square meters	1.44	1.4
Guardrail	Painted steel - 2 rail with kickplate	1	Length - Meters	4.00	4.0
Steel Framing	L75X75x6	1	Length - Meters	9.00	9.0
Ladders at Platforms	Ladder with Folding or Sliding Bottom	1	Length - Meters	5.50	5.5
Division 9					
Painting					
Jacking Frames	Epoxy Paint	8	Square meters	8.50	68.0
Pipe Piles	Epoxy Paint (inside and outside of pile)	16	Square meters	23.60	377.6
Pipe Pile Raises	Epoxy Paint (inside and outside of pile)	326	Square meters	17.27	5630.0

Steel Section Table

Steel Section	Metric Designation	Imperial Designation	Notes
Wide Flange	W200x19	W8x13	
	W250x67	W10x45	
	W610x101	W24x68	
Channel	C200x75	C8x11.5	
Angle	L75x75x6	L3x3x1/4	
	L130x130x9	L5x5x5/16	
Pipe	250x12.7	10" x strong	
	300x9.3	12" std	
	300x12.7	12" x strong	
	360x9.3	14" std	
HSS -Square	HS305x305x9.5	HSS12x12x0.375	CSA G40.2/21
	HS355x355x9.5	HSS14x14x0.375	
HSS - Round	HS355x9.5	14.0 Round HSS x 0.25	
Bolts	12.5 mm	1/2"	
	19 mm	3/4"	
	22 mm	7/8"	
	25 mm	1"	

HSS - Hollow Structural Section

Wide flange, channel shapes and other rolled members shall meet ASTM A992. These members shall have a minimum yield strength, Fy = 50 ksi (350 MPa).

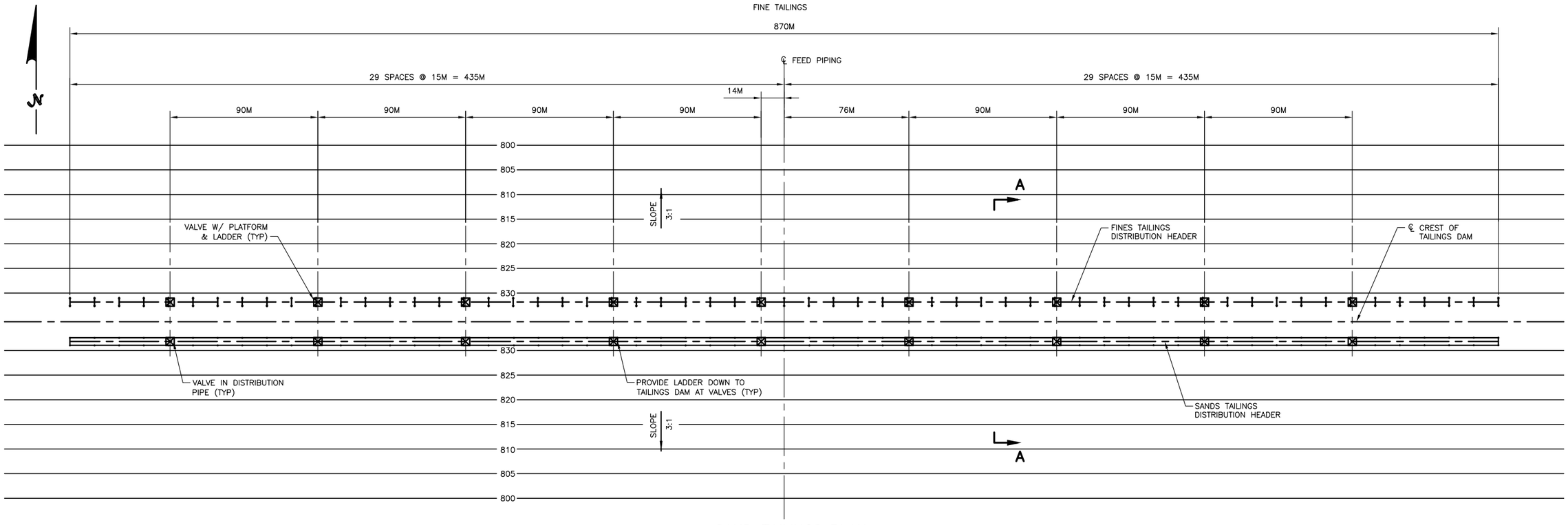
Angles and plate members shall meet ASTM A 36. These members shall have a minimum yield strength, Fy = 36 ksi (250 MPa).

Hollow Steel Sections shall meet the ASTM A500, grade B. These members shall have a minimum yield strength, Fy = 42 ksi (290 MPa).

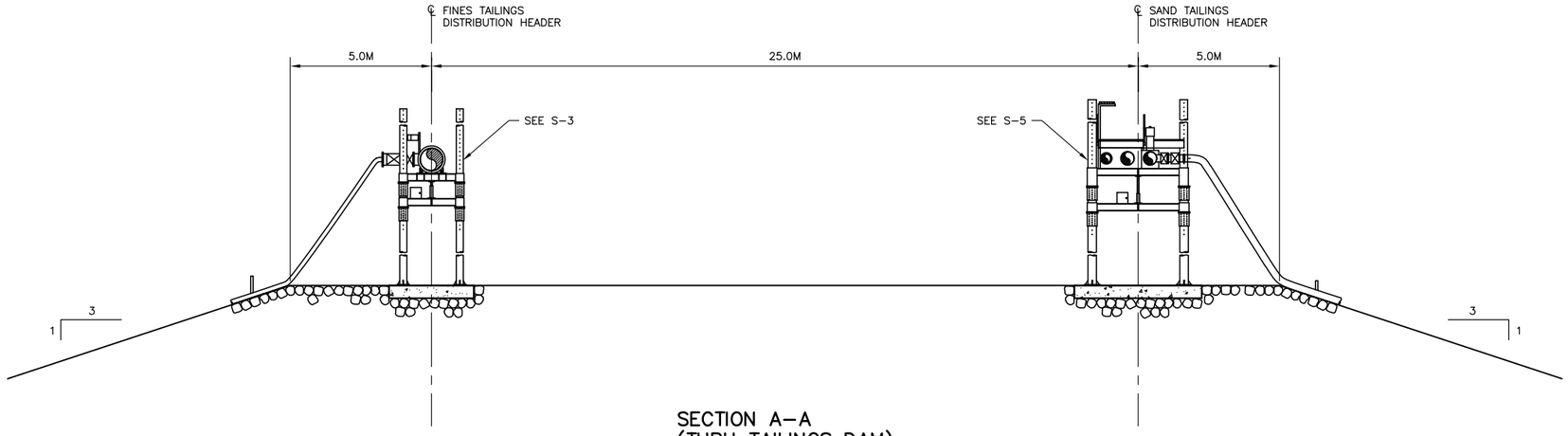
Pipe Sections shall have a minimum yield strength, Fy = 35 ksi (240 Mpa)

The steel shall meet the supplemental requirements of a Charpy V-Notch Impact Test.
The minimum energy used in the Impact test shall be 25 ft lb @ 10 degrees F or 34 joules @ -12degrees C.

DRAWINGS



SAND TAILINGS PLAN
SCALE: 1:1250



SECTION A–A (THRU TAILINGS DAM)
SCALE: 1:100

0 50M 100M

SCALES ARE FULL SIZE, SCALE ACCORDINGLY

0 1M 2M 3M 4M 5M

SCALES ARE FULL SIZE, SCALE ACCORDINGLY

FEASIBILTY STUDY
NOT FOR CONSTRUCTION

REVISIONS			
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CLIENT:

CASINO PROJECT

CASINO JACKING HEADER FEASIBILTY STUDY

TAILINGS STRUCTURES
GENERAL ARRANGEMENT

SMRC PROJECT NO.	DRAWING NO.
PC-2012-01	S-1
DESIGN BY: JI	
DRAWN BY: RC	
CHECKED BY:	SHEET: 1 OF 5

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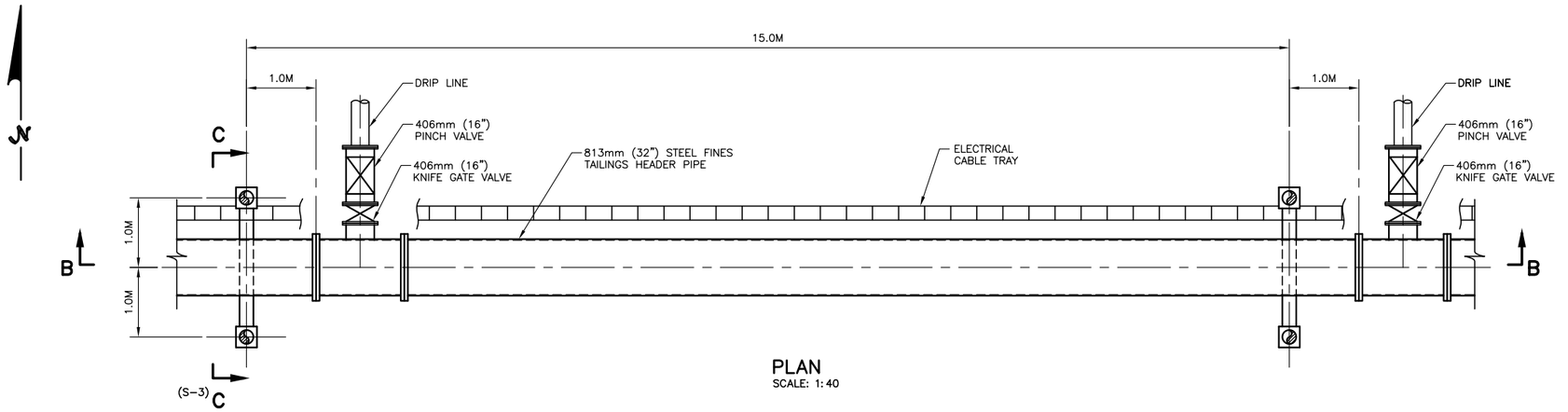

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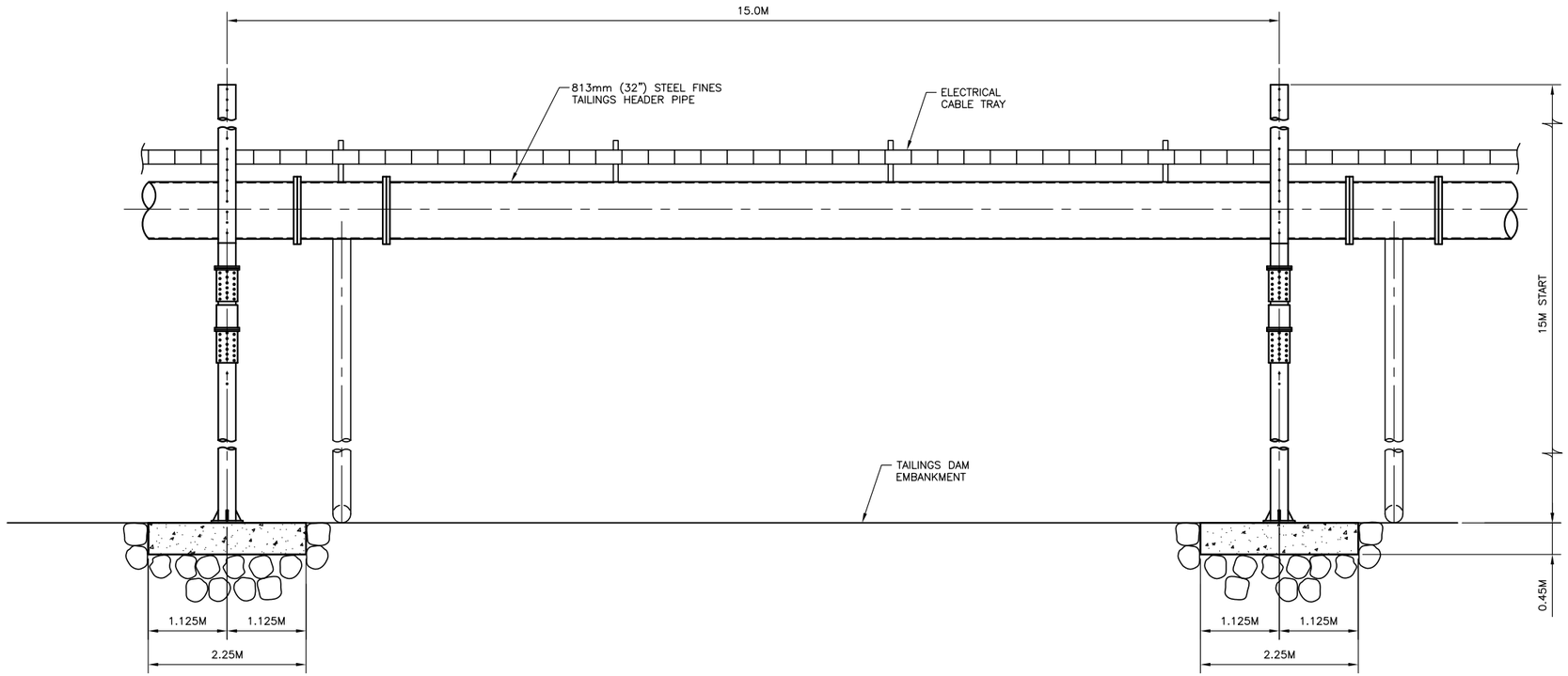

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0 1M 2M

SCALES ARE FULL SIZE,
SCALE ACCORDINGLY

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CASINO JACKING HEADER FEASIBILTY STUDY

FINES TAILINGS DISTRIBUTION HEADER
PLAN AND SECTION

SMRC PROJECT NO.	DRAWING NO.
PC-2012-01	S-2
DESIGN BY: JI	
DRAWN BY: RC	
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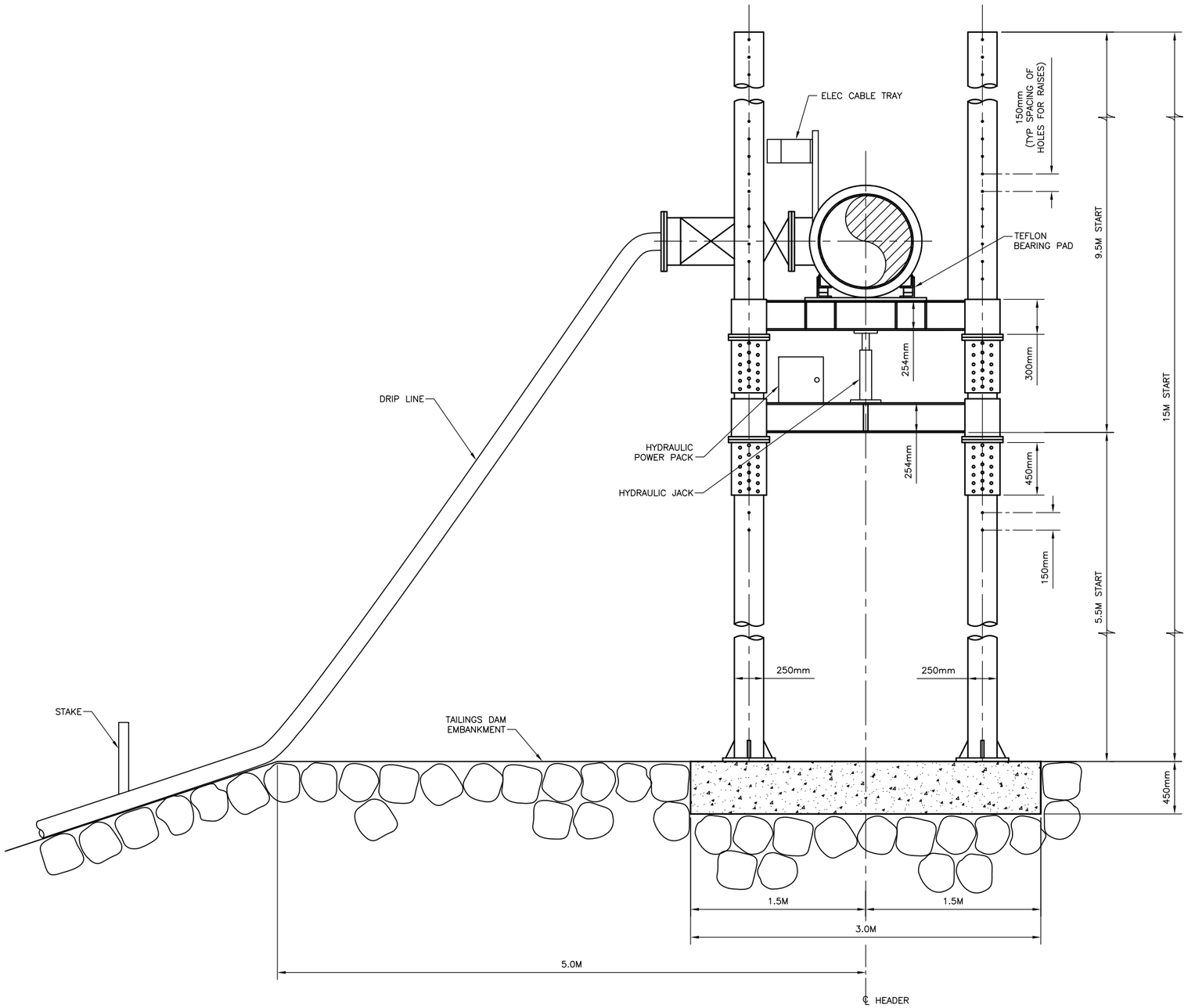

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SMRC PROJECT NO. PC–2012–01
DESIGN BY: JI
DRAWN BY: RC
CHECKED BY:
DRAWING NO. S–3
SHEET: 3 of 5

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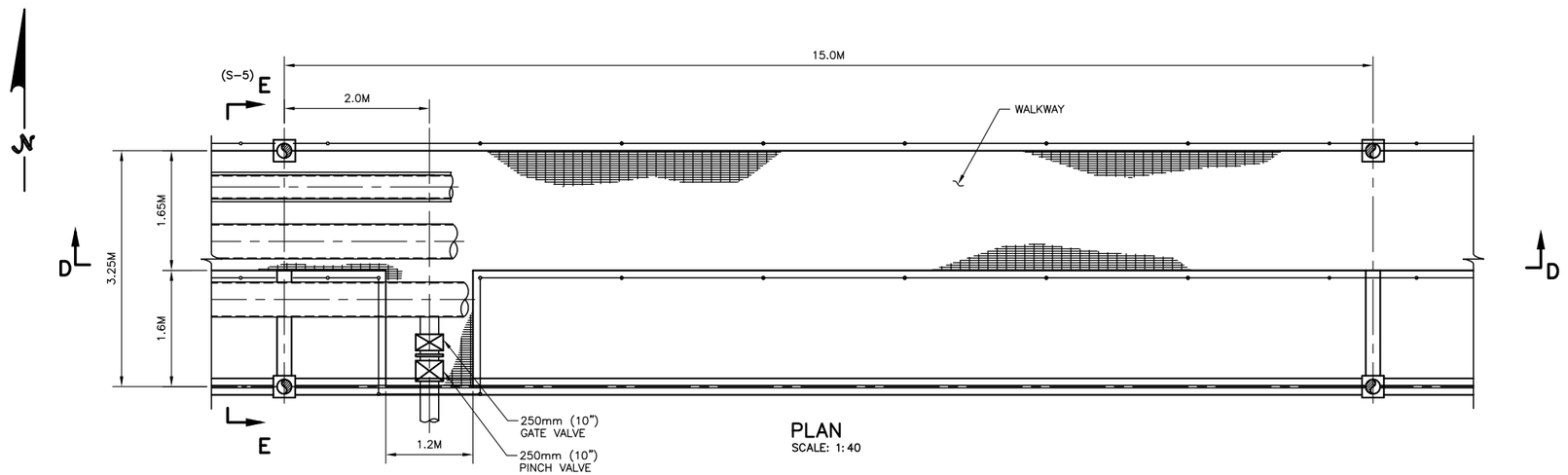

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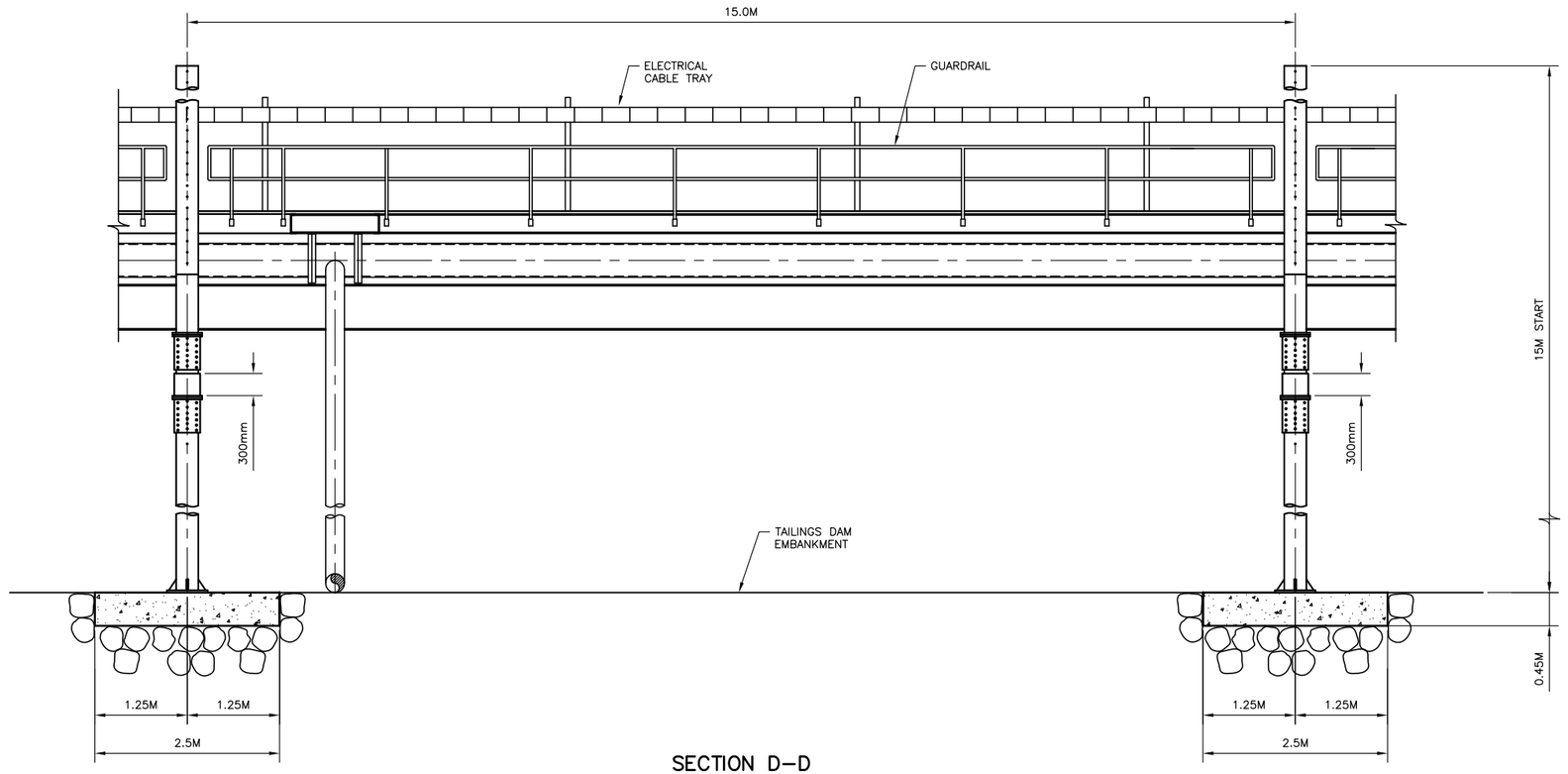

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CASINO JACKING HEADER FEASIBILTY STUDY

SAND TAILINGS DISTRIBUTION HEADER
PLAN AND SECTION

SMRC PROJECT NO.	DRAWING NO.
PC-2012-01	S-4
DESIGN BY: JI	
DRAWN BY: RC	
CHECKED BY:	SHEET: 4 OF 5

Page 49 of 193

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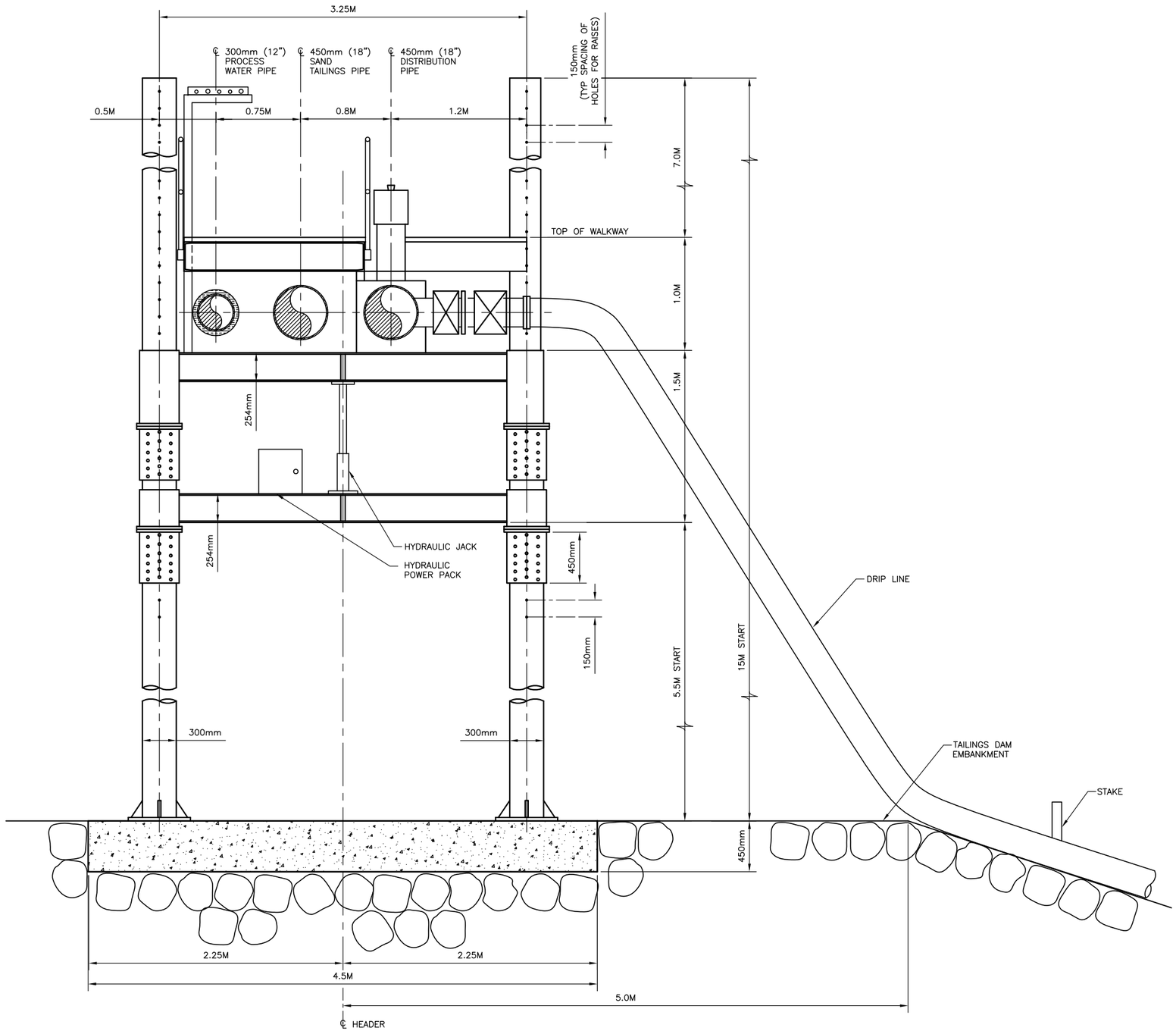

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0 1M 2M
SCALES ARE FULL SIZE, SCALE ACCORDINGLY

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SAND TAILINGS DISTRIBUTION HEADER SECTION

SMRC PROJECT NO.	DRAWING NO.
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DESIGN BY: JI	
DRAWN BY: RC	
CHECKED BY:	SHEET: 5 of 5

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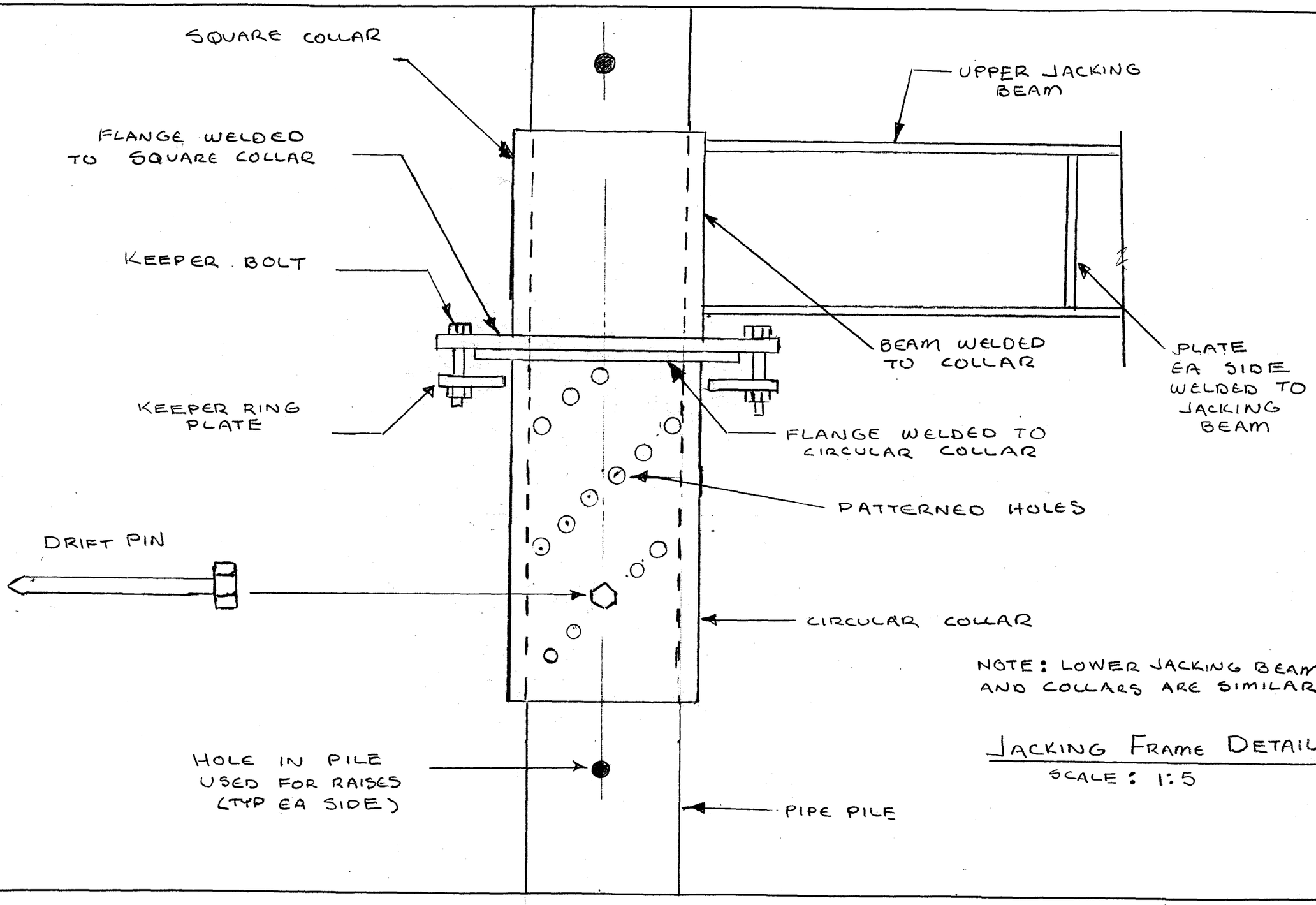

NOTE: LOWER JACKING BEAM AND COLLARS ARE SIMILAR

JACKING FRAME DETAIL

SCALE: 1:5

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CASINO PROJECT

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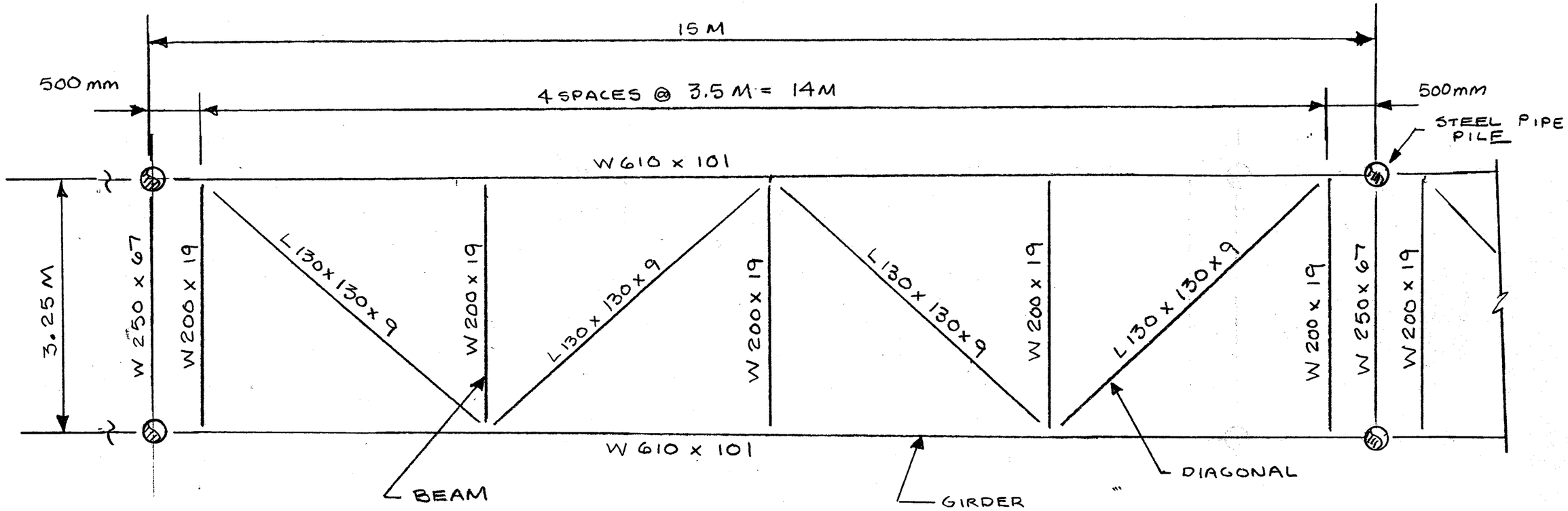
JACKING FRAME

SHEET 1



STEEL FRAMING PLAN

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CASINO PROJECT
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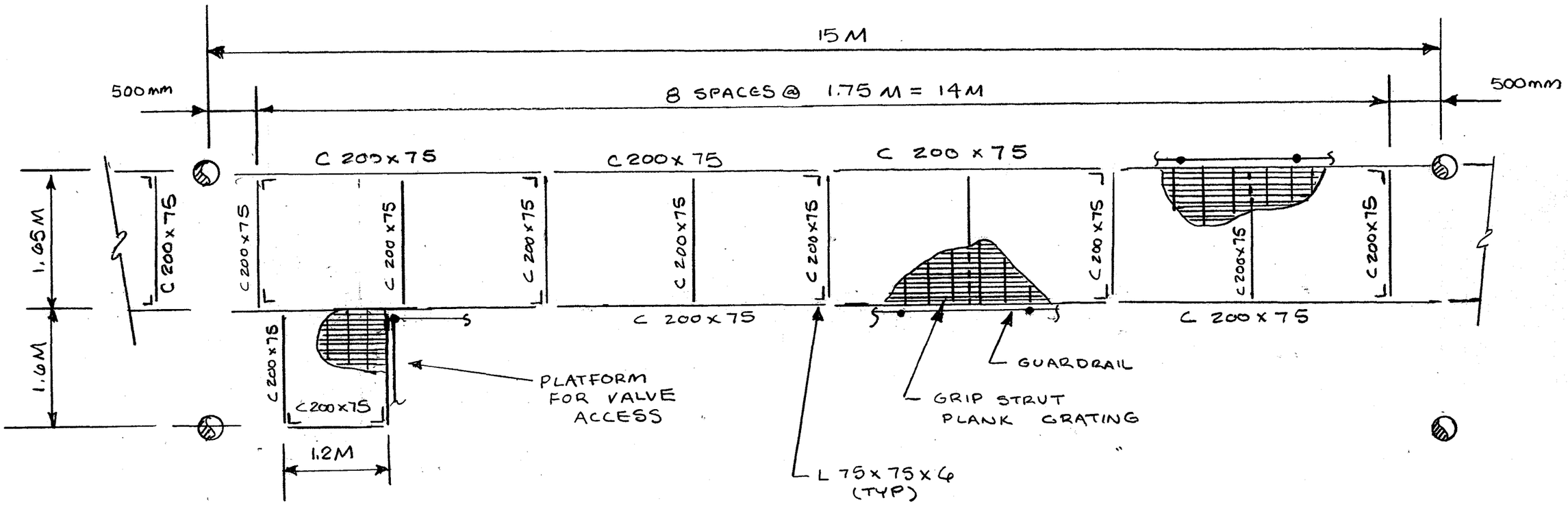
SAND TAILINGS JACKING STRUCTURE
SHEET 2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500mm
8 SPACES @ 1.75 M = 14M
500mm
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C 200 x 75
1.65M
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APPENDIX H – CYCLONE U/F PIPELINE MATERIAL SECTION – VALUE ENGINEERING

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Attention: Sanne Brinkman		*Tel No: +1 (604) 687-7706*
E-mail address: sbrinkman@knightpiesold.com		*Email: Mazyar.Jalayer@PatersonCooke.com*
Date: October 1st, 2012		*Page 1 of 5*
File: Docs/P&C	*Circulation: RC, YK, CK, SB*	*Reference: KPV-5277 Z02 Rev A*

Dear Sanne

U/F PIPELINE MATERIAL SELECTION, VALUE ENGINEERING

1. INTRODUCTION

This report outlines the result of a value engineering study for selecting optimal cyclone underflow pipeline configuration and materials.

The cyclone underflow pipeline delivers cyclone sand to the tailings embankment. The pipeline is located on a steep slope and is routed from cyclone plant to the jacking structure. Due to the substantial elevation difference between the jacking structure and the cyclone plant, up to 600m pipeline upper section will be operating under slack flow.

Velocity in the slack flow section is estimated to be around 10-11m/s. These high velocities will cause the pipeline to wear quickly. This section of pipeline needs to be replaced often. P&C identified the cost of pipeline maintenance and replacement to be significant especially in the northern climate.

To reduce pipeline maintenance and replacement cost, P&C propose two technologies which will remedy the problem:

(i) Ceramic orifice plate places along the pipeline to increase pipeline back pressure and limit the slack flow to a short section of pipeline
(ii) Ceramic lined pipe to combat pipeline wear due to high slack flow velocities.

1.1 Document Distribution, Revision and Approval History

Rev	Date	Distribution/ Revisions	Prepared	Reviewed	Client
A	1st Oct 2012	Issued for Review	MJ	YK	-

2. ASSUMPTION

P&C's wear database is used to estimate wear rates based on collected data of various mine sites. The collected data is scaled based on similar applications and particle characteristics. Using particle energy scaling method a wear rate of 9.165mm/1000hr was determined.

The following table summarizes the basis of design used for the value engineering. Due to substantial wear carbon steel (CS) sch 80 pipeline is used for the slack flow section. The pipe is allowed to wear down to 5mm and can be rotated twice before it has to be replaced.

Item	Value / Description	Source / Comments
Pipe size for slack flow section	18" CS sch 80	P&C selection
Pipe outside diameter	0.4572 m	Pipe standard
Pipe thickness	23.83 mm	Pipe standard
Min wear thickness	5 mm	P&C assumption
No. pipe rotation	2	P&C assumption
No. times pipe replaced	1.6 x per year	Calculated from 9.165mm/1000hr
Pipe rotation per year (9 months)	3.2 x per year	Calculated from 9.165mm/1000hr
Days between rotations	90 days	Calculated from 9.165mm/1000hr
18" sch 80 pipe material cost	$ 710.00 /m	P&C assumption
18" sch 80 installation cost	$ 290.00 /m	P&C assumption
18" sch 80 pipe rotation cost	$ 355.00 /m	P&C assumption
18" sch 10 installation cost	$ 167.00 /m	P&C assumption
18" sch 10 pipe rotation cost	$ 205.00 /m	P&C assumption
18" sch 10 w/ceramic liner Cost	$ 2185.00 /m	Vendor pricing
Ceramic choke	$ 21450 Each	Vendor pricing
Ceramic choke maintenance cost	10% of CAPEX	P&C assumption
Discount rate	8%	KP

For the purposed of this value engineering exercise only cost associated with the pipe section operating under slack flow will be analyzed. Pressurized pipe or pipe operating under full pipe flow will not be operating at high velocities and are subject to normal wear and using ceramic liners or chokes is not required.

3. OPTION NO. 1: NO ORIFICES, NO CERAMIC LINING

Option one is the primary basis for evaluating other options. In this option CS schedule 80 pipe is installed on the slack flow section. The pipe is allowed to wear down to 5mm after which it is

rotated and eventually replaced with a new pipe. Section of pipe is under slack flow will be up to year five of operation. The cost of installation, rotation and replacement are significant.

Table I shows the estimated CAPEX and OPEX for the 600m sch 80 pipe. The length of the pipe decreases with each subsequent year as result of rising dam elevation. The pipeline will no longer operate under slack flow after year 5. The NPV value is estimated to be $ 4,131,040.

Table I: OPEX and CAPEX for option No. 1

Year	Replaced Pipe Length	Pipe Installation Cost	Pipe Material Cost	Pipe Rotation Cost	Cost of Chokes	Total Cost
Year 0	600.0 m	$ 278,206	$ 681,125	$ 681,125	-	$ 1,640,457
Year 1	480.0 m	$ 222,565	$ 544,900	$ 544,900	-	$ 1,312,366
Year 2	360.0 m	$ 166,924	$ 408,675	$ 408,675	-	$ 984,274
Year 3	240.0 m	$ 111,282	$ 272,450	$ 272,450	-	$ 656,183
Year 4	120.0 m	$ 55,641	$ 136,225	$ 136,225	-	$ 328,091
Option No. 1 NPV						$ 4,131,040

4. OPTION NO. 2: ORIFICES INSTALLED, NO CERAMIC LINING

In option 2, the slack flow is controlled by placing ceramic orifices along the pipeline. These orifices are evenly place along the pipeline and are removed periodically in subsequent years. This allows slack flow to be limited to 250m of pipeline without backing up the flow which will cause the underflow collection box to over flow. It is estimated that the 10 chokes will be installed at year 0. Each choke will drop the head by 8 meters for a total of 80 meter of energy dissipation.

Table II shows the estimated CAPEX and OPEX for the 250m sch 80 pipe. The length of the pipe decreases with each subsequent year as result of rising dam elevation. The pipeline no longer operates under gravity flow after at five. All chocks will be removed at year five. The NPV value is estimated to be $ 1,985,660.

Table II: OPEX and CAPEX for option No. 2

Year	Replaced Pipe Length	Pipe Installation Cost	Pipe Material Cost	Pipe Rotation Cost	Cost of Chokes	Total Cost
Year 0	250.0 m	$ 115,919	$ 283,802	$ 283,802	$ 214,500	$ 898,024
Year 1	200.0 m	$ 92,735	$ 227,042	$ 227,042	$ 21,450	$ 568,269
Year 2	150.0 m	$ 69,552	$ 170,281	$ 170,281	$ 21,450	$ 431,564
Year 3	100.0 m	$ 46,368	$ 113,521	$ 113,521	$ 21,450	$ 294,860
Year 4	50.0 m	$ 23,184	$ 56,760	$ 56,760	$ 21,450	$ 158,155
Option No. 2 NPV						$ 1,985,660

5. OPTION NO. 3: NO ORIFICES, CERAMIC LINED PIPE INSTALLED

Option 3 utilizes ceramic lined pipe which are wear resistant in up to 30m/s slurry velocity. It is assumed that this pipe will last the life of the project without any replacement of rotation. In this option choke are not used and the slack flow and ceramic pipe length are estimated to be 600m.

Table III shows the estimated CAPEX and OPEX for the 600m CS 18 inch schedule 10 pipe lined with 6mm of IMATECH IMCM Ceramic Reinforced Polymer Composite. The NPV value is estimated to be $ 1,306,667.

Table III: OPEX and CAPEX for option No. 3

Year	Replaced Pipe Length	Pipe Installation Cost	Pipe Material Cost	Pipe Rotation Cost	Cost of Chokes	Total Cost
Year 0	600.0 m	$ 100,200	$ 1,311,000	-	-	$ 1,411,200
Year 1	-	-	-	-	-	-
Year 2	-	-	-	-	-	-
Year 3	-	-	-	-	-	-
Year 4	-	-	-	-	-	-
Option No. 3 NPV						$ 1,306,667

6. OPTION NO. 4: ORIFICES INSTALLED, CERAMIC LINED PIPE INSTALLED

In option four both technologies are utilized. Slack flow is controlled by placing ceramic orifices along the pipeline. These orifices limit the pipeline wear to 250 meter section of pipe. 18 inch CS schedule 10 Pipe lined with 6mm of IMATECH IMCM Ceramic Reinforced Polymer Composite is used for the 250 meter pipe section operating at high slack flow velocities.
Table IV shows the estimated CAPEX and OPEX for the 250m pipe section. The NPV value is estimated to be $ 808,838.

Table IV: OPEX and CAPEX for option No. 4

Year	Replaced Pipe Length	Pipe Installation Cost	Pipe Material Cost	Pipe Rotation Cost	Cost of Chokes	Total Cost
Year 0	250.0 m	$ 41,750	$ 546,250	-	$ 214,500	$ 802,500
Year 1	-	-	-	-	$ 21,450	$ 21,450
Year 2	-	-	-	-	$ 21,450	$ 21,450
Year 3	-	-	-	-	$ 21,450	$ 21,450
Year 4	-	-	-	-	$ 21,450	$ 21,450
Option No. 4 NPV						$ 808,838

7. RECOMMENDATION

Figure 1 shows the net present value (NPV) for the four options.

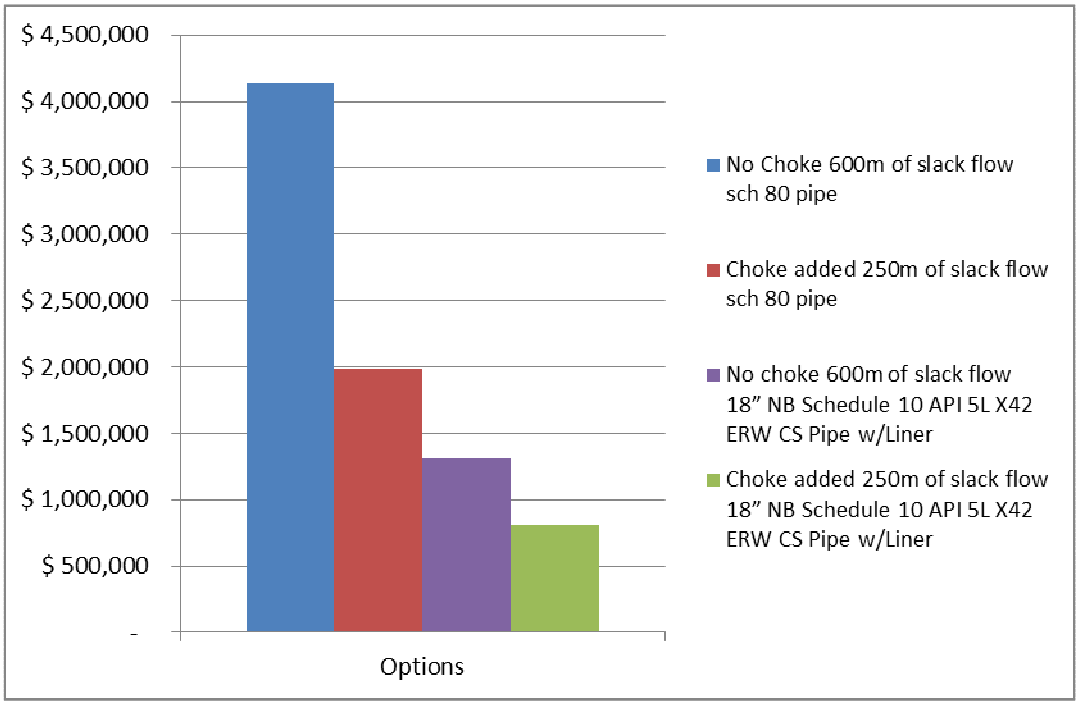


Figure 1 – NPV Compression between the Options

P&C recommends Option #4 – chokes and ceramic lined pipe. This option represents lowest NPV for the project.

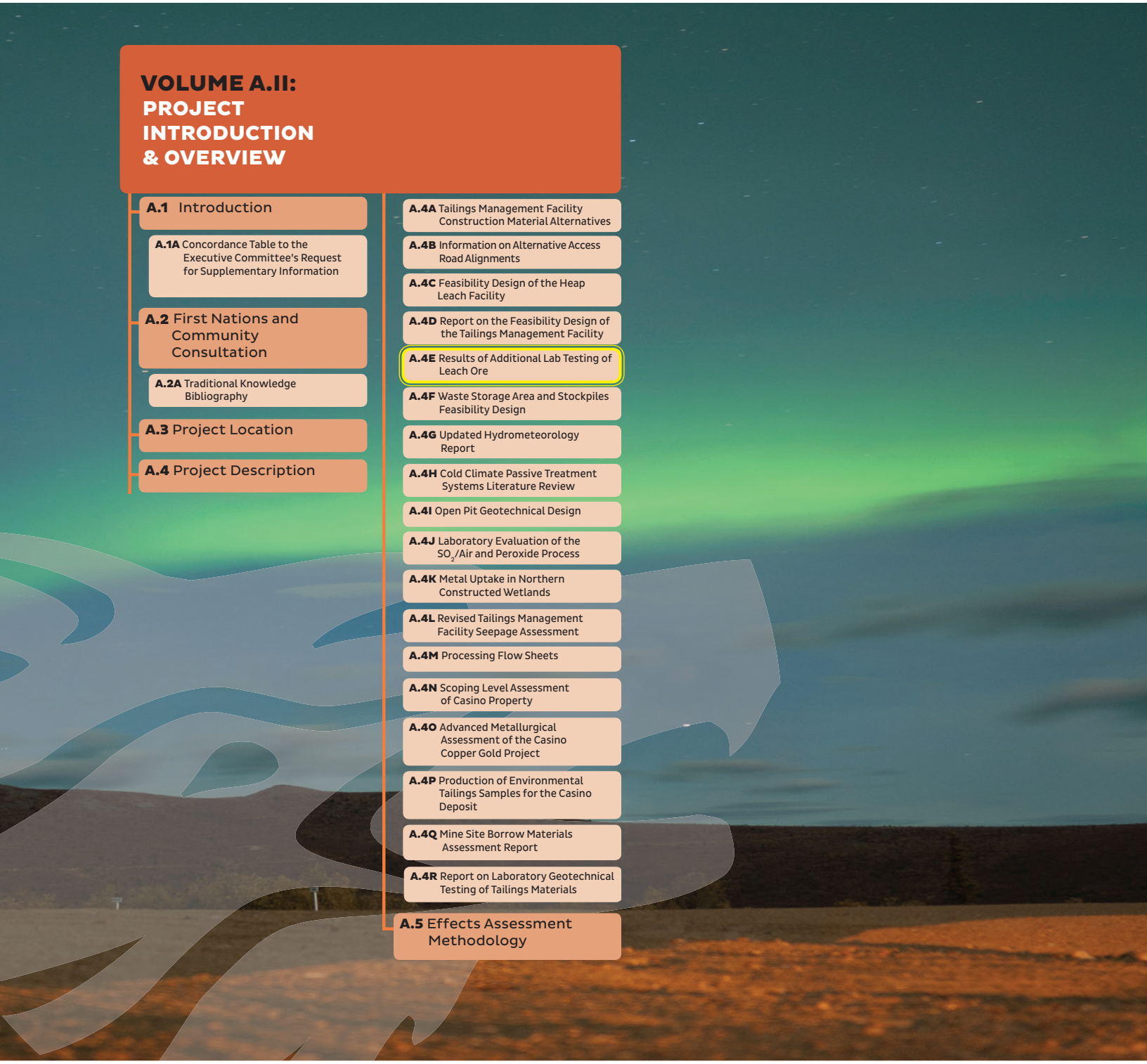
In this option, using 10 chokes will allow control and limit the slack flow only to first 250 meters of sand pipeline. P&C also recommend installing ceramic lined pipe on the 250 meters exposed to slack flow to further reduce maintenance cost and pipeline downtime.

Yours sincerely
Sent via email

Mazyar Jalayer
Project Engineer

Yarek Koziura
Project Manager

APPENDIX A.4E: Results of Additional Lab Testing of Leach Ore



CASINO PROJECT

COLUMN LEACH STUDY ON GOLD COMPOSITE SAMPLE

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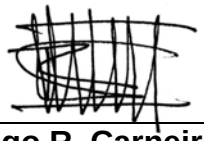

Rodrigo R. Carneiro, MS.
METCON Research Director

Document No. Q709-02-028
METCON Project No. M-709-02
May 2012

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2.1 Sample Preparation and Head Assay 2
2.2 Bottle Roll Testing 4
2.2 Open Cycle Column Leach Study 5

3.0 CONCLUSIONS AND RECOMMENDATIONS 7

4.0 ATTACHMENTS

Attachment 1 - Bottle Roll Testing
Attachment 2 - Column Leach Testing

1.0 INTRODUCTION

In October 2008, drill core samples from el Casino Project were received at METCON Research (METCON). These samples were air dried and prepared for a preliminary column leach study conducted at the METCON facility in Tucson, Arizona. The scope of the metallurgical study conducted included;

- Sample Preparation
- Head Assay Screen Analysis
- Bottle Roll Testing
- One Open Cycle Column Leach Test

The main objective of the column leach study was to determine the amenability of this composite sample to gold and silver extraction by heap leach type of leaching process. A secondary objective was to produce pregnant solutions and residues to be evaluated in an environmental impact study. The first 15 days of pregnant solution and the final leach residue were sent to a different laboratory per client's request.

The testing procedures utilized in the Casino project column leach test program are standard leach procedures and are common and acceptable in industrial practice. The metallurgical study was directed by Francisco A. Garcia and supervised by METCON personnel.

2.0 SUMMARY

A bottle roll test and one open cycle column leach test were conducted on a composite identified as Gold Composite No. 2. The primary objective of this test program was to generate gold and silver extraction, cyanide and calcium oxide consumption data on composite sample from the Casino Project. The data developed and metallurgical results obtained on this study are summarized in the following paragraphs.

2.1 Sample Preparation and Head Assay

On 30 October, 2009, approximately 137 kilograms of drill core samples were received at METCON facilities from EL Casino project. The drill core samples received were weighted and classified according to the identification on samples. Log in data was sent to the client to verify weights and samples identification. Table 1 summarizes the log in samples received.

Table 1
Summary of Samples Received at METCON

Sample ID	Interval (m)		Weight (kg)
	From	To	
HOLE: CAS-002	4.20	24.38	42.40
HOLE: CAS-003	1.40	24.38	37.00
HOLE: CAS-009	16.76	37.70	14.32
HOLE: CAS-011	23.00	44.00	38.84
HOLE: CAS-019	21.05	27.05	4.54
		Total	**137.10**

All samples received were screened to obtain as received particle size distribution (PSD). Each screen fraction was weighed and kept segregated in plastic bags previously identified with METCON project number, screen size and weight. Table 2 summarizes the as received particle size distribution of all samples combine.

Table 2
Summary of As Received Particle Size Distribution on Gold Composite No.2

NOMINAL OPENINGS			Sample Weights (kg)	Weight Distribution (%)	Retained (%)	Passing (%)
Millimeters	Inches	Tyler Mesh				
50.00	2		4.42	3.25	3.25	96.75
37.50	1.5		58.53	43.00	43.00	57.00
25.00	0.984	1	43.66	32.07	78.31	21.69
19.00	0.748	3/4	7.57	5.56	83.88	16.12
12.50	0.492	1/2	6.03	4.43	88.31	11.69
9.50	0.374	3/8	2.56	1.88	90.19	9.81
6.30	0.248	1/4	2.84	2.09	92.27	7.73
1.70	0.067	10	4.77	3.50	95.78	4.22
M I N U S		10	5.75	4.22	100.00	
TOTALS			**136.13**	**100.00**		

Base on the as received PSD, the sample was stage crush to 100 percent minus 37.5 mm (1.5 inch). Table 3 summarizes the final PSD on Gold Composite 2.

Table 3
Summary of Final Particle Size Distribution on Gold Composite 2

NOMINAL OPENINGS			Sample Weights (kg)	Weight Distribution (%)	Retained (%)	Passing (%)
Millimeters	Inches	Tyler Mesh				
37.50	1.500		0.00	100.00	0.00	0.00
25.00	0.984	1	85.68	63.03	63.03	36.97
19.00	0.748	3/4	15.57	11.45	74.48	25.52
12.50	0.492	1/2	11.05	8.13	82.61	17.39
9.50	0.374	3/8	4.16	3.06	85.67	14.33
6.30	0.248	1/4	4.66	3.43	89.10	10.90
1.70	0.067	10	7.14	5.25	94.35	5.65
M I N U S10			7.68	5.65	100.00	
		Total	**135.94**			

Two test charges of approximately 45 kilograms were split for column testing and head screen assay based on the above particle size distribution. The screen fractions from the head sample test charge was stage crushed to 100 percent minus 1.7 mm and approximately 1,000 grams were split from each screen fraction, pulverized to 100 percent minus 150 microns and approximately 150 grams were split and submitted for gold assay by fire assay/AA finish and silver by Geochem method. The gold, silver and copper analyses on the head sample are summarized in Table 4 below.

Table 4
Summary of Head Screen Assay Analysis

NOMINAL OPENINGS			Sample Weights (kg)	Weight Distribution (%)	Cumulative Weight Retained (%)	Gold			Silver			Copper		
Millimeters	Inches	Tyler Mesh				Assay (g/t)	Content	Distribution (%)	Assay (%)	Content	Distribution (%)	Assay (%)	Content	Distribution (%)
25.0	0.984	1	28.3	62.94	62.94	0.42	0.264	65.20	3.0	1.888	64.84	0.055	345.57	65.68
19.0	0.748	3/4	5.15	11.45	74.40	0.32	0.037	9.04	3.0	0.344	11.80	0.050	56.93	10.82
12.5	0.492	1/2	3.64	8.10	82.50	0.33	0.027	6.59	3.0	0.243	8.34	0.037	30.12	5.72
9.5	0.374	3/8	1.39	3.09	85.59	0.30	0.009	2.29	2.0	0.062	2.12	0.046	14.13	2.69
6.3	0.248	1/4	1.57	3.49	89.08	0.24	0.008	2.07	3.0	0.105	3.60	0.047	16.55	3.15
1.7	0.067	10	2.36	5.25	94.33	0.28	0.015	3.62	3.0	0.157	5.41	0.049	25.72	4.89
M I N U S		10	2.55	5.67	100.00	0.80	0.045	11.19	2.0	0.113	3.89	0.066	37.15	7.06
	TOTALS		44.96	100.00				100.00			100.00			100.00
CALCULATED ASSAY						0.41			2.9			0.053		
COMPOSITE ASSAY (Pulv.)						0.48			3.0			0.053		

The following comments relate to calculated gold, silver and copper analyses conducted on the head composite sample.

- Gold content in the head was 0.41 g/t and approximately 65 percent of the gold contained in the head sample reported to the 1 inch screen fraction.

- Silver content was low with 2.5 g/t and approximately 65 percent of this silver contained in the sample reported to the 1 inch fraction.

2.2 Bottle Roll Test

A minus 10 mesh composite sample was reconstituted based on the final PSD for bottle roll testing. The bottle roll testing was conducted under the following leaching conditions.

- Leach cycle of 48 hours.
- Test charge of 500 grams.
- 33 percent solids.
- 1 g/l of free sodium cyanide in solution.
- pH range of 10.5 to 11.
- Sampling at 3, 6, 24 hours.
- Pregnant solutions submitted for Au, Ag, Cu, pH, free calcium Oxide and sodium cyanide.

The following table summarizes the results obtained in the bottle roll leach test conducted on the gold Composite No. 2.

Table 5
Ambient 48 hr. Bottle Roll Leach Tests

Leach Test No.	NaCN Consumption (kg/tonne)	CaO Consumption (kg/tonne)	Leach Time (hr)	CUMULATIVE EXTRACTION				
				Au %	Ag %	Cu %	Au (g/t)	Ag (g/t)
BR-01	0.71	2.64	**48**	82.35	16.97	54.09	0.32	0.51

The following comments relate to bottle roll testing conducted on gold composite sample No. 2.

- Gold extraction of approximately 82 percent was achieved on the Gold Composite No. 2.

- A low Silver extraction of approximately 17 percent was obtained after 48 hours of leach cycle.

- A low cyanide consumption of 0.71 kg/tonne was observed.

- A high calcium oxide consumption of 2.64 kg/tonne was observed.

- The metallurgical developed on the bottle roll test are included in this report.

2.3 Open Cycle Column Leach Test

One 45 kilograms open cycle column leach tests was conducted at a crush size of approximately 100 percent passing 1.5 inches, Test charge for column test was reconstituted from individual screen fractions in accordance with the particle size distribution and loaded into 6 inch in diameter by 3 meter tall PVC columns. Prior to loading the columns, the calcium oxide consumed (kg/t) in 48 hour bottle roll was added to each test charge. The leaching parameters used in this column leach test are summarized below:

- Approximately 2.64 kg/tonne of calcium oxide was blended into test charge.
- The initial feed solution was prepared by adding reagent grade calcium oxide to Tucson tap water to obtain a solution pH of 11.00 followed by the addition of 1 gram of sodium cyanide per liter of solution. The column was irrigated at a flow rate of 12 liters per hour per square meter.
- Column test was conducted under open cycle type of leaching regime.
- Leach Cycle of 38 days.
- First 15 days of pregnant solution were sent to a Laboratory per client's request.
- All solution samples were assayed for gold, silver, copper, pH and free sodium cyanide and calcium oxide.
- Leach residue was shipped to a different laboratory per client's request.
- Metals extractions obtained in the column leach test are labeled as "Indicated Extraction" since the leached residue sample was not assayed.

The metallurgical data developed after 38 days of leaching are attached to this report. The following table summarizes the metallurgical results obtained in column leach test CL-01.

Table 6
Summary of Column Leach Test Conducted on Gold Composite No. 2

Test No.	Leach Day	Head Assay Screen (g/t)			Indicated Extraction (%)			Reagent Consumption (kg/t)	
		Au (g/t)	Ag (g/t)	Cu (g/t)	Au	Ag	Cu	NaCN	CaO
CL-01	38	0.41	2.9	526	50.45	17.90	18.75	0.40	3.59

The following comments relate to the column leach test conducted on the gold composite No.2.

- Indicated gold extraction of approximately 50 percent was obtained on this column test after 38 days of leach cycle.
- Indicated silver extraction of approximately 18 percent of the total silver contained in the head.
- Indicated copper extraction of approximately 19 percent of the total copper contained in the head.
- Low sodium cyanide consumption of 0.41 kg/t was observed in this composite sample.
- A high calcium oxide consumption of 2.9 kg/t was obtained after 38 days of leach cycle bottle roll test.

3.0 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations are based on the metallurgical data developed under open cycle cyanide column leach testing conducted on gold Composite Sample No. 2.

- Indicated gold extraction of approximately 50 percent was obtained on gold Composite Sample No. 2 after 38 days of leach cycle.
- Indicated silver extraction of approximately 18 percent was obtained.
- Indicated copper extraction of approximately 19 percent was obtained.
- Low sodium cyanide consumption of 0.41 kg/t was observed on this composite sample.
- High calcium oxide consumption of 2.9 kg/t was obtained in the bottle roll test.

4.0 ATTACHMENTS

Attachment 1 - Bottle Roll Testing
Attachment 2 - Column Leach Testing

ATTACHMENT 1

Bottle Roll Data

METCON Research

Standard Cyanide Bottle Leach Test Data Log

OBJECTIVE : **Cyanidation to make a preliminary assessment of gold, silver, and copper extraction**

CLIENT : **Western Copper Corporation**
SAMPLE I.D : **Gold Composite #2**
FEED WEIGHT : **500.00** grams
FEED SIZE : **P_{100} = 10 Mesh**

PROJECT NO : **M-709-02**
DATE BEGIN : **11/23/09**
DATE END : **11/25/09**
TEST No. : **BR-01**

CONDITION AND REAGENTS

OPERATION	SLURRY CONDITIONS						REAGENT ADDITION				PREGNANT SOLUTION ASSAY								
	Volume (liter)	Percent Solids	Leach Period(hr)	pHi/pHf				NaCN (g)	CaO (g)		NaCN (g/l)	CaO (g/l)	pH						
Conditioning	1.000	33.33	0	3.95/10.83					0.98										
Pregnant Solution	1.000	33.33	3	11.01				1.00	0.11		0.76	0.05	10.98						
Pregnant Solution	1.000	33.33	6	10.75				0.24	0.05		0.92	0.03	10.80						
Pregnant Solution	1.000	33.33	24	10.82				0.08	0.22		0.92	0.03	10.82						
Pregnant Solution	0.830		48	10.93							0.84	0.03	10.93						
Wash Solution (2)	0.640										0.24	0.02	10.71						
Cyanide and Lime Consumption (kg/tonne)								0.71	2.64										

REMARKS:
(1) 40 ml Aliquot sample was removed after 3, 6, and 24 hours of leaching
(2) The leach residue was water wash three times (3x200ml)

METALLURGICAL RESULTS

PRODUCT	VOLUME (ml)	WEIGHT (g)	ASSAYS Au (ppm)	Ag (ppm)	Cu (ppm)			CUMULATIVE CONTENT Au (mg)	Ag (mg)	Cu (mg)			CUMULATIVE EXTRACTION (3) Au (%)	Ag (%)	Cu (%)	Au (g/t)	Ag (g/t)	Cu (g/t)
3 hr. Pregnant Leach	1000		0.06	0.16	113			0.0600	0.1600	113.0			30.46	10.70	43.90	0.12	0.32	226.0
6 hr. Pregnant Leach	1000		0.10	0.19	123			0.1000	0.1964	127.5			50.77	13.14	49.55	0.20	0.39	255.0
24 hr. Pregnant Leach	1000		0.14	0.21	129			0.1440	0.2240	138.4			73.11	14.99	53.79	0.29	0.45	276.9
48 hr. Pregnant Leach (4)	830		0.18	0.24	127			0.1622	0.2536	139.2			82.35	16.97	54.09	0.32	0.51	278.4
Wash Solution	640		0.01	0.05	30													
Leach Residue		496.49	0.07	2.50	238			0.0348	1.2412	118.2			17.65	83.03	45.91			
Calc. Head			0.39	2.99	515			0.1970	1.4948	257.4			100.00	100.00	100.00			
Assay Head (5)		500.00	0.41	2.90	526			0.2050	1.4500	263.0								

REMARKS:
(3) Percent extraction based on calculated head (solutions plus leach residue contents)
(4) The 48 hr. pregnant solution metal content includes wash solutions and aliquot samples contents
(5) Composite assay head

ATTACHMENT 2

Column Leach Study

Summary of Results Current Date: 05/15/12

METCON Project No.: M-709-02

Western Copper Corporation

TEST No.: CL-01 CRUSH SIZE : 100% Passing 1-1/2 inch

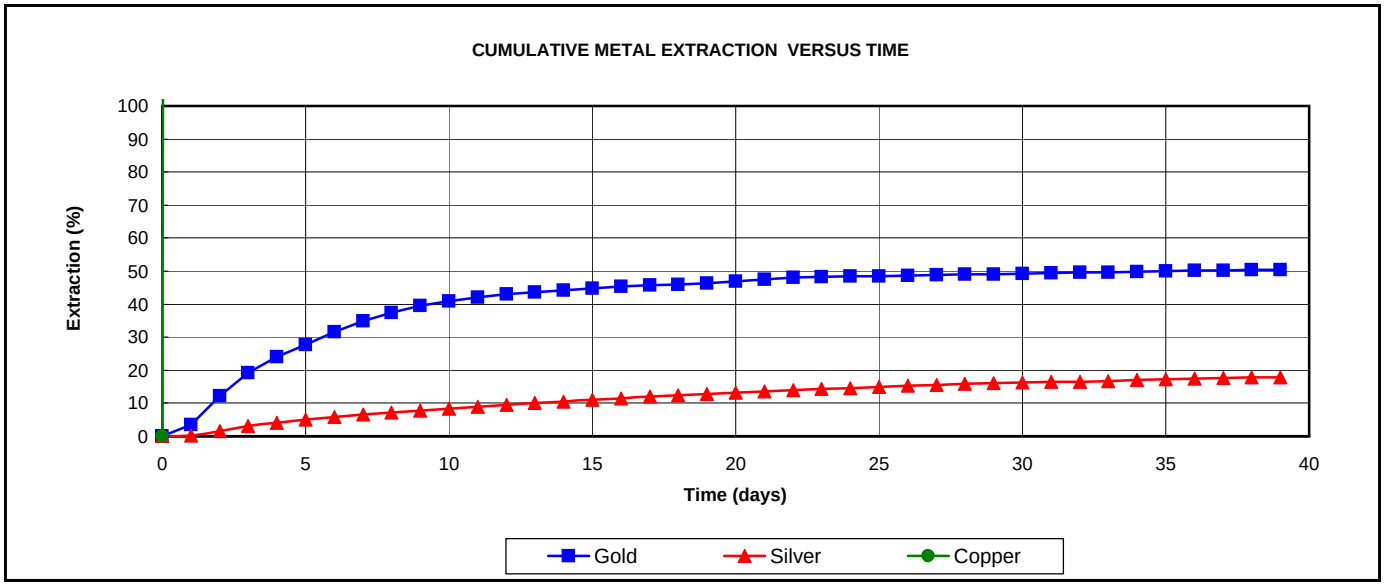
SAMPLE : Gold Composite # 2 CURE DOSAGE : 2.64 kg of CaO/tonne of sample

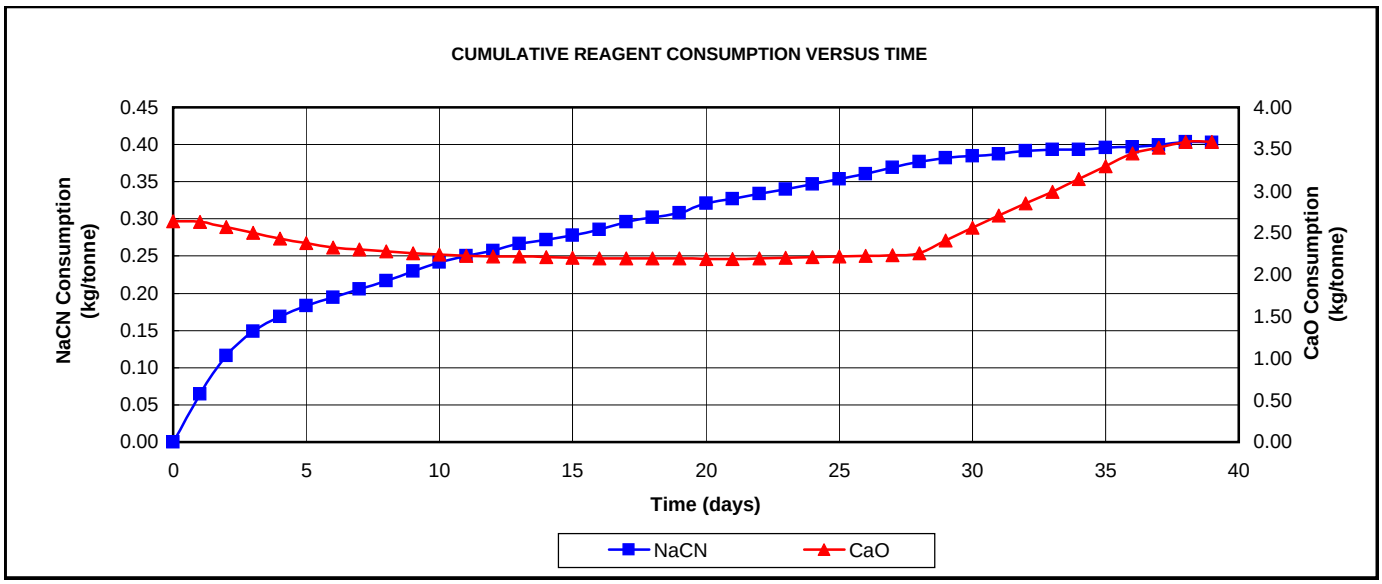
Preliminary Precious Metal Recovery and Reagent Consumption under Open Cycle Leaching

0

Cure Days	None
Leach Days	38
Wash Days	0
Drain Days	1
Total Cycle Days	39

PRODUCTS	Volume (liters)	Weight (kg)	Cumulative										
			Assay (g/tonne)			Contents (mg)			Percent Extraction			Consumption NaCN (kg/tonne)	Consumption CaO (kg/tonne)
			Au	Ag	Cu	Au	Ag	Cu	Au	Ag	Cu		
Feed Solution	206.40		0.00	0.00	0.00	0.00	0.00	0.00	50.45	17.90	18.75	0.40	3.59
Pregnant Solution	202.02		0.05	0.12	21.96	9.20	23.43	4435.99					
Leach Residue		44.90	0.00	0.00	0	0.00	0.00	0.00					
CALCULATIONS													
Metal Extracted			0.20	0.52	98.67	9.20	23.43	4435.99					
Calculated Head			0.20	0.52	0.010	9.20	23.43	4435.99					
Assay Head		44.96	0.41	2.91	0.053	18.23	130.94	23656.4					





METCON Research

TEST No. CL-01

PHYSICAL CHARACTERISTICS SHEET

CLIENT	Western Copper Corporation METCON Project No.: M-709-02	**TEST CONDITIONS**	
		TEST START	12/02/09
SAMPLE	Gold Composite # 2	**COLUMN SIZE**	6 inch diameter by 10 feet tall
		CRUSH SIZE	100% Passing 1-1/2 inch
		LEACH SOLUTION	500 ppm NaCN
OBJECTIVE	Preliminary Precious Metal Recovery and Reagent Consumption under Open Cycle Leaching	**CURE DOSAGE**	2.64 kg CaO/tonne of ore
		CURE CYCLE	0 days
		FLOWRATE	0.005 gpm/sq. ft - 12.22 lph/sq.m

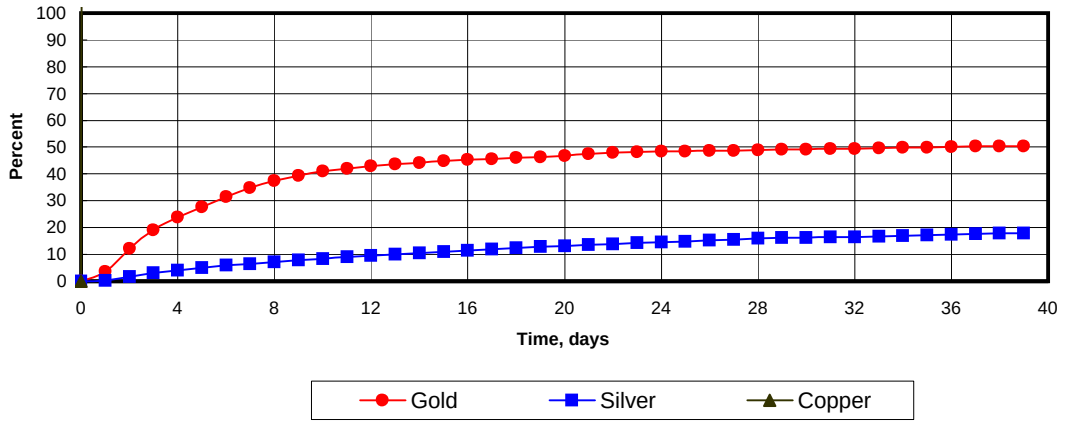
FLOWRATE (lph/sq m)			12.22	
CURE STAGE (days)			None	
COLUMN DIAMETER (mm)			152.40	
ELEMENTS ANALYZED	Au	Ag	Cu	
HEAD ASSAYS (grams per tonne)	0.41	2.9	0	
LEACH RESIDUE ASSAYS (grams per tonne)	0.00	0.0	0	
SAMPLE PERCENT MOISTURE AS RECEIVED (Dry Basis)			0.00	
SAMPLE WEIGHT BEFORE AGGLOMERATION (kg)			44.96	
AGGLOMERATED SAMPLE WEIGHT (kg)			44.96	
INITIAL SAMPLE PERCENT MOISTURE (including agglomeration water)			0.00	(Dry Basis)
INITIAL SAMPLE DRY WEIGHT (kg)			44.96	
INITIAL SAMPLE HEIGHT (m)			1.64	
INITIAL SAMPLE BULK DENSITY (kg/cu m)			1505	(Dry Basis)
FINAL SAMPLE HEIGHT (m)			1.61	
RESIDUE WET WEIGHT (kg)			48.34	
RESIDUE DRY WEIGHT (kg)			44.90	
VOLUME DRAINED (l)			0.72	
SUBSIDENCE (%)			1.94	
MOISTURE UNDER LEACH (%)			9.27	(Dry Basis)
MOISTURE RETAINED (%)			7.66	(Dry Basis)
FINAL SAMPLE BULK DENSITY (kg/cu m)			1532.26	(Dry Basis)

METCON Research

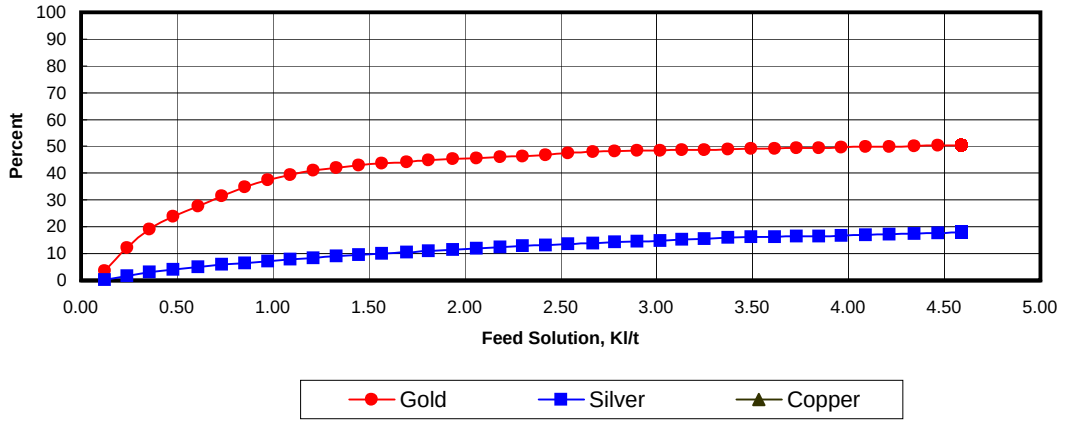
Test: CL-01 — Western Copper Corporation

Sample: Gold Composite # 2 — METCON Project No.: M-709-02

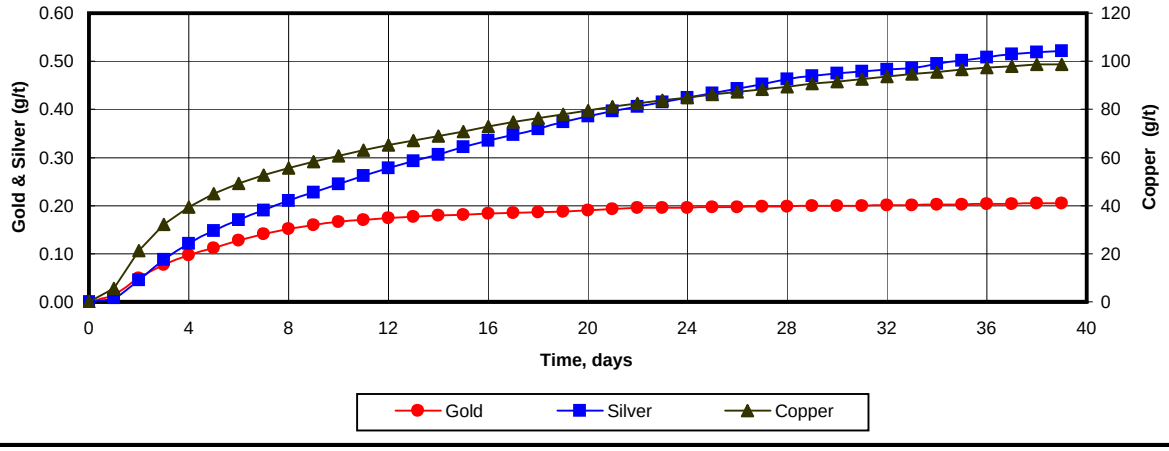
CUMULATIVE METAL EXTRACTION VERSUS TIME



CUMULATIVE METAL EXTRACTION VERSUS FEED SOLUTION (Kl/t)



CUMULATIVE GOLD EXTRACTION VERSUS TIME



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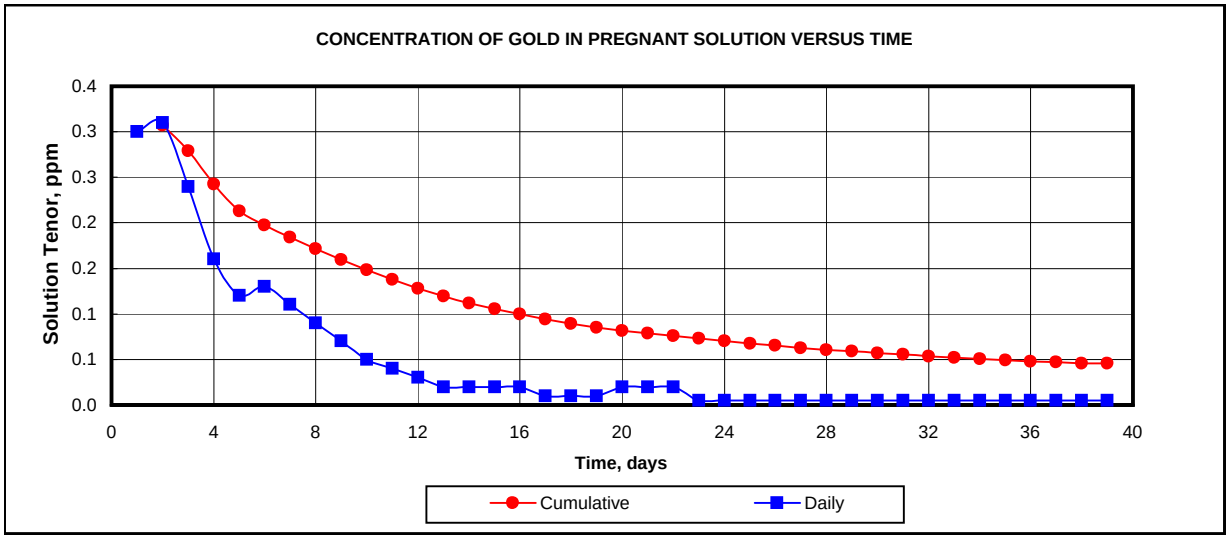
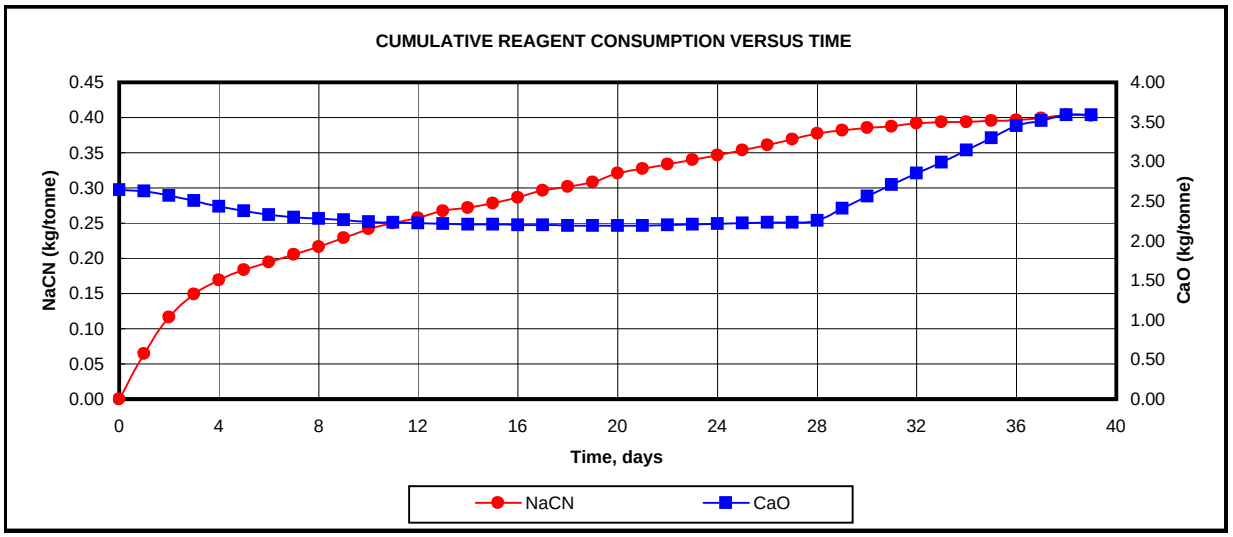
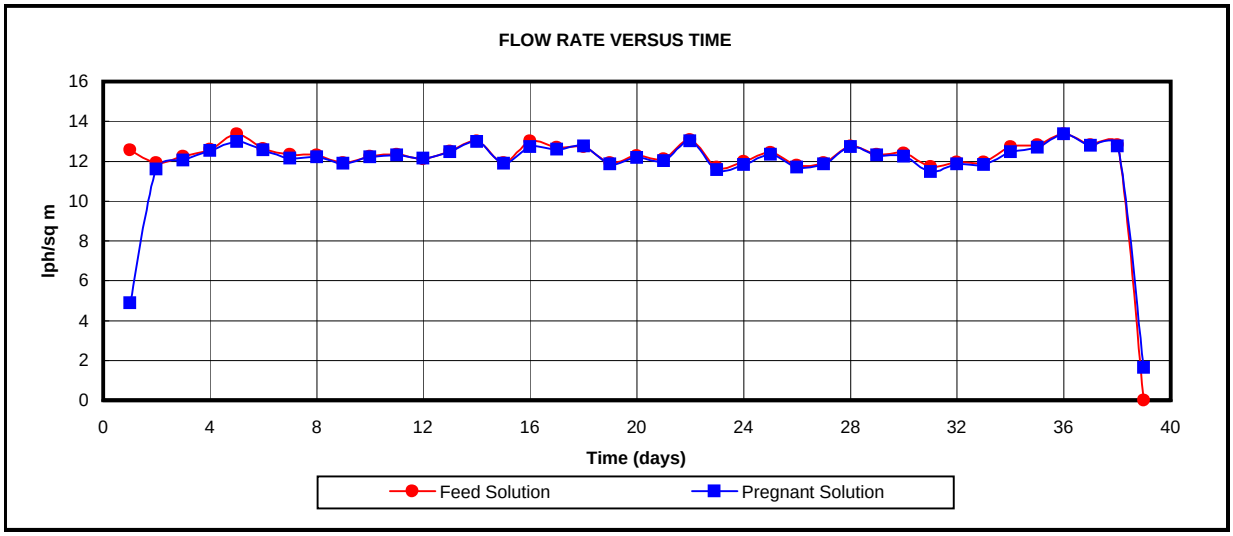
Test: CL-01 — Western Copper Corporation

Sample: Gold Composite # 2 — METCON Project No.: M-709-02







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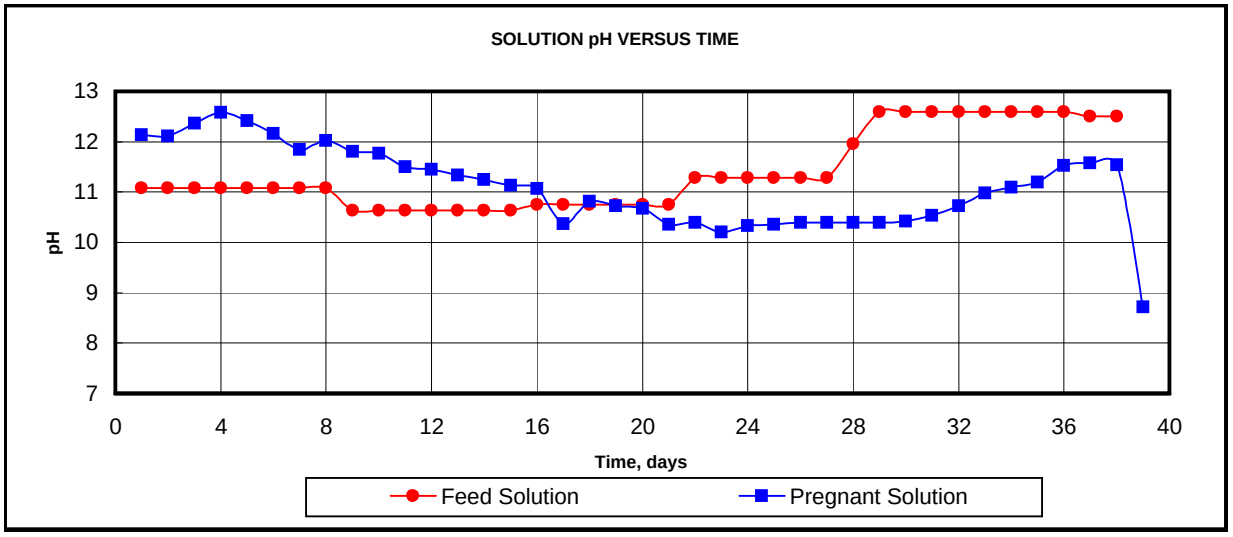
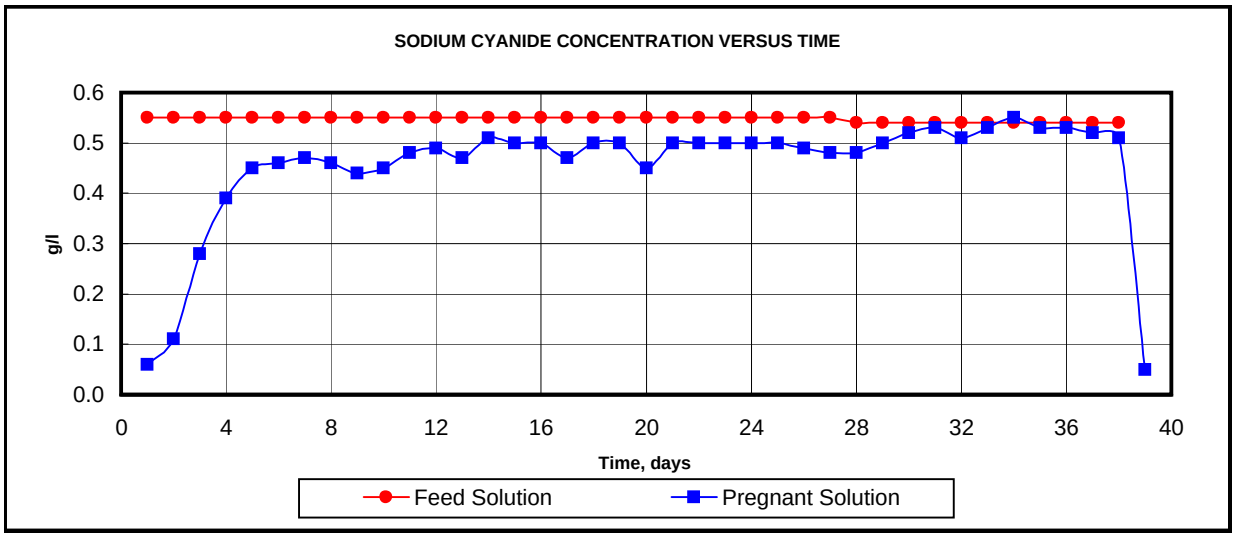
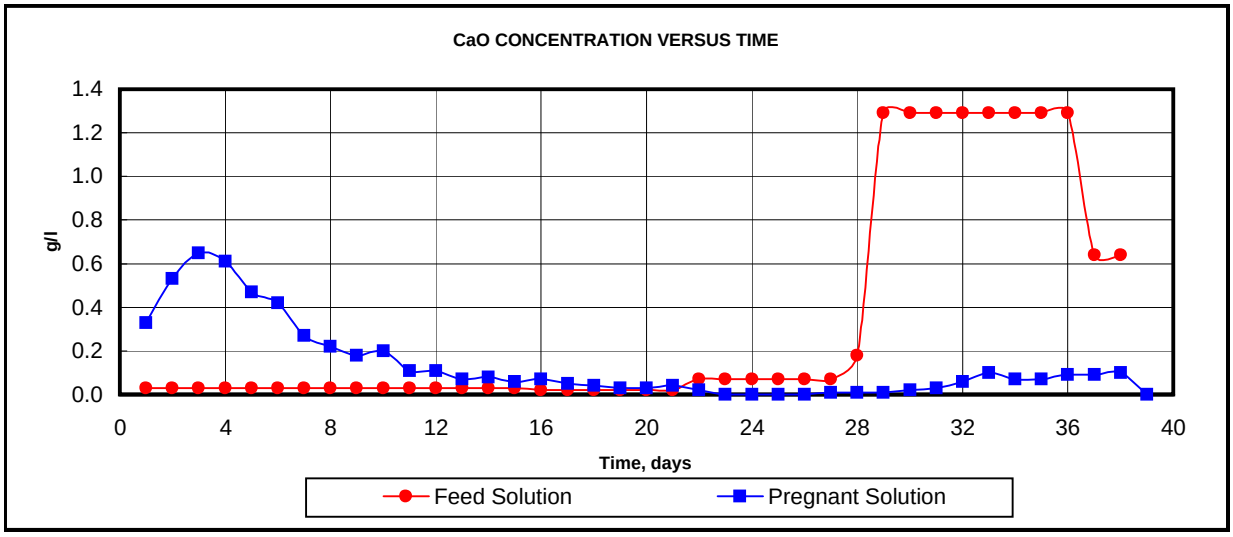
Test: CL-01 — Western Copper Corporation

Sample: Gold Composite # 2 — METCON Project No.: M-709-02







METCON Research
7701 BUSINESS PARK DRIVE
TUCSON , ARIZONA 85743

SCREEN ANALYSIS RESULTS
Western Copper Corporation
METCON Project No.: M-709-02

SCREEN ANALYSIS			Sample: **Column Leach Head CL-01 Gold Composite # 2 100% Passing 1-1/2 inch**											
NOMINAL OPENINGS						Gold			Silver			Copper		
Millimeters	Inches	Tyler Mesh	Sample Weights (kg)	Weight Distribution (%)	Cumulative Weight Retained (%)	Assay (g/t)	Content	Distribution (%)	Assay (g/t)	Content	Distribution (%)	Assay (%)	Content	Distribution (%)
25.0	0.984	1	28.3	62.94	62.94	0.42	0.264	65.20	3.00	1.888	64.84	0.055	0.03	65.68
19.0	0.748	3/4	5.15	11.45	74.40	0.32	0.037	9.04	3.00	0.344	11.80	0.050	0.01	10.82
12.5	0.492	1/2	3.64	8.10	82.50	0.33	0.027	6.59	3.00	0.243	8.34	0.037	0.00	5.72
9.5	0.374	3/8	1.39	3.09	85.59	0.30	0.009	2.29	2.00	0.062	2.12	0.046	0.00	2.69
6.3	0.248	1/4	1.57	3.49	89.08	0.24	0.008	2.07	3.00	0.105	3.60	0.047	0.00	3.15
1.7	0.067	10	2.36	5.25	94.33	0.28	0.015	3.62	3.00	0.157	5.41	0.049	0.00	4.89
M I N U S		10	2.55	5.67	100.00	0.80	0.045	11.19	2.00	0.113	3.89	0.066	0.00	7.06
TOTALS			44.96	100.00				100.00	19.00		100.00			100.00
CALCULATED ASSAY						0.41			2.91			0.053		
COMPOSITE ASSAY (Pulv.)						0.48			3.00			0.053		
COMPOSITE ASSAY (<10 mesh)														

METCON Research

TEST No. CL-01

Data Sheet

CLIENT	Western Copper Corporation	**TEST CONDITIONS**	
	METCON Project No.: M-709-02	**TEST START**	12/02/09
SAMPLE	Gold Composite # 2	**COLUMN SIZE**	6 inch diameter by 10 feet tall
		CRUSH SIZE	100% Passing 1-1/2 inch
		LEACH SOLUTION	500 ppm NaCN
OBJECTIVE	Preliminary Precious Metal Recovery	**CURE DOSAGE**	2.64 kg CaO/tonne of ore
	and Reagent Consumption under Open Cycle Leaching	**CURE CYCLE**	None Days
	0	**FLOWRATE**	12.22 lph/sq m (0.005 gpm/sq ft)

	Pregnant Leach Solution							**Feed Solution**							
		Free			Assays				Free			NaCN	Assays		
Time (Days)	Volume (l)	NaCN (g/l)	CaO (g/l)	pH	Au (ppm)	Ag (ppm)	Cu (ppm)	Volume (l)	NaCN (g/l)	CaO (g/l)	pH	Add/Rem. (grams)	Au (ppm)	Ag (ppm)	Cu (ppm)
Agglom.	0.00	0.00	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0	0.00	0.000	0.000	0.00
1	0.00	0.00	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0	0.00	0.000	0.000	0.00
2	0.00	0.00	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0	0.00	0.000	0.000	0.00
3	0.00	0.00	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0	0.00	0.000	0.000	0.00
Leach 1	2.15	0.06	0.33	12.13	0.30	0.17	118.00	5.52	0.55	0.03	11.08	0.00	0.00	0.00	0.00
2	5.10	0.11	0.53	12.11	0.31	0.33	138.00	5.24	0.55	0.03	11.08	0.00	0.00	0.00	0.00
3	5.24	0.28	0.65	12.37	0.24	0.36	93.00	5.33	0.55	0.03	11.08	0.00	0.00	0.00	0.00
4	5.54	0.39	0.61	12.58	0.16	0.27	59.00	5.57	0.55	0.03	11.08	0.00	0.00	0.00	0.00
5	5.63	0.45	0.47	12.42	0.12	0.21	44.00	5.79	0.55	0.03	11.08	0.00	0.00	0.00	0.00
6	5.51	0.46	0.42	12.16	0.13	0.19	36.00	5.54	0.55	0.03	11.08	0.00	0.00	0.00	0.00
7	5.34	0.47	0.27	11.84	0.11	0.17	29.00	5.43	0.55	0.03	11.08	0.00	0.00	0.00	0.00
8	5.36	0.46	0.22	12.02	0.09	0.16	24.00	5.40	0.55	0.03	11.08	0.00	0.00	0.00	0.00
9	5.18	0.44	0.18	11.80	0.07	0.15	22.00	5.20	0.55	0.03	10.64	0.00	0.00	0.00	0.00
10	5.36	0.45	0.20	11.77	0.05	0.15	21.00	5.38	0.55	0.03	10.64	0.00	0.00	0.00	0.00
11	5.40	0.48	0.11	11.50	0.04	0.14	19.00	5.42	0.55	0.03	10.64	0.00	0.00	0.00	0.00
12	5.32	0.49	0.11	11.45	0.03	0.14	18.00	5.30	0.55	0.03	10.64	0.00	0.00	0.00	0.00
13	5.38	0.47	0.07	11.34	0.02	0.12	17.00	5.40	0.55	0.03	10.64	0.00	0.00	0.00	0.00
14	5.74	0.51	0.08	11.25	0.02	0.11	15.00	5.75	0.55	0.03	10.64	0.00	0.00	0.00	0.00
15	5.18	0.50	0.06	11.13	0.02	0.13	16.00	5.20	0.55	0.03	10.64	0.00	0.00	0.00	0.00
16	5.57	0.50	0.07	11.07	0.02	0.11	16.00	5.70	0.55	0.02	10.75	0.00	0.00	0.00	0.00
17	5.52	0.47	0.05	10.37	0.01	0.10	14.60	5.55	0.55	0.02	10.75	0.00	0.00	0.00	0.00
18	5.56	0.50	0.04	10.81	0.01	0.10	13.70	5.55	0.55	0.02	10.75	0.00	0.00	0.00	0.00
19	5.23	0.50	0.03	10.73	0.01	0.12	13.60	5.26	0.55	0.02	10.75	0.00	0.00	0.00	0.00
20	5.30	0.45	0.03	10.67	0.02	0.10	13.50	5.33	0.55	0.02	10.75	0.00	0.00	0.00	0.00
21	5.26	0.50	0.04	10.36	0.02	0.09	14.00	5.30	0.55	0.02	10.75	0.00	0.00	0.00	0.00
22	5.72	0.50	0.02	10.39	0.02	0.08	11.00	5.75	0.55	0.07	11.29	0.00	0.00	0.00	0.00
23	5.08	0.50	0.00	10.20	0.01	0.08	11.00	5.14	0.55	0.07	11.29	0.00	0.00	0.00	0.00
24	5.18	0.50	0.00	10.33	0.01	0.08	10.30	5.24	0.55	0.07	11.29	0.00	0.00	0.00	0.00
25	5.40	0.50	0.00	10.36	0.01	0.08	9.40	5.45	0.55	0.07	11.29	0.00	0.00	0.00	0.00
26	5.08	0.49	0.00	10.39	0.01	0.08	9.30	5.13	0.55	0.07	11.29	0.00	0.00	0.00	0.00
27	5.22	0.48	0.01	10.39	0.01	0.08	10.20	5.26	0.55	0.07	11.29	0.00	0.00	0.00	0.00
28	5.53	0.48	0.01	10.40	0.01	0.09	9.50	5.55	0.54	0.18	11.96	0.00	0.00	0.00	0.00
29	5.40	0.50	0.01	10.40	0.01	0.05	9.30	5.42	0.54	1.29	12.59	0.00	0.00	0.00	0.00
30	5.42	0.52	0.02	10.42	0.01	0.05	8.30	5.48	0.54	1.29	12.59	0.00	0.00	0.00	0.00

METCON Research

TEST No. CL-01

Data Sheet

CLIENT	Western Copper Corporation	**TEST CONDITIONS**	
	METCON Project No.: M-709-02	**TEST START**	12/02/09
SAMPLE	Gold Composite # 2	**COLUMN SIZE**	6 inch diameter by 10 feet tall
		CRUSH SIZE	100% Passing 1-1/2 inch
		LEACH SOLUTION	500 ppm NaCN
OBJECTIVE	Preliminary Precious Metal Recovery	**CURE DOSAGE**	2.64 kg CaO/tonne of ore
	and Reagent Consumption under Open Cycle Leaching	**CURE CYCLE**	None Days
	0	**FLOWRATE**	12.22 lph/sq m (0.005 gpm/sq ft)

	Pregnant Leach Solution							**Feed Solution**							
		Free			Assays				Free			NaCN	Assays		
Time	Volume	NaCN	CaO	pH	Au	Ag	Cu	Volume	NaCN	CaO	pH	Add/Rem.	Au	Ag	Cu
(Days)	(l)	(g/l)	(g/l)		(ppm)	(ppm)	(ppm)	(l)	(g/l)	(g/l)		(grams)	(ppm)	(ppm)	(ppm)
31	4.99	0.53	0.03	10.53	0.01	0.03	9.60	5.10	0.54	1.29	12.59	0.00	0.00	0.00	0.00
32	5.22	0.51	0.06	10.72	0.01	0.03	7.80	5.28	0.54	1.29	12.59	0.00	0.00	0.00	0.00
33	5.14	0.53	0.10	10.98	0.01	0.03	9.30	5.20	0.54	1.29	12.59	0.00	0.00	0.00	0.00
34	5.54	0.55	0.07	11.09	0.01	0.07	7.70	5.65	0.54	1.29	12.59	0.00	0.00	0.00	0.00
35	5.50	0.53	0.07	11.20	0.01	0.06	7.00	5.55	0.54	1.29	12.59	0.00	0.00	0.00	0.00
36	5.86	0.53	0.09	11.53	0.01	0.05	6.00	5.85	0.54	1.29	12.59	0.00	0.00	0.00	0.00
37	5.54	0.52	0.09	11.57	0.01	0.05	6.00	5.55	0.54	0.64	12.50	0.00	0.00	0.00	0.00
38	5.62	0.51	0.10	11.54	0.01	0.04	5.00	5.65	0.54	0.64	12.50	0.00	0.00	0.00	0.00
39	0.72	0.05	0.00	8.71	0.01	0.11	2.75								
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METCON Research

TEST No. CL-01

METALLURGICAL RESULTS

CLIENT	Western Copper Corporation	**TEST CONDITIONS**		
	METCON Project No.: M-709-02	**TEST START**	12/02/09	
SAMPLE	Gold Composite # 2	**COLUMN SIZE**	6 inch diameter by 10 feet tall	
		CRUSH SIZE	100% Passing 1-1/2 inch	
		LEACH SOLUTION	500 ppm NaCN	
OBJECTIVE	Preliminary Precious Metal Recovery	**CURE DOSAGE**	2.64	kg CaO/tonne of ore
	and Reagent Consumption under Open Cycle Leaching	**CURE CYCLE**	None	Days
	0	**FLOWRATE**	12.22	lph/sq m (0.005 gpm/sq ft)

Time (Days)		Feed Solution Application Flow Rate (lph/sq m)	Feed Solution Application Flow Rate (Kl/t)	Cumulative Extraction (g/tonne) Au	Ag	Cu	Solution Grade (ppm) Au	Ag	Cu	Extraction (%) Au	Ag	Cu	Consumption NaCN (kg/tonne)	CaO (kg/tonne)
Agglom.													0.00	2.64
Rest	1			0.00	0.00	0.00				0.00	0.00	0.00	0.00	2.64
Rest	2			0.00	0.00	0.00				0.00	0.00	0.00	0.00	2.64
Rest	3			0.00	0.00	0.00				0.00	0.00	0.00	0.00	2.64
Leach	1	12.57	0.12	0.01	0.01	5.65				3.54	0.28	10734.35	0.06	2.63
	2	11.93	0.24	0.05	0.05	21.30				12.21	1.56	40485.30	0.12	2.57
	3	12.25	0.36	0.08	0.09	32.14	0.28	0.32	115.68	19.11	3.01	61085.23	0.15	2.50
	4	12.59	0.48	0.10	0.12	39.41	0.24	0.30	98.26	23.98	4.15	74907.20	0.17	2.43
	5	13.36	0.61	0.11	0.15	44.92	0.21	0.28	85.36	27.68	5.05	85369.49	0.18	2.37
	6	12.63	0.73	0.13	0.17	49.33	0.20	0.26	76.04	31.61	5.85	93754.54	0.19	2.33
	7	12.33	0.85	0.14	0.19	52.77	0.18	0.25	68.76	34.83	6.54	100300.76	0.21	2.30
	8	12.29	0.97	0.15	0.21	55.64	0.17	0.24	62.74	37.48	7.20	105738.62	0.22	2.28
	9	11.92	1.09	0.16	0.23	58.17	0.16	0.23	58.06	39.47	7.79	110555.92	0.23	2.26
	10	12.25	1.21	0.17	0.24	60.67	0.15	0.22	54.12	40.94	8.41	115314.04	0.24	2.24
	11	12.34	1.33	0.17	0.26	62.96	0.14	0.21	50.72	42.12	8.98	119651.14	0.25	2.23
	12	12.11	1.45	0.17	0.28	65.09	0.13	0.20	47.87	43.00	9.55	123699.09	0.26	2.22
	13	12.51	1.57	0.18	0.29	67.12	0.12	0.20	45.37	43.59	10.04	127565.28	0.27	2.21
	14	13.00	1.70	0.18	0.31	69.04	0.11	0.19	42.96	44.22	10.53	131204.89	0.27	2.21
	15	11.92	1.81	0.18	0.32	70.88	0.11	0.19	41.16	44.79	11.04	134708.38	0.28	2.20
	16	13.02	1.94	0.18	0.34	72.86	0.10	0.18	39.47	45.40	11.51	138475.65	0.29	2.20
	17	12.68	2.06	0.19	0.35	74.65	0.09	0.18	37.92	45.70	11.93	141882.43	0.30	2.20
	18	12.72	2.19	0.19	0.36	76.35	0.09	0.17	36.49	46.00	12.36	145102.36	0.30	2.19
	19	11.93	2.30	0.19	0.37	77.93	0.08	0.17	35.28	46.29	12.83	148106.20	0.31	2.19
	20	12.26	2.42	0.19	0.39	79.52	0.08	0.17	34.18	46.87	13.24	151127.90	0.32	2.19
	21	12.11	2.54	0.19	0.40	81.16	0.08	0.16	33.21	47.45	13.60	154240.80	0.33	2.19
	22	13.09	2.67	0.19	0.41	82.56	0.08	0.16	32.11	48.08	13.95	156900.55	0.33	2.19
	23	11.70	2.78	0.20	0.42	83.80	0.07	0.15	31.23	48.22	14.26	159262.70	0.34	2.20
	24	11.97	2.90	0.20	0.42	84.99	0.07	0.15	30.36	48.36	14.58	161518.07	0.35	2.21
	25	12.45	3.02	0.20	0.43	86.11	0.07	0.15	29.50	48.51	14.91	163663.79	0.35	2.22
	26	11.80	3.13	0.20	0.44	87.17	0.07	0.15	28.75	48.64	15.22	165660.88	0.36	2.23
	27	11.93	3.25	0.20	0.45	88.35	0.06	0.14	28.06	48.79	15.54	167911.61	0.37	2.23
	28	12.77	3.37	0.20	0.46	89.52	0.06	0.14	27.37	48.94	15.92	170132.36	0.38	2.26
	29	12.34	3.49	0.20	0.47	90.63	0.06	0.14	26.73	49.09	16.12	172255.26	0.38	2.41
	30	12.39	3.62	0.20	0.48	91.64	0.06	0.14	26.09	49.24	16.33	174156.90	0.39	2.56

METCON Research

TEST No. CL-01

METALLURGICAL RESULTS

CLIENT	Western Copper Corporation	**TEST CONDITIONS**	
	METCON Project No.: M-709-02	**TEST START**	12/02/09
SAMPLE	Gold Composite # 2	**COLUMN SIZE**	6 inch diameter by 10 feet tall
		CRUSH SIZE	100% Passing 1-1/2 inch
		LEACH SOLUTION	500 ppm NaCN
OBJECTIVE	Preliminary Precious Metal Recovery	**CURE DOSAGE**	2.64 kg CaO/tonne of ore
	and Reagent Consumption under Open Cycle Leaching	**CURE CYCLE**	None Days
	0	**FLOWRATE**	12.22 lph/sq m (0.005 gpm/sq ft)

Time		Feed Solution Application Flow Rate		Cumulative Extraction (g/tonne)			Cumulative Solution Grade (ppm)			Cumulative Extraction (%)			Consumption	
	(Days)	(lph/sq m)	(Kl/t)	Au	Ag	Cu	Au	Ag	Cu	Au	Ag	Cu	NaCN (kg/tonne)	CaO (kg/tonne)
	31	11.73	3.73	0.20	0.48	92.70	0.06	0.13	25.59	49.37	16.44	176181.89	0.39	2.71
	32	11.97	3.85	0.20	0.48	93.61	0.05	0.13	25.04	49.52	16.56	177903.03	0.39	2.85
	33	11.96	3.96	0.20	0.49	94.67	0.05	0.13	24.57	49.66	16.68	179923.71	0.39	2.99
	34	12.73	4.09	0.20	0.49	95.62	0.05	0.12	24.05	49.81	16.98	181726.95	0.39	3.14
	35	12.82	4.21	0.20	0.50	96.47	0.05	0.12	23.54	49.96	17.23	183354.41	0.40	3.29
	36	13.35	4.34	0.20	0.51	97.26	0.05	0.12	23.00	50.12	17.45	184840.69	0.40	3.45
	37	12.81	4.46	0.20	0.51	98.00	0.05	0.12	22.52	50.27	17.66	186245.81	0.40	3.52
	38	12.82	4.59	0.20	0.52	98.62	0.05	0.12	22.03	50.43	17.84	187433.65	0.40	3.59
Drain	39	0.00	4.59	0.20	0.52	98.67	0.05	0.12	21.96	50.45	17.90	187517.49	0.40	3.59
	40													
	41													
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CASINO MINING CORPORATION
CASINO PROJECT





GEOTECHNICAL LABORATORY TESTING OF LEACH ORE

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VA101-325/16-2
Rev 0
February 17, 2014

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CONSULTING
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CASINO MINING CORPORATION
CASINO PROJECT

GEOTECHNICAL LABORATORY TESTING OF LEACH ORE
VA101-325/16-2

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EXECUTIVE SUMMARY

This report presents the details and findings of a laboratory testing program to determine the geotechnical characteristics of leach ore for the Casino Project. A total of seven samples of leach ore material were provided by Casino Mining Corporation for laboratory testing at the Knight Piésold (KP) laboratory in Denver, Colorado. The samples were processed to gradations representative for the current design crushing process, and one sample was subjected to a leach column and unsaturated column test, prior to shipment to the KP laboratory.

The laboratory program included index tests, saturated hydraulic conductivity tests, and load-percolation tests. Specialized testing to determine the Soil-Water Characteristics Curve (SWCC) was undertaken on three samples at the Daniel B. Stephens and Associates (DBS) laboratory in Albuquerque, New Mexico.

Samples MET-11, MET-17, MET-19 and MET-20, as well as the leached ore sample CL-01, have similar particle size distributions. These samples comprise 85 to 90% gravel, 7 to 12% sand, 4% or less silt, and approximately 1% clay. Sample MET-02 is finer grained with approximately 73% gravel, 22% sand, 3% silt and 1% clay. Sample MET-05 is the finest leach ore material comprising roughly equal amounts of gravel and sand (48 and 45% respectively), 6% silt and 1% clay.

The ore samples are generally competent and exhibit little degradation under loading, although some particle breakage was observed for sample MET-02, which may reduce the hydraulic conductivity. The saturated hydraulic conductivity for the leached sample (CL-01) is lower than other samples with a similar particle size distribution. This may indicate that the leaching process does have some effect on hydraulic conductivity.

However, all test results indicate saturated hydraulic conductivities that are higher than the current design irrigation rate for ore leaching (12 l/hr/m^2, which is equivalent to 3.3×10^{-4} cm/s). This indicates that the proposed heap leach ore will not fully saturate under the design irrigation rate, even at the highest tested normal stress of 2720 kPa, which is equivalent to an approximately 150 m high heap (the maximum design heap height). Sample MET-05 and MET-11 can sustain irrigation rates of at least 10 times the current design rate. Ponding of solution on top of the ore sample due to saturation was observed for sample MET-02 at 120 l/hr/m^2 at the highest normal stress.

The DBS laboratory results indicate saturated hydraulic conductivities that are typically about one order of magnitude lower than the KP results for similar sample density. This can likely be attributed to the difference in the sample preparation method.

The steady state gravimetric moisture contents from the load-percolation tests (5 to 10%) are lower than those predicted from the SWCC (11 to 22%) at the current design irrigation rate of 12 l/hr/m^2.

It is recommended to do additional testing to determine the effect of the leaching process on the different types of ore. It is also recommended that the actual leach solution be used instead of tap water for conducting additional permeability and percolation testing. Additional strength and hydraulic conductivity testing is recommended for samples that are most affected by the leaching process.

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Appendix D SWCC Test Results (D.B. Stephens and Associates Laboratory)
Appendix E Load-Percolation Test Results (Knight Piésold Laboratory)

1 – INTRODUCTION

This report presents the details and findings of a laboratory testing program to determine the geotechnical characteristics of the leach ore for the Casino Project. A total of seven samples of leach ore material were provided by Casino Mining Corporation for laboratory testing at the Knight Piésold (KP) laboratory in Denver, Colorado. The laboratory program included index tests, saturated hydraulic conductivity tests, and load-percolation tests. The index testing was conducted to enable geotechnical classification of the materials. The saturated hydraulic conductivity tests were used to determine the compressibility and saturated hydraulic conductivity of the ore over a wide range of normal loads. The purpose of the load-percolation tests was to determine the behaviour of the material under unsaturated conditions. Results from these tests include the steady state moisture content under leach and the residual moisture content after draindown.

Specialized testing to determine the Soil-Water Characteristics Curve (SWCC) was undertaken on three samples at the Daniel B. Stephens and Associates (DBS) laboratory in Albuquerque, New Mexico. The SWCC relates the ore moisture content with the suction pressure, and defines the moisture holding potential of the ore.

The geotechnical and hydrological properties of the ore depend on the gradation of the material. The current leach ore crushing process has been specified in the feasibility study (M3 Engineering and Technology Corporation, 2013) as follows:

- The ore from run-of-mine (ROM) is reduced to minus 200 mm using a primary gyratory crusher
- The primary crusher discharge is reduced to minus 50 mm through screening and a secondary cone crusher, and
- The secondary crusher discharge passed through a secondary screen with an undersize of 80% passing 1.5” (38 mm).

Six leach ore samples (MET-02, 05, 11, 17, 19, and 20) were sampled in 2013 by excavator from different locations in the deposit area to represent the various types of leach ore. Samples MET-02 and MET-05 comprise Dawson Range Batholith Diorite and Granodiorite. Samples MET-11 and MET-17 consist of intrusive Breccia from the Proctor Mountain Suite, containing Granodiorite, Diorite and metamorphic fragments. The lithology of samples MET-19 and MET-20 is Patton Porphyry from the Proctor Mountain Suite. Details of the sampling are provided in Appendix A. ALS laboratories in Kamloops, B.C. processed the leach ore to gradations representative for the current design crushing process. Approximately 100 kg of each sample was sent to the KP laboratory.

One sample (CL-01) constitutes the residue from a leach column test. This sample is an oxide gold composite comprising varying lithologies. METCON Research (2012) prepared sample CL-01 from approximately 137 kg of drill core samples from select holes drilled in 2008 and 2009. These samples were air dried and crushed to 100 percent minus 37.5 mm (1.5 inch). A subsample of 45 kilograms was used for an open cycle column leach test using a 6 inch in diameter by 3 meter tall PVC column. Prior to loading the columns, approximately 2.64 kg/tonne of calcium oxide was blended into the test charge. The column test was conducted under an open cycle type of leaching regime, using a leach cycle of 38 days. The initial feed solution was prepared by adding reagent grade calcium oxide to Tucson tap water to obtain a solution pH of 11.00 followed by the addition of approximately 1 gram of sodium cyanide per liter of solution. The column was irrigated at a flow rate of 12 liters per hour per square meter, which is the current design solution application rate

(M3 Engineering and Technology Corporation, 2012). The residue after 38 days of leaching was sent to SGS Canada Inc. (SGS) in Burnaby B.C.

SGS conducted an unsaturated column test on the leach residue. Approximately 25 kg of sample was constituted in a 10 cm diameter acrylic column with a pervious base and bottom drain. The column was kept on continuous humid or dry air (as per client request) for six day intervals. One day prior to sampling the air was shut off and nanopure water trickle leached at approximately 1 mL/min. The quantity of nanopure water added was generally 300 to 500 mL providing sufficient leachate for geochemical analysis. After sampling, the bottom drain was closed and humid or dry air was applied until the next sampling day. The test comprised 14 sampling cycles, for a total duration of approximately 3 months. The remaining ore residue was sent to the KP laboratory for geotechnical and hydrological analysis.

2 – INDEX TESTS

2.1 GENERAL

Index testing was carried out on all seven leach ore samples. The Specific Gravity, Atterberg Limits (Plastic and Liquid Limits), and particle size distribution (screen and hydrometer) of the leach ore were determined. These tests provide a measure of the type and condition of the material, specifically the particle density, composition (size and distribution) and plasticity characteristics. Modified Proctor compaction tests were also completed to establish the relationship between moisture content and maximum dry density. The index properties can provide a relationship to material structural properties, including compressibility, hydraulic conductivity and strength.

A summary of the leach ore index test results is presented in Table 2.1. Detailed results of the index tests are included in Appendix B.

Table 2.1 Summary of Leach Ore Index Tests

Sample ID	Specific Gravity	Atterberg Limits			Particle Size Distribution				Modified Proctor Compaction	
		LL	PL	PI	% Gravel	% Sand	% Silt	% Clay	Maximum Dry Density (tonne/m^3)	Optimum Moisture Content (%)
CL-01	2.66	NP	NP	NP	85.0	10.0	4.0	1.0	2.35	5.3
MET-02	2.73	22	21	1	73.0	22.4	3.3	1.3	2.32	5.4
MET-05	2.67	17	NP	NP	48.3	44.5	6.2	1.0	2.01	6.8
MET-11	2.69	19	18	1	89.0	7.5	2.8	0.7	2.46	3.1
MET-17	2.64	24	19	5	84.6	12.2	2.0	1.2	2.31	3.9
MET-19	2.75	NP	NP	NP	88.2	9.5	1.5	0.8	2.35	4.4
MET-20	2.65	NP	NP	NP	86.3	10.3	2.5	0.9	2.31	3.9

NOTES:

1. Laboratory analyses performed at Knight Piésold and Co. Soils Laboratory in Denver, CO.
2. Particle Size Distribution by percent of sample weight.
3. NP = Non Plastic, LL= Liquid Limit, PL = Plastic Limit, PI = Plasticity Index.
4. The weighted average is reported for specific gravity. See detailed lab results for specific gravities of the fractions smaller and greater than 4.75 mm.
5. Modified proctor includes an oversize correction as per ASTM D4718.

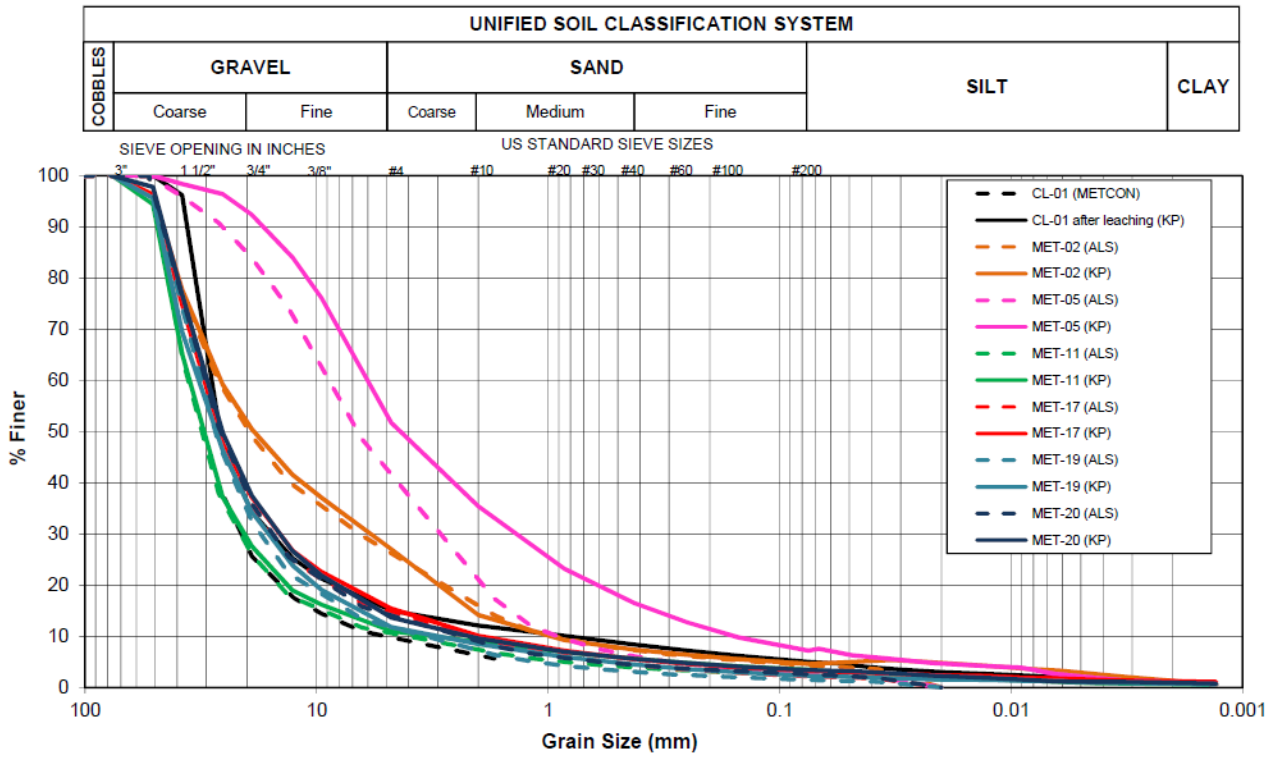
2.2 PARTICLE SIZE DISTRIBUTION

Mechanical sieve and hydrometer particle size analyses were carried out on each of the leach ore samples in accordance with ASTM standard D422 procedures. The hydrometer analysis was used to determine the silt and clay fraction particle sizes.

Samples MET-11, MET-17, MET-19 and MET-20, as well as the leached ore sample CL-01, have similar particle size distributions. These samples comprise 85 to 90% gravel, 7 to 12% sand, 4% or less silt, and approximately 1% clay. Sample MET-02 is finer grained with approximately 73% gravel, 22% sand, 3% silt and 1% clay. Sample MET-05 is the finest leach ore material comprising roughly equal amounts of gravel and sand (48 and 45% respectively), 6% silt and 1% clay.

The particle size distributions of the leach ore samples as received at the KP laboratory are presented on Figure 2.1, as well as gradations provided by ALS and METCON. The gradations of the samples that were not leached (MET-02 through MET-20) were determined by ALS after the crushing process. The particle size distribution for sample CL-01 was obtained by METCON after crushing, but before it was subjected to the leach and unsaturated column tests.

The particle size distributions from most samples as determined by KP are virtually identical to those provided by ALS, except for sample MET-05. The change in gradation for this sample is likely the result of degradation during transport and handling, which may indicate that this material is weaker and more prone to breakage than the other ore types. The particle size distribution of the leached sample (CL-01) as determined by KP is finer than that provided by METCON. The difference for this sample can be attributed to the fact that the METCON gradation was determined for the material before the leach and unsaturated column tests, whereas the KP gradation reflects the sample after these tests (in addition to any degradation due to transportation and material handling).



NOTES:

1. MET-02, MET-05, MET-11, MET-17, MET-19 and MET-20 data provided by ALS in Kamloops, B.C. after crushing, and by KP soil laboratory after transportation to Denver, CO. These samples were collected in 2013 and have not been subjected to leach column testing.
2. CL-01 data provided by METCON in Tucson, AZ. Gradation of the sample before it was subjected to leach column testing by METCON and unsaturated column testing by SGS.
3. CL-01 after leaching data provided by KP soil laboratory in Denver, CO. Gradation of the sample after it was subjected to leach column testing by METCON and unsaturated column testing by SGS.

Figure 2.1 Particle Size Distributions for Leach Ore Samples

2.3 SPECIFIC GRAVITY

The specific gravity of the leach ore material smaller than 4.75 mm (#4 sieve) was determined in accordance with ASTM standard D854. The coarse aggregate specific gravity for material retained on the #4 sieve was determined in accordance with ASTM standard C127. The weighted average of the specific gravity for each leach ore sample ranges from 2.64 to 2.75.

2.4 ATTERBERG LIMITS (PLASTICITY)

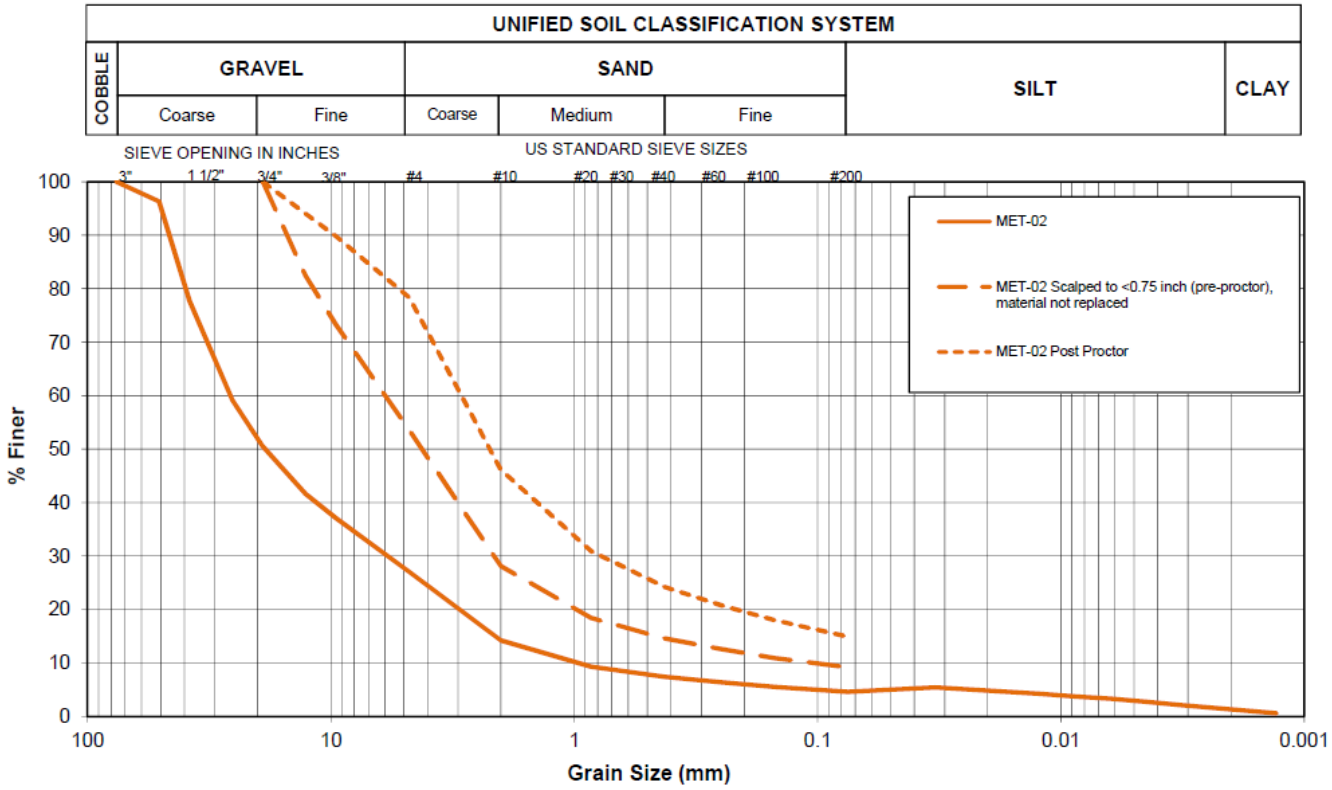
The Atterberg Limits (Plastic and Liquid Limits) of the leach ore samples were determined in accordance with the ASTM standard D4318 test procedure. The Atterberg Limits are only determined for the fraction of the sample smaller than 425 µm (No. 40 sieve). The material is non-plastic to slightly plastic, with a Plasticity Index (PI) of 5 or less.

2.5 MODIFIED PROCTOR (COMPACTION) TESTS

Modified Proctor compaction tests were completed in accordance with ASTM D1557, with oversize correction applied to each point as per ASTM D4718. The material was placed in a 6-inch mould and compacted at several moisture contents. The material greater than 3/4 inch is removed from each sample prior to testing.

The maximum dry density typically ranged from 2.31 to 2.46 t/m^3, except for the sample with the finest gradation (MET-05), which has a maximum dry density of 2.01 t/m^3. The optimum moisture content at which the maximum compaction is achieved varies from 3.1 to 6.8%.

The gradation of sample MET-02 was determined after Proctor testing to investigate the degradation of the material as a result of the compactive effort. The gradation before testing, after removal of the fraction greater than 3/4 inch, and after compaction testing is presented in Figure 2.2. The Proctor test resulted in significant degradation of the leach ore.



NOTES:

1. MET-02 data provided by KP soil laboratory in Denver, CO. This sample was collected in 2013 and has not been subjected to leach column testing.

Figure 2.2 Particle Size Distributions for MET-02 before and after Modified Proctor Test

3 – SATURATED HYDRAULIC CONDUCTIVITY TESTS

3.1 GENERAL

Saturated hydraulic conductivity tests were completed using rigid wall permeameters at both the KP and DBS laboratories. The purpose of the testing at the KP laboratory was to determine the saturated hydraulic conductivity over a range of normal loads. The saturated hydraulic conductivity tests were carried out in the DBS laboratory as part of the SWCC testing, and are discussed in Section 4.

The KP laboratory conducted saturated hydraulic conductivity tests on samples CL-01, MET-02, MET-05 and MET-11 using the constant head method. Sample CL-01 was selected as this sample was subjected to the leaching process during preceding test work. The other samples are considered to be representative of the fine, medium and coarse ore gradations. The tests were completed using an 8-inch rigid wall permeameter following USBR Procedure 5600 and 5605. Material greater than 1.5 inch was removed and replaced with finer gravel.

The material was placed loosely in the mould and tested at normal stresses of 200, 400, 800, 1600 and 2720 kPa.

Sieve analyses were completed on each sample material after the hydraulic conductivity tests to determine if the applied normal stress resulted in degradation of the leach ore (increase of fines content).

3.2 RESULTS AND INTERPRETATION

The results of the saturated hydraulic conductivity tests are summarized in Table 3.1. Detailed test results are included in Appendix C. The compaction of the sample as a result of the applied normal load is presented in Figure 3.1.

A correction is required for high permeability materials to account for head loss in the testing apparatus. A trial test without an ore sample was conducted to determine head loss in the apparatus, and the measured ore hydraulic conductivities were corrected for this head loss. Figure 3.2 shows the saturated hydraulic conductivity test results with and without head loss correction. The sample with the highest hydraulic conductivity (MET-11) requires the largest head loss correction. The results for pressures smaller than 1600 kPa are not reliable for this sample as the head losses in the apparatus exceed the applied heads.

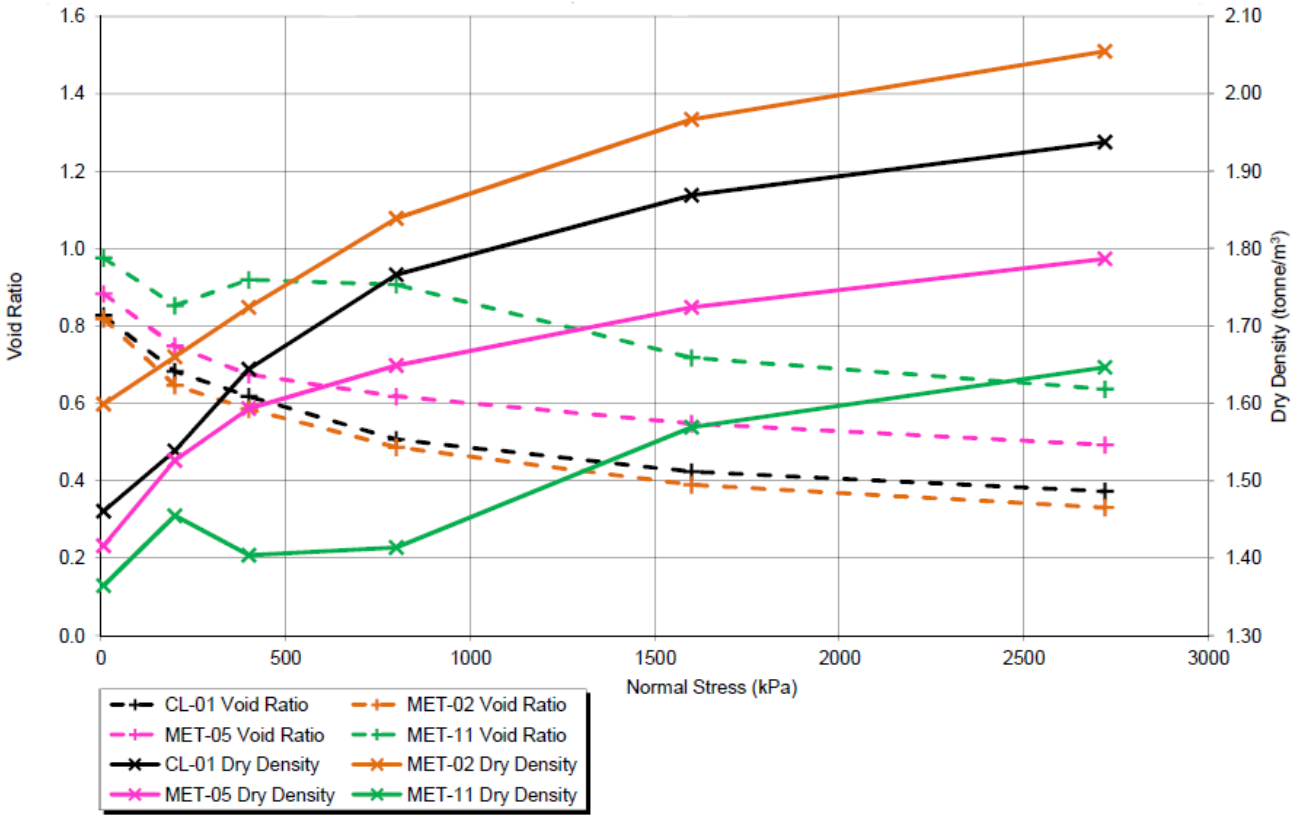
The saturated hydraulic conductivity is presented as a function of the normal stress and dry density on Figure 3.2 and Figure 3.3, respectively. All samples have decreasing saturated hydraulic conductivity with increasing normal stress and density. An increase of normal stress from 200 kPa to 2720 kPa decreases the saturated hydraulic conductivity by less than one order of magnitude. This trend is not as evident for sample CL-01. An additional test was conducted on sample CL-01 at 2720 kPa to verify that the test results were not affected by issues such as incomplete saturation. The results of the additional test were similar to the initial test, confirming the validity of the results.

Table 3.1 Summary of Saturated Hydraulic Conductivity Test Results from KP Lab

Sample ID	Normal Stress (kPa)	Dry Density (tonne/m^3)	K_{sat} (cm/s)	$K_{sat,head\ corrected}$ (cm/s)
MET-02	200	1.66	3.4E-01	5.7E-01
MET-02	400	1.72	2.9E-01	4.5E-01
MET-02	800	1.84	9.0E-02	9.6E-02
MET-02	1600	1.97	6.4E-02	6.7E-02
MET-02	2720	2.05	4.7E-02	4.8E-02
MET-05	200	1.53	3.2E-01	5.0E-01
MET-05	400	1.59	1.4E-01	1.8E-01
MET-05	800	1.65	1.1E-01	1.3E-01
MET-05	1600	1.72	8.2E-02	9.2E-02
MET-05	2720	1.79	5.9E-02	6.3E-02
MET-11	200	1.45	1.2E+00	Invalid (2)
MET-11	400	1.40	1.2E+00	Invalid (2)
MET-11	800	1.41	1.2E+00	Invalid (2)
MET-11	1600	1.57	8.8E-01	1.5E+01
MET-11	2720	1.65	7.6E-01	4.4E+00
CL-01	200	1.54	2.2E-01	3.0E-01
CL-01	400	1.64	4.0E-01	7.7E-01
CL-01	800	1.77	2.1E-01	2.8E-01
CL-01	1600	1.87	1.4E-01	1.7E-01
CL-01	2720	1.94	1.7E-01	2.1E-01
CL-01 Re-test	2720	1.84	2.3E-01	3.2E-01

NOTES:

1. No oversize correction applied.
2. Results invalid as the head loss in the apparatus exceeds the applied head.
3. K_{sat} = saturated hydraulic conductivity, not corrected for head loss in testing apparatus.
4. $K_{sat,head\ corrected}$ = saturated hydraulic conductivity, corrected for head loss in testing apparatus.



NOTES:

1. Tested on fraction of material passing 1.5 inch.
2. All tests conducted by KP using an 8-inch rigid wall permeameter.

Figure 3.1 Void Ratio and Dry Density versus Normal Stress

The test results show that the coarsest sample (MET-11) has the largest saturated hydraulic conductivity. The particle size distribution of the leached sample (CL-01) is similar to MET-11. The saturated hydraulic conductivity, however, is considerably lower and closer to that of MET-02 and MET-05. This may indicate that the leaching process does have some effect on hydraulic conductivity.

The saturated hydraulic conductivity represents the maximum rate at which solution can flow through the ore. A solution application rate higher than the saturated hydraulic conductivity results in saturation of the ore and ponding at the surface. This will affect the leaching environment and may lead to stability issues. The solution application rate should be well below the saturated hydraulic conductivity of the ore to avoid saturated conditions.

The current design solution application rate for ore leaching (12 l/hr/m^2) is included on Figure 3.2 and Figure 3.3. All test results indicate saturated hydraulic conductivities that are higher than the design irrigation rate. This indicates that the proposed heap leach ore will not fully saturate under the design irrigation rate, even at the highest tested normal stress of 2720 kPa, which is equivalent to an approximately 150 m high heap (the maximum design heap height).

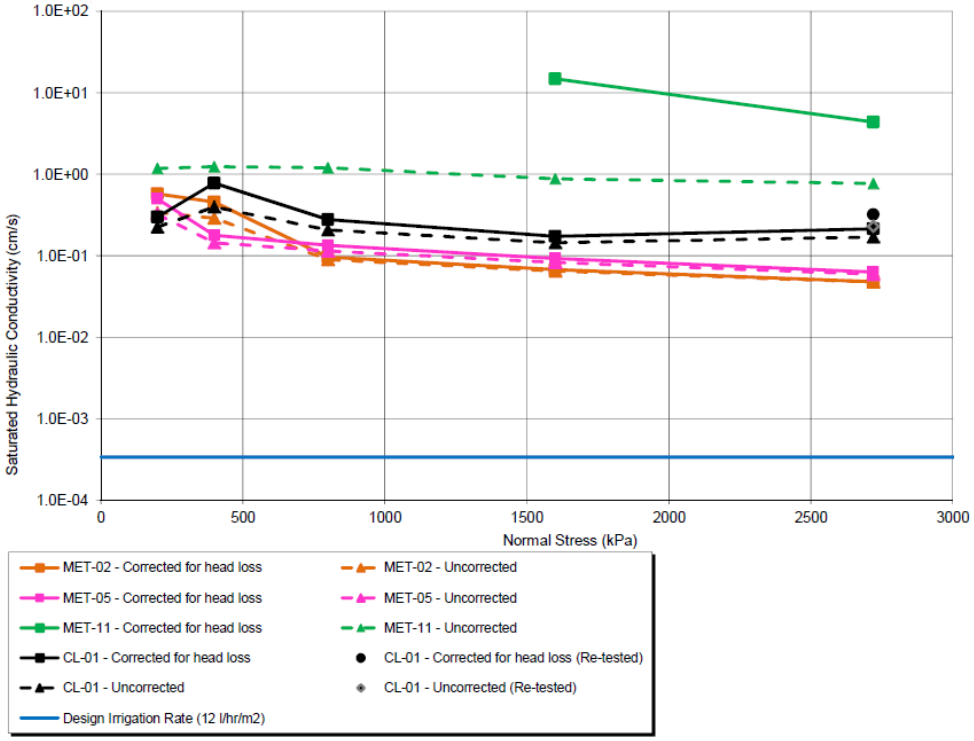


Figure 3.2 Saturated Hydraulic Conductivity versus Normal Stress

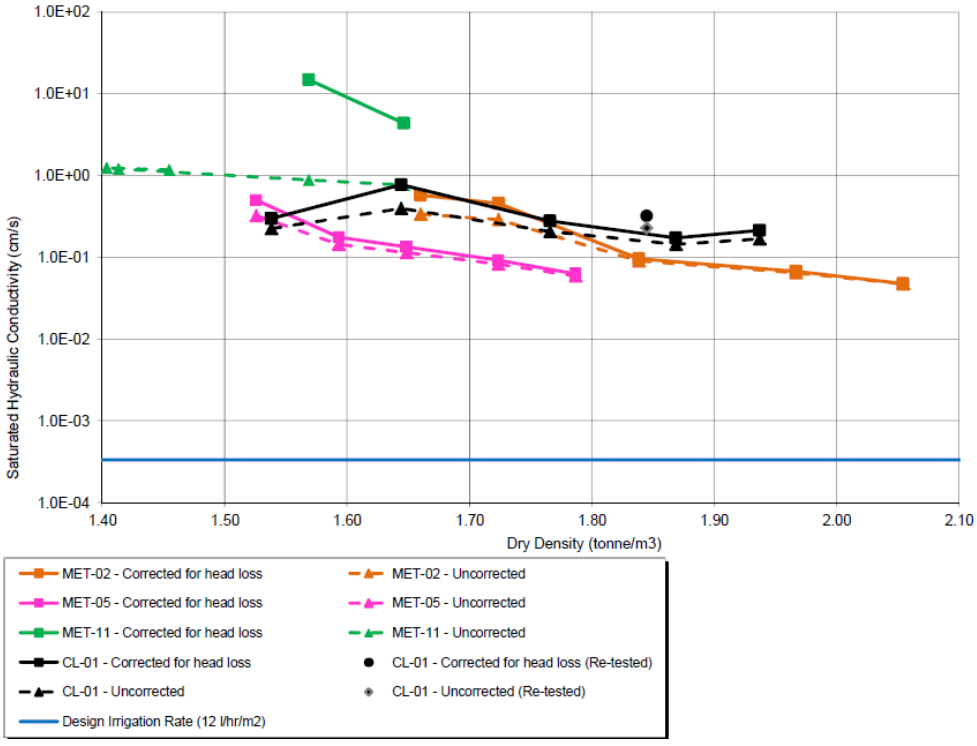
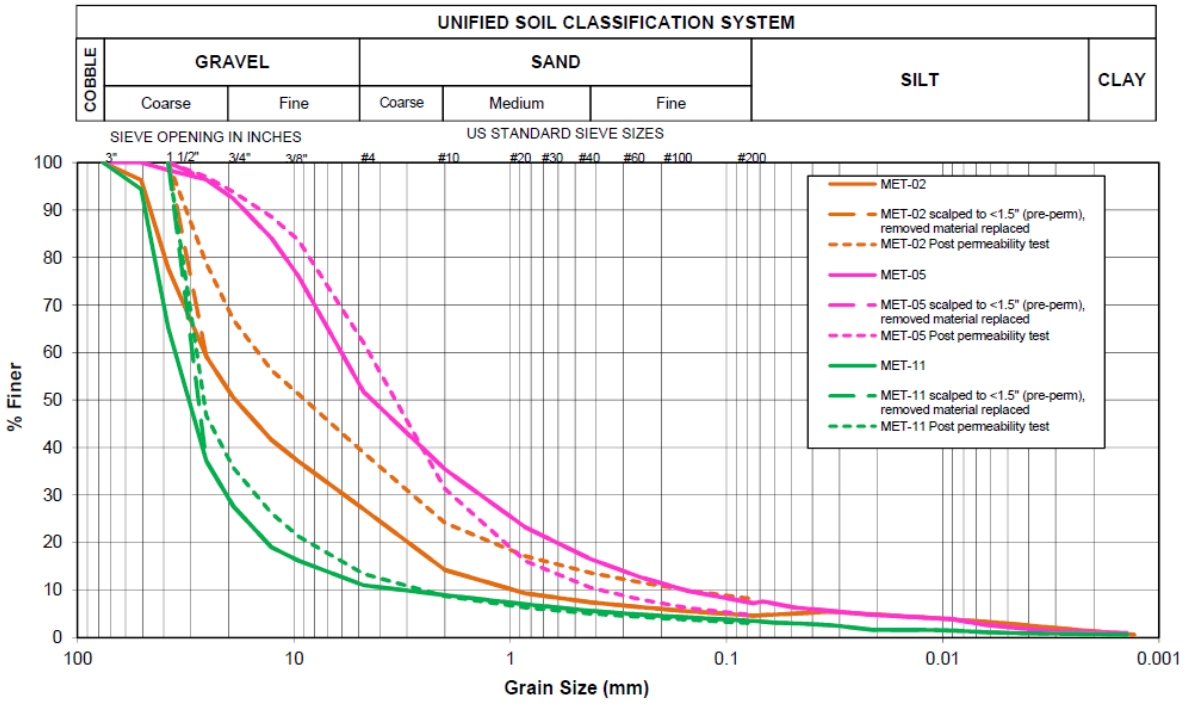


Figure 3.3 Saturated Hydraulic Conductivity versus Dry Density

Figure 3.4 displays the particle size distributions of samples MET-02, MET-05 and MET-11 before testing, after scalping off the material greater than 1.5 inch, and after hydraulic conductivity testing. Samples MET-05 and MET-11 have similar gradations before and after the hydraulic conductivity testing, indicating that there will be no significant degradation or particle breakage under heap leaching conditions. Sample MET-02 exhibits a larger change in gradation, which could indicate degradation and a reduced hydraulic conductivity.



NOTES:

1. MET-02, MET-05 and MET-11 data provided by KP soil laboratory in Denver, CO. These samples were collected in 2013 and have not been subjected to leach column testing.

Figure 3.4 Gradations Before and After Saturated Hydraulic Conductivity Tests

4 – SOIL-WATER CHARACTERISTIC CURVE TESTS

4.1 GENERAL

A soil-water characteristic curve (SWCC) relates the ore moisture content with the suction pressure, and defines the moisture holding potential of the ore. SWCCs are used to evaluate percolation and airflow studies within ore heaps.

Ore samples MET-02, MET-05 and MET-11 were tested by DBS to determine the SWCC. The remoulded samples were subjected to saturated hydraulic conductivity and moisture retention testing. The saturated hydraulic conductivity tests were conducted using the constant head method following ASTM D2434. The moisture retention testing included hanging column, pressure chamber, dewpoint potentiometer (all per ASTM D6836) and relative humidity chamber testing (Campbell and Gee, 1986). The interrelationship between moisture content, suction pressure, and hydraulic conductivity was derived by DBS using analytical equations (ASTM D6836; Van Genuchten, 1980).

The samples were tested in a 12-inch rigid wall permeameter. Material larger than 2 inch was removed and replaced with finer grained material. DBS remoulded and compacted the soil samples to match the densities achieved at 100 kPa and 2720 kPa normal stress from the KP laboratory testing, representing loose and dense samples. The densities that were targeted in the DBS laboratory included an oversize correction to account for the material greater than 1.5 inch that was removed in the KP laboratory testing. The target densities for the DBS samples (in tonne/m^3) are indicated in brackets in Table 4.1. Sample MET-05 (1.47 tonne/m^3) settled out during testing, leading to a higher density (1.62 tonne/m^3) than targeted.

4.2 RESULTS AND INTERPRETATION

The results of the saturated hydraulic conductivity tests are summarized in Table 4.1.

DBS presented saturated hydraulic conductivity results with and without a correction to compensate for the removal of material greater than 2 inch (Appendix D). The oversize correction uses the methodology published by Bouwer and Rice (1984). Their correction factors are based on testing of bi-modally graded materials containing uniform large rock fragments (boulders) and homogeneous fine earth fractions (pure sand). They found that an increase of the coarse fraction results in a more tortuous flowpatch, therefore reducing the hydraulic conductivity. However, research by Milczarek et al. (2006) on well graded material samples with varying amounts of gravel, show poor agreement with the published correction factors. They show that saturated hydraulic conductivity decreased with up to 30% gravel content but increased by orders of magnitude at higher gravel contents. They recommend that published correction factors not be used unless the sample is similar in gradation and bulk density to the soils tested by the published method. The tested leach ore materials have a coarse gradation with high gravel contents, which is different from the study by Bouwer and Rice. It is noted that the correction has little effect as the fraction greater than 2 inch is less than 6% by weight for all tested samples. Consequently no oversize correction is applied to the saturated hydraulic conductivity.

The DBS laboratory results indicate saturated hydraulic conductivities that are typically about one order of magnitude lower than the KP results for similar sample density. This can likely be attributed to the difference in the sample preparation method. The head loss in the testing apparatus is negligible for the hydraulic conductivities obtained by DBS, and therefore no head loss correction is

required. The DBS laboratory results indicate a decrease in hydraulic conductivity with increasing density, similar to the trend observed in the KP laboratory results. All test results show hydraulic saturated conductivities that are higher than the current design solution application rate of (12 l/hr/m^2, which is equivalent to 3.3 x 10^{-4} cm/s).

Table 4.1 Summary of Saturated Hydraulic Conductivity Test Results from DBS Lab

Sample ID	Normal Stress	Dry Density	K_{sat}
	(kPa)	(tonne/m^3)	(cm/s)
MET-02 (1.75)	Atmospheric	1.75	2.2E-02
MET-02 (2.00)	Atmospheric	2.00	2.0E-03
MET-05 (1.47)	Atmospheric	1.62	2.6E-02
MET-05 (1.79)	Atmospheric	1.79	1.6E-02
MET-11 (1.66)	Atmospheric	1.66	3.5E-02
MET-11 (1.94)	Atmospheric	1.94	1.9E-02

NOTES:
1. No oversize or head loss correction applied.
2. Sample MET-05 (1.47) settled out to a density of 1.62 tonne/m^3 during testing.
3. K_{sat} = saturated hydraulic conductivity, not corrected for head loss in testing apparatus.

The SWCC curves are presented on Figure 4.1 through Figure 4.3. The SWCC curves illustrate that hydraulic properties vary significantly with minor changes in grain size and moisture content. The particle size distribution in an actual ore heap is variable due to segregation from dumping and ore variability. The SWCC relationships will therefore vary more widely in practice than those obtained from the laboratory tests. The wide range in hydraulic properties may give rise to preferential flow paths, which are commonly seen in heap leach pads.

Figure 4.3 displays the hydraulic conductivity as a function of gravimetric moisture content. The design solution application rate is also included in the figure. The crushed ore samples are predicted to have gravimetric moisture contents ranging from 11 to 22% under steady state leaching conditions. However, the ore has a lower moisture content when it is crushed and placed on the heap. The gravimetric ore moisture content after placement is typically below 10%, which leads to a hydraulic conductivity that is lower than the irrigation rate. The solution will pool on top of the ore until the moisture content has increased (‘wet up’), and a hydraulic conductivity is reached that is compatible with the solution application rate.

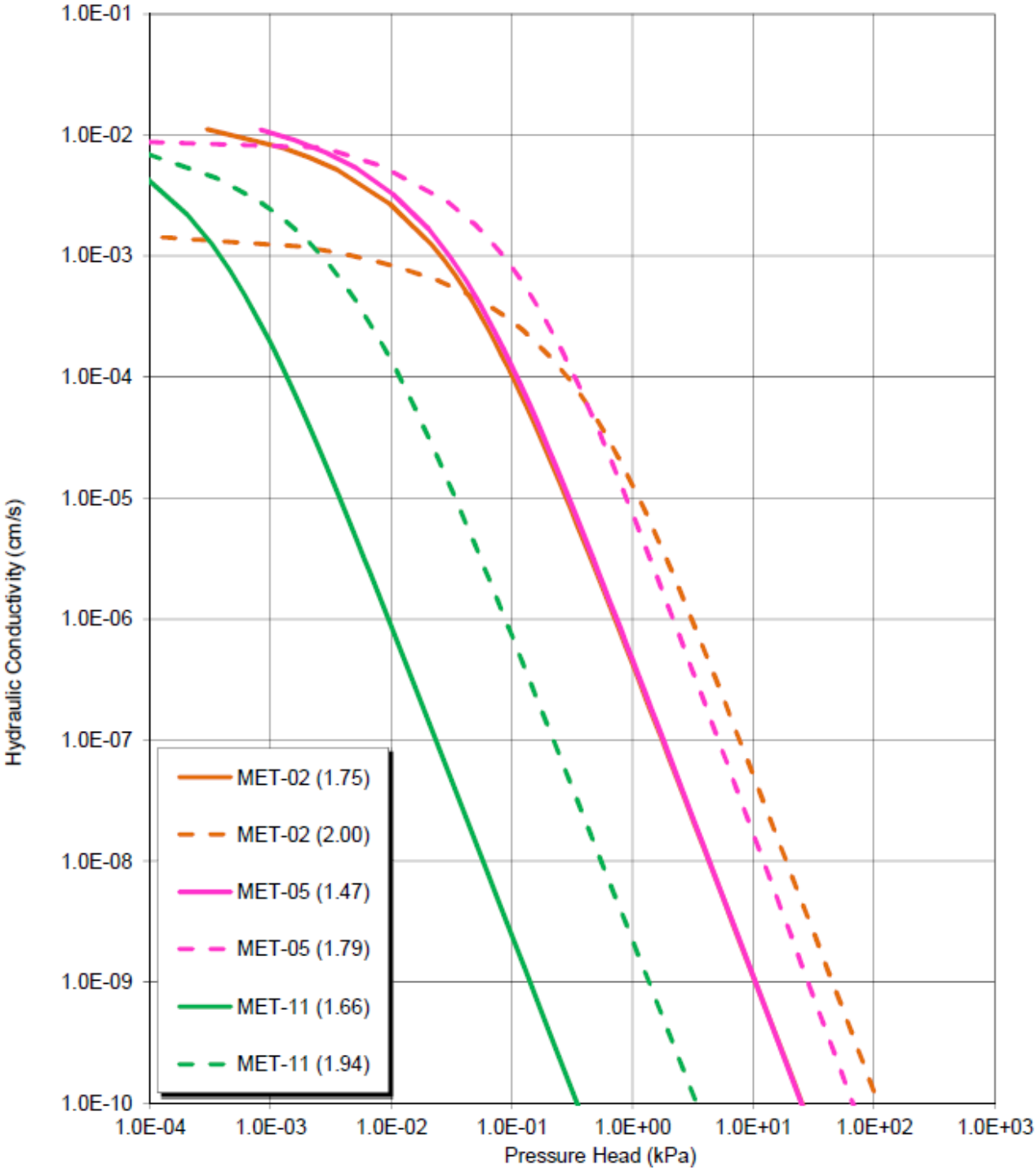


Figure 4.1 Hydraulic Conductivity versus Pressure Head

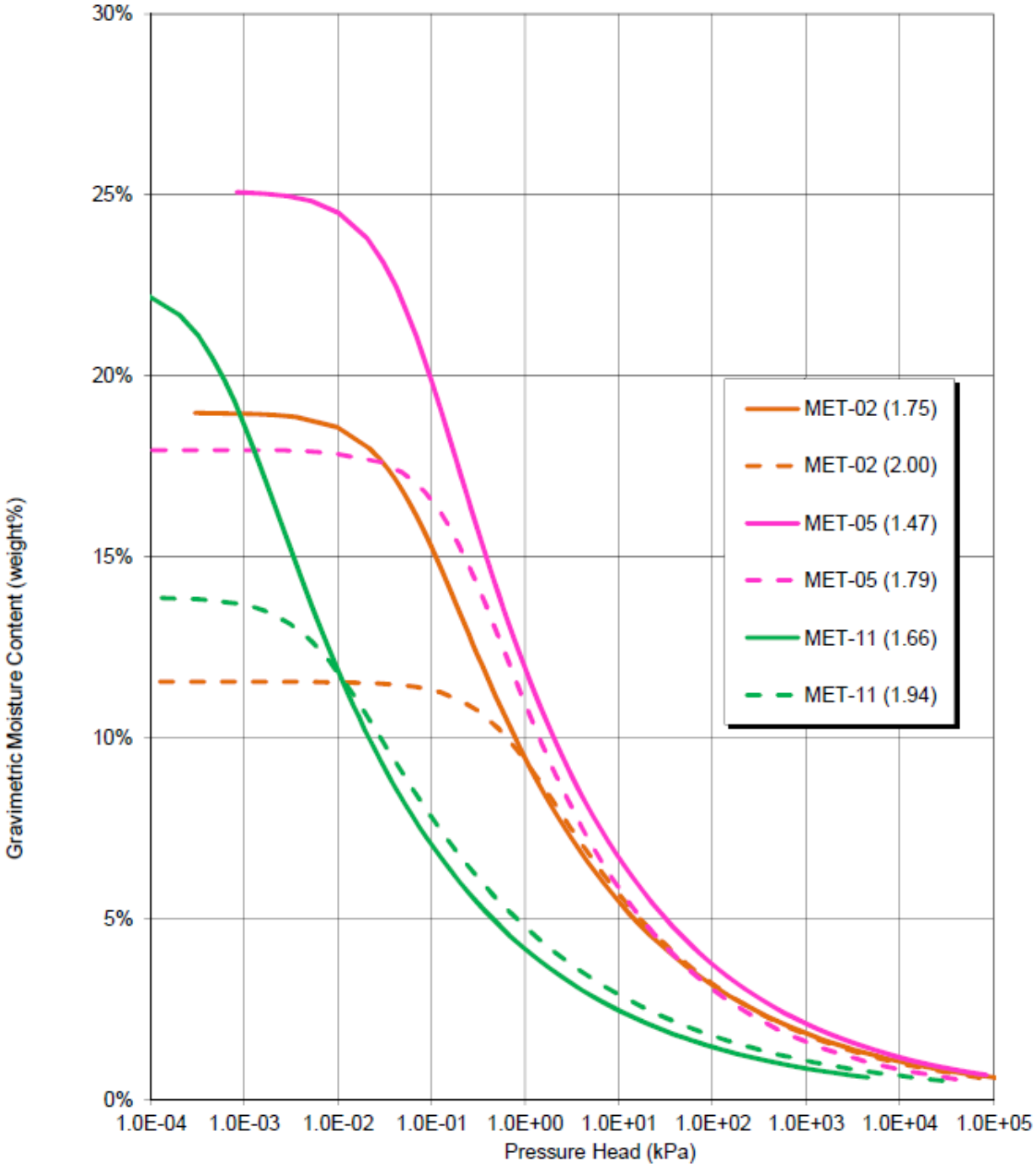


Figure 4.2 Gravimetric Moisture Content versus Pressure Head

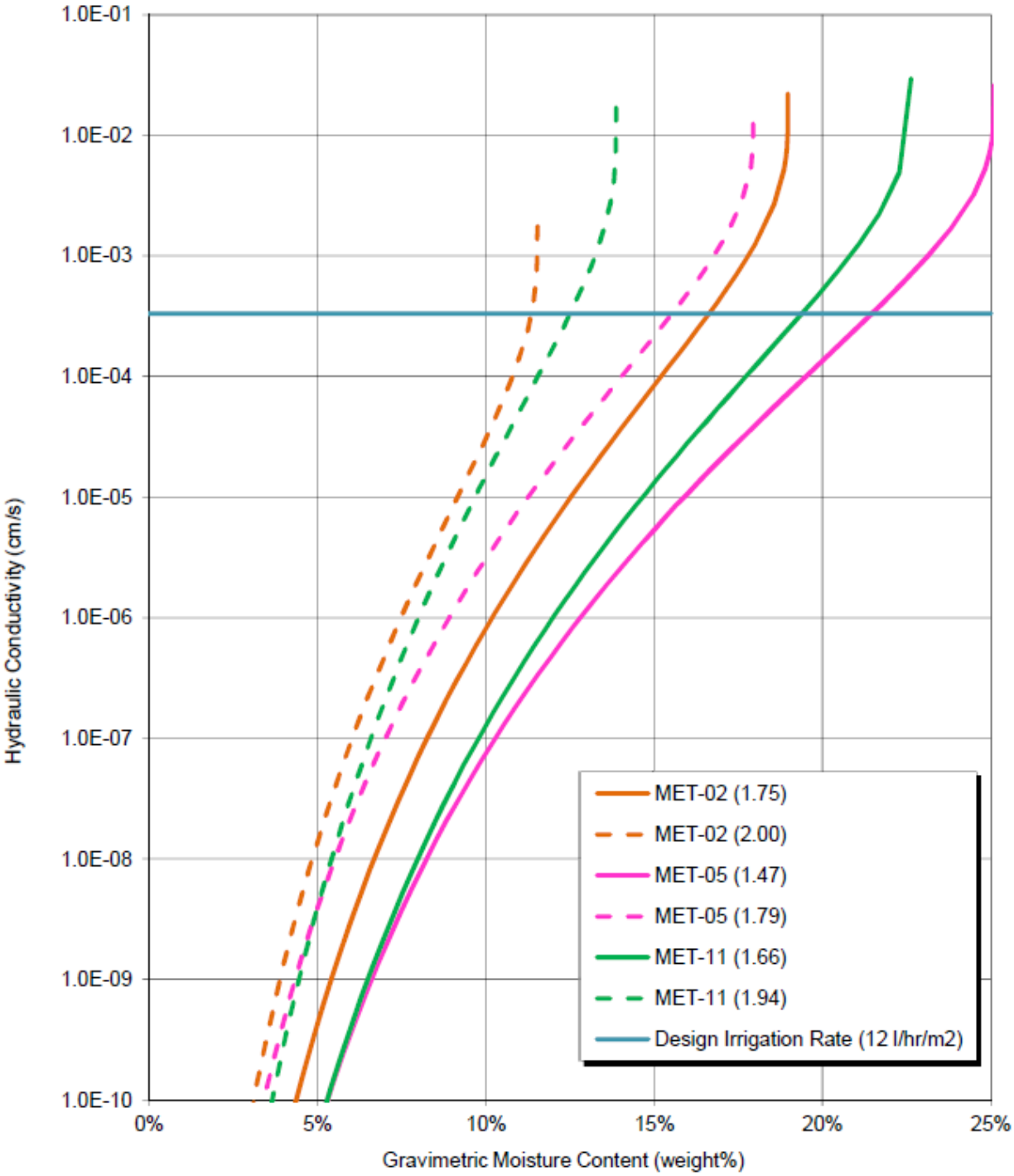


Figure 4.3 Hydraulic Conductivity versus Gravimetric Moisture Content

5 – LOAD-PERCOLATION TESTS

5.1 GENERAL

The purpose of the load-percolation tests is to determine the behaviour of the material under unsaturated conditions, and to determine what conditions (applied load and irrigation rate) are required to maintain unsaturated ore percolation. Results from these tests include the steady state moisture content under leach and the residual moisture content after draindown. These moisture content values are used in solution management (water balance) calculations.

Load-percolation tests were conducted by the KP laboratory on samples MET-02, MET-05, and MET-11. Material greater than 1.5 inch was removed from the samples and replaced with finer gravel. No standardized test procedure is available for the load-percolations test. A test procedure was developed based on a paper by Lupo (2012), as described below.

The load-percolation tests were conducted using the same 8-inch rigid-wall permeameter as used for the saturated hydraulic conductivity testing. The material was placed loosely in the test vessel, between porous plates and perforated load/bearing plates. The sample was loaded to a normal stress that was maintained throughout the test. Sample height was measured after loading to determine the bulk density and porosity of the ore.

Tap water was introduced at the top of the ore sample at a specified application rate and the effluent was collected at the bottom of the vessel. The inflow and outflow were measured during all stages of the test (including wetting, steady state and draindown) to determine when steady-state conditions were reached. The volume difference between the applied solution and effluent was used to estimate ore moisture content under leach and moisture up-take prior to leaching.

After steady-state conditions had been reached (i.e. inflow equals outflow), the sample was loaded to the next normal stress while maintaining the same irrigation rate. Irrigation continued until a new steady state developed. The sample was allowed to drain down by stopping the irrigation after loading stages as specified in Table 5.1. Measurement of the amount of effluent collected continued during draindown. The sample was removed from the apparatus after the draindown was completed (after approximately one day) and weighed to verify the moisture content. The sample was subjected to the next specified pressure or irrigation rate after determination of the draindown moisture content.

Table 5.1 Loading and Irrigation Schedule for Load-Percolation Tests

Normal Stress (kPa)	Irrigation Rate (litres/hour/m^2)
100	12
200	12
Draindown	
400	12
800	12
Draindown	
1600	12
2760	12
Draindown	
2760	120
Draindown	

5.2 RESULTS AND INTERPRETATION

The steady state and residual moisture contents for each sample are presented in Figure 5.1 through Figure 5.3. The test results are based on material smaller than 1.5 inch, and no oversize correction has been applied to the moisture contents. Detailed load-percolation test results are included in Appendix E.

The following observations were made:

- The steady state and residual moisture contents do not depend on normal stress.
- The steady state moisture content at 120 l/hr/m^2 is higher than that at 12 l/hr/m^2.
- The steady state moisture contents from the load-percolation tests (5 to 10%) are lower than those predicted from the SWCC (11 to 22%) at 12 l/hr/m^2.
- Ponding of solution on top of the ore sample was observed for sample MET-02 at 120 l/hr/m^2 at the highest normal stress (2760 kPa). Measurement of the degree of saturation confirmed that this sample was fully saturated. The test results indicate that saturation occurred between 3.3×10^{-4} and 3.3×10^{-3} cm/s, which is in agreement with the saturated hydraulic conductivity tests conducted at the DBS laboratory (2.0×10^{-3} cm/s). No ponding was observed for the other samples, which is also in agreement with the DBS laboratory results.
- All samples were unsaturated at the design irrigation rate (12 l/hr/m^2). Sample MET-05 and MET-11 can sustain irrigation rates of at least 10 times the current design rate.

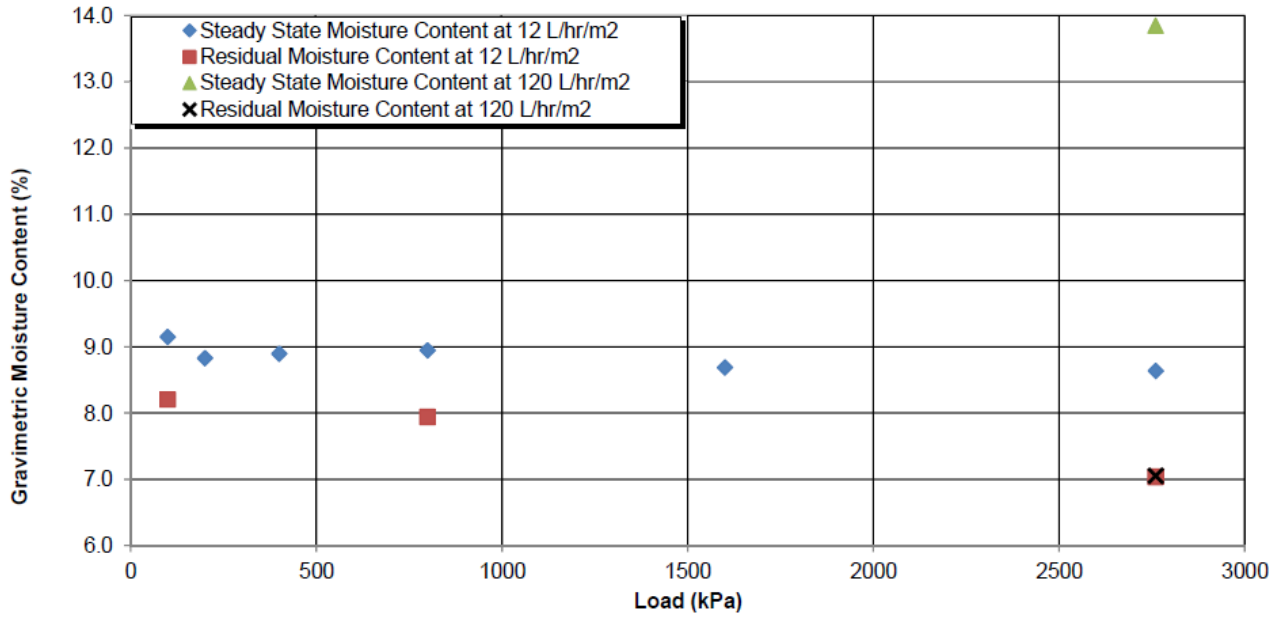


Figure 5.1 Load-Percolation Test Results for Sample MET-02

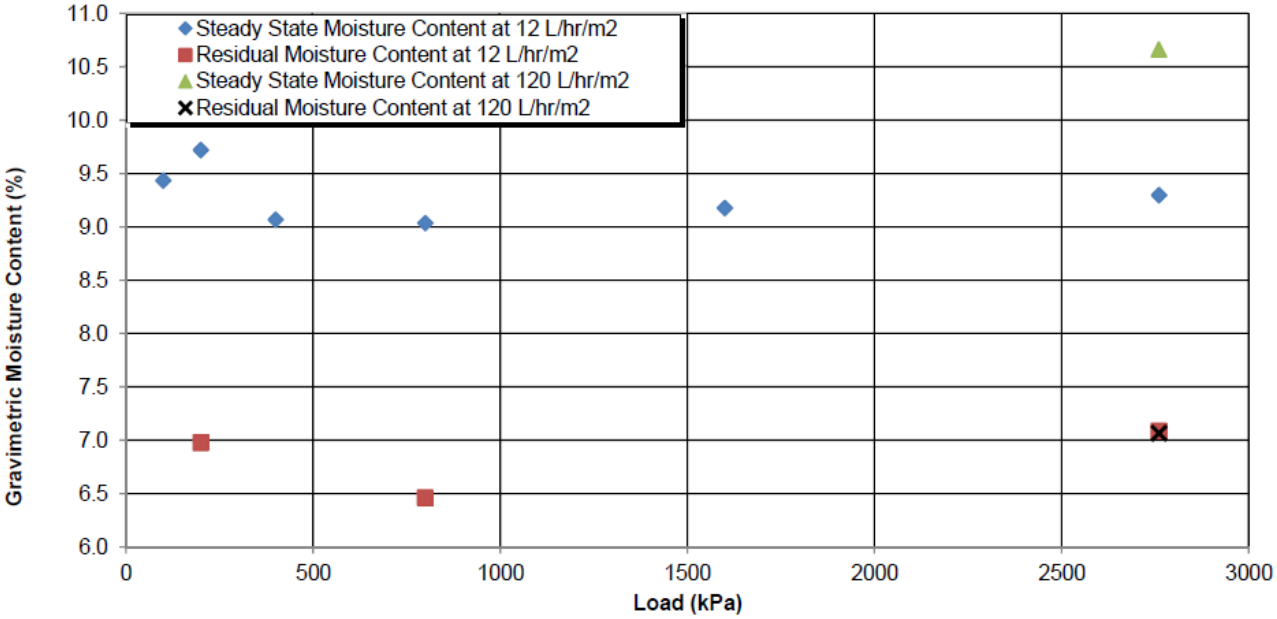
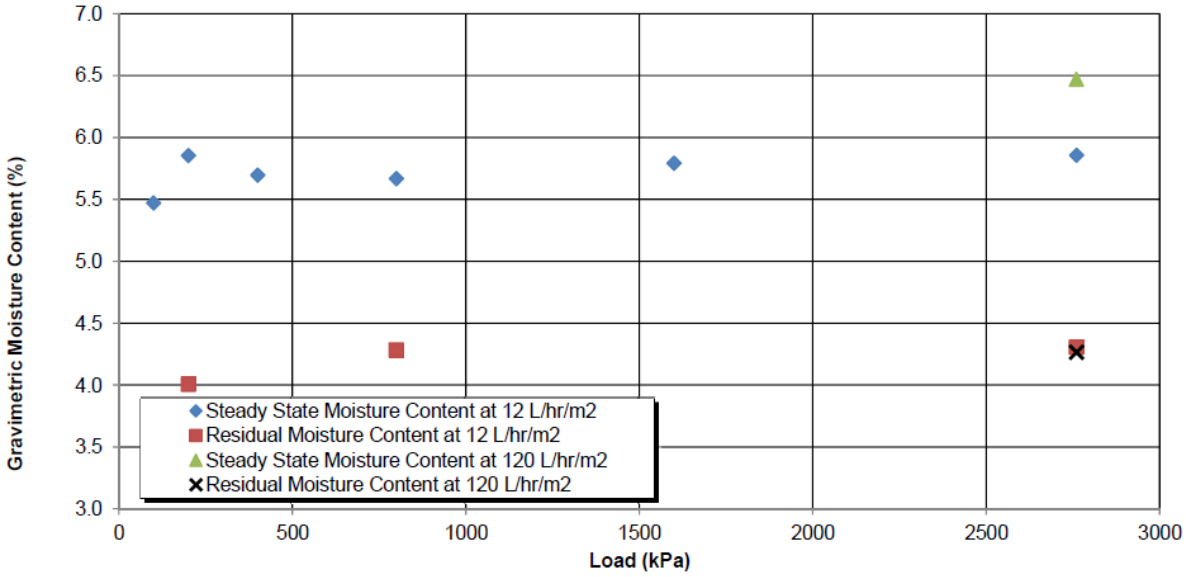


Figure 5.2 Load-Percolation Test Results for Sample MET-05



NOTES:

1. No oversize correction applied to the moisture contents.

Figure 5.3 Load-Percolation Test Results for Sample MET-11

6 – CONCLUSIONS

The ore samples are generally competent and exhibit little degradation under loading. Sample MET-05 displays most particle breakage as a result of material handling and transportation to the KP laboratory. Sample MET-02 exhibits the largest change in gradation before and after the hydraulic conductivity testing under load. This could indicate degradation and a reduced hydraulic conductivity for this ore under heap leaching conditions.

The test results show that the coarsest sample (MET-11) has the largest saturated hydraulic conductivity. The particle size distribution of the leached sample (CL-01) is similar to MET-11. The saturated hydraulic conductivity, however, is considerably lower and closer to that of MET-02 and MET-05. This may indicate that the leaching process does have some effect on hydraulic conductivity.

The results indicate a decrease in saturated hydraulic conductivity with increasing stress and density.

The DBS laboratory results indicate saturated hydraulic conductivities that are typically about one order of magnitude lower than the KPL results for similar sample density. This can likely be attributed to the difference in the sample preparation method.

The steady state gravimetric moisture contents from the load-percolation tests (5 to 10%) are lower than those predicted from the SWCC (11 to 22%) at the current design irrigation rate of 12 l/hr/m^2.

The steady state and residual moisture contents do not depend on normal stress. The steady state moisture content at 120 l/hr/m^2 is higher than that at 12 l/hr/m^2.

All test results indicate saturated hydraulic conductivities that are higher than the current design irrigation rate (12 l/hr/m^2, which is equivalent to 3.3×10^{-4} cm/s). This indicates that the proposed heap leach ore will not fully saturate under the design irrigation rate, even at the highest tested normal stress of 2720 kPa, which is equivalent to an approximately 150 m high heap (the maximum design heap height). Sample MET-05 and MET-11 can sustain irrigation rates of at least 10 times the current design rate. Ponding of solution on top of the ore sample due to saturation was observed for sample MET-02 at 120 l/hr/m^2 at the highest normal stress.

The SWCC curves illustrate that hydraulic properties vary significantly with minor changes in grain size and moisture content.

The crushed ore samples are predicted to have gravimetric moisture contents ranging from 11 to 22% under steady state leaching conditions based on the SWCC testing. However, the ore has a lower moisture content when it is crushed and placed on the heap. The gravimetric ore moisture content after placement is typically below 10%, which leads to a hydraulic conductivity that is lower than the irrigation rate. The solution will pool on top of the ore until the moisture content has increased (‘wet up’), and a hydraulic conductivity is reached that is compatible with the solution application rate.

The findings from the load-percolation tests are in agreement with the saturated hydraulic conductivity test results from the DBS laboratory.

7 – RECOMMENDATIONS

It is recommended to do additional testing to determine the effect of the leaching process on the different types of ore. It is also recommended that the actual leach solution be used instead of tap water for conducting additional permeability and percolation testing. Additional strength and hydraulic conductivity testing is recommended for samples that are most affected by the leaching process.

8 – REFERENCES

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Van Genuchten, M.T. 1980. A closed-form equation for predicting the hydraulic conductivity of unsaturated soils. Soil Science Society of America Journal Volume 44 p. 892-898

CERTIFICATION

This report was prepared and approved by the undersigned.

Prepared:

Sanne Brinkman, M.Sc.
Geological Engineering

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
G.R. Greenaway

Reviewed: Feb 17th, 2014.

Graham R. Greenaway, P.Eng.
Specialist Geotechnical Engineer

Approved:

FOR

Ken J. Brouwer, P.Eng.
President

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APPENDIX A

HEAP LEACH SAMPLING MEMO

(Pages A-1 to A-11)

WILLIAM DUNN ENTERPRISES

P.O. Box 10428
Whitehorse, Yukon Y1A7A1
TEL: 867.668-7814
EMAIL: wmwdunn@hotmail.com

Memo

Attn: Paul West-Sells

From: Wm. W. Dunn July 8, 2013

Re: Casino Project Heap Leach -Metallurgical Samples 2013

- After some initial discussion between Paul West-Sells, Heather Brown & Scott Casselman, a list of potential sample sites was forwarded on June 27th; (see attached memo from Heather Brown dated July 8, 2013)
- The directions were to take samples ~0.5 meter below the bedrock/talus interface;
- The samples were to be as dry as possible and from intact bedrock;
- I located all of the site on June 28th but did not sample on June 29th due to heavy rain
- Sampled sites MET02, 11, 17, 19, & 30 on June 30th
- Sampled site MET05 on July 1st
- The samples were placed in 45 Gal drums with sealable lids;
- All drums were marked with the sample number & location
- The drums were shipped to Whitehorse via Alkan and stored in Alkan's covered storage area.
- The drums were relabeled with the final destination, Sample number and sample UTM co-ordinates on July 5th for pickup and haulage to ALS, Kamloops, BC on Monday July 8th
- See details below

WILLIAM DUNN ENTERPRISES

P.O. Box 10428
Whitehorse, Yukon Y1A7A1
TEL: 867.668-7814
EMAIL: wmwdunn@hotmail.com

Met02-2013 sampled June 30, 2013

Sample #	Hole ID	Northing	Easting	Elev.	O/B m	Au gm/t
MET02_2013_Prop	94-297	610912.85	6958282.68	1374.14	2.44	0.45

Initial location



Intact Bedrock -hard



WILLIAM DUNN ENTERPRISES

P.O. Box 10428
Whitehorse, Yukon Y1A7A1
TEL: 867.668-7814
EMAIL: wmwdunn@hotmail.com

Met11-2013 sampled June 30, 2013

Sample #	Hole ID	Northing	Easting	Elev.	/B m	Au gm/t
MET11_2013_Prop	94-332	611006.49	6958361.40	1331.02	2.13	0.59

Initial location



Intact Bedrock -hard



WILLIAM DUNN ENTERPRISES

P.O. Box 10428
Whitehorse, Yukon Y1A7A1
TEL: 867.668-7814
EMAIL: wmwdunn@hotmail.com

Sample from ~1.5 m deep



WILLIAM DUNN ENTERPRISES

P.O. Box 10428
Whitehorse, Yukon Y1A7A1
TEL: 867.668-7814
EMAIL: wmwdunn@hotmail.com

Met17-2013 sampled June 30, 2013

Sample #	Hole ID	Northing	Easting	Elev.	O/B m	Au gm/t
MET05_2013_Prop	94-320	610763.32	6958002.76	1382.08	3.05	0.39

Initial location



~2 m into Intact Bedrock



WILLIAM DUNN ENTERPRISES

P.O. Box 10428
Whitehorse, Yukon Y1A7A1
TEL: 867.668-7814
EMAIL: wmwdunn@hotmail.com

Sample



WILLIAM DUNN ENTERPRISES

P.O. Box 10428
Whitehorse, Yukon Y1A7A1
TEL: 867.668-7814
EMAIL: wmwdunn@hotmail.com

Met19-2013 sampled June 30, 2013

Sample #	Hole ID	Northing	Easting	Elev.	O/B m	Au gm/t
MET19_2013_Prop	92-133	610877.95	6958426.88	1360.60	2.44	0.60

Initial location



Sample from ~ 1.5 m below bedrock interface



WILLIAM DUNN ENTERPRISES

P.O. Box 10428
Whitehorse, Yukon Y1A7A1
TEL: 867.668-7814
EMAIL: wmwdunn@hotmail.com

Met20-2013 sampled June 30, 2013

Sample #	Hole ID	Northing	Easting	Elev.	O/B m	Au gm/t
MET20_2013_Prop	92-141	610818.95	6958662.72	1314.27	3.65	0.39

Initial location



0.5 m very Hard –sample location



WILLIAM DUNN ENTERPRISES

P.O. Box 10428
Whitehorse, Yukon Y1A7A1
TEL: 867.668-7814
EMAIL: wmwdunn@hotmail.com

Met05-2013 sampled June 30, 2013

Sample #	Hole ID	Northing	Easting	Elev.	O/B m	Au gm/t
MET05_2013_Prop	94-320	610763.32	6958002.76	1382.08	3.05	0.39

Initial Site ~2 m into weathered bedrock –frozen –left 20 hrs then sampled



Sample location



WILLIAM DUNN ENTERPRISES

P.O. Box 10428
Whitehorse, Yukon Y1A7A1
TEL: 867.668-7814
EMAIL: wmwdunn@hotmail.com

Sample



WILLIAM DUNN ENTERPRISES

P.O. Box 10428
Whitehorse, Yukon Y1A7A1
TEL: 867.668-7814
EMAIL: wmwdunn@hotmail.com

Address placard:

Casino Mining Corp

Casino Project

2013 Heap Samples

MET02-2013

UTM CO-ORD: **610912 E 6958282 N**

SEND TO:

ALS Metallurgy

2937 Bowers Pl.

Kamloops, BC Canada V1S 1W5

For any questions please call:

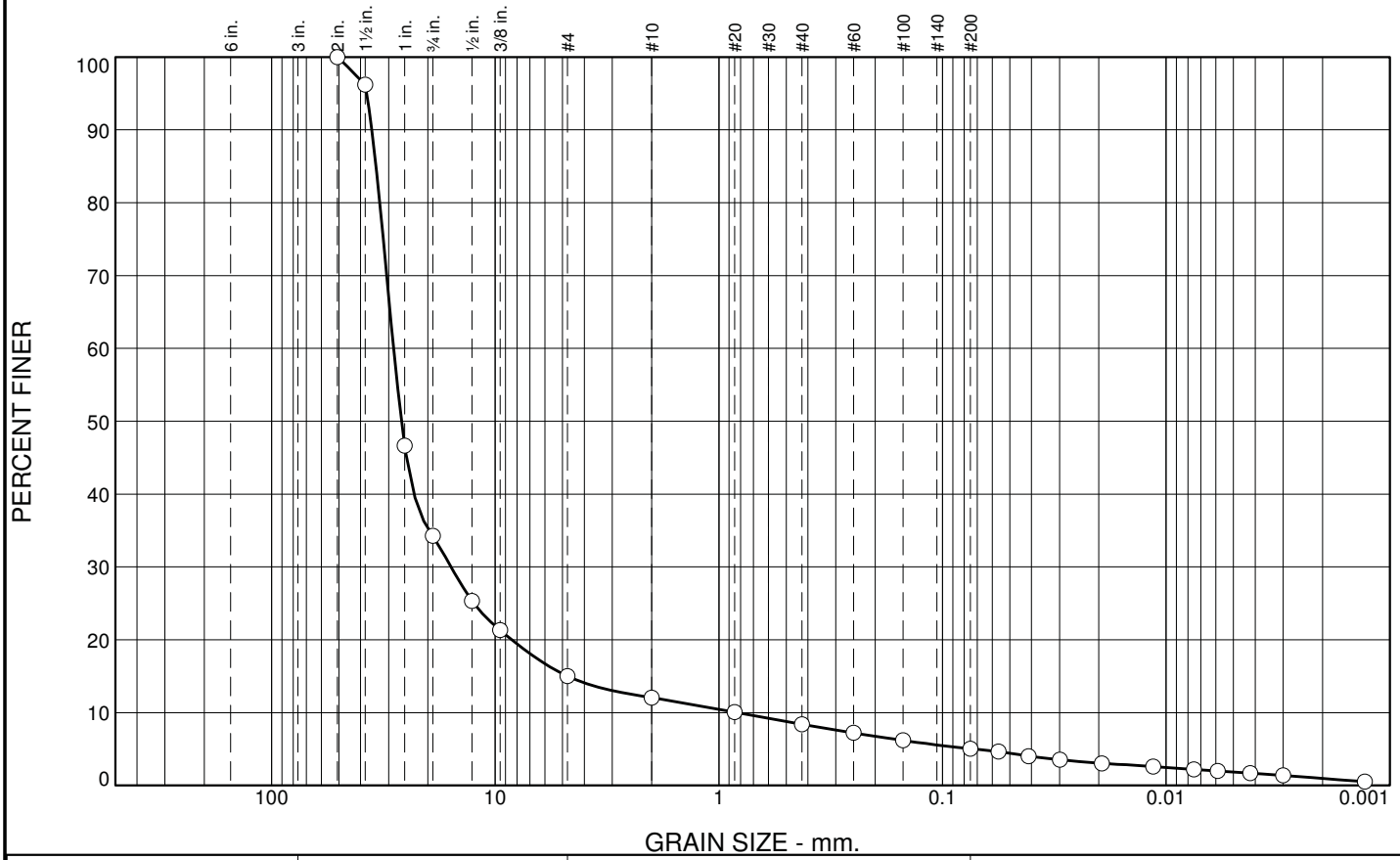
Heather Brown, **P.Geo** @ 604.638.2506

APPENDIX B

INDEX TEST RESULTS
(KNIGHT PIÉSOLD LABORATORY)

(Pages B-1 to B-27)

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	65.7	19.3	2.9	3.7	3.4	4.0	1.0

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
2	100.0		
1.5	96.2		
1	46.7		
.75	34.3		
.5	25.3		
.375	21.3		
#4	15.0		
#10	12.1		
#20	10.1		
#40	8.4		
#60	7.2		
#100	6.2		
#200	5.0		
0.0562 mm.	4.7		
0.0412 mm.	4.0		
0.0299 mm.	3.5		
0.0194 mm.	3.0		
0.0114 mm.	2.6		
0.0075 mm.	2.2		
0.0059 mm.	2.0		
0.0042 mm.	1.7		
0.0030 mm.	1.4		
0.0013 mm.	0.5		

* (no specification provided)

Soil Description

poorly graded GRAVEL with silt

Atterberg Limits

PL= NP LL= NP PI= NP

Coefficients

D_{90}= 35.6220 D_{85}= 34.1386 D_{60}= 28.4746
D_{50}= 26.2567 D_{30}= 15.7591 D_{15}= 4.7345
D_{10}= 0.8297 C_u= 34.32 C_c= 10.51

Classification

USCS= GP-GM AASHTO= A-1-a

Remarks

Sample No.: CL-01 Residue **Source of Sample:** **Date:** 8/1/2013
Location: Casino Gold Mine **Elev./Depth:**

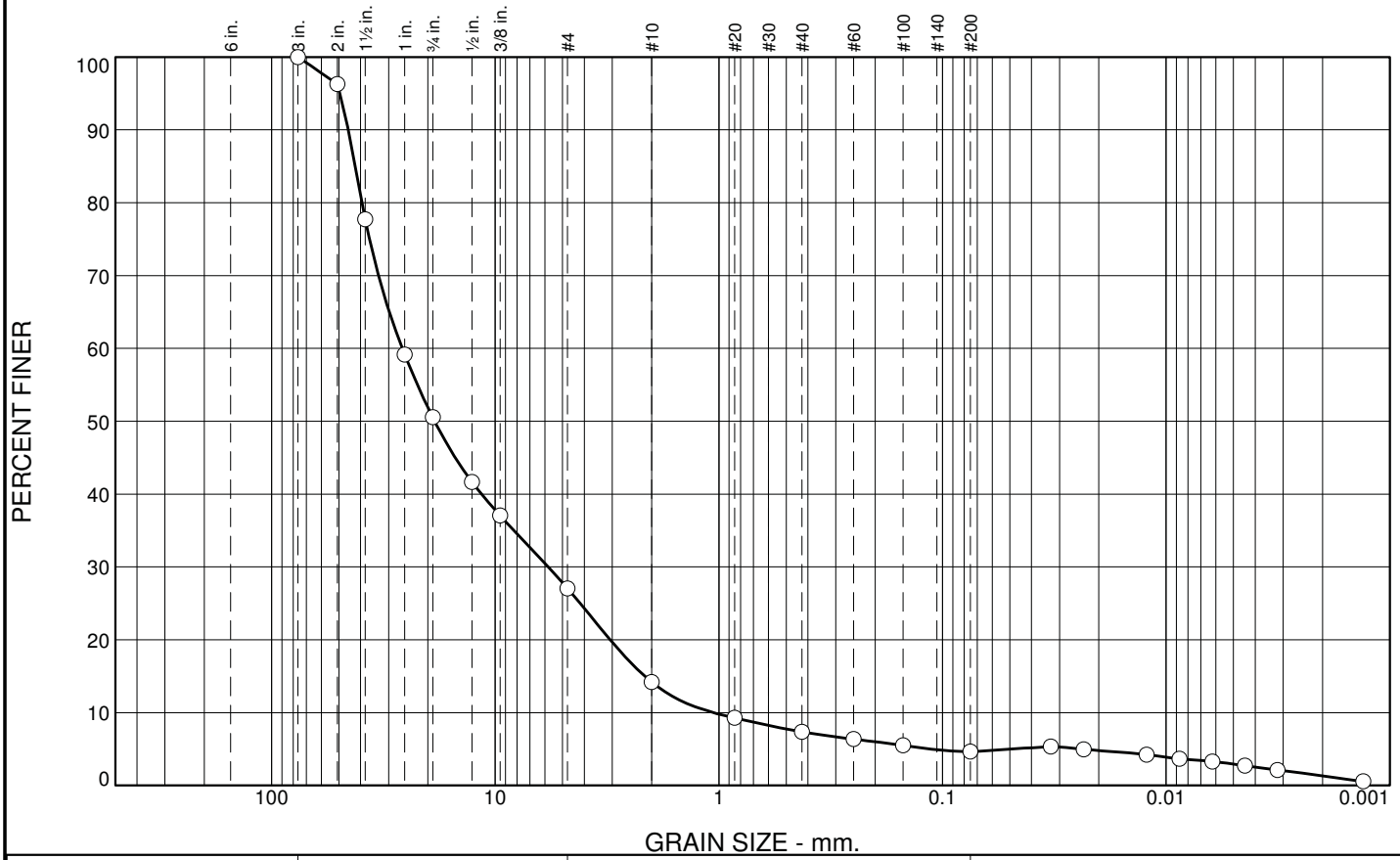
Knight Piésold CONSULTING

Client: Casino Mining Corporation
Project: Casino

Project No: VA101-00325/16 **Figure**

Tested By: RB/RV **Checked By:** DB

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	49.5	23.5	12.8	6.8	2.8	3.3	1.3

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3	100.0		
2	96.3		
1.5	77.7		
1	59.2		
.75	50.5		
.5	41.6		
.375	37.1		
#4	27.0		
#10	14.2		
#20	9.3		
#40	7.4		
#60	6.4		
#100	5.5		
#200	4.6		
0.0328 mm.	5.4		
0.0233 mm.	5.0		
0.0122 mm.	4.2		
0.0087 mm.	3.7		
0.0062 mm.	3.3		
0.0044 mm.	2.7		
0.0032 mm.	2.1		
0.0013 mm.	0.6		

* (no specification provided)

Soil Description

well-graded GRAVEL with sand

Atterberg Limits

PL= 21 LL= 22 PI= 1

Coefficients

D_{90}= 45.5068 D_{85}= 42.3321 D_{60}= 26.0351
D_{50}= 18.6576 D_{30}= 5.7946 D_{15}= 2.1458
D_{10}= 1.0549 C_u= 24.68 C_c= 1.22

Classification

USCS= GW AASHTO= A-1-a

Remarks

Sample No.: MET-02 **Source of Sample:** **Date:** 9/6/2013
Location: **Elev./Depth:**

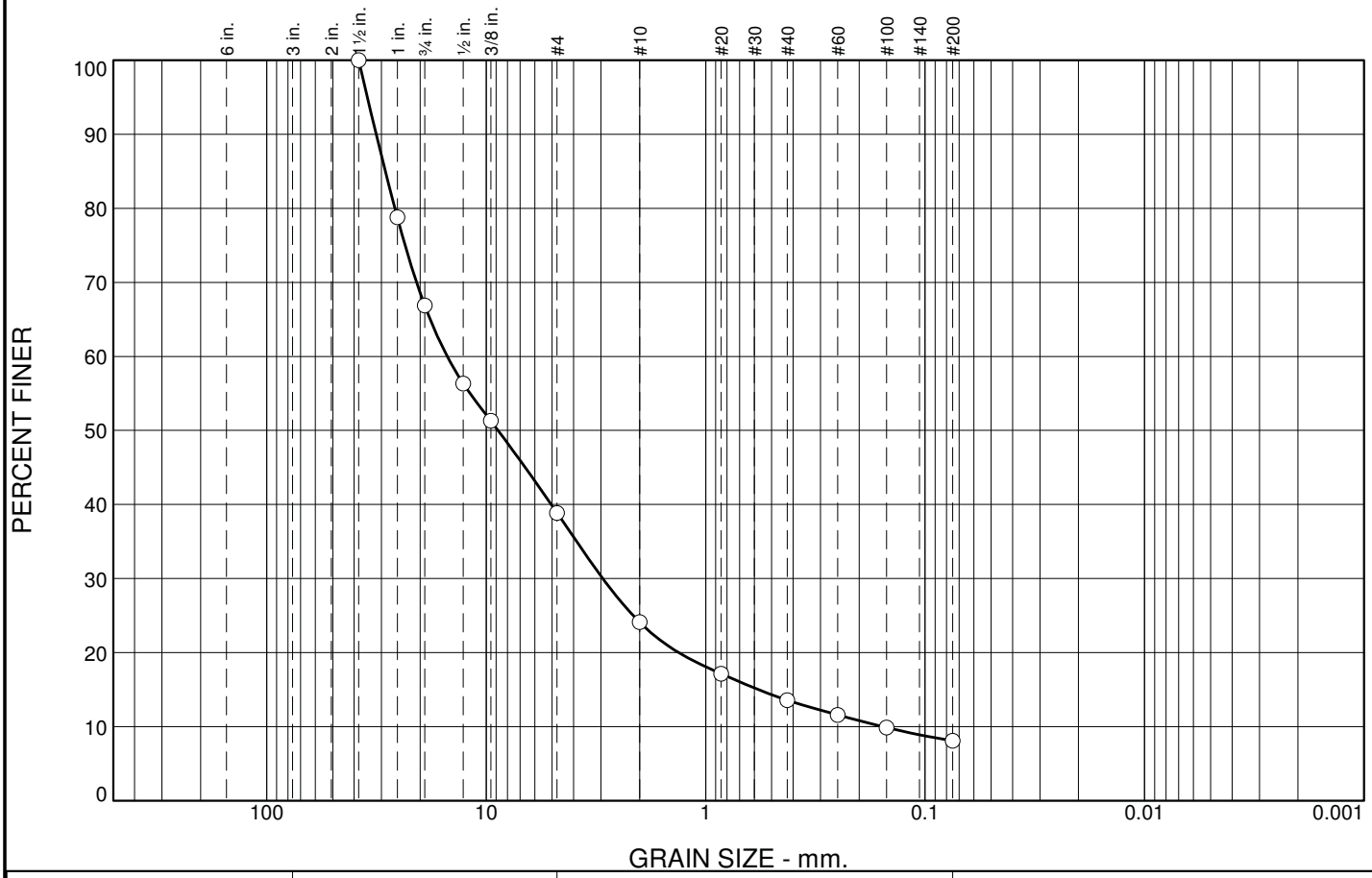
Knight Piésold CONSULTING

Client: Casino Mining Corporation
Project: Casino

Project No: VA101-00325/16 **Figure**

Tested By: RMV **Checked By:** Dab

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	33.1	28.0	14.8	10.5	5.5	8.1	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1.5	100.0		
1	78.8		
.75	66.9		
.5	56.3		
.375	51.3		
#4	38.9		
#10	24.1		
#20	17.1		
#40	13.6		
#60	11.6		
#100	9.9		
#200	8.1		

* (no specification provided)

Soil Description

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 31.6816 D_{85}= 28.7922 D_{60}= 15.0372
D_{50}= 8.8250 D_{30}= 2.9375 D_{15}= 0.5736
D_{10}= 0.1565 C_u= 96.08 C_c= 3.67

Classification

USCS= AASHTO=

Remarks

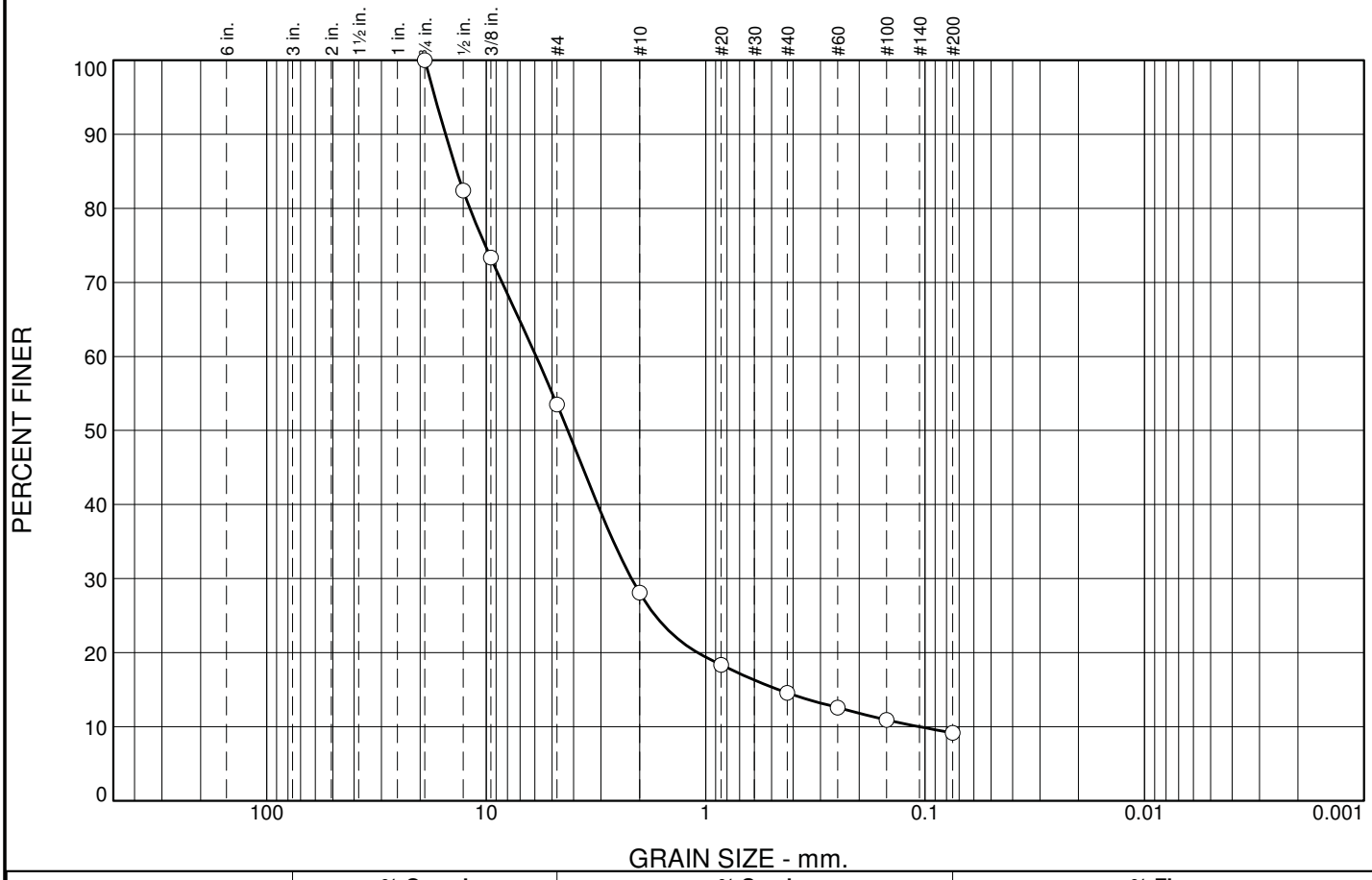
Sample No.: MET-02 **Source of Sample:** **Date:** 9/18/13
Location: Post Perm **Elev./Depth:**

Knight Piésold CONSULTING

Client: Casino Mining Corporation
Project: Casino

Project No: VA101-00325/16 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	46.5	25.4	13.5	5.4	9.2	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75	100.0		
.5	82.4		
.375	73.3		
#4	53.5		
#10	28.1		
#20	18.4		
#40	14.6		
#60	12.6		
#100	10.9		
#200	9.2		

* (no specification provided)

Soil Description

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 15.3179 D_{85}= 13.5980 D_{60}= 5.9201
D_{50}= 4.2474 D_{30}= 2.1755 D_{15}= 0.4652
D_{10}= 0.1062 C_u= 55.75 C_c= 7.53

Classification

USCS= AASHTO=

Remarks

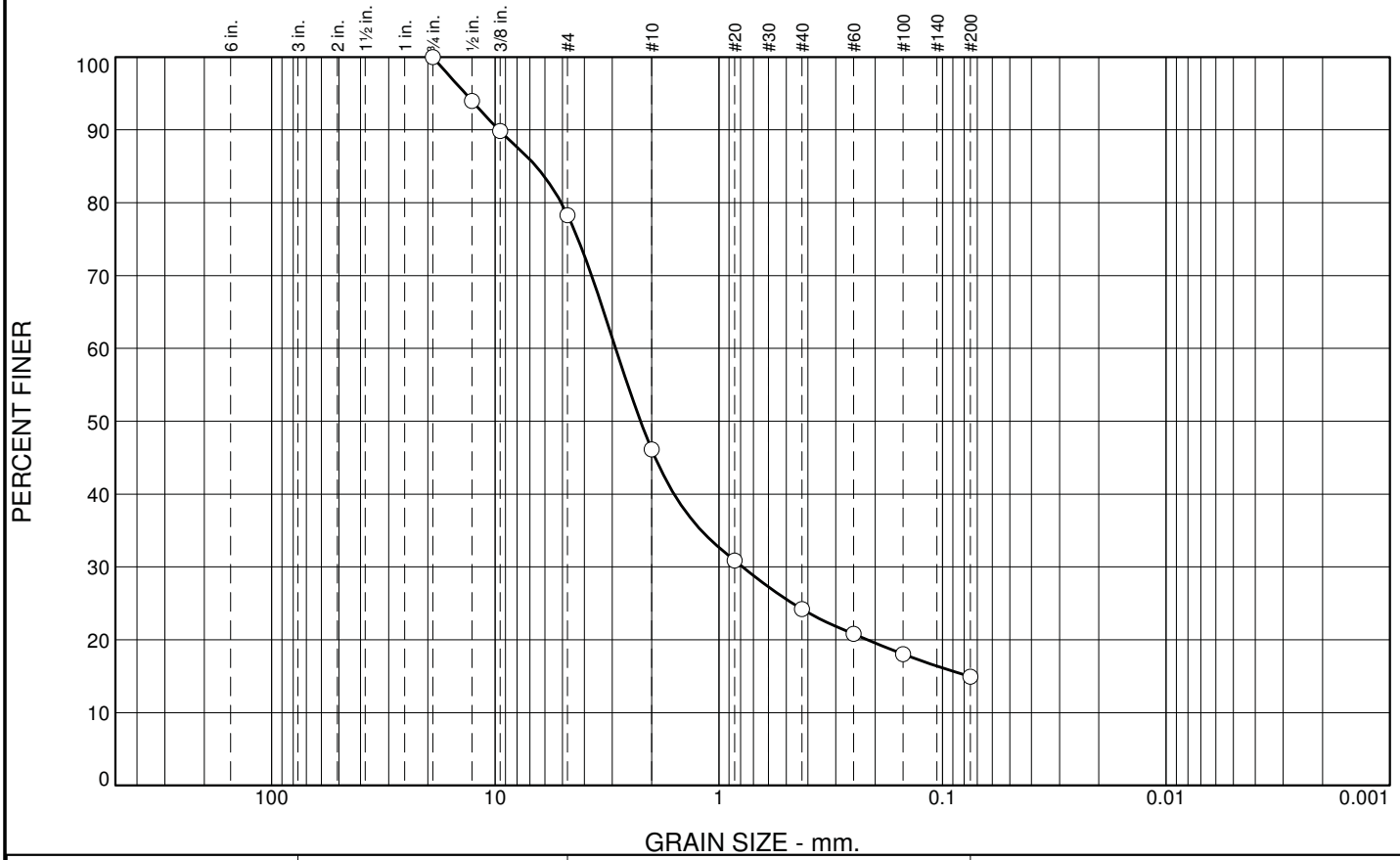
Sample No.: MET-02 **Source of Sample:** **Date:**
Location: As rec'd scalped to compare with post proctor PSA **Elev./Depth:**

Knight Piésold CONSULTING

Client: Casino Mining Corporation
Project: Casino

Project No: VA101-00325/16 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	21.7	32.2	21.9	9.3	14.9	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75	100.0		
.5	94.0		
.375	89.8		
#4	78.3		
#10	46.1		
#20	30.9		
#40	24.2		
#60	20.8		
#100	18.0		
#200	14.9		

* (no specification provided)

Soil Description

silty SAND with gravel

Atterberg Limits

PL= NP LL= NP PI= NP

Coefficients

D_{90}= 9.6560 D_{85}= 6.5738 D_{60}= 2.8934
D_{50}= 2.2414 D_{30}= 0.7830 D_{15}= 0.0761
D_{10}= C_u= C_c=

Classification

USCS= SM AASHTO= A-1-a

Remarks

Sample No.: MET-02PP **Source of Sample:** **Date:** 9/11/13
Location: Post Proctor **Elev./Depth:**

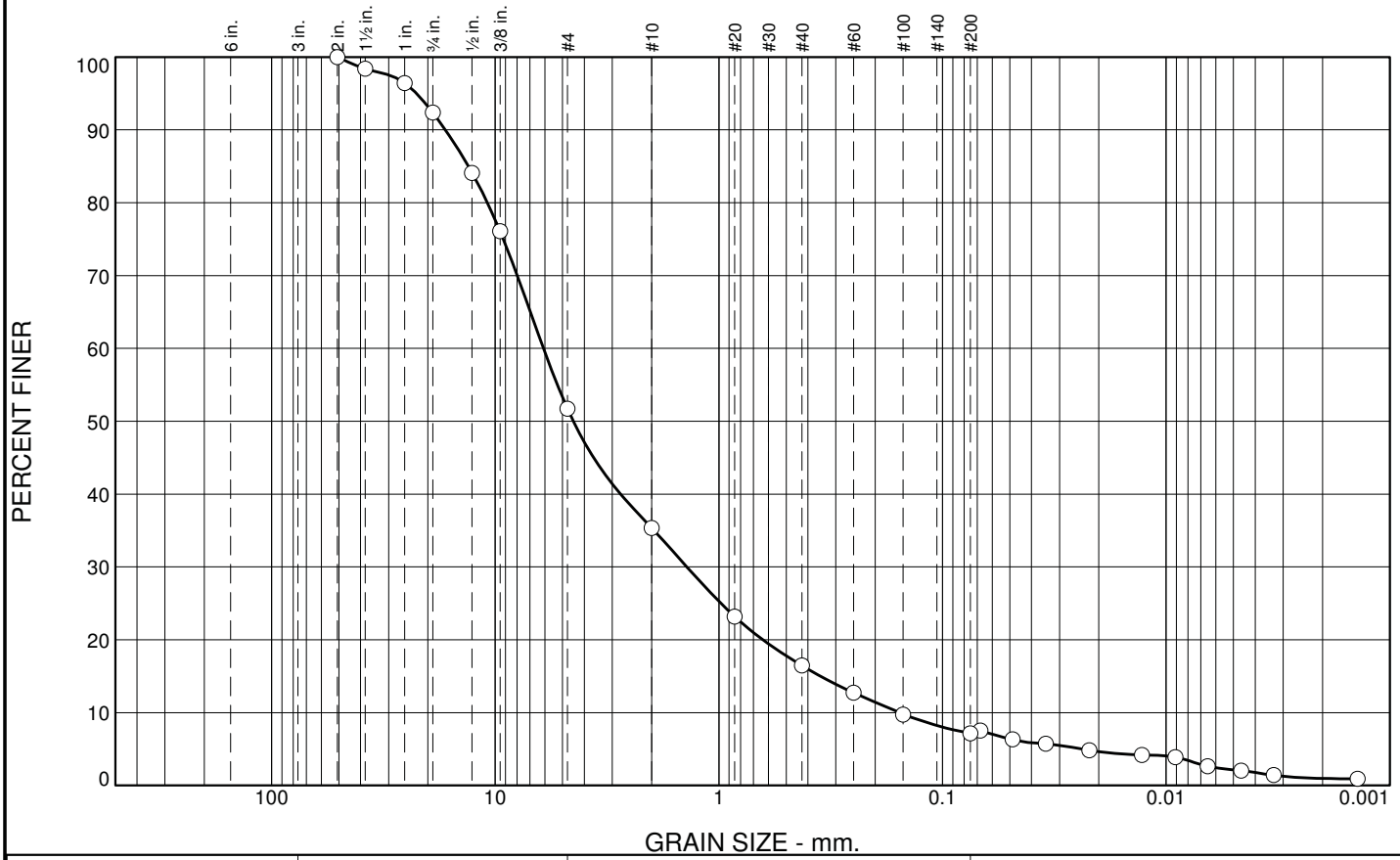
Knight Piésold CONSULTING

Client: Casino Mining Corporation
Project: Casino

Project No: VA101-00325/16 **Figure**

Tested By: RV **Checked By:** JDB

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	7.6	40.7	16.3	18.9	9.3	6.2	1.0

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
2	100.0		
1.5	98.4		
1	96.4		
.75	92.4		
.5	84.1		
.375	76.1		
#4	51.7		
#10	35.4		
#20	23.2		
#40	16.5		
#60	12.7		
#100	9.8		
#200	7.2		
0.0678 mm.	7.6		
0.0485 mm.	6.3		
0.0345 mm.	5.7		
0.0220 mm.	4.8		
0.0128 mm.	4.2		
0.0091 mm.	3.9		
0.0065 mm.	2.7		
0.0046 mm.	2.0		
0.0033 mm.	1.4		
0.0014 mm.	0.9		

* (no specification provided)

Soil Description

well-graded GRAVEL with silt and sand

Atterberg Limits

PL= NP LL= 17 PI= NP

Coefficients

D_{90}= 16.7315 D_{85}= 13.1979 D_{60}= 6.0860
D_{50}= 4.4748 D_{30}= 1.3902 D_{15}= 0.3509
D_{10}= 0.1560 C_u= 39.02 C_c= 2.04

Classification

USCS= GW-GM AASHTO= A-1-a

Remarks

Sample No.: MET-05 **Source of Sample:** **Date:** 9/20/2013
Location: As rec'd **Elev./Depth:**

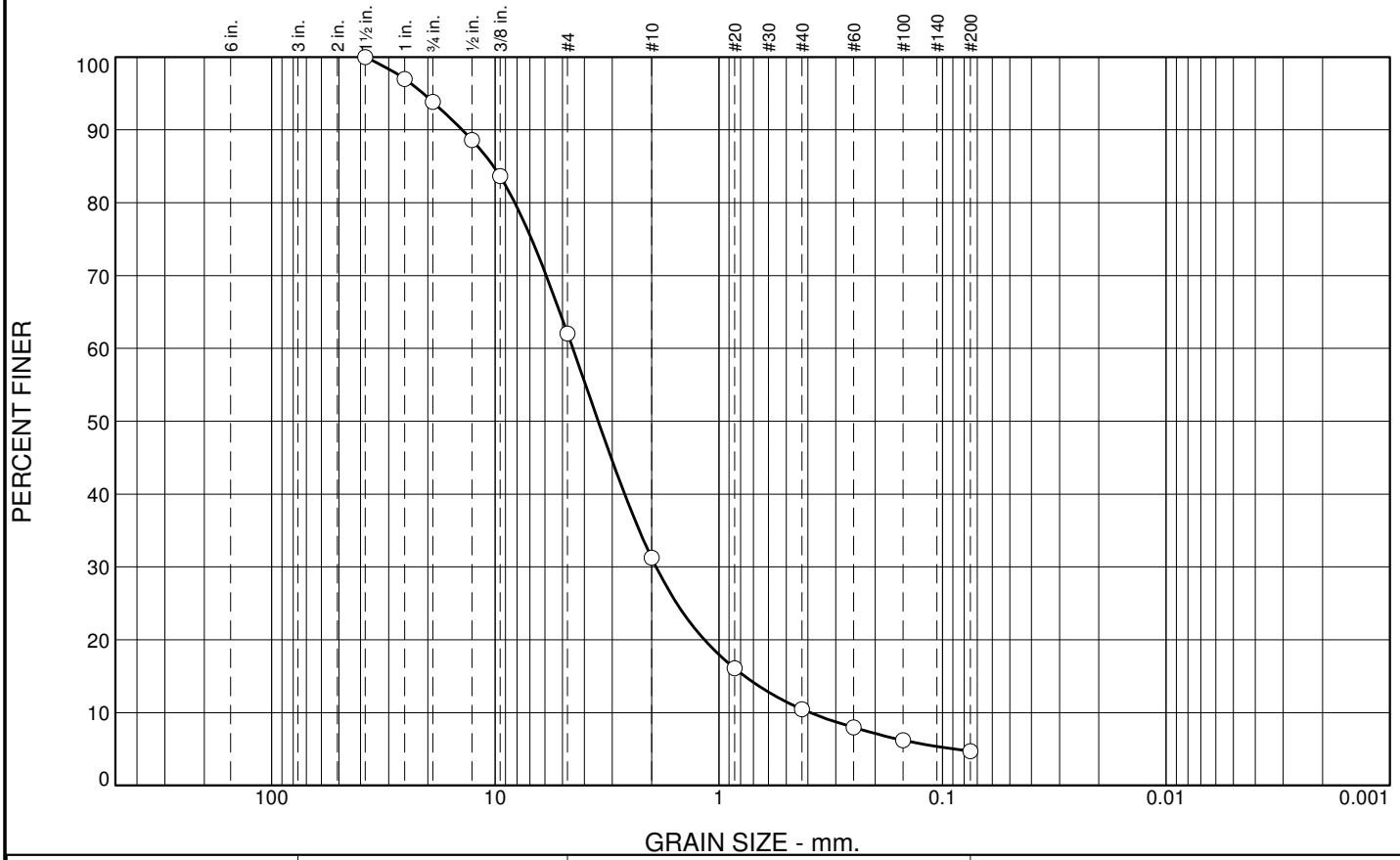
Knight Piésold CONSULTING

Client: Casino Mining Corporation
Project: Casino

Project No: VA101-00325/16 **Figure**

Tested By: RMV **Checked By:** DAB

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	6.2	31.8	30.7	20.8	5.8	4.7	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1.5	100.0		
1	97.0		
.75	93.8		
.5	88.6		
.375	83.7		
#4	62.0		
#10	31.3		
#20	16.1		
#40	10.5		
#60	8.0		
#100	6.2		
#200	4.7		

* (no specification provided)

Soil Description

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 14.0562 D_{85}= 10.1898 D_{60}= 4.5007
D_{50}= 3.4653 D_{30}= 1.9099 D_{15}= 0.7649
D_{10}= 0.3906 C_u= 11.52 C_c= 2.07

Classification

USCS= SW AASHTO=

Remarks

Sample No.: MET-05 **Source of Sample:** **Date:** 9/26/13
Location: Post perm **Elev./Depth:**

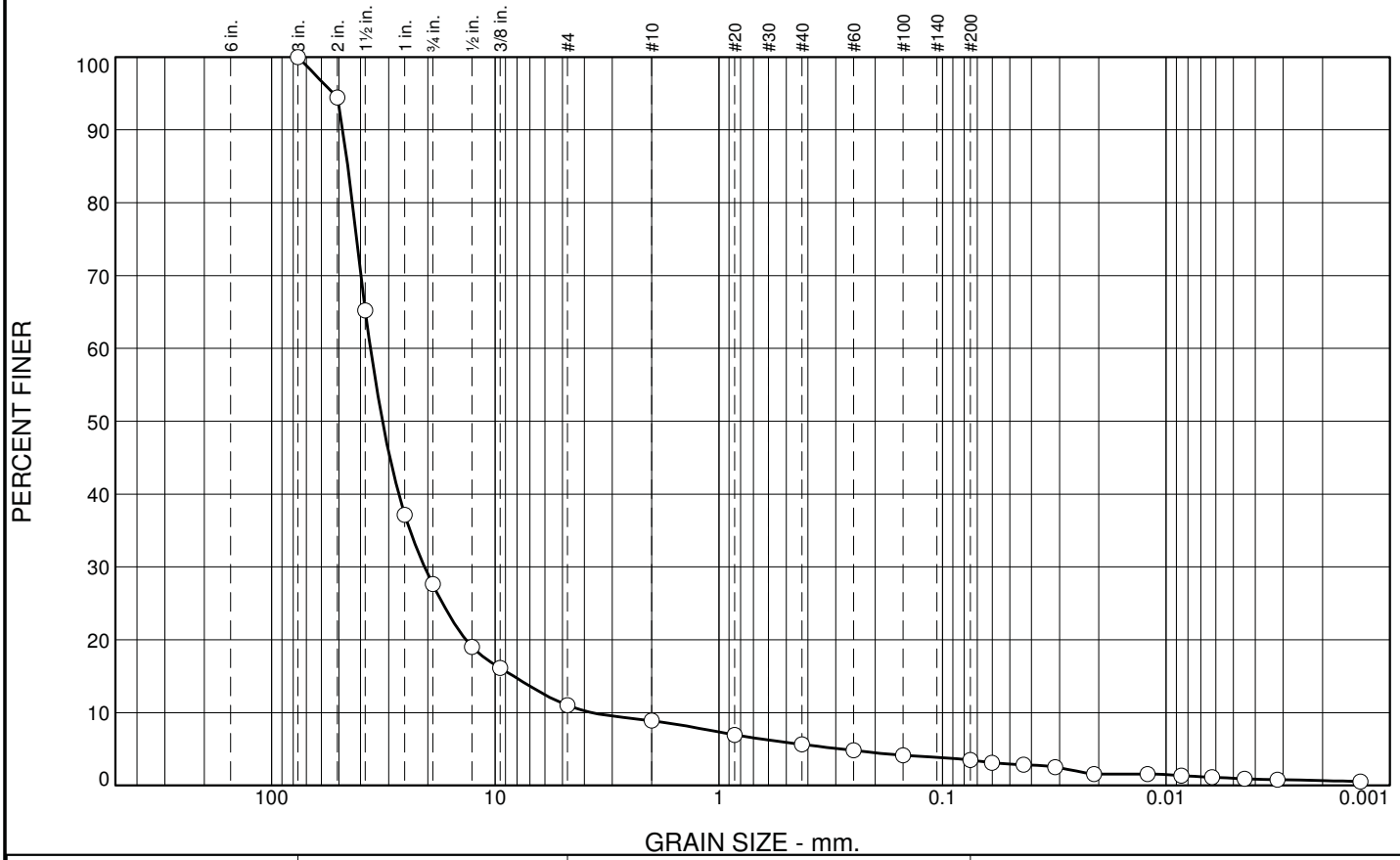
Knight Piésold CONSULTING

Client: Casino Mining Corporation
Project: Casino

Project No: VA101-00325/16 **Figure**

Tested By: DAB **Checked By:** JDB

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	72.4	16.6	2.1	3.3	2.1	2.8	0.7

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3	100.0		
2	94.4		
1.5	65.2		
1	37.2		
.75	27.6		
.5	19.0		
.375	16.2		
#4	11.0		
#10	8.9		
#20	7.0		
#40	5.6		
#60	4.8		
#100	4.2		
#200	3.5		
0.0602 mm.	3.1		
0.0434 mm.	2.9		
0.0314 mm.	2.5		
0.0210 mm.	1.6		
0.0121 mm.	1.6		
0.0086 mm.	1.4		
0.0062 mm.	1.1		
0.0045 mm.	0.9		
0.0032 mm.	0.8		
0.0014 mm.	0.6		

* (no specification provided)

Soil Description

poorly graded GRAVEL

Atterberg Limits

PL= 18 LL= 19 PI= 1

Coefficients

D_{90}= 48.1036 D_{85}= 45.6962 D_{60}= 36.1163
D_{50}= 31.9426 D_{30}= 20.7242 D_{15}= 8.2803
D_{10}= 3.6866 C_u= 9.80 C_c= 3.23

Classification

USCS= GP AASHTO= A-1-a

Remarks

Sample No.: MET-11 **Source of Sample:** **Date:** 9/20/2013
Location: As Rec'd **Elev./Depth:**

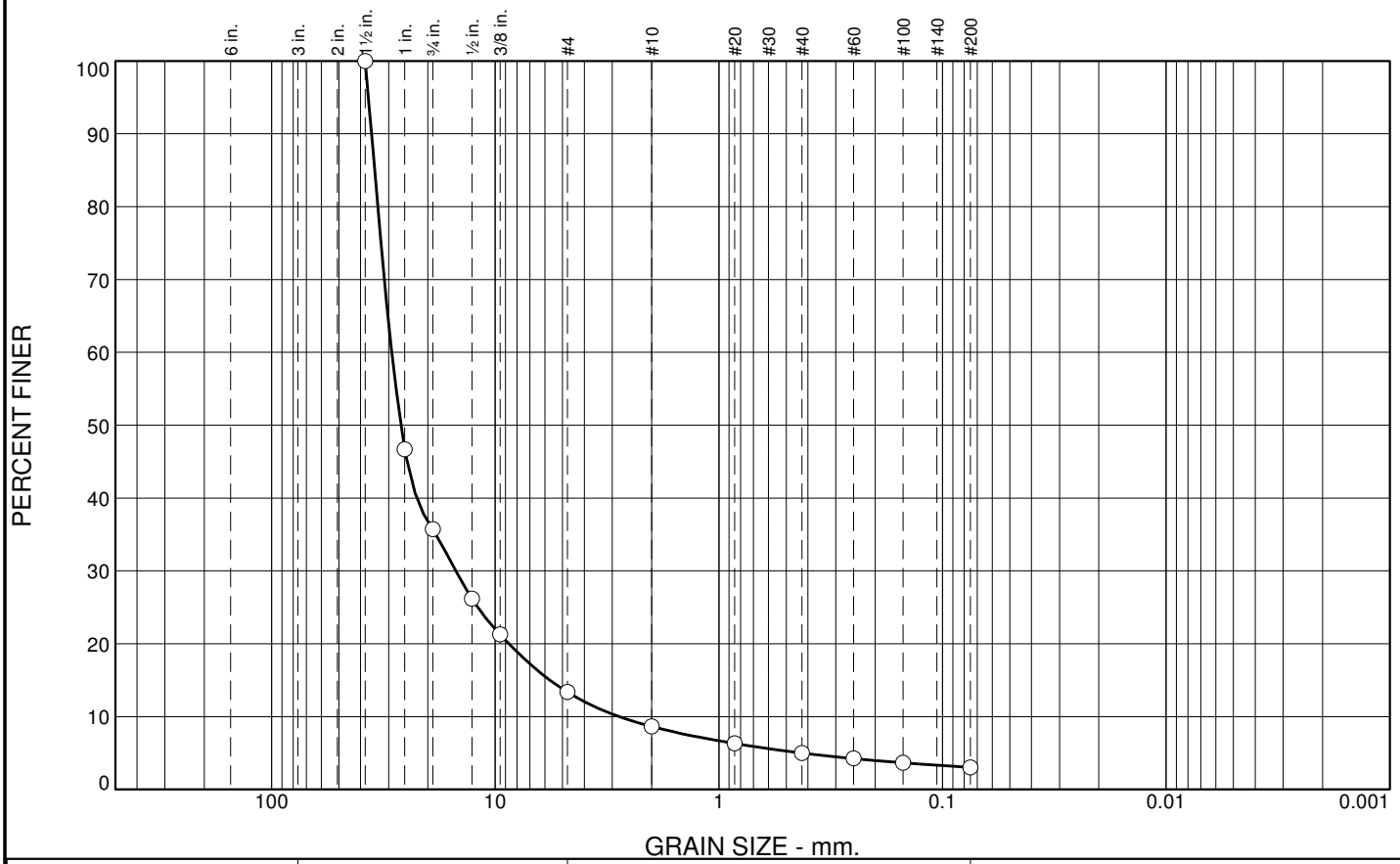
Knight Piésold CONSULTING

Client: Casino Mining Corporation
Project: Casino

Project No: VA101-00325/16 **Figure**

Tested By: RMV **Checked By:** DAB

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	64.3	22.3	4.7	3.7	2.0	3.0	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1.5	100.0		
1	46.7		
.75	35.7		
.5	26.2		
.375	21.3		
#4	13.4		
#10	8.7		
#20	6.3		
#40	5.0		
#60	4.3		
#100	3.7		
#200	3.0		

* (no specification provided)

Soil Description

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 35.7700 D_{85}= 34.6412 D_{60}= 29.0015
D_{50}= 26.4174 D_{30}= 14.9844 D_{15}= 5.6873
D_{10}= 2.7906 C_u= 10.39 C_c= 2.77

Classification

USCS= GW AASHTO=

Remarks

Sample No.: MET-11 **Source of Sample:** **Date:**
Location: Post perm **Elev./Depth:**

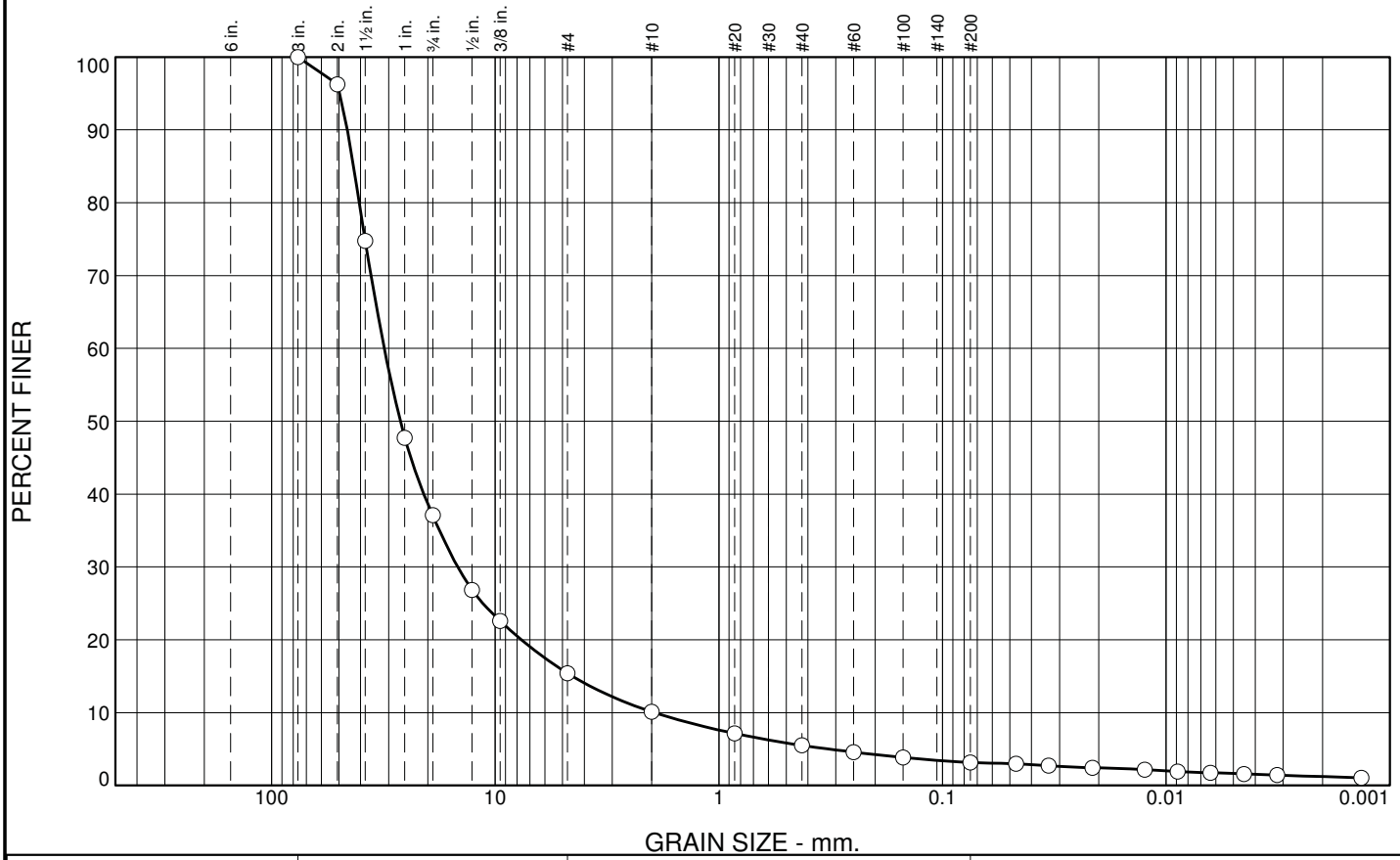
Knight Piésold CONSULTING

Client: Casino Mining Corporation
Project: Casino

Project No: VA101-00325/16 **Figure**

Tested By: DAB

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	62.9	21.7	5.3	4.6	2.3	2.0	1.2

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3	100.0		
2	96.3		
1.5	74.8		
1	47.7		
.75	37.1		
.5	26.8		
.375	22.6		
#4	15.4		
#10	10.1		
#20	7.2		
#40	5.5		
#60	4.6		
#100	3.9		
#200	3.2		
0.0469 mm.	3.0		
0.0335 mm.	2.7		
0.0214 mm.	2.4		
0.0125 mm.	2.2		
0.0089 mm.	1.9		
0.0063 mm.	1.8		
0.0045 mm.	1.6		
0.0032 mm.	1.4		
0.0013 mm.	1.1		

* (no specification provided)

Soil Description

poorly graded GRAVEL

Atterberg Limits

PL= 19 LL= 24 PI= 5

Coefficients

D_{90}= 45.9402 D_{85}= 43.0694 D_{60}= 31.3455
D_{50}= 26.5719 D_{30}= 14.7099 D_{15}= 4.5196
D_{10}= 1.9376 C_u= 16.18 C_c= 3.56

Classification

USCS= GP AASHTO= A-1-a

Remarks

Sample No.: MET-17 **Source of Sample:** Leach Ore **Date:** 11/4/2013
Location: As Rec'd **Elev./Depth:**

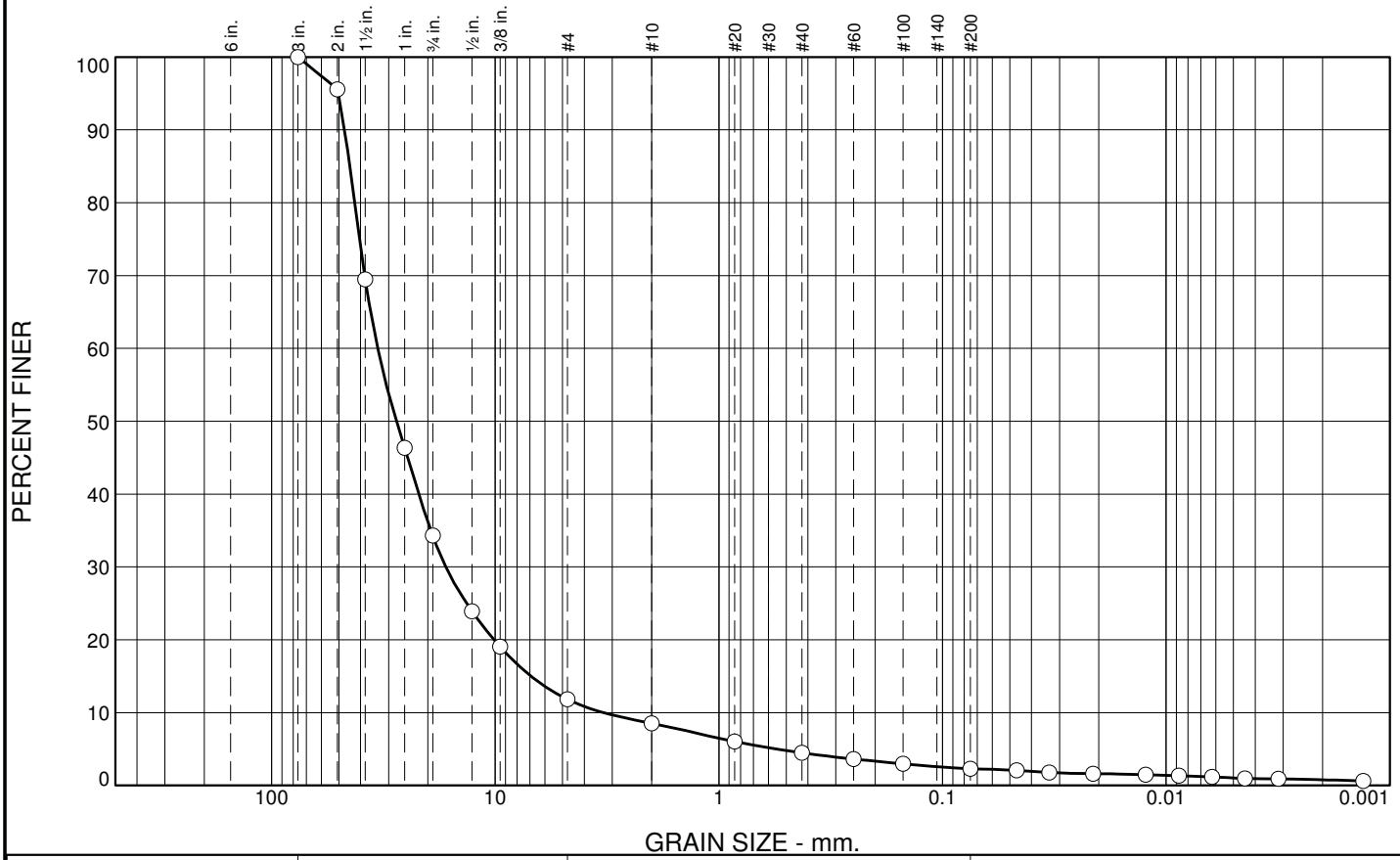
Knight Piésold CONSULTING

Client: Casino Mining Corporation
Project: Casino

Project No: VA101-00325/16 **Figure**

Tested By: RMV **Checked By:** DAB

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	65.7	22.5	3.3	4.0	2.2	1.5	0.8

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3	100.0		
2	95.6		
1.5	69.5		
1	46.4		
.75	34.3		
.5	23.9		
.375	19.1		
#4	11.8		
#10	8.5		
#20	6.0		
#40	4.5		
#60	3.6		
#100	3.0		
#200	2.3		
0.0466 mm.	2.1		
0.0334 mm.	1.8		
0.0212 mm.	1.6		
0.0123 mm.	1.5		
0.0088 mm.	1.3		
0.0062 mm.	1.2		
0.0044 mm.	1.0		
0.0031 mm.	0.9		
0.0013 mm.	0.6		

* (no specification provided)

Soil Description

well-graded GRAVEL

Atterberg Limits

PL= NP LL= NP PI= NP

Coefficients

D_{90}= 47.2339 D_{85}= 44.7439 D_{60}= 33.5294
D_{50}= 27.6145 D_{30}= 16.6310 D_{15}= 6.9114
D_{10}= 3.2899 C_u= 10.19 C_c= 2.51

Classification

USCS= GW AASHTO= A-1-a

Remarks

Sample No.: MET-19 **Source of Sample:** Leach Ore **Date:** 11/4/2013
Location: As Rec'd **Elev./Depth:**

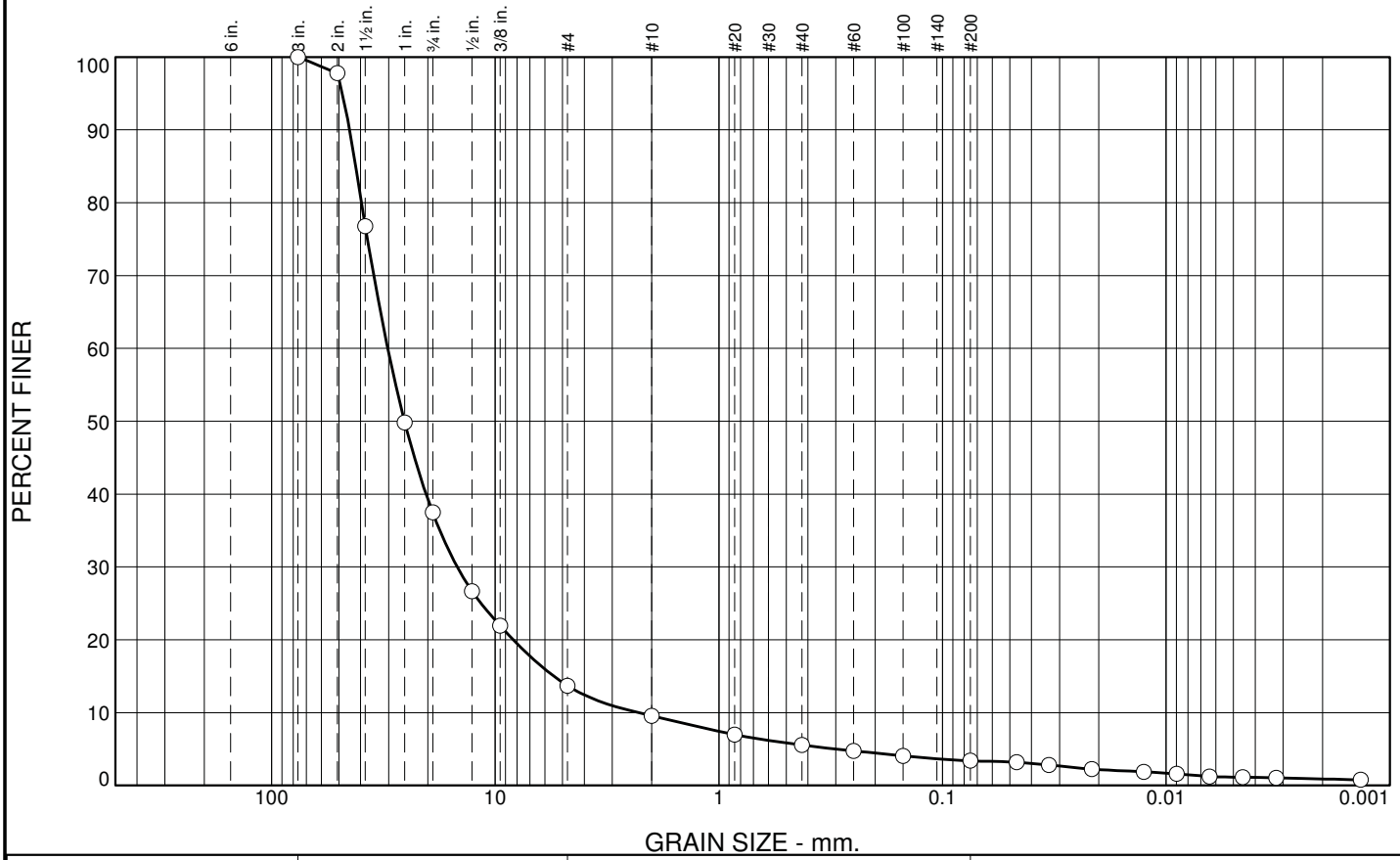
Knight Piésold CONSULTING

Client: Casino Mining Corporation
Project: Casino

Project No: VA101-00325/16 **Figure**

Tested By: RMV **Checked By:** DAB

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	62.5	23.8	4.1	4.0	2.2	2.5	0.9

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3	100.0		
2	97.8		
1.5	76.8		
1	49.8		
.75	37.5		
.5	26.7		
.375	21.9		
#4	13.7		
#10	9.6		
#20	7.0		
#40	5.6		
#60	4.8		
#100	4.1		
#200	3.4		
0.0466 mm.	3.2		
0.0334 mm.	2.8		
0.0215 mm.	2.3		
0.0126 mm.	1.9		
0.0090 mm.	1.6		
0.0064 mm.	1.2		
0.0045 mm.	1.1		
0.0032 mm.	1.1		
0.0013 mm.	0.8		

* (no specification provided)

Soil Description

poorly graded GRAVEL

Atterberg Limits

PL= NP LL= NP PI= NP

Coefficients

D_{90}= 44.8729 D_{85}= 42.1096 D_{60}= 30.2431
D_{50}= 25.4760 D_{30}= 14.7938 D_{15}= 5.4722
D_{10}= 2.2867 C_u= 13.23 C_c= 3.16

Classification

USCS= GP AASHTO= A-1-a

Remarks

Sample No.: MET-20 **Source of Sample:** Leach Ore **Date:** 11/4/2013
Location: As Rec'd **Elev./Depth:**

Knight Piésold CONSULTING

Client: Casino Mining Corporation
Project: Casino

Project No: VA101-00325/16 **Figure**

Tested By: RMV **Checked By:** DAB

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Specific Gravity - Coarse Aggregate

ASTM C 127

Project	*Casino*	*Project No.*	*VA101-00325/16*
Lab No.	*L2013-084*	*Date of Test*	*7/29/2013*
Tested By	*RV/DB*	*Checked By*	*JDB*

Run by / Date	DB/RV 7/29	DB/RV 9/6		Weighted Avg. Plus No. 4	
Sample No./ Depth	CL-01 Res.	MET-02	MET-02		
Sample Description	No. 4 - 2"	No. 4 - 2"	No. 4 - 2"		
No. of +3 in. pcs.					
Tare No.					
Saturated Surface Dry Aggregate + Tare	3836.1	5219.4	5219.4		
Dry Aggregate + Tare	3696.3	5036	5036		
Tare	229.7	348.5	348.5		
Saturated Surface Dry Aggregate (B)	3606.4	4870.9	4870.9		
Dry Aggregate (A)	3466.6	4687.5	4687.5		
Basket Submerged		0	0		
Saturated Aggregate Submerged (C)	2155.4	2968.3	2968.3		
Temperature of Water			24.1		
Correction Factor					
Apparent Specific Gravity (A / (A-C))	2.644	2.727	2.727	2.727	
Bulk Specific Gravity , SSD (B / (B-C))	2.485	2.560	2.560	2.560	
Bulk Specific Gravity (A / (B-C))	2.389	2.464	2.464	2.464	
Absorption (%)	4.0	3.9	3.9	3.9	
Percent Retained #4	85			73.0	
Percent Passing #4	15			27.0	
Gs of Aggregate Passing #4	2.744			2.746	
Weighted Average Specific Gravity	2.659			2.732	

Remarks:

Knight Piésold CONSULTING

Specific Gravity - Coarse Aggregate

ASTM C 127

Project	Casino	Project No.	VA101-00325/16
Lab No.	L2013-084	Date of Test	7/29/2013
Tested By	RV/DB	Checked By	JDB

Run by / Date	DB 9/25	DB 9/25	Weighted Avg. Plus No. 4		
Sample No./ Depth	MET-5	MET-5			
Sample Description	Plus 3/8"	No.4			
No. of +3 in. pcs.					
Tare No.					
Saturated Surface Dry Aggregate + Tare	2839.4	617.5			
Dry Aggregate + Tare	2750.1	601.6			
Tare	385.6	186.4			
Saturated Surface Dry Aggregate (B)	2453.8	431.1			
Dry Aggregate (A)	2364.5	415.2			
Basket Submerged	0	0			
Saturated Aggregate Submerged (C)	1464.5	259			
Temperature of Water	20	20			
Correction Factor					
Apparent Specific Gravity (A / (A-C))	2.627	2.658	2.643		
Bulk Specific Gravity , SSD (B / (B-C))	2.480	2.505	2.493		
Bulk Specific Gravity (A / (B-C))	2.390	2.413	2.401		
Absorption (%)	3.78	3.83	3.80		
Percent Retained #4			48.3		
Percent Passing #4			51.7		
Gs of Aggregate Passing #4			2.698		
Weighted Average Specific Gravity			2.667		

Remarks:

Knight Piésold CONSULTING

Specific Gravity - Coarse Aggregate

ASTM C 127

Project	Casino	Project No.	VA101-00325/16
Lab No.	L2013-084	Date of Test	7/29/2013
Tested By	RV/DB	Checked By	JDB

Run by / Date	RMV 9/30	RMV 9/30	Weighted Avg. Plus No. 4		
Sample No./ Depth	MET-11	MET-11			
Sample Description	Minus 3/4"	Plus 3/4"			
No. of +3 in. pcs.					
Tare No.					
Saturated Surface Dry Aggregate + Tare					
Dry Aggregate + Tare	3897.4	4643.7			
Tare	373.2	375.7			
Saturated Surface Dry Aggregate (B)	3599.6	4341.3			
Dry Aggregate (A)	3524.2	4268			
Basket Submerged					
Saturated Aggregate Submerged (C)	2219.7	2678.7			
Temperature of Water	23	23			
Correction Factor	1	1			
Apparent Specific Gravity (A / (A-C))	2.702	2.685	2.688		
Bulk Specific Gravity , SSD (B / (B-C))	2.609	2.611	2.611		
Bulk Specific Gravity (A / (B-C))	2.554	2.567	2.565		
Absorption (%)	2.14	1.72	1.80		
Percent Retained #4			89.0		
Percent Passing #4			11.0		
Gs of Aggregate Passing #4			2.739		
Weighted Average Specific Gravity			2.694		

Remarks:

Knight Piésold CONSULTING

Specific Gravity - Coarse Aggregate

ASTM C 127

Project	Casino	Project No.	VA101-00325/16
Lab No.	L2013-084	Date of Test	11/8/2013
Tested By	RV/DB	Checked By	JDB

Run by / Date	RMV 11/9	RMV 11/9	Weighted Avg. Plus No. 4		
Sample No./ Depth	MET-17	MET-17			
Sample Description	Minus 3/4"	Plus 3/4"			
No. of +3 in. pcs.					
Tare No.					
Saturated Surface Dry Aggregate + Tare	1987.2	4757.8			
Dry Aggregate + Tare	1941.9	4657.6			
Tare	373.2	389.6			
Saturated Surface Dry Aggregate (B)	1614	4368.2			
Dry Aggregate (A)	1568.7	4268			
Basket Submerged					
Saturated Aggregate Submerged (C)	976.7	2638.8			
Temperature of Water	24	24			
Correction Factor	1	1			
Apparent Specific Gravity (A / (A-C))	2.650	2.620	2.627		
Bulk Specific Gravity , SSD (B / (B-C))	2.533	2.526	2.528		
Bulk Specific Gravity (A / (B-C))	2.461	2.468	2.466		
Absorption (%)	2.89	2.35	2.49		
Percent Retained #4			84.6		
Percent Passing #4			15.4		
Gs of Aggregate Passing #4			2.711		
Weighted Average Specific Gravity			2.640		

Remarks:

Knight Piésold CONSULTING

Specific Gravity - Coarse Aggregate

ASTM C 127

Project	Casino	Project No.	VA101-00325/16
Lab No.	L2013-084	Date of Test	11/8/2013
Tested By	RV/DB	Checked By	JDB

Run by / Date	RMV 11/9	RMV 11/9	Weighted Avg. Plus No. 4		
Sample No./ Depth	MET-19	MET-19			
Sample Description	Minus 3/4"	Plus 3/4"			
No. of +3 in. pcs.					
Tare No.					
Saturated Surface Dry Aggregate + Tare	1946.2	4767.9			
Dry Aggregate + Tare	1885.5	4634.5			
Tare	242.7	259.2			
Saturated Surface Dry Aggregate (B)	1703.5	4508.7			
Dry Aggregate (A)	1642.8	4375.3			
Basket Submerged					
Saturated Aggregate Submerged (C)	1048.1	2774			
Temperature of Water	23	23			
Correction Factor	1	1			
Apparent Specific Gravity (A / (A-C))	2.762	2.732	2.740		
Bulk Specific Gravity , SSD (B / (B-C))	2.599	2.599	2.599		
Bulk Specific Gravity (A / (B-C))	2.507	2.522	2.518		
Absorption (%)	3.69	3.05	3.21		
Percent Retained #4			88.2		
Percent Passing #4			11.8		
Gs of Aggregate Passing #4			2.806		
Weighted Average Specific Gravity			2.748		

Remarks:

Knight Piésold CONSULTING

Specific Gravity - Coarse Aggregate

ASTM C 127

Project	Casino	Project No.	VA101-00325/16
Lab No.	L2013-084	Date of Test	11/8/2013
Tested By	RV/DB	Checked By	JDB

Run by / Date	RMV 11/8	RMV 11/8	Weighted Avg. Plus No. 4		
Sample No./ Depth	MET-20	MET-20			
Sample Description	Minus 3/4"	Plus 3/4"			
No. of +3 in. pcs.					
Tare No.					
Saturated Surface Dry Aggregate + Tare	3400.1	6597			
Dry Aggregate + Tare	3304.6	6456.5			
Tare	229.7	375.6			
Saturated Surface Dry Aggregate (B)	3170.4	6221.4			
Dry Aggregate (A)	3074.9	6080.9			
Basket Submerged					
Saturated Aggregate Submerged (C)	1923.7	3766.4			
Temperature of Water	22	22			
Correction Factor	1	1			
Apparent Specific Gravity (A / (A-C))	2.671	2.627	2.639		
Bulk Specific Gravity , SSD (B / (B-C))	2.543	2.534	2.537		
Bulk Specific Gravity (A / (B-C))	2.466	2.477	2.474		
Absorption (%)	3.11	2.31	2.53		
Percent Retained #4			86.3		
Percent Passing #4			13.7		
Gs. of Aggregate Passing #4			2.735		
Weighted Average Specific Gravity			2.652		

Remarks:

Knight Piésold

CONSULTING

Specific Gravity - Soil

ASTM D 854

Project	Casino	***Project No.***	VA101-325/16
Date Staged	9/20/2013	***Act. Code***	
Date Completed	9/21/2013	***Lab No.***	L2013-084
Tested By	RMV	***Checked By***	DAB/JDB

Sample No.	CL-01 Res.		MET-02		MET-05		MET-11		MET-17	
Sample Prep. (Wet or Dry)	Wet		Wet		Wet		Wet		Wet	
Flask No.										
1) Wt. of Flask + Soil										
2) Wt. of Flask										
3) Wt. of Soil (1-2)	37.96	38.54	43.62		41.82	41.86	41.48	41.41	34.26	34.24
4) Calibrated Wt. of Flask + Water	343.31	348.85	364.48		352.28	341.75	348.87	343.44	349.28	352.69
5) #3 + #4	381.27	387.39	408.10		394.10	383.61	390.35	384.85	383.54	386.93
6) Wt. of Flask + Water + Soil	367.43	373.39	392.23		378.64	368.10	375.22	369.76	370.93	374.27
7) Volume of Soil (5 - 6)	13.84	14.00	15.87		15.46	15.51	15.13	15.09	12.61	12.66
8) Test Temperature, deg. C	26.4	25.8	24.2		26.5	26.5	26.5	26.5	19.4	19.4
9) Temperature Correction, k	0.998473	0.998630	0.999040		0.998447	0.998447	0.998447	0.998447	1.000120	1.000120
10) Specific Gravity ((3 / 7) * k)	2.739	2.749	2.746		2.701	2.695	2.737	2.740	2.717	2.705
Reported Average, G_s @ 20 deg.C	2.744		2.746		2.698		2.739		2.711	
Tare										
Dry Soil + tare, g	413.83	430.77	438.05		437.53	436.32	436.58	434.88	437.23	427.25
Tare, g	375.87	392.23	394.43		395.71	394.46	395.1	393.47	402.97	393.01

General Notes: Line 9, k, is determined by dividing the density of water at test temperature recorded, by the density of water at 20 deg. C.

Knight Piésold

CONSULTING

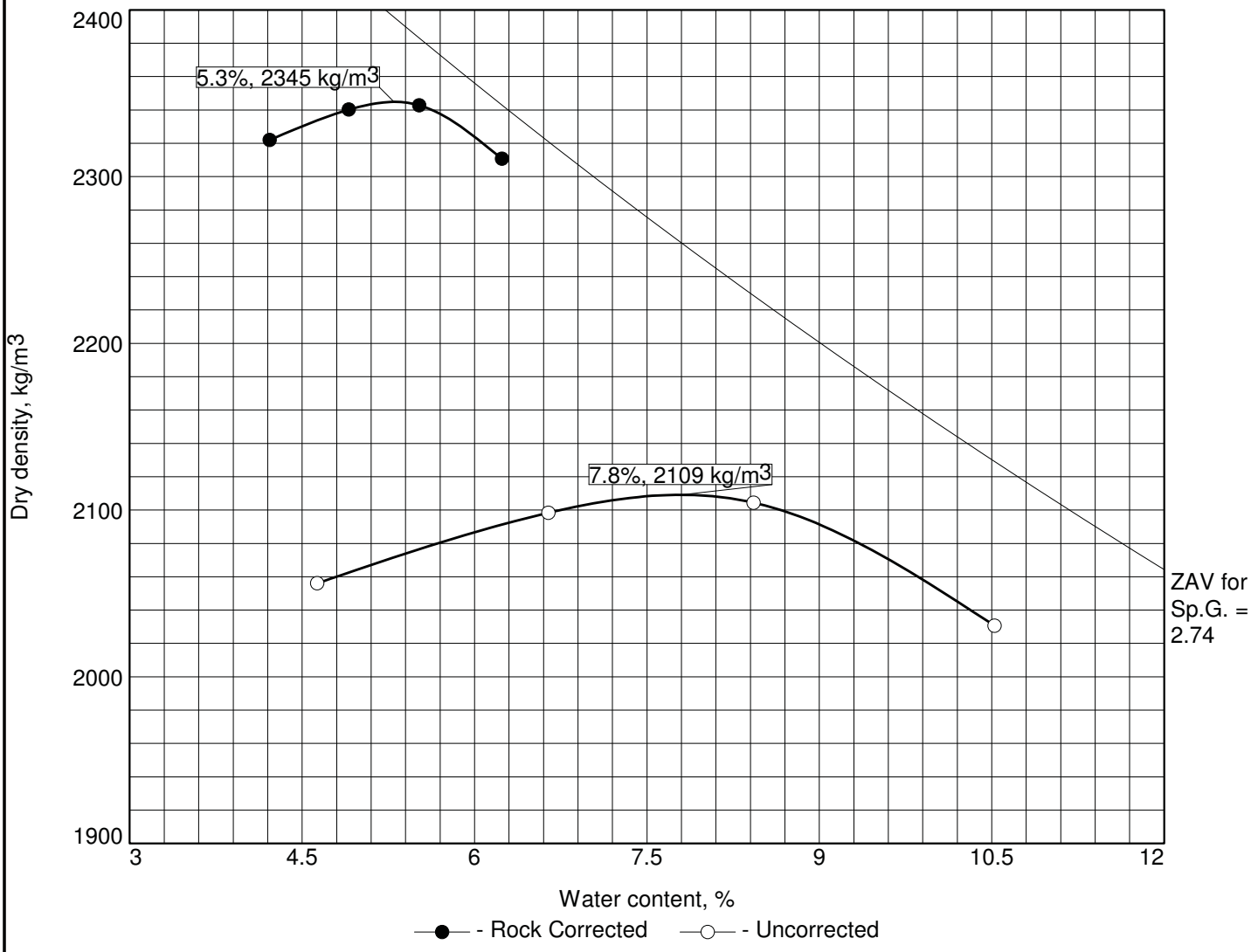
Specific Gravity - Soil

ASTM D 854

Project	Casino	***Project No.***	VA101-325/16
Date Staged	11/4/2013	***Act. Code***	
Date Completed	11/5/163	***Lab No.***	L2013-084
Tested By	RMV	***Checked By***	DAB/JDB

Sample No.	*MET-19*		*MET-20*							
Sample Prep. (Wet or Dry)	*Wet*		*Wet*							
Flask No.	*8*	*10*	*3*	*6*						
1) Wt. of Flask + Soil										
2) Wt. of Flask										
3) Wt. of Soil (1-2)	*35.02*	*35.14*	*34.41*	*34.38*						
4) Calibrated Wt. of Flask + Water	*342.12*	*343.84*	*364.78*	*342.48*						
5) #3 + #4	*377.14*	*378.98*	*399.19*	*376.86*						
6) Wt. of Flask + Water + Soil	*364.70*	*366.41*	*386.58*	*364.31*						
7) Volume of Soil (5 - 6)	*12.44*	*12.57*	*12.61*	*12.55*						
8) Test Temperature, deg. C	*19.5*	*19.5*	*18.9*	*18.9*						
9) Temperature Correction, k	*1.000100*	*1.000100*	*1.000220*	*1.000220*						
*10) Specific Gravity ((3 / 7) * k)*	*2.815*	*2.796*	*2.729*	*2.740*						
Reported Average, G_s @ 20 deg.C	*2.806*		*2.735*							
Tare										
Dry Soil + tare, g	*437.98*	*428.07*	*430.02*	*428.05*						
Tare, g	*402.96*	*392.93*	*395.61*	*393.67*						

General Notes: *Line 9, k, is determined by dividing the density of water at test temperature recorded, by the density of water at 20 deg. C.*



Test specification: ASTM D 1557-07 Method C Modified
ASTM D 4718-87 Oversize Corr. Applied to Each Test Point

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/4 in.	% < No.200
	USCS	AASHTO						
	GP-GM	A-1-a		2.744	NP	NP	65.7	5.0

ROCK CORRECTED TEST RESULTS	UNCORRECTED	MATERIAL DESCRIPTION
Maximum dry density = 2345 kg/m3	2109 kg/m3	poorly graded GRAVEL with silt
Optimum moisture = 5.3 %	7.8 %	

Project No. VA101-00325/16 **Client:** Casino Mining Corporation
Project: Casino
Date: 7/30/13
○ **Location:** Casino Gold Mine **Sample Number:** CL-01 Residue

Remarks:

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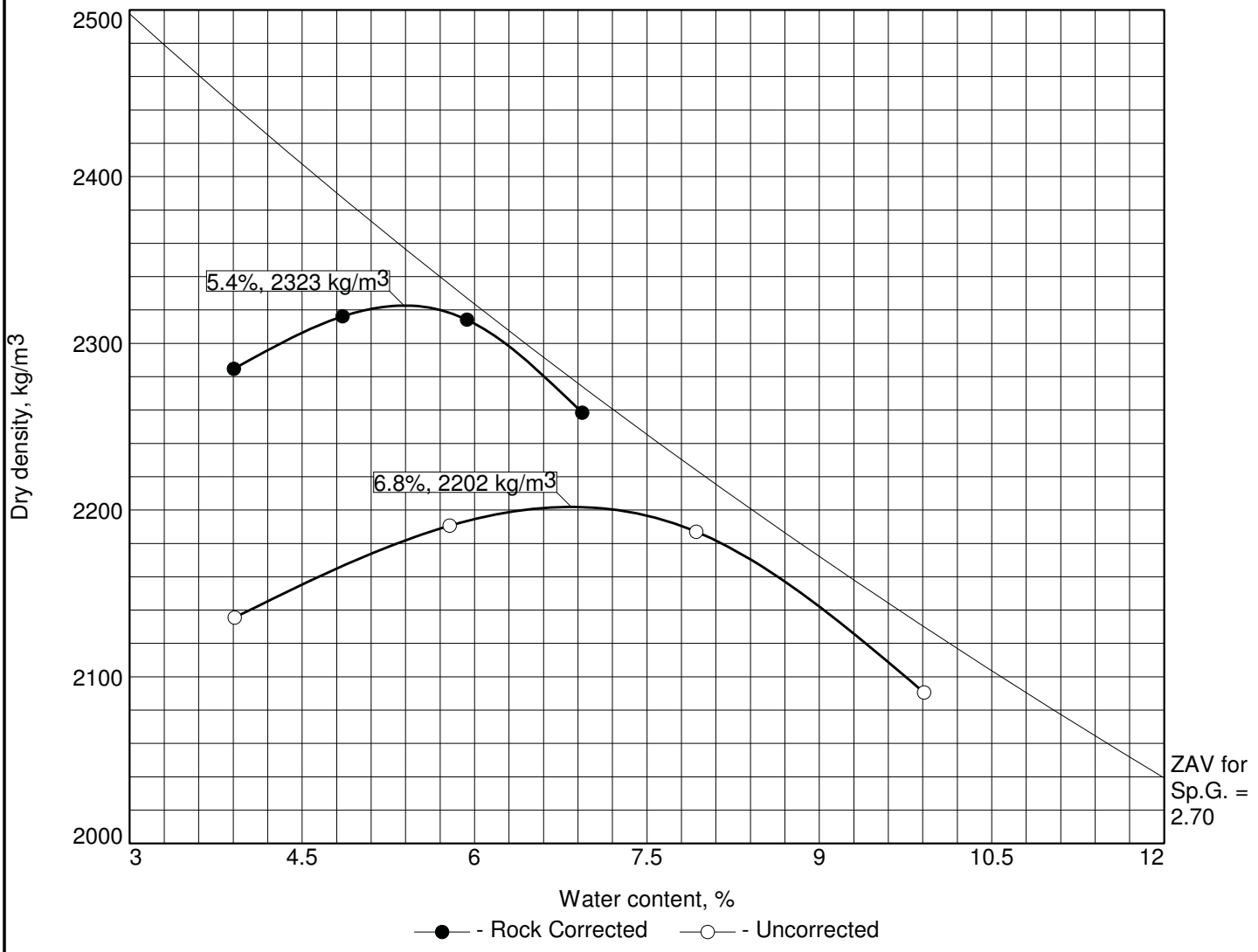
Figure

Tested By: RMV **Checked By:** DAB



Test specification: ASTM D 1557-07 Method C Modified
ASTM D 4718-87 Oversize Corr. Applied to Each Test Point

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/4 in.	% < No.200
	USCS	AASHTO						
	GW	A-1-a		2.746	22	1	49.5	4.6

ROCK CORRECTED TEST RESULTS	UNCORRECTED	MATERIAL DESCRIPTION
Maximum dry density = 2323 kg/m3	2202 kg/m3	well-graded GRAVEL with sand
Optimum moisture = 5.4 %	6.8 %	

Project No. VA101-00325/16 **Client:** Casino Mining Corporation
Project: Casino

Date: 9/6/13

○ **Source of Sample:** Leach Ore **Sample Number:** MET-02

Remarks:

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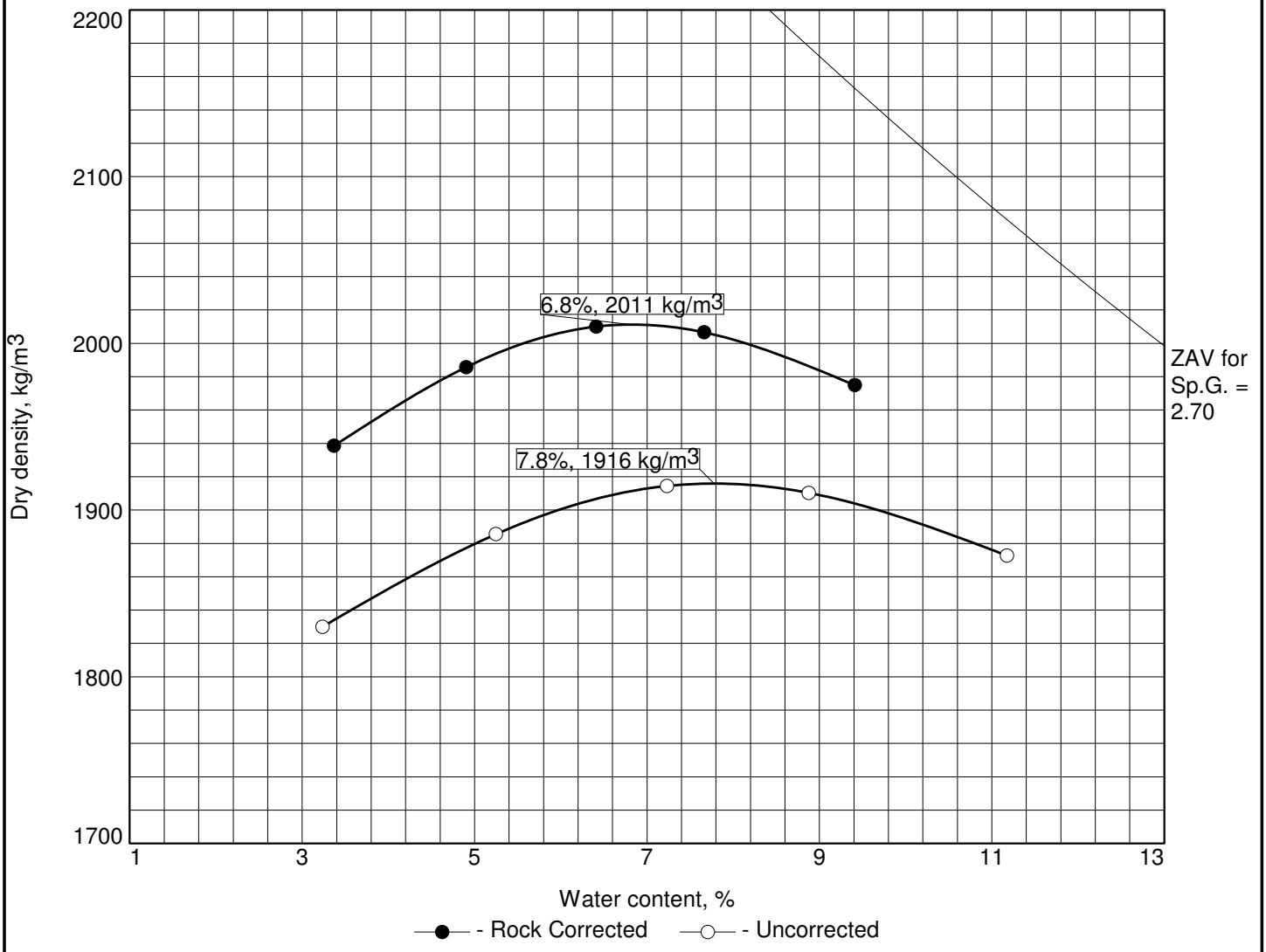
Figure

Tested By: RMV **Checked By:** DAB



Test specification: ASTM D 1557-07 Method B Modified
ASTM D 4718-87 Oversize Corr. Applied to Each Test Point

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/8 in.	% < No.200
	USCS	AASHTO						
	GW-GM	A-1-a		2.698	17	NP	23.9	7.2

ROCK CORRECTED TEST RESULTS	UNCORRECTED	MATERIAL DESCRIPTION
Maximum dry density = 2011 kg/m3	1916 kg/m3	well-graded GRAVEL with silt and sand
Optimum moisture = 6.8 %	7.8 %	

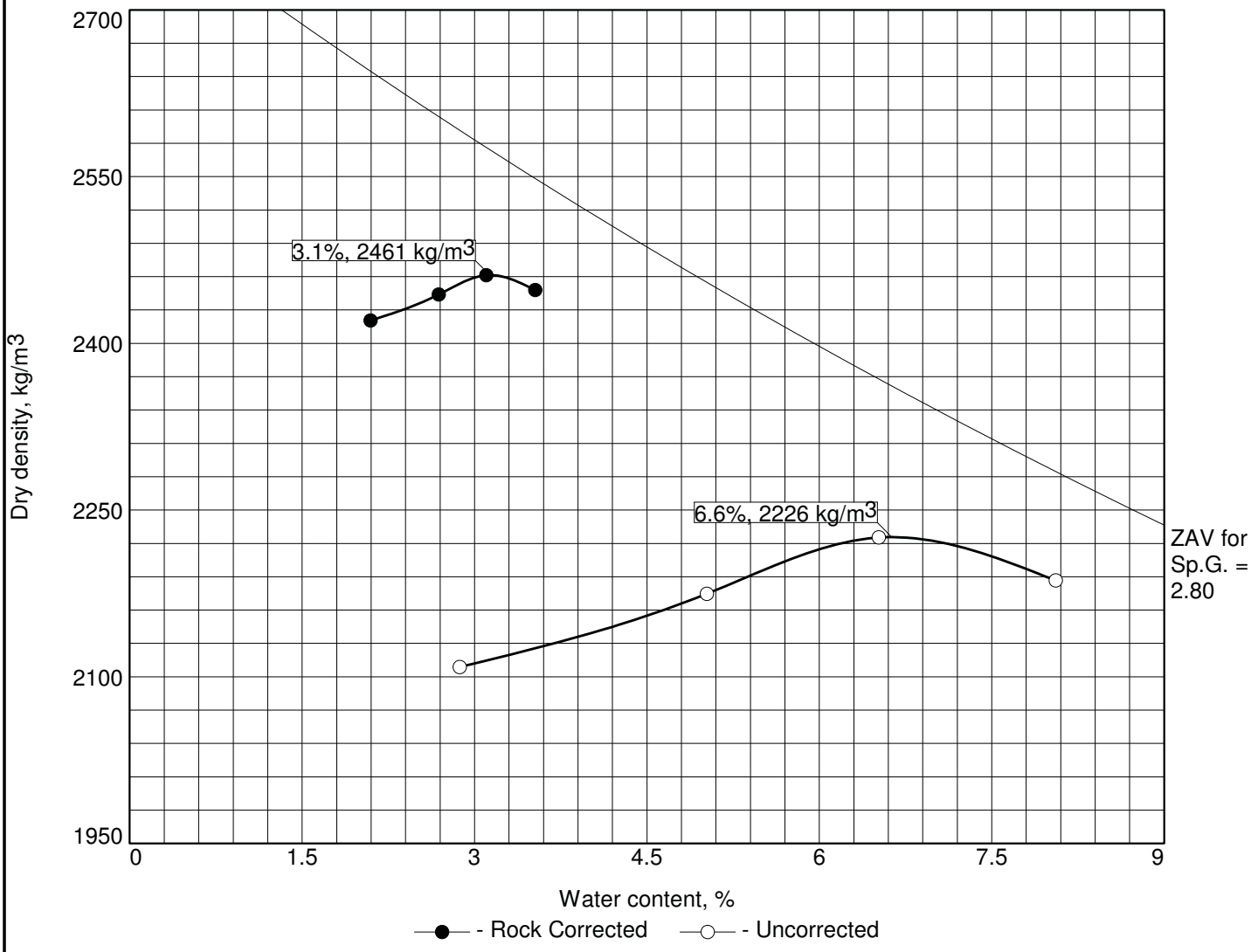
Project No. VA101-00325/16 **Client:** Casino Mining Corporation
Project: Casino
Date: 9/20/13
○ **Location:** As rec'd **Sample Number:** MET-05

Remarks:

Knight Piésold CONSULTING

Figure

Tested By: RMV **Checked By:** JDB



Test specification: ASTM D 1557-07 Method C Modified
ASTM D 4718-87 Oversize Corr. Applied to Each Test Point

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/4 in.	% < No.200
	USCS	AASHTO						
	GP	A-1-a		2.739	19	1	72.4	3.5

ROCK CORRECTED TEST RESULTS	UNCORRECTED	MATERIAL DESCRIPTION
Maximum dry density = 2461 kg/m3	2226 kg/m3	poorly graded GRAVEL
Optimum moisture = 3.1 %	6.6 %	

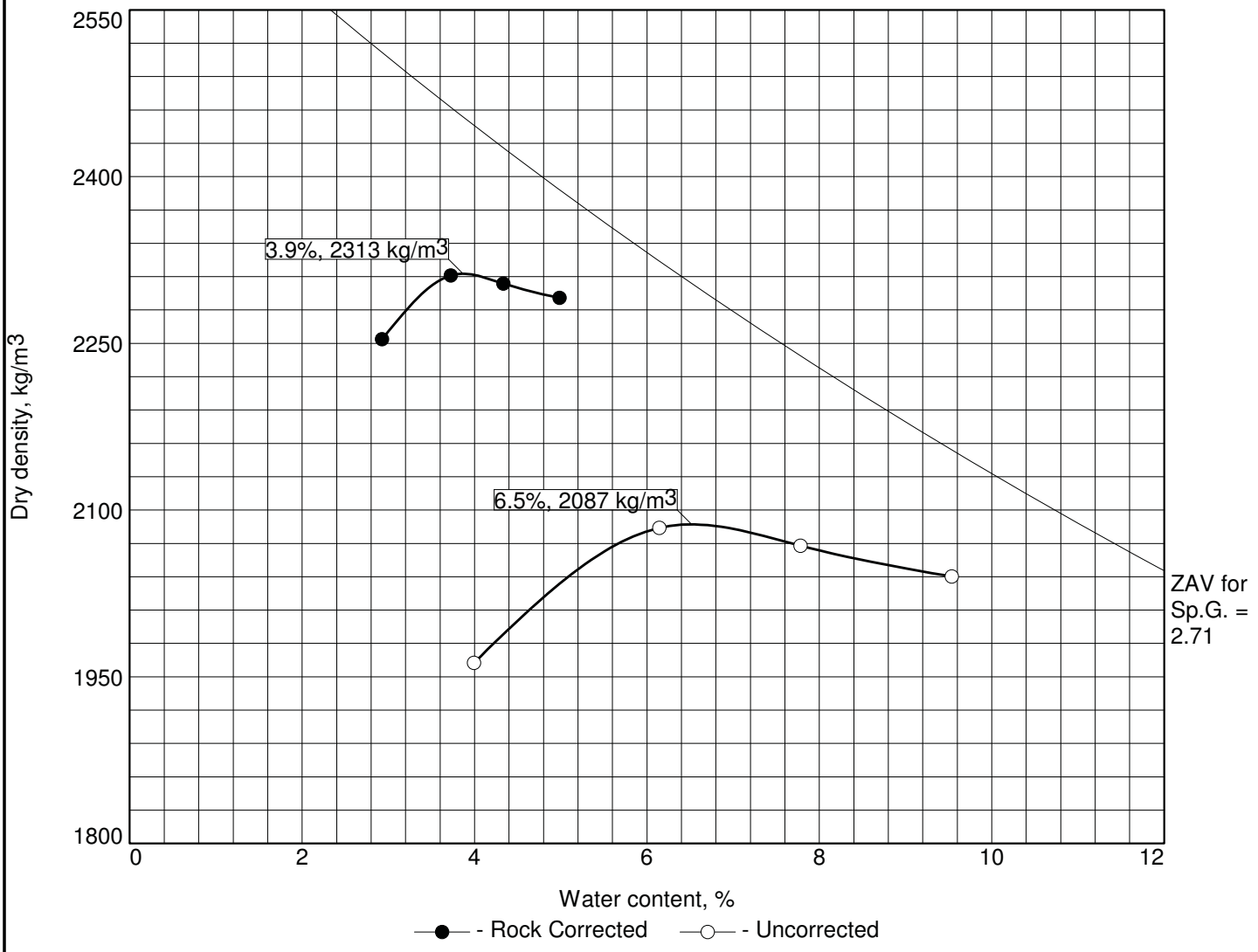
Project No. VA101-00325/16 **Client:** Casino Mining Corporation
Project: Casino
Date: 9/25/2013
○ **Location:** As Rec'd **Sample Number:** MET-11

Remarks:

Knight Piésold CONSULTING

Figure

Tested By: DAB **Checked By:** JDB



Test specification: ASTM D 1557-07 Method C Modified
ASTM D 4718-87 Oversize Corr. Applied to Each Test Point

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/4 in.	% < No.200
	USCS	AASHTO						
	GP	A-1-a		2.711	24	5	62.9	3.2

ROCK CORRECTED TEST RESULTS	UNCORRECTED	MATERIAL DESCRIPTION
Maximum dry density = 2313 kg/m3	2087 kg/m3	poorly graded GRAVEL
Optimum moisture = 3.9 %	6.5 %	

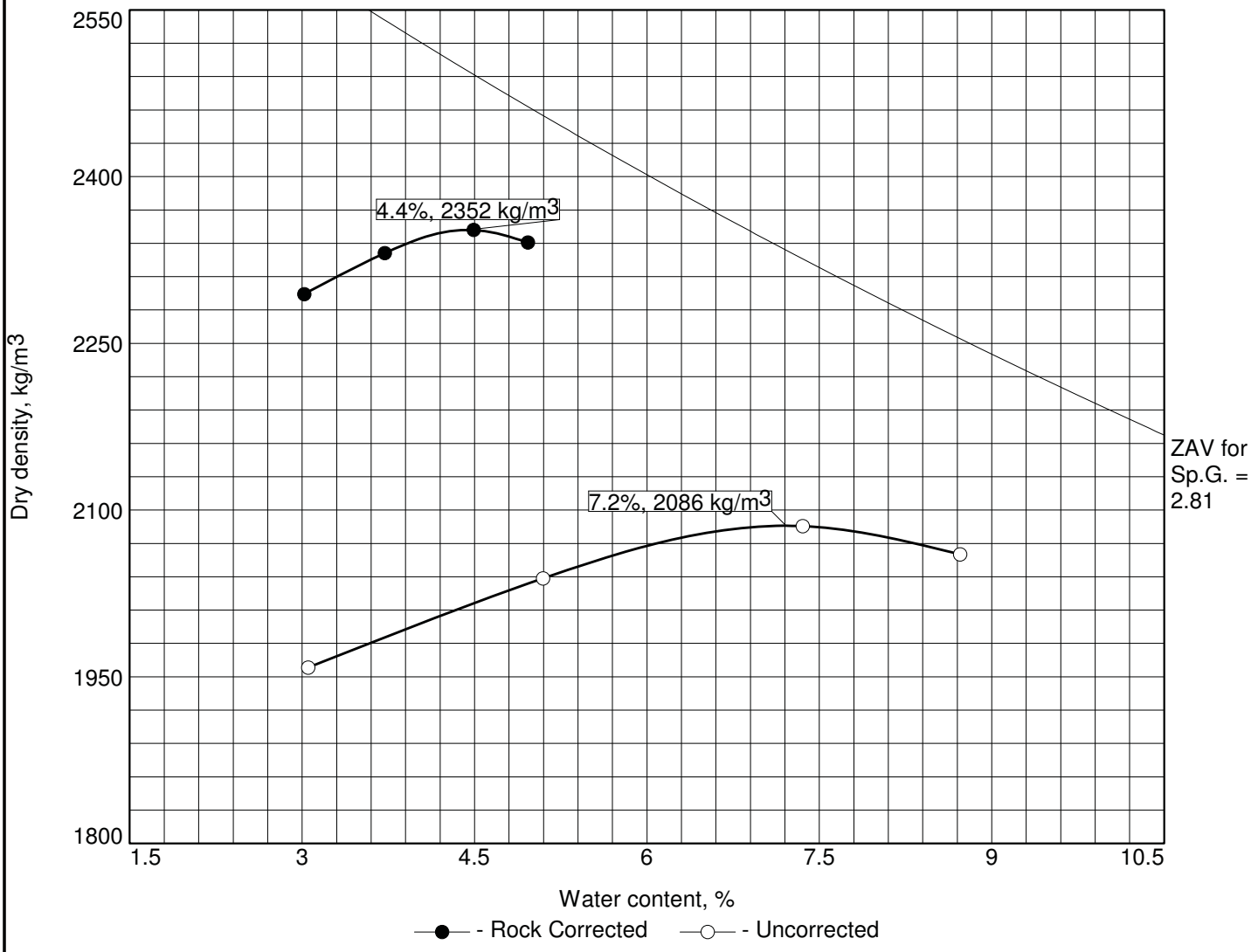
Project No. VA101-00325/16 **Client:** Casino Mining Corporation
Project: Casino
Date: 11/5/13
○ **Location:** As Rec'd **Sample Number:** MET-17

Remarks:

Knight Piésold CONSULTING

Figure

Tested By: RMV **Checked By:** DAB



Test specification: ASTM D 1557-07 Method C Modified
ASTM D 4718-87 Oversize Corr. Applied to Each Test Point

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/4 in.	% < No.200
	USCS	AASHTO						
	GW	A-1-a		2.806	NP	NP	65.7	2.3

ROCK CORRECTED TEST RESULTS	UNCORRECTED	MATERIAL DESCRIPTION
Maximum dry density = 2352 kg/m3	2086 kg/m3	well-graded GRAVEL
Optimum moisture = 4.4 %	7.2 %	

Project No. VA101-00325/16 **Client:** Casino Mining Corporation
Project: Casino

Date: 11/6/2013

○ **Location:** As Rec'd **Sample Number:** MET-19

Remarks:

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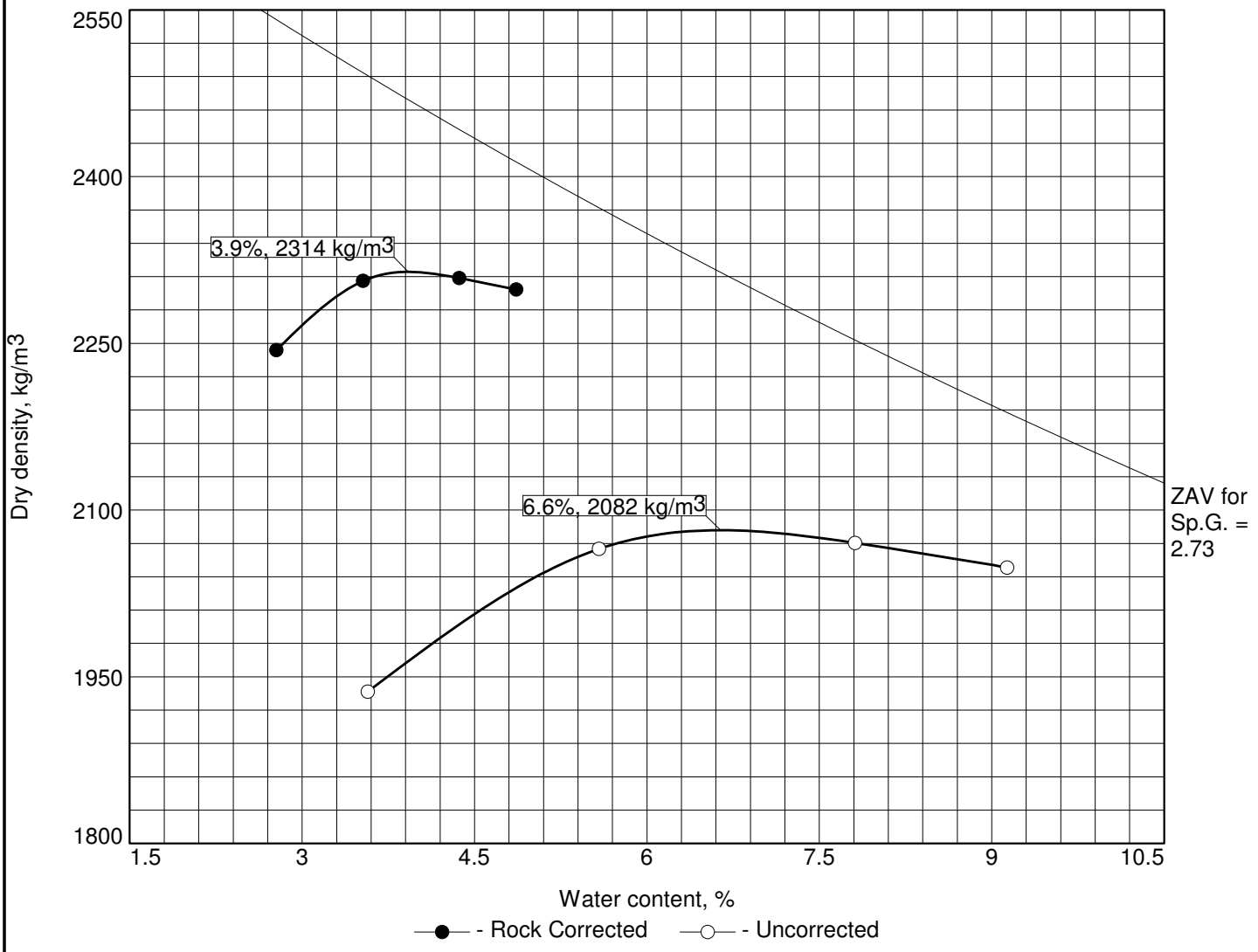
Figure

Tested By: RMV **Checked By:** DAB



Test specification: ASTM D 1557-07 Method C Modified
ASTM D 4718-87 Oversize Corr. Applied to Each Test Point

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/4 in.	% < No.200
	USCS	AASHTO						
	GP	A-1-a		2.734	NP	NP	62.5	3.4

ROCK CORRECTED TEST RESULTS	UNCORRECTED	MATERIAL DESCRIPTION
Maximum dry density = 2314 kg/m3	2082 kg/m3	poorly graded GRAVEL
Optimum moisture = 3.9 %	6.6 %	

Project No. VA101-00325/16 **Client:** Casino Mining Corporation
Project: Casino
Date: 11/7/2013
○ **Location:** As Rec'd **Sample Number:** MET-20

Remarks:

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Figure

Tested By: RMV **Checked By:** DAB

APPENDIX C

SATURATED HYDRAULIC CONDUCTIVITY TEST RESULTS (KNIGHT PIÉSOLD LABORATORY)

(Pages C-1 to C-11)

Knight Piésold CONSULTING

TABLE C.1

CASINO MINING CORPORATION
CASINO PROJECT

LEACH ORE TESTING
SATURATED HYDRAULIC CONDUCTIVITY TESTING BY KP

Print Feb/14/14 14:22:52

Sample ID	Normal Stress (kPa)	Dry Density (tonne/m^3)	K_{sat} (cm/s)	$K_{s,head\ corrected}$ (cm/s)
MET-02	200	1.66	3.4E-01	5.7E-01
MET-02	400	1.72	2.9E-01	4.5E-01
MET-02	800	1.84	9.0E-02	9.6E-02
MET-02	1600	1.97	6.4E-02	6.7E-02
MET-02	2720	2.05	4.7E-02	4.8E-02
MET-05	200	1.53	3.2E-01	5.0E-01
MET-05	400	1.59	1.4E-01	1.8E-01
MET-05	800	1.65	1.1E-01	1.3E-01
MET-05	1600	1.72	8.2E-02	9.2E-02
MET-05	2720	1.79	5.9E-02	6.3E-02
MET-11	200	1.45	1.2E+00	invalid (2)
MET-11	400	1.40	1.2E+00	invalid (2)
MET-11	800	1.41	1.2E+00	invalid (2)
MET-11	1600	1.57	8.8E-01	1.5E+01
MET-11	2720	1.65	7.6E-01	4.4E+00
CL-01	200	1.54	2.2E-01	3.0E-01
CL-01	400	1.64	4.0E-01	7.7E-01
CL-01	800	1.77	2.1E-01	2.8E-01
CL-01	1600	1.87	1.4E-01	1.7E-01
CL-01	2720	1.94	1.7E-01	2.1E-01
CL-01 re-test	2720	1.84	2.3E-01	3.2E-01

\\VAN11\Prj_file\1\01\00325\16\A\Data\Task 400 HLF\Ore Characterisation Testing\Lab Testing Casino\Processed Results\[Constant Head Permeability.xlsx]Su

NOTES:

1. No oversize correction applied.
2. Results invalid as the head loss in the apparatus exceeds the applied head.
3. K_{sat} = saturated hydraulic conductivity, not corrected for head loss in testing apparatus.
4. $K_{sat,head\ corrected}$ = saturated hydraulic conductivity, corrected for head loss in testing apparatus.
5. Head loss correction based on Trial 1.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	14FEB'14	ISSUED WITH REPORT VA101-325/16-2	ML	SB	GRG

Knight Piésold CONSULTING

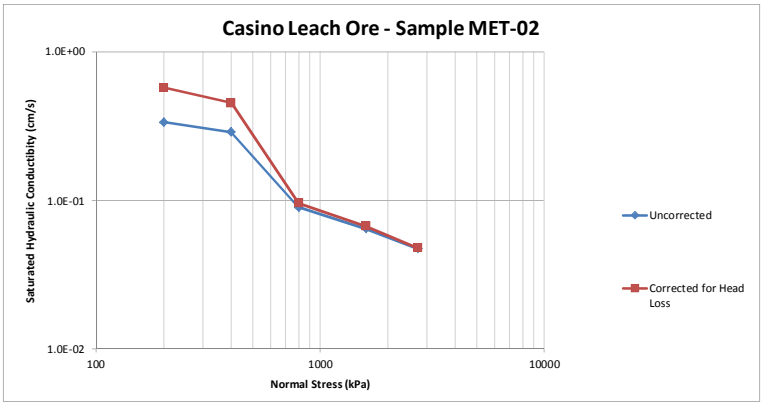
Constant Head Permeability

USBR 5605 - Amended

Project	Casino	Project No.	VA101-00325/16
Lab No.	L2013-084	Date of Test	09/12/13
Sample No.	MET-02	Tested By	DAB
Location		Checked By	JDB

Specimen Data

Target Dry Density, pcf	NA	Wet Sample Wt. + Tare, lbs.	21.484
Target Density, t/m^3	NA	Tare, lbs.	0.000
Moisture Content, %	6.36	Wet Sample Wt., lbs.	21.484
Mold Diameter, in.	8.02	Sample Length, in.	7.393
Mold Area, in.^{2}	50.52	Sample Volume, in.^{3}	373.5
Mold Area, ft^2	0.3508	Sample Volume, ft^3	0.2161
Depth to Mold Bottom, in.	8.700	Wet Density, pcf	99.4
		Initial Depth to Plate, in.	1.307
Normal Stress Range, kPa	200 400 800 1600 2720		



Permeability Trial Data

Normal Stress, kPa: 200 | Head, cm: 0.4
Avg. Depth to Plate, in.: 2.033 | Consolidated Length, in.: 6.667 | Wet Density, pcf: 110.2

Trial No.	Q cc	Time sec	Flow cc/sec	Permeability k, cm/sec	Head Loss cm	Corrected Head cm	Permeability k, cm/sec
1	45.9	18.1	2.540	3.3E-01	0.161746677	0.238253323	0.553919638
2	45.9	17.8	2.576	3.3E-01	0.164448393	0.235551607	0.568133122
3	45.9	17.5	2.618	3.4E-01	0.167673589	0.232326411	0.585549186
4	45.9	17.9	2.567	3.3E-01	0.163793464	0.236206536	0.564656661
5	45.9	17.5	2.629	3.4E-01	0.168467244	0.231532756	0.589911959
Averages			2.586	3.4E-01	0.165225874	0.234774126	0.572434113

Permeability Trial Data

Normal Stress, kPa: 400 | Head, cm: 0.4
Avg. Depth to Plate, in.: 2.280 | Consolidated Length, in.: 6.420 | Wet Density, pcf: 114.5

Trial No.	Q cc	Time sec	Flow cc/sec	Permeability k, cm/sec	Head Loss cm	Corrected Head cm	Permeability k, cm/sec
1	45.9	19.6	2.343	2.9E-01	0.146731022	0.253268978	0.462841209
2	45.9	20.8	2.212	2.8E-01	0.136682997	0.263317003	0.420292315
3	45.9	19.6	2.339	2.9E-01	0.1464478	0.2535522	0.461593763
4	45.9	19.8	2.321	2.9E-01	0.145008422	0.254991578	0.455298616
5	45.9	19.5	2.354	2.9E-01	0.14755813	0.25244187	0.466500866
Averages			2.304	2.9E-01	0.144485674	0.255514326	0.453305354

Permeability Trial Data

Normal Stress, kPa: 800 | Head, cm: 0.45
Avg. Depth to Plate, in.: 2.680 | Consolidated Length, in.: 6.020 | Wet Density, pcf: 122.1

Trial No.	Q cc	Time sec	Flow cc/sec	Permeability k, cm/sec	Head Loss cm	Corrected Head cm	Permeability k, cm/sec
1	22.95	26.5	0.867	9.0E-02	0.030326863	0.419673137	0.096920313
2	22.95	26.0	0.883	9.2E-02	0.03162709	0.41837291	0.099017073
3	22.95	27.5	0.835	8.7E-02	0.027687472	0.422312528	0.092707157
4	22.95	26.9	0.852	8.9E-02	0.029123575	0.420876425	0.094992423
5	22.95	26.7	0.859	9.0E-02	0.029693977	0.420306023	0.095904817
Averages			0.859	9.0E-02	0.029691795	0.420308205	0.095908357

Permeability Trial Data

Normal Stress, kPa: 1600 | Head, cm: 0.5
Avg. Depth to Plate, in.: 3.073 | Consolidated Length, in.: 5.627 | Wet Density, pcf: 130.6

Trial No.	Q cc	Time sec	Flow cc/sec	Permeability k, cm/sec	Head Loss cm	Corrected Head cm	Permeability k, cm/sec
1	22.95	31.6	0.7265	6.4E-02	0.018881167	0.481118833	0.066215302
2	22.95	30.5	0.7517	6.6E-02	0.020940316	0.479059684	0.068808789
3	22.95	31.3	0.7344	6.4E-02	0.019526651	0.480473349	0.067025648
4	22.95	31.7	0.7249	6.4E-02	0.01874997	0.48125003	0.066050889
5	22.95	31.3	0.7344	6.4E-02	0.019526651	0.480473349	0.067025648
Averages			0.7344	6.4E-02	0.019524951	0.480475049	0.067025255

Permeability Trial Data

Normal Stress, kPa: 2720 | Head, cm: 0.5
Avg. Depth to Plate, in.: 3.313 | Consolidated Length, in.: 5.387 | Wet Density, pcf: 136.4

Trial No.	Q cc	Time sec	Flow cc/sec	Permeability k, cm/sec	Head Loss cm	Corrected Head cm	Permeability k, cm/sec
1	22.95	40.8	0.5624	4.7E-02	0.00543242	0.49456758	0.047735136
2	22.95	40.7	0.5640	4.7E-02	0.005568743	0.494431257	0.047889113
3	22.95	40.5	0.5671	4.8E-02	0.005820746	0.494179254	0.048173998
4	22.95	41.1	0.5585	4.7E-02	0.005117395	0.494882605	0.047379675
5	22.95	41.1	0.5588	4.7E-02	0.005139756	0.494860244	0.047404889
Averages			0.5630	4.7E-02	0.005415812	0.494584188	0.047716562

Head Loss Correction

General Notes:
1) Tap water was used as permeant.
2) Flow conditions may vary depending on the particle distribution in the field.
3) Particles greater than 1.5" were removed and replaced with finer gravel prior to testing.
4) The sample was placed in the mold in a loose condition.
5) Audible breaking of rock noted during test.

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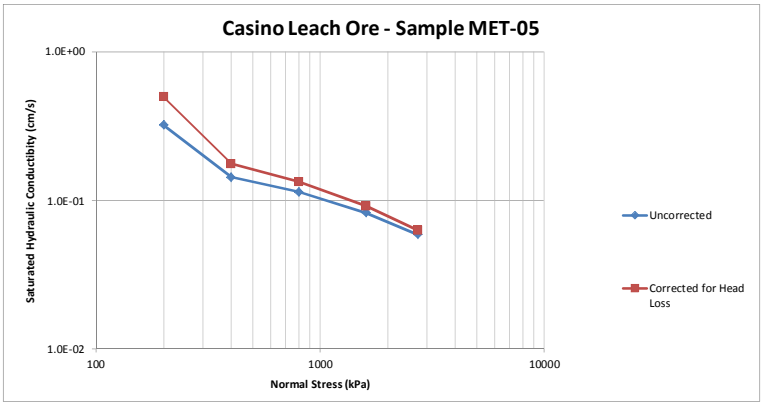
Constant Head Permeability

USBR 5605 - Amended

Project	Casino	Project No.	VA101-00325/16
Lab No.	L2013-084	Date of Test	09/23/13
Sample No.	MET-05	Tested By	DAB
Location		Checked By	JDB

Specimen Data

Target Dry Density, pcf	NA	Wet Sample Wt. + Tare, lbs.	20.217
Target Density, t/m^3	NA	Tare, lbs.	0.000
Moisture Content, %	6.76	Wet Sample Wt., lbs.	20.217
Mold Diameter, in.	8.02	Sample Length, in.	7.467
Mold Area, in.^{2}	50.52	Sample Volume, in.^{3}	377.2
Mold Area, ft^2	0.3508	Sample Volume, ft^3	0.2183
Depth to Mold Bottom, in.	8.700	Wet Density, pcf	92.6
		Initial Depth to Plate, in.	1.233
Normal Stress Range, kPa	200 400 800 1600 2720		



Permeability Trial Data

Normal Stress, kPa: 200 | Head, cm: 0.3
Avg. Depth to Plate, in.: 1.900 | Consolidated Length, in.: 6.800 | Wet Density, pcf: 101.7

Head Loss Correction

Trial No.	Q cc	Time sec	Flow cc/sec	Permeability k, cm/sec	Head Loss cm	Corrected Head cm	Permeability k, cm/sec
1	45.9	25.9	1.772	3.1E-01	0.102539752	0.197460248	0.47560115
2	45.9	25.6	1.796	3.2E-01	0.10438538	0.19561462	0.48647461
3	45.9	24.6	1.869	3.3E-01	0.110098556	0.189901444	0.521513684
4	45.9	24.9	1.843	3.3E-01	0.108048735	0.191951265	0.508695192
Averages			1.820	3.2E-01	0.106268106	0.193731894	0.498071159

Permeability Trial Data

Normal Stress, kPa: 400 | Head, cm: 1
Avg. Depth to Plate, in.: 2.187 | Consolidated Length, in.: 6.513 | Wet Density, pcf: 106.2

Trial No.	Q cc	Time sec	Flow cc/sec	Permeability k, cm/sec	Head Loss cm	Corrected Head cm	Permeability k, cm/sec
1	91.8	33.0	2.782	1.4E-01	0.179991107	0.820008893	0.172183685
2	91.8	33.9	2.710	1.4E-01	0.174616795	0.825383205	0.166668557
3	91.8	32.4	2.830	1.4E-01	0.183593747	0.816406253	0.175928958
4	91.8	31.3	2.938	1.5E-01	0.19165121	0.80834879	0.184448737
5	137.7	47.3	2.912	1.5E-01	0.189727018	0.810272982	0.182395906
Averages			2.815	1.4E-01	0.183915975	0.816084025	0.176325169

Permeability Trial Data

Normal Stress, kPa: 800 | Head, cm: 1
Avg. Depth to Plate, in.: 2.407 | Consolidated Length, in.: 6.293 | Wet Density, pcf: 109.9

Trial No.	Q cc	Time sec	Flow cc/sec	Permeability k, cm/sec	Head Loss cm	Corrected Head cm	Permeability k, cm/sec
1	45.9	19.8	2.314	1.1E-01	0.144470966	0.855529034	0.132615637
2	45.9	19.9	2.302	1.1E-01	0.143582048	0.856417952	0.131813606
3	45.9	19.8	2.317	1.1E-01	0.144739307	0.855260693	0.13285814
4	45.9	19.3	2.381	1.2E-01	0.14961084	0.85038916	0.137292373
5	45.9	19.9	2.312	1.1E-01	0.144381691	0.855618309	0.132534998
Averages			2.325	1.1E-01	0.14535697	0.85464303	0.133422951

Permeability Trial Data

Normal Stress, kPa: 1600 | Head, cm: 1
Avg. Depth to Plate, in.: 2.680 | Consolidated Length, in.: 6.020 | Wet Density, pcf: 114.9

Trial No.	Q cc	Time sec	Flow cc/sec	Permeability k, cm/sec	Head Loss cm	Corrected Head cm	Permeability k, cm/sec
1	45.9	25.5	1.7979	8.4E-02	0.104550503	0.895449497	0.094192865
2	45.9	26.2	1.7506	8.2E-02	0.100844851	0.899155149	0.091336127
3	45.9	26.0	1.7654	8.3E-02	0.102005775	0.897994225	0.09222805
4	91.8	52.8	1.7390	8.2E-02	0.099934717	0.900065283	0.090638819
5	91.8	53.1	1.7291	8.1E-02	0.099163817	0.900836183	0.090049512
Averages			1.7564	8.2E-02	0.101299933	0.898700067	0.091689075

Permeability Trial Data

Normal Stress, kPa: 2720 | Head, cm: 1.1
Avg. Depth to Plate, in.: 2.893 | Consolidated Length, in.: 5.807 | Wet Density, pcf: 119.1

Trial No.	Q cc	Time sec	Flow cc/sec	Permeability k, cm/sec	Head Loss cm	Corrected Head cm	Permeability k, cm/sec
1	45.9	32.5	1.4106	5.8E-02	0.074004475	1.025995525	0.062216022
2	45.9	32.3	1.4233	5.9E-02	0.075012437	1.024987563	0.062837216
3	45.9	31.7	1.4479	6.0E-02	0.076973268	1.023026732	0.064049981
4	45.9	31.9	1.4371	5.9E-02	0.076109568	1.023890432	0.063515081
5	45.9	33.0	1.3909	5.7E-02	0.072440959	1.027559041	0.061255421
Averages			1.4297	5.9E-02	0.074908141	1.025091859	0.062774744

General Notes:
1) Tap water was used as permeant.
2) Flow conditions may vary depending on the particle distribution in the field.
3) Particles greater than 1.5" were removed and replaced with finer gravel prior to testing.
4) The sample was placed in the mold in a loose condition.
5) Audible breaking of rock noted during test.

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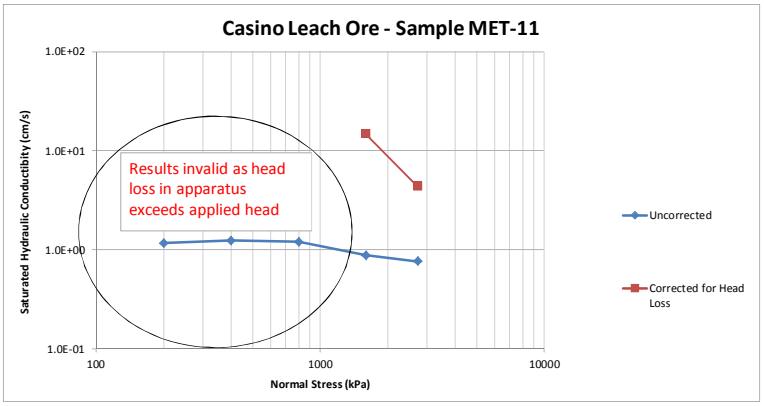
Constant Head Permeability
USBR 5605 - Amended

Project	Casino	Project No.	VA101-00325/16
Lab No.	L2013-084	Date of Test	09/27/13
Sample No.	MET-11	Tested By	DAB
Location		Checked By	JDB

Specimen Data

Target Dry Density, pcf	NA	Wet Sample Wt. + Tare, lbs.	20.250
Target Density, t/m^3	NA	Tare, lbs.	0.000
Moisture Content, %	4.01	Wet Sample Wt., lbs.	20.250
Mold Diameter, in.	8.02	Sample Length, in.	7.933
Mold Area, in.^{2}	50.52	Sample Volume, in.^{3}	400.8
Mold Area, ft^2	0.3508	Sample Volume, ft^3	0.2319
Depth to Mold Bottom, in.	8.700	Wet Density, pcf	87.3
		Initial Depth to Plate, in.	0.767
Normal Stress Range, kPa	200 400 800 1600 2720		



Permeability Trial Data

Normal Stress, kPa: 200 | Head, cm: 0.1 | Avg. Depth to Plate, in.: 1.367 | Consolidated Length, in.: 7.333 | Wet Density, pcf: 94.5

Head Loss Correction

Trial No.	Q cc	Time sec	Flow cc/sec	Permeability k, cm/sec	Head Loss cm	Corrected Head cm	Permeability k, cm/sec
1	45.9	23.2	1.979	1.1E+00	0.118693105	-0.018693105	-6.050801667
2	45.9	22.7	2.026	1.2E+00	0.122354506	-0.022354506	-5.180382405
3	45.9	22.1	2.081	1.2E+00	0.126551052	-0.026551052	-4.478245273
4	45.9	22.2	2.066	1.2E+00	0.125391922	-0.025391922	-4.648956457
5	45.9	22.3	2.057	1.2E+00	0.124746907	-0.024746907	-4.750886014
Averages			2.042	1.2E+00	0.123547498	-0.023547498	-5.021854363

Permeability Trial Data

Normal Stress, kPa: 400 | Head, cm: 0.1 | Avg. Depth to Plate, in.: 1.100 | Consolidated Length, in.: 7.600 | Wet Density, pcf: 91.1

Trial No.	Q cc	Time sec	Flow cc/sec	Permeability k, cm/sec	Head Loss cm	Corrected Head cm	Permeability k, cm/sec
1	46.8	22.7	2.060	1.2E+00	0.124939337	-0.024939337	-4.891780336
2	46.8	22.7	2.066	1.2E+00	0.125432056	-0.025432056	-4.811832647
3	46.8	22.1	2.121	1.3E+00	0.129703765	-0.029703765	-4.23002731
4	46.8	22.4	2.094	1.2E+00	0.12757715	-0.02757715	-4.497107628
5	46.8	22.9	2.048	1.2E+00	0.124031959	-0.024031959	-5.04759845
Averages			2.085	1.2E+00	0.126336854	-0.026336854	-4.695669274

Permeability Trial Data

Normal Stress, kPa: 800 | Head, cm: 0.1 | Avg. Depth to Plate, in.: 1.153 | Consolidated Length, in.: 7.547 | Wet Density, pcf: 91.8

Trial No.	Q cc	Time sec	Flow cc/sec	Permeability k, cm/sec	Head Loss cm	Corrected Head cm	Permeability k, cm/sec
1	46.8	23.1	2.030	1.2E+00	0.12265514	-0.02265514	-5.270881527
2	46.8	23.1	2.027	1.2E+00	0.122382519	-0.022382519	-5.325839184
3	46.8	22.5	2.077	1.2E+00	0.126283533	-0.026283533	-4.648105907
4	46.8	23.2	2.021	1.2E+00	0.121907603	-0.021907603	-5.424847424
5	46.8	22.9	2.045	1.2E+00	0.123823967	-0.023823967	-5.049528702
Averages			2.040	1.2E+00	0.123410552	-0.023410552	-5.143840549

Permeability Trial Data

Normal Stress, kPa: 1600 | Head, cm: 0.1 | Avg. Depth to Plate, in.: 1.900 | Consolidated Length, in.: 6.800 | Wet Density, pcf: 101.9

Trial No.	Q cc	Time sec	Flow cc/sec	Permeability k, cm/sec	Head Loss cm	Corrected Head cm	Permeability k, cm/sec
1	46.8	28.3	1.6520	8.8E-01	0.093098211	0.006901789	12.68373698
2	46.8	27.6	1.6944	9.0E-01	0.096437926	0.003562074	25.20744627
3	46.8	28.8	1.6278	8.6E-01	0.091197683	0.008802317	9.799877469
4	46.8	28.3	1.6549	8.8E-01	0.093328098	0.006671902	13.14396584
5	46.8	28.3	1.6549	8.8E-01	0.093328098	0.006671902	13.14396584
Averages			1.6568	8.8E-01	0.093478003	0.006521997	14.79579848

Permeability Trial Data

Normal Stress, kPa: 2720 | Head, cm: 0.1 | Avg. Depth to Plate, in.: 2.220 | Consolidated Length, in.: 6.480 | Wet Density, pcf: 106.9

Trial No.	Q cc	Time sec	Flow cc/sec	Permeability k, cm/sec	Head Loss cm	Corrected Head cm	Permeability k, cm/sec
1	46.8	30.6	1.5314	7.7E-01	0.083586379	0.016413621	4.711550534
2	46.8	31.0	1.5097	7.6E-01	0.081866302	0.018133698	4.204104677
3	46.8	31.0	1.5111	7.6E-01	0.081982075	0.018017925	4.235216437
4	46.8	31.2	1.4990	7.6E-01	0.081023893	0.018976107	3.989161236
5	46.8	30.6	1.5294	7.7E-01	0.083428028	0.016571972	4.660429829
Averages			1.5128	7.6E-01	0.082377335	0.017622665	4.360092542

General Notes:
1) Tap water was used as permeant.
2) Flow conditions may vary depending on the particle distribution in the field.
3) Particles greater than 1.5" were removed and replaced with finer gravel prior to testing.
4) The sample was placed in the mold in a loose condition.
5) Audible breaking of rock noted during test.

Knight Piésold CONSULTING

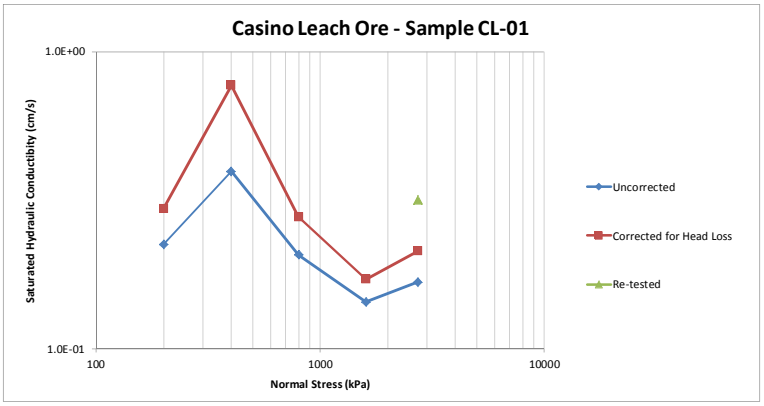
Constant Head Permeability
USBR 5605 - Amended

Project	Casino	Project No.	VA101-00325/16
Lab No.	L2013-084	Date of Test	10/14/13
Sample No.	CL-01 Residue	Tested By	DAB
Location		Checked By	JDB

Specimen Data

Target Dry Density, pcf	NA	Wet Sample Wt. + Tare, lbs.	20.006
Target Density, t/m^3	NA	Tare, lbs.	0.000
Moisture Content, %	2.78	Wet Sample Wt., lbs.	20.006
Mold Diameter, in.	8.02	Sample Length, in.	7.360
Mold Area, in.^{2}	50.52	Sample Volume, in.^{3}	371.8
Mold Area, ft^2	0.3508	Sample Volume, ft^3	0.2152
Depth to Mold Bottom, in.	8.700	Wet Density, pcf	93.0
		Initial Depth to Plate, in.	1.340

Normal Stress Range, kPa: 200 400 800 1600 2720



Permeability Trial Data

Normal Stress, psf: 200 | Head, cm: 0.4 | Avg. Depth to Plate, in.: 1.953 | Consolidated Length, in.: 6.747 | Wet Density, pcf: 101.4

Trial No.	Q cc	Time sec	Flow cc/sec	Permeability k, cm/sec	Head Loss cm	Corrected Head cm	Permeability k, cm/sec
1	46.8	27.9	1.677	2.2E-01	0.095053989	0.304946011	0.289117587
2	46.8	27.3	1.714	2.3E-01	0.097997959	0.302002041	0.298459068
3	46.8	27.5	1.704	2.2E-01	0.097164823	0.302835177	0.295796018
4	46.8	27.6	1.698	2.2E-01	0.096727768	0.303272232	0.294405177
5	46.8	26.9	1.742	2.3E-01	0.10015069	0.29984931	0.305412342
Averages			1.707	2.2E-01	0.097419046	0.302580954	0.296638038

Permeability Trial Data

Normal Stress, psf: 400 | Head, cm: 0.3 | Avg. Depth to Plate, in.: 2.213 | Consolidated Length, in.: 6.487 | Wet Density, pcf: 105.5

Trial No.	Q cc	Time sec	Flow cc/sec	Permeability k, cm/sec	Head Loss cm	Corrected Head cm	Permeability k, cm/sec
1	46.8	20.9	2.242	3.8E-01	0.139020321	0.160979679	0.704201563
2	46.8	19.5	2.396	4.0E-01	0.150802614	0.149197386	0.81194579
3	46.8	19.4	2.419	4.1E-01	0.152503353	0.147496647	0.828948165
4	46.8	20.1	2.327	3.9E-01	0.145519455	0.154480545	0.761560879
5	46.8	20.3	2.304	3.9E-01	0.143764266	0.156235734	0.745590208
Averages			2.346	4.0E-01	0.146322002	0.153677998	0.770449321

Permeability Trial Data

Normal Stress, psf: 800 | Head, cm: 0.4 | Avg. Depth to Plate, in.: 2.660 | Consolidated Length, in.: 6.040 | Wet Density, pcf: 113.3

Trial No.	Q cc	Time sec	Flow cc/sec	Permeability k, cm/sec	Head Loss cm	Corrected Head cm	Permeability k, cm/sec
1	46.8	26.8	1.746	2.1E-01	0.100456366	0.299543634	0.274300515
2	46.8	27.5	1.704	2.0E-01	0.097164823	0.302835177	0.264800348
3	46.8	26.1	1.797	2.1E-01	0.10444567	0.29555433	0.286113584
4	46.8	26.5	1.764	2.1E-01	0.101900476	0.298099524	0.27853835
5	46.8	26.2	1.787	2.1E-01	0.103694036	0.296305964	0.28386225
Averages			1.759	2.1E-01	0.101532274	0.298467726	0.27752301

Permeability Trial Data

Normal Stress, psf: 1600 | Head, cm: 0.4 | Avg. Depth to Plate, in.: 2.993 | Consolidated Length, in.: 5.707 | Wet Density, pcf: 119.9

Trial No.	Q cc	Time sec	Flow cc/sec	Permeability k, cm/sec	Head Loss cm	Corrected Head cm	Permeability k, cm/sec
1	46.8	35.8	1.3091	1.5E-01	0.065921686	0.334078314	0.174273011
2	46.8	36.1	1.2978	1.4E-01	0.065023294	0.334976706	0.172311449
3	46.8	36.0	1.2989	1.4E-01	0.065109577	0.334890423	0.172499355
4	46.8	35.9	1.3043	1.5E-01	0.0655431	0.3344569	0.173445035
5	46.8	37.2	1.2584	1.4E-01	0.061872111	0.338127889	0.165518787
Averages			1.2937	1.4E-01	0.064693953	0.335306047	0.171609527

Permeability Trial Data

Normal Stress, psf: 2720 | Head, cm: 0.4 | Avg. Depth to Plate, in.: 3.193 | Consolidated Length, in.: 5.507 | Wet Density, pcf: 124.3

Trial No.	Q cc	Time sec	Flow cc/sec	Permeability k, cm/sec	Head Loss cm	Corrected Head cm	Permeability k, cm/sec
1	46.8	29.9	1.5673	1.7E-01	0.086424029	0.313575971	0.214500886
2	46.8	30.1	1.5538	1.7E-01	0.085355132	0.314644868	0.211926883
3	46.8	30.1	1.5543	1.7E-01	0.085395913	0.314604087	0.212024747
4	46.8	29.7	1.5784	1.7E-01	0.087300617	0.312699383	0.216625684
5	46.8	30.1	1.5559	1.7E-01	0.085518413	0.314481587	0.21231888
Averages			1.5635	1.7E-01	0.085998821	0.314001179	0.213479416

General Notes:
1) Tap water was used as permeant.
2) Flow conditions may vary depending on the particle distribution in the field.
3) Particles greater than 1.5" were removed and replaced with finer gravel prior to testing.
4) The sample was placed in the mold in a loose condition.
5) Audible breaking of rock noted during test.

Knight Piésold CONSULTING

Constant Head Permeability
USBR 5605 - Amended

Project	*Casino*	*Project No.*	*DV101-00077/14*
Lab No.	*L2013-084*	*Date of Test*	*10/22/13*
Sample No.	*CL-01 Residue - Re-tested*	*Tested By*	*DAB*
Location		*Checked By*	*JDB*

Specimen Data

Target Dry Density, pcf		Wet Sample Wt. + Tare, lbs.	21.386
Target Density, t/m^3		Tare, lbs.	0.000
Moisture Content, %		Wet Sample Wt., lbs.	21.386
Mold Diameter, in.	8.02	Sample Length, in.	7.333
Mold Area, in.^{2}	50.52	Sample Volume, in.^{3}	370.4
Mold Area, ft^2	0.3508	Sample Volume, ft^3	0.2144
Depth to Mold Bottom, in.	8.700	Wet Density, pcf	99.8
		Initial Depth to Plate, in.	1.367
Normal Stress Range, kPa	2720		

Permeability Trial Data

Normal Stress, psf	2720			Head, cm	0.4
Avg. Depth to Plate, in.	2.520	Consolidated Length, in.	6.180	Wet Density, pcf	118.4

Head Loss Correction

Trial No.	Q cc	Time sec	Flow cc/sec	Permeability k, cm/sec	Head Loss cm	Corrected Head cm	Permeability k, cm/sec
1	46.8	25.8	1.813	2.2E-01	0.105752452	0.294247548	0.296779714
2	46.8	25.1	1.863	2.2E-01	0.109643243	0.290356757	0.3090178
3	46.8	24.1	1.940	2.3E-01	0.115661461	0.284338539	0.328641223
4	46.8	24.0	1.948	2.3E-01	0.116226687	0.283773313	0.330529135
5	46.8	24.3	1.930	2.3E-01	0.114852137	0.285147863	0.325951665
Averages			1.899	2.3E-01	0.112427196	0.287572804	0.318183907

General Notes:
1) Tap water was used as permeant.
2) Flow conditions may vary depending on the particle distribution in the field.
3) The sample was allowed to saturate overnight prior to initializing flow trials.
4) The sample was placed in the mold in a loose condition.
5) The sample was not agglomerated.

Knight Piésold CONSULTING

Constant Head Permeability Test

Rigid Wall Permeameter - USBR Procedure 5600/5605 Modified

Project	HEAD LOSS	Project No.	
Sample No.	Mold D	Date Tested	18/09/2013
Sample ID		Tested By	DAB/JDB
Description		File No.	

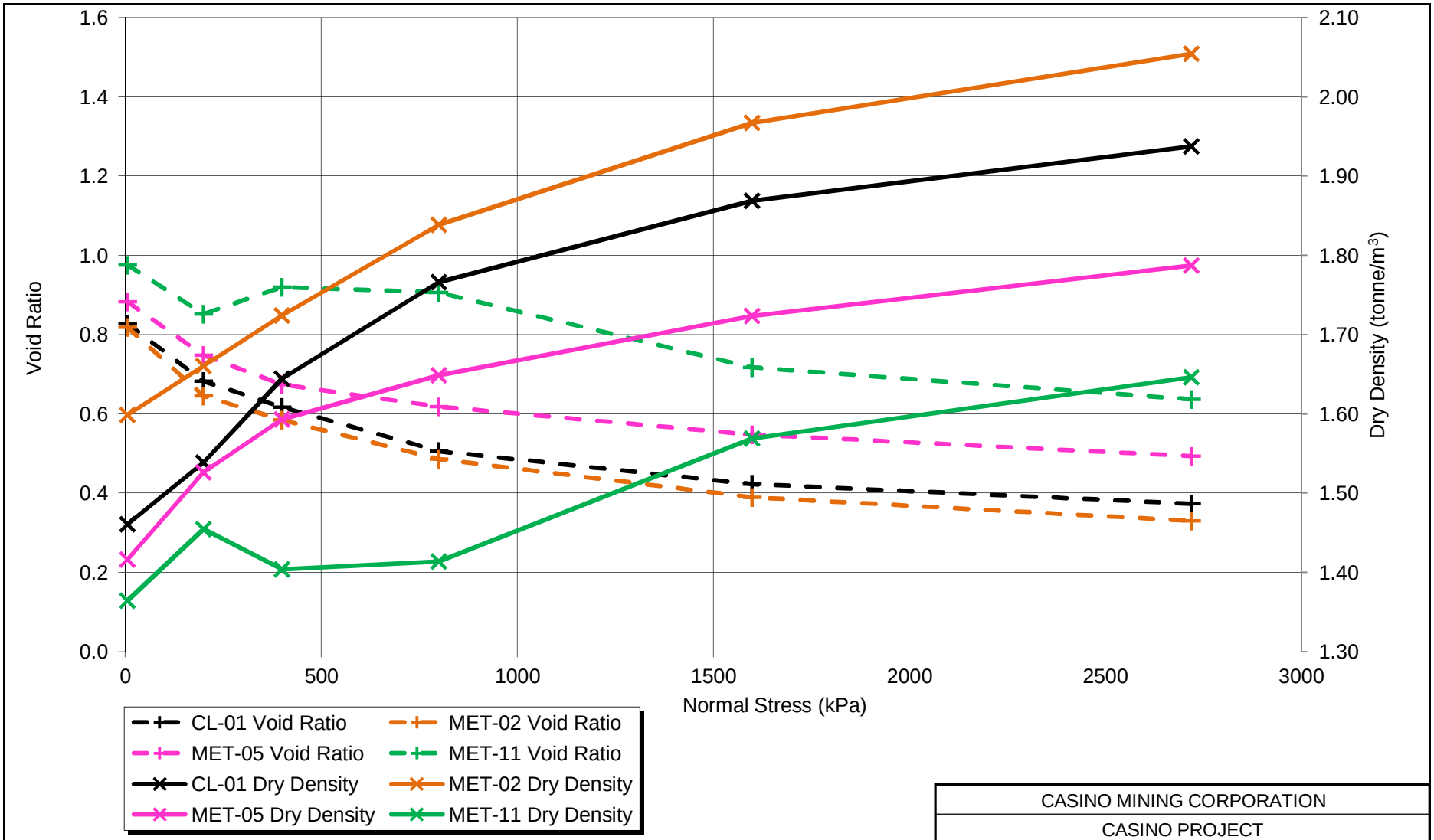
	US	Metric
Depth to Bot. of Mold, in./cm		
Depth to Plate, in./cm		
Sample Height, in./cm		
Initial Moisture Content, %		
Initial Sample Wet Wt., g/lbs.		
Dry Sample Wt., g/lbs.		

Moisture Content Data

	Initial	Final
Tare ID		
Wet Soil+Tare		
Dry Soil + Tare		
Tare		
Moist Content.%		

Mold Dia., in.	8.02
Mold Area, in^2	
Sample Vol., ft^3	
Buret Constant, a, ml/cm	45.9
Initial Wet Density, pcf	
Initial Dry Density, pcf	
Target Dry Density, pcf	

Date	Normal Load psf/gauge	Time Start	Time Stop	Elapsed Time min/sec.	Head Manometers: Inflow Height cm	Head Manometers: Outflow Height cm	Head Manometers: Average Head cm	Volume, cc: Initial Column Level cm	Volume, cc: Final Column Level cm	Volume, cc: Volume Change cc	Flow Rate CC/sec
18/09/2013	NA			43.72			0.05			45.9	1.050
				42.4						45.9	1.083
				43.15						45.9	1.064
				44.19						45.9	1.039
	Depth to plate measurements, in.:			1)	2)	3)	Avg.	L-			1.059
				24.34			0.1			45.9	1.886
				23.75						45.9	1.933
				25						45.9	1.836
				26.37						45.9	1.741
				49.68						91.8	1.848
				50.65						91.8	1.812
	Depth to plate measurements, in.:			1)	2)	3)	Avg.	L-			1.843
				15.63			0.2			45.9	2.937
				15.32						45.9	2.996
				15.38						45.9	2.984
				15.24						45.9	3.012
	Depth to plate measurements, in.:			1)	2)	3)	Avg.	L-			2.982
				8.16			0.4			45.9	5.625
				7.72						45.9	5.946
				7.87						45.9	5.832
				7.59						45.9	6.047
				7.53						45.9	6.096
				7.81						45.9	5.877
	Depth to plate measurements, in.:			1)	2)	3)	Avg.	L-			5.904
				12.44			0.5			91.8	7.379
				12.38						91.8	7.415
				12.07						91.8	7.606
				12.03						91.8	7.631
				12.47						91.8	7.362
	Depth to plate measurements, in.:			1)	2)	3)	Avg.	L-			7.479



NOTES:
1. Tested on fraction of material passing 1.5 inch.
2. All tests conducted by KP using a 8-inch rigid wall permeameter.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	14FEB'14	ISSUED WITH REPORT	ML	SB	GRG

CASINO MINING CORPORATION

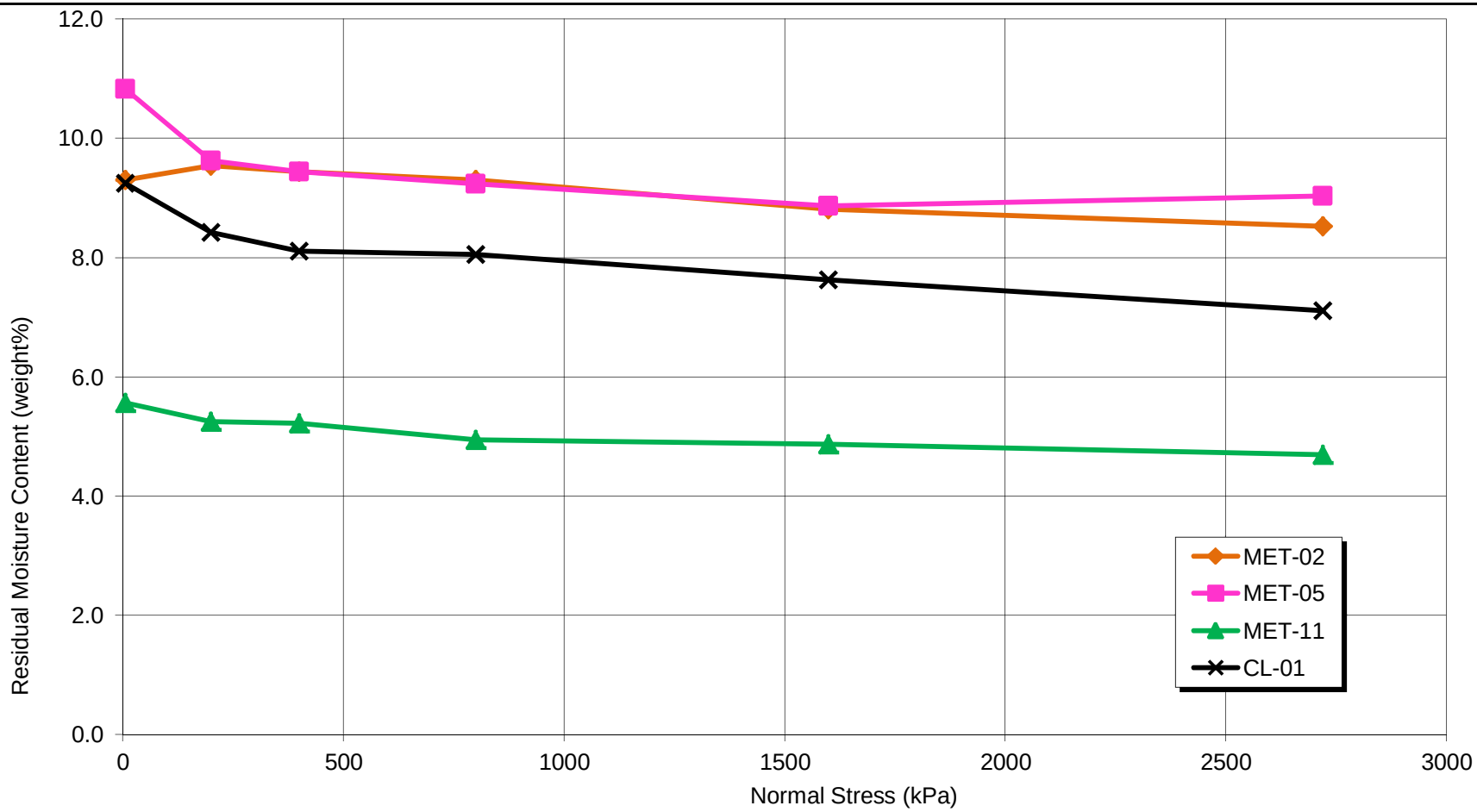
CASINO PROJECT

CONSTANT HEAD PERMEABILITY TESTS
VOID RATIO AND DRY DENSITY VS NORMAL STRESS

Knight Piésold CONSULTING

P/A NO. VA101-325/16 | REF. NO. 2

FIGURE C.1 | REV 0



NOTES:
1. Tested on fraction of material passing 1.5 inch.
2. All tests conducted by KP using a 8-inch rigid wall permeameter.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	14FEB'14	ISSUED WITH REPORT	ML	SB	GRG

CASINO MINING CORPORATION

CASINO PROJECT

CONSTANT HEAD PERMEABILITY TESTS
RESIDUAL MOISTURE CONTENT VS NORMAL STRESS

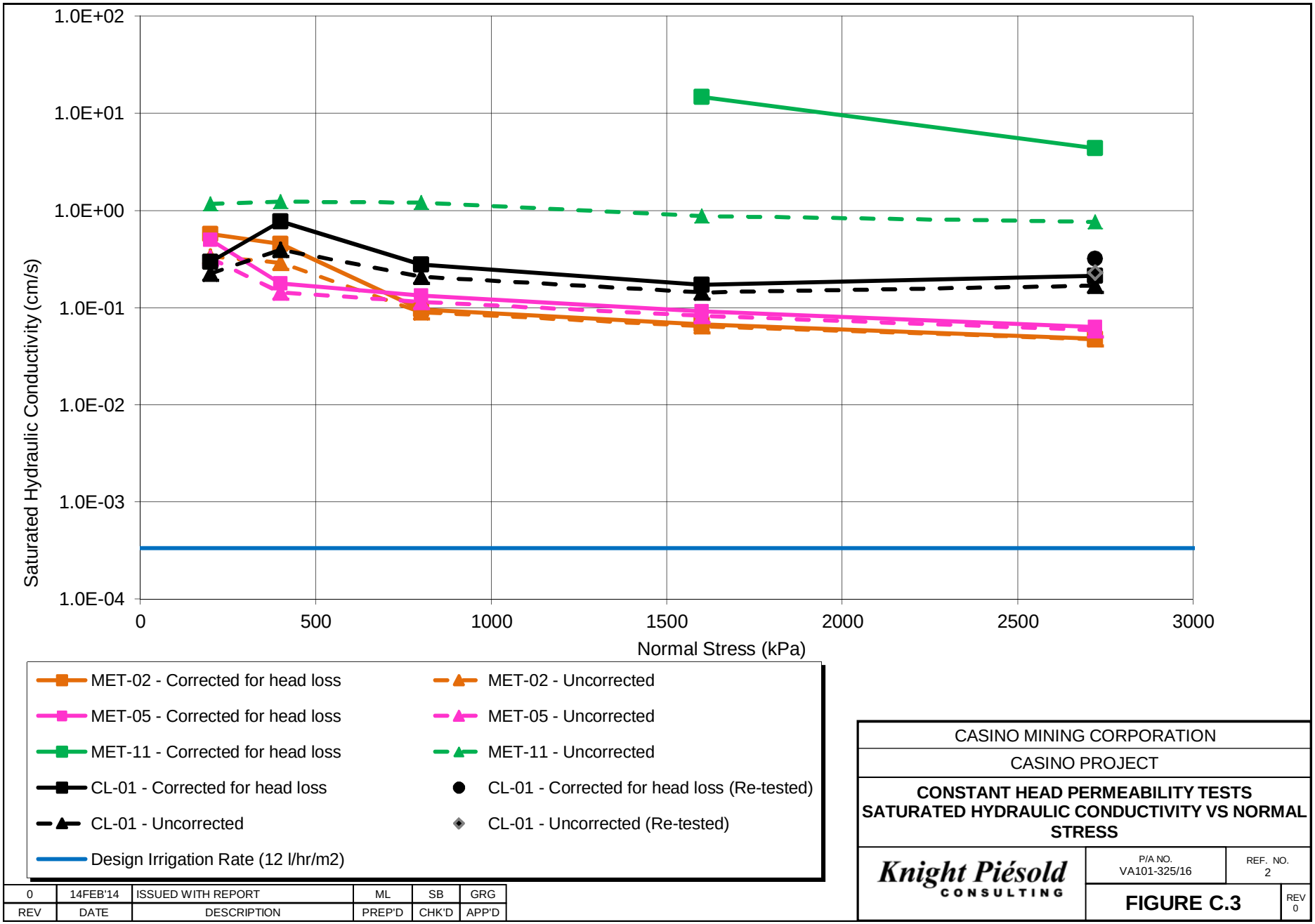
Knight Piésold CONSULTING

P/A NO. VA101-325/16

REF. NO. 2

FIGURE C.2

REV 0



REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	14FEB'14	ISSUED WITH REPORT	ML	SB	GRG

CASINO MINING CORPORATION

CASINO PROJECT

CONSTANT HEAD PERMEABILITY TESTS
SATURATED HYDRAULIC CONDUCTIVITY VS NORMAL STRESS

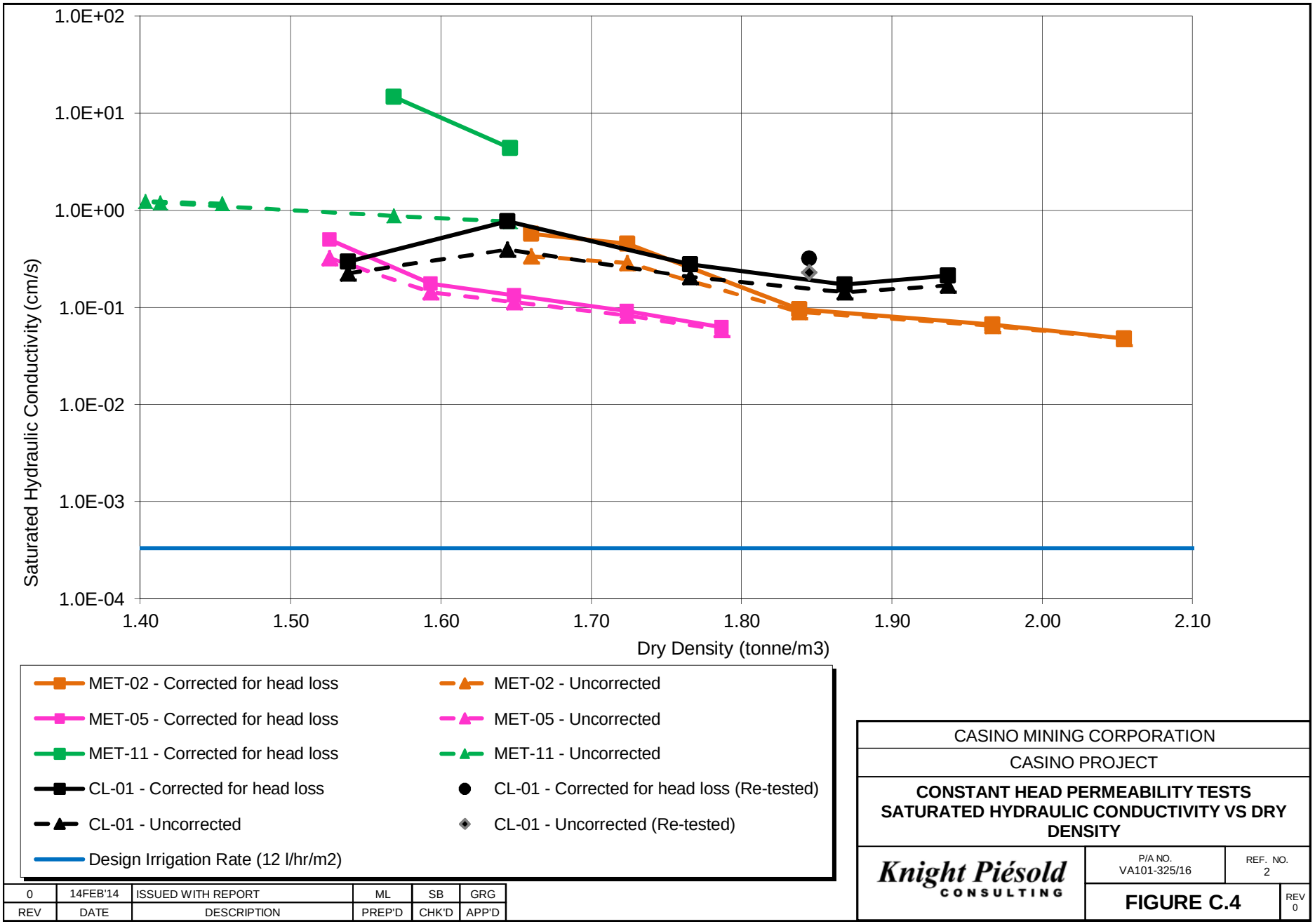
Knight Piésold CONSULTING

P/A NO. VA101-325/16

REF. NO. 2

FIGURE C.3

REV 0



REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	14FEB'14	ISSUED WITH REPORT	ML	SB	GRG

CASINO MINING CORPORATION

CASINO PROJECT

CONSTANT HEAD PERMEABILITY TESTS
SATURATED HYDRAULIC CONDUCTIVITY VS DRY DENSITY

Knight Piésold CONSULTING

P/A NO. VA101-325/16

REF. NO. 2

FIGURE C.4

REV 0

APPENDIX D

SWCC TEST RESULTS
(D.B. STEPHENS AND ASSOCIATES LABORATORY)

(Pages D-1 to D-85)

Laboratory Report for

Knight Piesold

Project: Casino, VA101-00325/16

January 9, 2014

Daniel B. Stephens & Associates, Inc.

4400 Alameda Blvd. NE, Suite C • Albuquerque, New Mexico 87113

January 9, 2014

Sanne Brinkman
Knight Piesold
Suite 1400 - 750 West Pender
Vancouver, BC V6C 2T8 Canada
(604) 685 0543

Re: DBS&A Laboratory Report for the Knight Piesold Casino, VA101-00325/16 Project

Dear Mr. Brinkman:

Enclosed is the report for the Knight Piesold Casino, VA101-00325/16 project samples. Please review this report and provide any comments as samples will be held for a maximum of 30 days. After 30 days samples will be returned or disposed of in an appropriate manner.

All testing results were evaluated subjectively for consistency and reasonableness, and the results appear to be reasonably representative of the material tested. However, DBS&A does not assume any responsibility for interpretations or analyses based on the data enclosed, nor can we guarantee that these data are fully representative of the undisturbed materials at the field site. We recommend that careful evaluation of these laboratory results be made for your particular application.

The testing utilized to generate the enclosed report employs methods that are standard for the industry. The results do not constitute a professional opinion by DBS&A, nor can the results affect any professional or expert opinions rendered with respect thereto by DBS&A. You have acknowledged that all the testing undertaken by us, and the report provided, constitutes mere test results using standardized methods, and cannot be used to disqualify DBS&A from rendering any professional or expert opinion, having waived any claim of conflict of interest by DBS&A.

We are pleased to provide this service to Knight Piesold and look forward to future laboratory testing on other projects. If you have any questions about the enclosed data, please do not hesitate to call.

Sincerely,

DANIEL B. STEPHENS & ASSOCIATES, INC.
SOIL TESTING & RESEARCH LABORATORY

Joleen Hines

Joleen Hines
Laboratory Supervising Manager

Enclosure

Daniel B. Stephens & Associates, Inc.
Soil Testing & Research Laboratory
4400 Alameda Blvd. NE, Suite C
Albuquerque, NM 87113
505-889-7752
FAX 505-889-0258

Summaries

Summary of Tests Performed

Laboratory Sample Number	Initial Soil Properties[1]			Saturated Hydraulic Conductivity[2]			Moisture Characteristics[3]								Particle Size[4]			Specific Gravity[5]		Air Perm-eability	Atterberg Limits	Proctor Compaction
	G	VM	VD	CH	FH	FW	HC	PP	FP	DPP	RH	EP	WHC	K_{unsat}	DS	WS	H	F	C			
MET-02 (1.75) MR	X	X		X			X			X	X			X								
MET-02 (2.00) MR	X	X		X			X			X	X			X								
MET-05 (1.47) MR	X	X		X			X			X	X			X								
MET-05 (1.79) MR	X	X		X			X			X	X			X								
MET-11 (1.66) MR	X	X		X			X			X	X			X								
MET-11 (1.94) MR	X	X		X			X			X	X			X								

[1] G = Gravimetric Moisture Content, VM = Volume Measurement Method, VD = Volume Displacement Method

[2] CH = Constant Head Rigid Wall, FH = Falling Head Rigid Wall, FW = Falling Head Rising Tail Flexible Wall

[3] HC = Hanging Column, PP = Pressure Plate, FP = Filter Paper, DPP = Dew Point Potentiometer, RH = Relative Humidity Box, EP = Effective Porosity, WHC = Water Holding Capacity, Kunsat = Calculated Unsaturated Hydraulic Conductivity

[4] DS = Dry Sieve, WS = Wet Sieve, H = Hydrometer

[5] F = Fine (<4.75mm), C = Coarse (>4.75mm)

Notes

Sample Receipt:
Three samples were received on November 4, 2013, each in two full to 3/4 full 5-gallon buckets.

Testing Notes:
The samples were prepared by remolding the material passing the 2" sieve to target remold densities provided by the client. The target remold densities were based on permeability tests that were performed using material finer than 1.5". The target remold densities were corrected to account for the material larger than 1.5" and finer than 2", based on the client provided target densities (for material <1.5") and grain size distributions. The adjusted target remold densities are provided in the table below:

	-1.5"			-2"		
	-1.5" Target Density #1	-1.5" Target Density #2		Mass % of Material <2"/>1.5"	-2" Target Density #1	-2" Target Density #2
	g/cm^3	g/cm^3		%	g/cm^3	g/cm^3
MET-02	1.63	2.06		19.52	1.77	2.16
MET-05	1.47	1.79		1.60	1.48	1.80
MET-11	1.37	1.65		30.93	1.66	1.93

Samples MET-02 and MET-05 were remolded after moisture correcting the material to a gravimetric moisture content of ~3%, and sample MET-11 was remolded after moisture correcting the material to a gravimetric moisture content of ~1%. The actual initial remolded density of each sample was added to the sample ID (in g/cc).

The remolded samples were subjected to initial properties, saturated hydraulic conductivity, and the hanging column and pressure chamber portions of the moisture retention testing. Oversize correction calculations are presented for sample MET-11, since the fraction of material larger than 2" was greater than 5% of the bulk sample mass.

Remaining bulk sample material was used for the dewpoint potentiometer and relative humidity chamber portions of the moisture retention testing.

Volume changes (settling) occurred for the 'MET-05 (1.47)' sample during the hanging column and pressure chamber portions of the analysis. The reported volumetric moisture contents are adjusted for volume changes, when applicable. Due to the irregularities formed on the sample surfaces, volume measurements obtained after the initial reading should be considered estimates.

Total porosity calculations in this report are based on the use of an assumed specific gravity value of 2.65.

Summary of Sample Preparation/Volume Changes

	Target Remold Parameters[1]			Actual Remold Data				Volume Change Post Saturation[2]				Volume Change Post Drying Curve[3]			
Sample Number	Moist. Cont. (%, g/g)	Dry Bulk Density (g/cm^3)	Dry Bulk Density (pcf)	Moist. Cont. (%, g/g)	Dry Bulk Density (g/cm^3)	Dry Bulk Density (pcf)	% of Target Density (%)	Dry Bulk Density (g/cm^3)	Dry Bulk Density (pcf)	% Volume Change (%)	% of Initial Density (%)	Dry Bulk Density (g/cm^3)	Dry Bulk Density (pcf)	% Volume Change (%)	% of Initial Density (%)
MET-02 (1.75)	3.0	1.77	110.5	4.0	1.75	109.46	99.1%	1.75	109.46	---	100.0%	1.75	109.46	---	100.0%
MET-02 (2.00)	3.0	2.16	134.8	3.3	2.00	124.87	92.6%	2.00	124.87	---	100.0%	2.00	124.87	---	100.0%
MET-05 (1.47)	3.0	1.48	92.39	3.55	1.47	91.85	99.4%	1.62	101.28	-9.3%	110.3%	1.62	101.28	-9.3%	110.3%
MET-05 (1.79)	3.0	1.80	112.37	3.63	1.79	111.60	99.3%	1.79	111.60	---	100.0%	1.79	111.60	---	100.0%
MET-11 (1.66)	1.0	1.66	103.63	0.93	1.66	103.54	99.9%	1.66	103.54	---	100.0%	1.66	103.54	---	100.0%
MET-11 (1.94)	1.0	1.93	120.49	0.60	1.94	120.97	100.4%	1.94	120.97	---	100.0%	1.94	120.97	---	100.0%

[1]Target Remold Parameters: Provided by the client, and adjusted for material larger than 1.5" and finer than 2", based on the client provided grain size distributions. See 'Notes' page for additional information.

[2]Volume Change Post Saturation: Volume change measurements were obtained after saturated hydraulic conductivity testing.

[3]Volume Change Post Drying Curve: Volume change measurements were obtained throughout hanging column and pressure plate testing. The 'Volume Change Post Drying Curve' values represent the final sample dimensions after the last pressure plate point.

Notes:

"+" indicates sample swelling, "-" indicates sample settling, and "---" indicates no volume change occurred.

Summary of Initial Moisture Content, Dry Bulk Density Wet Bulk Density and Calculated Porosity

Sample Number	Moisture Content				Dry Bulk Density (g/cm^3)	Wet Bulk Density (g/cm^3)	Calculated Porosity (%)
	As Received		Remolded				
	Gravimetric (%, g/g)	Volumetric (%, cm^3/cm^3)	Gravimetric (%, g/g)	Volumetric (%, cm^3/cm^3)			
MET-02 (1.75)	NA	NA	4.0	7.0	1.75	1.82	33.8
MET-02 (2.00)	NA	NA	3.3	6.6	2.00	2.07	24.5
MET-05 (1.47)	NA	NA	3.6	5.2	1.47	1.52	44.5
MET-05 (1.79)	NA	NA	3.6	6.5	1.79	1.85	32.5
MET-11 (1.66)	NA	NA	0.9	1.5	1.66	1.67	37.4
MET-11 (1.94)	NA	NA	0.6	1.2	1.94	1.95	26.9

NA = Not analyzed

--- = This sample was not remolded

Summary of Saturated Hydraulic Conductivity Tests

Sample Number	K_{sat} (cm/sec)	Oversize Corrected K_{sat} (cm/sec)	Method of Analysis	
			Constant Head	Falling Head
MET-02 (1.75)	2.2E-02	---	X	
MET-02 (2.00)	2.0E-03	---	X	
MET-05 (1.47)	2.6E-02	---	X	
MET-05 (1.79)	1.6E-02	---	X	
MET-11 (1.66)	3.5E-02	3.3E-02	X	
MET-11 (1.94)	1.9E-02	1.8E-02	X	

--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass
NR = Not requested
NA = Not applicable

Summary of Moisture Characteristics of the Initial Drainage Curve

Sample Number	Pressure Head (-cm water)	Moisture Content (%, cm^3/cm^3)
MET-02 (1.75)	0	33.2
	8	17.2
	15	13.3
	50	12.7
	150	11.8
	15297	1.0
	59148	0.6
	536823	0.4
	845560	0.4
MET-02 (2.00)	0	23.8
	8	18.1
	18	15.2
	50	14.5
	150	13.8
	19070	1.1
	139407	0.6
	614939	0.4
	845560	0.4
MET-05 (1.47)	0	36.9 ‡‡
	8	18.3 ‡‡
	19	13.5 ‡‡
	50	12.9 ‡‡
	150	11.5 ‡‡
	15807	1.5 ‡‡
	44871	0.8 ‡‡
	231393	0.4 ‡‡
	845560	0.2 ‡‡

‡‡ Volume adjustments are applicable at this matric potential (see data sheet for this sample).

Summary of Moisture Characteristics of the Initial Drainage Curve (Continued)

Sample Number	Pressure Head (-cm water)	Moisture Content (%, cm^3/cm^3)
MET-05 (1.79)	0	32.1
	8	21.2
	18	15.4
	48	13.0
	150	11.9
	13563	1.9
	30900	1.2
	102898	0.5
	845560	0.2
MET-11 (1.66)	0	37.6
	8	6.7
	19	5.7
	50	5.5
	150	4.8
	25495	0.4
	88009	0.3
	372125	0.2
	845560	0.1
MET-11 (1.94)	0	26.9
	8	8.5
	19	7.9
	50	7.7
	150	7.5
	15399	0.6
	48746	0.4
	307470	0.2
	845560	0.1

‡‡ Volume adjustments are applicable at this matric potential (see data sheet for this sample).

Summary of Calculated Unsaturated Hydraulic Properties

Sample Number	α (cm^{-1})	N (dimensionless)	θ_r (% vol)	θ_s (% vol)	Oversize Corrected θ_r (% vol)	Oversize Corrected θ_s (% vol)
MET-02 (1.75)	1.7714	1.2391	0.00	33.21	---	---
MET-02 (2.00)	0.1579	1.2526	0.00	23.08	---	---
MET-05 (1.47)	1.8216	1.2529	0.00	36.89	---	---
MET-05 (1.79)	0.5148	1.2829	0.00	32.13	---	---
MET-11 (1.66)	159.9412	1.2289	0.00	37.58	0.00	36.24
MET-11 (1.94)	13.4084	1.2167	0.00	26.92	0.00	25.80

--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass

NR = Not requested

NA = Not applicable

Initial Properties

Summary of Initial Moisture Content, Dry Bulk Density Wet Bulk Density and Calculated Porosity

Sample Number	Moisture Content				Dry Bulk Density (g/cm^3)	Wet Bulk Density (g/cm^3)	Calculated Porosity (%)
	As Received		Remolded				
	Gravimetric (%, g/g)	Volumetric (%, cm^3/cm^3)	Gravimetric (%, g/g)	Volumetric (%, cm^3/cm^3)			
MET-02 (1.75)	NA	NA	4.0	7.0	1.75	1.82	33.8
MET-02 (2.00)	NA	NA	3.3	6.6	2.00	2.07	24.5
MET-05 (1.47)	NA	NA	3.6	5.2	1.47	1.52	44.5
MET-05 (1.79)	NA	NA	3.6	6.5	1.79	1.85	32.5
MET-11 (1.66)	NA	NA	0.9	1.5	1.66	1.67	37.4
MET-11 (1.94)	NA	NA	0.6	1.2	1.94	1.95	26.9

NA = Not analyzed

--- = This sample was not remolded

Data for Initial Moisture Content, Bulk Density, Porosity, and Percent Saturation

Job Name: Knight Piesold
Job Number: LB13.0269.00
Sample Number: MET-02 (1.75)
Sample Tag ID: DV101-77/14 (L2013-101) (L2013-084)
Project: Casino, VA101-00325/16

	As Received	Remolded
Test Date:	NA	15-Nov-13
Field weight of sample* (g)*:*		22183.64
Tare weight, ring (g)*:*		2260.34
Tare weight, pan/plate (g)*:*		0.00
Tare weight, other (g)*:*		163.30
Dry weight of sample (g)*:*		19001.40
Sample volume (cm^3)*:*		10837.10
Assumed particle density (g/cm^3)*:*		2.65
Gravimetric Moisture Content (% g/g)*:*		4.0
Volumetric Moisture Content (% vol)*:*		7.0
Dry bulk density (g/cm^3)*:*		1.75
Wet bulk density (g/cm^3)*:*		1.82
Calculated Porosity (% vol)*:*		33.8
Percent Saturation:		20.7

Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

Comments:

* Weight including tares
NA = Not analyzed
--- = This sample was not remolded

Data for Initial Moisture Content, Bulk Density, Porosity, and Percent Saturation

Job Name: Knight Piesold
Job Number: LB13.0269.00
Sample Number: MET-02 (2.00)
Sample Tag ID: DV101-77/14 (L2013-101) (L2013-084)
Project: Casino, VA101-00325/16

	As Received	Remolded
Test Date:	NA	15-Nov-13
Field weight of sample* (g)*:*		26797.30
Tare weight, ring (g)*:*		2416.80
Tare weight, pan/plate (g)*:*		0.00
Tare weight, other (g)*:*		180.50
Dry weight of sample (g)*:*		23421.50
Sample volume (cm^3)*:*		11709.07
Assumed particle density (g/cm^3)*:*		2.65

Gravimetric Moisture Content (% g/g)*:*	3.3
Volumetric Moisture Content (% vol)*:*	6.6
Dry bulk density (g/cm^3)*:*	2.00
Wet bulk density (g/cm^3)*:*	2.07
Calculated Porosity (% vol)*:*	24.5
Percent Saturation:	27.1

Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

Comments:

* Weight including tares
NA = Not analyzed
--- = This sample was not remolded

Data for Initial Moisture Content, Bulk Density, Porosity, and Percent Saturation

Job Name: Knight Piesold
Job Number: LB13.0269.00
Sample Number: MET-05 (1.47)
Sample Tag ID: DV101-77/14 L2013-101
Project: Casino, VA101-00325/16

	As Received	Remolded
Test Date:	NA	15-Nov-13
Field weight of sample* (g)*:*		19270.54
Tare weight, ring (g)*:*		2325.24
Tare weight, pan/plate (g)*:*		0.00
Tare weight, other (g)*:*		165.30
Dry weight of sample (g)*:*		16204.00
Sample volume (cm^3)*:*		11013.55
Assumed particle density (g/cm^3)*:*		2.65
Gravimetric Moisture Content (% g/g)*:*		3.6
Volumetric Moisture Content (% vol)*:*		5.2
Dry bulk density (g/cm^3)*:*		1.47
Wet bulk density (g/cm^3)*:*		1.52
Calculated Porosity (% vol)*:*		44.5
Percent Saturation:		11.8

Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

Comments:

* Weight including tares
NA = Not analyzed
--- = This sample was not remolded

Data for Initial Moisture Content, Bulk Density, Porosity, and Percent Saturation

Job Name: Knight Piesold
Job Number: LB13.0269.00
Sample Number: MET-05 (1.79)
Sample Tag ID: DV101-77/14 L2013-101
Project: Casino, VA101-00325/16

	As Received	Remolded
Test Date:	NA	15-Nov-13
Field weight of sample* (g)*:*		22814.03
Tare weight, ring (g)*:*		2234.70
Tare weight, pan/plate (g)*:*		0.00
Tare weight, other (g)*:*		179.33
Dry weight of sample (g)*:*		19686.30
Sample volume (cm^3)*:*		11012.39
Assumed particle density (g/cm^3)*:*		2.65

Gravimetric Moisture Content (% g/g)*:*	3.6
Volumetric Moisture Content (% vol)*:*	6.5
Dry bulk density (g/cm^3)*:*	1.79
Wet bulk density (g/cm^3)*:*	1.85
Calculated Porosity (% vol)*:*	32.5
Percent Saturation:	19.9

Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

Comments:

* Weight including tares
NA = Not analyzed
--- = This sample was not remolded

Data for Initial Moisture Content, Bulk Density, Porosity, and Percent Saturation

Job Name: Knight Piesold
Job Number: LB13.0269.00
Sample Number: MET-11 (1.66)
Sample Tag ID: DV101-77/14
Project: Casino, VA101-00325/16

	As Received	Remolded
Test Date:	NA	14-Dec-13
Field weight of sample* (g)*:*		20672.26
Tare weight, ring (g)*:*		2291.76
Tare weight, pan/plate (g)*:*		0.00
Tare weight, other (g)*:*		180.50
Dry weight of sample (g)*:*		18031.98
Sample volume (cm^3)*:*		10871.77
Assumed particle density (g/cm^3)*:*		2.65

Gravimetric Moisture Content (% g/g)*:*	0.9
Volumetric Moisture Content (% vol)*:*	1.5
Dry bulk density (g/cm^3)*:*	1.66
Wet bulk density (g/cm^3)*:*	1.67
Calculated Porosity (% vol)*:*	37.4
Percent Saturation:	4.1

Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

Comments:

* Weight including tares
NA = Not analyzed
--- = This sample was not remolded

Data for Initial Moisture Content, Bulk Density, Porosity, and Percent Saturation

Job Name: Knight Piesold
Job Number: LB13.0269.00
Sample Number: MET-11 (1.94)
Sample Tag ID: DV101-77/14
Project: Casino, VA101-00325/16

	As Received	Remolded
Test Date:	NA	14-Dec-13
Field weight of sample* (g)*:*		23953.44
Tare weight, ring (g)*:*		2325.24
Tare weight, pan/plate (g)*:*		0.00
Tare weight, other (g)*:*		158.20
Dry weight of sample (g)*:*		21342.20
Sample volume (cm^3)*:*		11013.55
Assumed particle density (g/cm^3)*:*		2.65
Gravimetric Moisture Content (% g/g)*:*		0.6
Volumetric Moisture Content (% vol)*:*		1.2
Dry bulk density (g/cm^3)*:*		1.94
Wet bulk density (g/cm^3)*:*		1.95
Calculated Porosity (% vol)*:*		26.9
Percent Saturation:		4.3

Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

Comments:

* Weight including tares
NA = Not analyzed
--- = This sample was not remolded

Saturated Hydraulic Conductivity

Summary of Saturated Hydraulic Conductivity Tests

Sample Number	K_{sat} (cm/sec)	Oversize Corrected K_{sat} (cm/sec)	Method of Analysis	
			Constant Head	Falling Head
MET-02 (1.75)	2.2E-02	---	X	
MET-02 (2.00)	2.0E-03	---	X	
MET-05 (1.47)	2.6E-02	---	X	
MET-05 (1.79)	1.6E-02	---	X	
MET-11 (1.66)	3.5E-02	3.3E-02	X	
MET-11 (1.94)	1.9E-02	1.8E-02	X	

--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass
NR = Not requested
NA = Not applicable

Saturated Hydraulic Conductivity
Constant Head Method

Job name: Knight Piesold
Job number: LB13.0269.00
Sample number: MET-02 (1.75)
Sample Tag ID: DV101-77/14 (L2013-101) (L2013-084)
Project: Casino, VA101-00325/16

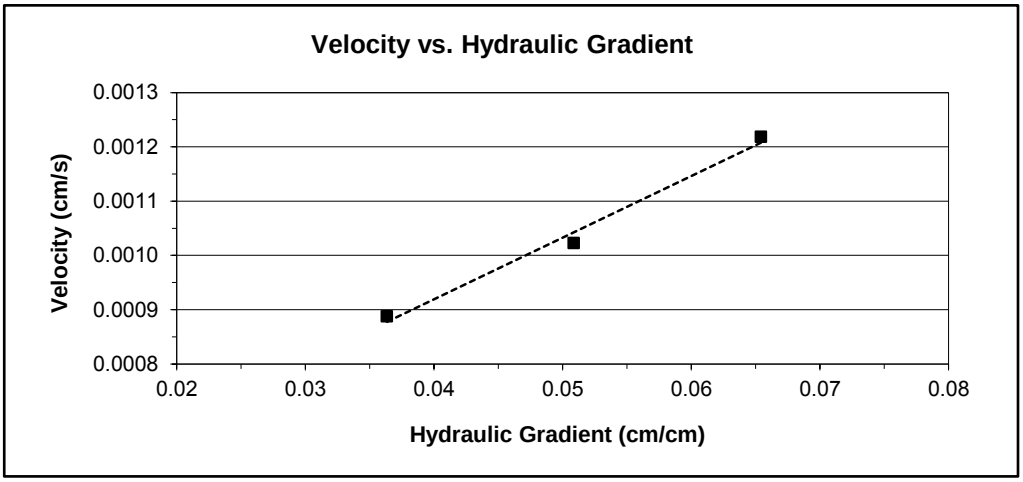
Type of water used: TAP
Collection vessel tare (g)*:* 114.91
Sample length (cm)*:* 13.76
Sample diameter (cm)*:* 30.07
Sample x-sectional area (cm^2)*:* 710.35

Date	Time	Temp (°C)	Head (cm)	Q + Tare (g)	Q (cm^3)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:								
19-Nov-13	10:25:00	18.0	0.9	166.83	51.9	60	1.9E-02	2.0E-02
19-Nov-13	10:26:00							
Test # 2:								
19-Nov-13	10:37:00	18.0	0.7	158.48	43.6	60	2.0E-02	2.1E-02
19-Nov-13	10:38:00							
Test # 3:								
19-Nov-13	10:49:00	18.0	0.5	152.74	37.8	60	2.4E-02	2.6E-02
19-Nov-13	10:50:00							

Average Ksat* (cm/sec)*: **2.2E-02**
Oversize Corrected Ksat* (cm/sec)*: **---**

Comments:

--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass



Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

Saturated Hydraulic Conductivity
Constant Head Method

Job name: Knight Piesold
Job number: LB13.0269.00
Sample number: MET-02 (2.00)
Sample Tag ID: DV101-77/14 (L2013-101) (L2013-084)
Project: Casino, VA101-00325/16

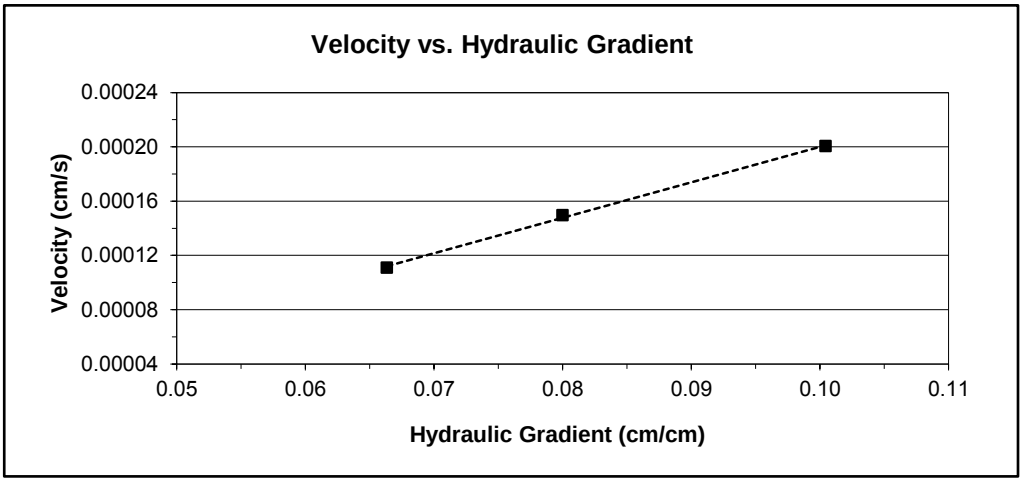
Type of water used: TAP
Collection vessel tare (g)*:* 114.91
Sample length (cm)*:* 14.67
Sample diameter (cm)*:* 30.09
Sample x-sectional area (cm^2)*:* 711.11

Date	Time	Temp (°C)	Head (cm)	Q + Tare (g)	Q (cm^3)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:								
19-Nov-13	11:51:00	18.5	1.4	123.46	8.6	60	2.1E-03	2.2E-03
19-Nov-13	11:52:00							
Test # 2:								
19-Nov-13	12:06:00	18.5	1.1	121.29	6.4	60	2.0E-03	2.1E-03
19-Nov-13	12:07:00							
Test # 3:								
19-Nov-13	12:32:00	18.5	0.9	119.64	4.7	60	1.8E-03	1.9E-03
19-Nov-13	12:33:00							

Average Ksat* (cm/sec)*: **2.0E-03**
Oversize Corrected Ksat* (cm/sec)*: **---**

Comments:

--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass



Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

Saturated Hydraulic Conductivity
Constant Head Method

Job name: Knight Piesold
Job number: LB13.0269.00
Sample number: MET-05 (1.47)
Sample Tag ID: DV101-77/14 L2013-101
Project: Casino, VA101-00325/16

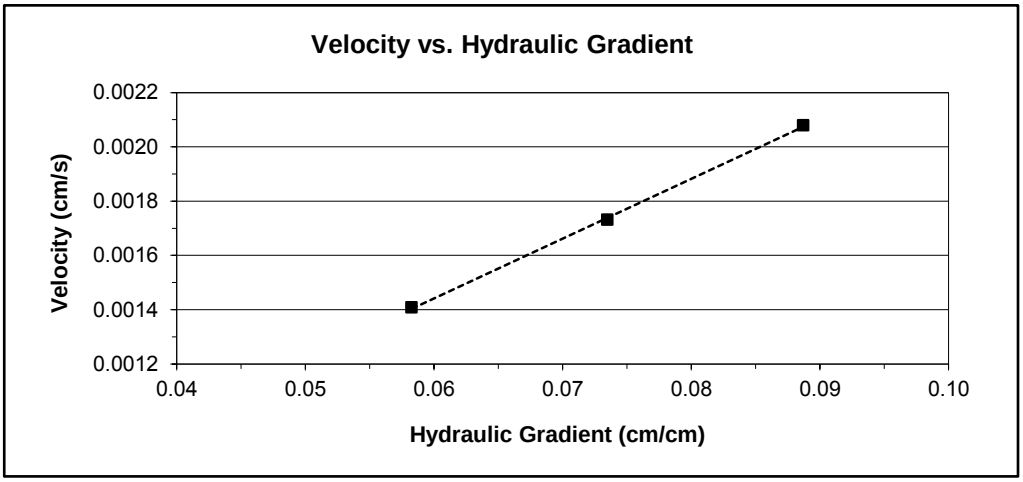
Type of water used: TAP
Collection vessel tare (g)*:* 114.91
Sample length (cm)*:* 13.14
Sample diameter (cm)*:* 30.22
Sample x-sectional area (cm^2)*:* 717.12

Date	Time	Temp (°C)	Head (cm)	Q + Tare (g)	Q (cm^3)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:								
19-Nov-13	13:03:30	19.0	1.1	204.33	89.4	60	2.5E-02	2.5E-02
19-Nov-13	13:04:30							
Test # 2:								
19-Nov-13	13:15:15	19.0	0.9	189.39	74.5	60	2.5E-02	2.6E-02
19-Nov-13	13:16:15							
Test # 3:								
19-Nov-13	13:28:45	19.0	0.7	175.46	60.6	60	2.6E-02	2.7E-02
19-Nov-13	13:29:45							

Average Ksat* (cm/sec)*: **2.6E-02**
Oversize Corrected Ksat* (cm/sec)*: **---**

Comments:

--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass



Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

Saturated Hydraulic Conductivity
Constant Head Method

Job name: Knight Piesold
Job number: LB13.0269.00
Sample number: MET-05 (1.79)
Sample Tag ID: DV101-77/14 L2013-101
Project: Casino, VA101-00325/16

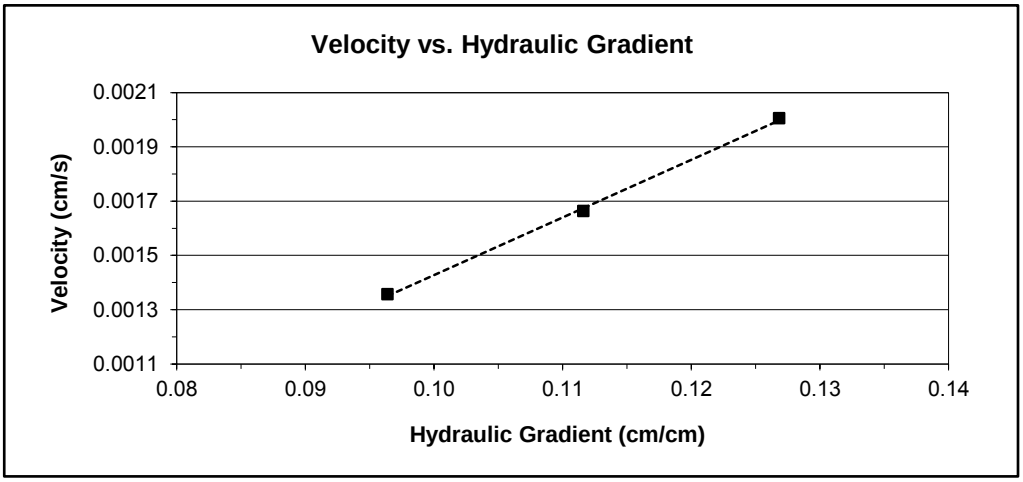
Type of water used: TAP
Collection vessel tare (g)*:* 114.91
Sample length (cm)*:* 13.13
Sample diameter (cm)*:* 30.24
Sample x-sectional area (cm^2)*:* 718.36

Date	Time	Temp (°C)	Head (cm)	Q + Tare (g)	Q (cm^3)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:								
19-Nov-13	14:17:15	19.0	1.6	201.31	86.4	60	1.6E-02	1.7E-02
19-Nov-13	14:18:15							
Test # 2:								
19-Nov-13	14:33:30	19.0	1.4	186.56	71.7	60	1.6E-02	1.6E-02
19-Nov-13	14:34:30							
Test # 3:								
19-Nov-13	14:53:15	19.0	1.2	173.38	58.5	60	1.5E-02	1.5E-02
19-Nov-13	14:54:15							

Average Ksat* (cm/sec)*: **1.6E-02**
Oversize Corrected Ksat* (cm/sec)*: **---**

Comments:

--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass



Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

Saturated Hydraulic Conductivity
Constant Head Method

Job name: Knight Piesold
Job number: LB13.0269.00
Sample number: MET-11 (1.66)
Sample Tag ID: DV101-77/14
Project: Casino, VA101-00325/16

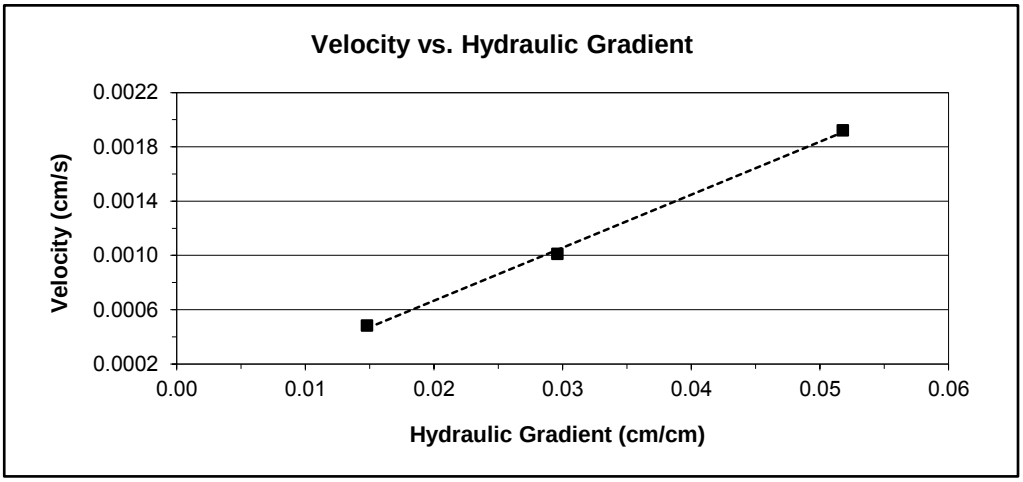
Type of water used: TAP
Collection vessel tare (g)*:* 111.10
Sample length (cm)*:* 13.51
Sample diameter (cm)*:* 30.06
Sample x-sectional area (cm^2)*:* 709.88

Date	Time	Temp (°C)	Head (cm)	Q + Tare (g)	Q (cm^3)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:								
16-Dec-13	10:08:00	19.5	0.7	192.90	81.8	60	3.7E-02	3.8E-02
16-Dec-13	10:09:00							
Test # 2:								
16-Dec-13	10:42:45	19.5	0.4	154.10	43.0	60	3.4E-02	3.5E-02
16-Dec-13	10:43:45							
Test # 3:								
16-Dec-13	10:58:30	19.5	0.2	131.60	20.5	60	3.3E-02	3.3E-02
16-Dec-13	10:59:30							

Average Ksat* (cm/sec)*: **3.5E-02**
Oversize Corrected Ksat* (cm/sec)*: **3.3E-02**

Comments:

--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass



Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

Oversize Correction Data Sheet

Job Name: Knight Piesold
Job Number: LB13.0269.00
Sample Number: MET-11 (1.66)
Sample Tag ID: DV101-77/14
Project: Casino, VA101-00325/16

Split (3/4", 3/8", #4): 2"
Calculated Porosity of Fines (% vol)*:* 29.0

	Coarse Fraction*	Fines Fraction	Composite
Subsample Mass (g)*:*	5.60	94.40	100.00
Bulk Density (g/cm^3)*:*	2.65	1.88	1.91
Volume of Solids (cm^3)*:*	2.11	35.62	37.74
Volume of Voids (cm^3)*:*	0.00	14.58	14.58
Total Volume (cm^3)*:*	2.11	50.21	52.32
Volumetric Fraction (%)*:*	4.04	95.96	100.00
Mass Fraction (%)*:*	5.60	94.40	100.00
Ksat (cm/sec)*:*	NM	3.5E-02	3.3E-02

* = Porosity and moisture content of coarse fraction assumed to be zero.
--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass
NM = Not measured

Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

Saturated Hydraulic Conductivity
Constant Head Method

Job name: Knight Piesold
Job number: LB13.0269.00
Sample number: MET-11 (1.94)
Sample Tag ID: DV101-77/14
Project: Casino, VA101-00325/16

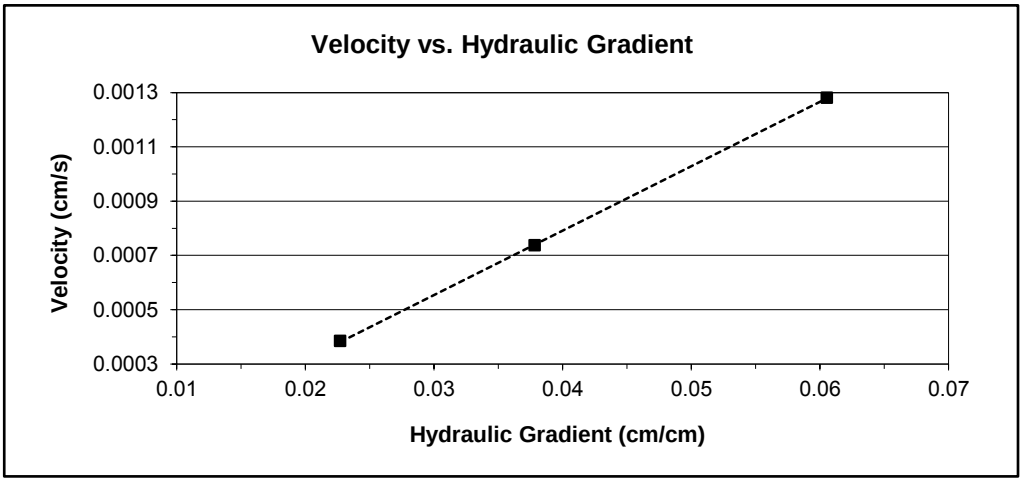
Type of water used: TAP
Collection vessel tare (g)*:* 114.90
Sample length (cm)*:* 13.21
Sample diameter (cm)*:* 30.22
Sample x-sectional area (cm^2)*:* 717.12

Date	Time	Temp (°C)	Head (cm)	Q + Tare (g)	Q (cm^3)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:								
16-Dec-13	10:09:45	19.5	0.8	170.00	55.1	60	2.1E-02	2.1E-02
16-Dec-13	10:10:45							
Test # 2:								
16-Dec-13	10:42:30	19.5	0.5	146.60	31.7	60	1.9E-02	2.0E-02
16-Dec-13	10:43:30							
Test # 3:								
16-Dec-13	10:58:45	19.5	0.3	131.40	16.5	60	1.7E-02	1.7E-02
16-Dec-13	10:59:45							

Average Ksat* (cm/sec)*: **1.9E-02**
Oversize Corrected Ksat* (cm/sec)*: **1.8E-02**

Comments:

--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass



Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

Oversize Correction Data Sheet

Job Name: Knight Piesold
Job Number: LB13.0269.00
Sample Number: MET-11 (1.94)
Sample Tag ID: DV101-77/14
Project: Casino, VA101-00325/16

Split (3/4", 3/8", #4): 2"
Calculated Porosity of Fines (% vol)*:* 15.0

	Coarse Fraction*	Fines Fraction	Composite
Subsample Mass (g)*:*	5.60	94.40	100.00
Bulk Density (g/cm^3)*:*	2.65	2.25	2.27
Volume of Solids (cm^3)*:*	2.11	35.62	37.74
Volume of Voids (cm^3)*:*	0.00	6.27	6.27
Total Volume (cm^3)*:*	2.11	41.90	44.01
Volumetric Fraction (%)*:*	4.80	95.20	100.00
Mass Fraction (%)*:*	5.60	94.40	100.00
Ksat (cm/sec)*:*	NM	1.9E-02	1.8E-02

* = Porosity and moisture content of coarse fraction assumed to be zero.
--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass
NM = Not measured

Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

Moisture Retention Characteristics

Summary of Moisture Characteristics of the Initial Drainage Curve

Sample Number	Pressure Head (-cm water)	Moisture Content (%, cm^3/cm^3)
MET-02 (1.75)	0	33.2
	8	17.2
	15	13.3
	50	12.7
	150	11.8
	15297	1.0
	59148	0.6
	536823	0.4
	845560	0.4
MET-02 (2.00)	0	23.8
	8	18.1
	18	15.2
	50	14.5
	150	13.8
	19070	1.1
	139407	0.6
	614939	0.4
	845560	0.4
MET-05 (1.47)	0	36.9 ‡‡
	8	18.3 ‡‡
	19	13.5 ‡‡
	50	12.9 ‡‡
	150	11.5 ‡‡
	15807	1.5 ‡‡
	44871	0.8 ‡‡
	231393	0.4 ‡‡
	845560	0.2 ‡‡

‡‡ Volume adjustments are applicable at this matric potential (see data sheet for this sample).

Summary of Moisture Characteristics of the Initial Drainage Curve (Continued)

Sample Number	Pressure Head (-cm water)	Moisture Content (%, cm^3/cm^3)
MET-05 (1.79)	0	32.1
	8	21.2
	18	15.4
	48	13.0
	150	11.9
	13563	1.9
	30900	1.2
	102898	0.5
	845560	0.2
MET-11 (1.66)	0	37.6
	8	6.7
	19	5.7
	50	5.5
	150	4.8
	25495	0.4
	88009	0.3
	372125	0.2
	845560	0.1
MET-11 (1.94)	0	26.9
	8	8.5
	19	7.9
	50	7.7
	150	7.5
	15399	0.6
	48746	0.4
	307470	0.2
	845560	0.1

‡‡ Volume adjustments are applicable at this matric potential (see data sheet for this sample).

Summary of Calculated Unsaturated Hydraulic Properties

Sample Number	α (cm^{-1})	N (dimensionless)	θ_r (% vol)	θ_s (% vol)	Oversize Corrected θ_r (% vol)	Oversize Corrected θ_s (% vol)
MET-02 (1.75)	1.7714	1.2391	0.00	33.21	---	---
MET-02 (2.00)	0.1579	1.2526	0.00	23.08	---	---
MET-05 (1.47)	1.8216	1.2529	0.00	36.89	---	---
MET-05 (1.79)	0.5148	1.2829	0.00	32.13	---	---
MET-11 (1.66)	159.9412	1.2289	0.00	37.58	0.00	36.24
MET-11 (1.94)	13.4084	1.2167	0.00	26.92	0.00	25.80

--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass

NR = Not requested

NA = Not applicable

Moisture Retention Data

Hanging Column / Pressure Plate

(Soil-Water Characteristic Curve)

Job Name: Knight Piesold
Job Number: LB13.0269.00
Sample Number: MET-02 (1.75)
Sample Tag ID: DV101-77/14 (L2013-101) (L2013-084)
Project: Casino, VA101-00325/16

Dry wt. of sample (g)*:* 19001.40
Tare wt., ring (g)*:* 2260.34
Tare wt., screen & clamp (g)*:* 163.30
Initial sample volume (cm^3)*:* 10837.10
Initial dry bulk density (g/cm^3)*:* 1.75
Assumed particle density (g/cm^3)*:* 2.65
Initial calculated total porosity (%)*:* 33.84

	Date	Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)
Hanging column:	21-Nov-13	15:30	25026.00	0	33.23
	13-Dec-13	15:30	23290.00	7.5	17.21
	17-Dec-13	13:00	22865.00	15.0	13.29
	20-Dec-13	14:20	22803.00	50.0	12.72
	28-Dec-13	13:10	22704.00	150.0	11.80

Volume Adjusted Data [1]

	Matric Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calculated Porosity (%)
Hanging column:	0.0	---	---	---	---
	7.5	---	---	---	---
	15.0	---	---	---	---
	50.0	---	---	---	---
	150.0	---	---	---	---

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent each of the volume change measurements obtained after saturated hydraulic conductivity testing and throughout hanging column/pressure plate testing. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Assumed density of water is 1.0 g/cm^3

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Technician Notes:

Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

Moisture Retention Data

Dew Point Potentiometer / Relative Humidity Box

(Soil-Water Characteristic Curve)

Sample Number: MET-02 (1.75)

Initial sample bulk density (g/cm^3)*:* 1.75

Fraction of test sample used (<2.00mm fraction) (%): 14.20

Dry weight of dew point potentiometer sample* (g)*:* 173.54

Tare weight, jar (g)*:* 114.00

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)
Dew point potentiometer:	23-Dec-13	16:29	176.05	15297	1.05
	18-Dec-13	16:45	175.06	59148	0.64
	18-Dec-13	13:40	174.49	536823	0.40

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Dew point potentiometer:	15297	---	---	---	---
	59148	---	---	---	---
	536823	---	---	---	---

Dry weight of relative humidity box sample* (g)*:* 74.74

Tare weight (g)*:* 38.03

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)
Relative humidity box:	20-Dec-13	15:30	75.26	845560	0.36

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Relative humidity box:	845560	---	---	---	---

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent the volume change measurements obtained after the last hanging column or pressure plate point. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

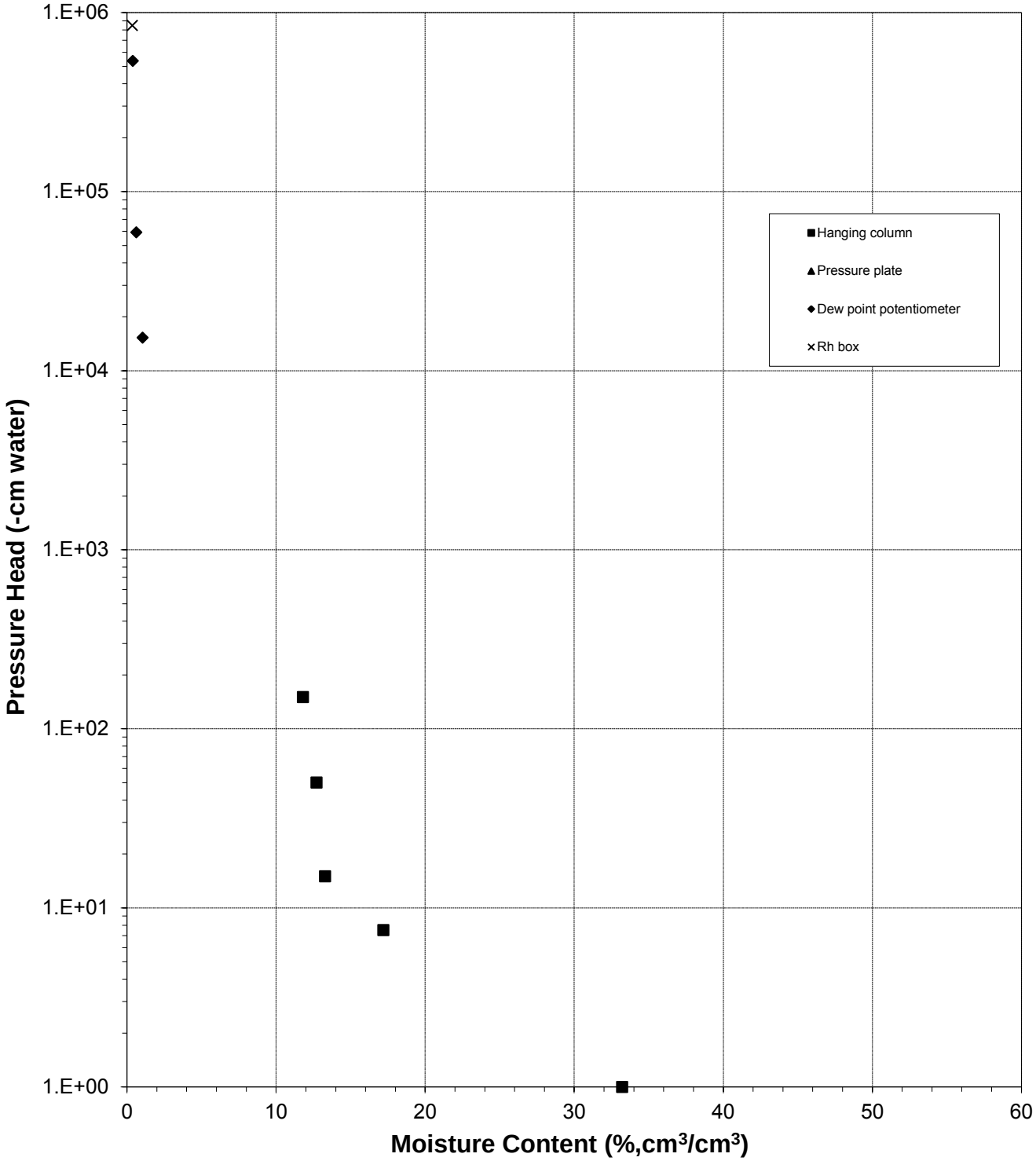
† Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm^3.

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

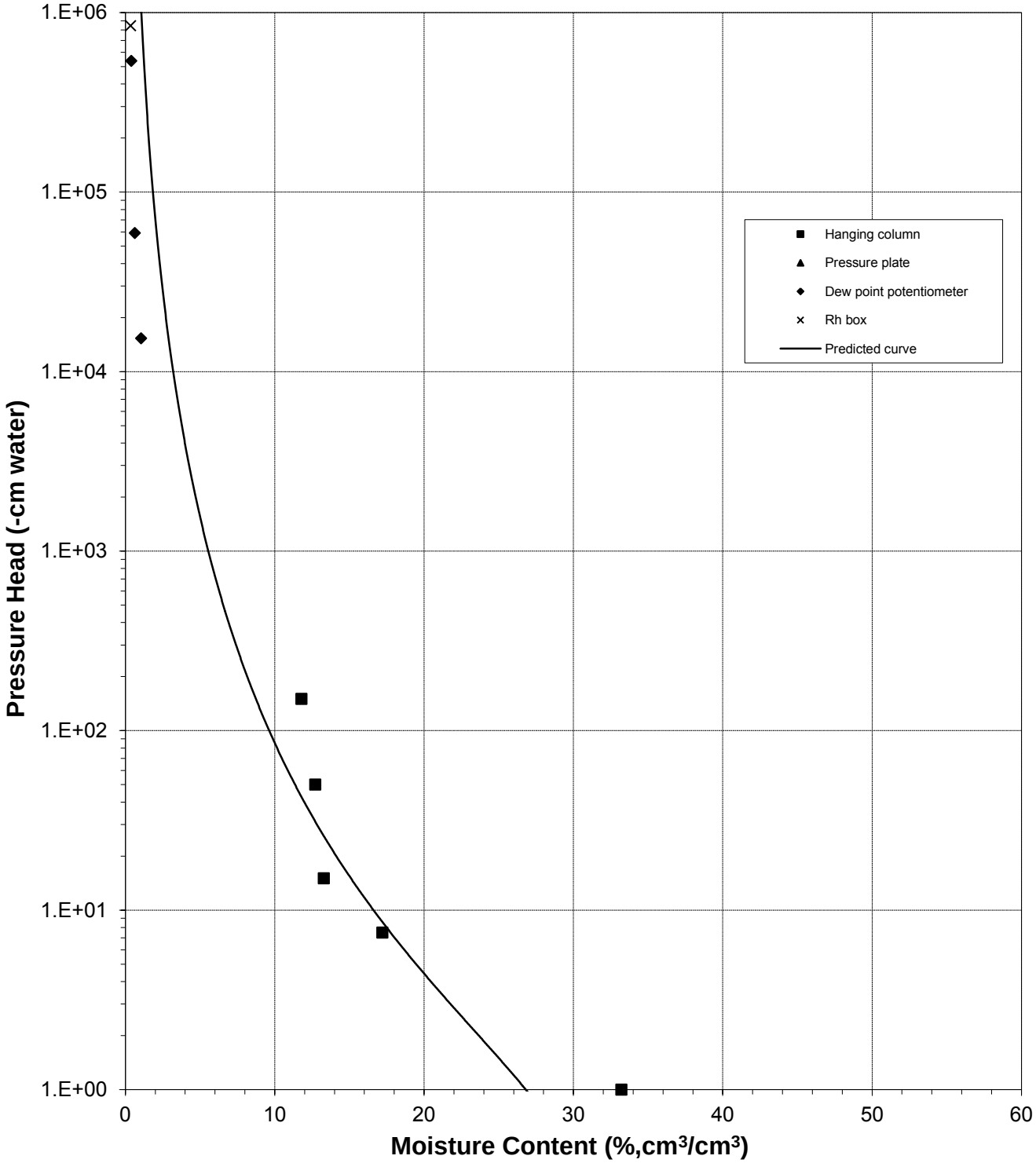
Water Retention Data Points

Sample Number: MET-02 (1.75)



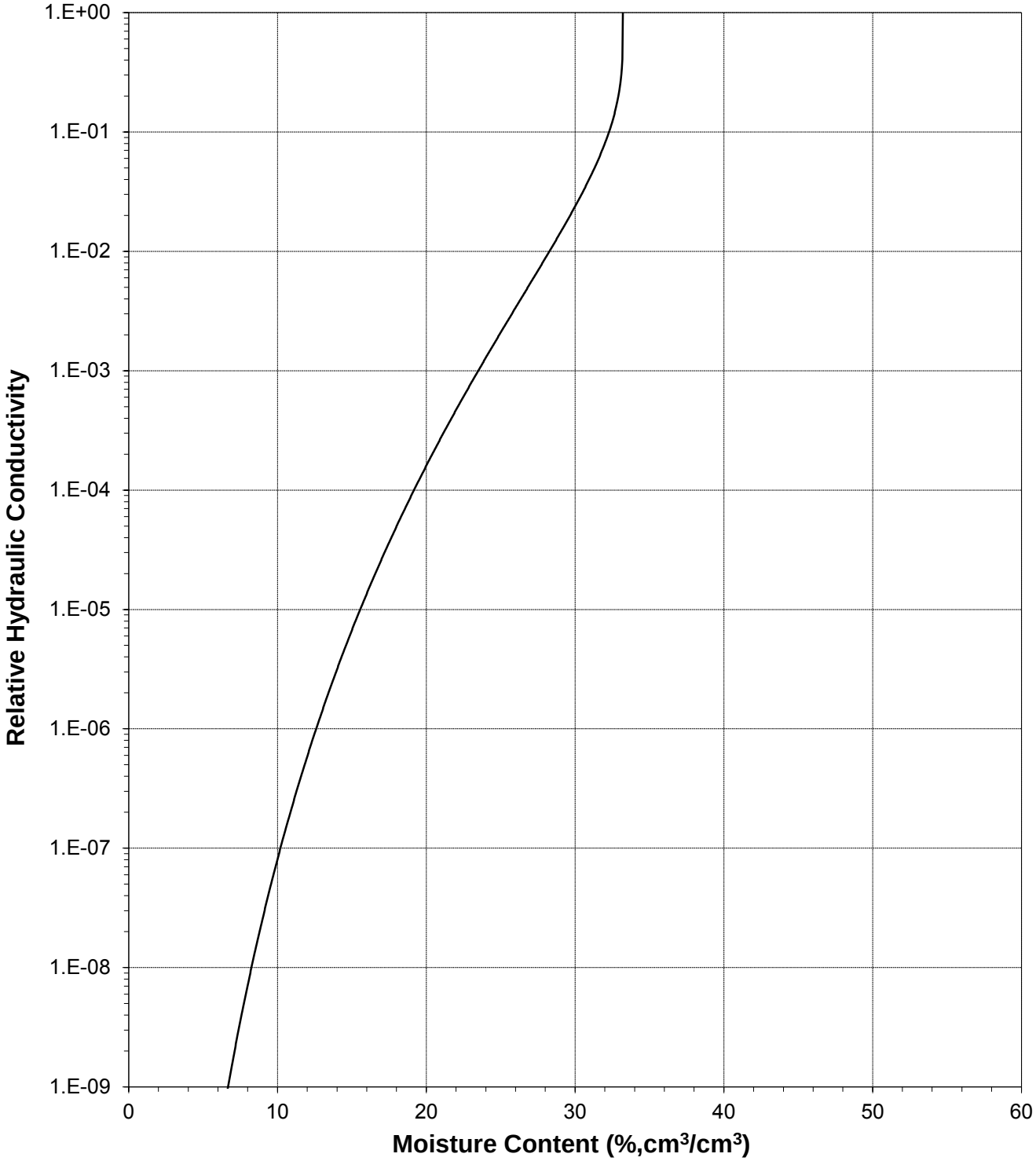
Predicted Water Retention Curve and Data Points

Sample Number: MET-02 (1.75)



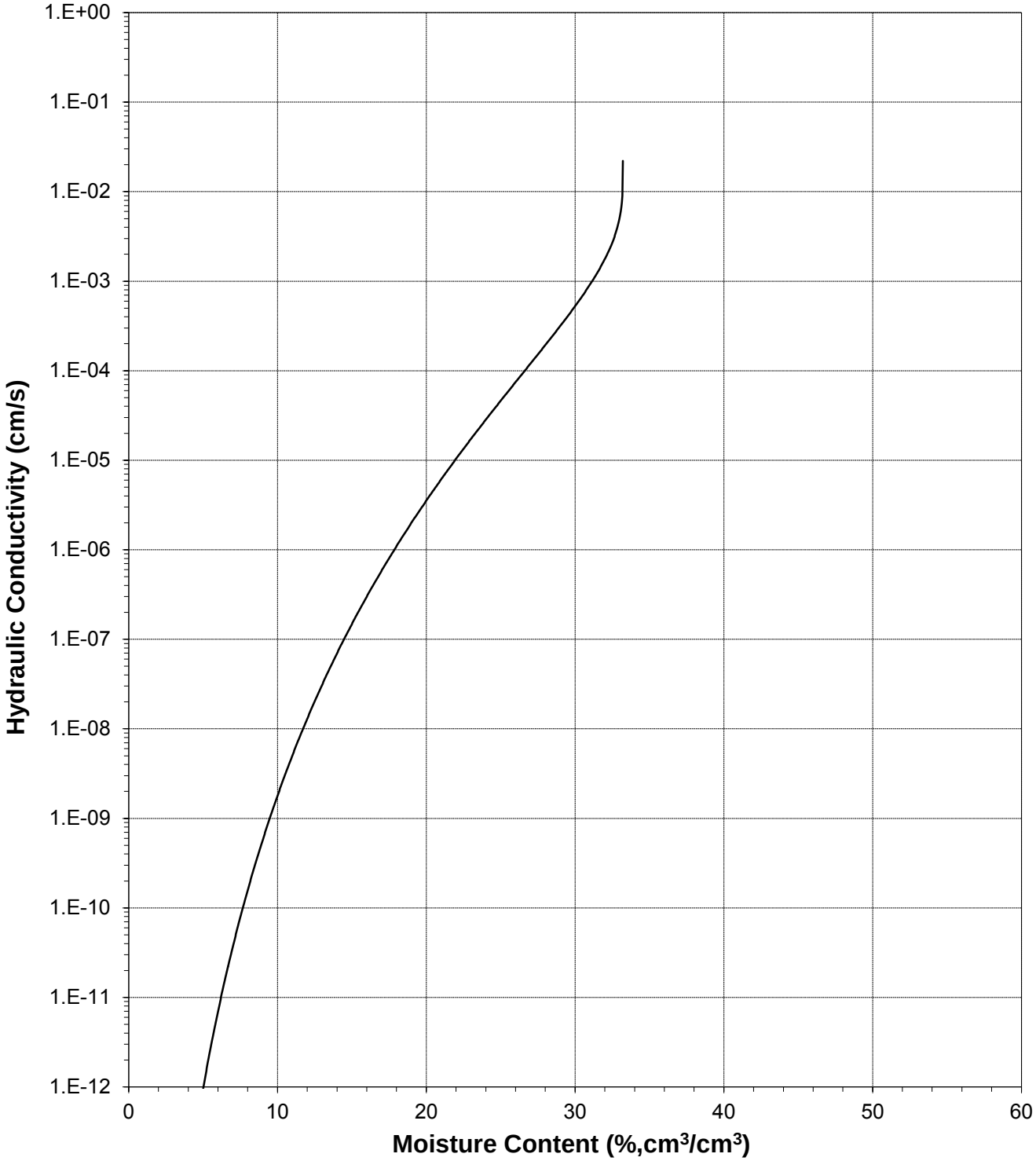
Plot of Relative Hydraulic Conductivity vs Moisture Content

Sample Number: MET-02 (1.75)



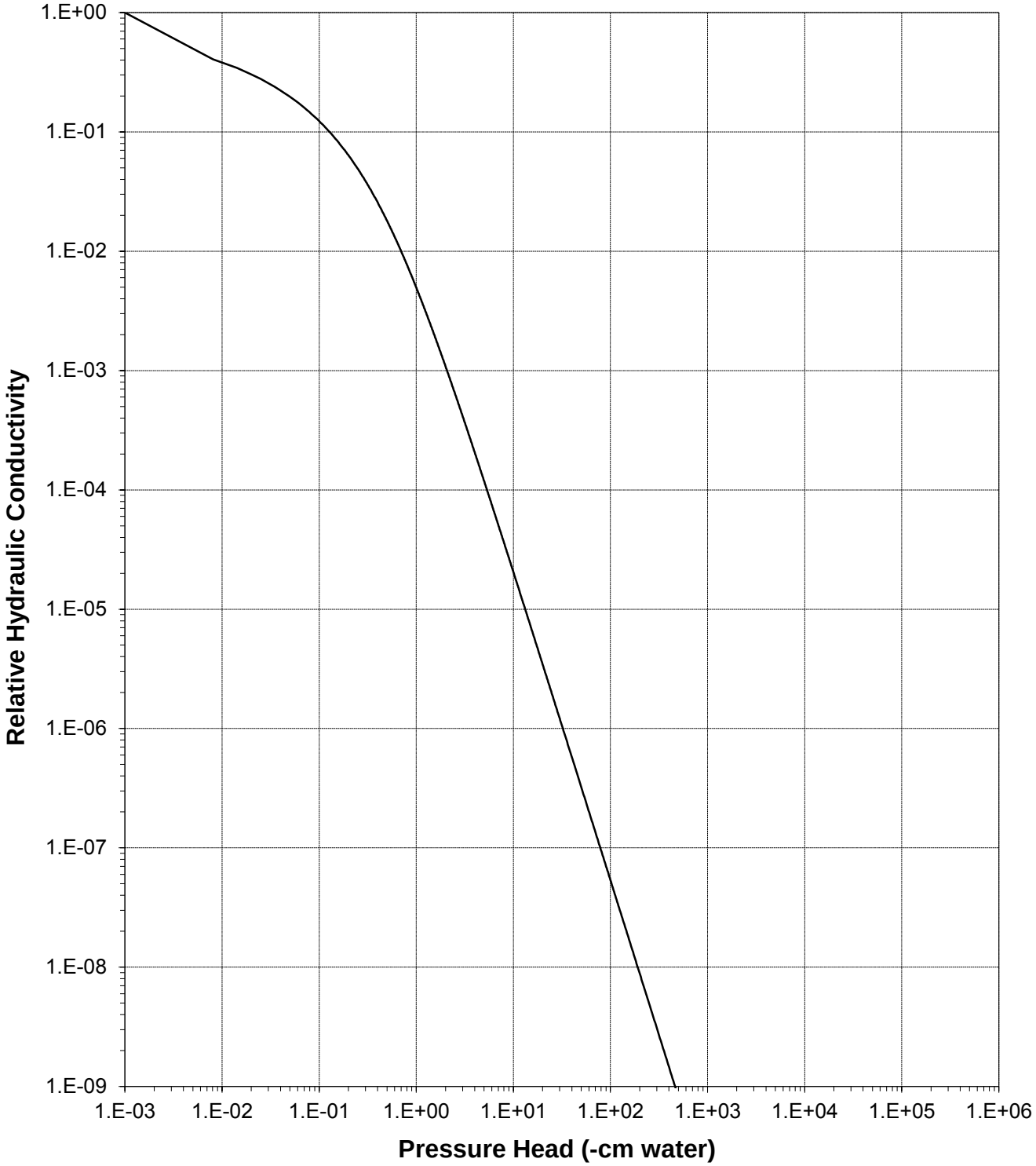
Plot of Hydraulic Conductivity vs Moisture Content

Sample Number: MET-02 (1.75)



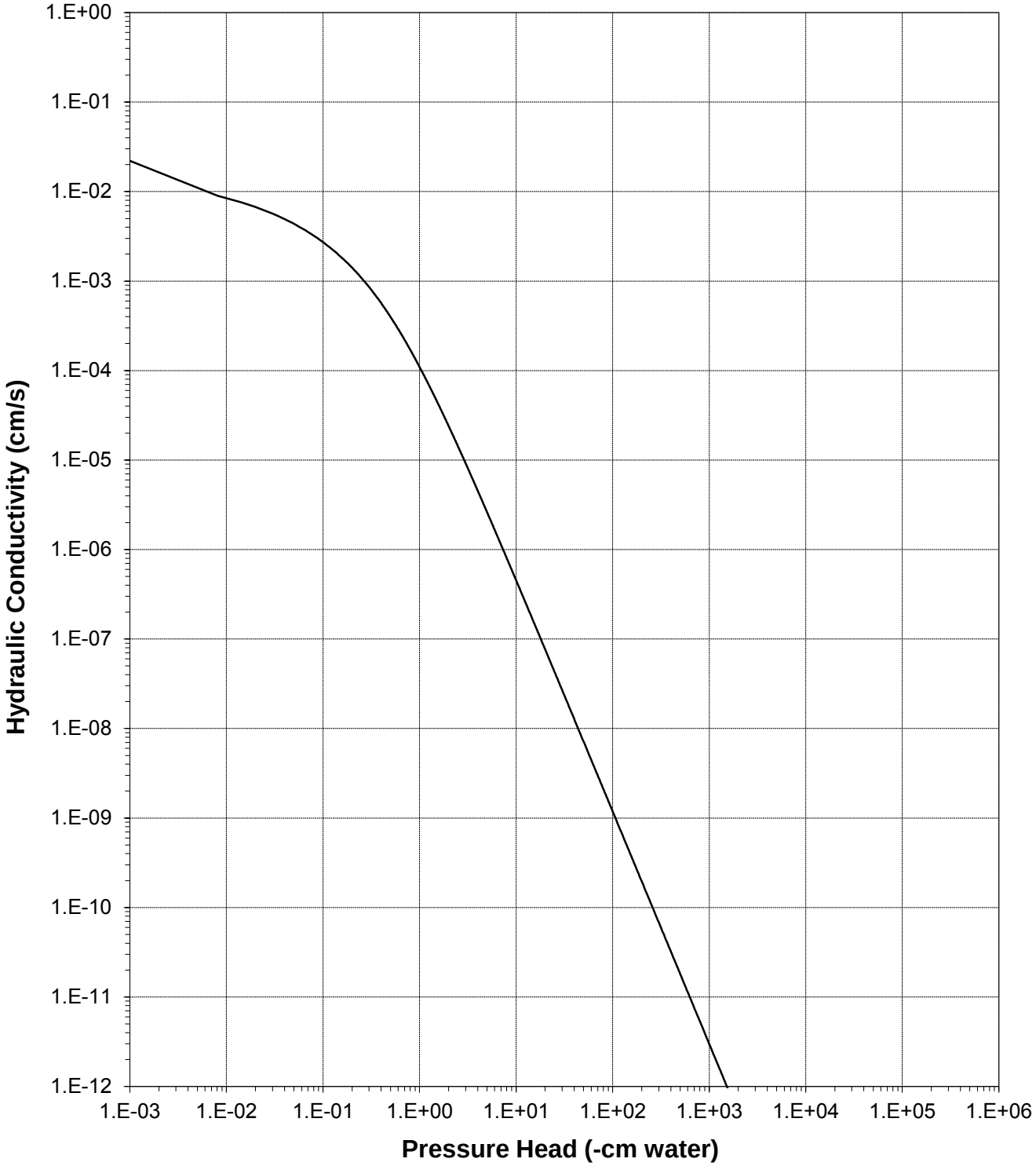
Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: MET-02 (1.75)



Plot of Hydraulic Conductivity vs Pressure Head

Sample Number: MET-02 (1.75)



Moisture Retention Data

Hanging Column / Pressure Plate

(Soil-Water Characteristic Curve)

Job Name: Knight Piesold
Job Number: LB13.0269.00
Sample Number: MET-02 (2.00)
Sample Tag ID: DV101-77/14 (L2013-101) (L2013-084)
Project: Casino, VA101-00325/16

Dry wt. of sample (g)*:* 23421.50
Tare wt., ring (g)*:* 2416.80
Tare wt., screen & clamp (g)*:* 180.50
Initial sample volume (cm^3)*:* 11709.07
Initial dry bulk density (g/cm^3)*:* 2.00
Assumed particle density (g/cm^3)*:* 2.65
Initial calculated total porosity (%)*:* 24.52

	Date	Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)
Hanging column:	21-Nov-13	15:40	28800.00	0	23.75
	13-Dec-13	15:00	28140.00	7.5	18.12
	17-Dec-13	12:45	27798.00	18.0	15.20
	20-Dec-13	14:30	27713.00	50.0	14.47
	2-Jan-14	13:00	27637.00	150.0	13.82

Volume Adjusted Data [1]

	Matric Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calculated Porosity (%)
Hanging column:	0.0	---	---	---	---
	7.5	---	---	---	---
	18.0	---	---	---	---
	50.0	---	---	---	---
	150.0	---	---	---	---

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent each of the volume change measurements obtained after saturated hydraulic conductivity testing and throughout hanging column/pressure plate testing. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Assumed density of water is 1.0 g/cm^3

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Technician Notes:

Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

Moisture Retention Data

Dew Point Potentiometer / Relative Humidity Box

(Soil-Water Characteristic Curve)

Sample Number: MET-02 (2.00)

Initial sample bulk density (g/cm^3)*:* 2.00

Fraction of test sample used (<2.00mm fraction) (%): 14.20

Dry weight of dew point potentiometer sample* (g)*:* 171.85

Tare weight, jar (g)*:* 113.46

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)
Dew point potentiometer:	31-Dec-13	12:30	174.09	19070	1.09
	18-Dec-13	15:30	173.05	139407	0.58
	18-Dec-13	13:50	172.75	614939	0.44

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Dew point potentiometer:	19070	---	---	---	---
	139407	---	---	---	---
	614939	---	---	---	---

Dry weight of relative humidity box sample* (g)*:* 91.80

Tare weight (g)*:* 41.63

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)
Relative humidity box:	20-Dec-13	15:30	92.45	845560	0.37

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Relative humidity box:	845560	---	---	---	---

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent the volume change measurements obtained after the last hanging column or pressure plate point. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

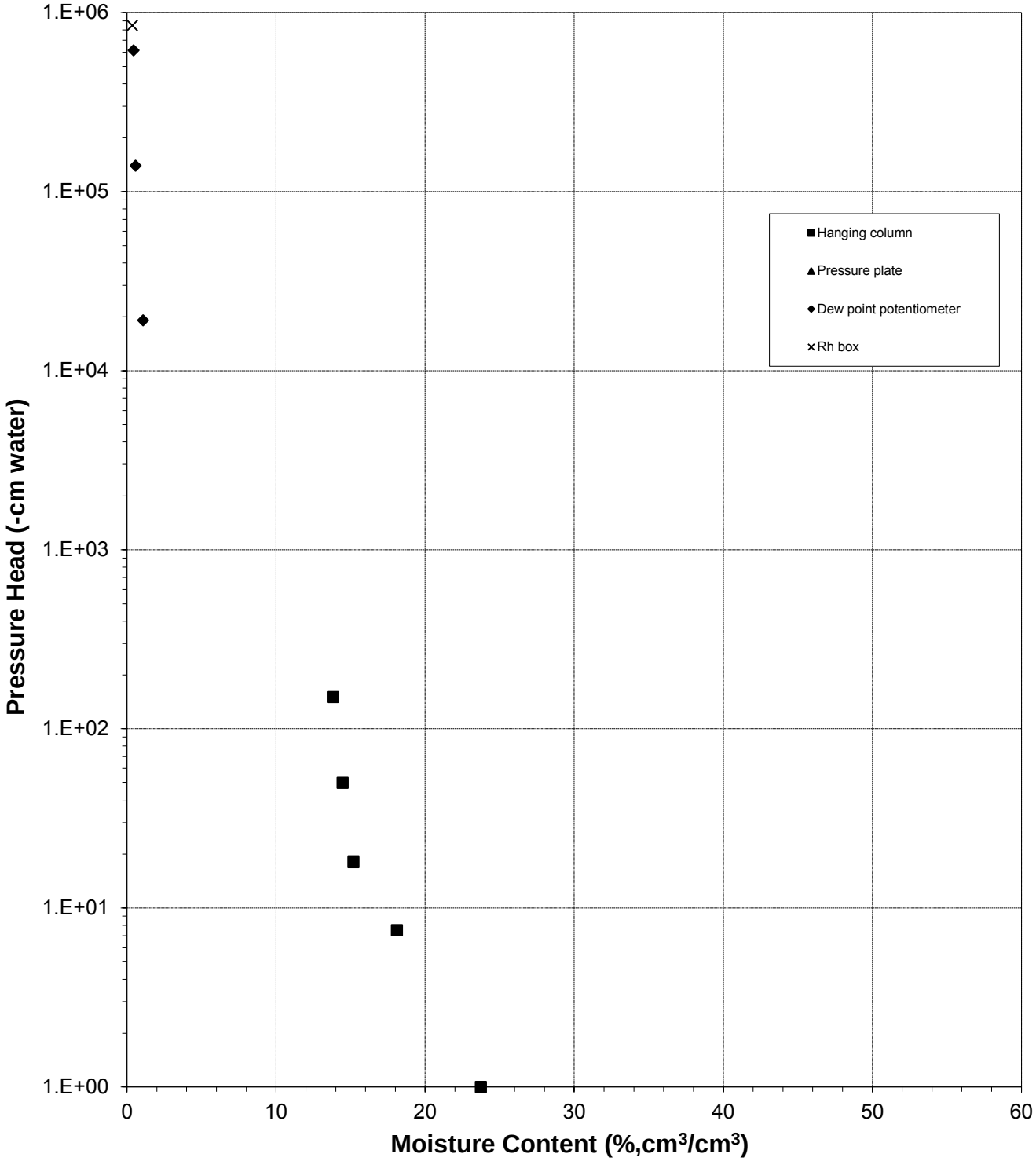
† Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm^3.

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

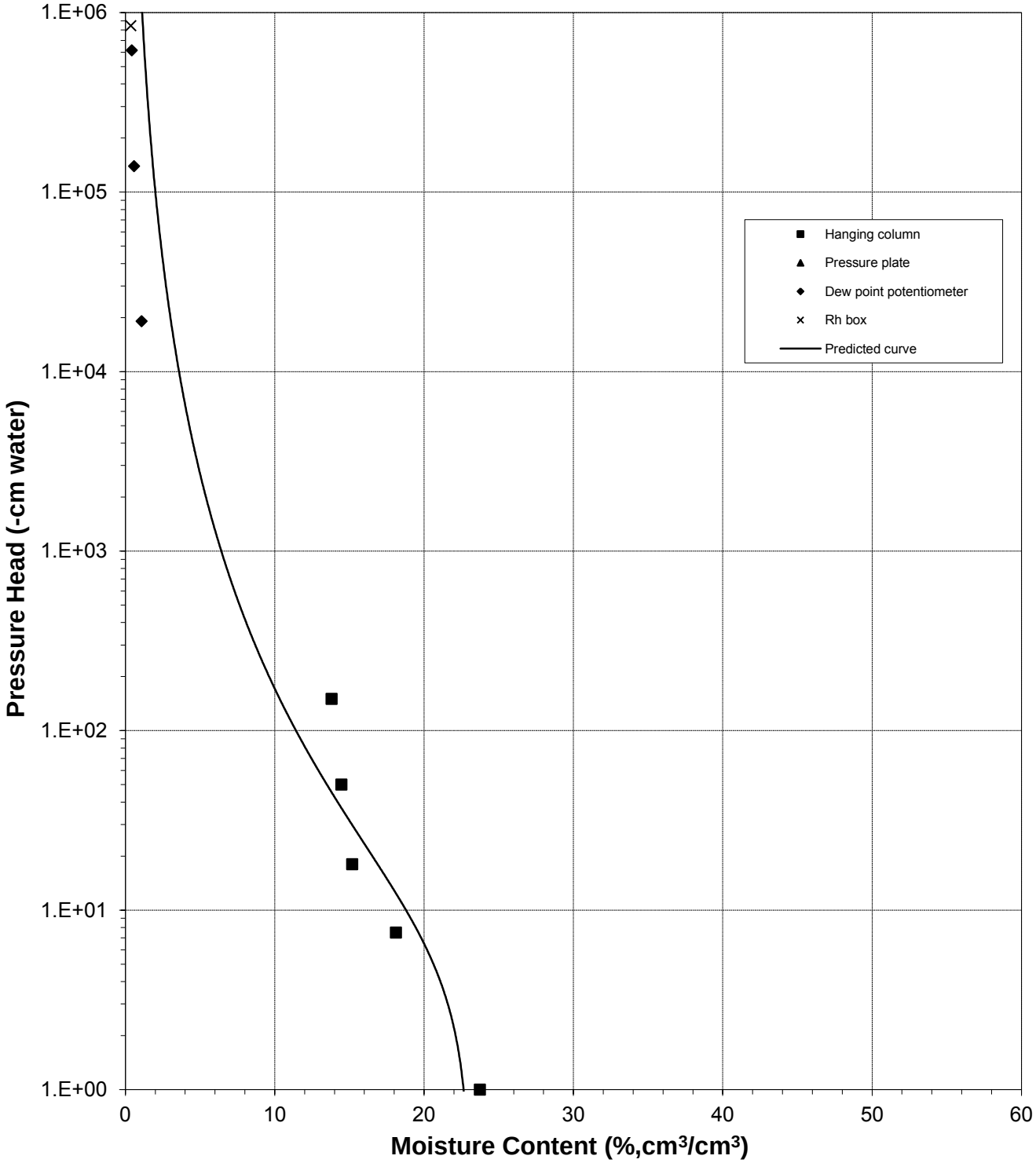
Water Retention Data Points

Sample Number: MET-02 (2.00)



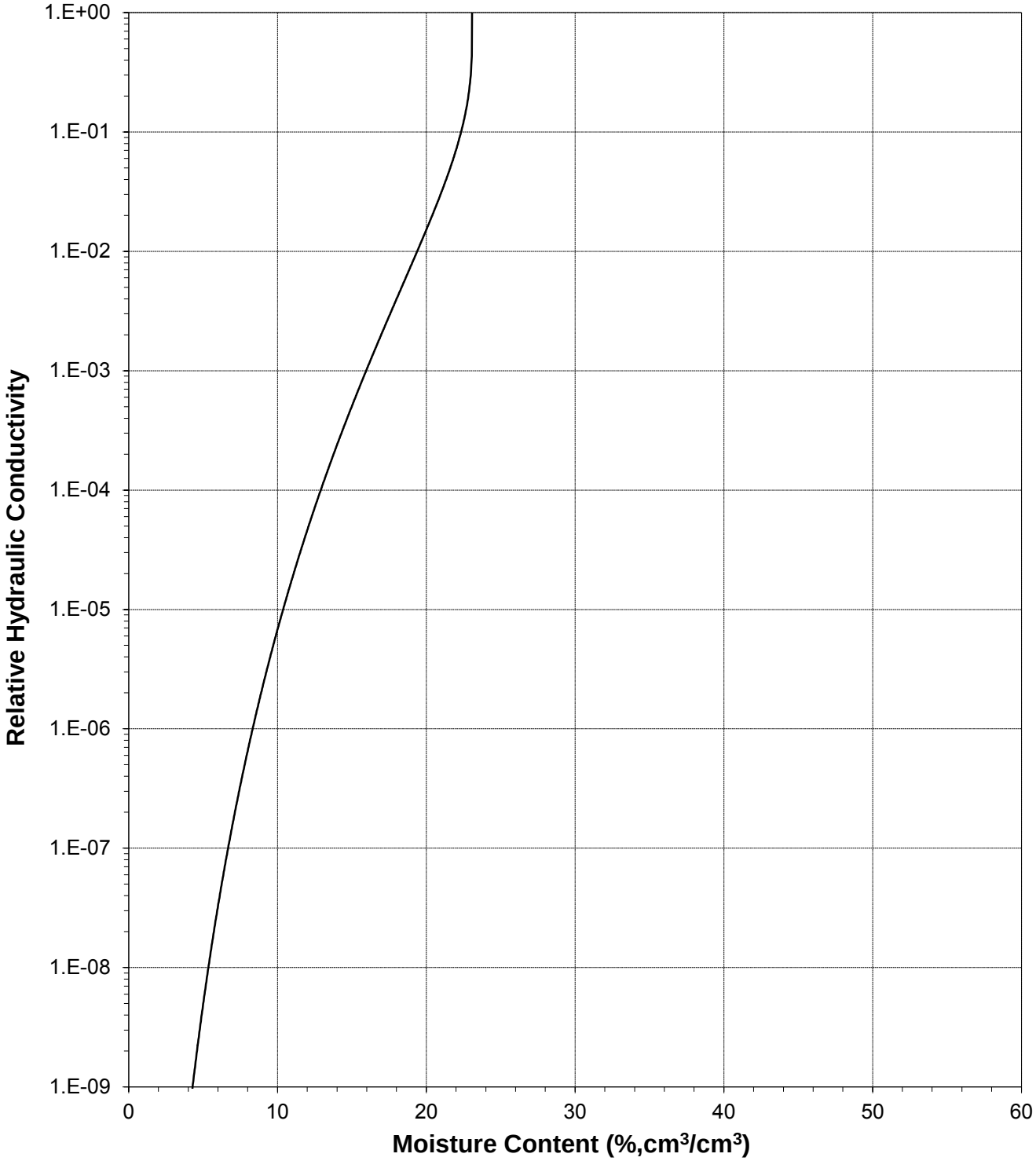
Predicted Water Retention Curve and Data Points

Sample Number: MET-02 (2.00)



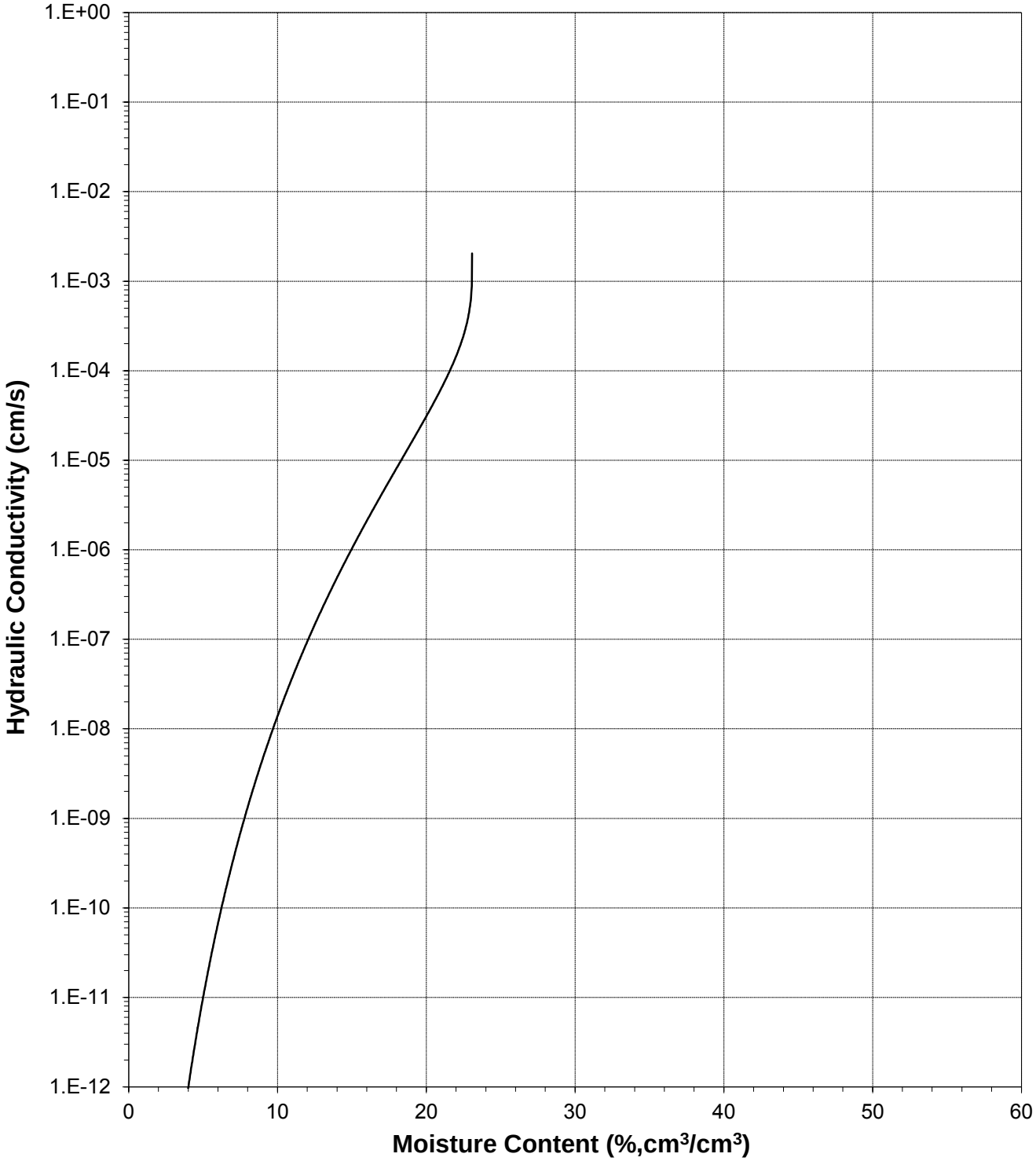
Plot of Relative Hydraulic Conductivity vs Moisture Content

Sample Number: MET-02 (2.00)



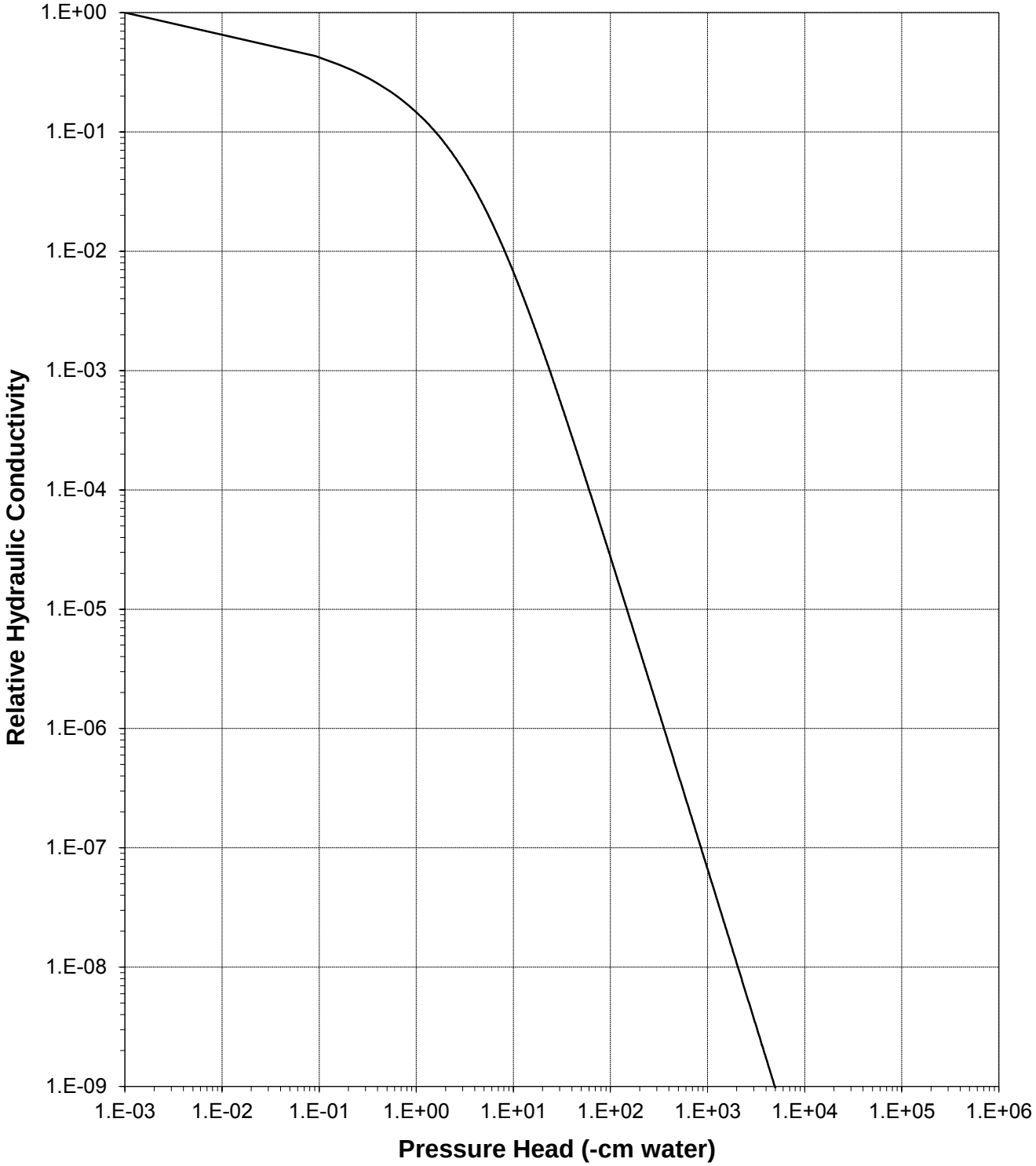
Plot of Hydraulic Conductivity vs Moisture Content

Sample Number: MET-02 (2.00)



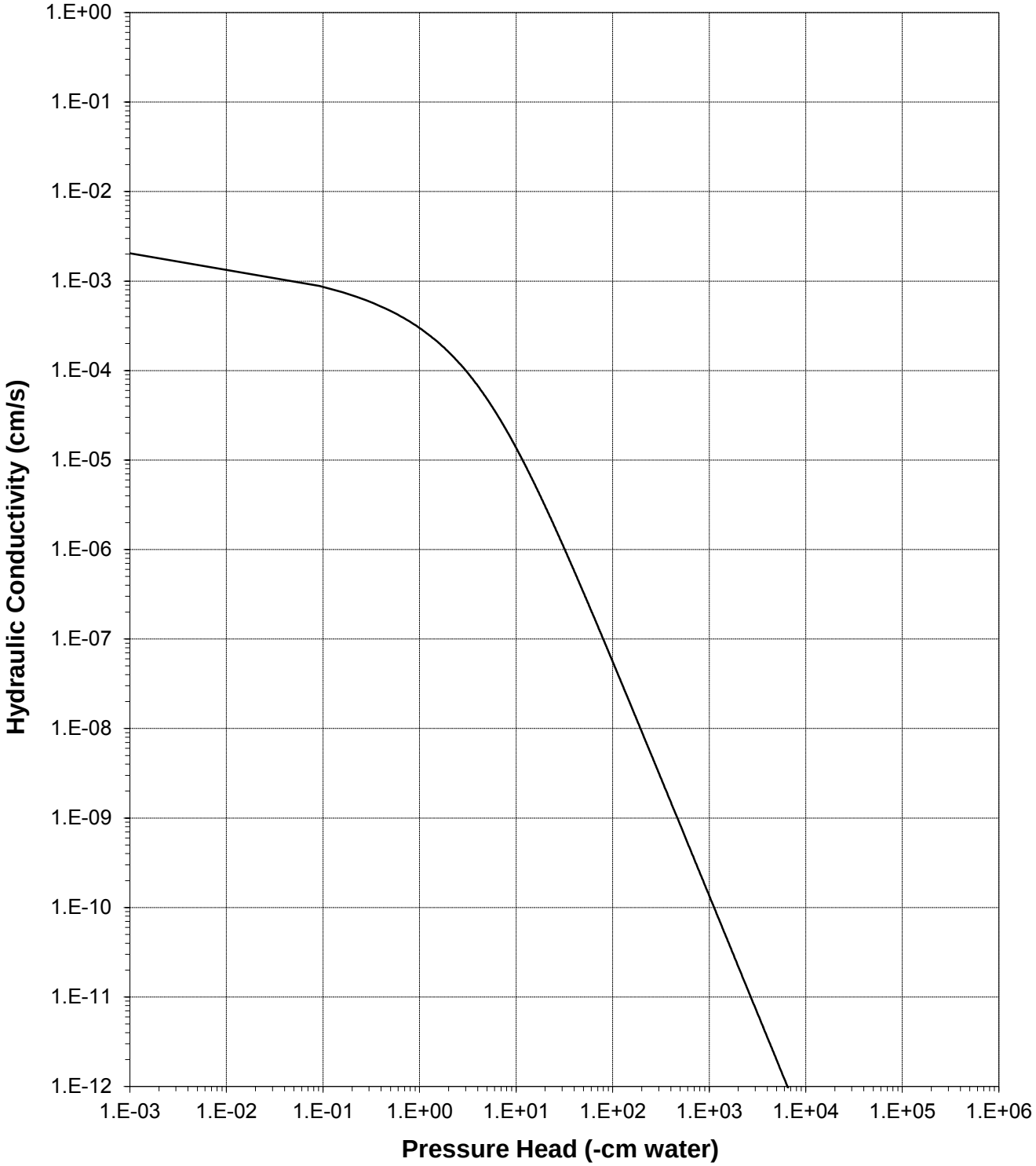
Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: MET-02 (2.00)



Plot of Hydraulic Conductivity vs Pressure Head

Sample Number: MET-02 (2.00)



Moisture Retention Data

Hanging Column / Pressure Plate

(Soil-Water Characteristic Curve)

Job Name: Knight Piesold
Job Number: LB13.0269.00
Sample Number: MET-05 (1.47)
Sample Tag ID: DV101-77/14 L2013-101
Project: Casino, VA101-00325/16

Dry wt. of sample (g)*:* 16204.00
Tare wt., ring (g)*:* 2325.24
Tare wt., screen & clamp (g)*:* 165.30
Initial sample volume (cm^3)*:* 11013.55
Initial dry bulk density (g/cm^3)*:* 1.47
Assumed particle density (g/cm^3)*:* 2.65
Initial calculated total porosity (%)*:* 44.48

	Date	Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content † (% vol)	
Hanging column:	21-Nov-13	16:20	22380.00	0	36.90	‡‡
	22-Nov-13	8:10	20519.00	7.5	18.27	‡‡
	26-Nov-13	7:45	20044.00	19.0	13.51	‡‡
	1-Dec-13	10:50	19984.00	49.5	12.91	‡‡
	10-Dec-13	13:00	19848.00	150.0	11.55	‡‡

Volume Adjusted Data [1]

	Matric Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calculated Porosity (%)
Hanging column:	0.0	9988.06	-9.31%	1.62	38.78
	7.5	9988.06	-9.31%	1.62	38.78
	19.0	9988.06	-9.31%	1.62	38.78
	49.5	9988.06	-9.31%	1.62	38.78
	150.0	9988.06	-9.31%	1.62	38.78

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent each of the volume change measurements obtained after saturated hydraulic conductivity testing and throughout hanging column/pressure plate testing. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Assumed density of water is 1.0 g/cm^3

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Technician Notes:

Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

Moisture Retention Data

Dew Point Potentiometer / Relative Humidity Box

(Soil-Water Characteristic Curve)

Sample Number: MET-05 (1.47)

Initial sample bulk density (g/cm^3)*:* 1.47

Fraction of test sample used (<2.00mm fraction) (%): 35.40

Dry weight of dew point potentiometer sample* (g)*:* 174.79

Tare weight, jar (g)*:* 112.70

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)	
Dew point potentiometer:	31-Dec-13	14:00	176.44	15807	1.53	‡‡
	23-Dec-13	16:53	175.66	44871	0.80	‡‡
	23-Dec-13	16:00	175.19	231393	0.37	‡‡

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Dew point potentiometer:	15807	9988.06	-9.31%	1.62	38.78
	44871	9988.06	-9.31%	1.62	38.78
	231393	9988.06	-9.31%	1.62	38.78

Dry weight of relative humidity box sample* (g)*:* 99.08

Tare weight (g)*:* 38.03

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)	
Relative humidity box:	20-Dec-13	15:30	99.32	845560	0.23	‡‡

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Relative humidity box:	845560	9988.06	-9.31%	1.62	38.78

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent the volume change measurements obtained after the last hanging column or pressure plate point. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

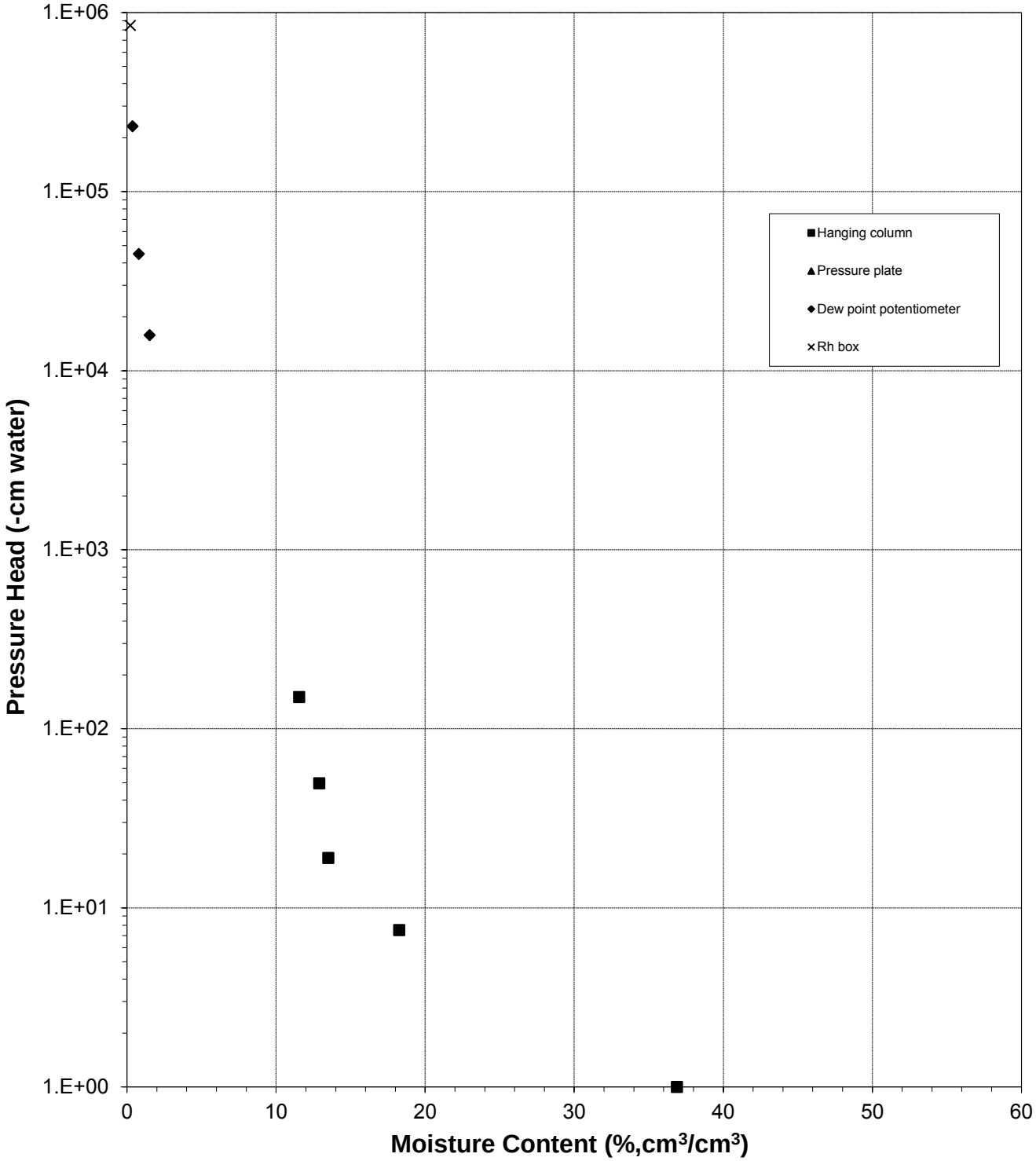
† Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm^3.

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

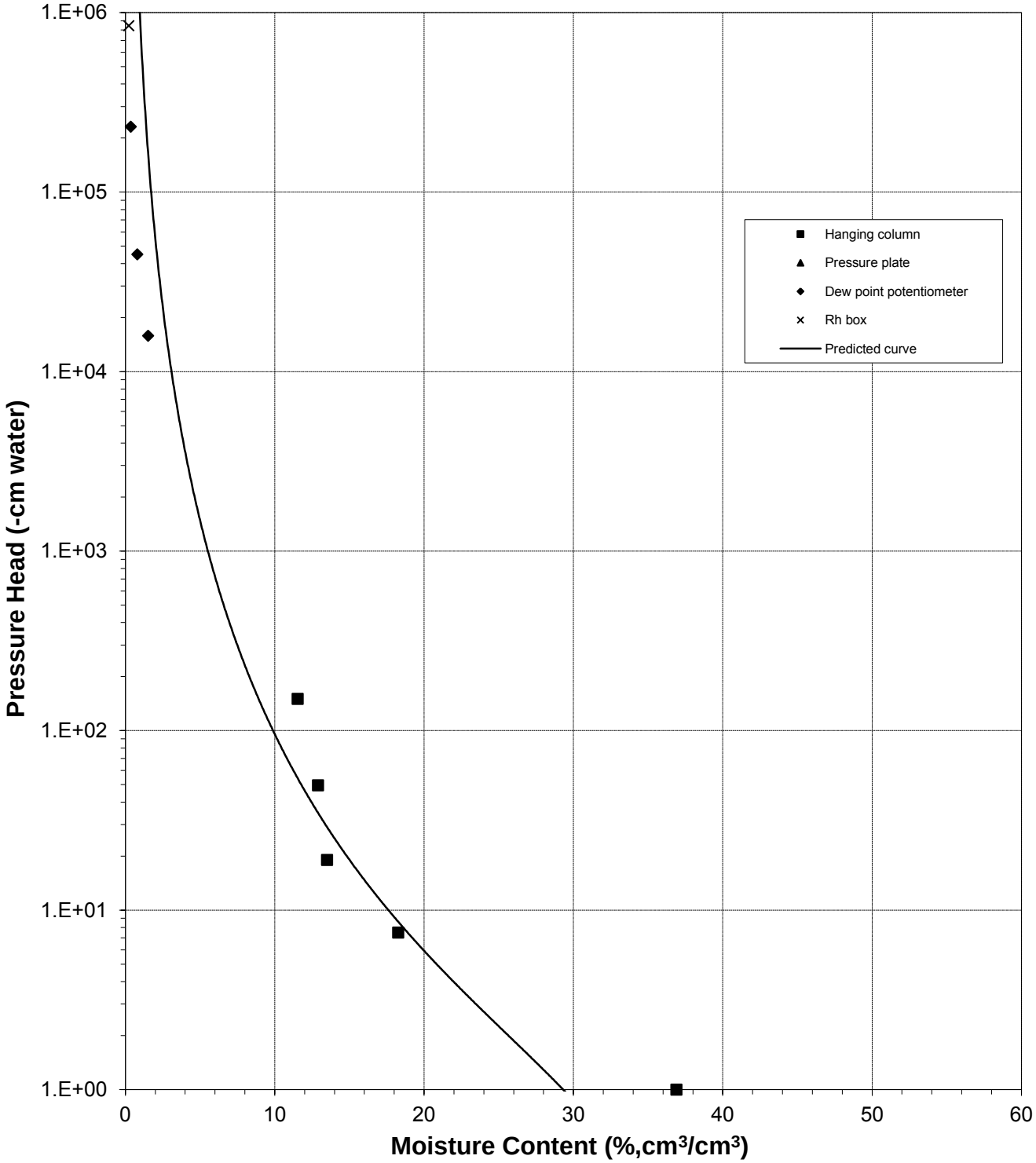
Water Retention Data Points

Sample Number: MET-05 (1.47)



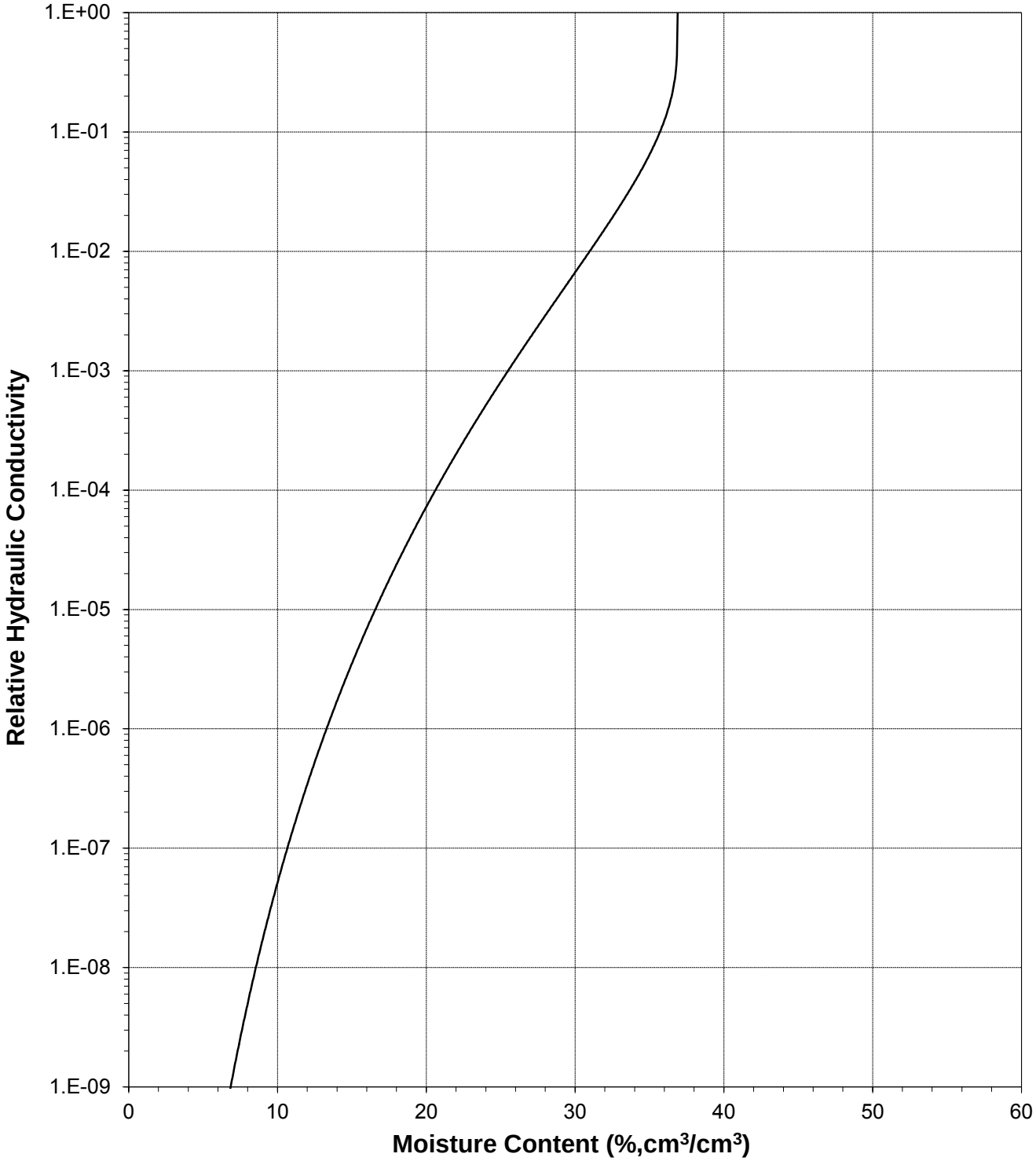
Predicted Water Retention Curve and Data Points

Sample Number: MET-05 (1.47)



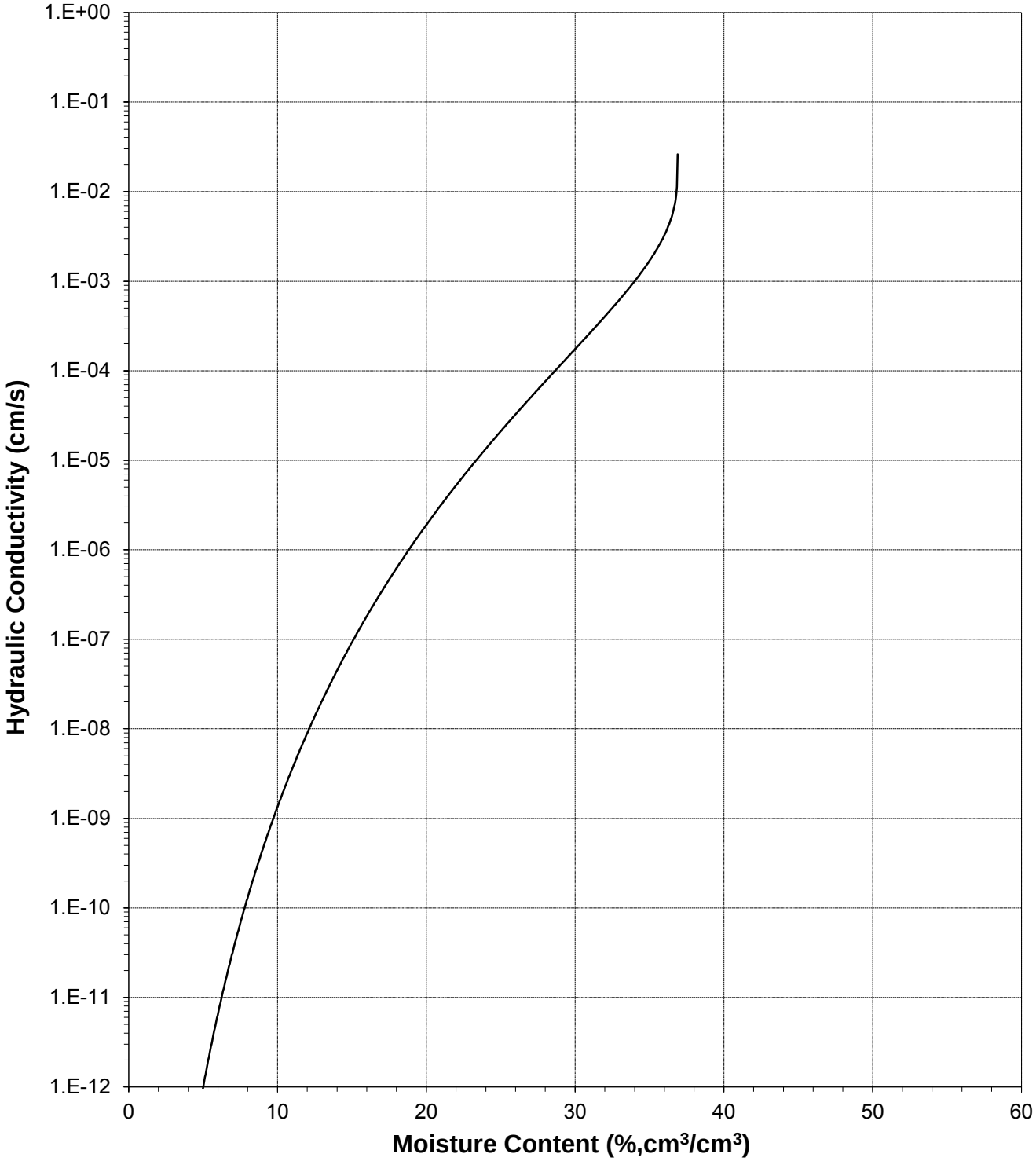
Plot of Relative Hydraulic Conductivity vs Moisture Content

Sample Number: MET-05 (1.47)



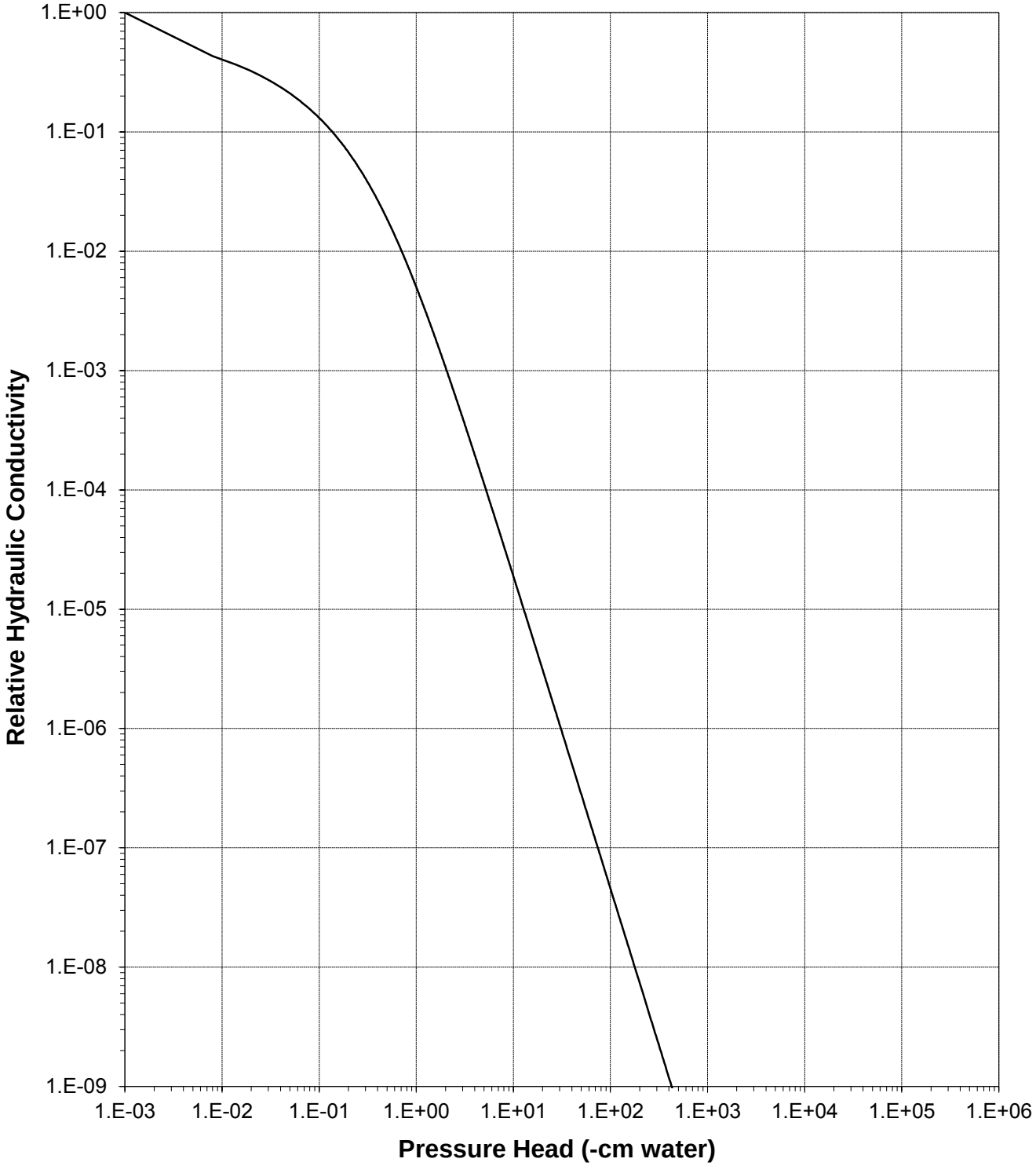
Plot of Hydraulic Conductivity vs Moisture Content

Sample Number: MET-05 (1.47)



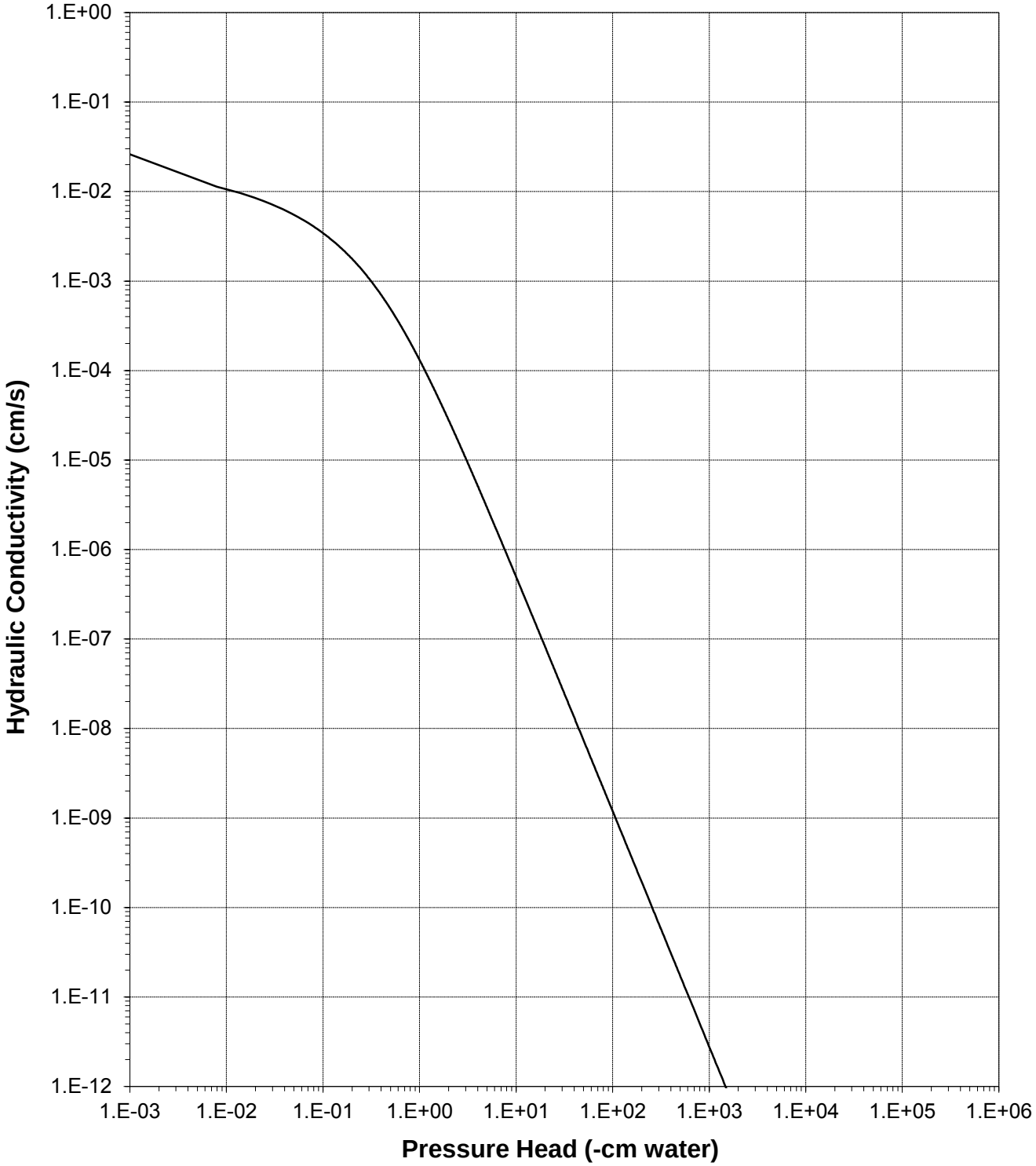
Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: MET-05 (1.47)



Plot of Hydraulic Conductivity vs Pressure Head

Sample Number: MET-05 (1.47)



Moisture Retention Data

Hanging Column / Pressure Plate

(Soil-Water Characteristic Curve)

Job Name: Knight Piesold
Job Number: LB13.0269.00
Sample Number: MET-05 (1.79)
Sample Tag ID: DV101-77/14 L2013-101
Project: Casino, VA101-00325/16

Dry wt. of sample (g)*:* 19686.30
Tare wt., ring (g)*:* 2234.70
Tare wt., screen & clamp (g)*:* 179.33
Initial sample volume (cm^3)*:* 11012.39
Initial dry bulk density (g/cm^3)*:* 1.79
Assumed particle density (g/cm^3)*:* 2.65
Initial calculated total porosity (%)*:* 32.54

	Date	Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content † (% vol)
Hanging column:	21-Nov-13	17:00	25640.00	0	32.14
	22-Nov-13	8:10	24433.00	7.5	21.18
	26-Nov-13	7:45	23794.00	17.5	15.38
	1-Dec-13	10:45	23527.00	48.0	12.96
	10-Dec-13	13:00	23408.00	150.0	11.87

Volume Adjusted Data [1]

	Matric Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calculated Porosity (%)
Hanging column:	0.0	---	---	---	---
	7.5	---	---	---	---
	17.5	---	---	---	---
	48.0	---	---	---	---
	150.0	---	---	---	---

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent each of the volume change measurements obtained after saturated hydraulic conductivity testing and throughout hanging column/pressure plate testing. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Assumed density of water is 1.0 g/cm^3

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Technician Notes:

Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

Moisture Retention Data

Dew Point Potentiometer / Relative Humidity Box

(Soil-Water Characteristic Curve)

Sample Number: MET-05 (1.79)

Initial sample bulk density (g/cm^3)*:* 1.79

Fraction of test sample used (<2.00mm fraction) (%): 35.40

Dry weight of dew point potentiometer sample* (g)*:* 175.15

Tare weight, jar (g)*:* 117.03

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)
Dew point potentiometer:	31-Dec-13	12:55	176.90	13563	1.91
	23-Dec-13	16:44	176.22	30900	1.17
	23-Dec-13	15:50	175.65	102898	0.54

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Dew point potentiometer:	13563	---	---	---	---
	30900	---	---	---	---
	102898	---	---	---	---

Dry weight of relative humidity box sample* (g)*:* 85.50

Tare weight (g)*:* 38.83

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)
Relative humidity box:	20-Dec-13	15:30	85.67	845560	0.24

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Relative humidity box:	845560	---	---	---	---

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent the volume change measurements obtained after the last hanging column or pressure plate point. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

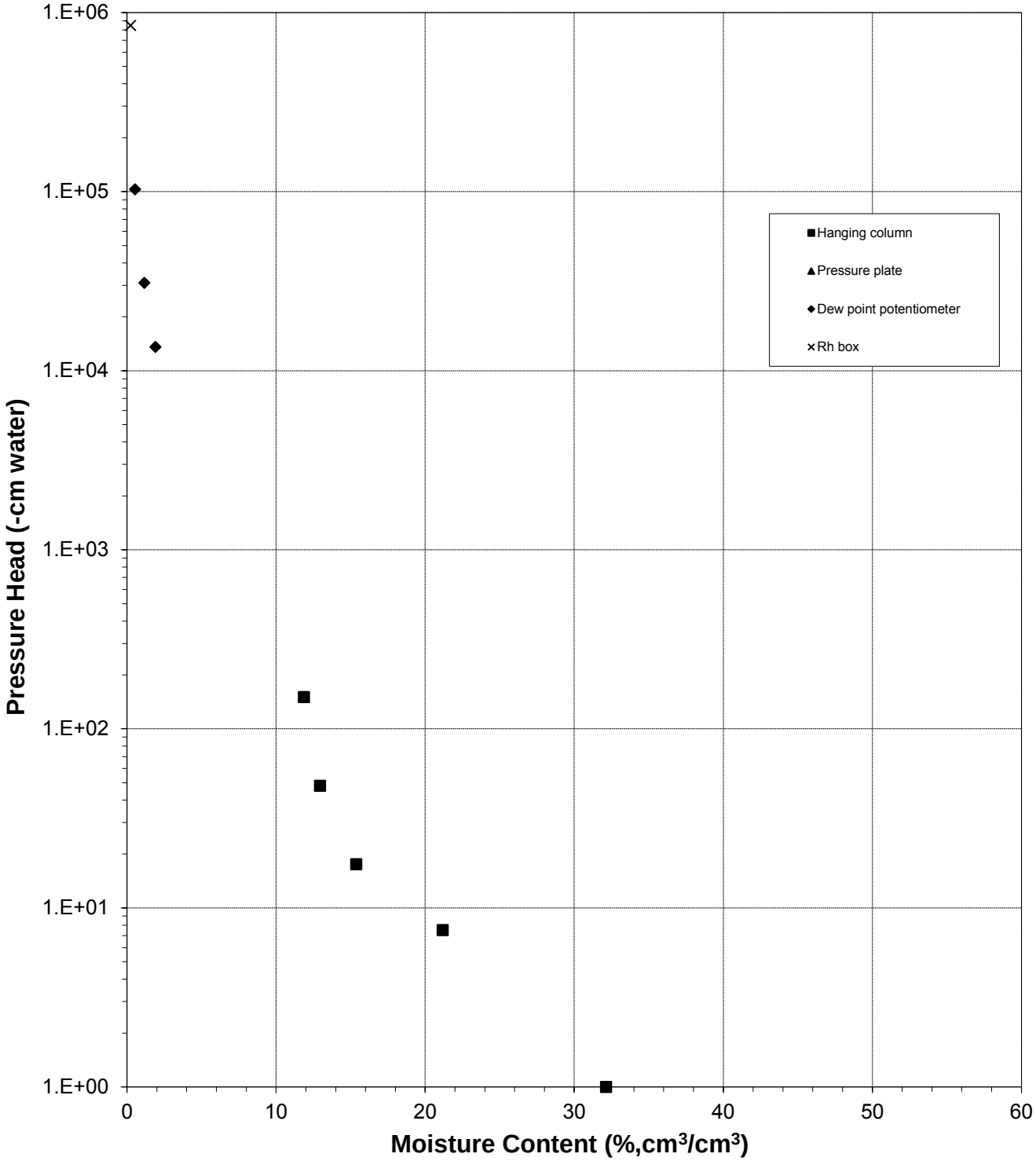
† Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm^3.

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

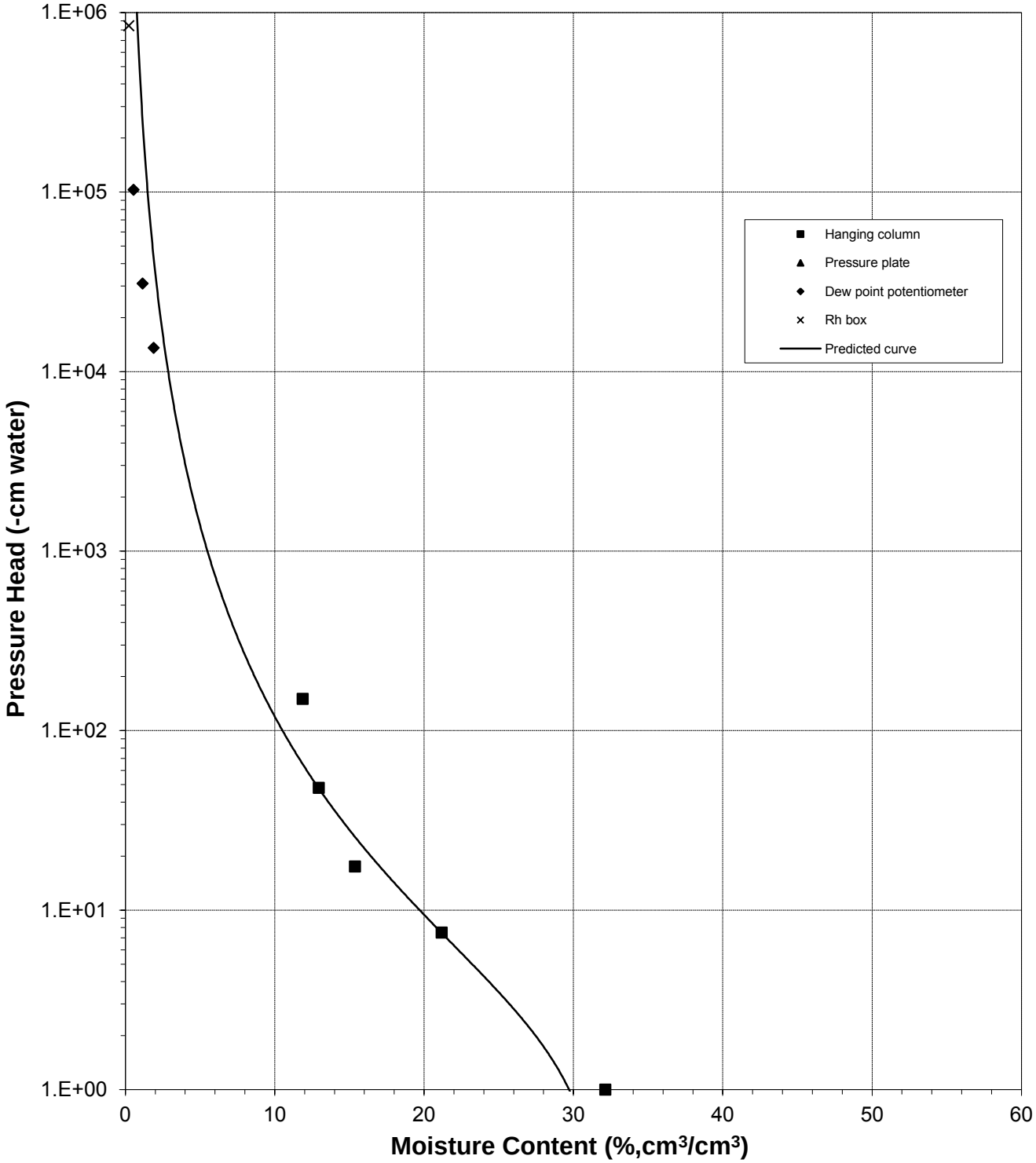
Water Retention Data Points

Sample Number: MET-05 (1.79)



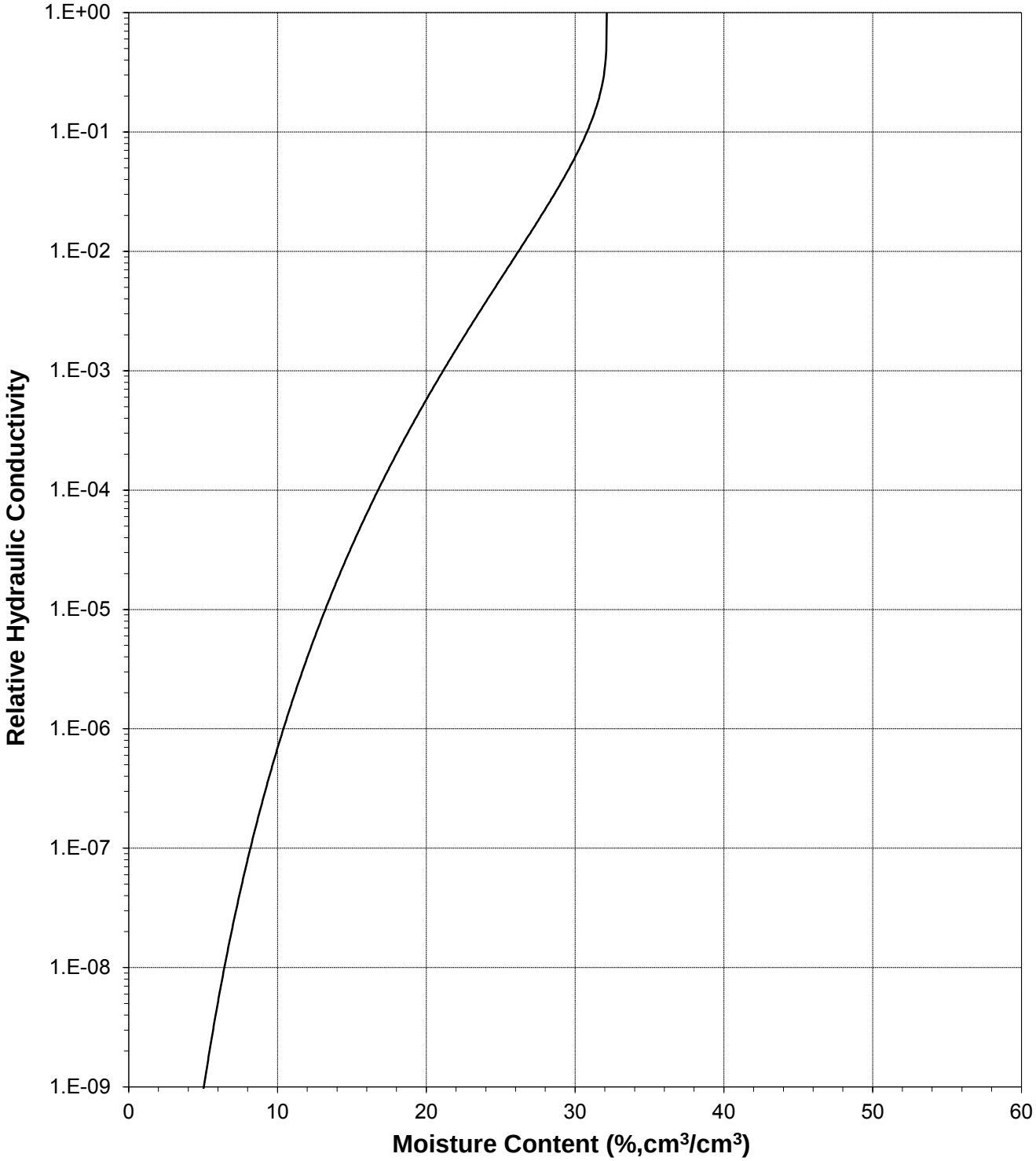
Predicted Water Retention Curve and Data Points

Sample Number: MET-05 (1.79)



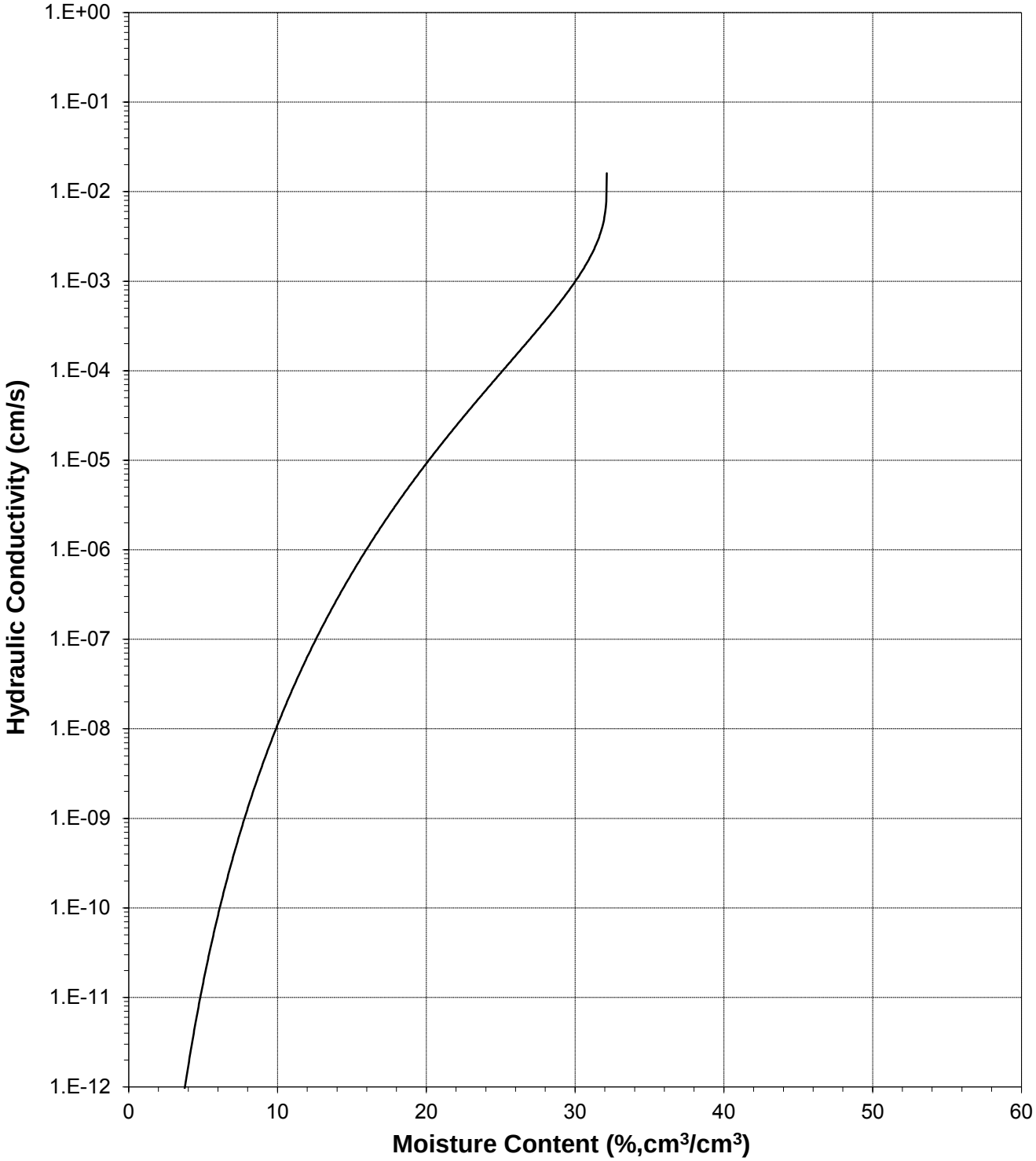
Plot of Relative Hydraulic Conductivity vs Moisture Content

Sample Number: MET-05 (1.79)



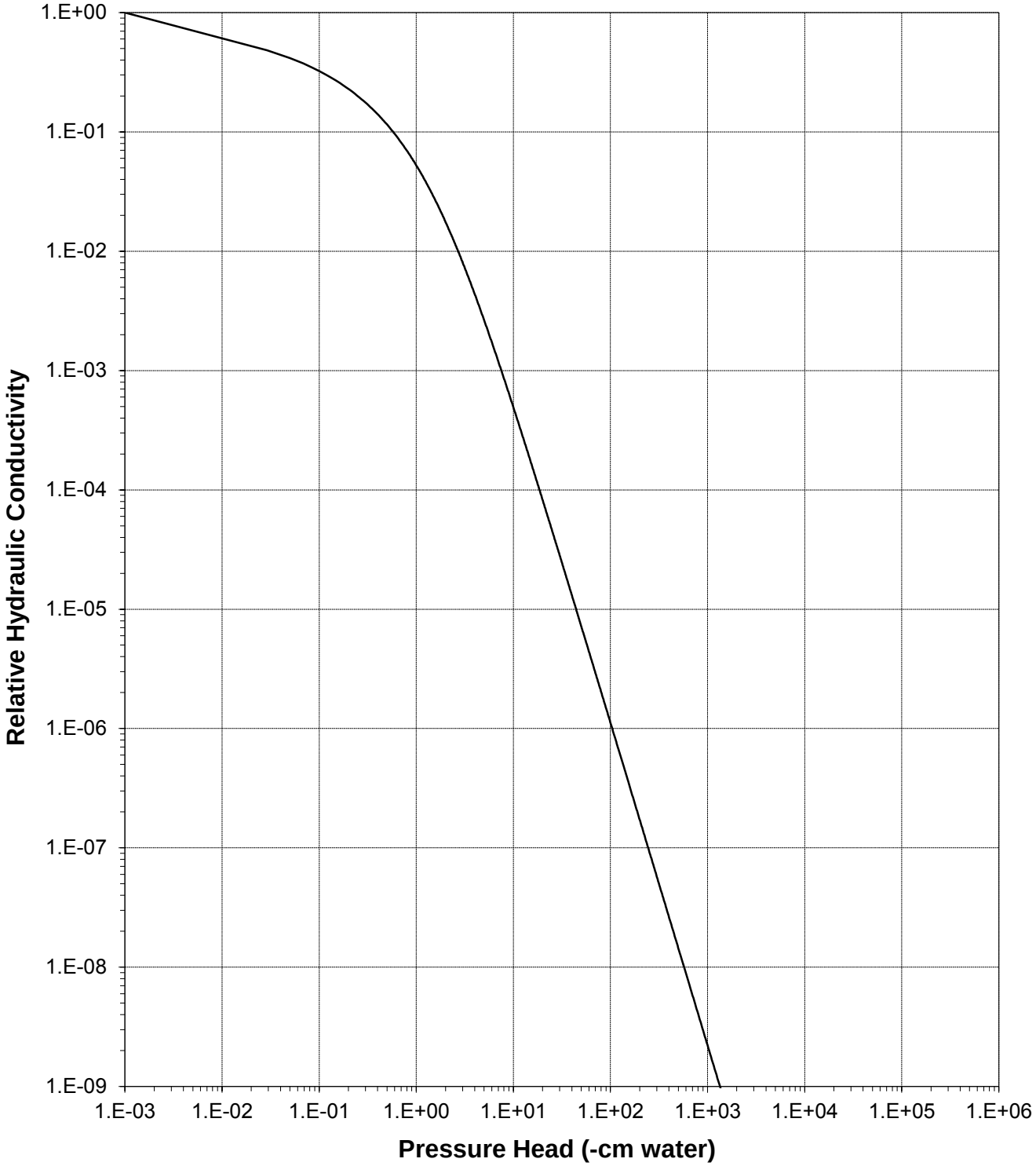
Plot of Hydraulic Conductivity vs Moisture Content

Sample Number: MET-05 (1.79)



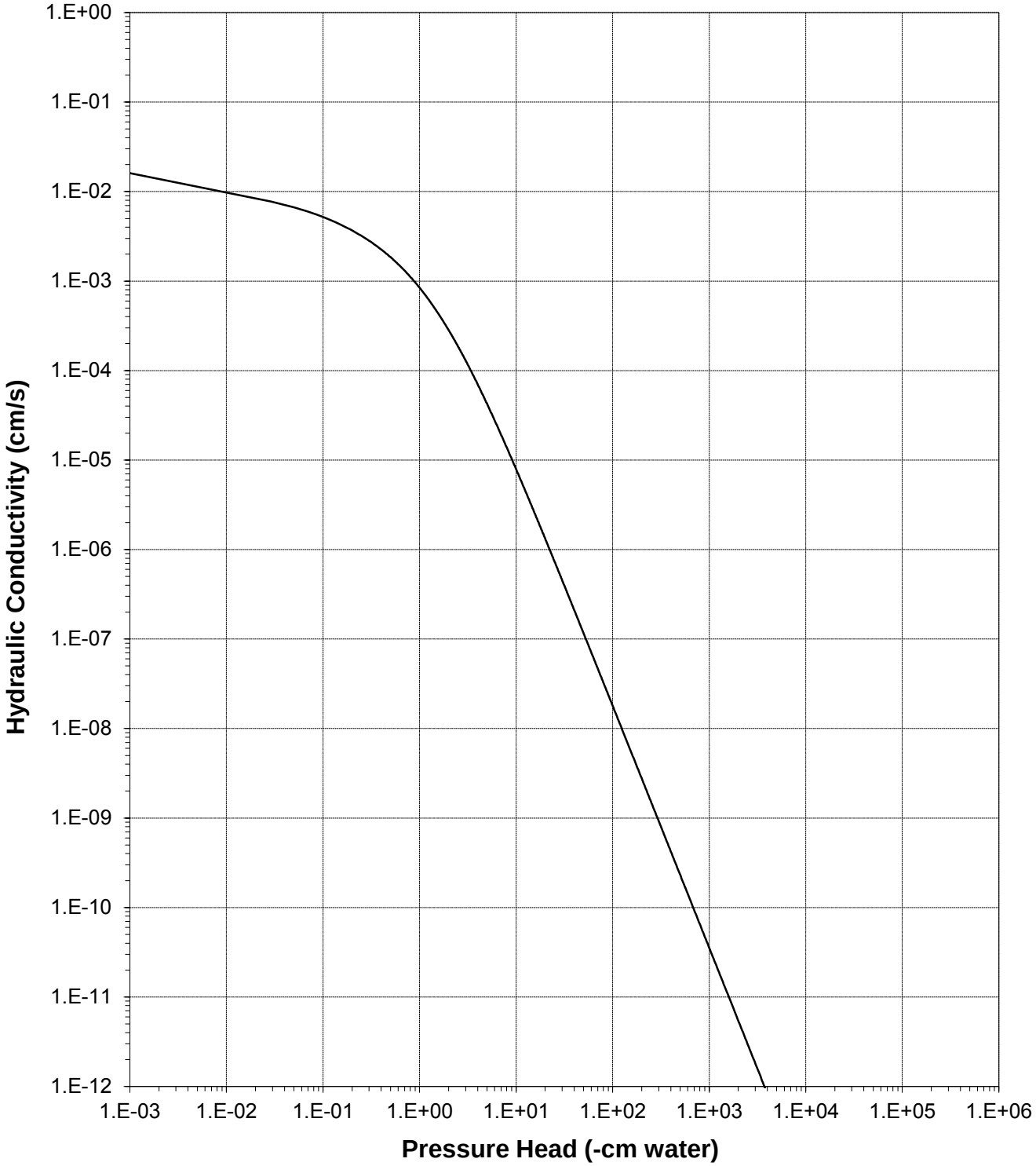
Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: MET-05 (1.79)



Plot of Hydraulic Conductivity vs Pressure Head

Sample Number: MET-05 (1.79)



Moisture Retention Data

Hanging Column / Pressure Plate

(Soil-Water Characteristic Curve)

Job Name: Knight Piesold
Job Number: LB13.0269.00
Sample Number: MET-11 (1.66)
Sample Tag ID: DV101-77/14
Project: Casino, VA101-00325/16

Dry wt. of sample (g)*:* 18031.98
Tare wt., ring (g)*:* 2291.76
Tare wt., screen & clamp (g)*:* 180.50
Initial sample volume (cm^3)*:* 10871.77
Initial dry bulk density (g/cm^3)*:* 1.66
Assumed particle density (g/cm^3)*:* 2.65
Initial calculated total porosity (%)*:* 37.41

	Date	Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content † (% vol)
Hanging column:	16-Dec-13	13:00	24590.00	0	37.58
	18-Dec-13	10:00	21238.00	7.5	6.75
	21-Dec-13	11:03	21129.00	18.5	5.75
	28-Dec-13	13:08	21101.00	50.0	5.49
	2-Jan-14	13:00	21029.00	150.0	4.83

Volume Adjusted Data [1]

	Matric Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calculated Porosity (%)
Hanging column:	0.0	---	---	---	---
	7.5	---	---	---	---
	18.5	---	---	---	---
	50.0	---	---	---	---
	150.0	---	---	---	---

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent each of the volume change measurements obtained after saturated hydraulic conductivity testing and throughout hanging column/pressure plate testing. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Assumed density of water is 1.0 g/cm^3

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Technician Notes:

Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

Moisture Retention Data

Dew Point Potentiometer / Relative Humidity Box

(Soil-Water Characteristic Curve)

Sample Number: MET-11 (1.66)

Initial sample bulk density (g/cm^3)*:* 1.66

Fraction of test sample used (<2.00mm fraction) (%): 8.90

Dry weight of dew point potentiometer sample* (g)*:* 176.32

Tare weight, jar (g)*:* 112.76

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)
Dew point potentiometer:	31-Dec-13	12:00	178.25	25495	0.45
	23-Dec-13	13:26	177.47	88009	0.27
	18-Dec-13	15:00	177.06	372125	0.17

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Dew point potentiometer:	25495	---	---	---	---
	88009	---	---	---	---
	372125	---	---	---	---

Dry weight of relative humidity box sample* (g)*:* 93.01

Tare weight (g)*:* 39.42

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)
Relative humidity box:	20-Dec-13	15:30	93.41	845560	0.11

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Relative humidity box:	845560	---	---	---	---

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent the volume change measurements obtained after the last hanging column or pressure plate point. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

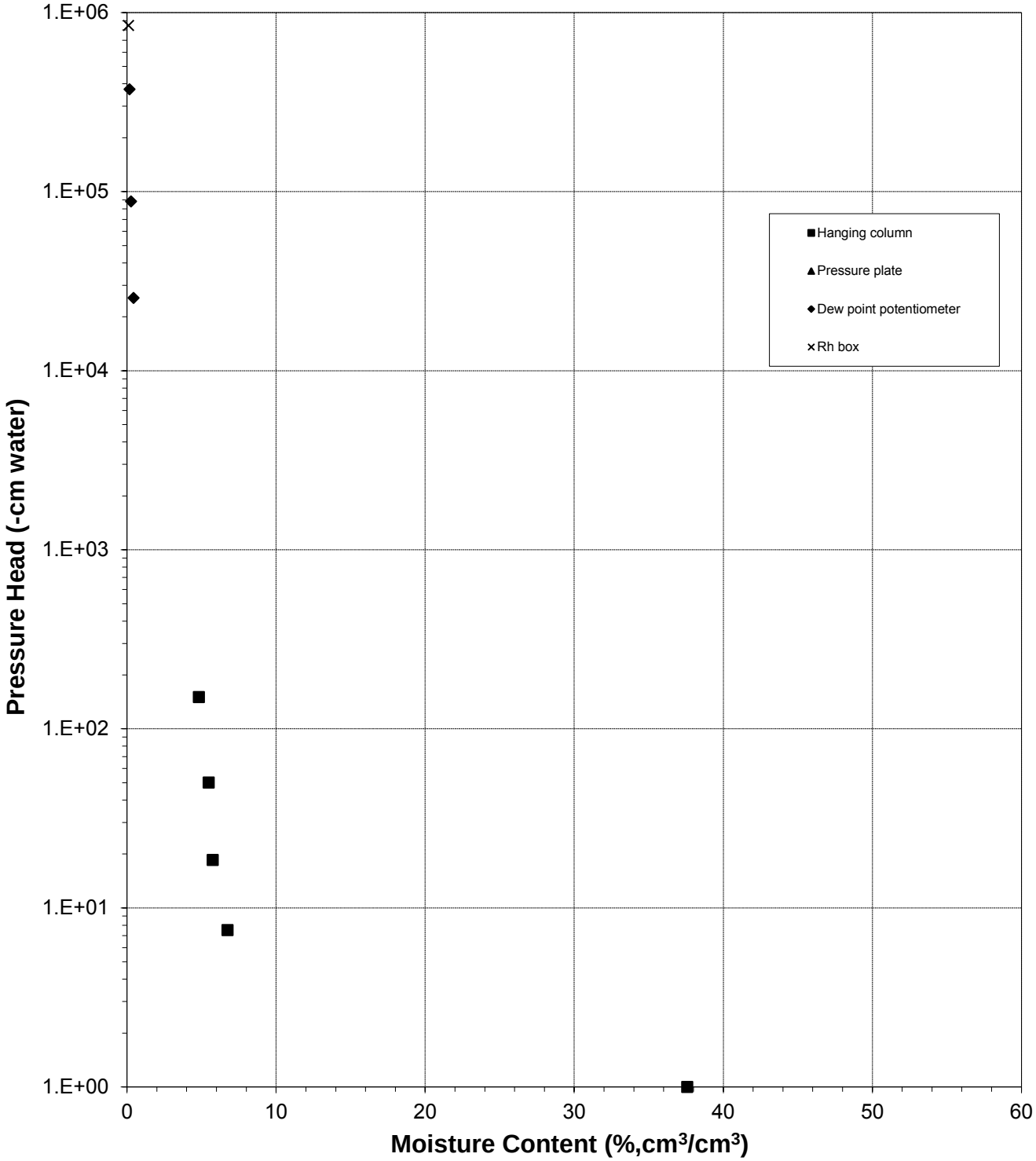
† Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm^3.

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

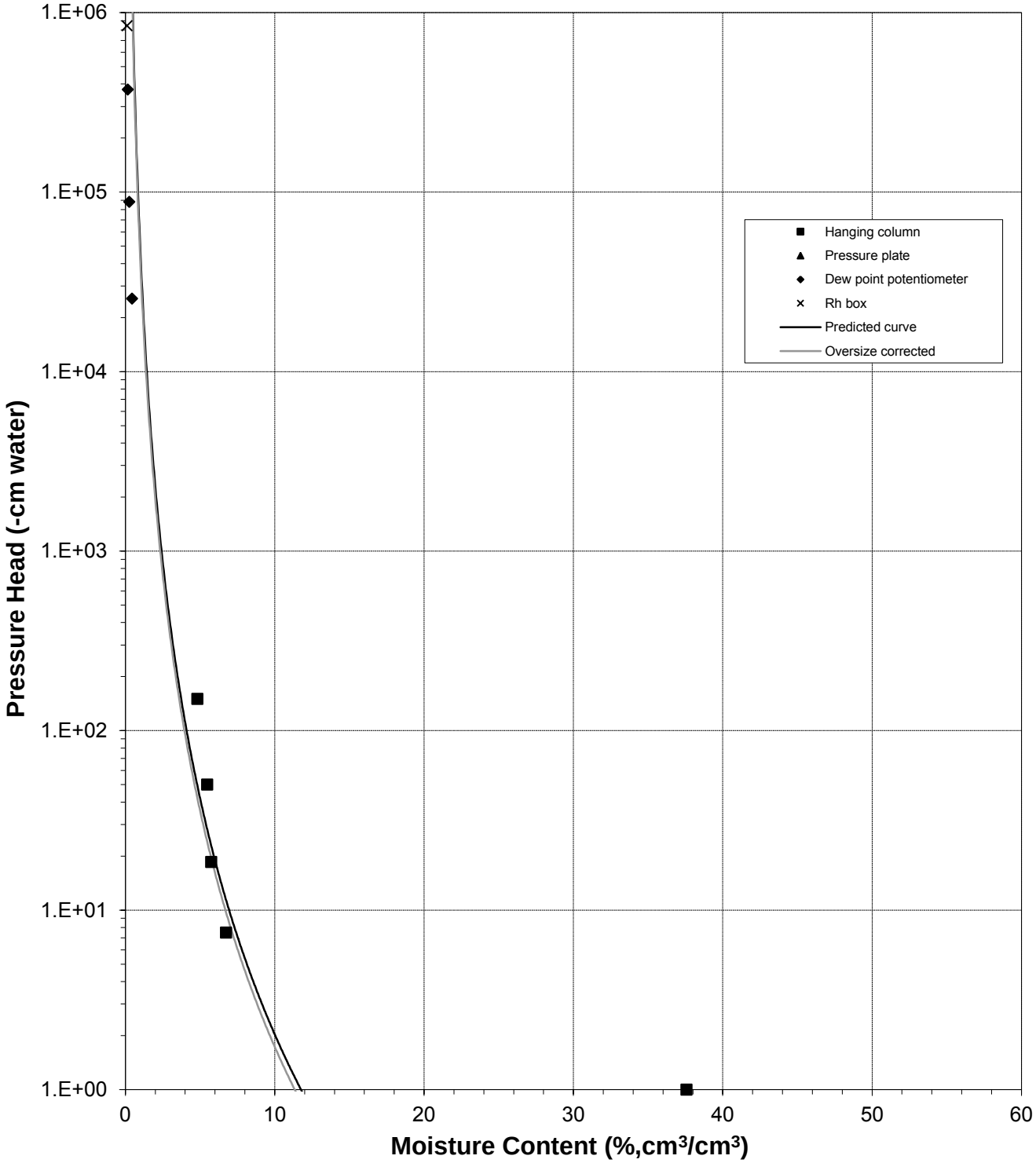
Water Retention Data Points

Sample Number: MET-11 (1.66)



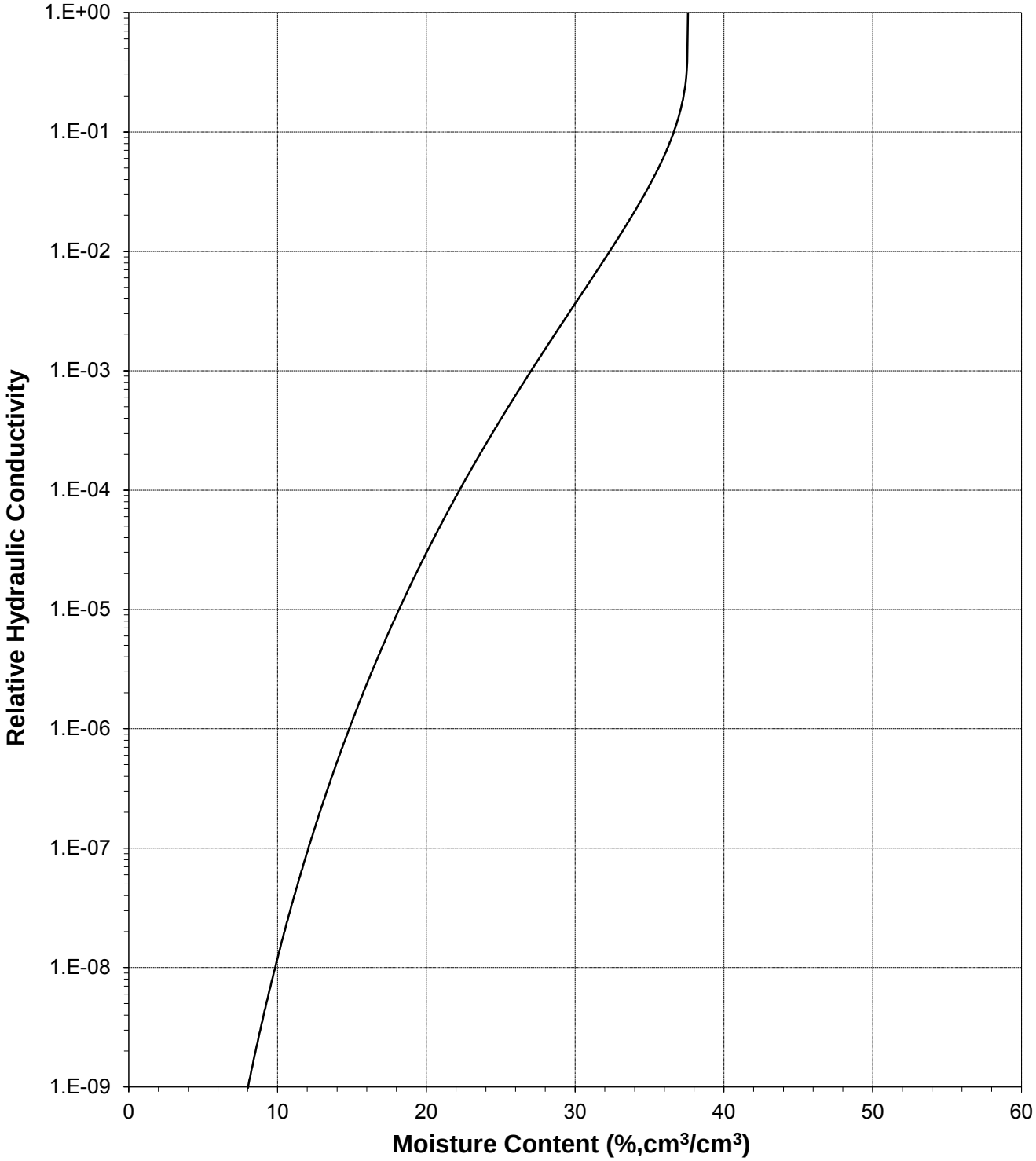
Predicted Water Retention Curve and Data Points

Sample Number: MET-11 (1.66)



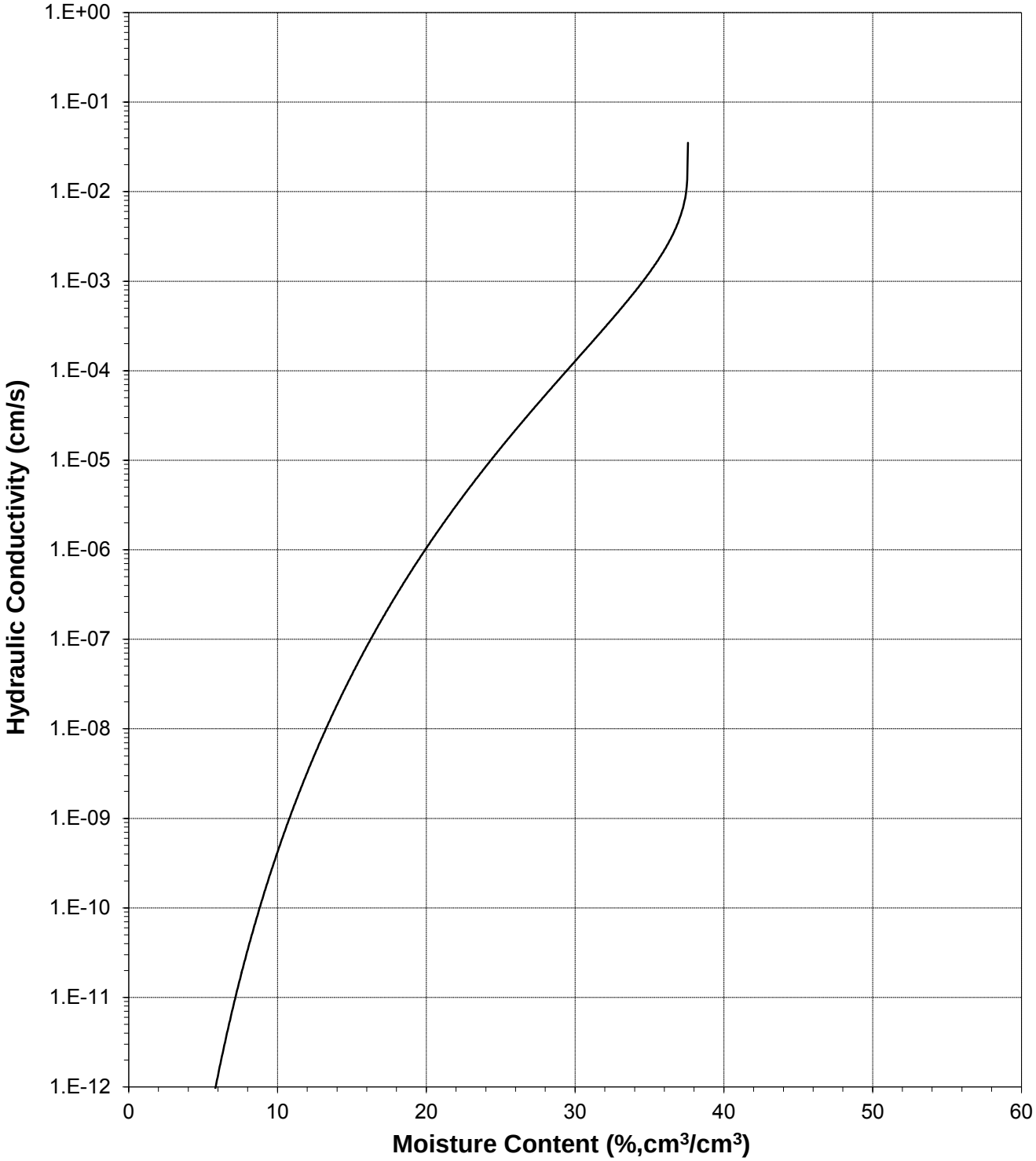
Plot of Relative Hydraulic Conductivity vs Moisture Content

Sample Number: MET-11 (1.66)



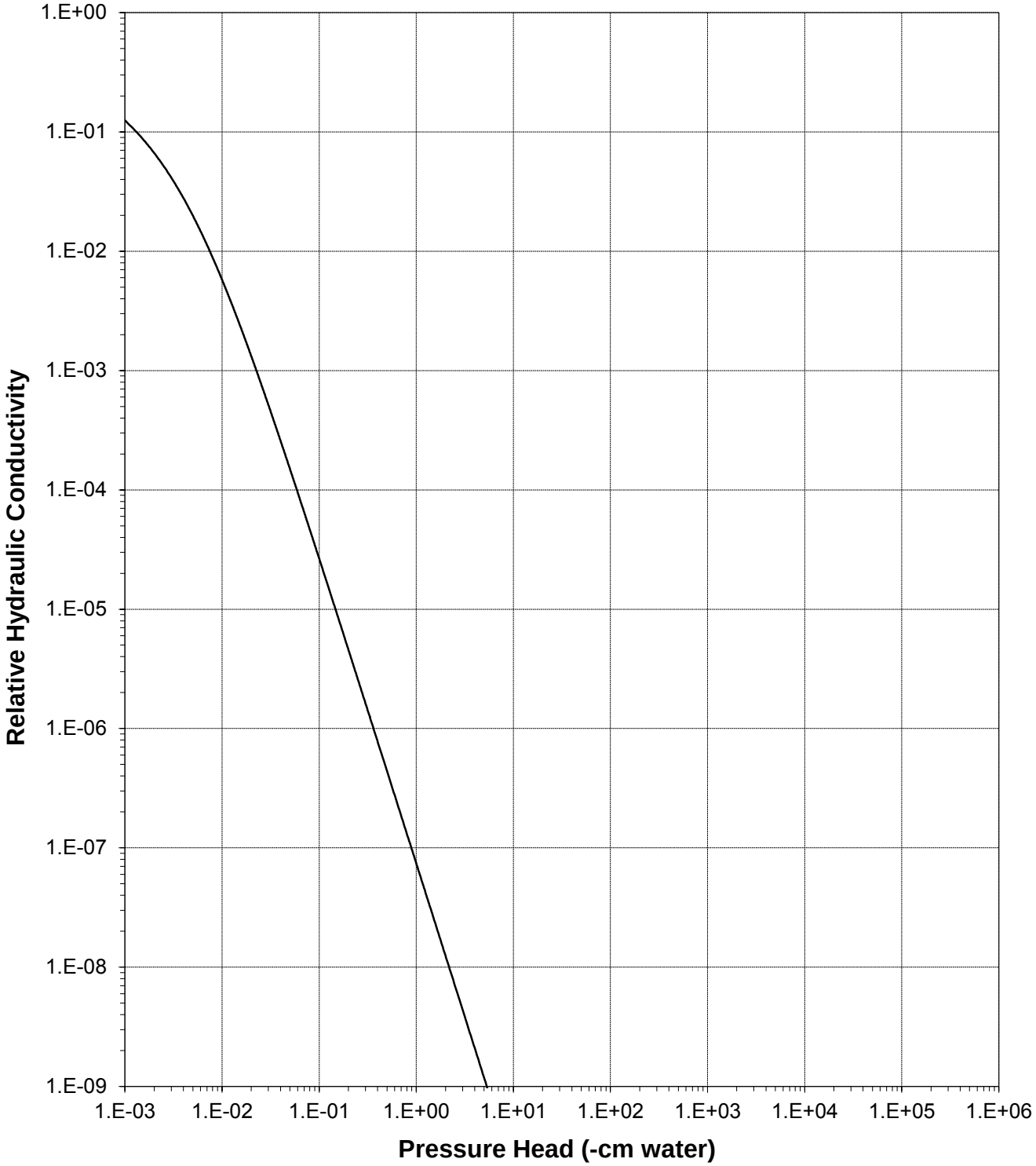
Plot of Hydraulic Conductivity vs Moisture Content

Sample Number: MET-11 (1.66)



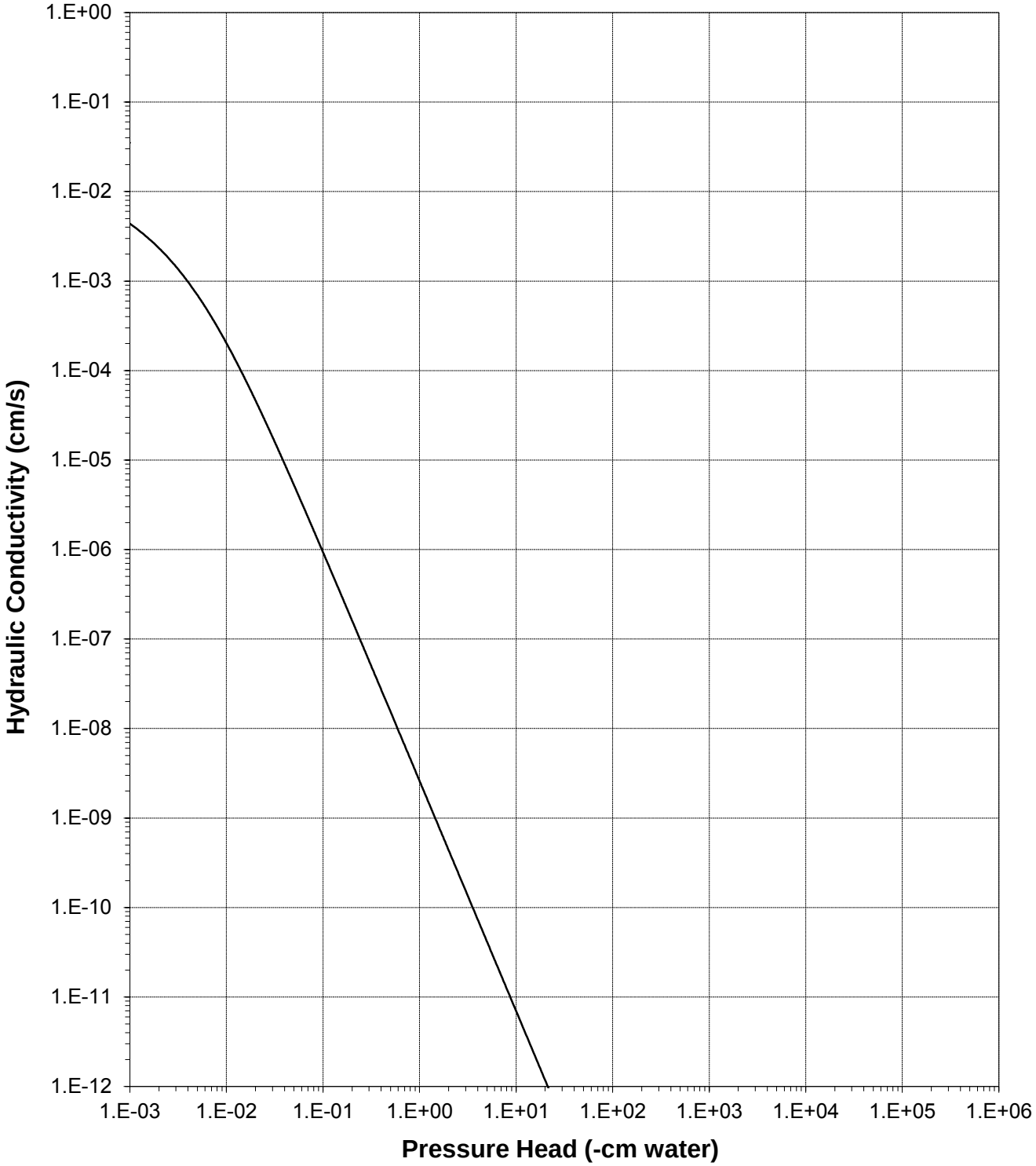
Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: MET-11 (1.66)



Plot of Hydraulic Conductivity vs Pressure Head

Sample Number: MET-11 (1.66)



Oversize Correction Data Sheet

Job Name: Knight Piesold
Job Number: LB13.0269.00
Sample Number: MET-11 (1.66)
Sample Tag ID: DV101-77/14
Project: Casino, VA101-00325/16

Split (3/4", 3/8", #4): 2"

	Coarse Fraction*	Fines Fraction**	Composite
Subsample Mass (g):	5.60	94.40	100.00
Mass Fraction (%):	5.60	94.40	100.00
Initial Sample θ_i			
Bulk Density (g/cm^3):	2.65	1.66	1.69
Calculated Porosity (% vol):	0.00	37.41	36.07
Volume of Solids (cm^3):	2.11	35.62	37.74
Volume of Voids (cm^3):	0.00	21.29	21.29
Total Volume (cm^3):	2.11	56.92	59.03
Volumetric Fraction (%):	3.58	96.42	100.00
Initial Moisture Content (% vol):	0.00	1.55	1.49
Saturated Sample θ_s			
Bulk Density (g/cm^3):	2.65	1.66	1.69
Calculated Porosity (% vol):	0.00	37.41	36.07
Volume of Solids (cm^3):	2.11	35.62	37.74
Volume of Voids (cm^3):	0.00	21.29	21.29
Total Volume (cm^3):	2.11	56.92	59.03
Volumetric Fraction (%):	3.58	96.42	100.00
Saturated Moisture Content (% vol):	0.00	37.58	36.24
Residual Sample θ_r			
Bulk Density (g/cm^3):	2.65	1.66	1.69
Calculated Porosity (% vol):	0.00	37.41	36.07
Volume of Solids (cm^3):	2.11	35.62	37.74
Volume of Voids (cm^3):	0.00	21.29	21.29
Total Volume (cm^3):	2.11	56.92	59.03
Volumetric Fraction (%):	3.58	96.42	100.00
Residual Moisture Content (% vol):	0.00	0.00	0.00
Ksat (cm/sec):	NM	3.5E-02	3.3E-02

* = Porosity and moisture content of coarse fraction assumed to be zero.
** = Volume adjusted, if applicable. See notes on Moisture Retention Data pages.
NM = Not measured

Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

Moisture Retention Data

Hanging Column / Pressure Plate

(Soil-Water Characteristic Curve)

Job Name: Knight Piesold
Job Number: LB13.0269.00
Sample Number: MET-11 (1.94)
Sample Tag ID: DV101-77/14
Project: Casino, VA101-00325/16

Dry wt. of sample (g)*:* 21342.20
Tare wt., ring (g)*:* 2325.24
Tare wt., screen & clamp (g)*:* 158.20
Initial sample volume (cm^3)*:* 11013.55
Initial dry bulk density (g/cm^3)*:* 1.94
Assumed particle density (g/cm^3)*:* 2.65
Initial calculated total porosity (%)*:* 26.87

	Date	Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content † (% vol)
Hanging column:	16-Dec-13	13:00	26790.00	0	26.92
	18-Dec-13	10:00	24766.00	7.5	8.54
	21-Dec-13	11:00	24691.00	19.0	7.86
	28-Dec-13	13:05	24671.00	50.0	7.68
	2-Jan-14	13:00	24651.00	150.0	7.49

Volume Adjusted Data [1]

	Matric Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calculated Porosity (%)
Hanging column:	0.0	---	---	---	---
	7.5	---	---	---	---
	19.0	---	---	---	---
	50.0	---	---	---	---
	150.0	---	---	---	---

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent each of the volume change measurements obtained after saturated hydraulic conductivity testing and throughout hanging column/pressure plate testing. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Assumed density of water is 1.0 g/cm^3

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Technician Notes:

Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

Moisture Retention Data

Dew Point Potentiometer / Relative Humidity Box

(Soil-Water Characteristic Curve)

Sample Number: MET-11 (1.94)

Initial sample bulk density (g/cm^3)*:* 1.94

Fraction of test sample used (<2.00mm fraction) (%): 8.90

Dry weight of dew point potentiometer sample* (g)*:* 168.94

Tare weight, jar (g)*:* 115.74

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)
Dew point potentiometer:	31-Dec-13	12:45	170.84	15399	0.62
	23-Dec-13	14:57	170.09	48746	0.37
	18-Dec-13	15:10	169.58	307470	0.21

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Dew point potentiometer:	15399	---	---	---	---
	48746	---	---	---	---
	307470	---	---	---	---

Dry weight of relative humidity box sample* (g)*:* 86.05

Tare weight (g)*:* 36.88

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)
Relative humidity box:	20-Dec-13	15:30	86.40	845560	0.13

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Relative humidity box:	845560	---	---	---	---

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent the volume change measurements obtained after the last hanging column or pressure plate point. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

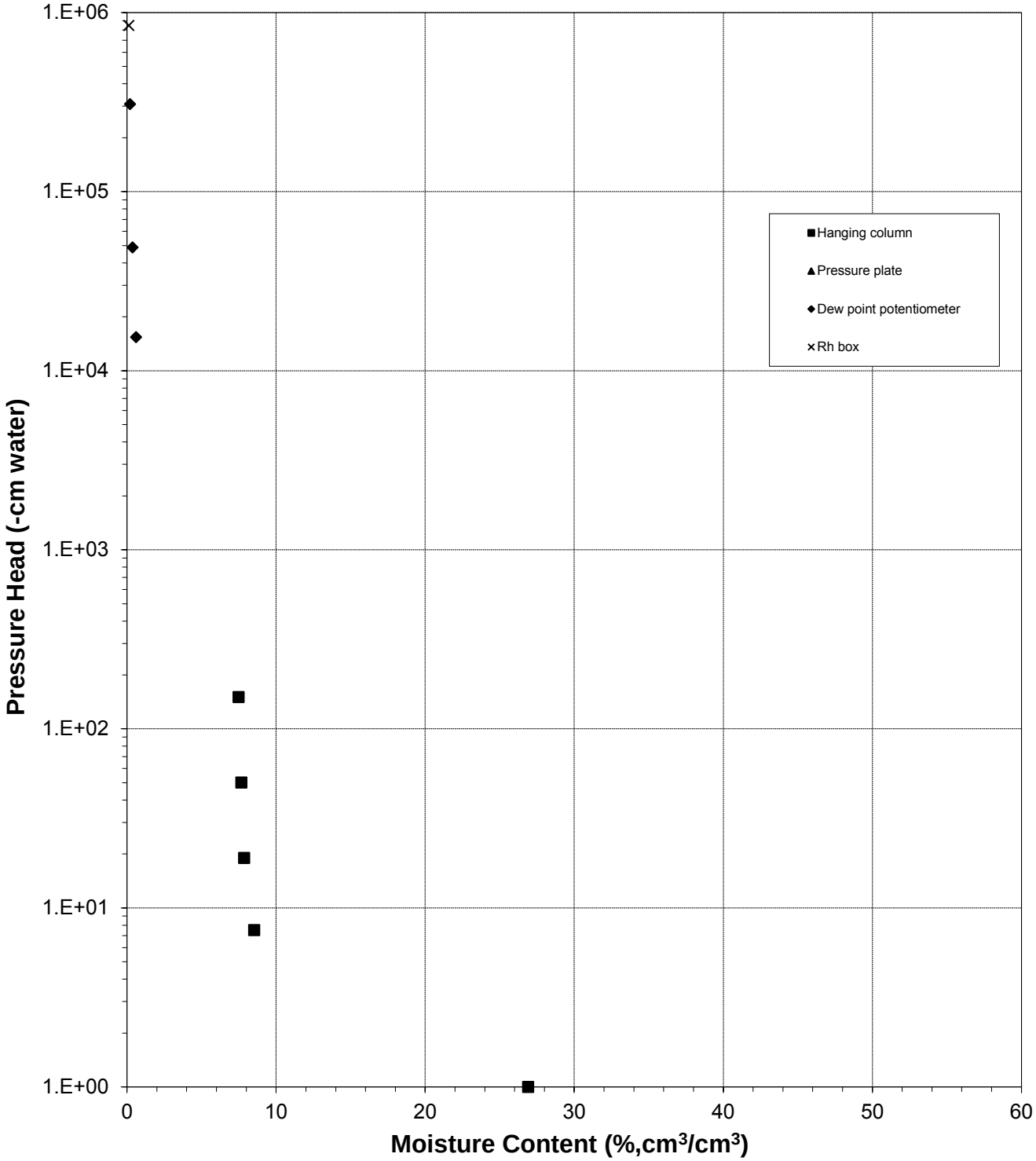
† Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm^3.

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

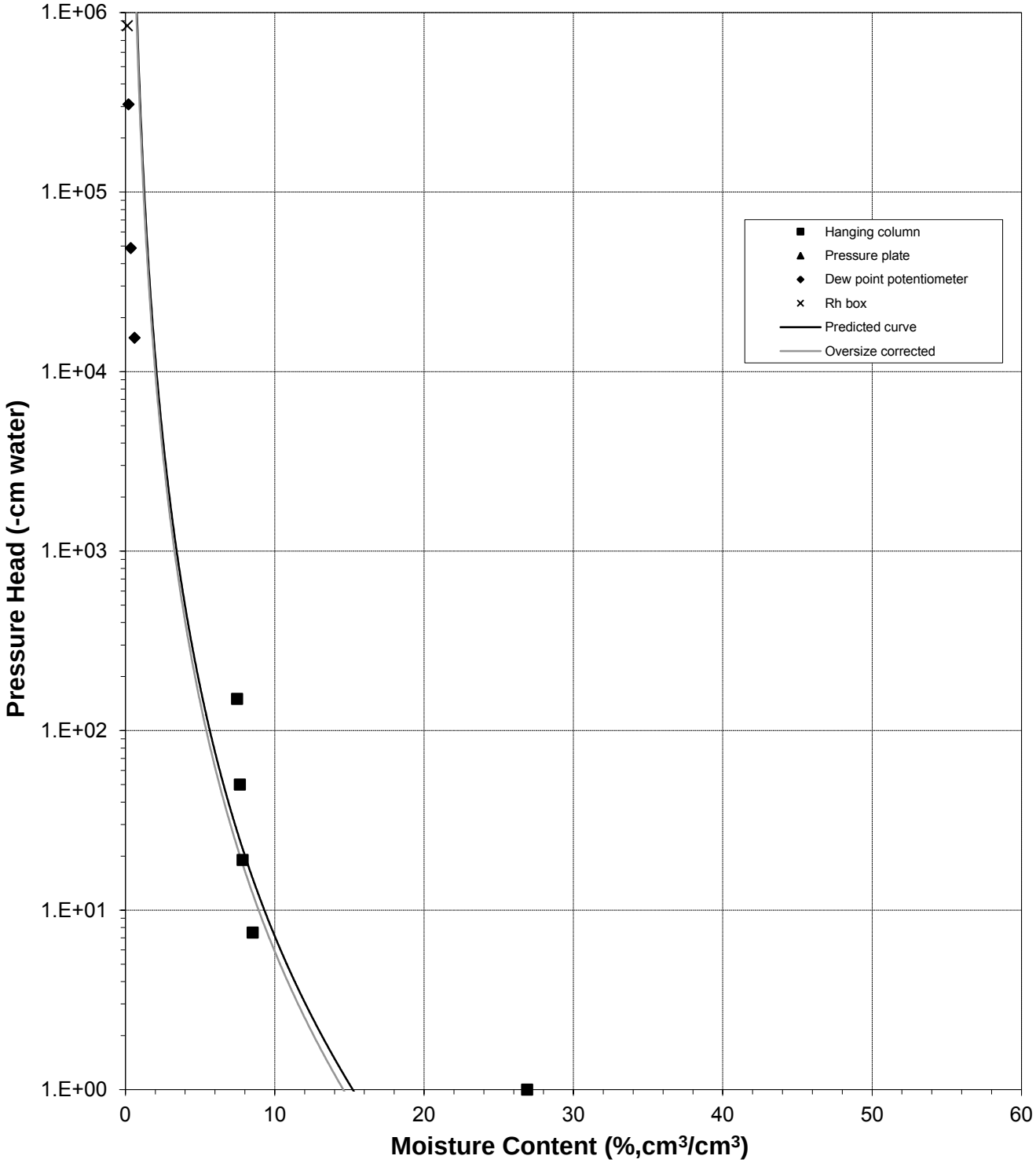
Water Retention Data Points

Sample Number: MET-11 (1.94)



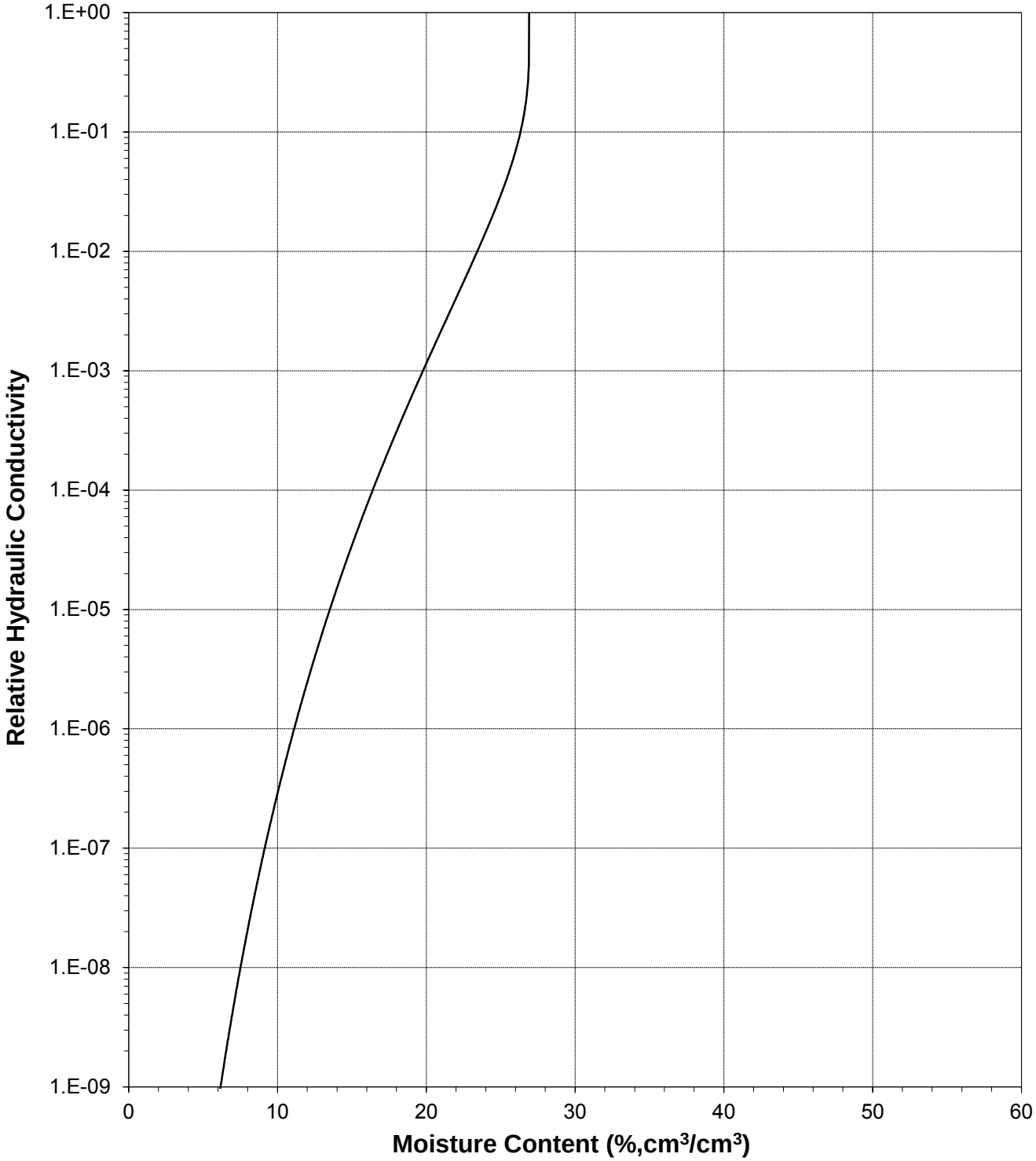
Predicted Water Retention Curve and Data Points

Sample Number: MET-11 (1.94)



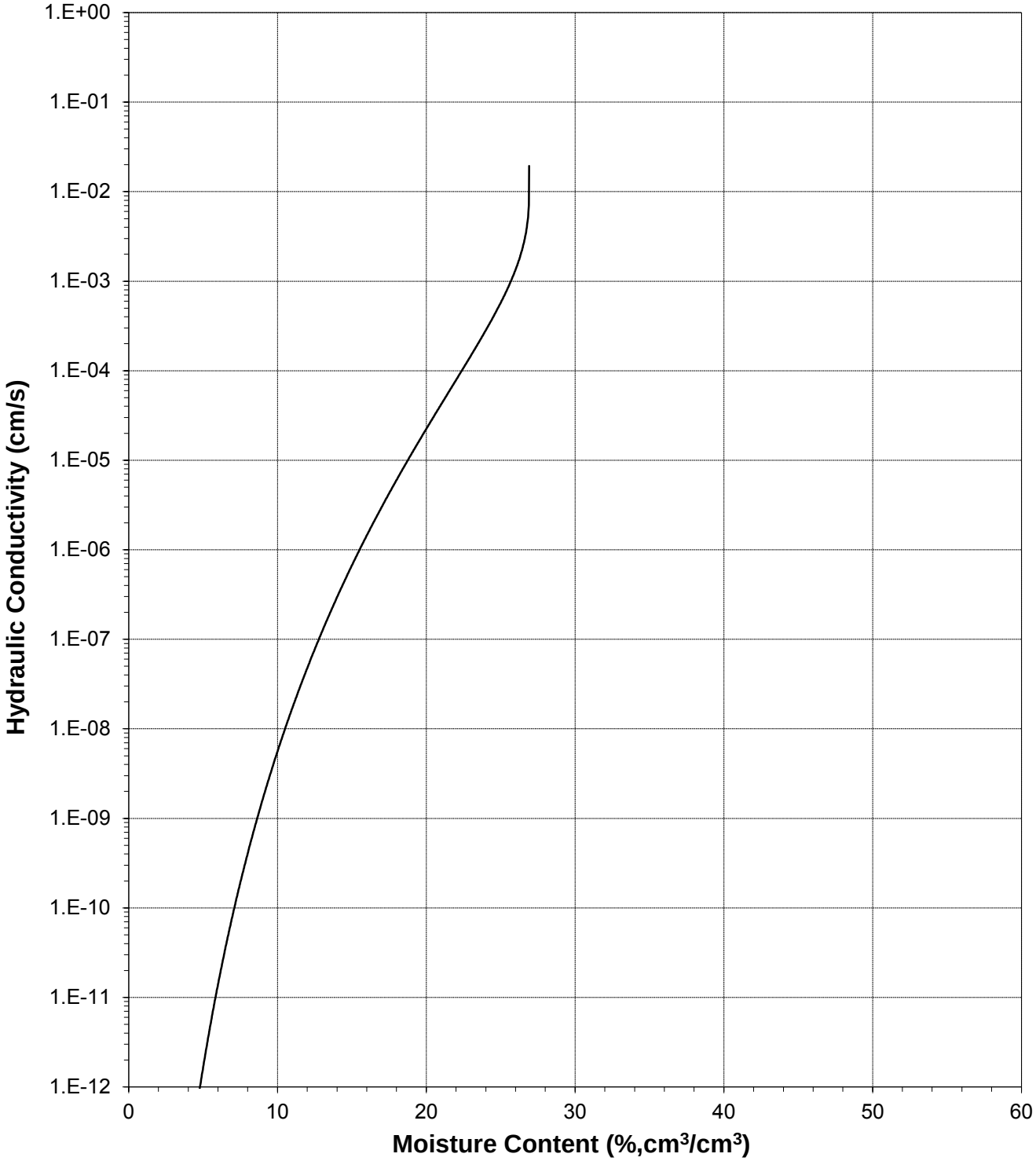
Plot of Relative Hydraulic Conductivity vs Moisture Content

Sample Number: MET-11 (1.94)



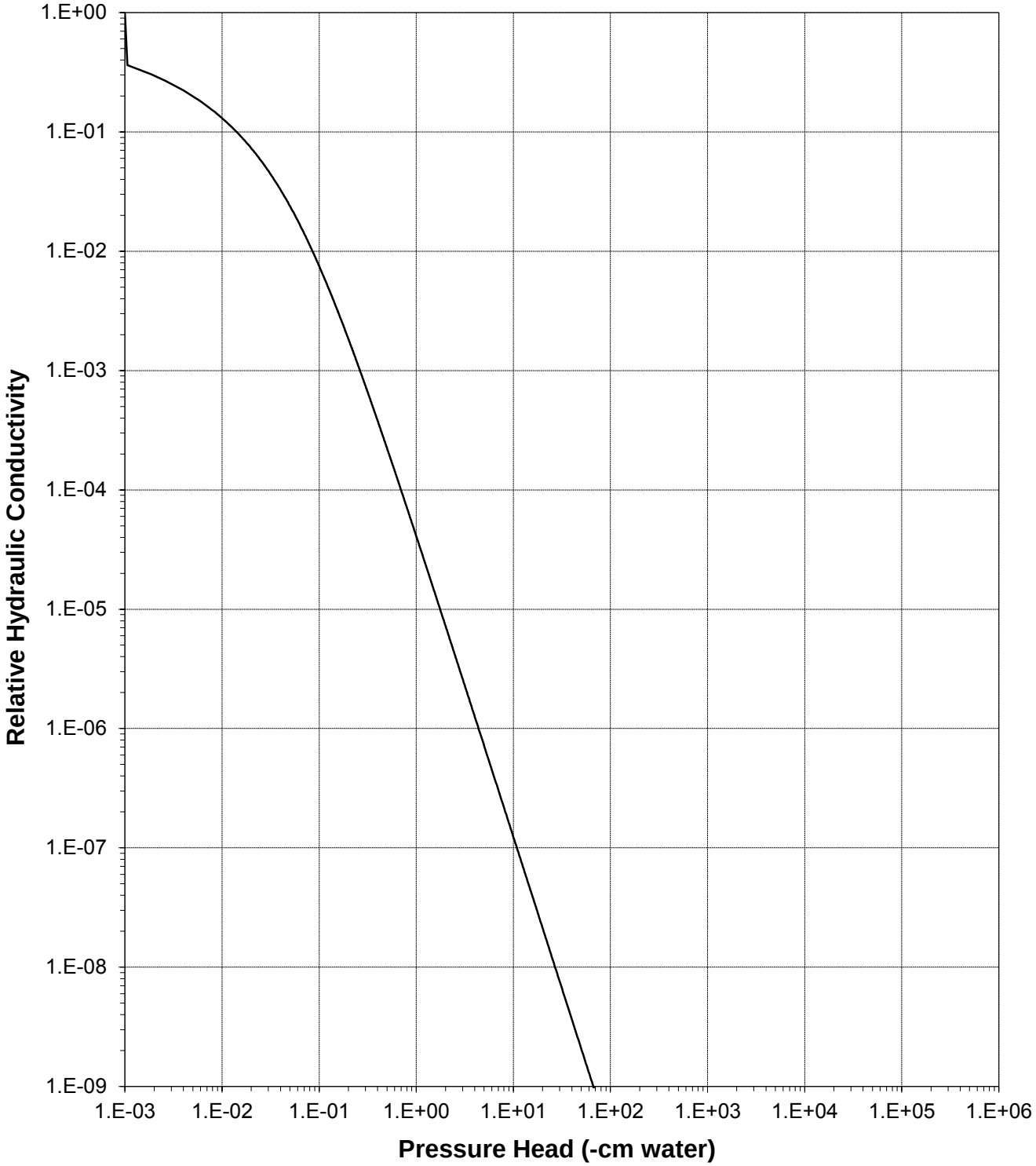
Plot of Hydraulic Conductivity vs Moisture Content

Sample Number: MET-11 (1.94)



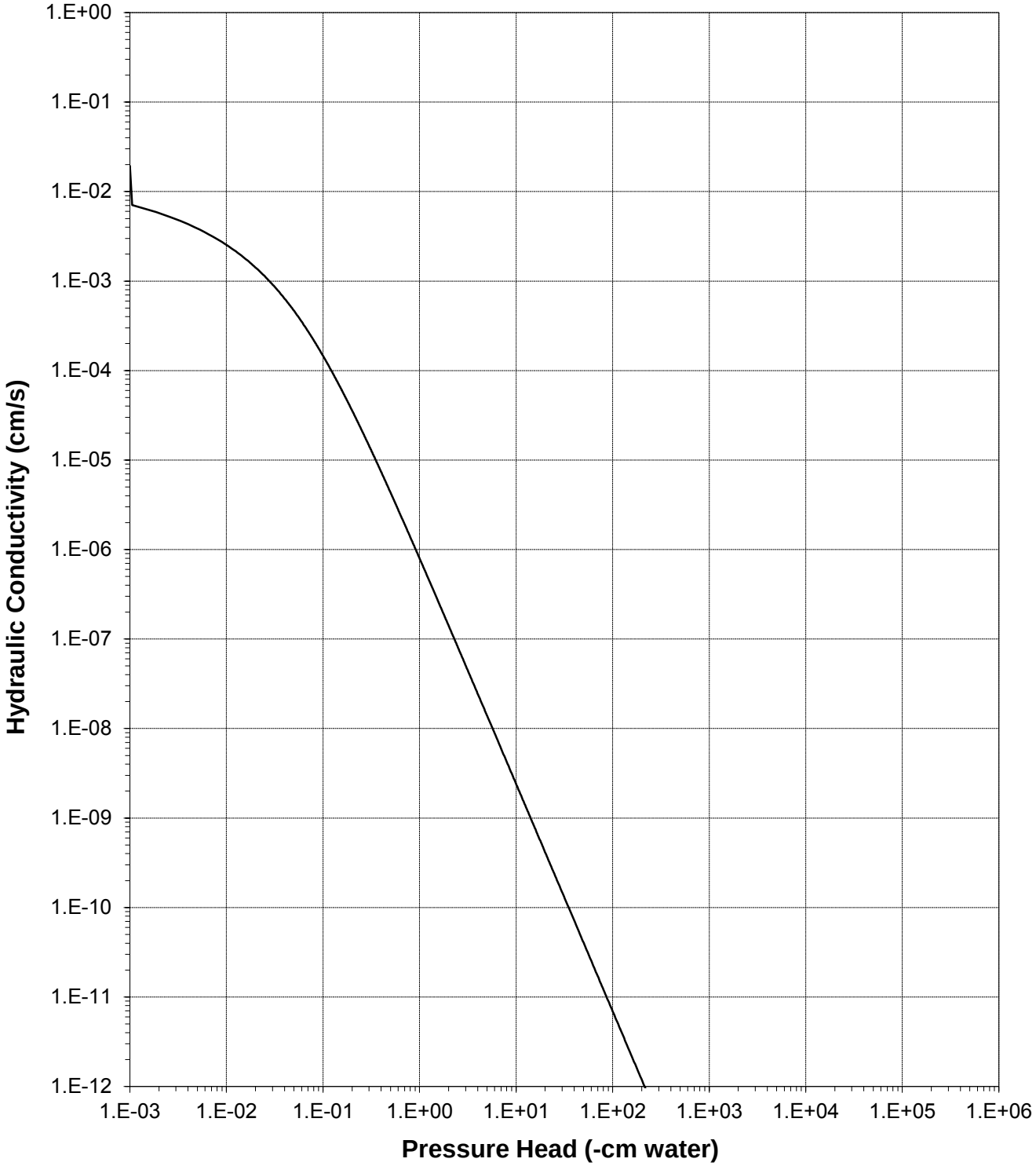
Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: MET-11 (1.94)



Plot of Hydraulic Conductivity vs Pressure Head

Sample Number: MET-11 (1.94)



Oversize Correction Data Sheet

Job Name: Knight Piesold
Job Number: LB13.0269.00
Sample Number: MET-11 (1.94)
Sample Tag ID: DV101-77/14
Project: Casino, VA101-00325/16

Split (3/4", 3/8", #4): 2"

	Coarse Fraction*	Fines Fraction**	Composite
Subsample Mass (g):	5.60	94.40	100.00
Mass Fraction (%):	5.60	94.40	100.00
Initial Sample θ_i			
Bulk Density (g/cm^3):	2.65	1.94	1.97
Calculated Porosity (% vol):	0.00	26.87	25.76
Volume of Solids (cm^3):	2.11	35.62	37.74
Volume of Voids (cm^3):	0.00	13.09	13.09
Total Volume (cm^3):	2.11	48.71	50.83
Volumetric Fraction (%):	4.16	95.84	100.00
Initial Moisture Content (% vol):	0.00	1.16	1.11
Saturated Sample θ_s			
Bulk Density (g/cm^3):	2.65	1.94	1.97
Calculated Porosity (% vol):	0.00	26.87	25.76
Volume of Solids (cm^3):	2.11	35.62	37.74
Volume of Voids (cm^3):	0.00	13.09	13.09
Total Volume (cm^3):	2.11	48.71	50.83
Volumetric Fraction (%):	4.16	95.84	100.00
Saturated Moisture Content (% vol):	0.00	26.92	25.80
Residual Sample θ_r			
Bulk Density (g/cm^3):	2.65	1.94	1.97
Calculated Porosity (% vol):	0.00	26.87	25.76
Volume of Solids (cm^3):	2.11	35.62	37.74
Volume of Voids (cm^3):	0.00	13.09	13.09
Total Volume (cm^3):	2.11	48.71	50.83
Volumetric Fraction (%):	4.16	95.84	100.00
Residual Moisture Content (% vol):	0.00	0.00	0.00
Ksat (cm/sec):	NM	1.9E-02	1.8E-02

* = Porosity and moisture content of coarse fraction assumed to be zero.
** = Volume adjusted, if applicable. See notes on Moisture Retention Data pages.
NM = Not measured

Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

Laboratory Tests and Methods

Tests and Methods

Dry Bulk Density:	ASTM D7263
Moisture Content:	ASTM D7263
Calculated Porosity:	ASTM D7263
Saturated Hydraulic Conductivity:	
Constant Head: (Rigid Wall)	ASTM D 2434 (modified apparatus)
Hanging Column Method:	ASTM D6836 (modified apparatus)
Pressure Plate Method:	ASTM D6836 (modified apparatus)
Water Potential (Dewpoint Potentiometer) Method:	ASTM D6836
Relative Humidity (Box) Method:	Campbell, G. and G. Gee. 1986. Water Potential: Miscellaneous Methods. Chp. 25, pp. 631-632, in A. Klute (ed.), Methods of Soil Analysis. Part 1. American Society of Agronomy, Madison, WI; Karathanasis & Hajek. 1982. Quantitative Evaluation of Water Adsorption on Soil Clays. SSA Journal 46:1321-1325
Moisture Retention Characteristics & Calculated Unsaturated Hydraulic Conductivity:	ASTM D6836; van Genuchten, M.T. 1980. A closed-form equation for predicting the hydraulic conductivity of unsaturated soils. SSSAJ 44:892-898; van Genuchten, M.T., F.J. Leij, and S.R. Yates. 1991. The RETC code for quantifying the hydraulic functions of unsaturated soils. Robert S. Kerr Environmental Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Ada, Oklahoma. EPA/600/2091/065. December 1991
Coarse Fraction (Gravel) Correction (calc):	ASTM D4718; Bouwer, H. and Rice, R.C. 1984. Hydraulic Properties of Stony Vadose Zones. Groundwater Vol. 22, No. 6

APPENDIX E

LOAD-PERCOLATION TEST RESULTS
(KNIGHT PIÉSOLD LABORATORY)

(Pages E-1 to E-18)

Knight Piésold CONSULTING

TABLE E.1

CASINO MINING CORPORATION
CASINO PROJECT

LOAD - PERCOLATION TEST
RESULTS SUMMARY FOR MET-02

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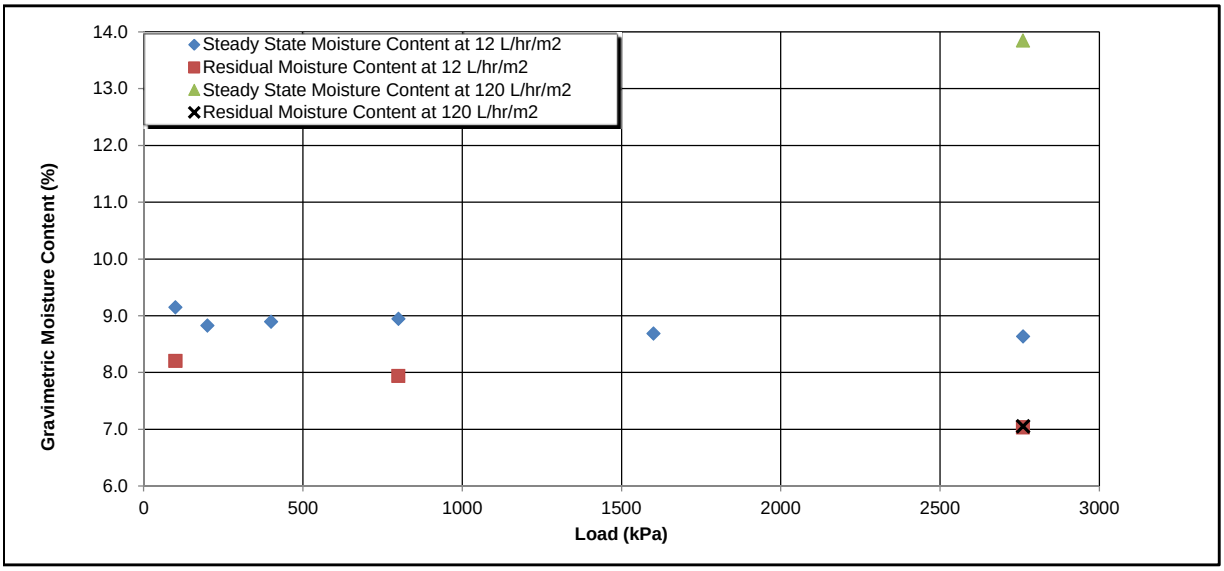
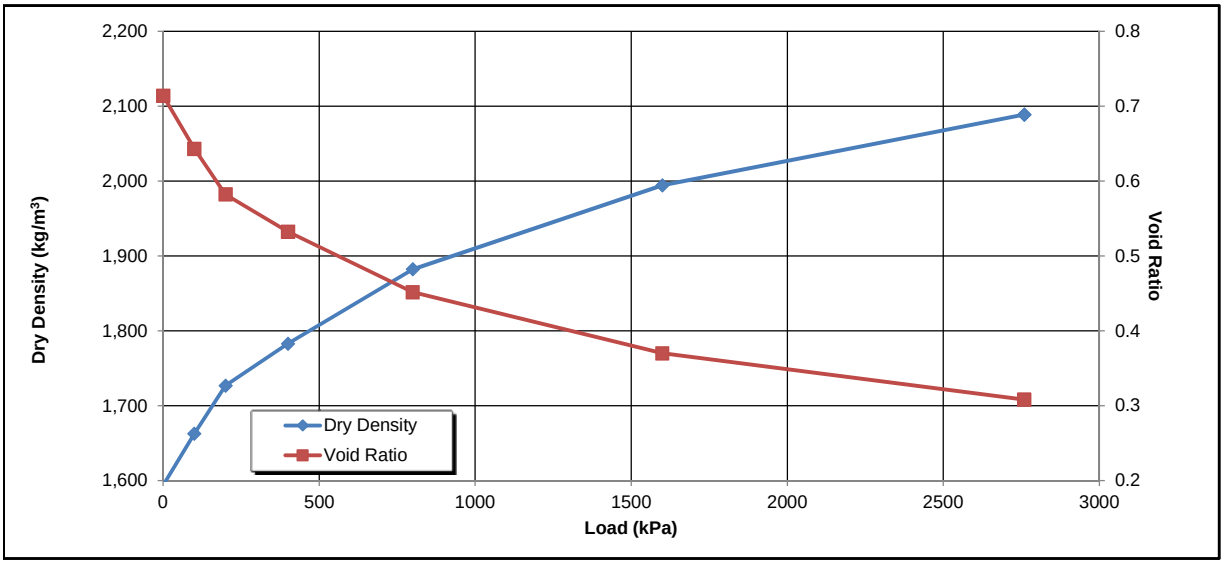
Load	Dry Density	Dry Density	Void Ratio	Irrigation Rate	Steady State Moisture Content under Irrigation	Degree of Saturation	Residual Moisture Content
(kPa)	(pcf)	(kg/m^3)		(L/hr/m^2)	(weight %)	(%)	(weight %)
0	99.5	1593.8	0.71	12			
100	103.8	1662.7	0.64	12	9.2	38.9	8.2
200	107.8	1726.8	0.58	12	8.8	41.4	
400	111.3	1782.9	0.53	12	8.9	45.6	
800	117.5	1882.2	0.45	12	8.9	54.1	7.9
1600	124.5	1994.3	0.37	12	8.7	64.2	
2760	130.4	2088.8	0.31	12	8.6	76.6	7.0
2760	130.4	2088.8	0.31	120	13.8	100.0	7.1





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NOTES:

1. Laboratory analyses performed at Knight Piésold and Co. Soils Laboratory in Denver, CO.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	14FEB'14	ISSUED WITH REPORT VA101-325/16-2	JDB	SB1	GRG

Knight Piésold
CONSULTING

TABLE E.2

CASINO MINING CORPORATION
CASINO PROJECT

LOAD - PERCOLATION TEST
RESULTS FOR MET-02

Project	Casino	Project No.	VA101-00325/16
Sample No.		Lab No.	L2013-084
Sample ID	MET-02	Task No.	
Description		Tested by	DAB
		Date:	08/10/2013

	US		Moisture Content Data	Initial	Final		
Depth to Bot. of Mold, in./cm	8.82					Mold Dia., in.	8.02
Depth to Plate, in./cm	1.833		Tare ID			Mold Area, in^2	50.517
Sample Height, in./cm	6.987					Sample Vol., ft^3	0.2043
			Wet Soil+Tare	6754.5	12659.5	Initial Wet Density, pcf	101.0
Initial Moisture Content, %	1.467	Sample mass. g	Dry Soil + Tare	6697	11963	Initial Dry Density, pcf	99.5
Initial Sample Wet Wt., g/lbs.	20.628	9356.7	Tare	2778	2781	Target Dry Density, pcf	NA
Dry Sample Wt.lbs	20.330	9221.4	Moist Content.%	1.467	7.585	Specific Gravity	2.732

					Inflow/outflow						
Date	Normal Load and Irrigation Rate	Time Start	Time Stop	Inflow Irrigation Tank g	Change in mass in g	Outflow Effluent Tank g	Change in mass out g	Difference in/out g	Cumulative Total water in g	Theoretical Sample mass g	Gravimetric Moisture Cont. %
08/10/2013	100 kPa	11:01		5689		854.5					
	12 l/hr/m2		15:23	3461.5	2227.5	2375.5	1521	706.5			
09/10/2013	refill	8:09		5746.9		878					
			9:29	5101.3	645.6	1521.5	643.5	2.1	708.6	10065.3	9.2
	Draindown					1521.5					
						1608.5	87	-87	621.6	9978.3	8.2
10/10/2013	200 kPa	7:56		6012.1		1608.5					
			10:31	5037.1	975	2526	917.5	57.5	679.1	10035.8	8.8
	400 kPa	10:56		4881.4		2690					
			13:00	4112.5	768.9	3453	763	5.9	685	10041.7	8.9
	800 kPa	13:17		4009.1		3570.5					
			14:15	3687	322.1	3888	317.5	4.6	689.6	10046.3	8.9
	Draindown	14:15				3888					
11/10/2013			9:45			3980.5	92.5	-92.5	597.1	9953.8	7.9
	1600 kPa	10:04		6034.5		3980.5					
			13:16	4835.1	1199.4	5111	1130.5	68.9	666	10022.7	8.7
	2760 kPa	13:38		4709.4		5248.5					
			15:21	4013.2	696.2	5949.5	701	-4.8	661.2	10017.9	8.6
14/10/2013	Draindown	13:16				2887					
15/10/2013			9:05			3034.5	147.5	-147.5	513.7	9870.4	7.0
	2760 kPa	10:10		15699.5		888					
	120 l/hr/m2		10:27	14561.5	1138	1398	510	628	1141.7	10498.4	13.8
									Water ponding on sample surface		
	Draindown	10:29				1398					
16/10/2013			8:08			2024.5	626.5	-626.5	515.2	9871.9	7.1

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NOTES:

1. Laboratory analyses performed at Knight Piésold and Co. Soils Laboratory in Denver, CO.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	14FEB'14	ISSUED WITH REPORT VA101-325/16-2	JDB	SB1	GRG

Knight Piésold CONSULTING

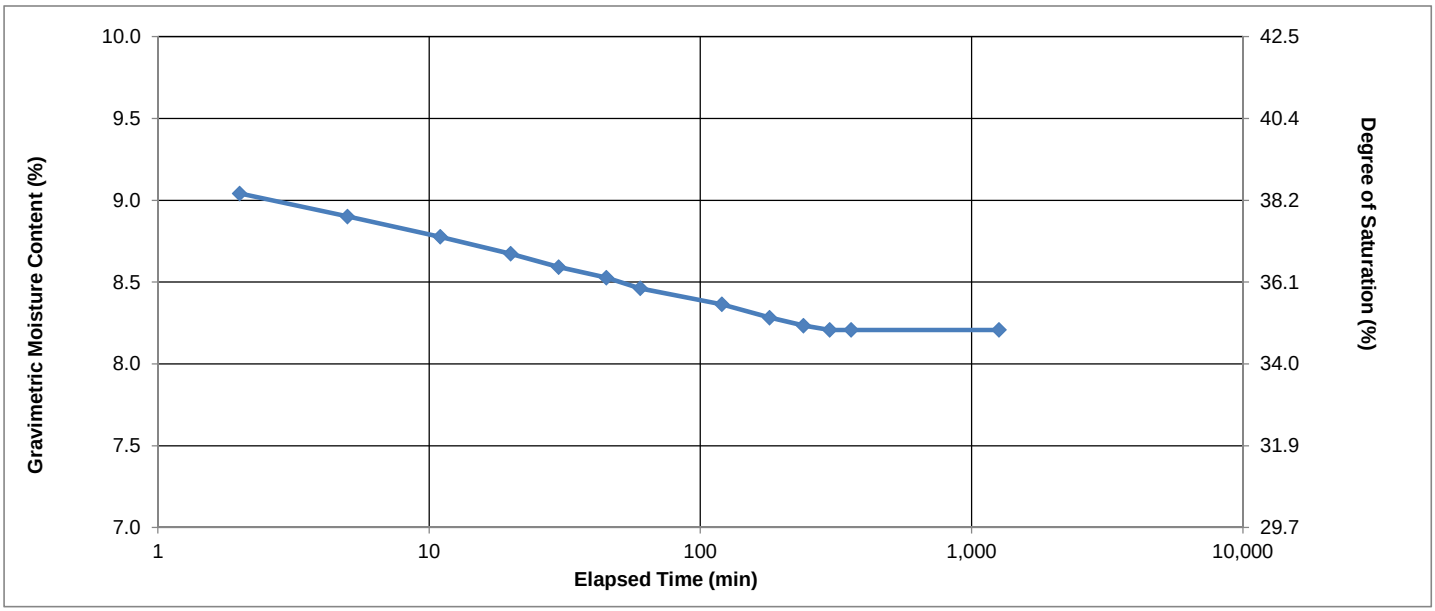
TABLE E.3

CASINO MINING CORPORATION
CASINO PROJECT

LOAD - PERCOLATION TEST
MET-02 DRAINDOWN DATA FOR 100 kPa, 12 l/hr/m2

Initial wet wt (lbs)	20.628	Consolidated Height (inch)	6.7
Initial wet wt. (g)	9356.700	Final vol. (ft^3)	0.196
Initial dry wt. (lbs)	20.330	Final dry density (pcf) at 100 kPa	103.8
Initial dry wt. (g)	9221.422	Final dry density (kg/m3) at 100 kPa	1662.6
Initial moisture wt. (kg)	135.278	Specific Gravity (-)	2.732
Initial MC (%)	1.47	Void Ratio (-)	0.643
Initial vol. (ft^3)	0.204		
Initial dry density (pcf)	99.5		
Flow rate (ml/min)	6.0		

Elapsed Time (min)	Outflow Mass	Change in Mass	Theoretical Sample Mass	Gravimetric Moisture Content	Degree of Saturation
(min)	(g)	(g)	(g)	(%)	(%)
0	1521.5	0.00	10065.25	9.2	38.87
2	1531.5	10.00	10055.25	9.0	38.41
5	1544.5	23.00	10042.25	8.9	37.81
11	1556	34.50	10030.75	8.8	37.28
20	1565.5	44.00	10021.25	8.7	36.84
30	1573	51.50	10013.75	8.6	36.50
45	1579	57.50	10007.75	8.5	36.22
60	1585	63.50	10001.75	8.5	35.94
120	1594	72.50	9992.75	8.4	35.53
180	1601.5	80.00	9985.25	8.3	35.18
240	1606	84.50	9980.75	8.2	34.98
300	1608.5	87.00	9978.25	8.2	34.86
360	1608.5	87.00	9978.25	8.2	34.86
1260	1608.5	87.00	9978.25	8.2	34.86



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NOTES:

1. Laboratory analyses performed at Knight Piésold and Co. Soils Laboratory in Denver, CO.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	14FEB'14	ISSUED WITH REPORT VA101-325/16-2	JDB	SB1	GRG

Knight Piésold CONSULTING

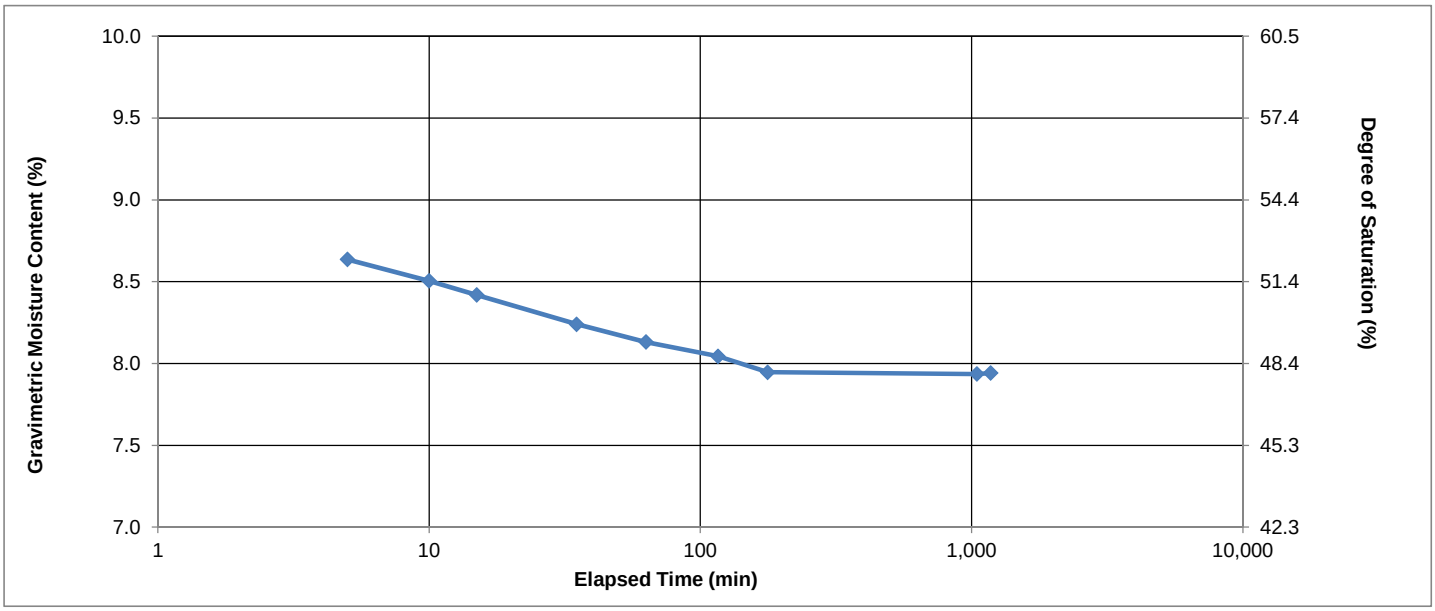
TABLE E.4

CASINO MINING CORPORATION
CASINO PROJECT

LOAD - PERCOLATION TEST
MET-02 DRAINDOWN DATA FOR 800 kPa, 12 l/hr/m2

Initial wet wt (lbs)	20.628	Consolidated Height (inch)	5.920
Initial wet wt. (g)	9356.700	Final vol. (ft^3)	0.173
Initial dry wt. (lbs)	20.330	Final dry density (pcf) at 100 kPa	117.5
Initial dry wt. (g)	9221.422	Final dry density (kg/m3) at 100 kPa	1881.7
Initial moisture wt. (kg)	135.278	Specific Gravity (-)	2.732
Initial MC (%)	1.47	Void Ratio (-)	0.452
Initial vol. (ft^3)	0.204		
Initial dry density (pcf)	99.5		
Flow rate (ml/min)	6.0		

Elapsed Time (min)	Outflow Mass	Change in Mass	Theoretical Sample Mass	Gravimetric Moisture Content	Degree of Saturation
(min)	(g)	(g)	(g)	(%)	(%)
0	3888	0.00	10046.25	8.9	54.08
5	3916.5	28.50	10017.75	8.6	52.21
10	3928.5	40.50	10005.75	8.5	51.42
15	3936.5	48.50	9997.75	8.4	50.90
35	3953	65.00	9981.25	8.2	49.81
63	3963	75.00	9971.25	8.1	49.16
116	3971	83.00	9963.25	8.0	48.63
177	3980	92.00	9954.25	7.9	48.04
1046	3981	93.00	9953.25	7.9	47.98
1175	3980.5	92.50	9953.75	7.9	48.01



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NOTES:

1. Laboratory analyses performed at Knight Piésold and Co. Soils Laboratory in Denver, CO.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	14FEB'14	ISSUED WITH REPORT VA101-325/16-2	JDB	SB1	GRG

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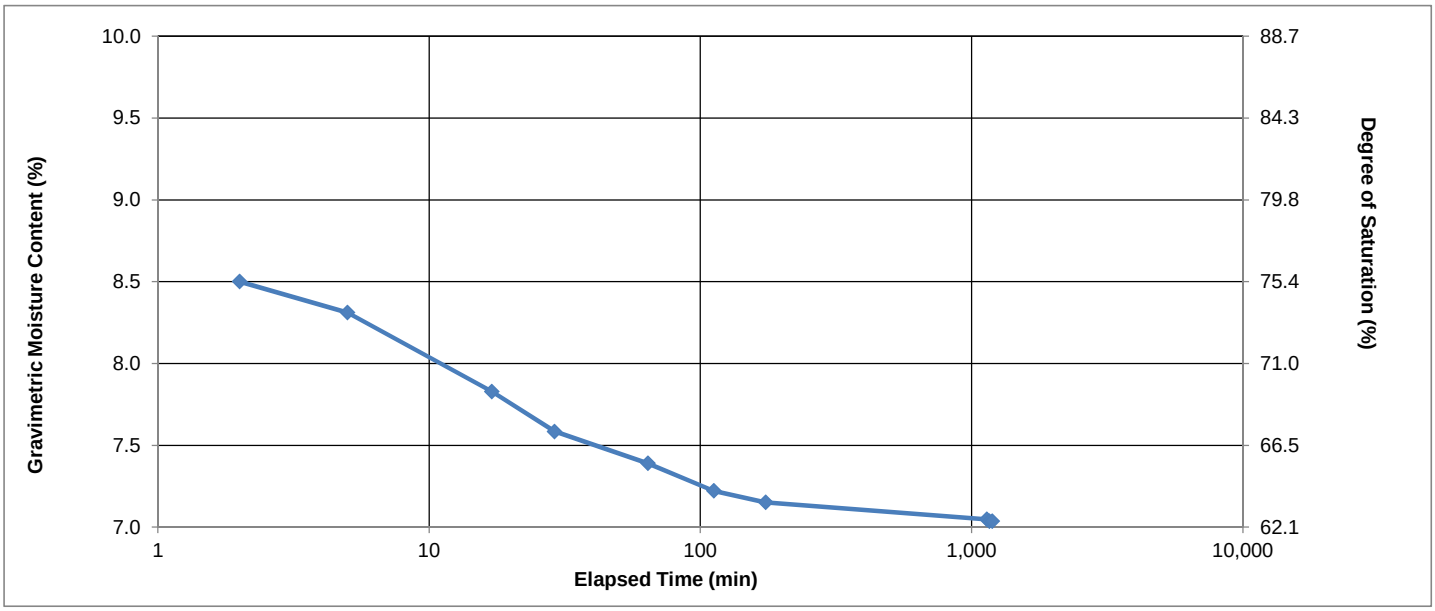
TABLE E.5

CASINO MINING CORPORATION
CASINO PROJECT

LOAD - PERCOLATION TEST
MET-02 DRAINDOWN DATA FOR 2760 kPa, 12 l/hr/m2

Initial wet wt (lbs)	20.628	Consolidated Height (inch)	5.333
Initial wet wt. (g)	9356.700	Final vol. (ft^3)	0.156
Initial dry wt. (lbs)	20.330	Final dry density (pcf) at 100 kPa	130.4
Initial dry wt. (g)	9221.422	Final dry density (kg/m3) at 100 kPa	2088.8
Initial moisture wt. (kg)	135.278	Specific Gravity (-)	2.732
Initial MC (%)	1.47	Void Ratio (-)	0.308
Initial vol. (ft^3)	0.204		
Initial dry density (pcf)	99.5		
Flow rate (ml/min)	6.0		

Elapsed Time (min)	Outflow Mass	Change in Mass	Theoretical Sample Mass	Gravimetric Moisture Content	Degree of Saturation
(min)	(g)	(g)	(g)	(%)	(%)
0	2887	0.00	10017.85	8.6	76.62
2	2899.5	12.50	10005.35	8.5	75.42
5	2917	30.00	9987.85	8.3	73.74
17	2961.5	74.50	9943.35	7.8	69.46
29	2984	97.00	9920.85	7.6	67.29
64	3002	115.00	9902.85	7.4	65.56
112	3017.5	130.50	9887.35	7.2	64.07
174	3024	137.00	9880.85	7.2	63.44
1137	3033.5	146.50	9871.35	7.0	62.53
1161	3034.5	147.50	9870.35	7.0	62.43
1191	3034.5	147.50	9870.35	7.0	62.43



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NOTES:

1. Laboratory analyses performed at Knight Piésold and Co. Soils Laboratory in Denver, CO.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	14FEB'14	ISSUED WITH REPORT VA101-325/16-2	JDB	SB1	GRG

Knight Piésold CONSULTING

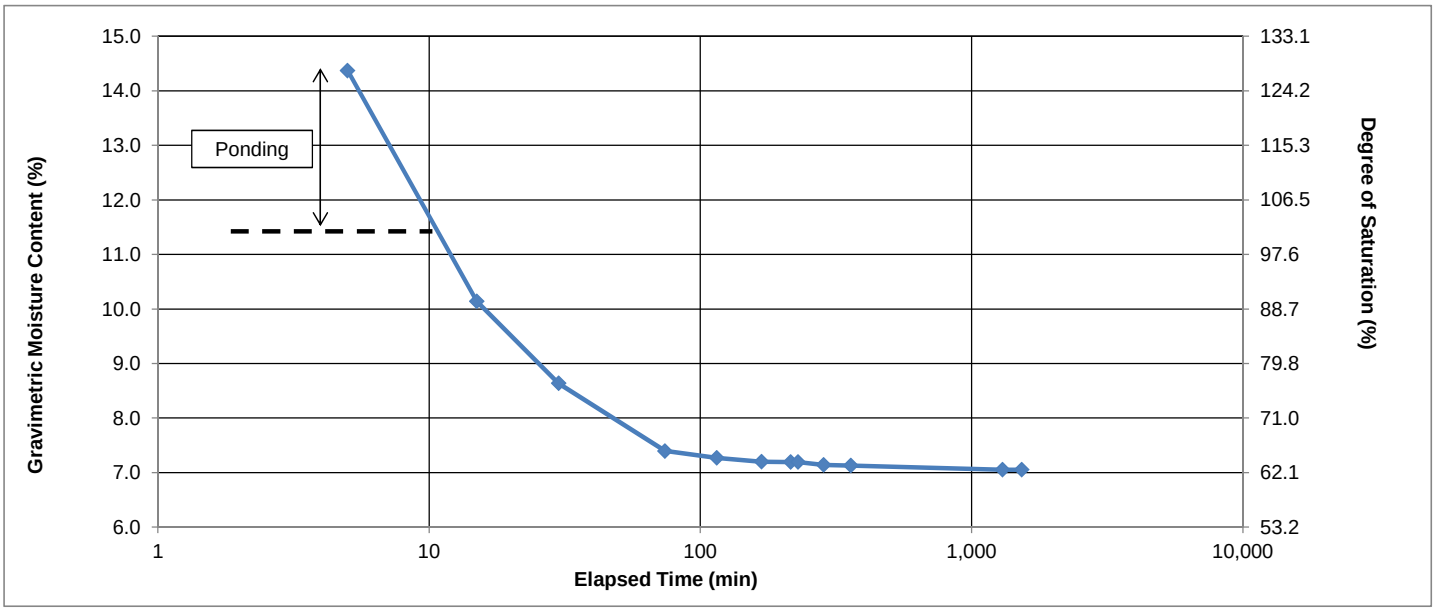
TABLE E.6

CASINO MINING CORPORATION
CASINO PROJECT

LOAD - PERCOLATION TEST
MET-02 DRAINDOWN DATA FOR 2760 kPa, 120 l/hr/m2

Initial wet wt (lbs)	20.628	Consolidated Height (inch)	5.333
Initial wet wt. (g)	9356.700	Final vol. (ft^3)	0.156
Initial dry wt. (lbs)	20.330	Final dry density (pcf) at 100 kPa	130.4
Initial dry wt. (g)	9221.422	Final dry density (kg/m3) at 100 kPa	2088.8
Initial moisture wt. (kg)	135.278	Specific Gravity (-)	2.732
Initial MC (%)	1.47	Void Ratio (-)	0.308
Initial vol. (ft^3)	0.204		
Initial dry density (pcf)	99.5		
Flow rate (ml/min)	60.0		

Elapsed Time (min)	Outflow Mass	Change in Mass	Theoretical Sample Mass	Gravimetric Moisture Content	Degree of Saturation
(min)	(g)	(g)	(g)	(%)	(%)
0	1398	0.00	10498.35	13.8	100.00
5	1349.5	-48.50	10546.85	14.4	100.00
15	1740	342.00	10156.35	10.1	89.95
30	1878.5	480.50	10017.85	8.6	76.62
74	1993	595.00	9903.35	7.4	65.61
115	2004.5	606.50	9891.85	7.3	64.50
168	2011	613.00	9885.35	7.2	63.88
215	2011.5	613.50	9884.85	7.2	63.83
229	2011.5	613.50	9884.85	7.2	63.83
285	2016.5	618.50	9879.85	7.1	63.35
359	2017.5	619.50	9878.85	7.1	63.25
1299	2024.5	626.50	9871.85	7.1	62.58
1531	2024.5	626.50	9871.85	7.1	62.58



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NOTES:

1. Laboratory analyses performed at Knight Piésold and Co. Soils Laboratory in Denver, CO.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	14FEB'14	ISSUED WITH REPORT VA101-325/16-2	JDB	SB1	GRG

Knight Piésold CONSULTING

TABLE E.7

CASINO MINING CORPORATION
CASINO PROJECT

LOAD - PERCOLATION TEST
RESULTS SUMMARY FOR MET-05

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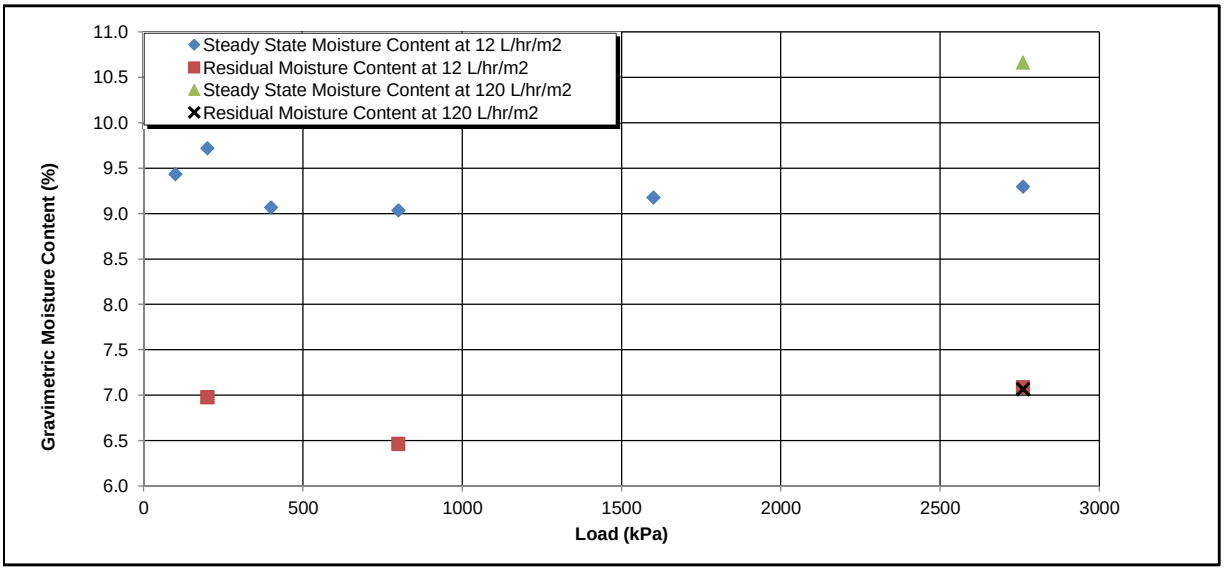
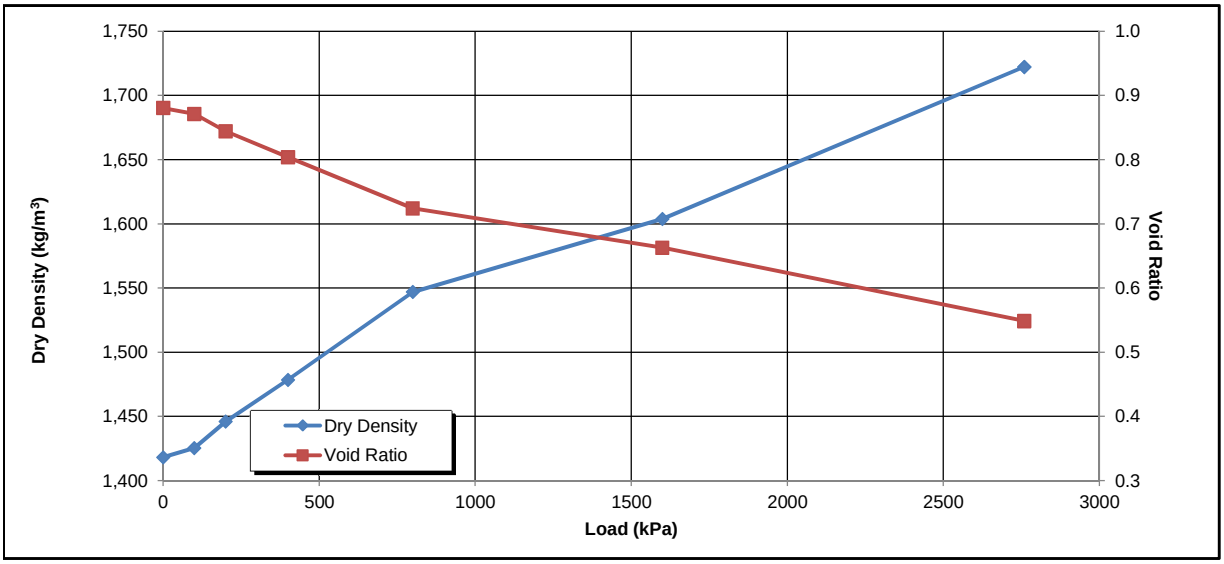
Load	Dry Density	Dry Density	Void Ratio	Irrigation Rate	Steady State Moisture Content under Irrigation	Degree of Saturation	Residual Moisture Content
(kPa)	(pcf)	(kg/m^3)		($L/hr/m^2$)	(weight %)	(%)	(weight %)
0	88.5	1418.3	0.88	12			
100	89.0	1425.3	0.87	12	9.4	28.9	
200	90.3	1446.0	0.84	12	9.7	30.7	7.0
400	92.3	1478.5	0.80	12	9.1	30.1	
800	96.6	1546.9	0.72	12	9.0	33.3	6.5
1600	100.1	1603.8	0.66	12	9.2	36.9	
2760	107.5	1722.1	0.55	12	9.3	45.2	7.1
2760	107.4	1722.1	0.55	120	10.7	51.8	7.1





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NOTES:

1. Laboratory analyses performed at Knight Piésold and Co. Soils Laboratory in Denver, CO.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	14FEB'14	ISSUED WITH REPORT VA101-325/16-2	JDB	SB1	GRG

Knight Piésold
CONSULTING

TABLE E.8

CASINO MINING CORPORATION
CASINO PROJECT

LOAD - PERCOLATION TEST
RESULTS FOR MET-05

Project	Casino	Project No.	VA101-00325/16
Sample No.		Lab No.	L2013-084
Sample ID	MET-05	Task No.	
Description		Tested by	DAB
		Date:	23/10/2013

	US		Moisture Content Data	Initial	Final		
Depth to Bot. of Mold, in./cm	8.9					Mold Dia., in.	8.02
Depth to Plate, in./cm	1.593		Tare ID			Mold Area, in^2	50.517
Sample Height, in./cm	7.307		Wet Soil+Tare	8232	11767.5	Sample Vol., ft^3	0.2136
			Dry Soil + Tare	7983	11146.5	Initial Wet Density, pcf	89.8
Initial Moisture Content, %	4.784	Sample mass. g	Tare	2778	2850	Initial Dry Density, pcf	88.54
Initial Sample Wet Wt., g/lbs.	19.19	8704.4	Moist Content.%	4.784	7.485	Target Dry Density, pcf	NA
Dry Sample Wt.lbs	18.314	8307.0				Specific Gravity	2.667

					Inflow/outflow							
Date	Normal Load and Irrigation Rate	Time Start	Time Stop	Inflow Irrigation Tank g	Change in mass in g	Outflow Effluent Tank g	Change in mass out g	Difference in/out g	Cumulative Total water in g	Theoretical Sample mass g	Actual Sample Mass g	Gravimetric Moisture Cont. %
24/10/2013	100kPa	8:20		5981.3		718						
	12 l/hr/m2		13:18	3895.5	2085.8	2417.5	1699.5	386.3	386.3	9090.7		9.43
	200kPa	13:29		6043		2489						
			16:09	4876.9	1166.1	3631.5	1142.5	23.6	409.9	9114.3		9.72
25/10/2013	Drain Down	9:34				1520						
27/10/2013			14:04			1729	209	-209	200.9	8905.3		
Measured after Draindown									182.3		8886.7	6.98
28/10/2013	400kPa	14:17		6047.6		1666						
			16:51	5544.1	503.5	1989	323					
29/10/2013	refill			6001.2		3095						
				5735.2	266	3368	273	173.5	355.8	9060.2		9.07
29/10/2013	800kPa	12:23		5636.6		3476.5						
			13:02	5397.3	239.3	3718.5	242	-2.7	353.1	9057.5		9.04
29/10/2013	Drain Down	13:02				3809						
31/10/2013			7:00			3975	166	-166	187.1	8891.5		
Measured after Draindown									139.7		8844.1	6.47
31/10/2013	1600kPa	7:30		6049.2		733.5						
			11:07	4568	1481.2	1989.5	1256	225.2	364.9	9069.3		9.18
01/11/2013	2760kPa	12:06		4229.9		2351						
			14:36	3455.2	774.7	3105.5	754.5					
02/11/2013	refill	7:22		5504.3		743.5						
			8:58	4841.9	662.4	1416	672.5	10.1	375.0	9079.4		9.30
	Drain Down	9:01				1464.5						
04/11/2013			6:24			1582.5	118	-118	257.0	8961.4		
Measured after Draindown									191.4		8895.8	7.09
	2760kPa	7:06		15409.5		731						
	120 l/hr/m2		8:54	8367	7042.5	7476.5	6745.5	297	488.4	9192.8		10.66
	Drain Down	8:59				7648.1						
05/11/2013			6:50			7764	115.9	-115.9	372.5	9076.9		
Measured after Draindown									189.7		8894.1	7.07

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NOTES:
1. Laboratory analyses performed at Knight Piésold and Co. Soils Laboratory in Denver, CO.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	14FEB'14	ISSUED WITH REPORT VA101-325/16-2	JDB	SB1	GRG

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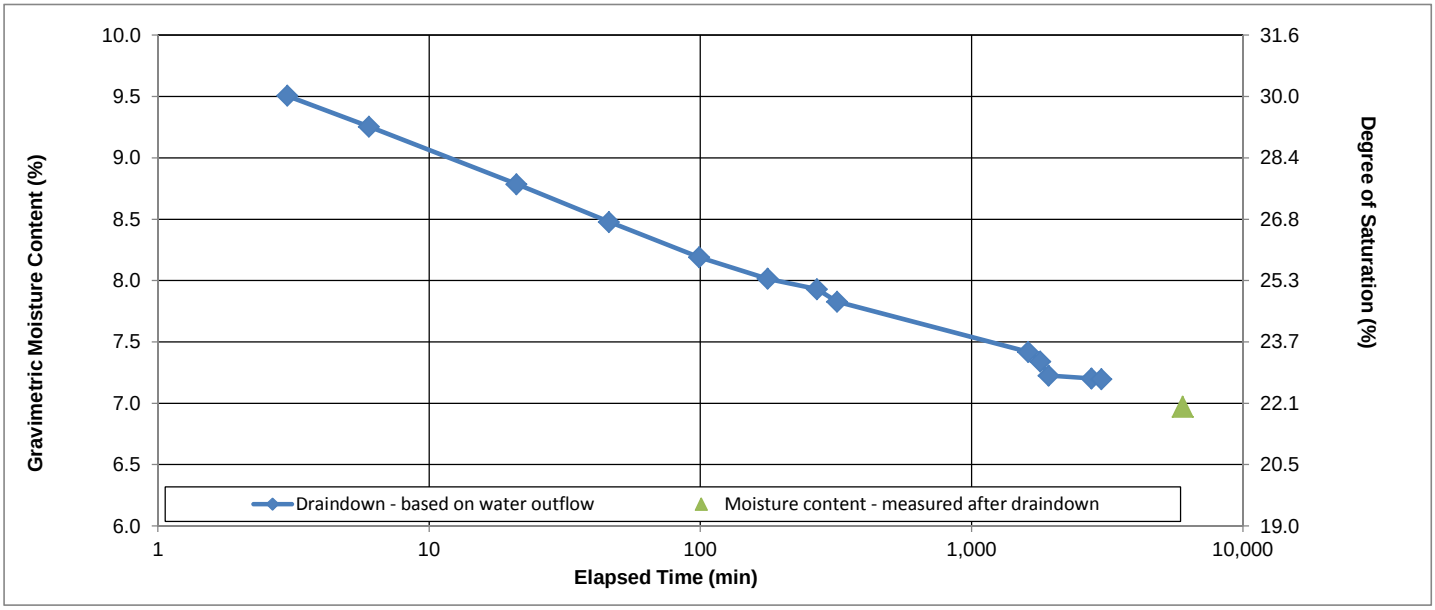
TABLE E.9

CASINO MINING CORPORATION
CASINO PROJECT

LOAD - PERCOLATION TEST
MET-05 DRAINDOWN DATA FOR 200 kPa, 12 l/hr/m2

Initial wet wt (lbs)	19.190	Consolidated Height (inch)	6.94
Initial wet wt. (g)	8704.392	Final vol. (ft^3)	0.203
Initial dry wt. (lbs)	18.315	Final dry density (pcf) at 200 kPa	90.3
Initial dry wt. (g)	8307.501	Final dry density (kg/m3) at 200 kPa	1446.0
Initial moisture wt. (kg)	396.891	Specific Gravity (-)	2.667
Initial MC (%)	4.78	Void Ratio (-)	0.844
Initial vol. (ft^3)	0.214		
Initial dry density (pcf)	85.7		
Flow rate (ml/min)	6.0		

Elapsed Time (min)	Outflow Mass	Change in Mass	Theoretical Sample Mass	Gravimetric Moisture Content	Degree of Saturation
(min)	(g)	(g)	(g)	(%)	(%)
0	1520	0.00	9114.29	9.7	30.67
3	1537	17.00	9097.29	9.5	30.03
6	1558	38.00	9076.29	9.3	29.23
21	1597	77.00	9037.29	8.8	27.75
46	1622.5	102.50	9011.79	8.5	26.78
99	1646.5	126.50	8987.79	8.2	25.87
177	1661	141.00	8973.29	8.0	25.31
269	1668	148.00	8966.29	7.9	25.05
319	1676.5	156.50	8957.79	7.8	24.72
1613	1710.5	190.50	8923.79	7.4	23.43
1788	1717	197.00	8917.29	7.3	23.18
1920	1726.5	206.50	8907.79	7.2	22.82
2762	1728.5	208.50	8905.79	7.2	22.75
3008	1729	209.00	8905.29	7.2	22.73
ACTUAL MASS - MEASURED AFTER DRAINDOWN			8886.70	7.0	22.02



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NOTES:

1. Laboratory analyses performed at Knight Piésold and Co. Soils Laboratory in Denver, CO.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	14FEB'14	ISSUED WITH REPORT VA101-325/16-2	JDB	SB1	GRG

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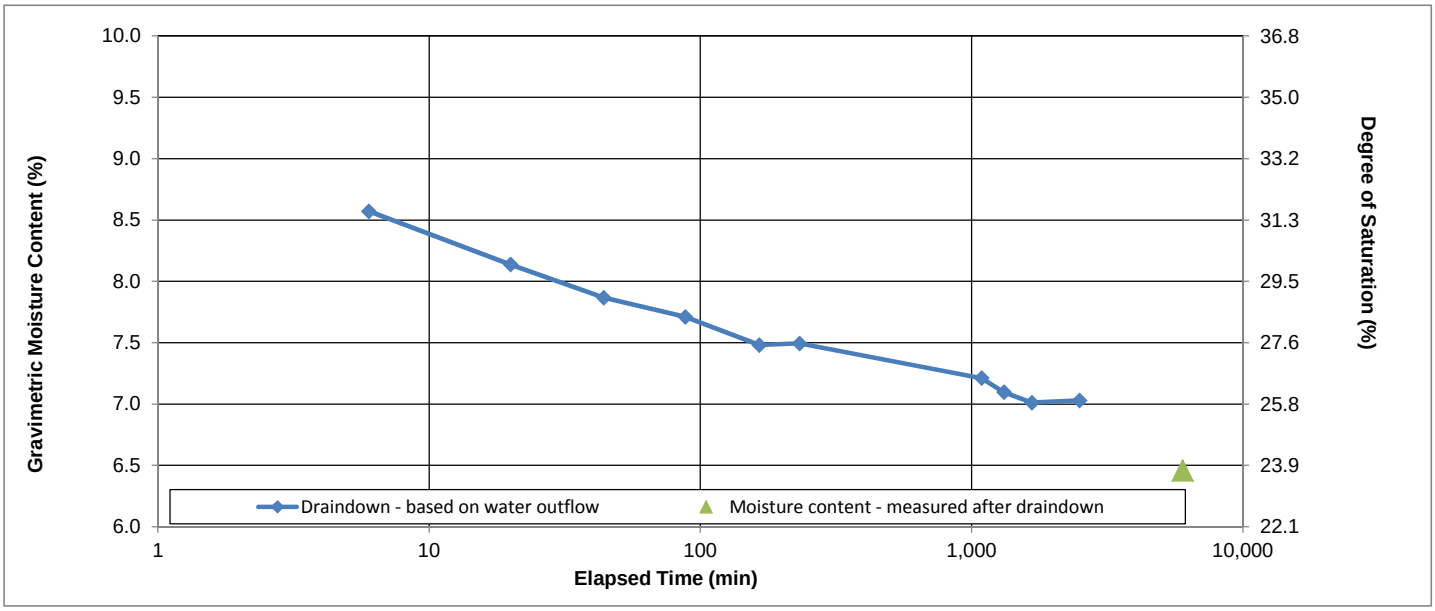
TABLE E.10

CASINO MINING CORPORATION
CASINO PROJECT

LOAD - PERCOLATION TEST
MET-05 DRAINDOWN DATA FOR 800 kPa, 12 l/hr/m2

Initial wet wt (lbs)	19.190	Consolidated Height (inch)	6.487
Initial wet wt. (g)	8704.392	Final vol. (ft^3)	0.190
Initial dry wt. (lbs)	18.315	Final dry density (pcf) at 100 kPa	96.6
Initial dry wt. (g)	8307.501	Final dry density (kg/m3) at 100 kPa	1547.0
Initial moisture wt. (kg)	396.891	Specific Gravity (-)	2.667
Initial MC (%)	4.78	Void Ratio (-)	0.724
Initial vol. (ft^3)	0.214		
Initial dry density (pcf)	85.7		
Flow rate (ml/min)	6.0		

Elapsed Time (min)	Outflow Mass	Change in Mass	Theoretical Sample Mass	Gravimetric Moisture Content	Degree of Saturation
(min)	(g)	(g)	(g)	(%)	(%)
0	3809	0.00	9057.54	9.0	33.26
6	3847	38.00	9019.54	8.6	31.57
20	3883	74.00	8983.54	8.1	29.98
44	3905.5	96.50	8961.04	7.9	28.98
88	3918.5	109.50	8948.04	7.7	28.40
165	3937.5	128.50	8929.04	7.5	27.56
232	3936.5	127.50	8930.04	7.5	27.60
1089	3960	151.00	8906.54	7.2	26.56
1316	3969.5	160.50	8897.04	7.1	26.14
1668	3976.5	167.50	8890.04	7.0	25.83
2498	3975	166.00	8891.54	7.0	25.90
ACTUAL MASS - MEASURED AFTER DRAINDOWN			8844.10	6.5	23.79



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NOTES:

1. Laboratory analyses performed at Knight Piésold and Co. Soils Laboratory in Denver, CO.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	14FEB'14	ISSUED WITH REPORT VA101-325/16-2	JDB	SB1	GRG

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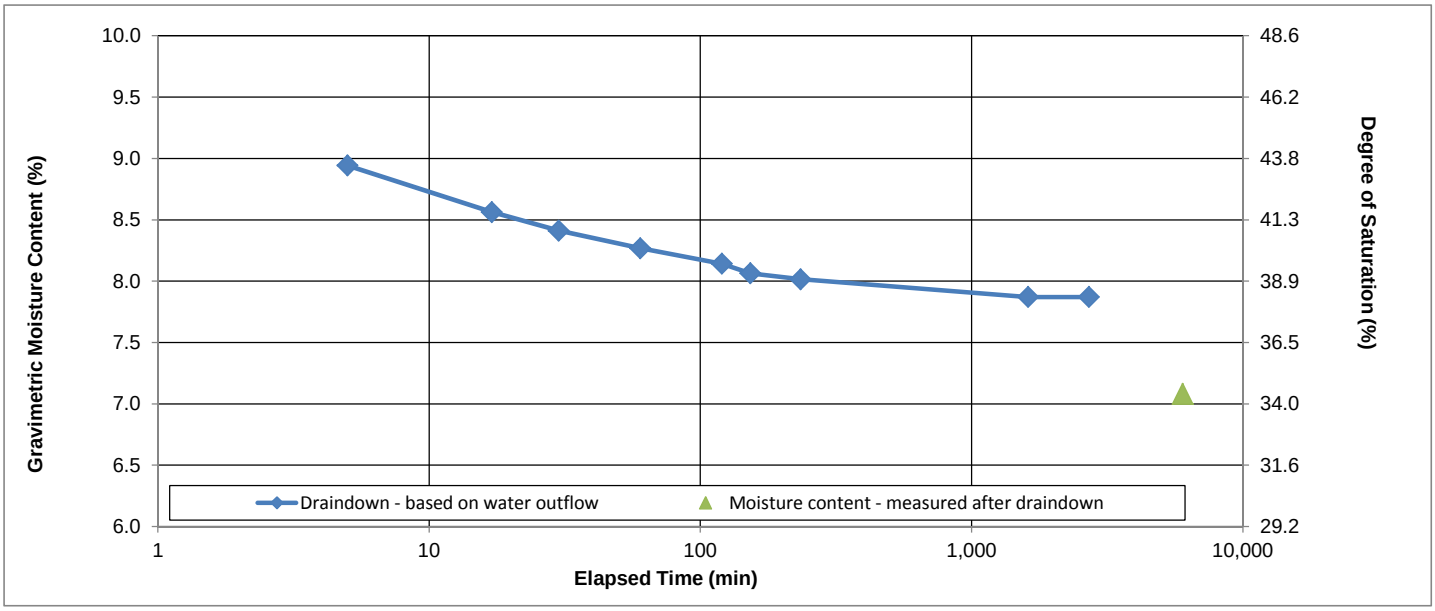
TABLE E.11

CASINO MINING CORPORATION
CASINO PROJECT

LOAD - PERCOLATION TEST
MET-05 DRAINDOWN DATA FOR 2760 kPa, 12 l/hr/m2

Initial wet wt (lbs)	19.190	Consolidated Height (inch)	5.827
Initial wet wt. (g)	8704.392	Final vol. (ft^3)	0.170
Initial dry wt. (lbs)	18.315	Final dry density (pcf) at 100 kPa	107.5
Initial dry wt. (g)	8307.501	Final dry density (kg/m3) at 100 kPa	1722.2
Initial moisture wt. (kg)	396.891	Specific Gravity (-)	2.667
Initial MC (%)	4.78	Void Ratio (-)	0.549
Initial vol. (ft^3)	0.214		
Initial dry density (pcf)	85.7		
Flow rate (ml/min)	6.0		

Elapsed Time (min)	Outflow Mass	Change in Mass	Theoretical Sample Mass	Gravimetric Moisture Content	Degree of Saturation
(min)	(g)	(g)	(g)	(%)	(%)
0	1464.5	0.00	9079.40	9.3	45.17
5	1493.5	29.00	9050.40	8.9	43.48
17	1525	60.50	9018.90	8.6	41.63
30	1537.5	73.00	9006.40	8.4	40.90
60	1549.5	85.00	8994.40	8.3	40.20
120	1560	95.50	8983.90	8.1	39.58
153	1566.5	102.00	8977.40	8.1	39.20
234	1570.5	106.00	8973.40	8.0	38.97
1614	1582.5	118.00	8961.40	7.9	38.27
2703	1582.5	118.00	8961.40	7.9	38.27
ACTUAL MASS - MEASURED AFTER DRAINDOWN			8895.80	7.1	34.43



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NOTES:

1. Laboratory analyses performed at Knight Piésold and Co. Soils Laboratory in Denver, CO.

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0	14FEB'14	ISSUED WITH REPORT VA101-325/16-2	JDB	SB1	GRG

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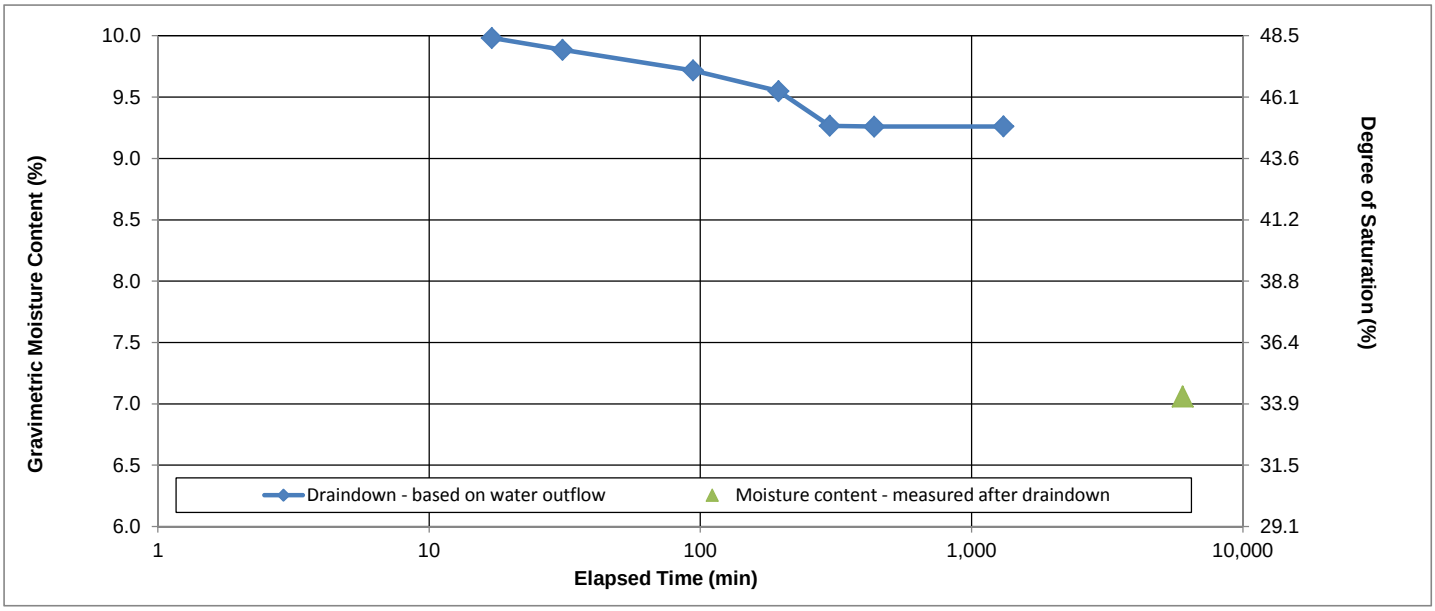
TABLE E.12

CASINO MINING CORPORATION
CASINO PROJECT

LOAD - PERCOLATION TEST
MET-05 DRAINDOWN DATA FOR 2760 kPa, 120 l/hr/m2

Initial wet wt (lbs)	19.190	Consolidated Height (inch)	5.833
Initial wet wt. (g)	8704.392	Final vol. (ft^3)	0.171
Initial dry wt. (lbs)	18.315	Final dry density (pcf) at 100 kPa	107.4
Initial dry wt. (g)	8307.501	Final dry density (kg/m3) at 100 kPa	1720.4
Initial moisture wt. (kg)	396.891	Specific Gravity (-)	2.667
Initial MC (%)	4.78	Void Ratio (-)	0.550
Initial vol. (ft^3)	0.214		
Initial dry density (pcf)	85.7		
Flow rate (ml/min)	6.0		

Elapsed Time (min)	Outflow Mass	Change in Mass	Theoretical Sample Mass	Gravimetric Moisture Content	Degree of Saturation
(min)	(g)	(g)	(g)	(%)	(%)
0	7648.1	0.00	9192.81	10.7	51.66
17	7704.1	56.00	9136.81	10.0	48.39
31	7712.1	64.00	9128.81	9.9	47.92
94	7726.1	78.00	9114.81	9.7	47.11
194	7740.1	92.00	9100.81	9.5	46.29
300	7763.6	115.50	9077.31	9.3	44.92
437	*7764.1*	116.00	9076.81	9.3	44.89
1311	7764	115.90	9076.91	9.3	44.90
ACTUAL MASS - MEASURED AFTER DRAINDOWN			8894.10	7.1	34.23



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NOTES:

1. Laboratory analyses performed at Knight Piésold and Co. Soils Laboratory in Denver, CO.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	14FEB'14	ISSUED WITH REPORT VA101-325/16-2	JDB	SB1	GRG

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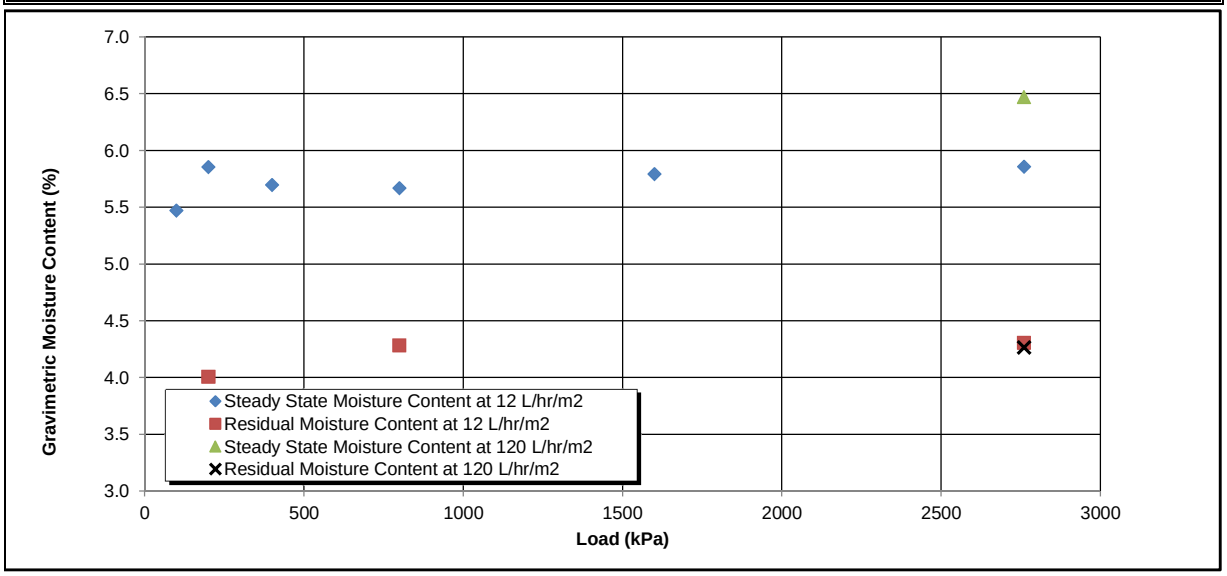
TABLE E.13

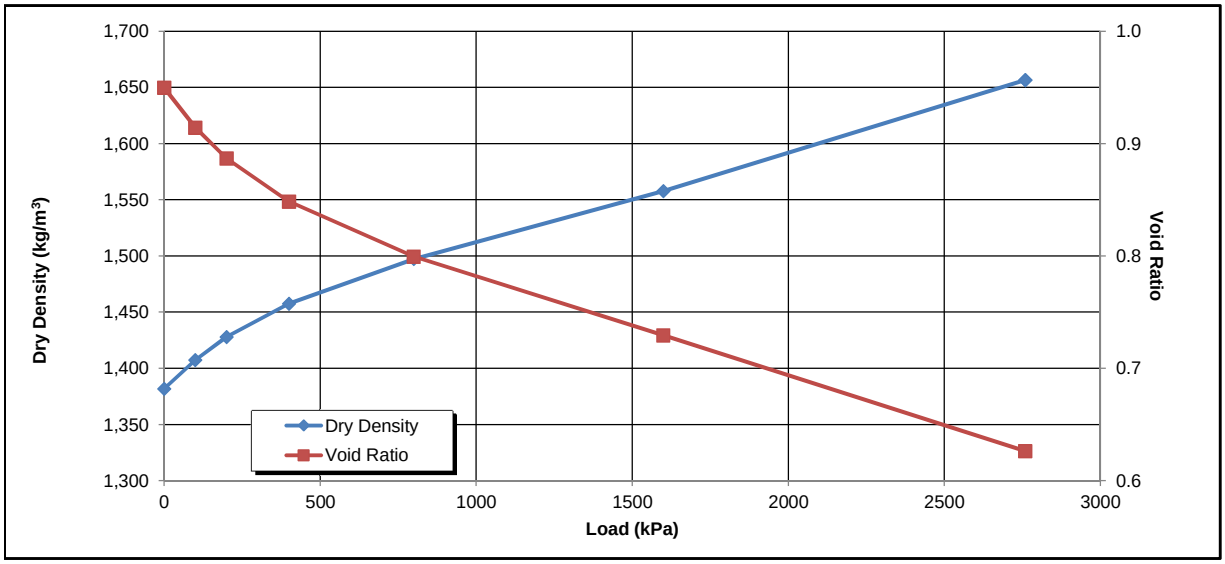
CASINO MINING CORPORATION
CASINO PROJECT

LOAD - PERCOLATION TEST
RESULTS SUMMARY FOR MET-11

Print Feb/14/14 14:04:28

Load	Dry Density	Dry Density	Void Ratio	Irrigation Rate	Steady State Moisture Content under Irrigation	Degree of Saturation	Residual Moisture Content
(kPa)	(pcf)	(kg/m^3)		($L/hr/m^2$)	(weight %)	(%)	(weight %)
0	86.26	1381.8	0.95	12			
100	87.86	1407.4	0.91	12	5.5	16.1	
200	89.14	1427.9	0.89	12	5.9	17.8	4.0
400	90.99	1457.5	0.85	12	5.7	18.1	
800	93.47	1497.2	0.80	12	5.7	19.1	4.3
1600	97.25	1557.8	0.73	12	5.8	21.4	
2760	103.42	1656.6	0.63	12	5.9	25.2	4.3
2760	103.42	1656.6	0.63	120	6.5	27.8	4.3





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NOTES:

1. Laboratory analyses performed at Knight Piésold and Co. Soils Laboratory in Denver, CO.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	14FEB'14	ISSUED WITH REPORT VA101-325/16-2	JDB	SB1	GRG

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TABLE E.14

CASINO MINING CORPORATION
CASINO PROJECT

LOAD - PERCOLATION TEST
RESULTS FOR MET-11

Project	Casino	Project No.	VA101-00325/16
Sample No.		Lab No.	L2013-084
Sample ID	MET-11	Task No.	
Description		Tested by	DAB
		Date:	05/11/2013

	US		Moisture Content Data	Initial	Final		
Depth to Bot. of Mold, in./cm	8.9					Mold Dia., in.	8.02
Depth to Plate, in./cm	1.467		Tare ID			Mold Area, in^2	50.517
Sample Height, in./cm	7.433		Wet Soil+Tare	7892.5	11640.5	Sample Vol., ft^3	0.2173
			Dry Soil + Tare	7789	11333	Initial Wet Density, pcf	88.0
Initial Moisture Content, %	1.467	Sample mass. g	Tare	2781	2849.5	Initial Dry Density, pcf	86.3
Initial Sample Wet Wt., g/lbs.	19.132	8678.1	Moist Content.%	2.067	3.625	Target Dry Density, pcf	NA
Dry Sample Wt.lbs	18.745	8502.3				Specific Gravity	2.694

					Inflow/outflow							
Date	Normal Load and Irrigation Rate	Time Start	Time Stop	Inflow Irrigation Tank g	Change in mass in g	Outflow Effluent Tank g	Change in mass out g	Difference in/out g	Cumulative Total water in g	Theoretical Sample mass g	Actual Sample Mass g	Gravimetric Moisture Cont. %
05/11/2013	100kPa	9:05		8754		725.5						
	12 l/hr/m2		16:10	5095	3659	4095	3369.5	289.5	289.5	8967.6		5.5
06/11/2013	200kPa	10:26		8768		729						
			11:48	8186	582	1278.5	549.5	32.5	322.0	9000.1		5.9
	Drain Down	11:51				1377						
07/11/2013			12:00			1405	28	-28	294.0	8972.1		
Measured after Draindown									165.1		8843.2	4.0
11/11/2013	400kPa	7:13		8178		1403.5						
			15:54	4844	3334	4594	3190.5	143.5	308.6	8986.7		5.7
12/11/2013	800kPa	11:40		6252		3240						
			15:46	4594	1658	4897	1657					
13/11/2013	refill	8:17		8000		1259						
			9:23	7548	452	1714.5	455.5	-2.5	306.1	8984.2		5.7
	Drain Down	9:23				1775.5						
14/11/2013			12:05			1871	95.5	-95.5	210.6	8888.7		
Measured after Draindown									188.7		8866.8	4.3
14/11/2013	1600kPa	12:21		7510		1871						
			17:08	5780	1730	3467	1596	134				
15/11/2013	refill			8528		907						
				7440	1088	2001	1094	128	316.7	8994.8		5.8
	2760kPa	12:18		7398		2048						
			16:39	5784	1614	3651	1603					
18/11/2013	refill	11:00		7692		1746						
			13:16	6630	1062	2813.5	1067.5	5.5	322.2	9000.3		5.9
	Drain Down	13:20				2895						
20/11/2013			15:23			2988	93	-93	229.2	8907.3		
Measured after Draindown									190.5		8868.6	4.3
25/11/2013	2760kPa	7:01		16578		796						
	120 l/hr/m2		8:18	11896	4682	5294	4498	184	374.5	9052.6		6.5
	Drain Down	8:18				6568						
27/11/2013			16:42			6702.5	134.5	-134.5	240.0	8918.1		
Measured after Draindown									186.9		8865.0	4.3

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NOTES:
1. Laboratory analyses performed at Knight Piésold and Co. Soils Laboratory in Denver, CO.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	14FEB'14	ISSUED WITH REPORT VA101-325/16-2	JDB	SB1	GRG

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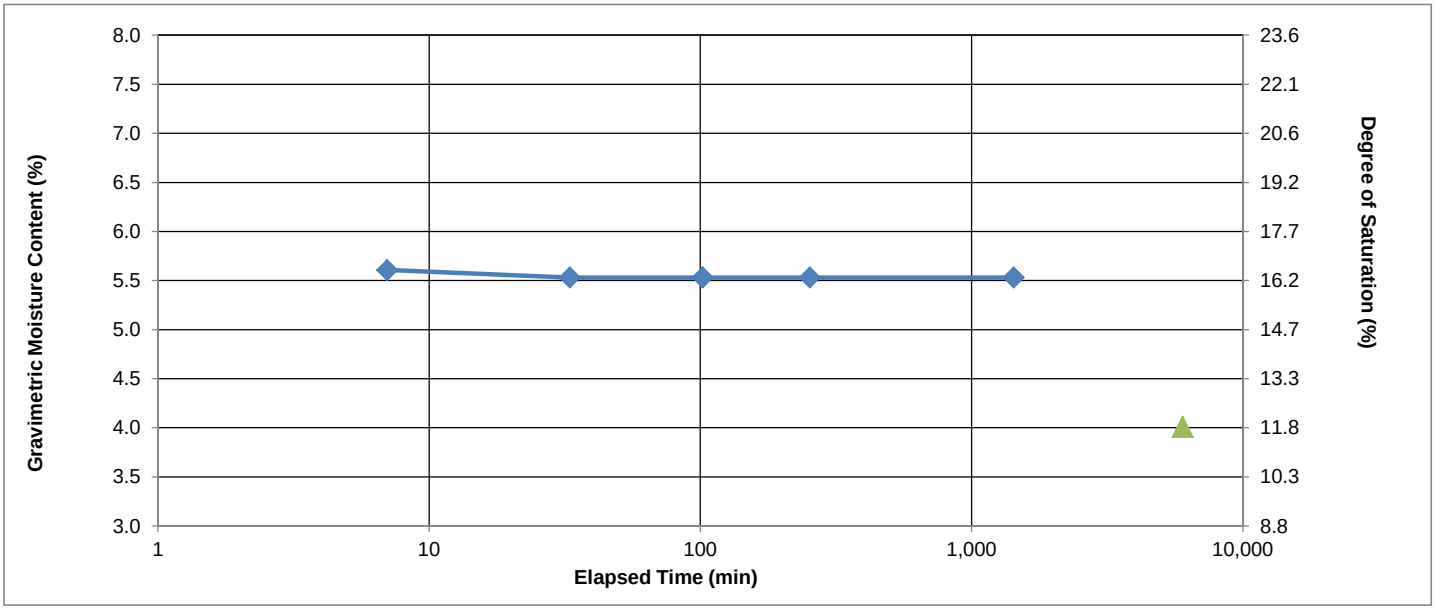
TABLE E.15

CASINO MINING CORPORATION
CASINO PROJECT

LOAD - PERCOLATION TEST
MET-11 DRAINDOWN DATA FOR 200 kPa, 12 l/hr/m2

Initial wet wt (lbs)	19.132	Consolidated Height (inch)	7.298
Initial wet wt. (g)	8678.084	Final vol. (ft^3)	0.213
Initial dry wt. (lbs)	18.745	Final dry density (pcf) at 100 kPa	87.9
Initial dry wt. (g)	8502.341	Final dry density (kg/m3) at 100 kPa	1407.3
Initial moisture wt. (kg)	175.743	Specific Gravity (-)	2.694
Initial MC (%)	2.07	Void Ratio (-)	0.914
Initial vol. (ft^3)	0.217		
Initial dry density (pcf)	86.3		
Flow rate (ml/min)	6.0		

Elapsed Time (min)	Outflow Mass	Change in Mass	Theoretical Sample Mass	Gravimetric Moisture Content	Degree of Saturation
(min)	(g)	(g)	(g)	(%)	(%)
0	1377.5	0.00	9000.08	5.9	17.25
7	1398.5	21.00	8979.08	5.6	16.52
33	1405	27.50	8972.58	5.5	16.30
102	1405	27.50	8972.58	5.5	16.30
253	1405	27.50	8972.58	5.5	16.30
1429	1405	27.50	8972.58	5.5	16.30
ACTUAL MASS - MEASURED AFTER DRAINDOWN			8843.20	4.0	11.81



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NOTES:

1. Laboratory analyses performed at Knight Piésold and Co. Soils Laboratory in Denver, CO.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	14FEB'14	ISSUED WITH REPORT VA101-325/16-2	JDB	SB1	GRG

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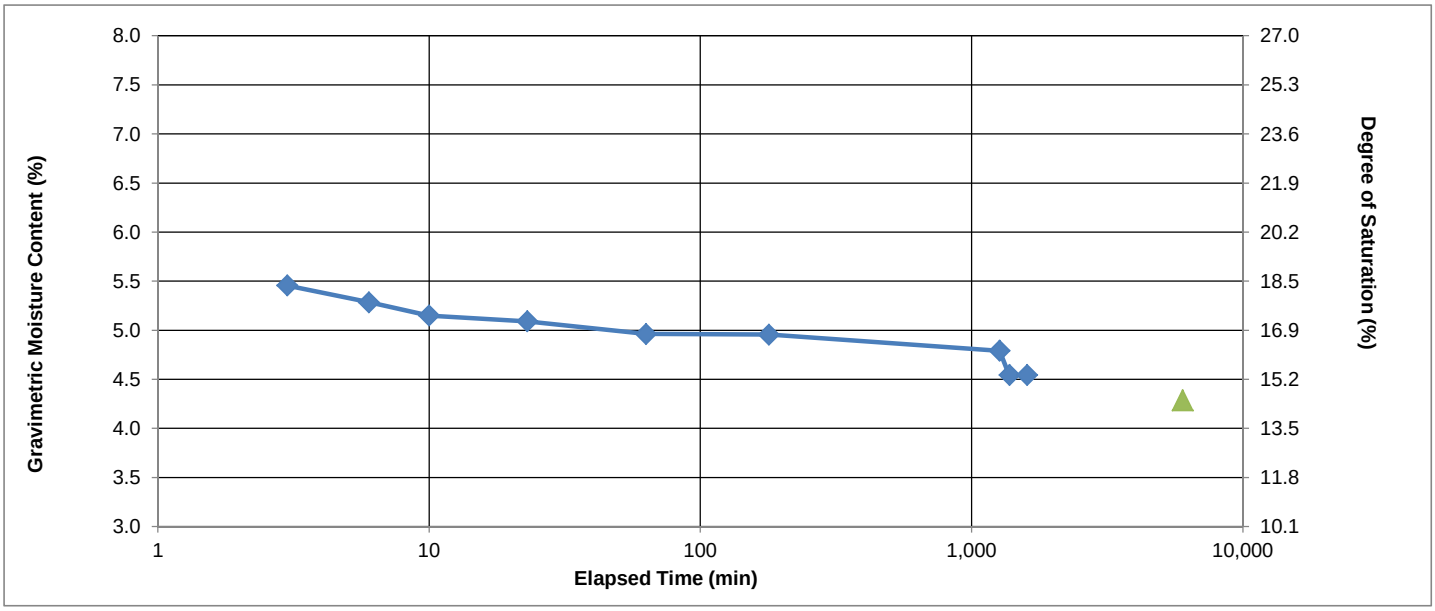
TABLE E.16

CASINO MINING CORPORATION
CASINO PROJECT

LOAD - PERCOLATION TEST
MET-11 DRAINDOWN DATA FOR 800 kPa, 12 l/hr/m2

Initial wet wt (lbs)	19.132	Consolidated Height (inch)	6.860
Initial wet wt. (g)	8678.084	Final vol. (ft^3)	0.201
Initial dry wt. (lbs)	18.745	Final dry density (pcf) at 100 kPa	93.5
Initial dry wt. (g)	8502.341	Final dry density (kg/m3) at 100 kPa	1497.2
Initial moisture wt. (kg)	175.743	Specific Gravity (-)	2.694
Initial MC (%)	2.07	Void Ratio (-)	0.799
Initial vol. (ft^3)	0.217		
Initial dry density (pcf)	86.3		
Flow rate (ml/min)	6.0		

Elapsed Time (min)	Outflow Mass	Change in Mass	Theoretical Sample Mass	Gravimetric Moisture Content	Degree of Saturation
(min)	(g)	(g)	(g)	(%)	(%)
0	1775.5	0.00	8984.20	5.7	19.10
3	1793.5	18.00	8966.20	5.5	18.39
6	1808	32.50	8951.70	5.3	17.81
10	1819.5	44.00	8940.20	5.1	17.36
23	1824.5	49.00	8935.20	5.1	17.16
63	1835.5	60.00	8924.20	5.0	16.72
179	1836	60.50	8923.70	5.0	16.70
1269	1850	74.50	8909.70	4.8	16.15
1379	1871	95.50	8888.70	4.5	15.31
1602	1871	95.50	8888.70	4.5	15.31
ACTUAL MASS - MEASURED AFTER DRAINDOWN			8866.78	4.3	14.45



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NOTES:

1. Laboratory analyses performed at Knight Piésold and Co. Soils Laboratory in Denver, CO.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	14FEB'14	ISSUED WITH REPORT VA101-325/16-2	JDB	SB1	GRG

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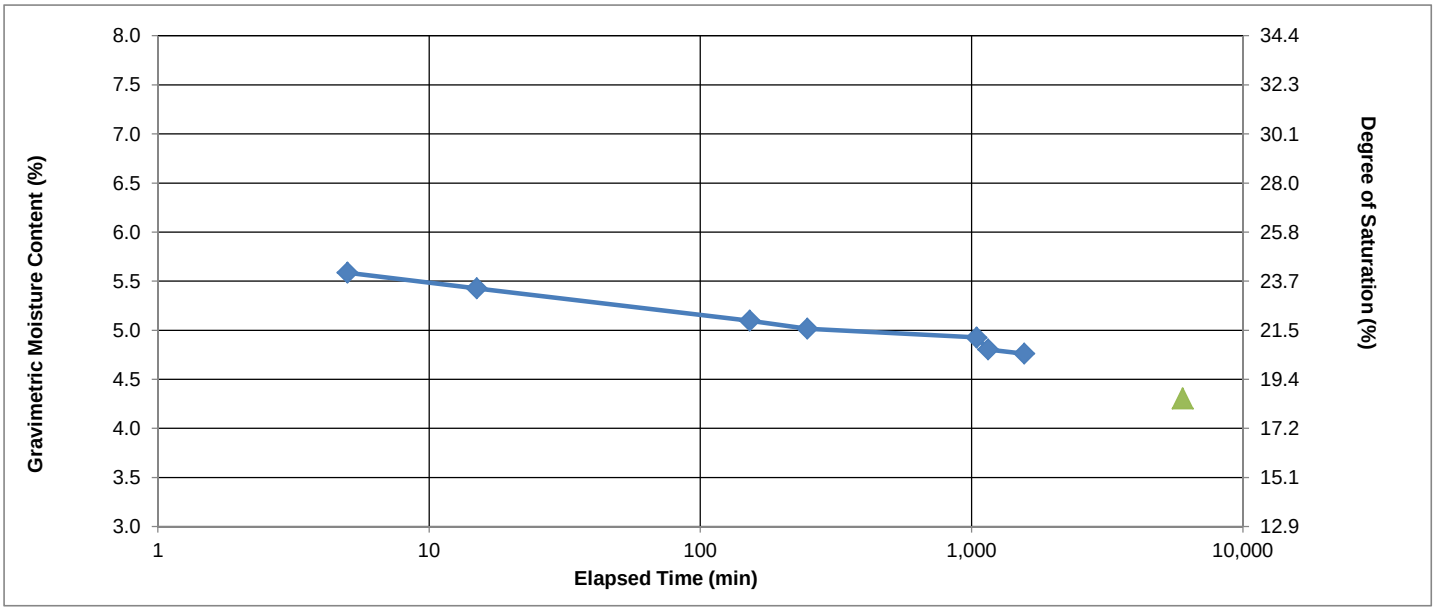
TABLE E.17

CASINO MINING CORPORATION
CASINO PROJECT

LOAD - PERCOLATION TEST
MET-11 DRAINDOWN DATA FOR 2760 kPa, 12 l/hr/m2

Initial wet wt (lbs)	19.132	Consolidated Height (inch)	6.200
Initial wet wt. (g)	8678.084	Final vol. (ft^3)	0.181
Initial dry wt. (lbs)	18.745	Final dry density (pcf) at 100 kPa	103.4
Initial dry wt. (g)	8502.341	Final dry density (kg/m3) at 100 kPa	1656.6
Initial moisture wt. (kg)	175.743	Specific Gravity (-)	2.694
Initial MC (%)	2.07	Void Ratio (-)	0.626
Initial vol. (ft^3)	0.217		
Initial dry density (pcf)	86.3		
Flow rate (ml/min)	6.0		

Elapsed Time (min)	Outflow Mass	Change in Mass	Theoretical Sample Mass	Gravimetric Moisture Content	Degree of Saturation
(min)	(g)	(g)	(g)	(%)	(%)
0	2895	0.00	9000.3	5.9	25.19
5	2918	23.00	8977.28	5.6	24.03
15	2931.5	36.50	8963.78	5.4	23.35
152	2959.5	64.50	8935.78	5.1	21.93
248	2966.5	71.50	8928.78	5.0	21.58
1044	2974	79.00	8921.28	4.9	21.20
1150	2984.5	89.50	8910.78	4.8	20.67
1563	2988	93.00	8907.28	4.8	20.49
ACTUAL MASS - MEASURED AFTER DRAINDOWN			8868.59	4.3	18.53



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NOTES:

1. Laboratory analyses performed at Knight Piésold and Co. Soils Laboratory in Denver, CO.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	14FEB'14	ISSUED WITH REPORT VA101-325/16-2	JDB	SB1	GRG

Knight Piésold CONSULTING

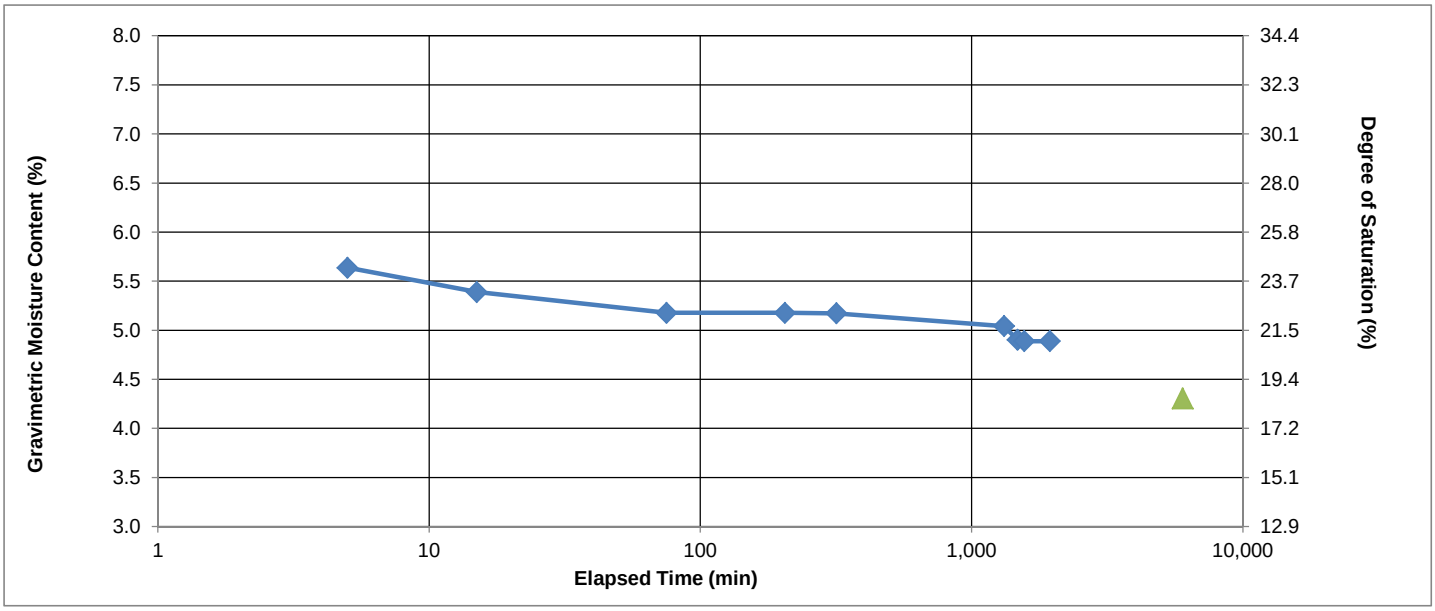
TABLE E.18

CASINO MINING CORPORATION
CASINO PROJECT

LOAD - PERCOLATION TEST
MET-11 DRAINDOWN DATA FOR 2760 kPa, 120 l/hr/m2

Initial wet wt (lbs)	19.132	Consolidated Height (inch)	6.200
Initial wet wt. (g)	8678.084	Final vol. (ft^3)	0.181
Initial dry wt. (lbs)	18.745	Final dry density (pcf) at 100 kPa	103.4
Initial dry wt. (g)	8502.341	Final dry density (kg/m3) at 100 kPa	1656.6
Initial moisture wt. (kg)	175.743	Specific Gravity (-)	2.694
Initial MC (%)	2.07	Void Ratio (-)	0.626
Initial vol. (ft^3)	0.217		
Initial dry density (pcf)	86.3		
Flow rate (ml/min)	60.0		

Elapsed Time (min)	Outflow Mass	Change in Mass	Theoretical Sample Mass	Gravimetric Moisture Content	Degree of Saturation
(min)	(g)	(g)	(g)	(%)	(%)
0	6568	0.00	9052.6	6.5	27.84
5	6639	71.00	8981.59	5.6	24.25
15	6660	92.00	8960.59	5.4	23.19
75	6678	110.00	8942.59	5.2	22.27
205	6678	110.00	8942.59	5.2	22.27
317	6678.5	110.50	8942.09	5.2	22.25
1317	6689.5	121.50	8931.09	5.0	21.69
1477	6701.5	133.50	8919.09	4.9	21.09
1565	6702.5	134.50	8918.09	4.9	21.04
1944	6702.5	134.50	8918.09	4.9	21.04
ACTUAL MASS - MEASURED AFTER DRAINDOWN			8864.96	4.3	18.52



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REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
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CASINO PROJECT

Column Leach Study on Lithology Composites

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October 2014

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1.0 INTRODUCTION

In October 2013, SGS E&S Engineering Solutions Inc. (SGS) submitted a proposal to Casino Mining Corporation for conducting a column leach study on lithology composite samples from the Casino Project. The metallurgical study was conducted at the SGS facility in Tucson, Arizona including the following scope of work:

- Sample Preparation and Head Sample Assays
- Cyanidation Bottle Roll Testing
- Cyanide Column Leach Testing
- Column Leach Test Residue Rinse Cycle Study

The main objective of the column leach study was to determine the amenability of the composite samples to gold and silver extractions by heap leach type of leaching process. The testing procedures utilized in this leach test program are standard leach procedures and are common and acceptable in industrial practice. The metallurgical study was conducted under the supervision of Rodrigo R. Carneiro, Director of Metallurgical Research.

2.0 SUMMARY

The column test program was conducted on three composite samples generated from the samples received from the Casino Project. The primary objective of this test program was to generate gold extraction, silver extraction, sodium cyanide and calcium oxide consumptions on the composite samples from the Casino Project. Cyanidation bottle roll tests were conducted at 100 percent minus 10 mesh sizes to evaluate the reagent consumption prior to the column leach testing.

The metallurgical data developed showed that approximately 62 percent and 83 percent of the gold contained in the head samples may be recovered by cyanide heap leach process. The data developed and metallurgical results obtained on this study are summarized in the following paragraphs.

2.1 Sample Preparation and Head Assays

Samples identified as MET-02, MET-05, MET-11, MET-17, MET-19 and MET-20 were received for metallurgical testing. See Appendix 1 for details on the samples received for metallurgical testing. Upon arrival the samples were logged in, blended to make three composite samples as listed below:

- Composite 1 (MET-02 / MET-05)
- Composite 2 (MET-11 / MET-17)
- Composite 3 (MET-19 / MET-20)

Each composite sample was processed using the standard operating procedures to prepare column test charges and samples for head screen assays. The head assay results obtained on the composite samples are summarized in the following table. Specific details on individual samples received for metallurgical testing, head sample preparation and assay results are discussed in Section 3.1 and Appendix 2. The following table summarizes the head assays on the composite samples.

Table 2.1
Summary of Head Assay Results

Sample ID	Au g/t	Ag g/t	Cu %	Fe %
Composite 1	0.27	0.85	0.01	1.65
Composite 2	0.54	2.70	0.05	2.24
Composite 3	0.63	2.77	0.07	5.12

The following comments relate to the head assay results developed on the three composite samples.

- Gold content ranged from approximately 0.27 g/t to 0.63 g/t. The highest gold content of 0.63 g/t was observed in Composite 3.

- Silver content ranged from approximately 0.85 g/t to 2.77 g/t. The highest silver content of 2.77 g/t was observed in Composite 3 sample.

- Low copper content was observed in all composite samples.

- Iron content ranged from approximately 1.65 percent to 5.12 percent. The highest iron content of 5.12 percent was observed in Composite 3.

2.2 Cyanidation Bottle Roll Testing on Composite Samples

Cyanidation bottle roll testing was conducted on each composite sample using a 1,000 gram test charge at 100 percent minus 10 mesh for 96 hours to evaluate cyanide and lime consumptions, and to determine lime dosage to be added to the test charge prior to the column loading.

The metallurgical data developed on the agitated cyanidation bottle roll testing on the composite samples are summarized in Table 2.2 below. Specific details relate to reagents additions, sampling schedule and mass balance are included in Section 3.2 and Appendix 3 in this report.

Table 2.2
Summary of Results
Bottle Roll Testing

Test No.	Sample ID	Assay Head			Calculated Head			% Extraction			Consumptions	
		Au (ppm)	Cu (ppm)	Ag (ppm)	Au (ppm)	Cu (ppm)	Ag (ppm)	Au (%)	Cu (%)	Ag (%)	NaCN (kg/t)	CaO (kg/t)
BR-01	Composite 1	0.270	72	0.8	0.255	147	0.9	80.40	11.52	20.71	0.293	2.701
BR-02	Composite 2	0.537	462	2.7	0.572	636	2.8	86.00	37.10	23.96	0.479	3.565
BR-03	Composite 3	0.627	729	2.8	0.642	854	3.0	82.86	7.45	29.58	0.130	4.180

The following comments relate to the metallurgical data obtained in the bottle roll tests on the three composite samples.

- Gold extraction ranged from approximately 80 percent to 86 percent. Composite 2 showed the highest gold extraction of 86.00 percent.

- Silver extraction ranged approximately from 21 percent to 30 percent. Composite 2 showed the highest silver extraction of 29.58 percent.

- Sodium cyanide consumption ranged from approximately 0.13 kg/t to 0.48 kg/t.

- Calcium oxide (lime) consumptions ranged from approximately 2.7 kg/t to 4.2 kg/t.

2.3 Open Cycle Column Leach Study

The open cycle column leach testing was conducted on the three composite samples prepared per instructions given by Casino Mining Corporation personnel. The column tests were conducted in 6 in x 10 ft PVC columns at the “as received” crush size. No crushing was conducted on the samples received for metallurgical testing.

Six column tests were conducted on three composite samples in duplicates and subjected to open cycle type of leach regime for 47 to 53 days followed by rinsing in open and closed cycle regimes for 44 to 79 days.

The feed solution containing approximately 700 mg/L of sodium cyanide and 300 mg/L of copper was used to leach the ore samples under open cycle type of leaching regime. Copper sulfate was added to feed solution to achieve the targeted concentration. The feed solution pH was maintained between 11 and 11.5 by adding reagent grade calcium oxide (CaO). The leaching parameters and test conditions are discussed in details in Section 3.3 in this report.

The summary of metallurgical results obtained from the column leach study on the composite samples after at least 104 days of leaching and rinsing cycles are presented in Table 2.3 below. Specific details relate to leaching conditions, solution assays, head and leach residue assays are included in Appendices 4 through 11 in this report.

Table 2.3
Summary of Locked Cycle Column Testing

Test No.	Sample ID.	Head Assay Screen (g/t)			Pregnant Solution pH	kl of Solution/t of Ore	Extraction (%)		Reagent Consumption (kg/t)	
		Au	Cu	Ag			Au	Ag	NaCN	CaO
		(g/t)	(g/t)	(g/t)						
CL-01	Composite 1	0.27	72.29	0.85	9.88	0.18	82.56	27.97	0.26	4.34
CL-02	Composite 1 Duplicate	0.27	72.27	0.85	9.85	0.19	81.90	27.78	0.20	4.18
CL-03	Composite 2	0.54	46.17	2.70	10.18	0.16	64.55	22.71	0.68	3.11
CL-04	Composite 2 Duplicate	0.54	46.19	2.70	10.23	0.16	62.31	16.63	0.44	3.10
CL-05	Composite 3	0.63	72.95	2.76	10.12	0.15	75.09	26.29	0.47	3.51
CL-06	Composite 3 Duplicate	0.63	72.95	2.77	10.39	0.15	73.28	26.01	0.19	3.38

The following comments relate to the column leach tests conducted on the three composite samples.

- Gold extraction on composite samples ranged from 62.31 percent to 82.56 percent. The highest gold extraction of approximately 83 percent was observed on the Composite 1 rinsed with re-circulating off solution.

- It seems that copper content in the feed solution did not have a significant impact on sodium cyanide consumption and gold extraction

- Silver extraction ranged from approximately 17 percent to 28 percent in all tests.

- Sodium cyanide consumption on the composite samples ranged from 0.19 kg/t to 0.68 kg/t.

- Calcium oxide (lime) consumption ranged from 3.10 kg/t to 4.34 kg/t.

- There is a good correlation of the gold and silver extractions between the duplicate column tests. See Appendices 4 through 10 for details on column leach mass balance and daily assays.

3.0 RESULTS AND DISCUSSIONS

The results of the head screen assays, agitated cyanidation bottle roll tests and column leach tests conducted on the composite samples tested are presented in the following paragraphs. Specific details related to leaching conditions and metallurgical data developed are included in Appendices 2 through 11 in this report.

3.1 Sample Preparation and Head Assay

In April 2014, six samples identified as MET-02, MET-05, MET-11, MET-17, MET-19 and MET-20 from the Casino Project were received for metallurgical testing. See Appendix 1 for samples received metallurgical testing. Upon arrival the samples were logged in and prepared according to the following steps:

- MET-02 and MET-05 samples were combined to generate Composite 1, MET-11 and MET-17 samples were combined to generate Composite 2 and MET-19 and MET-20 samples were combined to generate Composite 3.

- Each composite sample was air dried and screened using the 2 inch, 1-1/2 inch, 1 inch, 3/4 inch, 1/2 inch, 1/4 inch, 10 mesh and minus 10 mesh.

- Each screen fraction was weighed and the as received particle size distribution was calculated. Each screen fraction was kept segregated. See Appendix 2* for screen fraction weights and assay results.

- Two test charges of 89 kilograms for column testing and one test charge for head screen assays were reconstituted based on the “as received” particle size distribution.

- Each screen fraction from the head screen assays test charge was stage crushed to 100 percent minus 10 mesh. A sample of approximately 1,000 grams was split from each screen fraction, pulverized, and a portion of approximately 150 grams was split and submitted for gold, silver, copper, iron, cyanide soluble gold, cyanide soluble silver and cyanide soluble copper assays.

- A 1,000 gram sample was split from the minus 10 mesh fraction and submitted for wet/dry screen analysis using 14 mesh, 20 mesh, 28 mesh, 35 mesh, 48 mesh, 65 mesh, 100 mesh, 150 mesh, 200 mesh, 270 mesh and 400 mesh sieves.

- One pulverized composite of 1,000 grams was reconstituted from the pulverized fraction samples based on the “as received” particle size distribution, a portion was split and submitted for gold, silver, copper, iron, cyanide soluble gold, cyanide soluble silver and cyanide soluble copper assays.

- One 1,000 gram 100 percent minus 10 mesh test charge was prepared from the crushed (minus 10 mesh) head screen fraction samples based on the particle size distribution for agitated cyanide bottle roll testing.

Head screen assays on the composite samples for metallurgical testing are summarized in the following tables. Specific details relate to the screen fraction assays and size distributions are included in Appendix 2 in this report.

Table 3.1.1
Head Screen Assay on Composite 1
Summary of Results

SCREEN ANALYSIS			ANALYTICAL RESULTS							
NOMINAL OPENINGS			Au (g/t)		Ag (g/t)		Cu (%)		Fe (%)	
mm	Inch	Tyler Mesh	Assay	Distribution	Assay	Distribution	Assay	Distribution	Assay	Distribution
50.80	2	2"	0.460	3.46	1.200	2.88	0.022	6.18	1.700	2.09
38.10	1.500	1-1/2"	0.310	12.54	1.000	12.90	0.013	19.62	1.660	10.95
25.40	1.000	1"	0.260	11.55	0.900	12.76	0.004	6.63	1.780	12.90
19.05	0.750	3/4"	0.240	5.50	0.700	5.12	0.004	3.42	1.490	5.57
12.70	0.500	1/2"	0.230	7.01	0.700	6.81	0.006	6.83	1.480	7.36
6.35	0.250	1/4"	0.170	10.75	0.500	10.09	0.007	16.52	1.140	11.76
1.70	0.065	10	0.140	13.96	0.500	15.90	0.006	22.33	1.130	18.38
MINUS		-10	0.570	35.24	1.700	33.54	0.008	18.47	3.070	30.98
		TOTALS		**100.00**		**100.00**		**100.00**		**100.00**
		CALCULATED ASSAY	**0.270**		**0.846**		**0.007**		**1.654**	
COMPOSITE ASSAY (Pulverized)			**0.320**		**0.800**		**0.009**		**1.660**	

The following comments relate to the head assay results developed on the Composite1 sample.

- Gold content in screen fractions ranged from approximately 0.14 g/t to 0.57 g/t. The highest gold content of 0.57 g/t was observed in minus 10 mesh fraction. Calculated gold content for the overall sample is 0.27 g/t.

- Silver content in screen fractions ranged from approximately 0.5 g/t to 1.7 g/t. The highest silver content of 1.7 g/t was observed in minus 10 mesh fraction. Calculated silver content for the overall sample is 0.846 g/t.

- Low copper content was observed in all fractions. Calculated copper content for the overall sample was 0.007 percent.

- Iron content ranged from approximately 1.13 percent to 3.07 percent in the screen fractions. The highest iron content of 3.07 percent was observed in minus 10 mesh fraction. Calculated iron content for overall sample was 1.654 percent.

Table 3.1.2
Cyanide Soluble Gold, Silver and Copper Assays on Composite 1

SCREEN ANALYSIS			ANALYTICAL RESULTS					
NOMINAL OPENINGS			CN Soluble Au (g/t)		CN Soluble Ag (g/t)		CN Soluble Cu (%)	
mm	Inch	Tyler Mesh	Assay	Distribution	Assay	Distribution	Assay	Distribution
50.80	2	2"	0.340	2.48	0.990	2.85	0.005	2.55
38.10	1.500	1-1/2"	0.370	14.49	1.110	17.15	0.009	24.63
25.40	1.000	1"	0.310	13.33	0.850	14.43	0.006	18.04
19.05	0.750	3/4"	0.230	5.10	0.710	6.22	0.005	7.75
12.70	0.500	1/2"	0.150	4.43	0.670	7.80	0.004	8.25
6.35	0.250	1/4"	0.180	11.02	0.530	12.80	0.002	8.56
1.70	0.065	10	0.100	9.65	0.490	18.67	0.002	13.49
MINUS		-10	0.660	39.51	0.850	20.08	0.004	16.74
	TOTALS			**100.00**		**100.00**		**100.00**
CALCULATED ASSAY			**0.279**		**0.706**		**0.004**	
COMPOSITE ASSAY (Pulverized)			**0.230**		**0.710**		**0.004**	

The following comments relate to the cyanide soluble gold, cyanide soluble silver and cyanide soluble copper on Composite 1.

- Calculated cyanide soluble gold content is approximately 0.279 g/t. This indicates that the gold contained in the sample is soluble in cyanide.
- Calculated cyanide soluble silver content is approximately 0.706 g/t. This indicates that the silver contained in the sample is soluble in cyanide.
- Calculated cyanide soluble copper is 0.004 percent, therefore approximately 57 percent of the copper contained in the sample is soluble in cyanide.

Table 3.1.3
Head Screen Assay Results for Composite 2

SCREEN ANALYSIS			ANALYTICAL RESULTS							
NOMINAL OPENINGS			Au (g/t)		Ag (g/t)		Cu (%)		Fe (%)	
mm	Inch	Tyler Mesh	Assay	Distribution	Assay	Distribution	Assay	Distribution	Assay	Distribution
50.80	2	2"	0.460	6.04	2.700	7.06	0.036	5.50	2.150	6.76
38.10	1.500	1-1/2"	0.540	23.01	2.200	18.65	0.045	22.30	1.840	18.77
25.40	1.000	1"	0.510	28.13	2.600	28.53	0.034	21.81	2.110	27.87
19.05	0.750	3/4"	0.440	8.12	2.600	9.55	0.030	6.44	2.190	9.68
12.70	0.500	1/2"	0.460	7.42	2.200	7.06	0.062	11.64	2.220	8.58
6.35	0.250	1/4"	0.430	5.99	3.500	9.69	0.032	5.18	2.600	8.67
1.70	0.065	10	0.520	5.85	2.800	6.26	0.066	8.63	2.790	7.51
MINUS		-10	1.000	15.44	4.300	13.20	0.103	18.49	3.290	12.16
	TOTALS			**100.00**		**100.00**		**100.00**		**100.00**
CALCULATED ASSAY			**0.537**		**2.701**		**0.046**		**2.244**	
COMPOSITE ASSAY (Pulverized)			**0.550**		**2.700**		**0.051**		**2.330**	

The following comments relate to the head assay results developed on Composite 2.

- Gold content in screen fractions ranged from approximately 0.43 g/t to 1.00 g/t. The highest gold content of 1.00 g/t was observed in minus 10 mesh fraction. Calculated gold content for the overall sample is 0.537 g/t.

- Silver content in screen fractions ranged from approximately 2.2 g/t to 4.3 g/t. The highest silver content of 4.3 g/t was observed in minus 10 mesh fraction. Calculated silver content for the overall sample is 2.7 g/t.

- Copper content in screen fractions ranged from approximately 0.03 percent to 0.1 percent. The highest copper content of 0.1 percent was observed in minus 10 mesh fraction. Calculated copper content for the overall sample is 0.046 percent.

- Iron content ranged from approximately 1.84 percent to 3.29 percent in the screen fractions. The highest iron content of 3.29 percent was observed in minus 10 mesh fraction. Calculated iron content for overall sample is 2.244 percent.

Table 3.1.4
Cyanide Soluble Gold, Silver and Copper Assay Results for Composite 2

SCREEN ANALYSIS			ANALYTICAL RESULTS					
NOMINAL OPENINGS			CN Soluble Au (g/t)		CN Soluble Ag (g/t)		CN Soluble Cu (%)	
mm	Inch	ASTM	Assay	Distrib.	Assay	Distrib.	Assay	Distrib.
50.80	2	2"	0.410	5.74	2.160	6.79	0.020	6.94
38.10	1.500	1-1/2"	0.440	19.99	2.030	20.69	0.030	33.76
25.40	1.000	1"	0.480	28.24	2.320	30.61	0.017	24.77
19.05	0.750	3/4"	0.330	6.50	1.930	8.52	0.017	8.29
12.70	0.500	1/2"	0.410	7.06	2.270	8.76	0.018	7.67
6.35	0.250	1/4"	0.440	6.53	2.600	8.66	0.016	5.88
1.70	0.065	10	0.420	5.04	2.230	6.00	0.018	5.35
MINUS		-10	1.270	20.91	2.700	9.97	0.018	7.34
	TOTALS			**100.00**		**100.00**		**100.00**
CALCULATED ASSAY			**0.504**		**2.246**		**0.020**	
COMPOSITE ASSAY (Pulverized)			**0.530**		**2.700**		**0.018**	

The following comments relate to the cyanide soluble gold, cyanide soluble silver and cyanide soluble copper in Composite 2.

- Calculated cyanide soluble gold content in the Composite 2 was approximately 0.504 g/t. This indicates that approximately 94 percent of the gold contained in the sample is soluble in cyanide.

- Calculated cyanide soluble silver content was approximately 2.246 g/t. This indicates approximately 83 percent of the silver contained in the sample is soluble in cyanide.

- Calculated cyanide soluble copper is 0.020 percent, therefore approximately 43 percent of the copper contained in the sample is soluble in cyanide.

Table 3.1.5
Head Screen Assay Results for Composite 3

SCREEN ANALYSIS			ANALYTICAL RESULTS							
NOMINAL OPENINGS			Au (g/t)		Ag (g/t)		Cu (%)		Fe (%)	
mm	Inch	Tyler Mesh	Assay	Distribution	Assay	Distribution	Assay	Distribution	Assay	Distribution
50.80	2	2"	0.570	6.39	2.500	6.36	0.088	8.49	4.690	6.44
38.10	1.500	1-1/2"	0.490	18.98	2.600	22.86	0.074	24.66	4.780	22.68
25.40	1.000	1"	0.590	22.16	2.200	18.75	0.068	21.97	5.380	24.75
19.05	0.750	3/4"	0.570	10.08	2.500	10.03	0.069	10.50	4.860	10.53
12.70	0.500	1/2"	0.560	9.11	3.300	12.19	0.056	7.84	4.460	8.89
6.35	0.250	1/4"	0.630	9.24	2.500	8.32	0.070	8.83	4.950	8.89
1.70	0.065	10	0.620	7.55	2.600	7.18	0.069	7.23	5.390	8.04
MINUS		-10	1.490	16.49	5.700	14.31	0.110	10.47	7.210	9.77
	TOTALS			**100.00**		**100.00**		**100.00**		**100.00**
CALCULATED ASSAY			**0.627**		**2.765**		**0.073**		**5.122**	
COMPOSITE ASSAY (Pulverized)			**0.770**		**2.700**		**0.078**		**4.810**	

The following comments relate to the head assay results developed on Composite 3.

- Gold content in screen fractions ranged from approximately 0.49 g/t to 1.49 g/t. The highest gold content of 1.49 g/t was observed in minus 10 mesh fraction. Calculated gold content for overall sample is 0.627 g/t.

- Silver content in screen fractions ranged from approximately 2.2 g/t to 5.7 g/t. The highest silver content of 5.7 g/t was observed in minus 10 mesh fraction. Calculated silver content for overall sample is 0.846 g/t.

- Copper content in screen fractions ranged from approximately 0.06 percent to 0.11 percent. The highest copper content of 0.11 percent was observed in minus 10 mesh fraction. Calculated copper content for the overall sample is 0.073 percent.

- Iron content ranged from approximately 4.46 percent to 7.21 percent in the screen fractions. The highest iron content of 7.21 percent was observed in minus 10 mesh fraction. Calculated iron content for the overall sample is 5.122 percent.

Table 3.1.6
Cyanide Soluble Gold, Silver and Copper Assay Results for Composite 3

SCREEN ANALYSIS			ANALYTICAL RESULTS					
NOMINAL OPENINGS			CN Soluble Au (g/t)		CN Soluble Ag (g/t)		CN Soluble Cu (%)	
mm	Inch	US Mesh	Assay	Distrib.	Assay	Distrib.	Assay	Distrib.
50.80	2	2"	0.510	4.99	2.650	6.55	0.015	7.02
38.10	1.500	1-1/2"	0.370	12.50	2.370	20.25	0.014	22.64
25.40	1.000	1"	1.210	39.64	3.020	25.02	0.016	25.09
19.05	0.750	3/4"	0.460	7.10	2.420	9.44	0.015	11.08
12.70	0.500	1/2"	0.530	7.52	3.300	11.85	0.014	9.51
6.35	0.250	1/4"	0.510	6.52	2.620	8.48	0.015	9.18
1.70	0.065	10	0.510	5.42	2.630	7.06	0.015	7.62
	MINUS	-10	1.690	16.31	4.650	11.35	0.017	7.85
	TOTALS			**100.00**		**100.00**		**100.00**
CALCULATED ASSAY			**0.719**		**2.845**		**0.015**	
COMPOSITE ASSAY (Pulverized)			**0.530**		**2.960**		**0.016**	

The following comments relate to the cyanide soluble gold, cyanide soluble silver and cyanide soluble copper in the Composite 3.

- Calculated cyanide soluble gold content is approximately 0.719 g/t. This indicates that the gold contained in the sample is soluble in cyanide.

- Calculated cyanide soluble silver content is approximately 2.845 g/t. This indicates that the silver contained in the sample is soluble in cyanide.

- Calculated cyanide soluble copper is 0.015 percent, therefore approximately 20 percent of the copper contained in the sample is soluble in cyanide.

3.2 Cyanidation Bottle Roll Testing on Composite Samples

Cyanidation bottle testing was conducted on a test charge of 1,000 grams at 100 percent minus 10 mesh for 96 hours with a pulp density of approximately 45 percent solids, using 760 mg/L of sodium cyanide, 300 mg/L of copper.

The pulp pH was maintained between 11.00 and 11.50 throughout the test duration. The objective of the bottle roll testing was to evaluate cyanide and lime consumptions on the composite samples tested, and determine lime dosage to be added to the test charge prior to the column loading.

The metallurgical data developed on the agitated cyanidation bottle roll testing on the composite samples are summarized in Table 3.2 below. Specific details relate to reagents additions, sampling schedule and mass balance are included in Appendix 3 in this report.

Table 3.2
Summary of Results
Bottle Roll Testing

Test No.	Sample ID	Assay Head			Calculated Head			% Extraction			Consumptions	
		Au (ppm)	Cu (ppm)	Ag (ppm)	Au (ppm)	Cu (ppm)	Ag (ppm)	Au (%)	Cu (%)	Ag (%)	NaCN (kg/t)	CaO (kg/t)
BR-01	**Composite 1**	0.270	72	0.8	0.255	147	0.9	80.40	11.52	20.71	0.293	2.701
BR-02	**Composite 2**	0.537	462	2.7	0.572	636	2.8	86.00	37.10	23.96	0.479	3.565
BR-03	**Composite 3**	0.627	729	2.8	0.642	854	3.0	82.86	7.45	29.58	0.130	4.180

The following comments relate to the metallurgical data obtained in the bottle roll tests on Composite 1, Composite 2 and Composite 3 samples.

- Gold extraction ranged from approximately 80 percent to 86 percent. Composite 2 showed the highest gold extraction of 86 percent.
- Silver extraction ranged approximately from 21 percent to 30 percent.
- Sodium cyanide consumption ranged from 0.13 kg/t to 0.48 kg/t.
- Calcium oxide consumptions ranged from 2.7 kg/t to 4.2 kg/t.

3.3 Open Cycle Column Leach Testing

The column tests were conducted inside 6 inches in diameter by 10 feet height PVC columns using 89 kg test charges prepared from the composite samples. Approximately 70 percent of the calcium oxide consumption obtained in the bottle roll testing was added to the test charges prior to the column loading. The following table summarizes composite samples identification, leach cycle, rinse cycle and drain cycle durations.

Table 3.3.1
Leach and Rinse Cycle Periods

Test No.	Sample ID.	Leach Cycle (Days)	Recirculation[1] (Days)	Open[2] Cycle Rinse (Days)	Drain Cycle (Days)	Total Cycle (Days)
CL-01	COMPOSITE 1	47	44	2	3	142
CL-02	COMPOSITE 1 Dupl.	47	-	79	3	208
CL-03	COMPOSITE 2	53	56	2	3	172
CL-04	COMPOSITE 2 Dupl.	53	-	73	3	202
CL-05	COMPOSITE 3	53	56	2	3	172
CL-06	COMPOSITE 3 Dupl.	53	-	73	3	202

Remarks: (1) Daily off solution was re-circulated back to the feed solution.
(2) Tucson tap water was used for open cycle rinse.

The six column tests were conducted on three composite samples in duplicates and subjected to open cycle type of leach regime for 47 to 53 days using the below test conditions followed by rinsing in open and closed cycle regimes for 44 to 79 days.

The following leaching parameters and test conditions were common to the column leach tests conducted on the three composite samples:

- Approximately 70 percent of the calcium oxide (lime) consumption determined on each composite sample in the 96 hour bottle roll testing was added to each test charge and blended prior to loading in the columns.

- The feed solutions were prepared by adding reagent grade calcium oxide to de-ionized water to obtain a solution pH of 11.00 to 11.50 range followed by the addition of 750 mg of sodium cyanide and 300 mg of copper as copper sulfate per liter of solution. The columns were irrigated at a flow rate of 9.78 liters per hour per square meter.

- Pregnant leach solution samples were collected on daily basis and submitted for WADCN, gold, silver and copper assays. Free sodium cyanide and calcium oxide were also determined on the daily pregnant solution samples.

- Column tests were subjected to open cycle type of leaching regime for 47 days on CL-01 and CL-02 and 53 days on CL-03 through CL-06 followed by rinsing in open and closed cycles.

- At the end of the leach cycle, CL-01, CL-03 and CL-05 were set under locked cycle rinse regime by re-circulating the daily off solutions back to the feed solution after obtaining 1 liter of solution sample for WADCN analysis. Re-circulating rinse cycle lasted for 44 to 56 days, or until run out of solutions.

- Tucson tap water was used for columns CL-02, CL-04 and CL-06 that were rinsed in open cycle for 73 to 79 days. Approximately 1 liter of the daily effluent solution was submitted for WAD CN analysis. Report for the WADCN analysis is included in Appendix 13 in this report.

- At week 2, 4, 6 & 8 during cyanide leach cycle and week 0.5, 2, 4, 6, 8 and 10 during rinse cycle, 6 samples from each column test were collected and submitted for environmental analysis. The environmental sample collection procedure provided by Lorax Environmental in included in Appendix 12 in this report.

- Per instructions received from Casino Mining Corporation, approximately 25 kilograms and 15 kilograms of wet leached residue samples were split and submitted to for geotechnical and environmental studies respectively.

- Remaining wet residue samples were oven dried at 110 degree Celsius for 48 hours to determine moisture content. The dry leach residue was weighed and screened on the same suite of screens used in the head sample preparation stage and the fractions were kept segregated.

- Each individual screen fraction from the leach residue screen analysis was crushed to 100 percent minus 10 mesh utilizing laboratory jaw and cone crushers.

- A 1000 grams test charge were split out and approximately 150 grams was split out from each screen fraction and submitted for total gold and total silver by fire assay followed by atomic absorption finish and copper, iron assays. Cyanide soluble gold, cyanide soluble silver and cyanide soluble copper contents were also determined for each fraction.

- A 1,000 gram pulverized composite was prepared by reconstituting individual pulverized screen fractions based on the residue particle size distribution. A portion was split and submitted for total gold and total silver by fire assay followed by AA finish and copper, iron, cyanide soluble gold, cyanide soluble silver and cyanide soluble copper assay.

- As QA/QC the assay results for the pulverized residue composite was compared to the calculated residue assays of the individual pulverized screen fractions. Mass balance was conducted using the calculated assay results to determine the overall gold, silver and copper extractions.

- Gold, silver and copper extractions by screen fractions were also calculated based on the screen fraction results of the head and residue samples.

The summary of metallurgical results obtained from the column leach study on composite samples after at least 104 days of leaching and rinsing are presented in Table 3.3.2 below. Specific details relate to leaching conditions, solution assays, head and leach residue assays are included in Appendices 3 through 8 in this report.

Table 3.3.2
Locked Cycle Column Testing
Summary of Results

Composite Sample ID & Test No.	Metallurgical Products	Vol/Wt (l/kg)	Assays (ppm - g/t)			Extraction (%)			Reagent Consumption (kg/t)	
			Au	Cu	Ag	Au	Cu	Ag	NaCN	CaO
Composite 1 CL-01	Feed Solution	413.63	0.00	220	0.02	82.56	27.09	27.97	0.26	4.34
	Pregnant Solution	404.13	0.05	232	0.08					
	Leach Residue	88.82	0.04	92	0.66					
	Calculated Head (1)		0.25	125.79	0.92					
	Head Screen	88.92	0.27	72.29	0.85					
Composite 1 Duplicate CL-02	Feed Solution	553.08	0.00	107	0.00	81.90	14.92	27.78	0.20	4.18
	Pregnant Solution	542.24	0.04	111	0.04					
	Leach Residue	88.84	0.05	86	0.69					
	Calculated Head (1)		0.28	100.53	0.96					
	Head Screen	88.84	0.27	72.27	0.85					
Composite 2 CL-03	Feed Solution	474.45	0.04	312	0.12	64.55	32.30	22.71	0.68	3.11
	Pregnant Solution	468.00	0.10	349	0.27					
	Leach Residue	88.84	0.19	364	2.58					
	Calculated Head (1)		0.55	537.17	3.33					
	Head Screen	88.84	0.54	46.17	2.70					
Composite 2 Duplicate CL-04	Feed Solution	543.76	0.00	123	0.00	62.31	33.53	16.63	0.44	3.10
	Pregnant Solution	535.01	0.05	152	0.10					
	Leach Residue	88.80	0.20	317	2.97					
	Calculated Head (1)		0.52	476.58	3.56					
	Head Screen	88.80	0.54	46.19	2.70					
Composite 3 CL-05	Feed Solution	475.84	0.03	279	0.14	75.09	-9.61	26.29	0.47	3.51
	Pregnant Solution	469.28	0.11	272	0.34					
	Leach Residue	88.90	0.15	648	2.80					
	Calculated Head (1)		0.58	591.32	3.80					
	Head Screen	88.90	0.63	72.95	2.76					
Composite 3 Duplicate CL-06	Feed Solution	551.53	0.00	123	0.00	73.28	6.81	26.01	0.19	3.38
	Pregnant Solution	542.38	0.07	133	0.14					
	Leach Residue	88.88	0.15	701	2.45					
	Calculated Head (1)		0.57	752.68	3.31					
	Head Screen	88.88	0.63	72.95	2.77					

Remarks: (1) Metal Gold Content Extracted Plus Metal Content in Leach Residue Screen Fractions

The following comments relate to the open cycle column leach tests conducted on the three composite samples.

- Gold extraction on composite samples ranged from 62.31 percent to 82.56 percent. The highest gold extraction of approximately 83 percent was observed on the Composite 1 that the rinsed with re-circulating effluent solution.

- It seems that the copper content added to the feed solution did not have a significant impact on sodium cyanide consumption and gold extraction.

- Silver extraction ranged from approximately 17 percent to 28 percent.

- Sodium cyanide consumption on the composite samples ranged from 0.19 kg/t to 0.68 kg/t.

- Calcium oxide (lime) consumption ranged from 3.10 kg/t to 4.34 kg/t.

- There is a good correlation of the gold and silver extractions between the duplicate column tests.

3.4 Gold Extraction by Screen Fractions

Gold and silver extractions by fractions were calculated using the fraction weights, gold and silver assays of the head and leach residues screen fractions. The following table summarizes the gold extraction by screen fraction on the six column tests. Specific details relate to gold and silver extraction, and screen fraction degradation information are included in Appendices 4 through 9 in this report.

Table 3.4
Gold Extraction by Screen Fraction

Screen Fraction	Column Tests					
	CL-01	CL-02	CL-03	CL-04	CL-05	CL-06
2"	80.50	77.22	67.16	48.68	84.61	76.24
1-1/2"	63.32	81.75	36.87	55.54	76.17	70.84
1"	78.56	75.65	61.31	50.07	58.32	58.57
3/4"	83.21	77.14	58.24	51.19	67.09	79.20
1/2"	81.53	79.30	72.50	70.02	82.79	75.46
1/4"	88.83	77.07	86.19	80.50	87.43	84.82
10 mesh	85.57	67.19	85.08	82.64	87.01	83.92
-10 mesh	92.34	90.51	89.65	93.91	91.58	93.31
Overall Gold Extraction	**84.12**	**81.01**	**63.82**	**63.30**	**76.85**	**75.72**

The following comments relate to the gold extraction by screen fraction.

- Gold extractions ranged approximately from 37 percent to 94 percent in all fractions of the composites samples.

- In most column tests fractions finer than 1/4 inches showed more than 80 percent gold extraction.

- The minus 10 mesh fractions showed more than 90 percent gold extraction in all column tests.

- There is a good correlation between the gold extraction by screen fraction and gold extraction using the calculated head (see Table 3.3.2 above).

3.5 Column Rinse and Re-Circulation Stages

After conducting 47 to 53 days of open cycle type of leaching on CL-01, CL-03 and CL-05 tests, the three column tests were irrigated with the pregnant leach solutions collected from the last 7 days of the leach cycle. Daily effluent solutions from these columns were placed (re-circulated) in the feed solution reservoir after obtaining a daily one liter of sample for WADCN analysis. The objective of the effluent solution

re-circulation cycle was to observe natural degradation of the sodium cyanide contained in the leach solution.

The duplicate column tests, CL-02, CL-04 and CL-06, were rinsed with Tucson tap water after 47 to 53 days of open leach cycle and sampled on daily basis. One liter of daily effluent was collected and submitted for WADCN analysis.

Combined rinse solutions (60 liters) and combined pregnant solutions (60 liters) were shipped to ALS Laboratory in Vancouver for analysis per instructions received from personnel from Casino Mining Corporation.

3.6 Column Drain Down Data

Column drain down solutions volumes were recorded at the end of rinse cycle for 48 hours. Volumes were recorded every five minutes for the first one hour and every one hour for the next seven hours. Daily total drain solution volumes were also recorded and the cumulative drain down volumes were calculated and plotted in Appendix 10 in this report.

4.0 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations are based on the metallurgical data developed from the open cycle cyanide column leach testing and cyanide bottle roll testing conducted on three composite samples from the Casino Project.

4.1 COMPOSITE 1

The following comments relate to the column leach tests conducted on the Composite 1 sample .

- The composite sample contained approximately 0.27 g/t of gold and the gold contained in the sample is soluble cyanide soluble. After 47 days of leach and 46 to 82 days of rinse, approximately 82 percent of gold extraction was obtained in duplicate column tests.

- Silver content was at 0.85 g/t and approximately 83 percent of the silver contained in the sample is cyanide soluble. After 47 days of leach and 46 to 82 days of rinse cycles, approximately 28 percent of silver extraction was obtained.

- Sodium cyanide consumption ranged from 0.20 kg/t to 0.26 kg/t in the duplicate column tests.

- Calcium oxide (lime) consumption average approximately 4.26 kg/t for both column tests.

- Further column leach testing should be conducted at a crush size of 80 percent minus 3/8 inch to evaluate the impact on precious metal extraction.

4.2 COMPOSITE 2

The following comments relate to the column leach tests conducted on the Composite 2 sample.

- The composite sample contained approximately 0.54 g/t of gold and approximately 94 percent of the gold contained in the sample is soluble in cyanide. After 53 days of leach and 58 to 73 days of rinse, approximately 63 percent of gold extraction was obtained in duplicate column tests.

- Silver content was at 2.7 g/t and approximately 83 percent of the silver contained in the sample is soluble cyanide. After 53 days of leach and 58 to 73 days of rinse cycles, an average of approximately 20 percent of silver extraction was obtained in two columns.

- Sodium cyanide consumption was ranged from 0.44 kg/t to 0.68 kg/t in the duplicate column tests.

- Calcium oxide (lime) consumption averaged approximately 3.10 kg/t in both column tests.

- Further column leach testing should be conducted at a crush size of 80 percent minus 1/2 inch to evaluate the impact on precious metal extraction.

4.3 COMPOSITE 3

The following comments relate to the column leach tests conducted on the Composite 3 sample.

- The composite sample contained approximately 0.63 g/t of gold and the gold contained in the sample is soluble in cyanide. After 53 days of leach and 58 to 73 days of rinse, approximately 63 percent of gold extraction was obtained in duplicate column tests.

- Silver content was at 2.7 g/t and the silver contained in the sample is soluble in cyanide. After 53 days of leach and 58 to 73 days of rinse cycles, an average of approximately 26 percent of silver extraction was obtained in two columns.

- Sodium cyanide consumption was ranged from 0.19 kg/t to 0.47 kg/t in the duplicate column tests.

- Calcium oxide (lime) consumption averaged approximately 3.45 kg/t in both column tests.

- Further column leach testing should be conducted at a crush size of 80 percent minus 1/2 inch to evaluate the impact on precious metal extraction.

5.0 APPENDICES

Appendix 1 - Sample Log-In
Appendix 2 - As Received Screen Analysis and Assays
Appendix 3 - Cyanide BR Test Data
Appendix 4 - Column Leach Test CL-01 on Composite 1
Appendix 5 - Column Leach Test CL-02 on Composite 1 (Duplicate)
Appendix 6 - Column Leach Test CL-03 on Composite 2
Appendix 7 - Column Leach Test CL-04 on Composite 2 (Duplicate)
Appendix 8 - Column Leach Test CL-05 on Composite 3
Appendix 9 - Column Leach Test CL-06 on Composite 3 (Duplicate)
Appendix 10 - Drain Down Data for CL-01 to CL-06
Appendix 11 - Residue Screen Analysis and Assays
Appendix 12 - Lorax Environmental
Appendix 13 - WADCN Report of Analyses

APPENDIX 1

Sample Log-In

SGS E&S Engineering Solutions Inc.
SAMPLE LOG-IN FORM

Client	**Casino Project**		
Project Number	**M-709-03**	**Person's Name**	
Date Received		**Carrier/Shipper**	
Received By	**Salvador Gonzalez**	**Freight Number**	
Project Manager	**Rodrigo Carniero**	**Country of Origin**	**USA**

Sample Identiification		Net Weight	Unit	Container Type	Description	Comments
MET -17 KP		5.88	kg	Bucket	Delivery 1 - Bucket #01	
MET -17 KP	1/2"	3.70	kg	Bag	Delivery 1 - Bucket #01	
MET -17 KP	3/4"	9.34	kg	Bag	Delivery 1 - Bucket #01	
MET -17 KP	1"	25.14	kg	Bucket	Delivery 1 - Bucket #02	
#3 Proctor Rems	mix	28.72	kg	Bucket	Delivery 1 - Bucket #03	
#4 Proctor Rems	2"	3.06	kg	Bag	Delivery 1 - Bucket #04	
#4 Proctor Rems	1"	19.20	kg	Bucket	Delivery 1 - Bucket #04	
MET - 19KP	2"	3.54	kg	Bag	Delivery 1 - Bucket #06	
MET - 19KP	1"	21.88	kg	Bucket	Delivery 1 - Bucket #05	
MET - 19KP	3/4"	11.28	kg	Bag	Delivery 1 - Bucket #06	
MET - 19KP	1/2"	3.56	kg	Bag	Delivery 1 - Bucket #06	
Post Proctor Rems	mix	33.22	kg	Bucket	Delivery 1 - Bucket #07	
No Name	1-1/2"	24.12	kg	Bucket	Delivery 1 - Bucket #08	
MET-20KP Proctor Rems	mix	15.20	kg	Bucket	Delivery 1 - Bucket #09	
MET-20KP Proctor Rems	mix	30.64	kg	Bucket	Delivery 1 - Bucket #10	
MET-20KP Proctor Rems	1"	25.20	kg	Bucket	Delivery 1 - Bucket #11	
MET-20KP Proctor Rems	2"	1.40	kg	Bag	Delivery 1 - Bucket #12	
MET-20KP Proctor Rems	1-1/2"	25.18	kg	Bucket	Delivery 1 - Bucket #12	
KP MET-02 DBS	+2"	25.50	kg	Bucket	Delivery 3 - Bucket #01	
KP MET-02	+2"	16.84	kg	Bucket	Delivery 3 - Bucket #02	
Scraps	+2"	4.74	kg	Bag	Delivery 3 - Bucket #02	
South	-2"	1.00	kg	Bag	Delivery 3 - Bucket #02	
KP MET-02 (2.16) (1.77) 10/RH		161.30	g	Bag	Delivery 3 - Bucket #02	
KP MET-02 HP-4		59.13	g	Bag	Delivery 3 - Bucket #02	
KP MET-02 (2.16) RH		49.00	g	Bag	Delivery 3 - Bucket #02	
KP MET-02 (1.77) HP-4		59.14	g	Bag	Delivery 3 - Bucket #02	
KP MET-02 (1.77) RH		36.44	g	Bag	Delivery 3 - Bucket #02	
MET-05 DBS	-2"	26.66	kg	Bucket	Delivery 3 - Bucket #03	
MET - 05	-2"	9.36	kg	Bag	Delivery 3 - Bucket #04	
MET - 05	+2"	15.20	kg	Bucket	Delivery 3 - Bucket #04	
MET-05 South	-2"	884.50	g		Delivery 3 - Bucket #04	
KP MET-05 (1.48) (1.80) -10RH		176.60	g	Bag	Delivery 3 - Bucket #04	
KP MET-05 (180) HP-4		57.68	g	Bag	Delivery 3 - Bucket #04	
KP MET-05 (1.8) RH		45.17	g	Bag	Delivery 3 - Bucket #04	
KP MET-05 (1.48) HP-4		61.89	g	Bag	Delivery 3 - Bucket #04	
KP MET-05 (1.48) RH		59.06	g	Bag	Delivery 3 - Bucket #04	

SGS E&S Engineering Solutions Inc.
SAMPLE LOG-IN FORM

Client	**Casino Project**		
Project Number	**M-709-03**	**Person's Name**	
Date Received		**Carrier/Shipper**	
Received By	**Salvador Gonzalez**	**Freight Number**	
Project Manager	**Rodrigo Carniero**	**Country of Origin**	**USA**

Sample Identiification	Net Weight	Unit	Container Type	Description	Comments
MET-11 KP +2"	9.64	kg	Bucket	Delivery 3 - Bucket #05	
MET-11 KP -2"	4.50	kg	Bag	Delivery 3 - Bucket #05	
MET-11 KP -2"	6.90	kg	Bag	Delivery 3 - Bucket #05	
DBS MET-11 KP (1.93) HP-4	52.87	g	Bag	Delivery 3 - Bucket #05	
(1.66) HP-4	63.48	g	Bag	Delivery 3 - Bucket #05	
(1.66) RH	53.58	g	Bag	Delivery 3 - Bucket #05	
(1.93) RH	49.19	g	Bag	Delivery 3 - Bucket #05	
(1.66) (1.93) RH -10m	187.33	g	Bag	Delivery 3 - Bucket #05	
MET 11 DBS +2"	27.76	kg	Bucket	Delivery 3 - Bucket #06	

SGS E&S Engineering Solutions Inc.
SAMPLE LOG-IN FORM

Client	**Casino Project**		
Project Number	**M-709-03**	**Person's Name**	
Date Received		**Carrier/Shipper**	
Received By	**Salvador Gonzalez**	**Freight Number**	
Project Manager	**Rodrigo Carniero**	**Country of Origin**	**USA**

Sample Identiification		Net Weight	Unit	Container Type	Description	Comments
MET - 02	+1-1/2"	25.02	kg	Bucket	Delivery 2 - Bucket #44	
MET - 02	+1-1/2"	25.00	kg	Bucket	Delivery 2 - Bucket #45	
MET - 02	+1.0"	9.08	kg	Bucket	Delivery 2 - Bucket #46	
MET - 02	+1.0"	24.76	kg	Bucket	Delivery 2 - Bucket #47	
MET - 02	+3/4"	22.52	kg	Bucket	Delivery 2 - Bucket #48	
MET - 02	+1/4"	22.00	kg	Bucket	Delivery 2 - Bucket #49	
MET - 02	+1/2"	18.64	kg	Bucket	Delivery 2 - Bucket #50	
MET - 02	+10m	24.78	kg	Bucket	Delivery 2 - Bucket #51	
MET - 02	+10m	7.96	kg	Bucket	Delivery 2 - Bucket #54	
MET - 02	-10m	4.42	kg	Bucket	Delivery 2 - Bucket #52	
MET - 02	-10m	24.88	kg	Bucket	Delivery 2 - Bucket #53	
MET - 02	14m	103.37	g	Bag	Delivery 2 - Bucket #54	
MET - 02	20m	49.97	g	Bag	Delivery 2 - Bucket #54	
MET - 02	28m	44.23	g	Bag	Delivery 2 - Bucket #54	
MET - 02	35m	30.47	g	Bag	Delivery 2 - Bucket #54	
MET - 02	48m	26.85	g	Bag	Delivery 2 - Bucket #54	
MET - 02	65m	20.56	g	Bag	Delivery 2 - Bucket #54	
MET - 02	100m	18.22	g	Bag	Delivery 2 - Bucket #54	
MET - 02	150m	15.62	g	Bag	Delivery 2 - Bucket #54	
MET - 02	200m	14.76	g	Bag	Delivery 2 - Bucket #54	
MET - 02	270m	12.14	g	Bag	Delivery 2 - Bucket #54	
MET - 02	400m	10.10	g	Bag	Delivery 2 - Bucket #54	
MET - 02	-400m	103.64	g	Bag	Delivery 2 - Bucket #54	
MET - 05	+1-1/2"	7.44	kg	Bucket	Delivery 2 - Bucket #55	
MET - 05	+1.0"	8.70	kg	Bucket	Delivery 2 - Bucket #56	
MET - 05	+3/4"	12.28	kg	Bucket	Delivery 2 - Bucket #57	
MET - 05	+1/2"	17.52	kg	Bucket	Delivery 2 - Bucket #58	
MET - 05	+1/4"	21.68	kg	Bucket	Delivery 2 - Bucket #59	
MET - 05	+1/4"	24.46	kg	Bucket	Delivery 2 - Bucket #60	
MET - 05	+10m	24.64	kg	Bucket	Delivery 2 - Bucket #61	
MET - 05	+10m	26.74	kg	Bucket	Delivery 2 - Bucket #62	
MET - 05	-10m	30.52	kg	Bucket	Delivery 2 - Bucket #63	
MET - 05	+10m	5.08	kg	Bucket	Delivery 2 - Bucket #64	
MET - 05	14m	163.70	g	Bag	Delivery 2 - Bucket #64	
MET - 05	20m	77.44	g	Bag	Delivery 2 - Bucket #64	
MET - 05	28m	62.12	g	Bag	Delivery 2 - Bucket #64	
MET - 05	35m	40.67	g	Bag	Delivery 2 - Bucket #64	

SGS E&S Engineering Solutions Inc.
SAMPLE LOG-IN FORM

Client	**Casino Project**		
Project Number	**M-709-03**	**Person's Name**	
Date Received		**Carrier/Shipper**	
Received By	**Salvador Gonzalez**	**Freight Number**	
Project Manager	**Rodrigo Carniero**	**Country of Origin**	**USA**

Sample Identiification		Net Weight	Unit	Container Type	Description	Comments
MET - 05	48m	33.57	g	Bag	Delivery 2 - Bucket #64	
MET - 05	65m	24.35	g	Bag	Delivery 2 - Bucket #64	
MET - 05	100m	20.79	g	Bag	Delivery 2 - Bucket #64	
MET - 05	150m	16.03	g	Bag	Delivery 2 - Bucket #64	
MET - 05	200m	13.58	g	Bag	Delivery 2 - Bucket #64	
MET - 05	270m	10.04	g	Bag	Delivery 2 - Bucket #64	
MET - 05	400m	7.62	g	Bag	Delivery 2 - Bucket #64	
MET - 05	-400m	49.86	g	Bag	Delivery 2 - Bucket #64	

SGS E&S Engineering Solutions Inc.
SAMPLE LOG-IN FORM

Client	**Casino Project**		
Project Number	**M-709-03**	**Person's Name**	
Date Received		**Carrier/Shipper**	
Received By	**Salvador Gonzalez**	**Freight Number**	
Project Manager	**Rodrigo Carniero**	**Country of Origin**	**USA**

Sample Identiification		Net Weight	Unit	Container Type	Description	Comments
MET - 11	+1-1/2"	23.74	kg	Bucket	Delivery 2 - Bucket #24	
MET - 11	+1-1/2"	22.28	kg	Bucket	Delivery 2 - Bucket #25	
MET - 11	-1-1/2"	13.48	kg	Bucket	Delivery 2 - Bucket #26	
MET - 11	+ 1.0"	16.48	kg	Bucket	Delivery 2 - Bucket #27	
MET - 11	+ 1.0"	24.80	kg	Bucket	Delivery 2 - Bucket #28	
MET - 11	+3/4"	6.26	kg	Bucket	Delivery 2 - Bucket #29	
MET - 11	+3/4"	13.14	kg	Bucket	Delivery 2 - Bucket #30	
MET - 11	+1/2"	12.68	kg	Bucket	Delivery 2 - Bucket #31	
MET - 11	+1/4"	10.14	kg	Bucket	Delivery 2 - Bucket #32	
MET - 11	+10m	7.70	kg	Bucket	Delivery 2 - Bucket #33	
MET - 11	14m	84.58	g	Bag	Delivery 2 - Bucket #34	
MET - 11	20m	48.29	g	Bag	Delivery 2 - Bucket #34	
MET - 11	28m	47.35	g	Bag	Delivery 2 - Bucket #34	
MET - 11	35m	35.43	g	Bag	Delivery 2 - Bucket #34	
MET - 11	48m	32.31	g	Bag	Delivery 2 - Bucket #34	
MET - 11	65m	25.00	g	Bag	Delivery 2 - Bucket #34	
MET - 11	100m	22.12	g	Bag	Delivery 2 - Bucket #34	
MET - 11	150m	18.13	g	Bag	Delivery 2 - Bucket #34	
MET - 11	200m	17.70	g	Bag	Delivery 2 - Bucket #34	
MET - 11	270m	19.15	g	Bag	Delivery 2 - Bucket #34	
MET - 11	400m	24.61	g	Bag	Delivery 2 - Bucket #34	
MET - 11	-400m	125.06	g	Bag	Delivery 2 - Bucket #34	
MET -17	+1-1/2"	23.92	kg	Bucket	Delivery 2 - Bucket #12	
MET -17	+1-1/2"	1.76	kg	Bucket	Delivery 2 - Bucket #13	
MET - 17	+1-1/2"	22.76	kg	Bucket	Delivery 2 - Bucket #14	
MET - 17	+ 1.0"	23.50	kg	Bucket	Delivery 2 - Bucket #15	
MET - 17	+1.0"	23.66	kg	Bucket	Delivery 2 - Bucket #16	
MET - 17	+3/4"	17.30	kg	Bucket	Delivery 2 - Bucket #17	
MET - 17	+3/4"	8.72	kg	Bucket	Delivery 2 - Bucket #18	
MET - 17	+1/2"	14.12	kg	Bucket	Delivery 2 - Bucket #19	
MET - 17	+1/2"	3.06	kg	Bucket	Delivery 2 - Bucket #20	
MET - 17	+1/4"	15.88	kg	Bucket	Delivery 2 - Bucket #21	
MET - 17	+10m	13.96	kg	Bucket	Delivery 2 - Bucket #22	
MET - 17	-10m	15.10	kg	Bucket	Delivery 2 - Bucket #23	
MET - 17	14m	82.83	g	Bag	Delivery 2 - Bucket #23	
MET - 17	20m	53.58	g	Bag	Delivery 2 - Bucket #23	
MET - 17	28m	52.83	g	Bag	Delivery 2 - Bucket #23	

SGS E&S Engineering Solutions Inc.
SAMPLE LOG-IN FORM

Client	**Casino Project**		
Project Number	**M-709-03**	**Person's Name**	
Date Received		**Carrier/Shipper**	
Received By	**Salvador Gonzalez**	**Freight Number**	
Project Manager	**Rodrigo Carniero**	**Country of Origin**	**USA**

Sample Identiification		Net Weight	Unit	Container Type	Description	Comments
MET - 17	35m	39.93	g	Bag	Delivery 2 - Bucket #23	
MET - 17	48m	35.70	g	Bag	Delivery 2 - Bucket #23	
MET - 17	65m	26.76	g	Bag	Delivery 2 - Bucket #23	
MET - 17	100m	23.71	g	Bag	Delivery 2 - Bucket #23	
MET - 17	150m	18.88	g	Bag	Delivery 2 - Bucket #23	
MET - 17	200m	17.02	g	Bag	Delivery 2 - Bucket #23	
MET - 17	270m	13.28	g	Bag	Delivery 2 - Bucket #23	
MET - 17	400m	11.26	g	Bag	Delivery 2 - Bucket #23	
MET - 17	-400m	89.08	g	Bag	Delivery 2 - Bucket #23	

SGS E&S Engineering Solutions Inc.
SAMPLE LOG-IN FORM

Client	**Casino Project**		
Project Number	**M-709-03**	**Person's Name**	
Date Received		**Carrier/Shipper**	
Received By	**Salvador Gonzalez**	**Freight Number**	
Project Manager	**Rodrigo Carniero**	**Country of Origin**	**USA**

Sample Identiification		Net Weight	Unit	Container Type	Description	Comments
MET - 19	+1-1/2"	23.96	kg	Bucket	Delivery 2 - Bucket #01	
MET - 19	+1-1/2"	20.32	kg	Bucket	Delivery 2 - Bucket #02	
MET - 19	+1.0"	23.54	kg	Bucket	Delivery 2 - Bucket #03	
MET - 19	+ 1.0"	4.84	kg	Bucket	Delivery 2 - Bucket #10	
MET - 19	+ 1.0"	24.60	kg	Bucket	Delivery 2 - Bucket #11	
MET - 19	+3/4"	6.66	kg	Bucket	Delivery 2 - Bucket #08	
MET - 19	+3/4"	21.68	kg	Bucket	Delivery 2 - Bucket #09	
MET - 19	+1/2"	18.58	kg	Bucket	Delivery 2 - Bucket #04	
MET - 19	+1/4	16.24	kg	Bucket	Delivery 2 - Bucket #07	
MET - 19	+10m	12.96	kg	Bucket	Delivery 2 - Bucket #05	
MET - 19	-10 m	11.00	kg	Bucket	Delivery 2 - Bucket #06	
MET - 19	14m	107.49	g	Bag	Delivery 2 - Bucket #06	
MET - 19	20m	62.33	g	Bag	Delivery 2 - Bucket #06	
MET - 19	28m	59.74	g	Bag	Delivery 2 - Bucket #06	
MET - 19	35m	43.85	g	Bag	Delivery 2 - Bucket #06	
MET - 19	48m	39.29	g	Bag	Delivery 2 - Bucket #06	
MET - 19	65m	29.56	g	Bag	Delivery 2 - Bucket #06	
MET - 19	100m	26.38	g	Bag	Delivery 2 - Bucket #06	
MET - 19	150m	21.68	g	Bag	Delivery 2 - Bucket #06	
MET - 19	200m	20.35	g	Bag	Delivery 2 - Bucket #06	
MET - 19	270m	16.58	g	Bag	Delivery 2 - Bucket #07	
MET - 19	400m	14.57	g	Bag	Delivery 2 - Bucket #08	
MET - 19	-400m	86.60	g	Bag	Delivery 2 - Bucket #09	
MET - 20	+1-1/2"	21.00	kg	Bucket	Delivery 2 - Bucket #37	
MET - 20	+1-1/2"	24.86	kg	Bucket	Delivery 2 - Bucket #38	
MET - 20	+1.0"	24.08	kg	Bucket	Delivery 2 - Bucket #42	
MET - 20	+1.0"	21.04	kg	Bucket	Delivery 2 - Bucket #44	
MET - 20	+3/4"	9.26	kg	Bucket	Delivery 2 - Bucket #39	
MET - 20	+3/4"	18.50	kg	Bucket	Delivery 2 - Bucket #40	
MET - 20	+1/2"	19.20	kg	Bucket	Delivery 2 - Bucket #41	
MET - 20	+1/4"	17.70	kg	Bucket	Delivery 2 - Bucket #35	
MET - 20	+10m	14.20	kg	Bucket	Delivery 2 - Bucket #43	
MET - 20	-10m	14.10	kg	Bucket	Delivery 2 - Bucket #36	
MET - 20	14m	102.70	g	Bag	Delivery 2 - Bucket #43	
MET - 20	20m	59.58	g	Bag	Delivery 2 - Bucket #43	
MET - 20	28m	55.12	g	Bag	Delivery 2 - Bucket #43	
MET - 20	35m	39.49	g	Bag	Delivery 2 - Bucket #43	

SGS E&S Engineering Solutions Inc.
SAMPLE LOG-IN FORM

Client	**Casino Project**		
Project Number	**M-709-03**	**Person's Name**	
Date Received		**Carrier/Shipper**	
Received By	**Salvador Gonzalez**	**Freight Number**	
Project Manager	**Rodrigo Carniero**	**Country of Origin**	**USA**

Sample Identiification		Net Weight	Unit	Container Type	Description	Comments
MET - 20	48m	35.02	g	Bag	Delivery 2 - Bucket #43	
MET - 20	65m	26.69	g	Bag	Delivery 2 - Bucket #43	
MET - 20	100m	24.75	g	Bag	Delivery 2 - Bucket #43	
MET - 20	150m	20.80	g	Bag	Delivery 2 - Bucket #43	
MET - 20	200m	21.07	g	Bag	Delivery 2 - Bucket #43	
MET - 20	270m	21.18	g	Bag	Delivery 2 - Bucket #43	
MET - 20	400m	26.08	g	Bag	Delivery 2 - Bucket #43	
MET - 20	-400m	118.02	g	Bag	Delivery 2 - Bucket #43	

APPENDIX 2

As Received Screen Analysis and Assays

SGS Metcon / KD Engineering
SAMPLE DRY WEIGHT SUMMARY SHEET

Page Summary

Client	**Western Copper & Gold**	**Company Name**	**Western Copper & Gold**
Project Number	**M-709-03**	**Person's Name**	
Date Received		**Carrier/Shipper Name**	
Received By	**Salvador Gonzalez**	**Freight Number**	
Project Manager	**Natska Gantumur**	**Country of Origin**	**USA**

Sample Identification	Net Dry Weight	Unit	Available test charge (kg)	Column Size HxD (in)	Remarks
COMPOSITE-1 (MET-02 & MET-05)	386.84	kg	134+134+118	15ft x 6in	
COMPOSITE-2 (MET-11 & MET-17)	344.82	kg	134+134+76	15ft x 6in	
COMPOSITE-3 (MET-19 & MET-20)	368.37	kg	134+134+100	15ft x 6in	
Total Net Weight	**1100.03**	**kg**			

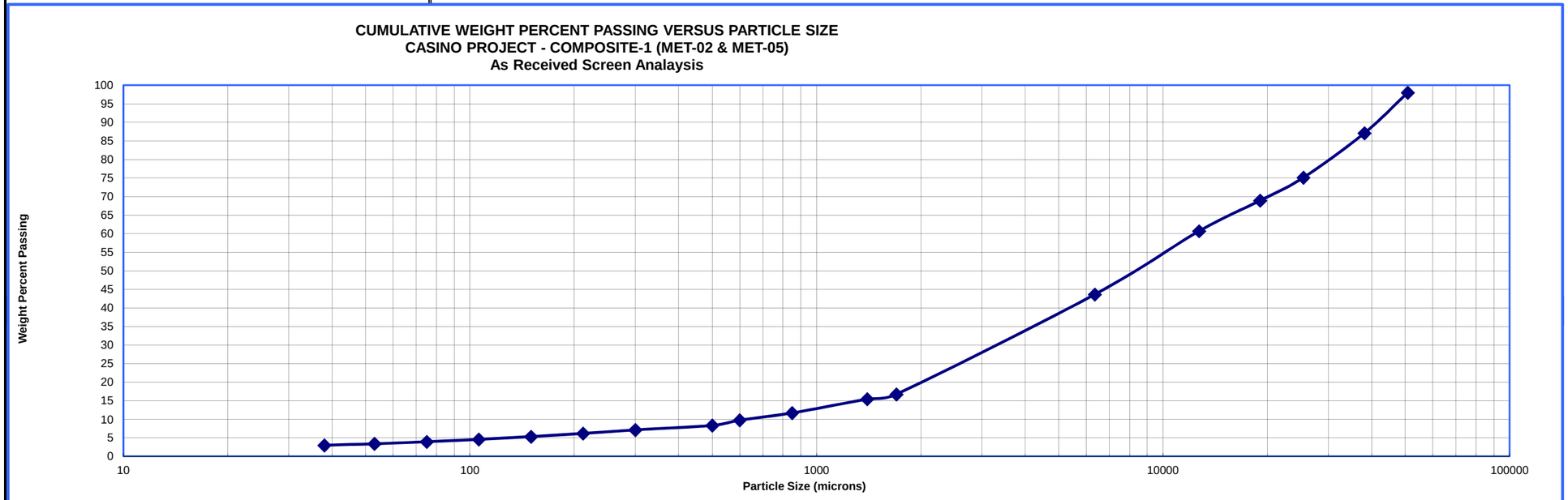
METCON FORM NO. L-SP281-1/2/01

SGS Metcon / KD Engineering
7701 BUSINESS PARK DRIVE
TUCSON , ARIZONA 85743
COMPOSITE SAMPLE AS RECEIVED SCREEN SIZES
Client ID: WESTERN COPPER 7 GOLD
Project No: M-709-03 - CASINO PROJECT
Sample ID: COMPOSITE-1 (MET-02 & MET-05)

SCREEN ANALYSIS — **Sample: P100 minus 3 inch** — **Size: As Received at METCON Research** — **ANALYTICAL RESULTS**

NOMINAL OPENINGS			Sample Weights (kg)	Weight Distribution (%)	Cumulative (%)		Au (g/t)			Ag (g/t)			Cu (%)			Fe (%)			CNAu (g/t)			CNAg (g/t)			CNCu (%)		
mm	Inch	ASTM			Retained	Passing	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.
50.80	2	2"	7.86	2.03	2.03	97.97	0.460	0.009	3.46	1.200	0.024	2.88	0.022	0.000	6.18	1.700	0.035	2.09	0.340	0.007	2.48	0.990	0.020	2.85	0.005	0.000	2.55
38.10	1.500	1-1/2"	42.22	10.91	12.95	87.05	0.310	0.034	12.54	1.000	0.109	12.90	0.013	0.001	19.62	1.660	0.181	10.95	0.370	0.040	14.49	1.110	0.121	17.15	0.009	0.001	24.63
25.40	1.000	1"	46.38	11.99	24.94	75.06	0.260	0.031	11.55	0.900	0.108	12.76	0.004	0.000	6.63	1.780	0.213	12.90	0.310	0.037	13.33	0.850	0.102	14.43	0.006	0.001	18.04
19.05	0.750	3/4"	23.92	6.18	31.12	68.88	0.240	0.015	5.50	0.700	0.043	5.12	0.004	0.000	3.42	1.490	0.092	5.57	0.230	0.014	5.10	0.710	0.044	6.22	0.005	0.000	7.75
12.70	0.500	1/2"	31.82	8.23	39.34	60.66	0.230	0.019	7.01	0.700	0.058	6.81	0.006	0.000	6.83	1.480	0.122	7.36	0.150	0.012	4.43	0.670	0.055	7.80	0.004	0.000	8.25
6.35	0.250	1/4"	66.00	17.06	56.41	43.59	0.170	0.029	10.75	0.500	0.085	10.09	0.007	0.001	16.52	1.140	0.194	11.76	0.180	0.031	11.02	0.530	0.090	12.80	0.002	0.000	8.56
1.70	0.065	10	104.08	26.91	83.31	16.69	0.140	0.038	13.96	0.500	0.135	15.90	0.006	0.002	22.33	1.130	0.304	18.38	0.100	0.027	9.65	0.490	0.132	18.67	0.002	0.001	13.49
1.40	0.055	14	4.96	1.28	84.59	15.41																					
0.85	0.033	20	14.49	3.74	88.34	11.66																					
0.60	0.024	28	7.53	1.95	90.28	9.72																					
0.50	0.020	35	5.45	1.41	91.69	8.31																					
0.30	0.012	48	4.68	1.21	92.90	7.10																					
0.21	0.008	65	3.66	0.95	93.85	6.15	0.570	0.095	35.24	1.700	0.284	33.54	0.008	0.001	18.47	3.070	0.512	30.98	0.660	0.110	39.51	0.850	0.142	20.08	0.004	0.001	16.74
0.15	0.006	100	3.37	0.87	94.72	5.28																					
0.11	0.004	150	2.88	0.74	95.46	4.54																					
0.08	0.003	200	2.47	0.64	96.10	3.90																					
0.05	0.002	270	2.06	0.53	96.63	3.37																					
0.04	0.001	400	1.60	0.41	97.05	2.95																					
M I N U S		-400	11.42	2.95	100.00	0.00																					
TOTALS			**386.84**	**100.00**				**0.270**	**100.00**		**0.846**	**100.00**		**0.007**	**100.00**		**1.654**	**100.00**		**0.279**	**100.00**		**0.706**	**100.00**		**0.004**	**100.00**
CALCULATED ASSAY							**0.270**			**0.846**			**0.007**			**1.654**			**0.279**			**0.706**			**0.004**		
COMPOSITE ASSAY (Pulverized)							**0.320**			**0.800**			**0.009**			**1.660**			**0.230**			**0.710**			**0.004**		

Sample ID	Assay Results						
COMPOSITE ASSAY (Pulverized)	Au (g/t)	Ag (g/t)	Cu (%)	Fe (%)	CNAu (g/t)	CNAg (g/t)	CNCu (%)
	0.320	0.800	0.009	1.660	0.230	0.710	0.004



SGS Metcon / KD Engineering
7701 BUSINESS PARK DRIVE
TUCSON , ARIZONA 85743
COMPOSITE SAMPLE AS RECEIVED SCREEN SIZES
Client ID: WESTERN COPPER 7 GOLD
Project No: M-709-03 - CASINO PROJECT
Sample ID: COMPOSITE-2 (MET-11 & MET-17)

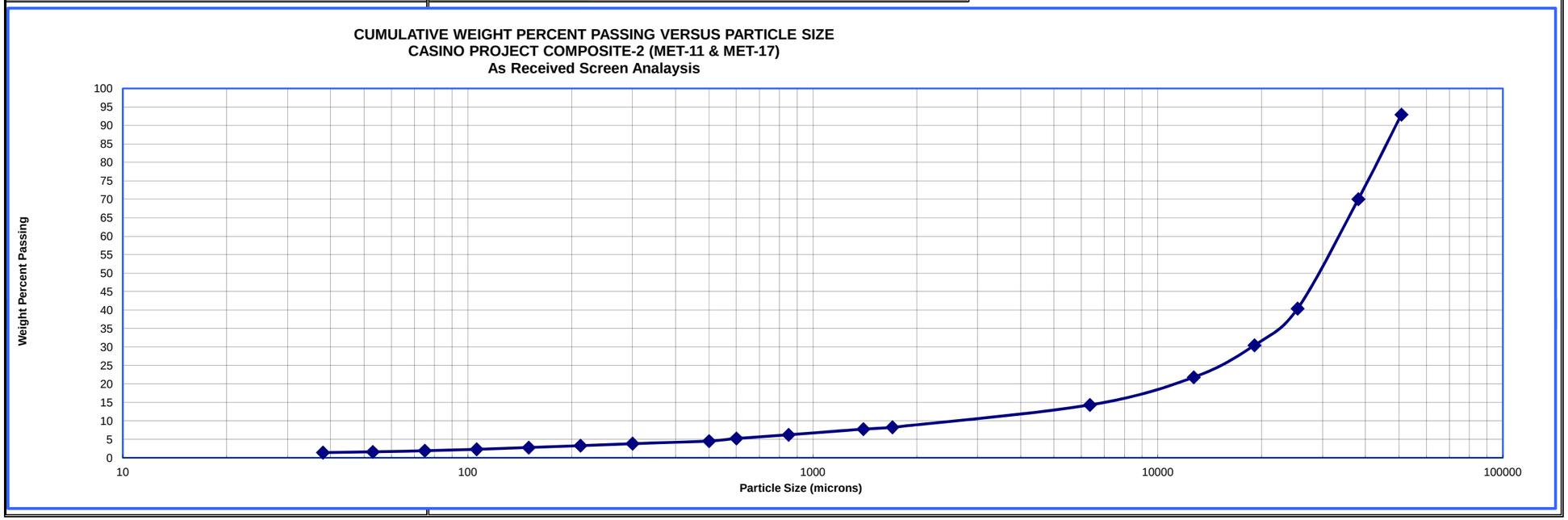
SCREEN ANALYSIS

Sample: P100 minus 3 inch
Size: As Received at METCON Research

ANALYTICAL RESULTS

NOMINAL OPENINGS			Sample Weights (kg)	Weight Distribution (%)	Cumulative (%)		Au (g/t)			Ag (g/t)			Cu (%)			Fe (%)			CNAu (g/t)			CNAg (g/t)			CNCu (%)		
mm	Inch	ASTM			Retained	Passing	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.
50.80	2	2"	24.34	7.06	7.06	92.94	0.460	0.032	6.04	2.700	0.191	7.06	0.036	0.003	5.50	2.150	0.152	6.76	0.410	0.029	5.74	2.160	0.152	6.79	0.020	0.001	6.94
38.10	1.500	1-1/2"	78.94	22.89	29.95	70.05	0.540	0.124	23.01	2.200	0.504	18.65	0.045	0.010	22.30	1.840	0.421	18.77	0.440	0.101	19.99	2.030	0.465	20.69	0.030	0.007	33.76
25.40	1.000	1"	102.20	29.64	59.59	40.41	0.510	0.151	28.13	2.600	0.771	28.53	0.034	0.010	21.81	2.110	0.625	27.87	0.480	0.142	28.24	2.320	0.688	30.61	0.017	0.005	24.77
19.05	0.750	3/4"	34.20	9.92	69.51	30.49	0.440	0.044	8.12	2.600	0.258	9.55	0.030	0.003	6.44	2.190	0.217	9.68	0.330	0.033	6.50	1.930	0.191	8.52	0.017	0.002	8.29
12.70	0.500	1/2"	29.90	8.67	78.18	21.82	0.460	0.040	7.42	2.200	0.191	7.06	0.062	0.005	11.64	2.220	0.193	8.58	0.410	0.036	7.06	2.270	0.197	8.76	0.018	0.002	7.67
6.35	0.250	1/4"	25.80	7.48	85.66	14.34	0.430	0.032	5.99	3.500	0.262	9.69	0.032	0.002	5.18	2.600	0.195	8.67	0.440	0.033	6.53	2.600	0.195	8.66	0.016	0.001	5.88
1.70	0.065	10	20.84	6.04	91.71	8.29	0.520	0.031	5.85	2.800	0.169	6.26	0.066	0.004	8.63	2.790	0.169	7.51	0.420	0.025	5.04	2.230	0.135	6.00	0.018	0.001	5.35
1.40	0.055	14	1.72	0.50	92.20	7.80																					
0.85	0.033	20	5.31	1.54	93.75	6.25																					
0.60	0.024	28	3.37	0.98	94.72	5.28																					
0.50	0.020	35	2.47	0.72	95.44	4.56																					
0.30	0.012	48	2.42	0.70	96.14	3.86																					
0.21	0.008	65	1.88	0.54	96.69	3.31	1.000	0.083	15.44	4.300	0.357	13.20	0.103	0.009	18.49	3.290	0.273	12.16	1.270	0.105	20.91	2.700	0.224	9.97	0.018	0.001	7.34
0.15	0.006	100	1.82	0.53	97.21	2.79																					
0.11	0.004	150	1.51	0.44	97.65	2.35																					
0.08	0.003	200	1.34	0.39	98.04	1.96																					
0.05	0.002	270	1.11	0.32	98.36	1.64																					
0.04	0.001	400	0.69	0.20	98.56	1.44																					
M I N U S		-400	4.96	1.44	100.00	0.00																					
TOTALS			**344.82**	**100.00**				**0.537**	**100.00**		**2.701**	**100.00**		**0.046**	**100.00**		**2.244**	**100.00**		**0.504**	**100.00**		**2.246**	**100.00**		**0.020**	**100.00**
CALCULATED ASSAY							**0.537**			**2.701**			**0.046**			**2.244**			**0.504**			**2.246**			**0.020**		
COMPOSITE ASSAY (Pulverized)							**0.550**			**2.700**			**0.051**			**2.330**			**0.530**			**2.700**			**0.018**		

Sample ID	Assay Results						
COMPOSITE ASSAY (Pulverized)	Au (g/t)	Ag (g/t)	Cu (%)	Fe (%)	CNAu (g/t)	CNAg (g/t)	CNCu (%)
	0.550	2.700	0.051	2.330	0.530	2.700	0.018



SGS Metcon / KD Engineering
7701 BUSINESS PARK DRIVE
TUCSON , ARIZONA 85743
COMPOSITE SAMPLE AS RECEIVED SCREEN SIZES
Client ID: WESTERN COPPER 7 GOLD
Project No: M-709-03 - CASINO PROJECT
Sample ID: COMPOSITE-3 (MET-19 & MET-20)

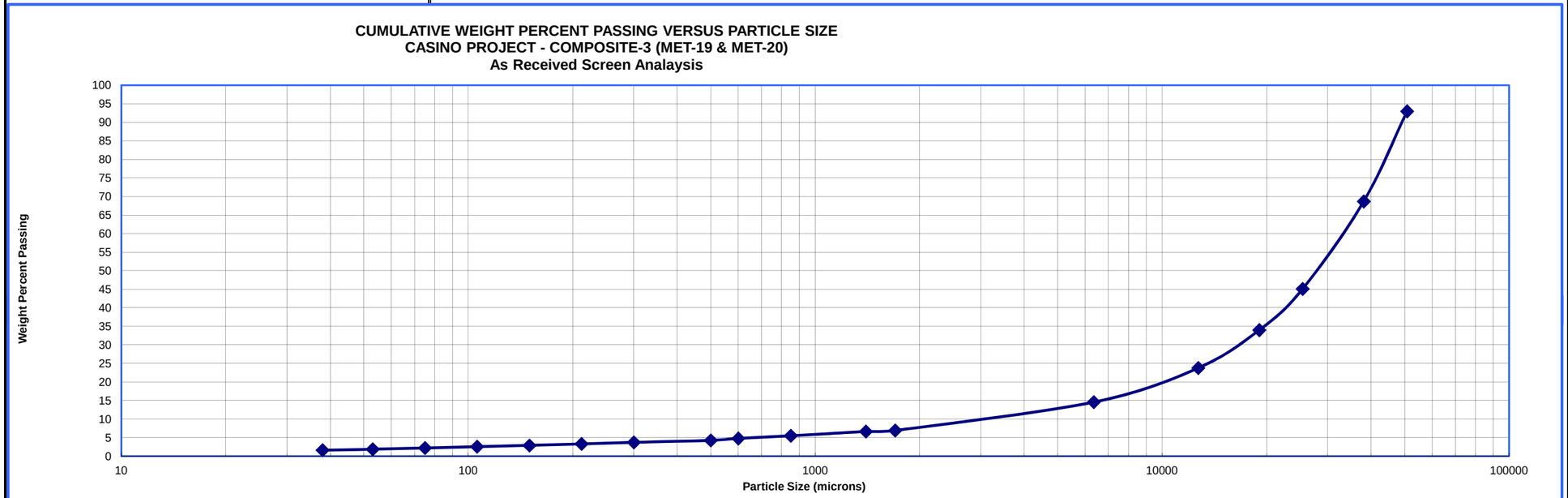
SCREEN ANALYSIS

Sample: P100 minus 3 inch
Size: As Received at METCON Research

ANALYTICAL RESULTS

NOMINAL OPENINGS			Sample Weights (kg)	Weight Distribution (%)	Cumulative (%)		Au (g/t)			Ag (g/t)			Cu (%)			Fe (%)			CNAu (g/t)			CNAg (g/t)			CNCu (%)		
mm	Inch	ASTM			Retained	Passing	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.
50.80	2	2"	25.91	7.03	7.03	92.97	0.570	0.040	6.39	2.500	0.176	6.36	0.088	0.006	8.49	4.690	0.330	6.44	0.510	0.036	4.99	2.650	0.186	6.55	0.015	0.001	7.02
38.10	1.500	1-1/2"	89.54	24.31	31.34	68.66	0.490	0.119	18.98	2.600	0.632	22.86	0.074	0.018	24.66	4.780	1.162	22.68	0.370	0.090	12.50	2.370	0.576	20.25	0.014	0.003	22.64
25.40	1.000	1"	86.80	23.56	54.90	45.10	0.590	0.139	22.16	2.200	0.518	18.75	0.068	0.016	21.97	5.380	1.268	24.75	1.210	0.285	39.64	3.020	0.712	25.02	0.016	0.004	25.09
19.05	0.750	3/4"	40.88	11.10	66.00	34.00	0.570	0.063	10.08	2.500	0.277	10.03	0.069	0.008	10.50	4.860	0.539	10.53	0.460	0.051	7.10	2.420	0.269	9.44	0.015	0.002	11.08
12.70	0.500	1/2"	37.62	10.21	76.21	23.79	0.560	0.057	9.11	3.300	0.337	12.19	0.056	0.006	7.84	4.460	0.455	8.89	0.530	0.054	7.52	3.300	0.337	11.85	0.014	0.001	9.51
6.35	0.250	1/4"	33.90	9.20	85.42	14.58	0.630	0.058	9.24	2.500	0.230	8.32	0.070	0.006	8.83	4.950	0.456	8.89	0.510	0.047	6.52	2.620	0.241	8.48	0.015	0.001	9.18
1.70	0.065	10	28.14	7.64	93.06	6.94	0.620	0.047	7.55	2.600	0.199	7.18	0.069	0.005	7.23	5.390	0.412	8.04	0.510	0.039	5.42	2.630	0.201	7.06	0.015	0.001	7.62
1.40	0.055	14	1.04	0.28	93.34	6.66																					
0.85	0.033	20	4.20	1.14	94.48	5.52																					
0.60	0.024	28	2.69	0.73	95.21	4.79																					
0.50	0.020	35	1.93	0.52	95.73	4.27																					
0.30	0.012	48	1.99	0.54	96.27	3.73																					
0.21	0.008	65	1.49	0.40	96.68	3.32	1.490	0.103	16.49	5.700	0.396	14.31	0.110	0.008	10.47	7.210	0.501	9.77	1.690	0.117	16.31	4.650	0.323	11.35	0.017	0.001	7.85
0.15	0.006	100	1.60	0.43	97.11	2.89																					
0.11	0.004	150	1.16	0.31	97.43	2.57																					
0.08	0.003	200	1.28	0.35	97.78	2.22																					
0.05	0.002	270	1.27	0.35	98.12	1.88																					
0.04	0.001	400	0.92	0.25	98.37	1.63																					
MINUS		-400	6.00	1.63	100.00	0.00																					
TOTALS			**368.37**	**100.00**				**0.627**	**100.00**		**2.765**	**100.00**		**0.073**	**100.00**		**5.122**	**100.00**		**0.719**	**100.00**		**2.845**	**100.00**		**0.015**	**100.00**
CALCULATED ASSAY							**0.627**			**2.765**			**0.073**			**5.122**			**0.719**			**2.845**			**0.015**		
COMPOSITE ASSAY (Pulverized)							**0.770**			**2.700**			**0.078**			**4.810**			**0.530**			**2.960**			**0.016**		

Sample ID	Assay Results						
COMPOSITE ASSAY (Pulverized)	Au (g/t)	Ag (g/t)	Cu (%)	Fe (%)	CNAu (g/t)	CNAg (g/t)	CNCu (%)
	0.770	2.700	0.078	4.810	0.530	2.960	0.016

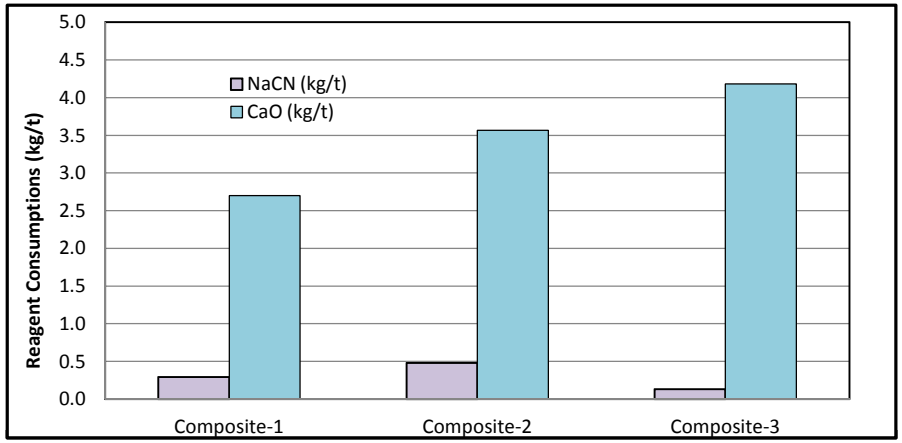


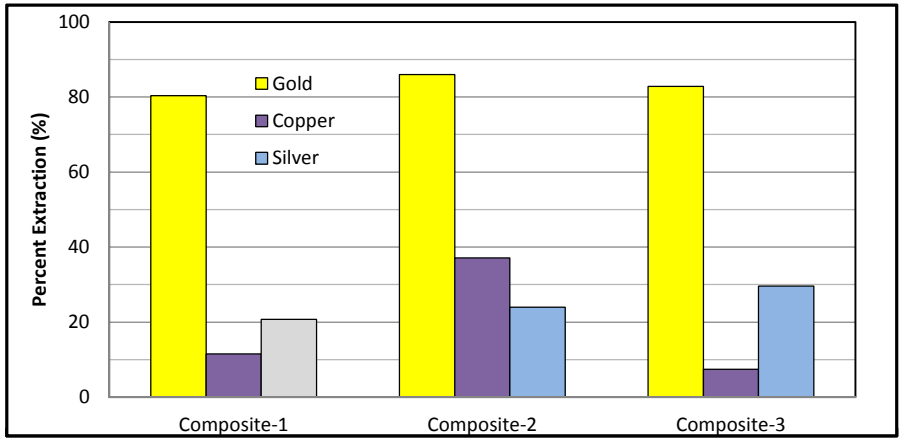
APPENDIX 3

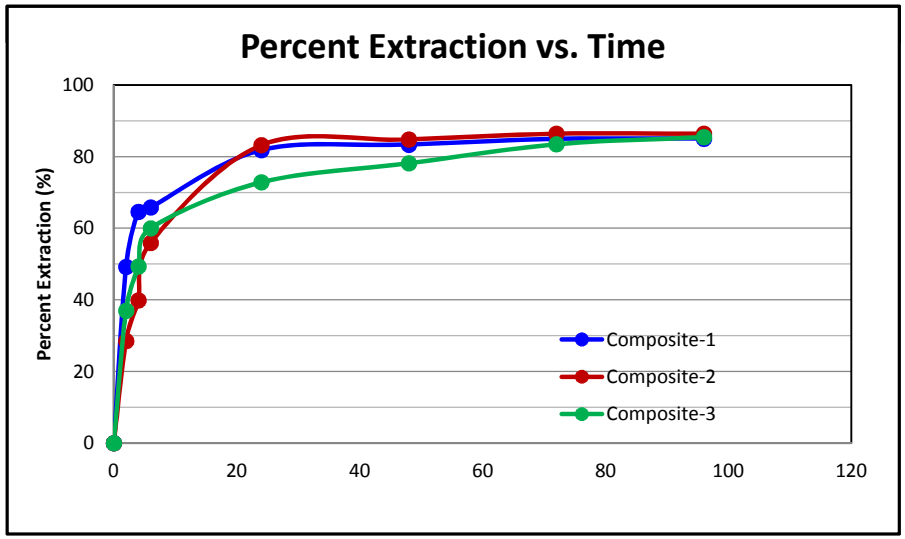
Cyanide BR Test Data

M-709-03 - Casino Project Bottle Roll Test
Summary of Results

Test No.	Sample ID	Assay Head			Calculated Head			Residue Grade			PLS Grade			% Extraction			Consumptions	
		Au (ppm)	Cu (ppm)	Ag (ppm)	Au (ppm)	Cu (ppm)	Ag (ppm)	Au (ppm)	Cu (ppm)	Ag (ppm)	Au (ppm)	Cu (ppm)	Ag (ppm)	Au (%)	Cu (%)	Ag (%)	NaCN (kg/t)	CaO (kg/t)
BR-01	Composite-1	0.270	72	0.8	0.255	147	0.9	0.050	130	0.7	0.16	256	0.13	80.40	11.52	20.71	0.293	2.701
BR-02	Composite-2	0.537	462	2.7	0.572	636	2.8	0.080	400	2.1	0.37	408	0.48	86.00	37.10	23.96	0.479	3.565
BR-03	Composite-3	0.627	729	2.8	0.642	854	3.0	0.110	790	2.1	0.41	290	0.64	82.86	7.45	29.58	0.130	4.180







SGS Metcon — **BOTTLE ROLL LEACH TEST DATA LOG**

OBJECTIVE	**AGITATED GOLD CYANIDATION TESTING BY BOTTLE ROLL**	**TEST CONDITIONS AND PARAMETERS:** 45% Solid, 760mg/L NaCN, 300mg/L Cu, pH=11.0-11.5, 100% minus 1	
CLIENT	**WESTERN COPPER & GOLD**	**NaCN Purity 95 %**	**PROJECT No.** **M-709-03**
SAMPLE I.D.	**COMPOSITE-1 (MET-02 & 05)**		**DATE BEGIN** **04/25/14**
FEED WEIGHT	**1000.00 grams**		**DATE END** **04/29/14**
FEED SIZE	**P100 MINUS 10 MESH**		**TEST No.** **BR-01**

CONDITIONS AND REAGENTS

PRODUCTS	PULP CONDITIONS					CaO (gram)		NaCN (gram)		PREGNANT SOLUTION CONDITIONS					FEED SOLUTION CONDITIONS			
	Volume (ml)	Percent Solids	Time Hours	pHi	pHf	In	Out	In	Out	Volume (ml)	pH	NaCN (gpl)	CaO (g/l)		Volume (ml)	pH	NaCN (g/l)	CaO (g/l)
Feed Leach Solution	1222	45	0	11.38	11.30	1.37		0.88				0.76			1222	11.30	0.723	1.121
Leaching (1)	1230	45	2	11.14	11.21	0.34	0.00	0.14	-0.02	25.00	11.09	0.64	0.18					
Leaching (1)	1223	45	4	11.16	11.19	0.14	0.00	0.00	-0.02	25.00	11.11	0.78	0.12					
Leaching (1)	1222	45	6	11.10	11.09	0.32	0.00	0.00	-0.02	25.00	11.06	0.75	0.07					
Leaching (1)	1223	45	24	11.30	11.31	0.33	-0.01	0.05	-0.02	25.00	11.27	0.72	0.24					
Leaching (1)	1222	45	48	11.18	11.14	0.17	-0.01	0.00	-0.02	25.00	11.10	0.74	0.26					
Leaching (1)	1223	45	72	11.24	11.24	0.29	-0.01	0.17	-0.02	25.00	11.19	0.62	0.32					
Leaching (1)	1224	45	96	11.24	11.25	0.00	0.00	0.00	-0.02	25.00	11.19	0.73	0.16					
Leaching / PLS (2)	1000	-	-	-	11.15	-	-	-	-	-	11.15	0.72	0.15					
Wash Solution	630	-	-	-	10.90	-	-	-	-	-	10.90	0.17	0.12					
							kg/t		kg/t									
Total Lime Consumption:							**2.701**											
Total Cyanide Consumption:									**0.293**									

REMARKS:

(1) A 25 ml Aliquot Sample Was Removed For Assays, Lime and Cyanide Titration. 25 ml of Distilled Water Were Added To Keep A Constant Volume
(2) Pregnant Leach Solution Volume was calculated based on the weight difference of net weight of the bottle and solids weight.
(3) Includes Metals Content Removed In Aliquot Samples Volumes

METALLURGICAL RESULTS

PRODUCTS	VOLUME (ml)	WEIGHT (g)	ASSAYS (ppm) Au (ppm)	Ag (ppm)	Cu (ppm)			CUMULATIVE CONTENT (mg) (3) Au (mg)	Ag (mg)	Cu (mg)			CUMULATIVE EXTRACTION Au (%)	Au (g/t)	Ag (%)	Ag (g/t)	Cu (%)
SOLUTIONS																	
Feed Leach Solution	1222				300					367			0.00		0.00		0.00
Pregnant Solution @ 2 Hr.	1230		0.10	0.11	281			0.126	0.138	353			49.22		15.64		-9.45
Pregnant Solution @ 4 Hr.	1223		0.13	0.12	279			0.165	0.153	355			64.60		17.28		-7.74
Pregnant Solution @ 6 Hr.	1222		0.13	0.12	271			0.168	0.155	352			65.82		17.60		-9.97
Pregnant Solution @ 24 Hr.	1223		0.16	0.12	267			0.209	0.158	354			81.81		17.95		-8.61
Pregnant Solution @ 48 Hr.	1222		0.16	0.12	262			0.212	0.161	354			83.31		18.28		-8.51
Pregnant Solution @ 72 Hr.	1223		0.16	0.12	260			0.217	0.164	358			84.93		18.63		-5.61
Pregnant Solution @ 96 Hr.	1224		0.16	0.13	256			0.217	0.177	360			84.99		20.03		-4.41
Pregnant Solution Filtrate	1000		0.16	0.13	256			0.181	0.148	303			80.44		20.89		11.72
Wash Solution	630		0.01	0.03	54			0.024	0.037	81							
SOLIDS																	
Leach Residue		997.76	**0.050**	**0.70**	**130**			0.050	0.698	130							
Calculated Head		1000.00	**0.255**	**0.88**	**147**			0.255	0.883	147							
Head		1000.00	**0.270**	**0.85**	**72**			0.270	0.846	72							

SGS Metcon — **BOTTLE ROLL LEACH TEST DATA LOG**

OBJECTIVE	**AGITATED GOLD CYANIDATION TESTING BY BOTTLE ROLL**	**TEST CONDITIONS AND PARAMETERS:** 45% Solid, 760mg/L NaCN, 300mg/L Cu, pH=11.0-11.5, 100% minus 1	
CLIENT	**WESTERN COPPER & GOLD**	**NaCN Purity 95 %**	**PROJECT No.** M-709-03
SAMPLE I.D.	**COMPOSITE-2 (MET-11 & 17)**		**DATE BEGIN** 04/25/14
FEED WEIGHT	**1000.00 grams**		**DATE END** 04/29/14
FEED SIZE	**P100 MINUS 10 MESH**		**TEST No.** BR-02

CONDITIONS AND REAGENTS

PRODUCTS	PULP CONDITIONS					CaO (gram)		NaCN (gram)		PREGNANT SOLUTION CONDITIONS					FEED SOLUTION CONDITIONS			
	Volume (ml)	Percent Solids	Time Hours	pHi	pHf	In	Out	In	Out	Volume (ml)	pH	NaCN (gpl)	CaO (g/l)		Volume (ml)	pH	NaCN (g/l)	CaO (g/l)
Feed Leach Solution	1222	45	0	11.38	11.24	1.73		0.88				0.76			1222	11.24	0.723	1.416
Leaching (1)	1228	45	2	11.04	11.11	0.44	0.00	0.39	-0.01	25.00	11.13	0.44	0.16					
Leaching (1)	1223	45	4	11.07	11.13	0.19	0.00	0.00	-0.02	25.00	11.08	0.78	0.08					
Leaching (1)	1222	45	6	11.06	11.04	0.65	0.00	0.00	-0.02	25.00	11.00	0.74	0.08					
Leaching (1)	1223	45	24	11.17	11.20	0.19	0.00	0.05	-0.02	25.00	11.18	0.72	0.14					
Leaching (1)	1222	45	48	11.12	11.14	0.20	0.00	0.00	-0.02	25.00	11.09	0.75	0.13					
Leaching (1)	1222	45	72	11.10	11.13	0.34	0.00	0.06	-0.02	25.00	11.08	0.71	0.14					
Leaching (1)	1222	45	96	11.10	11.10	0.00	0.00	0.00	-0.02	25.00	11.04	0.71	0.10					
Leaching / PLS (2)	1000	-	-	-	11.02	-	-	-	-	-	11.02	0.70	0.09					
Wash Solution	640	-	-	-	10.79	-	-	-	-	-	10.79	0.12	0.10					
							kg/t		kg/t									
Total Lime Consumption:							3.565											
Total Cyanide Consumption:									0.479									

REMARKS:

(1) A 25 ml Aliquot Sample Was Removed For Assays, Lime and Cyanide Titration. 25 ml of Distilled Water Were Added To Keep A Constant Volume
(2) Pregnant Leach Solution Volume was calculated based on the weight difference of net weight of the bottle and solids weight.
(3) Includes Metals Content Removed In Aliquot Samples Volumes

METALLURGICAL RESULTS

PRODUCTS	VOLUME (ml)	WEIGHT (g)	ASSAYS (ppm) Au (ppm)	Ag (ppm)	Cu (ppm)			CUMULATIVE CONTENT (mg) (3) Au (mg)	Ag (mg)	Cu (mg)			CUMULATIVE EXTRACTION Au (%)	Au (g/t)	Ag (%)	Ag (g/t)	Cu (%)
SOLUTIONS																	
Feed Leach Solution	1222				300					367			0.00		0.00		0.00
Pregnant Solution @ 2 Hr.	1228		0.13	0.37	417			0.163	0.464	523			28.51		16.79		24.55
Pregnant Solution @ 4 Hr.	1223		0.18	0.41	416			0.228	0.521	530			39.87		18.86		25.64
Pregnant Solution @ 6 Hr.	1222		0.25	0.43	416			0.320	0.556	540			55.92		20.13		27.23
Pregnant Solution @ 24 Hr.	1223		0.37	0.47	416			0.476	0.617	550			83.23		22.33		28.89
Pregnant Solution @ 48 Hr.	1222		0.37	0.48	414			0.485	0.641	558			84.79		23.20		30.08
Pregnant Solution @ 72 Hr.	1222		0.37	0.48	410			0.494	0.653	563			86.42		23.63		30.93
Pregnant Solution @ 96 Hr.	1222		0.37	0.48	408			0.494	0.653	571			86.43		23.64		32.17
Pregnant Solution Filtrate	1000		0.37	0.48	408			0.412	0.546	480			86.06		24.25		37.34
Wash Solution	640		0.06	0.09	80			0.080	0.124	124							
SOLIDS																	
Leach Residue		996.27	**0.080**	**2.10**	**400**			0.080	2.092	399							
Calculated Head		1000.00	**0.572**	**2.76**	**636**			0.572	2.762	636							
Head		1000.00	**0.537**	**2.70**	**462**			0.537	2.701	462							

SGS Metcon — **BOTTLE ROLL LEACH TEST DATA LOG**

OBJECTIVE	**AGITATED GOLD CYANIDATION TESTING BY BOTTLE ROLL**	**TEST CONDITIONS AND PARAMETERS:** 45% Solid, 760mg/L NaCN, 300mg/L Cu, pH=11.0-11.5, 100% minus 1	
CLIENT	**WESTERN COPPER & GOLD**	**NaCN Purity 95 %**	**PROJECT No.** M-709-03
SAMPLE I.D.	**COMPOSITE-3 (MET-19 & 20)**		**DATE BEGIN** 04/25/14
FEED WEIGHT	**1000.00 grams**		**DATE END** 04/29/14
FEED SIZE	**P100 MINUS 10 MESH**		**TEST No.** BR-03

CONDITIONS AND REAGENTS

PRODUCTS	PULP CONDITIONS					CaO (gram)		NaCN (gram)		PREGNANT SOLUTION CONDITIONS					FEED SOLUTION CONDITIONS			
	Volume (ml)	Percent Solids	Time Hours	pHi	pHf	In	Out	In	Out	Volume (ml)	pH	NaCN (gpl)	CaO (g/l)		Volume (ml)	pH	NaCN (g/l)	CaO (g/l)
Feed Leach Solution	1222	45	0	11.38	11.20	2.12		0.88				0.76			1222	11.20	0.723	1.735
Leaching (1)	1224	45	2	11.02	11.12	0.61	0.00	0.09	-0.02	25.00	11.09	0.69	0.11					
Leaching (1)	1223	45	4	11.03	11.09	0.22	0.00	0.00	-0.02	25.00	11.08	0.78	0.07					
Leaching (1)	1222	45	6	11.04	11.02	0.67	0.00	0.00	-0.02	25.00	11.00	0.75	0.08					
Leaching (1)	1222	45	24	11.16	11.19	0.22	0.00	0.07	-0.02	25.00	11.18	0.70	0.14					
Leaching (1)	1222	45	48	11.10	11.12	0.21	0.00	0.00	-0.02	25.00	11.06	0.74	0.16					
Leaching (1)	1221	45	72	11.10	11.12	0.37	0.00	0.06	-0.02	25.00	11.12	0.71	0.07					
Leaching (1)	1223	45	96	11.10	11.13	0.00	0.00	0.00	-0.02	25.00	11.09	0.73	0.13					
Leaching / PLS (2)	990	-	-	-	11.04	-	-	-	-	-	11.04	0.74	0.14					
Wash Solution	640	-	-	-	10.84	-	-	-	-	-	10.84	0.16	0.13					
							kg/t		kg/t									
Total Lime Consumption:							4.180											
Total Cyanide Consumption:									0.130									

REMARKS:

(1) A 25 ml Aliquot Sample Was Removed For Assays, Lime and Cyanide Titration. 25 ml of Distilled Water Were Added To Keep A Constant Volume
(2) Pregnant Leach Solution Volume was calculated based on the weight difference of net weight of the bottle and solids weight.
(3) Includes Metals Content Removed In Aliquot Samples Volumes

METALLURGICAL RESULTS

PRODUCTS	VOLUME (ml)	WEIGHT (g)	ASSAYS (ppm) Au (ppm)	Ag (ppm)	Cu (ppm)			CUMULATIVE CONTENT (mg) (3) Au (mg)	Ag (mg)	Cu (mg)			CUMULATIVE EXTRACTION Au (%)	Au (g/t)	Ag (%)	Ag (g/t)	Cu (%)
SOLUTIONS																	
Feed Leach Solution	1222				300					367			0.00		0.00		0.00
Pregnant Solution @ 2 Hr.	1224		0.19	0.46	311			0.237	0.575	389			36.99		19.27		2.57
Pregnant Solution @ 4 Hr.	1223		0.25	0.51	308			0.317	0.648	392			49.34		21.72		2.98
Pregnant Solution @ 6 Hr.	1222		0.30	0.54	305			0.385	0.697	396			59.99		23.39		3.41
Pregnant Solution @ 24 Hr.	1222		0.36	0.62	298			0.467	0.811	395			72.85		27.20		3.30
Pregnant Solution @ 48 Hr.	1222		0.38	0.62	297			0.502	0.827	401			78.15		27.72		4.03
Pregnant Solution @ 72 Hr.	1221		0.40	0.63	297			0.536	0.854	408			83.46		28.64		4.87
Pregnant Solution @ 96 Hr.	1223		0.41	0.63	292			0.548	0.855	410			85.44		28.66		5.05
Pregnant Solution Filtrate	990		0.41	0.64	290			0.453	0.718	340			82.89		29.70		7.61
Wash Solution	640		0.05	0.13	61			0.079	0.168	92							
SOLIDS																	
Leach Residue		998.24	**0.110**	**2.10**	**790**			0.110	2.096	789							
Calculated Head		1000.00	**0.642**	**2.98**	**854**			0.642	2.982	854							
Head		1000.00	**0.627**	**2.77**	**729**			0.627	2.765	729							

APPENDIX 4

Column Leach Test CL-01 on Composite 1

Summary of Results | **SGS Metcon** | Current Date: 09/26/14

SGS Metcon Project No.: M-709-03

Western Copper & Gold Corp. Casino Project

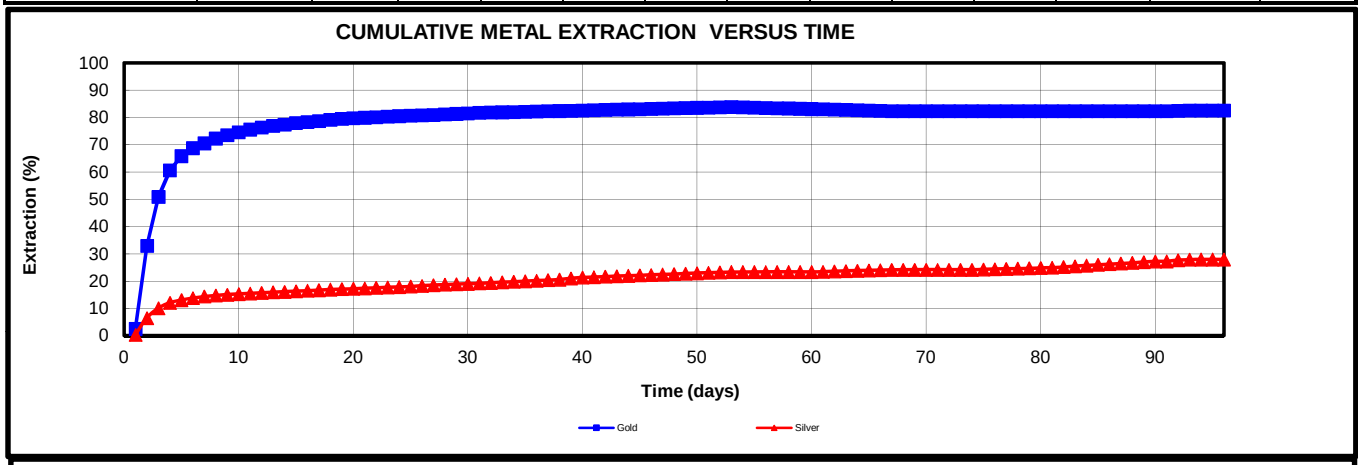
TEST No.: CL-01 | Crush Size: P100 minus 3 in.

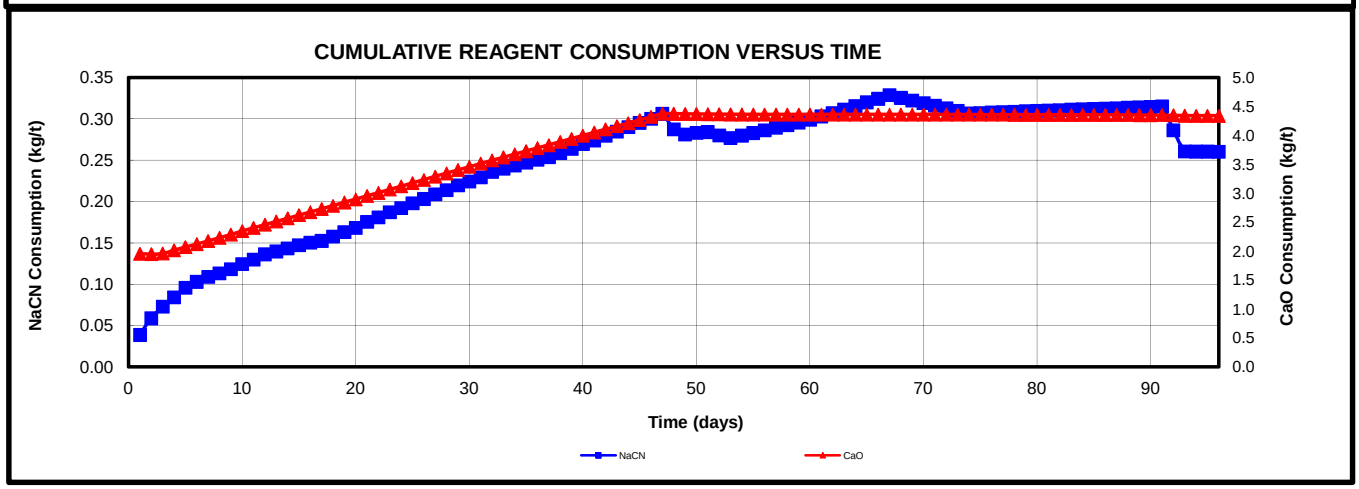
SAMPLE : Composite 1 (Met-02/05) | Lime Addition: 1.95 kg Lime/tonne of ore

Objective: Gold and Silver Extraction vs Time

Cure Days:	0
Leach Days:	91
Rest Days:	0
Wash Days:	2
Drain Days:	3
Total Cycle Days:	96

PRODUCTS	Volume	Weight	Cumulative										
			Assay (g/t)			Contents (mg)			Percent Extraction			Consumption	
												NaCN	CaO
	(liters)	(kg)	Au	Cu	Ag	Au	Cu	Ag	Au	Cu	Ag	(kg/t)	(kg/t)
Feed Solution	413.63		0.00	220	0.02	1.18	90896	8.05	82.56	27.09	27.97	0.26	4.34
Pregnant Solution	404.13		0.05	232	0.08	19.21	93927	30.95					
Leach Residue		88.82	0.04	92	0.66	3.81	8155	58.99					
CALCULATIONS													
Metal Extracted			0.20	34.08	0.26	18.02	3030	22.90					
Calculated Head			0.25	125.79	0.92	21.83	11185	81.89					
Assay Head		88.92	0.27	72.29	0.85	24.00	6428	75.20					

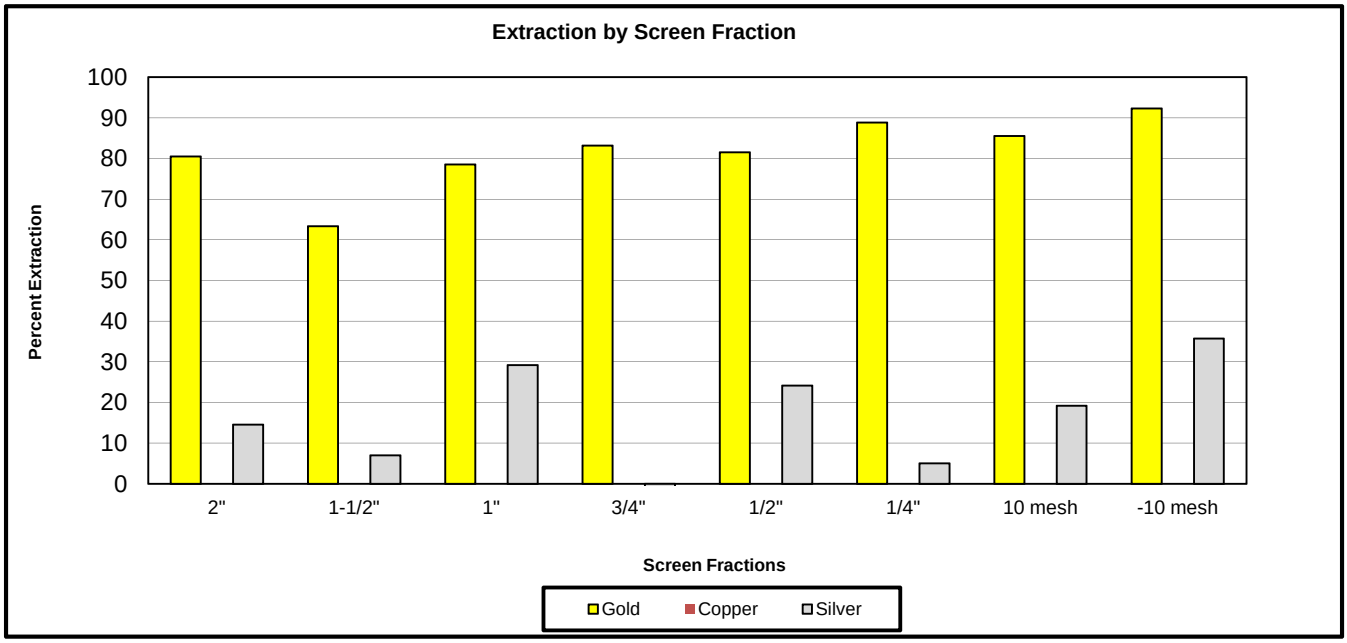




SGS Metcon

Test: CL-01
Sample: Composite 1 (Met-02/05)
Casino Project

Western Copper & Gold Corp.
SGS Metcon Project No.: M-709-03



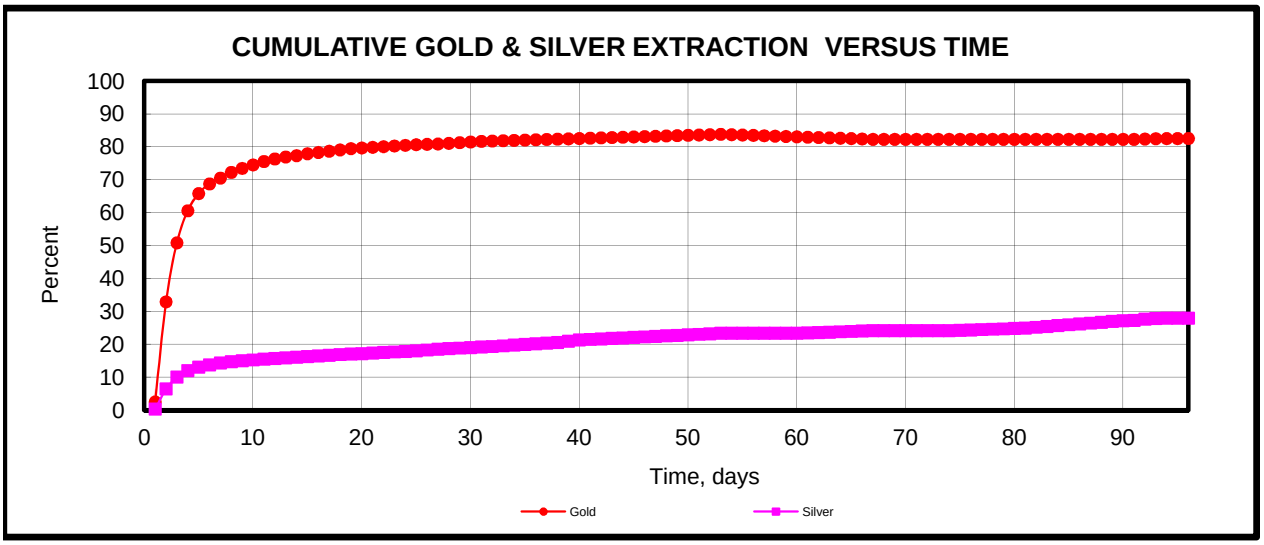
Test No. : CL-01

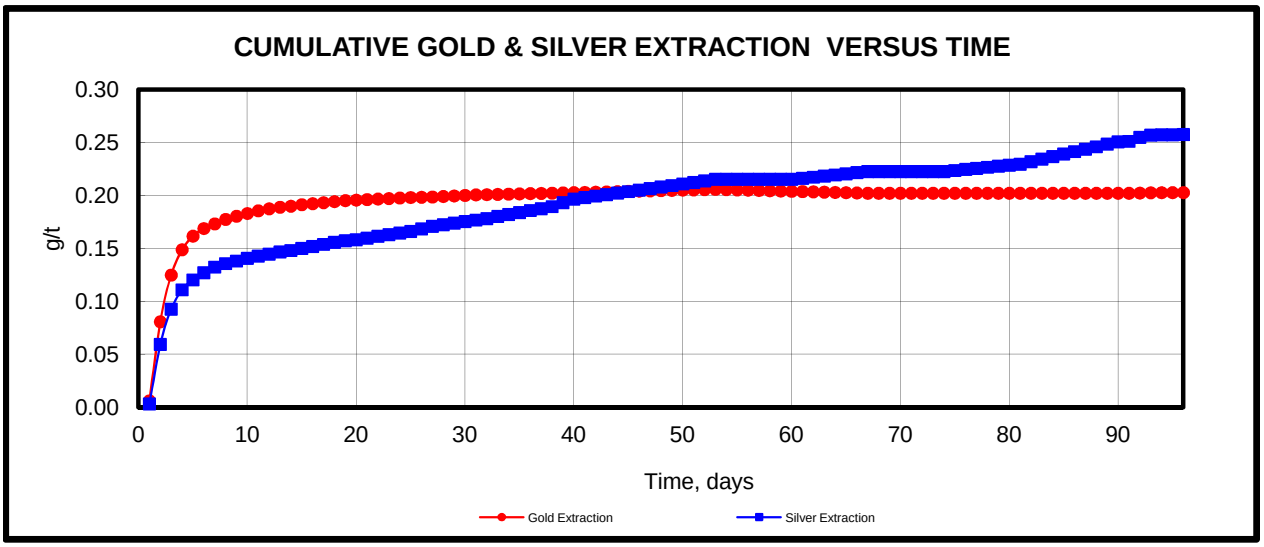
Screen Fraction	Head				Leach Residue				Percent Extraction			Degradation Index
	Weight	Assays (g/t)			Weight	Assays (g/t)						
	(kg)	Au	Cu	Ag	(kg)	Au	Cu	Ag	Au	Cu	Ag	(%)
2"	1.80	0.46	220	1.20	2.31	0.07	420	0.80	80.50	-	14.58	-28.13
1-1/2"	9.70	0.31	130	1.00	10.03	0.11	140	0.90	63.32	-	6.98	-3.36
1"	10.66	0.26	40	0.90	8.49	0.07	100	0.80	78.56	-	29.22	20.37
3/4"	5.50	0.24	40	0.70	5.54	0.04	90	0.80	83.21	-	-15.15	-0.75
1/2"	7.30	0.23	60	0.70	7.75	0.04	180	0.50	81.53	-	24.15	-6.19
1/4"	15.18	0.17	70	0.50	14.41	0.02	60	0.50	88.83	-	5.04	5.04
10 mesh	23.94	0.14	60	0.50	24.18	0.02	30	0.40	85.57	-	19.18	-1.02
-10 mesh	14.84	0.57	80	1.70	16.21	0.04	90	1.00	92.34	-	35.75	-9.22
Total	88.92	0.27	72	0.85	88.92	0.04	92	0.66	84.12		21.47	

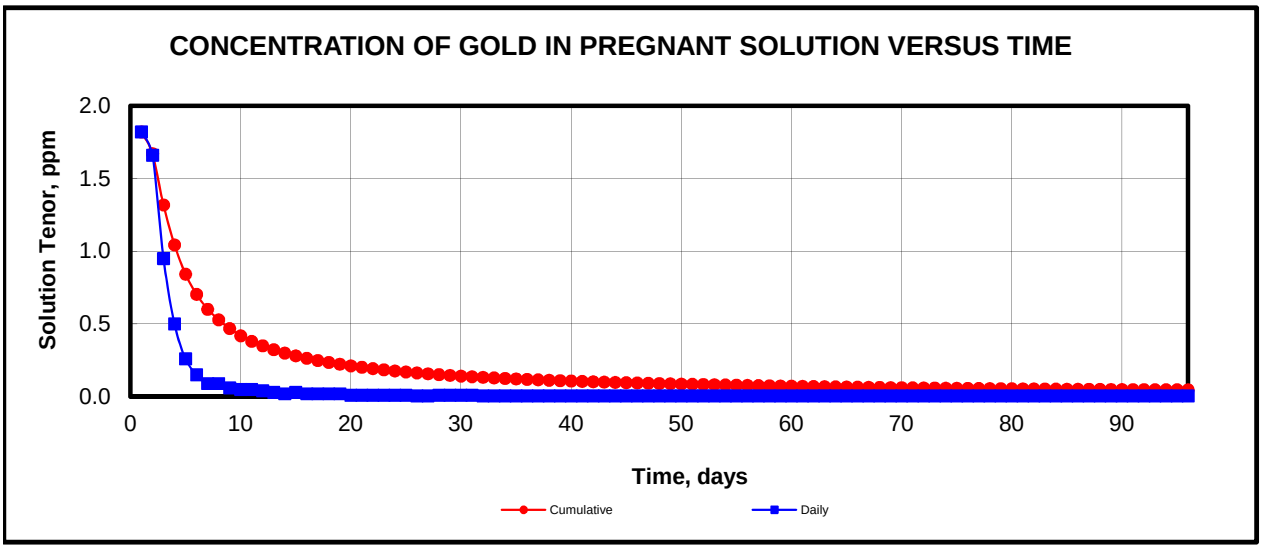
SGS Metcon

Test: CL-01 — Western Copper & Gold Corp.

Sample: Composite 1 (Met-02/05) — SGS Metcon Project No.: M-709-03



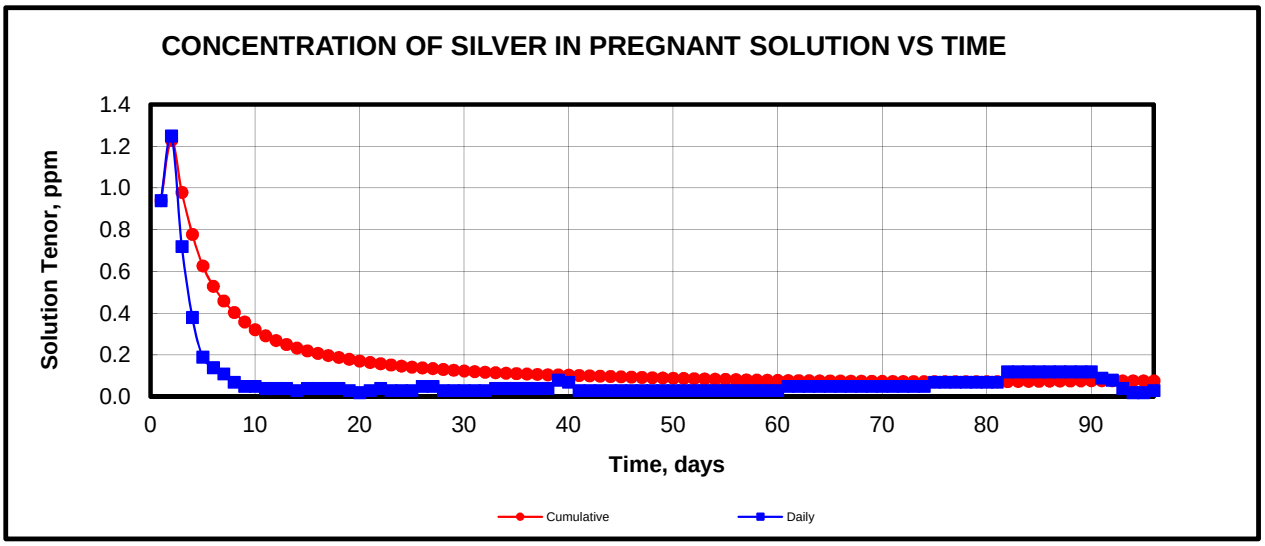


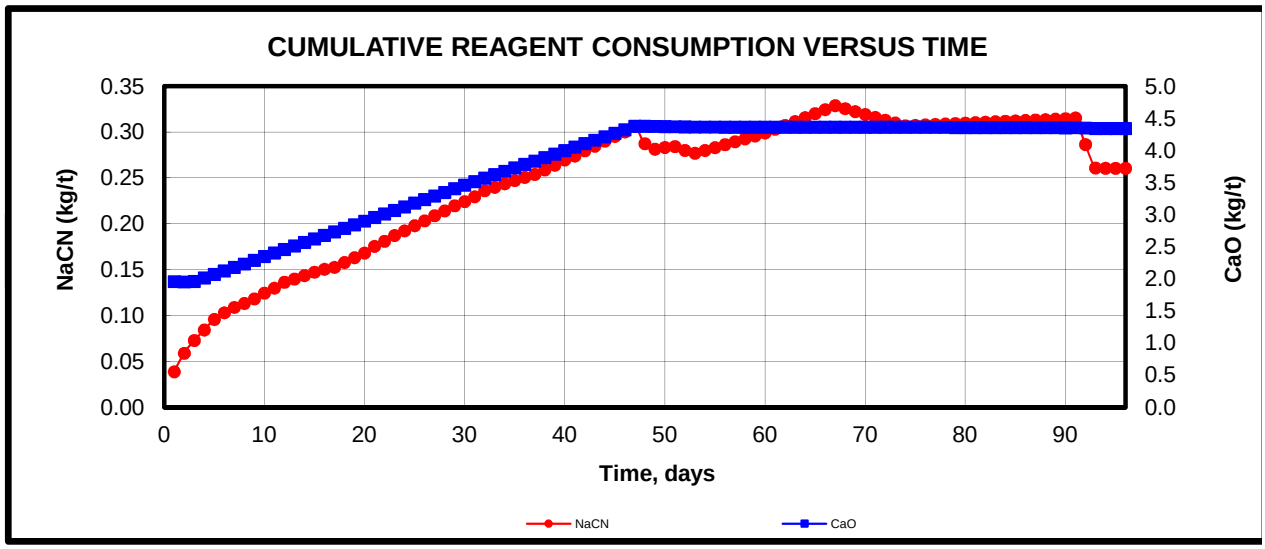


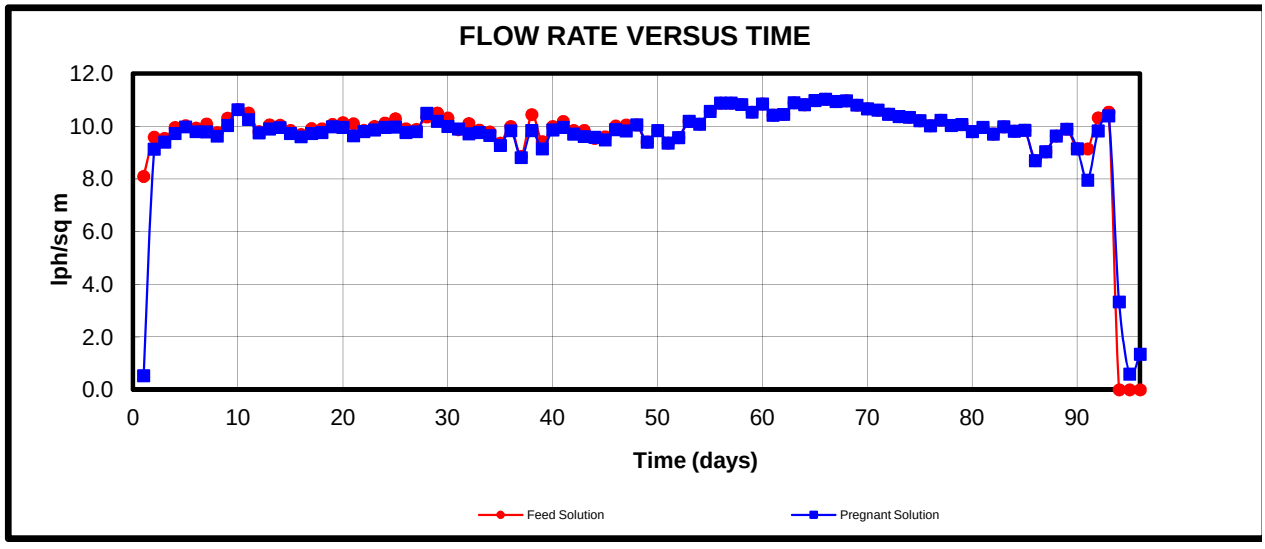
SGS Metcon

Test: CL-01 — Western Copper & Gold Corp.

Sample: Composite 1 (Met-02/05) — SGS Metcon Project No.: M-709-03



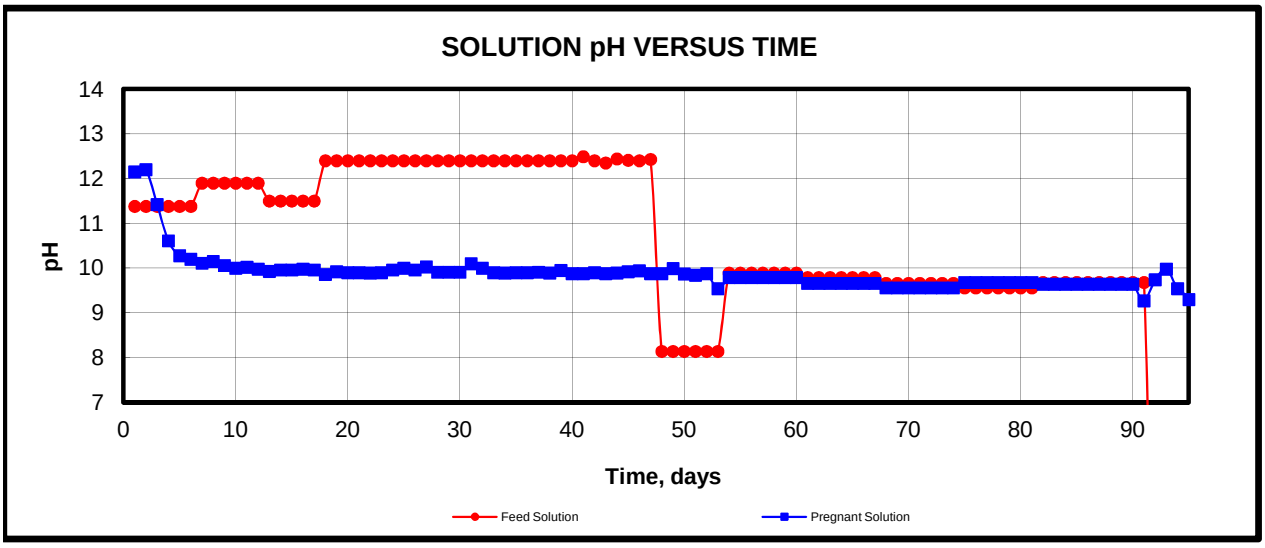


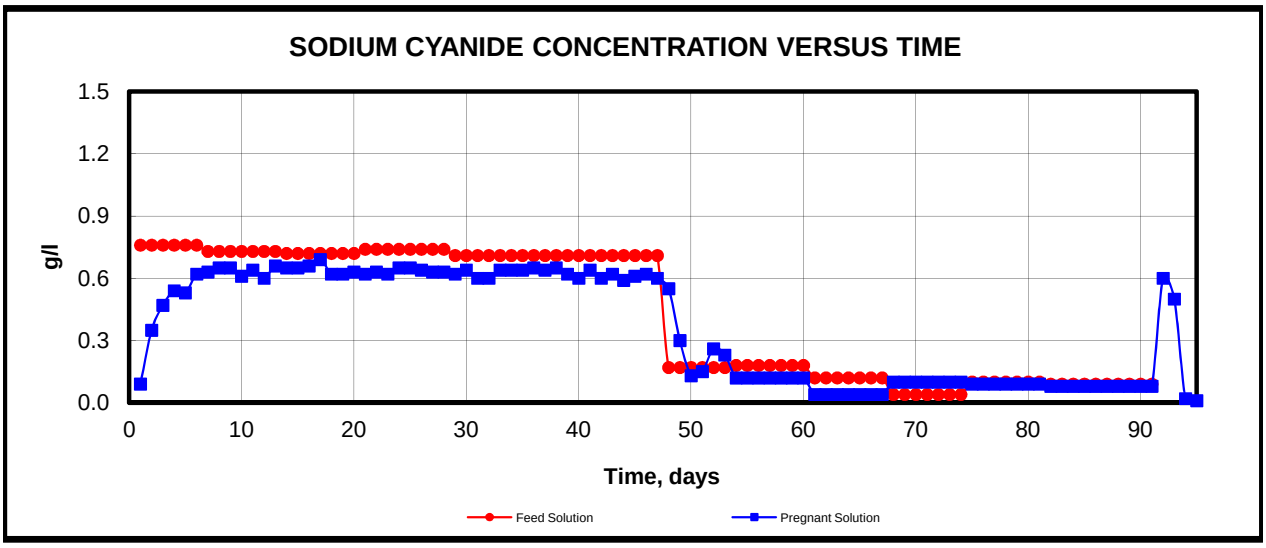


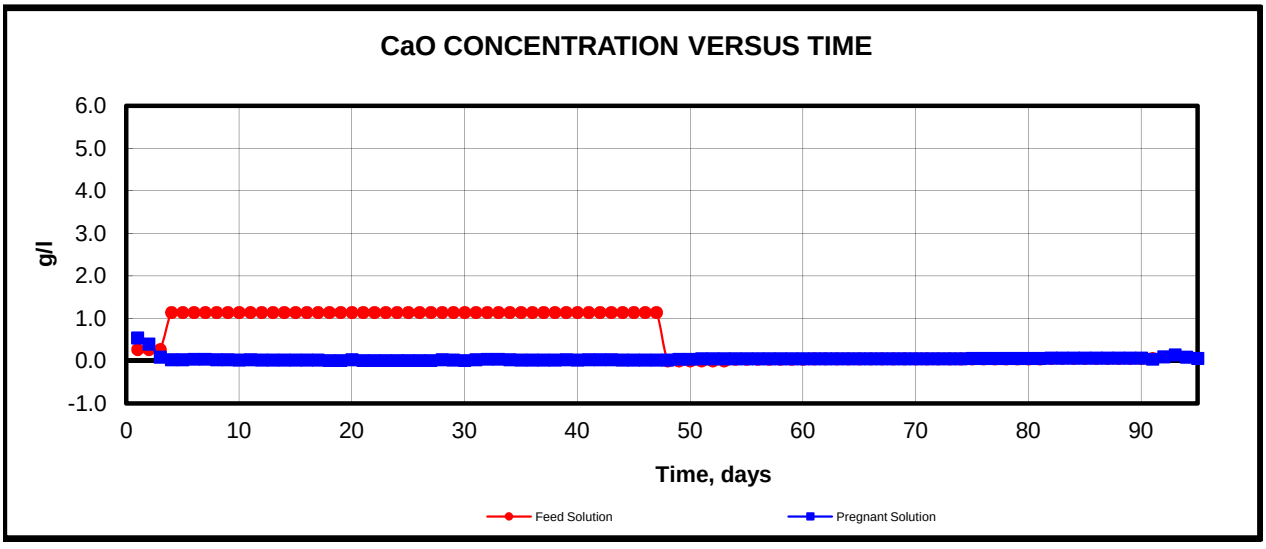
SGS Metcon

Test: CL-01 — Western Copper & Gold Corp.

Sample: Composite 1 (Met-02/05) — SGS Metcon Project No.: M-709-03







SGS Metcon

TEST No. CL-01

PHYSICAL CHARACTERISTICS SHEET

		TEST CONDITIONS	
CLIENT	Western Copper & Gold Corp. SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height
SAMPLE	Composite 1 (Met-02/05)	**CRUSH SIZE**	P100 minus 3 in.
		LEACH SOLUTION	750 ppm free NaCN, 300 ppm Cu
OBJECTIVE	Gold and Silver Extraction vs Time	**Lime Addition**	1.95 kg CaO/tonne of Ore
		CURE CYCLE	0 days
		FLOWRATE	9.78 lph/m2

FLOWRATE (lph/sq m)		9.78			
CURE STAGE (days)		0			
COLUMN DIAMETER (mm)		152.40			
ELEMENTS ANALYZED	Au	CNs Au	Ag	CNs Ag	Cu
HEAD ASSAYS (g per tonne)	0.27		0.85		72.29
LEACH RESIDUE ASSAYS (g per tonne)	0.04		0.66		91.82
SAMPLE PERCENT MOISTURE AS RECEIVED (Dry Basis)		0.00			
SAMPLE WEIGHT BEFORE AGGLOMERATION (kg)		88.92			
AGGLOMERATED SAMPLE WEIGHT (kg)		92.14			
INITIAL SAMPLE PERCENT MOISTURE (including agglomeration water)		3.62	(Dry Basis)		
INITIAL SAMPLE DRY WEIGHT (kg)		88.92			
INITIAL SAMPLE HEIGHT (m)		2.96			
INITIAL SAMPLE BULK DENSITY (kg/cu m)		1647	(Dry Basis)		
FINAL SAMPLE HEIGHT (m)		2.96			
RESIDUE WET WEIGHT (kg)		94.34			
RESIDUE DRY WEIGHT (kg)		88.82			
VOLUME DRAINED (l)		2.31			
SUBSIDENCE (%)		0.01			
MOISTURE UNDER LEACH (%)		8.82	(Dry Basis)		
MOISTURE RETAINED (%)		6.21	(Dry Basis)		
FINAL SAMPLE BULK DENSITY (kg/cu m)		1645	(Dry Basis)		

SGS Metcon
7701 BUSINESS PARK DRIVE
TUCSON , ARIZONA 85743

SCREEN ANALYSIS RESULTS
Western Copper & Gold Corp.
SGS Metcon Project No.: M-709-03
Casino Project

SCREEN ANALYSIS			Sample: **Column Leach Head** **CL-01** **Composite 1 (Met-02/05)** **Crush Size: P100 minus 3 in.**											
NOMINAL OPENINGS		Tyler	Sample	Weight	Cumulative Weight	Gold			Copper			Silver		
mm	Inches	Mesh	Weights (kg)	Distribution (%)	Retained (%)	Assay (gpt)	Content	Distribution (%)	Assay (gpt)	Content	Distribution (%)	Assay (gpt)	Content	Distribution (%)
50.80	2.000	2"	1.80	2.02	2.02	0.46	0.009	3.45	220	4.453	6.16	1.20	0.02	2.87
38.10	1.500	1-1/2"	9.70	10.91	12.93	0.31	0.034	12.53	130	14.181	19.62	1.00	0.11	12.90
25.40	1.000	1"	10.66	11.99	24.92	0.26	0.031	11.55	40	4.795	6.63	0.90	0.11	12.76
19.05	0.750	3/4"	5.50	6.19	31.11	0.24	0.015	5.50	40	2.474	3.42	0.70	0.04	5.12
12.70	0.500	1/2"	7.30	8.21	39.32	0.23	0.019	7.00	60	4.926	6.81	0.70	0.06	6.80
6.35	0.250	1/4"	15.18	17.07	56.39	0.17	0.029	10.75	70	11.950	16.53	0.50	0.09	10.09
1.70	0.065	10	23.94	26.92	83.31	0.14	0.038	13.97	60	16.154	22.35	0.50	0.13	15.92
MINUS		10	14.84	16.69	100.00	0.57	0.095	35.25	80	13.351	18.47	1.70	0.28	33.55
TOTALS			88.92	100.00				100.00			100.00			100.00
CALCULATED ASSAY						0.27			72			0.85		
COMPOSITE ASSAY (Pulv.)						0.32			90			0.80		

SCREEN ANALYSIS			Sample: **Column Leach Residue** **CL-01** **Composite 1 (Met-02/05)**											
NOMINAL OPENINGS		Tyler	Sample	Weight	Cumulative Weight	Gold			Copper			Silver		
mm	Inches	Mesh	Weights (kg)	Distribution (%)	Retained (%)	Assay (gpt)	Content	Distribution (%)	Assay (gpt)	Content	Distribution (%)	Assay (gpt)	Content	Distribution (%)
50.80	2.000	2"	1.44	2.59	2.59	0.07	0.002	4.24	420	10.893	11.86	0.80	0.02	3.12
38.10	1.500	1-1/2"	6.26	11.28	13.87	0.11	0.012	28.94	140	15.785	17.19	0.90	0.10	15.28
25.40	1.000	1"	5.30	9.55	23.41	0.07	0.007	15.59	100	9.546	10.40	0.80	0.08	11.50
19.05	0.750	3/4"	3.46	6.23	29.65	0.04	0.002	5.82	90	5.609	6.11	0.80	0.05	7.51
12.70	0.500	1/2"	4.84	8.72	38.36	0.04	0.003	8.14	180	15.692	17.09	0.50	0.04	6.56
6.35	0.250	1/4"	9.00	16.21	54.57	0.02	0.003	7.57	60	9.726	10.59	0.50	0.08	12.20
1.70	0.065	10	15.10	27.20	81.77	0.02	0.005	12.69	30	8.159	8.89	0.40	0.11	16.38
MINUS		10	10.12	18.23	100.00	0.04	0.007	17.01	90	16.405	17.87	1.00	0.18	27.44
TOTALS			55.52	100.00				100.00			100.00			100.00
CALCULATED ASSAY						0.04			92			0.66		
COMPOSITE ASSAY (Pulv.)						0.04			80			0.60		

SGS Metcon

TEST No. CL-01

Data Sheet

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**	
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height
SAMPLE	**Composite 1 (Met-02/05)**	**CRUSH SIZE**	P100 minus 3 in.
	0	**LEACH SOLUTION**	750 ppm free l g/l
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	1.95 kg CaO/tonne of ore
		CURE CYCLE	0 Days
		FLOWRATE	9.78 lph/m^2

		Pregnant Leach Solution							**Feed Solution**							
			Free			Assays (ppm)				Free			NaCN	Assays (ppm)		
Time (Days)		Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Au	Cu	Ag	Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Add/Rem. (grams)	Au	Cu	Ag
Leach	1	0.30	0.09	0.54	12.15	1.82	18.00	0.94	4.58	0.76	0.27	11.38		0.00	272.00	0.00
	2	4.00	0.35	0.40	12.20	1.66	153.00	1.25	4.20	0.76	0.27	11.38		0.00	272.00	0.00
	3	4.12	0.47	0.09	11.42	0.95	201.00	0.72	4.18	0.76	0.27	11.38		0.00	272.00	0.00
	4	4.26	0.54	0.03	10.61	0.50	243.00	0.38	4.36	0.76	1.14	11.38		0.00	272.00	0.00
	5	4.38	0.53	0.03	10.28	0.26	246.00	0.19	4.40	0.76	1.14	11.38		0.00	272.00	0.00
	6	4.28	0.62	0.04	10.20	0.15	270.00	0.14	4.34	0.76	1.14	11.38		0.00	272.00	0.00
	7	4.29	0.63	0.04	10.11	0.09	285.00	0.11	4.42	0.73	1.14	11.90		0.00	241.00	0.00
	8	4.22	0.65	0.03	10.15	0.09	283.00	0.07	4.28	0.73	1.14	11.90		0.00	241.00	0.00
	9	4.40	0.65	0.03	10.06	0.06	290.00	0.05	4.52	0.73	1.14	11.90		0.00	241.00	0.00
	10	4.64	0.61	0.02	10.00	0.05	293.00	0.05	4.64	0.73	1.14	11.90		0.00	241.00	0.00
	11	4.49	0.64	0.03	10.02	0.05	293.00	0.04	4.60	0.73	1.14	11.90		0.00	241.00	0.00
	12	4.28	0.60	0.02	9.98	0.04	308.00	0.04	4.30	0.73	1.14	11.90		0.00	241.00	0.00
	13	4.33	0.66	0.02	9.93	0.03	306.00	0.04	4.40	0.72	1.14	11.50		0.00	303.00	0.00
	14	4.36	0.65	0.02	9.96	0.02	318.00	0.03	4.40	0.72	1.14	11.50		0.00	303.00	0.00
	15	4.25	0.65	0.02	9.96	0.03	318.00	0.04	4.30	0.72	1.14	11.50		0.00	303.00	0.00
	16	4.20	0.66	0.02	9.98	0.02	301.00	0.04	4.24	0.72	1.14	11.50		0.00	303.00	0.00
	17	4.26	0.69	0.02	9.96	0.02	312.00	0.04	4.34	0.72	1.14	11.50		0.00	303.00	0.00
	18	4.28	0.62	0.01	9.86	0.02	309.00	0.04	4.34	0.72	1.14	12.40		0.00	303.00	0.00
	19	4.36	0.62	0.01	9.92	0.02	300.00	0.03	4.40	0.72	1.14	12.40		0.00	303.00	0.00
	20	4.36	0.63	0.03	9.90	0.01	299.00	0.02	4.44	0.72	1.14	12.40		0.00	303.00	0.00
	21	4.22	0.62	0.01	9.90	0.01	299.00	0.03	4.42	0.74	1.14	12.40		0.00	303.00	0.00
	22	4.30	0.63	0.01	9.89	0.01	297.00	0.04	4.32	0.74	1.14	12.40		0.00	303.00	0.00
	23	4.32	0.62	0.01	9.90	0.01	298.00	0.03	4.38	0.74	1.14	12.40		0.00	303.00	0.00
	24	4.35	0.65	0.01	9.96	0.01	300.00	0.03	4.42	0.74	1.14	12.40		0.00	303.00	0.00
	25	4.38	0.65	0.01	10.00	0.01	299.00	0.03	4.52	0.74	1.14	12.40		0.00	303.00	0.00
	26	4.28	0.64	0.01	9.96	0.01	307.00	0.05	4.34	0.74	1.14	12.40		0.00	303.00	0.00
	27	4.30	0.63	0.01	10.03	0.01	306.00	0.05	4.34	0.74	1.14	12.40		0.00	303.00	0.00
	28	4.58	0.63	0.01	9.91	0.01	305.00	0.03	4.52	0.74	1.14	12.40		0.00	303.00	0.00
	29	4.46	0.62	0.03	9.91	0.01	303.00	0.03	4.60	0.71	1.14	12.40		0.00	310.00	0.00
	30	4.36	0.64	0.02	9.91	0.01	305.00	0.03	4.50	0.71	1.14	12.40		0.00	310.00	0.00

SGS Metcon

TEST No. CL-01

Data Sheet

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**	
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height
SAMPLE	**Composite 1 (Met-02/05)**	**CRUSH SIZE**	P100 minus 3 in.
	0	**LEACH SOLUTION**	750 ppm free I g/l
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	1.95 kg CaO/tonne of ore
		CURE CYCLE	0 Days
		FLOWRATE	9.78 lph/m^2

		Pregnant Leach Solution							Feed Solution							
			Free			Assays (ppm)				Free			NaCN	Assays (ppm)		
Time (Days)		Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Au	Cu	Ag	Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Add/Rem. (grams)	Au	Cu	Ag
Leach	31	4.33	0.60	0.03	10.10	0.01	307.00	0.03	4.32	0.71	1.14	12.40		0.00	310.00	0.00
	32	4.27	0.60	0.04	10.00	0.01	307.00	0.03	4.44	0.71	1.14	12.40		0.00	310.00	0.00
	33	4.26	0.64	0.04	9.90	0.01	304.00	0.04	4.30	0.71	1.14	12.40		0.00	310.00	0.00
	34	4.24	0.64	0.03	9.89	0.01	307.00	0.04	4.30	0.71	1.14	12.40		0.00	310.00	0.00
	35	4.06	0.64	0.02	9.90	0.01	307.00	0.04	4.10	0.71	1.14	12.40		0.00	310.00	0.00
	36	4.29	0.65	0.02	9.90	0.01	305.00	0.04	4.36	0.71	1.14	12.40		0.00	303.00	0.00
	37	3.88	0.64	0.02	9.91	0.01	303.00	0.04	3.90	0.71	1.14	12.40		0.00	303.00	0.00
	38	4.24	0.65	0.02	9.89	0.01	303.00	0.04	4.50	0.71	1.14	12.40		0.00	303.00	0.00
	39	4.08	0.62	0.03	9.95	0.01	304.00	0.08	4.20	0.71	1.14	12.40		0.00	303.00	0.00
	40	4.28	0.60	0.02	9.88	0.01	299.00	0.07	4.34	0.71	1.14	12.40		0.00	303.00	0.00
	41	4.38	0.64	0.03	9.88	0.01	311.00	0.03	4.48	0.71	1.14	12.49		0.00	303.00	0.00
	42	4.24	0.60	0.03	9.90	0.01	313.00	0.03	4.30	0.71	1.14	12.40		0.00	303.00	0.00
	43	4.20	0.62	0.03	9.88	0.01	308.00	0.03	4.30	0.71	1.14	12.35		0.00	290.00	0.00
	44	4.20	0.59	0.02	9.89	0.01	309.00	0.03	4.18	0.71	1.14	12.44		0.00	290.00	0.00
	45	4.15	0.61	0.02	9.92	0.01	307.00	0.03	4.20	0.71	1.14	12.41		0.00	290.00	0.00
	46	4.32	0.62	0.02	9.94	0.01	311.00	0.03	4.38	0.71	1.14	12.40		0.00	290.00	0.00
	47	4.30	0.60	0.02	9.88	0.01	311.00	0.03	4.40	0.71	1.14	12.43		0.00	290.00	0.00
Wash	48	4.42	0.55	0.02	9.88	0.01	303.00	0.03	4.42	0.17	0.00	8.14		0.00	90.00	0.00
	49	4.10	0.30	0.04	9.99	0.01	214.00	0.03	4.10	0.17	0.00	8.14		0.00	90.00	0.00
	50	4.32	0.13	0.04	9.87	0.01	154.00	0.03	4.32	0.17	0.00	8.14		0.00	90.00	0.00
	51	4.10	0.15	0.05	9.84	0.01	161.00	0.03	4.10	0.17	0.00	8.14		0.00	90.00	0.00
	52	4.18	0.26	0.05	9.88	0.01	163.00	0.03	4.18	0.17	0.00	8.14		0.00	90.00	0.00
	53	4.47	0.23	0.05	9.54	0.01	164.00	0.03	4.47	0.17	0.00	8.14		0.00	90.00	0.00
	54	4.42	0.12	0.05	9.79	0.01	166.00	0.03	4.42	0.18	0.04	9.89		0.01	170.00	0.03
	55	4.61	0.12	0.05	9.79	0.01	166.00	0.03	4.61	0.18	0.04	9.89		0.01	170.00	0.03
	56	4.77	0.12	0.05	9.79	0.01	166.00	0.03	4.77	0.18	0.04	9.89		0.01	170.00	0.03
	57	4.77	0.12	0.05	9.79	0.01	166.00	0.03	4.77	0.18	0.04	9.89		0.01	170.00	0.03
	58	4.74	0.12	0.05	9.79	0.01	166.00	0.03	4.74	0.18	0.04	9.89		0.01	170.00	0.03
	59	4.60	0.12	0.05	9.79	0.01	166.00	0.03	4.60	0.18	0.04	9.89		0.01	170.00	0.03
	60	4.75	0.12	0.05	9.79	0.01	166.00	0.03	4.75	0.18	0.04	9.89		0.01	170.00	0.03

SGS Metcon

TEST No. CL-01

Data Sheet

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**	
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height
SAMPLE	**Composite 1 (Met-02/05)**	**CRUSH SIZE**	P100 minus 3 in.
	0	**LEACH SOLUTION**	750 ppm free l g/l
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	1.95 kg CaO/tonne of ore
		CURE CYCLE	0 Days
		FLOWRATE	9.78 lph/m^2

	Pregnant Leach Solution							**Feed Solution**							
		Free			Assays (ppm)				Free			NaCN	Assays (ppm)		
Time (Days)	Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Au	Cu	Ag	Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Add/Rem. (grams)	Au	Cu	Ag
Wash 61	4.57	0.04	0.05	9.66	0.01	168.00	0.05	4.57	0.12	0.05	9.79		0.01	166.00	0.03
62	4.57	0.04	0.05	9.66	0.01	168.00	0.05	4.57	0.12	0.05	9.79		0.01	166.00	0.03
63	4.77	0.04	0.05	9.66	0.01	168.00	0.05	4.77	0.12	0.05	9.79		0.01	166.00	0.03
64	4.74	0.04	0.05	9.66	0.01	168.00	0.05	4.74	0.12	0.05	9.79		0.01	166.00	0.03
65	4.82	0.04	0.05	9.66	0.01	168.00	0.05	4.82	0.12	0.05	9.79		0.01	166.00	0.03
66	4.82	0.04	0.05	9.66	0.01	168.00	0.05	4.82	0.12	0.05	9.79		0.01	166.00	0.03
67	4.80	0.04	0.05	9.66	0.01	168.00	0.05	4.80	0.12	0.05	9.79		0.01	166.00	0.03
68	4.80	0.10	0.05	9.56	0.01	171.00	0.05	4.80	0.04	0.05	9.66		0.01	168.00	0.05
69	4.73	0.10	0.05	9.56	0.01	171.00	0.05	4.73	0.04	0.05	9.66		0.01	168.00	0.05
70	4.68	0.10	0.05	9.56	0.01	171.00	0.05	4.68	0.04	0.05	9.66		0.01	168.00	0.05
71	4.62	0.10	0.05	9.56	0.01	171.00	0.05	4.62	0.04	0.05	9.66		0.01	168.00	0.05
72	4.58	0.10	0.05	9.56	0.01	171.00	0.05	4.58	0.04	0.05	9.66		0.01	168.00	0.05
73	4.55	0.10	0.05	9.56	0.01	171.00	0.05	4.55	0.04	0.05	9.66		0.01	168.00	0.05
74	4.54	0.10	0.05	9.56	0.01	171.00	0.05	4.54	0.04	0.05	9.66		0.01	168.00	0.05
75	4.45	0.09	0.06	9.68	0.01	174.00	0.07	4.45	0.10	0.05	9.56		0.01	171.00	0.05
76	4.40	0.09	0.06	9.68	0.01	174.00	0.07	4.40	0.10	0.05	9.56		0.01	171.00	0.05
77	4.48	0.09	0.06	9.68	0.01	174.00	0.07	4.48	0.10	0.05	9.56		0.01	171.00	0.05
78	4.39	0.09	0.06	9.68	0.01	174.00	0.07	4.39	0.10	0.05	9.56		0.01	171.00	0.05
79	4.41	0.09	0.06	9.68	0.01	174.00	0.07	4.41	0.10	0.05	9.56		0.01	171.00	0.05
80	4.29	0.09	0.06	9.68	0.01	174.00	0.07	4.29	0.10	0.05	9.56		0.01	171.00	0.05
81	4.36	0.09	0.06	9.68	0.01	174.00	0.07	4.36	0.10	0.05	9.56		0.01	171.00	0.05
82	4.25	0.08	0.07	9.64	0.01	185.00	0.12	4.25	0.09	0.06	9.68		0.01	174.00	0.07
83	4.37	0.08	0.07	9.64	0.01	185.00	0.12	4.37	0.09	0.06	9.68		0.01	174.00	0.07
84	4.30	0.08	0.07	9.64	0.01	185.00	0.12	4.30	0.09	0.06	9.68		0.01	174.00	0.07
85	4.32	0.08	0.07	9.64	0.01	185.00	0.12	4.32	0.09	0.06	9.68		0.01	174.00	0.07
86	3.80	0.08	0.07	9.64	0.01	185.00	0.12	3.80	0.09	0.06	9.68		0.01	174.00	0.07
87	3.95	0.08	0.07	9.64	0.01	185.00	0.12	3.95	0.09	0.06	9.68		0.01	174.00	0.07
88	4.22	0.08	0.07	9.64	0.01	185.00	0.12	4.22	0.09	0.06	9.68		0.01	174.00	0.07
89	4.34	0.08	0.07	9.64	0.01	185.00	0.12	4.34	0.09	0.06	9.68		0.01	174.00	0.07
90	4.00	0.08	0.07	9.64	0.01	185.00	0.12	4.00	0.09	0.06	9.68		0.01	174.00	0.07

SGS Metcon

TEST No. CL-01

Data Sheet

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**	
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height
SAMPLE	**Composite 1 (Met-02/05)**	**CRUSH SIZE**	P100 minus 3 in.
	0	**LEACH SOLUTION**	750 ppm free I g/l
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	1.95 kg CaO/tonne of ore
		CURE CYCLE	0 Days
		FLOWRATE	9.78 lph/m^2

		Pregnant Leach Solution							**Feed Solution**							
			Free			Assays (ppm)				Free			NaCN	Assays (ppm)		
Time (Days)		Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Au	Cu	Ag	Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Add/Rem. (grams)	Au	Cu	Ag
Wash	91	3.48	0.08	0.04	9.27	0.01	183.00	0.09	4.00	0.09	0.06	9.68		0.01	174.00	0.07
Rinse	92	4.30	0.60	0.10	9.74	0.01	172.00	0.08	4.52	0.00	0.00	0.00		0.00	0.00	0.00
Rinse	93	4.54	0.50	0.14	9.98	0.01	117.00	0.04	4.60	0.00	0.00	0.00		0.00	0.00	0.00
Drain	94	1.46	0.02	0.09	9.54	0.01	36.00	0.02	0.00	0.00	0.00	0.00		0.00	0.00	0.00
Drain	95	0.26	0.01	0.06	9.30	0.01	36.00	0.02	0.00	0.00	0.00	0.00		0.00	0.00	0.00
Drain	96	0.59	0.01	0.02	8.49	0.01	22.00	0.03	0.00	0.00	0.00	0.00		0.00	0.00	0.00

SGS Metcon

TEST No. CL-01

METALLURGICAL RESULTS

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**		
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14	
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height	
SAMPLE	**Composite 1 (Met-02/05)**	**CRUSH SIZE**	P100 minus 3 in.	
		LEACH SOLUTION	750 ppm fr g/l	
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	1.95	kg CaO/t of ore
		CURE CYCLE	0	Days
		FLOWRATE	9.78	lph/m^2

Time (Days)		Feed Solution Flow Rate (lph/sq m)	Cumulative										
			Extraction (g/t)			Solution Grade (ppm)			Extraction (%)			Consumption	
			Au	Cu	Ag	Au	Cu	Ag	Au	Cu	Ag	NaCN (kg/t)	CaO (kg/t)
Leach	1	8.10	0.01	-13.95	0.00	1.82	18.00	0.94	2.50	-11.09	0.34	0.04	1.96
	2	9.59	0.08	-19.91	0.06	1.67	143.58	1.23	32.92	-15.83	6.45	0.06	1.95
	3	9.54	0.12	-23.39	0.09	1.32	171.68	0.98	50.85	-18.59	10.07	0.07	1.96
	4	9.96	0.15	-25.08	0.11	1.04	195.64	0.78	60.60	-19.94	12.05	0.08	2.02
	5	10.02	0.16	-26.42	0.12	0.84	208.57	0.63	65.82	-21.01	13.07	0.10	2.07
	6	9.93	0.17	-26.70	0.13	0.70	220.89	0.53	68.76	-21.23	13.80	0.10	2.12
	7	10.09	0.17	-24.93	0.13	0.60	231.62	0.46	70.53	-19.82	14.37	0.11	2.18
	8	9.76	0.18	-23.10	0.14	0.53	238.88	0.40	72.27	-18.37	14.73	0.11	2.23
	9	10.31	0.18	-21.00	0.14	0.47	245.45	0.36	73.48	-16.70	15.00	0.12	2.29
	10	10.64	0.18	-18.29	0.14	0.42	251.12	0.32	74.54	-14.54	15.29	0.12	2.35
	11	10.51	0.19	-15.96	0.14	0.38	255.46	0.29	75.57	-12.69	15.51	0.13	2.40
	12	9.80	0.19	-12.79	0.14	0.35	260.18	0.27	76.36	-10.17	15.71	0.14	2.46
	13	10.06	0.19	-12.88	0.15	0.32	263.99	0.25	76.95	-10.24	15.93	0.14	2.51
	14	10.04	0.19	-12.29	0.15	0.30	268.17	0.23	77.35	-9.77	16.09	0.14	2.57
	15	9.84	0.19	-11.74	0.15	0.28	271.67	0.22	77.93	-9.33	16.29	0.15	2.62
	16	9.69	0.19	-11.97	0.15	0.26	273.57	0.21	78.32	-9.52	16.50	0.15	2.68
	17	9.91	0.19	-11.81	0.15	0.25	275.94	0.20	78.71	-9.39	16.71	0.15	2.73
	18	9.91	0.19	-11.73	0.16	0.24	277.87	0.19	79.10	-9.32	16.92	0.16	2.79
	19	10.07	0.20	-12.01	0.16	0.22	279.11	0.18	79.50	-9.55	17.08	0.16	2.84
	20	10.14	0.20	-12.48	0.16	0.21	280.17	0.17	79.70	-9.92	17.18	0.17	2.90
	21	10.10	0.20	-13.35	0.16	0.20	281.09	0.16	79.89	-10.61	17.34	0.18	2.95
	22	9.85	0.20	-13.71	0.16	0.19	281.84	0.16	80.09	-10.90	17.55	0.18	3.01
	23	10.00	0.20	-14.16	0.16	0.18	282.58	0.15	80.29	-11.25	17.70	0.19	3.07
	24	10.12	0.20	-14.54	0.16	0.18	283.34	0.15	80.49	-11.56	17.86	0.19	3.12
	25	10.29	0.20	-15.22	0.17	0.17	284.00	0.14	80.69	-12.10	18.02	0.20	3.18
	26	9.91	0.20	-15.23	0.17	0.16	284.92	0.14	80.79	-12.11	18.29	0.20	3.23
	27	9.89	0.20	-15.22	0.17	0.16	285.72	0.14	80.88	-12.10	18.55	0.21	3.29
	28	10.35	0.20	-14.91	0.17	0.15	286.48	0.13	81.09	-11.85	18.72	0.21	3.35
	29	10.51	0.20	-15.75	0.17	0.15	287.09	0.13	81.30	-12.52	18.88	0.22	3.40
	30	10.31	0.20	-16.48	0.18	0.14	287.71	0.12	81.50	-13.10	19.04	0.22	3.46

SGS Metcon

TEST No. CL-01

METALLURGICAL RESULTS

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**		
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14	
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height	
SAMPLE	**Composite 1 (Met-02/05)**	**CRUSH SIZE**	P100 minus 3 in.	
		LEACH SOLUTION	750 ppm fr g/l	
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	1.95	kg CaO/t of ore
		CURE CYCLE	0	Days
		FLOWRATE	9.78	lph/m^2

Time		**Feed Solution Flow Rate**	**Cumulative**										
			Extraction (g/t)			**Solution Grade (ppm)**			**Extraction (%)**			**Consumption**	
(Days)		**(lph/sq m)**	**Au**	**Cu**	**Ag**	**Au**	**Cu**	**Ag**	**Au**	**Cu**	**Ag**	**NaCN (kg/t)**	**CaO (kg/t)**
Leach	31	9.87	0.20	-16.59	0.18	0.14	288.35	0.12	81.70	-13.19	19.20	0.23	3.51
	32	10.11	0.20	-17.33	0.18	0.13	288.95	0.12	81.79	-13.78	19.35	0.24	3.57
	33	9.86	0.20	-17.76	0.18	0.13	289.41	0.12	81.89	-14.12	19.56	0.24	3.62
	34	9.79	0.20	-18.11	0.18	0.13	289.93	0.11	81.99	-14.40	19.77	0.24	3.68
	35	9.37	0.20	-18.39	0.18	0.12	290.40	0.11	82.08	-14.62	19.97	0.25	3.73
	36	9.99	0.20	-18.53	0.19	0.12	290.82	0.11	82.18	-14.73	20.18	0.25	3.78
	37	8.86	0.20	-18.60	0.19	0.12	291.12	0.11	82.27	-14.78	20.37	0.25	3.83
	38	10.45	0.20	-19.48	0.19	0.11	291.44	0.11	82.37	-15.49	20.57	0.26	3.89
	39	9.42	0.20	-19.85	0.19	0.11	291.75	0.11	82.46	-15.78	20.97	0.26	3.94
	40	10.00	0.20	-20.24	0.20	0.11	291.94	0.10	82.56	-16.09	21.34	0.27	4.00
	41	10.18	0.20	-20.19	0.20	0.10	292.42	0.10	82.66	-16.05	21.50	0.27	4.05
	42	9.84	0.20	-19.92	0.20	0.10	292.92	0.10	82.76	-15.83	21.65	0.28	4.11
	43	9.84	0.20	-19.39	0.20	0.10	293.27	0.10	82.85	-15.42	21.81	0.28	4.16
	44	9.54	0.20	-18.43	0.20	0.10	293.63	0.10	82.95	-14.65	21.96	0.29	4.21
	45	9.60	0.20	-17.80	0.20	0.10	293.92	0.10	83.04	-14.15	22.11	0.30	4.27
	46	10.01	0.20	-16.98	0.21	0.09	294.30	0.09	83.14	-13.50	22.27	0.30	4.32
	47	10.05	0.20	-16.29	0.21	0.09	294.67	0.09	83.24	-12.95	22.43	0.31	4.38
Wash	48	10.05	0.20	-5.70	0.21	0.09	294.85	0.09	83.34	-4.53	22.59	0.29	4.37
	49	9.40	0.20	0.02	0.21	0.09	293.24	0.09	83.44	0.02	22.74	0.28	4.37
	50	9.84	0.21	3.13	0.21	0.09	290.38	0.09	83.53	2.49	22.90	0.28	4.37
	51	9.37	0.21	6.40	0.21	0.09	287.90	0.09	83.63	5.09	23.05	0.28	4.37
	52	9.57	0.21	9.83	0.21	0.08	285.51	0.09	83.72	7.82	23.20	0.28	4.37
	53	10.19	0.21	13.55	0.22	0.08	283.08	0.09	83.83	10.77	23.37	0.28	4.36
	54	10.08	0.21	13.35	0.22	0.08	280.80	0.08	83.73	10.62	23.37	0.28	4.36
	55	10.57	0.21	13.15	0.22	0.08	278.52	0.08	83.62	10.45	23.37	0.28	4.36
	56	10.88	0.21	12.93	0.22	0.08	276.25	0.08	83.51	10.28	23.37	0.29	4.36
	57	10.88	0.20	12.72	0.22	0.08	274.07	0.08	83.40	10.11	23.37	0.29	4.36
	58	10.83	0.20	12.51	0.22	0.07	271.99	0.08	83.29	9.94	23.37	0.29	4.36
	59	10.54	0.20	12.30	0.22	0.07	270.05	0.08	83.19	9.78	23.37	0.30	4.36
	60	10.85	0.20	12.08	0.22	0.07	268.12	0.08	83.08	9.61	23.37	0.30	4.36

SGS Metcon

TEST No. CL-01

METALLURGICAL RESULTS

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**		
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14	
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height	
SAMPLE	**Composite 1 (Met-02/05)**	**CRUSH SIZE**	P100 minus 3 in.	
		LEACH SOLUTION	750 ppm fr	g/l
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	1.95	kg CaO/t of ore
		CURE CYCLE	0	Days
		FLOWRATE	9.78	lph/m^2

Time		Feed Solution Flow Rate	Cumulative										
			Extraction (g/t)			Solution Grade (ppm)			Extraction (%)			Consumption	
(Days)		(lph/sq m)	Au	Cu	Ag	Au	Cu	Ag	Au	Cu	Ag	NaCN (kg/t)	CaO (kg/t)
Wash	61	10.42	0.20	12.19	0.22	0.07	266.36	0.08	82.97	9.69	23.48	0.30	4.36
	62	10.45	0.20	12.29	0.22	0.07	264.66	0.08	82.87	9.77	23.59	0.31	4.36
	63	10.90	0.20	12.40	0.22	0.07	262.95	0.08	82.76	9.86	23.71	0.31	4.36
	64	10.82	0.20	12.50	0.22	0.07	261.31	0.08	82.65	9.94	23.82	0.32	4.36
	65	10.98	0.20	12.61	0.22	0.07	259.70	0.08	82.54	10.03	23.94	0.32	4.36
	66	11.03	0.20	12.72	0.22	0.07	258.14	0.08	82.43	10.11	24.06	0.32	4.36
	67	10.94	0.20	12.83	0.22	0.06	256.64	0.08	82.32	10.20	24.18	0.33	4.36
	68	10.97	0.20	12.99	0.22	0.06	255.24	0.07	82.32	10.33	24.18	0.33	4.36
	69	10.80	0.20	13.15	0.22	0.06	253.90	0.07	82.32	10.45	24.18	0.32	4.36
	70	10.67	0.20	13.31	0.22	0.06	252.62	0.07	82.32	10.58	24.18	0.32	4.36
	71	10.61	0.20	13.46	0.22	0.06	251.40	0.07	82.32	10.70	24.18	0.32	4.36
	72	10.46	0.20	13.62	0.22	0.06	250.22	0.07	82.32	10.83	24.18	0.31	4.36
	73	10.37	0.20	13.77	0.22	0.06	249.08	0.07	82.32	10.95	24.18	0.31	4.36
	74	10.34	0.20	13.93	0.22	0.06	247.97	0.07	82.32	11.07	24.18	0.31	4.36
	75	10.21	0.20	14.08	0.22	0.06	246.96	0.07	82.32	11.19	24.28	0.31	4.36
	76	10.02	0.20	14.22	0.22	0.06	245.99	0.07	82.32	11.31	24.39	0.31	4.36
	77	10.23	0.20	14.38	0.23	0.06	245.03	0.07	82.32	11.43	24.50	0.31	4.36
	78	10.03	0.20	14.52	0.23	0.06	244.11	0.07	82.32	11.55	24.61	0.31	4.36
	79	10.07	0.20	14.67	0.23	0.06	243.20	0.07	82.32	11.66	24.72	0.31	4.36
	80	9.80	0.20	14.82	0.23	0.05	242.35	0.07	82.32	11.78	24.82	0.31	4.36
	81	9.96	0.20	14.96	0.23	0.05	241.50	0.07	82.32	11.90	24.93	0.31	4.36
	82	9.71	0.20	15.49	0.23	0.05	240.83	0.07	82.32	12.31	25.19	0.31	4.36
	83	9.98	0.20	16.03	0.23	0.05	240.15	0.07	82.32	12.74	25.45	0.31	4.36
	84	9.82	0.20	16.56	0.24	0.05	239.50	0.07	82.32	13.17	25.72	0.31	4.36
	85	9.85	0.20	17.10	0.24	0.05	238.87	0.07	82.32	13.59	25.98	0.31	4.35
	86	8.70	0.20	17.57	0.24	0.05	238.32	0.08	82.32	13.97	26.21	0.31	4.35
	87	9.04	0.20	18.06	0.24	0.05	237.76	0.08	82.32	14.35	26.45	0.31	4.35
	88	9.63	0.20	18.58	0.25	0.05	237.17	0.08	82.32	14.77	26.71	0.31	4.35
	89	9.89	0.20	19.11	0.25	0.05	236.59	0.08	82.32	15.20	26.98	0.31	4.35
	90	9.15	0.20	19.61	0.25	0.05	236.06	0.08	82.32	15.59	27.22	0.31	4.35

SGS Metcon

TEST No. CL-01

METALLURGICAL RESULTS

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**		
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14	
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height	
SAMPLE	**Composite 1 (Met-02/05)**	**CRUSH SIZE**	P100 minus 3 in.	
		LEACH SOLUTION	750 ppm fr	g/l
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	1.95	kg CaO/t of ore
		CURE CYCLE	0	Days
		FLOWRATE	9.78	lph/m^2

Time		**Feed Solution Flow Rate**	**Cumulative**										
			Extraction (g/t)			**Solution Grade (ppm)**			**Extraction (%)**			**Consumption**	
(Days)		**(lph/sq m)**	**Au**	**Cu**	**Ag**	**Au**	**Cu**	**Ag**	**Au**	**Cu**	**Ag**	**NaCN (kg/t)**	**CaO (kg/t)**
Wash	91	9.14	0.20	18.94	0.25	0.05	235.59	0.08	82.31	15.06	27.26	0.32	4.35
Rinse	92	10.32	0.20	27.26	0.25	0.05	234.90	0.08	82.41	21.67	27.68	0.29	4.35
Rinse	93	10.54	0.20	33.23	0.26	0.05	233.57	0.08	82.51	26.42	27.90	0.26	4.34
Drain	94	0.00	0.20	33.83	0.26	0.05	232.85	0.08	82.54	26.89	27.94	0.26	4.34
Drain	95	0.00	0.20	33.93	0.26	0.05	232.72	0.08	82.55	26.97	27.94	0.26	4.34
Drain	96	0.00	0.20	34.08	0.26	0.05	232.42	0.08	82.56	27.09	27.97	0.26	4.34

APPENDIX 5

Column Leach Test CL-02 on Composite 1 (Duplicate)

Summary of Results | **SGS Metcon** | Current Date: 09/26/14

SGS Metcon Project No.: M-709-03

Western Copper & Gold Corp. Casino Project

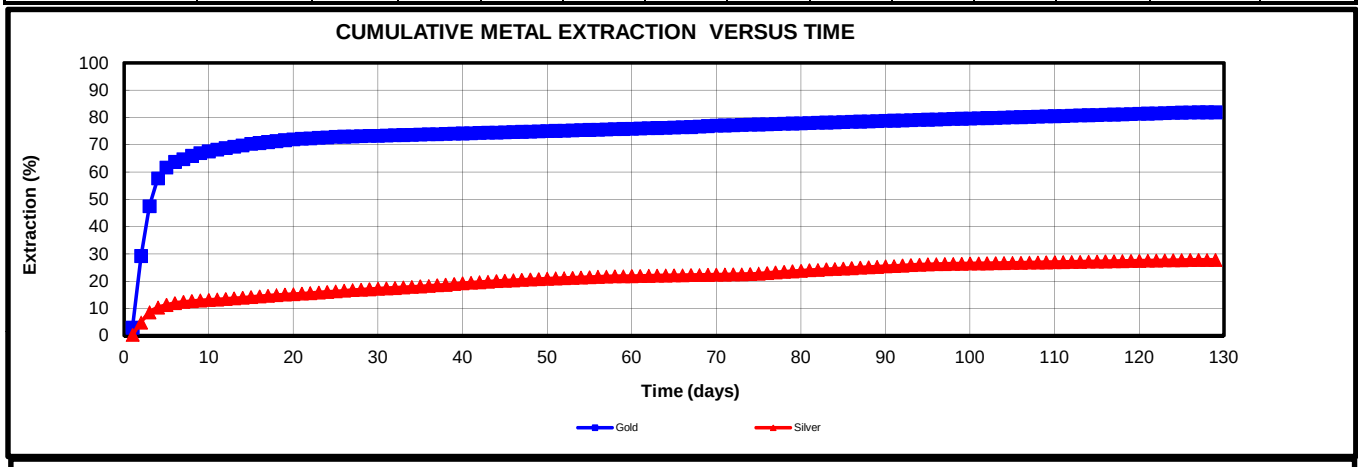
TEST No.: CL-02 | Crush Size: P100 minus 3 in.

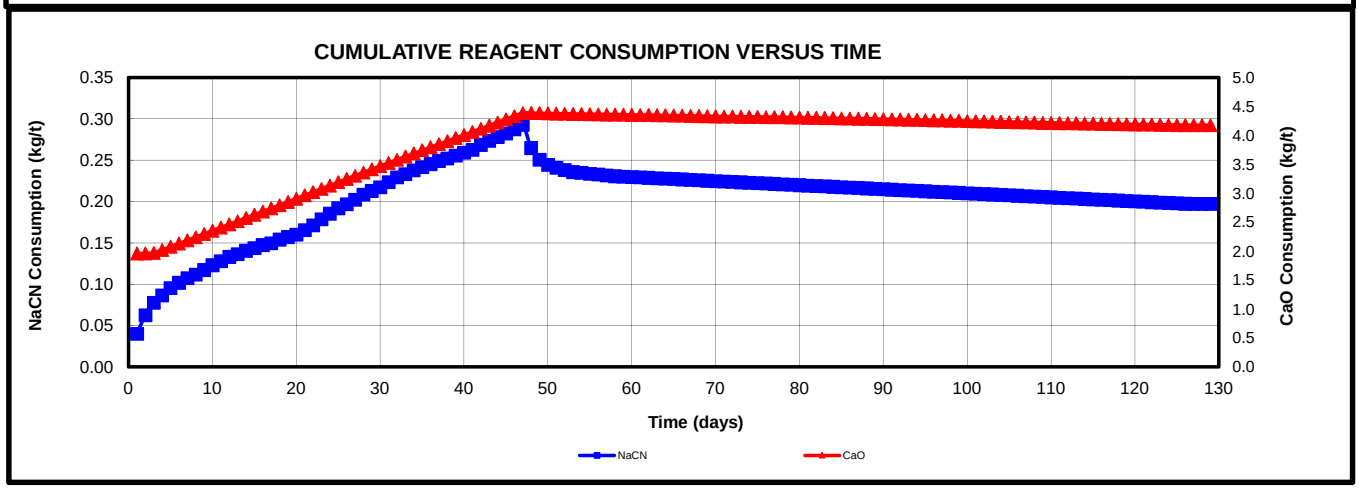
SAMPLE : Composite 1 (Met-02/05) | Lime Addition: 1.95 kg Lime/tonne of ore

Objective: Gold and Silver Extraction vs Time

Cure Days:	0
Leach Days:	47
Rest Days:	0
Wash Days:	79
Drain Days:	3
Total Cycle Days:	129

PRODUCTS	Volume	Weight	Cumulative										
			Assay (g/t)			Contents (mg)			Percent Extraction			Consumption	
												NaCN	CaO
	(liters)	(kg)	Au	Cu	Ag	Au	Cu	Ag	Au	Cu	Ag	(kg/t)	(kg/t)
Feed Solution	553.08		0.00	107	0.00	0.00	58979	0.00	81.90	14.92	27.78	0.20	4.18
Pregnant Solution	542.24		0.04	111	0.04	20.59	60312	23.62					
Leach Residue		88.84	0.05	86	0.69	4.55	7598	61.41					
CALCULATIONS													
Metal Extracted			0.23	15.00	0.27	20.59	1333	23.62					
Calculated Head			0.28	100.53	0.96	25.14	8931	85.04					
Assay Head		88.84	0.27	72.27	0.85	23.97	6421	75.12					

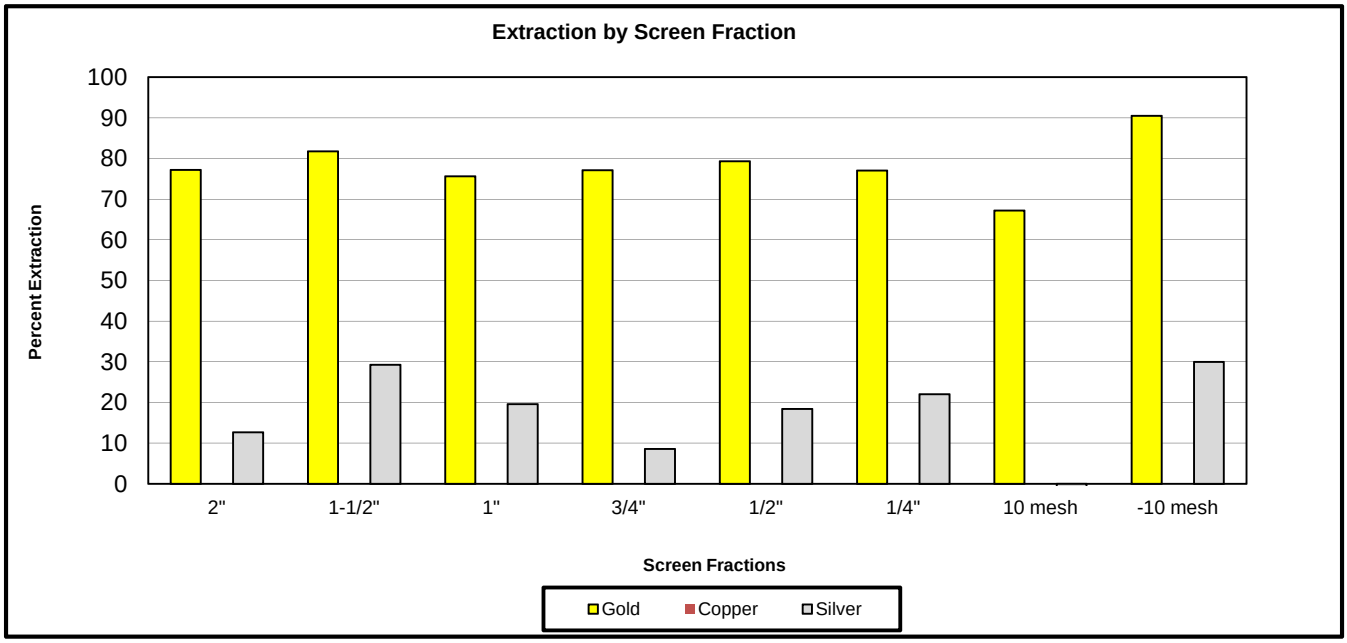




SGS Metcon

Test: CL-02
Sample: Composite 1 (Met-02/05)
Casino Project

Western Copper & Gold Corp.
SGS Metcon Project No.: M-709-03



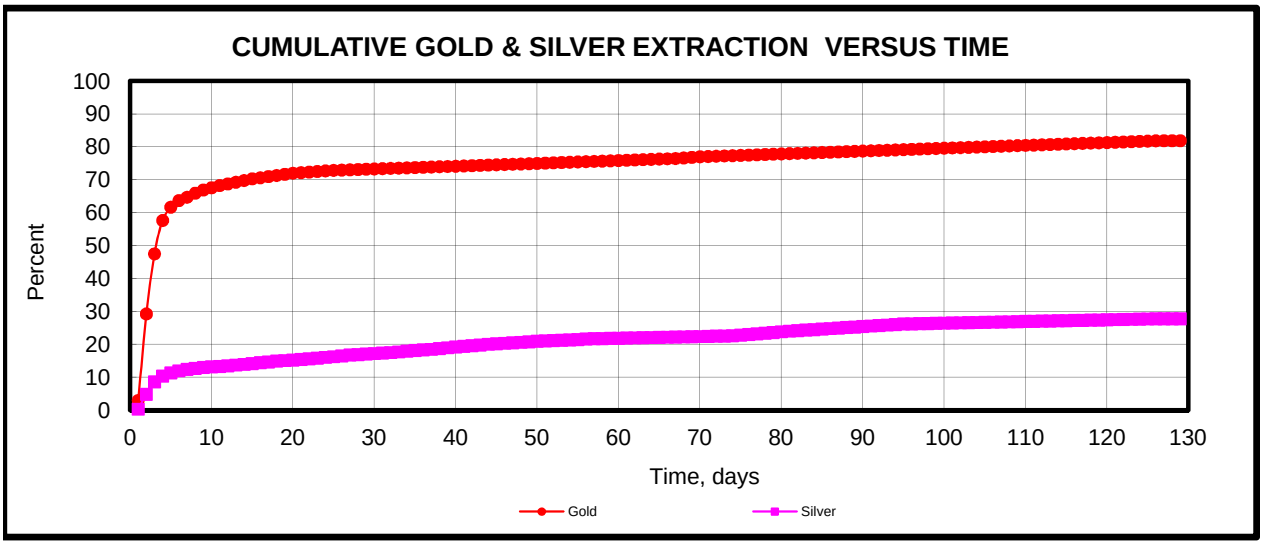
Test No. : CL-02

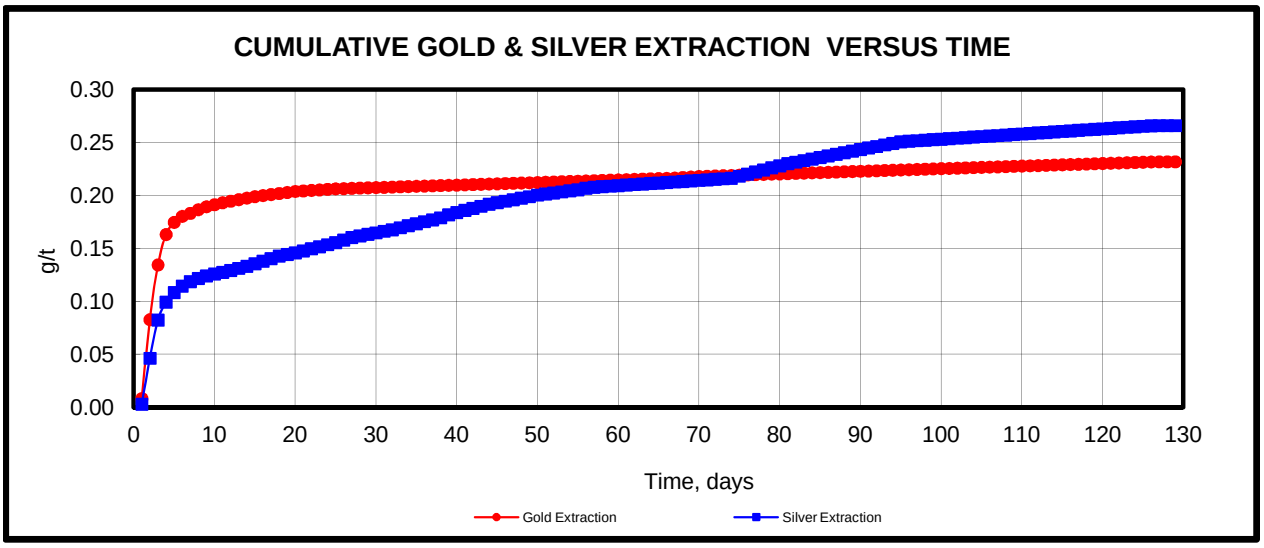
Screen Fraction	Head				Leach Residue				Percent Extraction			Degradation Index
	Weight	Assays (g/t)			Weight	Assays (g/t)						
	(kg)	Au	Cu	Ag	(kg)	Au	Cu	Ag	Au	Cu	Ag	(%)
2"	1.80	0.46	220	1.20	2.10	0.09	220	0.90	77.22	-	12.68	-16.43
1-1/2"	9.68	0.31	130	1.00	6.85	0.08	130	1.00	81.75	-	29.28	29.28
1"	10.66	0.26	40	0.90	9.64	0.07	130	0.80	75.65	-	19.61	9.57
3/4"	5.50	0.24	40	0.70	5.03	0.06	80	0.70	77.14	-	8.55	8.55
1/2"	7.28	0.23	60	0.70	6.93	0.05	80	0.60	79.30	-	18.37	4.76
1/4"	15.16	0.17	70	0.50	14.77	0.04	50	0.40	77.07	-	22.03	2.54
10 mesh	23.94	0.14	60	0.50	27.49	0.04	50	0.50	67.19	-	-14.82	-14.82
-10 mesh	14.82	0.57	80	1.70	16.03	0.05	120	1.10	90.51	-	30.00	-8.18
Total	88.84	0.27	72	0.85	88.84	0.05	86	0.69	81.01		18.25	

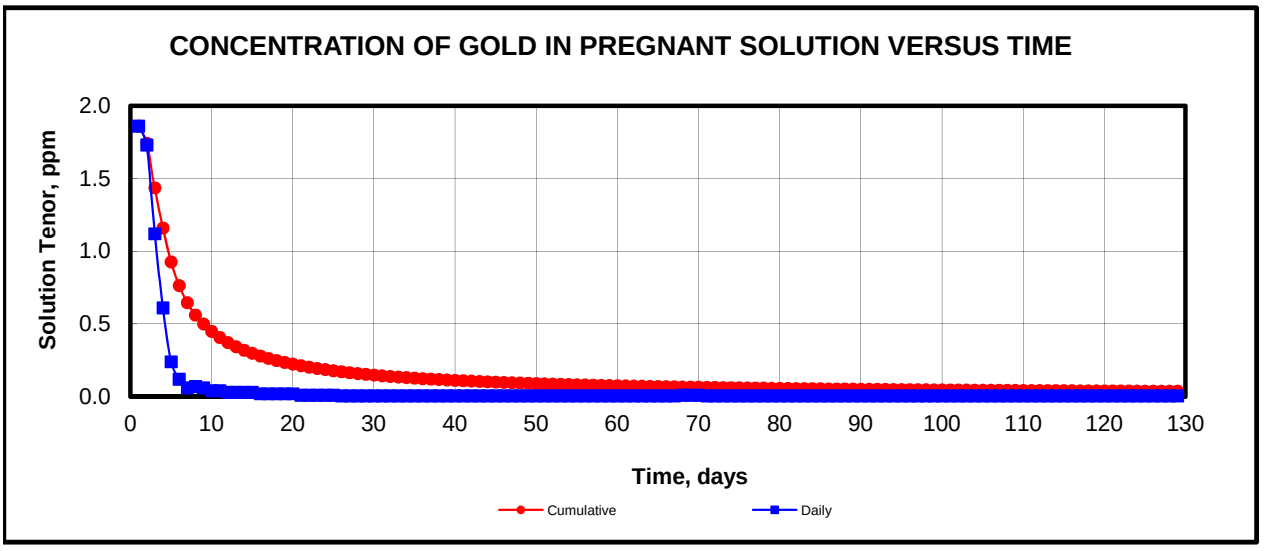
SGS Metcon

Test: CL-02 — Western Copper & Gold Corp.

Sample: Composite 1 (Met-02/05) — SGS Metcon Project No.: M-709-03



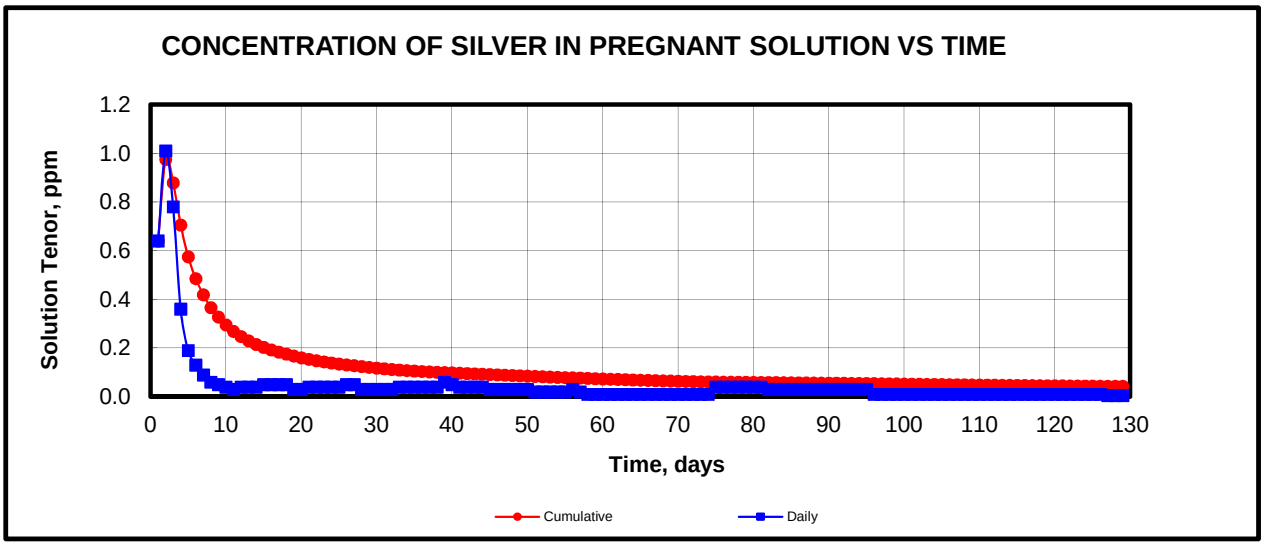


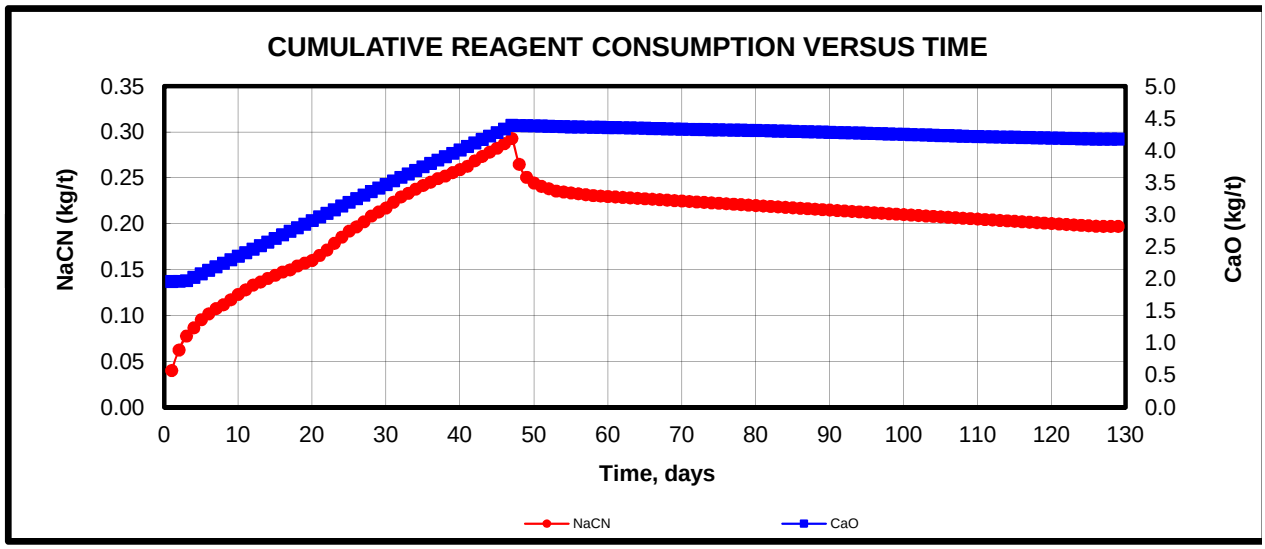


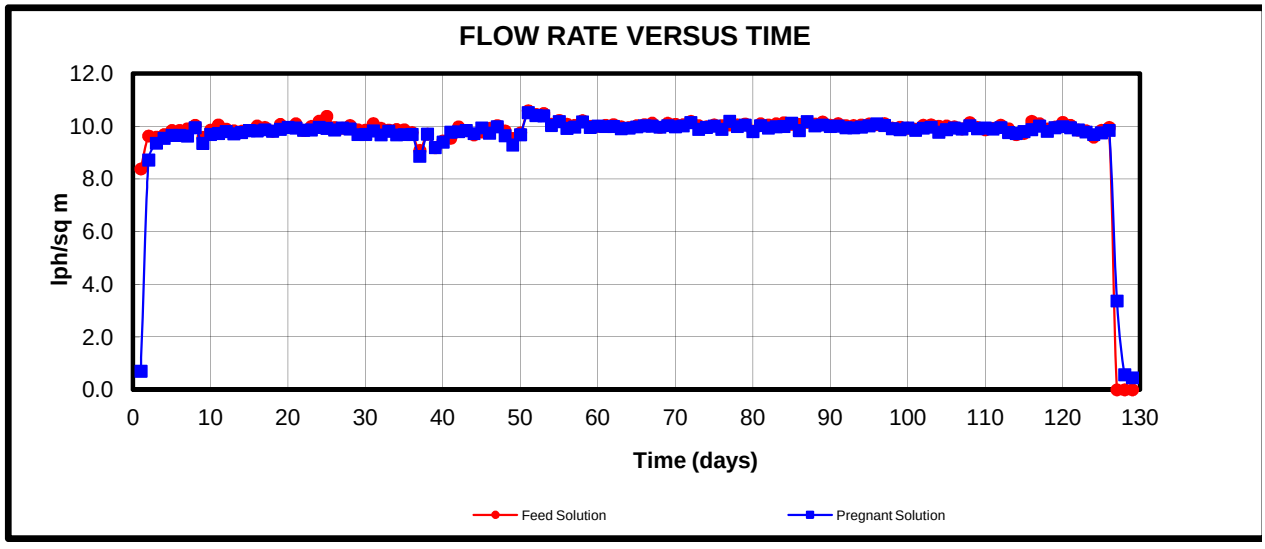
SGS Metcon

Test: CL-02 — Western Copper & Gold Corp.

Sample: Composite 1 (Met-02/05) — SGS Metcon Project No.: M-709-03



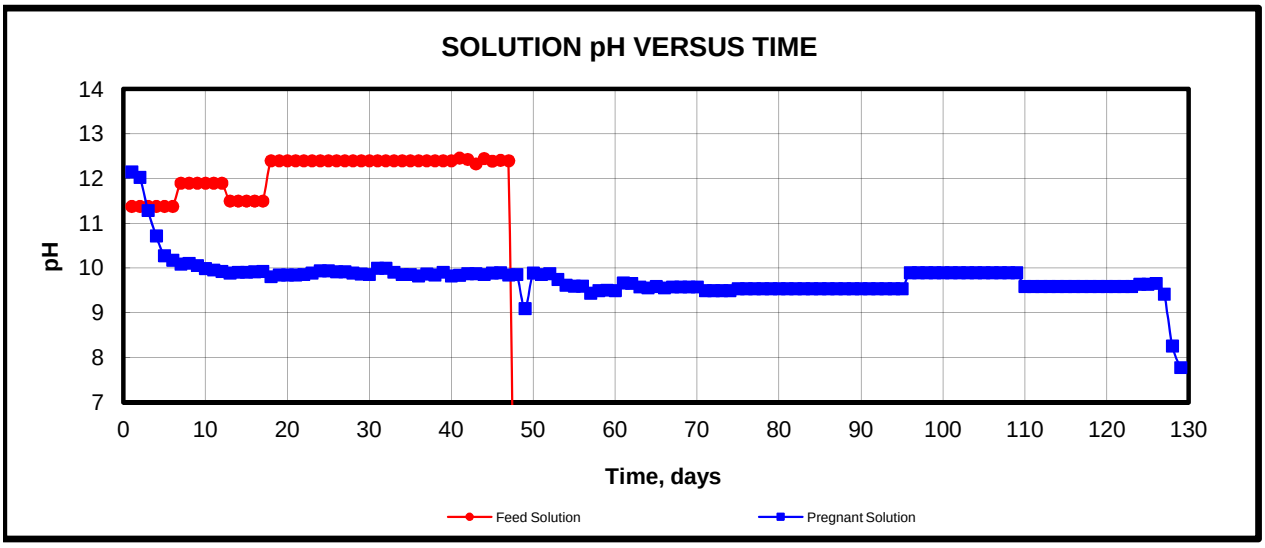


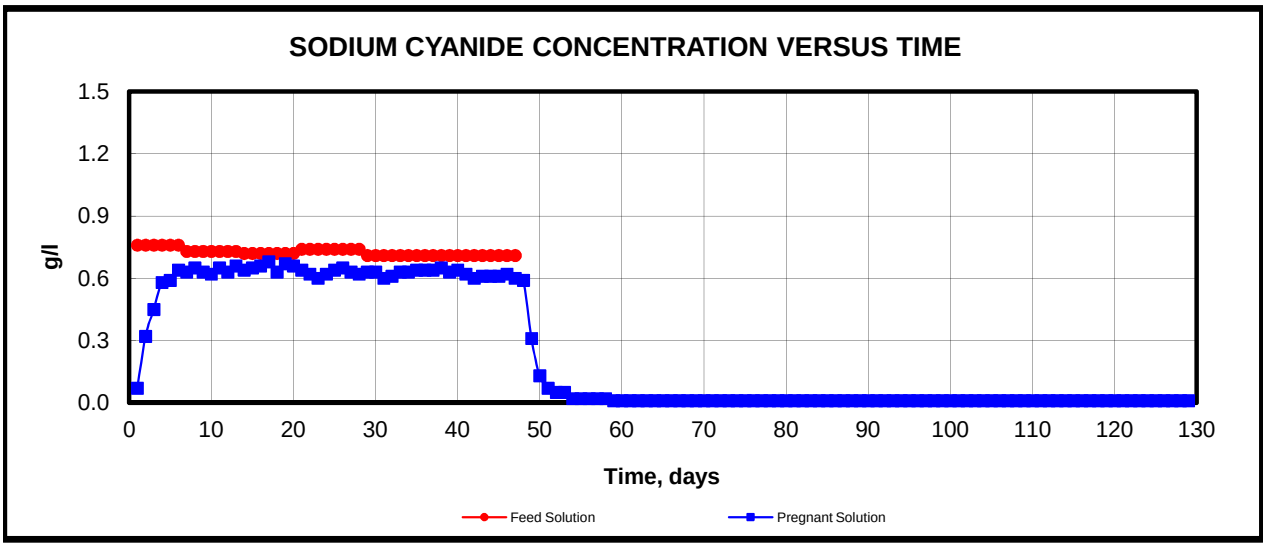


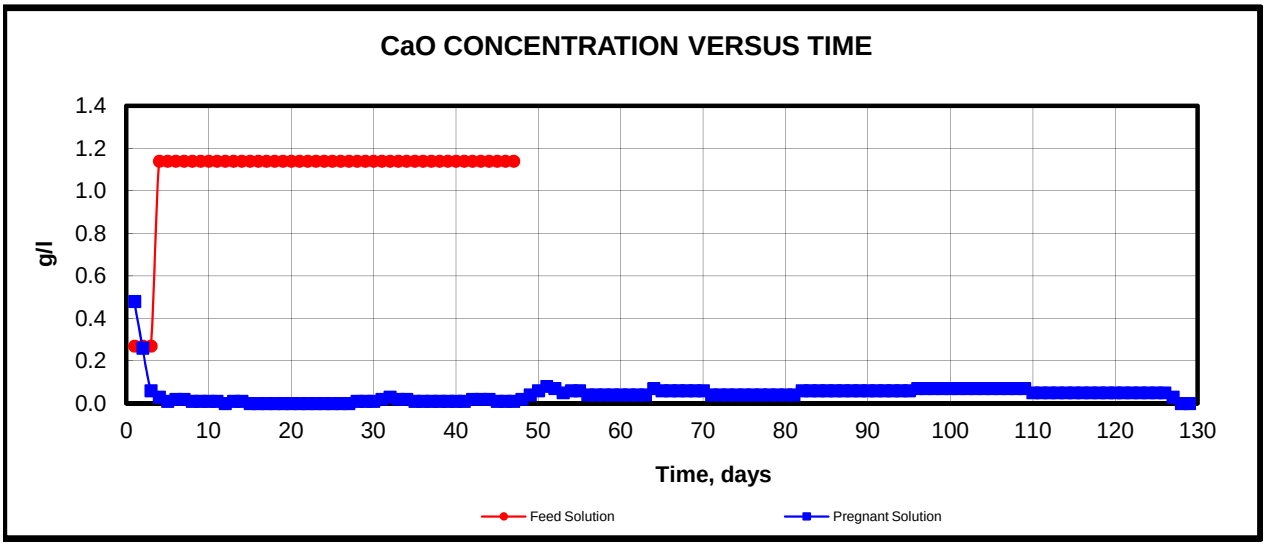
SGS Metcon

Test: CL-02 — Western Copper & Gold Corp.

Sample: Composite 1 (Met-02/05) — SGS Metcon Project No.: M-709-03







SGS Metcon

TEST No. CL-02

PHYSICAL CHARACTERISTICS SHEET

CLIENT	Western Copper & Gold Corp. SGS Metcon Project No.: M-709-03	**TEST CONDITIONS**	
		TEST START	05/01/14
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height
SAMPLE	Composite 1 (Met-02/05)	**CRUSH SIZE**	P100 minus 3 in.
		LEACH SOLUTION	750 ppm free NaCN, 300 ppm Cu
OBJECTIVE	Gold and Silver Extraction vs Time	**Lime Addition**	1.95 kg CaO/tonne of Ore
		CURE CYCLE	0 days
		FLOWRATE	9.78 lph/m2

FLOWRATE (lph/sq m)		9.78			
CURE STAGE (days)		0			
COLUMN DIAMETER (mm)		152.40			
ELEMENTS ANALYZED	Au	CNs Au	Ag	CNs Ag	Cu
HEAD ASSAYS (g per tonne)	0.27		0.85		72.27
LEACH RESIDUE ASSAYS (g per tonne)	0.05		0.69		85.53
SAMPLE PERCENT MOISTURE AS RECEIVED (Dry Basis)		0.00			
SAMPLE WEIGHT BEFORE AGGLOMERATION (kg)		88.84			
AGGLOMERATED SAMPLE WEIGHT (kg)		92.36			
INITIAL SAMPLE PERCENT MOISTURE (including agglomeration water)		3.96	(Dry Basis)		
INITIAL SAMPLE DRY WEIGHT (kg)		88.84			
INITIAL SAMPLE HEIGHT (m)		2.95			
INITIAL SAMPLE BULK DENSITY (kg/cu m)		1648	(Dry Basis)		
FINAL SAMPLE HEIGHT (m)		2.95			
RESIDUE WET WEIGHT (kg)		95.02			
RESIDUE DRY WEIGHT (kg)		88.84			
VOLUME DRAINED (l)		1.93			
SUBSIDENCE (%)		0.03			
MOISTURE UNDER LEACH (%)		9.13	(Dry Basis)		
MOISTURE RETAINED (%)		6.96	(Dry Basis)		
FINAL SAMPLE BULK DENSITY (kg/cu m)		1649	(Dry Basis)		

SGS Metcon
7701 BUSINESS PARK DRIVE
TUCSON , ARIZONA 85743

SCREEN ANALYSIS RESULTS
Western Copper & Gold Corp.
SGS Metcon Project No.: M-709-03
Casino Project

SCREEN ANALYSIS			Sample: **Column Leach Head** **CL-02** **Composite 1 (Met-02/05)** **Crush Size: P100 minus 3 in.**											
NOMINAL OPENINGS		Tyler	Sample	Weight	Cumulative Weight	Gold			Copper			Silver		
mm	Inches	Mesh	Weights (kg)	Distribution (%)	Retained (%)	Assay (gpt)	Content	Distribution (%)	Assay (gpt)	Content	Distribution (%)	Assay (gpt)	Content	Distribution (%)
50.80	2.000	2"	1.80	2.03	2.03	0.46	0.009	3.45	220	4.457	6.17	1.20	0.02	2.88
38.10	1.500	1-1/2"	9.68	10.90	12.92	0.31	0.034	12.52	130	14.165	19.60	1.00	0.11	12.89
25.40	1.000	1"	10.66	12.00	24.92	0.26	0.031	11.56	40	4.800	6.64	0.90	0.11	12.77
19.05	0.750	3/4"	5.50	6.19	31.11	0.24	0.015	5.51	40	2.476	3.43	0.70	0.04	5.12
12.70	0.500	1/2"	7.28	8.19	39.31	0.23	0.019	6.99	60	4.917	6.80	0.70	0.06	6.78
6.35	0.250	1/4"	15.16	17.06	56.37	0.17	0.029	10.75	70	11.945	16.53	0.50	0.09	10.09
1.70	0.065	10	23.94	26.95	83.32	0.14	0.038	13.98	60	16.168	22.37	0.50	0.13	15.93
MINUS		10	14.82	16.68	100.00	0.57	0.095	35.24	80	13.345	18.46	1.70	0.28	33.54
TOTALS			88.84	100.00				100.00			100.00			100.00
CALCULATED ASSAY						0.27			72			0.85		
COMPOSITE ASSAY (Pulv.)						0.32			90			0.80		

SCREEN ANALYSIS			Sample: **Column Leach Residue** **CL-02** **Composite 1 (Met-02/05)**											
NOMINAL OPENINGS		Tyler	Sample	Weight	Cumulative Weight	Gold			Copper			Silver		
mm	Inches	Mesh	Weights (kg)	Distribution (%)	Retained (%)	Assay (gpt)	Content	Distribution (%)	Assay (gpt)	Content	Distribution (%)	Assay (gpt)	Content	Distribution (%)
50.80	2.000	2"	1.20	2.36	2.36	0.09	0.002	4.14	220.00	5.190	6.07	0.90	0.02	3.07
38.10	1.500	1-1/2"	3.92	7.71	10.06	0.08	0.006	12.03	130.00	10.018	11.71	1.00	0.08	11.15
25.40	1.000	1"	5.52	10.85	20.92	0.07	0.008	14.83	130.00	14.107	16.49	0.80	0.09	12.56
19.05	0.750	3/4"	2.88	5.66	26.58	0.06	0.003	6.63	80.00	4.529	5.30	0.70	0.04	5.73
12.70	0.500	1/2"	3.97	7.80	34.38	0.05	0.004	7.62	80.00	6.243	7.30	0.60	0.05	6.77
6.35	0.250	1/4"	8.46	16.63	51.01	0.04	0.007	12.98	50.00	8.315	9.72	0.40	0.07	9.62
1.70	0.065	10	15.74	30.94	81.95	0.04	0.012	24.16	50.00	15.471	18.09	0.50	0.15	22.38
MINUS		10	9.18	18.05	100.00	0.05	0.009	17.61	120.00	21.655	25.32	1.10	0.20	28.72
TOTALS			50.87	100.00				100.00			100.00			100.00
CALCULATED ASSAY						0.05			86			0.69		
COMPOSITE ASSAY (Pulv.)						0.05			90			0.70		

SGS Metcon

TEST No. CL-02

Data Sheet

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**	
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height
SAMPLE	**Composite 1 (Met-02/05)**	**CRUSH SIZE**	P100 minus 3 in.
	0	**LEACH SOLUTION**	750 ppm free I g/l
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	1.95 kg CaO/tonne of ore
		CURE CYCLE	0 Days
		FLOWRATE	9.78 lph/m^2

		Pregnant Leach Solution							**Feed Solution**							
			Free			Assays (ppm)				Free			NaCN	Assays (ppm)		
Time (Days)		Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Au	Cu	Ag	Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Add/Rem. (grams)	Au	Cu	Ag
Leach	1	0.40	0.07	0.48	12.15	1.86	15.00	0.64	4.74	0.76	0.27	11.38		0.00	272.00	0.00
	2	3.82	0.32	0.26	12.03	1.73	134.00	1.01	4.22	0.76	0.27	11.38		0.00	272.00	0.00
	3	4.10	0.45	0.06	11.29	1.12	193.00	0.78	4.20	0.76	0.27	11.38		0.00	272.00	0.00
	4	4.18	0.58	0.03	10.72	0.61	239.00	0.36	4.24	0.76	1.14	11.38		0.00	272.00	0.00
	5	4.24	0.59	0.01	10.28	0.24	272.00	0.19	4.32	0.76	1.14	11.38		0.00	272.00	0.00
	6	4.22	0.64	0.02	10.18	0.12	280.00	0.13	4.30	0.76	1.14	11.38		0.00	272.00	0.00
	7	4.22	0.63	0.02	10.09	0.06	285.00	0.09	4.34	0.73	1.14	11.90		0.00	241.00	0.00
	8	4.36	0.65	0.01	10.11	0.07	280.00	0.06	4.40	0.73	1.14	11.90		0.00	241.00	0.00
	9	4.10	0.63	0.01	10.06	0.06	286.00	0.05	4.20	0.73	1.14	11.90		0.00	241.00	0.00
	10	4.23	0.62	0.01	9.99	0.04	287.00	0.04	4.30	0.73	1.14	11.90		0.00	241.00	0.00
	11	4.26	0.65	0.01	9.96	0.04	287.00	0.03	4.40	0.73	1.14	11.90		0.00	241.00	0.00
	12	4.30	0.63	0.00	9.93	0.03	300.00	0.04	4.34	0.73	1.14	11.90		0.00	241.00	0.00
	13	4.25	0.66	0.01	9.89	0.03	305.00	0.04	4.30	0.72	1.14	11.50		0.00	303.00	0.00
	14	4.28	0.64	0.01	9.91	0.03	314.00	0.04	4.30	0.72	1.14	11.50		0.00	303.00	0.00
	15	4.30	0.65	0.00	9.91	0.03	312.00	0.05	4.30	0.72	1.14	11.50		0.00	303.00	0.00
	16	4.30	0.66	0.00	9.92	0.02	314.00	0.05	4.38	0.72	1.14	11.50		0.00	303.00	0.00
	17	4.32	0.68	0.00	9.93	0.02	310.00	0.05	4.36	0.72	1.14	11.50		0.00	303.00	0.00
	18	4.30	0.63	0.00	9.81	0.02	304.00	0.05	4.30	0.72	1.14	12.40		0.00	303.00	0.00
	19	4.32	0.67	0.00	9.85	0.02	297.00	0.03	4.40	0.72	1.14	12.40		0.00	303.00	0.00
	20	4.36	0.66	0.00	9.85	0.02	300.00	0.03	4.36	0.72	1.14	12.40		0.00	303.00	0.00
	21	4.35	0.64	0.00	9.85	0.01	299.00	0.04	4.42	0.74	1.14	12.40		0.00	303.00	0.00
	22	4.32	0.62	0.00	9.86	0.01	304.00	0.04	4.32	0.74	1.14	12.40		0.00	303.00	0.00
	23	4.32	0.60	0.00	9.89	0.01	302.00	0.04	4.38	0.74	1.14	12.40		0.00	303.00	0.00
	24	4.35	0.62	0.00	9.94	0.01	305.00	0.04	4.45	0.74	1.14	12.40		0.00	303.00	0.00
	25	4.36	0.64	0.00	9.94	0.01	310.00	0.04	4.56	0.74	1.14	12.40		0.00	303.00	0.00
	26	4.32	0.65	0.00	9.92	0.01	308.00	0.05	4.36	0.74	1.14	12.40		0.00	303.00	0.00
	27	4.36	0.63	0.00	9.92	0.01	306.00	0.05	4.36	0.74	1.14	12.40		0.00	303.00	0.00
	28	4.32	0.62	0.00	9.89	0.01	293.00	0.03	4.38	0.74	1.14	12.40		0.00	303.00	0.00
	29	4.24	0.63	0.01	9.87	0.01	297.00	0.03	4.32	0.71	1.14	12.40		0.00	310.00	0.00
	30	4.23	0.63	0.01	9.86	0.01	293.00	0.03	4.30	0.71	1.14	12.40		0.00	310.00	0.00

SGS Metcon

TEST No. CL-02

Data Sheet

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**	
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height
SAMPLE	**Composite 1 (Met-02/05)**	**CRUSH SIZE**	P100 minus 3 in.
	0	**LEACH SOLUTION**	750 ppm free l g/l
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	1.95 kg CaO/tonne of ore
		CURE CYCLE	0 Days
		FLOWRATE	9.78 lph/m^2

		Pregnant Leach Solution							Feed Solution							
			Free			Assays (ppm)				Free			NaCN	Assays (ppm)		
Time (Days)		Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Au	Cu	Ag	Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Add/Rem. (grams)	Au	Cu	Ag
Leach	31	4.30	0.60	0.02	10.00	0.01	298.00	0.03	4.42	0.71	1.14	12.40		0.00	310.00	0.00
	32	4.25	0.61	0.03	10.00	0.01	300.00	0.03	4.36	0.71	1.14	12.40		0.00	310.00	0.00
	33	4.28	0.63	0.02	9.91	0.01	300.00	0.04	4.30	0.71	1.14	12.40		0.00	310.00	0.00
	34	4.25	0.63	0.02	9.86	0.01	303.00	0.04	4.34	0.71	1.14	12.40		0.00	310.00	0.00
	35	4.24	0.64	0.01	9.86	0.01	302.00	0.04	4.32	0.71	1.14	12.40		0.00	310.00	0.00
	36	4.23	0.64	0.01	9.83	0.01	300.00	0.04	4.26	0.71	1.14	12.40		0.00	303.00	0.00
	37	3.90	0.64	0.01	9.87	0.01	299.00	0.04	4.00	0.71	1.14	12.40		0.00	303.00	0.00
	38	4.18	0.65	0.01	9.85	0.01	298.00	0.04	4.18	0.71	1.14	12.40		0.00	303.00	0.00
	39	4.10	0.63	0.01	9.91	0.01	306.00	0.06	4.10	0.71	1.14	12.40		0.00	303.00	0.00
	40	4.08	0.64	0.01	9.83	0.01	305.00	0.05	4.10	0.71	1.14	12.40		0.00	303.00	0.00
	41	4.30	0.62	0.01	9.84	0.01	309.00	0.04	4.20	0.71	1.14	12.46		0.00	303.00	0.00
	42	4.28	0.60	0.02	9.88	0.01	309.00	0.04	4.36	0.71	1.14	12.43		0.00	290.00	0.00
	43	4.30	0.61	0.02	9.88	0.01	308.00	0.04	4.30	0.71	1.14	12.33		0.00	290.00	0.00
	44	4.26	0.61	0.02	9.86	0.01	309.00	0.04	4.24	0.71	1.14	12.45		0.00	290.00	0.00
	45	4.35	0.61	0.01	9.89	0.01	308.00	0.03	4.28	0.71	1.14	12.39		0.00	290.00	0.00
	46	4.26	0.62	0.01	9.90	0.01	305.00	0.03	4.34	0.71	1.14	12.41		0.00	290.00	0.00
	47	4.37	0.60	0.01	9.85	0.01	305.00	0.03	4.39	0.71	1.14	12.40		0.00	290.00	0.00
Wash	48	4.24	0.59	0.02	9.86	0.01	298.00	0.03	4.32	0.00	0.00	0.00		0.00	0.00	0.00
	49	4.05	0.31	0.04	9.10	0.01	192.00	0.03	4.16	0.00	0.00	0.00		0.00	0.00	0.00
	50	4.25	0.13	0.06	9.89	0.01	76.00	0.03	4.28	0.00	0.00	0.00		0.00	0.00	0.00
	51	4.61	0.07	0.08	9.86	0.01	22.00	0.02	4.64	0.00	0.00	0.00		0.00	0.00	0.00
	52	4.54	0.05	0.07	9.88	0.01	11.00	0.02	4.56	0.00	0.00	0.00		0.00	0.00	0.00
	53	4.56	0.05	0.05	9.75	0.01	6.00	0.02	4.60	0.00	0.00	0.00		0.00	0.00	0.00
	54	4.40	0.02	0.06	9.62	0.01	6.00	0.02	4.42	0.00	0.00	0.00		0.00	0.00	0.00
	55	4.44	0.02	0.06	9.60	0.01	4.00	0.02	4.46	0.00	0.00	0.00		0.00	0.00	0.00
	56	4.35	0.02	0.04	9.60	0.01	3.00	0.03	4.42	0.00	0.00	0.00		0.00	0.00	0.00
	57	4.37	0.02	0.04	9.44	0.01	2.00	0.02	4.40	0.00	0.00	0.00		0.00	0.00	0.00
	58	4.44	0.02	0.04	9.50	0.01	2.00	0.01	4.46	0.00	0.00	0.00		0.00	0.00	0.00
	59	4.36	0.01	0.04	9.51	0.01	2.00	0.01	4.38	0.00	0.00	0.00		0.00	0.00	0.00
	60	4.38	0.01	0.04	9.50	0.01	1.00	0.01	4.38	0.00	0.00	0.00		0.00	0.00	0.00

SGS Metcon

TEST No. CL-02

Data Sheet

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**	
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height
SAMPLE	**Composite 1 (Met-02/05)**	**CRUSH SIZE**	P100 minus 3 in.
	0	**LEACH SOLUTION**	750 ppm free l g/l
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	1.95 kg CaO/tonne of ore
		CURE CYCLE	0 Days
		FLOWRATE	9.78 lph/m^2

	Pregnant Leach Solution							**Feed Solution**							
		Free			Assays (ppm)				Free			NaCN	Assays (ppm)		
Time (Days)	Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Au	Cu	Ag	Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Add/Rem. (grams)	Au	Cu	Ag
Wash 61	4.38	0.01	0.04	9.67	0.01	0.05	0.01	4.40	0.00	0.00	0.00		0.00	0.00	0.00
62	4.37	0.01	0.04	9.66	0.01	0.05	0.01	4.40	0.00	0.00	0.00		0.00	0.00	0.00
63	4.34	0.01	0.04	9.58	0.01	0.05	0.01	4.37	0.00	0.00	0.00		0.00	0.00	0.00
64	4.35	0.01	0.07	9.56	0.01	0.05	0.01	4.36	0.00	0.00	0.00		0.00	0.00	0.00
65	4.38	0.01	0.06	9.59	0.01	0.05	0.01	4.40	0.00	0.00	0.00		0.00	0.00	0.00
66	4.38	0.01	0.06	9.56	0.01	0.05	0.01	4.40	0.00	0.00	0.00		0.00	0.00	0.00
67	4.39	0.01	0.06	9.58	0.01	0.05	0.01	4.44	0.00	0.00	0.00		0.00	0.00	0.00
68	4.36	0.01	0.06	9.58	0.01	1.00	0.01	4.36	0.00	0.00	0.00		0.00	0.00	0.00
69	4.39	0.01	0.06	9.58	0.01	1.00	0.01	4.43	0.00	0.00	0.00		0.00	0.00	0.00
70	4.38	0.01	0.06	9.58	0.01	1.00	0.01	4.42	0.00	0.00	0.00		0.00	0.00	0.00
71	4.36	0.01	0.04	9.50	0.01	4.00	0.01	4.38	0.00	0.00	0.00		0.00	0.00	0.00
72	4.44	0.01	0.04	9.50	0.01	4.00	0.01	4.46	0.00	0.00	0.00		0.00	0.00	0.00
73	4.34	0.01	0.04	9.50	0.01	4.00	0.01	4.40	0.00	0.00	0.00		0.00	0.00	0.00
74	4.37	0.01	0.04	9.50	0.01	4.00	0.01	4.38	0.00	0.00	0.00		0.00	0.00	0.00
75	4.36	0.01	0.04	9.54	0.01	0.00	0.04	4.38	0.00	0.00	0.00		0.00	0.00	0.00
76	4.34	0.01	0.04	9.54	0.01	0.00	0.04	4.40	0.00	0.00	0.00		0.00	0.00	0.00
77	4.46	0.01	0.04	9.54	0.01	0.00	0.04	4.40	0.00	0.00	0.00		0.00	0.00	0.00
78	4.37	0.01	0.04	9.54	0.01	0.00	0.04	4.40	0.00	0.00	0.00		0.00	0.00	0.00
79	4.40	0.01	0.04	9.54	0.01	0.00	0.04	4.42	0.00	0.00	0.00		0.00	0.00	0.00
80	4.29	0.01	0.04	9.54	0.01	0.00	0.04	4.30	0.00	0.00	0.00		0.00	0.00	0.00
81	4.39	0.01	0.04	9.54	0.01	0.00	0.04	4.42	0.00	0.00	0.00		0.00	0.00	0.00
82	4.35	0.01	0.06	9.54	0.01	0.50	0.03	4.40	0.00	0.00	0.00		0.00	0.00	0.00
83	4.37	0.01	0.06	9.54	0.01	0.50	0.03	4.42	0.00	0.00	0.00		0.00	0.00	0.00
84	4.38	0.01	0.06	9.54	0.01	0.50	0.03	4.44	0.00	0.00	0.00		0.00	0.00	0.00
85	4.44	0.01	0.06	9.54	0.01	0.50	0.03	4.42	0.00	0.00	0.00		0.00	0.00	0.00
86	4.30	0.01	0.06	9.54	0.01	0.50	0.03	4.40	0.00	0.00	0.00		0.00	0.00	0.00
87	4.45	0.01	0.06	9.54	0.01	0.50	0.03	4.44	0.00	0.00	0.00		0.00	0.00	0.00
88	4.39	0.01	0.06	9.54	0.01	0.50	0.03	4.42	0.00	0.00	0.00		0.00	0.00	0.00
89	4.41	0.01	0.06	9.54	0.01	0.50	0.03	4.46	0.00	0.00	0.00		0.00	0.00	0.00
90	4.37	0.01	0.06	9.54	0.01	0.50	0.03	4.39	0.00	0.00	0.00		0.00	0.00	0.00

SGS Metcon

TEST No. CL-02

Data Sheet

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**	
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height
SAMPLE	**Composite 1 (Met-02/05)**	**CRUSH SIZE**	P100 minus 3 in.
	0	**LEACH SOLUTION**	750 ppm free l g/l
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	1.95 kg CaO/tonne of ore
		CURE CYCLE	0 Days
		FLOWRATE	9.78 lph/m^2

	Pregnant Leach Solution							**Feed Solution**							
		Free			Assays (ppm)				Free			NaCN	Assays (ppm)		
Time (Days)	Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Au	Cu	Ag	Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Add/Rem. (grams)	Au	Cu	Ag
Wash 91	4.38	0.01	0.06	9.54	0.01	0.50	0.03	4.42	0.00	0.00	0.00		0.00	0.00	0.00
92	4.36	0.01	0.06	9.54	0.01	0.50	0.03	4.39	0.00	0.00	0.00		0.00	0.00	0.00
93	4.34	0.01	0.06	9.54	0.01	0.50	0.03	4.38	0.00	0.00	0.00		0.00	0.00	0.00
94	4.37	0.01	0.06	9.54	0.01	0.50	0.03	4.40	0.00	0.00	0.00		0.00	0.00	0.00
95	4.40	0.01	0.06	9.54	0.01	0.50	0.03	4.43	0.00	0.00	0.00		0.00	0.00	0.00
96	4.42	0.01	0.07	9.90	0.01	2.00	0.01	4.41	0.00	0.00	0.00		0.00	0.00	0.00
97	4.39	0.01	0.07	9.90	0.01	2.00	0.01	4.42	0.00	0.00	0.00		0.00	0.00	0.00
98	4.34	0.01	0.07	9.90	0.01	2.00	0.01	4.35	0.00	0.00	0.00		0.00	0.00	0.00
99	4.32	0.01	0.07	9.90	0.01	2.00	0.01	4.36	0.00	0.00	0.00		0.00	0.00	0.00
100	4.34	0.01	0.07	9.90	0.01	2.00	0.01	4.34	0.00	0.00	0.00		0.00	0.00	0.00
101	4.32	0.01	0.07	9.90	0.01	2.00	0.01	4.34	0.00	0.00	0.00		0.00	0.00	0.00
102	4.35	0.01	0.07	9.90	0.01	2.00	0.01	4.40	0.00	0.00	0.00		0.00	0.00	0.00
103	4.36	0.01	0.07	9.90	0.01	2.00	0.01	4.40	0.00	0.00	0.00		0.00	0.00	0.00
104	4.28	0.01	0.07	9.90	0.01	2.00	0.01	4.38	0.00	0.00	0.00		0.00	0.00	0.00
105	4.32	0.01	0.07	9.90	0.01	2.00	0.01	4.38	0.00	0.00	0.00		0.00	0.00	0.00
106	4.36	0.01	0.07	9.90	0.01	2.00	0.01	4.38	0.00	0.00	0.00		0.00	0.00	0.00
107	4.32	0.01	0.07	9.90	0.01	2.00	0.01	4.32	0.00	0.00	0.00		0.00	0.00	0.00
108	4.39	0.01	0.07	9.90	0.01	2.00	0.01	4.44	0.00	0.00	0.00		0.00	0.00	0.00
109	4.34	0.01	0.07	9.90	0.01	2.00	0.01	4.36	0.00	0.00	0.00		0.00	0.00	0.00
110	4.36	0.01	0.05	9.59	0.01	0.50	0.01	4.33	0.00	0.00	0.00		0.00	0.00	0.00
111	4.33	0.01	0.05	9.59	0.01	0.50	0.01	4.34	0.00	0.00	0.00		0.00	0.00	0.00
112	4.36	0.01	0.05	9.59	0.01	0.50	0.01	4.40	0.00	0.00	0.00		0.00	0.00	0.00
113	4.28	0.01	0.05	9.59	0.01	0.50	0.01	4.34	0.00	0.00	0.00		0.00	0.00	0.00
114	4.26	0.01	0.05	9.59	0.01	0.50	0.01	4.24	0.00	0.00	0.00		0.00	0.00	0.00
115	4.29	0.01	0.05	9.59	0.01	0.50	0.01	4.26	0.00	0.00	0.00		0.00	0.00	0.00
116	4.34	0.01	0.05	9.59	0.01	0.50	0.01	4.48	0.00	0.00	0.00		0.00	0.00	0.00
117	4.36	0.01	0.05	9.59	0.01	0.50	0.01	4.40	0.00	0.00	0.00		0.00	0.00	0.00
118	4.30	0.01	0.05	9.59	0.01	0.50	0.01	4.34	0.00	0.00	0.00		0.00	0.00	0.00
119	4.35	0.01	0.05	9.59	0.01	0.50	0.01	4.36	0.00	0.00	0.00		0.00	0.00	0.00
120	4.37	0.01	0.05	9.59	0.01	0.50	0.01	4.44	0.00	0.00	0.00		0.00	0.00	0.00

SGS Metcon

TEST No. CL-02

Data Sheet

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**	
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height
SAMPLE	**Composite 1 (Met-02/05)**	**CRUSH SIZE**	P100 minus 3 in.
	0	**LEACH SOLUTION**	750 ppm free I g/l
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	1.95 kg CaO/tonne of ore
		CURE CYCLE	0 Days
		FLOWRATE	9.78 lph/m^2

		Pregnant Leach Solution							**Feed Solution**							
			Free			Assays (ppm)				Free			NaCN	Assays (ppm)		
Time (Days)		Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Au	Cu	Ag	Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Add/Rem. (grams)	Au	Cu	Ag
Wash	121	4.36	0.01	0.05	9.59	0.01	0.50	0.01	4.40	0.00	0.00	0.00		0.00	0.00	0.00
	122	4.32	0.01	0.05	9.59	0.01	0.50	0.01	4.32	0.00	0.00	0.00		0.00	0.00	0.00
	123	4.28	0.01	0.05	9.59	0.01	0.50	0.01	4.30	0.00	0.00	0.00		0.00	0.00	0.00
	124	4.24	0.01	0.05	9.64	0.01	0.05	0.01	4.20	0.00	0.00	0.00		0.00	0.00	0.00
	125	4.26	0.01	0.05	9.64	0.01	0.05	0.01	4.30	0.00	0.00	0.00		0.00	0.00	0.00
	126	4.31	0.01	0.05	9.66	0.01	0.05	0.01	4.36	0.00	0.00	0.00		0.00	0.00	0.00
Drain	127	1.48	0.01	0.03	9.42	0.01	0.05	0.01	0.00	0.00	0.00	0.00		0.00	0.00	0.00
Drain	128	0.25	0.01	0.00	8.26	0.01	0.05	0.01	0.00	0.00	0.00	0.00		0.00	0.00	0.00
Drain	129	0.20	0.01	0.00	7.78	0.01	0.05	0.01	0.00	0.00	0.00	0.00		0.00	0.00	0.00

SGS Metcon

TEST No. CL-02

METALLURGICAL RESULTS

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**		
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14	
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height	
SAMPLE	**Composite 1 (Met-02/05)**	**CRUSH SIZE**	P100 minus 3 in.	
		LEACH SOLUTION	750 ppm fr g/l	
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	1.95	kg CaO/t of ore
		CURE CYCLE	0	Days
		FLOWRATE	9.78	lph/m^2

Time		Feed Solution Flow Rate	Cumulative										
			Extraction (g/t)			Solution Grade (ppm)			Extraction (%)			Consumption	
(Days)		(lph/sq m)	Au	Cu	Ag	Au	Cu	Ag	Au	Cu	Ag	NaCN (kg/t)	CaO (kg/t)
Leach	1	8.38	0.01	-14.44	0.00	1.86	15.00	0.64	2.96	-14.37	0.30	0.04	1.96
	2	9.63	0.08	-21.60	0.05	1.74	122.72	0.97	29.25	-21.49	4.84	0.06	1.96
	3	9.59	0.13	-25.56	0.08	1.44	157.35	0.88	47.51	-25.42	8.60	0.08	1.97
	4	9.68	0.16	-27.29	0.10	1.16	184.66	0.71	57.65	-27.15	10.37	0.09	2.03
	5	9.84	0.17	-27.54	0.11	0.93	206.78	0.57	61.70	-27.39	11.32	0.10	2.08
	6	9.84	0.18	-27.40	0.11	0.76	221.52	0.49	63.71	-27.26	11.96	0.10	2.13
	7	9.91	0.18	-25.64	0.12	0.65	232.16	0.42	64.72	-25.50	12.41	0.11	2.19
	8	10.04	0.19	-23.83	0.12	0.56	239.22	0.37	65.94	-23.71	12.71	0.11	2.25
	9	9.58	0.19	-22.03	0.12	0.50	244.92	0.33	66.91	-21.91	12.96	0.12	2.30
	10	9.86	0.19	-20.03	0.13	0.45	249.62	0.30	67.59	-19.92	13.15	0.12	2.35
	11	10.05	0.19	-18.20	0.13	0.41	253.40	0.27	68.26	-18.10	13.31	0.13	2.41
	12	9.89	0.19	-15.45	0.13	0.37	257.72	0.25	68.78	-15.37	13.51	0.13	2.46
	13	9.83	0.20	-15.53	0.13	0.34	261.68	0.23	69.28	-15.45	13.71	0.14	2.52
	14	9.82	0.20	-15.07	0.13	0.32	265.76	0.22	69.80	-14.99	13.91	0.14	2.57
	15	9.84	0.20	-14.63	0.14	0.30	269.11	0.20	70.31	-14.55	14.16	0.14	2.63
	16	10.01	0.20	-14.37	0.14	0.28	272.15	0.19	70.65	-14.29	14.41	0.15	2.69
	17	9.96	0.20	-14.17	0.14	0.26	274.56	0.18	70.99	-14.09	14.67	0.15	2.74
	18	9.82	0.20	-14.12	0.14	0.25	276.31	0.18	71.34	-14.04	14.92	0.15	2.80
	19	10.07	0.20	-14.68	0.14	0.24	277.48	0.17	71.68	-14.61	15.07	0.16	2.85
	20	9.96	0.20	-14.83	0.15	0.22	278.69	0.16	72.03	-14.75	15.23	0.16	2.91
	21	10.10	0.20	-15.26	0.15	0.21	279.73	0.15	72.20	-15.18	15.43	0.17	2.97
	22	9.85	0.20	-15.22	0.15	0.20	280.90	0.15	72.37	-15.14	15.64	0.17	3.02
	23	10.00	0.21	-15.47	0.15	0.19	281.87	0.14	72.54	-15.39	15.84	0.18	3.08
	24	10.19	0.21	-15.71	0.15	0.19	282.90	0.14	72.72	-15.63	16.04	0.19	3.13
	25	10.38	0.21	-16.05	0.16	0.18	284.05	0.13	72.89	-15.97	16.25	0.19	3.19
	26	9.95	0.21	-15.94	0.16	0.17	285.02	0.13	72.98	-15.86	16.50	0.20	3.25
	27	9.93	0.21	-15.80	0.16	0.17	285.84	0.13	73.06	-15.71	16.76	0.20	3.31
	28	10.03	0.21	-16.49	0.16	0.16	286.11	0.12	73.15	-16.40	16.91	0.21	3.36
	29	9.87	0.21	-17.39	0.16	0.15	286.49	0.12	73.23	-17.30	17.06	0.21	3.42
	30	9.86	0.21	-18.44	0.16	0.15	286.72	0.12	73.32	-18.34	17.21	0.22	3.47

SGS Metcon

TEST No. CL-02

METALLURGICAL RESULTS

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**		
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14	
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height	
SAMPLE	**Composite 1 (Met-02/05)**	**CRUSH SIZE**	P100 minus 3 in.	
		LEACH SOLUTION	750 ppm fr g/l	
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	1.95	kg CaO/t of ore
		CURE CYCLE	0	Days
		FLOWRATE	9.78	lph/m^2

Time		Feed Solution Flow Rate	Cumulative										
			Extraction (g/t)			Solution Grade (ppm)			Extraction (%)			Consumption	
(Days)		(lph/sq m)	Au	Cu	Ag	Au	Cu	Ag	Au	Cu	Ag	NaCN (kg/t)	CaO (kg/t)
Leach	31	10.10	0.21	-19.44	0.17	0.14	287.09	0.12	73.40	-19.34	17.36	0.22	3.53
	32	9.92	0.21	-20.30	0.17	0.14	287.51	0.11	73.49	-20.20	17.51	0.23	3.58
	33	9.86	0.21	-20.85	0.17	0.14	287.90	0.11	73.57	-20.74	17.71	0.23	3.64
	34	9.88	0.21	-21.50	0.17	0.13	288.35	0.11	73.66	-21.39	17.91	0.24	3.69
	35	9.87	0.21	-22.16	0.17	0.13	288.75	0.11	73.74	-22.05	18.11	0.24	3.75
	36	9.76	0.21	-22.41	0.18	0.12	289.07	0.10	73.83	-22.29	18.31	0.25	3.80
	37	9.09	0.21	-22.93	0.18	0.12	289.32	0.10	73.90	-22.80	18.49	0.25	3.85
	38	9.70	0.21	-23.16	0.18	0.12	289.55	0.10	73.99	-23.04	18.69	0.25	3.90
	39	9.19	0.21	-23.02	0.18	0.12	289.97	0.10	74.07	-22.90	18.98	0.26	3.96
	40	9.44	0.21	-23.00	0.18	0.11	290.34	0.10	74.15	-22.88	19.22	0.26	4.01
	41	9.55	0.21	-22.37	0.19	0.11	290.81	0.10	74.23	-22.25	19.42	0.26	4.06
	42	9.98	0.21	-21.71	0.19	0.11	291.26	0.10	74.32	-21.60	19.62	0.27	4.12
	43	9.84	0.21	-20.84	0.19	0.10	291.66	0.09	74.40	-20.73	19.83	0.27	4.17
	44	9.68	0.21	-19.87	0.19	0.10	292.06	0.09	74.49	-19.76	20.03	0.28	4.22
	45	9.78	0.21	-18.76	0.19	0.10	292.43	0.09	74.58	-18.66	20.18	0.28	4.28
	46	9.92	0.21	-18.30	0.19	0.10	292.71	0.09	74.66	-18.20	20.33	0.29	4.33
	47	10.03	0.21	-17.63	0.20	0.10	292.99	0.09	74.75	-17.53	20.48	0.29	4.39
Wash	48	9.83	0.21	-3.40	0.20	0.09	293.09	0.09	74.83	-3.39	20.63	0.26	4.39
	49	9.54	0.21	5.35	0.20	0.09	291.09	0.09	74.91	5.32	20.78	0.25	4.39
	50	9.75	0.21	8.99	0.20	0.09	286.70	0.09	75.00	8.94	20.93	0.24	4.38
	51	10.59	0.21	10.13	0.20	0.09	280.98	0.08	75.09	10.07	21.04	0.24	4.38
	52	10.45	0.21	10.69	0.20	0.09	275.35	0.08	75.18	10.63	21.14	0.24	4.38
	53	10.49	0.21	11.00	0.20	0.09	269.82	0.08	75.27	10.94	21.25	0.24	4.37
	54	10.08	0.21	11.29	0.20	0.08	264.70	0.08	75.36	11.23	21.35	0.23	4.37
	55	10.22	0.21	11.49	0.21	0.08	259.69	0.08	75.45	11.43	21.46	0.23	4.37
	56	10.08	0.21	11.64	0.21	0.08	254.94	0.08	75.53	11.58	21.61	0.23	4.37
	57	10.04	0.21	11.74	0.21	0.08	250.33	0.08	75.62	11.68	21.71	0.23	4.36
	58	10.22	0.21	11.84	0.21	0.08	245.82	0.08	75.71	11.78	21.77	0.23	4.36
	59	10.00	0.21	11.94	0.21	0.08	241.54	0.07	75.79	11.87	21.82	0.23	4.36
	60	10.00	0.21	11.99	0.21	0.08	237.38	0.07	75.88	11.92	21.87	0.23	4.36

SGS Metcon

TEST No. CL-02

METALLURGICAL RESULTS

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**		
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14	
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height	
SAMPLE	**Composite 1 (Met-02/05)**	**CRUSH SIZE**	P100 minus 3 in.	
		LEACH SOLUTION	750 ppm fr g/l	
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	1.95	kg CaO/t of ore
		CURE CYCLE	0	Days
		FLOWRATE	9.78	lph/m^2

Time		Feed Solution Flow Rate	Cumulative										
			Extraction (g/t)			Solution Grade (ppm)			Extraction (%)			Consumption	
(Days)		(lph/sq m)	Au	Cu	Ag	Au	Cu	Ag	Au	Cu	Ag	NaCN (kg/t)	CaO (kg/t)
Wash	61	10.04	0.21	11.99	0.21	0.07	233.34	0.07	75.97	11.93	21.92	0.23	4.36
	62	10.06	0.22	11.99	0.21	0.07	229.44	0.07	76.05	11.93	21.97	0.23	4.35
	63	9.98	0.22	11.99	0.21	0.07	225.70	0.07	76.14	11.93	22.02	0.23	4.35
	64	9.95	0.22	12.00	0.21	0.07	222.07	0.07	76.23	11.93	22.07	0.23	4.35
	65	10.02	0.22	12.00	0.21	0.07	218.53	0.07	76.31	11.94	22.12	0.23	4.35
	66	10.06	0.22	12.00	0.21	0.07	215.10	0.07	76.40	11.94	22.18	0.23	4.34
	67	10.12	0.22	12.00	0.21	0.07	211.77	0.07	76.49	11.94	22.23	0.23	4.34
	68	9.97	0.22	12.05	0.21	0.07	208.58	0.07	76.66	11.99	22.28	0.23	4.34
	69	10.12	0.22	12.10	0.21	0.07	205.46	0.06	76.84	12.04	22.33	0.23	4.33
	70	10.08	0.22	12.15	0.21	0.07	202.44	0.06	77.01	12.09	22.38	0.22	4.33
	71	10.06	0.22	12.35	0.21	0.06	199.57	0.06	77.10	12.28	22.43	0.22	4.33
	72	10.19	0.22	12.55	0.22	0.06	196.73	0.06	77.19	12.48	22.49	0.22	4.33
	73	10.02	0.22	12.74	0.22	0.06	194.03	0.06	77.27	12.68	22.54	0.22	4.32
	74	9.98	0.22	12.94	0.22	0.06	191.38	0.06	77.36	12.87	22.59	0.22	4.32
	75	10.05	0.22	12.94	0.22	0.06	188.76	0.06	77.45	12.87	22.79	0.22	4.32
	76	10.02	0.22	12.94	0.22	0.06	186.23	0.06	77.53	12.87	23.00	0.22	4.32
	77	10.05	0.22	12.94	0.22	0.06	183.69	0.06	77.62	12.87	23.21	0.22	4.32
	78	10.06	0.22	12.94	0.22	0.06	181.27	0.06	77.71	12.87	23.41	0.22	4.31
	79	10.09	0.22	12.94	0.23	0.06	178.90	0.06	77.80	12.87	23.62	0.22	4.31
	80	9.82	0.22	12.94	0.23	0.06	176.64	0.06	77.88	12.87	23.82	0.22	4.31
	81	10.10	0.22	12.94	0.23	0.06	174.39	0.06	77.97	12.87	24.03	0.22	4.31
	82	10.05	0.22	12.96	0.23	0.06	172.23	0.06	78.06	12.90	24.18	0.22	4.31
	83	10.10	0.22	12.99	0.23	0.06	170.10	0.06	78.14	12.92	24.34	0.22	4.30
	84	10.13	0.22	13.01	0.23	0.05	168.03	0.06	78.23	12.95	24.49	0.22	4.30
	85	10.08	0.22	13.04	0.24	0.05	165.98	0.06	78.32	12.97	24.65	0.22	4.30
	86	10.07	0.22	13.06	0.24	0.05	164.03	0.06	78.40	12.99	24.80	0.22	4.29
	87	10.16	0.22	13.09	0.24	0.05	162.07	0.06	78.49	13.02	24.96	0.22	4.29
	88	10.09	0.22	13.11	0.24	0.05	160.18	0.06	78.58	13.04	25.11	0.22	4.29
	89	10.17	0.22	13.14	0.24	0.05	158.33	0.06	78.67	13.07	25.27	0.22	4.29
	90	10.04	0.22	13.16	0.24	0.05	156.54	0.06	78.75	13.09	25.42	0.22	4.28

SGS Metcon

TEST No. CL-02

METALLURGICAL RESULTS

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**		
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14	
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height	
SAMPLE	**Composite 1 (Met-02/05)**	**CRUSH SIZE**	P100 minus 3 in.	
		LEACH SOLUTION	750 ppm fr g/l	
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	1.95	kg CaO/t of ore
		CURE CYCLE	0	Days
		FLOWRATE	9.78	lph/m^2

Time (Days)		Feed Solution Flow Rate (lph/sq m)	Cumulative										
			Extraction (g/t)			Solution Grade (ppm)			Extraction (%)			Consumption	
			Au	Cu	Ag	Au	Cu	Ag	Au	Cu	Ag	NaCN (kg/t)	CaO (kg/t)
Wash	91	10.10	0.22	13.19	0.24	0.05	154.78	0.06	78.84	13.12	25.57	0.21	4.28
	92	10.03	0.22	13.21	0.25	0.05	153.07	0.06	78.93	13.14	25.73	0.21	4.28
	93	10.03	0.22	13.24	0.25	0.05	151.40	0.06	79.01	13.17	25.88	0.21	4.27
	94	10.05	0.22	13.26	0.25	0.05	149.76	0.06	79.10	13.19	26.04	0.21	4.27
	95	10.09	0.22	13.29	0.25	0.05	148.14	0.05	79.19	13.21	26.19	0.21	4.27
	96	10.07	0.22	13.38	0.25	0.05	146.57	0.05	79.28	13.31	26.24	0.21	4.26
	97	10.10	0.22	13.48	0.25	0.05	145.04	0.05	79.36	13.41	26.29	0.21	4.26
	98	9.94	0.22	13.58	0.25	0.05	143.56	0.05	79.45	13.51	26.35	0.21	4.26
	99	9.97	0.23	13.68	0.25	0.05	142.12	0.05	79.54	13.61	26.40	0.21	4.25
	100	9.93	0.23	13.78	0.25	0.05	140.69	0.05	79.62	13.70	26.45	0.21	4.25
	101	9.89	0.23	13.87	0.25	0.05	139.31	0.05	79.71	13.80	26.50	0.21	4.25
	102	10.04	0.23	13.97	0.25	0.05	137.94	0.05	79.79	13.90	26.55	0.21	4.24
	103	10.06	0.23	14.07	0.25	0.05	136.60	0.05	79.88	14.00	26.60	0.21	4.24
	104	10.00	0.23	14.17	0.26	0.05	135.30	0.05	79.97	14.09	26.65	0.21	4.24
	105	10.01	0.23	14.26	0.26	0.04	134.02	0.05	80.05	14.19	26.70	0.21	4.23
	106	9.98	0.23	14.36	0.26	0.04	132.75	0.05	80.14	14.29	26.75	0.21	4.23
	107	9.90	0.23	14.46	0.26	0.04	131.52	0.05	80.22	14.38	26.80	0.21	4.23
	108	10.14	0.23	14.56	0.26	0.04	130.29	0.05	80.31	14.48	26.86	0.21	4.22
	109	9.96	0.23	14.66	0.26	0.04	129.10	0.05	80.40	14.58	26.91	0.21	4.22
	110	9.87	0.23	14.68	0.26	0.04	127.91	0.05	80.48	14.60	26.96	0.21	4.22
	111	9.92	0.23	14.70	0.26	0.04	126.75	0.05	80.57	14.63	27.01	0.20	4.21
	112	10.04	0.23	14.73	0.26	0.04	125.60	0.05	80.66	14.65	27.06	0.20	4.21
	113	9.91	0.23	14.75	0.26	0.04	124.50	0.05	80.74	14.67	27.11	0.20	4.21
	114	9.68	0.23	14.78	0.26	0.04	123.42	0.05	80.83	14.70	27.16	0.20	4.21
	115	9.73	0.23	14.80	0.26	0.04	122.35	0.05	80.91	14.72	27.21	0.20	4.20
	116	10.19	0.23	14.83	0.26	0.04	121.28	0.05	81.00	14.75	27.26	0.20	4.20
	117	10.10	0.23	14.85	0.26	0.04	120.23	0.05	81.09	14.77	27.31	0.20	4.20
	118	9.90	0.23	14.87	0.26	0.04	119.21	0.05	81.17	14.80	27.36	0.20	4.20
	119	9.97	0.23	14.90	0.26	0.04	118.20	0.05	81.26	14.82	27.41	0.20	4.20
	120	10.15	0.23	14.92	0.26	0.04	117.20	0.05	81.34	14.84	27.47	0.20	4.19

SGS Metcon

TEST No. CL-02

METALLURGICAL RESULTS

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**		
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14	
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height	
SAMPLE	**Composite 1 (Met-02/05)**	**CRUSH SIZE**	P100 minus 3 in.	
		LEACH SOLUTION	750 ppm fr	g/l
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	1.95	kg CaO/t of ore
		CURE CYCLE	0	Days
		FLOWRATE	9.78	lph/m^2

Time		**Feed Solution Flow Rate**	**Cumulative**										
			Extraction (g/t)			**Solution Grade (ppm)**			**Extraction (%)**			**Consumption**	
(Days)		**(lph/sq m)**	**Au**	**Cu**	**Ag**	**Au**	**Cu**	**Ag**	**Au**	**Cu**	**Ag**	**NaCN (kg/t)**	**CaO (kg/t)**
Wash	121	10.04	0.23	14.95	0.26	0.04	116.22	0.05	81.43	14.87	27.52	0.20	4.19
	122	9.86	0.23	14.97	0.26	0.04	115.27	0.04	81.52	14.89	27.57	0.20	4.19
	123	9.83	0.23	15.00	0.26	0.04	114.33	0.04	81.60	14.92	27.62	0.20	4.19
	124	9.59	0.23	15.00	0.26	0.04	113.42	0.04	81.69	14.92	27.67	0.20	4.18
	125	9.85	0.23	15.00	0.27	0.04	112.52	0.04	81.77	14.92	27.72	0.20	4.18
	126	9.96	0.23	15.00	0.27	0.04	111.63	0.04	81.86	14.92	27.77	0.20	4.18
Drain	127	0.00	0.23	15.00	0.27	0.04	111.32	0.04	81.89	14.92	27.78	0.20	4.18
Drain	128	0.00	0.23	15.00	0.27	0.04	111.27	0.04	81.89	14.92	27.78	0.20	4.18
Drain	129	0.00	0.23	15.00	0.27	0.04	111.23	0.04	81.90	14.92	27.78	0.20	4.18

APPENDIX 6

Column Leach Test CL-03 on Composite 2

Summary of Results | **SGS Metcon** | Current Date: 09/26/14

SGS Metcon Project No.: M-709-03

Western Copper & Gold Corp. Casino Project

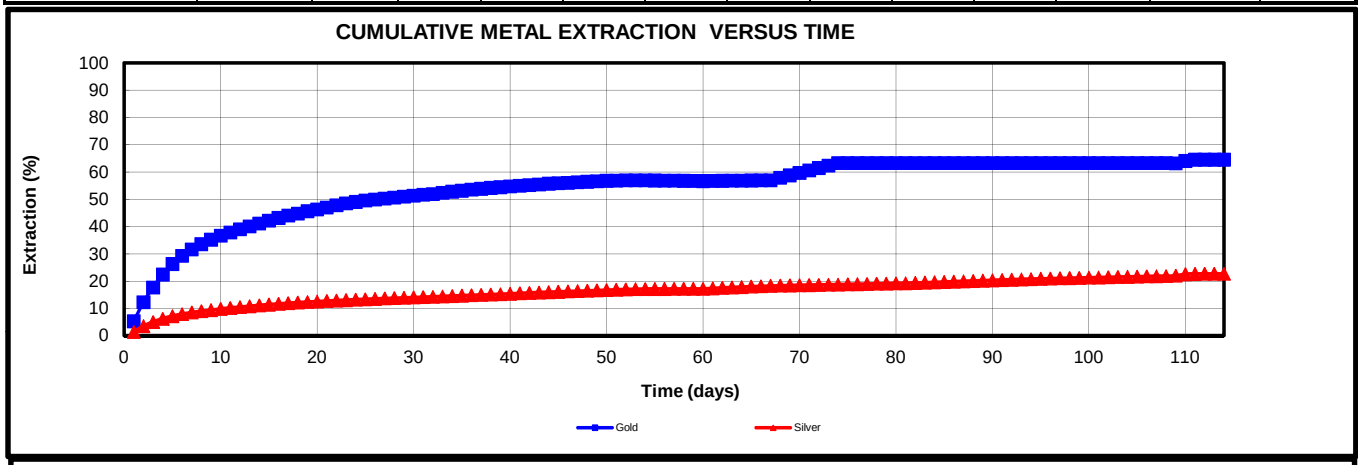
TEST No.: CL-03 | Crush Size: P100 minus 3 in.

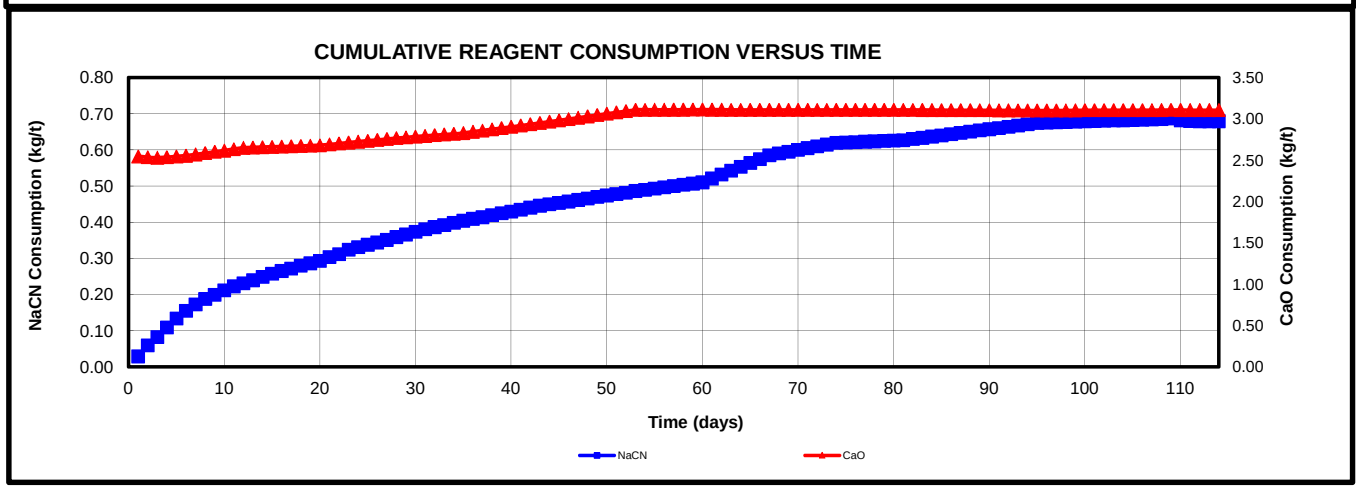
SAMPLE : Composite 2 (Met-11/17) | Lime Addition: 2.54 kg Lime/tonne of ore

Objective: Gold and Silver Extraction vs Time

Cure Days:	0
Leach Days:	109
Rest Days:	0
Wash Days:	2
Drain Days:	3
Total Cycle Days:	114

PRODUCTS	Volume	Weight	Cumulative										
			Assay (g/t)			Contents (mg)			Indicated Extraction			Consumption	
												NaCN	CaO
	(liters)	(kg)	Au	Cu	Ag	Au	Cu	Ag	Au	Cu	Ag	(kg/t)	(kg/t)
Feed Solution	474.45		0.04	312	0.12	16.71	148073	58.50	64.55	32.30	22.71	0.68	3.11
Pregnant Solution	468.00		0.10	349	0.27	48.15	163486	125.75					
Leach Residue		88.84	0.19	364	2.58	17.27	32309	228.84					
CALCULATIONS													
Metal Extracted			0.35	173.49	0.76	31.44	15413	67.25					
Calculated Head			0.55	537.17	3.33	48.71	47722	296.09					
Assay Head		88.84	0.54	46.17	2.70	47.73	4102	239.88					

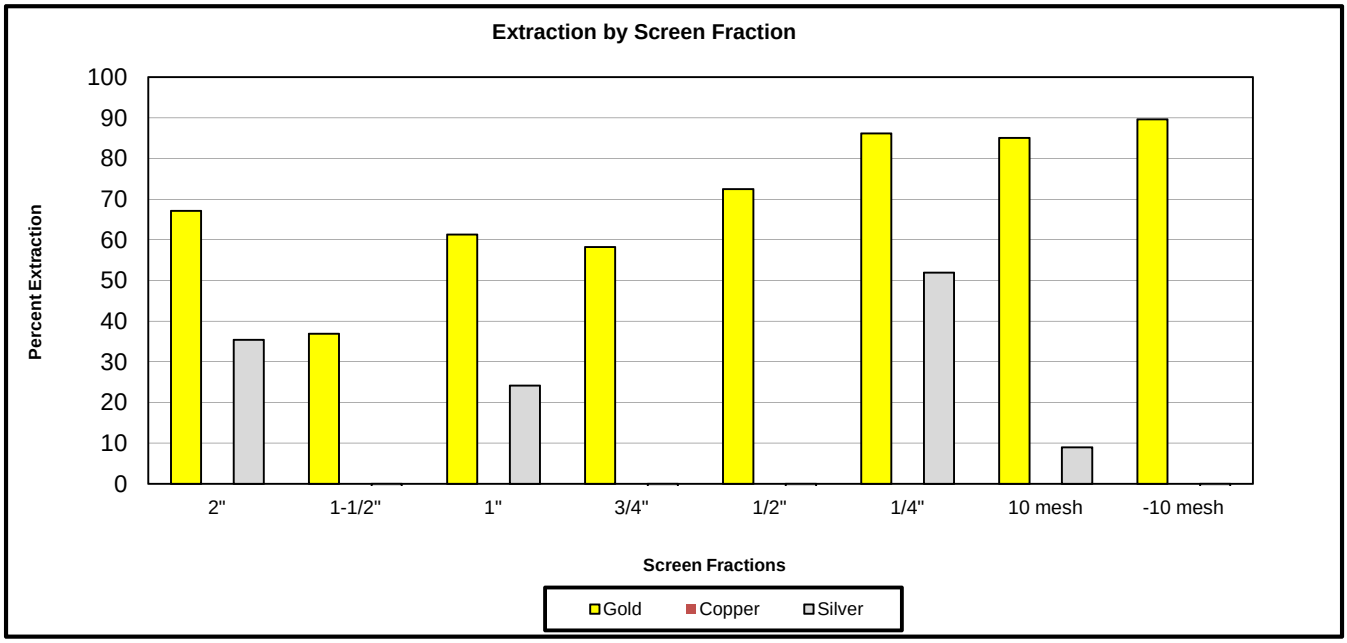




SGS Metcon

Test: CL-03
Sample: Composite 2 (Met-11/17)
Casino Project

Western Copper & Gold Corp.
SGS Metcon Project No.: M-709-03



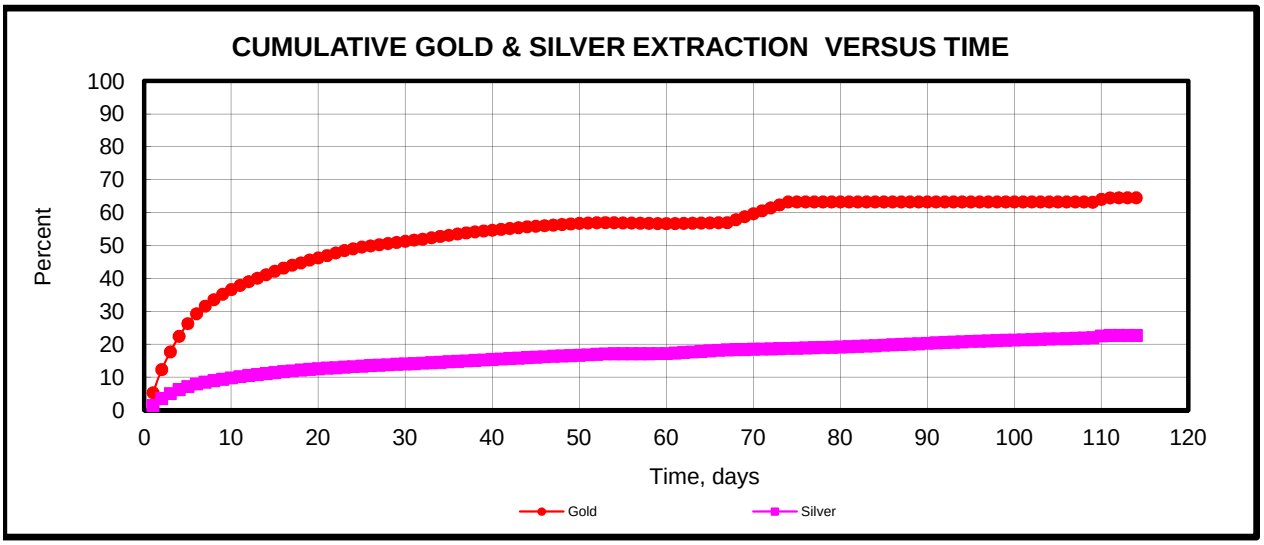
Test No. : CL-03

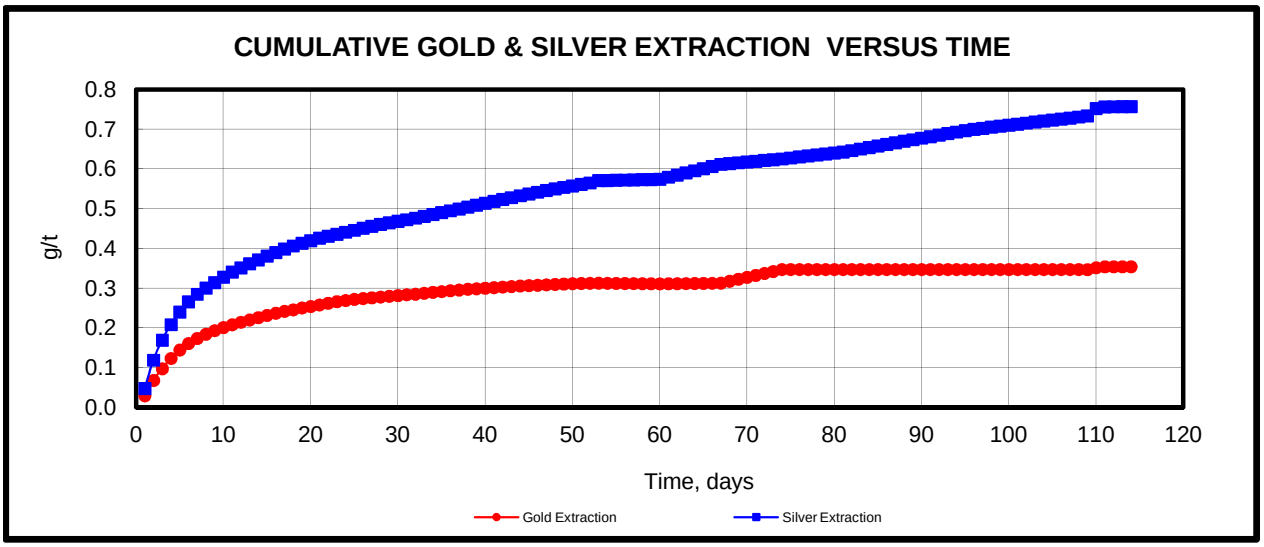
Screen Fraction	Head				Leach Residue				Percent Extraction			Degradation Index
	Weight	Assays (g/t)			Weight	Assays (g/t)						
	(kg)	Au	Cu	Ag	(kg)	Au	Cu	Ag	Au	Cu	Ag	(%)
2"	6.26	0.460	36	2.70	3.64	0.26	240	3.00	67.16	-	35.44	41.90
1-1/2"	20.44	0.540	45	2.20	23.23	0.30	350	2.30	36.87	-	-18.80	-13.64
1"	26.34	0.510	34	2.60	23.62	0.22	400	2.20	61.31	-	24.11	10.31
3/4"	8.82	0.440	30	2.60	10.80	0.15	330	2.60	58.24	-	-22.49	-22.49
1/2"	7.66	0.460	62	2.20	7.45	0.13	270	2.70	72.50	-	-19.43	2.68
1/4"	6.62	0.430	32	3.50	6.55	0.06	450	1.70	86.19	-	51.91	1.00
10 mesh	5.36	0.520	66	2.80	5.94	0.07	360	2.30	85.08	-	8.94	-10.86
-10 mesh	7.34	1.000	103	4.30	7.60	0.10	420	5.20	89.65	-	-25.19	-3.52
Total	88.84	0.54	46	2.70	88.84	0.19	364	2.58	63.82		4.60	

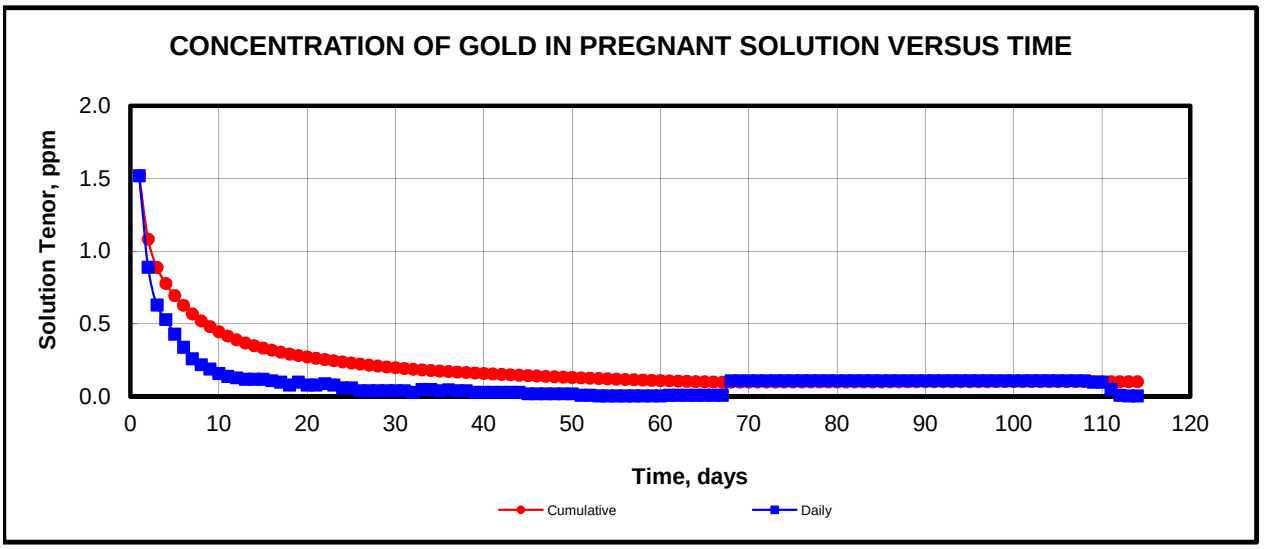
SGS Metcon

Test: CL-03 — Western Copper & Gold Corp.

Sample: Composite 2 (Met-11/17) — SGS Metcon Project No.: M-709-03



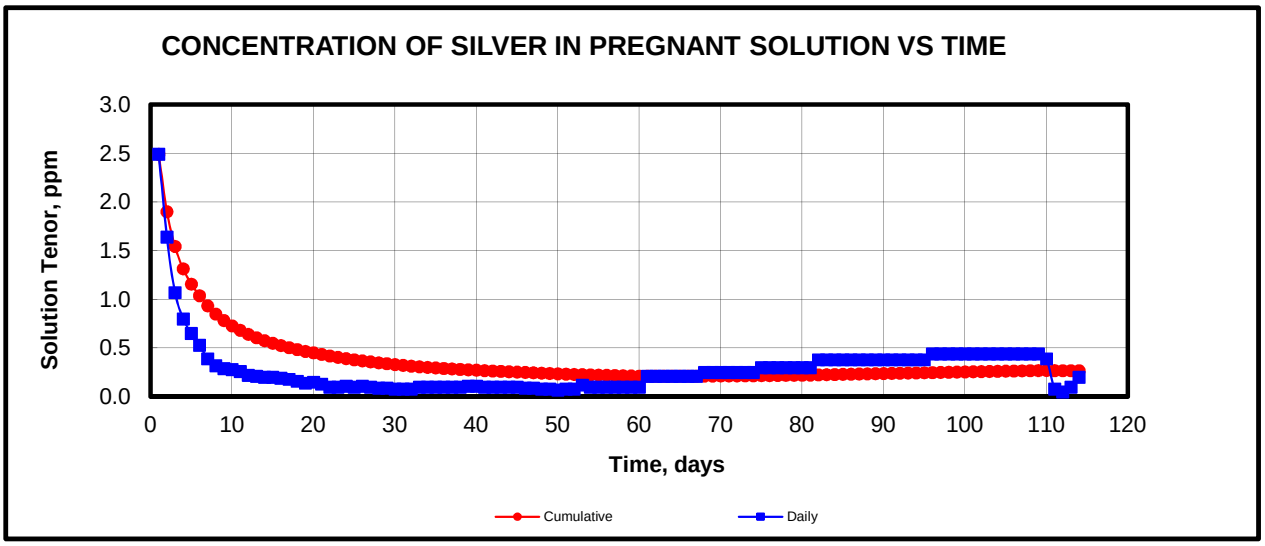


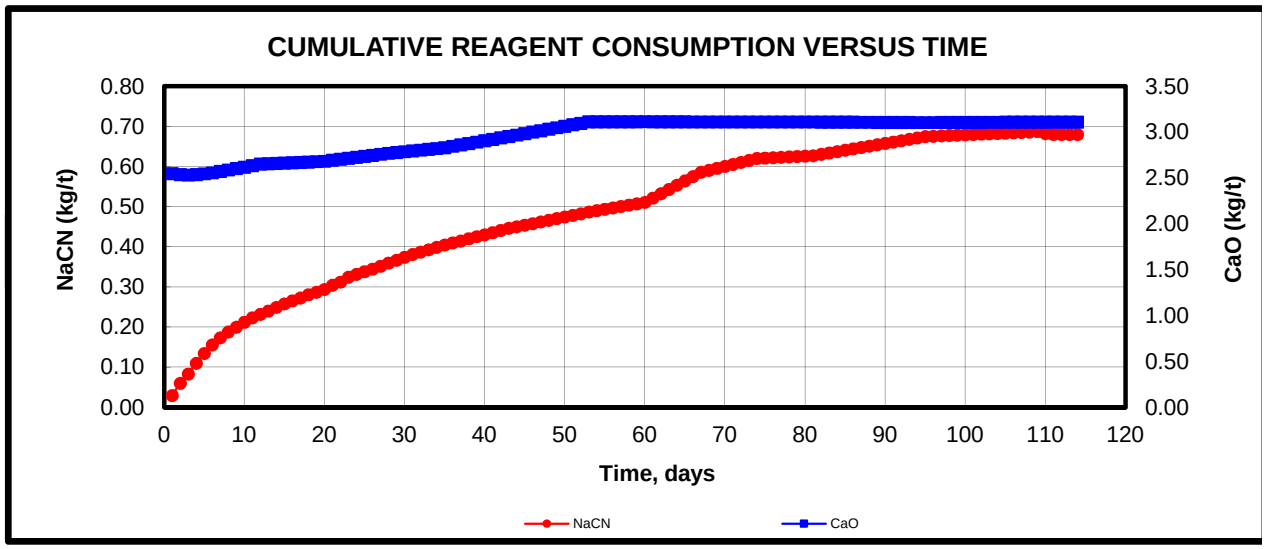


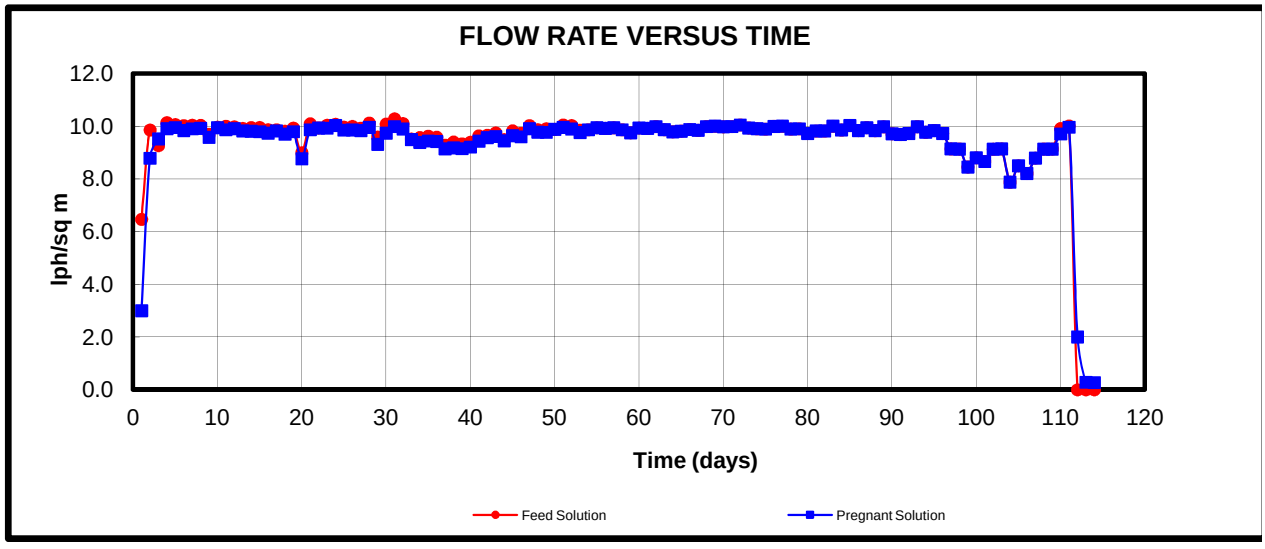
SGS Metcon

Test: CL-03 — Western Copper & Gold Corp.

Sample: Composite 2 (Met-11/17) — SGS Metcon Project No.: M-709-03



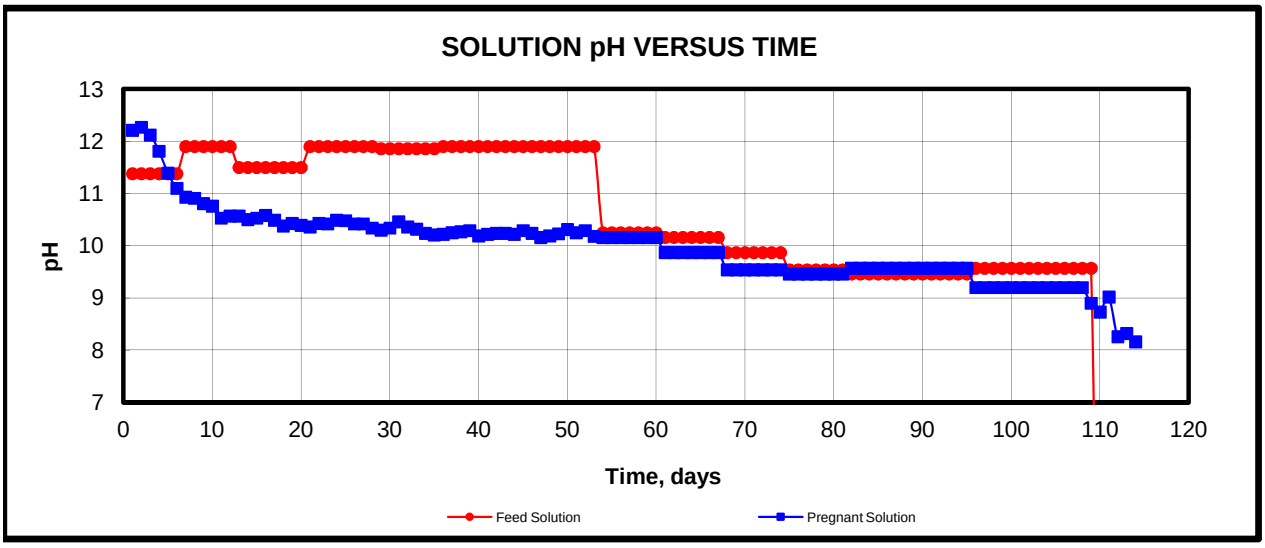


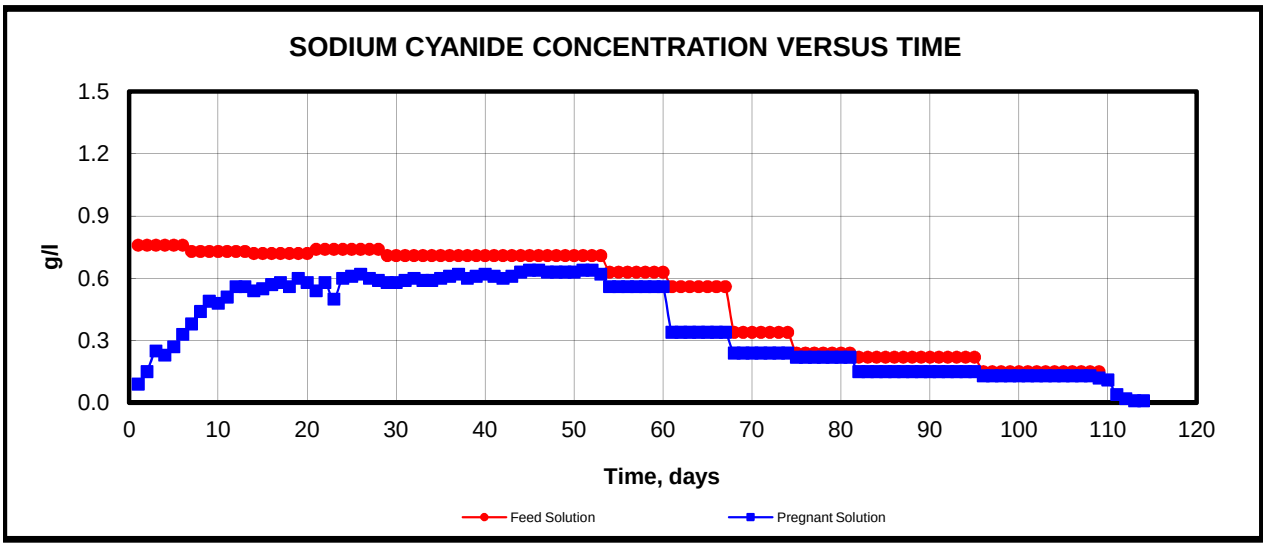


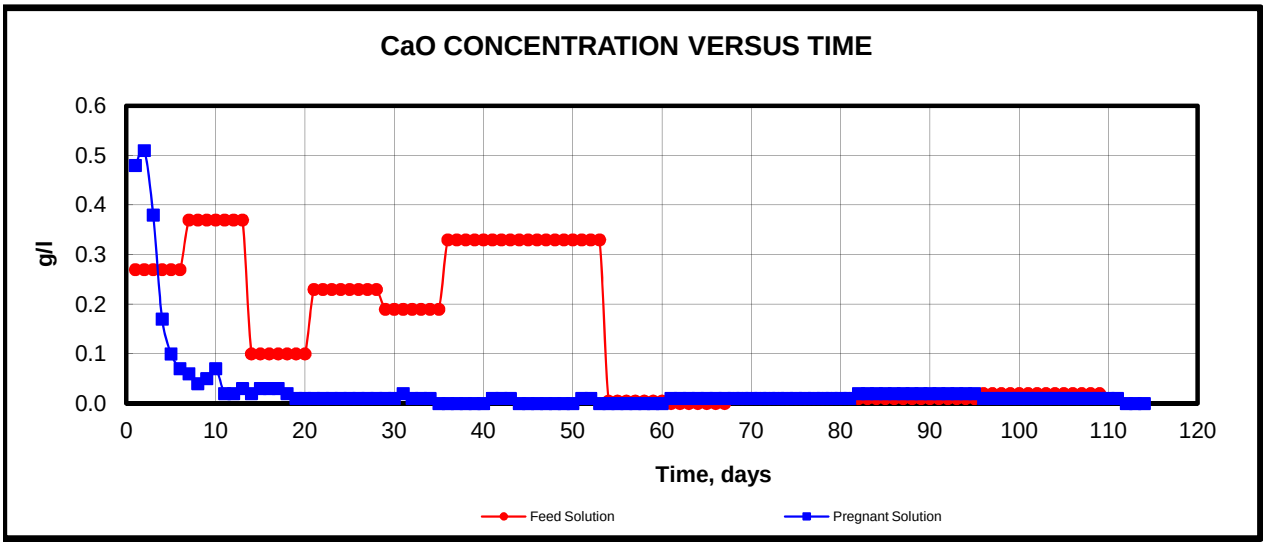
SGS Metcon

Test: CL-03 — Western Copper & Gold Corp.

Sample: Composite 2 (Met-11/17) — SGS Metcon Project No.: M-709-03







SGS Metcon

TEST No. CL-03

PHYSICAL CHARACTERISTICS SHEET

CLIENT	Western Copper & Gold Corp. SGS Metcon Project No.: M-709-03	**TEST CONDITIONS**	
		TEST START	05/01/14
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height
SAMPLE	Composite 2 (Met-11/17)	**CRUSH SIZE**	P100 minus 3 in.
		LEACH SOLUTION	750 ppm free NaCN, 300 ppm Cu
OBJECTIVE	Gold and Silver Extraction vs Time	**Lime Addition**	2.54 kg CaO/tonne of Ore
		CURE CYCLE	0 days
		FLOWRATE	9.78 lph/m2

FLOWRATE (lph/sq m)		9.78			
CURE STAGE (days)		0			
COLUMN DIAMETER (mm)		152.40			
ELEMENTS ANALYZED	Au	CNs Au	Ag	CNs Ag	Cu
HEAD ASSAYS (g per tonne)	0.54		2.70		46.17
LEACH RESIDUE ASSAYS (g per tonne)	0.19		2.58		363.68
SAMPLE PERCENT MOISTURE AS RECEIVED (Dry Basis)		0.00			
SAMPLE WEIGHT BEFORE AGGLOMERATION (kg)		88.84			
AGGLOMERATED SAMPLE WEIGHT (kg)		90.94			
INITIAL SAMPLE PERCENT MOISTURE (including agglomeration water)		2.36	(Dry Basis)		
INITIAL SAMPLE DRY WEIGHT (kg)		88.84			
INITIAL SAMPLE HEIGHT (m)		3.26			
INITIAL SAMPLE BULK DENSITY (kg/cu m)		1493	(Dry Basis)		
FINAL SAMPLE HEIGHT (m)		3.25			
RESIDUE WET WEIGHT (kg)		91.04			
RESIDUE DRY WEIGHT (kg)		88.84			
VOLUME DRAINED (l)		1.13			
SUBSIDENCE (%)		0.28			
MOISTURE UNDER LEACH (%)		3.74	(Dry Basis)		
MOISTURE RETAINED (%)		2.48	(Dry Basis)		
FINAL SAMPLE BULK DENSITY (kg/cu m)		1497	(Dry Basis)		

SGS Metcon
7701 BUSINESS PARK DRIVE
TUCSON , ARIZONA 85743

SCREEN ANALYSIS RESULTS
Western Copper & Gold Corp.
SGS Metcon Project No.: M-709-03
Casino Project

SCREEN ANALYSIS			Sample: **Column Leach Head** **CL-03** **Composite 2 (Met-11/17)** **Crush Size: P100 minus 3 in.**											
NOMINAL OPENINGS		Tyler	Sample	Weight	Cumulative Weight	Gold			Copper			Silver		
mm	Inches	Mesh	Weights (kg)	Distribution (%)	Retained (%)	Assay (gpt)	Content	Distribution (%)	Assay (gpt)	Content	Distribution (%)	Assay (gpt)	Content	Distribution (%)
50.80	2.000	2"	6.26	7.05	7.05	0.46	0.032	6.03	36	2.537	5.49	2.70	0.19	7.05
38.10	1.500	1-1/2"	20.44	23.01	30.05	0.54	0.124	23.13	45	10.353	22.42	2.20	0.51	18.75
25.40	1.000	1"	26.34	29.65	59.70	0.51	0.151	28.15	34	10.081	21.83	2.60	0.77	28.55
19.05	0.750	3/4"	8.82	9.93	69.63	0.44	0.044	8.13	30	2.978	6.45	2.60	0.26	9.56
12.70	0.500	1/2"	7.66	8.62	78.25	0.46	0.040	7.38	62	5.346	11.58	2.20	0.19	7.03
6.35	0.250	1/4"	6.62	7.45	85.70	0.43	0.032	5.96	32	2.385	5.16	3.50	0.26	9.66
1.70	0.065	10	5.36	6.03	91.74	0.52	0.031	5.84	66	3.982	8.62	2.80	0.17	6.26
MINUS		10	7.34	8.26	100.00	1	0.083	15.38	103	8.510	18.43	4.30	0.36	13.16
TOTALS			88.84	100.00				100.00			100.00			100.00
CALCULATED ASSAY						0.54			46			2.70		
COMPOSITE ASSAY (Pulv.)						0.55			51			2.70		

SCREEN ANALYSIS			Sample: **Column Leach Residue** **CL-03** **Composite 2 (Met-11/17)**											
NOMINAL OPENINGS		Tyler	Sample	Weight	Cumulative Weight	Gold			Copper			Silver		
mm	Inches	Mesh	Weights (kg)	Distribution (%)	Retained (%)	Assay (gpt)	Content	Distribution (%)	Assay (gpt)	Content	Distribution (%)	Assay (gpt)	Content	Distribution (%)
50.80	2.000	2"	2.02	4.09	4.09	0.26	0.011	5.48	240	9.826	2.70	3.00	0.12	4.77
38.10	1.500	1-1/2"	12.90	26.15	30.24	0.3	0.078	40.35	350	91.508	25.16	2.30	0.60	23.34
25.40	1.000	1"	13.12	26.59	56.83	0.22	0.059	30.09	400	106.364	29.25	2.20	0.59	22.71
19.05	0.750	3/4"	6.00	12.16	68.99	0.15	0.018	9.38	330	40.130	11.03	2.60	0.32	12.27
12.70	0.500	1/2"	4.14	8.39	77.38	0.13	0.011	5.61	270	22.655	6.23	2.70	0.23	8.80
6.35	0.250	1/4"	3.64	7.38	84.76	0.06	0.004	2.28	450	33.198	9.13	1.70	0.13	4.87
1.70	0.065	10	3.30	6.69	91.45	0.07	0.005	2.41	360	24.078	6.62	2.30	0.15	5.97
MINUS		10	4.22	8.55	100.00	0.1	0.009	4.40	420	35.922	9.88	5.20	0.44	17.27
TOTALS			49.34	100.00				100.00			100.00			100.00
CALCULATED ASSAY						0.19			364			2.58		
COMPOSITE ASSAY (Pulv.)						0.280			370			2.50		

SGS Metcon

TEST No. CL-03

Data Sheet

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**	
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height
SAMPLE	**Composite 2 (Met-11/17)**	**CRUSH SIZE**	P100 minus 3 in.
	0	**LEACH SOLUTION**	750 ppm free I g/l
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	2.54 kg CaO/tonne of ore
		CURE CYCLE	0 Days
		FLOWRATE	9.78 lph/m^2

		Pregnant Leach Solution							**Feed Solution**							
			Free			Assays (ppm)				Free			NaCN	Assays (ppm)		
Time (Days)		Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Au	Cu	Ag	Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Add/Rem. (grams)	Au	Cu	Ag
Leach	1	1.70	0.09	0.48	12.21	1.52	306.00	2.49	3.66	0.76	0.27	11.38		0.00	272.00	0.00
	2	3.85	0.15	0.51	12.27	0.89	416.00	1.64	4.32	0.76	0.27	11.38		0.00	272.00	0.00
	3	4.17	0.25	0.38	12.12	0.63	440.00	1.07	4.06	0.76	0.27	11.38		0.00	272.00	0.00
	4	4.34	0.23	0.17	11.81	0.53	443.00	0.80	4.44	0.76	0.27	11.38		0.00	272.00	0.00
	5	4.37	0.27	0.10	11.39	0.43	429.00	0.65	4.42	0.76	0.27	11.38		0.00	272.00	0.00
	6	4.30	0.33	0.07	11.10	0.34	406.00	0.53	4.38	0.76	0.27	11.38		0.00	272.00	0.00
	7	4.34	0.38	0.06	10.93	0.26	377.00	0.39	4.40	0.73	0.37	11.90		0.00	241.00	0.00
	8	4.35	0.44	0.04	10.91	0.22	371.00	0.32	4.40	0.73	0.37	11.90		0.00	241.00	0.00
	9	4.20	0.49	0.05	10.81	0.19	373.00	0.29	4.25	0.73	0.37	11.90		0.00	241.00	0.00
	10	4.34	0.48	0.07	10.76	0.16	379.00	0.28	4.35	0.73	0.37	11.90		0.00	241.00	0.00
	11	4.32	0.51	0.02	10.53	0.14	380.00	0.26	4.38	0.73	0.37	11.90		0.00	241.00	0.00
	12	4.35	0.56	0.02	10.57	0.13	376.00	0.22	4.38	0.73	0.37	11.90		0.00	241.00	0.00
	13	4.30	0.56	0.03	10.57	0.12	376.00	0.21	4.34	0.72	0.10	11.50		0.00	303.00	0.00
	14	4.30	0.54	0.02	10.50	0.12	373.00	0.20	4.36	0.72	0.10	11.50		0.00	303.00	0.00
	15	4.28	0.55	0.03	10.53	0.12	363.00	0.20	4.35	0.72	0.10	11.50		0.00	303.00	0.00
	16	4.26	0.57	0.03	10.58	0.11	362.00	0.19	4.32	0.72	0.10	11.50		0.00	303.00	0.00
	17	4.30	0.58	0.03	10.49	0.10	358.00	0.18	4.32	0.72	0.10	11.50		0.00	303.00	0.00
	18	4.25	0.56	0.02	10.38	0.08	354.00	0.16	4.30	0.72	0.10	11.50		0.00	303.00	0.00
	19	4.28	0.60	0.01	10.43	0.10	343.00	0.14	4.34	0.72	0.10	11.50		0.00	303.00	0.00
	20	3.84	0.58	0.01	10.39	0.08	347.00	0.15	3.94	0.72	0.10	11.50		0.00	303.00	0.00
	21	4.32	0.54	0.01	10.36	0.08	348.00	0.13	4.42	0.74	0.23	11.90		0.00	303.00	0.00
	22	4.36	0.58	0.01	10.43	0.09	350.00	0.10	4.36	0.74	0.23	11.90		0.00	303.00	0.00
	23	4.35	0.50	0.01	10.42	0.08	348.00	0.10	4.40	0.74	0.23	11.90		0.00	303.00	0.00
	24	4.38	0.60	0.01	10.49	0.06	351.00	0.11	4.40	0.74	0.23	11.90		0.00	303.00	0.00
	25	4.33	0.61	0.01	10.48	0.06	347.00	0.10	4.38	0.74	0.23	11.90		0.00	303.00	0.00
	26	4.32	0.62	0.01	10.42	0.04	335.00	0.11	4.38	0.74	0.23	11.90		0.00	303.00	0.00
	27	4.32	0.60	0.01	10.42	0.04	332.00	0.10	4.36	0.74	0.23	11.90		0.00	303.00	0.00
	28	4.35	0.59	0.01	10.34	0.04	321.00	0.09	4.42	0.74	0.23	11.90		0.00	303.00	0.00
	29	4.08	0.58	0.01	10.30	0.04	328.00	0.09	4.20	0.71	0.19	11.86		0.00	310.00	0.00
	30	4.25	0.58	0.01	10.34	0.04	322.00	0.08	4.40	0.71	0.19	11.86		0.00	310.00	0.00

SGS Metcon

TEST No. CL-03

Data Sheet

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**	
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height
SAMPLE	**Composite 2 (Met-11/17)**	**CRUSH SIZE**	P100 minus 3 in.
	0	**LEACH SOLUTION**	750 ppm free l g/l
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	2.54 kg CaO/tonne of ore
		CURE CYCLE	0 Days
		FLOWRATE	9.78 lph/m^2

		Pregnant Leach Solution							**Feed Solution**							
			Free			Assays (ppm)				Free			NaCN	Assays (ppm)		
Time (Days)		Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Au	Cu	Ag	Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Add/Rem. (grams)	Au	Cu	Ag
Leach	31	4.37	0.59	0.02	10.46	0.04	326.00	0.08	4.50	0.71	0.19	11.86		0.00	310.00	0.00
	32	4.35	0.60	0.01	10.36	0.03	328.00	0.08	4.44	0.71	0.19	11.86		0.00	310.00	0.00
	33	4.15	0.59	0.01	10.32	0.05	324.00	0.10	4.16	0.71	0.19	11.86		0.00	310.00	0.00
	34	4.12	0.59	0.01	10.24	0.05	322.00	0.10	4.20	0.71	0.19	11.86		0.00	310.00	0.00
	35	4.12	0.60	0.00	10.21	0.04	322.00	0.10	4.20	0.71	0.19	11.86		0.00	310.00	0.00
	36	4.15	0.61	0.00	10.22	0.05	318.00	0.10	4.22	0.71	0.33	11.90		0.00	303.00	0.00
	37	3.94	0.62	0.00	10.25	0.04	316.00	0.10	4.00	0.71	0.33	11.90		0.00	303.00	0.00
	38	4.06	0.60	0.00	10.27	0.04	318.00	0.10	4.16	0.71	0.33	11.90		0.00	303.00	0.00
	39	4.04	0.61	0.00	10.29	0.03	326.00	0.11	4.12	0.71	0.33	11.90		0.00	303.00	0.00
	40	4.00	0.62	0.00	10.19	0.03	320.00	0.11	4.08	0.71	0.33	11.90		0.00	303.00	0.00
	41	4.15	0.61	0.01	10.22	0.03	330.00	0.10	4.24	0.71	0.33	11.90		0.00	303.00	0.00
	42	4.18	0.60	0.01	10.24	0.03	330.00	0.10	4.22	0.71	0.33	11.90		0.00	303.00	0.00
	43	4.20	0.61	0.01	10.24	0.03	327.00	0.10	4.26	0.71	0.33	11.90		0.00	290.00	0.00
	44	4.14	0.63	0.00	10.22	0.03	329.00	0.10	4.16	0.71	0.33	11.90		0.00	290.00	0.00
	45	4.22	0.64	0.00	10.29	0.02	323.00	0.10	4.30	0.71	0.33	11.90		0.00	290.00	0.00
	46	4.20	0.64	0.00	10.24	0.02	327.00	0.09	4.26	0.71	0.33	11.90		0.00	290.00	0.00
	47	4.34	0.63	0.00	10.16	0.02	327.00	0.09	4.39	0.71	0.33	11.90		0.00	290.00	0.00
	48	4.30	0.63	0.00	10.19	0.02	236.00	0.08	4.34	0.71	0.33	11.90		0.00	290.00	0.00
	49	4.26	0.63	0.00	10.23	0.02	322.00	0.08	4.32	0.71	0.33	11.90		0.00	290.00	0.00
	50	4.34	0.63	0.00	10.31	0.02	316.00	0.07	4.34	0.71	0.33	11.90		0.00	290.00	0.00
	51	4.36	0.64	0.01	10.25	0.01	320.00	0.08	4.40	0.71	0.33	11.90		0.00	290.00	0.00
	52	4.32	0.64	0.01	10.29	0.01	323.00	0.08	4.38	0.71	0.33	11.90		0.00	290.00	0.00
	53	4.28	0.62	0.00	10.18	0.01	319.00	0.12	4.32	0.71	0.33	11.90		0.00	290.00	0.00
Wash	54	4.33	0.56	0.00	10.16	0.01	323.00	0.10	4.33	0.63	0.01	10.25		0.01	320.00	0.09
	55	4.34	0.56	0.00	10.16	0.01	323.00	0.10	4.34	0.63	0.01	10.25		0.01	320.00	0.09
	56	4.35	0.56	0.00	10.16	0.01	323.00	0.10	4.35	0.63	0.01	10.25		0.01	320.00	0.09
	57	4.36	0.56	0.00	10.16	0.01	323.00	0.10	4.36	0.63	0.01	10.25		0.01	320.00	0.09
	58	4.32	0.56	0.00	10.16	0.01	323.00	0.10	4.32	0.63	0.01	10.25		0.01	320.00	0.09
	59	4.26	0.56	0.00	10.16	0.01	323.00	0.10	4.26	0.63	0.01	10.25		0.01	320.00	0.09
	60	4.35	0.56	0.00	10.16	0.01	323.00	0.10	4.35	0.63	0.01	10.25		0.01	320.00	0.09

SGS Metcon

TEST No. CL-03

Data Sheet

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**	
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height
SAMPLE	**Composite 2 (Met-11/17)**	**CRUSH SIZE**	P100 minus 3 in.
	0	**LEACH SOLUTION**	750 ppm free l g/l
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	2.54 kg CaO/tonne of ore
		CURE CYCLE	0 Days
		FLOWRATE	9.78 lph/m^2

	Pregnant Leach Solution							**Feed Solution**							
		Free			Assays (ppm)				Free			NaCN	Assays (ppm)		
Time (Days)	Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Au	Cu	Ag	Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Add/Rem. (grams)	Au	Cu	Ag
Wash 61	4.35	0.34	0.01	9.87	0.01	337.00	0.21	4.35	0.56	0.00	10.16		0.01	323.00	0.10
62	4.37	0.34	0.01	9.87	0.01	337.00	0.21	4.37	0.56	0.00	10.16		0.01	323.00	0.10
63	4.32	0.34	0.01	9.87	0.01	337.00	0.21	4.32	0.56	0.00	10.16		0.01	323.00	0.10
64	4.29	0.34	0.01	9.87	0.01	337.00	0.21	4.29	0.56	0.00	10.16		0.01	323.00	0.10
65	4.31	0.34	0.01	9.87	0.01	337.00	0.21	4.31	0.56	0.00	10.16		0.01	323.00	0.10
66	4.32	0.34	0.01	9.87	0.01	337.00	0.21	4.32	0.56	0.00	10.16		0.01	323.00	0.10
67	4.32	0.34	0.01	9.87	0.01	337.00	0.21	4.32	0.56	0.00	10.16		0.01	323.00	0.10
68	4.37	0.24	0.01	9.54	0.11	350.00	0.25	4.37	0.34	0.01	9.87		0.01	337.00	0.21
69	4.38	0.24	0.01	9.54	0.11	350.00	0.25	4.38	0.34	0.01	9.87		0.01	337.00	0.21
70	4.38	0.24	0.01	9.54	0.11	350.00	0.25	4.38	0.34	0.01	9.87		0.01	337.00	0.21
71	4.35	0.24	0.01	9.54	0.11	350.00	0.25	4.35	0.34	0.01	9.87		0.01	337.00	0.21
72	4.40	0.24	0.01	9.54	0.11	350.00	0.25	4.40	0.34	0.01	9.87		0.01	337.00	0.21
73	4.36	0.24	0.01	9.54	0.11	350.00	0.25	4.36	0.34	0.01	9.87		0.01	337.00	0.21
74	4.35	0.24	0.01	9.54	0.11	350.00	0.25	4.35	0.34	0.01	9.87		0.01	337.00	0.21
75	4.31	0.22	0.01	9.46	0.11	346.00	0.30	4.31	0.24	0.01	9.54		0.11	350.00	0.25
76	4.39	0.22	0.01	9.46	0.11	346.00	0.30	4.39	0.24	0.01	9.54		0.11	350.00	0.25
77	4.38	0.22	0.01	9.46	0.11	346.00	0.30	4.38	0.24	0.01	9.54		0.11	350.00	0.25
78	4.33	0.22	0.01	9.46	0.11	346.00	0.30	4.33	0.24	0.01	9.54		0.11	350.00	0.25
79	4.34	0.22	0.01	9.46	0.11	346.00	0.30	4.34	0.24	0.01	9.54		0.11	350.00	0.25
80	4.26	0.22	0.01	9.46	0.11	346.00	0.30	4.26	0.24	0.01	9.54		0.11	350.00	0.25
81	4.30	0.22	0.01	9.46	0.11	346.00	0.30	4.30	0.24	0.01	9.54		0.11	350.00	0.25
82	4.30	0.15	0.02	9.57	0.11	381.00	0.38	4.30	0.22	0.01	9.46		0.11	346.00	0.30
83	4.38	0.15	0.02	9.57	0.11	381.00	0.38	4.38	0.22	0.01	9.46		0.11	346.00	0.30
84	4.32	0.15	0.02	9.57	0.11	381.00	0.38	4.32	0.22	0.01	9.46		0.11	346.00	0.30
85	4.40	0.15	0.02	9.57	0.11	381.00	0.38	4.40	0.22	0.01	9.46		0.11	346.00	0.30
86	4.30	0.15	0.02	9.57	0.11	381.00	0.38	4.30	0.22	0.01	9.46		0.11	346.00	0.30
87	4.35	0.15	0.02	9.57	0.11	381.00	0.38	4.35	0.22	0.01	9.46		0.11	346.00	0.30
88	4.31	0.15	0.02	9.57	0.11	381.00	0.38	4.31	0.22	0.01	9.46		0.11	346.00	0.30
89	4.38	0.15	0.02	9.57	0.11	381.00	0.38	4.38	0.22	0.01	9.46		0.11	346.00	0.30
90	4.25	0.15	0.02	9.57	0.11	381.00	0.38	4.25	0.22	0.01	9.46		0.11	346.00	0.30

SGS Metcon

TEST No. CL-03

Data Sheet

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**	
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height
SAMPLE	**Composite 2 (Met-11/17)**	**CRUSH SIZE**	P100 minus 3 in.
	0	**LEACH SOLUTION**	750 ppm free l g/l
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	2.54 kg CaO/tonne of ore
		CURE CYCLE	0 Days
		FLOWRATE	9.78 lph/m^2

		Pregnant Leach Solution							Feed Solution							
			Free			Assays (ppm)				Free			NaCN	Assays (ppm)		
Time (Days)		Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Au	Cu	Ag	Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Add/Rem. (grams)	Au	Cu	Ag
Wash	91	4.24	0.15	0.02	9.57	0.11	381.00	0.38	4.24	0.22	0.01	9.46		0.11	346.00	0.30
	92	4.26	0.15	0.02	9.57	0.11	381.00	0.38	4.26	0.22	0.01	9.46		0.11	346.00	0.30
	93	4.36	0.15	0.02	9.57	0.11	381.00	0.38	4.36	0.22	0.01	9.46		0.11	346.00	0.30
	94	4.28	0.15	0.02	9.57	0.11	381.00	0.38	4.28	0.22	0.01	9.46		0.11	346.00	0.30
	95	4.32	0.15	0.02	9.57	0.11	381.00	0.38	4.32	0.22	0.01	9.46		0.11	346.00	0.30
	96	4.26	0.13	0.01	9.20	0.11	385.00	0.44	4.26	0.15	0.02	9.57		0.11	381.00	0.38
	97	4.00	0.13	0.01	9.20	0.11	385.00	0.44	4.00	0.15	0.02	9.57		0.11	381.00	0.38
	98	4.00	0.13	0.01	9.20	0.11	385.00	0.44	4.00	0.15	0.02	9.57		0.11	381.00	0.38
	99	3.70	0.13	0.01	9.20	0.11	385.00	0.44	3.70	0.15	0.02	9.57		0.11	381.00	0.38
	100	3.85	0.13	0.01	9.20	0.11	385.00	0.44	3.85	0.15	0.02	9.57		0.11	381.00	0.38
	101	3.80	0.13	0.01	9.20	0.11	385.00	0.44	3.80	0.15	0.02	9.57		0.11	381.00	0.38
	102	4.00	0.13	0.01	9.20	0.11	385.00	0.44	4.00	0.15	0.02	9.57		0.11	381.00	0.38
	103	4.00	0.13	0.01	9.20	0.11	385.00	0.44	4.00	0.15	0.02	9.57		0.11	381.00	0.38
	104	3.45	0.13	0.01	9.20	0.11	385.00	0.44	3.45	0.15	0.02	9.57		0.11	381.00	0.38
	105	3.72	0.13	0.01	9.20	0.11	385.00	0.44	3.72	0.15	0.02	9.57		0.11	381.00	0.38
	106	3.59	0.13	0.01	9.20	0.11	385.00	0.44	3.59	0.15	0.02	9.57		0.11	381.00	0.38
	107	3.85	0.13	0.01	9.20	0.11	385.00	0.44	3.85	0.15	0.02	9.57		0.11	381.00	0.38
	108	4.00	0.13	0.01	9.20	0.11	385.00	0.44	4.00	0.15	0.02	9.57		0.11	381.00	0.38
	109	4.00	0.12	0.01	8.90	0.10	362.00	0.44	4.00	0.15	0.02	9.57		0.11	381.00	0.38
Rinse	110	4.26	0.11	0.01	8.73	0.10	327.00	0.39	4.35	0.00	0.00	0.00		0.00	0.00	0.00
Rinse	111	4.36	0.04	0.01	9.02	0.05	51.00	0.08	4.38	0.00	0.00	0.00		0.00	0.00	0.00
Drain	112	0.88	0.02	0.00	8.26	0.01	41.00	0.05	0.00	0.00	0.00	0.00		0.00	0.00	0.00
Drain	113	0.13	0.01	0.00	8.32	0.01	41.00	0.10	0.00	0.00	0.00	0.00		0.00	0.00	0.00
Drain	114	0.12	0.01	0.00	8.16	0.01	31.00	0.20	0.00	0.00	0.00	0.00		0.00	0.00	0.00

SGS Metcon

TEST No. CL-03

METALLURGICAL RESULTS

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**		
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14	
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height	
SAMPLE	**Composite 2 (Met-11/17)**	**CRUSH SIZE**	P100 minus 3 in.	
		LEACH SOLUTION	750 ppm fr g/l	
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	2.54	kg CaO/t of ore
		CURE CYCLE	0	Days
		FLOWRATE	9.78	lph/m^2

Time		Feed Solution Flow Rate	Cumulative										
			Extraction (g/t)			Solution Grade (ppm)			Extraction (%)			Consumption	
(Days)		(lph/sq m)	Au	Cu	Ag	Au	Cu	Ag	Au	Cu	Ag	NaCN (kg/t)	CaO (kg/t)
Leach	1	6.47	0.03	-5.35	0.05	1.52	306.00	2.49	5.30	-1.00	1.43	0.03	2.55
	2	9.86	0.07	-0.55	0.12	1.08	382.31	1.90	12.34	-0.10	3.56	0.06	2.54
	3	9.27	0.10	7.67	0.17	0.89	407.06	1.54	17.73	1.43	5.07	0.08	2.53
	4	10.14	0.12	15.72	0.21	0.78	418.15	1.31	22.45	2.93	6.24	0.11	2.54
	5	10.07	0.14	23.29	0.24	0.70	420.72	1.16	26.31	4.34	7.20	0.13	2.55
	6	10.03	0.16	29.53	0.27	0.63	417.94	1.04	29.31	5.50	7.97	0.16	2.56
	7	10.04	0.17	36.01	0.28	0.57	411.38	0.93	31.63	6.70	8.54	0.17	2.57
	8	10.04	0.18	42.24	0.30	0.52	405.79	0.85	33.59	7.86	9.01	0.19	2.59
	9	9.69	0.19	48.35	0.31	0.48	401.92	0.78	35.23	9.00	9.42	0.20	2.60
	10	9.97	0.20	55.06	0.33	0.45	399.43	0.73	36.66	10.25	9.83	0.21	2.62
	11	10.00	0.21	61.66	0.34	0.42	397.53	0.68	37.90	11.48	10.21	0.22	2.63
	12	9.98	0.21	68.19	0.35	0.39	395.61	0.64	39.06	12.69	10.54	0.23	2.65
	13	9.92	0.22	71.58	0.36	0.37	394.02	0.61	40.12	13.33	10.84	0.24	2.66
	14	9.95	0.23	74.77	0.37	0.35	392.44	0.58	41.18	13.92	11.13	0.25	2.66
	15	9.96	0.23	77.42	0.38	0.33	390.39	0.55	42.23	14.41	11.42	0.26	2.66
	16	9.87	0.24	80.04	0.39	0.32	388.55	0.53	43.20	14.90	11.69	0.27	2.67
	17	9.87	0.24	82.64	0.40	0.31	386.67	0.51	44.08	15.38	11.96	0.27	2.67
	18	9.82	0.25	84.91	0.41	0.29	384.81	0.49	44.78	15.81	12.19	0.28	2.67
	19	9.93	0.25	86.63	0.41	0.28	382.53	0.47	45.65	16.13	12.39	0.29	2.68
	20	9.00	0.25	88.19	0.42	0.27	380.87	0.45	46.29	16.42	12.58	0.29	2.68
	21	10.10	0.26	90.04	0.43	0.26	379.24	0.44	46.99	16.76	12.77	0.30	2.69
	22	9.94	0.26	92.34	0.43	0.26	377.84	0.42	47.80	17.19	12.92	0.31	2.70
	23	10.04	0.27	94.38	0.44	0.25	376.48	0.41	48.51	17.57	13.07	0.32	2.71
	24	10.08	0.27	96.67	0.44	0.24	375.36	0.39	49.05	18.00	13.23	0.33	2.73
	25	9.97	0.27	98.65	0.45	0.23	374.18	0.38	49.59	18.36	13.38	0.34	2.74
	26	10.00	0.27	100.00	0.45	0.22	372.62	0.37	49.94	18.62	13.54	0.34	2.75
	27	9.93	0.28	101.27	0.46	0.22	371.07	0.36	50.30	18.85	13.68	0.35	2.76
	28	10.12	0.28	101.92	0.46	0.21	369.21	0.35	50.65	18.97	13.81	0.36	2.77
	29	9.59	0.28	102.32	0.46	0.20	367.82	0.34	50.99	19.05	13.94	0.37	2.78
	30	10.09	0.28	102.38	0.47	0.20	366.27	0.33	51.34	19.06	14.05	0.37	2.79

SGS Metcon

TEST No. CL-03

METALLURGICAL RESULTS

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**		
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14	
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height	
SAMPLE	**Composite 2 (Met-11/17)**	**CRUSH SIZE**	P100 minus 3 in.	
		LEACH SOLUTION	750 ppm fr g/l	
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	2.54	kg CaO/t of ore
		CURE CYCLE	0	Days
		FLOWRATE	9.78	lph/m^2

Time		**Feed Solution Flow Rate**	**Cumulative**										
			Extraction (g/t)			**Solution Grade (ppm)**			**Extraction (%)**			**Consumption**	
(Days)		**(lph/sq m)**	**Au**	**Cu**	**Ag**	**Au**	**Cu**	**Ag**	**Au**	**Cu**	**Ag**	**NaCN (kg/t)**	**CaO (kg/t)**
Leach	31	10.29	0.28	102.71	0.47	0.19	364.92	0.32	51.70	19.12	14.17	0.38	2.79
	32	10.11	0.28	103.28	0.48	0.19	363.72	0.32	51.97	19.23	14.29	0.39	2.80
	33	9.52	0.29	103.89	0.48	0.18	362.53	0.31	52.39	19.34	14.43	0.39	2.81
	34	9.57	0.29	104.17	0.49	0.18	361.36	0.30	52.81	19.39	14.57	0.40	2.82
	35	9.63	0.29	104.45	0.49	0.18	360.25	0.30	53.15	19.44	14.71	0.40	2.83
	36	9.59	0.29	104.91	0.49	0.17	359.09	0.29	53.55	19.53	14.85	0.41	2.85
	37	9.28	0.30	105.28	0.50	0.17	357.99	0.29	53.88	19.60	14.98	0.41	2.86
	38	9.40	0.30	105.63	0.50	0.17	356.97	0.28	54.21	19.66	15.12	0.42	2.88
	39	9.33	0.30	106.40	0.51	0.16	356.20	0.28	54.46	19.81	15.27	0.43	2.89
	40	9.40	0.30	106.89	0.51	0.16	355.33	0.27	54.70	19.90	15.42	0.43	2.91
	41	9.64	0.30	107.85	0.52	0.16	354.72	0.27	54.96	20.08	15.56	0.44	2.92
	42	9.66	0.30	108.98	0.52	0.15	354.13	0.27	55.22	20.29	15.70	0.44	2.94
	43	9.75	0.30	110.54	0.53	0.15	353.49	0.26	55.48	20.58	15.84	0.45	2.95
	44	9.50	0.31	112.29	0.53	0.15	352.94	0.26	55.73	20.90	15.98	0.45	2.97
	45	9.83	0.31	113.59	0.54	0.15	352.26	0.25	55.90	21.15	16.12	0.45	2.98
	46	9.74	0.31	115.15	0.54	0.14	351.71	0.25	56.08	21.44	16.25	0.46	3.00
	47	10.03	0.31	116.79	0.55	0.14	351.16	0.25	56.26	21.74	16.38	0.46	3.02
	48	9.87	0.31	114.05	0.55	0.14	348.70	0.24	56.43	21.23	16.50	0.47	3.03
	49	9.91	0.31	115.39	0.55	0.13	348.14	0.24	56.61	21.48	16.61	0.47	3.05
	50	9.89	0.31	116.66	0.56	0.13	347.47	0.24	56.79	21.72	16.71	0.47	3.06
	51	10.05	0.31	118.00	0.56	0.13	346.91	0.23	56.87	21.97	16.83	0.48	3.08
	52	10.03	0.31	119.41	0.56	0.13	346.44	0.23	56.96	22.23	16.95	0.48	3.10
	53	9.85	0.31	120.67	0.57	0.13	345.91	0.23	57.01	22.46	17.12	0.49	3.11
Wash	54	9.87	0.31	120.82	0.57	0.12	345.47	0.23	56.96	22.49	17.14	0.49	3.11
	55	9.95	0.31	120.97	0.57	0.12	345.05	0.22	56.92	22.52	17.15	0.49	3.11
	56	9.92	0.31	121.11	0.57	0.12	344.64	0.22	56.87	22.55	17.17	0.50	3.11
	57	9.95	0.31	121.26	0.57	0.12	344.25	0.22	56.83	22.57	17.18	0.50	3.11
	58	9.87	0.31	121.41	0.57	0.11	343.87	0.22	56.78	22.60	17.20	0.50	3.11
	59	9.76	0.31	121.55	0.57	0.11	343.51	0.21	56.74	22.63	17.21	0.51	3.11
	60	9.94	0.31	121.70	0.57	0.11	343.16	0.21	56.70	22.66	17.23	0.51	3.11

SGS Metcon

TEST No. CL-03

METALLURGICAL RESULTS

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**		
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14	
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height	
SAMPLE	**Composite 2 (Met-11/17)**	**CRUSH SIZE**	P100 minus 3 in.	
		LEACH SOLUTION	750 ppm fr g/l	
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	2.54	kg CaO/t of ore
		CURE CYCLE	0	Days
		FLOWRATE	9.78	lph/m^2

Time (Days)		Feed Solution Flow Rate (lph/sq m)	Cumulative										
			Extraction (g/t)			Solution Grade (ppm)			Extraction (%)			Consumption	
			Au	Cu	Ag	Au	Cu	Ag	Au	Cu	Ag	NaCN (kg/t)	CaO (kg/t)
Wash	61	9.92	0.31	122.38	0.58	0.11	343.05	0.21	56.74	22.78	17.39	0.52	3.11
	62	9.99	0.31	123.07	0.58	0.11	342.95	0.21	56.79	22.91	17.55	0.53	3.11
	63	9.87	0.31	123.75	0.59	0.11	342.86	0.21	56.83	23.04	17.71	0.54	3.11
	64	9.79	0.31	124.43	0.60	0.10	342.76	0.21	56.87	23.16	17.87	0.55	3.11
	65	9.82	0.31	125.11	0.60	0.10	342.67	0.21	56.92	23.29	18.03	0.56	3.11
	66	9.88	0.31	125.79	0.61	0.10	342.58	0.21	56.96	23.42	18.19	0.57	3.11
	67	9.85	0.31	126.47	0.61	0.10	342.50	0.21	57.01	23.54	18.35	0.59	3.11
	68	9.99	0.32	127.11	0.61	0.10	342.61	0.21	57.90	23.66	18.41	0.59	3.11
	69	10.00	0.32	127.75	0.62	0.10	342.72	0.21	58.80	23.78	18.47	0.60	3.11
	70	9.98	0.33	128.39	0.62	0.10	342.83	0.21	59.70	23.90	18.53	0.60	3.11
	71	9.99	0.33	129.03	0.62	0.10	342.94	0.21	60.60	24.02	18.59	0.61	3.11
	72	10.05	0.34	129.67	0.62	0.10	343.04	0.22	61.50	24.14	18.65	0.61	3.11
	73	9.94	0.34	130.31	0.62	0.10	343.14	0.22	62.39	24.26	18.70	0.62	3.11
	74	9.91	0.35	130.94	0.63	0.10	343.23	0.22	63.29	24.38	18.76	0.62	3.11
	75	9.89	0.35	130.75	0.63	0.10	343.27	0.22	63.29	24.34	18.84	0.62	3.11
	76	10.00	0.35	130.55	0.63	0.10	343.31	0.22	63.29	24.30	18.91	0.62	3.11
	77	10.00	0.35	130.36	0.63	0.10	343.34	0.22	63.29	24.27	18.98	0.62	3.11
	78	9.90	0.35	130.16	0.64	0.10	343.38	0.22	63.29	24.23	19.06	0.62	3.11
	79	9.91	0.35	129.97	0.64	0.10	343.41	0.22	63.29	24.19	19.13	0.62	3.11
	80	9.73	0.35	129.77	0.64	0.10	343.44	0.22	63.29	24.16	19.20	0.63	3.11
	81	9.82	0.35	129.58	0.64	0.10	343.48	0.22	63.29	24.12	19.28	0.63	3.11
	82	9.82	0.35	131.27	0.65	0.10	343.94	0.23	63.29	24.44	19.39	0.63	3.11
	83	10.00	0.35	133.00	0.65	0.10	344.40	0.23	63.29	24.76	19.51	0.63	3.11
	84	9.86	0.35	134.70	0.65	0.10	344.84	0.23	63.29	25.08	19.63	0.64	3.11
	85	10.03	0.35	136.43	0.66	0.10	345.28	0.23	63.29	25.40	19.75	0.64	3.11
	86	9.84	0.35	138.13	0.66	0.10	345.70	0.23	63.29	25.71	19.86	0.64	3.11
	87	9.95	0.35	139.84	0.67	0.10	346.12	0.23	63.29	26.03	19.98	0.65	3.11
	88	9.84	0.35	141.54	0.67	0.10	346.52	0.24	63.29	26.35	20.10	0.65	3.11
	89	9.98	0.35	143.27	0.67	0.10	346.92	0.24	63.29	26.67	20.21	0.65	3.11
	90	9.72	0.35	144.94	0.68	0.10	347.30	0.24	63.29	26.98	20.33	0.66	3.11

SGS Metcon

TEST No. CL-03

METALLURGICAL RESULTS

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**		
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14	
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height	
SAMPLE	**Composite 2 (Met-11/17)**	**CRUSH SIZE**	P100 minus 3 in.	
		LEACH SOLUTION	750 ppm fr g/l	
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	2.54	kg CaO/t of ore
		CURE CYCLE	0	Days
		FLOWRATE	9.78	lph/m^2

Time		**Feed Solution Flow Rate**	**Cumulative**										
			Extraction (g/t)			**Solution Grade (ppm)**			**Extraction (%)**			**Consumption**	
	(Days)	**(lph/sq m)**	**Au**	**Cu**	**Ag**	**Au**	**Cu**	**Ag**	**Au**	**Cu**	**Ag**	**NaCN (kg/t)**	**CaO (kg/t)**
Wash	91	9.69	0.35	146.61	0.68	0.10	347.67	0.24	63.29	27.29	20.44	0.66	3.10
	92	9.73	0.35	148.29	0.69	0.10	348.03	0.24	63.29	27.61	20.56	0.66	3.10
	93	9.99	0.35	150.01	0.69	0.10	348.40	0.24	63.29	27.93	20.68	0.67	3.10
	94	9.78	0.35	151.69	0.69	0.10	348.74	0.25	63.29	28.24	20.79	0.67	3.10
	95	9.84	0.35	153.40	0.70	0.10	349.09	0.25	63.29	28.56	20.91	0.67	3.10
	96	9.73	0.35	153.59	0.70	0.10	349.46	0.25	63.29	28.59	20.99	0.68	3.10
	97	9.14	0.35	153.77	0.70	0.10	349.81	0.25	63.29	28.63	21.08	0.68	3.10
	98	9.14	0.35	153.95	0.71	0.10	350.15	0.25	63.29	28.66	21.16	0.68	3.10
	99	8.46	0.35	154.11	0.71	0.10	350.45	0.25	63.29	28.69	21.23	0.68	3.10
	100	8.81	0.35	154.29	0.71	0.10	350.77	0.26	63.29	28.72	21.31	0.68	3.11
	101	8.67	0.35	154.46	0.71	0.10	351.07	0.26	63.29	28.75	21.39	0.68	3.11
	102	9.13	0.35	154.64	0.72	0.10	351.39	0.26	63.29	28.79	21.47	0.68	3.11
	103	9.14	0.35	154.82	0.72	0.10	351.70	0.26	63.29	28.82	21.55	0.68	3.11
	104	7.88	0.35	154.97	0.72	0.10	351.96	0.26	63.29	28.85	21.62	0.68	3.11
	105	8.50	0.35	155.14	0.72	0.10	352.23	0.26	63.29	28.88	21.69	0.68	3.11
	106	8.21	0.35	155.30	0.73	0.10	352.50	0.27	63.29	28.91	21.77	0.68	3.11
	107	8.79	0.35	155.48	0.73	0.10	352.78	0.27	63.29	28.94	21.85	0.68	3.11
	108	9.14	0.35	155.66	0.73	0.10	353.06	0.27	63.29	28.98	21.93	0.69	3.11
	109	9.14	0.35	154.80	0.73	0.10	353.14	0.27	63.20	28.82	22.01	0.69	3.11
Rinse	110	9.92	0.35	170.48	0.75	0.10	352.90	0.27	64.08	31.74	22.57	0.68	3.11
Rinse	111	10.01	0.35	172.98	0.76	0.10	350.08	0.27	64.53	32.20	22.69	0.68	3.11
Drain	112	0.00	0.35	173.39	0.76	0.10	349.50	0.27	64.54	32.28	22.70	0.68	3.11
Drain	113	0.00	0.35	173.45	0.76	0.10	349.41	0.27	64.55	32.29	22.71	0.68	3.11
Drain	114	0.00	0.35	173.49	0.76	0.10	349.33	0.27	64.55	32.30	22.71	0.68	3.11

APPENDIX 7

Column Leach Test CL-04 on Composite 2 (Duplicate)

Summary of Results | **SGS Metcon** | Current Date: 09/26/14

SGS Metcon Project No.: M-709-03

Western Copper & Gold Corp. Casino Project

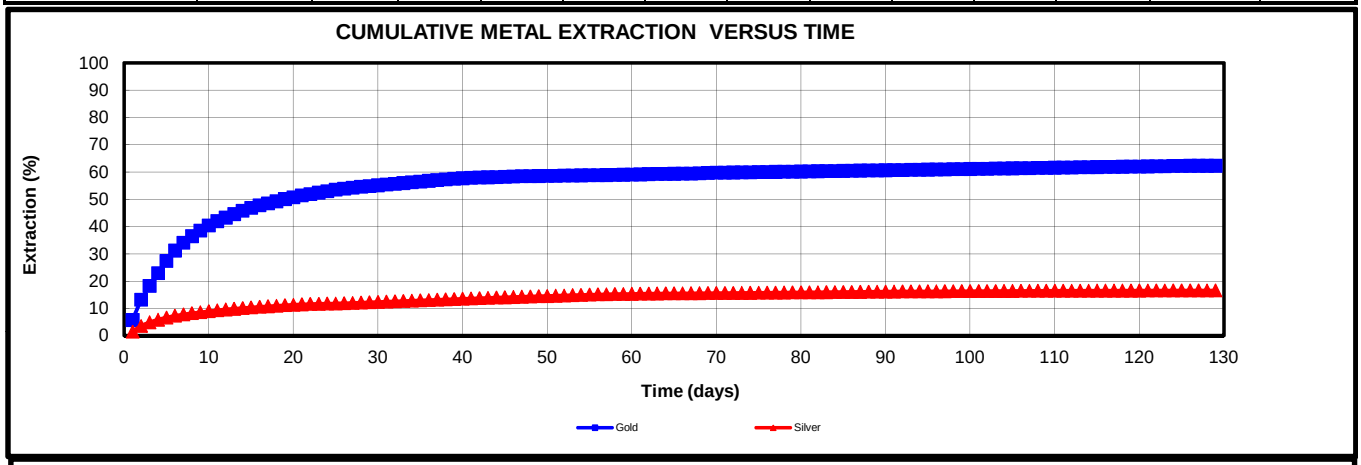
TEST No.: CL-04 | Crush Size: P100 minus 3 in.

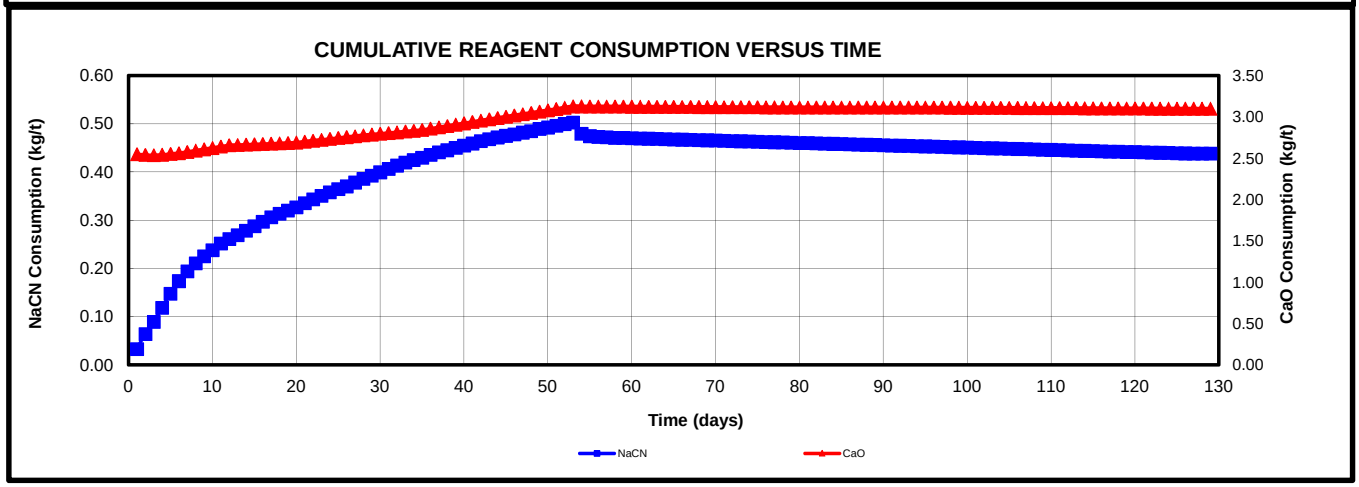
SAMPLE : Composite 2 (Met-11/17) | Lime Addition: 2.55 kg Lime/tonne of ore

Objective: Gold and Silver Extraction vs Time

Cure Days:	0
Leach Days:	53
Rest Days:	0
Wash Days:	73
Drain Days:	3
Total Cycle Days:	129

PRODUCTS	Volume	Weight	Cumulative										
			Assay (g/t)			Contents (mg)			Indicated Extraction			Consumption	
												NaCN	CaO
	(liters)	(kg)	Au	Cu	Ag	Au	Cu	Ag	Au	Cu	Ag	(kg/t)	(kg/t)
Feed Solution	543.76		0.00	123	0.00	0.00	66871	0.00	62.31	33.53	16.63	0.44	3.10
Pregnant Solution	535.01		0.05	152	0.10	28.96	81061	52.61					
Leach Residue		88.80	0.20	317	2.97	17.51	28130	263.73					
CALCULATIONS													
Metal Extracted			0.33	159.80	0.59	28.96	14190	52.61					
Calculated Head			0.52	476.58	3.56	46.47	42321	316.34					
Assay Head		88.80	0.54	46.19	2.70	47.71	4102	239.82					

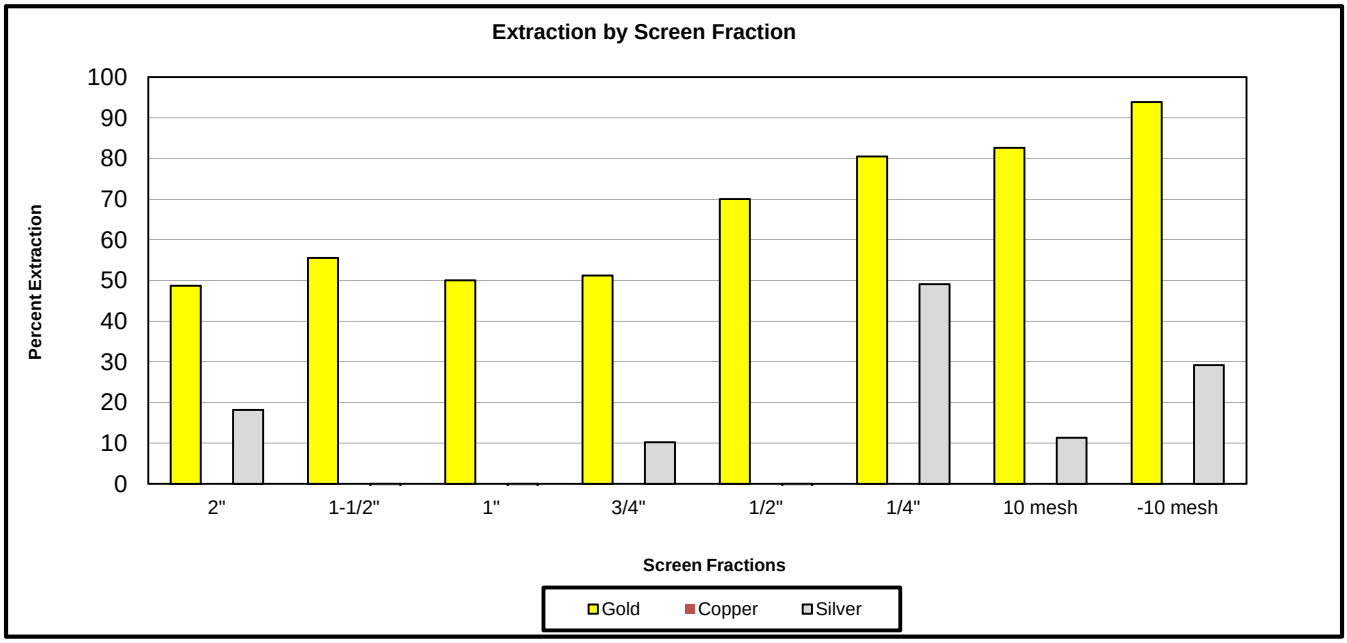




SGS Metcon

Test: CL-04
Sample: Composite 2 (Met-11/17)
Casino Project

Western Copper & Gold Corp.
SGS Metcon Project No.: M-709-03



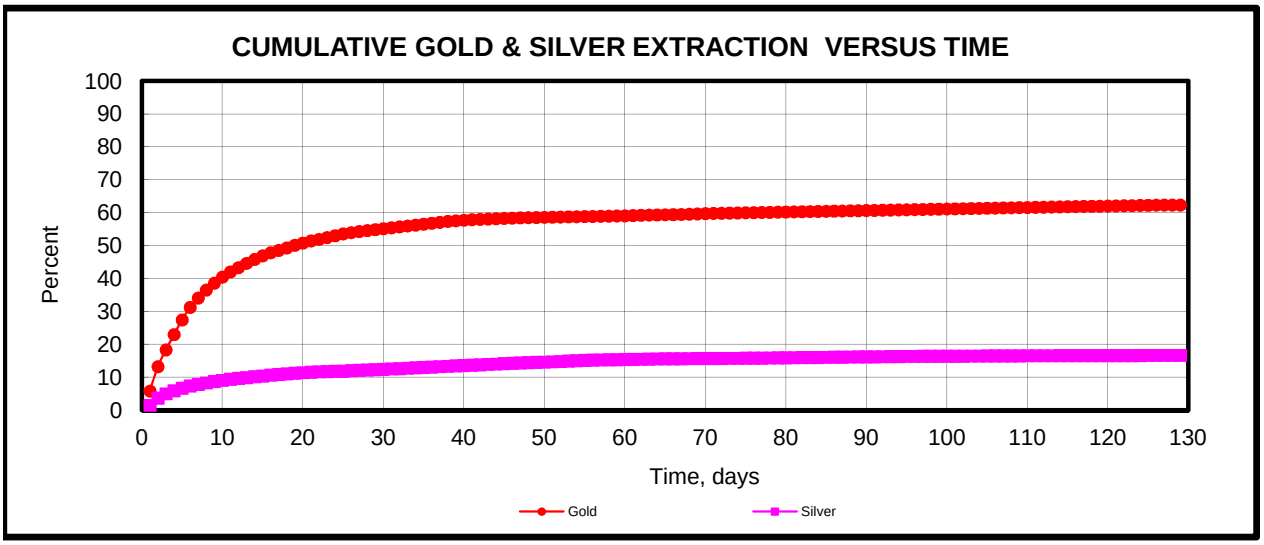
Test No. : CL-04

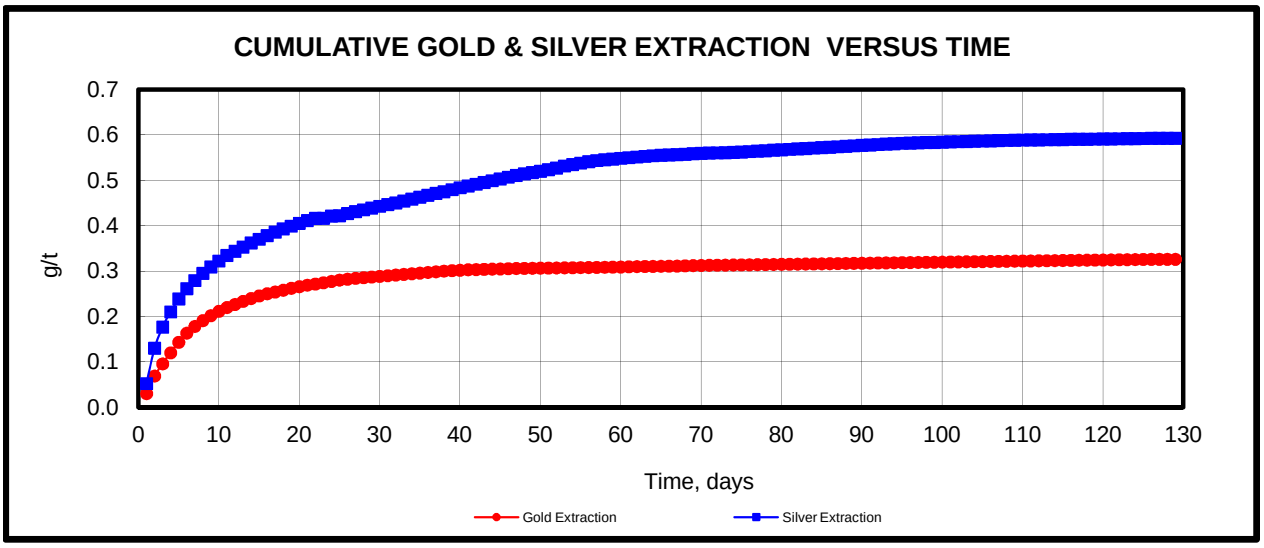
Screen Fraction	Head				Leach Residue				Percent Extraction			Degradation Index
	Weight	Assays (g/t)			Weight	Assays (g/t)						
	(kg)	Au	Cu	Ag	(kg)	Au	Cu	Ag	Au	Cu	Ag	(%)
2"	6.26	0.460	36	2.70	4.77	0.31	300	2.90	48.68	-	18.20	23.84
1-1/2"	20.38	0.540	45	2.20	20.39	0.24	210	3.70	55.54	-	-68.23	-0.03
1"	26.30	0.510	34	2.60	26.79	0.25	240	3.30	50.07	-	-29.29	-1.86
3/4"	8.84	0.440	30	2.60	8.25	0.23	340	2.50	51.19	-	10.22	6.63
1/2"	7.68	0.460	62	2.20	8.15	0.13	390	2.20	70.02	-	-6.08	-6.08
1/4"	6.62	0.430	32	3.50	6.94	0.08	430	1.70	80.50	-	49.10	-4.80
10 mesh	5.36	0.520	66	2.80	6.05	0.08	420	2.20	82.64	-	11.34	-12.84
-10 mesh	7.36	1.000	103	4.30	7.47	0.06	600	3.00	93.91	-	29.18	-1.51
Total	88.80	0.54	46	2.70	88.80	0.20	317	2.97	63.30		-9.97	

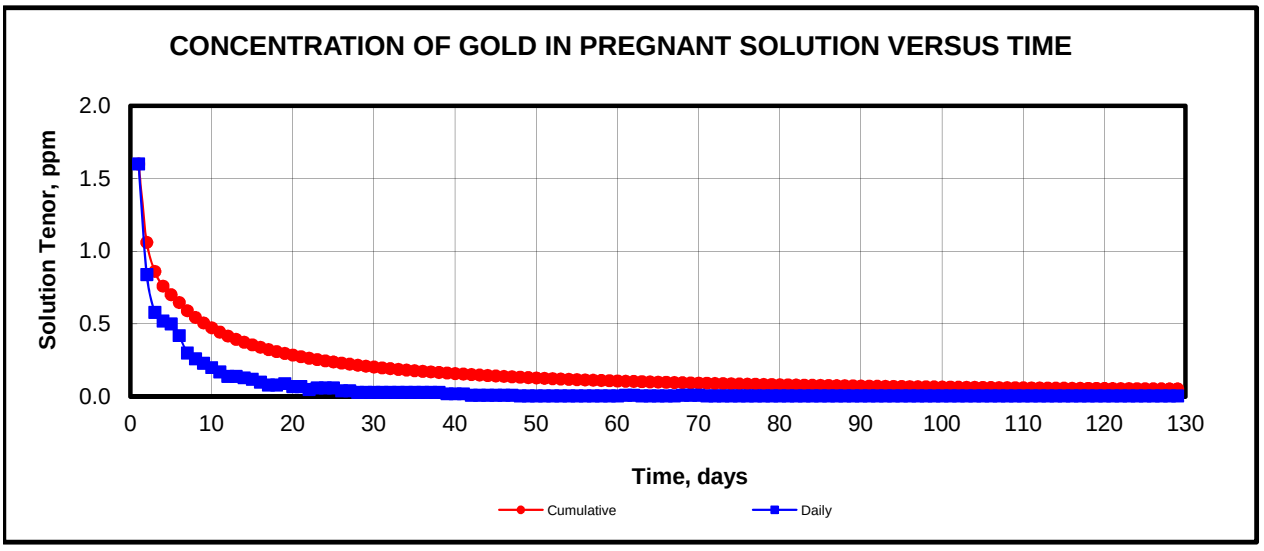
SGS Metcon

Test: CL-04 — Western Copper & Gold Corp.

Sample: Composite 2 (Met-11/17) — SGS Metcon Project No.: M-709-03



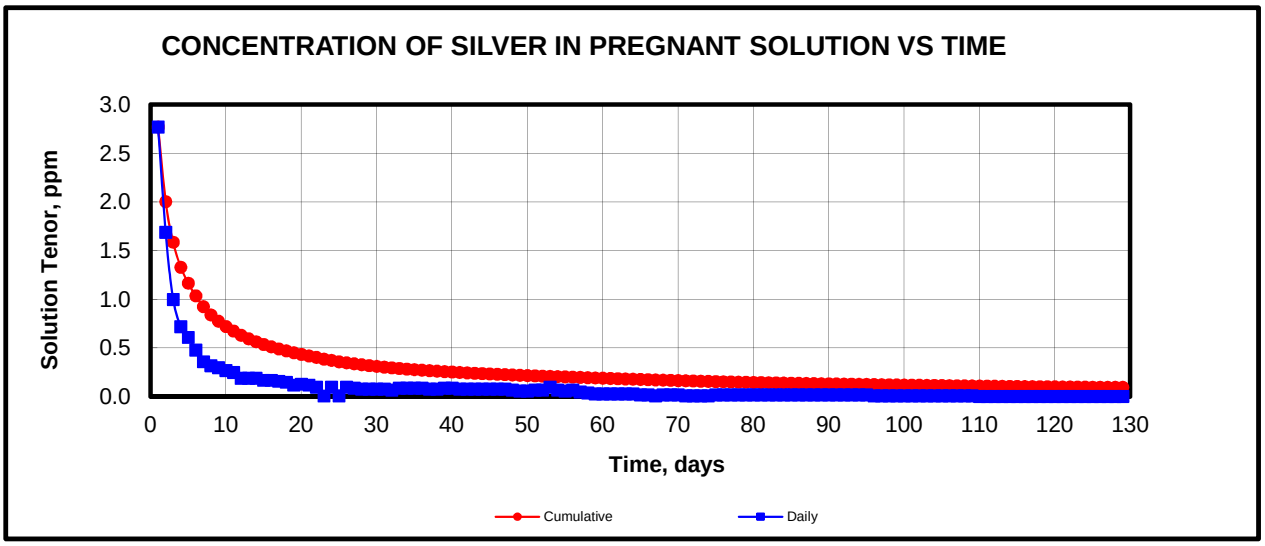


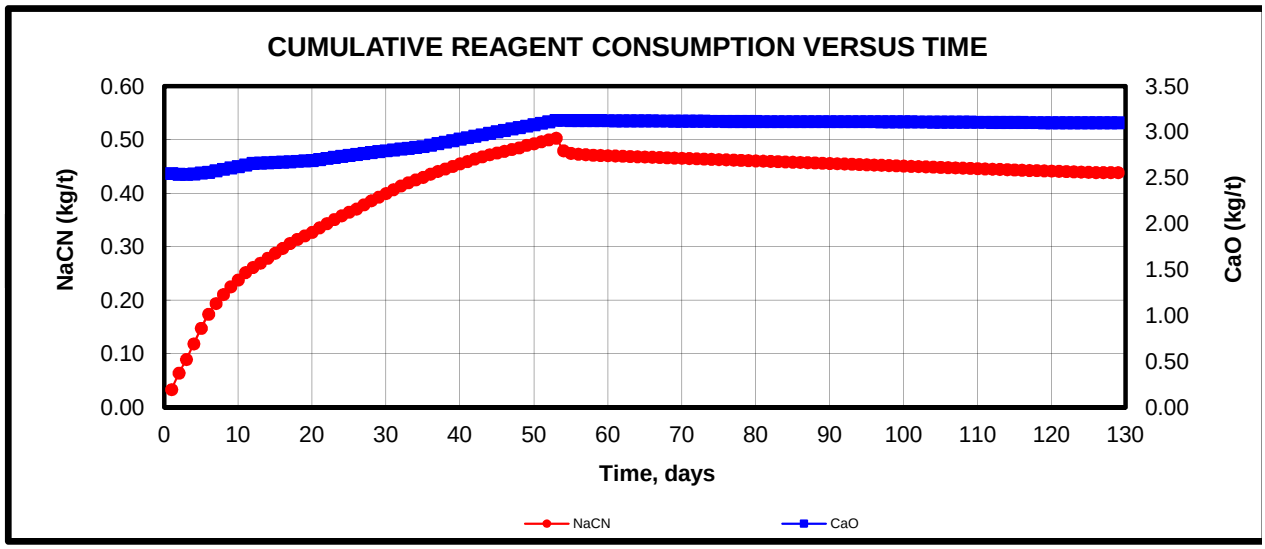


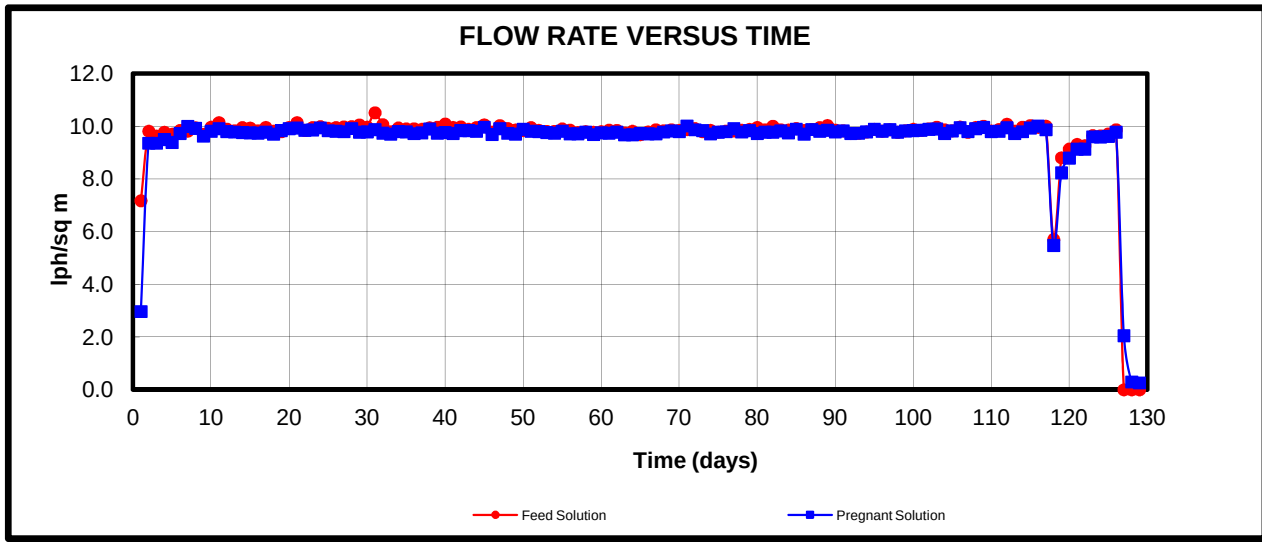
SGS Metcon

Test: CL-04 — Western Copper & Gold Corp.

Sample: Composite 2 (Met-11/17) — SGS Metcon Project No.: M-709-03



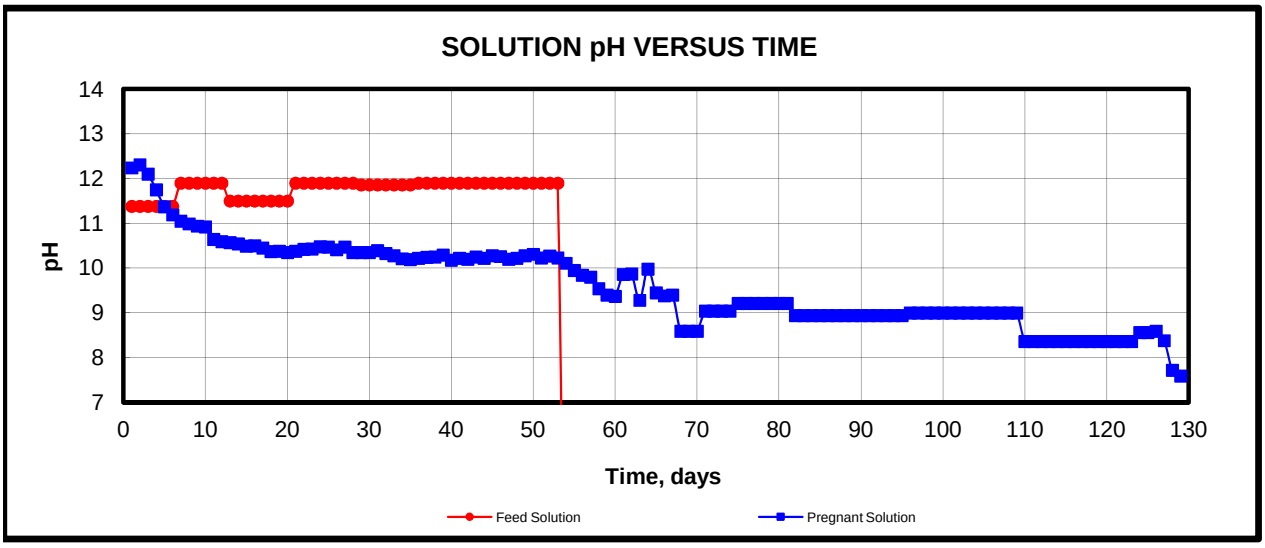


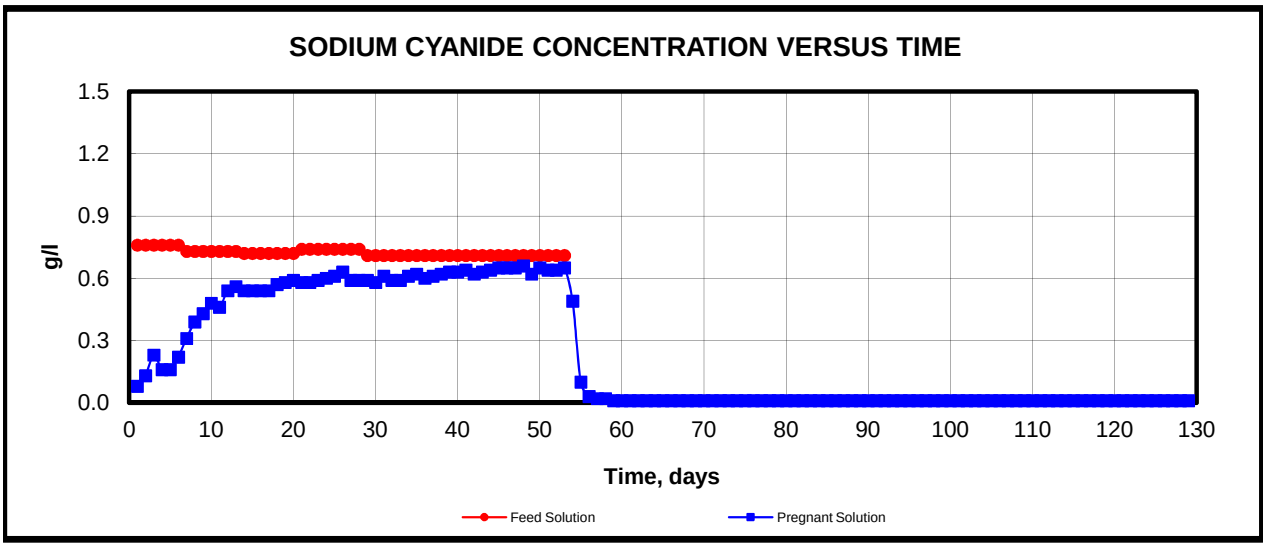


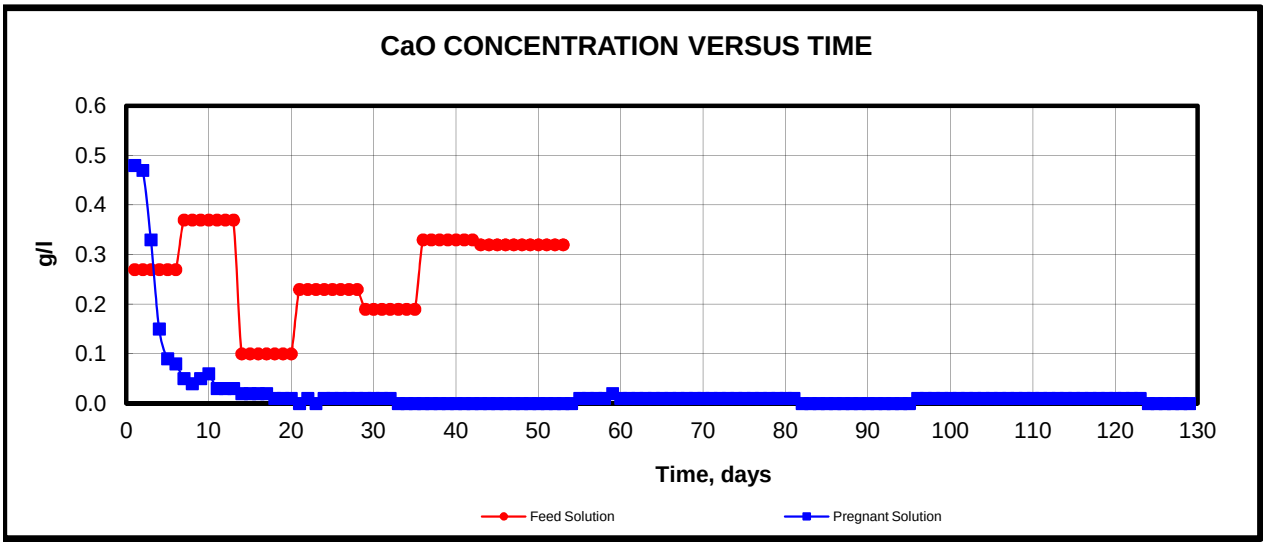
SGS Metcon

Test: CL-04 — Western Copper & Gold Corp.

Sample: Composite 2 (Met-11/17) — SGS Metcon Project No.: M-709-03







SGS Metcon

TEST No. CL-04

PHYSICAL CHARACTERISTICS SHEET

CLIENT	Western Copper & Gold Corp. SGS Metcon Project No.: M-709-03	**TEST CONDITIONS**	
		TEST START	05/01/14
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height
SAMPLE	Composite 2 (Met-11/17)	**CRUSH SIZE**	P100 minus 3 in.
		LEACH SOLUTION	750 ppm free NaCN, 300 ppm Cu
OBJECTIVE	Gold and Silver Extraction vs Time	**Lime Addition**	2.55 kg CaO/tonne of Ore
		CURE CYCLE	0 days
		FLOWRATE	9.78 lph/m2

FLOWRATE (lph/sq m)		9.78			
CURE STAGE (days)		0			
COLUMN DIAMETER (mm)		152.40			
ELEMENTS ANALYZED	Au	CNs Au	Ag	CNs Ag	Cu
HEAD ASSAYS (g per tonne)	0.54		2.70		46.19
LEACH RESIDUE ASSAYS (g per tonne)	0.20		2.97		316.78
SAMPLE PERCENT MOISTURE AS RECEIVED (Dry Basis)		0.00			
SAMPLE WEIGHT BEFORE AGGLOMERATION (kg)		88.80			
AGGLOMERATED SAMPLE WEIGHT (kg)		90.86			
INITIAL SAMPLE PERCENT MOISTURE (including agglomeration water)		2.32	(Dry Basis)		
INITIAL SAMPLE DRY WEIGHT (kg)		88.80			
INITIAL SAMPLE HEIGHT (m)		3.15			
INITIAL SAMPLE BULK DENSITY (kg/cu m)		1543	(Dry Basis)		
FINAL SAMPLE HEIGHT (m)		3.15			
RESIDUE WET WEIGHT (kg)		92.50			
RESIDUE DRY WEIGHT (kg)		88.80			
VOLUME DRAINED (l)		1.15			
SUBSIDENCE (%)		0.23			
MOISTURE UNDER LEACH (%)		5.46	(Dry Basis)		
MOISTURE RETAINED (%)		4.17	(Dry Basis)		
FINAL SAMPLE BULK DENSITY (kg/cu m)		1547	(Dry Basis)		

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7701 BUSINESS PARK DRIVE
TUCSON , ARIZONA 85743

SCREEN ANALYSIS RESULTS
Western Copper & Gold Corp.
SGS Metcon Project No.: M-709-03
Casino Project

SCREEN ANALYSIS			Sample: **Column Leach Head** **CL-04** **Composite 2 (Met-11/17)** **Crush Size: P100 minus 3 in.**											
NOMINAL OPENINGS		Tyler	Sample	Weight	Cumulative Weight	Gold			Copper			Silver		
mm	Inches	Mesh	Weights (kg)	Distribution (%)	Retained (%)	Assay (gpt)	Content	Distribution (%)	Assay (gpt)	Content	Distribution (%)	Assay (gpt)	Content	Distribution (%)
50.80	2.000	2"	6.26	7.05	7.05	0.46	0.032	6.04	36	2.538	5.49	2.70	0.19	7.05
38.10	1.500	1-1/2"	20.38	22.95	30.00	0.54	0.124	23.06	45	10.328	22.36	2.20	0.50	18.70
25.40	1.000	1"	26.30	29.62	59.62	0.51	0.151	28.11	34	10.070	21.80	2.60	0.77	28.51
19.05	0.750	3/4"	8.84	9.95	69.57	0.44	0.044	8.15	30	2.986	6.47	2.60	0.26	9.58
12.70	0.500	1/2"	7.68	8.65	78.22	0.46	0.040	7.40	62	5.362	11.61	2.20	0.19	7.05
6.35	0.250	1/4"	6.62	7.45	85.68	0.43	0.032	5.97	32	2.386	5.16	3.50	0.26	9.66
1.70	0.065	10	5.36	6.04	91.71	0.52	0.031	5.84	66	3.984	8.62	2.80	0.17	6.26
MINUS		10	7.36	8.29	100.00	1	0.083	15.43	103	8.537	18.48	4.30	0.36	13.20
TOTALS			88.80	100.00				100.00			100.00			100.00
CALCULATED ASSAY						0.54			46			2.70		
COMPOSITE ASSAY (Pulv.)						0.55			51			2.70		

SCREEN ANALYSIS			Sample: **Column Leach Residue** **CL-04** **Composite 2 (Met-11/17)**											
NOMINAL OPENINGS		Tyler	Sample	Weight	Cumulative Weight	Gold			Copper			Silver		
mm	Inches	Mesh	Weights (kg)	Distribution (%)	Retained (%)	Assay (gpt)	Content	Distribution (%)	Assay (gpt)	Content	Distribution (%)	Assay (gpt)	Content	Distribution (%)
50.80	2.000	2"	2.68	5.37	5.37	0.31	0.017	8.44	300	16.106	5.08	2.90	0.16	5.24
38.10	1.500	1-1/2"	11.46	22.96	28.33	0.24	0.055	27.94	210	48.209	15.22	3.70	0.85	28.60
25.40	1.000	1"	15.06	30.17	58.49	0.25	0.075	38.24	240	72.404	22.86	3.30	1.00	33.52
19.05	0.750	3/4"	4.64	9.29	67.79	0.23	0.021	10.84	340	31.603	9.98	2.50	0.23	7.82
12.70	0.500	1/2"	4.58	9.17	76.96	0.13	0.012	6.05	390	35.781	11.30	2.20	0.20	6.80
6.35	0.250	1/4"	3.90	7.81	84.78	0.08	0.006	3.17	430	33.594	10.60	1.70	0.13	4.47
1.70	0.065	10	3.40	6.81	91.59	0.08	0.005	2.76	420	28.606	9.03	2.20	0.15	5.05
MINUS		10	4.20	8.41	100.00	0.06	0.005	2.56	600	50.481	15.94	3.00	0.25	8.50
TOTALS			49.92	100.00				100.00			100.00			100.00
CALCULATED ASSAY						0.20			317			2.97		
COMPOSITE ASSAY (Pulv.)						0.19			320			3.00		

SGS Metcon

TEST No. CL-04

Data Sheet

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**	
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height
SAMPLE	**Composite 2 (Met-11/17)**	**CRUSH SIZE**	P100 minus 3 in.
		LEACH SOLUTION	750 ppm free l g/l
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	2.55 kg CaO/tonne of ore
		CURE CYCLE	0 Days
		FLOWRATE	9.78 lph/m^2

		Pregnant Leach Solution							**Feed Solution**							
			Free			Assays (ppm)				Free			NaCN	Assays (ppm)		
Time (Days)		Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Au	Cu	Ag	Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Add/Rem. (grams)	Au	Cu	Ag
Leach	1	1.68	0.08	0.48	12.24	1.60	234.00	2.77	4.06	0.76	0.27	11.38		0.00	272.00	0.00
	2	4.10	0.13	0.47	12.31	0.84	442.00	1.69	4.30	0.76	0.27	11.38		0.00	272.00	0.00
	3	4.10	0.23	0.33	12.10	0.58	486.00	1.00	4.22	0.76	0.27	11.38		0.00	272.00	0.00
	4	4.16	0.16	0.15	11.75	0.52	516.00	0.72	4.28	0.76	0.27	11.38		0.00	272.00	0.00
	5	4.12	0.16	0.09	11.37	0.50	493.00	0.61	4.26	0.76	0.27	11.38		0.00	272.00	0.00
	6	4.25	0.22	0.08	11.19	0.42	460.00	0.48	4.30	0.76	0.27	11.38		0.00	272.00	0.00
	7	4.38	0.31	0.05	11.05	0.30	411.00	0.36	4.30	0.73	0.37	11.90		0.00	241.00	0.00
	8	4.35	0.39	0.04	10.99	0.26	393.00	0.32	4.36	0.73	0.37	11.90		0.00	241.00	0.00
	9	4.22	0.43	0.05	10.94	0.23	391.00	0.30	4.25	0.73	0.37	11.90		0.00	241.00	0.00
	10	4.28	0.48	0.06	10.92	0.20	391.00	0.27	4.35	0.73	0.37	11.90		0.00	241.00	0.00
	11	4.34	0.46	0.03	10.64	0.17	379.00	0.25	4.44	0.73	0.37	11.90		0.00	241.00	0.00
	12	4.30	0.54	0.03	10.59	0.14	374.00	0.19	4.34	0.73	0.37	11.90		0.00	241.00	0.00
	13	4.28	0.56	0.03	10.57	0.14	378.00	0.19	4.30	0.72	0.10	11.50		0.00	303.00	0.00
	14	4.28	0.54	0.02	10.54	0.13	372.00	0.19	4.36	0.72	0.10	11.50		0.00	303.00	0.00
	15	4.26	0.54	0.02	10.49	0.12	370.00	0.17	4.34	0.72	0.10	11.50		0.00	303.00	0.00
	16	4.26	0.54	0.02	10.50	0.10	360.00	0.17	4.30	0.72	0.10	11.50		0.00	303.00	0.00
	17	4.28	0.54	0.02	10.45	0.08	355.00	0.16	4.36	0.72	0.10	11.50		0.00	303.00	0.00
	18	4.25	0.57	0.01	10.37	0.08	348.00	0.15	4.30	0.72	0.10	11.50		0.00	303.00	0.00
	19	4.30	0.58	0.01	10.38	0.09	340.00	0.12	4.28	0.72	0.10	11.50		0.00	303.00	0.00
	20	4.34	0.59	0.01	10.35	0.07	338.00	0.13	4.36	0.72	0.10	11.50		0.00	303.00	0.00
	21	4.35	0.58	0.00	10.38	0.07	341.00	0.12	4.44	0.74	0.23	11.90		0.00	303.00	0.00
	22	4.32	0.58	0.00	10.42	0.05	347.00	0.10	4.32	0.74	0.23	11.90		0.00	303.00	0.00
	23	4.32	0.59	0.01	10.43	0.06	340.00	0.01	4.36	0.74	0.23	11.90		0.00	303.00	0.00
	24	4.34	0.60	0.00	10.48	0.06	347.00	0.10	4.36	0.74	0.23	11.90		0.00	303.00	0.00
	25	4.32	0.61	0.01	10.47	0.06	348.00	0.01	4.36	0.74	0.23	11.90		0.00	303.00	0.00
	26	4.30	0.63	0.01	10.41	0.04	336.00	0.10	4.36	0.74	0.23	11.90		0.00	303.00	0.00
	27	4.30	0.59	0.01	10.47	0.04	336.00	0.09	4.38	0.74	0.23	11.90		0.00	303.00	0.00
	28	4.33	0.59	0.01	10.35	0.03	325.00	0.08	4.36	0.74	0.23	11.90		0.00	303.00	0.00
	29	4.28	0.59	0.01	10.35	0.03	318.00	0.08	4.40	0.71	0.19	11.86		0.00	310.00	0.00
	30	4.27	0.58	0.01	10.35	0.03	317.00	0.08	4.35	0.71	0.19	11.86		0.00	310.00	0.00

SGS Metcon

TEST No. CL-04

Data Sheet

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**	
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height
SAMPLE	**Composite 2 (Met-11/17)**	**CRUSH SIZE**	P100 minus 3 in.
		LEACH SOLUTION	750 ppm free l g/l
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	2.55 kg CaO/tonne of ore
		CURE CYCLE	0 Days
		FLOWRATE	9.78 lph/m^2

		Pregnant Leach Solution							**Feed Solution**							
			Free			Assays (ppm)				Free			NaCN	Assays (ppm)		
Time (Days)		Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Au	Cu	Ag	Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Add/Rem. (grams)	Au	Cu	Ag
Leach	31	4.32	0.61	0.01	10.39	0.03	324.00	0.08	4.60	0.71	0.19	11.86		0.00	310.00	0.00
	32	4.28	0.59	0.01	10.33	0.03	326.00	0.07	4.42	0.71	0.19	11.86		0.00	310.00	0.00
	33	4.24	0.59	0.00	10.28	0.03	318.00	0.09	4.28	0.71	0.19	11.86		0.00	310.00	0.00
	34	4.30	0.61	0.00	10.21	0.03	318.00	0.09	4.36	0.71	0.19	11.86		0.00	310.00	0.00
	35	4.27	0.62	0.00	10.19	0.03	317.00	0.09	4.32	0.71	0.19	11.86		0.00	310.00	0.00
	36	4.28	0.60	0.00	10.22	0.03	315.00	0.09	4.36	0.71	0.33	11.90		0.00	303.00	0.00
	37	4.20	0.61	0.00	10.24	0.03	315.00	0.08	4.26	0.71	0.33	11.90		0.00	303.00	0.00
	38	4.38	0.62	0.00	10.25	0.03	314.00	0.08	4.40	0.71	0.33	11.90		0.00	303.00	0.00
	39	4.30	0.63	0.00	10.29	0.02	314.00	0.09	4.40	0.71	0.33	11.90		0.00	303.00	0.00
	40	4.24	0.63	0.00	10.18	0.02	314.00	0.09	4.38	0.71	0.33	11.90		0.00	303.00	0.00
	41	4.28	0.64	0.00	10.22	0.02	330.00	0.08	4.38	0.71	0.33	11.90		0.00	303.00	0.00
	42	4.30	0.62	0.00	10.20	0.01	330.00	0.08	4.36	0.71	0.33	11.90		0.00	303.00	0.00
	43	4.30	0.63	0.00	10.25	0.01	325.00	0.08	4.32	0.71	0.32	11.90		0.00	290.00	0.00
	44	4.30	0.64	0.00	10.22	0.01	328.00	0.08	4.36	0.71	0.32	11.90		0.00	290.00	0.00
	45	4.36	0.65	0.00	10.28	0.01	325.00	0.08	4.40	0.71	0.32	11.90		0.00	290.00	0.00
	46	4.24	0.65	0.00	10.26	0.01	323.00	0.08	4.28	0.71	0.32	11.90		0.00	290.00	0.00
	47	4.34	0.65	0.00	10.20	0.01	323.00	0.08	4.39	0.71	0.32	11.90		0.00	290.00	0.00
	48	4.28	0.66	0.00	10.22	0.01	324.00	0.07	4.36	0.71	0.32	11.90		0.00	290.00	0.00
	49	4.23	0.62	0.00	10.28	0.01	316.00	0.06	4.30	0.71	0.32	11.90		0.00	290.00	0.00
	50	4.34	0.65	0.00	10.31	0.01	312.00	0.06	4.32	0.71	0.32	11.90		0.00	290.00	0.00
	51	4.30	0.64	0.00	10.23	0.01	314.00	0.07	4.36	0.71	0.32	11.90		0.00	290.00	0.00
	52	4.28	0.64	0.00	10.27	0.01	315.00	0.07	4.30	0.71	0.32	11.90		0.00	290.00	0.00
	53	4.28	0.65	0.00	10.23	0.01	314.00	0.10	4.30	0.71	0.32	11.90		0.00	290.00	0.00
Wash	54	4.27	0.49	0.00	10.11	0.01	262.00	0.07	4.30	0.00	0.00	0.00		0.00	0.00	0.00
	55	4.28	0.10	0.01	9.95	0.01	59.00	0.06	4.32	0.00	0.00	0.00		0.00	0.00	0.00
	56	4.26	0.03	0.01	9.84	0.01	22.00	0.07	4.32	0.00	0.00	0.00		0.00	0.00	0.00
	57	4.26	0.02	0.01	9.80	0.01	15.00	0.05	4.28	0.00	0.00	0.00		0.00	0.00	0.00
	58	4.29	0.02	0.01	9.54	0.01	10.00	0.04	4.30	0.00	0.00	0.00		0.00	0.00	0.00
	59	4.22	0.01	0.02	9.40	0.01	8.00	0.03	4.26	0.00	0.00	0.00		0.00	0.00	0.00
	60	4.27	0.01	0.01	9.37	0.01	8.00	0.03	4.29	0.00	0.00	0.00		0.00	0.00	0.00

SGS Metcon

TEST No. CL-04

Data Sheet

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**	
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height
SAMPLE	**Composite 2 (Met-11/17)**	**CRUSH SIZE**	P100 minus 3 in.
		LEACH SOLUTION	750 ppm free l g/l
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	2.55 kg CaO/tonne of ore
		CURE CYCLE	0 Days
		FLOWRATE	9.78 lph/m^2

	Pregnant Leach Solution							**Feed Solution**							
		Free			Assays (ppm)				Free			NaCN	Assays (ppm)		
Time (Days)	Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Au	Cu	Ag	Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Add/Rem. (grams)	Au	Cu	Ag
Wash 61	4.27	0.01	0.01	9.86	0.01	6.00	0.03	4.32	0.00	0.00	0.00		0.00	0.00	0.00
62	4.28	0.01	0.01	9.87	0.01	5.00	0.03	4.31	0.00	0.00	0.00		0.00	0.00	0.00
63	4.23	0.01	0.01	9.28	0.01	4.00	0.03	4.26	0.00	0.00	0.00		0.00	0.00	0.00
64	4.24	0.01	0.01	9.98	0.01	4.00	0.03	4.30	0.00	0.00	0.00		0.00	0.00	0.00
65	4.27	0.01	0.01	9.45	0.01	3.00	0.02	4.25	0.00	0.00	0.00		0.00	0.00	0.00
66	4.25	0.01	0.01	9.38	0.01	2.00	0.02	4.28	0.00	0.00	0.00		0.00	0.00	0.00
67	4.26	0.01	0.01	9.40	0.01	1.00	0.01	4.33	0.00	0.00	0.00		0.00	0.00	0.00
68	4.28	0.01	0.01	8.59	0.01	3.00	0.02	4.30	0.00	0.00	0.00		0.00	0.00	0.00
69	4.30	0.01	0.01	8.59	0.01	3.00	0.02	4.32	0.00	0.00	0.00		0.00	0.00	0.00
70	4.30	0.01	0.01	8.59	0.01	3.00	0.02	4.32	0.00	0.00	0.00		0.00	0.00	0.00
71	4.36	0.01	0.01	9.04	0.01	2.00	0.01	4.30	0.00	0.00	0.00		0.00	0.00	0.00
72	4.32	0.01	0.01	9.04	0.01	2.00	0.01	4.34	0.00	0.00	0.00		0.00	0.00	0.00
73	4.32	0.01	0.01	9.04	0.01	2.00	0.01	4.30	0.00	0.00	0.00		0.00	0.00	0.00
74	4.26	0.01	0.01	9.04	0.01	2.00	0.01	4.32	0.00	0.00	0.00		0.00	0.00	0.00
75	4.26	0.01	0.01	9.21	0.01	1.60	0.02	4.26	0.00	0.00	0.00		0.00	0.00	0.00
76	4.30	0.01	0.01	9.21	0.01	1.60	0.02	4.31	0.00	0.00	0.00		0.00	0.00	0.00
77	4.34	0.01	0.01	9.21	0.01	1.60	0.02	4.30	0.00	0.00	0.00		0.00	0.00	0.00
78	4.28	0.01	0.01	9.21	0.01	1.60	0.02	4.31	0.00	0.00	0.00		0.00	0.00	0.00
79	4.31	0.01	0.01	9.21	0.01	1.60	0.02	4.33	0.00	0.00	0.00		0.00	0.00	0.00
80	4.26	0.01	0.01	9.21	0.01	1.60	0.02	4.36	0.00	0.00	0.00		0.00	0.00	0.00
81	4.28	0.01	0.01	9.21	0.01	1.60	0.02	4.32	0.00	0.00	0.00		0.00	0.00	0.00
82	4.28	0.01	0.00	8.94	0.01	2.00	0.02	4.38	0.00	0.00	0.00		0.00	0.00	0.00
83	4.30	0.01	0.00	8.94	0.01	2.00	0.02	4.32	0.00	0.00	0.00		0.00	0.00	0.00
84	4.27	0.01	0.00	8.94	0.01	2.00	0.02	4.32	0.00	0.00	0.00		0.00	0.00	0.00
85	4.34	0.01	0.00	8.94	0.01	2.00	0.02	4.35	0.00	0.00	0.00		0.00	0.00	0.00
86	4.24	0.01	0.00	8.94	0.01	2.00	0.02	4.30	0.00	0.00	0.00		0.00	0.00	0.00
87	4.32	0.01	0.00	8.94	0.01	2.00	0.02	4.32	0.00	0.00	0.00		0.00	0.00	0.00
88	4.30	0.01	0.00	8.94	0.01	2.00	0.02	4.36	0.00	0.00	0.00		0.00	0.00	0.00
89	4.32	0.01	0.00	8.94	0.01	2.00	0.02	4.40	0.00	0.00	0.00		0.00	0.00	0.00
90	4.28	0.01	0.00	8.94	0.01	2.00	0.02	4.31	0.00	0.00	0.00		0.00	0.00	0.00

SGS Metcon

TEST No. CL-04

Data Sheet

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**	
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height
SAMPLE	**Composite 2 (Met-11/17)**	**CRUSH SIZE**	P100 minus 3 in.
		LEACH SOLUTION	750 ppm free l g/l
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	2.55 kg CaO/tonne of ore
		CURE CYCLE	0 Days
		FLOWRATE	9.78 lph/m^2

	Pregnant Leach Solution							**Feed Solution**							
		Free			Assays (ppm)				Free			NaCN	Assays (ppm)		
Time (Days)	Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Au	Cu	Ag	Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Add/Rem. (grams)	Au	Cu	Ag
Wash 91	4.30	0.01	0.00	8.94	0.01	2.00	0.02	4.30	0.00	0.00	0.00		0.00	0.00	0.00
92	4.26	0.01	0.00	8.94	0.01	2.00	0.02	4.26	0.00	0.00	0.00		0.00	0.00	0.00
93	4.25	0.01	0.00	8.94	0.01	2.00	0.02	4.25	0.00	0.00	0.00		0.00	0.00	0.00
94	4.29	0.01	0.00	8.94	0.01	2.00	0.02	4.29	0.00	0.00	0.00		0.00	0.00	0.00
95	4.34	0.01	0.00	8.94	0.01	2.00	0.02	4.34	0.00	0.00	0.00		0.00	0.00	0.00
96	4.30	0.01	0.01	9.00	0.01	6.00	0.01	4.30	0.00	0.00	0.00		0.00	0.00	0.00
97	4.32	0.01	0.01	9.00	0.01	6.00	0.01	4.32	0.00	0.00	0.00		0.00	0.00	0.00
98	4.28	0.01	0.01	9.00	0.01	6.00	0.01	4.28	0.00	0.00	0.00		0.00	0.00	0.00
99	4.30	0.01	0.01	9.00	0.01	6.00	0.01	4.30	0.00	0.00	0.00		0.00	0.00	0.00
100	4.30	0.01	0.01	9.00	0.01	6.00	0.01	4.32	0.00	0.00	0.00		0.00	0.00	0.00
101	4.32	0.01	0.01	9.00	0.01	6.00	0.01	4.32	0.00	0.00	0.00		0.00	0.00	0.00
102	4.33	0.01	0.01	9.00	0.01	6.00	0.01	4.34	0.00	0.00	0.00		0.00	0.00	0.00
103	4.33	0.01	0.01	9.00	0.01	6.00	0.01	4.36	0.00	0.00	0.00		0.00	0.00	0.00
104	4.26	0.01	0.01	9.00	0.01	6.00	0.01	4.32	0.00	0.00	0.00		0.00	0.00	0.00
105	4.30	0.01	0.01	9.00	0.01	6.00	0.01	4.30	0.00	0.00	0.00		0.00	0.00	0.00
106	4.35	0.01	0.01	9.00	0.01	6.00	0.01	4.36	0.00	0.00	0.00		0.00	0.00	0.00
107	4.29	0.01	0.01	9.00	0.01	6.00	0.01	4.28	0.00	0.00	0.00		0.00	0.00	0.00
108	4.34	0.01	0.01	9.00	0.01	6.00	0.01	4.36	0.00	0.00	0.00		0.00	0.00	0.00
109	4.36	0.01	0.01	9.00	0.01	6.00	0.01	4.38	0.00	0.00	0.00		0.00	0.00	0.00
110	4.30	0.01	0.01	8.36	0.01	0.50	0.01	4.31	0.00	0.00	0.00		0.00	0.00	0.00
111	4.29	0.01	0.01	8.36	0.01	0.50	0.01	4.32	0.00	0.00	0.00		0.00	0.00	0.00
112	4.36	0.01	0.01	8.36	0.01	0.50	0.01	4.42	0.00	0.00	0.00		0.00	0.00	0.00
113	4.26	0.01	0.01	8.36	0.01	0.50	0.01	4.30	0.00	0.00	0.00		0.00	0.00	0.00
114	4.29	0.01	0.01	8.36	0.01	0.50	0.01	4.36	0.00	0.00	0.00		0.00	0.00	0.00
115	4.35	0.01	0.01	8.36	0.01	0.50	0.01	4.39	0.00	0.00	0.00		0.00	0.00	0.00
116	4.40	0.01	0.01	8.36	0.01	0.50	0.01	4.38	0.00	0.00	0.00		0.00	0.00	0.00
117	4.30	0.01	0.01	8.36	0.01	0.50	0.01	4.36	0.00	0.00	0.00		0.00	0.00	0.00
118	2.40	0.01	0.01	8.36	0.01	0.50	0.01	2.50	0.00	0.00	0.00		0.00	0.00	0.00
119	3.60	0.01	0.01	8.36	0.01	0.50	0.01	3.85	0.00	0.00	0.00		0.00	0.00	0.00
120	3.85	0.01	0.01	8.36	0.01	0.50	0.01	4.00	0.00	0.00	0.00		0.00	0.00	0.00

SGS Metcon

TEST No. CL-04

Data Sheet

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**	
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height
SAMPLE	**Composite 2 (Met-11/17)**	**CRUSH SIZE**	P100 minus 3 in.
		LEACH SOLUTION	750 ppm free l g/l
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	2.55 kg CaO/tonne of ore
		CURE CYCLE	0 Days
		FLOWRATE	9.78 lph/m^2

		Pregnant Leach Solution							Feed Solution							
			Free			Assays (ppm)				Free			NaCN	Assays (ppm)		
Time (Days)		Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Au	Cu	Ag	Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Add/Rem. (grams)	Au	Cu	Ag
Wash	121	4.00	0.01	0.01	8.36	0.01	0.50	0.01	4.08	0.00	0.00	0.00		0.00	0.00	0.00
	122	4.00	0.01	0.01	8.36	0.01	0.50	0.01	4.06	0.00	0.00	0.00		0.00	0.00	0.00
	123	4.20	0.01	0.01	8.36	0.01	0.50	0.01	4.22	0.00	0.00	0.00		0.00	0.00	0.00
	124	4.20	0.01	0.00	8.56	0.01	0.50	0.01	4.22	0.00	0.00	0.00		0.00	0.00	0.00
	125	4.20	0.01	0.00	8.56	0.01	0.50	0.01	4.24	0.00	0.00	0.00		0.00	0.00	0.00
	126	4.28	0.01	0.00	8.59	0.01	0.50	0.01	4.32	0.00	0.00	0.00		0.00	0.00	0.00
Drain	127	0.90	0.01	0.00	8.38	0.01	0.50	0.01	0.00	0.00	0.00	0.00		0.00	0.00	0.00
Drain	128	0.13	0.01	0.00	7.72	0.01	0.50	0.01	0.00	0.00	0.00	0.00		0.00	0.00	0.00
Drain	129	0.12	0.01	0.00	7.59	0.01	0.50	0.01	0.00	0.00	0.00	0.00		0.00	0.00	0.00

SGS Metcon

TEST No. CL-04

METALLURGICAL RESULTS

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**		
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14	
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height	
SAMPLE	**Composite 2 (Met-11/17)**	**CRUSH SIZE**	P100 minus 3 in.	
		LEACH SOLUTION	750 ppm fr g/l	
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	2.55	kg CaO/t of ore
		CURE CYCLE	0	Days
		FLOWRATE	9.78	lph/m^2

Time		Feed Solution Flow Rate	Cumulative										
			Extraction (g/t)			Solution Grade (ppm)			Extraction (%)			Consumption	
(Days)		(lph/sq m)	Au	Cu	Ag	Au	Cu	Ag	Au	Cu	Ag	NaCN (kg/t)	CaO (kg/t)
Leach	1	7.18	0.03	-8.01	0.05	1.60	234.00	2.77	5.78	-1.68	1.47	0.03	2.55
	2	9.82	0.07	-0.77	0.13	1.06	381.54	2.00	13.20	-0.16	3.66	0.06	2.54
	3	9.63	0.10	8.74	0.18	0.86	424.89	1.59	18.31	1.83	4.96	0.09	2.54
	4	9.78	0.12	19.80	0.21	0.76	451.89	1.33	22.97	4.16	5.90	0.12	2.54
	5	9.70	0.14	29.63	0.24	0.70	461.21	1.17	27.40	6.22	6.70	0.15	2.55
	6	9.84	0.16	38.47	0.26	0.65	460.98	1.04	31.24	8.07	7.34	0.17	2.56
	7	9.82	0.18	47.08	0.28	0.59	452.81	0.93	34.07	9.88	7.84	0.19	2.58
	8	9.95	0.19	54.49	0.30	0.54	444.46	0.84	36.50	11.43	8.28	0.21	2.59
	9	9.69	0.20	61.54	0.31	0.51	438.08	0.78	38.59	12.91	8.68	0.23	2.61
	10	9.97	0.21	68.58	0.32	0.47	432.99	0.72	40.43	14.39	9.05	0.24	2.62
	11	10.14	0.22	75.05	0.33	0.44	427.67	0.68	42.02	15.75	9.39	0.25	2.64
	12	9.89	0.23	81.39	0.34	0.42	422.89	0.63	43.32	17.08	9.65	0.26	2.66
	13	9.83	0.23	84.93	0.35	0.39	419.23	0.60	44.61	17.82	9.91	0.27	2.66
	14	9.95	0.24	87.99	0.36	0.37	415.67	0.57	45.80	18.46	10.16	0.28	2.67
	15	9.93	0.25	90.93	0.37	0.36	412.49	0.54	46.90	19.08	10.39	0.29	2.67
	16	9.83	0.25	93.52	0.38	0.34	409.07	0.51	47.82	19.62	10.62	0.30	2.67
	17	9.96	0.25	95.76	0.39	0.32	405.75	0.49	48.56	20.09	10.84	0.31	2.68
	18	9.82	0.26	97.74	0.39	0.31	402.42	0.47	49.29	20.51	11.04	0.31	2.68
	19	9.80	0.26	99.60	0.40	0.30	398.99	0.45	50.12	20.90	11.20	0.32	2.69
	20	9.96	0.27	101.24	0.41	0.29	395.78	0.44	50.78	21.24	11.38	0.33	2.69
	21	10.14	0.27	102.80	0.41	0.28	393.04	0.42	51.43	21.57	11.55	0.34	2.70
	22	9.85	0.27	104.94	0.42	0.26	390.86	0.41	51.90	22.02	11.68	0.34	2.71
	23	9.95	0.27	106.60	0.42	0.26	388.56	0.39	52.45	22.37	11.69	0.35	2.72
	24	9.99	0.28	108.68	0.42	0.25	386.75	0.37	53.01	22.80	11.83	0.36	2.73
	25	9.92	0.28	110.74	0.42	0.24	385.15	0.36	53.57	23.24	11.85	0.36	2.75
	26	9.95	0.28	112.13	0.43	0.23	383.20	0.35	53.94	23.53	11.98	0.37	2.76
	27	9.98	0.28	113.45	0.43	0.22	381.40	0.34	54.31	23.81	12.10	0.38	2.77
	28	9.99	0.29	114.42	0.44	0.22	379.31	0.33	54.59	24.01	12.21	0.39	2.78
	29	10.05	0.29	114.39	0.44	0.21	377.15	0.32	54.87	24.00	12.32	0.39	2.79
	30	9.97	0.29	114.45	0.44	0.20	375.11	0.31	55.14	24.01	12.43	0.40	2.80

SGS Metcon

TEST No. CL-04

METALLURGICAL RESULTS

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**		
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14	
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height	
SAMPLE	**Composite 2 (Met-11/17)**	**CRUSH SIZE**	P100 minus 3 in.	
		LEACH SOLUTION	750 ppm fr g/l	
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	2.55	kg CaO/t of ore
		CURE CYCLE	0	Days
		FLOWRATE	9.78	lph/m^2

Time		Feed Solution Flow Rate	Cumulative										
			Extraction (g/t)			Solution Grade (ppm)			Extraction (%)			Consumption	
(Days)		(lph/sq m)	Au	Cu	Ag	Au	Cu	Ag	Au	Cu	Ag	NaCN (kg/t)	CaO (kg/t)
Leach	31	10.51	0.29	114.15	0.45	0.20	373.41	0.31	55.42	23.95	12.54	0.41	2.81
	32	10.06	0.29	114.43	0.45	0.19	371.90	0.30	55.70	24.01	12.63	0.41	2.81
	33	9.80	0.29	114.68	0.45	0.19	370.25	0.29	55.97	24.06	12.75	0.42	2.82
	34	9.94	0.29	114.86	0.46	0.18	368.67	0.29	56.25	24.10	12.88	0.42	2.83
	35	9.90	0.30	115.02	0.46	0.18	367.17	0.28	56.53	24.13	13.00	0.43	2.84
	36	9.90	0.30	115.32	0.47	0.17	365.70	0.27	56.80	24.20	13.12	0.44	2.86
	37	9.89	0.30	115.69	0.47	0.17	364.33	0.27	57.07	24.27	13.23	0.44	2.87
	38	9.95	0.30	116.16	0.48	0.17	362.95	0.26	57.36	24.37	13.34	0.45	2.89
	39	9.97	0.30	116.35	0.48	0.16	361.67	0.26	57.54	24.41	13.46	0.45	2.91
	40	10.09	0.30	116.40	0.48	0.16	360.47	0.25	57.72	24.42	13.58	0.46	2.92
	41	9.96	0.30	117.36	0.49	0.16	359.72	0.25	57.91	24.63	13.69	0.46	2.94
	42	9.98	0.30	118.46	0.49	0.15	358.99	0.25	58.00	24.86	13.80	0.46	2.96
	43	9.89	0.30	120.09	0.50	0.15	358.19	0.24	58.09	25.20	13.90	0.47	2.97
	44	9.95	0.30	121.74	0.50	0.15	357.49	0.24	58.19	25.54	14.01	0.47	2.99
	45	10.06	0.30	123.32	0.50	0.14	356.74	0.24	58.28	25.88	14.12	0.48	3.00
	46	9.78	0.31	124.77	0.51	0.14	356.01	0.23	58.37	26.18	14.23	0.48	3.02
	47	10.03	0.31	126.22	0.51	0.14	355.29	0.23	58.46	26.48	14.34	0.48	3.03
	48	9.92	0.31	127.60	0.51	0.13	354.62	0.23	58.51	26.77	14.44	0.48	3.05
	49	9.86	0.31	128.61	0.52	0.13	353.84	0.22	58.56	26.98	14.52	0.49	3.07
	50	9.84	0.31	129.75	0.52	0.13	352.98	0.22	58.60	27.22	14.60	0.49	3.08
	51	9.95	0.31	130.71	0.52	0.13	352.20	0.22	58.65	27.43	14.69	0.50	3.10
	52	9.85	0.31	131.85	0.53	0.12	351.48	0.21	58.69	27.67	14.79	0.50	3.11
	53	9.81	0.31	132.94	0.53	0.12	350.76	0.21	58.74	27.89	14.92	0.50	3.13
Wash	54	9.81	0.31	145.54	0.53	0.12	349.10	0.21	58.79	30.54	15.02	0.48	3.13
	55	9.90	0.31	148.39	0.54	0.12	343.77	0.21	58.83	31.14	15.10	0.47	3.13
	56	9.85	0.31	149.44	0.54	0.12	337.99	0.20	58.88	31.36	15.19	0.47	3.13
	57	9.76	0.31	150.16	0.54	0.11	332.29	0.20	58.92	31.51	15.26	0.47	3.13
	58	9.80	0.31	150.64	0.55	0.11	326.66	0.20	58.97	31.61	15.31	0.47	3.13
	59	9.78	0.31	151.02	0.55	0.11	321.28	0.19	59.02	31.69	15.35	0.47	3.12
	60	9.80	0.31	151.41	0.55	0.11	316.02	0.19	59.06	31.77	15.40	0.47	3.12

SGS Metcon

TEST No. CL-04

METALLURGICAL RESULTS

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**		
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14	
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height	
SAMPLE	**Composite 2 (Met-11/17)**	**CRUSH SIZE**	P100 minus 3 in.	
		LEACH SOLUTION	750 ppm fr g/l	
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	2.55	kg CaO/t of ore
		CURE CYCLE	0	Days
		FLOWRATE	9.78	lph/m^2

Time (Days)		Feed Solution Flow Rate (lph/sq m)	Cumulative										
			Extraction (g/t)			Solution Grade (ppm)			Extraction (%)			Consumption	
			Au	Cu	Ag	Au	Cu	Ag	Au	Cu	Ag	NaCN (kg/t)	CaO (kg/t)
Wash	61	9.85	0.31	151.70	0.55	0.11	310.89	0.19	59.15	31.83	15.44	0.47	3.12
	62	9.84	0.31	151.94	0.55	0.10	305.91	0.19	59.25	31.88	15.48	0.47	3.12
	63	9.74	0.31	152.13	0.55	0.10	301.13	0.18	59.29	31.92	15.52	0.47	3.12
	64	9.82	0.31	152.32	0.55	0.10	296.48	0.18	59.34	31.96	15.56	0.47	3.12
	65	9.68	0.31	152.46	0.56	0.10	291.93	0.18	59.38	31.99	15.58	0.47	3.12
	66	9.79	0.31	152.56	0.56	0.10	287.52	0.18	59.43	32.01	15.61	0.47	3.12
	67	9.87	0.31	152.61	0.56	0.10	283.23	0.17	59.47	32.02	15.62	0.47	3.12
	68	9.83	0.31	152.75	0.56	0.10	279.06	0.17	59.57	32.05	15.65	0.47	3.12
	69	9.87	0.31	152.90	0.56	0.09	275.01	0.17	59.66	32.08	15.68	0.47	3.12
	70	9.85	0.31	153.04	0.56	0.09	271.07	0.17	59.75	32.11	15.71	0.47	3.12
	71	9.88	0.31	153.14	0.56	0.09	267.17	0.17	59.80	32.13	15.72	0.46	3.12
	72	9.91	0.31	153.24	0.56	0.09	263.42	0.16	59.85	32.15	15.73	0.46	3.12
	73	9.79	0.31	153.33	0.56	0.09	259.78	0.16	59.89	32.17	15.75	0.46	3.12
	74	9.85	0.31	153.43	0.56	0.09	256.28	0.16	59.94	32.19	15.76	0.46	3.12
	75	9.78	0.31	153.51	0.56	0.09	252.87	0.16	59.98	32.21	15.79	0.46	3.12
	76	9.82	0.31	153.59	0.56	0.09	249.52	0.16	60.03	32.23	15.81	0.46	3.12
	77	9.82	0.31	153.66	0.56	0.09	246.23	0.15	60.08	32.24	15.84	0.46	3.12
	78	9.85	0.31	153.74	0.57	0.08	243.07	0.15	60.12	32.26	15.87	0.46	3.12
	79	9.88	0.31	153.82	0.57	0.08	239.97	0.15	60.17	32.28	15.90	0.46	3.11
	80	9.96	0.32	153.89	0.57	0.08	236.98	0.15	60.21	32.29	15.92	0.46	3.11
	81	9.87	0.32	153.97	0.57	0.08	234.06	0.15	60.26	32.31	15.95	0.46	3.11
	82	10.00	0.32	154.07	0.57	0.08	231.20	0.15	60.31	32.33	15.98	0.46	3.11
	83	9.87	0.32	154.17	0.57	0.08	228.41	0.14	60.35	32.35	16.00	0.46	3.11
	84	9.86	0.32	154.26	0.57	0.08	225.70	0.14	60.40	32.37	16.03	0.46	3.11
	85	9.92	0.32	154.36	0.57	0.08	223.02	0.14	60.45	32.39	16.06	0.46	3.11
	86	9.84	0.32	154.45	0.57	0.08	220.45	0.14	60.49	32.41	16.09	0.46	3.11
	87	9.88	0.32	154.55	0.57	0.08	217.90	0.14	60.54	32.43	16.11	0.46	3.11
	88	9.95	0.32	154.65	0.57	0.08	215.42	0.14	60.58	32.45	16.14	0.46	3.11
	89	10.03	0.32	154.75	0.58	0.07	212.98	0.14	60.63	32.47	16.17	0.46	3.11
	90	9.86	0.32	154.84	0.58	0.07	210.62	0.13	60.68	32.49	16.19	0.46	3.11

SGS Metcon

TEST No. CL-04

METALLURGICAL RESULTS

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**		
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14	
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height	
SAMPLE	**Composite 2 (Met-11/17)**	**CRUSH SIZE**	P100 minus 3 in.	
		LEACH SOLUTION	750 ppm fr g/l	
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	2.55	kg CaO/t of ore
		CURE CYCLE	0	Days
		FLOWRATE	9.78	lph/m^2

Time		**Feed Solution Flow Rate**	**Cumulative**										
			Extraction (g/t)			**Solution Grade (ppm)**			**Extraction (%)**			**Consumption**	
(Days)		**(lph/sq m)**	**Au**	**Cu**	**Ag**	**Au**	**Cu**	**Ag**	**Au**	**Cu**	**Ag**	**NaCN (kg/t)**	**CaO (kg/t)**
Wash	91	9.83	0.32	154.94	0.58	0.07	208.31	0.13	60.72	32.51	16.22	0.46	3.11
	92	9.73	0.32	155.04	0.58	0.07	206.06	0.13	60.77	32.53	16.25	0.45	3.11
	93	9.73	0.32	155.13	0.58	0.07	203.87	0.13	60.81	32.55	16.28	0.45	3.11
	94	9.79	0.32	155.23	0.58	0.07	201.70	0.13	60.86	32.57	16.30	0.45	3.11
	95	9.89	0.32	155.33	0.58	0.07	199.56	0.13	60.91	32.59	16.33	0.45	3.11
	96	9.82	0.32	155.62	0.58	0.07	197.52	0.13	60.95	32.65	16.34	0.45	3.11
	97	9.87	0.32	155.91	0.58	0.07	195.52	0.13	61.00	32.71	16.36	0.45	3.11
	98	9.78	0.32	156.20	0.58	0.07	193.57	0.12	61.05	32.77	16.37	0.45	3.11
	99	9.83	0.32	156.49	0.58	0.07	191.66	0.12	61.09	32.84	16.38	0.45	3.11
	100	9.89	0.32	156.78	0.58	0.07	189.78	0.12	61.14	32.90	16.40	0.45	3.11
	101	9.85	0.32	157.07	0.58	0.07	187.94	0.12	61.18	32.96	16.41	0.45	3.11
	102	9.91	0.32	157.36	0.59	0.07	186.12	0.12	61.23	33.02	16.43	0.45	3.11
	103	9.97	0.32	157.65	0.59	0.06	184.35	0.12	61.28	33.08	16.44	0.45	3.11
	104	9.87	0.32	157.94	0.59	0.06	182.63	0.12	61.32	33.14	16.45	0.45	3.11
	105	9.83	0.32	158.23	0.59	0.06	180.93	0.12	61.37	33.20	16.47	0.45	3.11
	106	9.97	0.32	158.53	0.59	0.06	179.25	0.12	61.42	33.26	16.48	0.45	3.11
	107	9.78	0.32	158.82	0.59	0.06	177.62	0.11	61.46	33.32	16.49	0.45	3.11
	108	9.96	0.32	159.11	0.59	0.06	176.00	0.11	61.51	33.39	16.51	0.45	3.11
	109	10.00	0.32	159.40	0.59	0.06	174.40	0.11	61.56	33.45	16.52	0.45	3.11
	110	9.82	0.32	159.43	0.59	0.06	172.81	0.11	61.60	33.45	16.53	0.45	3.11
	111	9.88	0.32	159.45	0.59	0.06	171.25	0.11	61.65	33.46	16.53	0.45	3.11
	112	10.08	0.32	159.48	0.59	0.06	169.69	0.11	61.70	33.46	16.54	0.44	3.11
	113	9.82	0.32	159.50	0.59	0.06	168.19	0.11	61.74	33.47	16.55	0.44	3.11
	114	9.97	0.32	159.53	0.59	0.06	166.71	0.11	61.79	33.47	16.55	0.44	3.10
	115	10.03	0.32	159.55	0.59	0.06	165.24	0.11	61.83	33.48	16.56	0.44	3.10
	116	9.96	0.32	159.58	0.59	0.06	163.78	0.11	61.88	33.48	16.57	0.44	3.10
	117	10.01	0.32	159.60	0.59	0.06	162.37	0.11	61.93	33.49	16.58	0.44	3.10
	118	5.70	0.32	159.61	0.59	0.06	161.59	0.10	61.95	33.49	16.58	0.44	3.10
	119	8.81	0.32	159.63	0.59	0.06	160.45	0.10	61.99	33.50	16.58	0.44	3.10
	120	9.14	0.32	159.65	0.59	0.06	159.24	0.10	62.03	33.50	16.59	0.44	3.10

SGS Metcon

TEST No. CL-04

METALLURGICAL RESULTS

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**		
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14	
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height	
SAMPLE	**Composite 2 (Met-11/17)**	**CRUSH SIZE**	P100 minus 3 in.	
		LEACH SOLUTION	750 ppm fr g/l	
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	2.55	kg CaO/t of ore
		CURE CYCLE	0	Days
		FLOWRATE	9.78	lph/m^2

Time		**Feed Solution Flow Rate**	**Cumulative**										
			Extraction (g/t)			**Solution Grade (ppm)**			**Extraction (%)**			**Consumption**	
(Days)		**(lph/sq m)**	**Au**	**Cu**	**Ag**	**Au**	**Cu**	**Ag**	**Au**	**Cu**	**Ag**	**NaCN (kg/t)**	**CaO (kg/t)**
Wash	121	9.31	0.32	159.68	0.59	0.06	158.00	0.10	62.08	33.50	16.60	0.44	3.10
	122	9.27	0.33	159.70	0.59	0.06	156.78	0.10	62.12	33.51	16.60	0.44	3.10
	123	9.65	0.33	159.72	0.59	0.06	155.52	0.10	62.17	33.51	16.61	0.44	3.10
	124	9.64	0.33	159.75	0.59	0.06	154.28	0.10	62.21	33.52	16.62	0.44	3.10
	125	9.71	0.33	159.77	0.59	0.05	153.06	0.10	62.26	33.52	16.62	0.44	3.10
	126	9.87	0.33	159.79	0.59	0.05	151.84	0.10	62.30	33.53	16.63	0.44	3.10
Drain	127	0.00	0.33	159.80	0.59	0.05	151.58	0.10	62.31	33.53	16.63	0.44	3.10
Drain	128	0.00	0.33	159.80	0.59	0.05	151.55	0.10	62.31	33.53	16.63	0.44	3.10
Drain	129	0.00	0.33	159.80	0.59	0.05	151.51	0.10	62.31	33.53	16.63	0.44	3.10

APPENDIX 8

Column Leach Test CL-05 on Composite 3

Summary of Results | **SGS Metcon** | Current Date: 09/26/14

SGS Metcon Project No.: M-709-03

Western Copper & Gold Corp. Casino Project

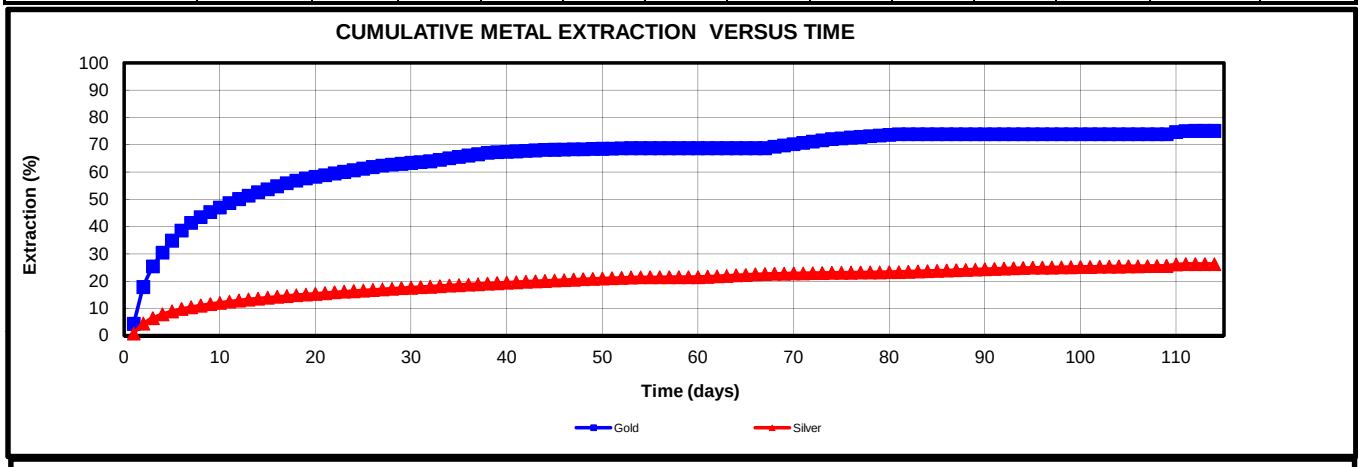
TEST No.: CL-05 | Crush Size: P100 minus 3 in.

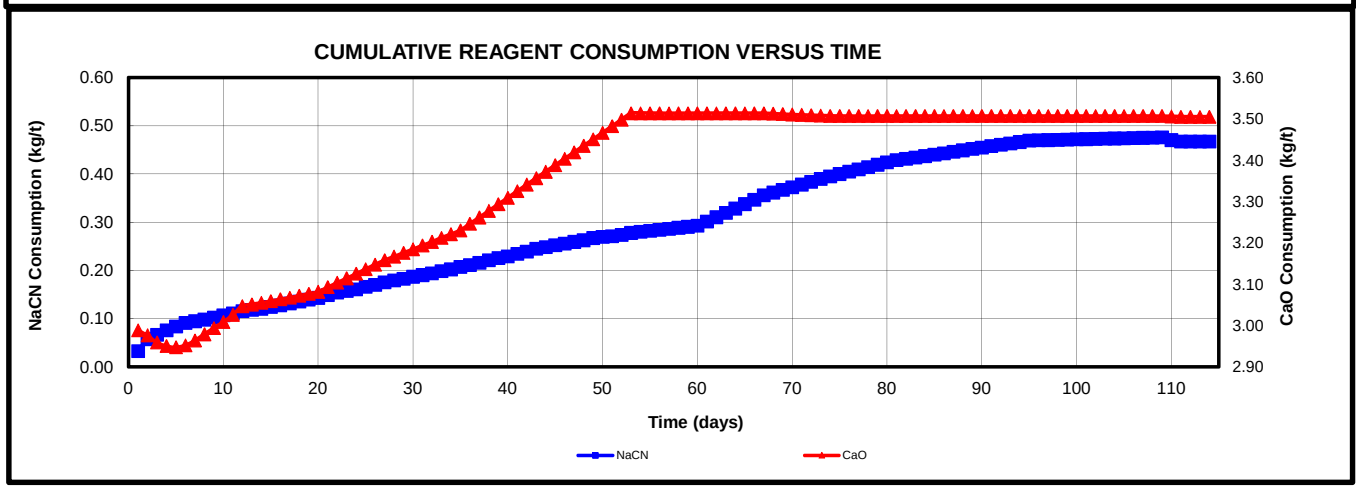
SAMPLE : Composite 3 (Met-19/20) | Lime Addition: 2.98 kg Lime/tonne of ore

Objective: Gold and Silver Extraction vs Time

Cure Days:	0
Leach Days:	109
Rest Days:	0
Wash Days:	2
Drain Days:	3
Total Cycle Days:	114

PRODUCTS	Volume	Weight	Cumulative										
			Assay (g/t)			Contents (mg)			Indicated Extraction			Consumption	
												NaCN	CaO
	(liters)	(kg)	Au	Cu	Ag	Au	Cu	Ag	Au	Cu	Ag	(kg/t)	(kg/t)
Feed Solution	475.84		0.03	279	0.14	14.80	132789	68.73	75.09	-9.61	26.29	0.47	3.51
Pregnant Solution	469.28		0.11	272	0.34	53.73	127737	157.63					
Leach Residue		88.90	0.15	648	2.80	12.92	57621	249.27					
CALCULATIONS													
Metal Extracted			0.44	-56.83	1.00	38.93	-5052	88.89					
Calculated Head			0.58	591.32	3.80	51.85	52569	338.16					
Assay Head		88.90	0.63	72.95	2.76	55.79	6485	245.81					

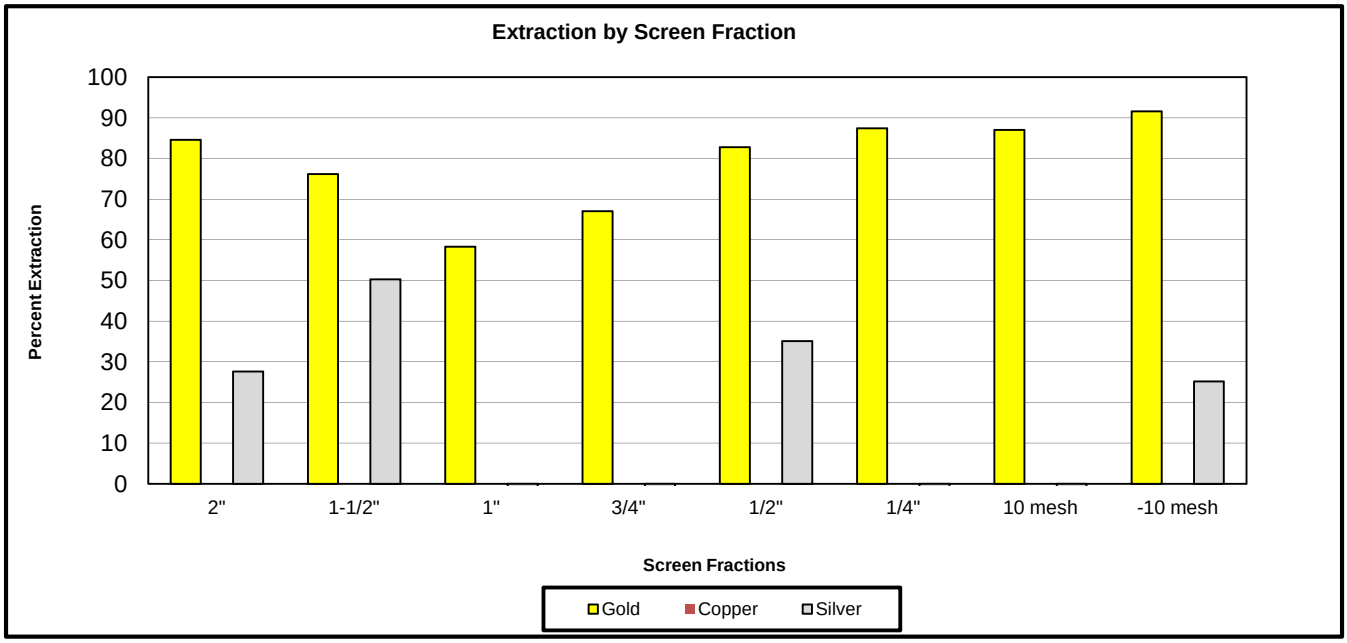




SGS Metcon

Test: CL-05
Sample: Composite 3 (Met-19/20)
Casino Project

Western Copper & Gold Corp.
SGS Metcon Project No.: M-709-03



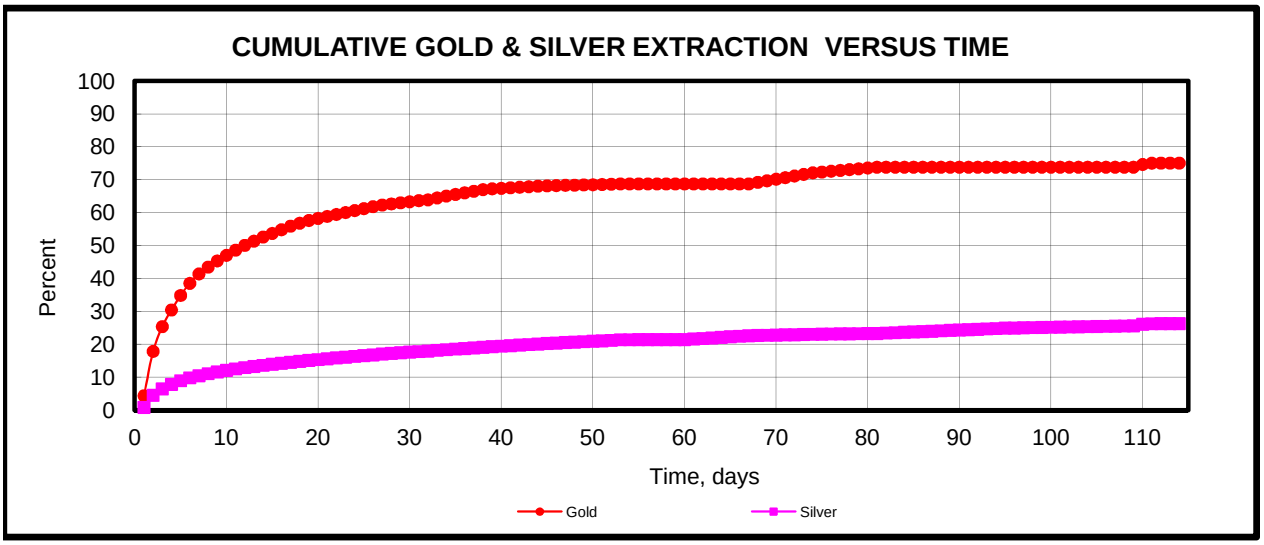
Test No. : CL-05

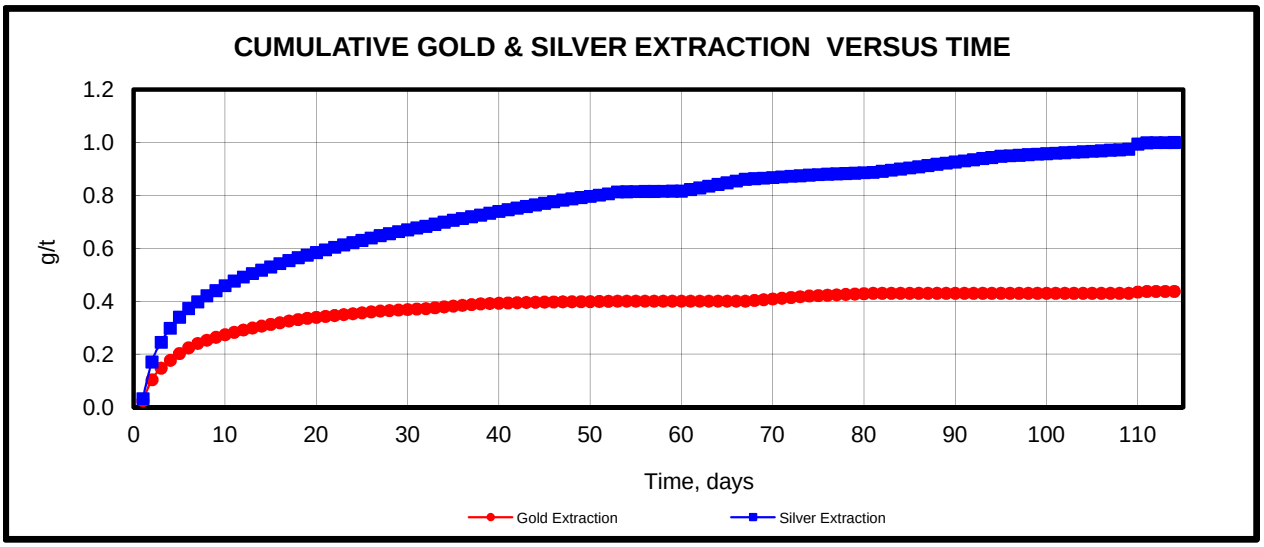
Screen Fraction	Head				Leach Residue				Percent Extraction			Degradation Index
	Weight	Assays (g/t)			Weight	Assays (g/t)						
	(kg)	Au	Cu	Ag	(kg)	Au	Cu	Ag	Au	Cu	Ag	(%)
2"	6.32	0.570	88	2.50	3.46	0.16	660	3.30	84.61	-	27.64	45.18
1-1/2"	21.58	0.490	74	2.60	9.00	0.28	680	3.10	76.17	-	50.27	58.29
1"	20.96	0.590	68	2.20	32.22	0.16	640	2.70	58.32	-	-88.64	-53.71
3/4"	9.84	0.570	69	2.50	9.72	0.19	570	3.00	67.09	-	-18.48	1.27
1/2"	9.04	0.560	56	3.30	9.68	0.09	670	2.00	82.79	-	35.11	-7.07
1/4"	8.18	0.630	70	2.50	9.25	0.07	530	3.00	87.43	-	-35.71	-13.09
10 mesh	6.80	0.620	69	2.60	7.82	0.07	610	2.60	87.01	-	-15.03	-15.03
-10 mesh	6.18	1.490	110	5.70	7.75	0.10	890	3.40	91.58	-	25.19	-25.41
Total	88.90	0.63	73	2.76	88.90	0.15	648	2.80	76.85		-1.41	

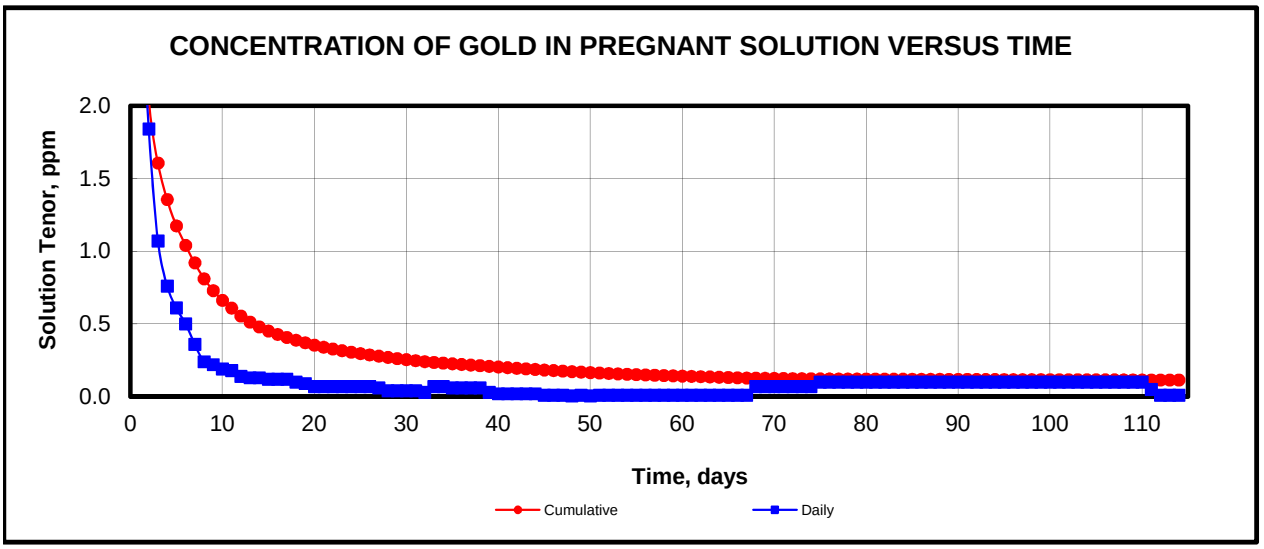
SGS Metcon

Test: CL-05 — Western Copper & Gold Corp.

Sample: Composite 3 (Met-19/20) — SGS Metcon Project No.: M-709-03



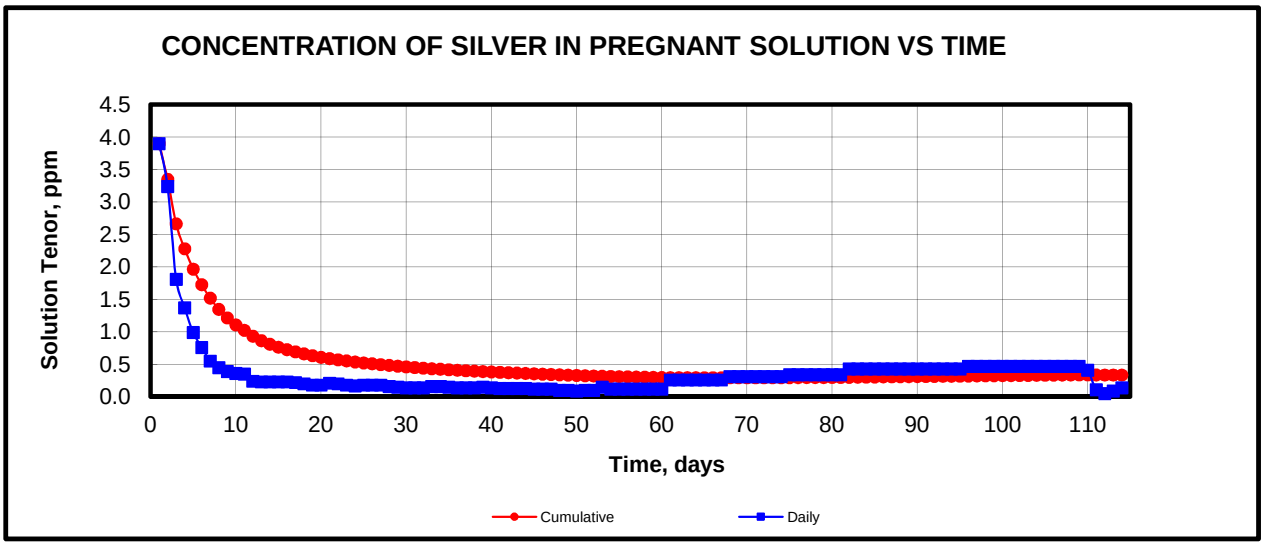


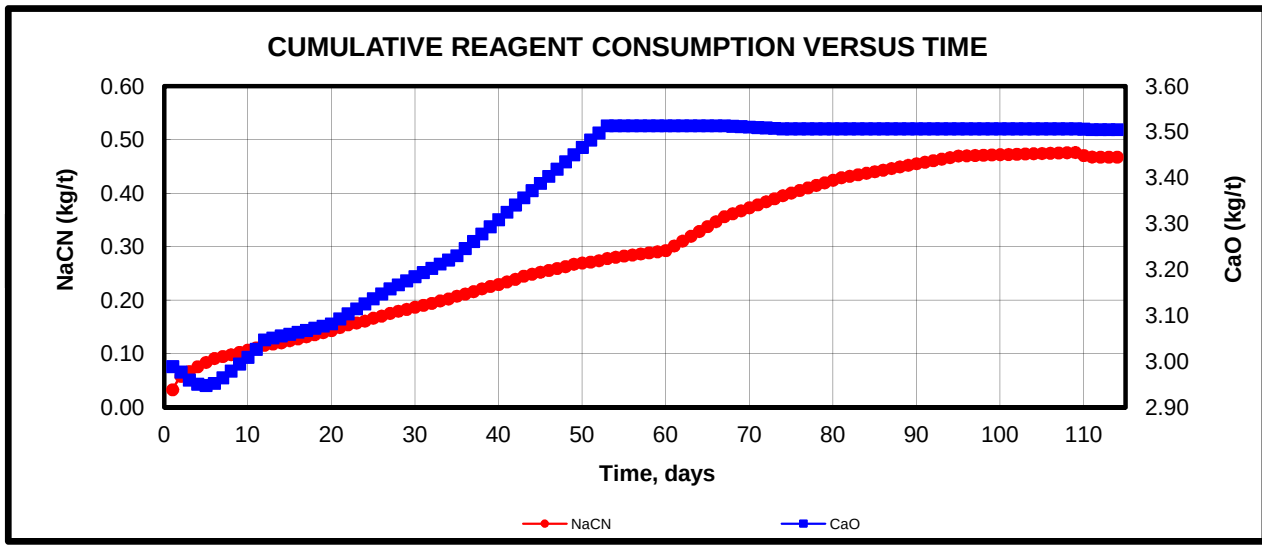


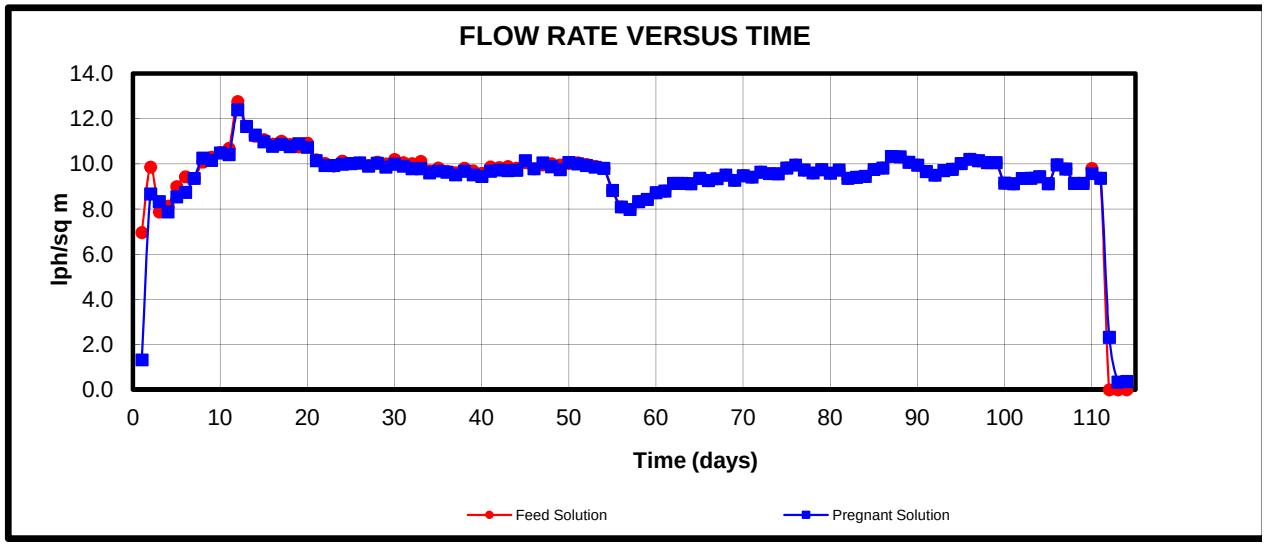
SGS Metcon

Test: CL-05 — Western Copper & Gold Corp.

Sample: Composite 3 (Met-19/20) — SGS Metcon Project No.: M-709-03



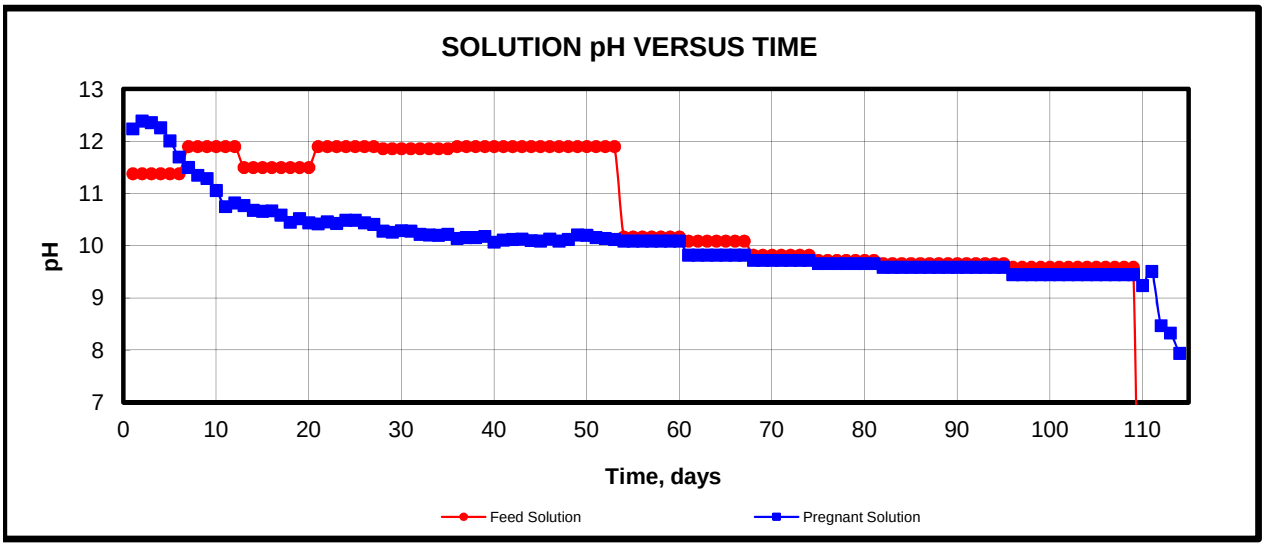


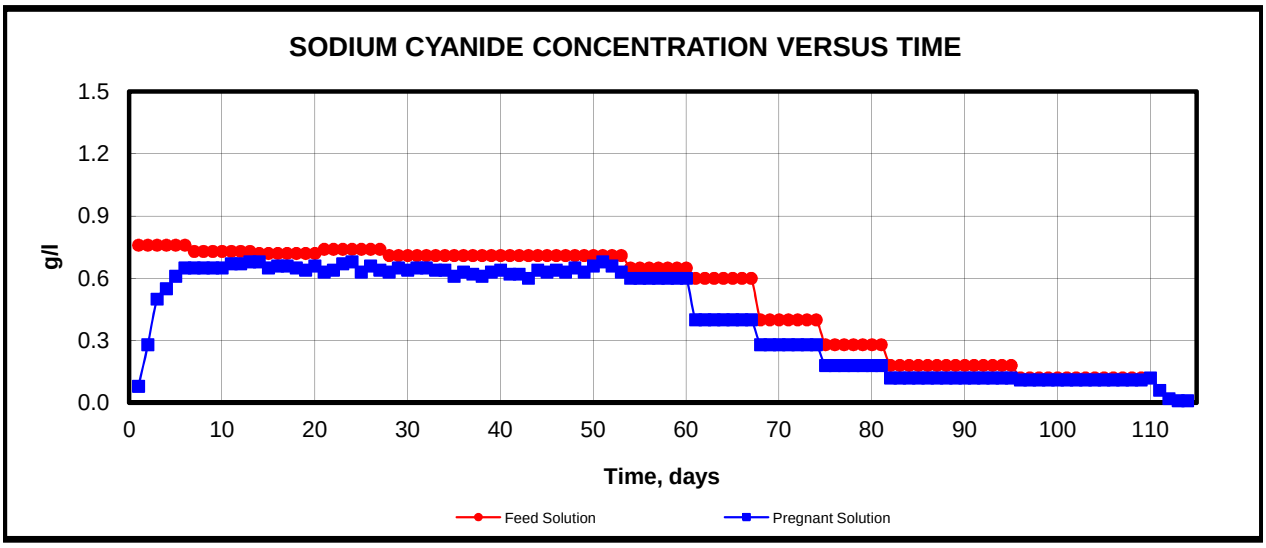


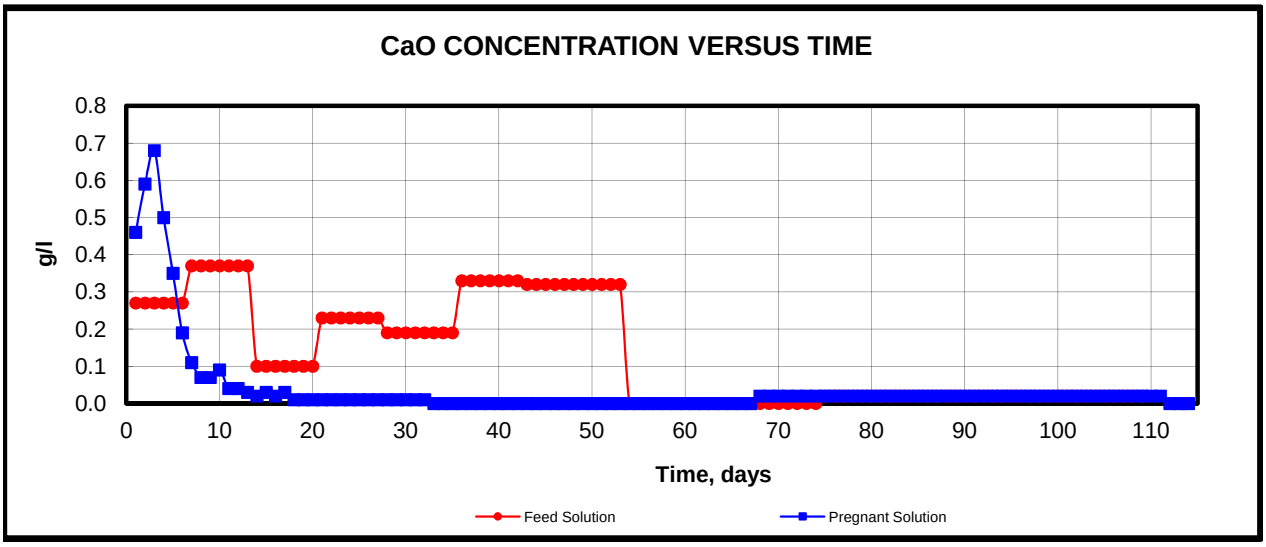
SGS Metcon

Test: CL-05 — Western Copper & Gold Corp.

Sample: Composite 3 (Met-19/20) — SGS Metcon Project No.: M-709-03







SGS Metcon

TEST No. CL-05

PHYSICAL CHARACTERISTICS SHEET

CLIENT	Western Copper & Gold Corp. SGS Metcon Project No.: M-709-03	**TEST CONDITIONS**	
		TEST START	05/01/14
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height
SAMPLE	Composite 3 (Met-19/20)	**CRUSH SIZE**	P100 minus 3 in.
		LEACH SOLUTION	750 ppm free NaCN, 300 ppm Cu
OBJECTIVE	Gold and Silver Extraction vs Time	**Lime Addition**	2.98 kg CaO/tonne of Ore
		CURE CYCLE	0 days
		FLOWRATE	9.78 lph/m2

FLOWRATE (lph/sq m)		9.78			
CURE STAGE (days)		0			
COLUMN DIAMETER (mm)		152.40			
ELEMENTS ANALYZED	Au	CNs Au	Ag	CNs Ag	Cu
HEAD ASSAYS (g per tonne)	0.63		2.76		72.95
LEACH RESIDUE ASSAYS (g per tonne)	0.15		2.80		648.16
SAMPLE PERCENT MOISTURE AS RECEIVED (Dry Basis)		0.00			
SAMPLE WEIGHT BEFORE AGGLOMERATION (kg)		88.90			
AGGLOMERATED SAMPLE WEIGHT (kg)		90.86			
INITIAL SAMPLE PERCENT MOISTURE (including agglomeration water)		2.20	(Dry Basis)		
INITIAL SAMPLE DRY WEIGHT (kg)		88.90			
INITIAL SAMPLE HEIGHT (m)		3.15			
INITIAL SAMPLE BULK DENSITY (kg/cu m)		1545	(Dry Basis)		
FINAL SAMPLE HEIGHT (m)		3.10			
RESIDUE WET WEIGHT (kg)		92.82			
RESIDUE DRY WEIGHT (kg)		88.90			
VOLUME DRAINED (l)		1.33			
SUBSIDENCE (%)		1.65			
MOISTURE UNDER LEACH (%)		5.91	(Dry Basis)		
MOISTURE RETAINED (%)		4.41	(Dry Basis)		
FINAL SAMPLE BULK DENSITY (kg/cu m)		1571	(Dry Basis)		

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7701 BUSINESS PARK DRIVE
TUCSON , ARIZONA 85743

SCREEN ANALYSIS RESULTS
Western Copper & Gold Corp.
SGS Metcon Project No.: M-709-03
Casino Project

SCREEN ANALYSIS			Sample: **Column Leach Head** **CL-05** **Composite 3 (Met-19/20)** **Crush Size: P100 minus 3 in.**											
NOMINAL OPENINGS		Tyler	Sample	Weight	Cumulative Weight	Gold			Copper			Silver		
mm	Inches	Mesh	Weights (kg)	Distribution (%)	Retained (%)	Assay (gpt)	Content	Distribution (%)	Assay (gpt)	Content	Distribution (%)	Assay (gpt)	Content	Distribution (%)
50.80	2.000	2"	6.32	7.11	7.11	0.57	0.041	6.46	88	6.256	8.58	2.50	0.18	6.43
38.10	1.500	1-1/2"	21.58	24.27	31.38	0.49	0.119	18.95	74	17.963	24.62	2.60	0.63	22.83
25.40	1.000	1"	20.96	23.58	54.96	0.59	0.139	22.17	68	16.032	21.98	2.20	0.52	18.76
19.05	0.750	3/4"	9.84	11.07	66.03	0.57	0.063	10.05	69	7.637	10.47	2.50	0.28	10.01
12.70	0.500	1/2"	9.04	10.17	76.20	0.56	0.057	9.07	56	5.694	7.81	3.30	0.34	12.14
6.35	0.250	1/4"	8.18	9.20	85.40	0.63	0.058	9.24	70	6.441	8.83	2.50	0.23	8.32
1.70	0.065	10	6.80	7.65	93.05	0.62	0.047	7.56	69	5.278	7.23	2.60	0.20	7.19
MINUS		10	6.18	6.95	100.00	1.49	0.104	16.50	110	7.647	10.48	5.70	0.40	14.33
TOTALS			88.90	100.00				100.00			100.00			100.00
CALCULATED ASSAY						0.63			73			2.76		
COMPOSITE ASSAY (Pulv.)						0.77			78			2.70		

SCREEN ANALYSIS			Sample: **Column Leach Residue** **CL-05** **Composite 3 (Met-19/20)**											
NOMINAL OPENINGS		Tyler	Sample	Weight	Cumulative Weight	Gold			Copper			Silver		
mm	Inches	Mesh	Weights (kg)	Distribution (%)	Retained (%)	Assay (gpt)	Content	Distribution (%)	Assay (gpt)	Content	Distribution (%)	Assay (gpt)	Content	Distribution (%)
50.80	2.000	2"	1.94	3.90	3.90	0.16	0.006	4.29	660	25.721	3.97	3.30	0.13	4.59
38.10	1.500	1-1/2"	5.04	10.12	14.02	0.28	0.028	19.51	680	68.847	10.62	3.10	0.31	11.19
25.40	1.000	1"	18.04	36.24	50.26	0.16	0.058	39.91	640	231.933	35.78	2.70	0.98	34.90
19.05	0.750	3/4"	5.44	10.93	61.19	0.19	0.021	14.29	570	62.290	9.61	3.00	0.33	11.69
12.70	0.500	1/2"	5.42	10.89	72.08	0.09	0.010	6.74	670	72.949	11.25	2.00	0.22	7.77
6.35	0.250	1/4"	5.18	10.41	82.48	0.07	0.007	5.01	530	55.151	8.51	3.00	0.31	11.13
1.70	0.065	10	4.38	8.80	91.28	0.07	0.006	4.24	610	53.672	8.28	2.60	0.23	8.16
MINUS		10	4.34	8.72	100.00	0.1	0.009	6.00	890	77.593	11.97	3.40	0.30	10.57
TOTALS			49.78	100.00				100.00			100.00			100.00
CALCULATED ASSAY						0.15			648			2.80		
COMPOSITE ASSAY (Pulv.)						0.16			670			2.90		

SGS Metcon

TEST No. CL-05

Data Sheet

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**	
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height
SAMPLE	**Composite 3 (Met-19/20)**	**CRUSH SIZE**	P100 minus 3 in.
		LEACH SOLUTION	750 ppm free l g/l
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	2.98 kg CaO/tonne of ore
		CURE CYCLE	0 Days
		FLOWRATE	9.78 lph/m^2

		Pregnant Leach Solution							**Feed Solution**							
			Free			Assays (ppm)				Free			NaCN	Assays (ppm)		
Time (Days)		Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Au	Cu	Ag	Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Add/Rem. (grams)	Au	Cu	Ag
Leach	1	0.75	0.08	0.46	12.24	3.03	172.00	3.90	3.94	0.76	0.27	11.38		0.00	272.00	0.00
	2	3.80	0.28	0.59	12.39	1.84	269.00	3.24	4.32	0.76	0.27	11.38		0.00	272.00	0.00
	3	3.65	0.50	0.68	12.36	1.07	315.00	1.81	3.45	0.76	0.27	11.38		0.00	272.00	0.00
	4	3.45	0.55	0.50	12.26	0.76	330.00	1.37	3.56	0.76	0.27	11.38		0.00	272.00	0.00
	5	3.75	0.61	0.35	12.01	0.61	332.00	0.99	3.95	0.76	0.27	11.38		0.00	272.00	0.00
	6	3.82	0.65	0.19	11.70	0.50	325.00	0.76	4.12	0.76	0.27	11.38		0.00	272.00	0.00
	7	4.10	0.65	0.11	11.50	0.36	313.00	0.55	4.10	0.73	0.37	11.90		0.00	241.00	0.00
	8	4.50	0.65	0.07	11.35	0.24	306.00	0.45	4.42	0.73	0.37	11.90		0.00	241.00	0.00
	9	4.44	0.65	0.07	11.29	0.22	311.00	0.39	4.50	0.73	0.37	11.90		0.00	241.00	0.00
	10	4.59	0.65	0.09	11.06	0.19	315.00	0.36	4.60	0.73	0.37	11.90		0.00	241.00	0.00
	11	4.56	0.67	0.04	10.75	0.18	317.00	0.35	4.68	0.73	0.37	11.90		0.00	241.00	0.00
	12	5.44	0.67	0.04	10.82	0.14	317.00	0.24	5.60	0.73	0.37	11.90		0.00	241.00	0.00
	13	5.10	0.68	0.03	10.77	0.13	321.00	0.23	5.10	0.72	0.10	11.50		0.00	303.00	0.00
	14	4.94	0.68	0.02	10.68	0.13	322.00	0.23	4.92	0.72	0.10	11.50		0.00	303.00	0.00
	15	4.80	0.65	0.03	10.66	0.12	320.00	0.23	4.84	0.72	0.10	11.50		0.00	303.00	0.00
	16	4.72	0.66	0.02	10.67	0.12	313.00	0.23	4.76	0.72	0.10	11.50		0.00	303.00	0.00
	17	4.76	0.66	0.03	10.59	0.12	309.00	0.22	4.82	0.72	0.10	11.50		0.00	303.00	0.00
	18	4.72	0.65	0.01	10.45	0.10	309.00	0.20	4.76	0.72	0.10	11.50		0.00	303.00	0.00
	19	4.76	0.64	0.01	10.52	0.09	305.00	0.18	4.70	0.72	0.10	11.50		0.00	303.00	0.00
	20	4.70	0.66	0.01	10.44	0.07	306.00	0.18	4.78	0.72	0.10	11.50		0.00	303.00	0.00
	21	4.44	0.63	0.01	10.42	0.07	315.00	0.21	4.46	0.74	0.23	11.90		0.00	303.00	0.00
	22	4.36	0.64	0.01	10.46	0.07	319.00	0.20	4.40	0.74	0.23	11.90		0.00	303.00	0.00
	23	4.35	0.67	0.01	10.43	0.07	316.00	0.18	4.34	0.74	0.23	11.90		0.00	303.00	0.00
	24	4.36	0.68	0.01	10.49	0.07	318.00	0.17	4.42	0.74	0.23	11.90		0.00	303.00	0.00
	25	4.40	0.63	0.01	10.49	0.07	320.00	0.18	4.40	0.74	0.23	11.90		0.00	303.00	0.00
	26	4.40	0.66	0.01	10.44	0.07	308.00	0.18	4.40	0.74	0.23	11.90		0.00	303.00	0.00
	27	4.35	0.64	0.01	10.41	0.06	305.00	0.18	4.36	0.74	0.23	11.90		0.00	303.00	0.00
	28	4.38	0.63	0.01	10.28	0.04	299.00	0.16	4.40	0.71	0.19	11.86		0.00	310.00	0.00
	29	4.32	0.65	0.01	10.26	0.04	303.00	0.15	4.38	0.71	0.19	11.86		0.00	310.00	0.00
	30	4.36	0.64	0.01	10.29	0.04	305.00	0.14	4.45	0.71	0.19	11.86		0.00	310.00	0.00

SGS Metcon

TEST No. CL-05

Data Sheet

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**	
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height
SAMPLE	**Composite 3 (Met-19/20)**	**CRUSH SIZE**	P100 minus 3 in.
		LEACH SOLUTION	750 ppm free l g/l
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	2.98 kg CaO/tonne of ore
		CURE CYCLE	0 Days
		FLOWRATE	9.78 lph/m^2

		Pregnant Leach Solution							**Feed Solution**							
			Free			Assays (ppm)				Free			NaCN	Assays (ppm)		
Time (Days)		Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Au	Cu	Ag	Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Add/Rem. (grams)	Au	Cu	Ag
Leach	31	4.33	0.65	0.01	10.28	0.04	304.00	0.14	4.40	0.71	0.19	11.86		0.00	310.00	0.00
	32	4.30	0.65	0.01	10.22	0.03	306.00	0.14	4.40	0.71	0.19	11.86		0.00	310.00	0.00
	33	4.28	0.64	0.00	10.21	0.07	321.00	0.16	4.42	0.71	0.19	11.86		0.00	310.00	0.00
	34	4.20	0.64	0.00	10.20	0.07	322.00	0.16	4.24	0.71	0.19	11.86		0.00	310.00	0.00
	35	4.24	0.61	0.00	10.22	0.06	326.00	0.15	4.30	0.71	0.19	11.86		0.00	310.00	0.00
	36	4.24	0.63	0.00	10.14	0.06	322.00	0.14	4.26	0.71	0.33	11.90		0.00	303.00	0.00
	37	4.10	0.62	0.00	10.16	0.06	322.00	0.14	4.14	0.71	0.33	11.90		0.00	303.00	0.00
	38	4.28	0.61	0.00	10.16	0.06	320.00	0.14	4.34	0.71	0.33	11.90		0.00	303.00	0.00
	39	4.20	0.63	0.00	10.18	0.03	307.00	0.15	4.28	0.71	0.33	11.90		0.00	303.00	0.00
	40	4.10	0.64	0.00	10.07	0.02	303.00	0.14	4.16	0.71	0.33	11.90		0.00	303.00	0.00
	41	4.26	0.62	0.00	10.11	0.02	312.00	0.13	4.34	0.71	0.33	11.90		0.00	303.00	0.00
	42	4.25	0.62	0.00	10.12	0.02	310.00	0.13	4.30	0.71	0.33	11.90		0.00	303.00	0.00
	43	4.24	0.60	0.00	10.13	0.02	314.00	0.13	4.32	0.71	0.32	11.90		0.00	290.00	0.00
	44	4.26	0.64	0.00	10.10	0.02	314.00	0.13	4.30	0.71	0.32	11.90		0.00	290.00	0.00
	45	4.44	0.63	0.00	10.09	0.01	314.00	0.12	4.40	0.71	0.32	11.90		0.00	290.00	0.00
	46	4.28	0.64	0.00	10.13	0.01	312.00	0.12	4.28	0.71	0.32	11.90		0.00	290.00	0.00
	47	4.40	0.63	0.00	10.09	0.01	312.00	0.12	4.36	0.71	0.32	11.90		0.00	290.00	0.00
	48	4.34	0.65	0.00	10.12	0.01	312.00	0.10	4.40	0.71	0.32	11.90		0.00	290.00	0.00
	49	4.25	0.63	0.00	10.21	0.01	310.00	0.10	4.34	0.71	0.32	11.90		0.00	290.00	0.00
	50	4.42	0.66	0.00	10.20	0.01	306.00	0.09	4.40	0.71	0.32	11.90		0.00	290.00	0.00
	51	4.38	0.68	0.00	10.16	0.01	310.00	0.10	4.40	0.71	0.32	11.90		0.00	290.00	0.00
	52	4.34	0.66	0.00	10.14	0.01	303.00	0.10	4.36	0.71	0.32	11.90		0.00	290.00	0.00
	53	4.32	0.63	0.00	10.12	0.01	308.00	0.15	4.34	0.71	0.32	11.90		0.00	290.00	0.00
Wash	54	4.30	0.60	0.00	10.09	0.01	309.00	0.12	4.30	0.65	0.00	10.17		0.01	307.00	0.11
	55	3.85	0.60	0.00	10.09	0.01	309.00	0.12	3.85	0.65	0.00	10.17		0.01	307.00	0.11
	56	3.55	0.60	0.00	10.09	0.01	309.00	0.12	3.55	0.65	0.00	10.17		0.01	307.00	0.11
	57	3.50	0.60	0.00	10.09	0.01	309.00	0.12	3.50	0.65	0.00	10.17		0.01	307.00	0.11
	58	3.65	0.60	0.00	10.09	0.01	309.00	0.12	3.65	0.65	0.00	10.17		0.01	307.00	0.11
	59	3.68	0.60	0.00	10.09	0.01	309.00	0.12	3.68	0.65	0.00	10.17		0.01	307.00	0.11
	60	3.82	0.60	0.00	10.09	0.01	309.00	0.12	3.82	0.65	0.00	10.17		0.01	307.00	0.11

SGS Metcon

TEST No. CL-05

Data Sheet

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**	
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height
SAMPLE	**Composite 3 (Met-19/20)**	**CRUSH SIZE**	P100 minus 3 in.
		LEACH SOLUTION	750 ppm free l g/l
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	2.98 kg CaO/tonne of ore
		CURE CYCLE	0 Days
		FLOWRATE	9.78 lph/m^2

	Pregnant Leach Solution							**Feed Solution**							
		Free			Assays (ppm)				Free			NaCN	Assays (ppm)		
Time (Days)	Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Au	Cu	Ag	Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Add/Rem. (grams)	Au	Cu	Ag
Wash 61	3.86	0.40	0.00	9.82	0.01	312.00	0.26	3.86	0.60	0.00	10.09		0.01	309.00	0.12
62	4.00	0.40	0.00	9.82	0.01	312.00	0.26	4.00	0.60	0.00	10.09		0.01	309.00	0.12
63	4.00	0.40	0.00	9.82	0.01	312.00	0.26	4.00	0.60	0.00	10.09		0.01	309.00	0.12
64	4.00	0.40	0.00	9.82	0.01	312.00	0.26	4.00	0.60	0.00	10.09		0.01	309.00	0.12
65	4.11	0.40	0.00	9.82	0.01	312.00	0.26	4.11	0.60	0.00	10.09		0.01	309.00	0.12
66	4.05	0.40	0.00	9.82	0.01	312.00	0.26	4.05	0.60	0.00	10.09		0.01	309.00	0.12
67	4.10	0.40	0.00	9.82	0.01	312.00	0.26	4.10	0.60	0.00	10.09		0.01	309.00	0.12
68	4.16	0.28	0.02	9.72	0.07	320.00	0.31	4.16	0.40	0.00	9.82		0.01	312.00	0.26
69	4.06	0.28	0.02	9.72	0.07	320.00	0.31	4.06	0.40	0.00	9.82		0.01	312.00	0.26
70	4.16	0.28	0.02	9.72	0.07	320.00	0.31	4.16	0.40	0.00	9.82		0.01	312.00	0.26
71	4.10	0.28	0.02	9.72	0.07	320.00	0.31	4.10	0.40	0.00	9.82		0.01	312.00	0.26
72	4.22	0.28	0.02	9.72	0.07	320.00	0.31	4.22	0.40	0.00	9.82		0.01	312.00	0.26
73	4.20	0.28	0.02	9.72	0.07	320.00	0.31	4.20	0.40	0.00	9.82		0.01	312.00	0.26
74	4.20	0.28	0.02	9.72	0.07	320.00	0.31	4.20	0.40	0.00	9.82		0.01	312.00	0.26
75	4.28	0.18	0.02	9.66	0.10	241.00	0.34	4.28	0.28	0.02	9.72		0.07	320.00	0.31
76	4.37	0.18	0.02	9.66	0.10	241.00	0.34	4.37	0.28	0.02	9.72		0.07	320.00	0.31
77	4.26	0.18	0.02	9.66	0.10	241.00	0.34	4.26	0.28	0.02	9.72		0.07	320.00	0.31
78	4.20	0.18	0.02	9.66	0.10	241.00	0.34	4.20	0.28	0.02	9.72		0.07	320.00	0.31
79	4.27	0.18	0.02	9.66	0.10	241.00	0.34	4.27	0.28	0.02	9.72		0.07	320.00	0.31
80	4.20	0.18	0.02	9.66	0.10	241.00	0.34	4.20	0.28	0.02	9.72		0.07	320.00	0.31
81	4.26	0.18	0.02	9.66	0.10	241.00	0.34	4.26	0.28	0.02	9.72		0.07	320.00	0.31
82	4.10	0.12	0.02	9.59	0.10	256.00	0.43	4.10	0.18	0.02	9.66		0.10	241.00	0.34
83	4.12	0.12	0.02	9.59	0.10	256.00	0.43	4.12	0.18	0.02	9.66		0.10	241.00	0.34
84	4.14	0.12	0.02	9.59	0.10	256.00	0.43	4.14	0.18	0.02	9.66		0.10	241.00	0.34
85	4.28	0.12	0.02	9.59	0.10	256.00	0.43	4.28	0.18	0.02	9.66		0.10	241.00	0.34
86	4.29	0.12	0.02	9.59	0.10	256.00	0.43	4.29	0.18	0.02	9.66		0.10	241.00	0.34
87	4.52	0.12	0.02	9.59	0.10	256.00	0.43	4.52	0.18	0.02	9.66		0.10	241.00	0.34
88	4.52	0.12	0.02	9.59	0.10	256.00	0.43	4.52	0.18	0.02	9.66		0.10	241.00	0.34
89	4.42	0.12	0.02	9.59	0.10	256.00	0.43	4.42	0.18	0.02	9.66		0.10	241.00	0.34
90	4.35	0.12	0.02	9.59	0.10	256.00	0.43	4.35	0.18	0.02	9.66		0.10	241.00	0.34

SGS Metcon

TEST No. CL-05

Data Sheet

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**	
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height
SAMPLE	**Composite 3 (Met-19/20)**	**CRUSH SIZE**	P100 minus 3 in.
		LEACH SOLUTION	750 ppm free I g/l
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	2.98 kg CaO/tonne of ore
		CURE CYCLE	0 Days
		FLOWRATE	9.78 lph/m^2

		Pregnant Leach Solution							**Feed Solution**							
			Free			Assays (ppm)				Free			NaCN	Assays (ppm)		
Time (Days)		Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Au	Cu	Ag	Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Add/Rem. (grams)	Au	Cu	Ag
Wash	91	4.23	0.12	0.02	9.59	0.10	256.00	0.43	4.23	0.18	0.02	9.66		0.10	241.00	0.34
	92	4.16	0.12	0.02	9.59	0.10	256.00	0.43	4.16	0.18	0.02	9.66		0.10	241.00	0.34
	93	4.24	0.12	0.02	9.59	0.10	256.00	0.43	4.24	0.18	0.02	9.66		0.10	241.00	0.34
	94	4.28	0.12	0.02	9.59	0.10	256.00	0.43	4.28	0.18	0.02	9.66		0.10	241.00	0.34
	95	4.40	0.12	0.02	9.59	0.10	256.00	0.43	4.40	0.18	0.02	9.66		0.10	241.00	0.34
	96	4.47	0.11	0.02	9.45	0.10	129.00	0.47	4.47	0.12	0.02	9.59		0.10	256.00	0.43
	97	4.44	0.11	0.02	9.45	0.10	129.00	0.47	4.44	0.12	0.02	9.59		0.10	256.00	0.43
	98	4.40	0.11	0.02	9.45	0.10	129.00	0.47	4.40	0.12	0.02	9.59		0.10	256.00	0.43
	99	4.40	0.11	0.02	9.45	0.10	129.00	0.47	4.40	0.12	0.02	9.59		0.10	256.00	0.43
	100	4.00	0.11	0.02	9.45	0.10	129.00	0.47	4.00	0.12	0.02	9.59		0.10	256.00	0.43
	101	4.00	0.11	0.02	9.45	0.10	129.00	0.47	4.00	0.12	0.02	9.59		0.10	256.00	0.43
	102	4.10	0.11	0.02	9.45	0.10	129.00	0.47	4.10	0.12	0.02	9.59		0.10	256.00	0.43
	103	4.10	0.11	0.02	9.45	0.10	129.00	0.47	4.10	0.12	0.02	9.59		0.10	256.00	0.43
	104	4.13	0.11	0.02	9.45	0.10	129.00	0.47	4.13	0.12	0.02	9.59		0.10	256.00	0.43
	105	4.00	0.11	0.02	9.45	0.10	129.00	0.47	4.00	0.12	0.02	9.59		0.10	256.00	0.43
	106	4.35	0.11	0.02	9.45	0.10	129.00	0.47	4.35	0.12	0.02	9.59		0.10	256.00	0.43
	107	4.28	0.11	0.02	9.45	0.10	129.00	0.47	4.28	0.12	0.02	9.59		0.10	256.00	0.43
	108	4.00	0.11	0.02	9.45	0.10	129.00	0.47	4.00	0.12	0.02	9.59		0.10	256.00	0.43
	109	4.00	0.11	0.02	9.45	0.10	129.00	0.47	4.00	0.12	0.02	9.59		0.10	256.00	0.43
Rinse	110	4.20	0.12	0.02	9.24	0.10	63.00	0.41	4.30	0.00	0.00	0.00		0.00	0.00	0.00
Rinse	111	4.10	0.06	0.02	9.51	0.05	26.00	0.11	4.10	0.00	0.00	0.00		0.00	0.00	0.00
Drain	112	1.02	0.02	0.00	8.47	0.01	1.00	0.05	0.00	0.00	0.00	0.00		0.00	0.00	0.00
Drain	113	0.15	0.01	0.00	8.33	0.01	1.00	0.09	0.00	0.00	0.00	0.00		0.00	0.00	0.00
Drain	114	0.16	0.01	0.00	7.94	0.01	1.00	0.14	0.00	0.00	0.00	0.00		0.00	0.00	0.00

SGS Metcon

TEST No. CL-05

METALLURGICAL RESULTS

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**		
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14	
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height	
SAMPLE	**Composite 3 (Met-19/20)**	**CRUSH SIZE**	P100 minus 3 in.	
		LEACH SOLUTION	750 ppm fr g/l	
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	2.98	kg CaO/t of ore
		CURE CYCLE	0	Days
		FLOWRATE	9.78	lph/m^2

Time		Feed Solution Flow Rate	Cumulative										
			Extraction (g/t)			Solution Grade (ppm)			Extraction (%)			Consumption	
(Days)		(lph/sq m)	Au	Cu	Ag	Au	Cu	Ag	Au	Cu	Ag	NaCN (kg/t)	CaO (kg/t)
Leach	1	6.96	0.03	-10.60	0.03	3.03	172.00	3.90	4.38	-1.79	0.86	0.03	2.99
	2	9.86	0.10	-12.32	0.17	2.04	253.01	3.35	17.87	-2.08	4.51	0.06	2.98
	3	7.87	0.15	-9.95	0.25	1.61	280.60	2.66	25.40	-1.68	6.46	0.07	2.96
	4	8.13	0.18	-8.03	0.30	1.36	295.23	2.28	30.46	-1.36	7.86	0.08	2.95
	5	9.00	0.20	-6.11	0.34	1.17	304.19	1.97	34.87	-1.03	8.96	0.08	2.95
	6	9.43	0.22	-4.75	0.37	1.04	308.32	1.73	38.55	-0.80	9.81	0.09	2.95
	7	9.36	0.24	-1.43	0.40	0.92	309.14	1.52	41.40	-0.24	10.48	0.10	2.96
	8	10.08	0.25	2.07	0.42	0.81	308.64	1.35	43.48	0.35	11.08	0.10	2.98
	9	10.30	0.26	5.41	0.44	0.73	308.96	1.22	45.37	0.91	11.59	0.10	2.99
	10	10.51	0.27	9.20	0.46	0.66	309.71	1.11	47.05	1.56	12.08	0.11	3.01
	11	10.69	0.28	12.77	0.48	0.61	310.52	1.03	48.63	2.16	12.55	0.11	3.03
	12	12.76	0.29	16.99	0.49	0.55	311.27	0.93	50.10	2.87	12.94	0.12	3.05
	13	11.66	0.30	18.02	0.51	0.51	312.22	0.86	51.38	3.05	13.28	0.12	3.05
	14	11.23	0.31	19.15	0.52	0.48	313.07	0.81	52.62	3.24	13.62	0.12	3.06
	15	11.08	0.31	19.93	0.53	0.45	313.61	0.76	53.73	3.37	13.95	0.12	3.06
	16	10.88	0.32	20.32	0.54	0.43	313.57	0.73	54.82	3.44	14.27	0.13	3.06
	17	11.01	0.33	20.44	0.55	0.41	313.26	0.69	55.92	3.46	14.58	0.13	3.07
	18	10.87	0.33	20.62	0.57	0.39	313.00	0.66	56.83	3.49	14.86	0.14	3.07
	19	10.76	0.34	20.93	0.57	0.37	312.53	0.63	57.66	3.54	15.11	0.14	3.08
	20	10.92	0.34	20.82	0.58	0.35	312.17	0.61	58.29	3.52	15.36	0.14	3.08
	21	10.19	0.34	21.35	0.59	0.34	312.31	0.59	58.89	3.61	15.64	0.15	3.09
	22	10.03	0.35	22.00	0.60	0.33	312.62	0.57	59.48	3.72	15.89	0.15	3.10
	23	9.91	0.35	22.67	0.61	0.32	312.77	0.55	60.07	3.83	16.13	0.16	3.11
	24	10.12	0.35	23.20	0.62	0.31	312.99	0.54	60.66	3.92	16.35	0.16	3.13
	25	10.02	0.36	24.04	0.63	0.30	313.28	0.52	61.25	4.07	16.58	0.17	3.14
	26	10.04	0.36	24.29	0.64	0.29	313.07	0.51	61.85	4.11	16.81	0.17	3.15
	27	9.93	0.36	24.35	0.65	0.28	312.77	0.50	62.35	4.12	17.05	0.18	3.16
	28	10.08	0.37	23.74	0.66	0.27	312.26	0.48	62.69	4.02	17.25	0.18	3.17
	29	10.00	0.37	23.19	0.66	0.26	311.94	0.47	63.02	3.92	17.44	0.18	3.18
	30	10.20	0.37	22.63	0.67	0.25	311.71	0.46	63.36	3.83	17.62	0.19	3.19

SGS Metcon

TEST No. CL-05

METALLURGICAL RESULTS

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**		
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14	
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height	
SAMPLE	**Composite 3 (Met-19/20)**	**CRUSH SIZE**	P100 minus 3 in.	
		LEACH SOLUTION	750 ppm fr g/l	
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	2.98	kg CaO/t of ore
		CURE CYCLE	0	Days
		FLOWRATE	9.78	lph/m^2

Time		Feed Solution Flow Rate	Cumulative										
			Extraction (g/t)			Solution Grade (ppm)			Extraction (%)			Consumption	
(Days)		(lph/sq m)	Au	Cu	Ag	Au	Cu	Ag	Au	Cu	Ag	NaCN (kg/t)	CaO (kg/t)
Leach	31	10.06	0.37	22.10	0.68	0.25	311.46	0.45	63.69	3.74	17.80	0.19	3.19
	32	10.02	0.37	21.56	0.68	0.24	311.29	0.44	63.94	3.65	17.98	0.19	3.20
	33	10.12	0.38	21.60	0.69	0.24	311.58	0.43	64.52	3.65	18.18	0.20	3.21
	34	9.70	0.38	22.02	0.70	0.23	311.88	0.43	65.08	3.72	18.38	0.20	3.22
	35	9.82	0.38	22.58	0.71	0.23	312.28	0.42	65.57	3.82	18.57	0.21	3.23
	36	9.68	0.39	23.42	0.71	0.22	312.54	0.41	66.07	3.96	18.75	0.21	3.25
	37	9.61	0.39	24.16	0.72	0.22	312.79	0.40	66.54	4.09	18.92	0.22	3.26
	38	9.81	0.39	24.77	0.73	0.21	312.98	0.40	67.04	4.19	19.09	0.22	3.28
	39	9.70	0.39	24.69	0.73	0.21	312.83	0.39	67.28	4.17	19.28	0.23	3.29
	40	9.58	0.39	24.48	0.74	0.20	312.59	0.38	67.44	4.14	19.45	0.23	3.31
	41	9.87	0.39	24.64	0.75	0.20	312.58	0.38	67.60	4.17	19.61	0.23	3.33
	42	9.84	0.40	24.81	0.75	0.20	312.52	0.37	67.76	4.19	19.78	0.24	3.34
	43	9.89	0.40	25.69	0.76	0.19	312.55	0.37	67.93	4.34	19.94	0.25	3.36
	44	9.82	0.40	26.71	0.76	0.19	312.58	0.36	68.09	4.52	20.10	0.25	3.37
	45	10.06	0.40	28.04	0.77	0.18	312.62	0.36	68.18	4.74	20.26	0.25	3.39
	46	9.78	0.40	29.10	0.78	0.18	312.60	0.35	68.26	4.92	20.41	0.26	3.40
	47	9.96	0.40	30.32	0.78	0.18	312.59	0.35	68.35	5.13	20.57	0.26	3.42
	48	10.01	0.40	31.19	0.79	0.17	312.58	0.34	68.39	5.28	20.70	0.26	3.44
	49	9.95	0.40	31.86	0.79	0.17	312.53	0.34	68.47	5.39	20.82	0.27	3.45
	50	10.02	0.40	32.72	0.80	0.17	312.39	0.33	68.51	5.53	20.94	0.27	3.47
	51	10.05	0.40	33.64	0.80	0.16	312.34	0.33	68.60	5.69	21.07	0.27	3.48
	52	9.98	0.40	34.21	0.81	0.16	312.16	0.32	68.68	5.78	21.20	0.27	3.50
	53	9.90	0.40	35.02	0.81	0.16	312.08	0.32	68.76	5.92	21.39	0.28	3.51
Wash	54	9.81	0.40	35.11	0.81	0.15	312.03	0.31	68.76	5.94	21.40	0.28	3.51
	55	8.82	0.40	35.20	0.81	0.15	311.98	0.31	68.76	5.95	21.41	0.28	3.51
	56	8.10	0.40	35.28	0.81	0.15	311.93	0.31	68.76	5.97	21.42	0.28	3.51
	57	7.98	0.40	35.36	0.82	0.15	311.89	0.31	68.76	5.98	21.44	0.29	3.51
	58	8.34	0.40	35.44	0.82	0.15	311.85	0.30	68.76	5.99	21.45	0.29	3.51
	59	8.43	0.40	35.52	0.82	0.14	311.81	0.30	68.76	6.01	21.46	0.29	3.51
	60	8.73	0.40	35.61	0.82	0.14	311.76	0.30	68.76	6.02	21.47	0.29	3.51

SGS Metcon

TEST No. CL-05

METALLURGICAL RESULTS

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**		
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14	
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height	
SAMPLE	**Composite 3 (Met-19/20)**	**CRUSH SIZE**	P100 minus 3 in.	
		LEACH SOLUTION	750 ppm fr g/l	
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	2.98	kg CaO/t of ore
		CURE CYCLE	0	Days
		FLOWRATE	9.78	lph/m^2

Time (Days)		Feed Solution Flow Rate (lph/sq m)	Cumulative										
			Extraction (g/t)			Solution Grade (ppm)			Extraction (%)			Consumption	
			Au	Cu	Ag	Au	Cu	Ag	Au	Cu	Ag	NaCN (kg/t)	CaO (kg/t)
Wash	61	8.80	0.40	35.74	0.82	0.14	311.77	0.30	68.76	6.04	21.63	0.30	3.51
	62	9.14	0.40	35.87	0.83	0.14	311.77	0.30	68.76	6.07	21.79	0.31	3.51
	63	9.14	0.40	36.01	0.84	0.14	311.77	0.30	68.76	6.09	21.96	0.32	3.51
	64	9.13	0.40	36.14	0.84	0.13	311.78	0.30	68.76	6.11	22.12	0.33	3.51
	65	9.36	0.40	36.28	0.85	0.13	311.78	0.29	68.76	6.14	22.29	0.34	3.51
	66	9.26	0.40	36.42	0.85	0.13	311.78	0.29	68.76	6.16	22.46	0.35	3.51
	67	9.35	0.40	36.56	0.86	0.13	311.79	0.29	68.76	6.18	22.63	0.36	3.51
	68	9.51	0.40	36.93	0.86	0.13	311.91	0.29	69.25	6.25	22.69	0.36	3.51
	69	9.27	0.41	37.30	0.87	0.13	312.02	0.29	69.71	6.31	22.75	0.37	3.51
	70	9.48	0.41	37.67	0.87	0.13	312.13	0.29	70.20	6.37	22.82	0.37	3.51
	71	9.42	0.41	38.04	0.87	0.13	312.24	0.29	70.67	6.43	22.88	0.38	3.51
	72	9.64	0.42	38.42	0.87	0.12	312.35	0.29	71.16	6.50	22.94	0.38	3.51
	73	9.57	0.42	38.80	0.87	0.12	312.45	0.29	71.65	6.56	23.00	0.39	3.51
	74	9.57	0.42	39.18	0.88	0.12	312.55	0.30	72.13	6.63	23.06	0.40	3.51
	75	9.82	0.42	35.37	0.88	0.12	311.58	0.30	72.38	5.98	23.10	0.40	3.51
	76	9.95	0.42	31.49	0.88	0.12	310.62	0.30	72.63	5.33	23.14	0.41	3.51
	77	9.73	0.43	27.70	0.88	0.12	309.70	0.30	72.88	4.69	23.18	0.41	3.51
	78	9.60	0.43	23.97	0.88	0.12	308.82	0.30	73.12	4.05	23.21	0.41	3.51
	79	9.75	0.43	20.18	0.88	0.12	307.95	0.30	73.37	3.41	23.25	0.42	3.51
	80	9.59	0.43	16.45	0.89	0.12	307.12	0.30	73.61	2.78	23.29	0.42	3.51
	81	9.73	0.43	12.66	0.89	0.12	306.29	0.30	73.86	2.14	23.33	0.43	3.51
	82	9.37	0.43	13.35	0.89	0.12	305.69	0.30	73.86	2.26	23.44	0.43	3.51
	83	9.41	0.43	14.05	0.90	0.12	305.11	0.30	73.86	2.38	23.55	0.43	3.51
	84	9.45	0.43	14.75	0.90	0.12	304.53	0.30	73.86	2.49	23.66	0.44	3.51
	85	9.76	0.43	15.47	0.90	0.12	303.95	0.31	73.86	2.62	23.77	0.44	3.51
	86	9.82	0.43	16.19	0.91	0.12	303.38	0.31	73.86	2.74	23.88	0.44	3.51
	87	10.34	0.43	16.95	0.91	0.12	302.80	0.31	73.86	2.87	24.00	0.45	3.51
	88	10.32	0.43	17.72	0.92	0.12	302.23	0.31	73.86	3.00	24.12	0.45	3.51
	89	10.08	0.43	18.46	0.92	0.12	301.68	0.31	73.86	3.12	24.24	0.45	3.51
	90	9.95	0.43	19.20	0.93	0.12	301.16	0.31	73.86	3.25	24.36	0.46	3.51

SGS Metcon

TEST No. CL-05

METALLURGICAL RESULTS

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**		
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14	
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height	
SAMPLE	**Composite 3 (Met-19/20)**	**CRUSH SIZE**	P100 minus 3 in.	
		LEACH SOLUTION	750 ppm fr g/l	
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	2.98	kg CaO/t of ore
		CURE CYCLE	0	Days
		FLOWRATE	9.78	lph/m^2

Time		**Feed Solution Flow Rate**	**Cumulative**										
			Extraction (g/t)			**Solution Grade (ppm)**			**Extraction (%)**			**Consumption**	
	(Days)	**(lph/sq m)**	**Au**	**Cu**	**Ag**	**Au**	**Cu**	**Ag**	**Au**	**Cu**	**Ag**	**NaCN (kg/t)**	**CaO (kg/t)**
Wash	91	9.67	0.43	19.91	0.93	0.12	300.66	0.31	73.86	3.37	24.47	0.46	3.51
	92	9.50	0.43	20.61	0.94	0.12	300.18	0.32	73.86	3.49	24.58	0.46	3.51
	93	9.71	0.43	21.33	0.94	0.12	299.71	0.32	73.86	3.61	24.69	0.46	3.51
	94	9.76	0.43	22.05	0.94	0.12	299.24	0.32	73.86	3.73	24.81	0.47	3.51
	95	10.02	0.43	22.79	0.95	0.12	298.76	0.32	73.86	3.85	24.93	0.47	3.51
	96	10.21	0.43	16.41	0.95	0.12	296.89	0.32	73.86	2.77	24.98	0.47	3.51
	97	10.14	0.43	10.06	0.95	0.12	295.07	0.32	73.86	1.70	25.03	0.47	3.51
	98	10.06	0.43	3.78	0.95	0.12	293.31	0.32	73.86	0.64	25.08	0.47	3.51
	99	10.06	0.43	-2.51	0.96	0.12	291.58	0.33	73.86	-0.42	25.13	0.47	3.51
	100	9.15	0.43	-8.22	0.96	0.12	290.04	0.33	73.86	-1.39	25.18	0.47	3.51
	101	9.12	0.43	-13.94	0.96	0.12	288.53	0.33	73.86	-2.36	25.23	0.47	3.51
	102	9.36	0.43	-19.79	0.96	0.12	287.01	0.33	73.86	-3.35	25.28	0.47	3.51
	103	9.37	0.43	-25.65	0.96	0.12	285.52	0.33	73.86	-4.34	25.33	0.47	3.51
	104	9.43	0.43	-31.55	0.97	0.12	284.05	0.33	73.86	-5.34	25.38	0.47	3.51
	105	9.13	0.43	-37.27	0.97	0.12	282.65	0.33	73.86	-6.30	25.42	0.47	3.51
	106	9.96	0.43	-43.48	0.97	0.12	281.16	0.33	73.86	-7.35	25.47	0.47	3.51
	107	9.78	0.43	-49.59	0.97	0.12	279.72	0.34	73.86	-8.39	25.52	0.48	3.51
	108	9.14	0.43	-55.31	0.97	0.12	278.39	0.34	73.86	-9.35	25.57	0.48	3.51
	109	9.14	0.43	-61.02	0.97	0.12	277.09	0.34	73.86	-10.32	25.62	0.48	3.51
Rinse	110	9.80	0.44	-58.05	0.99	0.12	275.15	0.34	74.67	-9.82	26.13	0.47	3.51
Rinse	111	9.37	0.44	-56.85	1.00	0.11	272.97	0.34	75.06	-9.61	26.26	0.47	3.51
Drain	112	0.00	0.44	-56.84	1.00	0.11	272.38	0.34	75.08	-9.61	26.28	0.47	3.51
Drain	113	0.00	0.44	-56.83	1.00	0.11	272.29	0.34	75.09	-9.61	26.28	0.47	3.51
Drain	114	0.00	0.44	-56.83	1.00	0.11	272.20	0.34	75.09	-9.61	26.29	0.47	3.51

APPENDIX 9

Column Leach Test CL-06 on Composite 3 (Duplicate)

Summary of Results | **SGS Metcon** | Current Date: 09/26/14

SGS Metcon Project No.: M-709-03

Western Copper & Gold Corp. Casino Project

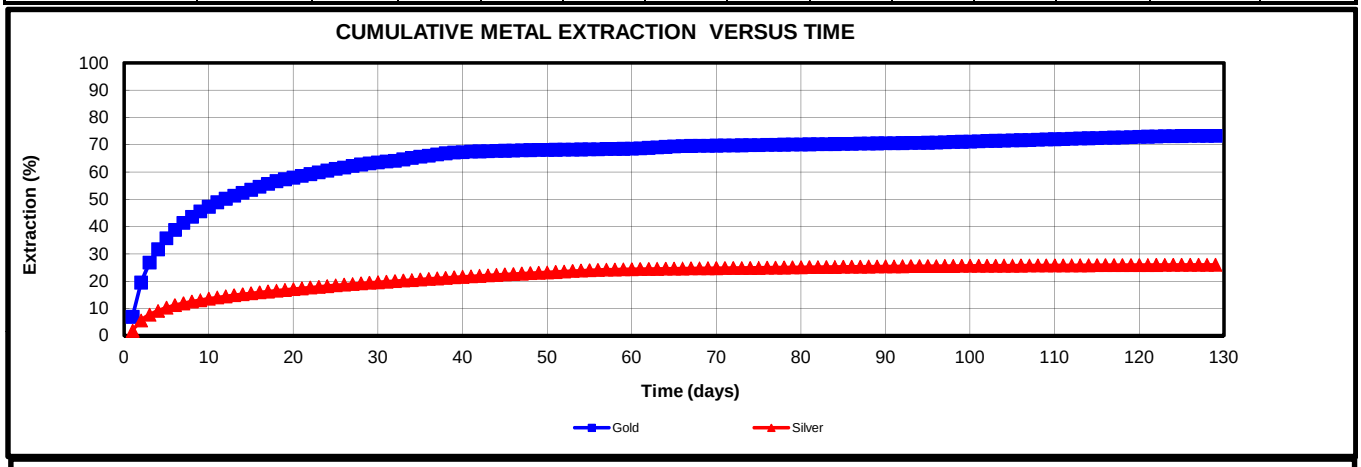
TEST No.: CL-06 | Crush Size: P100 minus 3 in.

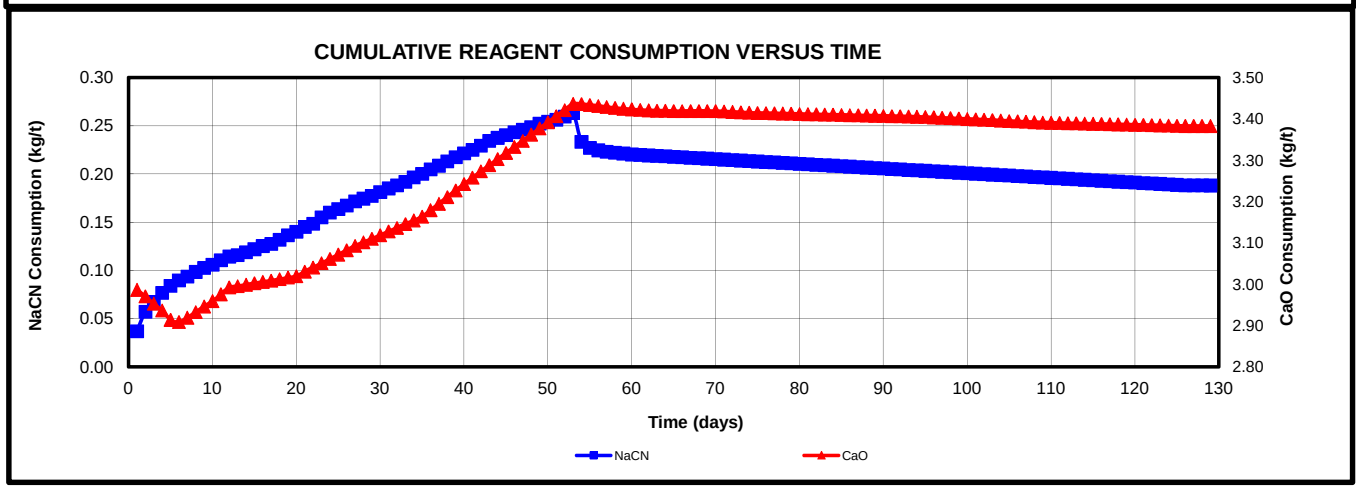
SAMPLE : Composite 3 (Met-19/20) | Lime Addition: 2.981773 kg Lime/tonne of ore

Objective: Gold and Silver Extraction vs Time

Cure Days:	0
Leach Days:	53
Rest Days:	0
Wash Days:	73
Drain Days:	3
Total Cycle Days:	129

PRODUCTS	Volume	Weight	Cumulative										
			Assay (g/t)			Contents (mg)			Indicated Extraction			Consumption	
												NaCN	CaO
	(liters)	(kg)	Au	Cu	Ag	Au	Cu	Ag	Au	Cu	Ag	(kg/t)	(kg/t)
Feed Solution	551.53		0.00	123	0.00	0.00	67623	0.00	73.28	6.81	26.01	0.19	3.38
Pregnant Solution	542.38		0.07	133	0.14	37.14	72176	76.58					
Leach Residue		88.88	0.15	701	2.45	13.54	62345	217.84					
CALCULATIONS													
Metal Extracted			0.42	51.23	0.86	37.14	4553	76.58					
Calculated Head			0.57	752.68	3.31	50.68	66898	294.42					
Assay Head		88.88	0.63	72.95	2.77	55.78	6484	245.79					

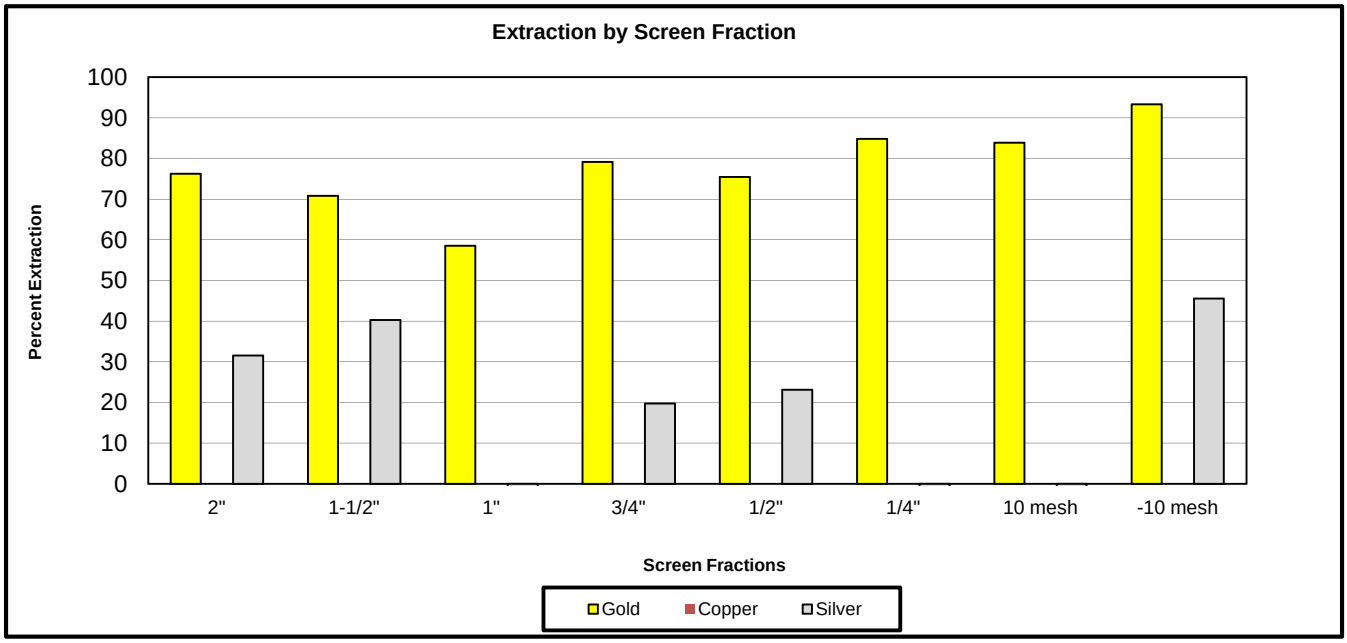




SGS Metcon

Test: CL-06
Sample: Composite 3 (Met-19/20)
Casino Project

Western Copper & Gold Corp.
SGS Metcon Project No.: M-709-03



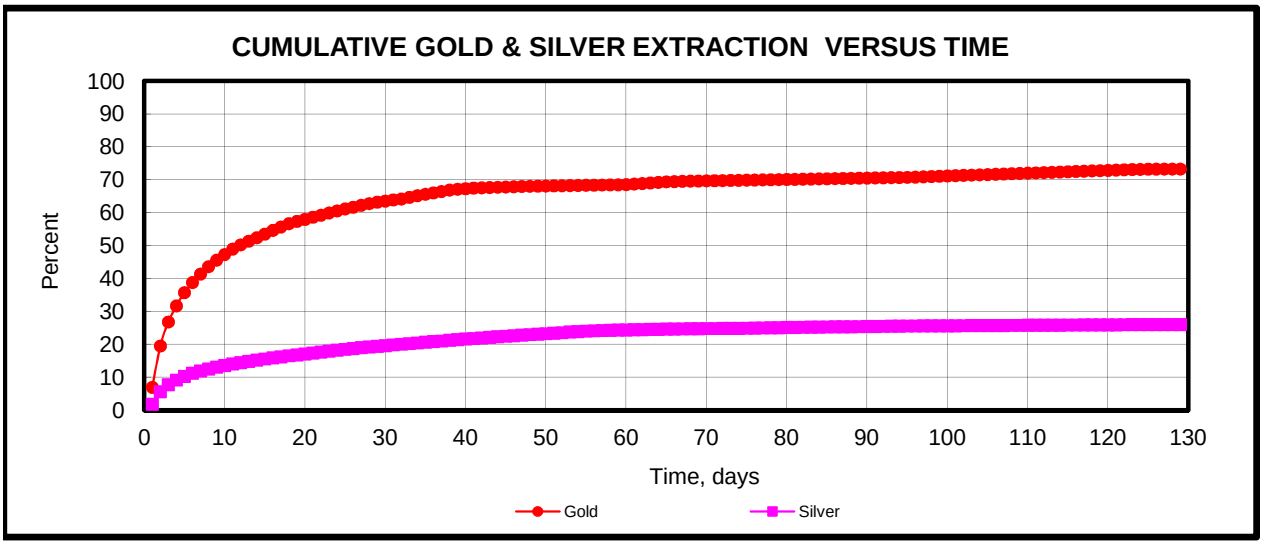
Test No. : CL-06

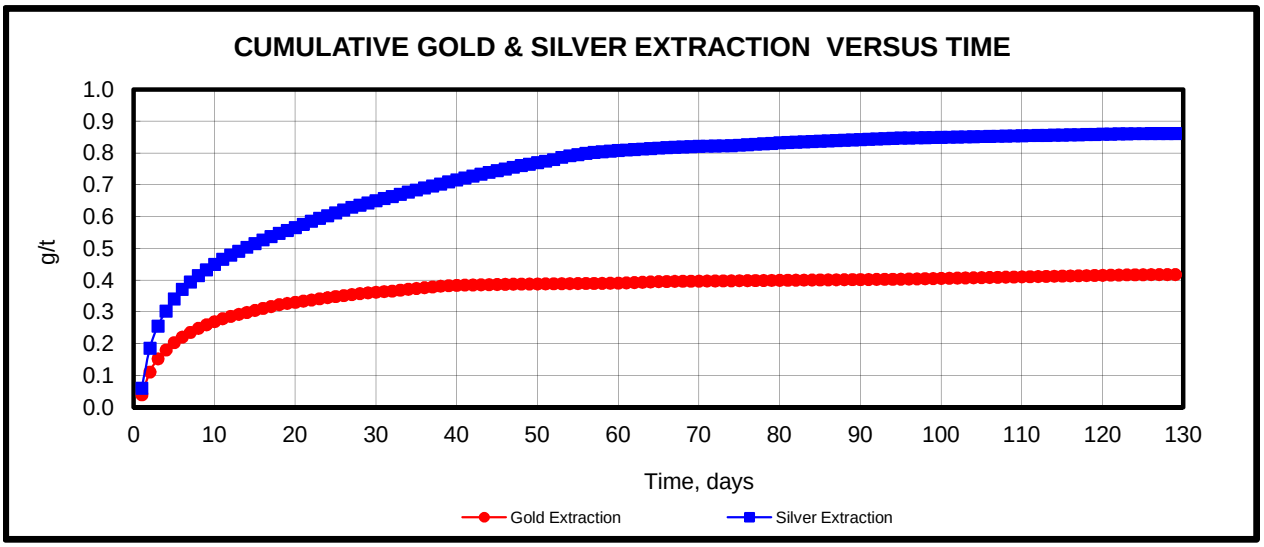
Screen Fraction	Head				Leach Residue				Percent Extraction			Degradation Index
	Weight	Assays (g/t)			Weight	Assays (g/t)						
	(kg)	Au	Cu	Ag	(kg)	Au	Cu	Ag	Au	Cu	Ag	(%)
2"	6.32	0.570	88	2.50	4.50	0.19	670	2.40	76.24	-	31.58	28.73
1-1/2"	21.58	0.490	74	2.60	13.41	0.23	830	2.50	70.84	-	40.26	37.88
1"	20.92	0.590	68	2.20	28.41	0.18	680	2.30	58.57	-	-41.97	-35.80
3/4"	9.84	0.570	69	2.50	8.97	0.13	720	2.20	79.20	-	19.75	8.81
1/2"	9.06	0.560	56	3.30	9.58	0.13	580	2.40	75.46	-	23.13	-5.70
1/4"	8.18	0.630	70	2.50	8.69	0.09	610	2.40	84.82	-	-1.98	-6.23
10 mesh	6.80	0.620	69	2.60	8.48	0.08	880	3.00	83.92	-	-43.83	-24.66
-10 mesh	6.18	1.490	110	5.70	6.85	0.09	600	2.80	93.31	-	45.59	-10.76
Total	88.88	0.63	72.95	2.77	88.88	0.15	701	2.45	75.72		11.37	

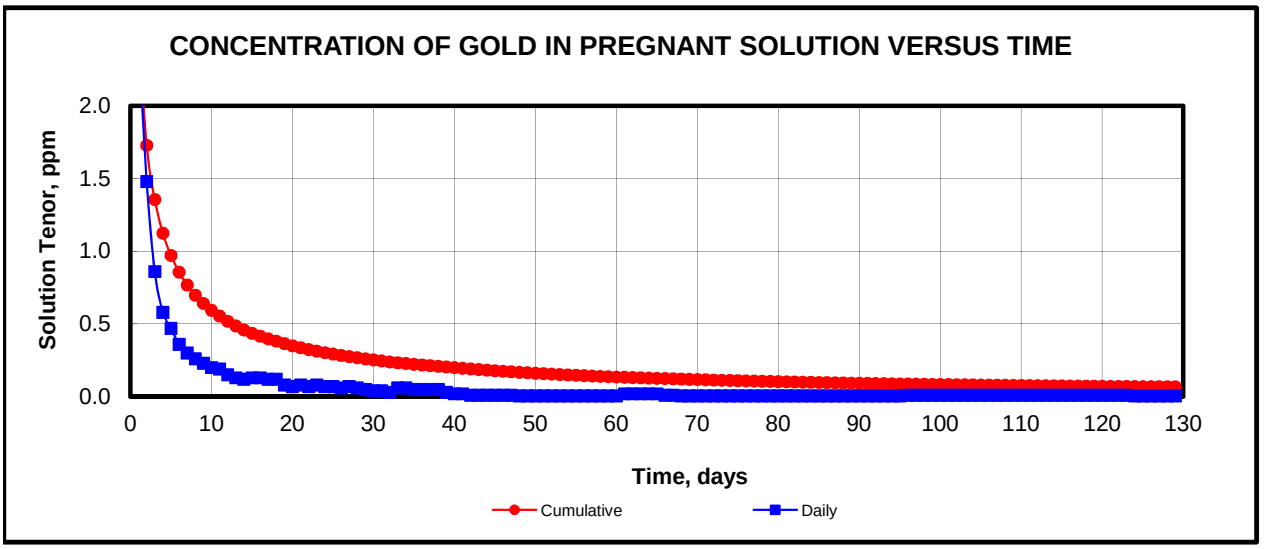
SGS Metcon

Test: CL-06 — Western Copper & Gold Corp.

Sample: Composite 3 (Met-19/20) — SGS Metcon Project No.: M-709-03



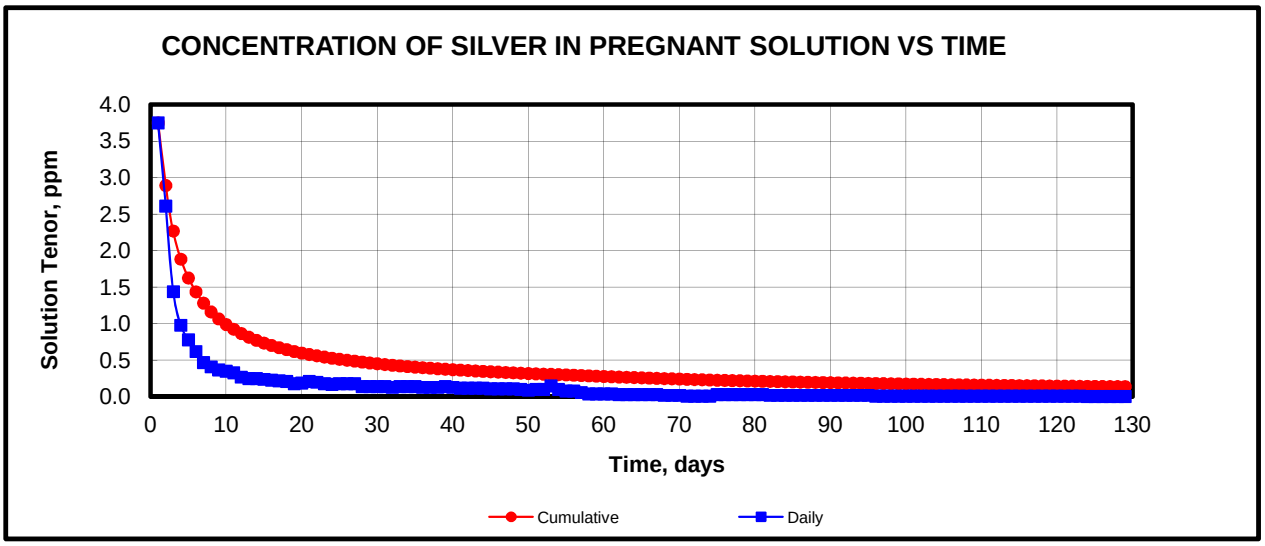


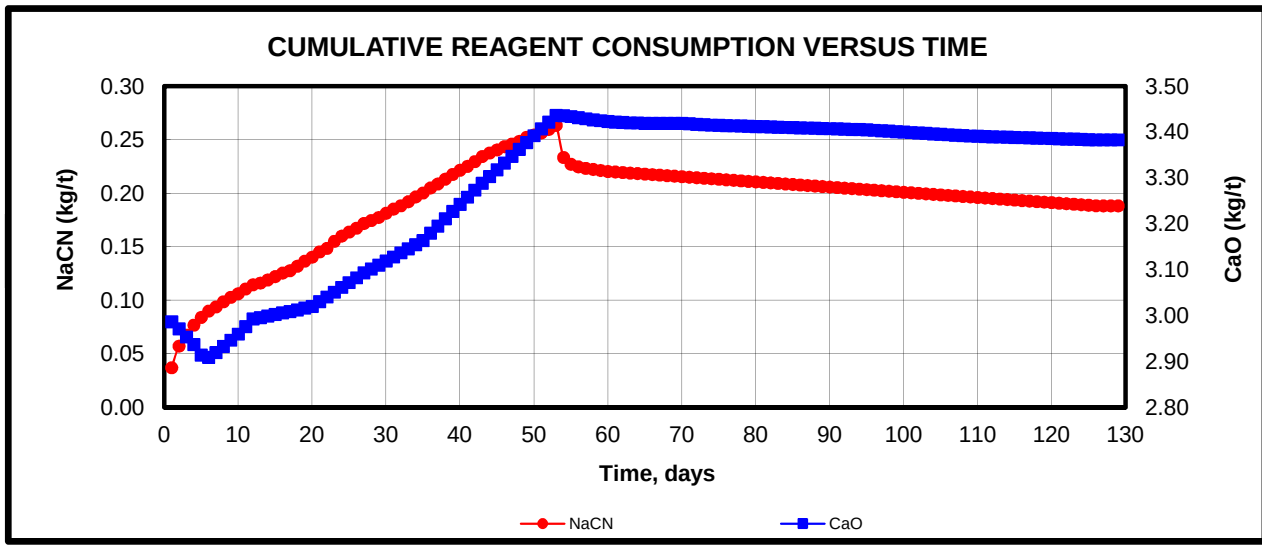


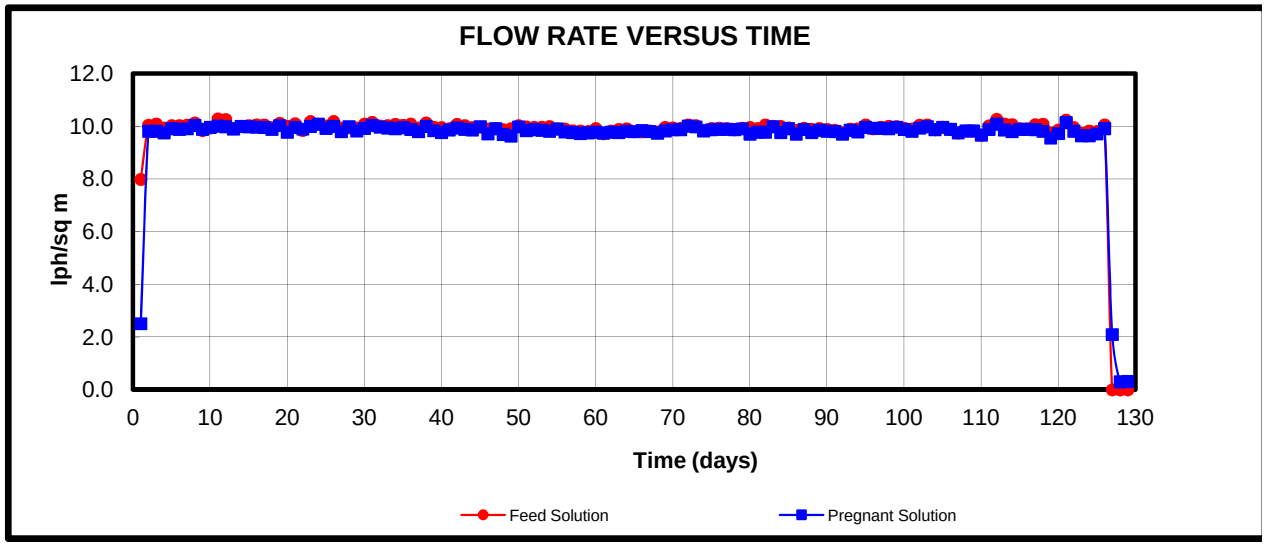
SGS Metcon

Test: CL-06 — Western Copper & Gold Corp.

Sample: Composite 3 (Met-19/20) — SGS Metcon Project No.: M-709-03



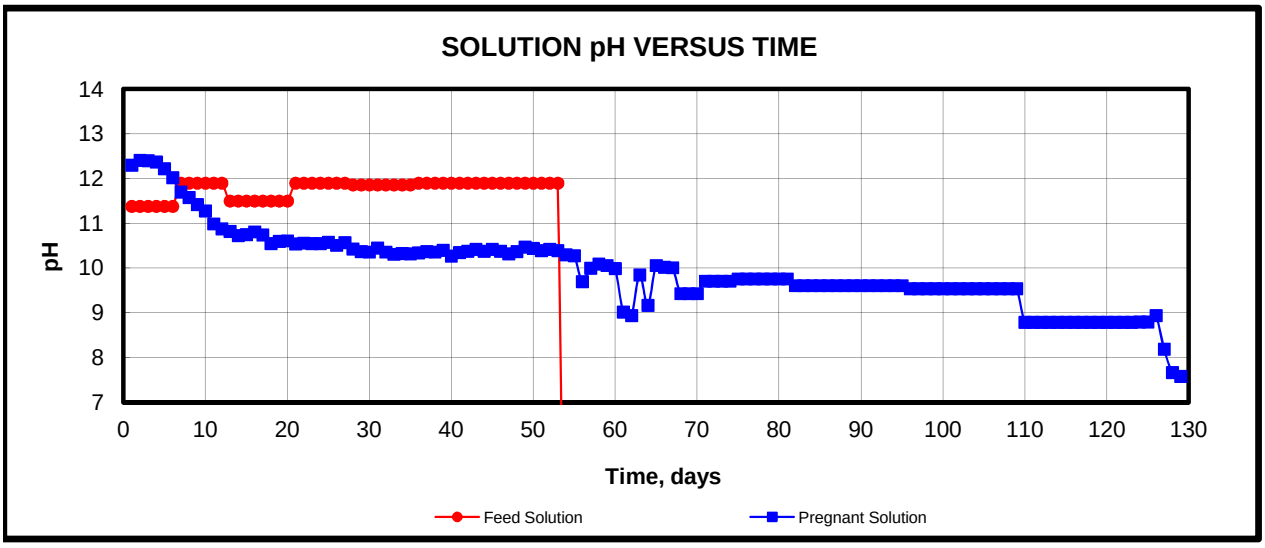


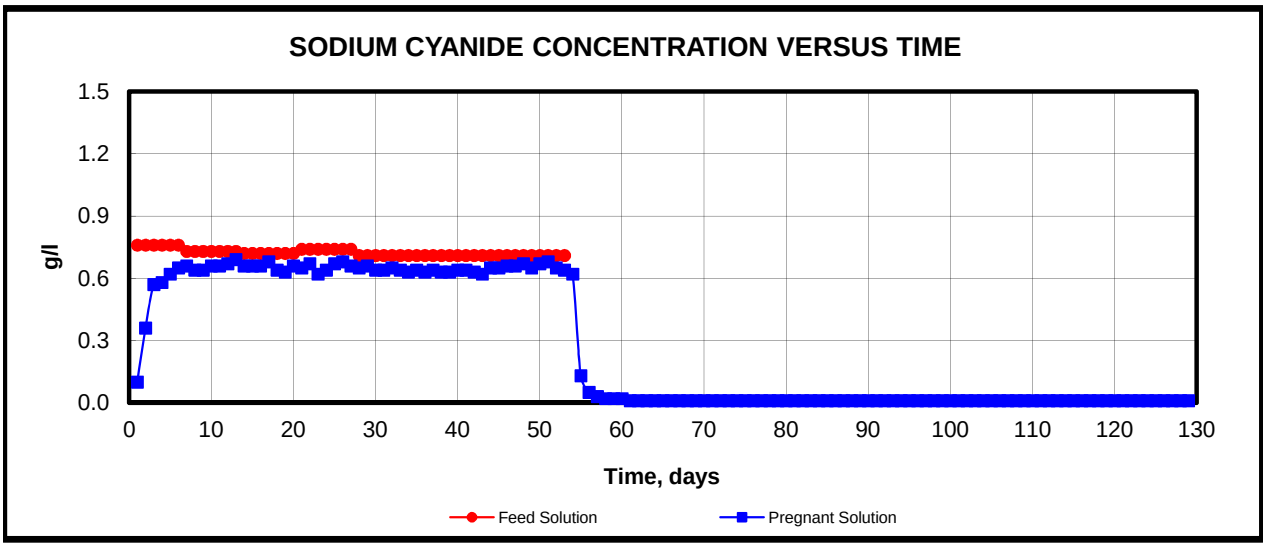


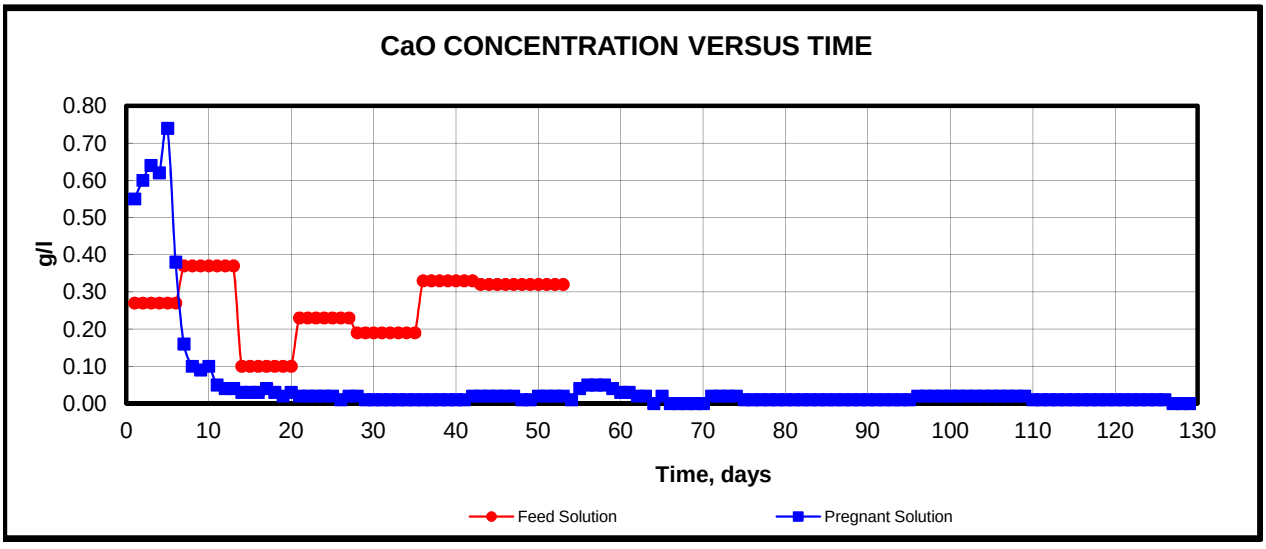
SGS Metcon

Test: CL-06 — Western Copper & Gold Corp.

Sample: Composite 3 (Met-19/20) — SGS Metcon Project No.: M-709-03







SGS Metcon

TEST No. CL-06

PHYSICAL CHARACTERISTICS SHEET

CLIENT	Western Copper & Gold Corp. SGS Metcon Project No.: M-709-03	**TEST CONDITIONS**	
		TEST START	05/01/14
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height
SAMPLE	Composite 3 (Met-19/20)	**CRUSH SIZE**	P100 minus 3 in.
		LEACH SOLUTION	750 ppm free NaCN, 300 ppm Cu
OBJECTIVE	Gold and Silver Extraction vs Time	**Lime Addition**	2.98 kg CaO/tonne of Ore
		CURE CYCLE	0 days
		FLOWRATE	9.78 lph/m2

FLOWRATE (lph/sq m)		9.78			
CURE STAGE (days)		0			
COLUMN DIAMETER (mm)		152.40			
ELEMENTS ANALYZED	Au	CNs Au	Ag	CNs Ag	Cu
HEAD ASSAYS (g per tonne)	0.63		2.77		72.95
LEACH RESIDUE ASSAYS (g per tonne)	0.15		2.45		701.45
SAMPLE PERCENT MOISTURE AS RECEIVED (Dry Basis)		0.00			
SAMPLE WEIGHT BEFORE AGGLOMERATION (kg)		88.88			
AGGLOMERATED SAMPLE WEIGHT (kg)		90.90			
INITIAL SAMPLE PERCENT MOISTURE (including agglomeration water)		2.27	(Dry Basis)		
INITIAL SAMPLE DRY WEIGHT (kg)		88.88			
INITIAL SAMPLE HEIGHT (m)		3.16			
INITIAL SAMPLE BULK DENSITY (kg/cu m)		1540	(Dry Basis)		
FINAL SAMPLE HEIGHT (m)		3.17			
RESIDUE WET WEIGHT (kg)		93.02			
RESIDUE DRY WEIGHT (kg)		88.88			
VOLUME DRAINED (l)		1.20			
SUBSIDENCE (%)		-0.08			
MOISTURE UNDER LEACH (%)		6.00	(Dry Basis)		
MOISTURE RETAINED (%)		4.66	(Dry Basis)		
FINAL SAMPLE BULK DENSITY (kg/cu m)		1539	(Dry Basis)		

SGS Metcon
7701 BUSINESS PARK DRIVE
TUCSON , ARIZONA 85743

SCREEN ANALYSIS RESULTS
Western Copper & Gold Corp.
SGS Metcon Project No.: M-709-03
Casino Project

SCREEN ANALYSIS			Sample: **Column Leach Head** **CL-06** **Composite 3 (Met-19/20)** **Crush Size: P100 minus 3 in.**											
NOMINAL OPENINGS		Tyler	Sample	Weight	Cumulative Weight	Gold			Copper			Silver		
mm	Inches	Mesh	Weights (kg)	Distribution (%)	Retained (%)	Assay (gpt)	Content	Distribution (%)	Assay (gpt)	Content	Distribution (%)	Assay (gpt)	Content	Distribution (%)
50.80	2.000	2"	6.32	7.11	7.11	0.57	0.041	6.46	88	6.257	8.58	2.50	0.18	6.43
38.10	1.500	1-1/2"	21.58	24.28	31.39	0.49	0.119	18.96	74	17.967	24.63	2.60	0.63	22.83
25.40	1.000	1"	20.92	23.54	54.93	0.59	0.139	22.13	68	16.005	21.94	2.20	0.52	18.73
19.05	0.750	3/4"	9.84	11.07	66.00	0.57	0.063	10.06	69	7.639	10.47	2.50	0.28	10.01
12.70	0.500	1/2"	9.06	10.19	76.19	0.56	0.057	9.10	56	5.708	7.83	3.30	0.34	12.16
6.35	0.250	1/4"	8.18	9.20	85.40	0.63	0.058	9.24	70	6.442	8.83	2.50	0.23	8.32
1.70	0.065	10	6.80	7.65	93.05	0.62	0.047	7.56	69	5.279	7.24	2.60	0.20	7.19
MINUS		10	6.18	6.95	100.00	1.49	0.104	16.51	110	7.649	10.48	5.70	0.40	14.33
TOTALS			88.88	100.00				100.00			100.00			100.00
CALCULATED ASSAY						0.63			73			2.77		
COMPOSITE ASSAY (Pulv.)						0.77			78			2.70		

SCREEN ANALYSIS			Sample: **Column Leach Residue** **CL-06** **Composite 3 (Met-19/20)**											
NOMINAL OPENINGS		Tyler	Sample	Weight	Cumulative Weight	Gold			Copper			Silver		
mm	Inches	Mesh	Weights (kg)	Distribution (%)	Retained (%)	Assay (gpt)	Content	Distribution (%)	Assay (gpt)	Content	Distribution (%)	Assay (gpt)	Content	Distribution (%)
50.80	2.000	2"	2.54	5.07	5.07	0.19	0.010	6.32	670	33.955	4.84	2.40	0.12	4.96
38.10	1.500	1-1/2"	7.56	15.08	20.15	0.23	0.035	22.77	830	125.196	17.85	2.50	0.38	15.39
25.40	1.000	1"	16.02	31.96	52.11	0.18	0.058	37.77	680	217.350	30.99	2.30	0.74	29.99
19.05	0.750	3/4"	5.06	10.10	62.21	0.13	0.013	8.61	720	72.690	10.36	2.20	0.22	9.06
12.70	0.500	1/2"	5.40	10.77	72.98	0.13	0.014	9.19	580	62.490	8.91	2.40	0.26	10.55
6.35	0.250	1/4"	4.90	9.78	82.76	0.09	0.009	5.78	610	59.637	8.50	2.40	0.23	9.57
1.70	0.065	10	4.78	9.54	92.30	0.08	0.008	5.01	880	83.927	11.96	3.00	0.29	11.67
MINUS		10	3.86	7.70	100.00	0.09	0.007	4.55	600	46.209	6.59	2.80	0.22	8.80
TOTALS			50.12	100.00				100.00			100.00			100.00
CALCULATED ASSAY						0.15			701			2.45		
COMPOSITE ASSAY (Pulv.)						0.15			660			2.60		

SGS Metcon

TEST No. CL-06

Data Sheet

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**	
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height
SAMPLE	**Composite 3 (Met-19/20)**	**CRUSH SIZE**	P100 minus 3 in.
	0	**LEACH SOLUTION**	750 ppm free l g/l
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	2.98 kg CaO/tonne of ore
		CURE CYCLE	0 Days
		FLOWRATE	9.78 lph/m^2

		Pregnant Leach Solution							**Feed Solution**							
			Free			Assays (ppm)				Free			NaCN	Assays (ppm)		
Time (Days)		Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Au	Cu	Ag	Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Add/Rem. (grams)	Au	Cu	Ag
Leach	1	1.42	0.10	0.55	12.30	2.48	196.00	3.75	4.52	0.76	0.27	11.38		0.00	272.00	0.00
	2	4.30	0.36	0.60	12.41	1.48	270.00	2.61	4.40	0.76	0.27	11.38		0.00	272.00	0.00
	3	4.30	0.57	0.64	12.40	0.86	321.00	1.44	4.42	0.76	0.27	11.38		0.00	272.00	0.00
	4	4.27	0.58	0.62	12.37	0.58	326.00	0.98	4.35	0.76	0.27	11.38		0.00	272.00	0.00
	5	4.35	0.62	0.74	12.22	0.47	323.00	0.78	4.40	0.76	0.27	11.38		0.00	272.00	0.00
	6	4.32	0.65	0.38	12.02	0.36	318.00	0.62	4.38	0.76	0.27	11.38		0.00	272.00	0.00
	7	4.34	0.66	0.16	11.70	0.30	311.00	0.47	4.40	0.73	0.37	11.90		0.00	241.00	0.00
	8	4.40	0.64	0.10	11.58	0.26	306.00	0.41	4.44	0.73	0.37	11.90		0.00	241.00	0.00
	9	4.32	0.64	0.09	11.42	0.23	315.00	0.37	4.30	0.73	0.37	11.90		0.00	241.00	0.00
	10	4.36	0.66	0.10	11.28	0.20	319.00	0.35	4.35	0.73	0.37	11.90		0.00	241.00	0.00
	11	4.38	0.66	0.05	10.99	0.19	319.00	0.33	4.50	0.73	0.37	11.90		0.00	241.00	0.00
	12	4.38	0.67	0.04	10.88	0.15	320.00	0.27	4.50	0.73	0.37	11.90		0.00	241.00	0.00
	13	4.33	0.69	0.04	10.82	0.13	320.00	0.25	4.34	0.72	0.10	11.50		0.00	303.00	0.00
	14	4.38	0.66	0.03	10.73	0.12	322.00	0.25	4.38	0.72	0.10	11.50		0.00	303.00	0.00
	15	4.36	0.66	0.03	10.75	0.13	315.00	0.24	4.38	0.72	0.10	11.50		0.00	303.00	0.00
	16	4.36	0.66	0.03	10.81	0.13	313.00	0.23	4.40	0.72	0.10	11.50		0.00	303.00	0.00
	17	4.36	0.68	0.04	10.74	0.12	308.00	0.22	4.40	0.72	0.10	11.50		0.00	303.00	0.00
	18	4.33	0.64	0.03	10.55	0.12	304.00	0.21	4.36	0.72	0.10	11.50		0.00	303.00	0.00
	19	4.38	0.63	0.02	10.60	0.08	302.00	0.18	4.42	0.72	0.10	11.50		0.00	303.00	0.00
	20	4.28	0.66	0.03	10.61	0.07	305.00	0.19	4.38	0.72	0.10	11.50		0.00	303.00	0.00
	21	4.36	0.65	0.02	10.54	0.08	308.00	0.21	4.42	0.74	0.23	11.90		0.00	303.00	0.00
	22	4.34	0.67	0.02	10.56	0.07	306.00	0.20	4.32	0.74	0.23	11.90		0.00	303.00	0.00
	23	4.38	0.62	0.02	10.55	0.08	310.00	0.18	4.46	0.74	0.23	11.90		0.00	303.00	0.00
	24	4.40	0.64	0.02	10.55	0.07	308.00	0.17	4.40	0.74	0.23	11.90		0.00	303.00	0.00
	25	4.36	0.67	0.02	10.58	0.07	305.00	0.18	4.40	0.74	0.23	11.90		0.00	303.00	0.00
	26	4.38	0.68	0.02	10.51	0.06	308.00	0.18	4.46	0.74	0.23	11.90		0.00	303.00	0.00
	27	4.30	0.66	0.01	10.57	0.07	307.00	0.18	4.36	0.74	0.23	11.90		0.00	303.00	0.00
	28	4.36	0.65	0.02	10.43	0.06	299.00	0.14	4.34	0.71	0.19	11.86		0.00	310.00	0.00
	29	4.30	0.66	0.02	10.37	0.05	302.00	0.14	4.35	0.71	0.19	11.86		0.00	310.00	0.00
	30	4.33	0.64	0.01	10.36	0.04	302.00	0.14	4.40	0.71	0.19	11.86		0.00	310.00	0.00

SGS Metcon

TEST No. CL-06

Data Sheet

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**	
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height
SAMPLE	**Composite 3 (Met-19/20)**	**CRUSH SIZE**	P100 minus 3 in.
	0	**LEACH SOLUTION**	750 ppm free l g/l
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	2.98 kg CaO/tonne of ore
		CURE CYCLE	0 Days
		FLOWRATE	9.78 lph/m^2

		Pregnant Leach Solution							**Feed Solution**							
			Free			Assays (ppm)				Free			NaCN	Assays (ppm)		
Time (Days)		Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Au	Cu	Ag	Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Add/Rem. (grams)	Au	Cu	Ag
Leach	31	4.39	0.64	0.01	10.45	0.04	302.00	0.14	4.44	0.71	0.19	11.86		0.00	310.00	0.00
	32	4.38	0.65	0.01	10.36	0.03	305.00	0.13	4.40	0.71	0.19	11.86		0.00	310.00	0.00
	33	4.34	0.64	0.01	10.31	0.06	321.00	0.14	4.38	0.71	0.19	11.86		0.00	310.00	0.00
	34	4.35	0.63	0.01	10.33	0.06	325.00	0.14	4.42	0.71	0.19	11.86		0.00	310.00	0.00
	35	4.34	0.64	0.01	10.32	0.05	323.00	0.14	4.38	0.71	0.19	11.86		0.00	310.00	0.00
	36	4.35	0.63	0.01	10.34	0.05	323.00	0.13	4.44	0.71	0.33	11.90		0.00	303.00	0.00
	37	4.22	0.64	0.01	10.37	0.05	323.00	0.13	4.28	0.71	0.33	11.90		0.00	303.00	0.00
	38	4.42	0.63	0.01	10.36	0.05	320.00	0.13	4.48	0.71	0.33	11.90		0.00	303.00	0.00
	39	4.34	0.63	0.01	10.40	0.03	300.00	0.14	4.40	0.71	0.33	11.90		0.00	303.00	0.00
	40	4.24	0.64	0.01	10.27	0.02	300.00	0.13	4.32	0.71	0.33	11.90		0.00	303.00	0.00
	41	4.34	0.64	0.01	10.35	0.02	310.00	0.12	4.36	0.71	0.33	11.90		0.00	303.00	0.00
	42	4.34	0.63	0.02	10.38	0.01	310.00	0.12	4.40	0.71	0.33	11.90		0.00	303.00	0.00
	43	4.32	0.62	0.02	10.42	0.01	314.00	0.12	4.38	0.71	0.32	11.90		0.00	290.00	0.00
	44	4.32	0.65	0.02	10.38	0.01	317.00	0.12	4.36	0.71	0.32	11.90		0.00	290.00	0.00
	45	4.37	0.65	0.02	10.42	0.01	314.00	0.11	4.36	0.71	0.32	11.90		0.00	290.00	0.00
	46	4.25	0.66	0.02	10.38	0.01	310.00	0.11	4.33	0.71	0.32	11.90		0.00	290.00	0.00
	47	4.34	0.66	0.02	10.32	0.01	310.00	0.11	4.34	0.71	0.32	11.90		0.00	290.00	0.00
	48	4.26	0.67	0.01	10.37	0.01	307.00	0.11	4.34	0.71	0.32	11.90		0.00	290.00	0.00
	49	4.20	0.65	0.01	10.47	0.01	307.00	0.10	4.32	0.71	0.32	11.90		0.00	290.00	0.00
	50	4.38	0.67	0.02	10.44	0.01	305.00	0.09	4.40	0.71	0.32	11.90		0.00	290.00	0.00
	51	4.31	0.68	0.02	10.39	0.01	308.00	0.10	4.37	0.71	0.32	11.90		0.00	290.00	0.00
	52	4.31	0.65	0.02	10.42	0.01	316.00	0.10	4.35	0.71	0.32	11.90		0.00	290.00	0.00
	53	4.32	0.64	0.02	10.39	0.01	308.00	0.15	4.37	0.71	0.32	11.90		0.00	290.00	0.00
Wash	54	4.30	0.62	0.01	10.30	0.01	249.00	0.10	4.38	0.00	0.00	0.00		0.00	0.00	0.00
	55	4.32	0.13	0.04	10.28	0.01	60.00	0.08	4.32	0.00	0.00	0.00		0.00	0.00	0.00
	56	4.29	0.05	0.05	9.70	0.01	21.00	0.08	4.34	0.00	0.00	0.00		0.00	0.00	0.00
	57	4.28	0.03	0.05	10.00	0.01	10.00	0.06	4.31	0.00	0.00	0.00		0.00	0.00	0.00
	58	4.26	0.02	0.05	10.09	0.01	7.00	0.04	4.30	0.00	0.00	0.00		0.00	0.00	0.00
	59	4.26	0.02	0.04	10.06	0.01	5.00	0.04	4.28	0.00	0.00	0.00		0.00	0.00	0.00
	60	4.28	0.02	0.03	9.99	0.01	4.00	0.04	4.34	0.00	0.00	0.00		0.00	0.00	0.00

SGS Metcon

TEST No. CL-06

Data Sheet

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**	
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height
SAMPLE	**Composite 3 (Met-19/20)**	**CRUSH SIZE**	P100 minus 3 in.
	0	**LEACH SOLUTION**	750 ppm free l g/l
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	2.98 kg CaO/tonne of ore
		CURE CYCLE	0 Days
		FLOWRATE	9.78 lph/m^2

	Pregnant Leach Solution							**Feed Solution**							
		Free			Assays (ppm)				Free			NaCN	Assays (ppm)		
Time (Days)	Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Au	Cu	Ag	Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Add/Rem. (grams)	Au	Cu	Ag
Wash 61	4.27	0.01	0.03	9.02	0.02	3.00	0.04	4.26	0.00	0.00	0.00		0.00	0.00	0.00
62	4.28	0.01	0.02	8.94	0.02	2.00	0.03	4.30	0.00	0.00	0.00		0.00	0.00	0.00
63	4.27	0.01	0.02	9.85	0.02	1.00	0.03	4.32	0.00	0.00	0.00		0.00	0.00	0.00
64	4.30	0.01	0.00	9.17	0.02	1.00	0.03	4.34	0.00	0.00	0.00		0.00	0.00	0.00
65	4.30	0.01	0.02	10.06	0.02	1.00	0.03	4.30	0.00	0.00	0.00		0.00	0.00	0.00
66	4.30	0.01	0.00	10.02	0.01	1.00	0.03	4.28	0.00	0.00	0.00		0.00	0.00	0.00
67	4.30	0.01	0.00	10.01	0.01	1.00	0.03	4.31	0.00	0.00	0.00		0.00	0.00	0.00
68	4.26	0.01	0.00	9.43	0.01	2.00	0.02	4.28	0.00	0.00	0.00		0.00	0.00	0.00
69	4.30	0.01	0.00	9.43	0.01	2.00	0.02	4.36	0.00	0.00	0.00		0.00	0.00	0.00
70	4.33	0.01	0.00	9.43	0.01	2.00	0.02	4.36	0.00	0.00	0.00		0.00	0.00	0.00
71	4.30	0.01	0.02	9.71	0.01	1.00	0.01	4.32	0.00	0.00	0.00		0.00	0.00	0.00
72	4.38	0.01	0.02	9.71	0.01	1.00	0.01	4.40	0.00	0.00	0.00		0.00	0.00	0.00
73	4.38	0.01	0.02	9.71	0.01	1.00	0.01	4.40	0.00	0.00	0.00		0.00	0.00	0.00
74	4.31	0.01	0.02	9.71	0.01	1.00	0.01	4.32	0.00	0.00	0.00		0.00	0.00	0.00
75	4.30	0.01	0.01	9.76	0.01	0.00	0.03	4.32	0.00	0.00	0.00		0.00	0.00	0.00
76	4.34	0.01	0.01	9.76	0.01	0.00	0.03	4.36	0.00	0.00	0.00		0.00	0.00	0.00
77	4.33	0.01	0.01	9.76	0.01	0.00	0.03	4.34	0.00	0.00	0.00		0.00	0.00	0.00
78	4.32	0.01	0.01	9.76	0.01	0.00	0.03	4.32	0.00	0.00	0.00		0.00	0.00	0.00
79	4.34	0.01	0.01	9.76	0.01	0.00	0.03	4.35	0.00	0.00	0.00		0.00	0.00	0.00
80	4.25	0.01	0.01	9.76	0.01	0.00	0.03	4.36	0.00	0.00	0.00		0.00	0.00	0.00
81	4.28	0.01	0.01	9.76	0.01	0.00	0.03	4.34	0.00	0.00	0.00		0.00	0.00	0.00
82	4.28	0.01	0.01	9.61	0.01	0.90	0.02	4.40	0.00	0.00	0.00		0.00	0.00	0.00
83	4.37	0.01	0.01	9.61	0.01	0.90	0.02	4.38	0.00	0.00	0.00		0.00	0.00	0.00
84	4.28	0.01	0.01	9.61	0.01	0.90	0.02	4.38	0.00	0.00	0.00		0.00	0.00	0.00
85	4.35	0.01	0.01	9.61	0.01	0.90	0.02	4.36	0.00	0.00	0.00		0.00	0.00	0.00
86	4.24	0.01	0.01	9.61	0.01	0.90	0.02	4.30	0.00	0.00	0.00		0.00	0.00	0.00
87	4.32	0.01	0.01	9.61	0.01	0.90	0.02	4.34	0.00	0.00	0.00		0.00	0.00	0.00
88	4.28	0.01	0.01	9.61	0.01	0.90	0.02	4.33	0.00	0.00	0.00		0.00	0.00	0.00
89	4.32	0.01	0.01	9.61	0.01	0.90	0.02	4.35	0.00	0.00	0.00		0.00	0.00	0.00
90	4.29	0.01	0.01	9.61	0.01	0.90	0.02	4.32	0.00	0.00	0.00		0.00	0.00	0.00

SGS Metcon

TEST No. CL-06

Data Sheet

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**	
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height
SAMPLE	**Composite 3 (Met-19/20)**	**CRUSH SIZE**	P100 minus 3 in.
	0	**LEACH SOLUTION**	750 ppm free l g/l
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	2.98 kg CaO/tonne of ore
		CURE CYCLE	0 Days
		FLOWRATE	9.78 lph/m^2

	Pregnant Leach Solution							Feed Solution							
		Free			Assays (ppm)				Free			NaCN	Assays (ppm)		
Time (Days)	Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Au	Cu	Ag	Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Add/Rem. (grams)	Au	Cu	Ag
Wash 91	4.29	0.01	0.01	9.61	0.01	0.90	0.02	4.31	0.00	0.00	0.00		0.00	0.00	0.00
92	4.25	0.01	0.01	9.61	0.01	0.90	0.02	4.27	0.00	0.00	0.00		0.00	0.00	0.00
93	4.30	0.01	0.01	9.61	0.01	0.90	0.02	4.32	0.00	0.00	0.00		0.00	0.00	0.00
94	4.29	0.01	0.01	9.61	0.01	0.90	0.02	4.34	0.00	0.00	0.00		0.00	0.00	0.00
95	4.37	0.01	0.01	9.61	0.01	0.90	0.02	4.41	0.00	0.00	0.00		0.00	0.00	0.00
96	4.35	0.01	0.02	9.54	0.01	1.00	0.01	4.34	0.00	0.00	0.00		0.00	0.00	0.00
97	4.34	0.01	0.02	9.54	0.01	1.00	0.01	4.36	0.00	0.00	0.00		0.00	0.00	0.00
98	4.34	0.01	0.02	9.54	0.01	1.00	0.01	4.38	0.00	0.00	0.00		0.00	0.00	0.00
99	4.36	0.01	0.02	9.54	0.01	1.00	0.01	4.37	0.00	0.00	0.00		0.00	0.00	0.00
100	4.32	0.01	0.02	9.54	0.01	1.00	0.01	4.34	0.00	0.00	0.00		0.00	0.00	0.00
101	4.30	0.01	0.02	9.54	0.01	1.00	0.01	4.34	0.00	0.00	0.00		0.00	0.00	0.00
102	4.35	0.01	0.02	9.54	0.01	1.00	0.01	4.40	0.00	0.00	0.00		0.00	0.00	0.00
103	4.37	0.01	0.02	9.54	0.01	1.00	0.01	4.40	0.00	0.00	0.00		0.00	0.00	0.00
104	4.32	0.01	0.02	9.54	0.01	1.00	0.01	4.32	0.00	0.00	0.00		0.00	0.00	0.00
105	4.36	0.01	0.02	9.54	0.01	1.00	0.01	4.36	0.00	0.00	0.00		0.00	0.00	0.00
106	4.33	0.01	0.02	9.54	0.01	1.00	0.01	4.33	0.00	0.00	0.00		0.00	0.00	0.00
107	4.26	0.01	0.02	9.54	0.01	1.00	0.01	4.26	0.00	0.00	0.00		0.00	0.00	0.00
108	4.30	0.01	0.02	9.54	0.01	1.00	0.01	4.30	0.00	0.00	0.00		0.00	0.00	0.00
109	4.30	0.01	0.02	9.54	0.01	1.00	0.01	4.30	0.00	0.00	0.00		0.00	0.00	0.00
110	4.24	0.01	0.01	8.79	0.01	1.00	0.01	4.24	0.00	0.00	0.00		0.00	0.00	0.00
111	4.32	0.01	0.01	8.79	0.01	1.00	0.01	4.38	0.00	0.00	0.00		0.00	0.00	0.00
112	4.42	0.01	0.01	8.79	0.01	1.00	0.01	4.50	0.00	0.00	0.00		0.00	0.00	0.00
113	4.32	0.01	0.01	8.79	0.01	1.00	0.01	4.42	0.00	0.00	0.00		0.00	0.00	0.00
114	4.29	0.01	0.01	8.79	0.01	1.00	0.01	4.40	0.00	0.00	0.00		0.00	0.00	0.00
115	4.35	0.01	0.01	8.79	0.01	1.00	0.01	4.36	0.00	0.00	0.00		0.00	0.00	0.00
116	4.33	0.01	0.01	8.79	0.01	1.00	0.01	4.34	0.00	0.00	0.00		0.00	0.00	0.00
117	4.30	0.01	0.01	8.79	0.01	1.00	0.01	4.38	0.00	0.00	0.00		0.00	0.00	0.00
118	4.30	0.01	0.01	8.79	0.01	1.00	0.01	4.42	0.00	0.00	0.00		0.00	0.00	0.00
119	4.18	0.01	0.01	8.79	0.01	1.00	0.01	4.26	0.00	0.00	0.00		0.00	0.00	0.00
120	4.26	0.01	0.01	8.79	0.01	1.00	0.01	4.32	0.00	0.00	0.00		0.00	0.00	0.00

SGS Metcon

TEST No. CL-06

Data Sheet

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**	
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height
SAMPLE	**Composite 3 (Met-19/20)**	**CRUSH SIZE**	P100 minus 3 in.
	0	**LEACH SOLUTION**	750 ppm free l g/l
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	2.98 kg CaO/tonne of ore
		CURE CYCLE	0 Days
		FLOWRATE	9.78 lph/m^2

		Pregnant Leach Solution							**Feed Solution**							
			Free			Assays (ppm)				Free			NaCN	Assays (ppm)		
Time (Days)		Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Au	Cu	Ag	Volume (l)	NaCN (gpl)	CaO (gpl)	pH	Add/Rem. (grams)	Au	Cu	Ag
Wash	121	4.44	0.01	0.01	8.79	0.01	1.00	0.01	4.48	0.00	0.00	0.00		0.00	0.00	0.00
	122	4.30	0.01	0.01	8.79	0.01	1.00	0.01	4.36	0.00	0.00	0.00		0.00	0.00	0.00
	123	4.22	0.01	0.01	8.79	0.01	1.00	0.01	4.26	0.00	0.00	0.00		0.00	0.00	0.00
	124	4.22	0.01	0.01	8.80	0.01	0.05	0.01	4.30	0.00	0.00	0.00		0.00	0.00	0.00
	125	4.24	0.01	0.01	8.80	0.01	0.05	0.01	4.28	0.00	0.00	0.00		0.00	0.00	0.00
	126	4.34	0.01	0.01	8.94	0.01	0.05	0.01	4.40	0.00	0.00	0.00		0.00	0.00	0.00
Drain	127	0.92	0.01	0.00	8.19	0.01	0.05	0.01	0.00	0.00	0.00	0.00		0.00	0.00	0.00
Drain	128	0.14	0.01	0.00	7.67	0.01	0.05	0.01	0.00	0.00	0.00	0.00		0.00	0.00	0.00
Drain	129	0.14	0.01	0.00	7.58	0.01	0.05	0.01	0.00	0.00	0.00	0.00		0.00	0.00	0.00

SGS Metcon

TEST No. CL-06

METALLURGICAL RESULTS

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**		
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14	
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height	
SAMPLE	**Composite 3 (Met-19/20)**	**CRUSH SIZE**	P100 minus 3 in.	
		LEACH SOLUTION	750 ppm fr g/l	
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	2.98	kg CaO/t of ore
		CURE CYCLE	0	Days
		FLOWRATE	9.78	lph/m^2

Time		Feed Solution Flow Rate	Cumulative										
			Extraction (g/t)			Solution Grade (ppm)			Extraction (%)			Consumption	
(Days)		(lph/sq m)	Au	Cu	Ag	Au	Cu	Ag	Au	Cu	Ag	NaCN (kg/t)	CaO (kg/t)
Leach	1	7.98	0.04	-10.70	0.06	2.48	196.00	3.75	6.95	-1.42	1.81	0.04	2.99
	2	10.04	0.11	-11.10	0.19	1.73	251.63	2.89	19.51	-1.48	5.62	0.06	2.97
	3	10.09	0.15	-9.10	0.26	1.36	281.40	2.27	26.80	-1.21	7.72	0.07	2.95
	4	9.94	0.18	-6.75	0.30	1.12	294.73	1.88	31.69	-0.90	9.14	0.08	2.94
	5	10.02	0.20	-4.41	0.34	0.97	301.32	1.63	35.73	-0.59	10.30	0.08	2.91
	6	10.03	0.22	-2.36	0.37	0.86	304.46	1.44	38.79	-0.31	11.21	0.09	2.91
	7	10.04	0.24	0.90	0.39	0.77	305.50	1.28	41.36	0.12	11.90	0.09	2.92
	8	10.13	0.25	4.01	0.41	0.70	305.57	1.16	43.62	0.53	12.51	0.10	2.93
	9	9.84	0.26	7.66	0.43	0.64	306.70	1.07	45.58	1.02	13.06	0.10	2.95
	10	9.94	0.27	11.51	0.45	0.59	308.03	0.99	47.30	1.53	13.57	0.11	2.96
	11	10.28	0.28	15.03	0.47	0.55	309.10	0.93	48.94	2.00	14.06	0.11	2.98
	12	10.26	0.29	18.60	0.48	0.52	310.07	0.87	50.24	2.47	14.47	0.11	2.99
	13	9.92	0.29	19.39	0.49	0.49	310.88	0.82	51.35	2.58	14.83	0.12	3.00
	14	10.00	0.30	20.33	0.50	0.46	311.72	0.77	52.39	2.70	15.21	0.12	3.00
	15	10.03	0.31	20.85	0.52	0.44	311.95	0.74	53.51	2.77	15.56	0.12	3.00
	16	10.06	0.31	21.20	0.53	0.42	312.02	0.70	54.63	2.82	15.90	0.13	3.01
	17	10.05	0.32	21.31	0.54	0.40	311.77	0.67	55.66	2.83	16.23	0.13	3.01
	18	9.95	0.32	21.26	0.55	0.38	311.32	0.65	56.68	2.82	16.54	0.13	3.01
	19	10.12	0.33	21.07	0.56	0.37	310.81	0.62	57.37	2.80	16.80	0.14	3.02
	20	10.00	0.33	20.83	0.57	0.35	310.52	0.60	57.97	2.77	17.08	0.14	3.02
	21	10.10	0.33	20.87	0.58	0.34	310.39	0.58	58.65	2.77	17.39	0.15	3.03
	22	9.85	0.34	21.09	0.59	0.32	310.19	0.56	59.25	2.80	17.69	0.15	3.04
	23	10.18	0.34	21.16	0.59	0.31	310.18	0.54	59.95	2.81	17.95	0.16	3.05
	24	10.08	0.35	21.40	0.60	0.30	310.08	0.53	60.55	2.84	18.21	0.16	3.06
	25	10.02	0.35	21.37	0.61	0.29	309.87	0.51	61.16	2.84	18.47	0.16	3.07
	26	10.18	0.35	21.34	0.62	0.28	309.80	0.50	61.67	2.84	18.74	0.17	3.08
	27	9.93	0.36	21.33	0.63	0.28	309.69	0.49	62.27	2.83	19.01	0.17	3.09
	28	9.94	0.36	20.86	0.64	0.27	309.30	0.48	62.78	2.77	19.21	0.17	3.10
	29	9.94	0.36	20.30	0.64	0.26	309.05	0.46	63.21	2.70	19.42	0.18	3.11
	30	10.09	0.36	19.66	0.65	0.25	308.81	0.45	63.55	2.61	19.62	0.18	3.12

SGS Metcon

TEST No. CL-06

METALLURGICAL RESULTS

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**		
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14	
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height	
SAMPLE	**Composite 3 (Met-19/20)**	**CRUSH SIZE**	P100 minus 3 in.	
		LEACH SOLUTION	750 ppm fr g/l	
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	2.98	kg CaO/t of ore
		CURE CYCLE	0	Days
		FLOWRATE	9.78	lph/m^2

Time		**Feed Solution Flow Rate**	**Cumulative**										
			Extraction (g/t)			**Solution Grade (ppm)**			**Extraction (%)**			**Consumption**	
(Days)		**(lph/sq m)**	**Au**	**Cu**	**Ag**	**Au**	**Cu**	**Ag**	**Au**	**Cu**	**Ag**	**NaCN (kg/t)**	**CaO (kg/t)**
Leach	31	10.15	0.36	19.09	0.66	0.25	308.58	0.44	63.90	2.54	19.83	0.19	3.13
	32	10.02	0.37	18.78	0.66	0.24	308.46	0.43	64.16	2.49	20.03	0.19	3.14
	33	10.03	0.37	19.18	0.67	0.23	308.85	0.42	64.67	2.55	20.23	0.19	3.15
	34	10.08	0.37	19.67	0.68	0.23	309.34	0.42	65.18	2.61	20.44	0.20	3.15
	35	10.04	0.37	20.16	0.68	0.22	309.73	0.41	65.61	2.68	20.65	0.20	3.16
	36	10.09	0.38	20.83	0.69	0.22	310.11	0.40	66.04	2.77	20.84	0.20	3.18
	37	9.93	0.38	21.58	0.70	0.21	310.45	0.39	66.46	2.87	21.02	0.21	3.19
	38	10.13	0.38	22.22	0.70	0.21	310.71	0.39	66.89	2.95	21.22	0.21	3.21
	39	9.97	0.38	21.87	0.71	0.20	310.44	0.38	67.15	2.91	21.43	0.22	3.23
	40	9.95	0.38	21.45	0.72	0.20	310.18	0.37	67.32	2.85	21.61	0.22	3.24
	41	9.91	0.38	21.73	0.72	0.20	310.17	0.37	67.49	2.89	21.79	0.23	3.26
	42	10.07	0.39	21.86	0.73	0.19	310.17	0.36	67.58	2.90	21.97	0.23	3.27
	43	10.03	0.39	22.83	0.73	0.19	310.26	0.35	67.66	3.03	22.14	0.23	3.29
	44	9.95	0.39	24.02	0.74	0.18	310.41	0.35	67.75	3.19	22.32	0.24	3.30
	45	9.97	0.39	25.23	0.74	0.18	310.49	0.34	67.83	3.35	22.48	0.24	3.32
	46	9.90	0.39	25.92	0.75	0.17	310.48	0.34	67.92	3.44	22.64	0.24	3.33
	47	9.91	0.39	26.90	0.76	0.17	310.47	0.33	68.00	3.57	22.80	0.25	3.35
	48	9.87	0.39	27.45	0.76	0.17	310.40	0.33	68.04	3.65	22.96	0.25	3.36
	49	9.91	0.39	27.87	0.77	0.16	310.33	0.32	68.09	3.70	23.10	0.25	3.38
	50	10.02	0.39	28.54	0.77	0.16	310.22	0.32	68.13	3.79	23.24	0.25	3.39
	51	9.97	0.39	29.22	0.77	0.16	310.18	0.32	68.17	3.88	23.38	0.26	3.41
	52	9.96	0.39	30.35	0.78	0.16	310.29	0.31	68.21	4.03	23.53	0.26	3.42
	53	9.97	0.39	31.06	0.79	0.15	310.25	0.31	68.26	4.13	23.75	0.26	3.44
Wash	54	9.99	0.39	43.11	0.79	0.15	309.11	0.30	68.30	5.73	23.90	0.23	3.44
	55	9.90	0.39	46.02	0.80	0.15	304.54	0.30	68.34	6.11	24.01	0.23	3.43
	56	9.90	0.39	47.04	0.80	0.14	299.47	0.30	68.38	6.25	24.13	0.22	3.43
	57	9.83	0.39	47.52	0.80	0.14	294.39	0.29	68.43	6.31	24.22	0.22	3.43
	58	9.82	0.39	47.85	0.80	0.14	289.46	0.29	68.47	6.36	24.28	0.22	3.43
	59	9.80	0.39	48.09	0.81	0.14	284.66	0.28	68.51	6.39	24.33	0.22	3.42
	60	9.91	0.39	48.28	0.81	0.14	279.98	0.28	68.55	6.42	24.39	0.22	3.42

SGS Metcon

TEST No. CL-06

METALLURGICAL RESULTS

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**		
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14	
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height	
SAMPLE	**Composite 3 (Met-19/20)**	**CRUSH SIZE**	P100 minus 3 in.	
		LEACH SOLUTION	750 ppm fr g/l	
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	2.98	kg CaO/t of ore
		CURE CYCLE	0	Days
		FLOWRATE	9.78	lph/m^2

Time (Days)		Feed Solution Flow Rate (lph/sq m)	Cumulative										
			Extraction (g/t)			Solution Grade (ppm)			Extraction (%)			Consumption	
			Au	Cu	Ag	Au	Cu	Ag	Au	Cu	Ag	NaCN (kg/t)	CaO (kg/t)
Wash	61	9.72	0.39	48.43	0.81	0.13	275.46	0.28	68.72	6.43	24.45	0.22	3.42
	62	9.82	0.39	48.53	0.81	0.13	271.05	0.27	68.89	6.45	24.49	0.22	3.42
	63	9.88	0.39	48.57	0.81	0.13	266.77	0.27	69.06	6.45	24.54	0.22	3.42
	64	9.91	0.39	48.62	0.81	0.13	262.60	0.26	69.23	6.46	24.58	0.22	3.42
	65	9.79	0.40	48.67	0.82	0.13	258.56	0.26	69.40	6.47	24.62	0.22	3.42
	66	9.79	0.40	48.72	0.82	0.12	254.64	0.26	69.48	6.47	24.67	0.22	3.42
	67	9.82	0.40	48.77	0.82	0.12	250.83	0.25	69.57	6.48	24.71	0.22	3.42
	68	9.78	0.40	48.86	0.82	0.12	247.19	0.25	69.61	6.49	24.74	0.22	3.42
	69	9.96	0.40	48.96	0.82	0.12	243.62	0.25	69.65	6.50	24.77	0.22	3.42
	70	9.94	0.40	49.06	0.82	0.12	240.13	0.24	69.69	6.52	24.80	0.22	3.42
	71	9.92	0.40	49.11	0.82	0.12	236.75	0.24	69.74	6.52	24.81	0.22	3.42
	72	10.05	0.40	49.15	0.82	0.11	233.40	0.24	69.78	6.53	24.83	0.21	3.42
	73	10.02	0.40	49.20	0.82	0.11	230.15	0.23	69.82	6.54	24.84	0.21	3.42
	74	9.85	0.40	49.25	0.82	0.11	227.04	0.23	69.87	6.54	24.86	0.21	3.42
	75	9.92	0.40	49.25	0.82	0.11	224.00	0.23	69.91	6.54	24.90	0.21	3.41
	76	9.93	0.40	49.25	0.83	0.11	221.01	0.23	69.95	6.54	24.95	0.21	3.41
	77	9.91	0.40	49.25	0.83	0.11	218.12	0.22	69.99	6.54	24.99	0.21	3.41
	78	9.87	0.40	49.25	0.83	0.11	215.30	0.22	70.04	6.54	25.04	0.21	3.41
	79	9.93	0.40	49.25	0.83	0.10	212.54	0.22	70.08	6.54	25.08	0.21	3.41
	80	9.96	0.40	49.25	0.83	0.10	209.91	0.22	70.12	6.54	25.12	0.21	3.41
	81	9.91	0.40	49.25	0.83	0.10	207.32	0.21	70.16	6.54	25.17	0.21	3.41
	82	10.05	0.40	49.30	0.83	0.10	204.81	0.21	70.21	6.55	25.20	0.21	3.41
	83	10.00	0.40	49.34	0.84	0.10	202.30	0.21	70.25	6.56	25.23	0.21	3.41
	84	10.00	0.40	49.38	0.84	0.10	199.91	0.21	70.29	6.56	25.25	0.21	3.41
	85	9.94	0.40	49.43	0.84	0.10	197.54	0.20	70.33	6.57	25.28	0.21	3.41
	86	9.84	0.40	49.47	0.84	0.10	195.28	0.20	70.38	6.57	25.31	0.21	3.41
	87	9.93	0.40	49.51	0.84	0.10	193.02	0.20	70.42	6.58	25.34	0.21	3.41
	88	9.88	0.40	49.56	0.84	0.09	190.85	0.20	70.46	6.58	25.37	0.21	3.41
	89	9.92	0.40	49.60	0.84	0.09	188.70	0.20	70.50	6.59	25.40	0.21	3.41
	90	9.88	0.40	49.64	0.84	0.09	186.61	0.19	70.55	6.60	25.43	0.21	3.41

SGS Metcon

TEST No. CL-06

METALLURGICAL RESULTS

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**		
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14	
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height	
SAMPLE	**Composite 3 (Met-19/20)**	**CRUSH SIZE**	P100 minus 3 in.	
		LEACH SOLUTION	750 ppm fr g/l	
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	2.98	kg CaO/t of ore
		CURE CYCLE	0	Days
		FLOWRATE	9.78	lph/m^2

Time		**Feed Solution Flow Rate**	**Cumulative**										
			Extraction (g/t)			**Solution Grade (ppm)**			**Extraction (%)**			**Consumption**	
	(Days)	**(lph/sq m)**	**Au**	**Cu**	**Ag**	**Au**	**Cu**	**Ag**	**Au**	**Cu**	**Ag**	**NaCN (kg/t)**	**CaO (kg/t)**
Wash	91	9.85	0.40	49.69	0.84	0.09	184.57	0.19	70.59	6.60	25.46	0.21	3.41
	92	9.75	0.40	49.73	0.84	0.09	182.59	0.19	70.63	6.61	25.49	0.20	3.41
	93	9.90	0.40	49.77	0.85	0.09	180.63	0.19	70.67	6.61	25.52	0.20	3.41
	94	9.91	0.40	49.82	0.85	0.09	178.72	0.19	70.71	6.62	25.55	0.20	3.41
	95	10.05	0.40	49.86	0.85	0.09	176.81	0.18	70.76	6.62	25.58	0.20	3.40
	96	9.91	0.40	49.91	0.85	0.09	174.95	0.18	70.84	6.63	25.59	0.20	3.40
	97	9.97	0.40	49.96	0.85	0.09	173.14	0.18	70.93	6.64	25.61	0.20	3.40
	98	10.00	0.40	50.01	0.85	0.09	171.36	0.18	71.01	6.64	25.62	0.20	3.40
	99	9.99	0.41	50.06	0.85	0.08	169.62	0.18	71.10	6.65	25.63	0.20	3.40
	100	9.93	0.41	50.11	0.85	0.08	167.92	0.18	71.19	6.66	25.65	0.20	3.40
	101	9.90	0.41	50.15	0.85	0.08	166.26	0.17	71.27	6.66	25.66	0.20	3.40
	102	10.04	0.41	50.20	0.85	0.08	164.62	0.17	71.36	6.67	25.68	0.20	3.40
	103	10.05	0.41	50.25	0.85	0.08	163.01	0.17	71.44	6.68	25.69	0.20	3.40
	104	9.87	0.41	50.30	0.85	0.08	161.44	0.17	71.53	6.68	25.71	0.20	3.40
	105	9.97	0.41	50.35	0.85	0.08	159.89	0.17	71.61	6.69	25.72	0.20	3.40
	106	9.88	0.41	50.40	0.85	0.08	158.38	0.17	71.70	6.70	25.74	0.20	3.39
	107	9.75	0.41	50.45	0.85	0.08	156.92	0.16	71.78	6.70	25.75	0.20	3.39
	108	9.82	0.41	50.50	0.85	0.08	155.47	0.16	71.87	6.71	25.77	0.20	3.39
	109	9.82	0.41	50.54	0.85	0.08	154.05	0.16	71.95	6.72	25.78	0.20	3.39
	110	9.66	0.41	50.59	0.85	0.08	152.68	0.16	72.04	6.72	25.80	0.20	3.39
	111	10.02	0.41	50.64	0.85	0.08	151.30	0.16	72.12	6.73	25.81	0.20	3.39
	112	10.26	0.41	50.69	0.86	0.08	149.92	0.16	72.21	6.73	25.83	0.20	3.39
	113	10.09	0.41	50.74	0.86	0.08	148.60	0.16	72.29	6.74	25.84	0.19	3.39
	114	10.06	0.41	50.79	0.86	0.07	147.31	0.16	72.38	6.75	25.85	0.19	3.39
	115	9.91	0.41	50.84	0.86	0.07	146.02	0.15	72.47	6.75	25.87	0.19	3.39
	116	9.91	0.41	50.88	0.86	0.07	144.76	0.15	72.55	6.76	25.88	0.19	3.39
	117	10.06	0.41	50.93	0.86	0.07	143.53	0.15	72.64	6.77	25.90	0.19	3.39
	118	10.08	0.41	50.98	0.86	0.07	142.32	0.15	72.72	6.77	25.91	0.19	3.39
	119	9.74	0.42	51.03	0.86	0.07	141.16	0.15	72.80	6.78	25.93	0.19	3.39
	120	9.86	0.42	51.08	0.86	0.07	140.01	0.15	72.89	6.79	25.94	0.19	3.39

SGS Metcon

TEST No. CL-06

METALLURGICAL RESULTS

CLIENT	Western Copper & Gold Corp.	**TEST CONDITIONS**		
	SGS Metcon Project No.: M-709-03	**TEST START**	05/01/14	
PROJECT	Casino Project	**COLUMN SIZE**	6 in. Diameter X 10 ft Height	
SAMPLE	**Composite 3 (Met-19/20)**	**CRUSH SIZE**	P100 minus 3 in.	
		LEACH SOLUTION	750 ppm fr	g/l
OBJECTIVE	Gold and Silver Extraction vs Time	**CURE DOSAGE**	2.98	kg CaO/t of ore
		CURE CYCLE	0	Days
		FLOWRATE	9.78	lph/m^2

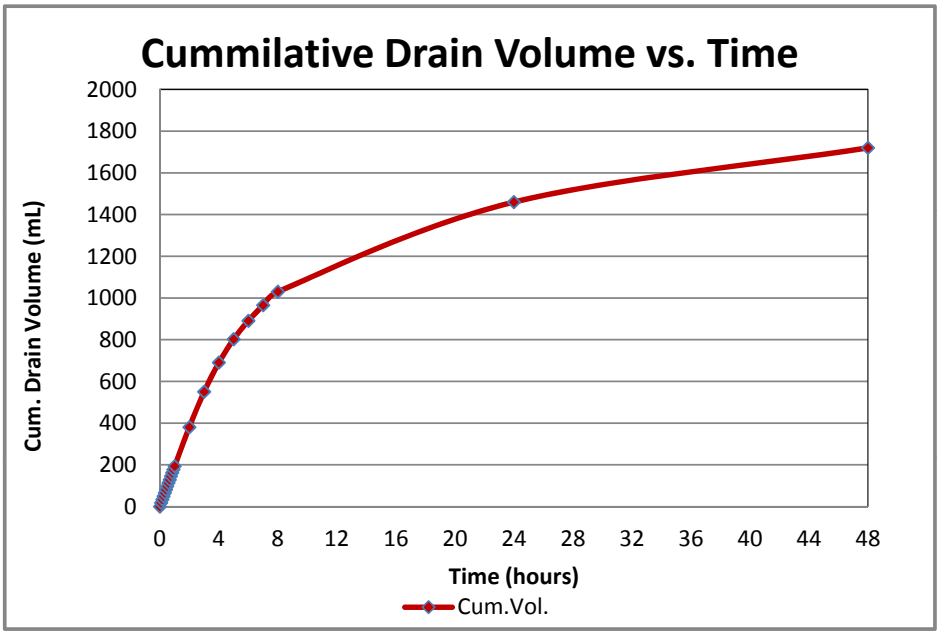
Time		**Feed Solution Flow Rate**	**Cumulative**										
			Extraction (g/t)			**Solution Grade (ppm)**			**Extraction (%)**			**Consumption**	
(Days)		**(lph/sq m)**	**Au**	**Cu**	**Ag**	**Au**	**Cu**	**Ag**	**Au**	**Cu**	**Ag**	**NaCN (kg/t)**	**CaO (kg/t)**
Wash	121	10.23	0.42	51.13	0.86	0.07	138.82	0.15	72.97	6.79	25.96	0.19	3.39
	122	9.95	0.42	51.17	0.86	0.07	137.69	0.15	73.06	6.80	25.97	0.19	3.38
	123	9.74	0.42	51.22	0.86	0.07	136.60	0.14	73.14	6.81	25.99	0.19	3.38
	124	9.82	0.42	51.22	0.86	0.07	135.51	0.14	73.18	6.81	25.99	0.19	3.38
	125	9.80	0.42	51.23	0.86	0.07	134.44	0.14	73.23	6.81	26.00	0.19	3.38
	126	10.05	0.42	51.23	0.86	0.07	133.37	0.14	73.27	6.81	26.01	0.19	3.38
Drain	127	0.00	0.42	51.23	0.86	0.07	133.14	0.14	73.28	6.81	26.01	0.19	3.38
Drain	128	0.00	0.42	51.23	0.86	0.07	133.11	0.14	73.28	6.81	26.01	0.19	3.38
Drain	129	0.00	0.42	51.23	0.86	0.07	133.07	0.14	73.28	6.81	26.01	0.19	3.38

APPENDIX 10

Drain Down Data for CL-01 to CL-06

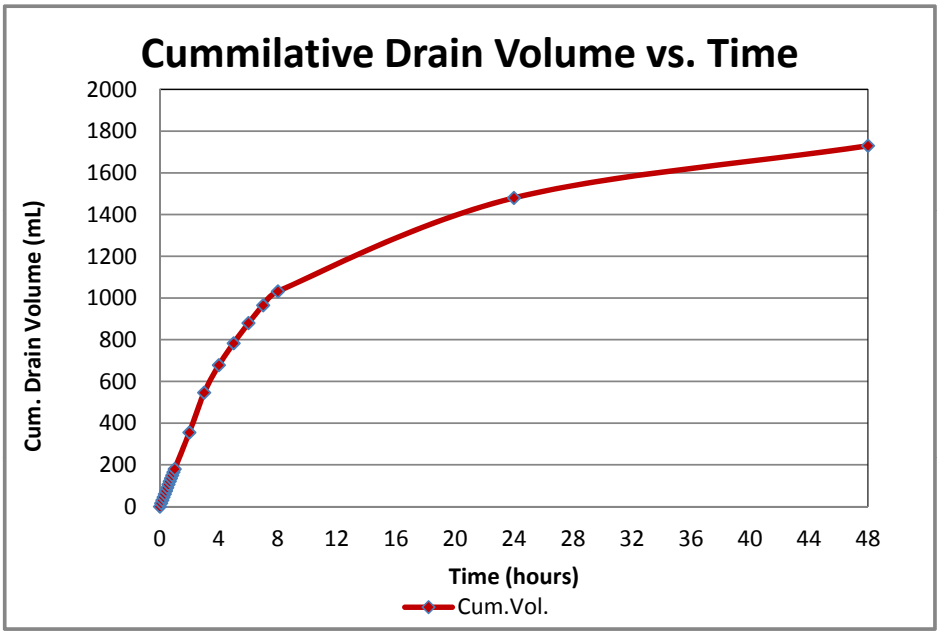
M-709-03 Drain Volume Measurements

Time			Drain Volumes (mL)	
			CL-01	
8 Aug. 2014	(min)	(hour)	Vol.	Cum.Vol.
7:00 AM	0	0.00	0.0	0.0
7:05 AM	5	0.08	18.0	18.0
7:10 AM	10	0.17	15.5	33.5
7:15 AM	15	0.25	16.0	49.5
7:20 AM	20	0.33	16.0	65.5
7:25 AM	25	0.42	16.0	81.5
7:30 AM	30	0.50	16.0	97.5
7:35 AM	35	0.58	16.0	113.5
7:40 AM	40	0.67	15.0	128.5
7:45 AM	45	0.75	17.0	145.5
7:50 AM	50	0.83	16.5	162.0
7:55 AM	55	0.92	15.5	177.5
8:00 AM	60	1.00	16.0	193.5
9:00 AM	120	2.00	187.0	380.5
10:00 AM	180	3.00	170.0	550.5
11:00 AM	240	4.00	140.0	690.5
12:00 PM	300	5.00	112.0	802.5
1:00 PM	360	6.00	88.0	890.5
2:00 PM	420	7.00	75.0	965.5
3:00 PM	480	8.00	65.0	1030.5
		24.00	1460.0	1460.0
		48.00	260.0	1720.0



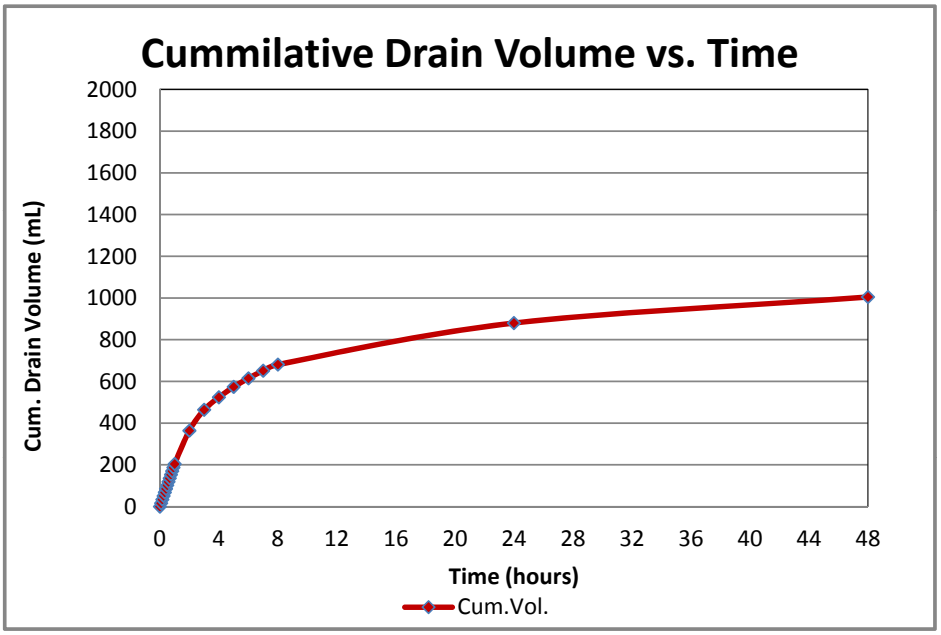
M-709-03 Drain Volume Measurements

Time			Drain Volumes (mL)	
			CL-02	
4 Sept. 2014	(min)	(hour)	Vol.	Cum.Vol.
7:00 AM	0	0.00	0.0	0.0
7:05 AM	5	0.08	16.0	16.0
7:10 AM	10	0.17	15.0	31.0
7:15 AM	15	0.25	14.0	45.0
7:20 AM	20	0.33	15.0	60.0
7:25 AM	25	0.42	15.5	75.5
7:30 AM	30	0.50	15.0	90.5
7:35 AM	35	0.58	15.5	106.0
7:40 AM	40	0.67	15.0	121.0
7:45 AM	45	0.75	14.5	135.5
7:50 AM	50	0.83	14.0	149.5
7:55 AM	55	0.92	15.5	165.0
8:00 AM	60	1.00	15.0	180.0
9:00 AM	120	2.00	175.0	355.0
10:00 AM	180	3.00	191.0	546.0
11:00 AM	240	4.00	132.0	678.0
12:00 PM	300	5.00	105.0	783.0
1:00 PM	360	6.00	97.0	880.0
2:00 PM	420	7.00	85.0	965.0
3:00 PM	480	8.00	67.0	1032.0
		24.00	1480.0	1480.0
		48.00	250.0	1730.0



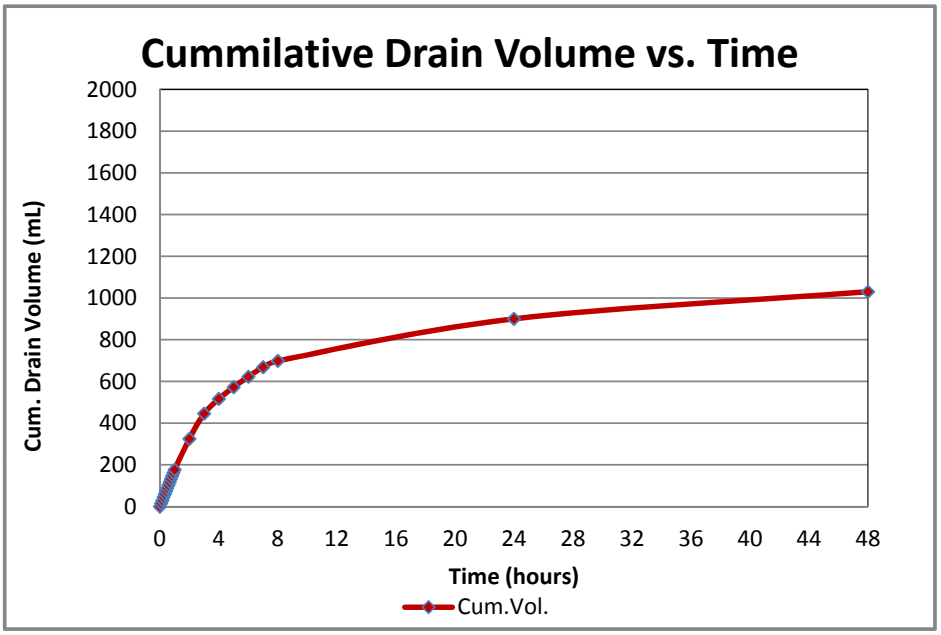
M-709-03 Drain Volume Measurements

Time			Drain Volumes (mL)	
			CL-03	
20 Aug. 2014	(min)	(hour)	Vol.	Cum.Vol.
7:00 AM	0	0.00	0.0	0.0
7:05 AM	5	0.08	16.0	16.0
7:10 AM	10	0.17	18.0	34.0
7:15 AM	15	0.25	17.0	51.0
7:20 AM	20	0.33	17.0	68.0
7:25 AM	25	0.42	17.0	85.0
7:30 AM	30	0.50	17.0	102.0
7:35 AM	35	0.58	17.0	119.0
7:40 AM	40	0.67	17.0	136.0
7:45 AM	45	0.75	17.0	153.0
7:50 AM	50	0.83	17.0	170.0
7:55 AM	55	0.92	17.0	187.0
8:00 AM	60	1.00	17.0	204.0
9:00 AM	120	2.00	160.0	364.0
10:00 AM	180	3.00	100.0	464.0
11:00 AM	240	4.00	60.0	524.0
12:00 PM	300	5.00	50.0	574.0
1:00 PM	360	6.00	41.0	615.0
2:00 PM	420	7.00	36.5	651.5
3:00 PM	480	8.00	29.5	681.0
		24.00	880.0	880.0
		48.00	125.0	1005.0



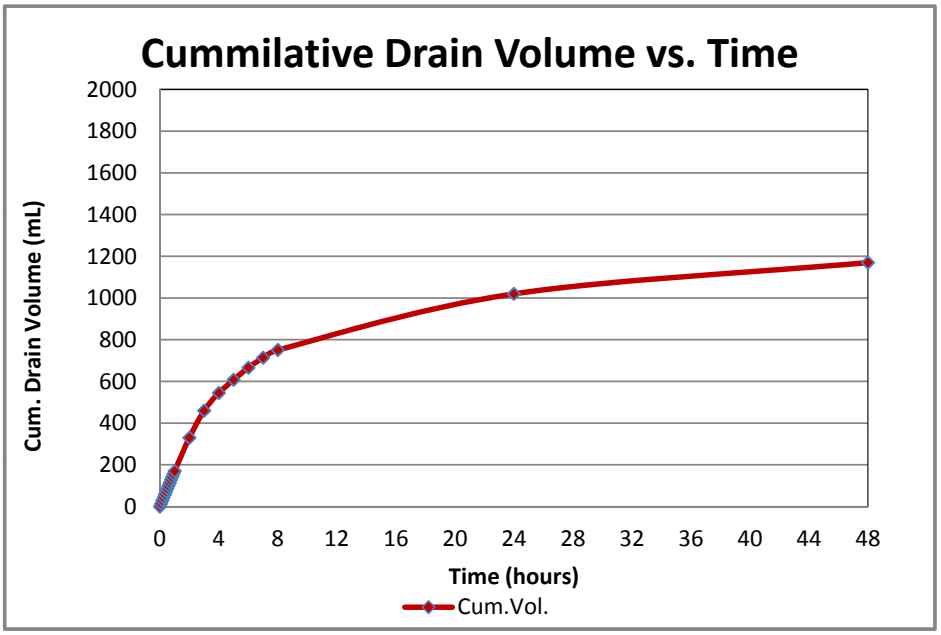
M-709-03 Drain Volume Measurements

Time			Drain Volumes (mL)	
			CL-04	
4 Sept. 2014	(min)	(hour)	Vol.	Cum.Vol.
7:00 AM	0	0.00	0.0	0.0
7:05 AM	5	0.08	15.5	15.5
7:10 AM	10	0.17	14.0	29.5
7:15 AM	15	0.25	15.5	45.0
7:20 AM	20	0.33	14.5	59.5
7:25 AM	25	0.42	15.0	74.5
7:30 AM	30	0.50	14.0	88.5
7:35 AM	35	0.58	14.5	103.0
7:40 AM	40	0.67	14.5	117.5
7:45 AM	45	0.75	15.0	132.5
7:50 AM	50	0.83	15.0	147.5
7:55 AM	55	0.92	14.5	162.0
8:00 AM	60	1.00	14.5	176.5
9:00 AM	120	2.00	148.0	324.5
10:00 AM	180	3.00	121.0	445.5
11:00 AM	240	4.00	71.0	516.5
12:00 PM	300	5.00	56.0	572.5
1:00 PM	360	6.00	50.0	622.5
2:00 PM	420	7.00	46.0	668.5
3:00 PM	480	8.00	30.0	698.5
		24.00	900.0	900.0
		48.00	130.0	1030.0



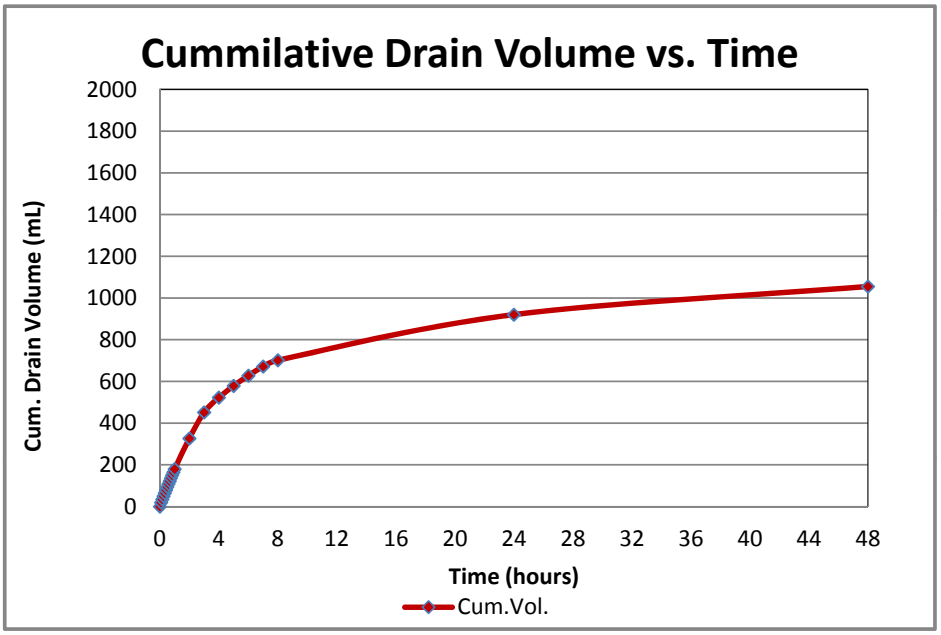
M-709-03 Drain Volume Measurements

Time			Drain Volumes (mL)	
			CL-05	
20 Aug. 2014	(min)	(hour)	Vol.	Cum.Vol.
7:00 AM	0	0.00	0.0	0.0
7:05 AM	5	0.08	14.0	14.0
7:10 AM	10	0.17	15.0	29.0
7:15 AM	15	0.25	14.0	43.0
7:20 AM	20	0.33	15.0	58.0
7:25 AM	25	0.42	14.0	72.0
7:30 AM	30	0.50	14.0	86.0
7:35 AM	35	0.58	14.0	100.0
7:40 AM	40	0.67	14.0	114.0
7:45 AM	45	0.75	14.0	128.0
7:50 AM	50	0.83	14.0	142.0
7:55 AM	55	0.92	14.0	156.0
8:00 AM	60	1.00	14.0	170.0
9:00 AM	120	2.00	160.0	330.0
10:00 AM	180	3.00	130.0	460.0
11:00 AM	240	4.00	85.0	545.0
12:00 PM	300	5.00	63.0	608.0
1:00 PM	360	6.00	58.0	666.0
2:00 PM	420	7.00	48.0	714.0
3:00 PM	480	8.00	37.0	751.0
		24.00	1020.0	1020.0
		48.00	150.0	1170.0



M-709-03 Drain Volume Measurements

Time			Drain Volumes (mL)	
			CL-06	
4 Sept. 2014	(min)	(hour)	Vol.	Cum.Vol.
7:00 AM	0	0.00	0.0	0.0
7:05 AM	5	0.08	19.0	19.0
7:10 AM	10	0.17	15.5	34.5
7:15 AM	15	0.25	15.0	49.5
7:20 AM	20	0.33	15.0	64.5
7:25 AM	25	0.42	15.0	79.5
7:30 AM	30	0.50	14.5	94.0
7:35 AM	35	0.58	14.0	108.0
7:40 AM	40	0.67	14.0	122.0
7:45 AM	45	0.75	14.5	136.5
7:50 AM	50	0.83	14.0	150.5
7:55 AM	55	0.92	14.0	164.5
8:00 AM	60	1.00	15.0	179.5
9:00 AM	120	2.00	147.0	326.5
10:00 AM	180	3.00	125.0	451.5
11:00 AM	240	4.00	71.0	522.5
12:00 PM	300	5.00	56.0	578.5
1:00 PM	360	6.00	49.0	627.5
2:00 PM	420	7.00	44.0	671.5
3:00 PM	480	8.00	30.0	701.5
		24.00	920.0	920.0
		48.00	135.0	1055.0



APPENDIX 11

Residue Screen Analysis and Assays

SGS Metcon / KD Engineering
7701 BUSINESS PARK DRIVE
TUCSON , ARIZONA 85743
COLUMN LEACH RESIDUE SAMPLE
Client ID: WESTERN COPPER & GOLD
Project No: M-709-03 - CASINO PROJECT
Sample ID: CL-01 (MET-02 & MET-05)

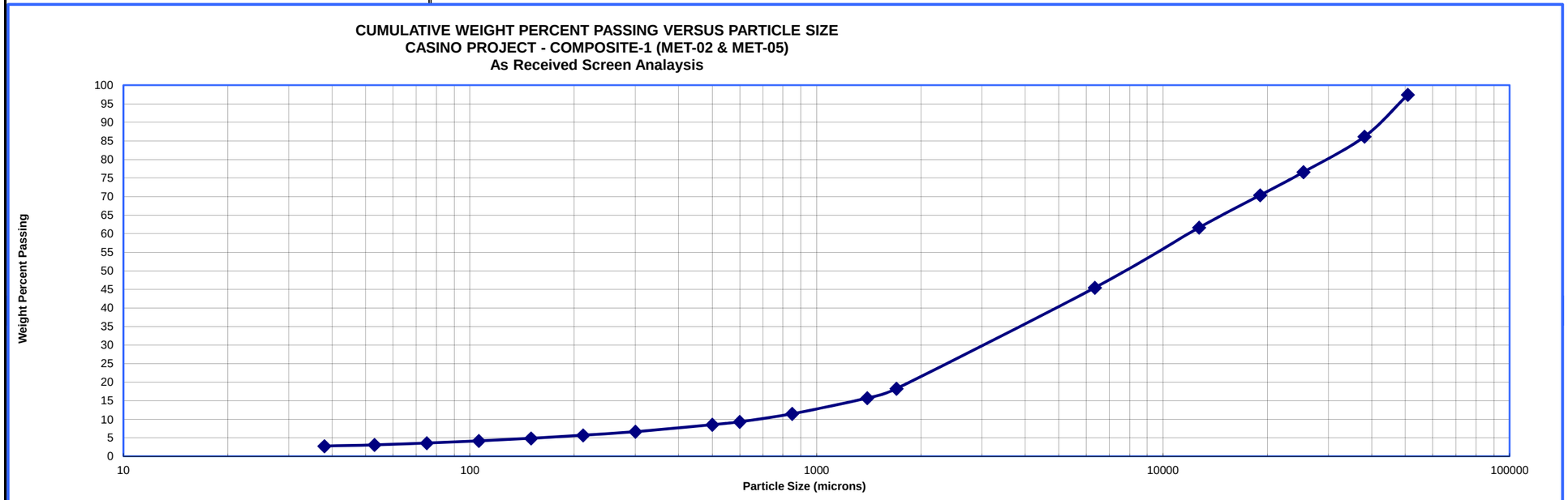
SCREEN ANALYSIS

Sample: P100 minus 3 inch
Size: As Received at METCON Research

ANALYTICAL RESULTS

NOMINAL OPENINGS			Sample Weights (kg)	Weight Distribution (%)	Cumulative (%)		Au (g/t)			Ag (g/t)			Cu (%)			Fe (%)			CNAu (g/t)			CNAg (g/t)			CNCu (%)		
mm	Inch	ASTM			Retained	Passing	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.
50.80	2	2"	1.44	2.59	2.59	97.41	0.070	0.002	4.24	0.800	0.021	3.12	0.042	0.001	11.86	1.910	0.050	3.42	0.090	0.002	4.36	0.180	0.005	2.39	0.003	0.000	5.00
38.10	1.500	1-1/2"	6.26	11.28	13.87	86.13	0.110	0.012	28.94	0.900	0.101	15.28	0.014	0.002	17.19	1.620	0.183	12.60	0.080	0.009	16.85	0.240	0.027	13.85	0.003	0.000	21.75
25.40	1.000	1"	5.30	9.55	23.41	76.59	0.070	0.007	15.59	0.800	0.076	11.50	0.010	0.001	10.40	1.590	0.152	10.47	0.060	0.006	10.70	0.200	0.019	9.78	0.002	0.000	12.28
19.05	0.750	3/4"	3.46	6.23	29.65	70.35	0.040	0.002	5.82	0.800	0.050	7.51	0.009	0.001	6.11	1.570	0.098	6.75	0.050	0.003	5.82	0.170	0.011	5.42	0.001	0.000	4.01
12.70	0.500	1/2"	4.84	8.72	38.36	61.64	0.040	0.003	8.14	0.500	0.044	6.56	0.018	0.002	17.09	1.340	0.117	8.06	0.090	0.008	14.65	0.180	0.016	8.03	0.001	0.000	5.61
6.35	0.250	1/4"	9.00	16.21	54.57	45.43	0.020	0.003	7.57	0.500	0.081	12.20	0.006	0.001	10.59	1.050	0.170	11.74	0.090	0.015	27.25	0.180	0.029	14.94	0.001	0.000	10.42
1.70	0.065	10	15.10	27.20	81.77	18.23	0.020	0.005	12.69	0.400	0.109	16.38	0.003	0.001	8.89	0.740	0.201	13.88	0.020	0.005	10.16	0.200	0.054	27.85	0.001	0.000	17.49
1.40	0.055	14	1.41	2.54	84.31	15.69																					
0.85	0.033	20	2.35	4.23	88.54	11.46																					
0.60	0.024	28	1.20	2.16	90.70	9.30																					
0.50	0.020	35	0.44	0.79	91.49	8.51																					
0.30	0.012	48	1.04	1.87	93.36	6.64																					
0.21	0.008	65	0.54	0.97	94.33	5.67	0.040	0.007	17.01	1.000	0.182	27.44	0.009	0.002	17.87	2.630	0.479	33.07	0.030	0.005	10.21	0.190	0.035	17.73	0.002	0.000	23.44
0.15	0.006	100	0.46	0.83	95.16	4.84																					
0.11	0.004	150	0.37	0.68	95.84	4.16																					
0.08	0.003	200	0.33	0.60	96.44	3.56																					
0.05	0.002	270	0.26	0.47	96.92	3.08																					
0.04	0.001	400	0.19	0.34	97.26	2.74																					
MINUS		-10	1.52	2.74	100.00	0.00																					
TOTALS			**55.52**	**100.00**				**0.043**	**100.00**		**0.664**	**100.00**		**0.009**	**100.00**		**1.449**	**100.00**		**0.054**	**100.00**		**0.195**	**100.00**		**0.002**	**100.00**
CALCULATED ASSAY							**0.043**			**0.664**			**0.009**			**1.449**			**0.054**			**0.195**			**0.002**		
COMPOSITE ASSAY (Pulverized)							**0.040**			**0.600**			**0.008**			**1.440**			**0.090**			**0.200**			**0.002**		

Sample ID	Assay Results						
COMPOSITE ASSAY (Pulverized)	Au (g/t)	Ag (g/t)	Cu (%)	Fe (%)	CNAu (g/t)	CNAg (g/t)	CNCu (%)
	0.040	0.600	0.008	1.440	0.090	0.200	0.002



SGS Metcon / KD Engineering
7701 BUSINESS PARK DRIVE
TUCSON , ARIZONA 85743
COLUMN LEACH RESIDUE SAMPLE
Client ID: WESTERN COPPER & GOLD
Project No: M-709-03 - CASINO PROJECT
Sample ID: CL-02 (MET-02 & MET-05)

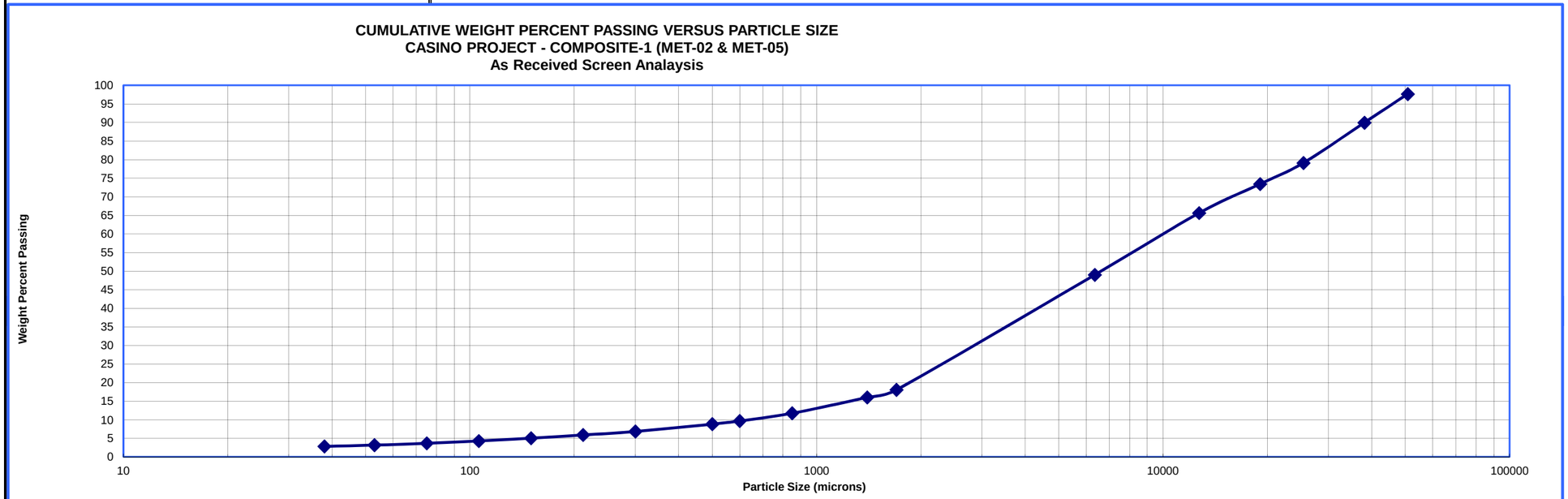
SCREEN ANALYSIS

Sample: P100 minus 3 inch
Size: As Received at METCON Research

ANALYTICAL RESULTS

NOMINAL OPENINGS			Sample Weights (kg)	Weight Distribution (%)	Cumulative (%)		Au (g/t)			Ag (g/t)			Cu (%)			Fe (%)			CNAu (g/t)			CNAg (g/t)			CNCu (%)		
mm	Inch	ASTM			Retained	Passing	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.
50.80	2	2"	1.20	2.36	2.36	97.64	0.090	0.002	4.14	0.900	0.021	3.07	0.022	0.001	6.07	1.730	0.041	2.50	0.005	0.000	2.36	0.180	0.004	2.36	0.004	0.000	6.23
38.10	1.500	1-1/2"	3.92	7.71	10.06	89.94	0.080	0.006	12.03	1.000	0.077	11.15	0.013	0.001	11.71	1.930	0.149	9.10	0.005	0.000	7.71	0.200	0.015	8.56	0.003	0.000	15.27
25.40	1.000	1"	5.52	10.85	20.92	79.08	0.070	0.008	14.83	0.800	0.087	12.56	0.013	0.001	16.49	1.730	0.188	11.49	0.005	0.001	10.85	0.190	0.021	11.45	0.002	0.000	14.34
19.05	0.750	3/4"	2.88	5.66	26.58	73.42	0.060	0.003	6.63	0.700	0.040	5.73	0.008	0.000	5.30	1.530	0.087	5.30	0.005	0.000	5.66	0.190	0.011	5.97	0.001	0.000	3.74
12.70	0.500	1/2"	3.97	7.80	34.38	65.62	0.050	0.004	7.62	0.600	0.047	6.77	0.008	0.001	7.30	1.450	0.113	6.93	0.005	0.000	7.80	0.180	0.014	7.80	0.001	0.000	5.16
6.35	0.250	1/4"	8.46	16.63	51.01	48.99	0.040	0.007	12.98	0.400	0.067	9.62	0.005	0.001	9.72	1.100	0.183	11.20	0.005	0.001	16.63	0.180	0.030	16.62	0.001	0.000	10.99
1.70	0.065	10	15.74	30.94	81.95	18.05	0.040	0.012	24.16	0.500	0.155	22.38	0.005	0.002	18.09	1.220	0.377	23.11	0.005	0.002	30.94	0.170	0.053	29.21	0.001	0.000	20.44
1.40	0.055	14	1.03	2.02	83.98	16.02																					
0.85	0.033	20	2.17	4.27	88.25	11.75																					
0.60	0.024	28	1.05	2.07	90.32	9.68																					
0.50	0.020	35	0.44	0.86	91.18	8.82																					
0.30	0.012	48	1.01	1.98	93.15	6.85																					
0.21	0.008	65	0.48	0.94	94.10	5.90	0.050	0.009	17.61	1.100	0.199	28.72	0.012	0.002	25.32	2.750	0.496	30.38	0.005	0.001	18.05	0.180	0.032	18.04	0.002	0.000	23.84
0.15	0.006	100	0.44	0.86	94.96	5.04																					
0.11	0.004	150	0.38	0.75	95.71	4.29																					
0.08	0.003	200	0.33	0.64	96.35	3.65																					
0.05	0.002	270	0.24	0.47	96.82	3.18																					
0.04	0.001	400	0.18	0.36	97.18	2.82																					
MINUS		-10	1.44	2.82	100.00	0.00																					
TOTALS			**50.87**	**100.00**				**0.051**	**100.00**		**0.691**	**100.00**		**0.009**	**100.00**		**1.634**	**100.00**		**0.005**	**100.00**		**0.180**	**100.00**		**0.002**	**100.00**
CALCULATED ASSAY							**0.051**			**0.691**			**0.009**			**1.634**			**0.005**			**0.180**			**0.002**		
COMPOSITE ASSAY (Pulverized)							**0.050**			**0.700**			**0.009**			**1.620**			**0.005**			**0.180**			**0.002**		

Sample ID	Assay Results						
COMPOSITE ASSAY (Pulverized)	Au (g/t)	Ag (g/t)	Cu (%)	Fe (%)	CNAu (g/t)	CNAg (g/t)	CNCu (%)
	0.050	0.700	0.009	1.620	0.005	0.180	0.002



SGS Metcon / KD Engineering
7701 BUSINESS PARK DRIVE
TUCSON , ARIZONA 85743
COLUMN LEACH RESIDUE SAMPLE
Client ID: WESTERN COPPER & GOLD
Project No: M-709-03 - CASINO PROJECT
Sample ID: CL-03 (MET-11 & MET-17)

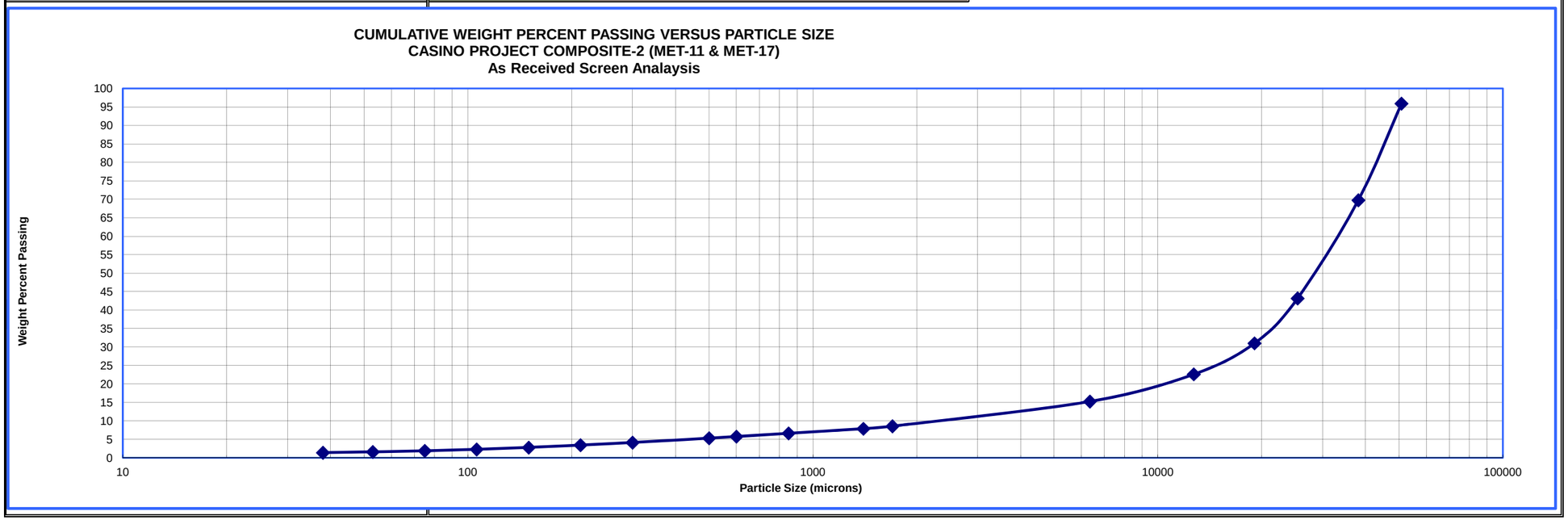
SCREEN ANALYSIS

Sample: P100 minus 3 inch
Size: As Received at METCON Research

ANALYTICAL RESULTS

NOMINAL OPENINGS			Sample Weights (kg)	Weight Distribution (%)	Cumulative (%)		Au (g/t)			Ag (g/t)			Cu (%)			Fe (%)			CNAu (g/t)			CNAg (g/t)			CNCu (%)		
mm	Inch	ASTM			Retained	Passing	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.
50.80	2	2"	2.02	4.09	4.09	95.91	0.260	0.011	5.48	3.000	0.123	4.77	0.024	0.001	2.70	1.870	0.077	3.82	0.180	0.007	5.98	2.000	0.082	6.38	0.014	0.001	4.37
38.10	1.500	1-1/2"	12.90	26.15	30.24	69.76	0.300	0.078	40.35	2.300	0.601	23.34	0.035	0.009	25.16	1.680	0.439	21.89	0.170	0.044	36.10	1.760	0.460	35.86	0.018	0.005	35.91
25.40	1.000	1"	13.12	26.59	56.83	43.17	0.220	0.059	30.09	2.200	0.585	22.71	0.040	0.011	29.25	1.690	0.449	22.40	0.110	0.029	23.75	1.680	0.447	34.81	0.020	0.005	40.58
19.05	0.750	3/4"	6.00	12.16	68.99	31.01	0.150	0.018	9.38	2.600	0.316	12.27	0.033	0.004	11.03	1.800	0.219	10.91	0.140	0.017	13.83	1.120	0.136	10.61	0.011	0.001	10.21
12.70	0.500	1/2"	4.14	8.39	77.38	22.62	0.130	0.011	5.61	2.700	0.227	8.80	0.027	0.002	6.23	1.980	0.166	8.28	0.120	0.010	8.18	0.700	0.059	4.58	0.005	0.000	3.20
6.35	0.250	1/4"	3.64	7.38	84.76	15.24	0.060	0.004	2.28	1.700	0.125	4.87	0.045	0.003	9.13	2.040	0.150	7.50	0.070	0.005	4.19	0.430	0.032	2.47	0.004	0.000	2.25
1.70	0.065	10	3.30	6.69	91.45	8.55	0.070	0.005	2.41	2.300	0.154	5.97	0.036	0.002	6.62	2.650	0.177	8.83	0.070	0.005	3.80	0.400	0.027	2.08	0.003	0.000	1.53
1.40	0.055	14	0.33	0.67	92.12	7.88																					
0.85	0.033	20	0.62	1.26	93.38	6.62																					
0.60	0.024	28	0.42	0.86	94.24	5.76																					
0.50	0.020	35	0.22	0.44	94.67	5.33																					
0.30	0.012	48	0.59	1.20	95.87	4.13																					
0.21	0.008	65	0.33	0.67	96.55	3.45	0.100	0.009	4.40	5.200	0.445	17.27	0.042	0.004	9.88	3.840	0.328	16.37	0.060	0.005	4.17	0.480	0.041	3.20	0.003	0.000	1.96
0.15	0.006	100	0.33	0.67	97.22	2.78																					
0.11	0.004	150	0.24	0.49	97.71	2.29																					
0.08	0.003	200	0.19	0.38	98.09	1.91																					
0.05	0.002	270	0.14	0.29	98.38	1.62																					
0.04	0.001	400	0.11	0.22	98.60	1.40																					
M I N U S		-10	0.69	1.40	100.00	0.00																					
TOTALS			**49.34**	**100.00**				**0.194**	**100.00**		**2.576**	**100.00**		**0.036**	**100.00**		**2.006**	**100.00**		**0.123**	**100.00**		**1.283**	**100.00**		**0.013**	**100.00**
CALCULATED ASSAY							**0.194**			**2.576**			**0.036**			**2.006**			**0.123**			**1.283**			**0.013**		
COMPOSITE ASSAY (Pulverized)							**0.280**			**2.500**			**0.037**			**1.990**			**0.170**			**0.900**			**0.008**		

Sample ID	Assay Results						
COMPOSITE ASSAY (Pulverized)	Au (g/t)	Ag (g/t)	Cu (%)	Fe (%)	CNAu (g/t)	CNAg (g/t)	CNCu (%)
	0.280	2.500	0.037	1.990	0.170	0.900	0.008



SGS Metcon / KD Engineering
7701 BUSINESS PARK DRIVE
TUCSON , ARIZONA 85743
COLUMN LEACH RESIDUE SAMPLE
Client ID: WESTERN COPPER & GOLD
Project No: M-709-03 - CASINO PROJECT
Sample ID: CL-04 (MET-11 & MET-17)

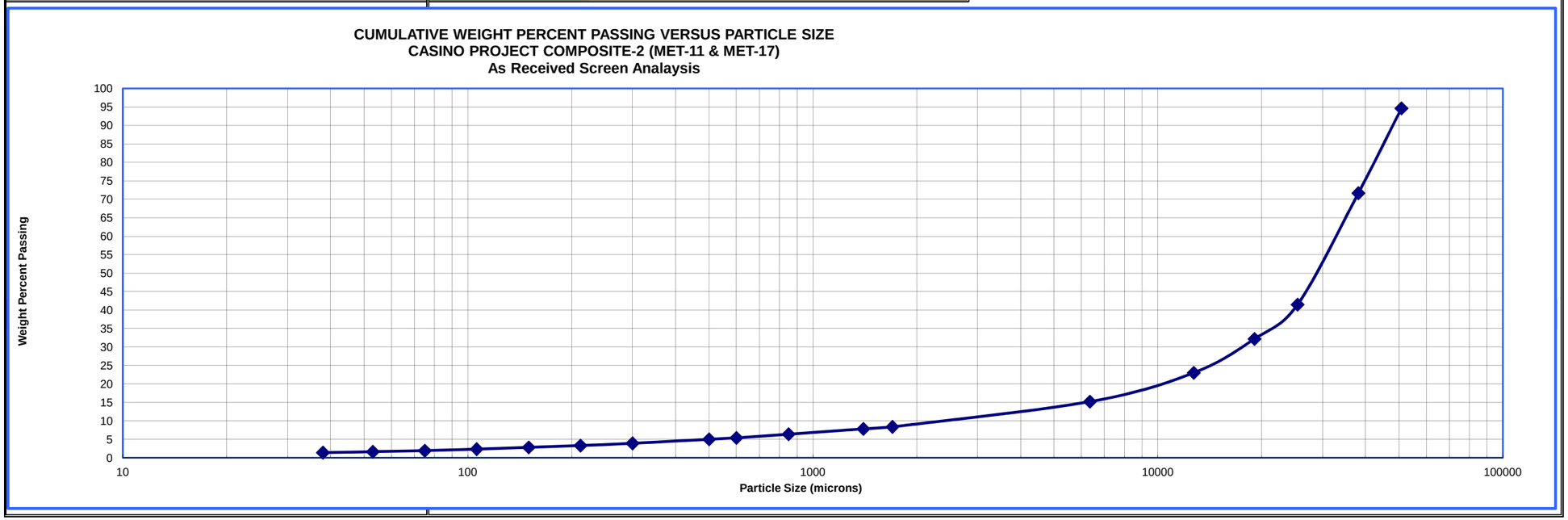
SCREEN ANALYSIS

Sample: P100 minus 3 inch
Size: As Received at METCON Research

ANALYTICAL RESULTS

NOMINAL OPENINGS			Sample Weights (kg)	Weight Distribution (%)	Cumulative (%)		Au (g/t)			Ag (g/t)			Cu (%)			Fe (%)			CNAu (g/t)			CNAg (g/t)			CNCu (%)		
mm	Inch	ASTM			Retained	Passing	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.
50.80	2	2"	2.68	5.37	5.37	94.63	0.310	0.017	8.44	2.900	0.156	5.24	0.030	0.002	5.08	2.080	0.112	4.69	0.150	0.008	7.86	1.830	0.098	7.29	0.015	0.001	9.02
38.10	1.500	1-1/2"	11.46	22.96	28.33	71.67	0.240	0.055	27.94	3.700	0.849	28.60	0.021	0.005	15.22	2.210	0.507	21.29	0.130	0.030	29.11	1.920	0.441	32.71	0.011	0.003	28.29
25.40	1.000	1"	15.06	30.17	58.49	41.51	0.250	0.075	38.24	3.300	0.996	33.52	0.024	0.007	22.86	2.370	0.715	30.00	0.140	0.042	41.20	1.680	0.507	37.61	0.010	0.003	33.80
19.05	0.750	3/4"	4.64	9.29	67.79	32.21	0.230	0.021	10.84	2.500	0.232	7.82	0.034	0.003	9.98	2.060	0.191	8.03	0.120	0.011	10.88	1.250	0.116	8.62	0.010	0.001	10.41
12.70	0.500	1/2"	4.58	9.17	76.96	23.04	0.130	0.012	6.05	2.200	0.202	6.80	0.039	0.004	11.30	2.110	0.194	8.12	0.070	0.006	6.26	0.780	0.072	5.31	0.008	0.001	8.22
6.35	0.250	1/4"	3.90	7.81	84.78	15.22	0.080	0.006	3.17	1.700	0.133	4.47	0.043	0.003	10.60	2.380	0.186	7.80	0.030	0.002	2.29	0.510	0.040	2.96	0.005	0.000	4.38
1.70	0.065	10	3.40	6.81	91.59	8.41	0.080	0.005	2.76	2.200	0.150	5.05	0.042	0.003	9.03	2.650	0.180	7.57	0.030	0.002	1.99	0.460	0.031	2.32	0.004	0.000	3.05
1.40	0.055	14	0.28	0.56	92.14	7.86																					
0.85	0.033	20	0.73	1.45	93.60	6.40																					
0.60	0.024	28	0.49	0.98	94.58	5.42																					
0.50	0.020	35	0.20	0.40	94.98	5.02																					
0.30	0.012	48	0.54	1.07	96.05	3.95																					
0.21	0.008	65	0.30	0.61	96.66	3.34	0.060	0.005	2.56	3.000	0.252	8.50	0.060	0.005	15.94	3.540	0.298	12.50	0.005	0.000	0.41	0.510	0.043	3.18	0.003	0.000	2.83
0.15	0.006	100	0.24	0.48	97.14	2.86																					
0.11	0.004	150	0.24	0.48	97.62	2.38																					
0.08	0.003	200	0.21	0.41	98.04	1.96																					
0.05	0.002	270	0.14	0.29	98.32	1.68																					
0.04	0.001	400	0.12	0.25	98.57	1.43																					
MINUS		-10	0.71	1.43	100.00	0.00																					
TOTALS			**49.92**	**100.00**				**0.197**	**100.00**		**2.970**	**100.00**		**0.032**	**100.00**		**2.383**	**100.00**		**0.103**	**100.00**		**1.348**	**100.00**		**0.009**	**100.00**
CALCULATED ASSAY							**0.197**			**2.970**			**0.032**			**2.383**			**0.103**			**1.348**			**0.009**		
COMPOSITE ASSAY (Pulverized)							**0.190**			**3.000**			**0.032**			**2.480**			**0.120**			**1.050**			**0.007**		

Sample ID	Assay Results						
COMPOSITE ASSAY (Pulverized)	Au (g/t)	Ag (g/t)	Cu (%)	Fe (%)	CNAu (g/t)	CNAg (g/t)	CNCu (%)
	0.190	3.000	0.032	2.480	0.120	1.050	0.007



SGS Metcon / KD Engineering
7701 BUSINESS PARK DRIVE
TUCSON , ARIZONA 85743
COLUMN LEACH RESIDUE SAMPLE
Client ID: WESTERN COPPER & GOLD
Project No: M-709-03 - CASINO PROJECT
Sample ID: CL-05 (MET-19 & MET-20)

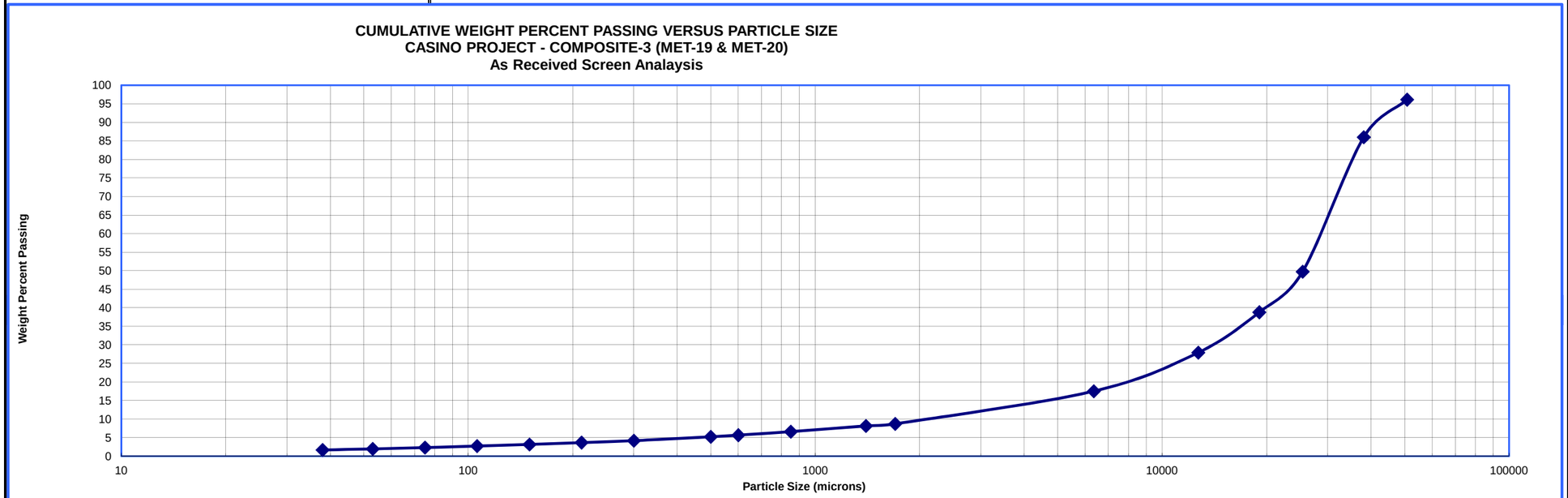
SCREEN ANALYSIS

Sample: P100 minus 3 inch
Size: As Received at METCON Research

ANALYTICAL RESULTS

NOMINAL OPENINGS			Sample Weights (kg)	Weight Distribution (%)	Cumulative (%)		Au (g/t)			Ag (g/t)			Cu (%)			Fe (%)			CNAu (g/t)			CNAg (g/t)			CNCu (%)		
mm	Inch	ASTM			Retained	Passing	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.
50.80	2	2"	1.94	3.90	3.90	96.10	0.160	0.006	4.29	3.300	0.129	4.59	0.066	0.003	3.97	4.640	0.181	4.11	0.200	0.008	11.31	1.990	0.078	6.53	0.011	0.000	8.23
38.10	1.500	1-1/2"	5.04	10.12	14.02	85.98	0.280	0.028	19.51	3.100	0.314	11.19	0.068	0.007	10.62	4.630	0.469	10.65	0.160	0.016	23.51	1.770	0.179	15.08	0.008	0.001	15.56
25.40	1.000	1"	18.04	36.24	50.26	49.74	0.160	0.058	39.91	2.700	0.978	34.90	0.064	0.023	35.78	4.000	1.450	32.92	0.090	0.033	47.33	1.340	0.486	40.86	0.007	0.003	48.72
19.05	0.750	3/4"	5.44	10.93	61.19	38.81	0.190	0.021	14.29	3.000	0.328	11.69	0.057	0.006	9.61	3.880	0.424	9.63	0.050	0.005	7.93	1.210	0.132	11.13	0.005	0.001	10.49
12.70	0.500	1/2"	5.42	10.89	72.08	27.92	0.090	0.010	6.74	2.000	0.218	7.77	0.067	0.007	11.25	4.400	0.479	10.88	0.050	0.005	7.90	0.810	0.088	7.42	0.003	0.000	6.27
6.35	0.250	1/4"	5.18	10.41	82.48	17.52	0.070	0.007	5.01	3.000	0.312	11.13	0.053	0.006	8.51	4.000	0.416	9.45	0.005	0.001	0.75	0.880	0.092	7.71	0.002	0.000	4.00
1.70	0.065	10	4.38	8.80	91.28	8.72	0.070	0.006	4.24	2.600	0.229	8.16	0.061	0.005	8.28	4.450	0.392	8.89	0.005	0.000	0.64	0.780	0.069	5.78	0.002	0.000	3.38
1.40	0.055	14	0.27	0.55	91.83	8.17																					
0.85	0.033	20	0.77	1.55	93.38	6.62																					
0.60	0.024	28	0.47	0.94	94.32	5.68																					
0.50	0.020	35	0.22	0.44	94.76	5.24																					
0.30	0.012	48	0.52	1.05	95.81	4.19																					
0.21	0.008	65	0.26	0.52	96.33	3.67	0.100	0.009	6.00	3.400	0.296	10.57	0.089	0.008	11.97	6.800	0.593	13.47	0.005	0.000	0.63	0.750	0.065	5.50	0.002	0.000	3.35
0.15	0.006	100	0.25	0.51	96.84	3.16																					
0.11	0.004	150	0.21	0.43	97.27	2.73																					
0.08	0.003	200	0.20	0.40	97.67	2.33																					
0.05	0.002	270	0.18	0.37	98.03	1.97																					
0.04	0.001	400	0.14	0.29	98.32	1.68																					
MINUS		-10	0.84	1.68	100.00	0.00																					
TOTALS			**49.78**	**100.00**				**0.145**	**100.00**		**2.804**	**100.00**		**0.065**	**100.00**		**4.403**	**100.00**		**0.069**	**100.00**		**1.188**	**100.00**		**0.005**	**100.00**
CALCULATED ASSAY							**0.145**			**2.804**			**0.065**			**4.403**			**0.069**			**1.188**			**0.005**		
COMPOSITE ASSAY (Pulverized)							**0.160**			**2.900**			**0.067**			**4.490**			**0.160**			**1.070**			**0.004**		

Sample ID	Assay Results						
COMPOSITE ASSAY (Pulverized)	Au (g/t)	Ag (g/t)	Cu (%)	Fe (%)	CNAu (g/t)	CNAg (g/t)	CNCu (%)
	0.160	2.900	0.067	4.490	0.160	1.070	0.004



SGS Metcon / KD Engineering
7701 BUSINESS PARK DRIVE
TUCSON , ARIZONA 85743
COLUMN LEACH RESIDUE SAMPLE
Client ID: WESTERN COPPER & GOLD
Project No: M-709-03 - CASINO PROJECT
Sample ID: CL-06 (MET-19 & MET-20)

SCREEN ANALYSIS

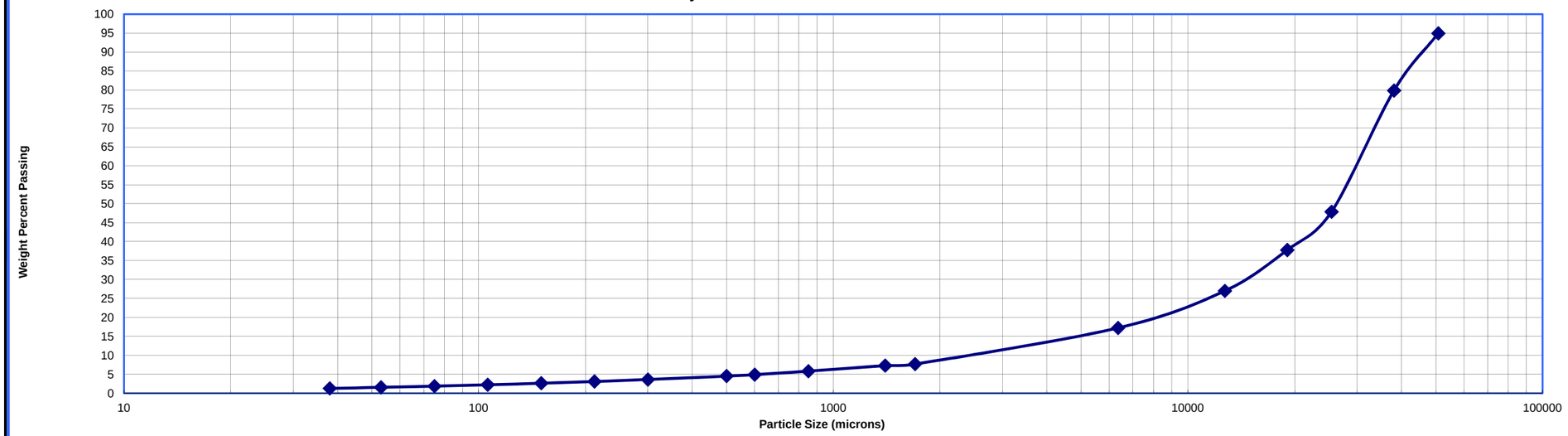
Sample: P100 minus 3 inch
Size: As Received at METCON Research

ANALYTICAL RESULTS

NOMINAL OPENINGS			Sample Weights (kg)	Weight Distribution (%)	Cumulative (%)		Au (g/t)			Ag (g/t)			Cu (%)			Fe (%)			CNAu (g/t)			CNAg (g/t)			CNCu (%)		
mm	Inch	ASTM			Retained	Passing	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.	Assay	Content	Distrib.
50.80	2	2"	2.54	5.07	5.07	94.93	0.190	0.010	6.32	2.400	0.122	4.96	0.067	0.003	4.84	3.900	0.198	4.12	0.120	0.006	12.34	1.180	0.060	5.02	0.008	0.000	8.42
38.10	1.500	1-1/2"	7.56	15.08	20.15	79.85	0.230	0.035	22.77	2.500	0.377	15.39	0.083	0.013	17.85	4.890	0.738	15.37	0.080	0.012	24.48	1.220	0.184	15.46	0.006	0.001	18.80
25.40	1.000	1"	16.02	31.96	52.11	47.89	0.180	0.058	37.77	2.300	0.735	29.99	0.068	0.022	30.99	4.730	1.512	31.51	0.060	0.019	38.90	1.620	0.518	43.50	0.007	0.002	46.47
19.05	0.750	3/4"	5.06	10.10	62.21	37.79	0.130	0.013	8.61	2.200	0.222	9.06	0.072	0.007	10.36	4.620	0.466	9.72	0.080	0.008	16.38	0.960	0.097	8.14	0.004	0.000	8.39
12.70	0.500	1/2"	5.40	10.77	72.98	27.02	0.130	0.014	9.19	2.400	0.259	10.55	0.058	0.006	8.91	4.200	0.453	9.43	0.010	0.001	2.19	0.970	0.105	8.78	0.003	0.000	6.71
6.35	0.250	1/4"	4.90	9.78	82.76	17.24	0.090	0.009	5.78	2.400	0.235	9.57	0.061	0.006	8.50	4.460	0.436	9.09	0.020	0.002	3.97	0.870	0.085	7.14	0.002	0.000	4.06
1.70	0.065	10	4.78	9.54	92.30	7.70	0.080	0.008	5.01	3.000	0.286	11.67	0.088	0.008	11.96	6.800	0.649	13.51	0.005	0.000	0.97	0.790	0.075	6.33	0.002	0.000	3.96
1.40	0.055	14	0.20	0.39	92.69	7.31																					
0.85	0.033	20	0.73	1.46	94.15	5.85																					
0.60	0.024	28	0.46	0.93	95.08	4.92																					
0.50	0.020	35	0.18	0.35	95.43	4.57																					
0.30	0.012	48	0.47	0.94	96.37	3.63																					
0.21	0.008	65	0.26	0.52	96.89	3.11	0.090	0.007	4.55	2.800	0.216	8.80	0.060	0.005	6.59	4.520	0.348	7.25	0.005	0.000	0.78	0.870	0.067	5.63	0.002	0.000	3.20
0.15	0.006	100	0.22	0.44	97.33	2.67																					
0.11	0.004	150	0.21	0.41	97.74	2.26																					
0.08	0.003	200	0.19	0.37	98.11	1.89																					
0.05	0.002	270	0.16	0.31	98.42	1.58																					
0.04	0.001	400	0.14	0.27	98.69	1.31																					
MINUS		-10	0.66	1.31	100.00	0.00																					
TOTALS			**50.12**	**100.00**				**0.152**	**100.00**		**2.451**	**100.00**		**0.070**	**100.00**		**4.799**	**100.00**		**0.049**	**100.00**		**1.190**	**100.00**		**0.005**	**100.00**
CALCULATED ASSAY							**0.152**			**2.451**			**0.070**			**4.799**			**0.049**			**1.190**			**0.005**		
COMPOSITE ASSAY (Pulverized)							**0.150**			**2.600**			**0.066**			**4.750**			**0.120**			**1.010**			**0.004**		

Sample ID	Assay Results						
COMPOSITE ASSAY (Pulverized)	Au (g/t)	Ag (g/t)	Cu (%)	Fe (%)	CNAu (g/t)	CNAg (g/t)	CNCu (%)
	0.150	2.600	0.066	4.750	0.120	1.010	0.004

CUMULATIVE WEIGHT PERCENT PASSING VERSUS PARTICLE SIZE
CASINO PROJECT - COMPOSITE-3 (MET-19 & MET-20)
As Received Screen Analaysis



APPENDIX 12

Lorax Environmental

TECHNICAL MEMORANDUM

To:	**Paul West-Sells, Heather Brown (Western Copper Corp)**	**Date: May 16 2014**
From:	**John Dockrey, Bruce Mattson**	**Project #: J862-6**
Subject:	**Environmental Sample Procedure of Cyanide Leach Columns - 2014**	

This technical memorandum provides instruction for the collection of leachate samples from the Casino CN leach columns. The columns will be operated in two phases, active cyanide leaching and rinsing. Distinct sampling requirements during each of the operational phases are outlined below.

Sampling Dates

Samples of column leachate needs to be collected four times from each column over the course of the CN leach test and four times during rinsing/recycling. Timing of sample collection during CN leaching and rinsing is outlined in Table 2. Note that leachate samples must be collected from column drainage produced within 24 hours of sample collection. In addition to column leachate, samples of the tap water used as influent and blank samples prepared with DI water need to be taken on certain occasions. Tap water is sampled to characterize the solution that the column is being irrigated with, while a blank of DI water sample needs to be collected every sampling event for QAQC.

Table 1:
Environmental sampling schedule during CN leaching

Solution to be Sampled	Date
Tap Water	week 2 & 6
Blank (DI water)	week 2, 4, 6 & 8
Leachate Sample (x6 Columns)	week 2, 4, 6 & 8

Table 2:
Environmental sampling schedule during rinsing and cycling of detoxified solution

Solution to be Sampled	Date
Tap Water	week 0.5 & 6
Blank (DI water)	week 0.5, 2, 4 & 6
Leachate Sample (x6 columns)	week 0.5, 2, 4 & 6

Sampling Supplies

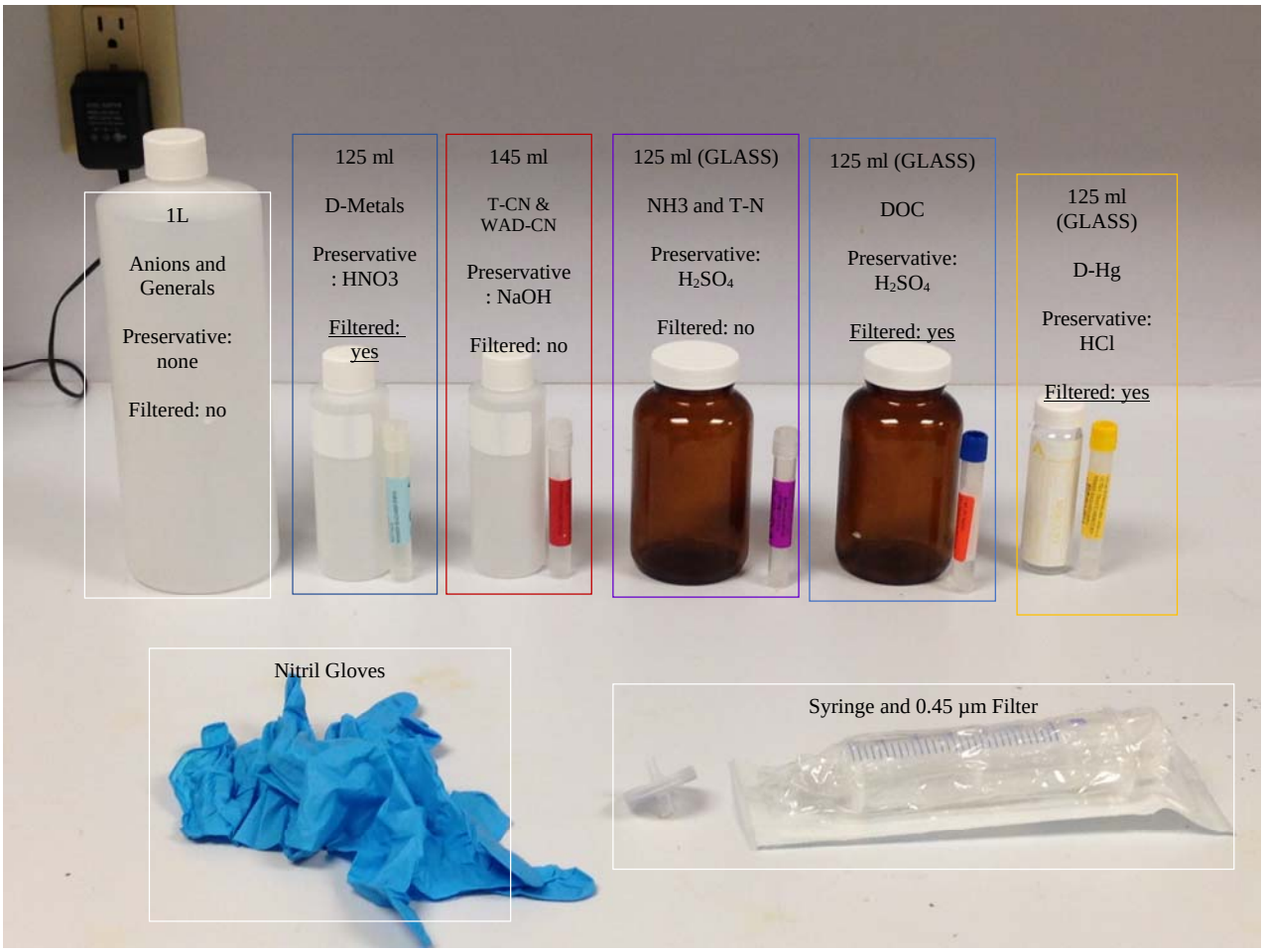
Sampling bottles, preservative, filters and syringes will be provided by ALS-Vancouver. Note that it is our understanding that at least 76 1L plastic bottles have already been delivered for the purposes of environmental sampling. ALS will provide the following supplies:

- 76 x 145 mL plastic bottles
- 76 x 125 ml plastic bottles
- 76 x 125 Glass bottles
- 76 x 250 ml plastic bottles
- 76 x HNO_3 preservative vials
- 76 x NaOH preservative vials
- 76 x H_2SO_4 preservatives for DOC
- 76 x H_2SO_4 preservative vials for NH_3 and T-Nitrogen
- Chain of custody forms
- Bottle labels
- 0.45 µm syringe filters
- Syringes

The following supplies will have to be sourced at site:

- Coolers and ice packs for sample shipment (Approximately 2 coolers per sampling event will be required).
- Nitril gloves
- DI water for blanks

Step 1: Prepare Bottles and Supplies



- Set out required bottles for each sample as illustrated in above photo and outlined in Table 3 below.
- Filter and syringe are provided along with bottles from ALS.
- Label each bottle with marker before proceeding to next step (analysis type and column ID).

Table 3:
List of Bottle Volumes and Sampling Requirements

Bottle Volume	Analyze For	Filter	Preserve
1 L	Anions and Physical tests	none	none
145 ml	WAD-CN and T-CN	none	NaOH
125 ml	D-Metals	yes	HNO_3
50 ml (GLASS)	D-Hg	yes	HCl
125 ml (GLASS)	Ammonia and T-N	none	H_2SO_4
125 ml (GLASS)	DOC	yes	H_2SO_4

Step 2: Filter samples if required and fill bottles



Samples Requiring Filtration (D-metals and DOC)

- Pull sample into syringe
- Attach Filter
- Push sample through filter and fill entire volume of the bottle. Leave small headspace for preservative.

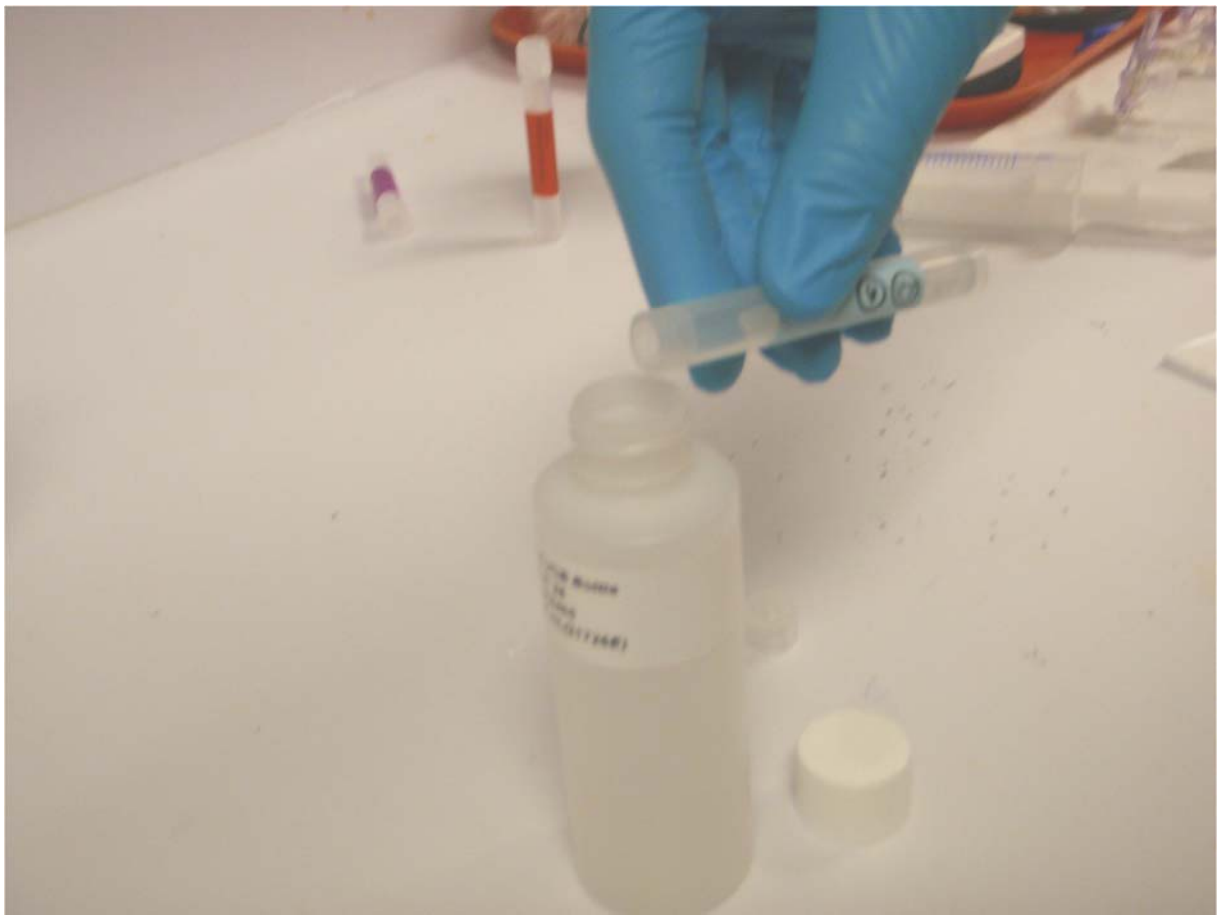
Note: DO NOT REUSE FILTERS OR SYRINGES

Note: SAMPLE MUST BE COLLECTED FROM LEACHATE PRODUCED WITHIN PAST 24 HOURS

Samples not requiring filtration (anions and physicals, T-CN &WAD-CN, T-N &NH3)

- Completely fill each of the sample bottles, leaving small volume for preservative if required.

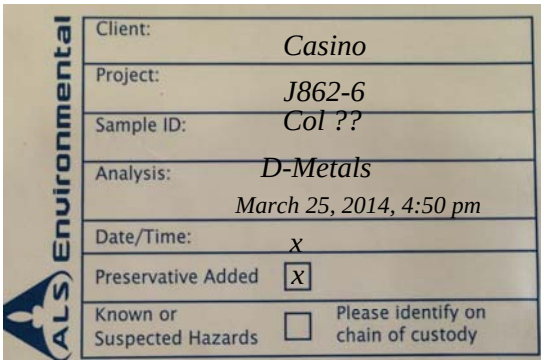
Step 3: Add Preservative



- Pore entire volume of preservative from preservative vials provided by ALS into sample bottles as required.
- Required preservatives are outlined in Table 1.

Note: DO NOT ADD PRESERVATIVES BEFORE BOTTLES ARE FILLED WITH SAMPLE

Step 4: Fill out Labels and Label Bottles





- Fill out labels provided by ALS as per example provided above
- Label should indicate, column sampled, date sampled, requested analysis (*i.e.*, D- metals, T-CN & WAD-CN, *etc*.) whether sample was filtered, whether preservative added (yes for D-Metals, DOC *etc*.) and known or suspected as hazardous (yes due to potential for high CN > 100 mg/L).
- Stick labels to appropriate bottles.

Step 5: Pack Cooler and fill out chain of custody form (COC)



- Pack samples in cooler with ice and copy of COC form.
- Example COC form is provided on next page
- Ship cooler as priority to:

ATTN: Ariel Tang
1988 Triumph Street
Vancouver, BC
V5L 1K5
Ariel.Tang@ALSEnviro.com
Tel: (604) 253-4188

ALS Environmental
www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

Affix ALS barcode label here
(lab use only)

COC Number: 14 -

Page 1 of 1

Report To		Report Format / Distribution		Select Service Level Below (Rush Turnaround Time (TAT) is not available for all tests)
Company:	Lorax Environmental	Select Report Format:	☐ PDF ☑ EXCEL ☐ EDD (DIGITAL)	R ☑ Regular (Standard TAT if received by 3 pm - business days)
Contact:	John Dockrey and Bruce Mattson	Quality Control (QC) Report with Report	☑ Yes ☐ No	P ☐ Priority (2-4 bus. days if received by 3pm) 50% surcharge - contact ALS to confirm TAT
Address:	2289 Burrard street, Vancouver V6J 3H9	☐ Criteria on Report - provide details below if box checked		E ☐ Emergency (1-2 bus. days if received by 3pm) 100% surcharge - contact ALS to confirm TAT
		Select Distribution:	☑ EMAIL ☐ MAIL ☐ FAX	E2 ☐ Same day or weekend emergency - contact ALS to confirm TAT and surcharge
Phone:	604-688-7173	Email 1 or Fax	john.dockrey@lorax.ca	Specify Date Required for E2,E or P:
		Email 2	Bruce.Mattson@lorax.ca	**Analysis Request**
Invoice To	Same as Report To ☐ Yes ☑ No	**Invoice Distribution**		Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below
	Copy of Invoice with Report ☑ Yes ☐ No	Select Invoice Distribution:	☑ EMAIL ☐ MAIL ☐ FAX	F/P | P | | P | F/P
Company:	Casino Mining Company	Email 1 or Fax	mmioska@casinomining.com	D-Metals; T-CN and WAD-CN; Acidity, Alkalinity, pH Anions and Nutrients; NH3 and T-N; DOC; D-Hg; Number of Containers
Contact:	Mary Mioska	Email 2		
Project Information		**Oil and Gas Required Fields (client use)**		
ALS Quote #:		Approver ID:	Cost Center:	
Job #:	J862-6	GL Account:	Routing Code:	
PO / AFE:		Activity Code:		
LSD:		Location:		
ALS Lab Work Order # (lab use only)		ALS Contact:	Sampler:	

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	D-Metals	T-CN and WAD-CN	Acidity, Alkalinity, pH Anions and Nutrients	NH3 and T-N	DOC	D-Hg	Number of Containers
	Col1			Water	R	R	R	R	R	R	6
	Col1b			Water	R	R	R	R	R	R	6
	Col2			Water	R	R	R	R	R	R	6
	Col2b			Water	R	R	R	R	R	R	6
	Col3			Water	R	R	R	R	R	R	6
	Col3b			Water	R	R	R	R	R	R	6
	Blank										

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ Yes ☐ No

Are samples for human drinking water use? ☐ Yes ☑ No

Special Instructions / Specify Criteria to add on report (client Use)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice packs Yes ☐ No ☐ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C			FINAL COOLER TEMPERATURES °C		

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by:	Date:	Time:	Received by:	Date:	Time:	Received by:	Date:	Time:

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY NA-FM-0326ev09Front/04January2014

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

APPENDIX 13

WADCN Report of Analyses

May 29, 2014

Natska Gantumur
SGS Metcon
7701 Business Park Dr.
Tucson, AZ 85743

TEL (520) 579-8315
FAX (303) 456-6998

Work Order No.: 14E0453
Order Name: M-709-03

RE: M-709-03

Dear Natska Gantumur,

Turner Laboratories, Inc. received 70 sample(s) on 05/13/2014 for the analyses presented in the following report.

All results are intended to be considered in their entirety, and Turner Laboratories, Inc. is not responsible for use of less than the complete report. Results apply only to the samples analyzed. Samples will be disposed of 30 days after issue of our report unless special arrangements are made.

The pages that follow may contain sensitive, privileged or confidential information intended solely for the addressee named above. If you receive this message and are not the agent or employee of the addressee, this communication has been sent in error. Please do not disseminate or copy any of the attached and notify the sender immediately by telephone. Please also return the attached sheet(s) to the sender by mail.

Please call if you have any questions.

Respectfully submitted,

Turner Laboratories, Inc.
ADHS License AZ0066



Terri Garcia
Technical Director

Client: SGS Metcon
Project: M-709-03
Work Order: 14E0453
Date Received: 05/13/2014

Order: M-709-03

Work Order Sample Summary

Lab Sample ID	Client Sample ID	Matrix	Collection Date/Time
14E0453-01	26162	Process Water	05/03/2014 0700
14E0453-02	26163	Process Water	05/04/2014 0700
14E0453-03	26164	Process Water	05/05/2014 0700
14E0453-04	26165	Process Water	05/06/2014 0700
14E0453-05	26166	Process Water	05/07/2014 0700
14E0453-06	26167	Process Water	05/08/2014 0700
14E0453-07	26168	Process Water	05/09/2014 0700
14E0453-08	26169	Process Water	05/10/2014 0700
14E0453-09	26170	Process Water	05/11/2014 0700
14E0453-10	26171	Process Water	05/12/2014 0700
14E0453-11	26172	Process Water	05/13/2014 0700
14E0453-12	26192	Process Water	05/03/2014 0700
14E0453-13	26193	Process Water	05/04/2014 0700
14E0453-14	26194	Process Water	05/05/2014 0700
14E0453-15	26195	Process Water	05/06/2014 0700
14E0453-16	26196	Process Water	05/07/2014 0700
14E0453-17	26197	Process Water	05/08/2014 0700
14E0453-18	26198	Process Water	05/09/2014 0700
14E0453-19	26199	Process Water	05/10/2014 0700
14E0453-20	26200	Process Water	05/11/2014 0700
14E0453-21	26201	Process Water	05/12/2014 0700
14E0453-22	26202	Process Water	05/13/2014 0700
14E0453-23	26221	Process Water	05/02/2014 0700
14E0453-24	26222	Process Water	05/03/2014 0700
14E0453-25	26223	Process Water	05/04/2014 0700
14E0453-26	26224	Process Water	05/05/2014 0700
14E0453-27	26225	Process Water	05/06/2014 0700
14E0453-28	26226	Process Water	05/07/2014 0700
14E0453-29	26227	Process Water	05/08/2014 0700
14E0453-30	26228	Process Water	05/09/2014 0700
14E0453-31	26229	Process Water	05/10/2014 0700
14E0453-32	26230	Process Water	05/11/2014 0700

14E0453-33	26231	Process Water	05/12/2014 0700
14E0453-34	26232	Process Water	05/13/2014 0700
14E0453-35	26251	Process Water	05/02/2014 0700
14E0453-36	26252	Process Water	05/03/2014 0700
14E0453-37	26253	Process Water	05/04/2014 0700
14E0453-38	26254	Process Water	05/05/2014 0700
14E0453-39	26255	Process Water	05/06/2014 0700
14E0453-40	26256	Process Water	05/07/2014 0700
14E0453-41	26257	Process Water	05/08/2014 0700
14E0453-42	26258	Process Water	05/09/2014 0700
14E0453-43	26259	Process Water	05/10/2014 0700
14E0453-44	26260	Process Water	05/11/2014 0700
14E0453-45	26261	Process Water	05/12/2014 0700
14E0453-46	26262	Process Water	05/13/2014 0700
14E0453-47	26281	Process Water	05/02/2014 0700
14E0453-48	26282	Process Water	05/03/2014 0700
14E0453-49	26283	Process Water	05/04/2014 0700
14E0453-50	26284	Process Water	05/05/2014 0700
14E0453-51	26285	Process Water	05/06/2014 0700
14E0453-52	26286	Process Water	05/07/2014 0700
14E0453-53	26287	Process Water	05/08/2014 0700
14E0453-54	26288	Process Water	05/09/2014 0700
14E0453-55	26289	Process Water	05/10/2014 0700
14E0453-56	26290	Process Water	05/11/2014 0700
14E0453-57	26291	Process Water	05/12/2014 0700
14E0453-58	26292	Process Water	05/13/2014 0700
14E0453-59	26311	Process Water	05/02/2014 0700
14E0453-60	26312	Process Water	05/03/2014 0700
14E0453-61	26313	Process Water	05/04/2014 0700
14E0453-62	26314	Process Water	05/05/2014 0700
14E0453-63	26315	Process Water	05/06/2014 0700
14E0453-64	26316	Process Water	05/07/2014 0700
14E0453-65	26317	Process Water	05/08/2014 0700
14E0453-66	26318	Process Water	05/09/2014 0700
14E0453-67	26319	Process Water	05/10/2014 0700
14E0453-68	26320	Process Water	05/11/2014 0700
14E0453-69	26321	Process Water	05/12/2014 0700
14E0453-70	26322	Process Water	05/13/2014 0700

Client: SGS Metcon
Project: M-709-03
Work Order: 14E0453
Date Received: 05/13/2014

Case Narrative

Cyanide WAD: Quality control samples contaminated by samples with high concentrations. MSD unusable due to formation of precipitant during color development.

The Arizona Department of Health Services does not license laboratories for the determination of Cyanide WAD in a wastewater matrix.

B7	Target analyte detected in method blank at or above the method reporting limit. Concentration found in the sample was 10 times above the concentration found in the method blank.
L1	The associated LCS/LCSD recovery was above laboratory acceptance limits.
N1	See case narrative.

All soil, sludge, and solid matrix determinations are reported on a wet weight basis unless otherwise noted.

ND	Not Detected at or above the PQL
PQL	Practical Quantitation Limit
DF	Dilution Factor

Client:	SGS Metcon	**Client Sample ID:**	26162
Project:	M-709-03	**Collection Date/Time:**	05/03/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-01	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	350	10		mg/L	100	05/14/2014 0900	05/15/2014 1300	EW

Client:	SGS Metcon	**Client Sample ID:**	26163
Project:	M-709-03	**Collection Date/Time:**	05/04/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-02	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	400	10		mg/L	100	05/14/2014 0900	05/15/2014 1300	EW

Client:	SGS Metcon	**Client Sample ID:**	26164
Project:	M-709-03	**Collection Date/Time:**	05/05/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-03	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	560	20		mg/L	200	05/14/2014 0900	05/15/2014 1300	EW

Client:	SGS Metcon	**Client Sample ID:**	26165
Project:	M-709-03	**Collection Date/Time:**	05/06/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-04	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	630	20		mg/L	200	05/15/2014 1400	05/16/2014 1630	EW

Client:	SGS Metcon	**Client Sample ID:**	26166
Project:	M-709-03	**Collection Date/Time:**	05/07/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-05	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	980	20		mg/L	200	05/15/2014 1400	05/16/2014 1630	EW

Client:	SGS Metcon	**Client Sample ID:**	26167
Project:	M-709-03	**Collection Date/Time:**	05/08/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-06	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	830	20		mg/L	200	05/15/2014 1400	05/16/2014 1630	EW

Client:	SGS Metcon	**Client Sample ID:**	26168
Project:	M-709-03	**Collection Date/Time:**	05/09/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-07	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	700	20		mg/L	200	05/19/2014 0805	05/20/2014 1420	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14E0453
Lab Sample ID: 14E0453-08

Client Sample ID: 26169
Collection Date/Time: 05/10/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	810	20		mg/L	200	05/19/2014 0805	05/20/2014 1420	EW

Client:	SGS Metcon	**Client Sample ID:**	26170
Project:	M-709-03	**Collection Date/Time:**	05/11/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-09	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	790	20		mg/L	200	05/19/2014 0805	05/20/2014 1420	EW

Client:	SGS Metcon	**Client Sample ID:**	26171
Project:	M-709-03	**Collection Date/Time:**	05/12/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-10	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	780	20		mg/L	200	05/19/2014 0805	05/20/2014 1420	EW

Client:	SGS Metcon	**Client Sample ID:**	26172
Project:	M-709-03	**Collection Date/Time:**	05/13/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-11	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	710	20		mg/L	200	05/20/2014 1100	05/21/2014 1610	EW

Client:	SGS Metcon	**Client Sample ID:**	26192
Project:	M-709-03	**Collection Date/Time:**	05/03/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-12	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	270	10		mg/L	100	05/14/2014 0900	05/15/2014 1300	EW

Client:	SGS Metcon	**Client Sample ID:**	26193
Project:	M-709-03	**Collection Date/Time:**	05/04/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-13	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	420	10		mg/L	100	05/14/2014 0900	05/15/2014 1300	EW

Client:	SGS Metcon	**Client Sample ID:**	26194
Project:	M-709-03	**Collection Date/Time:**	05/05/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-14	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	580	20		mg/L	200	05/14/2014 0900	05/15/2014 1300	EW

Client:	SGS Metcon	**Client Sample ID:**	26195
Project:	M-709-03	**Collection Date/Time:**	05/06/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-15	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	600	20		mg/L	200	05/15/2014 1400	05/16/2014 1630	EW

Client:	SGS Metcon	**Client Sample ID:**	26196
Project:	M-709-03	**Collection Date/Time:**	05/07/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-16	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	720	20		mg/L	200	05/15/2014 1400	05/16/2014 1630	EW

Client:	SGS Metcon	**Client Sample ID:**	26197
Project:	M-709-03	**Collection Date/Time:**	05/08/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-17	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	670	20		mg/L	200	05/15/2014 1400	05/16/2014 1630	EW

Client:	SGS Metcon	**Client Sample ID:**	26198
Project:	M-709-03	**Collection Date/Time:**	05/09/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-18	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	780	20		mg/L	200	05/19/2014 0805	05/20/2014 1420	EW

Client:	SGS Metcon	**Client Sample ID:**	26199
Project:	M-709-03	**Collection Date/Time:**	05/10/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-19	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	620	20		mg/L	200	05/19/2014 0805	05/20/2014 1420	EW

Client:	SGS Metcon	**Client Sample ID:**	26200
Project:	M-709-03	**Collection Date/Time:**	05/11/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-20	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	660	20		mg/L	200	05/19/2014 0805	05/20/2014 1420	EW

Client:	SGS Metcon	**Client Sample ID:**	26201
Project:	M-709-03	**Collection Date/Time:**	05/12/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-21	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	750	20		mg/L	200	05/19/2014 0805	05/20/2014 1420	EW

Client:	SGS Metcon	**Client Sample ID:**	26202
Project:	M-709-03	**Collection Date/Time:**	05/13/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-22	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	780	20		mg/L	200	05/20/2014 1100	05/21/2014 1610	EW

Client:	SGS Metcon	**Client Sample ID:**	26221
Project:	M-709-03	**Collection Date/Time:**	05/02/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-23	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	220	10		mg/L	100	05/14/2014 0900	05/15/2014 1300	EW

Client:	SGS Metcon	**Client Sample ID:**	26222
Project:	M-709-03	**Collection Date/Time:**	05/03/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-24	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	340	10		mg/L	100	05/14/2014 0900	05/15/2014 1300	EW

Client:	SGS Metcon	**Client Sample ID:**	26223
Project:	M-709-03	**Collection Date/Time:**	05/04/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-25	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	460	10		mg/L	100	05/14/2014 0900	05/15/2014 1300	EW

Client:	SGS Metcon	**Client Sample ID:**	26224
Project:	M-709-03	**Collection Date/Time:**	05/05/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-26	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	400	10		mg/L	100	05/14/2014 0900	05/15/2014 1300	EW

Client:	SGS Metcon	**Client Sample ID:**	26225
Project:	M-709-03	**Collection Date/Time:**	05/06/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-27	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	580	20		mg/L	200	05/15/2014 1400	05/16/2014 1630	EW

Client:	SGS Metcon	**Client Sample ID:**	26226
Project:	M-709-03	**Collection Date/Time:**	05/07/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-28	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	580	20		mg/L	200	05/15/2014 1400	05/16/2014 1630	EW

Client:	SGS Metcon	**Client Sample ID:**	26227
Project:	M-709-03	**Collection Date/Time:**	05/08/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-29	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	650	20		mg/L	200	05/15/2014 1400	05/16/2014 1630	EW

Client:	SGS Metcon	**Client Sample ID:**	26228
Project:	M-709-03	**Collection Date/Time:**	05/09/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-30	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	690	20		mg/L	200	05/19/2014 0805	05/20/2014 1420	EW

Client:	SGS Metcon	**Client Sample ID:**	26229
Project:	M-709-03	**Collection Date/Time:**	05/10/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-31	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	700	20		mg/L	200	05/19/2014 0805	05/20/2014 1420	EW

Client:	SGS Metcon	**Client Sample ID:**	26230
Project:	M-709-03	**Collection Date/Time:**	05/11/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-32	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	830	20		mg/L	200	05/19/2014 0805	05/20/2014 1420	EW

Client:	SGS Metcon	**Client Sample ID:**	26231
Project:	M-709-03	**Collection Date/Time:**	05/12/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-33	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	790	20		mg/L	200	05/20/2014 1100	05/21/2014 1610	EW

Client:	SGS Metcon	**Client Sample ID:**	26232
Project:	M-709-03	**Collection Date/Time:**	05/13/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-34	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	830	20		mg/L	200	05/20/2014 1100	05/21/2014 1610	EW

Client:	SGS Metcon	**Client Sample ID:**	26251
Project:	M-709-03	**Collection Date/Time:**	05/02/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-35	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	190	10		mg/L	100	05/14/2014 0900	05/15/2014 1300	EW

Client:	SGS Metcon	**Client Sample ID:**	26252
Project:	M-709-03	**Collection Date/Time:**	05/03/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-36	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	300	10		mg/L	100	05/14/2014 0900	05/15/2014 1300	EW

Client:	SGS Metcon	**Client Sample ID:**	26253
Project:	M-709-03	**Collection Date/Time:**	05/04/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-37	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	310	10		mg/L	100	05/14/2014 0900	05/15/2014 1300	EW

Client:	SGS Metcon	**Client Sample ID:**	26254
Project:	M-709-03	**Collection Date/Time:**	05/05/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-38	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	570	20		mg/L	200	05/15/2014 1400	05/16/2014 1630	EW

Client:	SGS Metcon	**Client Sample ID:**	26255
Project:	M-709-03	**Collection Date/Time:**	05/06/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-39	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	510	20		mg/L	200	05/15/2014 1400	05/16/2014 1630	EW

Client:	SGS Metcon	**Client Sample ID:**	26256
Project:	M-709-03	**Collection Date/Time:**	05/07/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-40	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	490	20		mg/L	200	05/15/2014 1400	05/16/2014 1630	EW

Client:	SGS Metcon	**Client Sample ID:**	26257
Project:	M-709-03	**Collection Date/Time:**	05/08/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-41	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	550	20		mg/L	200	05/15/2014 1400	05/16/2014 1630	EW

Client:	SGS Metcon	**Client Sample ID:**	26258
Project:	M-709-03	**Collection Date/Time:**	05/09/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-42	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	610	20		mg/L	200	05/19/2014 0805	05/20/2014 1420	EW

Client:	SGS Metcon	**Client Sample ID:**	26259
Project:	M-709-03	**Collection Date/Time:**	05/10/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-43	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	740	20		mg/L	200	05/19/2014 0805	05/20/2014 1420	EW

Client:	SGS Metcon	**Client Sample ID:**	26260
Project:	M-709-03	**Collection Date/Time:**	05/11/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-44	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	670	20		mg/L	200	05/19/2014 0805	05/20/2014 1420	EW

Client:	SGS Metcon	**Client Sample ID:**	26261
Project:	M-709-03	**Collection Date/Time:**	05/12/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-45	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	830	20		mg/L	200	05/20/2014 1100	05/21/2014 1610	EW

Client:	SGS Metcon	**Client Sample ID:**	26262
Project:	M-709-03	**Collection Date/Time:**	05/13/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-46	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	730	20		mg/L	200	05/20/2014 1100	05/21/2014 1610	EW

Client:	SGS Metcon	**Client Sample ID:**	26281
Project:	M-709-03	**Collection Date/Time:**	05/02/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-47	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	100	10		mg/L	100	05/14/2014 0900	05/15/2014 1300	EW

Client:	SGS Metcon	**Client Sample ID:**	26282
Project:	M-709-03	**Collection Date/Time:**	05/03/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-48	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	360	10		mg/L	100	05/14/2014 0900	05/15/2014 1300	EW

Client:	SGS Metcon	**Client Sample ID:**	26283
Project:	M-709-03	**Collection Date/Time:**	05/04/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-49	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	580	20		mg/L	200	05/14/2014 0900	05/15/2014 1300	EW

Client:	SGS Metcon	**Client Sample ID:**	26284
Project:	M-709-03	**Collection Date/Time:**	05/05/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-50	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	490	10		mg/L	100	05/14/2014 0900	05/15/2014 1300	EW

Client:	SGS Metcon	**Client Sample ID:**	26285
Project:	M-709-03	**Collection Date/Time:**	05/06/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-51	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	620	20		mg/L	200	05/15/2014 1400	05/16/2014 1630	EW

Client:	SGS Metcon	**Client Sample ID:**	26286
Project:	M-709-03	**Collection Date/Time:**	05/07/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-52	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	640	20		mg/L	200	05/15/2014 1400	05/16/2014 1630	EW

Client:	SGS Metcon	**Client Sample ID:**	26287
Project:	M-709-03	**Collection Date/Time:**	05/08/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-53	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	770	20		mg/L	200	05/15/2014 1400	05/16/2014 1630	EW

Client:	SGS Metcon	**Client Sample ID:**	26288
Project:	M-709-03	**Collection Date/Time:**	05/09/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-54	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	760	20		mg/L	200	05/19/2014 0805	05/20/2014 1420	EW

Client:	SGS Metcon	**Client Sample ID:**	26289
Project:	M-709-03	**Collection Date/Time:**	05/10/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-55	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	700	20		mg/L	200	05/19/2014 0805	05/20/2014 1420	EW

Client:	SGS Metcon	**Client Sample ID:**	26290
Project:	M-709-03	**Collection Date/Time:**	05/11/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-56	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	690	20		mg/L	200	05/19/2014 0805	05/20/2014 1420	EW

Client:	SGS Metcon	**Client Sample ID:**	26291
Project:	M-709-03	**Collection Date/Time:**	05/12/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-57	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	810	20		mg/L	200	05/20/2014 1100	05/21/2014 1610	EW

Client:	SGS Metcon	**Client Sample ID:**	26292
Project:	M-709-03	**Collection Date/Time:**	05/13/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-58	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	700	20		mg/L	200	05/20/2014 1100	05/21/2014 1610	EW

Client:	SGS Metcon	**Client Sample ID:**	26311
Project:	M-709-03	**Collection Date/Time:**	05/02/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-59	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	100	10		mg/L	100	05/14/2014 0900	05/15/2014 1300	EW

Client:	SGS Metcon	**Client Sample ID:**	26312
Project:	M-709-03	**Collection Date/Time:**	05/03/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-60	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	390	10		mg/L	100	05/14/2014 0900	05/15/2014 1300	EW

Client:	SGS Metcon	**Client Sample ID:**	26313
Project:	M-709-03	**Collection Date/Time:**	05/04/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-61	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	490	10		mg/L	100	05/14/2014 0900	05/15/2014 1300	EW

Client:	SGS Metcon	**Client Sample ID:**	26314
Project:	M-709-03	**Collection Date/Time:**	05/05/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-62	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	520	20		mg/L	200	05/15/2014 1400	05/16/2014 1630	EW

Client:	SGS Metcon	**Client Sample ID:**	26315
Project:	M-709-03	**Collection Date/Time:**	05/06/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-63	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	740	20		mg/L	200	05/15/2014 1400	05/16/2014 1630	EW

Client:	SGS Metcon	**Client Sample ID:**	26316
Project:	M-709-03	**Collection Date/Time:**	05/07/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-64	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	660	20		mg/L	200	05/15/2014 1400	05/16/2014 1630	EW

Client:	SGS Metcon	**Client Sample ID:**	26317
Project:	M-709-03	**Collection Date/Time:**	05/08/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-65	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	670	20		mg/L	200	05/15/2014 1400	05/16/2014 1630	EW

Client:	SGS Metcon	**Client Sample ID:**	26318
Project:	M-709-03	**Collection Date/Time:**	05/09/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-66	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	700	20		mg/L	200	05/19/2014 0805	05/20/2014 1420	EW

Client:	SGS Metcon	**Client Sample ID:**	26319
Project:	M-709-03	**Collection Date/Time:**	05/10/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-67	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	800	20		mg/L	200	05/19/2014 0805	05/20/2014 1420	EW

Client:	SGS Metcon	**Client Sample ID:**	26320
Project:	M-709-03	**Collection Date/Time:**	05/11/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-68	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	750	20		mg/L	200	05/19/2014 0805	05/20/2014 1420	EW

Client:	SGS Metcon	**Client Sample ID:**	26321
Project:	M-709-03	**Collection Date/Time:**	05/12/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-69	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	770	20		mg/L	200	05/20/2014 1100	05/21/2014 1610	EW

Client:	SGS Metcon	**Client Sample ID:**	26322
Project:	M-709-03	**Collection Date/Time:**	05/13/2014 0700
Work Order:	14E0453	**Matrix:**	Process Water
Lab Sample ID:	14E0453-70	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	810	20		mg/L	200	05/20/2014 1100	05/21/2014 1610	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14E0453
Date Received: 05/13/2014

QC Summary

Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Qual
Batch 1405161 - SM4500-CN I										
Blank (1405161-BLK1)				Prepared: 05/14/2014 Analyzed: 05/15/2014						
Cyanide	8.1	0.10	mg/L							B7, N1
LCS (1405161-BS1)				Prepared: 05/14/2014 Analyzed: 05/15/2014						
Cyanide	14	0.10	mg/L	2.000		719	90-110			L1, N1
LCS Dup (1405161-BSD1)				Prepared: 05/14/2014 Analyzed: 05/15/2014						
Cyanide	13	0.10	mg/L	2.000		627	90-110	14	20	L1, N1
Matrix Spike (1405161-MS1)		**Source: 14E0453-36**		Prepared: 05/14/2014 Analyzed: 05/15/2014						
Cyanide	16	0.10	mg/L	2.000	300	NR	70-130			N1
Batch 1405164 - SM4500-CN I										
Blank (1405164-BLK1)				Prepared: 05/15/2014 Analyzed: 05/16/2014						
Cyanide	0.12	0.10	mg/L							B7
LCS (1405164-BS1)				Prepared: 05/15/2014 Analyzed: 05/16/2014						
Cyanide	2.2	0.10	mg/L	2.000		110	90-110			
LCS Dup (1405164-BSD1)				Prepared: 05/15/2014 Analyzed: 05/16/2014						
Cyanide	2.0	0.10	mg/L	2.000		100	90-110	10	20	
Matrix Spike (1405164-MS1)		**Source: 14E0453-39**		Prepared: 05/15/2014 Analyzed: 05/16/2014						
Cyanide	1300	50	mg/L	1000	510	75	70-130			
Batch 1405188 - SM4500-CN I										
Blank (1405188-BLK1)				Prepared: 05/19/2014 Analyzed: 05/20/2014						
Cyanide	ND	0.10	mg/L							
LCS (1405188-BS1)				Prepared: 05/19/2014 Analyzed: 05/20/2014						
Cyanide	2.0	0.10	mg/L	2.000		100	90-110			
LCS Dup (1405188-BSD1)				Prepared: 05/19/2014 Analyzed: 05/20/2014						
Cyanide	2.0	0.10	mg/L	2.000		99	90-110	0.8	20	
Matrix Spike (1405188-MS1)		**Source: 14E0453-32**		Prepared: 05/19/2014 Analyzed: 05/20/2014						
Cyanide	2000	50	mg/L	1000	830	113	70-130			
Batch 1405209 - SM4500-CN I										
Blank (1405209-BLK1)				Prepared: 05/20/2014 Analyzed: 05/21/2014						
Cyanide	ND	0.10	mg/L							
LCS (1405209-BS1)				Prepared: 05/20/2014 Analyzed: 05/21/2014						
Cyanide	2.0	0.10	mg/L	2.000		100	90-110			
LCS Dup (1405209-BSD1)				Prepared: 05/20/2014 Analyzed: 05/21/2014						
Cyanide	2.0	0.10	mg/L	2.000		99	90-110	1	20	
Matrix Spike (1405209-MS1)		**Source: 14E0564-01**		Prepared: 05/20/2014 Analyzed: 05/21/2014						
Cyanide	1900	50	mg/L	1000	850	101	70-130			

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CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 14E0453 DATE 5/13/14 PAGE 1 OF 6

PROJECT NAME _Western Copper and Gold
CONTACT NAME : Natsagdorj Gantumur
COMPANY NAME : SGS Metcon
ADDRESS : 7701 N. Business Park Dr.
CITY Tucson STATE AZ ZIP CODE 85743
PHONE FAX
SAMPLER'S SIGNATURE Salvador Gonzalez

NUMBER OF CONTAINERS

CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX

Cyanide (WAD)

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*
26162	5/3/14	7:00		Process Water
26163	5/4/14	7:00		Process Water
26164	5/5/14	7:00		Process Water
26165	5/6/14	7:00		Process Water
26166	5/7/14	7:00		Process Water
26167	5/8/14	7:00		Process Water
26168	5/9/14	7:00		Process Water
26169	5/10/14	7:00		Process Water
26170	5/11/14	7:00		Process Water
26171	5/12/14	7:00		Process Water
26172	5/13/14	7:00		Process Water

1. RELINQUISHED BY: Salvador Gonzalez
Signature
Printed Name
Firm
5/13/14 16:00
Date/Time

2. RECEIVED BY:
Signature
Printed Name
Firm
Date/Time

TURNAROUND REQUIREMENTS:
____Standard (approx.10 days)*
____Next day ____2 Day ____5 Day*
____Email Preliminary Results To:
* Working Days

REPORT REQUIREMENTS:
____ I. Routine Report
____ II. Report (includes DUP,MS,MSD, as required, may be charged as samples)
____ III. Date Validation Report (Includes All Raw Data)
Add 10% to invoice

INVOICE INFORMATION:
Account ____ Y ____ N
P.O. # ____
Bill to: ____

SAMPLE RECEIPT:
Total Containers 70
Temperature 26.3
☐ Wet Ice ☐ Blue Ice
NO

3. RELINQUISHED BY:
Signature
Printed Name
Firm
Date/Time

4. RECEIVED BY:
Signature
Printed Name TURNER LABORATORIES, INC.
Firm 5/13/14 1600
Date/Time

*LEGEND
DW = DRINKING WATER
GW = GROUNDWATER
SD = SOLID
SG = SLUDGE
SL = SOIL
ST = STORMWATER
WW = WASTEWATER

SPECIAL INSTRUCTIONS/COMMENTS:

Compliance Analysis:	☐ Yes	☐ No	Custody Seals	☐	Preservation Confirmation	☑
ADEQ Forms:	☐ Yes	☐ No	Container Intact	☑	Appropriate Head Space	☑
Mail ADEQ Forms:	☐ Yes	☐ No	COC/Labels Agree	☑	Received Within Hold Time	☑

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Tucson, Arizona 85745
(520) 882-5880
Fax: (520) 882-9788
www.turnerlabs.com

CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 14E0453 DATE _____ PAGE 2 OF 6

PROJECT NAME _Western Copper and Gold

CONTACT NAME : Natsagdorj Gantumur

COMPANY NAME : SGS Metcon

ADDRESS : 7701 N. Business Park Dr.

CITY Tucson STATE AZ ZIP CODE 85743

PHONE _____ FAX

SAMPLER'S SIGNATURE Salvador Gonzalez

NUMBER OF CONTAINERS

CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*
26192	5/3/14	7:00		Process Water
26193	5/4/14	7:00		Process Water
26194	5/5/14	7:00		Process Water
26195	5/6/14	7:00		Process Water
26196	5/7/14	7:00		Process Water
26197	5/8-14	7:00		Process Water
26198	5-9-14	7:00		Process Water
26199	5-10-14	7:00		Process Water
26200	5-11-14	7:00		Process Water
26201	5-12-14	7:00		Process Water
26202	5-13-14	7:00		Process Water

1. RELINQUISHED BY: Salvador Gonzalez
Signature
Printed Name
Firm
5/13/14 16:00
Date/Time

2. RECEIVED BY:
Signature
Printed Name
Firm
Date/Time

TURNAROUND REQUIREMENTS:
____Standard (approx.10 days)*
____Next day ____2 Day ____5 Day*
____ Email Preliminary Results To:
* Working Days

REPORT REQUIREMENTS:
____ I. Routine Report
____ II. Report (includes DUP,MS,MSD, as required, may be charged as samples)
____ III. Date Validation Report (Includes All Raw Data)
Add 10% to invoice

INVOICE INFORMATION:
Account ____ Y ____ N
P.O. # _____
Bill to: _____

SAMPLE RECEIPT:
Total Containers 10
Temperature 26.3
☐ Wet Ice ☐ Blue Ice No

3. RELINQUISHED BY:
Signature
Printed Name
Time

4. RECEIVED BY:
Signature
Printed Name
TURNER LABORATORIES, INC.
Firm
5/13/14 1600
Date/Time

*LEGEND
DW = DRINKING WATER
GW = GROUNDWATER
SD = SOLID
SG = SLUDGE
SL = SOIL
ST = STORMWATER
WW = WASTEWATER

SPECIAL INSTRUCTIONS/COMMENTS:

Compliance Analysis:	☐ Yes	☐ No	Custody Seals	☐	Preservation Confirmation	☒
ADEQ Forms:	☐ Yes	☐ No	Container Intact	☑	Appropriate Head Space	☑
Mail ADEQ Forms:	☐ Yes	☐ No	COC/Labels Agree	☑	Received Within Hold Time	☑

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CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 14E0453 DATE 5/13/14 PAGE 3 OF 6

PROJECT NAME _Western Copper and Gold

CONTACT NAME : Natsagdorj Gantumur

COMPANY NAME : SGS Metcon

ADDRESS : 7701 N. Business Park Dr.

CITY Tucson STATE AZ ZIP CODE 85743

PHONE FAX

SAMPLER'S SIGNATURE Salvador Gonzalez

NUMBER OF CONTAINERS

CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*	Cyanide WAD
26221	5/2/14	7:00		Process Water	1
26222	5/3/14	7:00		Process Water	
26223	5/4/14	7:00		Process Water	
26224	5/5/14	7:00		Process Water	
26225	5/6/14	7:00		Process Water	
26226	5/7/14	7:00		Process Water	
26227	5/8/14	7:00		Process Water	
26228	5/9/14	7:00		Process Water	
26229	5/10/14	7:00		Process Water	
26230	5/11/14	7:00		Process Water	
26231	5/12/14	7:00		Process Water	
26232	5/13/14	7:00		Process Water	

1. RELINQUISHED BY:
Salvador Gonzalez
Signature
Printed Name
Firm
5/13/14 16:00
Date/Time

2. RECEIVED BY:
Signature
Printed Name
Firm
Date/Time

TURNAROUND REQUIREMENTS:
____Standard (approx.10 days)*
____Next day ____2 Day ____5 Day*
____Email Preliminary Results To:
* Working Days

REPORT REQUIREMENTS:
____ I. Routine Report
____ II. Report (includes DUP,MS,MSD, as required, may be charged as samples)
____ III. Date Validation Report (Includes All Raw Data)
Add 10% to invoice

INVOICE INFORMATION:
Account ____ Y ____ N
P.O. # ____
Bill to: ____

SAMPLE RECEIPT:
Total Containers 70
Temperature 26.3
☐ Wet Ice ☐ Blue Ice
NO

3. RELINQUISHED BY:
ure
d Name
Time

4. RECEIVED BY:
Signature
Printed Name
TURNER LABORATORIES, INC.
Firm
5/13/14
Date/Time

*LEGEND
DW = DRINKING WATER
GW = GROUNDWATER
SD = SOLID
SG = SLUDGE
SL = SOIL
ST = STORMWATER
WW = WASTEWATER

SPECIAL INSTRUCTIONS/COMMENTS:

Compliance Analysis:	☐ Yes	☐ No	Custody Seals	☐	Preservation Confirmation	☒
ADEQ Forms:	☐ Yes	☐ No	Container Intact	☒	Appropriate Head Space	☒
Mail ADEQ Forms:	☐ Yes	☐ No	COC/Labels Agree	☒	Received Within Hold Time	☒

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CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 14F0453 DATE _____ PAGE 4 OF 6

PROJECT NAME _Western Copper and Gold_____

CONTACT NAME : Natsagdorj Gantumur

COMPANY NAME : SGS Metcon

ADDRESS : 7701 N. Business Park Dr.

CITY Tucson STATE AZ ZIP CODE 85743

PHONE _____ FAX

SAMPLER'S SIGNATURE Salvador Gonzalez

NUMBER OF CONTAINERS

CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*	Cyanide WAD
26251	5-2-14	7:00		Process Water	
26252	5-3-14	7:00		Process Water	
26253	5-4-14	7:00		Process Water	
26254	5-5-14	7:00		Process Water	
26255	5-6-14	7:00		Process Water	
26256	5-7-14	7:00		Process Water	
26257	5-8-14	7:00		Process Water	
26258	5-9-14	7:00		Process Water	
26259	5-10-14	7:00		Process Water	
26260	5-11-14	7:00		Process Water	
26261	5-12-14	7:00		Process Water	
26262	5-13-14	7:00		Process Water	

1. RELINQUISHED BY: Salvador Gonzalez
Signature
Printed Name
Firm
5/13/14 16:00
Date/Time

2. RECEIVED BY:
Signature
Printed Name
Firm
Date/Time

TURNAROUND REQUIREMENTS:
____Standard (approx.10 days)*
____Next day ____2 Day ____5 Day*
____ Email Preliminary Results To:
* Working Days

REPORT REQUIREMENTS:
____ I. Routine Report
____ II. Report (includes DUP,MS,MSD, as required, may be charged as samples)
____ III. Date Validation Report (Includes All Raw Data)
Add 10% to invoice

INVOICE INFORMATION:
Account ____ Y ____ N
P.O. # _____
Bill to: _____

SAMPLE RECEIPT:
Total Containers 70
Temperature 26.5
☐ Wet Ice ☐ Blue Ice

3. RELINQUISHED BY:
ure
d Name
Time

4. RECEIVED BY:
Signature
Printed Name
TURNER LABORATORIES, INC.
Firm
5/13/14 1600
Date/Time

***LEGEND**
DW = DRINKING WATER
GW = GROUNDWATER
SD = SOLID
SG = SLUDGE
SL = SOIL
ST = STORMWATER
WW = WASTEWATER

SPECIAL INSTRUCTIONS/COMMENTS:

Compliance Analysis:	☐ Yes	☐ No	Custody Seals	☐	Preservation Confirmation	☒
ADEQ Forms:	☐ Yes	☐ No	Container Intact	☒	Appropriate Head Space	☐
Mail ADEQ Forms:	☐ Yes	☐ No	COC/Labels Agree	☐	Received Within Hold Time	☐

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CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 14E0453 DATE 5/13/14 PAGE 5 OF 6

PROJECT NAME _Western Copper and Gold

CONTACT NAME : Natsagdorj Gantumur

COMPANY NAME : SGS Metcon

ADDRESS : 7701 N. Business Park Dr.

CITY Tucson STATE AZ ZIP CODE 85743

PHONE FAX

SAMPLER'S SIGNATURE Salvador Gonzalez

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*	NUMBER OF CONTAINERS	CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX: Cyanide WAD
26281	5/2/14	7:00		Process Water		
26282	5/3/14	7:00		Process Water		
26283	5/4/14	7:00		Process Water		
26284	5/5/14	7:00		Process Water		
26285	5/6/14	7:00		Process Water		
26286	5/7/14	7:00		Process Water		
26287	5/8/14	7:00		Process Water		
26288	5/9/14	7:00		Process Water		
26289	5/10/14	7:00		Process Water		
26290	5/11/14	7:00		Process Water		
26291	5/12/14	7:00		Process Water		
26292	5/13/14	7:00		Process Water		

1. RELINQUISHED BY: Salvador Gonzalez
Signature
Printed Name
Firm
5/13/14 16:00
Date/Time

2. RECEIVED BY:
Signature
Printed Name
Firm
Date/Time

TURNAROUND REQUIREMENTS:
____Standard (approx.10 days)*
____Next day ____2 Day ____5 Day*
____ Email Preliminary Results To:
* Working Days

REPORT REQUIREMENTS:
____ I. Routine Report
____ II. Report (includes DUP,MS,MSD, as required, may be charged as samples)
____ III. Date Validation Report (Includes All Raw Data)
Add 10% to invoice

INVOICE INFORMATION:
Account ____ Y ____ N
P.O. #
Bill to:

SAMPLE RECEIPT:
Total Containers 70
Temperature 26.3
☐ Wet Ice ☐ Blue Ice

3. RELINQUISHED BY:
ture
d Name
Time

4. RECEIVED BY:
Signature
Printed Name
TURNER LABORATORIES, INC.
Firm
5/13/14 1600
Date/Time

*LEGEND
DW = DRINKING WATER
GW = GROUNDWATER
SD = SOLID
SG = SLUDGE
SL = SOIL
ST = STORMWATER
WW = WASTEWATER

SPECIAL INSTRUCTIONS/COMMENTS:

Compliance Analysis:	☐ Yes	☐ No	Custody Seals	☐	Preservation Confirmation	☒
ADEQ Forms:	☐ Yes	☐ No	Container Intact	☒	Appropriate Head Space	☒
Mail ADEQ Forms:	☐ Yes	☐ No	COC/Labels Agree	☒	Received Within Hold Time	☒

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CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 14E0453 DATE 5/13/14 PAGE 6 OF 6

PROJECT NAME Western Copper and Gold

CONTACT NAME: Natsagdorj Gantumur

COMPANY NAME: SGS Metcon

ADDRESS: 7701 N. Business Park Dr.

CITY Tucson STATE AZ ZIP CODE 85743

PHONE FAX

SAMPLER'S SIGNATURE Salvador Gonzalez

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*	NUMBER OF CONTAINERS	CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX: Cyanide WAD
26311	5-2-14	7:00		Process Water		
26312	5-3-14	7:00		Process Water		
26313	5-4-14	7:00		Process Water		
26314	5-5-14	7:00		Process Water		
26315	5-6-14	7:00		Process Water		
26316	5-7-14	7:00		Process Water		
26317	5-8-14	7:00		Process Water		
26318	5-9-14	7:00		Process Water		
26319	5-10-14	7:00		Process Water		
26320	5-11-14	7:00		Process Water		
26321	5-12-14	7:00		Process Water		
26322	5-13-14	7:00		Process Water		

1. RELINQUISHED BY: Salvador G
Signature
Printed Name
Firm
5/13/14 16:00
Date/Time

2. RECEIVED BY:
Signature
Printed Name
Firm
Date/Time

3. RELINQUISHED BY:
Signature
Printed Name
Time

4. RECEIVED BY:
Signature
Printed Name
TURNER LABORATORIES, INC.
Firm
5/13/14 1600
Date/Time

TURNAROUND REQUIREMENTS:
____Standard (approx.10 days)*
____Next day ____2 Day ____5 Day*
____ Email Preliminary Results To:
* Working Days

REPORT REQUIREMENTS:
____ I. Routine Report
____ II. Report (includes DUP,MS,MSD, as required, may be charged as samples)
____ III. Date Validation Report (Includes All Raw Data)
Add 10% to invoice

INVOICE INFORMATION:
Account ____ Y ____ N
P.O. #
Bill to:

SAMPLE RECEIPT:
Total Containers 70
Temperature 26.3
☐ Wet Ice ☐ Blue Ice
NO

***LEGEND**
DW = DRINKING WATER
GW = GROUNDWATER
SD = SOLID
SG = SLUDGE
SL = SOIL
ST = STORMWATER
WW = WASTEWATER

SPECIAL INSTRUCTIONS/COMMENTS:

Compliance Analysis:	☐ Yes	☐ No	Custody Seals	☐	Preservation Confirmation	☑
ADEQ Forms:	☐ Yes	☐ No	Container Intact	☑	Appropriate Head Space	☑
Mail ADEQ Forms:	☐ Yes	☐ No	COC/Labels Agree	☑	Received Within Hold Time	☑

June 08, 2014

Natska Gantumur
SGS Metcon
7701 Business Park Dr.
Tucson, AZ 85743

TEL (520) 579-8315
FAX (303) 456-6998

Work Order No.: 14E0564
Order Name: M-709-03

RE: M-709-03

Dear Natska Gantumur,

Turner Laboratories, Inc. received 36 sample(s) on 05/19/2014 for the analyses presented in the following report.

All results are intended to be considered in their entirety, and Turner Laboratories, Inc. is not responsible for use of less than the complete report. Results apply only to the samples analyzed. Samples will be disposed of 30 days after issue of our report unless special arrangements are made.

The pages that follow may contain sensitive, privileged or confidential information intended solely for the addressee named above. If you receive this message and are not the agent or employee of the addressee, this communication has been sent in error. Please do not disseminate or copy any of the attached and notify the sender immediately by telephone. Please also return the attached sheet(s) to the sender by mail.

Please call if you have any questions.

Respectfully submitted,

Turner Laboratories, Inc.
ADHS License AZ0066



Terri Garcia
Technical Director

Client: SGS Metcon
Project: M-709-03
Work Order: 14E0564
Date Received: 05/19/2014

Order: M-709-03

Work Order Sample Summary

Lab Sample ID	Client Sample ID	Matrix	Collection Date/Time
14E0564-01	26173	Process Water	05/14/2014 0700
14E0564-02	26174	Process Water	05/15/2014 0700
14E0564-03	26175	Process Water	05/16/2014 0700
14E0564-04	26176	Process Water	05/17/2014 0700
14E0564-05	26177	Process Water	05/18/2014 0700
14E0564-06	26178	Process Water	05/19/2014 0700
14E0564-07	26203	Process Water	05/14/2014 0700
14E0564-08	26204	Process Water	05/15/2014 0700
14E0564-09	26205	Process Water	05/16/2014 0700
14E0564-10	26206	Process Water	05/17/2014 0700
14E0564-11	26207	Process Water	05/18/2014 0700
14E0564-12	26208	Process Water	05/19/2014 0700
14E0564-13	26233	Process Water	05/14/2014 0700
14E0564-14	26234	Process Water	05/15/2014 0700
14E0564-15	26235	Process Water	05/16/2014 0700
14E0564-16	26236	Process Water	05/17/2014 0700
14E0564-17	26237	Process Water	05/18/2014 0700
14E0564-18	26238	Process Water	05/19/2014 0700
14E0564-19	26263	Process Water	05/14/2014 0700
14E0564-20	26264	Process Water	05/15/2014 0700
14E0564-21	26265	Process Water	05/16/2014 0700
14E0564-22	26266	Process Water	05/17/2014 0700
14E0564-23	26267	Process Water	05/18/2014 0700
14E0564-24	26268	Process Water	05/19/2014 0700
14E0564-25	26293	Process Water	05/14/2014 0700
14E0564-26	26294	Process Water	05/15/2014 0700
14E0564-27	26295	Process Water	05/16/2014 0700
14E0564-28	26296	Process Water	05/17/2014 0700
14E0564-29	26297	Process Water	05/18/2014 0700
14E0564-30	26298	Process Water	05/19/2014 0700
14E0564-31	26323	Process Water	05/14/2014 0700
14E0564-32	26324	Process Water	05/15/2014 0700

14E0564-33	26325	Process Water	05/16/2014 0700
14E0564-34	26326	Process Water	05/17/2014 0700
14E0564-35	26327	Process Water	05/18/2014 0700
14E0564-36	26328	Process Water	05/19/2014 0700

Client: SGS Metcon
Project: M-709-03
Work Order: 14E0564
Date Received: 05/19/2014

Case Narrative

All soil, sludge, and solid matrix determinations are reported on a wet weight basis unless otherwise noted.

ND Not Detected at or above the PQL

PQL Practical Quantitation Limit

DF Dilution Factor

Client:	SGS Metcon	**Client Sample ID:**	26173
Project:	M-709-03	**Collection Date/Time:**	05/14/2014 0700
Work Order:	14E0564	**Matrix:**	Process Water
Lab Sample ID:	14E0564-01	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	850	20		mg/L	200	05/20/2014 1100	05/21/2014 1610	EW

Client:	SGS Metcon	**Client Sample ID:**	26174
Project:	M-709-03	**Collection Date/Time:**	05/15/2014 0700
Work Order:	14E0564	**Matrix:**	Process Water
Lab Sample ID:	14E0564-02	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	780	20		mg/L	200	05/20/2014 1100	05/21/2014 1610	EW

Client:	SGS Metcon	**Client Sample ID:**	26175
Project:	M-709-03	**Collection Date/Time:**	05/16/2014 0700
Work Order:	14E0564	**Matrix:**	Process Water
Lab Sample ID:	14E0564-03	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	750	20		mg/L	200	05/27/2014 1030	05/28/2014 1145	EW

Client:	SGS Metcon	**Client Sample ID:**	26176
Project:	M-709-03	**Collection Date/Time:**	05/17/2014 0700
Work Order:	14E0564	**Matrix:**	Process Water
Lab Sample ID:	14E0564-04	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	790	20		mg/L	200	05/27/2014 1030	05/28/2014 1145	EW

Client:	SGS Metcon	**Client Sample ID:**	26177
Project:	M-709-03	**Collection Date/Time:**	05/18/2014 0700
Work Order:	14E0564	**Matrix:**	Process Water
Lab Sample ID:	14E0564-05	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	760	20		mg/L	200	05/27/2014 1030	05/28/2014 1145	EW

Client:	SGS Metcon	**Client Sample ID:**	26178
Project:	M-709-03	**Collection Date/Time:**	05/19/2014 0700
Work Order:	14E0564	**Matrix:**	Process Water
Lab Sample ID:	14E0564-06	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	720	20		mg/L	200	05/29/2014 0755	05/30/2014 1135	EW

Client:	SGS Metcon	**Client Sample ID:**	26203
Project:	M-709-03	**Collection Date/Time:**	05/14/2014 0700
Work Order:	14E0564	**Matrix:**	Process Water
Lab Sample ID:	14E0564-07	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	720	20		mg/L	200	05/20/2014 1100	05/21/2014 1610	EW

Client:	SGS Metcon	**Client Sample ID:**	26204
Project:	M-709-03	**Collection Date/Time:**	05/15/2014 0700
Work Order:	14E0564	**Matrix:**	Process Water
Lab Sample ID:	14E0564-08	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	840	20		mg/L	200	05/20/2014 1100	05/21/2014 1610	EW

Client:	SGS Metcon	**Client Sample ID:**	26205
Project:	M-709-03	**Collection Date/Time:**	05/16/2014 0700
Work Order:	14E0564	**Matrix:**	Process Water
Lab Sample ID:	14E0564-09	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	790	20		mg/L	200	05/27/2014 1030	05/28/2014 1145	EW

Client:	SGS Metcon	**Client Sample ID:**	26206
Project:	M-709-03	**Collection Date/Time:**	05/17/2014 0700
Work Order:	14E0564	**Matrix:**	Process Water
Lab Sample ID:	14E0564-10	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	780	20		mg/L	200	05/27/2014 1030	05/28/2014 1145	EW

Client:	SGS Metcon	**Client Sample ID:**	26207
Project:	M-709-03	**Collection Date/Time:**	05/18/2014 0700
Work Order:	14E0564	**Matrix:**	Process Water
Lab Sample ID:	14E0564-11	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	880	20		mg/L	200	05/27/2014 1030	05/28/2014 1145	EW

Client:	SGS Metcon	**Client Sample ID:**	26208
Project:	M-709-03	**Collection Date/Time:**	05/19/2014 0700
Work Order:	14E0564	**Matrix:**	Process Water
Lab Sample ID:	14E0564-12	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	670	20		mg/L	200	05/29/2014 0755	05/30/2014 1135	EW

Client:	SGS Metcon	**Client Sample ID:**	26233
Project:	M-709-03	**Collection Date/Time:**	05/14/2014 0700
Work Order:	14E0564	**Matrix:**	Process Water
Lab Sample ID:	14E0564-13	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	830	20		mg/L	200	05/20/2014 1100	05/21/2014 1610	EW

Client:	SGS Metcon	**Client Sample ID:**	26234
Project:	M-709-03	**Collection Date/Time:**	05/15/2014 0700
Work Order:	14E0564	**Matrix:**	Process Water
Lab Sample ID:	14E0564-14	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	830	20		mg/L	200	05/20/2014 1100	05/21/2014 1610	EW

Client:	SGS Metcon	**Client Sample ID:**	26235
Project:	M-709-03	**Collection Date/Time:**	05/16/2014 0700
Work Order:	14E0564	**Matrix:**	Process Water
Lab Sample ID:	14E0564-15	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	700	20		mg/L	200	05/27/2014 1030	05/28/2014 1145	EW

Client:	SGS Metcon	**Client Sample ID:**	26236
Project:	M-709-03	**Collection Date/Time:**	05/17/2014 0700
Work Order:	14E0564	**Matrix:**	Process Water
Lab Sample ID:	14E0564-16	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	700	20		mg/L	200	05/27/2014 1030	05/28/2014 1145	EW

Client:	SGS Metcon	**Client Sample ID:**	26237
Project:	M-709-03	**Collection Date/Time:**	05/18/2014 0700
Work Order:	14E0564	**Matrix:**	Process Water
Lab Sample ID:	14E0564-17	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	750	20		mg/L	200	05/27/2014 1030	05/28/2014 1145	EW

Client:	SGS Metcon	**Client Sample ID:**	26238
Project:	M-709-03	**Collection Date/Time:**	05/19/2014 0700
Work Order:	14E0564	**Matrix:**	Process Water
Lab Sample ID:	14E0564-18	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	720	20		mg/L	200	05/29/2014 0755	05/30/2014 1135	EW

Client:	SGS Metcon	**Client Sample ID:**	26263
Project:	M-709-03	**Collection Date/Time:**	05/14/2014 0700
Work Order:	14E0564	**Matrix:**	Process Water
Lab Sample ID:	14E0564-19	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	940	20		mg/L	200	05/20/2014 1100	05/21/2014 1610	EW

Client:	SGS Metcon	**Client Sample ID:**	26264
Project:	M-709-03	**Collection Date/Time:**	05/15/2014 0700
Work Order:	14E0564	**Matrix:**	Process Water
Lab Sample ID:	14E0564-20	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	780	20		mg/L	200	05/20/2014 1100	05/21/2014 1610	EW

Client:	SGS Metcon	**Client Sample ID:**	26265
Project:	M-709-03	**Collection Date/Time:**	05/16/2014 0700
Work Order:	14E0564	**Matrix:**	Process Water
Lab Sample ID:	14E0564-21	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	700	20		mg/L	200	05/27/2014 1030	05/28/2014 1145	EW

Client:	SGS Metcon	**Client Sample ID:**	26266
Project:	M-709-03	**Collection Date/Time:**	05/17/2014 0700
Work Order:	14E0564	**Matrix:**	Process Water
Lab Sample ID:	14E0564-22	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	720	20		mg/L	200	05/27/2014 1030	05/28/2014 1145	EW

Client:	SGS Metcon	**Client Sample ID:**	26267
Project:	M-709-03	**Collection Date/Time:**	05/18/2014 0700
Work Order:	14E0564	**Matrix:**	Process Water
Lab Sample ID:	14E0564-23	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	740	20		mg/L	200	05/27/2014 1030	05/28/2014 1145	EW

Client:	SGS Metcon	**Client Sample ID:**	26268
Project:	M-709-03	**Collection Date/Time:**	05/19/2014 0700
Work Order:	14E0564	**Matrix:**	Process Water
Lab Sample ID:	14E0564-24	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	690	20		mg/L	200	05/29/2014 0755	05/30/2014 1135	EW

Client:	SGS Metcon	**Client Sample ID:**	26293
Project:	M-709-03	**Collection Date/Time:**	05/14/2014 0700
Work Order:	14E0564	**Matrix:**	Process Water
Lab Sample ID:	14E0564-25	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	750	20		mg/L	200	05/20/2014 1100	05/21/2014 1610	EW

Client:	SGS Metcon	**Client Sample ID:**	26294
Project:	M-709-03	**Collection Date/Time:**	05/15/2014 0700
Work Order:	14E0564	**Matrix:**	Process Water
Lab Sample ID:	14E0564-26	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	780	20		mg/L	200	05/27/2014 1030	05/28/2014 1145	EW

Client:	SGS Metcon	**Client Sample ID:**	26295
Project:	M-709-03	**Collection Date/Time:**	05/16/2014 0700
Work Order:	14E0564	**Matrix:**	Process Water
Lab Sample ID:	14E0564-27	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	710	20		mg/L	200	05/27/2014 1030	05/28/2014 1145	EW

Client:	SGS Metcon	**Client Sample ID:**	26296
Project:	M-709-03	**Collection Date/Time:**	05/17/2014 0700
Work Order:	14E0564	**Matrix:**	Process Water
Lab Sample ID:	14E0564-28	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	710	20		mg/L	200	05/27/2014 1030	05/28/2014 1145	EW

Client:	SGS Metcon	**Client Sample ID:**	26297
Project:	M-709-03	**Collection Date/Time:**	05/18/2014 0700
Work Order:	14E0564	**Matrix:**	Process Water
Lab Sample ID:	14E0564-29	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	740	20		mg/L	200	05/27/2014 1030	05/28/2014 1145	EW

Client:	SGS Metcon	**Client Sample ID:**	26298
Project:	M-709-03	**Collection Date/Time:**	05/19/2014 0700
Work Order:	14E0564	**Matrix:**	Process Water
Lab Sample ID:	14E0564-30	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	710	20		mg/L	200	05/29/2014 0755	05/30/2014 1135	EW

Client:	SGS Metcon	**Client Sample ID:**	26323
Project:	M-709-03	**Collection Date/Time:**	05/14/2014 0700
Work Order:	14E0564	**Matrix:**	Process Water
Lab Sample ID:	14E0564-31	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	770	20		mg/L	200	05/20/2014 1100	05/21/2014 1610	EW

Client:	SGS Metcon	**Client Sample ID:**	26324
Project:	M-709-03	**Collection Date/Time:**	05/15/2014 0700
Work Order:	14E0564	**Matrix:**	Process Water
Lab Sample ID:	14E0564-32	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	760	20		mg/L	200	05/27/2014 1030	05/28/2014 1145	EW

Client:	SGS Metcon	**Client Sample ID:**	26325
Project:	M-709-03	**Collection Date/Time:**	05/16/2014 0700
Work Order:	14E0564	**Matrix:**	Process Water
Lab Sample ID:	14E0564-33	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	710	20		mg/L	200	05/27/2014 1030	05/28/2014 1145	EW

Client:	SGS Metcon	**Client Sample ID:**	26326
Project:	M-709-03	**Collection Date/Time:**	05/17/2014 0700
Work Order:	14E0564	**Matrix:**	Process Water
Lab Sample ID:	14E0564-34	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	690	20		mg/L	200	05/27/2014 1030	05/28/2014 1145	EW

Client:	SGS Metcon	**Client Sample ID:**	26327
Project:	M-709-03	**Collection Date/Time:**	05/18/2014 0700
Work Order:	14E0564	**Matrix:**	Process Water
Lab Sample ID:	14E0564-35	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	520	20		mg/L	200	05/27/2014 1030	05/28/2014 1145	EW

Client:	SGS Metcon	**Client Sample ID:**	26328
Project:	M-709-03	**Collection Date/Time:**	05/19/2014 0700
Work Order:	14E0564	**Matrix:**	Process Water
Lab Sample ID:	14E0564-36	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	660	20		mg/L	200	05/29/2014 0755	05/30/2014 1135	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14E0564
Date Received: 05/19/2014

QC Summary

Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Qual
Batch 1405209 - SM4500-CN I										
Blank (1405209-BLK1)				Prepared: 05/20/2014 Analyzed: 05/21/2014						
Cyanide	ND	0.10	mg/L							
LCS (1405209-BS1)				Prepared: 05/20/2014 Analyzed: 05/21/2014						
Cyanide	2.0	0.10	mg/L	2.000		100	90-110			
LCS Dup (1405209-BSD1)				Prepared: 05/20/2014 Analyzed: 05/21/2014						
Cyanide	2.0	0.10	mg/L	2.000		99	90-110	1	20	
Matrix Spike (1405209-MS1)		**Source: 14E0564-01**		Prepared: 05/20/2014 Analyzed: 05/21/2014						
Cyanide	1900	50	mg/L	1000	850	101	70-130			
Batch 1405267 - SM4500-CN I										
Blank (1405267-BLK1)				Prepared: 05/27/2014 Analyzed: 05/28/2014						
Cyanide	ND	0.10	mg/L							
LCS (1405267-BS1)				Prepared: 05/27/2014 Analyzed: 05/28/2014						
Cyanide	2.0	0.10	mg/L	2.000		99	90-110			
LCS Dup (1405267-BSD1)				Prepared: 05/27/2014 Analyzed: 05/28/2014						
Cyanide	1.9	0.10	mg/L	2.000		96	90-110	4	20	
Matrix Spike (1405267-MS1)		**Source: 14E0564-22**		Prepared: 05/27/2014 Analyzed: 05/28/2014						
Cyanide	1700	50	mg/L	1000	720	101	70-130			
Batch 1405299 - SM4500-CN I										
Blank (1405299-BLK1)				Prepared: 05/29/2014 Analyzed: 05/30/2014						
Cyanide	ND	0.10	mg/L							
LCS (1405299-BS1)				Prepared: 05/29/2014 Analyzed: 05/30/2014						
Cyanide	1.9	0.10	mg/L	2.000		97	90-110			
LCS Dup (1405299-BSD1)				Prepared: 05/29/2014 Analyzed: 05/30/2014						
Cyanide	2.0	0.10	mg/L	2.000		98	90-110	0.6	20	
Matrix Spike (1405299-MS1)		**Source: 14E0725-20**		Prepared: 05/29/2014 Analyzed: 05/30/2014						
Cyanide	1500	50	mg/L	1000	690	82	70-130			

TURNER LABORATORIES INC.
2445 N. Coyote Drive, Suite 104
Tucson, Arizona 85745
(520) 882-5880
Fax: (520) 882-9788
www.turnerlabs.com

CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 14E0564 DATE 5/19/14 PAGE 1 OF 6

PROJECT NAME Western Copper and Gold # _____
CONTACT NAME Natsagdorj Gantumur
COMPANY NAME SGS Metcon
ADDRESS 7701 N. Business Park Dr Tucson AZ
ZIP 85743 PHONE 579 83 15 EMAIL _____
SAMPLER'S SIGNATURE Salvador Gonzalez

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*	NUMBER OF CONTAINERS	CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX
26173	5/14/14	7:00		Process Water		✓
26174	5/15/14	7:00		Process Water		✓
26175	5/16/14	7:00		Process Water		✓
26176	5/17/14	7:00		Process Water		✓
26177	5/18/14	7:00		Process Water		✓
26178	5/19/14	7:00		Process Water		✓

1. RELINQUISHED BY: Salvador Gonzalez — Signature — Printed Name — Firm — 5/19/14 15:50 Date/Time

2. RECEIVED BY: Signature — Printed Name — Firm — Date/Time

3. RELINQUISHED BY: Signature — Printed Name — Firm — Date/Time

4. RECEIVED BY: Signature — Printed Name — TURNER LABORATORIES, INC. — Firm — 5/19/14 1550 Date/Time

TURNAROUND REQUIREMENTS:
- ✓ Standard (approx. 10 days)*
- ___ Next Day ___ 2 Day ___ 5 Day*
- ___ Email Preliminary Results

* Working Days

REPORT REQUIREMENTS:
- ___ I. Routine Report
- ___ II. Report (includes DUP, MS, MSD, as required, may be charged as samples)
- ___ III. Date Validation Report (Includes All Raw Data) Add 10% to invoice

INVOICE INFORMATION:
Account ___ Y ___ N
P.O. # _____
Bill to: _____

SAMPLE RECEIPT:
Total Containers 36
Temperature 25.2
- ☐ Wet Ice
- ☒ Ambient
- ☐ Blue Ice

* LEGEND SAMPLE MATRIX
DW = DRINKING WATER
GW = GROUNDWATER
SD = SOLID
SG = SLUDGE
SL = SOIL
ST = STORMWATER
WW = WASTEWATER

Compliance Analysis: ☐ Yes ☐ No	Custody Seals ☐	Preservation Confirmation ☒
ADEQ Forms: ☐ Yes ☐ No	Container Intact ☒	Appropriate Head Space ☒
Mail ADEQ Forms: ☐ Yes ☐ No	COC / Labels Agree ☒	Received Within Hold Time ☒

SPECIAL INSTRUCTIONS/COMMENTS:

TURNER LABORATORIES INC
2445 N. Coyote Drive, Suite 104
Tucson, Arizona 85745
(520) 882-5880
Fax: (520) 882-9788
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CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 14E0564 DATE 5/19/14 PAGE 2 OF 6

PROJECT NAME Western Copper and Gold # _____
CONTACT NAME Natsagdorj Gantumur
COMPANY NAME SGS Metcon
ADDRESS 7701 N. Business Park Dr Tucson AZ
ZIP 85743 PHONE 579 83 15 EMAIL _____
SAMPLER'S SIGNATURE Salvador Gonzalez

NUMBER OF CONTAINERS

CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*	Total ✓
26203	5/14/14	7:00		Process Water	✓
26204	5/15/14	7:00		Process Water	✓
26205	5/16/14	7:00		Process Water	✓
26206	5/17/14	7:00		Process Water	✓
26207	5/18/14	7:00		Process Water	✓
26208	5/19/14	7:00		Process Water	✓

Base Neutrals 625/8270 ☐ Acids ☐ Volatile Organics 624 ☐ 524.2 ☐ 8260 TTHMS ☐ HAA5 ☐ Chloride ☐ Sulfate ☐ Resistivity ☐ NO_2 ☐ NO_3 ☐ TKN ☐ TPH ☐ 1664 ☐ Oil & Grease VOA ☐ TCLP Analysis Semi-VOA ☐ Pest. ☐ TCLP ☐ Metals Dissolved ☐ Total ☐ RCRA8 ☐ Cyanide Total ☐ Amen. ☐ WAD ☑ SDWA-INORGANICS PRIMARY ☐ SECONDARY ☐ Coliform MPN ☐ PVA ☐ pH ☐ Fecal ☐ Cl_2 ☐ Cl ☐ Turb ☐ COD ☐ TSS ☐ BOD ☐

1. RELINQUISHED BY: Salvador Gonzalez — Signature — Printed Name — Firm — 5/19/14 15:50 Date/Time

2. RECEIVED BY: Signature — Printed Name — Firm — Date/Time

TURNAROUND REQUIREMENTS:
✓ Standard (approx. 10 days)*
___ Next Day ___ 2 Day ___ 5 Day*
___ Email Preliminary Results
* Working Days

REPORT REQUIREMENTS:
___ I. Routine Report
___ II. Report (includes DUP, MS, MSD, as required, may be charged as samples)
___ III. Date Validation Report (Includes All Raw Data) Add 10% to invoice

INVOICE INFORMATION:
Account ___ Y ___ N
P.O. # _____
Bill to: _____

SAMPLE RECEIPT:
Total Containers 36
Temperature 25.2
☐ Wet Ice
☒ Ambient
☐ Blue Ice

3. RELINQUISHED BY: Signature — Printed Name — Firm — Date/Time

4. RECEIVED BY: Signature — Printed Name — TURNER LABORATORIES, INC. — Firm — 5/19/14 1550 Date/Time

* LEGEND
SAMPLE MATRIX
DW = DRINKING WATER
GW = GROUNDWATER
SD = SOLID
SG = SLUDGE
SL = SOIL
ST = STORMWATER
WW = WASTEWATER

Compliance Analysis: ☐ Yes ☐ No		Custody Seals ☐	Preservation Confirmation ☒
ADEQ Forms: ☐ Yes ☐ No		Container Intact ☒	Appropriate Head Space ☒
Mail ADEQ Forms: ☐ Yes ☐ No		COC / Labels Agree ☒	Received Within Hold Time ☒

SPECIAL INSTRUCTIONS/COMMENTS:

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CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 14E0564 DATE 5/19/14 PAGE 3 OF 6

PROJECT NAME Western Copper and Gold # _____
CONTACT NAME Natsagdorj Gantumur
COMPANY NAME SGS Metcon
ADDRESS 7701 N. Business Park Dr Tucson AZ
ZIP 85743 PHONE 579 83 15 EMAIL _____
SAMPLER'S SIGNATURE Salvador Gonzalez

NUMBER OF CONTAINERS

CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*	Total
26233	5/14/14	7:00		Process Water	✓
26234	5/15/14	7:00		Process Water	✓
26235	5/16/14	7:00		Process Water	✓
26236	5/17/14	7:00		Process Water	✓
26237	5/18/14	7:00		Process Water	✓
26238	5/19/14	7:00		Process Water	✓

Base Neutrals 625/8270 ☐ Acids ☐
Volatile Organics ☐ 624 ☐ 524.2 ☐ 8260 ☐ TTHMS ☐ HAAS ☐
Chloride ☐ Sulfate ☐ Resistivity ☐
NO_2 ☐ NO_3 ☐ TKN ☐
TPH ☐ 1664 ☐ Oil & Grease ☐
VOA ☐ TCLP Analysis SemiVOA ☐ Pest. ☐
TCLP ☐ Metals Dissolved ☐ Total ☐ RCRA8 ☐
Total ☐ Cyanide Amen. ☐ WAD ☒
SDWA INORGANICS PRIMARY ☐ SECONDARY ☐
MPN ☐ Coliform PIA ☐ Fecal ☐
pH ☐ Cl_2 ☐ Cr_6 ☐ Turb ☐
COD ☐ TSS ☐ BOD ☐

1. RELINQUISHED BY:
Salvador Gonzalez
Signature
Printed Name
Firm
5/19/14 15:50
Date/Time

2. RECEIVED BY:
Signature
Printed Name
Firm
Date/Time

TURNAROUND REQUIREMENTS:
✓ Standard (approx. 10 days)*
___ Next Day ___ 2 Day ___ 5 Day*
___ Email Preliminary Results
* Working Days

REPORT REQUIREMENTS:
___ I. Routine Report
___ II. Report (includes DUP, MS, MSD, as required, may be charged as samples)
___ III. Date Validation Report (Includes All Raw Data) Add 10% to invoice

INVOICE INFORMATION:
Account ___ Y ___ N
P.O. # _____
Bill to: _____

SAMPLE RECEIPT:
Total Containers 36
Temperature 25.2
☐ Wet Ice
☒ Ambient
☐ Blue Ice

3. RELINQUISHED BY:
Signature
Printed Name
Firm
Date/Time

4. RECEIVED BY:
Signature
Printed Name
TURNER LABORATORIES, INC.
Firm
5/19/14 1550
Date/Time

* LEGEND
SAMPLE MATRIX
DW = DRINKING WATER
GW = GROUNDWATER
SD = SOLID
SG = SLUDGE
SL = SOIL
ST = STORMWATER
WW = WASTEWATER

Compliance Analysis: ☐ Yes ☐ No		Custody Seals ☐	Preservation Confirmation ☒
ADEQ Forms: ☐ Yes ☐ No		Container Intact ☒	Appropriate Head Space ☒
Mail ADEQ Forms: ☐ Yes ☐ No		COC / Labels Agree ☒	Received Within Hold Time ☒

SPECIAL INSTRUCTIONS/COMMENTS:

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CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 14E0564 DATE 5/19/14 PAGE 4 OF 6

PROJECT NAME Western Copper and Gold # _____
CONTACT NAME Natsaydori Gantumur
COMPANY NAME SGS Metcon
ADDRESS 7701 N. Business Park Dr Tucson AZ
ZIP 85743 PHONE 579 83 15 EMAIL _____
SAMPLER'S SIGNATURE Salvador Gonzalez

NUMBER OF CONTAINERS

CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*	Base Neutrals 625/8270	Acids	Volatile Organics 624	524.2	8260	TTHMS	HAA5	Chloride	Sulfate	Resistivity	NO_2	NO_3	TKN	TPH	1664	Oil & Grease	VOA	Semi-VOA	TCLP Analysis	Pest.	TCLP	Dissolved	Metals	Total	RCRA8	Total	Cyanide	Amen.	WAD	SDWA/INORGANICS PRIMARY	SECONDARY	MPN	Coliform	PIA	pH	Fecal	C_6	Cl_2	Turb	COD	TSS	BOD
26263	5/14/14	7:00		Process Water																										✓																
26264	5/15/14	7:00		Process Water																										✓																
26265	5/16/14	7:00		Process Water																										✓																
26266	5/17/14	7:00		Process Water																										✓																
26267	5/18/14	7:00		Process Water																										✓																
26268	5/19/14	7:00		Process Water																										✓																

1. RELINQUISHED BY:
Salvador Gonzalez
Signature
Printed Name
Firm
5/19/14 15:50
Date/Time

2. RECEIVED BY:
Signature
Printed Name
Firm
Date/Time

TURNAROUND REQUIREMENTS:
✓ Standard (approx. 10 days)*
___ Next Day ___ 2 Day ___ 5 Day*
___ Email Preliminary Results
* Working Days

REPORT REQUIREMENTS:
___ I. Routine Report
___ II. Report (includes DUP, MS, MSD, as required, may be charged as samples)
___ III. Date Validation Report (Includes All Raw Data) Add 10% to invoice

INVOICE INFORMATION:
Account ___ Y ___ N
P.O. # _____
Bill to: _____

SAMPLE RECEIPT:
Total Containers 36
Temperature 25.2
☐ Wet Ice
☒ Ambient
☐ Blue Ice

3. RELINQUISHED BY:
Signature
Printed Name
Firm
Date/Time

4. RECEIVED BY:
Signature
Printed Name
TURNER LABORATORIES, INC.
Firm
5/19/14
Date/Time

* LEGEND
SAMPLE MATRIX
DW = DRINKING WATER
GW = GROUNDWATER
SD = SOLID
SG = SLUDGE
SL = SOIL
ST = STORMWATER
WW = WASTEWATER

Compliance Analysis: ☐ Yes ☐ No
ADEQ Forms: ☐ Yes ☐ No
Mail ADEQ Forms: ☐ Yes ☐ No

Custody Seals ☐
Container Intact ☒
COC / Labels Agree ☒

Preservation Confirmation ☑
Appropriate Head Space ☑
Received Within Hold Time ☑

SPECIAL INSTRUCTIONS/COMMENTS:

TURNER LABORATORIES INC.
2445 N. Coyote Drive, Suite 104
Tucson, Arizona 85745
(520) 882-5880
Fax: (520) 882-9788
www.turnerlabs.com

CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 14E0564 DATE 5/19/14 PAGE 5 OF 6

PROJECT NAME Western Copper and Gold # _____
CONTACT NAME Natsagdorj Gantumur
COMPANY NAME SGS Metcon
ADDRESS 7701 N. Business Park Dr Tucson AZ
ZIP 85743 PHONE 579 83 15 EMAIL _____
SAMPLER'S SIGNATURE Salvador Gonzalez

NUMBER OF CONTAINERS

CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*	Base Neutrals 625/8270 ☐	Acids ☐	Volatile Organics 624 ☐	524.2 ☐	8260 ☐	TTHMS ☐	HAA5 ☐	Chloride ☐	Sulfate ☐	Resistivity ☐	NO_2 ☐	NO_3 ☐	TKN ☐	TPH ☐	1664 ☐	Oil & Grease ☐	VOA ☐	TCLP Analysis Semi-VOA ☐	Pest. ☐	TCLP ☐	Metals Total ☐	Dissolved ☐	RCRA8 ☐	Total ☐	Cyanide Amen. ☐	WAD ☒	SDWA/INORGANICS PRIMARY ☐	SECONDARY ☐	MPN ☐	Coliform PIA ☐	pH ☐	Fecal ☐	C_6 ☐	Cl_2 ☐	Turb ☐	COD ☐	TSS ☐	BOD ☐
26293	5/14/14	7:00		Process Water																								✓														
26294	5/15/14	7:00		Process Water																								✓														
26295	5/16/14	7:00		Process Water																								✓														
26296	5/17/14	7:00		Process Water																								✓														
26297	5/18/14	7:00		Process Water																								✓														
26298	5/19/14	7:00		Process Water																								✓														

1. RELINQUISHED BY:
Salvador Gonzalez
Signature
Printed Name
Firm
5/19/14 15:50
Date/Time

2. RECEIVED BY:
Signature
Printed Name
Firm
Date/Time

TURNAROUND REQUIREMENTS:
✓ Standard (approx. 10 days)*
___ Next Day ___ 2 Day ___ 5 Day*
___ Email Preliminary Results
* Working Days

REPORT REQUIREMENTS:
___ I. Routine Report
___ II. Report (includes DUP, MS, MSD, as required, may be charged as samples)
___ III. Date Validation Report (Includes All Raw Data) Add 10% to invoice

INVOICE INFORMATION:
Account ___ Y ___ N
P.O. # _____
Bill to: _____

SAMPLE RECEIPT:
Total Containers 36
Temperature 25.2
☐ Wet Ice
☒ Ambient
☐ Blue Ice

3. RELINQUISHED BY:
Signature
Printed Name
Firm
Date/Time

4. RECEIVED BY:
Signature
Printed Name
TURNER LABORATORIES, INC.
Firm
5/19/14 1550
Date/Time

* LEGEND
SAMPLE MATRIX
DW = DRINKING WATER
GW = GROUNDWATER
SD = SOLID
SG = SLUDGE
SL = SOIL
ST = STORMWATER
WW = WASTEWATER

Compliance Analysis: ☐ Yes ☐ No		Custody Seals ☐	Preservation Confirmation ☒
ADEQ Forms: ☐ Yes ☐ No		Container Intact ☒	Appropriate Head Space ☒
Mail ADEQ Forms: ☐ Yes ☐ No		COC / Labels Agree ☒	Received Within Hold Time ☒

SPECIAL INSTRUCTIONS/COMMENTS:

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CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 14E0564 DATE 5/19/14 PAGE 6 OF 6

PROJECT NAME Western Copper and Gold # _____
CONTACT NAME Natsagdorj Gantumur
COMPANY NAME SGS Metcon
ADDRESS 7701 N. Business Park Dr Tucson AZ
ZIP 85743 PHONE 579 83 15 EMAIL _____
SAMPLER'S SIGNATURE Salvador Gonzalez

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*	NUMBER OF CONTAINERS	CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX
26323	5/14/14	7:00		Process Water		✓ Cyanide Total, WAD
26324	5/15/14	7:00		Process Water		✓
26325	5/16/14	7:00		Process Water		✓
26326	5/17/14	7:00		Process Water		✓
26327	5/18/14	7:00		Process Water		✓
26328	5/19/14	7:00		Process Water		✓

Base Neutrals 625/8270 ☐ Acids ☐ Volatile Organics 624 ☐ 524.2 ☐ 8260 TTHMS ☐ HAA5 ☐ Chloride ☐ Sulfate ☐ Resistivity NO2 ☐ NO3 ☐ TKN ☐ TPH ☐ 1664 ☐ Oil & Grease VOA ☐ TCLP Analysis Semi-VOA ☐ Pest ☐ TCLP ☐ Metals Dissolved ☐ Total ☐ RCRA8 ☐ Cyanide Total ☐ Amen. ☐ WAD ☑ SDWA-INORGANICS PRIMARY ☐ SECONDARY ☐ Coliform MPN ☐ PIA ☐ pH ☐ Fecal ☐ Cl2 ☐ Cl2 ☐ Turb ☐ TSS ☐ BOD ☐ COD ☐

1. RELINQUISHED BY:
Salvador Gonzalez
Signature
Printed Name
Firm
5/19/14 15:50
Date/Time

2. RECEIVED BY:
Signature
Printed Name
Firm
Date/Time

TURNAROUND REQUIREMENTS:
✓ Standard (approx. 10 days)*
___ Next Day ___ 2 Day ___ 5 Day*
___ Email Preliminary Results
* Working Days

REPORT REQUIREMENTS:
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INVOICE INFORMATION:
Account ___ Y ___ N
P.O. # _____
Bill to: _____

SAMPLE RECEIPT:
Total Containers 36
Temperature 25.2
☐ Wet Ice
☑ Ambient
☐ Blue Ice

3. RELINQUISHED BY:
Signature
Printed Name
Firm
Date/Time

4. RECEIVED BY:
Signature
Printed Name
TURNER LABORATORIES, INC.
Firm
5/19/14 1550
Date/Time

* LEGEND
SAMPLE MATRIX
DW = DRINKING WATER
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Compliance Analysis: ☐ Yes ☐ No
ADEQ Forms: ☐ Yes ☐ No
Mail ADEQ Forms: ☐ Yes ☐ No

Custody Seals ☐
Container Intact ☒
COC / Labels Agree ☑

Preservation Confirmation ☒
Appropriate Head Space ☒
Received Within Hold Time ☑

SPECIAL INSTRUCTIONS/COMMENTS:

June 15, 2014

Natska Gantumur
SGS Metcon
7701 Business Park Dr.
Tucson, AZ 85743

TEL (520) 579-8315
FAX (303) 456-6998

Work Order No.: 14E0725
Order Name: M-709-03

RE: M-709-03

Dear Natska Gantumur,

Turner Laboratories, Inc. received 58 sample(s) on 05/28/2014 for the analyses presented in the following report.

All results are intended to be considered in their entirety, and Turner Laboratories, Inc. is not responsible for use of less than the complete report. Results apply only to the samples analyzed. Samples will be disposed of 30 days after issue of our report unless special arrangements are made.

The pages that follow may contain sensitive, privileged or confidential information intended solely for the addressee named above. If you receive this message and are not the agent or employee of the addressee, this communication has been sent in error. Please do not disseminate or copy any of the attached and notify the sender immediately by telephone. Please also return the attached sheet(s) to the sender by mail.

Please call if you have any questions.

Respectfully submitted,

Turner Laboratories, Inc.
ADHS License AZ0066



Terri Garcia
Technical Director

Client: SGS Metcon
Project: M-709-03
Work Order: 14E0725
Date Received: 05/28/2014

Order: M-709-03

Work Order Sample Summary

Lab Sample ID	Client Sample ID	Matrix	Collection Date/Time
14E0725-01	26179	Process Water	05/20/2014 0700
14E0725-02	26180	Process Water	05/21/2014 0700
14E0725-03	26181	Process Water	05/22/2014 0700
14E0725-04	26182	Process Water	05/23/2014 0700
14E0725-05	26183	Process Water	05/24/2014 0700
14E0725-06	26184	Process Water	05/25/2014 0700
14E0725-07	26185	Process Water	05/26/2014 0700
14E0725-08	26186	Process Water	05/27/2014 0700
14E0725-09	26187	Process Water	05/28/2014 0700
14E0725-10	26209	Process Water	05/20/2014 0700
14E0725-11	26210	Process Water	05/21/2014 0700
14E0725-12	26211	Process Water	05/22/2014 0700
14E0725-13	26212	Process Water	05/23/2014 0700
14E0725-14	26213	Process Water	05/24/2014 0700
14E0725-15	26214	Process Water	05/25/2014 0700
14E0725-16	26215	Process Water	05/26/2014 0700
14E0725-17	26216	Process Water	05/27/2014 0700
14E0725-18	26217	Process Water	05/28/2014 0700
14E0725-19	26239	Process Water	05/20/2014 0700
14E0725-20	26240	Process Water	05/21/2014 0700
14E0725-21	26241	Process Water	05/22/2014 0700
14E0725-22	26242	Process Water	05/23/2014 0700
14E0725-23	26243	Process Water	05/24/2014 0700
14E0725-24	26244	Process Water	05/25/2014 0700
14E0725-25	26245	Process Water	05/26/2014 0700
14E0725-26	26246	Process Water	05/27/2014 0700
14E0725-27	26247	Process Water	05/28/2014 0700
14E0725-28	26269	Process Water	05/20/2014 0700
14E0725-29	26270	Process Water	05/21/2014 0700
14E0725-30	26271	Process Water	05/22/2014 0700
14E0725-31	26272	Process Water	05/23/2014 0700
14E0725-32	26273	Process Water	05/24/2014 0700

14E0725-33	26274	Process Water	05/25/2014 0700
14E0725-34	26275	Process Water	05/26/2014 0700
14E0725-35	26276	Process Water	05/27/2014 0700
14E0725-36	26277	Process Water	05/28/2014 0700
14E0725-37	26299	Process Water	05/20/2014 0700
14E0725-38	26300	Process Water	05/21/2014 0700
14E0725-39	26301	Process Water	05/22/2014 0700
14E0725-40	26302	Process Water	05/23/2014 0700
14E0725-41	26303	Process Water	05/24/2014 0700
14E0725-42	26304	Process Water	05/25/2014 0700
14E0725-43	26305	Process Water	05/26/2014 0700
14E0725-44	26306	Process Water	05/27/2014 0700
14E0725-45	26307	Process Water	05/28/2014 0700
14E0725-46	26329	Process Water	05/20/2014 0700
14E0725-47	26330	Process Water	05/21/2014 0700
14E0725-48	26331	Process Water	05/22/2014 0700
14E0725-49	26332	Process Water	05/23/2014 0700
14E0725-50	26333	Process Water	05/24/2014 0700
14E0725-51	26334	Process Water	05/25/2014 0700
14E0725-52	26335	Process Water	05/26/2014 0700
14E0725-53	26336	Process Water	05/27/2014 0700
14E0725-54	26337	Process Water	05/28/2014 0700
14E0725-55	1008	Process Water	05/07/2014 0700
14E0725-56	1009	Process Water	05/14/2014 0700
14E0725-57	1010	Process Water	05/20/2014 0700
14E0725-58	1013	Process Water	05/28/2014 0700

Client: SGS Metcon
Project: M-709-03
Work Order: 14E0725
Date Received: 05/28/2014

Case Narrative

H3 Sample was received and/or analysis requested past holding time.

All soil, sludge, and solid matrix determinations are reported on a wet weight basis unless otherwise noted.

ND Not Detected at or above the PQL

PQL Practical Quantitation Limit

DF Dilution Factor

Client:	SGS Metcon	**Client Sample ID:**	26179
Project:	M-709-03	**Collection Date/Time:**	05/20/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-01	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	630	20		mg/L	200	05/29/2014 0755	05/30/2014 1135	EW

Client:	SGS Metcon	**Client Sample ID:**	26180
Project:	M-709-03	**Collection Date/Time:**	05/21/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-02	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	650	20		mg/L	200	06/02/2014 0720	06/03/2014 1035	EW

Client:	SGS Metcon	**Client Sample ID:**	26181
Project:	M-709-03	**Collection Date/Time:**	05/22/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-03	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	680	20		mg/L	200	06/02/2014 0720	06/03/2014 1035	EW

Client:	SGS Metcon	**Client Sample ID:**	26182
Project:	M-709-03	**Collection Date/Time:**	05/23/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-04	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	680	20		mg/L	200	06/02/2014 0720	06/03/2014 1035	EW

Client:	SGS Metcon	**Client Sample ID:**	26183
Project:	M-709-03	**Collection Date/Time:**	05/24/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-05	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	750	20		mg/L	200	06/02/2014 0720	06/03/2014 1035	EW

Client:	SGS Metcon	**Client Sample ID:**	26184
Project:	M-709-03	**Collection Date/Time:**	05/25/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-06	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	760	20		mg/L	200	06/02/2014 0720	06/03/2014 1035	EW

Client:	SGS Metcon	**Client Sample ID:**	26185
Project:	M-709-03	**Collection Date/Time:**	05/26/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-07	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	680	20		mg/L	200	06/04/2014 1200	06/05/2014 1705	EW

Client:	SGS Metcon	**Client Sample ID:**	26186
Project:	M-709-03	**Collection Date/Time:**	05/27/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-08	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	700	20		mg/L	200	06/04/2014 1200	06/05/2014 1705	EW

Client:	SGS Metcon	**Client Sample ID:**	26187
Project:	M-709-03	**Collection Date/Time:**	05/28/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-09	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	690	20		mg/L	200	06/09/2014 0725	06/10/2014 1105	EW

Client:	SGS Metcon	**Client Sample ID:**	26209
Project:	M-709-03	**Collection Date/Time:**	05/20/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-10	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	540	20		mg/L	200	05/29/2014 0755	05/30/2014 1135	EW

Client:	SGS Metcon	**Client Sample ID:**	26210
Project:	M-709-03	**Collection Date/Time:**	05/21/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-11	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	670	20		mg/L	200	05/29/2014 0755	05/30/2014 1135	EW

Client:	SGS Metcon	**Client Sample ID:**	26211
Project:	M-709-03	**Collection Date/Time:**	05/22/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-12	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	660	20		mg/L	200	06/02/2014 0720	06/03/2014 1035	EW

Client:	SGS Metcon	**Client Sample ID:**	26212
Project:	M-709-03	**Collection Date/Time:**	05/23/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-13	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	630	20		mg/L	200	06/02/2014 0720	06/03/2014 1035	EW

Client:	SGS Metcon	**Client Sample ID:**	26213
Project:	M-709-03	**Collection Date/Time:**	05/24/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-14	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	520	20		mg/L	200	06/02/2014 0720	06/03/2014 1035	EW

Client:	SGS Metcon	**Client Sample ID:**	26214
Project:	M-709-03	**Collection Date/Time:**	05/25/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-15	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	670	20		mg/L	200	06/04/2014 1200	06/05/2014 1705	EW

Client:	SGS Metcon	**Client Sample ID:**	26215
Project:	M-709-03	**Collection Date/Time:**	05/26/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-16	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	740	20		mg/L	200	06/04/2014 1200	06/05/2014 1705	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14E0725
Lab Sample ID: 14E0725-17

Client Sample ID: 26216
Collection Date/Time: 05/27/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	670	20		mg/L	200	06/04/2014 1200	06/05/2014 1705	EW

Client:	SGS Metcon	**Client Sample ID:**	26217
Project:	M-709-03	**Collection Date/Time:**	05/28/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-18	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	740	20		mg/L	200	06/09/2014 0725	06/10/2014 1105	EW

Client:	SGS Metcon	**Client Sample ID:**	26239
Project:	M-709-03	**Collection Date/Time:**	05/20/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-19	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	550	20		mg/L	200	05/29/2014 0755	05/30/2014 1135	EW

Client:	SGS Metcon	**Client Sample ID:**	26240
Project:	M-709-03	**Collection Date/Time:**	05/21/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-20	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	690	20		mg/L	200	05/29/2014 0755	05/30/2014 1135	EW

Client:	SGS Metcon	**Client Sample ID:**	26241
Project:	M-709-03	**Collection Date/Time:**	05/22/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-21	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	700	20		mg/L	200	06/02/2014 0720	06/03/2014 1035	EW

Client:	SGS Metcon	**Client Sample ID:**	26242
Project:	M-709-03	**Collection Date/Time:**	05/23/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-22	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	620	20		mg/L	200	06/02/2014 0720	06/03/2014 1035	EW

Client:	SGS Metcon	**Client Sample ID:**	26243
Project:	M-709-03	**Collection Date/Time:**	05/24/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-23	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	680	20		mg/L	200	06/02/2014 0720	06/03/2014 1035	EW

Client:	SGS Metcon	**Client Sample ID:**	26244
Project:	M-709-03	**Collection Date/Time:**	05/25/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-24	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	690	20		mg/L	200	06/04/2014 1200	06/05/2014 1705	EW

Client:	SGS Metcon	**Client Sample ID:**	26245
Project:	M-709-03	**Collection Date/Time:**	05/26/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-25	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	690	20		mg/L	200	06/04/2014 1200	06/05/2014 1705	EW

Client:	SGS Metcon	**Client Sample ID:**	26246
Project:	M-709-03	**Collection Date/Time:**	05/27/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-26	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	700	20		mg/L	200	06/04/2014 1200	06/05/2014 1705	EW

Client:	SGS Metcon	**Client Sample ID:**	26247
Project:	M-709-03	**Collection Date/Time:**	05/28/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-27	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	730	20		mg/L	200	06/09/2014 0725	06/10/2014 1105	EW

Client:	SGS Metcon	**Client Sample ID:**	26269
Project:	M-709-03	**Collection Date/Time:**	05/20/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-28	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	670	20		mg/L	200	05/29/2014 0755	05/30/2014 1135	EW

Client:	SGS Metcon	**Client Sample ID:**	26270
Project:	M-709-03	**Collection Date/Time:**	05/21/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-29	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	680	20		mg/L	200	05/29/2014 0755	05/30/2014 1135	EW

Client:	SGS Metcon	**Client Sample ID:**	26271
Project:	M-709-03	**Collection Date/Time:**	05/22/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-30	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	670	20		mg/L	200	06/02/2014 0720	06/03/2014 1035	EW

Client:	SGS Metcon	**Client Sample ID:**	26272
Project:	M-709-03	**Collection Date/Time:**	05/23/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-31	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	600	20		mg/L	200	06/02/2014 0720	06/03/2014 1035	EW

Client:	SGS Metcon	**Client Sample ID:**	26273
Project:	M-709-03	**Collection Date/Time:**	05/24/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-32	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	660	20		mg/L	200	06/02/2014 0720	06/03/2014 1035	EW

Client:	SGS Metcon	**Client Sample ID:**	26274
Project:	M-709-03	**Collection Date/Time:**	05/25/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-33	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	500	20		mg/L	200	06/04/2014 1200	06/05/2014 1705	EW

Client:	SGS Metcon	**Client Sample ID:**	26275
Project:	M-709-03	**Collection Date/Time:**	05/26/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-34	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	540	20		mg/L	200	06/04/2014 1200	06/05/2014 1705	EW

Client:	SGS Metcon	**Client Sample ID:**	26276
Project:	M-709-03	**Collection Date/Time:**	05/27/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-35	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	740	20		mg/L	200	06/04/2014 1200	06/05/2014 1705	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14E0725
Lab Sample ID: 14E0725-36

Client Sample ID: 26277
Collection Date/Time: 05/28/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	700	20		mg/L	200	06/09/2014 0725	06/10/2014 1105	EW

Client:	SGS Metcon	**Client Sample ID:**	26299
Project:	M-709-03	**Collection Date/Time:**	05/20/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-37	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	690	20		mg/L	200	05/29/2014 0755	05/30/2014 1135	EW

Client:	SGS Metcon	**Client Sample ID:**	26300
Project:	M-709-03	**Collection Date/Time:**	05/21/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-38	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	590	20		mg/L	200	05/29/2014 0755	05/30/2014 1135	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14E0725
Lab Sample ID: 14E0725-39

Client Sample ID: 26301
Collection Date/Time: 05/22/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	730	20		mg/L	200	06/02/2014 0720	06/03/2014 1035	EW

Client:	SGS Metcon	**Client Sample ID:**	26302
Project:	M-709-03	**Collection Date/Time:**	05/23/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-40	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	700	20		mg/L	200	06/02/2014 0720	06/03/2014 1035	EW

Client:	SGS Metcon	**Client Sample ID:**	26303
Project:	M-709-03	**Collection Date/Time:**	05/24/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-41	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	770	20		mg/L	200	06/02/2014 0720	06/03/2014 1035	EW

Client:	SGS Metcon	**Client Sample ID:**	26304
Project:	M-709-03	**Collection Date/Time:**	05/25/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-42	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	700	20		mg/L	200	06/04/2014 1200	06/05/2014 1705	EW

Client:	SGS Metcon	**Client Sample ID:**	26305
Project:	M-709-03	**Collection Date/Time:**	05/26/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-43	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	560	20		mg/L	200	06/04/2014 1200	06/05/2014 1705	EW

Client:	SGS Metcon	**Client Sample ID:**	26306
Project:	M-709-03	**Collection Date/Time:**	05/27/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-44	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	680	20		mg/L	200	06/04/2014 1200	06/05/2014 1705	EW

Client:	SGS Metcon	**Client Sample ID:**	26307
Project:	M-709-03	**Collection Date/Time:**	05/28/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-45	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	680	20		mg/L	200	06/04/2014 1200	06/05/2014 1705	EW

Client:	SGS Metcon	**Client Sample ID:**	26329
Project:	M-709-03	**Collection Date/Time:**	05/20/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-46	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	620	20		mg/L	200	05/29/2014 0755	05/30/2014 1135	EW

Client:	SGS Metcon	**Client Sample ID:**	26330
Project:	M-709-03	**Collection Date/Time:**	05/21/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-47	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	690	20		mg/L	200	05/29/2014 0755	05/30/2014 1135	EW

Client:	SGS Metcon	**Client Sample ID:**	26331
Project:	M-709-03	**Collection Date/Time:**	05/22/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-48	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	600	20		mg/L	200	06/02/2014 0720	06/03/2014 1035	EW

Client:	SGS Metcon	**Client Sample ID:**	26332
Project:	M-709-03	**Collection Date/Time:**	05/23/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-49	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	690	20		mg/L	200	06/02/2014 0720	06/03/2014 1035	EW

Client:	SGS Metcon	**Client Sample ID:**	26333
Project:	M-709-03	**Collection Date/Time:**	05/24/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-50	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	670	20		mg/L	200	06/02/2014 0720	06/03/2014 1035	EW

Client:	SGS Metcon	**Client Sample ID:**	26334
Project:	M-709-03	**Collection Date/Time:**	05/25/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-51	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	680	20		mg/L	200	06/04/2014 1200	06/05/2014 1705	EW

Client:	SGS Metcon	**Client Sample ID:**	26335
Project:	M-709-03	**Collection Date/Time:**	05/26/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-52	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	710	20		mg/L	200	06/04/2014 1200	06/05/2014 1705	EW

Client:	SGS Metcon	**Client Sample ID:**	26336
Project:	M-709-03	**Collection Date/Time:**	05/27/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-53	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	700	20		mg/L	200	06/04/2014 1200	06/05/2014 1705	EW

Client:	SGS Metcon	**Client Sample ID:**	26337
Project:	M-709-03	**Collection Date/Time:**	05/28/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-54	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	340	20		mg/L	200	06/04/2014 1200	06/05/2014 1705	EW

Client:	SGS Metcon	**Client Sample ID:**	1008
Project:	M-709-03	**Collection Date/Time:**	05/07/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-55	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	520	20	H3	mg/L	200	05/29/2014 0755	05/30/2014 1135	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14E0725
Lab Sample ID: 14E0725-56

Client Sample ID: 1009
Collection Date/Time: 05/14/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	580	20	H3	mg/L	200	05/29/2014 0755	05/30/2014 1135	EW

Client:	SGS Metcon	**Client Sample ID:**	1010
Project:	M-709-03	**Collection Date/Time:**	05/20/2014 0700
Work Order:	14E0725	**Matrix:**	Process Water
Lab Sample ID:	14E0725-57	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	610	20		mg/L	200	05/29/2014 0755	05/30/2014 1135	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14E0725
Lab Sample ID: 14E0725-58

Client Sample ID: 1013
Collection Date/Time: 05/28/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	550	20		mg/L	200	06/04/2014 1200	06/05/2014 1705	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14E0725
Date Received: 05/28/2014

QC Summary

Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Qual
Batch 1405299 - SM4500-CN I										
Blank (1405299-BLK1)				Prepared: 05/29/2014 Analyzed: 05/30/2014						
Cyanide	ND	0.10	mg/L							
LCS (1405299-BS1)				Prepared: 05/29/2014 Analyzed: 05/30/2014						
Cyanide	1.9	0.10	mg/L	2.000		97	90-110			
LCS Dup (1405299-BSD1)				Prepared: 05/29/2014 Analyzed: 05/30/2014						
Cyanide	2.0	0.10	mg/L	2.000		98	90-110	0.6	20	
Matrix Spike (1405299-MS1)		**Source: 14E0725-20**		Prepared: 05/29/2014 Analyzed: 05/30/2014						
Cyanide	1500	50	mg/L	1000	690	82	70-130			
Batch 1406002 - SM4500-CN I										
Blank (1406002-BLK1)				Prepared: 06/02/2014 Analyzed: 06/03/2014						
Cyanide	ND	0.10	mg/L							
LCS (1406002-BS1)				Prepared: 06/02/2014 Analyzed: 06/03/2014						
Cyanide	2.0	0.10	mg/L	2.000		101	90-110			
LCS Dup (1406002-BSD1)				Prepared: 06/02/2014 Analyzed: 06/03/2014						
Cyanide	1.8	0.10	mg/L	2.000		92	90-110	9	20	
Matrix Spike (1406002-MS1)		**Source: 14E0725-23**		Prepared: 06/02/2014 Analyzed: 06/03/2014						
Cyanide	1700	50	mg/L	1000	680	102	70-130			
Batch 1406030 - SM4500-CN I										
Blank (1406030-BLK1)				Prepared: 06/04/2014 Analyzed: 06/05/2014						
Cyanide	ND	0.10	mg/L							
LCS (1406030-BS1)				Prepared: 06/04/2014 Analyzed: 06/05/2014						
Cyanide	1.9	0.10	mg/L	2.000		93	90-110			
LCS Dup (1406030-BSD1)				Prepared: 06/04/2014 Analyzed: 06/05/2014						
Cyanide	1.9	0.10	mg/L	2.000		96	90-110	4	20	
Matrix Spike (1406030-MS1)		**Source: 14E0725-35**		Prepared: 06/04/2014 Analyzed: 06/05/2014						
Cyanide	1600	50	mg/L	1000	740	90	70-130			
Batch 1406073 - SM4500-CN I										
Blank (1406073-BLK1)				Prepared: 06/09/2014 Analyzed: 06/10/2014						
Cyanide	ND	0.10	mg/L							
LCS (1406073-BS1)				Prepared: 06/09/2014 Analyzed: 06/10/2014						
Cyanide	1.8	0.10	mg/L	2.000		91	90-110			
LCS Dup (1406073-BSD1)				Prepared: 06/09/2014 Analyzed: 06/10/2014						
Cyanide	1.8	0.10	mg/L	2.000		90	90-110	0.7	20	
Matrix Spike (1406073-MS1)		**Source: 14F0240-15**		Prepared: 06/09/2014 Analyzed: 06/10/2014						
Cyanide	1600	50	mg/L	1000	680	89	70-130			

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CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 14E0725 DATE 5/28/14 PAGE 1 OF 7

PROJECT NAME Wester Copper and Gold# _____
CONTACT NAME Natsagdorj Gantumer
COMPANY NAME SGS Metcon
ADDRESS 7701 N. Business Park Dr
ZIP 85743 PHONE 5798315 EMAIL _____
SAMPLER'S SIGNATURE Salvador Gonzalez

NUMBER OF CONTAINERS

CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*	Base Neutrals ☐ Acids ☐ 625/8270	Volatile Organics ☐ 624 ☐ 524.2 ☐ 8260	TTHMS ☐ HAA5 ☐	Chloride ☐ Sulfate ☐ Resistivity ☐	NO_3 ☐ NO_3 ☐ TKN ☐	TPH ☐ 1664 ☐ Oil & Grease ☐	VOA ☐ TCLP Analysis Semi-VOA ☐ Pest. ☐	TCLP ☐ Metals Dissolved ☐ Total ☐	RCRA8 ☐	Total ☐ Cyanide Amen. ☐ WAD ☐	SDWA-INORGANICS PRIMARY ☐ SECONDARY ☐	MPN ☐ Coliform PIA ☐ Fecal ☐	pH ☐ C_{fc} ☐ Cl_2 ☐ Turb ☐	COD ☐ TSS ☐ BOD ☐
26179	5/20/14	7:00		Process Water										/				
26180	5/21/14	7:00		Process Water										/				
26181	5/22/14	7:00		Process Water										/				
26182	5/23/14	7:00		Process Water										/				
26183	5/24/14	7:00		Process Water										/				
26184	5/25/14	7:00		Process Water										/				
26185	5/26/14	7:00		process Water										/				
26186	5/27/14	7:00		Process Water										/				
26187	5/28/14	7:00		Process Water										/				

1. RELINQUISHED BY: Salvador Gonzalez
Signature
Printed Name
Firm
5/28/14 16:10
Date/Time

2. RECEIVED BY:
Signature
Printed Name
Firm
Date/Time

TURNAROUND REQUIREMENTS:
____ **Standard (approx. 10 days)***
____ Next Day ____ 2 Day ____ 5 Day*
____ Email Preliminary Results
* **Working Days**

REPORT REQUIREMENTS:
____ I. Routine Report
____ II. Report (includes DUP, MS, MSD, as required, may be charged as samples)
____ III. Date Validation Report (Includes All Raw Data) Add 10% to invoice

INVOICE INFORMATION:
Account ____ Y ____ N
P.O. # _____
Bill to: _____

SAMPLE RECEIPT:
Total Containers 58
Temperature 24.6
☐ Wet Ice
☒ Ambient
☐ Blue Ice

3. RELINQUISHED BY:
Signature
Printed Name
Firm
Date/Time

4. RECEIVED BY:
Signature
Printed Name Kevin Bu
TURNER LABORATORIES, INC.
Firm
5/28/14 1610
Date/Time

* LEGEND
SAMPLE MATRIX
DW = DRINKING WATER
GW = GROUNDWATER
SD = SOLID
SG = SLUDGE
SL = SOIL
ST = STORMWATER
WW = WASTEWATER

Compliance Analysis: ☐ Yes ☐ No
ADEQ Forms: ☐ Yes ☐ No
Mail ADEQ Forms: ☐ Yes ☐ No

Custody Seals ☐
Container Intact ☒
COC / Labels Agree ☒

Preservation Confirmation ☒
Appropriate Head Space ☒
Received Within Hold Time ☒

SPECIAL INSTRUCTIONS/COMMENTS:

TURNER LABORATORIES INC.
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CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 14E0725 DATE 5/28/14 PAGE 2 OF 7

PROJECT NAME Wester Copper and Gold# _____
CONTACT NAME Natsagdorj Gantumer
COMPANY NAME SGS Metcon
ADDRESS 7701 N. Business Park Dr
ZIP 85743 PHONE 5798315 EMAIL _____
SAMPLER'S SIGNATURE Salvador Gonzalez

NUMBER OF CONTAINERS

CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*	Base Neutrals 625/8270	Acids	Volatile Organics 624	524.2	8260	TTHMS	HAA5	Chloride	Sulfate	Resistivity	NO_2	NO_3	TKN	TPH	1664	Oil & Grease	TCLP Analysis VOA	Semi-VOA	Pest.	TCLP	Metals	Dissolved	Total	RCRA8	Total	Cyanide Amen.	WAD	SDWA-INORGANICS PRIMARY	SECONDARY	MPN	Coliform PIA	pH	Fecal	Cl_2	Turb	TSS	BOD	COD
26209	5/20/14	7:00		Process Water																																							
26210	5/21/14	7:00		Process Water																																							
26211	5/22/14	7:00		Process Water																																							
26212	5/23/14	7:00		Process Water																																							
26213	5/24/14	7:00		Process Water																																							
26214	5/25/14	7:00		Process Water																																							
26215	5/26/14	7:00		Process Water																																							
26216	5/27/14	7:00		Process Water																																							
26217	5/28/14	7:00		Process Water																																							

1. RELINQUISHED BY:
Salvador Gonzalez
Signature
Printed Name
Firm
5/28/14 16:10
Date/Time

2. RECEIVED BY:
Signature
Printed Name
Firm
Date/Time

TURNAROUND REQUIREMENTS:
____ Standard (approx. 10 days)*
____ Next Day ____ 2 Day ____ 5 Day*
____ Email Preliminary Results
* Working Days

REPORT REQUIREMENTS:
____ I. Routine Report
____ II. Report (includes DUP, MS, MSD, as required, may be charged as samples)
____ III. Date Validation Report (Includes All Raw Data) Add 10% to invoice

INVOICE INFORMATION:
Account ____Y ____N
P.O. # _____
Bill to: _____

SAMPLE RECEIPT:
Total Containers 58
Temperature 24.6
☐ Wet Ice
☒ Ambient
☐ Blue Ice

3. RELINQUISHED BY:
Signature
Printed Name
Firm
Date/Time

4. RECEIVED BY:
Signature
Printed Name
TURNER LABORATORIES, INC.
Firm
5/28/14 1610
Date/Time

* LEGEND
SAMPLE MATRIX
DW = DRINKING WATER
GW = GROUNDWATER
SD = SOLID
SG = SLUDGE
SL = SOIL
ST = STORMWATER
WW = WASTEWATER

Compliance Analysis: ☐ Yes ☐ No		Custody Seals ☐	Preservation Confirmation ☒
ADEQ Forms: ☐ Yes ☐ No		Container Intact ☒	Appropriate Head Space ☒
Mail ADEQ Forms: ☐ Yes ☐ No		COC / Labels Agree ☒	Received Within Hold Time ☒

SPECIAL INSTRUCTIONS/COMMENTS:

TURNER LABORATORIES INC.
2445 N. Coyote Drive, Suite 104
Tucson, Arizona 85745
(520) 882-5880
Fax: (520) 882-9788
www.turnerlabs.com

CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 14E0725 DATE 5/28/14 PAGE 3 OF 7

PROJECT NAME Wester Copper and Gold #
CONTACT NAME Natsagdorj Gantumer
COMPANY NAME SGS Metcon
ADDRESS 7701 N. Business Park Dr
ZIP 85743 PHONE 5798315 EMAIL
SAMPLER'S SIGNATURE Salvador Gonzalez

CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*	NUMBER OF CONTAINERS	Base Neutrals ☐ 625/8270	Acids ☐	Volatile Organics ☐ 624	☐ 524.2	☐ 8260	TTHMS ☐	HAA5 ☐	☐ Chloride	☐ Sulfate	☐ Resistivity	NO_2 ☐	NO_3 ☐	TKN ☐	1664 ☐ TPH	☐ Oil & Grease	TCLP Analysis VOA ☐	Semi-VOA ☐	Pest. ☐	Metals TCLP ☐	Dissolved ☐	Total ☐	RCRA8 ☐	Cyanide Total ☐	Amen. ☐	WAD ☑	SDWA-INORGANICS PRIMARY ☐	SECONDARY ☐	Coliform MPN ☐	PIA ☐	Fecal ☐	pH ☐	Cr_6 ☐	Cl_2 ☐	☐ Turb	COD ☐	TSS ☐	BOD ☐				
26239	5/20/14	7:00		Process Water																								✓																	
26240	5/21/14	7:00		Process Water																								✓																	
26241	5/22/14	7:00		Process Water																								✓																	
26242	5/23/14	7:00		Process Water																								✓																	
26243	5/24/14	7:00		Process Water																								✓																	
26244	5/25/14	7:00		Process Water																								✓																	
26245	5/26/14	7:00		Process Water																								✓																	
26246	5/27/14	7:00		Process Water																								✓																	
26247	5/28/14	7:00		Process Water																								✓																	

1. RELINQUISHED BY:
Salvador Gonzalez
Signature
Printed Name
Firm
5/28/14 16:10
Date/Time

2. RECEIVED BY:
Signature
Printed Name
Firm
Date/Time

TURNAROUND REQUIREMENTS:
____ Standard (approx. 10 days)*
____ Next Day ____ 2 Day ____ 5 Day*
____ Email Preliminary Results
* Working Days

REPORT REQUIREMENTS:
____ I. Routine Report
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____ III. Date Validation Report (Includes All Raw Data) Add 10% to invoice

INVOICE INFORMATION:
Account ____ Y ____ N
P.O. #
Bill to:

SAMPLE RECEIPT:
Total Containers 58
Temperature 24.6
☐ Wet Ice
☒ Ambient
☐ Blue Ice

3. RELINQUISHED BY:
Signature
Printed Name
Firm
Date/Time

4. RECEIVED BY:
Signature
Printed Name
TURNER LABORATORIES, INC.
Firm
5/28/14 1610
Date/Time

* LEGEND
SAMPLE MATRIX
DW = DRINKING WATER
GW = GROUNDWATER
SD = SOLID
SG = SLUDGE
SL = SOIL
ST = STORMWATER
WW = WASTEWATER

Compliance Analysis: ☐ Yes ☐ No	Custody Seals ☐	Preservation Confirmation ☒
ADEQ Forms: ☐ Yes ☐ No	Container Intact ☒	Appropriate Head Space ☒
Mail ADEQ Forms: ☐ Yes ☐ No	COC / Labels Agree ☒	Received Within Hold Time ☒

SPECIAL INSTRUCTIONS/COMMENTS:

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CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 14E0725 DATE 5/28/14 PAGE 4 OF 7

PROJECT NAME Wester Copper and Gold# _____
CONTACT NAME Natsagdorj Gantumer
COMPANY NAME SGS Metcon
ADDRESS 7701 N. Business Park Dr
ZIP 85743 PHONE 5798315 EMAIL _____
SAMPLER'S SIGNATURE Salvador Gonzalez

NUMBER OF CONTAINERS

CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX

Base Neutrals ☐ Acids ☐ 625/8270
Volatile Organics ☐ 624 ☐ 524.2 ☐ 8260
TTHMS ☐ HAA5 ☐
Chloride ☐ Sulfate ☐ Resistivity ☐
NO_2 ☐ NO_3 ☐ TKN ☐
TPH ☐ 1664 ☐ Oil & Grease ☐
VOA ☐ TCLP Analysis Semi-VOA ☐ Pest. ☐
TCLP ☐ Metals Dissolved ☐ Total ☐ RCRA8 ☐
Total ☐ Cyanide Amen. ☐ WAD ☐
SDWA-INORGANICS PRIMARY ☐ SECONDARY ☐
MPN ☐ Coliform PIA ☐ Fecal ☐
pH ☐ Cr_6 ☐ Cl ☐ Turb ☐
COD ☐ TSS ☐ BOD ☐

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*
26269	5/20/14	7:00		Process Water
26270	5/21/14	7:00		Process Water
26271	5/22/14	7:00		Process Water
26272	5/23/14	7:00		Process Water
26273	5/24/14	7:00		Process Water
26274	5/25/14	7:00		Process Water
26275	5/26/14	7:00		process water
26276	5/27/14	7:00		Process Water
26277	5/28/14	7:00		Process Water

1. RELINQUISHED BY: Salvador Gonzalez — Signature — Printed Name — Firm — 5/28/14 16:10 Date/Time

2. RECEIVED BY: Signature — Printed Name — Firm — Date/Time

3. RELINQUISHED BY: Signature — Printed Name — Firm — Date/Time

4. RECEIVED BY: Signature — Printed Name: TURNER LABORATORIES, INC. — Firm — 5/28/14 1610 Date/Time

TURNAROUND REQUIREMENTS:
____ Standard (approx. 10 days)*
____ Next Day ____ 2 Day ____ 5 Day*
____ Email Preliminary Results
* Working Days

REPORT REQUIREMENTS:
____ I. Routine Report
____ II. Report (includes DUP, MS, MSD, as required, may be charged as samples)
____ III. Date Validation Report (Includes All Raw Data) Add 10% to invoice

INVOICE INFORMATION:
Account ____ Y ____ N
P.O. # _____
Bill to: _____

SAMPLE RECEIPT:
Total Containers 58
Temperature 24.6
☐ Wet Ice
☒ Ambient
☐ Blue Ice

* LEGEND SAMPLE MATRIX
DW = DRINKING WATER
GW = GROUNDWATER
SD = SOLID
SG = SLUDGE
SL = SOIL
ST = STORMWATER
WW = WASTEWATER

Compliance Analysis: ☐ Yes ☐ No
ADEQ Forms: ☐ Yes ☐ No
Mail ADEQ Forms: ☐ Yes ☐ No

Custody Seals ☐
Container Intact ☒
COC / Labels Agree ☒

Preservation Confirmation ☒
Appropriate Head Space ☒
Received Within Hold Time ☒

SPECIAL INSTRUCTIONS/COMMENTS:

TURNER LABORATORIES INC.
2445 N. Coyote Drive, Suite 104
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CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 14E0725 DATE 5/28/14 PAGE 5 OF 7

PROJECT NAME Wester Copper and Gold # _____
CONTACT NAME Natsagdorj Gantumer
COMPANY NAME SGS Metcon
ADDRESS 7701 N. Business Park Dr
ZIP 85743 PHONE 5798315 EMAIL _____
SAMPLER'S SIGNATURE Salvador Gonzalez

NUMBER OF CONTAINERS

CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX

Base Neutrals ☐ Acids ☐ 625/8270
Volatile Organics ☐ 624 ☐ 524.2 ☐ 8260 ☐ HAAS ☐ TTHMs
☐ Chloride ☐ Sulfate ☐ Resistivity
NO_2 ☐ NO_3 ☐ TKN ☐
☐ TPH ☐ 1664 ☐ Oil & Grease
VOA ☐ TCLP Analysis Semi-VOA ☐ Pest ☐
TCLP ☐ Dissolved ☐ Metals Total ☐ RCRA8 ☐
Total ☐ Cyanide Amen. ☐ WAD ☐
SDWA-INORGANICS PRIMARY ☐ SECONDARY ☐
MPN ☐ Coliform PIA ☐ Fecal ☐
pH ☐ Cr_6 ☐ Cl_2 ☐ Turb ☐
COD ☐ TSS ☐ BOD ☐

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*
26299	5/20/14	7:00		Process Water
26300	5/21/14	7:00		Process Water
26301	5/22/14	7:00		Process Water
26302	5/23/14	7:00		Process Water
26303	5/24/14	7:00		Process Water
26304	5/25/14	7:00		Process Water
26305	5/26/14	7:00		Process Water
26306	5/27/14	7:00		Process Water
26307	5/28/14	7:00		Process Water

1. RELINQUISHED BY:
Salvador Gonzalez
Signature
Printed Name
Firm
5/28/14 16:10
Date/Time

2. RECEIVED BY:
Signature
Printed Name
Firm
Date/Time

TURNAROUND REQUIREMENTS:
____ Standard (approx. 10 days)*
____ Next Day ____ 2 Day ____ 5 Day*
____ Email Preliminary Results
* Working Days

REPORT REQUIREMENTS:
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INVOICE INFORMATION:
Account ____ Y ____ N
P.O. # _____
Bill to: _____

SAMPLE RECEIPT:
Total Containers 58
Temperature 24.6
☐ Wet Ice
☒ Ambient
☐ Blue Ice

3. RELINQUISHED BY:
Signature
Printed Name
Firm
Date/Time

4. RECEIVED BY:
Signature
Printed Name
TURNER LABORATORIES, INC.
Firm
5/28/14 1610
Date/Time

* LEGEND
SAMPLE MATRIX
DW = DRINKING WATER
GW = GROUNDWATER
SD = SOLID
SG = SLUDGE
SL = SOIL
ST = STORMWATER
WW = WASTEWATER

Compliance Analysis: ☐ Yes ☐ No		Custody Seals ☐	Preservation Confirmation ☒
ADEQ Forms: ☐ Yes ☐ No		Container Intact ☒	Appropriate Head Space ☒
Mail ADEQ Forms: ☐ Yes ☐ No		COC / Labels Agree ☒	Received Within Hold Time ☒

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CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 14F0725 DATE 5/28/14 PAGE 6 OF 7

PROJECT NAME Wester Copper and Gold#
CONTACT NAME Natsagdorj Gantumer
COMPANY NAME SGS Metcon
ADDRESS 7701 N. Business Park Dr
ZIP 85743 PHONE 5798315 EMAIL
SAMPLER'S SIGNATURE Salvador Gonzalez

NUMBER OF CONTAINERS

CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX

Base Neutrals ☐ Acids ☐ 625/8270
Volatile Organics ☐ 624 ☐ 524.2 ☐ 8260
TTHMS ☐ HAA5 ☐
Chloride ☐ Sulfate ☐ Resistivity ☐
NO_2 ☐ NO_3 ☐ TKN ☐
TPH ☐ 1664 ☐ Oil & Grease ☐
VOA ☐ TCLP Analysis SemiVOA ☐ Pest ☐
TCLP ☐ Metals Dissolved ☐ Total ☐ RCRA8 ☐
Total ☐ Cyanide Amen. ☐ WAD ☐
SDWA-INORGANICS PRIMARY ☐ SECONDARY ☐
MPN ☐ Coliform PIA ☐ Fecal ☐
pH ☐ Cl ☐ Cl_2 ☐ Turb ☐
COD ☐ TSS ☐ BOD ☐

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*
26329	5/20/14	7:00		Process Water
26330	5/21/14	7:00		Process Water
26331	5/22/14	7:00		Process Water
26332	5/23/14	7:00		Process Water
26333	5/24/14	7:00		Process Water
26334	5/25/14	7:00		Process Water
26335	5/26/14	7:00		process Water
26336	5/27/14	7:00		Process Water
26337	5/28/14	7:00		Process Water

1. RELINQUISHED BY: Salvador Gonzalez
Signature
Printed Name
Firm
5/28/14 16:10
Date/Time

2. RECEIVED BY:
Signature
Printed Name
Firm
Date/Time

TURNAROUND REQUIREMENTS:
____ Standard (approx. 10 days)*
____ Next Day ____ 2 Day ____ 5 Day*
____ Email Preliminary Results
* Working Days

REPORT REQUIREMENTS:
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____ III. Date Validation Report (includes All Raw Data) Add 10% to invoice

INVOICE INFORMATION:
Account ____Y ____N
P.O. #
Bill to:

SAMPLE RECEIPT:
Total Containers 58
Temperature 24.6
☐ Wet Ice
☒ Ambient
☐ Blue Ice

3. RELINQUISHED BY:
Signature
Printed Name
Firm
Date/Time

4. RECEIVED BY:
Signature
Printed Name
TURNER LABORATORIES, INC.
Firm
5/28/14 1610
Date/Time

* LEGEND
SAMPLE MATRIX
DW = DRINKING WATER
GW = GROUNDWATER
SD = SOLID
SG = SLUDGE
SL = SOIL
ST = STORMWATER
WW = WASTEWATER

Compliance Analysis: ☐ Yes ☐ No
ADEQ Forms: ☐ Yes ☐ No
Mail ADEQ Forms: ☐ Yes ☐ No

Custody Seals ☐
Container Intact ☒
COC / Labels Agree ☒

Preservation Confirmation ☒
Appropriate Head Space ☒
Received Within Hold Time ☒

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CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 14E0725 DATE 5/28/14 PAGE 7 OF 7

PROJECT NAME Wester Copper and Gold
CONTACT NAME Natsagdorj Gantumer
COMPANY NAME SGS Metcon
ADDRESS 7701 N. Business Park Dr.
ZIP 85743 PHONE 579 83 15 EMAIL
SAMPLER'S SIGNATURE Salvador Gonzalez

NUMBER OF CONTAINERS

CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX

Base Neutrals ☐ Acids ☐ 625/8270
Volatile Organics ☐ 624 ☐ 524.2 ☐ 8260
TTHMS ☐ HAA5 ☐
Chloride ☐ Sulfate ☐ Resistivity ☐
NO_2 ☐ NO_3 ☐ TKN ☐
TPH ☐ 1664 ☐ Oil & Grease ☐
VOA ☐ TCLP Analysis Semi-VOA ☐ Pest. ☐
TCLP ☐ Metals Dissolved ☐ Total ☐ RCRA8 ☐
Total ☐ Cyanide Amen. ☐ WAD ☐
SDWA-INORGANICS PRIMARY ☐ SECONDARY ☐
MPN ☐ Coliform PIA ☐ Fecal ☐
pH ☐ C_6 ☐ Cl_2 ☐ Turb ☐
COD ☐ TSS ☐ BOD ☐

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*	Total
1008	5/7/14	7:00		Process Water	/
1009	5/14/14	7:00		Process Water	/
1010	5/20/14	7:00		Process Water	/
1013	5/28/14	7:00		Process Water	/

1. RELINQUISHED BY:
Salvador Gonzalez
Signature
Printed Name
Firm
5/28/14 16:10
Date/Time

2. RECEIVED BY:
Signature
Printed Name
Firm
Date/Time

TURNAROUND REQUIREMENTS:
____ Standard (approx. 10 days)*
____ Next Day ____ 2 Day ____ 5 Day*
____ Email Preliminary Results
* Working Days

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INVOICE INFORMATION:
Account ____ Y ____ N
P.O. #
Bill to:

SAMPLE RECEIPT:
Total Containers 58
Temperature 24.6
☐ Wet Ice
☒ Ambient
☐ Blue Ice

3. RELINQUISHED BY:
Signature
Printed Name
Firm
Date/Time

4. RECEIVED BY:
Signature
Kevin Bin
Printed Name
TURNER LABORATORIES, INC.
Firm
5/28/14 1610
Date/Time

* LEGEND
SAMPLE MATRIX
DW = DRINKING WATER
GW = GROUNDWATER
SD = SOLID
SG = SLUDGE
SL = SOIL
ST = STORMWATER
WW = WASTEWATER

Compliance Analysis: ☐ Yes ☐ No
ADEQ Forms: ☐ Yes ☐ No
Mail ADEQ Forms: ☐ Yes ☐ No

Custody Seals ☐
Container Intact ☑
COC / Labels Agree ☑

Preservation Confirmation ☒
Appropriate Head Space ☑
Received Within Hold Time ☑

SPECIAL INSTRUCTIONS/COMMENTS:

June 17, 2014

Natska Gantumur
SGS Metcon
7701 Business Park Dr.
Tucson, AZ 85743

TEL (520) 579-8315
FAX (303) 456-6998

Work Order No.: 14F0240
Order Name: M-709-03

RE: M-709-03

Dear Natska Gantumur,

Turner Laboratories, Inc. received 36 sample(s) on 06/03/2014 for the analyses presented in the following report.

All results are intended to be considered in their entirety, and Turner Laboratories, Inc. is not responsible for use of less than the complete report. Results apply only to the samples analyzed. Samples will be disposed of 30 days after issue of our report unless special arrangements are made.

The pages that follow may contain sensitive, privileged or confidential information intended solely for the addressee named above. If you receive this message and are not the agent or employee of the addressee, this communication has been sent in error. Please do not disseminate or copy any of the attached and notify the sender immediately by telephone. Please also return the attached sheet(s) to the sender by mail.

Please call if you have any questions.

Respectfully submitted,

Turner Laboratories, Inc.
ADHS License AZ0066



Terri Garcia
Technical Director

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0240
Date Received: 06/03/2014

Order: M-709-03

Work Order Sample Summary

Lab Sample ID	Client Sample ID	Matrix	Collection Date/Time
14F0240-01	26188	Process Water	05/29/2014 0700
14F0240-02	26189	Process Water	05/30/2014 0700
14F0240-03	26190	Process Water	05/31/2014 0700
14F0240-04	26683	Process Water	05/01/2014 0700
14F0240-05	26684	Process Water	05/02/2014 0700
14F0240-06	26685	Process Water	05/03/2014 0700
14F0240-07	26718	Process Water	05/29/2014 0700
14F0240-08	26719	Process Water	05/30/2014 0700
14F0240-09	26720	Process Water	05/31/2014 0700
14F0240-10	26713	Process Water	05/01/2014 0700
14F0240-11	26714	Process Water	05/02/2014 0700
14F0240-12	26715	Process Water	05/03/2014 0700
14F0240-13	26248	Process Water	05/29/2014 0700
14F0240-14	26249	Process Water	05/30/2014 0700
14F0240-15	26250	Process Water	05/31/2014 0700
14F0240-16	26243	Process Water	05/01/2014 0700
14F0240-17	26244	Process Water	05/02/2014 0700
14F0240-18	26245	Process Water	05/03/2014 0700
14F0240-19	26278	Process Water	05/29/2014 0700
14F0240-20	26279	Process Water	05/30/2014 0700
14F0240-21	26280	Process Water	05/31/2014 0700
14F0240-22	26773	Process Water	05/01/2014 0700
14F0240-23	26774	Process Water	05/02/2014 0700
14F0240-24	26775	Process Water	05/03/2014 0700
14F0240-25	26308	Process Water	05/29/2014 0700
14F0240-26	26309	Process Water	05/30/2014 0700
14F0240-27	26310	Process Water	05/31/2014 0700
14F0240-28	26803	Process Water	05/01/2014 0700
14F0240-29	26804	Process Water	05/02/2014 0700
14F0240-30	26805	Process Water	05/03/2014 0700
14F0240-31	26338	Process Water	05/29/2014 0700
14F0240-32	26339	Process Water	05/30/2014 0700

14F0240-33	263340	Process Water	05/31/2014 0700
14F0240-34	26833	Process Water	05/01/2014 0700
14F0240-35	26834	Process Water	05/02/2014 0700
14F0240-36	26835	Process Water	05/03/2014 0700

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0240
Date Received: 06/03/2014

Case Narrative

H3 Sample was received and/or analysis requested past holding time.

All soil, sludge, and solid matrix determinations are reported on a wet weight basis unless otherwise noted.

ND Not Detected at or above the PQL

PQL Practical Quantitation Limit

DF Dilution Factor

Client:	SGS Metcon	**Client Sample ID:**	26188
Project:	M-709-03	**Collection Date/Time:**	05/29/2014 0700
Work Order:	14F0240	**Matrix:**	Process Water
Lab Sample ID:	14F0240-01	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	700	20		mg/L	200	06/09/2014 0725	06/10/2014 1105	EW

Client:	SGS Metcon	**Client Sample ID:**	26189
Project:	M-709-03	**Collection Date/Time:**	05/30/2014 0700
Work Order:	14F0240	**Matrix:**	Process Water
Lab Sample ID:	14F0240-02	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	720	20		mg/L	200	06/09/2014 0725	06/10/2014 1105	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0240
Lab Sample ID: 14F0240-03

Client Sample ID: 26190
Collection Date/Time: 05/31/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	710	20		mg/L	200	06/11/2014 1030	06/12/2014 1505	EW

Client:	SGS Metcon	**Client Sample ID:**	26683
Project:	M-709-03	**Collection Date/Time:**	05/01/2014 0700
Work Order:	14F0240	**Matrix:**	Process Water
Lab Sample ID:	14F0240-04	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	670	20	H3	mg/L	200	06/11/2014 1030	06/12/2014 1505	EW

Client:	SGS Metcon	**Client Sample ID:**	26684
Project:	M-709-03	**Collection Date/Time:**	05/02/2014 0700
Work Order:	14F0240	**Matrix:**	Process Water
Lab Sample ID:	14F0240-05	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	650	20	H3	mg/L	200	06/11/2014 1030	06/12/2014 1505	EW

Client:	SGS Metcon	**Client Sample ID:**	26685
Project:	M-709-03	**Collection Date/Time:**	05/03/2014 0700
Work Order:	14F0240	**Matrix:**	Process Water
Lab Sample ID:	14F0240-06	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	670	20	H3	mg/L	200	06/11/2014 1030	06/12/2014 1505	EW

Client:	SGS Metcon	**Client Sample ID:**	26718
Project:	M-709-03	**Collection Date/Time:**	05/29/2014 0700
Work Order:	14F0240	**Matrix:**	Process Water
Lab Sample ID:	14F0240-07	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	710	20		mg/L	200	06/09/2014 0725	06/10/2014 1105	EW

Client:	SGS Metcon	**Client Sample ID:**	26719
Project:	M-709-03	**Collection Date/Time:**	05/30/2014 0700
Work Order:	14F0240	**Matrix:**	Process Water
Lab Sample ID:	14F0240-08	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	720	20		mg/L	200	06/09/2014 0725	06/10/2014 1105	EW

Client:	SGS Metcon	**Client Sample ID:**	26720
Project:	M-709-03	**Collection Date/Time:**	05/31/2014 0700
Work Order:	14F0240	**Matrix:**	Process Water
Lab Sample ID:	14F0240-09	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	660	20		mg/L	200	06/11/2014 1030	06/12/2014 1505	EW

Client:	SGS Metcon	**Client Sample ID:**	26713
Project:	M-709-03	**Collection Date/Time:**	05/01/2014 0700
Work Order:	14F0240	**Matrix:**	Process Water
Lab Sample ID:	14F0240-10	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	690	20	H3	mg/L	200	06/11/2014 1030	06/12/2014 1505	EW

Client:	SGS Metcon	**Client Sample ID:**	26714
Project:	M-709-03	**Collection Date/Time:**	05/02/2014 0700
Work Order:	14F0240	**Matrix:**	Process Water
Lab Sample ID:	14F0240-11	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	660	20	H3	mg/L	200	06/11/2014 1030	06/12/2014 1505	EW

Client:	SGS Metcon	**Client Sample ID:**	26715
Project:	M-709-03	**Collection Date/Time:**	05/03/2014 0700
Work Order:	14F0240	**Matrix:**	Process Water
Lab Sample ID:	14F0240-12	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	620	20	H3	mg/L	200	06/11/2014 1030	06/12/2014 1505	EW

Client:	SGS Metcon	**Client Sample ID:**	26248
Project:	M-709-03	**Collection Date/Time:**	05/29/2014 0700
Work Order:	14F0240	**Matrix:**	Process Water
Lab Sample ID:	14F0240-13	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	120	20		mg/L	200	06/09/2014 0725	06/10/2014 1105	EW

Client:	SGS Metcon	**Client Sample ID:**	26249
Project:	M-709-03	**Collection Date/Time:**	05/30/2014 0700
Work Order:	14F0240	**Matrix:**	Process Water
Lab Sample ID:	14F0240-14	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	620	20		mg/L	200	06/09/2014 0725	06/10/2014 1105	EW

Client:	SGS Metcon	**Client Sample ID:**	26250
Project:	M-709-03	**Collection Date/Time:**	05/31/2014 0700
Work Order:	14F0240	**Matrix:**	Process Water
Lab Sample ID:	14F0240-15	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	680	20		mg/L	200	06/09/2014 0725	06/10/2014 1105	EW

Client:	SGS Metcon	**Client Sample ID:**	26243
Project:	M-709-03	**Collection Date/Time:**	05/01/2014 0700
Work Order:	14F0240	**Matrix:**	Process Water
Lab Sample ID:	14F0240-16	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	660	20	H3	mg/L	200	06/11/2014 1030	06/12/2014 1505	EW

Client:	SGS Metcon	**Client Sample ID:**	26244
Project:	M-709-03	**Collection Date/Time:**	05/02/2014 0700
Work Order:	14F0240	**Matrix:**	Process Water
Lab Sample ID:	14F0240-17	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	570	20	H3	mg/L	200	06/11/2014 1030	06/12/2014 1505	EW

Client:	SGS Metcon	**Client Sample ID:**	26245
Project:	M-709-03	**Collection Date/Time:**	05/03/2014 0700
Work Order:	14F0240	**Matrix:**	Process Water
Lab Sample ID:	14F0240-18	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	650	20	H3	mg/L	200	06/11/2014 1030	06/12/2014 1505	EW

Client:	SGS Metcon	**Client Sample ID:**	26278
Project:	M-709-03	**Collection Date/Time:**	05/29/2014 0700
Work Order:	14F0240	**Matrix:**	Process Water
Lab Sample ID:	14F0240-19	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	710	20		mg/L	200	06/09/2014 0725	06/10/2014 1105	EW

Client:	SGS Metcon	**Client Sample ID:**	26279
Project:	M-709-03	**Collection Date/Time:**	05/30/2014 0700
Work Order:	14F0240	**Matrix:**	Process Water
Lab Sample ID:	14F0240-20	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	660	20		mg/L	200	06/09/2014 0725	06/10/2014 1105	EW

Client:	SGS Metcon	**Client Sample ID:**	26280
Project:	M-709-03	**Collection Date/Time:**	05/31/2014 0700
Work Order:	14F0240	**Matrix:**	Process Water
Lab Sample ID:	14F0240-21	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	690	20		mg/L	200	06/09/2014 0725	06/10/2014 1105	EW

Client:	SGS Metcon	**Client Sample ID:**	26773
Project:	M-709-03	**Collection Date/Time:**	05/01/2014 0700
Work Order:	14F0240	**Matrix:**	Process Water
Lab Sample ID:	14F0240-22	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	530	20	H3	mg/L	200	06/11/2014 1030	06/12/2014 1505	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0240
Lab Sample ID: 14F0240-23

Client Sample ID: 26774
Collection Date/Time: 05/02/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	670	20	H3	mg/L	200	06/11/2014 1030	06/12/2014 1505	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0240
Lab Sample ID: 14F0240-24

Client Sample ID: 26775
Collection Date/Time: 05/03/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	670	20	H3	mg/L	200	06/11/2014 1030	06/12/2014 1505	EW

Client:	SGS Metcon	**Client Sample ID:**	26308
Project:	M-709-03	**Collection Date/Time:**	05/29/2014 0700
Work Order:	14F0240	**Matrix:**	Process Water
Lab Sample ID:	14F0240-25	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	700	20		mg/L	200	06/09/2014 0725	06/10/2014 1105	EW

Client:	SGS Metcon	**Client Sample ID:**	26309
Project:	M-709-03	**Collection Date/Time:**	05/30/2014 0700
Work Order:	14F0240	**Matrix:**	Process Water
Lab Sample ID:	14F0240-26	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	710	20		mg/L	200	06/09/2014 0725	06/10/2014 1105	EW

Client:	SGS Metcon	**Client Sample ID:**	26310
Project:	M-709-03	**Collection Date/Time:**	05/31/2014 0700
Work Order:	14F0240	**Matrix:**	Process Water
Lab Sample ID:	14F0240-27	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	690	20		mg/L	200	06/09/2014 0725	06/10/2014 1105	EW

Client:	SGS Metcon	**Client Sample ID:**	26803
Project:	M-709-03	**Collection Date/Time:**	05/01/2014 0700
Work Order:	14F0240	**Matrix:**	Process Water
Lab Sample ID:	14F0240-28	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	680	20	H3	mg/L	200	06/11/2014 1030	06/12/2014 1505	EW

Client:	SGS Metcon	**Client Sample ID:**	26804
Project:	M-709-03	**Collection Date/Time:**	05/02/2014 0700
Work Order:	14F0240	**Matrix:**	Process Water
Lab Sample ID:	14F0240-29	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	670	20	H3	mg/L	200	06/11/2014 1030	06/12/2014 1505	EW

Client:	SGS Metcon	**Client Sample ID:**	26805
Project:	M-709-03	**Collection Date/Time:**	05/03/2014 0700
Work Order:	14F0240	**Matrix:**	Process Water
Lab Sample ID:	14F0240-30	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	660	20	H3	mg/L	200	06/11/2014 1030	06/12/2014 1505	EW

Client:	SGS Metcon	**Client Sample ID:**	26338
Project:	M-709-03	**Collection Date/Time:**	05/29/2014 0700
Work Order:	14F0240	**Matrix:**	Process Water
Lab Sample ID:	14F0240-31	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	620	20		mg/L	200	06/09/2014 0725	06/10/2014 1105	EW

Client:	SGS Metcon	**Client Sample ID:**	26339
Project:	M-709-03	**Collection Date/Time:**	05/30/2014 0700
Work Order:	14F0240	**Matrix:**	Process Water
Lab Sample ID:	14F0240-32	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	660	20		mg/L	200	06/09/2014 0725	06/10/2014 1105	EW

Client:	SGS Metcon	**Client Sample ID:**	263340
Project:	M-709-03	**Collection Date/Time:**	05/31/2014 0700
Work Order:	14F0240	**Matrix:**	Process Water
Lab Sample ID:	14F0240-33	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	650	20		mg/L	200	06/09/2014 0725	06/10/2014 1105	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0240
Lab Sample ID: 14F0240-34

Client Sample ID: 26833
Collection Date/Time: 05/01/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	550	20	H3	mg/L	200	06/11/2014 1030	06/12/2014 1505	EW

Client:	SGS Metcon	**Client Sample ID:**	26834
Project:	M-709-03	**Collection Date/Time:**	05/02/2014 0700
Work Order:	14F0240	**Matrix:**	Process Water
Lab Sample ID:	14F0240-35	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	630	20	H3	mg/L	200	06/11/2014 1030	06/12/2014 1505	EW

Client:	SGS Metcon	**Client Sample ID:**	26835
Project:	M-709-03	**Collection Date/Time:**	05/03/2014 0700
Work Order:	14F0240	**Matrix:**	Process Water
Lab Sample ID:	14F0240-36	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	650	20	H3	mg/L	200	06/11/2014 1030	06/12/2014 1505	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0240
Date Received: 06/03/2014

QC Summary

Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Qual
Batch 1406073 - SM4500-CN I										
Blank (1406073-BLK1)				Prepared: 06/09/2014 Analyzed: 06/10/2014						
Cyanide	ND	0.10	mg/L							
LCS (1406073-BS1)				Prepared: 06/09/2014 Analyzed: 06/10/2014						
Cyanide	1.8	0.10	mg/L	2.000		91	90-110			
LCS Dup (1406073-BSD1)				Prepared: 06/09/2014 Analyzed: 06/10/2014						
Cyanide	1.8	0.10	mg/L	2.000		90	90-110	0.7	20	
Matrix Spike (1406073-MS1)		**Source: 14F0240-15**		Prepared: 06/09/2014 Analyzed: 06/10/2014						
Cyanide	1600	50	mg/L	1000	680	89	70-130			
Batch 1406113 - SM4500-CN I										
Blank (1406113-BLK1)				Prepared: 06/11/2014 Analyzed: 06/12/2014						
Cyanide	ND	0.10	mg/L							
LCS (1406113-BS1)				Prepared: 06/11/2014 Analyzed: 06/12/2014						
Cyanide	1.9	0.10	mg/L	2.000		96	90-110			
LCS Dup (1406113-BSD1)				Prepared: 06/11/2014 Analyzed: 06/12/2014						
Cyanide	1.9	0.10	mg/L	2.000		94	90-110	2	20	
Matrix Spike (1406113-MS1)		**Source: 14F0240-18**		Prepared: 06/11/2014 Analyzed: 06/12/2014						
Cyanide	1500	50	mg/L	1000	650	87	70-130			

TURNER LABORATORIES INC.
2445 N. Coyote Drive, Suite 104
Tucson, Arizona 85745
(520) 882-5880
Fax: (520) 882-9788
www.turnerlabs.com

CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 14F0240 DATE _____ PAGE 1 OF 6

PROJECT NAME Wester Copper and Gold
CONTACT NAME Natsagdorj Gantumer
COMPANY NAME SGS Metcon
ADDRESS 7701 N. Business Park Dr
ZIP 85743 PHONE 5798315 EMAIL _____
SAMPLER'S SIGNATURE Salvador Gonzalez

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*	NUMBER OF CONTAINERS
26188	5/29/14	7:00		PW	1
26189	5/30/14	7:00		PW	1
26190	5/31/14	7:00		PW	1
26683	5/1/14	7:00		PW	1
26684	5/2/14	7:00		PW	1
26685	5/3/14	7:00		PW	1

CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX

Base Neutrals ☐ Acids ☐ 625/8270
Volatile Organics ☐ 624 ☐ 524.2 ☐ 8260 ☐ HAA5 ☐ TTHMs
☐ Chloride ☐ Sulfate ☐ Resistivity
NO_2 ☐ NO_3 ☐ TKN ☐
☐ TPH ☐ 1664 ☐ Oil & Grease
VOA ☐ Semi-VOA ☐ TCLP Analysis ☐ Pest.
TCLP ☐ Dissolved ☐ Metals ☐ Total ☐ RCRA8 ☐
Total ☐ Cyanide ☐ Amen. ☐ WAD ☑
SDWA-INORGANICS PRIMARY ☐ SECONDARY ☐
MPN ☐ Coliform ☐ PA ☐ Fecal ☐
pH ☐ Cl_2 ☐ Cl_2 ☐ Turb ☐
COD ☐ TSS ☐ BOD ☐

1. RELINQUISHED BY:
Salvador Gonzalez
Signature
Printed Name
Firm
5/3/14 1600
Date/Time

2. RECEIVED BY:
Signature
Printed Name
Firm
Date/Time

TURNAROUND REQUIREMENTS:
____ Standard (approx. 10 days)*
____ Next Day ____ 2 Day ____ 5 Day*
____ Email Preliminary Results
* Working Days

REPORT REQUIREMENTS:
____ I. Routine Report
____ II. Report (includes DUP, MS, MSD, as required, may be charged as samples)
____ III. Date Validation Report (Includes All Raw Data) Add 10% to invoice

INVOICE INFORMATION:
Account ____ Y ____ N
P.O. # _____
Bill to: _____

SAMPLE RECEIPT:
Total Containers 36
Temperature 30.9
☐ Wet Ice
☑ Ambient
☐ Blue Ice

3. RELINQUISHED BY:
Signature
Printed Name
Firm
Date/Time

4. RECEIVED BY:
Signature
Printed Name
TURNER LABORATORIES, INC.
Firm
6/2/14 1600
Date/Time

* LEGEND
SAMPLE MATRIX
DW = DRINKING WATER
GW = GROUNDWATER
SD = SOLID
SG = SLUDGE
SL = SOIL
ST = STORMWATER
WW = WASTEWATER

Compliance Analysis: ☐ Yes ☐ No
ADEQ Forms: ☐ Yes ☐ No
Mail ADEQ Forms: ☐ Yes ☐ No

Custody Seals ☐
Container Intact ☑
COC / Labels Agree ☑

Preservation Confirmation ☑
Appropriate Head Space N/A
Received Within Hold Time ☑

SPECIAL INSTRUCTIONS/COMMENTS:

TURNER LABORATORIES INC.
2445 N. Coyote Drive, Suite 104
Tucson, Arizona 85745
(520) 882-5880
Fax: (520) 882-9788
www.turnerlabs.com

CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 14F0240 DATE _____ PAGE 2 OF 6

PROJECT NAME Wester Copper and Gold
CONTACT NAME Natsagdorj Gantumer
COMPANY NAME SGS Metcon
ADDRESS 7701 N. Business Park Dr
ZIP 85743 PHONE 5798315 EMAIL _____
SAMPLER'S SIGNATURE Salvador Gonzalez

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*	NUMBER OF CONTAINERS
26718	5/29/14	7:00		PW	
26719	5/30/14	7:00		PW	
26720	5/31/14	7:00		PW	
26713	5/1/14	7:00		PW	
26714	5/2/14	7:00		PW	
26715	5/3/14	7:00		PW	

CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX

Base Neutrals ☐ Acids ☐ 625/8270
Volatile Organics ☐ 624 ☐ 524.2 ☐ 8260
TTHMS ☐ HAA5 ☐
Chloride ☐ Sulfate ☐ Resistivity ☐
NO_2 ☐ NO_3 ☐ TKN ☐
TPH ☐ 1664 ☐ Oil & Grease ☐
VOA ☐ TCLP Analysis Semi-VOA ☐ Pest. ☐
TCLP ☐ Metals Dissolved ☐ Total ☐ RCRA8 ☐
Total ☐ Cyanide Amen. ☐ WAD ☐
SDWA-INORGANICS PRIMARY ☐ SECONDARY ☐
MPN ☐ Coliform PIA ☐ Fecal ☐
pH ☐ Cr_6 ☐ Cl_2 ☐ Turb ☐
COD ☐ TSS ☐ BOD ☐

1. RELINQUISHED BY:
Salvador Gonzalez
Signature
Printed Name
Firm
6/3/14 16:01
Date/Time

2. RECEIVED BY:
Signature
Printed Name
Firm
Date/Time

TURNAROUND REQUIREMENTS:
____ Standard (approx. 10 days)*
____ Next Day ____ 2 Day ____ 5 Day*
____ Email Preliminary Results
* Working Days

REPORT REQUIREMENTS:
____ I. Routine Report
____ II. Report (includes DUP, MS, MSD, as required, may be charged as samples)
____ III. Date Validation Report (Includes All Raw Data) Add 10% to invoice

INVOICE INFORMATION:
Account ____ Y ____ N
P.O. # _____
Bill to: _____

SAMPLE RECEIPT:
Total Containers 36
Temperature 30.9
☐ Wet Ice
☑ Ambient
☐ Blue Ice

3. RELINQUISHED BY:
Signature
Printed Name
Firm
Date/Time

4. RECEIVED BY:
Signature
Printed Name
TURNER LABORATORIES, INC.
Firm
6/3/14 1601
Date/Time

* LEGEND
SAMPLE MATRIX
DW = DRINKING WATER
GW = GROUNDWATER
SD = SOLID
SG = SLUDGE
SL = SOIL
ST = STORMWATER
WW = WASTEWATER

Compliance Analysis: ☐ Yes ☐ No
ADEQ Forms: ☐ Yes ☐ No
Mail ADEQ Forms: ☐ Yes ☐ No

Custody Seals ☐
Container Intact ☑
COC / Labels Agree ☑

Preservation Confirmation ☑
Appropriate Head Space ☑
Received Within Hold Time ☑

SPECIAL INSTRUCTIONS/COMMENTS:

TURNER LABORATORIES INC.
2445 N. Coyote Drive, Suite 104
Tucson, Arizona 85745
(520) 882-5880
Fax: (520) 882-9788
www.turnerlabs.com

CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 14F0240 DATE _____ PAGE 3 OF 6

PROJECT NAME Wester Copper and Gold
CONTACT NAME Natsagdorj Gantumer
COMPANY NAME SGS Metcon
ADDRESS 7701 N. Business Park Dr
ZIP 85743 PHONE 5798315 EMAIL _____
SAMPLER'S SIGNATURE Salvador Gonzalez

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*	NUMBER OF CONTAINERS
26748	5/29/14	7:00		PW	
26749	5/30/14	7:00		PW	
26750	5/31/14	7:00		PW	
26743	5/1/14	7:00		PW	
26744	5/2/14	7:00		PW	
26745	5/3/14	7:00		PW	

CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX

Base Neutrals ☐ Acids ☐ 625/8270
Volatile Organics ☐ 624 ☐ 524.2 ☐ 8260
TTHMS ☐ HAA5 ☐
Chloride ☐ Sulfate ☐ Resistivity ☐
NO_2 ☐ NO_3 ☐ TKN ☐
TPH ☐ 1664 ☐ Oil & Grease ☐
VOA ☐ TCLP Analysis Semi-VOA ☐ Pest. ☐
TCLP ☐ Metals Dissolved ☐ Total ☐ RCRA8 ☐
Total ☐ Cyanide Amen. ☐ WAD ☐
SDWA-INORGANICS PRIMARY ☐ SECONDARY ☐
MPN ☐ Coliform PIA ☐ Fecal ☐
pH ☐ Cr_6 ☐ Cl ☐ Turb ☐
COD ☐ TSS ☐ BOD ☐

1. RELINQUISHED BY:
Salvador Gonzalez
Signature
Printed Name
Firm
6/3/14 16:01
Date/Time

2. RECEIVED BY:
Signature
Printed Name
Firm
Date/Time

TURNAROUND REQUIREMENTS:
____ Standard (approx. 10 days)*
____ Next Day ____ 2 Day ____ 5 Day*
____ Email Preliminary Results
* Working Days

REPORT REQUIREMENTS:
____ I. Routine Report
____ II. Report (includes DUP, MS, MSD, as required, may be charged as samples)
____ III. Date Validation Report (Includes All Raw Data) Add 10% to invoice

INVOICE INFORMATION:
Account ____ Y ____ N
P.O. # _____
Bill to: _____

SAMPLE RECEIPT:
Total Containers 36
Temperature 30.9
☐ Wet Ice
☑ Ambient
☐ Blue Ice

3. RELINQUISHED BY:
Signature
Printed Name
Firm
Date/Time

4. RECEIVED BY:
Signature
Printed Name
TURNER LABORATORIES, INC.
Firm
6/3/14 1600
Date/Time

* LEGEND
SAMPLE MATRIX
DW = DRINKING WATER
GW = GROUNDWATER
SD = SOLID
SG = SLUDGE
SL = SOIL
ST = STORMWATER
WW = WASTEWATER

Compliance Analysis: ☐ Yes ☐ No
ADEQ Forms: ☐ Yes ☐ No
Mail ADEQ Forms: ☐ Yes ☐ No

Custody Seals ☐
Container Intact ☑
COC / Labels Agree ☑

Preservation Confirmation ☑
Appropriate Head Space N/A
Received Within Hold Time ☑

SPECIAL INSTRUCTIONS/COMMENTS:

TURNER LABORATORIES INC.
2445 N. Coyote Drive, Suite 104
Tucson, Arizona 85745
(520) 882-5880
Fax: (520) 882-9788
www.turnerlabs.com

CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 14F0240 DATE _____ PAGE 4 OF 6

PROJECT NAME Ulster Copper and Gold
CONTACT NAME Natsagdori Gantumer
COMPANY NAME SGS Metcon
ADDRESS 7701 N. Business Park Dr
ZIP 85743 PHONE 5798315 EMAIL _____
SAMPLER'S SIGNATURE Salvador Gonzalez

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*	NUMBER OF CONTAINERS
26278	5/29/14	7:00		PW	
26279	5/30/14	7:00		PW	
26280	5/31/14	7:00		PW	
26773	5/1/14	7:00		PW	
26774	5/2/14	7:00		PW	
26775	5/3/14	7:00		PW	

CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX

Base Neutrals ☐ Acids ☐ 625/8270
Volatile Organics ☐ 624 ☐ 524.2 ☐ 8260 ☐ TTHMS ☐ HAA5
Chloride ☐ Sulfate ☐ Resistivity
NO_2 ☐ NO_3 ☐ TKN ☐
TPH ☐ 1664 ☐ Oil & Grease
VOA ☐ TCLP Analysis ☐ Semi-VOA ☐ Pest ☐
TCLP ☐ Dissolved ☐ Metals ☐ Total ☐ RCRA8 ☐
Total ☐ Cyanide ☐ Amen. ☐ WAD ☐
SDWA-INORGANICS PRIMARY ☐ SECONDARY ☐
MPN ☐ Coliform ☐ PIA ☐ Fecal ☐
pH ☐ Cr_6 ☐ Cl_2 ☐ Turb ☐
COD ☐ TSS ☐ BOD ☐

1. RELINQUISHED BY:
Salvador Gonzalez
Signature
Printed Name
Firm
6/3/14 16:01
Date/Time

2. RECEIVED BY:
Signature
Printed Name
Firm
Date/Time

3. RELINQUISHED BY:
Signature
Printed Name
Firm
Date/Time

4. RECEIVED BY:
Signature
Printed Name
TURNER LABORATORIES, INC.
Firm
6/3/14 1601
Date/Time

TURNAROUND REQUIREMENTS:
____ Standard (approx. 10 days)*
____ Next Day ____ 2 Day ____ 5 Day*
____ Email Preliminary Results
* Working Days

REPORT REQUIREMENTS:
____ I. Routine Report
____ II. Report (includes DUP, MS, MSD, as required, may be charged as samples)
____ III. Date Validation Report (Includes All Raw Data) Add 10% to invoice

INVOICE INFORMATION:
Account ____ Y ____ N
P.O. # _____
Bill to: _____

SAMPLE RECEIPT:
Total Containers 30
Temperature 30.9
☐ Wet Ice
☑ Ambient
☐ Blue Ice

* LEGEND SAMPLE MATRIX
DW = DRINKING WATER
GW = GROUNDWATER
SD = SOLID
SG = SLUDGE
SL = SOIL
ST = STORMWATER
WW = WASTEWATER

Compliance Analysis: ☐ Yes ☐ No
ADEQ Forms: ☐ Yes ☐ No
Mail ADEQ Forms: ☐ Yes ☐ No

Custody Seals ☐
Container Intact ☑
COC / Labels Agree ☑

Preservation Confirmation ☐
Appropriate Head Space N/A
Received Within Hold Time ☑

SPECIAL INSTRUCTIONS/COMMENTS:

TURNER LABORATORIES INC.
2445 N. Coyote Drive, Suite 104
Tucson, Arizona 85745
(520) 882-5880
Fax: (520) 882-9788
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CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 14F0240 DATE _____ PAGE 5 OF 6

PROJECT NAME Ulester Copper and Gold
CONTACT NAME Natsagdorj Gantomer
COMPANY NAME SGS Metcon
ADDRESS 7701 N. Business Park Dr
ZIP 85743 PHONE 5798315 EMAIL _____
SAMPLER'S SIGNATURE Salvador Gonzalez

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*	NUMBER OF CONTAINERS
26308	5/29/14	7:00		DW	
26309	5/30/14	7:00		DW	
26310	5/31/14	7:00		DW	
26803	5/1/14	7:00		DW	
26804	5/2/14	7:00		DW	
26805	5/3/14	7:00		DW	

CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX

Base Neutrals ☐ 625/8270 Acids ☐
Volatile Organics ☐ 624 ☐ 524.2 ☐ TTHMS ☐ 8260 ☐ HAAS ☐
Chloride ☐ Sulfate ☐ Resistivity ☐
NO_2 ☐ NO_3 ☐ TKN ☐
TPH ☐ 1664 ☐ Oil & Grease ☐
VOA ☐ TCLP Analysis Semi-VOA ☐ Pest. ☐
TCLP ☐ Metals Dissolved ☐ Total ☐ RCRA8 ☐
Total ☐ Cyanide Amen. ☐ WAD ☐
SDWA-INORGANICS PRIMARY ☐ SECONDARY ☐
MPN ☐ Coliform PIA ☐ Fecal ☐
pH ☐ C_l ☐ C_l ☐ Turb ☐
COD ☐ TSS ☐ BOD ☐

1. RELINQUISHED BY:
Salvador Gonzalez
Signature
Printed Name
Firm
6/3/14 16:01
Date/Time

2. RECEIVED BY:
Signature
Printed Name
Firm
Date/Time

TURNAROUND REQUIREMENTS:
____ Standard (approx. 10 days)*
____ Next Day ____ 2 Day ____ 5 Day*
____ Email Preliminary Results
* Working Days

REPORT REQUIREMENTS:
____ I. Routine Report
____ II. Report (includes DUP, MS, MSD, as required, may be charged as samples)
____ III. Date Validation Report (Includes All Raw Data) Add 10% to invoice

INVOICE INFORMATION:
Account ____ Y ____ N
P.O. # _____
Bill to: _____

SAMPLE RECEIPT:
Total Containers 36
Temperature 30.9
☐ Wet Ice
☑ Ambient
☐ Blue Ice

3. RELINQUISHED BY:
Signature
Printed Name
Firm
Date/Time

4. RECEIVED BY:
Signature
Printed Name
TURNER LABORATORIES, INC.
Firm
6/3/14 1601
Date/Time

* LEGEND
SAMPLE MATRIX
DW = DRINKING WATER
GW = GROUNDWATER
SD = SOLID
SG = SLUDGE
SL = SOIL
ST = STORMWATER
WW = WASTEWATER

Compliance Analysis: ☐ Yes ☐ No
ADEQ Forms: ☐ Yes ☐ No
Mail ADEQ Forms: ☐ Yes ☐ No

Custody Seals ☐
Container Intact ☑
COC / Labels Agree ☑

Preservation Confirmation ☑
Appropriate Head Space N/A
Received Within Hold Time ☑

SPECIAL INSTRUCTIONS/COMMENTS:

TURNER LABORATORIES INC
2445 N. Coyote Drive, Suite 104
Tucson, Arizona 85745
(520) 882-5880
Fax: (520) 882-9788
www.turnerlabs.com

CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 14F0240 DATE _____ PAGE 6 OF 6

PROJECT NAME Wester Copper and Gold
CONTACT NAME Natsagdorj Gantumer
COMPANY NAME SGS Metcon
ADDRESS 7701 N. Business Park Dr
ZIP 85743 PHONE 5798315 EMAIL _____
SAMPLER'S SIGNATURE Salvador Gonzalez

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*	NUMBER OF CONTAINERS	CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX
26338	5/29/14	7:00		PW		
26339	5/30/14	7:00		PW		
26340	5/31/14	7:00		PW		
26833	5/1/14	7:00		PW		
26834	5/2/14	7:00		PW		
26835	5/3/14	7:00		PW		

CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX: Base Neutrals 625/8270 ☐ Acids ☐ Volatile Organics ☐ 624 ☐ 524.2 ☐ 8260 ☐ TTHMS ☐ HAA5 ☐ Chloride ☐ Sulfate ☐ Resistivity ☐ NO_2 ☐ NO_3 ☐ TKN ☐ TPH ☐ 1664 ☐ Oil & Grease ☐ VOA ☐ TCLP Analysis Semi-VOA ☐ Pest. ☐ TCLP ☐ Metals Dissolved ☐ Total ☐ RCRA8 ☐ Total ☐ Cyanide Amen. ☐ WAD ☑ SDWA-INORGANICS PRIMARY ☐ SECONDARY ☐ MPN ☐ Coliform PA ☐ pH ☐ Fecal ☐ Cl_2 ☐ Turb ☐ COD ☐ TSS ☐ BOD ☐

1. RELINQUISHED BY:
Salvador Gonzalez
Signature
Printed Name
Firm
6/3/14 16:01
Date/Time

2. RECEIVED BY:
Signature
Printed Name
Firm
Date/Time

TURNAROUND REQUIREMENTS:
____ Standard (approx. 10 days)*
____ Next Day ____ 2 Day ____ 5 Day*
____ Email Preliminary Results
* Working Days

REPORT REQUIREMENTS:
____ I. Routine Report
____ II. Report (includes DUP, MS, MSD, as required, may be charged as samples)
____ III. Date Validation Report (Includes All Raw Data) Add 10% to invoice

INVOICE INFORMATION:
Account ____ Y ____ N
P.O. # _____
Bill to: _____

SAMPLE RECEIPT:
Total Containers 36
Temperature 30.9
☐ Wet Ice
☑ Ambient
☐ Blue Ice

3. RELINQUISHED BY:
Signature
Printed Name
Firm
Date/Time

4. RECEIVED BY:
Signature
Printed Name
TURNER LABORATORIES, INC.
Firm
6/3/14 1601
Date/Time

* LEGEND
SAMPLE MATRIX
DW = DRINKING WATER
GW = GROUNDWATER
SD = SOLID
SG = SLUDGE
SL = SOIL
ST = STORMWATER
WW = WASTEWATER

Compliance Analysis: ☐ Yes ☐ No
ADEQ Forms: ☐ Yes ☐ No
Mail ADEQ Forms: ☐ Yes ☐ No

Custody Seals ☐
Container Intact ☑
COC / Labels Agree ☑

Preservation Confirmation ☑
Appropriate Head Space ☑
Received Within Hold Time ☑

SPECIAL INSTRUCTIONS/COMMENTS:

July 08, 2014

Natska Gantumur
SGS Metcon
7701 Business Park Dr.
Tucson, AZ 85743

TEL (520) 579-8315
FAX (303) 456-6998

Work Order No.: 14F0604
Order Name: M-709-03

RE: M-709-03

Dear Natska Gantumur,

Turner Laboratories, Inc. received 42 sample(s) on 06/17/2014 for the analyses presented in the following report.

All results are intended to be considered in their entirety, and Turner Laboratories, Inc. is not responsible for use of less than the complete report. Results apply only to the samples analyzed. Samples will be disposed of 30 days after issue of our report unless special arrangements are made.

The pages that follow may contain sensitive, privileged or confidential information intended solely for the addressee named above. If you receive this message and are not the agent or employee of the addressee, this communication has been sent in error. Please do not disseminate or copy any of the attached and notify the sender immediately by telephone. Please also return the attached sheet(s) to the sender by mail.

Please call if you have any questions.

Respectfully submitted,

Turner Laboratories, Inc.
ADHS License AZ0066



Terri Garcia
Technical Director

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0604
Date Received: 06/17/2014

Order: M-709-03

Work Order Sample Summary

Lab Sample ID	Client Sample ID	Matrix	Collection Date/Time
14F0604-01	26693	Process Water	06/11/2014 0700
14F0604-02	26694	Process Water	06/12/2014 0700
14F0604-03	26695	Process Water	06/13/2014 0700
14F0604-04	26696	Process Water	06/14/2014 0700
14F0604-05	26697	Process Water	06/15/2014 0700
14F0604-06	26698	Process Water	06/16/2014 0700
14F0604-07	26699	Process Water	06/17/2014 0700
14F0604-08	26723	Process Water	06/11/2014 0700
14F0604-09	26724	Process Water	06/12/2014 0700
14F0604-10	26725	Process Water	06/13/2014 0700
14F0604-11	26726	Process Water	06/14/2014 0700
14F0604-12	26727	Process Water	06/15/2014 0700
14F0604-13	26728	Process Water	06/16/2014 0700
14F0604-14	26729	Process Water	06/17/2014 0700
14F0604-15	26753	Process Water	06/11/2014 0700
14F0604-16	26754	Process Water	06/12/2014 0700
14F0604-17	26755	Process Water	06/13/2014 0700
14F0604-18	26756	Process Water	06/14/2014 0700
14F0604-19	26757	Process Water	06/15/2014 0700
14F0604-20	26758	Process Water	06/16/2014 0700
14F0604-21	26759	Process Water	06/17/2014 0700
14F0604-22	26783	Process Water	06/11/2014 0700
14F0604-23	26784	Process Water	06/12/2014 0700
14F0604-24	26785	Process Water	06/13/2014 0700
14F0604-25	26786	Process Water	06/14/2014 0700
14F0604-26	26787	Process Water	06/15/2014 0700
14F0604-27	26788	Process Water	06/16/2014 0700
14F0604-28	26789	Process Water	06/17/2014 0700
14F0604-29	26813	Process Water	06/11/2014 0700
14F0604-30	26814	Process Water	06/12/2014 0700
14F0604-31	26815	Process Water	06/13/2014 0700
14F0604-32	26816	Process Water	06/14/2014 0700

14F0604-33	26817	Process Water	06/15/2014 0700
14F0604-34	26818	Process Water	06/16/2014 0700
14F0604-35	26819	Process Water	06/17/2014 0700
14F0604-36	26843	Process Water	06/11/2014 0700
14F0604-37	26844	Process Water	06/12/2014 0700
14F0604-38	26845	Process Water	06/13/2014 0700
14F0604-39	26846	Process Water	06/14/2014 0700
14F0604-40	26847	Process Water	06/15/2014 0700
14F0604-41	26848	Process Water	06/16/2014 0700
14F0604-42	26849	Process Water	06/17/2014 0700

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0604
Date Received: 06/17/2014

Case Narrative

M2 Matrix spike recovery was low; the associated LCS/LCSD was acceptable.

All soil, sludge, and solid matrix determinations are reported on a wet weight basis unless otherwise noted.

ND Not Detected at or above the PQL

PQL Practical Quantitation Limit

DF Dilution Factor

Client:	SGS Metcon	**Client Sample ID:**	26693
Project:	M-709-03	**Collection Date/Time:**	06/11/2014 0700
Work Order:	14F0604	**Matrix:**	Process Water
Lab Sample ID:	14F0604-01	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	660	20		mg/L	200	06/23/2014 0800	06/24/2014 1130	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0604
Lab Sample ID: 14F0604-02

Client Sample ID: 26694
Collection Date/Time: 06/12/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	340	20		mg/L	200	06/23/2014 0800	06/24/2014 1130	EW

Client:	SGS Metcon	**Client Sample ID:**	26695
Project:	M-709-03	**Collection Date/Time:**	06/13/2014 0700
Work Order:	14F0604	**Matrix:**	Process Water
Lab Sample ID:	14F0604-03	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	650	20		mg/L	200	06/23/2014 0800	06/24/2014 1130	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0604
Lab Sample ID: 14F0604-04

Client Sample ID: 26696
Collection Date/Time: 06/14/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	110	20		mg/L	200	06/26/2014 0800	06/27/2014 1615	EW

Client:	SGS Metcon	**Client Sample ID:**	26697
Project:	M-709-03	**Collection Date/Time:**	06/15/2014 0700
Work Order:	14F0604	**Matrix:**	Process Water
Lab Sample ID:	14F0604-05	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	670	20		mg/L	200	06/26/2014 0800	06/27/2014 1615	EW

Client:	SGS Metcon	**Client Sample ID:**	26698
Project:	M-709-03	**Collection Date/Time:**	06/16/2014 0700
Work Order:	14F0604	**Matrix:**	Process Water
Lab Sample ID:	14F0604-06	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	510	20		mg/L	200	06/26/2014 0800	06/27/2014 1615	EW

Client:	SGS Metcon	**Client Sample ID:**	26699
Project:	M-709-03	**Collection Date/Time:**	06/17/2014 0700
Work Order:	14F0604	**Matrix:**	Process Water
Lab Sample ID:	14F0604-07	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	640	20		mg/L	200	06/26/2014 0800	06/27/2014 1615	EW

Client:	SGS Metcon	**Client Sample ID:**	26723
Project:	M-709-03	**Collection Date/Time:**	06/11/2014 0700
Work Order:	14F0604	**Matrix:**	Process Water
Lab Sample ID:	14F0604-08	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	560	20		mg/L	200	06/23/2014 0800	06/24/2014 1130	EW

Client:	SGS Metcon	**Client Sample ID:**	26724
Project:	M-709-03	**Collection Date/Time:**	06/12/2014 0700
Work Order:	14F0604	**Matrix:**	Process Water
Lab Sample ID:	14F0604-09	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	710	20		mg/L	200	06/23/2014 0800	06/24/2014 1130	EW

Client:	SGS Metcon	**Client Sample ID:**	26725
Project:	M-709-03	**Collection Date/Time:**	06/13/2014 0700
Work Order:	14F0604	**Matrix:**	Process Water
Lab Sample ID:	14F0604-10	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	700	20		mg/L	200	06/23/2014 0800	06/24/2014 1130	EW

Client:	SGS Metcon	**Client Sample ID:**	26726
Project:	M-709-03	**Collection Date/Time:**	06/14/2014 0700
Work Order:	14F0604	**Matrix:**	Process Water
Lab Sample ID:	14F0604-11	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	130	20		mg/L	200	06/26/2014 0800	06/27/2014 1615	EW

Client:	SGS Metcon	**Client Sample ID:**	26727
Project:	M-709-03	**Collection Date/Time:**	06/15/2014 0700
Work Order:	14F0604	**Matrix:**	Process Water
Lab Sample ID:	14F0604-12	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	98	20		mg/L	200	06/26/2014 0800	06/27/2014 1615	EW

Client:	SGS Metcon	**Client Sample ID:**	26728
Project:	M-709-03	**Collection Date/Time:**	06/16/2014 0700
Work Order:	14F0604	**Matrix:**	Process Water
Lab Sample ID:	14F0604-13	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	730	20		mg/L	200	06/26/2014 0800	06/27/2014 1615	EW

Client:	SGS Metcon	**Client Sample ID:**	26729
Project:	M-709-03	**Collection Date/Time:**	06/17/2014 0700
Work Order:	14F0604	**Matrix:**	Process Water
Lab Sample ID:	14F0604-14	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	710	20		mg/L	200	06/30/2014 1400	07/01/2014 1730	EW

Client:	SGS Metcon	**Client Sample ID:**	26753
Project:	M-709-03	**Collection Date/Time:**	06/11/2014 0700
Work Order:	14F0604	**Matrix:**	Process Water
Lab Sample ID:	14F0604-15	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	720	20		mg/L	200	06/23/2014 0800	06/24/2014 1130	EW

Client:	SGS Metcon	**Client Sample ID:**	26754
Project:	M-709-03	**Collection Date/Time:**	06/12/2014 0700
Work Order:	14F0604	**Matrix:**	Process Water
Lab Sample ID:	14F0604-16	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	700	20		mg/L	200	06/23/2014 0800	06/24/2014 1130	EW

Client:	SGS Metcon	**Client Sample ID:**	26755
Project:	M-709-03	**Collection Date/Time:**	06/13/2014 0700
Work Order:	14F0604	**Matrix:**	Process Water
Lab Sample ID:	14F0604-17	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	590	20		mg/L	200	06/23/2014 0800	06/24/2014 1130	EW

Client:	SGS Metcon	**Client Sample ID:**	26756
Project:	M-709-03	**Collection Date/Time:**	06/14/2014 0700
Work Order:	14F0604	**Matrix:**	Process Water
Lab Sample ID:	14F0604-18	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	220	20		mg/L	200	06/26/2014 0800	06/27/2014 1615	EW

Client:	SGS Metcon	**Client Sample ID:**	26757
Project:	M-709-03	**Collection Date/Time:**	06/15/2014 0700
Work Order:	14F0604	**Matrix:**	Process Water
Lab Sample ID:	14F0604-19	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	110	20		mg/L	200	06/26/2014 0800	06/27/2014 1615	EW

Client:	SGS Metcon	**Client Sample ID:**	26758
Project:	M-709-03	**Collection Date/Time:**	06/16/2014 0700
Work Order:	14F0604	**Matrix:**	Process Water
Lab Sample ID:	14F0604-20	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	610	20		mg/L	200	06/26/2014 0800	06/27/2014 1615	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0604
Lab Sample ID: 14F0604-21

Client Sample ID: 26759
Collection Date/Time: 06/17/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	720	20		mg/L	200	06/30/2014 1400	07/01/2014 1730	EW

Client:	SGS Metcon	**Client Sample ID:**	26783
Project:	M-709-03	**Collection Date/Time:**	06/11/2014 0700
Work Order:	14F0604	**Matrix:**	Process Water
Lab Sample ID:	14F0604-22	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	420	20		mg/L	200	06/23/2014 0800	06/24/2014 1130	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0604
Lab Sample ID: 14F0604-23

Client Sample ID: 26784
Collection Date/Time: 06/12/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	700	20		mg/L	200	06/23/2014 0800	06/24/2014 1130	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0604
Lab Sample ID: 14F0604-24

Client Sample ID: 26785
Collection Date/Time: 06/13/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	190	20		mg/L	200	06/23/2014 0800	06/24/2014 1130	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0604
Lab Sample ID: 14F0604-25

Client Sample ID: 26786
Collection Date/Time: 06/14/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	680	20		mg/L	200	06/26/2014 0800	06/27/2014 1615	EW

Client:	SGS Metcon	**Client Sample ID:**	26787
Project:	M-709-03	**Collection Date/Time:**	06/15/2014 0700
Work Order:	14F0604	**Matrix:**	Process Water
Lab Sample ID:	14F0604-26	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	720	20		mg/L	200	06/26/2014 0800	06/27/2014 1615	EW

Client:	SGS Metcon	**Client Sample ID:**	26788
Project:	M-709-03	**Collection Date/Time:**	06/16/2014 0700
Work Order:	14F0604	**Matrix:**	Process Water
Lab Sample ID:	14F0604-27	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	690	20		mg/L	200	06/26/2014 0800	06/27/2014 1615	EW

Client:	SGS Metcon	**Client Sample ID:**	26789
Project:	M-709-03	**Collection Date/Time:**	06/17/2014 0700
Work Order:	14F0604	**Matrix:**	Process Water
Lab Sample ID:	14F0604-28	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	750	20		mg/L	200	06/30/2014 1400	07/01/2014 1730	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0604
Lab Sample ID: 14F0604-29

Client Sample ID: 26813
Collection Date/Time: 06/11/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	630	20		mg/L	200	06/23/2014 0800	06/24/2014 1130	EW

Client:	SGS Metcon	**Client Sample ID:**	26814
Project:	M-709-03	**Collection Date/Time:**	06/12/2014 0700
Work Order:	14F0604	**Matrix:**	Process Water
Lab Sample ID:	14F0604-30	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	570	20		mg/L	200	06/23/2014 0800	06/24/2014 1130	EW

Client:	SGS Metcon	**Client Sample ID:**	26815
Project:	M-709-03	**Collection Date/Time:**	06/13/2014 0700
Work Order:	14F0604	**Matrix:**	Process Water
Lab Sample ID:	14F0604-31	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	680	20		mg/L	200	06/23/2014 0800	06/24/2014 1130	EW

Client:	SGS Metcon	**Client Sample ID:**	26816
Project:	M-709-03	**Collection Date/Time:**	06/14/2014 0700
Work Order:	14F0604	**Matrix:**	Process Water
Lab Sample ID:	14F0604-32	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	660	20		mg/L	200	06/26/2014 0800	06/27/2014 1615	EW

Client:	SGS Metcon	**Client Sample ID:**	26817
Project:	M-709-03	**Collection Date/Time:**	06/15/2014 0700
Work Order:	14F0604	**Matrix:**	Process Water
Lab Sample ID:	14F0604-33	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	730	20		mg/L	200	06/26/2014 0800	06/27/2014 1615	EW

Client:	SGS Metcon	**Client Sample ID:**	26818
Project:	M-709-03	**Collection Date/Time:**	06/16/2014 0700
Work Order:	14F0604	**Matrix:**	Process Water
Lab Sample ID:	14F0604-34	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	790	20		mg/L	200	06/26/2014 0800	06/27/2014 1615	EW

Client:	SGS Metcon	**Client Sample ID:**	26819
Project:	M-709-03	**Collection Date/Time:**	06/17/2014 0700
Work Order:	14F0604	**Matrix:**	Process Water
Lab Sample ID:	14F0604-35	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	710	20		mg/L	200	06/30/2014 1400	07/01/2014 1730	EW

Client:	SGS Metcon	**Client Sample ID:**	26843
Project:	M-709-03	**Collection Date/Time:**	06/11/2014 0700
Work Order:	14F0604	**Matrix:**	Process Water
Lab Sample ID:	14F0604-36	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	720	20		mg/L	200	06/23/2014 0800	06/24/2014 1130	EW

Client:	SGS Metcon	**Client Sample ID:**	26844
Project:	M-709-03	**Collection Date/Time:**	06/12/2014 0700
Work Order:	14F0604	**Matrix:**	Process Water
Lab Sample ID:	14F0604-37	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	690	20		mg/L	200	06/23/2014 0800	06/24/2014 1130	EW

Client:	SGS Metcon	**Client Sample ID:**	26845
Project:	M-709-03	**Collection Date/Time:**	06/13/2014 0700
Work Order:	14F0604	**Matrix:**	Process Water
Lab Sample ID:	14F0604-38	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	720	20		mg/L	200	06/26/2014 0800	06/27/2014 1615	EW

Client:	SGS Metcon	**Client Sample ID:**	26846
Project:	M-709-03	**Collection Date/Time:**	06/14/2014 0700
Work Order:	14F0604	**Matrix:**	Process Water
Lab Sample ID:	14F0604-39	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	740	20		mg/L	200	06/26/2014 0800	06/27/2014 1615	EW

Client:	SGS Metcon	**Client Sample ID:**	26847
Project:	M-709-03	**Collection Date/Time:**	06/15/2014 0700
Work Order:	14F0604	**Matrix:**	Process Water
Lab Sample ID:	14F0604-40	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	700	20		mg/L	200	06/26/2014 0800	06/27/2014 1615	EW

Client:	SGS Metcon	**Client Sample ID:**	26848
Project:	M-709-03	**Collection Date/Time:**	06/16/2014 0700
Work Order:	14F0604	**Matrix:**	Process Water
Lab Sample ID:	14F0604-41	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	690	20		mg/L	200	06/26/2014 0800	06/27/2014 1615	EW

Client:	SGS Metcon	**Client Sample ID:**	26849
Project:	M-709-03	**Collection Date/Time:**	06/17/2014 0700
Work Order:	14F0604	**Matrix:**	Process Water
Lab Sample ID:	14F0604-42	**Order Name:**	M-709-03

Analyses	Result	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I								
Cyanide	740	20		mg/L	200	06/30/2014 1400	07/01/2014 1730	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0604
Date Received: 06/17/2014

QC Summary

Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Qual
Batch 1406239 - SM4500-CN I										
Blank (1406239-BLK1)				Prepared: 06/23/2014 Analyzed: 06/24/2014						
Cyanide	ND	0.10	mg/L							
LCS (1406239-BS1)				Prepared: 06/23/2014 Analyzed: 06/24/2014						
Cyanide	1.9	0.10	mg/L	2.000		95	90-110			
LCS Dup (1406239-BSD1)				Prepared: 06/23/2014 Analyzed: 06/24/2014						
Cyanide	2.0	0.10	mg/L	2.000		100	90-110	5	20	
Matrix Spike (1406239-MS1)		**Source: 14F0604-23**		Prepared: 06/23/2014 Analyzed: 06/24/2014						
Cyanide	1400	50	mg/L	1000	700	67	70-130			M2
Batch 1406288 - SM4500-CN I										
Blank (1406288-BLK1)				Prepared: 06/26/2014 Analyzed: 06/27/2014						
Cyanide	ND	0.10	mg/L							
LCS (1406288-BS1)				Prepared: 06/26/2014 Analyzed: 06/27/2014						
Cyanide	1.9	0.10	mg/L	2.000		94	90-110			
LCS Dup (1406288-BSD1)				Prepared: 06/26/2014 Analyzed: 06/27/2014						
Cyanide	1.8	0.10	mg/L	2.000		91	90-110	3	20	
Matrix Spike (1406288-MS1)		**Source: 14F0604-25**		Prepared: 06/26/2014 Analyzed: 06/27/2014						
Cyanide	1800	50	mg/L	1000	680	112	70-130			
Batch 1406292 - SM4500-CN I										
Blank (1406292-BLK1)				Prepared: 06/30/2014 Analyzed: 07/01/2014						
Cyanide	ND	0.10	mg/L							
LCS (1406292-BS1)				Prepared: 06/30/2014 Analyzed: 07/01/2014						
Cyanide	2.1	0.10	mg/L	2.000		104	90-110			
LCS Dup (1406292-BSD1)				Prepared: 06/30/2014 Analyzed: 07/01/2014						
Cyanide	2.1	0.10	mg/L	2.000		104	90-110	0.3	20	
Matrix Spike (1406292-MS1)		**Source: 14F0814-19**		Prepared: 06/30/2014 Analyzed: 07/01/2014						
Cyanide	1700	50	mg/L	1000	690	101	70-130			

TURNER LABORATORIES INC.
2445 N. Coyote Drive, Suite 104
Tucson, Arizona 85745
(520) 882-5880
Fax: (520) 882-9788
www.turnerlabs.com

CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 14F0604 DATE 6/17/14 PAGE 1 OF 6

PROJECT NAME Wester Copper and gold # _____
CONTACT NAME Mutsagdori Gantumer
COMPANY NAME SGS Metcon
ADDRESS 7701 N. Business Park Dr
ZIP 85743 PHONE 5798315 EMAIL _____
SAMPLER'S SIGNATURE Salvador Gonzalez

CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*	NUMBER OF CONTAINERS	Base Neutrals 625/8270 ☐	Acids ☐	Volatile Organics ☐ 624	☐ 524.2	☐ TTHMS	8260 ☐	HAA5 ☐	Chloride ☐	Sulfate ☐	Resistivity ☐	NO_2 ☐	NO_3 ☐	TKN ☐	TPH ☐	1664 ☐	Oil & Grease ☐	VOA ☐	TCLP Analysis Semi-VOA ☐	Pest. ☐	TCLP ☐	Metals Dissolved ☐	Total ☐	RCRA8 ☐	Total ☐	Cyanide Amen. ☐	WAD ☐	SDWA-INORGANICS PRIMARY ☐	SECONDARY ☐	MPN ☐	Coliform PIA ☐	Fecal ☐	pH ☐	C_l ☐	C_l ☐	Turb ☐	COD ☐	TSS ☐	BOD ☐
~~26692~~	~~6/10/14~~	~~7:00~~		~~P.W~~																																							
26693	6/11/14	7:00		P.W																								X															
26694	6/12/14	7:00		P.W																								X															
26695	6/13/14	7:00		P.W																								X															
26696	6/14/14	7:00		P.W																								X															
26697	6/15/14	7:00		P.W																								X															
26698	6/16/14	7:00		P.W																								X															
26699	6/17/14	7:00		P.W																								X															

1. RELINQUISHED BY: Salvador Gonzalez Signature _____ Printed Name _____ Firm _____ Date/Time 6/17/14 16:45

2. RECEIVED BY: Signature _____ Printed Name _____ Firm _____ Date/Time _____

3. RELINQUISHED BY: Signature _____ Printed Name _____ Firm _____ Date/Time _____

4. RECEIVED BY: Signature _____ Printed Name _____ Firm TURNER LABORATORIES, INC. Date/Time 6/17/14 1645

TURNAROUND REQUIREMENTS:
____ Standard (approx. 10 days)*
____ Next Day ____ 2 Day ____ 5 Day*
____ Email Preliminary Results
* Working Days

REPORT REQUIREMENTS:
____ I. Routine Report
____ II. Report (includes DUP, MS, MSD, as required, may be charged as samples)
____ III. Date Validation Report (Includes All Raw Data) Add 10% to invoice

INVOICE INFORMATION:
Account ____ Y ____ N
P.O. # _____
Bill to: _____

SAMPLE RECEIPT:
Total Containers 48 42 web 6/17/14
Temperature 28.6
☐ Wet Ice
☒ Ambient
☐ Blue Ice

* LEGEND
SAMPLE MATRIX
DW = DRINKING WATER
GW = GROUNDWATER
SD = SOLID
SG = SLUDGE
SL = SOIL
ST = STORMWATER
WW = WASTEWATER

Compliance Analysis: ☐ Yes ☐ No	Custody Seals ☐	Preservation Confirmation ☒
ADEQ Forms: ☐ Yes ☐ No	Container Intact ☒	Appropriate Head Space ☒
Mail ADEQ Forms: ☐ Yes ☐ No	COC / Labels Agree ☒	Received Within Hold Time ☒

SPECIAL INSTRUCTIONS/COMMENTS:

TURNER LABORATORIES INC.
2445 N. Coyote Drive, Suite 104
Tucson, Arizona 85745
(520) 882-5880
Fax: (520) 882-9788
www.turnerlabs.com

CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 14F0604 DATE 6/17/14 PAGE 2 OF 6

PROJECT NAME Wester Copper and gold # _____
CONTACT NAME Natsagdori Ganbumer
COMPANY NAME SGS Mekon
ADDRESS 7701 N. Business Park Dr
ZIP 85743 PHONE 5790315 EMAIL _____
SAMPLER'S SIGNATURE Salvador Gonzalez

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*	NUMBER OF CONTAINERS
~~[illegible]~~	~~6/[illegible]~~	~~7:00~~		~~P.W~~	
26723	6/11/14	7:00		P.W	
26724	6/12/14	7:00		P.W	
26725	6/13/14	7:00		P.W	
26726	6/14/14	7:00		P.W	
26727	6/15/14	7:00		P.W	
26728	6/16/14	7:00		P.W	
26729	6/17/14	7:00		P.W	

CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX

Base Neutrals 625/8270	Acids	Volatile Organics 624	524.2	8260 TTHMS	HAA5	Chloride	Sulfate	Resistivity	NO_2	NO_3	TKN	TPH 1664	Oil & Grease	VOA	TCLP Analysis Semi-VOA	Pest.	TCLP	Metals Dissolved	Total	RCRA8	Total	Cyanide Amen.	WAD	SDWA-INORGANICS PRIMARY	SECONDARY	MPN	Coliform PIA	pH	Fecal	C_6	Cl_2	Turb	COD	TSS	BOD
~~[illegible]~~																					~~[illegible]~~														
																					X													
																					X													
																					X													
																					X													
																					X													
																					X													
																					X													
																					X													

1. RELINQUISHED BY:
Salvador Gonzalez
Signature
Printed Name
Firm
6/17/14 16:45
Date/Time

2. RECEIVED BY:
Signature
Printed Name
Firm
Date/Time

TURNAROUND REQUIREMENTS:
____ Standard (approx. 10 days)*
____ Next Day ____ 2 Day ____ 5 Day*
____ Email Preliminary Results
* Working Days

REPORT REQUIREMENTS:
____ I. Routine Report
____ II. Report (includes DUP, MS, MSD, as required, may be charged as samples)
____ III. Date Validation Report (Includes All Raw Data) Add 10% to invoice

INVOICE INFORMATION:
Account ____ Y ____ N
P.O. # _____
Bill to: _____

SAMPLE RECEIPT:
Total Containers 42
Temperature 28.6
☐ Wet Ice
☒ Ambient
☐ Blue Ice

3. RELINQUISHED BY:
Signature
Printed Name
Firm
Date/Time

4. RECEIVED BY:
Signature
Printed Name
TURNER LABORATORIES, INC.
Firm
6/17/14 1645
Date/Time

* LEGEND
SAMPLE MATRIX
DW = DRINKING WATER
GW = GROUNDWATER
SD = SOLID
SG = SLUDGE
SL = SOIL
ST = STORMWATER
WW = WASTEWATER

Compliance Analysis: ☐ Yes ☐ No		Custody Seals ☐	Preservation Confirmation ☒
ADEQ Forms: ☐ Yes ☐ No		Container Intact ☒	Appropriate Head Space ☐
Mail ADEQ Forms: ☐ Yes ☐ No		COC / Labels Agree ☑	Received Within Hold Time ☒

SPECIAL INSTRUCTIONS/COMMENTS:

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CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 14F0604 DATE 6/17/14 PAGE 3 OF 6

PROJECT NAME Wester Copper and gold # _____
CONTACT NAME Mutsagdori Ganfumer
COMPANY NAME SGS Metcon
ADDRESS 7701 N. Business Park Dr
ZIP 85743 PHONE 5749315 EMAIL _____
SAMPLER'S SIGNATURE Salvador Gonzalez

NUMBER OF CONTAINERS

CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*	Base Neutrals 625/8270 ☐	Acids ☐	Volatile Organics ☐ 624 ☐	524.2 ☐	TTHMS ☐	8260 ☐	HAA5 ☐	Chloride ☐	Sulfate ☐	Resistivity ☐	NO_2 ☐	NO_3 ☐	TKN ☐	TPH ☐	1664 ☐	Oil & Grease ☐	VOA ☐	TCLP Analysis SemiVOA ☐	Pest. ☐	TCLP ☐	Metals	Total ☐	Dissolved ☐	RCRA8 ☐	Total ☐	Cyanide Amen. ☐	WAD ☐	SDWA-INORGANICS PRIMARY ☐	SECONDARY ☐	MPN ☐	Coliform FIA ☐	Fecal ☐	pH ☐	Cr_6 ☐	Cl ☐	COD ☐	Turb ☐	TSS ☐	BOD ☐
[illegible]	[illegible]	[illegible]		[illegible]																									X													
26753	6/11/14	7:00		P.W																									X													
26754	6/12/14	7:00		P.W																									X													
26755	6/13/14	7:00		P.W																									X													
26756	6/14/14	7:00		P.W																									X													
26757	6/15/14	7:00		P.W																									X													
26758	6/16/14	7:00		P.W																									X													
26759	6/17/14	7:00		P.W																									X													

1. RELINQUISHED BY:
Salvador Gonzalez
Signature
Printed Name
Firm
6/17/14 16:45
Date/Time

2. RECEIVED BY:
Signature
Printed Name
Firm
Date/Time

3. RELINQUISHED BY:
Signature
Printed Name
Firm
Date/Time

4. RECEIVED BY:
Signature
Printed Name
TURNER LABORATORIES, INC.
Firm
6/16/14 1645
Date/Time

TURNAROUND REQUIREMENTS:
____ Standard (approx. 10 days)*
____ Next Day ____ 2 Day ____ 5 Day*
____ Email Preliminary Results
* Working Days

REPORT REQUIREMENTS:
____ I. Routine Report
____ II. Report (includes DUP, MS, MSD, as required, may be charged as samples)
____ III. Date Validation Report (Includes All Raw Data) Add 10% to invoice

INVOICE INFORMATION:
Account ____ Y ____ N
P.O. # _____
Bill to: _____

SAMPLE RECEIPT:
Total Containers 42
Temperature 20.6
☐ Wet Ice
☒ Ambient
☐ Blue Ice

* LEGEND
SAMPLE MATRIX
DW = DRINKING WATER
GW = GROUNDWATER
SD = SOLID
SG = SLUDGE
SL = SOIL
ST = STORMWATER
WW = WASTEWATER

Compliance Analysis: ☐ Yes ☐ No
ADEQ Forms: ☐ Yes ☐ No
Mail ADEQ Forms: ☐ Yes ☐ No

Custody Seals ☐
Container Intact ☑
COC / Labels Agree ☑

Preservation Confirmation ☑
Appropriate Head Space ☒
Received Within Hold Time ☑

SPECIAL INSTRUCTIONS/COMMENTS:

2445 N. Coyote Drive, Suite 104
Tucson, Arizona 85745
(520) 882-5880
Fax: (520) 882-9788
www.turnerlabs.com

CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 14F0604 DATE 6/17/14 PAGE 4 OF 6

PROJECT NAME Wester Copper and gold #
CONTACT NAME Natsagdori Gantumer
COMPANY NAME SGS Metcon
ADDRESS 7701 N. Business Park Dr
ZIP 85743 PHONE 579836 EMAIL
SAMPLER'S SIGNATURE Salvador Gonzalez

CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*	NUMBER OF CONTAINERS	Base Neutrals ☐ 625/8270	Acids ☐	Volatile Organics ☐ 624	☐ 524.2	☐ 8260	TTHMS ☐	HAA5 ☐	☐ Chloride	☐ Sulfate	☐ Resistivity	NO_2 ☐	NO_3 ☐	TKN ☐	☐ TPH	1664 ☐ Oil & Grease	TCLP Analysis Semi-VOA ☐	Pest. ☐	VOA ☐	Metals TCLP ☐	Dissolved ☐	Total ☐	RCRA8 ☐	Cyanide Total ☐	Amen. ☐	WAD ☑	SDWA-INORGANICS PRIMARY ☐	SECONDARY ☐	Coliform MPN ☐	PIA ☐	Fecal ☐	pH ☐	Cr_6 ☐	Cl_2 ☐	Turb ☐	COD ☐	TSS ☐	BOD ☐
[illegible]	[illegible]	[illegible]		[illegible]																																					
26783	6/11/14	7:00		P.W																																					
26784	6/12/14	7:00		P.W																																					
26785	6/13/14	7:00		P.W																																					
26786	6/14/14	7:00		P.W																																					
26787	6/15/14	7:00		P.W																																					
26788	6/16/14	7:00		P.W																																					
26789	6/17/14	7:00		P.W																																					

1. RELINQUISHED BY:
Salvador Gonzalez
Signature
Printed Name
Firm
6/17/14 16:45
Date/Time

2. RECEIVED BY:
Signature
Printed Name
Firm
Date/Time

TURNAROUND REQUIREMENTS:
___ Standard (approx. 10 days)*
___ Next Day ___ 2 Day ___ 5 Day*
___ Email Preliminary Results
* Working Days

REPORT REQUIREMENTS:
___ I. Routine Report
___ II. Report (includes DUP, MS, MSD, as required, may be charged as samples)
___ III. Date Validation Report (Includes All Raw Data) Add 10% to invoice

INVOICE INFORMATION:
Account ___ Y ___ N
P.O. #
Bill to:

SAMPLE RECEIPT:
Total Containers 42
Temperature 28.6
☐ Wet Ice
☒ Ambient
☐ Blue Ice

3. RELINQUISHED BY:
Signature
Printed Name
Firm
Date/Time

4. RECEIVED BY:
Signature
Printed Name
TURNER LABORATORIES, INC.
Firm
6/17/14 1645
Date/Time

* LEGEND
SAMPLE MATRIX
DW = DRINKING WATER
GW = GROUNDWATER
SD = SOLID
SG = SLUDGE
SL = SOIL
ST = STORMWATER
WW = WASTEWATER

Compliance Analysis: ☐ Yes ☐ No
ADEQ Forms: ☐ Yes ☐ No
Mail ADEQ Forms: ☐ Yes ☐ No
Custody Seals ☐
Container Intact ☒
COC / Labels Agree ☐
Preservation Confirmation ☒
Appropriate Head Space ☐
Received Within Hold Time ☐

SPECIAL INSTRUCTIONS/COMMENTS:

TURNER LABORATORIES INC.
2445 N. Coyote Drive, Suite 104
Tucson, Arizona 85745
(520) 882-5880
Fax: (520) 882-9788
www.turnerlabs.com

CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 14F0604 DATE _____ PAGE 5 OF 6

PROJECT NAME Wester Copper and gold # _____
CONTACT NAME Natsagdori Ganbumer
COMPANY NAME SGS Metcon
ADDRESS 7701 N. Business Park Dr
ZIP 85743 PHONE 5798315 EMAIL _____
SAMPLER'S SIGNATURE Salvador Gonzalez

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*	NUMBER OF CONTAINERS	CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX
[illegible]	[illegible]	[illegible]		[illegible]		
26813	6/11/14	7:00		P.W		X
26814	6/12/14	7:00		P.W		X
26815	6/13/14	7:00		P.W		X
26816	6/14/14	7:00		P.W		X
26817	6/15/14	7:00		P.W		X
26818	6/16/14	7:00		P.W		X
26819	6/17/14	7:00		P.W		X

Base Neutrals 625/8270 ☐ Acids ☐ Volatile Organics ☐ 624 ☐ 524.2 ☐ TTHMS ☐ 8260 ☐ HAA5 ☐ Chloride ☐ Sulfate ☐ Resistivity ☐ NO_2 ☐ NO_3 ☐ TKN ☐ TPH ☐ 1664 ☐ Oil & Grease ☐ VOA ☐ TCLP Analysis Semi-VOA ☐ Pest. ☐ TCLP ☐ Metals Dissolved ☐ Total ☐ RCRA8 ☐ Total ☐ Cyanide Amen. ☐ WAD ☐ SDWA-INORGANICS PRIMARY ☐ SECONDARY ☐ MPN ☐ Coliform PIA ☐ Fecal ☐ pH ☐ Cl_2 ☐ Cl_2 ☐ Turb ☐ TSS ☐ BOD ☐ COD ☐

1. RELINQUISHED BY:	2. RECEIVED BY:	TURNAROUND REQUIREMENTS:	REPORT REQUIREMENTS:	INVOICE INFORMATION:	SAMPLE RECEIPT:
Signature: Salvador Gonzalez	Signature:	____ Standard (approx. 10 days)*	____ I. Routine Report	Account ____ Y ____ N	Total Containers: 47
Printed Name: [illegible]	Printed Name:	____ Next Day ____ 2 Day ____ 5 Day*	____ II. Report (includes DUP, MS, MSD, as required, may be charged as samples)	P.O. #	Temperature: 28.6
Firm:	Firm	____ Email Preliminary Results	____ III. Date Validation Report (includes All Raw Data) Add 10% to invoice	Bill to:	☐ Wet Ice
Date/Time: 6/17/14 16:45	Date/Time	* Working Days			☒ Ambient
					☐ Blue Ice

3. RELINQUISHED BY:	4. RECEIVED BY:
Signature	Signature
Printed Name	Printed Name
Firm	TURNER LABORATORIES, INC.
Date/Time	Firm
	Date/Time: 6/17/14 1645

* LEGEND
SAMPLE MATRIX
DW = DRINKING WATER
GW = GROUNDWATER
SD = SOLID
SG = SLUDGE
SL = SOIL
ST = STORMWATER
WW = WASTEWATER

Compliance Analysis: ☐ Yes ☐ No	Custody Seals ☐	Preservation Confirmation ☑
ADEQ Forms: ☐ Yes ☐ No	Container Intact ☒	Appropriate Head Space ☒
Mail ADEQ Forms: ☐ Yes ☐ No	COC / Labels Agree ☒	Received Within Hold Time ☒

SPECIAL INSTRUCTIONS/COMMENTS:

TURNER LABORATORIES INC.
2445 N. Coyote Drive, Suite 104
Tucson, Arizona 85745
(520) 882-5880
Fax: (520) 882-9788
www.turnerlabs.com

CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 14F0604 DATE 6/17/14 PAGE 6 OF 6

PROJECT NAME Wester Copper and gold #
CONTACT NAME Natsagdori Gantumer
COMPANY NAME SGS Metcon
ADDRESS 7701 N. Business Park Dr
ZIP 85743 PHONE 579835 EMAIL
SAMPLER'S SIGNATURE Salvador Gonzalez

CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*	NUMBER OF CONTAINERS	Base Neutrals ☐ 625/8270 Acids ☐	Volatile Organics ☐ 624 ☐ 524.2 ☐ 8260	TTHMS ☐ HAA5 ☐	☐ Chloride ☐ Sulfate ☐ Resistivity	NO_2 ☐ NO_3 ☐ TKN ☐	☐ TPH 1664 ☐ Oil & Grease	VOA ☐ TCLP Analysis Semi-VOA ☐ Pest. ☐	TCLP ☐ Dissolved ☐ Metals Total ☐ RCRA8 ☐	Total ☐ Cyanide Amen. ☐ WAD ☒	SDWA-INORGANICS PRIMARY ☐ SECONDARY ☐	MPN ☐ Coliform PIA ☐ Fecal ☐	pH ☐ Cr_6 ☐ Cl_2 ☐ Turb ☐	COD ☐ TSS ☐ BOD ☐			
[illegible]	[illegible]	[illegible]		[illegible]																	
26843	6/11/14	7:00		P.W											X						
26844	6/12/14	7:00		P.W											X						
26845	6/13/14	7:00		P.W											X						
26846	6/14/14	7:00		P.W											X						
26847	6/15/14	7:00		P.W											X						
26848	6/16/14	7:00		P.W											X						
26849	6/17/14	7:00		P.W											X						

1. RELINQUISHED BY:
Signature: Salvador Gonzalez
Printed Name:
Firm:
Date/Time: 6/17/14 16:45

2. RECEIVED BY:
Signature
Printed Name
Firm
Date/Time

TURNAROUND REQUIREMENTS:
___ Standard (approx. 10 days)*
___ Next Day ___ 2 Day ___ 5 Day*
___ Email Preliminary Results
* Working Days

REPORT REQUIREMENTS:
___ I. Routine Report
___ II. Report (includes DUP, MS, MSD, as required, may be charged as samples)
___ III. Date Validation Report (Includes All Raw Data) Add 10% to invoice

INVOICE INFORMATION:
Account ___ Y ___ N
P.O. #
Bill to:

SAMPLE RECEIPT:
Total Containers 92
Temperature 28.6
☐ Wet Ice
☒ Ambient
☐ Blue Ice

3. RELINQUISHED BY:
Signature
Printed Name
Firm
Date/Time

4. RECEIVED BY:
Signature
Printed Name
Firm: TURNER LABORATORIES, INC.
Date/Time: 6/17/14 1645

* LEGEND
SAMPLE MATRIX
DW = DRINKING WATER
GW = GROUNDWATER
SD = SOLID
SG = SLUDGE
SL = SOIL
ST = STORMWATER
WW = WASTEWATER

Compliance Analysis: ☐ Yes ☐ No
ADEQ Forms: ☐ Yes ☐ No
Mail ADEQ Forms: ☐ Yes ☐ No
Custody Seals ☐
Container Intact ☒
COC / Labels Agree ☒
Preservation Confirmation ☒
Appropriate Head Space ☒
Received Within Hold Time ☒

SPECIAL INSTRUCTIONS/COMMENTS:

July 21, 2014

Natska Gantumur
SGS Metcon
7701 Business Park Dr.
Tucson, AZ 85743

TEL (520) 579-8315
FAX (303) 456-6998

Work Order No.: 14F0814
Order Name: M-709-03

RE: M-709-03

Dear Natska Gantumur,

Turner Laboratories, Inc. received 51 sample(s) on 06/27/2014 for the analyses presented in the following report.

All results are intended to be considered in their entirety, and Turner Laboratories, Inc. is not responsible for use of less than the complete report. Results apply only to the samples analyzed. Samples will be disposed of 30 days after issue of our report unless special arrangements are made.

The pages that follow may contain sensitive, privileged or confidential information intended solely for the addressee named above. If you receive this message and are not the agent or employee of the addressee, this communication has been sent in error. Please do not disseminate or copy any of the attached and notify the sender immediately by telephone. Please also return the attached sheet(s) to the sender by mail.

Please call if you have any questions.

Respectfully submitted,

Turner Laboratories, Inc.
ADHS License AZ0066



Terri Garcia
Technical Director

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Date Received: 06/27/2014

Order: M-709-03

Work Order Sample Summary

Lab Sample ID	Client Sample ID	Matrix	Collection Date/Time
14F0814-01	26700	Process Water	06/18/2014 0700
14F0814-02	26701	Process Water	06/19/2014 0700
14F0814-03	26702	Process Water	06/20/2014 0700
14F0814-04	26703	Process Water	06/21/2014 0700
14F0814-05	26704	Process Water	06/22/2014 0700
14F0814-06	26705	Process Water	06/23/2014 0700
14F0814-07	26706	Process Water	06/24/2014 0700
14F0814-08	26730	Process Water	06/18/2014 0700
14F0814-09	26731	Process Water	06/19/2014 0700
14F0814-10	26732	Process Water	06/20/2014 0700
14F0814-11	26733	Process Water	06/21/2014 0700
14F0814-12	26734	Process Water	06/22/2014 0700
14F0814-13	26735	Process Water	06/23/2014 0700
14F0814-14	26736	Process Water	06/24/2014 0700
14F0814-15	26737	Process Water	06/25/2014 0700
14F0814-16	26738	Process Water	06/26/2014 0700
14F0814-17	26739	Process Water	06/27/2014 0700
14F0814-18	26760	Process Water	06/18/2014 0700
14F0814-19	26761	Process Water	06/19/2014 0700
14F0814-20	26762	Process Water	06/20/2014 0700
14F0814-21	26763	Process Water	06/21/2014 0700
14F0814-22	26764	Process Water	06/22/2014 0700
14F0814-23	26765	Process Water	06/23/2014 0700
14F0814-24	26766	Process Water	06/24/2014 0700
14F0814-25	26790	Process Water	06/18/2014 0700
14F0814-26	26791	Process Water	06/19/2014 0700
14F0814-27	26792	Process Water	06/20/2014 0700
14F0814-28	26793	Process Water	06/21/2014 0700
14F0814-29	26794	Process Water	06/22/2014 0700
14F0814-30	26795	Process Water	06/23/2014 0700
14F0814-31	26796	Process Water	06/24/2014 0700

14F0814-32	26797	Process Water	06/25/2014 0700
14F0814-33	26798	Process Water	06/26/2014 0700
14F0814-34	26799	Process Water	06/27/2014 0700
14F0814-35	26820	Process Water	06/18/2014 0700
14F0814-36	26821	Process Water	06/19/2014 0700
14F0814-37	26822	Process Water	06/20/2014 0700
14F0814-38	26823	Process Water	06/21/2014 0700
14F0814-39	26824	Process Water	06/22/2014 0700
14F0814-40	26825	Process Water	06/23/2014 0700
14F0814-41	26826	Process Water	06/24/2014 0700
14F0814-42	26850	Process Water	06/18/2014 0700
14F0814-43	26851	Process Water	06/19/2014 0700
14F0814-44	26852	Process Water	06/20/2014 0700
14F0814-45	26853	Process Water	06/21/2014 0700
14F0814-46	26854	Process Water	06/22/2014 0700
14F0814-47	26855	Process Water	06/23/2014 0700
14F0814-48	26856	Process Water	06/24/2014 0700
14F0814-49	26857	Process Water	06/25/2014 0700
14F0814-50	26858	Process Water	06/26/2014 0700
14F0814-51	26859	Process Water	06/27/2014 0700

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Date Received: 06/27/2014

Case Narrative

E4	Concentration estimated. Analyte was detected below laboratory Minimum Reporting Limit (MRL) but above MDL.
H1	Sample analysis was performed past holding time.

All soil, sludge, and solid matrix determinations are reported on a wet weight basis unless otherwise noted.

ND	Not Detected at or above the PQL
PQL	Practical Quantitation Limit
DF	Dilution Factor

Turner Laboratories, Inc.

Date: 07/21/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-01

Client Sample ID: 26700
Collection Date/Time: 06/18/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	710	3.7	20		mg/L	200	06/30/2014 1400	07/01/2014 1730	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-02

Client Sample ID: 26701
Collection Date/Time: 06/19/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	460	3.7	20		mg/L	200	06/30/2014 1400	07/01/2014 1730	EW

Turner Laboratories, Inc.

Date: 07/21/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-03

Client Sample ID: 26702
Collection Date/Time: 06/20/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	290	3.7	20		mg/L	200	07/02/2014 1000	07/03/2014 1645	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-04

Client Sample ID: 26703
Collection Date/Time: 06/21/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	280	3.7	20		mg/L	200	07/02/2014 1000	07/03/2014 1645	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-05

Client Sample ID: 26704
Collection Date/Time: 06/22/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	300	3.7	20		mg/L	200	07/02/2014 1000	07/03/2014 1645	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-06

Client Sample ID: 26705
Collection Date/Time: 06/23/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	290	3.7	20	H1	mg/L	200	07/10/2014 0800	07/11/2014 1455	EW

Turner Laboratories, Inc.

Date: 07/21/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-07

Client Sample ID: 26706
Collection Date/Time: 06/24/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	310	3.7	20	H1	mg/L	200	07/10/2014 0800	07/11/2014 1455	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-08

Client Sample ID: 26730
Collection Date/Time: 06/18/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	680	3.7	20		mg/L	200	06/30/2014 1400	07/01/2014 1730	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-09

Client Sample ID: 26731
Collection Date/Time: 06/19/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	400	3.7	20		mg/L	200	06/30/2014 1400	07/01/2014 1730	EW

Turner Laboratories, Inc.

Date: 07/21/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-10

Client Sample ID: 26732
Collection Date/Time: 06/20/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	200	3.7	20		mg/L	200	07/02/2014 1000	07/03/2014 1645	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-11

Client Sample ID: 26733
Collection Date/Time: 06/21/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	48	3.7	20		mg/L	200	07/02/2014 1000	07/03/2014 1645	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-12

Client Sample ID: 26734
Collection Date/Time: 06/22/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	30	3.7	20		mg/L	200	07/02/2014 1000	07/03/2014 1645	EW

Turner Laboratories, Inc.

Date: 07/21/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-13

Client Sample ID: 26735
Collection Date/Time: 06/23/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	21	3.7	20		mg/L	200	07/02/2014 1000	07/03/2014 1645	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-14

Client Sample ID: 26736
Collection Date/Time: 06/24/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	6.0	3.7	20	E4, H1	mg/L	200	07/10/2014 0800	07/11/2014 1455	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-15

Client Sample ID: 26737
Collection Date/Time: 06/25/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	6.0	3.7	20	E4, H1	mg/L	200	07/10/2014 0800	07/11/2014 1455	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-16

Client Sample ID: 26738
Collection Date/Time: 06/26/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	8.6	3.7	20	E4, H1	mg/L	200	07/10/2014 0800	07/11/2014 1455	EW

Turner Laboratories, Inc.

Date: 07/21/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-17

Client Sample ID: 26739
Collection Date/Time: 06/27/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	4.8	3.7	20	E4, H1	mg/L	200	07/10/2014 0800	07/11/2014 1455	EW

Turner Laboratories, Inc.

Date: 07/21/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-18

Client Sample ID: 26760
Collection Date/Time: 06/18/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	670	3.7	20		mg/L	200	06/30/2014 1400	07/01/2014 1730	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-19

Client Sample ID: 26761
Collection Date/Time: 06/19/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	690	3.7	20		mg/L	200	06/30/2014 1400	07/01/2014 1730	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-20

Client Sample ID: 26762
Collection Date/Time: 06/20/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	710	3.7	20		mg/L	200	07/02/2014 1000	07/03/2014 1645	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-21

Client Sample ID: 26763
Collection Date/Time: 06/21/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	650	3.7	20		mg/L	200	07/02/2014 1000	07/03/2014 1645	EW

Turner Laboratories, Inc.

Date: 07/21/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-22

Client Sample ID: 26764
Collection Date/Time: 06/22/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	690	3.7	20		mg/L	200	07/02/2014 1000	07/03/2014 1645	EW

Turner Laboratories, Inc.

Date: 07/21/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-23

Client Sample ID: 26765
Collection Date/Time: 06/23/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	650	3.7	20		mg/L	200	07/02/2014 1000	07/03/2014 1645	EW

Turner Laboratories, Inc.

Date: 07/21/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-24

Client Sample ID: 26766
Collection Date/Time: 06/24/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	650	3.7	20	H1	mg/L	200	07/10/2014 0800	07/11/2014 1455	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-25

Client Sample ID: 26790
Collection Date/Time: 06/18/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	680	3.7	20		mg/L	200	06/30/2014 1400	07/01/2014 1730	EW

Turner Laboratories, Inc.

Date: 07/21/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-26

Client Sample ID: 26791
Collection Date/Time: 06/19/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	660	3.7	20		mg/L	200	06/30/2014 1400	07/01/2014 1730	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-27

Client Sample ID: 26792
Collection Date/Time: 06/20/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	720	3.7	20		mg/L	200	06/30/2014 1400	07/01/2014 1730	EW

Turner Laboratories, Inc.

Date: 07/21/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-28

Client Sample ID: 26793
Collection Date/Time: 06/21/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	640	3.7	20		mg/L	200	07/02/2014 1000	07/03/2014 1645	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-29

Client Sample ID: 26794
Collection Date/Time: 06/22/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	620	3.7	20		mg/L	200	07/02/2014 1000	07/03/2014 1645	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-30

Client Sample ID: 26795
Collection Date/Time: 06/23/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	720	3.7	20		mg/L	200	07/02/2014 1000	07/03/2014 1645	EW

Turner Laboratories, Inc.

Date: 07/21/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-31

Client Sample ID: 26796
Collection Date/Time: 06/24/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	530	3.7	20	H1	mg/L	200	07/10/2014 0800	07/11/2014 1455	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-32

Client Sample ID: 26797
Collection Date/Time: 06/25/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	110	3.7	20	H1	mg/L	200	07/10/2014 0800	07/11/2014 1455	EW

Turner Laboratories, Inc.

Date: 07/21/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-33

Client Sample ID: 26798
Collection Date/Time: 06/26/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	39	3.7	20	H1	mg/L	200	07/10/2014 0800	07/11/2014 1455	EW

Turner Laboratories, Inc.

Date: 07/21/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-34

Client Sample ID: 26799
Collection Date/Time: 06/27/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	24	3.7	20	H1	mg/L	200	07/10/2014 0800	07/11/2014 1455	EW

Turner Laboratories, Inc.

Date: 07/21/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-35

Client Sample ID: 26820
Collection Date/Time: 06/18/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	690	3.7	20		mg/L	200	06/30/2014 1400	07/01/2014 1730	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-36

Client Sample ID: 26821
Collection Date/Time: 06/19/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	710	3.7	20		mg/L	200	06/30/2014 1400	07/01/2014 1730	EW

Turner Laboratories, Inc.

Date: 07/21/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-37

Client Sample ID: 26822
Collection Date/Time: 06/20/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	700	3.7	20		mg/L	200	06/30/2014 1400	07/01/2014 1730	EW

Turner Laboratories, Inc.

Date: 07/21/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-38

Client Sample ID: 26823
Collection Date/Time: 06/21/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	690	3.7	20		mg/L	200	07/02/2014 1000	07/03/2014 1645	EW

Turner Laboratories, Inc.

Date: 07/21/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-39

Client Sample ID: 26824
Collection Date/Time: 06/22/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	670	3.7	20		mg/L	200	07/02/2014 1000	07/03/2014 1645	EW

Turner Laboratories, Inc.

Date: 07/21/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-40

Client Sample ID: 26825
Collection Date/Time: 06/23/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	700	3.7	20		mg/L	200	07/02/2014 1000	07/03/2014 1645	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-41

Client Sample ID: 26826
Collection Date/Time: 06/24/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	660	3.7	20	H1	mg/L	200	07/10/2014 0800	07/11/2014 1455	EW

Turner Laboratories, Inc.

Date: 07/21/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-42

Client Sample ID: 26850
Collection Date/Time: 06/18/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	650	3.7	20		mg/L	200	06/30/2014 1400	07/01/2014 1730	EW

Turner Laboratories, Inc.

Date: 07/21/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-43

Client Sample ID: 26851
Collection Date/Time: 06/19/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	700	3.7	20		mg/L	200	06/30/2014 1400	07/01/2014 1730	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-44

Client Sample ID: 26852
Collection Date/Time: 06/20/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	680	3.7	20		mg/L	200	06/30/2014 1400	07/01/2014 1730	EW

Turner Laboratories, Inc.

Date: 07/21/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-45

Client Sample ID: 26853
Collection Date/Time: 06/21/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	700	3.7	20		mg/L	200	07/02/2014 1000	07/03/2014 1645	EW

Turner Laboratories, Inc.

Date: 07/21/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-46

Client Sample ID: 26854
Collection Date/Time: 06/22/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	680	3.7	20		mg/L	200	07/02/2014 1000	07/03/2014 1645	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-47

Client Sample ID: 26855
Collection Date/Time: 06/23/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	650	3.7	20		mg/L	200	07/02/2014 1000	07/03/2014 1645	EW

Turner Laboratories, Inc.

Date: 07/21/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-48

Client Sample ID: 26856
Collection Date/Time: 06/24/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	530	3.7	20	H1	mg/L	200	07/10/2014 0800	07/11/2014 1455	EW

Turner Laboratories, Inc.

Date: 07/21/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-49

Client Sample ID: 26857
Collection Date/Time: 06/25/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	130	3.7	20	H1	mg/L	200	07/10/2014 0800	07/11/2014 1455	EW

Turner Laboratories, Inc.

Date: 07/21/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-50

Client Sample ID: 26858
Collection Date/Time: 06/26/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	40	3.7	20	H1	mg/L	200	07/10/2014 0800	07/11/2014 1455	EW

Turner Laboratories, Inc.

Date: 07/21/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Lab Sample ID: 14F0814-51

Client Sample ID: 26859
Collection Date/Time: 06/27/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	24	3.7	20	H1	mg/L	200	07/10/2014 0800	07/11/2014 1455	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14F0814
Date Received: 06/27/2014

QC Summary

Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Qual
Batch 1406292 - SPECTRO PREP										
Blank (1406292-BLK1)				Prepared: 06/30/2014 Analyzed: 07/01/2014						
Cyanide	ND	0.10	mg/L							
LCS (1406292-BS1)				Prepared: 06/30/2014 Analyzed: 07/01/2014						
Cyanide	2.1	0.10	mg/L	2.000		104	90-110			
LCS Dup (1406292-BSD1)				Prepared: 06/30/2014 Analyzed: 07/01/2014						
Cyanide	2.1	0.10	mg/L	2.000		104	90-110	0.3	20	
Matrix Spike (1406292-MS1)		**Source: 14F0814-19**		Prepared: 06/30/2014 Analyzed: 07/01/2014						
Cyanide	1700	50	mg/L	1000	690	101	70-130			
Batch 1407013 - SPECTRO PREP										
Blank (1407013-BLK1)				Prepared: 07/02/2014 Analyzed: 07/03/2014						
Cyanide	ND	0.10	mg/L							
LCS (1407013-BS1)				Prepared: 07/02/2014 Analyzed: 07/03/2014						
Cyanide	1.8	0.10	mg/L	2.000		92	90-110			
LCS Dup (1407013-BSD1)				Prepared: 07/02/2014 Analyzed: 07/03/2014						
Cyanide	1.8	0.10	mg/L	2.000		91	90-110	0.7	20	
Matrix Spike (1407013-MS1)		**Source: 14F0814-23**		Prepared: 07/02/2014 Analyzed: 07/03/2014						
Cyanide	1600	50	mg/L	1000	650	92	70-130			
Batch 1407109 - SPECTRO PREP										
Blank (1407109-BLK1)				Prepared: 07/10/2014 Analyzed: 07/11/2014						
Cyanide	ND	0.10	mg/L							
LCS (1407109-BS1)				Prepared: 07/10/2014 Analyzed: 07/11/2014						
Cyanide	1.9	0.10	mg/L	2.000		95	90-110			
LCS Dup (1407109-BSD1)				Prepared: 07/10/2014 Analyzed: 07/11/2014						
Cyanide	1.9	0.10	mg/L	2.000		96	90-110	0.3	20	
Matrix Spike (1407109-MS1)		**Source: 14F0814-34**		Prepared: 07/10/2014 Analyzed: 07/11/2014						
Cyanide	990	50	mg/L	1000	24	96	70-130			

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CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 14F0814 DATE 6/27/14 PAGE 1 OF 6

PROJECT NAME Wester Copper and gold
CONTACT NAME Natsagdorj Ganturner
COMPANY NAME SGS Metcon
ADDRESS 7701 N. Business Park Dr
ZIP 85743 PHONE 5798315 EMAIL
SAMPLER'S SIGNATURE Salvador Gonzalez

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*	NUMBER OF CONTAINERS	CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX
26700	6/18/14	7:00		P.W		X
26701	6/19/14	7:00		P.W		X
26702	6/20/14	7:00		P.W		X
26703	6/21/14	7:00		P.W		X
26704	6/22/14	7:00		P.W		X
26705	6/23/14	7:00		P.W		X
26706	6/24/14	7:00		P.W		X

Base Neutrals 625/8270 ☐ Acids ☐ Volatile Organics ☐ 624 ☐ 524.2 ☐ 8260 ☐ TTHMS ☐ HAA5 ☐ Chloride ☐ Sulfate ☐ Resistivity ☐ NO_2 ☐ NO_3 ☐ TKN ☐ 1664 ☐ TPH ☐ Oil & Grease ☐ TCLP Analysis VOA ☐ Semi-VOA ☐ Pest. ☐ Metals TCLP ☐ Dissolved ☐ Total ☐ RCRA8 ☐ Cyanide Total ☐ Amen. ☐ WAD ☐ SDWA-INORGANICS PRIMARY ☐ SECONDARY ☐ Coliform MPN ☐ PIA ☐ pH ☐ Fecal ☐ C_6 ☐ Cl_2 ☐ Turb ☐ COD ☐ TSS ☐ BOD ☐

1. RELINQUISHED BY:
Salvador Gonzalez
Signature
Printed Name
Firm
6/27/14 16:00
Date/Time

2. RECEIVED BY:
Signature
Printed Name
Firm
Date/Time

3. RELINQUISHED BY:
Signature
Printed Name
Firm
Date/Time

4. RECEIVED BY:
Signature
Printed Name
TURNER LABORATORIES, INC.
Firm
6/27/14 1600
Date/Time

TURNAROUND REQUIREMENTS:
____ Standard (approx. 10 days)*
____ Next Day ____ 2 Day ____ 5 Day*
____ Email Preliminary Results
* Working Days

REPORT REQUIREMENTS:
____ I. Routine Report
____ II. Report (includes DUP, MS, MSD, as required, may be charged as samples)
____ III. Date Validation Report (Includes All Raw Data) Add 10% to invoice

INVOICE INFORMATION:
Account ____ Y ____ N
P.O. #
Bill to:

SAMPLE RECEIPT:
Total Containers 51
Temperature 25.2
☐ Wet Ice
☒ Ambient
☐ Blue Ice

* LEGEND
SAMPLE MATRIX
DW = DRINKING WATER
GW = GROUNDWATER
SD = SOLID
SG = SLUDGE
SL = SOIL
ST = STORMWATER
WW = WASTEWATER

Compliance Analysis: ☐ Yes ☐ No
ADEQ Forms: ☐ Yes ☐ No
Mail ADEQ Forms: ☐ Yes ☐ No

Custody Seals ☐
Container Intact ☒
COC / Labels Agree ☒

Preservation Confirmation ☒
Appropriate Head Space ☒
Received Within Hold Time ☒

SPECIAL INSTRUCTIONS/COMMENTS:

TURNER LABORATORIES INC.
2445 N. Coyote Drive, Suite 104
Tucson, Arizona 85745
(520) 882-5880
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CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 14F0814 DATE 6/27/14 PAGE 2 OF 6

PROJECT NAME Wester Copper and gold
CONTACT NAME Natsagdori Gantumer
COMPANY NAME SGS Metcon
ADDRESS 7701 N. Business Park Dr
ZIP 85743 PHONE 5798315 EMAIL
SAMPLER'S SIGNATURE Salvador Gonzalez

CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*	NUMBER OF CONTAINERS	Base Neutrals ☐ 625/8270	Acids ☐	Volatile Organics ☐ 624	☐ 524.2	☐ 8260	TTHMS ☐	HAA5 ☐	☐ Chloride	☐ Sulfate	☐ Resistivity	NO_2 ☐	NO_3 ☐	TKN ☐	1664 ☐ TPH	☐ Oil & Grease	TCLP Analysis VOA ☐	Semi-VOA ☐	Pest. ☐	Metals TCLP ☐	Dissolved ☐	Total ☐	RCRA8 ☐	Cyanide Total ☐	Amen. ☐	WAD ☒	SDWA-INORGANICS PRIMARY ☐	SECONDARY ☐	Coliform MPN ☐	PIA ☐	Fecal ☐	pH ☐	Cr_6 ☐	Cl_2 ☐	☐ Turb	COD ☐	TSS ☐	BOD ☐			
26730	6/18/14	7:00		P.W																								X																
26731	6/19/14	7:00		P.W																								X																
26732	6/20/14	7:00		P.W																								X																
26733	6/21/14	7:00		P.W																								X																
26734	6/22/14	7:00		P.W																								X																
26735	6/23/14	7:00		P.W																								X																
26736	6/24/14	7:00		P.W																								X																
26737	6/25/14	7:00		P.W																								X																
26738	6/26/14	7:00		P.W																								X																
26739	6/27/14	7:00		P.W																								X																

1. RELINQUISHED BY:
Salvador Gonzalez
Signature
Printed Name
Firm
6/27/14 16:00
Date/Time

2. RECEIVED BY:
Signature
Printed Name
Firm
Date/Time

TURNAROUND REQUIREMENTS:
____ Standard (approx. 10 days)*
____ Next Day ____ 2 Day ____ 5 Day*
____ Email Preliminary Results
* Working Days

REPORT REQUIREMENTS:
____ I. Routine Report
____ II. Report (includes DUP, MS, MSD, as required, may be charged as samples)
____ III. Date Validation Report (Includes All Raw Data) Add 10% to invoice

INVOICE INFORMATION:
Account ____ Y ____ N
P.O. #
Bill to:

SAMPLE RECEIPT:
Total Containers 51
Temperature 25.2
☐ Wet Ice
☒ Ambient
☐ Blue Ice

3. RELINQUISHED BY:
Signature
Printed Name
Firm
Date/Time

4. RECEIVED BY:
Signature
Printed Name
TURNER LABORATORIES, INC.
Firm
6/27/14 1600
Date/Time

* LEGEND
SAMPLE MATRIX
DW = DRINKING WATER
GW = GROUNDWATER
SD = SOLID
SG = SLUDGE
SL = SOIL
ST = STORMWATER
WW = WASTEWATER

Compliance Analysis: ☐ Yes ☐ No
ADEQ Forms: ☐ Yes ☐ No
Mail ADEQ Forms: ☐ Yes ☐ No
Custody Seals ☐
Container Intact ☒
COC / Labels Agree ☒
Preservation Confirmation ☒
Appropriate Head Space ☒
Received Within Hold Time ☒

SPECIAL INSTRUCTIONS/COMMENTS:

TURNER LABORATORIES INC.
2445 N. Coyote Drive, Suite 104
Tucson, Arizona 85745
(520) 882-5880
Fax: (520) 882-9788
www.turnerlabs.com

CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 14E0814 DATE 6/27/14 PAGE 3 OF 6

PROJECT NAME Wester Copper and gold
CONTACT NAME Natsagdorj Gantumer
COMPANY NAME SGS Metcon
ADDRESS 7701 N. Business Park Dr
ZIP 85743 PHONE 5798315 EMAIL
SAMPLER'S SIGNATURE Salvador Gonzalez

NUMBER OF CONTAINERS

CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*	Base Neutrals 625/8270	Acids	Volatile Organics 624	524.2	8260	TTHMS	HAA5	Chloride	Sulfate	Resistivity	NO_2	NO_3	TKN	TPH	1664	Oil & Grease	VOA	TCLP Analysis	Semi-VOA	Pest.	TCLP	Metals	Dissolved	Total	RCRA8	Total	Cyanide	Amen.	WAD	SDWA-INORGANICS PRIMARY	SECONDARY	MPN	Coliform	PIA	pH	Fecal	Cl_2	Cl	Turb	TSS	COD	BOD
26760	6/18/14	7:00		P.W																										X																
26761	6/19/14	7:00		P.W																										X																
26762	6/20/14	7:00		P.W																										X																
26763	6/21/14	7:00		P.W																										X																
26764	6/22/14	7:00		P.W																										X																
26765	6/23/14	7:00		P.W																										X																
26766	6/24/14	7:00		P.W																										X																

1. RELINQUISHED BY:
Salvador Gonzalez
Signature
Printed Name
Firm
6/27/14 16:00
Date/Time

2. RECEIVED BY:
Signature
Printed Name
Firm
Date/Time

TURNAROUND REQUIREMENTS:
____ Standard (approx. 10 days)*
____ Next Day ____ 2 Day ____ 5 Day*
____ Email Preliminary Results
* Working Days

REPORT REQUIREMENTS:
____ I. Routine Report
____ II. Report (includes DUP, MS, MSD, as required, may be charged as samples)
____ III. Date Validation Report (Includes All Raw Data) Add 10% to invoice

INVOICE INFORMATION:
Account ____ Y ____ N
P.O. #
Bill to:

SAMPLE RECEIPT:
Total Containers 51
Temperature 25.2
☐ Wet Ice
☒ Ambient
☐ Blue Ice

3. RELINQUISHED BY:
Signature
Printed Name
Firm
Date/Time

4. RECEIVED BY:
Signature
Printed Name
TURNER LABORATORIES, INC.
Firm
6/27/14 1600
Date/Time

* LEGEND
SAMPLE MATRIX
DW = DRINKING WATER
GW = GROUNDWATER
SD = SOLID
SG = SLUDGE
SL = SOIL
ST = STORMWATER
WW = WASTEWATER

Compliance Analysis: ☐ Yes ☐ No
ADEQ Forms: ☐ Yes ☐ No
Mail ADEQ Forms: ☐ Yes ☐ No

Custody Seals ☐
Container Intact ☒
COC / Labels Agree ☒

Preservation Confirmation ☒
Appropriate Head Space ☒
Received Within Hold Time ☒

SPECIAL INSTRUCTIONS/COMMENTS:

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Tucson, Arizona 85745
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CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 14F0814 DATE 6/27/14 PAGE 4 OF 6

PROJECT NAME Wester Copper and Gold
CONTACT NAME Natsagdorj Gantumer
COMPANY NAME SGS Metcon
ADDRESS 7701 N. Business Park Dr
ZIP 85743 PHONE 5798315 EMAIL
SAMPLER'S SIGNATURE Salvador Gonzalez

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*	NUMBER OF CONTAINERS	CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX
26790	6/18/14	7:00		P.W		X
26791	6/19/14	7:00		P.W		X
26792	6/20/14	7:00		P.W		X
26793	6/21/14	7:00		P.W		X
26794	6/22/14	7:00		P.W		X
26795	6/23/14	7:00		P.W		X
26796	6/24/14	7:00		P.W		X
26797	6/25/14	7:00		P.W		
26798	6/26/14	7:00		P.W		
26799	6/27/14	7:00		P.W		

Circle Analysis Requested and/or Check the Appropriate Box: Base Neutrals 625/8270 ☐ Acids ☐ Volatile Organics ☐ 624 ☐ 524.2 ☐ 8260 ☐ TTHMS ☐ HAA5 ☐ Chloride ☐ Sulfate ☐ Resistivity ☐ NO_3 ☐ NO_2 ☐ TKN ☐ TPH ☐ 1664 ☐ Oil & Grease ☐ VOA ☐ TCLP Analysis ☐ Semi-VOA ☐ Pest ☐ TCLP ☐ Metals ☐ Dissolved ☐ Total ☐ RCRA8 ☐ Total ☐ Cyanide ☐ Amen. ☐ WAD ☑ SDWA-INORGANICS ☐ PRIMARY ☐ SECONDARY ☐ Coliform ☐ MPN ☐ PIA ☐ Fecal ☐ pH ☐ Cl ☐ Cl_2 ☐ Turb ☐ COD ☐ TSS ☐ BOD ☐

1. RELINQUISHED BY:
Salvador Gonzalez
Signature
Printed Name
Firm
6/27/14 16:00
Date/Time

2. RECEIVED BY:
Signature
Printed Name
Firm
Date/Time

TURNAROUND REQUIREMENTS:
____ Standard (approx. 10 days)*
____ Next Day ____ 2 Day ____ 5 Day*
____ Email Preliminary Results
* Working Days

REPORT REQUIREMENTS:
____ I. Routine Report
____ II. Report (includes DUP, MS, MSD, as required, may be charged as samples)
____ III. Date Validation Report (Includes All Raw Data) Add 10% to invoice

INVOICE INFORMATION:
Account ____ Y ____ N
P.O. #
Bill to:

SAMPLE RECEIPT:
Total Containers 51
Temperature 25.2
☐ Wet Ice
☒ Ambient
☐ Blue Ice

3. RELINQUISHED BY:
Signature
Printed Name
Firm
Date/Time

4. RECEIVED BY:
Signature
Printed Name
TURNER LABORATORIES, INC.
Firm
6/27/14 1600
Date/Time

* LEGEND
SAMPLE MATRIX
DW = DRINKING WATER
GW = GROUNDWATER
SD = SOLID
SG = SLUDGE
SL = SOIL
ST = STORMWATER
WW = WASTEWATER

Compliance Analysis: ☐ Yes ☐ No
ADEQ Forms: ☐ Yes ☐ No
Mail ADEQ Forms: ☐ Yes ☐ No

Custody Seals ☐
Container Intact ☒
COC / Labels Agree ☒

Preservation Confirmation ☒
Appropriate Head Space ☒
Received Within Hold Time ☒

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2445 N. Coyote Drive, Suite 104
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CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 14F0814 DATE 6/27/14 PAGE 5 OF 6

PROJECT NAME Wester Copper and gold
CONTACT NAME Natsagdorj Ganturner
COMPANY NAME SGS Metcon
ADDRESS 7701 N. Business Park Dr
ZIP 85743 PHONE 5798315 EMAIL
SAMPLER'S SIGNATURE Salvador Gonzalez

NUMBER OF CONTAINERS

CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*	Cyanide Total ☐	Cyanide Amen. ☐	WAD ☑	SDWA-INORGANICS PRIMARY ☐	SECONDARY ☐	Coliform MPN ☐	Coliform PIA ☐	Fecal ☐	pH ☐	Cl2 ☐	Turb ☐	COD ☐	TSS ☐	BOD ☐
26820	6/18/14	7:00		P.W	X													
26821	6/19/14	7:00		P.W	X													
26822	6/20/14	7:00		P.W	X													
26823	6/21/14	7:00		P.W	X													
26824	6/22/14	7:00		P.W	X													
26825	6/23/14	7:00		P.W	X													
26826	6/24/14	7:00		P.W	X													

Base Neutrals 625/8270 ☐ Acids ☐ Volatile Organics 624 ☐ 524.2 ☐ 8260 TTHMS ☐ HAA5 ☐ Chloride ☐ Sulfate ☐ Resistivity NO3 ☐ NO2 ☐ TKN ☐ TPH ☐ 1664 Oil & Grease ☐ TCLP Analysis VOA ☐ SemiVOA ☐ Pest. ☐ Metals TCLP ☐ Total ☐ Dissolved ☐ RCRA8 ☐

1. RELINQUISHED BY:
Salvador Gonzalez
Signature
Printed Name
Firm
6/27/14 16:00
Date/Time

2. RECEIVED BY:
Signature
Printed Name
Firm
Date/Time

TURNAROUND REQUIREMENTS:
____ Standard (approx. 10 days)*
____ Next Day ____ 2 Day ____ 5 Day*
____ Email Preliminary Results
* Working Days

REPORT REQUIREMENTS:
____ I. Routine Report
____ II. Report (includes DUP, MS, MSD, as required, may be charged as samples)
____ III. Date Validation Report (Includes All Raw Data) Add 10% to invoice

INVOICE INFORMATION:
Account ____ Y ____ N
P.O. #
Bill to:

SAMPLE RECEIPT:
Total Containers 51
Temperature 25.2
☐ Wet Ice
☒ Ambient
☐ Blue Ice

3. RELINQUISHED BY:
Signature
Printed Name
Firm
Date/Time

4. RECEIVED BY:
Signature
Printed Name
TURNER LABORATORIES, INC.
Firm
6/27/14 1600
Date/Time

* LEGEND
SAMPLE MATRIX
DW = DRINKING WATER
GW = GROUNDWATER
SD = SOLID
SG = SLUDGE
SL = SOIL
ST = STORMWATER
WW = WASTEWATER

Compliance Analysis: ☐ Yes ☐ No
ADEQ Forms: ☐ Yes ☐ No
Mail ADEQ Forms: ☐ Yes ☐ No

Custody Seals ☐
Container Intact ☒
COC / Labels Agree ☑

Preservation Confirmation ☒
Appropriate Head Space ☑
Received Within Hold Time ☑

SPECIAL INSTRUCTIONS/COMMENTS:

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CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 14F0814 DATE 6/27/14 PAGE 6 OF 6

PROJECT NAME Wester Copper and gold
CONTACT NAME Natsagdori Gantumer
COMPANY NAME SGS Metcon
ADDRESS 7701 N. Business Park Dr
ZIP 85743 PHONE 5798315 EMAIL
SAMPLER'S SIGNATURE Salvador Gonzalez

CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*	NUMBER OF CONTAINERS	Base Neutrals ☐ 625/8270 Acids ☐	Volatile Organics ☐ 624 ☐ 524.2 ☐ 8260	TTHMS ☐ HAA5 ☐	☐ Chloride ☐ Sulfate ☐ Resistivity	NO_2 ☐ NO_3 ☐ TKN ☐	1664 ☐ TPH ☐ Oil & Grease	TCLP Analysis VOA ☐ Semi-VOA ☐ Pest. ☐	Metals TCLP ☐ Dissolved ☐ Total ☐ RCRA8 ☐	Cyanide Total ☐ Amen. ☐ WAD ☑	SDWA-INORGANICS PRIMARY ☐ SECONDARY ☐	Coliform MPN ☐ PIA ☐ Fecal ☐	pH ☐ Cr_6 ☐ Cl_2 ☐ Turb ☐	COD ☐ TSS ☐ BOD ☐			
26850	6/18/14	7:00		P.W										X							
26851	6/19/14	7:00		P.W										X							
26852	6/20/14	7:00		P.W										X							
26853	6/21/14	7:00		P.W										X							
26854	6/22/14	7:00		P.W										X							
26855	6/23/14	7:00		P.W										X							
26856	6/24/14	7:00		P.W										X							
26857	6/25/14	7:00		P.W										X							
26858	6/26/14	7:00		P.W										X							
26859	6/27/14	7:00		P.W										X							

1. RELINQUISHED BY:
Salvador Gonzalez
Signature
Printed Name
Firm
6/27/14 16:00
Date/Time

2. RECEIVED BY:
Signature
Printed Name
Firm
Date/Time

TURNAROUND REQUIREMENTS:
____ Standard (approx. 10 days)*
____ Next Day ____ 2 Day ____ 5 Day*
____ Email Preliminary Results
* Working Days

REPORT REQUIREMENTS:
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____ III. Date Validation Report (Includes All Raw Data) Add 10% to invoice

INVOICE INFORMATION:
Account ____ Y ____ N
P.O. #
Bill to:

SAMPLE RECEIPT:
Total Containers 51
Temperature 25.2
☐ Wet Ice
☒ Ambient
☐ Blue Ice

3. RELINQUISHED BY:
Signature
Printed Name
Firm
Date/Time

4. RECEIVED BY:
Signature
Printed Name
TURNER LABORATORIES, INC.
Firm
6/27/14 1600
Date/Time

* LEGEND
SAMPLE MATRIX
DW = DRINKING WATER
GW = GROUNDWATER
SD = SOLID
SG = SLUDGE
SL = SOIL
ST = STORMWATER
WW = WASTEWATER

Compliance Analysis: ☐ Yes ☐ No	Custody Seals ☐	Preservation Confirmation ☒
ADEQ Forms: ☐ Yes ☐ No	Container Intact ☒	Appropriate Head Space ☒
Mail ADEQ Forms: ☐ Yes ☐ No	COC / Labels Agree ☒	Received Within Hold Time ☒

SPECIAL INSTRUCTIONS/COMMENTS:

August 15, 2014

Natska Gantumur
SGS Metcon
7701 Business Park Dr.
Tucson, AZ 85743

TEL (520) 579-8315
FAX (303) 456-6998

Work Order No.: 14G0556
Order Name: M-709-03

RE: M-709-03

Dear Natska Gantumur,

Turner Laboratories, Inc. received 42 sample(s) on 07/11/2014 for the analyses presented in the following report.

All results are intended to be considered in their entirety, and Turner Laboratories, Inc. is not responsible for use of less than the complete report. Results apply only to the samples analyzed. Samples will be disposed of 30 days after issue of our report unless special arrangements are made.

The pages that follow may contain sensitive, privileged or confidential information intended solely for the addressee named above. If you receive this message and are not the agent or employee of the addressee, this communication has been sent in error. Please do not disseminate or copy any of the attached and notify the sender immediately by telephone. Please also return the attached sheet(s) to the sender by mail.

Please call if you have any questions.

Respectfully submitted,

Turner Laboratories, Inc.
ADHS License AZ0066



Terri Garcia
Technical Director

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Date Received: 07/11/2014

Order: M-709-03

Work Order Sample Summary

Lab Sample ID	Client Sample ID	Matrix	Collection Date/Time
14G0556-01	26740	Process Water	06/28/2014 0700
14G0556-02	26741	Process Water	06/29/2014 0700
14G0556-03	26742	Process Water	06/30/2014 0700
14G0556-04	27133	Process Water	07/01/2014 0700
14G0556-05	27134	Process Water	07/02/2014 0700
14G0556-06	27135	Process Water	07/03/2014 0700
14G0556-07	27136	Process Water	07/04/2014 0700
14G0556-08	27137	Process Water	07/05/2014 0700
14G0556-09	27138	Process Water	07/06/2014 0700
14G0556-10	27139	Process Water	07/07/2014 0700
14G0556-11	27140	Process Water	07/08/2014 0700
14G0556-12	27143	Process Water	07/11/2014 0700
14G0556-13	27103	Process Water	07/01/2014 0700
14G0556-14	27110	Process Water	07/08/2014 0700
14G0556-15	27163	Process Water	07/01/2014 0700
14G0556-16	27170	Process Water	07/08/2014 0700
14G0556-17	27223	Process Water	07/01/2014 0700
14G0556-18	27230	Process Water	07/08/2014 0700
14G0556-19	26800	Process Water	06/28/2014 0700
14G0556-20	26801	Process Water	06/29/2014 0700
14G0556-21	26802	Process Water	06/30/2014 0700
14G0556-22	27193	Process Water	07/01/2014 0700
14G0556-23	27194	Process Water	07/02/2014 0700
14G0556-24	27195	Process Water	07/03/2014 0700
14G0556-25	27196	Process Water	07/04/2014 0700
14G0556-26	27197	Process Water	07/05/2014 0700
14G0556-27	27198	Process Water	07/06/2014 0700
14G0556-28	27199	Process Water	07/07/2014 0700
14G0556-29	27200	Process Water	07/08/2014 0700
14G0556-30	27203	Process Water	07/11/2014 0700
14G0556-31	26860	Process Water	06/28/2014 0700

14G0556-32	26861	Process Water	06/29/2014 0700
14G0556-33	26862	Process Water	06/30/2014 0700
14G0556-34	27253	Process Water	07/01/2014 0700
14G0556-35	27254	Process Water	07/02/2014 0700
14G0556-36	27255	Process Water	07/03/2014 0700
14G0556-37	27256	Process Water	07/04/2014 0700
14G0556-38	27257	Process Water	07/05/2014 0700
14G0556-39	27258	Process Water	07/06/2014 0700
14G0556-40	27259	Process Water	07/07/2014 0700
14G0556-41	27260	Process Water	07/08/2014 0700
14G0556-42	27263	Process Water	07/11/2014 0700

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Date Received: 07/11/2014

Case Narrative

E4	Concentration estimated. Analyte was detected below laboratory Minimum Reporting Limit (MRL) but above MDL.
H1	Sample analysis was performed past holding time.

All soil, sludge, and solid matrix determinations are reported on a wet weight basis unless otherwise noted.

ND	Not Detected at or above the PQL
PQL	Practical Quantitation Limit
DF	Dilution Factor

Turner Laboratories, Inc.

Date: 08/15/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Lab Sample ID: 14G0556-01

Client Sample ID: 26740
Collection Date/Time: 06/28/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	4.8	3.7	20	E4	mg/L	200	07/30/2014 0730	07/31/2014 1615	EW

Turner Laboratories, Inc.

Date: 08/15/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Lab Sample ID: 14G0556-02

Client Sample ID: 26741
Collection Date/Time: 06/29/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	6.0	3.7	20	E4	mg/L	200	07/30/2014 0730	07/31/2014 1615	EW

Turner Laboratories, Inc.

Date: 08/15/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Lab Sample ID: 14G0556-03

Client Sample ID: 26742
Collection Date/Time: 06/30/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	4.8	3.7	20	E4	mg/L	200	07/30/2014 0730	07/31/2014 1615	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Lab Sample ID: 14G0556-04

Client Sample ID: 27133
Collection Date/Time: 07/01/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	3.8	3.7	20	E4	mg/L	200	07/30/2014 0730	07/31/2014 1615	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Lab Sample ID: 14G0556-05

Client Sample ID: 27134
Collection Date/Time: 07/02/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	8.2	3.7	20	E4	mg/L	200	07/30/2014 0730	07/31/2014 1615	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Lab Sample ID: 14G0556-06

Client Sample ID: 27135
Collection Date/Time: 07/03/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	7.2	3.7	20	E4	mg/L	200	07/30/2014 0730	07/31/2014 1615	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Lab Sample ID: 14G0556-07

Client Sample ID: 27136
Collection Date/Time: 07/04/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	4.6	3.7	20	E4	mg/L	200	07/16/2014 0900	07/17/2014 1600	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Lab Sample ID: 14G0556-08

Client Sample ID: 27137
Collection Date/Time: 07/05/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	5.8	3.7	20	E4	mg/L	200	07/16/2014 0900	07/17/2014 1600	EW

Turner Laboratories, Inc.

Date: 08/15/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Lab Sample ID: 14G0556-09

Client Sample ID: 27138
Collection Date/Time: 07/06/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	4.6	3.7	20	E4	mg/L	200	07/16/2014 0900	07/17/2014 1600	EW

Turner Laboratories, Inc.

Date: 08/15/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Lab Sample ID: 14G0556-10

Client Sample ID: 27139
Collection Date/Time: 07/07/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	5.8	3.7	20	E4	mg/L	200	07/16/2014 0900	07/17/2014 1600	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Lab Sample ID: 14G0556-11

Client Sample ID: 27140
Collection Date/Time: 07/08/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	4.6	3.7	20	E4	mg/L	200	07/16/2014 0900	07/17/2014 1600	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Lab Sample ID: 14G0556-12

Client Sample ID: 27143
Collection Date/Time: 07/11/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	4.6	3.7	20	E4	mg/L	200	07/16/2014 0900	07/17/2014 1600	EW

Turner Laboratories, Inc.

Date: 08/15/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Lab Sample ID: 14G0556-13

Client Sample ID: 27103
Collection Date/Time: 07/01/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	190	3.7	20		mg/L	200	07/30/2014 0730	07/31/2014 1615	EW

Turner Laboratories, Inc.

Date: 08/15/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Lab Sample ID: 14G0556-14

Client Sample ID: 27110
Collection Date/Time: 07/08/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	240	3.7	20		mg/L	200	07/16/2014 0900	07/17/2014 1600	EW

Turner Laboratories, Inc.

Date: 08/15/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Lab Sample ID: 14G0556-15

Client Sample ID: 27163
Collection Date/Time: 07/01/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	560	3.7	20		mg/L	200	07/30/2014 0730	07/31/2014 1615	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Lab Sample ID: 14G0556-16

Client Sample ID: 27170
Collection Date/Time: 07/08/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	500	3.7	20		mg/L	200	07/16/2014 0900	07/17/2014 1600	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Lab Sample ID: 14G0556-17

Client Sample ID: 27223
Collection Date/Time: 07/01/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	550	3.7	20		mg/L	200	07/30/2014 0730	07/31/2014 1615	EW

Turner Laboratories, Inc.

Date: 08/15/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Lab Sample ID: 14G0556-18

Client Sample ID: 27230
Collection Date/Time: 07/08/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	490	3.7	20		mg/L	200	07/16/2014 0900	07/17/2014 1600	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Lab Sample ID: 14G0556-19

Client Sample ID: 26800
Collection Date/Time: 06/28/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	17	3.7	20	E4	mg/L	200	07/30/2014 0730	07/31/2014 1615	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Lab Sample ID: 14G0556-20

Client Sample ID: 26801
Collection Date/Time: 06/29/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	16	3.7	20	E4	mg/L	200	07/30/2014 0730	07/31/2014 1615	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Lab Sample ID: 14G0556-21

Client Sample ID: 26802
Collection Date/Time: 06/30/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	14	3.7	20	E4	mg/L	200	07/30/2014 0730	07/31/2014 1615	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Lab Sample ID: 14G0556-22

Client Sample ID: 27193
Collection Date/Time: 07/01/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	11	3.7	20	E4	mg/L	200	07/30/2014 0730	07/31/2014 1615	EW

Turner Laboratories, Inc.

Date: 08/15/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Lab Sample ID: 14G0556-23

Client Sample ID: 27194
Collection Date/Time: 07/02/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	11	3.7	20	E4	mg/L	200	07/30/2014 0730	07/31/2014 1615	EW

Turner Laboratories, Inc.

Date: 08/15/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Lab Sample ID: 14G0556-24

Client Sample ID: 27195
Collection Date/Time: 07/03/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	16	3.7	20	E4, H1	mg/L	200	08/12/2014 0950	08/13/2014 1635	EW

Turner Laboratories, Inc.

Date: 08/15/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Lab Sample ID: 14G0556-25

Client Sample ID: 27196
Collection Date/Time: 07/04/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	9.4	3.7	20	E4	mg/L	200	07/16/2014 0900	07/17/2014 1600	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Lab Sample ID: 14G0556-26

Client Sample ID: 27197
Collection Date/Time: 07/05/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	11	3.7	20	E4	mg/L	200	07/16/2014 0900	07/17/2014 1600	EW

Turner Laboratories, Inc.

Date: 08/15/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Lab Sample ID: 14G0556-27

Client Sample ID: 27198
Collection Date/Time: 07/06/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	11	3.7	20	E4	mg/L	200	07/16/2014 0900	07/17/2014 1600	EW

Turner Laboratories, Inc.

Date: 08/15/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Lab Sample ID: 14G0556-28

Client Sample ID: 27199
Collection Date/Time: 07/07/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	12	3.7	20	E4	mg/L	200	07/16/2014 0900	07/17/2014 1600	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Lab Sample ID: 14G0556-29

Client Sample ID: 27200
Collection Date/Time: 07/08/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	8.2	3.7	20	E4	mg/L	200	07/16/2014 0900	07/17/2014 1600	EW

Turner Laboratories, Inc.

Date: 08/15/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Lab Sample ID: 14G0556-30

Client Sample ID: 27203
Collection Date/Time: 07/11/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	8.2	3.7	20	E4	mg/L	200	07/16/2014 0900	07/17/2014 1600	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Lab Sample ID: 14G0556-31

Client Sample ID: 26860
Collection Date/Time: 06/28/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	20	3.7	20	E4, H1	mg/L	200	08/12/2014 0950	08/13/2014 1635	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Lab Sample ID: 14G0556-32

Client Sample ID: 26861
Collection Date/Time: 06/29/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	16	3.7	20	E4, H1	mg/L	200	08/12/2014 0950	08/13/2014 1635	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Lab Sample ID: 14G0556-33

Client Sample ID: 26862
Collection Date/Time: 06/30/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	16	3.7	20	E4, H1	mg/L	200	08/12/2014 0950	08/13/2014 1635	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Lab Sample ID: 14G0556-34

Client Sample ID: 27253
Collection Date/Time: 07/01/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	13	3.7	20	E4, H1	mg/L	200	08/12/2014 0950	08/13/2014 1635	EW

Turner Laboratories, Inc.

Date: 08/15/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Lab Sample ID: 14G0556-35

Client Sample ID: 27254
Collection Date/Time: 07/02/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	13	3.7	20	E4, H1	mg/L	200	08/12/2014 0950	08/13/2014 1635	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Lab Sample ID: 14G0556-36

Client Sample ID: 27255
Collection Date/Time: 07/03/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	13	3.7	20	E4, H1	mg/L	200	08/12/2014 0950	08/13/2014 1635	EW

Turner Laboratories, Inc.

Date: 08/15/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Lab Sample ID: 14G0556-37

Client Sample ID: 27256
Collection Date/Time: 07/04/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	11	3.7	20	E4	mg/L	200	07/16/2014 0900	07/17/2014 1600	EW

Turner Laboratories, Inc.

Date: 08/15/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Lab Sample ID: 14G0556-38

Client Sample ID: 27257
Collection Date/Time: 07/05/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	8.2	3.7	20	E4	mg/L	200	07/16/2014 0900	07/17/2014 1600	EW

Turner Laboratories, Inc.

Date: 08/15/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Lab Sample ID: 14G0556-39

Client Sample ID: 27258
Collection Date/Time: 07/06/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	9.4	3.7	20	E4	mg/L	200	07/16/2014 0900	07/17/2014 1600	EW

Turner Laboratories, Inc.

Date: 08/15/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Lab Sample ID: 14G0556-40

Client Sample ID: 27259
Collection Date/Time: 07/07/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	5.8	3.7	20	E4	mg/L	200	07/16/2014 0900	07/17/2014 1600	EW

Turner Laboratories, Inc.

Date: 08/15/2014

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Lab Sample ID: 14G0556-41

Client Sample ID: 27260
Collection Date/Time: 07/08/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	9.4	3.7	20	E4	mg/L	200	07/16/2014 0900	07/17/2014 1600	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Lab Sample ID: 14G0556-42

Client Sample ID: 27263
Collection Date/Time: 07/11/2014 0700
Matrix: Process Water
Order Name: M-709-03

Analyses	Result	MDL	PQL	Qual	Units	DF	Prep Date	Analysis Date	Analyst
Cyanide-SM4500-CN I									
Cyanide	12	3.7	20	E4, H1	mg/L	200	08/12/2014 0950	08/13/2014 1635	EW

Client: SGS Metcon
Project: M-709-03
Work Order: 14G0556
Date Received: 07/11/2014

QC Summary

Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Qual
Batch 1407235 - SPECTRO PREP										
Blank (1407235-BLK1)				Prepared: 07/16/2014 Analyzed: 07/17/2014						
Cyanide	ND	0.10	mg/L							
LCS (1407235-BS1)				Prepared: 07/16/2014 Analyzed: 07/17/2014						
Cyanide	2.0	0.10	mg/L	2.000		101	90-110			
LCS Dup (1407235-BSD1)				Prepared: 07/16/2014 Analyzed: 07/17/2014						
Cyanide	2.0	0.10	mg/L	2.000		101	90-110	0	20	
Matrix Spike (1407235-MS1)		**Source: 14G0556-26**		Prepared: 07/16/2014 Analyzed: 07/17/2014						
Cyanide	960	50	mg/L	1000	11	95	70-130			
Batch 1407342 - SPECTRO PREP										
Blank (1407342-BLK1)				Prepared: 07/30/2014 Analyzed: 07/31/2014						
Cyanide	ND	0.10	mg/L							
LCS (1407342-BS1)				Prepared: 07/30/2014 Analyzed: 07/31/2014						
Cyanide	1.9	0.10	mg/L	2.000		96	90-110			
LCS Dup (1407342-BSD1)				Prepared: 07/30/2014 Analyzed: 07/31/2014						
Cyanide	1.8	0.10	mg/L	2.000		91	90-110	5	20	
Matrix Spike (1407342-MS1)		**Source: 14G0556-05**		Prepared: 07/30/2014 Analyzed: 07/31/2014						
Cyanide	920	50	mg/L	1000	8.2	91	70-130			
Batch 1408111 - SPECTRO PREP										
Blank (1408111-BLK1)				Prepared: 08/12/2014 Analyzed: 08/13/2014						
Cyanide	ND	0.10	mg/L							
LCS (1408111-BS1)				Prepared: 08/12/2014 Analyzed: 08/13/2014						
Cyanide	1.8	0.10	mg/L	2.000		91	90-110			
LCS Dup (1408111-BSD1)				Prepared: 08/12/2014 Analyzed: 08/13/2014						
Cyanide	1.8	0.10	mg/L	2.000		91	90-110	0.3	20	
Matrix Spike (1408111-MS1)		**Source: 14G0834-03**		Prepared: 08/12/2014 Analyzed: 08/13/2014						
Cyanide	1400	50	mg/L	1000	390	104	70-130			

TURNER LABORATORIES INC.
2445 N. Coyote Drive, Suite 104
Tucson, Arizona 85745
(520) 882-5880
Fax: (520) 882-9788
www.turnerlabs.com

CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 1460556 DATE 7/11/14 PAGE 1 OF 6

PROJECT NAME Wester Copper and gold #
CONTACT NAME Natsagdori Gantumer
COMPANY NAME SGS METCON
ADDRESS 7701 N. Busines Park Dr
ZIP 85743 PHONE 5798315 EMAIL
SAMPLER'S SIGNATURE Salvador Gonzalez

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*	NUMBER OF CONTAINERS	CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX
26740	6/28/14	7:00		P.W		X
26741	6/29/14	7:00		P.W		X
26742	6/30/14	7:00		P.W		X
27133	7/1/14	7:00		P.W		X
27134	7/2/14	7:00		P.W		X
27135	7/3/14	7:00		P.W		X
27136	7/4/14	7:00		P.W		X
27137	7/5/14	7:00		P.W		X
27138	7/6/14	7:00		P.W		X
27139	7/7/14	7:00		P.W		X

Circle Analysis Requested and/or Check the Appropriate Box: Base Neutrals 625/8270 ☐ Acids ☐ | Volatile Organics ☐ 624 ☐ 524.2 ☐ 8260 ☐ TTHMS ☐ HAA5 ☐ | ☐ Chloride ☐ Sulfate ☐ Resistivity | NO_2 ☐ NO_3 ☐ TKN ☐ | ☐ TPH ☐ 1664 ☐ Oil & Grease | VOA ☐ TCLP Analysis SemiVOA ☐ Pest. ☐ | TCLP ☐ Dissolved ☐ Metals ☐ Total ☐ RCRA8 ☐ | Total ☐ Cyanide Amen. ☐ WAD ☑ | SDWA-INORGANICS PRIMARY ☐ SECONDARY ☐ | MPN ☐ Coliform PIA ☐ Fecal ☐ | pH ☐ Cr_6 ☐ Cl_2 ☐ Turb ☐ | COD ☐ TSS ☐ BOD ☐

1. RELINQUISHED BY:
Salvador Gonzalez
Signature
Printed Name
Firm
7/11/14 15:55
Date/Time

2. RECEIVED BY:
Signature
Printed Name
Firm
Date/Time

TURNAROUND REQUIREMENTS:
____ Standard (approx. 10 days)*
____ Next Day ____ 2 Day ____ 5 Day*
____ Email Preliminary Results
* Working Days

REPORT REQUIREMENTS:
____ I. Routine Report
____ II. Report (includes DUP, MS, MSD, as required, may be charged as samples)
____ III. Date Validation Report (Includes All Raw Data) Add 10% to invoice

INVOICE INFORMATION:
Account ____Y ____N
P.O. #
Bill to:

SAMPLE RECEIPT:
Total Containers 42
Temperature 25.6
☐ Wet Ice
☒ Ambient
☐ Blue Ice

3. RELINQUISHED BY:
Signature
Printed Name
Firm
Date/Time

4. RECEIVED BY:
Signature
Printed Name
TURNER LABORATORIES, INC.
Firm
7/11/14 1555
Date/Time

* LEGEND SAMPLE MATRIX
DW = DRINKING WATER
GW = GROUNDWATER
SD = SOLID
SG = SLUDGE
SL = SOIL
ST = STORMWATER
WW = WASTEWATER

Compliance Analysis: ☐ Yes ☐ No
ADEQ Forms: ☐ Yes ☐ No
Mail ADEQ Forms: ☐ Yes ☐ No

Custody Seals ☐
Container Intact ☑
COC / Labels Agree ☑

Preservation Confirmation ☑
Appropriate Head Space ☑
Received Within Hold Time ☑

SPECIAL INSTRUCTIONS/COMMENTS:

TURNER LABORATORIES INC.
2445 N. Coyote Drive, Suite 104
Tucson, Arizona 85745
(520) 882-5880
Fax: (520) 882-9788
www.turnerlabs.com

CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 1460556 DATE 7/11/14 PAGE 2 OF 6

PROJECT NAME Wester Copper and gold # _____
CONTACT NAME Natsagdori Gantumer
COMPANY NAME SGS METCON
ADDRESS 7701 N. Busines Park Dr
ZIP 85743 PHONE 5798315 EMAIL _____
SAMPLER'S SIGNATURE Salvador Gonzalez

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*	NUMBER OF CONTAINERS	CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX: Cyanide Total	WAD ☑
27140	7/8/14	7:00		P.W		X	
27143	7/11/14	7:00		P.W		X	
27103	7/1/14	7:00		P.W		X	
27110	7/8/14	7:00		P.W		X	
27163	7/1/14	7:00		P.W		X	
27170	7/8/14	7:00		P.W		X	
27223	7/1/14	7:00		P.W		X	
27230	7/8/14	7:00		P.W		X	

1. RELINQUISHED BY: Salvador Gonzalez — Signature; Printed Name; Firm; 7/11/14 15:55 Date/Time

2. RECEIVED BY: Signature; Printed Name; Firm; Date/Time

3. RELINQUISHED BY: Signature; Printed Name; Firm; Date/Time

4. RECEIVED BY: Signature; Printed Name: TURNER LABORATORIES, INC.; Firm; 7/11/14 1555 Date/Time

TURNAROUND REQUIREMENTS:
- ____ Standard (approx. 10 days)*
- ____ Next Day ____ 2 Day ____ 5 Day*
- ____ Email Preliminary Results

* Working Days

REPORT REQUIREMENTS:
- ____ I. Routine Report
- ____ II. Report (includes DUP, MS, MSD, as required, may be charged as samples)
- ____ III. Date Validation Report (Includes All Raw Data) Add 10% to invoice

INVOICE INFORMATION:
Account ____ Y ____ N
P.O. # _____
Bill to: _____

SAMPLE RECEIPT:
Total Containers 42
Temperature 25.6
- ☐ Wet Ice
- ☒ Ambient
- ☐ Blue Ice

* LEGEND SAMPLE MATRIX
DW = DRINKING WATER
GW = GROUNDWATER
SD = SOLID
SG = SLUDGE
SL = SOIL
ST = STORMWATER
WW = WASTEWATER

Compliance Analysis: ☐ Yes ☐ No	Custody Seals ☐	Preservation Confirmation ☑
ADEQ Forms: ☐ Yes ☐ No	Container Intact ☑	Appropriate Head Space ☑
Mail ADEQ Forms: ☐ Yes ☐ No	COC / Labels Agree ☑	Received Within Hold Time ☑

SPECIAL INSTRUCTIONS/COMMENTS:

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CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 1460556 DATE 7/11/14 PAGE 3 OF 6

PROJECT NAME Wester Copper and gold #
CONTACT NAME Natsagdori Gantumer
COMPANY NAME SGS METCON
ADDRESS 7701 N. Busines Park Dr
ZIP 85743 PHONE 5798315 EMAIL
SAMPLER'S SIGNATURE Salvador Gonzalez

CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*	NUMBER OF CONTAINERS	Base Neutrals ☐ 625/8270	Volatile Organics ☐ 624 ☐ 524.2 ☐ 8260	TTHMS ☐	HAA5 ☐	☐ Chloride ☐ Sulfate ☐ Resistivity	NO_2 ☐ NO_3 ☐ TKN ☐	1664 ☐ TPH ☐ Oil & Grease	TCLP Analysis VOA ☐ Semi-VOA ☐ Pest. ☐	Metals TCLP ☐ Dissolved ☐ Total ☐ RCRAB ☐	Cyanide Total ☐ Amen. ☐ WAD ☑	SDWA-INORGANICS PRIMARY ☐ SECONDARY ☐	Coliform MPN ☐ PIA ☐ Fecal ☐	pH ☐ Cr_6 ☐ Cl_2 ☐ Turb	COD ☐ TSS ☐ BOD ☐				
26800	6/28/14	7:00		P.W											X								
26801	6/29/14	7:00		P.W											X								
26802	6/30/14	7:00		P.W											X								
27193	7/1/14	7:00		P.W											X								
27194	7/2/14	7:00		P.W											X								
27195	7/3/14	7:00		P.W											X								
27196	7/4/14	7:00		P.W											X								
27197	7/5/14	7:00		P.W											X								
27198	7/6/14	7:00		P.W											X								
27199	7/7/14	7:00		P.W											X								

1. RELINQUISHED BY:
Salvador Gonzalez
Signature
Printed Name
Firm
7/11/14 15:55
Date/Time

2. RECEIVED BY:
Signature
Printed Name
Firm
Date/Time

TURNAROUND REQUIREMENTS:
___ Standard (approx. 10 days)*
___ Next Day ___ 2 Day ___ 5 Day*
___ Email Preliminary Results
* Working Days

REPORT REQUIREMENTS:
___ I. Routine Report
___ II. Report (includes DUP, MS, MSD, as required, may be charged as samples)
___ III. Date Validation Report (Includes All Raw Data) Add 10% to invoice

INVOICE INFORMATION:
Account ___ Y ___ N
P.O. #
Bill to:

SAMPLE RECEIPT:
Total Containers 42
Temperature 25.6
☐ Wet Ice
☒ Ambient
☐ Blue Ice

3. RELINQUISHED BY:
Signature
Printed Name
Firm
Date/Time

4. RECEIVED BY:
Signature
Printed Name
TURNER LABORATORIES, INC.
Firm
7/11/14 1555
Date/Time

* LEGEND
SAMPLE MATRIX
DW = DRINKING WATER
GW = GROUNDWATER
SD = SOLID
SG = SLUDGE
SL = SOIL
ST = STORMWATER
WW = WASTEWATER

Compliance Analysis: ☐ Yes ☐ No	Custody Seals ☐	Preservation Confirmation ☒
ADEQ Forms: ☐ Yes ☐ No	Container Intact ☒	Appropriate Head Space ☒
Mail ADEQ Forms: ☐ Yes ☐ No	COC / Labels Agree ☒	Received Within Hold Time ☒

SPECIAL INSTRUCTIONS/COMMENTS:

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CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 1460556 DATE 7/11/14 PAGE 4 OF 6

PROJECT NAME Wester Copper and gold # _____
CONTACT NAME Natsagdori Gantumer
COMPANY NAME SGS METCON
ADDRESS 7701 N. Busines Park Dr
ZIP 85743 PHONE 5798315 EMAIL _____
SAMPLER'S SIGNATURE Salvador Gonzalez

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*	NUMBER OF CONTAINERS	CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX
27200	7/8/14	7:00		P.W		X
27203	7/11/14	7:00		P.W		X

Base Neutrals ☐ Acids ☐ 625/8270 | Volatile Organics ☐ 624 ☐ 524.2 ☐ 8260 ☐ TTHMS ☐ HAA5 ☐ | Chloride ☐ Sulfate ☐ Resistivity ☐ | NO_2 ☐ NO_3 ☐ TKN ☐ | TPH ☐ 1664 ☐ Oil & Grease ☐ | VOA ☐ TCLP Analysis Semi-VOA ☐ Pest. ☐ | TCLP ☐ Dissolved ☐ Metals Total ☐ RCRA8 ☐ | Total ☐ Cyanide Amen. ☐ WAD ☐ | SDWA-INORGANICS PRIMARY ☐ SECONDARY ☐ | MPN ☐ Coliform PA ☐ Fecal ☐ | pH ☐ Cr_6 ☐ Cl_2 ☐ Turb ☐ | COD ☐ TSS ☐ BOD ☐

1. RELINQUISHED BY:
Salvador Gonzalez
Signature
Printed Name
Firm
7/11/14 15:55
Date/Time

2. RECEIVED BY:
Signature
Printed Name
Firm
Date/Time

TURNAROUND REQUIREMENTS:
____ Standard (approx. 10 days)*
____ Next Day ____ 2 Day ____ 5 Day*
____ Email Preliminary Results
* Working Days

REPORT REQUIREMENTS:
____ I. Routine Report
____ II. Report (includes DUP, MS, MSD, as required, may be charged as samples)
____ III. Date Validation Report (Includes All Raw Data) Add 10% to invoice

INVOICE INFORMATION:
Account ____ Y ____ N
P.O. # _____
Bill to: _____

SAMPLE RECEIPT:
Total Containers 42
Temperature 25.6
☐ Wet Ice
☒ Ambient
☐ Blue Ice

3. RELINQUISHED BY:
Signature
Printed Name
Firm
Date/Time

4. RECEIVED BY:
Signature
Printed Name
TURNER LABORATORIES, INC.
Firm
7/14/14 1555
Date/Time

* LEGEND SAMPLE MATRIX
DW = DRINKING WATER
GW = GROUNDWATER
SD = SOLID
SG = SLUDGE
SL = SOIL
ST = STORMWATER
WW = WASTEWATER

Compliance Analysis: ☐ Yes ☐ No
ADEQ Forms: ☐ Yes ☐ No
Mail ADEQ Forms: ☐ Yes ☐ No

Custody Seals ☐
Container Intact ☒
COC / Labels Agree ☒

Preservation Confirmation ☒
Appropriate Head Space ☒
Received Within Hold Time ☒

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CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 1460556 DATE 7/11/14 PAGE 5 OF 6

PROJECT NAME Wester Copper and gold # _____
CONTACT NAME Natsagdorj Gantumer
COMPANY NAME SGS METCON
ADDRESS 7701 N. Busines Park Dr
ZIP 85743 PHONE 5798315 EMAIL _____
SAMPLER'S SIGNATURE Salvador Gonzalez

NUMBER OF CONTAINERS

CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*	Base Neutrals 625/8270	Acids	Volatile Organics 624	524.2	8260	THMS	HAA5	Chloride	Sulfate	Resistivity	NO_2	NO_3	TKN	TPH	1664	Oil & Grease	VOA	TCLP Analysis Semi-VOA	Pest.	TCLP	Metals	Dissolved	Total	RCRA8	Total	Cyanide Amen.	WAD	SDWA-INORGANICS PRIMARY	SECONDARY	MPN	Coliform PIA	Fecal	pH	Cr,	Cl,	Turb	COD	TSS	BOD
26860	6/28/14	7:00		P.W																								X															
26861	6/29/14	7:00		P.W																								X															
26862	6/30/14	7:00		P.W																								X															
27253	7/1/14	7:00		P.W																								X															
27254	7/2/14	7:00		P.W																								X															
27255	7/3/14	7:00		P.W																								X															
27256	7/4/14	7:00		P.W																								X															
27257	7/5/14	7:00		P.W																								X															
27258	7/6/14	7:00		P.W																								X															
27259	7/7/14	7:00		P.W																								X															

1. RELINQUISHED BY:
Salvador Gonzalez
Signature
Printed Name
Firm
7/11/14 15:55
Date/Time

2. RECEIVED BY:
Signature
Printed Name
Firm
Date/Time

TURNAROUND REQUIREMENTS:
____ Standard (approx. 10 days)*
____ Next Day ____ 2 Day ____ 5 Day*
____ Email Preliminary Results
* Working Days

REPORT REQUIREMENTS:
____ I. Routine Report
____ II. Report (includes DUP, MS, MSD, as required, may be charged as samples)
____ III. Date Validation Report (Includes All Raw Data) Add 10% to invoice

INVOICE INFORMATION:
Account ____ Y ____ N
P.O. # _____
Bill to: _____

SAMPLE RECEIPT:
Total Containers 42
Temperature 25.6
☐ Wet Ice
☒ Ambient
☐ Blue Ice

3. RELINQUISHED BY:
Signature
Printed Name
Firm
Date/Time

4. RECEIVED BY:
Signature
Printed Name
TURNER LABORATORIES, INC.
Firm
7/11/14 1555
Date/Time

* LEGEND
SAMPLE MATRIX
DW = DRINKING WATER
GW = GROUNDWATER
SD = SOLID
SG = SLUDGE
SL = SOIL
ST = STORMWATER
WW = WASTEWATER

Compliance Analysis: ☐ Yes ☐ No		Custody Seals ☐	Preservation Confirmation ☒
ADEQ Forms: ☐ Yes ☐ No		Container Intact ☒	Appropriate Head Space ☐
Mail ADEQ Forms: ☐ Yes ☐ No		COC / Labels Agree ☒	Received Within Hold Time ☒

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Tucson, Arizona 85745
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CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

TURNER WORK ORDER # 1460556 DATE 7/11/14 PAGE 6 OF 6

PROJECT NAME Wester Copper and gold # _____
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COMPANY NAME SGS METCON
ADDRESS 7701 N. Busines Park Dr
ZIP 85743 PHONE 5798315 EMAIL _____
SAMPLER'S SIGNATURE Salvador Gonzalez

NUMBER OF CONTAINERS

CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX

Base Neutrals ☐ Acids ☐ 625/8270
Volatile Organics ☐ 624 ☐ 524.2 ☐ 8260 ☐ TTHMS ☐ HAA5
Chloride ☐ Sulfate ☐ Resistivity
NO_2 ☐ NO_3 ☐ TKN ☐
TPH ☐ 1664 ☐ Oil & Grease
VOA ☐ TCLP Analysis Semi-VOA ☐ Pest. ☐
TCLP ☐ Dissolved ☐ Metals ☐ Total ☐ RCRA8 ☐
Total ☐ Cyanide Amen. ☐ WAD ☑
SDWA-INORGANICS PRIMARY ☐ SECONDARY ☐
MPN ☐ Coliform PIA ☐ Fecal ☐
pH ☐ Cr_6 ☐ Cl ☐ Turb ☐
COD ☐ TSS ☐ BOD ☐

SAMPLE I.D.	DATE	TIME	LAB I.D.	SAMPLE MATRIX*	NUMBER OF CONTAINERS	CIRCLE ANALYSIS REQUESTED AND/OR CHECK THE APPROPRIATE BOX
27260	7/8/14	7:00		P.W		X
27263	7/11/14	7:00		P.W		X

1. RELINQUISHED BY:
Salvador Gonzalez
Signature
Printed Name
Firm
7/11/14 15:55
Date/Time

2. RECEIVED BY:
Signature
Printed Name
Firm
Date/Time

TURNAROUND REQUIREMENTS:
____ Standard (approx. 10 days)*
____ Next Day ____ 2 Day ____ 5 Day*
____ Email Preliminary Results
* Working Days

REPORT REQUIREMENTS:
____ I. Routine Report
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____ III. Date Validation Report (Includes All Raw Data) Add 10% to invoice

INVOICE INFORMATION:
Account ____ Y ____ N
P.O. # _____
Bill to: _____

SAMPLE RECEIPT:
Total Containers 42
Temperature 25.6
☐ Wet Ice
☑ Ambient
☐ Blue Ice

3. RELINQUISHED BY:
Signature
Printed Name
Firm
Date/Time

4. RECEIVED BY:
Signature
Printed Name
TURNER LABORATORIES, INC.
Firm
7/11/14 1555
Date/Time

* LEGEND
SAMPLE MATRIX
DW = DRINKING WATER
GW = GROUNDWATER
SD = SOLID
SG = SLUDGE
SL = SOIL
ST = STORMWATER
WW = WASTEWATER

Compliance Analysis: ☐ Yes ☐ No
ADEQ Forms: ☐ Yes ☐ No
Mail ADEQ Forms: ☐ Yes ☐ No

Custody Seals ☐
Container Intact ☑
COC / Labels Agree ☑

Preservation Confirmation ☑
Appropriate Head Space ☑
Received Within Hold Time ☑

SPECIAL INSTRUCTIONS/COMMENTS:

FLSmidth USA, Inc.
Ore Characterization & Process Mineralogy Labs
7158 S. FLSmidth Drive
Midvale, UT 84047-5559 · USA
Tel +1 801 871-7681 · Fax +1 801 871 7681
www.flsmidth.com

Casino Mining Corporation – Casino Samples

Date 1 October 2014
To Heather Brown

Copies to Wolfgang Baum
From Kevin Ausburn
Filing "R:\Projects\2014 Projects\M-14085 Western Copper & Gold Casino Samples\Reports\M-14085 Final Report on Casino Samples.docx"
Subject Final Report on Casino Samples

Background and Objective

Casino Mining Corporation requested a baseline mineralogical analysis of select leach feed ores from their Casino gold-copper-molybdenum project. The objective of the mineralogical work was to provide:

1. An overall characterization of the gangue mineralogy.
2. Identify the cyanide consuming minerals.
3. Determine the concentration of clay minerals.
4. Identify the mode of occurrence of gold.
5. Check the ore samples for potential leach refractoriness and/or optimization factors.

Samples Received and Methods of Analysis

Three composite ore samples were received. A listing of the received samples, along with their assigned laboratory identifications, is presented in Table 1. Photographs of the received samples are presented in Figures A1 to A3 in the appendix of this report.

Table 1. Received Samples

Sample Description	OCPM Lab ID
Composite 02/05	M-14085-001
Composite 11/17	M-14085-002
Composite 19/20	M-14085-003

The samples were prepared for the following:

- Chemical analyses on the head samples including multi-element ICP, Total Carbon, Organic Carbon, Fire Assay Au/Ag, and Au Cyanide Shake-Leach Test.
  - The ambient cyanide shake-leach test was performed on 10 g of ore with a p95 of -106 micron. Leach time was 1 hours. The shake-leach test was performed at four different cyanide strengths (0.1, 3, 15, & 50 g/L CN). The procedure used for the shake leach testing is included in the appendix of this report.
- Gravity Separation via Vanning Plaque.
  - Material for the gravity separation was stage crushed to 100% passing 65 Tyler Mesh (-212 micron) and the slime portion (-25 microns) was screened off prior to the gravity separation.
- The gravity concentrate, gravity tails, and slimes fraction were all analyzed for Au & Ag via Fire Assay.
  - These gravity products were also measured by QEMSCAN in order to determine the copper deportment.
- Optical Microscopy. All feed samples (minus 10 mesh material) and the gravity concentrate were also examined via stereomicroscope and polarized light microscopy to check for any free gold, identify copper sulfides, other trace minerals and assess pertinent textural features.
- Quantitative X-Ray Diffraction (XRD) and Cation Exchange Capacity (CEC) analyses were performed on the head samples in order to determine the bulk mineralogy and swelling clay.

Discussion of Results

Chemical Analyses

The results of the cyanide soluble gold (CN Sol Au) shake leach test are presented in Table 2, while the remaining chemical analyses are presented in Table 3. The pertinent findings of the chemical analyses can be summarized as follows:

- The gold content in the three composites is low, ranging from 0.32 ppm to 0.6 ppm. Silver concentrations in the feeds are equally low (< 3 ppm).

- The cyanide soluble gold response for composite 11/17 & 19/20 was similar with gold extractions of >90% at 15g/L cyanide and almost 100% gold extraction at 50g/L cyanide. Approximately 60 % of the gold was readily soluble in cyanide in composite 02/05 at 3g/L cyanide; however, only minor additional extraction was achieved with the higher cyanide strengths. Figure 1 presents a graph of the gold extractions.

  - Note these extraction rates are based of shake leach test on pulverized material. It is recommended that bottle roll leach test and/or column leach test be performed in order to establish more realistic extraction rates.

- The copper concentration in the samples was low and ranged from 0.01 Wt. % to 0.09 Wt. %. The majority of the copper was non-acid soluble.

- The organic carbon concentration in the ore composites were <0.1 Wt. %.

Table 2. Gold Grade & Cyanide Soluble Extractions

	Cyanide Concentration		0.1 g/L CN	0.1 g/L CN	3 g/L CN	3 g/L CN	15 g/L CN	15 g/L CN	50 g/L CN	50 g/L CN
Sample Description	OCPM Lab ID	Au ppm	CN Sol Au ppm	CN Sol Au %	CN Sol Au ppm	CN Sol Au %	CN Sol Au ppm	CN Sol Au %	CN Sol Au ppm	CN Sol Au %
Composite 02/05	M14085-0001-001	0.32	0.03	10	0.19	59	0.19	60	0.24	75
Composite 11/17	M14085-0002-001	0.47	0.02	4	0.31	65	0.47	99	0.47	100
Composite 19/20	M14085-0003-001	0.60	0.07	12	0.36	60	0.57	94	0.58	97

Figure 1. Gold Extraction (based of Cyanide Shake Leach Tests)

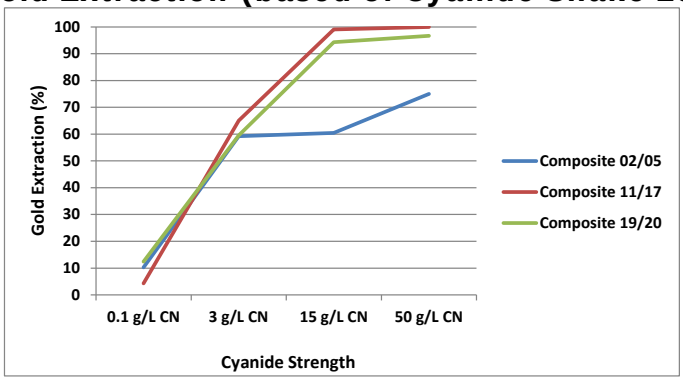


Table 3. Chemical Analyses

Sample Description	OCPM Lab ID	Au ppm	Ag ppm	C Wt. %	Organic C Wt. %	Al Wt. %	As ppm	Ba Wt. %	Be ppm	Bi Wt. %
Composite 02/05	M14085-0001-001	0.32	< 2.0	0.02	<0.1	6.36	97.9	0.11	< 2.0	< 0.001
Composite 11/17	M14085-0002-001	0.47	2.9	0.02	<0.1	6.27	99.0	0.17	< 2.0	< 0.001
Composite 19/20	M14085-0003-001	0.60	2.9	0.04	<0.1	6.10	54.5	0.15	< 2.0	< 0.001

Sample Description	OCPM Lab ID	Ca Wt. %	Cd ppm	Ce ppm	Co ppm	Cr ppm	Cs ppm	Cu Wt. %	ASCu Wt. %	Dy ppm
Composite 02/05	M14085-0001-001	0.07	< 2.0	66.5	< 2.0	10.8	5.7	0.01	0.00	< 2.0
Composite 11/17	M14085-0002-001	0.04	< 2.0	100.2	< 2.0	18.4	5.9	0.06	0.02	< 2.0
Composite 19/20	M14085-0003-001	0.06	< 2.0	107.0	4.2	18.5	7.1	0.09	0.01	2.3

Sample Description	OCPM Lab ID	Er ppm	Fe Wt. %	Ga ppm	Gd ppm	Hf ppm	Ho ppm	Ir ppm	K Wt. %	La ppm
Composite 02/05	M14085-0001-001	< 2.0	2.24	94.4	3.5	2.7	< 2.0	< 2.0	3.21	38.6
Composite 11/17	M14085-0002-001	< 2.0	2.62	127.5	4.5	< 2.0	< 2.0	< 2.0	4.75	64.2
Composite 19/20	M14085-0003-001	< 2.0	5.93	122.0	5.4	< 2.0	< 2.0	< 2.0	4.51	67.0

Sample Description	OCPM Lab ID	Li ppm	Lu ppm	Mg Wt. %	Mn Wt. %	Mo Wt. %	Na Wt. %	Nb ppm	Nd ppm	Ni Wt. %
Composite 02/05	M14085-0001-001	7.3	< 2.0	0.34	0.00	0.01	0.15	3.6	23.4	0.003
Composite 11/17	M14085-0002-001	9.3	< 2.0	0.24	0.00	0.02	0.24	< 2.0	32.2	< 0.0015
Composite 19/20	M14085-0003-001	7.1	< 2.0	0.35	0.01	0.02	0.42	4.2	34.0	< 0.0015

Sample Description	OCPM Lab ID	P Wt. %	Pb Wt. %	Pd ppm	Pr ppm	Rb ppm	Re ppm	S Wt. %	Sb ppm	Se ppm
Composite 02/05	M14085-0001-001	0.04	0.00	2.5	6.9	151.0	< 2.0	0.39	7.1	< 6.0
Composite 11/17	M14085-0002-001	0.05	0.01	< 2.0	9.8	168.0	< 2.0	0.51	11.2	< 6.0
Composite 19/20	M14085-0003-001	0.04	0.00	2.2	10.6	183.0	< 2.0	0.42	3.7	< 6.0

Sample Description	OCPM Lab ID	Sm ppm	Sn Wt. %	Sr ppm	Ta ppm	Tb ppm	Te ppm	Th ppm	Ti ppm	Tl ppm
Composite 02/05	M14085-0001-001	4.0	< 0.001	26.6	3.2	< 2.0	< 2.0	22.9	1515.0	< 2.0
Composite 11/17	M14085-0002-001	4.9	< 0.001	103.5	2.7	< 2.0	< 2.0	21.1	1014.5	< 2.0
Composite 19/20	M14085-0003-001	5.2	< 0.001	135.0	2.6	< 2.0	< 2.0	18.3	1235.0	< 2.0

Sample Description	OCPM Lab ID	Tm ppm	U ppm	V ppm	W Wt. %	Y ppm	Yb ppm	Zn Wt. %	Zr Wt. %
Composite 02/05	M14085-0001-001	< 2.0	2.5	95.0	0.01	< 22.0	0.8	0.00	0.02
Composite 11/17	M14085-0002-001	< 2.0	9.8	64.6	0.01	< 22.0	0.9	0.00	0.01
Composite 19/20	M14085-0003-001	< 2.0	4.8	68.0	0.01	< 22.0	1.2	0.01	0.01

Bulk Mineralogy

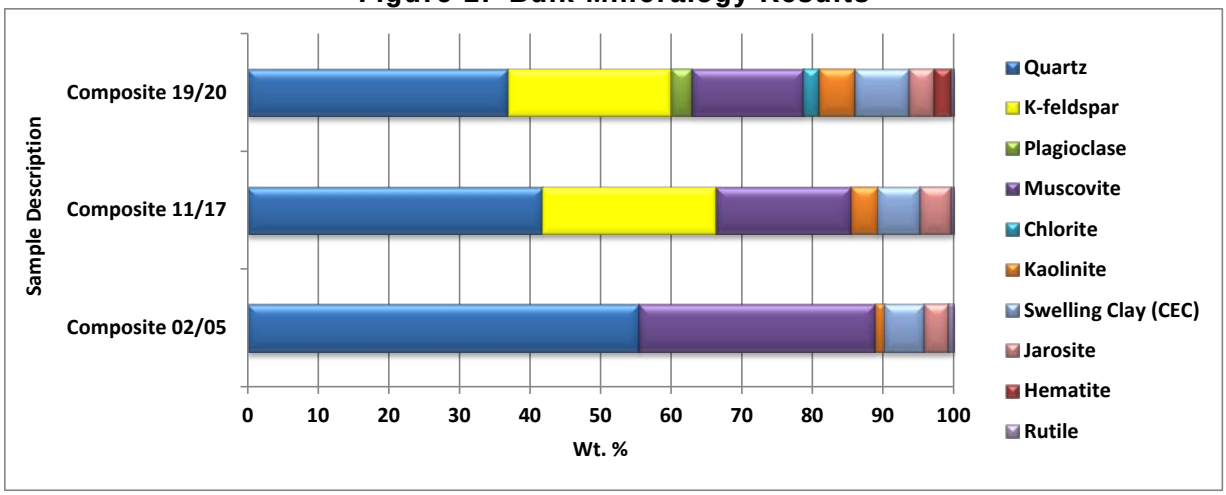
The bulk mineralogy results (XRD/CEC) on the received samples are presented in Table 4 and graphically illustrated in Figure 2. The following summarizes the findings from the bulk mineralogy work:

- Composite 02/05 is a quartz-muscovite rock with minor amounts of clay, jarosite, and rutile. Composites 11/17 & 19/20 are both similar and are dominated by quartz, K-feldspar, and muscovite.
- The main difference between composite 11/17 & 19/20 is that the latter contains hematite.
- It is pointed out that all samples contain variable amounts of hydrous iron oxides (limonitic material, goethite-like phases). These compounds are notoriously poorly crystalline to amorphous which means the concentration reported by XRD may be low.

Table 4. Bulk Mineralogy Results

Sample Description	Composite 02/05	Composite 11/17	Composite 19/20
OCPM Lab ID	M-14085-001	M-14085-002	M-14085-003
Phase Name	Wt. %	Wt. %	Wt. %
Quartz	55.5	41.7	36.8
K-feldspar	0.0	24.6	23.2
Plagioclase	0.0	0.0	3.0
Muscovite	33.4	19.0	15.7
Chlorite	0.0	0.0	2.2
Kaolinite	1.3	3.8	5.1
Swelling Clay (CEC)	5.5	6.0	7.7
Jarosite	3.5	4.4	3.5
Hematite	0.0	0.0	2.4
Rutile	0.7	0.4	0.4

Figure 2. Bulk Mineralogy Results



Optical Microscopy of Head Samples

The optical microscope examination of the -10 mesh petri dish head samples can be summarized as follows:

- The ore consists of a quartz-feldspar matrix with elevated amounts (5-10%) of hydrous iron oxides and/or admixed jarositic iron sulfates some of which are jarosite proper, goethite-like material and/or are tentatively classified as limonitic phases. Some of these hydrous iron oxidation products are finely disseminated stains, coatings, fracture fillings and/or more massive fragments.

- The gangue matrices of these composites have been subject to extensive alteration (ferruginous alteration, clay alteration and potassic alteration/sericitization). In addition, the composites received contain minor to moderate amounts of rutile, hematite and traces of magnetite.

- The earthy nature of the alteration will result in generation of -25 micron slimes during processing.

- The samples contain trace amounts of pyrite, chalcopyrite, chalcocite and covellite. These sulfide minerals are commonly encapsulated within Fe oxides/hydroxide minerals indicating that Fe oxides/hydroxides are an oxidation product of the sulfides. As such, any gold associated with the original sulfides would now be associated with the Fe oxide/hydroxides.

Photomicrographs illustrating the as-received material and showing pertinent features of the select minerals and textures are shown in Figures A1 to A12 in the appendix of this report.

Gravity Separation

The results of the gravity separation are shown in Table 5 and are summarized below:

- The results of the bench-scale gravity separation via vanning plaque indicated that (at a liberation size of 65 Tyler mesh and de-sliming at 500 Tyler mesh), 50 to 64% of the gold reported to the -500 mesh slimes.

- Slightly less than one third of the gold (22 to 27%) remained in the gravity tails fraction. This gold is most likely encapsulated in siliceous gangue.

- Recovery of gold into the gravity concentrate was negligible.

- It is pointed out that, due to the limitation of sample material and the very low gold concentrations, the gravity data and the gold distributions are considered “trend/drift data”. Follow-up and confirmatory gravity tests on larger samples are recommended using a gravity table.

Table 5. Gravity Separation Results

Sample Description	OCPM ID	Fraction	Weight grams	Weight Percentage	Au ppm	Au Distr. %	Ag ppm
Composite 02/05	M-14085-001	Head	679.4	-	0.32	-	< 2.0
Composite 02/05	M-14085-001	Cal. Head	639.4	100	0.22	100	<4
Composite 02/05	M-14085-001	Gravity Con	11.8	2	1.07	9	<4
Composite 02/05	M-14085-001	Gravity Tails	408.8	64	0.09	27	<4
Composite 02/05	M-14085-001	Slimes (-25 µm)	218.8	34	0.41	64	<4
Composite 11/17	M-14085-002	Head	692.6	-	0.47	-	2.9
Composite 11/17	M-14085-002	Cal. Head	675.9	100	0.45	100	<4
Composite 11/17	M-14085-002	Gravity Con	22.1	3	2.51	18	<4
Composite 11/17	M-14085-002	Gravity Tails	437.6	65	0.19	27	<4
Composite 11/17	M-14085-002	Slimes (-25 µm)	216.1	32	0.77	55	<4
Composite 19/20	M-14085-003	Head	686.0	-	0.60	-	2.9
Composite 19/20	M-14085-003	Cal. Head	670.5	100	0.54	100	<4
Composite 19/20	M-14085-003	Gravity Con	112.9	17	1.00	31	<4
Composite 19/20	M-14085-003	Gravity Tails	341.0	51	0.24	22	<4
Composite 19/20	M-14085-003	Slimes (-25 µm)	216.7	32	0.78	47	<4

Mode of Occurrence of Gold

Given the very low gold grades of the composites it is very difficult to mineralogically characterize the gold occurrence. As such, the following observations should be considered preliminary:

- Based on the results of the cyanide shake leach tests it is concluded that the majority of the low gold values present in the samples occur as native gold.
    - The optical microscope examination of the composite samples or their gravity concentrates did not show any evidence of native gold at the microscope's detection limit of +/- 1 micron. Although the shake leach cyanide extraction results are positive, it is cautioned that minor refractoriness of gold to leaching could be caused by submicroscopic gold in sulfides, native gold encapsulated in impervious iron oxide, hydroxide or jarosite matrices, and, of course, native gold encapsulated in quartz/feldspar minerals.
    - The encapsulation of gold within quartz and/or iron oxide/hydroxides is likely the reason that 30% of the gold in composite 02/05 was refractory in the cyanide shake leach tests.
- Although extremely high gold extractions were observed during the analytical shake-leach tests, it is cautioned that in a heap leach environment and considering the gangue minerals, cyanide consumers and clay content, oxide cap heap leaching will most likely achieve lower (~60-75%) gold extractions.
- The determination of the presence of submicroscopic gold in sulfides or other phases was beyond the scope of this analysis and would require detailed D-SIMS work.

Mode of Occurrence of Copper

The QEMSCAN measurements from the individual gravity products were used to calculate the copper deportment for each sample. The copper deportment is shown in Table 6 and summarized as follows:

- The majority of copper was not detected by the QEMSCAN measurements. Approximately 33% of the copper in composite 02/05 was detectable, while only ~8 percent was detectable in composites 11/17 & 19/20.
    - This indicates that the copper is present in low (<5 Wt. %) concentrations in phases.
- Chalcopyrite was the dominant copper mineral identified by QEMSCAN. Ultra-trace amounts of bornite & covellite were also detected.
- A Cu-bearing iron oxide phase was detected in composite 11/17 & 19/20. This phase has copper concentration >5 Wt. %.

Table 6. QEMSCAN Copper Deportment

OCPM ID	M-14085-001	M-14085-002	M-14085-003
Sample Description	Composite 02/05	Composite 11/17	Composite 19/20
Mineral / Element	Mass Cu%	Mass Cu%	Mass Cu%
Cu-bearing Iron Oxide	0.0000	0.0002	0.0032
Chalcopyrite	0.0032	0.0038	0.0033
Bornite	0.0001	0.0001	0.0001
Chalcocite	0.0000	0.0000	0.0001
Covellite	0.0000	0.0001	0.0000
Other Cu	0.0000	0.0002	0.0000
Total QEMSCAN Cu	0.0033	0.0044	0.0069
ICP Cu	0.0100	0.0560	0.0850
Dist.% measured by QS	33.34	7.79	8.06

Note: Confidence in the QEMSCAN measurements is typically only to the first decimal place (0.1 Wt. %). Due to the extremely low concentrations the reported phases are shown to the fourth decimal place; however, there is likely significant variance in the data.

Copper X-Ray maps were produced via Scanning Electron Microscope (SEM) equipped with Energy Dispersion Spectrometers (EDS) because the QEMSCAN measurements only accounted for minor amounts of the copper present in the samples. These X-Ray maps allow for a quick scan of the samples to locate any phases that contain copper >1 Wt. %. Based on these X-Ray maps it was apparent that the majority of iron oxides/hydroxides and iron sulfates all contain minor concentrations of copper. The X-Ray maps, along with selected X-Ray spectra, are presented in Figure A13 through A18 in the appendix.

While no quantitative micro-chemistry was performed on these copper-bearing iron phases it was apparent that their copper concentration varied based on their energy dispersion X-Ray spectra. Given their variable copper content and low copper concentration it is not feasible to try to determine the full copper deportment via QEMSCAN. However, it is concluded that the majority of copper not identified by QEMSCAN occurs within these iron oxides/hydroxide and iron sulfate phases. This agrees with the optical observation that the iron oxides/hydroxides & iron sulfate phases are replacement (oxidation) products of primary sulfides. As such, it is reasonable to conclude that there would be some copper contained within the alteration product if the original sulfide was copper-bearing.

Conclusions & Recommendations

Although the potential process detriments related to mineralogy may prove to be a minimal concern in the actual heap leach operation, they are pointed out hereinafter in order to enable rapid optimization – should leach problems be encountered. Further, it is noted that all conclusions and recommendations are strictly based on the three composite samples received. Potential variances inherent in other ore types or alteration suites cannot be assessed or extrapolated on the basis of these three samples.

- The ore samples received represent a quartz-K-feldspar-muscovite matrix. Heap leach detriments (permeability and wetting) could originate from elevated clay contents (i.e. feed material with >10% Total Clay). Further, ore feeds high in swelling clay (>10%) could conceivably contribute to agglomeration problems.

- QEMSCAN measurements only accounted for ~33% of the copper in composite 02/05 and only ~8 percent in composites 11/17 & 19/20.

    - Chalcopyrite was the dominant copper mineral detected by QEMSCAN.

    - Copper X-Ray maps showed that a significant amount of iron oxides/hydroxides & iron sulfate phases contain minor (<5 Wt. %) concentrations of copper. It is tentatively concluded that the majority of copper in these samples occurs within these iron oxides/hydroxides & iron sulfate phases.

    - Verification of the copper concentrations in non-copper sulfides (i.e. copper-bearing iron oxides/hydroxides, copper-bearing gangue, etc…) would require detailed microprobe and/or D-SIMS analyses.

- Since rock and alteration may introduce some variance in regard to hardness and abrasion, it is recommended that a robust mineralogical ore profiling be completed to assist in minimizing spikes in hardness and related metallurgical issues.

- The cyanide gold extraction rate was similar for composite 11/17 & 19/20 with >90% extraction being achieved with 15g/L CN strength. Composite 02/05 only achieved ~60% gold extraction with 15g/L CN strength.

    - These extraction results are based off lab shake leach tests and should only be used as relative values. Bottle roll leach test and/or column leach test should be performed in order to establish actual cyanide soluble gold extraction rates.

- No visible gold was observed in the received composites or in their gravity concentrates. Considering the lack of observed gold and the cyanide soluble results, it is speculated that the gold primarily occurs as sub-microscopic native gold.

    - Given the low grades of the material it is extremely difficult to mineralogically characterize the occurrence of gold. As such it is recommended that a true diagnostic leach test be performed in order to establish a reasonable deportation of gold. In addition, D-SIMS work could be considered in order to determine the gold occurrence.

- The predominant cyanide consumers are copper sulfides in concert with earthy iron oxidation products and clays. High amounts of jarositic and limonitic material admixed with clays may impact overall wettability of liberated/accessible gold. Further, these minerals may induce potential mineral preg robbing or –borrowing (note: finely disseminated goethite and jarosite, especially after crushing, may exhibit reactive/sorptive surface areas of 50 to 100 m^2 per gram[1]).

- Any ore samples (i.e. their leach residues) which exhibit substantially lower precious metals extractions should be subjected to a gold deportment analysis to assess the reason(s) for the lower extractive response (e.g. true locking in gangue, slimes coatings, or iron salt scaling).

- High(er) amounts of acidic minerals (such as jarosite or alunite) could contribute to pH changes in the heap which may hamper optimal cyanidation. Continuous monitoring of the gangue mineralogy is recommended.

- Due to the presence of various detrimental alteration minerals, the hydrometallurgical ore treatment may require the use of anti-scalants.

[1] Krendelev, F.P. et al. (1978). A ^{195}Au study of the sorption of gold by natural layer silicates and iron hydroxides (in Russian). Geokhimiya, Vol. 6, pp 891-899

APPENDIX

SOP for Cyanide Soluble Shake Leach Procedure

1. Pulverize a rotary split aliquot of the sample to a p95 of -106 microns (i.e. assay pulp).
2. Weigh 10.000 ± 0.200 grams of sample material into a 50-mL centrifuge tube.
3. Under a fume hood, add 20.0 mL of sodium cyanide solution to the sample.
4. Swirl sample to homogenize and place it on the shaker table for an hour.
5. Centrifuge for three minutes.
6. Decant portion to 15 mL test tube.
7. Analyze on AA or ICP for gold.

Note: Sodium hydroxide used to maintain pH 12 in CN solution

Figure A1. Photograph of Composite 02/05 (As-Received)



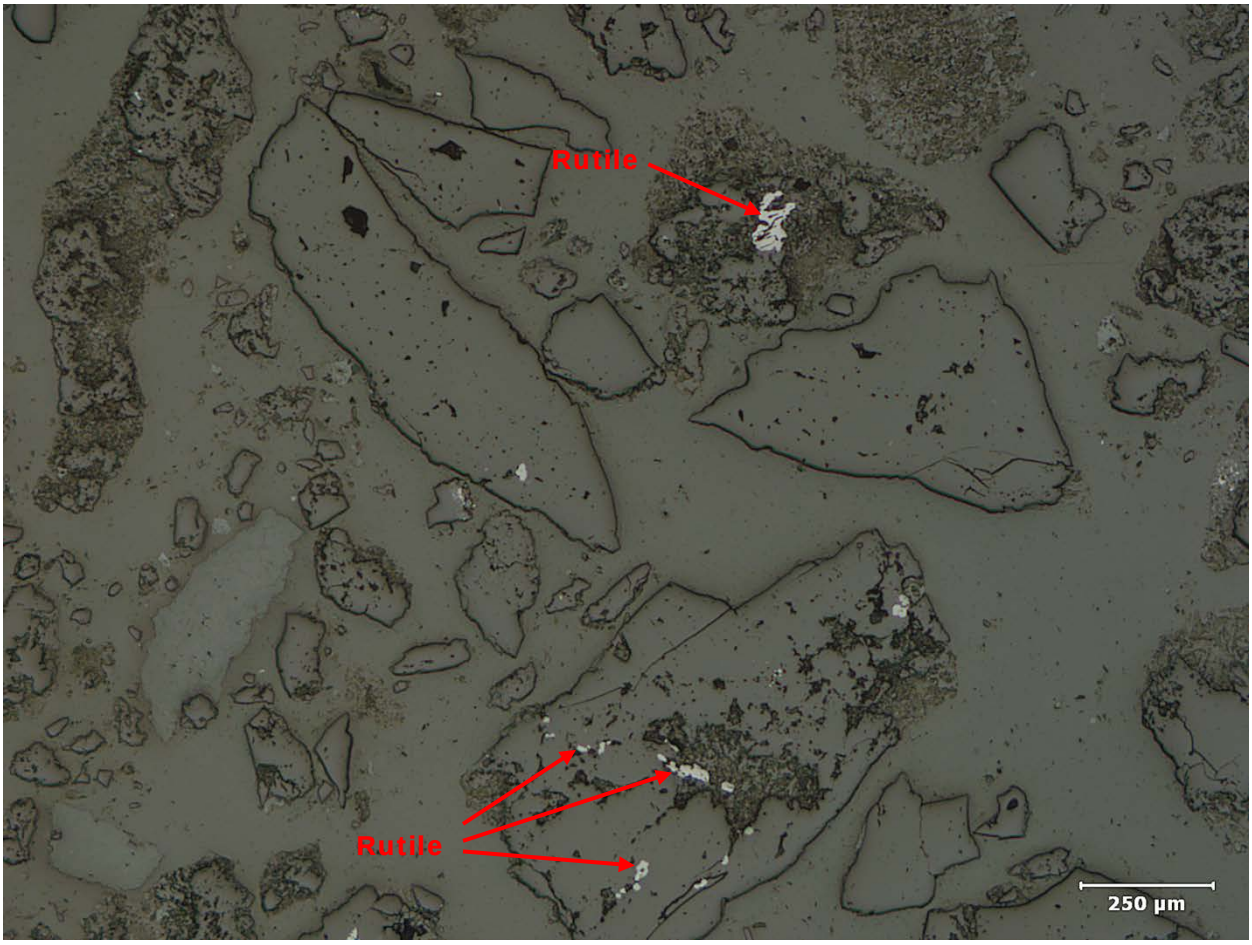
Figure A2. Photograph of Composite 11/17 (As-Received)



Figure A3. Photograph of Composite 19/20 (As-Received)

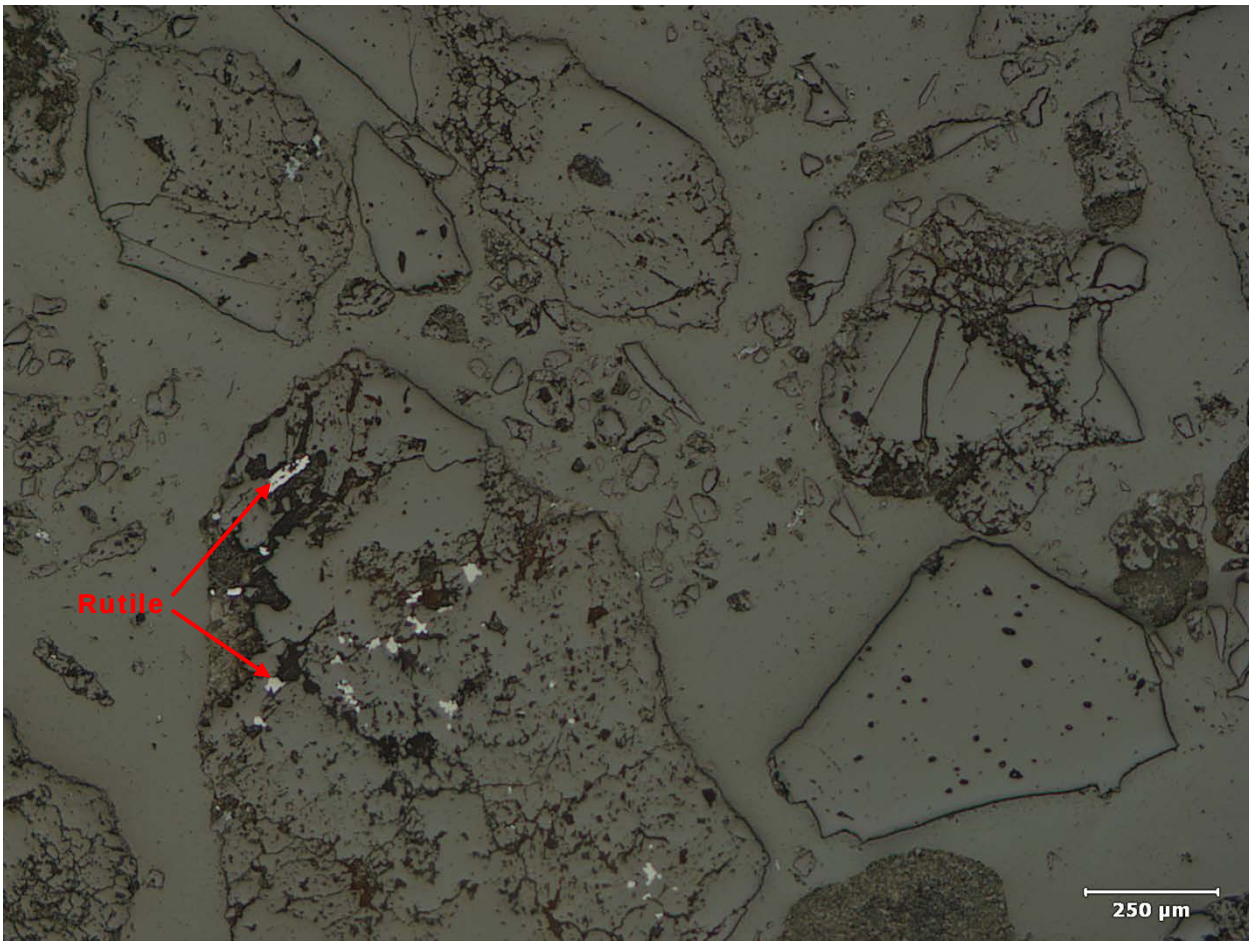


Figure A4. Reflected Light Photomicrograph of Composite 02/05 (As-Received)



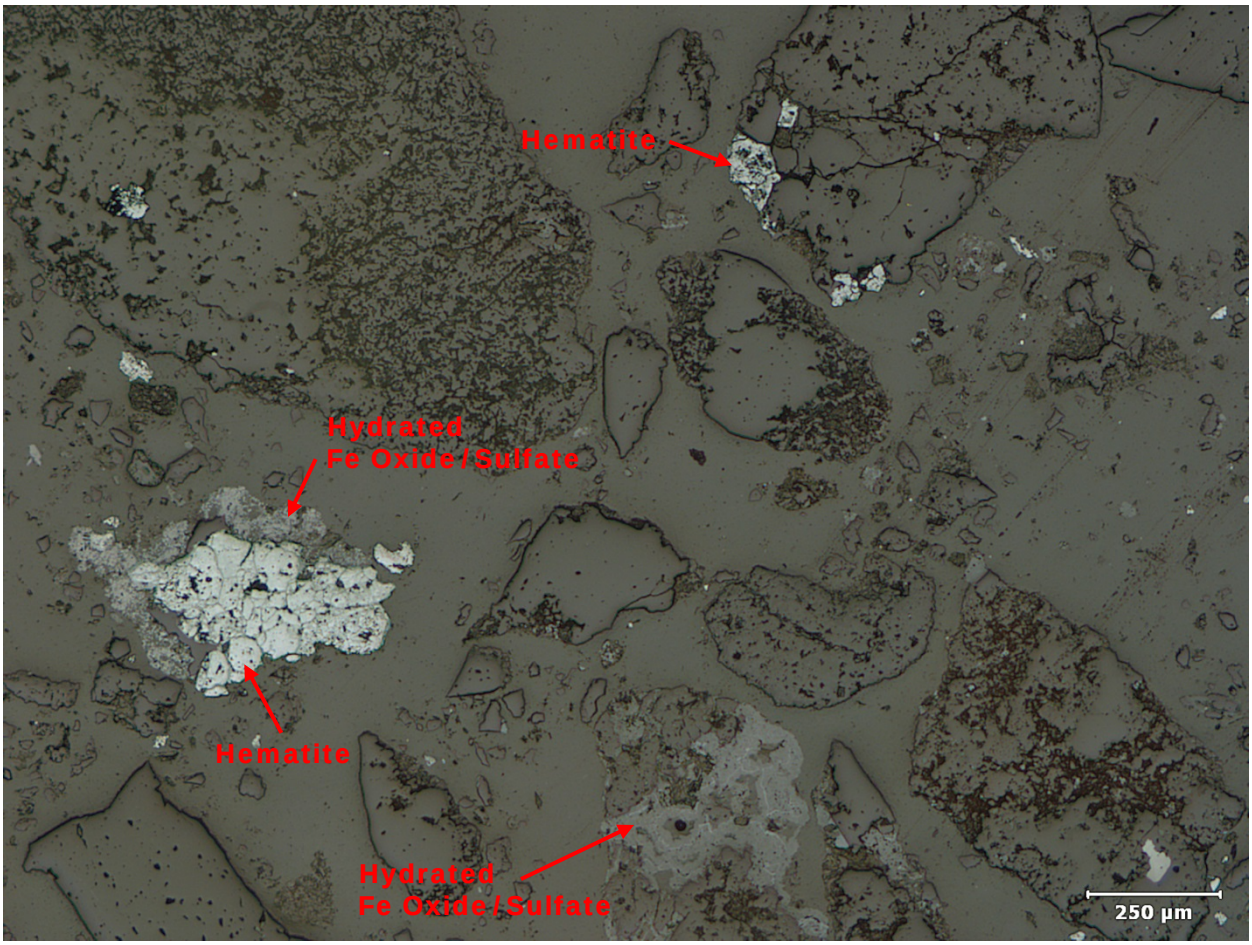
Rutile within rock matrix

Figure A5. Reflected Light Photomicrograph of Composite 11/17 (As-Received)



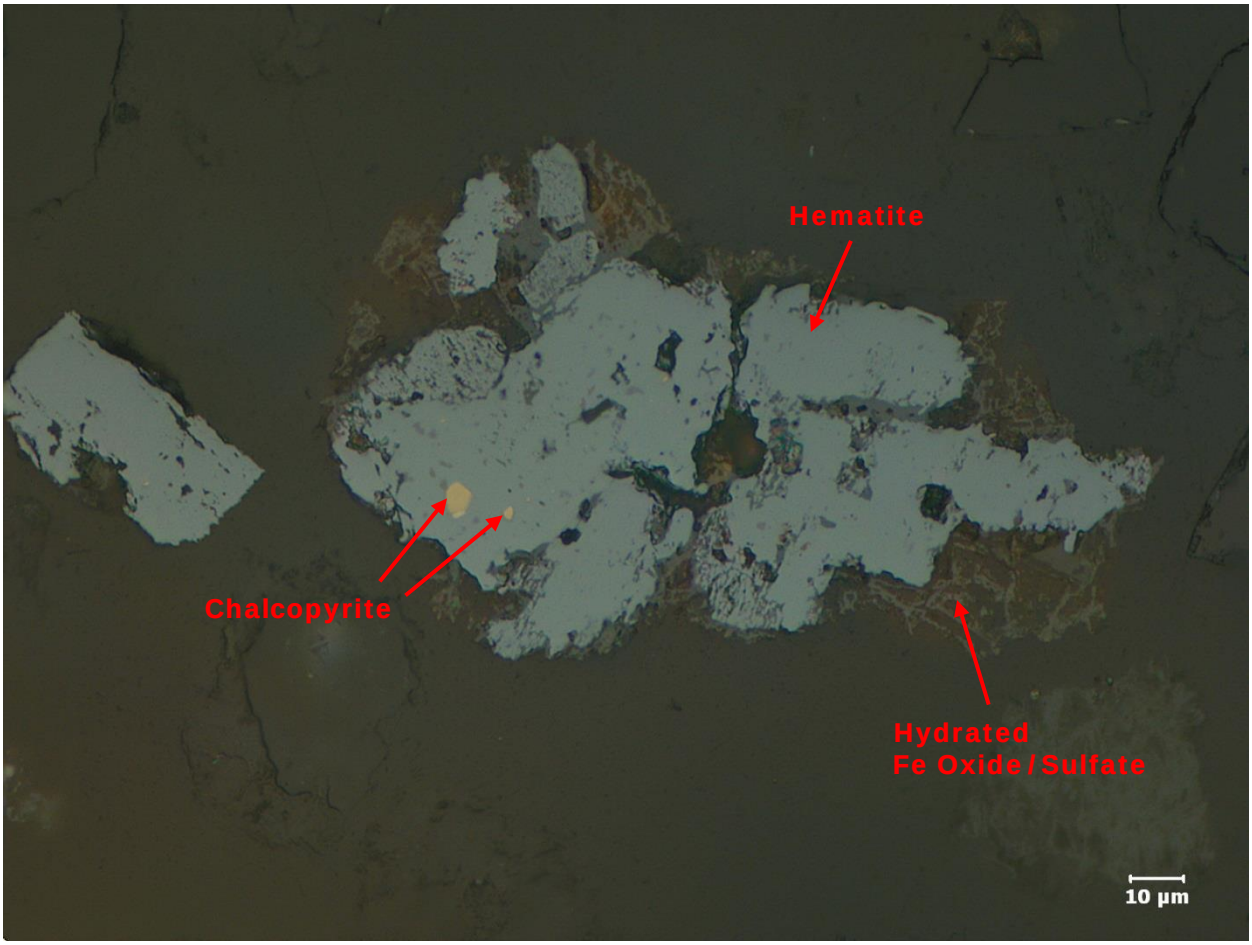
Rutile within rock matrix

Figure A6. Reflected Light Photomicrograph of Composite 19/20 (As-Received)



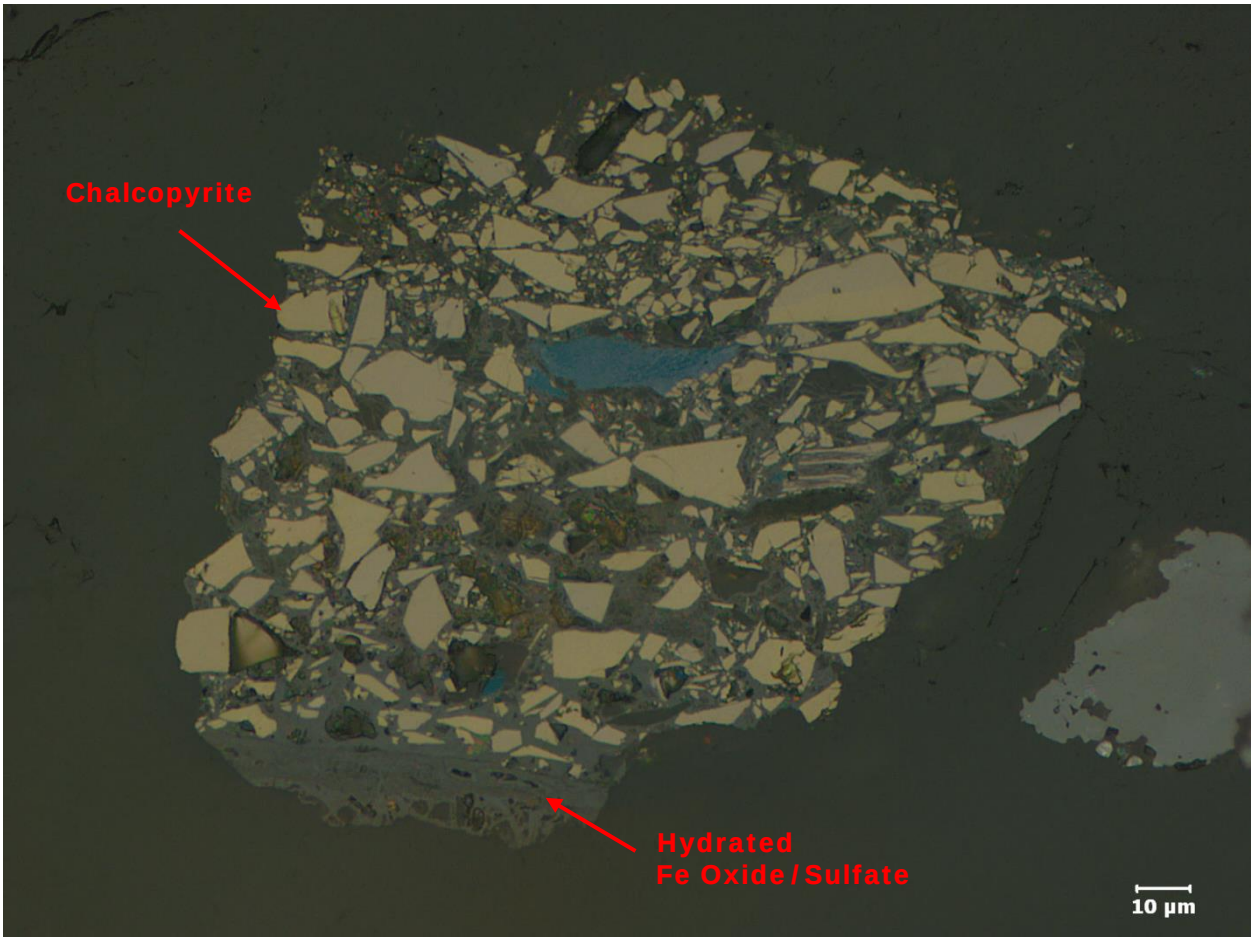
Fe Oxide/hydroxide phases within the rock matrix

Figure A7. Reflected Light Photomicrograph of Composite 02/05 (Gravity Con)



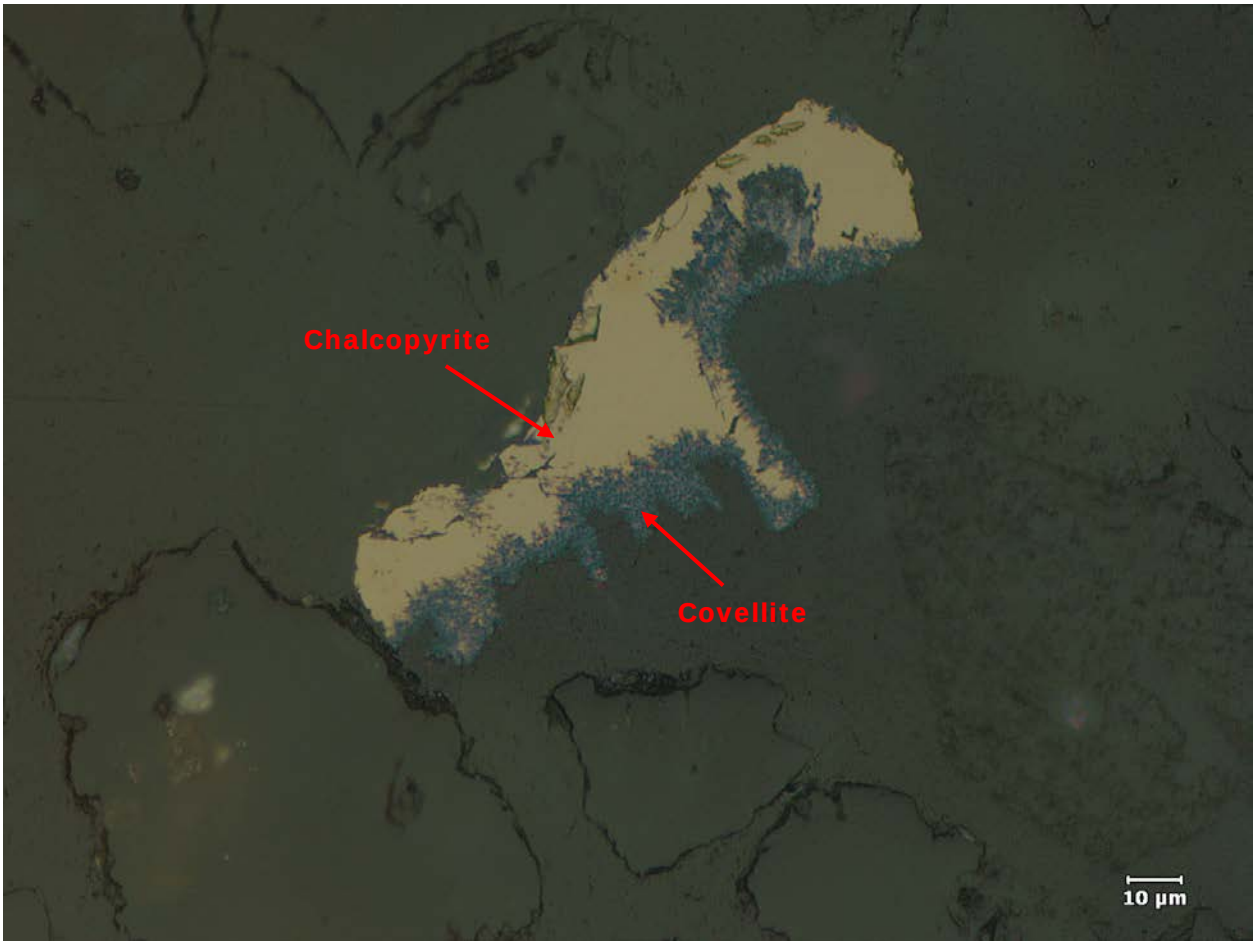
Minor amounts of sulfide minerals were observed within Fe Oxide/hydroxide phases indicating that the Fe Oxide/hydroxide is an oxidation product of the sulfides.

Figure A8. Reflected Light Photomicrograph of Composite 02/05 (Gravity Con)



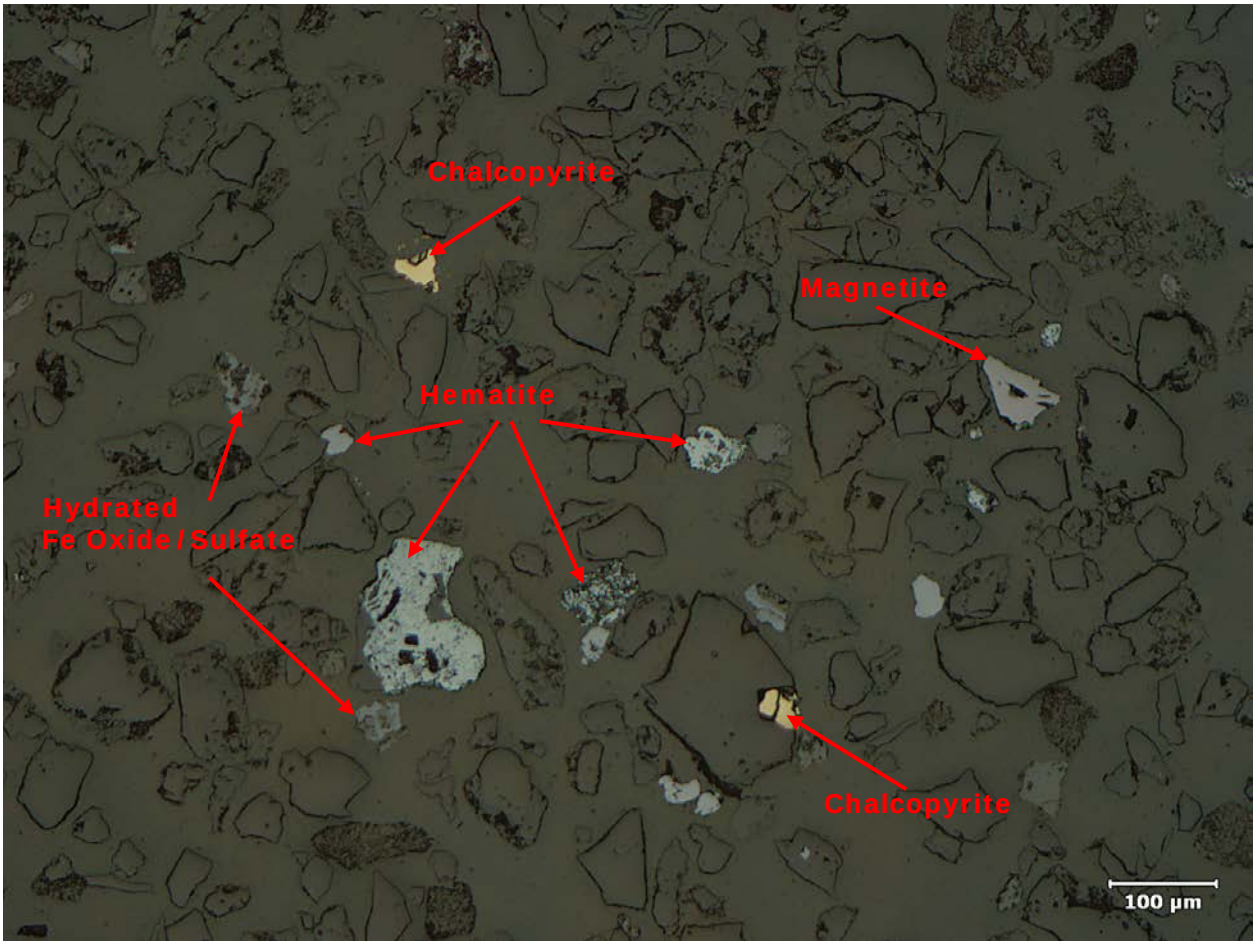
Massive amounts of chalcopyrite cemented together by hydrated iron oxide/sulfate. This texture was rare and was only observed in Composite 02/05. Trace amounts of covellite (blue) is also included within the particle.

Figure A9. Reflected Light Photomicrograph of Composite 02/05 (Gravity Con)



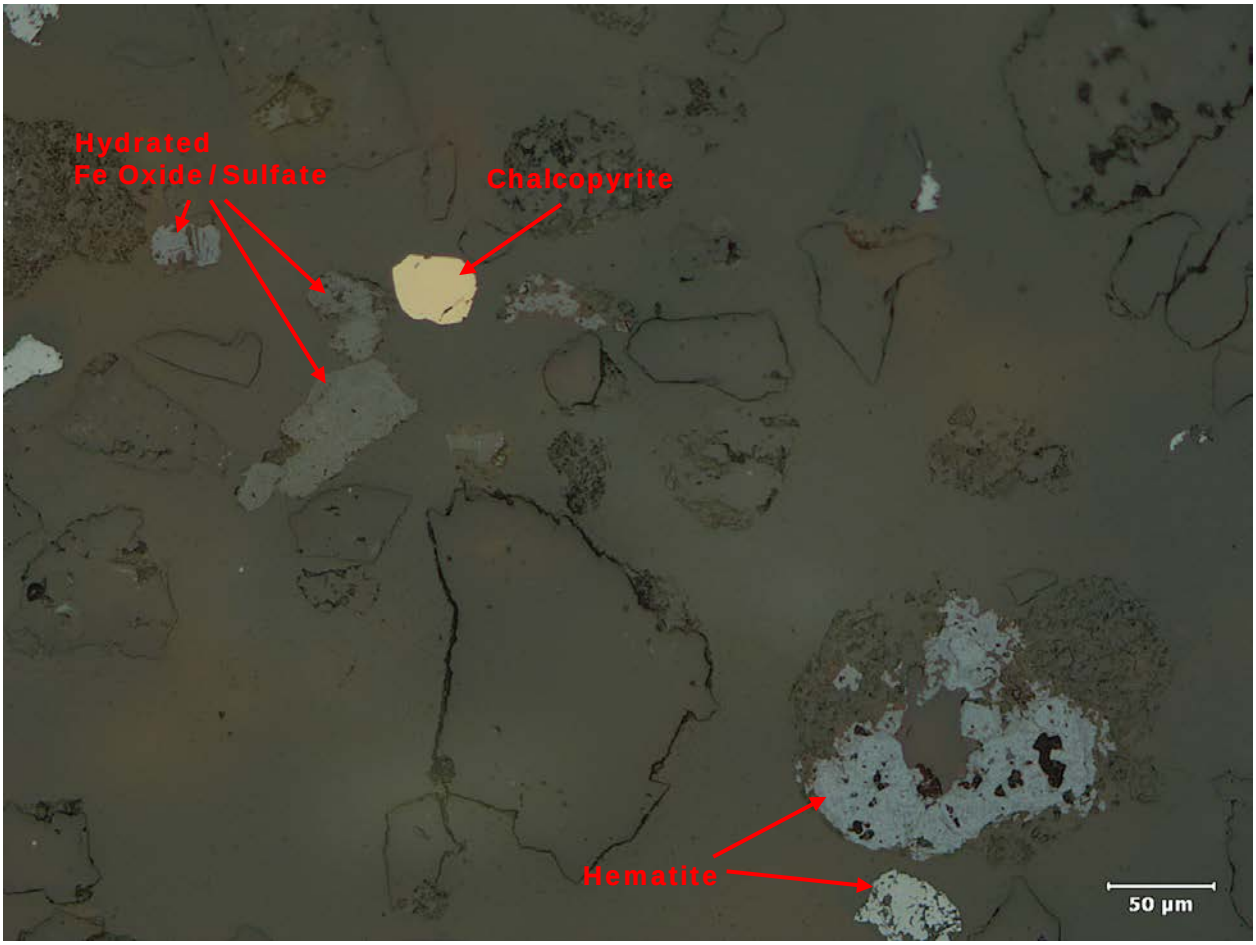
Chalcopyrite particle that shows advance stages of oxidation into covellite.

Figure A10. Reflected Light Photomicrograph of Composite 11/17 (Gravity Con)



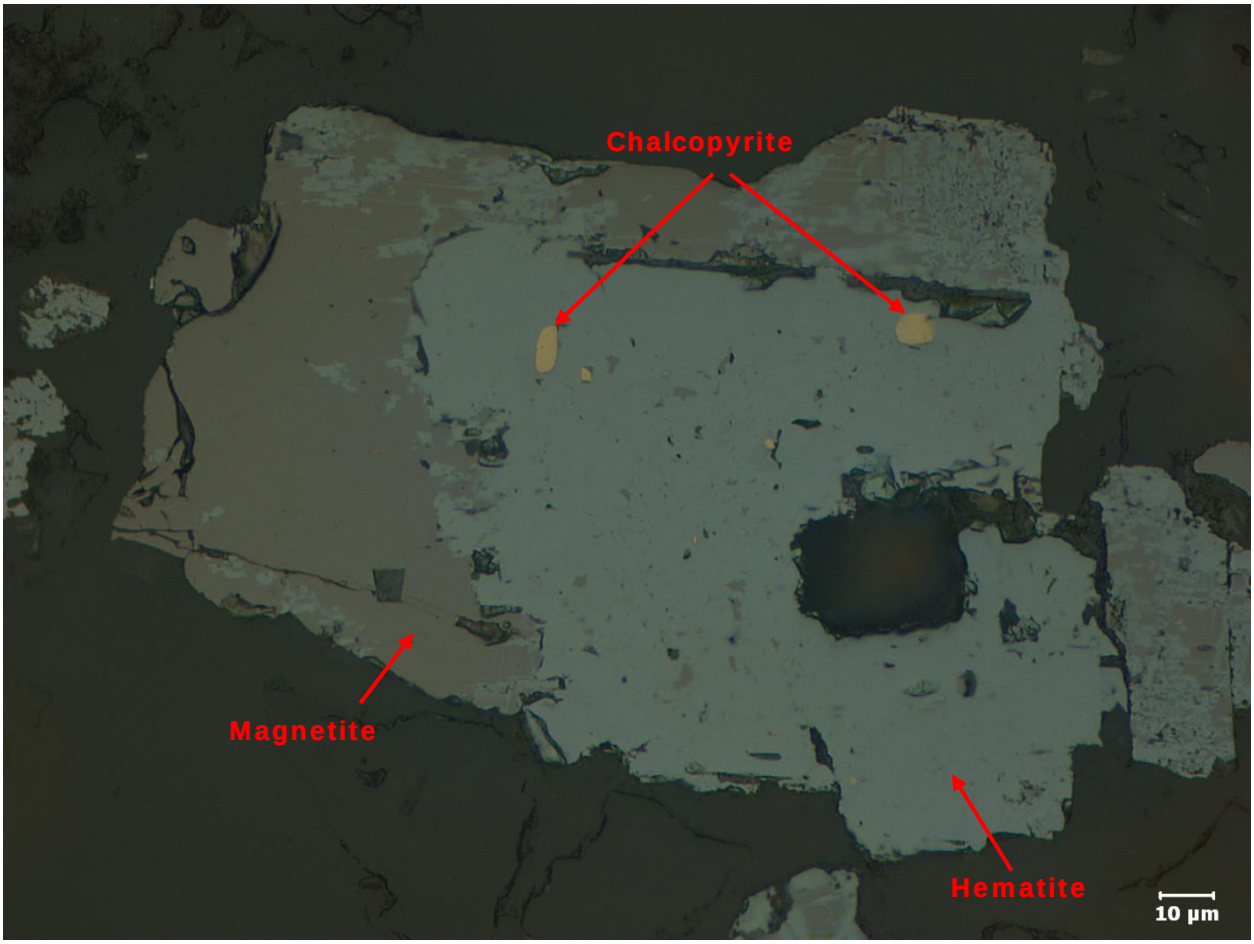
Discrete chalcopyrite grains were observed in the gravity concentrate.

Figure A11. Reflected Light Photomicrograph of Composite 19/20 (Gravity Con)



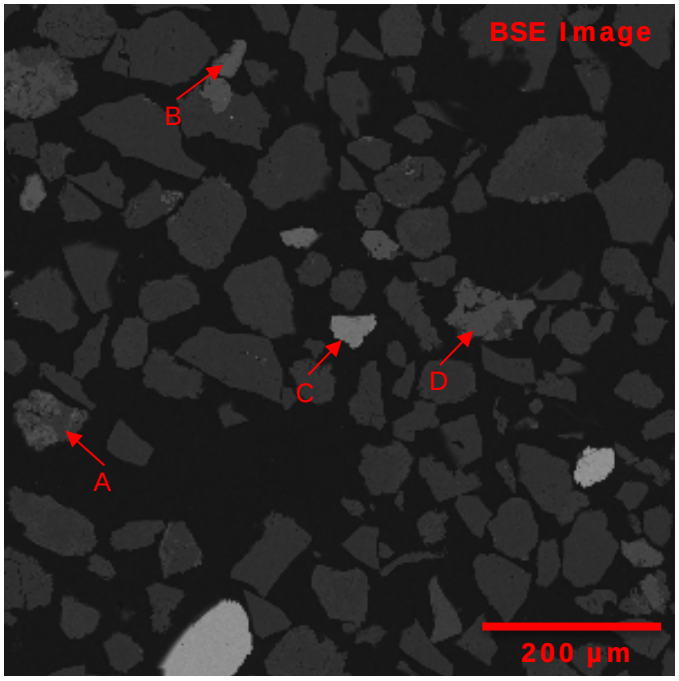
Discrete chalcopyrite grains were observed in the gravity concentrate

Figure A12. Reflected Light Photomicrograph of Composite 19/20 (Gravity Con)

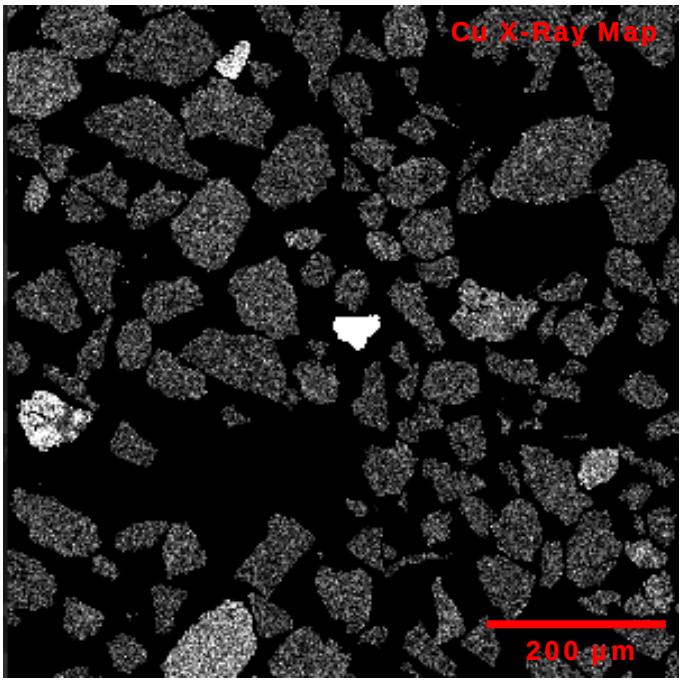


Minor amounts of sulfide minerals were observed within Fe Oxide/hydroxide phases indicating that the Fe Oxide/hydroxide is an oxidation product of the sulfides.

Figure A13. SEM image (BSE) and corresponding Cu X-Ray Map Composite 02/05



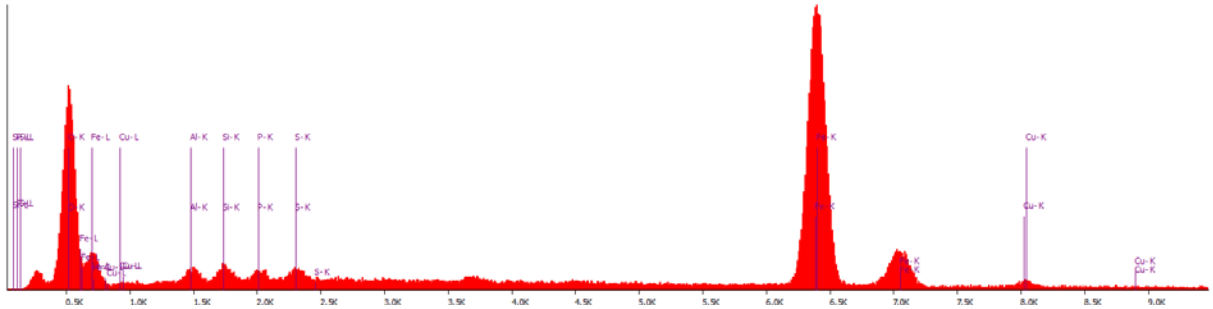
Note: labeled particles are identified in Figure A14



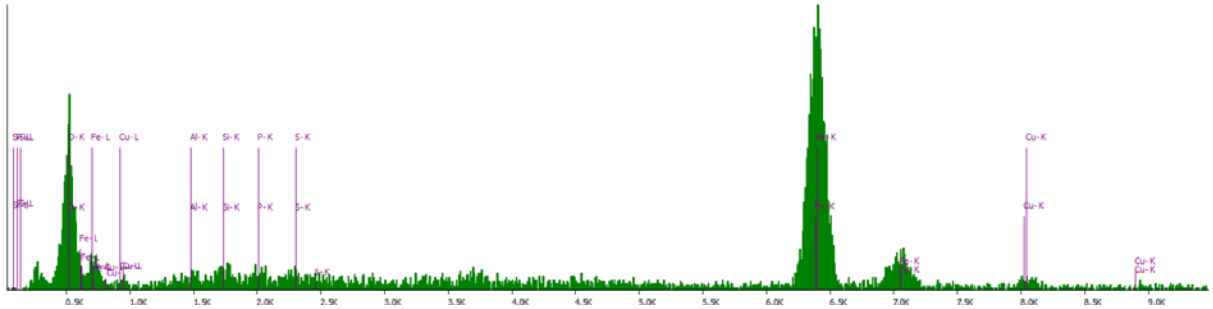
Note: brighter (whiter) particles contain copper

Figure A14. Energy Dispersion Spectrum of Copper-Bearing Particles in Figure A13 Composite 02/05

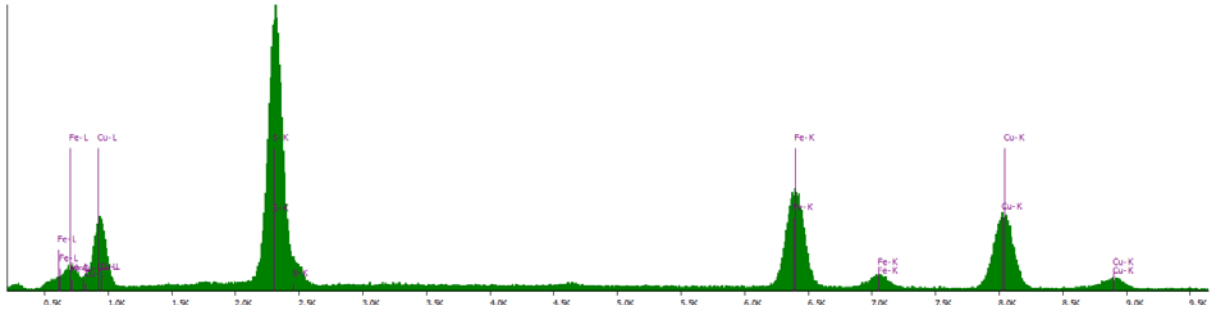
A: Copper bearing Iron Oxide



B: Copper bearing Iron Oxide



C: Chalcopyrite



D: Copper bearing Jarosite

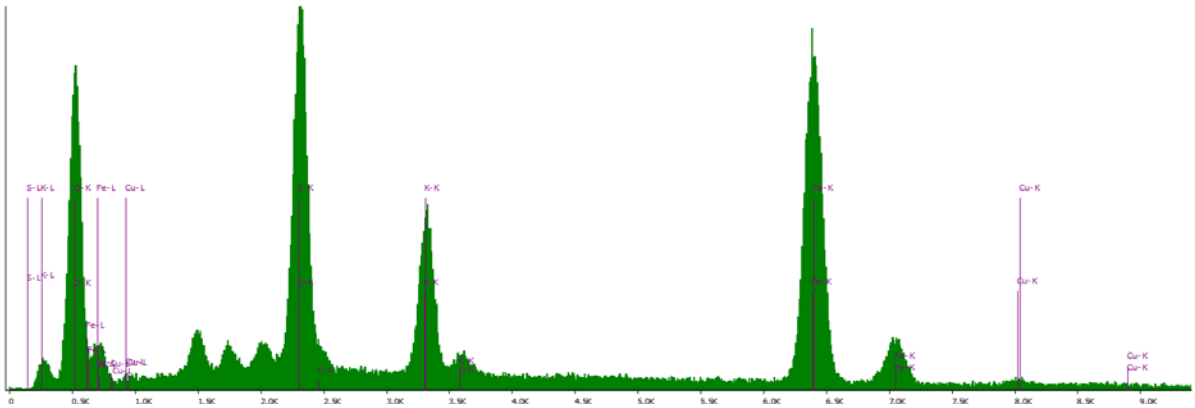
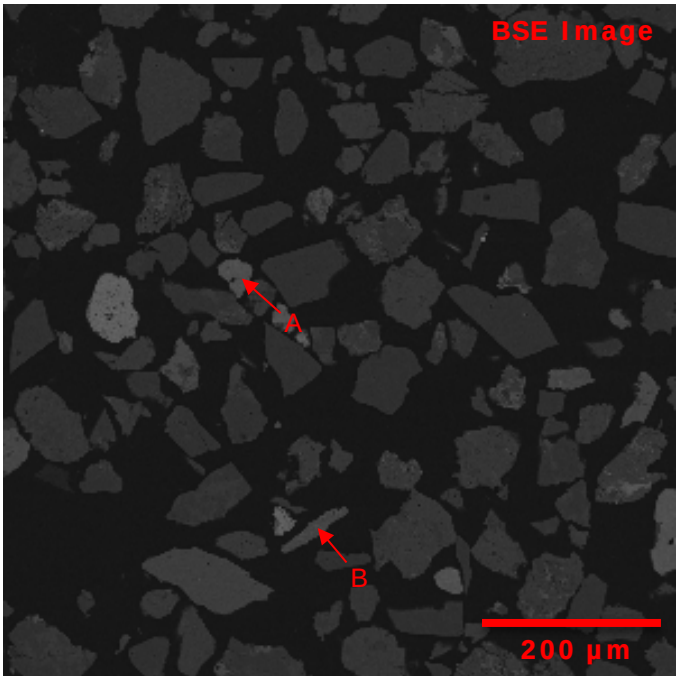
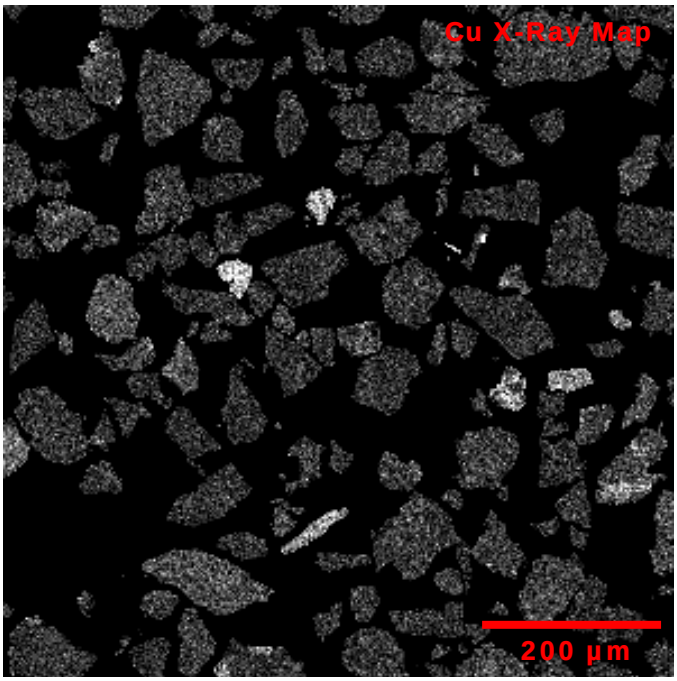


Figure A15. SEM image (BSE) and corresponding Cu X-Ray Map Composite 11/17



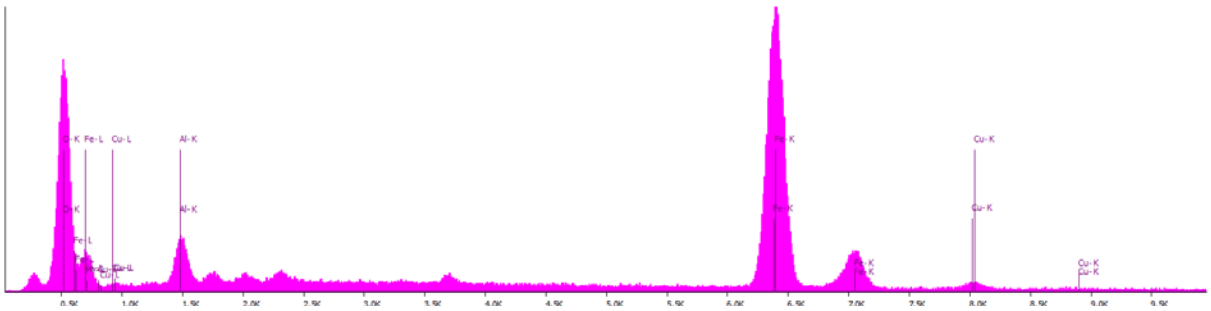
Note: labeled particles are identified in Figure A16



Note: brighter (whiter) particles contain copper

Figure A16. Energy Dispersion Spectrum of Copper-Bearing Particles in Figure A15 Composite 11/17

A: Copper bearing Iron Oxide



B: Copper bearing Jarosite

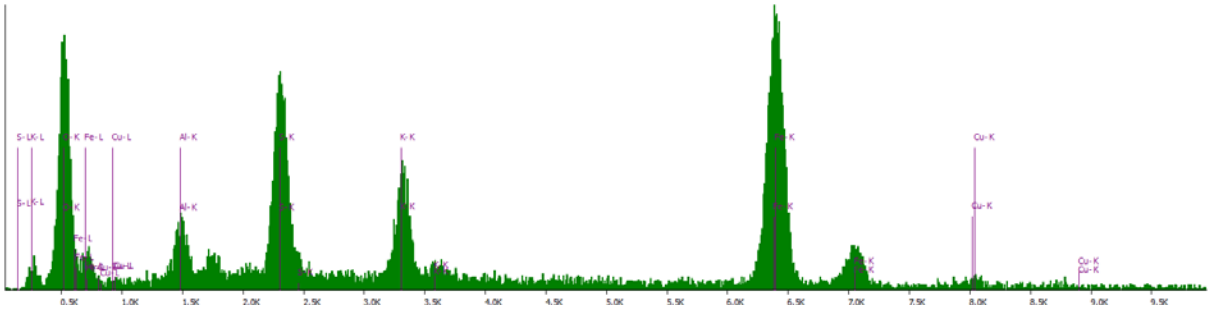
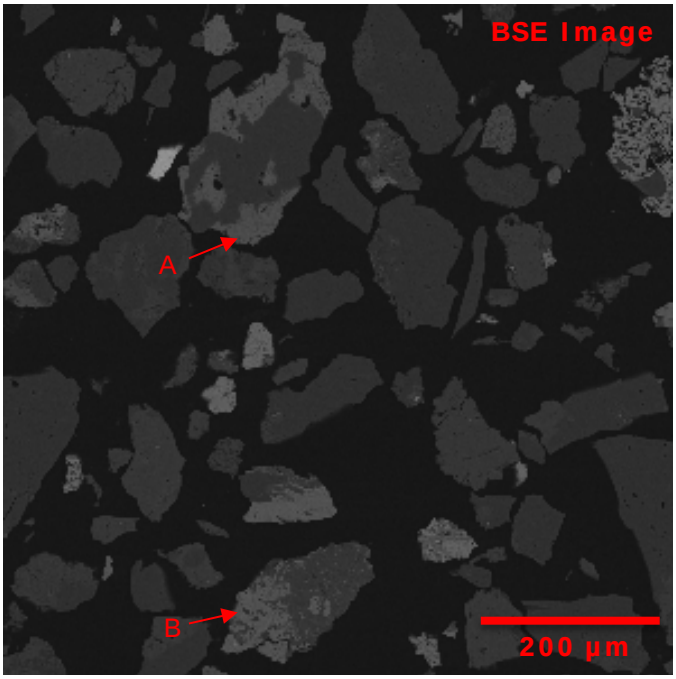
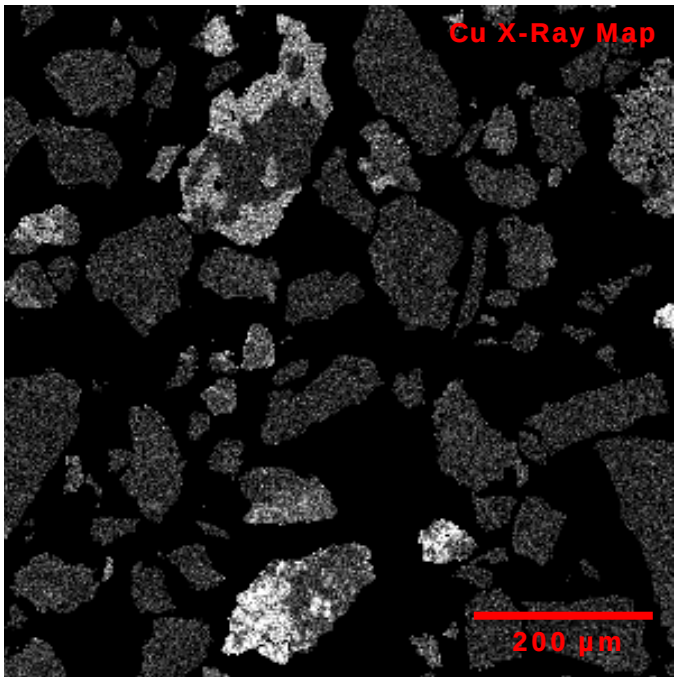


Figure A17. SEM image (BSE) and corresponding Cu X-Ray Map Composite 19/20



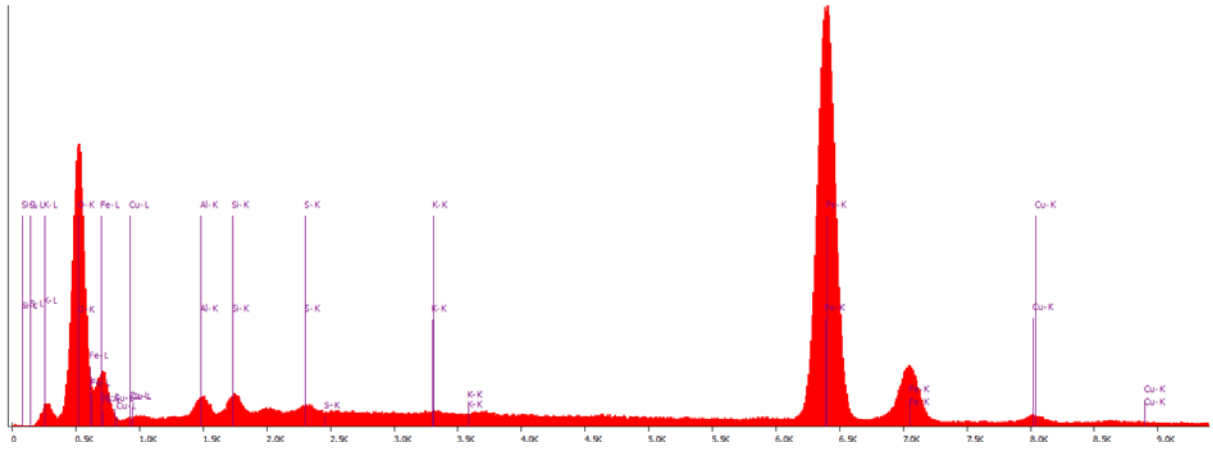
Note: labeled particles are identified in Figure A18



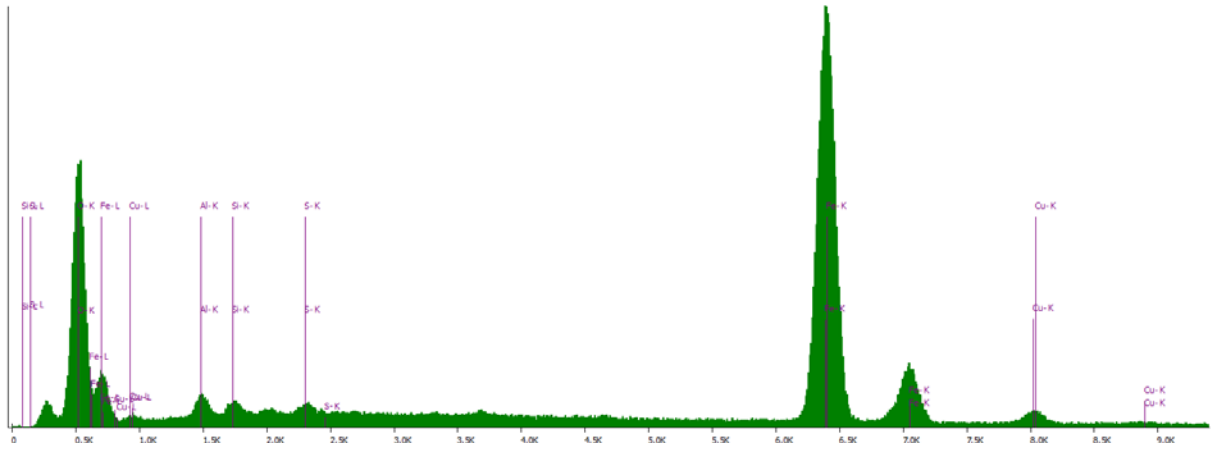
Note: brighter (whiter) particles contain copper

Figure A18. Energy Dispersion Spectrum of Copper-Bearing Particles in Figure A17 Composite 19/20

A: Copper bearing Iron Oxide



B: Copper bearing Iron Oxide



CASINO PROJECT

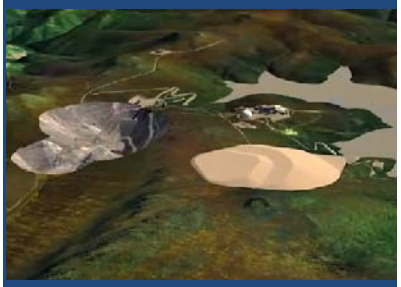
ORE CHARACTERIZATION

REVISION 2

PREPARED FOR:

Western Copper & Gold Corporation

JANUARY 22, 2015







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EXECUTIVE SUMMARY

Hydrodynamic characterization of two Casino head samples was undertaken to define the physical and hydraulic response of the ore. The samples included Composites Met 02-05 and Met 11-17 which represent 1:1 blends of the individual samples Met 02 and Met 05; and Met 11 and Met 17, respectively.

The metallurgical data indicate average head grades of the metals of interest; Au (0.32 ppm & 0.50 ppm), Ag (1.0 ppm & 3.0 ppm), Cu (0.01% and 0.053%) for composites Met 02-05 and Met 11-17, respectively. These samples show high levels of Al (6.9% & 6.7%), Fe (2.3% & 2.6%), K (3.3% & 4.6%), and S (0.4% & 0.6%). Some trace elements are present; Ba (1,187 ppm & 1,614 ppm), Bi (3 ppm & 2 ppm), Mo (61 ppm & 181 ppm), Ti (1500 ppm & 972 ppm), Pb (20 ppm & 123 ppm), and Th (16 ppm & 17 ppm) which could have some influence in gold extraction. The grade by size data indicate that Au and Ag are not uniformly distributed along the PSD of these composites. Met 02-05 has most of its metal value (35%) on the size fractions smaller than 1.7 mm. In contrast, Met 11-17 has most of its metal value (>25%) on rock fragments larger than 25.4 mm.

The mineralogical characterization indicates that Au occurs primarily as sub-microscopic native gold. Potential cyanide consuming minerals include metal sulfides including copper, iron, arsenic and zinc; iron oxide-hydroxides such as Limonite and Jarosite which can also act as preg-robbing; and secondary alumino-silicates and swelling clays. Shake leach tests conducted by FL Smidth leads us to believe that: the increased recovery on composites Met 11-17 (and Met 19-20) at very high CN-concentrations results from the dissolution of sulfide minerals (sulfide encapsulation due to, but not exclusively, copper sulfides) which may be coating the Au minerals and dissolve at high CN concentrations. On the other hand, the ultimate Au recovery in Met 02-05 is likely associated to silica encapsulation.

A few key findings from the hydrodynamic characterization are as follows:

- Agglomeration of individual composites and blending produce improved hydrodynamic performance which increases the range of heap heights supported by these samples. For instance, 2:1 blend of Met 02-05 and Met 11-17 sample agglomerated to a Level 3 (L3) could support a heap height close to 140 m. The more competent composite Met 11-17 would support percolation leaching to heights up to 140 m even without agglomeration.
- The Casino head samples are competent and show limited compaction and loss of percolation capacity along a 140-m heap profile. Notwithstanding the strong nature of the Casino samples, it appears that the key considerations for the adequate leaching of the **non-agglomerated** Casino ore include:
    - The permeability for Composite Met 02-05 or a blend thereof as the heap height increases beyond 70 m, and
    - Effective solution-to-ore contact for Composite Met 11-17 if not blended.
- As a result of the very competent nature of the Met 11-17 and its low content of fines, the void space is dominated by macro-porosity. This macro-porosity provides, on the one hand, high solution percolation capacity, but in the other limits wettability of the ore. The large component of the macro-porosity translates into gravity-dominated flow where limited horizontal movement of solution occurs leading to inefficient wetting and hence limited metallurgical performance. Typically, this type of flow

condition combined with non-agglomerated ore leads to reduced metal extraction, inefficient reagent (cyanide and lime) utilization and protracted leach cycles. Blending with Met 02-05 will improve the wettability of composite Met 11-17.

- The results from the Hydrodynamic Column Tests (HCTs) confirm that composites Met 02-05 and Met 11-17 will effectively support percolation leaching during the initial stages of the operation as shown by the results of the Hydrodynamic Column Tests (HCTs) for a 32-m heap with a solution application rate of 10 L/h/m^2.
- According to the results from the HCTs, the best performing sample is Met 02-05 as it produces a good solution-to-ore contact which should promote efficient gold dissolution and recovery.
- Blending and agglomeration leads to improved hydrodynamic performance of these two composites which is expected to also improve their metallurgical performance.

As part of its characterization technology HGS has developed the Integrated Column Test (ICT), a procedure that allows simultaneous determination of hydrodynamic and metallurgical performance). Application of this procedure, at no cost to WCG, on the Casino samples shows that:

- Preliminary gold recoveries of about 70% for Composite Met 02-05 and 30% for Met 11-17.
- These results seem to be in good agreement with the conclusions arising from the available physical, hydrodynamic, metallurgical and mineralogical data.
- Based on the metallurgical data, gold recovery on composite Met 11-17 may be hindered due to coating by sulfide minerals (sulfide encapsulation due to, but not exclusively, copper sulfides) while ultimate recovery from Met 02-05 is likely associated to silica encapsulation.

The work conducted as part of this study and other available data show that:

1) There are significant physical, hydrodynamic, metallurgical and mineralogical differences between the two composites evaluated on this study.
2) Ore preparation practices (crushing, blending, and agglomeration) would have a significant impact on the metallurgical performance of the ore. Operational design should consider agglomeration, blending or both to improve the hydrodynamic properties of these composites.
3) For composite Met 02-05, the optimal solution application rate would be equal to or smaller than 10 L/h/m^2 to balance between reagent delivery and air-percolation capacity.
4) For composite Met 11-17, the optimal solution application rate would be equal to or smaller than 6 L/h/m^2 to balance between reagent delivery and solution-to-ore contact.
5) A 2:1 blend of Met 02-05 and Met 11-17 may perform better than the each of the individual composites. Agglomeration of this blend would allow leaching this material to the 140-m design height.
6) The distance between drip points should not be larger than 30 cm.
7) The irrigation for both of these composites should follow a ramp-up irrigation scheme (RUI).

A fact that needs to be considered in the interpretation of the results presented in this report is that all the samples tested to date represent fresh ore. A multi-lift heap is susceptible to weathering, slumping, differential settlement, and for oxide-gold to chemical-induced decrepitation to a lesser extent. All of these mechanisms negatively impact the hydrodynamic properties of the ore and increase the potential solution and metal inventory. Therefore, it is critical that hydrodynamic properties of the leached residue be determined to

optimize the design and operational conditions of the heap. Additional HCTs for process optimization are recommended at heap design heights once the mine operation starts and the ore has been exposed to at least three leaching cycles.

Section 4.0 of this document presents additional discussion of the results and recommendations aimed to improve the design and eventual performance of the heap leaching process of the Casino project.

1.0 TEST PROGRAM AND BASIC METALLURGICAL DATA

1.1 Characterization Program

WCG provided two different composite head samples, namely Composite Met 02-05 and Composite Met 11-17. It is understood that these composites represent a one-to-one blend of the individual samples by the same name (i.e., Met 02, Met 05, Met 11, and Met 17). A total of 89 kg already separated into eight size fractions was supplied by SGS/Metcon (Metcon). As indicated on the test matrix presented in Figure 2.1, each of the samples was subjected to the Stacking Test procedure under three different conditions:

- As-received dry ore mixed with 2.93 kg of pebble lime per ton of ore (kg/t) per Metcon results from their bottle role tests and the value used on the recent metallurgical columns;
- As-received dry ore mixed with powder lime at 2.93 kg/t per Metcon recipe used on the ongoing metallurgical columns;
- A sample mixed with 2.93 kg/t of powder lime and agglomerated with alkalinity amended tap water with a pH of 11.3.

The non-agglomerated samples represent a benchmark to assess the potential benefits from agglomeration. After these tests, it was recommended that for practical purposes the use of pebble lime be discontinued and any future work use only powder lime.

The characterization program consisted of:

a) Review of available particle size distribution (PSD) information,

b) Agglomeration trials to define the optimal moisture content for each PSD,

c) Review of metallurgical and mineralogical data,

d) Stacking Tests to determine the potential hydrodynamic behavior of the samples to select the most promising agglomeration conditions, and

e) Hydrodynamic Column Tests on three PSD to determine the potential operation conditions for these samples for a 32-m heap.

The following paragraphs provide a summary of the data reviewed as part of this study, testing methods and the most relevant results from the application of these tests to the Casino ore. The last section of this document presents a number of recommendations on the basis of these findings.

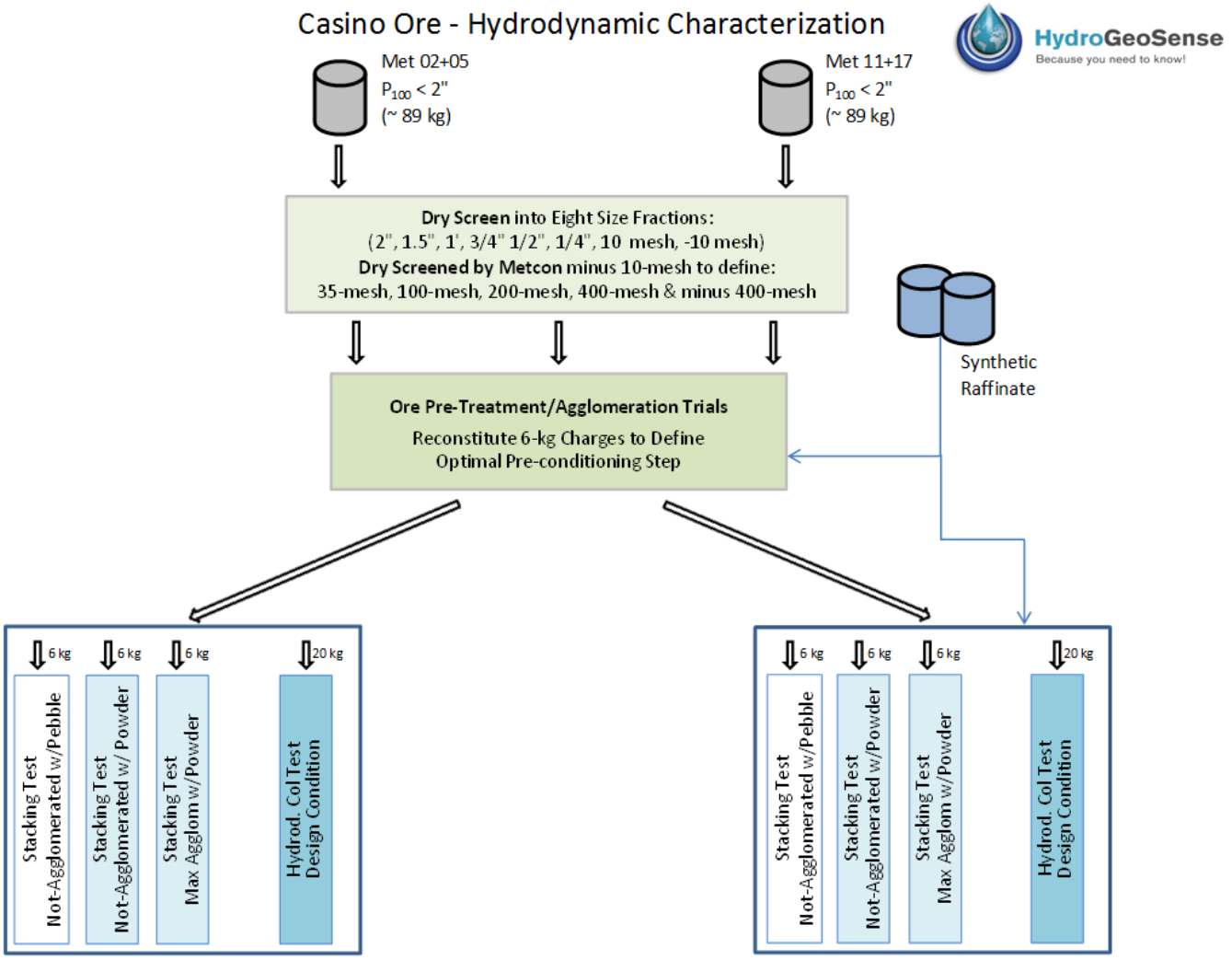

Figure 1.1 Casino – Final Test Matrix

1.2 Particle Size Distribution

The particle size distribution (PSD) for the head ore samples was determined by Metcon and is summarized in Figure 1.1. For comparison, HGS used the PSD of the individual ore samples determined by ALS Metallurgy to determine the PSD of the 1:1 composites also presented as in Figure 1.1. It is noted that none of the ALS' PSD showed particle sizes larger than 5.cm (2") while the two composites received from Metcon (M 02-05 and M 11-17) contained particle sizes larger than 5 cm. Overall, the PSD for the 1:1 composites determined from ALS' PSDs are similar to those reported by Metcon, indicating good consistency between the procedures used by these laboratories.

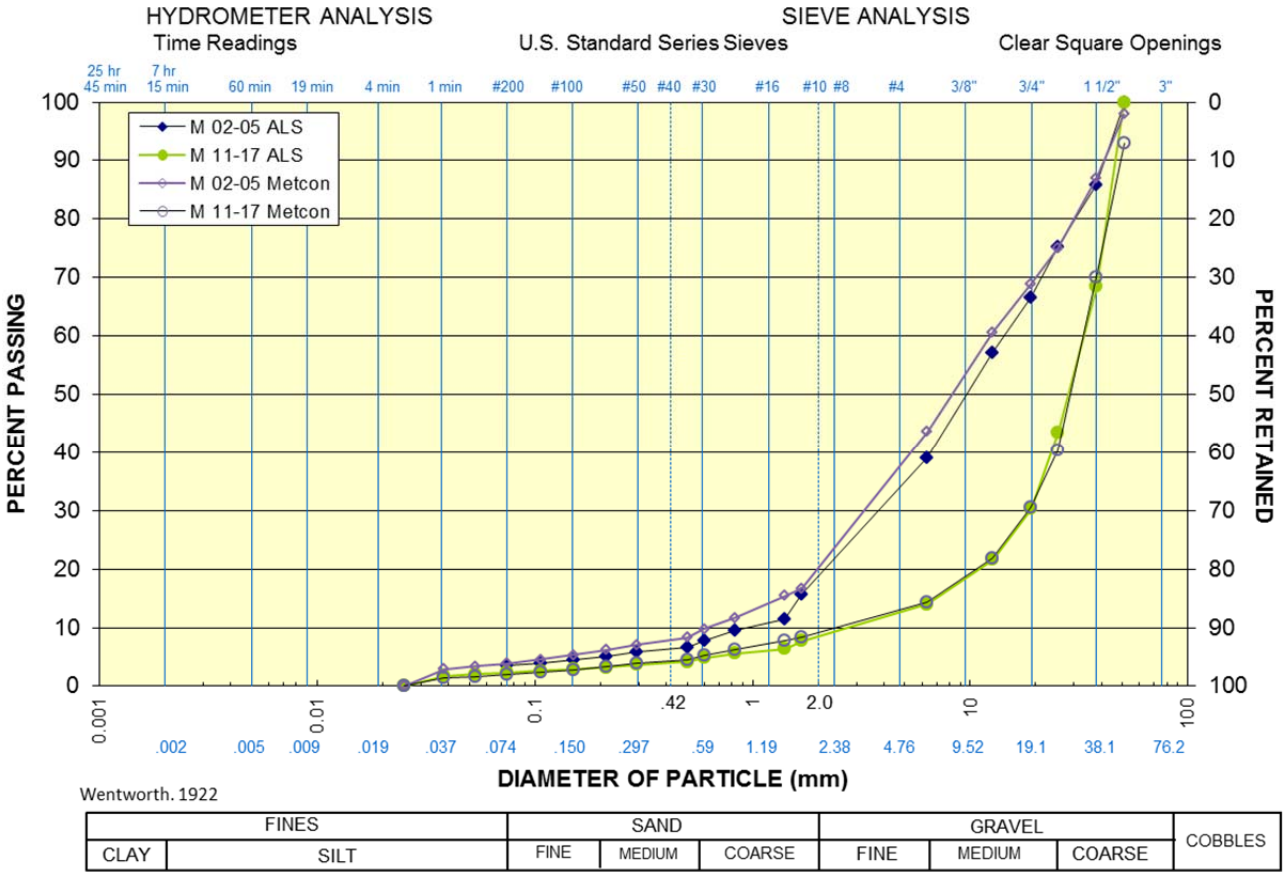

Figure 1.2 Particle size distribution TMC Fresh ore

From the PSD of each composite the P_{80} (the particle size larger than 80% of the rock fragments) and the main size fractions (gravel, sand and fines) can be determined (Table 1.1). These data show that:

- The **P_{80}** of M 02-05 is 30.6 mm while that for the M 11-17 composite is 43.6 mm.
- The fines:sand:gravel partition of the Casino ore is: 3.9:12.8:83.3 for the M 02-05 composite and 2.0:6.3:91.7 for the composite M 11-17. This partition of the main size fractions indicates that as long as the rock fragments are stable, these composites should be permeable to allow percolation through the heap of a significant height.
- However, it is noted that the large gravel content (more so for composite M 11-17) could promote solution channelization and low wetting efficiency.
- The Stacking and Hydrodynamic Column Tests described below provide additional insight in this potential issue.

Table 1.1 Particle size distribution from Metcon				
Sample ID	**P_{80} (mm)**	**Gravel (%)**	**Sand (%)**	**Fines (%)**
M 02-05	30.6	83.3	12.8	3.9
M 11-17	43.6	91.7	6.3	2.0

1.3 Ore Specific Gravity

The Casino samples were tested to determine the Specific Gravity (SG) of the solids on each of the main size fractions (gravel, sand and fines). An accurate determination of the porosity (void ratio) of the sample requires an accurate value of the SG. Difference in the SG on the main fractions indicates potential differences on the alteration type and extent of the rock mass. In the case of alteration differences between the size fractions, these data also provide a better estimate of the overall specific gravity of the sample. The average SG for the Casino is estimated at 2.660 for M 02-05 and 2.632 for M 11-17.

Table 1.2 Specific Gravity		
	Specific Gravity	
Fraction	**M 02-05**	**M 11-17**
Gravel	2.673	2.641
Sand	2.575	2.529
Fines	2.678	2.556
Overall	**2.660**	**2.632**

The difference in specific gravity of the gravel, sand, and the fines may be indicative of varying degrees of alteration among these fractions, and in this particular case, also between the two composites.

1.4 Head Assay Determination

In order to get an understanding of the relationship between the hydrodynamic behavior and the potential metallurgical performance of the Casino samples the data presented by ALS and Metcon are briefly summarized in this section.

ALS assayed each size fraction of samples M 02, M 05, M 11, and M 17 for total copper, iron, sulfur, and gold as well as for multi-element ICP analysis. Metcon performed head assays for gold and silver on the two composites delivered (M 02-05 and M 11-17) to HGS.

HGS recommended mineralogical characterization (QEMSCAN or Quantitative XRD and optical microscopy) of the Casino composites to better understand the mineral species responsible for the occurrence of the Au/Ag values. A one kilogram test charge was prepared for each of these composites (including M19-20) and submitted for mineralogical analysis to FL Smidth during the first week of August 2014. The results of this characterization are summarized below in section 1.4.3.

Table 1.3 summarizes the total copper, iron, sulfur, gold, and silver of the individual samples (Met 02, Met 05, Met 11, Met 17) based on the ICP analysis by ALS and composite samples (Met 02-05 and Met 11-17) determined by Metcon. These data show that:

- Sample Met 05 contains less copper, iron, gold and silver than any of the other individual samples summarized on Table 3.1. It is noted from the individual PSD of this sample that 95% of the rock fragments are smaller than 38.1 mm (1.5") while the average of the other (including Met 19 and 20) is only about 72% (Met 11 has only 63.3% of its mass smaller than 38.1 mm). This information suggests that Met 05 may represent a more altered zone of the deposit.

- M 11-17 has the highest Au and Ag content, although it also has the highest Cu content (530 ppm) of the two composites. Depending on the copper solubility, this higher Cu content might promote CN consumption and interfere with Au/Ag absorption.

- The calculated head assays from the ALS data are similar to those reported by Metcon for copper and gold but the calculated silver content is slightly larger than the values reported by Metcon. Overall, the agreement between these two independent evaluations is quite good.

Table 1.3 Summary of Head Assays

Lab	ALS					Metcon		
Sample ID	Cu (%)	Fe (%)	S (%)	Au (ppm)	Ag (ppm)	Cu (%)	Au (ppm)	Ag (ppm)
Met 02	0.018	3.2	0.64	0.52	1.59			
Met 05	0.002	1.4	0.18	0.20	0.52			
Met 11	0.022	3.2	0.94	0.42	4.62			
Met 17	0.083	2.1	0.31	0.64	2.15			
Met 02-05*	0.010	2.30	0.41	0.36	1.06	0.009	0.32	0.8
Met 11-17*	0.053	2.65	0.63	0.53	3.39	0.051	0.55	2.7

*Composite assays calculated from individual assays assuming a 1:1 mix

- The S content would indicate that the iron on the Casino sample occurs mostly as oxides rather than sulfide minerals. If this is correct, there would be some potential for the iron-oxides to encapsulate or coat the gold minerals and the reaction of sulfides minerals to consume oxygen and lower the pH.

1.4.1 ICP Elemental Analysis

ALS (2013) reports the results from a 48-element ICP scan on seven size fractions which provides a general indication of the geochemical composition of the samples. The results from ALS AR-ICP analysis were combined with the percent of each of the particle size fraction to determine the elemental composition for each of the samples and the two composites of interest for this evaluation. The resulting calculations are summarized in tabular form in Table 1.4 and graphically in Figure 1.2.

Inspection of the data summarized in Table 1.4 and Figure 1.2 indicates that:

- Only three elements are reported with concentration larger than 1% (10,000 ppm), namely: Al (ranging from 6.2% in Met 05 to 7.6% in Met 02), Fe (ranging from 1.4% in Met 05 to 3.2% in Met 02), and K (ranging from 3.0% in Met 05 to 5.1% in Met 17). All of these are highlighted in Table 1.4.
- Similarly, Calcium (ranging from 0.019% in Met 05 to 0.058% in Met 11) and Magnesium (ranging from 0.22% in Met 05 to 0.39% in Met 02) are also present. To the extent that these minerals are associated to Dolomite or Calcite they could reduce the alkalinity requirements of the leaching process.
- The concentrations of the metals of interest (in blue font in Table 1.3) are as follows: Ag (ranging from 0.5 ppm in Met 05 to 4.6 ppm in Met 02), and Cu (ranging from 0.01% in Met 05 to 0.08% in Met 02). As mentioned before, at the higher concentrations (>100 ppm) copper, if sufficiently soluble, has the potential to promote CN consumption and interfere with Au/Ag absorption.
- Several trace metals are reported to be present, namely; As, Ba, Cd, Pb, Rb, Ti, V and Zr although only Ba and Ti are reported to have concentrations of about or larger than 1,000 ppm.
- There is a good agreement between the Cu and S concentrations derived from the ICP analysis and the head assays reported above.
- Similarly, there is good agreement between the Cu and Ag grades estimated from the ICP with those reported by Metcon for both composites.
- Based on the results from the ICP characterization, it can be concluded that the chemical composition for composites M 02-05 and M 11-17 is quite similar with the exception of the concentrations of Ag, Cu, Mo, Sr, U and Zn (see Figure 1.2).

1.4.2 Mineral distribution as a function of particle size

Both ALS (2013) and Metcon (2014[1]) reported Au and Ag head grades as a function of particle size. The Au and Ag grade and the percent retained for each size fraction is summarized in Figure 1.3 and Table 1.5. These data show that:

- The overall trend depicted by these two sets of data for the Au and Ag head grades is consistent.
- The gold and silver content vary in proportion to each other. For Met 02-05 the average ratio of Au to Ag is about 0.33 while for Met 11-17 is about 0.19 which remain fairly constant over the various size fractions. As such, it would be expected that Met 02-05 would leach more efficiently than Met 11-17.
- For Met 02-05, the gold and silver content shows a consistent reduction from the coarsest to the 1.7 mm fraction and then a noticeable increase on the minus 1.7 mm fraction. This type of metal distribution requires good solution-to ore contact in order to efficiently leach the coarse fractions.
- For M 11-17, the gold and silver content is relatively constant over the size fraction although, similar to that observed for Met 02-05, it shows a noticeable increase (a factor of two) in the minus 1.7 mm fraction. Given the coarse nature of this composite, efficient leaching of the Au/Ag from both the coarse and fine fractions will require careful selection of the irrigation scheme.

[1] Metcon 2014. Email communication from Narsagdorj Gatumur, July 12, 2014.

Table 1.4 ICP Elemental Analysis (After ALS, 2013)						
Element	Met 02 (ppm)	Met 05 (ppm)	Met 11 (ppm)	Met 17 (ppm)	Met 02-05 (ppm)	Met 11-17 (ppm)
Ag	1.6	0.5	4.6	2.2	1.1	3.4
Al	75,540	61,784	66,419	67,115	68,662	66,767
As	85.1	14.6	82.4	38.7	49.8	60.5
Ba	1,178	1,196	1,666	1,561	1,187	1,614
Be	1.4	0.4	1.0	1.0	0.9	1.0
Bi	2.8	3.3	2.2	1.3	3.1	1.7
Ca	450	194	576	264	322	420
Cd	0.1	0.0	0.4	0.1	0.1	0.2
Ce	60.6	47.0	73.1	98.2	53.8	85.6
Co	1.6	0.6	2.8	1.7	1.1	2.3
Cr	164	165	192	188	165	190
Cs	7.5	1.0	5.5	4.7	4.2	5.1
Cu	183.9	18.5	224.6	827.2	101.2	525.9
Fe	32,043	13,731	31,703	20,814	22,887	26,258
Ga	15.4	15.6	13.8	12.0	15.5	12.9
Ge	0.2	0.2	0.2	0.2	0.2	0.2
Hf	0.8	1.3	0.9	1.0	1.0	1.0
In	0.2	0.0	0.2	0.1	0.1	0.2
K	35,185	30,356	42,142	50,782	32,770	46,462
La	35.1	28.5	40.5	67.0	31.8	53.7
Li	11.4	5.2	11.8	10.8	8.3	11.3
Mg	3,871	2,222	2,733	2,365	3,047	2,549
Mn	60	20	76	39	40	37
Mo	81.3	20.0	68.9	293.5	50.6	181.2
Na	1,045	918	1,311	2,388	982	1,850
Nb	2.8	3.5	2.8	2.8	3.1	2.8
Ni	5.4	3.8	5.0	7.4	4.6	6.2
P	1,141	112	590	558	626	574
Pb	27.8	11.6	211.7	34.3	19.7	123.0
Rb	175.4	130.3	171.8	185.2	152.9	178.5
Re	0.004	0.002	0.006	0.005	0.003	0.005
S	6,412	1,788	9,381	3,139	4,100	6,260
Sb	7.8	2.5	16.0	6.9	5.1	11.5
Sc	13.4	9.8	6.3	8.1	11.6	7.2
Se	2	6	4	3	4	4
Sn	5.9	12.6	5.4	4.6	9.2	5.0
Sr	26.8	21.9	80.5	92.5	24.3	86.5
Ta	0.3	0.4	0.2	0.2	0.3	0.2
Te	0.3	0.7	1.1	0.1	0.5	0.6
Th	22.9	8.5	20.6	12.4	15.7	16.5
Ti	1,624	1,310	926	1,018	1,467	972
Tl	1.9	0.9	1.9	1.7	1.4	1.8
U	1.9	1.2	2.1	11.6	1.5	6.9
V	87	72	46	62	80	54
W	32.2	57.3	33.1	69.1	44.8	51.1
Y	6.1	3.3	5.1	5.5	4.7	5.3
Zn	24	4	45	30	14	37
Zr	18.3	29.7	24.8	29.8	24.0	27.3

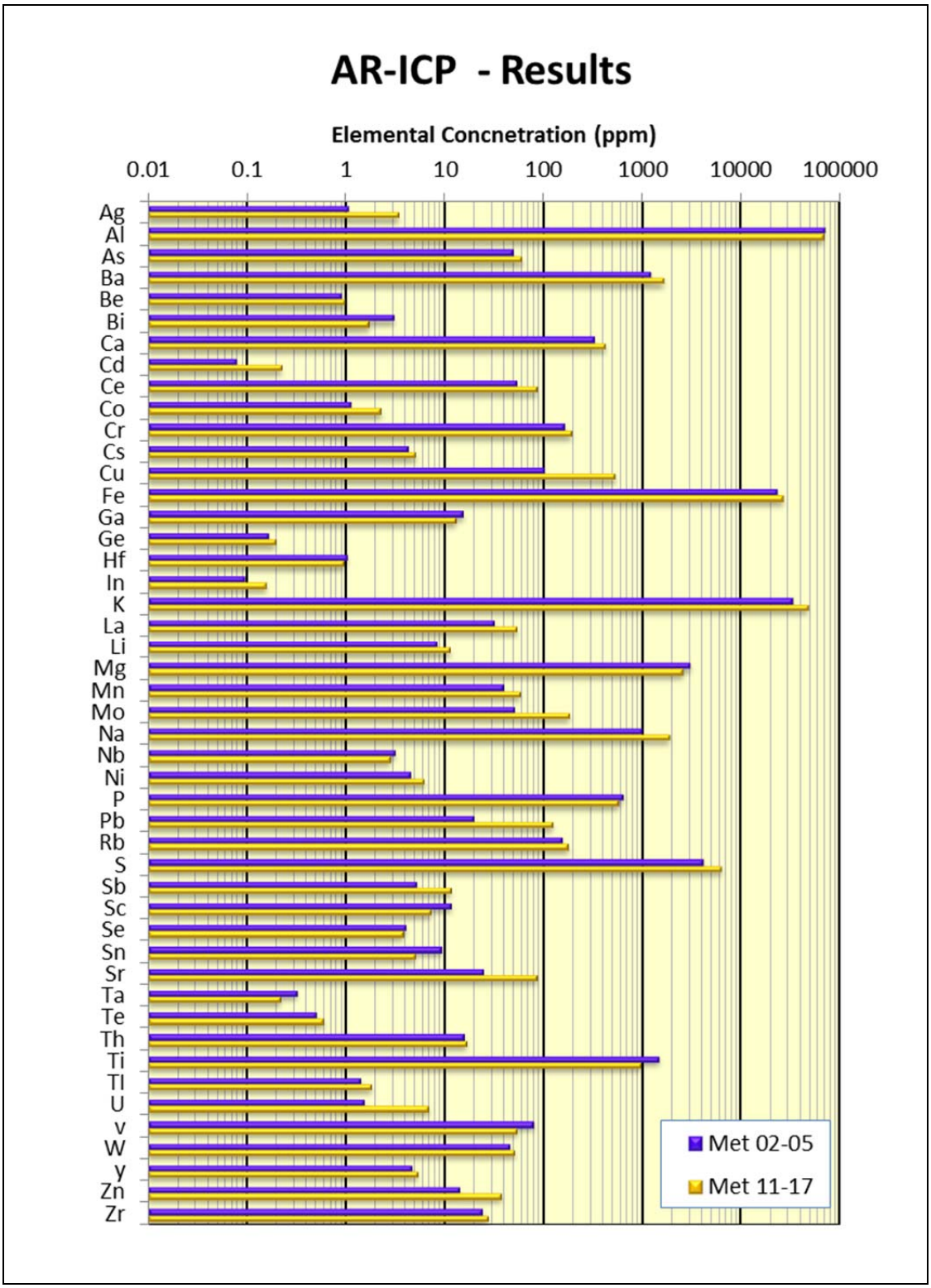

Figure 1.2 AR-ICP on pulps of Casino composites

Table 1.5 Gold and Silver content by size fraction						
Size Fraction	ALS (2013)			Metcon (2014)		
	W. Retained (%)	Au (ppm)	Ag (ppm)	W. Retained (%)	Au (ppm)	Ag (ppm)
Met 02-05						
2"	0			2.03	0.46	1.20
+1.5"	14.15	0.65	1.72	10.91	0.31	1.00
+1"	10.55	0.37	1.17	11.99	0.26	0.90
+3/4"	8.85	0.29	1.03	6.18	0.24	0.70
+1/2"	9.35	0.22	0.76	8.23	0.23	0.70
+1/4"	18.05	0.20	0.66	17.06	0.17	0.50
+10 mesh	23.40	0.20	0.70	26.91	0.14	0.50
-10 mesh	15.7	0.64	1.55	16.69	0.57	1.70
Met 11-17						
2"	0			7.06	0.46	2.70
+1.5"	31.60	0.28	2.70	22.89	0.54	2.20
+1"	25.00	0.47	2.93	29.64	0.51	2.60
+3/4"	13.15	0.70	3.34	9.92	0.44	2.60
+1/2"	8.70	0.52	3.04	8.67	0.46	2.20
+1/4"	7.60	0.56	3.45	7.48	0.43	3.50
+10 mesh	6.30	0.52	4.00	6.04	0.52	2.80
-10 mesh	7.75	1.53	7.53	8.29	1.00	4.30

- According to the Metcon data, for Met 02-05 about 16% of the Au and about 16% of the Ag occurs in the size fractions larger than 25.4 mm (1") in size. For Met 11-17 about 29% of the Au and more than 25% of the Ag occur on these coarse fractions.
- Similarly, Metcon's data show that for Met 02-05 35% of the Au and about 34% of the Ag are present in the minus 1.7 mm fraction. For Met 11-17 these numbers are 15.4% and 13.2%, respectively. These data suggest that everything else being equal, Met 02-05 should leach better than Met 11-17.
- A comparison between the data generated by ALS with the assays determined by Metcon shows that these data sets produce similar results lending confidence to the head assay values.

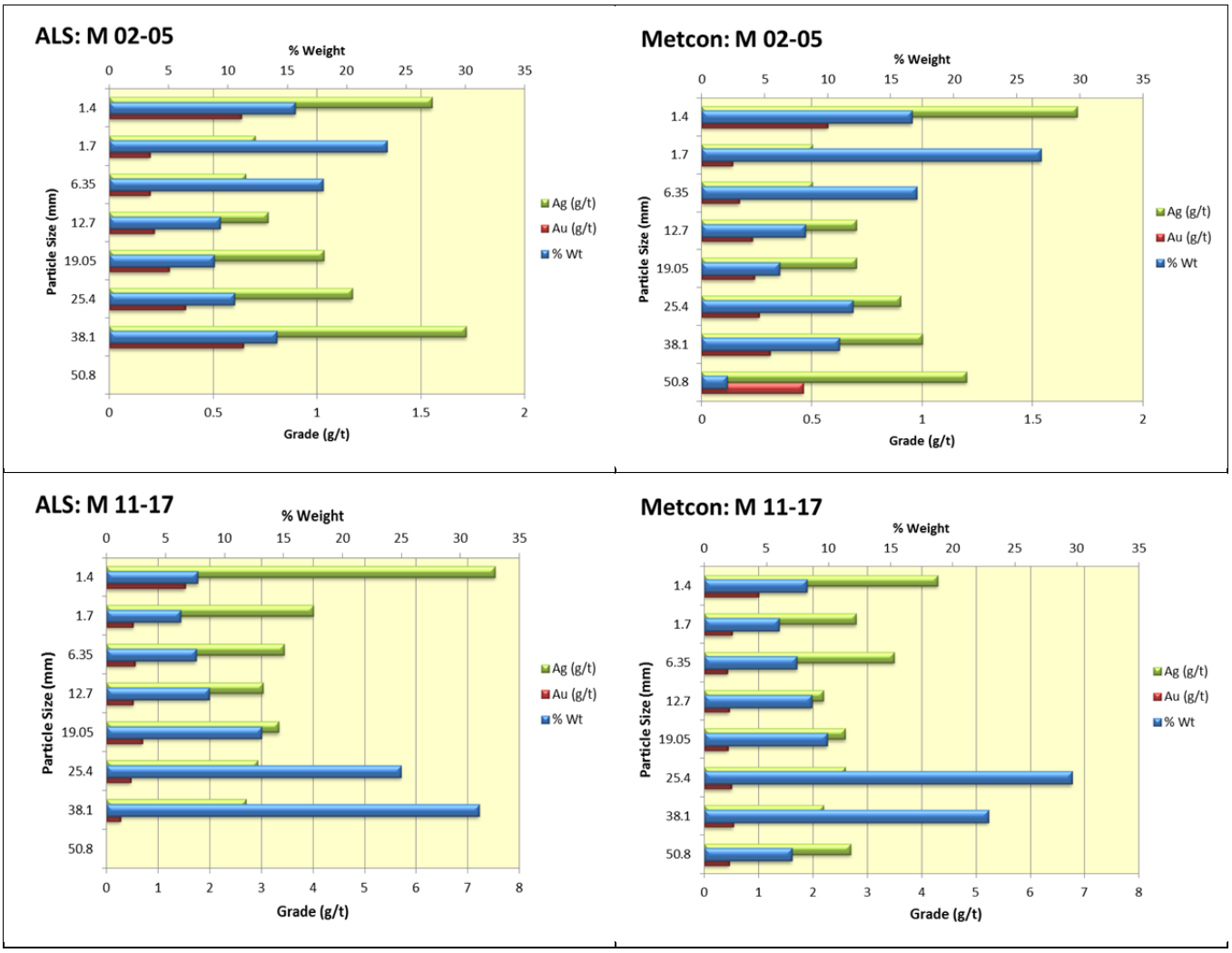

Figure 1.3 Gold and silver grade distributions by size fraction and percent retained

1.4.3 Mineralogical characterization

HGS recommended to WCG to undertake mineralogical characterization of the samples in an attempt to understand the mineral assemblage responsible for the mineralization. HGS coordinated with SGS personnel to deliver a one-kilogram split of each of the three Casino composites to FL Smidth to determine: the gangue mineralogy, abundance of clay minerals, potential cyanide consuming minerals, and mode of gold occurrence. In addition, WCG undertook QEMSCAN of the composites.

For completeness and to help with the interpretation of the data derived during this characterization effort, the following paragraphs provide a brief discussion of the findings by FLS for the two composites of interest, namely;

Met 02-05 and Met 11-17. For a complete analysis and discussion of the procedures used to generate these data the interested reader is refer to the FLS report (FLS, 2014)[2].

Gangue mineralogy

The bulk gangue mineralogy determined by FLS is summarized graphically in Figure 1.4. These data show:

- The gangue is composed predominantly by quartz ($Si0_2$) and alumino-silicate minerals; K-feldspar ($2KAlSi_3O_8$) and Muscovite ($KAl_2(AlSi_3)O_{10}(OH)_2$). Chlorite ($(Mg,Fe)_3(Si,Al)_4O_{10}(OH)_2 \bullet (Mg,Fe)_3(OH)_6$) is present in a minor amount in Met 19-20. These minerals make up about 88%, 85% and 81% of the gangue minerals in Met 02-05, Met 11-17 and Met 19-20, respectively.
- The quartz fraction is quite different from each of the composites, 55.5% for Met 02-05, 41.7% for Met 11-17 and 36.8% for Met 190-20.
- The secondary alumino-silicate minerals include Kaolinite ($Al_2Si_2O_5(OH)$), with some swelling clays representing 5.5%, 6.0% and 7.7% for Met 02-05, Met 11-17 and Met 19-20, respectively.
- Iron oxides include Jarosite ($KFe^{3+}{}_3(OH)_6(SO_4)_2$) and Hematite ($Fe_2O_3$). The presence of these minerals confirms the conclusion reached from the ICP data regarding iron in the Casino samples being indeed representative of oxide minerals.
- The concentrations of Ti identified by the ICP analysis are explained by the presence of Rutile (TiO_2) in all three composites.
- Met 11-17 and Met 19-20 are similar except for the presence of Plagioclase (a transition feldspar), Chlorite, and Hematite on the latter.

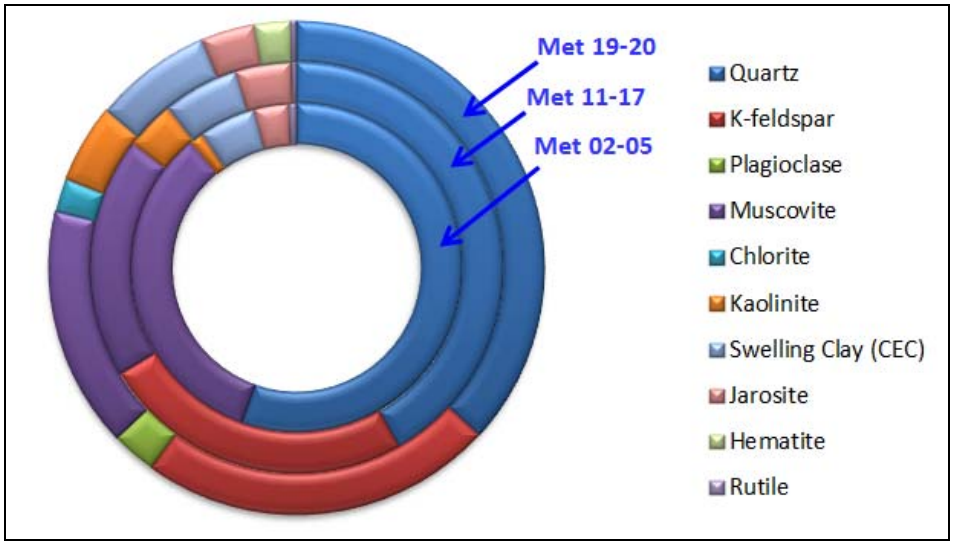

Figure 1.4 Casino – Bulk gangue mineralogy (After FLS, 2014)

[2] FLSmidth 2014. Draft Technical Report, M-14085 Western Copper & Gold Casino Samples.

Potential Cyanide Consuming Minerals

Based on the mineralogical characterization from FLS and other mineralogical data, the potential CN consuming minerals include:

- Metal sulfides including copper, iron, arsenic and zinc;
- Iron oxide-hydroxides such as Limonite and Jarosite which can also act as preg-robbing. Further, Jarosite as well as other acidic materials may also induce lower pH values which may promote CN destruction; and
- Secondary alumino-silicates and swelling clays to a minor extent.

Mode of Gold Occurrence and Potential Solubility

The FLS report indicates that:

- Given the low grades of the material it is extremely difficult to mineralogically characterize the occurrence of gold and further characterization was recommended by FLS.
- From the fact that no visible gold was observed in the received composites or in their gravity concentrates, and the results of the cyanide solubility, FLS conclude that the gold occurs primarily as sub-microscopic native gold.
- Shake leach tests at various concentrations of CN were used to determine the potential solubility of gold. These tests were conducted on 10 g with a P_{95} of minus 106 micron and show that:
    - Au recoveries increase with increased CN concentrations. A CN concentration of 3 g/L results in an average Au recovery of about 61% for all the three composites;
    - Increasing CN concentration produces additional Au recovery for composites Met 11-17 and Met 19-20 but not for composite Met 02-05. Even at a CN concentration of 50 g/L at which the other composites yielded an Au recovery greater than 97%, the recovery for the latter was only 75%.
    - It is our contention that the additional recovery on the first two composites results from the dissolution of sulfide minerals (sulfide encapsulation due to, but not exclusively, copper sulfides) which may be coating the Au minerals and dissolve in the presence of higher CN concentrations. On the other hand, the limited Au recovery in Met 02-05 is likely associated to silica encapsulation.

The available head grade for composites Met 02-05 and Met 11-17 for copper, Au and Ag are summarized in Table 1.6. These data show a good correspondence between these three data sets lending confidence in the sample preparation and analytical methods as well as on the values of the head assays.

Given the low Au grade on these composites, it would be important to understand the minerals responsible for the copper values. FL Smidth recommended and conducted QEMSCAN analysis to try to identify the copper minerals present on these samples. However, FLS indicated that given the low concentration of Cu (< 5%) and the accuracy of this method (0.1% by weight), only a small fraction of the Cu (33% for M 02-05 and ~8% for M11-17 and M 19-20) was detected which prevented full determination of Cu deportment. Notwithstanding these limitations, the QEMSCAN characterization shows that Chalcopyrite is the dominant Cu-sulfide and that

some Cu bearing Iron Oxides are present in M 11-17 and M 19-20 but not in M 02-05. The results from the FLS study reinforce our conclusion that Met 02-05 would metallurgically outperform the other two composites.

Table 1.6 Head Grades for Casino Composites

Lab	ALS*			FLS			Metcon		
Sample ID	Cu (%)	Au (ppm)	Ag (ppm)	Cu (%)	Au (ppm)	Ag (ppm)	Cu (%)	Au (ppm)	Ag (ppm)
Met 02-05	0.010	0.36	1.06	0.01	0.32	<2.0	0.009	0.32	0.8
Met 11-17	0.053	0.53	3.39	0.06	0.47	2.9	0.051	0.55	2.7

*Composite assays calculated from individual assays assuming a 1:1 mix

2.0 HYDRODYNAMIC CHARACTERIZATION

Over the years, the leaching community has bought into the false precept that as long as an ore is very permeable it is good for a leaching process and therefore standard geotechnical characterization is typically limited to the measurement of the saturated hydraulic conductivity. ROM ore and crushed ore devoid of fines are good illustrations of the falsehood of this assertion. In these materials, the leaching solution will indeed move quickly through the ore bed but it will do so with minimal solution-to-ore contact resulting in an inefficient leaching process. Solution bypass through the coarse fractions and pooling on the fines fractions is a common occurrence in ROM heaps which leads to inefficient metal recovery. As discussed in the following paragraphs, a leaching material must not only be permeable but should satisfy a number of other physical and hydraulic requirements.

Industrial experience worldwide shows that the lack of ore preparation standards, in general, and of agglomeration standards, in specific, results in significant variability from day to day and from operation to operation. Improved agglomeration significantly enhances hydrodynamic performance of the ore and hence the metallurgical performance of the process. With this in mind, HGS developed the following scale to qualify the condition of the ore delivered to a heap; a non-agglomerated sample is assigned a Level 0 (L0), while a sample that has been fully agglomerated is assigned a Level 5 (L5). Most crushed, agglomerated ore leaching operations are working with an intermediate agglomerated product with a quality below L3. Recent experience shows that attaining higher levels of agglomeration (L3 to L5) is feasible once the necessary conditions have been identified and operators have been properly trained[3]. It is important to recognize that low levels of agglomeration and ROM ore placement result in particle size segregation along the heap profile, which in turn promotes solution segregation (channeling), protracted leach cycles and overall poor leaching efficiency.

[3] Guzman, A., R.E. Scheffel and S. Flaherty 2006. *Geochemical Profiling of a sulfide leaching operation: A case study*. SME 2006 Spring Meeting. March 2006 St. Louis, Mo

Application of the above agglomeration scale helps explain the discrepancies often encountered amongst metallurgical tests as well as the difference between lab-scale tests and industrial leaching operations. We have concluded[4] that optimal agglomeration needs to satisfy the following specifications:

1.0 Bind all the dispersed fines to minimize their negative effect on the percolation and solution-retention capacity of the ore;

1.1 The percolation capacity of the ore should be at least 100 times larger than the typical application rate (10^{-4} cm/s) for a dynamic heap, and at least 1,000 times larger than this rate for a multi-lift heap.

1.2 The maximum solution retention capacity during irrigation should result in a liquid degree of saturation smaller than or equal to 75% for an oxide-leaching operation or 60% for a sulfide leaching operation.

1.3 Air conductivity should remain larger than 10^{-3} cm/s.

2.0 The resulting porous structure yields at the maximum lift/heap height a total porosity larger than 30% which is partitioned between macro- and micro-porosity of about 50:50 to facilitate bulk solution movement and intimate contact between solution and ore;

3.0 The porous structure is sufficiently resilient to withstand deformation and physical stress resulting from the design heap-height;

4.0 The agglomeration product is sufficiently resilient to chemical decrepitation;

5.0 The agglomeration product and resulting porous structure is able to withstand flooding without major loss of structural integrity; and

6.0 Produce an agglomeration product which promotes leaching bed homogeneity, uniform flow distribution and equal opportunity-leaching for all the size fractions.

All these specifications are more critical in the case of a multi-lift heap where the material will be exposed to the cumulative effect chemical decrepitation and compaction resulting from multiple leaching cycles. In general, alkaline leaching conditions (as those used in the leaching of Au and Ag) produce less decrepitation than that observed in acidic leaching conditions (as those used in the leaching of Cu, Zn and Ni) so the conditions specified on item 1) above may be relaxed slightly.

With these requirements in mind, two testing procedures (the Stacking Test and the Hydrodynamic Column Test) were developed based on experience from the hydrological sciences and observations in more than 50 leaching operations worldwide. **These test procedures provide the most complete characterization of the physical and hydrodynamic properties of an ore-for-leach available to the mining industry.**

[4] A. Guzman, S. Robertson and B. Calienes, Constitutive relationships for the representation of a heap leach process, in The **Heap Leach** Solutions 2013 Proceedings Vancouver, Canada, September 22-25, 2013.

Extensive experience with the application of these procedures to the leaching processes on a variety of minerals including crushed-agglomerated ore and ROM ore indicates that:

- Ore bulk density controls the hydrodynamic performance of the ore;
- Bulk density varies in a non-linear fashion along the heap profile and strongly depends on ore preparation practices (particle size distribution, crushing approach, agglomeration and additives, and stacking mode);
- Hydrodynamic performance controls operational conditions, metallurgical performance as well as geotechnical performance of the ore mass; and
- As such, it is critical to recognize that operational conditions for a given ore sample depend on ore preparation techniques, method of stacking and equally important, the bulk density of the ore.

In practical terms, a large difference between the Stacking Test results from Level 0 and Level 5 material indicates a strong sensitivity of the hydrodynamic properties of the ore and highlights the need for optimizing the agglomeration process. On the other hand, a relatively small gap between L0 and L5 STs suggests that the ore is robust enough and that a sub-optimal agglomeration product would not greatly impact the performance of the leaching process.

The following sections provide a brief overview of these procedures, test conditions, and the results from their application to the Casino head composites.

2.1 Testing Solution

Testing with a representative solution (density, viscosity, and bulk chemistry) is a key procedural practice that has been overlooked during the measurement of hydrodynamic properties in the context of the design of many heap leaching operations. This oversight typically results on erroneous conclusions regarding the hydraulic performance of the ore. With this in mind, the tests requiring solution were conducted as follows:

- Tap water with 0.13 g of lime per liter of water to obtain a pH close to 11.3 for the agglomerating solution and Stacking Tests.
- The HCTs used tap water with 0.10 g/L of lime, a pH of 11.2 plus 0.5 g/L of NaCN for the irrigating solution.

Saturated hydraulic conductivity tests were conducted using synthetic raffinate to make the results from these tests as representative as possible. The moisture content values represented in Table 2.1 represent the optimal moisture required to achieve an agglomeration level of L3 (the typical attainable at an industrial scale without much difficulty).

Hydraulic conductivity is directly proportional to the solution density and inversely proportional to the viscosity of the solution. The specific gravity (S.G.) of the synthetic raffinate was measured at 1.00. It is noted that all values of saturated hydraulic conductivity reported on this document have been normalized to a temperature of 20°C to account for the variation of solution viscosity as a function of temperature.

2.2 Stacking Tests

A Stacking Test[5] (ST) simulates the lithostatic load resulting from the weight of the ore as the height of the heap increases. A ST is performed by placing an ore sample into a test cell and mechanically increasing the confining load to simulate the effect of heap height on the bulk density of the ore. The load is increased in a stepwise fashion, allowing for height stabilization during each of the loading steps. The density and permeability of the ore are measured at each step and then the load is increased to simulate additional lithostatic loading. The maximum load for a stacking test is selected to represent either the maximum lift height in the case of a dynamic heap or the maximum heap height in the case of a permanent (multi-lift) heap[6]. A soft-ore produces a steep density profile indicative of a rapidly changing hydraulic conductivity profile while a competent ore produces relatively flat density and conductivity profiles. The stacking test is conducted under partially saturated conditions, containing only the moisture of agglomeration (or as-drained moisture in some cases), as opposed to fully saturated conditions typically employed in similar studies conducted by geotechnical practitioners. The results from a Stacking Test include:

- *Density profile* – defines the relationship between the ore density and heap height. This profile provides a direct measurement of the physical integrity of the ore sample under load and, as such, it quantifies the robustness of the pore structure resulting from the selected ore-preparation practice;
- *Hydraulic conductivity profile* – defines the relationship between the ore conductivity and heap height. These data represent a direct measurement of the integrity of the porous structure and its resilience under various heap heights and determines the effect of physical and chemical decrepitation (when using a leached sample) on the percolation capacity of the ore;
- *The minimum hydraulic conductivity of the sample* – By design, the results from a Stacking Test represent the bulk density, ore permeability and, at the end of the test, the saturated hydraulic conductivity of unit volume of ore located at the bottom of the heap. Therefore, the saturated hydraulic conductivity value at the end of the load-sequence indicates whether the heap is sufficiently permeable at its ultimate height to allow free drainage of the pregnant leach solution (PLS) to the collection system;
- *Preliminary estimates of total-, micro- and macro-porosity* – these preliminary estimates provide a direct indication of the capacity of the sample to support percolation leaching. Ample data from industrial operations indicate that a total porosity of at least 30% is required for proper solution and air percolation. In addition, a 50:50 portioning of the porosity into micro- and macro-components has been determined to provide a good balance between advection and diffusion controlled solution movement.

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[5] A. Guzman and R.E. Scheffel, The Fundamentals of Physical Characterization of Ore for Leach, in International Symposium Hydrometallurgy (6th: 2008 Phoenix, AZ). Edited by C.A. Young et al., SME.

[6] A. Guzman, S. Robertson and B. Calienes, Constitutive relationships for the representation of a heap leach process, in The **Heap Leach** Solutions 2013 Proceedings Vancouver, Canada, September 22-25, 2013.

- *The maximum lift and heap height* – Data from the density and permeability profiles provide a direct measurement of the lift and heap height at which the leaching process will allow unimpeded percolation of solution.

As described above, two composites from the Casino ore body were subjected to the ST procedure under different conditions of agglomeration. To accommodate the coarser nature of Met 11-17, the STs were conducted on 8" diameter cells. The agglomerated samples were targeted to an optimal condition (L5), however, due to the high proportion of gravel size fragments agglomeration for Met 02-05 reached an intermediate level of agglomeration (L3) while the coarser composite Met 11-17 reached a low level of agglomeration (L2). In addition, to fulfilling the tests the test matrix (Figure 2.1), we also tested a 1:1 blend of Met 02-05 and Met 11-17 under a non-agglomerated condition and a 2:1 blend of these composites under a L# agglomeration level. A total of 8 STs were conducted as summarized in Table 2.1.

Figures 2.1a and 2.1b present a visual record of the samples used during this characterization; non-agglomerated (L0) and agglomerated (L2 and L3). As indicated by the contrast in porous structure between the L0 and L3 samples, despite the low level of fines on the Casino samples, it seems likely that agglomeration has a positive impact on the hydrodynamic performance of the ore – more so for sample Met 02-05 with smaller top size and larger amount of fines. Agglomeration of the 2:1 blend of M 02-05 and M 11-17 (Figure 2.1b) produces a significant improvement of the porous structure when compared with the agglomerated samples of either one of these composites (Figure 2.1a).

Table 2.1 presents the sample identification (ID) together with the conditions for each of the STs. The sample ID contains information about the Composite (M-02-05, M-11-17 or Blend of these two), type of lime mixed with the initial non-agglomerated sample (Peb for Pebble and Pow for Powder), and the level of agglomeration (L0, L2 or L3). Powder lime was used for the remaining tests (agglomerated samples, blended non-agglomerated sample and the samples used on the HCTs described below). Also included are the Specific Gravity, the moisture content, maximum test height, minimum and maximum bulk density, minimum and maximum air conductivity, and minimum saturated hydraulic conductivity.

As indicated in Table 2.1, a 1:1 blend of composites Met 02-05 and Met 11-17 was prepared and tested under non-agglomerated conditions to evaluate the potential benefit of mixing these two samples. An additional 2:1 blend of these samples was prepared and tested under a L3 agglomeration level to document the beneficial impact of agglomeration on the Casino composites.

The samples were initially tested to a maximum heap height of about 70 m for the initial, then to about 140 m to simulate the range of heap heights considered within the current heap design. As discussed below, the load sequence was selected to generate sufficient detail over the range of heap heights relevant to the current multi-lift heap. It is noted that the slope of all the density profiles generated to date seem to steepen once the simulated heap height increases beyond twenty meters.

By design a Stacking Test determines the effect of lithostatic load on the degree of compaction of a sample. These results are presented on and X-Y semi-log plot where the Y-axis represents the bulk density (dry mass of ore per unit volume) and the X-axis represents the lithostatic load expressed in terms of the associated heap height. The shape of the density profile is in general diagnostic of the physical competence (strength) of the ore

such that a "soft" or "weak" ore is characterized by a steep density profile while a competent, strong sample is described by a flatter density profile. It is noted, however, that the slope of the density profile is also affected by the initial porous structure of the sample such that the density profile of a fully agglomerated sample might be steeper than that from the corresponding non-agglomerated sample. Notwithstanding, this stepper density profile, the fully agglomerated samples invariably have a much higher percolation capacity than the non-agglomerated sample due to its more organized porous structure.

As such, interpretation of the results from a ST requires combined analysis of the density and conductivity profiles as well as the preliminary estimates of the total porosity and its partition into macro and micro. The following sections present a summary of the results in graphical form for the density and the conductivity profile as well as the partition of porosity into its micro- and macro-components to facilitate evaluation of the impact of the various testing conditions.

Appendix A at the end this document presents the laboratory report for each of the STs conducted as part of this investigation.

Sample	L0 w/ Pebble Lime	L0 w/ Powder Lime	Agglomerated w/ Powder Lime
M 02-05			
M 12-17			

Figure 2.1a Photographs of Casino samples

	Test Charge	Close-up	Detailed View
L0			
L3			

Figure 2.1b Photographs of Casino M02-05 & M11-17 blend 2:1 agglomerated

Table 2.1 Stacking Tests Conditions and Results										
Test ID	SG	Agglomeration		H_{Max}	Bulk Density			Ks min	Ka min	Ka max
	( )	Level	Moisture	(m)	Min (t/m^3)	Max (t/m^3)		(cm/s)	(cm/s)	(cm/s)
M-02-05-Peb-L0	2.660	L0	0.4%	70.6	1.68	1.84	?	1.1E-01	1.6E-02	2.3E-02
M-02-05-Pow-L0	2.660	L0	0.4%	71.2	1.65	1.84	?	9.9E-02	1.2E-02	1.5E-02
M-02-05-L3	2.660	L3	5.7%	129.2	1.51	1.91	?	1.0E-01	2.4E-02	5.8E-01
M-11-17-Peb-L0	2.632	L0	0.3%	82.5	1.40	1.57	✓	2.3E-01	6.1E-01	7.5E-01
M-11-17-Pow-L0	2.632	L0	0.3%	120.3	1.36	1.56	?	7.7E-02	1.4E-01	2.4E-01
M-11-17-L2	2.632	L2	2.4%	147.7	1.43	1.73	✓	2.0E-01	4.2E-01	2.6E+00
M02-05+M11-17 1:1-L0	2.645	L0	0.3%	138.1	1.51	1.88	?	1.4E-01	3.6E-02	1.1E-01
M02-05/M11-17 2:1-L3	2.651	L3	5.5%	130.7	1.43	1.89	?	1.5E-01	2.7E-02	7.2E-01

2.2.1 STs on Casino Composite Met 02-05

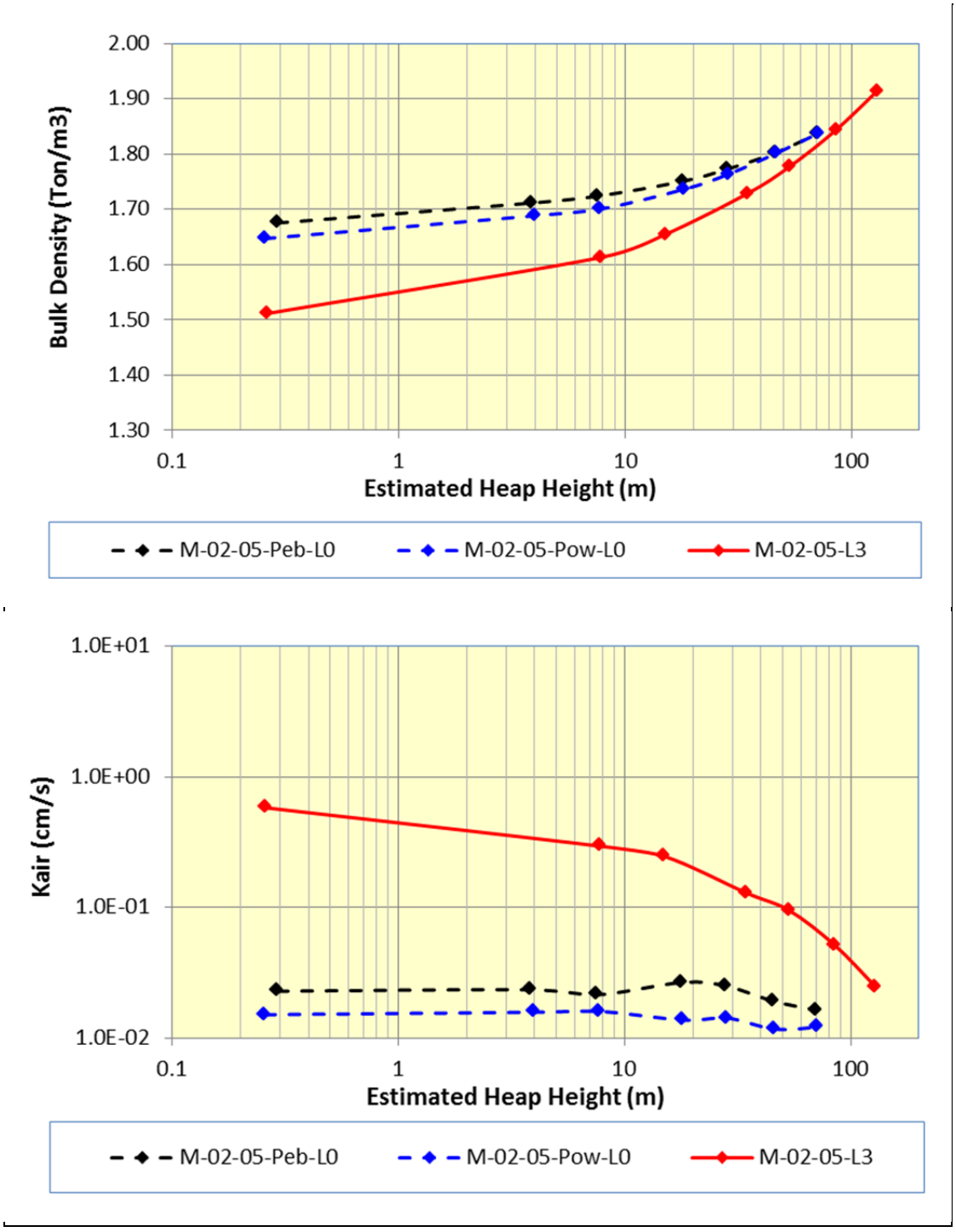


Figure 2.2 Density and conductivity profiles for Composite Met 02-05

2.2.2 STs on Casino Composite Met 11-17

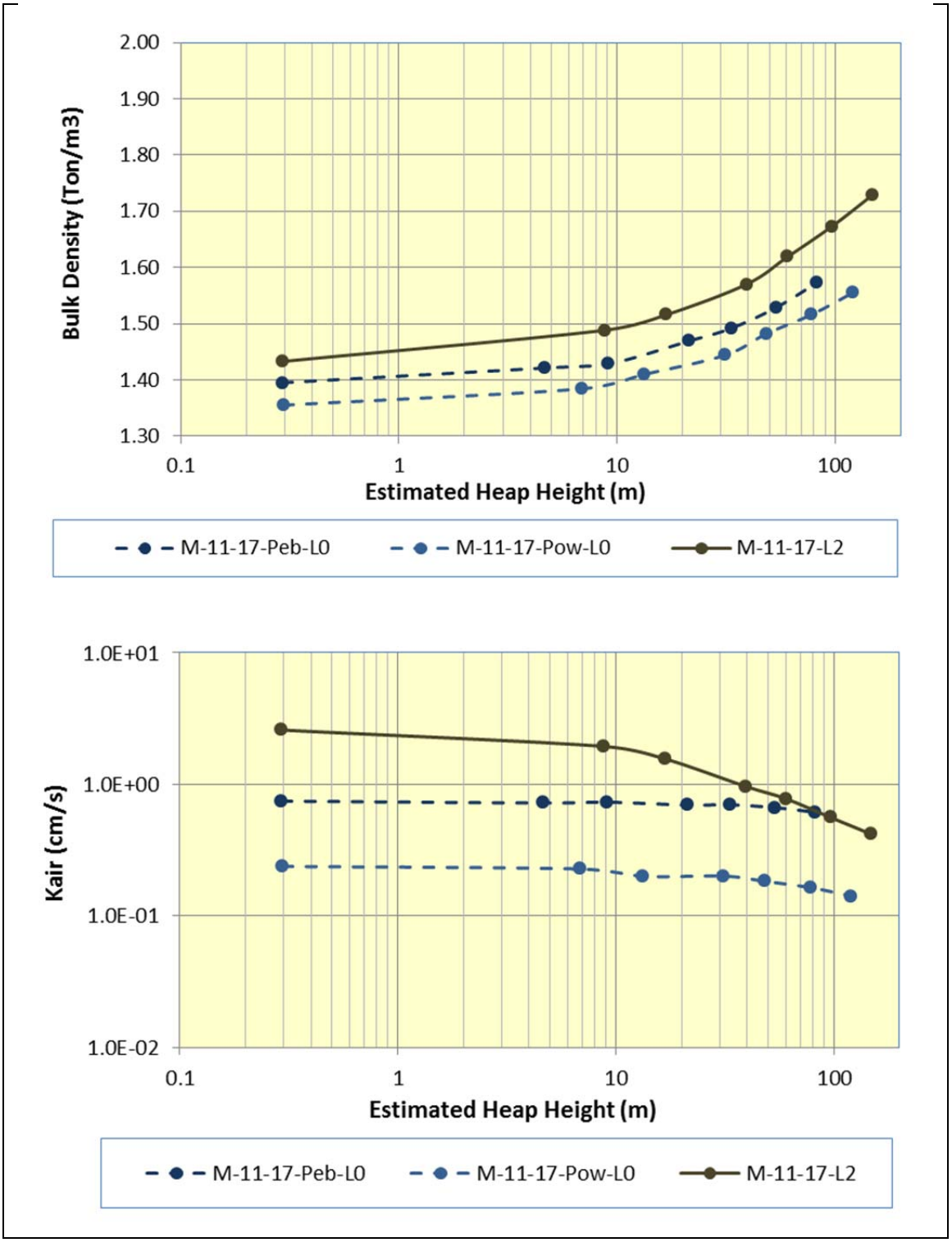


Figure 2.3 Density and conductivity profiles for Met 11-17

2.2.3 Comparison of STs Results for Blended Casino Composite

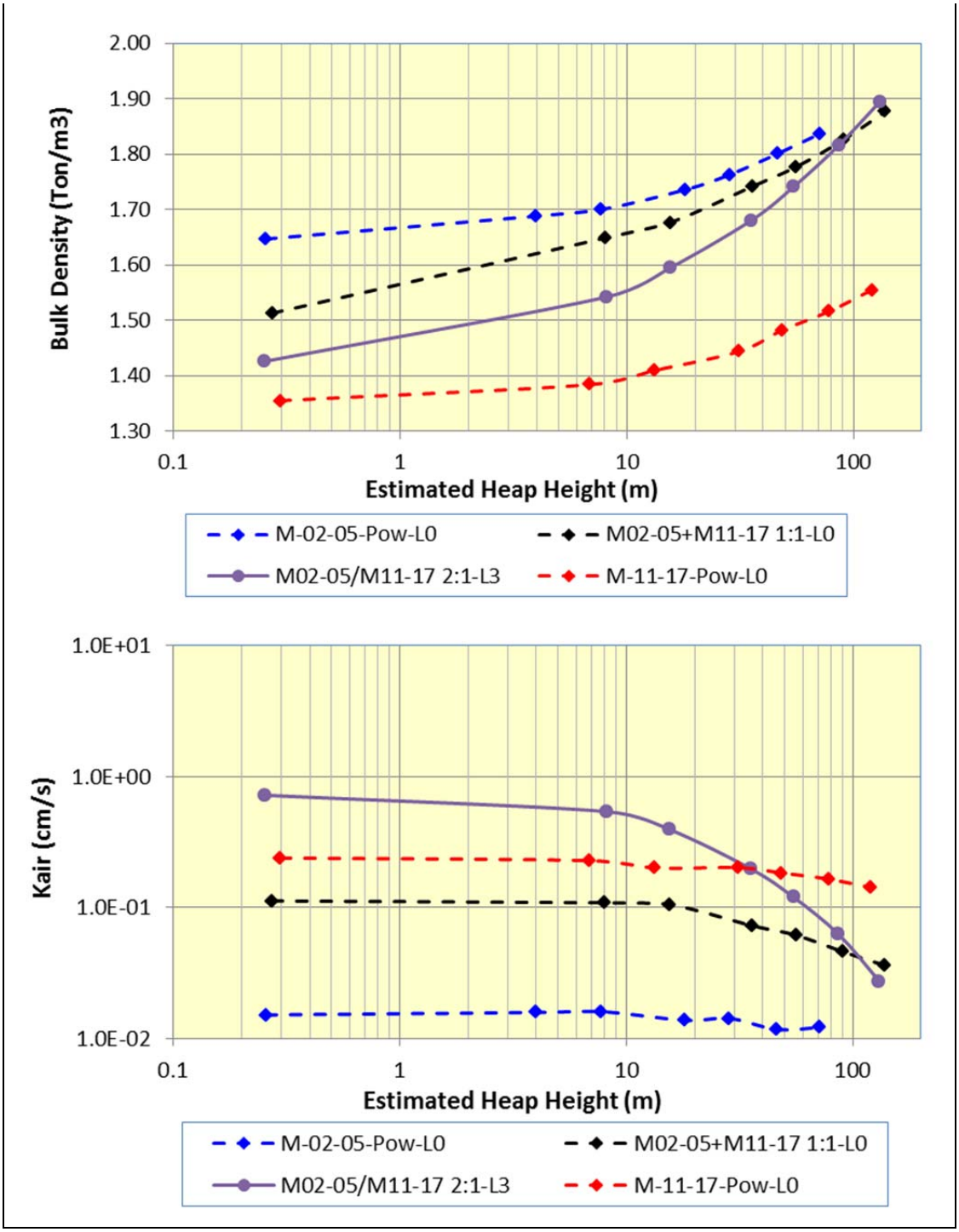


Figure 2.4 Comparison of Density and conductivity profiles for Blended Composite

2.2.5 Preliminary values of porosity partitioning

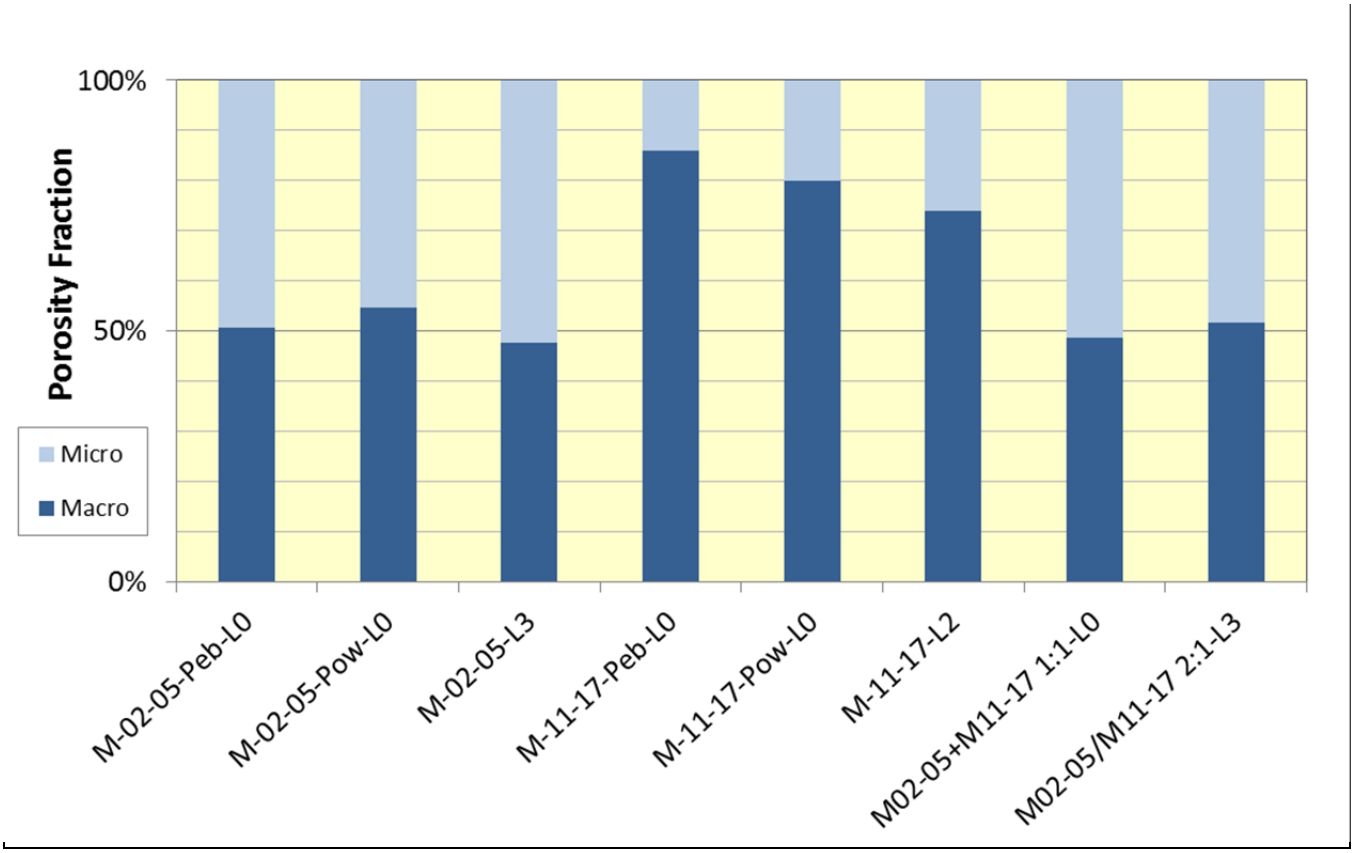


Figure 2.7 Partition of total porosity

2.2.6 Discussion of Stacking Tests Results

The results from the STs for the Casino samples are presented in Figures 2.2 to 2.4. Inspection of these data shows that:

- The bulk density and conductivity of all the samples are a function of the heap height. As the heap height increases the density increases and the conductivity (percolation capacity) decreases in a non-linear fashion. The change in these properties is relatively minor over the range of heap heights evaluated on this study (h < 145 m) indicating that the Casino composites are mechanically competent.
- The type of lime used for alkalinity amendment has an effect on both the density and conductivity profiles. This is interesting in that the alkalinity dosage was identical (2.93 kg/t) on these samples and the only difference was the texture of the lime; pebble or powder.
- The results from the STs show that alkalinity amendment with pebble lime slightly increases the density and the conductivity of these two composites. Although, the industrial significance of these difference is minor because using pebble lime would not be practical, they highlight some very important technical details:

  - The texture of the fines (dispersed versus clumped in this particular case) has a measurable effect on the hydrodynamic response of a sample;
  - The shape and actual values of the density and conductivity profiles are able to identify changes as small as 0.3% in the pore structure; and
  - Designing optimal conditions by controlling the PSD, ore preparation practices (as shown below) and measuring the impact of these changes via the Stacking Tests are attainable.
- Agglomeration (although not optimal due to the level of fines present on the Casino samples used for this evaluation; < 4% minus 200-mesh) provides a noticeable improvement on both the density and conductivity profiles with respect to those of the non-agglomerated samples even for the very coarse composite (Met 11-17).
- The conductivity profiles (bottom frames on Figures 2.2 to 2.3) confirm the beneficial effect of agglomeration showing an increase in conductivity of one order of magnitude (a factor of 10) for both composites (Met 02-05 and Met 11-17).
- Similarly, blending and agglomeration (Figure 2.4) produce a significant improvement on both the density and conductivity profiles. **These results show that ore preparation practices are therefore critical for an improved performance of the process.**
- Blending and agglomeration of Met 02-05 and Met 11-17 produced an improved sample from the hydrodynamic point of view, namely:
  - The density profile of the blended samples fall between those from the two original composites showing the incremental benefit of blending alone (M02-05+M11-17 1:1 L-0) and blending and agglomeration (M02-05/M11-17 2:1 L-3). The density of the agglomerated sample is smaller than that of the blended, non-agglomerated sample.
  - The conductivity profile of the blended samples is higher than that from the original M02-05-Pow-L0 composite showing the incremental benefit of blending alone (M02-05+M11-17 1:1 L-0) and blending and agglomeration (M02-05/M11-17 2:1 L-3) which produce conductivity values larger than those measured for the original M11-17-Pow-L0 composite. The conductivity of the agglomerated sample is larger than that of the blended, non-agglomerated sample.
  - These data indicate that blending all these samples would be beneficial for both composites from the point of view of their hydrodynamic performance (increasing conductivity for Met 02-05 and reducing the negative effect of the high gravel content for Met 11-17). Agglomeration further increase the benefit of blending.
  - Depending of the location of these composites with respect to the mining plan, blending all of these samples may be advantageous for the metallurgical process.
- Overall, the heap height has a small effect on the conductivity of the ore. As part of the ST procedure, each sample is fully saturated with synthetic raffinate, allowed to drain under the influence of gravity, and then reloaded to the maximum heap height simulated during the tests (~140 m). This portion of the ST determines the physical stability of the ore and its potential compaction at residual liquid saturation (typically larger than the optimal moisture of agglomeration) as expected to occur during the life of the multi-lift heap. The maximum compaction during reload was observed for the agglomerated samples. However, even **these values are smaller than 4.8% indicating a competent ore whose porous**

structure is able to withstand flooded conditions and the full lithostatic stress at its residual saturation.

Industrial experience on several different ore types (oxide and sulfide minerals) suggests that:

- For a dynamic (on and off) heap, a minimum saturated hydraulic conductivity of 100 times the application rate is required. For the recommended application rate of 6 L/h/m^2 (1.67 x 10^{-4} cm/s), this requirement translates into a minimum saturated hydraulic conductivity of 600 L/h/m^2 (1.67 x10^{-2} cm/s). For a multiple-lift (permanent) heap, the minimum saturated hydraulic conductivity requirement is 1,000 times the application rate to account for potential decrepitation, slumping and compaction. This requirement translates into a minimum saturated hydraulic conductivity of 6,000 L/h/m^2 (1.67 x10^{-1} cm/s) for a permanent heap.
    - As indicated in Table 2.1, all the samples tested during this program satisfy the requirement for a dynamic heap but some samples fall short of the requirement for the permanent heap. Of the samples prepared with powder lime, the non-agglomerated Composite Met 11-17 has the smallest K_s value (7.7 x 10^{-2} cm/s - 46% of the required value) while the projected minimum K_s for Composite Met 02-05 (9.9 x 10^{-2} cm/s) would be about 60% of the required hydraulic conductivity.
    - The minimum K_s value for the blend of these composites is 1.4 x 10^{-1} cm/s, interestingly higher than that for each of the composites. This improvement is attributed in the one hand to contribution of the coarser material from Met 11-17 and the beneficial effect of the sand fraction from Met 02-05 which prevents the migration of fines from Met 11-17. The fines tend to migrate and deposit along the heap profile forming low permeability layers.
    - Agglomeration increases the minimum saturated hydraulic conductivity of Composite Met 11-17 by a factor of three to 2.0 x 10^{-1} cm/s (120% of the required Ks) and has a smaller, though still positive, effect on Composite Met 05-02 (1.0 x 10^{-1} cm/s; 60% of the required K_s).
    - Blending produces a saturated hydraulic conductivity which essentially meets the 1,000 larger than the application rate requirement (1.4 x10^{-1} cm/s for M02-05+M11-17 1:1 L0) while the blended and agglomerated sample slight improves on the hydraulic conductivity (1.5 x10^{-1} cm/s for M02-05+M11-17 2:1 L3).
- As the total porosity approaches a value of 30% the ability of the ore to support percolation leaching is diminished. In addition, an optimal partition of the pore space consists of 50% micro-pores and 50% macro-pores to provide a good balance between advection and diffusion controlled solution movement. Inspection of the preliminary estimates of porosity and its partition into micro- and macro-components summarized in Table 2.2 below and Figure 2.7 shows that for the samples prepared with powder lime:
    - The total porosity of the agglomerated samples is smaller than that of the non-agglomerated samples; 31% versus 29% for Met 02-05 and 41% versus 35% for Met 11-17.

- The partitioning of the pore space of the Met 02-05 samples is close to the optimal; a macro/micro ratio of 55/45 for the non-agglomerated sample and slightly improved (48/52) for the agglomerated sample.
- However, the partitioning of the pore space for the Met 11-17 samples is dominated by macro-porosity (80/20 for the non-agglomerated and 74/26 for the agglomerated sample. The smaller improvement on composite Met 11-17 is due to its low fines content (2.0%) and its high gravel component (91.7%).
- Interestingly, the blended composite has a slightly lower total porosity (30%) but a macro- to micro-porosity partition of 49/51which is very close to the optimal (50/50).
- Similarly, the agglomerated 2:1 blend of M 02-05 and M 11-17 produces a micro to macro partition of 50:50.

- **The large component of the macro-porosity of the Met 11-17 non-agglomerated composite would translate into gravity-dominated flow where limited horizontal movement of solution occurs leading to inefficient wetting and limited metallurgical performance.** This type of flow conditions leads to poor metal extraction, inefficient reagent utilization and protracted leach cycles.
- In other words, an ore sample can be too permeable to be efficiently leached and more so if the irrigation scheme is not properly designed and operated to counteract the gravity-dominated flow.
- Composite Met 02-05 when not agglomerated may be able to support a percolation leaching process in heap with heights up to 70 m. An L3 level of agglomeration improves the percolation of this sample such that a heap as tall as 100 m may be supported.
- Notwithstanding the potential complications resulting from flow channelization, composite Met 11-17 may support percolation leaching in a heap with heights up to 140 m.
- Blending would lead to improved hydrodynamic and metallurgical performance of these two composites. The ST data from the agglomerated 2:1 blend of M 02-05 and M 11-17 indicate that this sample could support a heap height close to 140 m.

Table 2.2 Preliminary Estimates of Porosity

Test ID	SG	Agglomeration		H_{Max}	Minimum Porosity			Fraction (%)	
	( )	Level	Moisture	(m)	Total	Macro	Micro	Macro	Micro
M-02-05-Peb-L0	2.660	L0	0.4%	70.6	0.31	0.16	0.15	50.6	49.4
M-02-05-Pow-L0	2.660	L0	0.4%	71.2	0.31	0.17	0.14	54.6	45.4
M-02-05-L3	2.660	L3	5.7%	129.2	0.29	0.14	0.15	47.6	52.4
M-11-17-Peb-L0	2.632	L0	0.3%	82.5	0.40	0.35	0.06	85.9	14.1
M-11-17-Pow-L0	2.632	L0	0.3%	120.3	0.41	0.33	0.08	80.0	20.0
M-11-17-L2	2.632	L2	2.4%	147.7	0.35	0.26	0.09	73.9	26.1
M02-05+M11-17 1:1-L0	2.645	L0	0.3%	138.1	0.30	0.14	0.15	48.6	51.4
M02-05/M11-17 2:1-L3	2.651	L3	5.5%	130.7	0.30	0.15	0.14	51.6	48.4

- An important fact that needs to be considered in the analysis and interpretation of the results of the Stacking Tests is that all the samples tested to date represent fresh ore. Leaching typically results in chemical-induced decrepitation (more so under acidic conditions than alkaline conditions) which in turn negatively impacts the hydrodynamic properties of the ore. **Given that the Casino heap leaching process is designed as a multi-lift operation, it would be important that hydrodynamic properties of the leached residue after a three to four leach cycles be determined to define the potential impact of decrepitation on the long term operation of the heap. Given the favorable response of the blended, agglomerated samples it is expected that this long term condition could be easily managed.**

2.3 Hydrodynamic Column Tests

The hydrodynamic column test procedure provides the most complete characterization of the physical and hydrodynamic properties of an ore-for-leach at given bulk density. A Hydrodynamic Column Test (HCT) is performed by placing an ore sample into a column and subjecting the sample to a confining pressure equivalent to desired lift or heap height. The diameter of the test cell is selected to minimize potential wall effects on the determination of hydrodynamic parameters of the ore sample. Once the sample has been placed onto the test cell, the irrigation rate is varied over several orders of magnitude to evaluate the corresponding degree of saturation and the resiliency of the porous structure as the ore becomes increasingly wet. Each irrigation rate period is extended until steady state flow conditions are developed at which point the corresponding degree of saturation is measured. The maximum solution application rate is determined by the value at which the surface of the column becomes saturated (flooded). Once the ore is flooded, a saturated hydraulic conductivity test is conducted to quantify the maximum flow capacity of the ore (K_s). The relationship between irrigation rate and degree of liquid saturation (solution retention) varies from sample to sample and is strongly influenced by the ore preparation practice.

The parameters obtained from a HCT include: a) saturated hydraulic conductivity, b) hydraulic conductivity as a function of solution content (hydraulic conductivity curve), c) the moisture retention curve (the relationship between degree of saturation and pore pressure), d) the air permeability as a function of solution content (air conductivity curve), e) the drain down curve, and f) total, macro-, micro- and residual-porosity. As such, **the HCT provides a complete characterization of the potential hydrodynamic response of an ore sample under a percolation leaching process.** A description of each of the parameters obtained from the HCT test is as follows:

a) *Saturated hydraulic conductivity* – defines the maximum capacity of the ore to allow percolation of leaching solution. A saturated hydraulic conductivity (K_s) greater than or equal to 10^{-2} cm/s is a necessary but not sufficient condition to ensure an adequate metallurgical performance of an ore under percolation leaching at an industrial scale. As indicated above, the actual criteria for an adequate K_s is different for a dynamic heap (initial K_s greater than 100 times the application rate) than for a multi-lift, permanent heap (initial K_s greater than 1,000 times the application rate);

b) *Moisture retention curve* – provides the degree of saturation (moisture content) of the sample as a function of capillary (pore) pressure and hence defines the energy state of the solution within the pore

space. This parameter is critical if numerical modeling of the flow process would be pursued but not critical from a practical point of view of design of the leaching process;

c) *Hydraulic conductivity curve* – indicates the degree of liquid saturation resulting from a steady-state solution application rate. This is the critical parameter in the design of the leaching/bio-oxidation process since the liquid saturation not only defines the ability of the ore to allow solution and air movement (from the air permeability curve described below) through an ore sample, but also determines the mechanical stability of the ore;

d) *Air permeability curve* – provides the air flow capacity of the ore as a function of degree of liquid saturation (solution application rate). This is a fundamental design parameter for forced or natural aeration system, which has not been traditionally considered;

e) *Drain down curve* – provides an idea of the rate of solution drainage due to the action of gravity. It represents a critical parameter necessary to estimate residual solution (and metal) inventory, required rest time before over-stacking (for a permanent heap) or removal of the leached residue (for a dynamic heap), as well as the potential discharge volume and rate during closure and post-closure conditions;

f) *Total-, micro-, macro-, and residual-porosity* – the total porosity indicates the pore space per unit volume of the sample. For a given ore sample, in general, and in an agglomerated ore in particular, the macro porosity is associated with the pore space between rock particles/agglomerates while the micro-porosity represents the pore space within rock particles/agglomerates themselves. The residual porosity is the fraction of the pore space which will remain saturated even after a prolonged drain down period. Optimal agglomeration process produces a 50:50 micro to macro partition and minimizes the residual porosity.

By design a sample subjected to HCT represents a unit volume of ore located at the bottom of the lift (heap) – the target bulk density is selected from the results of a Stacking Test on the same sample. This location experiences the most stringent conditions since it is exposed to the maximum lithostatic load and to the maximum degree of liquid saturation along the heap profile. If the hydraulic performance of this portion of the heap/lift is adequate, it is reasonable to conclude that the rest of the heap/lift profile will perform just as well or better.

The results from an HCT provide all the necessary information to understand movement of solution and air under a percolation leaching process. In other words, the HCT generates all the parameters required in the context of numerical representation (Computational Fluid Dynamics, CFD) of the leaching process. **From the more practical point of view, the HCT answers the key question for the design of a heap – the degree of saturation resulting from a given application rate.** Experience shows that for an oxide leach the maximum liquid saturation should be kept below 85% and ideally below 75% to accommodate the natural variability associated with the heap stacking process. Leaching of a sulphide ore typically requires that the degree of saturation remains below 60% to ensure that forced (or natural) aeration is properly supported. **As such, the operating degree of saturation is the critical design parameter as it controls solution-ore contact, aeration capacity of heap, and mechanical stability of the heap.**

From the point of view of the design of a leaching operation, hydrodynamic characterization provides a way to quantify the benefits from alternative ore preparation approaches (from mining methods, to crushing, to agglomeration and stacking) so these results can be used to select the most favorable ore preparation techniques and maximum bulk density for a given ore sample. In addition, this type of information can be used to select optimal operational conditions, including maximum lift height, maximum heap height, irrigation and aeration schemes and schedule as well as to determine the operation moisture content, drain-down moisture and maximum air intake among others.

As indicated by the Test Matrix (Figure 1.1) a HCT was conducted on each of the composites Met 02-05 and Met 11-17. The conditions for the HCTs were selected per WCG personnel to represent non-agglomerated ore. Table 2.3 summarizes the conditions used during the HCTs. The density of the samples, a critical variable which is in many cases overlooked on standard metallurgical column tests, was selected to represent a 32-m heap to ensure proper operation for the first several lifts.

Table 2.3 Hydrodynamic Column - Test matrix

Sample ID	Top Size (mm)	P_{80} (mm)	Bulk Density (t/m^3)	Agglomerate Level
Met 02-05	~50	30.6	1.770	L0
Met 11-17	~55	43.6	1.530	L0

One of the key pieces of information derived from a HCT is the hydraulic conductivity curve; the relationship between solution application rate and degree of liquid saturation (or saturation). In general, the shape of the hydraulic conductivity curve is influenced by the particle size distribution, ore conditioning/curing and moisture content, the blending ratio of the ore type, the type of solution used during the agglomeration process, the quality of agglomeration and the bulk density. All these parameters can be changed as part of the design of an operation so they constitute the **ore preparation practices**. As such, the shape of the curve is diagnostic of the effect of the ore preparation practices on the hydraulic response of an ore sample. The hydraulic conductivity curves derived for the Casino fresh ore samples are summarized in graphical form on the top frame of Figure 2.8.

A hydraulic conductivity curve can be read in two different ways:

1. To obtain the operational saturation associated to a given solution application rate (equivalent to the hydraulic conductivity); enter the plot along the y-axis, move horizontally to intercept the conductivity curve and then move downward to find the corresponding degree of saturation on the x-axis; or
2. To obtain the solution application rate (hydraulic conductivity) able to be sustained by a given degree of saturation enter the plot along the x-axis, move upward to intercept the curve and then horizontally to intercept the y-axis to find the corresponding solution application rate.

It is noted that in the context of the HCT and specifically for the hydraulic conductivity curve, because of the conditions imposed during this test, under steady-state flow conditions the solution application rate is closely

equivalent to the hydraulic conductivity of the ore. Hence, we refer to these variables interchangeably throughout the rest of this document.

In addition to defining the relationship between irrigation rate and degree of liquid saturation (moisture content), the HCT procedure allows for the simultaneous determination of the air conductivity of an ore sample. The air conductivity is a critical parameter in the design of an aeration system that is typically overlooked. The lower frame of Figure 2.8 presents a graphical summary of the measurements of air for the two Casino non-agglomerated composites. The lab reports included in Appendix B present the numerical results from these tests.

From the operational point of view, the results from the HCTs on these TMC samples indicate that near the bottom of a 32-m heap:

- For the application rate (10 L/h/m^2) used by Metcon on their recent metallurgical columns, the Casino samples would operate at a degree of saturation below 56% for Composite Met 02-05, and 23.2% for Composite Met 11-17.
- It is noted that the degree of saturation obtained for Met 11-17 is one of the lowest of all samples tested by HGS to date. This low operational degree of saturation arises from the fact that nearly 74% of the void space of this composite is macro-porosity.
- These results confirm the preliminary determination obtained from the STs; **from the hydraulic point of view the Casino samples, even when not agglomerated, would easily support percolation leaching of a 32-m heap (lift).**
- It is important to note that slumping during initial irrigation of the lifts, potential decrepitation during leaching and destruction of the pore structure due to increase overburden stress will necessarily increase the density and degree of saturation as depicted in Figure 2.8. **Based on the results from the STs presented above, it is expected that these effects would be relatively minor for heap heights below 70 m.**
- **It is recommended, however, that leached residue from the recent Metcon columns or from the first lift once the operation is started be tested under the ST procedure to assess the potential impact of one leach cycle on the density and conductivity profiles of these two composites. If these results show a significant difference from the tests on the head samples, HCTs should be conducted to better assess the impact of leaching on the hydrodynamic properties of the Casino ore and the potential changes to the current heap design.**

As described in the previous section, the total porosity and its partition into macro and micro components are important parameters for the design of a heap leach process. Experience shows that a 50:50 partition between micro and macro porosity produces optimal hydrodynamic performance. Table 2.4 below summarizes the estimated total porosity, macro-, micro- and micro-residual porosity derived from the analysis of the drain down curves derived from the HCTs. The sum of the micro-drainable porosity and the micro-residual yields the micro-porosity.

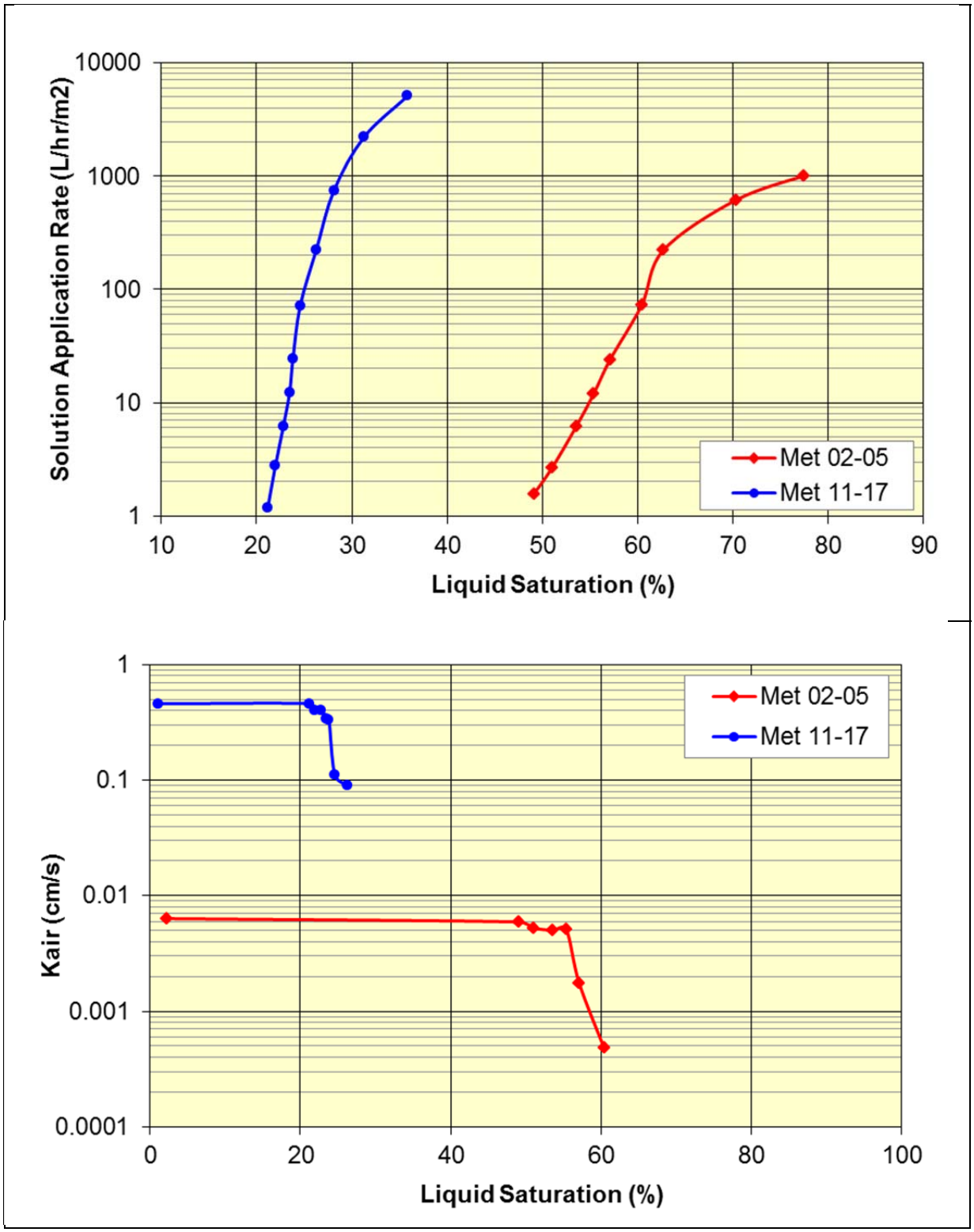


Figure 2.8 TMC – Conductivity Curves

Table 2.4 – Porosity Values					
Sample	Total	Drainable	Macro	Micro Drainable	Micro Residual
Met 02-05-L0	0.331	0.197	0.137	0.059	0.134
Met 11-17-L0	0.409	0.347	0.302	0.045	0.063

These data show that the Composite Met 02-05 has a macro-micro porosity partition of 42:58, while for the Composite Met 11-17 this partition is 74:26. These ratios suggest that Met 02-25 may be most suitable for the leaching process. It is important to note that the ST results on the 1:1 and 2:1 blend of these two composites resulted on improved hydrodynamic properties for both of the individual composites.

The air conductivity curve presented in the bottom frame of Figure 2.8 highlights a number of important aspects of two-phase flow associated to the porous structure in the context of natural and/or forced aeration:

- In general, air conductivity is a strong function of the PSD, degree of saturation and bulk density. In this particular case the spread on between the curves arises from the differences in the PSD of the samples.
- Typically, at low degree of liquid saturation (low moisture values) the air conductivity is nearly constant. The conductivity decreases slightly with increased saturation to the point when the degree of saturation reaches a threshold saturation value (S*) beyond which the conductivity drops rapidly.
- In this particular case, both composites follow this pattern but with significant different magnitudes – the initial air conductivity of Met 11-17 is almost 100 larger than that of Met 02-05.
- In general, the threshold saturation value at which air conductivity begins its rapid reduction is a function of the ore and the ore management practice (degree of agglomeration, top crush size, agglomeration additives, bulk density of the ore as placed, etc.). This saturation threshold corresponds to the moisture content at which the air-filled porosity starts to become discontinuous which greatly increases the resistance for air flow.
- It is important to note that this saturation threshold is, for most of the ore samples we have tested, far from full saturation (i.e., air flow is impaired much before all the pore space is occupied by solution). For most ores, the ability of a sample to allow air flow is, for all practical purposes, lost as the liquid saturation reaches a value of about 65%. For the Casino samples, the threshold saturation value for which the air permeability becomes smaller than that require to allow unimpeded air flow varies significantly for each of the composites:
    - For the Met 02-05, the air conductivity starts its rapid reduction at a saturation value of about S* = 55.4%;
    - For the Met 11-17, the saturation threshold occurs at about 22% despite the otherwise very permeable sample.
- Under natural aeration, air enters the heap through the top surface of the heap and its slopes. This air flow results from density differences due to thermal gradients between the heap and the atmosphere

and changes in atmospheric pressure. The force gradients resulting from these processes are small, so efficient aeration requires high air permeability values (> 10^{-3} cm/s).

- Table 2.5 below summarizes the operational conditions in terms of the liquid degree of saturation and corresponding air conductivity for the each of the non-agglomerated Casino samples under a nominal application rate of 10 L/h/m^2 (2.8 x10^{-4} cm/s). Also included in Table 2.5 is the threshold saturation (S*) for each of the samples. For this solution application rate:
    - The operational liquid saturation of the Casino samples is: 55% for Met 02-05, and 23.2% for the Met 11-17.
    - The operational degree of saturation is about the same as the saturation threshold for these composites which may limit the effectiveness of natural aeration (under irrigation rate of 10 L/h/m^2). A smaller irrigation rate will improve the natural aeration on these composites.
    - It is noted that the operational degree of saturation is basically the same as the threshold saturation value at which the air conductivity starts its rapid reduction – which indicates that any upset condition (strong precipitation, variability in the irrigation rate, increased level of fines, localized compaction, etc.) resulting in increased saturation would produce a marked reduction in the air conductivity**.** Empirical evidence shows that the rate of dissolution decreases by more than a factor of two as oxygen decreases by a factor of two.
    - Given the Au and Ag as well as the Cu grades, it is expected that the oxygen demand associated to cyanide leaching will be small. The available information indicates that aeration requirements may be larger for Met 11-17 given its higher Cu content than for composite Met 02-05.

Table 2.5 – Operational conditions at 10 L/h/m^2

Sample	S* (%)	S (%)	K_a (cm/s)
Met 02-05-L0	55.4	55.0	5.0 x 10^{-3}
Met 11-17-L0	22.0	23.2	4.5 x 10^{-1}

A couple of additional remarks arising from the HCT results are as follows:

- The degree of saturation resulting from the solution irrigation rate combined with the residual porosity presented above provide an estimate of the dynamic moisture for each sample for a given solution application rate. For instance, for a solution irrigation rate of 10 L/h/m^2 the dynamic moisture for Composite Met 02-15 is: 48 liters of solution per cubic meter of ore (L/m^3), and 32 L/m^3 for the coarser composite (**Met 11-17**).
- Industrial experience from many different ore types and various minerals shows that, in most instances, the hydrodynamic performance controls the metallurgical performance of a percolation leaching process. In this particular case, **it appears that the key considerations for the adequate leaching of the non-agglomerated Casino ore are:**
    - The permeability for Composite Met 02-05 or a blend thereof, and

- Effective solution-to-ore contact for Composite Met 11-17 if not blended.

Accurate numerical modeling of the solution and gas movement through a heap leach requires, as a minimum, knowledge of:

- The relationship between hydraulic conductivity and the degree of saturation (top frame of Figure 2.8),
- The relationship between the air conductivity and the degree of liquid saturation (bottom frame of Figure 2.8) – not critical for the Casino composites evaluated as part of this effort; and
- The relationship between degree of saturation and the pore pressure (Figure 2.9), known in the hydrological community as the moisture characteristic curve.

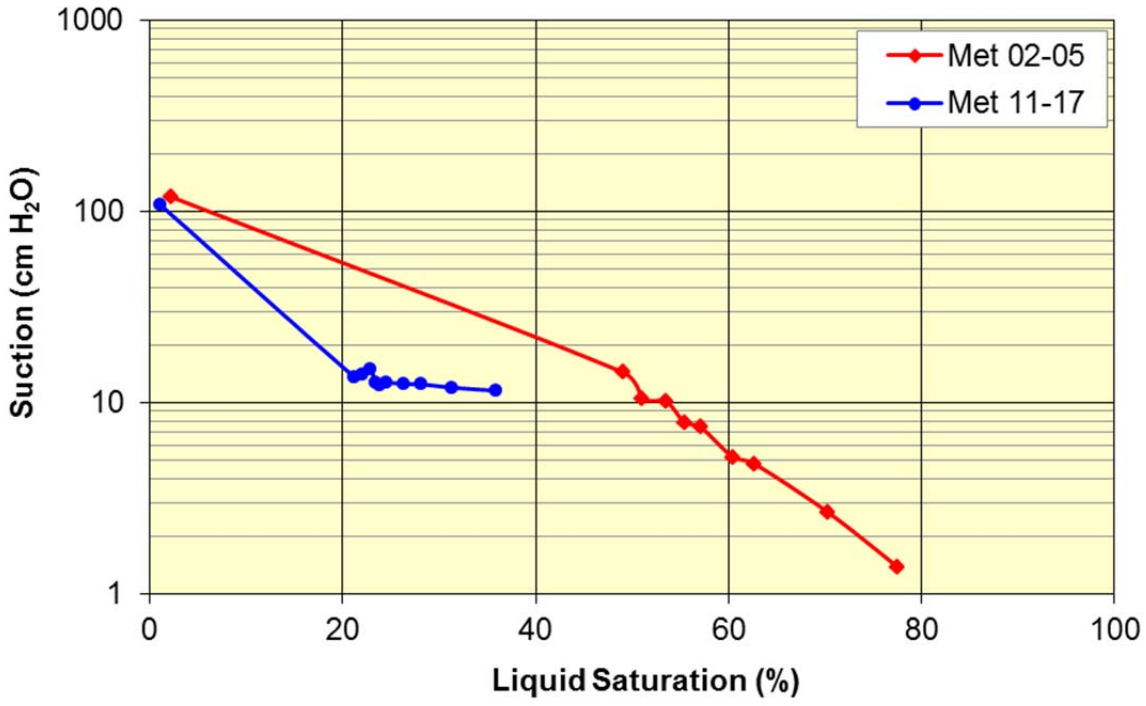


Figure 2.9 Casino – Moisture retention curve

It is noted that **the HCT is the only procedure that allows direct measurement of these properties concurrently and in a single sample in the context of multi-phase flow for the mining industry or otherwise.**

Because numerical analysis is not the focus of this characterization effort, the relationship between liquid saturation and pore pressure is not further discussed. However, it is worthwhile noting that the operational pore pressure for the Casino is 30 cm for Met 02-05 and about 12 cm for Met 11-17 at a solution application rate of 10 L/h/m^2. Availability of these data greatly facilitates modeling solution movement (wetting and draining) and reactive transport of the heap leach process.

3.0 PRELIMINARY METALLURGICAL PERFORMANCE

HGS continues to develop testing procedures for the optimal characterization of ore for leach. As part of this development, the HCT has been modified to included chemical testing of the feed and discharge solution to obtain a preliminary evaluation of the potential metallurgical performance of a sample. The resulting procedure is termed the Integrated Column Test (ICT) as it provides, for the first time in the history of leaching, all the hydrodynamic and critical metallurgical data on a single sample. It is our contention this integrated approach will greatly enhance our ability interpret the results of metallurgical tests, scale-up laboratory data, and build comprehensive numerical models of the leaching process.

The ICT procedure was applied to the Casino samples in order to generate a first estimate of metal extraction. Solution samples were collected and assayed for Au, Ag, Cu, NaCN and CaO in addition to the HCTs included on the original Scope of Work. It is noted, that this activity was undertaken as part of HGS development work therefore at no expense to WCG. As such, the results presented below are strictly preliminary and for information purpose only. It is noted however that the metallurgical data derived from the ICTs is in complete agreement with the conclusions derived from the physical, metallurgical, mineralogical and hydrodynamic characterization data presented in the above paragraphs.

The overall solution balance summarizing the metallurgical performance of composites Met 02-05 and Met 11-17 is presented in Figures 3.1 and 3.2, respectively. Table 3.1 presents the total metal recovery and reagent consumption. All the laboratory data and calculations of recovery could be made available to WCG in the future if necessary. The following paragraphs present a brief discussion of the more relevant findings from these data.

Table 3.1 – Preliminary metallurgical performance

	Recovery (%)			Consumption (kg/t)	
Sample ID	Au	Ag	Cu	NaCN	CaO
Met 02-05-L0	80.3	18.3	6.8	0.21	3.03
Met 11-17-L0	42.0	17.5	19.0	0.32	2.96

Inspection of the metal recovery and reagent consumption record for each of the composites indicates the following:

- As expected, Met 02-05 out performs the Au recovery of Met 11-17. It is noted that the Au recovery of Met 02-05 is quite fast (nearly 65% recovery in the first four days of operation) compared to that of Met 11-17 (25% recovery in seven days). The faster kinetics are likely associated to the finer size distribution of the former.
- The percent gold recovery for Met 02-05 is almost twice as high as that of Met 11-17 while the silver recovery for these composites is about the same (~18%).

- The last two days on the operation of the ICTs represent the flushing stage which in this particular case is shown to contribute about 10% of the Au recovery.
- It is noted, that copper extraction is higher in Met 11-17 (19.0% versus 6.8% in Met 02-05) which may explain the lower Au recovery of the former. Higher copper extraction can result in cyanide and oxygen consumption which tends to slow down the rate of gold dissolution. It would be important to completely determine the mineral composition of the copper species present in Met 11-17 to understand their potential impact on the performance of this composite at the industrial scale.
- The reagent utilization efficiency (g of Au dissolved by kg of NaCN) is 1.05 g/kg for Met 02-05 and 0.72 g/kg for Met 11-17 which indicates a more favorable leaching condition for the former.
- The reagent utilization efficiency of lime is 0.073 g/Kg for Met 02-05 and 0.078 g/Kg for Met 11-17.

Based on the conditions of the HCT it is concluded that leaching of these composites on a heap leach setting could result in Au recoveries of about 70% for Met 02-05 and about 30% for Met 11-17. **It is recommended that these preliminary results be compared to the larger scale column tests recently completed by Metcon in order to:**

a) Compare the calculated extractions, and more importantly;
b) Evaluate the potential scale-up factors required for the design of the industrial scale process.

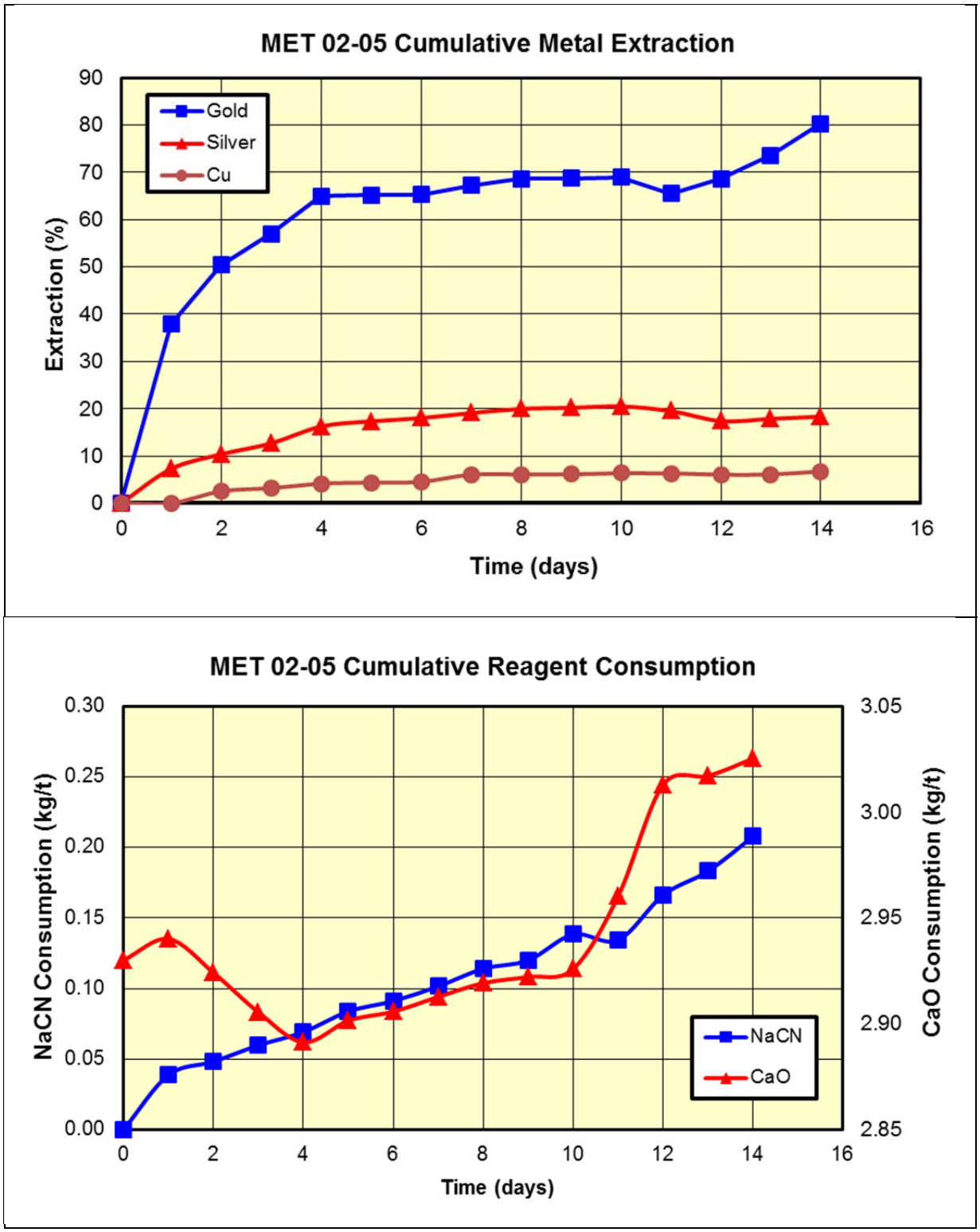


Figure 3.1 Met 02-05 – Preliminary metallurgical performance

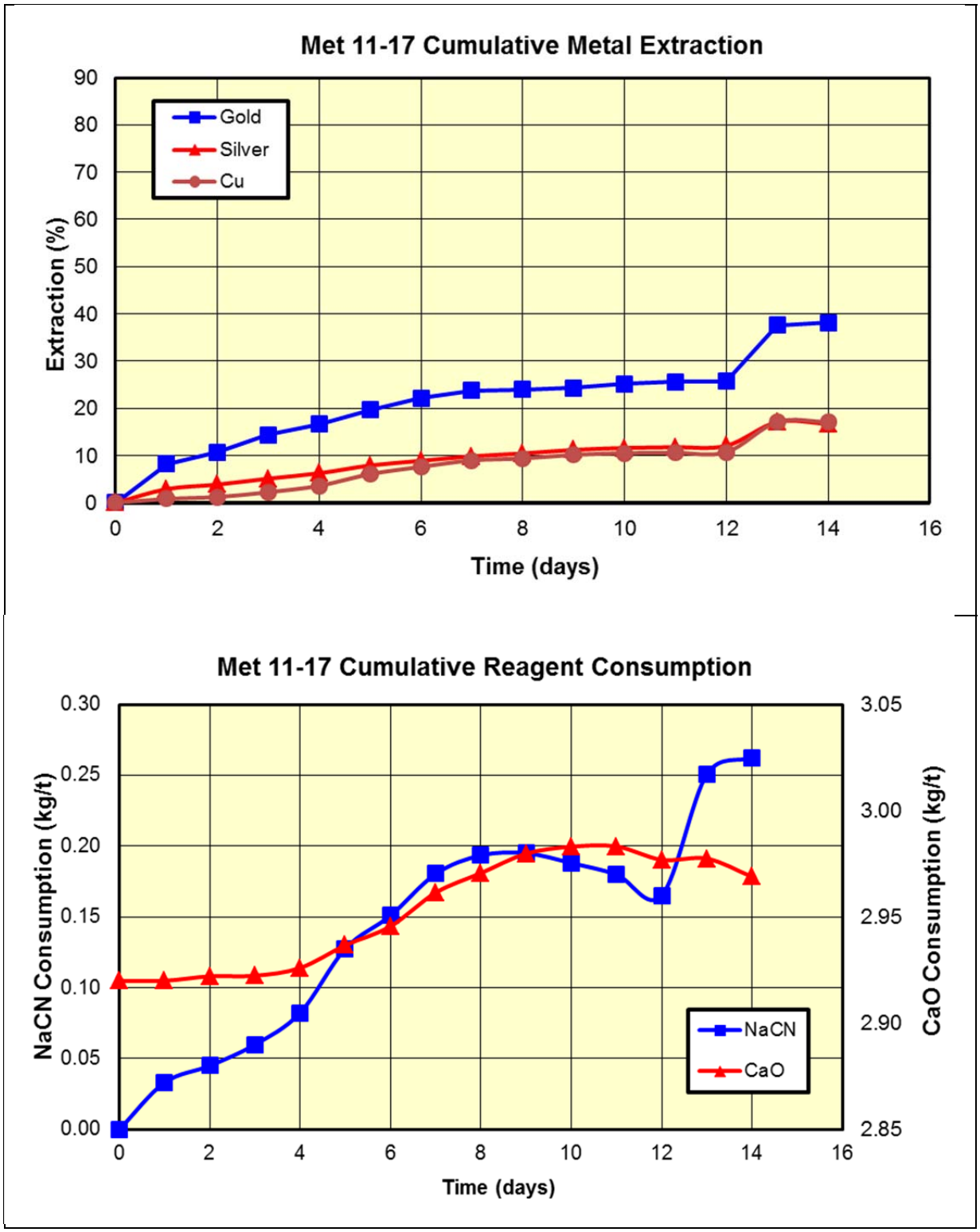


Figure 3.2 Met 11-17 – Preliminary metallurgical performance

4.0 CONCLUSIONS AND RECOMMEDATIONS

4.1 Conclusions

By necessity, the volume of rock analyzed by the work summarized on this document is small compared to the ore deposit. It is therefore critical that WCG develop a good understanding of the representativeness of these samples with respect to the ore body and the spatial distribution of the metallurgical composites with respect to the mine plan. This understanding will provide the basis for planning the mining sequence and identifying the opportunities for ore blending.

The main findings from the characterization activities and the data review presented in this document are as follows:

- There are significant physical, hydrodynamic, metallurgical and mineralogical differences between the two composites evaluated on this study. It is therefore important that a good understanding of their relative contribution and occurrence (location and timing) with respect to the mine plan be developed to assist with the conceptual design of the leaching process.
- Au and Ag are not uniformly distributed along the PSD of these composites. Met 02-05 has most of its metal value (35%) on the size fractions smaller than 1.7 mm and thus should be quite leachable. In contrast, Met 11-17 has most of its metal value (>25%) on rock fragments larger than 25.4 mm.
- The mineralogical characterization indicates that Au occurs primarily as sub-microscopic native gold.
- In addition bulk mineralogy indicates the gangue is composed predominantly by quartz and alumino-silicate minerals. The quartz fraction is quite different from each of the composites, 55.5% for Met 02-05, 41.7% for Met 11-17 and 36.8% for Met 19-20. Secondary minerals include Kaolinite ($Al_2Si_2O_5(OH)$) and swelling clays representing 5.5%, 6.0% and 7.7% for Met 02-05, Met 11-17 and Met 19-20, respectively.
- The competent nature of the Casino samples and their hydrodynamic performance would suggest that the bulk of the swelling clays are present within the crystalline structure of the feldspars and are not present as dispersed clays which tend to reduce he percolation capacity.
- Potential CN consuming minerals include metal sulfides including copper, iron, arsenic and zinc; iron oxide-hydroxides such as Limonite and Jarosite which can also act as preg-robbing; and secondary alumino-silicates and swelling clays.
- Shake leach tests conducted by FL Smidth leads us to believe that: the additional recovery on composites Met 11-17 and Met 19-20 at very high CN-concentrations results from the dissolution of sulfide minerals (sulfide encapsulation due to, but not exclusively, copper sulfides) which may be coating the Au minerals and dissolve in the presence of higher CN concentrations. On the other hand, the limited Au recovery in Met 02-05 is likely associated to silica encapsulation.
- The Casino ore is competent and contains a relatively low level of fines (< 4% minus 200-mesh) which results in a high percolation capacity and physically competent samples for the crush sizes (P_{100} 50 mm with a $\mathbf{P_{80}}$ of 30.6 mm for Met 02-05 and 43.6 mm for Met 11-17) evaluated in this study.
- This low level of fines (minus 200-mesh) is in contrast with the amount of swelling clays reported by the mineralogical characterization. The competent nature of the Casino samples and their hydrodynamic

performance would suggest that the bulk of the swelling clays are present within the crystalline structure of the feldspars. In other words, only small portion of the swelling clays are present in a dispersed fines which minimizes their negative impact on the hydrodynamic properties of these samples.

- The ST results show that heap height has a minimal effect on both the density and the conductivity of either composite which is indicative of a stiff, competent ore whose porous structure is able to withstand flooded conditions and the full lithostatic stress (up to 140 m) at its residual saturation.
- Notwithstanding the strong nature of the Casino samples;
    - Met 11-17 has a large macro-porosity which translates into gravity-dominated flow with limited horizontal movement of solution which typically leads to inefficient wetting and hence reduced metallurgical performance. This type of flow condition is responsible for lower metal extraction, inefficient reagent (CN, CaO and oxygen) utilization and protracted leach cycles.
    - At the 140-m lift height, only composite Met 11-17 satisfies the requirement that the minimum saturated hydraulic conductivity be larger than 1,000 times the application rate (assumed for this study as 6 L/h/m^2 based on the results from the hydrodynamic characterization presented in this document). The rationale behind the minimum K_s value of 1.7×10^{-1} cm/s considers the negative effect of slumping, decrepitation (weathering) of the ore during the life of the heap on the hydrodynamic properties of the ore.
    - The total porosity of the non-agglomerated Met 02-05 at a heap height of 71 m is 31% which compared to the minimal requirement of 30% may indicate that this particular condition may not support a heap height beyond 80 m.
    - For Met 11-17, the data suggest that it would support percolation leaching in a heap up to 140 m in height, but it may do so with significant solution channelization.
- **The results from the STs suggests that blending of the two composites (Met 02-05 and Met 11-17) even without agglomeration will improve the hydrodynamic (and potentially the metallurgical performance) of both composites.**
- **Similarly, despite the coarse nature and the limited amount of fines in the Casino ore, the results from the STs suggest that agglomerating these composites will result in a noticeable improvement of their hydrodynamic properties even for the very coarse Met 11-17.** Another important benefit from agglomeration with leaching solution (alkaline cyanide) is that the reagents are uniformly delivered to all the ore and the dissolution of minerals kick-started. This mode of reagent delivery is a significant improvement with respect to that attained on a typical ROM operation.
- **The ST data from the 2:1 blend of M 02-05 and M 11-17 indicate that this sample when agglomerated could support a heap height close to 140 m. These results show that ore preparation practices are therefore critical for an improved performance of the process.**
- An important fact that needs to be considered in the analysis and interpretation of the results is that all the samples considered in this report represent fresh ore. Leaching typically results in chemical-induced decrepitation (more so under acidic conditions than alkaline conditions) and exposure to ambient conditions lead to weathering both which negatively impact the hydrodynamic properties of the ore. **Given that the Casino heap leaching process is designed as a multi-lift operation, it would be important that hydrodynamic properties of the leached residue after three to four leach**

cycles be determined to define the potential impact of decrepitation to the long term operation of the heap.

- The results from the Hydrodynamic Column Tests (HCTs) show that composite Met 02-05 and Met 11-17 will easily support percolation leaching on the first several lifts (a 32-m heap was evaluated during this effort) with a solution application rate of up to 10 L/h/m^2. This conclusion is based on the following observations:
    - The data generated indicate that the degree of saturation associated to a 10 L/h/m^2 solution application rate would be below 56% for Composite Met 02-05, and 23.2% for Composite Met 11-17.
    - The macro-micro porosity partition for Composite Met 02-05 is 42:58, while that for Composite Met 11-17 is 74:26.
- It appears that the key considerations for the adequate leaching of the Casino ore **when not agglomerated** could be:
    - The permeability for Composite Met 02-05 or a blend thereof as the heap height increases beyond 70 m, and
    - Effective solution-to-ore contact for Composite Met 11-17 if not blended.
- The preliminary metallurgical performance of these two composites confirms that the conclusions based on the physical, hydrodynamic, metallurgical and mineralogical information regarding the potential metal recovery from the Casino composites are correct;
    - The metallurgical data show that gold recoveries of about 80% for Met 02-05 and 42% for Met 11-17. The corresponding silver recovery is about 18% for either of these composites. When the conditions of the HCTs are analyzed in the context of a heap leach operation, it is expected that Met 02-05 could yield gold recoveries of about 70% while Met 11-17 could produce gold recoveries of about 30%.
    - The better metallurgical performance of Met 02-05 compared to that of Met 11-17 is also confirmed by the better cyanide utilization efficiency (1.05 g/kg for Met 02-05 and 0.72 g/kg for Met 11-17).
- It is our contention, based on all the information presented in this document, that gold recovery from composite Met 11-17 **when not blended and agglomerated** may be hindered by gravity dominated flow and potentially by coatings of sulfide minerals (sulfide encapsulation due to, but not exclusively, copper sulfides) while ultimate recovery from Met 02-05 is likely associated to silica encapsulation.

4.2 Recommendations

- Given the difference in the properties of the composites, the design of the leaching process should consider the opportunities for segregation and/or blending of the materials delivered to the heap to ensure the best operational conditions. A clear understanding of abundance and location of the various composites with respect to the mining plan would be a critical piece of information for this task.

- The understanding of the abundance and location of the individual composites (02, 05, 11, 117, 19 and 20) would be critical for the design of the leaching process. For instance, in composite Met 02-05, sample Met 05 has about 40% of the Au and Fe, 30% of the Ag and S, and 11% of the Cu than values reported for Met 02. Selection of blending should consider the hydrodynamic performance and the mineralogical characteristics of the individual samples to enhance the potential leaching performance of the composite.
- QEMSCAN results on the Casino composites show that Chalcopyrite is the dominant Cu-sulfide and that some Cu bearing Iron Oxides are present in M 11-17 and Met 19-20 but not in Met 02-05, which may explain the limited gold recovery on composite Met 11-17. The impact of copper mineralization on Met 11-17 on Au dissolution and cyanide consumption should be carefully considered during the selection of blending options.
- Given the competent nature of the Casino samples tested during this study, Met 11-17 in particular, it is recommended that additional hydrodynamic and metallurgical tests be conducted on this sample under the following conditions:
    - Crushed ore with a top size between 1.25" to 1.5" to be evaluated under the ST procedure to select the best candidate for Integrated Column Tests (ICTs). Given the amount of gold on the coarser fraction, this may result in better gold liberation – albeit the potential issue with the interference from the copper minerals.
- Given the more permeable and very coarse nature of Met 11-17, blending it with Met 02-05 even under a non-agglomerated condition increases the heap height supported by the latter composite. As indicated by the ST results, agglomeration of a 2:1 blend produces a much improved condition from the point of view of solution percolation and likely air movement.
- Future metallurgical testing of the blend (Met 02-05+Met 11-17) should focus on determining the potential negative impact of the copper minerals on the performance of Met 02-05.
- Even though the non-agglomerated Casino composites would support heap heights between 70 m to 140 m, the hydrodynamic characterization indicates that substantial benefits could be derived from blending and proper agglomeration of the samples. In addition to the improved hydrodynamic performance, agglomeration has the added benefits of uniform reagent delivery and kick-starting of the leaching process. It is recommended that agglomeration of the Casino composites be further considered.
- Another important parameter that needs to be considered is the moisture of the ore as-mined and during stacking. The moisture content of stacking determines the potential for compaction and particle size segregation. If the decision is made that the ore will not be agglomerated, it is recommended that some additional STs be conducted once the material is being placed on the heap at the *in situ* moisture content to confirm that no over-compaction of the ore would occur.
- Industrial experience shows that a permanent (multi-lift) heap design can be strongly impacted by excessive solution inventory. Although the Casino ore is quite permeable and shows favorable drainage characteristics, a trade-off study should be conducted comparing the financial benefits of a dynamic heap versus the multi-lift heap currently considered. Elevated solution and metal inventory would be more significant for Met 02-05 than for Met 11-17, so it should be explicitly considered in the context of the recommended trade-off study.

- The data presented in this document shows that the hydrodynamic performance of composites Met 02-05 and Met 11-17 would be more than adequate during the initial stages of the operation as clearly shown by the results of the HCTs for a heap height of 32 m; (i.e., four lifts of 8 m). Although the optimal irrigation schedule and application rate would be best determined via a three-dimensional numerical model which includes all the geometric characteristics of the Casino heap, the hydrodynamic and metallurgical properties of the ore presented in this document, the following design specifications are recommended:
    - Given the current crush size ($\mathbf{P_{100}}$ ~50 mm), a maximum distance between drippers of 30 cm and the solution application rate no larger than 10 L/h/m^2 for Composite Met 02-05 and no larger than 6 L/h/m^2 for Composite Met 11-17 are recommended.
    - The irrigation for both of these composites should follow a ramp-up irrigation scheme (RUI) whereby the average application rate for the first few days is 25% of the target rate and is maintained until solution discharge is equal to the solution application; the second flow step is 50% of the target and is continued until steady state flow (in=out) is achieved; the third flow step is 75% of the target flow rate and is continued to steady state flow at which point the full target application is applied on a continuous basis.
    - A rinsing period at the end of the leaching should be designed and instituted. Again, this is best done using the information presented in this document in combination of a 3-D flow model, however, based on the analysis so far it seems that the duration of the rinse cycle should be at least 10 days and at an irrigation rate of 200% the target irrigation.
- Given that the Casino is designed as a multi-heap leaching process, it is critical that the hydrodynamic properties of the leached residue be determined to define the potential impact of weathering, slumping and potential leaching-induced decrepitation to the long-term performance of the heap. It is recommended that leached residue, either from the recently completed columns at Metcon or from the future operation after three or four leach-cycles, be used for this purpose. If these results show a significant difference from the tests on the head samples, HCTs to be conducted to better assess the impact of leaching on the hydrodynamic properties of the Casino ore and the potential changes to the current heap design.
- Finally, It is recommended that the preliminary metallurgical results be compared to the larger scale column tests recently completed by Metcon in order to:
    i) Compare the calculated extractions, and more importantly;
    ii) Evaluate the potential scale-up factors required for the design of the industrial scale process.

APPENDIX A

STACKING TESTS

LABORATORY REPORTS

HYDRODYNAMIC LABORATORY REPORT

HydroGeoSense
Because you need to know!

STACKING TEST - Density and Permeability Profiles

SAMPLE DESCRIPTION

Client/Project: WCG Date Tested: 6/25/2014

Sample ID: M-02-05-Peb Mine/Project Site: Casino

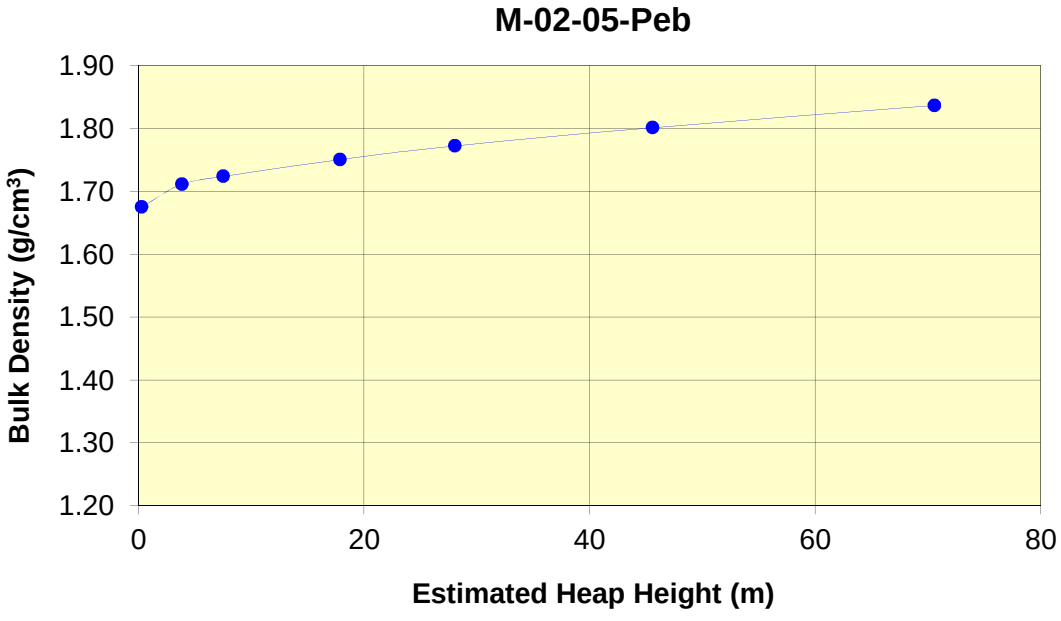
Description: Fresh ore non-agglomerated w/None

Cell Diameter: 15.55 cm S.G.: 2.66 Grav.M.C.: 0.4% Agglomeration. Level: L0

NUMERICAL RESULTS

Est Heap Height (m)	Dry Bulk Density (g/cm^3)	Permeability (cm^2)	Porosity ( )
0.3	1.68	3.6E-06	0.37
3.9	1.71	3.7E-06	0.36
7.5	1.72	3.4E-06	0.35
17.9	1.75	4.2E-06	0.34
28.1	1.77	3.9E-06	0.33
45.6	1.80	3.0E-06	0.32
70.6	1.84	2.6E-06	0.31

GRAPHICAL RESULTS



HYDRODYNAMIC LABORATORY REPORT

HydroGeoSense
Because you need to know!

STACKING TEST - Hydraulic Conductivity versus dry bulk density

SAMPLE DESCRIPTION

Client/Project: WCG Date Tested: 6/25/2014

Sample ID: M-02-05-Peb Mine/Project Site: Casino

Description: Fresh ore non-agglomerated w/None

Cell Diameter: 15.55 cm S.G.: 2.66 Grav.M.C.: 0.4% Agglomeration. Level: L0

NUMERICAL RESULTS

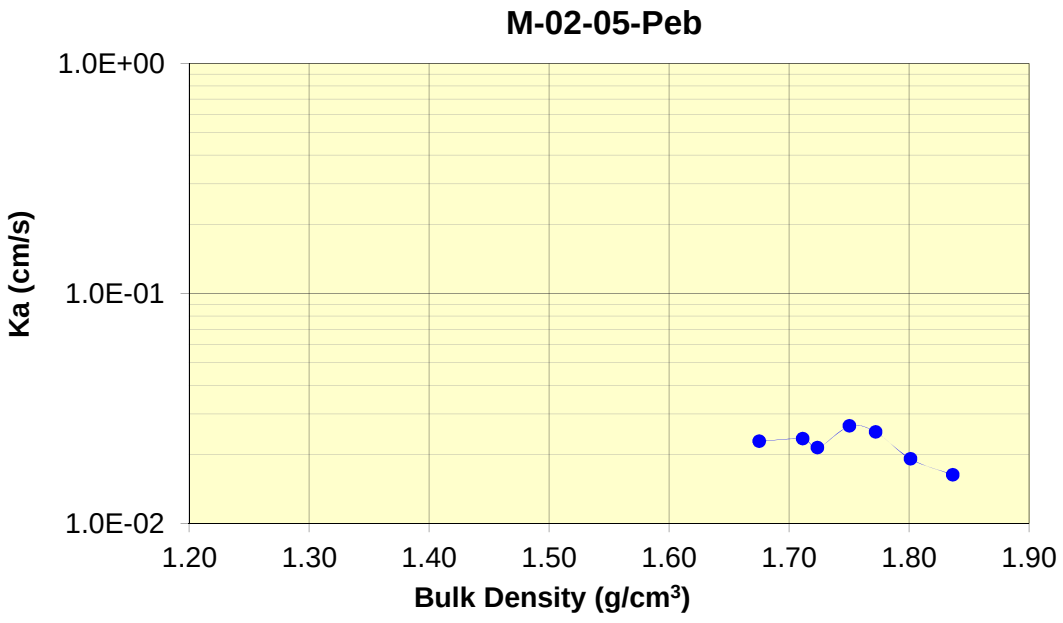
Est Heap Height (m)	Dry Bulk Density (g/cm3)	Ka (cm/s)	Kw (cm/s)
0.3	1.68	2.3E-02	1.5E-01
3.9	1.71	2.3E-02	1.5E-01
7.5	1.72	2.1E-02	1.4E-01
17.9	1.75	2.7E-02	1.7E-01
28.1	1.77	2.5E-02	1.6E-01
45.6	1.80	1.9E-02	1.2E-01
70.6	1.84	1.6E-02	1.1E-01

Final Ks available? 1.1E-01 cm/s

Ks/Ka = 6.51

Two Flow Meters in Parallel? No

GRAPHICAL RESULTS



CONSTANT HEAD - HYDRAULIC CONDUCTIVITY TEST

HydroGeoSense
Because you need to know!

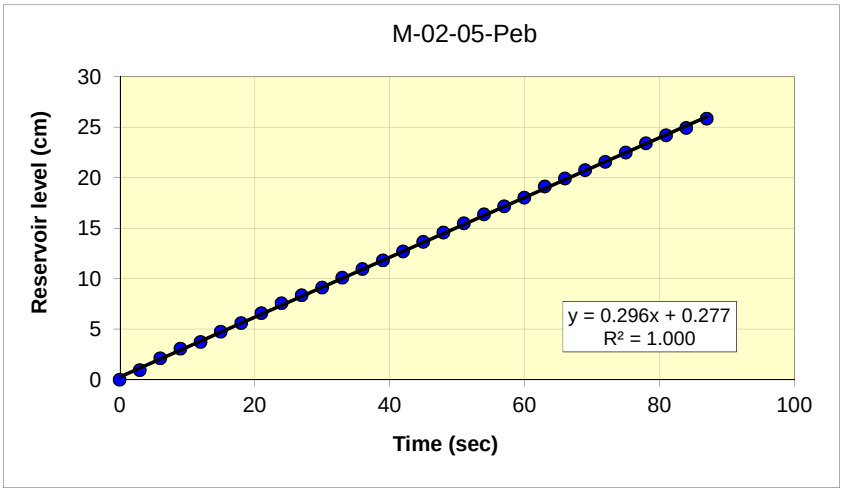
Client:	WCG	**Date:**	6/25/2014	**Time:**	15:14
Sample ID:	M-02-05-Peb			**Operator(s):**	ACS
Wet Ore Mass (g):	6,036.0	**Initial Grav. Moist. Content:**	0.4 %	**T:**	28.5 C
Bottom of ore (cm):	31.4	(from collar to top of grid)		**Initial Head Space (cm):**	14.2
Cell Diameter (in):	6.0	**Cell Area (cm^2):**	189.81	**Final Head Space (cm):**	14.0
Reservoir Area (cm^2):	42.85	**Bubble Inlet Elev (cm):**	54.0	**Discharge Elevation(cm):**	45

Test - Data

dt (s):	3
Time	Reservoir Level (cm)
0	0.00
3	0.93
6	2.10
9	3.05
12	3.73
15	4.75
18	5.60
21	6.57
24	7.55
27	8.35
30	9.10
33	10.08
36	10.95
39	11.80
42	12.70
45	13.64
48	14.55
51	15.47
54	16.35
57	17.15
60	18.00
63	19.12
66	19.90
69	20.74
72	21.55
75	22.47
78	23.38
81	24.17
84	24.90
87	25.83

Ks Data Analysis

First Row:	20	Last Row:	49.00	Q (cm^3/s):	12.68
Sample Height:	17.3 cm			dh (cm):	9.0



ρ_b = 1.83 g/cm^3

K_s = 1.3E-01 cm/s at T = 28.5 C

Standard Temperature = 20.0 C

	Viscosity (mPa S)	Density (g/cm^3)
at T °C	0.824	9.954E-01
at Standard Temperature (°C)	1.002	9.974E-01

$K_{s\ Standard\ T}$ = 1.1E-01

10-Min Drain Down Analysis

Preliminary Volumetric porosity partitioning estimates				
Total	**Macro**	**Fraction**	**Micro**	**Fraction**
0.31	0.16	0.51	0.15	0.49
Preliminary Gravimetric porosity partitioning estimates				
	0.16	0.51	0.15	0.49

HYDRODYNAMIC LABORATORY REPORT

HydroGeoSense
Because you need to know!

STACKING TEST - Density and Permeability Profiles

SAMPLE DESCRIPTION

Client/Project: Casino Date Tested: 6/25/2014

Sample ID: M-02-05-Pow Mine/Project Site: WCG

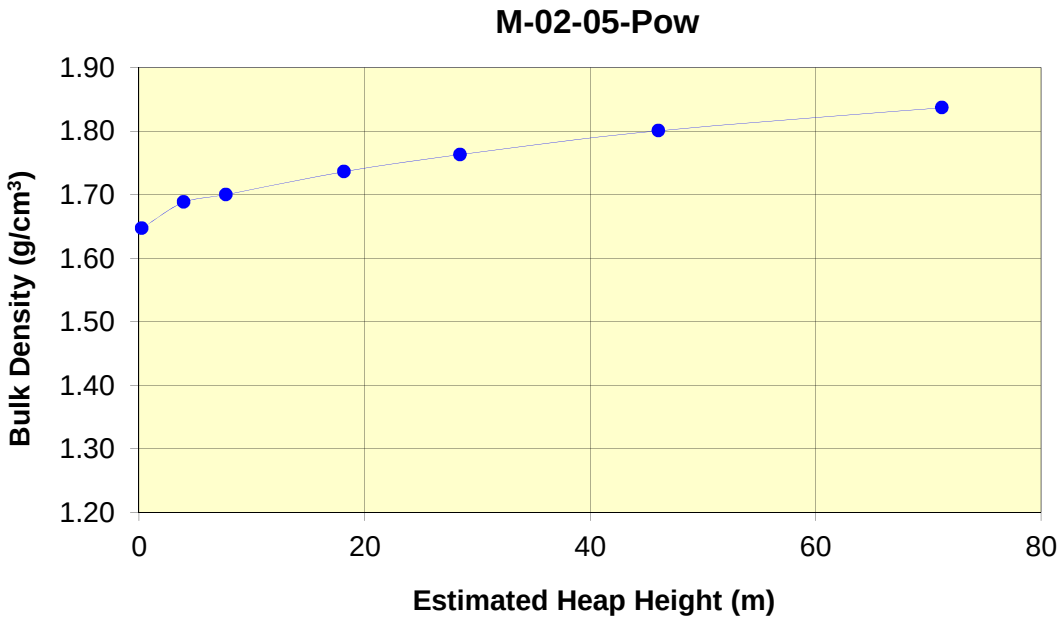
Description: Fresh ore non-agglomerated w/None

Cell Diameter: 15.48 cm S.G.: 2.66 Grav.M.C.: 0.4% Agglomeration. Level: L0

NUMERICAL RESULTS

Est Heap Height (m)	Dry Bulk Density (g/cm^3)	Permeability (cm^2)	Porosity ( )
0.3	1.65	2.4E-06	0.38
4.0	1.69	2.5E-06	0.37
7.7	1.70	2.5E-06	0.36
18.2	1.74	2.2E-06	0.35
28.5	1.76	2.2E-06	0.34
46.1	1.80	1.8E-06	0.32
71.2	1.84	1.9E-06	0.31

GRAPHICAL RESULTS



HYDRODYNAMIC LABORATORY REPORT

HydroGeoSense
Because you need to know!

STACKING TEST - Hydraulic Conductivity versus dry bulk density

SAMPLE DESCRIPTION

Client/Project: Casino Date Tested: 6/25/2014

Sample ID: M-02-05-Pow Mine/Project Site: WCG

Description: Fresh ore non-agglomerated w/None

Cell Diameter: 15.48 cm S.G.: 2.66 Grav.M.C.: 0.4% Agglomeration. Level: L0

NUMERICAL RESULTS

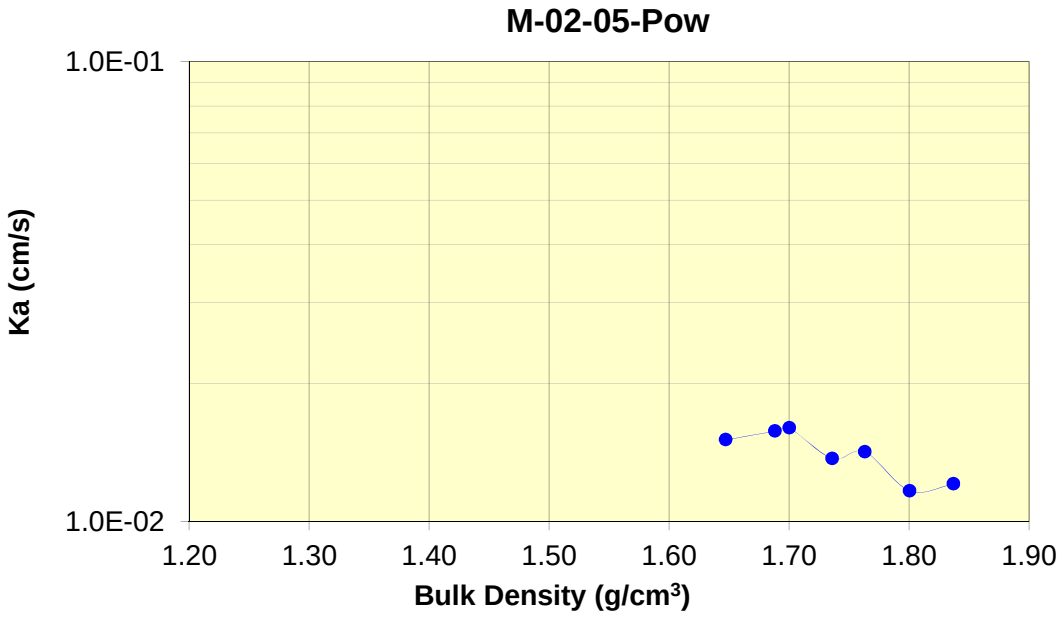
Est Heap Height (m)	Dry Bulk Density (g/cm3)	Ka (cm/s)	Kw (cm/s)
0.3	1.65	1.5E-02	1.2E-01
4.0	1.69	1.6E-02	1.3E-01
7.7	1.70	1.6E-02	1.3E-01
18.2	1.74	1.4E-02	1.1E-01
28.5	1.76	1.4E-02	1.2E-01
46.1	1.80	1.2E-02	9.5E-02
71.2	1.84	1.2E-02	9.9E-02

Final Ks available? 9.9E-02 cm/s

Ks/Ka = 8.18

Two Flow Meters in Parallel? No

GRAPHICAL RESULTS



CONSTANT HEAD - HYDRAULIC CONDUCTIVITY TEST

HydroGeoSense
Because you need to know!

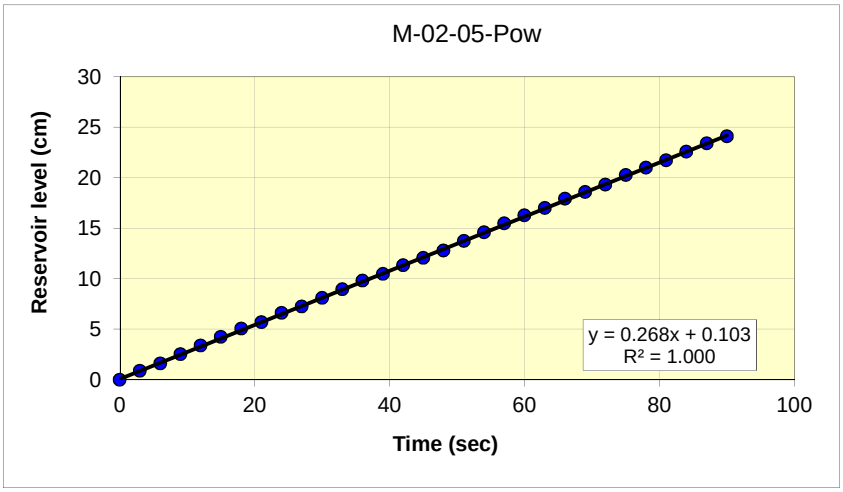
Client:	Casino	**Date:**	6/25/2014	**Time:**	16:47
Sample ID:	M-02-05-Pow			**Operator(s):**	RGS
Wet Ore Mass (g):	6,069.0	**Initial Grav. Moist. Content:**	0.4 %	**T:**	28.1 C
Bottom of ore (cm):	31.0 (from collar to top of grid)			**Initial Head Space (cm):**	13.5
Cell Diameter (in):	6.0	**Cell Area (cm^2):**	188.10	**Final Head Space (cm):**	13.4
Reservoir Area (cm^2):	42.85	**Bubble Inlet Elev (cm):**	54.0	**Discharge Elevation(cm):**	45

Test - Data

dt (s):	3
Time	Reservoir Level (cm)
0	0.00
3	0.88
6	1.60
9	2.52
12	3.37
15	4.23
18	5.05
21	5.70
24	6.62
27	7.25
30	8.10
33	8.95
36	9.80
39	10.48
42	11.32
45	12.07
48	12.80
51	13.75
54	14.60
57	15.47
60	16.27
63	17.00
66	17.90
69	18.57
72	19.30
75	20.25
78	21.00
81	21.70
84	22.56
87	23.40
90	24.10

Ks Data Analysis

First Row: 20 Last Row: 50.00 Q (cm^3/s): 11.47
Sample Height: 17.5 cm dh (cm): 9.0



ρ_b = 1.83 g/cm^3

K_s = 1.2E-01 cm/s at T = 28.1 C

Standard Temperature = 20.0 C

	Viscosity (mPa S)	Density (g/cm^3)
at T °C	0.831	9.955E-01
at Standard Temperature (°C)	1.002	9.974E-01

$K_{s\ Standard\ T}$ = 9.9E-02

10-Min Drain Down Analysis

Preliminary Volumetric porosity partitioning estimates				
Total	**Macro**	**Fraction**	**Micro**	**Fraction**
0.31	0.17	0.55	0.14	0.45
Preliminary Gravimetric porosity partitioning estimates				
	0.17	0.55	0.14	0.45

HYDRODYNAMIC LABORATORY REPORT

HydroGeoSense
Because you need to know!

STACKING TEST - Density and Permeability Profiles

SAMPLE DESCRIPTION

Client/Project: WCG Date Tested: 6/27/2014

Sample ID: M-02-05 Mine/Project Site: Casino

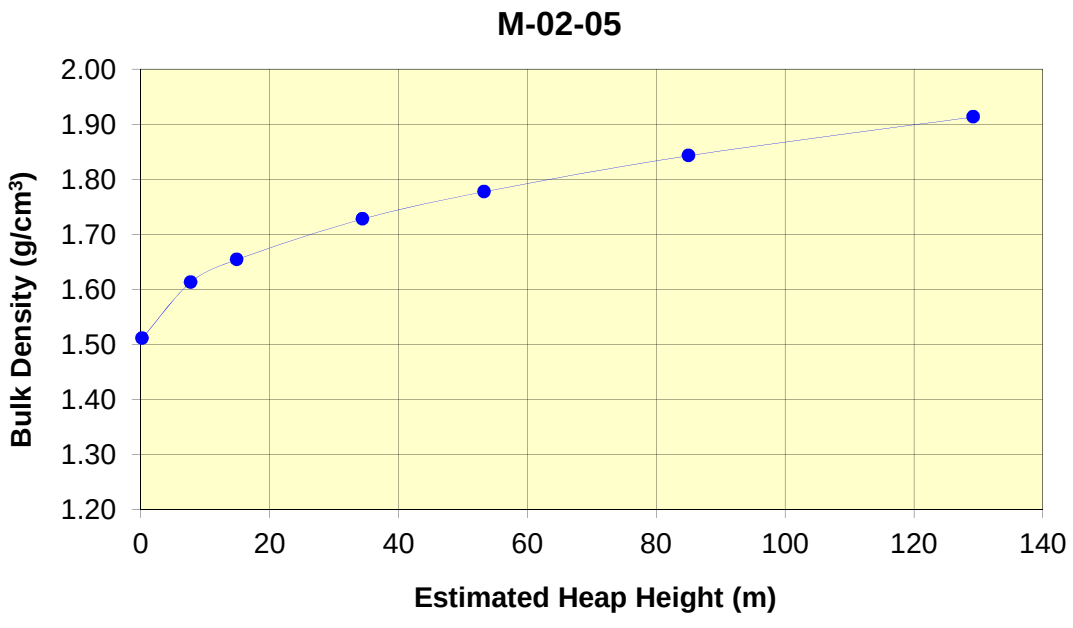
Description: Fresh ore agglomerated w/H2O w/Lime at a pH 11.0

Cell Diameter: 20.30 cm S.G.: 2.66 Grav.M.C.: 5.7% Agglomeration Level: L3

NUMERICAL RESULTS

Est Heap Height (m)	Dry Bulk Density (g/cm^3)	Permeability (cm^2)	Porosity ( )
0.3	1.51	9.1E-05	0.43
7.8	1.61	4.6E-05	0.39
15.0	1.65	3.9E-05	0.38
34.5	1.73	2.0E-05	0.35
53.3	1.78	1.5E-05	0.33
85.1	1.84	8.0E-06	0.31
129.2	1.91	3.8E-06	0.28

GRAPHICAL RESULTS



HYDRODYNAMIC LABORATORY REPORT

HydroGeoSense
Because you need to know!

STACKING TEST - Hydraulic Conductivity versus dry bulk density

SAMPLE DESCRIPTION

Client/Project: WCG Date Tested: 6/27/2014

Sample ID: M-02-05 Mine/Project Site: Casino

Description: Fresh ore agglomerated w/H2O w/Lime at a pH 11.0

Cell Diameter: 20.30 cm S.G.: 2.66 Grav.M.C.: 5.7% Agglomeration. Level: L3

NUMERICAL RESULTS

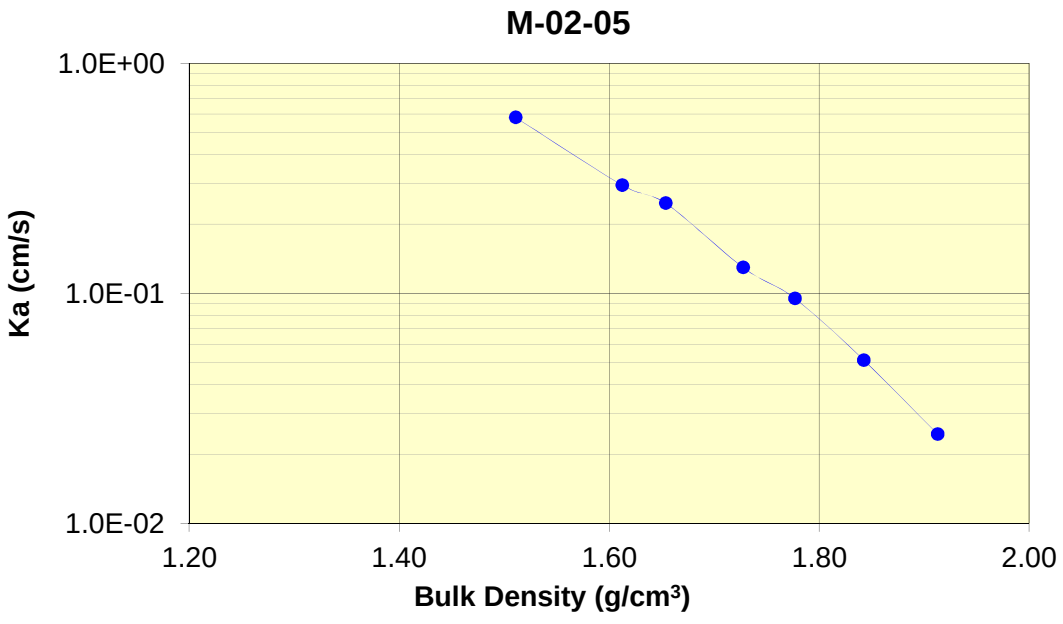
Est Heap Height (m)	Dry Bulk Density (g/cm3)	Ka (cm/s)	Kw (cm/s)
0.3	1.51	5.8E-01	2.5E+00
7.8	1.61	2.9E-01	1.3E+00
15.0	1.65	2.5E-01	1.1E+00
34.5	1.73	1.3E-01	5.5E-01
53.3	1.78	9.5E-02	4.1E-01
85.1	1.84	5.1E-02	2.2E-01
129.2	1.91	2.4E-02	1.0E-01

Final Ks available? 1.0E-01 cm/s

Ks/Ka = 4.28

Two Flow Meters in Parallel? Yes

GRAPHICAL RESULTS



CONSTANT HEAD - HYDRAULIC CONDUCTIVITY TEST

HydroGeoSense
Because you need to know!

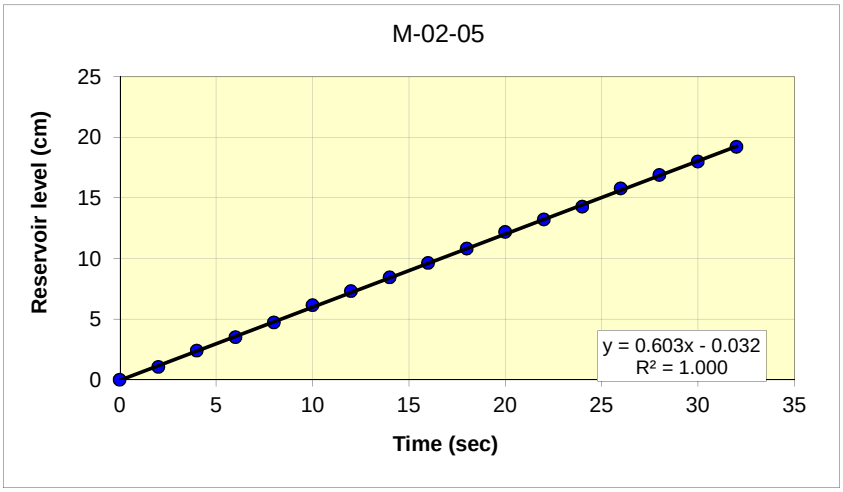
Client:	WCG	**Date:**	6/27/2014	**Time:**	17:32
Sample ID:	M-02-05			**Operator(s):**	RGS
Wet Ore Mass (g):	11,252.0	**Initial Grav. Moist. Content:**	5.7 %	**T:**	38.1 C
Bottom of ore (cm):	28.0 (from collar to top of grid)			**Initial Head Space (cm):**	10.8
Cell Diameter (in):	8.0	**Cell Area (cm^2):**	323.79	**Final Head Space (cm):**	10.5
Reservoir Area (cm^2):	42.85	**Bubble Inlet Elev (cm):**	54.0	**Discharge Elevation(cm):**	45

Test - Data

dt (s):	2
Time	Reservoir Level (cm)
0	0.00
2	1.05
4	2.40
6	3.50
8	4.72
10	6.13
12	7.30
14	8.45
16	9.62
18	10.80
20	12.18
22	13.22
24	14.28
26	15.78
28	16.88
30	18.00
32	19.20

Ks Data Analysis

First Row:	20	Last Row:	36.00	Q (cm^3/s):	25.84
Sample Height:	17.3 cm			dh (cm):	9.0



ρ_b = 1.90 g/cm^3

K_s = 1.5E-01 cm/s at T = 38.1 C

Standard Temperature = 20.0 C

	Viscosity (mPa S)	Density (g/cm^3)
at T °C	0.676	9.925E-01
at Standard Temperature (°C)	1.002	9.974E-01

$K_{s\ Standard\ T}$ = 1.0E-01

10-Min Drain Down Analysis

Preliminary Volumetric porosity partitioning estimates				
Total	**Macro**	**Fraction**	**Micro**	**Fraction**
0.29	0.14	0.48	0.15	0.52
Preliminary Gravimetric porosity partitioning estimates				
	0.14	0.48	0.15	0.52

HYDRODYNAMIC LABORATORY REPORT

HydroGeoSense
Because you need to know!

STACKING TEST - Density and Permeability Profiles

SAMPLE DESCRIPTION

Client/Project: WGC Date Tested: 6/26/2014

Sample ID: M-11-17-Peb Mine/Project Site: Casino

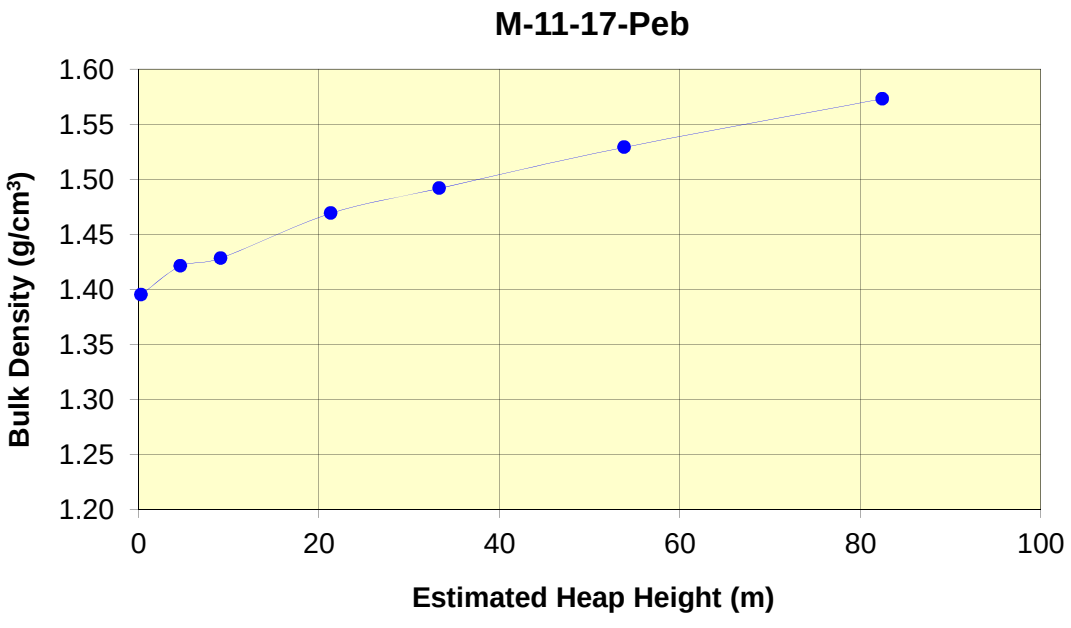
Description: Fresh ore non-agglomerated w/None

Cell Diameter: 15.55 cm S.G.: 2.63 Grav.M.C.: 0.3% Agglomeration Level: L0

NUMERICAL RESULTS

Est Heap Height (m)	Dry Bulk Density (g/cm^3)	Permeability (cm^2)	Porosity ( )
0.3	1.40	1.2E-04	0.47
4.7	1.42	1.1E-04	0.46
9.1	1.43	1.2E-04	0.46
21.3	1.47	1.1E-04	0.44
33.4	1.49	1.1E-04	0.43
53.8	1.53	1.0E-04	0.42
82.5	1.57	9.6E-05	0.40

GRAPHICAL RESULTS



HYDRODYNAMIC LABORATORY REPORT

HydroGeoSense
Because you need to know!

STACKING TEST - Hydraulic Conductivity versus dry bulk density

SAMPLE DESCRIPTION

Client/Project: WGC Date Tested: 6/26/2014

Sample ID: M-11-17-Peb Mine/Project Site: Casino

Description: Fresh ore non-agglomerated w/None

Cell Diameter: 15.55 cm S.G.: 2.63 Grav.M.C.: 0.3% Agglomeration. Level: L0

NUMERICAL RESULTS

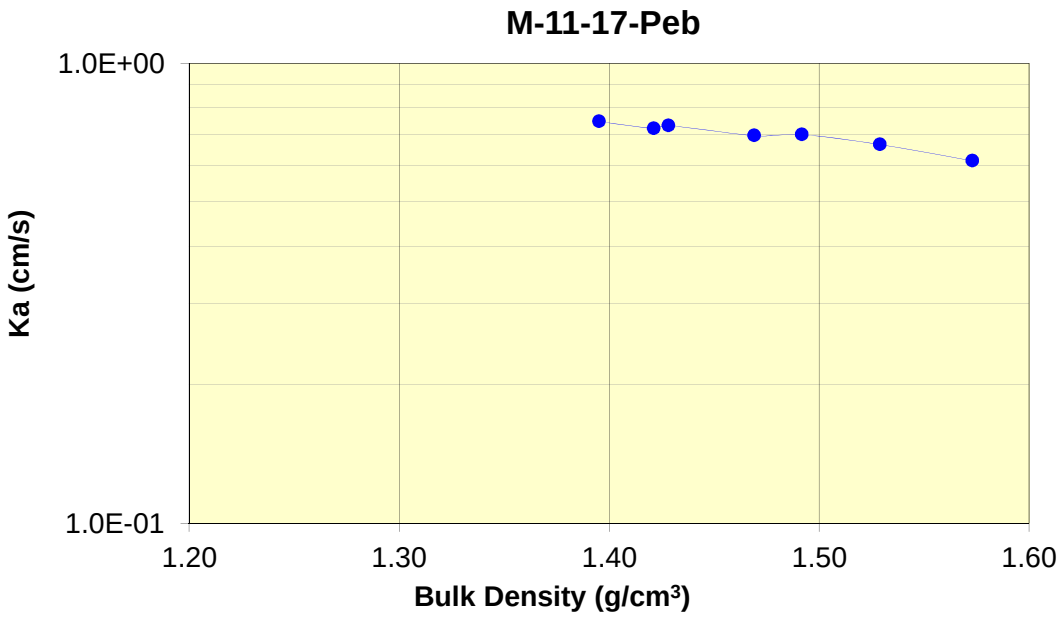
Est Heap Height (m)	Dry Bulk Density (g/cm3)	Ka (cm/s)	Kw (cm/s)
0.3	1.40	7.5E-01	2.8E-01
4.7	1.42	7.2E-01	2.7E-01
9.1	1.43	7.3E-01	2.7E-01
21.3	1.47	7.0E-01	2.6E-01
33.4	1.49	7.0E-01	2.6E-01
53.8	1.53	6.7E-01	2.5E-01
82.5	1.57	6.1E-01	2.3E-01

Final Ks available? 2.3E-01 cm/s

Ks/Ka = 0.38

Two Flow Meters in Parallel? Yes

GRAPHICAL RESULTS



CONSTANT HEAD - HYDRAULIC CONDUCTIVITY TEST

HydroGeoSense
Because you need to know!

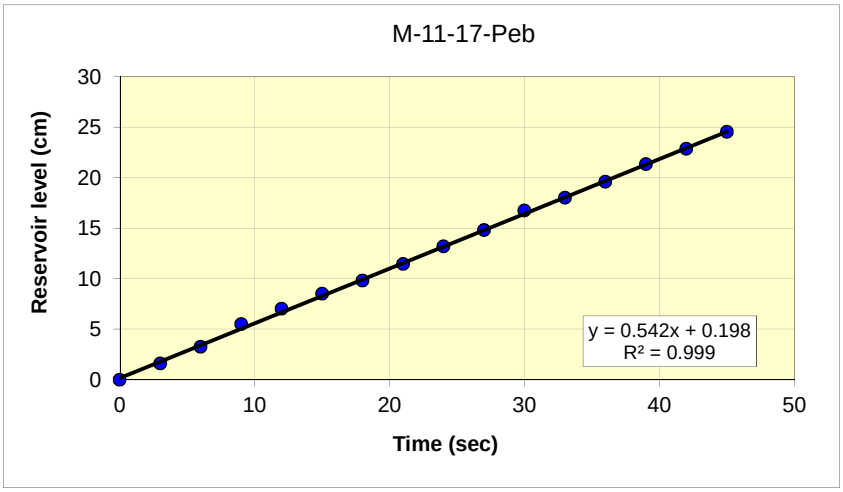
Client:	WGC	**Date:**	6/26/2014	**Time:**	16:48
Sample ID:	M-11-17-Peb			**Operator(s):**	ACS
Wet Ore Mass (g):	6,032.0	**Initial Grav. Moist. Content:**	0.3 %	**T:**	27.7 C
Bottom of ore (cm):	31.4	(from collar to top of grid)		**Initial Head Space (cm):**	11.3
Cell Diameter (in):	6.0	**Cell Area (cm^2):**	189.81	**Final Head Space (cm):**	11.2
Reservoir Area (cm^2):	42.85	**Bubble Inlet Elev (cm):**	54.0	**Discharge Elevation(cm):**	45

Test - Data

dt (s):	3
Time	Reservoir Level (cm)
0	0.00
3	1.60
6	3.25
9	5.50
12	7.03
15	8.50
18	9.80
21	11.45
24	13.20
27	14.82
30	16.75
33	18.00
36	19.60
39	21.35
42	22.86
45	24.55

Ks Data Analysis

First Row:	20	Last Row:	35.00	Q (cm^3/s):	23.22
Sample Height:	20.2 cm			dh (cm):	9.0



ρ_b = 1.57 g/cm^3

K_s = 2.7E-01 cm/s at T = 27.7 C

Standard Temperature = 20.0 C

	Viscosity (mPa S)	Density (g/cm^3)
at T °C	0.838	9.956E-01
at Standard Temperature (°C)	1.002	9.974E-01

$K_{s\ Standard\ T}$ = 2.3E-01

10-Min Drain Down Analysis

Preliminary Volumetric porosity partitioning estimates				
Total	**Macro**	**Fraction**	**Micro**	**Fraction**
0.40	0.35	0.86	0.06	0.14
Preliminary Gravimetric porosity partitioning estimates				
	0.35	0.86	0.06	0.14

HYDRODYNAMIC LABORATORY REPORT

HydroGeoSense
Because you need to know!

STACKING TEST - Density and Permeability Profiles

SAMPLE DESCRIPTION

Client/Project: Casino Date Tested: 6/26/2014

Sample ID: M-11-17-Pow Mine/Project Site: WCG

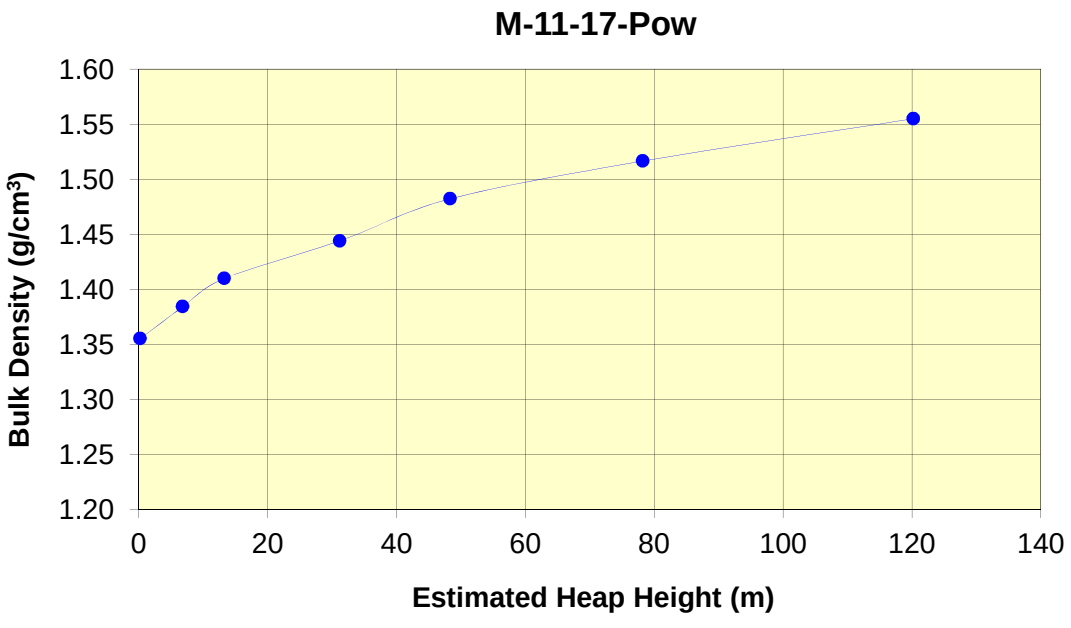
Description: Fresh ore non-agglomerated w/None

Cell Diameter: 15.48 cm S.G.: 2.63 Grav.M.C.: 0.3% Agglomeration Level: L0

NUMERICAL RESULTS

Est Heap Height (m)	Dry Bulk Density (g/cm^3)	Permeability (cm^2)	Porosity ( )
0.3	1.36	3.7E-05	0.49
6.9	1.38	3.6E-05	0.47
13.3	1.41	3.1E-05	0.46
31.2	1.44	3.2E-05	0.45
48.4	1.48	2.9E-05	0.44
78.2	1.52	2.6E-05	0.42
120.3	1.56	2.2E-05	0.41

GRAPHICAL RESULTS



HYDRODYNAMIC LABORATORY REPORT

HydroGeoSense
Because you need to know!

STACKING TEST - Hydraulic Conductivity versus dry bulk density

SAMPLE DESCRIPTION

Client/Project: Casino Date Tested: 6/26/2014

Sample ID: M-11-17-Pow Mine/Project Site: WCG

Description: Fresh ore non-agglomerated w/None

Cell Diameter: 15.48 cm S.G.: 2.63 Grav.M.C.: 0.3% Agglomeration. Level: L0

NUMERICAL RESULTS

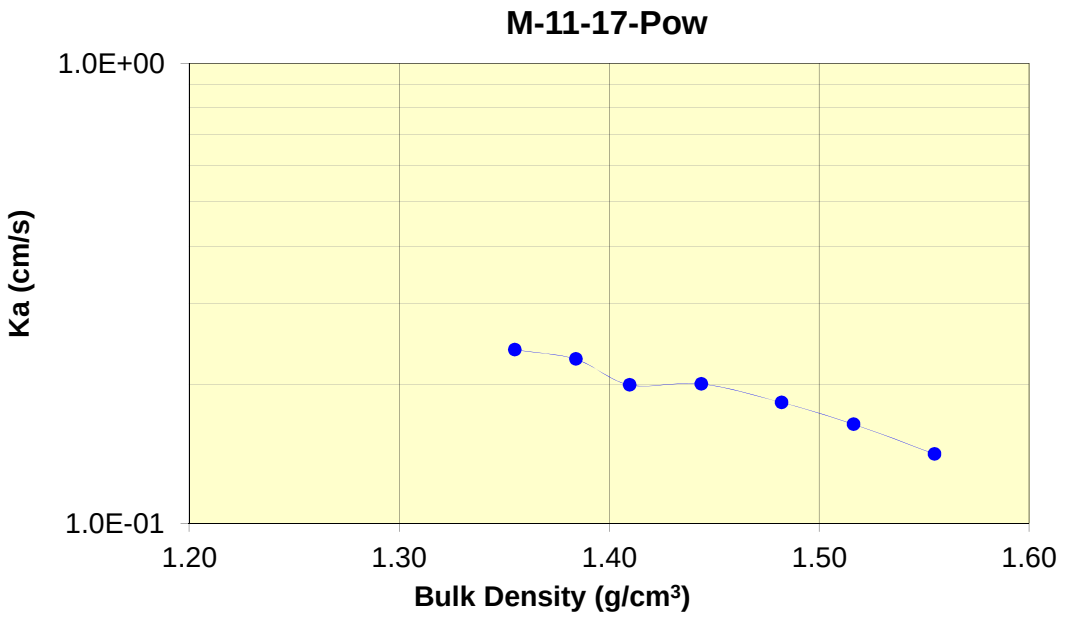
Est Heap Height (m)	Dry Bulk Density (g/cm3)	Ka (cm/s)	Kw (cm/s)
0.3	1.36	2.4E-01	1.3E-01
6.9	1.38	2.3E-01	1.2E-01
13.3	1.41	2.0E-01	1.1E-01
31.2	1.44	2.0E-01	1.1E-01
48.4	1.48	1.8E-01	1.0E-01
78.2	1.52	1.6E-01	9.0E-02
120.3	1.56	1.4E-01	7.7E-02

Final Ks available? 7.7E-02 cm/s

Ks/Ka = 0.55

Two Flow Meters in Parallel? Yes

GRAPHICAL RESULTS



CONSTANT HEAD - HYDRAULIC CONDUCTIVITY TEST

HydroGeoSense
Because you need to know!

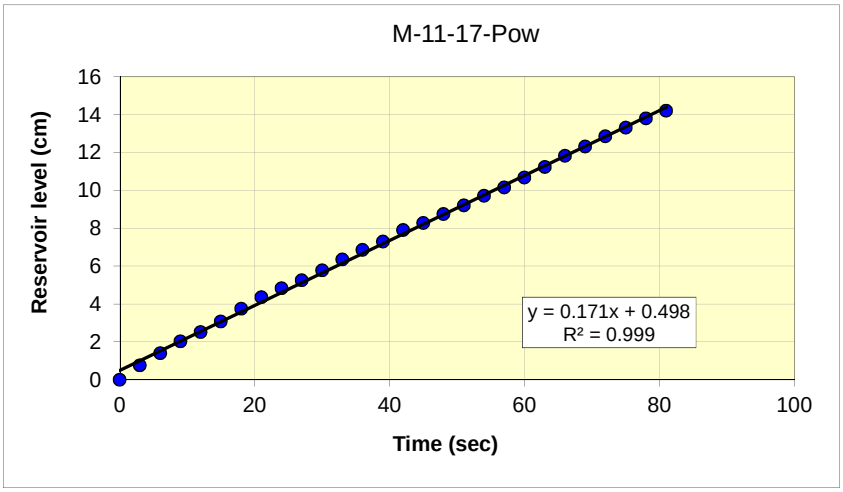
Client:	Casino	**Date:**	6/26/2014	**Time:**	10:26
Sample ID:	M-11-17-Pow			**Operator(s):**	RGS
Wet Ore Mass (g):	5,998.0	**Initial Grav. Moist. Content:**	0.3 %	**T:**	25.8 C
Bottom of ore (cm):	31.7	(from collar to top of grid)		**Initial Head Space (cm):**	11.3
Cell Diameter (in):	6.0	**Cell Area (cm^2):**	188.10	**Final Head Space (cm):**	11.3
Reservoir Area (cm^2):	42.85	**Bubble Inlet Elev (cm):**	54.0	**Discharge Elevation(cm):**	45

Test - Data

dt (s):	3
Time	Reservoir Level (cm)
0	0.00
3	0.75
6	1.40
9	2.02
12	2.52
15	3.07
18	3.75
21	4.35
24	4.82
27	5.25
30	5.77
33	6.35
36	6.85
39	7.30
42	7.90
45	8.27
48	8.75
51	9.20
54	9.70
57	10.15
60	10.67
63	11.23
66	11.81
69	12.30
72	12.85
75	13.30
78	13.80
81	14.20

Ks Data Analysis

First Row: 20 Last Row: 47.00 Q (cm^3/s): 7.35
Sample Height: 20.4 cm dh (cm): 9.0



ρ_b = 1.56 g/cm^3

K_s = 8.9E-02 cm/s at T = 25.8 C

Standard Temperature = 20.0 C

	Viscosity (mPa S)	Density (g/cm^3)
at T °C	0.874	9.961E-01
at Standard Temperature (°C)	1.002	9.974E-01

$K_{s\ Standard\ T}$ = 7.7E-02

10-Min Drain Down Analysis

Preliminary Volumetric porosity partitioning estimates				
Total	**Macro**	**Fraction**	**Micro**	**Fraction**
0.41	0.33	0.80	0.08	0.20
Preliminary Gravimetric porosity partitioning estimates				
	0.33	0.80	0.08	0.20

HYDRODYNAMIC LABORATORY REPORT

HydroGeoSense
Because you need to know!

STACKING TEST - Density and Permeability Profiles

SAMPLE DESCRIPTION

Client/Project: Casino Date Tested: 6/27/2014

Sample ID: M-11-17 Mine/Project Site: WCG

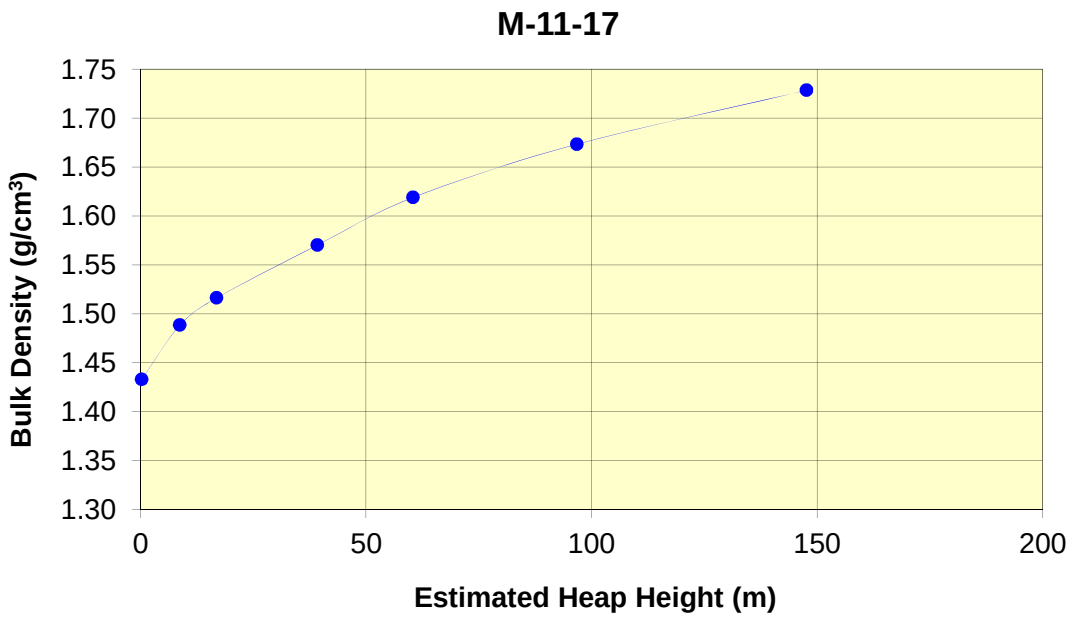
Description: Fresh ore Agglomerated w/H20 w/Lime at pH 11.0

Cell Diameter: 20.30 cm S.G.: 2.63 Grav.M.C.: 2.4% Agglomeration Level: L2

NUMERICAL RESULTS

Est Heap Height (m)	Dry Bulk Density (g/cm^3)	Permeability (cm^2)	Porosity ( )
0.3	1.43	4.1E-04	0.46
8.8	1.49	3.1E-04	0.43
16.9	1.52	2.4E-04	0.42
39.2	1.57	1.5E-04	0.40
60.5	1.62	1.2E-04	0.38
96.7	1.67	8.8E-05	0.36
147.7	1.73	6.6E-05	0.34

GRAPHICAL RESULTS



HYDRODYNAMIC LABORATORY REPORT

HydroGeoSense
Because you need to know!

STACKING TEST - Hydraulic Conductivity versus dry bulk density

SAMPLE DESCRIPTION

Client/Project: Casino Date Tested: 6/27/2014

Sample ID: M-11-17 Mine/Project Site: WCG

Description: Fresh ore Agglomerated w/H20 w/Lime at pH 11.0

Cell Diameter: 20.30 cm S.G.: 2.63 Grav.M.C.: 2.4% Agglomeration. Level: L2

NUMERICAL RESULTS

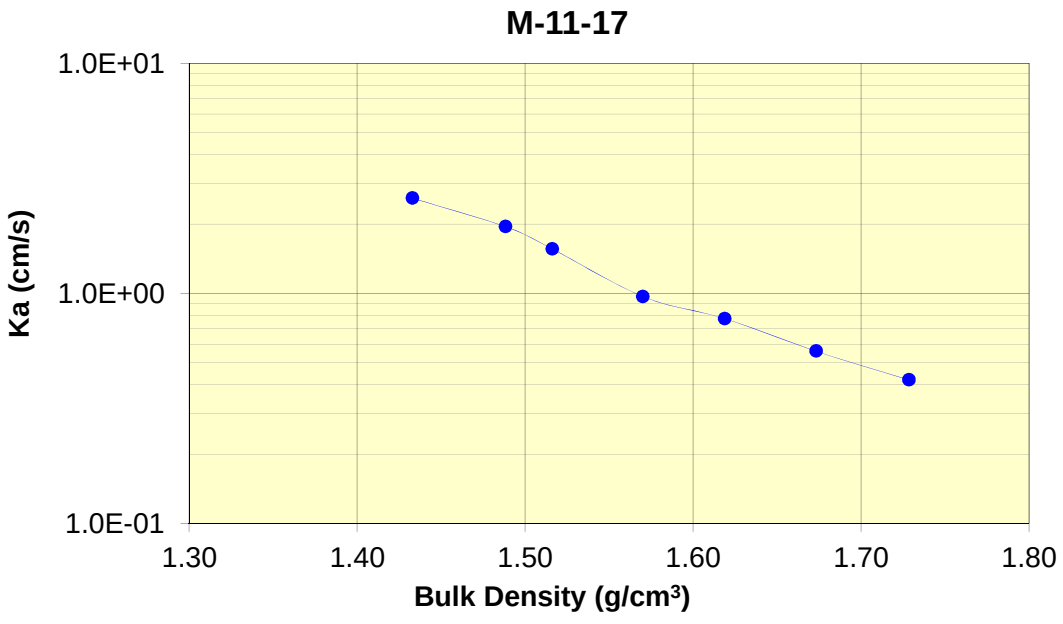
Est Heap Height (m)	Dry Bulk Density (g/cm3)	Ka (cm/s)	Kw (cm/s)
0.3	1.43	2.6E+00	1.2E+00
8.8	1.49	1.9E+00	9.4E-01
16.9	1.52	1.6E+00	7.5E-01
39.2	1.57	9.7E-01	4.7E-01
60.5	1.62	7.8E-01	3.7E-01
96.7	1.67	5.6E-01	2.7E-01
147.7	1.73	4.2E-01	2.0E-01

Final Ks available? 2.0E-01 cm/s

Ks/Ka = 0.48

Two Flow Meters in Parallel? Yes

GRAPHICAL RESULTS



CONSTANT HEAD - HYDRAULIC CONDUCTIVITY TEST

HydroGeoSense
Because you need to know!

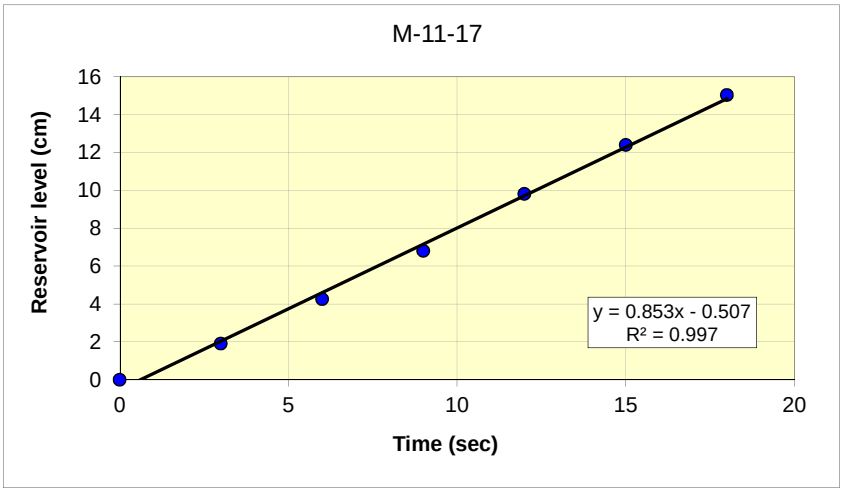
Client:	Casino	**Date:**	6/27/2014	**Time:**	14:23
Sample ID:	M-11-17			**Operator(s):**	RGS
Wet Ore Mass (g):	10,925.0	**Initial Grav. Moist. Content:**	2.4 %	**T:**	27.7 C
Bottom of ore (cm):	28.0	(from collar to top of grid)		**Initial Head Space (cm):**	8.9
Cell Diameter (in):	8.0	**Cell Area (cm^2):**	323.79	**Final Head Space (cm):**	8.7
Reservoir Area (cm^2):	42.85	**Bubble Inlet Elev (cm):**	54.0	**Discharge Elevation(cm):**	45

Test - Data

dt (s):	3
Time	Reservoir Level (cm)
0	0.00
3	1.90
6	4.25
9	6.80
12	9.80
15	12.40
18	15.03

Ks Data Analysis

First Row:	20	Last Row:	26.00	Q (cm^3/s):	36.54
Sample Height:	19.2 cm			dh (cm):	9.0



ρ_b = 1.72 g/cm^3

K_s = 2.4E-01 cm/s at T = 27.7 C

Standard Temperature = 20.0 C

	Viscosity (mPa S)	Density (g/cm^3)
at T °C	0.838	9.956E-01
at Standard Temperature (°C)	1.002	9.974E-01

$K_{s\ Standard\ T}$ = 2.0E-01

10-Min Drain Down Analysis

Preliminary Volumetric porosity partitioning estimates				
Total	**Macro**	**Fraction**	**Micro**	**Fraction**
0.35	0.26	0.74	0.09	0.26
Preliminary Gravimetric porosity partitioning estimates				
	0.26	0.74	0.09	0.26

HYDRODYNAMIC LABORATORY REPORT

HydroGeoSense
Because you need to know!

STACKING TEST - Density and Permeability Profiles

SAMPLE DESCRIPTION

Client/Project: WCG Date Tested: 7/3/2014

Sample ID: M-Blend Mine/Project Site: Casino

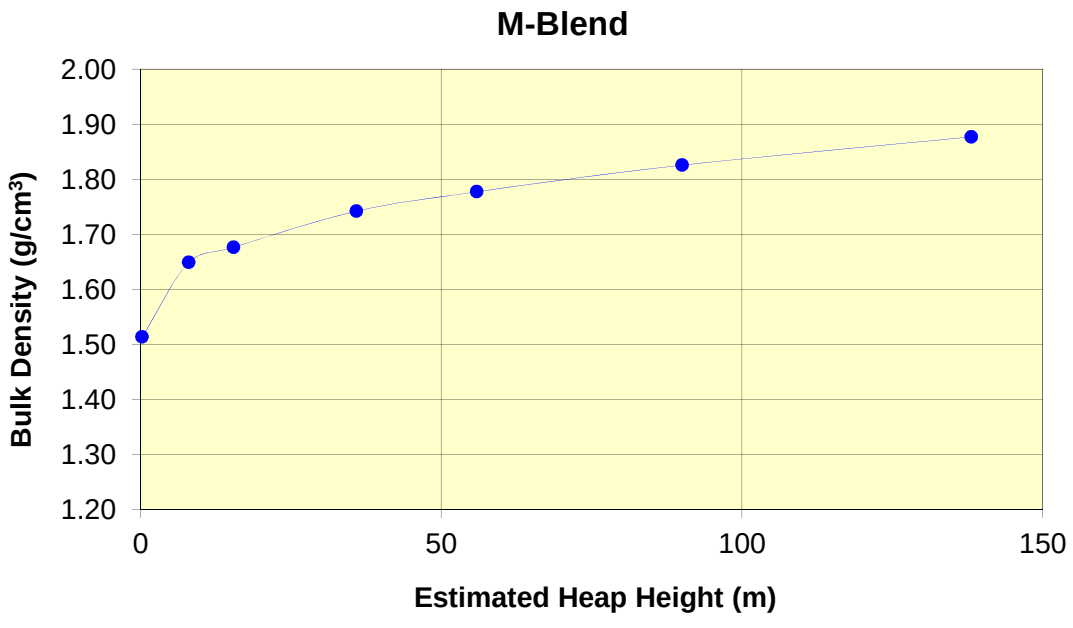
Description: Fresh non-agglomerated w/N/A

Cell Diameter: 20.35 cm S.G.: 2.65 Grav.M.C.: 0.3% Agglomeration Level: L0

NUMERICAL RESULTS

Est Heap Height (m)	Dry Bulk Density (g/cm^3)	Permeability (cm^2)	Porosity ( )
0.3	1.51	1.8E-05	0.43
8.0	1.65	1.7E-05	0.38
15.5	1.68	1.7E-05	0.37
35.9	1.74	1.1E-05	0.34
55.9	1.78	9.6E-06	0.33
90.0	1.83	7.2E-06	0.31
138.1	1.88	5.7E-06	0.29

GRAPHICAL RESULTS



HYDRODYNAMIC LABORATORY REPORT

HydroGeoSense
Because you need to know!

STACKING TEST - Hydraulic Conductivity versus dry bulk density

SAMPLE DESCRIPTION

Client/Project: WCG Date Tested: 7/3/2014

Sample ID: M-Blend Mine/Project Site: Casino

Description: Fresh non-agglomerated w/N/A

Cell Diameter: 20.35 cm S.G.: 2.65 Grav.M.C.: 0.3% Agglomeration. Level: L0

NUMERICAL RESULTS

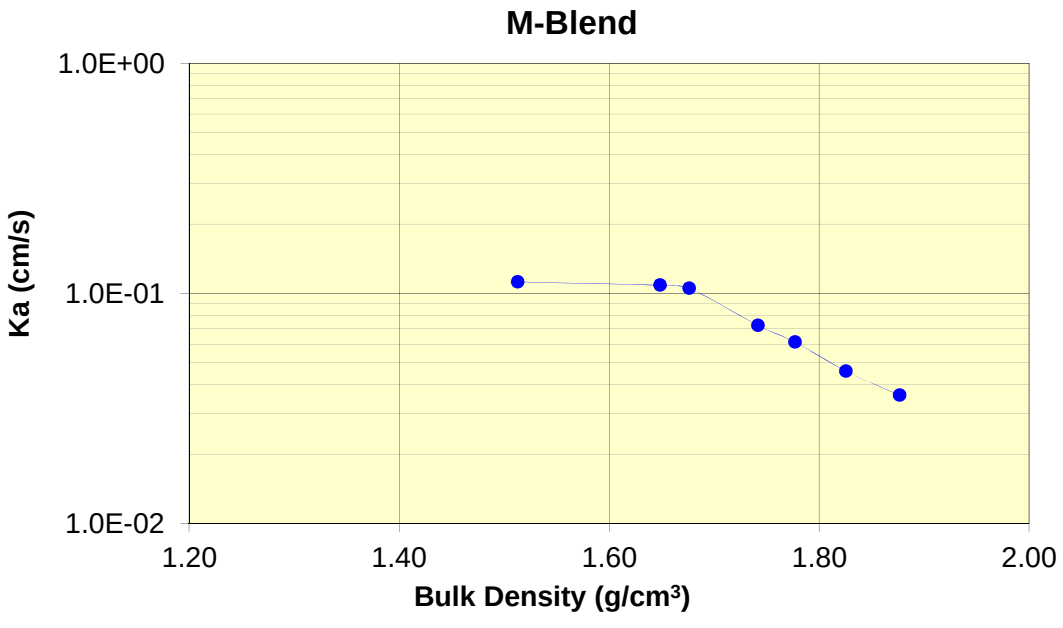
Est Heap Height (m)	Dry Bulk Density (g/cm3)	Ka (cm/s)	Kw (cm/s)
0.3	1.51	1.1E-01	4.3E-01
8.0	1.65	1.1E-01	4.1E-01
15.5	1.68	1.1E-01	4.0E-01
35.9	1.74	7.2E-02	2.8E-01
55.9	1.78	6.1E-02	2.3E-01
90.0	1.83	4.6E-02	1.8E-01
138.1	1.88	3.6E-02	1.4E-01

Final Ks available? 1.4E-01 cm/s

Ks/Ka = 3.83

Two Flow Meters in Parallel? Yes

GRAPHICAL RESULTS



CONSTANT HEAD - HYDRAULIC CONDUCTIVITY TEST

HydroGeoSense
Because you need to know!

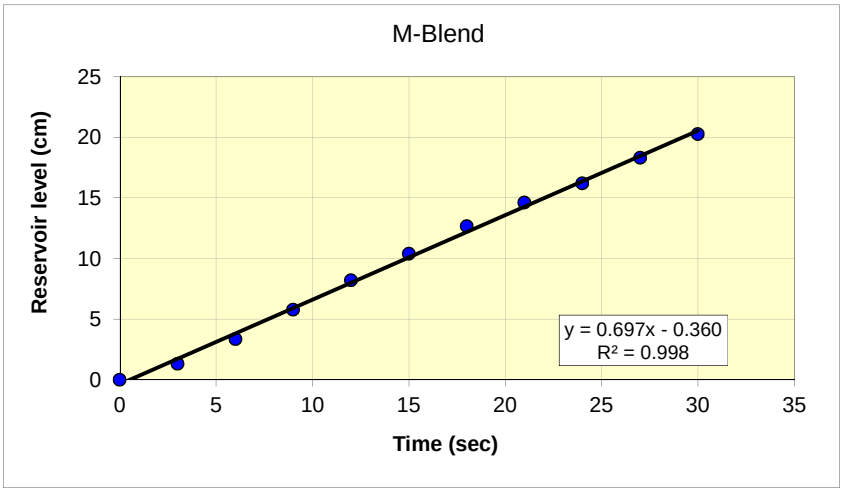
Client:	WCG	**Date:**	7/3/2014	**Time:**	15:06
Sample ID:	M-Blend			**Operator(s):**	Agg
Wet Ore Mass (g):	10,372.0	**Initial Grav. Moist. Content:**	0.3 %	**T:**	30.4 C
Bottom of ore (cm):	28.0	(from collar to top of grid)		**Initial Head Space (cm):**	11.1
Cell Diameter (in):	8.0	**Cell Area (cm^2):**	325.39	**Final Head Space (cm):**	10.8
Reservoir Area (cm^2):	42.85	**Bubble Inlet Elev (cm):**	54.0	**Discharge Elevation(cm):**	45

Test - Data

dt (s):	3
Time	Reservoir Level (cm)
0	0.00
3	1.30
6	3.35
9	5.78
12	8.20
15	10.38
18	12.65
21	14.60
24	16.20
27	18.30
30	20.27

Ks Data Analysis

First Row:	20	Last Row:	30.00	Q (cm^3/s):	29.86
Sample Height:	17.1 cm			dh (cm):	9.0



ρ_b = 1.86 g/cm^3

K_s = 1.7E-01 cm/s at T = 30.4 C

Standard Temperature = 20.0 C

	Viscosity (mPa S)	Density (g/cm^3)
at T °C	0.790	9.948E-01
at Standard Temperature (°C)	1.002	9.974E-01

$K_{s\ Standard\ T}$ = 1.4E-01

10-Min Drain Down Analysis

Preliminary Volumetric porosity partitioning estimates				
Total	**Macro**	**Fraction**	**Micro**	**Fraction**
0.30	0.14	0.49	0.15	0.51
Preliminary Gravimetric porosity partitioning estimates				
	0.14	0.48	0.15	0.52

APENDICE B

HYDRODYNAMIC COLUMN TESTS

LABORATORY REPORTS

HYDRODYNAMIC LABORATORY REPORT

HydroGeoSense
Because you need to know!

HYDRODYNAMIC COLUMN TEST - Hydraulic Conductivity Curve & Saturation Characteristic Curve

SAMPLE DESCRIPTION

Client/Project: WCG

Date Tested: July 11, 2014

Sample ID: Met 02-05

Mine/Project Site: Casino

Description: Not Agglomerated w/ 2.93 kg/t lime

Moisture Content of Agglomeration: 0.42%

Raffinate Description: Synthetic, pH ~11

Test Parameters

Init. Bulk Density: 1.77

Ore S.G.: 2.66

Solution S.G.: 1.00

Level of Agglomeration: L0

NUMERICAL RESULTS

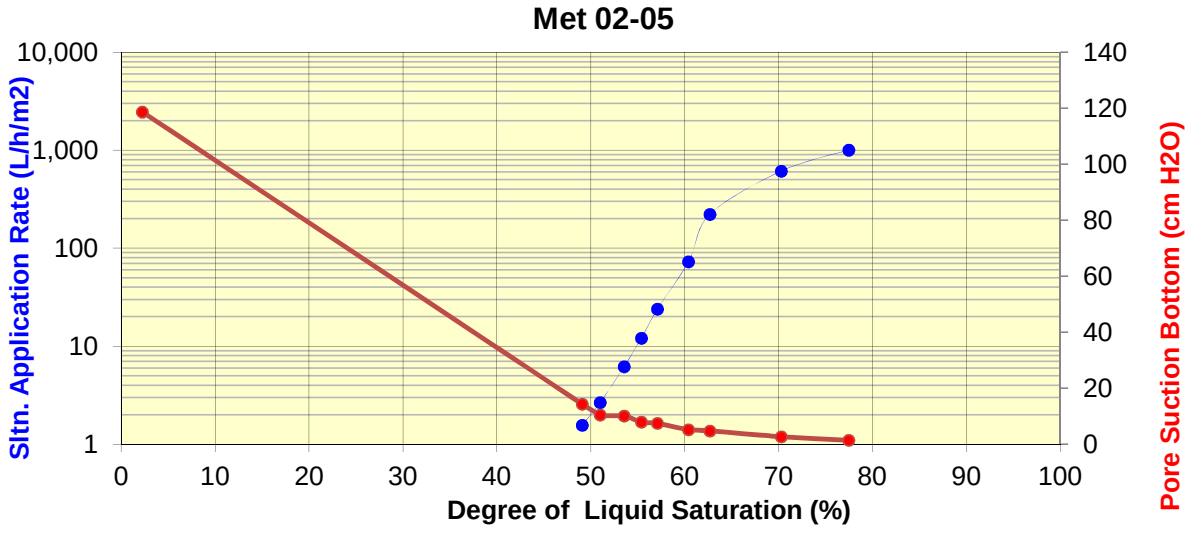
193

Sltn. Application Rate ($L/h/m^2$)	Grav. Moist. Cont. Dry Basis ($\%w_s$)	Pore Suction Top ($cm\ H_2O$)	Pore Suction Bottom ($cm\ H_2O$)	Degree of Liquid Saturation (%)
0.0	0.4	118.7	227.7	2.2
1.6	9.2	14.3	6.7	49.1
2.7	9.6	10.4	3.7	51.0
6.2	10.1	10.1	2.1	53.6
12.1	10.4	7.9	1.4	55.4
23.9	10.7	7.4	1.2	57.1
72.8	11.3	5.2	1.6	60.4
221.8	11.7	4.8	1.7	62.7
612.7	13.1	2.7	0.9	70.3
1005.2	14.4	1.4	1.4	77.5

Porosity Estimates

Total:	0.331	**Drained:**	0.197	**Macro:**	0.137	**Micro**					
						Drainable:	0.059	**Residual:**	0.134	**Micro-Total:**	0.193
Porosity Fraction:			0.594		0.415		0.179		0.406		0.585

GRAPHICAL RESULTS



HYDRODYNAMIC LABORATORY REPORT

HydroGeoSense
Because you need to know!

HYDRODYNAMIC COLUMN TEST - Conductivity Curves

SAMPLE DESCRIPTION

Client/Project: WCG

Date Tested: July 11, 2014

Sample ID: Met 02-05

Mine/Project Site: Casino

Description: Not Agglomerated w/ 2.93 kg/t lime

Moisture Content of Agglomeration: 0.42%

Raffinate Description: Synthetic, pH ~11

Test Parameters

Init. Bulk Density: 1.77

Ore S.G.: 2.66

Solution S.G.: 1.00

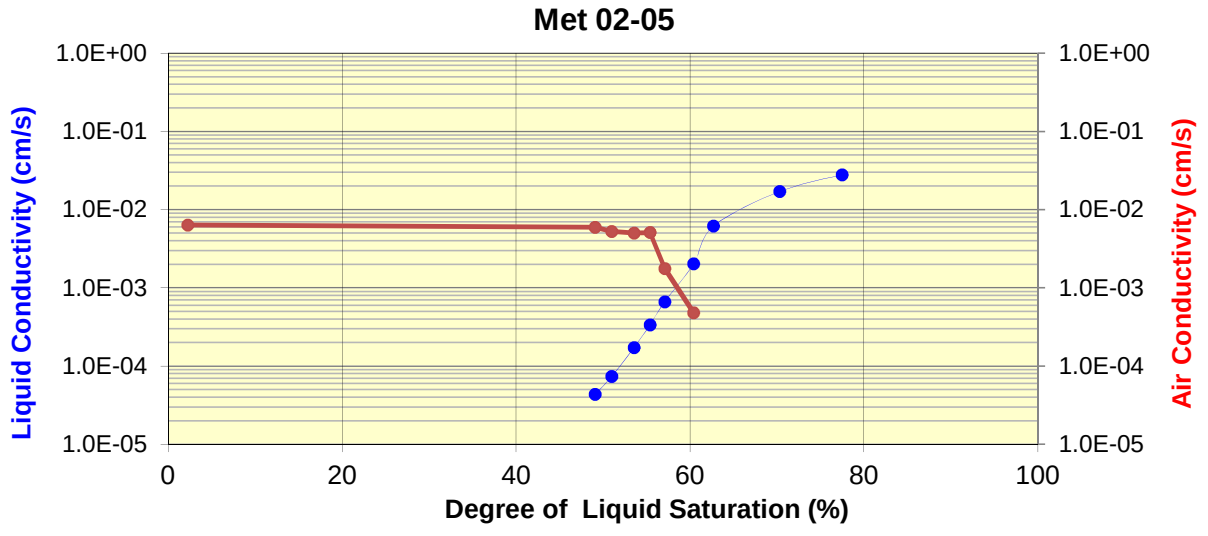
Level of Agglomeration: L0

NUMERICAL RESULTS

193

Sltn. Application Rate ($L/h/m^2$)	Degree of Liquid Saturation (%)	Pore Suction (cm H_2O)	Conductivity Liquid (cm/s)	Conductivity Air (cm/s)
	2.2	118.7		6.3E-03
1.6	49.1	14.3	4.3E-05	5.9E-03
2.7	51.0	10.4	7.4E-05	5.3E-03
6.2	53.6	10.1	1.7E-04	5.0E-03
12.1	55.4	7.9	3.3E-04	5.1E-03
23.9	57.1	7.4	6.6E-04	1.8E-03
72.8	60.4	5.2	2.0E-03	4.8E-04
221.8	62.7	4.8	6.2E-03	
612.7	70.3	2.7	1.7E-02	
1005.2	77.5	1.4	2.8E-02	

GRAPHICAL RESULTS



HYDRODYNAMIC LABORATORY REPORT

HydroGeoSense
Because you need to know!

HYDRODYNAMIC COLUMN TEST - Hydraulic Conductivity Curve & Saturation Characteristic Curve

SAMPLE DESCRIPTION

Client/Project: WCG

Date Tested: July 11, 2014

Sample ID: Met 11-17

Mine/Project Site: Casino

Description: Not Agglomerated w/2.93 kg/t Lime

Moisture Content of Agglomeration: 0.30%

Raffinate Description: Synthetic, pH ~11

Test Parameters

Init. Bulk Density: 1.54

Ore S.G.: 2.63

Solution S.G.: 1.00

Level of Agglomeration: L0

NUMERICAL RESULTS

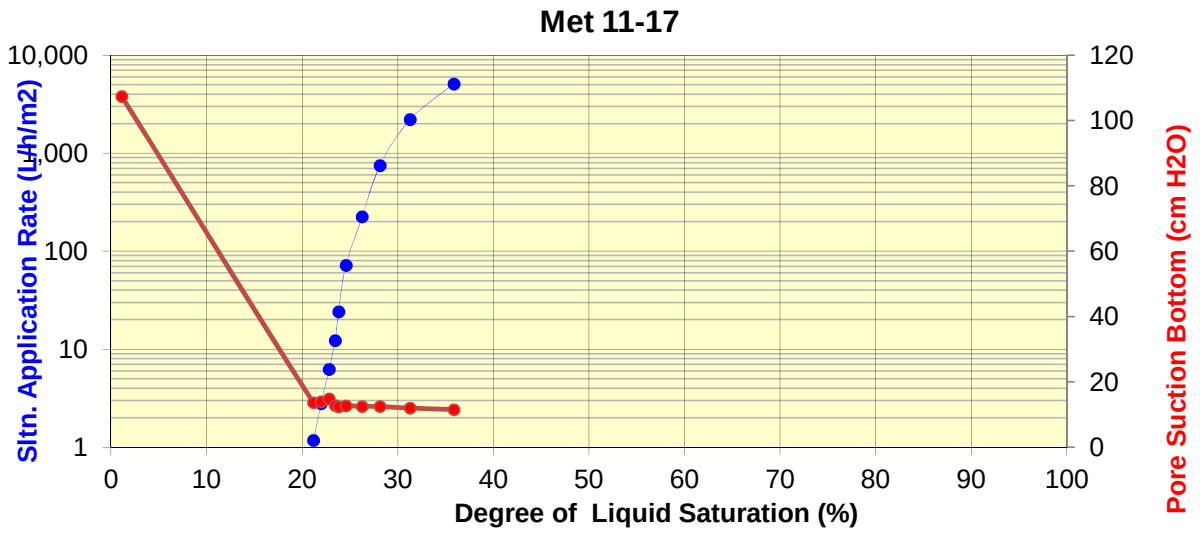
193

Sltn. Application Rate ($L/h/m^2$)	Grav. Moist. Cont. Dry Basis ($\%w_s$)	Pore Suction Top ($cm\ H_2O$)	Pore Suction Bottom ($cm\ H_2O$)	Degree of Liquid Saturation (%)
0.0	0.3	107.4	265.0	1.1
1.2	5.7	13.6	5.1	21.2
2.8	6.0	13.9	4.5	22.0
6.2	6.2	14.8	3.4	22.8
12.2	6.3	12.7	2.8	23.5
24.2	6.4	12.3	2.1	23.8
71.8	6.6	12.7	2.2	24.6
224.8	7.0	12.5	1.2	26.3
748.6	7.5	12.4	0.9	28.1
2213.4	8.3	12.0	0.9	31.3
5097.2	9.5	11.5	1.6	35.9

Porosity Estimates

Total:	0.409	**Drained:**	0.347	**Macro:**	0.302	**Micro**					
						Drainable:	0.045	**Residual:**	0.063	**Micro-Total:**	0.107
Porosity Fraction:			0.847		0.738		0.109		0.153		0.262

GRAPHICAL RESULTS



HYDRODYNAMIC LABORATORY REPORT

HydroGeoSense
Because you need to know!

HYDRODYNAMIC COLUMN TEST - Conductivity Curves

SAMPLE DESCRIPTION

Client/Project: WCG

Date Tested: July 11, 2014

Sample ID: Met 11-17

Mine/Project Site: Casino

Description: Not Agglomerated w/2.93 kg/t Lime

Moisture Content of Agglomeration: 0.30%

Raffinate Description: Synthetic, pH ~11

Test Parameters

Init. Bulk Density: 1.54

Ore S.G.: 2.63

Solution S.G.: 1.00

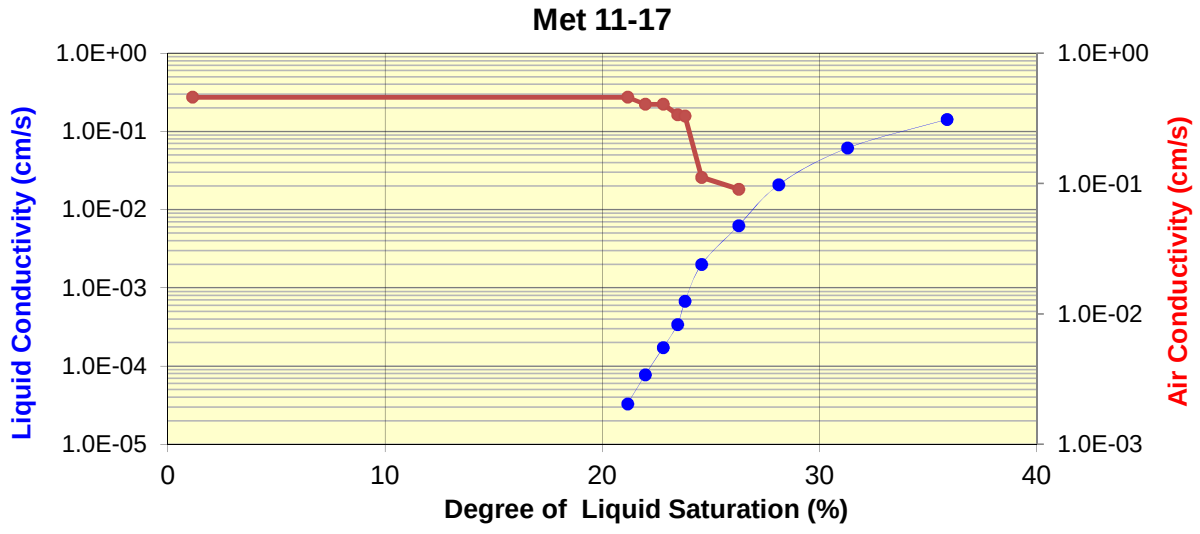
Level of Agglomeration: L0

NUMERICAL RESULTS

193

Sltn. Application Rate ($L/h/m^2$)	Degree of Liquid Saturation (%)	Pore Suction ($cm\ H_2O$)	Conductivity Liquid (cm/s)	Conductivity Air (cm/s)
	1.1	107.4		4.6E-01
1.2	21.2	13.6	3.3E-05	4.6E-01
2.8	22.0	13.9	7.7E-05	4.1E-01
6.2	22.8	14.8	1.7E-04	4.1E-01
12.2	23.5	12.7	3.4E-04	3.4E-01
24.2	23.8	12.3	6.7E-04	3.3E-01
71.8	24.6	12.7	2.0E-03	1.1E-01
224.8	26.3	12.5	6.2E-03	9.1E-02
748.6	28.1	12.4	2.1E-02	
2213.4	31.3	12.0	6.1E-02	
5097.2	35.9	11.5	1.4E-01	

GRAPHICAL RESULTS



Gekko Global Cyanide Detox Group Testwork Report

Casino Mining Corp – Casino Project Detox Testwork Report

T1196

22 January 2015



Version: 1.0
Date: 22 January 2015
Status: Final Report

For more information on procedures and test work results:

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Revision History

Version	***Date***	***Author***	***Description***
0.1	20/01/2015	Ben Adaszynski	Draft Test work Report
0.2	22/01/2015	Nee San Yap	Peer Reviewed
1.0	22/01/2015	Ben Adaszynski	Final Report

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Executive Summary

This report presents results of test work undertaken on two detox feed sample solutions from Casino Mining Corp's Casino Project. The aim of the test work was to determine the conditions to achieve a target of less than 1 mg/L CN_{WAD}. The two solutions were a PLS solution with higher cyanide and dissolved metal content and a RINSE solution that was approximately ten times more dilute than the PLS solution. Both solutions were tested using the SO_2/O_2 and H_2O_2 cyanide destruction processes.

An analysis of the samples received shows that the PLS Solution contained approximately 794 mg/L CN_{WAD}, 312 mg/L Cu, 0.28 mg/L Zn, 0.2 mg/L Fe and Nickel was below the detection limits of 0.1 mg/L. The RINSE Solution contained approximately 72 mg/L CN_{WAD}, 32 mg/L Cu, 0.1 mg/L Fe with Nickel and Zinc each below the detection limit of 0.1 mg/L.

When treating the PLS solution the extended confirmation test demonstrated that under the conditions of 3.5 $gSO_2/\ gCN_{WAD}$, pH 9.5, 182 minutes of retention time, and no copper addition the SO_2/O_2 cyanide destruction process was able to achieve an effluent with a CN_{WAD} content of approximately 0.3 mg/L. There were no conditions found where the H_2O_2 process achieved the target of less than 1.0 mg/L CN_{WAD} in the effluent.

The treatment of the RINSE solution through the extended confirmation test found that using 3.5 $gSO_2/\ gCN_{WAD}$, pH 9.5, 52 minutes of retention time, and no copper addition the SO_2/O_2 cyanide destruction process was able to achieve an effluent with a CN_{WAD} content of approximately 0.3 mg/L.

The alternative H_2O_2 process was also successful to achieve an effluent with a CN_{WAD} content of less than 0.2 mg/L using the conditions of 3.2 $gH_2O_2/\ gCN_{WAD}$, pH 9.5, 63 minutes of retention time, and no copper addition.

From this test work program the Gekko Cyanide Detox Group is able to modify the existing cyanide destruction circuit to be a robust cyanide destruction system that will be able to consistently meet effluent requirements.

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1. Introduction

Gekko Systems was contacted to provide cyanide destruction test work for Casino Mining's Casino Project. The purpose of the test work was to determine the conditions that obtain the target of less than 1 mg/L CN_{WAD} on high cyanide PLS solution and a low cyanide RINSE solution.

The test work utilized the sulphur dioxide – air (SO_2/O_2) cyanide removal process (also known as the INCO process), and the hydrogen peroxide process. These processes require the presence of soluble copper (which acts as a catalyst), to oxidize cyanide (CN^-) to cyanate (OCN). The copper required is often present in the feed as a copper cyanide complex, or otherwise can be added as a solution of copper sulphate.

1.1. Definitions and Acronyms

These are the definitions and acronyms used in this document.

Term or Acronym	***Definition***
AAS	Atomic Absorption Spectrometry
CN^-_f	Free cyanide
CN_P	Cyanide measured by picric acid method
CN_T or CN_{TOTAL}	Total cyanide
CN_{WAD}	Weak Acid Dissociable Cyanide
Cu	Copper
$CuSO_4$	Copper Sulphate
DO	Dissolved Oxygen
Detox	Cyanide Detoxification
Gekko	Gekko Systems Pty Ltd
ICP	Inductively Coupled Plasma
O_2	Oxygen
SMBS or $Na_2S_2O_5$	Sodium Metabisulphite
pH	Solution Alkalinity
SO_2	Sulphur Dioxide
µm	Micrometre

2. Sample Receipt and Preparation

2.1. Sample Receipt

Approximately 60 litres of each PLS and RINSE sample were received at the Gekko facilities in Vancouver as 3 containers of “PLS” solution and 3 containers of “RINSE” solution on August 19th 2014.

2.2. Sample Preparation

The PLS solution was found to contain 793.8 mg/L CN_{WAD} when it was received and the RINSE solution contained 72.5 mg/L CN_{WAD}. Both samples underwent an ICP scan and a summary of the critical metals is provided in Table 1.

For full assay results see Appendix A.

Table 1: Critical Metals Summary of Detox Feed

Feed Analysis					
	CN_{WAD} mg/L	Cu mg/L	Ni mg/L	Fe mg/L	Zn mg/L
PLS SOLUTION	793.8	312	<0.1	0.2	0.28
RINSE SOLUTION	72.47	31.5	<0.1	0.1	<0.1

3. Experimental Procedure

3.1. Laboratory Set-up

The experimental set up for the cyanide destruction tests comprised of a reaction vessel (overflowing at 1.5L) equipped with a Rushton turbine, baffles, a dissolved oxygen and pH probe, a cyanide sensing silver electrode (Dyna Probe) and a reagent reservoir for Sodium Metabisulphite ($Na_2S_2O_5$) or Hydrogen Peroxide (H_2O_2), and lime ($Ca(OH)_2$) addition. Figure 1 below shows the set up.



Figure 1: Laboratory Set-up

3.2. Test and Analytical Procedures

An initial batch test was performed to lower the detox feed CN_{WAD} levels to below 1.0 mg/L in the reactor, with the treated solution obtained from this test used as starting material for continuous treatment testing. In all subsequent tests, the solution remaining in the reactor at the conclusion of the treatment was used as the starting material for the next experiment.

To ensure adequate mixing within the reactor, the agitator was operated between 400 and 500 RPM. Reagent flow rates were set according to pre-selected feed conditions and continually monitored. Sodium Metabisulphite was used as the source of sulphur dioxide and hydrogen peroxide 50% w/w solution was used as the peroxide source. Air was injected into the reactor below the agitator to maintain the required dissolved oxygen level. No additional copper catalyst was required.

The cyanide destruction process was monitored on a continuous basis using a cyanide sensing silver electrode (Dyna Probe) that produces readings in mV. The dissolved oxygen levels and pH were also continuously monitored.

Representative samples of treated effluent were taken at each replacement for analysis. A minimum of three replacements of the detox reactor tank was used to produce a representative result. The effluents were filtered using a 0.45 µm membrane filter and immediately prepared for the colorimetric determination of CN_{WAD} using the buffered picric acid method (CN_P). All filtrates were tested for silver, copper, nickel, iron and zinc.

The cyanide concentration determined by the picric acid method includes all cyanide species except cyanide complexed with iron or gold in solution. Therefore, CN_P is greater than or equal to CN_{WAD} and is reported as CN_{WAD} in this report. If required, the total cyanide (CN_T) can be accurately estimated using the formula: $CN_T = CN_P + 2.795 \times Fe$ (mg/L).

4. Results

During the testing of the solution the process conditions were adjusted in successive tests to minimise the CN_{WAD} and residual base metals in the effluent and to optimise operating conditions. Two solutions were tested; a higher cyanide and higher metal content "PLS" solution and a lower cyanide and lower metal content "RINSE" solution.

4.1. PLS Solution

The PLS Solution contained approximately 794 mg/L CN_{WAD}, 312 mg/L Cu, 0.28 mg/L Zn, 0.2 mg/L Fe and no detectable Ni. The solution was detoxified using both the SO_2/O_2 and the H_2O_2 processes. The retention time was tested between the range of 86 minutes and 187 minutes for the SO_2/O_2 tests and for the H_2O_2 tests a range of 61 minutes to 194 minutes was tested. Retention time was investigated to determine the time required for cyanide destruction and possible reduction in reagent consumption. During the test work, the pH was controlled automatically by addition of lime to the pH set points of 8.5 and 9.5 for both processes. It was demonstrated that additional copper catalyst was not required for successful cyanide destruction.

A summary of all the conditions tested and results is provided in Table 2.

Table 2: Summary of PLS Solution Cyanide Destruction Tests

Test	Conditions					Product Solution Analysis						
	Reagent:CN_{WAD} g/g	Cu addition mg/L	Retention Time min	pH	Lime:Reagent g/g	CN_P mg/L	Ag mg/L	Cu mg/L	Ni mg/L	Fe mg/L	Zn mg/L	CN_{TOT} mg/L
T1 - SMBS - PLS	6.3	0	86.4	8.5	0.29	1.69	0.3	13.5	<0.1	<0.2	<0.1	1.7
T2 - SMBS - PLS	6.6	0	118.7	8.6	0.32	1.04	0.2	9.5	<0.1	<0.2	<0.1	1.0
T3 - SMBS - PLS	6.2	0	184.0	9.5	0.56	0.30	0.2	1.1	<0.1	<0.2	<0.1	0.3
T4 - SMBS - PLS	4.9	0	181.5	9.5	0.50	0.31	0.2	2.5	<0.1	<0.2	<0.1	0.3
T17 - SMBS - PLS	3.5	0	173.6	9.5	1.44	<0.2	0.1	1.0	<0.1	<0.2	<0.1	<0.2
T18 - SMBS - PLS	2.6	0	187.3	9.5	2.27	2.09	0.2	4.8	<0.1	<0.2	<0.1	2.1
T19 - SMBS - PLS	3.5	0	122.7	9.6	1.12	0.54	0.1	5.2	<0.1	<0.2	<0.1	0.5
T5 - H2O2 - PLS	5.4	0	61.3	8.8	0.00	26.79	0.2	73.9	<0.1	<0.2	<0.1	26.8
T6 - H2O2 - PLS	5.8	0	116.4	8.6	0.00	12.33	0.2	30.8	-	<0.2	0.1	12.3
T7 - H2O2 - PLS	5.1	0	194.6	9.5	0.16	37.98	0.2	51.2	-	<0.2	<0.1	38.0
T8 - H2O2 - PLS	7.0	0	175.2	9.1	0.42	40.50	0.3	66.3	-	<0.2	<0.1	40.5

4.1.1. SO_2/O_2 Process Results

4.1.1.1. Effect of SO_2 Dosage

The sulphur dioxide dosage ratio was varied between 2.6 to 6.6 gSO_2/gCN_{WAD}. Table 3 provides a comparison between tests and shows that at a retention time of 174 minutes and a minimum addition of 3.5 gSO_2/gCN_{WAD}, the process was able to reduce the CN_{WAD} to <0.2 mg/L. Increases in SO_2 addition did not further reduce the CN_{WAD} content in the effluent. Reducing the SO_2 addition to 2.6 gSO_2/gCN_{WAD} caused an unstable reaction with the CN_{WAD} in the effluent slowly rising.

Table 3: Effect of SO_2 Dosage on Cyanide Destruction

Test	Conditions					Product Solution Analysis						
	Reagent:CN_{WAD} g/g	Cu addition mg/L	Retention Time min	pH	Lime:Reagent g/g	CN_P mg/L	Ag mg/L	Cu mg/L	Ni mg/L	Fe mg/L	Zn mg/L	CN_{TOT} mg/L
T3 - SMBS - PLS	6.2	0	184.0	9.5	0.56	0.30	0.2	1.1	0.0	0.0	0.0	0.30
T4 - SMBS - PLS	4.9	0	181.5	9.5	0.50	0.31	0.2	2.5	0.0	0.0	0.0	0.31
T17 - SMBS - PLS	3.5	0	173.6	9.5	1.44	<0.2	0.1	1.0	0.0	0.0	0.0	<0.2
T18 - SMBS - PLS	2.6	0	187.3	9.5	2.27	2.09	0.2	4.8	0.0	0.0	0.0	2.09

4.1.1.2. Effect of Retention Time

The retention time was varied between approximately 86 minutes to 187 minutes. A comparison between tests, as summarised in Table 4, shows that at the same SO_2 dosage ratio and pH, reducing the retention time from 174 minutes to 123 minutes resulted in a higher CN_{WAD} and dissolved copper content in the effluent.

Table 4: Effect of Retention Time on Cyanide Destruction

Test	Conditions					Product Solution Analysis						
	Reagent:CN_{WAD} g/g	Cu addition mg/L	Retention Time min	pH	Lime:Reagent g/g	CN_P mg/L	Ag mg/L	Cu mg/L	Ni mg/L	Fe mg/L	Zn mg/L	CN_{TOT} mg/L
T17 - SMBS - PLS	3.5	0	173.6	9.5	1.44	<0.2	0.1	1.0	<0.1	<0.2	<0.1	<0.2
T19 - SMBS - PLS	3.5	0	122.7	9.6	1.12	0.54	0.1	5.2	<0.1	<0.2	<0.1	0.5

4.1.1.3. Effect of pH

Table 5 illustrates the effect of pH on the cyanide destruction process. A pH between 8.0 and 9.0 is commonly used in the SO_2/O_2 process. In this test work, the pH was set to 8.5 and 9.5. It was found that increasing the pH resulted in a decrease in the cyanide level in the effluent and reduced the amount of copper dissolved in solution.

Table 5: Effect of pH on Cyanide Destruction

Test	Conditions					Product Solution Analysis						
	Reagent:CN_{WAD} g/g	Cu addition mg/L	Retention Time min	pH	Lime:Reagent g/g	CN_P mg/L	Ag mg/L	Cu mg/L	Ni mg/L	Fe mg/L	Zn mg/L	CN_{TOT} mg/L
T1 - SMBS - PLS	6.3	0	86.4	8.5	0.29	1.69	0.3	13.5	<0.1	<0.2	<0.1	1.7
T3 - SMBS - PLS	6.2	0	184.0	9.5	0.56	0.30	0.2	1.1	<0.1	<0.2	<0.1	0.3

4.1.2. H_2O_2 Process Results

4.1.2.1. Effect of H_2O_2 Dosage

The H_2O_2 dosage ratio was varied from 5.1 to 7.0 gH_2O_2/gCN_{WAD} and a comparison of the results can be found in Table 6. The tests found that even at a high dosage rate of 7.0 gH_2O_2/gCN_{WAD} the process was not able to achieve the target of less than 1.0 mg/L CN_{WAD} in the effluent. It is believed that the presence of fine metal hydroxide solids formed by the precipitation of base metals caused the peroxide to dissociate before it could oxidize the cyanide molecules.

Table 6: Effect of H_2O_2 Addition Rate on Cyanide Destruction

Test	Conditions					Product Solution Analysis						
	Reagent:CN_{WAD} g/g	Cu addition mg/L	Retention Time min	pH	Lime:Reagent g/g	CN_P mg/L	Ag mg/L	Cu mg/L	Ni mg/L	Fe mg/L	Zn mg/L	CN_{TOT} mg/L
T7 - H2O2 - PLS	5.1	0	194.6	9.5	0.16	37.98	0.2	51.2	-	<0.2	<0.1	38.0
T8 - H2O2 - PLS	7.0	0	175.2	9.1	0.42	40.50	0.3	66.3	-	<0.2	<0.1	40.5

4.1.2.2. Effect of Retention Time

The retention time was varied between approximately 61 minutes and 195 minutes. While increasing the retention time did produce a stable cyanide content in the effluent it failed to meet the target of less than 1 mg/L CN_{WAD}.

Table 7: Effect of Retention Time on Cyanide Destruction

Test	Conditions					Product Solution Analysis						
	Reagent:CN_{WAD} g/g	Cu addition mg/L	Retention Time min	pH	Lime:Reagent g/g	CN_P mg/L	Ag mg/L	Cu mg/L	Ni mg/L	Fe mg/L	Zn mg/L	CN_{TOT} mg/L
T5 - H2O2 - PLS	5.4	0	61.3	8.8	0.00	26.79	0.2	73.9	<0.1	<0.2	<0.1	26.8
T6 - H2O2 - PLS	5.8	0	116.4	8.6	0.00	12.33	0.2	30.8	-	<0.2	0.1	12.3

4.1.2.3. Effect of pH

Table 8 illustrates the effect of pH on the cyanide destruction process. A pH between 8.5 and 9.5 is commonly used in the H_2O_2 process. In this test work, the pH was set to 8.5 and 9.5. It was found that increasing the pH produced an unsteady reaction with an increasing CN_{WAD} content in the effluent as the test continued. A higher dissolved copper was also detected in the effluent.

Table 8: Effect of pH on Cyanide Destruction

Test	Conditions					Product Solution Analysis						
	Reagent:CN_{WAD} g/g	Cu addition mg/L	Retention Time min	pH	Lime:Reagent g/g	CN_P mg/L	Ag mg/L	Cu mg/L	Ni mg/L	Fe mg/L	Zn mg/L	CN_{TOT} mg/L
T6 - H2O2 - PLS	5.8	0	116.4	8.6	0.00	12.33	0.2	30.8	-	<0.2	0.1	12.3
T7 - H2O2 - PLS	5.1	0	194.6	9.5	0.16	37.98	0.2	51.2	-	<0.2	<0.1	38.0

4.1.3. Extended Confirmation Test

A longer confirmation test was run to demonstrate that the reaction had achieved steady state conditions at an acceptable cyanide discharge level. The results are summarised in Table 9. The conditions selected for this test were based on the best results achieved during the test work optimisation program and selected as 3.5 gSO_2/ gCN_{WAD}, pH 9.5, 182 minutes of retention time, and no copper addition to match the conditions of Test 17. During the test it was observed that there was a problem with the addition of sodium metabisulphite causing the CN_{WAD} levels to rise. Once this was corrected the CN_{WAD} content in the effluent quickly recovered. The end result was an effluent that contained approximately 0.3 mg/L CN_{WAD}. Effluent from the final displacement also underwent cyanide speciation with the results provided in Table 10.

A full ICP-MS scan was conducted on the final solution as well as cyanide speciation which can be found in Appendix B.

Table 9: Summary of the Confirmation Test

Sample Description	CNp	Ag	Cu	Ni	Fe	Zn	pH	COMMENTS
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L		
Feed	760.00	0.20	328	<0.05	0.18	0.29	9.68	
1st Reactor Replacement	2.31	0.09	5.21	<0.05	<0.10	<0.05	9.75	
2nd Reactor Replacement	5.28	0.17	11.30	<0.05	<0.10	<0.05	9.60	Meta supply malfunction!
3rd Reactor Replacement	0.28	0.14	2.49	<0.05	<0.10	<0.05	9.53	
4th Reactor Replacement	0.29	0.16	2.21	<0.05	<0.10	<0.05	9.54	
5th Reactor Replacement	0.26	0.13	2.17	<0.05	<0.10	<0.05	9.52	

Table 10: Cyanide Speciation

Cyanide Species	Cyanate (mg/L)	EDTA-CN (mg/L)	WAD-CN (mg/L)	SCN (mg/L)
Average Value	873	0.19	0.17	4.8

4.2. RINSE Solution

The RINSE Solution contained approximately 72 mg/L CN_{WAD}, 32 mg/L Cu, 0.1 mg/L Fe and no detectable Zn or Ni. The solution was detoxified using both the SO_2/O_2 and the H_2O_2 processes. The retention time was tested between the range of 32 minutes and 70 minutes for the SO_2/O_2 tests and for the H_2O_2 tests a range of 32 minutes to 63 minutes was tested. Retention time was investigated to determine the time required for cyanide destruction and possible reduction in reagent consumption. During the test work, the pH was controlled automatically by addition of lime to the pH set point of 9.5 for both processes based on the results from the PLS tests. It was demonstrated that additional copper catalyst was not required for successful cyanide destruction.

A summary of all the conditions tested and results is provided in Table 11.

Table 11: Summary of RINSE Solution Cyanide Destruction Tests

Test	Conditions					Product Solution Analysis						
	Reagent:CN_{WAD} g/g	Cu addition mg/L	Retention Time min	pH	Lime:Reagent g/g	CN_P mg/L	Ag mg/L	Cu mg/L	Ni mg/L	Fe mg/L	Zn mg/L	CN_{TOT} mg/L
T9 - SMBS - RINSE	5.2	0	61.6	9.5	1.82	<0.2	<0.1	0.5	<0.1	<0.2	<0.1	<0.2
T10 - SMBS - RINSE	5.4	0	32.3	9.5	1.00	1.73	<0.1	1.5	<0.1	<0.2	<0.1	1.7
T11 - SMBS - RINSE	4.3	0	61.9	9.5	2.34	<0.2	<0.1	0.7	<0.1	<0.2	<0.1	<0.2
T12 - SMBS - RINSE	3.7	0	70.1	9.6	3.12	<0.2	<0.1	0.6	<0.1	<0.2	<0.1	<0.2
T13 - H2O2 - RINSE	5.4	0	32.3	9.5	1.05	1.81	<0.1	0.8	<0.1	<0.2	<0.1	1.8
T14 - H2O2 - RINSE	4.5	0	33.1	9.5	0.42	<0.2	<0.1	0.3	<0.1	<0.2	<0.1	<0.2
T15 - H2O2 - RINSE	3.2	0	32.1	9.6	0.92	6.69	<0.1	1.8	<0.1	<0.2	<0.1	6.7
T16 - H2O2 - RINSE	3.2	0	62.8	9.5	1.52	0.95	<0.1	1.5	<0.1	<0.2	<0.1	1.0

4.2.1. SO_2/O_2 Process Results

4.2.1.1. Effect of SO_2 Dosage

The sulphur dioxide dosage ratio was varied between 3.7 to 5.4 gSO_2/gCN_{WAD}. Table 12 provides a comparison between tests and shows that at a retention time of 70 minutes and a minimum addition of 3.7 gSO_2/gCN_{WAD}, the process was able to reduce the CN_{WAD} to <0.2 mg/L. Increases in SO_2 addition did not further reduce the CN_{WAD} content in the effluent.

Table 12: Effect of SO_2 Dosage on Cyanide Destruction

Test	Conditions					Product Solution Analysis						
	Reagent:CN_{WAD} g/g	Cu addition mg/L	Retention Time min	pH	Lime:Reagent g/g	CN_P mg/L	Ag mg/L	Cu mg/L	Ni mg/L	Fe mg/L	Zn mg/L	CN_{TOT} mg/L
T9 - SMBS - RINSE	5.2	0	61.6	9.5	1.82	<0.2	<0.1	0.5	<0.1	<0.2	<0.1	<0.2
T10 - SMBS - RINSE	5.4	0	32.3	9.5	1.00	1.73	<0.1	1.5	<0.1	<0.2	<0.1	1.7
T11 - SMBS - RINSE	4.3	0	61.9	9.5	2.34	<0.2	<0.1	0.7	<0.1	<0.2	<0.1	<0.2

4.2.1.2. Effect of Retention Time

The retention time was varied between approximately 32 minutes to 70 minutes. A comparison between tests, as summarised in Table 13, shows that at the same SO_2 dosage ratio and pH, reducing the retention time from 62 minutes to 32 minutes resulted in a higher CN_{WAD} and dissolved copper content in the effluent.

Table 13: Effect of Retention Time on Cyanide Destruction

Test	Conditions					Product Solution Analysis						
	Reagent:CN_{WAD} g/g	Cu addition mg/L	Retention Time min	pH	Lime:Reagent g/g	CN_P mg/L	Ag mg/L	Cu mg/L	Ni mg/L	Fe mg/L	Zn mg/L	CN_{TOT} mg/L
T9 - SMBS - RINSE	5.2	0	61.6	9.5	1.82	<0.2	<0.1	0.5	<0.1	<0.2	<0.1	<0.2
T10 - SMBS - RINSE	5.4	0	32.3	9.5	1.00	1.73	<0.1	1.5	<0.1	<0.2	<0.1	1.7

4.2.2. H_2O_2 Process Results

4.2.2.1. Effect of H_2O_2 Dosage

The H_2O_2 dosage ratio was varied from 3.2 to 5.4 gH_2O_2/gCN_{WAD} and a comparison of the results can be found in Table 14. The tests found that the maximum cyanide destruction occurred at 4.5 gH_2O_2/gCN_{WAD} with 33 minutes of retention time achieving less than 0.2 mg/L CN_{WAD} in the effluent. Further reducing the H_2O_2 addition to 3.2 gH_2O_2/gCN_{WAD} required 63 minutes of retention time to achieve 0.95 mg/L CN_{WAD} in the effluent, slightly below the target.

Table 14: Effect of H_2O_2 Addition Rate on Cyanide Destruction

Test	Conditions					Product Solution Analysis						
	Reagent:CN_{WAD} g/g	Cu addition mg/L	Retention Time min	pH	Lime:Reagent g/g	CN_P mg/L	Ag mg/L	Cu mg/L	Ni mg/L	Fe mg/L	Zn mg/L	CN_{TOT} mg/L
T13 - H2O2 - RINSE	5.4	0	32.3	9.5	1.05	1.81	<0.1	0.8	<0.1	<0.2	<0.1	1.8
T14 - H2O2 - RINSE	4.5	0	33.1	9.5	0.42	<0.2	<0.1	0.3	<0.1	<0.2	<0.1	<0.2
T15 - H2O2 - RINSE	3.2	0	32.1	9.6	0.92	6.69	<0.1	1.8	<0.1	<0.2	<0.1	6.7
T16 - H2O2 - RINSE	3.2	0	62.8	9.5	1.52	0.95	<0.1	1.5	<0.1	<0.2	<0.1	1.0

4.2.2.2. Effect of Retention Time

The retention time was varied between approximately 32 minutes and 63 minutes. Increasing the retention time allowed for a lower H_2O_2 dosage that was still able to achieve the effluent target of less than 1 mg/L CN_{WAD} in solution. Results are shown in Table 15.

Table 15: Effect of Retention Time on Cyanide Destruction

Test	Conditions					Product Solution Analysis						
	Reagent:CN_{WAD} g/g	Cu addition mg/L	Retention Time min	pH	Lime:Reagent g/g	CN_P mg/L	Ag mg/L	Cu mg/L	Ni mg/L	Fe mg/L	Zn mg/L	CN_{TOT} mg/L
T14 - H2O2 - RINSE	4.5	0	33.1	9.5	0.42	<0.2	<0.1	0.3	<0.1	<0.2	<0.1	<0.2
T15 - H2O2 - RINSE	3.2	0	32.1	9.6	0.92	6.69	<0.1	1.8	<0.1	<0.2	<0.1	6.7
T16 - H2O2 - RINSE	3.2	0	62.8	9.5	1.52	0.95	<0.1	1.5	<0.1	<0.2	<0.1	1.0

4.2.1. Extended Confirmation Test

A longer confirmation test was run to demonstrate that the reaction had achieved steady state conditions at an acceptable cyanide discharge level. The results are summarised in Table 16. The conditions selected for this test were based on the best results achieved during the test work optimisation program and selected as 3.5 gSO_2/ gCN_{WAD}, pH 9.5, 52 minutes of retention time, and no copper addition to match the conditions of Test 12. The test initially struggled due to an overdosing of lime that caused the pH to increase to 11.6 but was slowly able to recover and reduce the CN_{WAD} content of the effluent well below the target of less than 1 mg/L CN_{WAD}. The end result was an effluent that contained approximately 0.3 mg/L CN_{WAD}. Effluent from the final displacement also underwent cyanide speciation with the results provided in Table 17.

A full ICP-MS scan was conducted on the final solution as well as cyanide speciation which can be found in Appendix B.

Table 16: Summary of the Confirmation Test

Sample Description	CNp mg/L	Ag mg/L	Cu mg/L	Ni mg/L	Fe mg/L	Zn mg/L	pH
Feed	80.0	<0.05	30	<0.05	<0.10	<0.05	10.5
1st Reactor Replacement	5.52	<0.05	0.56	<0.05	<0.10	<0.05	11.6
2nd Reactor Replacement	3.30	*missed ICP sample					9.61
3rd Reactor Replacement	1.62	<0.05	2.78	<0.05	<0.10	<0.05	9.84
4th Reactor Replacement	1.07	<0.05	1.50	<0.05	<0.10	<0.05	9.53
5th Reactor Replacement	0.31	<0.05	2.03	<0.05	<0.10	<0.05	9.55

Table 17: Cyanide Speciation

Cyanide Species	Cyanate (mg/L)	EDTA-CN (mg/L)	WAD-CN (mg/L)	SCN (mg/L)
Average Value	70	<0.1	<0.1	0.8

5. Concluding Comments

From the results of the test work the following concluding comments can be made:

5.1. PLS Solution

- The analysis of the PLS feed solution showed it contained an average of 794 mg/L CN_{WAD} 312 mg/L Cu, 0.28 mg/L Zn, 0.2 mg/L Fe with Ni below the detection limit of 0.1 mg/L.

- Test work showed that only the SO_2/O_2 process was suitable for cyanide destruction of the PLS solution. It is believed that the H_2O_2 process failed due to the high amount of copper precipitate formed during the detox reaction. The presence of these solids would cause the hydrogen peroxide to decompose before it could oxidize the cyanide.

- A minimum dosage of 3.5 gSO_2/ gCN_{WAD} was able to achieve less than 0.2 mg/L CN_{WAD} in the effluent. Further reduction in SO_2 dosage resulted in an unstable reaction that failed to meet the targeted 1.0 mg/L CN_{WAD} and increasing the SO_2 addition did not achieve a lower CN_{WAD} content in the effluent.

- To minimize reagent consumption and improve effluent quality a retention time of approximately 180 minutes was required to achieve less than 1.0 mg/L CN_{WAD} in the effluent. Reducing the retention time failed to achieve the target even with higher SO_2 dosage.

- It was necessary to conduct the tests at pH 9.5 to remove residual copper from the solution.

- Under the conditions of 3.5 gSO_2/ gCN_{WAD}, pH 9.5, 182 minutes of retention time, and no copper addition the SO_2/O_2 cyanide destruction process was able to achieve an effluent with a CN_{WAD} content of approximately 0.3 mg/L.

5.2. RINSE Solution

- The analysis of the RINSE solution showed it contained an average of 72 mg/L CN_{WAD}, 32 mg/L Cu, 0.1 mg/L Fe and no detectable Zn or Ni.

- Test work showed that both the SO_2/O_2 and H_2O_2 processes could be used to reduce the CN_{WAD} content in the effluent to less than 1.0 mg/L

- A minimum dosage of 3.7 gSO_2/ gCN_{WAD} was able to achieve less than 0.2 mg/L CN_{WAD} in the effluent. Increasing the SO_2 addition did not achieve a lower CN_{WAD} content in the effluent.

- To minimize reagent consumption and improve effluent quality a retention time of approximately 60 minutes was required to achieve less than 1.0 mg/L CN_{WAD} in the effluent. Reducing the retention time failed to achieve the target even with higher SO_2 dosage.

- It was necessary to conduct the tests at pH 9.5 to remove residual copper from the solution.

- Under the conditions of 3.5 gSO_2/ gCN_{WAD}, pH 9.5, 52 minutes of retention time, and no copper addition the SO_2/O_2 cyanide destruction process was able to achieve an effluent with a CN_{WAD} content of approximately 0.3 mg/L.

- A minimum dosage of 4.5 gH_2O_2/gCN_{WAD} was required to achieve less than 0.2 mg/L CN_{WAD} in the effluent using 33 minutes of retention time. Reducing the dosage of hydrogen peroxide to 3.2 gH_2O_2/gCN_{WAD} required 63 minutes of retention time to achieve 0.95 mg/L CN_{WAD} in the effluent, slightly under the target of 1.0 mg/L CN_{WAD}.

- Under the conditions of as 3.5 gH_2O_2/ gCN_{WAD}, pH 9.5, 52 minutes of retention time, and no Copper addition the H_2O_2 cyanide destruction process was able to achieve an effluent with a CN_{WAD} content of approximately 0.3 mg/L.

6. Recommendations

The SO_2/O_2 process will be suitable for treatment of both solutions while the H_2O_2 process is limited to the conditions of the RINSE solution.

From this test work program the Gekko Cyanide Detox Group is able to design a full scale cyanide destruction circuit that will be able to consistently meet effluent requirements.

Appendix A – Detox Feed Solution Assays

Table A1: ICP of Detox Feed Solutions

CSR TOTAL METALS IN WATER (WATER)			
Maxxam ID		KQ6027	KQ6028
Sampling Date		2014/09/19 11:30	2014/09/19 11:30
COC Number		8397016	8397016
	Units	**PLS**	**RINSE**
Calculated Parameters			
Total Hardness (CaCO3)	mg/L	605	251
Total Metals by ICPMS			
Total Aluminum (Al)	ug/L	570	1200
Total Antimony (Sb)	ug/L	8.3	11.1
Total Arsenic (As)	ug/L	39.6	54.1
Total Barium (Ba)	ug/L	77	20.7
Total Beryllium (Be)	ug/L	<1.0	<0.10
Total Bismuth (Bi)	ug/L	<10	<1.0
Total Boron (B)	ug/L	<500	<50
Total Cadmium (Cd)	ug/L	3.06	0.111
Total Chromium (Cr)	ug/L	20	5.9
Total Cobalt (Co)	ug/L	5.4	2.22
Total Copper (Cu)	ug/L	312000	31500
Total Iron (Fe)	ug/L	180	67
Total Lead (Pb)	ug/L	<2.0	0.99
Total Lithium (Li)	ug/L	<50	<5.0
Total Manganese (Mn)	ug/L	<10	<1.0
Total Mercury (Hg)	ug/L	9.21	0.093
Total Molybdenum (Mo)	ug/L	6220	1310
Total Nickel (Ni)	ug/L	37	4.1
Total Selenium (Se)	ug/L	30.7	14.2
Total Silicon (Si)	ug/L	26500	39700
Total Silver (Ag)	ug/L	185	21.6
Total Strontium (Sr)	ug/L	320	198
Total Thallium (Tl)	ug/L	<0.50	0.154
Total Tin (Sn)	ug/L	<50	<5.0
Total Titanium (Ti)	ug/L	<50	<5.0
Total Uranium (U)	ug/L	<1.0	3.23
Total Vanadium (V)	ug/L	<50	<5.0
Total Zinc (Zn)	ug/L	278	29.9
Total Zirconium (Zr)	ug/L	<5.0	<0.50
Total Calcium (Ca)	mg/L	242	100
Total Magnesium (Mg)	mg/L	<0.50	0.099
Total Potassium (K)	mg/L	42.5	16.6
Total Sodium (Na)	mg/L	688	230
Total Sulphur (S)	mg/L	324	169

Appendix B – Confirmation Test Solution Assays

Table B1: ICP of Detox Effluent Solutions

Sample ID	Detoxified PLS Solution Effluent	Detoxified RINSE Solution Effluent
	mg/L	mg/L
ELEMENTS		
Ag Silver	0.12	0.02
Al Aluminium	0.19	0.04
As Arsenic	<0.02	0.03
Au Gold	0.13	0.01
B Boron	<0.05	<0.05
Ba Barium	0.02	0.01
Be Beryllium	<0.001	<0.001
Bi Bismuth	<0.05	<0.05
Ca Calcium	766	146
Cd Cadmium	<0.001	<0.001
Co Cobalt	0.020	<0.005
Cr Chromium	0.02	0.01
Cu Copper	2.03	1.82
Fe Iron	<0.01	<0.01
K Potassium	41.7	14.8
Li Lithium	<0.01	<0.01
Mg Magnesium	1.91	0.32
Mn Manganese	<0.001	<0.001
Mo Molybdenum	6.97	1.07
Na Sodium	N/A	N/A
Ni Nickel	<0.005	<0.005
P Phosphorus	0.35	0.16
Pb Lead	<0.02	<0.02
S Sulfur	1494	302
Sb Antimony	<0.02	<0.02
Se Selenium	<0.02	<0.02
Si Silicon	5.22	25.78
Sn Tin	0.049	<0.02
Sr Strontium	0.52	0.18
Ti Titanium	<0.01	<0.01
Tl Thallium	<0.02	<0.02
U Uranium	<0.05	<0.05
V Vanadium	<0.01	<0.01
Zn Zinc	0.006	<0.005

Table B2: CN Speciation of Detox Effluent Solutions

Log-In#	Sample	Initial NH3-N (mg/L)	After Hydrolysis NH3-N (mg/L)	Total Cyanate [(After Hydrolysis NH3-N) - (Initial NH3-N)]x3 (mg/L)	Reported Cyanate (mg/L)
N/A	Detoxified PLS Solution	32.4	323.3	872.70	873
N/A	Detoxified RINSE Solution	4.63	27.9	69.78	70

Thiocyanate Analysis

Reference: TJ02p188

Log-In#	Sample	SCN (mg/L)
N/A	Detoxified PLS Solution	4.77
	Detoxified PLS Solution - duplicate	4.82
N/A	Detoxified RINSE Solution	0.802

Cyanide Analysis

Reference: TJ02p190

Log-In#	Sample	WAD-CN (mg/L)	EDTA-CN (mg/L)
N/A	Detoxified PLS Solution	0.179	0.188
N/A	Detoxified PLS Solution - duplicate	0.165	0.189

Log-In#	Sample	WAD-CN (mg/L)	EDTA-CN (mg/L)
N/A	Detoxified RINSE Solution	<0.1	<0.1
N/A	Detoxified RINSE Solution - duplicate	<0.1	<0.1

Appendix C – Disclaimer

Gekko has undertaken test work to characterize the response of your ore to certain separation techniques and/or to help your own experts make a decision as to whether you wish to purchase our product and, if so, the number and type.

It is important that you understand that:

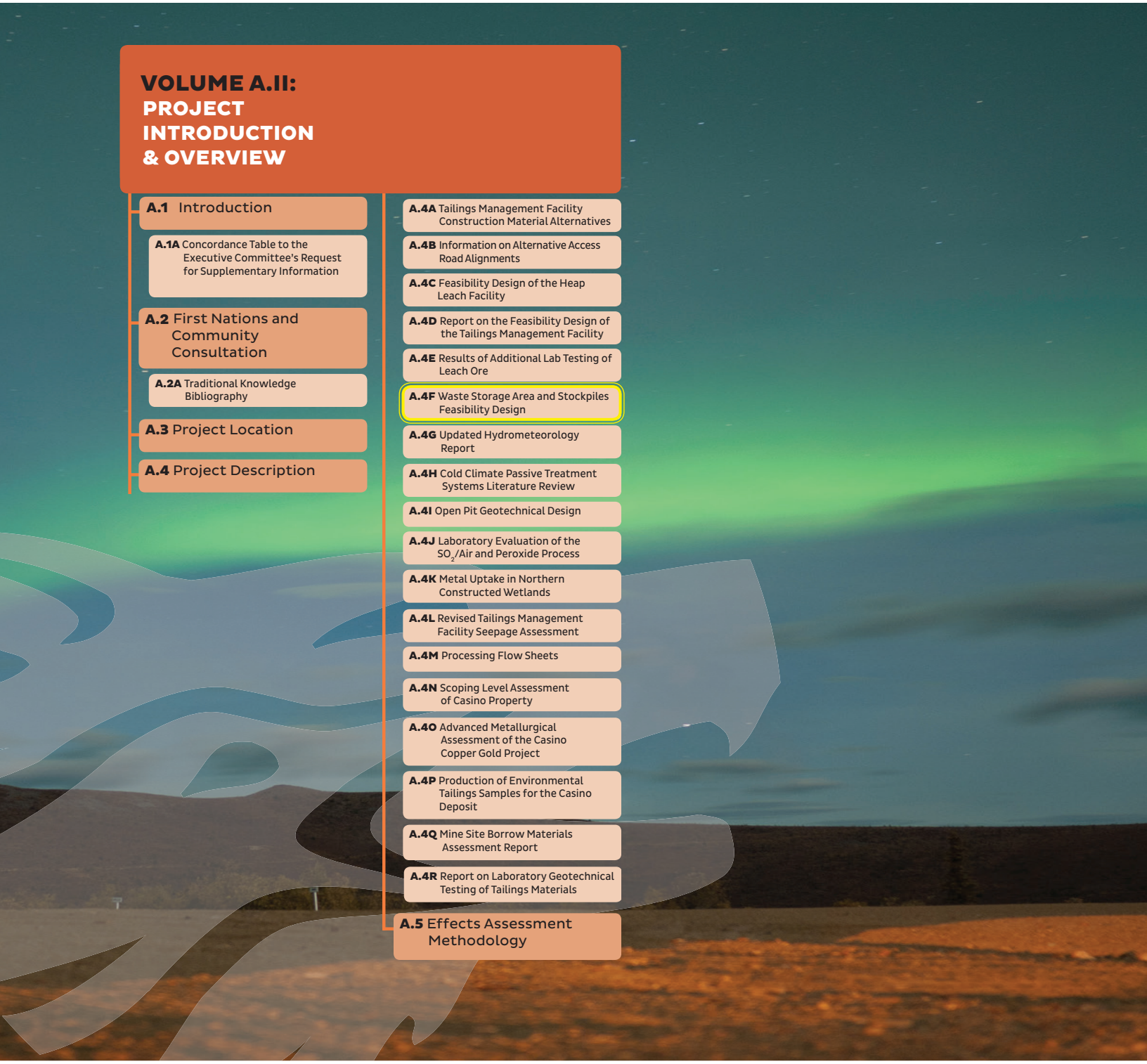
- *You must have your own experts examine the detailed analysis in our report to decide its applicability to your project.*
- *We analyse only the sample you provide. Any one of a number of factors may cause that sample inaccurately to reflect the ore body. You must determine the extent to which the sample represents the ore body. That includes the detection limits and confidence intervals relevant to our results.*

At all times we endeavour to provide accurate test work outcomes but you should not use our results as a basis for your broader business decisions about your project.

If we have not exercised due care with our tests, the limit of our liability, both at common law and under any statute, will be to provide a further set of test results to you free of charge. You indemnify us with respect to all other loss and damage of every kind, including, without limitation:

- *damage to or loss of property;*
- *injury to or death of any person; and*
- *economic and consequential loss arising from the negligent act or omission of us or anyone else in connection with our test*

APPENDIX A.4F: Waste Storage Area and Stockpiles Feasibility Design



CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT





WASTE STORAGE AREA AND STOCKPILES FEASIBILITY DESIGN

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CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

WASTE STORAGE AREA AND STOCKPILES FEASIBILITY DESIGN
VA101-325/8-12

Rev	Description	Date	Approved
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EXECUTIVE SUMMARY

The Casino Copper-Gold Project Feasibility design includes for the safe and secure management of mine waste materials, ore stockpiles and topsoil stockpiles.

Storage piles have been designed to accommodate the following materials:

- Potentially reactive (PAG and ML) waste rock and overburden
- Stockpiled ore (Low Grade ore, Supergene Oxide ore and Gold leach ore), and
- Topsoil/overburden materials.

The quantities and classification of mine waste and ore materials is based on the mine production schedule provided by Casino Mining Corporation.

The primary waste management facility for the project is the Tailings Management Facility (TMF). The TMF has been sized to provide sufficient capacity to store approximately 956 million tonnes of tailings (including cyclone sand tailings used as embankment fill) and co-disposal of up to 658 million tonnes of potentially reactive waste rock and overburden, comprising Potentially Acid Generating (PAG) and Metal Leaching (ML) materials. The findings of geochemical waste characterization studies indicate that almost all of the waste material is PAG and/or ML. These PAG and ML waste materials will be placed and stored subaqueously in a Waste Storage Area (WSA) located within the TMF.

Approximately 157.5 million tonnes of additional mined ore will be processed at a Heap Leach Facility (HLF) located south of the open pit. This gold ore will be stored in a temporarily stockpile near the crusher on the valley slope east of the open pit and at the northern end of the TMF. This stockpiled ore will report to the heap leach facility over a period of about 18 years, starting in the pre-production years (3 years prior to mill start-up) and continuing up to Year 15 of mill operations.

During mine operations approximately 144 million tonnes of Low Grade ore and 32 million tonnes of Supergene Oxide (SOX) ore will be stored in temporary stockpiles. The SOX ore will be stockpiled at a location between the open pit and plant site during the pre-production years and in Year 1 of mill operations, and report to the mill during Years 4 to 12 together with direct feed mill ore. Mined Low Grade ore will be stockpiled up to Year 17 in locations generally east and south of the plant site, on valley slopes above the TMF. Low Grade ore mined after Year 12 can also be stockpiled at the same location used for the SOX ore south of the open pit. The stockpiled Low Grade ore will be milled during the last four years of mine operations (Years 19 to 22).

It is anticipated that approximately 2 to 3 million tonnes of Non-Acid Generating (NAG) waste rock (leach cap material) will be produced during pre-production mining. This material will be used in the construction of the TMF Starter (Stage 1) embankment. Any NAG waste rock that is either unsuitable for use as a construction material or in excess of construction material requirements will be placed in the WSA or an adjacent surface dump.

The temporary storage of topsoil recovered during the construction of mine site facilities is required to ensure sufficient reclamation medium is available for mine closure. Topsoil recovered during construction will be stockpiled at select locations close to the material source.

General site characteristics including physiographic setting, hydrometeorology and seismicity are presented. Review of historical earthquake records and regional tectonics indicates that the Casino

Project site is situated in a region of low seismicity and moderate seismic hazard. A summary of geotechnical conditions at the WSA, ore stockpiles and topsoil stockpiles is also provided.

Specific design and operating requirements for the WSA, ore stockpiles and topsoil stockpiles are provided. The general arrangement and configuration of the Waste Storage Area and ore stockpiles is presented, including their development over the life of mine.

The WSA and temporary stockpiles have been designed to remain stable under both static and seismic loading conditions. Surface water and diversion ditching has been designed to divert surface flow around the ore stockpiles to minimise contact with the water. General requirements and expectations for reclamation and closure of the WSA and stockpiles are presented.

Quantity estimates for materials and work activities required for initial construction and ongoing operations of the ore stockpiles and topsoil stockpiles are provided, including foundation clearing and preparation of ore stockpile foundations, surface water management and sediment control.

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1 – INTRODUCTION

1.1 PROJECT OVERVIEW

The Casino Copper-Gold Project is a venture by Casino Mining Corporation (CMC) to develop an open pit copper-gold-molybdenum mine in the Yukon Territory. The project is located in the Dawson Range Mountains of the Klondike Plateau approximately 300 km northwest of Whitehorse, Yukon, Canada, as shown on Figure 1.1. This area is somewhat unique in that the region was not glaciated during the Wisconsin Advance. The deposit is hosted by the Prospector Mountain Suite, a suite of igneous intrusive rocks with an intense hydrothermal alteration overprint. The deposit will be mined using open pit methods with a nominal mill throughput of approximately 125,000 tonnes/day (tpd) of ore over a 22 year operating life. During the 22 year operating period the deposit will be mined over a period of approximately 18 years using conventional open pit methods. The milling of ore stockpiled during the open pit operation will continue for the remainder of the mine life (approximately 4 years).

The proposed components of the project facilities include an open pit up to 600 meters deep containing a mineable reserve of approximately 965 million tonnes of mill ore. The primary waste management facility is the Tailings Management Facility (TMF). The TMF has been sized to provide sufficient capacity to store approximately 956 million tonnes of tailings (including cyclone sand tailings used as embankment fill) and co-disposal of up to 658 million tonnes of potentially reactive waste rock and overburden, comprising Potentially Acid Generating (PAG) and Metal Leaching (ML) materials. The findings of geochemical waste characterization studies indicate that almost all of the waste material is PAG and/or ML. These PAG and ML waste materials will be placed and stored subaqueously in a Waste Storage Area (WSA) located within the TMF. Details of the Feasibility design of the TMF are presented in the Knight Piésold Ltd. (KPL) report “Feasibility Design of the Tailings Management Facility” (Ref. No. VA101-325/8-10, December, 2012). A general arrangement of the project site is shown on Figure 1.2. Typical sections showing the development of the TMF and WSA during mine operations (Years 1, 4, 10 and 22) are provided on Figure 1.3.

Approximately 157.5 million tonnes of additional mined ore will be processed at a Heap Leach Facility (HLF) located south of the open pit. This gold ore will be stored in a temporarily stockpile near the crusher on the valley slope east of the open pit and at the northern end of the TMF. This stockpiled ore will report to the heap leach facility over a period of about 18 years, starting in the pre-production years (3 years prior to mill start-up) and continuing up to Year 15 of mill operations. Details of the Feasibility design of the HLF are presented in the KPL report “Feasibility Design of the Heap Leach Facility” (Ref. No. VA101-325/8-9, December, 2012). Heap leach facility operations will commence during pre-production stripping of the open pit.

During mine operations approximately 144 million tonnes of Low Grade ore and 32 million tonnes of Supergene Oxide (SOX) ore will be stored in temporary stockpiles. The SOX ore will be stockpiled at a location between the open pit and plant site during the pre-production years and in Year 1 of mill operations, and report to the mill during Years 4 to 12 together with direct feed mill ore. Mined Low Grade ore will be stockpiled up to Year 17 in locations generally east and south of the plant site, on valley slopes above the TMF. Low Grade ore mined after Year 12 can also be stockpiled at the

same location used for the SOX ore south of the open pit. The stockpiled Low Grade ore will be milled during the last four years of mine operations (Years 19 to 22).

It is anticipated that approximately 2 to 3 million tonnes of Non-Acid Generating (NAG) waste rock (leach cap material) will be produced during pre-production mining. This material will be used in the construction of the TMF Starter (Stage 1) embankment. Any NAG waste rock that is either unsuitable for use as a construction material or in excess of construction material requirements will be placed in the WSA or an adjacent surface dump.

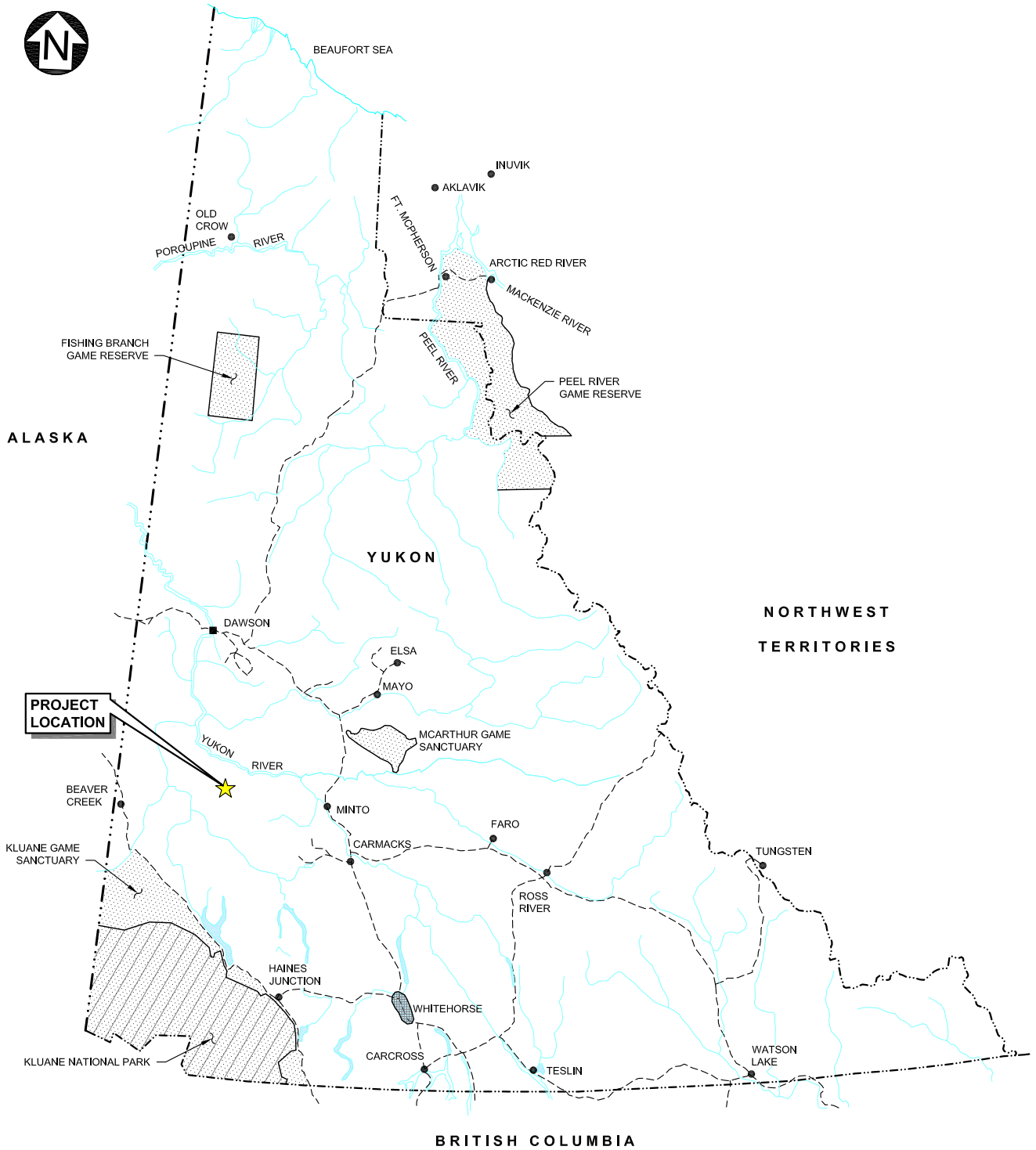
The temporary storage of topsoil recovered during the construction of mine site facilities is required to ensure sufficient reclamation medium is available for mine closure. Topsoil recovered during construction will be stockpiled at select locations close to the material source. The topsoil stockpiles are comparatively low and flat with gently sloped faces.

The general layouts of the ore and topsoil stockpiles are included on Figure 1.2.

1.2 SCOPE OF REPORT

This report summarizes the geotechnical design of the Waste Storage Area (WSA), stockpiled ore and topsoil stockpiles. Specific aspects addressed in this report include the following:

- Site characteristics including physiographic setting, hydrometeorology and seismicity
- Geotechnical conditions at the WSA and stockpile areas
- Layout and design of the WSA within the TMF
- Layout and design of ore stockpiles
- Layout and design of topsoil stockpiles
- Surface water management, including sediment control measures, and
- Reclamation and closure.



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CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

PROJECT LOCATION MAP

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P/A NO. VA101-325/8

REF NO. 12

FIGURE 1.1

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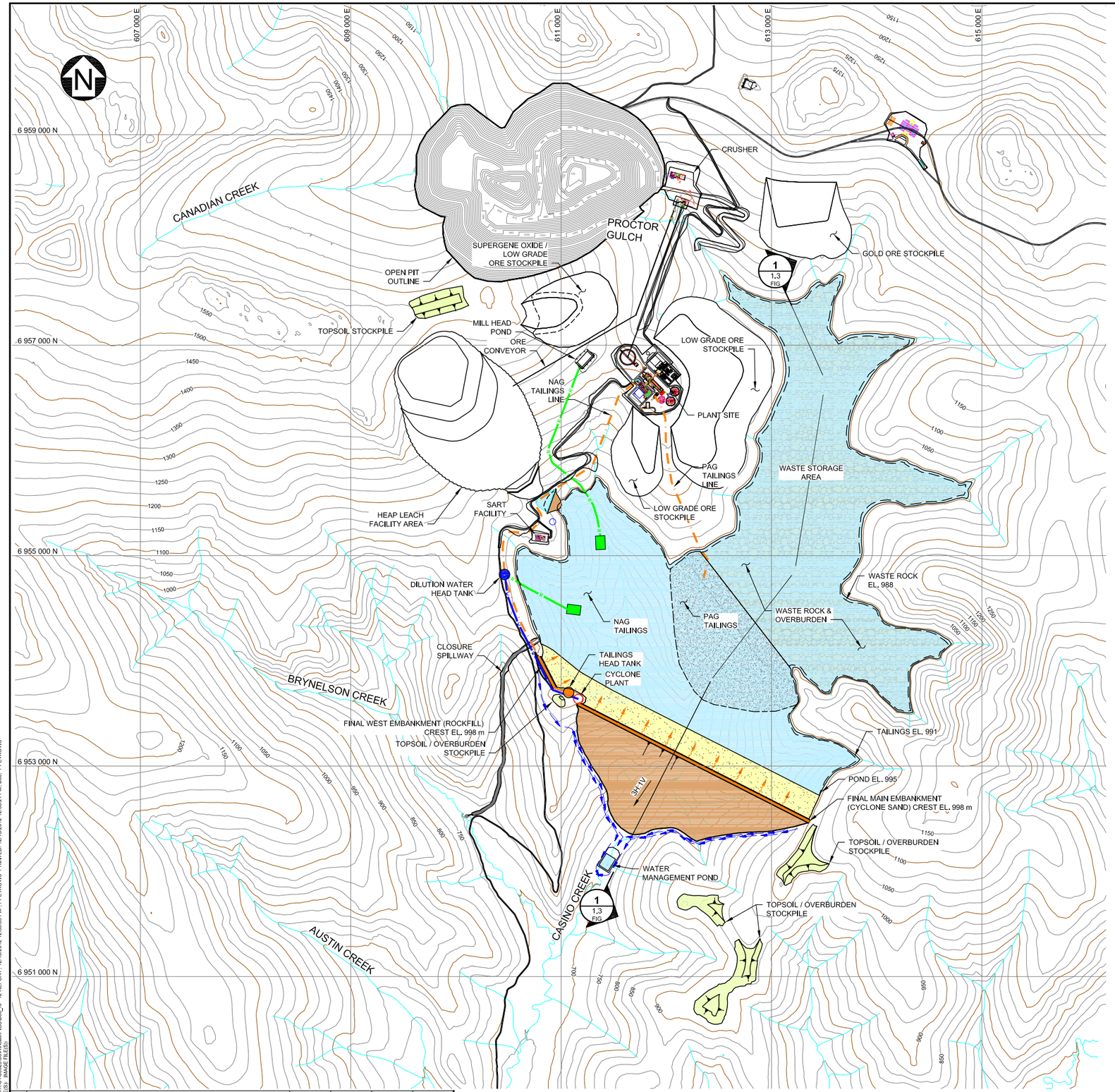

NOTES:

1. COORDINATE GRID IS UTM (WGS84/NAD83) ZONE 7 (m).
2. CONTOUR INTERVAL IS 25 METRES.
3. DIMENSIONS ARE IN METRES UNLESS NOTED.
4. OPEN PIT AS PROVIDED BY CASINO MINING CORPORATION (NOVEMBER 2012).
5. PLANT SITE AND CRUSHER LAYOUT PROVIDED BY M3 ENGINEERING AND TECHNOLOGY CORPORATION (OCTOBER 4, 2012).
6. ORE AND TOPSOIL STOCKPILES ARE SHOWN AT THEIR MAXIMUM SIZE DURING OPERATIONS.

LEGEND:

- TOPSOIL / OVERBURDEN
- TAILINGS
- EMBANKMENT (CYCLONE SAND)
- EMBANKMENT (ROCKFILL)
- POND
- TAILINGS PIPELINES
- RECLAIM PIPELINES
- WATER PIPELINES
- TAILINGS HEAD TANK
- DILUTION WATER HEAD TANK
- CYCLONE PLANT
- DIVERSION DITCHES

SCALE A 400 200 0 400 800 1200 1600 2000 m

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CASINO COPPER-GOLD PROJECT

MINE SITE GENERAL ARRANGEMENT

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FIGURE 1.2 | REV 0

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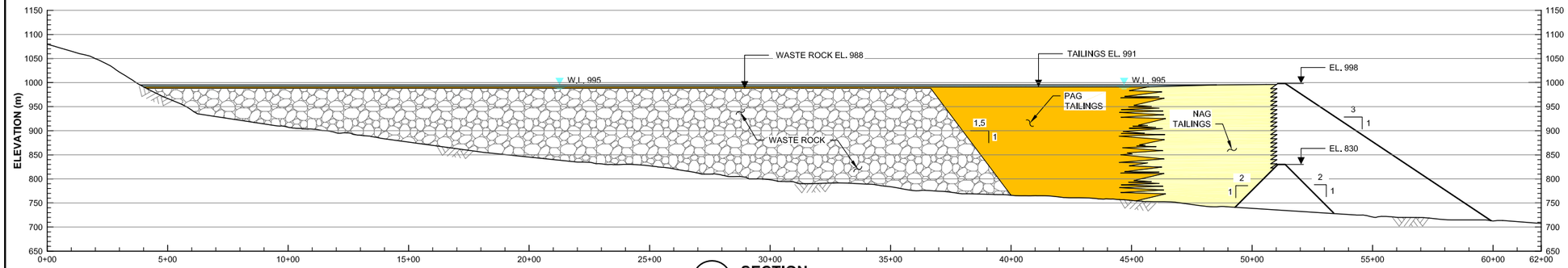
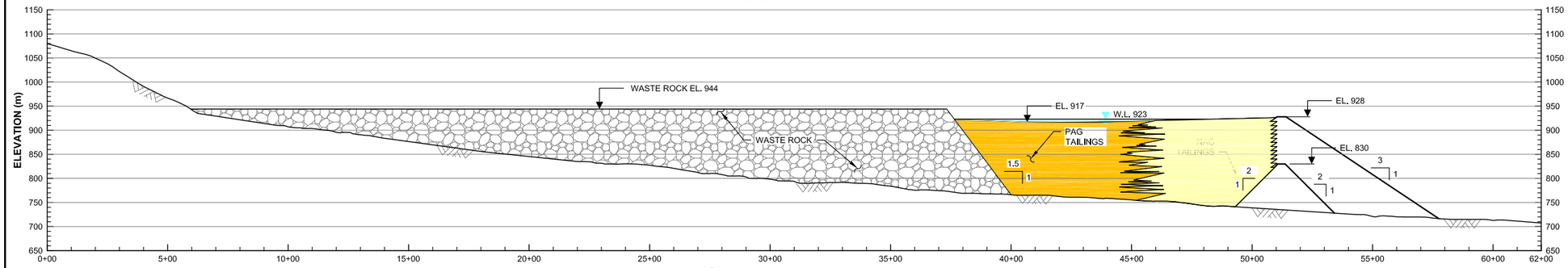
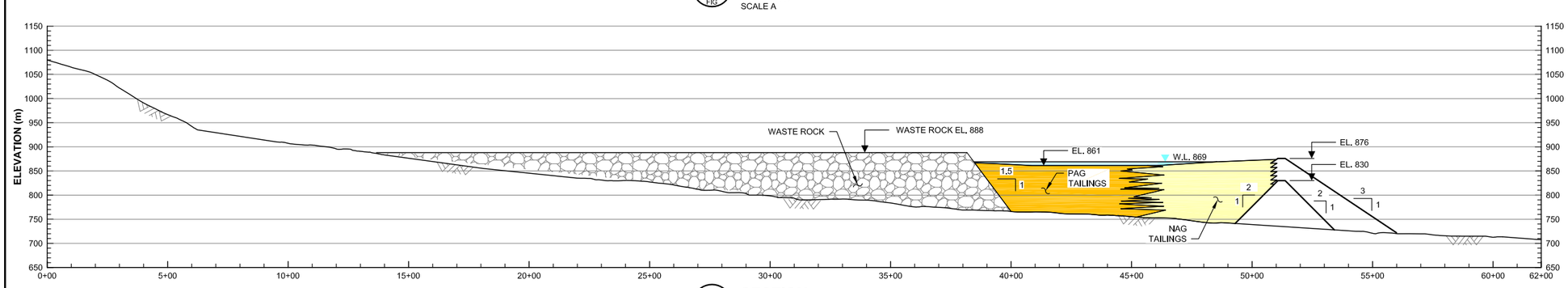


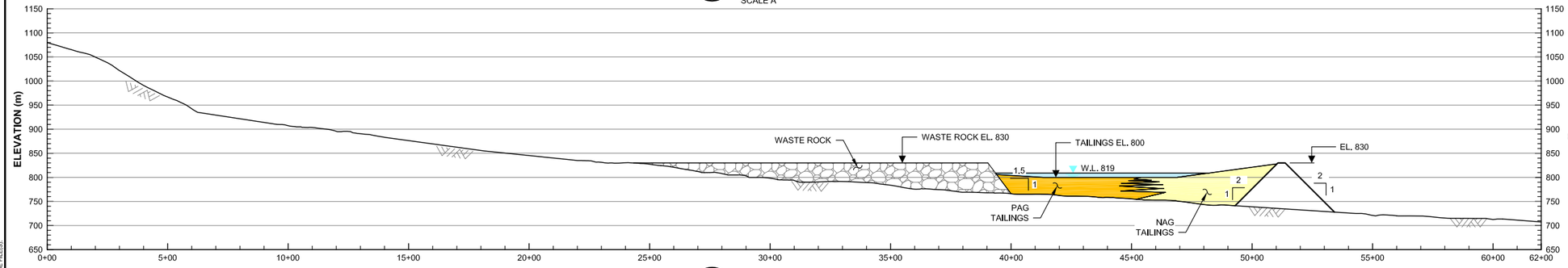
1 / 1.2 FIG **SECTION**
YEAR 22
SCALE A



1 / 1.2 FIG **SECTION**
YEAR 10
SCALE A



1 / 1.2 FIG **SECTION**
YEAR 4
SCALE A



1 / 1.2 FIG **SECTION**
YEAR 1
SCALE A

NOTES:

1. DIMENSIONS ARE IN METRES UNLESS NOTED.

VERT. SCALE 100 50 0 100 200 300 400 500 m

HORIZ. SCALE 200 100 0 200 400 600 800 1000 m

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

TAILINGS MANAGEMENT FACILITY
WASTE DEPOSITION STRATEGY
TYPICAL SECTIONS (YEARS 1, 4, 10 and 22)

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P/A NO.	REF NO.
VA101-325/8	12

FIGURE 1.3 REV 0

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2 – SITE CHARACTERISTICS

2.1 PHYSIOGRAPHIC SETTING

The project is located in the Dawson Range Mountains of the Klondike Plateau. The area is somewhat unique in that the region was not glaciated during the Wisconsin Advance. The characteristic terrain features are smooth, rolling topography, with moderate to deeply incised valleys. Major drainage channels extend below 1,000 m elevation. Most of the terrain lies between 900 m and 1,500 m elevation, except in the valley bottom of Casino Creek which drops to about 700 m elevation.

The Tailings Management Facility (TMF), which incorporates the Waste Storage Area, is situated within the Casino Creek valley. The valley bottoms throughout the project area, with impeded drainage, have prominent permafrost features such as ice-rich peat plateaus, palsas, hummocky tussock fields and polygons. Ore stockpiles are generally situated on south to east facing slopes between the TMF and the open pit. These slopes are generally better drained and have frost susceptible soil. Topsoil/overburden stockpiles from stripping for the TMF Main Embankment are located on flatter slopes and hill top areas south of the TMF. Topsoil from stripping of the HLF area is stockpiled on a ridge located between the open pit and HLF at an elevation of about 1400 m.

2.2 HYDROMETEOROLOGY

The climate at the Casino Project area is characterized by long, cold, dry winters and short, warm, wet summers, with conditions varying according to altitude and aspect. Streamflow in the region is typically highest in May due to melting of the winter snowpack. Annual peak instantaneous flows commonly occur in this freshet period on larger rivers, but on smaller streams they may also occur in summer or early autumn due to intense rain or rain on snow events. Flows decrease throughout the winter and minimum flows typically occur in March or April.

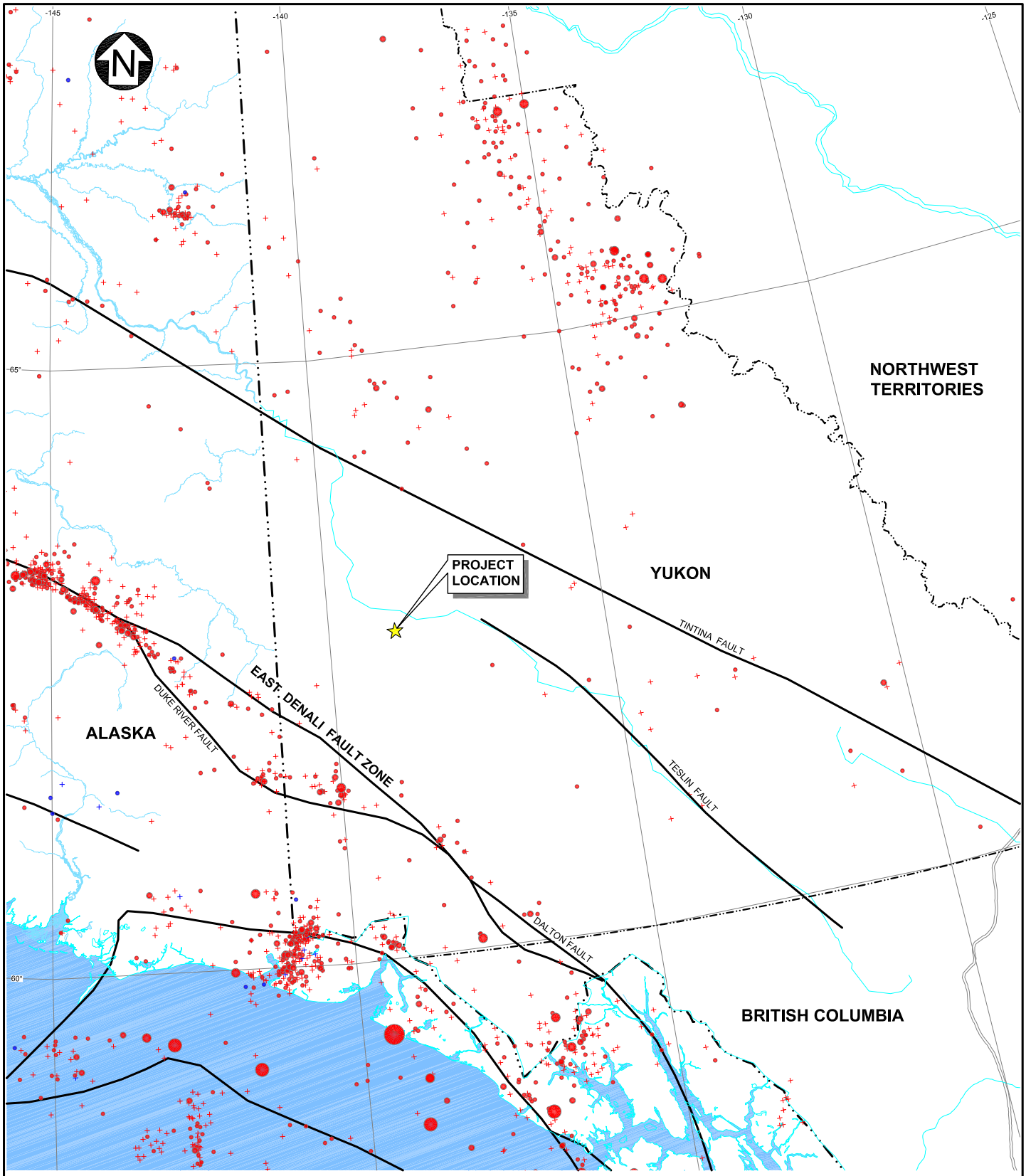
The climate and hydrology at the Casino Project site have been assessed based on both short-term site data and longer-term regional data. Climatic data were collected on-site at the Project climate station located in the upper Casino Creek sub-watershed at an elevation of 1200 m. The period of site record extends from 1993 to 1994 and from 2008 to 2011. Preliminary streamflow data were collected by Hallam Knight Piésold in 1993 and 1994. A new data streamflow collection program was initiated by AECOM in 2008, with the installation of ten streamflow gauging stations. As of 2012, nine streamflow gauging stations are considered to be in active operation and continue to be operated at present by Knight Piésold Ltd (KPL).

The mean annual unit runoff for undisturbed catchments in the project area was estimated to be approximately 183 mm, based on the long-term estimates of streamflow for the hydrology station W4 on Casino Creek. The mean annual precipitation is estimated to be 510 mm, with 65% falling as rain and 35% falling as snow. The annual potential evapotranspiration value is estimated to be 300 mm, based on measured temperatures at the Project site climate station, and long-term regional temperature records. Details of the hydrometeorological analyses are presented in the KPL report “Updated Hydrometeorology Report” (Ref. No. VA101-325/8-11, July 9, 2012).

2.3 SEISMICITY

The region of the southwest Yukon Territory and northwest British Columbia is one of the most seismically active areas in Canada. The seismic hazard in the region is also influenced by the seismically active region of southeast Alaska. The coastal region has experienced many large earthquakes, including events with magnitudes in the range of magnitude 7.0 to 8.0. In 1958 a magnitude 7.9 earthquake occurred along the Fairweather fault (the northern extension of the Queen Charlotte transform fault). The most significant inland zone of seismicity follows the Dalton and Duke River segments of the Denali fault zone through the southwest Yukon. Farther inland there is only minor seismicity between the Denali and Tintina fault systems, including the region of the Casino Project site.

A probabilistic seismic hazard assessment has been carried out for the Casino project site to provide seismic parameters for design of project facilities. Details and results of the seismic hazard analysis are provided in the KPL report "Feasibility Design of the Tailings Management Facility" (Ref. No. VA101-325/8-10, December, 2012). Figure 2.1 shows the regional tectonics and historical seismicity of the Yukon and surrounding regions. Review of historical earthquake records and regional tectonics indicates that the Casino Project site is situated in a region of low seismicity and moderate seismic hazard.



SYMBOL SIZE PROPORTIONAL TO MAGNITUDE

- 3.5 - 3.9
- 4.0 - 4.9
- 5.0 - 5.9
- 6.0 - 6.9
- 7.0 - 7.9
- 8.0 - 8.9
- 9.0 +

NOTES:

1. GLOBAL COORDINATE SYSTEM IS UTM WITH NAD83 DATUM, ZONE 10 m, CENTRAL MERIDIAN.
2. HISTORICAL EARTHQUAKE DATA FROM NRCAN, USGS, AND NGDC DATABASES.
3. INCLUDES RECORDED EARTHQUAKES FROM 1600 TO 1973 (MAGNITUDE > 6.0) AND FROM 1973 TO SEPTEMBER 2012 (MAGNITUDE > 3.5).

SCALE A: 50 25 0 50 100 150 200 250 km

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

REGIONAL TECTONICS AND HISTORICAL SEISMICITY

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FIGURE 2.1 | REV 0

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3 – GEOTECHNICAL CONDITIONS

Geological information and geotechnical conditions for the WSA, ore stockpiles and topsoil stockpiles has been derived from interpretation of information and data provided by KPL site investigations at the project site in 1993, 1994, 2010, 2011 and 2012. These site investigations have included test pitting, geotechnical drilling, laboratory testing of recovered rock core and bulk soil samples, in situ permeability testing and geophysical surveys. The locations of site investigations in the area of the ore stockpiles are shown on Figure 3.1. The locations of site investigations in the area of the TMF, WSA and topsoil/overburden stockpiles located south of the TMF are shown on Figure 3.2.

Detailed results of previous geotechnical investigations at the Casino Project site are included in KPL reports:

- "Report on Preliminary Surficial Geotechnical Investigations" (Ref. No. 1831/1, March, 1994)
- "Data Compilation Report on 1994 Geotechnical/Hydrogeological Investigations" (Ref. No. 1832/2, February 22, 1995)
- "2010 Geotechnical Site Investigation Data Report" (Ref. No. VA101-325/3-4, November 2, 2010)
- "2011 Geotechnical Site Investigation Data Report – Waste Management Facilities" (Ref. No., VA101-325/8-5, December, 2012), and
- "2012 Geotechnical Site Investigation Data Report – Waste Management Facilities" (Ref. No., VA101-325/8-14, December, 2012).

A summary of the geotechnical conditions for the Waste Storage Area, ore stockpile areas and topsoil stockpile areas are provided in the following sections.

3.1 WASTE STORAGE AREA

The waste storage area is located in the upstream part of the TMF impoundment area, in Casino Creek valley. The WSA is underlain by the following geotechnical units:

- Overburden:
  - Topsoil
  - Silty SAND to GRAVEL with some cobbles, trace clay (residual soil and colluvial veneer) along valley ridges and upper slopes
  - SILT and SAND with some gravel and cobbles, trace clay (colluvial apron) and interbedded SAND and gravelly SAND with some cobbles (alluvium) along the lower slopes and valley bottom
- Weathered Bedrock, and
- Fresh Bedrock.

The ridges and upper slopes of Casino Creek valley are characterized by well drained colluvial and residual sandy soils, supporting stands of tall spruce and poplar. The colluvial veneer is locally overlying residual soils near the top of the slopes. The colluvium is relatively thin along the upper part of particularly south facing slopes, and generally absent on ridges where residual soils predominate.

The colluvial veneer along the slopes of the valley is comprised of a fine to medium grained sand with some silt, supporting coarse gravel and cobble sized broken rock fragments. The thickness and

organic content generally increase down-slope. On north-facing slopes, the colluvial veneer is mostly frozen.

Along slopes and ridges in Casino Creek valley the depth to bedrock varies from about 0.5 to 7.5 metres, with an average overburden thickness of between 2 and 3 metres. The depth to bedrock is considerably larger near the valley bottom, where slopes are gentler. An overburden thickness of up to 23 metres has been observed in the valley bottom near the proposed Main Embankment, and conditions are expected to be similar in the waste storage area. This material is classified as colluvial apron, which has a higher fines and organic content than the colluvial veneer. The colluvial apron is mostly frozen, with excess ice and massive ice layers. The colluvial apron is underlain by alluvium close to Casino Creek. The alluvium is coarse grained and comprised of interbedded sands and gravelly sands with cobbles, and is mostly unfrozen due to the presence of Casino Creek.

Dawson Range Batholith (Mid-Cretaceous) is the main country rock in the WSA area and is dominantly granodiorite in composition. Quartz monzonite and diorite are less abundant.

Permafrost is discontinuous along Casino Creek valley and is restricted primarily to valley bottoms, north-facing slopes and local shaded areas.

3.2 ORE STOCKPILE AREAS

The proposed ore stockpiles are located on south to east-facing slopes near the plant site and open pit. Vegetation in these areas is comprised primarily of deciduous black spruce with thin moss and forest litter cover. Soil profiles throughout the areas typically comprise a thin veneer of organic rich topsoil and colluvium overlying in situ weathered residual soils or competent bedrock. The ore stockpile areas have the following generalized stratigraphy:

- Overburden:
  - Topsoil with many cobbles and boulders
  - Silty to gravelly SAND with some cobbles and boulders (Residual Soil and Colluvium)
- Weathered Bedrock, and
- Fresh Bedrock.

The topsoil thickness is typically less than 0.3 m, and comprises dry to moist organic-rich sandy silt with peat layers. Coarse talus blocks are found throughout the stockpile areas and are common at higher elevations such as the proposed gold ore and supergene oxide stockpiles. The underlying soil generally consists of loose silty sand to sandy silt with some gravel, cobbles and boulders (Residual Soil and Colluvium). It typically ranges in thickness from 0.3 to 3 m.

The overburden is often underlain by up to two meters of weathered bedrock. The bedrock is locally completely weathered and friable. Total depths to competent bedrock range from about 0.5 to 4 m with an average depth of approximately two meters. However, the depth to bedrock is greater in the Gold Ore stockpile area located east of the open pit. All test pits were refused on dense frozen soils at this location, and no bedrock was encountered. The overburden thickness typically exceeds five meters in the area of the Gold Ore stockpile.

The bedrock is predominantly comprised of medium strong, slightly weathered Dawson Range Batholith Granodiorite, with locally Quartz Monzonite.

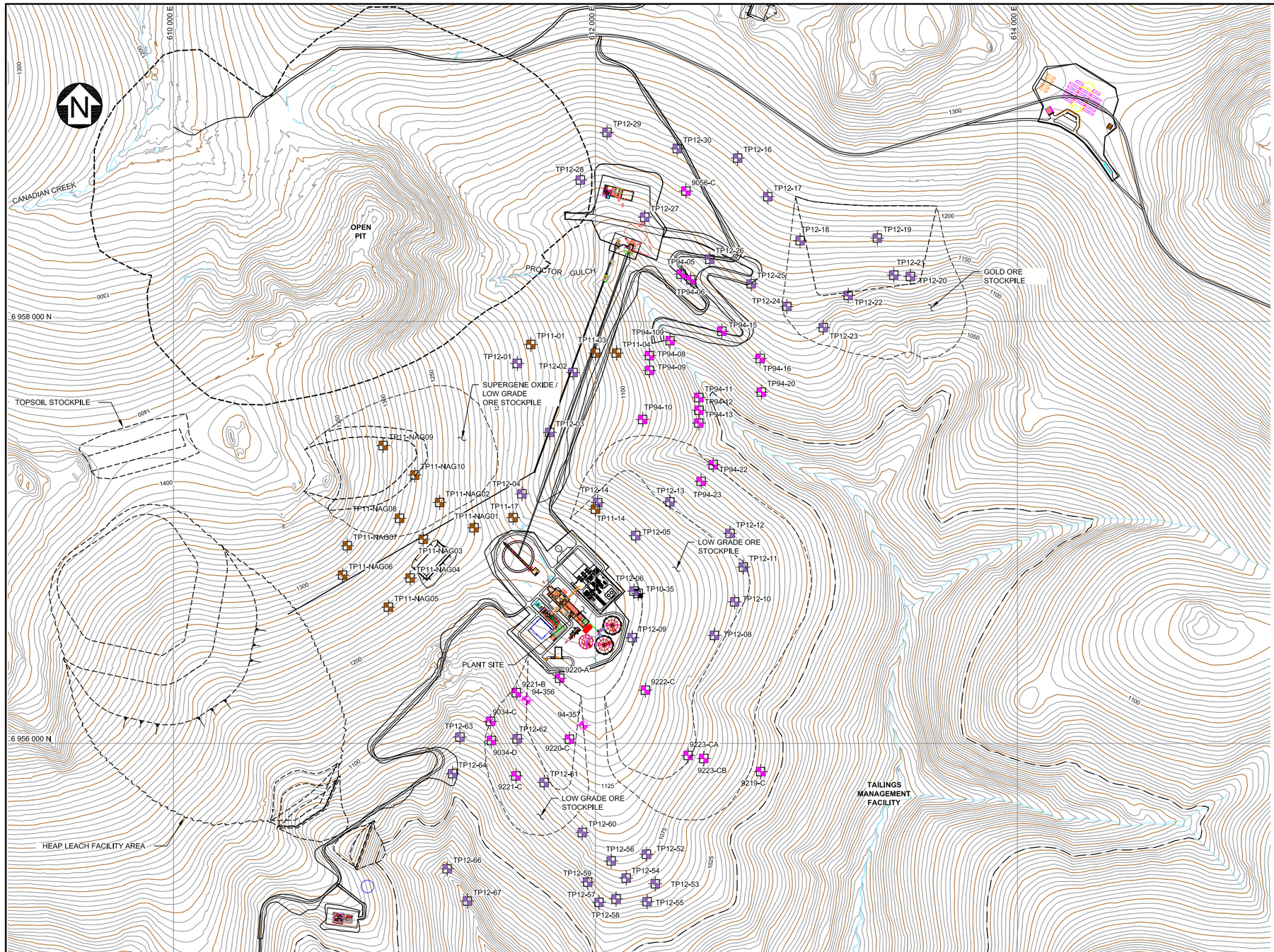
Discontinuous zones of permafrost were recorded throughout the stockpile areas. Thin ice lenses were found in the overburden and interstitial ice crystals were observed in completely weathered bedrock.

Other areas are characterized by well-drained colluvial and/or residual sandy soils supporting stands of tall spruce and poplar.

A perched water table was observed directly below ground surface in several test pits with frozen soils. The maximum depth at which the groundwater table was observed was approximately two to three metres below ground surface in all Ore stockpile areas. In the majority of the test pits no water level was observed.

3.3 TOPSOIL STOCKPILE AREAS

Limited site investigations have been performed to date at the proposed locations of the topsoil stockpiles, north of the HLF and south of the TMF. The topsoil stockpiles are located at hilltop areas, which are characterized by a thin layer of topsoil, underlain by residual soil and bedrock. The residual soil generally consists of loose silty sands and gravels, with some cobbles and boulders. A maximum overburden thickness of approximately 3 m is expected. Permafrost is generally limited or absent in hilltop areas.



NOTES:

1. COORDINATE GRID IS UTM (WGS84/NAD83) ZONE 7 (m).
2. CONTOUR INTERVAL IS 5 METRES.
3. DIMENSIONS ARE IN METRES UNLESS NOTED.
4. PLANT SITE AND CRUSHER LAYOUT PROVIDED BY M3 ENGINEERING AND TECHNOLOGY CORPORATION (OCTOBER 4, 2012).
5. OPEN PIT PROVIDED BY CASINO MINING CORPORATION (NOVEMBER 2012).
6. ONLY SELECT TEST PITS AND DRILLHOLES ARE SHOWN FROM PREVIOUS SITE INVESTIGATION PROGRAMS.
7. ORE AND TOPSOIL STOCKPILES ARE SHOWN AT THEIR MAXIMUM SIZE DURING OPERATIONS.

LEGEND:

- 1993 AND 1994 TEST PIT
- 2010 TEST PIT
- 2011 TEST PIT
- 2012 TEST PIT
- 2012 GEOTECHNICAL DRILLHOLE
- 1994 GEOTECHNICAL DRILLHOLE

SCALE A: 200 100 0 200 400 600 800 1000 m

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CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

ORE STOCKPILES AREA SITE INVESTIGATIONS

Knight Piésold CONSULTING

P/A NO. VA101-325/8 | REF NO. 12

FIGURE 3.1 | REV 0

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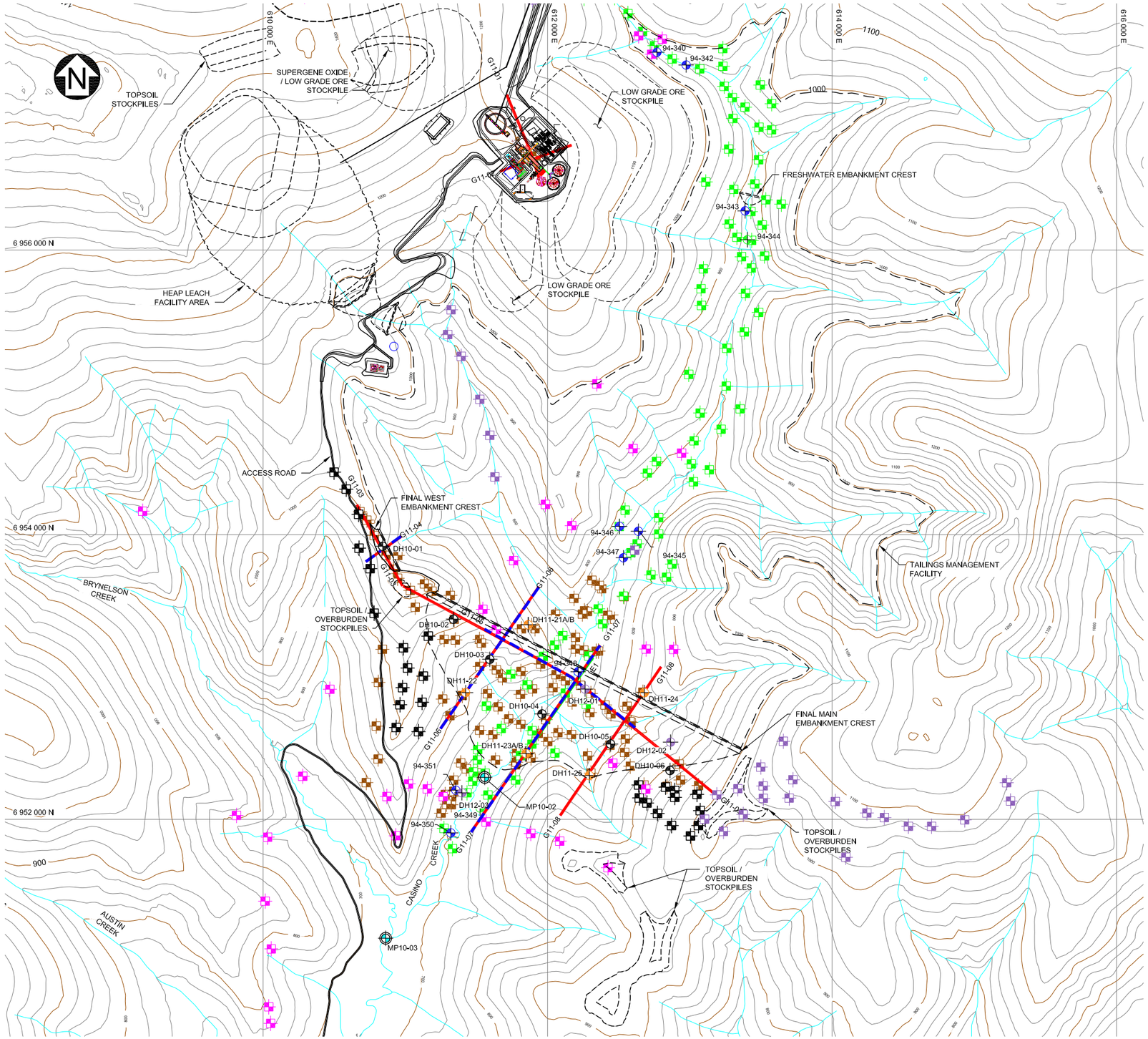

LEGEND:

- DH12-01 — 2012 GEOTECHNICAL DRILLHOLE
- DH11-30 — 2011 GEOTECHNICAL DRILLHOLE
- MW11-01A — 2011 MONITORING WELL
- MP10-01 — MINI PIEZOMETER
- HG10-01 — 2010 HYDROGEOLOGICAL DRILLHOLE
- DH10-01 — 2010 GEOTECHNICAL DRILLHOLE
- 94-305 — 1994 GEOTECHNICAL DRILLHOLE
- 94-344 — 1994 GEOTECHNICAL DRILLHOLE WITH THERMISTOR
- 94-350 — 1994 GEOTECHNICAL DRILLHOLE WITH 50 mm DIA. WELL
- 2012 TEST PIT LOCATION
- 2011 TEST PIT LOCATION
- 2010 TEST PIT LOCATION
- 1994 TEST PIT LOCATION
- 1993 TEST TRENCH LOCATION
- 2011 SEISMIC REFRACTION LINE
- 2011 GROUND PENETRATING RADAR (GPR) LINE
- 2011 EM31 LINE

NOTES:

1. COORDINATE GRID IS UTM (WGS84/NAD83) ZONE 7 (m).
2. CONTOUR INTERVAL IS 25 METRES.
3. DIMENSIONS ARE IN METRES UNLESS NOTED.
4. TEST PITS ID'S ARE NOT SHOWN ON FIGURE TO IMPROVE CLARITY.
5. PLANT SITE AND CRUSHER LAYOUT PROVIDED BY M3 ENGINEERING AND TECHNOLOGY CORPORATION (OCTOBER 4, 2012)
6. HEAP LEACH PAD IS SHOWN AT ITS MAXIMUM SIZE.
7. ORE AND TOPSOIL STOCKPILES ARE SHOWN AT THEIR MAXIMUM SIZE DURING OPERATIONS.

SCALE A: 300 150 0 500 1000 1500 m

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CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

TAILINGS MANAGEMENT FACILITY AREA SITE INVESTIGATIONS

Knight Piésold CONSULTING

P/A NO. VA101-325/8 | REF NO. 12

FIGURE 3.2 | REV 0

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4 – WASTE STORAGE AREA AND STOCKPILES DESIGN

4.1 DESIGN BASIS

All mine waste rock and overburden material generated by open pit operations is to be stored in an environmentally sound, safe and secure manner in a permanent storage facility.

The current mine production schedule indicates that a total of approximately 658 million tonnes of waste rock and overburden will be produced over the life of the mine. A geochemical waste characterization program has been completed by Others to predict the potential reactivity of waste rock and overburden materials from the open pit. The findings of these studies indicate that almost all of this waste material comprises Potentially Acid Generating (PAG) and Metal Leaching (ML) materials. These PAG and ML waste materials will be placed and stored subaqueously in a Waste Storage Area (WSA) located within the Tailings Management Facility (TMF). The TMF has been sized to provide sufficient capacity to store approximately 956 million tonnes of tailings (including cyclone sand tailings used as embankment fill) and subaqueous disposal of 658 million tonnes of potentially reactive waste materials. Tailings and potentially reactive waste rock and overburden materials will be deposited in the TMF concurrently over the mine life.

In addition to the WSA, temporary ore stockpiles and a number of topsoil stockpiles will be located at engineered storage sites.

Approximately 157.5 million tonnes of gold ore will be processed at the Heap Leach Facility (HLF). This gold ore will be stored in a temporarily stockpile near to the crusher and will report to the heap leach facility over a period of about 18 years, starting in the pre-production years (3 years prior to mill start-up) and continuing up to Year 15 of mill operations. Heap leach facility operations will commence during pre-production stripping of the open pit.

During mine operations approximately 144 million tonnes of Low Grade ore and 32 million tonnes of Supergene Oxide (SOX) ore will be stored in temporary stockpiles. The SOX ore will be stockpiled during the pre-production years and in Year 1 of mill operations, and report to the mill during Years 4 to 12 together with direct feed mill ore. Low Grade ore will be stockpiled up to Year 17 and milled during the last four years of mine operations (Years 19 to 22).

It is anticipated that approximately 2 to 3 million tonnes of Non-Acid Generating (NAG) waste rock (leach cap material) will be produced during pre-production mining. This material will be used in the construction of the TMF Starter (Stage 1) embankment. Any NAG waste rock that is either unsuitable for use as a construction material or in excess of construction material requirements will be placed in the WSA or an adjacent surface dump.

The temporary storage of topsoil recovered during the construction of mine site facilities is required to ensure sufficient reclamation medium is available for mine closure. Topsoil recovered during construction will be stockpiled at select locations close to the material source.

A summary of the annual mine production schedule is presented in Table 4.1. Table 4.2 summarises the annual production and handling schedule of stockpiled ore.

Knight Piésold CONSULTING

TABLE 4.1

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

FEASIBILITY DESIGN OF WASTE STORAGE AREA AND STOCKPILES
SUMMARY OF MINE PRODUCTION SCHEDULE

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YEAR	ORE TO MILL				CONCENTRATE	TAILINGS		WASTE MATERIAL			
	Direct Feed	Ore Stockpiles		Total	Concentrate	NAG	PAG	Hypogene	Supergene	Unclassified Waste	Total Waste
		Low Grade	Supergene Oxide								
	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes
PP	0	0	0	0	0	0	0	0	9,470,000	210,000	9,680,000
1	34,500,000	0	0	34,500,000	345,000	27,324,000	6,831,000	5,000	22,429,000	78,000	22,512,000
2	45,928,000	0	0	45,928,000	459,280	36,374,976	9,093,744	159,000	29,031,000	116,000	29,306,000
3	45,814,000	0	0	45,814,000	458,140	36,284,688	9,071,172	943,000	36,757,000	211,000	37,911,000
4	42,056,000	0	3,600,000	45,656,000	456,560	36,159,552	9,039,888	573,000	38,759,000	31,000	39,363,000
5	41,653,000	0	3,600,000	45,253,000	452,530	35,840,376	8,960,094	10,690,000	30,585,000	64,000	41,339,000
6	41,605,000	0	3,600,000	45,205,000	452,050	35,802,360	8,950,590	14,096,000	20,972,000	21,000	35,089,000
7	41,576,000	0	3,600,000	45,176,000	451,760	35,779,392	8,944,848	10,579,000	27,036,000	64,000	37,679,000
8	42,145,000	0	3,600,000	45,745,000	457,450	36,230,040	9,057,510	12,401,000	25,529,000	39,000	37,969,000
9	42,491,000	0	3,600,000	46,091,000	460,910	36,504,072	9,126,018	8,952,000	26,680,000	226,000	35,858,000
10	41,175,000	0	3,600,000	44,775,000	447,750	35,461,800	8,865,450	6,369,000	28,591,000	55,000	35,015,000
11	41,095,000	0	3,600,000	44,695,000	446,950	35,398,440	8,849,610	7,931,000	44,635,000	132,000	52,698,000
12	42,251,000	0	3,610,000	45,861,000	458,610	36,321,912	9,080,478	15,273,000	32,380,000	10,000	47,663,000
13	46,249,000	0	0	46,249,000	462,490	36,629,208	9,157,302	20,341,000	23,455,000	1,000	43,797,000
14	45,798,000	0	0	45,798,000	457,980	36,272,016	9,068,004	31,372,000	11,413,000	0	42,785,000
15	45,187,000	0	0	45,187,000	451,870	35,788,104	8,947,026	31,379,000	6,445,000	5,000	37,829,000
16	45,064,000	0	0	45,064,000	450,640	35,690,688	8,922,672	37,370,000	563,000	1,000	37,934,000
17	44,772,000	0	0	44,772,000	447,720	35,459,424	8,864,856	20,242,000	0	0	20,242,000
18	44,934,000	0	0	44,934,000	449,340	35,587,728	8,896,932	8,266,000	0	0	8,266,000
19	14,676,000	30,915,000	0	45,591,000	455,910	36,108,072	9,027,018	4,932,000	0	0	4,932,000
20	0	45,053,000	0	45,053,000	450,530	35,681,976	8,920,494	0	0	0	0
21	0	44,985,000	0	44,985,000	449,850	35,628,120	8,907,030	0	0	0	0
22	0	22,875,000	0	22,875,000	228,750	18,117,000	4,529,250	0	0	0	0
TOTALS	788,969,000	143,828,000	32,410,000	965,207,000	9,652,070	764,443,944	191,110,986	241,873,000	414,730,000	1,264,000	657,867,000

M:\1\01\00325\08\A\Report\12 - Waste Storage Areas & Stockpiles\Rev 0\Table\[Table 4.1 Rev 0 - Waste Production Schedule.xlsx]Table 4.1

NOTES:

1. MINE SCHEDULE PROVIDED BY CASINO MINING CORPORATION (NOVEMBER 01, 2012).
2. PP = PRE-PRODUCTION YEARS -3, -2 AND -1.
3. CONCENTRATE ASSUMED TO BE 1% OF MILL FEED.
4. POTENTIALLY ACID GENERATING (PAG) TAILINGS ASSUMED TO BE 20% OF TOTAL TAILINGS; NON-ACID GENERATING (NAG) TAILINGS ASSUMED TO BE 80% OF TOTAL TAILINGS.
5. APPROXIMATELY 2 MILLION Tonnes OF WASTE ROCK IS NON-REACTIVE AND BECOMES AVAILABLE DURING PRE-PRODUCTION.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	07DEC'12	ISSUED WITH REPORT VA101-325/8-12	SB	GRG	KJB

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TABLE 4.2

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

FEASIBILITY DESIGN OF WASTE STORAGE AREA AND STOCKPILES
ORE PRODUCTION AND STOCKPILE SCHEDULE

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YEAR		LOW GRADE ORE			SUPERGENE OXIDE			GOLD ORE (HEAP LEACH FACILITY)			Total Ore in Stockpiles
		To Stockpile Tonnes	From Stockpile to Mill Tonnes	Stockpile Size Tonnes	To Stockpile Tonnes	From Stockpile to Mill Tonnes	Stockpile Size Tonnes	Gold Ore to Stockpile Tonnes	Gold Ore Stockpile to Crusher Tonnes	Stockpile Size Tonnes	Tonnes
PP	-3	0	0	0	20,000	0	20,000	0	0	0	20,000
	-2	0	0	0	2,806,000	0	2,826,000	5,072,000	0	5,072,000	7,898,000
	-1	184,000	0	184,000	9,950,000	0	12,776,000	12,529,000	0	17,601,000	30,561,000
1		839,000	0	1,023,000	19,634,000	0	32,410,000	9,542,000	0	27,143,000	60,576,000
2		7,187,000	0	8,210,000	0	0	32,410,000	8,454,000	0	35,597,000	76,217,000
3		3,396,000	0	11,606,000	0	0	32,410,000	3,754,000	0	39,351,000	83,367,000
4		10,772,000	0	22,378,000	0	3,600,000	28,810,000	0	1,316,000	38,035,000	89,223,000
5		16,513,000	0	38,891,000	0	3,600,000	25,210,000	0	8,630,000	29,405,000	93,506,000
6		22,234,000	0	61,125,000	0	3,600,000	21,610,000	0	8,053,000	21,352,000	104,087,000
7		11,972,000	0	73,097,000	0	3,600,000	18,010,000	0	352,000	21,000,000	112,107,000
8		6,775,000	0	79,872,000	0	3,600,000	14,410,000	3,986,000	0	24,986,000	119,268,000
9		8,299,000	0	88,171,000	0	3,600,000	10,810,000	4,227,000	0	29,213,000	128,194,000
10		5,575,000	0	93,746,000	0	3,600,000	7,210,000	9,110,000	0	38,323,000	139,279,000
11		4,944,000	0	98,690,000	0	3,600,000	3,610,000	0	7,862,000	30,461,000	132,761,000
12		9,461,000	0	108,151,000	0	3,610,000	0	0	8,500,000	21,961,000	130,112,000
13		9,029,000	0	117,180,000	0	0	0	0	8,200,000	13,761,000	130,941,000
14		6,670,000	0	123,850,000	0	0	0	0	8,887,000	4,874,000	128,724,000
15		8,620,000	0	132,470,000	0	0	0	0	4,874,000	0	132,470,000
16		7,142,000	0	139,612,000	0	0	0	0	0	0	139,612,000
17		4,216,000	0	143,828,000	0	0	0	0	0	0	143,828,000
18		0	0	143,828,000	0	0	0	0	0	0	143,828,000
19		0	30,915,000	112,913,000	0	0	0	0	0	0	112,913,000
20		0	45,053,000	67,860,000	0	0	0	0	0	0	67,860,000
21		0	44,985,000	22,875,000	0	0	0	0	0	0	22,875,000
22		0	22,875,000	0	0	0	0	0	0	0	0
TOTALS		143,828,000	143,828,000		32,410,000	32,410,000		56,674,000	56,674,000		

M:\1\01\00325\08\A\Report\12 - Waste Storage Areas & Stockpiles\Rev 0\Table\[Table 4.2 Rev 0 - Ore Production and Stockpile Schedule.xlsx]Table 4.2

NOTES:

1. MINE SCHEDULE PROVIDED BY CASINO MINING CORPORATION (VERSION "SCHED01NOV2012").
2. PP = PRE-PRODUCTION YEARS -3, -2 AND -1.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	07DEC'12	ISSUED WITH REPORT VA101-325/8-12	SB	LM	KJB

The WSA and temporary stockpiles will be designed to remain stable under both static and seismic loading conditions. The minimum acceptable factor of safety for waste and ore stockpiles under static conditions is 1.3 for short-term operating conditions and 1.5 after closure and reclamation. All ore and topsoil stockpiles will be removed before or at closure of the mine. In the event of a premature mine closure it is anticipated that the stockpiled ore would need to be hauled to the TMF for disposal, or potentially re-handled for processing at the mill for delivery to the TMF as tailings. Details of the closure plan are being developed by Others.

The design earthquake defined for seismic stability assessment of the stockpile slopes is the 1 in 500 year earthquake, with a corresponding peak ground acceleration of 0.08g (mean hazard value on soft rock/very dense soil) and earthquake magnitude of 8.0. A factor of safety under seismic conditions of less than 1.0 is acceptable provided that any predicted deformations resulting from seismic loading are not significant, and would not impact mine site facilities, including the WSA and TMF.

The 1 in 100 year 24-hour storm event is defined as the design storm event for the sizing of surface runoff and diversion ditches for ore stockpiles. The 24-hour precipitation depth associated with this storm event was estimated according to the Rainfall Frequency Atlas of Canada (Hogg and Carr, 1965) as presented in the KPL report "Updated Hydrometeorology Report" (Ref. No. VA101-325/8-11, July 9, 2012).

A summary of the design basis for the WSA and stockpiles is presented in Table 4.3.

4.2 DESIGN AND OPERATION

Storage piles have been designed to accommodate the following materials:

- Potentially reactive (PAG and ML) waste rock and overburden
- Stockpiled ore (Low Grade ore, Supergene Oxide ore and Gold leach ore), and
- Topsoil/overburden materials.

The location and configuration of the Waste Storage Area and ore stockpiles is presented on the overall site general arrangement plan shown on Figure 1.2**.** A plan view of the WSA and stockpiles development over the life of mine is shown for Year -1 (Pre-production), Year 1, Year 4, Year 10 and Year 22 (Final) on Figures 4.1 to 4.5 respectively. Figure 4.6 shows typical slope configurations for the ore stockpiles and topsoil stockpiles.

The specific design and operating requirements for the WSA, ore stockpiles and topsoil stockpiles are described in the following sections.

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TABLE 4.3

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

SUMMARY OF DESIGN BASIS FOR WASTE STORAGE AREA AND STOCKPILES

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ITEM	DESIGN CRITERIA
Mine Production	• Total ore milled = 965.2 million tonnes (Mt) • Mine Operating Life = 22 years (+ 3 pre-production years) • Mill throughput= ~125,000 tpd • Heap Leach operations= ~157,5 million tonnes of gold ore
Stockpiled Ore	• Topsoil from embankment foundation preparation will be stockpiled for reclamation. • Low grade ore stockpiled during operations ◦ Maximum size = 143.8 Mt • Supergene Oxide ore stockpiled during operations ◦ Maximum size = 32.4 Mt • Gold Ore stockpiled during operations (reports to Heap Leach Facility) ◦ Maximum size = 39.4 Mt
Potentially Reactive Waste Rock and Overburden	• Produced from years 1 to 19 and stored in Waste Storage Area (WSA). • Total waste production is 658 million tonnes (overburden and waste rock) at variable rate.
Non Reactive Waste Rock (Leach Cap material)	• Approximately 2 to 3 million tonnes produced in pre-production years • Used for TMF Stage 1 (Starter) Embankment construction
Seismic Criteria	• Design Earthquake: 1/500 year event • Magnitude = 8.0 • Peak ground acceleration = 0.08g (Mean hazard value for soft rock / very dense soil conditions)
Stability Criteria	• The minimum acceptable factors of safety for each case considered are as follows: ◦ Short term (during mine operations) 1.3 ◦ Long term (closure) 1.5 (all stockpiles processed or removed to TMF prior to closure) ◦ For seismic loading condition, a factor of safety less than 1.0 is acceptable provided that any predicted deformations are minor, and would not impact mine site facilities, including the WSA and TMF.
Water Management	• Diversion ditches constructed upstream as required to minimize contact water with ore stockpiles. • Design storm event for ditch sizing is the 1 in 100 year event.
Closure Criteria	• Final crest of WSA to be levelled and contoured as required to provide long term stability. • Footprint of ore stockpiles to be covered with suitable topsoil and revegetated. • Stockpiled topsoil / overburden material used for reclamation of TMF and HLF.

M:\1\01\00325\08\A\Report\12 - Waste Storage Areas & Stockpiles\Rev 0\Table\[Table 4.3 Rev 0 - Summary of Design Basis.xls]Design Basis - Table 4.3

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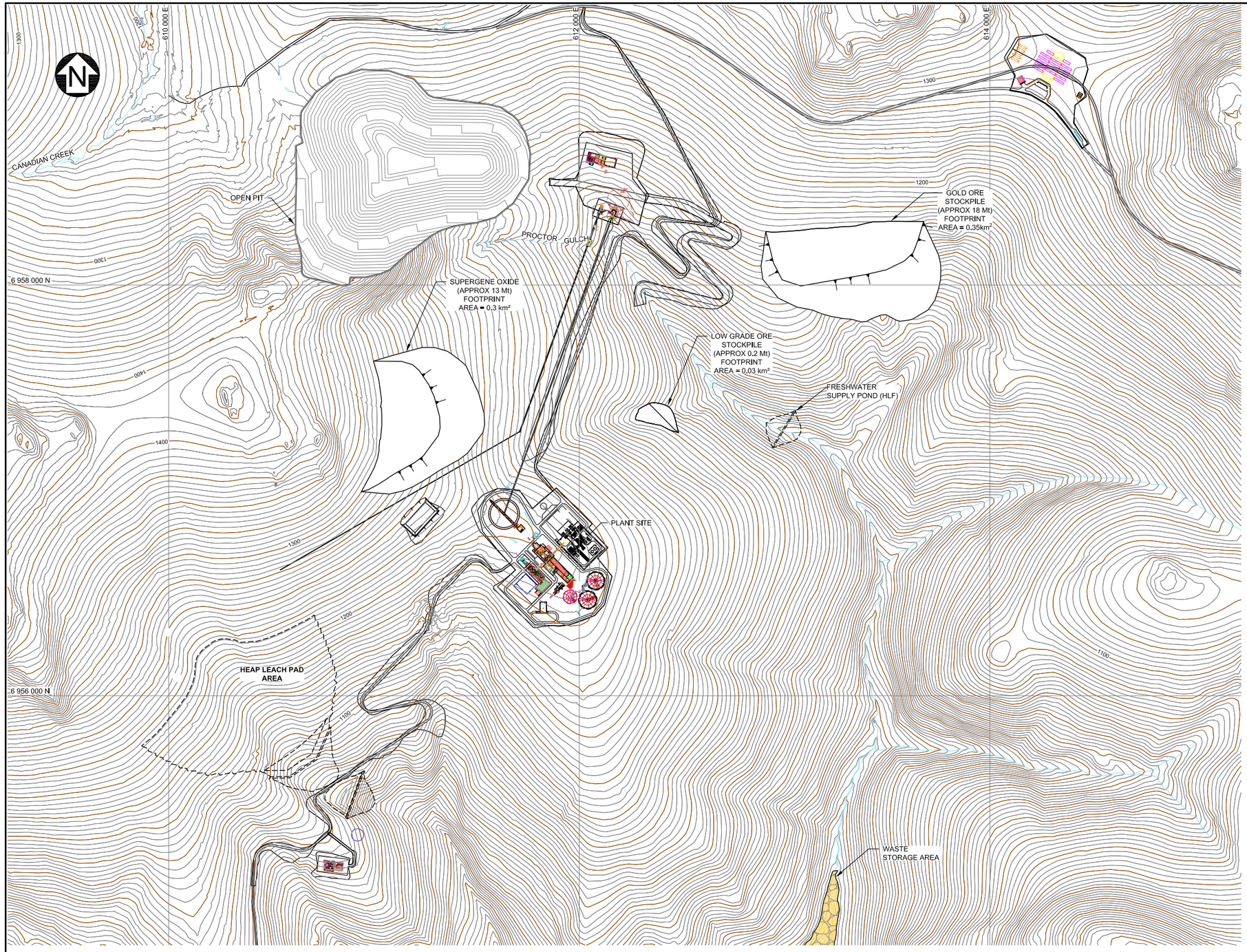

NOTES:

1. COORDINATE GRID IS UTM (WGS84/NAD83) ZONE 7 (m).
2. CONTOUR INTERVAL IS 5 METRES.
3. DIMENSIONS ARE IN METRES UNLESS NOTED.
4. PLANT SITE AND CRUSHER LAYOUT PROVIDED BY M3 ENGINEERING AND TECHNOLOGY CORPORATION (OCTOBER 4, 2012).
5. OPEN PIT AS PROVIDED BY CASINO MINING CORPORATION (NOVEMBER 2012).

SCALE A: 200 100 0 200 400 600 800 1000 m

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

GENERAL ARRANGEMENT OF ORE STOCKPILES - YEAR -1 (PRE-PRODUCTION)

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P/A NO. VA101-325/8 | REF NO. 12 | REV 0

FIGURE 4.1

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
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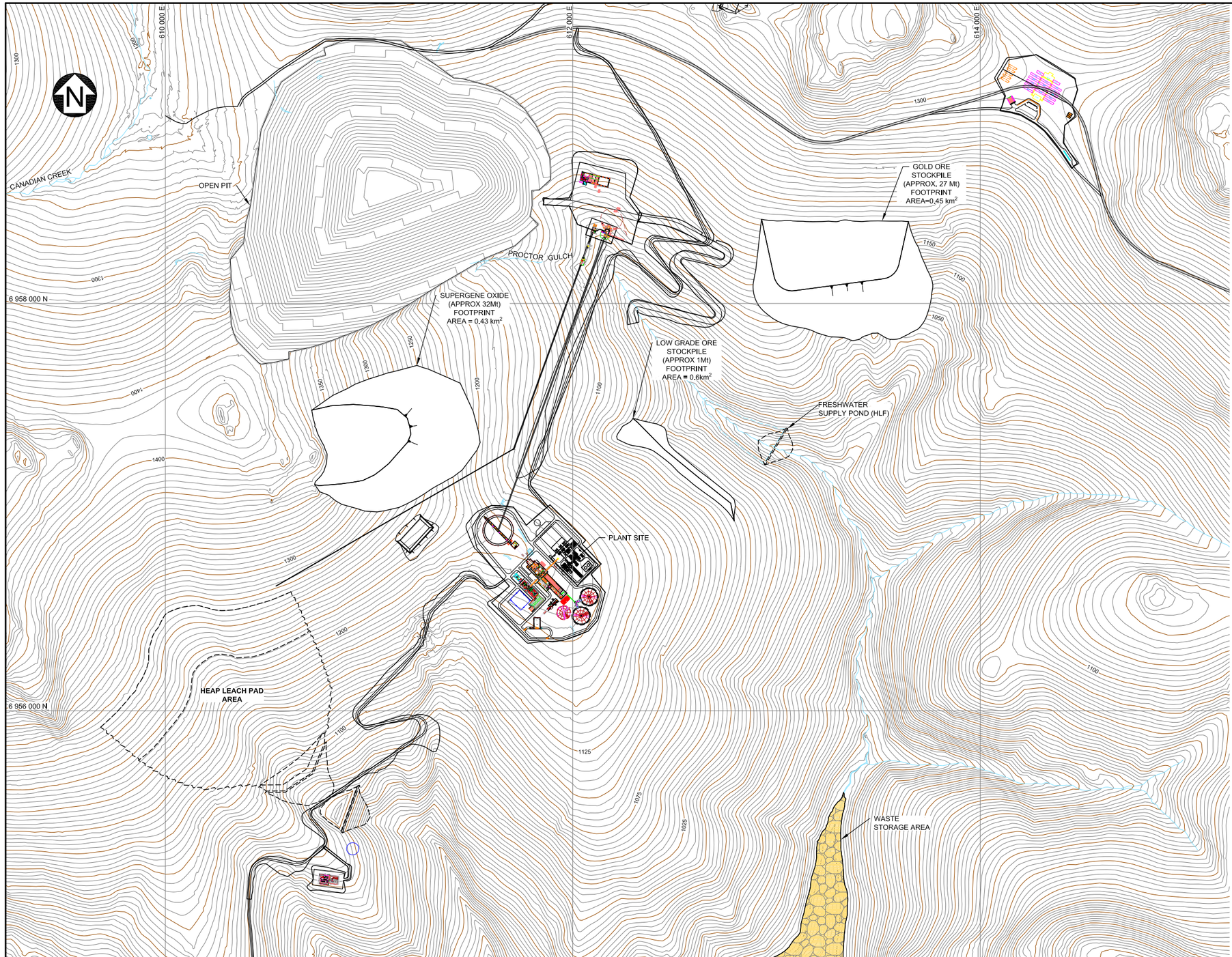

NOTES:

1. COORDINATE GRID IS UTM (WGS84/NAD83) ZONE 7 (m).
2. CONTOUR INTERVAL IS 5 METRES.
3. DIMENSIONS ARE IN METRES UNLESS NOTED.
4. PLANT SITE AND CRUSHER LAYOUT PROVIDED BY M3 ENGINEERING AND TECHNOLOGY CORPORATION (OCTOBER 4, 2012).
5. OPEN PIT AS PROVIDED BY CASINO MINING CORPORATION (NOVEMBER 2012).

SCALE A 200 100 0 200 400 600 800 1000 m

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

GENERAL ARRANGEMENT OF ORE STOCKPILES - YEAR 1

Knight Piésold CONSULTING

P/A NO.	REF NO.
VA101-325/8	12

FIGURE 4.2 REV 0

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
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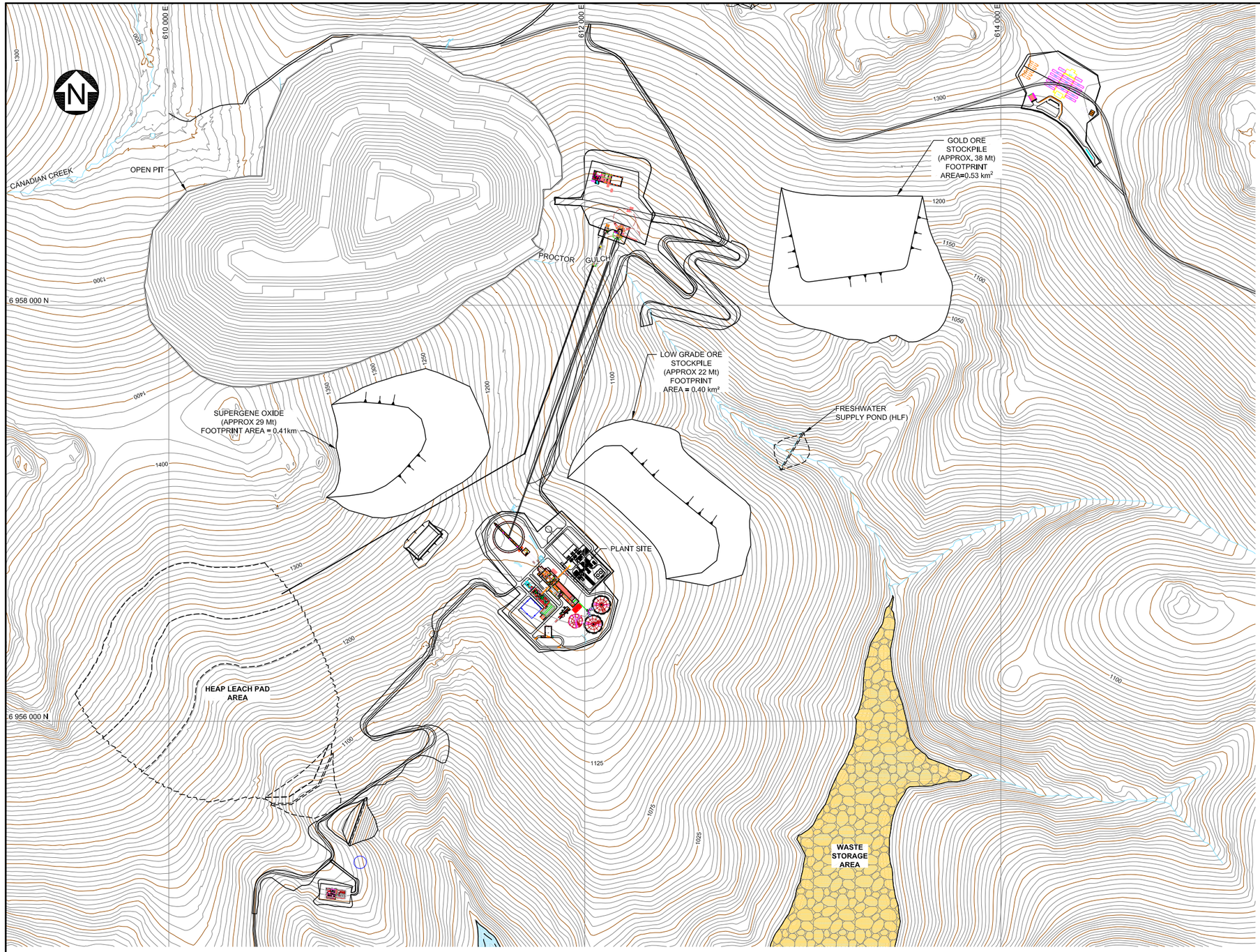

NOTES:

1. COORDINATE GRID IS UTM (WGS84/NAD83) ZONE 7 (m).
2. CONTOUR INTERVAL IS 5 METRES.
3. DIMENSIONS ARE IN METRES UNLESS NOTED.
4. PLANT SITE AND CRUSHER LAYOUT PROVIDED BY M3 ENGINEERING AND TECHNOLOGY CORPORATION (OCTOBER 4, 2012).
5. OPEN PIT AS PROVIDED BY CASINO MINING CORPORATION (NOVEMBER 2012).

SCALE A: 200 100 0 200 400 600 800 1000 m

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	18DEC'12	ISSUED WITH REPORT	BH/LM	NSD/PP	GRG	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

GENERAL ARRANGEMENT OF ORE STOCKPILES - YEAR 4

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P/A NO. VA101-325/8

REF NO. 12

FIGURE 4.3

REV 0

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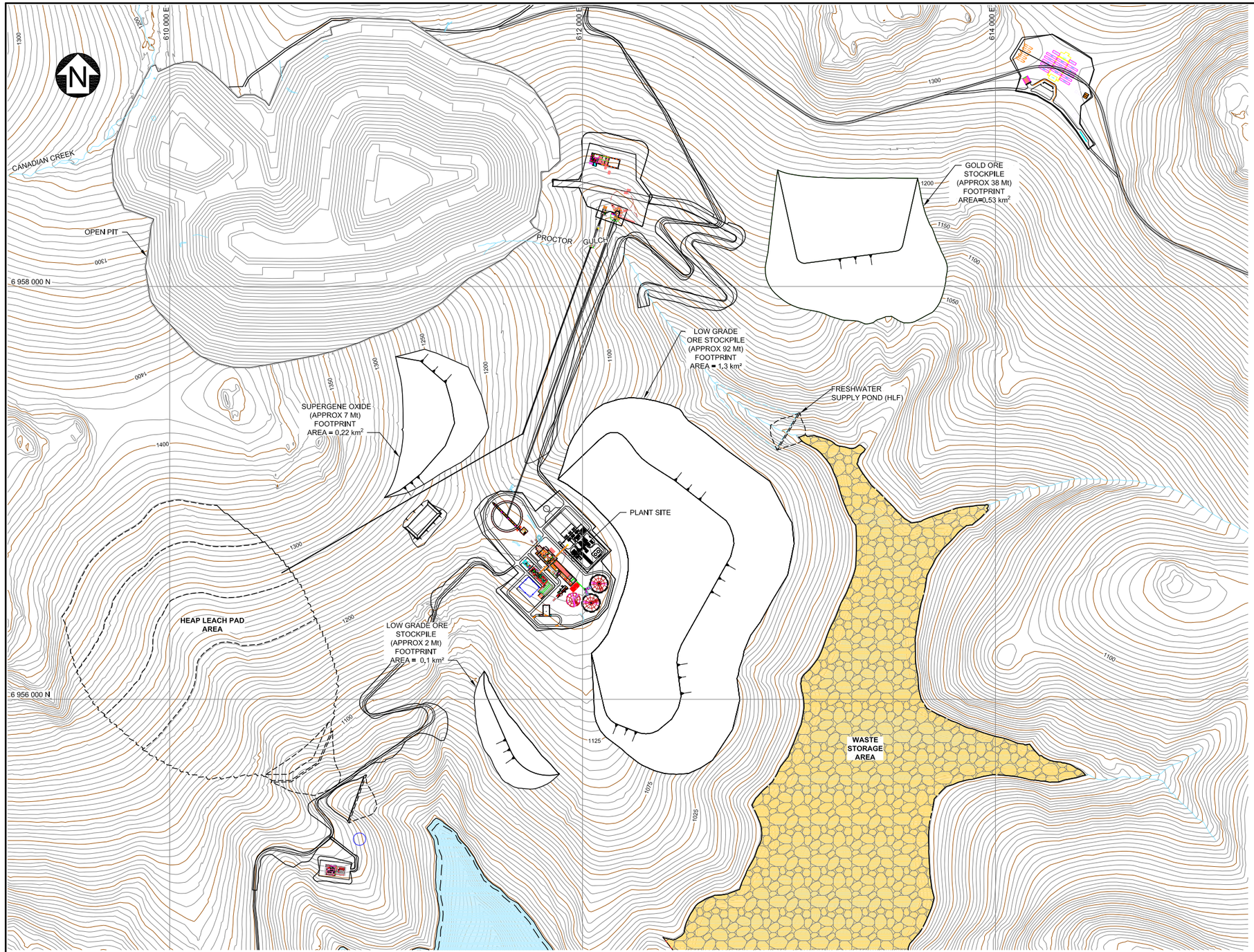

NOTES:

1. COORDINATE GRID IS UTM (WGS84/NAD83) ZONE 7 (m).
2. CONTOUR INTERVAL IS 5 METRES.
3. DIMENSIONS ARE IN METRES UNLESS NOTED.
4. PLANT SITE AND CRUSHER LAYOUT PROVIDED BY M3 ENGINEERING AND TECHNOLOGY CORPORATION (OCTOBER 4, 2012).
5. OPEN PIT AS PROVIDED BY CASINO MINING CORPORATION (NOVEMBER 2012).

SCALE A: 200 100 0 200 400 600 800 1000 m

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CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

GENERAL ARRANGEMENT OF ORE STOCKPILES - YEAR 10

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P/A NO. VA101-325/8 | REF NO. 12

FIGURE 4.4 | REV 0

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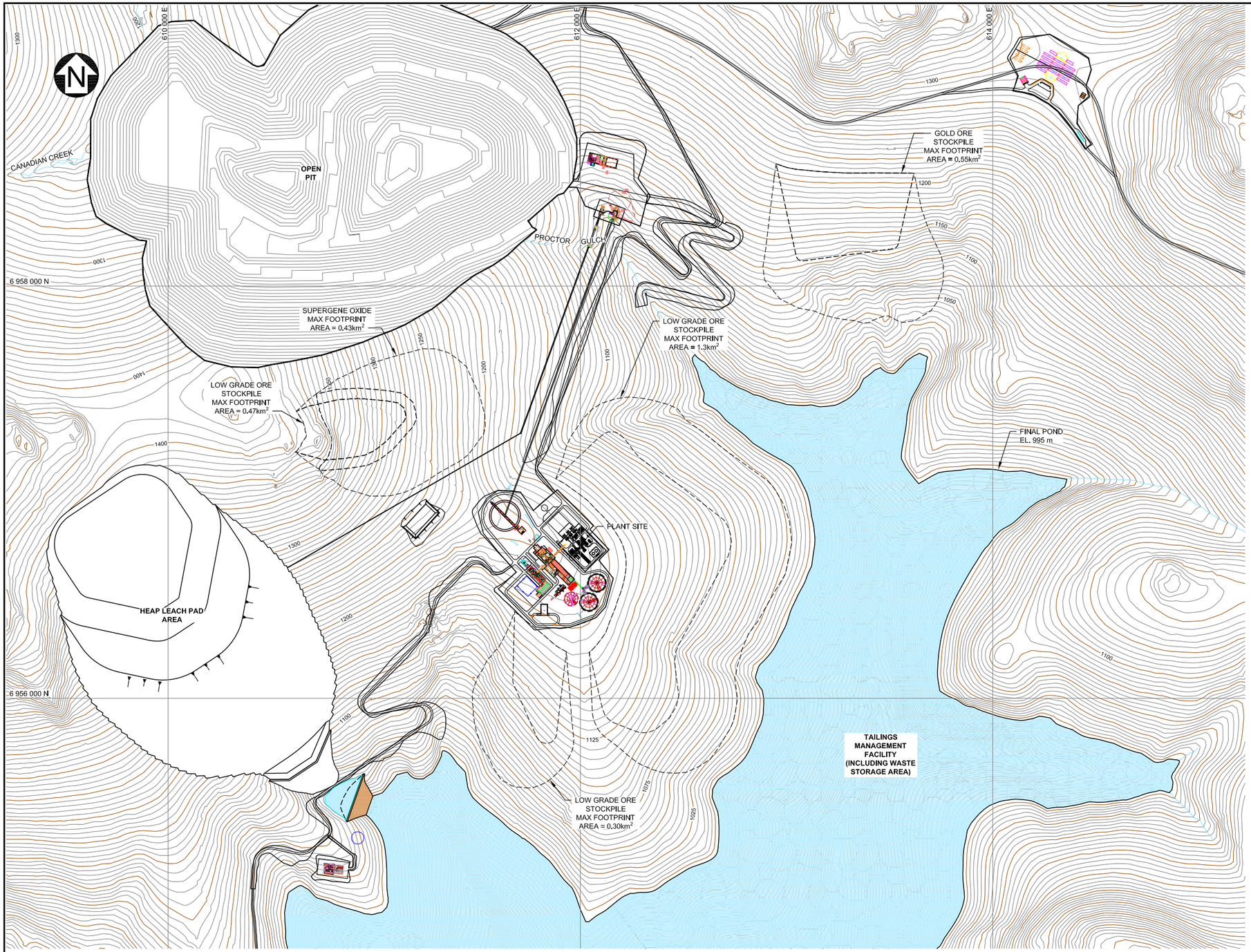

NOTES:

1. COORDINATE GRID IS UTM (WGS84/NAD83) ZONE 7 (m).
2. CONTOUR INTERVAL IS 5 METRES.
3. DIMENSIONS ARE IN METRES UNLESS NOTED.
4. PLANT SITE AND CRUSHER LAYOUT PROVIDED BY M3 ENGINEERING AND TECHNOLOGY CORPORATION (OCTOBER 4, 2012).
5. OPEN PIT IS SHOWN AT ITS FINAL OUTLINE AS PROVIDED BY CASINO MINING CORPORATION (NOVEMBER 2012).
6. ORE STOCKPILES ARE SHOWN AT THEIR MAXIMUM SIZE DURING OPERATIONS. ALL STOCKPILES REMOVED DURING OPERATIONS OR AT CLOSURE.

SCALE A 200 100 0 200 400 600 800 1000 m

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	18DEC'12	ISSUED WITH REPORT	BH/LM	NSD/PP	GRG	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

GENERAL ARRANGEMENT OF ORE STOCKPILES - YEAR 22

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P/A NO. VA101-325/8 | REF NO. 12

FIGURE 4.5 | REV 0

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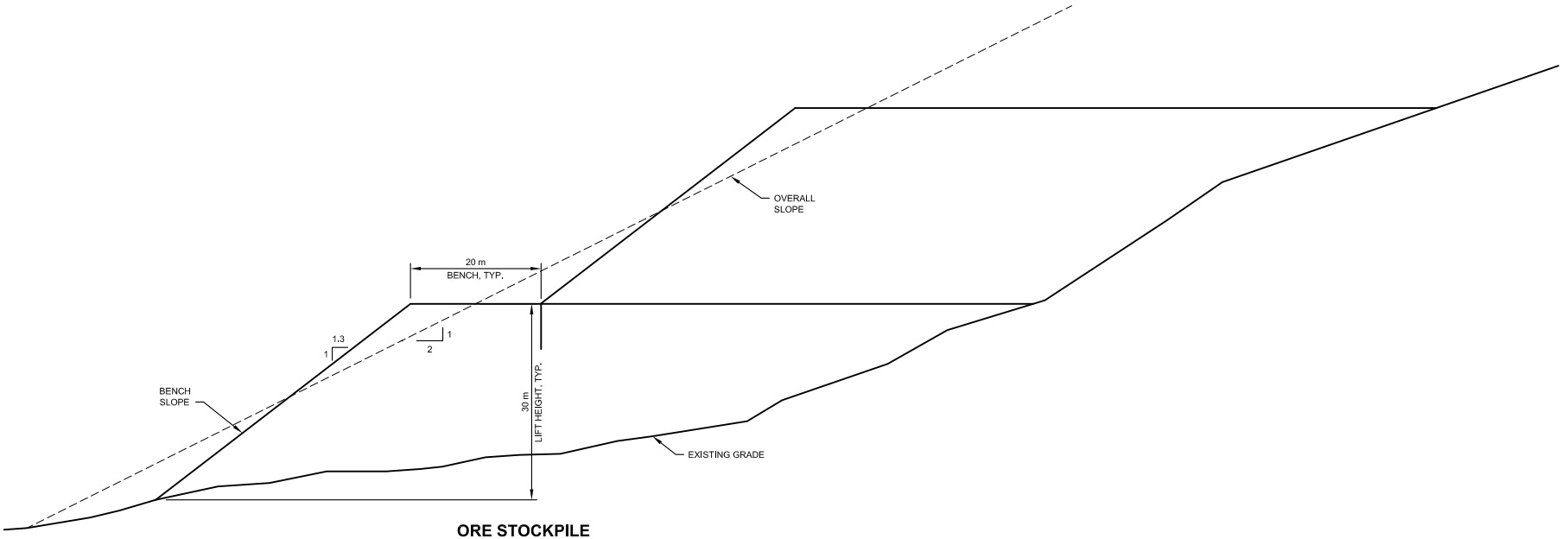
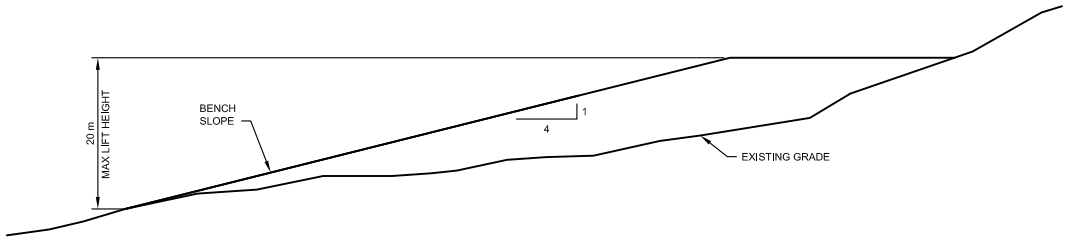


ORE STOCKPILE
SCALE A



TOPSOIL
SCALE A

SCALE A 10 5 0 10 20 30 40 50 m

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

ORE AND TOPSOIL STOCKPILES SLOPE CONFIGURATIONS

Knight Piésold CONSULTING

P/A NO. VA101-325/08 | REF NO. 12

FIGURE 4.6 | REV 0

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	18DEC'12	ISSUED WITH REPORT	SB	PP	GRG	KJB

4.2.1 Waste Storage Area

Approximately 658 million tonnes of potentially reactive (PAG and ML) waste rock and overburden material from the open pit will be placed into the WSA. The WSA will be operated to maintain a minimum separation between the WSA and the TMF embankments of approximately one km. This separation will allow development of a NAG tailings beach between the TMF embankments and the WSA. The tailings deposit will provide a low permeability transition zone between the coarse, permeable waste rock and the TMF embankments. This low permeability zone will function as a seepage limitation and control measure.

Development of the WSA is based on the mine production schedule presented in Table 4.1. It will be developed with a similar rate of rise as the tailings. The on-going maximum elevation of the WSA will be maintained at an elevation above the potential flood level of the TMF supernatant pond. The crest will be maintained several metres higher than the tailings and supernatant pond to provide a dry, stable surface for access and placement of material. The crest of the WSA will be covered with tailings and submerged by the supernatant pond in the later years of the mine life when stockpiled low grade ore is being milled after open pit mining is complete. Based on the current mine production schedule, approximately four years of tailings deposition will occur after final placement of waste rock in the WSA.

Waste rock deposition shall satisfy short and long term stability requirements. An overall slope of 1.5H:1V has been assumed for design purposes, but steeper slopes may be achieved in practice.

The following are recommended methods of construction and operation to ensure on going stability and performance of the WSA:

- Waste rock and overburden will be transported from the open pit using haul trucks. The material may be end dumped over the face or spread by dozers over the crest of the waste dump.
- Trial sections may be constructed in the field during the initial stages of development to monitor waste pile stability and foundation performance.
- Waste rock shall be end dumped over the crest to allow for maximum segregation of the coarser material at the base of each bench. For overburden materials, end dumping short of the crest and dozing over may be required.

These methods may be updated and revised, as necessary, based on field observations and performance monitoring during the initial stages of WSA development.

Details of the design and operation of the TMF, including the co-disposal of waste rock and overburden materials within the WSA, are provided in the KPL report “Feasibility Design of the Tailings Management Facility” (Ref. No. VA101-325/8-10, December, 2012).

4.2.2 Ore Stockpiles

Stockpiled ore will be placed on the south to east facing slopes between the TMF and the open pit, and will expand progressively over the mine life. The stockpiled ore will vary over the mine life, as shown in Table 4.2, with a peak of approximately 144 million tonnes of Low Grade ore stockpiled in Year 17. The stockpiled ore will be milled over the later years of the mine life. Low Grade ore mined after Year 12 can be stockpiled at the same location used for the SOX ore stockpile, located south of the open pit. SOX ore stockpiled in pre-production and Year 1 of mill operations will report to the mill in Years 4 to 12.

The following are recommended methods of construction and operation to ensure stockpile stability and to allow easy recovery of the ore. These methods may be updated and revised, as necessary, based on field observations and performance monitoring during the initial stages of waste pile construction.

Pre-Production

- Clear vegetated areas and strip the foundations prior to loading to remove the organic layer and to initiate the melting of any permafrost or frozen soils
- Strip topsoil to windrow for use during reclamation
- Remove any ice rich, frost susceptible and unsuitable soft or thawed and saturated materials in the foundation prior to ore placement, and
- Construct diversion and runoff collection ditches where required.

Operations

- Ore material will be transported from the pit using haul trucks. The material will be end dumped and spread by dozers over the crest of the pile.
- Load the ore stockpile in lifts starting at the toe and working progressively upslope. Each lift may be developed at the angle of repose for the material (approximately 1.3H:1V). However, benches should be left along the toe of each successive lift to establish a maximum overall slope angle of 2H:1V.
- The lifts should be loaded and developed in a direction parallel to the slope wherever possible to avoid stress concentrations associated with “nose” configurations where the axis of the pile extends outward and perpendicular to the slope.
- Trial sections should be constructed in the field during the initial stages of development to monitor pile stability and foundation performance.

The prepared base of the stockpiles will function as a working platform during the re-handling of the ore for milling.

Unsuitable soils excavated from the footprint of the ore stockpiles can be placed within the TMF. It is recommended to excavate down to competent bedrock in areas where permafrost or frozen soils are encountered during construction. Bedrock is generally encountered at shallow depths throughout the stockpile areas with an assumed average depth of approximately two meters, and will provide a solid foundation that is not susceptible to frost effects. However, the depth to bedrock is deeper (over 5 metres) in the area of the gold leach ore stockpile. For this area, and any other areas where the depth to competent bedrock is deep, it may be preferable to develop the stockpile configuration to provide suitable stability by buttressing at the toe of the pile.

Diversion ditches will be required upstream of the ore stockpiles to minimize the contact of runoff water with the ore. Details of the surface water management strategy are described in Section 4.4.

4.2.3 Topsoil Stockpiles

Topsoil materials will be stripped during development of the plant site, the open pit, ore stockpiles, HLF and the TMF embankments. The topsoil will be placed in stockpiles for use in reclamation activities. The stockpiles will generally be located within two kilometres of the material source. Topsoil salvaged from the base of ore stockpiles will be windrowed around the toe of the piles. The location of the various topsoil stockpiles is shown on the general arrangement plan on Figure 1.2.

Initial construction and ongoing development of mine site facilities will require that topsoil and organic material be salvaged from select areas of ground disturbance. Soil salvaging and stockpiling operations will require a variety of management practices to ensure that soils are handled and stored properly during all phases of the mine development. Soil management practices to be carried out for soil stripping, salvage and stockpiling are summarized below:

- Wet conditions will be avoided when possible during soil salvage operations.
- Excessive traffic will be avoided during the salvage process to minimize admixing, compaction and rutting.
- Traffic will be confined to established routes to avoid unnecessary compaction of soil in undisturbed areas.
- Soil will be stockpiled in locations to minimize the possibility of further disturbance.
- Stockpile locations will, where possible, be located a sufficient distance away from operations to protect soils from contamination from risk of spills or metal deposition.
- Protective ditches will be constructed where practical around stockpiles to prevent any spill reaching stockpiles.
- Erosion will be managed by limiting the height and slope of stockpiles. Erosion control measures will be implemented including prompt vegetation establishment on topsoil stockpiles to reduce exposure of bare soil.
- Where possible soil stockpiles will be oriented to reduce wind erosion and located to reduce wind exposure.

These methods may be updated and revised, as necessary, based on field observations and performance monitoring during stockpile development. Toe berms to ensure stockpile stability may be required, based on foundation conditions and the strength characteristics and condition of the stockpiled material.

The topsoil stockpiles will be limited to a maximum height of about 20 m (crest to downstream toe), with consideration of site-specific ground conditions, and constructed as wrap around dumps in an ascending sequence. This construction method is used to improve overall stability as each constructed lift will act as a buttress for the toe of the next lift. In addition, the topsoil stockpiles will be constructed such that the overall slope angle will average 14 degrees (4H:1V). These flat overall topsoil stockpile slopes will minimize the risk of slope instability, reduce erosion potential and improve the amenability for vegetation growth. The use of topsoil for concurrent reclamation activities will reduce the quantity of material required to be stockpiled. Figure 4.7 shows the slope configuration for the topsoil stockpiles.

It is anticipated that some overburden material will also be required for reclamation and erosion control of the downstream slopes of TMF embankments. Overburden and topsoil materials will be stockpiled separately.

4.3 STABILITY OF WASTE STORAGE AREA AND STOCKPILES

A stability assessment has been carried out for the WSA, topsoil stockpiles and ore stockpiles.

The stability of the WSA is not a concern, as the slope of the waste material adjacent to the tailings deposit is buttressed by the tailings, with only a few metres height of the waste pile above the surface of the tailings. Acceptable slopes and benching of the waste rock will depend on the

elevation difference between the waste rock, tailings and supernatant pond during operations, as well as the condition of the tailings. An overall slope of 1.5H:1V has been assumed for design purposes, as shown on Figure 1.3, but steeper slopes may be achieved in practice. Any sloughing and ravelling of waste material into the tailings and supernatant pond will not impact the integrity of the TMF. The tailings embankments are typically over one kilometre from the WSA and it is anticipated that there will be a significant tailings beach width (over 200 metres) that slopes upward between the pond and embankments.

To provide stability the slopes of the topsoil stockpiles are comparatively low and flat, with gently sloped faces with an overall slope angle of about 14 degrees (4H:1V). Toe berms to ensure stockpile stability may be required, based on the foundation conditions encountered and the strength characteristics and condition of the stockpiled material.

Numerical stability analyses have been carried out for the ore stockpiles. Two sections have been considered:

- Low Grade ore stockpile, with an overall slope of 2H:1V and overburden thickness of 3 metres, representing the stockpile located south of the open pit, and
- Gold Leach ore stockpile, with an overall slope of 2H:1V and overburden thickness of 10 metres (located in an area where the thickness of the overburden is typically greater than 5 metres).

The conditions and stability of the other Low Grade ore stockpiles are similar to or better than those identified for the Low Grade ore stockpile south of the open pit, based on consideration of overburden thickness and ground slope.

Figures 4.7 and 4.8 show the stockpile sections and material parameters used in the stability analyses for the Low Grade ore stockpile and Gold Leach ore stockpile respectively. Both sections are based on the maximum stockpile height achieved during operations.

The stability analyses for the ore stockpiles were carried out using the limit equilibrium computer program SLOPE/W. In this program a systematic search was performed to obtain the minimum factor of safety from a number of potential slip surfaces. Factors of safety were calculated using the rigorous Morgenstern-Price method of analysis. In accordance with standard industry practice, the minimum acceptable factor of safety for waste and ore stockpiles under static conditions is 1.3 for short-term operating conditions and 1.5 after reclamation and abandonment. Seismic loading was modelled by performing a pseudo-static analysis. A factor of safety under seismic conditions of less than 1.0 is acceptable provided that any predicted deformations resulting from seismic loading are not significant, and would not impact mine site facilities, including the WSA and TMF.

The design earthquake has been taken as the 1 in 500 year return period event, consistent with the Operating Basis Earthquake (OBE) defined for the TMF. The corresponding mean peak ground acceleration is 0.08g. A design earthquake magnitude of 8.0 has been selected based on a review of regional tectonics, potential seismic source zones in the region and historical seismicity.

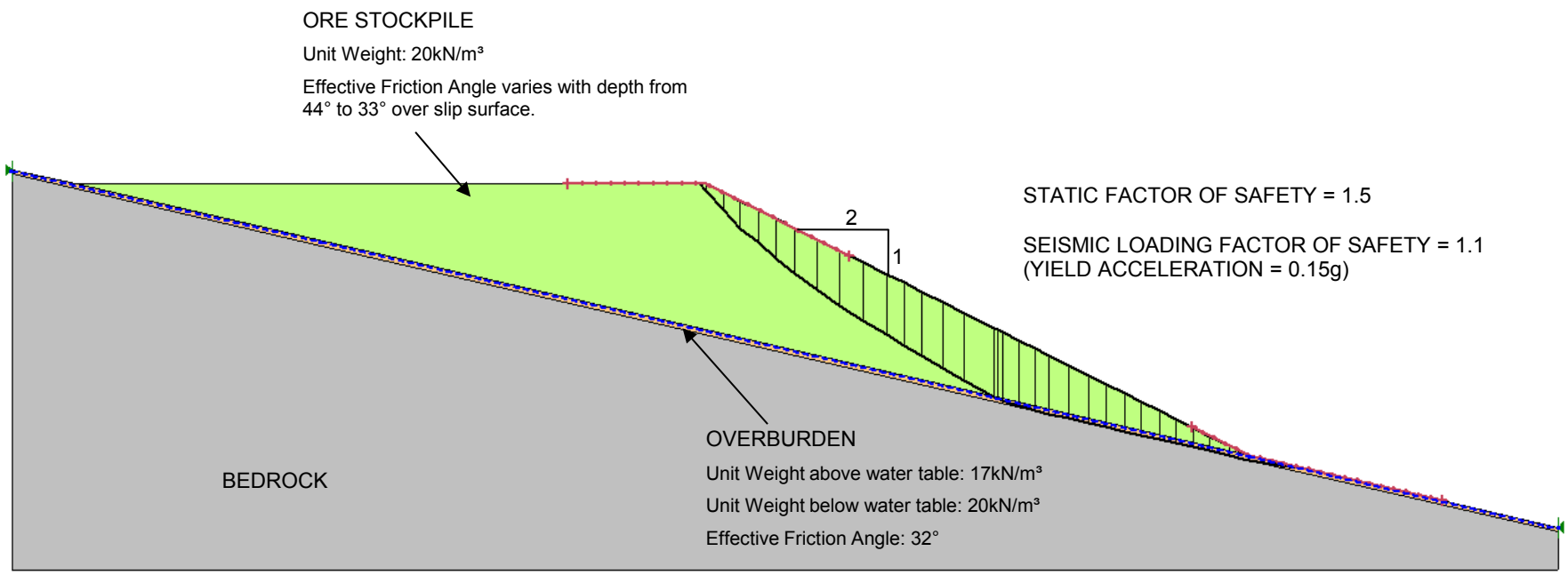
The following parameters and assumptions were incorporated into the stability analyses:

- The unit weights used for the stockpiled ore and foundation soils were based on typical values for similar materials. An average bulk unit weight of 20 kN/m^3 was used for the stockpiled ore materials. Unit weights of 17 kN/m^3 and 20 kN/m^3 were used for the foundation overburden soils above and below the water table respectively.

- The effective friction angle of the overburden materials at the base of stockpile is assumed to be 32 degrees for cleared foundations (all unsuitable and ice rich soils are assumed to be removed).
- The shear strength for stockpiled ore material has been defined using a conservative strength function that defines the variation of shear strength with normal stress. The strength function is based on published information on the shear strength properties of granular rock fill materials (Leps, 1970).
- The phreatic surface was assumed to be one metre below the base of the ore stockpile. This is based on information provided by test pitting during the site investigation programs.
- There are no excess pore water pressures generated by thawing of foundation materials. It is assumed that appropriate foundation preparation and/or excavation have been conducted in any areas with ice rich and frozen soils.

The minimum calculated static factor of safety is 1.5 for the Low Grade ore stockpile and 1.4 for the Gold Leach ore stockpile (about 1.35 for small shallow slip surfaces). These results indicate that the proposed configuration of the stockpile slopes is adequate to maintain short term (operational) static stability (factors of safety greater than 1.3). The potential slip surface and minimum static factor of safety calculated from the analyses are included on Figures 4.7 and Figure 4.8. In the event of a premature mine closure it is anticipated that the stockpiled ore would need to be hauled to the TMF for disposal, or potentially re-handled for processing at the mill for delivery to the TMF as tailings. Details of the closure plan are being developed by Others.

The seismic stability assessment of the ore stockpiles has included an estimation of potential seismically induced deformations from the design earthquake. To account for the possible amplification of ground accelerations as seismic waves propagate through stockpile, an amplification factor of 1.5 was assumed, resulting in an estimated average maximum acceleration of 0.12g within the waste rock pile. Potential deformations under earthquake loading have been estimated using the simplified methods of Newmark (1965) and Makdisi-Seed (1977). Predicted deformations calculated for the design earthquake are negligible. The consequences of a stockpile slope failure due to earthquake shaking is minimal and restricted to minor displacement of the surface of the stockpile slopes (ravelling). There would be a negligible impact on the integrity of the stockpile and little, if any, impact on other mine site facilities.



NOTES:

1. PHREATIC SURFACE ASSUMED TO BE AT A DEPTH OF 1 METRE BELOW BASE OF STOCKPILE.
2. AVERAGE OVERBURDEN THICKNESS OF 3 METRES ASSUMED.
3. STOCKPILE SECTION REPRESENTS MAXIMUM HEIGHT OF LOW GRADE ORE STOCKPILES (190 METRES FOR STOCKPILE LOCATED SOUTH OF OPEN PIT).

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ORE STOCKPILE STABILITY ANALYSIS
LOW GRADE ORE STOCKPILE

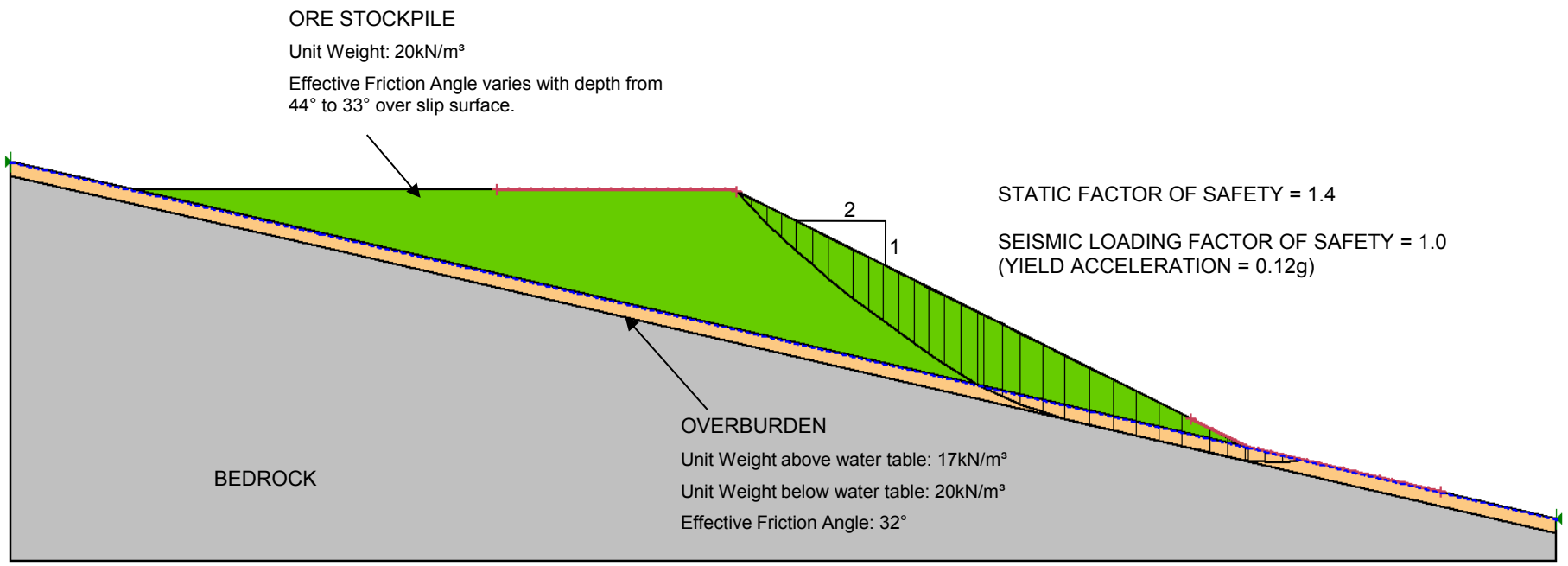
Knight Piésold CONSULTING

P/A NO. VA101-325/8

REF. NO. 12

FIGURE 4.7

REV 0



NOTES:

1. PHREATIC SURFACE ASSUMED TO BE AT A DEPTH OF 1 METRE BELOW BASE OF STOCKPILE.
2. AVERAGE OVERBURDEN THICKNESS OF 10 METRES ASSUMED.
3. STOCKPILE SECTION REPRESENTS MAXIMUM HEIGHT OF ORE STOCKPILE (180 METRES).

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	07DEC'12	ISSUED WITH REPORT	LM	GRG	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

ORE STOCKPILE STABILITY ANALYSIS
GOLD LEACH ORE STOCKPILE

Knight Piésold CONSULTING

P/A NO. VA101-325/8

REF. NO. 12

FIGURE 4.8

REV 0

4.4 SURFACE WATER MANAGEMENT AND SEDIMENT CONTROL

The surface and diversion ditching system which discharges to the TMF basin, is designed to divert surface flow around the ore stockpiles to minimise contact with the water. The collection of seepage from the toe of the ore will not be required. The diversion ditching system consists of a series of ditches constructed along the upslope side of the stockpiles and are designed to meet the following design criteria:

- Design storm conveyance: 1 in 100 year 24-hour duration storm event
- Minimum freeboard = 0.3 m
- Maximum design storm flow depth = 0.5 m
- Minimum ditch grade = 0.01 m/m
- Minimum channel side slope = 2H:1V

Evaluation of the estimated surface runoff for the 1 in 100 year 24-hour storm event was undertaken using the Hydrologic Engineering Centre Hydrologic Modeling System (HEC-HMS). HEC-HMS simulates the precipitation-runoff processes of dendritic drainage basins and uses site specific data to accurately capture the specific climate and catchment conditions, including storm precipitation intensity distribution, snowmelt, catchment slope, drainage and precipitation losses.

Two different ditch systems are required for the diversion runoff: 'earth lined' and 'erosion protected'. The earth lined ditch sections are those portions of ditch with shallow grades and low flow velocities. The erosion protection ditch sections will require either riprap or synthetic lining to prevent ditch scouring and erosion when conveying runoff water at steeper grades and higher velocity flows. Based on the topography at Site, the total ditch widths range between three to four metres for protected ditch sections and four to five metres for the shallow-grade earth lined sections.

Sediment control fencing will be placed around the down-gradient perimeter sections of the stockpiles to prevent sediment discharge from the stockpiles.

4.5 RECLAMATION AND CLOSURE

Reclamation of ore stockpile footprints will be required for mine closure. As much as practical the reclamation will be carried out concurrent with mine operations.

It is anticipated that reclamation of the footprint of ore stockpiles will take place in the later years of mine operations and post mill closure as stockpiled ore is milled and the stockpile footprints are exposed. Reclamation will be conducted in conjunction with on-going environmental monitoring to ensure that sediment control and water quality objectives and criteria are met. A general arrangement of the project site at the end of operations (Year 22) is shown on Figure 4.5 including the location and configuration of the final WSA within the TMF.

The WSA will be fully contained within the final TMF at closure. No closure activities will be required on the WSA to ensure long-term geotechnical stability and integrity. The final configuration of the TMF and WSA provides a tailings layer approximately 3 metres thick over the surface of the WSA (assuming a horizontal tailings surface) with a 4 metre deep supernatant pond over the tailings layer at the end of operations (Year 22). A minimum cover of 2 metres of water is recommended to ensure geochemical containment of the WSA materials.

Topsoil and overburden materials stockpiled south of the TMF will be used for reclamation of the TMF beach and the downstream slope of the TMF Main Embankment. For the West Saddle Embankment a small quantity of topsoil and overburden will be stockpiled nearby and used for reclamation of the downstream slope. The topsoil stockpile located south of the open pit will be used for reclamation of the Heap Leach Facility. The windrow topsoil located at the toe of the ore stockpiles will be used to reclaim the stripped area of the stockpile foundations.

A closure and reclamation plan for the project is being developed by Others.

5 – SCHEDULE OF QUANTITIES

Quantity estimates for the materials and work items required for initial construction and for ongoing operations of the ore stockpiles and topsoil stockpiles are presented in Table 5.1. Quantities have been estimated for the following components of stockpile development and operation:

- Foundation clearing and preparation of ore stockpiles foundations
- Surface water management ditching, and
- Erosion and sediment control.

The estimated maximum footprint area for each of the ore stockpiles is included on Figure 4.5.

An average depth of 0.3 metres was assumed for stripping and grubbing of ore stockpiles footprints. Excavation of unsuitable overburden materials was assumed to a depth of 3 metres for the Low Grade ore and SOX ore stockpiles. Excavation of unsuitable overburden materials to a depth of 5 metres was assumed for the Gold Leach ore stockpile, where the depth of overburden is greater.

The Feasibility level quantities were measured on the basis of the designs and dimensions shown on the relevant Figures of this report. These quantities have been developed to enable costing to be conducted to a level of accuracy of ± 15 percent. It is understood that the all capital costs and operating costs will be prepared by Others.

The cost estimate will also need to include the following items:

- Site haul roads to ore/topsoil stockpiles and the WSA
- Haulage of ore and topsoil materials to/from stockpiles
- Haulage of potentially reactive mine waste rock and overburden materials to the WSA, and
- Excavation of unsuitable (ice-rich and frost susceptible) soils from the ore stockpiles, and haulage and placement of these materials into the TMF.

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TABLE 5.1

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

FEASIBILITY DESIGN STUDIES
SCHEDULE OF QUANTITIES FOR STOCKPILES

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Item Number	Description	Unit	PP	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11
			Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity
1	**ORE STOCKPILES**													
a	**North-East Gold Ore Stockpile**													
	Clearing	m^2	347,000	94,000	71,000	35,000	0	0	0	0	0	0	0	0
	Stripping and Grubbing (0.3m thick)	m^3	104,200	28,300	21,200	10,400	0	0	0	0	0	0	0	0
	Excavation unsuitable material (5m thick)	m^3	1,736,100	471,800	352,500	172,500	0	0	0	0	0	0	0	0
	Diversion Ditching Earth lined, 4 to 5 metres wide	m	670	0	0	0	0	0	0	0	0	0	0	0
	Diversion Ditching Erosion protected, 3 to 4 metres wide	m	950	0	0	0	0	0	0	0	0	0	0	0
b	**North-West Supergene Oxide and later Low Grade Ore Stockpiles**													
	Clearing	m^2	288,000	144,000	0	0	0	0	0	0	0	0	0	0
	Stripping and Grubbing (0.3m thick)	m^3	86,300	43,300	0	0	0	0	0	0	0	0	0	0
	Excavation unsuitable material (3m thick)	m^3	863,300	433,000	0	0	0	0	0	0	0	0	0	0
	Diversion Ditching Earth lined, 4 to 5 metres wide	m	400	0	0	0	0	0	0	0	0	0	0	0
	Diversion Ditching Erosion protected, 3 to 4 metres wide	m	1,530	0	0	0	0	0	0	0	0	0	0	0
c	**South-East Low Grade Ore Stockpile**													
	Clearing	m^2	3,000	15,000	128,000	61,000	193,000	150,000	314,000	169,000	96,000	117,000	54,000	0
	Stripping and Grubbing (0.3m thick)	m^3	1,000	4,500	38,500	18,200	57,800	44,900	94,300	50,800	28,700	35,200	16,200	0
	Excavation unsuitable material (3m thick)	m^3	9,900	44,900	385,000	181,900	578,300	448,600	942,500	507,500	287,200	351,800	162,300	0
	Diversion Ditching Earth lined, 4 to 5 metres wide	m	510	0	0	0	0	510	0	0	0	0	0	0
	Diversion Ditching Erosion protected, 3 to 4 metres wide	m	970	0	0	0	0	0	0	0	0	0	0	0
d	**South-West Low Grade Ore Stockpiles**													
	Clearing	m^2	0	0	0	0	0	0	0	0	0	0	103,000	109,000
	Stripping and Grubbing (0.3m thick)	m^3	0	0	0	0	0	0	0	0	0	0	30,900	32,700
	Excavation unsuitable material (3m thick)	m^3	0	0	0	0	0	0	0	0	0	0	309,000	327,000
	Diversion Ditching Earth lined, 4 to 5 metres wide	m	0	0	0	0	0	0	0	0	0	0	320	0
	Diversion Ditching Erosion protected, 3 to 4 metres wide	m	0	0	0	0	0	0	0	0	0	0	970	0
2	**SEDIMENT AND EROSION CONTROL BMP'S ALLOWANCE[3]**	PS												

Item Number	Description	Unit	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22
			Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity
1	**ORE STOCKPILES**												
a	**North-East Gold Ore Stockpile**												
	Clearing	m^2	0	0	0	0	0	0	0	0	0	0	0
	Stripping and Grubbing (0.3m thick)	m^3	0	0	0	0	0	0	0	0	0	0	0
	Excavation unsuitable material (5m thick)	m^3	0	0	0	0	0	0	0	0	0	0	0
	Diversion Ditching Earth lined, 4 to 5 metres wide	m	0	0	0	0	0	0	0	0	0	0	0
	Diversion Ditching Erosion protected, 3 to 4 metres wide	m	0	0	0	0	0	0	0	0	0	0	0
b	**North-West Supergene Oxide and later Low Grade Ore Stockpiles**												
	Clearing	m^2	0	0	0	0	6,000	31,000	0	0	0	0	0
	Stripping and Grubbing (0.3m thick)	m^3	0	0	0	0	1,700	9,300	0	0	0	0	0
	Excavation unsuitable material (3m thick)	m^3	0	0	0	0	16,800	92,600	0	0	0	0	0
	Diversion Ditching Earth lined, 4 to 5 metres wide	m	0	0	0	0	250	0	0	0	0	0	0
	Diversion Ditching Erosion protected, 3 to 4 metres wide	m	0	0	0	0	130	0	0	0	0	0	0
c	**South-East Low Grade Ore Stockpile**												
	Clearing	m^2	0	0	0	0	0	0	0	0	0	0	0
	Stripping and Grubbing (0.3m thick)	m^3	0	0	0	0	0	0	0	0	0	0	0
	Excavation unsuitable material (3m thick)	m^3	0	0	0	0	0	0	0	0	0	0	0
	Diversion Ditching Earth lined, 4 to 5 metres wide	m	0	0	0	0	0	0	0	0	0	0	0
	Diversion Ditching Erosion protected, 3 to 4 metres wide	m	0	0	0	0	0	0	0	0	0	0	0
d	**South-West Low Grade Ore Stockpiles**												
	Clearing	m^2	89,000	0	0	0	0	0	0	0	0	0	0
	Stripping and Grubbing (0.3m thick)	m^3	26,600	0	0	0	0	0	0	0	0	0	0
	Excavation unsuitable material (3m thick)	m^3	266,300	0	0	0	0	0	0	0	0	0	0
	Diversion Ditching Earth lined, 4 to 5 metres wide	m	0	0	0	0	0	0	0	0	0	0	0
	Diversion Ditching Erosion protected, 3 to 4 metres wide	m	0	0	0	0	0	0	0	0	0	0	0
2	**SEDIMENT AND EROSION CONTROL BMP'S ALLOWANCE[3]**	PS											

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NOTES:

1. PS = PROVISIONAL SUM.
2. NO CONTINGENCY ADDED TO QUANTITIES
3. SEDIMENT AND EROSION CONTROL INCLUDES SEDIMENT FENCING AROUND THE PERIMETER OF THE ORE STOCKPILES, AND EROSION PROTECTION/STABILIZATION OF TOPSOIL STOCKPILES.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	07DEC'12	ISSUED WITH REPORT VA101-325/8-12	LM	SB	KJB

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7 – CERTIFICATION

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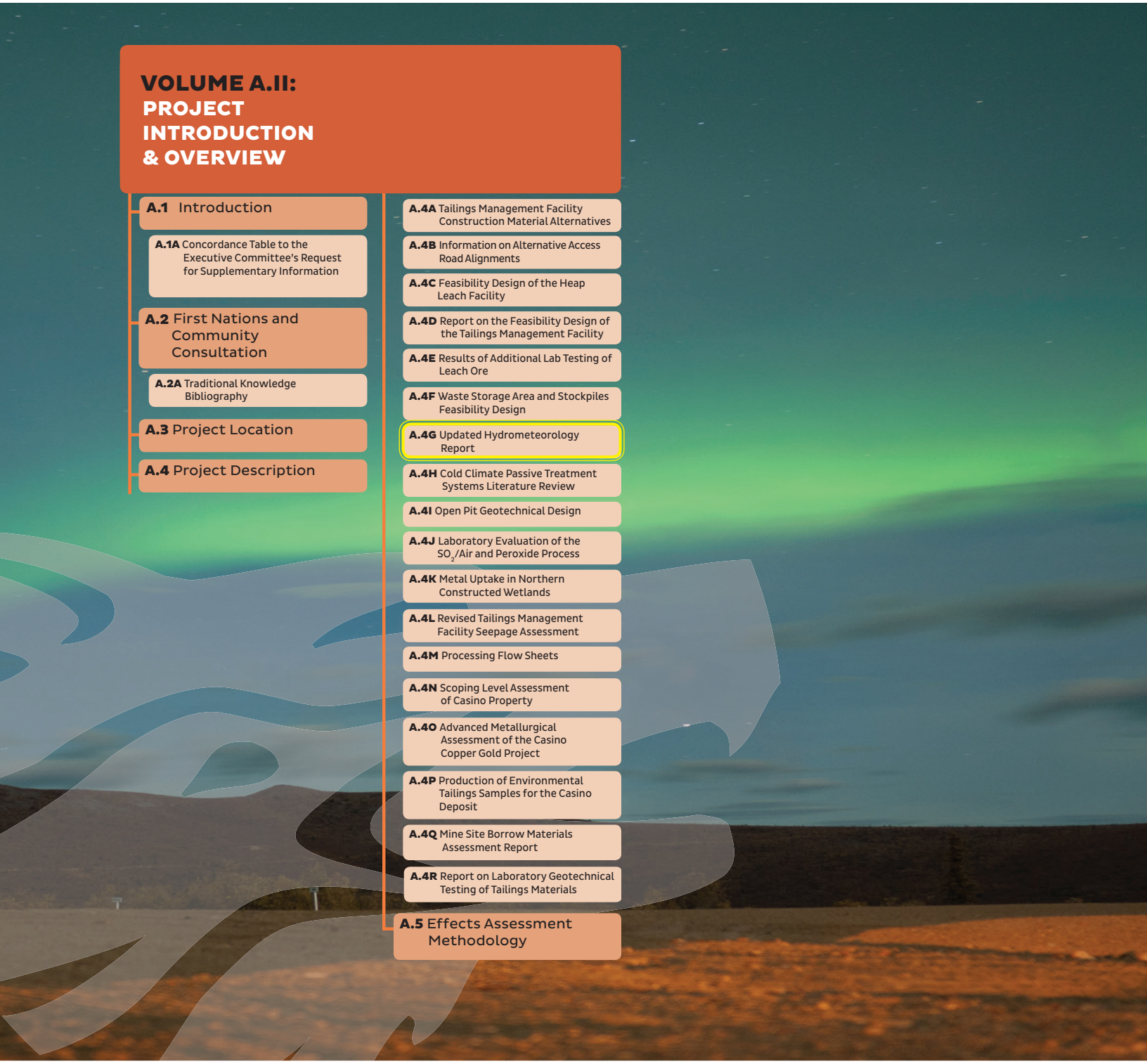
APPENDIX A.4G: Updated Hydrometeorology Report



CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT





UPDATED HYDROMETEOROLOGY REPORT

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VA101-325/8-11
Rev 0
July 9, 2012

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CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT
UPDATED HYDROMETEOROLOGY REPORT
(REF. NO. VA101-325/8-11)

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CASINO MINIING CORPORATION
CASINO COPPER-GOLD PROJECT

UPDATED HYDROMETEOROLOGY REPORT
(REF. NO. VA101-325/8-11)

EXECUTIVE SUMMARY

This hydrometeorology report provides climatic and hydrologic information for the Casino Copper-Gold Project in Yukon Territory, Canada. Specific climatic estimates are provided for the Project climate station situated at 1,200 m elevation, along with guidance on scaling these estimates to different elevations within the Project area. Hydrologic estimates are provided for nine gauging stations in the two watersheds that drain the Project area (Dip and Britannia Creek watersheds). The climatic and hydrologic estimates presented in this report are based on the available measured site data, in conjunction with regional regression analyses, which have been used to generate long-term synthetic data series for key climatic parameters and streamflow.

This report supersedes an earlier version, dated June 15, 2010 (KPL, 2010), which presented data collected up to 2009. This updated version incorporates an additional two years of climate and streamflow records (2010-2011) collected in the Project area and provides refined estimates of climatic and hydrologic parameters. Overall, the updated estimates for key parameters are in agreement with previously estimated values.

The estimated values for key climatic parameters, referenced to the Project site climate station at 1,200 m elevation, are presented below:

CLIMATIC PARAMETERS (1,200 M ELEVATION)	VALUE
Mean Annual Temperature	-3 C
Mean January Temperature	-17 C
Mean July Temperature	12 C
Extreme Minimum Temperature	-50 C
Extreme Maximum Temperature	30 C
Mean Annual Precipitation	510 mm
Mean Annual Rainfall	330 mm
Mean Annual Snowfall (Water-Equivalent)	180 mm
Mean Annual Rainfall/Snowfall Distribution	65% / 35%
2-Year 24-Hr Rainfall	29 mm
200-Year 24-Hr Rainfall	56 mm
Mean Annual Wind Speed	2.2 m/s
Maximum Wind Gust Speed	11.1 m/s
Prevailing Wind Direction	Southwesterly
Mean Annual Relative Humidity	68%
Mean Annual Potential Evapotranspiration	300 mm
Mean Annual Maximum Snow Water-Equivalent	140 mm
Mean Monthly Snowmelt for May (Water-Equivalent)	120 mm

Temperature and precipitation can be adjusted to reflect conditions at different elevations according to the following guidelines:

CLIMATIC PARAMETER ELEVATION ADJUSTMENTS	VALUE
Mean Monthly Temperature (April through October)	-0.6 C per 100 m
Mean Monthly Temperature (November through March)	Increases with elevation
Mean Annual Precipitation	+5% per 100 m

The streamflow and unit runoff results for gauging station W4 on Lower Casino Creek are presented below:

HYDROLOGIC PARAMETERS (LOWER CASINO CREEK (W4), DRAINAGE AREA 82 KM^2)	VALUE
Mean Annual Discharge	0.48 m^3/s
Mean Annual Unit Runoff	5.8 $l/s/km^2$
Mean Annual Runoff (Depth Equivalent)	180 mm/yr
Mean Monthly Discharge for May	1.37 m^3/s
Mean Monthly Unit Runoff for May	16.7 $l/s/km^2$
Mean Monthly Unit Runoff for May (Depth Equivalent)	45 mm/mo.
Natural Catchment Runoff Coefficient	0.4
2-Year Instantaneous Peak Flow	12 m^3/s
200-Year Instantaneous Peak Flow	40 m^3/s
10-Year, 7-Day Low Flow	0 m^3/s
10-Year Dry Monthly Flow	0.37 m^3/s
10-Year Wet Monthly Flow	3.01 m^3/s

Potential climate change effects have not been considered explicitly in any of the hydrometeorological estimates presented above, except for peak flows. Appropriate allowances for potential climate change effects should be made where necessary.

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CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

UPDATED HYDROMETEOROLOGY REPORT
(REF. NO. VA101-325/8-11)

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CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

UPDATED HYDROMETEOROLOGY REPORT (REF. NO. VA101-325/8-11)

SECTION 1.0 - INTRODUCTION

1.1 PROJECT DESCRIPTION

The Casino Copper-Gold Project is located in the Dawson Mountain Range of the Klondike Plateau approximately 300 km northwest of Whitehorse, Yukon Territory, as shown on Figure 1.1. The Casino Project is situated in the Dip Creek and Britannia Creek watersheds. Dip Creek drains southwest, eventually flowing into the White River, which is a tributary of the Yukon River. Britannia Creek drains north directly into the Yukon River.

The Project ore body is situated on a ridge between the Dip Creek and Britannia Creek watersheds. More specifically, the ore body straddles the drainage divide between the Casino Creek sub-watershed (tributary to Dip Creek) and the Canadian Creek sub-watershed (tributary to Britannia Creek). The Project includes an airstrip located in Dip Creek valley and a barge landing on the Yukon River near the Britannia Creek confluence. Access roads to these features will follow the Casino and Dip Creek valleys (to the airstrip) and the Canadian and Britannia Creek valleys (to the barge landing). The main access road to the Project area will connect to Carmacks.

1.2 REGIONAL SETTING

The Project is located within the Boreal Cordillera ecozone, which comprises much of the southern Yukon and a large portion of northern British Columbia, and more specifically within the Dawson Range ecoregion (NRC, 2010). The Boreal Cordillera ecozone is broadly characterized by the presence of several mountain ranges, including the Dawson Range, that trend in the north-westerly direction and include extensive plateau regions. The plateaus consist of flat or gently rolling upland terrain separated by broad valleys and lowlands.

The climate is characterized by long, cold, dry winters and short, warm, wet summers, with conditions varying according to altitude and aspect. Streamflow in the region is typically highest in May due to melting of the winter snowpack. Annual peak instantaneous flows commonly occur in this freshet period on larger rivers, but on smaller streams they may also occur in summer or early autumn due to intense rain or rain on snow events. Flows decrease throughout the winter and minimum flows typically occur in March or April.

The locations of regional climate and streamflow gauging stations operated by the Meteorological Service of Canada (MSC) and the Water Survey of Canada (WSC), respectively, are shown on Figure 1.2.

1.3 REPORT CONTENT

The climatic parameters presented in this report consist of the following:

- Temperature
- Rainfall, snowfall, and total precipitation
- Wind speed and direction
- Relative humidity
- Evapotranspiration, and
- Snowfall, snow accumulation, and snowmelt.

Climatic data were collected on-site at the Project climate station located in the upper Casino Creek sub-watershed at an elevation of 1,200 m. The period of site record extends from 1993 to 1994, and from 2008 to present. The site temperature and precipitation data were compared to the long-term record from the MSC climate station at Pelly Ranch, located 80 km to the east at an elevation of 454 m. Linear regression analyses of temperature and precipitation between the Casino and Pelly Ranch climate stations are described in Section 2.0 of this report along with the results of the analysis: a 54-year synthetic series of monthly temperature and precipitation at the Casino station, from which summary statistics have been computed.

Hydrologic information consists of streamflow, unit runoff, and runoff coefficient. Preliminary streamflow data were collected by Hallam Knight Piésold in 1993 and 1994. A new data collection program was initiated by AECOM in 2008, and continues to be operated at present by Knight Piésold Ltd. (KPL). KPL (2012) provided a comprehensive analysis of all available streamflow data and described a regional regression analysis used to generate a 33-year synthetic daily streamflow series for each of the nine gauging station locations in the Project area. Summary statistics of the 33-year streamflow series are presented in Section 3.0 of this report.

The following key hydrologic statistics for each gauging station presented are:

- Mean annual and monthly discharge and unit runoff
- Peak flows for various return periods from 2 years to 200 years
- 10-year, 7-day low flow
- 10-year wet and dry monthly flows, and
- Runoff coefficient (Lower Casino Creek station only).

SECTION 2.0 - CLIMATE

2.1 DATA SOURCES

2.1.1 Regional Climate Stations

Regional climate stations are operated by the MSC for several locations within the Klondike Plateau region and within 150 km of the Project location. The locations of selected stations are shown on Figure 1.2. The period of record, elevation, and mean annual temperature and precipitation at each station are provided in Table 2.1.

The MSC operated a climate station (Casino Creek, 2100310) within the general Project area, with measured data recorded between 1969 and 1995, with no years of complete record. The station elevation was 1,100 m. Based on the incomplete data for this station, the mean annual precipitation is approximately 400 mm with a mean annual temperature of -4 C.

Seven regional stations, listed in Table 2.1, have greater than 20 complete years of record. These stations are all situated in low-elevation settings (around 370 m to 650 m). Of these stations, Pelly Ranch is located closest to the Project area (approximately 80 km to the east of the Project area). Mean annual precipitation at the seven long-term stations ranges from around 290 mm to 420 mm, and mean annual temperature values ranging from around -3 C to -6 C.

2.1.2 Regional Climate Maps

Natural Resources Canada (NRC) maps of mean annual precipitation and lake evaporation in Yukon Territory are presented on Figures 2.1 and 2.2, respectively. The Project location lies in the middle of a broad zone of relatively low precipitation aligned northwest-southeast between large mountain ranges to the southwest (the St. Elias Mountains near the Pacific Coast) and the northeast (the Mackenzie Mountains along the Northwest Territories border), as shown on Figure 2.1. The zone of less than 400 mm mean annual precipitation roughly coincides with the Klondike Plateau. More specifically, the Project location is shown to lie in an area with less than 300 mm of mean annual precipitation, although this map (Figure 2.1) is based on relatively few regional climate stations and has a low resolution that does not account for local orographic effects. Mean annual lake evaporation in Yukon Territory is shown on Figure 2.2 to be more dependent on latitude than topography, although this map also does not account for local elevation effects. The Project location is shown to lie in an area with slightly less than 300 mm in mean annual lake evaporation.

2.1.3 Project Site Climate Station

In 1993, Hallam Knight Piésold Ltd. was retained by Pacific Sentinel Gold Corp. to undertake an environmental monitoring program for the Casino Project, which included both meteorology and hydrology monitoring programs. The field techniques followed during the program were presented in the report “Casino Project Baseline Environmental and Socioeconomic Studies” (HKPL, 1993). The data collection program involved the installation of a climate station near the Casino exploration camp, which measured both temperature and precipitation. This station

operated from 1993 to 1995. A new Project climate station was established at approximately the same location on October 3, 2008, and has been operational since that time. The active climate station is maintained by RWDI Air Inc. The location of the Project climate station in the upper Casino Creek sub-watershed is shown on Figure 2.3. The station elevation is approximately 1,200 m.

The climate station apparatus consists of a 10 m high, free-standing tower equipped with instrumentation, a datalogger and a logger enclosure (RWDI, 2012). The station records air temperature, rainfall, wind speed and direction, relative humidity, barometric pressure, and snow depth. The datalogger is equipped with a satellite modem and can be accessed remotely.

2.1.4 Project Site Snow Course

Yukon Environment has collected 33 years of snowpack data (1977-2011) at a snow course located near the Project site (snow course 09CD-SC01). The snow course is situated at an elevation of 1,065 m, and its location is shown on Figure 2.3. Snow depth and snow water-equivalent (SWE) are measured each year at the beginning of March, April, and May, followed by a measurement in mid-May.

2.2 TEMPERATURE

2.2.1 Region

Mean monthly temperature values for the long-term regional climate stations are presented on Table 2.2. These sites range in elevation from around 370 m to 650 m. Temperatures are warmest in July, with mean monthly temperatures ranging from 14 C to 16 C. Temperatures are coldest in January, with mean monthly temperatures ranging from -25 C to -28 C.

2.2.2 Project Site

2.2.2.1 Long-Term Synthetic Series Generation

The long-term temperature record at Pelly Ranch (2100880) was used as the basis for generating a long-term synthetic series of monthly temperature values at the Project site climate station. The Pelly Ranch record was missing nine months of temperature data between 2008 and 2011, so these were first estimated by regression analysis of monthly temperatures between Pelly Ranch and Dawson A, resulting in a 54-year infilled record available for modelling temperature at the Project site. Separate analyses were performed for each month in which estimated values were required at Pelly Ranch. Monthly temperatures were found to be well-correlated at Pelly Ranch and Dawson A, with coefficients of determination (R^2) values ranging from 0.91 to 0.97.

The concurrent temperature records from the Pelly Ranch and Project site climate stations were then correlated using a standard linear regression. The concurrent monthly temperature values for both stations used in the regression analysis are summarized in Table 2.3.

The concurrent monthly temperatures for the two stations were found to be strongly correlated in the warmer months (April through October), but more weakly correlated in the colder months (November through March). For April through October, the temperatures at the Project site were generally 1 C to 4 C cooler than Pelly Ranch, consistent with the higher elevation at the Project site. For November to March, the temperatures at the Project site were warmer compared to Pelly Ranch by an average of 5 C and up to 15 C. This is attributed to the settling of cold air in valleys during winter and the consequent temperature inversions that are often experienced between valley bottom sites (e.g. Pelly Ranch) and ridges (e.g. Project site) under such conditions. For the regression analysis, two relationships were developed, using a Pelly Ranch temperature threshold of -7 C to partition the data. For the warmer months with monthly temperatures above -7 C at Pelly Ranch (approximately April through October), the coefficient of determination (R^2) was 0.96. For the colder months with monthly temperatures below -7 C at Pelly Ranch (approximately November through March), the coefficient of determination (R^2) was 0.50. A 54-year synthetic series of monthly temperature values for the Project site climate station was generated by applying the two regression relationships to the Pelly Ranch monthly temperature record. For the period of record in which the Pelly Ranch data overlaps the Project site data, the actual measured data from the Project site were inserted into the temperature series for use in lieu of synthetic values.

2.2.2.2 Mean Annual and Monthly Temperature

The estimated long-term mean annual and monthly temperatures at the Project site climate station according to the synthetic temperature series are presented in Table 2.3. The mean annual temperature from the Project site temperature series is -2.9 C (round to -3 C). For comparison, the mean annual temperature recorded at the Project site climate station from 1993 to 2011 was -2.2 C. The mean July temperature at the Project site according to the synthetic temperature series is 11.6 C (round to 12 C), which is 2 C to 4 C cooler than the regional stations discussed in Section 2.2.1 and shown in Table 2.2. The mean January temperature at the Project site according to the synthetic temperature series is -16.8 C (-17 C), which is 8 C to 11 C warmer than the regional stations discussed in Section 2.2.1 and shown in Table 2.2.

2.2.2.3 Extreme Temperatures

The extreme maximum and minimum recorded temperatures at Pelly Ranch according to the 1971-2000 climate normals are 35 C and -60 C, respectively. According to the regression relationships described in Section 2.2.2.1, the corresponding maximum temperature at the Project climate station would be around 30 C. The corresponding minimum temperature at the Project station is more difficult to estimate due to the weaker correlation in winter temperatures, but it would be considerably warmer than -60 C.

The maximum and minimum temperatures recorded at the Project climate station between 2008 and 2011 are 26 C and -40 C, respectively. Based on the site data and the Pelly Ranch estimates, the estimated long-term extreme temperatures for the Project climate station are 30 C and -50 C.

2.3 PRECIPITATION

2.3.1 Region

Mean monthly and annual rainfall, snowfall and total precipitation values for the long-term regional climate stations are presented in Table 2.4. The mean monthly precipitation at all stations is greatest during the summer months of June through August, and lowest during the late winter months of February through April. Most of the precipitation falls in the form of snow during the months of November through March, and in the form of rain during the months of May through September. More snow than rain falls in the shoulder months of April and October, but mixed rain and snow conditions are common. The fraction of annual precipitation that falls in the form of rain/snow at these regional stations ranges from 56%/44% to 71%/29%.

2.3.2 Project Site

2.3.2.1 Long-Term Synthetic Series Generation

The long-term precipitation record at Pelly Ranch (2100880) was used as the basis for generating a long-term synthetic series of monthly precipitation at the Project site climate station. The Pelly Ranch record was missing nine months of precipitation data between 2008 and 2011, so these were first estimated by regression analysis of monthly precipitation between Pelly Ranch and two other stations: Dawson A and Mayo. Monthly precipitation at Pelly Ranch and the two other stations were not well-correlated, with coefficient of determination (R^2) values of 0.28 and 0.49 for Dawson A and Mayo, respectively. The missing monthly precipitation values at Pelly Ranch were estimated by taking the average of the values predicted by the Dawson A and Mayo regression relationships for each given month.

The concurrent precipitation records from the Pelly Ranch and Project site climate stations were correlated using a standard linear regression analysis. The rain gauge at the Project site climate station was not equipped to record snowfall, and rainfall measurements during the winter and shoulder months were likely affected from snow and ice interference. Therefore, only the Project site precipitation records for the months of May through September were considered in the regression analysis. It is assumed that any snow that fell during these months was captured in the rain gauge and recorded as the snow melted, so that the recorded rainfall in the months of May through September can be considered to represent total precipitation. The monthly precipitation values from Pelly Ranch and the Project site that were used in the regression analysis are summarized in Table 2.5.

The monthly precipitation at the two locations was found to be moderately well-correlated (R^2 = 0.63). A linear trendline forced through the origin had a slope of 1.66 (i.e. Project site precipitation exceeded Pelly Ranch precipitation by 66%). The elevation difference between Pelly Ranch (454 m elevation) and the Project site climate station (1,200 m elevation) is 746 m. If the difference in precipitation between the two climate stations were entirely attributable to orographic effects, then the corresponding orographic factor is 7% per 100 m elevation, which is close to the typical value for this region of 5% per 100 m. The 1.66 scaling factor was applied to the entire monthly precipitation record at Pelly Ranch to generate a long-term synthetic series of

monthly precipitation at the Project site climate station. In doing so, it was assumed that the observed precipitation ratio between the two sites in the months of May through September is also applicable to the winter months.

2.3.2.2 Mean Annual and Monthly Precipitation

The long-term estimated mean annual and monthly precipitation values at the Project site climate station according to the synthetic precipitation series are summarized in Table 2.5. The mean annual precipitation for the Project site based on the synthetic series is approximately 507 mm, of which 302 mm (60%) falls in the months of May through September. For comparison, the average precipitation for the months of May through September recorded at the Project site climate station from 1993 to 2011 was 329 mm. Mean monthly precipitation values at the Project site, according to the synthetic precipitation series, range from 17 mm in April to 91 mm in July.

The distribution of precipitation between rainfall and snowfall at the Project site was estimated by assuming that 100% of precipitation in the months of May through September falls as rain, 100% of precipitation in the months of November through March falls as snow, and 50% falls in each form in the shoulder months of April and October. The regional rainfall/snowfall distributions presented in Table 2.4 suggest that snowfall amounts may be greater than 50% in April and October, but it is expected that a significant portion of the snowfall in those months would melt relatively soon after falling so knowing the precise ratio of rainfall and snowfall in those months is not overly important. According to this distribution, 65% of annual precipitation falls as rain (329 mm) and 35% falls as snow (179 mm).

In order to reflect the uncertainty in the precipitation estimates, the recommended values for mean annual rainfall, snowfall, and total precipitation are 330 mm, 180 mm, and 510 mm, respectively.

2.3.2.3 Extreme 24-Hour Rainfall

The Rainfall Frequency Atlas of Canada (Hogg and Carr, 1985) provides a methodology for estimating the mean and standard deviations for the annual extreme 24-hour rainfall values. The resulting return period values were estimated using a Gumbel distribution. The results for the Project site climate station are presented in Table 2.6. The 24-hour rainfall depths range from 29 mm for a 2-year return period, to 56 mm for a 200-year return period.

For comparison, the maximum daily rainfall recorded at the Project site from 2009 to 2011 was 31.6 mm, which corresponds to a return period between 2 and 5 years according to the Rainfall Frequency Atlas. The maximum daily rainfall recorded at Pelly Ranch according to the 1971-2000 climate normals is 34.8 mm. Scaled by 1.66 to the Project site (according to the regression relationship for monthly precipitation), this would equate to 57 mm at the Project site, or close to a 200-year return period. Both of the above comparisons are taken to indicate that the extreme 24-hour rainfall estimates predicted by the Rainfall Frequency Atlas are reasonable.

2.4 WIND SPEED AND DIRECTION

Wind speed and direction are measured on-site at the Project climate station and data are available for the period from October 2008 through October 2011. A regional analysis to account for long-term variability in wind conditions was not deemed necessary.

The Project site wind speed data are presented in Table 2.7. The mean annual wind speed is 2.2 m/s (7.9 km/hr). The mean monthly wind speeds are higher in the spring, summer and autumn and lower in the winter. Monthly means range from 1.7 m/s in November and December, to 2.7 m/s in May. The maximum wind gust speed recorded between 2008 and 2011 was 11.1 m/s (RWDI, 2012). The predominant wind direction was southwesterly.

2.5 RELATIVE HUMIDITY

Relative humidity is measured on-site at the Project climate station and data are available for the period from October 2008 through October 2011. A regional analysis to account for long-term variability in humidity conditions was not deemed necessary.

The Project site relative humidity data are presented in Table 2.8. The mean annual relative humidity is 68%. Mean monthly relative humidity values are lowest in the spring (52% to 63% in the months of March through May) and higher throughout the rest of the year (67% to 76% in the months of June through February).

2.6 EVAPOTRANSPIRATION

In the 2010 hydrometeorology report (KPL, 2010), the Thornthwaite Equation was selected as the preferred method for estimating monthly and annual potential evapotranspiration (PET) at the Project site. The Thornthwaite equation (Thornthwaite, 1948) only requires mean monthly temperature as an input, as shown below. The equation assumes that PET is zero when the mean monthly temperature is below 0 C.

$$ET_0 = \begin{cases} 0, T < 0 \deg C \\ 16\left(\frac{10T_i}{I}\right)^a, 0 \le T \le 26.5 \deg C \\ -415.85 + 32.24T_i - 0.43T_i^2, T \ge 26.5 \deg C \end{cases}$$

Where:

PET_0 = Potential evapotranspiration (mm/month)
T_i = Mean monthly temperature (°C)
I = Heat index, sum of 12 monthly index values (i)
i = Monthly heat index
a = Empirically derived exponent, which is a function of I

And:

$$i = \left(\frac{T}{5}\right)^{1.514}$$

$$a = 6.75*10^{-7} I^3 - 7.71*10^{-5} I^2 + 1.79*10^{-2} I + 0.49$$

Monthly PET values based on measured temperatures at the Project site climate station, and long-term mean monthly PET values based on the synthetic temperature series for the Project site climate station, are presented in Table 2.9. Potential evapotranspiration values generally provide reasonable estimates of lake evaporation rates, and therefore the long-term values in Table 2.9 are assumed to be appropriate for estimating evaporation from lakes and ponds in the Project area.

The mean annual PET calculated for the period of site data collection is 321 mm. The estimated long-term mean annual PET is 304 mm. To reflect the uncertainties involved in estimating this value, the recommended value of mean annual PET at the Project site climate station is 300 mm.

2.7 SNOW ACCUMULATION AND MELT

The SWE measurements recorded at the Yukon Environment snow course 09CD-SC01 are presented in Table 2.10. The annual maximum SWE was typically recorded at the start of April or the start of May, with an approximately even distribution of occurrences between the two dates. The mean annual maximum SWE over the period of record is 141 mm. This value supports the estimated value of mean annual snowfall (180 mm) that was discussed in Section 2.3.2.2, since some of the snowfall is lost to sublimation or melt during the winter and early spring.

Monthly snowmelt in April and May was calculated from the SWE measurements by taking the difference of the values for April melt, and assuming that the entire snowpack was melted by the start of June. In years where the annual maximum SWE was recorded in May, the monthly melt for April was assumed to be zero. This method likely underestimates April snowmelt because it does not account for temporary snow accumulation and corresponding melt between the early April and early May measurement dates. Conversely, this method likely overestimates May snowmelt because the complete snowpack might not melt before the start of June in some years.

The estimated mean monthly snowmelt rates for April and May are 22 mm and 118 mm, respectively. These values represent 17% and 82%, respectively, of the annual melt after the date of maximum SWE accumulation.

The recommended, rounded value for mean annual maximum SWE is 140 mm. The recommended, rounded value for mean monthly snowmelt in May is 120 mm.

SECTION 3.0 - HYDROLOGY

3.1 REGIONAL STREAMFLOW ANALYSIS

The Water Survey of Canada (WSC) has operated nine streamflow gauging stations in the relative vicinity of the Project site (stations located within a 150 km radius and within the Dawson Range and Klondike Plateau) for varying periods over the past few decades. The locations of the regional WSC stations are presented on Figure 1.2.

All of the regional stations gauge flows from drainage areas much larger than the Project watersheds, and only five of the regional stations are currently active. Of the nine regional gauging stations, Big Creek has the smallest drainage area (1,750 km^2), and was deemed the most representative of the Project area streams. For this reason, Big Creek was selected as a regional surrogate for modelling streamflow at the Project area gauging stations. A more detailed rationale for the selection of the Big Creek gauging station is provided in KPL (2012).

A long-term synthetic flow series was developed for each Project station using a ranked regression modelling approach, which involved regressing ranked daily flows measured at the Project station against concurrent ranked daily flows from the WSC gauging station on Big Creek. The equations describing the regression trends were then applied to the 33-year streamflow record on Big Creek (1975-2010, excluding 1984, and 1994-1995), to produce synthetic daily flow series for the Project stations. A more detailed description of the regression analysis is provided in KPL (2012).

3.2 PROJECT AREA STREAMFLOW

3.2.1 Streamflow Measurement

Ten streamflow gauging stations have been operated in the Project area at various times since 2008. At present, nine streamflow gauging stations are considered to be in active operation, with one site deactivated in 2011 (W1) due to the development and natural destruction of a beaver dam, which interfered with the station's hydraulic control and caused the loss of the 2011 data. The locations of all active and discontinued stations are presented on Figure 3.1, and a simple schematic of the station network is provided on Figure 3.2. There are three stations in the Britannia Creek watershed (including the one deactivated station) and seven stations in the Dip Creek watershed. The latter can be further subdivided into four stations in the Casino Creek sub-watershed and three on the Dip Creek mainstem or the Victor Creek sub-watershed. The drainage areas at the Project gauging stations are provided in an inset table on Figure 3.1. Station W16, located on lower Dip Creek, has the largest drainage area of the Project gauging stations, at 384 km^2. Stations W18 and W11, located in the upper part of Casino Creek sub-watershed, have the smallest drainage areas, at 25 km^2 and 39 km^2, respectively.

An example measured streamflow hydrograph for the Lower Casino Creek gauging station (W4), including winter flow approximations and instantaneous discharge measurements, is shown on Figure 3.3. This hydrograph is indicative of the variable flows that occur in the Project area streams throughout the year, with multiple rain and snowmelt driven peak flow events throughout the spring, summer, and autumn, and low flows from late autumn through early spring.

3.2.2 Mean Monthly Discharge and Unit Runoff

The mean monthly and mean annual long-term synthetic flow estimates for the Project gauging stations are summarized in Table 3.1 (discharge) and Table 3.2 (unit runoff). The unit runoff results presented in Table 3.2 illustrate the following patterns:

- Mean annual unit runoff at the nine Project gauging stations ranges between 5.1 l/s/km^2 and 7.6 l/s/km^2, or 160 mm to 240 mm in annual runoff depth.
- The lowest unit runoff values (5.1 l/s/km^2 to 5.6 l/s/km^2) were estimated in the Britannia Creek watershed (stations W3 and W14), at the Lower Dip Creek station (W16), and in Upper Casino Creek (W11). The low unit runoff at the latter station is thought to be affected by surface flow losses to ground in the vicinity of the gauging station.
- Mean annual unit runoff at the gauging stations other than W11 in the Casino Creek sub-basin (W4, H18, and W18) range from 5.8 l/s/km^2 to 6.5 l/s/km^2, or 180 mm to 200 mm in annual runoff depth.
- Maximum monthly unit runoff occurs in May, corresponding with the month of maximum snowmelt, with mean values ranging between 13 l/s/km^2 and 29 l/s/km^2.
- In the Casino Creek sub-basin (other than station W11), mean May unit runoff ranges from 17 l/s/km^2 to 19 l/s/km^2.
- Mean monthly unit runoff at all stations is estimated to reach a minimum of 0.1 l/s/km^2 in the months of March and April.

At the Lower Casino Creek gauging station (W4), the key streamflow and unit runoff values are as follows:

- Drainage area: 82 km^2.
- Mean annual discharge: 0.48 m^3/s.
- Mean annual runoff: 5.8 l/s/km^2 or 183 mm/yr.
- Mean monthly discharge for May: 1.37 m^3/s.
- Mean monthly unit runoff for May: 16.7 l/s/km^2 or 45 mm/mo.

3.2.3 Peak Flows

Return period peak flows were calculated based on frequency analysis of the 33-year synthetic flow series for each station. These results were compared against an alternate set of peak flow estimates generated using a regional method (Janowicz, 1989). In general, the peak flow estimates generated by statistical analysis of the synthetic flow series exceeded the regional estimates based on Janowicz (1989). The latter are based on streamflow records from larger watersheds, which might not scale accurately to smaller watersheds with more flashy runoff response. A more detailed description of the peak flow analysis methodology and comparison of results are provided in KPL (2012).

The peak flows generated by statistical analysis of the synthetic series are recommended for adoption for Project design, with the inclusion of a 15% safety factor to account for potentially greater weather extremes and permafrost activity due to climate change. The recommended peak values for each station are presented in Table 3.3.

The highest peak flows per unit area were estimated for the Dip Creek and Victor Creek stations (W9, W16, R2), where the 200-year peak flow values equate to peak unit runoff values of 0.8 to 1.2 $m^3/s/km^2$. The 200-year peak flow values in the Britannia Creek watershed and Casino Creek sub-watershed equate to peak unit runoff values of 0.5 to 0.9 $m^3/s/km^2$.

These peak flow values contain considerable uncertainty due to the extent of rating curve extrapolation required to estimate high flows at the Project gauging stations, and uncertainties in the modelling of extreme flows based on the Big Creek record.

3.2.4 Low Flows

Janowicz (1990) provides a methodology for estimating 10-year 7-day low flows in Yukon Territory, based largely on streamflow records from larger rivers than are found in the Project area. Based on this regional methodology, non-zero flows are predicted in the Project area streams. However, site observations in late winter 2010 found that flows were zero or closely approached zero at all locations in the Project area. On this basis, the 10-year, 7-day low flow at all sites in the Project area is assumed to be zero.

3.2.5 Dry and Wet Monthly Flows

The variability of monthly flows at each Project station was characterized by calculating monthly average flows for a 10-year wet and 10-year dry return period. These monthly average flows were calculated based on the long-term synthetic flow series for each station using the Palisade Decision Tools @RISK statistical software.

For each month at each Project streamflow station, a statistical distribution was fit to the 33 monthly flow values in the synthetic flow series. The 10th and 90th percentile values of the distribution represent the 10-year dry and 10-year wet monthly flows, respectively. The results are presented in Table 3.4 (10-year dry) and Table 3.5 (10-year wet).

In May, the month with greatest mean monthly discharge, the 10-year dry and wet monthly discharge values at gauging station W4 (Lower Casino Creek) are 0.37 m^3/s and 3.01 m^3/s, respectively. They equate to 27% and 220% of the mean monthly discharge for May (1.37 m^3/s).

SECTION 4.0 - WATER BALANCE MODELLING INPUTS

4.1 GENERAL

This section defines additional hydrometeorological parameters required for engineering design and water balance modelling. These parameters help to quantify climatic variability, orographic effects and runoff coefficients for the Project area.

4.2 TEMPERATURE

The standard adiabatic lapse rate for temperature is -0.6 C per 100 m of elevation increase. This lapse rate can be applied to estimate temperatures in the Project area during the spring, summer, and autumn months. In the winter, temperature inversions are the norm, so temperature increases with elevation, but the relationship between elevation and temperature is not well-defined.

4.3 PRECIPITATION

4.3.1 Orographic Effect

The estimated orographic factor for precipitation is 5% per 100 m of elevation increase. This value is based on experience in assessing orographic factor elsewhere in Yukon Territory and British Columbia, and is in general agreement with the equivalent factor of 7% per 100 m between Pelly Ranch and the Project site.

4.3.2 Coefficient of Variation

The year-to-year variability of monthly precipitation in the Project area is quantified by coefficient of variation (Cv) values derived from regional data. The Cv represents the standard deviation normalized by mean. Cv values are typically required as input for stochastic water balance modelling. Monthly Cv values for precipitation in the Casino Creek Project area were estimated as the average monthly values of historical precipitation records for Beaver Creek A, Dawson A and Pelly Ranch. The estimated Cv values are summarised in Table 4.1.

4.4 EFFECTIVE RUNOFF COEFFICIENT

An effective runoff coefficient was estimated for the streamflow gauging station on Lower Casino Creek (W4). The Casino Creek sub-watershed contains no glaciers and therefore there is expected to be a reasonably direct relationship between annual precipitation and unit runoff. The effective runoff coefficient accounts for losses due to sublimation and evapotranspiration.

The effective runoff coefficient of 0.39 was calculated as the ratio of the mean annual unit runoff (183 mm) and mean annual precipitation at the mean elevation of the W4 drainage basin (475 mm). The recommended effective runoff coefficient is rounded to 0.4.

In May, the month with maximum snowmelt and streamflow, the calculated runoff coefficient is only 0.29. This is based on mean monthly snowmelt of 118 mm (no adjustment from snow course at 1,100 m elevation), mean monthly precipitation of 35 mm (adjusted from 37 mm at climate station), and mean monthly unit runoff of 45 mm at gauging station W4. The lower runoff coefficient in May might be related to springtime groundwater recharge, but also reflects uncertainties in the estimation of monthly snowmelt. It is recommended to use the rounded runoff coefficient of 0.4 in all months of the year.

SECTION 5.0 - CONCLUSIONS

The recommend values for key climatic parameters, referenced to the Project site climate station at 1,200 m elevation, are presented below:

CLIMATIC PARAMETERS (1,200 M ELEVATION)	VALUE
Mean Annual Temperature	-3 C
Mean January Temperature	-17 C
Mean July Temperature	12 C
Extreme Minimum Temperature	-50 C
Extreme Maximum Temperature	30 C
Mean Annual Precipitation	510 mm
Mean Annual Rainfall	330 mm
Mean Annual Snowfall (Water-Equivalent)	180 mm
Mean Annual Rainfall/Snowfall Distribution	65% / 35%
2-Year 24-Hr Rainfall	29 mm
200-Year 24-Hr Rainfall	56 mm
Mean Annual Wind Speed	2.2 m/s
Maximum Wind Gust Speed	11.1 m/s
Prevailing Wind Direction	Southwesterly
Mean Annual Relative Humidity	68%
Mean Annual Potential Evapotranspiration	300 mm
Mean Annual Maximum Snow Water-Equivalent	140 mm
Mean Monthly Snowmelt for May (Water-Equivalent)	120 mm

Temperature and precipitation can be adjusted to reflect conditions at different elevations according to the following guidelines:

CLIMATIC PARAMETER ELEVATION ADJUSTMENTS	VALUE
Mean Monthly Temperature (April through October)	-0.6 C per 100 m
Mean Monthly Temperature (November through March)	Increases with elevation
Mean Annual Precipitation	+5% per 100 m

The streamflow and unit runoff results for gauging station W4 on Lower Casino Creek are presented below:

HYDROLOGIC PARAMETERS (LOWER CASINO CREEK (W4), DRAINAGE AREA 82 KM^2)	VALUE
Mean Annual Discharge	0.48 m^3/s
Mean Annual Unit Runoff	5.8 $l/s/km^2$
Mean Annual Runoff (Depth Equivalent)	180 mm/yr
Mean Monthly Discharge for May	1.37 m^3/s
Mean Monthly Unit Runoff for May	16.7 $l/s/km^2$
Mean Monthly Unit Runoff for May (Depth Equivalent)	45 mm/mo.
Natural Catchment Runoff Coefficient	0.4
2-Year Instantaneous Peak Flow	12 m^3/s
200-Year Instantaneous Peak Flow	40 m^3/s
10-Year, 7-Day Low Flow	0 m^3/s
10-Year Dry Monthly Flow	0.37 m^3/s
10-Year Wet Monthly Flow	3.01 m^3/s

Potential climate change effects have not been considered explicitly in any of the hydrometeorological estimates presented above, except for peak flows. Appropriate allowances for potential climate change effects should be made where necessary.

SECTION 6.0 - REFERENCES

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SECTION 7.0 - CERTIFICATION

This report was prepared, reviewed and approved by the undersigned.



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TABLE 2.1

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

REGIONAL MSC CLIMATE STATIONS

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MSC Station Name	Station ID.	Years of Record	Complete Years of Record	Start Year	End Year	Latitude	Longitude	Elevation (m)	Mean Annual Temperature (C)	Mean Annual Precipitation (mm)
Mayo A	2100700	87	81	1925	2011	63° 37'	135° 52'	504	-3.2	303
Pelly Ranch	2100880	60	51	1951	2011	62° 49'	137° 22'	454	-3.8	304
Carmacks	2100300	45	33	1963	2007	62° 06'	136° 18'	525	-2.8	287
Beaver Creek A	2100160	41	29	1968	2011	62° 24'	140° 52'	649	-5.4	417
Dawson A	2100402	36	27	1976	2011	64° 02'	139° 07'	370	-4.1	324
McQuesten	2100719	26	22	1986	2011	63° 36'	137° 31'	457	-3.3	343
Snag A	2101000	24	22	1943	1966	62° 02'	140° 24'	587	-5.8	371
Casino Creek	2100310	7	0	1969	1995	62° 43'	138° 49'	1100	-4.4	399

M:\1\01\00325\08\A\Data\Task 1100 - Hydrometeorology\[MSC_WSC_stations.xls]MSC stations

NOTES:

1. DATA OBTAINED FROM THE METEOROLOGICAL SERVICES OF CANADA BRANCH (MSC) OF ENVIRONMENT CANADA.
2. STATIONS WITH LESS THAN FIVE COMPLETE YEARS OF RECORD NOT INCLUDED WITH THE EXCEPTION OF CASINO CREEK.
3. ONLY ONE STATION WAS SELECTED WHERE CLUSTERS OF STATIONS EXIST, SUCH AS DAWSON.
4. MEAN ANNUAL TEMPERATURE AND PRECIPITATION VALUES BASED ON RECORDS TO 2007.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	27JUN'12	ISSUED WITH REPORT VA101-325/8-11	TR	CJN	KJB

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TABLE 2.2

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

MEAN MONTHLY TEMPERATURES AT REGIONAL CLIMATE STATIONS

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MSC Station Name	Station ID.	Period of Record	Complete Years of Record	Temperature (°C)												
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mayo A	2100700	1925-2011	79	-25.4	-19.5	-10.7	-0.1	8.1	13.7	15.3	12.5	6.4	-2.2	-15.3	-22.3	-3.2
Pelly Ranch	2100880	1951-2011	52	-27.3	-20.5	-11.7	0.2	7.9	13.5	15.3	12.6	6.6	-2.5	-15.9	-24.4	-3.8
Carmacks	2100300	1963-2007	31	-25.4	-17.9	-10.1	0.5	7.6	13.5	15.3	12.9	6.8	-1.8	13.9	-22.0	-3.0
Beaver Creek A	2100160	1968-2011	29	-27.0	-20.8	-12.7	-1.8	6.3	12.0	13.8	11.1	4.5	-6.2	-19.1	-24.8	-5.4
Dawson A	2100402	1976-2011	26	-26.1	-21.9	-12.4	0.0	8.3	13.9	15.7	12.5	6.0	-4.4	-17.4	-23.9	-4.1
McQuesten	2100719	1986-2011	22	-24.9	-18.8	-11.1	0.9	8.3	13.7	15.2	12.2	5.8	-3.4	-16.4	-21.3	-3.3
Snag A	2101000	1943-1966	22	-28.1	-22.3	-13.9	-2.9	6.5	12.0	13.9	11.2	5.1	-5.4	-18.9	-27.3	-5.8
Casino Creek	2100310	1969-1995	0	-17.2	-16.7	-12.3	-6.8	2.5	9.6	11.8	9.4	3.2	-5.6	-15.4	-14.8	-4.4

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NOTES:

1. DATA OBTAINED FROM THE METEOROLOGICAL SERVICES OF CANADA BRANCH (MSC) OF ENVIRONMENT CANADA.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	27JUN'12	ISSUED WITH REPORT VA101-325/8-11	TR	CJN	KJB

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TABLE 2.3

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

MONTHLY TEMPERATURE DATA USED FOR REGRESSION ANALYSIS

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Climate Station	Elevation (m)	Temperature (°C)													
		Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Pelly Ranch	454	1993	-	-	-	2.2	9.4	13.9	16.0	12.9	6.6	0.6	-14.3	-18.2	
		1994	-27.4	-27.4	-7.8	3.3	8.3	13.5	16.5	15.9	6.1	-1.4	-18.9	-26.6	**-3.8**
		1995	-23.3	-	-	-	-	-	-	-	-	-	-	-	
		2008	-	-	-	-	-	-	-	-	-	-2.5	1.7	-27.4	
		2009	-25.7	-22.4	-12.9	0.2	9.0	15.0	17.2	13.3	8.1	-0.3	-12.8	-18.7	**-2.5**
		2010	-20.8	-13.3	-5.1	3.5	10.0	14.1	15.2	0.8	1.4	1.4	1.7	2.3	**0.9**
		2011	-	-	-	1.2	9.9	14.0	15.6	12.9	8.1	-	-	-	
		Average	**-24.3**	**-21.0**	**-8.6**	**2.1**	**9.3**	**14.1**	**16.1**	**11.2**	**6.1**	**-0.4**	**-8.5**	**-17.7**	**-1.8**
Casino Project Site	1200	1993	-	-	-	1.7	7.7	10.6	12.4	9.8	4.7	-2.3	-10.3	-13.2	
		1994	-21.3	-22.1	-6.7	1.8	5.8	10.3	13.5	13.8	4.1	-2.8	-16.8	-11.7	**-2.7**
		1995	-11.0	-	-	-	-	-	-	-	-	-	-	-	
		2008	-	-	-	-	-	-	-	-	-	-6.7	-10.2	-16.2	
		2009	-18.4	-15.0	-14.2	-2.8	6.0	10.4	14.0	9.4	5.6	-2.8	-13.5	-11.2	**-2.7**
		2010	-13.6	-7.5	-7.7	-0.7	7.2	9.0	11.3	10.6	3.7	-3.4	-8.9	-17.7	**-1.5**
		2011	-	-	-	-2.8	6.0	8.7	10.5	8.1	4.9	-	-	-	
		Average	**-16.1**	**-14.9**	**-9.5**	**-0.6**	**6.5**	**9.8**	**12.3**	**10.3**	**4.6**	**-3.6**	**-12.0**	**-14.0**	**-2.2**
		Long-term est.	**-16.8**	**-14.0**	**-10.2**	**-1.9**	**5.0**	**10.0**	**11.6**	**9.2**	**3.8**	**-4.5**	**-12.1**	**-15.3**	**-2.9**

M:\1\01\00325\08\A\Data\Task 1100 - Hydrometeorology\[Temperature_2011.xls]Table 2.3

NOTES:

1. THE LONG-TERM TEMPERATURE VALUES WERE ESTIMATED BASED ON A REGRESSION ANALYSIS WITH CONCURRENT CASINO AND PELLY RANCH DATA.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	27JUN'12	ISSUED WITH REPORT VA101-325/8-11	TR	CJN	KJB

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TABLE 2.4

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

MEAN MONTHLY PRECIPITATION AT REGIONAL CLIMATE STATIONS

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MSC Station Name	Station ID.	Period of Record	Elevation (m)	Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Beaver Creek	2100160	1969 - 2005	649	rain (mm)	0.0	0.0	0.0	1.2	30.2	73.0	102.3	57.5	27.5	2.9	0.0	0.0	294.7
				% annual precip.	0.0%	0.0%	0.0%	0.3%	7.2%	17.5%	24.5%	13.8%	6.6%	0.7%	0.0%	0.0%	70.6%
				snow (mm)	14.1	11.1	11.7	11.9	5.9	0.1	0.0	1.2	9.7	25.0	18.5	13.4	122.6
				% annual precip.	3.4%	2.7%	2.8%	2.9%	1.4%	0.0%	0.0%	0.3%	2.3%	6.0%	4.4%	3.2%	29.4%
				precip.(mm)	14.1	11.1	11.7	13.1	36.2	73.1	102.3	58.7	37.2	27.9	18.5	13.4	417.2
				% annual precip.	3.4%	2.7%	2.8%	3.1%	8.7%	17.5%	24.5%	14.1%	8.9%	6.7%	4.4%	3.2%	100.0%
Snag A	2101000	1944 - 1965	587	rain (mm)	0.1	0.0	0.2	2.1	24.1	56.0	74.9	48.1	22.5	1.8	0.3	0.0	230.2
				% annual precip.	0.0%	0.0%	0.1%	0.6%	6.5%	15.1%	20.1%	12.9%	6.0%	0.5%	0.1%	0.0%	61.9%
				snow (mm)	21.7	16.2	15.8	13.2	6.1	0.7	0.0	0.3	5.8	18.6	21.9	21.8	141.9
				% annual precip.	5.8%	4.4%	4.2%	3.5%	1.6%	0.2%	0.0%	0.1%	1.6%	5.0%	5.9%	5.9%	38.1%
				precip.(mm)	21.7	16.2	16.0	15.3	30.2	56.7	74.9	48.4	28.3	20.3	22.2	21.8	372.0
				% annual precip.	5.8%	4.4%	4.3%	4.1%	8.1%	15.2%	20.1%	13.0%	7.6%	5.5%	6.0%	5.9%	100.0%
Pelly Ranch	2100880	1955 - 2006	454	rain (mm)	0.0	0.0	0.2	3.6	23.2	37.0	54.9	38.5	26.2	7.3	0.4	0.0	191.2
				% annual precip.	0.0%	0.0%	0.1%	1.2%	7.6%	12.1%	17.9%	12.6%	8.6%	2.4%	0.1%	0.0%	62.5%
				snow (mm)	19.8	14.7	11.3	6.6	0.5	0.0	0.0	0.0	2.3	15.1	24.4	19.9	114.6
				% annual precip.	6.5%	4.8%	3.7%	2.2%	0.2%	0.0%	0.0%	0.0%	0.7%	4.9%	8.0%	6.5%	37.5%
				precip.(mm)	19.8	14.7	11.5	10.2	23.7	37.0	54.9	38.5	28.5	22.4	24.9	19.9	305.9
				% annual precip.	5.3%	4.0%	3.1%	2.7%	6.4%	9.9%	14.8%	10.3%	7.7%	6.0%	6.7%	5.4%	100.0%
Dawson A	2100402	1977 - 2005	370	rain (mm)	0.0	0.0	0.3	2.2	25.9	40.4	50.6	41.6	32.9	8.9	0.1	0.4	203.3
				% annual precip.	0.0%	0.0%	0.1%	0.6%	7.1%	11.1%	13.9%	11.5%	9.0%	2.4%	0.0%	0.1%	56.0%
				snow (mm)	25.3	17.6	12.8	7.0	2.3	0.0	0.0	0.4	3.9	25.9	35.7	28.8	159.7
				% annual precip.	7.0%	4.9%	3.5%	1.9%	0.6%	0.0%	0.0%	0.1%	1.1%	7.1%	9.8%	7.9%	44.0%
				precip.(mm)	25.3	17.7	13.1	9.2	28.2	40.4	50.6	42.0	36.8	34.7	35.8	29.2	363.0
				% annual precip.	7.0%	4.9%	3.6%	2.5%	7.8%	11.1%	13.9%	11.6%	10.1%	9.6%	9.9%	8.0%	100.0%

M:\1\01\00325\08\A\Data\Task 1100 - Hydrometeorology\[Precip_2011.xls]Table 2.4

NOTES:

1. ONLY COMPLETE YEARS OF RECORD UP TO 2006 WERE USED.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	27JUN'12	ISSUED WITH REPORT VA101-325/8-11	TR	CJN	KJB

Knight Piésold CONSULTING

TABLE 2.5

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

MONTHLY PRECIPITATION DATA USED FOR REGRESSION ANALYSIS

Print Jul/09/12 14:28

Climate Station	Elevation (m)	Measured Precipitation (mm)												
		Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Pelly Ranch	454	1993	24.9	6.8	34.4	8.8	18.4	16.8	61.9	40.0	20.8	28.1	34.8	7.0	**303**
		1994	24.6	4.8	15.9	7.7	37.8	53.6	36.2	8.6	21.6	27.4	27.4	3.6	**269**
		2007	19.3	7.4	30.1	12.0	3.0	36.8	50.7	24.8	57.7	23.9	18.8	32.0	**317**
		2008	22.0	8.9	1.9	19.0	14.4	23.1	68.2	105.4	32.2	23.0	19.6	16.3	**354**
		2009	34.6	16.6	24.1	13.2	12.6	22.4	11.2	100.4	18.8	20.4	26.6	12.9	**314**
		2010	18.5	2.4	7.0	4.0	9.6	37.4	89.0	38.4	10.9	14.8	14.1	7.8	**254**
		2011	11.8	26.4	2.5	4.4	21.6	98.7	102.0	54.0	14.2	12.3	56.7	25.8	**430**
		Average	**22.2**	**10.5**	**16.6**	**9.9**	**16.8**	**41.3**	**59.9**	**53.1**	**25.2**	**21.4**	**28.3**	**15.0**	**320**
Casino Project Site	1200	1993					62.8	73.7	131.9	43.2	31.6				
		1994					38.0	46.0	96.2	37.8	10.6				
		2007					-	-	-	-	-				
		2008					-	-	-	-	-				
		2009					19.7	96.8	31.3	90.9	27.2				
		2010					21.3	92.6	147.1	-	-				
		2011					21.1	169.6	161.2	98.2	9.2				
		Average					**32.6**	**95.7**	**113.5**	**67.5**	**19.7**				
		Long-term est.	**32.4**	**24.3**	**18.9**	**16.7**	**36.6**	**61.8**	**90.5**	**66.6**	**46.9**	**37.5**	**42.4**	**32.7**	**507**
		Long-term rounded													
		Rainfall est.	**0**	**0**	**0**	**8**	**37**	**62**	**91**	**67**	**47**	**18**	**0**	**0**	**330**
		Snowfall est.	**32**	**24**	**19**	**9**	**0**	**0**	**0**	**0**	**0**	**20**	**43**	**33**	**180**
		Total est.	**32**	**24**	**19**	**17**	**37**	**62**	**91**	**67**	**47**	**38**	**43**	**33**	**510**

M:\1\01\00325\08\A\Data\Task 1100 - Hydrometeorology\[Precip_2011.xls]Table 2.5

NOTES:

1. THE CASINO SITE METEOROLOGICAL STATION, BOTH HISTORICALLY AND PRESENTLY, WAS ASSUMED TO COLLECT ONLY RAINFALL DATA DUE TO THE INSTRUMENT SET-UP, THEREFORE THE PRECIPITATION DATA COLLECTED IN THE MONTHS OF OCTOBER TO APRIL IS PRESENTED FOR INFORMATION PURPOSES ONLY BUT WAS NOT USED IN THE ANALYSIS OF MEAN ANNUAL PRECIPITATION FOR THE SITE.
2. IT WAS ASSUMED THAT PRECIPITATION COLLECTED DURING MAY TO SEPTEMBER FELL AS RAIN, SINCE THE AVERAGE MONTHLY TEMPERATURES DURING THESE MONTHS WAS ABOVE ZERO.
3. THE LONG-TERM PRECIPITATION VALUES WERE ESTIMATED BASED ON A REGRESSION ANALYSIS OF CONCURRENT CASINO AND PELLY RANCH DATA.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	27JUN'12	ISSUED WITH REPORT VA101-325/8-11	TR	CJN	CJN

Knight Piésold CONSULTING

TABLE 2.6

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

EXTREME 24-HOUR RAINFALL DEPTH AT THE PROJECT SITE CLIMATE STATION

Print Jul/09/12 14:39

Climate Station	Elevation (m)	Return Period (years)	24-Hr Rainfall (mm)
Casino Project Site	1200	2	29
		5	35
		10	39
		15	42
		20	43
		25	45
		50	49
		100	53
		200	56

M:\1\01\00325\08\A\Data\Task 1100 - Hydrometeorology\[Snowpack & IDF.xlsx]Table 2.6

NOTES:

1. 24-HOUR RAINFALL DEPTHS ESTIMATED ACCORDING TO THE RAINFALL FREQUENCY ATLAS OF CANADA (HOGG AND CARR, 1985).

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	22JUN'12	ISSUED WITH REPORT VA101-325/8-11	CJN	EER	KJB

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TABLE 2.7

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

MONTHLY WIND SPEED AT THE PROJECT SITE CLIMATE STATION

Print Jul/09/12 14:44

Climate Station	Elevation (m)	Wind Speed (m/s)													
		Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Casino Project Site	1200	2008											1.8	1.5	
		2009	2.0	2.0	2.9	2.2	2.5	2.7	2.5	2.4	2.2	2.3	1.6	1.5	**2.2**
		2010	1.7	1.8	3.0	2.8	2.6	2.5	2.4	2.2	2.4	2.4	1.7	2.1	**2.3**
		2011			2.0	2.7	2.9	2.4	2.2	2.3	2.5	1.9			
		Average	1.8	1.9	2.6	2.6	2.7	2.5	2.4	2.3	2.4	2.2	1.7	1.7	**2.2**

M:\1\01\00325\08\A\Data\Task 1100 - Hydrometeorology\[Summary tables.xlsx]Table 2.7

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	27JUN'12	ISSUED WITH REPORT VA101-325/8-11	TR	CJN	KJB

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TABLE 2.8

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

MONTHLY RELATIVE HUMIDITY AT THE PROJECT SITE CLIMATE STATION

Print Jul/09/12 14:41

Climate Station	Elevation (m)	Relative Humidity (%)													
		Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Casino Project Site	1200	2008											71	69	
		2009	72	67	71	56	51	62	53	75	71	80	78	70	**67**
		2010	77	67	64	57	49	71	72	71	71	76	79	79	**69**
		2011			55	62	56	77	77	75	64	53			
		Average	74	67	63	59	52	70	67	74	68	70	76	72	**68**

M:\1\01\00325\08\A\Data\Task 1100 - Hydrometeorology\[Summary tables.xlsx]Table 2.8

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	27JUN'12	ISSUED WITH REPORT VA101-325/8-11	TR	CJN	KJB

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TABLE 2.9

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

MONTHLY POTENTIAL EVAPOTRANSPIRATION AT THE PROJECT SITE CLIMATE STATION

Print Jul/09/12 14:46

Climate Station	Elevation (m)	Method	Year	Evapotranspiration (mm)												
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Casino Project Site	1200	Thornthwaite Equation	1993	0	0	0	20	57	71	80	67	40	0	0	0	335
			1994	0	0	0	19	44	68	83	84	35	0	0	0	332
			1995	0	0	0	20	53	76	78	63	53	0	0	0	343
			2008	0	0	0	0	53	74	74	67	39	0	0	0	307
			2009	0	0	0	0	48	70	87	65	45	0	0	0	316
			2010	0	0	0	0	57	66	77	74	36	0	0	0	310
			2011	0	0	0	0	53	68	76	64	46	0	0	0	308
			Measurement Period Average	0	0	0	8	52	71	79	69	42	0	0	0	321
			Long-term Est.	**0**	**0**	**0**	**2**	**45**	**72**	**80**	**68**	**37**	**0**	**0**	**0**	**304**

M:\1\01\00325\12\A\Data\Task 310 - Hydrology\Watershed Model\Climate Inputs\[PET_20120622.xls]Table 2.9

NOTES:

1. POTENTIAL EVAPOTRANSPIRATION VALUES WERE CALCULATED BASED THE THORNTHWAITE EQUATION AND USING THE SYNTHETIC TEMPERATURE SERIES FOR THE PROJECT CLIMATE STATION. THE SYNTHETIC SERIES CONTAINS MEASURED DATA WITHIN THE MEASUREMENT PERIOD.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	22JUN'12	ISSUED WITH REPORT VA101-325/8-11	CJN	EER	JGC

Knight Piésold CONSULTING

TABLE 2.10

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

MONTHLY SNOWPACK AND SNOWMELT AT THE CASINO CREEK SNOW COURSE

Print Jul/09/12 14:38

Snow Course	Elevation (m)	Year	Annual Maximum SWE (mm)	Monthly Snow Melt (mm)		Monthly Snow Melt (%)	
				April	May	April	May
Casino Creek (09CD-SC01)	1065	1977	125	0	125	0%	100%
		1978	98	12	86	12%	88%
		1979	170	25	145	15%	85%
		1980	95	0	95	0%	100%
		1981	88	0	88	0%	100%
		1982	173	0	173	0%	100%
		1983	120	40	80	33%	67%
		1984	139	0	139	0%	100%
		1985	180	0	180	0%	100%
		1986	168	0	168	0%	100%
		1987	117	0	117	0%	100%
		1988	99	45	54	45%	55%
		1989	136	56	80	41%	59%
		1990	144	44	100	31%	69%
		1991	225	58	167	26%	74%
		1992	207	0	207	0%	100%
		1993	190	0	190	0%	100%
		1994	110	54	56	49%	51%
		1995	104	0	104	0%	100%
		1996	118	8	110	7%	93%
		1997	149	55	94	37%	63%
		1998	88	88	0	100%	0%
		1999	126	0	126	0%	100%
		2000	158	9	149	6%	94%
		2001	147	0	147	0%	100%
		2002	118	0	118	0%	100%
		2003	90	21	60	23%	67%
		2004	152	0	152	0%	100%
		2005	199	106	93	53%	47%
		2006	134	13	121	10%	90%
		2007	124	0	124	0%	100%
		2008	122	111	0	91%	0%
		2009	208	0	208	0%	100%
		2010	128	22	106	17%	83%
		2011	182	0	182	0%	100%
		Mean	**141**	**22**	**118**	**17%**	**82%**

M:\1\01\00325\08\A\Data\Task 1100 - Hydrometeorology\[Snowpack & IDF.xlsx]Table 2.10

NOTES:

1. THE CASINO CREEK SNOW COURSE IS OPERATED BY YUKON ENVIRONMENT.
2. SWE = SNOW WATER-EQUIVALENT.
3. MONTHLY SNOWMELT WAS ESTIMATED BY SUBTRACTION OF CONSECUTIVE SWE MEASUREMENTS. MELT WAS ASSUMED TO BE ZERO IN CASES WHERE SWE INCREASED IN THE LATTER MEASUREMENT.
4. THE SNOWMELT ESTIMATES ASSUME THAT 100% OF SNOW MELTS BY THE END OF MAY, WHICH IS LIKELY NOT VALID IN ALL YEARS, ESPECIALLY IN THOSE YEARS WHERE MAXIMUM SWE OCCURRED IN MID-MAY.
5. MONTHLY SNOWMELT (%) REFERS TO THE FRACTION OF ANNUAL MAXIMUM SWE THAT MELTED IN A GIVEN MONTH.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	22JUN'12	ISSUED WITH REPORT VA101-325/8-11	CJN	EER	JGC

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CONSULTING

TABLE 3.1

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

LONG-TERM MEAN MONTHLY AND ANNUAL DISCHARGE AT PROJECT STREAMFLOW STATIONS

Print Jul/09/12 15:02:04

Station	Drainage Area (km^2)	Mean Monthly Discharge (m^3/s)												
		January	February	March	April	May	June	July	August	September	October	November	December	**Mean Annual**
Britannia Creek (W14)	45	0.01	0.00	0.00	0.05	0.72	0.51	0.50	0.41	0.30	0.18	0.04	0.02	**0.23**
Canadian Creek (W3)	64	0.01	0.01	0.01	0.07	1.03	0.72	0.71	0.59	0.43	0.25	0.05	0.02	**0.33**
Lower Dip Creek (W16)	384	0.07	0.04	0.04	0.43	6.82	4.03	4.38	3.56	3.75	2.11	0.31	0.14	**2.16**
Upper Dip Creek (W9)	194	0.03	0.02	0.02	0.22	3.92	2.05	2.74	2.24	1.82	1.04	0.16	0.07	**1.20**
Victor Creek (R2)	85	0.01	0.01	0.01	0.10	2.45	1.44	1.24	1.08	0.76	0.44	0.07	0.03	**0.64**
Lower Casino Creek (W4)	82	0.01	0.01	0.01	0.09	1.37	0.79	1.02	0.95	0.84	0.47	0.07	0.03	**0.48**
Middle Casino Creek (H18)	67	0.01	0.01	0.01	0.08	1.22	0.71	0.80	0.86	0.69	0.39	0.05	0.02	**0.41**
Upper Casino Creek (W11)	39	0.01	0.00	0.00	0.04	0.51	0.31	0.44	0.41	0.37	0.23	0.03	0.01	**0.20**
Brynelsen Creek (W18)	25	0.00	0.00	0.00	0.03	0.47	0.31	0.28	0.35	0.28	0.19	0.02	0.01	**0.16**

M:\1\01\00325\06\A\Data\Hydrology\2 - Baseline Report Data\[LT Mean Monthly Unit Runoff.xlsx]Table 3.1 Mean Discharge

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	26JUN'12	ISSUED WITH REPORT VA101-325/8-11	DK	KT	JGC

Knight Piésold
CONSULTING

TABLE 3.2

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

LONG-TERM MEAN MONTHLY AND ANNUAL UNIT RUNOFF AT PROJECT STREAMFLOW STATIONS

Print Jul/09/12 15:02:04

Station	Drainage Area (km^2)	Mean Monthly Unit Runoff ($l/s/km^2$)												
		January	February	March	April	May	June	July	August	September	October	November	December	**Mean Annual**
Britannia Creek (W14)	45	0.2	0.1	0.1	1.1	16.0	11.2	11.1	9.2	6.7	3.9	0.8	0.4	**5.1**
Canadian Creek (W3)	64	0.2	0.1	0.1	1.1	16.0	11.2	11.1	9.2	6.7	3.9	0.8	0.4	**5.1**
Lower Dip Creek (W16)	384	0.2	0.1	0.1	1.1	17.8	10.5	11.4	9.3	9.8	5.5	0.8	0.4	**5.6**
Upper Dip Creek (W9)	194	0.2	0.1	0.1	1.1	20.2	10.6	14.1	11.5	9.4	5.3	0.8	0.4	**6.2**
Victor Creek (R2)	85	0.2	0.1	0.1	1.1	29.0	17.0	14.6	12.8	9.0	5.2	0.8	0.4	**7.6**
Lower Casino Creek (W4)	82	0.2	0.1	0.1	1.1	16.7	9.6	12.4	11.6	10.3	5.7	0.8	0.4	**5.8**
Middle Casino Creek (H18)	67	0.2	0.1	0.1	1.1	18.3	10.6	11.9	12.8	10.3	5.9	0.8	0.4	**6.1**
Upper Casino Creek (W11)	39	0.2	0.1	0.1	1.1	13.2	8.0	11.3	10.6	9.6	6.0	0.8	0.4	**5.1**
Brynelsen Creek (W18)	25	0.2	0.1	0.1	1.1	18.8	12.2	11.3	14.0	11.3	7.6	0.8	0.4	**6.5**

M:\1\01\00325\06\A\Data\Hydrology\2 - Baseline Report Data\[LT Mean Monthly Unit Runoff.xlsx]Table 3.2 mean unit runoff

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	27JUN'12	ISSUED WITH REPORT VA101-325/8-11	DK	KT	JGC

Knight Piésold
CONSULTING

TABLE 3.3

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

RECOMMENDED PEAK FLOW VALUES FOR PROJECT STREAMFLOW STATIONS

Print Jul/09/12 14:49:07

Station	Return Period Peak Instantaneous Discharge (m^3/s)							
	Mean Annual	2 Year	5 Year	10 Year	20 Year	50 Year	100 Year	200 Year
Britannia Creek (W14)	6	5	8	11	13	17	21	25
Canadian Creek (W3)	10	8	14	19	25	35	45	57
Lower Dip Creek (W16)	88	70	125	169	218	292	359	435
Upper Dip Creek (W9)	44	39	68	86	104	126	142	158
Victor Creek (R2)	23	19	32	42	54	71	86	103
Lower Casino Creek (W4)	13	12	20	24	28	33	37	40
Middle Casino Creek (H18)	13	11	20	26	33	44	52	61
Upper Casino Creek (W11)	6	5	8	11	13	16	19	22
Brynelsen Creek (W18)	4	3	5	7	9	11	13	15

M:\1\01\00325\06\A\Data\Hydrology\2 - Baseline Report Data\[Peak Flows_30apr12.xlsx]Table 3.3

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	30APR'12	ISSUED WITH REPORT VA101-325/8-11	DK	CJN	JGC

Knight Piésold CONSULTING

TABLE 3.4

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

10-YEAR DRY MONTHLY FLOWS AT PROJECT STREAMFLOW STATIONS

Print Jul/09/12 15:01:18

Station	Drainage Area (km^2)	10-Year Dry Monthly Discharge (m^3/s)											
		January	February	March	April	May	June	July	August	September	October	November	December
Britannia Creek (W14)	45	0.00	0.00	0.00	0.00	0.30	0.29	0.10	0.19	0.16	0.15	0.01	0.00
Canadian Creek (W3)	64	0.00	0.00	0.00	0.13	0.42	0.35	0.22	0.25	0.24	0.20	0.02	0.00
Lower Dip Creek (W16)	384	0.01	0.01	0.01	0.00	1.90	1.22	1.32	0.80	1.74	1.22	0.09	0.02
Upper Dip Creek (W9)	194	0.00	0.00	0.00	0.00	0.86	0.60	1.08	1.06	1.00	0.81	0.05	0.01
Victor Creek (R2)	85	0.00	0.00	0.00	0.00	0.52	0.31	0.45	0.47	0.46	0.39	0.02	0.01
Lower Casino Creek (W4)	82	0.00	0.00	0.00	0.00	0.37	0.22	0.21	0.46	0.47	0.28	0.02	0.01
Middle Casino Creek (H18)	67	0.00	0.00	0.00	0.01	0.40	0.30	0.28	0.37	0.41	0.34	0.02	0.00
Upper Casino Creek (W11)	39	0.00	0.00	0.00	0.00	0.17	0.13	0.18	0.23	0.24	0.22	0.01	0.00
Brynelsen Creek (W18)	25	0.00	0.00	0.00	0.02	0.22	0.17	0.04	0.21	0.20	0.18	0.01	0.00

M:\1\01\00325\06\A\Data\Hydrology\2 - Baseline Report Data\[Wet and Dry.xlsx]Table 3.4, 10 Year Dry

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	26JUN'12	ISSUED WITH REPORT VA101-325/8-11	SB	CJN	KJB

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TABLE 3.5

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

10-YEAR WET MONTHLY FLOWS AT PROJECT STREAMFLOW STATIONS

Print Jul/09/12 14:49:48

Station	Drainage Area (km^2)	10-Year Wet Monthly Discharge (m^3/s)											
		January	February	March	April	May	June	July	August	September	October	November	December
Britannia Creek (W14)	45	0.02	0.01	0.01	0.12	1.35	0.81	0.84	0.80	0.50	0.21	0.07	0.04
Canadian Creek (W3)	64	0.02	0.01	0.02	0.27	1.75	1.02	1.06	0.99	0.66	0.29	0.09	0.05
Lower Dip Creek (W16)	384	0.11	0.07	0.08	1.04	14.07	7.26	7.73	8.05	4.62	2.32	0.48	0.27
Upper Dip Creek (W9)	194	0.07	0.04	0.04	0.55	10.55	4.03	4.58	3.54	2.90	1.29	0.29	0.16
Victor Creek (R2)	85	0.03	0.02	0.02	0.37	5.91	2.68	2.39	2.01	1.31	0.56	0.13	0.07
Lower Casino Creek (W4)	82	0.03	0.02	0.02	0.20	3.01	1.61	1.33	1.36	1.17	0.60	0.12	0.07
Middle Casino Creek (H18)	67	0.02	0.01	0.02	0.25	3.14	1.43	1.12	1.20	1.00	0.51	0.10	0.08
Upper Casino Creek (W11)	39	0.01	0.01	0.01	0.08	0.96	0.58	0.60	0.44	0.39	0.27	0.06	0.03
Brynelsen Creek (W18)	25	0.01	0.01	0.01	0.12	1.10	0.62	0.32	0.52	0.39	0.23	0.04	0.02

M:\1\01\00325\06\A\Data\Hydrology\2 - Baseline Report Data\[Wet and Dry.xlsx]Table 3.5 10 Year Wet

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	28JUN'12	ISSUED WITH REPORT VA101-325/8-11	SB	CJN	KJB

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TABLE 4.1

CASINO MINING CORPORATION
CASINO CREEK COPPER-GOLD PROJECT

MONTHLY PRECIPITATION COEFFICIENT OF VARIATION AT REGIONAL CLIMATE STATIONS

09/07/2012 14:24

Location	Parameter	Coefficient of Variation											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Casino Site (1200 m)	Precipitation	0.53	0.73	0.79	0.91	0.52	0.41	0.46	0.45	0.62	0.54	0.47	0.56

M:\1\01\00325\08\A\Data\Task 1100 - Hydrometeorology\[Precip Cv.xlsx]Table 4.1

NOTES:

1. COEFFICIENT OF VARIATION = STANDARD DEVIATION/ MEAN
2. THE COEFFICIENT OF VARIATION VALUES WERE BASED ON AVERAGE REGIONAL DATA RECORDED AT BEAVER A, PELLY AND DAWSON A.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	27JUN'12	ISSUED WITH REPORT VA101-325/8-11	CJN	EER	KJB

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TABLE 4.2

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

EFFECTIVE RUNOFF COEFFICIENT

Print Jul/09/12 15:03

Drainage Basin	Basin Characteristics		Mean Annual Precipitation (mm)		Mean Annual Discharge and Runoff		Effective Runoff Coefficient
	Drainage Area (km^2)	Mean Elevation (m)	El. 1200 m	El. 1066 m	Discharge (m^3/s)	Runoff (mm)	
Lower Casino Creek (W4)	82	1066	507	475	0.48	183	0.4

M:\1\01\00325\08\A\Data\Task 1100 - Hydrometeorology\[Runoff Coeff 2012.xlsx]Table_RC

NOTES:

1. MEAN ANNUAL PRECIPITATION AT MEAN BASIN ELEVATION WAS ESTIMATED USING AN OROGRAPHIC FACTOR OF 5% PER 100 m.

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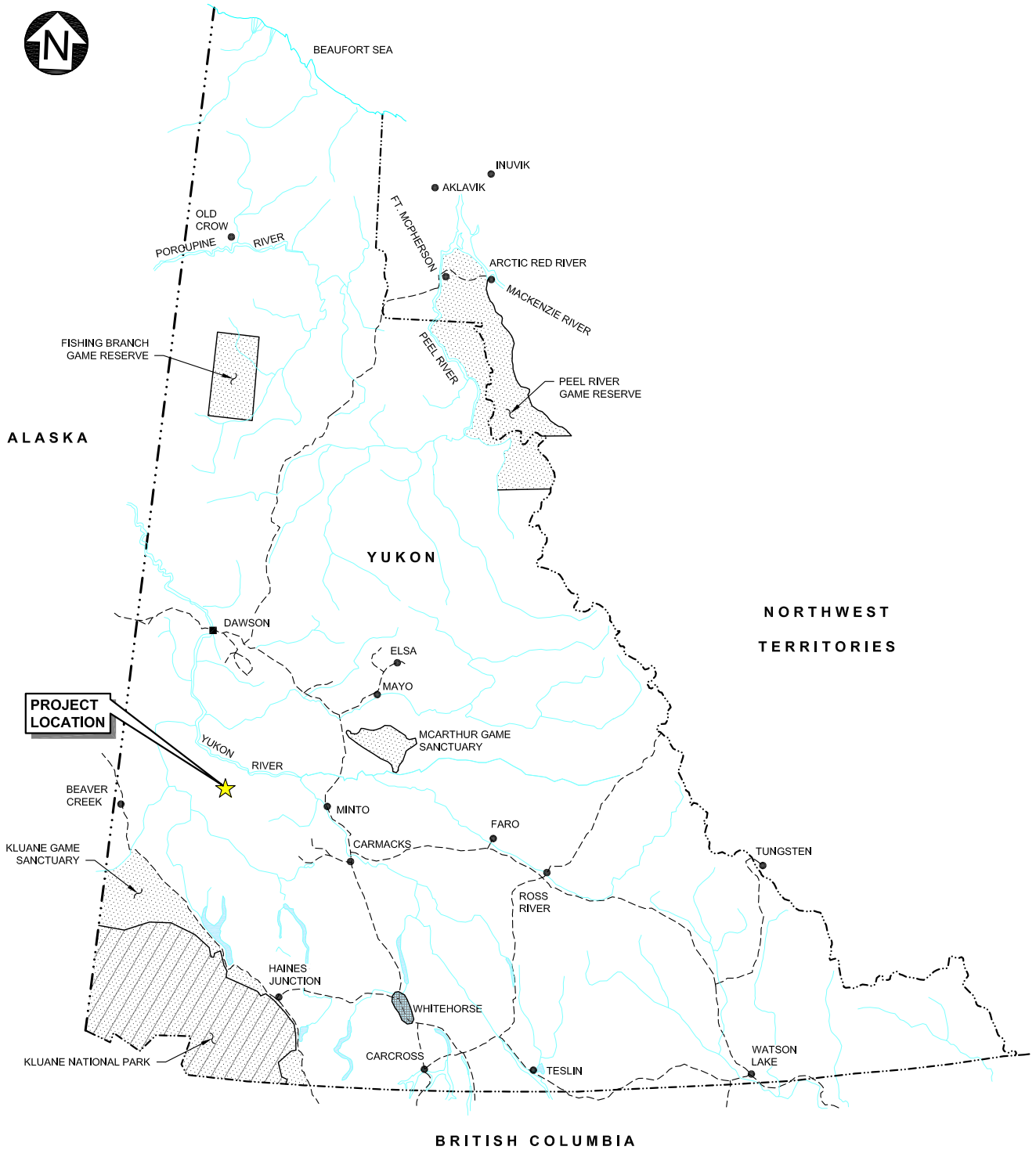

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

PROJECT LOCATION MAP

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	26JUN'12	ISSUED WITH REPORT	CJN	WAL	GRG	KJB

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P/A NO. VA101-325/8

REF NO. 11

FIGURE 1.1

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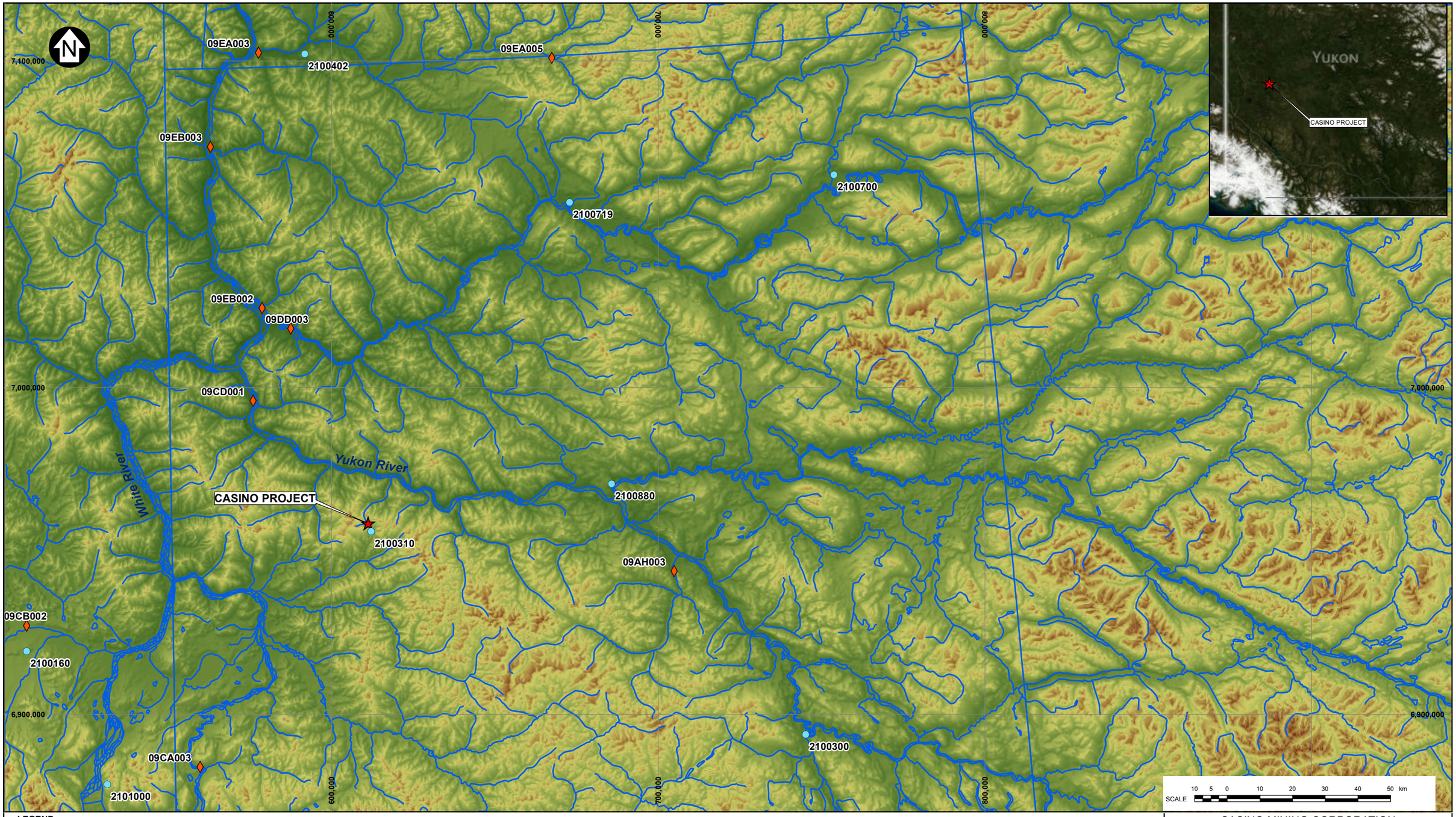

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LEGEND:

- PROJECT LOCATION
- REGIONAL CLIMATE STATION
- REGIONAL STREAMFLOW GAUGE
- RIVER/CREEK

ELEVATION RANGE (M)

- < 500
- 500 - 1000
- 1000 - 1500
- 1500 - 2000
- > 2000

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	21JUN'12	ISSUED WITH REPORT	AMD	AMD	CJN	JPH

NOTES:

1. BASE MAP: NATURAL RESOURCES CANADA DEM

2. COORDINATE GRID IS IN METRES/DEGREES.
COORDINATE SYSTEM: NAD 1983 UTM ZONE 7N.

3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:1,100,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

REGIONAL CLIMATE AND STREAMFLOW GAUGING STATIONS

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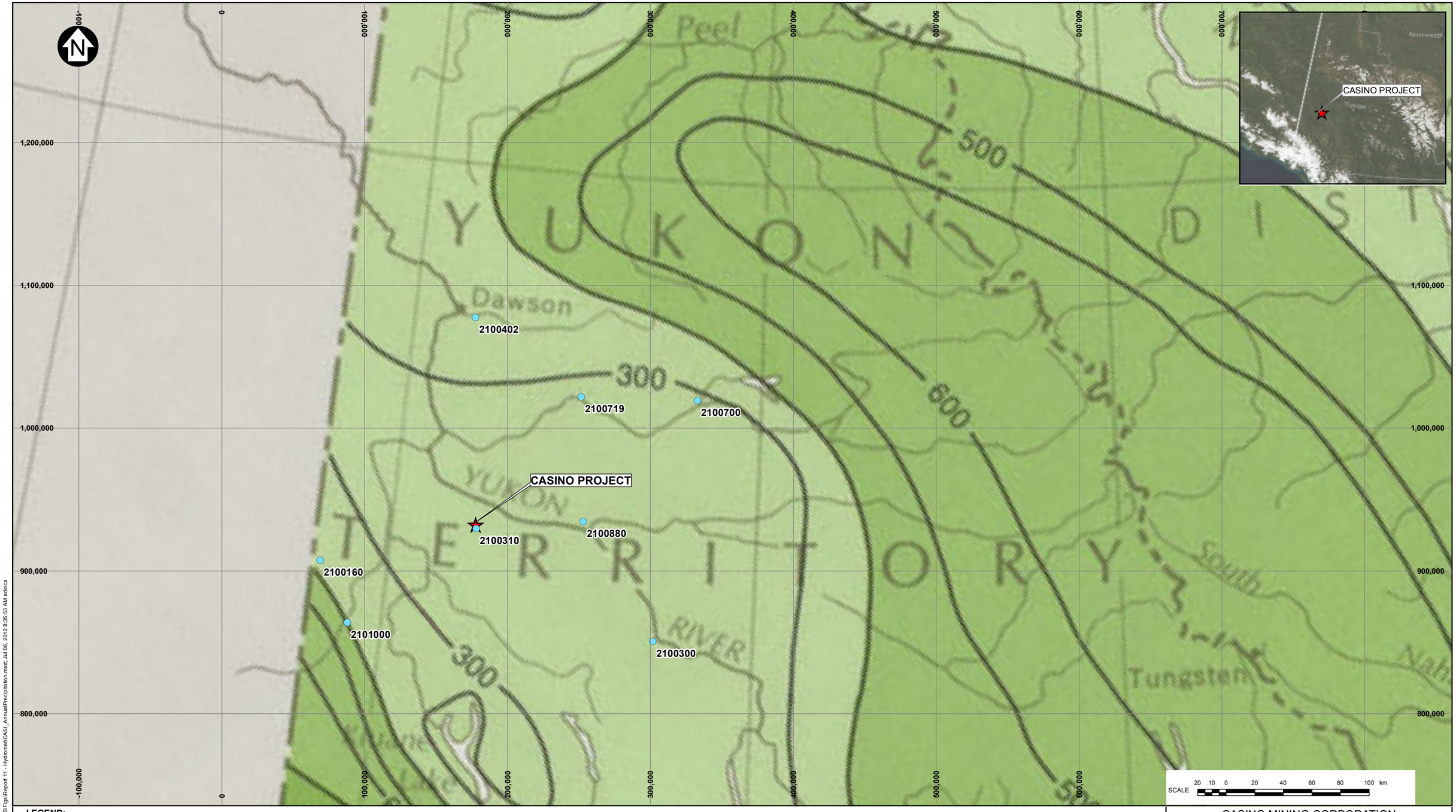
P/A NO.	REF NO.
VA101-325/8	11

FIGURE 1.2

REV 0



LEGEND:

- PROJECT LOCATION
- REGIONAL CLIMATE STATION

NOTES:

1. BASE MAP: NATURAL RESOURCES CANADA HYDROLOGICAL ATLAS MEAN ANNUAL LAKE EVAPORATION. VALUES ARE IN MILLIMETRES AND BASED ON 10-YEAR PERIOD 1957-1966.

2. COORDINATE GRID IS IN METRES/DEGREES. COORDINATE SYSTEM: ALBERS CONICAL EQUAL AREA.

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CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

REGIONAL MEAN ANNUAL PRECIPITATION

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P/A NO. VA101-325/8

REF NO. 11

FIGURE 2.1

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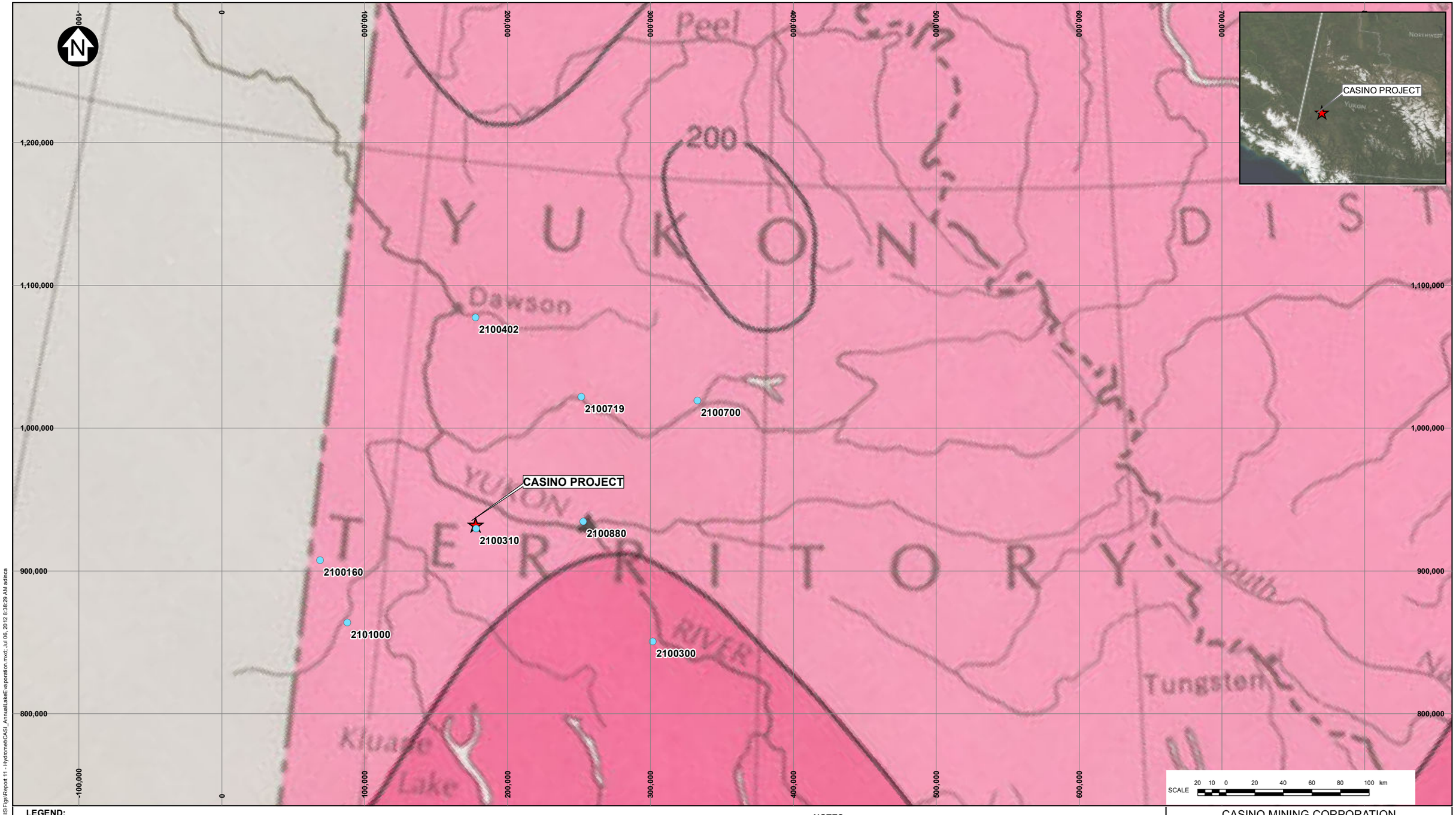

LEGEND:

- PROJECT LOCATION
- REGIONAL CLIMATE STATION

NOTES:

1. BASE MAP: NATURAL RESOURCES CANADA HYDROLOGICAL ATLAS MEAN ANNUAL LAKE EVAPORATION. VALUES ARE IN MILLIMETRES AND BASED ON 10-YEAR PERIOD 1957-1966.

2. COORDINATE GRID IS IN METRES/DEGREES. COORDINATE SYSTEM: ALBERS CONICAL EQUAL AREA.

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CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

REGIONAL MEAN ANNUAL LAKE EVAPORATION

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REF NO. 11

FIGURE 2.2

REV 0

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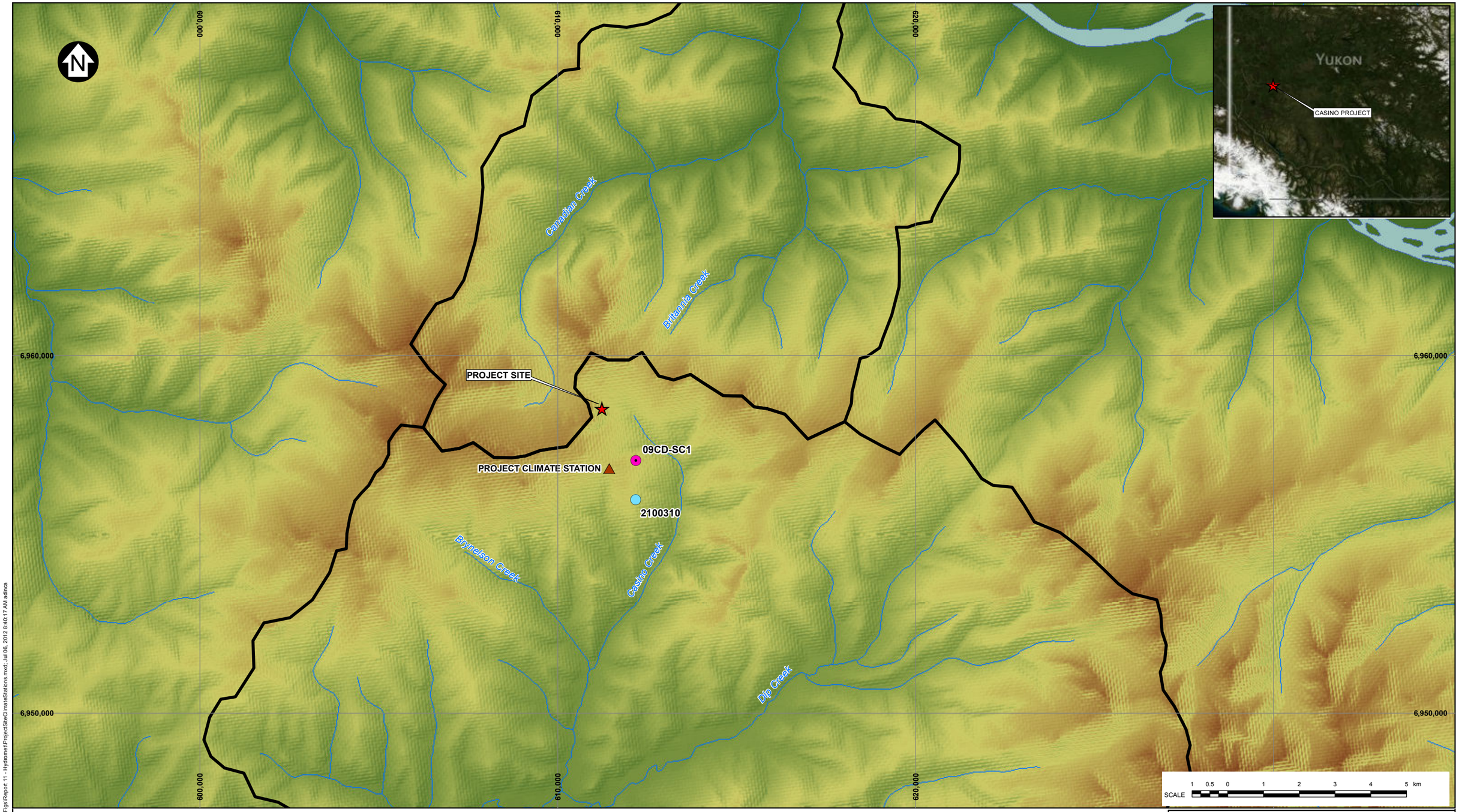

LEGEND:

- PROJECT LOCATION
- ACTIVE PROJECT CLIMATE STATION
- DISCONTINUED MSC CLIMATE STATION
- ACTIVE YUKON ENVIRONMENT SNOW COURSE
- RIVER/CREEK
- WATERSHED BOUNDARY

ELEVATION RANGE (M)

- < 500
- 500 - 1000
- 1000 - 1500
- 1500 - 2000
- > 2000

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
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NOTES:

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CASINO COPPER-GOLD PROJECT

PROJECT SITE CLIMATE STATION AND SNOW COURSE LOCATIONS

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P/A NO.	REF NO.
VA101-325/8	11

FIGURE 2.3 REV 0

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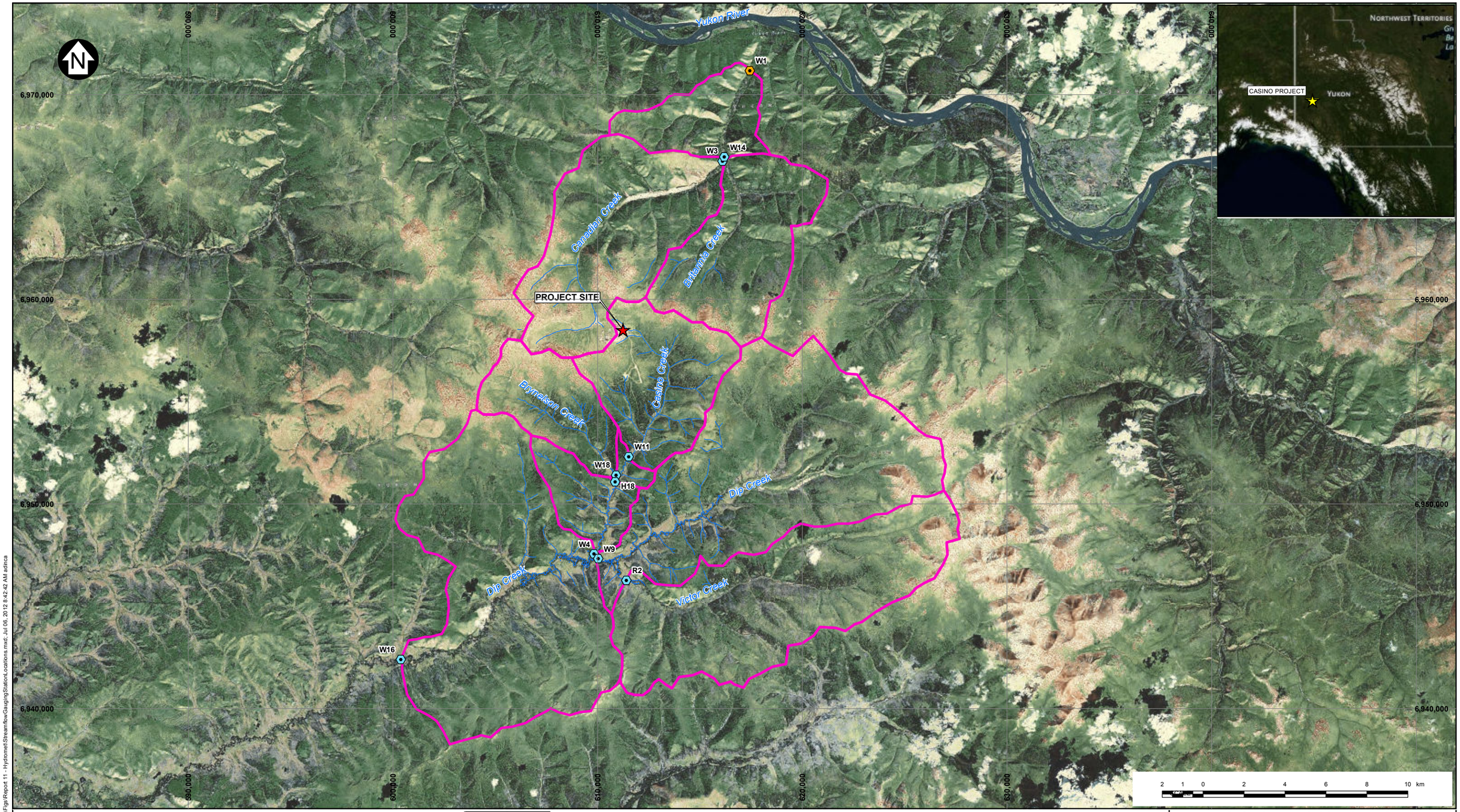

LEGEND:

- PROJECT LOCATION
- ACTIVE STREAMFLOW GAUGING STATION
- DISCONTINUED STREAMFLOW GAUGING STATION
- RIVER/CREEK
- WATERSHED BOUNDARY

Station	Area (km²)
W14	45
W3	64
W16	384
W9	194
R2	85
W4	82
H18	67
W11	39
W18	25

NOTES:

1. BASE MAP: ESRI ARCGIS ONLINE BING MAPS.

2. COORDINATE GRID IS IN METRES/DEGREES.
COORDINATE SYSTEM: NAD 1983 UTM ZONE 7N.

3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:175,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.

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CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

PROJECT AREA
STREAMFLOW GAUGING STATION LOCATIONS

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P/A NO. VA101-325/8 | REF NO. 11

FIGURE 3.1 | REV 0

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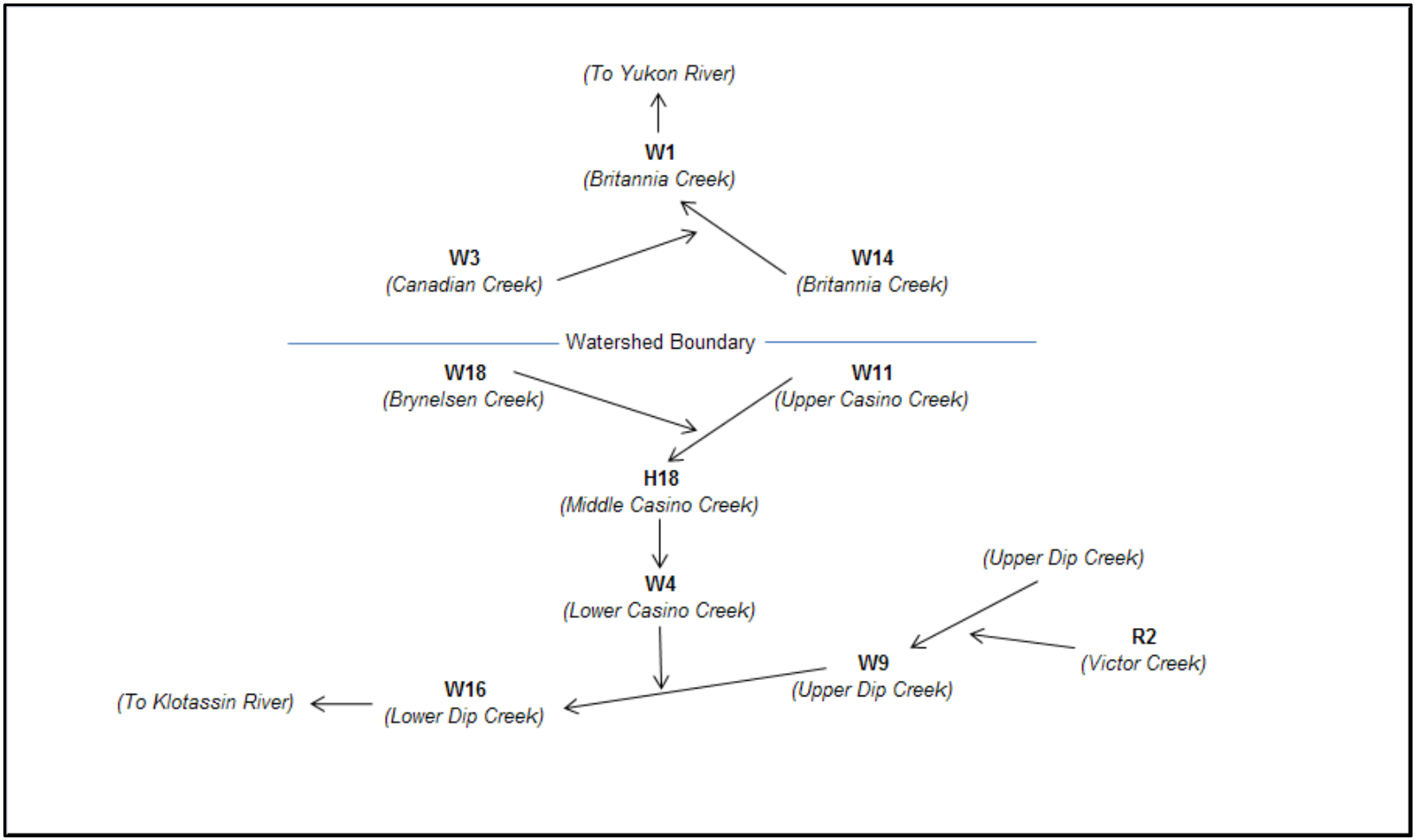

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CASINO COPPER-GOLD PROJECT

STREAMFLOW GAUGING NETWORK SCHEMATIC

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REF. NO. 11

FIGURE 3.2

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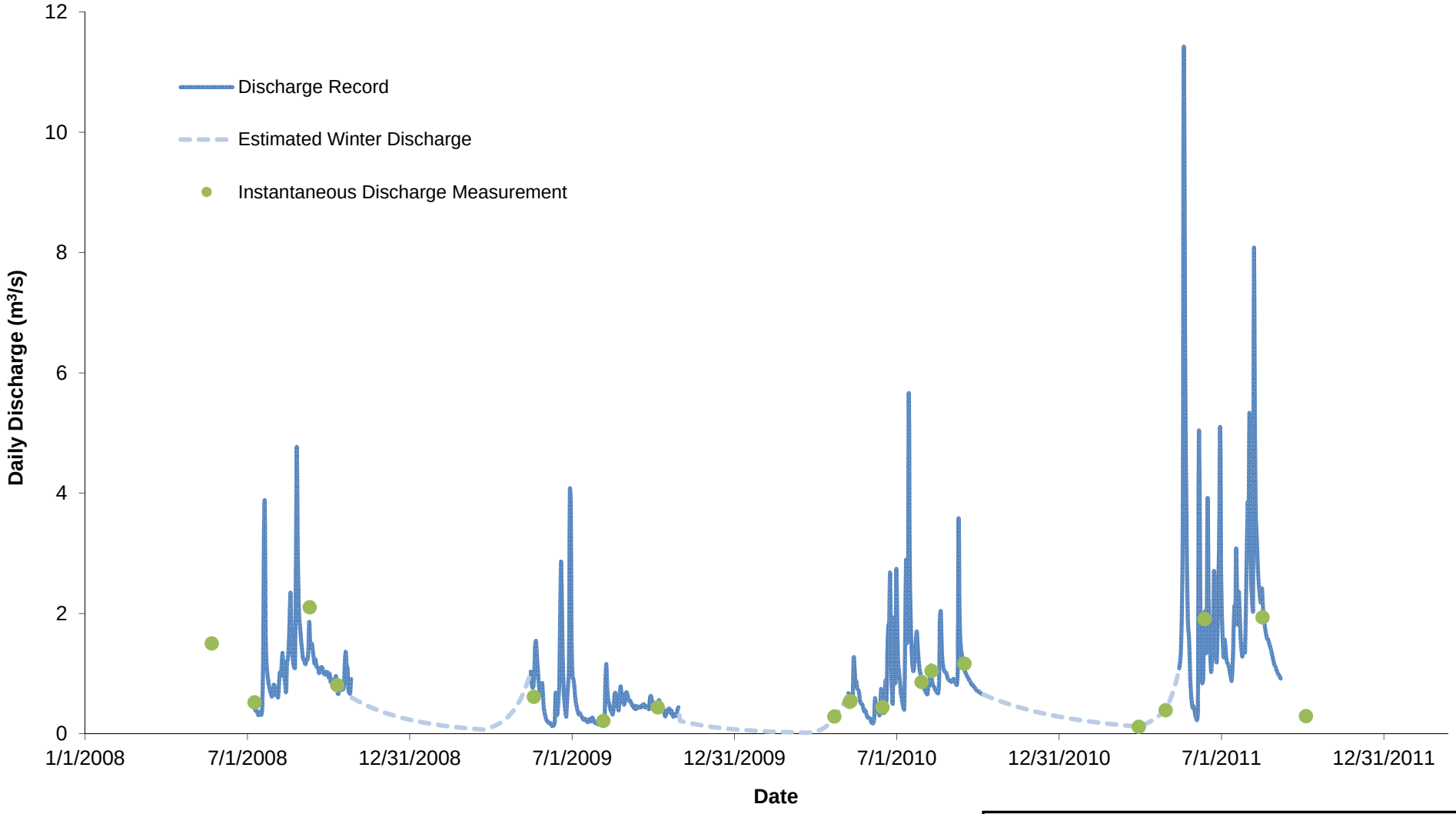

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CASINO COPPER-GOLD PROJECT

LOWER CASINO CREEK STATION (W4)
MEASURED DISCHARGE HYDROGRAPH

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P/A NO. VA101-325/8

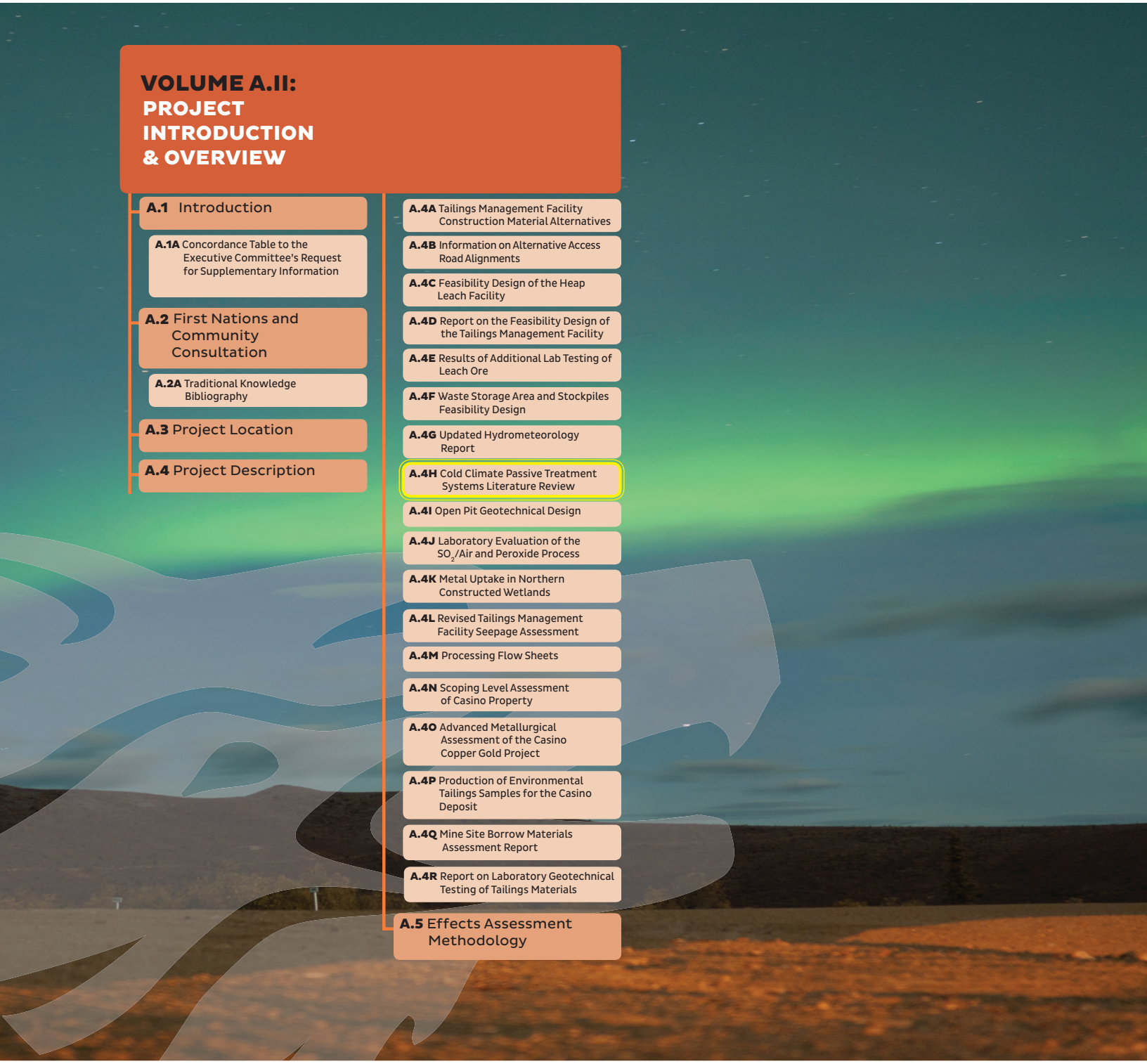
REF. NO. 11

FIGURE 3.3

REV 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	27APR'12	ISSUED WITH REPORT	DK	KT	JGC

APPENDIX A.4H: Cold Climate Passive Treatment Systems Literature Review





Passive Treatment of Mine Impacted Water In Cold Climates: A Review

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Executive summary

In this review, we evaluate the challenges encountered and the adaptations required for the successful treatment of mine-impacted waters in cold climates with Passive Treatment Systems (PTSs). Engineered PTSs are modeled on natural wetlands, which have been shown to effectively treat water with high metal concentrations through natural attenuation. PTSs include constructed wetlands, bioreactors, and hybrid systems. Some of the challenges associated with implementing cold climate PTSs include cold temperatures, remote locations and limited access in winter, which can lead to freezing pipes and surface water, variable seasonal flow, and low productivity of microbial and macrophytic communities. Many adaptations have been implemented to address these cold climate challenges including burial of pipes to avoid hydraulic failure, insulation to avoid freezing surface waters, bypasses and overflows to maintain constant flow, summer establishment of microbial and macrophytic communities and the addition of liquid carbon sources to offset reduced organic matter decomposition in cold temperatures. While further investigation and development is necessary to fully understand the factors affecting cold climate PTSs, with sufficient research and planning PTSs can be successfully implemented in cold climates.

Acknowledgements

This review was funded by a NSERC Applied Research and Development grant held by Yukon College and Casino Mining Corporation. We would like to thank Andre Sobolewski of Clear Coast Consulting for his expertise and contribution to the document.

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1. BACKGROUND

Passive treatment of mine impacted water has become increasingly common over the last 30 years. While natural attenuation of contaminants in wetlands, bogs and swamps has been well documented (McGregor, 2002; Sobolewski, 1997), recent advances in the design and construction of engineered passive treatment systems (PTSs) has resulted in more efficient contaminant removal (USEPA 2014; INAP 2010; Mays & Edwards, 2001; MEND 1996). PTSs consist of constructed wetlands (CWs), bioreactors, or some combination and/or variation on both of these components. Other types of PTSs exist, such as in-pit or in-pond treatment systems, but these are more specialized and will not be reviewed here.

Natural wetlands provide important information about the processes that drive PTSs, as well as, acting as water treatment systems in their own right. Natural wetlands and bogs have been removing contaminants from water for centuries (Gusek, 2008). From cupriferous and uraniferous bogs (Sobolewski, 2013) to bog iron ore deposits (Gusek, 2008), many examples of natural attenuation of metals in wetlands exist (e.g., Boyle, 1995; Wieder and Lang, 1982). Numerous studies have found evidence of metal retention in natural wetlands from natural and anthropogenic sources (Table 1). Natural wetlands can also give us an indication of the potential for the long-term performance of CWs. A wetland in Ireland has been assimilating metal-laden water from an abandoned Pb/Zn mine for over 120 years without interference (Sheoran and Sheoran, 2006). A natural wetland receiving drainage high in Fe, Zn and Mn from an iron ore mine in the Rocky Mountains was found to retain metals at a rate of 90%, 65% and 25%, respectively (August et al, 2002). The wetland received mine drainage for over a century and had accumulated large amounts of metal oxides and sulfides. This likely resulted in a decrease in efficiency overtime, as at the time of the study the wetland was found to be a sink for all metals during the winter, but then became a source for Zn and Mn during the summer when flows were higher. Similarly, a fen in Northern Manitoba treating Ni mine drainage was found to remove 96% of the Ni (Hambley, 1996). While higher levels of Ni were observed in the effluent in the spring and after heavy rains, sequential extractions of the soils indicated that 97% of the Ni captured by the fen would be unlikely to be remobilized. In another natural wetland receiving drainage from an abandoned Pb/Zn mine in Ireland, retention of 95% of Zn and 65% of As was observed (Beining and Otte, 1997). The wetland has been receiving mine drainage for over a century and is estimated to have reached only 30% of its capacity. A wetland receiving coal mining drainage high in Se removed 83% of the inflowing metal concentration (from 364 mg/L to 22mg/L) and selenium-reducing bacteria and SRB were found at high levels (Baldwin and Hodaly, 2003). Finally, a natural wetland established below the Silver King mine in Elsa, Yukon, was shown to completely remove Zn from mine drainage during winter months, even when temperatures decreased below -40°C (Sobolewski, 2003a). Evidence of sulfide generation was uncovered during this study, indicating that SRB were active and could account for metal removal.

Natural wetlands have been treating mine-impacted water in cold climates since mining activity began and while several studies indicate their efficacy and longevity, their effectiveness over long time periods and the effects of seasonal variation on efficiency still remains poorly documented. Understanding the effects of changes in water flow through the seasons would better inform PTS designers to adapt their own systems for cold climates. Natural wetlands also help to inform the scale necessary for treatment wetlands. The longevity of natural wetlands, particularly in cold climates, indicates that a well-designed PTS may last for decades to centuries.

Table 1: Natural wetlands shown to ameliorate mine drainage (Sobolewski, 1999, p.26).

Wetlands that only partly improve mine water quality

Mine	Location	Dominant plant Species	Acidic Drainage	Water quality parameter	Ref.
Abandoned tin, zinc mines	St Hilary Mining District, West Cornwall, U. K	*Juncus effusus, Phragmites australis*	No	Cu yes, Zn no	Brown, 1997
Carbonate mine	Montana	*Carex rostrata*	Yes	Al no, Fe yes, Pb yes	Dollhopf *et al.*, 1988
Coal mines	Eastern United States	*Typha, Scirpus* spp.	Yes	pH, Al, Fe, Mn	Kleinmann, 1996
Coal mine	Mpumalanga mining district, South Africa	*Typha,* spp.	Yes	pH, Al, Fe, Mn	Limpitlaw and Bloem, 1996
Dunka Mine	Minnesota, United States	Peat bogs	Yes	Cu, Ni	Eger *et al.*, 1994
Equity silver	British Columbia, Canada	Sedges	Yes	Cu	Mehling, 1985
Mt. Washington Mine	British Columbia, Canada	*Eriophorum angustifolium*	Yes	Cu, Al	Coombes, 1998
Natural wetlands at 35 coal mines	Pennsylvania, USA	*Mainly Typha,* spp., others also noted	Yes	pH, Al, Fe, Mn	Stark, 1990
Ranger Mine	Jabiru, Australia	*Eleocharis sphacelata Typha* species	No	U	Jones *et al.*, 1996
St. Kevin Gulch	Colorado, USA		Yes	Fe yes, Zn no	Walton-Day, 1994
Unnamed coal mine	Ohio, USA	*Sphagnum* spp.	Yes	pH, Fe, Mn	Huntsman, Solch and Porter, 1978
Tug Fork coal mine	West Virginia, U.S.A.	*Sphagnum* spp.	Yes	pH, Fe, Mn	Wieder and Lang, 1982

Wetlands which improve mine water quality to full environmental compliance

Mine	Location	Dominant plant Species	Acidic Drainage	Water quality parameter	Ref.
Abandoned Lead/ Zinc mines	Glendalough, County Wicklow, Ireland	*Molinia caerulea, Juncus acutiflorus*	Yes	As, Cd (?), Pb (?), Zn	Beining and Otte, 1996
Birchtree Mine	Manitoba, Canada	*Agrostis, Carex* spp. *Typha latifolia*	No	Ni	Hambley, 1996
Cluff Lake, Rabbit Lake	Saskatchewan, Canada	*Carex* species *Sphagnum* moss	No	U	TAEM, 1995; Sinclair, 1996
Con Mine	Northwest Territories, Canada	*Carex* species *Sphagnum* moss	No	CN^-, As	Ball, 1993
Hilton Mine	Mt. Isa, Queensland, Australia	Reeds, algae	No	Fe, Mn, Tl, Zn	Jones and Chapman, 1995
Pacific Mine	Utah, USA	?	No	Cd, Pb, Zn	Lidstone and Anderson, 1993
Quirke Mine	Ontario, Canada	*Typha latifolia*	Some	Fe, Ra-226	Davé, 1993
Silver Queen	British Columbia, Canada	Sedges	No	Zn	Higgs, 1996
Star Lake, Jolu	Saskatchewan, Canada	*Carex* species *Sphagnum* moss	No	CN^-, Cu	Gormely *et al.*, 1990
Tom's Gully Gold Mine	Darwin, Australia	*Melaleuca, Typha domingensis*	No	As, Co, Cu, Fe, Pb, Mn, Ni, Zn	Noller, Woods and Ross, 1994
United Keno Hill Mines	Yukon Territories, Canada	*Carex* species *Sphagnum* moss	No	Fe, Mn, Pb, Ag, Zn	Boyle, 1965
Woodcutter's Mine	Darwin, Australia	*Typha* species	No	Cd, Mn, Pb, Zn	Noller, Woods and Ross, 1994

In Yukon, Canada, effluent from hard rock mines can have neutral or acidic pH and be high in a suite of heavy metals, depending on the local geology (Nordin, 2010). Contaminated mine drainage

often requires treatment prior to discharge to the receiving environment. Yukon mines have expressed interest in implementing PTSs to treat contaminated drainage and in some cases have already begun research to develop such systems (i.e. Minto Mine, Casino Mine, Faro Mine, United Keno Hill Mine, Brewery Creek, Eagle Gold and Wolverine Mine). There are distinct advantages to PTSs in remote locations with limited access and power. Passive systems should ideally be able to function for decades with no power (Gusek & Wildeman, 2002). While most systems are not truly "walk-away" scenarios, they are generally lower maintenance than active systems (Johnson & Hallberg, 2005).

Some of the challenges facing PTSs in cold climates include hydraulic failure due to freezing in winter, reduced microbial activity, and increased water flows during spring melt. Many adaptations have been developed to overcome these challenges such as insulating and/or burying PTSs, maintaining constant flows through the use of bypasses and overflows, and providing carbon sources to feed bacteria during times of slower organic matter decomposition. There have been varying degrees of success, but hurdles have been overcome and many advances have been made in the use of PTSs in cold climates.

With the proliferation of PTSs around the world and the growing interest in Yukon, it is necessary to synthesize some of the successes and failures of PTSs, particularly in a northern context. This review aims to summarize many of the PTSs that have been used to treat mine-impacted water and address some of the challenges and future research directions associated with implementing these systems in cold climates. This review focusses primarily on PTSs for the treatment of mine-impacted water, although systems that treat other types of effluent are discussed where relevant cold climate adaptations have been used.

2. PASSIVE TREATMENT SYSTEMS

PTSs are generally defined as water treatment systems that require little or no maintenance once installed (Johnson & Hallberg, 2005). This is contrasted with active treatment systems (treatment plants), which use mechanical devices operated by workers and require continual flow control, reagent input, sludge/residual removal and power. More specifically PTSs can be described as water treatment systems that sequentially remove contaminants using biological or geochemical processes (Gusek & Wildeman, 2002). They are typically designed to last for decades and be less costly over the long term than active treatment systems. However, they can also require much more space and may be constrained by site limitations, such as topography (Johnson & Hallberg, 2005).

PTSs capitalize on natural attenuation processes that naturally occur in wetlands. Wetlands generally have an aerobic zone where plants thrive and oxidative conditions dominate. Below this is an anaerobic zone where reductive processes dominate and sulfate-reducing bacteria (SRB) thrive (Gusek, 2002). In each zone, different reactions occur that precipitate different contaminants. In the aerobic zone, hydroxide and oxide precipitation occurs and in the anaerobic zone sulfide and carbonate precipitation is catalyzed by microorganisms. Some contaminants like chromium, selenium or uranium are retained by reductive immobilization in these anaerobic environments. Filtration and adsorption by detritus are also important processes occurring in both zones. PTSs promote these processes by using organic materials as substrates for microbial activity, as well as, local native plant species as the living wetland layer. The chosen substrate is often waste material that can be obtained at low cost.

Additionally, organic material such as wood chips or sawdust can often be obtained on-site or nearby, reducing or eliminating transport costs (Gusek, 2002).

Metal removal in PTSs can be divided into abiotic or biotic processes. Technologies that rely on abiotic processes include anoxic limestone drains (ALDs), open limestone channels, diversion drains, vertical flow limestone drains and others. All these systems rely on limestone to neutralize acid drainage and remove aluminum and iron. They are often used in combination with other biotic passive treatments. For example, successive alkalinity producing systems (SAPS) or vertical flow limestone drains rely on the percolation of acidic water through a layer of compost, where the carbon dioxide produced by its microbial decomposition greatly enhances limestone dissolution (Kepler & McCleary, 1994). These systems are used to treat waters with high acidity, aluminum or ferric iron, which cannot be treated by other limestone-based PTSs.

Systems that rely on biotic processes can be divided into aerobic and anaerobic systems. Aerobic wetlands rely on oxidative processes to remove metals (primarily iron) and are most often constructed to treat mine water that has net alkalinity (Hedin et. al., 1994, Johnson & Hallberg, 2005). Anaerobic wetlands, or bioreactors, are used to treat neutral, metal rich water by reductive processes. They are typically applied at base and precious metal mines to remove metals that were originally present as sulphides and were released during the mining process (Sobolewski, 1999). Constructed wetlands and bioreactors are further detailed in Section **Error! Reference source not found.** and **Error! Reference source not found.** below.

The technology behind PTSs has evolved considerably over the last 20 years. A landmark development was the publication of an Information Circular by the former US Bureau of Mines (Hedin et al, 1994). This document presented for the first time design criteria that were field-validated, along with a decision-making flow chart that identified the different types of treatment required for different types of mine waters. The information circular focused on acid drainage from abandoned coal mines in Eastern Appalachia, where the authors had gained their experience. More recently, Gusek (2008) expanded this flow chart by including additional forms of treatment that were predominantly developed for abandoned base and precious mines in Western USA and Canada. This chart presents the multitude of PTS components and possible configurations available for industry and those involved in reclamation (Figure 1).

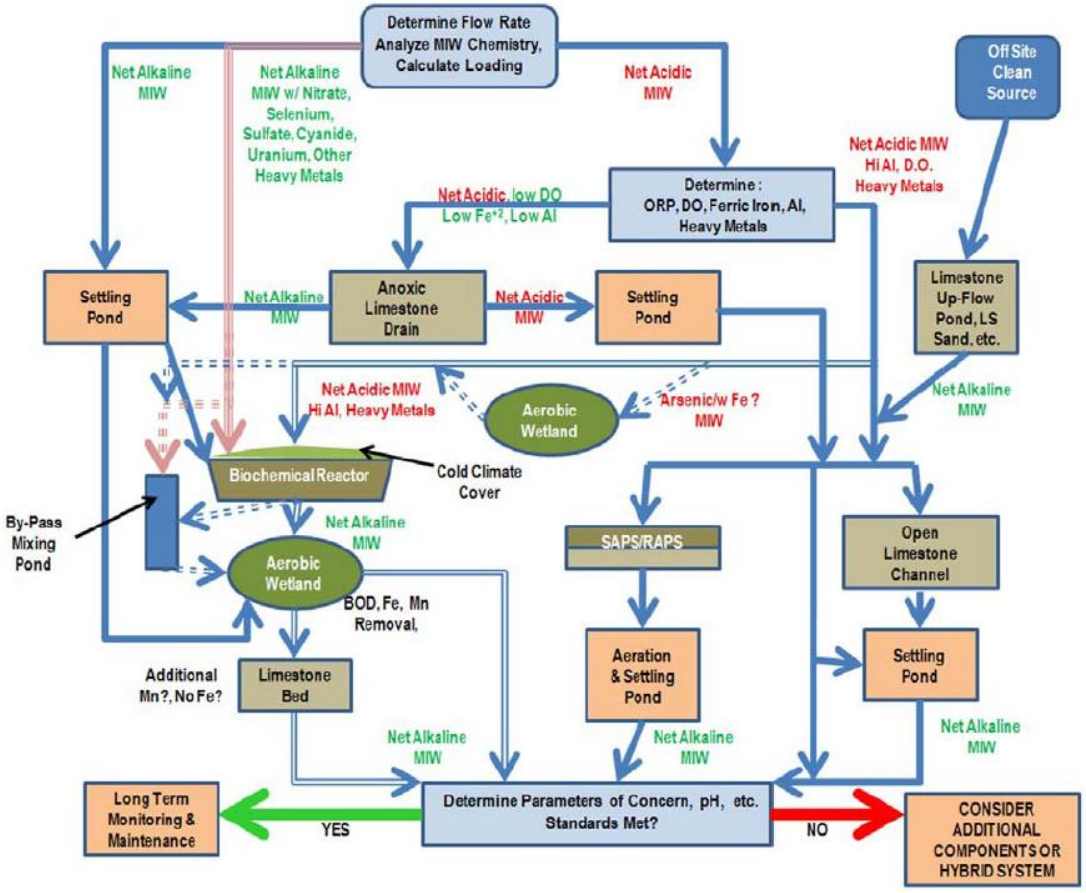

Figure 1: Flow chart for selecting PTS based on water chemistry and flow (adapted from Hedin et al, 1994 by Gusek, 2008, p. 4).

2.1. Constructed wetlands

Constructed wetlands (CWs) are defined as engineered wetlands that use natural processes associated with vegetation, soil and microbes to treat contaminated water (Mander & Jenssen, 2003). The basic processes that operate in CWs include nutrient uptake, bacterial degradation, filtration, oxidation, precipitation, sedimentation and adsorption (Sheoran & Sheoran, 2006). The characteristics of wetlands that contribute to their effectiveness in treating contaminated water include: high productivity, microbial diversity, organic matter accumulation, high reactive surface area and slow water flow (Sobolewski, 1999). It is these characteristics that designers seek to emulate when creating CWs, and many CWs are more efficient at removing metals than natural wetlands (Sheoran & Sheoran, 2006). CWs are used all over the world for treating various types of effluent. They have been used extensively in cold climates for municipal wastewater treatment (Mander & Jenssen, 2003) and in several northern settings for mine drainage (Nyquist & Greger, 2009; Sobolewski 1996a; Sobolewski 1996b; Duncan, 2002; Goulet & Pick, 2001).

Surface flow wetlands often consist of an excavated pond lined with an impermeable substrate, such as clay or geotextile and are filled with porous materials like peat (Eger & Eger, 1991), or sand (Nyquist & Greger, 2009), then fertilized (Sobolewski, 1996b) and planted with local wetland plants (Figure 2a). Sub-surface flow wetlands are similarly constructed but attempt to direct the flow through the root zone of the plants (Figure 2b). In both cases, the wetland bed is gently sloped so that water flows by gravity.

In Europe, sub-surface flow CWs are most often used to treat municipal wastewater (Galletti et al, 2010; Hiley, 2003; Vyzamal & Krasa, 2003), whereas in North America, they are most often used to treat mine drainage. Native wetland plants are generally chosen based on their ease of propagation and transplantation, water depth tolerance, root structure, and metal accumulation properties. Many studies have assessed the role of plants in CWs and most have found that plants uptake only a small fraction of the metals sequestered by a CW with most of the metal retention occurring in the roots (Noller et al, 1994; Sobolewski, 1999; August et al, 2002; Deng et al, 2004; Galletti et al, 2010; Mitsch & Wise, 1998; Nyquist & Greger, 2009; Taylor & Crowder, 1983; Vyzamal & Krasa, 2003; Ye et al, 2001) or on the surface of belowground biomass in a metal-rich plaque layer (Weis & Weis, 2004). It has been hypothesized that low translocation of metals from roots to shoots is a strategy of metal-tolerant plants (Taylor & Crowder, 1983; Deng et al, 2004). Metal uptake in plants varies considerably depending on the plant species, contaminants being treated, and the pH of water and sediment (Weis & Weis, 2004).

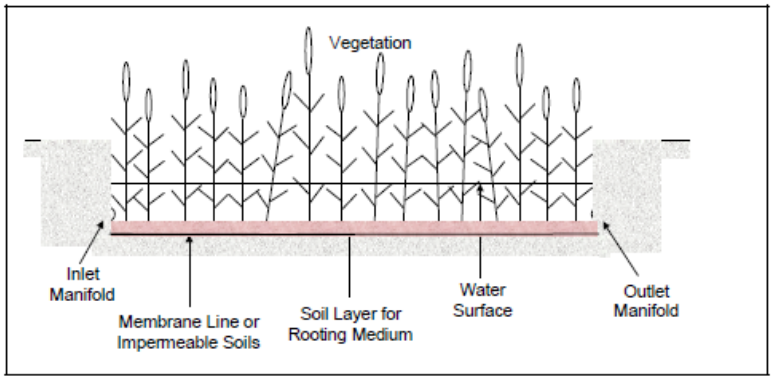

Figure 2a: Surface flow wetland (adapted from a drawing by SC Reed from EPA, 2000a, p. 1).

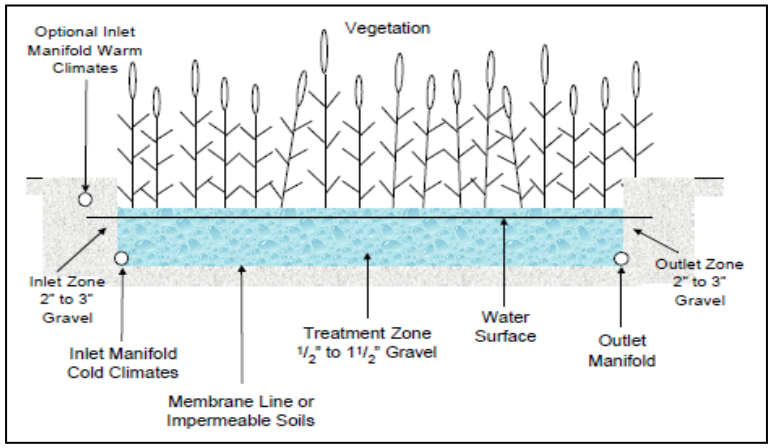

Figure 2b: Sub-surface flow wetland (adapted from a drawing by SC Reed from EPA, 2000b, p. 1).

2.2. Bioreactors

Bioreactors (or anaerobic wetlands) are PTSs that are contained in an excavation, pond, tank or even a mine shaft. It is filled with a solid reactive mixture made up of sand, gravel, compost, manure, wood chips, sawdust, or other organic material from nearby sources (Figure 3) (Schmidtova & Baldwin, 2011). The most effective reactive mixture generally contains an organic carbon source, a bacterial inoculum, a solid porous medium, a nitrogen source and a neutralizing agent (Zagury & Neculita, 2007). As mine water percolates vertically or horizontally through the substrate material, decomposing organic matter provides nutrients that fuel the activity of sulfate reducing bacteria (SRB) and other microorganisms that provide treatment (Hashim et al, 2011). The SRB then produce bicarbonates, which increases the pH while reducing sulphates to sulphides, which in turn precipitate with metals to form highly insoluble metal sulphides (Zagury & Neculita, 2007). Some bioreactors also rely on other anaerobic bacteria to remove nitrate (Reinsel, 1998) or selenium (Pahler et. al., 2007).

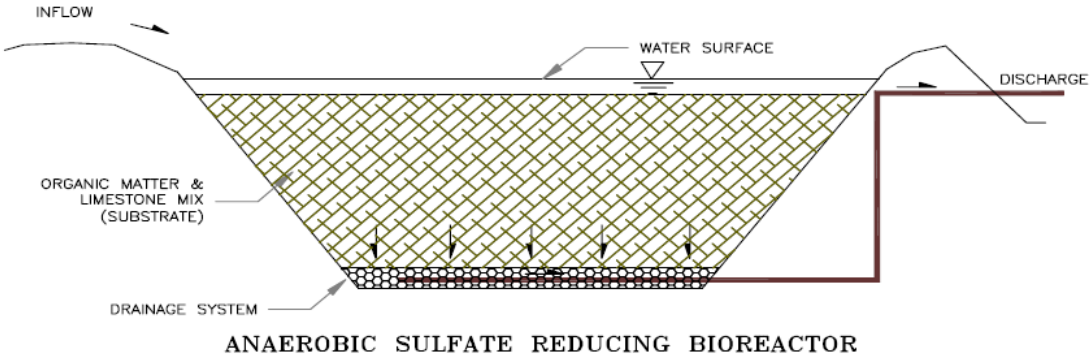

Figure 3: Typical bioreactor design (Gusek, 2002, p. 3).

Bioreactors can be used in combination with other PTS components such as limestone pretreatment to increase pH, constructed wetlands and aerobic cells (Figure 4). Bioreactors have been used at numerous mine sites in cold climates with limited access and power (Duncan et al, 2002; Ettner, 2007; Kuyucak, et al, 2006; Nordwick et al, 2007; Sobolewksi, 2010; Zagury & Neculita, 2007) due to low construction and operating costs (Schmidtova & Baldwin, 2011) and their ability to work year-round in sub-zero temperatures (Kuyucak et al, 2006).

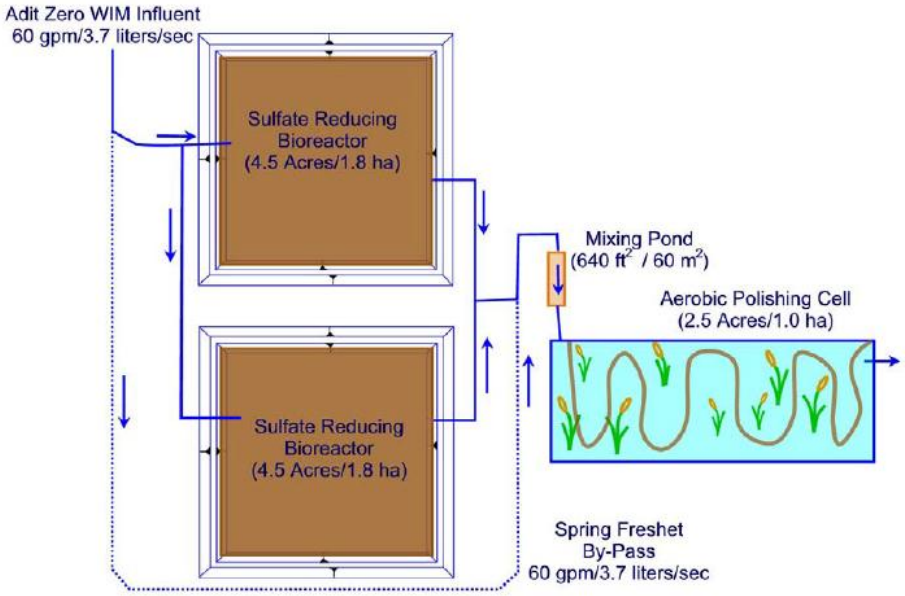

Figure 4: Hypothetical hybrid system with bioreactor and aerobic wetland components (Gusek & Conroy, 2007, p. 265).

2.3. Pilot and full scale PTSs

Many PTSs are currently being employed to treat contaminants in northern and/or cold climate environments (Table 2). While many lab and bench scale experiments are documented in the literature, our focus is only on those that have reached pilot and full scale implementation. For the purposes of this review, full scale passive treatment projects are defined as those that are constructed on-site to deal with a large portion of the effluent being produced. Pilot scale projects are experimental PTSs and are generally implemented on-site to increase the likelihood of successful full scale design (Gusek, 2002). An overview of pilot and full scale PTSs studies is provided in Table 2 including the metal removal rates observed. Note that this survey is not fully comprehensive and only reflective of the available literature, as there are PTSs that have operated for years, but have never been documented.

Table 2: Overview of Pilot and Full Scale Passive Treatment Systems

Passive Treatment Type	Components	Target Contamination	Location	Scale	Duration	Removal rates	Reference
Bioreactor	Bioreactor cell	Zn, Fe, Mn, Ni, Cd, Cu,	United Keno Hill Mine, Yukon, Canada	Pilot scale	2 years	Zn (98-99%), Mn (99%), Sb (80%), As (58-80%)	Alexco, 2012
CW	HSSF wetland & aerobic polishing cell	Cu, Zn, Pb, Fe	Clear Creek/Central City, Colorado, USA.	Pilot scale	n/a	Cu (99%), Zn (98%), Pb (94%), Fe (86%)	Banks et al, 1997
CW	Aerobic wetland and permeable reactive barrier	Fe, Mn, Al, Ni	Northumberland, UK	Full scale	2 years (ongoing)	Fe (99%), Mn (66%), Ni (83%), Al (80%)*	Batty & Younger, 2004
Bioreactor	BCR, aerobic polishing cell, aeration cell	Se, Tl, Zn	Montana, USA	Pilot scale	4 months (ongoing)	Se & Tl (99.5%), Zn (97%)	Blumenstein & Gusek, 2008
CW	3 different wetlands constructed in duplicate	Cu, Fe, S, Se	Minto Mine, Yukon, Canada	Pilot scale	1 year (ongoing)	Cu (89%), Se (26%)	Contango Stategies, 2013
Hybrid	ALDs, sedimentation ponds, CW, SAPS	Fe	Howe Bridge SAPS, Pennsylvania, USA	Full scale	7 years	Fe (50-69%)	Demchak et al, 2001
Bioreactor	SAPS, settling pond, SAPS	Fe, Al	Filson SAPS, Pennsylvania, USA	Full scale	4 years	Fe (90%), Al (20-50%)	Demchak et al, 2001
Bioreactor	Holding pond, SAPS	Fe, Al	Sommerville SAPS, Pennsylvania, USA	Full scale	3 years	Al (30%), Fe (increased)	Demchak et al, 2001
Bioreactor	SAPS, settling pond	Fe, Al	McKinley SAPS, Pennsylvania, USA	Full scale	2 years	Fe (92%), Al (25-90%)	Demchak et al, 2001
Hybrid	2 vertical upflow anaerobic bioreactors, 3 HSSF wetlands, sand filter, holding pond	As, Zn, Cd	Teck Metals Smelter, Trail, BC, Canada	Full scale	5 years (ongoing)	91% to 100% net removal efficiency	Duncan et al. 2002; Duncan, 2010
CW	5 surface flow wetland systems	Ni	Dunka Mine, Minnesota, USA	Small scale	18 years (ongoing)	Ni (30-90%)	Eger et al, 1991; Eger & Eger, 2005; Eger & Beatty, 2013
Bioreactor	Pretreatment pond, 2 bioreactors, settling pond, flushing pond & aeration channel	Al, Cu, Fe, Ni, Se, Zn	Leviathan Mine, California, USA	Full scale	2 years (ongoing)	Al (99%), Cu (99%), Fe (95%), Ni (86%), Zn (98%), Se (20%)	EPA, 2005
Bioreactor	Vertical flow cell, limestone drain, settling pond	Fe, Al, Mn	Indiana County, Pennsylvania, USA	Full scale	7 years	Al (Up to 90%)	Eppley & Gusek, 2009

Cold climate PTSs are highlighted in grey.

*calculated based on available published data. ALD=anoxic limestone drain, BCR=biochemical reactor, CW=constructed wetland, HSSF=horizontal subsurface flow wetland, SAPS=successive alkalinity producing system.

Table 2 (continued): Overview of Pilot and Full Scale Passive Treatment Systems

Passive Treatment Type	Components	Target Contamination	Location	Scale	Duration	Removal rates	Reference
Bioreactor	Limestone drain, 4 anaerobic basins	Cu, Zn, Cd, Pb, Cr, Ni	Kongens Mine, Norway	Pilot scale to full scale	4 years (ongoing)	Cu (85%), Zn (48%), Cd (98%), Pb (82%), Cr (71%), Ni (24%)	Ettner, 2007
Bioreactor	4 anaerobic basins	Ni. Al, Cu, Cd, Zn, Cr	Titania mine, Norway	Pilot scale to full scale	8 years (ongoing)	Ni (35-98%), Al (98%), Cu (98%), Cd (98%), Zn (99%), Cr (64%)	Ettner, 1999
CW	2 HSSF wetlands	Cu, Ni, Zn	Ferrara, Italy	Pilot scale	1 year	Cu (3.4-9%), Ni (25-35%), Zn (26%)	Galletti et al, 2010
CW	Surge pond, 4 sub-surface flow anaerobic cells, 2 aerobic polishing cells	Fe, Zn, Mn, Cd, Cu, Zn, As	Butte, Montana, USA	Pilot scale	2 years	Fe (37%), Zn (99%), Mn (45%), Cu (97%), Cd (99%), As (-38%)*	Gammons et al, 2000
CW	Liming circuit, free water ponds & permeable treatment walls	Fe, Zn, Mn, Cd, Cu, Zn, As	Butte, Montana, USA	Pilot scale	2 years	Fe (99%), Zn (99%), Mn (99%), Cu (97%), Cd (97%), As (53%)	Gammons et al, 2000
Bioreactor	Biofilter	As	Wood Cadillac Mine, Quebec, Canada	Full scale	7 years	As (81%)	Germain & Cyr, 2003; Tasse et al, 2003; Libeiro, 2007
CW	Surface flow wetland	Fe, Mn	Kanata, Ontario	Full scale	2 years (ongoing)	Fe (15-31%), Mn (23-49%)	Goulet & Pick, 2001
CW	CW with permeable barriers	Cu, Zn, Cd, Pb, Ni, Cb, Fe, Mn, As	Curilo, Bulgaria	Full scale	10 years	n/a	Groudev et al, 2008
Bioreactor	Settling basin, 2 anaerobic bioreactors, rock filter & aeration pond	Pb, Zn, Cd, Cu	West Fork, Missouri, USA	Full scale	4 years (est. 30 yr lifetime)	Pb (90%), Zn (80%), Cd (>33%), Cu (>78%)*	Gusek et al, 2000
Bioreactor	Vertical flow BCR, mixing basin, flow dispersion zone	Fe, Al, Cu, Zn, Cd, Mn	Golinsky Mine, California, USA	Full scale	6 years (ongoing)	Zn (~80%), Fe (~99%), Cu (~97%)*	Gusek et al, 2011

Cold climate PTSs are highlighted in grey.

*calculated based on available published data. ALD=anoxic limestone drain, BCR=biochemical reactor, CW=constructed wetland, HSSF=horizontal subsurface flow wetland, SAPS=successive alkalinity producing system.

Table 2 (continued): Overview of Pilot and Full Scale Passive Treatment Systems

Passive Treatment Type	Components	Target Contamination	Location	Scale	Duration	Removal rates	Reference
Hybrid	Vertical flow BCR, mixing pond, vegetated aerobic polishing cell	Fe, Cu, Zn, Cd	Iron King/Copper Chief Mine, Arizona, USA	Full scale	3 years (ongoing)	Al (50%), Cu (93%), Zn (96%), Cd (>89%), Mn (20%)*	Gusek et al, 2013
Hybrid	2 anaerobic bioreactors & aerobic surface flow wetland	Fe, Zn, Cu, Cd, Al	Haile Gold Mine, South Carolina, USA	Full scale	5 years (ongoing)	Fe (85%), Zn (80-100%), Cu (53%), Cd (94%), Al (97%)*	Gusek & Schneider, 2010
CW	6 connected ponds & CW	Fe	Marchand PTS, Pennsylvania, USA	Full scale	7 years (ongoing)	Fe (99%)	Hedin, 2013
CW	2 cell CW	Fe, Al	Quaking Houses, UK	Full scale	1 year (est. 15-20 yr life)	Fe (45%), Al (63%)	Jarvis & Younger, 1999
Bioreactor	Collection ditch, anaerobic cell, oxidation pond & limestone drain	Ni, Cu, Zn, Fe, Al, Mn	Cadillac Molybdenite Mine, N.Quebec, Canada	Full scale	2 years (ongoing)	Al (78%), Cu (97%), Fe (99%), Mn (40%), Ni (98%), Zn (99%)*	Kuyucak,2006
CW	HSSF wetland	Ni, Al, Cu, Pb, Zn, Cr, Fe, Mn	Flanders, Belgium	Full scale	3 years (ongoing)	Ni (49%), Al (93%), Cu (90%), Pb (53%), Zn (87%), Cr (66%), Fe (-50%), Mn (-103)	Lesage et al, 2007
CW	Surface flow wetland	Cr, Ni, Zn	Bahco metallurgical plant, Argentina	Full scale	2 years (ongoing)	Cr (86%), Ni (67%), Zn (95%)	Maine et al. 2006
CW	4 cell CW	Fe, Mn, As	Jackson County, Alabama, USA	Full scale	15 years	Fe (98%), Mn (79%), As (100%)	Mays & Edwards, 2001
CW	3 cell CW	Fe, Mn, Zn, Cd, B, As, Pb	Stevenson, Alabama, USA	Full scale	14 years	Fe (97%), Mn (47%), Zn (33%), Cd (100%), B (52%), As (99%), Pb (26%)	Mays & Edwards, 2001
CW	6 CW cells & 2 anaerobic cells	Fe, Al	Ohio, USA	Pilot scale	>1 year	Fe (84%), Al (36%)	Misch & Wise, 1998
Hybrid	Oxidation pond, surface flow wetlands, vertical flow bioreactors, re-aeration ponds, limestone beds & polishing pond	Fe, Zn, Pb, Cd, As, Ni	Mayer Ranch PTS, Oklahoma, USA	Full scale	4 years (ongoing)	Fe (99%), Zn (99%), Ni (96%)*	Nairn, 2013

Cold climate PTSs are highlighted in grey.

*calculated based on available published data. ALD=anoxic limestone drain, BCR=biochemical reactor, CW=constructed wetland, HSSF=horizontal subsurface flow wetland, SAPS=successive alkalinity producing system.

Table 2 (continued): Overview of Pilot and Full Scale Passive Treatment Systems

Passive Treatment Type	Components	Target Contamination	Location	Scale	Duration	Removal rates	Reference
Bioreactor	Subsurface bioreactor	Fe, Al, As, Zn, Mn, Cd, Cu	Lilly/Orphan Boy Mine, Montana, USA	Full scale	11 years	Fe (65%), Zn (99%), Al (>99%), Mn (75%), As (96%), Cd (>98%), Cu (>99%)*	Nordwick et al, 2006
Bioreactor	Pretreatment, above & below ground bioreactors	Fe, Al, Mn, As, Cd, Cu	Calliope Mine, Butte, Montana, USA	Full scale	3 years	Fe (99%), Al (99%), Mn (32%), As (0%), Cd (19%), Cu (98%)*	Nordwick et al, 2006
Bioreactor	Anaerobic reactor, passive alkalinity addition, anaerobic reactor, passive aeration, aerobic reactor	Fe, Zn, Mn, Al, As, Cd, Cu	Surething Mine, Montana, USA	Pilot scale	Ongoing	Mn (99%) & As (92%)	Nordwick et al, 2006
CW	4 surface flow wetlands	Fe, Zn, Cu, Cd	Kristineberg mine, Sweden	Pilot scale	1 year	Cu (36-57%)	Nyquist & Greger, 2009
CW	Horizontal flow wetland, cascade filters	Mn, Cu, Zn, Cd, Pb, Cr	Sewage Processing Plant, Przywidz, Poland	Full scale	2 years (ongoing)	Pb (60%), Cu (57%), Zn (50%), Cd (67%), Mn (75%)*	Obarska-Pempkowiak & Klimkowska, 1999
CW	Sedimentation pond, aerobic cells, anaerobic cells	Zn, Mo	Antamina Mine, Peru	Full scale	9 years (ongoing)	Zn (51%), Mo (65%)	Plewes et al, 2009
Bioreactor	Vertical flow BCR	Se	Grand Junction, Colorado, USA	Pilot scale	1 year	Se (98%)	Rutkowski et al, 2010
CW	2 CWs (1 large & 1 small)	Cu	Bell Copper Mine, Smither BC, Canada	Pilot scale	2 years	Cu (40-98%)	Sobolewski et al, 1994
CW	CW	Zn	United Keno Hill Mine, Yukon, Canada	Pilot scale	4 months	Zn (90%)	Sobolewski, 1996b
Bioreactor	5 anaerobic cells	Al, Fe, Cd, Cu, Zn	Tulsequah Chief Mine, BC, Canada	Pilot & Full scale	4 years	Al (92%), Fe (97%), Cd (46%), Cu (80%), Zn (32%)*	Sobolewski, 2010.
Bioreactor	2 parallel bioreactors	Se	Smoky River coal mine, BC, Canada	Pilot scale	1 year	Se (97%)	Sobolewski, 2010.
CW	Surface flow wetland	Cu	Campbell Mine, Ontario, Canada	Full scale	14 years	Cu (90-95%)	Sobolewski, pers comm.

Cold climate PTSs are highlighted in grey.

*calculated based on available published data. ALD=anoxic limestone drain, BCR=biochemical reactor, CW=constructed wetland, HSSF=horizontal subsurface flow wetland, SAPS=successive alkalinity producing system.

Table 2 (continued): Overview of Pilot and Full Scale Passive Treatment Systems

Passive Treatment Type	Components	Target Contamination	Location	Scale	Duration	Removal rates	Reference
Hybrid	Fixed film aerobic reactor, biological trickle filter	Al, Fe, Mn, Sr, Zn	Merrick Landfill, North Bay, Ontario, Canada	Pilot scale	1 year	Al (80%), Fe (96%), Mn (87%), Sr (41%), Zn (60%)*	Speer et al, 2012
Hybrid	Fixed film aerobic reactor, sand & gravel CW	Al, Fe, Mn, Sr, Zn	Merrick Landfill, North Bay, Ontario, Canada	Pilot scale	1 year	Al (80%), Fe (95%), Mn (60%), Sr (41%), Zn (60%)*	Speer et al, 2012
CW	Pretreatment basin, aeration cascade, limestone channel & 2 wetlands	Fe, Mn, Zn, As	Jales mining site, North Portugal	Full scale	6 years (ongoing)	n/a	Valente et al, 2012
CW	2 parallel sub-surface horizontal flow CWs	Mn, Al, Cu, Zn	Prague, Czech Republic	Full scale	3 years (ongoing)	Mn (80.9%), Al (>82.3%), Cu (>91.1%), Zn (>97.5%)	Vyzamal & Krasa, 2003
Bioreactor	5 BCRs	Fe, Al	Tab Simco coal mine, Illinois, USA	Pilot scale	4 months	Fe (56%), Al (95%)	Walters et al, 2013
CW	Vegetated wetland and stabilization pond	Pb, Zn, Cd	Pb/Zn mine, China	Full scale	16 years (ongoing)	Cd (94%), Pb (99%), Zn (97%)	Yang et al, 2006
CW	4 wetland cells	Fe, Mn, Co, Ni	Springdale, Pennsylvania, USA	Full scale	2 years (ongoing)	Fe (94%), Mn (98%), Co (96%), Ni (63%)	Ye et al, 2001

Cold climate PTSs are highlighted in grey.

*calculated based on available published data. ALD=anoxic limestone drain, BCR=biochemical reactor, CW=constructed wetland, HSSF=horizontal subsurface flow wetland, SAPS=successive alkalinity producing system.

3. NORTHERN ENVIRONMENTS

PTSs in northern environments are often located in remote locations with limited access and power, short growing seasons and cold winter temperatures, conditions which can present challenges for PTS design. These challenges however, are also often reasons for choosing PTSs, which can be constructed to operate year-round with little maintenance and no power.

For the purposes of this review, cold climates are described as those that may experience freezing conditions during the winter months. This definition allows the inclusion of any PTS that may experience seasonal variations in efficiency and may employ adaptations for cold temperatures. The main problems faced by PTSs in cold climates are hydraulic failure due to freezing, ice formation and insufficient biological activity at low temperatures (Wittgren & Maehlum, 1997; Mander & Jenssen, 2003). Due to the interest in implementing PTSs in cold climates and the need to develop site-specific systems, many adaptations for cold climate PTSs have been examined and case studies illustrating the implementation of cold climate PTSs are detailed in Section 3.2.

3.1. Cold climate effects

Seasonal variations occur in most PTSs due to changes in water flow, senescence of aquatic plants, metabolic activities of microorganisms and variations in temperature and pH. Some wetlands may lose efficiency during the winter months while still meeting water treatment objectives (Groudev et al, 2008). In other cases, no seasonal variation in effectiveness has been found due to complex relationships between oxidation, temperature and pH which maintain the treatment regime regardless of climatic conditions (Hedin, 2013). Some of the main cold climate conditions potentially affecting PTS effectiveness are discussed below.

3.1.1. Temperature

Water temperature changes diurnally and annually. Diurnal temperature changes by approximately 5°C, while annual changes vary depending on latitude and climate. For example, in warm seasons water temperature is approximately equal to air temperature. During periods of ice cover, water temperature is maintained near 0°C for the duration with no diurnal variation (Kadlec & Reddy, 2001). Water temperature directly affects microbial activity by reducing metabolic reaction rates (Oberholster et al, 2014). In addition, plant matter decomposition and adsorption has been shown to decrease as temperature is lowered (Kadlec & Reddy, 2001). The solubility of oxygen (Kadlec & Reddy, 2001) and carbon doxide (Hedin, 2013) is also strongly temperature dependent with greater solubility at lower temperatures. The increased oxygenation in winter can aid aerobic processes, although ice cover can impede oxygenation during the winter and create anoxic conditions (Fortin et al, 2000). Maintaining oxic conditions in sediments during winter has been recommended to increase Fe and Mn retention (Goulet & Pick, 2001). In a PTS in Pennsylvania, Hedin (2013) found there was greater mixing of unfrozen ponds in winter due to density gradients in the water column. Cool water on top continually sunk to the bottom which forced the CO_2-rich deep water to the surface where it degassed. This caused changes in pH and subsequently Fe oxidation rates (Hedin, 2013). This PTS is discussed in greater detail in Section 3.2.10. In general, lower temperatures in winter have the effect of slowing down both biotic and abiotic processes that are essential to the functioning of PTSs, however, in many cases temperature

and efficiency are not directly related. For example, at Silver King mine, Yukon, Canada samples were collected with distance from an adit into a natural wetland/muskeg in the months of December, January and February, when temperatures ranged from -26°C to -49°C (Sobolewski, 2003a). In all three months Zn concentrations dropped from 1.2 mg/L at the adit to 0.15-0.61 mg/L within 160 m from the adit into the wetland. Diagnostic sequential leach analysis was used to identify metal removal processes during these winter months and both Cd and Zn were found mostly adsorbed onto or coprecipitated with iron and manganese oxides (Sobolewski, 2003b). More discussion on cold climate impact on microbial activity is presented in 3.1.3.

3.1.2. pH

pH is very important in PTSs treating mine-impacted water as it affects the solubility, oxidation, adsorption and biological removal of metals (Sheoran & Sheoran, 2006). The solubility of many metals is pH-dependent, with metal solubility typically increasing to toxic levels at lower pH values (Figure 5). For certain metals, such as aluminum or iron, raising water pH to neutrality is usually sufficient to decrease their concentrations to acceptable levels. Other metals, such as cadmium, manganese or zinc, can be soluble at neutral pH and cannot be removed by simple pH adjustment. The solubility of certain contaminants, such as nitrate or selenium, is largely unaffected by pH. Finally, the solubility of certain gases, particularly carbon dioxide, is pH-dependent and changes in solution pH will affect their concentrations. CO_2 degassing has been found to increase at colder temperatures due to greater mixing of the water column (Hedin, 2013) and as CO_2 is released, pH increases. CO_2 degassing has also been found to improve iron and trace metal removal in PTSs likely due to the increase in pH (Nairn, 2013). Conversely, CO_2 solubility also increases at lower temperature which may have the effect of lowering pH.

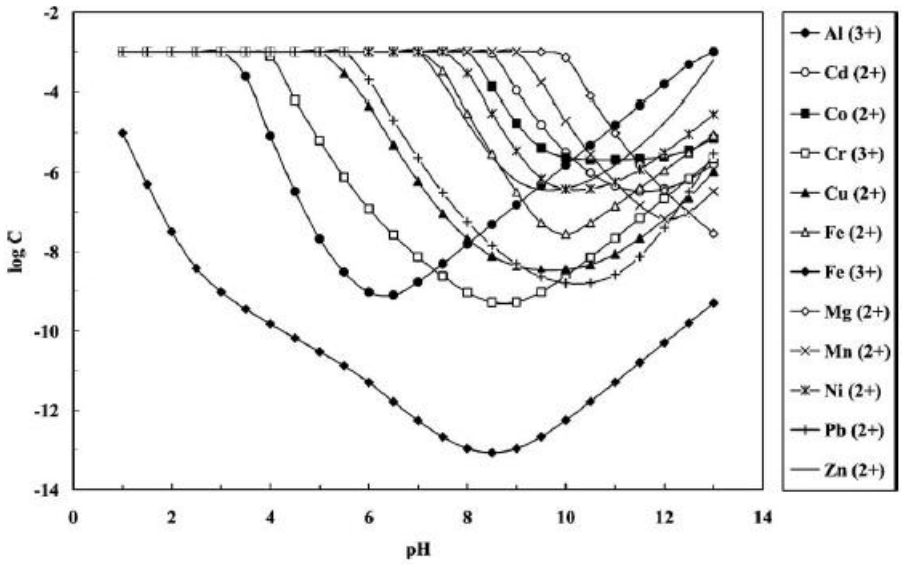

Figure 5: Solubility of different metal hydroxides based on chemical equilibrium calculations using the MINQL+ software. Stimulation conditions: T=25°C, $CI_i = 10^{-2}$ M and $(metal)_i = 10^{-3}$M (Blais et al, 2008, p.137).

Additionally, the precipitation of metals salts, such as aluminum or iron hydroxides can drive significant changes in pH. In some cases, the oxidation and precipitation of dissolved iron may be sufficient to acidify mine water to unacceptable levels. The alkalinity and acidity of water are essential parameters to consider in predicting overall changes in pH that might occur in PTSs.

Biological processes, such as the decomposition of organic matter and plant uptake of metals, are affected by water pH. The sulphate-reducing bacteria (SRB) that are responsible for metal removal, grow within a pH range of 5.5-8.5. Therefore, low water pH hinders their growth and ability to remove metals. Lowering pH has been shown to decrease sulfate reduction rates (Tsukamoto et al, 2004), which is why many PTSs employ pretreatment by ALDs or other limestone-based unit processes. Photosynthesis and respiration have the effect of increasing pH due to the removal of CO_2, therefore pH is likely to be greater in the summer due to growth of algae and plant biomass. pH has been found to have a positive effect on the bioavailability of some metals to some plant species (Deng et al, 2004). Numerous studies have found that temperature and seasonal variation affect pH in PTSs, however the relationship between temperature and pH is complex and requires further study.

3.1.3. Microbial activity

In general, microbial activity decreases with temperature. However, cold-adapted SRB have been studied extensively in the Arctic and Antarctic (Camenzuli et al, 2014; Robador et al, 2009; Sagemann, et al, 1998) and many have adaptations that sustain sulfate reduction rates at colder temperatures. Anaerobic bacteria have been found to grow very slowly below 15°C (Hiley, 2003), although in a CW in Ontario, SRB were found to thrive during winter. Goulet and Pick (2001) showed that the largest SRB populations in a wetland were in December when the water was ~1°C and determined that sulfate reduction rates were highest under those conditions. While sulfate reduction rates are generally lower at colder temperatures and cold-adapted SRB may have higher optimum growth temperatures, sulfate reduction rates may still be maintained at levels similar to those in temperate climates (Fortin et al, 2013). Cold-adapted SRB in the Arctic have been found to be more limited by organic substrate availability than by temperature (Sagemann et al, 1998). Fortin et al. (2013) suggest that decreased organic decomposition in cold temperatures caused the SRB to compensate by increasing their numbers, which maintained the sulfate reduction rates throughout the year. Panos et al. (2013) found that temperature has a large influence on the development of SRB; SRB did not develop at temperatures below 6°C. Despite this, Fe removal efficiency was still relatively high indicating other processes, such as adsorption, may be responsible for maintaining metal removal at lower temperatures (Panos et al, 2013). On the other hand, in a bioreactor at the Calliope mine (Section 3.2.8), results suggested that freezing SRB did not affect their activity during the rest of the year (Nordwick et al, 2006). In a pilot bioreactor in Wyoming, sulfate reduction rates were reduced by 20% in the winter when water temperatures were below 1°C, although this was not enough of a reduction to affect the treatment performance of the bioreactor (Gusek, 2002). In a column experiment on the performance of anaerobic bioreactors at low temperatures, Gould et al. (2012) found that Zn removal fell from 99% to 60% when the temperature was lowered from 20°C to 4°C. They compensated for the loss of efficiency by feeding the columns with liquid carbon (glucose and lactate/acetate) and achieved >95% Zn removal efficiency at 4°C (Gould et al, 2012). Liquid carbon sources can maintain microbial activity in bioreactors over the winter months when cold temperatures reduce organic matter decomposition (Sobolewski, 2010).

3.1.4. Water flow

In cold climates, water flow changes seasonally with large increases in flow in the spring when the snow melts and low flows throughout the winter. Drastic changes in flow present challenges to PTS designers. In a natural wetland in the Rocky Mountains, spring snowmelt caused an increase in the flow to the wetland, which decreased the concentration of metals. The wetland was found to be a sink for Zn and Mn in the summer and a source in the winter due to changes in flow conditions and microbial activity, with the greatest disturbances to treatment efficiency occurring during spring snowmelt (August et al, 2002). Higher flows during spring runoff and throughout the summer likely created more exposed mineral surface area and allowed more of the products of weathering to be flushed out. The higher flows, however, were offset by the increased retention of metals in the wetland. Similar flushing effects were experienced at a subsurface bioreactor constructed in a mineshaft in Montana (Nordwick et al, 2006). Oxygenated spring run-off infiltrated through the ground and mobilized historic metal precipitates creating higher metal concentrations in the effluent in the spring. At a bioreactor in Norway, Cu removal efficiency was found to be highest when water flows were low and constant during the summer (Ettner, 2007). Unlike the majority of sites that experience lower flows in the winter, at this site flows were found to increase in the winter, which resulted in a dramatic drop in removal efficiency. These factors must be accounted for in the design of PTSs.

It is clear that seasonal variations affect the efficiency of PTSs but more work is needed to elucidate the specific mechanisms occurring in cold climate PTSs. Understanding of a site's hydrology, climate, precipitation regime and seasonal water flows allows PTS designers to address site-specific limitations in cold climates. In addition, better understanding of seasonal variations and their effects on metal leaching and metal removal mechanisms will improve the efficiency and reliability of PTSs operating year-round in cold climates.

3.2. Cold climate case studies

Numerous PTSs have been constructed in cold climates at various scales. Below are highlighted case studies of PTSs that demonstrate adaptations in their design for year-round operation in cold climates. Some are successful full scale designs, while others reveal some of the obstacles that may be encountered by PTS designers in cold climates.

3.2.1. United Keno Hill Mine, Yukon – Constructed wetland

In 1995, a pilot wetland was constructed at UKHM and monitored over one year to assess the possibility of treating adit discharge with high levels of Zn (30 mg/L) and other heavy metals (Sobolewski, 1996; Burns, 2000). An area below the Galkeno 900 adit was excavated, fertilized and planted with *Carex aquatilis* collected from a nearby uncontaminated wetland. The plants were allowed to establish for approximately one month, then effluent was piped into a lined pond and then into the wetland. Plywood baffles were subsequently added to distribute the flow evenly throughout the wetland (Figure 6). Zinc removal rates reached up to 90% efficiency in the first season (Table 2), however, the concentration never dropped below 3 ppm, which is well above the 0.5 ppm discharge limit. Other heavy metals were below acceptable limits and more than 80-90% of Co, Ni and Mn were removed. Results from this CW indicated that longer hydraulic retention times within the pilot wetland would have increased the Zn removal efficiency. In addition, Sobolewski (1996) suggested that allowing

vegetation to more fully establish (>35% was unvegetated) would likely improve efficiency. Metal removal in the CW was directly correlated with sulfate reduction, suggesting that Zn was removed as a Zn sulfide precipitate. Wetland plants were analyzed from the natural wetland and the results suggested that contaminants uptake from the sediments into the plants was limited.



Figure 6: CW at Galkeno 900 adit with plywood baffles to help distribute flow evenly (Burns, 2000, p.38).

The CW at the Galkeno 900 adit was only operational for a short time and never reached a steady state before flow was redirected to a limestone treatment system inside the mine adit. The wetland was, however, subject to further analysis in 1999 (Burns, 2000). The author reported that four years after transplant, *Carex aquatilis* had fully covered the constructed wetlands. Below-ground seepage from a waste rock pile was observed to be travelling to the wetland so samples were taken to determine the levels and distribution of contaminants in the wetland. The metal concentrations in sediments decreased with distance from the seep while the concentrations in plants were relatively consistent, except for the concentration of Zn which decreased with distance from the seep. The data indicates that the wetland continues to attenuate metals in the discharge waters.

3.2.2. United Keno Hill Mine, Yukon – Anaerobic bioreactor

In 2008 at UKHM, a pilot horizontal flow bioreactor was constructed on-site at the Galkeno 900 adit (Figure 7 and 8) (Alexco, 2012). A pit was excavated, lined and then filled with waste rock. The pit contained 3 m deep waste rock with a 1.2 m soil cover on top to reduce ice formation in the bioreactor. In March 2011, there was up to 60 cm of ice in the bioreactor. All of the pipes and valves were buried at least 1 m belowground and those running under roadbeds were covered in heat trace. Baffles were installed to distribute the flow throughout the pit. The bioreactor was filled with untreated adit water and sucrose, methanol and/or milk solids were added to stimulate SRB growth in October 2008 and

January and July 2009. From October to July of 2009, the water was recirculated in the bioreactor in a closed circuit and strong sulfate-reducing conditions developed. The flow-through phase then began and constant additions of methanol were initiated. The flow rate was initially 0.5 L/sec (21 days residence time), which was then increased to 1 L/sec (10.5 days residence time) and then reduced to 0.75 L/sec for the rest of the operational phase. At low flows 99.8% of Zn was removed and at higher flow rates 97.8% was removed (Table 2). While the Zn discharge limit (0.5 mg/L) was met consistently at the low flow rate, it was sometimes exceeded at higher rates. It was observed that the residence time within the bioreactor was a major factor affecting metal removal efficiency. While Zn was the primary contaminant of concern, 80% of As was removed at a flow rate of 1 L/sec. Cd was removed to below detection limits and 97.5% of Ni was removed at low flows, but only ~50% was removed at higher flows. Iron and Mn were efficiently removed (99%) during the recirculation phase, but during the operational phase, when the reducing conditions were fully established, Fe and Mn were remobilized resulting in slow release of these metals over the course of operation. The bed of the bioreactor was composed only of waste rock, so sorption was not likely a factor in removing metals; sulfate reduction and metal sulphide precipitation were the primary mechanisms. Some of the engineering problems encountered included uneven distribution of flow and decreased contact with the substrate (i.e. so-called 'dead zones') and pump failure and power outages resulting in pipes freezing and the system having to be shut-down temporarily. A gravity fed system and/or back-up power would have helped to avoid the difficulties of maintaining a constant flow in the winter (Alexco, 2012).



Figure 7: Bellekeno pilot bioreactor under construction in 2008 (left) and after 5 years (right) (Alexco, 2012, p. 6).

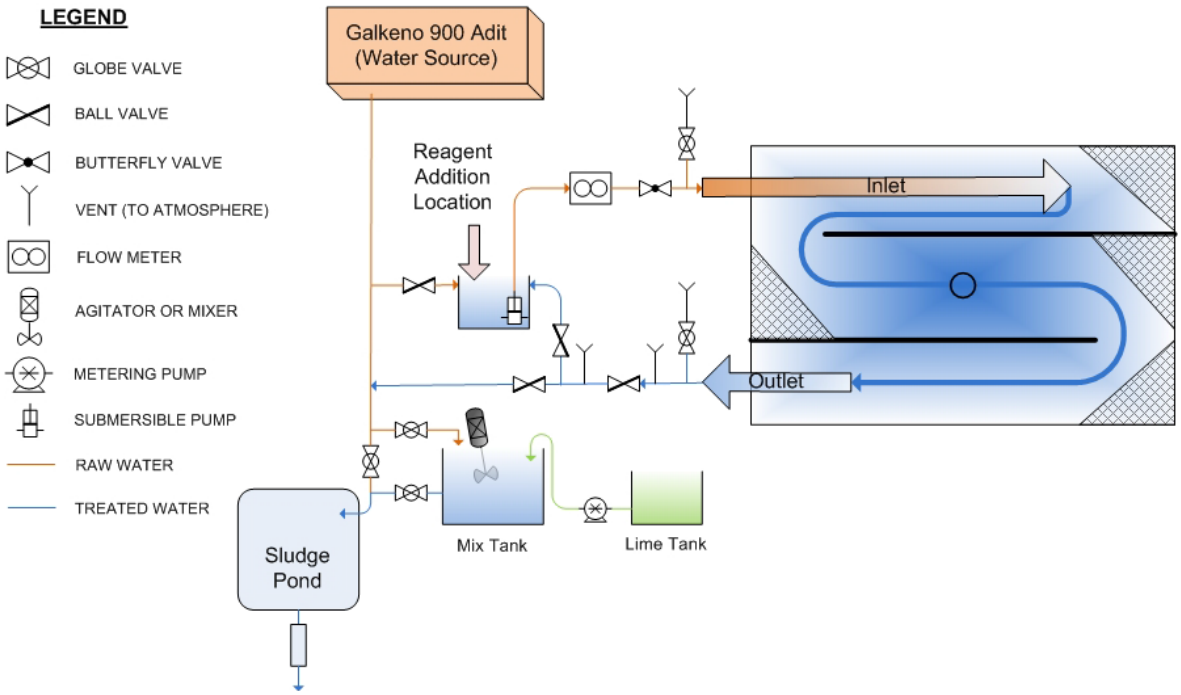

Figure 8: Layout of Galkeno 900 bioreactor (Alexco, 2012, p.7).

3.2.3. Tulsequah Chief & Smoky River Coal Mine, BC

At the Tulsequah Chief Mine (Cu, Pb/Zn) in Northern British Columbia, acidic rock drainage was successfully treated using a 66 m^3 anaerobic bioreactor built inside the mine adit (Sobolewski 2010). Wood mulch was used in the bioreactor; however, as the ambient temperature in the reactor was low (6-8°C), wood mulch decomposition was too slow to maintain anaerobic conditions. To overcome the issue, ethylene glycol was subsequently added to the influent to create reducing conditions, decreasing the dissolved oxygen levels and kick-starting SRB activity. A full scale five cell, 200 m long, bioreactor was then built based on the pilot test results and monitored over four years. The first three cells received a wood mulch/limestone mix to reduce acidity and the two final cells received sulfur prills (elemental sulfur in pellet form) and supported SRB. Ethylene glycol was dripped into cells one and four. The front three cells consistently removed Al and Fe, but also gradually accumulated sludge, which caused failure after four years of operation, while the final cells removed Cd, Cu and some Zn (Table 3). The bioreactor operated year-round without maintenance in the winter and was constructed in areas with limited space, access and power.

Table 3: Metal concentrations in drainage and discharge from Tulsequah Chief pilot and full scale bioreactors (adapted from Sobolewski, 2010).

Parameter	ARD	Pilot-scale bioreactor	Full-scale bioreactor
pH	3.0-3.7	6.0-6.7	6.1-6.7
Al (mg/L)	10-30	0.1-1.0	0.06-2.5
Cd (mg/L)	0.22-0.47	<0.050	0.07-0.30
Cu (mg/L)	16-30	0.1-1.0	2-7
Fe (mg/L)	20-120	0.1-2.0	0.04-4.0
Zn (mg/L)	56-120	30-50	42-77

3.2.4. Smoky River Coal Mine, BC

Two 5 m^3 pilot scale bioreactors were constructed in parallel at the Smoky River Coal Mine to treat Se-contaminated water in an area where access, space and power were severely restricted, (Sobolewski, 2010). The bioreactors were filled with gravel, wood chips, manure, lime and bonemeal, inoculated with Se-reducing bacteria and fed with ethylene glycol as a liquid carbon source. The liquid carbon source helped to sustain necessary microbial processes (Sobolewski, 2010). The bioreactors effectively removed 97% of the Se from September to November 2008 (Figure 9), even when temperatures dropped to 2°C. This case study, along with other studies previously mentioned (i.e. Galkeno 900 and Tulsequah Chief) demonstrates that addition of a liquid carbon source may allow anaerobic bioreactors to keep operating with high efficiency on northern mine sites under winter conditions.

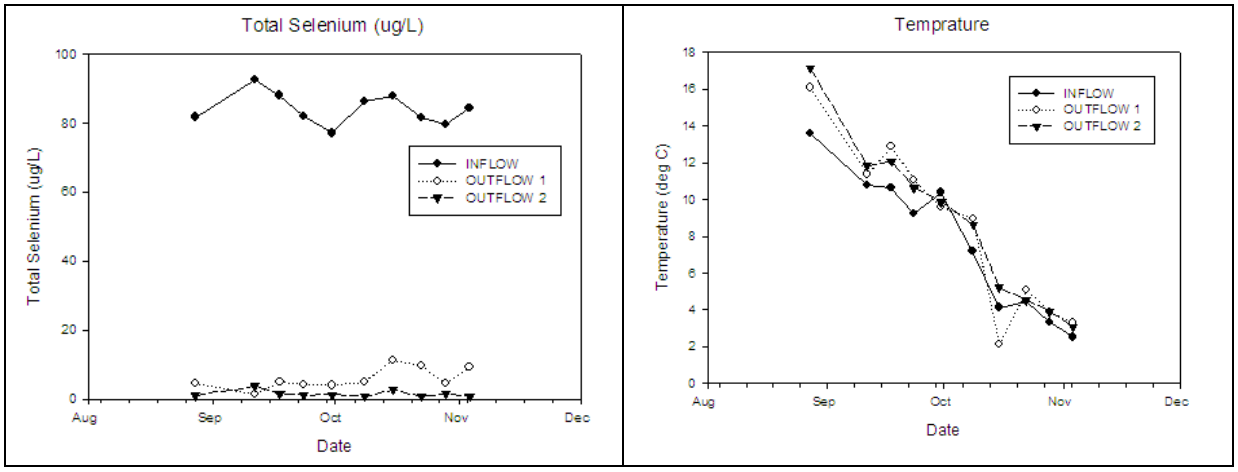

Figure 9: Selenium removal as a function of temperature at Smoky River Coal (Sobolewski, 2010, p. 2)

3.2.5. Kongens & Folldal Mines, Norway

In Norway, bioreactors have been tested for the treatment of acidic mine drainage at both active and abandoned mines in cold climates (Ettner 2007). A first pilot bioreactor system was constructed at the Kongens Mine in northern Norway in 1999, consisting of a pre-treatment limestone drain and four anaerobic cells filled with organic waste materials, rotted hay, sawdust, tree clippings and $CaCO_3$. However, the substrate was found to be inappropriate due to low hydraulic conductivity which caused clogging. Highlighting the importance of thorough design, the substrates were revisited and a new bioreactor system was constructed in 2002 using rotted hay, sand and coarse birch tree materials. In this reactor, up to 85% Cu 48% Zn, 98% Cd, 82% Pb, 71% Cr and 24% Ni were removed in this second pilot system, however Cu removal was significantly reduced in winter months. This reduction was correlated with a drastic increase in the flow rate in the bioreactor (Figure 10). To overcome this issue and avoid high flow variations, a full-scale bioreactor was constructed in 2006 which consists of two identical cells, one receiving a constant flow and the other receiving smaller, but variable flow rates.

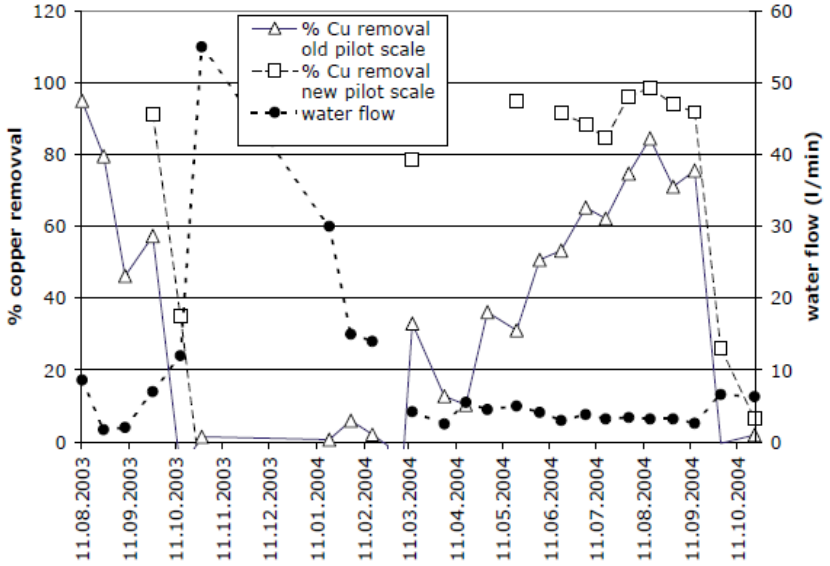

Figure 10: Copper removal (%) by pilot anaerobic reactors versus water flows (Ettner 2007, p.3)

Using a similar design, a pilot bioreactor system was built at the Folldal mine in 2006, with four 8 by 1.5 m basins filled with rotten hay, tree clippings, shell sand and gypsum to act as an extra sulfate source (Ettner 2007). The bioreactors were filled with water in the fall and left to rest for the winter with no flow. Unfortunately, no monitoring data were available from when system was restarted in the spring. However, the study indicated that cold winter temperatures did not prevent inoculation of the bioreactors by microorganisms and development of anaerobic conditions, low Eh and signs of sulfide precipitates were reported.

3.2.6. Bell Copper Mine, BC

At the Bell Copper mine in Smithers, BC, two experimental wetlands were constructed to determine the effectiveness of a year-round CW in a northern environment for treatment of Cu-contaminated water (Sobolewski et al, 1994). Two membrane lined ponds (300 m^2 and 75 m^2) were constructed, fertilized with manure and planted with peat mats dominated by sedges (*Carex aquatilis* and *Carex laeviculmis*). The ponds were also planted with cattails (*Typha latifolia*) and beaked sedges (*Carex rostrata*) and were fully vegetated within a year (Figure 11). For the first year, the wetlands were fed with low flows of mine drainage with low levels of Cu (0.3-1 ppm) at a pH of 6-8. They were 98% effective at removing Cu (Figure 12) throughout the winter months when the wetlands were covered in ice and even when the influent Cu concentrations occasionally spiked to 10 ppm (Sobolewski et. al., 1994). Mine drainage with high levels of Cu (35-50 ppm) at pH 3.5 was then introduced to the wetlands. For the first six weeks, they maintained removal efficiency, but then gradually started deteriorating reaching 40% efficiency for the large wetland and 80% for the small one. Both a decrease in pH and SRB population were observed concurrently with the reduction of Cu removal efficiency. The reduction of efficiency of the wetland was likely due to reduction in the activity and growth of SRB, which were not acclimated to the low water pH. Longer retention times and pretreatment to increase pH were suggested as means to address the shortcomings of these wetlands for treatment of highly contaminated mine drainage (Sobolewski et al, 1994).

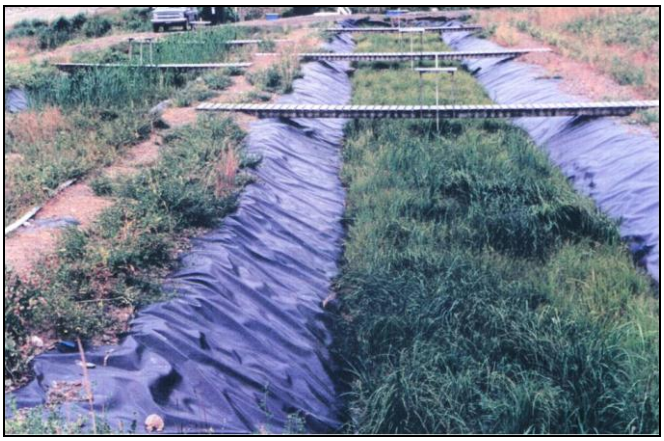

Figure 11: Pilot wetlands at the Bell Copper Mine (Sobolewski A., personal communications, November 12, 2014).

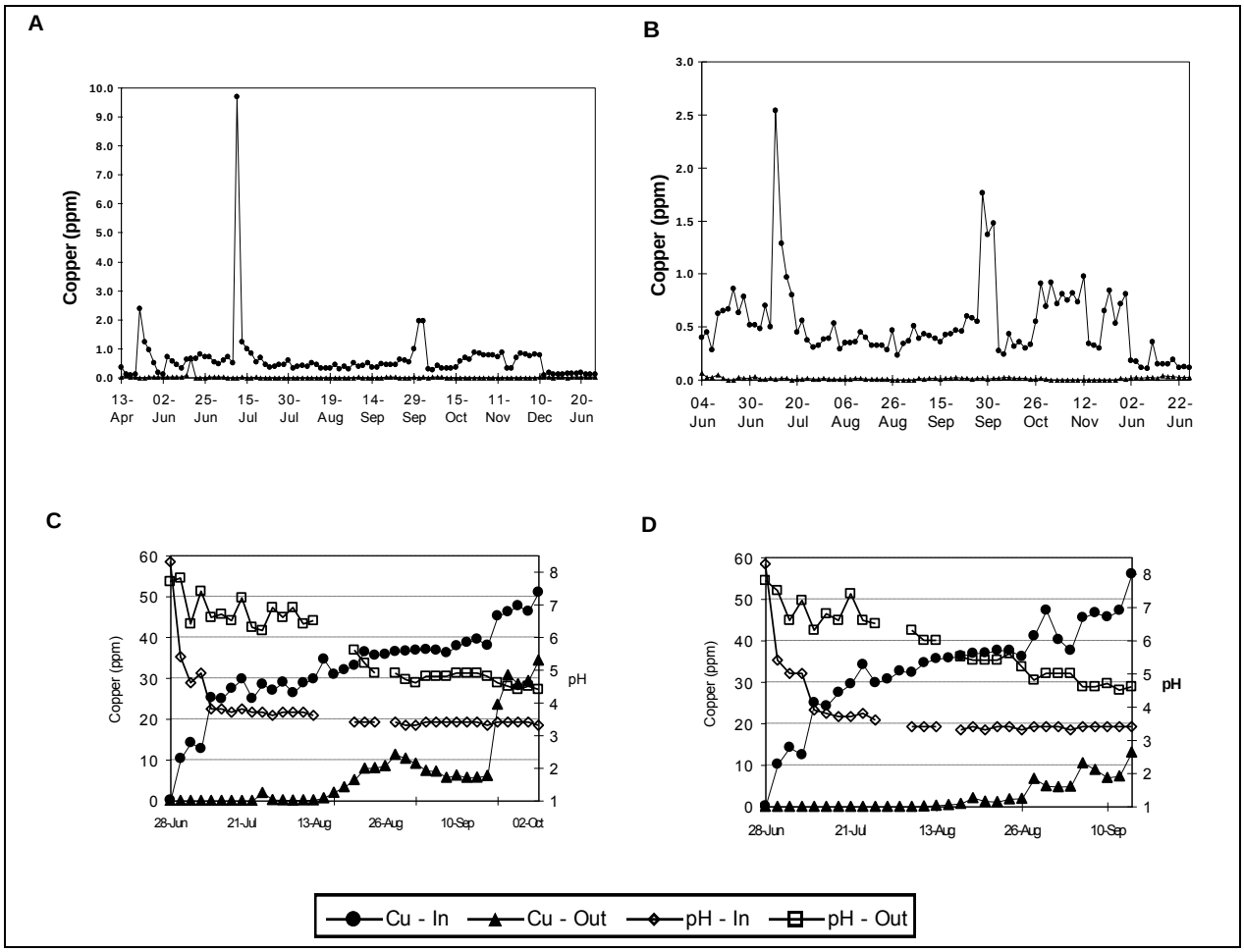

Figure 12: Copper concentrations and pH of influent and effluent for the large (A, C) and small pond (B, D) at low strength (A, B) and high strength feed (C, D) (April 1992 to Oct 1993, Sobolewski et al, 1994, p. 686). Note different scales used in A and B.

3.2.7. Lilly/Orphan Boy Mine, Montana

At the Lilly/Orphan Boy Mine in Montana, USA an in-situ bioreactor was constructed and operated between 1994 and 2005 to treat ARD at the abandoned mine (Canty, 2000; Nordwick et al, 2006; Bless et al, 2008). The bioreactor was built within an old mineshaft, approximately 9 m below the static water level. Organic matter, cow manure and straw were placed on a platform inside the shaft with mine water flowing upward through the organic substrate (Figure 13). This below-ground design offered protection from the cold winter temperatures (ambient temperature was 8 °C) and worked successfully for over 11 years. Removal efficiencies were between 98% and >99% for Al, Cd, Cu and Zn and 96% for As. However, the mineshaft bioreactor design also came with challenges, including metal leaching within the mine tunnel as water travelled out through the portal, creating effluent with, in some cases, higher contaminant concentrations (As and Fe) (Table 4). Additionally, this system was affected by snowmelt and spring run-off. Higher metal concentrations in the spring were attributed to greater metal leaching from the rocks by oxidation due to oxygenated surface water infiltrating into fractures in the rocks and tunnel walls (Nordwick et al, 2006). For most metals, metal removal had

seasonal variability with high removal efficiencies during the summer, but low removal efficiencies at all other times of the year (Figure 14). However, Mn and Zn were removed effectively year-round.

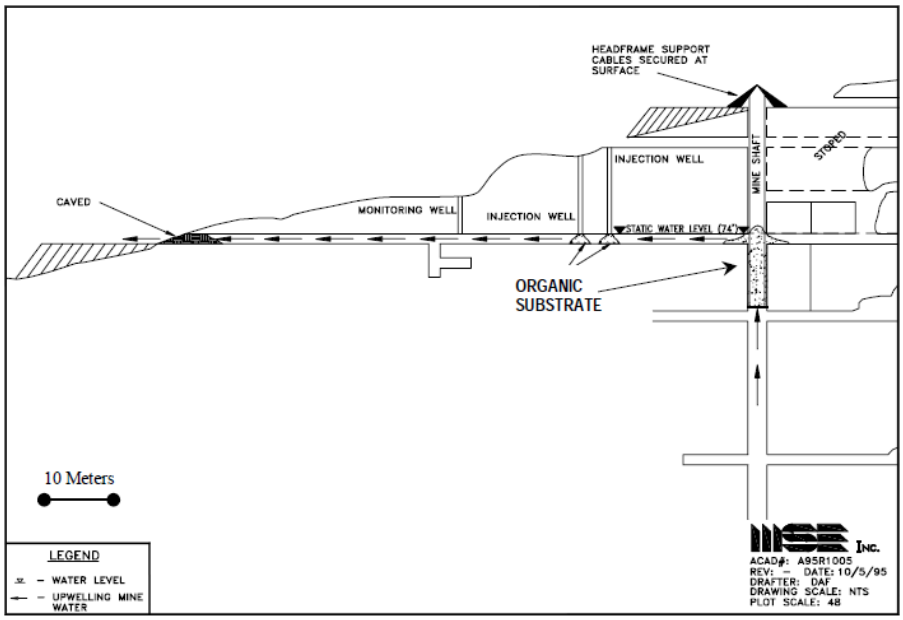

Figure 13: Underground bioreactor at Lilly/Orphan Boy Mine, Montana (Nordwick et al, 2006, p. 1412).

Table 4: Representative mine water chemistry at Lilly/Orphan passive treatment system (dissolved metals in mg/L) (Bless et al, 2008, p. 243).

Sample	Month	Fe	Zn	Al	Mn	As	Cd	Cu	SO_4	pH
Pretreatment shaft	Several	27.7	26.1	9.7	6.2	1.07	0.33	0.32	277	3.0
Pretreatment portal	Several	14.1	19.4	7.4	5.5	0.08	0.24	0.33	213	3.4
Treated tunnel water	March 2001	9.3	<0.01	<0.02	1.4	0.02	<0.005	0.022	59	7.4
	May 2001	13.2	0.06	<0.02	2.7	0.13	<0.005	<0.005	214	7.0
Treated portal effluent	March 2001	30.8	10.1	0.2	5.5	5.26	0.040	<0.002	161	6.1
	May 2001	11.2	28.8	11.2	6.4	0.05	0.301	0.686	394	3.4

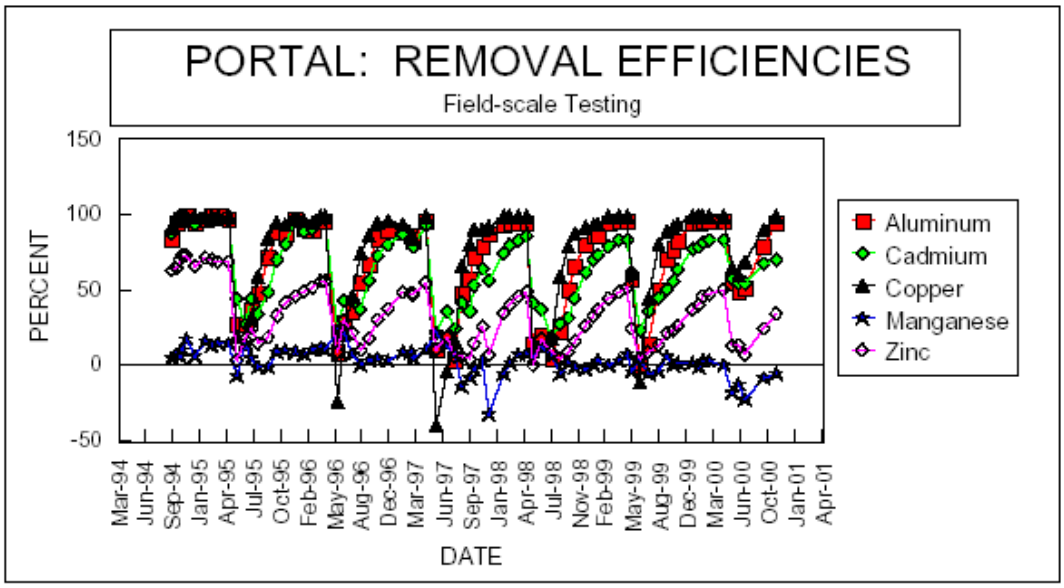

Figure 14: Metal removal in Lilly/Orphan Boy Mine (Canty, 2000, p. 3).

3.2.8. Calliope Mine, Montana

Pilot-scale bioreactors were built at the Calliope Mine in Montana to determine the effect of freezing on SRB (Nordwick et al, 2006; Wilmoth 2002). Two bioreactors were placed in trenches (21.8m and 18.6m long) and one was constructed aboveground (22.1m long) to investigate the impact of seasonal freezing and thawing on treatment performance (Figure 15). The trenches were filled with cow manure, straw, limestone and Terracell^{TM} to prevent organic matter settling, improve permeability and ensure uniform flow through the bioreactors (Figure 16). The systems were operated with a horizontal flow and 4.5 days residence time (+1 day pretreatment in the longer belowground system). Once the SRB populations were established, the mine water was introduced. Zinc, Cu, and Cd were removed as sulfides through bacterial activity while Fe, Mn, Al and As removal was affected by SRB only in an indirect manner by responding to increased pH caused by SRB activity. Zn, Cu and Cd were removed from the ARD to approximately 500 to 800 µg/L for Zn, 80 µg/L for Cu, and 5 µg/L for Cd in both the belowground and aboveground configurations, indicating that at Calliope site, the bioreactor efficiencies were not affected by freezing and thawing. Removal of Fe, Al and Cu was very effective (99%), whereas As was not removed at all and Mn were removed to a lesser extent (32%). Plugging by chemical precipitates affected the flow rate during operation. However it was observed after deconstruction of the aboveground bioreactor that less organic material would have been just as effective, which would have increased the permeability without compromising the efficiency. Overall, a uniform horizontal flow was successfully achieved in the bioreactors. The pilot project also demonstrated that SRB need time to establish, but once established and supplied with organic carbon, they can maintain an active population at temperatures ranging from 2°C to 16°C, without being affected by winter conditions (Figure 16). Additionally, a well-established population can withstand freezing in winter with little or no effect on their activity during the rest of the year.

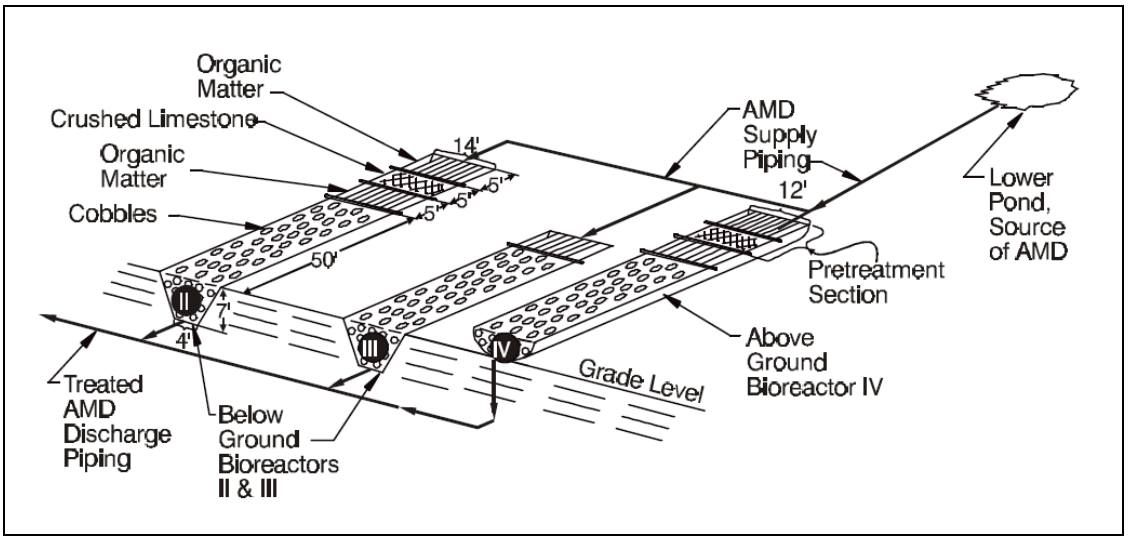

Figure 15: SRB bioreactors at Calliope Mine (Wilmoth, 2002, p.21).

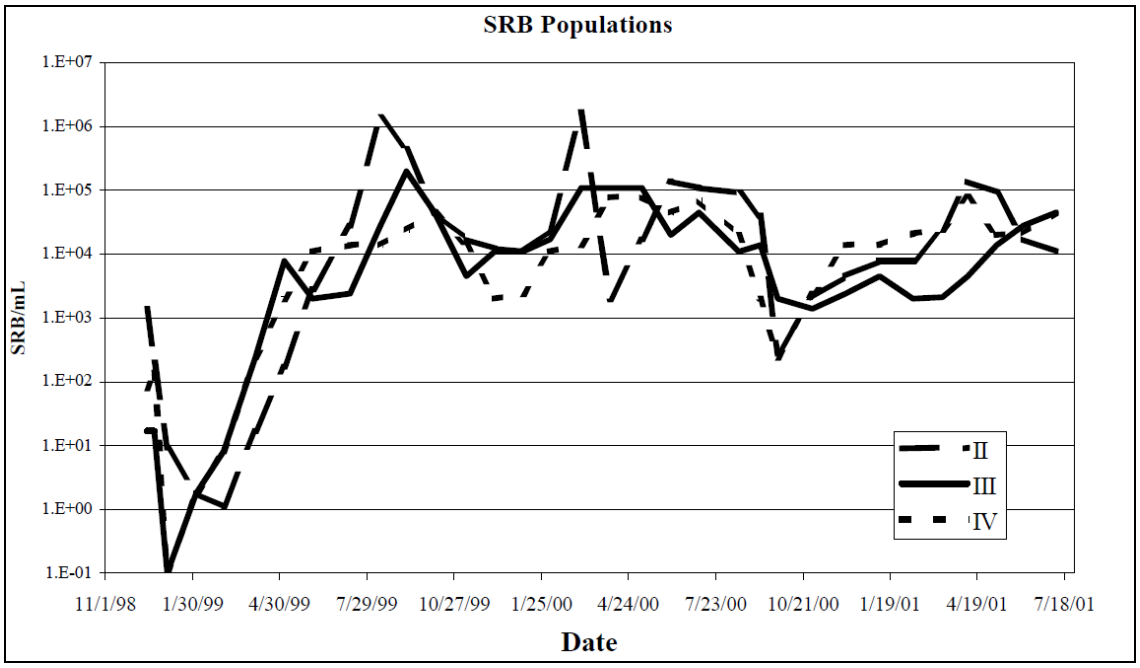

Figure 16: SRB population variation over 3 years in below-ground (II and III) and above-ground (IV) bioreactors at Calliope mine, Montana (Wilmoth, 2002, p. 35).

3.2.9. Cadillac Molybdenite Mine, Quebec

At the decommissioned Cadillac Molybdenite Mine in Northern Quebec a 170 m^3 bioreactor was constructed to treat ARD with acidic pH ranging from 2.7-5.6 (Kuyucak et al, 2006). Passive treatment was chosen due to the lower cost and maintenance as compared to an active system and the remoteness and limited access for much of the year. The extreme cold for 6 months of the year (average -20°C) also presented a challenge in the design of the system. The treatment unit consisted of a collection ditch, an anaerobic cell filled with wood chips, limestone, hay and manure, followed by an oxidation pond and a limestone drain (Figure 17). The nutrient mixture was allowed to condition for 2 months prior to installation in the cell to allow the establishment of SRB before winter. In addition, an overflow drain was installed in the anaerobic cell and the collection ditch to allow excess mine drainage to bypass the SRB cell and help keep uniform flow in the bioreactor. The surface of the collection ditch and anaerobic cell were covered with 50 mm polystyrene sheets and 0.25 m of clay to prevent freezing (Figure 18). During the winter, the effluent temperature dropped to 3°C and the anaerobic cell was at 4°C. Since its implementation in 2004, removal to below regulated limits for Cu (0.3 mg/L), Ni (0.5 mg/L) and Zn (0.5 mg/L) has been successful (Table 5). Iron removal was not as successful during the winter, when settling of Fe precipitates in the oxidation pond was inhibited by freezing. Aluminum removal was also improved during the summer as SRB activity increased. Monitoring of the site continues and an expansion is planned to accommodate all of the effluent.

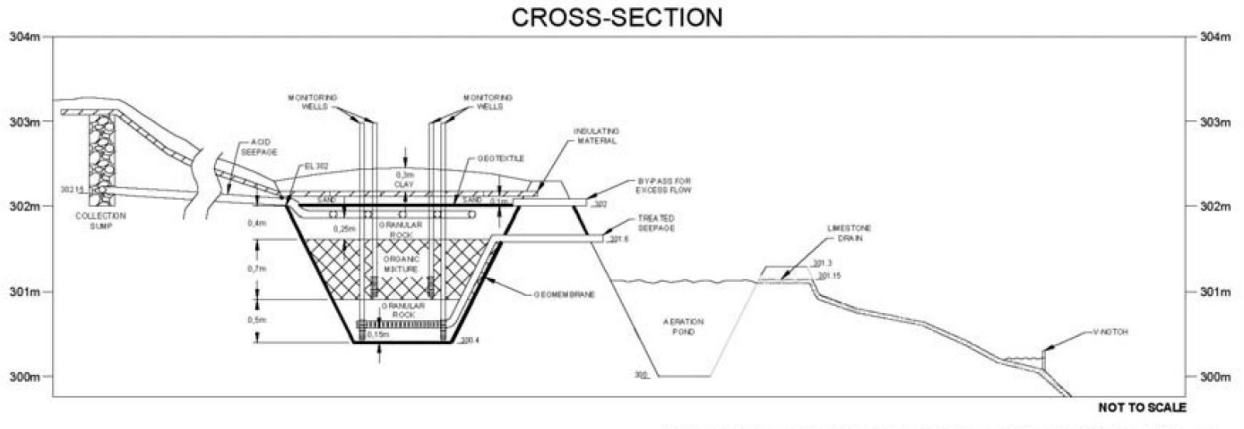

Figure 17: Bioreactor design at the Cadillac mine in Quebec (Kuyucak et al, 2006, p. 988).

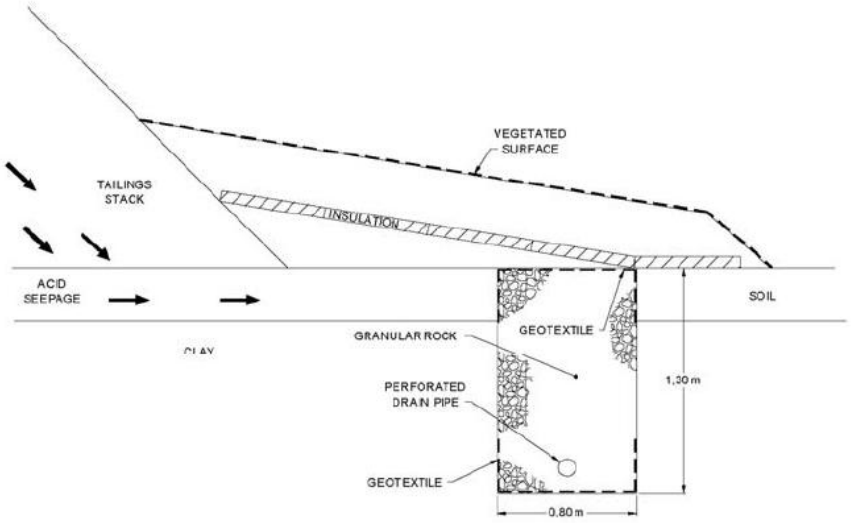

Figure 18: Cross-section of the collection ditch at the Cadillac mine PTS illustrating the use of insulation above the seepage (Kuyucak, et al, 2006, p.989).

Table 5: Water quality before and after passive treatment system at Cadillac mine, Quebec (from Kuyucak et al, 2006, p.982)

Parameter *	Directive 019	Before Treatment	After Treatment						
		Average *	Nov'04	Dec'04	Jan'05	Feb'05	Mar'05	Apr'05	Average 2005
pH	6.5	3.45	6.4	6.3	6.3	6.3	6.4	6.6	6.7
TSS	25	230	32	3.5	17	22	14	17	11.7
Al	-	43	-	-	-	18	19	11	9.4
Cu	0.3	0.3	0.1	0.06	<0.01	<0.01	<0.01	<0.01	0.008
Fe**	3	13.5 (32)***	10.5	11	2.8	1	0.6	0.3	0.12
Mn	-	5.8	-	-	-	5.7	5.5	3	3.5
Ni	0.5	0.6	0.33	0.18	0.04	0.02	0.02	<0.01	0.01
Zn	0.5	1.35	0.48	0.3	0.02	0.02	0.02	0.02	0.012
SO_4	-	887	798	690	700	620	500	360	-

* All in mg/L except pH
** >90% of iron was in Fe(II) form
*** average in 2005

3.2.10. Marchand Mine, Pennsylvania

In a PTS treating coal mine drainage in Pennsylvania, Hedin (2013) found that seasonality did not significantly affect Fe removal efficiency over a six year monitoring period. The system is comprised of 6 connected ponds and a CW planted with a mix of aquatic species (Figure 19). Models predicted Fe oxidation rates would be 10 times slower in cold seasons than in warm seasons (-15°C to +35°C); however, that was not the case in this PTS; Fe removal was found to be temperature independent (Figure 20). An inverse relationship between pH and temperature offset the expected reduction in efficiency. CO_2 solubility increases as temperature decreases, so it was unexpected when CO_2 degassing increased at colder temperatures in the ponds. This was likely due to more thorough mixing at colder temperatures. Surface waters are continually cooled and sink due to density gradients resulting in deep water that is more saturated with CO_2 coming to the surface and degassing. The increased degassing causes an increase in pH, which in turn increases Fe oxidation rates. Although this process can account for the results observed in the ponds, the seasonal dynamics in the wetland cell were far more complex. While the temperature in the oxidation ponds never fell below 4°C, portions of the wetland froze during cold weather and it was largely covered with ice during cold periods. The ice cover reduced gas exchange processes during the winter and biological activity increased during the summer. As a whole, the PTS was effective year-round at reducing Fe levels to below permissible limits (Table 2) and Fe removal efficiency did not change seasonally. Additionally, the iron sludge precipitated in the ponds is recoverable and may be sold to offset the treatment costs (Hedin, 2013). This case study highlights the complex interactions that can occur between temperature-sensitive processes, complicating predictions of temperature effects on removal rates.

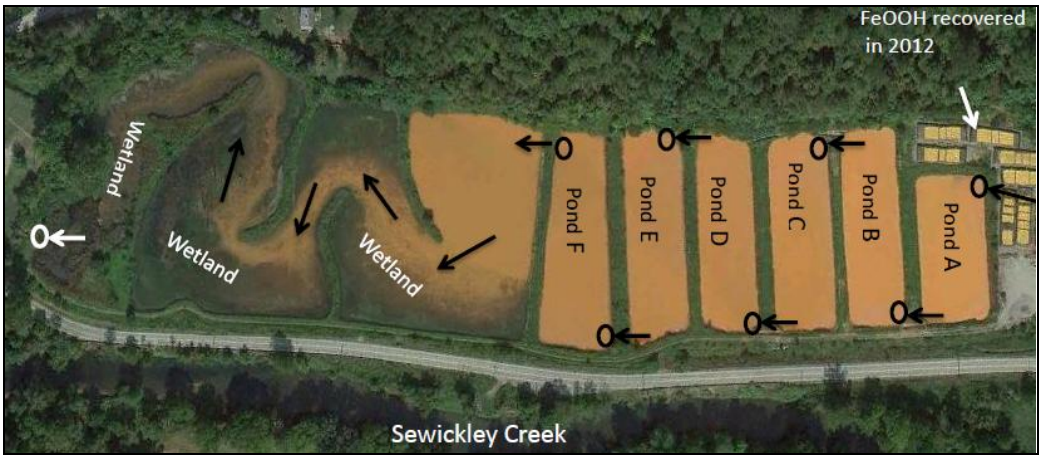

Figure 19: Aerial view of the Marchand mine bioreactor ponds, wetlands and recovered iron sludge (Hedin, 2013, p.9).

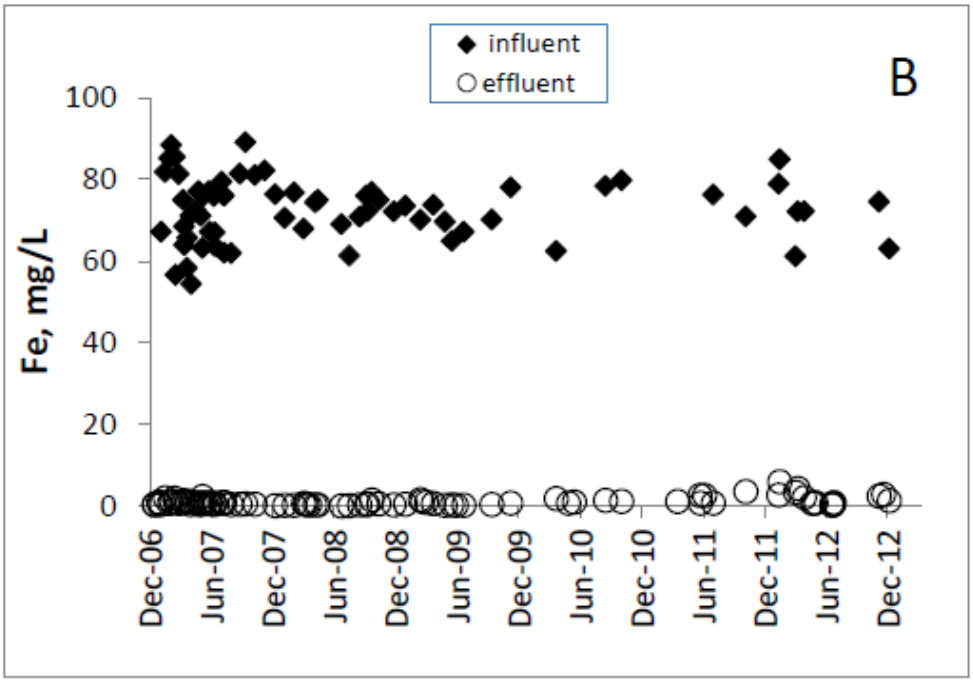

Figure 20: Total Fe concentration at influent and effluent of the Marchand mine treatment system, Pensylvania (Hedin, 2013, p.10).

3.2.11. Teck Smelter, Trail, BC

A PTS was constructed near Trail, BC to treat effluent containing very high concentrations of As, Zn and Cd from a Pb/Zn smelter (Table 6) (Duncan et al, 2002; Mattes et al, 2004). The first phase, constructed in 1997, consisted of three wetland cells (50 m^2 for 1st and 2nd cell and 300 m^2 for 3rd cell). The first cell was planted with *Brassica spp*. and *Helianthus annuus*, the second planted with *Calamagrostis canadensis* and other native grasses from the local area and the third cell was planted with *Typha latifolia* (Figure 21). The cells were initially watered with stream water to allow root growth to establish during the first year. In 1998, a vertical sub-surface flow bioreactor was built upstream with pulp mill biosolids, sand and cow manure. It was designed to allow 1 m of standing water to sit on top to protect it from winter freezing and to ensure it stayed anaerobic. Additionally, all pipes and control valves were buried below 0.9 m. Due to plugging in the first bioreactor and to increase Zn removal, another bioreactor cell was similarly constructed in 2000, upstream of the first (Figure 21), which was subsequently rebuilt. The second cell included limestone to increase the pH and thus improve Zn removal efficiency. The system was fully winterized for year-round operation, although was shut down due to a frozen pipe after a year of operation. After two years of operation (spread over a 5 year period), the system reached a net removal efficiency of 96% for As, Cd and Zn (Table 6), although As levels in the effluent were still not below stringent discharge limits. While seasonal efficiencies are not available, this system purportedly works efficiently year-round and successfully withstands freezing conditions.

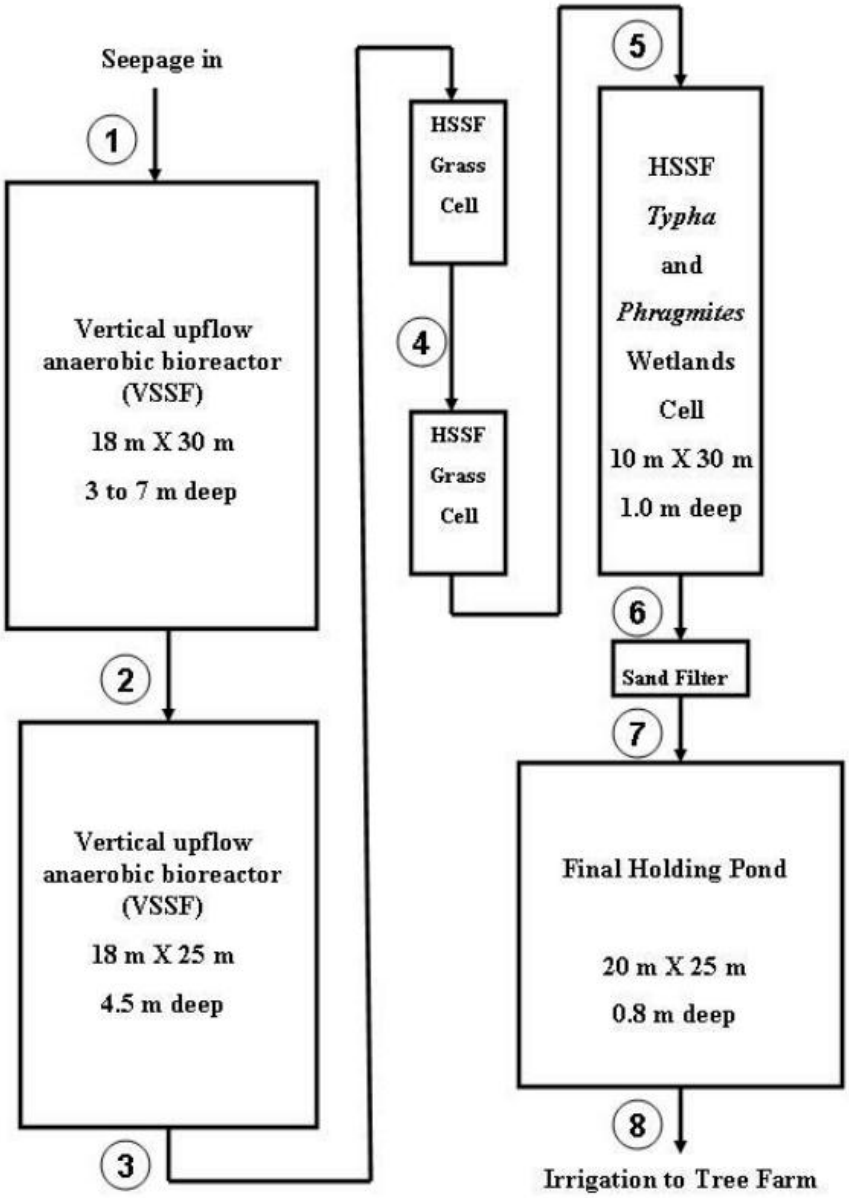

Figure 21: Diagram of the sequence of PT components at the Teck smelter, Trail, BC (Duncan, 2010, p. 40).

Table 6: Metal concentrations (ppm) and percentage removal during to operating periods (257 and 576 days) of the passive treatment system at Teck smelter, Trail, BC (Duncan et al, 2002, p.5).

Sample Point	As. Conc.	% Removed	Cd. Conc.	% Removed	Zn Conc.	% Removed
Input	69.5		5.1		355	
Anaerobic 1	18.7	73.1	2.1	58.8	177	50.0
Anaerobic 2	8.2	56.1	0.4	81.0	101	43.4
Cell 1	5.0	39.0	0.1	75.0	55.4	45.2
Cell 2	4.7	1.5	0.1	0.00	46.8	15.5
Cell 3	1.5	68.1	0.04	60.0	19.8	57.7
Final Pond	1.3	13.3	0.03	25.0	15.1	23.7
Total %		98.1		99.4		95.7

3.2.12. Uranium mine, Curilo, Bulgaria

A four cell constructed wetland in Curilo, Bulgaria successfully treated acidic drainage (pH 2-4) from a uranium deposit over a 10 year period (Groudev et al, 2008). The wetland cells were lined with a mixture of soil, plant and spent mushroom compost, cow manure, crushed limestone, silt and sand. Several barriers of this mixture were placed perpendicularly to the water flow. The wetland was vegetated with *Typha latifolia*, *Typha angustifolia, Phragmites australis, Scirpus lacustris,* and some *Juncus, Eleocharis, Poa* and *Carex* species. The wetlands significantly reduced heavy metal concentrations year-round, operating with a flow-rate between 0.2 to 1.0 L/s and a residence time between 0.5 and 5 days (Table 7). While efficiency was strongly temperature dependent, the effluent metal concentrations during the winter months (when water temperatures were below 5°C) were still below permissible discharge concentrations. Microbial activity was lower in wintertime; however, the longer residence time (i.e. lower flow) helped to sustain satisfactory removal efficiency. High metal concentrations measured in dead biomass indicated that sorption processes by dead plants and clays played an important role in removing metals in during the winter (Groudev et al, 2008).

Table 7: Water quality data before and after treatment by constructed wetlands at Curilo, Bulgaria (Groudev et al, 2008, p.94).

Parameters	Before treatment	After treatment	Permissible levels for waters used in agriculture and industry
Temperature, °C	(+0.1)–(+25.1)	(+0.1)–(+28.0)	–
pH	2.15–4.15	6.51–7.92	6–9
Total dissolved solids, mg/l	590–3250	341–2804	1500
Solids, mg/l	23–170	15–122	100
Dissolved organic carbon, mg/l	0.3–4.6	18–88	20
Sulphates, mg/l	341–1784	280–1254	400
Uranium, mg/l	0.28–4.82	<0.10	0.6
Radium. Bq/l	0.05–0.55	<0.05	0.15
Copper, mg/l	0.41–14.9	<0.1–<0.5	0.5
Zinc, mg/l	0.80–24.2	<0.5	10
Cadmium, mg/l	0.01–0.12	<0.01	0.02
Lead, mg/l	0.10–0.82	<0.10	0.2
Nickel, mg/l	0.32–7.35	<0.1–<0.5	0.5
Cobalt, mg/l	0.23–6.20	<0.1–<0.5	0.5
Iron, mg/l	73–1072	<1–14	5
Manganese, mg/l	0.95–55	<0.5–6.4	0.8
Arsenic, mg/l	0.01–0.59	<0.01–<0.1	0.8

3.2.13. Wood Cadillac, QC

An anaerobic bioreactor was built at the historic Wood Cadillac mine site, in northwestern Quebec, to treat an As-rich effluent. The tailings at Wood Cadillac are sulphidic with an excess of buffering capacity, producing neutral mine drainage (Tasse et al, 2003). The 50 x 57 x 1 m bioreactor was filled with local yellow birch bark to create reducing conditions and fed with seepage at average flow rates of 7.3L/sec in 2000 and 5.0 L/sec. in 2002 (Germain and Cyr, 2003). The biofilter displayed high As removal efficiencies, even in November with a typical seasonal temperature decrease (Figure 22) and the concentrations of As were lowered to below 0.057 mg/L except in June 2001. Overall, this bioreactor fulfilled its objectives over the first three years when it was monitored. Later in 2004, after 5-years of operation and with no interventions, Libeiro (2007) studied the bioreactor again and reported that As removal was still achieved by the reactor, lowering the inlet concentration of 0.03-0.26 mg/L down to 0.002-0.05 mg/L at the bioreactor outlet.

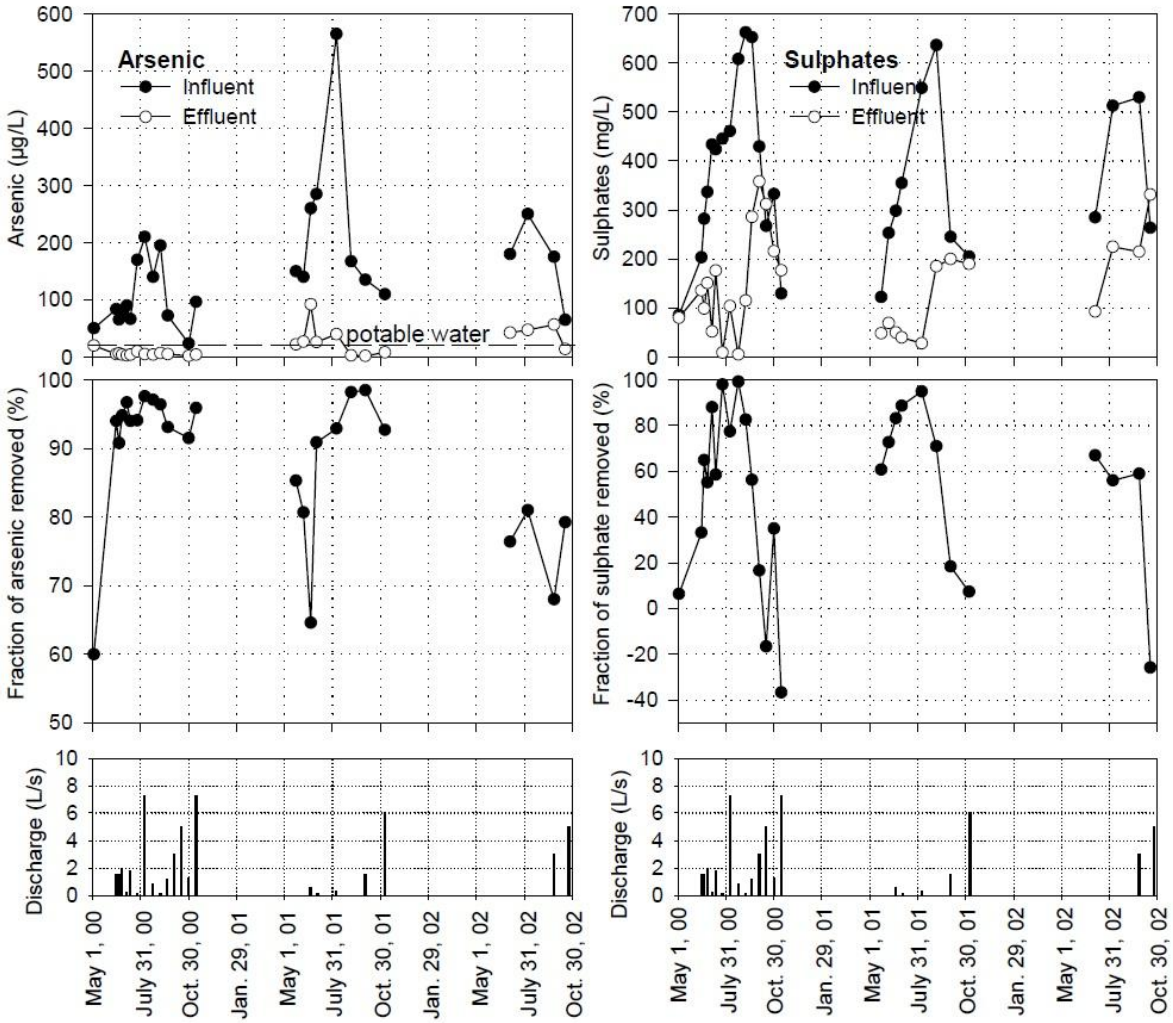

Figure 22: Arsenic and sulphates at the influent and effluent of the biofilter and their respective fraction removed from May 2000 to October 2002. Measured discharge rates are also shown (Germain and Cyr, 2003, p. 7).

3.3. Cold climate solutions

Several pilot scale and full scale PTSs have been built in cold climates and while the efficacy of these PTSs varies, many have successfully treated mine-impacted water (Sobolewski et al, 1994; Nordin, 2000; Duncan, 2002; Wilmoth, 2002; Kuyucak et al, 2006; Groudev et al, 2008; Sobolewski, 2010; Alexco, 2012; Hedin, 2013). It is clear, however, that cold climate adaptations are required for PTSs in these environments. While site-specific adaptations are often required, some basic principles are common to most cold climate PTSs, discussed below.

3.3.1. Burial and insulation

Freezing temperatures cause obvious problems where liquid water is concerned. Solutions are also relatively straightforward. Freezing of PTSs due to cold ambient winter temperatures can be avoided by underground burial or belowground operation. To avoid hydraulic failure caused by freezing, pipes should be buried below the frost line and/or heat-traced (Duncan, 2002; Alexco, 2012). Bioreactors may also be built in abandoned mineshafts to allow year-round operation in cold climates (Nordwick et al, 2006).

Insulating PTSs from freezing can also be achieved in various ways. Insulation may be in the form of burial under organic matter, vegetation or standing water, as in the case of horizontal sub-surface flow wetlands (Duncan et al, 2002); insulation with a layer of straw (Kadlec et al, 2003); polystyrene sheets (Kuyucak et al, 2006); air pockets (Giaever, 2003); or snow cover (Kadlec et al, 2003). For systems in the far north, the design must account for interactions with permafrost, both in the short-term (potential freezing from the sides and bottom of excavations) and in the long-term (subsidence induced by loss of permafrost). If precautions are taken then maintenance of above zero temperatures in bioreactors or CWs can be relatively easy, as decomposition and bacterial activity help to maintain temperatures.

3.3.2. Establishment of biotic communities

PTSs rely on biotic components for which seasons of high productivity are often short and also coincide with periods when construction takes place. Bacteria and vegetation in northern environments are adapted to survive and thrive in these conditions, however, in engineered systems the time needed to establish these communities can be overlooked. Due to extreme seasonal variation in cold climates, any PTS with components of vegetation or microorganisms must prepare for periods of low or no productivity. Construction should be planned such that vegetation is allowed to fully establish in wetlands before mine-impacted water is introduced (Goulet & Pick, 2001). Typically, excavation of beds and other earthworks will be done in the fall, while plant propagation and fertilization is done in early spring, allowing a full growing season to recover from transplantation shock and establishment of a sturdy root system.

Similarly, SRB populations need time to colonize substrates prior to introduction of contaminated waters and cold temperatures (Gusek, 2002; Kuyucak et al, 2006; Nordwick et al, 2006; Alexco, 2012). Starting passive systems in warm ambient temperatures at the beginning of the summer is often the best way to ensure the survival and establishment of SRB and macrophytic communities. Burial of the organic layer can also aid in the establishment of dense biotic communities (Kuyucak et al, 2006). More specifically, when a new PTS is commissioned in the fall, establishment of the microbial community and satisfactory removal efficiencies might require 3 to 12 months (Wilmoth, 2002; Hedin, 2013). Sufficient establishment of biotic communities can be a challenge in cold climates with short growing seasons, but is often crucial to the efficient functioning of PTSs.

3.3.3. Maintenance of constant flow

Constant, steady flow through a PTS is essential to maintain hydraulic retention times and to avoid freezing. Hydraulic failure due to freezing may occur if flow is decreased below a minimum rate. Additionally, increased flow during spring run-off can be detrimental to the efficiency of a PTS. Flow

through PTSs should be maintained at a constant rate through different seasons to reduce the potential of flushing out heavy metals (August et al, 2002; Nordwick, 2006). Flushing of metals may also occur as a result of system shutdowns or addition of new treatment cells (Duncan, 2010). To aid in maintaining constant flow, flow equalization ponds should be designed upstream of the treatment system. Overflows may also be necessary to accommodate spring run-off or surges in flow (Kuyucak et al, 2006). Bypasses may be necessary for components that may not function in winter. Parallel systems can also be used to accommodate increases in flows (Ettner, 2007). Recirculation of treated water at times of low flow volume may also be a solution for some PTSs. While maintaining constant flow is not an easy task in areas with extreme seasonal variation in flow rates, solutions do exist and further innovation will continue to improve this aspect of PTSs.

3.3.4. Liquid carbon sources

Bioreactors that rely on bacterial activity to treat mine-impacted water experience reductions in organic matter decomposition during the winter when cold temperatures cause limited productivity. To offset the reduction in organic matter decomposition, which feeds SRB, the addition of liquid carbon may be advantageous (Tsukamoto et al, 2004; USEPA, 2005; Sobolewski, 2010 Alexco, 2012; Gould et al, 2012). Often, the increased and year-round treatment performance more than offsets increased costs incurred by the need for reagent addition (Sobolewski, pers. Comm., October, 2014). Glucose, lactate/acetate, ethanol, methanol, ethylene glycol and other carbon sources have all been used to supplement bioreactors. Finding the optimal liquid carbon source and concentration required often relies on bench or lab-scale testing.

3.4. Knowledge gaps

Mining companies in the North attempting to implement PTSs face many challenges and despite the growing body of knowledge on their performance in cold climates, there are areas that require future research. As more cold climate PTSs are developed and implemented, our understanding of the factors affecting their efficiency and long term performance will continue to grow.

3.4.1. Seasonal variation in efficiency

While some studies have assessed seasonal variation in pilot-scale PTSs (Goulet & Pick, 2001; August et al, 2002; Gusek, 2002; Hedin, 2013; Panos et al, 2013), a greater understanding of the factors that affect efficiency losses would help PTS designers maximize the potential of their PTS. Understanding the metabolic activities of SRB and the entire scope of the microbial communities present in bioreactors and wetlands at permanently low temperatures is crucial (Robador et al, 2009). More importantly, studies are needed to determine if a relationship can be established between summer and winter metal removal rates and rates of sulfate reduction, carbon consumption, metal precipitation and sorption (Gammons et. al., 2000). Such seasonally-adjusted rates will support the development of seasonally-adjusted treatment performance and design criteria for PTSs that function year-round. Often, site-specific factors such as precipitation, temperature, pH, type of mine discharge and PTS design will interact in novel ways creating unique situations. However, with more PTS being built in cold climates, patterns about the behaviour of such systems are starting to emerge.

3.4.2. Abiotic factors in winter

A number of studies have highlighted the importance of abiotic factors in removing metals during winter months (e.g., Kwong and Whitley, 1993; MacGregor, 2002). Freeze/thaw cycles affect metal attenuation in sediments and can cause diffusion into permafrost which may lead to long-term storage (MacGregor, 2002). Sedimentation may also play an important role in CWs in the winter (Wittgren & Maehlum, 1997). These abiotic factors could be incorporated into the design of PTSs to improve winter treatment performance. As in Section 3.3.1, these factors may be unique in each setting; however as more cold climate PTSs are developed, the interplay between biotic and abiotic factors will be better understood.

3.4.3. Local species and feedstocks

Most of the research about wetland plants and organic substrates in PTSs has been done in temperate regions. As PTSs are introduced into new environments, native species and local feedstocks will have to be identified. Native plant species should be chosen to minimize the risk of introducing invasive species and to ensure that the plants are adapted to their environment. Identification of native plants that are metal tolerant and are low shoot accumulators (Stolz & Greger, 2002) requires lab, bench and pilot trials. Additionally, locally available substrates for SRB activity in bioreactors and CWs should be identified. Ideally these will be waste materials that are available on-site or nearby. While organic substrates like manure, peat, woodchips and sawdust might be easily obtained in more southern areas, these materials are often not as plentiful in remote, northern mine sites. Identification and characterization of potential feedstocks would allow PTS designers to choose the appropriate substrate for their system.

3.4.4. Expected lifetime of PTSs in cold climates

The design life of PTSs are generally not well-understood, especially in cold climates, although many natural wetlands seem to demonstrate the longevity sought after by PTS designers. Predicting the lifetime of a PTS is essential to planning its construction, as well as potential maintenance requirements. Characterization of potential organic substrates can help to optimize the long-term performance of bioreactors (Neculita et al, 2010). Research into organic substrates available in the north and their behaviour in PTSs would serve to better predict the potential lifespans of cold climate PTSs. Further research and monitoring of natural wetlands receiving mine drainage might also help elucidate the mechanisms and characteristics of long term treatment wetlands.

3.4.5. Optimal organic carbon source

Addition of a liquid carbon source to PTSs can be a useful approach to offset the loss of efficiency in cold temperatures. Reduced decomposition of organic matter can cause a reduction in microbial activity and populations. SRB and other microorganisms can be fed with a liquid carbon source to maintain their activity and population throughout the winter months. Studies have assessed various different organic carbon sources for supplementing bioreactors in cold climates (Tsukamoto et al, 2004; EPA, 2005; Gould et al, 2012; Sobolewski, 2010). Further research is required to assess the effect of carbon feed and the rate of carbon consumption in order to help predict the carbon amounts required to design efficient PTS in cold climate locations. Optimizing a carbon source for cold climate

bioreactors will enhance their performance; however, the engineering requirements and costs for systems that supply organic carbon sources should also be assessed.

4. CONCLUSION

With increasing industrial activity in northern Canada there is a need for research, development and implementation of cost effective systems that ensure long term environmental protection. Passive treatment of mine impacted water has become increasingly common over the last 30 years. Passive treatment systems (PTSs) often consist of constructed wetlands (CWs), bioreactors, or some combination and/or variation on both of these components. These PTSs are sustainable alternatives to active treatment systems and represent the next generation of mine water treatment.

Natural wetlands have been treating mine-impacted water in cold climates since mining activity began and provide important information about the processes that drive PTSs, as well as providing insight into the potential for the long-term performance of CWs. Numerous studies have found evidence of metal retention in natural wetlands from both natural and anthropogenic sources of contamination. Following observed natural attenuation processes and metal retention demonstrated in natural wetlands, engineered PTSs have been designed and implemented to treat contaminated water worldwide.

Mine sites in northern environments are often located in remote locations with limited access and power, short growing seasons and cold winter temperatures, conditions which can present challenges for PTS design. These challenges however, are also often reasons for choosing PTSs, which can be constructed to operate year-round with little maintenance and no power. PTSs should ideally be able to function for decades with no power and while most systems are not truly “walk-away” scenarios, they are generally much lower maintenance than active systems. Implementation of PTSs in cold climates has been less common to date; however, several pilot scale and full scale PTSs have been built in cold climates. While the efficacy of these PTSs varies, many have successfully treated mine-impacted water to meet or exceed water quality objectives.

While success in cold climates has been variable, many PTSs have been highly successful (Norway, Bulgaria, BC, Yukon, and Quebec). Often, site-specific factors such as precipitation, temperature, pH, mine discharge chemistry and PTS design will interact in novel ways creating unique situations. As PTSs are constructed in cold climate, remote environments, patterns regarding the behaviour of such systems are starting to emerge. It is clear from this review that PTSs can be successfully implemented in cold climates, provided extensive planning and research in regards to design and construction are taken into consideration to address challenges encountered in northern environments. Some of the challenges facing PTSs in cold climates include hydraulic failure due to freezing in winter, reduced microbial activity, and increased water flows during spring melt. Many adaptations have been developed to overcome these challenges such as burial and insulation of pipes to prevent freezing, allowing sufficient time for the biotic community to establish following construction, ensuring constant flow over the season and identifying appropriate feedstocks and carbon sources that promote SRB and other microorganisms. Due to not only the site-specific challenges associated with implementing PTSs, but the additional challenges in cold climates, laboratory, bench- and field- scale experiments are needed prior to full scale implementation. However, due to the many advantages PTSs provide over active systems, these systems should be strongly considered for use in the North.

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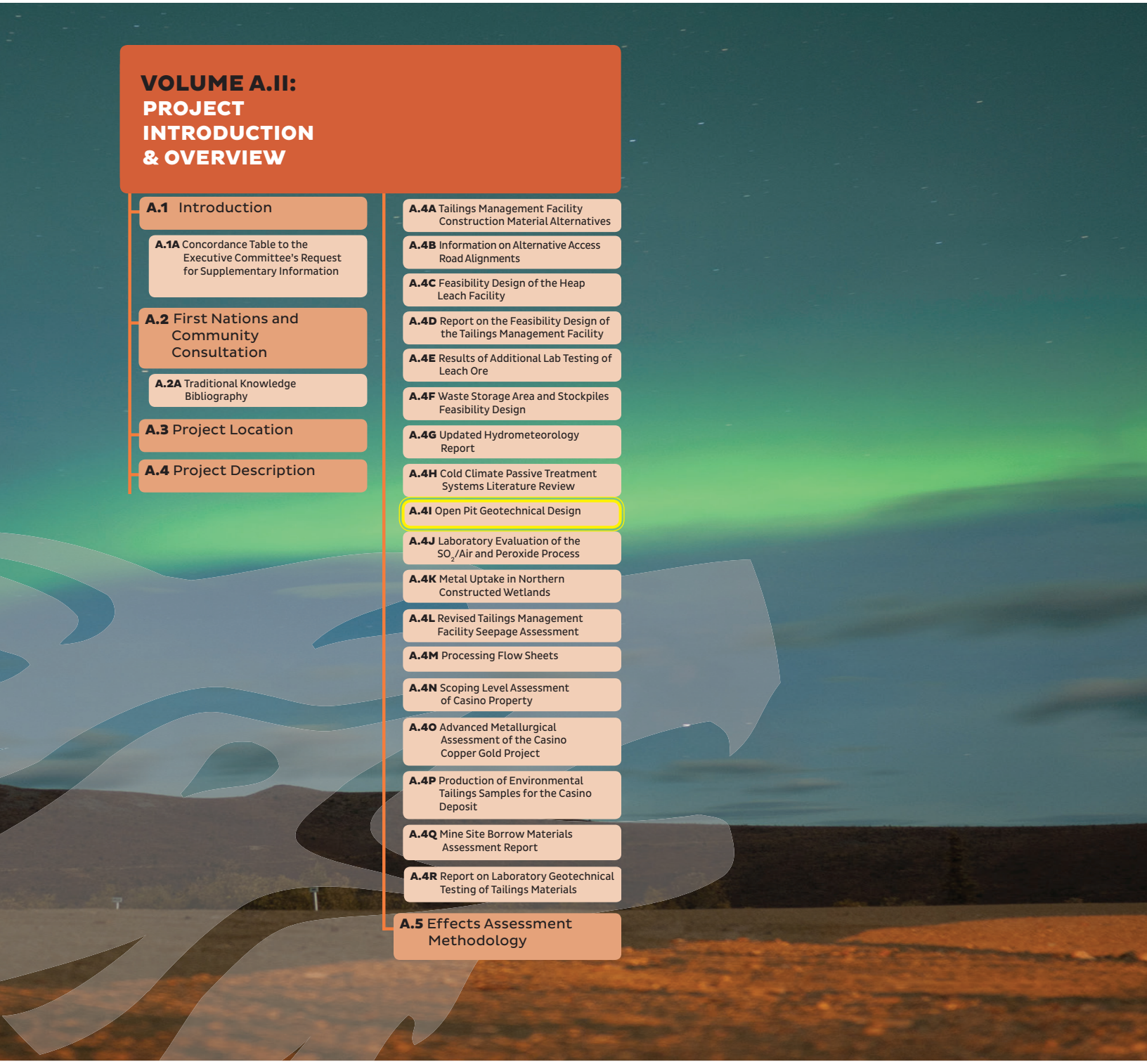
APPENDIX A.4I: Open Pit Geotechnical Design



CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT





OPEN PIT GEOTECHNICAL DESIGN

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EXECUTIVE SUMMARY

Casino Mining Corporation (CMC) is currently evaluating the Casino Copper-Gold Project, a proposed copper-gold-molybdenum mine located in the Dawson Range Mountains of the Klondike Plateau, approximately 300 km northwest of Whitehorse, Yukon Territory, Canada.

The deposit is hosted by the Casino Complex, a suite of igneous intrusive rocks with an intense hydrothermal alteration overprint. The project site is unique as the region was not glaciated during the Wisconsin Advance. The proposed mine calls for 120,000 tonnes per day (tpd) of ore production using open pit methods.

Knight Piésold Ltd. (KPL) has been retained to complete a Feasibility level geotechnical assessment and pit slope design for the proposed Casino open pit. Geotechnical site investigations were completed by KPL in 1994, 2010, and 2011, to collect geomechanical and hydrogeological data for open pit slope design. A preliminary pit slope geotechnical assessment was completed in 2008 based on a review of the 1994 geomechanical data and presented in the KPL report "Preliminary Open Pit Slope Design" (Ref. No. VA07-01637, January 2008). Additional site investigation data were collected by KPL during May to August of 2010 and CMC produced an updated pit shell model the following November. KPL completed a review of the new pit shell model using the 1994 and 2010 geomechanical data and presented the results in the report "Updated Open Pit Slope Design" (Ref. No. VA10-01460, February 2011). A supplementary geotechnical site investigation program was performed in 2011 to collect additional geotechnical data in support of a Feasibility level pit slope design. The findings of the site investigation are presented in the report "2011 Geomechanical Site Investigation Data Report – Open Pit" (Ref. No. VA101-325/8-6, April 2012).

A simplified geotechnical model was developed for pit slope design, which includes four geotechnical domains as follows:

- Overburden (silty SAND and GRAVEL with trace clay, residual soils and talus)
- Weathered Zone (largely within the Dawson Range Batholith unit)
- Prospector Mountain Suite (Late Cretaceous, Patton Porphyry, Explosion Breccia, Intrusion Breccia), and
- Dawson Range Batholith (Middle Cretaceous, Granodiorite and Diorite).

Overburden is present as a thin veneer across most of the deposit area, but is up to 30 m thick in localized areas near the northern edge of the proposed pit. Weathered Bedrock underlies the overburden and varies in depth from 30 to 200 m throughout the deposit area. The Dawson Range Batholith (DRB) domain occupies the majority of the deposit. The central and southwest portions of the deposit are exposed within the Prospector Mountain Suite (PMS) domain.

The proposed open pit includes two major mining zones, namely the Main Pit and West Pit, respectively. A total of eight design sectors were delineated for pit slope stability assessment based on the projected wall geology and wall orientations. Sub sectors were defined to differentiate the overburden and weathered zones from the fresh bedrock.

Kinematic stability analyses were performed for all design sectors using stereographic techniques to determine the failure modes that are kinematically possible in bench and/or multi-bench scale slopes. Multi-bench scale wedge failures are kinematically possible in the M-North and W-North Sectors. Multi-bench planar failures are kinematically possible in the M-South and W-North Sectors.

In addition, bench scale wedge, planar, and toppling features were identified in various design sectors. Bench face angles and inter-ramp slope angles have been selected to reduce the risk from structurally controlled wall failures.

Large-scale multi-bench rock mass slope stability was assessed through the use of limit equilibrium modelling methods. Limit equilibrium stability models were set up for overburden slopes, inter-ramp slopes within each geotechnical domain, and final M-North, M-Northeast, and W-West Walls, respectively. The analysis indicates that the following pit slope angles are achievable if low damage wall blasting practices and effective slope depressurization measures are implemented:

Design Sector	Slope Height	Wall Geology	Bench Face Angle	Bench Height	Bench Width	**Inter-ramp Angle**	Max Inter-ramp Slope Height	**Overall Slope Angle**
	M		°	m	m	**°**	m	**°**
M-North	30	Overburden	40	5	4	**27**	200	**39**
	600	DRB	60	15	8	**42**		
M-Northeast	30	Overburden	40	5	4	**27**	100[(1)]/200	**40**
	600	DRB	65	15	8	**45**		
M-South	540	PMS, DRB	65	15	8	**45**	200	**42**
Central	210	PMS	65	15	8	**45**	200	**N/A**
W-North	285	DRB	60	15	8	**42**	200	**39**
W-South	480	DRB	65	15	8	**45**	200	**42**
W-Southwest	345	PMS	65	15	8	**45**	200	**42**
W-West	210	DRB	65	15	8	**45**	200	**42**

NOTES:

1. A 100-m high inter-ramp slope is recommended for slopes developed in weathered bedrock. The maximum height for the inter-ramp slopes in fresh rock is 200 m.

A conceptual pit water management plan was also developed for costing purposes. It includes surface water diversion ditches, vertical pumping wells, horizontal drains, and pit dewatering systems. Groundwater seepage into the pit was estimated to be in the order of 190 L/sec for the final pit configuration. The pit dewatering systems were designed to remove pit water from a 1 in 10 year 24 hour storm event. It was determined that approximately 1390 L/sec would flow into the pit during the design storm event. Two pumps operating at a combined capacity of 320 L/sec would be required to dewater the pit over a six day period. Booster pump stations have been included at every 100 m rise in elevation.

Careful controlled blasting should be conducted to minimize the blasting damage to the pit walls. Catch benches should be cleaned as required to ensure effectiveness. Scaling loose material off of the walls is recommended to reduce the hazard of falling rock. It is recommended that horizontal drains and vertical pump wells be installed during mining operations to reduce pore water pressure in the middle and lower slopes.

An extensive geotechnical monitoring program is recommended to detect slope instabilities that may occur during operations. Geotechnical mapping of the pit walls and any tension cracks, installation and regular monitoring of surface prisms, and the implementation of automated pit wall deformation monitoring systems are recommended as part of the monitoring program.

It is recommended that additional geomechanical and hydrogeological data collection be collected during the early stages of pit operations. The data collection programs may include bench surface mapping, piezometer installation and monitoring. Additional information will be used to enhance the geotechnical database, update the rock mass structural model, and refine the hydrogeological model. The pit design should be optimized when additional geotechnical information becomes available. The final pit designs and pit dewatering plans should be reviewed by qualified geotechnical engineers.

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1 – INTRODUCTION

1.1 PROJECT BACKGROUND

Casino Mining Corporation (CMC) is currently evaluating the Casino Copper-Gold Project, a proposed copper-gold-molybdenum mine, in the Yukon Territory. The project is located in the Dawson Range Mountains of the Klondike Plateau approximately 300 km northwest of Whitehorse, Yukon Territory, Canada, as shown on Figure 1.1. This area is unique as the region was not glaciated during the Wisconsin Advance.

The deposit is hosted by the Casino Complex, a suite of igneous intrusive rocks with an intense hydrothermal alteration overprint. The deposit will be mined using open pit methods with a nominal mill throughput of 120,000 tonnes per day (tpd) of ore. The general arrangement of the project site is shown on Figure 1.2.

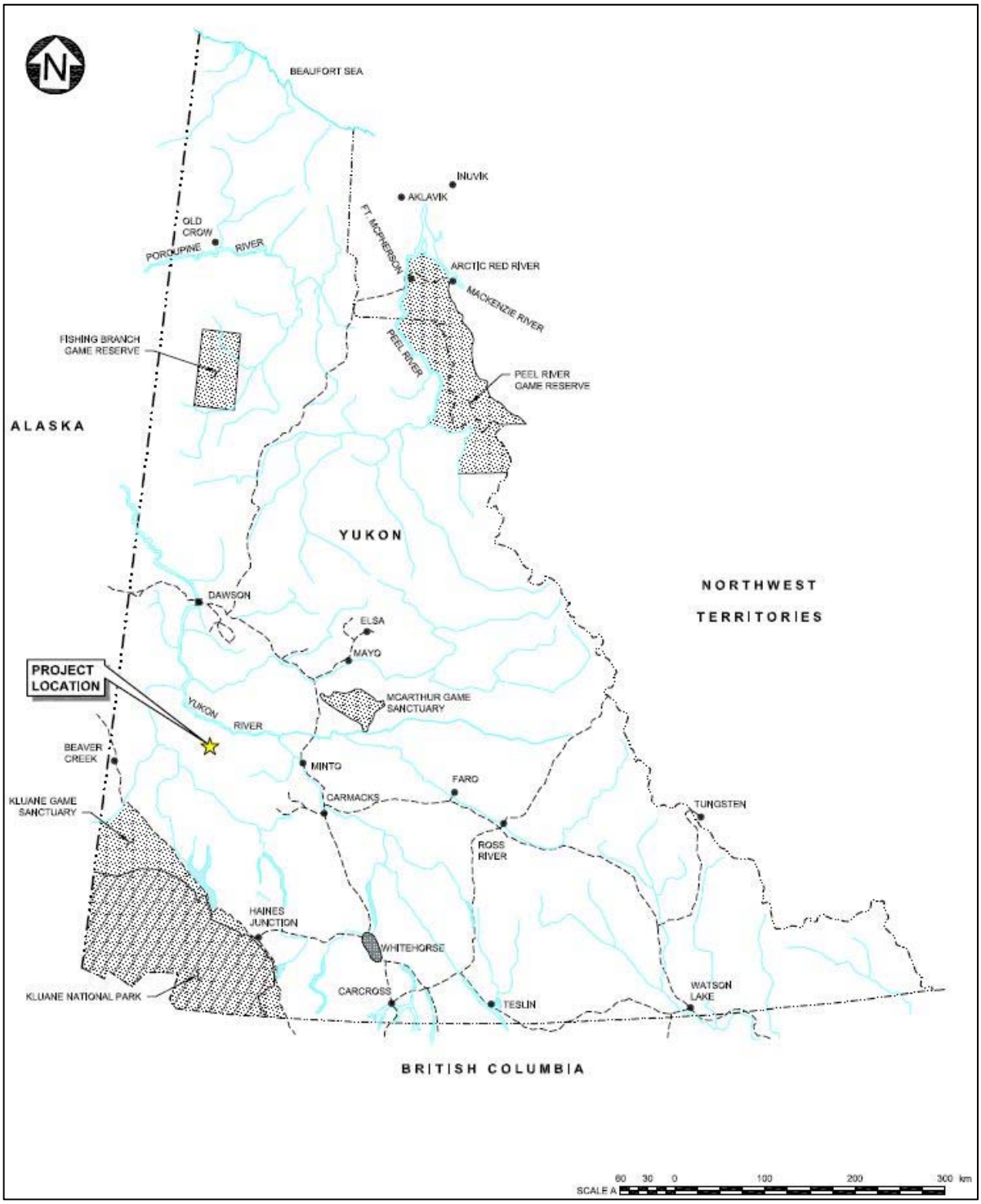
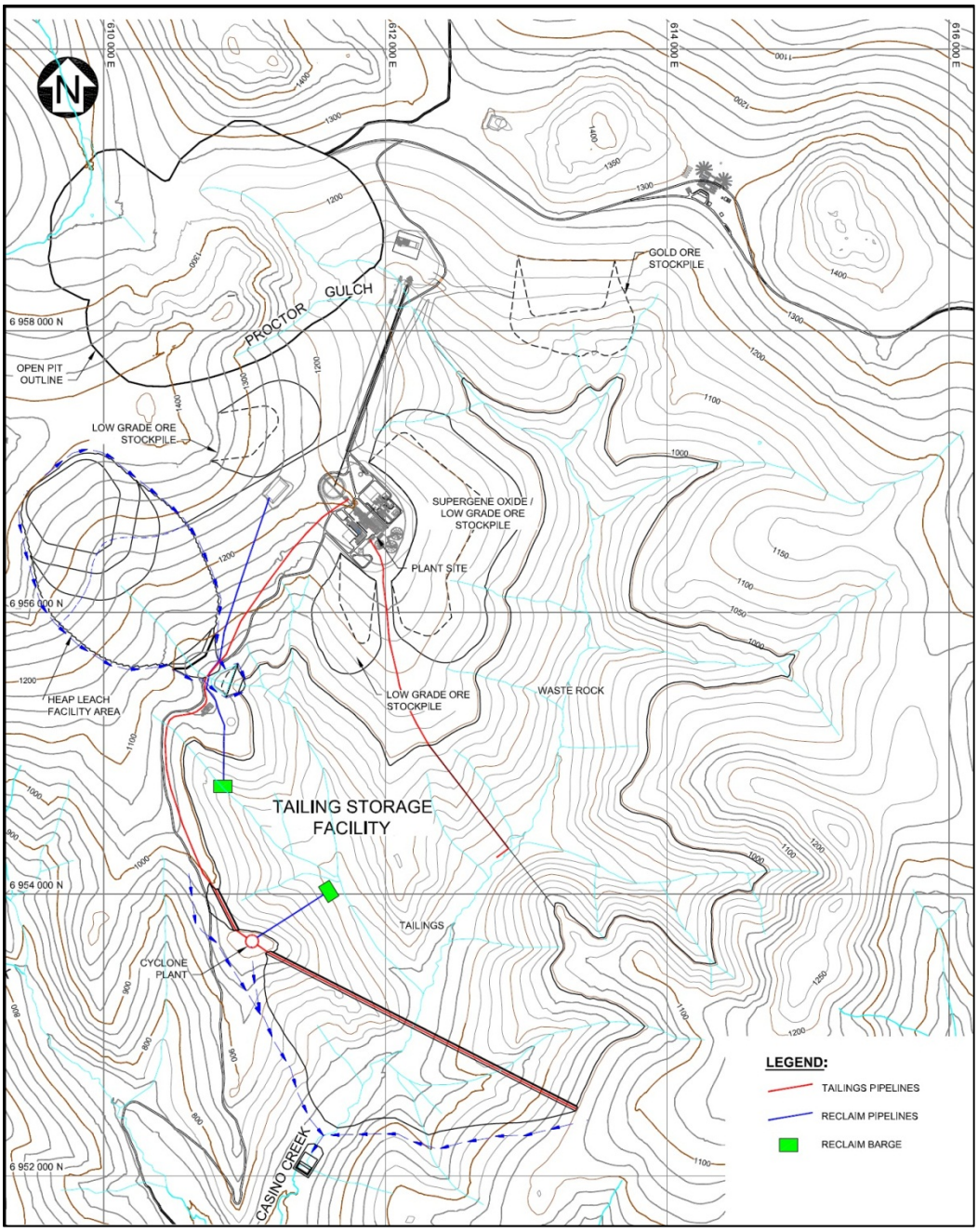


Figure 1.1 Project Location Map



NOTES:

1. COORDINATE GRID IS UTM (WGS84 / NAD83) ZONE 7 (m).
2. CONTOUR INTERVAL IS 25 m.
3. OPEN PIT OUTLINE PROVIDED BY CASINO MINING CORPORATION (SEPTEMBER 2012).
4. PLANT SITE AND CRUSHER LAYOUT PROVIDED BY M3 ENGINEERING AND TECHNOLOGY CORPORATION (AUGUST, 2012)
5. ORE STOCKPILES ARE SHOWN AT THEIR MAXIMUM SIZE DURING OPERATIONS.

Figure 1.2 Mine Site – General Arrangement

1.2 PREVIOUS WORK

Knight Piésold Ltd. (KPL) has been involved in the Casino Project since the early 1990's. Previous work relating to the investigation and design of the Casino Open Pit included the following:

- **Preliminary Surficial Geotechnical Investigations** – Approximately 20 geotechnical trenches were excavated for visual description and preliminary characterization of surficial materials in 1993. Representative soil samples were collected for laboratory testing, including particle size analyses, natural moisture contents, Atterberg limits (plasticity), compaction tests and permeability tests. The results of the site investigations are included in KPL report "Report on Preliminary Surficial Geotechnical Investigations" (Ref. No. 1831/1, March 1994).
- **1994 Geotechnical and Hydrogeotechnical Investigations** – KPL drilled and logged 11 drillholes throughout the open pit area. Groundwater monitoring wells were installed in three drillholes, and thermistors were installed in three other holes. In situ packer, falling head permeability tests, and shut-in pressure tests were conducted within the drillholes, and representative rock core was collected for laboratory testing. Point load testing was conducted on site on select rock core samples. The results of the investigations are included in KPL report "Data Compilation Report on 1994 Geotechnical and Hydrogeotechnical Investigations" (Ref. No. 1832/2, February 1995).
- **Preliminary Open Pit Slope Design** – A preliminary open pit geotechnical assessment of the 1995 pit shell model was completed in 2008 utilizing the available relevant geotechnical data. Kinematic and limit equilibrium stability analyses were performed. Recommendations for bench geometry, inter-ramp slope and overall slope angles were provided in KPL Letter Report "Preliminary Open Pit Slope Design" (Ref. No. VA07-01637, January 2008).
- **2010 Geotechnical Site Investigation** – Three oriented geomechanical holes were completed in 2010. In situ permeability testing was conducted at regular intervals during drilling. A standpipe piezometer was installed in one drill hole and vibrating wire piezometers were installed (by AECOM) in the remaining two holes. Packer hydraulic conductivity (Lugeon) tests were conducted at selected intervals in all of the drillholes. The results of the investigations performed by KPL are included in KPL report "2010 Geotechnical Site Investigation Data Report" (Ref. No. VA101-325/3-4, November 2010).
- **Updated Open Pit Slope Design** – KPL completed an updated pit slope geotechnical design for the Pre-feasibility study. This updated geotechnical study was conducted to incorporate the 2010 Geotechnical Site Investigation data into the existing open pit pre-feasibility design. Recommendations for bench geometry, inter-ramp slope and overall slope angles were provided in KPL Letter Report "Updated Open Pit Slope Design" (Ref. No. VA10-01460, February 2011).
- **2011 Site Investigation** – Five oriented geomechanical holes were completed in the summer of 2011. In situ packer permeability testing was performed at regular intervals during drilling. Standpipe piezometers were installed in three of the drill holes. Borehole surveys were conducted in three holes using an acoustic televiewer. Overburden and rock core samples were collected for laboratory testing. The results of the investigation are included in KPL report "2011 Geomechanical Site Investigation Data Report" (Ref. No. VA101-325/8-6, 2012).

Additional work has been performed on site by AECOM in support of the feasibility study. AECOM has installed a total of 2 thermistors, 7 vibrating wire piezometers, and 10 (mini) piezometers in the open pit area between 2008 and 2010. The hydrogeological investigations by AECOM are

summarized in the report "Casino Project – Hydrogeological Technical Report – DRAFT" (Ref. No. 60146995-9, March 2011).

1.3 SCOPE OF WORK

KPL has been retained to conduct a feasibility level geotechnical design for the Casino open pit. The geomechanical and hydrogeological information collected from the previous field programs was utilized to develop a geotechnical database for the feasibility level pit slope design. The open pit geotechnical assessment included:

- Geotechnical characterization and geotechnical model development
- Slope stability analyses
- Conceptual pit water management plan, and
- Pit slope recommendations.

This report presents the major findings along with recommendations for the Casino pit slope development and pit water management.

2 – GENERAL SITE SETTING

2.1 PHYSIOGRAPHY

The Casino Porphyry Copper-Gold-Molybdenum Project is located in the west-central region of the Yukon Territory in an overlapping zone featuring the Yukon Cataclastic Terrane to the North, and the Yukon Crystalline Terrane to the South (M3, May 2011). The site lies within the Boreal Cordillera ecozone, which includes several mountain ranges such as the northwest trending Dawson's Range Mountains. The region is characterized by well-rounded ridges and rolling hills that reach a maximum elevation of 1675 masl. It also includes several extensive plateau regions. The hills are deeply cut by a series of dendritic drainages of the Yukon River watershed, with the primary drainage channels occurring below an elevation of 1000 masl (M3, May 2011).

The Dawson's Range exhibits unique surficial geology because the area did not experience continental glaciation during the Pleistocene. The effects of minor alpine glaciation such as cirques and terminal moraines are present in some areas (M3, May 2011).

2.2 REGIONAL GEOLOGY

The Casino Deposit is centered in an Upper-Cretaceous aged tonalite porphyry stock that is elongated in the east-west direction. The stock intrudes Mesozoic granitoids of the Dawson's Range Batholith as well as Paleozoic schists and gneisses of the Yukon Crystalline Complex (M3, May 2011).

The intrusion of the tonalite stock caused extensive brecciation of the country rocks, which is best developed at the eastern end of the stock where the fracture system extends up to 400 m wide in plan view (M3, May 2011). The fractures in the stock and country rocks have copper, gold, and molybdenum mineralization from hydrothermal fluids which flooded the brecciated rocks.

Outcrop exposure is rare as the overburden is extensive. Soils are found ranging from coarse talus of the immature horizons at higher elevations to more mature soil horizons and thick organic layers on the valley floors.

2.3 CLIMATE AND HYDROMETEOROLOGY

The climate of the west-central Yukon is considered sub-arctic, with widespread permafrost on north-facing slopes and discontinuous permafrost on south-facing slopes. It is characterized by long, cold, dry winters and short, warm, wet summers. Typical wind speeds in the region are relatively stable throughout the year at approximately 2.3 m/s from the southwest direction (KPL, June 2010).

The mean monthly temperatures range from approximately -18.1°C in January to 11.1°C in July (M3, May 2011) and are moderated by the effects of the Pacific Ocean. The daily maximum temperatures occur in July and are typically around 30°C (KPL, June 2010).

Precipitation is generally highest during the summer months of July and August and lowest during the winter months of February to April. The estimated mean annual precipitation is approximately 500 mm, falling as snow throughout the months of November to March, as rain from May to September, and as a mixture of the two in the remaining months. The highest humidity values are generally 70 to 80% and are experienced in the fall and early winter. The lowest humidity values are generally 50 to 60% and experienced in the spring and early summer (KPL, June 2010).

2.4 HYDROGEOLOGY

The Casino Project is situated on a small divide, with the North slopes draining into Canadian Creek and Britannia Creek, which are tributaries of the Yukon River. Slopes situated on the south side of the divide drain into Casino Creek and its subsidiary Dip Creek, which is a tributary of the Donjek and Yukon Rivers (M3, May 2011).

Flow patterns of Big Creek, the Indian River, and the Little South Klondike River were compared using data from 1983, 1985-1991, and 1993 in order to come up with a reasonable representation of expected flow patterns for the site area. These water bodies were used because they are contained within similar watersheds and occur over terrain similar to the Casino Project site (KPL, June 2010).

The analysis resulted in the production of similar bi-modal hydrographs with peak flows during the freshet, which most commonly occurs in May as a result of spring melting. Second, smaller peaks occur in late summer as a result of increased rainfall as well as melting of the active permafrost layer. Low flows occur during the winter when precipitation falls as snow and many of the smaller streams freeze solid. The approximate evapotranspiration value was determined to be 308 mm annually (KPL, June 2010).

2.5 SEISMICITY

The region of the southwest Yukon Territory and northwest British Columbia is one of the most seismically active areas in Canada. The seismic hazard in the region is also influenced by the seismically active region of southeast Alaska. The coastal region has experienced many large earthquakes, including events with magnitudes in the range of magnitude 7.0 to 8.0. In 1958 a magnitude 7.9 earthquake occurred along the Fairweather fault (the northern extension of the Queen Charlotte transform fault). The most significant inland zone of seismicity follows the Dalton and Duke River segments of the Denali fault zone through the southwest Yukon. Farther inland there is only minor seismicity between the Denali and Tintina fault systems, including the region of the Casino Project site.

Review of historical earthquake records and regional tectonics indicates that the Casino Project site is situated in a region of low seismic hazard. A probabilistic seismic hazard analysis has been carried out using the database of Natural Resources Canada. The results are summarized in Table 2.1 in terms of earthquake return period, probability of exceedance (for a 23 year design operating life) and median average maximum ground acceleration.

Table 2.1 Summary of Probabilistic Seismic Hazard Analysis

Return Period (Years)	Probability of Exceedance[1] (%)	Peak Ground Acceleration (PGA)	
		Median PGA[2,3] (g)	Estimated Mean PGA[3,4] (g)
100	21%	0.04	0.05
475	5%	0.07	0.08
1000	2%	0.08	0.10
2500	1%	0.11	0.14

NOTES:

1. PROBABILITY OF EXCEEDANCE CALCULATED FOR A DESIGN LIFE OF 23 YEARS.
   $q = 1^{-(-L/T)}$
   WHERE: q = PROBABILITY OF EXCEEDANCE
   L = DESIGN LIFE IN YEARS
   T = RETURN PERIOD IN YEARS
2. PEAK GROUND ACCELERATIONS OBTAINED FROM THE SEISMIC HAZARD DATABASE OF NATURAL RESOURCES CANADA.
3. PEAK GROUND ACCELERATIONS ARE FOR "VERY DENSE/SOFT ROCK" (SITE CLASS C), AS DEFINED BY THE NATIONAL BUILDING CODE OF CANADA (2005).
4. MEAN PGA VALUES ESTIMATED AS 1.2 X MEDIAN VALUES.

The corresponding maximum acceleration is 0.07g for a return period of 475 years, confirming a low seismic hazard for the site.

3 – FUNDAMENTALS OF PIT SLOPE DESIGN

3.1 GENERAL

The objective of the pit slope design is to determine the steepest, practical slope angles for the open pit mine to maximize the extraction of the identified ore resource. This must be balanced against the fact that over-steepened slopes may lead to the development of large instabilities that could ultimately impact worker safety, productivity and mine profitability. The pit slope design approach is based on achieving an acceptable level of risk and incorporating this into the stability analyses as a Factor of Safety (FOS) and/or Probability of Failure (POF).

This section briefly introduces pit slope terminology that is used throughout this report and some of the key geotechnical and mining factors that can impact slope design. In addition, a summary of the analysis techniques utilized during this study and the adopted risk management approach are discussed.

3.2 PIT SLOPE CONFIGURATIONS

The inter-relationships between bench geometry, inter-ramp slope angle and the overall slope angle are illustrated on Figure 3.1. The primary components of a pit design are as follows:

- **Bench Geometry** – The heights of benches are typically determined by the size of the shovel chosen for the mining operation. The bench face angle is typically selected in such a way as to reduce the amount of material that may detach and fall from the face or crest. The bench width is sized to prevent small wedges and blocks from the bench faces falling down the slope and potentially impacting personnel and equipment. The resulting bench geometry will dictate the inter-ramp slope angle. Double or triple benches can be used in certain circumstances to steepen inter-ramp slopes.
- **Inter-ramp Slope** – The maximum inter-ramp slope angle is typically dictated by the bench geometry. However, it is also necessary to evaluate the potential for multiple bench scale instabilities due to large-scale structural features such as faults, shear zones, bedding planes, foliation, etc. In some cases, these persistent features may completely control the achievable inter-ramp angles and the slope may have to be flattened to account for their presence.
- **Overall Slope** – The overall slope angle that is achieved in a pit is typically flatter than the maximum inter-ramp angle due to the inclusion of haulage ramps. Other factors that may reduce the overall slope angles are things such as, rock mass strength, groundwater pressures, blasting vibration, stress conditions and mine equipment requirements.

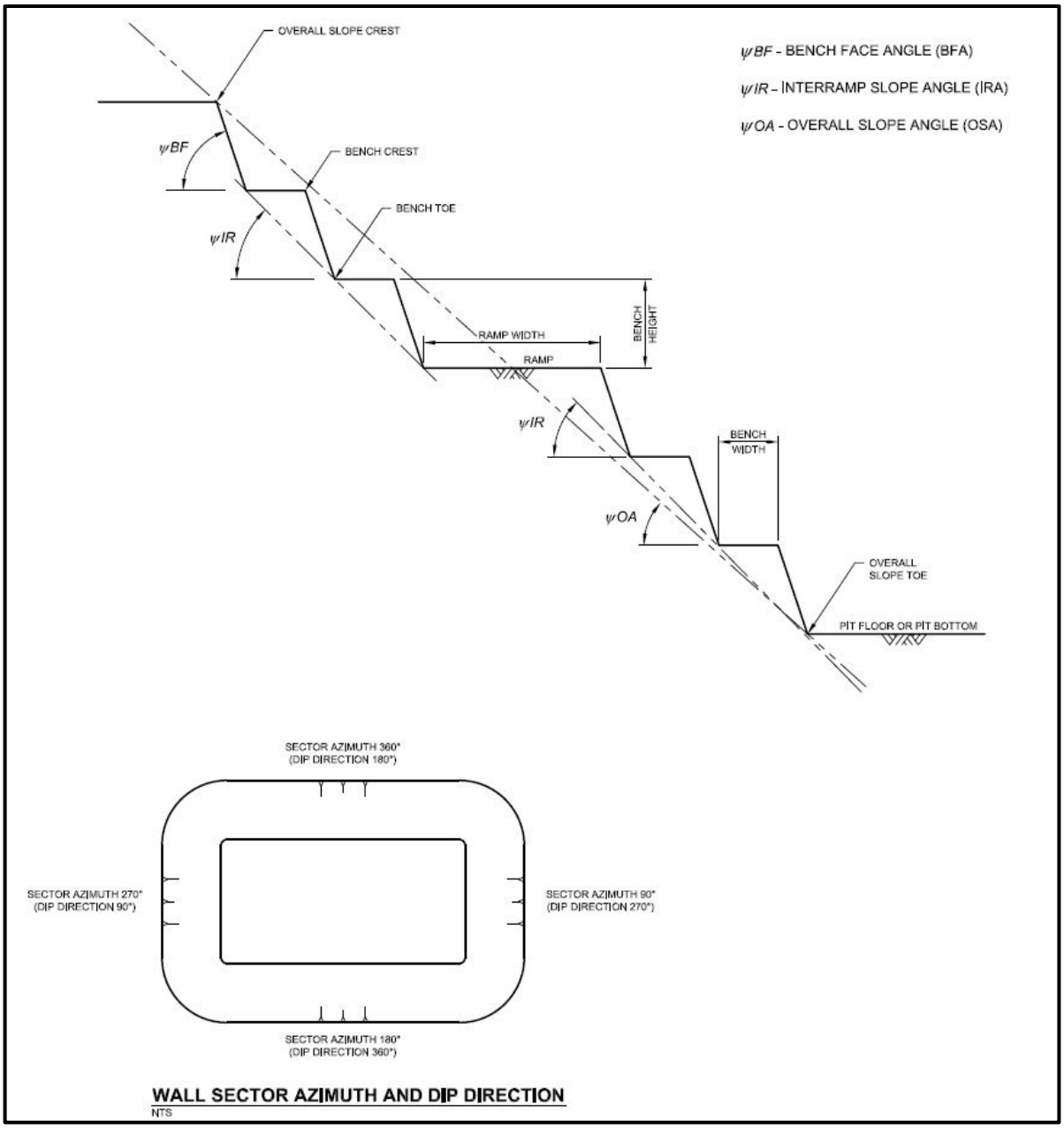


Figure 3.1 Typical Open Pit Slope Configurations

3.3 KEY CONSIDERATIONS FOR PIT SLOPE STABILITY

The stability of open pit slopes in rock is typically controlled by the following key geotechnical and mining factors:

- **Lithology and Alteration** – The rock types intersected by the final pit walls and level of alteration are main factors that impact eventual stability of the pit. Geotechnical domains are created by grouping rock masses with similar geomechanical characteristics.

- **Structural Geology** – Large-scale structural features such as the orientation and strength of major, continuous geological features such as faults, shear planes, weak bedding planes, structural fabric, and/or persistent planar joints will strongly influence the overall stability of the pit walls.
- **Rock Mass Structure** – Small-scale rock mass structural features such as the orientation, strength, and persistence of smaller scale structural features such as joints will control the stability of individual benches and may ultimately restrict the inter-ramp slope angles.
- **Rock Mass Quality and Strength** – Rock mass quality is characterized by using Rock Mass Rating (RMR_{89}), a classification system developed by Bieniawski (1989). Rock mass strength is typically estimated via intact rock strength. Lower rock mass strength may reduce the overall slope angles.
- **Groundwater Conditions –** High groundwater pressures and water pressure in tension cracks will reduce the rock mass shear strength and may adversely impact slope stability. Slope depressurization programs can reduce water pressure behind the pit walls and allow steeper pit slopes to be developed.
- **Blasting Practices** – Production blasting can cause considerable damage to the rock mass along interim and final pit walls. This increased disturbance can be accounted for during design by incorporating a reduction in the effective strength of the rock mass. Controlled blasting programs near the final wall can be implemented to reduce blasting induced disturbances and allow steeper slopes.
- **Stress Conditions –** Mining induces stress changes due to lateral unloading within the vicinity of the pit. Strain due to stress release can lead to reductions in the quality of the rock mass and increases in slope displacements. Localized changes in pit wall geometry, which result in 'noses', can cause a decrease in the stress regime. This decrease can result in an increased incidence of ravelling type instability in these areas. Modifying the geometry and mining sequence can sometimes manage these stress changes to enhance the integrity of the final pit walls.

3.4 METHODOLOGY FOR PIT SLOPE STABILITY

The pit stability assessment was completed by defining representative geotechnical domains with similar geology, structure, rock mass quality and strength characteristics. A series of pit design sectors were then defined by incorporating the mine geometry into the geotechnical domains and a number of different types of stability analyses were undertaken to determine appropriate slope angles for a given open pit slope. Slope stability analyses undertaken in this study included:

- **Kinematic Stability Analyses** – Stereographic analyses were conducted using the structural data to identify the kinematically possible failure modes of the pit walls. Appropriate bench face angles and/or inter-ramp slope angles were assigned in such a way as to reduce the potential for discontinuities to form unstable wedges or planes. Typically, it is not cost-effective to eliminate all potentially unstable blocks and a certain percentage of bench face instability is acceptable. Most of the smaller unstable features will be removed by the scaling process.
- **Rock Mass Stability Analyses** – Limit equilibrium analyses of the rock slopes were performed to estimate the FOS against large-scale, multiple-bench slope failures. Inter-ramp slopes and select overall pit slopes were modelled as part of these analyses.

3.5 ACCEPTANCE CRITERIA FOR PIT SLOPE DESIGN

The recommended pit slope configurations are developed using data interpreted from a simplified geotechnical model, the rock mass characteristics and groundwater conditions. As this data may be limited or variably distributed and/or of uncertain quality the target level of confidence during a feasibility level pit slope study is typically around 50% to 70%. A general guidance to pit slope design acceptance criteria is summarized below in Table 3.1 (after Read and Stacey, 2009); suggested FOS targets for open pit design at Casino are highlighted in **Bold**.

Table 3.1 Summary of Pit Slope Design Acceptance Criteria

Slope Scale	Consequences of Failure	Acceptance Criteria		
		FOS (min) (Static)	FOS (min) (Dynamic)	POF (max) P[FOS≤1]
Bench	Low to High	1.1	N/A	25% - 50%
Inter-ramp	Low	1.15 - 1.2	1.0	25%
	Medium	**1.2**	**1.0**	**20%**
	High	1.2 – 1.3	1.1	10%
Overall	Low	1.2 – 1.3	1.0	15% - 20%
	Medium	**1.3**	**1.05**	**5% - 10%**
	High	1.3 – 1.5	1.1	≤5%

It is noted that there are few recorded instances in which earthquakes have been shown to produce significant slope instability in hard rock open pits. In most cases earthquakes have produced small shallow slides and rock falls in rock slopes, but none on a scale sufficient to disrupt mining operations (Read and Stacey, 2009). Therefore, given the nature of the low seismic hazard at the site, slope stability under seismic (earthquake) conditions is not a significant consideration for the pit slope design for the Casino Project.

4 – GEOTECHNICAL CHARACTERIZATION

4.1 GENERAL

The feasibility study for the open pit utilized information collected during the 1994, 2012, and 2011 geotechnical site investigation programs. The field programs included diamond drilling and logging of oriented core, in situ permeability testing and piezometer installation.

The characterization of the open pit geotechnical conditions was based on all relevant geological, geomechanical, and hydrogeological information from both geotechnical and exploration drill holes, including descriptive geological and geotechnical logging, in situ tests, field testwork and laboratory results.

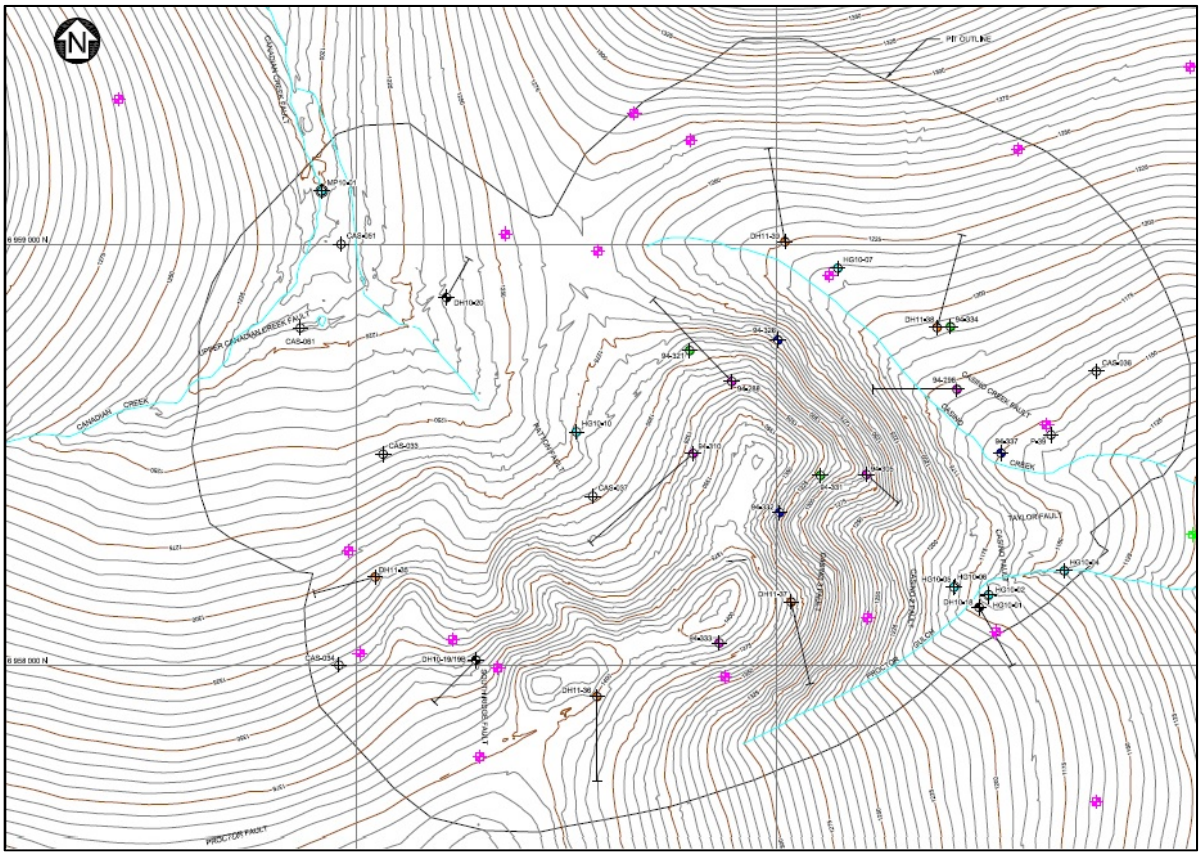
4.2 DATA SOURCES

The information presented comes from a variety of sources and has been compiled to present the basis for establishing a simplified geotechnical model for pit slope design. The compiled data addresses the four main areas of information required for the pit slope design: geology, structure, rock mass and hydrogeology.

The sources of information that contributed to the development of the geotechnical model for open pit design include:

- 1994 Geotechnical/Hydrogeotechnical Investigations (KPL, February 1995)
- 1994 Exploration and Geotechnical Drilling Program (Pacific Sentinel Gold Corp., 1995)
- 2010 Geotechnical Site Investigation (KPL, November 2010)
- 2010 Hydrometeorology Report (KPL, June 2010)
- 2011 Geotechnical Site Investigation (KPL, April 2012)

Figure 4.1 shows the locations of the geotechnical drill holes and test pits completed within the open pit area during the 1994, 2010 and 2011 site investigation programs. A summary of all geotechnical drill holes completed during these programs is included in Table 4.1. Detailed results for overburden and rock laboratory testing, rock mass quality and rock mass structure characterization are presented in the Data Compilation Report on 1994 Geotechnical/Hydrogeotechnical Investigations (Ref. No. 1832/2, February 1995), 2010 Geotechnical Site Investigation Data Report (Ref. No. VA101-325/3-4, November 2010) and 2011 Geomechanical Site Investigation Data Report (Ref. No. VA101-325/8-6, April 2012).



LEGEND:

DH11-35	2011 GEOTECHNICAL DRILLHOLE
MP10-01	MINI PIEZOMETER
HG10-01	2010 HYDROGEOLOGICAL DRILLHOLE
DH10-01	2010 GEOTECHNICAL DRILLHOLE
CAS-033	EXPLORATION DRILLHOLE WITH PIEZOMETER OR THERMISTOR
94-305	1994 GEOTECHNICAL DRILLHOLE
94-344	1994 GEOTECHNICAL DRILLHOLE WITH THERMISTOR
94-350	1994 GEOTECHNICAL DRILLHOLE WITH 50 mm DIA. WELL
	2010 TEST PIT LOCATION
	1994 TEST PIT LOCATION
	1993 TEST TRENCH LOCATION

NOTES:

1. COORDINATE GRID IS UTM (WGS84 / NAD83) ZONE 7 (m).
2. CONTOUR INTERVAL IS 5 m.
3. OPEN PIT OUTLINE PROVIDED BY CASINO MINING CORPORATION (SEPTEMBER 2012)

Figure 4.1 Open Pit Area – 1994, 2010 and 2011 Investigation Plans

Table 4.1 Summary of Open Pit Drillholes

Drillhole ID	Coordinates[1, 2]		Elevation	Azimuth	Dip	Hole Size	Total Depth	Depth to Bedrock
	Northing	Easting						
	(m)	(m)	(m)	(°)	(°)	Nominal	(m)	(m)
94-288	6,958,675	610,893	1,312	316	-43	HQ3	270.1	5.0
94-298	6,958,656	611,428	1,164	270	-45	HQ3	199.9	12.5
94-305	6,958,454	611,213	1,278	132	-55	HQ3	144.8	1.0
94-310	6,958,504	610,801	1,326	229	-42	HQ3	291.3	5.0
94-321	6,958,748	610,792	1,273	0	-90	HQ3	150.0	2.5
94-326	6,958,773	611,003	1,252	0	-90	HQ3	139.9	2.5
94-331	6,958,451	611,103	1,310	0	-90	HQ3	155.2	3.0
94-332	6,958,363	611,007	1,324	0	-90	HQ3	169.8	1.0
94-333	6,958,054	610,863	1,383	0	-90	HQ3	104.2	2.5
94-334	6,958,805	611,413	1,184	0	-90	HQ3	125.6	15.0
94-337	6,958,505	611,533	1,142	0	-90	HQ3	122.5	12.0
DH10-18	6,958,135	611,483	1,171	150	-70	NTW3	426.7	14.3
DH10-19	6,958,014	610,285	1,359	225	-70	NTW3	68.6	1.5
DH10-19B	6,958,015	610,287	1,359	225	-70	NTW3	397.1	1.5
DH10-20	6,958,872	610,213	1,234	030	-70	NTW3	298.7	3.1
DH11-35	6,958,210	610,044	1,296	262	-59	HTW/NTW	300.2	2.0
DH11-36	6,957,926	610,572	1,390	188	-60	HTW/NTW	368.8	4.6
DH11-37	6,958,151	611,034	1,349	172	-60	HTW/NTW	402.3	0.0
DH11-38	6,958,803	611,381	1,185	17	-62	HTW/NTW	449.3	23.6
DH11-39	6,959,007	611,019	1,220	346	-61	HTW/NTW	449.6	27.4
CAS-51	6,959,001	609,963	1,206	121	-89	HTW/NTW	268.2	-

NOTES:

1. UTM NAD 83 COORDINATES.
2. DRILLHOLE COORDINATES AND ELEVATION MEASURED USING A HANDHELD GARMIN GPS UNIT.
3. ALL DEPTH MEASUREMENTS ARE TAKEN WITH RESPECT TO GROUND SURFACE LEVEL, ALONG THE DRILLHOLE.
4. REFLEX ACT I CORE ORIENTATION SYSTEM USED FOR ALL 2010 DRILLHOLES.
5. REFLEX ACT II RD CORE ORIENTATION SYSTEM USED FOR ALL 2011 DRILLHOLES.

4.3 GEOLOGY

4.3.1 Overburden

Mechanical weathering has played a dominant role in the production of overburden. Frost action and weathering processes have broken down the top of the bedrock into angular cobble to silt sized particles, referred to as “residual soils” by the project team. The relatively high silt content for residual soils indicated enrichment with windblown loess.

Colluvial deposits have formed along slopes, with the windblown loess and residual soils mixing during transportation downslope. The mixing process causes the colluvium to be locally organic rich. Blocky talus or scree is common at the base of slopes in the deposit area.

The typical composition of the overburden is SAND to GRAVEL with some cobbles and trace clay. The overburden is typically loose to medium dense. The thickness of overburden varies considerably throughout the open pit area due to preferential weathering of bedrock along shear, alteration and fault zones. Drill logs indicate that overburden is negligible in the south side of the deposit, but as thick at 30 m along the north side of the main deposit.

4.3.2 Bedrock

The Casino deposit is centred in a complex of quartz monzonites, intrusion breccias, shallow porphyritic intrusions, and a central breccia to microbreccia body. The major lithology units in the deposit area (from Pacific Sentinel Corp., 1995) are summarized below:

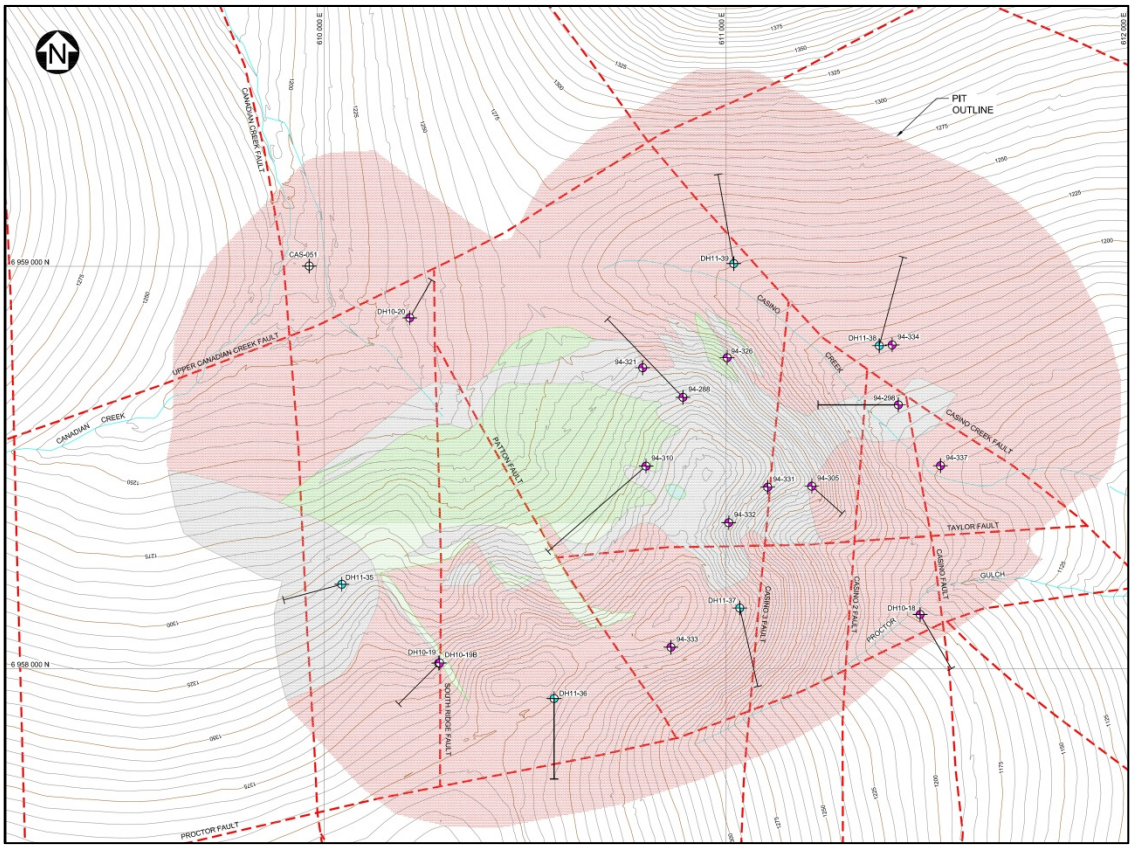
- Patton Porphyry (Late Cretaceous) – The main body of the Patton Porphyry is a relatively small stock approximately 300 by 800 m and is surrounded by an altered intrusive breccia in contact with rocks of the Dawson Range. The Patton Porphyry also forms discontinuous dykes ranging from less than one to tens of meters wide, intersecting both the Patton Porphyry plug and the Dawson Range Batholith.
- Intrusive/Contact Breccia (Late Cretaceous) – The intrusive/contact breccia surrounding the main Patton Porphyry body consists of granodiorite, diorite, and metamorphic fragments in a fine-grained Patton Porphyry matrix.
- Explosive Breccia – Abundant fragments of the Patton Porphyry and its intrusive breccia are present in a late explosive breccia pipe. The unit indicates multiple episodes of brecciation as it contains 5 to 50% ragged fragments of altered intrusive breccia and host rock, with lesser fragments of quartz-phyric Patton Porphyry.
- Dawson Range Batholith (Middle Cretaceous) – The Dawson Range Batholith (DRB) is the main country rock of the deposit, and is characterized by hornblende-biotite-quartz diorite, hornblende-biotite diorite, and biotite-hornblende granodiorite.

Minor lithological units that have been encountered in the open pit area include Yukon Metamorphic rocks (comprised of metasediments, metavolcanics, gneiss and quartzite) and several mafic dykes.

A sub-surficial bedrock geology map is shown on Figure 4.2.

Potassic alteration is centered on and related to the microbreccia that forms the core of Patton Hill. It produced fine grained aggregates of K-feldspar and disseminations of magnetite and biotite. Phyllic alteration typically forms texture destructive quartz-sericite envelopes to quartz-pyrite veinlets (Pacific Sentinel Corp., 1995).

Weathered bedrock is present through the deposit area, varying in thickness from several tens of metres to 200 m thick. The weathered bedrock was identified during the 2010 and 2011 site investigations as part of the geotechnical logging of the drill core. Bedrock was classified as “weathered” if weathering processes have considerably weakened the rock and penetrative discoloration has occurred.



LEGEND:

LATE CRETACEOUS - PROSPECTOR MOUNTAIN SUITE

- BRECCIA (EXPLOSION AND INTRUSION)
- PATTON PORPHYRY (DYKES AND HYPABYSAL INTRUSION)

MID CRETACEOUS - DAWSON RANGE BATHOLITH

- DIORITE TO GRANODIORITE
- FAULT
- GEOMECHANICAL DRILLHOLE
- EXPLORATION HOLE WITH TELEVIEWER SURREYS

NOTES:

1. COORDINATE GRID IS UTM (WGS84 / NAD83) ZONE 7 (m).
2. CONTOUR INTERVAL IS 5 m.
3. GEOLOGY PROVIDED BY CASINO MINING CORPORATION (NOVEMBER 2010).
4. OPEN PIT OUTLINE PROVIDED BY CASINO MINING CORPORATION (SEPTEMBER 2012)

Figure 4.2 Sub-Surficial Geology and Geotechnical Drillhole Locations

4.4 STRUCTURE

4.4.1 Data Collection Methods

The structure of the bedrock within the open pit area was identified from data collected during the 1994, 2010 and 2011 site investigation programs. Oriented core logs and data from bore hole televiewer surveys were used to create a structural database.

Twelve oriented drill holes have been completed within the open pit area. Four holes were completed in 1994 (DH94-288, DH94-298, DH94-305 and DH94-310), three in 2010 (DH10-18 to 20), and five holes in 2011 (DH11-35 to 39). Drill core during the 2010 and 2011 geotechnical investigations was oriented using the Reflex ACT I and ACT II RD (respectively) core orientation systems.

Borehole televiewer surveys were completed in three drill holes (CAS-051, DH11-35 and DH11-36). The boreholes were scanned using an acoustic televiewer (ATV) probe by the COLOG Division of Layne Christiensen Company (COLOG) and the dip/dip direction of each fracture was calculated from the resulting images. The fractures were also ranked based on the apparent aperture of the feature; from 0 for sealed structures to 5 for major fractures with large openings or breakouts.

Large scale structural features, such as faults, were delineated by the Casino geologists. The surface traces of identified faults are illustrated on Figure 4.2. Fault traces plotted onto the pit shell model indicate that the faults are sub-vertical.

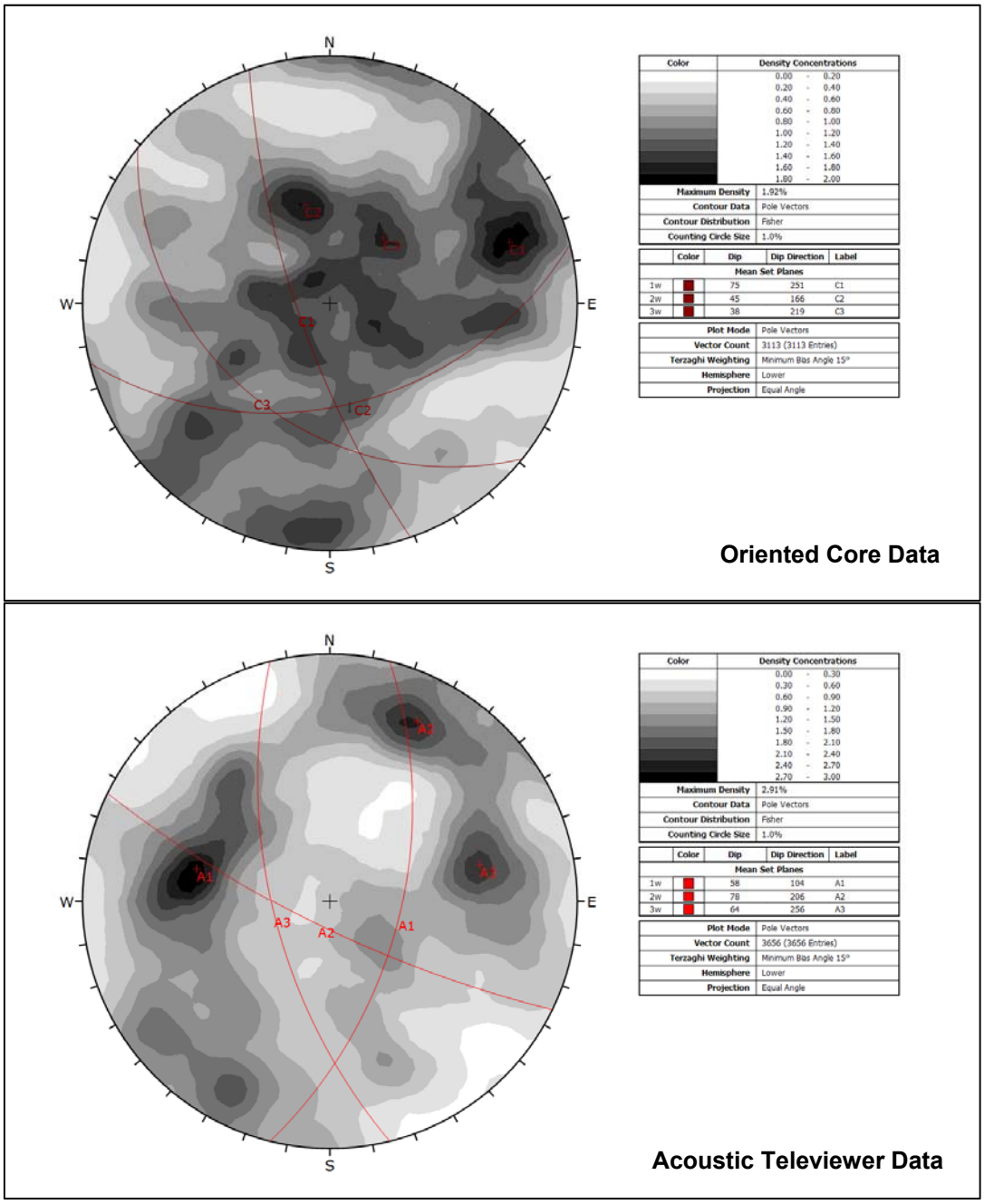
4.4.2 Data Quality Control

Overall pit structure was plotted on stereonets using the Rocscience Inc. DIPS software (DIPS). The data was sorted by source type (oriented core and ATV) and plotted on individual stereonets. All oriented core data and ATV data was corrected for orientation bias using borehole traverse information. Survey Data from the ATV and a Reflex EZ-Shot survey tool was used to compile the borehole traverses.

4.4.3 Structural Orientations

Stereographic plots of the oriented core data and ATV data are shown on Figure 4.3. Eastward and westward trending discontinuity sets are present in both data sets. The oriented core data indicates that these discontinuity sets are typically moderately dipping. The ATV data shows that the east/west dipping discontinuity sets are steeply dipping.

The steeply dipping discontinuity sets presented in the ATV data can be seen as minor pole concentrations within the oriented core data. The discrepancy between the oriented core and ATV data sets is due to the size of each data base and the location of the drill holes in which the ATV surveys were completed. Approximately 8000 discontinuities were measured in the oriented core drilled throughout the open pit area, whereas the ATV survey was conducted within the western end of the open pit and only 250 discontinuities (after filtering out rank 0 and 1 rated features) were recorded.



NOTES:

1. ACOUSTIC TELEVIEWER DATA COLLECTED BY COLOG DURING THE 2011 GEOTECHNICAL SITE INVESTIGATION PROGRAM.
2. ORIENTED CORE DATA PROVIDED BY KNIGHT PIÉSOLD LTD. DURING THE 2010 AND 2011 GEOTECHNICAL SITE INVESTIGATIONS PROGRAMS.

Figure 4.3 Overall Rock Mass Structure

Several faults are present within the Casino deposit area. The largest fault affecting the deposit area on the property is the Casino Creek Fault, a broadly curved steeply dipping, strike-slip fault trending at 310°. Numerous small faults are present on the east side of the Casino Creek Fault, as indicated by the 1994 drill holes. Most of these faults have sub-horizontal slickensides and chlorite-hematite alteration. The Patton Fault also runs through the deposit area, and is sub-vertical with an approximate 310° trend. This fault heads south from Canadian Creek and ends near Patton Hill. A number of other faults have also been identified in the deposit area, and are typically sub-vertical to vertical.

4.5 ROCK MASS

4.5.1 Geotechnical Domains

The geological units that are present on site were grouped into four geotechnical domains for the purpose of geotechnical characterization and stability analysis. The geotechnical domains are as follows:

- Overburden – The overburden is classified as loose to medium dense sand and gravel with some cobbles and trace clay. Overburden is typically found along the northeast rim of the pit with a maximum thickness of 30 m.
- Weathered Zone – The weathered diorite/granodiorite rock vary in thickness from tens to 200 m within the deposit.
- Prospector Mountain Suite (PMS) – The late Cretaceous Patton Porphyry, intrusion breccia and explosive breccia rocks comprise the PMS domain.
- Dawson Range Batholith (DRB) – The middle Cretaceous diorite and granodiorite that comprise the DRB domain.

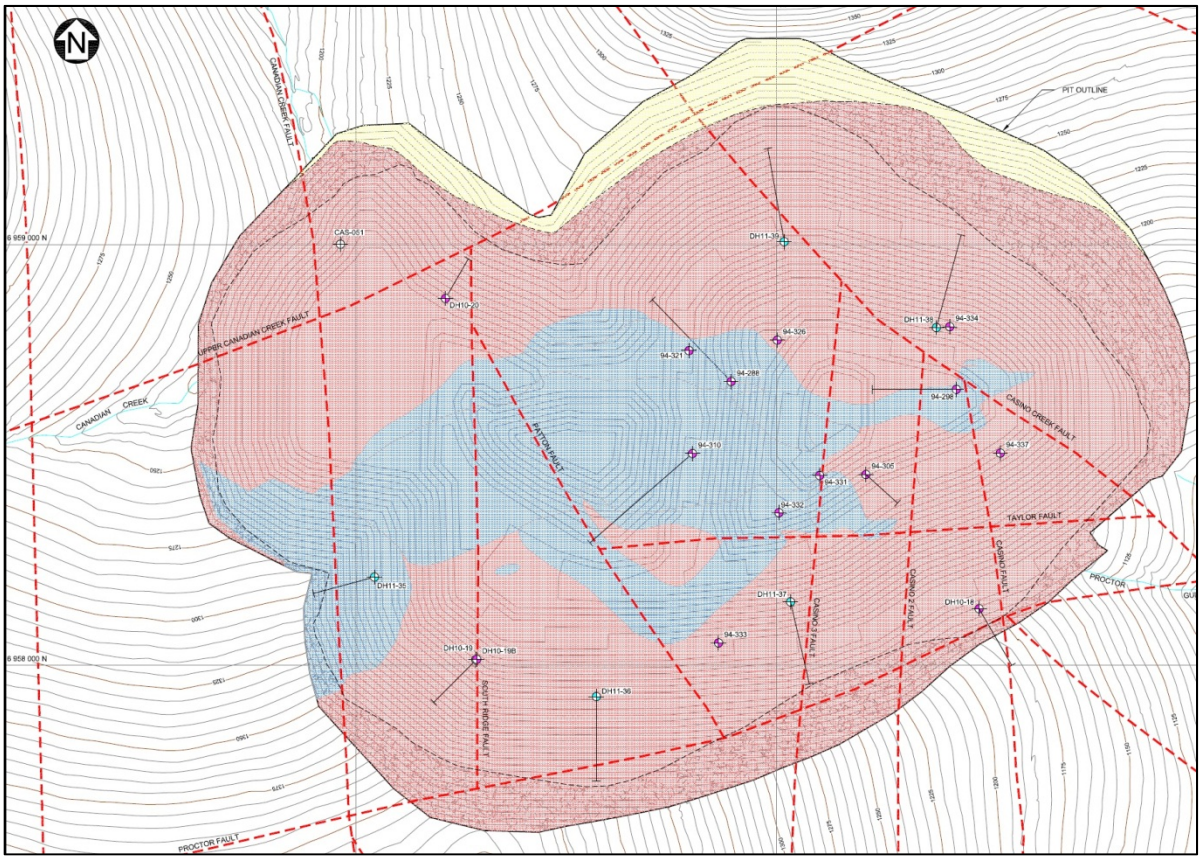
A preliminary pit shell was utilized to project the final wall geology for the Casino open pit. The projected wall geology is presented on Figure 4.4 along with the fault traces.

4.5.2 Intact Rock Strength

Field estimates of intact rock strength were collected for each drill run. A number of core samples were selected for laboratory point load and Unconfined Compressive Strength (UCS) testing. The test results were compiled and grouped by geotechnical domain.

A summary of the laboratory rock strength values and the average rock strength by geotechnical domain can be seen on Table 4.2. Results of the laboratory rock strength testing indicates that the PMS and DRB domains are considered “Hard” rock with average UCS values of 51 and 55 MPa respectively.

No samples from the Weathered Zone were selected for laboratory strength testing. The intact rock strength of the weathered bedrock in each geotechnical domain was assumed to be equal to one standard deviation below the average rock mass UCS. The strength of the weathered PMS and DRB domains are 31 and 39 MPa, respectively, and are considered “Average” strength rock.



LEGEND:

- OVERBURDEN
- WEATHERED ZONE
- DAWSON RANGE BATHOLITH
- PROSPECTOR MOUNTAIN SUITE
- FAULT
- GEOMECHANICAL DRILLHOLE
- EXPLORATION HOLE WITH TELEVIEWER SURREYS

NOTES:

1. COORDINATE GRID IS UTM (WGS84 / NAD83) ZONE 7 (m).
2. CONTOUR INTERVAL IS 15 m FOR THE PIT AND 5 m FOR THE SURROUNDING TOPOGRAPHY.
3. PIT WALL GEOLOGY PROVIDED BY CASINO MINING CORPORATION (NOVEMBER 2010).
4. FAULTS ARE ASSUMED TO BE SUB-VERTICAL
5. WEATHERED BEDROCK DEPTHS PROJECT ONTO PIT WALLS BASED ON 2010 AND 2011 GEOMECHANICAL DRILLING DATA.

Figure 4.4 Projected Pit Wall Geology

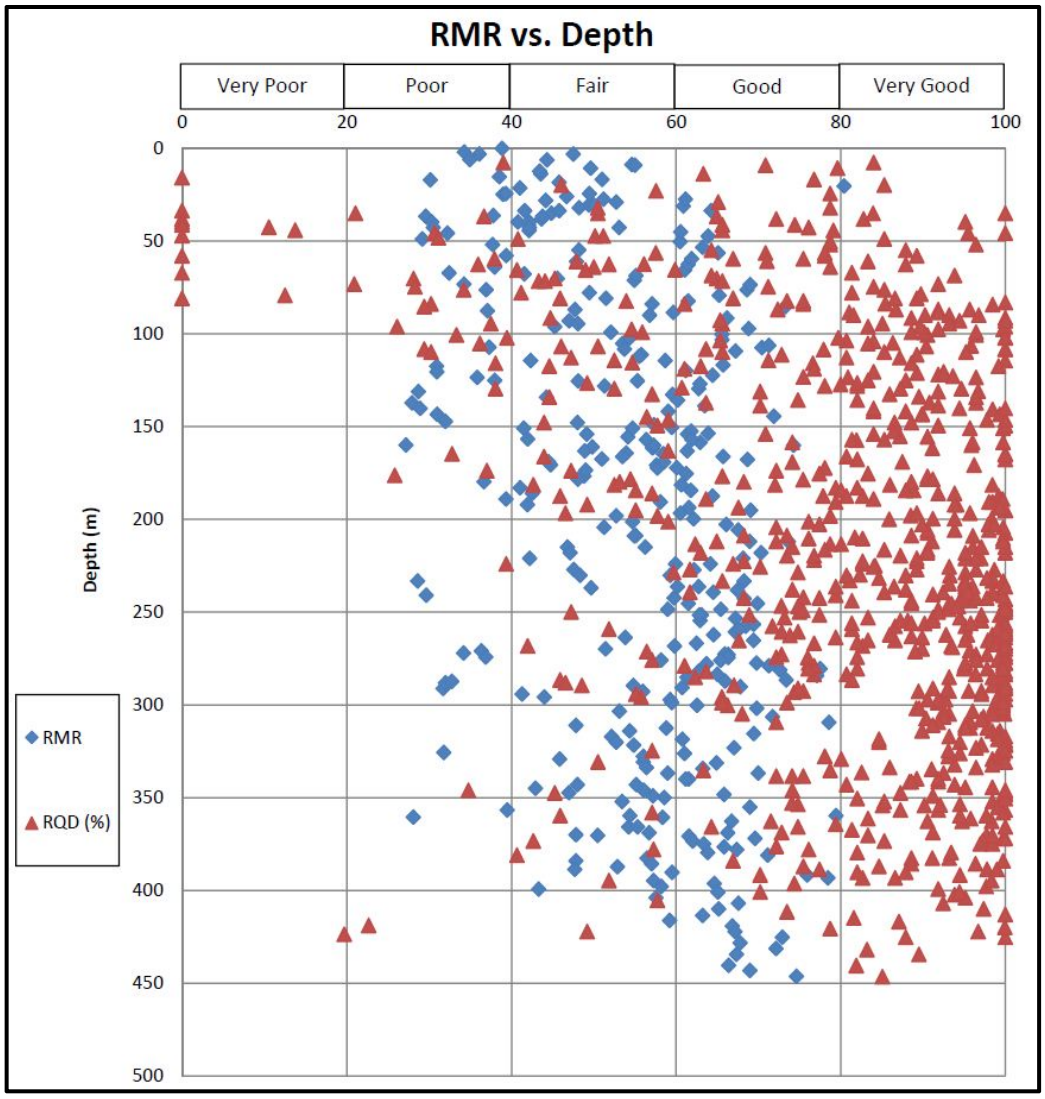
Table 4.2 Summary of Rock Mass Properties

Rock Mass Properties		Prospector Moutain Suite			Dawson Range Batholith		
UCS	Zone[3]	Weathered Zone	Fresh		Weathered Zone	Fresh	
	Number of Samples	-	19		-	9	
	Mean (MPa)	31	51		39	55	
	Median (MPa)	-	54		-	50	
	Std. Dev. (MPa)	-	19		-	16	
	Maxium (MPa)	-	76		-	92	
	Minimum (MPa)	-	11		-	40	
	Rock Hardness Rating	R3 - Average Rock	R4 - Hard Rock		R3 - Average Rock	R4 - Hard Rock	
Young's Modulus (GPa)		26			21		
Poisson's Ratio		0.14			0.18		
Zone		Weathered Zone	Fresh	All	Weathered Zone	Fresh	All
RQD	Number of Runs Measured	536	235	771	283	956	1239
	Mean (%)	42	81	54	33	72	63
	Median (%)	43	92	57	30	82	74
	Std. Dev. (%)	30	24	33	26	29	33
RMR89	Numbers of Discontinuities Measured	108	235	343	192	957	1149
	Mean	47	59	55	41	59	56
	Median	46	61	57	40	61	58
	Std. Dev.	11	10	12	11	11	13
	Rock Mass Quality Description	FAIR	FAIR	FAIR	FAIR	FAIR	FAIR
Hydraulic Conductivity (m/sec)		6.E-08					

4.5.3 Rock Mass Quality

RMR_{89} values were calculated for each drill run during the 2010 and 2011 site investigations, and the data was compiled and organized by geotechnical domain. The drill hole RQD and RMR vs. depth for the two rock geotechnical domains are illustrated on Figure 4.5 and Figure 4.6. It is noted that while RQD shows trends of increasing with depth, the average RMR typically remains constant.

A summary of the RMR_{89} values and resulting average rock mass quality by geotechnical domain can be seen on Table 4.2. The PMS and DRB domains are considered “FAIR” quality rock with average RMR_{89} values of 61 for fresh bedrock. The RMR_{89} values for weathered bedrock are 47 and 41 for the PMS and DRB domains, as logged during the 2010 and 2011 site investigations.



NOTES:

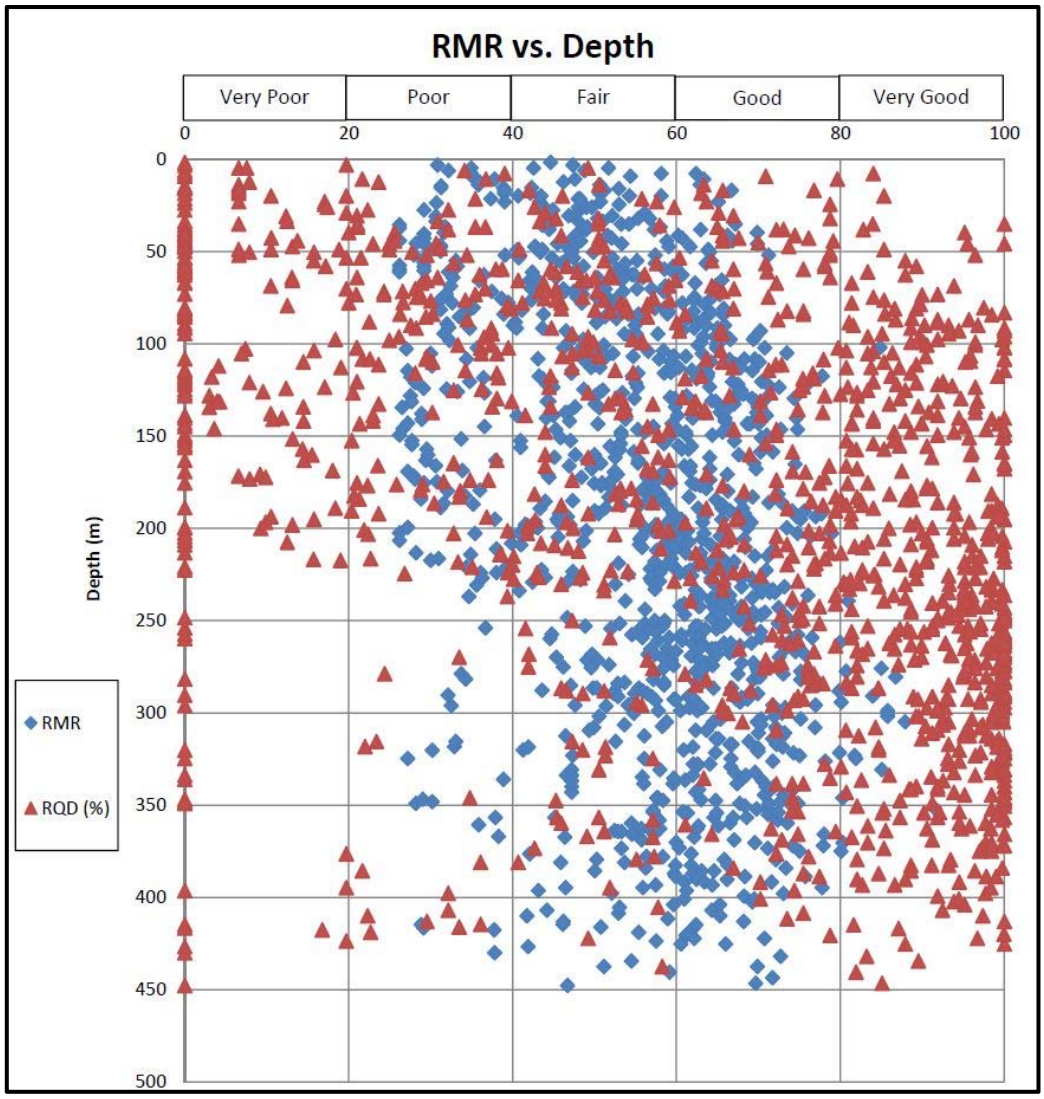
1. "DEPTHS" ARE INCLINED DRILL HOLE DEPTHS.

Figure 4.5 RQD and RMR vs. Depth for Prospector Mountain Suite Domain

4.5.4 Overburden Strength Parameters

Samples of overburden were collected within the open pit area during the 2011 site investigation and sent to the Knight Piésold Soil Laboratory in Denver for soil index testing and classification. No in situ density tests of the overburden were performed; however, field logs indicate that the overburden is typically loose to medium dense. A unit weight of 18.7 kN/m^3 was assumed for the overburden material as a typical value for medium dense soils.

The overburden is assumed to be a cohesionless material. A base friction angle (phi) of 30° was assumed for the material as shown in Table 4.3.



NOTES:

1. "DEPTHS" ARE INCLINED DRILL HOLE DEPTHS.

Figure 4.6 RQD and RMR vs. Depth for Dawson Range Batholith Domain

4.5.5 Rock Mass Strength Parameters

The overall rock mass strength parameters were derived using the Hoek-Brown criterion (2002 edition). The characteristics of the rock mass are described by lithology, intact rock strength and rock mass quality. The strength properties can be adjusted to account of the expected level of rock disturbance. Rock mass disturbance is typically caused by blasting damage and from strains resulting from stress changes in the pit walls due to unloading during mining. The design values of the rock mass strength parameters are summarized in Table 4.3.

Table 4.3 Summary of Design Parameters of Soil and Rock

Material		Unit Weight (kN/m^3)	UCS[1] (MPa)	GSI[2]	Friction Angle (°)	Confining Stress (kPa)	m_i[5]
Overburden		18.7			30[3]	-	-
Dawson Range Batholith	Weathered	26.2	39	36	See Note 4	1500	25
	Fresh		55	54			
Prospector Mountain Suite	Weathered	26.2	31	42	See Note 4	1500	19
	Fresh		51	54			

NOTES:

1. UCS VALUES FROM LAB TESTING OF ROCK SAMPLES. TEST RESULTS WERE AVERAGED TO PROVIDE UCS VALUE.
2. GSI = RMR -5. RMR VALUES FROM BORE HOLE LOGS WERE AVERAGED FOR EACH GEOTECHNICAL DOMAIN AND STATE OF WEATHERING.
3. A SENSITIVITY ANALYSIS WAS PERFORMED ON OVERBURDEN USING ASSUMED FRICTION ANGLES FO 25° TO 35°.
4. FRICTION ANGLE DETERMINED USING SHEAR STRENGTH FUNCTION CALCULATED USING UCS, mi AND GSI.
5. INTACT ROCK CONSTANT, mi, ASSUMED AS TYPICAL VALUES FOR ROCK TYPE (HOEK-BROWN, 2007).

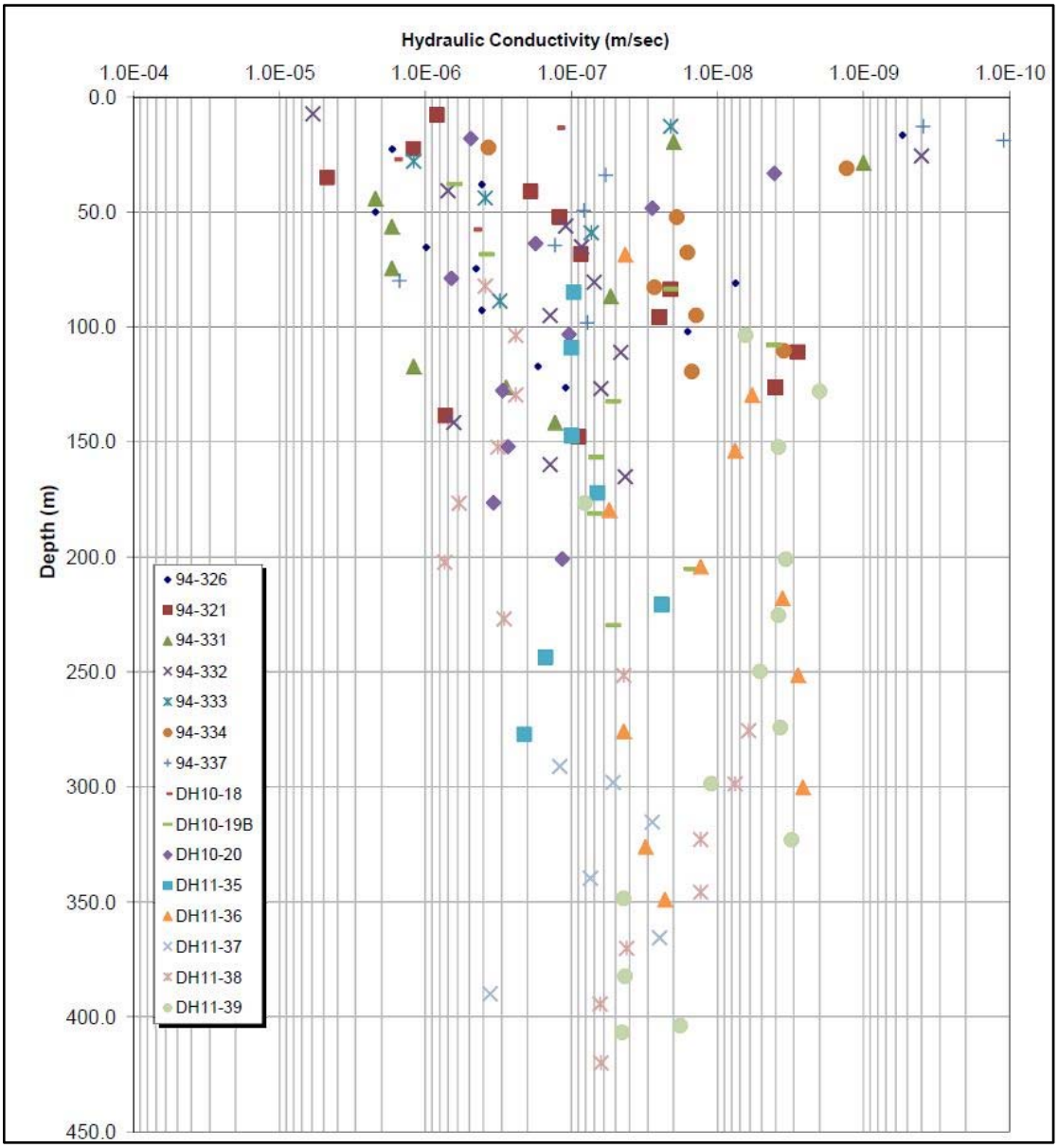
The UCS values of each geotechnical domain were determined from laboratory rock strength testing results. The lithological factor (m_i) has been estimated for each domain according to the general rock types. The m_i values are 19 for the PMS domain (representative of breccia) and 25 for the DRB domain (representative of diorite).

The Geological Strength Index (GSI) was estimated based on the RMR values. GSI was introduced by Hoek et. Al. (1995) to overcome issues with the RMR values for very poor quality rock masses. For better quality rock masses (GSI > 25), the value of GSI can be estimated from Bieniawski's RMR (1989) as GSI = RMR - 5. Therefore, as the RMR values are greater than 25, the GSI values are assumed to be mathematically equivalent to the equation above.

4.6 HYDROGEOLOGY

The groundwater level in the deposit area typically varies from 3 m below surface to 30 m. A groundwater depth of 100 m was observed in the southwest region of the deposit (Hole DH10-19B).

In situ hydrogeological testing performed during the 1994, 2010 and 2011 site investigations indicate that the hydraulic conductivity of the rock mass varies between $1x10^{-5}$ m/sec to $1x10^{-9}$ m/sec within the upper 150 m of bedrock. The permeability of the rock reduces moderately with depth, with tested hydraulic conductivities of $1x10^{-7}$ to $1x10^{-9}$ m/sec observed. A summary of hydraulic conductivity vs. depth is shown on Figure 4.7. The average hydraulic conductivity of the rock mass, taken as the geometric mean of the tested permeability results, is $6x10^{-8}$ m/sec.



NOTES:

1. HYDRAULIC CONDUCTIVITIES PLOTTED AGAINST INCLINED DEPTH OF DRILLHOLE.

Figure 4.7 Summary of Rock Mass Hydraulic Conductivities

5 – PIT SLOPE STABILITY ASSESSMENT

5.1 GENERAL

The proposed Casino open pit will extend to a maximum depth of approximately 590 m. The feasibility pit slope design considered site specific data collected during site investigations throughout 1994 to 2011. A series of design sectors were delineated for pit slope assessment. Both kinematic and soil/rock mass slope stability analyses were performed to determine appropriate slope configurations for each design sector.

5.2 PIT DESIGN SECTORS

CMC developed a pit shell model in September 2011, which contains two distinct mining zones, the Main Pit and the West Pit, which will be developed concurrently during operations. A total of eight pit design sectors were delineated primarily based on the nominal pit wall orientations with a secondary consideration to pit wall geology.

Figure 5.1 shows the projected pit wall geology along with the proposed design sectors. The thickness of the weathered bedrock within each design sector was estimated by the RQD and RMR profiles of the geotechnical holes. The RQD and RMR vs. Inclined Depth plots of the 1994, 2010 and 2011 drill holes are presented in Appendix A with respect to each pit design sector. The depth to fresh bedrock was indicated on the 2010 and 2011 drillhole plots and estimated based on a comparison of RQD values in the 1994 drillholes. The estimated extent of the weathered bedrock within the final pit walls is also illustrated on Figure 5.1. A brief description of the design sectors is shown in Table 5.1.

5.3 KINEMATIC SLOPE STABILITY ANALYSES

5.3.1 General

The purpose of these analyses was to identify the kinematically possible failure modes within each design sector using the stereographic technique. Bench geometry was selected to reduce the potential for small-scale discontinuities to form bench-scale instabilities. Inter-ramp angles were determined to reduce the potential of multiple bench failure to an acceptable level.

5.3.2 Modes of Failure

Kinematically possible failure modes in rock slopes typically include planar, wedge and toppling failures. These failure modes will occur if discontinuities are pervasive at bench scale or greater, if weak infilling is present along the discontinuities, or if the geometry of the discontinuities is conducive to failure. Stereographic analyses of peak pole concentrations of the discontinuity data can be used to identify potential modes of failure. A brief introduction on each mode of failure is provided below:

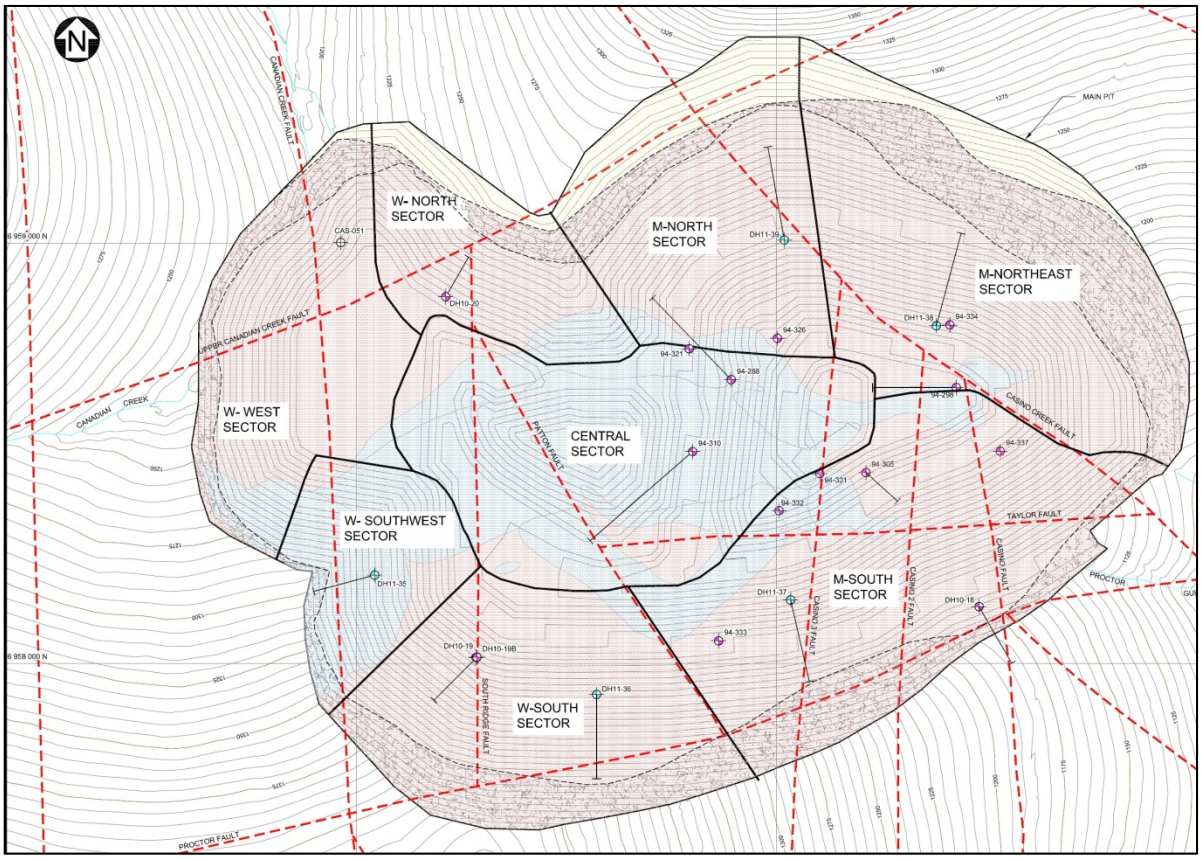
- **Planar Failure** – This failure mode is kinematically possible where a discontinuity plane sits at a shallower inclination than the slope face (daylights) and at an angle steeper than the friction angle.
- **Wedge Failure** – This failure mode is kinematically possible where the plunge of the intersection of two planes (sliding vector) is inclined less than the slope face (daylights) and at an angle

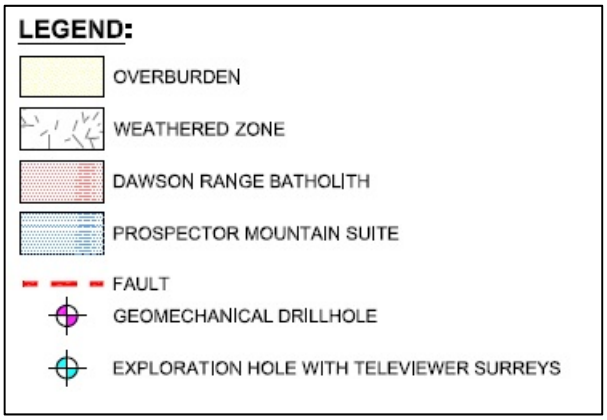
greater than the combined friction angle which is determined from the characteristics of each plane that forms the wedge. Where kinematics are the controlling factor, the recommended pit slope angles have been adjusted to reduce the potential for large-scale, multiple bench wedge failures.

- **Toppling Failure** – This failure mode is kinematically possible due to interlayer slip along discontinuity surfaces where sub-vertical jointing dips into the slope at a steep angle β. The condition for toppling to occur is when $\beta > (\phi j + (90 - \Psi))$, where Ψ is the slope face angle and ϕj is the friction angle (Goodman, 1989).

Table 5.1 Summary of Design Sectors

Sector	Maximum Slope Height (m)	Wall Orientations (°)	Geotechnical Domains	Overburden Thickness (m)	Weathered Bedrock Thickness (m)
M-North	630	135, 170	DRB	30	60
M-Northeast	630	195, 220, 240, 270	DRB	30	250
M-South	540	325, 255	DRB, PMS	-	125
Central	210	030, 100, 180	PMS	-	-
W-North	285	180, 215, 240	DRB	-	50
W-South	480	000, 040	DRB	-	3 to 65
W-Southwest	345	010, 090	PMS	-	60
W-West	210	090, 135	DRB	-	60





NOTES:

1. COORDINATE GRID IS UTM (WGS84 / NAD83) ZONE 7 (m).
2. CONTOUR INTERVAL IS 15 m FOR THE PIT AND 5 m FOR THE SURROUNDING TOPOGRAPHY.
3. PIT WALL GEOLOGY PROVIDED BY CASINO MINING CORPORATION (NOVEMBER 2010).
4. FAULTS ARE ASSUMED TO BE SUB-VERTICAL
5. WEATHERED BEDROCK DEPTHS PROJECT ONTO PIT WALLS BASED ON 2010 AND 2011 GEOMECHANICAL DRILLING DATA.

Figure 5.1 Open Pit Design Sectors

5.3.3 Stereographic Analysis

Stereographic analyses have been carried out for each design sector using the DIPS program (Rocscience Inc., 2001). The analysis assumes that failures will occur as the results of sliding blocks or wedges along the defects of rock mass. This type of analysis does not consider slope failure within the rock mass. Stereographic plots for individual oriented core hole and televiewer survey hole are presented in Appendix B. The drillhole rock mass structural data were grouped by design sectors for further kinematic stability analyses.

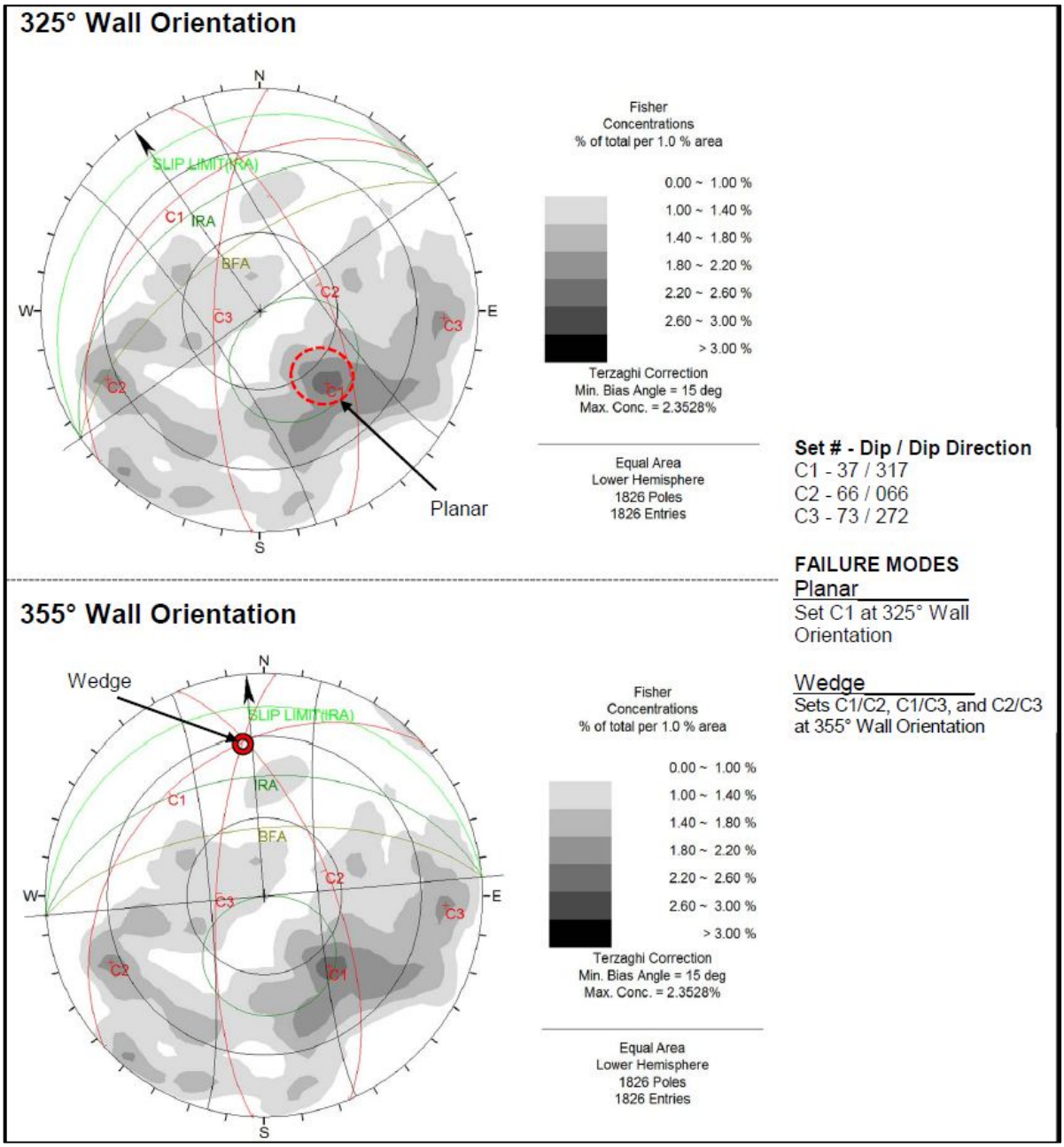
Pit wall orientations were measured from a preliminary pit shell model provided by CMC in 2010. Where the pit walls contain a pronounced curve, multiple analyses were conducted to account for the changing pit wall dip direction within the sector.

A joint friction angle of 29° was used for all discontinuities. This value is based on the results of direct shear testing performed on samples collected during the 2011 site investigation.

Multiple stereographic plots were created for each design sector in order to account for the variation of pit wall orientations within each sector. The results of the kinematic stability analyses are summarized on Table 5.2. A brief discussion for each design sector is provided below:

- **M-North Sector** – This sector was comprised of a curved section of pit wall with pit wall dip directions of 135° to 170°. Multi-bench wedge failure is kinematically possible within this sector. Variation and scatter within the discontinuity sets may result in bench scale planar and wedge failures to develop. Slightly flatter bench face and inter-ramp angles are recommended for this sector.
- **M-Northeast Sector** – This sector encompasses the majority of the east side of the Main Pit and includes a pronounced curve (pit wall dip direction varies from 195° to 270°). Bench scale wedge failures are kinematically possible.
- **M-South Sector** – This sector is comprised of a shallowly curved wall with pit wall dip directions of 325° to 355°. Multi-bench planar and wedge failures are kinematically possible. Slightly flatter bench face and inter-ramp angles are recommended for this sector.
- **Central Sector** – This sector is comprised of central bottom section of the pit, with major wall orientations of 030°, 100°, and 180°. Multi-bench wedge failure modes are identified for the south facing walls in the Central Sector.
- **W-North Sector** – The W-North Sector is a moderately curved wall that ranges in pit wall dip direction from 180° to 240°. Multi-bench planar and wedge failures are kinematically possible. Therefore, slightly flatter bench face and inter-ramp angles are recommended for this sector.
- **W-South Sector** – The W-South Sector is moderately curved with pit wall dip directions ranging from 000° to 040°. Toppling failure is kinematically possible at both the inter-ramp and bench scales.
- **W-Southwest Sector** – The W-South Sector contains a sharply curved wall with nominal pit wall dip directions ranging of 010° and 090°. The potential for kinematically controlled failures is less significant in this sector.
- **W-West Sector** – This sector encompasses the west side of the West Pit and is moderately curved with pit wall dip directions ranging from 090° to 135°. Bench scale planar and wedge failures are kinematically possible.

A typical stereographic analysis is illustrated on Figure 5.2. Detailed results of the kinematic stability analyses are shown in Appendix B.



NOTES:

1. ACOUSTIC TELEVIEWER DATA NOT COLLECTED IN THE M-SOUTH SECTOR.
2. ORIENTED CORE DATA COLLECTED BY KNIGHT PIÉSOLD LTD. DURING THE 1994, 2010 AND 2011 GEOTECHNICAL SITE INVESTIGATIONS.

Figure 5.2 Typical Stereographic Analyses Results - M-South Sector - 325°, 355°

Table 5.2 Summary of Structure and Kinematically Possible Failure Modes

Pit	Sector	Drill Hole	Discontinuity Sets (DIP / DIP DIRECTION)		Wall Orientation (°)	BFA Planar	BFA Wedge	BFA Topple	IRA Planar	IRA Wedge	IRA Topple	Comment
			Oriented Core	Acoustic Televiewer								
Main	M-North	DH94-288, DH11-39	C1 - 45/189, C2 - 68/100, C3 - 43/143, C4 - 27/284	No Data Available	135°	C3	-	-	-	-	-	Scatter and variation within the C3 discontinuity set may allow for the formation of planar features.
					170°	-	C1/C2, C1/C3, C2/C3	-	-	C1/C2, C1/C3, C2/C3	-	Wedge failures kinematically possible. Scatter and variation within the C1 and C3 discontinuity sets may allow for the formation
	M-Northeast	DH94-298, DH11-38	C1 - 47/098, C2 - 68/136, C3 - 84/177, C4 - 68/271	No Data Available	195°	-	C2/C4	-	-	C2/C4	-	Inter-ramp scale wedge failure kinematically possible, wedge slip line at limit of inter-ramp angle.
					220°	-	C2/C4	-	-	-	-	Bench scale wedge failure is kinematically possible, wedge slip line is at limit of inter-ramp angle.
					240°	-	-	-	-	-	-	No possible kinematically controlled failure mechanisms.
					270°	-	-	-	-	-	-	Some toppling failure possible due to scatter and variation in structural set C1
	M-South	DH94-305, DH10-18, DH11-37	C1 - 37/317, C2 - 66/066, C3 - 73/272	No Data Available	325°	-	-	-	C1	-	-	Planar failures kinematically possible due to set C1.
					355°	-	C1/C2, C1/C3, C2/C3	-	-	C1/C2, C1/C3, C2/C3	-	Wedge failure kinematically possible, however is at limit of assumed friction angle.
Central		DH94-288, DH94-310	C1 - 26/207, C2 - 29/278, C3 - 67/092, C4 - 41/147, C5 - 72/232	No Data Available	030°	-	-	-	-	-	-	No possible kinematically controlled failure mechanisms.
					100°	-	-	-	-	-	-	No possible kinematically controlled failure mechanisms.
					180°	-	-	-	-	C3/C4, C3/C5, C4/C5	-	Inter-ramp scale wedge failures kinematically possible.
West	W-North	DH10-20	C1 - 49/186, C2 - 41/250, C3 - 67/104	No Data Available	180°	-	C1/C3	-	C1	-	-	Scatter and variation within the C1 discontinuity set may allow for the formation of planar features.
					215°	-	C1/C2	-	C1	C1/C2	-	Planar failures kinematically possible due to set C2. Wedge failure kinematically possible due to interactions of sets C1 and C2.
					240°	-	C1/C2	-	C2	C1/C2	-	Planar failures kinematically possible due to set C2. Wedge failure kinematically possible due to interactions of sets C1 and C2.
	W-South	DH10-19B, DH11-36	C1 - 00/267, C2 - 89/045, C3 - 79/063,	A1 - 58/003, A2 - 69/251	000°	-	-	-	-	-	-	No possible kinematically controlled failure mechanisms.
					040°	-	-	C2	-	-	-	Toppling failure is kinematically possible.
	W-Southwest	DH11-35	C1 - 87/043, C2 - 34/309, C3 - 14/179	A1 - 85/232, A2 - 64/341, A3 - 32/299	010°	-	-	-	-	-	-	No possible kinematically controlled failure mechanisms.
					090°	-	-	-	-	-	-	No possible kinematically controlled failure mechanisms.
	W-West	CAS-051	No Data Available	A1 - 59/103, A2 - 76/204, A3 - 61/141	090°	A1	-	-	-	-	-	Bench scale toppling failure is kinematically possible.
					135°	A3	A1/A3	-	-	-	-	Bench scale wedge and toppling failure is kinematically possible.

5.3.1 Bench Face Angle Analysis

Further bench face angle analyses were conducted using the SWEDGE limit equilibrium program (Rocscience Inc.) for the M-North, M-Northeast, and W-North Sectors. Wedge failures are kinematically possible in these areas. Cumulative bench scale wedge and planar failures were

estimated based on the structural discontinuity sets identified within each design sector in comparison to the relevant bench geometry. The bench height was 15 m, the bench widths were 8 m, and the targeted bench reliability was 70%. The results of the bench face angle analyses are shown in Appendix B.

5.3.2 Implications of Kinematic Analysis Results

The bench face angles have been reduced to 60° to offset the risk of planar and wedge failures occurring within the M-North and W-North Sectors. The inter-ramp slopes, which are dictated by bench geometry, will be 42° within these sectors to lower the risk of multi-bench planar/wedge failures.

5.4 OVERBURDEN AND ROCK MASS SLOPE STABILITY ANALYSES

5.4.1 General

The maximum achievable overall slope angle in large open pit mines may be controlled by the overburden/rock mass strength. Limit equilibrium stability analyses were performed using the SLOPE/W computer program (GEO-SLOPE International Ltd., 2007). The limit equilibrium analyses were completed to evaluate the overall slope stability of the jointed rock mass and overburden. A minimum FOS of 1.2 has been targeted for inter-ramp slopes, and 1.3 for the overall pit slopes (Read & Stacey, 2009).

The overburden model utilizes soil unit weight and friction angle as the primary material parameters. Intact rock strength, the Hoek-Brown constant for rock mass (mi), GSI, unit weight, and blast disturbance factors are the primary material parameters used in the bedrock slope models.

5.4.2 Rock Mass Disturbance

The overall rock mass strength parameters were derived using the Hoek-Brown failure criterion (2002 edition). The characteristics of the rock mass are described by lithology, intact rock strength and rock mass quality. The strength properties can be adjusted to account for the expected level of rock disturbance. Rock mass disturbance is typically caused by blast damage and from strains resulting from stress relaxation in the pit walls due to unloading during mining.

Hoek et al., 2002 recommends that the utilized rock mass strengths be downgraded to disturbed values to account for rock mass disturbance associated with heavy production blasting and stress relief. He indicates that a disturbance factor of 0.7 would be appropriate for a mechanical excavation where no blasting damage is expected. KPL experience indicates that a disturbance factor approaching a value of 0.85 may be achievable for moderate height slopes with the application of controlled production blasting practices (buffer blasting). A value of 1.0 is assumed for conventional production blasting. Disturbance values of 0.85 and 1.0 were selected for the limit equilibrium analyses to demonstrate the impact of blasting damage.

Faults were not modelled explicitly as part of the limit equilibrium analysis. The faults within the pit are sub-vertical, and are expected to account for some localized areas of instability, but are not considered to be controlling factors for the stability of the ultimate slopes.

5.4.3 Overburden Slope Stability Analyses

Overburden is typically negligible throughout much of the open pit deposit area; except in the northern area of the Main Pit where it is upwards of 30 m deep.

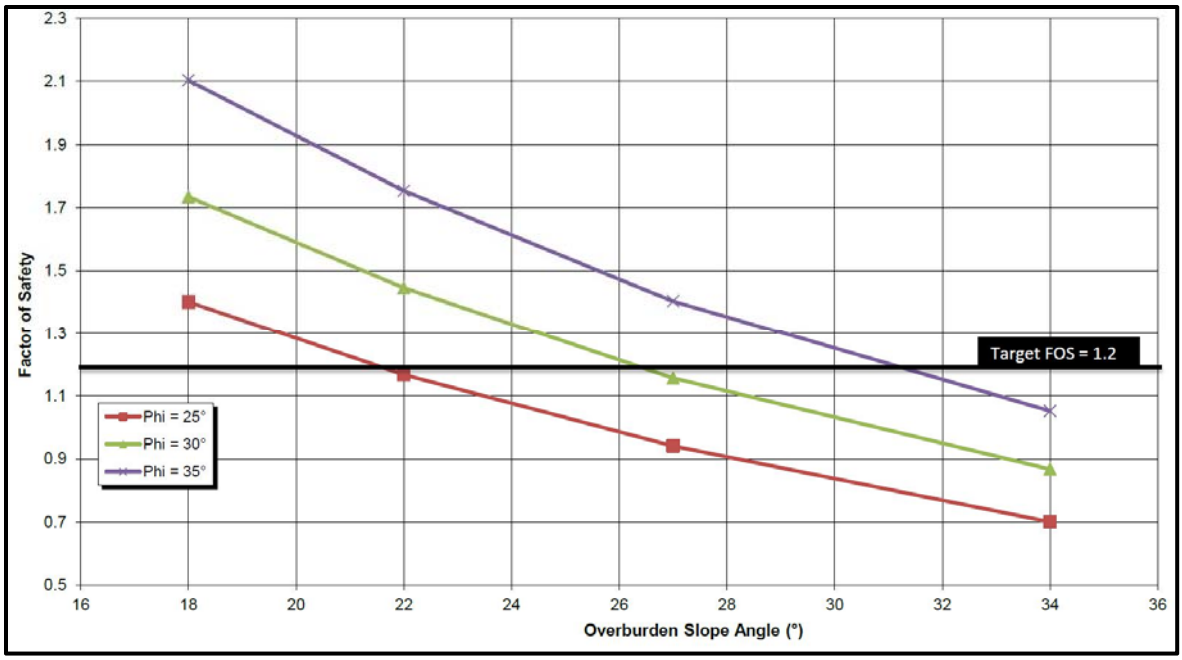
Five overall slope angles (18°, 22°, 27°, and 34°) were modelled for a 30-m high overburden slope, to represent the 3H:1V to 1H:1V slopes, assuming both partially saturated and fully drained (dry) conditions. The pore water pressure within the partially saturated slopes was modelled as 20% of the overburden stress (i.e., with a coefficient of pore water pressure, Ru, of 0.2). The purpose of running multiple scenarios was to show the impact of steepening the overburden slope angle on the FOS.

The friction angle of the overburden material was estimated based on experience with similar soil materials as no laboratory testing data is available for the overburden within the open pit area. A base case friction angle of 30° was adopted in these analyses. Further sensitivity analyses were conducted to account for a range of potential soil friction angles. A range of friction angles from 25° to 35° was used with the assumed base case of 30° for the sensitivity analyses.

The results of the base case analyses are summarized in Table 5.3 and Figure 5.3 shows the computed FOS with respect to various slope angles. A 2H:1V (approximately 27°) overburden slope may be achieved if the slope is completely drained and the friction angle of the overburden material is at least 30°.

Table 5.3 Summary of Overburden Analyses

Geotechnical Unit	Overall Slope Angle (°)	Groundwater Condition	Factor of Safety
Overburden	34 (1.5H:1V)	Partially Saturated	0.6
		Fully Drained	0.9
	27 (2H:1V)	Partially Saturated	0.9
		Fully Drained	1.2
	22 (2.5H:1V)	Partially Saturated	1.1
		Fully Drained	1.5
	18 (3H:1V)	Partially Saturated	1.4
		Fully Drained	1.7



NOTES:
1. BASE CASE SCENARIO ASSUMES A 30 m HIGH, COMPLETELY DRAINED (DRY) SLOPE.
2. FRICTION ANGLE (PHI) ASSUMED FOR THE SENSITIVITY ANALYSES.

Figure 5.3 Overburden Slope Stability Analysis Results FOS vs. Slope Angle

5.4.4 Rock Mass Inter-Ramp Slope Stability Analyses

Inter-ramp slope models were created to determine the stability of the disturbed rock mass during mining operations in both fresh bedrock and weathered bedrock. These simplified models utilized a single geotechnical domain with disturbed rock mass parameters (the entire model has a disturbance factor applied).

Read and Stacey, 2009, indicate that 200 m is typically the highest practical inter-ramp slope height that should be utilized for open pit slope design. Therefore, haulage ramps and/or step-outs should be included as appropriate to limit the inter-ramp slope height. Models were created for slope heights of 100 m, to show the FOS achievable under moderate slopes heights, and 200 m to show the effect on the FOS of the inter-ramp slope at the maximum height. An inter-ramp slope angle of 45° was utilized in the analyses for both fresh and weathered bedrock. Disturbance factors of 0.85 and 1 were applied to the models to demonstrate the impact of blasting practices.

Groundwater was modelled using a piezometric line to represent the phreatic surface of the water. It was assumed that hydrostatic conditions exist below the piezometric line. Two groundwater cases were modelled; a fully saturated slope and the other with the phreatic surface set 30 m back horizontally from the pit face.

Table 5.4 summarizes the results of the rock mass slope stability analyses for both geotechnical domains, in both weathered and fresh bedrock, at an inter-ramp scale. A blasting disturbance factor (D) of 1 was considered for the base case as it is assumed that conventional production blasting will be utilized during interim pit wall development.

Slope laybacks or widened haul ramps should be constructed every 100 m in weathered bedrock slopes. Fresh bedrock inter-ramp slopes can be built up to 200 m in height before slope laybacks will be required. Groundwater depressurization measures are required in both weathered and fresh bedrock slopes. Detailed modelling setup and results are shown in Appendix C.

Table 5.4 Summary of Inter-ramp Slope Stability Analyses

Geotechnical Unit (1)	Inter-Ramp Slope Angle	Slope Height	Blast Disturbance D	Groundwater Depressurization (2)	Factor of Safety	
					Bedrock Condition	
	(degrees)	(m)		(m from pit wall)	Weathered	Fresh
DRB	45	100	0.85	0	0.6	1.5
				30	1.6	2.6
			1	0	0.5	1.3
				30	**1.3**	2.3
		200	0.85	0	0.6	1.2
				30	1.1	1.8
			1	0	0.5	1.0
				30	0.9	**1.6**
PMS	45	100	0.85	0	0.7	1.4
				30	1.6	2.4
			1	0	0.6	1.2
				30	**1.3**	2.1
		200	0.85	0	0.6	1.1
				30	1.1	1.6
			1	0	0.5	1.0
				30	0.9	**1.4**

NOTES:

1. DRB = DAWSON RANGE BATHOLITH, PMS = PROSPECTOR MOUNTAIN SUITE
2. GROUNDWATER DEPRESSURIZATION SET TO SIMULATE INSTALLATION OF HORIZONTAL DRAINS IN PIT WALL
3. **BOLD** FONT INDICATES BASE CASE ANALYSIS SCENARIO.

5.4.5 Overall Slope Stability Analyses

The M-North, M-Northeast, M-South, and W-Southwest pit walls were analysed using limit equilibrium techniques. These sectors contain the tallest slopes in the pit within each of the geotechnical domains. Overall slopes angles of 40° were utilized in the analyses, based on the pit shell model provided by CMC (November, 2010).

Disturbance factors (D) of 0.85 and 1 were applied to the face of each modelled slope. The disturbed section was projected 60 m horizontally into the pit walls to simulate blasting damage from production blasting (Hoek 2012). The disturbed zone was expanded near the base of the slope to reflect increased stress caused by the relaxation and rebound of the rock mass as the pit is excavated. The extent of the induced stress zone was established using a simplified 2D stress

model analyzed in Examine2D (Rocscience Inc.). A disturbance factor of zero was applied to the rock mass beyond the disturbed zone as assigning a disturbance factor to the entire overall slope will result in overly conservative model results (Hoek, 2012). The multiple disturbance factors were utilized to show the effect of production blasting vs. controlled production blasting on the overall stability of the open pit. The base case scenario assumes a disturbance factor of D = 1 for the final pit walls considering additional stress-induced disturbance in very high pit slopes.

A piezometric line was utilized to establish groundwater pressure in the slope. Three groundwater conditions were modelled to simulate a fully saturated slope, a slope where the weathered bedrock allows drainage (is dry) but is saturated below, and a slope with drained weathered bedrock and a phreatic surface simulating horizontal drains within the pit walls. It is conservatively assumed that hydrostatic pressures exist below the phreatic surface. The base case stability analysis assumes the weathered bedrock is drained and 30 m of horizontal depressurization in all pit walls.

Table 5.5 summarizes the results for the overall slope stability analyses of the M-North, M-Northeast, M-South and W-West pit walls and their calculated FOS. The results of the overall slope stability analyses are shown on Figure 5.4 and Figure 5.5. Detailed modelling results are shown in Appendix C.

The weathered bedrock within the M-Northeast Sector is upwards of 250 m thick. A FOS of 1.2 is the maximum achievable FOS within this sector. It is noted that the failure slip surface occurs entirely within the weathered bedrock. As such, the stability of this slope will be governed by the inter-ramp scale stability of the weathered bedrock. The M-Northeast Sector was not considered as a base case scenario for overall slope stability.

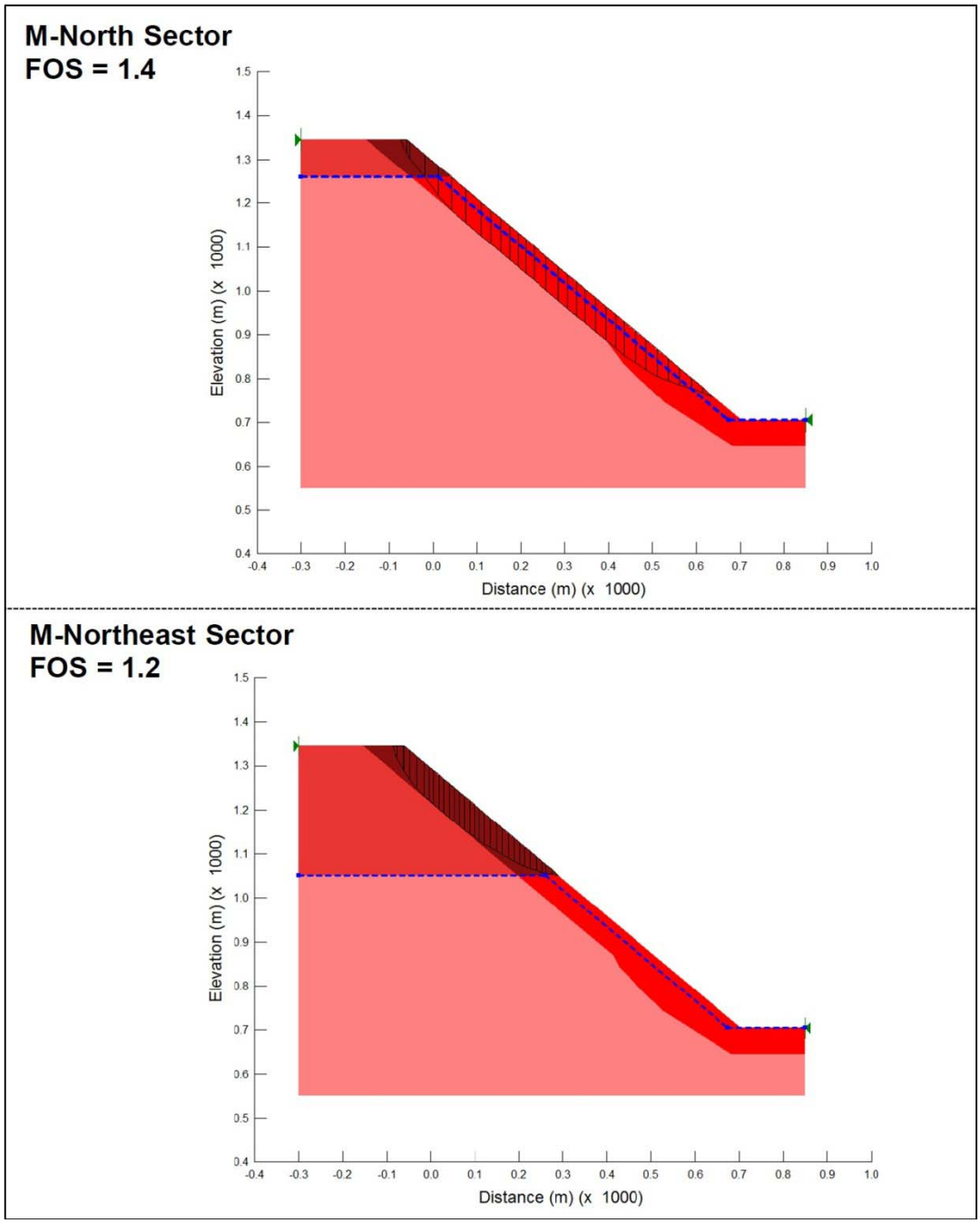
The results of the base case stability analyses show that a FOS of 1.3 is achievable in the final pit slopes of the M-North, M-South, and W-Southwest Sectors at overall slopes angles of 40°. The predicted failure surface runs through the blast disturbed rock. Slope depressurization by use of horizontal drains and drainage of the weathered bedrock is required for slope stabilization. Vertical pumping may be required if the weathered bedrock does not drain naturally and if cold winter conditions preclude the effectiveness of the horizontal drains. This should be assessed during the early stages of mining operations and adjusted as necessary to facilitate slope depressurization.

Table 5.5 Summary of Overall Slope Stability Analyses

Pit Design Sector	Geotechnical Units [1]	Total Slope Height	Overall Slope Angle	Depth to Fresh Bedrock	Disturbance Factor	Groundwater Depressurization		Factor of Safety
						Vertical	Horizontal Groundwater Depressurization[2]	
		(m)	(°)	(m)	(D)	(m)	(m from pit wall)	
M-North	DRB	630	40	85	1	85 (Assume drainage of weathered bedrock)	30	1.4
M-Northeast	DRB	630	40	250	1	250 (Assume drainage of weathered bedrock)	30	1.2
M-South	PMS and DRB	540	40	3	1	3 (Assume drainage of weathered bedrock)	30	1.3
W- Southwest	PMS	345	40	60	1	60 (Assume drainage of weathered bedrock)	30	1.6

NOTES:

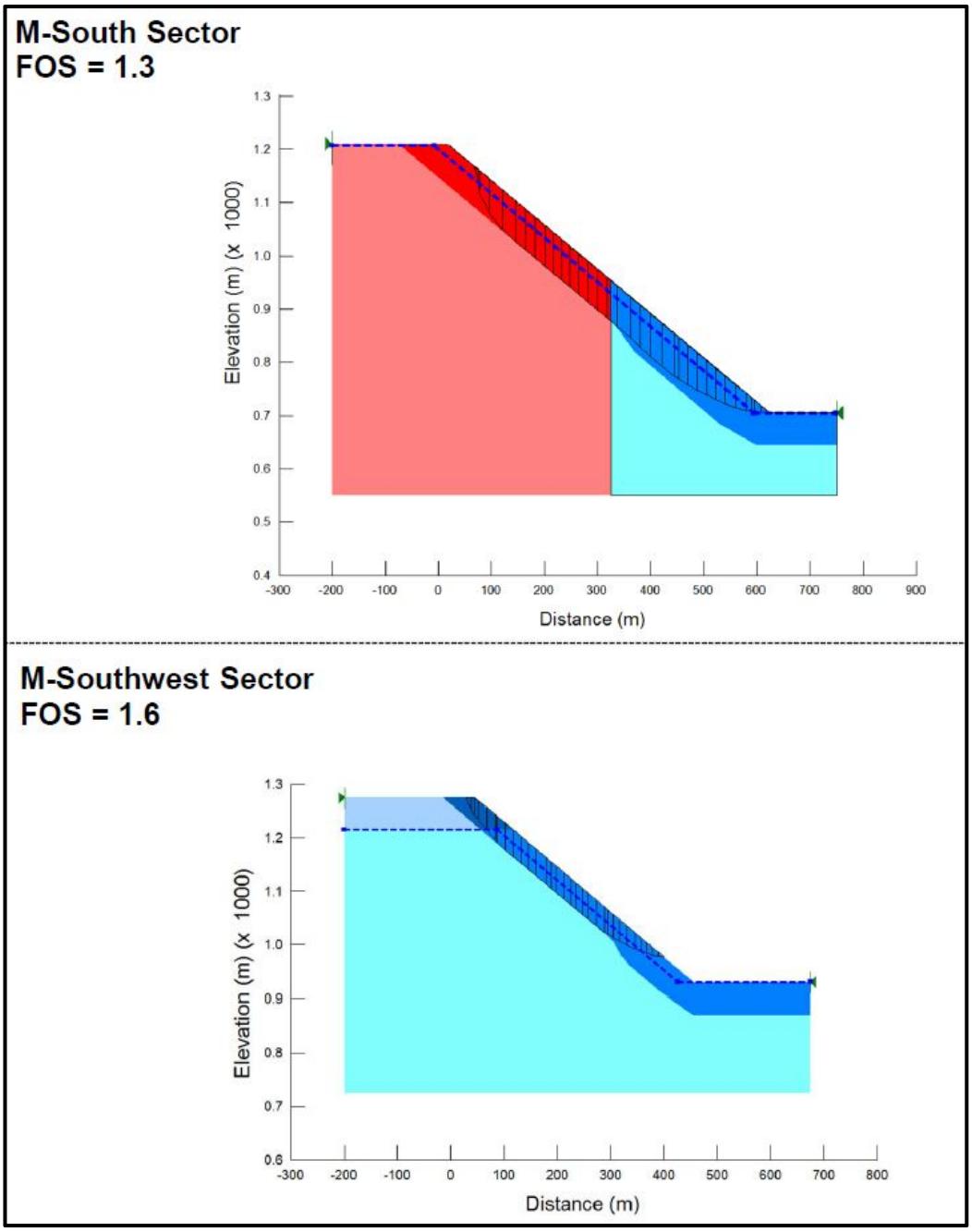
1. DRB = DAWSON RANGE BATHOLITH, PMS = PROSPECTOR MOUNTAIN SUITE
2. GROUNDWATER DEPRESSURIZATION SET TO SIMULATE INSTALLATION OF HORIZONTAL DRAINS IN PIT WALL



NOTES:

1. ACOUSTIC TELEVIEWER DATA NOT COLLECTED IN THE M-SOUTH SECTOR.
2. ORIENTED CORE DATA COLLECTED BY KNIGHT PIESOLD LTD. DURING THE 1994, 2010 AND 2011 GEOTECHNICAL SITE INVESTIGATION

Figure 5.4 Overall Slope Stability Analyses Results – M-North and M-Northeast Sectors



NOTES:

1. ACOUSTIC TELEVIEWER DATA NOT COLLECTED IN THE M-SOUTH SECTOR.
2. ORIENTED CORE DATA COLLECTED BY KNIGHT PIESOLD LTD. DURING THE 1994, 2010 AND 2011 GEOTECHNICAL SITE INVESTIGATION

Figure 5.5 Overall Slope Stability Analyses Results – M-South and W-Southwest Sectors

6 – PIT WATER MANAGEMENT PLAN

6.1 GENERAL

The development of the open pit will have a significant impact on the local hydrogeologic regime, as the pit will become a groundwater discharge area. The existing groundwater table is near surface and will gradually be lowered during pit development. Pit inflows are likely to come primarily from the North and West edges of the pit, where topography slopes towards the final pit rim.

The pit water management systems will comprise a combination of techniques including surface water diversion ditches, vertical pumping wells, horizontal wall drains and water collection systems. These measures will be implemented as a staged observational approach during pit development and will involve the installation of depressurization measures and associated monitoring of groundwater pressures. This will enable an assessment of the pit slope drainage capability and the requirements for additional installations.

A conceptual level pit water management plan has been developed for groundwater depressurization and for the controlled removal of both groundwater inflows and precipitation runoff from within the pit. The pit water management systems should include allowances for:

- Diversion ditches to collect surface runoff, snowmelt and seepage along the pit crest and the base of the Weathered Bedrock materials.
- Horizontal drains installed in both interim and final pit walls
- A series of pumps and collection systems which transfer water from the pit excavation to a surface sump located near the primary crusher for recycle to the milling process, and
- Modifications to the depressurization systems to account for the extreme cold during winter months and the high inflows during the freshet period.

These depressurization/dewatering features are discussed in more along with the estimates of pit inflows. The pit shell model provided by CMC (November, 2010) was utilized for the pit water management assessment.

6.2 SURFACE WATER DIVERSION

Diversion ditches along the north and west pit crest are required to divert the surface runoff away from the pit during operations. These surface runoff ditches will capture and divert the majority of all runoff, snowmelt and infiltration before the water flows into the pit and will reduce power requirements for pumping from the deeper levels of the pit. Ditches will need to be modified for different stages of pit development. It may be appropriate to include low permeability glacial till or synthetic liner materials along sections of these ditches in order to reduce ditch leakage.

6.3 SLOPE DEPRESSURIZATION SYSTEM

Pit slope depressurization reduces pore water pressure within the overburden and rock mass, which in turn minimizes the potential of slope failures developing. Vertical wells and pumps can be used in conjunction with horizontal drains to depressurize the slopes. Diversion ditches and pumps can be utilized to divert surface water and seepage out and away from the pit.

6.3.1 Vertical Pumping Wells

An allowance for deep vertical pumping should be included in the feasibility study. It was assumed for the purposes of the overall slope stability analyses that the weathered bedrock present at the surface of the deposit will drain freely. However, the weathered bedrock varies in thickness throughout the pit area and the permeability of weathered rock mass may vary throughout the pit. Vertical wells may be required along the North Walls of the pit to reduce pore water pressures and the flow of groundwater into the pit.

Several faults intersect the deposit area and may act as preferential flow paths for groundwater inflow into the pit. The installation of wells into the faults may be required to reduce groundwater inflow. An allowance of 20 vertical depressurization wells should be included for Feasibility costing purposes. The typical depth of the wells is assumed to be in the order of 300 m.

Well pumping rates were estimated by determining the steady state radial flow to a well in the presence of constant recharge. A 300 m deep well pumping at 2 L/sec is estimated to provide sufficient drawdown for slope stabilization.

6.3.2 Horizontal Drains

Horizontal drains provide an efficient and cost effective mechanism for the control of groundwater inflows and for depressurization of open pit slopes. The effectiveness of horizontal drain installations is dependent upon the permeability of the rock mass along with the length and spacing of the drains. It is impossible to accurately predict the exact location or spacing of the horizontal drains that will be required during operations and it is essential that the dewatering program be continuously modified throughout operations as additional information becomes available on the hydrogeologic conditions in the open pit.

Drain holes will be drilled sub-horizontally, at approximately 3° to 5° above horizontal. It is recommended that the horizontal drains be drilled 50 to 100 m into the middle and lower pit slopes. Experience has shown that 100 m is a reasonable, practical and economic target length for horizontal drain installations.

The spacing of the horizontal drains must be determined such that adequate effective drainage is achieved at a point midway between adjacent installations. This spacing will be determined during open pit development and through observation and monitoring of piezometric conditions within the pit slopes. It is recognized that the actual drain spacing will likely vary across different areas of the open pit. The M-North, M-Northeast, M-South, and W-North Sectors may require a greater density of horizontal drains to reduce the risk of wedge failures developing.

For design purposes, the following average horizontal drain spacings have been estimated based on experience from other open pit operations. Centre to centre drain spacing for horizontal drains installed within interim pit slopes has been estimated at 150 m on average. Interim pit slopes are defined as those slopes that will remain for a period of at least 2 years. The spacing for drains installed within final pit slopes has been estimated at 60 m on average.

It is anticipated that the horizontal drains will freeze during the winter season. KPL experience on other projects in Canada has shown that the freezing of the rock mass and drains may have an

impact on slope behaviour. Additional depressurization from vertical pumping wells may be necessary, particularly during the winter months to maintain slope depressurization.

6.4 PIT DEWATERING SYSTEM

6.4.1 General

The estimates for water inflow volumes into the pit were developed based on meteorological and hydrogeological data collected from the project area in conjunction with groundwater monitoring and permeability testing conducted during the 1994, 2010, and 2011 geotechnical investigations.

Potential sources of pit inflows include:

- Dewatering of fissures and fractures into the rock mass
- Infiltration of precipitation into the groundwater system
- Surface runoff, and
- Direct precipitation into the pit.

Pit inflows were calculated using the Mass Balance Approach coupled with a simplified Dupuit approximation equation for steady radial flow (Freeze and Cherry, 1979). The Mass Balance Approach for estimating pit inflows has been proposed by Brown (1988). With this approach, a rough approximation of pit inflows was estimated by assuming a percent infiltration of precipitation into the groundwater system. The pit inflows were calculated for the final stage of pit development for the mean annual precipitation, ten year wet year precipitation, and storm event precipitation occurring over a 24 hour period.

Removal of water from the pit should be performed using a sump and pump system. Sumps should be installed in the lowest point of the pit as excavation progresses. Booster pumps should be placed every 100 m of elevation change or less. Additional sumps may be required during operations to adequately collect all pit seepage water.

6.4.2 Inflows from Average Annual Precipitation

Values for the mean annual precipitation and runoff coefficients were taken from the 2010 Casino Hydrometeorology Report (KP Ref. No. VA101-329/5-3). Twenty-four hour rainfall events were calculated based on more recent hydrometeorology data.

The Casino open pit area has a mean annual precipitation of 500 mm. It is assumed that all surface water will be diverted away from the pit through the use of diversion channels, so the average pit inflows from precipitation will come from direct precipitation onto the pit and groundwater infiltration.

It is assumed that 66% of the surface water will infiltrate the groundwater system before collecting in the pit sumps, and as such a runoff coefficient of 0.44 was applied. The calculated inflows from the average annual precipitation are listed on Table 6.1. An annual pit inflow, averaged over the course of the year, is estimated to be 49 L/sec for the final pit.

This approach does not account for groundwater inflows from underground aquifers and meteoric water that has infiltrated the groundwater regime.

Table 6.1 Open Pit Inflows and Pump Design

	Pit Stage	Estimate of Seepage Inflow		Inflow from Average Annual Precipitation	Total Average Annual Pumping Requirement	Inflow from 1 in 10 yr. 24 Hour Storm Event	Dewatering Period	Design Pump Flow
		(m^3/s)	(l/s)	(l/s)	(l/s)	(l/s)	(days)	(l/s)
Pit Seepage Inflow and Pumping Requirements	1	0.022	22	14	**36**	398	4	**130**
	2	0.075	75	24	**99**	695	6	**160**
	3	0.085	85	23	**108**	656	6	**150**
	4	0.102	102	40	**142**	1,149	5	**310**
	Final	0.140	140	49	**189**	1,390	6	**320**

	Pit Stage	Surface Area	Plan Area	Average Ground Elevation	Pit Bottom Elevation	Average Depth	Equivalent Radius of Excavation	Radius of Influence
		(m^2)	(m^2)	(m)	(m)	(m)	(m)	(m)
Final Open Pit Parameters	1	989,602	882,000	1,230	960	270	561	1,061
	2	1,890,515	1,539,000	1,240	795	445	776	1,276
	3	1,837,056	1,453,000	1,240	765	475	765	1,265
	4	2,928,443	2,545,000	1,240	765	475	965	1,465
	Final	3,565,756	3,079,000	1,240	705	535	1,065	1,565

	Average Annual Precipitation	10 Year Wet Annual Precipitation	1:10yr. 24hr. Storm Event	Overall Average K
Input Parameters	(mm)	(mm)	(mm)	(m/s)
	500	889	39	6.0E-08

NOTES:

1. ESTIMATED PIT SEEPAGE INFLOWS ARE CALCULATED USING THE DUPUIT APPROXIMATION EQUATION FOR STEADY RADIAL FLOW IN AN UNCONFINED AQUIFER.
2. PIT SURFACE AND PLAN AREAS ARE CALCULATED ASSUMING THE PIT IS CONICAL WITH A CONSTANT RADIUS AT THE CREST ELEVATION AND PIT BOTTOM. PIT RADII ARE APPROXIMATE MEASUREMENTS FROM THE STAGED PIT SHELL MODELS.
3. THE CAPACITY OF THE PIT PUMPING SYSTEM SHOULD COVER THE SUM OF GROUNDWATER SEEPAGE AND DIRECT PRECIPITATIONS. GROUNDWATER LEVEL IS ASSUMED TO BE NEAR THE SURFACE FOR THE PURPOSE OF INFLOW CALCULATIONS.
4. DESIGN PUMP FLOW BASED ON 120% BASE PUMPING + 24 HOUR STORM RUNOFF REMOVED OVER THE SPECIFIED DEWATERING PERIOD.
5. MAIN PIT AND WEST PIT EXCAVATED INTO SEPARATE PIT BOTTOMS STARTING IN STAGE 4. TWO PUMPS WITH A COMBINED CAPACITY OF ~320 L/SEC ARE RECOMMENDED TO DEWATER THE PIT DURING THE 1 IN 10 YEAR STORM EVENT.

6.4.3 Groundwater Inflow Estimates

A simplified estimate of groundwater inflow into an open pit can be made using the Dupuit approximation equation for steady radial flow in an unconfined aquifer. This approach assumes that flow is horizontal and the hydraulic gradient is equal to the slope of the groundwater table at the

seepage face and does not vary with depth. Groundwater inflow estimates using this approach are reported to be in good agreement with more detailed analytical methods when the gradient is low and the depth of the unconfined flow is shallow. The radial inflow (Q) to the pit can be calculated as follows:

$$Q = \frac{\pi k H^2}{\ln(R/r)}$$

Where:

- *k* is the average hydraulic conductivity of the rock mass. A k value of $6x10^{-8}$ m/sec has been assumed for the open pit, which is based on the geometric mean of test results from the 1994, 2010, and 2011 geotechnical site investigations.
- *H* is the head drop in the pit, and the maximum drop of 535 m has been assumed for the final pit by estimating an average slope height of 535 m and an average groundwater level of 0 m (i.e. ground surface).
- *r* is the equivalent radius of pit excavation and is calculated as the square root of the total pit surface area divided by π.
- *R* is the radius of influence and it is estimated as the equivalent radius of excavation plus 500m.

The maximum seepage inflow into the final pit has been estimated as 140 l/s (2220 gpm) by using the Dupuit Approximation equation. By including the inflows from direct precipitation of 49 l/s (based on the long term average annual precipitation for the site of 500 mm), a total pit average annual dewatering rate of 189 l/s (3000 gpm) has been estimated for the final pit configuration.

6.4.4 Storm Event Inflows

The dewatering system for the open pit will be required to handle the water flow resulting from a 24 hour storm period. A 1 in 10 year return period for the storm event was assumed for these calculations, based on experience with other open pit mines in the Yukon. This return period has a typical rainfall amount of 39 mm. The maximum operating capacity of the dewatering system was designed to remove storm event inflows over a period of four to six days, depending on the size of the pit at each development stage.

The open pit, once fully excavated, will take on approximately 1390 L/sec of water during a 24 hour rainfall event, in addition to the 189 L/sec from regular average annual inflows. The dewatering period will be adjusted by pit stage to reduce pumping requirements to approximately 300 L/sec for any given stage of mining. A design factor of 120% was applied for the pump design flow. The final pit dewatering system will require six days at a flow rate of 320 L/sec to dewater the pit. Table 6.1 shows the calculated inflows to the pit during the five main development stages and required pumping rate. It is assumed that a single pump operating at 160 L/sec will be sufficient to dewater the pit during stages one through three, as only one pit will be developed during these stages. The Main and West pits become distinct pit with separate pit bottoms during the development of Stage 4. It is recommended that another 160 L/sec capacity pump be installed to handle pit flows for a combined pumping capacity of 320 L/sec.

7 – PIT SLOPE DESIGN AND IMPLEMENTATION

7.1 GENERAL

The proposed Casino pit slopes will extend to a maximum depth of 630 m, making this pit one of the largest in the world. This feasibility pit slope design has considered site-specific geotechnical and hydrogeological information collected from site investigations from 1994 to 2011. Operational considerations related to the recommended slope angles are included in this section as well as a discussion of the experience encountered at other large open pit operations in Canada.

7.2 RECOMMENDED PIT SLOPE ANGLES

7.2.1 General

Recommended bench geometries and pit slope angles are summarized in Table 7.1. These recommendations are based on the results of the kinematic and rock mass stability analyses. Recommended slope angles are discussed below.

7.2.2 Bench Geometries

Bench geometries were selected to reduce the potential of small-scale discontinuities from forming unstable wedges and blocks etc. that can affect bench face integrity and reduce the effectiveness of rock all containment. The bench face angles derived from the kinematic analyses are as steep as can reasonably be achieved given the characteristics of the rock masses. Small bench-scale toppling and revelling type failures are expected due to the fractured nature of the bedrock; however, these failures can be removed during initial excavation or controlled through a normal bench maintenance program.

The pit benches are design to be 8 m wide with a 15 m high single bench configuration. The kinematic stability analyses undertaken in this study indicate that a bench face angle of 65° is expected to be achievable in the majority of pit walls throughout the pit. The exceptions to this design are the M-North and W-North Sectors, which have exhibited the potential for multi-bench planar and wedge failures. A bench face angle of 60° is recommended for these sectors, based on the results of the bench face angle analyses.

7.2.3 Inter-ramp Slopes

The inter-ramp slope angle is typically dictated by the bench geometry and controlled by large-scale structural features. A 15 m high single-bench configuration is recommended within all sectors. An inter-ramp angle of 45° can be used for most of design sectors. The inter-ramp angles in the M-North and W-North Sectors are recommended to be 42°, to reduce the risk of multi-bench wedge failures occurring.

Overburden should be cleared from the edges of the pit at a 2H:1V slope. A wider catcher bench should be developed along the bedrock contact to provide additional capacity for debris containment and seepage control.

Table 7.1 Recommended Open Pit Slope Angles

Design Sector	Max. Slope Height	Wall Geology	Bench Face Angle	Bench Height	Bench Width	Inter-ramp Angle	Max. Inter-ramp Slope Height	Max. Overall Slope Angle	Comments
	m		°	m	m	°	m	°	
M-North	630	Overburden	**40**	**5**	**4**	**27**	**200**	**39**	Reduction of inter-ramp angle to 42° will reduce the risk of multi-bench wedge failure in bedrock.
		DRB	**60**	**15**	**8**	**42**			
M-Northeast	630	Overburden	**40**	**5**	**4**	**27**	**100 (in Weathered Zone) 200 (in Fresh Bedrock)**	**40**	Weathered Zone down to 250 m deep, additional stepouts / ramps should be incorporated into the Weathered Zone slopes.
		DRB	**65**	**15**	**8**	**45**			
M-South	540	DRB, PMS	**65**	**15**	**8**	**45**	**200**	**42**	Potential planar and wedge failures are kinematically possible, but at the limit of the defect friction angle.
Central	210	PMS	**65**	**15**	**8**	**45**	**200**	**N/A**	Central lower pit walls with various orientations. The south facing maybe subject to potential wedge failure.
W-North	285	DRB	**60**	**15**	**8**	**42**	**200**	**39**	Reduction of the inter-ramp slope to 42° will reduce the risk of multi-bench planar and wedge failures.
W-South	480	DRB	**65**	**15**	**8**	**45**	**200**	**42**	Potential bench scale toppling failure is expected.
W-Southwest	345	PMS	**65**	**15**	**8**	**45**	**200**	**42**	
W-West	225	DRB	**65**	**15**	**8**	**45**	**200**	**42**	Potential bench scale planar failure is expected.

NOTES:
1. MAXIMUM SLOPE HEIGHT REPRESENTS THE HIGHEST WALL IN EACH DESIGN SECTOR.
2. RECOMMENDED SLOPE ANGLES DETERMINED BY THE KINEMATIC AND ROCK MASS STABILITY ANALYSES.
3. OVERBURDEN IS NEGLIGIBLE IN THE WESTERN AND SOUTHERN PIT WALLS.
4. THE OVERALL SLOPE ANGLES INCLUDED 1 TO 3 STEPOUTS OR HAUL RAMPS IN THE FINAL PIT WALLS.

7.2.4 Overall Slopes

The overall slope angle is determined by slope height, rock mass strength, groundwater pressure, blasting disturbance, and is typically restricted by inter-ramp angles. The overall slopes will be

flattened by incorporating haul ramps and cleanout benches into the pit wall design. It is recommended that the overall slope angles within the pit not be greater than 40° for the Main Pit and 42° in the West Pit.

7.3 OPERATIONAL CONSIDERATIONS

7.3.1 Controlled Blasting

Blasting disturbance is one of the controlling factors for rock mass strength and for overall stability. Slope instabilities are often triggered by the progressive deterioration (ravelling) of the wall face and this process often initiates with the detachment of small rock blocks bounded by the rock mass discontinuities. The preservation of rock mass integrity during mining is critical to prevent these progressive failures and is required to achieve the steepest bench face angles possible.

Pit slope angles are less critical in the early stages since the stripping ratio is typically controlled by the final overall pit slopes. Conventional production blasting can be used for the interim pit wall development. The initial pit can be developed with variable slopes and blast patterns to develop the optimal blast design for the final pit walls. Careful controlled production blasting practices are recommended for the final pit walls in order to reduce face damage and achieve steep slopes, particularly for the slopes situated in weathered bedrock and the M-North and M-Northeast sector walls. It is important that blast hole lengths be staggered so the bottom of the hole does not intercept the crest of the bench below. Trial blasts are also recommended wherever there is a substantial change in rock mass characteristics in order to evaluate and optimize blast performance.

7.3.2 Excavation and Scaling

It is important that the benches be kept clear and that the bench faces be maintained regularly so that they remain functional during mining operations. Scaling will be an important part of the bench maintenance program and may be conducted after blasting in areas where access is still available. Routine scaling may allow the bench widths to be minimized due to a reduction in the volume of material to be controlled.

7.3.3 Slope Depressurization

Groundwater is another key consideration for the overall pit slope stability. High water pressure can be expected within the pit walls and the slope depressurization measures include construction of surface ditches, perimeter pumping wells and horizontal drains are recommended for slope stabilization. The proposed slope depressurization program has been previously discussed in Section 6.3.

7.3.4 Slope Monitoring

Pro-active geotechnical monitoring is recommended for all stages of pit development. The monitoring program should be implemented as a staged approach and include detailed geotechnical and tension crack mapping, as well as a suitable combination of surface displacement monitoring (surface prisms and wireline extensometers) and piezometers. Sufficient staffing resources should be allocated to collect, process and interpret the geotechnical monitoring data on a weekly basis or as frequently as required. The timely identification of accelerated movements from surface

displacement monitoring and tension cracks will be critical. Up-to-date reports on the status of highwall stability should be compiled and discussed regularly with operation personnel. These reports will also assist mine engineering staff in their efforts to optimize final pit slopes and improve the effectiveness of the controlled blasting program. All seeps and springs should be inspected, mapped and photographed. Large-scale structures should be characterized and monitored as they have the potential to develop into tension cracks.

A typical geotechnical monitoring schedule is presented in Table 7.2. Detailed monitoring requirements are as follows:

- **Geotechnical Mapping** – Detailed geotechnical mapping should be carried out along all newly formed benches along the pit highwalls. Information to be noted should include the orientation of the main fracture sets, the type, thickness, extent (persistence) and frequency of any infilling (clay, gouge, chlorite, sericite, etc.), the distribution of joint spacings, the nature of the fracture surfaces (smooth, planar, polished, slickensided etc.) and any observations of seepage. Detailed maps for each bench face and a complete database should be compiled to include all of the recorded geotechnical data. All relevant (and particularly adverse) geotechnical information should be updated on weekly mine plans to ensure that mine planners and operations personnel are aware of the current geotechnical conditions. The geotechnical mapping will also provide the quantitative and qualitative information needed to conduct ongoing highwall stability assessments during mining activities.
- **Tension Crack Mapping** – Detailed tension crack mapping should be carried out along all newly formed benches. Information to be noted should include the surveyed location, orientation, aperture and both vertical and lateral extents of all tension cracks. The development of all tension cracks should be very carefully observed. The frequency of mapping and observations should be commensurate with the rate of development of individual tension cracks. Initial mapping and inspections should be carried out on a weekly basis. Simple extensometers should be installed across any significant tension cracks to confirm the rate and overall extent of movement. A detailed map and database should be compiled to include all the recorded data. The occurrence of tension cracks should be highlighted and presented on mine plans on a weekly basis so that mine planners and operations personnel are aware of the current ground conditions along the pit highwalls. Areas of slope movement that are associated with the development of tension cracks should also be monitored with surface displacement prisms as discussed below.
- **Surface Prism Monitoring** – Surface displacement monitoring survey prisms should be established along the highwalls to detect the onset of any possible movement/sliding at various locations within the vertical sequence of mining development of the open pit. An initial series of surface displacement monitoring prisms should be established along the crest of the highwalls as early in the mine-sequence as possible so that baseline information can be obtained. A subsequent series of surface displacement monitoring prisms should be established along all newly exposed benches. Prism surveying should be undertaken at regular intervals to develop a comprehensive record of highwall deformation. Data should be evaluated on an ongoing basis to enable the early detection of instability and allow for safe mining operations.
- **Piezometer Installation** - Enhanced depressurization will be required in order to provide an adequate factor of safety for the highwalls. As such, the extent to which the groundwater pore pressure decreases is important to assess. It is recommended that piezometers be installed to

allow long-term monitoring of groundwater depressurization over the life of the mine. These piezometers will be progressively installed during operations and locations for new piezometers should be reviewed on an annual basis.

- **Automated Monitoring Systems** – New advances in technologies allow for detailed monitoring of pit slopes. A number of systems are available that can be implemented to provide varying levels of monitoring detail. Slope Stability Radar utilizes a mobile radar station to continually scan selected slope areas. This method is not affected by dust, smoke or rain, and can provide near-real time monitoring of slope movement. Total stations can be set up as automated systems to scan surface prisms at regular intervals. These systems are typically packaged with operating software that allows users to specify monitoring frequency, scanning detail and scope, as well as set alarms to be triggered if specified movement thresholds are exceeded.

Table 7.2 Recommended Open Pit Geotechnical Monitoring Practices

Monitoring Items	Estimated Quantity	Suggested Monitoring Schedule	
		Active Mining Area	Inactive Mining Area
General Visual Inspection	N/A	Daily	Weekly
Geotechnical Mapping	All new bench faces	Monthly	Twice monthly
Tension Crack Mapping	As required	Weekly	Twice monthly
Surface Prism Monitoring	As required	Bi-weekly to Daily - Depends on the rate of displacement and location	Weekly
Time Domain Reflector System	As required, intersecting major slip planes.	As required, monitoring frequency should increase with rate of slip plane movement	As required, monitoring frequency should increase with rate of slip plane movement
Piezometer Monitoring	As required	Twice monthly	Monthly

NOTES:

1. VISUAL INSPECTIONS OF ALL FACES MAY BE REQUIRED AT THE BEGINNING OF EACH SHIFT AND WEEKLY INSPECTIONS OF THE HIGHWALL SHOULD BE COMPLETED."
2. ADDITIONAL CRACK MAPPING AND PRISM SURVEY MONITORING SHOULD BE CONDUCTED FOLLOWING SIGNIFICANT RAINFALL OR HEAVY BLASTING IN THE AREA."
3. SENSITIVE FACILITIES, WHERE SMALL DISPLACEMENTS WOULD RESULT IN DAMAGE TO THE FACILITY MAY REQUIRE MORE PRECISE MONITORING METHODS AND MORE FREQUENT MEASUREMENTS."

7.4 PRECEDENT PRACTICE

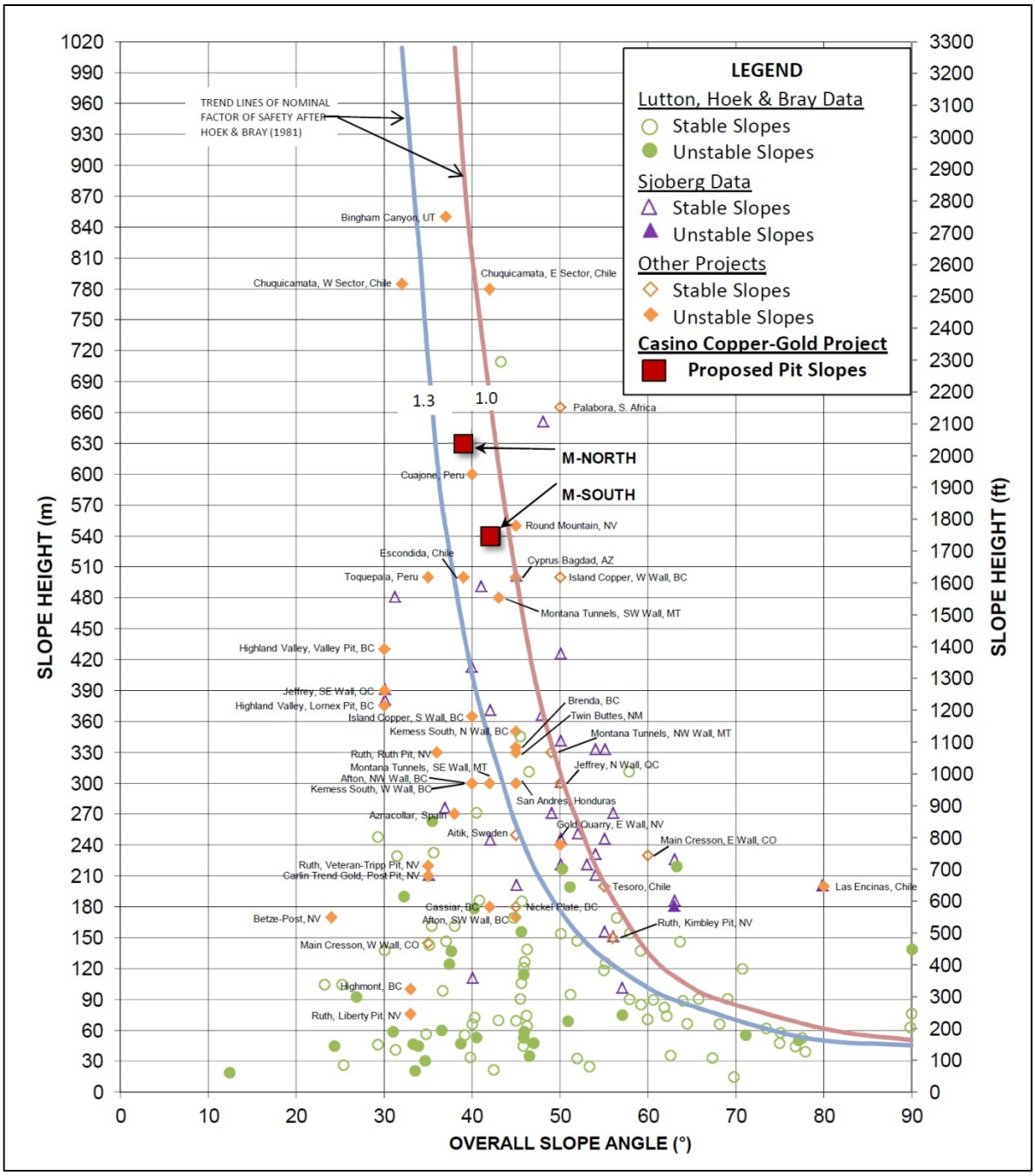
Pit slope stability depends on a variety of site-specific factors (geological structure, alteration rock strength, groundwater conditions, discontinuity characteristics and orientation, pit geometry, blasting practices, stress conditions, climatic conditions, and time) which make it difficult to provide direct comparisons with other operations. However, it is still quite useful to review the successes and problems encountered at other open pit operations in order to recognize opportunities and potential

constraints for the proposed open pit development. A summary plot of pit depth vs. slope angles achieved in various operations around the world is illustrated on Figure 7.1.

At an ultimate depth of up to 600 m, the pit slopes within the Casino open pit are significantly higher than most operating mines in Canada. The precedent for such large open pits is very limited, but the ultimate depths projected for some of these currently active open pits suggest that the proposed overall slope angles for the Casino open pit will be achievable provided that the recommended operational measures are implemented.

It is important to note that almost all of these large open pit operations, including porphyry copper mines, have encountered slope stability problems in some area of the mine. The experiences at most of the large open pits suggest that there is a significant likelihood that some area(s) of the pit slope will require flattening during operations in response to slope movement. Therefore, the mine plans should remain flexible so that extra stepouts/buttresses can be maintained in critical areas of the pit until the end of the mine life at which point lower factors of safety can be tolerated.

This comparison also highlights the importance of developing and maintaining good controlled blasting practices, effective groundwater depressurization measures and geotechnical data collection. It is also noted in these case studies, that adverse structural conditions have had a major impact on pit slope stability.



NOTES:

1. ORIGINAL DATA POINTS AFTER LUTTON 1970, HOEK AND BRAY 1981, AND SJOBERG 1996.
2. ADDITIONAL DATA FROM KNIGHT PIESOLD PROJECTS AND OTHERS.

Figure 7.1 Slope Height versus Slope Angle – Precedent for Hard Rock Surfaces

8 – SUMMARY AND RECOMMENDATIONS

The fundamental consideration for the geotechnical design of the Casino Open Pit at the feasibility stage is related to determining allowable inter-ramp and overall slope angles. These angles will affect the stripping ratio and the amount of ore that can be economically removed from the mineralized zone. The stability analyses confirm that the recommended pit slope angles presented in Table 7.1 are reasonable and appropriate. However, these slope designs have a number of operational constraints including careful controlled blasting and effective slope depressurization. An extensive geotechnical monitoring program should also be implemented throughout the pit operations.

It is recommended that additional geomechanical and hydrogeological data collection be conducted during the early stages of pit operations. The data collection programs may include bench surface mapping, piezometer installation and monitoring. Additional information will be used to fill the data gaps, enhance the geotechnical database, update the rock mass structural model, and refine the hydrogeological model. The pit design should be optimized when additional geotechnical information becomes available. The final pit designs and pit dewatering plans should be reviewed by qualified geotechnical engineers.

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Read, J. and Stacey, P., Guidelines for Open Pit Slope Design, CSIRO, 2009.

10 – CERTIFICATION

This report was prepared, reviewed and approved by the undersigned.

Prepared: _____

FOR Greg Magoon, P.Eng.
Project Engineer

Reviewed: _____ October 12, 2012

Daniel Y. Yang, P.Eng.
Senior Geotechnical Engineer

Approved: _____

Ken Brouwer, P.Eng.
Managing Director

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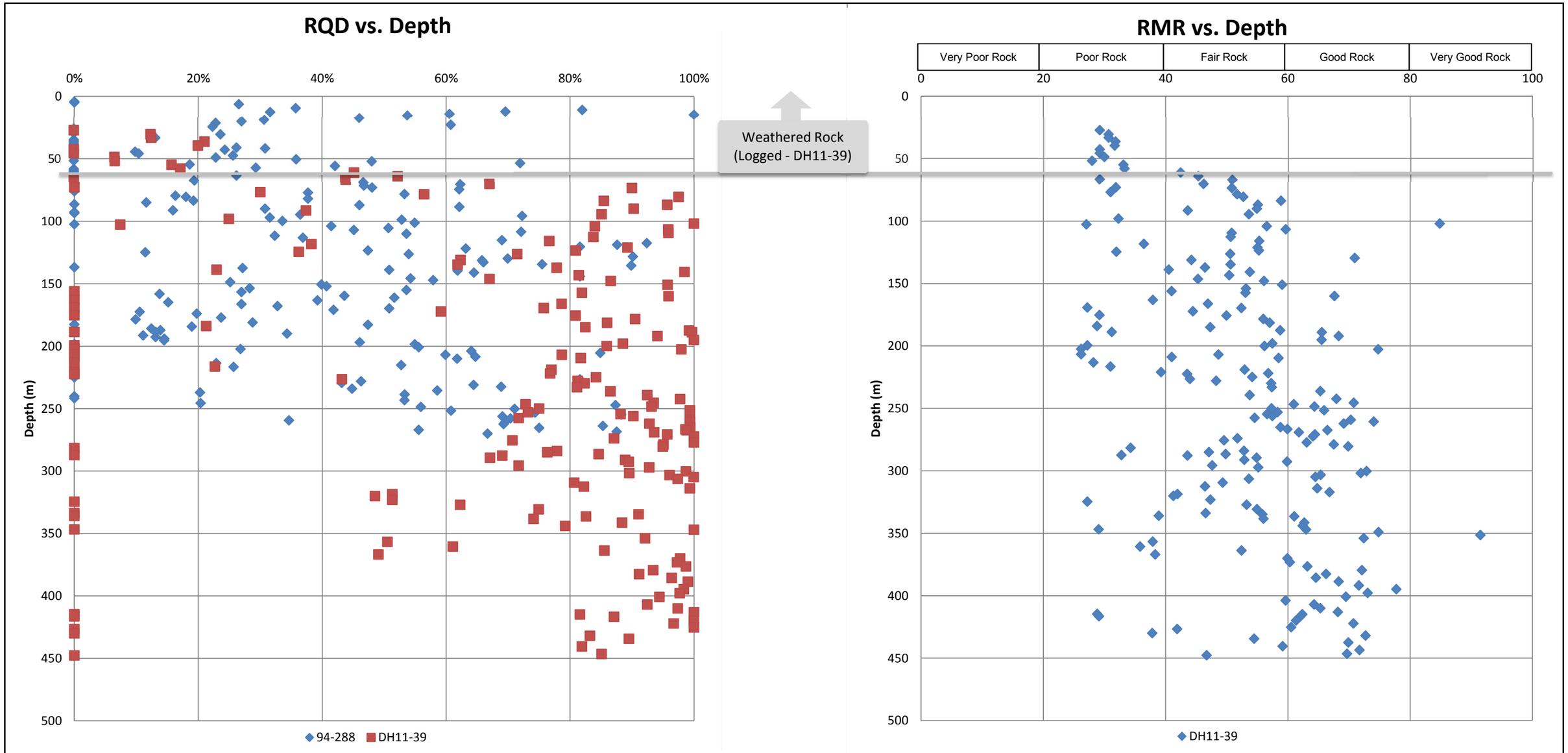
APPENDIX A

RQD AND RMR VS. HOLE DEPTHS CHARTS

(Pages A-1 to A-7)



NOTES:

1. "DEPTHS" ARE INCLINED DRILL HOLE DEPTHS.

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CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

OPEN PIT GEOTECHNICAL DESIGN
RQD AND RMR VS. DEPTH FOR
M-NORTH SECTOR

Knight Piésold CONSULTING

P/A NO. VA101-325/8

REF. NO. 7

APPENDIX A.1

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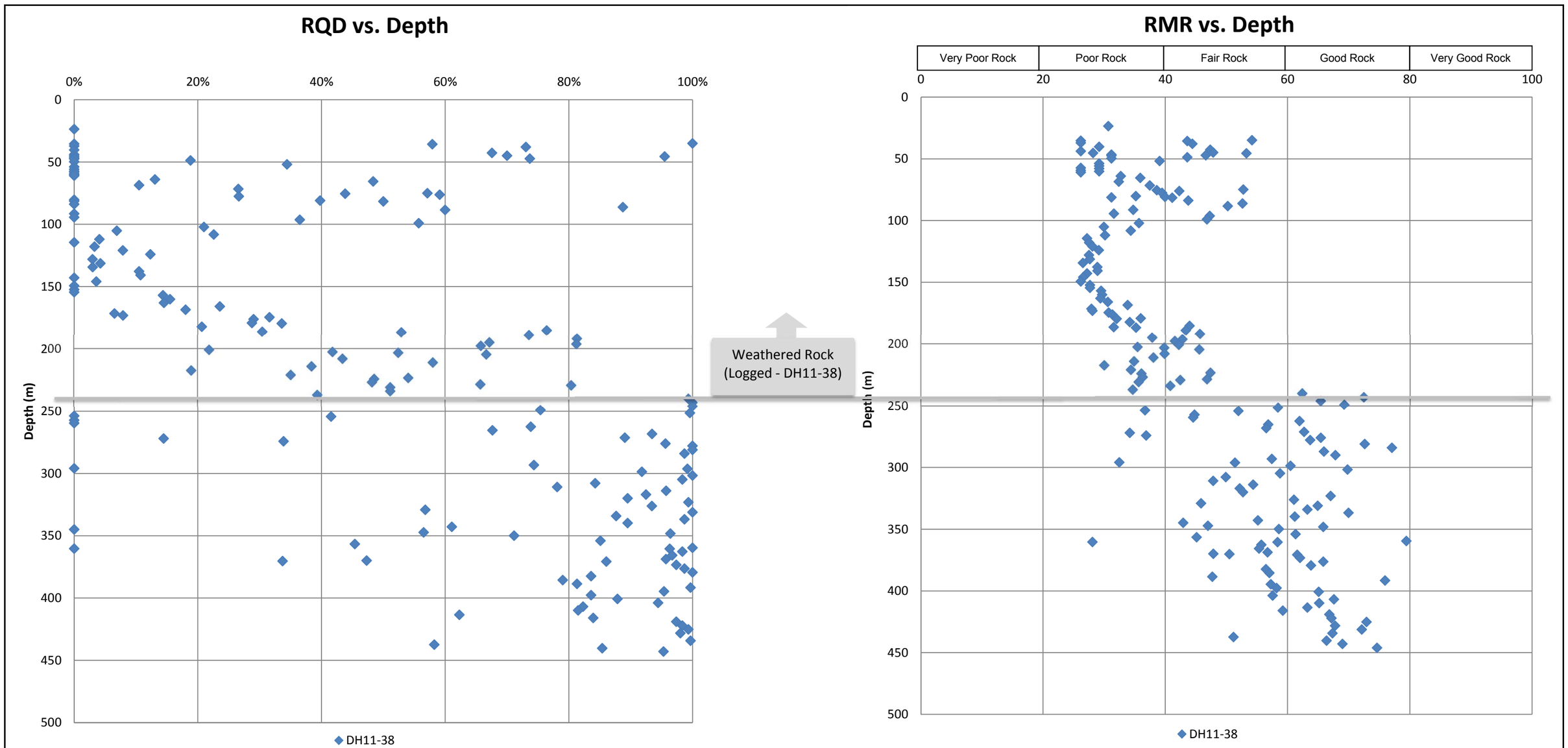

NOTES:

1. "DEPTHS" ARE INCLINED DRILL HOLE DEPTHS.

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OPEN PIT GEOTECHNICAL DESIGN
RQD AND RMR VS. DEPTH FOR
M-NORTHEAST SECTOR

Knight Piésold CONSULTING

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REF. NO. 7

APPENDIX A.2

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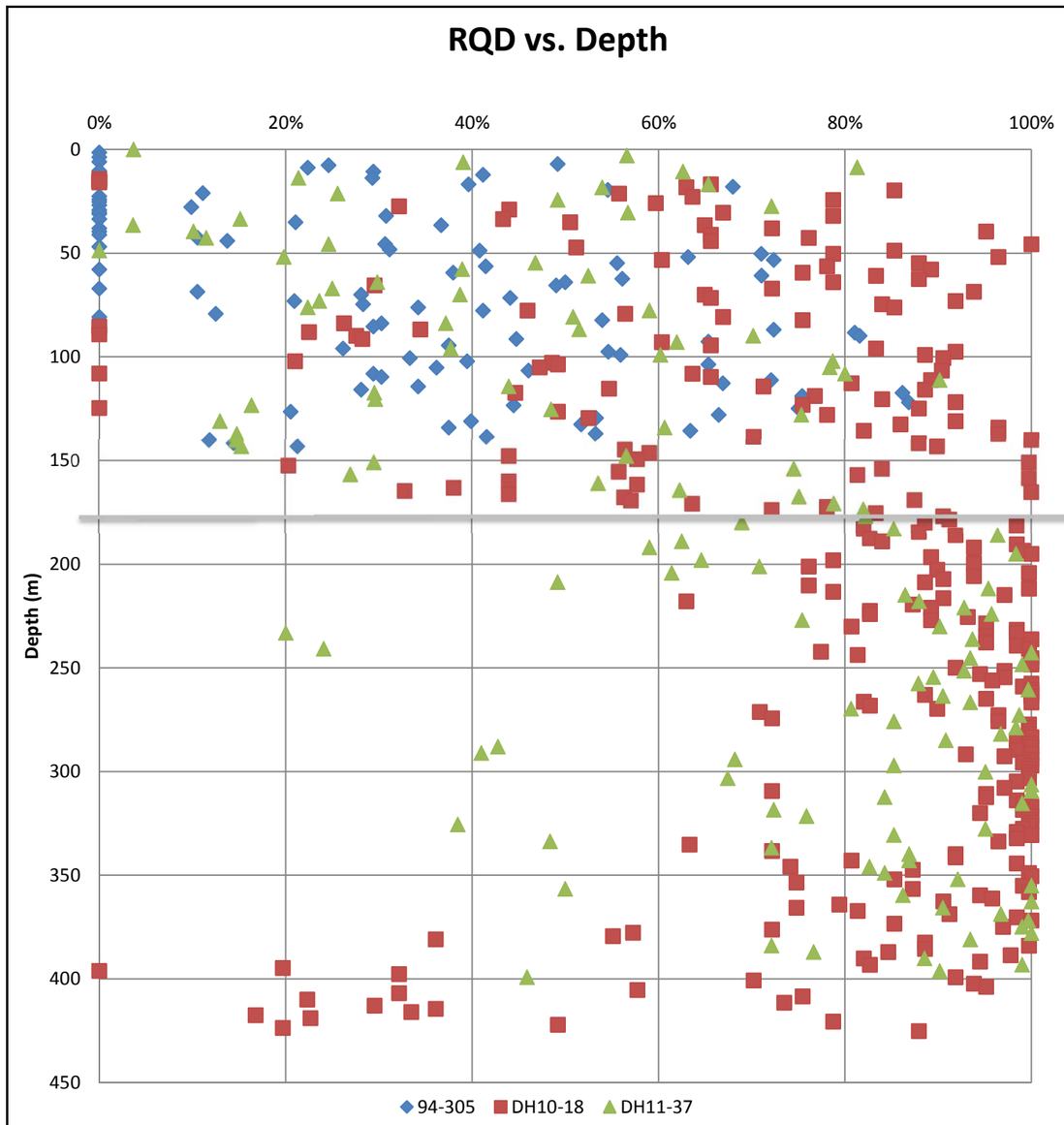
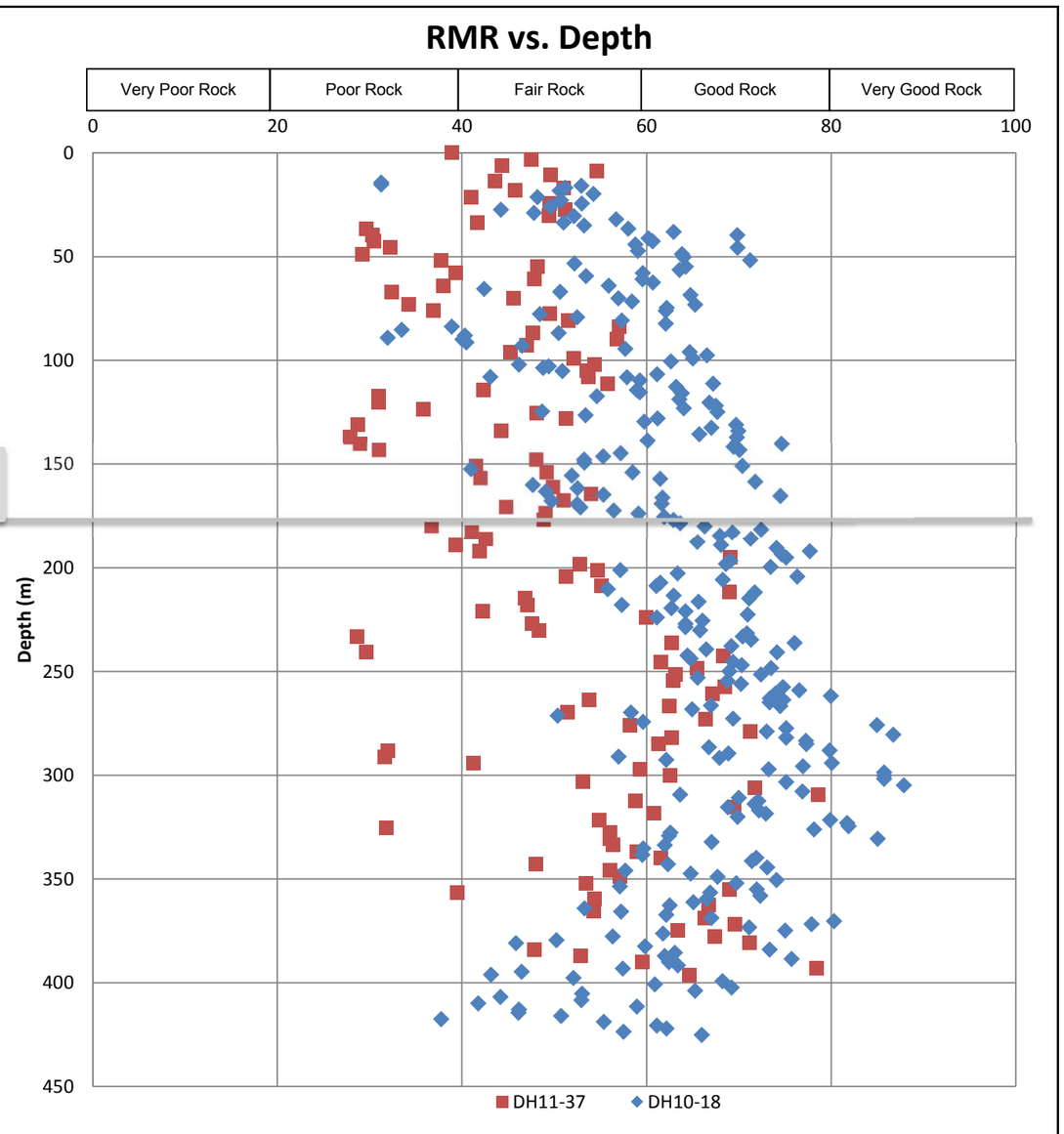


Weathered Rock
(Logged - DH11-37)



NOTES:
1. "DEPTHS" ARE INCLINED DRILL HOLE DEPTHS.

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OPEN PIT GEOTECHNICAL DESIGN
RQD AND RMR VS. DEPTH FOR
M-SOUTH SECTOR

Knight Piésold CONSULTING

P/A NO. VA101-325/8

REF. NO. 7

APPENDIX A.3

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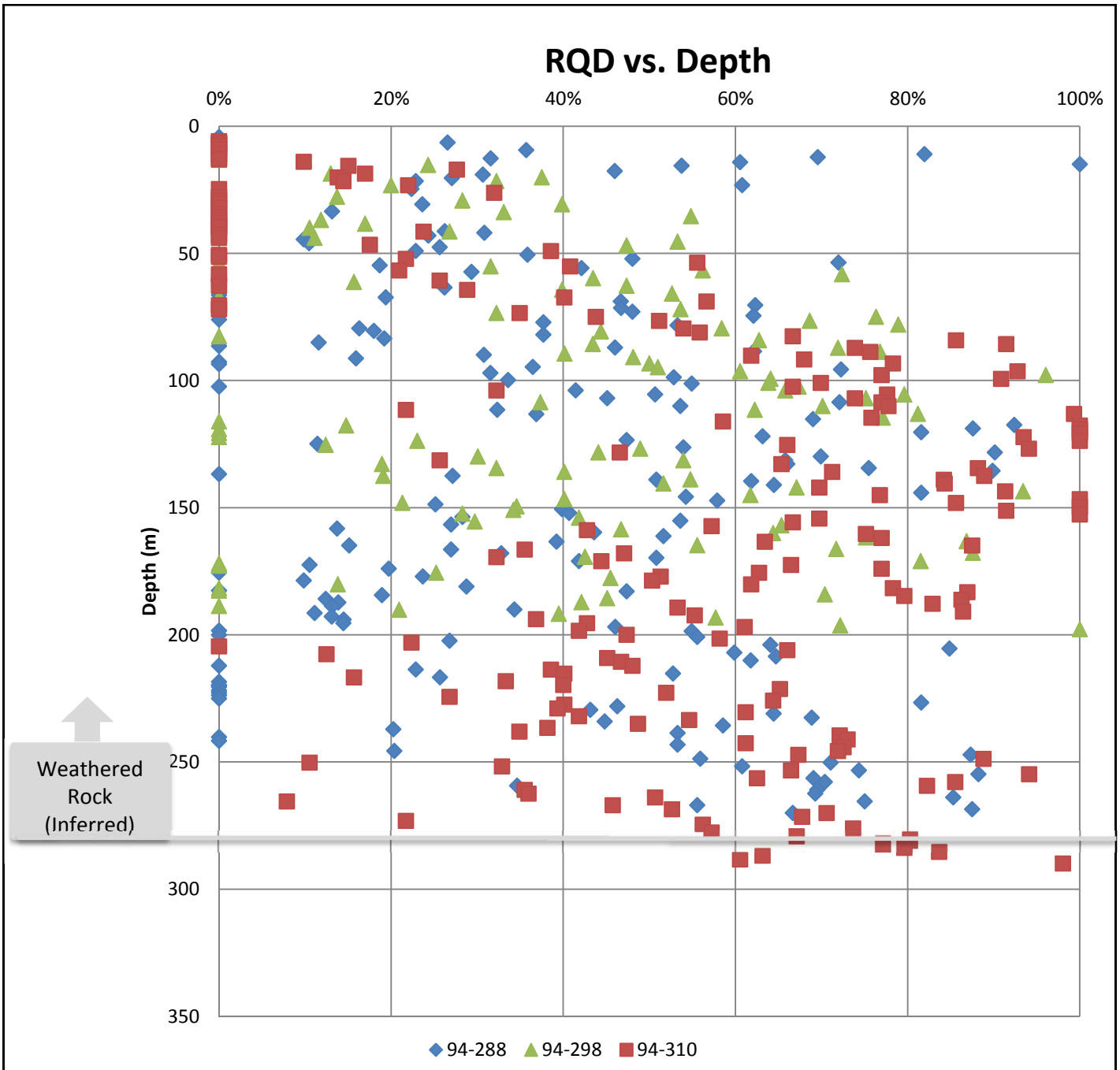

NOTES:
1. "DEPTHS" ARE INCLINED DRILL HOLE DEPTHS.
2. RMR DATA WAS NOT COLLECTED IN CAS-051

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CASINO COPPER-GOLD PROJECT

OPEN PIT GEOTECHNICAL DESIGN
RQD VS. DEPTH FOR
M-WEST SECTOR

Knight Piésold CONSULTING

P/A NO. VA101-325/8

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APPENDIX A.4

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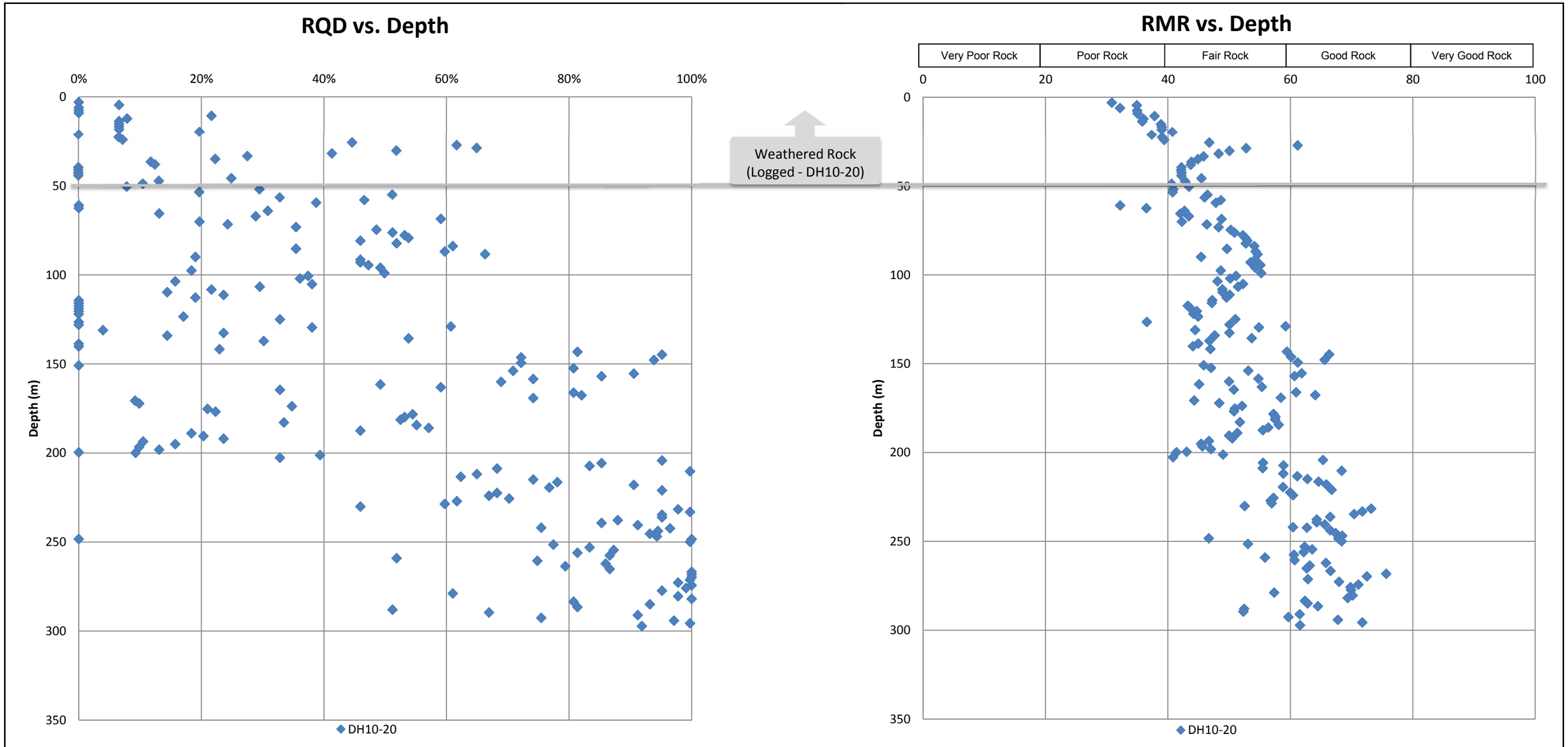

NOTES:
1. "DEPTHS" ARE INCLINED DRILL HOLE DEPTHS.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
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CASINO COPPER-GOLD PROJECT

OPEN PIT GEOTECHNICAL DESIGN
RQD AND RMR VS. DEPTH FOR
W-NORTH SECTOR

Knight Piésold CONSULTING

P/A NO. VA101-325/8

REF. NO. 7

APPENDIX A.5

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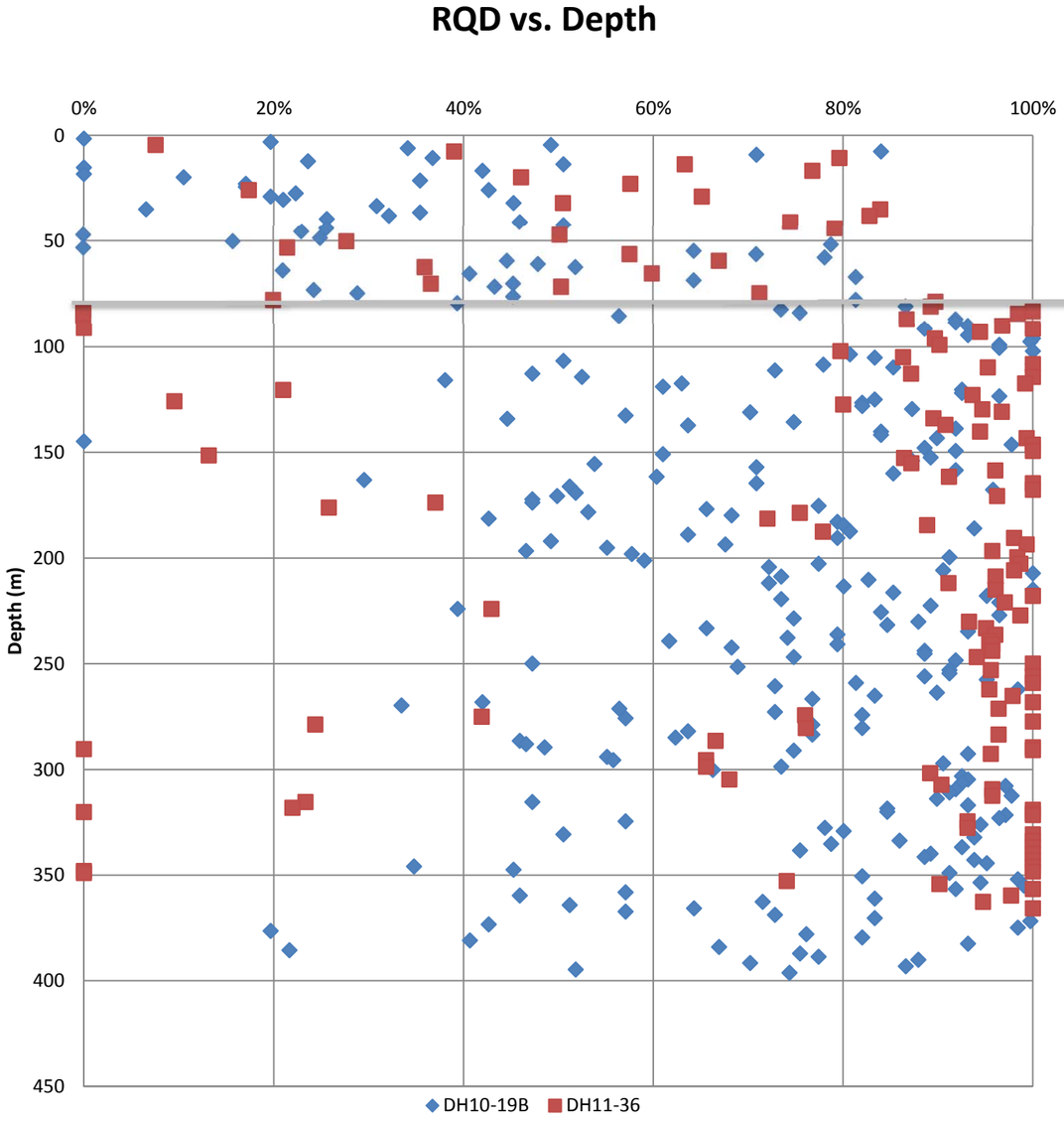

Weathered Rock
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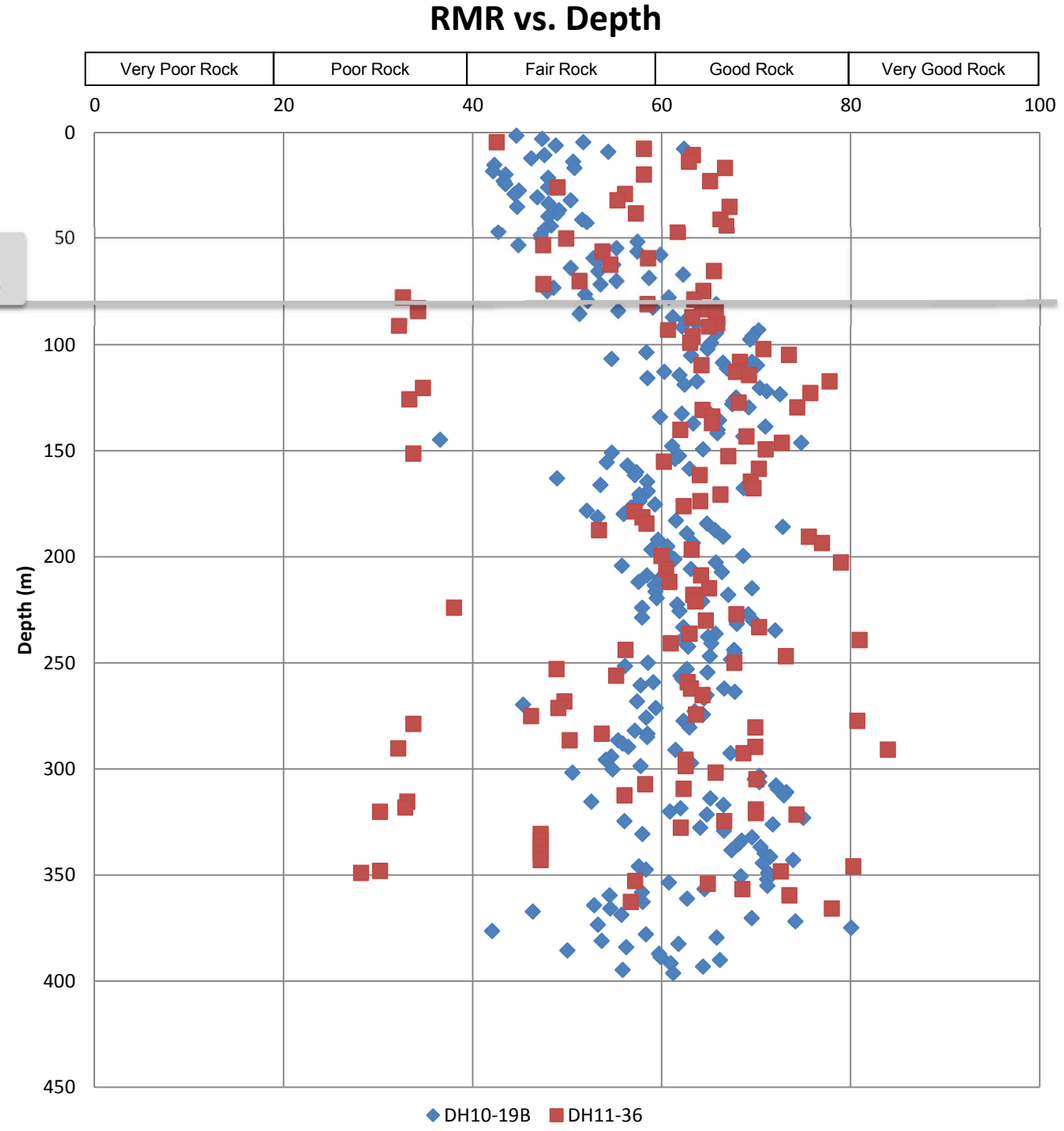

NOTES:
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REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
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CASINO COPPER-GOLD PROJECT

OPEN PIT GEOTECHNICAL DESIGN
RQD AND RMR VS. DEPTH FOR
W-SOUTH SECTOR

Knight Piésold CONSULTING

P/A NO. VA101-325/8

REF. NO. 7

APPENDIX A.6

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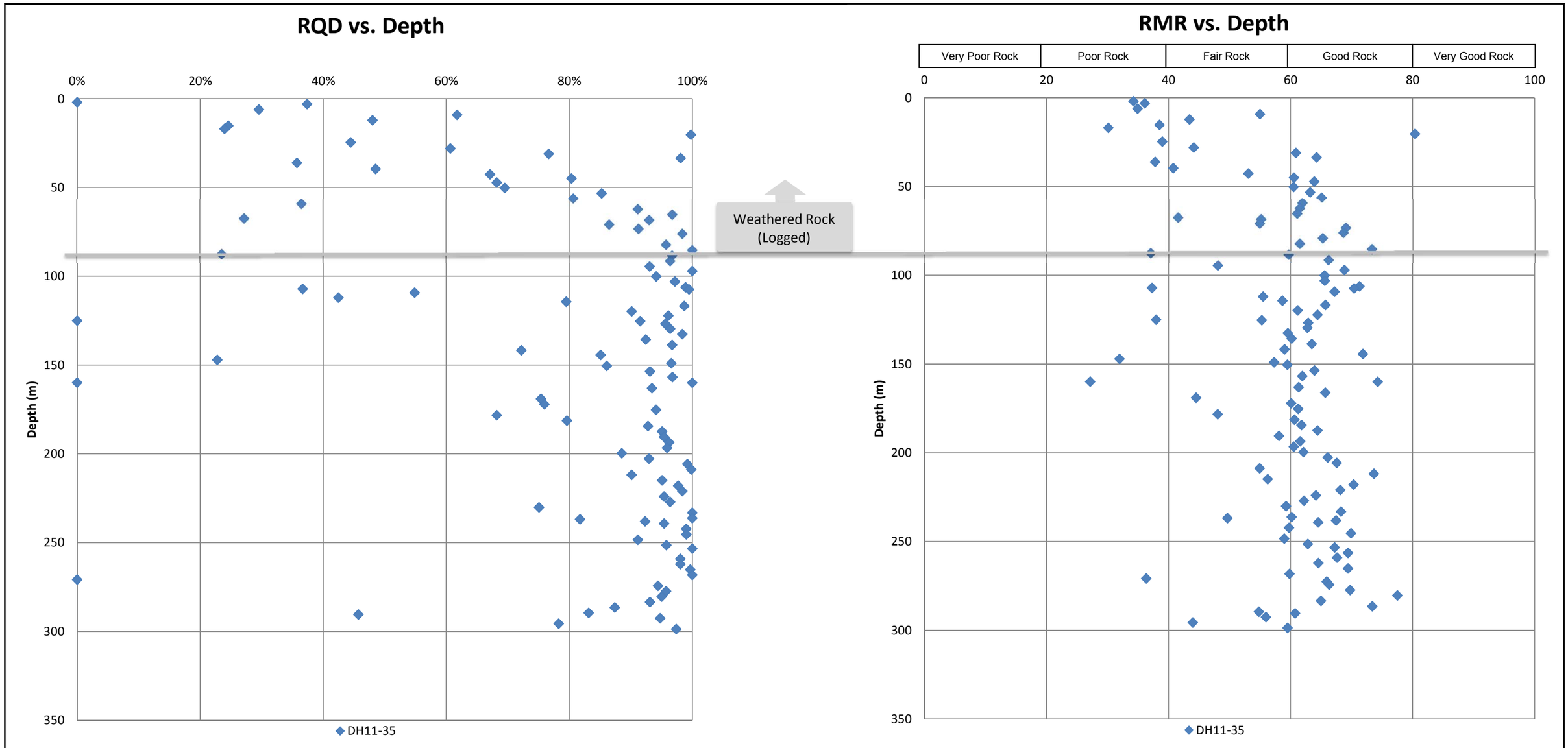

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CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

OPEN PIT GEOTECHNICAL DESIGN
RQD AND RMR VS. DEPTH FOR
W-WEST SECTOR

Knight Piésold CONSULTING

P/A NO. VA101-325/8

REF. NO. 7

APPENDIX A.7

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APPENDIX B

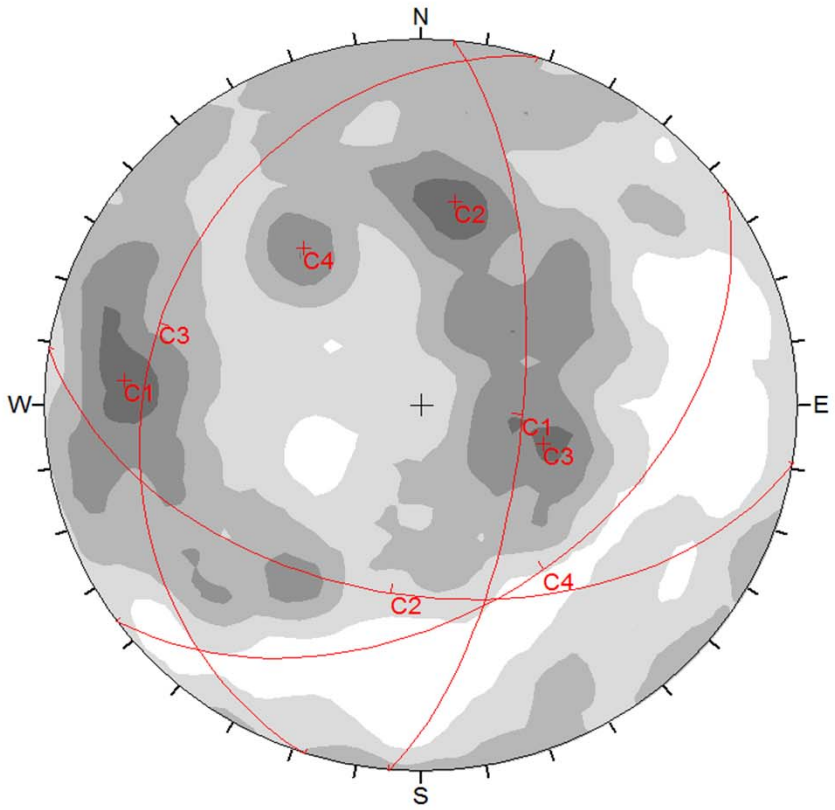
KINEMATIC STABILITY ANALYSES

Appendix B1 Stereographic Plots of Geomechanical Holes
Appendix B2 Kinematic Stability Analyses Detailed Results

APPENDIX B1

STEREOGRAPHIC PLOTS OF GEOMECHANICAL HOLES

(Pages B1-1 to B1-15)



Fisher
Concentrations
% of total per 1.0 % area

0.00 ~ 0.50 %
0.50 ~ 1.00 %
1.00 ~ 1.50 %
1.50 ~ 2.00 %
2.00 ~ 2.50 %
2.50 ~ 3.00 %
3.00 ~ 3.50 %

Terzaghi Correction
Min. Bias Angle = 15 deg
Max. Conc. = 2.4318%

Equal Area
Lower Hemisphere
1732 Poles
1732 Entries

Oriented Core Data

Set # - Dip / Dip Direction

C1 - 68 / 095
C2 - 47 / 189
C3 - 28 / 288
C4 - 44 / 144

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	12JUL'12	ISSUED WITH REPORT	JBC	GM	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

OPEN PIT GEOTECHNICAL DESIGN
STEREOGRAPHIC PLOT OF DH94-288

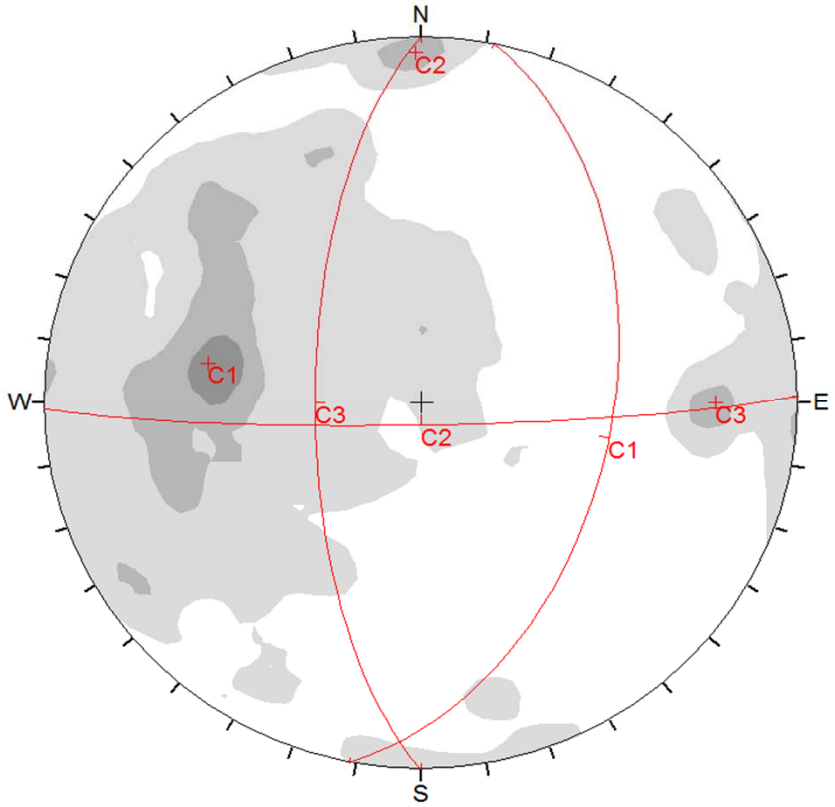
Knight Piésold CONSULTING

P/A NO. VA101-325/8

REF. NO. 7

APPENDIX B1.1

REV 0



Fisher
Concentrations
% of total per 1.0 % area

0.00 ~ 1.00 %
1.00 ~ 2.00 %
2.00 ~ 3.00 %
3.00 ~ 4.00 %
4.00 ~ 5.00 %
5.00 ~ 6.00 %
6.00 ~ 7.00 %

Terzaghi Correction
Min. Bias Angle = 15 deg
Max. Conc. = 3.6329%

Equal Area
Lower Hemisphere
767 Poles
767 Entries

Oriented Core Data

Set # - Dip / Dip Direction

C1 - 48 / 101
C2 - 85 / 179
C3 - 67 / 270

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	12JUL'12	ISSUED WITH REPORT	JBC	GM	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

OPEN PIT GEOTECHNICAL DESIGN
STEREOGRAPHIC PLOT OF DH94-298

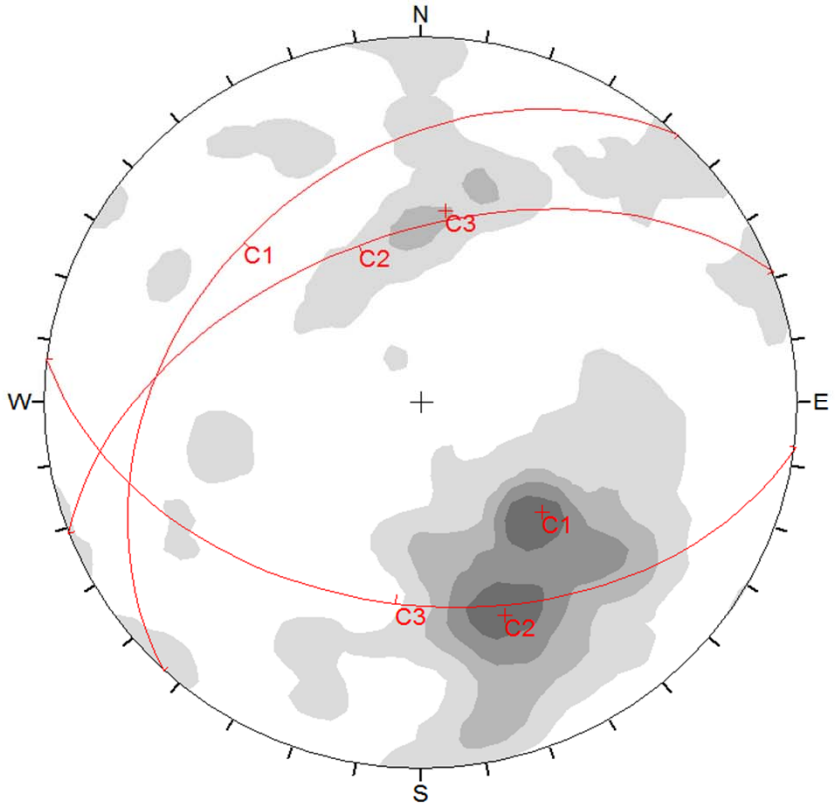
Knight Piésold CONSULTING

P/A NO. VA101-325/8

REF. NO. 7

APPENDIX B1.2

REV 0



Fisher
Concentrations
% of total per 1.0 % area

0.00 ~ 1.00 %
1.00 ~ 2.00 %
2.00 ~ 3.00 %
3.00 ~ 4.00 %
4.00 ~ 5.00 %
5.00 ~ 6.00 %
6.00 ~ 7.00 %

Terzaghi Correction
Min. Bias Angle = 15 deg
Max. Conc. = 4.8067%

Equal Area
Lower Hemisphere
564 Poles
564 Entries

Oriented Core Data

Set # - Dip / Dip Direction

C1 - 36 / 313
C2 - 52 / 339
C3 - 44 / 187

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	12JUL'12	ISSUED WITH REPORT	JBC	GM	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

OPEN PIT GEOTECHNICAL DESIGN
STEREOGRAPHIC PLOT OF DH94-305

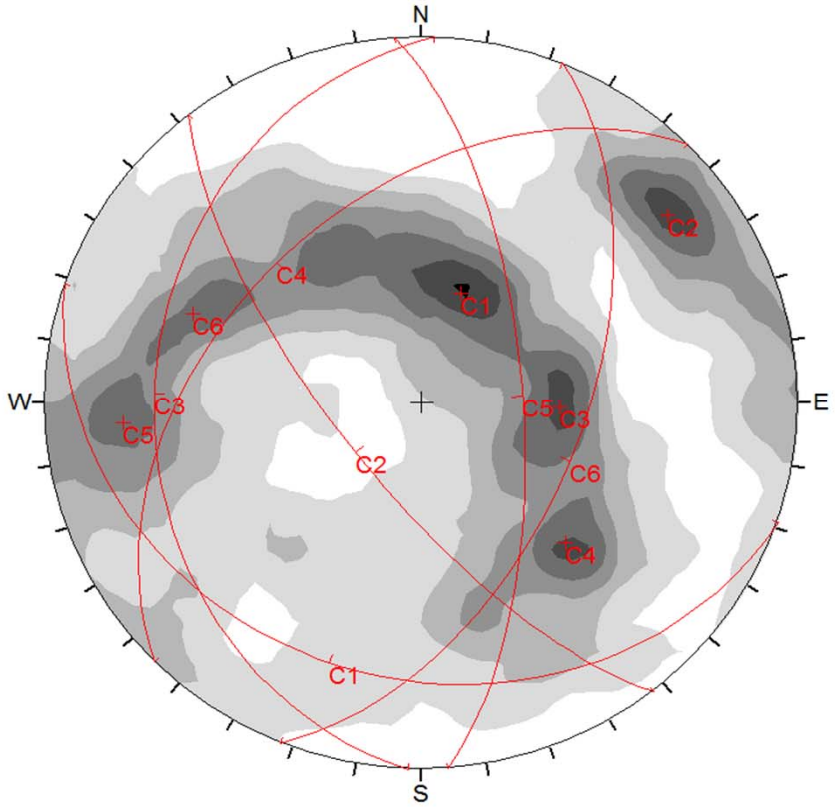
Knight Piésold CONSULTING

P/A NO. VA101-325/8

REF. NO. 7

APPENDIX B1.3

REV 0



Fisher
Concentrations
% of total per 1.0 % area

0.00 ~ 0.50 %
0.50 ~ 1.00 %
1.00 ~ 1.50 %
1.50 ~ 2.00 %
2.00 ~ 2.50 %
2.50 ~ 3.00 %
3.00 ~ 3.50 %

Terzaghi Correction
Min. Bias Angle = 15 deg
Max. Conc. = 3.0522%

Equal Area
Lower Hemisphere
1645 Poles
1645 Entries

Oriented Core Data

Set # - Dip / Dip Direction

C1 - 26 / 199
C2 - 72 / 232
C3 - 30 / 272
C4 - 45 / 315
C5 - 68 / 086
C6 - 55 / 112

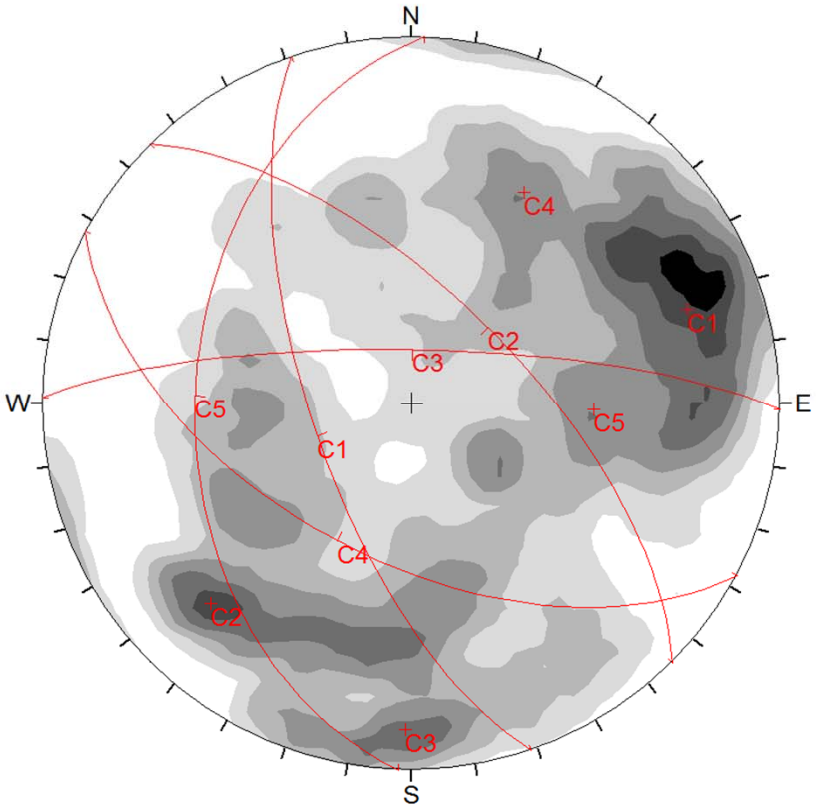
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	12JUL'12	ISSUED WITH REPORT	JBC	GM	KJB

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

OPEN PIT GEOTECHNICAL DESIGN
STEREOGRAPHIC PLOT OF DH94-310

Knight Piésold CONSULTING

P/A NO. VA101-325/8
REF. NO. 7
APPENDIX B1.4
REV 0



Fisher
Concentrations
% of total per 1.0 % area

0.00 ~ 0.50 %
0.50 ~ 1.00 %
1.00 ~ 1.50 %
1.50 ~ 2.00 %
2.00 ~ 2.50 %
2.50 ~ 3.00 %
3.00 ~ 3.50 %

Terzaghi Correction
Min. Bias Angle = 15 deg
Max. Conc. = 3.3620%

Equal Area
Lower Hemisphere
788 Poles
788 Entries

Oriented Core Data

Set # - Dip / Dip Direction

C1 - 68 / 251
C2 - 66 / 045
C3 - 78 / 001
C4 - 55 / 208
C5 - 41 / 272

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	12JUL'12	ISSUED WITH REPORT	JBC	GM	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

OPEN PIT GEOTECHNICAL DESIGN
STEREOGRAPHIC PLOT OF DH10-18

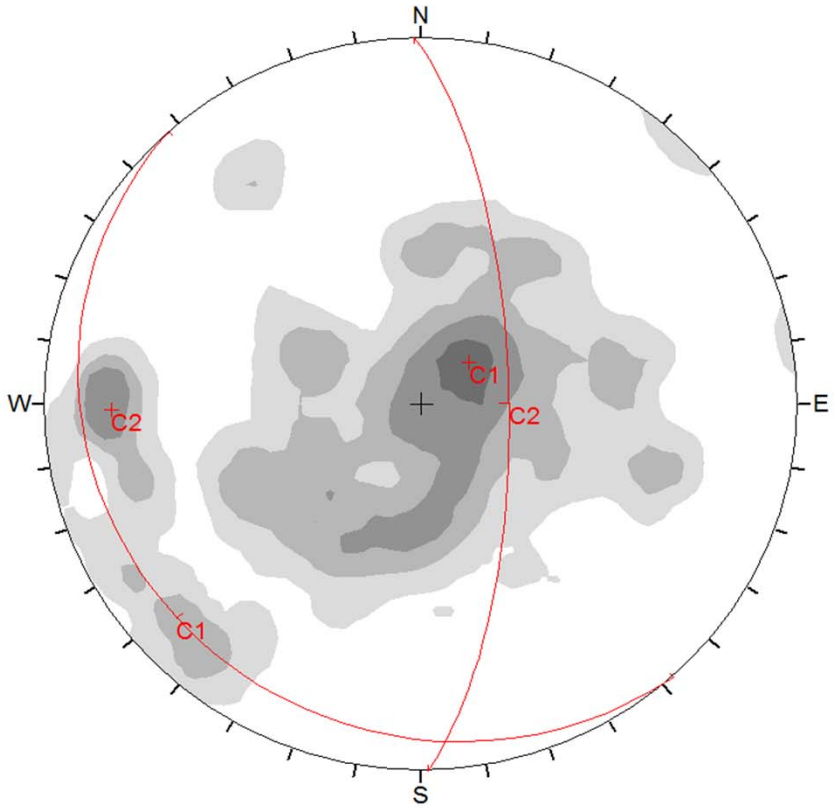
Knight Piésold CONSULTING

P/A NO. VA101-325/8

REF. NO. 7

APPENDIX B1.5

REV 0



Fisher
Concentrations
% of total per 1.0 % area

0.00 ~ 1.00 %
1.00 ~ 2.00 %
2.00 ~ 3.00 %
3.00 ~ 4.00 %
4.00 ~ 5.00 %
5.00 ~ 6.00 %
6.00 ~ 7.00 %

Terzaghi Correction
Min. Bias Angle = 15 deg
Max. Conc. = 4.7000%

Equal Area
Lower Hemisphere
300 Poles
300 Entries

Oriented Core Data

Set # - Dip / Dip Direction

C1 - 14 / 228
C2 - 71 / 089

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	12JUL'12	ISSUED WITH REPORT	JBC	GM	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

OPEN PIT GEOTECHNICAL DESIGN
STEREOGRAPHIC PLOT OF DH10-19B

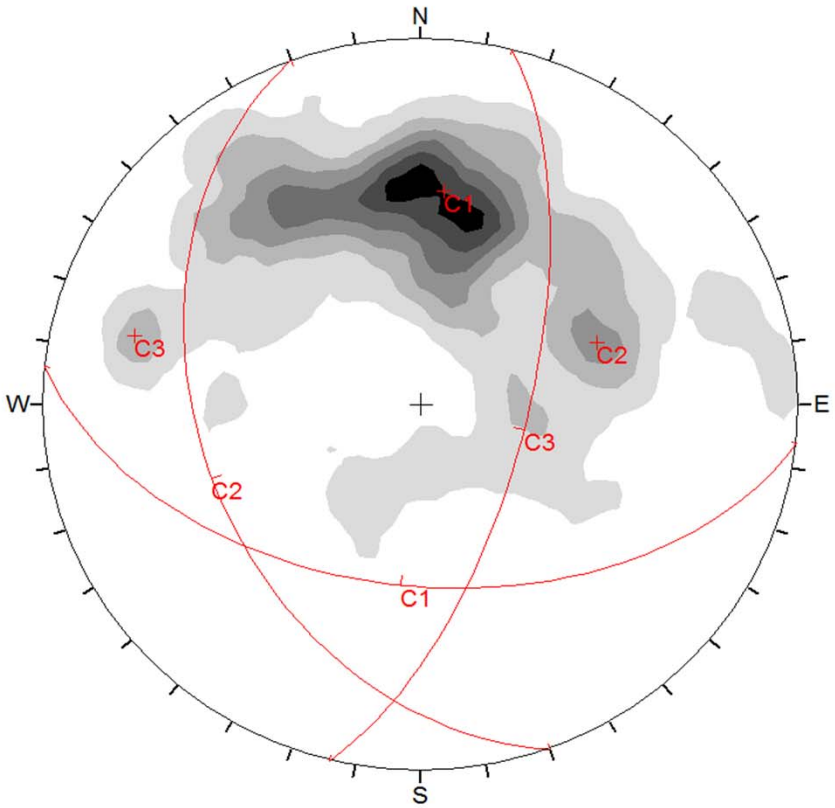
Knight Piésold CONSULTING

P/A NO. VA101-325/8

REF. NO. 7

APPENDIX B1.6

REV 0



Fisher
Concentrations
% of total per 1.0 % area

0.00 ~ 1.00 %
1.00 ~ 2.00 %
2.00 ~ 3.00 %
3.00 ~ 4.00 %
4.00 ~ 5.00 %
5.00 ~ 6.00 %
6.00 ~ 7.00 %

Terzaghi Correction
Min. Bias Angle = 15 deg
Max. Conc. = 6.6813%

Equal Area
Lower Hemisphere
448 Poles
448 Entries

Oriented Core Data

Set # - Dip / Dip Direction

C1 - 49 / 186
C2 - 41 / 250
C3 - 67 / 104

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	12JUL'12	ISSUED WITH REPORT	JBC	GM	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

OPEN PIT GEOTECHNICAL DESIGN
STEREOGRAPHIC PLOT OF DH10-20

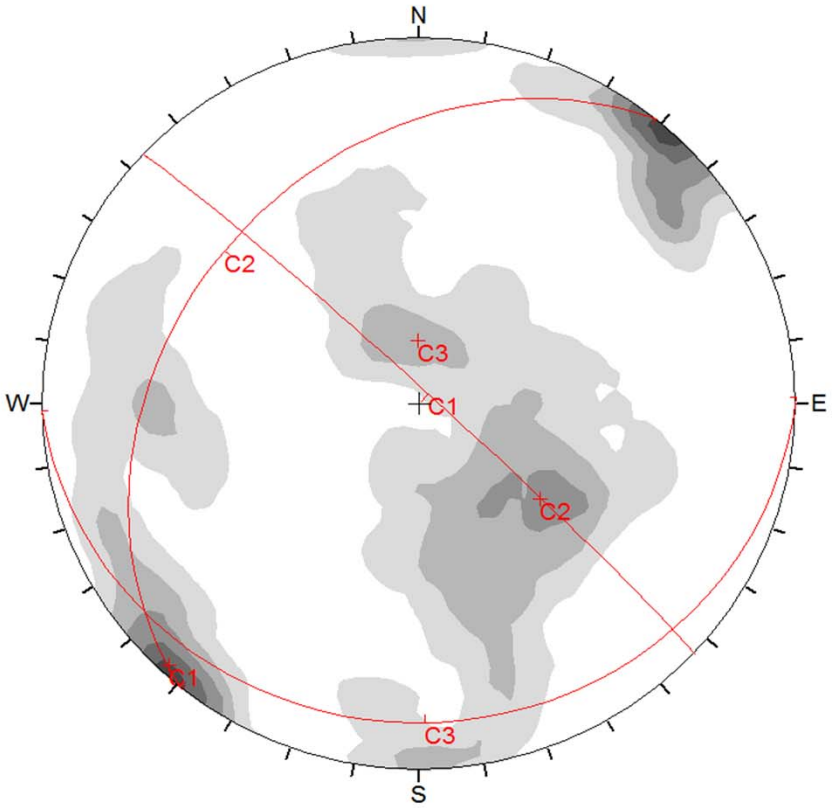
Knight Piésold CONSULTING

P/A NO. VA101-325/8

REF. NO. 7

APPENDIX B1.7

REV 0



Fisher
Concentrations
% of total per 1.0 % area

0.00 ~ 1.00 %
1.00 ~ 2.00 %
2.00 ~ 3.00 %
3.00 ~ 4.00 %
4.00 ~ 5.00 %
5.00 ~ 6.00 %
6.00 ~ 7.00 %

Terzaghi Correction
Min. Bias Angle = 15 deg
Max. Conc. = 5.5676%

Equal Area
Lower Hemisphere
419 Poles
419 Entries

Oriented Core Data

Set # - Dip / Dip Direction

C1 - 87 / 043
C2 - 34 / 309
C3 - 14 /179

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	12JUL'12	ISSUED WITH REPORT	JBC	GM	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

OPEN PIT GEOTECHNICAL DESIGN
STEREOGRAPHIC PLOT OF DH11-35

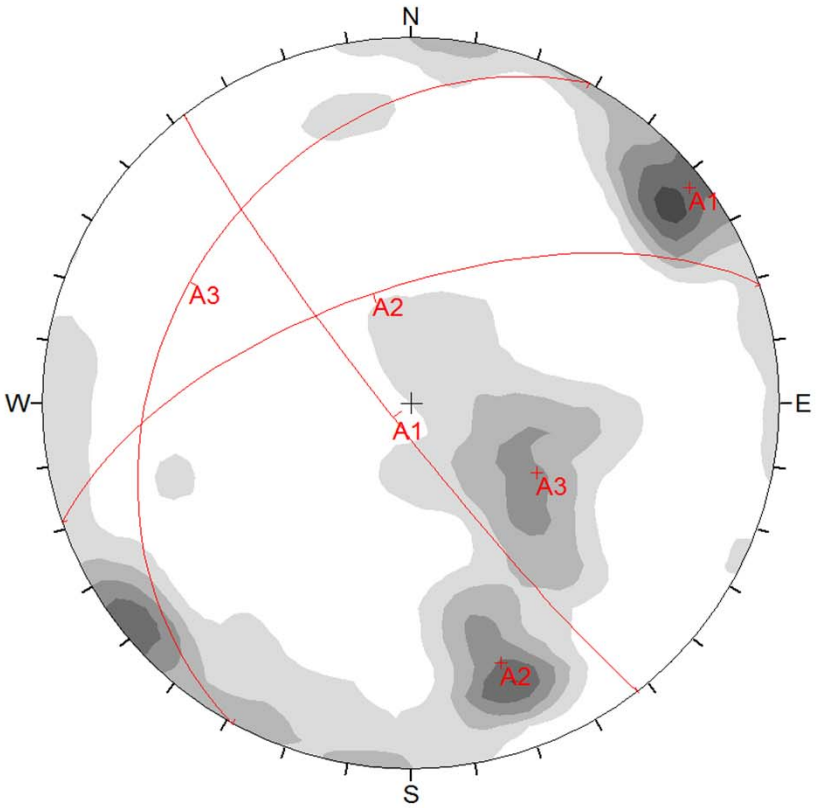
Knight Piésold CONSULTING

P/A NO. VA101-325/8

REF. NO. 7

APPENDIX B1.8

REV 0



Fisher
Concentrations
% of total per 1.0 % area

0.00 ~ 1.00 %
1.00 ~ 2.00 %
2.00 ~ 3.00 %
3.00 ~ 4.00 %
4.00 ~ 5.00 %
5.00 ~ 6.00 %
6.00 ~ 7.00 %

Terzaghi Correction
Min. Bias Angle = 15 deg
Max. Conc. = 5.6219%

Equal Area
Lower Hemisphere
649 Poles
649 Entries

Acoustic Televiewer Data

Set # - Dip / Dip Direction

A1 - 85 / 232
A2 - 64 / 341
A3 - 32 / 299

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	12JUL'12	ISSUED WITH REPORT	JBC	GM	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

OPEN PIT GEOTECHNICAL DESIGN
STEREOGRAPHIC PLOT OF DH11-35

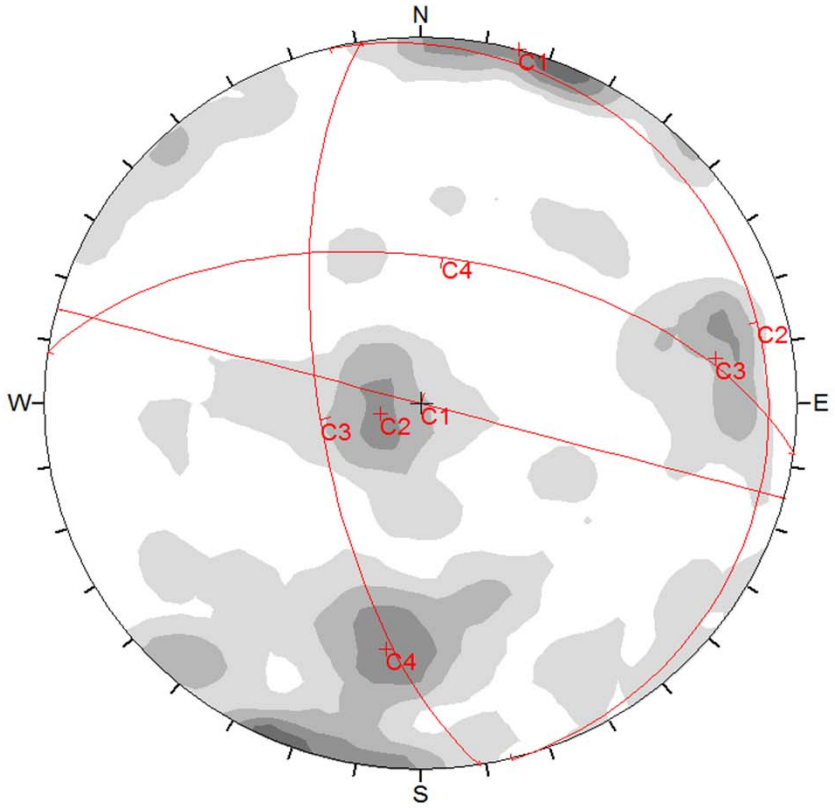
Knight Piésold CONSULTING

P/A NO. VA101-325/8

REF. NO. 7

APPENDIX B1.9

REV 0



Fisher
Concentrations
% of total per 1.0 % area

0.00 ~ 1.00 %
1.00 ~ 2.00 %
2.00 ~ 3.00 %
3.00 ~ 4.00 %
4.00 ~ 5.00 %
5.00 ~ 6.00 %
6.00 ~ 7.00 %

Terzaghi Correction
Min. Bias Angle = 15 deg
Max. Conc. = 5.0581%

Equal Area
Lower Hemisphere
260 Poles
260 Entries

Oriented Core Data

Set # - Dip / Dip Direction

C1 - 90 / 195
C2 - 09 / 076
C3 - 68 / 261
C4 - 57 / 008

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	12JUL'12	ISSUED WITH REPORT	JBC	GM	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

OPEN PIT GEOTECHNICAL DESIGN
STEREOGRAPHIC PLOT OF DH11-36

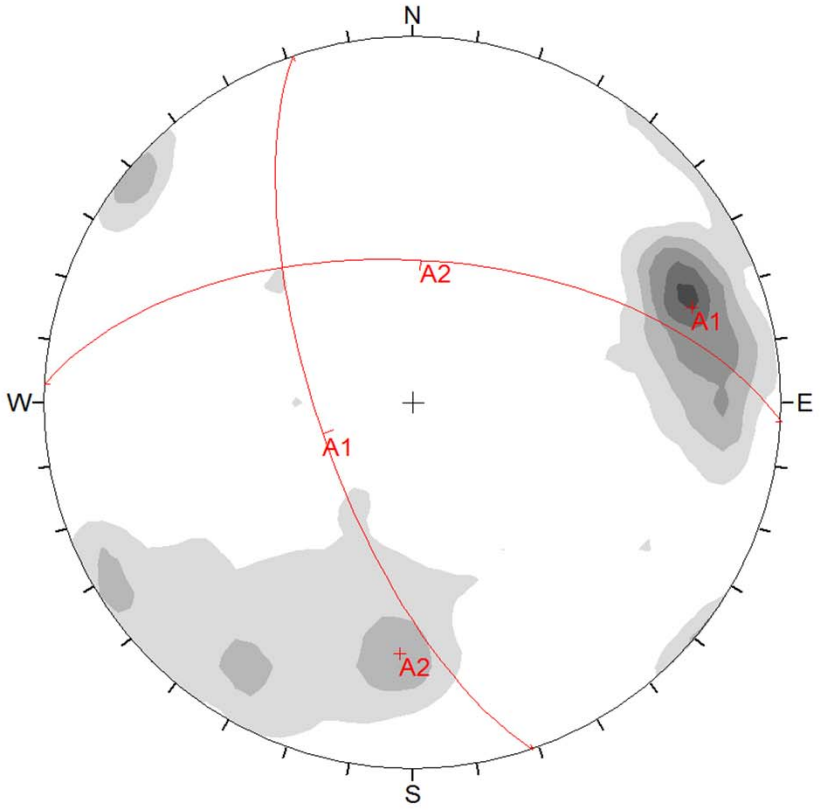
Knight Piésold CONSULTING

P/A NO. VA101-325/8

REF. NO. 7

APPENDIX B1.10

REV 0



Fisher
Concentrations
% of total per 1.0 % area

0.00 ~ 1.50 %
1.50 ~ 3.00 %
3.00 ~ 4.50 %
4.50 ~ 6.00 %
6.00 ~ 7.50 %
7.50 ~ 9.00 %
9.00 ~ 10.50 %

Terzaghi Correction
Min. Bias Angle = 15 deg
Max. Conc. = 8.2605%

Equal Area
Lower Hemisphere
283 Poles
283 Entries

Acoustic Televiewer Data

Set # - Dip / Dip Direction

A1 - 58 / 003
A2 - 69 / 251

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	12JUL'12	ISSUED WITH REPORT	JBC	GM	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

OPEN PIT GEOTECHNICAL DESIGN
STEREOGRAPHIC PLOT OF DH11-36

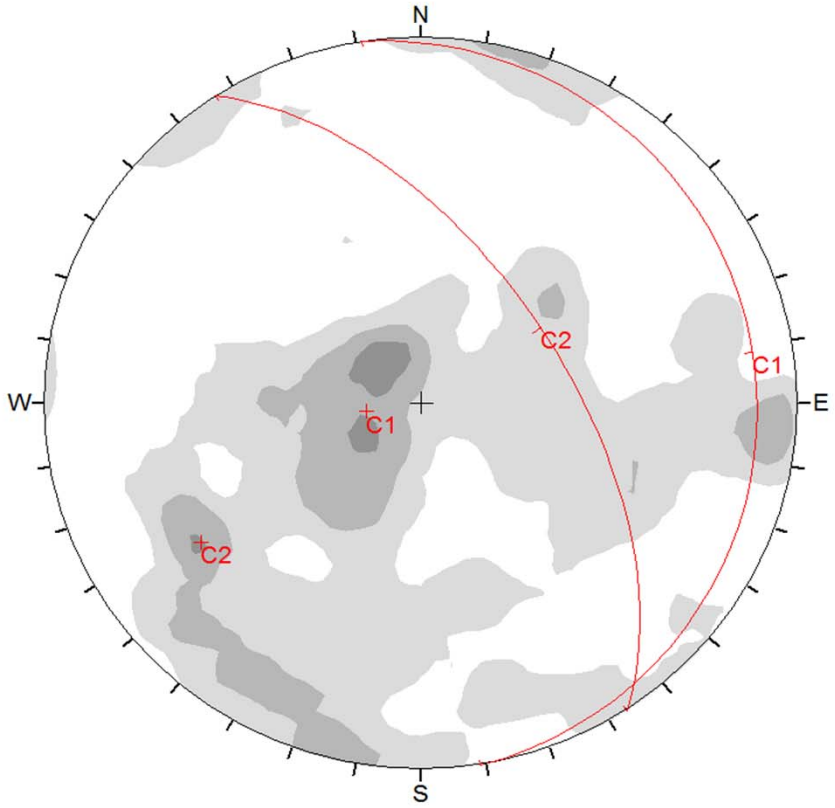
Knight Piésold CONSULTING

P/A NO. VA101-325/8

REF. NO. 7

APPENDIX B1.11

REV 0



Fisher
Concentrations
% of total per 1.0 % area

0.00 ~ 1.00 %
1.00 ~ 2.00 %
2.00 ~ 3.00 %
3.00 ~ 4.00 %
4.00 ~ 5.00 %
5.00 ~ 6.00 %
6.00 ~ 7.00 %

Terzaghi Correction
Min. Bias Angle = 15 deg
Max. Conc. = 3.7267%

Equal Area
Lower Hemisphere
474 Poles
474 Entries

Oriented Core Data

Set # - Dip / Dip Direction

C1 - 12 / 081
C2 - 59 / 057

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	12JUL'12	ISSUED WITH REPORT	JBC	GM	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

OPEN PIT GEOTECHNICAL DESIGN
STEREOGRAPHIC PLOT OF DH11-37

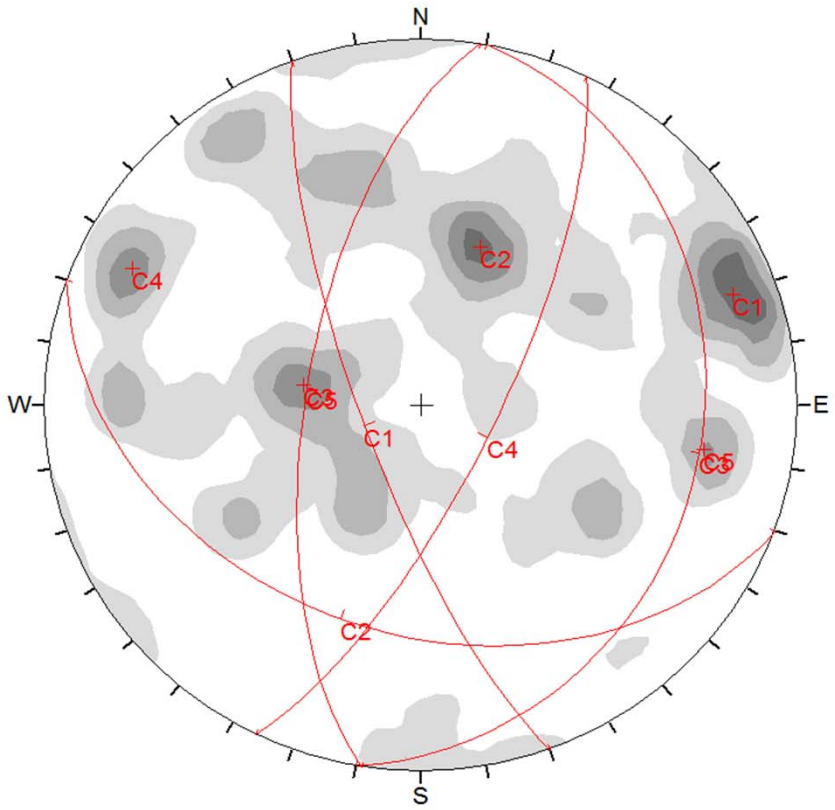
Knight Piésold CONSULTING

P/A NO. VA101-325/8

REF. NO. 7

APPENDIX B1.12

REV 0



Fisher
Concentrations
% of total per 1.0 % area

0.00 ~ 1.00 %
1.00 ~ 2.00 %
2.00 ~ 3.00 %
3.00 ~ 4.00 %
4.00 ~ 5.00 %
5.00 ~ 6.00 %
6.00 ~ 7.00 %

Terzaghi Correction
Min. Bias Angle = 15 deg
Max. Conc. = 5.0324%

Equal Area
Lower Hemisphere
245 Poles
245 Entries

Oriented Core Data

Set # - Dip / Dip Direction

C1 - 77 / 250
C2 - 38 / 200
C3 - 26 / 100
C4 - 74 / 116
C5 - 65 / 279

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	12JUL'12	ISSUED WITH REPORT	JBC	GM	KJB

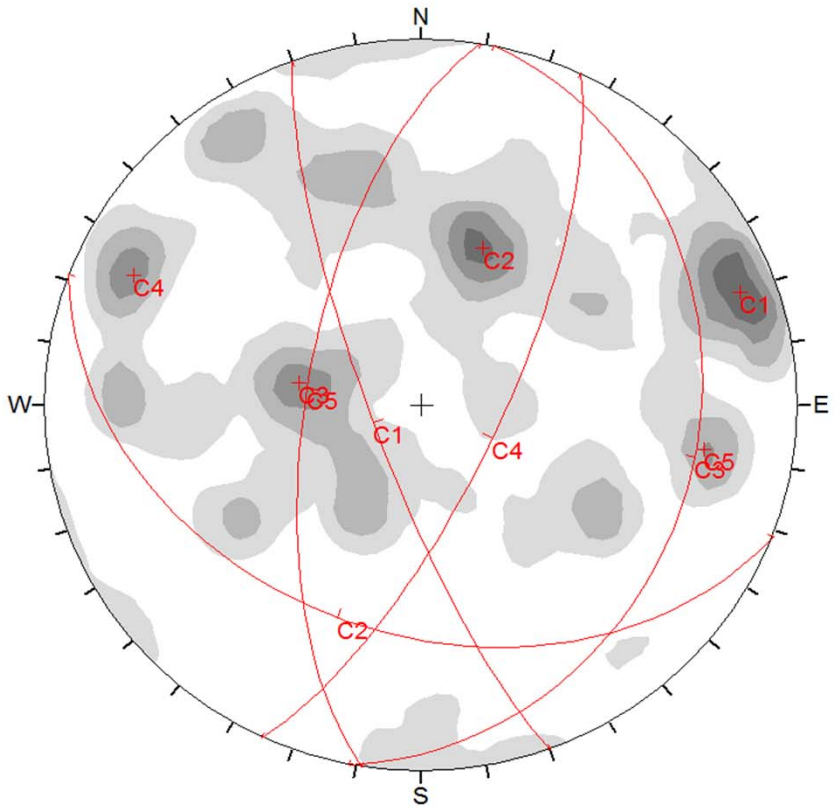
CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

OPEN PIT GEOTECHNICAL DESIGN
STEREOGRAPHIC PLOT OF DH11-38

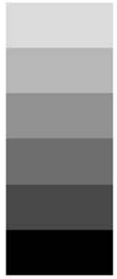
Knight Piésold CONSULTING

P/A NO. VA101-325/8
REF. NO. 7

APPENDIX B1.13
REV 0



Fisher
Concentrations
% of total per 1.0 % area



0.00 ~ 1.00 %
1.00 ~ 2.00 %
2.00 ~ 3.00 %
3.00 ~ 4.00 %
4.00 ~ 5.00 %
5.00 ~ 6.00 %
6.00 ~ 7.00 %

Terzaghi Correction
Min. Bias Angle = 15 deg
Max. Conc. = 5.0324%

Equal Area
Lower Hemisphere
245 Poles
245 Entries

Oriented Core Data

Set # - Dip / Dip Direction

C1 - 79 / 250
C2 - 38 / 201
C3 - 27 / 101
C4 - 73 / 115
C5 - 65 / 279

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	12JUL'12	ISSUED WITH REPORT	JBC	GM	KJB

CASINO MINING CORPORATION

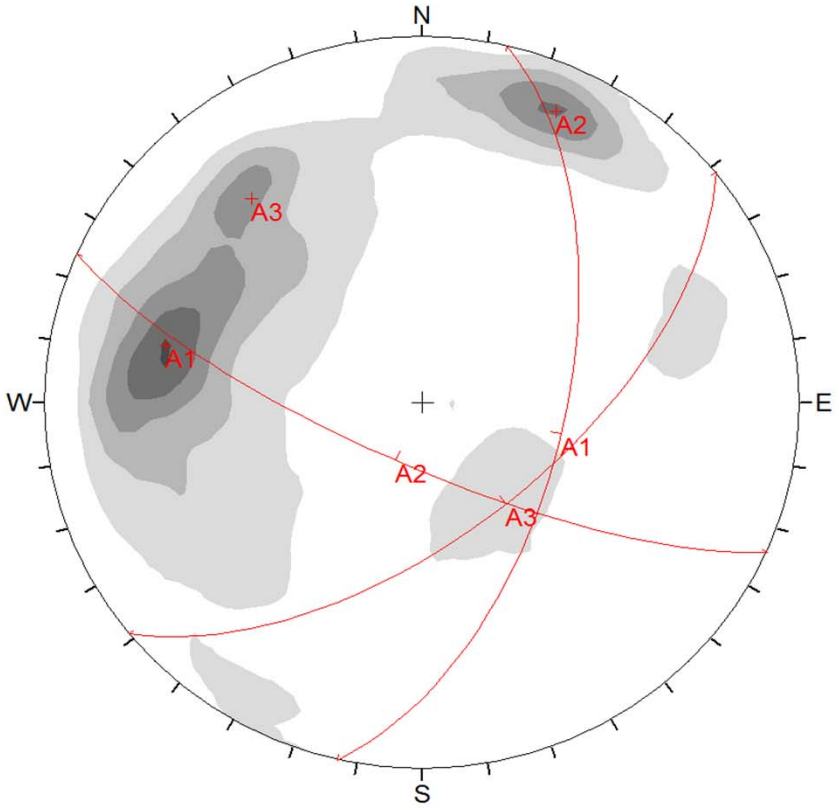
CASINO COPPER-GOLD PROJECT

OPEN PIT GEOTECHNICAL DESIGN
STEREOGRAPHIC PLOT OF DH11-39

Knight Piésold CONSULTING

P/A NO. VA101-325/8 | REF. NO. 7

APPENDIX B1.14 | REV 0



Fisher
Concentrations
% of total per 1.0 % area

0.00 ~ 1.00 %
1.00 ~ 2.00 %
2.00 ~ 3.00 %
3.00 ~ 4.00 %
4.00 ~ 5.00 %
5.00 ~ 6.00 %
6.00 ~ 7.00 %

Terzaghi Correction
Min. Bias Angle = 15 deg
Max. Conc. = 5.1105%

Equal Area
Lower Hemisphere
2032 Poles
2032 Entries

Acoustic Televiewer Data

Set # - Dip / Dip Direction

A1 - 59 / 103
A2 - 76 / 204
A3 - 61 / 141

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	12JUL'12	ISSUED WITH REPORT	JBC	GM	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

OPEN PIT GEOTECHNICAL DESIGN
STEREOGRAPHIC PLOT OF CAS-051

Knight Piésold CONSULTING

P/A NO. VA101-325/8

REF. NO. 7

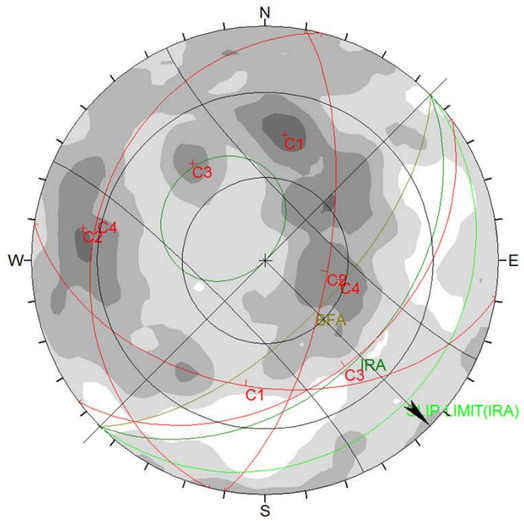
APPENDIX B1.15

REV 0

APPENDIX B2

KINEMATIC STABILITY ANALYSES DETAILED RESULTS

(Pages B2-1 to B2-11)



Fisher
Concentrations
% of total per 1.0 % area

0.00 ~ 0.50 %
0.50 ~ 1.00 %
1.00 ~ 1.50 %
1.50 ~ 2.00 %
2.00 ~ 2.50 %
2.50 ~ 3.00 %
3.00 ~ 3.50 %

Terzaghi Correction
Min. Bias Angle = 15 deg
Max. Conc. = 2.3940%

Equal Area
Lower Hemisphere
1977 Poles
1977 Entries

Oriented Core Data 135° Wall Orientation

Set # - Dip / Dip Direction

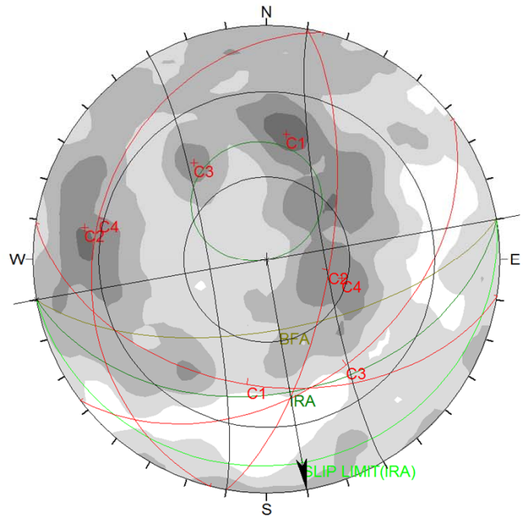
C1 - 45 / 189
C2 - 68 / 100
C3 - 43 / 143
C4 - 27 / 284

FAILURE MODES

Planar
C3

Wedge

Toppling



Fisher
Concentrations
% of total per 1.0 % area

0.00 ~ 0.50 %
0.50 ~ 1.00 %
1.00 ~ 1.50 %
1.50 ~ 2.00 %
2.00 ~ 2.50 %
2.50 ~ 3.00 %
3.00 ~ 3.50 %

Terzaghi Correction
Min. Bias Angle = 15 deg
Max. Conc. = 2.3940%

Equal Area
Lower Hemisphere
1977 Poles
1977 Entries

Oriented Core Data 170° Wall Orientation

Set # - Dip / Dip Direction

C1 - 45 / 189
C2 - 68 / 100
C3 - 43 / 143
C4 - 27 / 284

FAILURE MODES

Planar

Wedge
C1/C2, C1/C3, C2/C3

Toppling

NOTES:

1. ACOUSTIC TELEVIEWER DATA NOT COLLECTED IN THE M-NORTH SECTOR.
2. ORIENTED CORE DATA COLLECTED BY KNIGHT PIESOLD LTD. DURING THE 1994 AND 2011 GEOTECHNICAL SITE INVESTIGATIONS.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	25APR'12	ISSUED WITH REPORT	NS	GM	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

OPEN PIT GEOTECHNICAL DESIGN
KINEMATIC ANALYSIS RESULTS
M-NORTH SECTOR - 135°, 170°

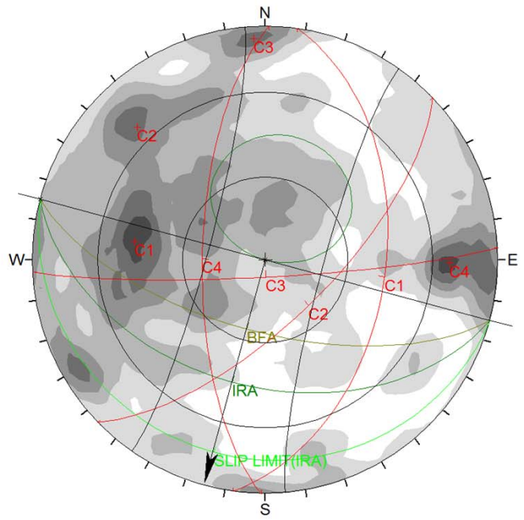
Knight Piésold CONSULTING

P/A NO. VA101-325/8

REF. NO. 7

APPENDIX B2.1

REV 0



Fisher
Concentrations
% of total per 1.0 % area

0.00 ~ 0.50 %
0.50 ~ 1.00 %
1.00 ~ 1.50 %
1.50 ~ 2.00 %
2.00 ~ 2.50 %
2.50 ~ 3.00 %
3.00 ~ 3.50 %

Terzaghi Correction
Min. Bias Angle = 15 deg
Max. Conc. = 2.9545%

Equal Area
Lower Hemisphere
1012 Poles
1012 Entries

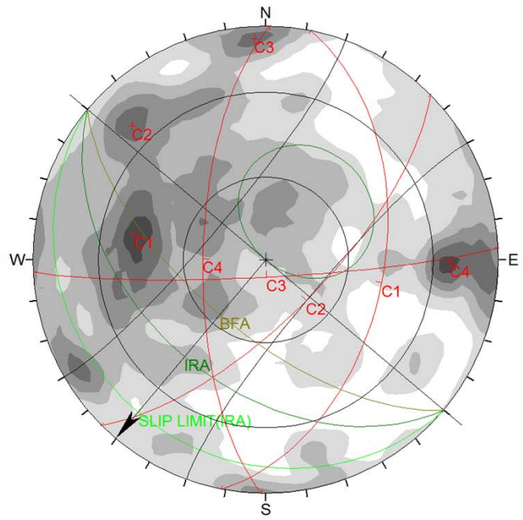
Oriented Core Data 195° Wall Orientation

Set # - Dip / Dip Direction
C1 - 47 / 098
C2 - 68 / 136
C3 - 84 / 177
C4 - 68 / 271

FAILURE MODES
Planar

Wedge
C2/C4

Toppling



Fisher
Concentrations
% of total per 1.0 % area

0.00 ~ 0.50 %
0.50 ~ 1.00 %
1.00 ~ 1.50 %
1.50 ~ 2.00 %
2.00 ~ 2.50 %
2.50 ~ 3.00 %
3.00 ~ 3.50 %

Terzaghi Correction
Min. Bias Angle = 15 deg
Max. Conc. = 2.9545%

Equal Area
Lower Hemisphere
1012 Poles
1012 Entries

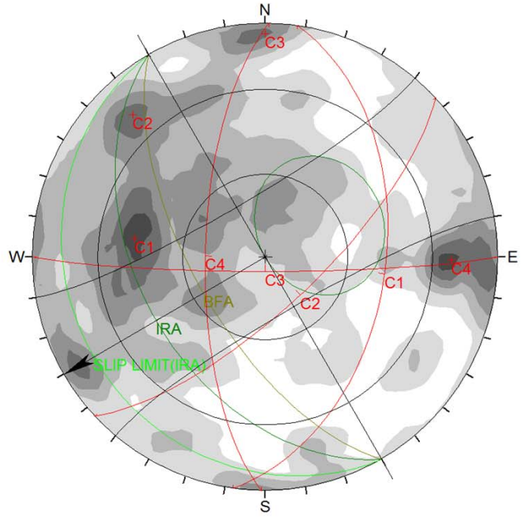
Oriented Core Data 220° Wall Orientation

Set # - Dip / Dip Direction
C1 - 47 / 098
C2 - 68 / 136
C3 - 84 / 177
C4 - 68 / 271

FAILURE MODES
Planar

Wedge
C2/C4

Toppling



Fisher
Concentrations
% of total per 1.0 % area

0.00 ~ 0.50 %
0.50 ~ 1.00 %
1.00 ~ 1.50 %
1.50 ~ 2.00 %
2.00 ~ 2.50 %
2.50 ~ 3.00 %
3.00 ~ 3.50 %

Terzaghi Correction
Min. Bias Angle = 15 deg
Max. Conc. = 2.9545%

Equal Area
Lower Hemisphere
1012 Poles
1012 Entries

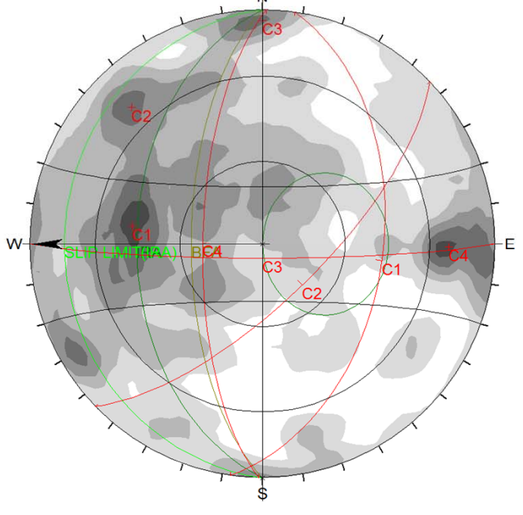
Oriented Core Data 240° Wall Orientation

Set # - Dip / Dip Direction
C1 - 47 / 098
C2 - 68 / 136
C3 - 84 / 177
C4 - 68 / 271

FAILURE MODES
Planar

Wedge

Toppling



Fisher
Concentrations
% of total per 1.0 % area

0.00 ~ 0.50 %
0.50 ~ 1.00 %
1.00 ~ 1.50 %
1.50 ~ 2.00 %
2.00 ~ 2.50 %
2.50 ~ 3.00 %
3.00 ~ 3.50 %

Terzaghi Correction
Min. Bias Angle = 15 deg
Max. Conc. = 2.9545%

Equal Area
Lower Hemisphere
1012 Poles
1012 Entries

Oriented Core Data 270° Wall Orientation

Set # - Dip / Dip Direction
C1 - 47 / 098
C2 - 68 / 136
C3 - 84 / 177
C4 - 68 / 271

FAILURE MODES
Planar

Wedge

Toppling

NOTES:
1. ACOUSTIC TELEVIEWER DATA NOT COLLECTED IN THE M-NORTHEAST SECTOR.
2. ORIENTED CORE DATA COLLECTED BY KNIGHT PIESOLD LTD. DURING THE 1994 GEOTECHNICAL SITE INVESTIGATION.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	25APR'12	ISSUED WITH REPORT	NS	GM	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

OPEN PIT GEOTECHNICAL DESIGN
KINEMATIC ANALYSIS RESULTS
M-NORTHEAST SECTOR - 195°, 220°, 240°, 270°

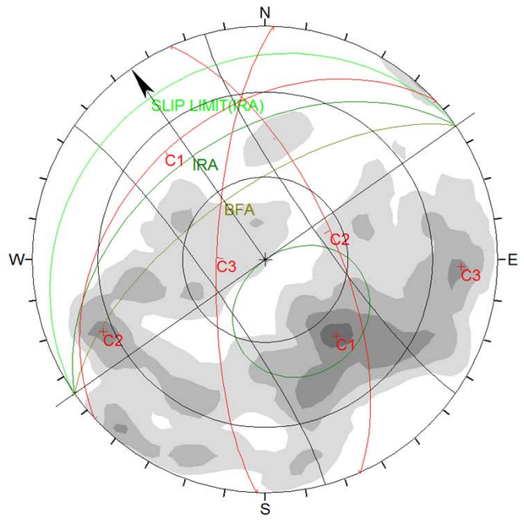
Knight Piésold CONSULTING

P/A NO. VA101-325/8

REF. NO. 7

APPENDIX B2.2

REV 0



Fisher
Concentrations
% of total per 1.0 % area

0.00 ~ 1.00 %
1.00 ~ 1.40 %
1.40 ~ 1.80 %
1.80 ~ 2.20 %
2.20 ~ 2.60 %
2.60 ~ 3.00 %
> 3.00 %

Terzaghi Correction
Min. Bias Angle = 15 deg
Max. Conc. = 2.3528%

Equal Area
Lower Hemisphere
1826 Poles
1826 Entries

Oriented Core Data 325° Wall Orientation

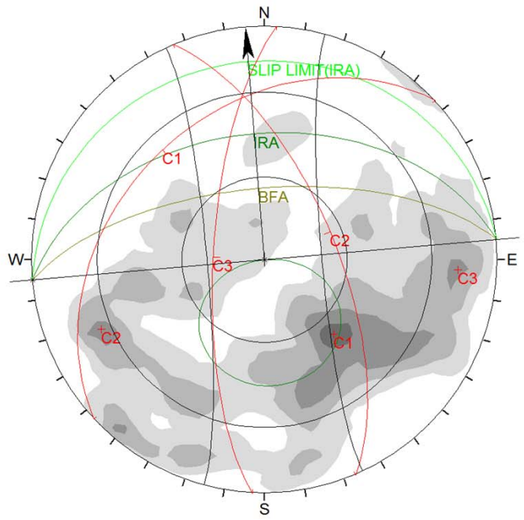
Set # - Dip / Dip Direction
C1 - 37 / 317
C2 - 66 / 066
C3 - 73 / 272

FAILURE MODES

Planar
C1

Wedge

Toppling



Fisher
Concentrations
% of total per 1.0 % area

0.00 ~ 1.00 %
1.00 ~ 1.40 %
1.40 ~ 1.80 %
1.80 ~ 2.20 %
2.20 ~ 2.60 %
2.60 ~ 3.00 %
> 3.00 %

Terzaghi Correction
Min. Bias Angle = 15 deg
Max. Conc. = 2.3528%

Equal Area
Lower Hemisphere
1826 Poles
1826 Entries

Oriented Core Data 355° Wall Orientation

Set # - Dip / Dip Direction
C1 - 37 / 317
C2 - 66 / 066
C3 - 73 / 272

FAILURE MODES

Planar

Wedge
C1/C2, C1/C3, C2/C3

Toppling

NOTES:
1. ACOUSTIC TELEVIEWER DATA NOT COLLECTED IN THE M-SOUTH SECTOR.
2. ORIENTED CORE DATA COLLECTED BY KNIGHT PIESOLD LTD. DURING THE 1994, 2010 AND 2011 GEOTECHNICAL SITE INVESTIGATIONS.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	25APR'12	ISSUED WITH REPORT	NS	GM	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

OPEN PIT GEOTECHNICAL DESIGN
KINEMATIC ANALYSIS RESULTS
M-SOUTH SECTOR - 325°, 355°

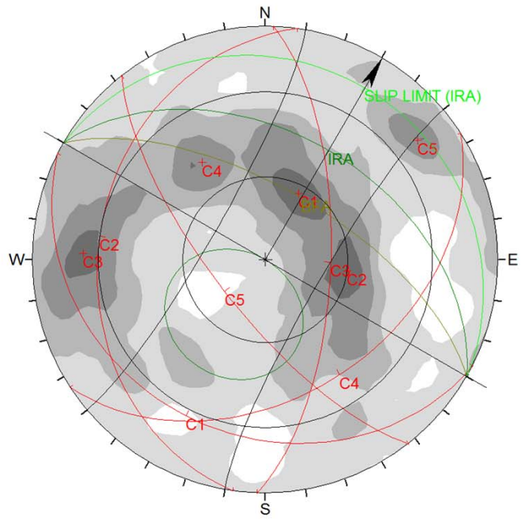
Knight Piésold CONSULTING

P/A NO. VA101-325/8

REF. NO. 7

APPENDIX B2.3

REV 0



Fisher
Concentrations
% of total per 1.0 % area

0.00 ~ 0.50 %
0.50 ~ 1.00 %
1.00 ~ 1.50 %
1.50 ~ 2.00 %
2.00 ~ 2.50 %
2.50 ~ 3.00 %
3.00 ~ 3.50 %

Terzaghi Correction
Min. Bias Angle = 15 deg
Max. Conc. = 2.4642%

Equal Area
Lower Hemisphere
3377 Poles
3377 Entries

Oriented Core Data 030° Wall Orientation

Set # - Dip / Dip Direction

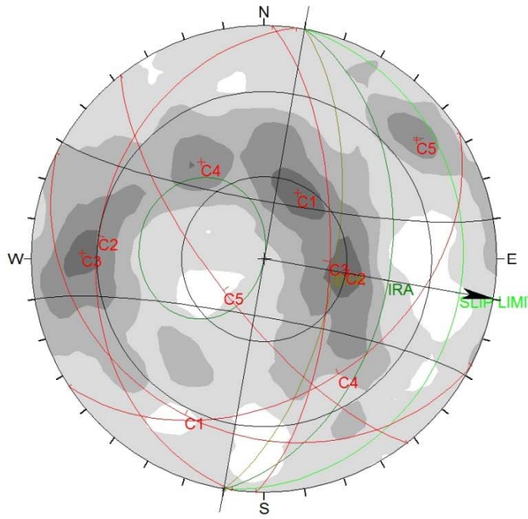
C1 - 26 / 207
C2 - 29 / 278
C3 - 67 / 092
C4 - 41 / 147
C5 - 72 / 232

FAILURE MODES

Planar

Wedge

Toppling



Fisher
Concentrations
% of total per 1.0 % area

0.00 ~ 0.50 %
0.50 ~ 1.00 %
1.00 ~ 1.50 %
1.50 ~ 2.00 %
2.00 ~ 2.50 %
2.50 ~ 3.00 %
3.00 ~ 3.50 %

Terzaghi Correction
Min. Bias Angle = 15 deg
Max. Conc. = 2.4642%

Equal Area
Lower Hemisphere
3377 Poles
3377 Entries

Oriented Core Data 100° Wall Orientation

Set # - Dip / Dip Direction

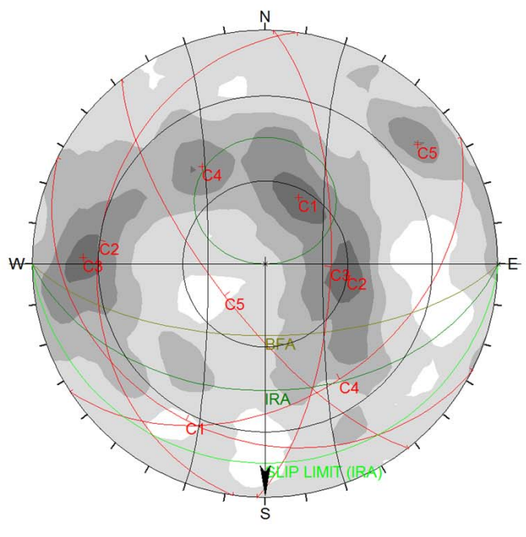
C1 - 26 / 207
C2 - 29 / 278
C3 - 67 / 092
C4 - 41 / 147
C5 - 72 / 232

FAILURE MODES

Planar

Wedge

Toppling



Fisher
Concentrations
% of total per 1.0 % area

0.00 ~ 0.50 %
0.50 ~ 1.00 %
1.00 ~ 1.50 %
1.50 ~ 2.00 %
2.00 ~ 2.50 %
2.50 ~ 3.00 %
3.00 ~ 3.50 %

Terzaghi Correction
Min. Bias Angle = 15 deg
Max. Conc. = 2.4642%

Equal Area
Lower Hemisphere
3377 Poles
3377 Entries

Oriented Core Data 180° Wall Orientation

Set # - Dip / Dip Direction

C1 - 26 / 207
C2 - 29 / 278
C3 - 67 / 092
C4 - 41 / 147
C5 - 72 / 232

FAILURE MODES

Planar

Wedge

C3/C4, C3/C5, C4/C5

Toppling

NOTES:

1. ACOUSTIC TELEVIEWER DATA NOT COLLECTED IN THE CENTRAL SECTOR.
2. ORIENTED CORE DATA COLLECTED BY KNIGHT PIESOLD LTD. DURING THE 1994 GEOTECHNICAL SITE INVESTIGATION.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	25APR'12	ISSUED WITH REPORT	NS	GM	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

OPEN PIT GEOTECHNICAL DESIGN
KINEMATIC ANALYSIS RESULTS
CENTRAL SECTOR - 030°, 100°, 180°

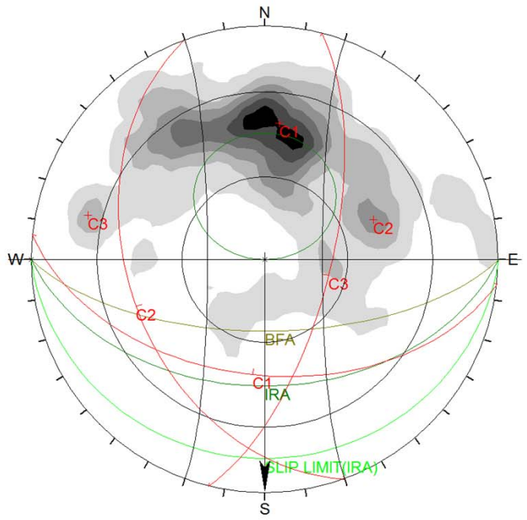
Knight Piésold CONSULTING

P/A NO. VA101-325/8

REF. NO. 7

APPENDIX B2.4

REV 0



Fisher
Concentrations
% of total per 1.0 % area

0.00 ~ 1.00 %
1.00 ~ 2.00 %
2.00 ~ 3.00 %
3.00 ~ 4.00 %
4.00 ~ 5.00 %
5.00 ~ 6.00 %
6.00 ~ 7.00 %

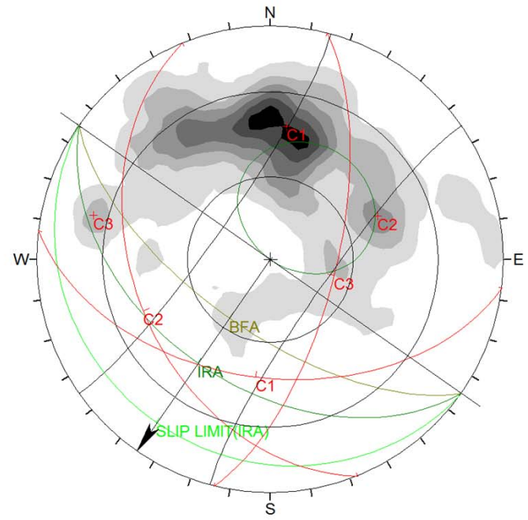
Terzaghi Correction
Min. Bias Angle = 15 deg
Max. Conc. = 6.6813%

Equal Area
Lower Hemisphere
448 Poles
448 Entries

Oriented Core Data 180° Wall Orientation

Set # - Dip / Dip Direction
C1 - 49 / 186
C2 - 41 / 250
C3 - 67 / 104

FAILURE MODES
Planar
Wedge
Toppling



Fisher
Concentrations
% of total per 1.0 % area

0.00 ~ 1.00 %
1.00 ~ 2.00 %
2.00 ~ 3.00 %
3.00 ~ 4.00 %
4.00 ~ 5.00 %
5.00 ~ 6.00 %
6.00 ~ 7.00 %

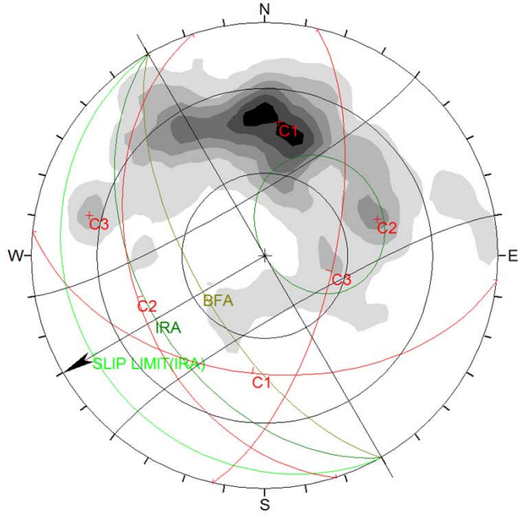
Terzaghi Correction
Min. Bias Angle = 15 deg
Max. Conc. = 6.6813%

Equal Area
Lower Hemisphere
448 Poles
448 Entries

Oriented Core Data 215° Wall Orientation

Set # - Dip / Dip Direction
C1 - 49 / 186
C2 - 41 / 250
C3 - 67 / 104

FAILURE MODES
Planar
C2
Wedge
C1/C2
Toppling



Fisher
Concentrations
% of total per 1.0 % area

0.00 ~ 1.00 %
1.00 ~ 2.00 %
2.00 ~ 3.00 %
3.00 ~ 4.00 %
4.00 ~ 5.00 %
5.00 ~ 6.00 %
6.00 ~ 7.00 %

Terzaghi Correction
Min. Bias Angle = 15 deg
Max. Conc. = 6.6813%

Equal Area
Lower Hemisphere
448 Poles
448 Entries

Oriented Core Data 240° Wall Orientation

Set # - Dip / Dip Direction
C1 - 49 / 186
C2 - 41 / 250
C3 - 67 / 104

FAILURE MODES
Planar
C2
Wedge
C1/C2
Toppling

NOTES:
1. ACOUSTIC TELEVIEWER DATA NOT COLLECTED IN THE W-NORTH SECTOR.
2. ORIENTED CORE DATA COLLECTED BY KNIGHT PIESOLD LTD. DURING THE 2010 GEOTECHNICAL SITE INVESTIGATION.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	25APR'12	ISSUED WITH REPORT	NS	GM	KJB

CASINO MINING CORPORATION

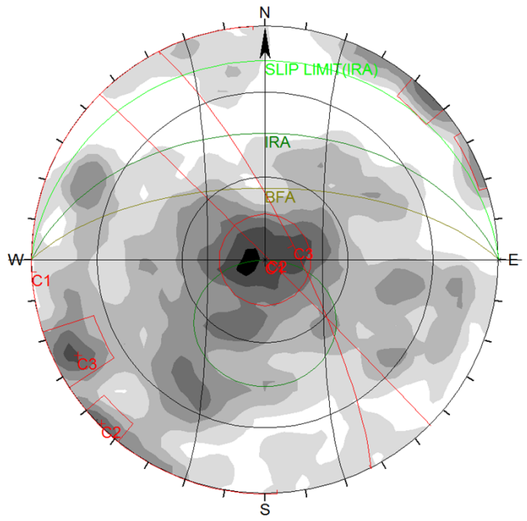
CASINO COPPER-GOLD PROJECT

OPEN PIT GEOTECHNICAL DESIGN
KINEMATIC ANALYSIS RESULTS
W-NORTH SECTOR - 180°, 215°, 240°

Knight Piésold CONSULTING

P/A NO. VA101-325/8 | REF. NO. 7

APPENDIX B2.5 | REV 0



Fisher
Concentrations
% of total per 1.0 % area

0.00 ~ 0.50 %
0.50 ~ 1.00 %
1.00 ~ 1.50 %
1.50 ~ 2.00 %
2.00 ~ 2.50 %
2.50 ~ 3.00 %
3.00 ~ 3.50 %

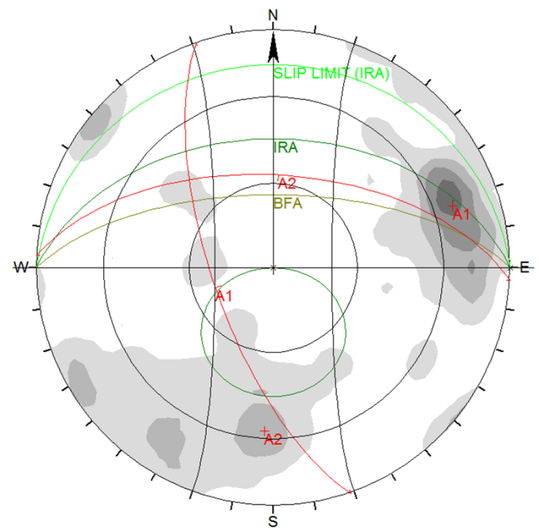
Terzaghi Correction
Min. Bias Angle = 15 deg
Max. Conc. = 3.2181%

Equal Area
Lower Hemisphere
560 Poles
560 Entries

Oriented Core Data 000° Wall Orientation

Set # - Dip / Dip Direction
C1 - 00 / 267
C2 - 89 / 045
C3 - 79 / 063

FAILURE MODES
Planar
Wedge
Toppling



Fisher
Concentrations
% of total per 1.0 % area

0.00 ~ 1.00 %
1.00 ~ 2.80 %
2.80 ~ 4.60 %
4.60 ~ 6.40 %
6.40 ~ 8.20 %
8.20 ~ 10.00 %
>10.00 %

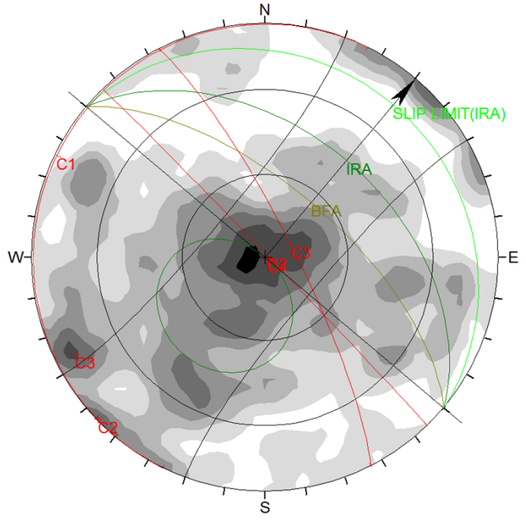
Terzaghi Correction
Min. Bias Angle = 15 deg
Max. Conc. = 8.2605%

Equal Area
Lower Hemisphere
283 Poles
283 Entries

Acoustic Televiewer Data 000° Wall Orientation

Set # - Dip / Dip Direction
A1 - 58 / 003
A2 - 69 / 251

FAILURE MODES
Planar
Wedge
Toppling



Fisher
Concentrations
% of total per 1.0 % area

0.00 ~ 0.50 %
0.50 ~ 1.00 %
1.00 ~ 1.50 %
1.50 ~ 2.00 %
2.00 ~ 2.50 %
2.50 ~ 3.00 %
3.00 ~ 3.50 %

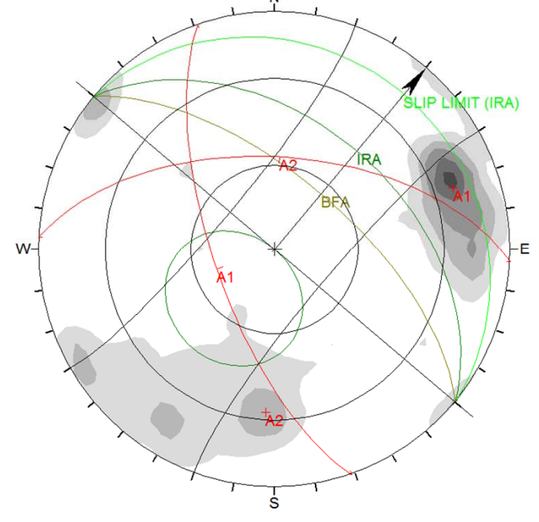
Terzaghi Correction
Min. Bias Angle = 15 deg
Max. Conc. = 3.2181%

Equal Area
Lower Hemisphere
560 Poles
560 Entries

Oriented Core Data 040° Wall Orientation

Set # - Dip / Dip Direction
C1 - 00 / 267
C2 - 89 / 045
C3 - 79 / 063

FAILURE MODES
Planar
Wedge
Toppling
C2



Fisher
Concentrations
% of total per 1.0 % area

0.00 ~ 1.50 %
1.50 ~ 3.00 %
3.00 ~ 4.50 %
4.50 ~ 6.00 %
6.00 ~ 7.50 %
7.50 ~ 9.00 %
9.00 ~ 10.50 %

Terzaghi Correction
Min. Bias Angle = 15 deg
Max. Conc. = 8.2605%

Equal Area
Lower Hemisphere
283 Poles
283 Entries

Acoustic Televiewer Data 040° Wall Orientation

Set # - Dip / Dip Direction
A1 - 58 / 003
A2 - 69 / 251

FAILURE MODES
Planar
Wedge
Toppling

NOTES:
1. ACOUSTIC TELEVIEWER DATA COLLECTED BY COLOG DURING THE 2008 AND 2011 GEOTECHNICAL SITE INVESTIGATIONS.
2. ORIENTED CORE DATA COLLECTED BY KNIGHT PIESOLD LTD. DURING THE 2010 AND 2011 GEOTECHNICAL SITE INVESTIGATIONS.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	25APR'12	ISSUED WITH REPORT	NS	GM	KJB

CASINO MINING CORPORATION

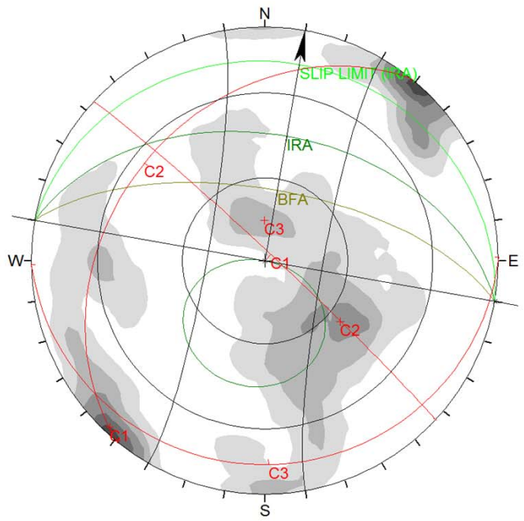
CASINO COPPER-GOLD PROJECT

OPEN PIT GEOTECHNICAL DESIGN
KINEMATIC ANALYSIS RESULTS
W-SOUTH SECTOR - 000° , 040°

Knight Piésold CONSULTING

P/A NO. VA101-325/8 | REF. NO. 7

APPENDIX B2.6 | REV 0



Fisher
Concentrations
% of total per 1.0 % area

0.00 ~ 1.00 %
1.00 ~ 2.00 %
2.00 ~ 3.00 %
3.00 ~ 4.00 %
4.00 ~ 5.00 %
5.00 ~ 6.00 %
6.00 ~ 7.00 %

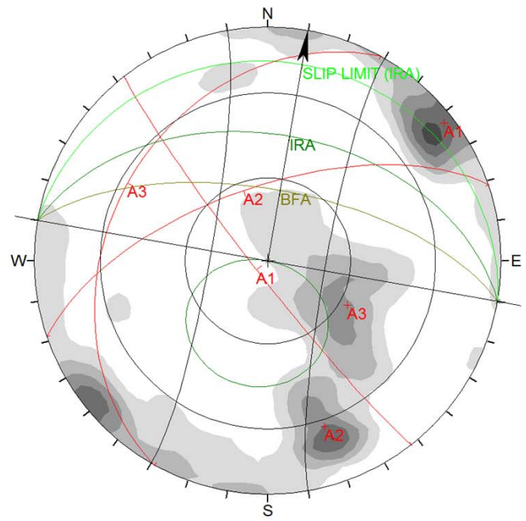
Terzaghi Correction
Min. Bias Angle = 15 deg
Max. Conc. = 5.5676%

Equal Area
Lower Hemisphere
419 Poles
419 Entries

Oriented Core Data 010° Wall Orientation

Set # - Dip / Dip Direction
C1 - 87 / 043
C2 - 34 / 309
C3 - 14 / 179

FAILURE MODES
Planar
Wedge
Toppling



Fisher
Concentrations
% of total per 1.0 % area

0.00 ~ 1.00 %
1.00 ~ 2.00 %
2.00 ~ 3.00 %
3.00 ~ 4.00 %
4.00 ~ 5.00 %
5.00 ~ 6.00 %
6.00 ~ 7.00 %

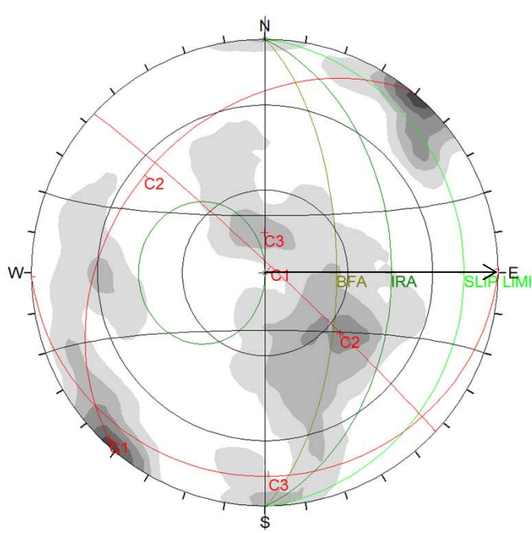
Terzaghi Correction
Min. Bias Angle = 15 deg
Max. Conc. = 5.6219%

Equal Area
Lower Hemisphere
649 Poles
649 Entries

Acoustic Televiewer Data 010° Wall Orientation

Set # - Dip / Dip Direction
A1 - 85 / 232
A2 - 64 / 341
A3 - 32 / 299

FAILURE MODES
Planar
Wedge
Toppling



Fisher
Concentrations
% of total per 1.0 % area

0.00 ~ 1.00 %
1.00 ~ 2.00 %
2.00 ~ 3.00 %
3.00 ~ 4.00 %
4.00 ~ 5.00 %
5.00 ~ 6.00 %
6.00 ~ 7.00 %

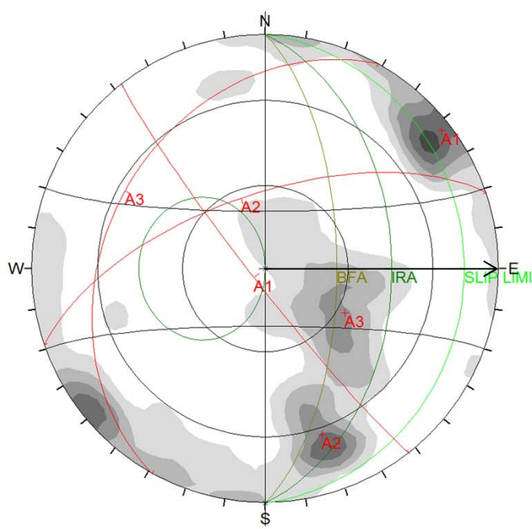
Terzaghi Correction
Min. Bias Angle = 15 deg
Max. Conc. = 5.5676%

Equal Area
Lower Hemisphere
419 Poles
419 Entries

Oriented Core Data 090° Wall Orientation

Set # - Dip / Dip Direction
C1 - 87 / 043
C2 - 34 / 309
C3 - 14 / 179

FAILURE MODES
Planar
Wedge
Toppling



Fisher
Concentrations
% of total per 1.0 % area

0.00 ~ 1.00 %
1.00 ~ 2.00 %
2.00 ~ 3.00 %
3.00 ~ 4.00 %
4.00 ~ 5.00 %
5.00 ~ 6.00 %
6.00 ~ 7.00 %

Terzaghi Correction
Min. Bias Angle = 15 deg
Max. Conc. = 5.6219%

Equal Area
Lower Hemisphere
649 Poles
649 Entries

Acoustic Televiewer Data 090° Wall Orientation

Set # - Dip / Dip Direction
A1 - 85 / 232
A2 - 64 / 341
A3 - 32 / 299

FAILURE MODES
Planar
Wedge
Toppling

NOTES:
1. ORIENTED CORE DATA COLLECTED BY KNIGHT PIESOLD LTD. DURING THE 2011 GEOTECHNICAL SITE INVESTIGATION.
2. ACOUSTIC TELEVIEWER DATA COLLECTED BY COLOG DURING THE 2008 AND 2011 GEOTECHNICAL SITE INVESTIGATIONS.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	25APR'12	ISSUED WITH REPORT	NS	GM	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

OPEN PIT GEOTECHNICAL DESIGN
KINEMATIC ANALYSIS RESULTS
W-SOUTHWEST SECTOR - 010°, 090°

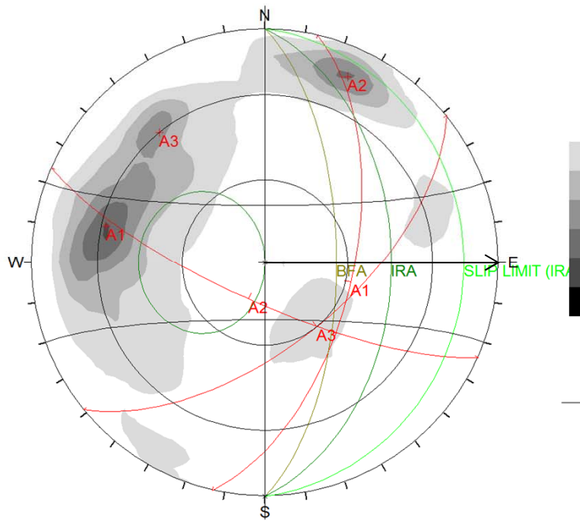
Knight Piésold CONSULTING

P/A NO. VA101-325/8

REF. NO. 7

APPENDIX B2.7

REV 0



Fisher
Concentrations
% of total per 1.0 % area

0.00 ~ 1.00 %
1.00 ~ 2.00 %
2.00 ~ 3.00 %
3.00 ~ 4.00 %
4.00 ~ 5.00 %
5.00 ~ 6.00 %
6.00 ~ 7.00 %

Terzaghi Correction
Min. Bias Angle = 15 deg
Max. Conc. = 5.1105%

Equal Area
Lower Hemisphere
2032 Poles
2032 Entries

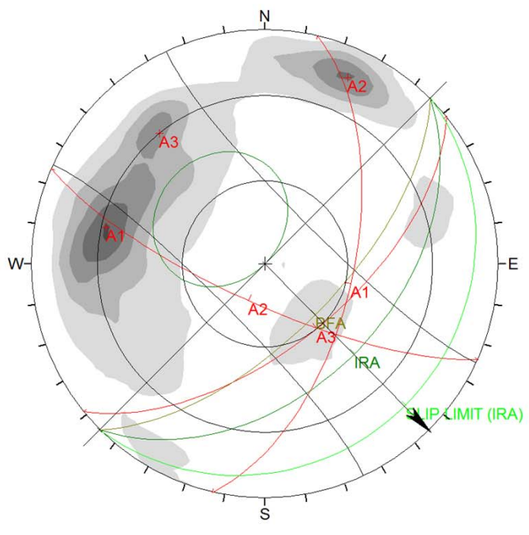
Acoustic Televiewer Data 090° Wall Orientation

Set # - Dip / Dip Direction
A1 - 59 / 103
A2 - 76 / 204
A3 - 61 / 141

FAILURE MODES
Planar

Wedge

Toppling



Fisher
Concentrations
% of total per 1.0 % area

0.00 ~ 1.00 %
1.00 ~ 2.00 %
2.00 ~ 3.00 %
3.00 ~ 4.00 %
4.00 ~ 5.00 %
5.00 ~ 6.00 %
6.00 ~ 7.00 %

Terzaghi Correction
Min. Bias Angle = 15 deg
Max. Conc. = 5.1105%

Equal Area
Lower Hemisphere
2032 Poles
2032 Entries

Acoustic Televiewer Data 135° Wall Orientation

Set # - Dip / Dip Direction
A1 - 59 / 103
A2 - 76 / 204
A3 - 61 / 141

FAILURE MODES
Planar

Wedge
A1/A3

Toppling

NOTES:
1. ACOUSTIC TELEVIEWER DATA COLLECTED BY COLOG DURING THE 2008 AND 2011 GEOTECHNICAL SITE INVESTIGATIONS.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	25APR12	ISSUED WITH REPORT	NS	GM	KJB

CASINO MINING CORPORATION

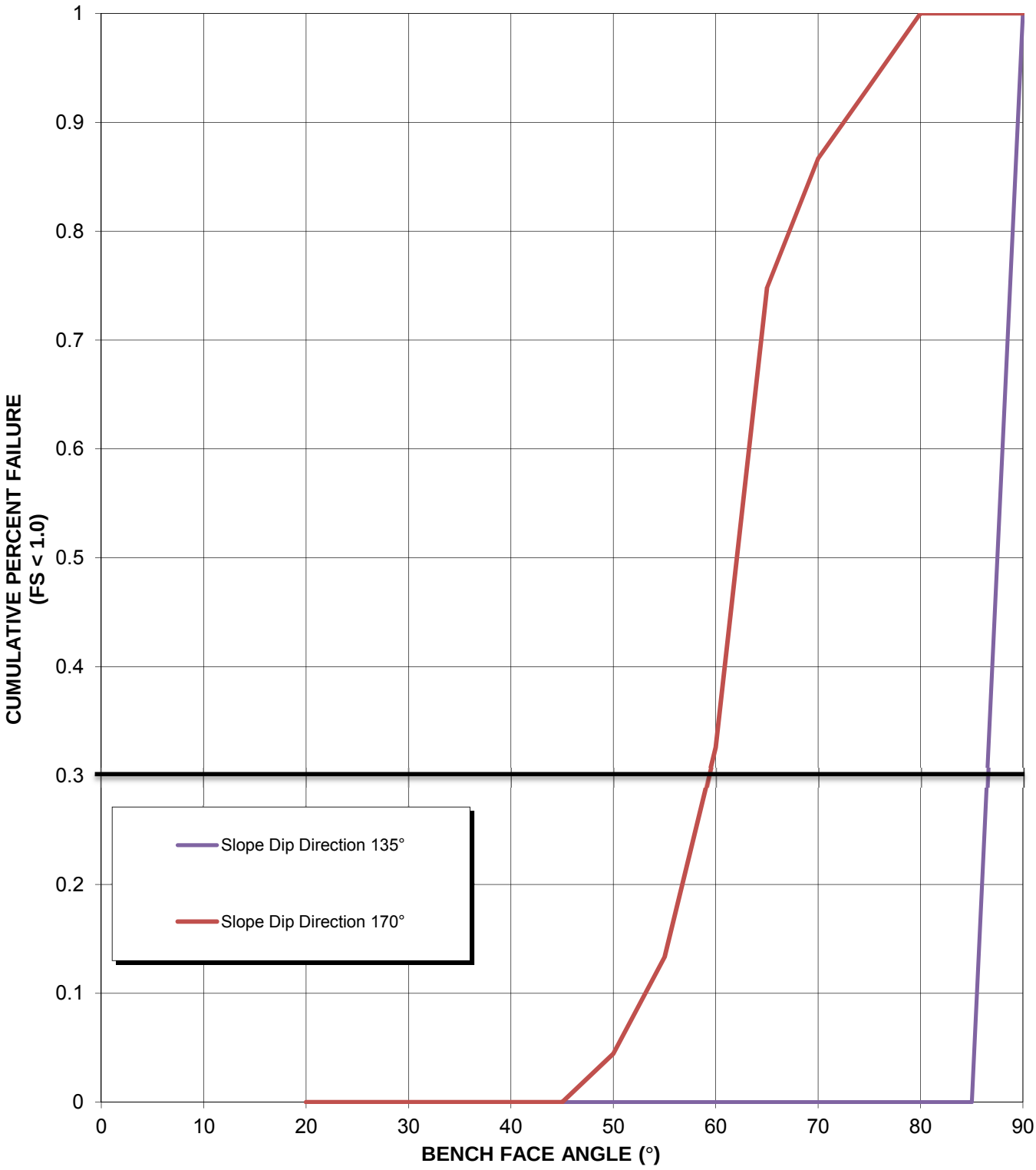
CASINO COPPER-GOLD PROJECT

OPEN PIT GEOTECHNICAL DESIGN
KINEMATIC ANALYSIS RESULTS
W-WEST SECTOR - 090°, 135°

Knight Piésold CONSULTING

P/A NO. VA101-325/8 | REF. NO. 7

APPENDIX B2.8 | REV 0



NOTES:
1. SWEGE 5.0 SOFTWARE USED FOR ANALYSES.
2. JOINT COHESION OF 50 kPa ASSUMED.
3. DRILLHOLE DATA SORTED BY DISCONTINUITY SET.

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

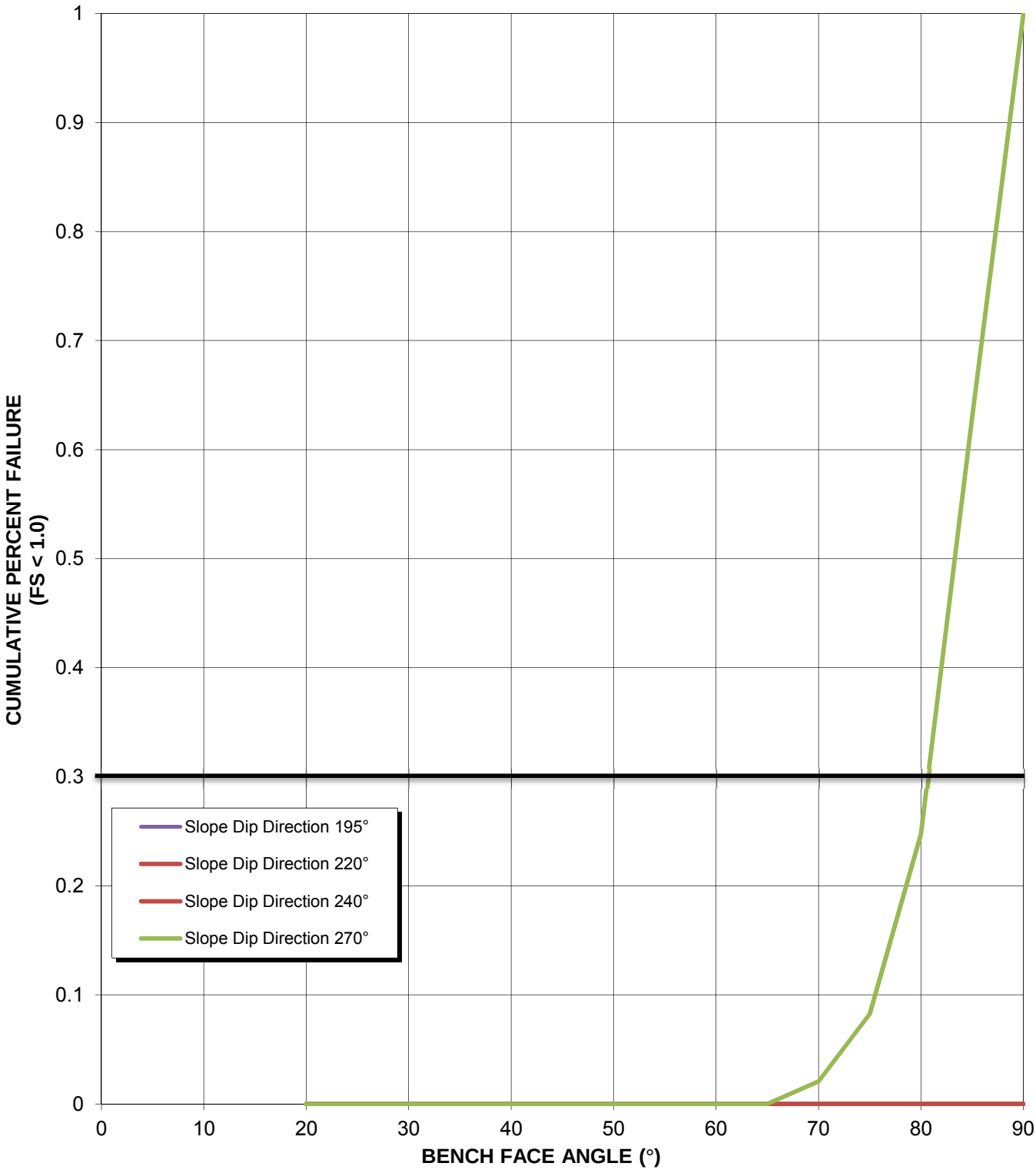
OPEN PIT GEOTECHNICAL DESIGN
BENCH FACE ANGLE ANALYSIS -
M-NORTH SECTOR

Knight Piésold CONSULTING

P/A NO. VA101-325/8 | REF. NO. 7

APPENDIX B2.9 | REV 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	12JUN'12	ISSUED WITH REPORT	GM	DAY	KJB



NOTES:
1. SWEGE 5.0 SOFTWARE USED FOR ANALYSES.
2. JOINT COHESION OF 50 kPa ASSUMED.
3. DRILLHOLE DATA SORTED BY JOINT SET COMPRISED OF DATA FROM ALL HOLES IN SECTOR.

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

OPEN PIT GEOTECHNICAL DESIGN
BENCH FACE ANGLE ANALYSIS
M-NORTHEAST SECTOR

Knight Piésold CONSULTING

P/A NO. VA101-325/8 | REF. NO. 7

APPENDIX B2.10 | REV 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
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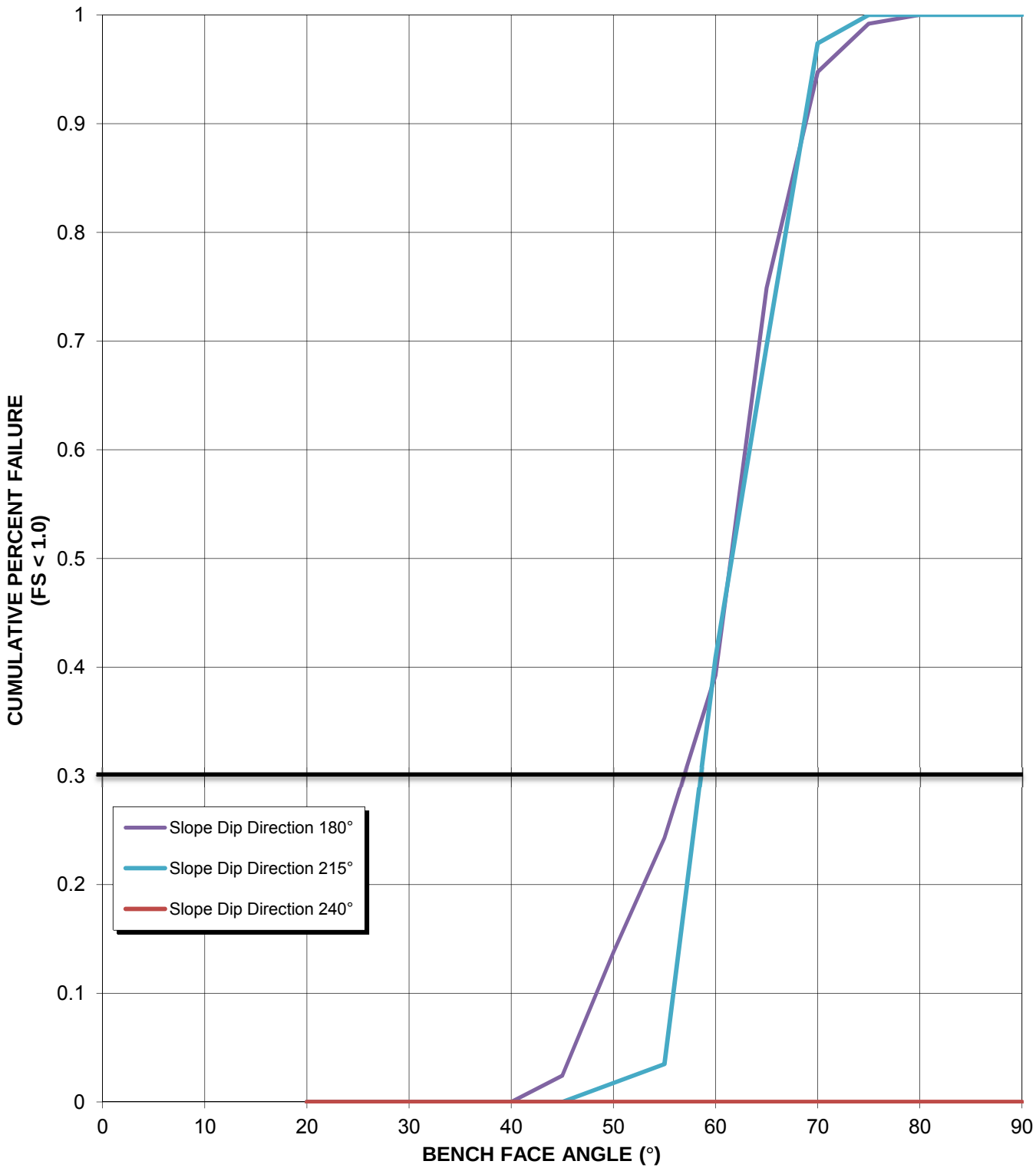

NOTES:
1. SWEGE 5.0 SOFTWARE USED FOR ANALYSES.
2. JOINT COHESION OF 50 kPa ASSUMED.
3. DRILLHOLE DATA SORTED BY DISCONTINUITY SET.

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

OPEN PIT GEOTECHNICAL DESIGN
BENCH FACE ANGLE ANALYSIS
W-NORTH SECTOR

Knight Piésold CONSULTING

P/A NO. VA101-325/8 | REF. NO. 7

APPENDIX B2.11 | REV 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	12JUN'12	ISSUED WITH REPORT	GM	DAY	KJB

APPENDIX C

LIMIT EQUILIBRIUM STABILITY ANALYSES

Appendix C1 Summary of Inter-ramp Stability Analysis
Appendix C2 Sensitivity Analysis and Limit Equilibrium Analysis

APPENDIX C1

SUMMARY OF INTER-RAMP STABILITY ANALYSIS

(Pages C1-1 to C1-2)

APPENDIX C1.1

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

OPEN PIT GEOTECHNICAL DESIGN
SUMMARY OF INTER-RAMP STABILITY ANALYSIS RESULTS FOR FRESH BEDROCK

Print Oct/04/12 10:01:33

Geotechnical Unit (1)	Inter-Ramp Slope Angle (degrees)	Slope Height (m)	Blast Disturbance	Groundwater Depressurization (2) (m from pit wall)	Factor of Safety
DRB	45	100	0.85	0	1.5
				30	2.6
			1	0	1.3
				30	2.3
		200	0.85	0	1.2
				30	1.8
			1	0	1.0
				30	**1.6**
PMS	45	100	0.85	0	1.4
				30	2.4
			1	0	1.2
				30	2.1
		200	0.85	0	1.1
				30	1.6
			1	0	1.0
				30	**1.4**

M:\1\01\00325\08\A\Report\7 - 2012 Open Pit Slope Design\Rev 0\Appendices\Appendix C - Limit Equilibrium Stability Analyses\[Appendix C1- C1-1 and C1-2.xlsm]Appen

NOTES:

1. DRB = DAWSON RANGE BATHOLITH, PMS = PROSPECTOR MOUNTAIN SUITE
2. GROUNDWATER DEPRESSURIZATION SET TO SIMULATE INSTALLATION OF HORIZONTAL DRAINS IN PIT WALL
3. **BOLD** FONT INDICATES BASE CASE ANALYSIS SCENARIO.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	29MAY'12	ISSUED WITH REPORT VA101-325/8-7	JAG	GM	KJB

APPENDIX C1.2

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

OPEN PIT GEOTECHNICAL DESIGN
SUMMARY OF INTER-RAMP STABILITY ANALYSIS RESULTS FOR WEATHERED BEDROCK

Print Oct/04/12 10:01:33

Geotechnical Unit (1)	Inter-Ramp Slope Angle (degrees)	Slope Height (m)	Blast Disturbance	Groundwater Depressurization (2) (m from pit wall)	Factor of Safety
DRB	45	100	0.85	0	0.6
				30	1.6
			1	0	0.5
				30	**1.3**
		200	0.85	0	0.6
				30	1.1
			1	0	0.5
				30	0.9
PMS	45	100	0.85	0	0.7
				30	1.6
			1	0	0.6
				30	**1.3**
		200	0.85	0	0.6
				30	1.1
			1	0	0.5
				30	0.9

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NOTES:

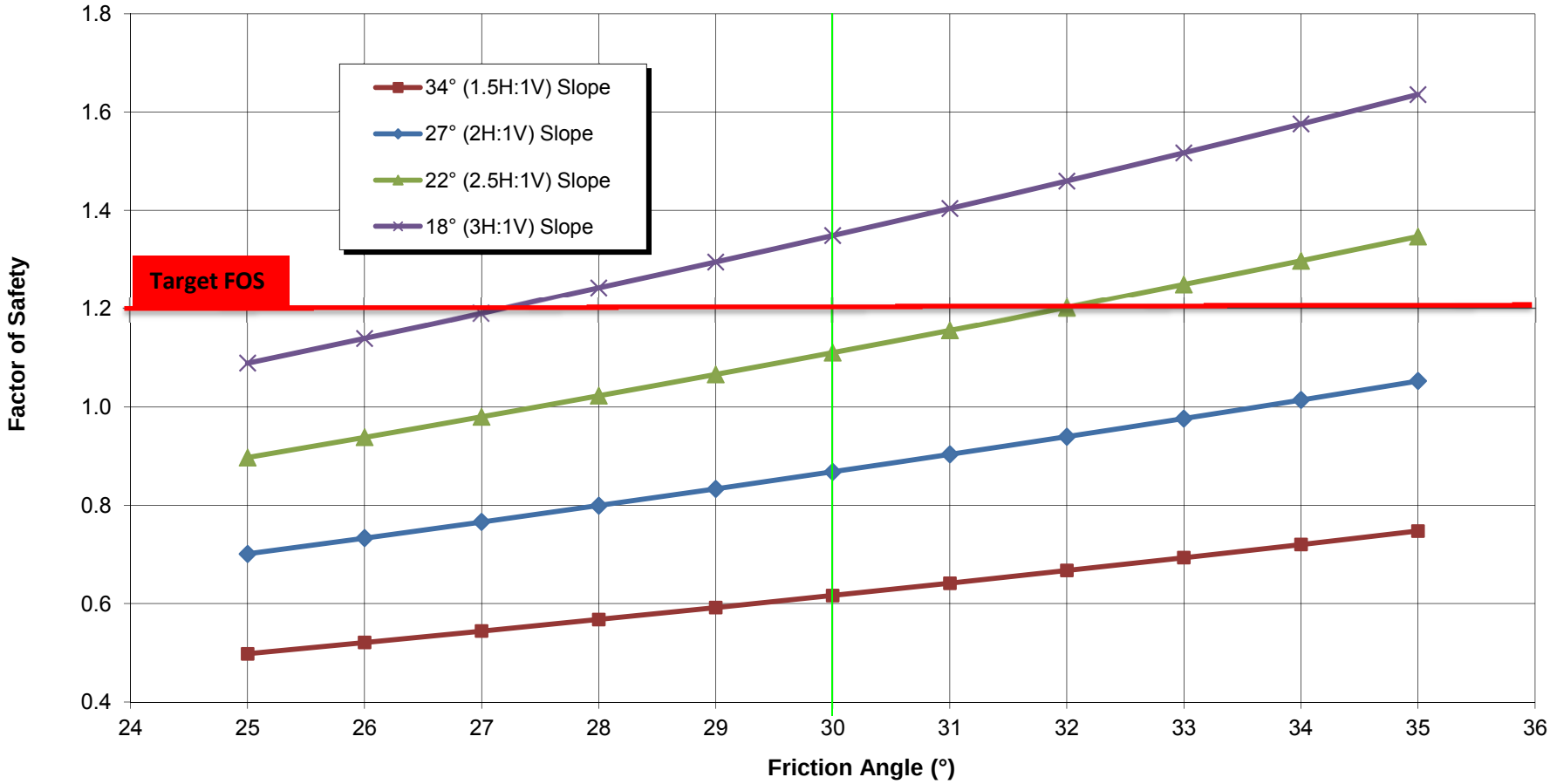
1. DRB = DAWSON RANGE BATHOLITH, PMS = PROSPECTOR MOUNTAIN SUITE
2. GROUNDWATER DEPRESSURIZATION SET TO SIMULATE INSTALLATION OF HORIZONTAL DRAINS IN PIT WALL
3. **BOLD** FONT INDICATES BASE CASE ANALYSIS SCENARIO.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	29MAY'12	ISSUED WITH REPORT VA101-325/8-7	JAG	GM	KJB

APPENDIX C2

SENSITIVITY ANALYSIS AND LIMIT EQUILIBRIUM ANALYSIS

(Pages C2-1 to C2-10)



NOTES:
1. SENSITIVITY ANALYSIS OF FRICTION ANGLE CONDUCTED BETWEEN 25° AND 35°.
2. MEDIAN FRICTION ANGLE IS 30°.
3. HORIZONTAL TO VERTICAL SLOPE RATIOS OF 1.5:1, 2:1, 2.5:1 AND 3:1 ARE SHOWN.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	25JUL'12	ISSUED WITH REPORT	GM	DAY	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

OPEN PIT GEOTECHNICAL DESIGN
SENSITIVITY ANALYSIS OF OVERBURDEN
PARTIALLY SATURATED SLOPE

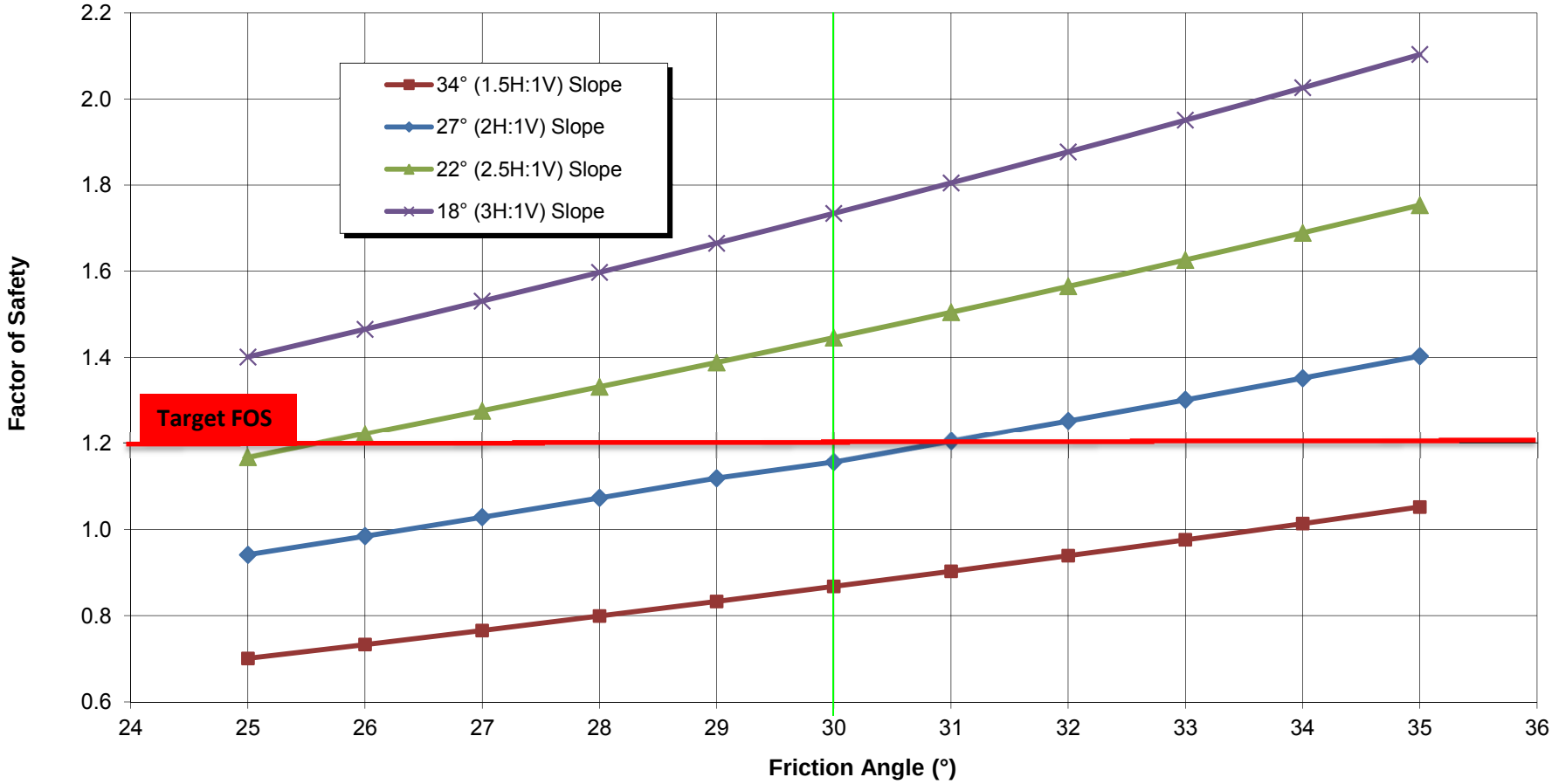
Knight Piésold CONSULTING

P/A NO. VA101-325/8

REF. NO. 7

APPENDIX C2.1

REV 0



NOTES:
1. SENSITIVITY ANALYSIS OF FRICTION ANGLE CONDUCTED BETWEEN 25° AND 35°.
2. MEDIAN FRICTION ANGLE IS 30°.
3. HORIZONTAL TO VERTICAL SLOPE RATIOS OF 1.5:1, 2:1, 2.5:1 AND 3:1 ARE SHOWN.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	25JUL'12	ISSUED WITH REPORT	GM	DAY	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

OPEN PIT GEOTECHNICAL DESIGN
SENSITIVITY ANALYSIS OF OVERBURDEN
FULLY DRAINED SLOPE

Knight Piésold CONSULTING

P/A NO. VA101-325/8

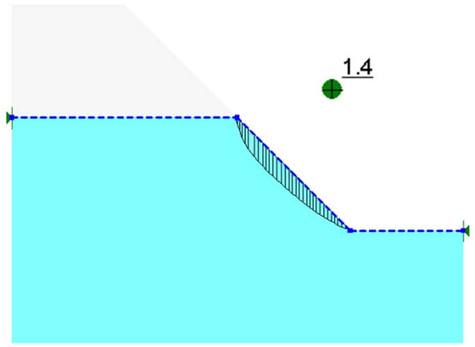
REF. NO. 7

APPENDIX C2.2

REV 0

100 m Slope Height

Fully Saturated Slope



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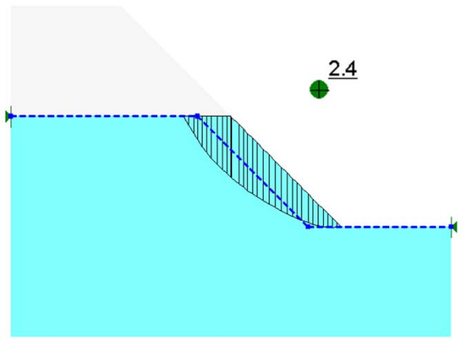
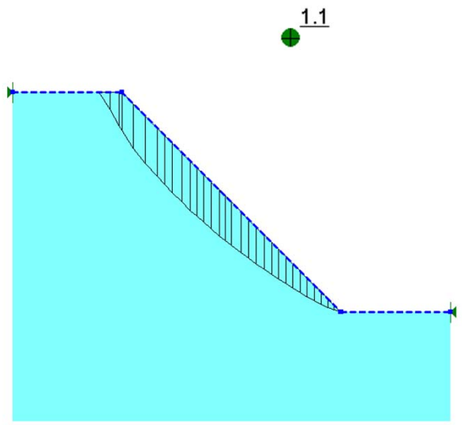


200 m Slope Height

Fully Saturated Slope



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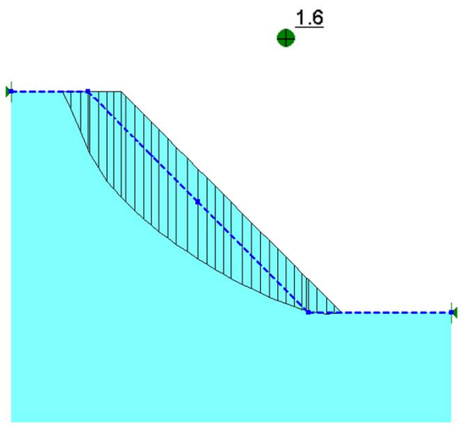
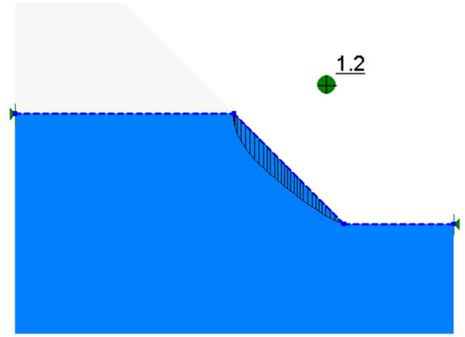


100 m Slope Height

Fully Saturated Slope



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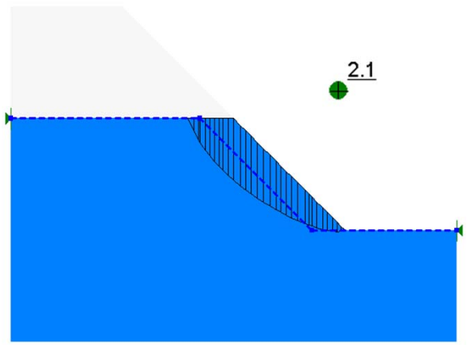
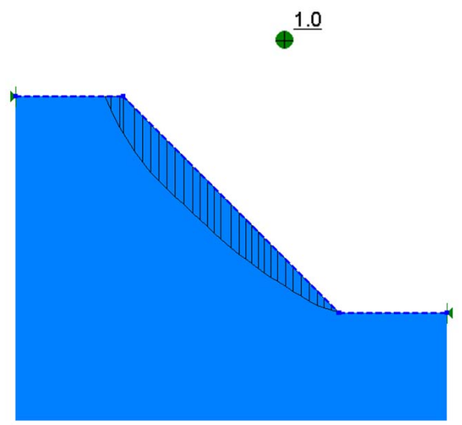


200 m Slope Height

Fully Saturated Slope



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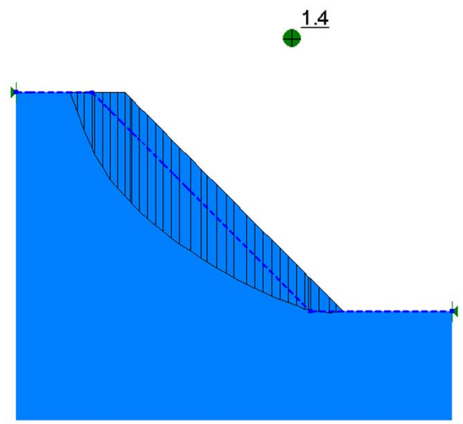

NOTES:

1. SLOPE ANGLE OF 45° USED FOR ALL MODELS SHOWN.
2. PMS = PROSPECTOR MOUNTAIN SUITE
3. GROUNDWATER DEPRESSURIZATION SET TO SIMULATE INSTALLATION OF HORIZONTAL DRAINS IN PIT WALL

.

Intact PMS(2) with Disturbance = 0.85

Intact PMS(2) with Disturbance = 1

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	18MAY'12	ISSUED WITH REPORT	JAG	GM	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

OPEN PIT GEOTECHNICAL DESIGN
LIMIT EQUILIBRIUM ANALYSIS
INTER-RAMP SLOPE ANALYSIS-PMS

Knight Piésold CONSULTING

P/A NO. VA101-325/8

REF. NO. 7

APPENDIX C2.3

REV 0

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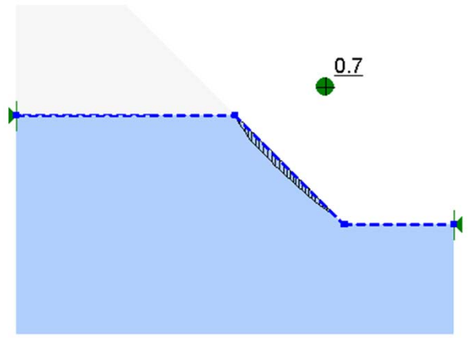
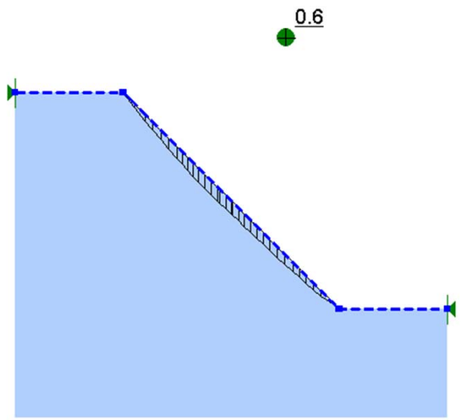
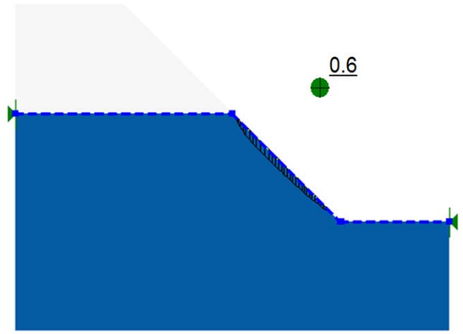
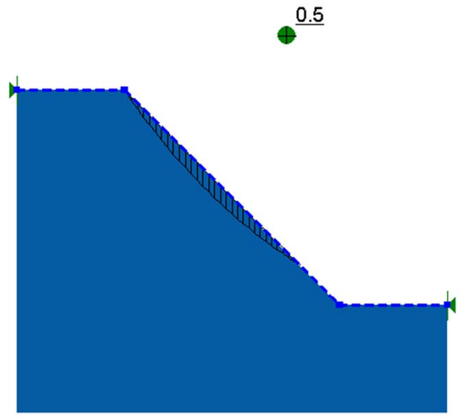
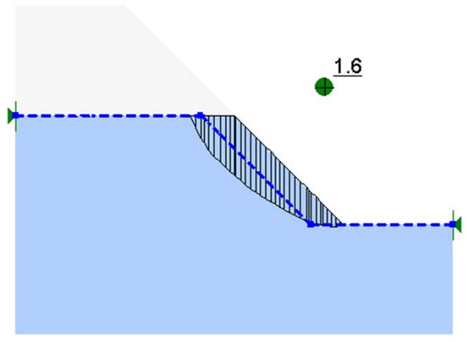
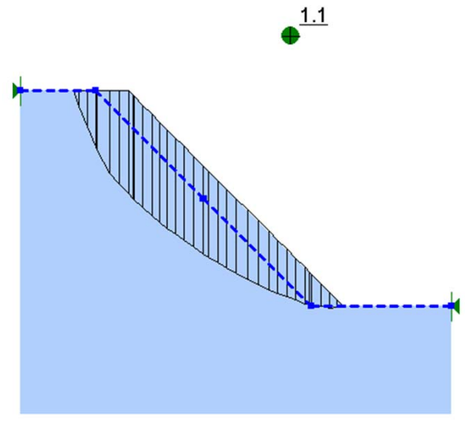
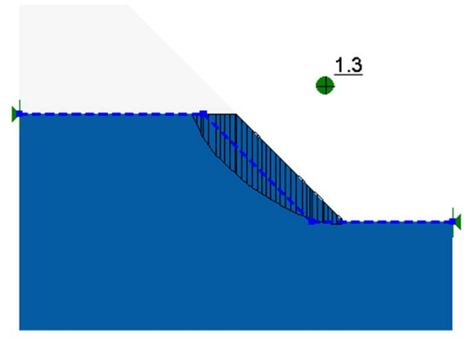
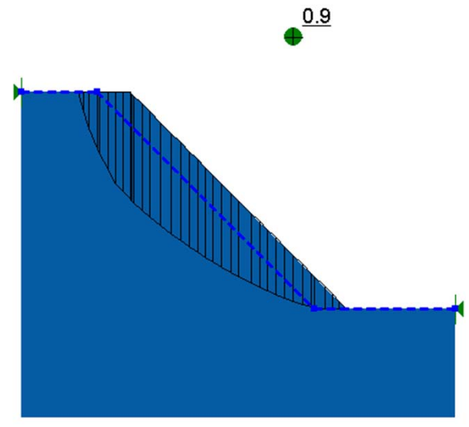
Fully Saturated Slope	Fully Saturated Slope	Fully Saturated Slope	Fully Saturated Slope
			
30 m Depressurization	30 m Depressurization	30 m Depressurization	30 m Depressurization
			

NOTES:
1. SLOPE ANGLE OF 45° USED FOR ALL MODELS SHOWN.
2. PMS = PROSPECTOR MOUNTAIN SUITE
3. GROUNDWATER DEPRESSURIZATION SET TO SIMULATE INSTALLATION OF HORIZONTAL DRAINS IN PIT WALL

.

Weathered PMS(2) with Disturbance = 0.85

Weathered PMS(2) with Disturbance = 1

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	18MAY'12	ISSUED WITH REPORT	JAG	GM	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

OPEN PIT GEOTECHNICAL DESIGN
LIMIT EQUILIBRIUM ANALYSIS
INTER-RAMP SLOPE STABILITY - PMS WEATHERED

Knight Piésold CONSULTING

P/A NO. VA101-325/8

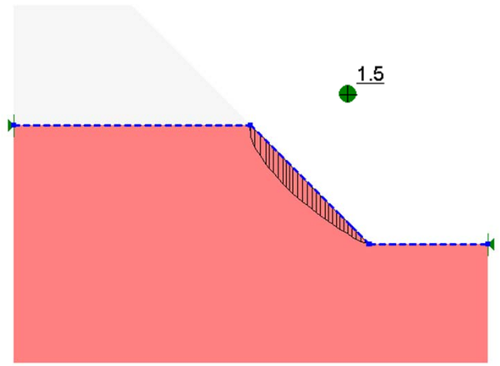
REF. NO. 7

APPENDIX C2.4

REV 0

100 m Slope Height

Fully Saturated Slope



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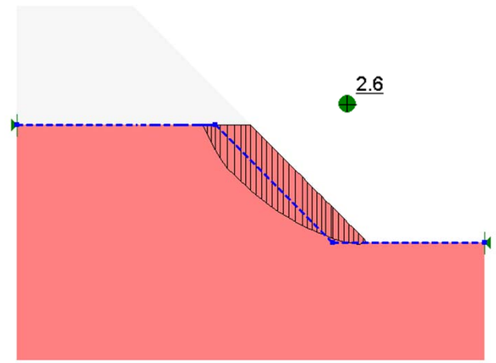
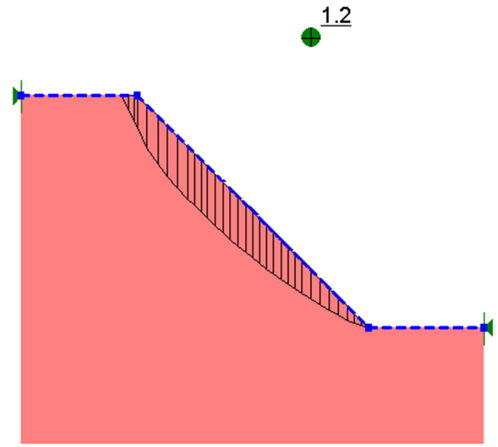


200 m Slope Height

Fully Saturated Slope



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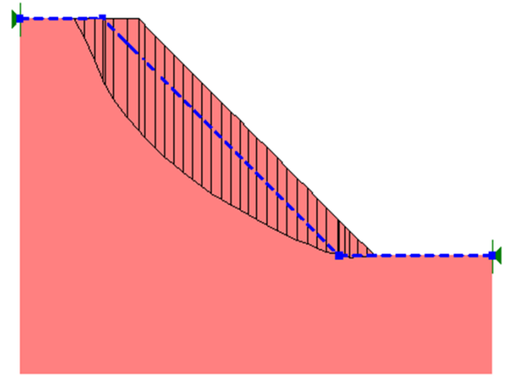
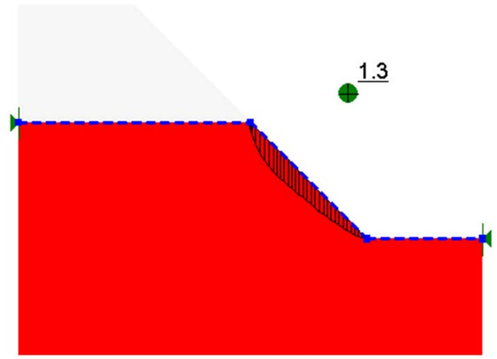


100 m Slope Height

Fully Saturated Slope



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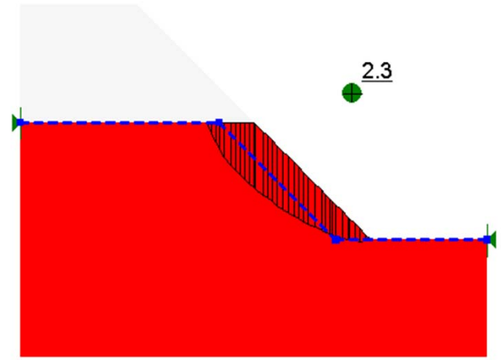
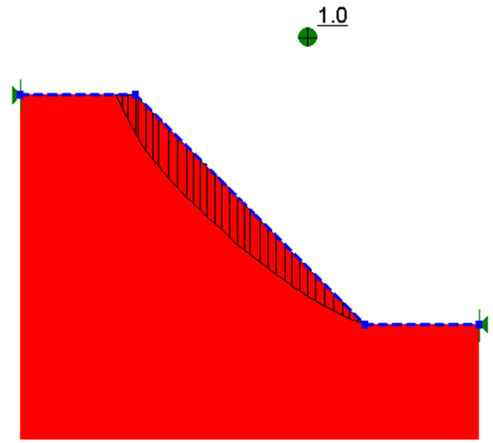


200 m Slope Height

Fully Saturated Slope



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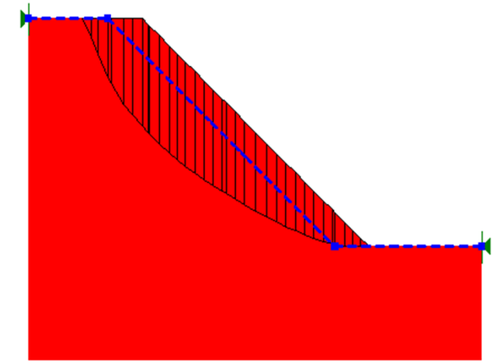

NOTES:
1. SLOPE ANGLE OF 45° USED FOR ALL MODELS SHOWN.
2. DRB = DAWSON RANGE BATHOLITH
3. GROUNDWATER DEPRESSURIZATION SET TO SIMULATE INSTALLATION OF HORIZONTAL DRAINS IN PIT WALL

Intact DRB[(2)] with Disturbance = 0.85

Intact DRB[(2)] with Disturbance = 1

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	18MAY'12	ISSUED WITH REPORT	JAG	GM	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

OPEN PIT GEOTECHNICAL DESIGN
LIMIT EQUILIBRIUM ANALYSIS
INTER-RAMP SLOPE STABILITY - DRB

Knight Piésold CONSULTING

P/A NO. VA101-325/8

REF. NO. 7

APPENDIX C2.5

REV 0

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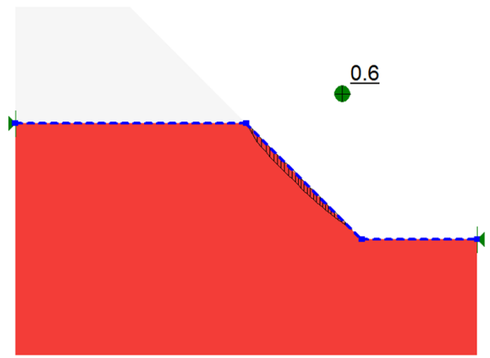
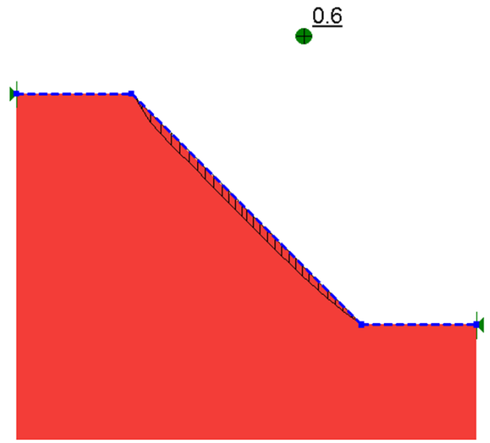
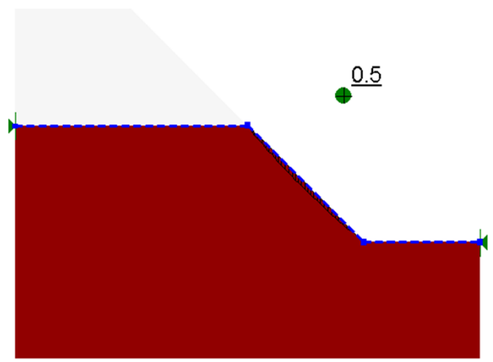
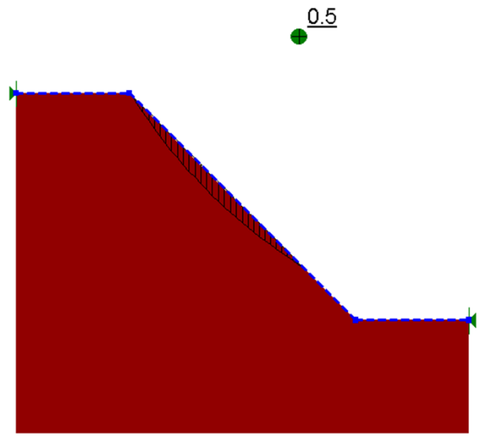
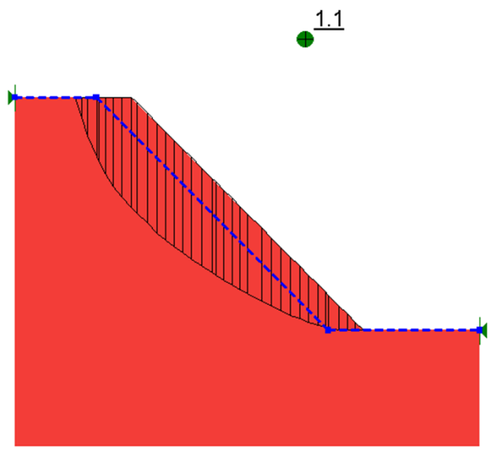
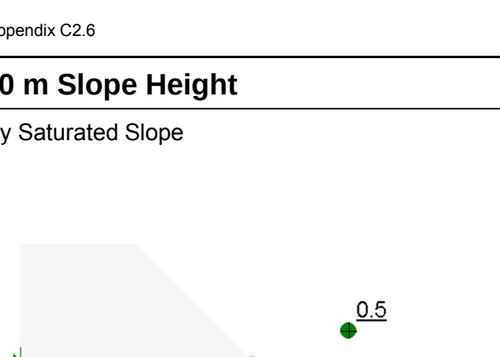
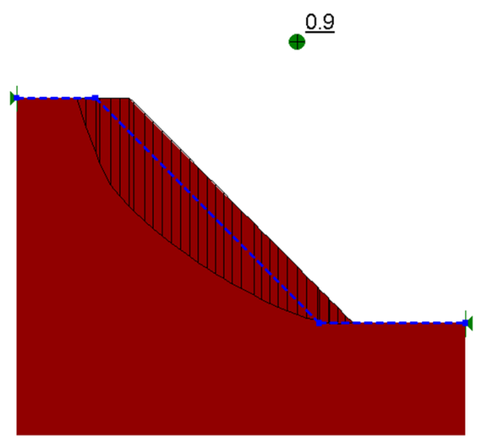
Fully Saturated Slope	Fully Saturated Slope	Fully Saturated Slope	Fully Saturated Slope
			
30 m Depressurization	30 m Depressurization	30 m Depressurization	30 m Depressurization
			

NOTES:
1. SLOPE ANGLE OF 45° USED FOR ALL MODELS SHOWN.
2. DRB = DAWSON RANGE BATHOLITH
3. GROUNDWATER DEPRESSURIZATION SET TO SIMULATE INSTALLATION OF HORIZONTAL DRAINS IN PIT WALL

Weathered DRB(2) with Disturbance = 0.85

Weathered DRB(2) with Disturbance = 1

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	18MAY'12	ISSUED WITH REPORT	JAG	GM	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

OPEN PIT GEOTECHNICAL DESIGN
LIMIT EQUILIBRIUM ANALYSIS
INTER-RAMP SLOPE STABILITY - DRB WEATHERED

Knight Piésold CONSULTING

P/A NO. VA101-325/8

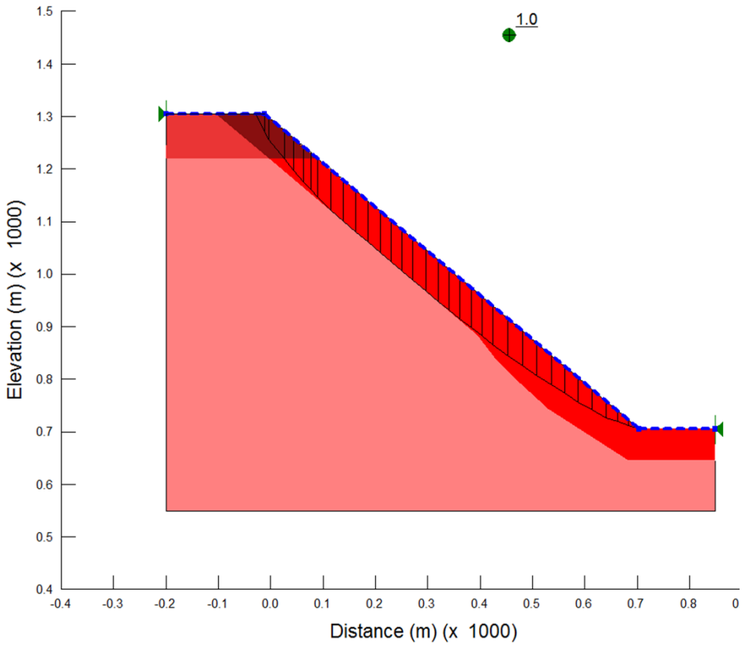
REF. NO. 7

APPENDIX C2.6

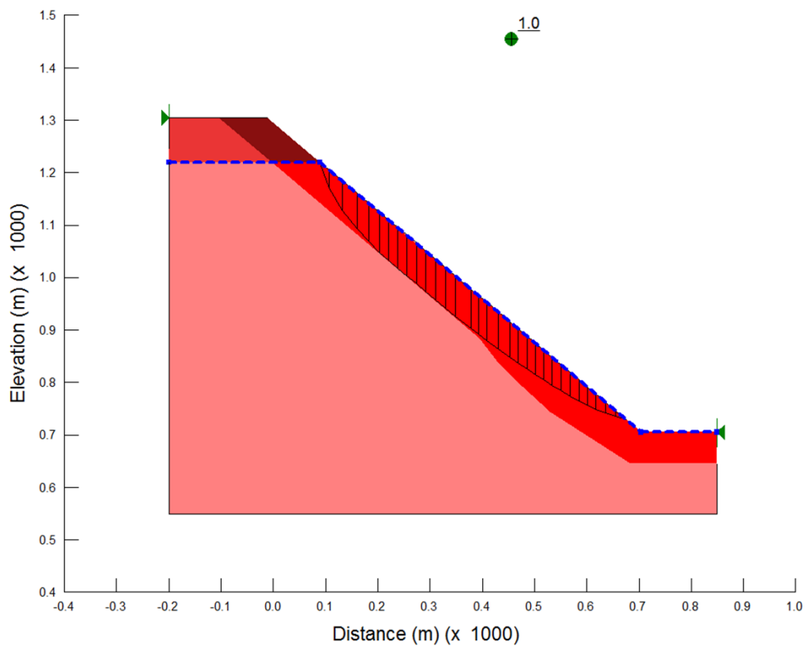
REV 0

M-North: 40° Overall Slope

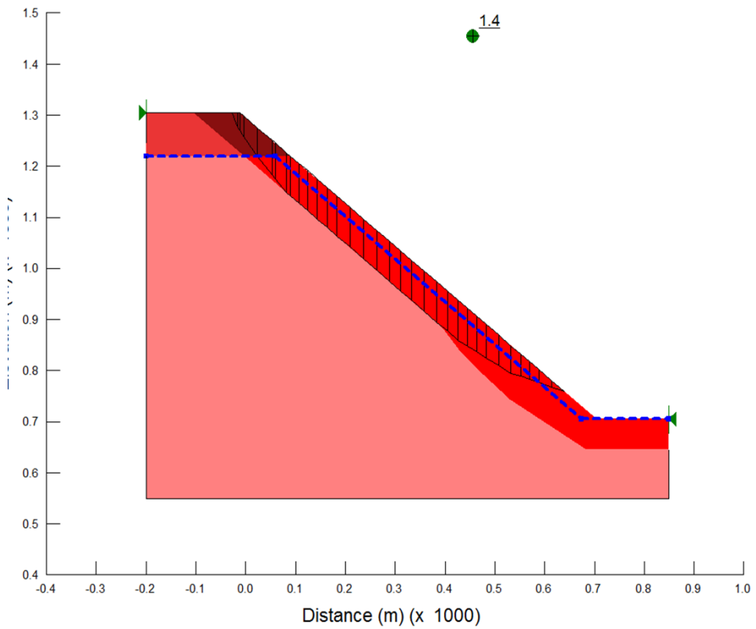
Fully Saturated Slope



Assumed Drainage of Weathered Rock



30 m Horizontal Depressurization



NOTES:

1. SLIP SURFACES SHOWN FOR STATIC CONDITIONS.
2. DISTURBANCE FACTORS OF D = 1 USED FOR ALL MODELS SHOWN.
3. DRB = DAWSON RANGE BATHOLITH.
4. ESTIMATED DRAWDOWN BASED ON MEASURED GROUNDWATER LEVELS DURING LUGEON PACKER TESTS FOR DH11-39.
5. GROUNDWATER DEPRESSURIZATION SET TO SIMULATE INSTALLATION OF HORIZONTAL DRAINS IN PIT WALL.

- Intact DRB(2)
- Intact DRB(2) with Disturbance
- Weathered DRB(2)
- Weathered DRB(2) with Disturbance

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	18MAY'12	ISSUED WITH REPORT	JAG	GM	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

OPEN PIT GEOTECHNICAL DESIGN
LIMIT EQUILIBRIUM ANALYSIS
M-NORTH WALL

Knight Piésold CONSULTING

P/A NO. VA101-325/8

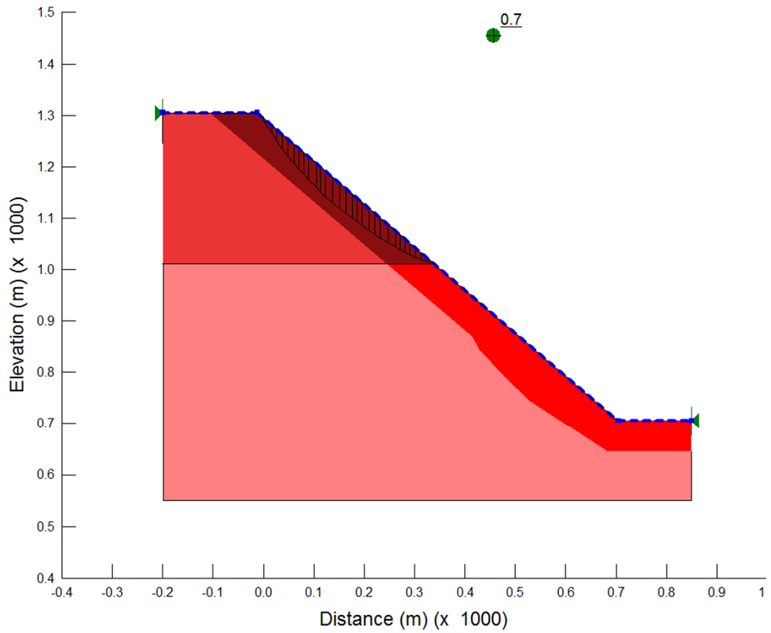
REF. NO. 7

APPENDIX C2.7

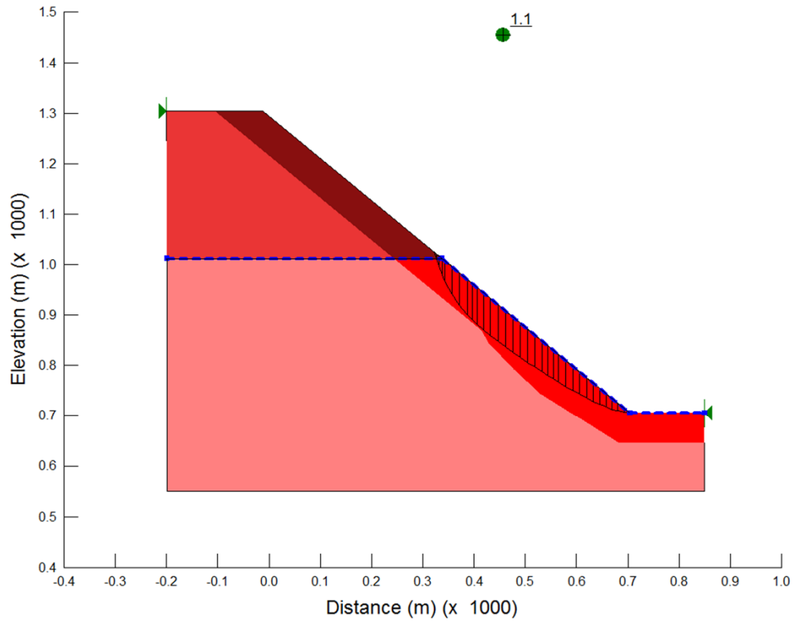
REV 0

M-Northeast: 40° Overall Slope

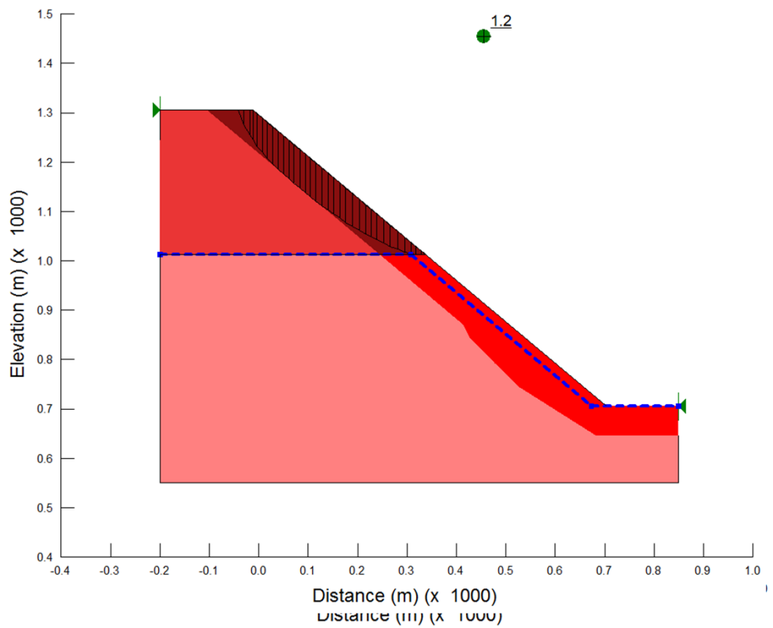
Fully Saturated Slope



Assumed Drainage of Weathered Rock



30 m Horizontal Depressurization



NOTES:

1. SLIP SURFACES SHOWN FOR STATIC CONDITIONS.
2. DISTURBANCE FACTORS OF D = 1 USED FOR ALL MODELS SHOWN.
3. DRB = DAWSON RANGE BATHOLITH.
4. ESTIMATED DRAWDOWN BASED ON MEASURED GROUNDWATER LEVELS DURING LUGEON PACKER TESTS FOR DH11-38.
5. GROUNDWATER DEPRESSURIZATION SET TO SIMULATE INSTALLATION OF HORIZONTAL DRAINS IN PIT WALL.

- Intact DRB(2)
- Intact DRB(2) with Disturbance
- Weathered DRB(2)
- Weathered DRB(2) with Disturbance

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	18MAY'12	ISSUED WITH REPORT	JAG	GM	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

OPEN PIT GEOTECHNICAL DESIGN
LIMIT EQUILIBRIUM ANALYSIS
M-NORTHEAST WALL

Knight Piésold CONSULTING

P/A NO. VA101-325/8

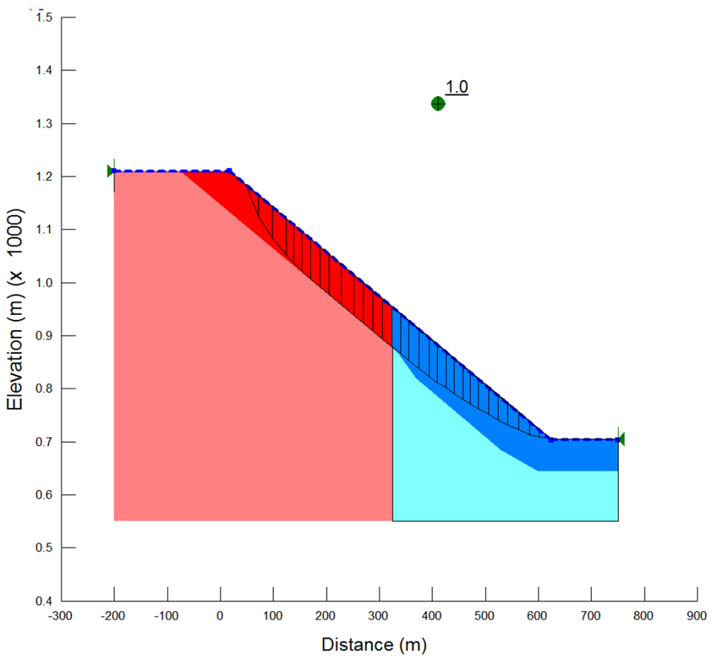
REF. NO. 7

APPENDIX C2.8

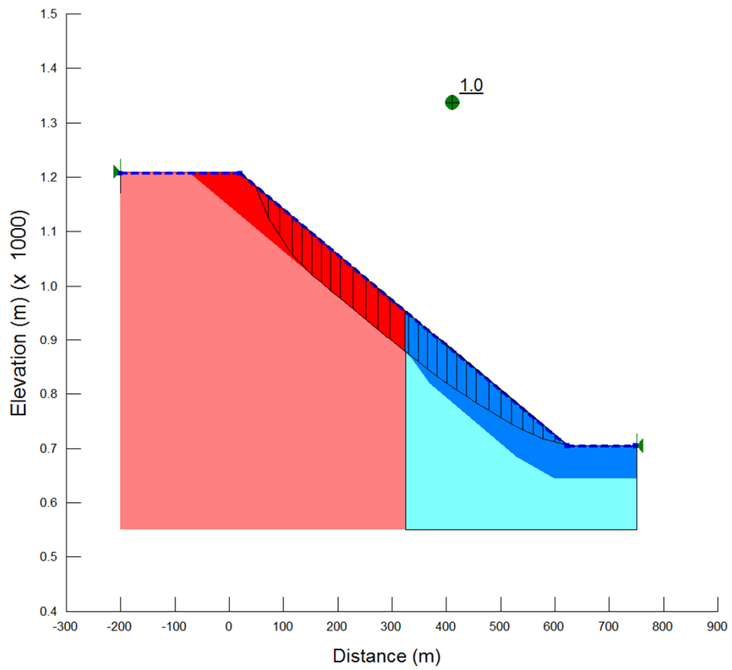
REV 0

M-South: 40° Overall Slope

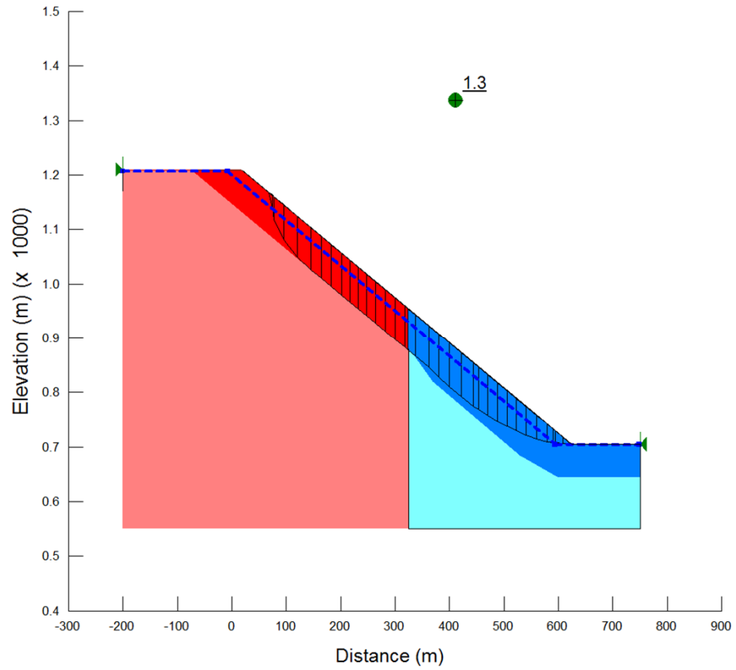
Fully Saturated Slope



Assumed Drainage of Weathered Rock



30 m Horizontal Depressurization



NOTES:
1. SLIP SURFACES SHOWN FOR STATIC CONDITIONS.
2. DISTURBANCE FACTORS OF D = 1 USED FOR ALL MODELS SHOWN.
3.DRB = DAWSON RANGE BATHOLITH.
4.PMS = PROSPECTOR MOUNTAIN SUITE.
5. ESTIMATED DRAWDOWN BASED ON MEASURED GROUNDWATER LEVELS DURING LUGEON PACKER TESTS FOR DH11-37.
6. GROUNDWATER DEPRESSURIZATION SET TO SIMULATE INSTALLATION OF HORIZONTAL DRAINS IN PIT WALL.

- Intact DRB(2)
- Intact DRB(2) with Disturbance
- Weathered DRB(2)
- Weathered DRB(2) with Disturbance
- Intact PMS(2)
- Intact PMS(2) with Disturbance

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	18MAY'12	ISSUED WITH REPORT	JAG	GM	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

OPEN PIT GEOTECHNICAL DESIGN
LIMIT EQUILIBRIUM ANALYSIS
M-SOUTH WALL

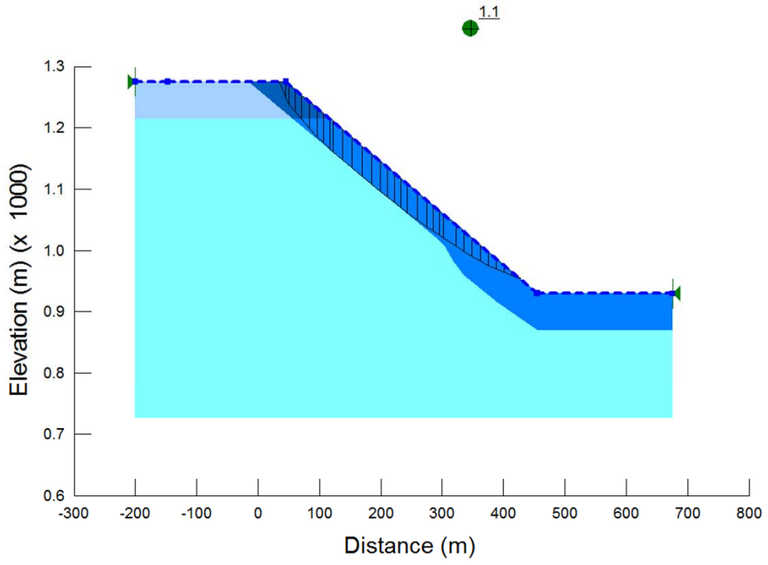
Knight Piésold CONSULTING

P/A NO. VA101-325/8 | REF. NO. 7

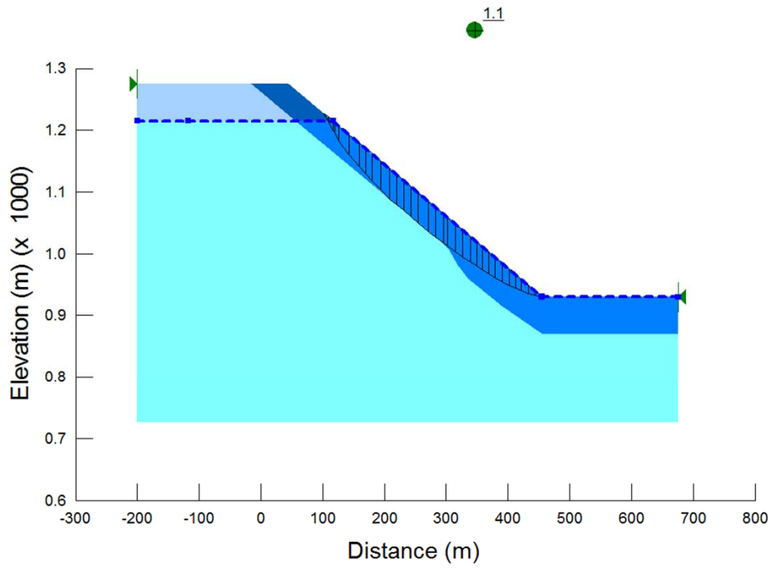
APPENDIX C2.9 | REV 0

W-Southwest: 40° Overall Slope

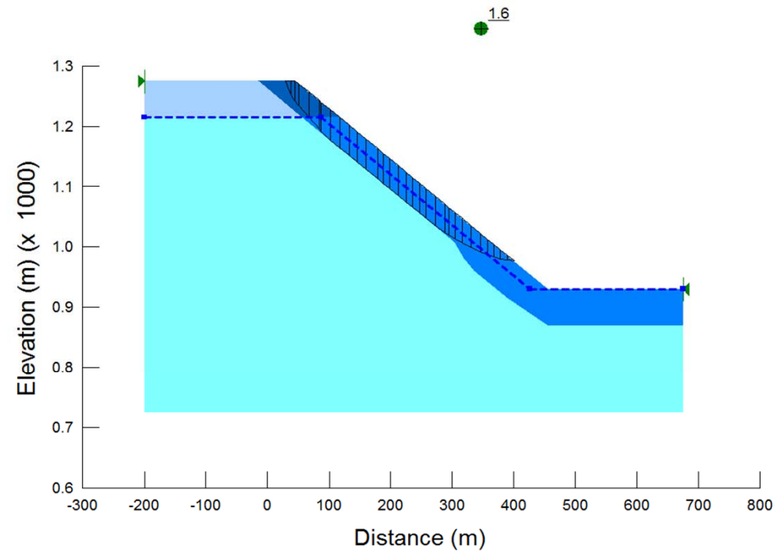
Fully Saturated Slope



Assumed Drainage of Weathered Rock



30 m Horizontal Depressurization



NOTES:
1. SLIP SURFACES SHOWN FOR STATIC CONDITIONS.
2. DISTURBANCE FACTORS OF D = 1 USED FOR ALL MODELS SHOWN.
3.PMS = PROSPECTOR MOUNTAIN SUITE.
4. ESTIMATED DRAWDOWN BASED ON MEASURED GROUNDWATER LEVELS DURING LUGEON PACKER TESTS FOR DH11-35.
5. GROUNDWATER DEPRESSURIZATION SET TO SIMULATE INSTALLATION OF HORIZONTAL DRAINS IN PIT WALL.

- Intact PMS(2)
- Intact PMS(2) with Disturbance
- Weathered PMS(2)
- Weathered PMS(2) with Disturbance

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	18JUL'12	ISSUED WITH REPORT	GM	GM	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

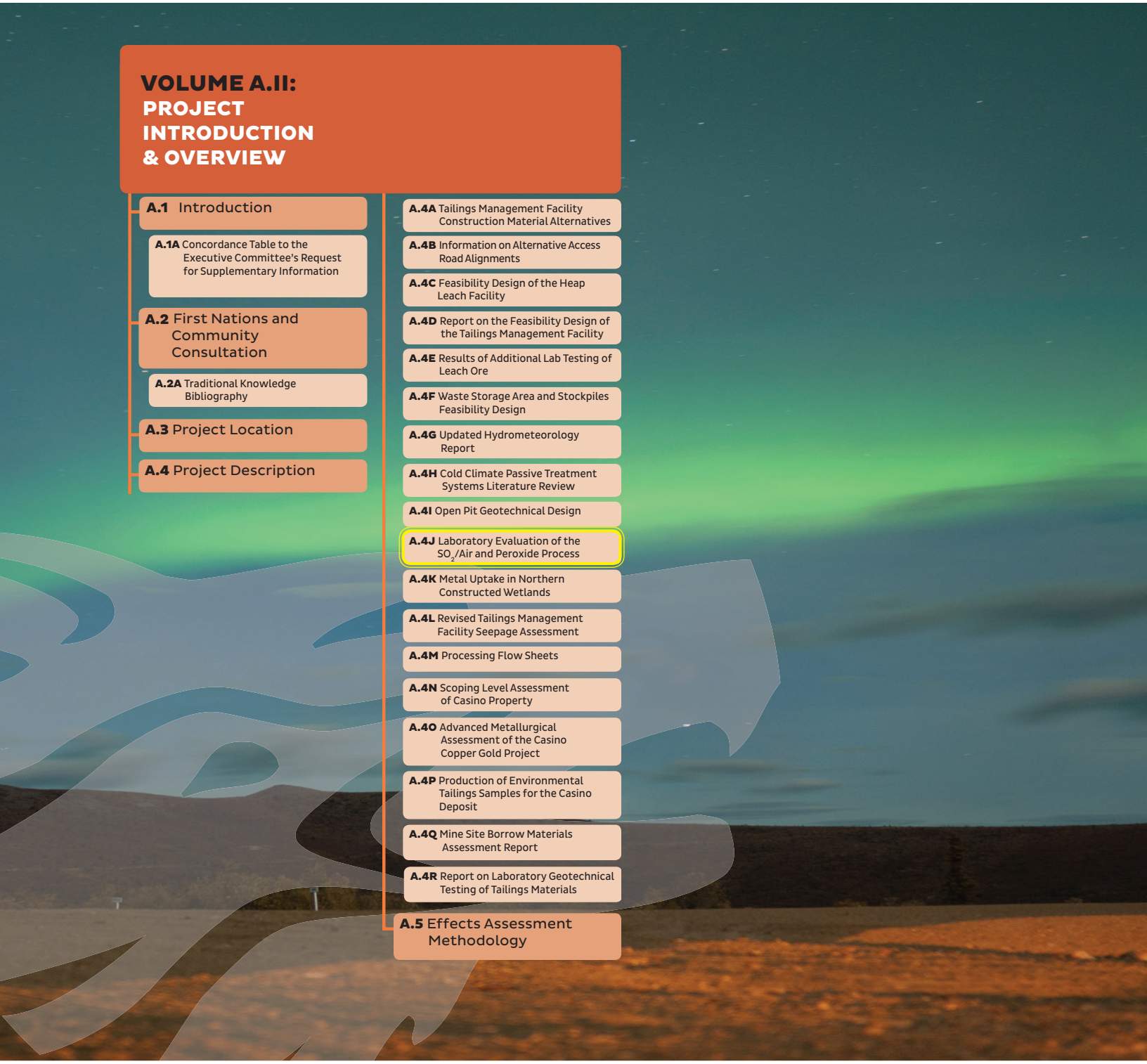
OPEN PIT GEOTECHNICAL DESIGN
LIMIT EQUILIBRIUM ANALYSIS
W-SOUTHWEST WALL

Knight Piésold CONSULTING

P/A NO. VA101-325/8 | REF. NO. 7

APPENDIX C2.10 | REV 0

APPENDIX A.4J: Laboratory Evaluation of the SO_2/Air and Peroxide Process



LABORATORY EVALUATION OF THE SO_2/AIR AND PEROXIDE PROCESS

CYANIDE REMOVAL PROCESS FOR SOLUTION TREATMENT

FOR

Casino Project
Western Copper Corporation
Canada

January, 2010

PREPARED

BY

R&C Environmental Services Inc.
Ontario, Canada

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10. Disclaimer

Statement of Confidentiality

The enclosed report contains confidential information which is intended solely for the use of the recipient Western Copper Corporation Casino Project. Terms and conditions respecting the disclosure or release of any of the contained information to any third party are prohibited.

1. EXECUTIVE SUMMARY

The SO_2/Air cyanide destruction process and the Peroxide process were successful in reducing the residual CN_{WAD} (weak acid dissociable cyanide) to below 0.20 mg/L targets put in place by Western Copper Corporation. In general a good effluent quality was achieved for both process treatments used. The levels of base metals removal also showed good improvement for both process treatments used.

The solution was effectively treated using a single stage operating with approximately 60 minutes of retention and an SO_2 dosage of 5.0 g/g CN_{WAD}. A pH of 9.50 was found to be suitable for effective cyanide removal with minimal need of lime for pH control.

The need of copper sulphate ($CuSO_4$) addition was not required for effective removal of cyanide. The copper present in the feed solution was enough for the process to be catalytic during this test program. At the actual treatment facility, copper sulphate addition will be dependent upon the relative concentration of copper in the feed.

The Peroxide process test work did show good results but did require the addition of acid to keep the pH at set point of 9.5. Please note that during normal plant conditions it is not expected that acid would be required due to higher than normal pH found in the feed solution of 12.1. The solution was effectively treated using a single stage operating with approximately 60 minutes of retention and an H_2O_2 dosage of 6:1 molar ratio to CN_{WAD} was required to meet the 0.20 mg/L CN_{WAD}. A pH of 9.50 was found to be sufficient for effective cyanide removal metal precipitation.

Due to cost of the peroxide it is suggested that based on comparison of both the SO_2/Air and Peroxide process that peroxide is not cost effective process to be used at the Casino project.

2. SCOPE OF WORK

The present test work program was undertaken at the request of Western Copper Corporation on solutions produced after test work evaluation performed on the heap leach process for recovery of metals. The work included investigations of SO_2/AIR process and Peroxide process. The laboratory program was conducted at the Barrick Technology Centre in Vancouver, British Columbia. The detailed scope of work was according to the agreement between Western Copper Corporation and R&C Environmental Consulting Services Inc. of Ontario, Canada, and included the following:

- The objectives were to test the SO_2/Air and Peroxide process for effective removal of cyanide from feeds collected after the heap leach process under normal operating conditions.
- A target of less 1.0 mg/L CN_{WAD} had been set out by Western Copper Corporation as the objective to meet the present cyanide permits required under Canadian code agreement.
- Continuous cyanide destruction by the SO_2/AIR process to determine the effectiveness of the process solution effluents.
- Continuous cyanide destruction by Peroxide process to determine the effectiveness of the process solution effluents.
- Chemical characterization (cyanide speciation, dissolved metals, pH) of all process feed and residual streams when possible by site or off site laboratories.
- Final report summarizing results of the test work program and providing operating cost estimates for the various test options as well as conclusions and recommendations for process selection.

2.1 Feed Samples

A 20 liter sample was provided from the previous test work performed on the heap leach process. Western Copper personnel identified the sample as initial preg solution from Metcon Research's leach column Cl-01, taken in December 2009. Each day the feed solution was sampled and tested for cyanide weak acid dissociable using the picric acid method. Also samples of the feed solution were tested for metal's using the ICP method. Based on the results conditions of the test were established.

3. PROCESS DESCRIPTIONS

3.1 SO_2/AIR

The SO_2/AIR process can be applied to the treatment of both cyanide solutions and pulps, however, it is in the area of slurry treatment (CIP/CIL pulps or re-pulped filter cakes from a Merrill-Crowe circuit) where the process has enjoyed a recognized worldwide reputation. Main advantages of the process are the removal of the total cyanide to levels of about 1 mg/l, in a single-stage continuous reactor and low operating costs.

The technology uses sulfur dioxide (SO_2), in various reagent forms, (sodium sulfite, sodium metabisulfite, ammonium bisulfite, liquid SO_2, and SO_2 containing roaster gas or SO_2 from burning elemental sulfur) in combination with air (or pure oxygen). Stoichiometrically, the process requires a ratio of approximately 2.5 g of SO_2/g of CN_{WAD}. The oxidation of cyanide is in accordance with one of the following overall reactions:

$$CN^- + Na_2SO_3 + O_2 \rightarrow OCN^- + Na_2SO_4$$

Or:

$$CN^- + ½\ Na_2S_2O_5 + O_2 + ½\ H_2O \rightarrow OCN^- + ½\ Na_2SO_4 + ½\ H_2SO_4$$

Or:

$$CN^- + SO_2 + O_2 + H_2O \rightarrow OCN^- + H_2SO_4$$

As shown above, the oxidation of cyanide produces cyanate (OCN^-) and, depending on the SO_2 reagent, produces sulfuric acid (H_2SO_4) as an intermediate. At the prevailing pH of the process, however, the sulfuric acid is continuously neutralized with lime producing calcium sulfate dihydrate (gypsum), as follows:

$$H_2SO_4 + Ca(OH)_2 \rightarrow CaSO_4 \bullet 2H_2O$$

The process will oxidize free cyanide and all cyanide complexes with copper, nickel, zinc, silver, and cadmium. The oxidation is catalyzed by soluble copper (Cu^{2+}), which, if required, can be supplemented by addition of copper sulfate solution. As cyanide is oxidized, metals are liberated and precipitated out of solution as hydroxides by the following reactions:

$$Me^+ + OH^- \rightarrow MeOH$$

Or:

$$Me^{2+} + 2OH^- \rightarrow Me(OH)_2$$

Cyanide present in the form of a strong complex, bound with either iron, cobalt, or gold, and is not oxidized by the process. Gold cyanide, of course, should not be a concern for a destruction unit, as it is recovered by carbon within the plant. Removal of the iron and cobalt cyanide complexes is achieved by precipitation with copper or zinc, according to the following reactions:

$$Me^{2+} + Fe(CN)_6^{4-} \rightarrow Me_2Fe(CN)_6$$

Or:

$$Me^{2+} + Co(CN)_6^{4-} \rightarrow Me_2Co(CN)_6$$

Generally, the SO_2/AIR process works best in the pH range of 8 to 9 and optimum operating pH is determined during the test work program. Optimization of both pH operating range and reagent consumption has proven to be site-specific for all ore types tested to date.

Cyanate produced by oxidation of cyanide slowly hydrolyzes to carbonate and ammonium as follows:

$$OCN^- + 2H^+ + H_2O \rightarrow CO_2 + NH_4^+$$

Or:

$$OCN^- + OH^- + H_2O \rightarrow CO_3^{2-} + NH_3$$

Depending on pH.

3.2 Hydrogen Peroxide and Caro's Acid

Hydrogen peroxide (H_2O_2) has a well-established reputation as the process of choice for treating clear cyanide solutions. The primary benefit of hydrogen peroxide is that it is a "clean" chemical in the sense that the reaction product of the H_2O_2 itself is simply water. In a peroxide treatment system there will be no appreciable increase in the dissolved solids concentration; scaling and undesirable salting conditions are avoided. This is an important factor in any flow sheet scenario incorporating a filtration stage.

The oxidation of cyanide with peroxide produces cyanate and water as shown in the following equation:

$$CN^- + H_2O_2 \rightarrow OCN^- + H_2O$$

The cyanate subsequently hydrolyzes slowly to produce ammonium and carbonate ions:

$$OCN^- + 2H^+ + H_2O \rightarrow CO_2 + NH_4^+$$

or:

$$OCN^- + OH^- + H_2O \rightarrow CO_3^{2-} + NH_3$$

depending on the pH.

Although ammonia (NH_3) is toxic to fish at low levels, it is almost entirely available in the far less toxic cationic form (NH_4^+) at the natural pH of open waterways.

If excess hydrogen peroxide is present in the treated wastewater, it rapidly decomposes to water and oxygen, presenting no environmental threat:

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

Hydrogen peroxide is capable of oxidizing both "free" cyanide (CN_f) and complexes (titratable cyanide):

$$CN^-, HCN, NaCN, KCN, Ca(CN)_2, Cd(CN)_4^{2-}, Zn(CN)_4^{2-}$$

and "weak acid dissociable" cyanide (CN_{WAD}) complexes, which include the above mentioned titratable cyanide species as well as the following metal cyanide species:

$$Cu(CN)_2^-,\ Cu(CN)_3^{2-},\ Cu(CN)_4^{3-},\ Ag(CN)_2^-,\ Ni(CN)_4^{2-}$$

In contrast, the following metal cyanide complexes cannot be oxidized by hydrogen peroxide. These compounds, along with CN_{WAD} complexes, are measured as "total" cyanide (CN_{tot}):

$$Au(CN)^{2-},\ Fe(CN)_6^{3-},\ Fe(CN)_6^{4-},\ Co(CN)_6^{4-}$$

However, it is still possible to achieve CN_{tot} limits by precipitating the $Fe(CN)_6^{4-}$ with, for example, copper ions:

$$Fe(CN)_6^{4-} + 2Cu^{2+} \rightarrow Cu_2Fe(CN)_6 \text{ (solid)}$$

This can normally be accomplished by lowering the pH to 8 to 9 in the presence of copper hydroxide. Occasionally, more copper must be added in the form of copper sulfate to achieve the desired CN_{tot} level.

The cyanide destruction reaction using peroxide is relatively fast in most wastewater samples. The presence of transition metals, especially copper, helps to accelerate the reaction. However, effluents that contain little or no metals may require a catalyst in order to accommodate a treatment circuit with limited effluent retention capabilities. Copper sulfate pentahydrate additions are ideal for this purpose.

Low effluent temperatures will significantly slow down the reaction time. Therefore, cyanide destruction circuits must be designed with sufficient retention time to allow the reaction to go to completion at the lowest possible effluent temperature experienced at a particular site. If shorter retention times are desired, more copper catalyst can be added to reduce the cyanide destruction reaction time.

Hydrogen peroxide can be shipped safely at high concentrations (up to 70% by weight H_2O_2) and stored for long periods of time without appreciable loss of activity, which makes H_2O_2 an ideal choice for remote locations. H_2O_2 has proven invaluable for emergency detoxification programs, where low capital costs and quick start-up are essential requirements.

4. Analytical Procedures

Two to three reactor displacements were carried out before representative samples of treated effluent were taken. The effluents were filtered and immediately prepared for the spectrophotometric determination of cyanide (CN_p) using the buffered picric acid method.

Filtrates were also analyzed for copper (Cu), and iron (Fe) using atomic absorption. The base metals samples were analyzed by site facility or independent laboratories. Also feed and final solutions were submitted to an independent laboratory for an ICP scan and cyanide.

Note: The cyanide concentration determined by the picric acid method (CN_p) includes all the cyanide except that complexed with iron in solution. Therefore, CN_p is greater than or equal to CN_{WAD} (weak acid dissociable cyanide) and is reported as CN_{WAD} in this report. The total cyanide (CN_T) can be accurately estimated using the formula: $CN_T = CN_{WAD} + 2.795 \times Fe$ (mg/L).

5. TEST RESULTS

5.1 Test Procedures

The SO_2/AIR process was carried out in continuous mode in a properly aerated and agitated reactor, as would be the case in typical plant operations for either slurry or barren solution. Reagents (sodium metabisulfite and copper sulfate if required) were added in continuous mode and the pH was controlled by automatic addition of a lime suspension. Tests were carried out at room temperature. Samples of feed and treated effluent were taken at regular intervals for process monitoring and final samples taken at steady state conditions.

The Peroxide process was also carried out in continuous mode in an agitated reactor, unlike the SO_2/Air process the peroxide process does not require air addition due oxygen being produced by the peroxide as it decomposes. The pH was controlled by automatic addition of acid (H_2SO_4). Tests were carried out at room temperature. Samples of feed and treated effluent were taken at regular intervals for process monitoring and final samples taken at steady state conditions.

5.2 Treatment Objectives

The treatment objectives were to meet less than 1.0 mg/L CNwad in all cases. The 1.0 mg/L CN_{WAD} objective corresponds to the desired effluent quality at point of entry to the tailings pond. Please note that the treated solution would be recycled to the heap until the heap leach pad is totally rinsed and free of cyanide before any of the waters would be pumped the final tailings pond. This procedure would limit the amount of solution required to rinse out the heap.

5.3 Solution Treatment

5.3.1 SO_2/AIR

The test work was carried out in continuous mode using SMBS and air addition, and provided the overall results.

Test	pH	KG	D.O	Meta	Cu	Feed	$Ca(OH)_2$	CN load	SO_2 Ratio	Cu Ratio	$Ca(OH)_2$	Ret Time	Solution
No		mV	ppm	mL/hr.	mL/hr.	mL/hr.	mL/hr.	g/hr.	gSO_2/ gCN	ppm	g $Ca(OH)_2/gSO_2$	min	Lit/hr.
T-1	9.5	9	8.7	24	0.0	1400	0.0	0.294	5.22	0.0	0.09	58.6	1.40
T-2	9.5	-6	8.5	24	0.0	1400	0.0	0.294	4.00	0.0	0.22	58.2	1.40
T-3	9.5	-50	8.5	24	0.0	1400	0.0	0.294	3.47	0.0	0.26	58.2	1.40
AVG	9.5	-34	8.6	24	0.0	1400	0.0	0.294	4.23	0.0	0.19	58.3	1.40

Sample	No.	CNp	Cu	Fe	pH	Calculated
Feeds		ppm	ppm	ppm		CN total
Test 1		210	89.8	0.1	12.1	210.37
Test 2		210	89.8	0.1	12.1	210.37
Test 3		210	89.8	0.1	12.1	210.37
	AVG	210	89.8	0.1	12.1	210.37

Sample	No.	CNp	Cu	Fe	pH	Calculated
Treated		ppm	ppm	ppm		CN total
Test 1		0.2	0.41	0.01	9.5	0.23
Test 2		0.6	0.67	0.01	9.5	0.63
Test 3		1.1			9.5	
	AVG	0.63	0.54	0.01	9.5	

5.4 Solution Treatment Solution Treatment

5.4.1 Peroxide

The test work was carried out in continuous mode using peroxide and provided the overall results.

Test No	pH	KG mV	D.O ppm	H_2O_2 mL/hr.	Cu mL/hr.	Feed mL/hr.	H_2SO_4 mL/hr.	CN load g/hr.	H_2O_2 Molar Ratio	Cu Ratio ppm	H_2SO_4 gH_2SO_4/gH_2O_2	Ret Time min	Solution Lit/hr.
T-1	9.5	-165	11.9	24	0.0	1400	5.0	0.288	5.0	0.0	0.05	59.8	1.40
T-2	9.5	-165	10.9	24	0.0	1400	30.0	0.288	3.0	0.0	0.52	58.7	1.40
T-3	9.5	-21	9.6	24	0.0	1400	30.0	0.286	6.0	0.0	0.26	58.7	1.40
AVG	9.5	-117	10.9	24	0.0	1400	0.0	0.287	4.66	0.0	0.27	58.7	1.40

Sample Feeds	No.	CNp ppm	Cu ppm	Fe ppm	pH	Calculated CN total
T-1		**206.0**	**89.8**	**0.1**	**12.1**	**206.2**
T-2		**206.0**	**89.8**	**0.1**	**12.1**	**206.2**
T-3		**204.0**	**89.3**	**0.1**	**11.9**	**204.2**
	AVG	**205.3**	**89.5**	**0.1**	**12.1**	**205.53**

Sample Treated	No.	CNp ppm	Cu ppm	Fe ppm	pH	Calculated CN total
T-1		**0.40**	**0.61**	**0.01**	**9.5**	**0.43**
T-2		**36.3**	**61.36**	**0.01**	**9.5**	**36.33**
T-3		**0.20**	**0.50**	**0.02**	**9.5**	**0.26**
	AVG	**12.3**	**20.82**	**0.01**	**9.5**	**12.34**

6. DISCUSSION of RESULTS

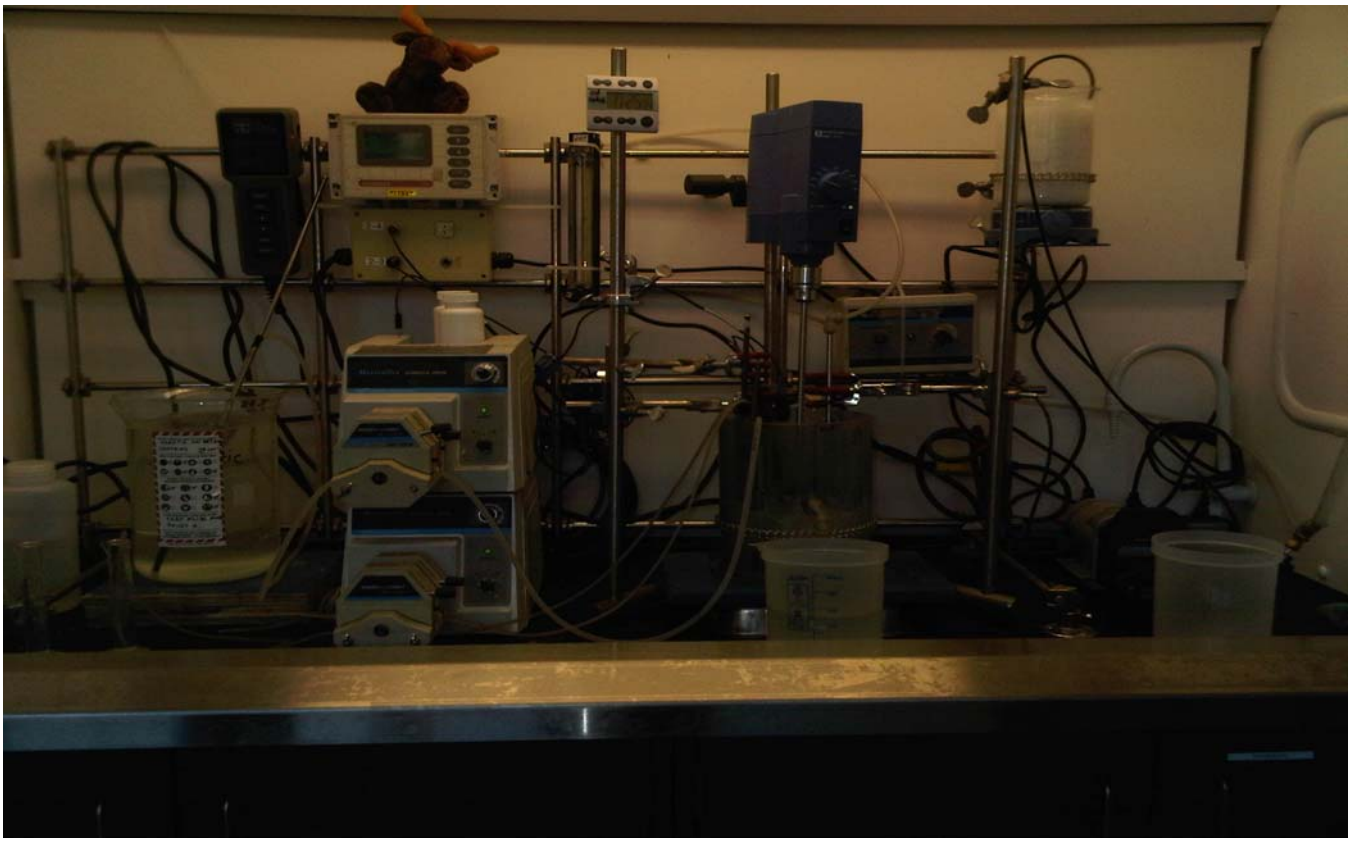
The present discussion deals with the relative effectiveness of the various treatments process options for the Casino Project.

6.1 Solution Treatment

Any discussion on the relative merits of the effectiveness of the processes (SO_2/Air, Peroxide) must center on the choice of the best result per process and the cost tonne of solution treated.

In the case of the Peroxide and SO_2/Air processes, the best result was that result that achieved the limit with the lowest reagent addition rates. The highest reasonable or typical reagent addition was chosen as the best value.

7. Typical Laboratory Set-up



8. Typical Reagent Consumptions

CASINO - PROJECT
OPERATING COST ESTIMATES:

SO_2/AIR PROCESS-USING Sodium Metabisulphite
BASIS: 1,000 m3 / day and 210 mg/L CNwad
ITEM CONSUMPTION UNIT COST OPERATING
DAILY COST: (CAD$)

SMBS 1,404 kgs/day @ 750 $/t = $379,080/year.
$Ca(OH)_2$ 210 kgs/day @ 210 $/t =$16,200/year.
TOTAL COST PER YEAR $395,280

Peroxide PROCESS-USING 70% H_20_2
BASIS: 1,000 m3 / day and 210 mg/L CNwad
ITEM CONSUMPTION UNIT COST OPERATING
DAILY COST: (CAD$)

H_2O_2 1,824 kgs/day @ 860 $/t = $564,710
H_2SO_4 0 t/yr @ 240 $/t = $157,593
TOTAL $722,303

Please Note that the above figures do not include capital and electrical cost involved in operating each of the process.

9. CONCLUSIONS AND RECOMMENDATIONS

Based on the test work, both SO_2/AIR and Peroxide effectively detoxify the effluents of the solutions tested, meeting or achieving lower than the 1.0 ppm CN_{WAD} target.

For economic reasons, the SO_2/AIR process is recommended over the peroxide process because of the advantages in operating and capital cost compared to the peroxide process. A Sulphur system configured to include a sulphur burner offers substantial operating cost savings. The additional capital for a sulphur burner would have a short payback period (based on present operating costs). Process selection for the Casino project will be highly driven by reagent pricing and capital cost. The SO2/Air process equipment can also be utilized for both solution and slurry treatment if required in the second phase of the project. On the basis of the present reagent price portfolio, the SO2/Air process is favored by a relatively inexpensive meta cost and the peroxide being penalized by quite expensive H_2O_2, reagent and capital cost.

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Certificate#: 10B0685
Client: Western Copper Corporation
Project: Western Copper
Shipment#:
PO#:
No. of Samples: 2
Analysis #1: Ultratrace ICPMS Water Package
Analysis #2: S Zr
Analysis #3:
Comment #1:
Comment #2:
Date In: Feb 25, 2010
Date Out: Mar 04, 2010

		Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu	Fe	Pb	Li	Mg	Mn	Hg	Mo
Minimum detection		1	0.05	1	0.05	0.05	0.05	20	0.05	1	0.5	0.02	0.1	10	0.1	1	50	0.05	0.1	0.1
Maximum detection		100000	5000	100000	5000	5000	5000	100000	5000	500000	50000	2000	10000	500000	20000	500000	500000	5000	100000	10000
Method		3005A/6020	3005A/6020	3005A/6020	3005A/6020	3005A/6020	3005A/6020	3005A/6020	3005A/6020	3005A/6020	3005A/6020	3005A/6020	3005A/6020	3005A/6020	3005A/6020	3005A/6020	3005A/6020	3005A/6020	3005A/6020	3005A/6020
Sample Name	SampleType	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Test # 1&2 (Diss)	Solution	44	0.40	2	15.40	<0.05	<0.05	<20	0.60	439234	<0.5	404.70	194.7	673	<0.1	<1	271	0.20	1.3	4175.6
Test # 1&2 (Tot)	Solution	85	1.30	<1	81.10	0.10	0.40	113	<0.05	439742	<0.5	438.40	218.3	586	0.4	<1	285	0.20	5.3	4229.6
RE Test # 1&2 (Diss)	Repeat	45	0.50	2	15.20	<0.05	<0.05	<20	0.60	436301	<0.5	402.60	192.0	675	<0.1	<1	289	0.20	1.4	4114.7

** Values highlighted (in yellow) are over the high detection limit for the corresponding methods. Other testing methods would be suggested. Please call for details.*

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ISO 9001::

Certificate#: 10B0685
Client: Western Copper Corporation
Project: Western Copper
Shipment#:
PO#:
No. of Samples: 2
Analysis #1: Ultratrace ICPMS Water Package
Analysis #2: S Zr
Analysis #3:
Comment #1:
Comment #2:
Date In: Feb 25, 2010
Date Out: Mar 04, 2010

Minimum detection	0.2	20	50	0.5	1	0.05	50	0.5	0.01	10	0.01	0.05	0.02	1	0.5	0.5
Maximum detection	20000	500000	500000	50000	500000	5000	500000	50000	1000	100000	1000	5000	10000	100000	50000	50000
Method	3005A/6020	3005A/6020	3005A/6020	3005A/6020	3005A/6020	3005A/6020	3005A/6020	3005A/6020	3005A/6020	3005A/6020	3005A/6020	3005A/6020	3005A/6020	3005A/6020	3005A/6020	3005A/6020
Sample Name	Ni	P	K	Se	Si	Ag	Na	S	Sr	Ti	Tl	Sn	U	V	Zn	Zr
	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Test # 1&2 (Diss)	13.4	<20	7409	22.2	877	3.80	434548	554904.6	565.40	<10	0.10	9.30	0.10	5	5.1	<0.5
Test # 1&2 (Tot)	14.4	<20	7501	23.5	1732	32.00	436658	548722.4	590.20	<10	0.10	9.90	0.10	<1	9.4	0.8
RE Test # 1&2 (Diss)	13.7	<20	7506	21.1	895	3.60	432691	552541.9	570.00	<10	0.10	8.80	0.10	5	4.6	<0.5

** Values highlighted (in yellow) are over the high de*

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Certificate#: 10B0686
Client: Western Copper Corporation
Project: Western Copper
Shipment#:
PO#:
No. of Samples: 1
Analysis #1: Au,Cond,TDS,Alk,SO4,Cl,F,Br,P,O-PO4
Analysis #2: pH,NO3-N,NO2-N,NH4,NH3-N,SCN,CN(WAD
Analysis #3: CN(T)CN-free
Comment #1: connect with job 10B0685
Comment #2:
Date In: Feb 25, 2010
Date Out: Mar 03, 2010

Minimum detection		0.01	0.01	0.1	1	1	1	0.1	0.1	0.1	0.1	0.1
Maximum detection		5000	14	999	100000	10000	10000	10000	1000	100	9999.9	9999.9
Method		FA/AAS	ENV	Env	STDM2540C	2320B	Env	Env-IC	Env-IC	Env-IC	Env-Dig_IC	Env-IC
Sample Name	SampleType	Au mg/L	pH --	Cond mS/Cm	TDS mg/L	Ttl Alk mg/L-CaCO3	SO4-2 mg/L	Cl- mg/L	F- mg/L	Br- mg/L	PO4-3(T) mg/L	O-PO4 mg/L
Test # 1&2	Solution	0.15	7.99	3.5	3186	81	1701	35.0	0.3	<0.1	<0.1	<0.1
RE Test # 1&2	Repeat	0.16	8.02	3.5	3170	81	1691	35.1	0.3	<0.1	<0.1	<0.1
Blank iPL	Blk iPL	<0.01	--	--	--	--	--	--	--	--	--	--
OXI67	Std iPL	1.82	--	--	--	--	--	--	--	--	--	--
OXI67 REF	Std iPL	1.82	--	--	--	--	--	--	--	--	--	--

** Values highlighted (in yellow) are over the high detection limit for the corresponding methods. Other testing methods would be suggested. Please call for details.*

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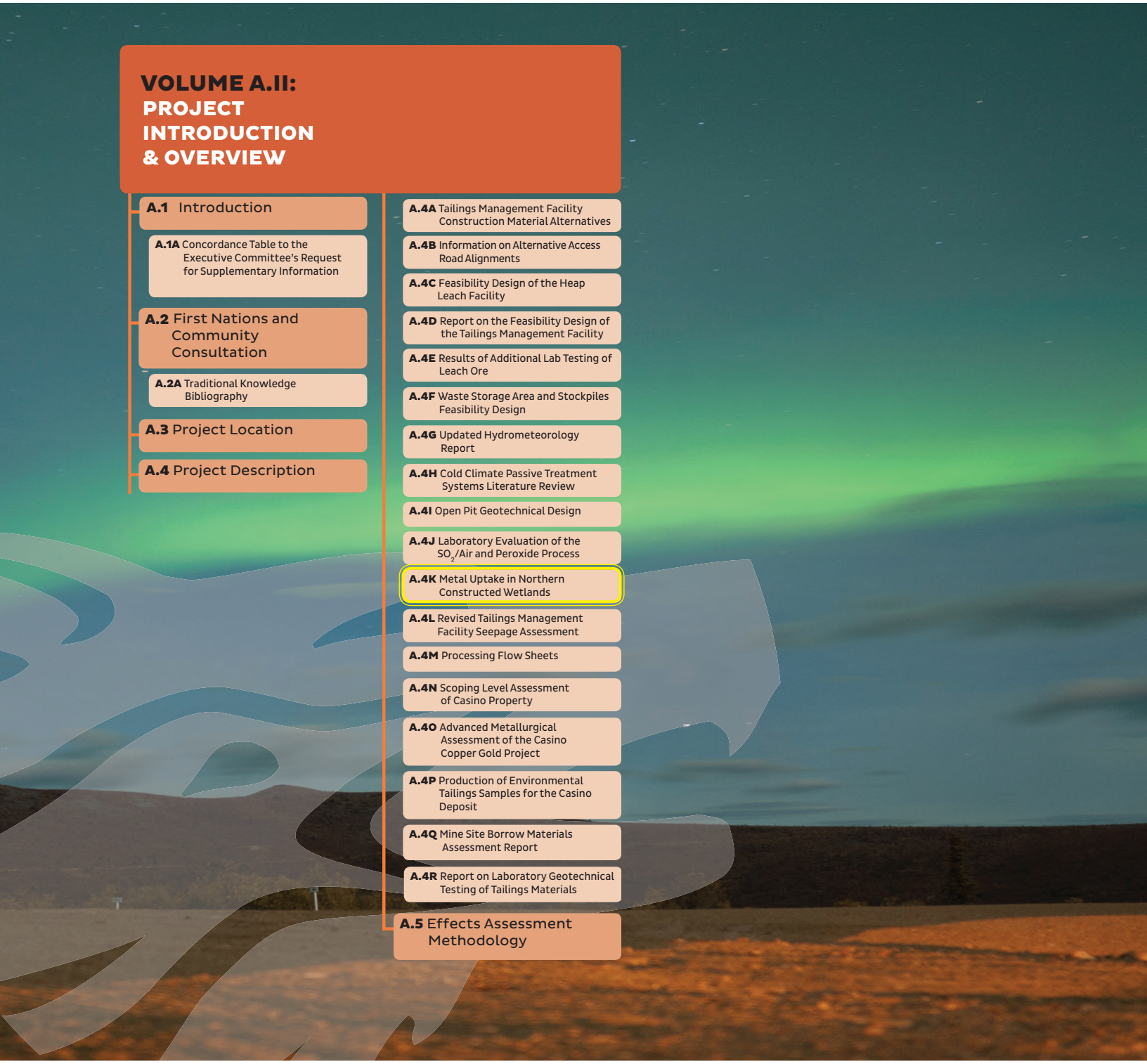
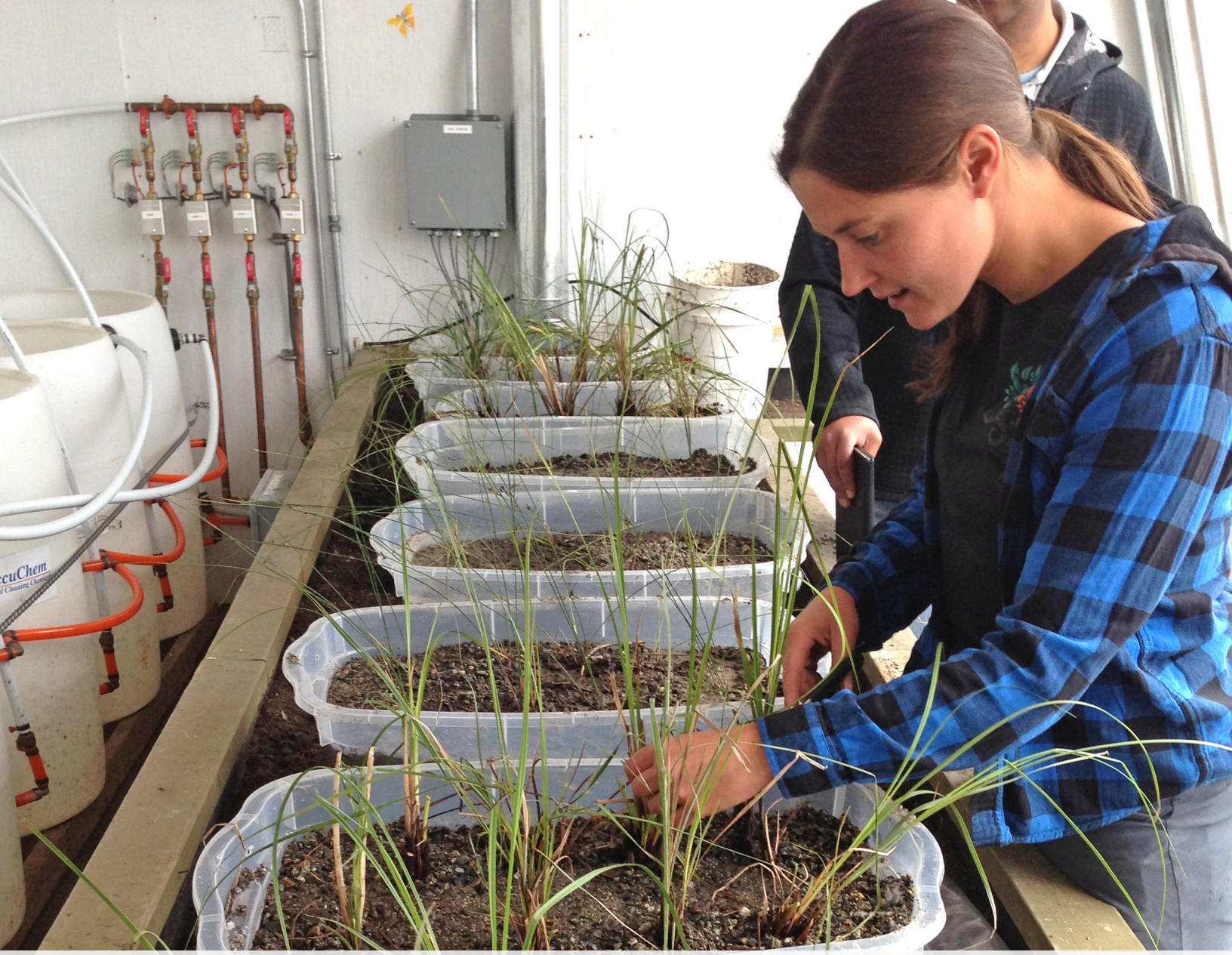
Certificate#: 10B0686
Client: Western Copper Corporation
Project: Western Copper
Shipment#:
PO#:
No. of Samples: 1
Analysis #1: Au,Cond,TDS,Alk,SO4,Cl,F,Br,P,O-PO4
Analysis #2: pH,NO3-N,NO2-N,NH4,NH3-N,SCN,CN(WAD
Analysis #3: CN(T)CN-free
Comment #1: connect with job 10B0685
Comment #2:
Date In: Feb 25, 2010
Date Out: Mar 03, 2010

Minimum detection	0.1	0.01	0.03	0.1	0.005	0.005	0.005	1
Maximum detection	9999.9	999	1400	1400	99999.999	99999.999	99999.999	10000
Method	Env-IC	Env	STDM4500	Env-IC	Env	4500-CN-E	4500-CN-I	Env
Sample Name	NO3-N mg/L	NO2-N mg/L	NH4 mg/L	NH3-N mg/L	Free CN- mg/L	(Total)CN- mg/L	(WAD)CN- mg/L	SCN- mg/L
Test # 1&2	1.0	59.14	14.57	11.3	0.097	0.217	0.101	3
RE Test # 1&2	1.0	60.02	14.83	11.5	0.099	0.222	0.106	3
Blank iPL	--	--	--	--	--	--	--	--
OXI67	--	--	--	--	--	--	--	--
OXI67 REF	--	--	--	--	--	--	--	--

** Values highlighted (in yellow) are over the high detection limit*

APPENDIX A.4K: Metal Uptake in Northern Constructed Wetlands





Metal Uptake in Northern Constructed Wetlands

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EXECUTIVE SUMMARY

Constructed wetlands (CWs) have been employed as passive treatment systems for metal contaminated mine drainage in Canada. However, relatively few CWs have been documented in northern environments and further studies are needed to understand the metal removal mechanisms in wetlands operating under cold climates, with short growing seasons. The goal of this study was to evaluate the performance of laboratory-scale CWs for the removal of Cd, Cu, Se and Zn, as well as, to evaluate Cu and Se uptake in two northern plant species (*Carex aquatilis* and *Juncus balticus*). Eight laboratory-scale wetlands were constructed using local materials, including locally harvested plant species and microorganisms and operated under northern summer conditions for 10 weeks. The CWs were fed continuously with synthetic influent containing Cd, Cu, Fe, Se and Zn at concentrations predicted at mine closure. Average removal efficiencies of 96%, 99%, 79% and 97% were observed for Cd, Cu, Se and Zn respectively. There were no significant differences in plant establishment or growth between our CW treatments, or any evidence of increasing Cu uptake with increasing contaminant availability in either northern plant species. Increased belowground uptake of Se was observed at the higher influent concentration in the Pit treatment. However, overall our study suggests that uptake of contaminants by these two northern species is very minor (<0.06% Cu and <0.11% Se, except for *C. aquatilis* in one treatment <0.2% Cu and <0.4 % Se) and likely does not pose a risk to the surrounding environment. We conclude that CWs could operate as successful passive treatment solutions in a northern environment, at least during the summer months, pending further studies on winter treatment. Further studies are required to examine seasonal metal removal rates in relation to rates of sulfate reduction, carbon consumption, metal precipitation and sorption. In addition, potential contaminant uptake and the influence of functional plant characteristics on metal removal in a suite of northern plant species would further assist in the development of large-scale long-term northern CWs.

ACKNOWLEDGEMENTS

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Table 1 Average and standard deviation for pH, SO4, Cd, Cu, Se and Zn concentrations in the influents between Week 2 and 10 for each of the CW treatments. Values below quantification limit are assumed to be equal to the quantification limit of 0.05 ug Cd/L, 0.6 ug Cu/L, 0.7 ug Se/L and 0.4 ug Zn/L. 11

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1. BACKGROUND

Constructed wetlands (CWs) are biogeochemical systems where an effluent flows through a plant-soil matrix and natural processes reduce pollutant levels to a given discharge limit (Bathia and Goyal 2014). CWs have been applied for treatment of municipal, agricultural and industrial effluents with complex physical, chemical and/or biological mechanisms (Kaldec and Knight 1996, Kaldec and Wallace 2008). Once established, CWs can become self-sustaining ecosystems with the plants providing yearly renewal of carbon to fuel microbial activity (Contango Strategies 2014). CWs have been proposed as a sustainable and long-term solution for water treatment at mine closure in Canada due to their low maintenance and operational cost requirements and high removal capacity (Eger and Kairies Beatty 2013; Sheoran and Sheoran 2006). However, relatively few wetlands have been used in northern environments and further studies are needed to design systems that will best fit the remediation objectives and environmental constraints (Kaldec and Reddy 2001).

The processes involved in metals removal from mine-impacted water include, but are not limited to, reduction/oxidation, precipitation, bio-sorption, bioaccumulation and volatilization (Sobolewski 1999, Guittonny-Philippe et al 2014). Microbial sulfate reduction processes and metal precipitation as sulfide salts in the anaerobic zone of the substrate is considered a major mechanism for metal sequestration in CWs (Arroyo et al 2013). While wetland sediments are known to act as a sink for heavy metals (Sheoran and Sheoran 2006, Baldwin and Hodaly 2003, August et al 2002), bioaccumulation in plants is also considered to some extent a metal removal pathway. Metal uptake by plants growing in wetlands treating mine-impacted waters has been sparsely studied with records of metal uptake by *Carex aquatilis* and *C. rostrata* (August et al 2002, Stoltz and Greger 2002, Nyquist and Greger 2009), *Juncus maritimus* and *J. effuses* (Conesa et al 2011, Rahman et al 2011), *Typha latifolia* and *T. domingensis* (Mitsh and Wise 1998, Taylor and Crowder 1983, Maine et al 2006), *Phragmites australis* (Batty and Younger 2004, Stoltz and Greger 2002, Nyquist and Greger 2009) *Eichhornia crassipes* (Maine et al 2006) and *Salix Sp*. (Stoltz and Greger 2002). In most of these cases heavy metals were reported to be largely found in plant roots with minimal or no uptake into shoots. Metal uptake potential in aboveground shoots should be well characterized in CWs that are used for mine closure, as it could pose a risk by exposing foraging wildlife to contaminants. Uptake by wetlands plants can be strongly affected by the water chemistry, the plant species (Deng et al 2004, Sheoran 2006), as well as, the redox conditions and geochemistry in the wetland substrate (Sobolewski 2010).

Implementation of two large CWs has been proposed as part of the billion-ton Copper-Gold Casino deposit project, located in the Yukon, 300 km northwest of Whitehorse. CWs have been proposed as a passive option for remediation to mitigate the risk of metals discharge into the downstream environment. One 10 ha CW has been proposed to treat discharge from the 3.14 km^2 open pit, which then flows into the proposed 1,120 ha Tailings Management Facilities (TMF). A second 6 ha CW has been proposed down-gradient of the TMF for final water treatment before release into the Casino Creek watershed (Casino Mining Corp 2014). This plan was submitted earlier this year for revision under the Yukon Socio-Economic and Environmental Assessment Act, one of the regulations framing environmental permitting in Yukon Territory. However, very few data on northern wetlands

with northern plants are available in the literature and a deeper understanding of northern wetland systems and plant uptake capacity is required for assessment and development of passive water treatment in the North.

The three objectives of this study were to: 1) Assess the short term efficiency of laboratory-scale CWs for mine effluents containing Cd, Cu, Fe, Se and Zn, 2) assess the potential uptake of Cu and Se by two northern wetlands plants, and 3) examine the influence of a methanol-amendment on metals removal by the laboratory-scale CWs.

2. MATERIAL AND METHODS

2.1. Laboratory-scale wetland setup

Eight laboratory-scale CWs were established in late June 2014 in the Yukon Research Centre greenhouse (Fig. 1). Each wetland consisted of a 47 L tote filled with 35 L soil substrate (13 cm height) made up of a homogeneous mixture of 5% (v/v) peat (Premier®, PremierTech Horticulture, Rivière-du-Loup, Quebec), 55% (v/v) washed sand (GE Cement plant, Whitehorse) and 40% (v/v) washed pea gravel (GE Cement plant, Whitehorse) (Fig. 2). Hydraulic conductivity tests were conducted to achieve the appropriate ratio of peat, sand and pea gravel to allow for a 5 ml/min flow rate with a hydraulic residence time of approximately 5 days (Fig. 3). *Carex aquatilis* and *Juncus balticus*, two plant species common in northern natural wetlands with different root oxygen exchange rates, were collected from a natural wetland located on McIntyre Creek in Whitehorse, YT (60°44'48.6"N 135°06'17.5"W) (Fig. 4). Eight plugs of either species containing rhizomes, roots and approximately 250 ml of natural wetland substrate were transplanted from the natural wetland into each laboratory-scale CW. Each wetland contained only one species; therefore, 4 wetlands contained *C. aquatilis* and 4 contained *J. balticus*. Two days after transplant, fertilizer was added (Alaska® Fish Fertilizer 5-1-1, Lilly Miller, dosage of 20 ml/m^2). The CWs were then saturated with tap water up to the level of the substrate surface and left undisturbed (no flow) for 2 weeks to allow the rhizomes to establish and the microorganisms within the transplanted substrate to incubate. Tap water was then circulated for another 2 weeks through the CWs. After 4 weeks of incubation with tap water, the aboveground biomass was removed at a height of 2 cm, leaving no shoots. Synthetic influents containing metals were then circulated through the CWs for 10 weeks and new shoot growth was monitored.

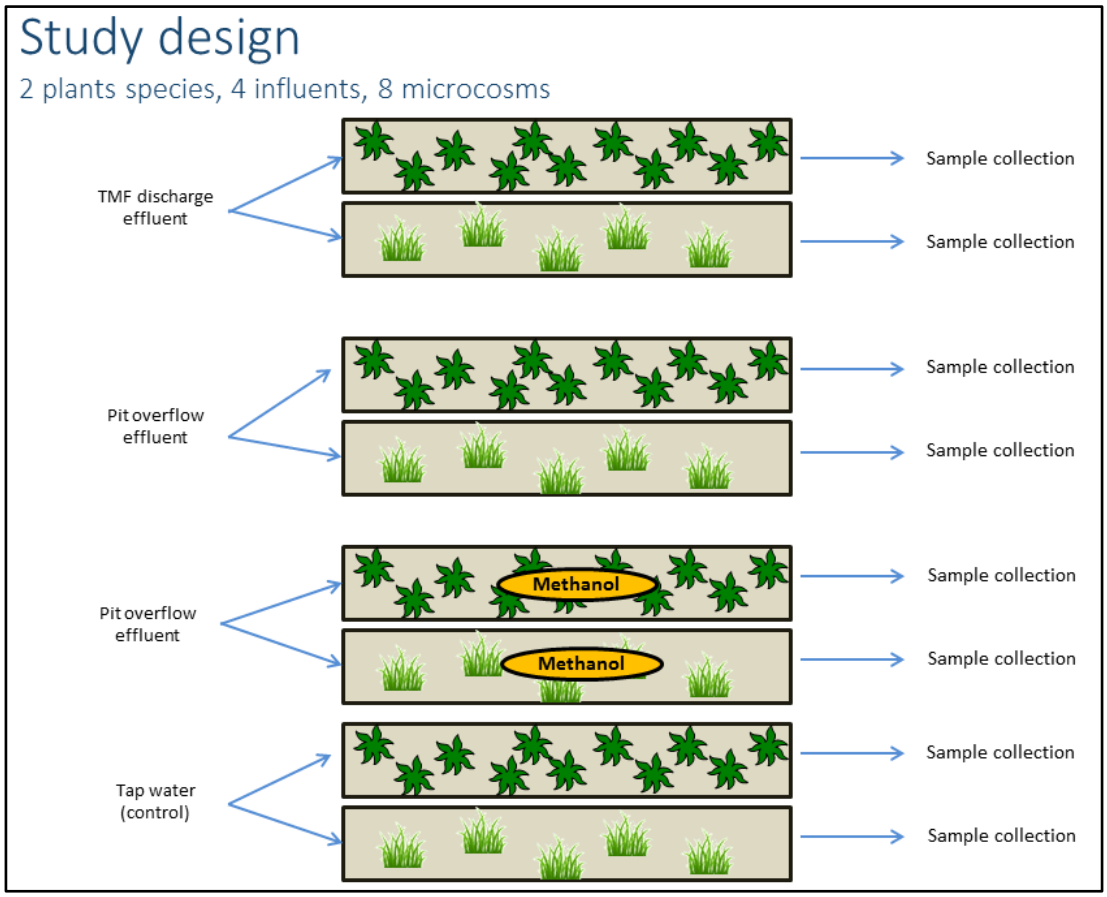

Figure 1 **Constructed Wetland (CW) study design using two plant species (*Carex aquatailis* and *Juncus balticus*) and 4 different synthetic influents (TMF, Pit, Pit(MeOH) and Control) for a total of 8 laboratory-scale CWs.**

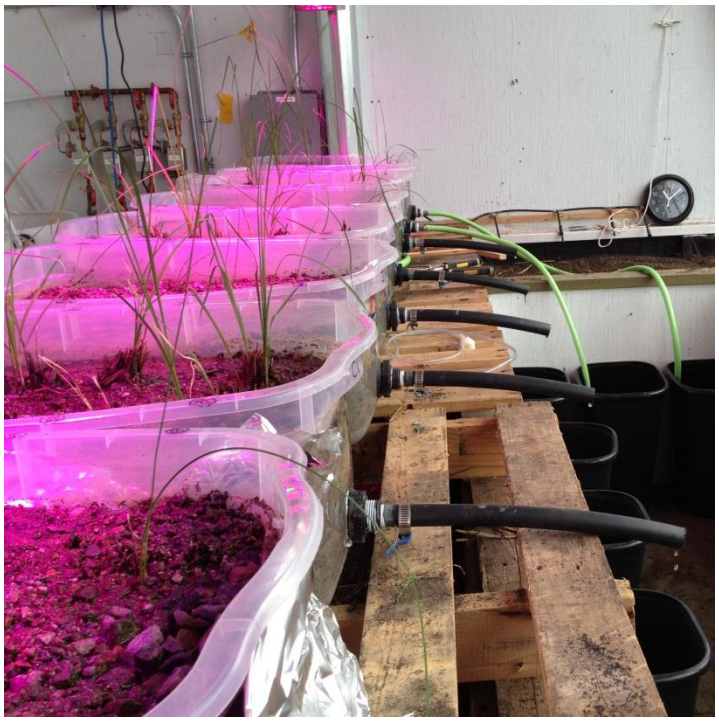

Figure 2 Laboratory-scale constructed wetlands with northern plant species, *Carex aquatailis* and *Juncus balticus*.



Figure 3 Sampling *Carex aquatailis* and *Juncus balticus* for the constructed wetlands from a natural wetland located on McIntyre Creek in Whitehorse, YT.



Figure 4 Hydraulic conductivity testing to determine the appropriate ratio of peat, sand and pea gravel to achieve a 5 ml/min flow rate with a hydraulic residence time of approximately 5 days.

2.2. Synthetic influent preparation

Synthetic influents were prepared weekly by dissolving $CdSO_4*8/3H_2O$ (Acros Organics, ACS Reagent), $CuSO_4*5H_2O$ (Fisher Scientific, Fisher Bioreagents), $FeSO_4*7H_2O$ (Fisher Scientific, Reagent Grade), SeO_2 (anhydrous; Acros Organics, 99.8%) $ZnSO_4*7H_2O$ (Acros Organics, ACS Reagent) and Na_2SO_4 (anhydrous; Fisher scientific; Lab Grade) in DI water. Four CWs each had different water treatments (4 water treatments x 2 species for a total of 8 CWs):

i) TMF with metal concentrations that reflected the concentrations predicted at closure in the Tailings Management Facility,

ii) Pit with metal concentrations predicted at closure in the open pit,

iii) Pit(MeOH) with Pit metal concentrations and the addition of 1% MeOH (Fisher Scientific) added weekly and

iv) City of Whitehorse tap water that was considered a Control treatment (Fig. 1).

pH was similar in all influents while Cd, Cu and Se concentrations were about twice in the Pit treatment as in the TMF treatment (Table 1). Cadmium, Se and Zn concentrations in the tap water Control were below quantification limits or quantified under 5% of the measured concentrations in TMF, Pit and Pit(MeOH) (Table 1). Cu concentrations were detected in tap water (35.3 ± 14.4 ug/L) that were approximately 30% of the concentrations found in the TMF influent.

Table 1 Average and standard deviation for pH, SO_4, Cd, Cu, Se and Zn concentrations in the influents between Week 2 and 10 for each of the CW treatments. Values below quantification limit are assumed to be equal to the quantification limit of 0.05 ug Cd/L, 0.6 ug Cu/L, 0.7 ug Se/L and 0.4 ug Zn/L.

	Control	TMF	Pit	Pit(MeOH)
pH	7.9 ± 0.3	7.8 ± 0.1	7.9 ± 0.1	7.7 ± 0.1
Cd (ug/L)	0.07 ± 0.05	1.6 ± 0.9	6.1 ± 0.44	5.5 ± 0.74
Cu (ug/L)	35 ± 14	121 ± 33	644 ± 181	607 ± 192
Se (ug/L)	0.7 ± 0.0	2.8 ± 1.2	4.4 ± 1.7	4.5 ± 2.3
Zn (ug/L)	24 ± 3.7	525 ± 63	576 ± 53	540 ± 84
SO_4 (mg/L)	37 ± 3.3	600 ± 243	610 ± 237	496 ± 215

2.3. Laboratory-scale constructed wetlands operation and monitoring

The 8 CWs were operated and monitored over 10 weeks following 4 weeks of incubation in a greenhouse under northern summer conditions. Temperature was 11°C with no light from 23:00-5:00 and 16°C with 175 µmol/m^2/s of light from 5:00-23:00. Synthetic influents or tap water were pumped at the bottom of the substrate using a multi-channel peristaltic pump (Masterflex pump, head and C-flex tubing) at 5 ml/min with sub-surface vertical flow (Fig. 5). The hydraulic residence time was approximately 5 days. Effluents from the CWs were discharged into outlet collection containers. The volume of the effluent accumulated in the collection containers over a week were recorded while pH measurements and samples were collected weekly. Samples for total metal analysis were preserved with 5% HNO_3 (trace metal grade) and stored at 4°C and samples for sulfate analysis were stored frozen.



Figure 5 Synthetic influents or tap water being pumped at the bottom of the substrate using a multi-channel peristaltic pump (Masterflex pump, head and C-flex tubing) at 5 ml/min with sub-surface vertical flow.

At the end of the experiment period, Oxygen Reduction Potential (ORP) and pH were measured in the center of each CW at a depth of 5 cm and 10 cm from the outlet. CWs were drained and interstitial water that remained within the substrate was sampled and preserved with 5% HNO3 (trace metal grade) for total Cu and Se analysis. All plant materials were extracted from the wetland and above- and belowground biomass were carefully washed with DI water, brushing the materials to remove any remaining soil particles. Root and shoot length were recorded and dry biomass was determined following drying at 105°C for 72 hrs. Three replicates of live shoots and roots were further analyzed for metal content. Wetland substrates from each CW were thoroughly mixed, sampled and also analyzed for metal contents.

2.4. Contaminants Analysis

Total Cd, Cu, Se and Zn metal concentrations in effluents were measured using Perkin Elmer PinAAcle Atomic Absorption (AA) analyzer (Perkin Elmer, Waltham, MA). Cadmium, Cu and Se were analyzed by Graphite Furnace (GFAA) and Zn by Flame (FAA). The Quantification Limits (QL) used in this work have been defined for each element as 10-σ and are 0.05 ug Cd/L, 0.6 ug Cu/L, 0.7 ug Se/L and 0.4 ug Zn/L. Calibrations were completed on a daily basis using single element standards (SCP Science, Baie D'Urfé, QC), and blanks and mixed verification standards (Perkin Elmer, Waltham, MA) were analyzed every 15 samples. Up to ±20% deviation was tolerated for the verification standards at the low end of the calibration curve and up to ±10% on the high end of the calibration curve. Quality control reports and analysis details are reported in Appendix A. pH was measured using Oakton PCD650 meter (Vernon Hills, IL) with a double junction pH electrode. Sulfate was analyzed by spectrophotometry using a SmartChem 170® Automated Discrete Analyzer (Westco, Guelph, ON) according to the STM Method D516-90, 02. Biomass samples were digested with nitric acid (trace metal grade) according to the method described by Zarcinas et al (1987) while substrate samples were digested with aqua regia according to USEPA reference method 3050B.

2.5. Statistical analyses

All data were tested to meet the assumptions of ANOVA and log transformation and boxcox transformations were performed. Differences in contaminant outlet concentrations, pH and SO_4 consumption between CW treatments were examined using repeated measures ANOVA with TukeyHSD posthoc comparisons (significant differences indicated by $p<0.05$ for all comparisons). Due to independent replication for CW vegetation (i.e. *Carex aquatailis* and *Juncus balticus*) ANOVA was TukeyHSD posthoc comparisons ($p<0.05$) was used. All analyses were conducted in R (R package version 2.1.50). Mass balance calculations and partitioning of Cu and Se into CW elements (i.e. water, substrate and plants) was conducted by summing total Cu and Se contained in the plant (metal content in above and belowground biomass x biomass weight before and after the experiment), in the soil (metal content in the soil x dry weight of soil contained in each CW before and after the experiment including initial peat, natural substrate and fish fertilizer), the water flowing in and out of the wetlands (weekly measurements of metal concentrations and volumes) and the interstitial water contained within the CWs at the end of the experiment.

3. RESULTS

3.1. Heavy metal removal from contaminated waters

The laboratory-scale constructed wetlands demonstrated a strong ability to remove heavy metals from contaminated water. Total removal efficiencies above or equal to 96%, 99%, 79% and 97% were observed for Cd, Cu, Se and Zn respectively, across the four CWs treating Pit and TMF synthetic influents (Fig. 6). Although the Pit treatment had higher metal concentrations in the influent (Table 1), there were no significant differences in the outlet contaminant concentrations between the different CWs treatments (repeated measures ANOVA with Tukey posthoc, $p>0.05$ for all comparisons). These consistently high metal removal efficiencies across CW treatments, regardless of synthetic influent concentrations, suggest that the short-term metal removal capacity of these laboratory-scale CWs were not reached. Further studies that include higher concentrations of contaminant inputs, larger-scale wetlands and a greater duration of treatment would be highly useful in determining the long-term metal sequestration capacity.

Although the CWs were only at a small laboratory-scale, the Cd, Cu and Zn removal efficiencies observed were similar to the efficiencies observed in other pilot or full-scale wetlands. Removal efficiencies of 94-99% for Cd (Gammons et al 2000, Yang et al 2006), 89-97% for Cu (Banks et al 1997, Gammons et al 2000, Lesage et al 2007, Contango Strategies 2014) and 87-98% for Zn (Sobolewski 1996, Banks et al 1997, Yang et al 2006, Lesage et al 2007) have been reported. Selenium treatment of mine-impacted water by CWs seems less common than transition metals treatment and Se had the lowest average removal compared with the other contaminants. However, removal efficiencies above 83 % were observed in this study. In another study examining a northern wetland planted with the same *Carex* species, an efficiency of 26% was reported for Se removal (Contango Strategies 2014). This low efficiency was attributed to the elevated concentrations of nitrate, which competes over Se as an electron-acceptor.

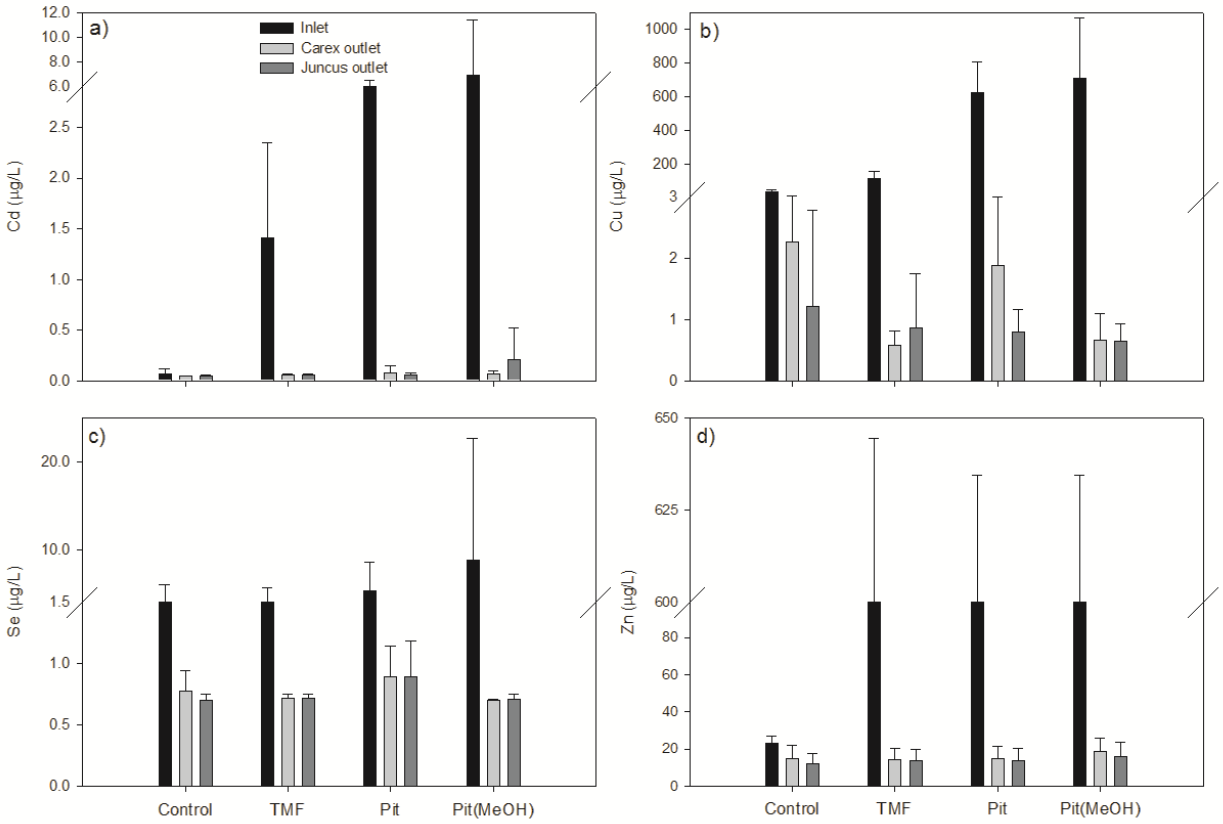

Figure 6 Cd (a), Cu (b), Se (c) and Zn (d) concentrations in CWs with C. aquatilis (Carex) and *J. balticus* (Juncus) fed with Control, TMF, Pit or Pit(MeOH) waters. Bars represent means with standard error. There were no significant differences in the outlet concentrations for any of the contaminants between the wetland treatments (repeated measures ANOVA with Tukey posthoc (p>0.05 for all comparisons). Note the broken Y-axis.

Over the trial a significant increase in pH in the TMF, Pit and Pit(MeOH) treatments was detected compared to the Control treatment (ANOVA with Tukey posthoc, $p<0.05$ for all comparisons) (Fig. 7). Starting at week 7 significant increases in pH were observed for the Pit(MeOH) treatment compared to all other treatments. In addition, higher consumption of SO_4 was observed for the Pit(MeOH) treatment where a carbon source (i.e.1% MeOH) was being added to the CWs. Both CWs with a Pit(MeOH) treatment had higher consumption of SO_4 compared with the Pit treatments starting at week 6 (Fig. 8). Although, the Pit(MeOH) with *J. balticus* was not significantly higher than the Pit treatment with *J. balticus*, both the Pit(MeOH) treatments were significantly higher than the Pit treatment with *C. aquatilis* (ANOVA with Tukey posthoc, $p=0.05$ for Carex and $p=0.02$ for Juncus). An increase in reducing conditions in the CW substrate of the Pit(MeOH) treatment was observed, with an average Oxygen Reducing Potential (ORP) of -341.9 mV, compared to an average of -109.4 mV when no MeOH was added (i.e. Pit). Black deposits on the wetland surface, characteristic of sulfide precipitates, and odiferous evidence of H_2S from the Pit(MeOH) CWs indicated a strong reducing environment (Fig. 9). Low ORP, increased SO_4 consumption and black deposits on the wetland surface for the Pit(MeOH) treatment likely indicate that

methanol addition to the CWs was stimulating microbial-induced sulfate reduction (Eq. 1) and subsequent metal sulfide salts precipitation (Eq. 2). Reduction of one mol of sulfate leads to the production of 3 moles of bicarbonate (HCO_3^-), which likely explains the increase in pH observed in Fig. 7 as bicarbonate consumes hydrogen ions (Eq. 3).

(Eq. 1) $$4\,CH_3OH + 3\,SO_4^{2-} \xrightarrow{microbial} 3\,HCO_3^- + 3HS^- + 5\,H_2O + CO_2$$

(Eq. 2) $$HS^- + M^{2+} \leftrightarrow MS(s) + H^+$$

(Eq. 3) $$HCO_3^- + H^+ \leftrightarrow H_2O + CO_2$$

In natural wetlands organic matter decomposition typically decreases the ambient redox potential. Organic carbon acts as an electron donor to microorganisms, such as sulfate-reducing bacteria, which reduce sulfate (SO_4) releasing sulfide (S^2) (Sobolewski 2010). Sulfide is highly reactive and forms insoluble metal salts, such as CdS, CuS and ZnS. To offset the reduction in organic matter decomposition often encountered in northern wetlands and bioreactors, addition of liquid carbon may be advantageous (Tsukamoto et al 2004, Sobolewski 2010, Alexco 2012, Gould et al 2012). The addition of liquid methanol at 1% (v/v) in the Pit(MeOH) treatment was intended to assess the impact of additional carbon sources on the substrate conditions and subsequently on the metal uptake by northern wetland plant species. It appears that the addition of liquid methanol did impact the substrate conditions and led to greater reducing conditions, although significantly higher heavy metal removal efficiency was not observed (Fig. 6). Therefore, the presence of electron donors in the substrate was likely not a limiting factor in the Pit CWs that were not fed with methanol. In addition, the Pit(MeOH) CWs may have produced HS^- in excess accounting for the odor associated with this treatment.

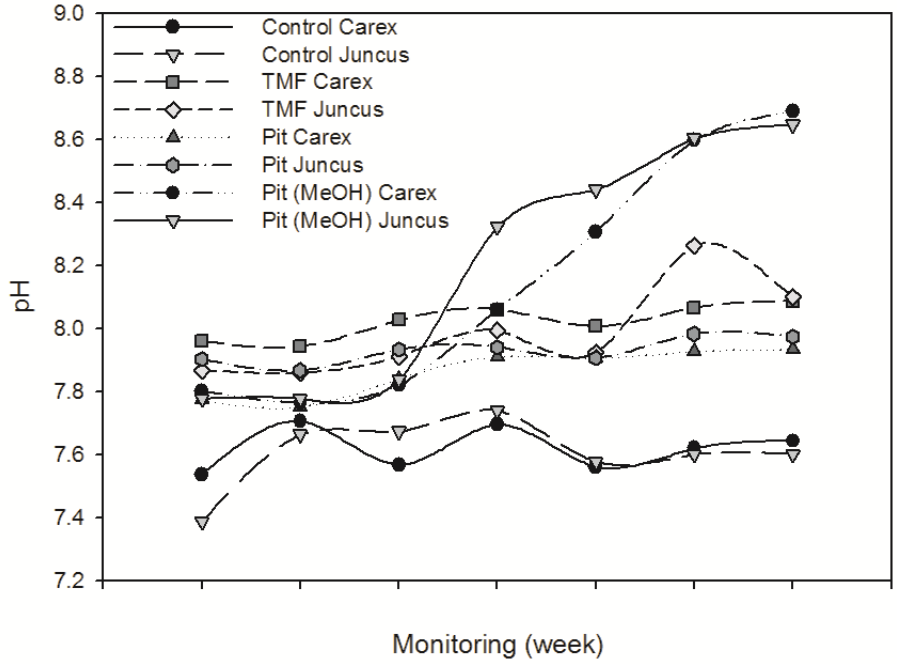

Figure 7 pH of outlet waters for each CW treatment monitored from week 4 to week 10 of the laboratory-scale trial. At week 7 significant increases in pH were observed

for the Pit(MeOH) treatment compared to all other treatments. Similarly, both the TMF and Pit treatment had significant increases in pH compared to the control (ANOVA with TukeyHSD, p<0.05 for all comparisons).

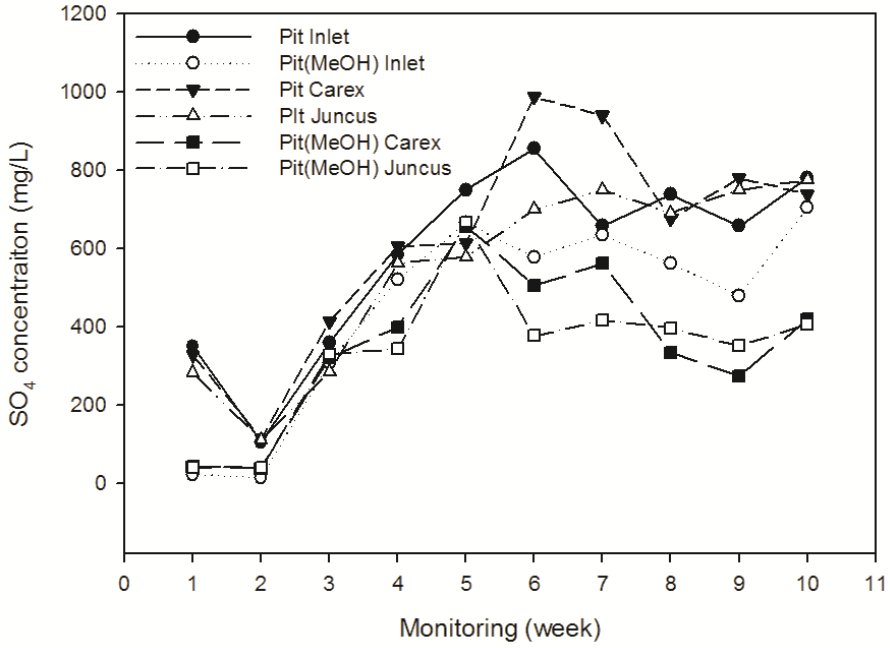

Figure 8 Sulfate concentration in the inlet and outlet waters of the Pit and Pit(MeOH) CWs with *C. aquatilis* (Carex) and *J. Balticus* (Juncus) monitored over the 10 week trial. Significantly higher sulfate consumption (i.e. Inlet-Outlet for each CW) for both Pit(MeOH) CWs compared with the Carex Pit treatment were detected (ANOVA with Tukey posthoc, p=0.05 for Carex and p=0.02 for Juncus).



Figure 9 Black deposits on the wetland surface, characteristic of sulfide precipitates found only in the Pit(MeOH) CW treatment. In addition, an odiferous evidence of H_2S from the Pit(MeOH) was present.

To better understand the mechanisms by which metal sequestration occurs in northern CWs further studies are required. In particular, characterization of metal endpoints, examination of the relative importance of sorption versus metal precipitation and characterization of the microbial community and its' activity are needed. Understanding the metabolic activities of SRB and the entire scope of the microbial communities present in wetlands at permanently low temperatures is crucial (Robador et al 2009). More importantly, studies are needed to determine if a relationship can be established between summer and winter metal removal rates and rates of sulfate reduction, carbon consumption, metal precipitation and sorption (Gammons et. al. 2000). Such seasonally-adjusted rates will support the development of seasonally-adjusted treatment performance and design criteria for northern CWs that function year-round.

Metal uptake by plants is thought to depend on the geochemistry in the substrate and is affected by the speciation and availability of the metals. At the end of 10 weeks of treatment in our laboratory-scale study shoots of both *C. aquatilis* and *J. balticus* were yellowed and dead in the Pit(MeOH) treatment. Sulfide is known as a strong phytotoxcin to plants by causing basic disturbance to cell metabolism and energy transfer, which can hamper plant nutrient uptake (Lamers et al 2013). Death of plants within the Pit(MeOH) treatment and the strong H_2S odour may indicate that the concentration of organic carbon used was too high. In addition, other sources of carbon may be more appropriate for use in northern CWs with northern plant species. Glucose, lactate/acetate, ethanol, methanol, ethylene glycol are all carbon sources that have been used to supplement northern bioreactors or CWs (Ness et al. 2014). Further studies are needed to examine the influence of sources and concentrations of carbon in northern CWs and how these may influence metal sequestration in both wetland substrates and plants.

3.2. Establishment, growth and metal uptake of northern wetland plants

There were no significant differences in metal removal efficiency or pH between CW treatments containing either *C. aquatalis* or *J. balticus*. Nor were there significant differences in the shoot and root length or in the above and belowground biomass across our different CW treatments for either of the northern plant species (Table 2; ANOVA with TukeyHSD posthoc, $p>0.05$ for all comparisons). While growth of belowground biomass was more difficult to quantify for the transplants, aboveground biomass was removed for both species prior to initiating treatment with contaminated synthetic influent; therefore, strong growth within 10 weeks with stems as long as 74 cm and 50 cm for *C. aquatalis* and *J. balticus*, respectively, was observed. With the exception of mortality of both species in the Pit(MeOH) treatment, discussed above, the establishment and growth of both plant species did not appear to be negatively impacted by the addition of contaminants into the CWs. Our study suggests that both of these species may be good candidates for northern CWs due to their vigorous growth, high tolerance to contaminants and limited uptake of Cu and Se.

Although no treatment effects on establishment were observed, *C. aquatalis* had a 53% survival rate and *J. balticus* had only a 38% survival rate following transplanting. The results suggest that if using locally transplanted materials high numbers of replicate plants may be needed to account for transplant related mortality. Although transplantation of plant materials is advantageous since plants are adapted to the local conditions (Galbrand et al. 2008), much higher rates of plant propagation success can be achieved by purchasing plugs from commercial native plant nurseries. However, plant materials for growing plugs should ultimately be sourced from as close as possible to the site of the CW. Further determination of species for northern CWs requires an evaluation of a much larger suite of locally available plants. To ensure effective naturalization of the vegetation community to be established in a CW, community modeling based on surveying of plant communities inhabiting similar local natural wetlands, including vegetation composition, structure and abundance should be conducted (Daigle and Havinga 1996, Hoag 2003). Based on the following criteria, species can be further screened for suitability in CWs: (a) phytoremediation potential (especially metal uptake), (b) sedimentation and erosion control, (c) habitat function, (d) public deterrent potential and (e) rate of plant establishment, tolerances and maintenance requirements (Galbrand et al. 2008).

Table 2 Average and standard deviation of root and shoot length and biomass (dry weight) *of Carex aquatilis* (Carex) and *Juncus balticus* (Juncus) after 10 weeks of growth in constructed wetlands (CWs) treated with either Control, Pit, TMF and Pit(MeOH) waters. There were no significant differences in root and shoot length or biomass between the CW treatments for either species (ANOVA, p>0.05 for all comparisons).

Plant species	CW Treatment	Root length (cm)	Shoot length (cm)	Root biomass (g)	Shoot biomass (g)
Carex	Control	20 ± 8.9	35 ± 21	0.38 ± 0.23	0.76 ± 0.47
	TMF	24 ± 21	35 ± 22	0.50 ± 0.23	9.2 ± 23
	Pit	25 ± 20	24 ± 23	0.42 ± 0.27	1.4 ± 1.2
	Pit(MeOH)	21 ± 9.1	28 ± 18	0.49 ± 0.23	0.91 ± 0.31
Juncus	Control	11± 10	25 ± 24	0.29 ± 0.31	0.30 ± 0.19
	TMF	11 ± 7.1	15 ± 12	0.27 ± 0.21	0.20 ± 0.14
	Pit	10 ± 6.1	21± 15	0.25 ± 0.15	0.21± 0.07
	Pit(MeOH)	7.2 ± 2.8	16 ± 8.8	0.30 ± 0.21	0.23 ± 0.09

No significant uptake of Cu or Se into the aboveground biomass by *C. aquatilis* or *J. balticus* was observed in this study. Furthermore, there was no significant difference in above or belowground Cu content in either plant species across the different CWs treatments (Fig. 10; ANOVA, p=0.51). Although in most treatments Cu content was observed to be slightly higher in the belowground biomass compared to the aboveground biomass this was not significant, suggesting an almost equal distribution of Cu throughout the biomass of *C. aquatilis* and *J. balticus*. Analysis of Cu content in *C. aquatilis* and *J. balticus* shoots taken directly from the natural wetland collection site found concentrations of 7.07 ± 2.79 and 7.14 ± 2.71 mg/kg respectively. Despite the differences in the root oxygen exchange

between these two species (*C. aquatilis* 6.7 µmol O_2 loss/g dry root/day vs *J. balticus* 9.9 µmol O_2 loss/g dry root/day (Taylor 2009)) there were no differences in their uptake of Cu within the CWs. Contango Strategies (2014) reported similar Cu contents (4 to 20 mg Cu/kg) in *C. aquatilis* growing in a natural wetland area where Cu-loaded seepages are known to occur within the Minto Cu-Au mine area in the Yukon Territory. Even though small-scale experiments have been shown to overestimate metal plant uptake capability (Conesa et al 2007), both the results from this study and those observed from the natural wetland located at Minto mine (Contango Strategies 2014) suggest a low tendency for Cu uptake in these wetland plants. Other studies have found Cu uptake in *Carex* spp. For example in a CW treating acid mine drainage in Sweden, *Carex rostrata* had Cu concentrations of 84 ± 9 mg/kg in belowground biomass and 12 ± 1.0 mg/kg in aboveground biomass, which exceeds the 3 ±1 mg/kg and 1.3 ±0.3 mg/kg found in the control plants respectively (Nyquist and Greger 2009). Similarly elevated levels of Cu were found in the biomass of *C. rostrata* grown on submerged tailings in northern Sweden (22.6 mg/kg) compared to untreated plants (4-15 mg/kg), but in both cases the aboveground biomass was well below levels that were deemed tolerable for animals (25-800 mg/kg in air dried forage) (Stoltz and Greger 2002).

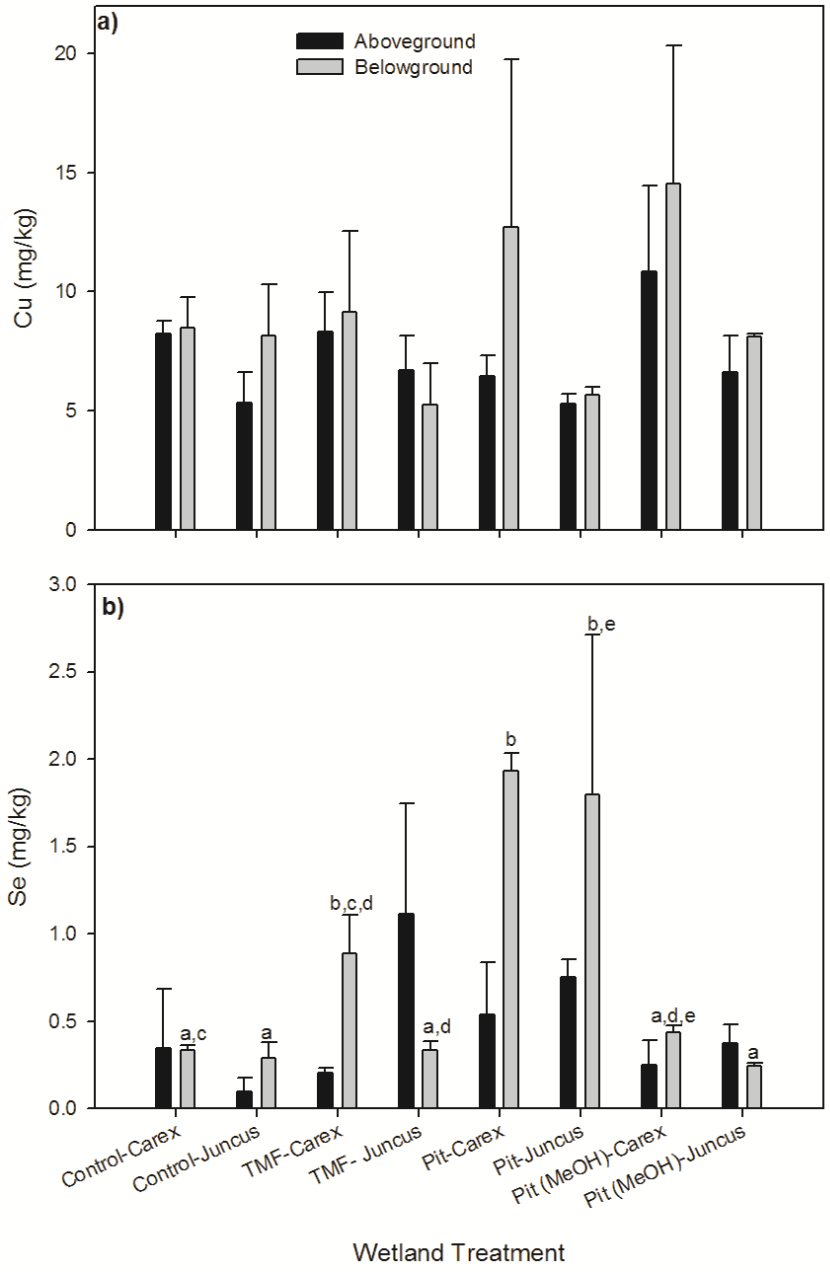

Figure 10 **Copper and Selenium content in *C. aquatilis* (Carex) and *J. balticus* (Juncus) in constructed laboratory-scale wetlands after 10 weeks of operation with tap water (Control), TMF, Pit or Pit (MeOH) synthetic waters. There was no significant difference in Cu content of above or belowground biomass across the treatments for either northern plant species (ANOVA, p=0.51). We detected significantly higher Se in belowground biomass in the Pit treatment compared with the control and pit (MeOH) treatments for both Carex and Juncus (ANOVA, p<0.05 for all comparisons). Bar represent means with standard error. Different letters indicate significantly different means.**

Se uptake into the aboveground biomass had a similar trend as Cu with no significant differences across the CWs treatments for either species (ANOVA, p=0.12). Analysis of Se content in *C. aquatilis* and *J. balticus* shoots taken directly from the natural wetland collection site had concentrations of 0.25 ± 0.01 and 0.29 ± 0.14 mg/kg respectively. Very few studies have examined Se uptake in CWs, however, the belowground systems of *Schoenoplectus californicus* and *Typha angustifolia* were observed to sorb and bioconcentrate Se in a pilot constructed wetland for flue gas desulfurization wastewater treatment (Sundberg-Jones and Hassan 2007). Sorption on roots accounted for 4.4 +2.7 mg/kg for *S. californicus* and 0.5 +0.4 mg/kg for *T. angustifolia*, however when both adsorption and plant tissue were considered Se concentrations were as high as 4224 +2843 mg/kg for *S. californicus* and 170 +109 mg/kg for *T. angustifolia*. In a CW vegetated mainly with *Scirpus robustus*, *Polypogon monspeliensis* and *Typha latifolia* treating oil-refinery effluent approximately 90% of the Se entering the CW was removed (Hansen et al 1998, de Sousa et al 1999), however these wetland plants accumulated Se in their tissues at concentrations that were at least 3 orders of magnitude above those in the effluent (deSousa et al 1999). It should be noted that the concentration of Se in both of these systems far exceeded the highest Se concentration the laboratory-scale CWs (4.5 µg/L) with concentrations of 8.5 mg/L and 1.6 mg/L respectively.

Water-saturated soil conditions and the resulting low ORP appear to limit the Se concentration in *Carex* spp., for example under saturated soil conditions the average Se concentration in *Carex* spp. was found to be 17.7 µg/L $\pm$11.0 versus 43.4 µg/L $\pm$ 15.9 in normal alpine soils (Michner et al 2007). The most highly oxidized species of Se is selenate ($SeO4^-$), which is water-soluble and readily assimilated by plants, and is the form commonly found in alkaline soil where cases of Se toxicity occur (Lakin 1972, van Dorst and Peterson 1984, Michner et al 2007). Since reduced forms of Se are less available it is the abundance of the various species of Se, rather than total concentration that governs availability. The overall low levels of Se uptake observed in both *C. aquatilis* and *J. balticus* therefore, may in part be related to the water-saturated and low ORP conditions typical of wetlands.

Both northern plant species had higher Se content in the Pit treatment compared with both of their respective Control and Pit(MeOH) treatments (ANOVA with TukeyHSD posthoc, *C. aquatilis*, p <0.01 and 0.03; *J. balticus*, p<0.01 for both comparisons; Fig 10). It is not surprising that the only uptake observed in this study occurred in the belowground biomass. Many other studies have observed that the concentrations of heavy metals in various parts of macrophytes growing in CWs and natural wetlands, generally decrease in the order of roots >rhizomes > leaves > stems (Vymazal and Březinová 2015). Higher belowground Se in the Pit treatment corresponds with the higher level of contaminants in the synthetic influent (Table 1). However, in the Pit(MeOH) treatment we did not see a similar increase in uptake of Se into the belowground biomass despite the same levels of Se being introduced to the system. In the Pit(MeOH) treatment we observed a 100% mortality rate of both species by week 10, which, as discussed above, is likely due to the phytotoxicity of sulphide. Progressive death of the belowground system would reduce Se uptake. Alternatively metal precipitation associated with increased SRB activity in the Pit(MeOH) CWs may have reduced the bioavailability of Se to *C. aquatilis* and *J. balticus.*

Hyperaccumulators are defined as plants that complete their life cycle with foliar metal concentrations exceeding (mg/kg dry weight, DW) Cd > 100, Ni and Cu > 1000, and Zn and

Mn > 10,000 (Zavoda et al 2001, Marchand et al 2010). However, to date, no emergent wetland plants have been identified as hyperaccumulators. As our results confirm, metal removal through uptake by macrophytes in wetlands is relatively minor compared to other processes. Although the concentrations of heavy metals in plants growing in CWs vary considerably between species and systems, the concentrations are generally within the range commonly found in natural stands (Vymazal and Březinová 2015). The importance of macrophytes in these systems is to provide organic matter needed to perpetuate the biogeochemical processes in the substrate through die-back, and organic compounds via exudation from the roots (Jenssen et al 1993, Marchand et al 2010). Although investigating potential uptake of contaminants in a greater number of northern plant species, both at higher influent concentrations and over longer time periods is advisable, examination of other functions that wetland plants provide may be more informative for northern CW design. For example, higher removal efficiency has been observed for Zn and Cu when monocots rather than dicots are used. Since uptake in plants is not an important factor in metal removal in wetlands, differences between monocots and dicots with respect to metal acquisition cannot account for the differences in removal (Marchand et al 2010). Differences in rooting morphology and exudation of organic compounds may be the cause of this variation. Monocots have adventitious rooting systems with a greater surface area and produce phytosiderophores that chelate metals such as ferric iron due to their amine and carboxyl groups (Kidd et al 2009), whereas dicots have vertical tap roots and no phytosiderophore production (Marchand et al 2010). Further examination of the functional characteristics of northern wetland plant species in relation to long-term metal sequestration would be highly valuable. In addition, heavy metal concentrations in wetland plant biomass vary considerably during the season, but do not follow the well-known pattern for nutrients (Vymazal and Březinová 2015). In cold climates maximum concentrations of nutrients, such as nitrogen and phosphorus, tend to occur early in the growing season, while the maximum standing stock for nutrients (i.e. nutrient concentrations within plants), tends to occur later in the season at the time of maximum biomass (Vymazal and Březinová 2015). However, the standing stock for heavy metals has no consistent temporal pattern and varies both between metals and between plant species (Vymazal and Kröpfelová 2008, Vymazal and Březinová 2015). Further studies examining the seasonal patterns of heavy metal concentrations in wetland plant biomass are needed to assist in predicting any potential contaminant availability to the surrounding environment.

3.3. Cu and Se distribution within the CWs

As discussed previously, high efficiencies were observed for removal of Cu (>99%) and Se (>79%) from influent waters by the wetlands (Fig. 6). Analysis of the distribution of both contaminants in the water, plants and substrate systems suggests that both Cu and Se were primarily contained within the substrate in all the CWs as indicated by high percentile amounts (Table 3). More than 99.8% of the total load of Cu and >90.2% of the total load of Se were measured in the substrate at the end of the experiment.

Conversely, in all of the CW treatments for both Cu and Se, <0.06% of Cu and <0.11% of Se was found in plant biomass, with the exception of the TMF treatment with *C. aquatilis* (i.e. <0.2% Cu and <0.4 % Se) (Table 3). The loads in mg of metal in biomass are calculated as

the metal contents (in mg/kg) times the weight of biomass (in kg). Noteworthy, although metal concentrations are generally smaller in the shoots than in the roots, the loads measured in the shoots are higher as it reflects the larger biomass produced aboveground. Nonetheless, metal uptake by *C. aquatilis* or by *J. balticus* is clearly not a major Cu or Se removal mechanism in the CWs studied. Similar observations were made for Fe uptake by Mitsh and Wise (1998) who observed <0.07 % uptake in a constructed wetland in Ohio and by August et al (2002) who measured <0.5 % uptake in a natural wetland in Colorado. In northern Sweden *Carex rostrata*, *Eriophorum angustifolium* and *Phragmites australis* were observed to uptake of Zn, Cu and Cd at <0.4%, 0.3% and 2.9% respectively (Nyquist and Greger 2009). In smaller-scale experiments in greenhouses, Allende et al. (2014) and Rahman et al (2011) reported that <0.11% and 1% of the total mass of As load in the wetlands was uptaken by *P. autralis* and *J. effuses* shoots respectively.

Overall, our study supports the findings of others that suggest metal removal mechanisms are most likely driven by chemical and microbial reactions occurring within the substrates (Sobolewski 1999, Sheoran and Sheoran 2006, Vymazal and Březinová 2015). In addition, we found a higher average removal efficiency for Cu (99%) than for Se (79%) and we also found a larger distribution of Cu in the substrate (>99.8%) compared with Se (90.2-98.0%). This higher removal efficiency of Cu appears to be primarily the result of metal sequestration within the wetlands substrate. With the exception of the TMF CW treatment with *C. aquatilis*, the percentage of total Se in plants was higher than for Cu in all of CW treatments. Although the percentages for both contaminants in plant biomass were still very low, the partitioning of Se into plants may be more of a concern than the partitioning of Cu into plants. Due to the lack of information on Se uptake into wetland plants and the observed trend in this study, further examination of Se uptake in plants is recommended.

Table 3 Distribution of total Copper and Selenium partitioned by water, plants and substrate for each constructed wetland (CW) treatment and plant species (*Carex aquatilis* (Carex) and *Juncus balticus* (Juncus)) after 10 weeks of treatment with synthetic contaminated waters. Values are given in mg Cu or Se and values in parentheses are percentile amounts of total mass of Cu or Se in the CWs.

Copper						
CW Treatment	TMF	Pit	Pit(MeOH)	TMF	Pit	Pit(MeOH)
	Carex	Carex	Carex	Juncus	Juncus	Juncus
Total load (mg)	318.6	306.4	604.3	257.2	503.0	604.3
Distribution						
Water	0.41 (0.13)	0.97 (0.32)	0.50 (0.08)	0.57 (0.22)	0.44 (0.09)	0.37 (0.06)
effluent	0.31 (0.10)	0.95 (0.31)	0.46 (0.08)	0.45 (0.18)	0.43 (0.08)	0.35 (0.06)
Interstitial	0.10 (0.03)	0.02 (0.01)	0.04 (0.01)	0.12 (0.05)	0.02 (0.004)	0.02 (0.003)
Plants	0.74 (0.23)	0.19 (0.06)	0.14 (0.02)	0.03 (0.01)	0.03 (0.01)	0.03 (0.01)
Shoots	0.70 (0.22)	0.14 (0.05)	0.07 (0.01)	0.01 (0.01)	0.01 (0.003)	0.01 (0.002)
Roots	0.04 (0.01)	0.04 (0.01)	0.07 (0.01)	0.02 (0.01)	0.02 (0.004)	0.02 (0.003)
Substrate	317 (99.6)	305 (99.6)	604 (99.9)	257 (99.8)	503 (99.9)	604 (99.9)

Selenium						
CW Treatment	TMF	Pit	Pit(MeOH)	TMF	Pit	Pit(MeOH)
Plant Species	Carex	Carex	Carex	Juncus	Juncus	Juncus
Total load (mg)	8.20	10.89	19.07	3.96	5.69	9.14
Distribution						
Water	0.38 (4.69)	0.47 (4.35)	0.38 (1.99)	0.38 (9.72)	0.48 (8.50)	0.38 (4.23)
effluent	0.38 (4.67)	0.47 (4.32)	0.38 (1.98)	0.38 (9.66)	0.48 (8.42)	0.38 (4.20)
Interstitial	0.002 (0.03)	0.002 (0.02)	0.003 (0.02)	0.002 (0.06)	0.004 (0.08)	0.003 (0.03)
Plants	0.03 (0.39)	0.01 (0.11)	0.005 (0.03)	0.002 (0.06)	0.004 (0.08)	0.001 (0.01)
Shoots	0.03 (0.34)	0.005 (0.05)	0.003 (0.02)	0.001 (0.03)	0.001 (0.03)	0.0004 (0.01)
Roots	0.004 (0.05)	0.006 (0.06)	0.001 (0.01)	0.001 (0.03)	0.002 (0.05)	0.0005 (0.01)
Substrate	7.78 (94.9)	10.4 (95.5)	18.7 (98.0)	3.58 (90.2)	5.20 (91.4)	8.75 (95.8)

4. SUMMARY OF KEY FINDINGS

The laboratory-scale CWs evaluated herein demonstrated a strong ability to remove contaminants from synthetically contaminated waters with average removal efficiencies above or equal to 96%, 99%, 79% and 97% for Cd, Cu, Se and Zn respectively. Even with increased contaminant concentrations in the influent waters (i.e. Pit treatment compared to TMF treatment) there was no decline in removal efficiencies suggesting that the short-term metal removal capacity of these laboratory-scale CWs was not reached. While transplant related mortality did reduce the overall biomass accumulation in our CWs, no treatment effects on the establishment and growth of the two northern plant species *C.*

aquatilis and *J. balticus* were observed. Furthermore, there was no evidence of Cu or Se uptake into the aboveground biomass of either species with increasing contaminant availability. Increased belowground uptake of Se was observed at the higher influent concentration in the Pit treatment. Overall, this study suggests that uptake of contaminants by these two northern species is very minor (i.e. <0.06% Cu and <0.11% Se, except for *C. aquatilis* in the TMF CW <0.2% Cu and <0.4 % Se) and likely does not pose a risk to the surrounding environment. This study concludes that CWs could operate as successful passive treatment solutions in a northern environment, at least during the summer months. Further studies are required to examine seasonal metal removal rates in relation to rates of sulfate reduction, carbon consumption, metal precipitation and sorption. In addition, potential contaminant uptake and the influence of functional plant characteristics on metal removal in a suite of northern plant species would further assist in the development of large-scale long-term northern CWs.

5. RECOMMENDATIONS FOR FUTURE WORK

- Further studies that include higher concentrations of contaminant inputs, larger-scale wetlands and a greater duration of treatment would be highly useful in determining the long-term metal sequestration capacity.

- To better understand the mechanisms by which metal sequestration occurs in northern CWs further studies are required. In particular, characterization of metal endpoints, speciation of the sequestered metals and characterization of the microbial community and its' activity are needed.

- Understanding the metabolic activities of SRB and the entire scope of the microbial communities present in wetlands at permanently low temperatures is crucial. Examination of the microbial community in natural wetlands, particularly those receiving contaminants would be highly informative.

- Studies are needed to determine if a relationship can be established between summer and winter metal removal rates and rates of sulfate reduction, carbon consumption, metal precipitation and sorption. Such seasonally-adjusted rates will support the development of seasonally-adjusted treatment performance and design criteria for northern CWs that function year-round.

- Further studies are needed to examine the influence of sources and concentrations of carbon in northern CWs and how these may influence metal sequestration in both wetland substrates and plants.

- Determination of species for northern CWs requires an evaluation of a much larger suite of locally available plants. To ensure effective naturalization of the vegetation community to be established in a CW, community modeling based on surveying of plant communities inhabiting similar local natural wetlands is needed.

- Local naturally occurring wetland species should also be screened for their suitability for inclusion in CWs based upon, phytoremediation potential,

sedimentation and erosion control, habitat function and rate of plant establishment, tolerance and maintenance requirements.

- Due to the lack of information on Se sequestration in CWs and Se uptake in plants, as well as, the observed uptake in the belowground systems of *Carex aquatilis* and *Juncus balticus*, special attention should be given to future studies focusing on Se.

- In addition to investigating potential uptake of contaminants in a greater number of northern plant species, both at higher influent concentrations and over longer time periods, examination of other functions that wetland plants provide may be more informative for northern CW design.

- Since contaminant concentrations within the biomass of wetland plants are known to be inconsistent both between metals and between species, further studies examining the seasonal patterns of heavy metal concentrations in wetland plant biomass are needed to assist in predicting any potential contaminant availability to the surrounding environment.

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APPENDIX 1 –METAL ANALYSIS QC REPORT

YRC AA QC Report

Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AAS	**Standards source**	SCP
Element	Se 196.03	**QC Source**	Perkin Elmer Mixed Std
Date	08/08/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	nonlinear through zero	**Correlation coefficient**	0.9998
Detection Limit	0.68		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
blank	-0.001524084		
1 ppb	0.001851502		
2 ppb	0.003652053		
5 ppb	0.009825244		
10 ppb	0.019049594		
25 ppb	0.043194113		
50 ppb	0.0793924		
Blank	0.000904054	0.4726	
low level	0.00219665	1.1513	115.13
high level	0.081705997	51.3574	102.71
WL1 Jul 8	0.021114221	11.5221	
WL2 Jul 8	0.034464359	19.3699	
WL3 Jul 8	0.097203726	63.5675	
WL3 Jul 8	0.047490741	27.4935	
WL4 Jul 8	0.004434268	2.3351	
WL5 Jul 8	0.002755716	1.4460	
WL6 Jul 8	0.017093365	9.2470	
Blank	0.00033602	0.1754	
low level	0.002305341	1.2086	120.86
high level	0.083042277	52.3727	104.75

Conditions	Flame AAS	**Standards source**	SCP
Element/Wavelength	Zn 213.86	**QC Source**	Perkin Elmer Mixed Std
Date	14/8/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero		Mid level: ±10%
Detection Limit	5.40	**Correlation coefficient**	0.9999

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
blank	0.000303142		
10 ppb	0.006022659		
300 ppb	0.176270286		
1000 ppb	0.51803534		
2000 ppb	0.869532822		
blank	-0.00056963		
low level	0.006047574	9.9913	99.91
high level	0.86735619	1998.9544	99.95
mid level	0.528209761	1015.7440	101.57
Jul 28 WL11	0.002382633	≤5.40	
Jul 28 WL12	0.002510663	≤5.40	
Aug 4 WL1	0.231781411	404.2098	

YRC AA QC Report

Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	Flame AAS	**Standards source**	SCP
Element/Wavelength	Zn 213.86	**QC Source**	Perkin Elmer Mixed Std
Date	14/8/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero		Mid level: ±10%
Detection Limit	5.40	**Correlation coefficient**	0.9999

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
Aug 4 WL2	0.003522687	5.8167	
Aug 4 WL3	0.003371875	5.5675	
blank	0.000905874	1.4950	
low level	0.007121771	11.7687	117.69
high level	0.879597615	2044.6623	102.23
mid level	0.534811921	1031.1847	103.12
Aug 4 WL4	0.284752591	504.0325	
Aug 4 WL5	0.004906346	8.1040	
Aug 4 WL6	0.002582176	≤5.40	
Aug 4 WL7	0.347224255	626.2643	
Aug 4 WL8	0.003907462	6.4526	
Aug 4 WL9	0.003652403	6.0311	
Aug 4 WL10	0.012273354	20.3037	
Aug 4 WL11	0.001474971	≤5.40	
Aug 4 WL12	0.002237319	≤5.40	
blank	-0.000899909	-1.4846	
low level	0.005534711	9.1429	91.43
high level	0.898394559	2117.4138	105.87
mid level	0.5375641	1037.7343	103.77
Aug 11 WL1	0.253697425	445.1050	
Aug 11 WL2	0.003760389	6.2096	
Aug 11 WL3	0.00519786	8.5859	
Aug 11 WL4	0.285375123	505.2129	
Aug 11 WL5	0.005849777	9.6641	
Aug 11 WL6	0.004665631	7.7059	
Aug 11 WL7	0.201471013	348.5222	
Aug 11 WL8	0.006467837	10.6865	
Aug 11 WL9	0.005945815	9.8229	
Aug 11 WL10	0.015883962	26.2970	
Aug 11 WL11	0.004762752	7.8664	
Aug 11 WL12	0.004112321	6.7912	
blank	-0.000143279	-0.2364	
low level	0.006247081	10.3213	103.21
high level	0.902166953	2132.3851	106.62
mid level	0.538387825	1039.5920	103.96

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Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AAS	**Standards source**	SCP
Analyte	Se 196.03	**QC Source**	Perkin Elmer Mixed Std
Date	14/08/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9962
Detection Limit	0.68		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
blank	-0.001879649		
1 ppb	0.002548482		
2 ppb	0.005625086		
5 ppb	0.013254335		
10 ppb	0.027608774		
25 ppb	0.07572147		
50 ppb	0.131108067		
Blank	0.000105518	0.0386	
low level	0.003141609	1.1493	114.93
high level	0.132579196	47.7766	95.55
Jul 28 WL1	0.024583933	8.9710	
Jul 28 WL1	0.042621681	15.5205	
Jul 28 WL2	0.001888707	0.6910	
Jul 28 WL3	0.001772567	≤0.68	
Jul 28 WL4	0.037318965	13.5980	
Jul 28 WL5	0.003071641	1.1237	
Jul 28 WL6	0.004290238	1.5693	
Jul 28 WL7	0.132625429	47.7930	
Jul 28 WL8	0.001228877	≤0.68	
Jul 28 WL9	0.001787561	≤0.68	
Jul 28 WL10	0.037161375	13.5408	
Blank	0.000590224	0.2160	
low level	0.002801649	1.0250	102.50
high level	0.132102696	47.6075	95.22
Jul 28 WL11	0.002795962	1.0229	
Jul 28 WL11	0.024692547	9.0105	
Jul 28 WL12	0.002202501	0.8058	
Aug 4 WL1	0.010234333	3.7409	
Aug 4 WL2	0.001857484	≤0.68	
Aug 4 WL3	0.002246496	0.8219	
Aug 4 WL4	0.015758616	5.7565	
Aug 4 WL5	0.002423472	0.8867	
Aug 4 WL6	0.002577976	0.9432	
Aug 4 WL7	0.021894301	7.9920	
Aug 4 WL8	0.001954852	0.7152	
Blank	-0.000329388	-0.1205	
low level	0.002586221	0.9462	94.62
high level	0.148552387	53.4342	106.87
Aug 4 WL9	0.001178027	≤0.68	
Aug 4 WL9	0.022324406	8.1486	

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Conditions	GF AAS	**Standards source**	SCP
Analyte	Se 196.03	**QC Source**	Perkin Elmer Mixed Std
Date	14/08/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9962
Detection Limit	0.68		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
Aug 4 WL10	0.001698192	0.6214	
Aug 4 WL11	0.001390676	≤0.68	
Aug 4 WL12	0.001263633	≤0.68	
Aug 11 WL1	0.006677422	2.4418	
Aug 11 WL2	0.002159801	0.7902	
Aug 11 WL3	0.00200744	0.7345	
Aug 11 WL4	0.009793499	3.5800	
Aug 11 WL5	0.002964604	1.0846	
Aug 11 WL6	0.002785984	1.0192	
Blank	-0.000212777	-0.0779	
low level	0.002885126	1.0555	105.55
high level	0.135228944	48.7166	97.43
Aug 11 WL7	0.008058052	2.9462	
Aug 11 WL7	0.021569587	7.8738	
Aug 11 WL8	0.001082891	≤0.68	
Aug 11 WL9	0.0022478	0.8224	
Aug 11 WL10	0.001296226	≤0.68	
Aug 11 WL11	0.001736488	≤0.68	
Aug 11 WL12	0.001058766	≤0.68	
Aug 14 WL1	0.012261924	4.4810	
Aug 14 WL4	0.015243826	5.5688	
Aug 14 WL7	0.02128361	7.7697	
Aug 14 WL10	0.001653774	≤0.68	
Blank	-8.72E-05	-0.0319	
low level	0.002409657	0.8816	88.16
high level	0.135619348	48.8550	97.71

Conditions	GF AAS	**Standards source**	SCP
Analyte	Cd 228.80	**QC Source**	Perkin Elmer Mixed Std
Date	09/02/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9995
Detection Limit	0.05		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
blank	-0.003331556		
0.1 ppb	0.008115575		
0.2 ppb	0.015560695		
0.5 ppb	0.043761667		
1 ppb	0.086968326		
2 ppb	0.17535536		

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Conditions	GF AAS	**Standards source**	SCP
Analyte	Cd 228.80	**QC Source**	Perkin Elmer Mixed Std
Date	09/02/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9995
Detection Limit	0.05		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
5 ppb	0.423729351		
blank	-5.93E-06	-0.0001	
low level	0.007931778	0.0949	94.87
high level	0.4341052	5.0074	100.15
Aug 4 WL1	0.100526814	1.1928	
blank	0.000557584	0.0067	
low level	0.008340819	0.0998	99.76
high level	0.45475571	5.2366	104.73
Aug 4 WL2	0.000846988	≤0.05	
Aug 4 WL3	0.000816887	≤0.05	
Aug 4 WL3	0.094463713	1.1215	
Aug 4 WL4	0.478070996	5.4944	
Aug 4 WL4	0.242172088	2.8390	
Aug 4 WL5	0.00266314	≤0.05	
Aug 4 WL6	0.001746556	≤0.05	
Aug 4 WL7	0.556964874	6.3594	
Aug 4 WL7	0.445227303	5.1310	
Aug 4 WL7	0.130533011	1.5449	
Aug 4 WL8	0.000771359	≤0.05	
blank	0.001870404	0.0224	
low level	0.009936529	0.1188	118.83
high level	0.455448797	5.2443	104.89
Aug 4 WL9	0.002286002	≤0.05	
Aug 4 WL10	-0.000261605	≤0.05	
Aug 4 WL11	0.000592602	≤0.05	
Aug 4 WL12	-2.85E-05	≤0.05	
Aug 11 WL1	0.128411823	1.5200	
Aug 11 WL1	0.201327626	2.3684	
Aug 11 WL2	0.002159314	≤0.05	
Aug 11 WL3	0.00365273	≤0.05	
Aug 11 WL4	0.466416337	5.3657	
Aug 11 WL4	0.264933057	3.0998	
Aug 11 WL5	0.0040489	≤0.05	
blank	-0.000703975	-0.0084	
low level	0.009319608	0.1115	111.46
high level	0.45086362	5.1935	103.87
Aug 11 WL6	0.001991877	≤0.05	
Aug 11 WL7	0.369772176	4.2884	
Aug 11 WL8	0.003386749	≤0.05	
Aug 11 WL9	0.004944395	0.0592	

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Conditions	GF AAS	**Standards source**	SCP
Analyte	Cd 228.80	**QC Source**	Perkin Elmer Mixed Std
Date	09/02/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9995
Detection Limit	0.05		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
Aug 11 WL10	0.000175505	≤0.05	
Aug 11 WL11	0.001644273	≤0.05	
Aug 11 WL11	0.09781941	1.1610	
Aug 11 WL12	0.00070503	≤0.05	
Aug 14 WL1	0.148505422	1.7549	
Aug 14 WL4	0.504965968	5.7905	
Aug 14 WL4	0.272503422	3.1863	
blank	-0.000606952	-0.0073	
low level	0.009007601	0.1077	107.73
high level	0.467973912	5.3829	107.66
Aug 14 WL7	0.526362571	6.0252	
Aug 14 WL7	0.28186189	3.2932	
Aug 14 WL10	0.017070479	0.2040	
Aug 18 WL2	0.00429138	0.0513	
Aug 18 WL3	0.005397818	0.0646	
Aug 18 WL5	0.007108622	0.0850	
Aug 18 WL6	0.008084996	0.0967	
Aug 18 WL8	0.00798436	0.0955	
Aug 18 WL8	0.088932148	1.0563	
Aug 18 WL9	0.045987351	0.5482	
Aug 18 WL11	-0.000498076	≤0.05	
blank	6.05E-05	0.0007	
low level	0.008992254	0.1075	107.54
high level	0.474209326	5.4518	109.04
Aug 18 WL12	0.001384125	≤0.05	
blank	0.000138315	0.0017	
low level	0.008988161	0.1075	107.50
high level	0.452607598	5.2128	104.26

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Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Se 196.03	**QC Source**	Perkin Elmer Mixed Std
Date	09/04/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9989
Detection Limit	0.68		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
blank	-0.000924804		
1 ppb	0.002179419		
2 ppb	0.00394895		
5 ppb	0.01160137		
10 ppb	0.024136548		
25 ppb	0.061092115		
50 ppb	0.120173986		
Blank	0.000523937	0.2364	
low level	0.002045318	0.9213	92.13
high level	0.128374185	51.4079	102.82
Aug 4 WL1	0.010206643	4.5607	
Aug 4 WL2	0.002074029	0.9342	
Aug 4 WL3	0.002297185	1.0345	
Aug 4 WL3	0.025183107	11.0900	
Aug 4 WL4	0.015273901	6.7912	
Aug 4 WL5	0.002160848	0.9732	
Aug 4 WL6	0.002484341	1.1186	
Aug 4 WL7	0.021431334	9.4721	
Aug 4 WL8	0.001046304	≤0.68	
Aug 4 WL9	0.001355678	≤0.68	
Aug 4 WL10	0.001704024	0.7678	
Blank	-5.43E-05	-0.0245	
low level	0.002344869	1.0559	105.59
high level	0.129725445	51.8875	103.77
Aug 4 WL11	0.00153172	0.6903	
Aug 4 WL12	0.0011148	≤0.68	
Aug 11 WL1	0.005989162	2.6873	
Aug 11 WL1	0.018588816	8.2385	
Aug 11 WL2	0.001690287	0.7616	
Aug 11 WL3	0.001424201	≤0.68	
Aug 11 WL4	0.010297334	4.6008	
Aug 11 WL5	0.002933624	1.3203	
Aug 11 WL6	0.001416259	≤0.68	
Aug 11 WL7	0.008869006	3.9682	
Aug 11 WL8	0.001199705	≤0.68	
Blank	-9.18E-05	-0.0415	
low level	0.002641518	1.1891	118.91
high level	0.131847244	52.6381	105.28
Aug 11 WL9	0.001410542	≤0.68	
Aug 11 WL10	0.001213391	≤0.68	

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Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Se 196.03	**QC Source**	Perkin Elmer Mixed Std
Date	09/04/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9989
Detection Limit	0.68		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
Aug 11 WL11	0.001148154	≤0.68	
Aug 11 WL11	0.022544018	9.9532	
Aug 11 WL12	0.001106	≤0.68	
Aug 14 WL1	0.011097428	4.9544	
Aug 14 WL4	0.016904722	7.5044	
Aug 14 WL7	0.020614976	9.1185	
Aug 14 WL10	0.001460851	≤0.68	
Aug 18 WL2	0.00175023	0.7886	
Aug 18 WL3	0.001007379	≤0.68	
Blank	-0.000382122	-0.1725	
low level	0.002616343	1.1778	117.78
high level	0.132284115	52.7923	105.58
Aug 18 WL5	0.001947331	0.8772	
Aug 18 WL6	0.002648805	1.1924	
Aug 18 WL8	0.000995318	≤0.68	
Aug 18 WL8	0.015114963	6.7216	
Aug 18 WL9	0.00116432	≤0.68	
Aug 18 WL11	0.001109198	≤0.68	
Aug 18 WL12	0.001164352	≤0.68	
Blank	-0.000379849	-0.1715	
low level	0.002527278	1.1378	113.78
high level	0.131890087	52.6533	105.31

Conditions	Flame AAS	**Standards source**	SCP
Element/Wavelength	Zn 213.86	**QC Source**	Perkin Elmer Mixed Std
Date	09/09/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero		Mid level: ±10%
Detection Limit	5.40	**Correlation coefficient**	0.9949

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
blank	0.001720502		
10 ppb	0.004214334		
300 ppb	0.168835188		
1000 ppb	0.516298064		
2000 ppb	0.866859074		
blank	-0.00166597	-3.2584	
low level	0.004391502	8.5947	85.95
high level	0.850163415	1827.0318	91.35
mid level	0.511293875	1057.2792	105.73
Aug 14 WL1	0.266204164	535.8041	

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Conditions	Flame AAS	**Standards source**	SCP
Element/Wavelength	Zn 213.86	**QC Source**	Perkin Elmer Mixed Std
Date	09/09/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero		Mid level: ±10%
Detection Limit	5.40	**Correlation coefficient**	0.9949

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
Aug 14 WL4	0.281848194	568.2576	
Aug 14 WL7	0.298955972	603.8745	
Aug 14 WL10	0.011106746	21.7527	
blank	-0.001833912	-3.5868	
low level	0.004987383	9.7615	97.62
high level	0.854423026	1837.0720	91.85
mid level	0.504719251	1042.8745	104.29
Aug 18 WL2	0.011709385	22.9362	
Aug 18 WL2	0.008678152	16.9919	
Aug 18 WL3	0.007118474	13.9357	
Aug 18 WL5	0.008313125	16.2766	
Aug 18 WL6	0.006633667	12.9860	
Aug 18 WL8	0.008368634	16.3853	
Aug 18 WL9	0.008282143	16.2159	
Aug 18 WL11	0.013097502	25.6570	
Aug 18 WL12	0.007449708	14.5848	
Aug 18 WL12	0.007689014	15.0536	
blank	-0.000866621	-1.6951	
low level	0.005754929	11.2647	112.65
high level	0.845057784	1814.9443	90.75
mid level	0.512236157	1059.3030	105.93
Aug 21 WL2	0.006700812	13.1176	
Aug 21 WL2	0.007552138	14.7854	
Aug 21 WL3	0.006661507	13.0405	
Aug 21 WL5	0.006600151	12.9203	
Aug 21 WL6	0.004914165	9.6182	
Aug 21 WL8	0.007298528	14.2885	
Aug 21 WL9	0.005816139	11.3846	
Aug 21 WL11	0.004309029	8.4332	
Aug 21 WL12	0.005664984	11.0886	
Aug 21 WL12	0.00593474	11.6169	
blank	-0.00235655	-4.6088	
low level	0.004453023	8.7152	87.15
high level	0.849797607	1826.1514	91.31
mid level	0.509979993	1054.3598	105.44
Aug 21 WL1	0.277257095	558.7176	
Aug 21 WL4	0.277059868	558.3181	
Aug 21 WL7	0.00887566	17.3790	
Aug 21 WL10	0.008970489	17.5648	
Aug 21 WL7	0.288240621	581.5519	

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Conditions	Flame AAS	**Standards source**	SCP
Element/Wavelength	Zn 213.86	**QC Source**	Perkin Elmer Mixed Std
Date	09/09/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero		Mid level: ±10%
Detection Limit	5.40	**Correlation coefficient**	0.9949

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
Aug 22 WL2	0.0076565	14.9899	
Aug 22 WL3	0.005812442	11.3774	
Aug 22 WL3	0.006441952	12.6104	
Aug 22 WL5	0.006554127	12.8302	
Aug 22 WL6	0.007323358	14.3372	
Aug 22 WL8	0.006672226	13.0615	
Aug 22 WL9	0.008364496	16.3773	
Aug 22 WL9	0.008827707	17.2850	
Aug 22 WL11	0.004772811	9.3414	
Aug 22 WL12	0.005598708	10.9588	
blank	-0.001840914	-3.6005	
low level	0.005093732	9.9698	99.70
high level	0.842711308	1809.5170	90.48
mid level	0.515087913	1065.5478	106.55
Aug 25 WL2	0.006577767	12.8765	
Aug 25 WL2	0.006211399	12.1588	
Aug 25 WL2	0.005479728	10.7257	
Aug 25 WL3	0.005279522	10.3337	
Aug 25 WL3	0.00606176	11.8657	
Aug 25 WL3	0.006033953	11.8113	
Aug 25 WL5	0.006470919	12.6672	
Aug 25 WL6	0.005656724	11.0724	
Aug 25 WL8	0.007305649	14.3025	
Aug 25 WL8	0.008143671	15.9445	
Aug 25 WL9	0.007112422	13.9239	
Aug 25 WL11	0.010909316	21.3656	
Aug 25 WL12	0.003462103	6.7751	
blank	-0.00338644	-6.6222	
low level	0.00390577	7.6437	76.44

Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Cu 324.75	**QC Source**	Perkin Elmer Mixed Std
Date	23/9/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9991/0.9933
Detection Limit	0.57		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
blank	0.002021639		
0.5 ppb	0.002556265		
1 ppb	0.004112648		

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Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Cu 324.75	**QC Source**	Perkin Elmer Mixed Std
Date	23/9/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9991/0.9933
Detection Limit	0.57		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
2 ppb	0.007880763		
5 ppb	0.020396179		
10 ppb	0.04147264		
25 ppb	0.105115715		
blank	-8.94E-05	-0.0204	
low level	0.001886435	0.4306	86.13
high level	0.104755312	25.6377	102.55
Aug 4 WL1	0.002171989	49.5903	
Aug 4 WL1	0.009257615	212.3515	
Aug 4 WL2	0.005566461	1.2737	
Aug 4 WL3	0.004399891	1.0060	
Aug 4 WL4	0.018329237	422.9581	
Aug 4 WL5	0.00415604	0.9501	
Aug 4 WL6	0.004104299	0.9383	
Aug 4 WL7	0.021546267	498.2526	
blank	-0.000133889	-0.0305	
low level	0.002033564	0.4643	92.85
high level	0.107151706	26.2683	105.07
blank	0.00115203		
0.5 ppb	0.003008864		
1 ppb	0.004143695		
2 ppb	0.007814518		
5 ppb	0.019864043		
10 ppb	0.039258411		
25 ppb	0.098492606		
Aug 4 WL8	0.008646259	1.8565	
Aug 4 WL9	0.006236636	1.3313	
Aug 4 WL10	0.079096419	20.5312	
Aug 4 WL11	0.005206185	1.1085	
Aug 4 WL11	0.012293497	2.6635	
Aug 4 WL12	0.005369748	1.1438	
Aug 11 WL1	0.004017371	85.2937	
Aug 11 WL2	0.001694562	≤0.57	
Aug 11 WL3	0.001232136	≤0.57	
Aug 11 WL4	0.020746434	459.0967	
Aug 11 WL5	0.003282011	0.6956	
blank	-0.000294205	-0.0618	
low level	0.002455856	0.5194	103.89
high level	0.104746744	29.4271	117.71

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Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Se 196.03	**QC Source**	Perkin Elmer Mixed Std
Date	10/03/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9999/0.9999
Detection Limit	0.68		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
blank	-0.002242679		
1 ppb	0.002906817		
2 ppb	0.005975021		
5 ppb	0.013905937		
10 ppb	0.027073951		
25 ppb	0.066081708		
50 ppb	0.12768428		
Blank	0.000784481	0.2657	
low level	0.003404753	1.1656	116.56
high level	0.127976085	50.1077	100.22
Aug 21 WL1	0.005070508	1.7467	
Aug 21 WL1	0.01126537	3.9582	
Aug 25 WL2	0.00084686	≤0.68	
Aug 25 WL3	0.001112898	≤0.68	
Aug 21 WL4	0.00523533	1.8045	
Aug 25 WL5	0.00105555	≤0.68	
Aug 25 WL6	0.000751423	≤0.68	
Aug 21 WL7	0.005685648	1.9628	
Aug 25 WL8	0.000376847	≤0.68	
Aug 25 WL9	0.000838325	≤0.68	
Aug 21 WL10	0.000945175	≤0.68	
Blank	0.000837897	0.2839	
low level	0.003041743	1.0399	103.99
high level	0.127514001	49.9198	99.84
Aug 25 WL11	0.000445558	≤0.68	
Aug 25 WL11	0.015604325	5.5459	
Aug 25 WL12	0.000398654	≤0.68	
Aug 28 WL1	0.00577754	1.9952	
Sep 1 WL2	0.001208936	≤0.68	
Sep 1 WL3	0.000425236	≤0.68	
Aug 28 WL4	0.010520164	3.6884	
Sep 1 WL5	0.001033825	≤0.68	
Sep 1 WL6	0.000182214	≤0.68	
Aug 28 WL7	0.008052689	2.8021	
Sep 1 WL8	0.000380202	≤0.68	
Blank	0.001455855	0.4945	
low level	0.002371739	0.8087	80.87
high level	0.129257385	50.6289	101.26
Sep 1 WL9	0.000214605	≤0.68	
Sep 1 WL9	0.007472072	2.5952	

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Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Se 196.03	**QC Source**	Perkin Elmer Mixed Std
Date	10/03/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9999/0.9999
Detection Limit	0.68		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
Aug 28 WL10	0.000738918	≤0.68	
Sep 1 WL11	0.000182051	≤0.68	
Sep 1 WL12	0.000434983	≤0.68	
Sep 4 WL1	-5.13E-05	≤0.68	
Sep 8 WL2	0.0008358	≤0.68	
Sep 8 WL3	0.000640263	≤0.68	
Sep 4 WL4	0.005663419	1.9550	
Sep 8 WL5	0.000547937	≤0.68	
Sep 8 WL6	0.000737062	≤0.68	
Blank	0.001057757	0.3587	
low level	0.002693087	0.9194	91.94
high level	0.12902248	50.5333	101.07
Sep 4 WL7	0.006073605	2.0996	
Sep 4 WL7	0.011162352	3.9208	
Sep 8 WL8	0.000651822	≤0.68	
Sep 8 WL9	-0.000284445	≤0.68	
Sep 4 WL10	0.000473433	≤0.68	
Sep 8 WL11	0.000769834	≤0.68	
Sep 8 WL12	0.000456853	≤0.68	
Sep 11 WL1	0.007582452	2.6345	
Sep 15 WL2	0.001188998	≤0.68	
Sep 15 WL3	0.000270971	≤0.68	
Sep 11 WL4	0.014071446	4.9819	
Blank	-0.000272831	-0.0920	
low level	0.002395199	0.8168	81.68
high level	0.129990646	50.9272	101.85
Sep 15 WL5	0.004180689	1.4355	
Sep 15 WL5	0.01137816	3.9991	
Sep 15 WL6	0.000350961	≤0.68	
Sep 11 WL7	0.014340692	5.0807	
Sep 15 WL8	0.000233479	≤0.68	
Sep 15 WL9	0.000714803	≤0.68	
Sep 11 WL10	0.000744549	≤0.68	
Sep 15 WL11	0.000386659	≤0.68	
Sep 15 WL12	0.000726097	≤0.68	
Sep 18 WL1	0.009673825	3.3832	
Sep 22 WL2	0.000685108	≤0.68	
Blank	0.000371134	0.1255	
low level	0.002793687	0.9541	95.41
high level	0.129941362	50.9071	101.81

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Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Se 196.03	**QC Source**	Perkin Elmer Mixed Std
Date	10/03/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9999/0.9999
Detection Limit	0.68		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
Sep 22 WL3	0.00089484	≤0.68	
Sep 22 WL3	0.007680107	2.6693	
Sep 18 WL4	0.014451862	5.1216	
Sep 22 WL5	0.00063528	≤0.68	
Sep 22 WL6	0.000871539	≤0.68	
Sep 18 WL7	0.014237663	5.0429	
Sep 22 WL8	0.000214632	≤0.68	
Sep 22 WL9	0.000556132	≤0.68	
Sep 18 WL10	0.001178629	≤0.68	
Sep 22 WL11	0.000233898	≤0.68	
Sep 22 WL12	0.000945904	≤0.68	
Blank	0.001017828	0.3451	
low level	0.002396637	0.8172	81.72
high level	0.126317834	49.4334	98.87
blank	-0.002306704		
1 ppb	0.002210213		
2 ppb	0.004418832		
5 ppb	0.011242485		
10 ppb	0.023637822		
25 ppb	0.060400348		
50 ppb	0.123888266		
Blank	0.000984829	0.4491	
low level	0.002497452	1.1315	113.15
high level	0.118855434	48.0203	96.04
Sep 25 WL1	0.008841176	3.9176	
Sep 25 WL1	0.016426842	7.1399	
Sep 29 WL2	0.001138537	≤0.68	
Sep 29 WL3	0.001082364	≤0.68	
Sep 25 WL4	0.015460042	6.7340	
Sep 29 WL5	0.000966319	≤0.68	
Sep 29 WL6	0.000926813	≤0.68	
Sep 25 WL7	0.011531595	5.0712	
Sep 29 WL8	0.000699483	≤0.68	
Sep 29 WL9	0.000796952	≤0.68	
Sep 25 WL10	0.000821831	≤0.68	
Blank	0.000669421	0.3057	
low level	0.002028892	0.9211	92.11
high level	0.126310417	50.9468	101.89
Sep 29 WL11	0.00253344	1.1477	
Sep 29 WL11	0.024791081	10.6098	

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Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Se 196.03	**QC Source**	Perkin Elmer Mixed Std
Date	10/03/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9999/0.9999
Detection Limit	0.68		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
Sep 29 WL12	0.001254789	≤0.68	
Oct1 WL1	0.007020291	3.1285	
Oct1 WL4	0.008402776	3.7283	
Oct1 WL7	0.010587002	4.6677	
Oct1 WL10	0.000843314	≤0.68	
Jul 28 WL10	0.019868712	8.5761	
Blank	0.000146174	0.0669	
low level	0.002256379	1.0233	102.33
high level	0.124294107	50.1555	100.31

Conditions	Flame AAS	**Standards source**	SCP
Element/Wavelength	Zn 213.86	**QC Source**	Perkin Elmer Mixed Std
Date	20/10/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero		Mid level: ±10%
Detection Limit	5.40	**Correlation coefficient**	0.9998/0.9999

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
blank	0.420360173		
10 ppb	0.005966746		
300 ppb	0.1789273		
1000 ppb	0.528848007		
2000 ppb	0.903043039		
blank	-0.001515436	-2.5126	
low level	0.006339549	10.5236	105.24
high level	0.906217808	2026.5109	101.33
mid level	0.531644518	990.0639	99.01
Aug 28 WL1	0.328393087	578.6193	
Sep1 WL2	0.012714532	21.1258	
Sep1 WL3	0.010694989	17.7649	
Aug 28 WL4	0.361235833	641.4593	
Sep1 WL5	0.011652229	19.3577	
Sep1 WL6	0.011591494	19.2566	
Aug 28 WL7	0.284075498	495.5948	
Sep1 WL8	0.012450578	20.6865	
Sep1 WL9	0.011973891	19.8930	
Aug 28 WL10	0.018984512	31.5746	
Aug 28 WL10	0.016169278	26.8800	
blank	-0.001071608	-1.7768	
low level	0.005099276	8.4631	84.63
high level	0.900125916	2004.3207	100.22

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Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	Flame AAS	**Standards source**	SCP
Element/Wavelength	Zn 213.86	**QC Source**	Perkin Elmer Mixed Std
Date	20/10/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero		Mid level: ±10%
Detection Limit	5.40	**Correlation coefficient**	0.9998/0.9999

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
mid level	0.529838529	986.2038	98.62
Sep1 WL11	0.009895092	16.4344	
Sep1 WL11	0.00834672	13.8595	
Sep1 WL12	0.007399771	12.2854	
Sep 4 WL1	0.320582801	563.8838	
Sep 8 WL2	0.009164648	15.2195	
Sep 8 WL2	0.009302224	15.4483	
Sep 8 WL2	0.009991965	16.5955	
Sep 8 WL3	0.00786674	13.0615	
Sep 4 WL4	0.335455119	592.0138	
Sep 8 WL5	0.009405436	15.6199	
Sep 8 WL6	0.008295518	13.7743	
Sep 4 WL7	0.293133727	512.4083	
Sep 8 WL8	0.011429451	18.9870	
blank	-0.000889507	-1.4750	
low level	0.005577574	9.2576	92.58
high level	0.891481966	1973.1457	98.66
mid level	0.542922104	1014.7879	101.48
Sep 8 WL9	0.012680452	21.0693	
Sep 8 WL9	0.011218303	18.6357	
Sep 4 WL10	0.014918947	24.7968	
Sep 8 WL11	0.009308917	15.4594	
Sep 8 WL12	0.007542543	12.5226	
Sep 11 WL1	0.338269899	597.3698	
Sep 15 WL2	0.01355407	22.5236	
blank	-0.001054448	-1.7484	
low level	0.005654432	9.3852	93.85
high level	0.871800262	1902.9510	95.15
mid level	0.532543902	992.1868	99.22
blank	-0.002160573		
10 ppb	0.005701579		
300 ppb	0.156842622		
1000 ppb	0.486758137		
2000 ppb	0.82515406		
blank	0.001055874	1.8768	
low level	0.005873037	10.4532	104.53
high level	0.821551192	1980.9958	99.05
mid level	0.482366448	1003.9894	100.40
Sep 15 WL3	0.011089602	19.7671	
Sep 11 WL4	0.325598192	640.2363	

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Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	Flame AAS	**Standards source**	SCP
Element/Wavelength	Zn 213.86	**QC Source**	Perkin Elmer Mixed Std
Date	20/10/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero		Mid level: ±10%
Detection Limit	5.40	**Correlation coefficient**	0.9998/0.9999

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
Sep 15 WL5	0.014367731	25.6342	
Sep 15 WL6	0.013729625	24.4913	
Sep 11 WL7	0.280834386	543.9034	
Sep 15 WL8	0.014923794	26.6306	
Sep 15 WL9	0.013572007	24.2090	
Sep 11 WL10	0.015996852	28.5540	
Sep 15 WL11	0.010462949	18.6468	
Sep 15 WL12	0.011146085	19.8682	
blank	0.000525414	0.9338	
low level	0.006208232	11.0509	110.51
high level	0.848258291	2072.9494	103.65
mid level	0.493882267	1032.4675	103.25
Sep 18 WL1	0.265214306	510.9919	
Sep 22 WL2	0.010108991	18.0142	
Sep 22 WL3	0.011558928	20.6064	
Sep 18 WL4	0.284493218	551.6652	
Sep 22 WL5	0.00820523	14.6138	
Sep 22 WL6	0.009296288	16.5623	
Sep 22 WL6	0.008642791	15.3950	
Sep 18 WL7	0.285457341	553.7146	
Sep 22 WL8	0.012810645	22.8460	
Sep 22 WL9	0.013977812	24.9358	
Sep 18 WL10	0.014930596	26.6427	
Sep 22 WL11	0.009584577	17.0771	
Sep 22 WL12	0.009119938	16.2472	
blank	-0.000666624	-1.1843	
low level	0.00491572	8.7470	87.47
high level	0.847111227	2068.9553	103.45
mid level	0.493615578	1031.9337	103.19
Sep 25 WL1	0.273675506	528.7758	
Sep 29 WL2	0.009994445	17.8095	
Sep 29 WL3	0.011831648	21.0942	
Sep 25 WL4	0.319073339	626.0077	
Sep 29 WL5	0.012524489	22.3339	
Sep 29 WL6	0.012620316	22.5054	
Sep 25 WL7	0.304686756	594.8568	
Sep 29 WL8	0.015896201	28.3735	
Sep 29 WL9	0.013222954	23.5841	
Sep 25 WL10	0.011789986	21.0197	
Sep 29 WL11	0.011487331	20.4784	

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Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	Flame AAS	**Standards source**	SCP
Element/Wavelength	Zn 213.86	**QC Source**	Perkin Elmer Mixed Std
Date	20/10/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero		Mid level: ±10%
Detection Limit	5.40	**Correlation coefficient**	0.9998/0.9999

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
Sep 29 WL12	0.010703869	19.0774	
blank	0.000544883	0.9684	
low level	0.00607136	10.8068	108.07
high level	0.844765802	2061.3352	103.07
blank	-0.004187681		
10 ppb	0.007499846		
300 ppb	0.172956124		
1000 ppb	0.501478551		
2000 ppb	0.855038044		
blank	0.004600027	6.2642	
low level	0.008542029	11.6807	116.81
high level	0.855454992	1989.0195	99.45
mid level	0.504115793	1032.4798	103.25
Oct1 WL1	0.249006146	437.9382	
Oct1 WL4	0.298150762	543.5597	
Oct1 WL4	0.309601464	568.6435	
Oct1 WL7	0.305417049	559.3826	
Oct1 WL10	0.007116039	9.7108	
Oct2 WL2	0.060719371	89.0190	
blank	-0.000304524	-0.4108	
low level	0.006046573	8.2385	82.39
high level	0.865180926	2017.2012	100.86
mid level	0.506430055	1038.4319	103.84
Oct2 WL3	0.04570743	65.7522	
Oct2 WL3	0.039369475	56.1633	
Oct2 WL5	0.048083337	69.3705	
Oct2 WL6	0.03063359	43.2108	
Oct2 WL6	0.029321744	41.2740	
Oct2 WL8	0.101845187	156.5709	
Oct2 WL9	0.070085168	103.9868	
Oct2 WL9	0.064832934	95.5056	
Oct2 WL11	0.016377309	22.6458	
Oct2 WL12	0.014068009	19.3906	
Oct2 WL12	0.013289913	18.2967	
blank	-0.000308608	-0.4163	
low level	0.007063092	9.6377	96.38
high level	0.838952864	1941.5494	97.08
mid level	0.510868935	1049.6322	104.96

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Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Se 196.03	**QC Source**	Perkin Elmer Mixed Std
Date	24/10/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9992
Detection Limit	0.68		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
blank	0.000487194		
1 ppb	0.001961169		
2 ppb	0.004667266		
5 ppb	0.012688935		
10 ppb	0.025438482		
25 ppb	0.062104194		
50 ppb	0.122908614		
Blank	-0.000453045	-0.1932	
low level	0.002183181	0.9297	92.97
high level	0.135461216	53.2238	106.45
Oct 2 WL2	0.00136311	≤0.68	
Oct 2 WL2	0.006912836	2.9351	
Oct 2 WL3	0.001318478	≤0.68	
Oct 2 WL5	-0.000331929	≤0.68	
Blank	-0.000262655	-0.1120	
low level	0.00258288	1.0996	109.96
high level	0.126856609	50.0931	100.19
Oct 2 WL6	0.00304865	1.2975	
Oct 2 WL8	0.002432184	1.0356	
Oct 2 WL9	0.002258739	0.9618	
Oct 2 WL11	0.000194264	≤0.68	
Oct 2 WL12	0.00085298	≤0.68	
Blank	-0.000364903	-0.1556	
low level	0.002145221	0.9136	91.36
high level	0.128834595	50.8156	1.00

Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Cu 324.75	**QC Source**	Perkin Elmer Mixed Std
Date	11/07/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9993/0.9999/0.9955
Detection Limit	0.57		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
blank	0.002084538		
0.5 ppb	0.001725028		
1 ppb	0.003593875		
2 ppb	0.007163194		
5 ppb	0.018541995		
10 ppb	0.038956882		
25 ppb	0.094758603		

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Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Cu 324.75	**QC Source**	Perkin Elmer Mixed Std
Date	11/07/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9993/0.9999/0.9955
Detection Limit	0.57		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
blank	0.00092491	0.2574	
low level	0.00191356	0.5320	106.40
high level	0.105185181	26.9313	107.73
2R	0.015177904	41.7382	
2R	0.022636752	61.8700	
2S	0.03027003	82.2199	
5R	0.016699025	45.8638	
5S	0.024164941	65.9643	
8R	0.050224222	134.2433	
8S	0.022571161	61.6940	
11R	0.028621995	77.8477	
11R	0.002230765	6.2005	
11S	0.01577296	43.3534	
12R	0.010733847	29.6257	
blank	-0.000315004	-0.0877	
low level	0.001856548	0.5162	103.24
high level	0.106036971	27.1317	108.53
blank	0.003068128		
0.5 ppb	0.000876996		
1 ppb	0.002850681		
2 ppb	0.006750018		
5 ppb	0.018063193		
10 ppb	0.037843036		
25 ppb	0.096132177		
12S	0.019568825	54.0344	
12S	0.026462665	71.7271	
14R	0.020897122	57.4488	
blank	-0.001784071	-1.9987	
low level	0.001514088	0.5691	113.83
high level	0.10756439	27.8761	111.50
14S	0.015772361	44.2526	
18R	0.017219664	47.9864	
18S	0.020258913	55.8087	
20R	0.013427214	38.1854	
20S	0.022320825	61.1051	
21R	0.028090394	75.8968	
21S	0.021479354	58.9445	
25R	0.02249885	61.5621	
blank	-0.001561816	-1.3535	
low level	0.001145679	0.4454	89.08

YRC AA QC Report

Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Cu 324.75	**QC Source**	Perkin Elmer Mixed Std
Date	11/07/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9993/0.9999/0.9955
Detection Limit	0.57		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
high level	0.097862387	25.4018	101.61
25S	0.013482071	38.3276	
25S	0.020953443	57.5935	
26R	0.022963856	6.2756	
26S	0.016790637	4.6880	
32R	0.012089984	3.4713	
32S	0.012077779	3.4681	
S1	0.052526041	13.8350	
S2	0.029578901	7.9708	
S3	0.027431697	7.4210	
B1	0.072017559	18.8092	
B2	0.216143871	55.5619	
B2	0.116198833	60.1562	
B2	0.116198833	60.1562	
blank	-0.000149757	-0.0702	
low level	0.001336869	0.5104	102.07
high level	0.097461777	25.2996	101.20
B3	0.075975091	19.8189	
B3	0.083663169	21.7801	
B2	0.006404558	19.7321	
P2R	0.448884188	114.8986	
P2R	0.235414511	120.9503	
P2R	0.011166671	12.9232	
P2S	0.020145441	5.5517	
P11R	0.010897535	3.1606	
P11S	0.014108302	3.9950	
P26R	0.02356283	6.4292	
P26S	0.019261555	5.3244	
blank	-0.001678355	-1.6410	
low level	0.001462204	0.5521	110.41
high level	0.098062842	25.4529	101.81
0.5 ppb	0.001791648		
1 ppb	0.004514763		
2 ppb	0.012082321		
5 ppb	0.019226983		
10 ppb	0.038921798		
25 ppb	0.104004945		
blank	-2.25E-05	-0.0048	
low level	0.002384256	0.5096	101.92
high level	0.0979602	24.4174	97.67

YRC AA QC Report

Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Cu 324.75	**QC Source**	Perkin Elmer Mixed Std
Date	11/07/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9993/0.9999/0.9955
Detection Limit	0.57		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
P42R	0.017739006	3.8804	
P42S	0.014899893	3.2453	
P50R	0.017997169	3.9384	
P50S	0.00969844	2.0958	
P36R	0.017798024	3.8936	
P36R	0.013618135	2.9603	
P36S	0.018504839	4.0526	
blank	0.000142295	0.0303	
low level	0.002588355	0.5534	110.68
high level	0.100722546	25.2271	100.91

Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Cu 324.75	**QC Source**	Perkin Elmer Mixed Std
Date	11/12/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9999/0.9998
Detection Limit	0.57		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
blank	0.00239559		
0.5 ppb	0.001097302		
1 ppb	0.002559348		
2 ppb	0.005894417		
5 ppb	0.016282656		
10 ppb	0.033441745		
25 ppb	0.08878132		
blank	0.000100366	0.0433	
low level	0.001420153	0.5719	114.38
high level	0.093096118	26.1850	104.74
36R	0.016621973	52.1900	
36R	0.02223021	67.9186	
36S	0.01039415	34.3243	
38R	0.009052253	30.3710	
38S	0.014277105	45.5321	
40R	0.039159023	114.6508	
40S	0.040504892	118.3428	
42R	0.013231625	42.5408	
42S	0.011066815	36.2876	
43R	0.014596527	46.4430	
43S	0.014830786	47.1101	
blank	7.04E-05	0.0305	

YRC AA QC Report

Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Cu 324.75	**QC Source**	Perkin Elmer Mixed Std
Date	11/12/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9999/0.9998
Detection Limit	0.57		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
low level	0.001241068	0.5039	100.78
high level	0.097127928	27.2824	109.13
blank	0.002192108		
0.5 ppb	0.001844367		
1 ppb	0.003524253		
2 ppb	0.006557337		
5 ppb	0.016921205		
10 ppb	0.03611567		
25 ppb	0.09805002		
blank	0.000785158	0.2271	
low level	0.001542654	0.4458	89.17
high level	0.095427231	24.6116	98.45
47R	0.007003199	20.0992	
47R	0.013189139	37.5565	
47S	0.006480025	18.6101	
49R	0.020220383	57.0704	
49S	0.015978824	45.3402	
50R	0.018613442	52.6410	
50S	0.016589285	47.0361	
56R	0.009744753	27.8700	
56S	0.014479034	41.1623	
57R	0.000890611	2.5761	
57S	0.000543778	1.5736	
blank	-3.37E-05	-0.0098	
low level	0.001655702	0.4785	95.69
high level	0.096222314	24.7941	99.18
60R	0.018899864	53.4318	
60R	0.003398137	9.7977	
60S	0.001209984	3.4985	
62R	0.00693535	19.9062	
62S	0.000919556	2.6598	
S1	0.000194329	≤0.57	
S2	0.001063065	3.0743	
S3	-0.000354423	≤0.57	
B1	0.001332616	3.8525	
B2	0.000993766	2.8741	
B3	0.000573069	1.6583	
blank	-0.000197967	-0.0573	
low level	0.001589567	0.4594	91.88
high level	0.09821582	25.2501	101.00

YRC AA QC Report

Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Cu 324.75	**QC Source**	Perkin Elmer Mixed Std
Date	11/12/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9999/0.9998
Detection Limit	0.57		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
S1	0.000651924	1.8863	
S1	0.003128018	9.0220	
57R	-0.000449681	≤0.57	
57S	0.012964081	36.9262	
62S	0.006378906	18.3221	
S1	0.019584919	55.3209	
S2	0.020781999	58.6142	
S3	0.019615613	55.4055	
57R	-0.00058176	≤0.57	
blank	0.000586839	0.1698	
low level	0.002010394	0.5807	116.14
high level	0.098079503	25.2190	100.88
57R	0.000346623	1.0033	
Oct2-Cont-Car	0.0046792	13.4692	
Oct2-Cont-Jun	0.005940063	17.0711	
Oct2-PitC-Car	0.003772748	108.7260	
Oct2-PitC-Jun	0.0008224	23.7905	
Oct2-TMF-Car	0.01160311	33.1067	
blank	0.000216849	0.0628	
low level	0.001413557	0.4086	81.72
high level	0.103192236	26.3795	105.52
Oct2-TMF-Jun	0.011849071	33.7979	
Oct2-Pit-Car	-0.00055869	≤0.57	
Oct2-Pit-Jun	-0.000767135	≤0.57	
blank	0.00041745	0.1208	
low level	0.001817681	0.5251	105.03
high level	0.104756743	26.7319	106.93
Oct2-Pit-Jun	-0.000188959	≤0.57	
Oct2-Pit-Car	-0.000520331	≤0.57	
57R	0.018950981	53.5729	
blank	0.000298669	0.0865	
low level	0.001675301	0.4841	96.82
high level	0.106841387	27.1996	108.80

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Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AA-MS	**Standards source**	SCP
Element/Wavelength	Cu 324.75	**QC Source**	Perkin Elmer Mixed Std
Date	13/11/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9997
Detection Limit	0.57		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
blank	0.002698205		
0.5 ppb	0.002096831		
1 ppb	0.00268443		
2 ppb	0.006416297		
5 ppb	0.016885123		
10 ppb	0.035039951		
25 ppb	0.090619001		
blank	5.22E-05	0.0151	
low level	0.001909017	0.5521	110.43
high level	0.094536353	26.3529	105.41
Oct2-TMF-Car	0.018338068	5.2687	
Oct2-Pit-Car	0.02229913	6.3965	
Oct2-Pit-Jun	0.02136957	6.1322	
blank	0.000800192	0.2315	
low level	0.001738996	0.5030	100.60
high level	0.092664172	25.8499	103.40

Conditions	GF AA-MS	**Standards source**	SCP
Element/Wavelength	Se 196.03	**QC Source**	Perkin Elmer Mixed Std
Date	14/11/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9993
Detection Limit	0.68		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
blank	-0.00020016		
1 ppb	0.002202941		
2 ppb	0.005342407		
5 ppb	0.012240822		
10 ppb	0.026372351		
25 ppb	0.062275826		
50 ppb	0.115137247		
Blank	-0.000263706	-0.1046	
low level	0.002540199	1.0094	100.94
high level	0.107689826	45.3700	90.74
B1	0.00363194	1.4441	
B2	0.002182959	0.8673	
B3	0.003111839	1.2370	
S1	0.006581208	2.6210	
Blank	0.000153587	0.0610	
low level	0.002701332	1.0736	107.36

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Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AA-MS	**Standards source**	SCP
Element/Wavelength	Se 196.03	**QC Source**	Perkin Elmer Mixed Std
Date	14/11/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9993
Detection Limit	0.68		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
high level	0.118990096	50.4572	100.91
S2	0.006154059	2.4503	
S3	0.005412402	2.1542	
P2R	0.008157373	3.2515	
P2S	0.005014653	1.9954	
P11R	0.006330826	2.5209	
P11S	0.005926202	2.3593	
P26R	0.005713715	2.2744	
P26S	0.004913956	1.9552	
2R	0.012396381	4.9525	
2S	0.009741985	3.8864	
Blank	0.001254775	0.4983	
low level	0.002653361	1.0545	105.45
high level	0.117767398	49.9036	99.81
5R	0.02252169	9.0474	
5S	0.003454532	1.3735	
8R	0.045761731	18.6196	
8S	0.010393169	4.1477	
11R	0.019477787	7.8116	
11S	0.009136588	3.6437	
12R	0.019682828	7.8948	
12S	0.014816684	5.9272	
14R	0.017890041	7.1687	
14S	0.016351154	6.5465	
Blank	-0.000558103	-0.2214	
low level	0.002784676	1.1067	110.67
high level	0.123513826	52.5123	105.02
18R	0.018013391	7.2186	
18S	0.005918615	2.3563	
20R	0.009058676	3.6125	
20S	0.006308185	2.5119	
21R	0.016957061	6.7914	
21S	0.005644038	2.2466	
25R	0.004879355	1.9414	
25S	0.005720097	2.2770	
26R	0.007815612	3.1147	
26S	0.012934033	5.1688	
Blank	0.000159446	0.0633	
low level	0.002462278	0.9784	97.84
high level	0.122751804	52.1654	104.33

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Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AA-MS	**Standards source**	SCP
Element/Wavelength	Se 196.03	**QC Source**	Perkin Elmer Mixed Std
Date	14/11/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9993
Detection Limit	0.68		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
32R	0.007268585	2.8958	
32S	0.012415528	4.9602	
Blank	-7.37E-05	-0.0292	
low level	0.002896816	1.1514	115.14
high level	0.124635842	53.0237	106.05

Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Se 196.03	**QC Source**	Perkin Elmer Mixed Std
Date	21/1/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9998/0.9992
Detection Limit	0.68		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
blank	0.000654297		
1 ppb	0.002381765		
2 ppb	0.004384457		
5 ppb	0.010194361		
10 ppb	0.022043857		
25 ppb	0.056310803		
50 ppb	0.110146362		
Blank	-5.40E-05	-0.0243	
low level	0.001968726	0.8862	88.62
high level	0.113881563	51.6465	103.29
B1	-0.000368901	≤0.68	
B1	0.025803528	11.6341	
B2	-0.000117625	≤0.68	
B3	-7.52E-05	≤0.68	
S1	0.002382341	1.0725	
S2	0.001816988	0.8179	
S3	0.001131602	≤0.68	
36R	0.003968414	1.7867	
36S	0.00249049	1.1212	
38R	0.004272275	1.9235	
38S	0.001478981	≤0.68	
Blank	-0.000706464	-0.3180	
low level	0.001996756	0.8989	89.89
high level	0.120465209	54.6561	109.31
40R	0.005088691	2.2912	
40R	0.02926857	13.1994	
40S	0.007241999	3.2612	

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Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Se 196.03	**QC Source**	Perkin Elmer Mixed Std
Date	21/1/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9998/0.9992
Detection Limit	0.68		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
42R	0.002509036	1.1295	
42S	0.003054619	1.3752	
43R	0.003411661	1.5359	
43S	0.006572578	2.9596	
47R	0.002770528	1.2473	
47S	0.003988505	1.7957	
49R	0.004683099	2.1085	
49S	0.000797869	≤0.68	
Blank	-4.97E-05	-0.0224	
low level	0.001946065	0.8760	87.60
high level	0.120814524	54.8159	109.63
blank	0.000379221		
1 ppb	0.001939501		
2 ppb	0.004479326		
5 ppb	0.011917518		
10 ppb	0.025793855		
25 ppb	0.060880264		
50 ppb	0.134687601		
Blank	-0.000959307	-0.4229	
low level	0.002547866	1.1193	111.93
high level	0.120561097	47.2749	94.55
50R	0.004856353	2.1284	
50R	0.029955186	12.8018	
50S	0.000403869	≤0.68	
56R	0.003633222	1.5943	
56S	0.012709533	5.5261	
57R	0.002594036	1.1395	
57S	0.001458485	≤0.68	
60R	0.005677392	2.4862	
60S	0.00330461	1.4506	
62R	0.003092133	1.3576	
62S	-0.000188699	≤0.68	
high level	0.128700238	50.0954	100.19
Blank	-0.00088139	-0.3886	
low level	0.00250946	1.1025	110.25
P36R	0.006895944	3.0161	
P36R	0.03398552	14.4663	
P36S	0.002156889	0.9479	
P42R	0.006967483	3.0471	
P42S	0.001854583	0.8153	

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Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Se 196.03	**QC Source**	Perkin Elmer Mixed Std
Date	21/1/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9998/0.9992
Detection Limit	0.68		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
P50R	0.006433997	2.8153	
P50S	0.002478843	1.0890	
B1	0.029188528	12.4836	
B2	0.005825097	2.5505	
B3	0.005116343	2.2418	
S1	0.050722266	2123.9369	
Blank	0.000362586	0.1596	
low level	0.002383811	1.0474	104.74
high level	0.114828173	45.2631	90.53
S2	0.07577841	3097.7038	
S2	0.092068998	3706.3545	
S3	0.062205417	2576.0329	
Blank	0.000459274	0.2022	
low level	0.002713453	1.1918	119.18
high level	0.115634496	45.5473	91.09

Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Cu 324.75	**QC Source**	Perkin Elmer Mixed Std
Date	24/11/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9994
Detection Limit	0.57		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
blank	0.001191273		
0.5 ppb	0.003484426		
1 ppb	0.003840771		
2 ppb	0.008125533		
5 ppb	0.021762119		
10 ppb	0.046049765		
25 ppb	0.117747726		
0.5 ppb	0.002752097		
1 ppb	0.004428422		
blank	-0.000358457	-0.0767	
low level	0.002124163	0.4546	90.92
high level	0.111021956	24.0886	96.35
blank	3.11E-05	0.0067	
60S	0.184379167	40.3804	
60S	0.091883052	39.7755	
blank	-0.000320434	-6.8558	
low level	0.002223097	47.5788	95.16

YRC AA QC Report

Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Cu 324.75	**QC Source**	Perkin Elmer Mixed Std
Date	24/11/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9994
Detection Limit	0.57		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
high level	0.110857891	240.5248	96.21
PCC1	0.053121876	11.4420	
PCC2	0.044884359	9.6577	
PCC3	0.048596695	10.4613	
PCJ1	0.047110031	10.1394	
PCJ2	0.033809339	7.2646	
PCJ3	0.069497229	15.0000	
PC1	0.043652316	9.3911	
PC2	0.041805239	8.9917	
PC3	0.038790883	8.3402	
PJ1	0.076679274	16.5651	
blank	0.000767867	16.4309	
low level	0.00230115	49.2498	98.50
high level	0.106512755	230.9701	92.39
PJ2	0.044726791	9.6236	
PJ3	0.032088306	6.8933	
TJ1	0.017245604	3.6979	
TJ2	0.031294714	6.7221	
TJ3	0.036325926	7.8078	
TC1	0.016730862	3.5873	
TC2	0.023094817	4.9557	
TC3	0.0272307	5.8462	
S1	0.678328741	158.5782	
S1	0.476221754	216.6808	
S1	0.272867797	241.7767	
S1	0.272867797	241.7767	
blank	0.001017221	21.7673	
low level	0.002606895	55.7956	111.59
high level	0.108826741	236.0571	94.42
Sp1	0.141343407	30.7858	
Sp1	0.070767537	30.5532	
Sp2	0.143978066	31.3701	
Sp2	0.072326005	31.2322	
Sp3	0.135147768	29.4131	
Sp3	0.067268036	29.0295	
CC1	0.036050732	7.7484	
CC2	0.028468853	6.1130	
CC3	0.029409602	6.3157	
CJ1	0.014640894	3.1383	
blank	0.00020317	4.3472	

YRC AA QC Report

Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Cu 324.75	**QC Source**	Perkin Elmer Mixed Std
Date	24/11/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9994
Detection Limit	0.57		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
low level	0.002076432	44.4391	88.88
high level	0.110064756	238.7799	95.51
PreMin1	0.282778612	62.7200	
PreMin1	0.282778612	62.7200	
CJ2	0.03151509	6.7697	
CJ3	0.022825	4.8976	
B1	0.006628798	14.1948	
B2	0.006492568	1.3903	
B3	0.006450583	1.3813	
PreMud1	0.047272626	10.1746	
PreMud2	0.042616333	9.1671	
PreMud3	0.02123167	4.5548	
preMin1	0.016885969	3.6206	
blank	0.000251616	5.3838	
low level	0.00220291	47.1467	94.29
high level	0.112983028	245.2017	98.08
preMin2	0.020774893	4.4566	
PreMin3	0.022397624	4.8057	
blank	0.000458628	0.0981	
low level	0.00243592	0.5214	104.27
high level	0.118450715	25.7246	102.90
S3	0.113240776	24.5769	
S2	0.125168061	27.2066	
S2	0.063631361	27.4475	
S1	0.125014194	27.1727	
S1	0.06255466	26.9794	
blank	0.001107517	0.2370	
low level	0.002554003	0.5466	109.33
high level	0.12176247	26.4550	105.82

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Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Se 196.03	**QC Source**	Perkin Elmer Mixed Std
Date	25/11/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9987
Detection Limit	0.68		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
blank	0.000798239		
1 ppb	0.002353703		
2 ppb	0.004167162		
5 ppb	0.009993193		
10 ppb	0.021883981		
25 ppb	0.055150505		
50 ppb	0.096837007		
Blank	0.000810504	0.3682	
low level	0.001837857	0.8357	83.57
high level	0.09566737	47.9226	95.85
PCC1	0.002716392	123.6212	
PCC2	-0.000161921	≤0.68	
PCC3	0.002107249	95.8420	
PCC2	0.00711462	3.2519	
PCJ1	0.006618074	302.3455	
PCJ2	0.007679514	351.2055	
PCJ3	0.005870373	267.9888	
PC1	0.005069665	231.2528	
PC2	0.003638604	165.7409	
PC2	0.030776693	1440.4157	
PC3	0.004364084	198.9292	
Blank	-0.000786377	-0.3566	
low level	0.001815786	0.8256	82.56
high level	0.090900599	45.3008	90.60
S1	0.108711627	55.2376	
S1	0.040054384	37.8481	
PJ1	0.005337319	243.5262	
PJ2	0.00501984	228.9688	
PJ3	0.004709709	214.7572	
TJ1	0.003399502	154.8132	
TJ2	0.004152577	189.2486	
TJ3	0.003134844	142.7235	
TC1	0.005153422	235.0928	
TC2	0.004781828	218.0612	
Blank	0.000517368	0.2349	
low level	0.002152857	0.9792	97.92
high level	0.092745246	46.3122	92.62
TC3	0.018120387	837.3443	
Sp1	0.067307052	3271.0892	
Sp2	0.064667841	3134.1292	

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Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Se 196.03	**QC Source**	Perkin Elmer Mixed Std
Date	25/11/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9987
Detection Limit	0.68		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
Sp3	0.055989574	2689.0718	
CC1	0.004496873	205.0090	
CC2	0.003215413	146.4032	
CC3	0.003043217	138.5393	
CJ1	0.002879023	131.0434	
CJ2	0.002809783	127.8831	
CJ3	0.002758704	125.5520	
Blank	0.000390451	0.1773	
low level	0.002133496	0.9704	97.04
high level	0.099198713	49.8825	99.76
B1	0.075878726	3721.2003	
B2	0.012430788	571.1791	
B3	0.008493731	388.7551	
PreMud1	0.006981649	319.0700	
PreMud2	0.00520693	237.5463	
PreMud3	0.006384028	291.5857	
preMin1	0.00203522	92.5595	
preMin2	0.001837177	83.5364	
PreMin3	0.00193968	88.2061	
S3	0.074993951	3674.3610	
Blank	1.23E-05	0.0056	
low level	0.002145089	0.9757	97.57
high level	0.0927814	46.3321	92.66
S2	0.088716556	4410.8556	
S1	0.084485686	4181.4766	
Blank	-0.000173284	-0.0786	
low level	0.00185101	0.8417	84.17
high level	0.091274177	45.5053	91.01

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Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Cu 324.75	**QC Source**	Perkin Elmer Mixed Std
Date	12/03/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9991
Detection Limit	0.57		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
blank	0.001587511		
0.5 ppb	0.002121027		
1 ppb	0.004637727		
2 ppb	0.008500616		
5 ppb	0.017990999		
10 ppb	0.045343474		
25 ppb	0.118435827		
blank	0.001206153	0.2847	
low level	0.002509736	0.5917	118.35
high level	0.104958433	22.6176	90.47
2R	0.009258871	21.6958	
2S	0.007445809	17.4763	
5R	0.015358993	35.7905	
5S	0.016503203	38.4169	
B1	0.00184378	4.3499	
Std1	0.203354842	404.7635	
Std1	0.099226104	429.7162	
B2	0.003780381	8.9029	
B3	0.002222143	5.2407	
Std2	0.194827879	3903.7339	
Std2	0.101006217	4367.6914	
blank	0.00114433	0.2701	
low level	0.002130544	0.5025	100.50
high level	0.105393143	22.7030	90.81
Std2	0.018925585	439.5924	
Std3	0.018336559	426.1381	
CRM1	0.020309818	47.1154	
CRM2	0.017540006	40.7921	
CRM3	0.020177073	46.8131	
8R	0.076677605	169.2537	
8S	0.020418698	47.3633	
11R	0.016721475	38.9173	
11S	0.01418389	33.0875	
12R	0.014709317	34.2968	
blank	-0.000170869	-0.0404	
low level	0.001942261	0.4582	91.64
high level	0.10742539	23.1014	92.41
Spike1	0.101789231	219.9324	
12S	0.011967715	27.9741	
14R	0.01648041	38.3647	

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Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Cu 324.75	**QC Source**	Perkin Elmer Mixed Std
Date	12/03/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9991
Detection Limit	0.57		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
14S	0.014197708	33.1194	
18R	0.013006057	30.3725	
18S	0.028187534	64.9280	
20R	0.020204899	46.8765	
20S	0.034276055	78.5233	
21R	0.03467285	79.4041	
21S	0.013149377	30.7031	
blank	-0.000149217	-0.0353	
low level	0.002451254	0.5780	115.60
high level	0.109426719	23.4924	93.97
25R	0.009729601	22.7891	
25S	0.017200275	40.0143	
26R	0.030860459	70.9147	
26S	0.011533823	26.9706	
32R	0.008622248	20.2158	
32S	0.008079646	18.9530	
Spk2	0.088263015	192.9040	
Spk3	0.107151741	230.4782	
blank	0.000813219	0.1920	
low level	0.002066159	0.4874	97.47
high level	0.10694554	23.0074	92.03

Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Se 196.03	**QC Source**	Perkin Elmer Mixed Std
Date	12/08/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9951
Detection Limit	0.68		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
blank	0.000259518		
1 ppb	0.001571383		
2 ppb	0.003705629		
5 ppb	0.012170606		
10 ppb	0.023490547		
25 ppb	0.061833449		
50 ppb	0.11307452		
Blank	0.000130387	0.0622	
low level	0.001700243	0.8100	81.00
high level	0.125251916	50.8903	101.78
2R	0.017887457	8.3328	

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Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Se 196.03	**QC Source**	Perkin Elmer Mixed Std
Date	12/08/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9951
Detection Limit	0.68		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
2R	0.042294616	19.0676	
2S	0.009001922	4.2450	
5R	0.021217985	9.8396	
5S	0.001784991	0.8502	
8R	0.02952803	13.5404	
8S	0.00417187	1.9805	
11R	0.011329553	5.3255	
11S	0.009130092	4.3047	
12R	0.013486987	6.3209	
12S	0.011622713	5.4611	
Blank	0.000176873	0.0844	
low level	0.002022556	0.9631	96.31
high level	0.130910423	52.8335	105.67
plantstd	0.060092694	26.4692	
14R	0.05107107	22.7604	
14S	0.007622652	3.6015	
18R	0.013043162	6.1166	
18S	0.005536992	2.6236	
20R	0.007771418	3.6710	
20S	0.002626617	1.2496	
21R	0.011207938	5.2692	
21S	0.001528462	0.7283	
25R	0.002616591	1.2449	
Blank	-0.000366492	-0.1751	
low level	0.002039643	0.9712	97.12
high level	0.133798611	53.8153	107.63
25S	0.004373988	2.0759	
26R	0.007032014	3.3251	
26S	0.004556726	2.1621	
32R	0.005484612	2.5990	
32S	0.179696435	68.5670	
32S	0.009925349	9.3490	
S1	0.001905883	0.9077	
S2	0.00166515	0.7933	
S3	0.002547492	1.2121	
B1	-0.000305232	≤0.68	
Blank	-0.000772525	-0.3693	
low level	0.002155311	1.0261	102.61
high level	0.133112707	53.5827	107.17
B2	-0.000775337	≤0.68	

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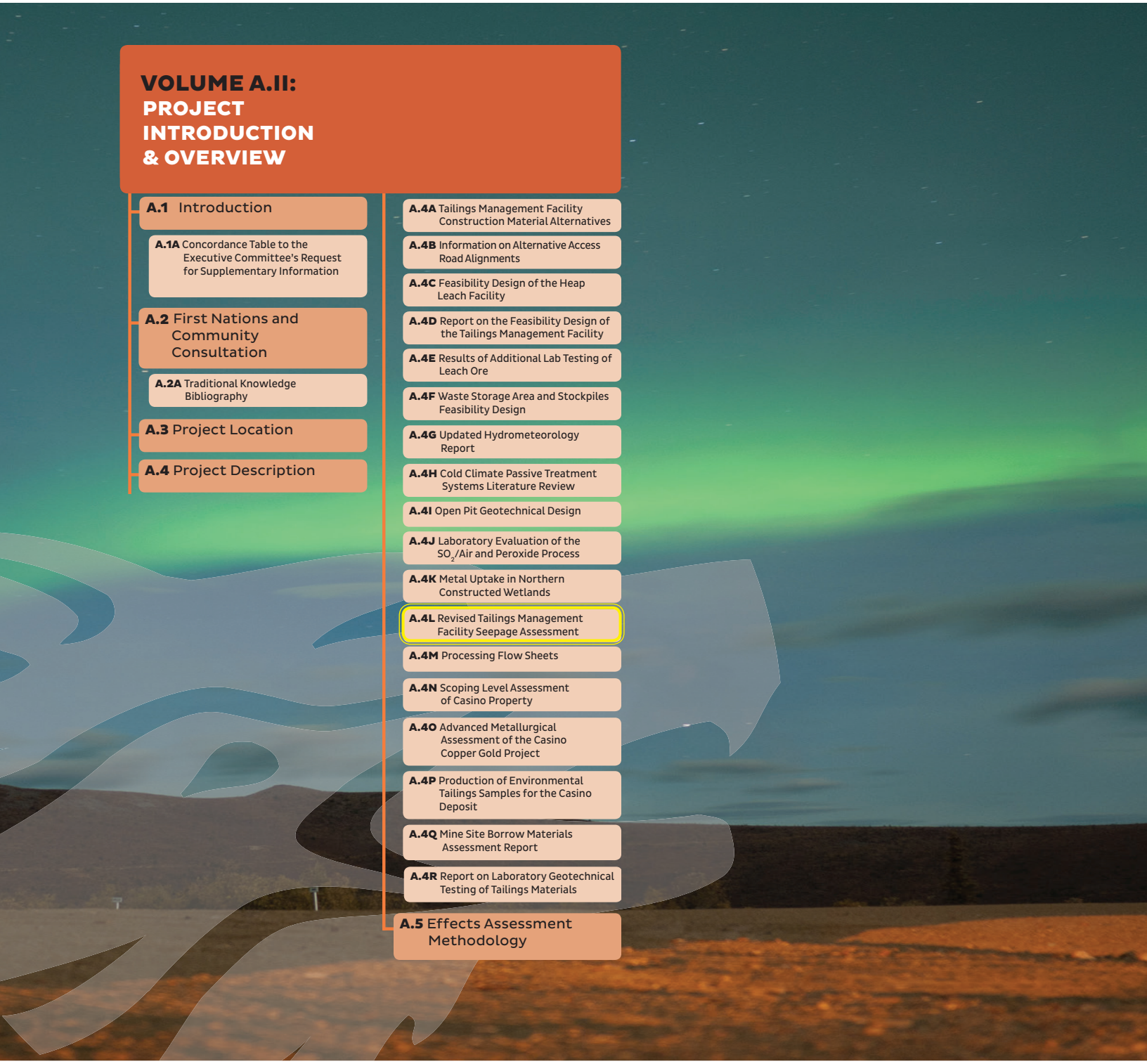
Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Se 196.03	**QC Source**	Perkin Elmer Mixed Std
Date	12/08/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9951
Detection Limit	0.68		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
B3	-0.000655707	≤0.68	
Std1	0.084597209	36.1204	
Std2	0.058146097	25.6763	
Std3	0.069860811	30.3887	
Spike1	0.05236324	23.2970	
Spike2	0.033792732	15.4078	
Spike3	0.0416624	18.7983	
Blank	-0.000284031	-0.1357	
low level	0.002023657	0.9636	96.36
high level	0.132026274	53.2136	106.43

APPENDIX A.4L: Revised Tailings Management Facility Seepage Assessment



CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT





REPORT ON REVISED TAILINGS MANAGEMENT FACILITY SEEPAGE ASSESSMENT

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CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

REPORT ON REVISED TAILINGS MANAGEMENT FACILITY SEEPAGE ASSESSMENT
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1 – INTRODUCTION

The Casino Copper-Gold Project is a venture by Casino Mining Copper Corporation to develop an Open Pit copper-gold-molybdenum mine in the Yukon Territory. The project is located in the Dawson Range Mountains of the Klondike Plateau, approximately 300 km northwest of Whitehorse, Yukon Territory, Canada. This area is somewhat unique in that the region was not glaciated during the Wisconsin Advance. The deposit is hosted by the Casino Complex, a suite of igneous intrusive rocks, with an intense hydrothermal alteration overprint. The deposit will be mined using Open Pit methods with a nominal mill throughput of approximately 125,000 tonnes/day (tpd) of ore.

The Tailings Management Facility (TMF) has been designed to provide environmentally secure storage for co-disposal of 956 million tonnes of tailings and 658 million tonnes of potentially reactive waste rock and overburden materials, placed in a Waste Storage Area within the TMF.

The current mine waste production schedule indicates that only a small quantity of the potentially reactive material will be classified as Hypogene in the initial years of mining (up to the end of Year 4), with the large majority comprising Supergene waste materials. Thereafter the production of Hypogene waste material increases significantly. After Year 4 of operations the mine waste reporting to the Waste Storage Area will be a mixture of Hypogene and Supergene materials in varying proportions each year.

There will be two separate tailings streams reporting to the TMF from the mill. The principal rougher stream (approximately 80% of the total tailings) will be Non Acid Generating (NAG) tailings. A second stream (20%) will be Potentially Acid Generating (PAG) tailings material that will be handled and stored separately and maintained under water. For approximately nine months of each year (on average) the NAG tailings will be passed through a cyclone plant to produce clean sand (low fines) for embankment construction. The cyclone plant will also produce a low solids content cyclone overflow stream (finer fraction of the tailings) which will be discharged into the TMF.

Tailings confinement within the TMF is provided by a Main Embankment across the Casino Creek Valley and a smaller West Saddle Embankment located northwest of the Main Embankment. The embankments will be constructed as a water-retaining dam with a central core zone. The Main Embankment will be developed in stages throughout the life of the project using cycloned sand fill, suitable borrow materials, and non-reactive waste rock materials from initial stripping operations at the Open Pit. The West Saddle Embankment will be constructed at the south-western corner of the TMF and is required at the start of operations to provide a pipeline corridor at a suitable grade for tailings delivery to the cyclone sand plant and TMF. The West Saddle embankment will comprise an earth-rockfill dam, constructed from local borrow materials.

Seepage flows within and from the TMF will result from a combination of three primary processes:

- Consolidation seepage from the tailings deposit
- Steady-state seepage through the tailings deposit, through the confining embankments and also into original ground, and
- Percolation of process water directly into natural ground where the supernatant pond is in contact with natural soils or rock.

Seepage flows from the tailings deposit will occur throughout operations as tailings are discharged into the facility, and will continue after the end of operations until consolidation is complete. A

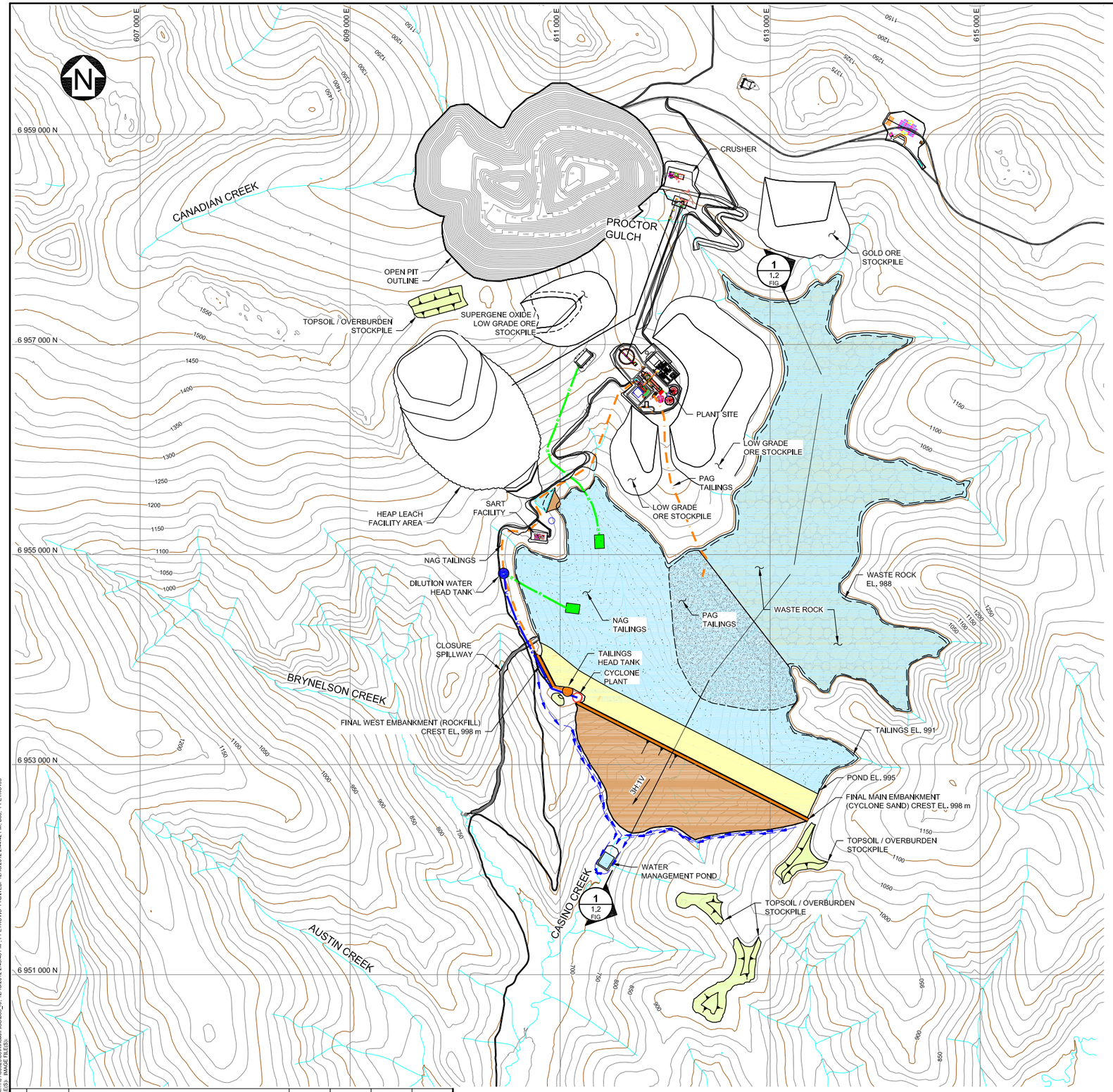
substantial component of the consolidation seepage will be expelled from the tailings into the overlying supernatant pond, particularly after the initial few years of operations as the depth of the tailings deposit increases.

It is anticipated that a significant portion of seepage losses from the TMF will be returned to the facility via a seepage collection and recycle system.

Detailed analyses have been carried out to predict seepage flows within and from the TMF. This has included tailings consolidation modelling and steady-state seepage analyses for conditions during operations and after closure. Figure 1.1 shows the final arrangement of the TMF at the end of operations. Figure 1.2 shows schematic sections through the final TMF, with the various components identified.

It is anticipated that the predicted seepage flows will be incorporated into a site wide water balance and water quality model to be developed for the project. The various flow components and corresponding seepage rates provided by the tailings consolidation modelling and seepage analyses can be used to predict water quality during operations and for several decades after the cessation of operations.

Details of the tailings consolidation modelling and steady-state seepage analyses for the TMF are presented in the following sections.



NOTES:

1. COORDINATE GRID IS UTM (WGS84/NAD83) ZONE 7 (m).
2. CONTOUR INTERVAL IS 25 METRES.
3. DIMENSIONS ARE IN METRES UNLESS NOTED.
4. OPEN PIT AS PROVIDED BY CASINO MINING CORPORATION (NOVEMBER 2012).
5. PLANT SITE AND CRUSHER LAYOUT PROVIDED BY M3ENGINEERING AND TECHNOLOGY CORPORATION (OCTOBER 4, 2012).
6. ORE AND TOPSOIL STOCKPILES ARE SHOWN AT THEIR MAXIMUM SIZE DURING OPERATIONS.

LEGEND:

- TOPSOIL / OVERBURDEN
- TAILINGS
- EMBANKMENT
- POND
- TAILINGS PIPELINES
- RECLAIM PIPELINES
- WATER PIPELINES
- TAILINGS HEAD TANK
- DILUTION WATER HEAD TANK
- CYCLONE PLANT

SCALE A: 400 200 0 400 800 1200 1600 2000 m

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	18DEC'12	ISSUED WITH REPORT	SB	PP	GRG	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

TAILINGS MANAGEMENT FACILITY
GENERAL ARRANGEMENT
PLAN - FINAL (YEAR 22)

Knight Piésold CONSULTING

P/A NO. VA101-325/8 | REF NO. 13 | REV 0

FIGURE 1.1

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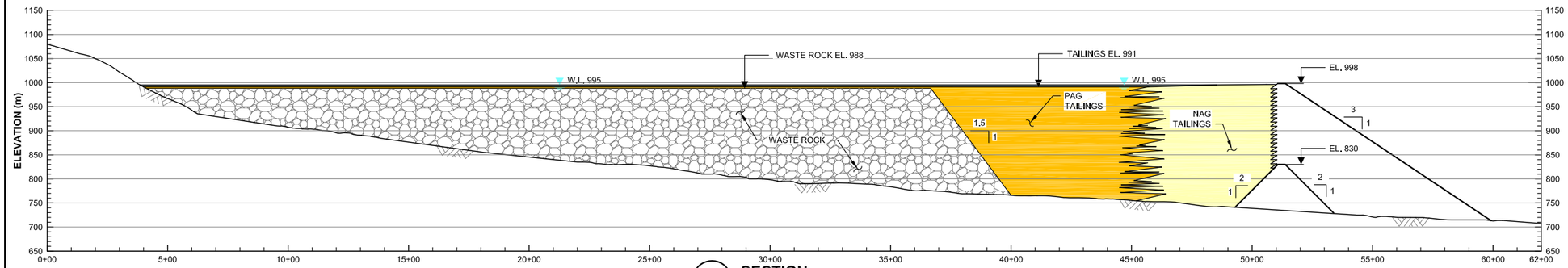
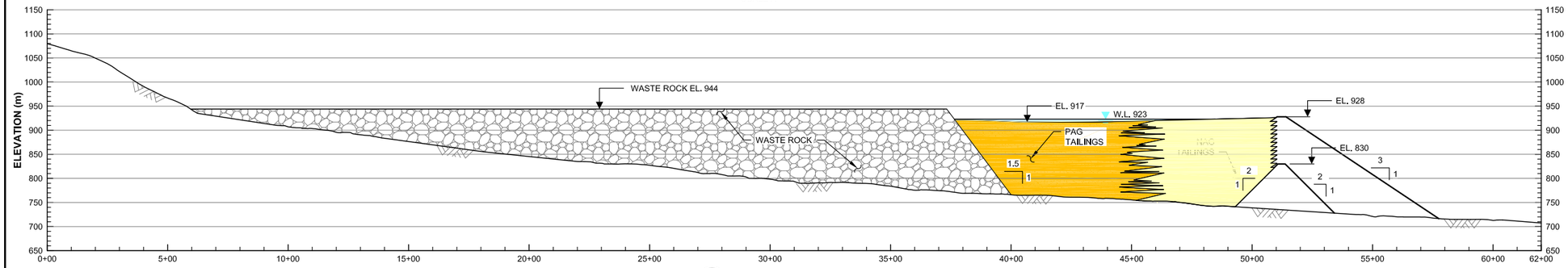
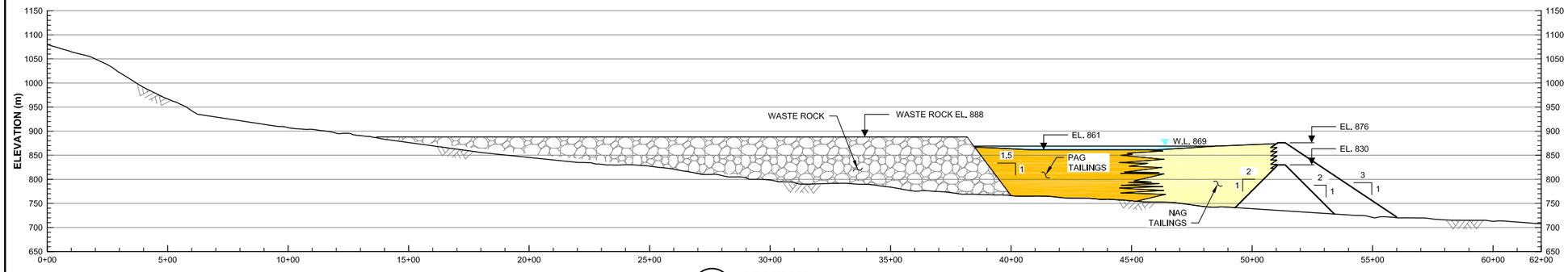


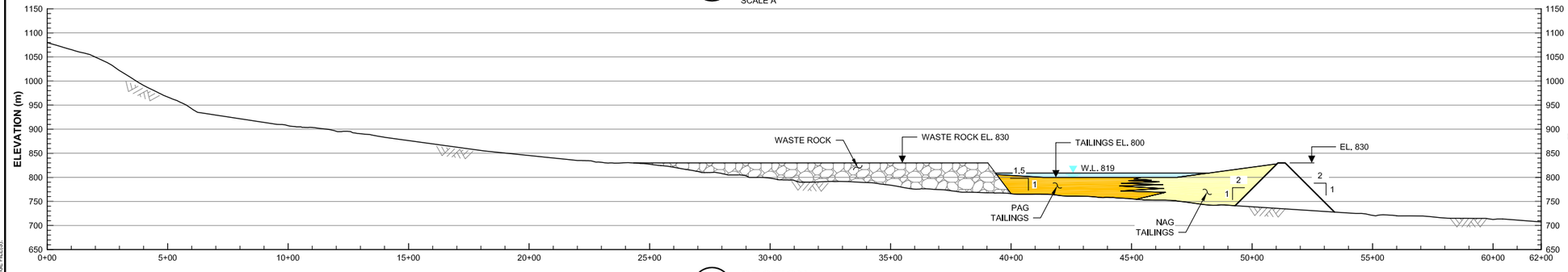
1 / 1.1 FIG **SECTION**
YEAR 22
SCALE A



1 / 1.1 FIG **SECTION**
YEAR 10
SCALE A



1 / 1.1 FIG **SECTION**
YEAR 4
SCALE A



1 / 1.1 FIG **SECTION**
YEAR 1
SCALE A

NOTES:

1. DIMENSIONS ARE IN METRES UNLESS NOTED.

VERT. SCALE 100 50 0 100 200 300 400 500 m
HORIZ. SCALE 200 100 0 200 400 600 800 1000 m

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	18DEC'12	ISSUED WITH REPORT	SB	PP	GRG	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

TAILINGS MANAGEMENT FACILITY
GENERAL ARRANGEMENT
TYPICAL SECTIONS - YEARS 1, 4, 10, 22

Knight Piésold CONSULTING

P/A NO. VA101-325/8 | REF NO. 13 | REV 0

FIGURE 1.2

SAVED: M:\101\00325\08\A\acad\FIGS\B110_d - 13.REPORT , 12/18/2012 1:53:24 PM , PPETKOVIC PRINTED: 12/18/2012 1:54:00 PM, BB4 , PPETKOVIC
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2 – TAILINGS CONSOLIDATION ANALYSIS

2.1 GENERAL

On-going consolidation of the tailings deposit is an important consideration in the prediction of seepage water flows within and from the TMF during operations and after closure. Consolidation occurs continuously within the tailings deposit during deposition, and will continue after completion of operations until all excess pore pressures have dissipated. Expulsion of pore fluids during consolidation of the tailings can add a substantial contribution to the total seepage from the tailings deposit. The process of consolidation also produces settlement of the tailings surface and a corresponding increase in the density of the tailings.

Knight Piésold Ltd. (KPL) has developed a one-dimensional finite difference computer model which predicts the magnitude and rate of tailings consolidation, the amount of consolidation seepage (water losses from the deposit) and the corresponding average density of the deposit. This model incorporates the expected consolidation characteristics of the tailings, the deposition rate (tailings and waste rock) and large strain consolidation theory.

Analyses were performed to predict average tailings densities and consolidation seepage rates during operation of the TMF and for several decades after closure of the facility.

2.2 PARAMETERS AND ASSUMPTIONS

The following parameters and assumptions were incorporated into the tailings consolidation model:

- 80% of the total tailings production was assumed to be NAG tailings and 20% PAG tailings.
- Actual NAG tailings tonnages assumed to report to the TMF for each year of operations were calculated to allow for NAG tailings material removed as cyclone sand for embankment construction (approximately 50% of the total NAG tailings production).
- For the tailings materials reporting to the TMF for disposal, 54% is assumed to be cyclone overflow (fine tailings), 26% whole NAG tailings and 20% PAG tailings. Whole NAG tailings are discharged into the TMF during periods when cycloning operations are suspended (typically during the colder winter months). The cyclone sand plant is assumed to be in operation for 9 months of the year (with a 90% sand plant availability during this period).
- Void ratio versus effective stress and coefficient of consolidation versus effective stress relationships for the cyclone overflow and whole NAG tailings were based on laboratory testwork carried out in 2012 on samples of Casino tailings. Details of the tailings laboratory testing are presented in KPL report “Laboratory Geotechnical Testing of Tailings Materials” (Ref. No. VA101-325/8-1, December, 2012).
- An initial settled dry density of 0.9 tonne/m^3 was used for the cyclone overflow material, based on the results of laboratory settling tests for a slurry sample with an initial solids content of approximately 24%. The low solids content is based on the expected cycloning requirements to achieve a clean sand product (less than 15% fines) for embankment fill material.
- An initial settled dry density of 1.1 tonne/m^3 was used for the NAG whole tailings, based on the results of laboratory settling tests for a tailings slurry sample with a design initial solids content of approximately 55%.
- Laboratory testing to define the consolidation and compressibility characteristics of the PAG tailings has not been completed to date. The PAG tailings material is finer-grained than the NAG

whole tailings (implying a lower density) but the specific gravity is higher (higher density of solids). Therefore, the PAG tailings are assumed to achieve in situ densities similar to the NAG whole tailings.

- Evaporative losses from the exposed tailings surface are not accounted for in the consolidation model. Surface desiccation of tailings beach areas will further assist in consolidation and densification of the deposit. Therefore, the predicted volume of tailings consolidation seepage is likely conservatively high.

Both undrained and drained base flow conditions were considered in the modelling and a weighted average used to best represent the impeded flow (permeability) characteristics of the TMF basin and confining embankments. The influence of lateral seepage flows towards the more free draining (sandier) tailings beach areas was also considered.

2.3 SUMMARY OF RESULTS

Average dry density and consolidation seepage amounts for the tailings deposit with time during operations were estimated from consideration of the relative proportion of NAG whole tailings, PAG tailings and cyclone overflow material reporting to the TMF.

An average tailings dry density of approximately 1.2 tonne/m^3 was predicted for the initial three years of operations, increasing to about 1.3 tonne/m^3 by Year 4 and 1.4 tonne/m^3 by Year 5. Thereafter, the average dry density is predicted to increase gradually to approximately 1.5 tonne/m^3 by the end of operations when tailings deposition ceases. The density of the deposit will increase once tailings deposition ceases at closure and self-weight consolidation continues, assisted by surface desiccation due to evaporation from exposed tailings beach areas. Following the end of operations the average dry density of the tailings deposit is predicted to increase to approximately 1.55 to 1.6 tonne/m^3 once fully consolidated conditions are achieved.

The tailings consolidation analysis was used to estimate the quantity of pore water liberated from the tailings deposit during operations and following cessation of operations (post-closure). Consolidation seepage rates have been estimated by multiplying the predicted unit seepage rate by the estimated plan area of the tailings deposit. The area of tailings increases with time during operations at the TMF, but will remain essentially constant after operations cease. The actual area has been adjusted (reduced) appropriately to account for the presence of the potentially reactive Waste Storage Area within the TMF. During operations (active tailings deposition) the consolidation seepage rates are predicted to be about 180 l/sec in Year 1, increasing thereafter to about 300 l/sec by Year 5 and approximately 400 l/sec by the end of operations. Following the end of operations the predicted consolidation seepage rate decreases substantially to less than 100 l/sec within one year and to less than 50 l/sec after 5 years. Consolidation seepage decreases further to less than 10 l/sec after about 30 years.

The large majority of consolidation seepage from the tailings deposit (typically about 80% to 90%) flows upwards and towards the supernatant pond. The upward seepage flow is due to excess pore water pressure conditions within the tailings deposit, particularly fresher tailings nearer to the surface. Most of the remaining consolidation seepage will likely flow toward the more free-draining tailings beach areas, confining embankments and Waste Storage Area. The percentage of downward consolidation seepage is minor. The low quantity of downward consolidation seepage is due to the increasing drainage path length during operations (between freshly deposited tailings and

the base of the TMF) and the low permeability of deeper, more consolidated, tailings at the base of the facility.

The tailings are predicted to remain partially consolidated during operations and for a period of time after closure until all excess pore water pressures have dissipated. The average degree of consolidation at the end of operations is estimated to be approximately 60% or higher for much of the tailings deposit. The degree of consolidation is predicted to be less than 50% in some areas where the tailings thickness is greatest (over 150 metres thick). However, those tailings closest to the embankments and discharge points are expected to consolidate faster due to the more free draining nature of sandier tailings forming the beach areas (due to segregation). The average degree of consolidation in these tailings is expected to be approximately 90% (close to fully consolidated).

The actual time taken for complete consolidation will be dependent on the in situ consolidation characteristics of the tailings material. Reduced consolidation seepage may continue for several decades until complete tailings consolidation is achieved.

3 – TMF SEEPAGE ANALYSIS

3.1 GENERAL

Steady-state seepage analyses for the TMF were carried out to estimate the amount of seepage through the embankments and foundation materials. The analyses were completed using the finite element computer program SEEP/W. Seepage rates through the Main Embankment, West Saddle Embankment and tailings basin were examined.

The seepage rate through foundation materials and embankment fill zones is influenced by the following factors:

- Permeability of the embankment zones
- Permeability of the foundation materials
- The thickness and permeability of the tailings stored within the TMF
- Distribution of potentially reactive waste rock within the TMF
- Seepage gradients in the embankment and foundation zones, and
- The seepage area available (increases with time during operations).

The seepage flow rate will vary over the life of the TMF as it gradually fills with tailings, mine waste rock and supernatant water. During operation of the TMF the tailings deposit will increase in thickness and generally decrease in permeability due to on-going consolidation. The seepage analyses have been performed to predict seepage flows from the TMF at various stages throughout operations (Stage 1, Year 10 and Final).

Foundation conditions incorporated into the seepage analyses are based on information provided by previous geotechnical site investigation programs carried out in 1993, 1994, 2010, 2011 and 2012. Details of the site investigations and the foundation conditions defined for the TMF basin are presented in the following KPL reports:

- "Report on Preliminary Surficial Geotechnical Investigations" (Ref. No. 1831/1, March, 1994)
- "Data Compilation Report on 1994 Geotechnical/Hydrogeological Investigations" (Ref. No. 1832/2, February 22, 1995)
- "2010 Geotechnical Site Investigation Data Report" (Ref. No. VA101-325/3-4, November 2, 2010)
- "2011 Geotechnical Site Investigation Data Report – Waste Management Facilities" (Ref. No., VA101-325/8-5, December, 2012), and
- "2012 Geotechnical Site Investigation Data Report" (Ref. No., VA101-325/8-14, December, 2012).

The seepage analyses have been based on representative simplified cross-sections through the TMF, as shown on Figures 3.1 to 3.5 for the Main Embankment and on Figure 3.6 for the West Saddle Embankment. Two cross-sections were defined for the Main Embankment, Section A at the middle of the dam (deepest section) and a generic Section B representing conditions at each of the two abutments.

Based on the present mine production schedule and development strategy, approximately three years of tailings deposition will occur after final placement of potentially reactive waste rock in the Waste Storage Area. This will result in a thin layer of tailings over the top of the waste rock (approximately 3 metres thick). This tailings layer will have a negligible influence on seepage flows

from the TMF and was conservatively omitted from the seepage analysis. However, there is potential for the layer to reduce upward diffusion into the supernatant pond. The potential benefit, if any, of the tailings layer will be considered as part of on-going water quality studies for the TMF.

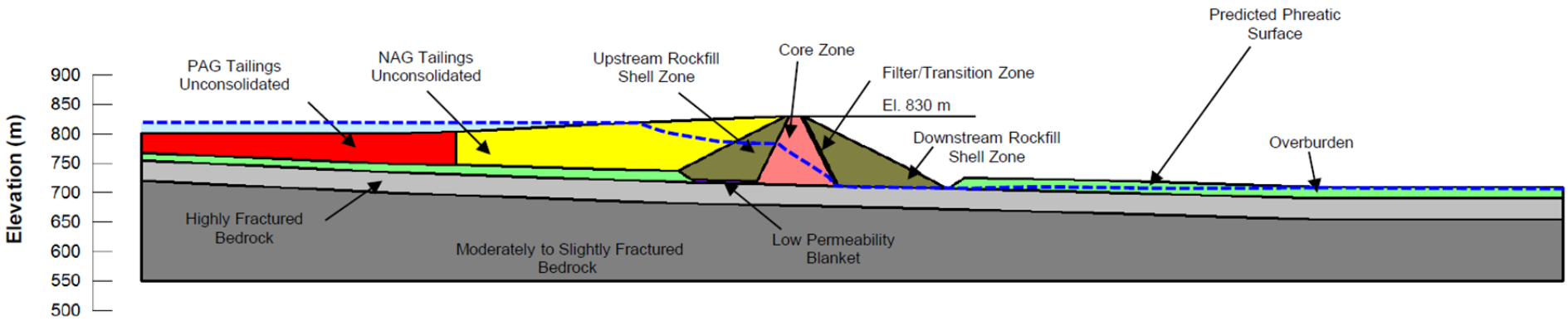


Figure 3.1 Tailings Management Facility – Steady-State Seepage Analysis – Main Embankment Section A - Stage 1 (EL. 830 m)

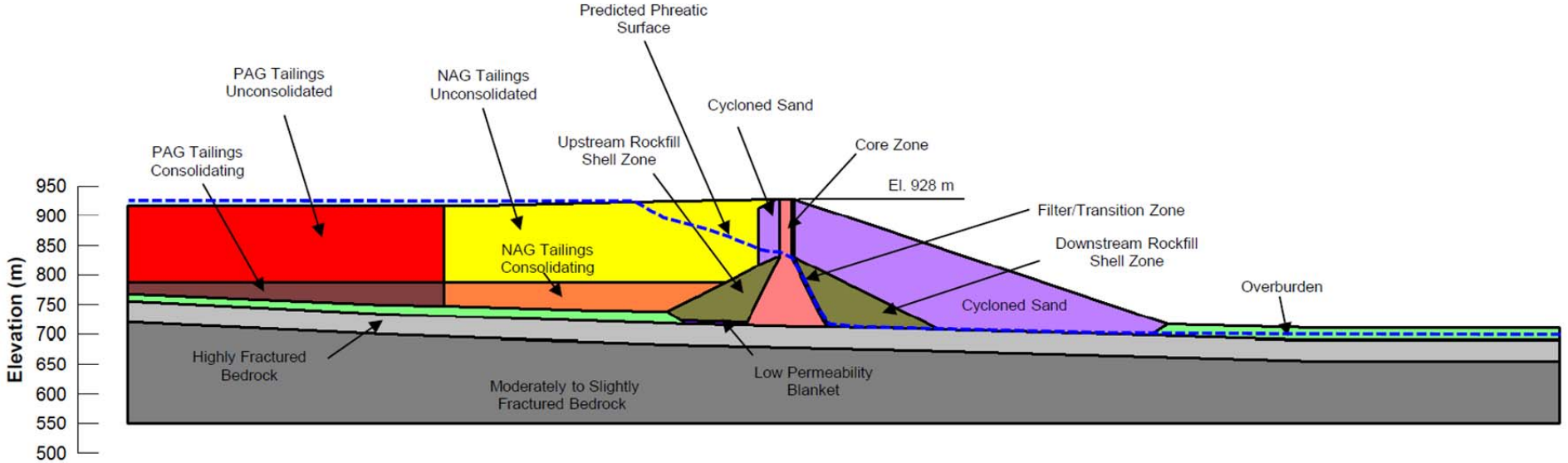


Figure 3.2 Tailings Management Facility – Steady-State Seepage Analysis – Main Embankment Section A - Year 10 (EL. 928 m)

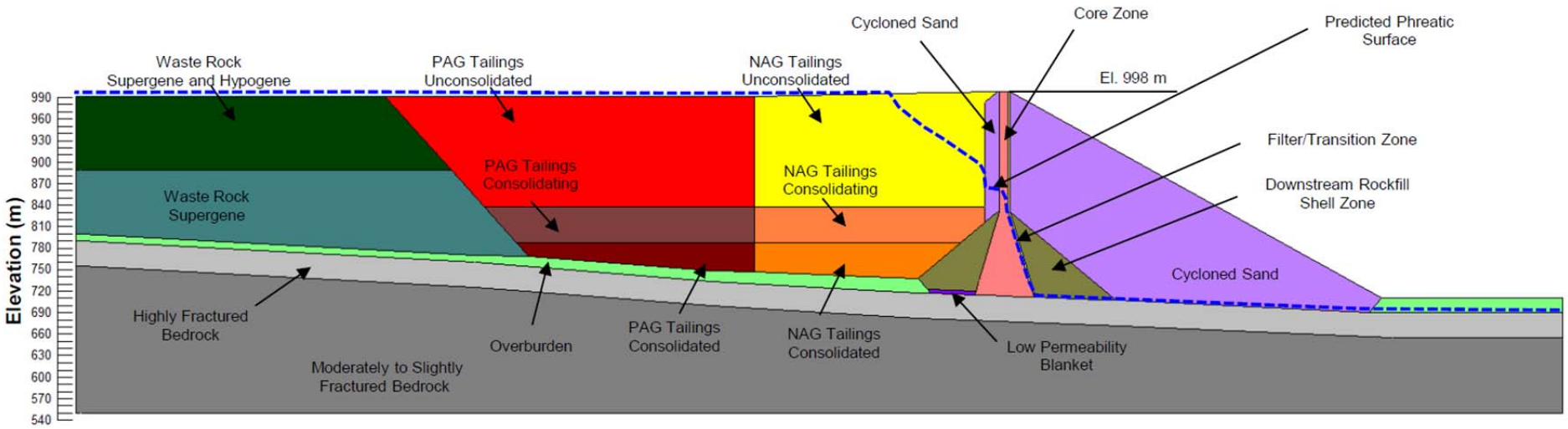


Figure 3.3 Tailings Management Facility – Steady-State Seepage Analysis – Main Embankment Section A - Final (EL. 998 m)

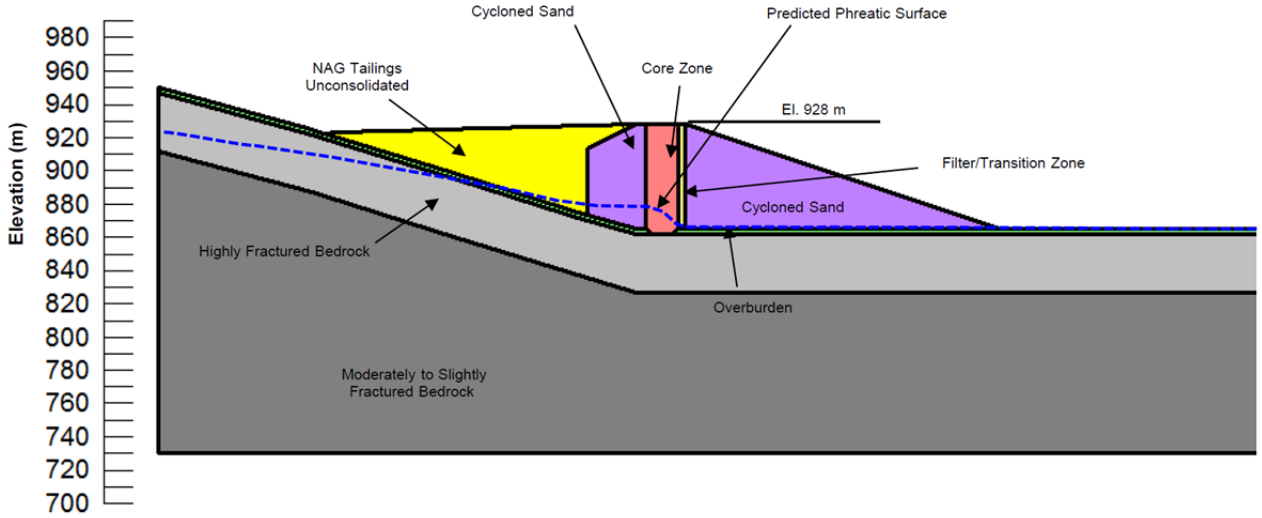


Figure 3.4 Tailings Management Facility – Steady-State Seepage Analysis – Main Embankment Section B - Year 10 (EL. 928 m)

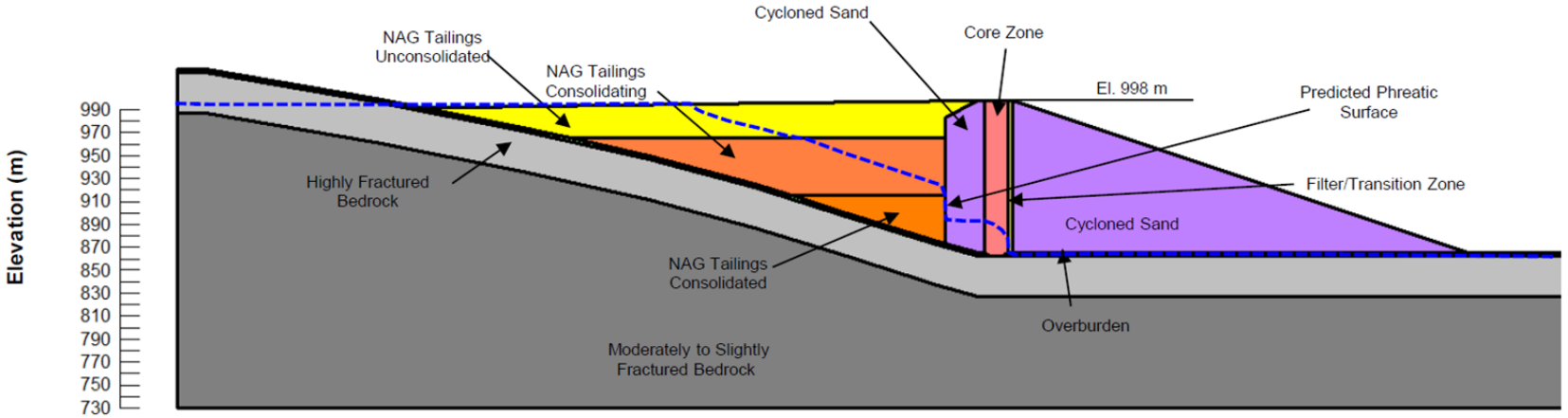


Figure 3.5 Tailings Management Facility – Steady-State Seepage Analysis – Main Embankment Section B - Final (EL. 998 m)

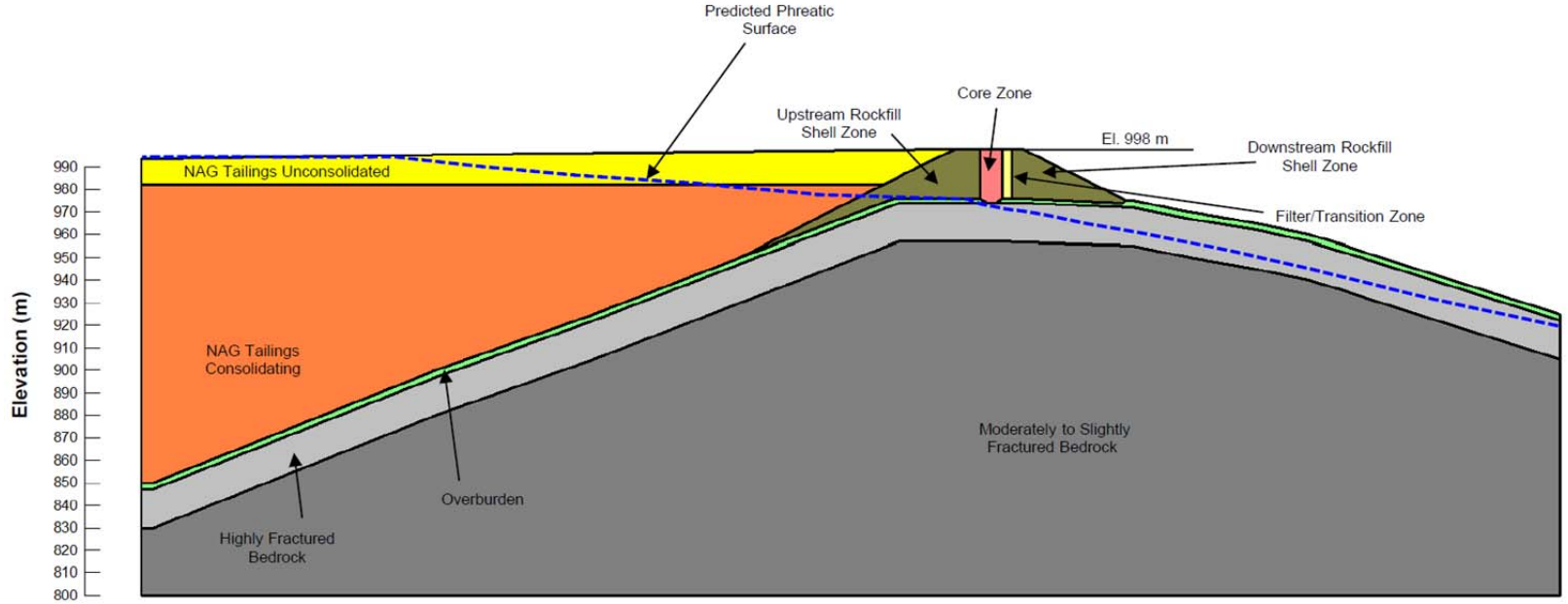


Figure 3.6 Tailings Management Facility – Steady-State Seepage Assessment – West Saddle Embankment - Final (EL. 998 m)

3.2 SUMMARY OF MATERIAL PERMEABILITIES

Saturated and unsaturated permeabilities were determined for each of the embankment fill zones, tailings deposit and foundation materials. In assigning unsaturated permeability values, typical functions for similar material types were used.

All foundation saturated permeability values are based on the results of in situ testing performed during the 1994, 2010, 2011 and 2012 geotechnical site investigation programs. The saturated permeability values used for the embankments, tailings deposit and foundation materials are summarized in Table 3.1 and described below:

- The NAG tailings were assigned permeability values based on the results of laboratory testing, presented in the KPL report "Laboratory Geotechnical Testing of Tailings Materials" (Ref. No. VA101-325/8-1, December, 2012) and consolidation modelling described in Section 2.0 of this report. Tailings located at the base of the TMF were assigned a lower permeability to account for a higher degree of consolidation in these tailings. A vertical permeability of 1×10^{-5} cm/s was assigned to unconsolidated tailings located within the upper portion of the tailings deposit. The estimated vertical permeability of deeper consolidating tailings ranges from 2×10^{-6} cm/s (bottom of the deposit) to 5×10^{-6} cm/s (partially consolidated or shallower tailings) depending on the thickness of the tailings deposit and the time during operations. To account for sub horizontal laminations (layers) formed from material segregation during deposition, the horizontal permeability of the tailings deposit was assumed to be one order of magnitude greater than the vertical permeability.
- The PAG tailings were assumed to have the same permeabilities as the NAG tailings. The PAG tailings are finer-grained than the NAG whole tailings and cyclone overflow and therefore are likely to have permeabilities similar or lower than these materials.
- Potentially reactive mine waste (waste rock and overburden) materials within the Waste Storage Area were assigned an average permeability of 1×10^{-2} cm/s.
- Core Zone material was assigned a vertical permeability of 1×10^{-5} cm/s. The material is assumed to be isotropic. Laboratory permeability test results on compacted residual soil samples from 1993, 2010, 2011 and 2012 test pit samples indicate that permeabilities range from approximately 1×10^{-5} cm/s to 1×10^{-9} cm/s, depending on material gradation, moisture content, compactive effort and confining pressure. The more recent testing carried out in 2010, 2011 and 2012 indicate that permeability values in the range of approximately 1×10^{-6} cm/s to 1×10^{-5} cm/s are typically achievable for the finer grained soils present at the project site. However, additional investigations will be required to confirm the extent and availability of sufficient suitable borrow materials for embankment core zone construction throughout the life of the facility. The laboratory testing also suggests that the permeability will reduce at higher confining stresses, with a permeability decrease from 1×10^{-5} cm/s to 1×10^{-6} cm/s reported for an increase in confining stress from 200 kPa to 600 kPa. Confining stresses will exceed 600 kPa in the majority of the embankment core zone for the TMF Main Embankment (from about 30 metres below the dam crest). Therefore, it is expected that a permeability of about 1×10^{-6} cm/s, and perhaps less, will be achieved in the majority of the core material.
- A 5 m thick low permeability blanket of core zone material is placed under the upstream part of the starter dam to increase the seepage path length. The material was assigned a permeability of 1×10^{-6} cm/s.

- Embankment rockfill shell zones (Stage 1 Main Embankment and West Saddle Embankment) and filter/transition zones were assigned a vertical permeability of 1 x 10^{-2} cm/s. The results of the model reveal that these zones are essentially fully drained and do not affect the results of the analysis.
- Cycloned sand embankment fill in the upstream and downstream shell zones was assigned an average permeability of 1 x 10^{-3} cm/s, based on the results of permeability tests on a manufactured sample of cyclone sand material. The laboratory testing indicated that the permeability of the cyclone sand did not reduce significantly at high stresses. Details of the laboratory testing are provided in the KPL report "Geotechnical Laboratory Testing of Tailings Materials" (Ref. No. VA101-325/8-1, December, 2012).
- The foundation overburden (sands and gravels) was assigned a vertical permeability of 1.0 x 10^{-5} cm/s, based on in situ testing carried out during previous site investigations (packer permeability tests in 1994 and falling head permeability tests in 2010 and 2011). The material is assumed to be isotropic.
- It is assumed that granodiorite forms the basement of the TMF. Two layers within the granodiorite were modelled to represent the decreasing level of weathering and fracturing within the rock with depth. The top layer of granodiorite identified as highly fractured rock was assigned a vertical permeability of 5 x 10^{-5} cm/s. The bedrock underlying the highly fractured layer was identified as slightly to moderately fractured and assigned a vertical permeability of 1 x 10^{-5} cm/s. The rock is assumed to be isotropic. The adopted permeabilities are representative values provided by packer permeability tests carried out in 1994 and packer permeability and falling head tests in 2010 and 2011. Some of the in situ testing results indicate a lower permeability of about 1 x 10^{-6} cm/s or less. However, it is difficult to delineate the extent of lower permeability rock zones from the available data. The inclusion of a lower permeability bedrock layer at depth does not have a significant influence on predicted seepage values. Therefore, it has not been included in the seepage model.

Discontinuous permafrost is present along Casino valley, where the TMF is situated. Permafrost is primarily present at the valley bottom, north facing slopes and shaded areas. Saturated frozen soil and rock have a much lower permeability when frozen compared to a thawed or unfrozen state. Frozen overburden and bedrock that are underlying part of the tailings impoundment and embankment are expected to thaw over time, as the tailings and water stored in the TMF will act as a heat source. Permeabilities representing unfrozen overburden and bedrock were therefore used in the seepage model.

In situ hydraulic conductivity tests (falling head and packer permeability tests) were performed in the TMF area during previous site investigations. Test results showing very low hydraulic conductivities were excluded from the analysis as these potentially indicate frozen soil or rock. Thermistors were installed during the 2012 site investigations to provide a better understanding of the thermal regime in the bedrock.

Table 3.1 Tailings Management Facility – Summary of Material Permeabilities

Area	Material Type	Saturated Permeability, kv (cm/s)	Saturated Permeability, kh (cm/s)	kv/kh
Embankment	Compacted Low Permeability Core Zone	1.0E-05	1.0E-05	1.0
	Compacted Low Permeability Upstream Blanket	1.0E-06	1.0E-06	1.0
	Local Borrow Rockfill	1.0E-02	1.0E-02	1.0
	Filter/Transition Zone	1.0E-02	1.0E-02	1.0
	Cyclone Sand	1.0E-03	1.0E-03	1.0
Embankment Foundation	Overburden	1.0E-05	1.0E-05	1.0
	Highly Fractured Bedrock	5.0E-05	5.0E-05	1.0
	Slightly to Moderately Fractured Bedrock	1.0E-05	1.0E-05	1.0
Tailings Impoundment	Waste Rock (2)	1.0E-02	1.0E-02	1.0
	Unconsolidated Tailings (3)	1.0E-05	1.0E-04	0.1
	Consolidating Tailings (3)	5.0E-06	5.0E-05	0.1
	Consolidated Tailings (3)	2.0E-06	2.0E-05	0.1

NOTES:

1. kv = vertical permeability, kh = horizontal permeability.
2. Supergene and Hypogene waste rock are assumed to have the same permeabilities.
3. PAG and NAG tailings are assumed to have the same consolidation and permeability properties.

3.3 BOUNDARY CONDITIONS AND FLUX SECTIONS

Boundary conditions used in the seepage analyses were selected to represent the hydrogeological conditions expected during operations at the TMF. The boundary conditions used in the analyses are summarized as follows:

- Review boundary conditions were assigned downstream of the embankment core zone. This enables the location of the phreatic surface through the embankment and foundation materials to be determined during the seepage analyses.
- The right-hand boundary (downstream of the embankment) was assigned a hydrostatic head consistent with existing groundwater conditions.
- A total head (hydrostatic) boundary was used to represent the tailings pond elevation. For the Final embankment configuration a tailings pond elevation of 995 m was used. A tailings beach width of 250 m was assumed, separating the pond from the embankment.

The results of tailings consolidation modelling (described in Section 2.0) indicate that excess pore water pressures will likely exist within much of the tailings deposit during operations and for a period of time after closure of the TMF (particularly in zones of finer and deeper tailings) until fully consolidated conditions are achieved. However, the tailings beach areas adjacent to the embankments are expected to be more consolidated during operations (and likely close to fully consolidated conditions). Consequently, it is considered reasonable to assume hydrostatic pore water pressure conditions within the tailings for the embankment seepage modelling. Excess pore pressures within unconsolidated and consolidating tailings will produce consolidation seepage flows, with the majority flowing upwards to the supernatant pond, as discussed in Section 2.3.

Flux sections were included in the seepage models at appropriate locations to estimate seepage flows through the embankments and foundation units.

3.4 SUMMARY OF RESULTS

The results of the steady-state seepage analyses provided by the SEEP/W models are shown on Figures 3.1 to 3.3 for Section A through the Stage 1, Year 10 and Final Main Embankment, Figures 3.4 and 3.5 for Section B through the Year 10 and Final Main Embankment, and Figure 3.6 for the Final West Saddle Embankment. These figures include the computed location of the phreatic surface within the tailings deposit and confining embankment.

Computed seepage flux values for the Main Embankment and West Saddle Embankment sections were used with representative crest lengths to provide an estimate of the total seepage rate from the TMF. Flow rates were estimated for seepage components passing through the embankments and passing directly into the TMF foundation. An estimate was also provided for the average unit flow rates through the various materials stored in the impoundment (NAG tailings, PAG tailings and potentially reactive waste rock and overburden materials). The results of the steady-state seepage analyses are summarized in Table 3.2 and Figure 3.7.

The predicted total seepage rate from the TMF is approximately 6 l/s for the pre-production (Stage 1A) embankment with a start-up water pond only (prior to tailings deposition). The seepage rate is approximately 5 l/sec for Stage 1B (end of Year 1), increasing to about 20 l/sec by Year 10 and approximately 40 l/sec for the final embankment arrangement (El. 998 m). Reducing the permeability of the embankment core zone from 1×10^{-5} cm/s to 1×10^{-6} cm/s reduces the predicted seepage rates by only approximately 10%.

Approximately two-thirds of the total seepage is estimated to flow directly into original ground and about one-third through the low permeability core zones of the Main Embankment and West Saddle Embankment. For the final TMF arrangement approximately 97 % of the total seepage through the embankments is estimated to flow through the Main Embankment and 3 % through the West Saddle Embankment.

The quantity of seepage predicted to flow from the base of the waste storage area (Hypogene and Supergene Waste Rock) is estimated to be less than 10% of the total seepage passing directly into original ground (TMF foundation). The remaining seepage into the TMF foundation passes through the tailings deposit. Approximately 10 % of the foundation seepage is estimated to flow through the base of the PAG tailings. A significant portion of the seepage passing into the TMF foundation will likely flow towards the Main Embankment.

An embankment drainage system has been provided to collect excess water resulting from cyclone sand deposition and seepage through the embankment and foundation. The provision of embankment underdrainage will enable a significant portion of the total seepage to be intercepted and routed to seepage collection ponds for recovery and return to the TMF.

A schematic diagram of predicted seepage flow paths for the Final TMF (end of operations), are shown on Figure 3.7. The predicted seepage flows have been incorporated into a site wide water balance and can be used for water quality modelling.

Long-term (post-closure) seepage rates from the TMF are expected to be similar to the predicted values for the final embankment arrangement at the end of operations, but will be dependent on the reclamation and closure plan developed for the facility.

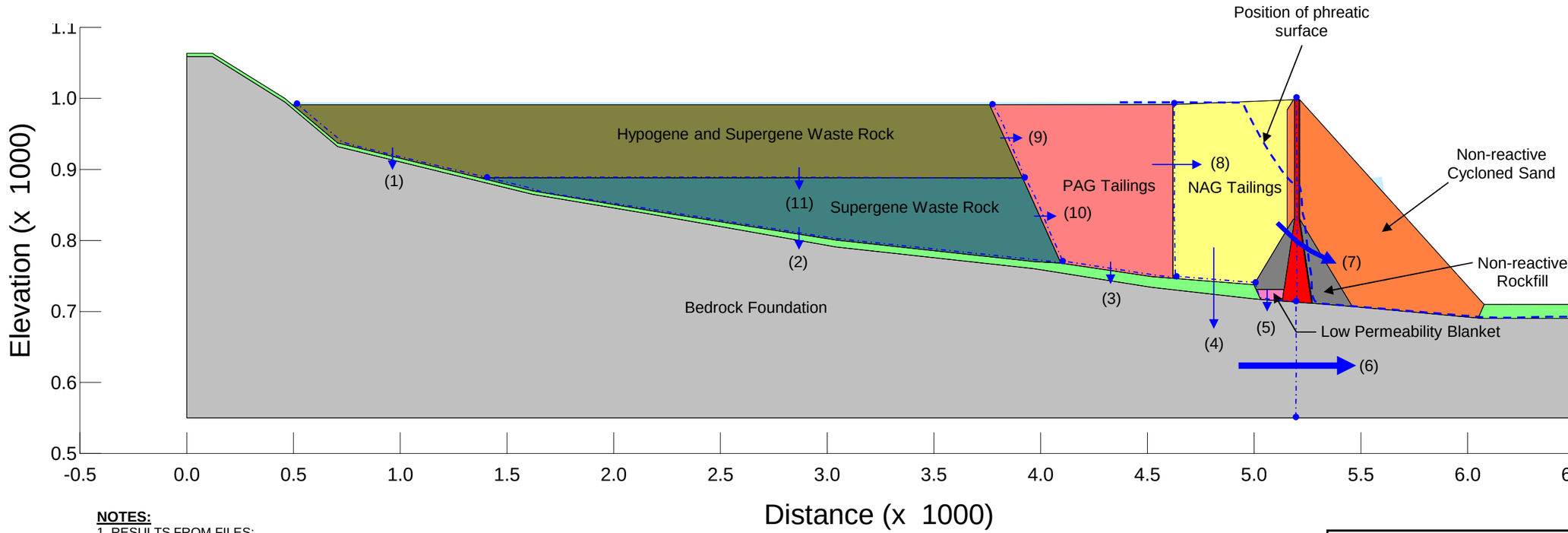
Table 3.2 Tailings Management Facility – Summary of Predicted Seepage Rates

Embankment	Year of Operations	Embankment Crest Elevation	Supernatant Pond Elevation	Estimated Seepage		
				Embankment	Foundation	Total
		(m)	(m)	(l/s)	(l/s)	(l/s)
Main	PP(1)	830	791	1	5	6
	1	830	819	1	4	5
	10	928	923	5	16	21
	22	998	995	13	26	39
West	22	998	995	<<1	1	1

NOTES:

1. Pre-production is prior to tailings deposition (start-up water pond only).

Seepage Component	Estimated Average Unit Flux ($m^3/s/m^2$)	Estimated Seepage (l/s)
(1) Seepage from Supergene and Hypogene Waste Rock to Foundation	3E-14	<1
(2) Seepage from Supergene Waste Rock to Foundation	7E-07	1
(3) Seepage from PAG Tailings to Foundation	3E-06	3
(4) Seepage from NAG Tailings to Foundation	4E-06	18
(5) Seepage from Upstream Starter Shell to Foundation	4E-05	4
(6) Total Seepage through Foundation under the Embankment	6E-05	27
(7) Seepage through Embankment Core	5E-05	13
(8) Seepage from PAG Tailings to NAG Tailings	4E-05	11
(9) Seepage from Hypogene and Supergene Waste Rock to PAG Tailings	6E-06	<1
(10) Seepage from Supergene Waste Rock to PAG Tailings	2E-05	1
(11) Seepage from Hypogene and Supergene Waste Rock to Supergene Waste Rock	2E-06	2



NOTES:

1. RESULTS FROM FILES:
   - "2012 Main Emb - Imp 998 m__starter 830_blanket_c1e-7 b1e-8m_s_REVISED.gsz" DATED 2012/12/16
2. CORE ZONE CONDUCTIVITY 1E-5 cm/s; UPSTREAM BLANKET CONDUCTIVITY 1E-6 cm/s

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
1	17DEC'12	ISSUED WITH REPORT	SB	GRG	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

TAILINGS MANAGEMENT FACILITY
SCHEMATIC OF SEEPAGE FLOW PATHS
AND ESTIMATED SEEPAGE FOR FINAL TMF

Knight Piésold CONSULTING

P/A NO. VA101-325/8

REF. NO. 13

FIGURE 3.7

REV 1

4 – SUMMARY

Detailed analyses have been carried out to predict seepage flows within and from the TMF. This has included tailings consolidation and seepage modelling and steady-state seepage analyses for conditions during operations and after closure of the TMF.

Tailings consolidation analyses were performed to predict average tailings dry densities and consolidation seepage rates during operation of the TMF and for several decades after closure. The tailings are predicted to remain partially consolidated during operations and for a period of time after closure. However, those tailings closest to the embankments are expected to consolidate faster due to the more free draining nature of sandier material forming tailings beach areas. Consolidation seepage rates are predicted to range from approximately 180 to 400 l/sec during operations (average of approximately 350 l/sec), reducing substantially after the end of operations to less than 100 l/sec within one year, less than 50 l/sec after 5 years and less than 10 l/sec within 30 years. The large majority of the tailings consolidation seepage will report to the supernatant pond. The actual time taken for complete consolidation will be dependent on the in situ consolidation characteristics of the tailings material. Reduced consolidation seepage may continue for several decades until complete tailings consolidation is achieved.

Steady-state seepage analyses indicate that the total seepage rate from the TMF is approximately 6 l/s during Preproduction (Stage 1A, with only a start-up water pond), 5 l/sec for Stage 1B (End of Year 1), increasing to about 20 l/sec by Year 10 and approximately 40 l/sec for the final embankment arrangement (Year 22, with a crest elevation of 998 m). The majority of the seepage is expected to flow directly into original ground, with only approximately one-third of the total seepage flowing through the low permeability core zones of the confining embankments. The quantity of seepage predicted to flow from the base of the potentially reactive waste storage area is estimated to be less than 10% of the total seepage passing directly into original ground (TMF foundation). The remaining seepage into the TMF foundation passes through the tailings deposit. Approximately 10% of the foundation seepage is estimated to flow through the base of the PAG tailings. A significant portion of the seepage will likely flow toward the Main Embankment.

For the final TMF arrangement approximately 97 % of embankment seepage is estimated to flow through the Main Embankment. The remaining 3 % of embankment seepage is through the smaller West Saddle Embankment.

Design provisions to minimize seepage losses include a low permeability core zone within the confining embankments, a low permeability upstream blanket for the Main Embankment, and development of tailings beaches (which isolate the supernatant pond from the embankments) to the extent possible while still maintaining subaqueous disposal of potentially reactive waste rock and PAG tailings during operations and post-closure.

An embankment drainage system has been provided to collect excess water resulting from cyclone sand deposition and seepage through the embankment and foundation. The provision of embankment underdrainage will enable a significant portion of the total seepage to be intercepted and routed to seepage collection ponds for recovery and return to the TMF.

The results of this seepage assessment have been incorporated into a site wide water balance model, developed to define and track the distribution of water inputs and outputs for the TMF. The various flow components and corresponding seepage rates provided by the tailings consolidation

modelling and seepage analyses can be used to predict water quality during operations and for long-term conditions after the cessation of operations.

5 – CERTIFICATION

This report was prepared, reviewed and approved by the undersigned.

Prepared:

Sanne Brinkman, M.Sc.
Geological Engineering

PROFESSIONAL ENGINEER
YUKON TERRITORY
GRAHAM R. GREENAWAY
Dec. 19th 2012

Reviewed:

Graham R.Greenaway, P.Eng.
Specialist Geotechnical Engineer

Approved:

Ken J. Brouwer, P.Eng.
Managing Director

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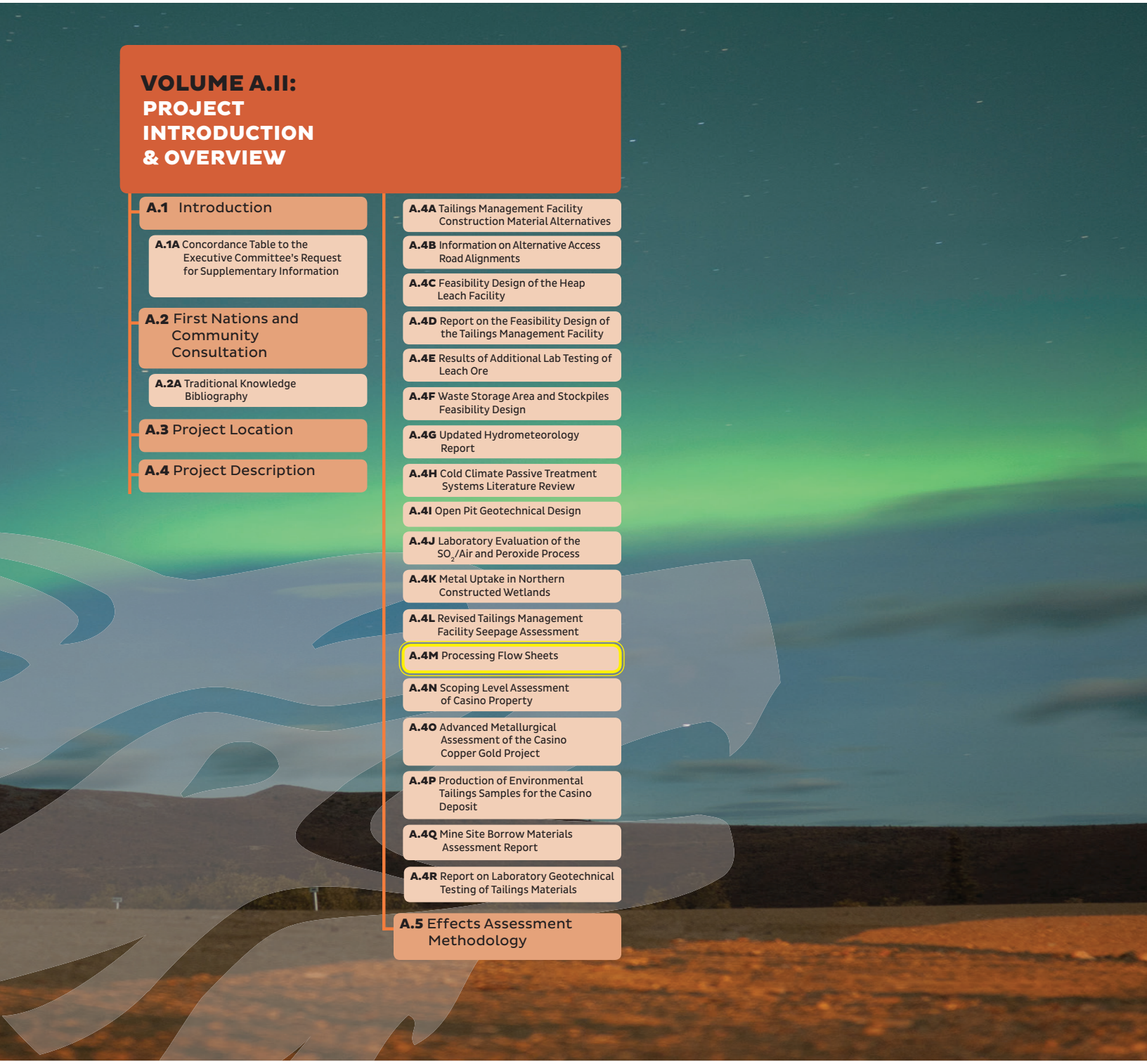
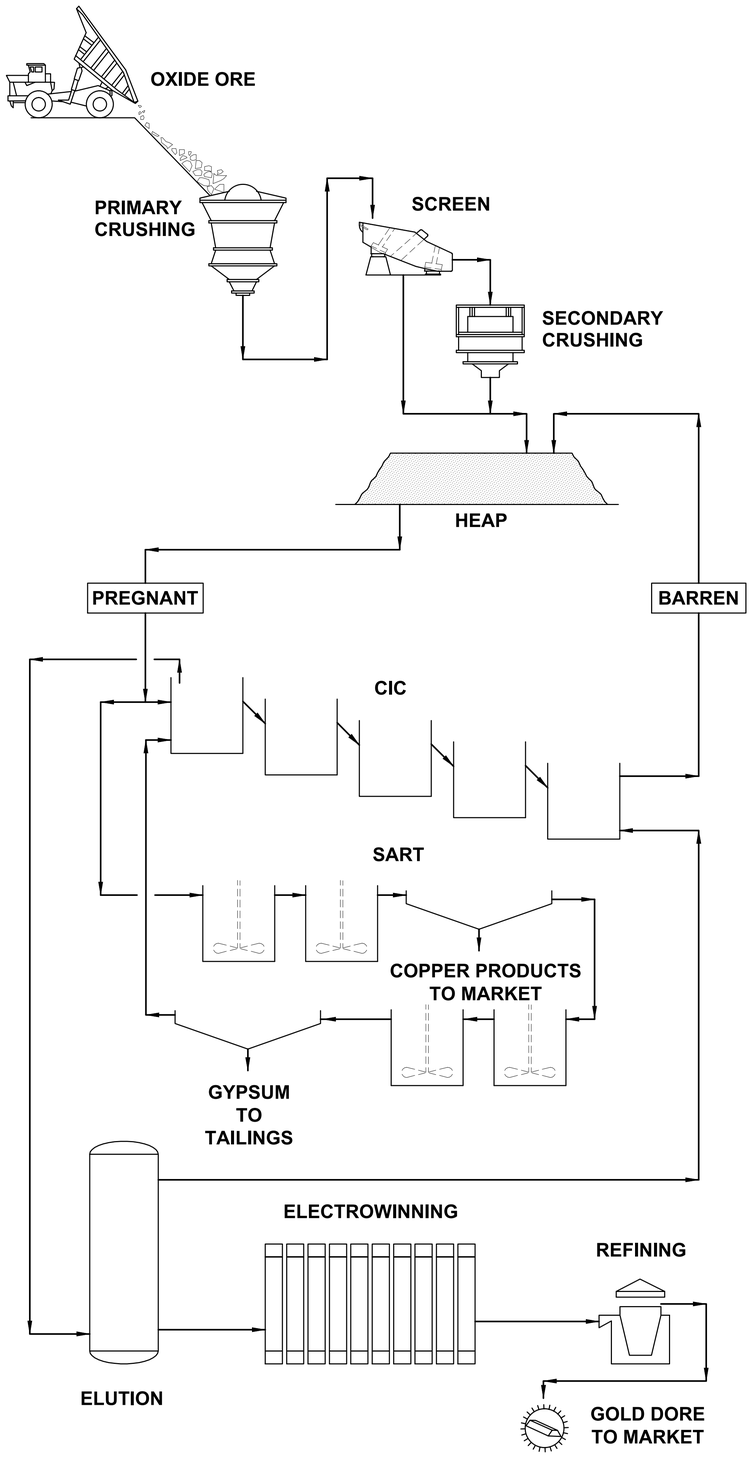
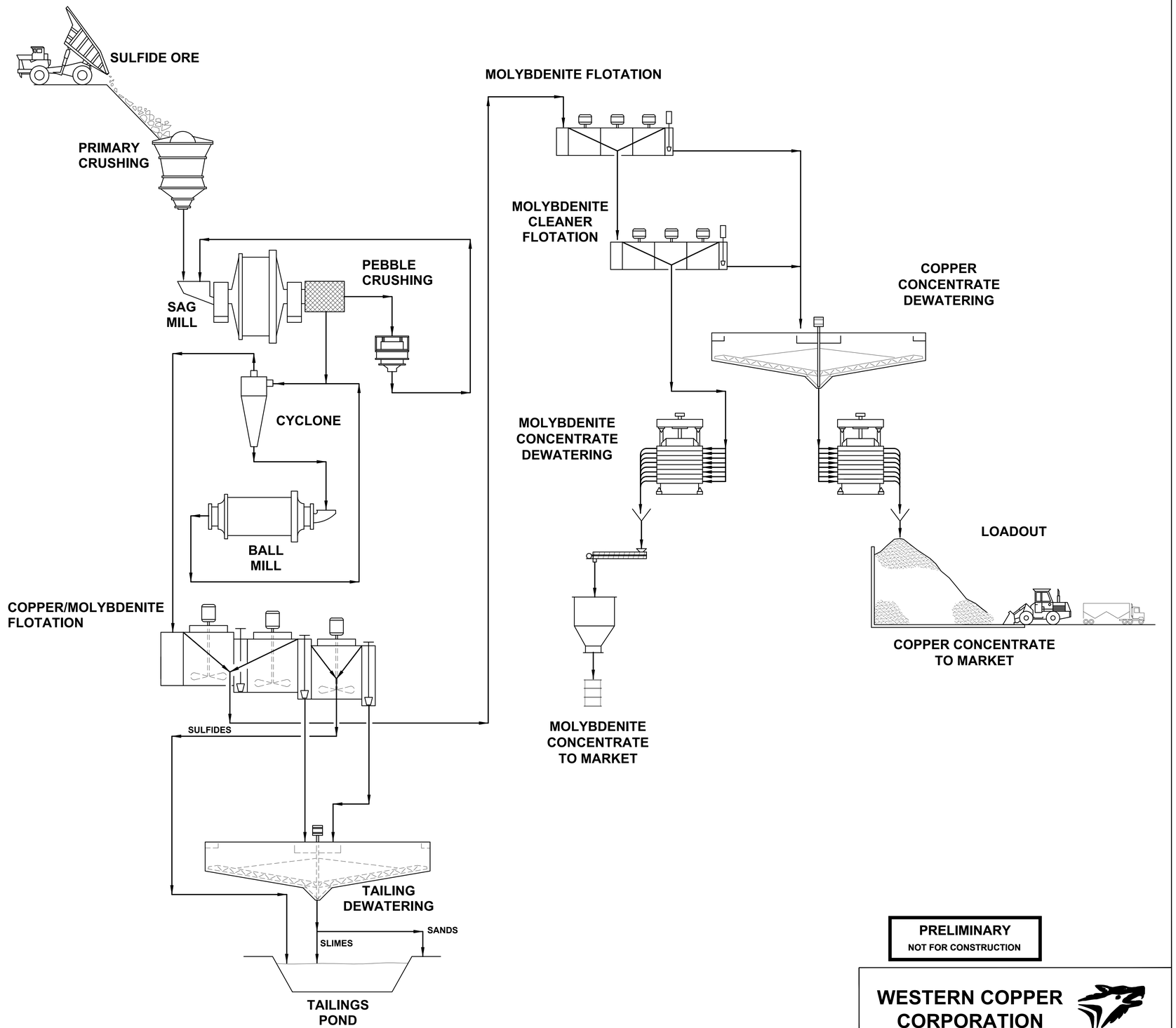
APPENDIX A.4M: Processing Flow Sheets



HEAP LEACH



COPPER - MOLYBDENUM FLOTATION



PRELIMINARY
NOT FOR CONSTRUCTION

WESTERN COPPER CORPORATION

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REVISIONS					
NO.	DESCRIPTION	BY	APP'D	DATE	CLIENT

REVISIONS					
NO.	DESCRIPTION	BY	APP'D	DATE	CLIENT

SCALE:	NONE	DATE
DESIGNED BY	BB	APR 12
DRAWN BY	ACW	APR 12
CHECKED BY		
PROJECT MGR		
CLIENT APPR.		

m3 ARCHITECTURE ENGINEERING CONSTRUCTION MANAGEMENT
Tucson, Arizona
Chandler, Arizona
Hermosillo, Sonora Mexico
www. m3eng.com

CASINO FEASIBILITY STUDY

CASINO SITE FLOW SHEET GENERAL OVERALL PROCESS

PROJECT NO. M3-PN 120001
DWG NO. **000-FS-001**
REV NO. P2
DATE 16 AUG 12

File: P:\2012\120001\TO BE ISSUED (092)\FS\000-FS-001 P2.dwg LAST UPDATE:8/16/2012 8:00 AM BY: BBS700

TAILING THICKENERS
000-FS-006

CRUSHER OVERHEAD CRANE
100-HO-001

CRUSHER AREA DUST COLLECTOR
100-DC-001

TO ATMOS.

ROM STOCKPILE

ROCK BREAKER
100-RP-001

CRUSHER DUMP HOPPER
100-BN-001

PRIMARY CRUSHER
100-CR-001

CRUSHER DISCHARGE HOPPER
100-BN-002

CRUSHING AREA SUMP PUMP
100-PP-001

MAGNET
100-MG-001

CRUSHER DISCHARGE FEEDER
100-FE-001

STOCKPILE FEED CONVEYOR
150-CV-001

METAL DETECTOR
150-MD-001

BELT SCALE
150-SC-001

STOCKPILE AREA SUMP PUMP
200-PP-002

STOCKPILE FEED DUST COLLECTOR
200-DC-002

TO ATMOS.

STOCKPILE BUILDING
150-BG-001

COARSE ORE STOCKPILE
(75,000 TON LIVE)

RECLAIM TUNNEL DUST COLLECTOR
200-DC-003

TO ATMOS.

RECLAIM FEEDER
200-FE-002

RECLAIM FEEDER
200-FE-003

RECLAIM FEEDER
200-FE-004

RECLAIM FEEDER
200-FE-005

SAG MILL BALL LOADING SYSTEM
200-MS-002

SAG MILL FEED CONVEYOR
200-CV-003

BELT SCALE
200-SC-003

TO SAG MILL
000-FS-003

CONTROL ROOM
100-BG-001

RECLAIM ELECTRICAL BUILDING
200-BG-001

CRUSHING AREA AIR RECEIVER
100-PV-001

CRUSHER BUILDING
100-BG-004

LUBE PACKAGE
100-CR-001-LB

ECCENTRIC REMOVAL CART
100-MS-001

INSTRUMENT AIR DRYER
100-DR-001

CRUSHING AREA AIR COMPRESSOR
100-CM-001

VENTILATION FAN
200-FN-001

MAGNET TOTE BOX
100-BX-001

NOTES:

1. SULPHIDE CIRCUIT WILL PROCESS 43,800,000 TONNES OF ORE PER YEAR.
2. SULPHIDE CIRCUIT IS SCHEDULED TO OPERATE 365 DAYS PER YEAR.
3. SULPHIDE CIRCUIT IS DESIGNED FOR A NOMINAL CAPACITY OF 120,000 TONNES PER DAY.
4. CRUSHING PLANT IS DESIGNED TO OPERATE 24 HOURS PER DAY AT 80% PLANT AVAILABILITY:

$$\frac{120{,}000 \text{ TPD}}{24 \text{ HR/D} \times 0.80} = 6{,}250 \text{ TPH}$$

5. GRINDING, FLOTATION, AND THICKENING PLANT IS DESIGNED TO OPERATE 24 HOURS PER DAY AT 93% AVAILABILITY:

$$\frac{120{,}000 \text{ TPD}}{24 \text{ HR/D} \times 0.93} = 5{,}376 \text{ TPH}$$

Stream #	2	4	20	21	23
Solids, t/h	6,250	6,250	1,792	0	5,376
Solution, t/h	193	193	55	0	166
Slurry, t/h	6,443	6,443	1,848	0	5,543
% Solids	97.0	97.0	97.0	0.0	97.0
% Cu	0.293	0.293	0.293		0.293
% Mo	0.024	0.024	0.024		0.024
Au, g/t	0.356	0.356	0.356		0.356
S.G. Solids	2.7	2.7	2.7		2.7
S.G. Solution	1.0	1.0	1.0	0.0	1.0
S.G. Slurry	2.6	2.6	2.6	0.0	2.6
Slurry, m^3/h	2,493	2,493	715	0	2,144

LEGEND:

- MAIN PROCESS FLOW
- AUXILIARY FLOW
- INTERMITTENT FLOW
- EQUIPMENT PACKAGE
- WATER SPRAY

PRELIMINARY
NOT FOR CONSTRUCTION

DO NOT SCALE 11x17 DRAWINGS

CASINO MINING CORPORATION

CASINO FEASIBILITY STUDY

CASINO PROJECT
GENERAL
FLOW SHEET
PRIMARY CRUSHING & STORAGE

PROJECT NO. M3-PN 120001
DWG NO. 000-FS-002
REV NO. P2
DATE 09 NOV 12

REFERENCES DWG. NO.	REFERENCES TITLE	REFERENCES DWG. NO.	REFERENCES TITLE

REVISIONS NO.	DESCRIPTION	BY	APP'D	DATE	CLIENT

REVISIONS NO.	DESCRIPTION	BY	APP'D	DATE	CLIENT

		DATE
SCALE:	NONE	
DESIGNED BY	BB	APR 12
DRAWN BY	ACW	APR 12
CHECKED BY		
PROJECT MGR		
CLIENT APPR.		

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File: P:\2012\120001\TO BE ISSUED (092)\FS\000-FS-002 P2.dwg LAST UPDATE:11/9/2012 8:09 AM BY: BBS700

PROCESS WATER
000-FS-013
301
COARSE ORE
000-FS-002
23
CONVEYOR
200-CV-003
58
59
55
16
SAG AREA SUMP PUMP
300-PP-003
56
TROMMEL SCREEN
300-SR-001
61
PEBBLE WASH SCREEN
300-SR-010
LIME
000-FS-011
SAG MILL
300-ML-001
FRESH WATER
000-FS-014
TO MILL COOLING SYSTEM
(NOTE: CLOSED LOOP SYSTEM)
60
38
PEBBLE CONVEYOR No. 1
300-CV-004
MAGNET
300-MG-002
MAGNET
300-MG-003
BELT SCALE
300-SC-002
36
METAL DETECTOR
300-MD-002
PEBBLE CONVEYOR No. 2
300-CV-005
DIVERTER GATE
300-DG-001
SAG OVERSIZE SURGE BIN
300-BN-003
PEBBLE CRUSHER FEEDER
300-FE-006
300-FE-007
300-FE-008
70
PEBBLE CRUSHER AREA SUMP PUMP
300-PP-005
PEBBLE CRUSHER
300-CR-002
300-CR-003
300-CR-004
29
49
PARTICLE SIZE MONITOR
300-SH-002
PSM
CYCLONE CLUSTER
300-CY-003
300-CY-004
CYCLONE O/F BOX
300-BX-006
31
51
PRIMARY SAMPLER
300-SA-003
BALL MILL
300-ML-003
52
48
28
SAMPLER FEED TANK
300-TK-003
SECONDARY SAMPLER
300-SA-004
PARTICLE SIZE MONITOR
300-SH-001
PSM
CYCLONE O/F BOX
300-BX-005
GRINDING AREA SUMP PUMP
300-PP-004
CYCLONE FEED SUMP
300-SU-001
CYCLONE FEED PUMP
300-PP-006
300-PP-007
300-PP-008
300-PP-009
300-PP-010 SPARE
54
CYCLONE CLUSTER
300-CY-001
300-CY-002
26
PRIMARY SAMPLER
300-SA-001
49
000-FS-004
TO ROUGHER FLOTATION CIRCUIT
30
35
GLAND WATER
000-FS-014
302
SAMPLER FEED TANK
300-TK-002
SECONDARY SAMPLER
300-SA-002
27
BALL MILL
300-ML-002
25
28
000-FS-004
TO ROUGHER FLOTATION CIRCUIT

LEGEND:

- MAIN PROCESS FLOW
- AUXILIARY FLOW
- INTERMITTENT FLOW
- EQUIPMENT PACKAGE
- WATER SPRAY

SAG MILL LINER BOLT REMOVAL TOOL
300-MS-003
SAG MILL LUBE PACKAGE
300-ML-001-LB
SAG MILL HYDRAULIC JACKING SYSTEM
300-MS-004
SAG MILL JACKING CRADLE
300-MS-005
BALL MILL LUBE PACKAGE
300-ML-002-LB
300-ML-003-LB
BALL MILL LINER BOLT REMOVAL TOOL
300-MS-006
BALL MILL JACKING CRADLE
300-MS-007
MAGNET TOTE BOX
300-BX-001
300-BX-002
BALL MILL BALL LOADING SYSTEM
300-MS-008
SAG MILL LINER HANDLER
300-LH-001
BALL MILL LINER HANDLER
300-LH-002
CONTROL ROOM
300-BG-003
PLANT AIR COMPRESSOR
300-CM-002
300-CM-003
BALL MILL CRANE
300-HO-003
INSTRUMENT AIR DRYER
300-DR-002
AIR RECEIVER
300-PV-002
INSTRUMENT AIR RECEIVER
300-PV-003
CYCLONE CRANE
300-HO-004
SAG MILL CRANE
300-HO-002
CHILLERS
300-HX-001
300-HX-002
300-HX-003
LINER HANDLER TOOL KIT
300-LH-003
```

| Stream # | 16 | 23 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 35 | 36 | 38 | 48 | 49 | 51 | 52 | 54 | 55 | 56 | 58 | 59 | 60 | 61 | 70 | 301 | 302 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Solids, t/h | 6,183 | 5,376 | 9,409 | 6,720 | 6,720 | 2,688 | 0 | 0 | 0 | 0 | 807 | 142 | 9,409 | 2,688 | 6,720 | 6,720 | 0 | 0 | 0 | 0 | 0 | 5,234 | 949 | 807 | 0 | 0 |
| Solution, t/h | 209 | 166 | 7,476 | 2,614 | 2,614 | 4,863 | 5,791 | 84 | 0 | 84 | 42 | 239 | 7,476 | 4,863 | 2,614 | 2,614 | 0 | 232 | 123 | 2,318 | 927 | 3,527 | 50 | 42 | 9,269 | 168 |
| Slurry, t/h | 6,392 | 5,543 | 16,885 | 9,334 | 9,334 | 7,551 | 5,791 | 84 | 0 | 84 | 849 | 382 | 16,885 | 7,551 | 9,334 | 9,334 | 0 | 232 | 123 | 2,318 | 927 | 8,761 | 999 | 849 | 9,269 | 168 |
| % Solids | 96.7 | 97.0 | 55.7 | 72.0 | 72.0 | 35.6 | 0.0 | 0.0 | 0.0 | 0.0 | 95.0 | 37.3 | 55.7 | 35.6 | 72.0 | 72.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 59.7 | 95.0 | 95.0 | 0.0 | 0.0 |
| % Cu | 0.293 | 0.293 | 0.293 | 0.293 | 0.293 | 0.293 | | | | | 0.293 | 0.293 | 0.293 | 0.293 | 0.293 | 0.293 | | | | | | 0.293 | 0.293 | 0.293 | | |
| % Mo | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 | | | | | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 | | | | | | 0.024 | 0.024 | 0.024 | | |
| Au, g/t | 0.356 | 0.356 | 0.356 | 0.356 | 0.356 | 0.356 | | | | | 0.356 | 0.356 | 0.356 | 0.356 | 0.356 | 0.356 | | | | | | 0.356 | 0.356 | 0.356 | | |
| S.G. Solids | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | | | | | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | | | | | | 2.7 | 2.7 | 2.7 | | |
| S.G. Solution | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| S.G. Slurry | 2.6 | 2.6 | 1.5 | 1.8 | 1.8 | 1.3 | 1.0 | 1.0 | 1.0 | 1.0 | 2.5 | 1.3 | 1.5 | 1.3 | 1.8 | 1.8 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.6 | 2.5 | 2.5 | 1.0 | 1.0 |
| Slurry, $m^3/h$ | 2,483 | 2,144 | 10,950 | 5,090 | 5,090 | 5,860 | 5,801 | 84 | 0 | 84 | 399 | 292 | 10,950 | 5,860 | 5,090 | 5,090 | 0 | 232 | 123 | 2,322 | 929 | 5,459 | 399 | 339 | 9,285 | 168 |

**PRELIMINARY**
**NOT FOR CONSTRUCTION**

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| REFERENCES | | REFERENCES | |
|---|---|---|---|
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| REVISIONS | | | | | | REVISIONS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| NO. | DESCRIPTION | BY | APP'D | DATE | CLIENT | NO. | DESCRIPTION | BY | APP'D | DATE | CLIENT |
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| | | DATE |
|---|---|---|
| SCALE: | NONE | |
| DESIGNED BY | BB | APR 12 |
| DRAWN BY | ACW | APR 12 |
| CHECKED BY | | |
| PROJECT MGR | | |
| CLIENT APPR. | | |

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Chandler, Arizona
Hermosillo, Sonora Mexico
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**WESTERN COPPER CORPORATION**

# CASINO FEASIBILITY STUDY

## CASINO SITE FLOW SHEET GENERAL GRINDING & CLASSIFICATION

PROJECT NO. M3-PN 120001
DWG NO. 000-FS-003
REV NO. P2
DATE 16 AUG 12

File: P:\2012\120001\TO BE ISSUED (5912)\FS\000-FS-003 P2.dwg LAST UPDATE:8/16/2012 8:00 AM BY: BB5700
```

PROMOTER No. 2
000-FS-012
MOLY COLLECTOR
000-FS-011
MIBC
000-FS-011
CYCLONE O' FLOW
000-FS-003
300-SA-001
PROMOTER No. 1
000-FS-012
PROMOTER No. 2
000-FS-012
PROMOTER No. 1
000-FS-012
MIBC
000-FS-011
CYCLONE O' FLOW
000-FS-003
300-SA-003
REGRIND AREA SUMP PUMP 400-PP-028
000-FS-005
PROCESS WATER
000-FS-013
Cu-Mo THICKENER O'FLOW
000-FS-007
Cu 2nd CLEANER TAILING PUMP
000-FS-005
PROMOTER No. 2
000-FS-012
MOLY COLLECTOR
000-FS-011
MIBC
000-FS-011
PROMOTER No. 1
000-FS-012

68
261
28
107
75
108
49
261
319
125
95
85
90
331
331
334
334

ROUGHER FLOTATION CELL
400-FC-001 400-FC-005
400-FC-002 400-FC-006
400-FC-003 400-FC-007
400-FC-004

PYRITE SCAVENGER CELLS
400-FC-008 400-FC-010
400-FC-009 400-FC-011

PYRITE SCAVENGER CELLS (FUTURE)
400-FC-012
400-FC-013

PAX

ROUGHER AREA SUMP PUMP
400-PP-027

ROUGHER FLOTATION CELL
400-FC-101 400-FC-103 400-FC-105
400-FC-102 400-FC-104 400-FC-106
400-FC-107

PYRITE SCAVENGER CELLS
400-FC-108 400-FC-110
400-FC-109 400-FC-111

PYRITE SCAVENGER CELLS (FUTURE)
400-FC-112
400-FC-113

ROUGHER AREA SUMP PUMP
400-PP-026

COPPER 1st CLEANER DISTRIBUTOR
400-BX-001

ROUGHER CONCENTRATE SAMPLER
400-SA-014

ROUGHER CONCENTRATE PUMP
400-PP-031
400-PP-032

ROUGHER CONCENTRATE SUMP
400-SU-007

COPPER 1st CLEANER CELLS
400-FC-021 400-FC-023 400-FC-025
400-FC-022 400-FC-024 400-FC-026

CLEANER AREA SUMP PUMP
400-PP-029

COPPER 1st CLEANER CELLS
400-FC-121 400-FC-124
400-FC-122 400-FC-125
400-FC-123 400-FC-126

PROMOTER No. 1
Mo COLLECTOR
PROMOTER No. 2

180
241
242
181
195
332
336
332
336

PRIMARY SAMPLER
400-SA-015

ROUGHER CONCENTRATE SAMPLER
400-SA-013

SAMPLER FEED TANK
400-TK-005

SECONDARY SAMPLER
400-SA-016

PRIMARY SAMPLER
400-SA-017

SAMPLER FEED TANK
400-TK-004

SECONDARY SAMPLER
400-SA-018

Cu 1st CLEANER TAILING SAMPLER
400-SA-022

Cu 1st CLEANER TAILING SAMPLER
400-SA-023

PYRITE THICKENER
000-FS-006

TAIL THICKENER
000-FS-006

PYRITE THICKENER
000-FS-006

PYRITE THICKENER
000-FS-006

REGRIND FEED SUMP
400-SU-002
000-FS-005

REGRIND FEED SUMP
400-SU-002
000-FS-005

Stream #	28	49	68	75	85	90	95	107	108	125	180	181	195	241	242	261	319	331	332	334	336
Solids, t/h	2,688	2,688	0	0	0	403	806	0	403	167	2,151	2,151	134	134	0	0	0	487	380	0	107
Solution, t/h	4,863	4,863	65	65	448	1,389	2,778	448	1,389	1,084	3,738	3,738	463	463	149	64	1,563	1,931	1,681	119	369
Slurry, t/h	7,551	7,551	65	65	448	1,792	3,584	448	1,792	1,251	5,888	5,888	597	597	149	64	1,563	2,418	2,061	119	476
% Solids	35.6	35.6	0.0	0.0	0.0	22.5	22.5	0.0	22.5	13.4	36.5	36.5	22.5	22.5	0.0	0.0	0.0	20.1	18.4	0.0	22.5
% Cu	0.293	0.293				1.72	1.7		1.72	0.76	0.02	0.02	0.35	0.35				1.55	0.16		6.50
% Mo	0.024	0.024				0.11	0.11		0.11	0.07	0.00	0.00	0.10	0.10				0.10	0.02		0.41
Au, g/t	0.356	0.356				1.76	1.8		1.76	1.27	0.07	0.07	0.74	0.74				1.67	0.32		6.47
S.G. Solids	2.72	2.72				2.92	2.92		2.92	3.66	2.65	2.65	3.29	3.29				3.03	2.87		3.75
S.G. Solution	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
S.G. Slurry	1.29	1.29	1.00	1.00	1.00	1.17	1.17	1.00	1.17	1.11	1.29	1.29	1.18	1.18	1.00	1.00	1.00	1.15	1.13	1.00	1.20
Slurry, m^3/h	5,860	5,860	65	65	449	1,529	3,058	449	1,529	1,132	4,554	4,554	505	505	150	64	1,566	2,095	1,816	119	398

LEGEND:
- MAIN PROCESS FLOW
- AUXILIARY FLOW
- INTERMITTENT FLOW
- EQUIPMENT PACKAGE
- WATER SPRAY

PRELIMINARY
NOT FOR CONSTRUCTION

DO NOT SCALE 11x17 DRAWINGS

REFERENCES		REFERENCES	
DWG. NO.	TITLE	DWG. NO.	TITLE

REVISIONS					
NO.	DESCRIPTION	BY	APP'D	DATE	CLIENT

REVISIONS					
NO.	DESCRIPTION	BY	APP'D	DATE	CLIENT

		DATE
SCALE:	NONE	
DESIGNED BY	BB	APR 12
DRAWN BY	ACW	APR 12
CHECKED BY		
PROJECT MGR		
CLIENT APPR.		

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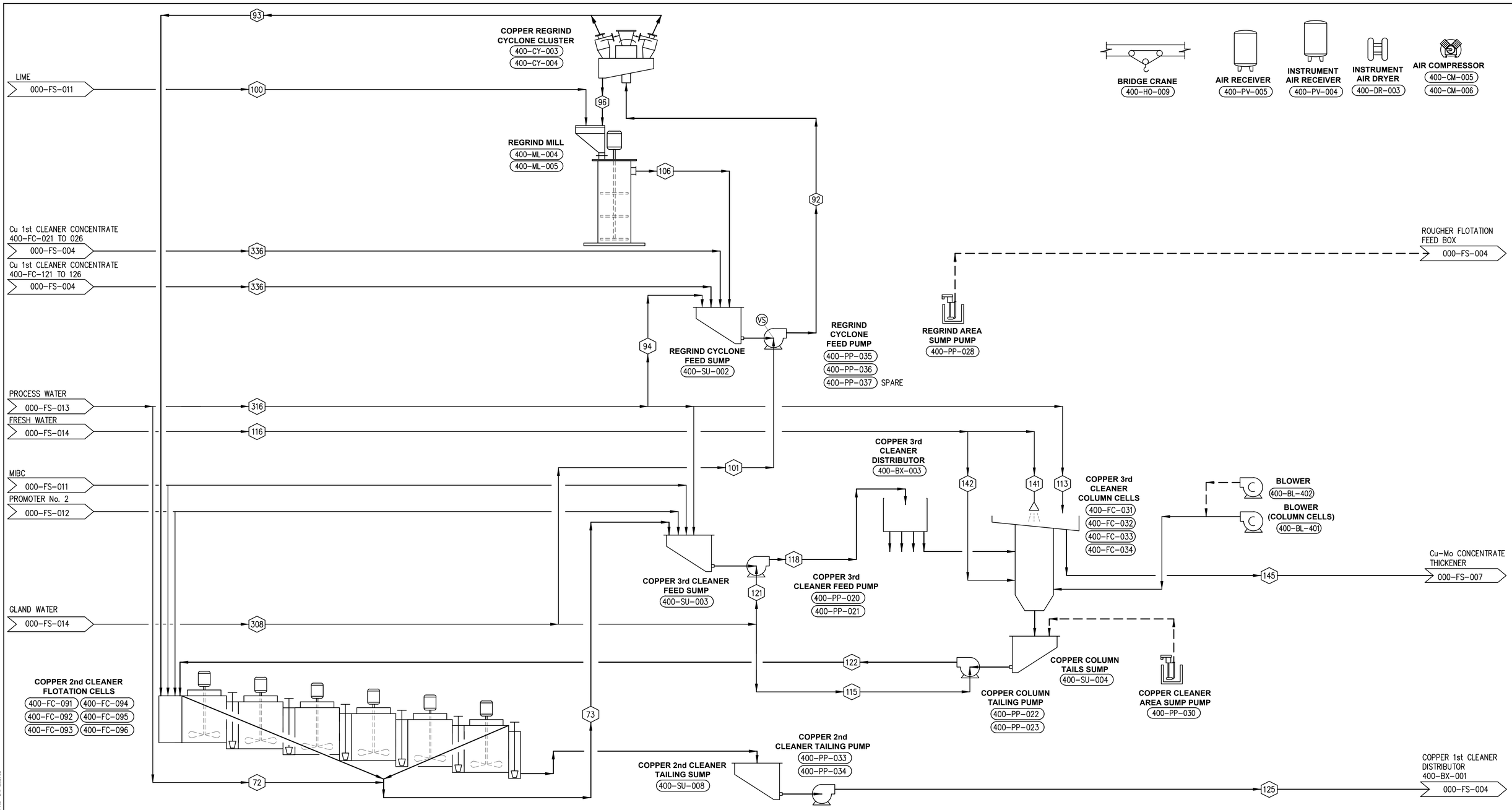
CASINO MINING CORPORATION

CASINO FEASIBILITY STUDY

CASINO PROJECT
GENERAL
FLOW SHEET
Cu ROUGHER FLOTATION

PROJECT NO. M3-PN 120001
DWG NO. **000-FS-004**
REV NO. P3
DATE 19 OCT 12

File: P:\2012\120001\To BE ISSUED (592)\FS\000-FS-004 P3.dwg LAST UPDATE:10/19/2012 11:23 AM BY: BB5700



Stream #	72	73	92	93	94	96	100	101	106	113	115	116	118	121	122	125	141	142	145	308	316	336
Solids, t/h	0	90	643	214	0	428	0	0	428	0	0	0	90	0	43	167	0	0.0	47	0	0	107
Solution, t/h	263	473	1,062	777	0	286	22	17	286	74	6	120	479	6	518	1,084	120	0.5	161	28	337	369
Slurry, t/h	263	563	1,705	991	0	714	22	17	714	74	6	120	569	6	561	1,251	120	0.5	208	28	337	476
% Solids	0.0	16.0	37.7	21.6	0.0	60.0	0.0	0.0	60.0	0.0	0.0	0.0	15.8	0.0	7.7	13.4	0.0	0.0	22.5	0.0	0.0	22.5
% Cu		18.7	6.5	6.5		6.5			6.5				18.7		9.7	0.8			27.0			6.5
% Mo		1.11	0.41	0.41		0.41			0.41				1.11		0.58	0.07			1.60			0.41
Au, g/t		17.3	6.5	6.5		6.5			6.5				17.3		9.0	1.3			25.0			6.5
S.G. Solids		3.9	3.7	3.7		3.7			3.7				3.9		3.8	3.7			4.1			3.7
S.G. Solution	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
S.G. Slurry	1.0	1.1	1.4	1.2	1.0	1.8	1.0	1.0	1.8	1.0	1.0	1.0	1.1	1.0	1.1	1.1	1.0	1.0	1.2	1.0	1.0	1.2
Slurry, m^3/h	263	497	1,236	835	0	400	22	17	400	75	6	121	502	6	530	1,132	120	0.5	173	28	338	398

LEGEND:
- MAIN PROCESS FLOW
- AUXILIARY FLOW
- INTERMITTENT FLOW
- EQUIPMENT PACKAGE
- WATER SPRAY

PRELIMINARY
NOT FOR CONSTRUCTION

DO NOT SCALE 11x17 DRAWINGS

REFERENCES DWG. NO.	REFERENCES TITLE	REFERENCES DWG. NO.	REFERENCES TITLE

REVISIONS NO.	DESCRIPTION	BY	APPD	DATE	CLIENT

REVISIONS NO.	DESCRIPTION	BY	APPD	DATE	CLIENT

		DATE
SCALE:	NONE	
DESIGNED BY	BB	APR 12
DRAWN BY	ACW	APR 12
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PROJECT MGR		
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CASINO FEASIBILITY STUDY

CASINO SITE FLOW SHEET GENERAL Cu CLEANER FLOTATION

PROJECT NO. M3-PN 120001
DWG NO. 000-FS-005
REV NO. P2
DATE 16 AUG 12

File: P:\2012\120001\10 BE ISSUED (592)\FS\000-FS-005 P2.dwg LAST UPDATE:8/16/2012 8:00 AM BY: BB5700

RECLAIM WATER BOOSTER TANK
000-FS-013
517
ANTISCALANT
–
FLOCCULANT
000-FS-012
CRUSHING AREA
000-FS-002
PRIMARY SAMPLER 400-SA-015
000-FS-004
180
PRIMARY SAMPLER 400-SA-017
000-FS-004
181
135
136
SPRAY BAR
131
TAILING THICKENERS
600-TH-004
600-TH-005
TAILING THICKENER AREA SUMP PUMP
600-PP-129
TAILING THICKENER RECIRCULATE PUMPS
600-PP-134
600-PP-133
132
TAILING THICKENER OVERFLOW SUMP PUMP
600-SU-101
TAILING THICKENER OVERFLOW PUMPS
600-PP-130
600-PP-131
600-PP-132
130
EMERGENCY CONTAINMENT POND
GLAND WATER
000-FS-014
PYRITE CONCENTRATE
000-FS-004
241
PYRITE CONCENTRATE
000-FS-004
195
Cu 1ST CLEANER TAILS
000-FS-004
332
Cu 1ST CLEANER TAILS
000-FS-004
332
FLOCCULANT
000-FS-012
147
PROCESS WATER POND
000-FS-013
TAILING CYCLONE PLANT HEAD WATER TANK
600-TK-001
SEAL WATER FILTER
600-FL-001
600-FL-002
F
WATER BUFFER TANK
600-TK-004
SEAL WATER TANK
600-TK-005
SEAL WATER PUMP (FUTURE)
600-PP-241
THROUGH
600-PP-248
520
506
TAILING CYCLONE CLUSTER
600-CY-200
519
508
NOTE 1
502
TAILING CYCLONE FEED SUMP
600-SU-200
TAILING CYCLONE OVERFLOW PUMP (FUTURE)
600-PP-237
600-PP-238 STAND-BY
TAILING CYCLONE OVERFLOW SUMP
600-SU-201
TAILING CYCLONE UNDERFLOW PUMP (FUTURE)
600-PP-231 600-PP-234 STAND-BY
600-PP-232 600-PP-235 STAND-BY
600-PP-233 600-PP-236 STAND-BY
TAILING CYCLONE UNDERFLOW SUMP
600-SU-202
"NET" PRECIP.
600
506
532
RECLAIM WATER BOOSTER STATION
144 517
000-FS-013
528
TAILING POND
159
151
SOLIDS
RETAINED IN SETTLED SOLIDS
RECLAIM WATER BARGE
STAND-BY 600-MS-603
600-MS-604
TAILING RECLAIM BARGE PUMP
600-PP-136 600-PP-161 STAND-BY
600-PP-137 600-PP-162 STAND-BY
600-PP-145 600-PP-163 STAND-BY
600-PP-146 600-PP-164 STAND-BY
600-PP-147 600-PP-165 STAND-BY
STAND-BY 600-PP-148 600-PP-166 STAND-BY
SEEPAGE PUMPS
600-PP-143
600-PP-144
247
245
PYRITE THICKENER
600-TH-006
246
PYRITE THICKENER UNDERFLOW PUMPS
600-PP-151
600-PP-152
PYRITE THICKENER AREA SUMP PUMP
600-PP-150

LEGEND:
MAIN PROCESS FLOW
AUXILIARY FLOW
INTERMITTENT FLOW
EQUIPMENT PACKAGE

D8 DOZER
600-EQ-601
600-EQ-602

NOTES:
1. TAILING CYCLONE PLANT WILL OPERATE APPROXIMATELY 9 MONTHS PER YEAR. TAILING CYCLONE PLANT WILL BE BYPASSED DURING TIMES OF EXTREMELY COLD WEATHER, APPROXIMATELY 3 MONTHS PER YEAR.

Stream #	130	131	132	135	136	144	147	151	159	180	181	195	241
Solids, t/h	4,301	0	4,301	0	0	0	0	0	5,329	2,151	2,151	134	134
Solution, t/h	3,519	3,963	3,519	2	5	3,222	6,988	2,007	0	3,738	3,738	463	463
Slurry, t/h	7,820	3,963	7,820	2	5	3,222	6,988	2,007	5,329	5,888	5,888	597	597
% Solids	55.0	0.0	55.0	0.0	0.0	0.0	0.0	0.0	100.0	36.5	36.5	22.5	22.5
% Cu	0.022		0.022						0.058	0.022	0.022	0.352	0.352
% Mo	0.003		0.003						0.010	0.003	0.003	0.099	0.099
Au, g/t	0.069		0.069						0.139	0.069	0.069	0.741	0.741
S.G. Solids	2.65		2.65						2.71	2.65	2.65	3.29	3.29
S.G. Solution	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00
S.G. Slurry	1.52	1.00	1.52	1.00	1.00	1.00	1.00	1.00	2.71	1.29	1.29	1.18	1.18
Slurry, m^3/h	5,145	3,970	5,145	2	5	3,228	7,000	2,011	1,966	4,554	4,554	505	505

Stream #	245	246	247	332	502	506	508	517	519	520	528	532	600
Solids, t/h	0	1,028	1,028	380	4,301	2,142	2,159	0	0	0	5,329	2,159	0
Solution, t/h	3,031	1,257	1,257	1,681	7,646	6,888	759	4,531	404	4,127	2,007	1,163	453
Slurry, t/h	3,031	2,285	2,285	2,061	11,947	9,030	2,918	4,531	404	4,127	7,337	3,322	453
% Solids	0.0	45.0	45.0	18.4	36.0	23.7	74.0	0.0		0.0	72.6	65.0	0.0
% Cu		0.210	0.210	0.159	0.022	0.022	0.022				0.058	0.022	
% Mo		0.040	0.040	0.019	0.003	0.003	0.003				0.010	0.003	
Au, g/t		0.431	0.431	0.322	0.069	0.069	0.069				0.139	0.069	
S.G. Solids		2.97	2.97	2.87	2.65	2.65	2.65				2.71	2.65	
S.G. Solution	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
S.G. Slurry	1.00	1.42	1.42	1.13	1.29	1.17	1.85	1.00	1.00	1.00	1.84	1.68	1.00
Slurry, m^3/h	3,036	1,605	1,605	1,816	9,280	7,707	1,573	4,539	405	4,134	3,977	1,978	454

PRELIMINARY
NOT FOR CONSTRUCTION

DO NOT SCALE 11x17 DRAWINGS

REFERENCES		REFERENCES	
DWG. NO.	TITLE	DWG. NO.	TITLE

REVISIONS					
NO.	DESCRIPTION	BY	APP'D	DATE	CLIENT

REVISIONS					
NO.	DESCRIPTION	BY	APP'D	DATE	CLIENT

		DATE
SCALE:	NONE	
DESIGNED BY	BB	APR 12
DRAWN BY	ACW	APR 12
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CASINO MINING CORPORATION

CASINO FEASIBILITY STUDY

CASINO PROJECT
GENERAL
FLOW SHEET
TAILING DEWATERING

PROJECT NO. M3-PN 120001
DWG NO. 000-FS-006
REV NO. P4
DATE 09 NOV 12

Files: P:\2012\120001\TO BE ISSUED (592)\FS\000-FS-006 P4.dwg LAST UPDATE:11/9/2012 8:08 AM BY: BB5700

NITROGEN
000-FS-011

NaHS
000-FS-012

LIME
000-FS-011

MIBC
000-FS-011

MOLY COLLECTOR
000-FS-011

PROMOTER NO. 1
000-FS-012

Mo 2ND CLEANER TAILS
000-FS-008
214

NaHS
000-FS-012

FRESH WATER
000-FS-014
317

FILTRATE PUMP
000-FS-010
235

Cu 3RD CLEANER COLUMN CONCENTRATE
000-FS-005
145

188

189

SPRAY BAR

149

CuMo CONCENTRATE THICKENER
500-TH-001

CuMo CONCENTRATE OVERFLOW PUMP
500-PP-051
500-PP-053

CuMo CONCENTRATE THICKENER OVERFLOW SUMP
500-SU-011

CuMo CONCENTRATE THICKENER AREA SUMP PUMP
500-PP-071

CuMo CONCENTRATE THICKENER UNDERFLOW PUMP
500-PP-054
500-PP-055

152

VS

153

154

GLAND WATER
000-FS-014
318

MOLY ROUGHER CONDITIONING TANK No. 1
400-TK-006
AGITATOR
400-AG-006

MOLY ROUGHER CONDITIONING TANK No. 2
400-TK-007
AGITATOR
400-AG-007

161

162

165

MOLY ROUGHER FLOTATION CELLS
400-FC-041
400-FC-042
400-FC-043
400-FC-044
400-FC-045
400-FC-046
400-FC-047

MULTI-STREAM ANALYZER
400-SA-021

ROUGHER FLOTATION
000-FS-004
187

MOLY ROUGHER CONCENTRATE SAMPLER
400-SA-012

MOLY ROUGHER TAILS SAMPLER
400-SA-019

320

MOLY 1st CLEANER FEED PUMP
400-PP-059
400-PP-060

170

MOLY 1st CLEANER FLOTATION CELLS
400-FC-061
400-FC-062
400-FC-063
400-FC-064
400-FC-065
400-FC-066
400-FC-067

164

COPPER CONCENTRATE THICKENER
000-FS-009

169

MOLY 1st CLEANER CONCENTRATE SAMPLER
400-SA-020

MOLY 1st CLEANER TAILS SAMPLER
400-SA-010

176

174

COPPER CONCENTRATE THICKENER
000-FS-009

178

185

MOLY REGRIND PUMP
400-PP-056
400-PP-057

MOLY REGRIND SUMP
400-SU-012

179

MOLY REGRIND MILL
400-ML-020

182

Mo 2ND CLEANER FEED SUMP 400-SU-013
000-FS-008

MOLY ROUGHER AREA SUMP PUMP
400-PP-052

LEGEND:
- MAIN PROCESS FLOW
- AUXILIARY FLOW
- INTERMITTENT FLOW
- EQUIPMENT PACKAGE
- WATER SPRAY

Stream #	145	149	152	153	154	161	162	164	165	169	170	174
Solids, t/h	46.9	0.0	46.9	0.0	46.9	0.0	46.9	40.9	0.0	0.0	8.0	4.6
Solution, t/h	161.4	132.9	38.3	0.9	39.2	47.8	87.0	78.1	8.9	2.3	56.4	48.3
Slurry, t/h	208.3	132.9	85.2	0.9	86.0	47.8	133.9	119.1	8.9	2.3	64.5	52.9
% Solids	22.5	0.0	55.0	0.0	54.5	0.0	35.0	34.4	0.0	0.0	12.5	8.6
% Cu	27.00		27.00		27.00		27.00	28.43			16.01	21.99
% Mo	1.60		1.60		1.60		1.60	0.09			12.47	0.66
S.G. Solids	4.1		4.1		4.1		4.1	4.1			4.1	4.0
S.G. Solution	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
S.G. Slurry	1.2	1.0	1.7	1.0	1.7	1.0	1.4	1.3	1.0	1.0	1.1	1.1
Slurry, m³/h	173.2	133.2	49.9	0.9	50.7	47.9	98.7	88.3	8.9	2.3	58.5	49.6

Stream #	176	178	179	182	185	187	188	189	214	235	317	318	320
Solids, t/h	3.5	3.5	0.0	3.5	0.0	0.0	0.0	0.0	2.1	0.0	0.0	0.0	5.9
Solution, t/h	10.4	10.6	0.1	10.6	0.0	128.4	2.3	2.3	38.7	5.3	59.0	1.0	17.8
Slurry, t/h	13.9	14.0	0.1	14.0	0.0	128.4	2.3	2.3	40.8	5.3	59.0	1.0	23.7
% Solids	25.0	24.8	0.0	24.8	0.0	0.0	0.0	0.0	5.2	0.0	0.0	0.0	25.0
% Cu	8.15	8.15		8.15					13.00				17.09
% Mo	28.00	28.00		28.00					13.79				12.00
S.G. Solids	4.2	4.2		4.2					4.0				4.1
S.G. Solution	1.0	1.0	1.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
S.G. Slurry	1.2	1.2	1.0	1.2	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.2
Slurry, m³/h	11.3	11.4	0.1	11.4	0.0	128.6	2.3	2.3	39.3	5.3	59.1	1.0	19.2

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REFERENCES DWG. NO.	REFERENCES TITLE	REFERENCES DWG. NO.	REFERENCES TITLE

REVISIONS NO.	DESCRIPTION	BY	APP'D	DATE	CLIENT

REVISIONS NO.	DESCRIPTION	BY	APP'D	DATE	CLIENT

		DATE
SCALE:	NONE	
DESIGNED BY	BB	APR 12
DRAWN BY	ACW	APR 12
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PROJECT MGR		
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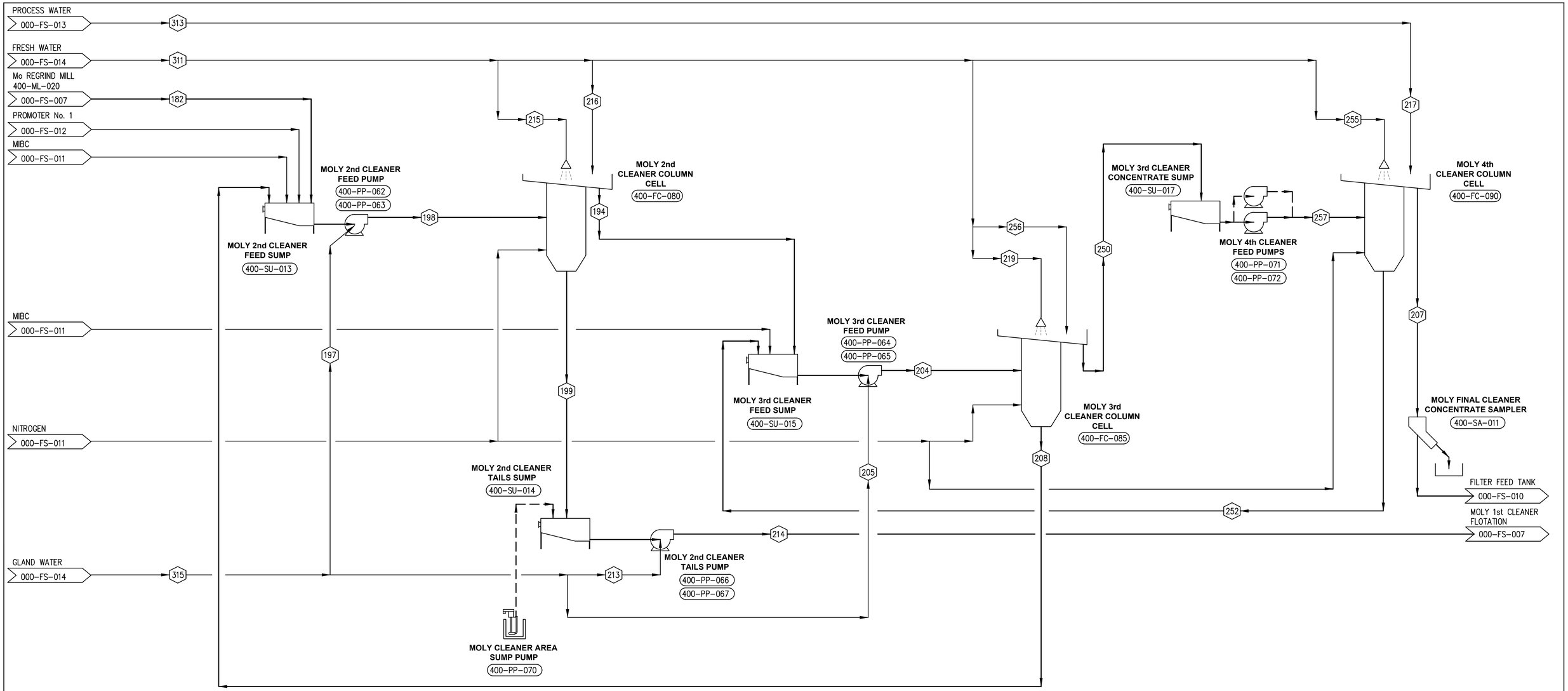
CASINO FEASIBILITY STUDY

CASINO SITE
FLOW SHEET
GENERAL
Mo ROUGHER FLOTATION

PROJECT NO. M3-PN 120001
DWG NO. 000-FS-007
REV NO. P1
DATE 15 JUN 12

File: P:\2012\120001\10_BE ISSUED (092)\FS\000-FS-007 P1.dwg LAST UPDATE:6/15/2012 1:41 PM BY: BB5700



Stream #	182	194	197	198	199	204	205	207	208	213	214	215	216	217	219	250	252	255	256	257	311	313	315
Solids, t/h	3.5	2.4	0.0	4.5	2.1	3.0	0.0	1.4	1.1	0.0	2.1	0.0	0.0	0.0	0.0	1.9	0.6	0.0	0.0	1.9	0.0	0.0	0.0
Solution, t/h	10.6	9.7	0.4	34.7	38.7	22.0	0.2	5.4	23.8	0.0	38.7	9.6	4.1	2.3	6.2	10.9	12.0	4.3	6.4	10.9	30.6	2.3	0.6
Slurry, t/h	14.0	12.2	0.4	39.3	40.8	25.0	0.2	6.8	24.8	0.0	40.8	9.6	4.1	2.3	6.2	12.8	12.6	4.3	6.4	12.8	30.6	2.3	0.6
% Solids	24.8	20.0	0.0	11.6	5.2	12.0	0.0	20.0	4.3	0.0	5.2	0.0	0.0	0.0	0.0	15.0	4.4	0.0	0.0	15.0	0.0	0.0	0.0
% Cu	8.15	3.77		8.06	13.00	3.78		0.60	7.79		13.00					1.53	3.81			1.53			
% Mo	28.00	38.00		26.73	13.79	36.99		50.00	22.68		13.79					45.00	32.70			45.00			
S.G. Solids	4.2	4.4		4.2	4.0	4.3		4.6	4.1		4.0					4.5	4.2			4.5			
S.G. Solution	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
S.G. Slurry	1.2	1.2	1.0	1.1	1.0	1.1	1.0	1.2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.0	1.0	1.0	1.1	1.0	1.0	1.0
Slurry, m^3/h	11.4	10.3	0.4	35.9	39.3	22.7	0.2	5.8	24.1	0.0	39.3	9.6	4.1	2.3	6.3	11.3	12.2	4.3	6.4	11.3	30.7	2.3	0.6

LEGEND:

- MAIN PROCESS FLOW
- AUXILIARY FLOW
- INTERMITTENT FLOW
- EQUIPMENT PACKAGE
- WATER SPRAY

PRELIMINARY
NOT FOR CONSTRUCTION

DO NOT SCALE 11x17 DRAWINGS

WESTERN COPPER CORPORATION

REFERENCES DWG. NO.	REFERENCES TITLE	REFERENCES DWG. NO.	REFERENCES TITLE

REVISIONS NO.	DESCRIPTION	BY	APP'D	DATE	CLIENT

REVISIONS NO.	DESCRIPTION	BY	APP'D	DATE	CLIENT

		DATE
SCALE:	NONE	
DESIGNED BY	BB	APR 12
DRAWN BY	ACW	APR 12
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PROJECT MGR		
CLIENT APPR.		

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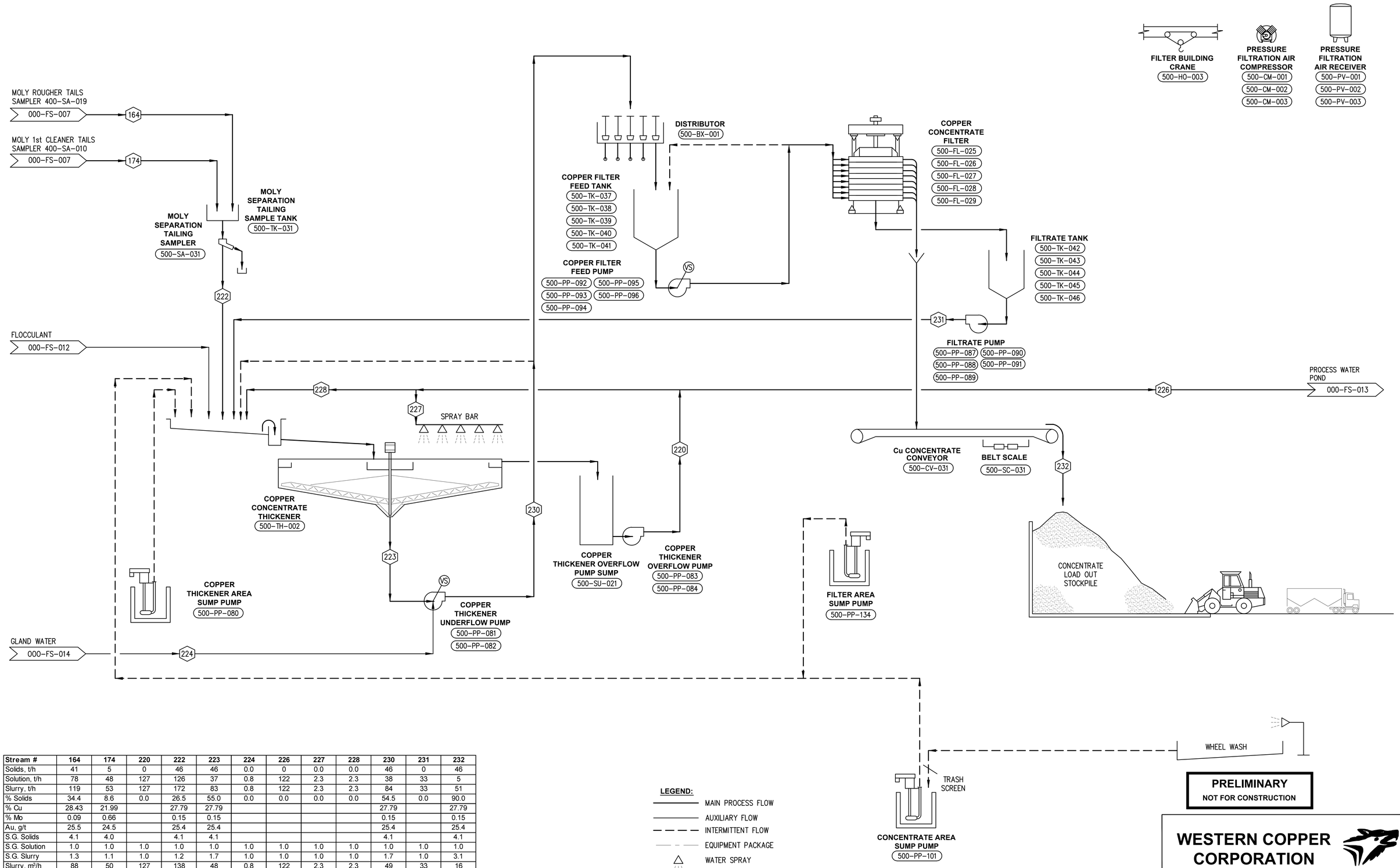
CASINO FEASIBILITY STUDY

CASINO SITE FLOW SHEET GENERAL Mo CLEANER FLOTATION

PROJECT NO. M3-PN 120001
DWG NO. 000-FS-008
REV NO. P1
DATE 15 JUN 12

File: P:\2012\120001\10 BE ISSUED (092)\FS\000-FS-008 P1.dwg LAST UPDATE:6/15/2012 1:41 PM BY: BB5700



Stream #	164	174	220	222	223	224	226	227	228	230	231	232
Solids, t/h	41	5	0	46	46	0.0	0	0.0	0.0	46	0	46
Solution, t/h	78	48	127	126	37	0.8	122	2.3	2.3	38	33	5
Slurry, t/h	119	53	127	172	83	0.8	122	2.3	2.3	84	33	51
% Solids	34.4	8.6	0.0	26.5	55.0	0.0	0.0	0.0	0.0	54.5	0.0	90.0
% Cu	28.43	21.99		27.79	27.79					27.79		27.79
% Mo	0.09	0.66		0.15	0.15					0.15		0.15
Au, g/t	25.5	24.5		25.4	25.4					25.4		25.4
S.G. Solids	4.1	4.0		4.1	4.1					4.1		4.1
S.G. Solution	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
S.G. Slurry	1.3	1.1	1.0	1.2	1.7	1.0	1.0	1.0	1.0	1.7	1.0	3.1
Slurry, m³/h	88	50	127	138	48	0.8	122	2.3	2.3	49	33	16

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REFERENCES		REFERENCES		REVISIONS						REVISIONS					
DWG. NO.	TITLE	DWG. NO.	TITLE	NO.	DESCRIPTION	BY	APP'D	DATE	CLIENT	NO.	DESCRIPTION	BY	APP'D	DATE	CLIENT

SCALE: NONE		DATE
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DRAWN BY	ACW	APR 12
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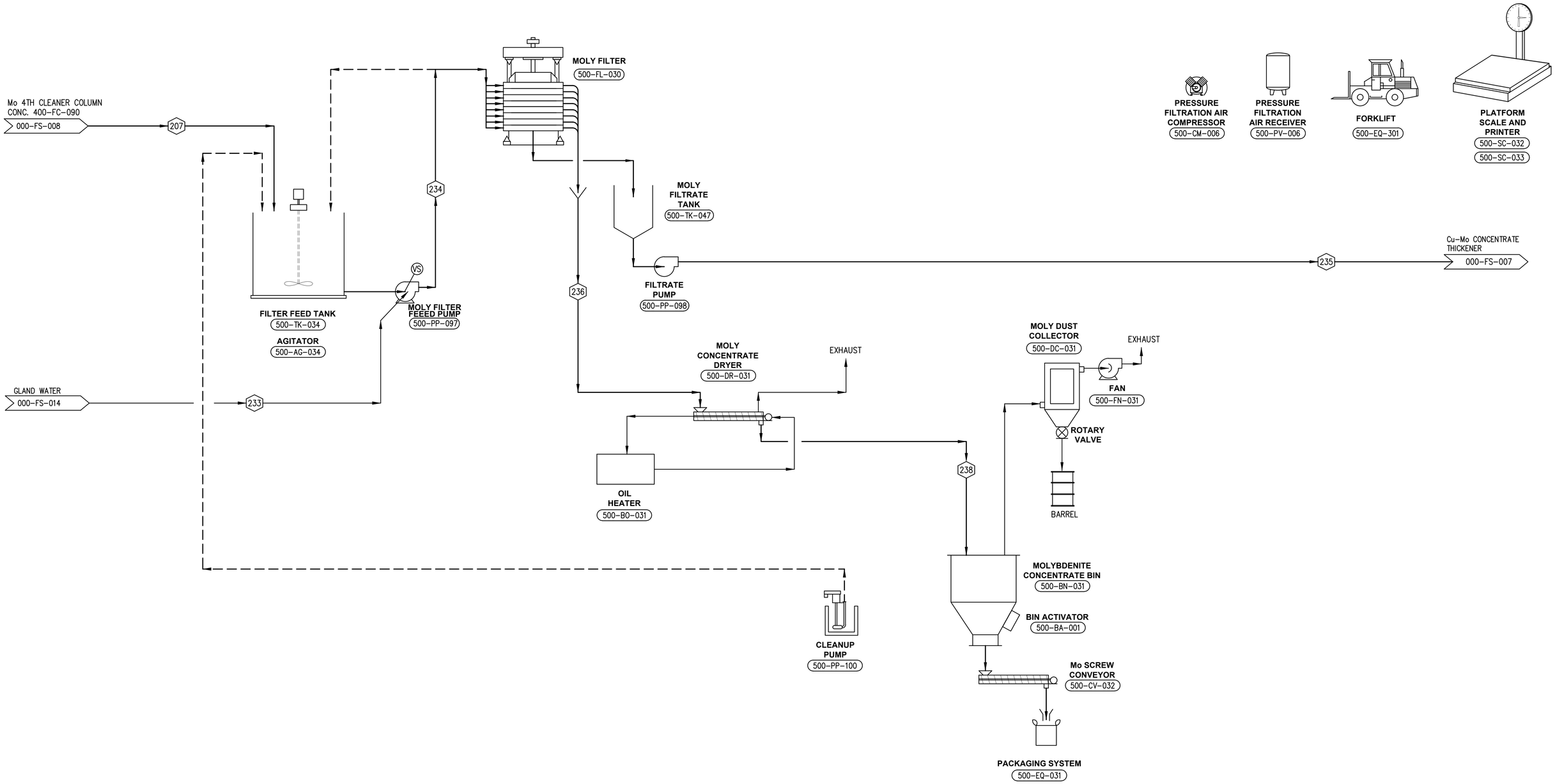
CASINO FEASIBILITY STUDY

CASINO SITE
FLOW SHEET
GENERAL
Cu CONCENTRATE DEWATERING

PROJECT NO. M3-PN 120001
DWG NO. 000-FS-009
REV NO. P1
DATE 15 JUN 12

File: P:\2012\120001\TO BE ISSUED (592)\FS\000-FS-009 P1.dwg LAST UPDATE:6/15/2012 1:41 PM BY: BB5700



Stream #	207	233	234	235	236	238
Solids, t/h	1.4	0.0	1.4	0.0	1.4	1.4
Solution, t/h	5.4	0.1	5.5	5.3	0.2	0.1
Slurry, t/h	6.8	0.1	6.9	5.3	1.5	1.4
% Solids	20.0	0.0	19.8	0.0	88.0	96.0
% Cu	0.60		0.60		0.60	0.60
% Mo	50.00		50.00		50.00	50.00
Au, g/t	12.6		12.6		12.6	12.6
S.G. Solids	4.6		4.6		4.6	4.6
S.G. Solution	1.0	1.0	1.0	1.0	1.0	1.0
S.G. Slurry	1.2	1.0	1.2	1.0	3.2	4.0
Slurry, m³/h	5.8	0.1	5.8	5.3	0.5	0.4

LEGEND:

- MAIN PROCESS FLOW
- AUXILIARY FLOW
- INTERMITTENT FLOW
- EQUIPMENT PACKAGE
- WATER SPRAY

PRELIMINARY
NOT FOR CONSTRUCTION

REFERENCES		REFERENCES	
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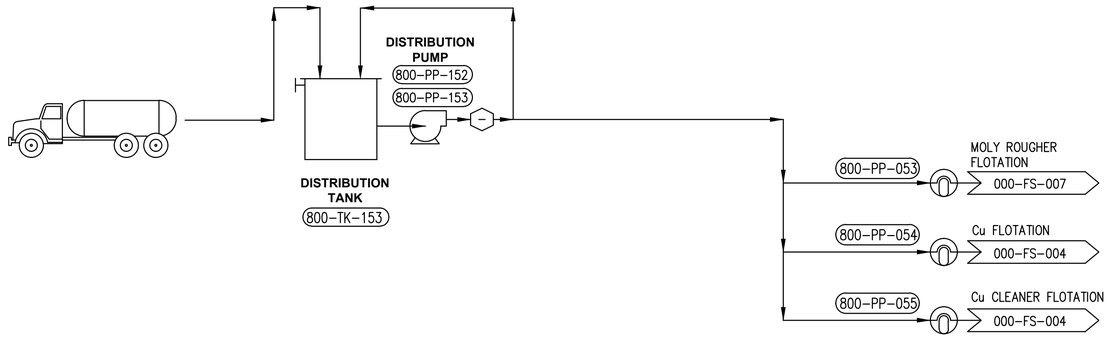
CASINO FEASIBILITY STUDY

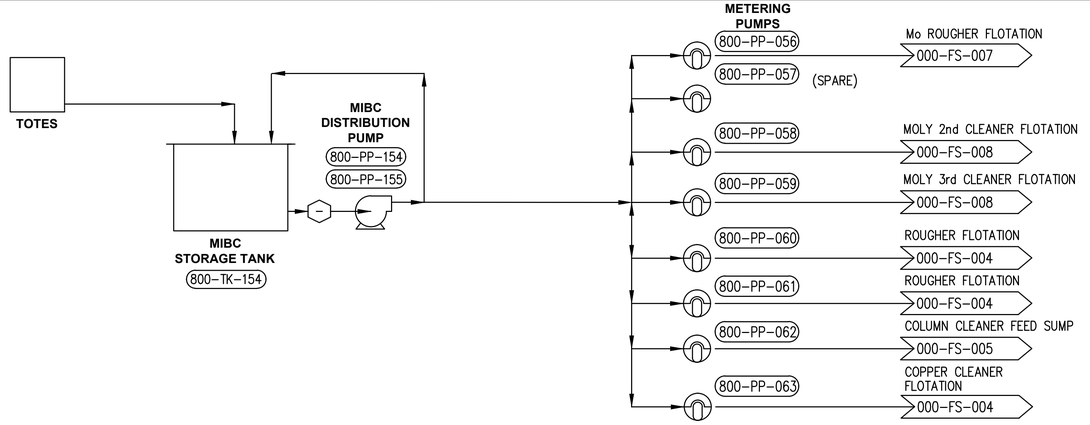
CASINO SITE FLOW SHEET GENERAL Mo CONCENTRATE DEWATERING

PROJECT NO. M3-PN 120001
DWG NO. 000-FS-010
REV NO. P2
DATE 16 AUG 12

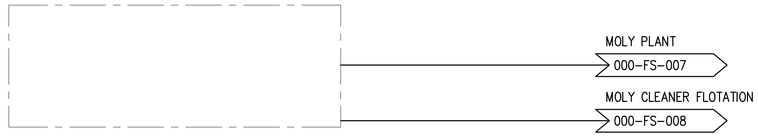
File: P:\2012\12000\10 BE ISSUED (592)\FS\000-FS-010 P2.dwg LAST UPDATE:8/16/2012 8:00 AM BY: BBG700



MOLY COLLECTOR (No. 2 DIESEL FUEL) SYSTEM

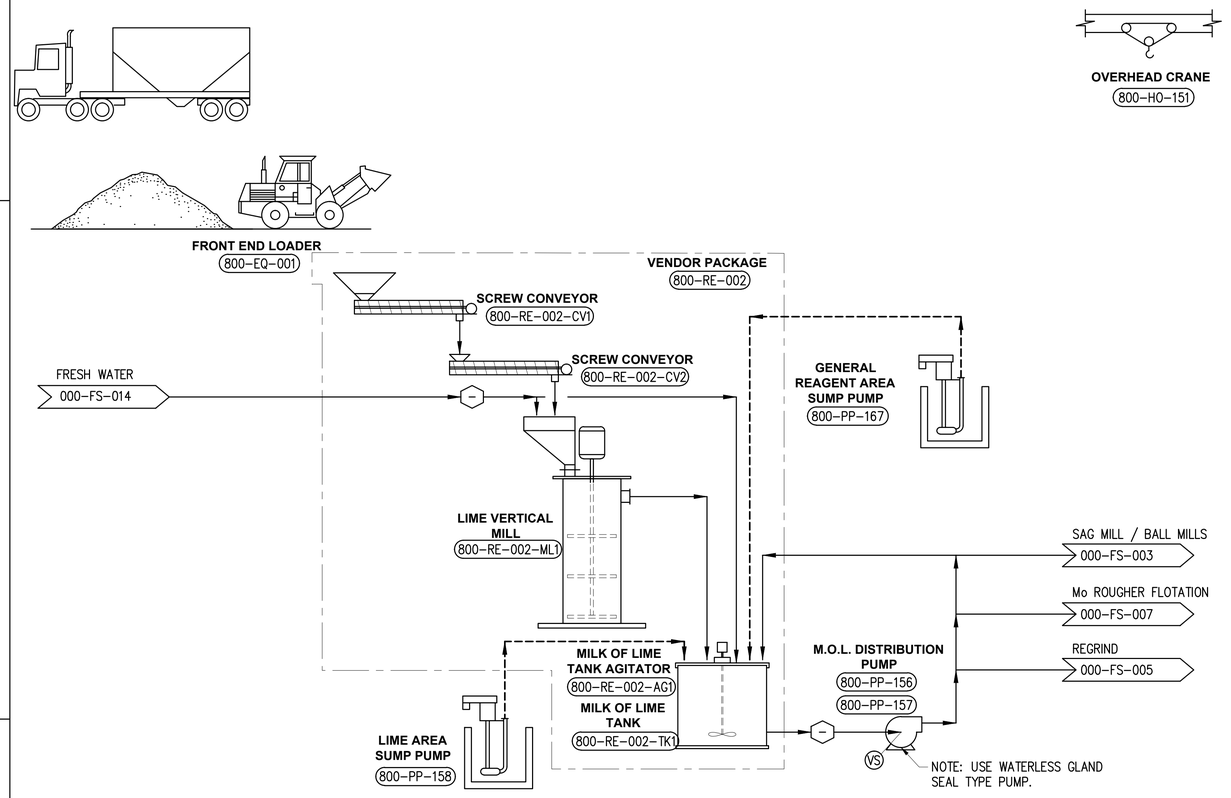


MIBC (FROTHER) SYSTEM



NITROGEN PACKAGE 800-RE-003

XANTHATE SYSTEM (PAX 350)



LIME SYSTEM

LEGEND:

- MAIN PROCESS FLOW
- AUXILIARY FLOW
- INTERMITTENT FLOW
- EQUIPMENT PACKAGE
- WATER SPRAY

PRELIMINARY
NOT FOR CONSTRUCTION

DO NOT SCALE 11x17 DRAWINGS

REFERENCES		REFERENCES	
DWG. NO.	TITLE	DWG. NO.	TITLE

REVISIONS					
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REVISIONS					
NO.	DESCRIPTION	BY	APP'D	DATE	CLIENT

SCALE:	NONE	DATE
DESIGNED BY	BB	APR 12
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CLIENT APPR.		

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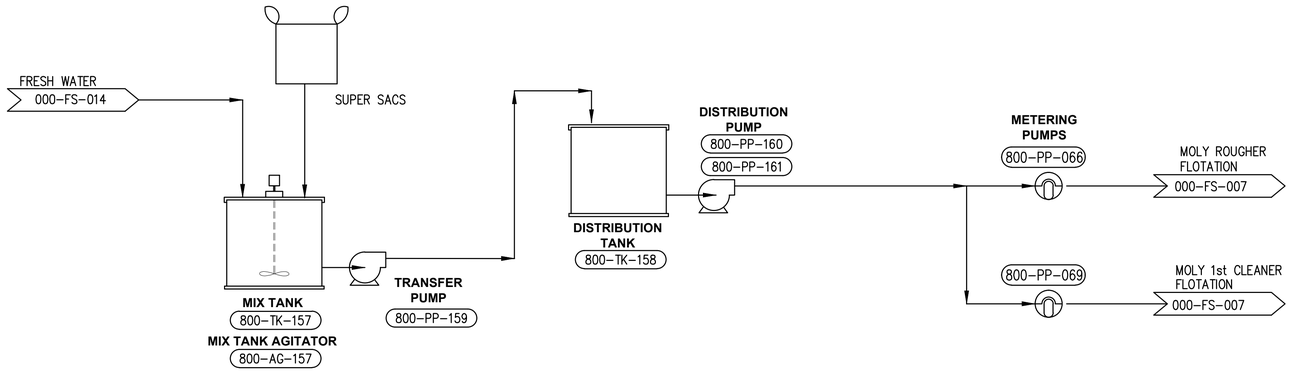
CASINO FEASIBILITY STUDY

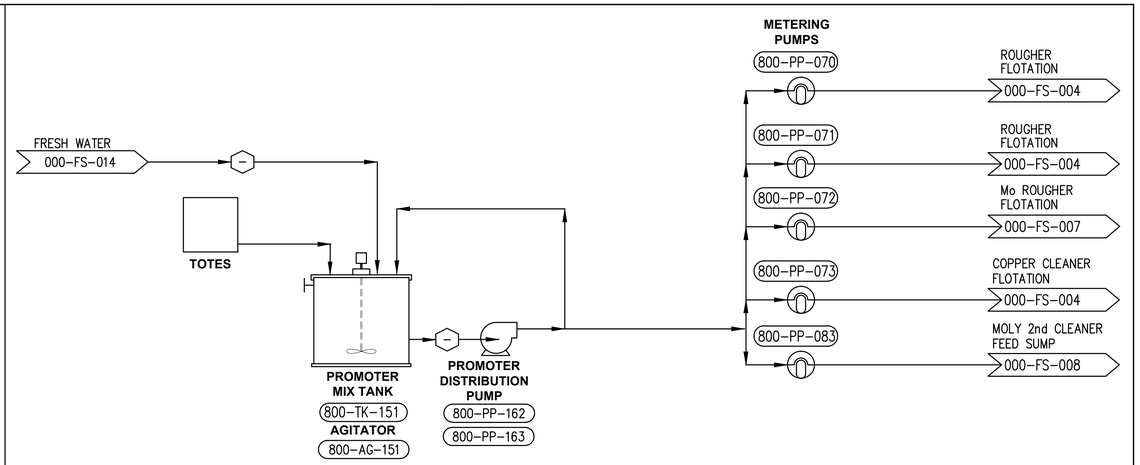
CASINO SITE FLOW SHEET GENERAL REAGENTS SHEET 1

PROJECT NO. M3-PN 120001	
DWG NO.	000-FS-011
REV NO.	P2
DATE	16 AUG 12

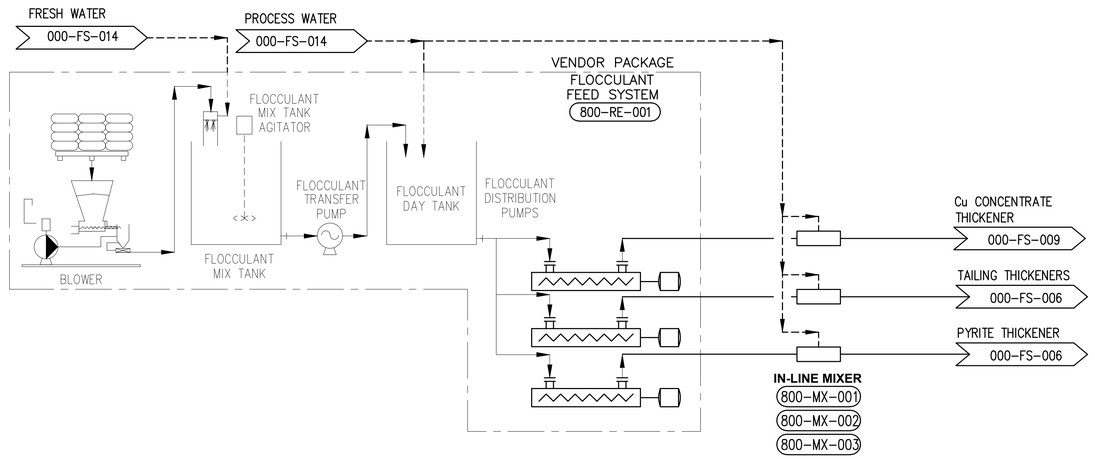
File: P:\2012\120001\TO BE ISSUED (5th)\FS\000-FS-011 P2.dwg LAST UPDATE:8/16/2012 8:00 AM BY: BB5700



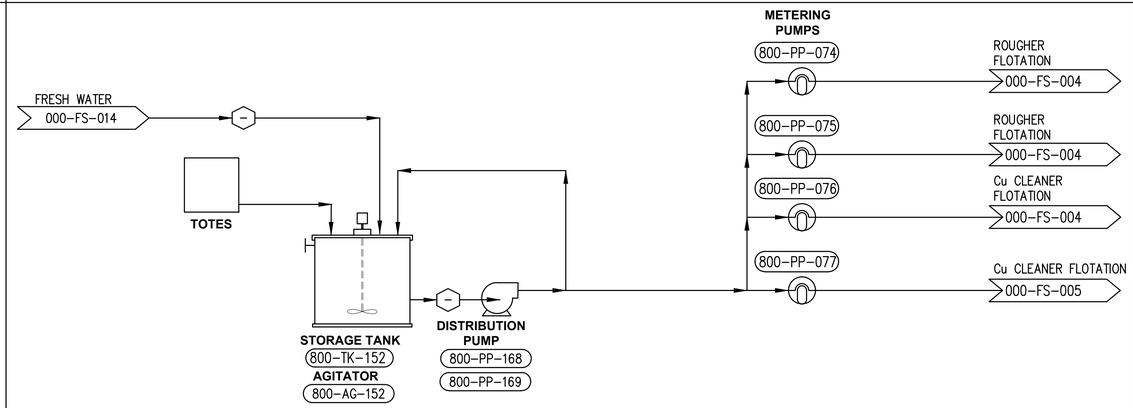
SODIUM HYDROSULFIDE (NaHS)



PROMOTER No. 1 (AEROPHINE 3418A) SYSTEM



FLOCCULANT SYSTEM



PROMOTER No. 2 (AERO FLOAT 208) SYSTEM

LEGEND:

- MAIN PROCESS FLOW
- AUXILIARY FLOW
- INTERMITTENT FLOW
- EQUIPMENT PACKAGE
- WATER SPRAY

PRELIMINARY
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WESTERN COPPER CORPORATION

REFERENCES		REFERENCES		REVISIONS						REVISIONS					
DWG. NO.	TITLE	DWG. NO.	TITLE	NO.	DESCRIPTION	BY	APP'D	DATE	CLIENT	NO.	DESCRIPTION	BY	APP'D	DATE	CLIENT

		DATE
SCALE:	NONE	
DESIGNED BY	BB	APR 12
DRAWN BY	ACW	APR 12
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PROJECT MGR		
CLIENT APPR.		

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CASINO FEASIBILITY STUDY

CASINO SITE FLOW SHEET GENERAL REAGENTS SHEET 2

PROJECT NO. M3-PN 120001
DWG NO. **000-FS-012**
REV NO. P1
DATE 15 JUN 12

File: P:\2012\120001\TO BE ISSUED (5923)\FS\000-FS-012 P1.dwg LAST UPDATE:6/15/2012 1:42 PM BY: BB5700

FRESH WATER POND
000-FS-014

MAKE-UP FRESH WATER
304

RECLAIM WATER BARGE PUMPS
000-FS-006

144

144

RECLAIM WATER SUMP
600-SU-102

RECLAIM BOOSTER PUMP
650-PP-638
650-PP-639
650-PP-640
650-PP-641
650-PP-642

Cu THICKENER O'FLOW
000-FS-009

226

TAILING THICKENER O'FLOW
000-FS-006

147

RUN-OFF
–

PIT DEWATERING
–

PRECIPITATION
–

EVAPORATION
–

PROCESS WATER POND
650-PD-002

301
GRINDING
000-FS-003

319
ROUGHER FLOTATION
000-FS-004

316
COPPER CLEANER FLOTATION
000-FS-005

313
MOLYBDENITE FLOTATION
000-FS-008

–
FLOCCULANT DISTRIBUTION
000-FS-012

275
CIL CIRCUIT
000-FS-015

–
CLEAN-UP HOSE STATIONS
–

LEGEND:

MAIN PROCESS FLOW

INTERMITTENT FLOW

Stream #	144	147	226	275	301	304	313	316	319
Solids, t/h	0	0	0	0	0	0	0	0	0
Solution, t/h	3,245	7,014	122	11	9,305	852	2	345	1,570
Slurry, t/h	3,245	7,014	122	11	9,305	852	2	345	1,570
S.G. Slurry	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Slurry, m^3/h	3,251	7,027	122	11	9,321	853	2	346	1,573

PRELIMINARY
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REFERENCES DWG. NO.	REFERENCES TITLE	REFERENCES DWG. NO.	REFERENCES TITLE

REVISIONS NO.	DESCRIPTION	BY	APP'D	DATE	CLIENT

REVISIONS NO.	DESCRIPTION	BY	APP'D	DATE	CLIENT

		DATE
SCALE:	NONE	
DESIGNED BY	BB	APR 12
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CASINO FEASIBILITY STUDY

CASINO SITE FLOW SHEET GENERAL PROCESS WATER

PROJECT NO. M3-PN 120001
DWG NO. **000-FS-013**
REV NO. P1
DATE 15 JUN 12

File: P:\2012\120001\10 BE ISSUED (092)\FS\000-FS-013 P1.dwg LAST UPDATE:6/15/2012 1:42 PM BY: BB5700

FRESH WATER POND
000-FS-014
304
MAKE-UP FRESH WATER

Cu THICKENER O'FLOW
000-FS-009
226

TAILING THICKENER O'FLOW
000-FS-006
147

RUN-OFF
-

PIT DEWATERING
-

PRECIPITATION
-

EVAPORATION
-

PROCESS WATER POND
650-PD-002

144

144 517

RECLAIM BOOSTER PUMP
600-PP-173
600-PP-174
600-PP-175 STAND-BY

RECLAIM BOOSTER TANK
600-TK-003

301 GRINDING 000-FS-003

319 ROUGHER FLOTATION 000-FS-004

316 COPPER CLEANER FLOTATION 000-FS-005

313 MOLYBDENITE FLOTATION 000-FS-008

- FLOCCULANT DISTRIBUTION 000-FS-012

- CLEAN-UP HOSE STATIONS -

517 TAILING CYCLONE PLANT 000-FS-006

RECLAIM WATER BARGE PUMPS
000-FS-006

144 517

RECLAIM BOOSTER PUMP
600-PP-167
600-PP-168
600-PP-169
600-PP-170
600-PP-171
600-PP-172 STAND-BY

RECLAIM BOOSTER TANK
600-TK-002

Stream #	144	147	226	301	304	313	316	319	517
Solids, t/h	0	0	0	0	0	0	0	0	0
Solution, t/h	3,222	6,988	122	9,269	840	2	337	1,563	4,531
Slurry, t/h	3,222	6,988	122	9,269	840	2	337	1,563	4,531
S.G. Slurry	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Slurry, m³/h	3,228	7,000	122	9,285	841	2	338	1,566	4,539

LEGEND:

——— MAIN PROCESS FLOW

– – – – INTERMITTENT FLOW

PRELIMINARY
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CASINO MINING CORPORATION

CASINO FEASIBILITY STUDY

CASINO PROJECT GENERAL FLOW SHEET PROCESS WATER

PROJECT NO. M3-PN 120001
DWG NO. 000-FS-013
REV NO. P4
DATE 09 NOV 12

REFERENCES		REFERENCES		REVISIONS						REVISIONS					
DWG. NO.	TITLE	DWG. NO.	TITLE	NO.	DESCRIPTION	BY	APP'D	DATE	CLIENT	NO.	DESCRIPTION	BY	APP'D	DATE	CLIENT

		DATE
SCALE:	NONE	
DESIGNED BY	BB	APR 12
DRAWN BY	ACW	APR 12
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PROJECT MGR		
CLIENT APPR.		

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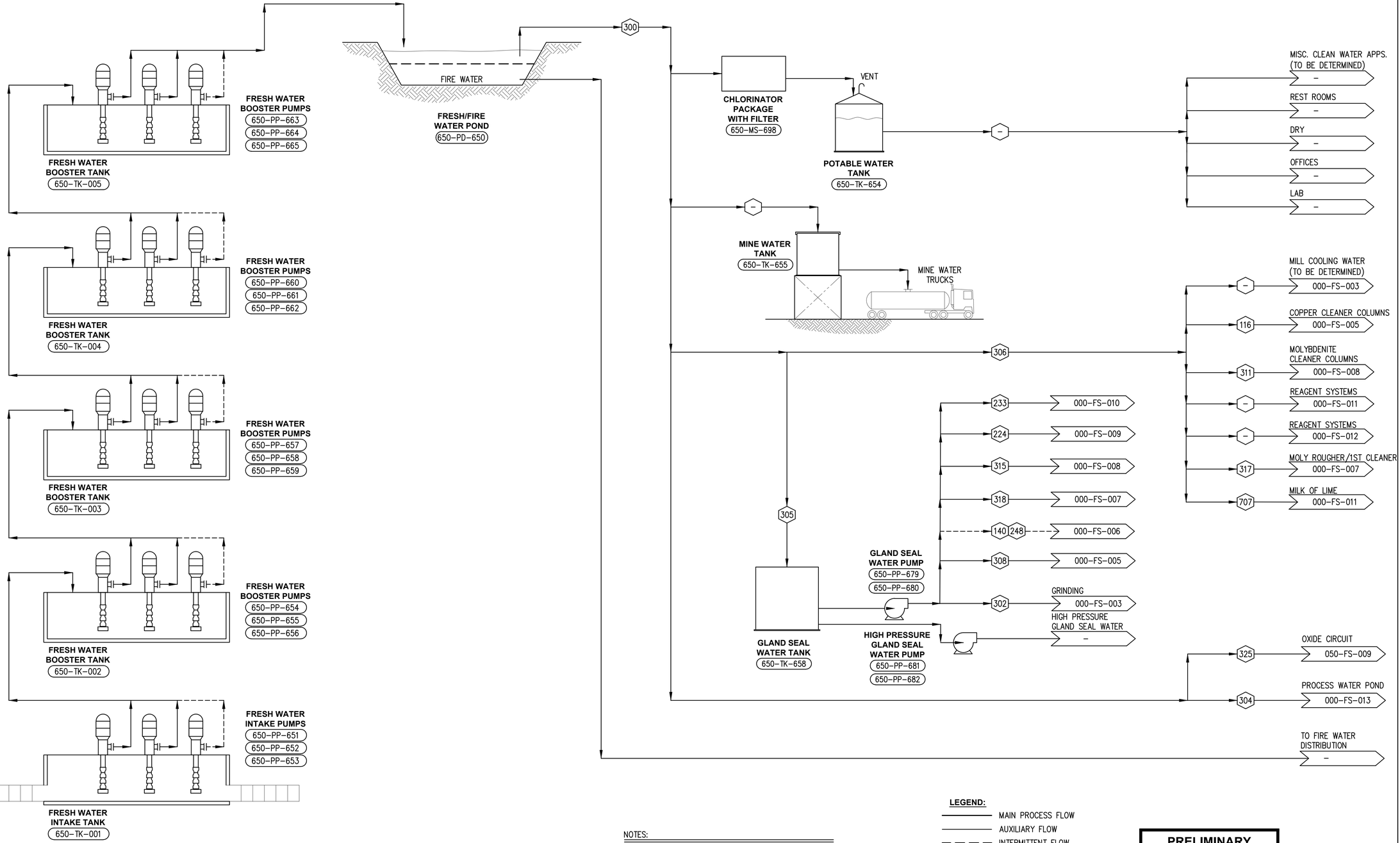
File: F:\2012\120001\TO BE ISSUED (592)\FS\000-FS-013 P4.dwg LAST UPDATE:11/9/2012 8:08 AM BY: BBS700



Stream #	116	140	224	233	248	300	302	304	305	306	308	311	315	317	318	325	707
Solids, t/h	0	0.0	0.0	0.0	0.0	0	0	0	0	0	0	0	0.0	0	0.0	0	0
Solution, t/h	120	0.0	0.8	0.1	0.0	1,543	168	840	199	355	28	31	0.6	59	1.0	150	145
Slurry, t/h	120	0.0	0.8	0.1	0.0	1,543	168	840	199	355	28	31	0.6	59	1.0	150	145
S.G. Slurry	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Slurry, m^3/h	121	0.0	0.8	0.1	0.0	1,545	168	841	199	356	28	31	0.6	59	1.0	150	145

NOTES:

1. DESIGN OF THE FRESH WATER SYSTEM, FROM THE INTAKE STRUCTURE TO THE FRESH/FIRE WATER POND ON SITE, SHALL HAVE A MAXIMUM CAPACITY OF 15,000 GALLONS PER MINUTE.

LEGEND:

- MAIN PROCESS FLOW
- AUXILIARY FLOW
- INTERMITTENT FLOW
- EQUIPMENT PACKAGE
- WATER SPRAY

PRELIMINARY
NOT FOR CONSTRUCTION

CASINO MINING CORPORATION

DO NOT SCALE 11x17 DRAWINGS

REFERENCES		REFERENCES	
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CASINO FEASIBILITY STUDY

CASINO PROJECT
GENERAL
FLOW SHEET
FRESH WATER

PROJECT NO. M3-PN 120001
DWG NO. **000-FS-014**
REV NO. P4
DATE 09 NOV 12

File: F:\2012\120001\TO BE ISSUED (3921)\FS\000-FS-014 P4.dwg LAST UPDATE:11/9/2012 8:09 AM BY: BBS700

PYRITE LEACH / CIL CIRCUIT REMOVED FROM DESIGN

LEGEND

- MAIN PROCESS FLOW
- AUXILIARY FLOW
- ALTERNATIVE PROCESS FLOW
- EQUIPMENT PACKAGE

PRELIMINARY
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WESTERN COPPER CORPORATION

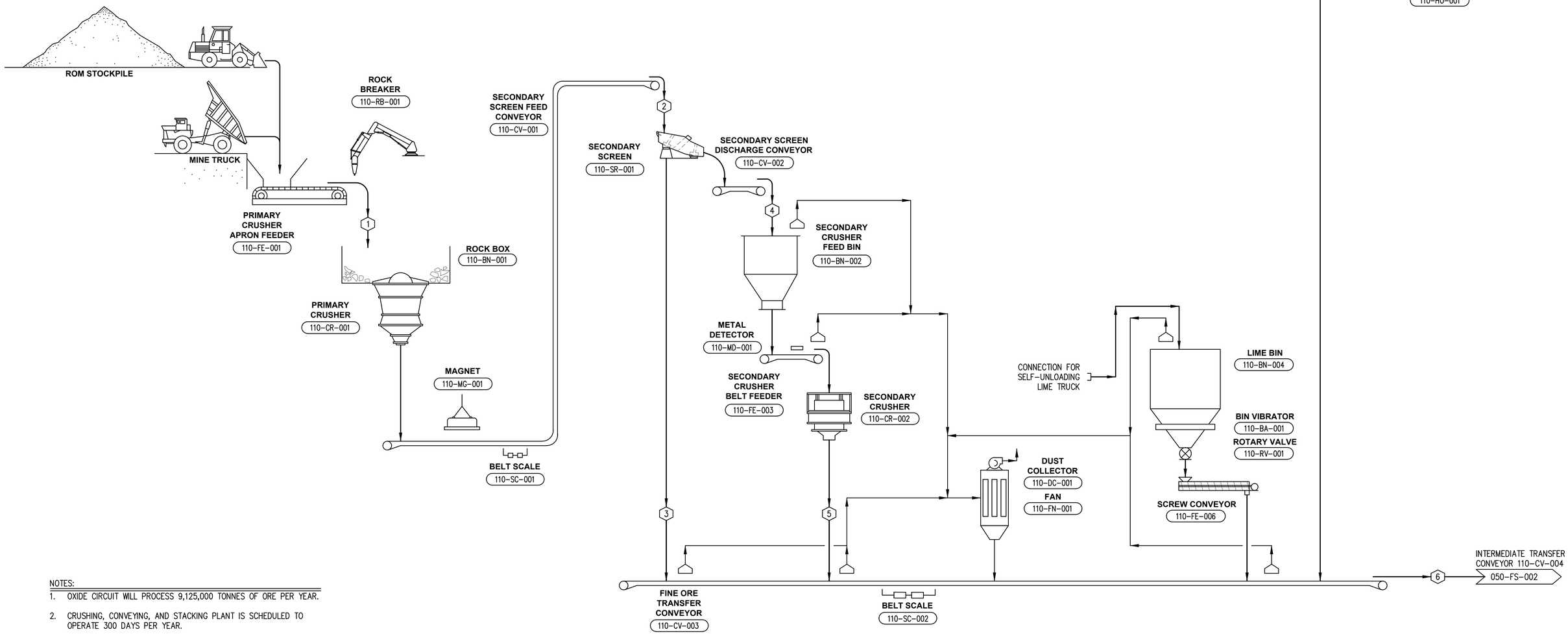
CASINO FEASIBILITY STUDY

CASINO SITE
FLOW SHEET
GENERAL
PYRITE LEACH / CIL

PROJECT NO. M3-PN 120001
DWG NO. **000-FS-015**
REV NO. P2
DATE 16 AUG 12

File: P:\2012\120001\10 BE ISSUED (592)\FS\000-FS-015 P2.dwg LAST UPDATE:8/16/2012 7:59 AM BY: BB5700

GYPSUM THICKENER UNDERFLOW
050-FS-007



NOTES:

1. OXIDE CIRCUIT WILL PROCESS 9,125,000 TONNES OF ORE PER YEAR.
2. CRUSHING, CONVEYING, AND STACKING PLANT IS SCHEDULED TO OPERATE 300 DAYS PER YEAR.
3. CRUSHING, CONVEYING, AND STACKING PLANT IS DESIGNED FOR A NOMINAL CAPACITY OF 30,417 TONNES PER DAY.
4. CRUSHING, CONVEYING, AND STACKING PLANT IS DESIGNED TO OPERATE 24 HOURS PER DAY AT 75% PLANT AVAILABILITY:

$$\frac{30{,}417 \text{ TPD}}{24 \text{ HR/D} \times 0.75} = 1{,}690 \text{ TPH}$$

DESCRIPTION	ROM ORE	2o Screen Feed	2o Screen U'Size	2o Screen O'Size	2o Crush. Discharge	Crushed Ore
Stream Number	**1**	**2**	**3**	**4**	**5**	**6**
Solids, t/h	1,689.8	1,689.8	439.4	1,250.5	1,250.5	1,689.8
Total, t/h	1,724.3	1,724.3	448.3	1,276.0	1,276.0	1,724.3
Solids, dry t/d	30,417	30,417	7,908	22,508	22,508	30,417
Total, t/d	31,037	31,037	8,070	22,968	22,968	31,037
Moisture Content, %	2.0	2.0	2.0	2.0	2.0	2.0
Au Content, g/t	0.45	0.45	0.45	0.45	0.45	0.45
Ag Content, g/t	3.00	3.00	3.00	3.00	3.00	3.00
Cu Content, %	0.05	0.05	0.05	0.05	0.05	0.05

LEGEND:

- MAIN PROCESS FLOW
- AUXILIARY FLOW
- INTERMITTENT FLOW
- EQUIPMENT PACKAGE

PRELIMINARY
NOT FOR CONSTRUCTION

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SCALE:	NONE	DATE
DESIGNED BY	BB	JUL 12
DRAWN BY	ACW	JUL 12
CHECKED BY		
PROJECT MGR		
CLIENT APPR.		

m3 ARCHITECTURE ENGINEERING CONSTRUCTION MANAGEMENT
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Chandler, Arizona
Hermosillo, Sonora Mexico
www. m3eng.com

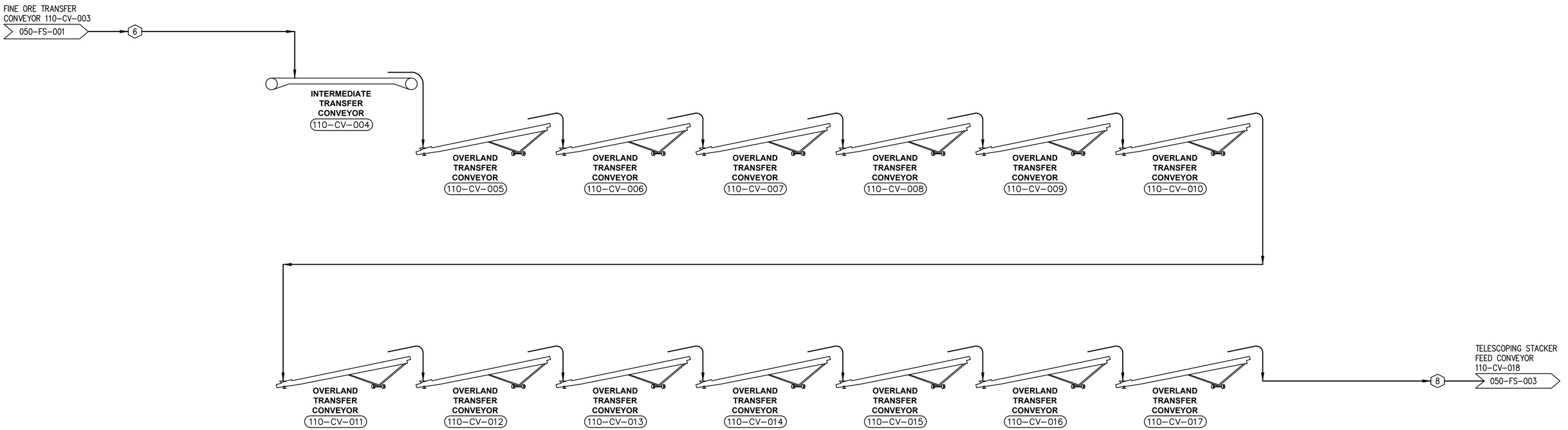
CASINO MINING CORPORATION

CASINO FEASIBILITY STUDY

CASINO PROJECT
OXIDE CIRCUIT
FLOW SHEET
PRIMARY/SECONDARY CRUSHING

PROJECT NO. M3-PN 120001
DWG NO. **050-FS-001**
REV NO. P3
DATE 09 NOV 12

Files: P:\2012\120001\TO BE ISSUED (5902)\FS\050-FS-001 P3.dwg LAST UPDATE:11/9/2012 8:09 AM BY: BB5700



NOTES:

1. OXIDE CIRCUIT WILL PROCESS 9,125,000 TONNES OF ORE PER YEAR.
2. CRUSHING, CONVEYING, AND STACKING PLANT IS SCHEDULED TO OPERATE 300 DAYS PER YEAR.
3. CRUSHING, CONVEYING, AND STACKING PLANT IS DESIGNED FOR A NOMINAL CAPACITY OF 30,417 TONNES PER DAY.
4. CRUSHING, CONVEYING, AND STACKING PLANT IS DESIGNED TO OPERATE 24 HOURS PER DAY AT 75% PLANT AVAILABILITY:

$$\frac{30{,}417 \text{ TPD}}{24 \text{ HR/D} \times 0.75} = 1{,}690 \text{ TPH}$$

DESCRIPTION	Crushed Ore	Crushed Ore
Stream Number	**6**	**8**
Solids, t/h	1,689.8	1,689.8
Total, t/h	1,724.3	1,724.3
Solids, dry t/d	30,417	30,417
Total, t/d	31,037	31,037
Moisture Content, %	2.0	2.0
Au Content, g/t	0.450	0.450
Ag Content, g/t	3.000	3.000
Cu Content, %	0.050	0.050

LEGEND:

- MAIN PROCESS FLOW
- AUXILIARY FLOW
- INTERMITTENT FLOW
- EQUIPMENT PACKAGE

PRELIMINARY
NOT FOR CONSTRUCTION

DO NOT SCALE 11x17 DRAWINGS

REFERENCES		REFERENCES	
DWG. NO.	TITLE	DWG. NO.	TITLE

REVISIONS						REVISIONS					
NO.	DESCRIPTION	BY	APP'D	DATE	CLIENT	NO.	DESCRIPTION	BY	APP'D	DATE	CLIENT

SCALE:	NONE	
DESIGNED BY	BB	JUL 12
DRAWN BY	ACW	JUL 12
CHECKED BY		
PROJECT MGR		
CLIENT APPR.		

ARCHITECTURE
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CASINO MINING CORPORATION

CASINO FEASIBILITY STUDY

CASINO PROJECT OXIDE CIRCUIT FLOW SHEET OVERLAND CONVEYANCE

PROJECT NO. M3-PN 120001
DWG NO. **050-FS-002**
REV NO. P3
DATE 09 NOV 12

File: F:\2012\120001\TO BE ISSUED (592)\FS\050-FS-002 P3.dwg LAST UPDATE:11/9/2012 8:58 AM BY: BBS700

GYPSUM THICKENER UNDERFLOW
050–FS–007

FROM BARREN SOLUTION FILTERS
050–FS–004
24

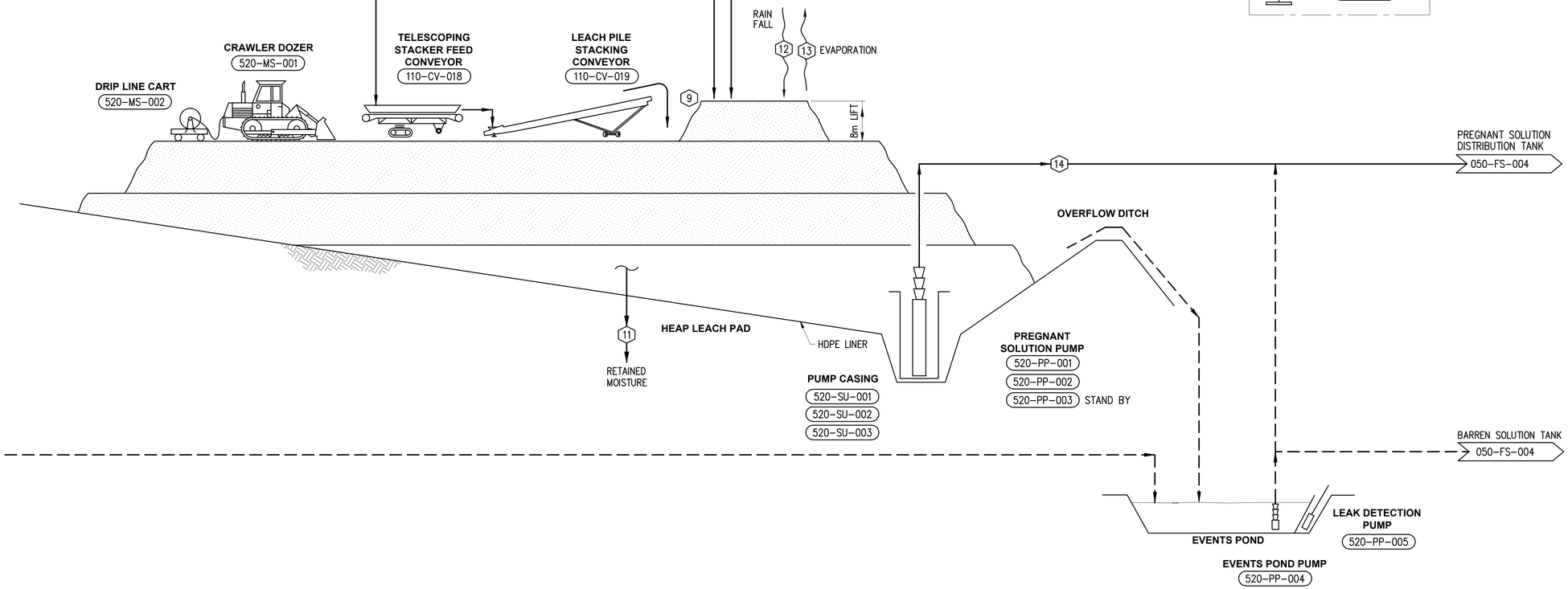
FROM OVERLAND CONVEYORS
050–FS–002
8

NOTES:

1. OXIDE CIRCUIT WILL PROCESS 9,125,000 TONNES OF ORE PER YEAR.
2. CRUSHING, CONVEYING, AND STACKING PLANT IS SCHEDULED TO OPERATE 300 DAYS PER YEAR.
3. CRUSHING, CONVEYING, AND STACKING PLANT IS DESIGNED FOR A NOMINAL CAPACITY OF 30,417 TONNES PER DAY.
4. CRUSHING, CONVEYING, AND STACKING PLANT IS DESIGNED TO OPERATE 24 HOURS PER DAY AT 75% PLANT AVAILABILITY:

$$\frac{30{,}417 \text{ TPD}}{24 \text{ HR/D} \times 0.75} = 1{,}690 \text{ TPH}$$

5. LEACHING CIRCUIT IS SCHEDULED TO OPERATE 365 DAYS PER YEAR.
6. LEACHING CIRCUIT IS DESIGNED FOR A NOMINAL CAPACITY OF 25,000 TONNES PER DAY.
7. LEACHING CIRCUIT FLOW RATES ARE BASED ON NOMINAL CAPACITY, 24 HOURS PER DAY, AND 98% PLANT AVAILABILITY.
8. NET OF PRECIPITATION AND EVAPORATION FLOWS ARE SET AT A MINIMUM FOR DETERMINATION OF MAXIMUM INSTANTANEOUS REQUIREMENT OF MAKE UP WATER.
9. SEEPAGE IS ASSUMED TO BE NEGLIGIBLE.



DESCRIPTION	Ore Stacking	Heap Leach Ore	Retained Moisture	Average Rainfall	Average Evap.	Pregnant Solution	Barren Solution
Stream Number	**8**	**9**	**11**	**12**	**13**	**14**	**24**
Flow rate, m^3/hr	-	-	115.7	1.6	0.3	1,223.0	1,312.0
Flow rate, m^3/d	-	-	2,778	38.1	6.3	-	-
Flow rate, damp t/d	31,037	25,510	27,778	-	-	-	-
Moisture Content, %	2.0	2.0	10.0	-	-	-	-
Solids, dry t/d	30,417	25,000	25,000	-	-	-	-
Au Content, g/t	0.450	0.450	-	-	-	-	-
Au Content, mg/l	-	-	-	-	-	0.249	0.012
Ag Content, g/t	3.000	3.000	-	-	-	-	-
Ag Content, mg/l	-	-	-	-	-	0.383	0.179
Cu Content, %	0.050	0.050	-	-	-	-	-
Cu Content, g/l	-	-	-	-	-	0.400	0.356

LEGEND:

- MAIN PROCESS FLOW
- AUXILIARY FLOW
- INTERMITTENT FLOW
- EQUIPMENT PACKAGE

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CASINO MINING CORPORATION

CASINO FEASIBILITY STUDY

CASINO PROJECT
OXIDE CIRCUIT
FLOW SHEET
HEAP LEACH

PROJECT NO. M3-PN 120001
DWG NO. **050-FS-003**
REV NO. P3
DATE 09 NOV 12

File: P:\2012\120001\TO BE ISSUED (992)\FS\050-FS-003 P3.dwg LAST UPDATE:11/9/2012 8:09 AM BY: BBS700

PROCESS WATER 050-FS-009 → 23

EVENTS POND 050-FS-003

ANTISCALANT 050-FS-010

ACTIVATED CARBON STORAGE TANK 050-FS-006 — OVERFLOW

CYANIDE AREA SUMP 050-FS-008

CAUSTIC 050-FS-008

ASSAY LAB SUMP PUMP 050-FS-009

PREGNANT SOLUTION PUMPS 050-FS-003 → 14

CYANIDE 050-FS-008

CARBON FINES FILTER 050-FS-005 — FILTRATE

SPENT ACID 050-FS-005

BARREN SOLUTION TANK 580-TK-001

BARREN SOLUTION PUMP, VFD 580-PP-006, 580-PP-007, 580-PP-106
TDH156m 703m3/h
450 kW (EACH)

BARREN SOLUTION SAMPLER 580-SA-001

BARREN SOLUTION FILTER 580-FL-001

DRAIN

HEAP LEACH 050-FS-003 → 24

CARBON TRANSFER PUMP 050-FS-005

STRIP 050-FS-005

CARBON ATTRITION & QUENCH 050-FS-006

REFINERY 050-FS-006

NaCN,NaOH 050-FS-008

STRIP COLUMN TRANSFER 050-FS-005

KILN FEED SCREEN 050-FS-005

FLOCCULANT DISTRIBUTION 050-FS-010

TO EVENTS POND 050-FS-003

TO SART 050-FS-007 → 15

ADR FEED PUMP 580-PP-031, 580-PP-032

PREGNANT SOLUTION DISTRIBUTION TANK 580-TK-031

SART FEED PUMP 540-PP-001, 540-PP-002

REGENERATION SPILLAGE 050-FS-005

CARBON REGENERATION 050-FS-006

CARBON DISTRIBUTOR 050-FS-005 → 22

TRASH SCREEN 580-SR-001
1.5m X 2.5m
TOTE

CARBON TRANSFER PUMP 580-PP-001, 580-PP-003, 580-PP-002, 580-PP-004, 580-PP-005

ADSORPTION COLUMN 580-CO-001, 580-CO-004, 580-CO-002, 580-CO-005, 580-CO-003 — 3.85mX4m; 28.5m3

CARBON SIZING SCREEN 580-SR-004
1200mm, 1.12kW

FROM SART 050-FS-007 → 19

CYANIDE 050-FS-008

STRIP AREA SPILLAGE 050-FS-005

CARBON DISTRIBUTOR 050-FS-005 → 21

CARBON DISTRIBUTOR 050-FS-005

(BY GRAVITY) CARBON FINES TANK 050-FS-005

PREGNANT LEACH SOLUTION SAMPLER 580-SA-002 → 20

BARREN COLUMN SAMPLER 580-SA-003

DRAIN

CARBON TRANSFER PUMP 580-PP-101, 580-PP-103, 580-PP-102, 580-PP-104, 580-PP-105

ADSORPTION COLUMN 580-CO-006, 580-CO-009, 580-CO-007, 580-CO-010, 580-CO-008 — 3.85mX4m; 28.5m3

CARBON SIZING SCREEN 580-SR-005
1200mm, 1.12kW

CARBON SAFETY SCREEN 580-SR-002
1.5x2.5m

DRAIN

CARBON ADSORPTION AREA PUMP 580-PP-008

CARBON DISTRIBUTOR 050-FS-005

(BY GRAVITY) CARBON QUENCH TANK 050-FS-006

LEGEND:
- MAIN PROCESS FLOW
- AUXILIARY FLOW
- INTERMITTENT FLOW
- EQUIPMENT PACKAGE

DESCRIPTION	Pregnant Solution	PLS to SART	SART Bypass	SART PLS Return	Total ADR Feed	Carbon Au Recov	Loaded Carbon	Stripped Carbon	Process Water	Barren Solution
Stream Number	**14**	**15**	**16**	**19**	**20**	**-**	**21**	**22**	**23**	**24**
Flow rate, m^3/hr	1,223.0	150.0	1,073.0	149.6	1,223.0	-	-	-	89.0	1,312.0
Solids, dry t/d	-	-	-	-	-	-	2.67	2.67	-	-
Au Content, g/t	-	-	-	-	-	-	2,602	20	-	-
Au Content, mg/l	0.249	0.249	0.249	0.249	0.249	-	-	-	-	0.012
Ag Content, g/t	-	-	-	-	-	-	-	-	-	-
Ag Content, mg/l	0.383	0.383	0.383	0.383	0.383	-	-	-	-	0.179
Cu Content, g/l	0.400	0.400	0.400	0.038	0.356	-	-	-	-	0.356

PRELIMINARY
NOT FOR CONSTRUCTION

DO NOT SCALE 11x17 DRAWINGS

CASINO MINING CORPORATION

CASINO FEASIBILITY STUDY

CASINO PROJECT OXIDE CIRCUIT FLOW SHEET GOLD ADSORPTION

PROJECT NO. M3-PN 120001
DWG NO. **050-FS-004**
REV NO. P3
DATE 09 NOV 12

REFERENCES DWG. NO.	REFERENCES TITLE	REFERENCES DWG. NO.	REFERENCES TITLE

REVISIONS NO.	DESCRIPTION	BY	APP'D	DATE	CLIENT

REVISIONS NO.	DESCRIPTION	BY	APP'D	DATE	CLIENT

		DATE
SCALE:	NONE	
DESIGNED BY	BB	JUL 12
DRAWN BY	ACW	JUL 12
CHECKED BY		
PROJECT MGR		
CLIENT APPR.		

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CARBON ATTRITION TANK
050-FS-006
OVERFLOW
KILN DRAIN
050-FS-006
CARBON SIZING SCREENS
050-FS-004
(BY GRAVITY)
LOADED CARBON
050-FS-004
BARREN SOLUTION TANK
050-FS-004
CARBON TRANSFER PUMP No. 2
050-FS-004
CARBON TRANSFER PUMP No. 2
050-FS-004
TO ATMOSPHERE
ACID WASH VENT FAN
580-FN-001
CARBON DISTRIBUTOR TANK
580-TK-002
BARREN SOLUTION TANK
050-FS-004
BARREN SOLUTION TANK
050-FS-004
FRESH WATER
050-FS-009
HCl ACID SUPPLY
050-FS-008
CAUSTIC SOLUTION
050-FS-008
ACID WASH COLUMN
6m3,MSRL
580-TK-003
STRIP COLUMN No. 1
6.5m3,2.5Te
580-TK-005
RECOVERY HEAT EXCHANGER
580-HX-001
STRIP SOLUTION HEATER NO.1
580-HT-001
STRIP SOLUTION HEATER NO. 2
580-HT-002
TO ATMOSPHERE
(BYPASS)
BARREN SOLUTION TANK
050-FS-004
TO SART PRECIPITATION REACTOR
050-FS-007
CARBON SIZING SCREENS
050-FS-004
TO SART PRECIPITATION REACTOR
050-FS-007
COLD STRIP
KILN FEED TANK
050-FS-006
(DRAIN)
KILN FEED DEWATERING SCREEN
580-SR-003
CARBON FINES AGITATOR
580-AG-001
CARBON SIZING SCREEN
050-FS-004
CARBON FINES FILTER
580-FL-003
FILTRATE
BARREN SOLUTION TANK
000-FS-004
CARBON FINES TANK
580-TK-008
CARBON FINES PUMP
580-PP-022
OFFSITE TREATMENT
DRUMS
REGENERATION AREA SPILLAGE PUMP
580-PP-014
CARBON STRIP TRANSFER PUMP
580-PP-011
STRIP COLUMN No. 2
6.5m3,2.51e
580-TK-006
TRIM HEAT EXCHANGER
580-HX-002
E/W BARREN RETURN TANK
580-TK-007
BARREN RETURN PUMP
580-PP-013
ELECTROWINNING CELLS
050-FS-006
ADSORPTION COLUMNS
050-FS-004
CONC. ACID AREA SUMP PUMP
580-PP-009
DILUTE ACID TANK
580-TK-004
ACID WASH PUMP
580-PP-010
ACID WASH CARBON TRANSFER PUMP
580-PP-012
(BYPASS DURING HEATING CYCLE)
BARREN SOLUTION
050-FS-004
ELECTROWINNING CELLS
050-FS-006
CYANIDE SOLUTION
050-FS-008
CAUSTIC SOLUTION
050-FS-008
REFINERY SPILLAGE
050-FS-006
TO ATMOSPHERE
STRIP AREA SUMP PUMP
580-PP-020
FRESH WATER
050-FS-009
SAFETY STN SHOWER & EYEWASH/ACID AREA
580-SF-001
BARREN STRIP SOLUTION TANK
580-TK-009
BARREN STRIP SOLUTION PUMP
580-PP-015
580-PP-016
FRESH WATER
050-FS-009
SAFETY STN CARBON STRIP AREA
580-SF-003

NOTE: 1. STRIP CIRCUIT DESIGNED TO DO ONE STRIP AT A TIME.

LEGEND:
- MAIN PROCESS FLOW
- AUXILIARY FLOW
- INTERMITTENT FLOW
- EQUIPMENT PACKAGE

PRELIMINARY
NOT FOR CONSTRUCTION

DO NOT SCALE 11x17 DRAWINGS

REFERENCES		REFERENCES	
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REVISIONS					
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Hermosillo, Sonora Mexico
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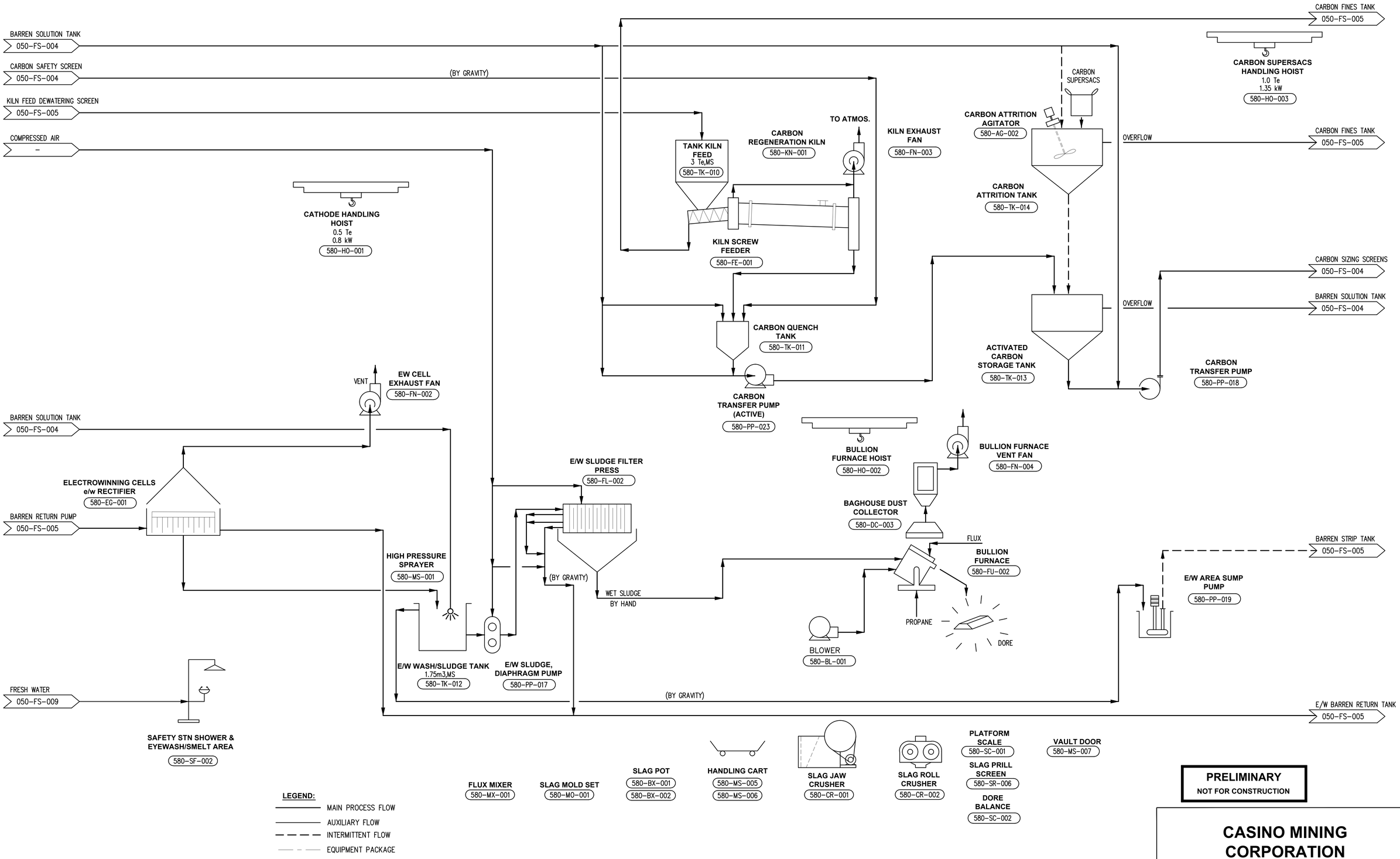
CASINO MINING CORPORATION

CASINO FEASIBILITY STUDY

CASINO PROJECT OXIDE CIRCUIT FLOW SHEET CARBON WASH / STRIP

PROJECT NO. M3-PN 120001
DWG NO. 050-FS-005
REV NO. P3
DATE 09 NOV 12

File: P:\2012\120001\TO BE ISSUED (592)\VS\050-FS-005 P3.dwg LAST UPDATE:11/9/2012 8:09 AM BY: BB5700



PRELIMINARY
NOT FOR CONSTRUCTION

DO NOT SCALE 11x17 DRAWINGS

CASINO MINING CORPORATION

CASINO FEASIBILITY STUDY

CASINO PROJECT
OXIDE CIRCUIT
FLOW SHEET
EW, CARBON REGEN, SMELTING

PROJECT NO. M3-PN 120001
DWG NO. 050-FS-006
REV NO. P2
DATE 24 OCT 12

REFERENCES		REFERENCES		REVISIONS						REVISIONS					
DWG. NO.	TITLE	DWG. NO.	TITLE	NO.	DESCRIPTION	BY	APP'D	DATE	CLIENT	NO.	DESCRIPTION	BY	APP'D	DATE	CLIENT

		DATE
SCALE:	NONE	
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DRAWN BY	ACW	JUL 12
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PROJECT MGR		
CLIENT APPR.		

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File: P:\2012\120001\ISSUED (5/91)\050\FS\050-FS-006 P2.dwg LAST UPDATE:10/24/2012 12:43 PM BY: BB5700

ANTI-SCALANT
050-FS-010

FLOCCULANT
050-FS-010

SCRUBBER
050-FS-010

MILK OF LIME
050-FS-008

FLOCCULANT
050-FS-010

VENT TO SCRUBBER
050-FS-010

SULFURIC ACID
050-FS-010

SULFURIC ACID IN-LINE MIXER
540-MX-002

NaHS
050-FS-008

NaHS IN-LINE MIXER
540-MX-001

15

SART FEED PUMP
050-FS-004

DILUTE ACID
050-FS-005

COLD STRIP
050-FS-005

DRAIN

SART FEED FILTER
540-FL-002

PRECIPITATION REACTOR
540-TK-001
AGITATOR
540-AG-001

Cu_2S THICKENER
540-TH-001

NEUTRALIZATION FEED TANK
540-TK-004

NEUTRALIZATION FEED PUMP
540-PP-009
540-PP-010

NEUTRALIZATION REACTOR No. 1
540-TK-005
AGITATOR
540-AG-005

NEUTRALIZATION REACTOR No. 2
540-TK-006
AGITATOR
540-AG-006

GYPSUM THICKENER
540-TH-002

TREATED SOLUTION TANK
540-TK-008

TREATED SOLUTION PUMP
540-PP-016
540-PP-017

TREATED SOLUTION FILTER
540-FL-003
540-FL-004

19

TO ADR
050-FS-004

Cu_2S UNDERFLOW RECIRCULATION PUMP
540-PP-003
540-PP-004

Cu_2S UNDERFLOW ADVANCE PUMP
540-PP-005

GYPSUM UNDERFLOW RECIRCULATION PUMP
540-PP-011
540-PP-012

GYPSUM UNDERFLOW ADVANCE PUMP
540-PP-013

GYPSUM HOLDING TANK
540-TK-007
AGITATOR
540-AG-007

GYPSUM SLURRY PUMP
540-PP-014
540-PP-015

TO HEAP LEACH CONVEYORS
050-FS-001

SODIUM HYDROXIDE
050-FS-008

Cu_2S UNDERFLOW NEUTRALIZATION TANK
540-TK-002
AGITATOR
540-AG-002

Cu_2S HOLDING TANK
540-TK-003
AGITATOR
540-AG-003

Cu_2S HOLDING TANK PUMP
540-PP-006

PLANT AIR
–

WATER (CAKE WASH)
050-FS-009

WATER (DIAPHRAGM)
050-FS-009

Cu_2S FILTER PRESS
540-FL-001

Cu_2S FILTER CAKE CONVEYOR
540-CV-001

DRYER FEED BIN
540-BN-002
DISAGGREGATOR
540-MS-001

Cu_2S DRYER
540-DR-001

18

DRIED Cu_2S STORAGE BIN
540-BN-003

SUPER SACK

DRIED COPPER PRECIPITATE

BAG ROLLING CONVEYOR
540-CV-002

DESCRIPTION	PLS to SART	Cu_2S Product	Gypsum Thick OF
Stream Number	**15**	**18**	**19**
Flow rate, m^3/hr	150.0	-	149.6
Au Content, mg/l	0.249	-	0.249
Ag Content, mg/l	0.383	-	0.383
Cu Content, g/l	0.400	-	0.038

EYEWASH / SAFETY SHOWER
540-SF-001
THROUGH
540-SF-011

PLANT AIR COMPRESSOR
540-CM-001
540-CM-002

PLANT AIR RECEIVER
540-PV-001

INSTRUMENT AIR DRYER
540-DR-002

INSTRUMENT AIR RECEIVER
540-PV-002

BRIDGE CRANE
540-HO-001
540-HO-002

LEGEND:
- MAIN PROCESS FLOW
- AUXILIARY FLOW
- INTERMITTENT FLOW
- EQUIPMENT PACKAGE

PRELIMINARY
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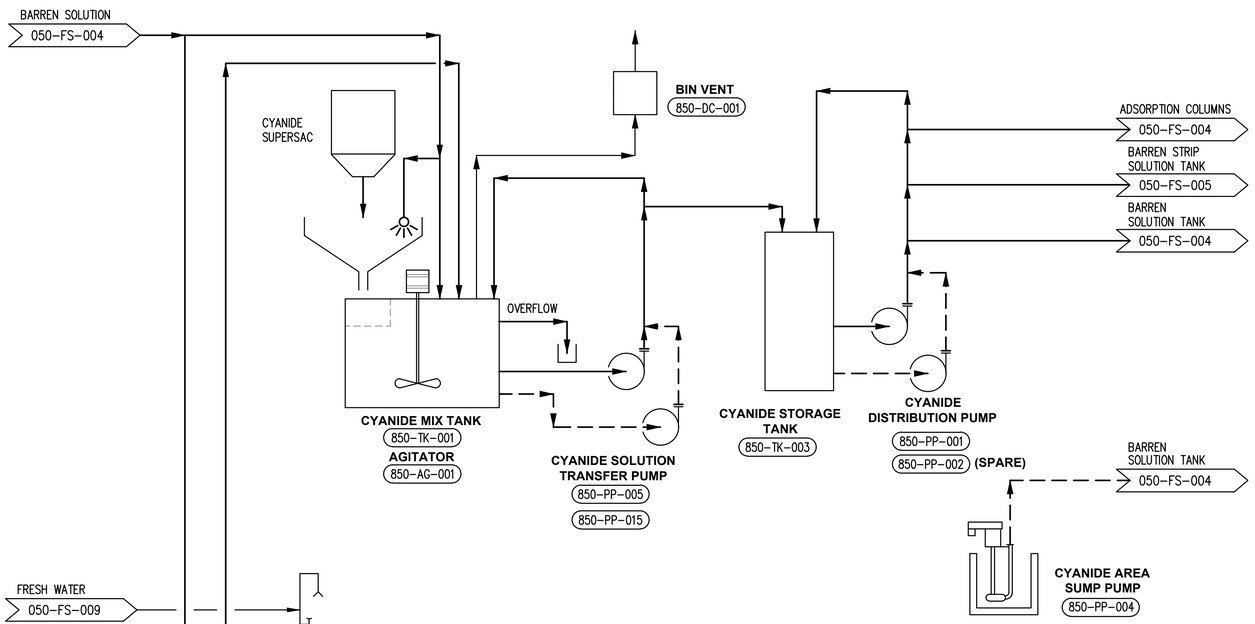
CASINO MINING CORPORATION

CASINO FEASIBILITY STUDY

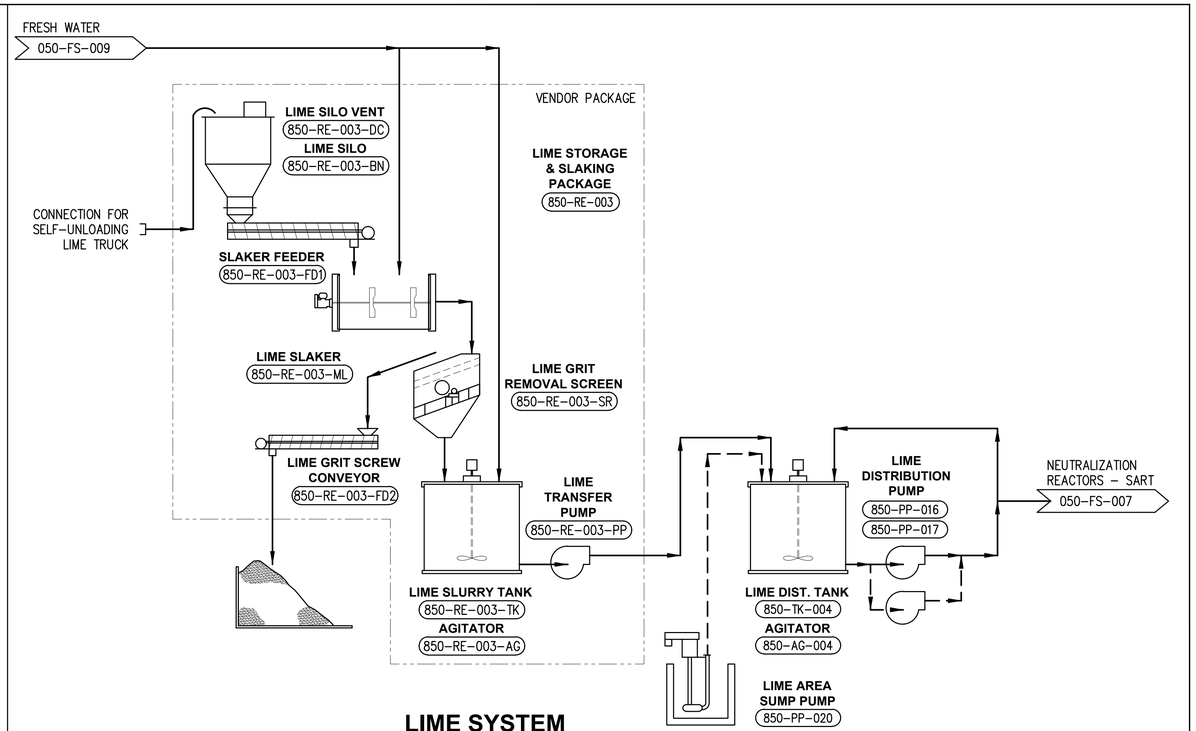
CASINO PROJECT
OXIDE CIRCUIT
FLOW SHEET
SART PROCESS

PROJECT NO. M3-PN 120001
DWG NO. 050-FS-007
REV NO. P3
DATE 09 NOV 12

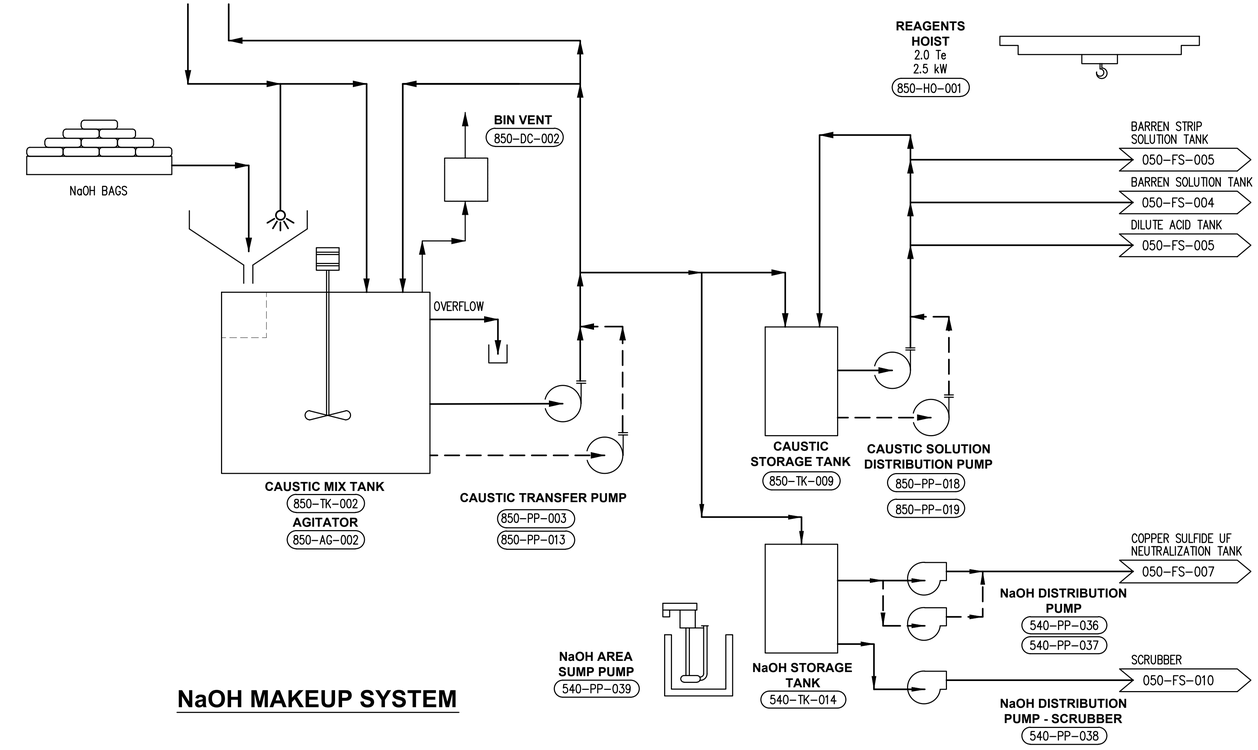
File: P:\2012\120001\10. BE ISSUE\ 5921\FS\050-FS-007 P3.dwg LAST UPDATE:11/9/2012 8:38 AM BY: BB5700



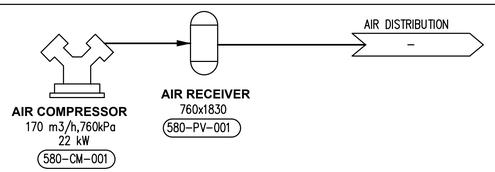
CYANIDE MAKEUP SYSTEM



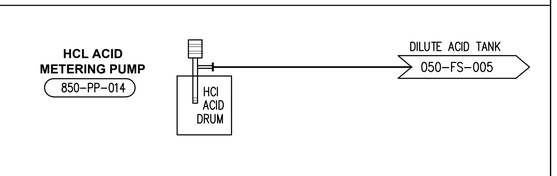
LIME SYSTEM



NaOH MAKEUP SYSTEM



AIR SYSTEM



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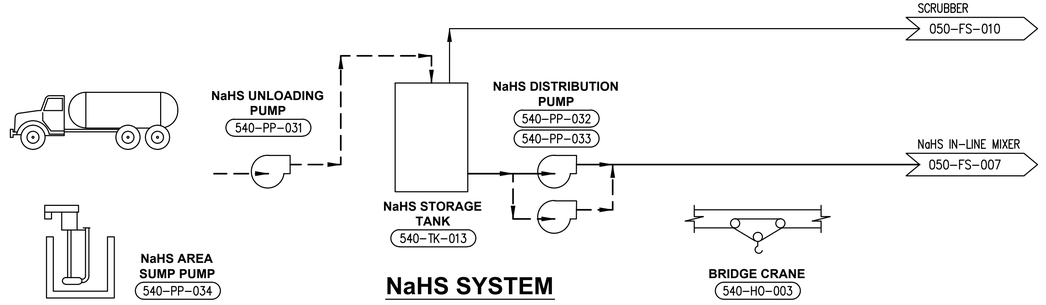

NaHS SYSTEM

LEGEND:

- MAIN PROCESS FLOW
- AUXILIARY FLOW
- INTERMITTENT FLOW
- EQUIPMENT PACKAGE

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CASINO MINING CORPORATION

CASINO FEASIBILITY STUDY

CASINO PROJECT
OXIDE CIRCUIT
FLOW SHEET
REAGENTS SHEET 1

PROJECT NO. M3-PN 120001
DWG NO. **050-FS-008**
REV NO. P3
DATE 09 NOV 12

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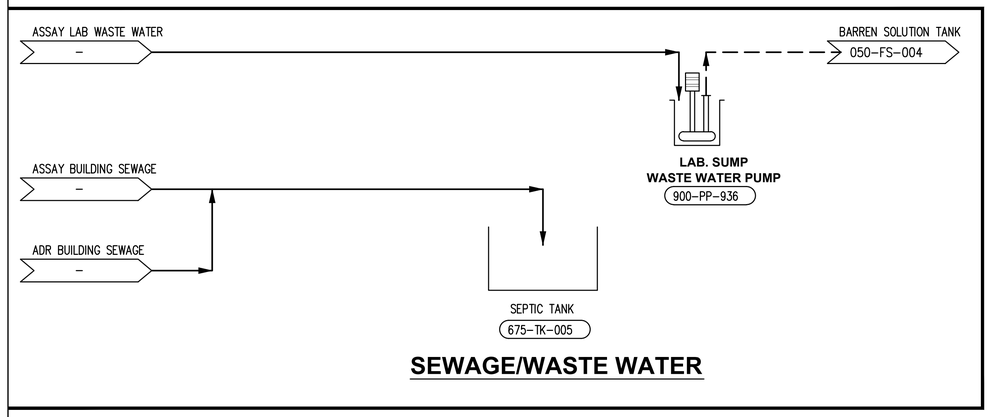
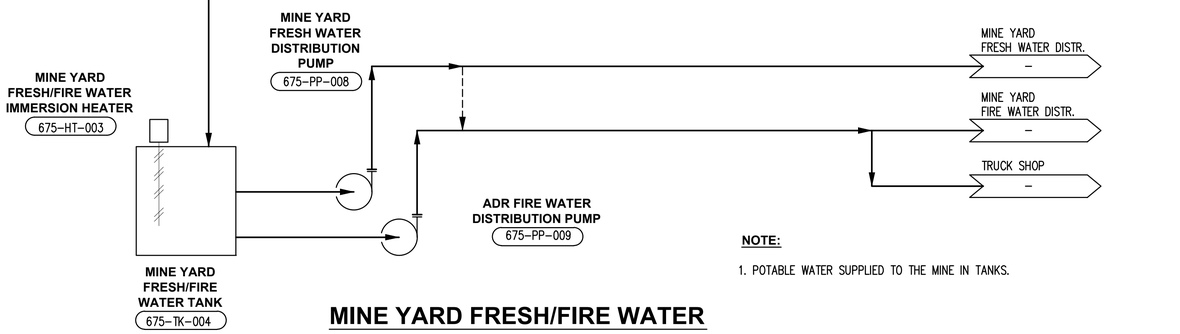


SEWAGE/WASTE WATER

FRESH/FIRE WATER



NOTE:

1. POTABLE WATER SUPPLIED TO THE MINE IN TANKS.

MINE YARD FRESH/FIRE WATER

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- MAIN PROCESS FLOW
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OXIDE CIRCUIT
FLOW SHEET
WATER SUPPLY / DISTRIBUTION

PROJECT NO. M3-PN 120001
DWG NO. **050-FS-009**
REV NO. P2
DATE 09 NOV 12

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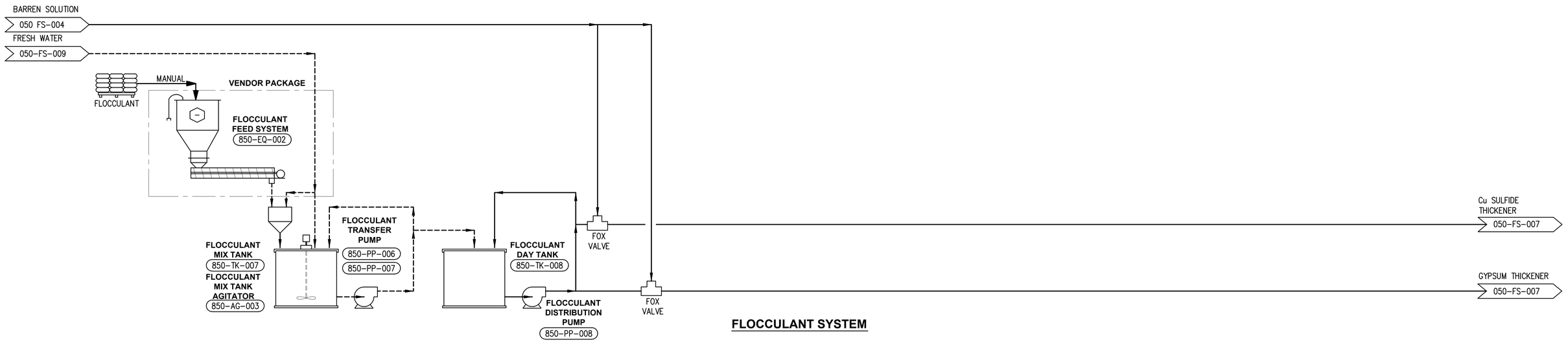

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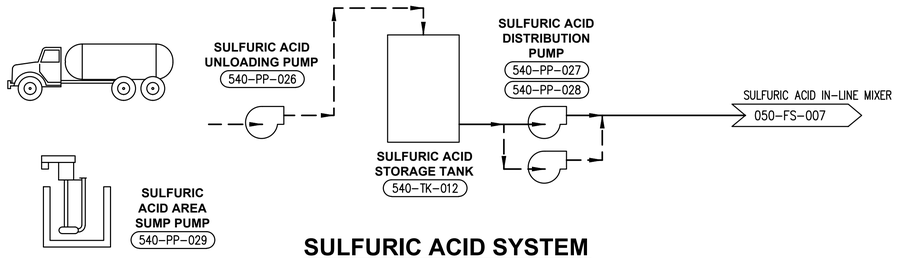

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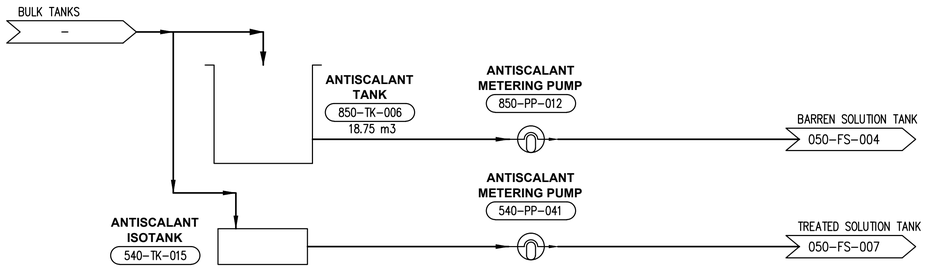

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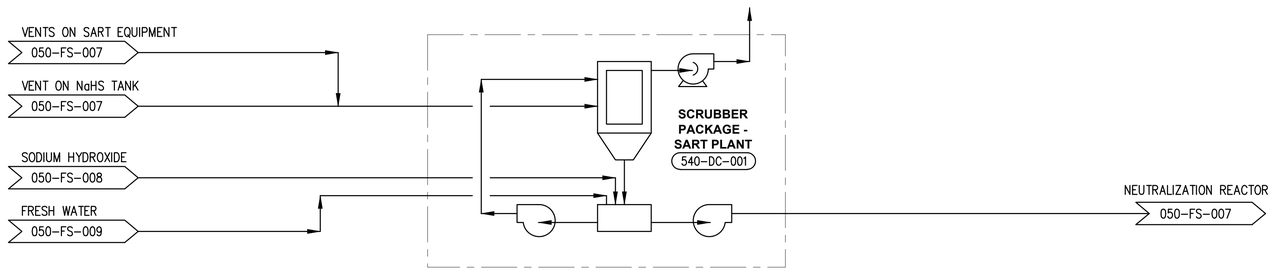

SCRUBBER - SART PLANT

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- INTERMITTENT FLOW
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CASINO MINING CORPORATION

CASINO FEASIBILITY STUDY

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CASINO PROJECT
OXIDE CIRCUIT
FLOW SHEET
REAGENTS SHEET 2

PROJECT NO. M3-PN 120001
DWG NO. 050-FS-010
REV NO. P1
DATE 24 OCT 12

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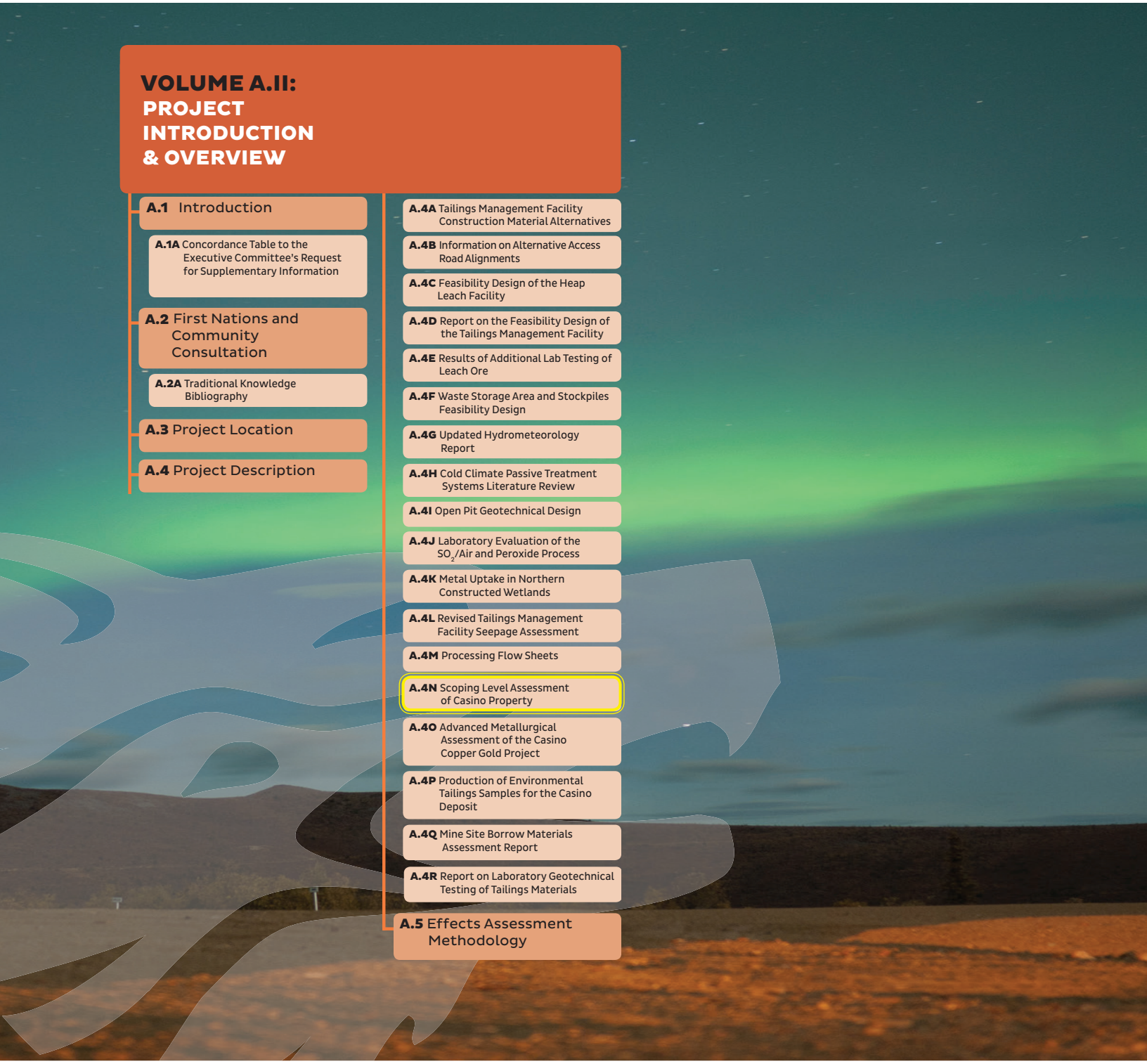
APPENDIX A.4N: Scoping Level Assessment of Casino Property



SCOPING LEVEL ASSESSMENT OF CASINO PROPERTY

WESTERN COPPER CORPORATION

KM2721

January 28, 2011

G&T METALLURGICAL SERVICES LTD.

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Aralia Pojhan, EIT
Project Metallurgist

Tom Shouldice, P.Eng.
President



January 28, 2011

KM2721

Report Distribution:
Paul West-Sells, Western Copper Corp., Vancouver, BC – 2 Copies
Stacy Freudigmann, Canenco Canada Inc., Vancouver, BC – 1 Copy
G&T Metallurgical Services Ltd., Kamloops, BC – 1 Copy

1.0 Introduction

Western Copper Corporation is currently conducting a pre-feasibility assessment of the Casino Project, located 300 kilometres northwest of Whitehorse, Yukon. The deposit is described as porphyry mineralization with geological zones of oxide, supergene, and hypogene mineralization.

This study was designed and executed at the request of Dr. Paul West-Sells, Senior Metallurgist at Western Copper Corporation. On behalf of Western Copper Corporation, Mr. Adam Hesse and Mr. Stacy Freudigmann, of Canenco Canada Inc., also provided technical input on the design of the program. The objectives of this program, as described by Dr. West-Sells, were as follows:

- Develop a suitable process for extracting copper, molybdenum, and gold from a composite, designated SUP Composite 2010, representing the supergene mineralization zone of the deposit.

- Develop a flowsheet to optimize a sequential pyrite circuit.

- Produce sufficient pyrite concentrate and tailings in a pilot plant program, for subsequent environmental test work.

- Produce sands from the pilot plant tailings for further geochemical and geotechnical test work.

The composite used in this program represented the supergene zone and was constructed from 62 drill core samples. The program commenced in early August 2010 and was completed in January 2011. All test data was communicated to Mr. Adam Hesse and Mr. Stacy Freudigmann, as it was generated. Following the test work, preparation of this technical report commenced.

The following technical brief summarizes the key technical points of the program. All of the test data generated through the execution of this program can be reviewed in a series of appendices attached to this brief. The appendices are arranged as follows:

Appendix I - Sample Origin
Appendix II - Flotation Test Data
Appendix III - Particle Sizing Data
Appendix IV - Special Assay Data
Appendix V - Mineralogical Data

2.0 Ore Characteristics

The composition of chemicals and minerals in an ore and how they fragment from each other during the grinding process are important characteristics that effect flowsheet design and metallurgical performance. The following subsections discuss these characteristics for the Casino SUP Composite 2010.

2.1 Chemical and Mineral Content

The chemical and mineral composition of SUP Composite 2010 were determined by standard assaying techniques and Particle Mineral Analysis (PMA) using QEMSCAN. The results are summarized in Table 1.

Approximately 0.3 percent copper was detected in this sample. Weak acid soluble copper accounted for 10 percent of the total copper. Copper measured by this acid dissolution method, typically carbonates and some oxides and hydroxides, are often difficult to recover using conventional flotation methodologies.

Approximately 37 percent of the total copper responded to cyanide digestion. This digestion protocol is an effective indicator of the presence of copper sulphides, chalcocite and covellite.

Gold and silver in the feed were present at 0.25 and 2.5 g/tonne, respectively. Molybdenum was also present in this sample at 0.04 percent.

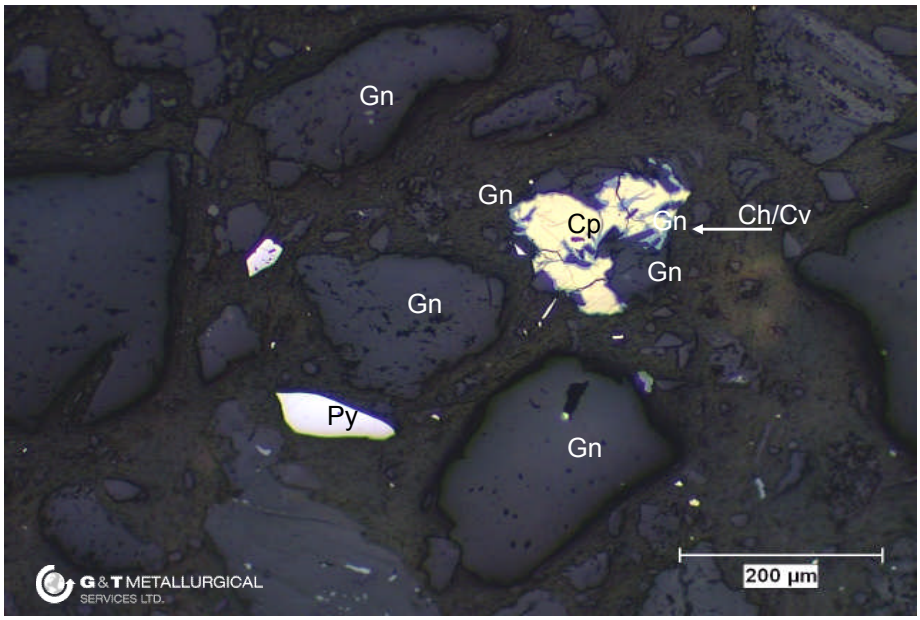
Chalcopyrite accounted for the majority of the copper in the feed, followed by chalcocite and covellite. Small amounts of bornite were also detected in the sample. Pyrite accounted for the main sulphide mineral at 4.2 percent of the feed mass.

TABLE 1
CHEMICAL AND MINERAL CONTENT

Element or Mineral	Symbol	Units	SUP Composite 2010
Element			
Copper	Cu	%	0.30
Weak Acid Soluble Copper	Cu(ox)	%	0.03
Cyanide Soluble Copper	$Cu^{(CN)}$	%	0.11
Iron	Fe	%	3.5
Molybdenum	Mo	%	0.036
Sulphur	S	%	2.88
Gold	Au	g/t	0.25
Silver	Ag	g/t	2
Mineral			
Chalcopyrite	Cp	%	0.43
Bornite	Bn	%	0.01
Chalcocite/Covellite	Ch	%	0.15
Molybdenite	Md	%	0.05
Pyrite	Py	%	4.24
Gangue	Gn	%	95.1

Note: a) Detailed head assay and mineralogical data are located in Appendices IV and V.

PHOTOMICROGRAPH 1
SUP COMPOSITE 2010 - 253µm K_{80}



Note: Cp-Chalcopyrite, Ch/Cv-Chalcocite/Covellite, Py-Pyrite, Gn-Gangue.

2.2 Mineral Fragmentation

The mineral fragmentation characteristics of SUP Composite 2010 were determined at a nominal grind sizing of 142µm K_{80}. This analysis was conducted on four sized fractions using PMA. An overall summary of the mineral fragmentation characteristics are displayed in Table 2.

TABLE 2
MINERAL FRAGMENTATION CHARACTERISTICS – 142µm K_{80}

Mineral Status	Mineral Liberation-two-dimensional			
	Cs	Md	Py	Gn
Liberated	**53**	**41**	65	98
Binary - Cs		3	9	1
Binary - Md	<1		<1	<1
Binary - Py	14	5		1
Binary - Gn	**28**	**52**	24	
Multiphase	5	0	1	<1
Total	100	100	100	100

Note: Additional mineralogical data can be located in Appendix V.

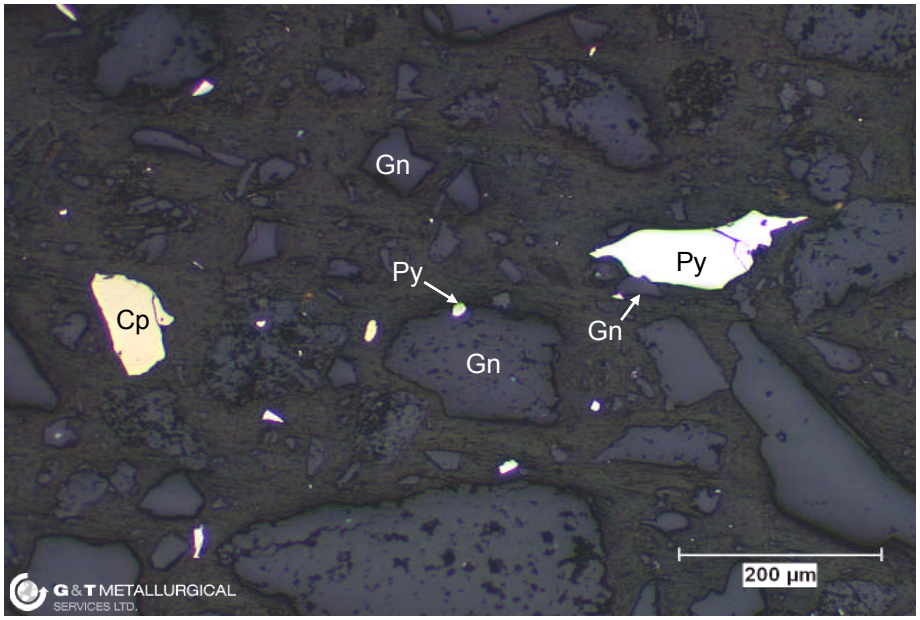
Copper sulphide minerals in the sample were 53 percent liberated. The majority of the unliberated copper sulphides, at 28 percent, were locked in binary structures with non-sulphide gangue minerals. These particles were sufficiently rich in copper sulphide, to be recovered successfully into the rougher circuit concentrate.

An additional 14 percent of the copper sulphides were locked in binary form with pyrite. These particles contained a low concentration of copper sulphides and may be an obstacle in producing a high grade concentrate.

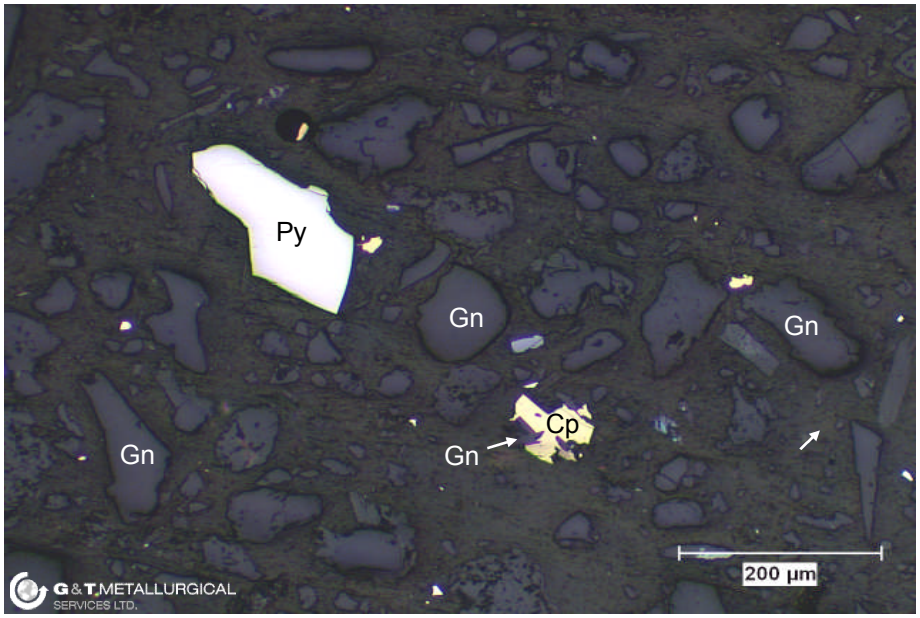
Molybdenite was 41 percent liberated when assessed in two dimensions. The majority of the unliberated molybdenite was locked in binary structures with gangue. These particles contained 40 percent molybdenite and, therefore are likely to be recovered in rougher flotation.

PHOTOMICROGRAPH 2
CASINO – SUP Composite 2010
KM2721

142µm K_{80}



142µm K_{80}



Note: Cp-Chalcopyrite, Py-Pyrite, Gn-Gangue

2.2 Mineral Fragmentation-continued

The mineral fragmentation data can be manipulated to estimate the effect of primary grind sizing on mineral liberation. These analyses are displayed in Figure 1A. Liberation values at four various grind sizes were extrapolated using the measured data at 142μm K_{80}.

As shown in Figure 1A, the changes in mineral liberation were relatively small over the primary grind size range shown. This data would indicate that rougher flotation will be relatively insensitive to changes in primary grind size.

The limiting grade recovery curve for this sample, ground to 142μm K_{80}, is displayed in Figure 1B. This graph displays the maximum achievable grade and recovery points, based on recovery from the feed into the rougher concentrate. Operating plants, constrained by equipment inefficiencies, usually operate just below the indicated curves.

The charts indicate that high grade concentrates can be produced. However, additional regrinding will be required to efficiently produce both high grade concentrates and at high copper recoveries.

Achieving high copper mineral recovery, while maintaining selectivity against pyrite, will be critical to developing a successful process for this sample.

FIGURE 1A
EFFECT OF PRIMARY GRIND SIZE ON LIBERATION

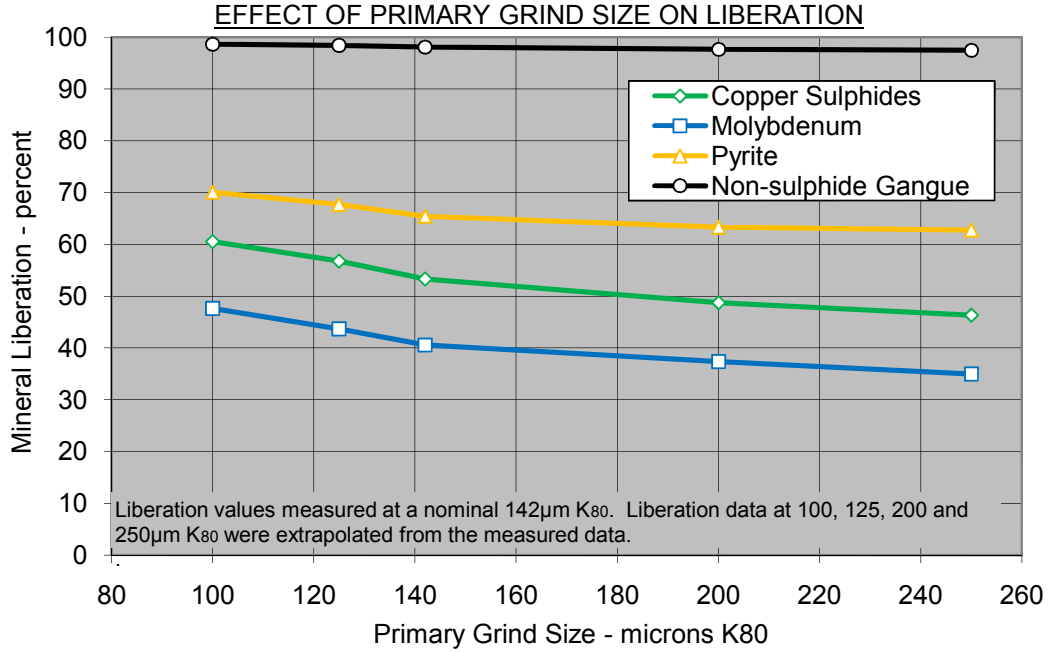
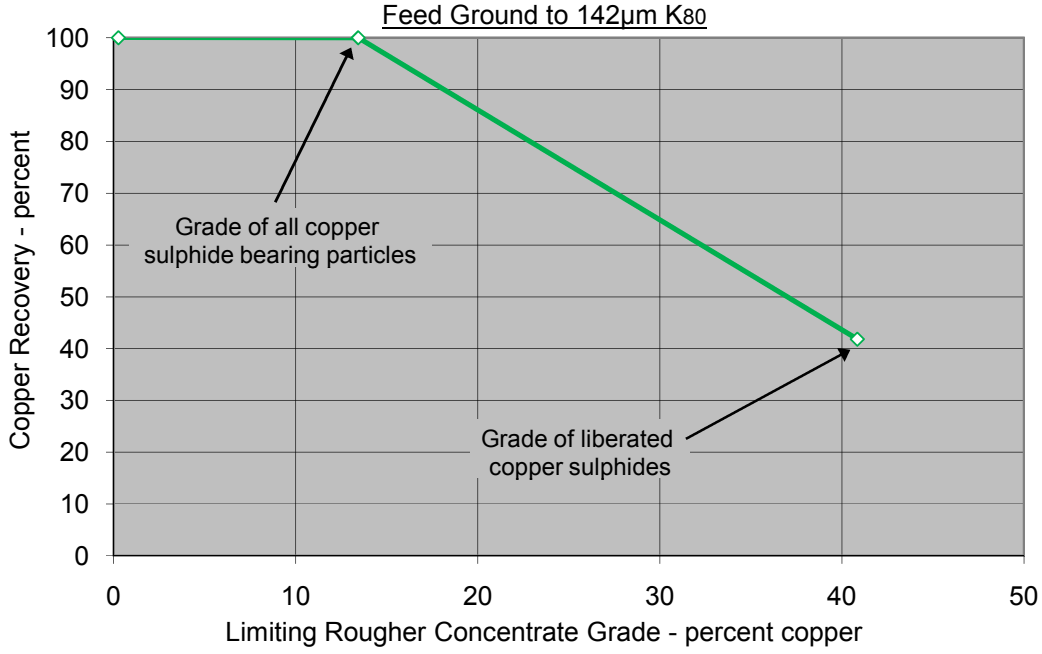


FIGURE 1B
MINERALOGICALLY LIMITING GRADE RECOVERY CHART
Feed Ground to 142µm K80



3.0 Flotation Testing

A series of rougher and cleaner flotation tests were conducted on SUP Composite 2010 to investigate the metallurgical response of the sample to conventional flotation processing. The test program culminated with a series of locked cycle tests.

3.1 Flowsheet Development

The flowsheets and range of test conditions that were utilized in this test program are illustrated in Figure 2.

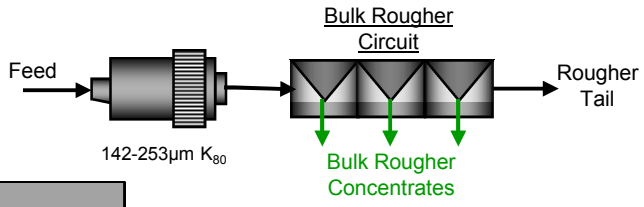
Primary grind sizes ranging between 142 and 253µm K_{80} were targeted in these tests. Various reagents were also evaluated. These included fuel oil as the molybdenum collector and, for the majority of the test work, 3418A and 208 were used for collecting copper and gold into a bulk concentrate. Rougher flotation response was investigated at natural pH, which was around 6.6 and up to pH levels of 11.0, modulated through the addition of lime.

The rougher concentrate was reground to a target sizing of 17 to 33µm K_{80}, prior to the three stages of lime modulated dilution cleaning. The initial regrind targets were based on estimates of liberation, observed in the flotation feed streams.

A series of locked cycle tests investigated the estimates of metallurgical performance anticipated from a continuous operation. The effect of a subsequent pyrite circuit was also investigated to: a) increase gold recovery from the feed, and b) to desulphidize the final tailings stream. The addition of a cleaner scavenger stage in order to increase molybdenum recovery to the final concentrate was also investigated.

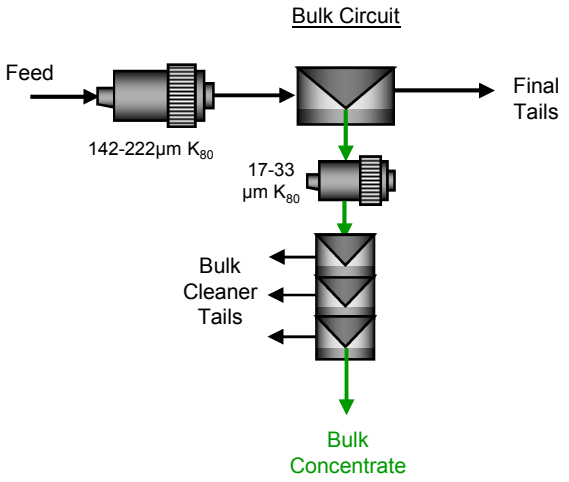
FIGURE 2

ROUGHER AND CLEANER FLOWSHEET DEVELOPMENT



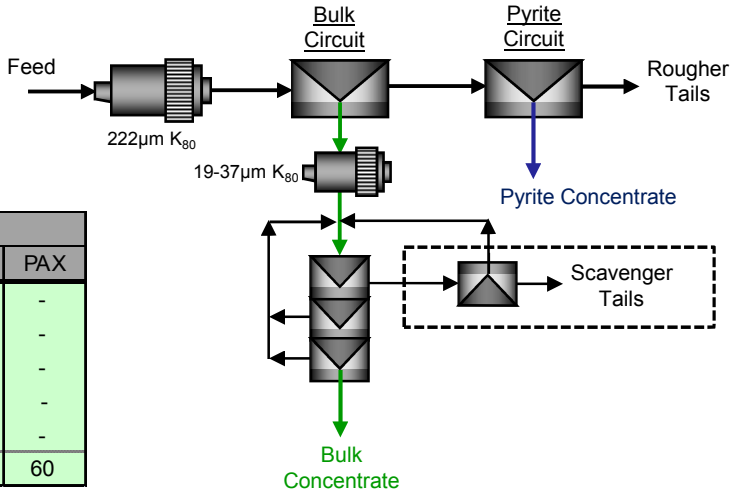
Nominal Rougher Test Conditions

Stage	pH	Reagents g/tonne					
		Lime	Fuel Oil	3418A	208	NaHS	AM28
Primary Grind	6.6-11.0	200-2800	20	-	-	0-50	0-50
Roughers	6.5-11.0	√	-	4-10	8-20	0-50	0-50



Nominal Cleaner Test Conditions

Stage	pH	Reagents g/tonne				
		Lime	Fuel Oil	3418A	208	PAX
Primary Grind	10.4-11.2	2800	20	-	-	-
Roughers	11.0-11.1	√	-	4-8	8-16	0-4
Regrind	11.1-11.5	500	10-20	-	-	-
Cleaners	11.0-11.1	√	0-20	3-4	6-8	0-5



Locked Cycle Test Conditions

Stage	pH	Reagents g/tonne				
		Lime	Fuel Oil	3418A	208	PAX
Primary Grind	11.0	2900	20	-	-	-
Roughers	11.0	-	-	8	16	-
Regrind	11.0	500	20	-	-	-
Cleaners	11.0	√	20	3	6	-
Cleaner Scav	11.0	-	20	-	-	-
Pyrite Roughers	11.0	-	-	-	-	60

Note: Detailed test conditions can be found in Appendix II.

3.2 Rougher Test Results

A total of 17 rougher flotation tests were conducted in this program to investigate variables such as primary grind size, pH, and collector type. A graphical representation of the relevant test results are displayed in Figures 3 and 4.

3.2.1 Effect of Primary Grind Size on Rougher Flotation

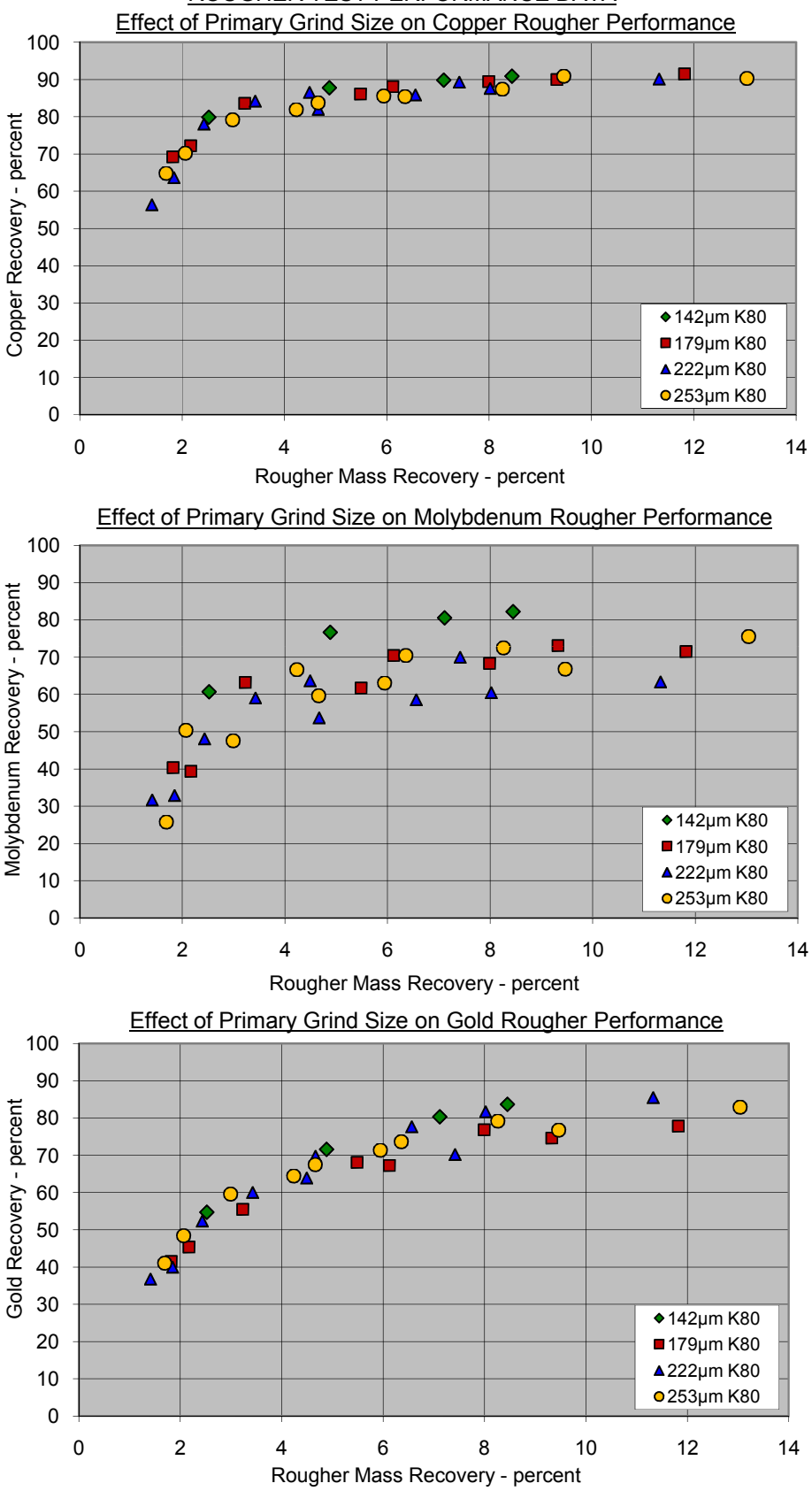
Tests aimed at investigating the effect of primary grind size on rougher flotation performance were conducted in this program. The results indicated that there was no perceptible effect of primary grind size on copper rougher flotation response over the range of primary grind sizes tested; 142µm to 253µm K_{80}.

For these tests, on average, copper was 90 percent recovered into a rougher concentrate, containing approximately 10 percent of the feed mass.

The test results suggest a slight decrease in molybdenum and gold performance when primary grind size was increased to 179µm K_{80}. However, between 179 and 253µm K_{80}, both molybdenum and gold recovery to the rougher concentrate was mainly unaffected.

At a primary grind size of 142µm K_{80}, molybdenum and gold were, 82 and 84 percent respectively, recovered into a rougher concentrate, containing approximately 8 percent of the feed mass. At coarser primary grind sizes, molybdenum and gold were, on average, 70 and 77 percent recovered into a rougher concentrate, containing 10 percent of the feed mass.

FIGURE 3
ROUGHER TEST PERFORMANCE DATA



3.2.2 Effect of pH on Rougher Flotation

Tests aimed at investigating the effect of pH on rougher circuit* metallurgical response showed that elevated pulp pH improved initial flotation kinetics for copper as well as resulted in copper recoveries of 90 percent. At a coarser primary grind size, tests conducted at pH 9.0 and 10.0, resulted in lower copper recoveries of approximately 85 percent to the rougher concentrate. Tests conducted at the composite's natural pH of approximately 6.6, resulted in poor copper metallurgical performance.

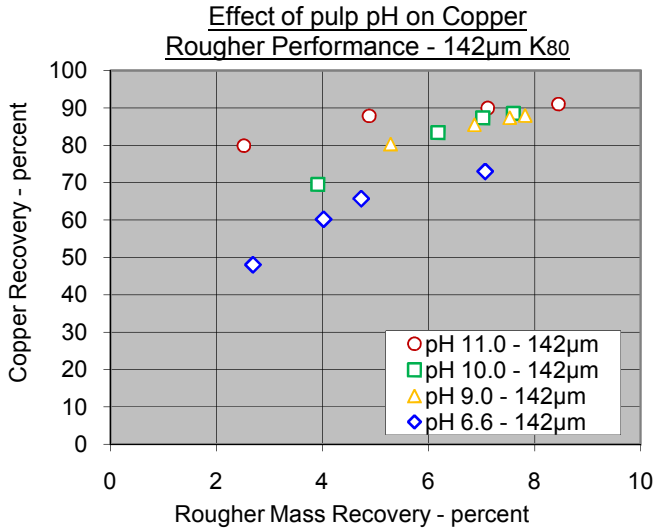
In general, the most favorable molybdenum metallurgical performance was observed at lower rougher pulp pH, while gold rougher metallurgical performance was mainly unaffected by pH levels, at the coarser primary grind size.

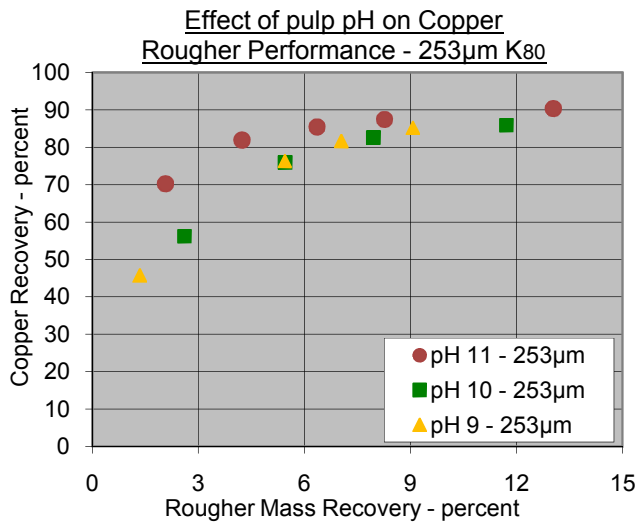
Due to the high pyrite content in this sample, the majority of the rougher test work in this program was conducted using selective collectors 3418A and 208 as the copper and gold collecting agents, and fuel oil to collect molybdenum.

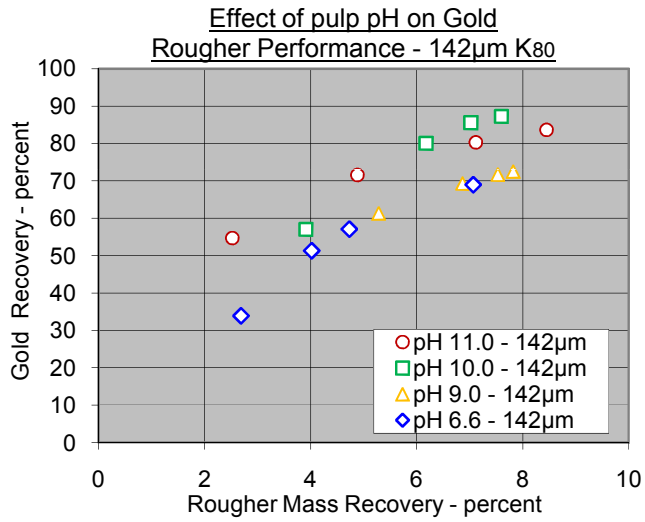
The optimum test conditions used to carry on with the test program were at a primary grind size of approximately 222µm K_{80}, pH 11.0, using 3418A, 208, and fuel oil. At these conditions, at a rougher mass recovery of approximately 8 percent, copper, molybdenum, and gold were, on average, 91, 67, and 78 percent, respectively, recovered into the rougher concentrate.

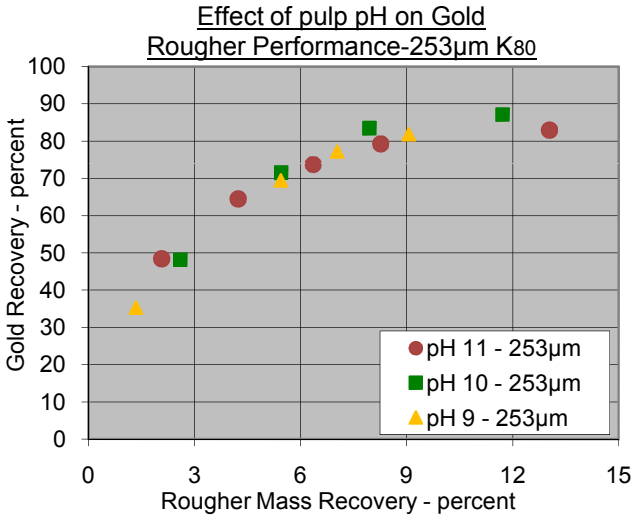
* At the request of the client, two tests were conducted using NaHS and AM28 as the collecting agents in an attempt to increase oxide copper recovery to the rougher concentrate. These tests were not successful in doing so. Results are displayed in Figure IV-2 found in Appendix IV-Special Assay Data.

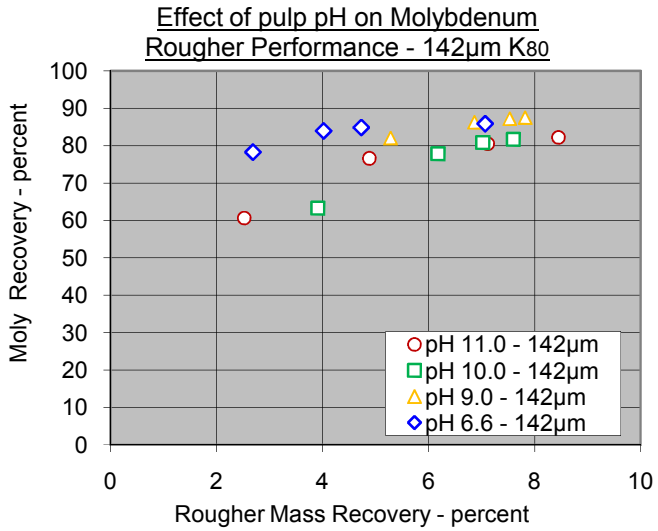
FIGURE 4
ROUGHER TEST PERFORMANCE DATA

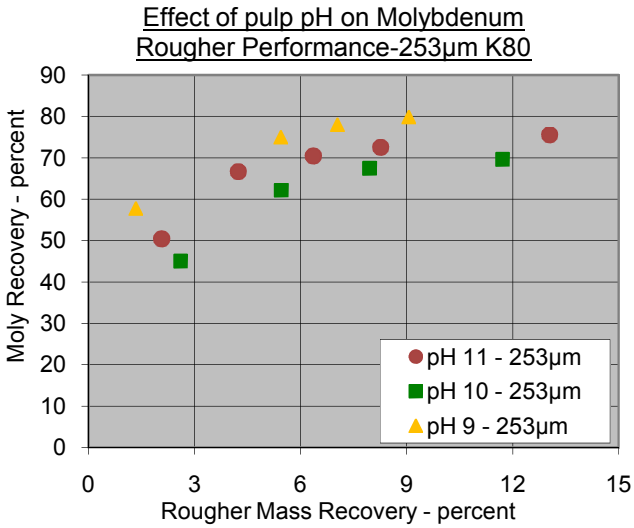












Note: Detailed test data is located in Appendix II.

3.3 Cleaner Test Results

Ten open circuit batch cleaner tests were conducted in this test program. As indicated by the mineralogical analysis, regrind product sizing would be a key variable governing the efficiency of the flotation process. Most of the batch cleaner tests were focused on assessing regrinding effects. A number of open circuit batch cleaner tests were also conducted to examine the effect of using a stronger collector. A summary of the test results, displayed in Figure 5, indicate the following points of interest:

- Regrinding the rougher concentrate to a nominal 20µm K_{80} produced the best metallurgical performance for the copper sulphides and gold. For these tests, copper and gold were, on average, 82 and 63 percent recovered into a bulk concentrate, grading 32 percent copper and 20 g/tonne gold.

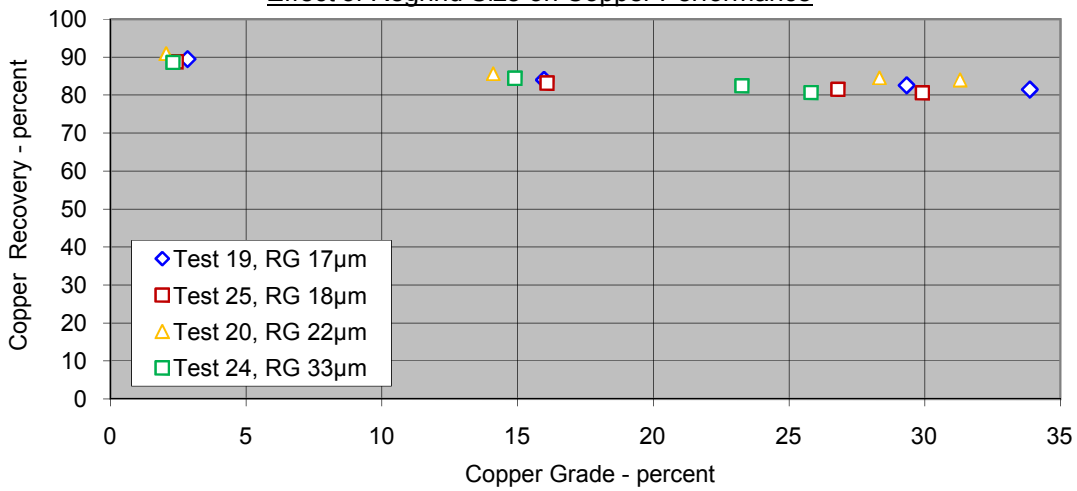
- Regrind sizing did not perceptibly influence the molybdenum metallurgy on the cleaner blocks. At a nominal regrind discharge size of 20µm K_{80}, molybdenum was, on average, 42 percent recovered into the bulk concentrate, grading 1.9 percent molybdenum.

- Increasing regrind size to approximately 33µm K_{80}, resulted in a decline in both copper and gold performance.

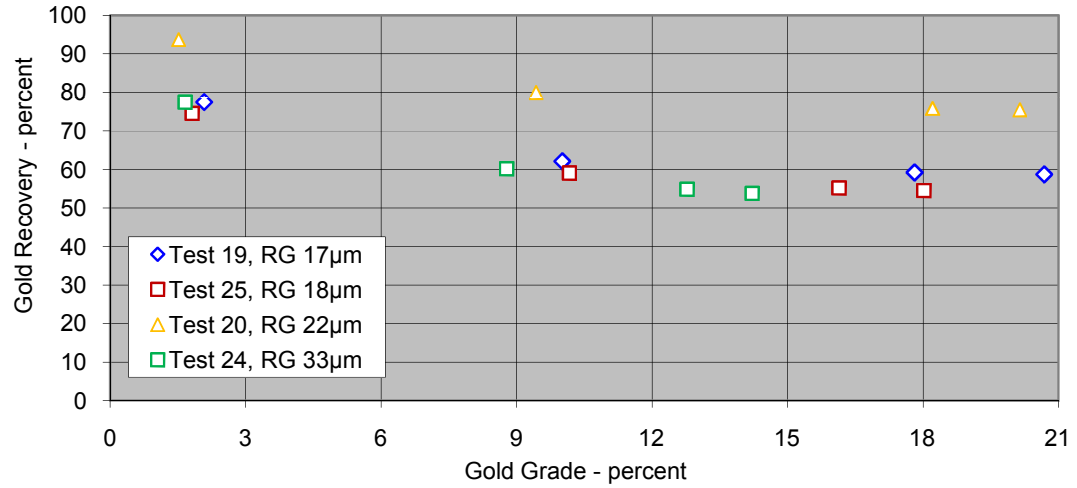
A series of cleaner tests, not shown in Figure 5, were conducted using a stronger collecting reagent, potassium amyl xanthate (PAX). For these tests, enough selectivity against pyrite, in the cleaner circuit, was not obtained, resulting in a low grade bulk concentrate. Two additional cleaner tests were also conducted at the request of the client, examining the effect of a target grind size of 200µm K_{80}, and the effect of two stage regrinding. No improvement on metallurgical performance was observed for these tests. The results are presented in Appendix IV, Figure IV-1.

FIGURE 5
CLEANER TEST PERFORMANCE DATA

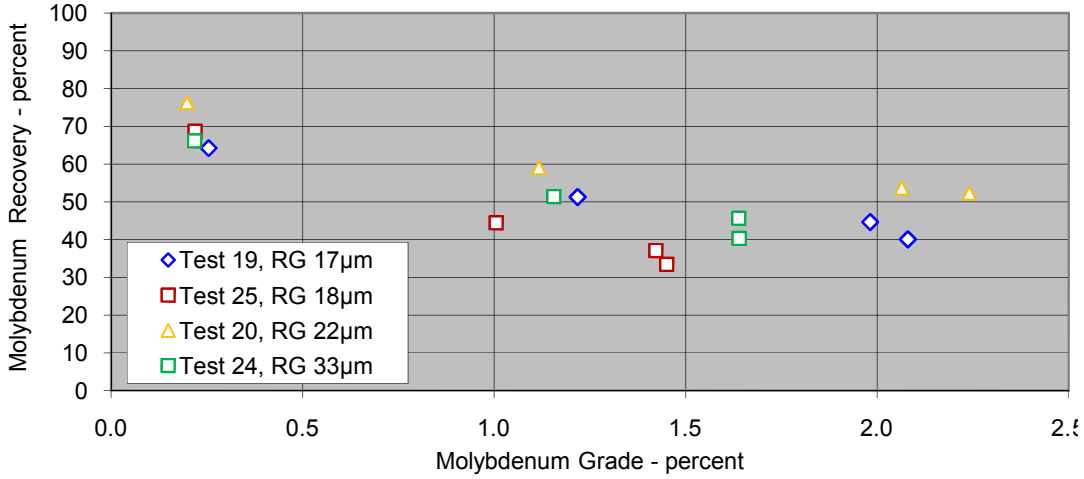
Effect of Regrind Size on Copper Performance



Effect of Regrind Size on Gold Performance



Effect of Regrind Size on Molybdenum Performance



Note: Additional test data is located in Appendix II.

3.4 Pyrite Flotation and Cyanidation Test Results

A series of two product cleaner tests were conducted with the objective of desulphidizing the final tailing streams and increasing gold recovery from the feed. In these tests, the bulk circuit rougher tailings were subjected to an additional pyrite flotation step. The pyrite rougher concentrate, along with the bulk first cleaner tailings, were then cleaned using three stages of dilution cleaning.

The pyrite cleaner concentrate from these tests were then subjected to cyanide leaching with and without a regrind stage prior to leaching. Cyanide levels were maintained at 1,000 ppm, while the pH level was modulated to 11.0. A schematic of the test flowsheets and a summary of test results are displayed in Figure 6. The following key points follow from an inspection of the data:

- The final tailing stream contained 3.3 percent of the feed sulphur, grading 0.1 percent sulphur.

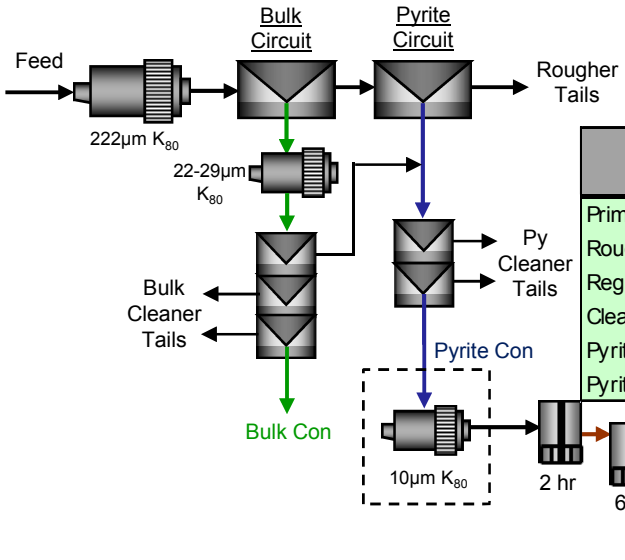
- On average, 15 percent of the feed gold was recovered into the pyrite concentrate, grading 0.76 g/tonne gold. This concentrate also contained, on average, 6 percent of the feed copper, assaying at 0.41 percent copper.

- Approximately 76 percent of the gold and 99 percent of the copper contained in the pyrite concentrate were extracted into solution after 48 hours of cyanide leaching. For this test, cyanide consumption was extremely high at 7.8 kg/tonne. Lime consumption was measured to be 1.4 kg/tonne.

- Regrinding the pyrite concentrate to approximately 10µm K_{80}, prior to leaching, did not improve gold extraction into solution. Cyanide consumptions were lower at 5.3 kg/tonne while lime consumption increased to 2.5 kg/tonne.

FIGURE 6

PYRITE FLOWSHEET DEVELOPMENT AND TEST DATA



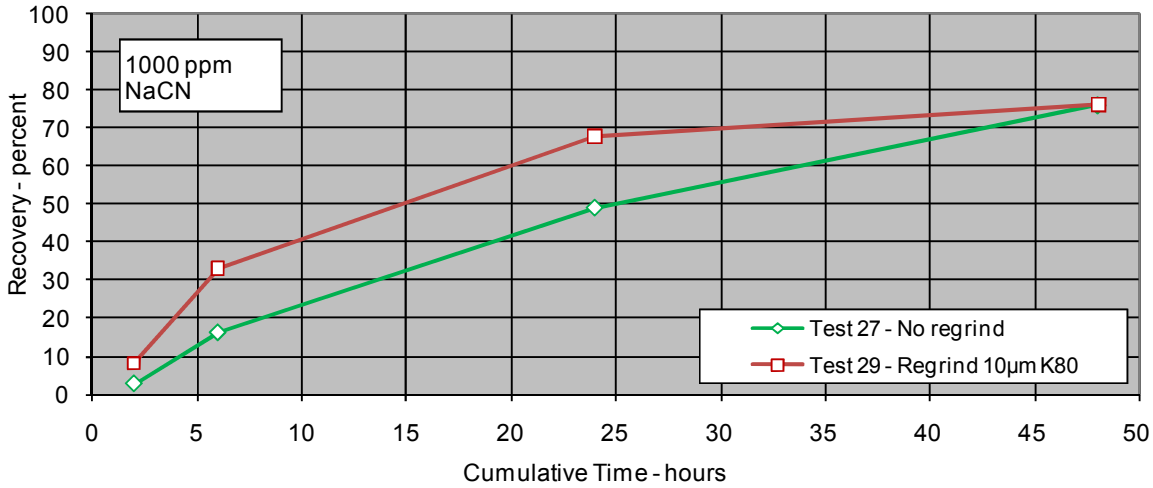
Nominal Test Conditions

Stage	pH	Reagents g/tonne				
		Lime	Fuel Oil	3418A	208	PAX
Primary Grind	11.0	2800	20	-	-	-
Roughers	11.0	√	-	4	8	-
Regrind	11.0	500	20	-	-	-
Cleaners	11.0	√	20	4	8	-
Pyrite Roughers	10.5	-	-	-	-	60
Pyrite Cleaners	11.0	-	-	-	-	180

Average Metallurgical Balance – Tests 27 and 29

Product	Mass	Assay - percent or g/t						Distribution - percent					
	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Bulk Con	0.7	31.9	1.10	26.3	33.6	162	19.7	78.5	23.4	5.1	9.4	49.1	66.5
Bulk 3rd Clnr Tail	0.3	1.4	0.71	21.1	21.7	17	3.6	1.5	6.7	1.8	2.7	2.3	5.4
Bulk 2nd Clnr Tail	1.3	0.5	0.27	20.0	20.4	7	0.8	2.3	10.5	7.3	10.7	4.1	4.9
Pyrite Con	**4.2**	**0.43**	**0.28**	**36.6**	**38.1**	**7**	**0.83**	**6.3**	**34.5**	**42.3**	**63.1**	**12.4**	**16.6**
Pyrite 2nd Clnr Tail	1.4	0.12	0.02	4.3	3.1	2	0.26	0.6	1.0	1.7	1.7	1.0	1.7
Pyrite 1st Clnr Tail	6.2	0.15	0.03	4.6	4.1	2	0.10	3.2	6.2	7.8	9.9	5.7	2.9
Pyrite Ro Tail	85.8	0.03	0.007	1.5	**0.07**	1	0.01	7.6	17.8	33.9	**2.4**	25.4	2.0
Feed	100	0.29	0.034	3.6	2.62	2	0.23	100	100	100	100	100	100

Gold Extraction From Pyrite Concentrate



Note: Detailed test conditions and results can be found in Appendix II.

3.5 Locked Cycle Test Results

A series of locked cycle tests were conducted in this program to establish the estimates of metallurgical performance, anticipated from a continuous process. Figure 7 displays the flowsheet schematic used in these samples, along with a summary of test results.

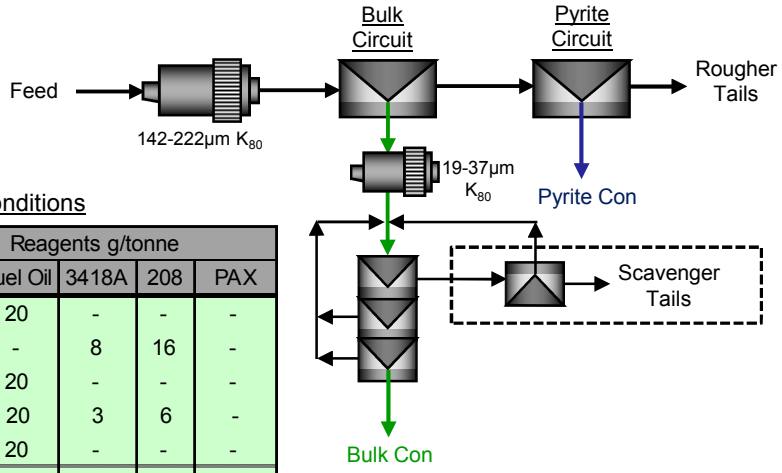
The results of these tests determined that, by implementing a cleaner scavenger step, molybdenum recovery to the final concentrate can be increased. At a primary grind size of 222µm K_{80}, and following a regrind target size of 20µm K_{80}, a copper recovery to the final concentrate of 88 percent, grading 26 percent copper, was obtained. For this test, molybdenum was 47 percent recovered into the final concentrate, grading 1.6 percent molybdenum.

In an attempt to reduce the loss of fine molybdenum particles to the final concentrate, a locked cycle test was conducted to investigate a coarser regrind size, targeting 31µm K_{80}. For this test, molybdenum recovery increased to approximately 57 percent in the final concentrate grading 1.5 percent molybdenum. However, as indicated by cleaner test data, at a coarser regrind size, copper performance declined. For this test, copper was 84 percent recovered from the feed to the final concentrate grading 21 percent copper.

For the purpose of comparison to previously tested Casino samples, and at the request of the client, a single locked cycle test was conducted at a finer primary grind size of 142µm K_{80}. Again, as determined by initial rougher test work, molybdenum performance increased while copper performance was unaffected. For this test, molybdenum from the feed was 56 percent recovered into the final concentrate grading 1.8 percent molybdenum. Copper recovery to the final concentrate was 87 percent, grading 26 percent copper.

FIGURE 7

LOCKED CYCLE TEST FLOWSHEET DEVELOPMENT AND TEST DATA



Nominal Test Conditions

Stage	pH	Reagents g/tonne				
		Lime	Fuel Oil	3418A	208	PAX
Primary Grind	11.0	2900	20	-	-	-
Roughers	11.0	-	-	8	16	-
Regrind	11.0	500	20	-	-	-
Cleaners	11.0	√	20	3	6	-
Cleaner Scav	11.0	-	20	-	-	-
Pyrite Roughers	11.0	-	-	-	-	60

Locked Cycle Test Results

Product	Size - microns K_{80}		Mass	Assay - percent or g/t						Distribution - percent					
	Primary	Regrind	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Test 33															
Bulk Concentrate			**0.8**	**29.5**	**1.49**	**25.1**	**34.5**	**179**	**20.1**	**82.3**	**34.5**	**5.7**	**10.2**	**51.9**	**70.7**
Bulk 1st Cleaner Tail	222	19	15.3	0.13	0.09	13.6	14.3	4	0.21	7.2	40.0	61.4	84.6	20.3	14.8
Pyrite Rougher Conc			6.4	0.11	0.023	2.2	1.21	2	0.04	2.5	4.5	4.1	3.0	4.4	1.2
Pyrite Rougher Tail			77.5	0.03	0.009	1.3	0.08	0.8	0.04	8.0	21.1	28.8	2.3	23.5	13.3
Test 34															
Bulk Concentrate			**0.9**	**25.9**	**1.55**	**26.2**	**34.9**	**152**	**18.8**	**87.6**	**46.9**	**7.3**	**12.2**	**62.3**	**66.4**
Bulk Cleaner Scav Tail	222	20	14.5	0.08	0.044	11.7	13.3	3	0.22	4.0	20.8	51.2	73.1	17.0	12.2
Pyrite Rougher Conc			5.6	0.14	0.028	6.4	5.78	2	0.22	2.8	5.1	10.8	12.2	4.9	4.8
Pyrite Rougher Tail			79.1	0.02	0.010	1.3	0.08	0.5	0.05	5.7	27.2	30.8	2.4	15.8	16.6
Test 35															
Bulk Concentrate			**0.9**	**25.7**	**1.82**	**27.7**	**33.9**	**154**	**17.3**	**86.8**	**55.7**	**7.3**	**12.6**	**57.9**	**68.8**
Bulk 1st Cleaner Tail	142	19	14.7	0.10	0.057	13.9	14.2	3	0.26	5.0	27.2	56.9	81.9	15.2	16.3
Pyrite Rougher Conc			3.7	0.12	0.023	3.5	2.37	2	0.20	1.5	2.8	3.6	3.5	3.0	3.1
Pyrite Rougher Tail			80.6	0.02	0.006	1.4	0.06	0.7	0.04	6.6	14.3	32.1	2.0	23.9	11.8
Test 36															
Bulk Concentrate			**1.3**	**18.3**	**1.40**	**30.7**	**37.5**	**94**	**11.5**	**82.3**	**53.3**	**10.2**	**17.8**	**58.5**	**64.4**
Bulk 1st Cleaner Tail	222	37	14.8	0.14	0.044	12.2	12.3	3	0.31	7.1	19.5	47.2	68.3	23.1	20.1
Pyrite Rougher Conc			6.1	0.13	0.028	5.2	4.93	2	0.20	2.8	5.0	8.2	11.2	5.2	5.3
Pyrite Rougher Tail			77.9	0.03	0.010	1.7	0.09	0.3	0.03	7.8	22.2	34.4	2.6	13.3	10.2
Test 37															
Bulk Concentrate			**1.1**	**21.0**	**1.53**	**31.2**	**37.9**	**114**	**11.7**	**83.5**	**57.0**	**9.5**	**15.5**	**68.4**	**64.1**
Bulk Cleaner Scav Tail	222	31	16.1	0.09	0.028	11.0	10.8	2	0.16	5.1	15.0	49.1	64.2	18.7	12.8
Pyrite Rougher Conc			5.3	0.14	0.029	8.6	9.08	2	0.24	2.6	5.2	12.6	17.7	6.7	6.2
Pyrite Rougher Tail			77.5	0.03	0.009	1.3	0.09	0.1	0.04	8.8	22.8	28.8	2.5	6.3	17.0

Notes: a) Detailed test conditions and results can be found in Appendix II.
b) Ag and Au assays in g/tonne, all others in percent.

4.0 Mineralogical Assessment of The Process

To assess opportunities for metallurgical improvements, Particle Mineral Analysis (PMA) using QEMSCAN was performed on the exit streams produced in locked cycle Test 34. The results of this assessment provided information regarding the potential to improve the grade of the final copper concentrate. The analysis also determined the opportunities for reducing copper losses to the tailings streams.

4.1 Quality of the Concentrate

A summary of the status of diluents contained in the final bulk concentrate is displayed in Figure 8A. The following points may be of interest:

- Most of the diluents contained in the concentrate occurred as liberated pyrite. Chemical changes to the flotation circuit would be required to reject more of the pyrite from the concentrate. More selective conditions of flotation, however, would likely result in lower copper recovery.

- Gangue was the second highest diluent in the bulk concentrate. The majority of the gangue reporting to the bulk concentrate was observed to be liberated particles finer than 14µm K_{80}, likely a result of froth entrainment.

- The limiting grade recovery chart for the bulk concentrate indicates that concentrates assaying between 38 and 40 percent copper could theoretically be produced from this composite as a result of rejecting all non-copper sulphide bearing particles. Typically, losses in copper recovery are incurred when higher grade concentrate are targeted.

FIGURE 8A
DISTRIBUTION OF MINERALS BY SIZE AND CLASS INTO THE BULK CONCENTRATE - TEST 34

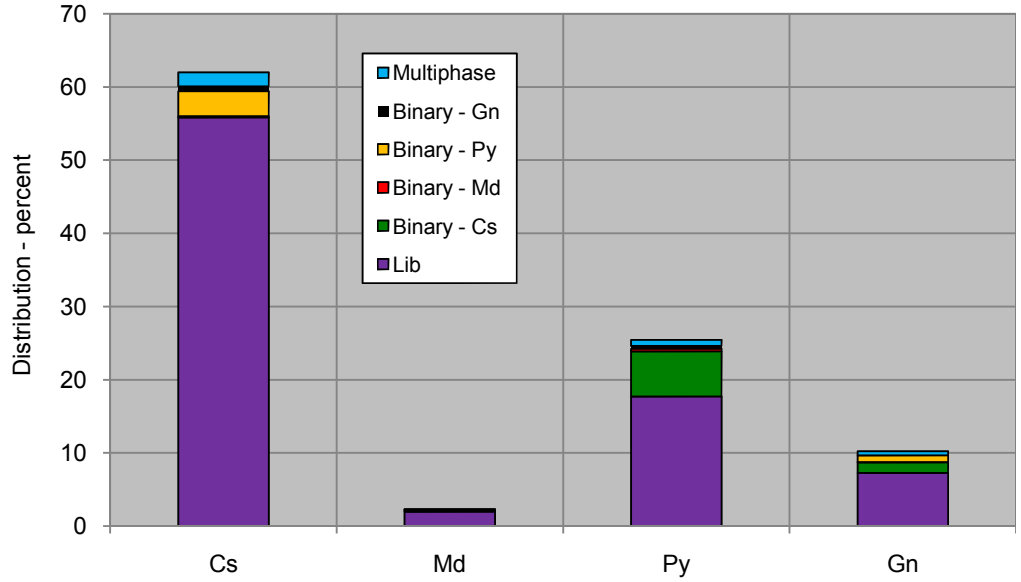
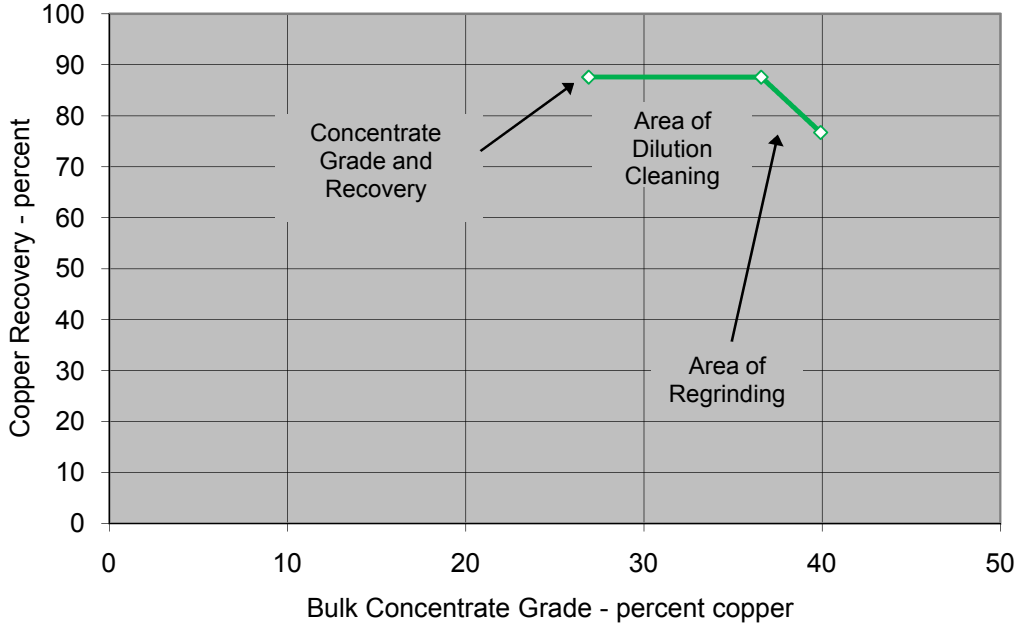


FIGURE 8B
MINERALOGICALLY LIMITING GRADE RECOVERY CHART
Based on Recovery into Test 34, Bulk Concentrate from the Bulk Rougher Feed



4.2 Losses to the Final Tails

A modal analysis was carried out on the scavenger tailing, pyrite concentrate and pyrite rougher tailing streams produced in Test 34. Analysis of the modal data, with respect to losses to the tailing streams*, is shown in Figure 9. The following comments may be of interest:

- The majority of the copper losses to the bulk rougher tails occurred as binary particles with non-sulphide gangue. Most of these particles are either coarser than 150µm or finer than 13µm K_{80}.

- Liberated copper sulphides accounted for 28 percent of the copper losses in the bulk rougher tailing stream. Most of these particles were sized finer than 13µm K_{80}. Liberated copper sulphide particles in this size range are generally difficult targets to recover by flotation.

- About 25 percent of the copper sulphide in the scavenger tailing was liberated. The majority of liberated and non-liberated copper sulphide in this stream was finer than 13µm. There is a limited scope for improving copper recoveries from this stream.

- The majority of the molybdenite lost to the bulk rougher tails occurred as coarse binary particles with non-sulphide gangue. Test 35 results, not shown in the figure, indicate molybdenum losses to this stream may be reduced at a finer primary grind size.

- Liberated molybdenite accounted for the majority of molybdenite losses to the scavenger tails. About half of these particles were finer than 13µm K_{80}. This loss profile is often observed in operating plants.

* The pyrite concentrate and pyrite rougher tailing stream analysis were combined in this section to represent losses to the bulk rougher tailing stream. For individual stream data, see Appendix V-Mineralogical Data.

FIGURE 9A
DISTRIBUTION OF COPPER LOSSES BY SIZE AND CLASS INTO THE TAILINGS - Test 34

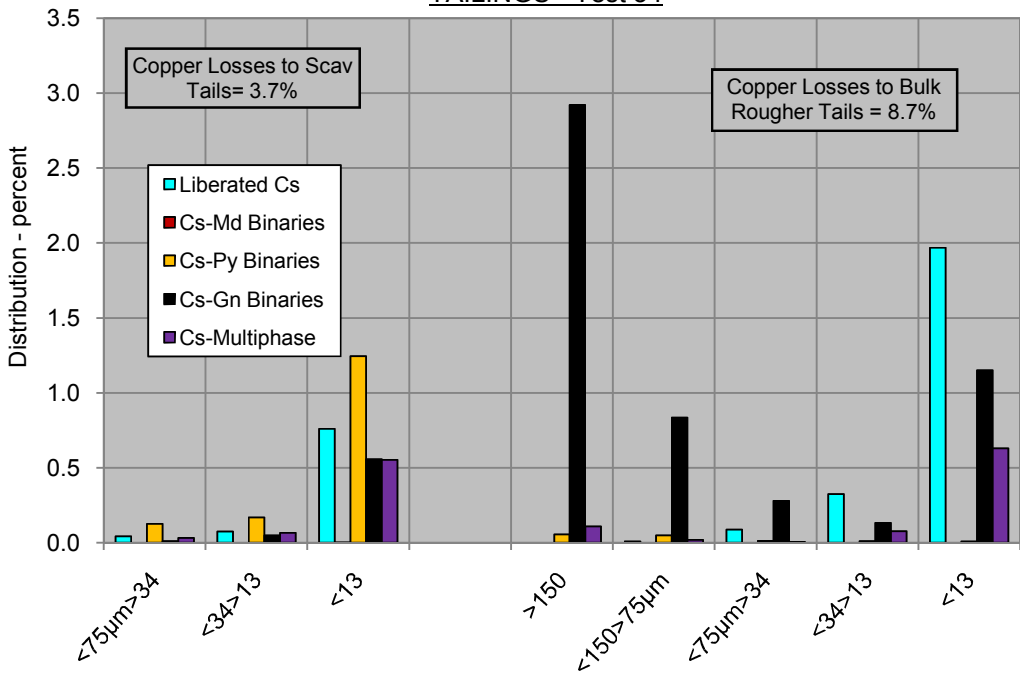
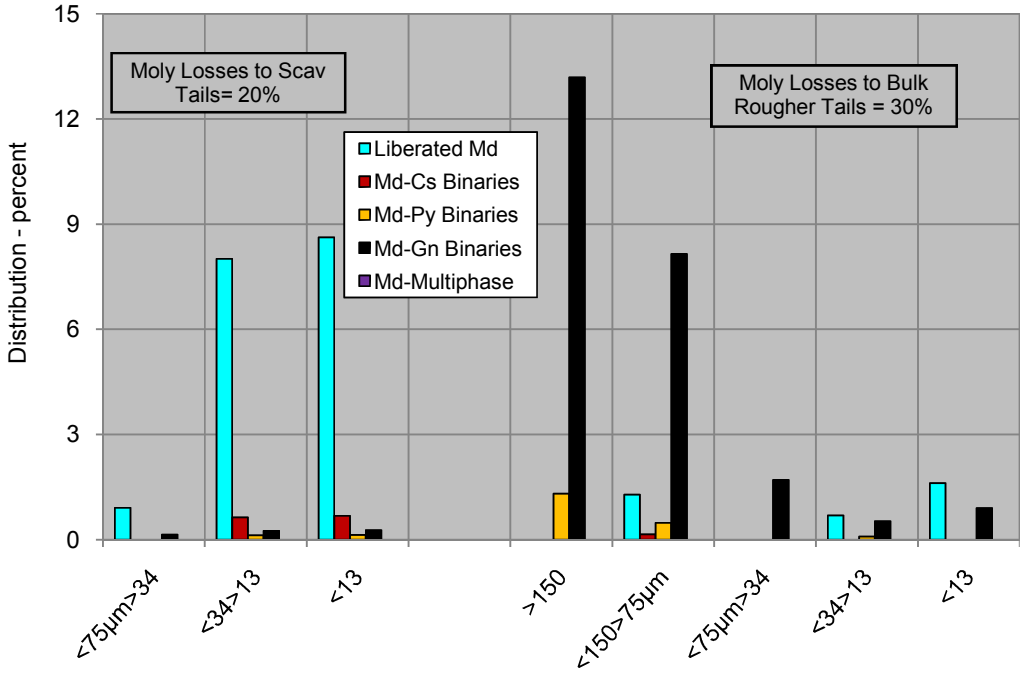


FIGURE 9B
DISTRIBUTION OF MOLYBDENUM LOSSES BY SIZE AND CLASS INTO THE TAILINGS - Test 34



Note: Detailed modal anlysis data can be located in Appendix V.

5.0 Concentrate Quality

The bulk concentrates taken from locked cycle Test 33 were subjected to a detailed chemical analyses. Major components and minor elements present in the concentrate were determined using specific element assay techniques.

The principal objective of this test work was to determine if the floatation concentrate produced from the Casino deposit contained any components, which might adversely affect smelter acceptance. The results are presented in Table 3.

The bulk concentrate was relatively free of deleterious elements that may attract a smelter penalty.

Gold and silver content in the concentrate were present at approximately 21 and 179 g/tonne, respectively.

It is recommended that specific advice from experts in the field of smelter contracts be sought regarding the trigger points for the imposition of penalty payments.

TABLE 3
MINOR ELEMENT ASSAYS
Test 33

Element	Symbol	Units	Method	Bulk Concentrate III-V
Aluminum	Al	%	WR ICP-OES	0.48
Antimony	Sb	g/t	2 Acid ICP-OES	102
Arsenic	As	g/t	2 Acid ICP-OES	199
Bismuth	Bi	g/t	2 Acid ICP-OES	88
Cadmium	Cd	g/t	AR FAAS	32
Calcium	Ca	%	WR ICP-OES	0.13
Carbon	C	%	Leco	0.24
Cobalt	Co	g/t	AR FAAS	68
Copper	Cu	%	Titr	30.7
Fluorine	F	g/t	Fusion ISE	92
Gold	Au	g/t	FA FAAS	20.5
Iron	Fe	%	AR FAAS	24.3
Lead	Pb	%	AR FAAS	0.05
Magnesium	Mg	%	WR ICP-OES	0.06
Manganese	Mn	%	WR ICP-OES	0.002
Mercury	Hg	g/t	LeForte rt CV-AAS	<1
Molybdenum	Mo	%	2 Acid FAAS*	1.50
Nickel	Ni	g/t	AR FAAS	96
Phosphorus	P	g/t	3 Acid ICP-OES	83
Selenium	Se	g/t	ESHKA ICP-OES	46
Silicon	Si	%	Fusion ICP-OES	1
Sulphur	S	%	Leco	34.6
Silver	Ag	g/t	AR FAAS	179
Zinc	Zn	%	AR FAAS	0.13

Notes:

Analytical Methods

CV-AAS	Cold vapour flameless atomic absorption spectrometry
FAAS	Flame atomic absorption spectrometry
ICP-OES	Inductively coupled plasma - optical emission spectroscopy
Leco	Leco induction furnace
ISE	ion selective electrode
Titr	Classical wet method titration

Digestion Methods

2 Acid	Hydrochloric acid and nitric acid
2 Acid*	Hydrochloric acid, nitric acid and potassium chlorate
2 Acid**	Nitric acid and bromine
3 Acid	Hydrochloric acid, nitric acid and perchloric acid
4 Acid	Hydrochloric acid, nitric acid, hydrofluoric acid and perchloric acid
AR	Aqua regia - 3:1 hydrochloric acid:nitric acid
ESHKA	Magnesium oxide, sodium carbonate sinter
FA	Fire assay fusion
Fusion	Sodium peroxide fusion
Leco	Combusion
LeForte rt	Reverse aqua regia - 1:3 hydrochloric acid:nitric acid, at room temperature
WR	Hydrochloric acid, nitric acid and hydrofluoric acid

6.0 Ancillary Studies

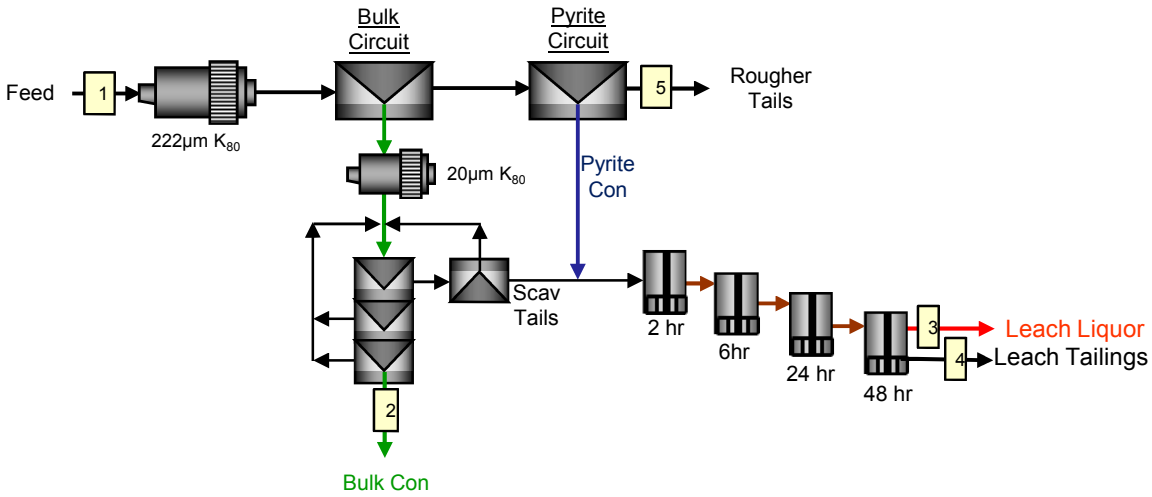
At the request of the client, the pyrite rougher concentrate and cleaner scavenger tailings from locked cycle Test 34 were combined and split into two, approximately 500 gram, charges. The two charges were subjected to two standard cyanide leaching bottle roll tests in order to assess the potential for extracting gold from this sample. The flowsheet used for this test is displayed in Figure 10.

The product was then fed to a 48 hour cyanidation bottle roll test. The sodium cyanide concentration was maintained at 2,000 ppm and the cyanidation pH at 11.0 using lime.

At a target sodium cyanide concentration of 2,000 ppm, the average sodium cyanide consumption was about 2.3 kg/tonne. Lime consumption was about 2.5 kg/tonne under these conditions. After 48 hours of cyanide leaching, on average, 74 percent of the gold from the pyrite concentrate and cleaner scavenger tails were extracted to solution. This converts to a gold recovery of approximately 12.5 percent from the locked cycle test feed.

FIGURE 10

CYANIDE LEACH TEST FLOWSHEET AND DATA



Locked Cycle Test Conditions

Stage	pH	Reagents g/tonne				
		Lime	Fuel Oil	3418A	208	PAX
Primary Grind	11.0	2900	20	-	-	-
Roughers	11.0	-	-	8	16	-
Regrind	11.0	500	20	-	-	-
Cleaners	11.0	√	20	3	6	-
Cleaner Scav	11.0	-	20	-	-	-
Pyrite Roughers	11.0	-	-	-	-	60

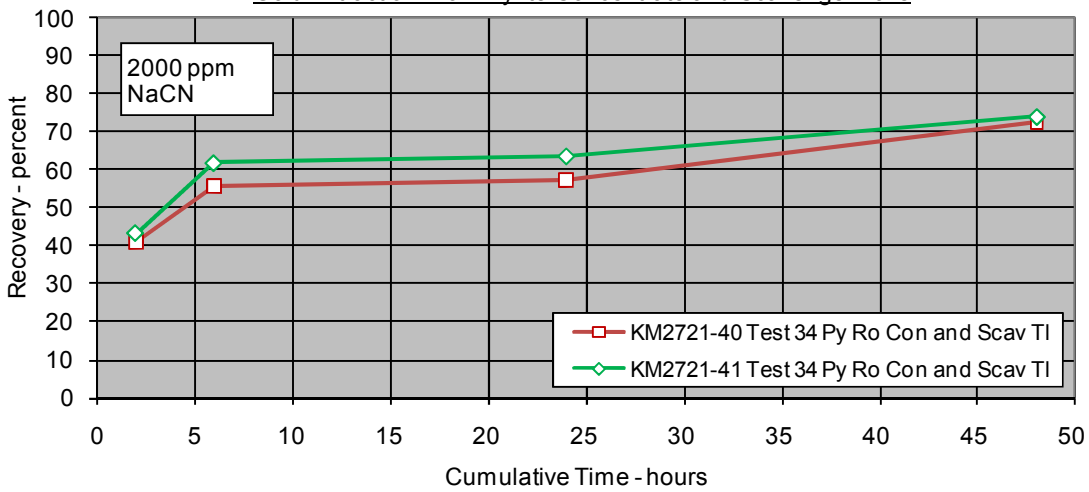
Cyanide Leach Test Conditions

pH	Reagent Consumed - kg/t	
	Lime	NaCN
11.0	2.5	2.3

Overall Gold Recovery from the Feed

Stream		Grade	Recovery from Feed
Number	Name	g/tonne	percent
1	Feed	0.26	100
2	**Bulk Concentrate**	**18.8**	**66.4**
3	**Leach Liquor**	**-**	**12.5**
4	Leach Tails	0.07	4.5
5	Pyrite Rougher Tails	0.05	16.6

Gold Extraction From Pyrite Concentrate and Scavenger Tails



Notes: a) Detailed test conditions and results can be found in Appendix II.
b) Leach liquor gold recovery is based on the average of Test 40 and 41.

7.0 Conclusions and Recommendations

Samples from the Casino deposit, designated SUP Composite 2010, were used in this program of study. The composite contained approximately 0.30 percent copper and 0.037 percent molybdenum. Chalcopyrite accounted for the majority of the copper in this sample. Pyrite accounted for the main sulphide mineral at 4 percent of the feed mass.

At a primary grind sizing of 142µm K_{80}, the two-dimensional copper sulphide liberation was 53 percent. The mineral fragmentation characteristics of the composite indicated that liberations of copper sulphides were only slightly affected by primary grind size. The data suggests that coarser levels of primary grind size, up to 250µm K_{80} may be instituted to produce adequate flotation performance in the rougher circuit.

Molybdenite at 142µm K_{80} primary grind size was 41 percent liberated when assessed in two dimensions. The majority of the molybdenite interlocking occurred in binaries with non-sulphide gangue particles, which were rich in molybdenite and likely to be recovered in rougher flotation.

Rougher test results in this program indicated that copper flotation response is virtually unaffected by primary grind size over the range of 142 to 253µm K_{80}. Molybdenum performance, however, declined at a primary grind size of 179µm K_{80} and coarser.

It was also determined from the rougher test results that increased pH levels improved copper performance.

Cleaner test results indicated that a nominal regrind size of 20µm K_{80}, results in the most favorable copper and gold performances. Regrind size over the range of 17 to 33µm K_{80}, did not affect molybdenum performance. However, copper and gold performance declined at the coarser regrind size.

Cleaner tests, involving a sequential pyrite circuit, were successful in desulphidizing the rougher tails. Following the pyrite circuit, the rougher tailings contained less than 0.1 percent sulphur.

An attempt to recover more gold from the pyrite cleaner concentrate, through cyanide leaching, resulted in approximately 11 percent of the feed gold being extracted into solution after 48 hours of cyanide leaching. Approximately 6 percent copper was also present in the pyrite concentrate, 99 percent of which was extracted to solution. Due to the high cyanide soluble copper content, cyanide consumption for this test was extremely high at approximately 7.8 kg/tonne.

At a primary grind size of 222µm K_{80}, following a regrind of approximately 20µm $K_{80,}$ and a pulp pH of 11.0, copper was, at best, 88 percent recovered into a final concentrate, grading 26 percent copper. For this test, molybdenum and gold were 47 and 66 percent recovered into the final concentrate, respectively, grading 1.6 percent molybdenum and 18.8 g/tonne gold. The tests results indicated that by implementing a cleaner scavenger stage molybdenum recovery to the final concentrate improved.

Locked cycle test results indicated that by increasing the regrind size to approximately 35µm K_{80}, an improvement in molybdenum metallurgical performance can be obtained. However, copper metallurgical performance decreased significantly.

The locked cycle test results also confirmed that at a finer primary grind size of 142µm K_{80}, molybdenum metallurgical performance increased, while copper performance was unaffected.

Mineral analysis of the locked cycle test exit streams determined that the main diluent in the bulk concentrate consists of mainly liberated pyrite particles. More selective flotation conditions may assist in the rejection of these particles,

however, this would likely result in lower copper recoveries. The majority of the copper losses to the final tailings occurred as very fine liberated particles, which are generally difficult targets to recover by flotation and were typical of similar operating circuits.

Minor element scans on the bulk concentrate from a selected locked cycle test showed that the concentrate is generally free of deleterious elements, however, advice from experts in the field of smelter contracts should be sought regarding this matter.

APPENDIX I – KM2721

SAMPLE ORIGIN

1.0 Sample Origin

Samples for this Casino Project were received at G&T Metallurgical Services Ltd. in three shipments, on August 5, 10, and 13 of 2010. Table I-1 displays the mass and identification of samples received. Upon receipt, samples were checked and certain samples disposed of, based on instructions from Mr. Adam Hesse, metallurgical consultant for Western Copper Corporation. All individual samples were stage crushed to -6 mesh and homogenized. Representative cuts were removed and assayed for elements of interest in this project as shown in Table I-2.

Following Mr. Hesse's instructions, a single global composite was constructed from select samples. Samples for the composite were homogenized and rotary split into 2 kilogram charges. Table I-3 displays the mass and identification of samples, used to construct the global composite, designated Master Composite 1.

Representative duplicate cuts were removed and assayed for elements of interest in this project as shown in Table I-4. Near the end of the program, at the request of Dr. Paul West-Sells, the Master Composite 1 sample name was changed to SUP Composite 2010.

A second SUP Composite 2010 was constructed from the drill core material for environmental test work. This material was constructed based on the same compositing instructions as the initial composite and was designated SUP Composite 2010-2. Head assays were conducted on this composite to confirm uniformity with the original sample. The results are displayed in Table I-5.

TABLE I-1A
MASS AND IDENTIFICATION OF SAMPLES RECEIVED
August 5, 2010

Sample ID	Mass kg	Sample Form
CAS-043 64.17-67.17	3.09	Quarter Core
CAS-043 67.17-69.35	3.09	Quarter Core
CAS-043 69.35-71.45	3.24	Quarter Core
CAS-044 53.65-56.65	4.53	Quarter Core
CAS-044 56.65-59.65	5.64	Quarter Core
CAS-044 59.65-62.65	3.07	Quarter Core
CAS-045 76.95-79.95	3.27	Quarter Core
CAS-045 79.95-82.95	3.21	Quarter Core
CAS-045 82.95-86.95	4.49	Quarter Core
CAS-048 118.50-121.50	3.84	Quarter Core
CAS-048 121.50-124.50	3.98	Quarter Core
CAS-048 124.50-127.50	3.02	Quarter Core
CAS-049 106.40-109.40	3.26	Quarter Core
CAS-049 109.40-111.80	3.4	Quarter Core
CAS-049 111.80-113.80	2.22	Quarter Core
CAS-049 130.00-132.00	2.35	Quarter Core
CAS-049 132.00-134.20	3.31	Quarter Core
CAS-049 134.20-137.20	4.34	Quarter Core
CAS-050 148.30-151.30	3.92	Quarter Core
CAS-050 151.30-154.30	3.83	Quarter Core
CAS-050 154.30-157.30	4.06	Quarter Core
CAS-050 79.90-82.90	3.68	Quarter Core
CAS-050 82.90-85.90	2.98	Quarter Core
CAS-050 85.90-88.90	4.11	Quarter Core
CAS-051 103.37-106.37	4.13	Quarter Core
CAS-051 106.37-109.37	4.65	Quarter Core
CAS-051 109.37-112.37	4.06	Quarter Core
CAS-051 57.80-60.80	2.75	Quarter Core
CAS-051 60.80-63.80	2.81	Quarter Core
CAS-051 63.80-65.28	1.44	Quarter Core
CAS-051 79.07-82.07	3.45	Quarter Core
CAS-051 82.07-85.07	2.85	Quarter Core
CAS-051 85.07-86.72	2.61	Quarter Core
CAS-052 62.60-64.25	2.49	Quarter Core
CAS-052 64.25-66.75	3.13	Quarter Core
CAS-052 66.75-69.75	4.47	Quarter Core
CAS-053 63.80-66.80	3.48	Quarter Core
CAS-053 66.80-69.00	3.27	Quarter Core
CAS-053 69.00-71.25	2.85	Quarter Core
CAS-054 69.70-72.70	3.3	Quarter Core
CAS-054 72.70-75.70	3.18	Quarter Core
CAS-054 75.70-78.70	3.29	Quarter Core
CAS-055 76.30-79.30	3.91	Quarter Core
CAS-055 79.30-82.30	3.15	Quarter Core
CAS-055 82.30-85.30	4.68	Quarter Core

Sample ID	Mass kg	Sample Form
CAS-057 154.00-156.85	4	Quarter Core
CAS-057 156.85-159.15	3.16	Quarter Core
CAS-059 104.00-106.30	1.42	Quarter Core
CAS-059 106.30-109.30	3.62	Quarter Core
CAS-059 109.30-111.35	5.43	Quarter Core
CAS-059 50.60-53.60	3.09	Quarter Core
CAS-059 53.60-56.60	2.97	Quarter Core
CAS-059 56.60-59.60	2.56	Quarter Core
CAS-060 84.57-87.57	5.03	Quarter Core
CAS-060 87.57-90.57	3.87	Quarter Core
CAS-060 90.57-92.30	2.87	Quarter Core
CAS-061 110.77-113.77	6.75	Quarter Core
CAS-061 113.77-115.82	3.66	Quarter Core
CAS-061 115.82-118.82	5.88	Quarter Core
CAS-061 62.48-65.48	4.4	Quarter Core
CAS-061 65.48-68.48	3.39	Quarter Core
CAS-061 68.48-70.48	1.85	Quarter Core
CAS-062 132.30-135.30	4.72	Quarter Core
CAS-062 135.30-138.30	3.88	Quarter Core
CAS-062 138.30-140.10	2.73	Quarter Core
CAS-062 173.65-176.65	5.86	Quarter Core
CAS-062 176.65-179.65	3.55	Quarter Core
CAS-062 179.65-182.65	3.95	Quarter Core
CAS-062 92.90-95.90	3.68	Quarter Core
CAS-062 95.90-98.90	3.27	Quarter Core
CAS-062 98.90-101.90	4.87	Quarter Core
CAS-063 109.30-112.30	4.5	Quarter Core
CAS-063 112.30-115.30	3.54	Quarter Core
CAS-063 115.30-118.30	3.92	Quarter Core
CAS-063 70.50-73.50	3.51	Quarter Core
CAS-063 73.50-75.50	1.57	Quarter Core
CAS-063 75.50-77.10	2.25	Quarter Core
CAS-066 107.30-110.30	4.55	Quarter Core
CAS-066 110.30-113.30	4.83	Quarter Core
CAS-066 113.30-116.30	5.18	Quarter Core
CAS-066 125.30-128.30	4.57	Quarter Core
CAS-066 128.30-131.30	3.86	Quarter Core
CAS-066 131.30-134.30	4.37	Quarter Core
CAS-066 146.30-149.30	3.18	Quarter Core
CAS-066 149.30-151.90	3.95	Quarter Core
CAS-066 151.90-154.25	2.56	Quarter Core
CAS-067 169.60-172.60	4.85	Quarter Core
CAS-067 172.60-175.60	4.95	Quarter Core
CAS-067 175.60-178.60	4	Quarter Core
CAS-067 184.60-187.60	4.63	Quarter Core

TABLE I-1A Continued
MASS AND IDENTIFICATION OF SAMPLES RECEIVED
August 5, 2010

Sample ID	Mass kg	Sample Form
CAS-056 58.10-61.10	3.66	Quarter Core
CAS-056 61.10-64.10	3.39	Quarter Core
CAS-056 64.10-67.08	3.29	Quarter Core
CAS-056 86.70-89.70	4.35	Quarter Core
CAS-056 89.70-91.70	2.48	Quarter Core
CAS-056 91.70-93.00	2.46	Quarter Core
CAS-057 151.00-154.00	4.43	Quarter Core
CAS-069 172.90-175.90	2.17	Quarter Core
CAS-070 140.0-143.0	5.11	Quarter Core
CAS-070 143.0-146.0	4.49	Quarter Core
CAS-070 146.0-149.0	3.43	Quarter Core
CAS-070 168.30-171.10	3.34	Quarter Core
CAS-070 171.10-174.10	4.28	Quarter Core
CAS-070 174.10-177.10	3.23	Quarter Core
CAS-070 183.10-186.10	4.67	Quarter Core
CAS-070 186.10-188.25	4.01	Quarter Core
CAS-070 188.25-190.70	3	Quarter Core
CAS-071 72.60-75.60	3.25	Quarter Core
CAS-071 75.60-78.60	1.96	Quarter Core
CAS-071 78.60-81.60	2.63	Quarter Core
CAS-073 109.70-112.70	3.93	Quarter Core
CAS-073 112.70-115.70	4.67	Quarter Core

Sample ID	Mass kg	Sample Form
CAS-067 187.60-189.60	2.76	Quarter Core
CAS-067 189.60-191.10	3.17	Quarter Core
CAS-069 135.25-138.25	3.02	Quarter Core
CAS-069 138.25-141.25	4.67	Quarter Core
CAS-069 141.25-142.85	2.5	Quarter Core
CAS-069 167.30-169.90	3.82	Quarter Core
CAS-069 169.90-172.90	3.13	Quarter Core
CAS-073 115.70-118.65	1.7	Quarter Core
CAS-073 138.70-141.70	3.36	Quarter Core
CAS-073 141.70-144.70	3.14	Quarter Core
CAS-073 144.70-147.70	3.2	Quarter Core
CAS-073 168.30-171.30	3.92	Quarter Core
CAS-073 171.30-174.30	3.98	Quarter Core
CAS-073 174.30-177.30	4.09	Quarter Core
CAS-074 163.15-166.15	4.13	Quarter Core
CAS-074 166.15-169.15	2.49	Quarter Core
CAS-074 169.15-171.15	4.07	Quarter Core
CAS-074 186.70-189.70	2.55	Quarter Core
CAS-074 189.70-192.70	4.84	Quarter Core
CAS-074 192.70-194.20	2.4	Quarter Core
CAS-074 201.50-203.64	3.02	Quarter Core
CAS-074 203.64-206.64	2.85	Quarter Core

TABLE I-1B
MASS AND IDENTIFICATION OF SAMPLES RECEIVED
August 10, 2010

Sample ID	Mass kg	Sample Form
CAS-043 61.17-64.17	3	Quarter Core
CAS-044 59.65-62.65	2.1	Quarter Core
CAS-045 73.95-76.95	4.1	Quarter Core
CAS-049 113.80-115.80	2.9	Quarter Core
CAS-049 137.20-140.20	3.5	Quarter Core
CAS-050 157.30-160.30	3.5	Quarter Core
CAS-050 88.90-91.00	2	Quarter Core
CAS-051 100.37-103.37	2.2	Quarter Core
CAS-051 54.80-57.80	2.4	Quarter Core
CAS-051 78.34-79.07	2.1	Quarter Core
CAS-052 69.75-72.75	4.2	Quarter Core
CAS-053 60.80-63.80	3.4	Quarter Core
CAS-054 78.70-81.70	2.6	Quarter Core
CAS-055 75.30-76.30	2.3	Quarter Core
CAS-056 67.08-70.08	4.7	Quarter Core
CAS-056 84.20-86.70	1.6	Quarter Core
CAS-057 148.00-151.00	4.9	Quarter Core
CAS-059 102.00-104.00	2.4	Quarter Core
CAS-059 59.60-61.60	1.9	Quarter Core
CAS-060 92.30-93.85	1.1	Quarter Core
CAS-061 118.82-120.82	2.5	Quarter Core
CAS-061 70.48-72.63	2.5	Quarter Core
CAS-062 101.90-104.90	4.5	Quarter Core
CAS-062 130.60-132.30	2.9	Quarter Core

Sample ID	Mass kg	Sample Form
CAS-062 170.65-173.65	3	Quarter Core
CAS-063 118.30-121.30	4.4	Quarter Core
CAS-063 154.25-157.25	4.1	Quarter Core
CAS-063 157.25-159.25	3	Quarter Core
CAS-063 159.25-161.90	2.6	Quarter Core
CAS-063 161.90-163.60	2.6	Quarter Core
CAS-063 67.50-70.50	3.1	Quarter Core
CAS-066 104.30-107.30	3.4	Quarter Core
CAS-066 134.30-137.30	5.5	Quarter Core
CAS-066 143.30-146.30	5.5	Quarter Core
CAS-067 166.60-169.60	3.4	Quarter Core
CAS-067 191.10-193.70	3.4	Quarter Core
CAS-069 142.85-144.45	2.2	Quarter Core
CAS-069 175.90-178.90	5.2	Quarter Core
CAS-070 137.00-140.00	3.5	Quarter Core
CAS-070 177.10-180.10	5.8	Quarter Core
CAS-070 190.70-193.70	4.2	Quarter Core
CAS-071 81.60-54.60	3.2	Quarter Core
CAS-073 118.65-121.65	2.5	Quarter Core
CAS-073 147.70-150.70	2.1	Quarter Core
CAS-073 177.30-180.30	3.7	Quarter Core
CAS-074 171.15-173.00	2.3	Quarter Core
CAS-074 183.70-186.70	4.2	Quarter Core
CAS-074 208.79-211.79	4	Quarter Core

TABLE I-1C
MASS AND IDENTIFICATION OF SAMPLES RECEIVED
August 13, 2010

Sample ID	Mass kg	Sample Form
CAS-002 114.30-117.35	6.8	Quarter Core
CAS-002 117.35-120.40	7.6	Quarter Core
CAS-002 120.40-123.44	7.2	Quarter Core
CAS-002 123.44-126.49	6.8	Quarter Core
CAS-002 138.98-141.73	6.3	Quarter Core
CAS-002 141.73-144.78	6.6	Quarter Core
CAS-002 144.78-147.83	7.3	Quarter Core
CAS-002 147.83-150.88	3	Quarter Core
CAS-002 176.78-179.83	6.8	Quarter Core
CAS-002 179.83-181.36	2.7	Quarter Core
CAS-002 181.36-183.18	2.7	Quarter Core
CAS-002 183.18-185.62	4	Quarter Core
CAS-003 155.45-157.10	3.8	Quarter Core
CAS-003 157.10-158.50	3.4	Quarter Core
CAS-003 158.50-160.88	5.4	Quarter Core
CAS-003 160.88-163.07	6.6	Quarter Core
CAS-005 54.50-57.50	3.8	Quarter Core
CAS-005 57.50-60.50	4.3	Quarter Core
CAS-005 60.50-63.45	4.2	Quarter Core
CAS-005 63.45-66.00	2.5	Quarter Core
CAS-005 89.10-92.10	3.8	Quarter Core
CAS-005 92.10-94.30	2.6	Quarter Core
CAS-005 94.30-95.40	1.2	Quarter Core
CAS-005 95.40-97.00	1.5	Quarter Core
CAS-006 66.40-69.80	4.2	Quarter Core
CAS-006 69.80-72.80	3.1	Quarter Core
CAS-006 72.80-75.00	3.5	Quarter Core
CAS-019 36.05-39.05	3.4	Quarter Core
CAS-019 39.05-41.15	2.6	Quarter Core
CAS-019 41.15-44.15	3.2	Quarter Core
CAS-019 44.15-47.15	3.4	Quarter Core
CAS-022 49.50-52.50	2.9	Quarter Core
CAS-022 52.50-55.00	2	Quarter Core
CAS-022 55.00-58.00	2.8	Quarter Core
CAS-022 58.00-60.60	2.8	Quarter Core
CAS-025 145.00-148.00	4.3	Quarter Core
CAS-025 148.00-151.00	5.4	Quarter Core
CAS-025 151.00-152.41	2.2	Quarter Core
CAS-025 152.41-155.00	3.2	Quarter Core
CAS-025 62.50-63.20	1.1	Quarter Core
CAS-025 63.20-65.55	3.1	Quarter Core
CAS-025 65.55-68.00	3.7	Quarter Core
CAS-025 68.00-70.00	2.2	Quarter Core
CAS-025 82.29-85.00	4.4	Quarter Core
CAS-025 85.00-87.00	2.6	Quarter Core

Sample ID	Mass kg	Sample Form
CAS-025 87.00-88.56	1.9	Quarter Core
CAS-025 88.56-91.22	3.6	Quarter Core
CAS-026 100.00-102.00	3	Quarter Core
CAS-026 102.00-104.30	3.2	Quarter Core
CAS-026 97.00-100.00	3.1	Quarter Core
CAS-028 160.00-163.00	2.5	Quarter Core
CAS-028 163.00-166.00	3.1	Quarter Core
CAS-028 166.00-169.00	3.4	Quarter Core
CAS-028 169.00-172.00	3.1	Quarter Core
CAS-028 184.55-187.00	3.1	Quarter Core
CAS-028 187.00-189.00	2.6	Quarter Core
CAS-028 189.00-191.00	2.6	Quarter Core
CAS-028 191.00-194.00	4.1	Quarter Core
CAS-030 190.75-193.75	3.1	Quarter Core
CAS-030 193.75-196.75	3.6	Quarter Core
CAS-030 196.75-199.75	2.8	Quarter Core
CAS-030 199.75-201.17	1.7	Quarter Core
CAS-030 222.00-224.00	3.4	Quarter Core
CAS-030 224.00-227.00	3.7	Quarter Core
CAS-030 227.00-229.00	1.9	Quarter Core
CAS-030 229.00-230.90	2	Quarter Core
CAS-032 156.35-159.35	4.4	Quarter Core
CAS-032 159.35-162.35	3.8	Quarter Core
CAS-032 162.35-165.35	4.4	Quarter Core
CAS-032 165.35-167.30	2.6	Quarter Core
CAS-032 176.30-178.30	2.9	Quarter Core
CAS-032 178.30-179.60	1.8	Quarter Core
CAS-032 179.60-182.60	4.3	Quarter Core
CAS-032 182.60-185.00	3.8	Quarter Core
CAS-033 141.60-143.60	2.2	Quarter Core
CAS-033 143.60-145.90	3.6	Quarter Core
CAS-033 145.90-148.90	4.1	Quarter Core
CAS-033 148.90-151.90	3.6	Quarter Core
CAS-033 69.00-72.00	3.4	Quarter Core
CAS-033 72.00-75.00	4.5	Quarter Core
CAS-033 75.00-78.00	3.3	Quarter Core
CAS-033 78.00-81.00	2.8	Quarter Core
CAS-040 106.15-109.15	3.1	Quarter Core
CAS-040 109.15-112.15	3.4	Quarter Core
CAS-040 112.15-115.15	2.9	Quarter Core
CAS-040 115.15-117.35	1.9	Quarter Core
CAS-040 156.30-159.30	2.7	Quarter Core
CAS-040 159.30-162.30	3.2	Quarter Core
CAS-040 162.30-164.30	2.1	Quarter Core
CAS-040 164.30-166.50	2.1	Quarter Core

TABLE I-2

VARIABILITY HEAD ASSAYS

Sample	Assay - percent or g/tonne								
	Cu	Fe	Ag	Mo	S	Au	As	Cu(ox)	$Cu_{(CN)}$
Sample 1	0.29	1.9	4	0.031	2.22	0.34	0.004	0.01	0.05
Sample 2	0.40	2.7	4	0.019	3.61	0.34	0.003	0.03	0.19
Sample 3	0.38	1.8	5	0.035	1.70	0.47	0.003	0.02	0.05
Sample 4	0.30	2.4	3	0.063	2.39	0.38	0.002	0.02	0.17
Sample 5	0.56	1.5	3	0.073	2.09	0.54	0.002	0.04	0.33
Sample 6	0.24	1.6	2	0.086	1.97	0.25	<0.001	0.02	0.09
Sample 7	0.35	3.7	2	0.045	3.37	0.18	0.002	0.04	0.21
Sample 8	0.34	7.4	3	0.018	6.39	0.16	0.002	0.05	0.20
Sample 9	0.33	5.2	4	0.024	5.95	0.27	0.002	0.03	0.13
Sample 10	0.18	5.8	4	0.039	5.39	0.21	0.005	0.02	0.04
Sample 11	0.15	4.9	3	0.010	2.56	0.16	0.003	0.01	0.02
Sample 12	0.15	7.2	2	0.010	6.77	0.06	0.003	0.02	0.05
Sample 13	0.21	4.3	3	0.004	3.80	0.48	0.004	0.01	0.02
Sample 14	0.10	4.5	2	0.004	3.93	0.15	0.004	0.00	0.01
Sample 15	0.18	5.7	3	0.052	6.15	0.18	0.004	0.01	0.02
Sample 16	0.15	4.6	4	0.021	4.27	0.44	0.004	0.01	0.01
Sample 17	0.20	4.6	4	0.012	5.37	0.47	0.004	0.01	0.02
Sample 18	0.36	3.4	2	0.018	2.35	0.37	0.003	0.03	0.25
Sample 19	0.50	2.8	4	0.020	2.54	0.57	0.002	0.04	0.17
Sample 20	0.31	2.8	2	0.029	3.28	0.23	0.002	0.03	0.14
Sample 21	0.26	2.0	3	0.016	2.60	0.19	0.002	0.03	0.15
Sample 22	0.32	3.6	3	0.012	3.43	0.33	0.002	0.03	0.10
Sample 23	0.31	2.9	3	0.013	2.90	0.34	0.002	0.02	0.08
Sample 24	0.38	3.3	4	0.002	2.12	0.28	0.003	0.03	0.18
Sample 25	0.21	3.2	2	0.002	1.74	0.27	0.003	0.00	0.00
Sample 26	0.25	2.7	2	0.008	3.11	0.22	0.002	0.01	0.03
Sample 27	0.53	3.6	2	0.004	1.09	0.41	0.001	0.04	0.32
Sample 28	0.15	2.8	2	0.024	1.02	0.20	0.005	0.01	0.01
Sample 29	0.16	2.3	1	0.003	2.50	0.21	0.004	0.01	0.03
Sample 30	0.28	1.4	2	0.017	0.93	0.24	0.002	0.04	0.17
Sample 31	0.17	2.5	3	0.012	1.68	0.16	0.003	0.01	0.01
Sample 32	0.37	4.5	3	0.005	1.99	0.65	0.004	0.02	0.05
Sample 33	0.23	3.6	1	0.004	1.78	0.25	0.003	0.03	0.08
Sample 34	0.19	1.7	1	0.004	1.36	0.15	0.002	0.02	0.05

TABLE I-2 Continued
VARIABILITY HEAD ASSAYS

Sample	Assay - percent or g/tonne								
	Cu	Fe	Ag	Mo	S	Au	As	Cu(ox)	Cu(CN)
Sample 35	0.22	3.3	2	0.016	1.60	0.18	0.003	0.05	0.06
Sample 36	0.38	2.9	2	0.011	1.62	0.30	0.002	0.04	0.21
Sample 37	0.34	3.4	2	0.042	1.67	0.26	0.003	0.02	0.11
Sample 38	0.20	4.8	4	0.007	4.17	0.15	0.006	0.00	0.00
Sample 39	0.26	1.7	2	0.019	1.77	0.22	0.002	0.04	0.15
Sample 40	0.18	1.6	2	0.032	1.44	0.27	0.002	0.01	0.02
Sample 41	0.16	1.7	1	0.024	1.43	0.15	0.002	0.01	0.04
Sample 42	0.15	2.7	2	0.014	2.08	0.16	0.002	0.01	0.01
Sample 44	0.14	4.5	2	0.008	2.26	0.25	0.007	0.02	0.03
Sample 46	0.39	4.5	2	0.012	3.92	0.22	0.009	0.08	0.19
Sample 47	0.30	0.8	1	0.042	0.64	0.15	0.004	0.03	0.10
Sample 48	0.32	1.0	1	0.038	0.87	0.25	0.003	0.03	0.11
Sample 49	0.32	1.1	1	0.029	0.76	0.19	0.003	0.03	0.05
Sample 50	0.10	3.0	2	0.002	3.49	0.21	0.002	0.01	0.05
Sample 51	0.32	1.9	2	0.022	1.91	0.12	0.003	0.06	0.07
Sample 52	0.21	4.3	2	0.021	0.87	0.25	0.004	0.01	0.00
Sample 53	0.21	2.3	1	0.023	1.09	0.15	0.005	0.02	0.03
Sample 54	0.26	4.0	2	0.013	1.02	0.19	0.002	0.04	0.09
Sample 55	0.26	3.0	2	0.002	1.22	0.26	0.003	0.03	0.12
Sample 56	0.32	3.6	3	0.550	4.31	0.10	0.003	0.06	0.16
Sample 57	0.62	5.6	2	0.176	6.12	0.09	0.001	0.08	0.46
Sample 58	0.17	3.9	3	0.070	2.85	0.15	0.002	0.01	0.01
Sample 59	0.64	3.6	5	0.084	3.82	0.27	0.003	0.07	0.14
Sample 60	0.30	4.0	3	0.027	4.30	0.13	0.001	0.03	0.14
Sample 61	0.22	3.5	2	0.031	2.16	0.20	0.001	0.01	0.05
Sample 62	0.32	1.6	2	0.042	2.17	0.22	0.002	0.03	0.16
Sample 63	0.46	2.6	2	0.078	3.53	0.10	0.003	0.07	0.30
Sample 64	0.34	5.2	3	0.011	6.51	0.25	0.003	0.04	0.22
Sample 65	0.44	3.8	4	0.068	5.04	0.29	0.002	0.04	0.23
Sample 66	0.41	1.8	4	0.040	2.13	0.26	0.001	0.03	0.18
Sample 67	0.16	4.1	2	0.024	2.36	0.16	0.002	0.01	0.01
Sample 68	0.30	4.1	2	0.015	3.61	0.07	0.001	0.04	0.20
Sample 69	0.25	3.9	2	0.006	3.96	0.30	0.001	0.04	0.12

TABLE I-3
MASTER COMPOSITE 1 CONSTRUCTION

Sample Identification	Mass in Composite kg
Sample 01	2.18
Sample 02	2.18
Sample 03	2.18
Sample 04	2.18
Sample 05	2.18
Sample 06	2.18
Sample 07	2.18
Sample 08	2.18
Sample 09	2.18
Sample 10	2.18
Sample 11	2.18
Sample 12	2.18
Sample 13	2.18
Sample 14	2.18
Sample 15	2.18
Sample 16	2.18
Sample 17	2.18
Sample 18	2.18
Sample 19	2.18
Sample 20	2.18
Sample 21	2.18
Sample 22	2.18
Sample 23	2.18
Sample 24	2.18
Sample 25	2.18
Sample 26	2.18
Sample 27	2.18
Sample 28	2.18
Sample 29	2.18
Sample 30	2.18
Sample 31	2.18
Sample 32	2.18

Sample Identification	Mass in Composite kg
Sample 33	2.18
Sample 34	2.18
Sample 35	2.18
Sample 36	2.18
Sample 37	2.18
Sample 38	2.18
Sample 39	2.18
Sample 40	2.18
Sample 41	2.18
Sample 42	2.18
Sample 44	2.18
Sample 45	2.18
Sample 46	2.18
Sample 53	2.18
Sample 54	2.18
Sample 55	2.18
Sample 56	2.18
Sample 57	2.18
Sample 58	2.18
Sample 59	2.18
Sample 60	2.18
Sample 61	2.18
Sample 62	2.18
Sample 63	2.18
Sample 64	2.18
Sample 65	2.18
Sample 66	2.18
Sample 67	2.18
Sample 68	2.18
Sample 69	2.18
Total	135.16

TABLE I-4
REPLICATE HEAD ASSAY DATA

Sample	Assay - percent or g/tonne								
	Cu	Fe	Ag	Mo	S	Au	As	CuOx	CuCN
SUP Composite 2010 Head 3	0.31	3.44	2	0.037	2.88	0.26	0.001	0.03	0.11
SUP Composite 2010 Head 4	0.29	3.49	3	0.035	2.87	0.24	0.001	0.03	0.10
Average	**0.30**	**3.47**	**2**	**0.036**	**2.88**	**0.25**	**0.001**	**0.03**	**0.11**

TABLE I-5
REPLICATE HEAD ASSAY DATA

Sample	Assay - percent or g/tonne								
	Cu	Fe	Ag	Mo	S	Au	As	CuOx	CuCN
SUP Composite 2010-2 Head 1	0.29	3.50	2	0.032	2.81	0.18	0.001	0.03	0.11
SUP Composite 2010-2 Head 2	0.28	3.50	3	0.032	2.94	0.20	0.001	0.03	0.11
Average	**0.29**	**3.50**	**2**	**0.032**	**2.88**	**0.19**	**0.001**	**0.03**	**0.11**

Note: Ag and Au assays in g/tonne, all other assays in percent.

APPENDIX II – KM2721

FLOTATION TEST DATA

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PROJECT NO: KM2721-01

PURPOSE: Preliminary Rougher Rate Test.

PROCEDURE: Perform a standard one product rougher test.

FEED: 2 kg of SUP Composite 2010 ore ground to a nominal 142µm K_{80}.

FLOWSHEET: 1

Stage	Reagents Added g/tonne				Time (minutes)			pH
	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	20				14			6.6
BULK CIRCUIT:								
Rougher 1		2	4	45		1	2	6.7
Rougher 2		2	4	-		1	2	6.3
Rougher 3		2	4	-		1	2	6.4
Rougher 4		2	4	-		1	2	6.5

Flotation Data	Rougher
Flotation Machine:	D2A
Cell Size in liters:	4.4
Aspiration:	Air
Impeller Speed in rpm:	1100

Grinding Data	Primary Grind
Mill:	M3-Mild
Charge/Material:	20kg-Mild
Water:	1000 ml

KM2721-01 SUP Composite 2010

Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t						Distribution - percent					
	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Bulk Ro Con 1	52.7	2.7	5.29	0.96	11.9	12.8	23	3.03	48.1	78.3	9.4	13.4	27.9	34.0
Bulk Ro Con 2	26.1	1.3	2.69	0.14	15.5	16.9	15	3.14	12.1	5.7	6.0	8.8	9.1	17.4
Bulk Ro Con 3	13.9	0.7	2.30	0.043	29.5	30.1	12	1.95	5.5	0.9	6.1	8.3	4.0	5.8
Bulk Ro Con 4	45.8	2.3	0.92	0.014	29.0	29.2	7	1.22	7.3	1.0	19.8	26.5	7.8	11.9
Bulk Ro Tail	1822.4	92.9	0.09	0.005	2.2	1.19	1	0.08	27.0	14.1	58.7	43.0	51.1	31.0
Feed	1960.9	100	0.30	0.033	3.4	2.57	2	0.24	100	100	100	100	100	100

KM2721-01 SUP Composite 2010

Cumulative Metallurgical Balance

Cumulative	Cum. Weight		Assay - percent or g/t						Distribution - percent					
Product	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Product 1	52.7	2.7	5.29	0.96	11.9	12.8	23	3.03	48.1	78.3	9.4	13.4	27.9	34.0
Product 1 to 2	78.8	4.0	4.43	0.69	13.1	14.2	20	3.07	60.2	84.0	15.4	22.1	37.1	51.4
Product 1 to 3	92.7	4.7	4.11	0.59	15.6	16.5	19	2.90	65.7	84.9	21.5	30.4	41.1	57.1
Product 1 to 4	138.5	7.1	3.05	0.40	20.0	20.7	15	2.35	73.0	85.9	41.3	57.0	48.9	69.0
Product 5	1822.4	92.9	0.09	0.005	2.2	1.19	1	0.08	27.0	14.1	58.7	43.0	51.1	31.0
Feed	1960.9	100	0.30	0.033	3.4	2.57	2	0.24	100	100	100	100	100	100

PROJECT NO: KM2721-02

PURPOSE: To Repeat Test 1 at pH 9.0.

PROCEDURE: Perform a standard one product rougher test.

FEED: 2 kg of SUP Composite 2010 ore ground to a nominal 142µm K_{80}.

FLOWSHEET: 1

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	200	20				14			6.8
BULK CIRCUIT:									
Rougher 1	900		2	4	23		1	2	9.0
Rougher 2	√		2	4	-		1	2	9.0
Rougher 3	√		2	4	-		1	2	9.0
Rougher 4	√		2	4	8		1	2	9.0

Flotation Data	Rougher	
Flotation Machine:	D2A	
Cell Size in liters:	4.4	
Aspiration:	Air	
Impeller Speed in rpm:	1100	

Grinding Data	Primary Grind
Mill:	M3-Mild
Charge/Material:	20kg-Mild
Water:	1000 ml

KM2721-02 SUP Composite 2010

Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t						Distribution - percent					
	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Bulk Ro Con 1	157.6	8.0	2.81	0.41	27.8	32.4	15	2.34	81.0	85.2	61.6	92.8	59.7	79.7
Bulk Ro Con 2	22.0	1.1	1.16	0.081	7.8	6.75	9	1.16	4.7	2.4	2.4	2.7	5.1	5.5
Bulk Ro Con 3	9.1	0.5	0.72	0.038	4.0	3.06	8	0.55	1.2	0.5	0.5	0.5	1.8	1.1
Bulk Ro Con 4	10.3	0.5	0.43	0.019	3.9	2.51	5	0.22	0.8	0.3	0.6	0.5	1.4	0.5
Bulk Ro Tail	1764.7	89.9	0.04	0.005	1.4	0.11	1	0.03	12.3	11.7	35.0	3.6	32.0	13.2
Feed	1963.7	100	0.28	0.038	3.6	2.80	2	0.24	100	100	100	100	100	100

KM2721-02 SUP Composite 2010

Cumulative Metallurgical Balance

Cumulative	Cum. Weight		Assay - percent or g/t						Distribution - percent					
Product	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Product 1	157.6	8.0	2.81	0.41	27.8	32.4	15	2.34	81.0	85.2	61.6	92.8	59.7	79.7
Product 1 to 2	179.6	9.1	2.61	0.37	25.4	29.3	14	2.19	85.7	87.5	64.0	95.5	64.8	85.2
Product 1 to 3	188.7	9.6	2.52	0.35	24.3	28.0	14	2.11	86.9	88.0	64.5	96.0	66.6	86.3
Product 1 to 4	199.0	10.1	2.41	0.33	23.3	26.7	13	2.02	87.7	88.3	65.0	96.4	68.0	86.8
Product 5	1764.7	89.9	0.04	0.005	1.4	0.11	1	0.03	12.3	11.7	35.0	3.6	32.0	13.2
Feed	1963.7	100	0.28	0.038	3.6	2.80	2	0.24	100	100	100	100	100	100

PROJECT NO: KM2721-03

PURPOSE: To Repeat Test 1 at pH 11.0.

PROCEDURE: Perform a standard one product rougher test.

FEED: 2 kg of SUP Composite 2010 ore ground to a nominal 142µm K_{80}.

FLOWSHEET: 1

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	1000	20				14			8.7
BULK CIRCUIT:									
Rougher 1	1100		2	4	23		1	2	11.0
Rougher 2	√		2	4	-		1	2	11.0
Rougher 3	√		2	4	8		1	2	11.0
Rougher 4	√		2	4	8		1	2	11.0

Flotation Data	Rougher	
Flotation Machine:	D2A	
Cell Size in liters:	4.4	
Aspiration:	Air	
Impeller Speed in rpm:	1100	

Grinding Data	Primary Grind
Mill:	M3-Mild
Charge/Material:	20kg-Mild
Water:	1000 ml

KM2721-03 SUP Composite 2010

Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t						Distribution - percent					
	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Bulk Ro Con 1	107.9	5.5	4.60	0.46	26.0	32.2	20	3.05	83.6	78.1	39.5	61.0	53.8	67.3
Bulk Ro Con 2	56.7	2.9	0.53	0.060	24.6	25.7	6	0.94	5.1	5.3	19.6	25.6	8.8	10.9
Bulk Ro Con 3	35.3	1.8	0.28	0.028	11.1	9.79	4	0.52	1.7	1.5	5.5	6.1	3.6	3.8
Bulk Ro Con 4	65.9	3.3	0.15	0.016	3.9	3.17	2	0.14	1.7	1.6	3.7	3.7	3.8	1.9
Bulk Ro Tail	1708.6	86.5	0.03	0.005	1.3	0.12	1	0.05	8.1	13.4	31.7	3.6	30.0	16.1
Feed	1974.4	100	0.30	0.032	3.6	2.88	2	0.25	100	100	100	100	100	100

KM2721-03 SUP Composite 2010

Cumulative Metallurgical Balance

Cumulative	Cum. Weight		Assay - percent or g/t						Distribution - percent					
Product	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Product 1	107.9	5.5	4.60	0.46	26.0	32.2	20	3.05	83.6	78.1	39.5	61.0	53.8	67.3
Product 1 to 2	164.6	8.3	3.20	0.32	25.5	30.0	15	2.32	88.6	83.4	59.1	86.7	62.6	78.2
Product 1 to 3	199.9	10.1	2.68	0.27	23.0	26.4	13	2.01	90.3	85.0	64.6	92.7	66.2	82.0
Product 1 to 4	265.8	13.5	2.05	0.21	18.3	20.6	11	1.54	91.9	86.6	68.3	96.4	70.0	83.9
Product 5	1708.6	86.5	0.03	0.005	1.3	0.12	1	0.05	8.1	13.4	31.7	3.6	30.0	16.1
Feed	1974.4	100	0.30	0.032	3.60	2.88	2	0.25	100	100	100	100	100	100

PROJECT NO: KM2721-04

PURPOSE: To Repeat Test 1 at pH 9.0.

PROCEDURE: Perform a standard one product rougher test at pH 9.0.

FEED: 2 kg of SUP Composite 2010 ore ground to a nominal 142µm K_{80}.

FLOWSHEET: 1

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	1100	20				14			8.9
BULK CIRCUIT:									
Rougher 1	35		2	4	23		1	2	9.0
Rougher 2	√		2	4	-		1	2	9.0
Rougher 3	√		2	4	8		1	2	9.0
Rougher 4	√		2	4	-		1	2	9.0

Flotation Data	Rougher	
Flotation Machine:	D2A	
Cell Size in liters:	4.4	
Aspiration:	Air	
Impeller Speed in rpm:	1100	

Grinding Data	Primary Grind
Mill:	M3-Mild
Charge/Material:	20kg-Mild
Water:	1000 ml

KM2721-04 SUP Composite 2010

Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t						Distribution - percent					
	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Bulk Ro Con 1	103.9	5.3	4.20	0.57	25.1	37.4	20	3.11	80.4	82.0	39.3	71.5	49.3	61.3
Bulk Ro Con 2	31.1	1.6	0.90	0.098	29.8	34.8	10	1.35	5.2	4.2	14.0	19.9	7.5	8.0
Bulk Ro Con 3	13.1	0.7	0.77	0.052	17.5	17.1	10	0.97	1.9	0.9	3.5	4.1	3.1	2.4
Bulk Ro Con 4	5.7	0.3	0.59	0.038	8.1	6.81	10	0.72	0.6	0.3	0.7	0.7	1.3	0.8
Bulk Ro Tail	1812.6	92.2	0.04	0.005	1.6	0.11	1	0.08	12.0	12.5	42.6	3.7	38.9	27.5
Feed	1966.4	100	0.28	0.037	3.4	2.76	2	0.27	100	100	100	100	100	100

KM2721-04 SUP Composite 2010

Cumulative Metallurgical Balance

Cumulative	Cum. Weight		Assay - percent or g/t						Distribution - percent					
Product	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Product 1	103.9	5.3	4.20	0.57	25.1	37.4	20	3.11	80.4	82.0	39.3	71.5	49.3	61.3
Product 1 to 2	135.0	6.9	3.44	0.46	26.2	36.8	18	2.70	85.5	86.2	53.3	91.4	56.8	69.3
Product 1 to 3	148.1	7.5	3.20	0.43	25.4	35.1	17	2.55	87.4	87.2	56.7	95.5	59.8	71.7
Product 1 to 4	153.8	7.8	3.11	0.41	24.8	34.0	17	2.48	88.0	87.5	57.4	96.3	61.1	72.5
Product 5	1812.6	92.2	0.04	0.005	1.6	0.11	1	0.08	12.0	12.5	42.6	3.7	38.9	27.5
Feed	1966.4	100	0.28	0.037	3.4	2.76	2	0.27	100	100	100	100	100	100

PROJECT NO: KM2721-05

PURPOSE: To Repeat Test 3 with more lime in the mill.

PROCEDURE: Perform a standard one product rougher test.

FEED: 2 kg of SUP Composite 2010 ore ground to a nominal 142µm K_{80}.

FLOWSHEET: 1

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	2800	20				14			11.1
BULK CIRCUIT:									
Rougher 1	-		2	4	23		1	2	11.0
Rougher 2	-		2	4	-		1	2	11.0
Rougher 3	-		2	4	-		1	2	11.0
Rougher 4	√		2	4	-		1	2	11.0

Flotation Data	Rougher	
Flotation Machine:	D2A	
Cell Size in liters:	4.4	
Aspiration:	Air	
Impeller Speed in rpm:	1100	

Grinding Data	Primary Grind
Mill:	M3-Mild
Charge/Material:	20kg-Mild
Water:	1000 ml

KM2721-05 SUP Composite 2010

Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t						Distribution - percent					
	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Bulk Ro Con 1	49.8	2.5	9.60	0.87	24.1	30.8	45	4.87	79.9	60.7	17.1	29.6	51.2	54.8
Bulk Ro Con 2	46.6	2.4	1.02	0.24	30.5	34.9	11	1.60	7.9	15.9	20.3	31.4	11.8	16.8
Bulk Ro Con 3	44.1	2.2	0.28	0.063	27.7	33.1	5	0.88	2.1	3.9	17.4	28.2	5.5	8.8
Bulk Ro Con 4	26.3	1.3	0.24	0.046	13.8	11.4	4	0.56	1.1	1.7	5.2	5.8	2.4	3.3
Bulk Ro Tail	1808.0	91.6	0.03	0.007	1.6	0.14	1	0.04	9.1	17.7	40.0	4.9	29.1	16.3
Feed	1974.8	100	0.30	0.036	3.5	2.62	2	0.22	100	100	100	100	100	100

KM2721-05 SUP Composite 2010

Cumulative Metallurgical Balance

Cumulative	Cum. Weight		Assay - percent or g/t						Distribution - percent					
Product	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Product 1	49.8	2.5	9.60	0.87	24.1	30.8	45	4.87	79.9	60.7	17.1	29.6	51.2	54.8
Product 1 to 2	96.4	4.9	5.45	0.57	27.2	32.8	28	3.29	87.8	76.7	37.4	61.1	63.0	71.6
Product 1 to 3	140.5	7.1	3.83	0.41	27.4	32.9	21	2.53	89.9	80.6	54.8	89.3	68.5	80.3
Product 1 to 4	166.8	8.4	3.26	0.35	25.2	29.5	18	2.22	90.9	82.3	60.0	95.1	70.9	83.7
Product 5	1808.0	91.6	0.03	0.007	1.6	0.14	1	0.04	9.1	17.7	40.0	4.9	29.1	16.3
Feed	1974.8	100	0.30	0.036	3.5	2.62	2	0.22	100	100	100	100	100	100

PROJECT NO: KM2721-06

PURPOSE: To Investigate pH 10.0.

PROCEDURE: Perform a standard one product rougher test.

FEED: 2 kg of SUP Composite 2010 ore ground to a nominal 142µm K_{80}.

FLOWSHEET: 1

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	2000	20				14			9.9
BULK CIRCUIT:									
Rougher 1	30		2	4	23		1	2	10.0
Rougher 2	√		2	4	-		1	2	10.0
Rougher 3	√		2	4	-		1	2	10.0
Rougher 4	√		2	4	8		1	2	10.0

Flotation Data	Rougher	
Flotation Machine:	D2B	
Cell Size in liters:	4.4	
Aspiration:	Air	
Impeller Speed in rpm:	1100	

Grinding Data	Primary Grind
Mill:	M4-Mild
Charge/Material:	20kg-Mild
Water:	1000 ml

KM2721-06 SUP Composite 2010

Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t						Distribution - percent					
	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Bulk Ro Con 1	76.9	3.9	5.00	0.57	34.0	40.5	29	3.17	69.5	63.4	37.6	60.0	52.2	57.1
Bulk Ro Con 2	44.5	2.3	1.72	0.23	30.0	36.4	18	2.21	13.8	14.5	19.2	31.2	18.5	23.0
Bulk Ro Con 3	16.6	0.8	1.31	0.12	14.0	17.8	15	1.41	3.9	3.0	3.3	5.7	5.7	5.5
Bulk Ro Con 4	11.3	0.6	0.58	0.052	3.7	3.00	8	0.63	1.2	0.8	0.6	0.7	2.1	1.7
Bulk Ro Tail	1816.2	92.4	0.04	0.007	1.5	0.07	1	0.03	11.5	18.3	39.2	2.5	21.5	12.8
Feed	1965.5	100	0.28	0.035	3.5	2.64	2	0.22	100	100	100	100	100	100

KM2721-06 SUP Composite 2010

Cumulative Metallurgical Balance

Cumulative	Cum. Weight		Assay - percent or g/t						Distribution - percent					
Product	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Product 1	76.9	3.9	5.00	0.57	34.0	40.5	29	3.17	69.5	63.4	37.6	60.0	52.2	57.1
Product 1 to 2	121.4	6.2	3.80	0.45	32.5	39.0	25	2.82	83.4	77.9	56.8	91.2	70.7	80.1
Product 1 to 3	138.0	7.0	3.50	0.41	30.3	36.4	23	2.65	87.3	80.9	60.2	96.8	76.4	85.6
Product 1 to 4	149.3	7.6	3.28	0.38	28.3	33.9	22	2.50	88.5	81.7	60.8	97.5	78.5	87.2
Product 5	1816.2	92.4	0.04	0.007	1.5	0.07	1	0.03	11.5	18.3	39.2	2.5	21.5	12.8
Feed	1965.5	100	0.28	0.035	3.54	2.64	2	0.22	100	100	100	100	100	100

PROJECT NO: KM2721-07

PURPOSE: To Repeat Test 5 at a Primary Grind of 179μm K_{80}.

PROCEDURE: Perform a standard one product rougher test.

FEED: 2 kg of SUP Composite 2010 ore ground to a nominal 179μm K_{80}.

FLOWSHEET: 1

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	2800	20				12			10.9
BULK CIRCUIT:									
Rougher 1			2	4			1	2	11.0
Rougher 2			2	4			1	2	11.0
Rougher 3			2	4			1	2	11.0
Rougher 4			2	4			1	4	11.0

Flotation Data	Rougher	
Flotation Machine:	D2A	
Cell Size in liters:	4.4	
Aspiration:	Air	
Impeller Speed in rpm:	1100	

Grinding Data	Primary Grind
Mill:	M3-Mild
Charge/Material:	20kg-Mild
Water:	1000 ml

KM2721-07 SUP Composite 2010

Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t						Distribution - percent					
	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Bulk Ro Con 1	42.7	2.2	10.0	0.56	26.8	34.2	40	4.99	72.2	39.3	16.6	29.0	43.8	45.3
Bulk Ro Con 2	65.3	3.3	1.26	0.21	31.3	32.6	9	1.64	13.9	22.4	29.6	42.3	15.7	22.8
Bulk Ro Con 3	49.3	2.5	0.40	0.081	19.7	21.0	7	0.83	3.3	6.6	14.1	20.6	9.2	8.7
Bulk Ro Con 4	75.4	3.8	0.16	0.026	3.8	3.07	2	0.06	2.0	3.2	4.1	4.6	4.5	1.0
Bulk Ro Tail	1735.8	88.2	0.03	0.010	1.4	0.10	1	0.06	8.5	28.5	35.7	3.6	26.9	22.2
Feed	1968.5	100	0.30	0.031	3.5	2.56	2	0.24	100	100	100	100	100	100

KM2721-07 SUP Composite 2010

Cumulative Metallurgical Balance

Cumulative	Cum. Weight		Assay - percent or g/t						Distribution - percent					
Product	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Product 1	42.7	2.2	10.0	0.56	26.8	34.2	40	4.99	72.2	39.3	16.6	29.0	43.8	45.3
Product 1 to 2	108.0	5.5	4.72	0.35	29.5	33.2	21	2.96	86.1	61.7	46.1	71.3	59.5	68.1
Product 1 to 3	157.3	8.0	3.36	0.26	26.4	29.4	17	2.29	89.4	68.3	60.2	91.9	68.7	76.9
Product 1 to 4	232.7	11.8	2.33	0.19	19.1	20.9	12	1.57	91.5	71.5	64.3	96.4	73.1	77.8
Product 5	1735.8	88.2	0.03	0.010	1.4	0.10	1	0.06	8.5	28.5	35.7	3.6	26.9	22.2
Feed	1968.5	100	0.30	0.031	3.51	2.56	2	0.24	100	100	100	100	100	100

PROJECT NO: KM2721-08

PURPOSE: To Investigate the Effect of AM28 Addition.

PROCEDURE: Perform a standard one product rougher test.

FEED: 2 kg of SUP Composite 2010 ore ground to a nominal 142µm K_{80}.

FLOWSHEET: 1

Stage	Reagents Added g/tonne						Time (minutes)			pH	Temp
	Lime	Fuel Oil	AM28	3418A	208	MIBC	Grind	Cond.	Float		°C
Primary Grind	2800	20	50				14			9.8	
		Redox									
BULK CIRCUIT:		-198									
Rougher 1	720	-83		2	4	15		1	2	11.0	21°
Rougher 2	√	-83		2	4	-		1	2	11.0	22°
Rougher 3	√	-50		2	4	-		1	2	11.0	23°
Rougher 4	√	-50		2	4	-		1	2	11.0	24°
Rougher 5	√	-46	50	2	4	-		1	2	11.0	24°

Flotation Data	Rougher
Flotation Machine:	D2A
Cell Size in liters:	4.4
Aspiration:	Air
Impeller Speed in rpm:	1100

Grinding Data	Primary Grind
Mill:	M3-Mild
Charge/Material:	20kg-Mild
Water:	1000 ml

KM2721-08 SUP Composite 2010

Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t						Distribution - percent					
	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Bulk Ro Con 1	35.6	1.8	11.1	1.10	27.8	30.8	56	6.02	71.9	57.6	14.9	22.6	24.6	54.1
Bulk Ro Con 2	31.6	1.6	2.48	0.32	24.4	27.5	33	2.17	14.3	15.0	11.6	17.9	12.9	17.3
Bulk Ro Con 3	59.6	3.0	0.30	0.051	25.9	27.6	10	1.00	3.3	4.5	23.3	33.9	7.0	15.0
Bulk Ro Con 4	41.1	2.1	0.17	0.028	14.5	16.2	8	0.58	1.3	1.7	9.0	13.7	4.0	6.0
Bulk Ro Con 5	32.6	1.7	0.11	0.013	7.3	6.06	3	0.12	0.7	0.6	3.6	4.1	1.3	1.0
Bulk Ro Tail	1761.9	89.8	0.03	0.008	1.4	0.21	2	0.02	8.7	20.7	37.5	7.8	50.2	6.7
Feed	1962.4	100	0.28	0.035	3.4	2.47	4	0.20	100	100	100	100	100	100

KM2721-08 SUP Composite 2010

Cumulative Metallurgical Balance

Cumulative	Cum. Weight		Assay - percent or g/t						Distribution - percent					
Product	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Product 1	35.6	1.8	11.1	1.10	27.8	30.8	56	6.02	71.9	57.6	14.9	22.6	24.6	54.1
Product 1 to 2	67.2	3.4	7.05	0.73	26.2	29.2	45	4.21	86.2	72.5	26.6	40.5	37.5	71.4
Product 1 to 3	126.8	6.5	3.88	0.41	26.1	28.5	28	2.70	89.4	77.0	49.9	74.4	44.5	86.4
Product 1 to 4	167.9	8.6	2.97	0.32	23.2	25.5	23	2.18	90.7	78.7	58.9	88.2	48.5	92.3
Product 1 to 5	200.5	10.2	2.50	0.27	20.6	22.3	20	1.85	91.3	79.3	62.5	92.2	49.8	93.3
Product 6	1761.9	89.8	0.03	0.008	1.4	0.21	2	0.02	8.7	20.7	37.5	7.8	50.2	6.7
Feed	1962.4	100	0.28	0.035	3.37	2.47	4	0.20	100	100	100	100	100	100

PROJECT NO: KM2721-09

PURPOSE: To Investigate the Effect of NASH Addition.

PROCEDURE: Perform a standard one product rougher test.

FEED: 2 kg of SUP Composite 2010 ore ground to a nominal 142µm K_{80}.

FLOWSHEET: 1

Stage	Reagents Added g/tonne						Time (minutes)			pH	Temp
	Lime	Fuel Oil	NASH	3418A	208	MIBC	Grind	Cond.	Float		°C
Primary Grind	2800	20	50				14			9.9	20°
		Redox									
BULK CIRCUIT:		-60									
Rougher 1	600	-55		2	4	23		1	2	11.0	20°
Rougher 2	√	-65		2	4	-		1	2	11.0	22°
Rougher 3	√	-51		2	4	-		1	2	11.0	23°
Rougher 4	√	-25		2	4	-		1	2	11.0	24°
Rougher 5	√	-240	50	2	4	-		1	2	11.0	25°

Flotation Data	Rougher
Flotation Machine:	D2A
Cell Size in liters:	4.4
Aspiration:	Air
Impeller Speed in rpm:	1100

Grinding Data	Primary Grind
Mill:	M3-Mild
Charge/Material:	20kg-Mild
Water:	1000 ml

KM2721-09 SUP Composite 2010

Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t						Distribution - percent					
	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Bulk Ro Con 1	45.5	2.3	9.10	0.71	30.3	31.8	50	4.71	72.2	43.4	20.0	28.7	47.7	53.1
Bulk Ro Con 2	22.9	1.2	3.30	0.62	23.7	27.0	26	2.60	13.2	19.1	7.9	12.3	12.7	14.8
Bulk Ro Con 3	20.9	1.1	0.82	0.31	19.7	21.7	12	1.24	3.0	8.9	6.0	9.0	5.2	6.4
Bulk Ro Con 4	21.8	1.1	0.31	0.086	11.6	11.00	6	0.47	1.2	2.5	3.7	4.8	2.8	2.5
Bulk Ro Con 5	102.6	5.2	0.12	0.017	19.4	20.7	4	0.40	2.1	2.4	28.9	42.1	9.3	10.2
Bulk Ro Tail	1756.5	89.2	0.03	0.010	1.3	0.09	1	0.03	8.3	23.7	33.5	3.2	22.3	13.0
Feed	1970.2	100	0.29	0.038	3.5	2.56	2	0.20	100	100	100	100	100	100

KM2721-09 SUP Composite 2010

Cumulative Metallurgical Balance

Cumulative	Cum. Weight		Assay - percent or g/t						Distribution - percent					
Product	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Product 1	45.5	2.3	9.10	0.71	30.3	31.8	50	4.71	72.2	43.4	20.0	28.7	47.7	53.1
Product 1 to 2	68.4	3.5	7.16	0.68	28.1	30.2	42	4.00	85.4	62.5	27.9	40.9	60.4	67.9
Product 1 to 3	89.3	4.5	5.67	0.59	26.1	28.2	35	3.35	88.4	71.4	33.9	49.9	65.6	74.3
Product 1 to 4	111.1	5.6	4.62	0.49	23.3	24.8	29	2.79	89.6	73.9	37.6	54.7	68.4	76.8
Product 1 to 5	213.7	10.8	2.46	0.26	21.4	22.8	17	1.64	91.7	76.3	66.5	96.8	77.7	87.0
Product 6	1756.5	89.2	0.03	0.010	1.3	0.09	1	0.03	8.3	23.7	33.5	3.2	22.3	13.0
Feed	1970.2	100	0.29	0.038	3.49	2.56	2	0.20	100	100	100	100	100	100

PROJECT NO: KM2721-10

PURPOSE: Preliminary Batch Cleaner Test.

PROCEDURE: Perform a standard one product cleaner test.

FEED: 2 kg of SUP Composite 2010 ore ground to a nominal 142µm K_{80}.
Bulk Regrind Discharge Size 17µm K_{80}.

FLOWSHEET: 1

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	2800	20				14			10.4
BULK CIRCUIT:									
Rougher 1	650		2	4	8		1	2	11.0
Rougher 2	√		2	4	0		1	2	11.0
Rougher 3	√		2	4	0		1	2	11.0
Rougher 4	√		2	4	8		1	2	11.0
Regrind	500	10				10			11.1
Cleaner 1	0		1	2	24		1	5	11.0
Cleaner 2	√		1	2	24		1	4	11.0
Cleaner 3	√		1	2	24		1	3	11.0

Flotation Data	Rougher	Cleaner
Flotation Machine:	D2A	D1B
Cell Size in liters:	4.4	2.2
Aspiration:	Air	
Impeller Speed in rpm:	1100	1200

Grinding Data	Primary Grind	Bulk Regrind
Mill:	M3-Mild	Stirred Mill
Charge/Material:	20kg-Mild	1.2kg-Beads
Water:	1000 ml	estimated

KM2721-10 SUP Composite 2010

Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t						Distribution - percent					
	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Bulk Concentrate	13.9	0.7	34.3	1.63	24.4	34.3	224	28.2	82.7	36.3	4.8	9.0	52.2	80.2
Bulk 3rd Cleaner Tail*	2.6	0.1	6.60	1.76	26.4	30.9	147	2.01	3.0	7.3	1.0	1.5	6.4	1.1
Bulk 2nd Cleaner Tail	11.2	0.6	1.05	0.62	18.6	19.1	24	2.01	2.0	11.1	3.0	4.1	4.6	4.6
Bulk 1st Cleaner Tail	161.9	8.2	0.13	0.086	17.5	18.0	5	0.32	3.6	22.3	40.3	55.2	12.8	10.5
Bulk Rougher Tails	1785.9	90.4	0.03	0.008	2.0	0.89	1	0.01	8.7	22.9	51.0	30.1	24.0	3.7
Feed	1975.5	100	0.29	0.032	3.6	2.67	3	0.25	100	100	100	100	100	100

* Not enough sample for gold assay. Value was estimated.

KM2721-10 SUP Composite 2010

Cumulative Metallurgical Balance

Cumulative	Cum. Weight		Assay - percent or g/t						Distribution - percent					
Product	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Product 1	13.9	0.7	34.3	1.63	24.4	34.3	224	28.2	82.7	36.3	4.8	9.0	52.2	80.2
Product 1 to 2	16.5	0.8	29.9	1.65	24.7	33.8	212	24.1	85.6	43.6	5.8	10.6	58.7	81.3
Product 1 to 3	27.7	1.4	18.3	1.23	22.2	27.8	136	15.1	87.7	54.8	8.8	14.6	63.3	85.9
Product 1 to 4	189.6	9.6	2.78	0.25	18.2	19.4	24	2.48	91.3	77.1	49.0	69.9	76.0	96.3
Product 5	1785.9	90.4	0.03	0.008	2.0	0.89	1	0.01	8.7	22.9	51.0	30.1	24.0	3.7
Feed	1975.5	100	0.29	0.032	3.6	2.67	3	0.25	100	100	100	100	100	100

PROJECT NO: KM2721-11

PURPOSE: Investigate a Primary Grind of 222μm.

PROCEDURE: Perform a standard one product rougher test.

FEED: 2 kg of SUP Composite 2010 ore ground to a nominal 222μm K_{80}.

FLOWSHEET: 1

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	2800	20				10			11.0
BULK CIRCUIT:									
Rougher 1	0		1	2	23		1	2	11.0
Rougher 2	√		1	2	-		1	2	11.0
Rougher 3	√		1	2	-		1	2	11.0
Rougher 4	√		1	2	-		1	2	11.0
Rougher 5	√		4	8	-		1	6	11.0

Flotation Data	Rougher	
Flotation Machine:	D2A	
Cell Size in liters:	4.4	
Aspiration:	Air	
Impeller Speed in rpm:	1100	

Grinding Data	Primary Grind
Mill:	M3-Mild
Charge/Material:	20kg-Mild
Water:	1000 ml

KM2721-11 SUP Composite 2010

Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t						Distribution - percent					
	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Bulk Ro Con 1	27.7	1.4	11.1	0.74	26.2	30.6	57	6.10	56.4	31.6	9.8	14.9	36.9	36.8
Bulk Ro Con 2	20.0	1.0	5.90	0.53	22.4	24.3	27	3.58	21.6	16.4	6.0	8.6	12.7	15.6
Bulk Ro Con 3	19.6	1.0	1.73	0.36	20.4	18.4	15	1.80	6.2	11.0	5.4	6.4	6.7	7.7
Bulk Ro Con 4	20.9	1.1	0.61	0.14	13.1	14.3	7	0.86	2.3	4.7	3.7	5.3	3.5	3.9
Bulk Ro Con 5	57.4	2.9	0.26	0.071	9.7	12.2	5	0.50	2.7	6.3	7.5	12.3	6.4	6.3
Bulk Ro Tail	1818.0	92.6	0.03	0.011	2.8	1.64	1	0.08	10.7	30.0	67.6	52.5	33.8	29.8
Feed	1963.6	100	0.28	0.033	3.8	2.89	2	0.23	100	100	100	100	100	100

KM2721-11 SUP Composite 2010

Cumulative Metallurgical Balance

Cumulative	Cum. Weight		Assay - percent or g/t						Distribution - percent					
Product	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Product 1	27.7	1.4	11.1	0.74	26.2	30.6	57	6.10	56.4	31.6	9.8	14.9	36.9	36.8
Product 1 to 2	47.7	2.4	8.92	0.66	24.6	28.0	45	5.04	78.0	48.1	15.8	23.5	49.5	52.4
Product 1 to 3	67.3	3.4	6.83	0.57	23.4	25.2	36	4.10	84.3	59.0	21.2	29.9	56.3	60.1
Product 1 to 4	88.2	4.5	5.35	0.47	20.9	22.6	29	3.33	86.6	63.7	24.9	35.1	59.8	63.9
Product 1 to 5	145.6	7.4	3.35	0.31	16.5	18.5	20	2.21	89.3	70.0	32.4	47.5	66.2	70.2
Product 6	1818.0	92.6	0.03	0.011	2.8	1.64	1	0.08	10.7	30.0	67.6	52.5	33.8	29.8
Feed	1963.6	100	0.28	0.033	3.8	2.89	2	0.23	100	100	100	100	100	100

PROJECT NO: KM2721-12

PURPOSE: Investigate a Primary Grind of 253μm.

PROCEDURE: Perform a standard one product rougher test.

FEED: 2 kg of SUP Composite 2010 ore ground to a nominal 253μm K_{80}.

FLOWSHEET: 1

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	2800	20				9			11.0
BULK CIRCUIT:									
Rougher 1			1	2	15		1	2	11.0
Rougher 2			1	2	-		1	2	11.0
Rougher 3			1	2	-		1	2	11.0
Rougher 4			1	2	-		1	2	11.0
Rougher 5			4	8	-		1	6	11.0

Flotation Data	Rougher	
Flotation Machine:	D2A	
Cell Size in liters:	4.4	
Aspiration:	Air	
Impeller Speed in rpm:	1100	

Grinding Data	Primary Grind
Mill:	M3-Mild
Charge/Material:	20kg-Mild
Water:	1000 ml

KM2721-12 SUP Composite 2010

Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t						Distribution - percent					
	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Bulk Ro Con 1	33.2	1.7	11.1	0.53	25.4	27.4	48	5.69	64.9	25.7	12.8	16.5	39.5	41.1
Bulk Ro Con 2	25.6	1.3	3.19	0.58	22.7	26.0	18	3.33	14.4	21.9	8.8	12.1	11.6	18.5
Bulk Ro Con 3	32.8	1.7	0.78	0.25	22.8	18.5	10	1.11	4.5	12.0	11.3	11.0	7.9	7.9
Bulk Ro Con 4	25.3	1.3	0.41	0.094	13.1	19.3	6	0.70	1.8	3.5	5.0	8.9	4.0	3.9
Bulk Ro Con 5	69.2	3.5	0.44	0.036	13.1	12.6	4	0.36	5.4	3.7	13.7	15.8	6.2	5.4
Bulk Ro Tail	1780.9	90.5	0.03	0.013	1.8	1.10	1	0.06	9.1	33.2	48.3	35.6	30.8	23.2
Feed	1967.0	100	0.29	0.035	3.4	2.80	2	0.23	100	100	100	100	100	100

KM2721-12 SUP Composite 2010

Cumulative Metallurgical Balance

Cumulative	Cum. Weight		Assay - percent or g/t						Distribution - percent					
Product	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Product 1	33.2	1.7	11.1	0.53	25.4	27.4	48	5.69	64.9	25.7	12.8	16.5	39.5	41.1
Product 1 to 2	58.8	3.0	7.66	0.55	24.2	26.8	35	4.66	79.2	47.6	21.6	28.6	51.1	59.6
Product 1 to 3	91.6	4.7	5.19	0.44	23.7	23.8	26	3.39	83.7	59.6	32.9	39.7	59.0	67.5
Product 1 to 4	116.9	5.9	4.16	0.37	21.4	22.8	22	2.81	85.6	63.1	37.9	48.5	63.0	71.4
Product 1 to 5	186.1	9.5	2.78	0.24	18.3	19.0	15	1.90	90.9	66.8	51.7	64.4	69.2	76.8
Product 6	1780.9	90.5	0.03	0.013	1.8	1.10	1	0.06	9.1	33.2	48.3	35.6	30.8	23.2
Feed	1967.0	100	0.29	0.035	3.4	2.80	2	0.23	100	100	100	100	100	100

PROJECT NO: KM2721-13

PURPOSE: To Repeat Test 5 with Less Collector.

PROCEDURE: Perform a standard one product rougher test.

FEED: 2 kg of SUP Composite 2010 ore ground to a nominal 142µm K_{80}.

FLOWSHEET: 1

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	2800	20				14			11.0
BULK CIRCUIT:									
Rougher 1	0		1	2	15		1	2	11.0
Rougher 2	√		1	2	-		1	2	11.0
Rougher 3	√		1	2	8		1	2	11.0
Rougher 4	√		1	2	-		1	2	11.0

Flotation Data	Rougher	
Flotation Machine:	D2A	
Cell Size in liters:	4.4	
Aspiration:	Air	
Impeller Speed in rpm:	1100	

Grinding Data	Primary Grind
Mill:	M3-Mild
Charge/Material:	20kg-Mild
Water:	1000 ml

KM2721-13 SUP Composite 2010

Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t						Distribution - percent					
	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Bulk Ro Con 1	29.1	1.5	12.7	0.84	28.4	30.6	72	7.11	69.0	37.5	11.4	18.0	49.7	44.5
Bulk Ro Con 2	34.2	1.7	2.54	0.53	31.5	28.3	19	2.45	16.2	28.0	14.8	19.6	15.0	18.1
Bulk Ro Con 3	57.7	2.9	0.31	0.075	31.2	26.4	6	1.05	3.3	6.6	24.7	30.8	8.6	13.1
Bulk Ro Con 4	83.7	4.3	0.14	0.027	12.6	14.5	3	0.41	2.2	3.5	14.5	24.5	5.8	7.4
Bulk Ro Tail	1761.5	89.6	0.03	0.009	1.4	0.20	1	0.04	9.2	24.3	34.6	7.1	20.9	16.9
Feed	1966.2	100	0.27	0.033	3.7	2.52	2	0.24	100	100	100	100	100	100

KM2721-13 SUP Composite 2010

Cumulative Metallurgical Balance

Cumulative	Cum. Weight		Assay - percent or g/t						Distribution - percent					
Product	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Product 1	29.1	1.5	12.7	0.84	28.4	30.6	72	7.11	69.0	37.5	11.4	18.0	49.7	44.5
Product 1 to 2	63.3	3.2	7.21	0.67	30.1	29.4	43	4.59	85.3	65.5	26.2	37.6	64.7	62.6
Product 1 to 3	121.0	6.2	3.92	0.39	30.6	27.9	26	2.91	88.6	72.2	50.9	68.3	73.3	75.6
Product 1 to 4	204.7	10.4	2.37	0.24	23.2	22.4	16	1.89	90.8	75.7	65.4	92.9	79.1	83.1
Product 5	1761.5	89.6	0.03	0.009	1.4	0.20	1	0.04	9.2	24.3	34.6	7.1	20.9	16.9
Feed	1966.2	100	0.27	0.033	3.7	2.52	2	0.24	100	100	100	100	100	100

PROJECT NO: KM2721-14

PURPOSE: To Repeat Test 7 with Less Collector.

PROCEDURE: Perform a standard one product rougher test.

FEED: 2 kg of SUP Composite 2010 ore ground to a nominal 179µm K_{80}.

FLOWSHEET: 1

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	2800	20				12			11.1
BULK CIRCUIT:									
Rougher 1	0		1	2	15		1	2	11.1
Rougher 2	0		1	2	-		1	2	11.0
Rougher 3	√		1	2	-		1	2	11.0
Rougher 4	√		1	2	-		1	4	11.0

Flotation Data	Rougher	
Flotation Machine:	D2A	
Cell Size in liters:	4.4	
Aspiration:	Air	
Impeller Speed in rpm:	1100	

Grinding Data	Primary Grind
Mill:	M3-Mild
Charge/Material:	20kg-Mild
Water:	1000 ml

KM2721-14 SUP Composite 2010

Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t						Distribution - percent					
	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Bulk Ro Con 1	35.7	1.8	10.7	0.67	28.2	29.9	50	6.08	69.3	40.4	13.4	21.8	46.5	41.5
Bulk Ro Con 2	27.6	1.4	2.87	0.49	28.9	28.2	21	2.66	14.4	22.8	10.6	15.9	14.8	14.0
Bulk Ro Con 3	56.7	2.9	0.43	0.076	33.3	22.4	7	1.08	4.4	7.2	25.2	25.9	9.5	11.7
Bulk Ro Con 4	62.9	3.2	0.17	0.025	18.1	22.7	4	0.61	1.9	2.6	15.2	29.2	6.2	7.4
Bulk Ro Tail	1778.1	90.7	0.03	0.009	1.5	0.20	1	0.07	10.0	26.9	35.6	7.2	23.0	25.4
Feed	1961.0	100	0.28	0.030	3.8	2.50	2	0.27	100	100	100	100	100	100

KM2721-14 SUP Composite 2010

Cumulative Metallurgical Balance

Cumulative	Cum. Weight		Assay - percent or g/t						Distribution - percent					
Product	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Product 1	35.7	1.8	10.7	0.67	28.2	29.9	50	6.08	69.3	40.4	13.4	21.8	46.5	41.5
Product 1 to 2	63.3	3.2	7.29	0.59	28.5	29.2	37	4.59	83.6	63.2	24.1	37.7	61.3	55.5
Product 1 to 3	120.0	6.1	4.05	0.35	30.8	26.0	23	2.93	88.1	70.4	49.2	63.6	70.9	67.2
Product 1 to 4	182.9	9.3	2.71	0.24	26.4	24.8	16	2.13	90.0	73.1	64.4	92.8	77.0	74.6
Product 5	1778.1	90.7	0.03	0.009	1.5	0.20	1	0.07	10.0	26.9	35.6	7.2	23.0	25.4
Feed	1961.0	100	0.28	0.030	3.8	2.50	2	0.27	100	100	100	100	100	100

PROJECT NO: KM2721-15

PURPOSE: To Repeat Test 11.

PROCEDURE: Perform a standard one product rougher test.

FEED: 2 kg of SUP Composite 2010 ore ground to a nominal 222µm K_{80}.

FLOWSHEET: 1

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	2800	20				10			11.0
BULK CIRCUIT:									
Rougher 1	0		1	2	15		1	2	11.0
Rougher 2	√		1	2	-		1	2	11.0
Rougher 3	√		1	2	-		1	2	11.0
Rougher 4	√		1	2	8		1	2	11.0
Rougher 5	√		4	8	-		1	6	11.0

Flotation Data	Rougher	
Flotation Machine:	D2A	
Cell Size in liters:	4.4	
Aspiration:	Air	
Impeller Speed in rpm:	1100	

Grinding Data	Primary Grind
Mill:	M3-Mild
Charge/Material:	20kg-Mild
Water:	1000 ml

KM2721-15 SUP Composite 2010

Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t						Distribution - percent					
	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Bulk Ro Con 1	36.1	1.8	9.60	0.61	30.2	32.1	54	5.91	63.7	32.9	14.9	23.7	44.4	40.0
Bulk Ro Con 2	55.2	2.8	1.81	0.25	31.7	36.5	14	2.88	18.4	20.9	23.9	41.2	18.2	29.8
Bulk Ro Con 3	37.1	1.9	0.57	0.086	28.8	19.3	9	1.13	3.9	4.8	14.6	14.7	7.6	7.9
Bulk Ro Con 4	28.6	1.5	0.33	0.045	18.3	14.0	8	0.76	1.7	1.9	7.1	8.2	5.2	4.1
Bulk Ro Con 5	64.6	3.3	0.21	0.030	6.4	5.87	3	0.31	2.5	2.9	5.6	7.8	4.7	3.8
Bulk Ro Tail	1735.6	88.7	0.03	0.014	1.4	0.13	1	0.04	9.9	36.6	33.9	4.4	19.9	14.5
Feed	1957.2	100	0.28	0.034	3.7	2.50	2	0.27	100	100	100	100	100	100

KM2721-15 SUP Composite 2010

Cumulative Metallurgical Balance

Cumulative	Cum. Weight		Assay - percent or g/t						Distribution - percent					
Product	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Product 1	36.1	1.8	9.60	0.61	30.2	32.1	54	5.91	63.7	32.9	14.9	23.7	44.4	40.0
Product 1 to 2	91.3	4.7	4.89	0.39	31.1	34.8	30	4.08	82.0	53.8	38.8	65.0	62.6	69.8
Product 1 to 3	128.4	6.6	3.64	0.30	30.4	30.3	24	3.23	85.9	58.6	53.3	79.6	70.2	77.6
Product 1 to 4	157.0	8.0	3.04	0.26	28.2	27.3	21	2.78	87.6	60.5	60.5	87.8	75.4	81.7
Product 1 to 5	221.6	11.3	2.21	0.19	21.9	21.1	16	2.06	90.1	63.4	66.1	95.6	80.1	85.5
Product 6	1735.6	88.7	0.03	0.014	1.4	0.13	1	0.04	9.9	36.6	33.9	4.4	19.9	14.5
Feed	1957.2	100	0.28	0.034	3.7	2.50	2	0.27	100	100	100	100	100	100

PROJECT NO: KM2721-16

PURPOSE: To Repeat Test 12.

PROCEDURE: Perform a standard one product rougher test.

FEED: 2 kg of SUP Composite 2010 ore ground to a nominal 253µm K_{80}.

FLOWSHEET: 1

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	2800	20				9			11.1
BULK CIRCUIT:									
Rougher 1	0		1	2	15		1	2	11.1
Rougher 2	0		1	2	-		1	2	11.0
Rougher 3	√		1	2	8		1	2	11.0
Rougher 4	√		1	2	-		1	2	11.0
Rougher 5	√		4	8	-		1	6	11.0

Flotation Data	Rougher	
Flotation Machine:	D2A	
Cell Size in liters:	4.4	
Aspiration:	Air	
Impeller Speed in rpm:	1100	

Grinding Data	Primary Grind
Mill:	M3-Mild
Charge/Material:	20kg-Mild
Water:	1000 ml

KM2721-16 SUP Composite 2010

Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t						Distribution - percent					
	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Bulk Ro Con 1	40.5	2.1	10.1	0.78	28.2	29.8	42	5.31	70.3	50.4	16.0	24.9	46.3	48.4
Bulk Ro Con 2	42.5	2.2	1.60	0.24	26.7	31.0	12	1.68	11.7	16.3	15.9	27.2	14.1	16.1
Bulk Ro Con 3	41.6	2.1	0.49	0.057	29.3	24.2	5	0.98	3.5	3.8	17.1	20.8	5.4	9.2
Bulk Ro Con 4	37.4	1.9	0.31	0.035	20.5	22.9	5	0.66	2.0	2.1	10.7	17.7	5.3	5.6
Bulk Ro Con 5	93.7	4.8	0.18	0.020	4.4	3.17	2	0.17	2.9	3.0	5.7	6.1	5.8	3.7
Bulk Ro Tail	1705.5	87.0	0.03	0.009	1.5	0.09	1	0.04	9.7	24.5	34.6	3.2	23.1	17.1
Feed	1961.2	100	0.30	0.032	3.6	2.47	2	0.23	100	100	100	100	100	100

KM2721-16 SUP Composite 2010

Cumulative Metallurgical Balance

Cumulative	Cum. Weight		Assay - percent or g/t						Distribution - percent					
Product	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Product 1	40.5	2.1	10.1	0.78	28.2	29.8	42	5.31	70.3	50.4	16.0	24.9	46.3	48.4
Product 1 to 2	83.0	4.2	5.75	0.50	27.4	30.4	27	3.45	81.9	66.7	31.9	52.2	60.4	64.5
Product 1 to 3	124.6	6.4	3.99	0.35	28.1	28.3	19	2.63	85.4	70.4	48.9	73.0	65.8	73.7
Product 1 to 4	162.0	8.3	3.14	0.28	26.3	27.1	16	2.17	87.4	72.5	59.7	90.6	71.1	79.2
Product 1 to 5	255.7	13.0	2.06	0.19	18.3	18.3	11	1.44	90.3	75.5	65.4	96.8	76.9	82.9
Product 6	1705.5	87.0	0.03	0.009	1.5	0.09	1	0.04	9.7	24.5	34.6	3.2	23.1	17.1
Feed	1961.2	100	0.30	0.032	3.6	2.47	2	0.23	100	100	100	100	100	100

PROJECT NO: KM2721-17

PURPOSE: To Investigate a Primary Grind Size of 253μm K_{80} at pH 9.0.

PROCEDURE: Perform a standard one product rougher test.

FEED: 2 kg of SUP Composite 2010 ore ground to a nominal 253μm K_{80}.

FLOWSHEET: 1

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	1100	20				9			9.0
BULK CIRCUIT:									
Rougher 1	0		1	2	23		1	2	9.0
Rougher 2	√		1	2	-		1	2	9.0
Rougher 3	√		1	2	-		1	2	9.0
Rougher 4	√		1	2	-		1	2	9.0

Flotation Data	Rougher	
Flotation Machine:	D2A	
Cell Size in liters:	4.4	
Aspiration:	Air	
Impeller Speed in rpm:	1100	

Grinding Data	Primary Grind
Mill:	M3-Mild
Charge/Material:	20kg-Mild
Water:	1000 ml

KM2721-17 SUP Composite 2010

Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t						Distribution - percent					
	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Bulk Ro Con 1	26.3	1.3	9.20	1.36	30.2	33.2	42	5.93	45.8	57.7	11.3	17.5	27.2	35.3
Bulk Ro Con 2	80.4	4.1	2.01	0.13	34.9	35.5	12	1.88	30.6	17.3	39.9	57.2	22.6	34.2
Bulk Ro Con 3	31.3	1.6	0.90	0.059	21.6	21.1	9	1.10	5.3	3.0	9.6	13.2	6.5	7.8
Bulk Ro Con 4	39.7	2.0	0.47	0.029	4.1	4.39	5	0.52	3.5	1.9	2.3	3.5	4.5	4.6
Bulk Ro Tail	1783.2	90.9	0.04	0.007	1.5	0.24	1	0.05	14.8	20.2	36.8	8.6	39.2	18.2
Feed	1960.9	100	0.27	0.032	3.6	2.54	2	0.23	100	100	100	100	100	100

KM2721-17 SUP Composite 2010

Cumulative Metallurgical Balance

Cumulative	Cum. Weight		Assay - percent or g/t						Distribution - percent					
Product	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Product 1	26.3	1.3	9.20	1.36	30.2	33.2	42	5.93	45.8	57.7	11.3	17.5	27.2	35.3
Product 1 to 2	106.7	5.4	3.78	0.44	33.7	34.9	19	2.88	76.3	75.0	51.2	74.7	49.8	69.4
Product 1 to 3	138.0	7.0	3.13	0.35	31.0	31.8	17	2.47	81.6	78.0	60.9	87.9	56.3	77.2
Product 1 to 4	177.7	9.1	2.53	0.28	25.0	25.7	14	2.04	85.2	79.8	63.2	91.4	60.8	81.8
Product 5	1783.2	90.9	0.04	0.007	1.5	0.24	1	0.05	14.8	20.2	36.8	8.6	39.2	18.2
Feed	1960.9	100	0.27	0.032	3.6	2.54	2	0.23	100	100	100	100	100	100

PROJECT NO: KM2721-18

PURPOSE: To Investigate a Primary Grind Size of 253μm K_{80} at pH 10.0.

PROCEDURE: Perform a standard one product rougher test.

FEED: 2 kg of SUP Composite 2010 ore ground to a nominal 253μm K_{80}.

FLOWSHEET: 1

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	2050	20				9			10.2
BULK CIRCUIT:									
Rougher 1	0		1	2	23		1	2	10.1
Rougher 2	0		1	2	√		1	2	10.1
Rougher 3	0		1	2	√		1	2	10.0
Rougher 4	0		1	2	√		1	2	10.0

Flotation Data	Rougher	
Flotation Machine:	D2A	
Cell Size in liters:	4.4	
Aspiration:	Air	
Impeller Speed in rpm:	1100	

Grinding Data	Primary Grind
Mill:	M3-Mild
Charge/Material:	20kg-Mild
Water:	1000 ml

KM2721-18 SUP Composite 2010

Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t						Distribution - percent					
	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Bulk Ro Con 1	51.2	2.6	6.20	0.60	32.1	34.8	33	3.79	56.2	45.0	23.0	34.4	36.5	48.1
Bulk Ro Con 2	56.0	2.8	1.99	0.21	32.1	34.7	15	1.69	19.7	17.1	25.2	37.6	18.2	23.4
Bulk Ro Con 3	49.1	2.5	0.77	0.074	18.4	19.7	9	0.98	6.7	5.3	12.6	18.7	9.8	11.9
Bulk Ro Con 4	74.0	3.8	0.25	0.020	3.1	2.74	3	0.20	3.3	2.2	3.2	3.9	5.2	3.6
Bulk Ro Tail	1736.0	88.3	0.05	0.012	1.5	0.16	1	0.03	14.1	30.4	36.0	5.4	30.3	12.9
Feed	1966.3	100	0.29	0.035	3.6	2.63	2	0.21	100	100	100	100	100	100

KM2721-18 SUP Composite 2010

Cumulative Metallurgical Balance

Cumulative	Cum. Weight		Assay - percent or g/t						Distribution - percent					
Product	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Product 1	51.2	2.6	6.20	0.60	32.1	34.8	33	3.79	56.2	45.0	23.0	34.4	36.5	48.1
Product 1 to 2	107.2	5.5	4.00	0.40	32.1	34.7	23	2.69	75.9	62.2	48.2	72.0	54.8	71.5
Product 1 to 3	156.3	7.9	2.99	0.30	27.8	30.0	19	2.15	82.6	67.5	60.8	90.7	64.5	83.4
Product 1 to 4	230.3	11.7	2.11	0.21	19.9	21.3	14	1.53	85.9	69.6	64.0	94.6	69.7	87.1
Product 5	1736.0	88.3	0.05	0.012	1.5	0.16	1	0.03	14.1	30.4	36.0	5.4	30.3	12.9
Feed	1966.3	100	0.29	0.035	3.6	2.63	2	0.21	100	100	100	100	100	100

PROJECT NO: KM2721-19

PURPOSE: To Repeat Test 10 at a Coarse Primary Grind.

PROCEDURE: Perform a standard one product cleaner test.

FEED: 2 kg of SUP Composite 2010 ore ground to a nominal 222µm K_{80}.
Bulk Regrind Discharge Size 17µm K_{80}.

FLOWSHEET: 1

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	2800	20				10			11.1
BULK CIRCUIT:									
Rougher 1	0		1	2	15		1	2	11.1
Rougher 2	0		1	2	-		1	2	11.0
Rougher 3	√		1	2	-		1	2	11.0
Rougher 4	√		1	2	8		1	2	11.0
Regrind	500	20				10			11.4
Cleaner 1	0		2	4	24		1	5	11.0
Cleaner 2	√	10	1	2	24		1	4	11.0
Cleaner 3	√	10	1	2	24		1	3	11.0

Flotation Data	Rougher	Cleaner
Flotation Machine:	D2A	D1B
Cell Size in liters:	4.4	2.2
Aspiration:	Air	
Impeller Speed in rpm:	1100	1200

Grinding Data	Primary Grind	Bulk Regrind
Mill:	M3-Mild	Stirred Mill
Charge/Material:	20kg-Mild	1.2kg-Beads
Water:	1000 ml	estimated

KM2721-19 SUP Composite 2010

Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t						Distribution - percent					
	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Bulk Concentrate	13.5	0.7	33.9	2.08	24.5	33.8	164	20.7	81.4	40.0	4.8	8.7	55.3	58.7
Bulk 3rd Cleaner Tail*	2.3	0.1	2.68	1.40	24.6	29.6	33	1.01	1.1	4.6	0.8	1.3	1.9	0.5
Bulk 2nd Cleaner Tail	13.7	0.7	0.59	0.34	22.4	25.2	10	1.01	1.4	6.6	4.5	6.6	3.4	2.9
Bulk 1st Cleaner Tail	147.4	7.5	0.21	0.062	22.8	26.1	3	0.50	5.5	13.0	49.1	73.1	12.5	15.4
Bulk Rougher Tails	1790.0	91.0	0.03	0.014	1.6	0.30	1	0.06	10.5	35.7	40.8	10.3	26.8	22.5
Feed	1966.9	100	0.29	0.036	3.5	2.67	2	0.24	100	100	100	100	100	100

* Not enough sample for gold assay. Value was estimated.

KM2721-19 SUP Composite 2010

Cumulative Metallurgical Balance

Cumulative Product	Cum. Weight		Assay - percent or g/t						Distribution - percent					
	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Product 1	13.5	0.7	33.9	2.08	24.5	33.8	164	20.7	81.4	40.0	4.8	8.7	55.3	58.7
Product 1 to 2	15.8	0.8	29.3	1.98	24.5	33.2	145	17.8	82.5	44.6	5.7	10.0	57.2	59.2
Product 1 to 3	29.5	1.5	16.0	1.22	23.5	29.5	82	10.0	84.0	51.2	10.1	16.5	60.6	62.1
Product 1 to 4	176.9	9.0	2.84	0.25	22.9	26.7	17	2.08	89.5	64.3	59.2	89.7	73.2	77.5
Product 5	1790.0	91.0	0.03	0.014	1.6	0.30	1	0.06	10.5	35.7	40.8	10.3	26.8	22.5
Feed	1966.9	100	0.29	0.036	3.5	2.67	2	0.24	100	100	100	100	100	100

PROJECT NO: KM2721-20

PURPOSE: To Repeat Test 19 with More Mass Pull.

PROCEDURE: Perform a standard one product cleaner test.

FEED: 2 kg of SUP Composite 2010 ore ground to a nominal 222µm K_{80}.
Bulk Regrind Discharge Size 22µm K_{80}.

FLOWSHEET: 2

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	2800	20				10			11.1
BULK CIRCUIT:									
Rougher 1	0		2	4	15		1	2	11.1
Rougher 2	0		2	4	-		1	2	11.0
Rougher 3	√		2	4	-		1	2	11.0
Rougher 4	√		2	4	8		1	2	11.0
Regrind	500	20				10			11.3
Cleaner 1	0		1	2	24		1	5	11.0
Cleaner 2	√	10	1	2	24		1	4	11.0
Cleaner 3	√	10	1	2	24		1	3	11.0

Flotation Data	Rougher	Cleaner
Flotation Machine:	D2A	D1B
Cell Size in liters:	4.4	2.2
Aspiration:	Air	
Impeller Speed in rpm:	1100	1200

Grinding Data	Primary Grind	Bulk Regrind
Mill:	M3-Mild	Stirred Mill
Charge/Material:	20kg-Mild	1.2kg-Beads
Water:	1000 ml	estimated

KM2721-20 SUP Composite 2010

Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t						Distribution - percent					
	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Bulk Concentrate	15.2	0.8	31.3	2.24	25.5	35.5	165	20.1	84.0	52.3	5.7	10.4	57.0	75.5
Bulk 3rd Cleaner Tail*	1.7	0.1	1.73	0.49	20.7	23.7	8	0.95	0.5	1.3	0.5	0.8	0.3	0.4
Bulk 2nd Cleaner Tail	17.5	0.9	0.36	0.20	16.4	18.0	8	0.95	1.1	5.4	4.2	6.1	3.1	4.1
Bulk 1st Cleaner Tail	215.9	11.0	0.14	0.052	17.8	18.8	3	0.26	5.3	17.3	56.7	78.3	16.2	13.7
Bulk Rougher Tails	1715.1	87.3	0.03	0.009	1.3	0.14	1	0.01	9.1	23.7	32.9	4.5	23.4	6.3
Feed	1965.4	100	0.29	0.033	3.5	2.64	2	0.21	100	100	100	100	100	100

* Not enough sample for gold and silver assay. Value was estimated.

KM2721-20 SUP Composite 2010

Cumulative Metallurgical Balance

Cumulative Product	Cum. Weight		Assay - percent or g/t						Distribution - percent					
	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Product 1	15.2	0.8	31.3	2.24	25.5	35.5	165	20.1	84.0	52.3	5.7	10.4	57.0	75.5
Product 1 to 2	16.9	0.9	28.3	2.06	25.0	34.3	149	18.2	84.5	53.6	6.2	11.2	57.3	75.9
Product 1 to 3	34.4	1.8	14.1	1.12	20.6	26.0	77	9.43	85.6	59.0	10.5	17.3	60.4	80.0
Product 1 to 4	250.3	12.7	2.06	0.20	18.2	19.8	13	1.52	90.9	76.3	67.1	95.5	76.6	93.7
Product 5	1715.1	87.3	0.03	0.009	1.3	0.14	1	0.01	9.1	23.7	32.9	4.5	23.4	6.3
Feed	1965.4	100	0.29	0.033	3.5	2.64	2	0.21	100	100	100	100	100	100

PROJECT NO: KM2721-21

PURPOSE: To Investigate PAX as the Primary Collector.

PROCEDURE: Perform a standard one product cleaner test.

FEED: 2 kg of SUP Composite 2010 ore ground to a nominal 222µm K_{80}.
Bulk Regrind Discharge Size 20µm K_{80}.

FLOWSHEET: 2

Stage	Reagents Added g/tonne				Time (minutes)			pH
	Lime	Fuel Oil	PAX	MIBC	Grind	Cond.	Float	
Primary Grind	2800	20			10			11.1
BULK CIRCUIT:								
Rougher 1	0		1	15		1	2	11.1
Rougher 2	0		1	-		1	2	11.0
Rougher 3	√		1	8		1	2	11.0
Rougher 4	√		1	8		1	2	11.0
Regrind	500	20			10			11.3
Cleaner 1	0		1	24		1	5	11.0
Cleaner 2	√	10	1	24		1	4	11.0
Cleaner 3	√	10	1	24		1	3	11.0

Grinding Data	Primary Grind	Bulk Regrind
Mill:	M3-Mild	Stirred Mill
Charge/Material:	20kg-Mild	1.2kg-Beads
Water:	1000 ml	estimated

Flotation Data	Rougher	Cleaner
Flotation Machine:	D2A	D1B
Cell Size in liters:	4.4	2.2
Aspiration:	Air	
Impeller Speed in rpm:	1100	1200

KM2721-21 SUP Composite 2010

Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t						Distribution - percent					
	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Bulk Concentrate	13.9	0.7	31.9	1.68	26.3	36.5	187	18.9	80.5	37.4	5.2	9.5	61.8	75.7
Bulk 3rd Cleaner Tail*	1.6	0.1	2.86	1.13	22.7	27.7	30	1.20	0.8	2.9	0.5	0.8	1.2	0.6
Bulk 2nd Cleaner Tail	9.3	0.5	0.61	0.36	16.0	18.8	10	1.20	1.0	5.4	2.1	3.3	2.3	3.2
Bulk 1st Cleaner Tail	195.3	9.9	0.21	0.093	19.4	22.7	4	0.32	7.4	29.1	53.7	83.0	18.1	18.0
Bulk Rougher Tails	1748.4	88.8	0.03	0.009	1.6	0.11	0.4	0.01	10.2	25.2	38.4	3.4	16.6	2.5
Feed	1968.5	100	0.28	0.032	3.6	2.71	2	0.18	100	100	100	100	100	100

* Not enough sample for gold assay. Value was estimated.

KM2721-21 SUP Composite 2010

Cumulative Metallurgical Balance

Cumulative Product	Cum. Weight		Assay - percent or g/t						Distribution - percent					
	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Product 1	13.9	0.7	31.9	1.68	26.3	36.5	187	18.9	80.5	37.4	5.2	9.5	61.8	75.7
Product 1 to 2	15.5	0.8	28.9	1.62	25.9	35.6	171	17.1	81.4	40.3	5.7	10.3	63.0	76.3
Product 1 to 3	24.8	1.3	18.3	1.15	22.2	29.3	111	11.1	82.4	45.7	7.8	13.6	65.3	79.5
Product 1 to 4	220.1	11.2	2.25	0.21	19.7	23.4	16	1.54	89.8	74.8	61.6	96.6	83.4	97.5
Product 5	1748.4	88.8	0.03	0.009	1.6	0.11	0.4	0.01	10.2	25.2	38.4	3.4	16.6	2.5
Feed	1968.5	100	0.28	0.032	3.6	2.71	2	0.18	100	100	100	100	100	100

PROJECT NO: KM2721-22

PURPOSE: To Repeat Test 21 with More Collector in the Cleaner.

PROCEDURE: Perform a standard one product cleaner test.

FEED: 2 kg of SUP Composite 2010 ore ground to a nominal 222µm K_{80}.
Bulk Regrind Discharge Size 23µm K_{80}.

FLOWSHEET: 2

Stage	Reagents Added g/tonne				Time (minutes)			pH
	Lime	Fuel Oil	PAX	MIBC	Grind	Cond.	Float	
Primary Grind	2800	20			10			11.0
BULK CIRCUIT:								
Rougher 1	0		1	15		1	2	11.0
Rougher 2	√		1	-		1	2	11.0
Rougher 3	√		1	8		1	2	11.0
Rougher 4	√		1	-		1	2	11.0
Regrind	500	20			10			11.3
Cleaner 1	-		3	15		1	5	11.3
Cleaner 2	√	10	1	15		1	3	11.0
Cleaner 3	√	10	1	15		1	3	11.0

Grinding Data	Primary Grind	Bulk Regrind
Mill:	M3-Mild	Stirred Mill
Charge/Material:	20kg-Mild	1.2kg-Beads
Water:	1000 ml	estimated

Flotation Data	Rougher	Cleaner
Flotation Machine:	D2A	D1B
Cell Size in liters:	4.4	2.2
Aspiration:	Air	
Impeller Speed in rpm:	1100	1200

KM2721-22 SUP Composite 2010

Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t						Distribution - percent					
	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Bulk Concentrate	19.0	1.0	24.7	2.43	30.5	37.2	136	15.0	82.5	62.3	7.8	13.7	58.7	58.3
Bulk 3rd Cleaner Tail*	2.9	0.1	0.98	0.24	18.8	19.0	20	0.92	0.5	0.9	0.7	1.1	1.3	0.5
Bulk 2nd Cleaner Tail	18.9	1.0	0.33	0.12	15.9	15.8	7	0.92	1.1	3.1	4.1	5.8	3.0	3.6
Bulk 1st Cleaner Tail	222.4	11.3	0.10	0.020	17.0	17.5	3	0.29	3.9	6.0	51.2	75.2	13.6	13.2
Bulk Rougher Tails	1709.7	86.7	0.04	0.012	1.6	0.13	1	0.07	12.0	27.7	36.1	4.3	23.3	24.5
Feed	1972.9	100	0.29	0.038	3.7	2.62	2	0.25	100	100	100	100	100	100

* Not enough sample for gold assay. Value was estimated.

KM2721-22 SUP Composite 2010

Cumulative Metallurgical Balance

Cumulative	Cum. Weight		Assay - percent or g/t						Distribution - percent					
Product	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Product 1	19.0	1.0	24.7	2.43	30.5	37.2	136	15.0	82.5	62.3	7.8	13.7	58.7	58.3
Product 1 to 2	21.9	1.1	21.6	2.14	29.0	34.8	121	13.1	83.0	63.2	8.6	14.7	60.0	58.8
Product 1 to 3	40.8	2.1	11.7	1.20	22.9	26.0	68	7.48	84.1	66.3	12.7	20.5	63.1	62.4
Product 1 to 4	263.2	13.3	1.90	0.20	17.9	18.8	13	1.40	88.0	72.3	63.9	95.7	76.7	75.5
Product 5	1709.7	86.7	0.04	0.012	1.6	0.13	1	0.07	12.0	27.7	36.1	4.3	23.3	24.5
Feed	1972.9	100	0.29	0.038	3.7	2.62	2	0.25	100	100	100	100	100	100

PROJECT NO: KM2721-23

PURPOSE: To Repeat Test 22.

PROCEDURE: Perform a standard one product cleaner test.

FEED: 2 kg of SUP Composite 2010 ore ground to a nominal 222µm K_{80}.
Bulk Regrind Discharge Size 24µm K_{80}.

FLOWSHEET: 2

Stage	Reagents Added g/tonne				Time (minutes)			pH
	Lime	Fuel Oil	PAX	MIBC	Grind	Cond.	Float	
Primary Grind	2800	20			10			10.7
BULK CIRCUIT:								
Rougher 1	200		1	15		1	2	11.0
Rougher 2	-		1	-		1	2	11.0
Rougher 3	√		1	8		1	2	11.0
Rougher 4	√		1	-		1	2	11.0
Regrind	500	20			10			11.2
Cleaner 1	-	-	3	15		1	5	11.2
Cleaner 2	√	10	1	15		1	4	11.0
Cleaner 3	√	10	1	15		1	3	11.0

Grinding Data	Primary Grind	Bulk Regrind
Mill:	M3-Mild	Stirred Mill
Charge/Material:	20kg-Mild	1.2kg-Beads
Water:	1000 ml	estimated

Flotation Data	Rougher	Cleaner
Flotation Machine:	D2A	D1B
Cell Size in liters:	4.4	2.2
Aspiration:	Air	
Impeller Speed in rpm:	1100	1200

KM2721-23 SUP Composite 2010

Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t						Distribution - percent					
	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Bulk Concentrate	17.9	0.9	25.4	1.60	27.5	36.2	154	13.2	80.5	39.4	6.8	12.6	64.6	56.8
Bulk 3rd Cleaner Tail*	4.0	0.2	2.08	1.15	22.2	23.8	28	1.46	1.5	6.3	1.2	1.9	2.7	1.4
Bulk 2nd Cleaner Tail	22.9	1.2	0.52	0.31	17.7	18.6	8	1.46	2.1	9.9	5.6	8.3	4.5	8.0
Bulk 1st Cleaner Tail	184.5	9.4	0.15	0.072	20.0	20.3	3	0.48	4.9	18.3	51.1	72.9	12.1	21.3
Bulk Rougher Tails	1723.9	88.3	0.04	0.011	1.5	0.13	0.4	0.03	11.0	26.1	35.3	4.3	16.2	12.4
Feed	1953.2	100	0.29	0.037	3.7	2.63	2	0.21	100	100	100	100	100	100

* Not enough sample for gold assay. Value was estimated.

KM2721-23 SUP Composite 2010

Cumulative Metallurgical Balance

Cumulative	Cum. Weight		Assay - percent or g/t						Distribution - percent					
Product	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Product 1	17.9	0.9	25.4	1.60	27.5	36.2	154	13.2	80.5	39.4	6.8	12.6	64.6	56.8
Product 1 to 2	21.9	1.1	21.1	1.52	26.5	33.9	131	11.0	82.0	45.7	8.0	14.5	67.2	58.2
Product 1 to 3	44.8	2.3	10.6	0.90	22.0	26.1	68	6.15	84.1	55.6	13.6	22.8	71.7	66.3
Product 1 to 4	229.3	11.7	2.19	0.23	20.4	21.4	16	1.59	89.0	73.9	64.7	95.7	83.8	87.6
Product 5	1723.9	88.3	0.04	0.011	1.5	0.13	0.4	0.03	11.0	26.1	35.3	4.3	16.2	12.4
Feed	1953.2	100	0.29	0.037	3.7	2.63	2	0.21	100	100	100	100	100	100

PROJECT NO: KM2721-24

PURPOSE: To Investigate a Coarse Regrind.

PROCEDURE: Perform a standard one product cleaner test.

FEED: 2 kg of SUP Composite 2010 ore ground to a nominal 222µm K_{80}.
Bulk Regrind Discharge Size 33µm K_{80}.

FLOWSHEET: 2

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	2800	20				10			11.2
BULK CIRCUIT:									
Rougher 1	0		1	2	15		1	2	11.2
Rougher 2	0		1	2	-		1	2	11.1
Rougher 3	0		1	2	-		1	2	11.0
Rougher 4	√		1	2	-		1	2	11.0
Regrind	500	20				5			11.5
Cleaner 1	0		1	2	24		1	5	11.3
Cleaner 2	√	10	1	2	24		1	4	11.0
Cleaner 3	√	10	1	2	24		1	3	11.0

Grinding Data	Primary Grind	Bulk Regrind
Mill:	M3-Mild	Stirred Mill
Charge/Material:	20kg-Mild	1.2kg-Beads
Water:	1000 ml	estimated

Flotation Data	Rougher	Cleaner
Flotation Machine:	D2A	D1E
Cell Size in liters:	4.4	2.2
Aspiration:	Air	
Impeller Speed in rpm:	1100	1200

KM2721-24 SUP Composite 2010

Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t						Distribution - percent					
	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Bulk Concentrate	17.9	0.9	25.8	1.64	29.7	38.2	140	14.2	80.7	40.4	7.4	13.2	55.4	53.9
Bulk 3rd Cleaner Tail*	2.4	0.1	4.31	1.62	29.6	33.8	15	2.08	1.8	5.3	1.0	1.6	0.8	1.1
Bulk 2nd Cleaner Tail	12.1	0.6	0.89	0.346	18.0	18.7	15	2.08	1.9	5.8	3.1	4.4	4.0	5.3
Bulk 1st Cleaner Tail	188.0	9.5	0.13	0.057	19.6	20.6	4.0	0.43	4.3	14.7	51.6	74.6	16.6	17.3
Bulk Rougher Tails	1756.1	88.8	0.04	0.014	1.5	0.19	1	0.06	11.4	33.8	36.9	6.3	23.3	22.5
Feed	1976.5	100	0.29	0.037	3.6	2.63	2.3	0.24	100	100	100	100	100	100

* Not enough sample for Au and Ag assays. Values were estimated.

KM2721-24 SUP Composite 2010

Cumulative Metallurgical Balance

Cumulative Product	Cum. Weight		Assay - percent or g/t						Distribution - percent					
	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Product 1	17.9	0.9	25.8	1.64	29.7	38.2	140	14.2	80.7	40.4	7.4	13.2	55.4	53.9
Product 1 to 2	20.3	1.0	23.3	1.64	29.7	37.7	125	12.8	82.5	45.7	8.4	14.7	56.2	54.9
Product 1 to 3	32.4	1.6	14.9	1.16	25.3	30.6	84	8.78	84.4	51.5	11.5	19.1	60.1	60.3
Product 1 to 4	220.4	11.2	2.30	0.218	20.4	22.1	16	1.66	88.6	66.2	63.1	93.7	76.7	77.5
Product 5	1756.1	88.8	0.04	0.014	1.5	0.19	1	0.06	11.4	33.8	36.9	6.3	23.3	22.5
Feed	1976.5	100	0.29	0.037	3.6	2.63	2.3	0.24	100	100	100	100	100	100

PROJECT NO: KM2721-25

PURPOSE: To Investigate a Finer Regrind.

PROCEDURE: Perform a standard one product cleaner test.

FEED: 2 kg of SUP Composite 2010 ore ground to a nominal 222µm K_{80}.
Bulk Regrind Discharge Size 18µm K_{80}.

FLOWSHEET: 2

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	2800	20				10			11.2
BULK CIRCUIT:									
Rougher 1	0		1	2	15		1	2	11.2
Rougher 2	0		1	2	-		1	2	11.1
Rougher 3	0		1	2	-		1	2	11.0
Rougher 4	√		1	2	-		1	2	11.0
Regrind	500	20				15			11.4
Cleaner 1	0		2	4	24		1	5	11.0
Cleaner 2	√	10	1	2	24		1	4	11.0
Cleaner 3	√	10	1	2	24		1	3	11.0

Grinding Data	Primary Grind	Bulk Regrind
Mill:	M3-Mild	Stirred Mill
Charge/Material:	20kg-Mild	1.2kg-Beads
Water:	1000 ml	estimated

Flotation Data	Rougher	Cleaner
Flotation Machine:	D2A	D1E
Cell Size in liters:	4.4	2.2
Aspiration:	Air	
Impeller Speed in rpm:	1100	1200

KM2721-25 SUP Composite 2010

Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t						Distribution - percent					
	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Bulk Concentrate	15.5	0.8	29.9	1.45	27.3	35.2	164	18.0	80.6	33.5	6.1	10.2	56.8	54.6
Bulk 3rd Cleaner Tail*	2.0	0.1	2.69	1.20	23.7	29.7	12	1.60	0.9	3.6	0.7	1.1	0.5	0.6
Bulk 2nd Cleaner Tail	12.2	0.6	0.72	0.41	19.7	22.3	12	1.60	1.5	7.4	3.4	5.1	3.1	3.8
Bulk 1st Cleaner Tail	180.7	9.2	0.18	0.090	20.9	22.6	4	0.44	5.7	24.3	54.2	76.7	16.1	15.6
Bulk Rougher Tails	1746.3	89.2	0.04	0.012	1.4	0.21	1	0.07	11.2	31.2	35.6	6.8	23.4	25.4
Feed	1956.7	100	0.29	0.034	3.6	2.72	2	0.26	100	100	100	100	100	100

* Not enough sample for gold assay. Value was estimated.

KM2721-25 SUP Composite 2010

Cumulative Metallurgical Balance

Cumulative	Cum. Weight		Assay - percent or g/t						Distribution - percent					
Product	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Product 1	15.5	0.8	29.9	1.45	27.3	35.2	164	18.0	80.6	33.5	6.1	10.2	56.8	54.6
Product 1 to 2	17.5	0.9	26.8	1.42	26.9	34.6	147	16.1	81.6	37.1	6.8	11.4	57.3	55.2
Product 1 to 3	29.7	1.5	16.1	1.00	23.9	29.5	91	10.2	83.1	44.5	10.2	16.5	60.4	59.0
Product 1 to 4	210.4	10.8	2.42	0.22	21.3	23.6	16	1.81	88.8	68.8	64.4	93.2	76.6	74.6
Product 5	1746.3	89.2	0.04	0.012	1.4	0.21	1	0.07	11.2	31.2	35.6	6.8	23.4	25.4
Feed	1956.7	100	0.29	0.034	3.6	2.72	2	0.26	100	100	100	100	100	100

PROJECT NO: KM2721-26

PURPOSE: To Investigate a Pyrite Circuit.

PROCEDURE: Perform a standard two product cleaner test. The bulk first cleaner tail gets fed to the pyrite rougher circuit.

FEED: 2 kg of SUP Composite 2010 ore ground to a nominal 222µm K_{80}.
Bulk Regrind Discharge Size 18µm K_{80}.
Py Rougher Concentrate 68µm K_{80}.

FLOWSHEET: 2

Stage	Reagents Added g/tonne						Time (minutes)			pH
	Lime	Fuel Oil	PAX	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	2800	20					10			10.7
BULK CIRCUIT:										
Rougher 1	100			1	2	23		1	2	11.0
Rougher 2	√			1	2	-		1	2	11.0
Rougher 3	√			1	2	-		1	2	11.0
Rougher 4	√			1	2	-		1	2	11.0
Regrind	500	20					10			11.4
Cleaner 1	0			2	4	32		1	5	11.1
Cleaner 2	-	10		1	2	24		1	4	11.0
Cleaner 3	-	10		1	2	24		1	3	11.0
PYRITE CIRCUIT										
Rougher 1	0		30			15		1	6	10.5
Rougher 2	0		30			15		1	8	10.5
Cleaner 1			40			45		1	5	9.2
Cleaner 2			20			32		1	4	8.8

Grinding Data	Primary Grind	Bulk Regrind
Mill:	M3-Mild	Stirred Mill
Charge/Material:	20kg-Mild	1.2kg-Beads
Water:	1000 ml	estimated

Flotation Data	Rougher	Cleaner
Flotation Machine:	D2A	D1B
Cell Size in liters:	4.4	2.2
Aspiration:	Air	
Impeller Speed in rpm:	1100	1200

KM2721-26 SUP Composite 2010

Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t							Distribution - percent					
	grams	%	Cu	Mo	Fe	S	Ag	Au	As	Cu	Mo	Fe	S	Ag	Au
Bulk Con	11.6	0.6	35.8	1.65	24.4	34.9	176	23.3		74.9	25.7	4.2	8.4	47.2	61.9
Bulk 3rd Clnr Tail*	1.7	0.1	5.78	1.33	23.0	28.2	20	1.63		1.8	3.0	0.6	1.0	0.8	0.6
Bulk 2nd Clnr Tail	16.1	0.8	1.75	0.50	19.8	22.3	20	1.63		5.1	10.9	4.7	7.4	7.4	6.0
Pyrite Con	84.4	4.3	0.39	0.22	38.2	39.9	8	0.68	0.017	5.9	24.8	47.6	69.7	15.0	13.2
Pyrite 2nd Clnr Tail	26.9	1.4	0.19	0.090	7.0	6.29	4	0.16	0.004	0.9	3.3	2.8	3.5	2.2	1.0
Pyrite 1st Clnr Tail	193.3	9.8	0.08	0.023	2.6	1.43	1	0.14	0.002	2.9	6.0	7.4	5.7	4.9	6.1
Pyrite Ro Tail	1631.5	83.0	0.03	0.012	1.4	0.13	1	0.03	0.001	8.5	26.3	32.8	4.2	22.6	11.2
Feed	1965.5	100	0.28	0.038	3.4	2.46	2	0.22		100	100	100	100	100	100

*Not enough mass for Au and Ag assay. Value was estimated.

KM2721-26 SUP Composite 2010

Cumulative Metallurgical Balance

Cumulative	Cum. Weight		Assay - percent or g/t							Distribution - percent					
Product	grams	%	Cu	Mo	Fe	S	Ag	Au	As	Cu	Mo	Fe	S	Ag	Au
Product 1	11.6	0.6	35.8	1.65	24.4	34.9	176	17.8		74.9	25.7	4.2	8.4	47.2	61.9
Product 1 to 2	13.3	0.7	32.0	1.61	24.2	34.0	156	15.8		76.7	28.7	4.8	9.4	47.9	62.5
Product 1 to 3	29.4	1.5	15.4	1.00	21.8	27.6	81	8.22		81.7	39.6	9.5	16.8	55.3	68.5
Product 4	84.4	4.3	0.39	0.22	38.2	39.9	8	0.78		5.9	24.8	47.6	69.7	15.0	13.2
Product 4 to 5	111.3	5.7	0.34	0.19	30.7	31.8	7	0.68		6.9	28.1	50.4	73.2	17.2	14.2
Product 4 to 6	304.6	15.5	0.18	0.083	12.8	12.5	3	0.32		9.7	34.1	57.8	79.0	22.1	20.3
Product 7	1631.5	83.0	0.03	0.012	1.4	0.13	1	0.03		8.5	26.3	32.8	4.2	22.6	11.2
Feed	1965.5	100	0.28	0.038	3.4	2.46	2	0.22		100	100	100	100	100	100

PROJECT NO: KM2721-27

PURPOSE: To Produce Pyrite Concentrate for Cyanide Leaching.

PROCEDURE: Perform a standard two product cleaner test.

FEED: 6 kg of SUP Composite 2010 ore ground to a nominal 222µm K_{80}.
Bulk Regrind Discharge Size 22µm K_{80}.
Pyrite Cleaner Feed 33µm K_{80}.

FLOWSHEET: 2

Stage	Reagents Added g/tonne						Time (minutes)			pH
	Lime	Fuel Oil	PAX	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	2800	20					10			11.1
BULK CIRCUIT:										
Rougher 1	0			1	2	23		1	2	11.1
Rougher 2	√			1	2			1	2	11.0
Rougher 3	√			1	2			1	2	11.0
Rougher 4	√			1	2			1	2	11.0
Regrind	500	20					10			11.3
Cleaner 1	0			2	4	8		1	5	11.2
Cleaner 2	√	10		1	2	8		1	4	11.0
Cleaner 3	√	10		1	2	8		1	3	11.0
PYRITE CIRCUIT										
Rougher 1			60			8		1	6	10.6
Cleaner 1			120			4		1	13	10.5
Cleaner 2			60			4		1	9	10.5

Grinding Data	Primary Grind	Bulk Regrind
Mill:	M3-Mild	Stirred Mill
Charge/Material:	20kg-Mild	1.2kg-Beads
Water:	1000 ml	estimated

Flotation Data	Rougher	Blk Clnr1	Clnr 2+3	Py Clnr
Flotation Machine:	D2A	D1B	D1B	D1B
Cell Size in liters:	4.4	4.4	2.2	2.2
Aspiration:	Air			
Impeller Speed in rpm:	1100	1200	1200	1200

KM2721-27 SUP Composite 2010

Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t							Distribution - percent					
	grams	%	Cu	Mo	Fe	S	Ag	Au	As	Cu	Mo	Fe	S	Ag	Au
Bulk Con	42.4	0.7	31.9	1.10	26.3	33.6	162	19.7		78.5	23.4	5.1	9.4	49.1	66.5
Bulk 3rd Clnr Tail	18.8	0.3	1.42	0.710	21.1	21.7	17	3.58		1.5	6.7	1.8	2.7	2.3	5.4
Bulk 2nd Clnr Tail	79.3	1.3	0.49	0.265	20.0	20.4	7	0.78		2.3	10.5	7.3	10.7	4.1	4.9
Pyrite Con*	250.7	4.2	0.43	0.275	36.6	38.1	7	0.83	nes	6.3	34.5	42.3	63.1	12.4	16.6
Pyrite 2nd Clnr Tail	83.4	1.4	0.12	0.023	4.3	3.14	2	0.26	0.002	0.6	1.0	1.7	1.7	1.0	1.7
Pyrite 1st Clnr Tail	364.7	6.2	0.15	0.034	4.6	4.10	2	0.10	0.002	3.2	6.2	7.8	9.9	5.7	2.9
Pyrite Ro Tail	5067.2	85.8	0.03	0.007	1.5	0.07	1	0.01	0.001	7.6	17.8	33.9	2.4	25.4	2.0
Feed	5906.5	100	0.29	0.034	3.7	2.56	2	0.21		100	100	100	100	100	100

*Not enough sample for arsenic assay.

KM2721-27 SUP Composite 2010

Cumulative Metallurgical Balance

Cumulative	Cum. Weight		Assay - percent or g/t							Distribution - percent					
Product	grams	%	Cu	Mo	Fe	S	Ag	Au	As	Cu	Mo	Fe	S	Ag	Au
Product 1	42.4	0.7	31.9	1.10	26.3	33.6	162	19.7		78.5	23.4	5.1	9.4	49.1	66.5
Product 1 to 2	61.2	1.0	22.5	0.980	24.7	29.9	117	14.7		80.1	30.0	7.0	12.1	51.4	71.8
Product 1 to 3	140.5	2.4	10.1	0.577	22.0	24.6	55	6.86		82.3	40.6	14.3	22.8	55.6	76.8
Product 4	250.7	4.2	0.43	0.275	36.6	38.1	7	0.83		6.3	34.5	42.3	63.1	12.4	16.6
Product 4 to 5	334.1	5.7	0.35	0.212	28.5	29.4	6	0.69		6.8	35.5	44.0	64.9	13.3	18.3
Product 4 to 6	698.8	11.8	0.25	0.119	16.1	16.2	4	0.38		10.0	41.7	51.8	74.7	19.1	21.2
Product 7	5067.2	85.8	0.03	0.007	1.5	0.07	1	0.01		7.6	17.8	33.9	2.4	25.4	2.0
Feed	5906.5	100	0.29	0.034	3.7	2.56	2	0.21		100	100	100	100	100	100

PROJECT NO: KM2721-28

PURPOSE: To Perform a Cyanide Leach on a Pyrite Concentrate.

PROCEDURE: Standard bottle roll procedure. Agitate on rolls using cyanide and lime.

SAMPLE: 234 g KM2721-27 Pyrite Concentrate at a nominal 27μm $K_{80.}$

Parameter	Time	Added (g)		Residual (g)		Consumed (g)		pH	Dissolved
	Cum	NaCN	CaO	NaCN	CaO	NaCN	CaO		O_2 (mg/L)
Natural	-	-	-	-	-	-	-	7.8	1.01
Leach 1	2	0.49	0.34	0.00	0.07	0.49	0.27	11.0	4.24
Leach 2	6	0.49	0.00	0.00	0.07	0.49	0.00	11.0	4.77
Leach 3	24	0.49	0.00	0.02	0.02	0.47	0.05	11.0	5.26
Leach 4	48	0.48	0.00	0.13	0.01	0.37	0.01	11.0	5.36
Total	48	1.95	0.34	0.13	0.01	1.82	0.33	-	-

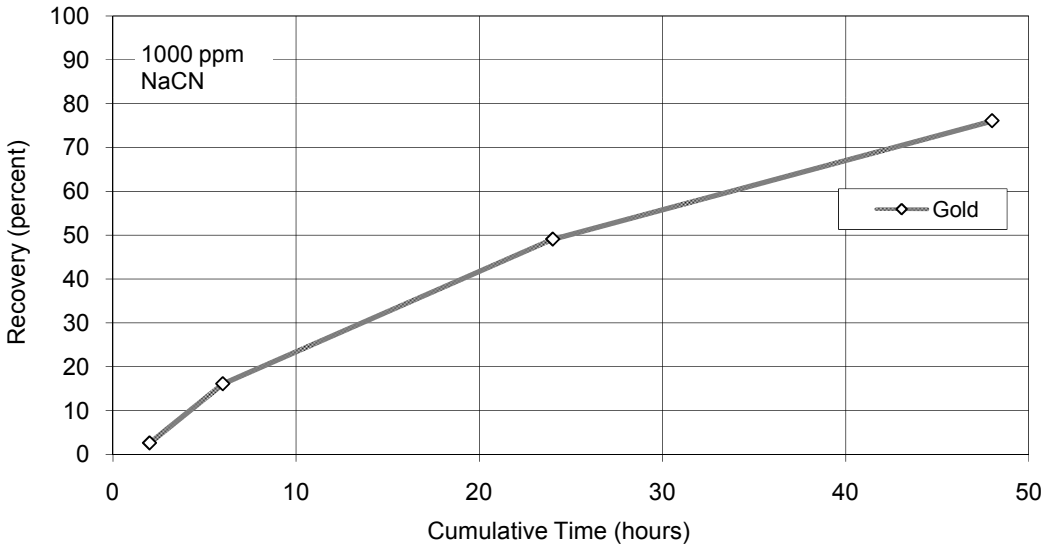
Mass of Sample	234
Volume of Water	468
Pulp Density	33

NaCN Consumption	7.8 kg/tonne
Lime Consumption	1.4 kg/tonne

KM2721-28 Test 27 Pyrite Concentrate
Cumulative Metallurgical Balance

Product	Cumulative Time - Hrs	Volume or Mass	Units	Assay - g/t		Distribution - percent	
				Gold	Copper	Gold	Copper
Cyanide Liquor (2 hr)	2	468	ml	0.01	421	2.7	20.4
Cyanide Liquor (6 hr)	6	468	ml	0.06	813	16.1	40.7
Cyanide Liquor (24 hr)	24	468	ml	0.18	1150	49.1	59.6
Cyanide Liquor (48 hr)	48	468	ml	0.27	1890	76.2	99.0
Cyanidation Tails	-	232.9	g	0.18	40	23.8	1.0
Calculated Feed		234	g	0.75	4125	100.0	100.0

Cyanide Leach Kinetic Curves



PROJECT NO: KM2721-29

PURPOSE: To Repeat Test 27.

PROCEDURE: Perform a standard two product cleaner test.

FEED: 6 kg of SUP Composite 2010 ore ground to a nominal 222µm K_{80}.
Bulk Regrind Discharge Size 29µm K_{80}.
Pyrite Cleaner Concentrate 45µm K_{80}.

FLOWSHEET: 2

Stage	Reagents Added g/tonne						Time (minutes)			pH
	Lime	Fuel Oil	PAX	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	2800	20					10			11.1
BULK CIRCUIT:										
Rougher 1	0			1	2	23		1	2	11.1
Rougher 2	√			1	2	-		1	2	11.0
Rougher 3	√			1	2	-		1	2	11.0
Rougher 4	√			1	2	-		1	2	11.0
Regrind	500	20					10			11.1
Cleaner 1	0	-		2	4	8		1	5	11.1
Cleaner 2	√	10		1	2	8		1	4	11.0
Cleaner 3	√	10		1	2	4		1	3	11.0
PYRITE CIRCUIT										
Rougher 1			60			-		1	6	10.7
Cleaner 1			120			8		1	13	10.8
Cleaner 2			60			8		1	9	11.0

Grinding Data	Primary Grind	Bulk Regrind
Mill:	M3-Mild	Stirred Mill
Charge/Material:	20kg-Mild	1.2kg-Beads
Water:	1000 ml	estimated

Flotation Data	Rougher	Blk Clnr1	Clnr 2+3	Py Clnr
Flotation Machine:	D2A	D1B	D1B	D1B
Cell Size in liters:	4.4	4.4	2.2	2.2
Aspiration:	Air			
Impeller Speed in rpm:	1100	1200	1200	1200

KM2721-29 SUP Composite 2010

Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t							Distribution - percent					
	grams	%	Cu	Mo	Fe	S	Ag	Au	As	Cu	Mo	Fe	S	Ag	Au
Bulk Con	58.4	1.0	25.8	1.93	28.5	37.6	156	16.2		86.3	57.3	7.8	13.8	58.8	64.0
Bulk 3rd Clnr Tail	10.6	0.2	0.68	0.630	20.1	21.9	17	2.26		0.4	3.4	1.0	1.5	1.1	1.6
Bulk 2nd Clnr Tail	65.0	1.1	0.19	0.130	17.2	17.4	5	0.34		0.7	4.3	5.2	7.1	2.2	1.5
Pyrite Con	303.7	5.1	0.15	0.089	34.0	38.6	5	0.57	0.012	2.6	13.7	48.5	73.9	9.0	11.6
Pyrite 2nd Clnr Tail	110.5	1.9	0.10	0.005	2.1	0.58	1	0.08	0.001	0.6	0.3	1.1	0.4	0.9	0.6
Pyrite 1st Clnr Tail	319.0	5.4	0.05	0.003	1.6	0.17	1	0.02	0.002	1.0	0.5	2.5	0.3	1.9	0.4
Pyrite Ro Tail	5053.1	85.4	0.03	0.008	1.4	0.09	1	0.06	0.001	8.4	20.5	33.9	2.9	26.1	20.2
Feed	5920.3	100	0.29	0.033	3.6	2.68	3	0.25		100	100	100	100	100	100

KM2721-29 SUP Composite 2010

Cumulative Metallurgical Balance

Cumulative	Cum. Weight		Assay - percent or g/t							Distribution - percent					
Product	grams	%	Cu	Mo	Fe	S	Ag	Au	As	Cu	Mo	Fe	S	Ag	Au
Product 1	58.4	1.0	25.8	1.93	28.5	37.6	156	16.2		86.3	57.3	7.8	13.8	58.8	64.0
Product 1 to 2	69.0	1.2	21.9	1.73	27.2	35.2	135	14.1		86.7	60.7	8.8	15.3	59.9	65.6
Product 1 to 3	134.0	2.3	11.4	0.954	22.4	26.6	72	7.42		87.4	65.0	14.1	22.4	62.1	67.1
Product 4	303.7	5.1	0.15	0.089	34.0	38.6	5	0.57		2.6	13.7	48.5	73.9	9.0	11.6
Product 4 to 5	414.2	7.0	0.14	0.067	25.5	28.5	4	0.44		3.2	14.0	49.6	74.3	9.9	12.2
Product 4 to 6	733.2	12.4	0.10	0.039	15.1	16.2	2	0.26		4.2	14.5	52.0	74.6	11.8	12.7
Product 7	5053.1	85.4	0.03	0.008	1.4	0.09	1	0.06		8.4	20.5	33.9	2.9	26.1	20.2
Feed	5920.3	100	0.29	0.033	3.6	2.68	3	0.25		100	100	100	100	100	100

PROJECT NO: KM2721-30

PURPOSE: To Repeat Test 28 but with Regrind.

PROCEDURE: Standard bottle roll procedure. Agitate on rolls using cyanide and lime.

SAMPLE: 287 g KM2721-29 Pyrite Concentrate ground for 30 minutes to reach a nominal 10µm $K_{80.}$ Cyanidation Tails 10µm K_{80}.

Parameter	Time	Added (g)		Residual (g)		Consumed (g)		pH	Dissolved
	Cum	NaCN	CaO	NaCN	CaO	NaCN	CaO		O_2 (mg/L)
Natural	-	-	-	-	-	-	-	7.7	1.10
Leach 1	2	0.61	0.65	0.11	0.03	0.50	0.62	11.0	3.61
Leach 2	6	0.51	0.00	0.17	0.03	0.45	0.00	11.4	5.90
Leach 3	24	0.45	0.00	0.30	0.01	0.32	0.02	11.3	6.00
Leach 4	48	0.32	0.07	0.38	0.00	0.24	0.08	11.0	6.12
Total	48	1.89	0.72	0.38	0.00	1.51	0.72	-	-

Mass of Sample	287
Volume of Water	576
Pulp Density	33

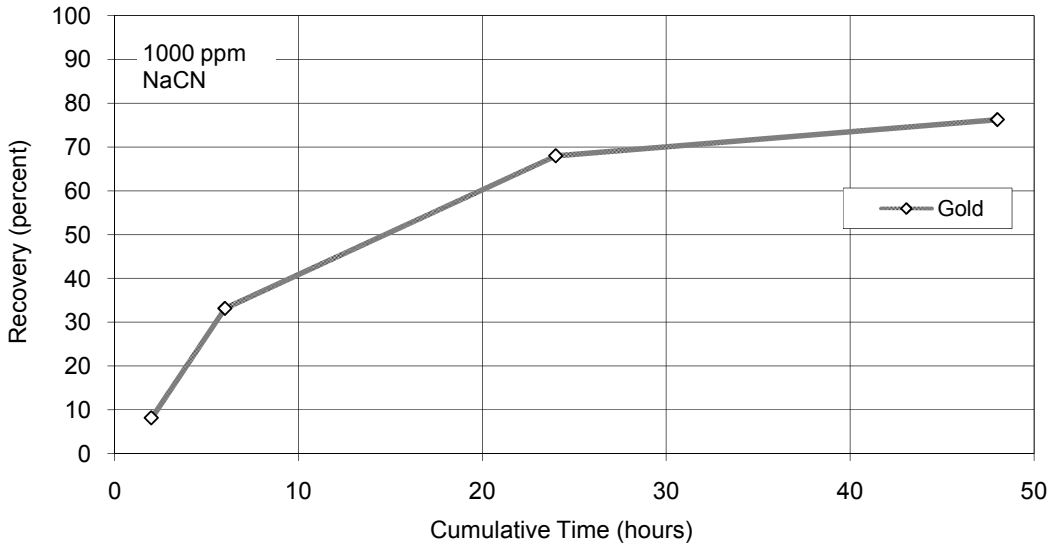
NaCN Consumption	5.3 kg/tonne
Lime Consumption	2.5 kg/tonne

KM2721-30 Test 29 Pyrite Concentrate
Cumulative Metallurgical Balance

Product	Cumulative Time - Hrs	Volume or Mass	Units	Assay - g/t		Distribution - percent	
				Gold	Copper	Gold	Copper
Cyanide Liquor (2 hr)*	2	468	ml	0.02	595	8.2	82.4
Cyanide Liquor (6 hr)*	6	468	ml	0.08	595	33.2	87.7
Cyanide Liquor (24 hr)	24	468	ml	0.16	595	68.0	92.9
Cyanide Liquor (48 hr)	48	468	ml	0.17	595	76.3	98.2
Cyanidation Tails	-	302	g	0.09	20	23.7	1.8
Calculated Feed		304	g	0.38	1113	100.0	100.0

*Copper Values were estimated

Cyanide Leach Kinetic Curves



PROJECT NO: KM2721-31

PURPOSE: To Repeat Test 20.

PROCEDURE: Perform a standard one product cleaner test.

FEED: 2 kg of SUP Composite 2010 ore ground to a nominal 222µm K_{80}.
Bulk Regrind Discharge Size 27µm K_{80}.

FLOWSHEET: 2

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	2800	20				10			11.1
BULK CIRCUIT:									
Rougher 1	0		2	4	15		1	2	11.0
Rougher 2	0		2	4	-		1	2	11.0
Rougher 3	√		2	4	-		1	2	11.0
Rougher 4	√		2	4	-		1	2	11.0
Regrind	500	20				10			11.1
Cleaner 1	-		1	2	15		1	5	11.1
Cleaner 2	√	10	1	2	15		1	4	11.0
Cleaner 3	√	10	1	2	15		1	3	11.0

Flotation Data	Rougher	Cleaner
Flotation Machine:	D2D	D1E
Cell Size in liters:	4.4	2.2
Aspiration:	Air	
Impeller Speed in rpm:	1100	1200

Grinding Data	Primary Grind	Bulk Regrind
Mill:	M3-Mild	Stirred Mill
Charge/Material:	20kg-Mild	1.2kg-Beads
Water:	1000 ml	estimated

KM2721-31 SUP Composite 2010

Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t						Distribution - percent					
	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Bulk Concentrate	17.7	0.9	26.8	1.78	29.5	35.9	135	17.0	83.5	49.9	7.4	13.0	48.7	72.6
Bulk 3rd Cleaner Tail*	2.2	0.1	1.80	1.23	26.3	27.2	34	1.20	0.7	4.3	0.8	1.2	1.5	0.6
Bulk 2nd Cleaner Tail	18.0	0.9	0.29	0.229	14.6	14.1	7	1.20	0.9	6.5	3.7	5.2	2.5	5.2
Bulk 1st Cleaner Tail	249.5	12.7	0.08	0.032	14.9	14.3	2	0.26	3.7	12.6	53.0	73.2	9.7	15.5
Bulk Rougher Tails	1680.8	85.4	0.04	0.010	1.5	0.21	1	0.01	11.2	26.6	35.0	7.3	37.7	6.1
Feed	1968.2	100	0.29	0.032	3.6	2.48	2	0.21	100	100	100	100	100	100

* Not enough sample for gold assay. Value was estimated.

KM2721-31 SUP Composite 2010

Cumulative Metallurgical Balance

Cumulative Product	Cum. Weight		Assay - percent or g/t						Distribution - percent					
	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Product 1	17.7	0.9	26.8	1.78	29.5	35.9	135	17.0	83.5	49.9	7.4	13.0	48.7	72.6
Product 1 to 2	19.9	1.0	24.0	1.72	29.1	34.9	124	15.3	84.2	54.2	8.3	14.3	50.2	73.2
Product 1 to 3	37.9	1.9	12.8	1.01	22.2	25.0	68	8.60	85.1	60.7	12.0	19.5	52.7	78.4
Product 1 to 4	287.4	14.6	1.76	0.161	15.9	15.7	11	1.36	88.8	73.4	65.0	92.7	62.3	93.9
Product 5	1680.8	85.4	0.04	0.010	1.5	0.21	1	0.01	11.2	26.6	35.0	7.3	37.7	6.1
Feed	1968.2	100	0.29	0.032	3.6	2.48	2	0.21	100	100	100	100	100	100

PROJECT NO: KM2721-32

PURPOSE: To Repeat Test 31 with More Collector.

PROCEDURE: Perform a standard one product cleaner test.

FEED: 2 kg of SUP Composite 2010 ore ground to a nominal 222µm K_{80}.
Bulk Regrind Discharge Size 23µm K_{80}.

FLOWSHEET: 2

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	2800	20				10			11.1
BULK CIRCUIT:									
Rougher 1	0		3	4	15		1	2	11.1
Rougher 2	√		3	4	-		1	2	11.0
Rougher 3	√		3	4	-		1	2	11.0
Rougher 4	√		3	4	-		1	2	11.0
Regrind	500	20				10			11.3
Cleaner 1	-		2	2	15		1	5	11.3
Cleaner 2	√	10	2	2	15		1	4	11.0
Cleaner 3	√	10	2	2	15		1	3	11.0

Flotation Data	Rougher	Cleaner
Flotation Machine:	D2D	D1E
Cell Size in liters:	4.4	2.2
Aspiration:	Air	
Impeller Speed in rpm:	1100	1200

Grinding Data	Primary Grind	Bulk Regrind
Mill:	M3-Mild	Stirred Mill
Charge/Material:	20kg-Mild	1.2kg-Beads
Water:	1000 ml	estimated

KM2721-32 SUP Composite 2010

Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t						Distribution - percent					
	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Bulk Concentrate	17.3	0.9	26.8	2.04	27.4	35.3	130	16.9	83.4	50.3	6.6	12.4	62.7	69.4
Bulk 3rd Cleaner Tail*	3.9	0.2	0.90	0.490	18.1	18.9	16	0.70	0.6	2.7	1.0	1.5	1.8	0.6
Bulk 2nd Cleaner Tail	27.7	1.4	0.22	0.127	15.0	14.9	5	0.70	1.1	5.0	5.7	8.4	3.6	4.6
Bulk 1st Cleaner Tail	236.8	12.0	0.08	0.032	15.6	15.0	2	0.24	3.4	10.8	51.1	72.3	13.2	13.5
Bulk Rougher Tails	1681.1	85.5	0.04	0.013	1.5	0.16	0.4	0.03	11.5	31.2	35.6	5.4	18.7	11.9
Feed	1966.8	100	0.28	0.036	3.7	2.50	2	0.21	100	100	100	100	100	100

* Not enough sample for gold assay. Value was estimated.

KM2721-32 SUP Composite 2010

Cumulative Metallurgical Balance

Cumulative Product	Cum. Weight		Assay - percent or g/t						Distribution - percent					
	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Product 1	17.3	0.9	26.8	2.04	27.4	35.3	130	16.9	83.4	50.3	6.6	12.4	62.7	69.4
Product 1 to 2	21.2	1.1	22.0	1.75	25.7	32.3	109	13.9	84.0	53.0	7.5	13.9	64.5	70.0
Product 1 to 3	48.9	2.5	9.68	0.833	19.6	22.4	50	6.43	85.1	58.0	13.3	22.3	68.0	74.6
Product 1 to 4	285.7	14.5	1.72	0.169	16.3	16.3	10	1.30	88.5	68.8	64.4	94.6	81.3	88.1
Product 5	1681.1	85.5	0.04	0.013	1.5	0.16	0.4	0.03	11.5	31.2	35.6	5.4	18.7	11.9
Feed	1966.8	100	0.28	0.036	3.7	2.50	2	0.21	100	100	100	100	100	100

PROJECT NO: KM2721-33

PURPOSE: Preliminary Locked Cycle Test.

PROCEDURE: Perform a standard two product locked cycle test.

FEED: 5 x 2 kg of SUP Composite 2010 ore ground to a nominal 222µm K_{80}.
Bulk Regrind Discharge Size 19µm K_{80}.
Py Rougher Concentrate 41µm K_{80}.

FLOWSHEET: 3

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	2900	20				10			11.0
BULK CIRCUIT:									
Rougher 1	-		2	4	8		1	2	11.0
Rougher 2	√		2	4	-		1	2	11.0
Rougher 3	-		2	4	8		1	2	11.0
Rougher 4	√		2	4	-		1	2	11.0
Regrind	500	20				18			11.0
Cleaner 1	0	-	1	2	30		1	5	11.0
Cleaner 2	√	10	1	2	30		1	4	11.0
Cleaner 3	√	10	1	2	30		1	3	11.0
PYRITE CIRCUIT:				PAX					
Rougher 1	-			60	8		1	6	10.9

Flotation Data	Rougher	Cleaner
Flotation Machine:	D2A	D1B
Cell Size in liters:	4.4	2.2
Aspiration:	Air	
Impeller Speed in rpm:	1100	1200

Grinding Data	Primary Grind	Bulk Regrind
Mill:	M3-Mild	Stirred Mill
Charge/Material:	20kg-Mild	1.2kg-Beads
Water:	1000 ml	estimated

KM2721-33

Estimated Dry Weight Table

Product	Cycles - Weight (gms)				
	I	II	III	IV	V
BULK CIRCUIT					
Rougher Concentrate	330	400	305	305	310
Cleaner Tail 1	300	430	330	340	365
Cleaner Tail 2	53	62	66	67	58
Cleaner Tail 3	8	10	9	12	7
Bulk Concentrate	18	22	18	18	18
PYRITE CIRCUIT					
Rougher Concentrate	150	130	210	150	120
Primary Discharge pH	10.8	11.0	11.0	11.0	11.0

KM2721-33 SUP Composite 2010

OVERALL CYCLE TEST MASS AND METALLURGICAL BALANCE

Product	Weight	Weight	Assay - percent or g/t						Distribution - percent					
	g	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Bulk Concentrate I	17.3	0.2	24.7	1.23	28.3	37.3	120	15.2	15.7	6.6	1.5	2.5	8.5	12.2
Bulk Concentrate II	19.6	0.2	23.6	1.27	29.4	37.5	126	14.2	17.0	7.7	1.7	2.9	10.1	12.9
Bulk Concentrate III	14.2	0.1	32.3	1.49	23.6	34.9	182	21.3	16.9	6.5	1.0	1.9	10.6	14.0
Bulk Concentrate IV	14.6	0.1	30.8	1.57	23.6	33.9	172	20.2	16.5	7.1	1.0	1.9	10.3	13.7
Bulk Concentrate V	15.7	0.2	28.2	1.41	26.5	35.0	186	19.9	16.3	6.8	1.2	2.1	12.0	14.5
Bulk 3rd Cleaner Tail	5.2	0.1	2.25	1.24	17.1	19.6	43	2.87	0.4	2.0	0.3	0.4	0.9	0.7
Bulk 2nd Cleaner Tail	43.0	0.4	0.50	0.332	12.7	14.0	10	0.74	0.8	4.4	1.6	2.3	1.8	1.5
Bulk 1st Cleaner Tail I	278.5	2.8	0.09	0.046	11.2	11.3	3	0.36	0.9	4.0	9.3	12.3	3.1	4.7
Bulk 1st Cleaner Tail II	398.4	4.0	0.09	0.051	10.0	10.6	3	0.18	1.2	6.3	11.9	16.4	4.2	3.3
Bulk 1st Cleaner Tail III	289.9	2.9	0.13	0.075	13.4	14.3	3	0.18	1.4	6.7	11.6	16.1	3.4	2.4
Bulk 1st Cleaner Tail IV	293.4	3.0	0.14	0.090	13.9	14.5	3	0.22	1.5	8.2	12.2	16.6	4.0	3.0
Bulk 1st Cleaner Tail V	311.8	3.2	0.12	0.083	13.3	14.1	4	0.20	1.4	8.0	12.4	17.1	4.7	2.9
Pyrite Rougher Conc I	148.0	1.5	0.10	0.026	4.9	4.70	2	0.10	0.5	1.2	2.2	2.7	1.2	0.7
Pyrite Rougher Conc II	115.7	1.2	0.10	0.027	2.2	1.29	2	0.04	0.4	1.0	0.7	0.6	0.8	0.2
Pyrite Rougher Conc III	185.5	1.9	0.08	0.023	2.4	1.20	1	0.04	0.6	1.3	1.3	0.9	1.1	0.3
Pyrite Rougher Conc IV	140.0	1.4	0.09	0.022	2.1	0.97	2	0.04	0.4	1.0	0.9	0.5	0.9	0.3
Pyrite Rougher Conc V	111.8	1.1	0.13	0.025	2.3	1.50	2	0.04	0.5	0.9	0.8	0.7	1.0	0.2
Pyrite Rougher Tail I	1491.2	15.1	0.03	0.009	1.3	0.07	1	0.01	1.4	4.2	5.8	0.4	4.3	1.0
Pyrite Rougher Tail II	1451.1	14.7	0.03	0.008	1.3	0.07	1	0.05	1.4	3.6	5.5	0.4	3.6	3.0
Pyrite Rougher Tail III	1466.6	14.9	0.03	0.009	1.3	0.05	1	0.04	1.3	4.1	5.5	0.3	3.6	3.1
Pyrite Rougher Tail IV	1522.1	15.4	0.03	0.009	1.3	0.08	1	0.03	1.5	4.2	5.8	0.4	3.7	2.1
Pyrite Rougher Tail V	1541.7	15.6	0.03	0.009	1.2	0.08	1	0.04	1.8	4.3	5.7	0.5	6.3	3.2
FEED	9875	100.0	0.28	0.033	3.4	2.60	2	0.22	100.0	100.0	100.0	100.0	100.0	100.0

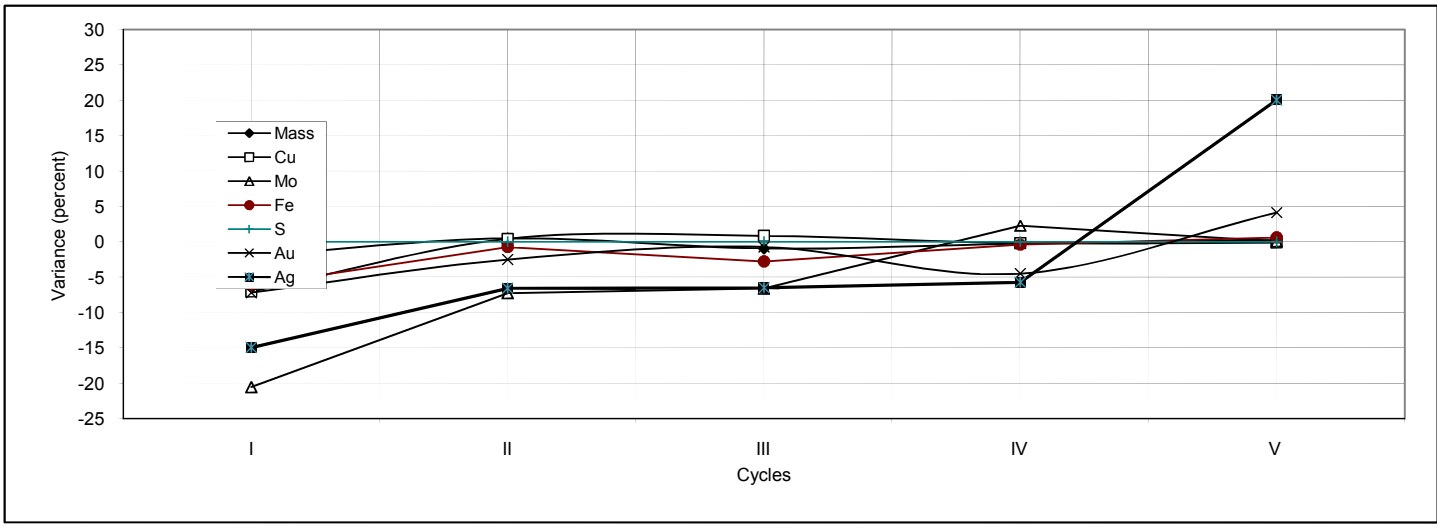
KM2721-33 SUP Composite 2010

METALLURGICAL BALANCES BY TEST CYCLES

Product	Weight	Weight	Assay - percent or g/t						Distribution - percent					
	g	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
CYCLE IV														
Flotation Feed	1970.1	100.0	0.28	0.034	3.4	2.54	2	0.21	100.0	100.0	100.0	100.0	100.0	100.0
Bulk Concentrate	14.6	0.7	30.8	1.57	23.6	33.9	172	20.2	82.9	34.7	5.2	9.9	54.6	71.9
Bulk 1st Cleaner Tail	293.4	14.9	0.14	0.090	13.9	14.5	3	0.22	7.6	39.9	61.2	85.1	21.0	15.7
Pyrite Rougher Conc	140.0	7.1	0.09	0.022	2.1	0.97	2	0.04	2.2	4.7	4.4	2.7	4.6	1.4
Pyrite Rougher Tail	1522.1	77.3	0.03	0.009	1.3	0.08	1	0.03	7.3	20.7	29.2	2.3	19.8	11.1
CYCLE V														
Flotation Feed	1981.0	100.0	0.27	0.033	3.4	2.64	3	0.23	100.0	100.0	100.0	100.0	100.0	100.0
Bulk Concentrate	15.7	0.8	28.2	1.41	26.5	35.0	186	19.9	81.6	34.2	6.2	10.5	49.8	69.7
Bulk 1st Cleaner Tail	311.8	15.7	0.12	0.083	13.3	14.1	4	0.20	6.9	40.0	61.6	84.1	19.7	13.9
Pyrite Rougher Conc	111.8	5.6	0.13	0.025	2.3	1.50	2	0.04	2.7	4.3	3.8	3.2	4.2	1.0
Pyrite Rougher Tail	1541.7	77.8	0.03	0.009	1.2	0.08	1	0.04	8.8	21.5	28.4	2.2	26.3	15.4
CYCLES IV and V														
Flotation Feed	3951.1	100.0	0.27	0.033	3.4	2.59	3	0.22	100.0	100.0	100.0	100.0	100.0	100.0
Bulk Concentrate	30.3	0.8	29.5	1.49	25.1	34.5	179	20.1	82.3	34.5	5.7	10.2	51.9	70.7
Bulk 1st Cleaner Tail	605.2	15.3	0.13	0.086	13.6	14.3	4	0.21	7.2	40.0	61.4	84.6	20.3	14.8
Pyrite Rougher Conc	251.8	6.4	0.11	0.023	2.2	1.21	2	0.04	2.5	4.5	4.1	3.0	4.4	1.2
Pyrite Rougher Tail	3063.8	77.5	0.03	0.009	1.3	0.08	1	0.04	8.0	21.1	28.8	2.3	23.5	13.3

Cycle Test Stability Data

Cycles	Mass		Calculated Head						Metal Unit Variances (%)					
	g/cycle	%Var.	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
I	1935.0	-2.03	0.26	0.027	3.2	2.38	2	0.21	-7	-21	-6	-10	-15	-7
II	1984.8	0.49	0.28	0.030	3.3	2.62	2	0.21	0	-7	-1	1	-7	-3
III	1956.2	-0.95	0.28	0.031	3.3	2.52	2	0.22	1	-7	-3	-4	-7	-1
IV	1970.1	-0.25	0.28	0.034	3.4	2.54	2	0.21	0	2	0	-3	-6	-5
V	1981.0	0.30	0.27	0.033	3.4	2.64	3	0.23	0	0	1	2	20	4
Total	1975.06	-	0.28	0.033	3.4	2.60	2	0.22	-	-	-	-	-	-



KM2721-33 SUP Composite 2010

CYCLES (IV+V) MASS BALANCE FLOWSHEET AND METALLURGICAL BALANCE DATA

Flotation Stream		Weight	Assay (percent or g/t)						Distribution (percent)					
No.	Product	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
1	Bulk Rougher Feed	100.0	0.27	0.033	3.4	2.59	3	0.22	100.0	100.0	100.0	100.0	100.0	100.0
2	Bulk Rougher Tail	83.9	0.03	0.009	1.3	0.08	1	0.04	10.5	25.6	32.9	5.2	27.8	14.5
3	Bulk Rougher Concentrate	16.1	1.53	0.153	14.1	15.3	12	1.16	89.5	74.4	67.1	94.8	72.2	85.5
4	Bulk 1st Cleaner Feed	18.5	1.42	0.190	14.0	15.2	12	1.13	95.6	106.0	76.6	108.5	84.9	96.3
5	Bulk 1st Cleaner Tail	15.3	0.13	0.086	13.6	14.3	4	0.21	7.2	40.0	61.4	84.6	20.3	14.8
6	Bulk 1st Clnr Concentrate	3.2	7.59	0.683	16.0	19.4	54	5.54	88.4	66.1	15.1	23.9	64.7	81.6
7	Bulk 2nd Cleaner Tail	2.2	0.50	0.332	12.7	14.0	10	0.74	3.9	21.8	8.1	11.7	8.5	7.4
8	Bulk 2nd Cleaner Concentrate	1.0	22.5	1.42	23.1	30.7	144	15.7	84.4	44.3	7.0	12.2	56.1	74.2
9	Bulk 3rd Cleaner Tail	0.3	2.25	1.24	17.1	19.6	43	2.87	2.1	9.8	1.3	2.0	4.2	3.5
10	Bulk 3rd Cleaner Concentrate	0.8	29.5	1.49	25.1	34.5	179	20.1	82.3	34.5	5.7	10.2	51.9	70.7
11	Pyrite Rougher Conc	6.4	0.11	0.023	2.2	1.21	2	0.04	2.5	4.5	4.1	3.0	4.4	1.2
12	Pyrite Rougher Tail	77.5	0.03	0.009	1.3	0.08	1	0.04	8.0	21.1	28.8	2.3	23.5	13.3
13	Total Tail	92.9	0.05	0.022	3.3	2.42	1	0.07	15.3	61.1	90.2	86.8	43.7	28.1

PROJECT NO: KM2721-34

PURPOSE: To Repeat Test 33 With an Addition Scavenger in Cleaner Circuit.

PROCEDURE: Perform a standard two product locked cycle test.

FEED: 5 x 2 kg of Master Composite 1 ore ground to a nominal 222µm K_{80}.
Bulk Regrind Discharge Size - 20µm K_{80}.

FLOWSHEET: 3

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	2900	20				10			10.9
BULK CIRCUIT:									
Rougher 1	100		2	4	23		1	2	11.0
Rougher 2	√		2	4	-		1	2	11.0
Rougher 3	√		2	4	8		1	2	11.0
Rougher 4	√		2	4	8		1	2	11.0
Regrind	500	20				18			11.0
Cleaner 1	-	-	1	2	15		1	5	11.0
Cleaner 2	√	10	1	2	15		1	4	11.0
Cleaner 3	√	10	1	2	15		1	3	11.0
Cleaner Scavenger	-	20	-	-	-		1	2	11.0
PYRITE CIRCUIT:				PAX					
Rougher 1				60	8		1	6	10.8

Flotation Data	Rougher	Cleaner
Flotation Machine:	D2A	D1B
Cell Size in liters:	4.4	2.2
Aspiration:	Air	
Impeller Speed in rpm:	1100	1200

Grinding Data	Primary Grind	Bulk Regrind
Mill:	M3-Mild	Stirred Mill
Charge/Material:	20kg-Mild	1.2kg-Beads
Water:	1000 ml	estimated

KM2721-34
Estimated Dry Weight Table

Product	Cycles - Weight (gms)				
	I	II	III	IV	V
BULK CIRCUIT					
Rougher Concentrate	300	300	330	300	300
Cleaner Scavenger Con	30	36	27	31	27
Cleaner Scavenger Tail	180	310	320	325	335
Cleaner Tail 2	38	47	69	69	60
Cleaner Tail 3	7	8	14	11	9
Bulk Concentrate	18	21	22	21	21
PYRITE CIRCUIT					
Rougher Concentrate	210	110	130	110	125
Primary Discharge pH	10.9	10.8	10.7	10.7	10.9

KM2721-34 SUP Composite 2010

OVERALL CYCLE TEST MASS AND METALLURGICAL BALANCE

Product	Weight	Weight	Assay - percent or g/t						Distribution - percent					
	g	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Bulk Concentrate I	15.0	0.2	31.7	1.58	23.7	33.2	180	27.6	17.4	7.7	1.1	1.9	12.0	15.6
Bulk Concentrate II	18.0	0.2	26.3	1.12	25.4	32.5	162	20.3	17.3	6.5	1.4	2.2	12.9	13.7
Bulk Concentrate III	20.5	0.2	22.7	1.53	28.1	34.1	128	17.2	17.0	10.2	1.7	2.6	11.6	13.3
Bulk Concentrate IV	18.2	0.2	26.1	1.60	25.7	35.5	158	17.8	17.4	9.4	1.4	2.4	12.7	12.2
Bulk Concentrate V	18.4	0.2	25.7	1.51	26.6	34.3	146	19.9	17.3	9.0	1.5	2.4	11.9	13.7
Bulk 3rd Cleaner Tail	6.3	0.1	1.26	1.47	18.7	20.4	25	3.20	0.3	3.0	0.4	0.5	0.7	0.8
Bulk 2nd Cleaner Tail	46.6	0.5	0.29	0.250	13.3	14.3	7	0.64	0.5	3.8	1.9	2.5	1.4	1.1
Bulk Cleaner Scav Con	20.2	0.2	0.31	0.464	13.7	14.8	7	0.49	0.2	3.0	0.8	1.1	0.6	0.4
Bulk Cleaner Scav Tail I	233.3	2.4	0.07	0.033	13.6	14.8	2	0.24	0.6	2.5	9.5	13.0	2.1	2.1
Bulk Cleaner Scav Tail II	265.5	2.7	0.08	0.054	13.9	15.2	2	0.20	0.7	4.6	11.0	15.2	2.2	2.0
Bulk Cleaner Scav Tail III	281.8	2.9	0.07	0.033	9.20	9.42	2	0.24	0.7	3.0	7.8	10.0	2.4	2.5
Bulk Cleaner Scav Tail IV	278.0	2.8	0.07	0.043	11.1	11.7	3	0.20	0.7	3.9	9.2	12.3	3.8	2.1
Bulk Cleaner Scav Tail V	295.9	3.0	0.08	0.045	12.3	14.8	2	0.24	0.8	4.3	10.9	16.5	2.9	2.7
Pyrite Rougher Conc I	187.4	1.9	0.07	0.046	2.6	1.25	1	0.12	0.5	2.8	1.4	0.9	1.0	0.8
Pyrite Rougher Conc II	98.9	1.0	0.12	0.024	3.4	3.40	2	0.18	0.4	0.8	1.0	1.3	0.9	0.7
Pyrite Rougher Conc III	120.9	1.2	0.10	0.020	15.0	17.6	3	0.37	0.4	0.8	5.4	8.0	1.4	1.7
Pyrite Rougher Conc IV	101.8	1.0	0.12	0.028	11.0	10.8	2	0.30	0.5	0.9	3.3	4.1	1.0	1.1
Pyrite Rougher Conc V	119.2	1.2	0.15	0.028	2.5	1.50	2	0.16	0.6	1.1	0.9	0.7	0.9	0.7
Pyrite Rougher Tail I	1486.1	15.0	0.02	0.006	1.3	0.11	1	0.04	1.1	2.9	5.7	0.6	5.3	2.2
Pyrite Rougher Tail II	1582.4	16.0	0.03	0.010	1.3	0.06	0.4	0.06	1.8	5.1	6.0	0.4	2.8	3.6
Pyrite Rougher Tail III	1531.5	15.5	0.03	0.008	1.2	0.07	1	0.01	1.4	4.0	5.7	0.4	3.4	0.6
Pyrite Rougher Tail IV	1577.6	16.0	0.02	0.010	1.3	0.10	1	0.04	1.0	5.1	5.9	0.6	3.5	2.4
Pyrite Rougher Tail V	1561.1	15.8	0.02	0.011	1.3	0.05	0.4	0.07	1.2	5.6	6.2	0.3	2.8	4.1
FEED	9885	100.0	0.28	0.031	3.4	2.68	2	0.27	100.0	100.0	100.0	100.0	100.0	100.0

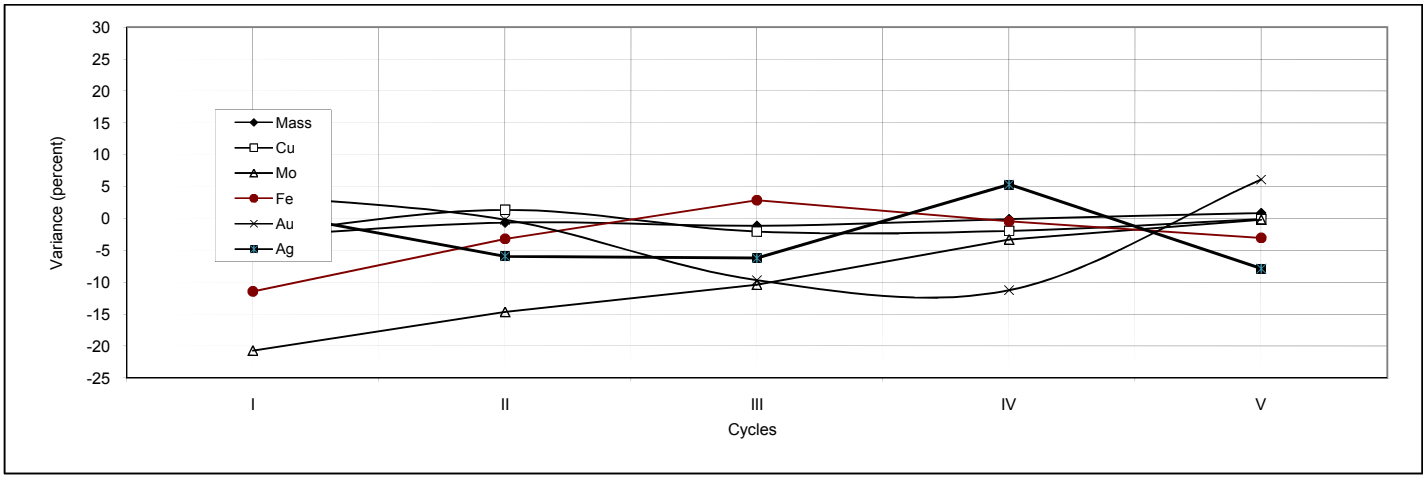
KM2721-34 SUP Composite 2010

METALLURGICAL BALANCES BY TEST CYCLES

Product	Weight	Weight	Assay - percent or g/t						Distribution - percent					
	g	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
CYCLE IV														
Flotation Feed	1975.6	100.0	0.27	0.030	3.37	2.61	2	0.24	100.0	100.0	100.0	100.0	100.0	100.0
Bulk Concentrate	18.2	0.9	26.1	1.60	25.7	35.5	158	17.8	88.6	48.8	7.0	12.5	60.4	68.4
Bulk Cleaner Scav Tail	278.0	14.1	0.07	0.043	11.1	11.7	3	0.20	3.7	20.0	46.3	63.0	18.1	11.8
Pyrite Rougher Conc	101.8	5.2	0.12	0.028	11.0	10.8	2	0.30	2.3	4.8	16.8	21.3	4.9	6.5
Pyrite Rougher Tail	1577.6	79.9	0.02	0.010	1.3	0.10	1	0.04	5.3	26.4	29.8	3.2	16.6	13.3
CYCLE V														
Flotation Feed	1994.6	100.0	0.27	0.031	3.3	2.64	2	0.28	100.0	100.0	100.0	100.0	100.0	100.0
Bulk Concentrate	18.4	0.9	25.7	1.51	26.6	34.3	146	19.9	86.6	45.1	7.5	12.0	64.5	64.7
Bulk Cleaner Scav Tail	295.9	14.8	0.08	0.045	12.3	14.8	2	0.24	4.2	21.6	56.1	83.0	15.6	12.6
Pyrite Rougher Conc	119.2	6.0	0.15	0.028	2.5	1.50	2	0.16	3.2	5.4	4.6	3.4	4.9	3.4
Pyrite Rougher Tail	1561.1	78.3	0.02	0.011	1.3	0.05	0.4	0.07	6.0	27.9	31.8	1.6	15.0	19.3
CYCLES IV and V														
Flotation Feed	3970.2	100.0	0.27	0.031	3.3	2.63	2	0.26	100.0	100.0	100.0	100.0	100.0	100.0
Bulk Concentrate	36.6	0.9	25.9	1.55	26.2	34.9	152	18.8	87.6	46.9	7.3	12.2	62.3	66.4
Bulk Cleaner Scav Tail	573.9	14.5	0.08	0.044	11.7	13.3	3	0.22	4.0	20.8	51.2	73.1	17.0	12.2
Pyrite Rougher Conc	221.0	5.6	0.14	0.028	6.4	5.78	2	0.22	2.8	5.1	10.8	12.2	4.9	4.8
Pyrite Rougher Tail	3138.7	79.1	0.02	0.010	1.3	0.08	0.5	0.05	5.7	27.2	30.8	2.4	15.8	16.6

Cycle Test Stability Data

Cycles	Mass		Calculated Head						Metal Unit Variances (%)					
	g/cycle	%Var.	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
I	1921.8	-2.79	0.28	0.025	3.1	2.26	2.38	0.29	-2	-21	-11	-18	1	4
II	1964.8	-0.61	0.28	0.027	3.3	2.57	2.16	0.27	1	-15	-3	-5	-6	0
III	1954.7	-1.12	0.27	0.028	3.5	2.86	2.17	0.25	-2	-10	3	5	-6	-10
IV	1975.6	-0.07	0.27	0.030	3.4	2.61	2.41	0.24	-2	-3	0	-3	5	-11
V	1994.6	0.89	0.27	0.031	3.3	2.64	2.09	0.28	0	0	-3	-1	-8	6
Total	1976.9	-	0.28	0.031	3.4	2.68	2.29	0.27	-	-	-	-	-	-



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CYCLES (IV+V) MASS BALANCE FLOWSHEET AND METALLURGICAL BALANCE DATA

Flotation Stream		Weight	Assay (percent or g/t)						Distribution (percent)					
No.	Product	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
1	Bulk Rougher Feed	100.0	0.27	0.031	3.3	2.63	2	0.26	100.0	100.0	100.0	100.0	100.0	100.0
2	Bulk Rougher Tail	84.6	0.03	0.012	1.6	0.45	1	0.07	8.4	32.3	41.6	14.6	20.7	21.4
3	Bulk Rougher Concentrate	15.4	1.62	0.135	12.6	14.6	12	1.34	91.6	67.7	58.4	85.4	79.3	78.6
4	Bulk 1st Cleaner Feed	19.0	1.38	0.188	12.8	14.7	11	1.24	96.1	117.4	73.8	106.2	92.6	90.1
5	Bulk Cleaner Scav Con	1.0	0.31	0.464	13.7	14.8	7	0.49	0.6	15.4	4.2	5.7	2.9	1.9
6	Bulk Cleaner Scav Tail	14.5	0.08	0.044	11.7	13.3	3	0.22	4.0	20.8	51.2	73.1	17.0	12.2
7	Bulk 1st Clnr Concentrate	3.6	6.98	0.694	17.1	20.2	46	5.56	91.5	81.2	18.4	27.4	72.7	76.0
8	Bulk 2nd Cleaner Tail	2.3	0.29	0.250	13.3	14.3	7	0.64	2.5	19.1	9.4	12.7	6.9	5.7
9	Bulk 2nd Cleaner Concentrate	1.2	19.6	1.53	24.3	31.2	120	14.8	89.1	62.1	9.1	14.7	65.8	70.3
10	Bulk 3rd Cleaner Tail	0.3	1.26	1.47	18.7	20.4	25	3.20	1.5	15.2	1.8	2.5	3.5	3.9
11	Bulk 3rd Cleaner Concentrate	0.9	25.9	1.55	26.2	34.9	152	18.8	87.6	46.9	7.3	12.2	62.3	66.4
12	Pyrite Rougher Conc	5.6	0.14	0.028	6.4	5.78	2	0.22	2.8	5.1	10.8	12.2	4.9	4.8
13	Pyrite Rougher Tail	79.1	0.02	0.010	1.3	0.08	0.5	0.05	5.7	27.2	30.8	2.4	15.8	16.6
14	Total Tail	93.5	0.04	0.017	3.3	2.47	1	0.09	12.4	53.1	92.7	87.8	37.7	33.6

PROJECT NO: KM2721-35

PURPOSE: To Investigate a Finer Primary Grind.

PROCEDURE: Perform a standard two product locked cycle test.

FEED: 5 x 2 kg of Master Composite 1 ore ground to a nominal 142µm K_{80}.
Bulk Regrind Discharge Size - 19µm K_{80}.

FLOWSHEET: 3

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	2900	20				14			10.9
BULK CIRCUIT:									
Rougher 1	90		2	4	23		1	2	11.0
Rougher 2	√		2	4	-		1	2	11.0
Rougher 3	√		2	4	-		1	2	11.0
Rougher 4	√		2	4	8		1	2	11.0
Regrind	500	20				18			11.0
Cleaner 1	0	-	1	2	15		1	5	11.0
Cleaner 2	√	10	1	2	15		1	4	11.0
Cleaner 3	√	10	1	2	15		1	3	11.0
PYRITE CIRCUIT:				PAX					
Rougher 1	0			60			1	6	10.8

Flotation Data	Rougher	Cleaner
Flotation Machine:	D2A	D1B
Cell Size in liters:	4.4	2.2
Aspiration:	Air	
Impeller Speed in rpm:	1100	1200

Grinding Data	Primary Grind	Bulk Regrind
Mill:	M3-Mild	Stirred Mill
Charge/Material:	20kg-Mild	1.2kg-Beads
Water:	1000 ml	estimated

KM2721-35

Estimated Dry Weight Table

Product	Cycles - Weight (gms)				
	I	II	III	IV	V
BULK CIRCUIT					
Rougher Concentrate	300	315	320	320	310
Cleaner Tail 1	270	305	355	375	305
Cleaner Tail 2	42	59	63	58	63
Cleaner Tail 3	9	14	10	8	15
Bulk Concentrate	19	23	23	20	22
PYRITE CIRCUIT					
Rougher Concentrate	90	150	80	95	90
Primary Discharge pH	10.8	10.8	10.8	10.8	10.9

KM2721-35 SUP Composite 2010

OVERALL CYCLE TEST MASS AND METALLURGICAL BALANCE

Product	Weight	Weight	Assay - percent or g/t						Distribution - percent					
	g	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Bulk Concentrate I	17.2	0.2	27.8	1.69	27.7	33.5	153	17.9	16.9	9.2	1.3	2.3	10.9	13.2
Bulk Concentrate II	20.6	0.2	22.6	1.21	30.7	35.0	116	14.2	16.5	7.9	1.7	2.8	9.9	12.5
Bulk Concentrate III	20.3	0.2	25.0	1.73	29.4	35.5	139	17.2	18.0	11.1	1.6	2.8	11.7	15.0
Bulk Concentrate IV	18.4	0.2	26.3	1.93	27.8	34.2	171	18.6	17.1	11.2	1.4	2.5	13.1	14.7
Bulk Concentrate V	19.1	0.2	25.1	1.72	27.6	33.7	138	16.1	17.0	10.4	1.4	2.5	11.0	13.2
Bulk 3rd Cleaner Tail	11.0	0.1	1.22	0.960	16.3	17.6	19	1.00	0.5	3.3	0.5	0.8	0.9	0.5
Bulk 2nd Cleaner Tail	50.5	0.5	0.32	0.243	12.8	13.6	6	0.60	0.6	3.9	1.7	2.7	1.3	1.3
Bulk 1st Cleaner Tail I	230.1	2.3	0.10	0.041	14.4	15.0	3	0.30	0.8	3.0	8.8	13.5	3.1	3.0
Bulk 1st Cleaner Tail II	270.4	2.7	0.09	0.057	10.4	10.5	2	0.32	0.8	4.9	7.5	11.1	2.7	3.7
Bulk 1st Cleaner Tail III	312.7	3.2	0.08	0.030	12.3	12.9	2	0.24	0.9	3.0	10.2	15.8	2.6	3.2
Bulk 1st Cleaner Tail IV	305.8	3.1	0.09	0.055	13.6	13.7	3	0.24	0.9	5.3	11.0	16.4	3.4	3.2
Bulk 1st Cleaner Tail V	276.4	2.8	0.11	0.060	14.2	14.7	3	0.29	1.0	5.2	10.4	15.9	2.9	3.4
Pyrite Rougher Conc I	72.5	0.7	0.11	0.053	6.3	6.23	2	0.18	0.3	1.2	1.2	1.8	0.7	0.6
Pyrite Rougher Conc II	129.1	1.3	0.08	0.069	10.8	10.7	2	0.24	0.4	2.8	3.7	5.4	1.2	1.3
Pyrite Rougher Conc III	61.8	0.6	0.12	0.028	3.2	2.06	2	0.12	0.3	0.5	0.5	0.5	0.4	0.3
Pyrite Rougher Conc IV	79.5	0.8	0.12	0.025	3.7	2.78	2	0.20	0.3	0.6	0.8	0.9	0.7	0.7
Pyrite Rougher Conc V	68.0	0.7	0.11	0.021	3.3	1.90	2	0.20	0.3	0.5	0.6	0.5	0.6	0.6
Pyrite Rougher Tail I	1625.2	16.4	0.02	0.005	1.4	0.07	0.4	0.01	1.2	2.6	6.0	0.4	2.7	0.7
Pyrite Rougher Tail II	1543.5	15.6	0.05	0.009	2.8	0.07	1	0.03	2.5	4.4	11.5	0.4	5.8	2.0
Pyrite Rougher Tail III	1584.2	16.0	0.02	0.007	1.4	0.07	1	0.03	1.1	3.5	6.1	0.4	4.6	2.0
Pyrite Rougher Tail IV	1580.6	16.0	0.02	0.005	1.4	0.06	1	0.03	1.2	2.5	6.0	0.4	5.3	2.0
Pyrite Rougher Tail V	1608.3	16.2	0.02	0.006	1.4	0.07	1	0.04	1.4	3.0	6.1	0.4	4.7	2.8
FEED	9905	100.0	0.28	0.032	3.8	2.58	2	0.23	100.0	100.0	100.0	100.0	100.0	100.0

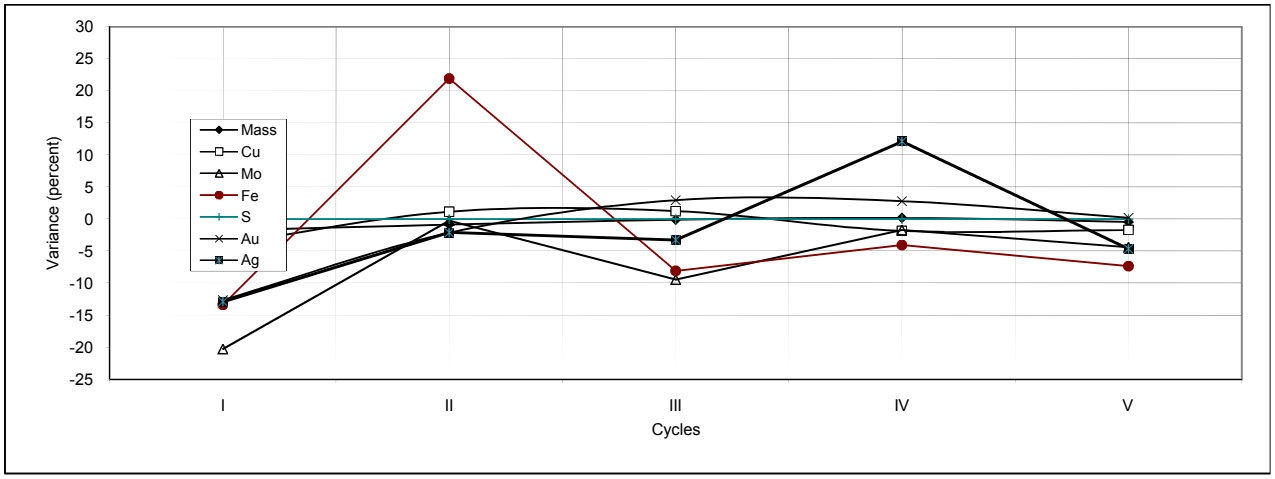
KM2721-35 SUP Composite 2010

METALLURGICAL BALANCES BY TEST CYCLES

Product	Weight	Weight	Assay - percent or g/t						Distribution - percent					
	g	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
CYCLE IV														
Flotation Feed	1984.3	100.0	0.28	0.031	3.64	2.59	3	0.24	100.0	100.0	100.0	100.0	100.0	100.0
Bulk Concentrate	18.4	0.9	26.3	1.93	27.8	34.2	171	18.6	87.3	57.1	7.1	12.3	58.3	71.4
Bulk 1st Cleaner Tail	305.8	15.4	0.09	0.055	13.6	13.7	3	0.24	4.7	27.0	57.6	81.6	15.3	15.3
Pyrite Rougher Conc	79.5	4.0	0.12	0.025	3.7	2.78	2	0.20	1.7	3.2	4.1	4.3	2.9	3.3
Pyrite Rougher Tail	1580.6	79.7	0.02	0.005	1.4	0.06	1	0.03	6.3	12.7	31.3	1.8	23.4	9.9
CYCLE V														
Flotation Feed	1971.8	100.0	0.28	0.031	3.5	2.51	2	0.24	100.0	100.0	100.0	100.0	100.0	100.0
Bulk Concentrate	19.1	1.0	25.1	1.72	27.6	33.7	138	16.1	86.4	54.3	7.6	13.0	57.4	66.1
Bulk 1st Cleaner Tail	276.4	14.0	0.11	0.060	14.2	14.7	3	0.29	5.3	27.4	56.3	82.2	15.1	17.2
Pyrite Rougher Conc	68.0	3.4	0.11	0.021	3.3	1.90	2	0.20	1.3	2.4	3.2	2.6	3.0	2.9
Pyrite Rougher Tail	1608.3	81.6	0.02	0.006	1.4	0.07	1	0.04	7.0	15.9	33.0	2.2	24.5	13.8
CYCLES IV and V														
Flotation Feed	3956.1	100.0	0.28	0.031	3.6	2.55	3	0.24	100.0	100.0	100.0	100.0	100.0	100.0
Bulk Concentrate	37.5	0.9	25.7	1.82	27.7	33.9	154	17.3	86.8	55.7	7.3	12.6	57.9	68.8
Bulk 1st Cleaner Tail	582.2	14.7	0.10	0.057	13.9	14.2	3	0.26	5.0	27.2	56.9	81.9	15.2	16.3
Pyrite Rougher Conc	147.5	3.7	0.12	0.023	3.5	2.37	2	0.20	1.5	2.8	3.6	3.5	3.0	3.1
Pyrite Rougher Tail	3188.9	80.6	0.02	0.006	1.4	0.06	1	0.04	6.6	14.3	32.1	2.0	23.9	11.8

Cycle Test Stability Data

Cycles	Mass		Calculated Head						Metal Unit Variances (%)					
	g/cycle	%Var.	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
I	1945.0	-1.82	0.28	0.026	3.4	2.36	2.16	0.21	-4	-20	-13	-10	-13	-13
II	1963.6	-0.88	0.29	0.032	4.7	2.57	2.40	0.23	1	0	22	-1	-2	-2
III	1979.0	-0.10	0.29	0.029	3.5	2.52	2.35	0.24	1	-9	-8	-3	-3	3
IV	1984.3	0.16	0.28	0.031	3.6	2.59	2.72	0.24	-2	-2	-4	0	12	3
V	1971.8	-0.47	0.28	0.031	3.5	2.51	2.33	0.24	-2	-4	-7	-3	-5	0
Total	1981	-	0.28	0.032	3.8	2.58	2.43	0.23	-	-	-	-	-	-



KM2721-35 SUP Composite 2010

CYCLES (IV+V) MASS BALANCE FLOWSHEET AND METALLURGICAL BALANCE DATA

Flotation Stream		Weight	Assay (percent or g/t)						Distribution (percent)					
No.	Product	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
1	Bulk Rougher Feed	100.0	0.28	0.031	3.6	2.55	3	0.24	100.0	100.0	100.0	100.0	100.0	100.0
2	Bulk Rougher Tail	84.3	0.02	0.006	1.4	0.06	1	0.04	8.2	17.1	35.8	5.5	26.9	15.0
3	Bulk Rougher Concentrate	15.7	1.64	0.164	14.7	15.4	12	1.30	91.8	82.9	64.2	94.5	73.1	85.0
4	Bulk 1st Cleaner Feed	18.8	1.45	0.199	14.5	15.2	11	1.19	97.2	120.2	75.9	112.1	83.6	93.8
5	Bulk 1st Cleaner Tail	14.7	0.10	0.057	13.9	14.2	3	0.26	5.0	27.2	56.9	81.9	15.2	16.3
6	Bulk 1st Clnr Concentrate	4.1	6.35	0.710	16.8	18.9	42	4.55	92.2	93.0	19.0	30.2	68.4	77.6
7	Bulk 2nd Cleaner Tail	2.6	0.32	0.243	12.8	13.6	6	0.60	2.9	20.1	9.1	13.7	6.3	6.4
8	Bulk 2nd Cleaner Concentrate	1.5	16.6	1.50	23.5	27.9	104	11.3	89.2	73.0	9.8	16.5	62.1	71.1
9	Bulk 3rd Cleaner Tail	0.6	1.22	0.960	16.3	17.6	19	1.00	2.4	17.3	2.5	3.9	4.2	2.3
10	Bulk 3rd Cleaner Concentrate	0.9	25.7	1.82	27.7	33.9	154	17.3	86.8	55.7	7.3	12.6	57.9	68.8
11	Pyrite Rougher Conc	3.7	0.12	0.023	3.5	2.37	2	0.20	1.5	2.8	3.6	3.5	3.0	3.1
12	Pyrite Rougher Tail	80.6	0.02	0.006	1.4	0.06	1	0.04	6.6	14.3	32.1	2.0	23.9	11.8
13	Total Tail	95.3	0.03	0.014	3.4	2.24	1	0.07	11.7	41.5	89.0	83.9	39.1	28.1

PROJECT NO: KM2721-36

PURPOSE: To Investigate a Coarser Regrind in a Locked Cycle Test.

PROCEDURE: Perform a standard two product locked cycle test.

FEED: 5 x 2 kg of SUP Composite 1 ore ground to a nominal 222µm K_{80}.
Bulk Regrind Discharge Size - 37µm K_{80}.

FLOWSHEET: 3

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	2900	20				10			10.6
BULK CIRCUIT:									
Rougher 1	400		2	4	15		1	2	11.0
Rougher 2	√		2	4	-		1	2	11.0
Rougher 3	√		2	4	8		1	2	11.0
Rougher 4	√		2	4	-		1	2	11.0
Regrind	500	20				6			11.0
Cleaner 1	0	-	1	2	15		1	4	11.0
Cleaner 2	√	10	1	2	15		1	3	11.0
Cleaner 3	√	10	1	2	15		1	2	11.0
PYRITE CIRCUIT:			PAX						
Rougher 1	0		60		8		1	6	10.7

Flotation Data	Rougher	Cleaner
Flotation Machine:	D2A	D1E
Cell Size in liters:	4.4	2.2
Aspiration:	Air	
Impeller Speed in rpm:	1100	1200

Grinding Data	Primary Grind	Bulk Regrind
Mill:	M3-Mild	Stirred Mill
Charge/Material:	20kg-Mild	1.2kg-Beads
Water:	1000 ml	estimated

KM2721-36

Estimated Dry Weight Table

Product	Cycles - Weight (gms)				
	I	II	III	IV	V
BULK CIRCUIT					
Rougher Concentrate	300	305	305	310	315
Cleaner Tail 1	285	285	290	305	325
Cleaner Tail 2	25	42	38	48	37
Cleaner Tail 3	6	5	7	10	6
Bulk Concentrate	25	28	26	27	26
PYRITE CIRCUIT					
Rougher Concentrate	115	130	165	135	130
Primary Discharge pH	10.9	10.6	10.6	10.8	10.6

KM2721-36 SUP Composite 2010

OVERALL CYCLE TEST MASS AND METALLURGICAL BALANCE

Product	Weight	Weight	Assay - percent or g/t						Distribution - percent					
	g	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Bulk Concentrate I	25.5	0.3	18.8	1.35	30.5	38.9	98	10.7	16.7	10.5	2.1	3.8	12.2	12.0
Bulk Concentrate II	28.7	0.3	17.0	1.40	31.5	39.2	80	9.45	17.0	12.3	2.5	4.3	11.2	11.9
Bulk Concentrate III	25.8	0.3	18.5	1.31	32.0	38.0	106	11.0	16.7	10.3	2.3	3.8	13.3	12.4
Bulk Concentrate IV	24.1	0.2	17.8	1.43	31.1	37.3	92	13.1	15.0	10.5	2.0	3.4	10.8	13.8
Bulk Concentrate V	26.2	0.3	18.8	1.37	30.4	37.6	96	10.1	17.3	11.0	2.2	3.8	12.2	11.6
Bulk 3rd Cleaner Tail*	4.2	0.0	1.88	1.09	16.1	16.9	13	0.99	0.3	1.4	0.2	0.3	0.3	0.2
Bulk 2nd Cleaner Tail	26.0	0.3	0.62	0.329	11.2	10.9	10	0.99	0.6	2.6	0.8	1.1	1.2	1.1
Bulk 1st Cleaner Tail I	256.2	2.6	0.09	0.016	13.8	14.2	2	0.29	0.8	1.3	9.6	13.9	2.7	3.3
Bulk 1st Cleaner Tail II	260.8	2.6	0.13	0.036	12.2	12.5	4	0.30	1.1	2.9	8.7	12.5	4.6	3.4
Bulk 1st Cleaner Tail III	263.3	2.7	0.13	0.041	12.0	11.3	4	0.27	1.2	3.3	8.6	11.4	4.6	3.1
Bulk 1st Cleaner Tail IV	287.0	2.9	0.13	0.041	12.7	12.6	4	0.32	1.3	3.6	9.9	13.8	4.9	4.0
Bulk 1st Cleaner Tail V	297.0	3.0	0.14	0.047	11.8	12.1	3	0.30	1.5	4.3	9.6	13.8	4.2	3.9
Pyrite Rougher Conc I	106.8	1.1	0.12	0.027	2.7	1.54	1	0.12	0.5	0.9	0.8	0.6	0.7	0.6
Pyrite Rougher Conc II	124.4	1.3	0.11	0.018	5.3	5.17	2	0.18	0.5	0.7	1.8	2.5	1.0	1.0
Pyrite Rougher Conc III	152.1	1.5	0.11	0.023	8.3	6.69	2	0.20	0.6	1.1	3.4	3.9	1.3	1.3
Pyrite Rougher Conc IV	124.0	1.3	0.13	0.028	4.3	3.16	1	0.14	0.5	1.1	1.5	1.5	0.8	0.8
Pyrite Rougher Conc V	117.0	1.2	0.13	0.027	6.1	6.80	2	0.26	0.5	1.0	1.9	3.0	1.2	1.3
Pyrite Rougher Tail I	1564.4	15.8	0.03	0.008	1.5	0.09	0.4	0.07	1.6	3.8	6.3	0.5	3.0	4.8
Pyrite Rougher Tail II	1551.4	15.7	0.03	0.009	1.4	0.09	0.3	0.04	1.5	4.3	5.8	0.5	2.3	2.7
Pyrite Rougher Tail III	1533.0	15.5	0.03	0.010	1.4	0.09	0.3	0.04	1.6	4.4	5.9	0.5	2.2	2.7
Pyrite Rougher Tail IV	1526.6	15.5	0.03	0.008	1.9	0.09	0.4	0.03	1.5	3.7	7.9	0.5	3.0	2.0
Pyrite Rougher Tail V	1551.8	15.7	0.03	0.011	1.5	0.09	0.3	0.03	1.6	5.2	6.3	0.6	2.3	2.0
FEED	9876	100.0	0.29	0.033	3.7	2.64	2	0.23	100.0	100.0	100.0	100.0	100.0	100.0

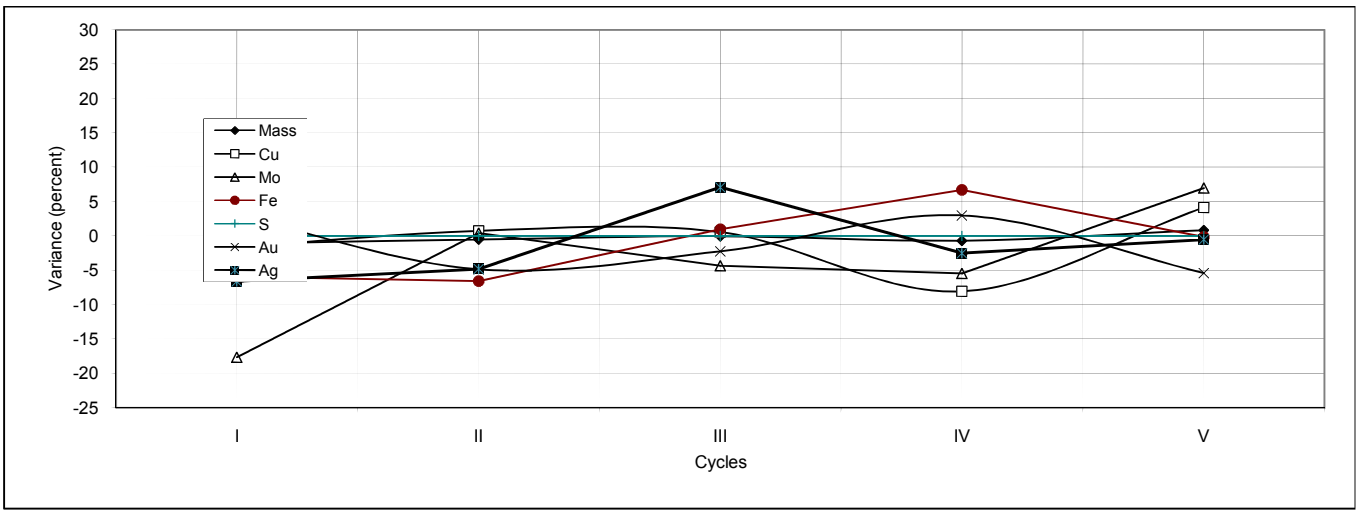
KM2721-36 SUP Composite 2010

METALLURGICAL BALANCES BY TEST CYCLES

Product	Weight	Weight	Assay - percent or g/t						Distribution - percent					
	g	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
CYCLE IV														
Flotation Feed	1961.7	100.0	0.27	0.032	4.0	2.57	2	0.24	100.0	100.0	100.0	100.0	100.0	100.0
Bulk Concentrate	24.1	1.2	17.8	1.43	31.1	37.3	92	13.1	81.7	55.7	9.6	17.8	55.3	67.0
Bulk 1st Cleaner Tail	287.0	14.6	0.13	0.041	12.7	12.6	4	0.32	7.2	19.0	46.6	71.7	25.1	19.6
Pyrite Rougher Conc	124.0	6.3	0.13	0.028	4.3	3.16	1	0.14	3.0	5.6	6.8	7.8	4.3	3.7
Pyrite Rougher Tail	1526.6	77.8	0.03	0.008	1.9	0.09	0.4	0.03	8.1	19.7	37.1	2.7	15.2	9.7
CYCLE V														
Flotation Feed	1992.0	100.0	0.30	0.035	3.7	2.77	2	0.22	100.0	100.0	100.0	100.0	100.0	100.0
Bulk Concentrate	26.2	1.3	18.8	1.37	30.4	37.6	96	10.1	82.8	51.2	10.9	17.8	61.5	61.5
Bulk 1st Cleaner Tail	297.0	14.9	0.14	0.047	11.8	12.1	3	0.30	7.0	19.9	47.8	65.1	21.1	20.6
Pyrite Rougher Conc	117.0	5.9	0.13	0.027	6.1	6.80	2	0.26	2.6	4.5	9.7	14.4	6.0	7.1
Pyrite Rougher Tail	1551.8	77.9	0.03	0.011	1.5	0.09	0.3	0.03	7.6	24.4	31.6	2.6	11.4	10.8
CYCLES IV and V														
Flotation Feed	3953.7	100.0	0.28	0.033	3.8	2.67	2	0.23	100.0	100.0	100.0	100.0	100.0	100.0
Bulk Concentrate	50.3	1.3	18.3	1.40	30.7	37.5	94	11.5	82.3	53.3	10.2	17.8	58.5	64.4
Bulk 1st Cleaner Tail	584.0	14.8	0.14	0.044	12.2	12.3	3	0.31	7.1	19.5	47.2	68.3	23.1	20.1
Pyrite Rougher Conc	241.0	6.1	0.13	0.028	5.2	4.93	2	0.20	2.8	5.0	8.2	11.2	5.2	5.3
Pyrite Rougher Tail	3078.4	77.9	0.03	0.010	1.7	0.09	0.3	0.03	7.8	22.2	34.4	2.6	13.3	10.2

Cycle Test Stability Data

Cycles	Mass		Calculated Head						Metal Unit Variances (%)					
	g/cycle	%Var.	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
I	1952.9	-1.13	0.29	0.028	3.5	2.5	2	0.24	-2	-18	-6	-6	-7	3
II	1965.3	-0.50	0.29	0.033	3.5	2.6	2	0.22	1	0	-7	-1	-5	-5
III	1974.2	-0.05	0.29	0.032	3.8	2.6	2	0.23	1	-4	1	-2	7	-2
IV	1961.7	-0.69	0.27	0.032	4.0	2.6	2	0.24	-8	-5	7	-3	-3	3
V	1992.0	0.85	0.30	0.035	3.7	2.8	2	0.22	4	7	0	6	-1	-5
Total	1975.26	-	0.29	0.033	3.7	2.6	2	0.23	-	-	-	-	-	-



KM2721-36 SUP Composite 2010

CYCLES (IV+V) MASS BALANCE FLOWSHEET AND METALLURGICAL BALANCE DATA

Flotation Stream		Weight	Assay (percent or g/t)						Distribution (percent)					
No.	Product	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
1	Bulk Rougher Feed	100.0	0.28	0.033	3.8	2.67	2	0.23	100.0	100.0	100.0	100.0	100.0	100.0
2	Bulk Rougher Tail	84.0	0.03	0.010	1.7	0.09	0.3	0.03	10.6	27.2	42.6	13.9	18.5	15.5
3	Bulk Rougher Concentrate	16.0	1.58	0.151	13.7	14.3	10	1.20	89.4	72.8	57.4	86.1	81.5	84.5
4	Bulk 1st Cleaner Feed	17.6	1.51	0.176	13.6	14.1	10	1.18	93.7	92.5	62.1	92.8	88.9	91.0
5	Bulk 1st Cleaner Tail	14.8	0.14	0.044	12.2	12.3	3	0.31	7.1	19.5	47.2	68.3	23.1	20.1
6	Bulk 1st Clnr Concentrate	2.8	8.79	0.875	20.5	23.5	48	5.80	86.6	73.0	14.9	24.5	65.9	71.0
7	Bulk 2nd Cleaner Tail	1.3	0.62	0.329	11.2	10.9	10	0.99	2.9	12.9	3.8	5.3	6.1	5.7
8	Bulk 2nd Cleaner Concentrate	1.5	16.0	1.35	28.7	34.5	83	10.0	83.7	60.2	11.1	19.2	59.8	65.3
9	Bulk 3rd Cleaner Tail	0.2	1.88	1.09	16.1	16.9	13	0.99	1.4	6.9	0.9	1.3	1.4	0.9
10	Bulk 3rd Cleaner Concentrate	1.3	18.3	1.40	30.7	37.5	94	11.5	82.3	53.3	10.2	17.8	58.5	64.4
11	Pyrite Rougher Conc	6.1	0.13	0.028	5.2	4.93	2	0.20	2.8	5.0	8.2	11.2	5.2	5.3
12	Pyrite Rougher Tail	77.9	0.03	0.010	1.7	0.09	0.3	0.03	7.8	22.2	34.4	2.6	13.3	10.2
13	Total Tail	92.6	0.05	0.015	3.4	2.04	1	0.07	15.0	41.7	81.6	70.9	36.3	30.3

PROJECT NO: KM2721-37

PURPOSE: To Repeat Test 36 With a Cleaner Scavenger Circuit.

PROCEDURE: Perform a standard two product locked cycle test.

FEED: 5 x 2 kg of SUP Composite 1 ore ground to a nominal 222µm K_{80}.
Bulk Regrind Discharge Size - 31µm K_{80}.

FLOWSHEET: 3

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	2900	20				10			11.0
BULK CIRCUIT:									
Rougher 1	-		2	4	8			2	11.0
Rougher 2	√		2	4	8			2	11.0
Rougher 3	-		2	4	-			2	11.0
Rougher 4	√		2	4	-			2	11.0
Regrind	500	20				6			11.0
Cleaner 1	0		1	2	15		1	4	11.0
Cleaner 2	√	10	1	2	15		1	3	11.0
Cleaner 3	√	10	1	2	15		1	2	11.0
Cleaner Scavenger	0	20			0		1	2	11.0
PYRITE CIRCUIT:			PAX						
Rougher 1			60		8		1	6	10.8

Flotation Data	Rougher	Cleaner
Flotation Machine:	D2D	D1E
Cell Size in liters:	4.4	2.2
Aspiration:	Air	
Impeller Speed in rpm:	1100	1200

Grinding Data	Primary Grind	Bulk Regrind
Mill:	M3-Mild	Stirred Mill
Charge/Material:	20kg-Mild	1.2kg-Beads
Water:	1000 ml	estimated

KM2721-37

Estimated Dry Weight Table

Product	Cycles - Weight (gms)				
	I	II	III	IV	V
BULK CIRCUIT					
Rougher Concentrate	275	300	290	305	350
Cleaner Scavenger Con	25	32	32	33	27
Cleaner Scavenger Tail	240	300	310	345	380
Cleaner Tail 2	24	43	53	56	48
Cleaner Tail 3	4	6	9	8	8
Bulk Concentrate	23	28	22	23	23
PYRITE CIRCUIT					
Rougher Concentrate	110	115	145	110	120
Primary Discharge pH	11.0	11.0	11.0	11.0	11.0

KM2721-37 SUP Composite 2010

OVERALL CYCLE TEST MASS AND METALLURGICAL BALANCE

Product	Weight	Weight	Assay - percent or g/t						Distribution - percent					
	g	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Bulk Concentrate I	21.9	0.2	17.9	1.53	31.6	38.4	84	10.1	14.5	10.6	2.0	3.3	8.5	11.1
Bulk Concentrate II	28.3	0.3	16.0	1.58	32.6	40.0	88	8.55	16.8	14.1	2.7	4.5	11.5	12.1
Bulk Concentrate III	20.2	0.2	23.0	1.99	30.4	36.5	124	13.7	17.3	12.7	1.8	2.9	11.6	13.8
Bulk Concentrate IV	21.4	0.2	21.2	1.41	31.1	37.8	112	11.7	16.8	9.5	1.9	3.2	11.1	12.6
Bulk Concentrate V	22.3	0.2	20.8	1.65	31.3	38.0	116	11.7	17.2	11.6	2.0	3.3	11.9	13.1
Bulk 3rd Cleaner Tail*	4.8	0.1	1.77	0.960	18.9	20.5	28	0.93	0.3	1.5	0.3	0.4	0.6	0.2
Bulk 2nd Cleaner Tail	36.8	0.4	0.59	0.312	11.7	11.4	10	0.93	0.8	3.6	1.2	1.7	1.6	1.7
Bulk Cleaner Scav Con	20.3	0.2	0.61	0.485	14.8	14.8	11	0.81	0.5	3.1	0.9	1.2	1.0	0.8
Bulk Cleaner Scav Tail I	210.6	2.2	0.11	0.014	13.2	12.7	3	0.18	0.8	0.9	8.0	10.5	2.4	1.9
Bulk Cleaner Scav Tail II	261.3	2.7	0.09	0.009	12.8	11.7	2	0.20	0.9	0.7	9.7	12.0	2.8	2.6
Bulk Cleaner Scav Tail III	261.8	2.7	0.08	0.010	10.4	9.83	2	0.16	0.8	0.8	7.9	10.1	2.4	2.1
Bulk Cleaner Scav Tail IV	298.5	3.1	0.09	0.026	10.5	10.0	2	0.18	1.0	2.5	9.1	11.7	3.2	2.7
Bulk Cleaner Scav Tail V	337.9	3.5	0.08	0.029	11.5	11.5	2	0.14	1.0	3.1	11.2	15.3	3.1	2.4
Pyrite Rougher Conc I	96.3	1.0	0.09	0.019	3.7	2.96	1	0.17	0.3	0.6	1.0	1.1	0.6	0.8
Pyrite Rougher Conc II	106.9	1.1	0.12	0.020	4.9	5.75	2	0.22	0.5	0.7	1.5	2.4	1.0	1.2
Pyrite Rougher Conc III	136.9	1.4	0.12	0.034	11.8	11.8	3	0.24	0.6	1.5	4.7	6.4	1.7	1.6
Pyrite Rougher Conc IV	100.7	1.1	0.13	0.032	13.8	14.9	3	0.28	0.5	1.0	4.0	5.9	1.3	1.4
Pyrite Rougher Conc V	107.4	1.1	0.15	0.027	3.8	3.63	2	0.20	0.6	0.9	1.2	1.5	0.9	1.1
Pyrite Rougher Tail I	1330.0	13.9	0.03	0.008	1.3	0.07	3	0.05	1.4	3.4	5.0	0.4	18.4	3.0
Pyrite Rougher Tail II	1554.0	16.2	0.03	0.010	1.4	0.11	0.2	0.04	2.0	4.7	6.1	0.6	1.4	3.4
Pyrite Rougher Tail III	1541.6	16.1	0.03	0.008	1.3	0.08	0.1	0.04	1.8	3.9	5.9	0.5	0.7	3.5
Pyrite Rougher Tail IV	1542.2	16.1	0.03	0.010	1.3	0.09	0.1	0.04	1.9	4.6	5.9	0.5	0.7	3.4
Pyrite Rougher Tail V	1515.1	15.8	0.03	0.008	1.4	0.09	0.2	0.04	1.7	3.8	6.0	0.5	1.4	3.4
FEED	9577	100.0	0.28	0.033	3.6	2.65	2	0.21	100.0	100.0	100.0	100.0	100.0	100.0

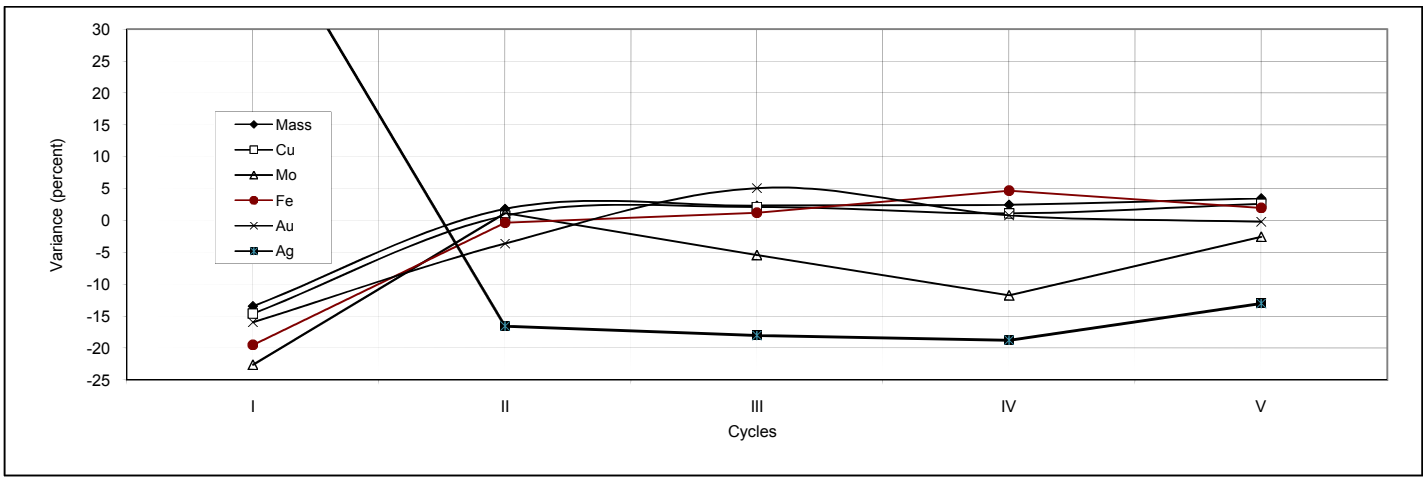
KM2721-37 SUP Composite 2010

METALLURGICAL BALANCES BY TEST CYCLES

Product	Weight	Weight	Assay - percent or g/t						Distribution - percent					
	g	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
CYCLE IV														
Flotation Feed	1962.8	100.0	0.28	0.028	3.69	2.76	2	0.20	100.0	100.0	100.0	100.0	100.0	100.0
Bulk Concentrate	21.4	1.1	21.2	1.41	31.1	37.8	112	11.7	83.2	54.1	9.2	14.9	68.1	62.4
Bulk Cleaner Scav Tail	298.5	15.2	0.09	0.026	10.5	10.0	2	0.18	5.2	13.9	43.3	54.8	19.5	13.6
Pyrite Rougher Conc	100.7	5.1	0.13	0.032	13.8	14.9	3	0.28	2.3	5.8	19.2	27.7	8.0	7.0
Pyrite Rougher Tail	1542.2	78.6	0.03	0.010	1.33	0.09	0.1	0.04	9.4	26.3	28.3	2.6	4.4	17.0
CYCLE V														
Flotation Feed	1982.7	100.0	0.28	0.031	3.56	2.65	2	0.20	100.0	100.0	100.0	100.0	100.0	100.0
Bulk Concentrate	22.3	1.1	20.8	1.65	31.3	38.0	116	11.7	83.9	59.7	9.9	16.1	68.6	65.7
Bulk Cleaner Scav Tail	337.9	17.0	0.08	0.029	11.5	11.5	2	0.14	5.0	15.9	55.1	74.0	17.9	11.9
Pyrite Rougher Conc	107.4	5.4	0.15	0.027	3.79	3.63	2	0.20	2.9	4.7	5.8	7.4	5.4	5.4
Pyrite Rougher Tail	1515.1	76.4	0.03	0.008	1.36	0.09	0.2	0.04	8.2	19.7	29.2	2.5	8.0	17.0
CYCLES IV and V														
Flotation Feed	3945.5	100.0	0.28	0.030	3.62	2.70	2	0.20	100.0	100.0	100.0	100.0	100.0	100.0
Bulk Concentrate	43.7	1.1	21.0	1.53	31.2	37.9	114	11.7	83.5	57.0	9.5	15.5	68.4	64.1
Bulk Cleaner Scav Tail	636.4	16.1	0.09	0.028	11.0	10.8	2	0.16	5.1	15.0	49.1	64.2	18.7	12.8
Pyrite Rougher Conc	208.1	5.3	0.14	0.029	8.63	9.08	2	0.24	2.6	5.2	12.6	17.7	6.7	6.2
Pyrite Rougher Tail	3057.3	77.5	0.03	0.009	1.34	0.09	0.1	0.04	8.8	22.8	28.8	2.5	6.3	17.0

Cycle Test Stability Data

Cycles	Mass		Calculated Head						Metal Unit Variances (%)					
	g/cycle	%Var.	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
I	1658.8	-13.40	0.28	0.029	3.4	2.35	3.9	0.20	-15	-23	-19	-23	50	-16
II	1950.5	1.83	0.28	0.033	3.5	2.55	1.9	0.20	1	1	0	-2	-17	-4
III	1960.5	2.35	0.28	0.031	3.6	2.58	1.8	0.21	2	-5	1	-1	-18	5
IV	1962.8	2.47	0.28	0.028	3.7	2.76	1.8	0.20	1	-12	5	7	-19	1
V	1982.7	3.51	0.28	0.031	3.6	2.65	1.9	0.20	3	-3	2	3	-13	0
Total	1915.4	-	0.28	0.033	3.6	2.65	2.3	0.21	-	-	-	-	-	-



KM2721-37 SUP Composite 2010

CYCLES (IV+V) MASS BALANCE FLOWSHEET AND METALLURGICAL BALANCE DATA

Flotation Stream		Weight	Assay (percent or g/t)						Distribution (percent)					
No.	Product	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
1	Bulk Rougher Feed	100.0	0.28	0.030	3.6	2.70	2	0.20	100.0	100.0	100.0	100.0	100.0	100.0
2	Bulk Rougher Tail	82.8	0.04	0.010	1.8	0.66	0.3	0.06	11.4	28.0	41.3	20.2	12.9	23.2
3	Bulk Rougher Concentrate	17.2	1.43	0.124	12.3	12.5	9	0.90	88.6	72.0	58.7	79.8	87.1	76.8
4	Bulk 1st Cleaner Feed	20.4	1.30	0.169	12.5	12.6	10	0.90	95.0	115.9	70.1	95.0	106.5	90.5
5	Bulk Cleaner Scav Con	1.0	0.61	0.485	14.8	14.8	11	0.81	0.9	16.7	4.2	5.6	6.2	4.1
6	Bulk Cleaner Scav Tail	16.1	0.09	0.028	11.0	10.8	2	0.16	5.1	15.0	49.1	64.2	18.7	12.8
7	Bulk 1st Clnr Concentrate	3.2	7.72	0.783	19.0	21.2	47	4.66	89.0	84.3	16.8	25.2	81.7	73.6
8	Bulk 2nd Cleaner Tail	1.9	0.59	0.312	11.7	11.4	10	0.93	3.9	19.5	6.0	7.8	9.6	8.5
9	Bulk 2nd Cleaner Concentrate	1.3	17.5	1.430	29.0	34.8	99	9.79	85.1	64.8	10.8	17.4	72.0	65.2
10	Bulk 3rd Cleaner Tail	0.2	1.77	0.960	18.9	20.5	28	0.93	1.5	7.8	1.3	1.8	3.6	1.1
11	Bulk 3rd Cleaner Concentrate	1.1	21.0	1.532	31.2	37.9	114	11.7	83.5	57.0	9.5	15.5	68.4	64.1
12	Pyrite Rougher Conc	5.3	0.14	0.029	8.6	9.08	2	0.24	2.6	5.2	12.6	17.7	6.7	6.2
13	Pyrite Rougher Tail	77.5	0.03	0.009	1.3	0.09	0.1	0.04	8.8	22.8	28.8	2.5	6.3	17.0
14	Total Tail	93.6	0.05	0.014	3.5	2.44	1	0.08	16.5	43.0	90.5	84.5	31.6	35.9

PROJECT NO: KM2721-38

PURPOSE: To Produce Products for Environmental Analysis.

PROCEDURE: Perform a standard two product cleaner test.

FEED: 10 x 2 kg of SUP Composite 2010 ore ground to a nominal 222µm K_{80}.
Bulk Regrind Discharge - 17µm K_{80}.

FLOWSHEET: 2

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	3250	20				10			10.8
BULK CIRCUIT:									
Rougher 1	180		2	4	23		1	2	11.0
Rougher 2	√		2	4	-		1	2	11.0
Rougher 3	√		2	4	-		1	2	11.0
Rougher 4	√		2	4	-		1	2	11.0
Regrind	500	20				18			10.7
Cleaner 1	50	-	1	2	15		1	5	11.0
Cleaner 2	√	10	1	2	15		1	4	11.0
Cleaner 3	√	10	1	2	15		1	3	11.0
Cleaner Scavenger	√	20			15		1	2	11.0
PYRITE CIRCUIT:			PAX						
Rougher 1	0		60		8		1	6	10.8

Flotation Data	Rougher	Cleaner
Flotation Machine:	D2A	D1B
Cell Size in liters:	4.4	2.2
Aspiration:	Air	
Impeller Speed in rpm:	1100	1200

Grinding Data	Primary Grind	Bulk Regrind
Mill:	M3-Mild	Stirred Mill
Charge/Material:	20kg-Mild	1.2kg-Beads
Water:	1000 ml	estimated

KM2721-38 SUP Composite 2010-2

Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t						Distribution - percent					
	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Bulk Con	182.0	0.9	27.0	1.26	25.2	33.4	150	15.6	82.6	33.3	5.9	10.6	57.3	71.9
Bulk 3rd Clnr Tail	16.1	0.1	1.31	1.10	17.5	17.8	11	1.88	0.4	2.6	0.4	0.5	0.4	0.8
Bulk 2nd Clnr Tail	86.4	0.4	0.32	0.307	14.6	14.6	7	0.41	0.5	3.9	1.6	2.2	1.2	0.9
Bulk Clnr Scav Con	34.4	0.2	0.23	0.476	14.1	15.0	6	0.33	0.1	2.4	0.6	0.9	0.4	0.3
Bulk Clnr Scav Tail	2803	14.1	0.09	0.070	11.5	11.4	2	0.16	4.3	28.5	41.8	56.0	14.1	11.3
Pyrite Ro Con	1256	6.3	0.13	0.038	12.9	12.3	3	0.22	2.7	6.9	21.0	27.1	7.1	7.0
Pyrite Ro Tail	15477	78.0	0.04	0.010	1.4	0.10	1	0.02	9.4	22.5	28.7	2.7	19.5	7.8
Feed	19855	100	0.30	0.035	3.9	2.88	2	0.20	100	100	100	100	100	100

KM2721-38 SUP Composite 2010-2

Cumulative Metallurgical Balance

Cumulative	Cum. Weight		Assay - percent or g/t						Distribution - percent					
Product	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Product 1	182.0	0.9	27.0	1.26	25.2	33.4	150	15.6	82.6	33.3	5.9	10.6	57.3	71.9
Product 1 to 2	198.1	1.0	24.9	1.25	24.6	32.1	139	14.5	83.0	35.9	6.3	11.1	57.6	72.7
Product 1 to 3	284.5	1.4	17.4	0.962	21.5	26.8	99	10.2	83.4	39.7	7.9	13.4	58.9	73.6
Product 1 to 4	318.9	1.6	15.6	0.909	20.7	25.5	89	9.17	83.6	42.1	8.6	14.3	59.3	73.9
Product 1 to 5	3122	15.7	1.67	0.156	12.4	12.8	11	1.08	87.9	70.6	50.3	70.2	73.4	85.2
Product 6	1256	6.3	0.13	0.038	12.9	12.3	3	0.22	2.7	6.9	21.0	27.1	7.1	7.0
Product 7	15477	78.0	0.04	0.010	1.4	0.10	1	0.02	9.4	22.5	28.7	2.7	19.5	7.8
Feed	19855	100	0.30	0.035	3.9	2.88	2	0.20	100	100	100	100	100	100

PROJECT NO: KM2721-39

PURPOSE: Investigate a 200μm Primary Grind.

PROCEDURE: Perform a standard one product cleaner test.

FEED: 2 kg of SUP Composite 2010 ore ground to a nominal 185μm K_{80}.
Bulk Regrind Discharge - 14μm K_{80}.

FLOWSHEET: 2

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	3000	20				11			10.5
BULK CIRCUIT:									
Rougher 1	290		2	4	8		1	2	11.0
Rougher 2	√		2	4	8		1	2	11.0
Rougher 3	√		2	4	-		1	2	11.0
Rougher 4	√		2	4	-		1	2	11.0
Regrind	500	20				18			11.0
Cleaner 1	-		1	2	15		1	5	11.0
Cleaner 2	√	10	1	2	15		1	4	11.0
Cleaner 3	√	10	1	2	15		1	3	11.0
Cleaner Scavenger	√	20	-	-	-		1	2	11.0
PYRITE CIRCUIT:				PAX					
Rougher 1				60			1	6	10.6

Flotation Data	Rougher	Cleaner
Flotation Machine:	D2A	D1B
Cell Size in liters:	4.4	2.2
Aspiration:	Air	
Impeller Speed in rpm:	1100	1200

Grinding Data	Primary Grind	Bulk Regrind
Mill:	M3-Mild	Stirred Mill
Charge/Material:	20kg-Mild	1.2kg-Beads
Water:	1000 ml	estimated

KM2721-39 SUP Composite 2010-2

Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t						Distribution - percent					
	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Bulk Con	15.0	0.8	33.2	1.57	24.6	33.1	173	21.6	85.6	40.2	5.0	9.6	56.5	76.8
Bulk 3rd Clnr Tail*	6.0	0.3	0.82	0.730	19.2	19.4	26	0.65	0.8	7.5	1.6	2.2	3.4	0.9
Bulk 2nd Clnr Tail	30.7	1.6	0.28	0.251	18.7	18.5	6	0.65	1.5	13.1	7.8	10.9	3.7	4.7
Bulk Clnr Scav Con	22.4	1.1	0.26	0.331	18.9	18.1	5	0.41	1.0	12.6	5.8	7.8	2.6	2.2
Bulk Clnr Scav Tail	193	9.8	0.08	0.045	17.8	17.6	3	0.10	2.7	14.8	46.8	65.4	13.0	4.6
Pyrite Ro Con	97	4.9	0.09	0.048	2.5	1.17	2	0.14	1.4	7.9	3.3	2.2	3.2	3.2
Pyrite Ro Tail	1608	81.5	0.03	0.001	1.4	0.06	1	0.02	6.9	3.8	29.8	1.9	17.5	7.6
Feed	1972	100	0.29	0.030	3.7	2.64	2	0	100	100	100	100	100	100

*Not enough sample for Au assay, value was estimated.

KM2721-39 SUP Composite 2010-2

Cumulative Metallurgical Balance

Cumulative Product	Cum. Weight		Assay - percent or g/t						Distribution - percent					
	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Product 1	15.0	0.8	33.2	1.57	24.6	33.1	173	21.6	85.6	40.2	5.0	9.6	56.5	76.8
Product 1 to 2	21.0	1.1	23.9	1.33	23.1	29.2	131	15.6	86.5	47.6	6.6	11.8	59.9	77.7
Product 1 to 3	51.7	2.6	9.89	0.689	20.5	22.8	57	6.72	87.9	60.8	14.4	22.7	63.7	82.4
Product 1 to 4	74.1	3.8	6.98	0.581	20.0	21.4	41	4.81	88.9	73.4	20.2	30.5	66.3	84.6
Product 1 to 5	267	13.5	2.00	0.194	18.4	18.7	14	1.41	91.7	88.2	66.9	95.9	79.3	89.2
Product 6	97	4.9	0.09	0.048	2.5	1.17	2	0.14	1.4	7.9	3.3	2.2	3.2	3.2
Product 7	1608	81.5	0.03	0.001	1.4	0.06	1	0.02	6.9	3.8	29.8	1.9	17.5	7.6
Feed	1972	100	0.29	0.030	3.7	2.64	2	0.21	100	100	100	100	100	100

PROJECT NO: KM2721-40

PURPOSE: To Perform a Cyanide Leach on Scavenger Tailings and Pyrite Rougher Concentrate Blend.

PROCEDURE: Standard bottle roll procedure. Agitate on rolls using cyanide and lime.

SAMPLE: 500 g KM2721-34 Pyrite Rougher Concentrate and Bulk Cleaner Scavenger Tailings.

Parameter	Time	Added (g)		Residual (g)		Consumed (g)		pH	Dissolved
	Cum	NaCN	CaO	NaCN	CaO	NaCN	CaO		O_2 (mg/L)
Natural	-	-	-	-	-	-	-	7.3	3.64
Leach 1	2	2.00	0.93	1.39	0.04	0.61	0.89	11.0	7.61
Leach 2	6	0.61	0.12	1.84	0.03	0.16	0.13	11.0	7.04
Leach 3	24	0.16	0.00	1.75	0.00	0.25	0.03	11.0	7.22
Leach 4	48	0.25	0.11	1.76	0.00	0.24	0.11	11.0	7.18
Total	48	3.02	1.16	1.76	0.00	1.26	1.16	-	-

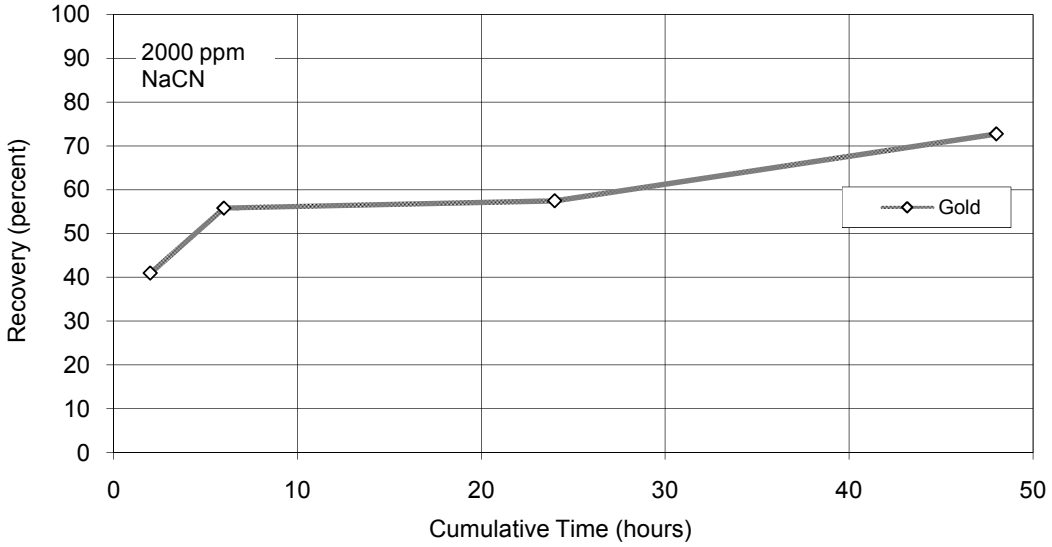
Mass of Sample	500
Volume of Water	1000
Pulp Density	33

NaCN Consumption	2.5 kg/tonne
Lime Consumption	2.3 kg/tonne

KM2721-40 Test 34 Pyrite Rougher Concentrate and Bulk Cleaner Scavenger Tailing
Cumulative Metallurgical Balance

Product	Cumulative Time - Hrs	Volume or Mass	Units	Assay - g/t		Distribution - percent	
				Gold	Copper	Gold	Copper
Cyanide Liquor (2 hr)*	2	1000	ml	0.06	166	41.0	35.7
Cyanide Liquor (6 hr)*	6	1000	ml	0.08	177	55.8	39.2
Cyanide Liquor (24 hr)	24	1000	ml	0.08	195	57.5	44.2
Cyanide Liquor (48 hr)	48	1000	ml	0.10	199	72.8	46.3
Cyanidation Tails	-	499	g	0.08	500	27.2	53.7
Calculated Feed		500	g	0.29	929	100.0	100.0

Cyanide Leach Kinetic Curves



PROJECT NO: KM2721-41

PURPOSE: To Repeat Test 40.

PROCEDURE: Standard bottle roll procedure. Agitate on rolls using cyanide and lime.

SAMPLE: 500 g KM2721-34 Pyrite Rougher Concentrate and Bulk Cleaner Scavenger Tailings.

Parameter	Time	Added (g)		Residual (g)		Consumed (g)		pH	Dissolved
	Cum	NaCN	CaO	NaCN	CaO	NaCN	CaO		O_2 (mg/L)
Natural	-	-	-	-	-	-	-	7.3	3.62
Leach 1	2	2.00	0.96	1.38	0.04	0.62	0.92	11.0	7.39
Leach 2	6	0.62	0.00	1.83	0.02	0.17	0.02	11.0	7.18
Leach 3	24	0.17	0.06	1.76	0.00	0.24	0.08	11.0	7.27
Leach 4	48	0.24	0.15	1.80	0.00	0.20	0.15	11.0	7.15
Total	48	3.03	1.17	1.80	0.00	1.23	1.17	-	-

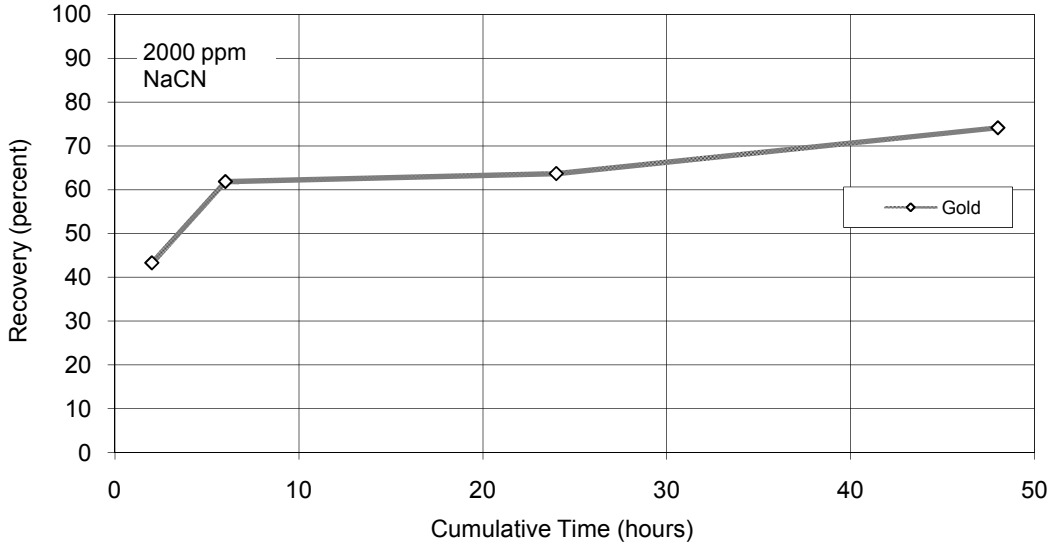
Mass of Sample	500
Volume of Water	1000
Pulp Density	33

NaCN Consumption	2.5 kg/tonne
Lime Consumption	2.3 kg/tonne

KM2721-41
Test 34 Pyrite Rougher Concentrate and Bulk Cleaner Scavenger Tailings
Cumulative Metallurgical Balance

Product	Cumulative Time - Hrs	Volume or Mass	Units	Assay - g/t		Distribution - percent	
				Gold	Copper	Gold	Copper
Cyanide Liquor (2 hr)*	2	1000	ml	0.05	168	43.3	38.4
Cyanide Liquor (6 hr)*	6	1000	ml	0.07	181	61.9	42.5
Cyanide Liquor (24 hr)	24	1000	ml	0.07	199	63.7	47.9
Cyanide Liquor (48 hr)	48	1000	ml	0.08	202	74.2	49.9
Cyanidation Tails	-	498	g	0.06	440	25.8	50.1
Calculated Feed		500	g	0.23	875	100.0	100.0

Cyanide Leach Kinetic Curves



PROJECT NO: KM2721-42

PURPOSE: To Investigate Two Regrind Stages in the Cleaner Circuit.

PROCEDURE: Perform a standard two product cleaner test.

FEED: 2 kg of SUP Composite 2010-2 ore ground to a nominal 222µm K_{80}.
Bulk Regrind Discharge 1 - 97µm K_{80}.
Bulk Regrind Discharge 2 - 21µm K_{80}.

FLOWSHEET: 2

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	2900	20				10			10.4
BULK CIRCUIT:									
Rougher 1	300		2	4	23		1	2	11.0
Rougher 2	√		2	4	-		1	2	11.0
Rougher 3	√		2	4	-		1	2	11.0
Rougher 4	√		2	4	8		1	2	11.0
Regrind 1	250	20				5			11.0
Cleaner 1	25	0	1	2	15		1	5	11.0
Regrind 2	250	10				5			11.4
Cleaner 2	0	10	1	2	24		1	5	11.0
Cleaner 3	√	10	1	2	24		1	4	11.0
Cleaner Scavenger	√	20			15		1	2	11.0
PYRITE CIRCUIT:			PAX						
Rougher 1	0		15		-		1	0.5	10.6
Rougher 2	0		15		8		1	0.5	10.6
Rougher 3	0		10		-		1	1	10.5
Rougher 4	0		10		-		1	2	10.5
Rougher 5	0		10		-		1	2	10.4

Grinding Data	Primary Grind	Bulk Regrind 1	Bulk Regrind 2
Mill:	M3-Mild	Stirred Mill	Stirred Mill
Charge/Material:	20kg-Mild	1.2kg-Beads	1.2kg-Beads
Water:	1000 ml	estimated	estimated

Flotation Data	Rougher	Cleaner
Flotation Machine:	D2A	D1B
Cell Size in liters:	4.4	2.2
Aspiration:	Air	
Impeller Speed in rpm:	1100	1200

KM2721-42 SUP Composite 2010-2

Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t						Distribution - percent					
	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Bulk Con	13.0	0.7	29.9	2.46	25.7	32.8	148	18.5	69.2	50.2	4.5	7.9	33.2	56.0
Bulk 3rd Clnr Tail	9.7	0.5	2.29	0.51	29.6	31.7	21	1.98	4.0	7.8	3.9	5.7	3.5	4.5
Bulk 2nd Clnr Tail	56.3	2.9	0.72	0.14	29.1	31.4	10	1.14	7.2	12.5	22.2	32.7	9.2	15.0
Bulk Clnr Scav Con	14.1	0.7	0.76	0.12	28.8	25.5	10	1.29	1.9	2.6	5.5	6.7	2.4	4.2
Bulk Clnr Scav Tail	207.5	10.6	0.13	0.016	11.6	11.2	3	0.26	4.8	5.2	32.5	43.0	10.4	12.6
Pyrite Ro Con 1	22.6	1.2	0.27	0.018	2.9	1.82	4	0.22	1.1	0.6	0.9	0.8	1.7	1.2
Pyrite Ro Con 2	18.6	0.9	0.28	0.033	2.6	1.80	3	0.22	0.9	1.0	0.6	0.6	0.9	1.0
Pyrite Ro Con 3	23.5	1.2	0.22	0.021	2.1	0.92	5	0.14	0.9	0.8	0.7	0.4	1.9	0.8
Pyrite Ro Con 4	37.4	1.9	0.14	0.020	1.7	0.42	6	0.12	0.9	1.2	0.9	0.3	3.9	1.0
Pyrite Ro Con 5	33.8	1.7	0.10	0.027	1.6	0.29	39	0.02	0.6	1.4	0.7	0.2	22.4	0.2
Pyrite Ro Tail	1524.4	77.7	0.03	0.007	1.3	0.06	0	0.01	8.4	16.7	27.6	1.8	10.5	3.6
Feed	1961	100	0.29	0.032	3.8	2.76	3	0.22	100	100	100	100	100	100

*Not enough sample for Au assay, value was estimated.

KM2721-42 SUP Composite 2010-2

Cumulative Metallurgical Balance

Cumulative Product	Cum. Weight		Assay - percent or g/t						Distribution - percent					
	grams	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Product 1	13.0	0.7	29.9	2.46	25.7	32.8	148	18.5	69.2	50.2	4.5	7.9	33.2	56.0
Product 1 to 2	22.7	1.2	18.1	1.63	27.4	32.3	94	11.4	73.2	58.0	8.4	13.6	36.7	60.5
Product 1 to 3	79.0	4.0	5.71	0.57	28.6	31.7	34	4.09	80.4	70.4	30.6	46.3	45.9	75.5
Product 1 to 4	93.1	4.7	4.96	0.50	28.6	30.7	30	3.67	82.3	73.1	36.0	52.9	48.3	79.8
Product 1 to 5	300.6	15.3	1.63	0.17	16.9	17.2	11	1.32	87.1	78.3	68.6	95.9	58.7	92.4
Product 6	22.6	1.2	0.27	0.018	2.9	1.82	4	0.22	1.1	0.6	0.9	0.8	1.7	1.2
Product 6 to 7	41.2	2.1	0.27	0.025	2.7	1.81	4	0.22	2.0	1.6	1.5	1.4	2.6	2.1
Product 6 to 8	64.7	3.3	0.25	0.023	2.5	1.49	4	0.19	2.9	2.4	2.2	1.8	4.5	2.9
Product 6 to 9	102.1	5.2	0.21	0.022	2.2	1.10	5	0.16	3.9	3.6	3.1	2.1	8.3	3.9
Product 6 to 10	135.9	6.9	0.18	0.023	2.1	0.90	13	0.13	4.5	5.0	3.8	2.3	30.8	4.1
Product 11	1660.3	84.7	0.04	0.008	1.4	0.13	1	0.02	12.9	21.7	31.4	4.1	41.3	7.6
Feed	1961	100	0.29	0.032	3.8	2.76	3	0.22	100	100	100	100	100	100

APPENDIX III – KM2721

PARTICLE SIZING DATA

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TABLE III-1
SCREEN ANALYSIS
KM2721 SUP Composite 2010 - 9 Minute Grind Calibration

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	10.40	89.6
65 Mesh	212	18.60	71.0
100 Mesh	150	13.40	57.6
150 Mesh	106	9.20	48.4
200 Mesh	75	7.80	40.6
270 Mesh	53	6.30	34.3
400 Mesh	38	5.20	29.1
TOTAL		100.00	**

K80 =253µm

Note: 9 min. grind calibration using 2 kg. Ore, 1000 ml water and
20 kg. of Mild Steel rods in Mill: M3

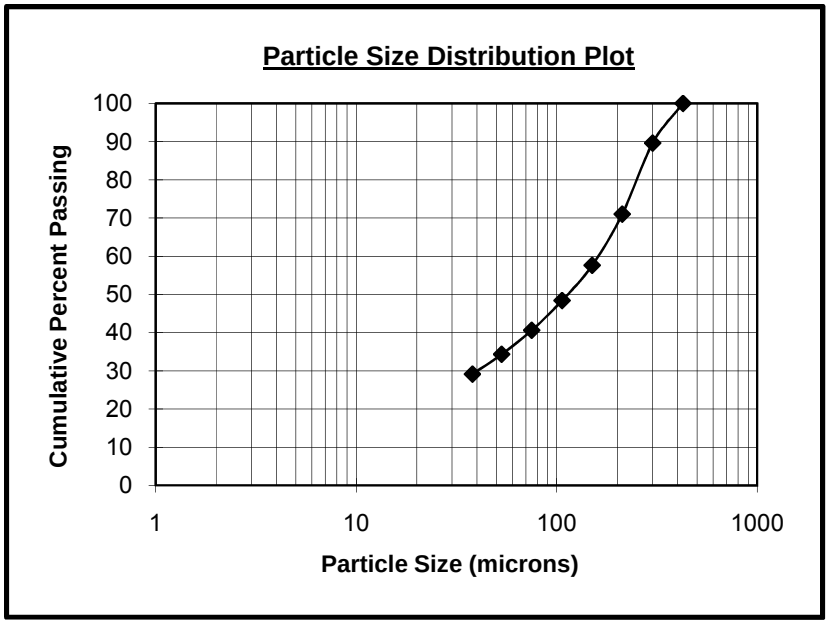


TABLE III-2
SCREEN ANALYSIS
KM2721 SUP Composite 2010 - 10 Minute Grind Calibration

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	4.90	95.1
65 Mesh	212	17.30	77.8
100 Mesh	150	14.20	63.6
150 Mesh	106	11.60	52.0
200 Mesh	75	8.90	43.1
270 Mesh	53	7.30	35.8
400 Mesh	38	6.00	29.8
TOTAL		100.00	**

K80 =222µm

Note: 10 min. grind calibration using 2 kg. Ore, 1000 ml water and
20 kg. of Mild Steel rods in Mill: M4

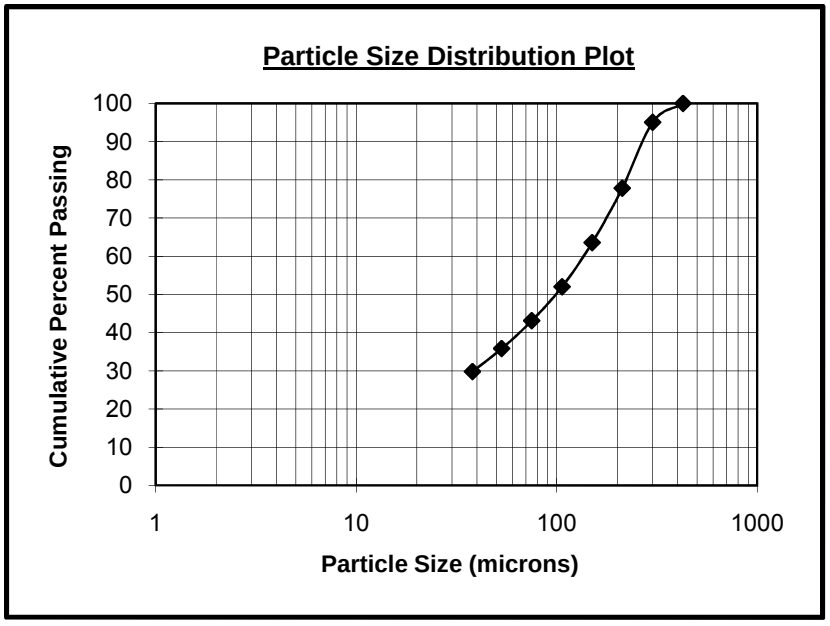


TABLE III-3
SCREEN ANALYSIS
KM2721 SUP Composite 2010 - 12 Minute Grind Calibration

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	0.40	99.6
65 Mesh	212	10.30	89.3
100 Mesh	150	18.20	71.1
150 Mesh	106	13.40	57.7
200 Mesh	75	10.60	47.1
270 Mesh	53	8.40	38.7
400 Mesh	38	6.30	32.4
TOTAL		100.00	**

K80 =179µm

Note: 12 min. grind calibration using 2 kg. Ore, 1000 ml water and
20 kg. of Mild Steel rods in Mill: M4

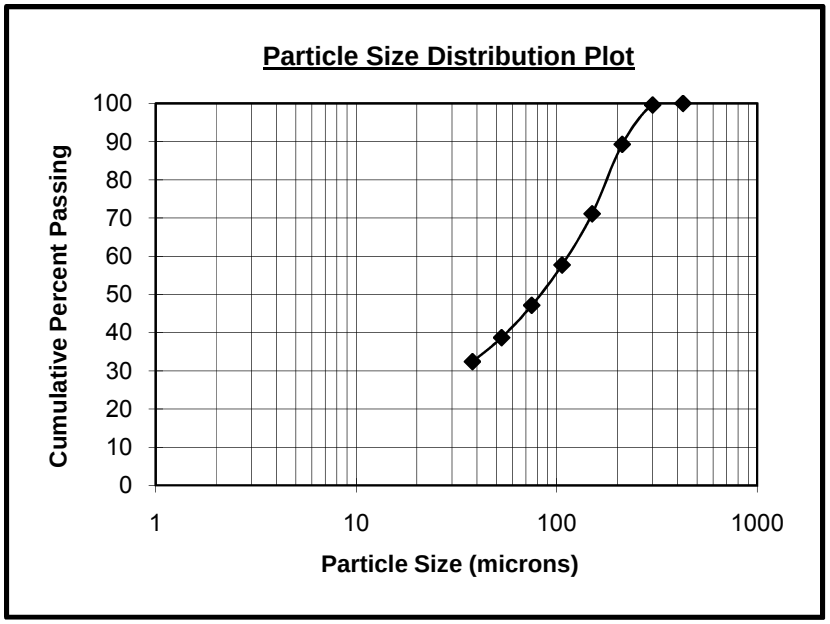


TABLE III-4
CYCLOSIZING ANALYSIS
KM2721 SUP Composite 2010 - 14 Minute Grind Calibration

Product	Size (µm)		Weight % Retained	Cumulative % Passing
	Limiting	Effective		
48 Mesh	300	300	0.00	100.0
65 Mesh	212	212	2.30	97.7
100 Mesh	150	150	14.80	82.9
150 Mesh	106	106	16.80	66.1
200 Mesh	75	75	12.90	53.2
270 Mesh	53	53	8.20	45.0
Cyclone 1	45	44	2.70	42.3
Cyclone 2	31	31	5.00	37.3
Cyclone 3	22	22	6.10	31.2
Cyclone 4	15	15	5.40	25.8
Cyclone 5	12	12	4.20	21.6
Total			100.00	**

Operating Conditions	Measured	Factor
Temperature (°C)	17.20	1.030
Specific Gravity	2.70	0.997
Flow Rate (mm)	180	1.012
Elutriation Time (min)	20	0.955
Overall Factor		0.993
K80 Size (microns)		**142**

Note: 14 min. grind calibration using 2 kg. Ore, 1000 ml water and
20 kg. of Mild Steel rods in Mill: M3

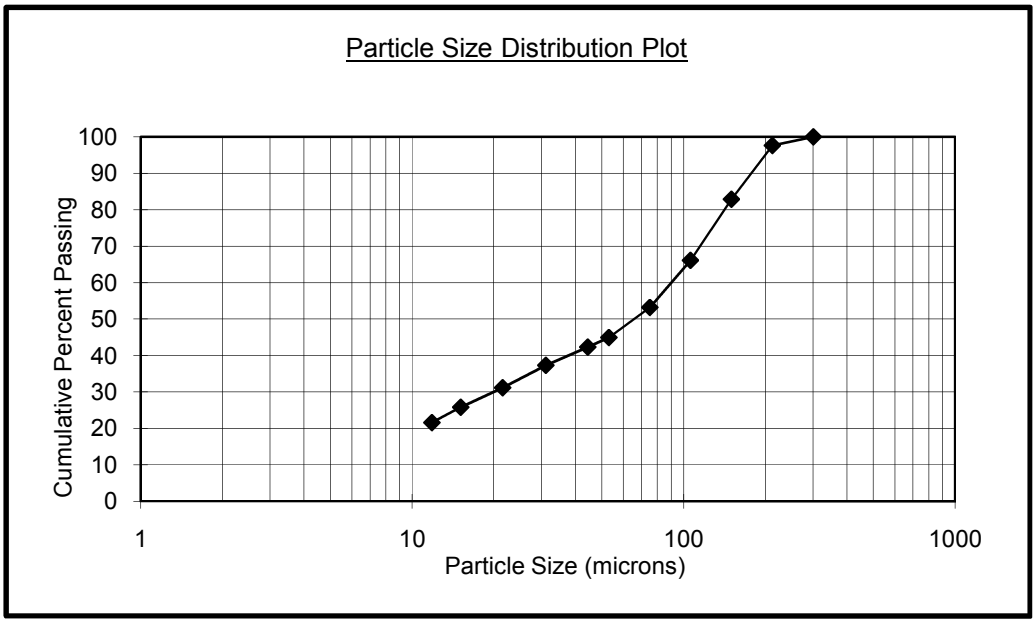


TABLE III-5
CYCLOSIZING ANALYSIS
KM2721-34 Bulk Concentrate I to V

Product	Size (µm)		Weight % Retained	Cumulative % Passing
	Limiting	Effective		
150 Mesh	106	106	0.00	100.0
200 Mesh	75	75	6.50	93.5
270 Mesh	53	53	10.00	83.5
Cyclone 1	50	38	1.50	82.0
Cyclone 2	33	25	2.50	79.5
Cyclone 3	23	17	4.50	75.0
Cyclone 4	16	12	10.50	64.5
Cyclone 5	13	10	11.50	53.0
Total			100.00	**

Operating Conditions	Measured	Factor
Temperature (°C)	8.50	1.165
Specific Gravity	4.56	0.677
Flow Rate (mm)	180	1.012
Elutriation Time (min)	20	0.955
Overall Factor		0.762
K80 Size (microns)		**27**

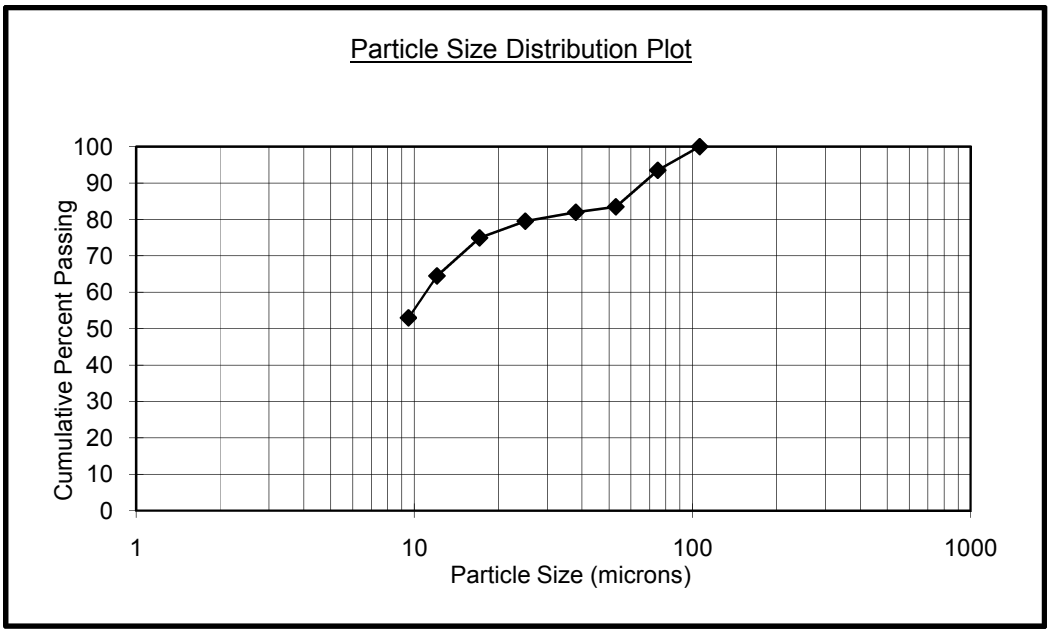


TABLE III-6
CYCLOSIZING ANALYSIS
KM2721-34 Bulk Cleaner Scavenger Tail IV & V

Product	Size (µm)		Weight % Retained	Cumulative % Passing
	Limiting	Effective		
35 Mesh	425	425	0.00	100.0
48 Mesh	300	300	1.30	98.7
65 Mesh	212	212	1.30	97.4
100 Mesh	150	150	1.10	96.3
150 Mesh	106	106	0.70	95.6
200 Mesh	75	75	0.90	94.7
270 Mesh	53	53	0.90	93.8
Cyclone 1	45	48	0.60	93.2
Cyclone 2	31	34	1.40	91.8
Cyclone 3	22	23	4.20	87.6
Cyclone 4	15	16	7.60	80.0
Cyclone 5	12	13	7.60	72.4
Total			100.00	**

Operating Conditions	Measured	Factor
Temperature (°C)	8.50	1.165
Specific Gravity	2.85	0.954
Flow Rate (mm)	180	1.012
Elutriation Time (min)	20	0.955
Overall Factor		1.075
K80 Size (microns)		**16**

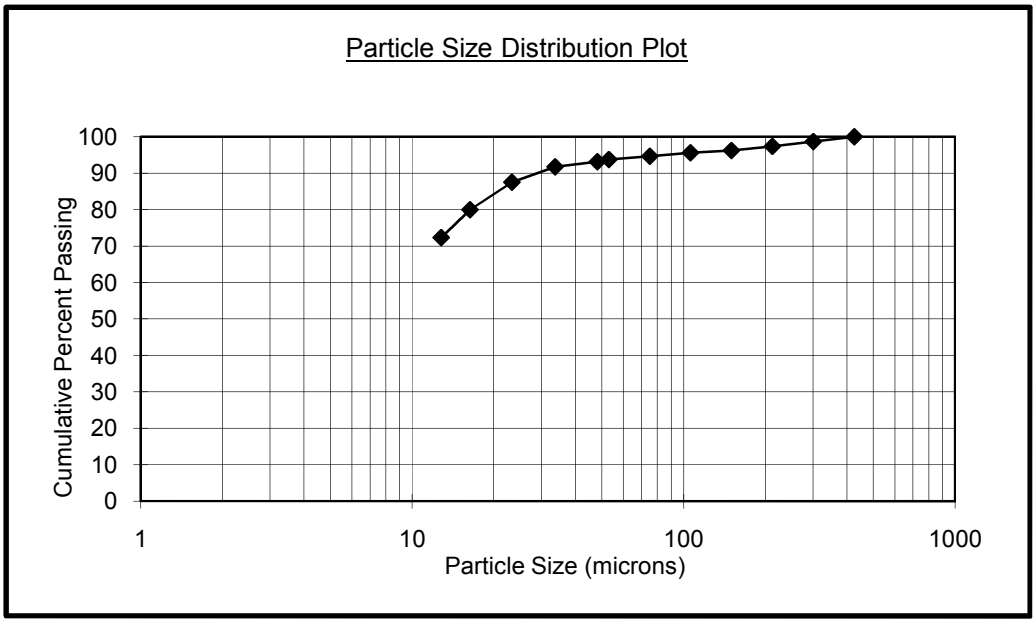


TABLE III-7
CYCLOSIZING ANALYSIS
KM2721-34 Pyrite Rougher Concentrate III & V

Product	Size (µm)		Weight % Retained	Cumulative % Passing
	Limiting	Effective		
35 Mesh	425	425	0.00	100.0
48 Mesh	300	300	8.50	91.5
65 Mesh	212	212	29.10	62.4
100 Mesh	150	150	15.00	47.4
150 Mesh	106	106	7.10	40.3
200 Mesh	75	75	4.00	36.3
270 Mesh	53	53	3.30	33.0
Cyclone 1	50	50	0.90	32.1
Cyclone 2	33	33	1.00	31.1
Cyclone 3	23	23	2.20	28.9
Cyclone 4	16	16	2.60	26.3
Cyclone 5	13	13	2.10	24.2
Total			100.00	**

Operating Conditions	Measured	Factor
Temperature (°C)	8.50	1.165
Specific Gravity	3.11	0.889
Flow Rate (mm)	180	1.012
Elutriation Time (min)	20	0.955
Overall Factor		1.001
K80 Size (microns)		**266**

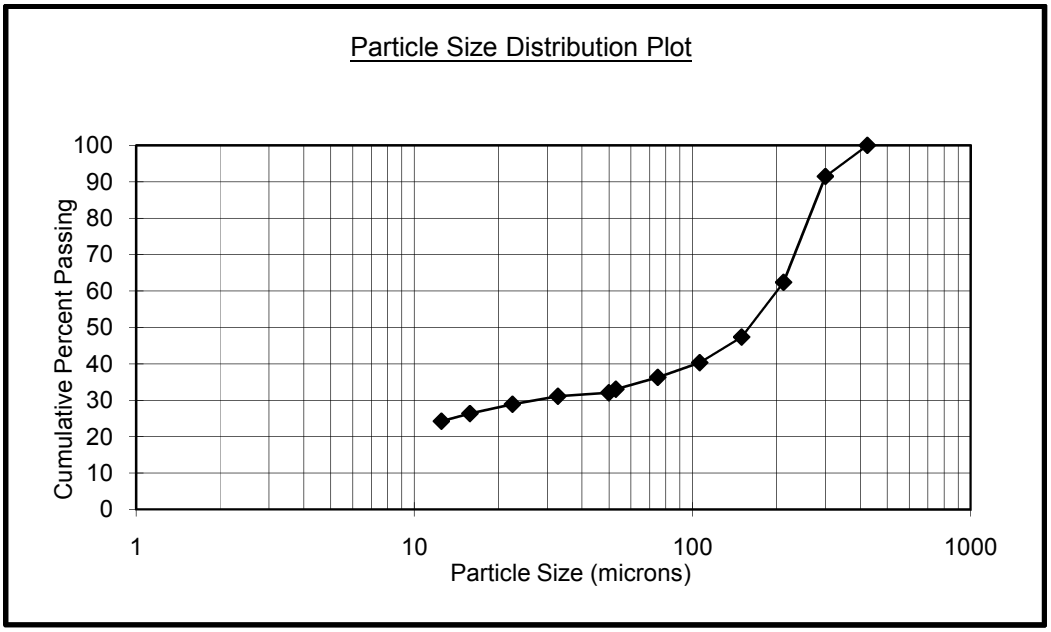


TABLE III-8
CYCLOSIZING ANALYSIS
KM2721-34 Pyrite Rougher Tail IV & V

Product	Size (µm)		Weight % Retained	Cumulative % Passing
	Limiting	Effective		
35 Mesh	425	425	0.00	100.0
48 Mesh	300	300	4.10	95.9
65 Mesh	212	212	16.10	79.8
100 Mesh	150	150	15.50	64.3
150 Mesh	106	106	11.20	53.1
200 Mesh	75	75	9.30	43.8
270 Mesh	53	53	7.40	36.4
Cyclone 1	45	46	0.30	36.1
Cyclone 2	31	32	2.30	33.8
Cyclone 3	22	22	5.30	28.5
Cyclone 4	15	16	4.40	24.1
Cyclone 5	12	12	2.80	21.3
Total			100.00	**

Operating Conditions	Measured	Factor
Temperature (°C)	8.50	1.165
Specific Gravity	3.04	0.906
Flow Rate (mm)	180	1.012
Elutriation Time (min)	20	0.955
Overall Factor		1.021
K80 Size (microns)		**213**

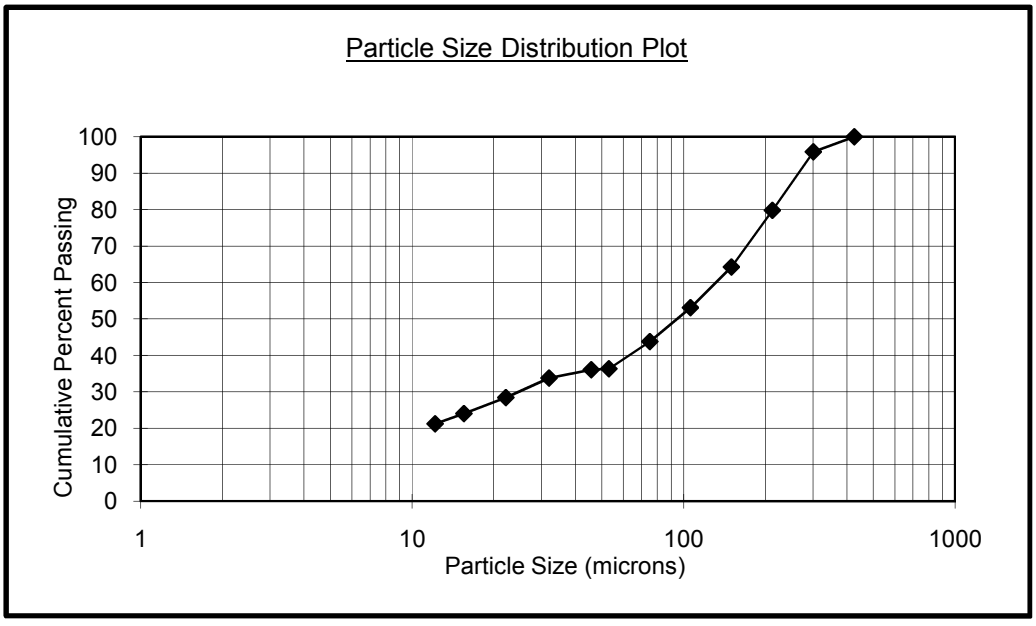


TABLE III-9
SCREEN ANALYSIS
KM2721-34 Pyrite Rougher Tail Cycles IV & V

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	4.60	95.4
65 Mesh	212	16.30	79.1
100 Mesh	150	15.70	63.4
150 Mesh	106	11.20	52.2
200 Mesh	75	9.60	42.6
270 Mesh	53	7.40	35.2
400 Mesh	38	4.90	30.3
TOTAL		100.00	**

K80 =216µm

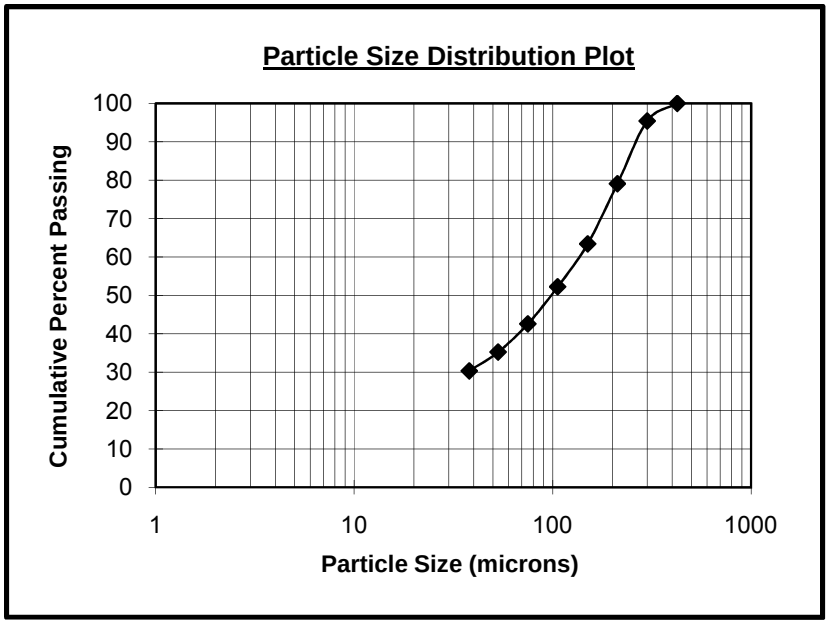
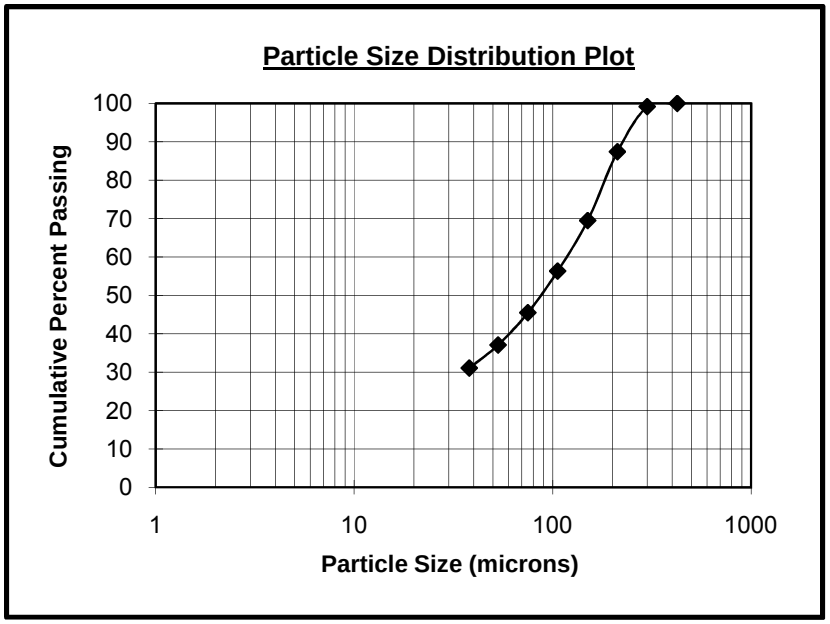


TABLE III-10
SCREEN ANALYSIS
KM2721-39 Pyrite Rougher Tail

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	0.80	99.2
65 Mesh	212	11.80	87.4
100 Mesh	150	17.90	69.5
150 Mesh	106	13.20	56.3
200 Mesh	75	10.80	45.5
270 Mesh	53	8.40	37.1
400 Mesh	38	6.00	31.1
TOTAL		100.00	**

K80 =185µm



G&T METALLURGICAL SERVICES LTD.

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM2721-10

Sample Name:
Bulk Regrind Discharge - Average

Measured by:
Natasha

Edited by:
Natasha

Measured:
Wednesday, September 08, 2010 3:30:12 PM

Analysed:
Wednesday, September 08, 2010 3:30:13 PM

Particle Name:
Silica 0.01

Particle RI:
1.544

Dispersant Name:
Water

Accessory Name:
Hydro 2000MU (A)

Absorption:
0.01

Dispersant RI:
1.330

Analysis model:
General purpose

Size range:
0.100 to 1000.000 um

Weighted Residual:
1.285 %

Sensitivity:
Normal

Obscuration:
18.54 %

Result Emulation:
Off

Concentration:
0.0149 %Vol

Specific Surface Area:
0.367 m²/g

Span :
2.580

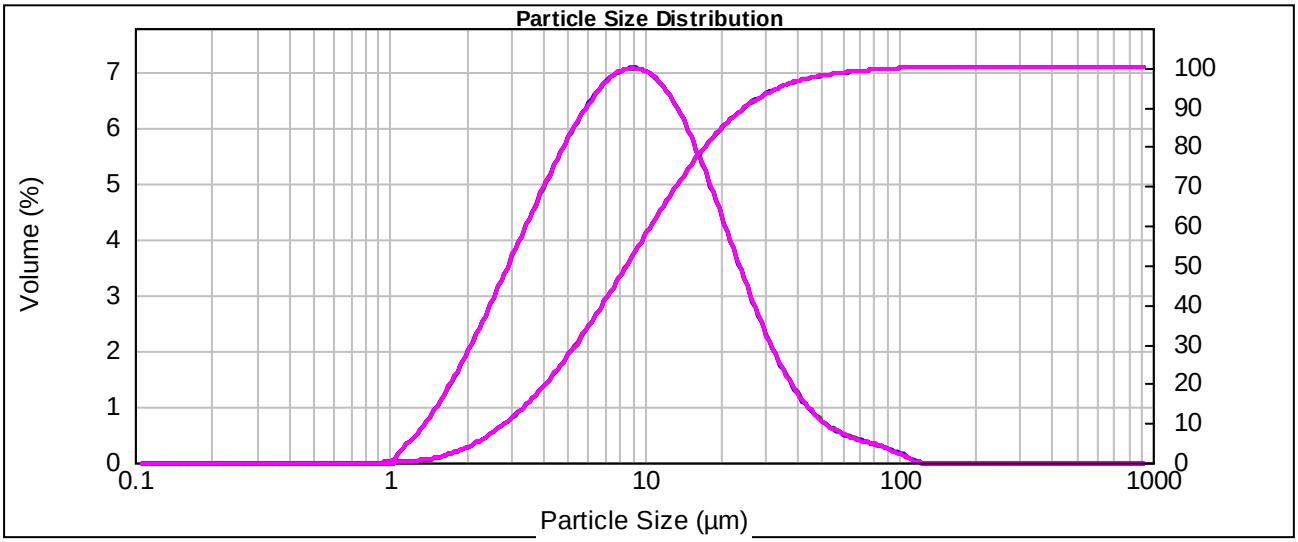
Surface Weighted Mean D[3,2]:
6.168 um

Uniformity:
0.86

Vol. Weighted Mean D[4,3]:
12.215 um

Result units:
Volume

d(0.1): 2.864 um d(0.5): 8.577 um **d(0.8): 17.417 um** d(0.9): 24.992 um d(0.98): 50 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.00
0.437	0.00
0.479	0.00

Size (µm)	Volume In %
0.479	0.00
0.525	0.00
0.575	0.00
0.631	0.00
0.692	0.00
0.759	0.00
0.832	0.00
0.912	0.00
1.000	0.04
1.096	0.17
1.202	0.28
1.318	0.41
1.445	0.57
1.585	0.75
1.738	0.95
1.905	1.15
2.089	1.38
2.291	1.60

Size (µm)	Volume In %
2.291	1.60
2.512	1.84
2.754	2.08
3.020	2.32
3.311	2.57
3.631	2.81
3.981	3.04
4.365	3.27
4.786	3.49
5.248	3.68
5.754	3.86
6.310	4.01
6.918	4.12
7.586	4.20
8.318	4.24
9.120	4.24
10.000	4.19
10.965	4.10

Size (µm)	Volume In %
10.965	4.10
12.023	3.96
13.183	3.77
14.454	3.55
15.849	3.29
17.378	3.00
19.055	2.70
20.893	2.39
22.909	2.09
25.119	1.79
27.542	1.51
30.200	1.26
33.113	1.04
36.308	0.84
39.811	0.68
43.652	0.55
47.863	0.45
52.481	0.37

Size (µm)	Volume In %
52.481	0.37
57.544	0.31
63.096	0.27
69.183	0.23
75.858	0.20
83.176	0.17
91.201	0.12
100.000	0.09
109.648	0.02
120.226	0.00
131.826	0.00
144.544	0.00
158.489	0.00
173.780	0.00
190.546	0.00
208.930	0.00
229.087	0.00
251.189	0.00

Size (µm)	Volume In %
251.189	0.00
275.423	0.00
301.995	0.00
331.131	0.00
363.078	0.00
398.107	0.00
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	0.00

Operator notes:

G&T METALLURGICAL SERVICES LTD.

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM2721-19

Sample Name:
Bulk Regrind Discharge - Average

Measured by:
Hoang

Edited by:
Hoang

Measured:
Wednesday, September 29, 2010 9:12:29 AM

Analysed:
Wednesday, September 29, 2010 9:12:30 AM

Particle Name: Silica 0.1
Particle RI: 1.544
Dispersant Name: Water

Accessory Name: Hydro 2000MU (A)
Absorption: 0.1
Dispersant RI: 1.330

Analysis model: General purpose
Size range: 0.100 to 1000.000 um
Weighted Residual: 0.466 %

Sensitivity: Normal
Obscuration: 19.50 %
Result Emulation: Off

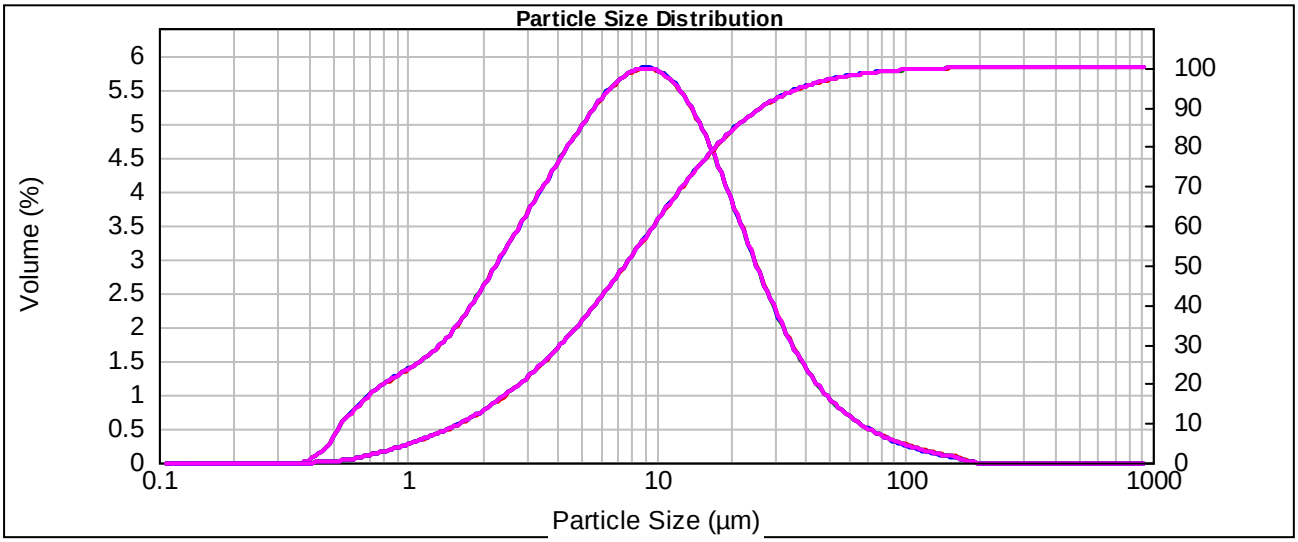
Concentration: 0.0119 %Vol
Specific Surface Area: 0.57 m²/g

Span : 3.329
Surface Weighted Mean D[3,2]: 3.972 um

Uniformity: 1.14
Vol. Weighted Mean D[4,3]: 12.224 um

Result units: Volume

d(0.1): 1.638 um d(0.5): 7.511 um **d(0.8): 17.412 um** d(0.9): 26.642 um d(0.98): 60.34 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.00
0.437	0.03
0.479	0.10

Size (µm)	Volume In %
0.479	0.22
0.525	0.37
0.575	0.46
0.631	0.54
0.692	0.63
0.759	0.69
0.832	0.75
0.912	0.80
1.000	0.85
1.096	0.91
1.202	0.98
1.318	1.06
1.445	1.16
1.585	1.28
1.738	1.41
1.905	1.55
2.089	1.69
2.291	1.84

Size (µm)	Volume In %
2.291	1.84
2.512	1.99
2.754	2.14
3.020	2.28
3.311	2.43
3.631	2.57
3.981	2.72
4.365	2.86
4.786	2.99
5.248	3.11
5.754	3.23
6.310	3.33
6.918	3.41
7.586	3.47
8.318	3.50
9.120	3.50
10.000	3.47
10.965	3.40

Size (µm)	Volume In %
10.965	3.40
12.023	3.30
13.183	3.16
14.454	2.99
15.849	2.80
17.378	2.58
19.055	2.36
20.893	2.13
22.909	1.89
25.119	1.67
27.542	1.45
30.200	1.26
33.113	1.08
36.308	0.92
39.811	0.78
43.652	0.67
47.863	0.56
52.481	0.48

Size (µm)	Volume In %
52.481	0.48
57.544	0.41
63.096	0.35
69.183	0.29
75.858	0.25
83.176	0.21
91.201	0.18
100.000	0.14
109.648	0.12
120.226	0.09
131.826	0.07
144.544	0.06
158.489	0.04
173.780	0.01
190.546	0.00
208.930	0.00
229.087	0.00
251.189	0.00

Size (µm)	Volume In %
251.189	0.00
275.423	0.00
301.995	0.00
331.131	0.00
363.078	0.00
398.107	0.00
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	0.00

Operator notes:

G&T METALLURGICAL SERVICES LTD.

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM2721-20

Sample Name:
Bulk Regrind Discharge - Average

Measured by:
Hoang

Edited by:
Hoang

Measured:
Wednesday, September 29, 2010 8:59:29 AM

Analysed:
Wednesday, September 29, 2010 8:59:30 AM

Particle Name: Silica 0.01
Particle RI: 1.544
Dispersant Name: Water

Accessory Name: Hydro 2000MU (A)
Absorption: 0.01
Dispersant RI: 1.330

Analysis model: General purpose
Size range: 0.100 to 1000.000 um
Weighted Residual: 0.120 %

Sensitivity: Normal
Obscuration: 19.13 %
Result Emulation: Off

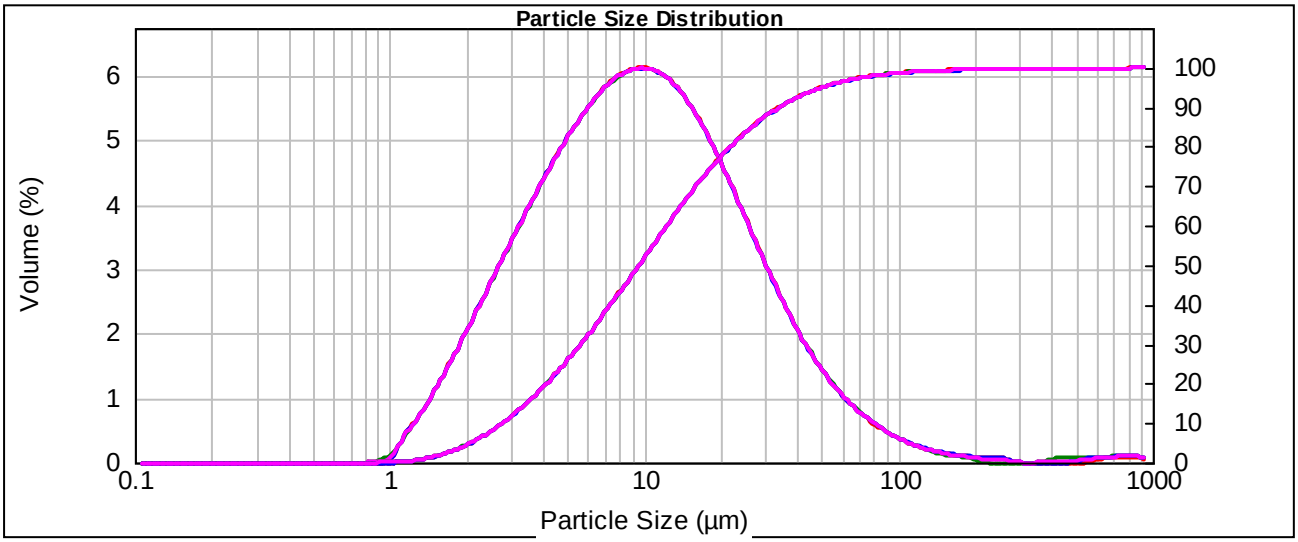
Concentration: 0.0158 %Vol
Specific Surface Area: 0.355 m²/g

Span : 3.282
Surface Weighted Mean D[3,2]: 6.378 um

Uniformity: 1.36
Vol. Weighted Mean D[4,3]: 17.991 um

Result units: Volume

d(0.1): 2.779 um d(0.5): 9.535 um **d(0.8): 21.889 um** d(0.9): 34.074 um d(0.98): 80.4 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.00
0.437	0.00
0.479	0.00

Size (µm)	Volume In %
0.479	0.00
0.525	0.00
0.575	0.00
0.631	0.00
0.692	0.00
0.759	0.00
0.832	0.00
0.912	0.01
1.000	0.09
1.096	0.26
1.202	0.38
1.318	0.51
1.445	0.68
1.585	0.85
1.738	1.03
1.905	1.22
2.089	1.41
2.291	1.59

Size (µm)	Volume In %
2.291	1.59
2.512	1.79
2.754	1.98
3.020	2.17
3.311	2.35
3.631	2.54
3.981	2.71
4.365	2.88
4.786	3.04
5.248	3.19
5.754	3.32
6.310	3.44
6.918	3.53
7.586	3.61
8.318	3.66
9.120	3.68
10.000	3.68
10.965	3.64

Size (µm)	Volume In %
10.965	3.64
12.023	3.57
13.183	3.47
14.454	3.35
15.849	3.19
17.378	3.02
19.055	2.82
20.893	2.61
22.909	2.39
25.119	2.17
27.542	1.95
30.200	1.73
33.113	1.53
36.308	1.34
39.811	1.17
43.652	1.01
47.863	0.86
52.481	0.74

Size (µm)	Volume In %
52.481	0.74
57.544	0.63
63.096	0.53
69.183	0.44
75.858	0.37
83.176	0.31
91.201	0.25
100.000	0.21
109.648	0.16
120.226	0.13
131.826	0.11
144.544	0.08
158.489	0.07
173.780	0.06
190.546	0.05
208.930	0.03
229.087	0.03
251.189	0.03

Size (µm)	Volume In %
251.189	0.03
275.423	0.00
301.995	0.00
331.131	0.00
363.078	0.01
398.107	0.01
436.516	0.01
478.630	0.02
524.807	0.03
575.440	0.04
630.957	0.05
691.831	0.06
758.578	0.06
831.764	0.06
912.011	0.02
1000.000	

Operator notes:

TABLE III-14

G&T METALLURGICAL SERVICES LTD.

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM2721-21

Sample Name:
Bulk Regrind Discharge - Average

Measured by:
Hoang

Edited by:
Hoang

Measured:
Wednesday, September 29, 2010 9:03:00 AM

Analysed:
Wednesday, September 29, 2010 9:03:01 AM

Particle Name: Silica 0.01
Particle RI: 1.544
Dispersant Name: Water

Accessory Name: Hydro 2000MU (A)
Absorption: 0.01
Dispersant RI: 1.330

Analysis model: General purpose
Size range: 0.100 to 1000.000 um
Weighted Residual: 0.240 %

Sensitivity: Normal
Obscuration: 16.66 %
Result Emulation: Off

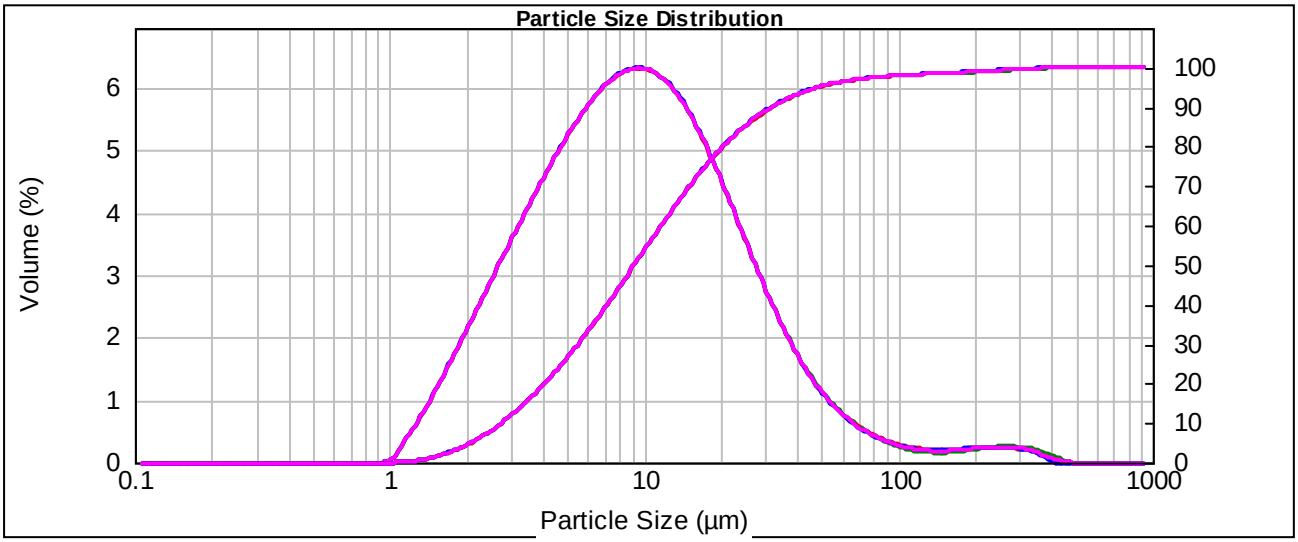
Concentration: 0.0133 %Vol
Specific Surface Area: 0.362 m²/g

Span : 3.156
Surface Weighted Mean D[3,2]: 6.260 um

Uniformity: 1.33
Vol. Weighted Mean D[4,3]: 17.147 um

Result units: Volume

d(0.1): 2.754 um d(0.5): 9.153 um **d(0.8): 20.440 um** d(0.9): 31.640 um d(0.98): 96.77 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.00
0.437	0.00
0.479	0.00

Size (µm)	Volume In %
0.479	0.00
0.525	0.00
0.575	0.00
0.631	0.00
0.692	0.00
0.759	0.00
0.832	0.00
0.912	0.00
1.000	0.05
1.096	0.21
1.202	0.35
1.318	0.51
1.445	0.69
1.585	0.88
1.738	1.07
1.905	1.26
2.089	1.46
2.291	

Size (µm)	Volume In %
2.291	1.66
2.512	1.86
2.754	2.05
3.020	2.25
3.311	2.44
3.631	2.63
3.981	2.81
4.365	2.99
4.786	3.15
5.248	3.31
5.754	3.45
6.310	3.57
6.918	3.67
7.586	3.74
8.318	3.79
9.120	3.81
10.000	3.79
10.965	

Size (µm)	Volume In %
10.965	3.74
12.023	3.65
13.183	3.52
14.454	3.37
15.849	3.19
17.378	2.97
19.055	2.75
20.893	2.51
22.909	2.26
25.119	2.02
27.542	1.78
30.200	1.55
33.113	1.34
36.308	1.14
39.811	0.97
43.652	0.81
47.863	0.68
52.481	

Size (µm)	Volume In %
52.481	0.56
57.544	0.47
63.096	0.38
69.183	0.32
75.858	0.26
83.176	0.22
91.201	0.18
100.000	0.15
109.648	0.13
120.226	0.12
131.826	0.11
144.544	0.11
158.489	0.12
173.780	0.13
190.546	0.14
208.930	0.15
229.087	0.15
251.189	

Size (µm)	Volume In %
251.189	0.15
275.423	0.14
301.995	0.13
331.131	0.11
363.078	0.06
398.107	0.03
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

G&T METALLURGICAL SERVICES LTD.

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM2721-22

Sample Name:
Bulk Regrind Discharge - Average

Measured by:
Hoang

Edited by:
Hoang

Measured:
Wednesday, September 29, 2010 3:12:05 PM

Analysed:
Wednesday, September 29, 2010 3:12:06 PM

Particle Name: Silica 0.01
Particle RI: 1.544
Dispersant Name: Water

Accessory Name: Hydro 2000MU (A)
Absorption: 0.01
Dispersant RI: 1.330

Analysis model: General purpose
Size range: 0.100 to 1000.000 um
Weighted Residual: 0.391 %

Sensitivity: Normal
Obscuration: 18.79 %
Result Emulation: Off

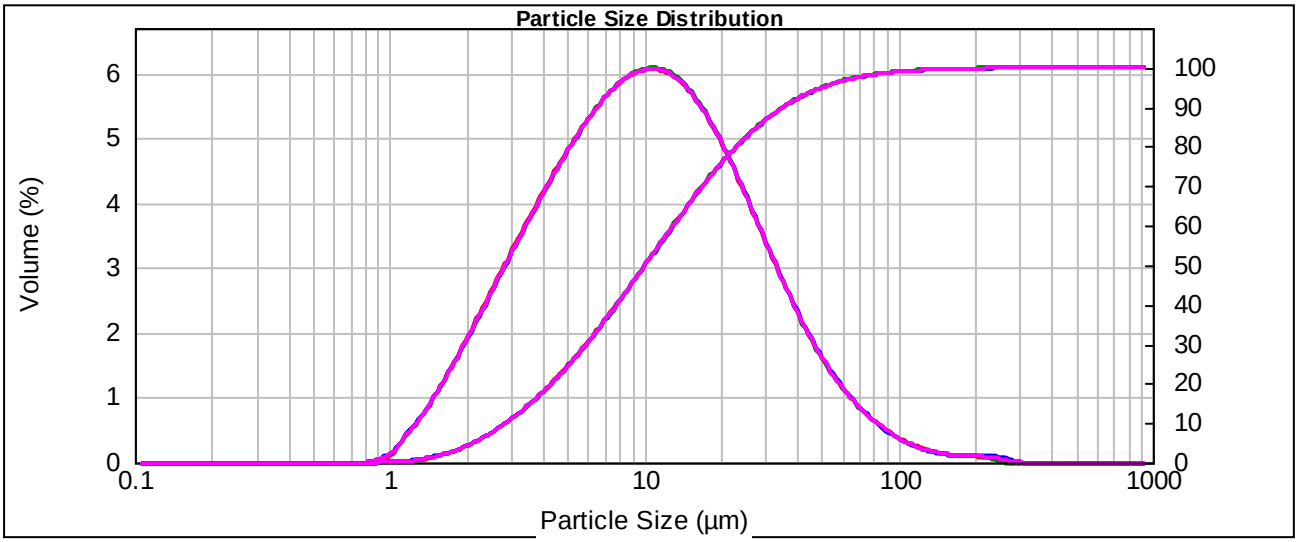
Concentration: 0.0161 %Vol
Specific Surface Area: 0.342 m²/g

Span : 3.200
Surface Weighted Mean D[3,2]: 6.614 um

Uniformity: 1.09
Vol. Weighted Mean D[4,3]: 16.311 um

Result units: Volume

d(0.1): 2.871 um d(0.5): 10.109 um **d(0.8): 23.080 um** d(0.9): 35.217 um d(0.98): 74.91 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.00
0.437	0.00
0.479	0.00

Size (µm)	Volume In %
0.479	0.00
0.525	0.00
0.575	0.00
0.631	0.00
0.692	0.00
0.759	0.00
0.832	0.01
0.912	0.05
1.000	0.11
1.096	0.24
1.202	0.35
1.318	0.48
1.445	0.62
1.585	0.79
1.738	0.95
1.905	1.13
2.089	1.31
2.291	1.49

Size (µm)	Volume In %
2.291	1.49
2.512	1.67
2.754	1.86
3.020	2.04
3.311	2.22
3.631	2.40
3.981	2.57
4.365	2.73
4.786	2.89
5.248	3.04
5.754	3.18
6.310	3.31
6.918	3.42
7.586	3.51
8.318	3.58
9.120	3.63
10.000	3.66
10.965	3.65

Size (µm)	Volume In %
10.965	3.65
12.023	3.61
13.183	3.55
14.454	3.45
15.849	3.33
17.378	3.17
19.055	3.00
20.893	2.80
22.909	2.59
25.119	2.37
27.542	2.15
30.200	1.93
33.113	1.72
36.308	1.51
39.811	1.32
43.652	1.14
47.863	0.97
52.481	0.83

Size (µm)	Volume In %
52.481	0.83
57.544	0.70
63.096	0.58
69.183	0.48
75.858	0.39
83.176	0.32
91.201	0.25
100.000	0.20
109.648	0.16
120.226	0.12
131.826	0.10
144.544	0.08
158.489	0.07
173.780	0.06
190.546	0.06
208.930	0.06
229.087	0.04
251.189	0.03

Size (µm)	Volume In %
251.189	0.03
275.423	0.00
301.995	0.00
331.131	0.00
363.078	0.00
398.107	0.00
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	0.00

Operator notes:

G&T METALLURGICAL SERVICES LTD.

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM2721-23

Sample Name:
Bulk Regrind Discharge - Average

Measured by:
julie

Edited by:
julie

Measured:
Monday, October 04, 2010 7:44:27 AM

Analysed:
Monday, October 04, 2010 7:44:28 AM

Particle Name: Silica 0.01
Particle RI: 1.544
Dispersant Name: Water

Accessory Name: Hydro 2000MU (A)
Absorption: 0.01
Dispersant RI: 1.330

Analysis model: General purpose
Size range: 0.100 to 1000.000 um
Weighted Residual: 0.168 %

Sensitivity: Normal
Obscuration: 15.77 %
Result Emulation: Off

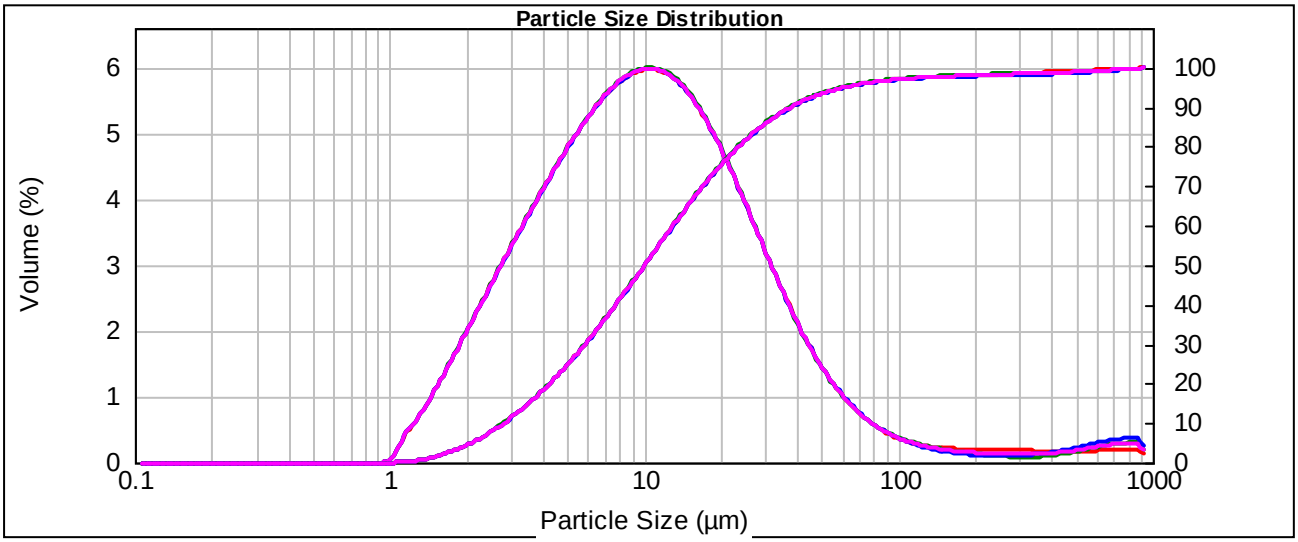
Concentration: 0.0133 %Vol
Specific Surface Area: 0.344 m²/g

Span : 3.472
Surface Weighted Mean D[3,2]: 6.591 um

Uniformity: 2.05
Vol. Weighted Mean D[4,3]: 25.912 um

Result units: Volume

d(0.1): 2.822 um d(0.5): 10.057 um **d(0.8): 23.541 um** d(0.9): 37.742 um d(0.98): 183.76 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.00
0.437	0.00
0.479	0.00

Size (µm)	Volume In %
0.479	0.00
0.525	0.00
0.575	0.00
0.631	0.00
0.692	0.00
0.759	0.00
0.832	0.00
0.912	0.00
1.000	0.07
1.096	0.25
1.202	0.37
1.318	0.50
1.445	0.67
1.585	0.84
1.738	1.01
1.905	1.19
2.089	1.37
2.291	1.54

Size (µm)	Volume In %
2.291	1.54
2.512	1.72
2.754	1.90
3.020	2.07
3.311	2.24
3.631	2.41
3.981	2.57
4.365	2.73
4.786	2.88
5.248	3.03
5.754	3.16
6.310	3.28
6.918	3.39
7.586	3.48
8.318	3.55
9.120	3.59
10.000	3.60
10.965	3.59

Size (µm)	Volume In %
10.965	3.59
12.023	3.55
13.183	3.47
14.454	3.37
15.849	3.23
17.378	3.07
19.055	2.89
20.893	2.69
22.909	2.47
25.119	2.25
27.542	2.03
30.200	1.80
33.113	1.59
36.308	1.39
39.811	1.20
43.652	1.03
47.863	0.87
52.481	0.73

Size (µm)	Volume In %
52.481	0.73
57.544	0.61
63.096	0.51
69.183	0.42
75.858	0.35
83.176	0.29
91.201	0.25
100.000	0.21
109.648	0.18
120.226	0.15
131.826	0.13
144.544	0.12
158.489	0.11
173.780	0.10
190.546	0.09
208.930	0.09
229.087	0.08
251.189	0.08

Size (µm)	Volume In %
251.189	0.08
275.423	0.08
301.995	0.08
331.131	0.08
363.078	0.08
398.107	0.09
436.516	0.10
478.630	0.11
524.807	0.13
575.440	0.14
630.957	0.16
691.831	0.17
758.578	0.17
831.764	0.17
912.011	0.17
1000.000	0.05

Operator notes:

TABLE III-17

G&T METALLURGICAL SERVICES LTD.

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM2721-24

Sample Name:
Bulk Regrind Discharge - Average

Measured by:
julie

Edited by:
julie

Measured:
Tuesday, October 05, 2010 2:41:51 PM

Analysed:
Tuesday, October 05, 2010 2:41:52 PM

Particle Name:
Silica 0.01

Particle RI:
1.544

Dispersant Name:
Water

Accessory Name:
Hydro 2000MU (A)

Absorption:
0.01

Dispersant RI:
1.330

Analysis model:
General purpose

Size range:
0.100 to 1000.000 um

Weighted Residual:
0.122 %

Sensitivity:
Normal

Obscuration:
18.62 %

Result Emulation:
Off

Concentration:
0.0175 %Vol

Span :
4.428

Uniformity:
1.65

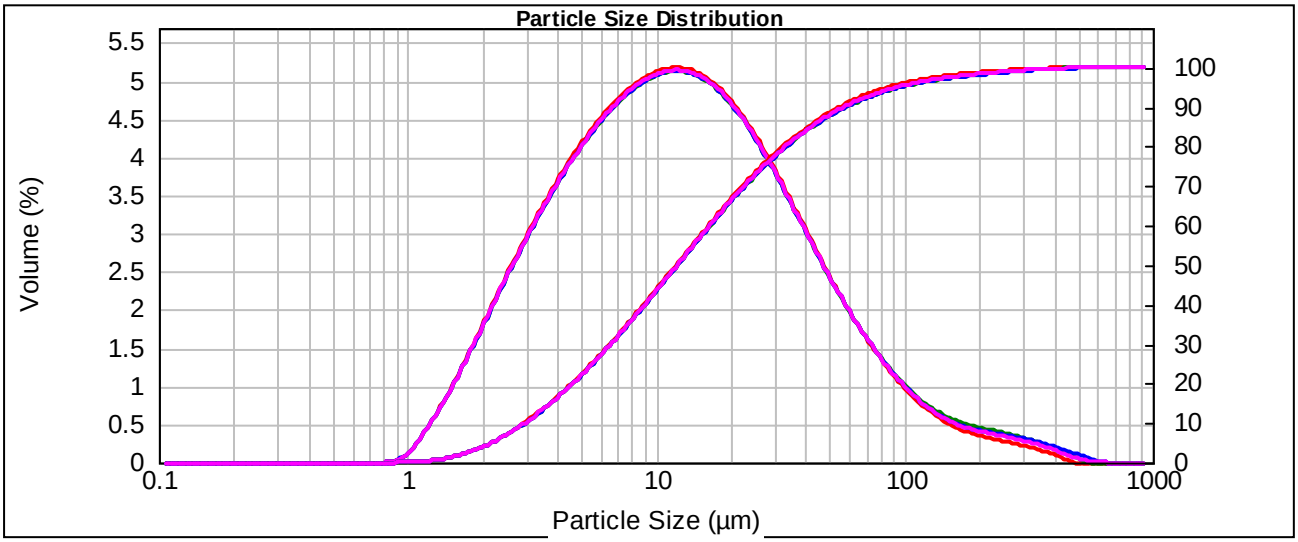
Result units:
Volume

Specific Surface Area:
0.311 m²/g

Surface Weighted Mean D[3,2]:
7.277 um

Vol. Weighted Mean D[4,3]:
25.989 um

d(0.1): 2.966 um d(0.5): 12.166 um **d(0.8): 33.056 um** d(0.9): 56.831 um d(0.98): 170.75 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.00
0.437	0.00
0.479	0.00

Size (µm)	Volume In %
0.479	0.00
0.525	0.00
0.575	0.00
0.631	0.00
0.692	0.00
0.759	0.00
0.832	0.01
0.912	0.04
1.000	0.10
1.096	0.22
1.202	0.33
1.318	0.46
1.445	0.60
1.585	0.75
1.738	0.91
1.905	1.07
2.089	1.23
2.291	1.39

Size (µm)	Volume In %
2.291	1.39
2.512	1.55
2.754	1.70
3.020	1.85
3.311	1.99
3.631	2.13
3.981	2.26
4.365	2.39
4.786	2.50
5.248	2.61
5.754	2.71
6.310	2.79
6.918	2.87
7.586	2.94
8.318	3.00
9.120	3.04
10.000	3.08
10.965	3.09

Size (µm)	Volume In %
10.965	3.09
12.023	3.09
13.183	3.08
14.454	3.05
15.849	3.00
17.378	2.93
19.055	2.84
20.893	2.74
22.909	2.63
25.119	2.50
27.542	2.36
30.200	2.22
33.113	2.07
36.308	1.91
39.811	1.76
43.652	1.61
47.863	1.46
52.481	1.32

Size (µm)	Volume In %
52.481	1.32
57.544	1.19
63.096	1.06
69.183	0.95
75.858	0.84
83.176	0.74
91.201	0.64
100.000	0.56
109.648	0.49
120.226	0.43
131.826	0.37
144.544	0.33
158.489	0.29
173.780	0.27
190.546	0.25
208.930	0.23
229.087	0.22
251.189	0.20

Size (µm)	Volume In %
251.189	0.20
275.423	0.18
301.995	0.16
331.131	0.14
363.078	0.12
398.107	0.09
436.516	0.05
478.630	0.03
524.807	0.01
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	0.00

Operator notes:

G&T METALLURGICAL SERVICES LTD.

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM2721-25

Sample Name:
Bulk Regrind Discharge - Average

Measured by:
julie

Edited by:
julie

Measured:
Tuesday, October 05, 2010 3:06:57 PM

Analysed:
Tuesday, October 05, 2010 3:06:58 PM

Particle Name: Silica 0.01
Particle RI: 1.544
Dispersant Name: Water

Accessory Name: Hydro 2000MU (A)
Absorption: 0.01
Dispersant RI: 1.330

Analysis model: General purpose
Size range: 0.100 to 1000.000 um
Weighted Residual: 0.202 %

Sensitivity: Normal
Obscuration: 15.33 %
Result Emulation: Off

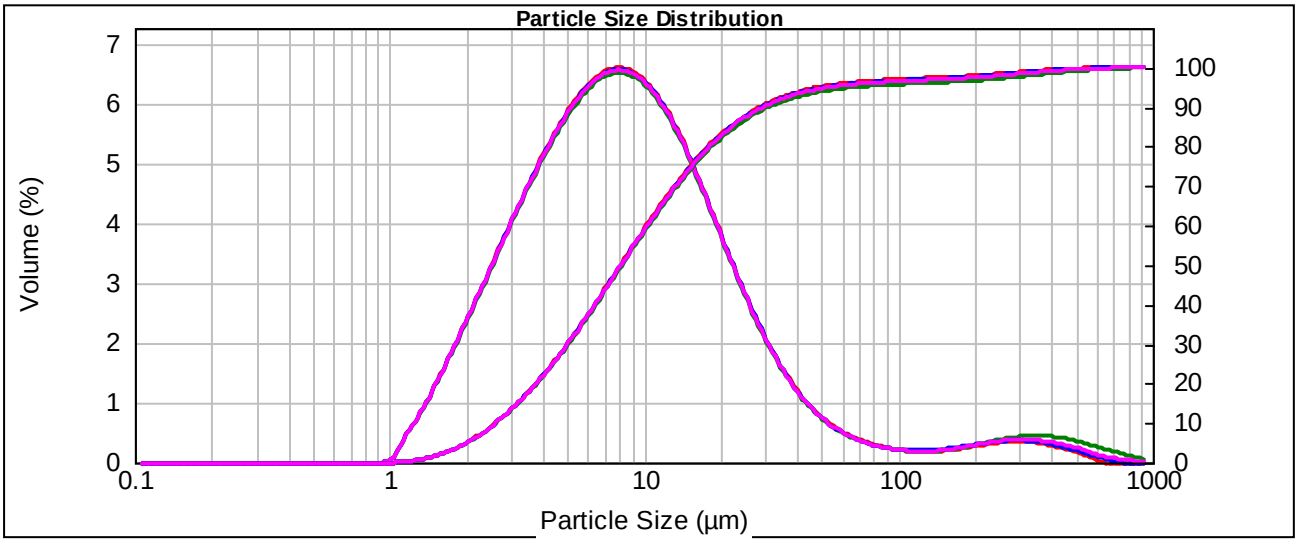
Concentration: 0.0112 %Vol
Specific Surface Area: 0.389 m²/g

Span : 3.279
Surface Weighted Mean D[3,2]: 5.820 um

Uniformity: 2.12
Vol. Weighted Mean D[4,3]: 21.760 um

Result units: Volume

d(0.1): 2.614 um d(0.5): 8.136 um **d(0.8): 18.112 um** d(0.9): 29.293 um d(0.98): 249.18 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.00
0.437	0.00
0.479	0.00

Size (µm)	Volume In %
0.479	0.00
0.525	0.00
0.575	0.00
0.631	0.00
0.692	0.00
0.759	0.00
0.832	0.00
0.912	0.00
1.000	0.00
1.096	0.06
1.202	0.25
1.318	0.40
1.445	0.58
1.585	0.77
1.738	0.98
1.905	1.19
2.089	1.41
2.291	1.63

Size (µm)	Volume In %
2.291	1.85
2.512	2.08
2.754	2.31
3.020	2.53
3.311	2.75
3.631	2.96
3.981	3.16
4.365	3.35
4.786	3.51
5.248	3.66
5.754	3.78
6.310	3.87
6.918	3.93
7.586	3.95
8.318	3.93
9.120	3.87
10.000	3.78
10.965	3.65

Size (µm)	Volume In %
10.965	3.65
12.023	3.48
13.183	3.28
14.454	3.06
15.849	2.82
17.378	2.56
19.055	2.31
20.893	2.05
22.909	1.79
25.119	1.56
27.542	1.34
30.200	1.13
33.113	0.95
36.308	0.79
39.811	0.66
43.652	0.54
47.863	0.45
52.481	0.37

Size (µm)	Volume In %
52.481	0.37
57.544	0.30
63.096	0.25
69.183	0.21
75.858	0.18
83.176	0.15
91.201	0.14
100.000	0.12
109.648	0.12
120.226	0.11
131.826	0.12
144.544	0.13
158.489	0.14
173.780	0.16
190.546	0.17
208.930	0.19
229.087	0.21
251.189	0.22

Size (µm)	Volume In %
251.189	0.22
275.423	0.23
301.995	0.23
331.131	0.23
363.078	0.22
398.107	0.20
436.516	0.17
478.630	0.15
524.807	0.12
575.440	0.12
630.957	0.08
691.831	0.06
758.578	0.04
831.764	0.02
912.011	0.02
1000.000	0.01

Operator notes:

G&T METALLURGICAL SERVICES LTD.

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM2721-26

Sample Name:
Bulk Regrind Discharge - Average

Measured by:
Kent

Edited by:
Kent

Measured:
Tuesday, October 12, 2010 2:51:27 PM

Analysed:
Tuesday, October 12, 2010 2:51:28 PM

Particle Name: Silica 1.0
Particle RI: 1.544
Dispersant Name: Water

Accessory Name: Hydro 2000MU (A)
Absorption: 1
Dispersant RI: 1.330

Analysis model: General purpose
Size range: 0.100 to 1000.000 um
Weighted Residual: 0.238 %

Sensitivity: Normal
Obscuration: 19.06 %
Result Emulation: Off

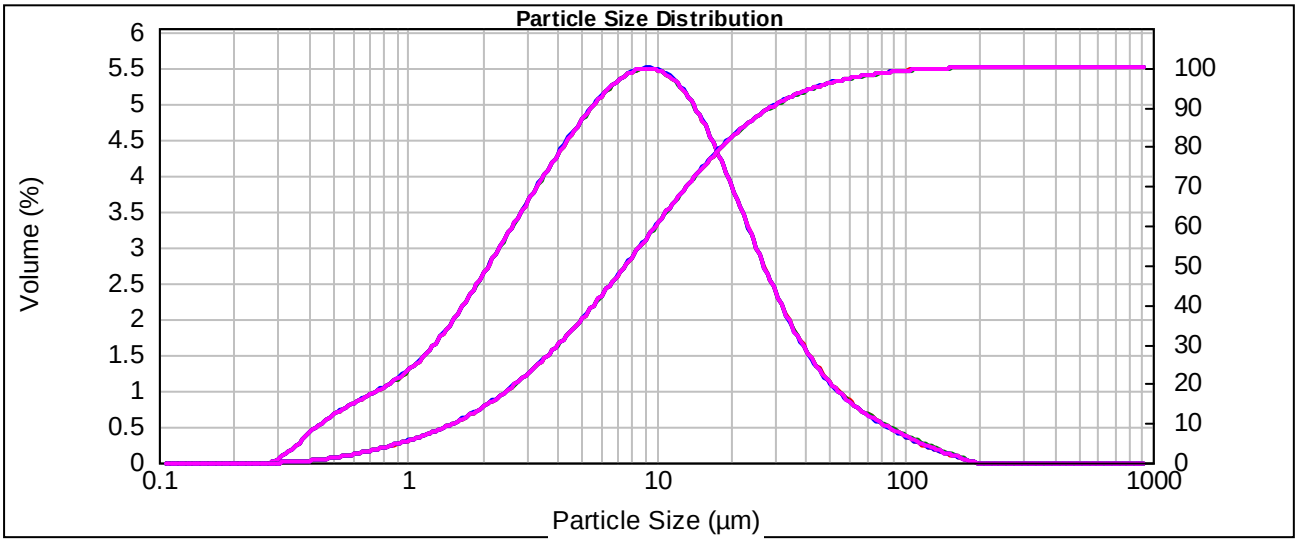
Concentration: 0.0096 %Vol
Specific Surface Area: 1.63 m²/g

Span : 3.649
Surface Weighted Mean D[3,2]: 3.671 um

Uniformity: 1.25
Vol. Weighted Mean D[4,3]: 13.017 um

Result units: Volume

d(0.1): 1.539 um d(0.5): 7.562 um **d(0.8): 18.437 um** d(0.9): 29.135 um d(0.98): 69.32 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.06
0.331	0.12
0.363	0.20
0.398	0.28
0.437	0.34
0.479	

Size (µm)	Volume In %
0.479	0.39
0.525	0.45
0.575	0.49
0.631	0.54
0.692	0.58
0.759	0.63
0.832	0.68
0.912	0.73
1.000	0.80
1.096	0.88
1.202	0.97
1.318	1.07
1.445	1.18
1.585	1.31
1.738	1.43
1.905	1.56
2.089	1.70
2.291	

Size (µm)	Volume In %
2.291	1.83
2.512	1.97
2.754	2.11
3.020	2.24
3.311	2.38
3.631	2.51
3.981	2.63
4.365	2.75
4.786	2.87
5.248	2.98
5.754	3.07
6.310	3.16
6.918	3.22
7.586	3.28
8.318	3.30
9.120	3.31
10.000	3.29
10.965	

Size (µm)	Volume In %
10.965	3.23
12.023	3.15
13.183	3.04
14.454	2.90
15.849	2.73
17.378	2.55
19.055	2.35
20.893	2.14
22.909	1.93
25.119	1.73
27.542	1.53
30.200	1.34
33.113	1.18
36.308	1.02
39.811	0.89
43.652	0.77
47.863	0.67
52.481	

Size (µm)	Volume In %
52.481	0.59
57.544	0.51
63.096	0.45
69.183	0.39
75.858	0.34
83.176	0.29
91.201	0.25
100.000	0.21
109.648	0.17
120.226	0.13
131.826	0.10
144.544	0.07
158.489	0.05
173.780	0.01
190.546	0.00
208.930	0.00
229.087	0.00
251.189	

Size (µm)	Volume In %
251.189	0.00
275.423	0.00
301.995	0.00
331.131	0.00
363.078	0.00
398.107	0.00
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

G&T METALLURGICAL SERVICES LTD.

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM2721-26

Sample Name:
Pyrite Rougher Concentrate - Average

Measured by:
Kent

Edited by:
Kent

Measured:
Tuesday, October 12, 2010 3:01:25 PM

Analysed:
Tuesday, October 12, 2010 3:01:26 PM

Particle Name:
Silica 1.0

Particle RI:
1.544

Dispersant Name:
Water

Accessory Name:
Hydro 2000MU (A)

Absorption:
1

Dispersant RI:
1.330

Analysis model:
General purpose

Size range:
0.100 to 1000.000 um

Weighted Residual:
0.331 %

Sensitivity:
Normal

Obscuration:
18.51 %

Result Emulation:
Off

Concentration:
0.0110 %Vol

Span :
23.684

Uniformity:
5.59

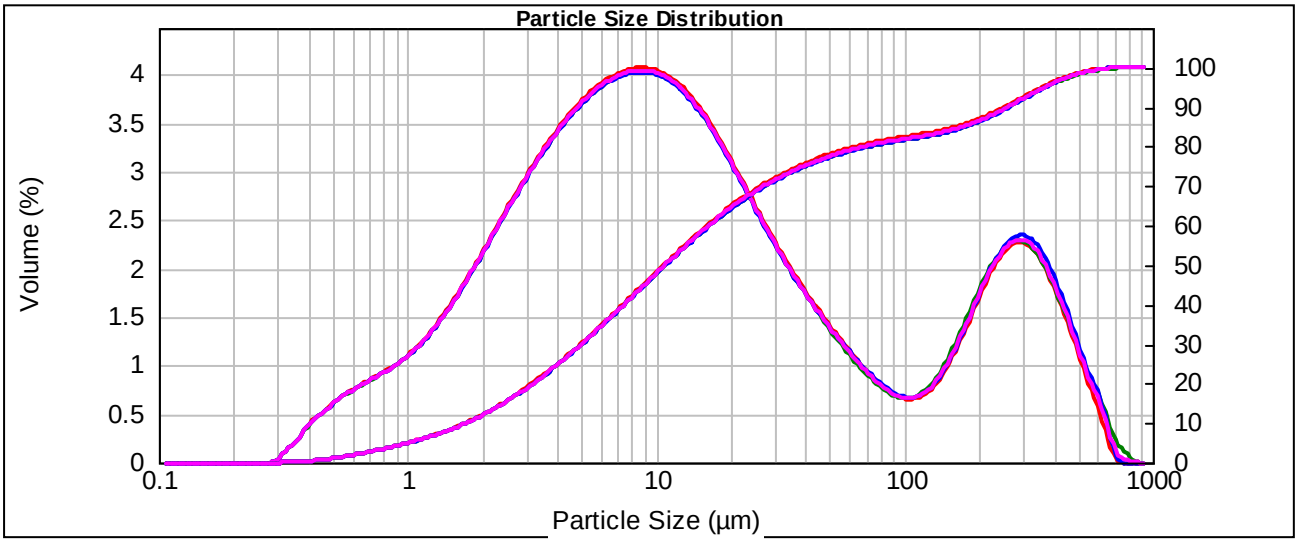
Result units:
Volume

Specific Surface Area:
1.38 m²/g

Surface Weighted Mean D[3,2]:
4.358 um

Vol. Weighted Mean D[4,3]:
65.279 um

d(0.1): 1.715 um d(0.5): 10.859 um **d(0.8): 68.145 um** d(0.9): 258.910 um d(0.98): 473.23 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.06
0.331	0.11
0.363	0.19
0.398	0.26
0.437	0.31
0.479	

Size (µm)	Volume In %
0.479	0.36
0.525	0.41
0.575	0.45
0.631	0.49
0.692	0.52
0.759	0.55
0.832	0.59
0.912	0.63
1.000	0.69
1.096	0.75
1.202	0.82
1.318	0.90
1.445	0.99
1.585	1.09
1.738	1.19
1.905	1.29
2.089	1.40
2.291	

Size (µm)	Volume In %
2.291	1.51
2.512	1.62
2.754	1.72
3.020	1.82
3.311	1.92
3.631	2.01
3.981	2.09
4.365	2.17
4.786	2.23
5.248	2.29
5.754	2.34
6.310	2.38
6.918	2.41
7.586	2.43
8.318	2.43
9.120	2.43
10.000	2.43
10.965	2.41

Size (µm)	Volume In %
10.965	2.37
12.023	2.32
13.183	2.26
14.454	2.18
15.849	2.09
17.378	1.98
19.055	1.87
20.893	1.76
22.909	1.64
25.119	1.53
27.542	1.41
30.200	1.30
33.113	1.20
36.308	1.10
39.811	1.01
43.652	0.92
47.863	0.84
52.481	

Size (µm)	Volume In %
52.481	0.76
57.544	0.68
63.096	0.61
69.183	0.54
75.858	0.48
83.176	0.44
91.201	0.41
100.000	0.40
109.648	0.41
120.226	0.46
131.826	0.53
144.544	0.63
158.489	0.76
173.780	0.90
190.546	1.04
208.930	1.18
229.087	1.29
251.189	

Size (µm)	Volume In %
251.189	1.36
275.423	1.39
301.995	1.37
331.131	1.30
363.078	1.19
398.107	1.05
436.516	0.88
478.630	0.71
524.807	0.53
575.440	0.40
630.957	0.21
691.831	0.04
758.578	0.01
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

G&T METALLURGICAL SERVICES LTD.

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM2721-27

Sample Name:
Bulk Regrind Discharge - Average

Measured by:
Hoang

Edited by:
Hoang

Measured:
Saturday, October 16, 2010 8:29:10 AM

Analysed:
Saturday, October 16, 2010 8:29:11 AM

Particle Name: Silica 0.1
Particle RI: 1.544
Dispersant Name: Water

Accessory Name: Hydro 2000MU (A)
Absorption: 0.1
Dispersant RI: 1.330

Analysis model: General purpose
Size range: 0.100 to 1000.000 um
Weighted Residual: 0.585 %

Sensitivity: Normal
Obscuration: 16.20 %
Result Emulation: Off

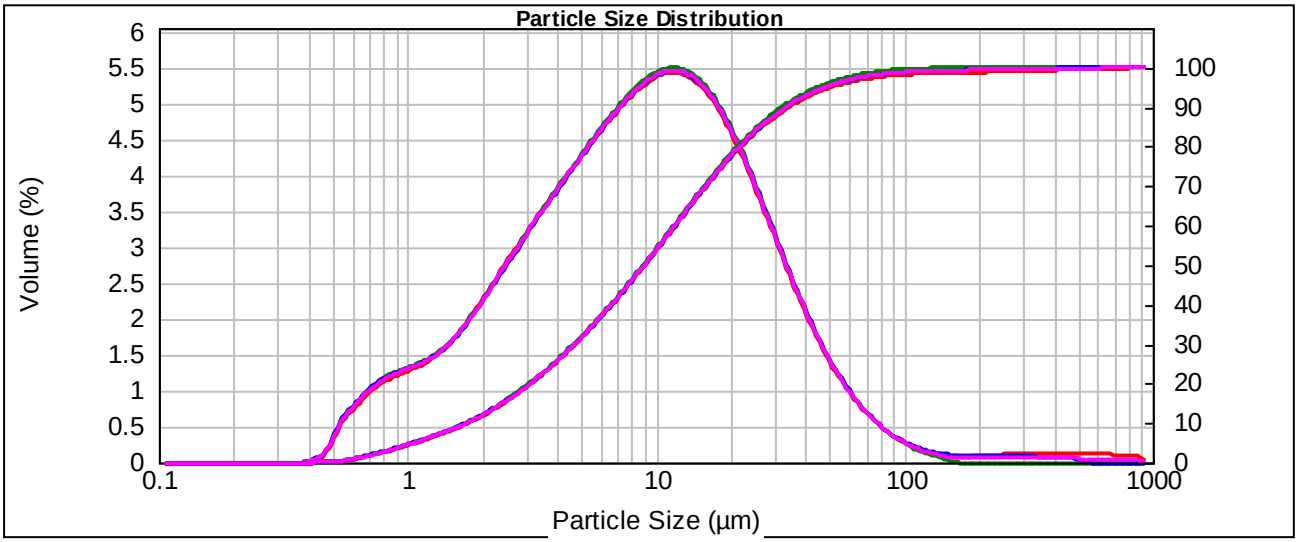
Concentration: 0.0106 %Vol
Specific Surface Area: 0.526 m²/g

Span : 3.510
Surface Weighted Mean D[3,2]: 4.308 um

Uniformity: 1.38
Vol. Weighted Mean D[4,3]: 16.486 um

Result units: Volume

d(0.1): 1.726 um d(0.5): 8.962 um **d(0.8): 21.692 um** d(0.9): 33.185 um d(0.98): 73.02 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.00
0.437	0.02
0.479	0.06

Size (µm)	Volume In %
0.479	0.19
0.525	0.37
0.575	0.46
0.631	0.55
0.692	0.63
0.759	0.69
0.832	0.73
0.912	0.77
1.000	0.80
1.096	0.83
1.202	0.88
1.318	0.94
1.445	1.02
1.585	1.12
1.738	1.23
1.905	1.35
2.089	1.48
2.291	

Size (µm)	Volume In %
2.291	1.60
2.512	1.73
2.754	1.86
3.020	1.98
3.311	2.10
3.631	2.22
3.981	2.34
4.365	2.45
4.786	2.57
5.248	2.68
5.754	2.79
6.310	2.89
6.918	2.99
7.586	3.08
8.318	3.16
9.120	3.22
10.000	3.27
10.965	

Size (µm)	Volume In %
10.965	3.29
12.023	3.28
13.183	3.24
14.454	3.18
15.849	3.08
17.378	2.95
19.055	2.80
20.893	2.62
22.909	2.42
25.119	2.22
27.542	2.00
30.200	1.79
33.113	1.58
36.308	1.37
39.811	1.19
43.652	1.01
47.863	0.85
52.481	

Size (µm)	Volume In %
52.481	0.72
57.544	0.59
63.096	0.48
69.183	0.39
75.858	0.31
83.176	0.25
91.201	0.19
100.000	0.15
109.648	0.11
120.226	0.08
131.826	0.06
144.544	0.05
158.489	0.04
173.780	0.04
190.546	0.04
208.930	0.04
229.087	0.04
251.189	

Size (µm)	Volume In %
251.189	0.04
275.423	0.04
301.995	0.04
331.131	0.04
363.078	0.04
398.107	0.04
436.516	0.04
478.630	0.03
524.807	0.02
575.440	0.02
630.957	0.02
691.831	0.02
758.578	0.02
831.764	0.02
912.011	0.00
1000.000	

Operator notes:

G&T METALLURGICAL SERVICES LTD.

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM2721-27

Sample Name:
Pyrite Cleaner Feed - Average

Measured by:
Hoang

Edited by:
Hoang

Measured:
Saturday, October 16, 2010 8:35:36 AM

Analysed:
Saturday, October 16, 2010 8:35:37 AM

Particle Name: Silica 1.0
Particle RI: 1.544
Dispersant Name: Water

Accessory Name: Hydro 2000MU (A)
Absorption: 1
Dispersant RI: 1.330

Analysis model: General purpose
Size range: 0.100 to 1000.000 um
Weighted Residual: 0.281 %

Sensitivity: Normal
Obscuration: 19.56 %
Result Emulation: Off

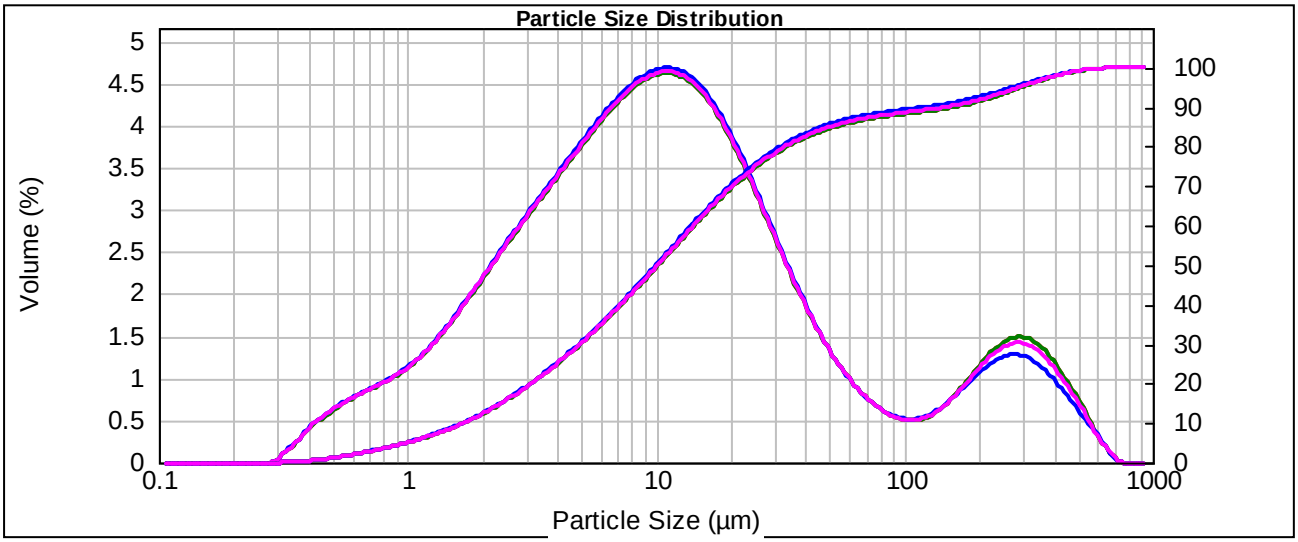
Concentration: 0.0113 %Vol
Specific Surface Area: 1.43 m²/g

Span : 14.164
Surface Weighted Mean D[3,2]: 4.189 um

Uniformity: 3.99
Vol. Weighted Mean D[4,3]: 44.840 um

Result units: Volume

d(0.1): 1.672 um d(0.5): 10.124 um **d(0.8): 33.036 um** d(0.9): 145.067 um d(0.98): 408.26 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.07
0.331	0.12
0.363	0.20
0.398	0.27
0.437	0.32
0.479	

Size (µm)	Volume In %
0.479	0.38
0.525	0.42
0.575	0.46
0.631	0.50
0.692	0.53
0.759	0.57
0.832	0.61
0.912	0.65
1.000	0.71
1.096	0.77
1.202	0.84
1.318	0.92
1.445	1.01
1.585	1.11
1.738	1.21
1.905	1.31
2.089	1.42
2.291	

Size (µm)	Volume In %
2.291	1.52
2.512	1.61
2.754	1.71
3.020	1.81
3.311	1.90
3.631	1.99
3.981	2.09
4.365	2.18
4.786	2.27
5.248	2.36
5.754	2.45
6.310	2.53
6.918	2.61
7.586	2.68
8.318	2.73
9.120	2.77
10.000	2.79
10.965	

Size (µm)	Volume In %
10.965	2.79
12.023	2.77
13.183	2.73
14.454	2.66
15.849	2.57
17.378	2.46
19.055	2.33
20.893	2.19
22.909	2.03
25.119	1.86
27.542	1.69
30.200	1.52
33.113	1.36
36.308	1.20
39.811	1.06
43.652	0.92
47.863	0.80
52.481	

Size (µm)	Volume In %
52.481	0.69
57.544	0.60
63.096	0.51
69.183	0.44
75.858	0.39
83.176	0.34
91.201	0.31
100.000	0.30
109.648	0.31
120.226	0.33
131.826	0.38
144.544	0.44
158.489	0.51
173.780	0.59
190.546	0.67
208.930	0.75
229.087	0.81
251.189	

Size (µm)	Volume In %
251.189	0.84
275.423	0.86
301.995	0.84
331.131	0.80
363.078	0.73
398.107	0.64
436.516	0.53
478.630	0.43
524.807	0.32
575.440	0.17
630.957	0.11
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

G&T METALLURGICAL SERVICES LTD.

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM2721-28

Sample Name:
Cyanide Tail - Average

Measured by:
Kent

Edited by:
Kent

Measured:
Wednesday, November 03, 2010 10:48:35 AM

Analysed:
Wednesday, November 03, 2010 10:48:36 AM

Particle Name: Silica 1.0
Particle RI: 1.544
Dispersant Name: Water

Accessory Name: Hydro 2000MU (A)
Absorption: 1
Dispersant RI: 1.330

Analysis model: General purpose
Size range: 0.100 to 1000.000 um
Weighted Residual: 0.490 %

Sensitivity: Normal
Obscuration: 10.35 %
Result Emulation: Off

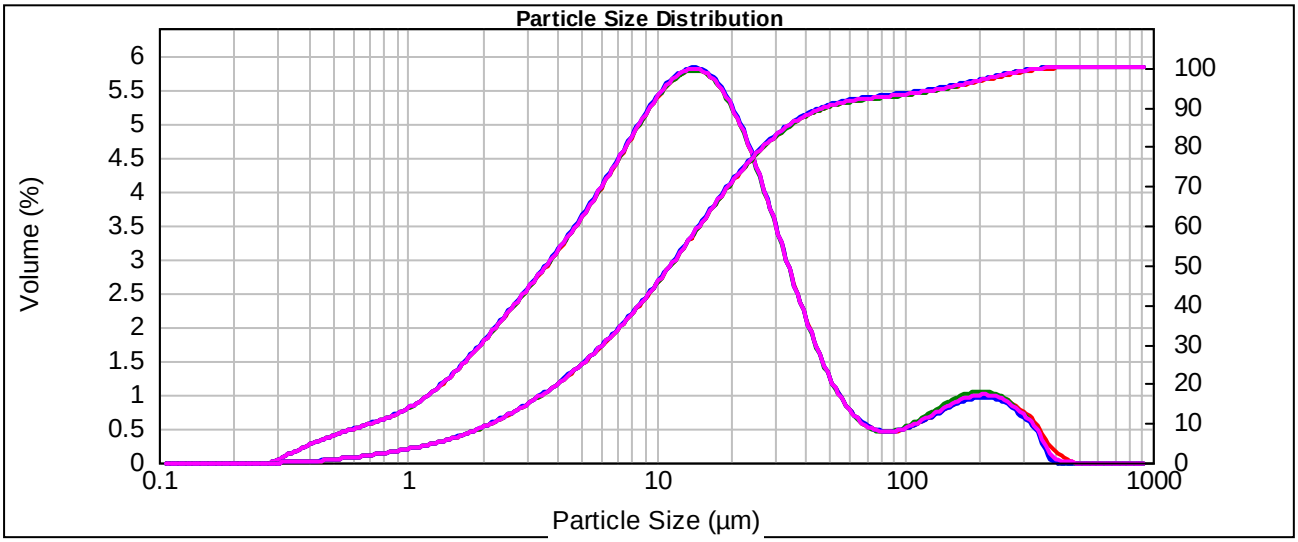
Concentration: 0.0069 %Vol
Specific Surface Area: 1.18 m²/g

Span : 4.020
Surface Weighted Mean D[3,2]: 5.065 um

Uniformity: 1.94
Vol. Weighted Mean D[4,3]: 27.598 um

Result units: Volume

d(0.1): 2.186 um d(0.5): 11.467 um **d(0.8): 27.094 um** d(0.9): 48.290 um d(0.98): 242.62 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.05
0.331	0.09
0.363	0.13
0.398	0.18
0.437	0.21
0.479	

Size (µm)	Volume In %
0.479	0.24
0.525	0.27
0.575	0.30
0.631	0.32
0.692	0.35
0.759	0.38
0.832	0.42
0.912	0.46
1.000	0.50
1.096	0.56
1.202	0.62
1.318	0.70
1.445	0.78
1.585	0.87
1.738	0.96
1.905	1.06
2.089	1.16
2.291	

Size (µm)	Volume In %
2.291	1.26
2.512	1.37
2.754	1.48
3.020	1.58
3.311	1.70
3.631	1.81
3.981	1.92
4.365	2.05
4.786	2.17
5.248	2.30
5.754	2.44
6.310	2.58
6.918	2.73
7.586	2.88
8.318	3.03
9.120	3.16
10.000	3.29
10.965	

Size (µm)	Volume In %
10.965	3.39
12.023	3.46
13.183	3.49
14.454	3.48
15.849	3.43
17.378	3.33
19.055	3.19
20.893	3.00
22.909	2.78
25.119	2.53
27.542	2.26
30.200	1.98
33.113	1.70
36.308	1.43
39.811	1.18
43.652	0.95
47.863	0.75
52.481	

Size (µm)	Volume In %
52.481	0.59
57.544	0.46
63.096	0.37
69.183	0.31
75.858	0.28
83.176	0.27
91.201	0.29
100.000	0.32
109.648	0.36
120.226	0.41
131.826	0.46
144.544	0.51
158.489	0.55
173.780	0.58
190.546	0.60
208.930	0.60
229.087	0.58
251.189	

Size (µm)	Volume In %
251.189	0.54
275.423	0.46
301.995	0.39
331.131	0.28
363.078	0.09
398.107	0.03
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

G&T METALLURGICAL SERVICES LTD.

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM2721-29

Sample Name:
Bulk Regrind Discharge - Average

Measured by:
julie

Edited by:
julie

Measured:
Tuesday, October 26, 2010 12:25:03 PM

Analysed:
Tuesday, October 26, 2010 12:25:04 PM

Particle Name: Silica 0.01
Particle RI: 1.544
Dispersant Name: Water

Accessory Name: Hydro 2000MU (A)
Absorption: 0.01
Dispersant RI: 1.330

Analysis model: General purpose
Size range: 0.100 to 1000.000 um
Weighted Residual: 0.135 %

Sensitivity: Normal
Obscuration: 16.87 %
Result Emulation: Off

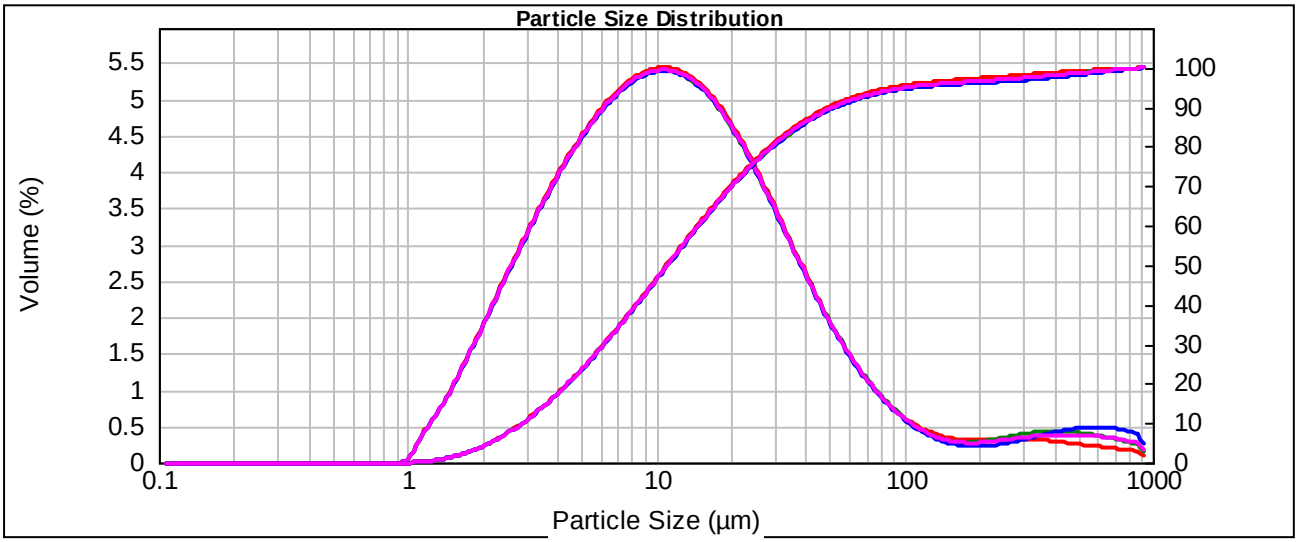
Concentration: 0.0151 %Vol
Specific Surface Area: 0.324 m²/g

Span : 4.391
Surface Weighted Mean D[3,2]: 6.991 um

Uniformity: 2.54
Vol. Weighted Mean D[4,3]: 33.822 um

Result units: Volume

d(0.1): 2.903 um d(0.5): 11.117 um **d(0.8): 29.261 um** d(0.9): 51.714 um d(0.98): 384.93 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.00
0.437	0.00
0.479	0.00

Size (µm)	Volume In %
0.479	0.00
0.525	0.00
0.575	0.00
0.631	0.00
0.692	0.00
0.759	0.00
0.832	0.00
0.912	0.00
1.000	0.00
1.096	0.06
1.202	0.24
1.318	0.34
1.445	0.47
1.585	0.62
1.738	0.78
1.905	0.95
2.089	1.12
2.291	1.29

Size (µm)	Volume In %
2.291	1.46
2.512	1.64
2.754	1.81
3.020	1.97
3.311	2.13
3.631	2.28
3.981	2.43
4.365	2.57
4.786	2.69
5.248	2.81
5.754	2.91
6.310	3.01
6.918	3.09
7.586	3.15
8.318	3.20
9.120	3.23
10.000	3.25
10.965	

Size (µm)	Volume In %
10.965	3.25
12.023	3.22
13.183	3.18
14.454	3.11
15.849	3.03
17.378	2.92
19.055	2.80
20.893	2.66
22.909	2.51
25.119	2.35
27.542	2.18
30.200	2.00
33.113	1.83
36.308	1.65
39.811	1.48
43.652	1.32
47.863	1.16
52.481	

Size (µm)	Volume In %
52.481	1.02
57.544	0.89
63.096	0.77
69.183	0.66
75.858	0.56
83.176	0.47
91.201	0.40
100.000	0.33
109.648	0.28
120.226	0.24
131.826	0.20
144.544	0.18
158.489	0.17
173.780	0.16
190.546	0.16
208.930	0.17
229.087	0.18
251.189	

Size (µm)	Volume In %
251.189	0.19
275.423	0.20
301.995	0.21
331.131	0.22
363.078	0.23
398.107	0.23
436.516	0.23
478.630	0.23
524.807	0.22
575.440	0.22
630.957	0.21
691.831	0.20
758.578	0.18
831.764	0.16
912.011	0.05
1000.000	

Operator notes:

G&T METALLURGICAL SERVICES LTD.

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM2721-29

Sample Name:
Pyrite Cleaner Concentrate - Average

Measured by:
Natasha

Edited by:
Natasha

Measured:
Tuesday, October 26, 2010 11:54:04 AM

Analysed:
Tuesday, October 26, 2010 11:54:05 AM

Particle Name: Silica 1.0
Particle RI: 1.544
Dispersant Name: Water

Accessory Name: Hydro 2000MU (A)
Absorption: 1
Dispersant RI: 1.330

Analysis model: General purpose
Size range: 0.100 to 1000.000 um
Weighted Residual: 0.213 %

Sensitivity: Normal
Obscuration: 11.42 %
Result Emulation: Off

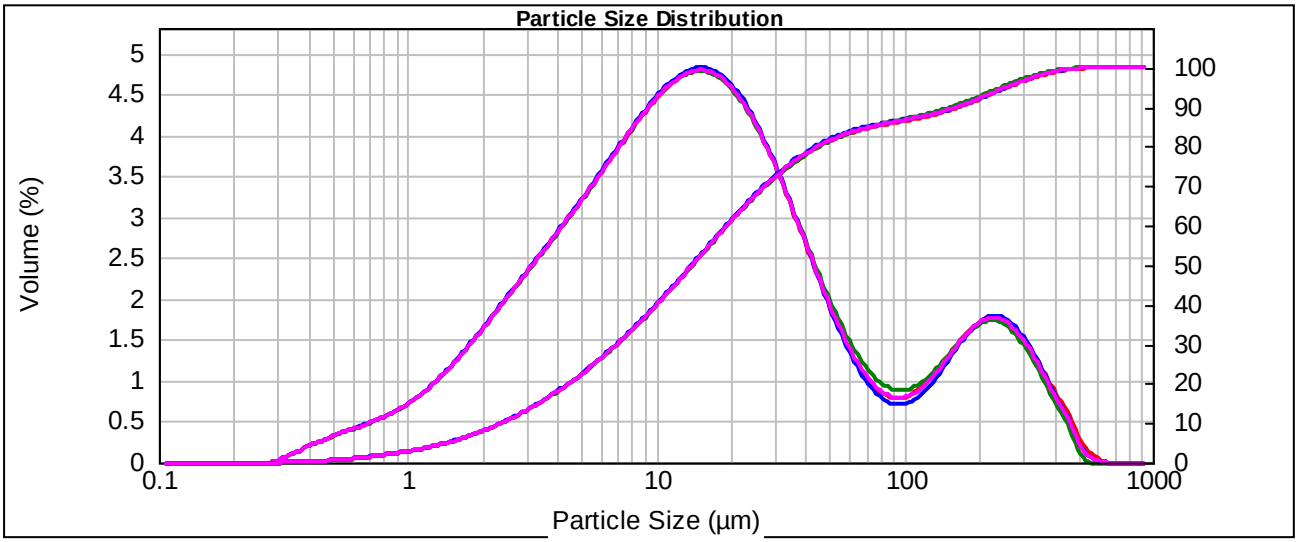
Concentration: 0.0087 %Vol
Specific Surface Area: 1.04 m²/g

Span : 11.266
Surface Weighted Mean D[3,2]: 5.742 um

Uniformity: 2.86
Vol. Weighted Mean D[4,3]: 46.154 um

Result units: Volume

d(0.1): 2.388 um d(0.5): 13.988 um **d(0.8): 44.649 um** d(0.9): 159.967 um d(0.98): 341.83 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.04
0.331	0.07
0.363	0.10
0.398	0.14
0.437	0.17
0.479	0.19
0.525	0.22
0.575	0.25
0.631	0.27
0.692	0.30
0.759	0.33
0.832	0.37
0.912	0.41
1.000	0.45
1.096	0.51
1.202	0.57
1.318	0.64
1.445	0.72
1.585	0.80
1.738	0.89
1.905	0.98
2.089	1.07
2.291	1.16
2.512	1.26
2.754	1.35
3.020	1.45
3.311	1.54
3.631	1.64
3.981	1.73
4.365	1.83
4.786	1.93
5.248	2.03
5.754	2.14
6.310	2.24
6.918	2.34
7.586	2.45
8.318	2.55
9.120	2.64
10.000	2.72
10.965	2.79
12.023	2.85
13.183	2.88
14.454	2.89
15.849	2.88
17.378	2.84
19.055	2.78
20.893	2.68
22.909	2.57
25.119	2.43
27.542	2.27
30.200	2.10
33.113	1.92
36.308	1.73
39.811	1.53
43.652	1.35
47.863	1.16
52.481	0.99
57.544	0.84
63.096	0.71
69.183	0.61
75.858	0.54
83.176	0.49
91.201	0.48
100.000	0.49
109.648	0.54
120.226	0.60
131.826	0.69
144.544	0.78
158.489	0.88
173.780	0.97
190.546	1.03
208.930	1.06
229.087	1.06
251.189	1.02
275.423	0.95
301.995	0.85
331.131	0.72
363.078	0.58
398.107	0.44
436.516	0.32
478.630	0.14
524.807	0.05
575.440	0.01
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	0.00

Operator notes: *Average of 3 measurements from 2721*

G&T METALLURGICAL SERVICES LTD.

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM2721-30

Sample Name:
Cyanide Tail - Average

Measured by:
Kent

Edited by:
Kent

Measured:
Wednesday, November 03, 2010 10:53:04 AM

Analysed:
Wednesday, November 03, 2010 10:53:05 AM

Particle Name: Silica 1.0
Particle RI: 1.544
Dispersant Name: Water

Accessory Name: Hydro 2000MU (A)
Absorption: 1
Dispersant RI: 1.330

Analysis model: General purpose
Size range: 0.100 to 1000.000 um
Weighted Residual: 0.138 %

Sensitivity: Normal
Obscuration: 17.78 %
Result Emulation: Off

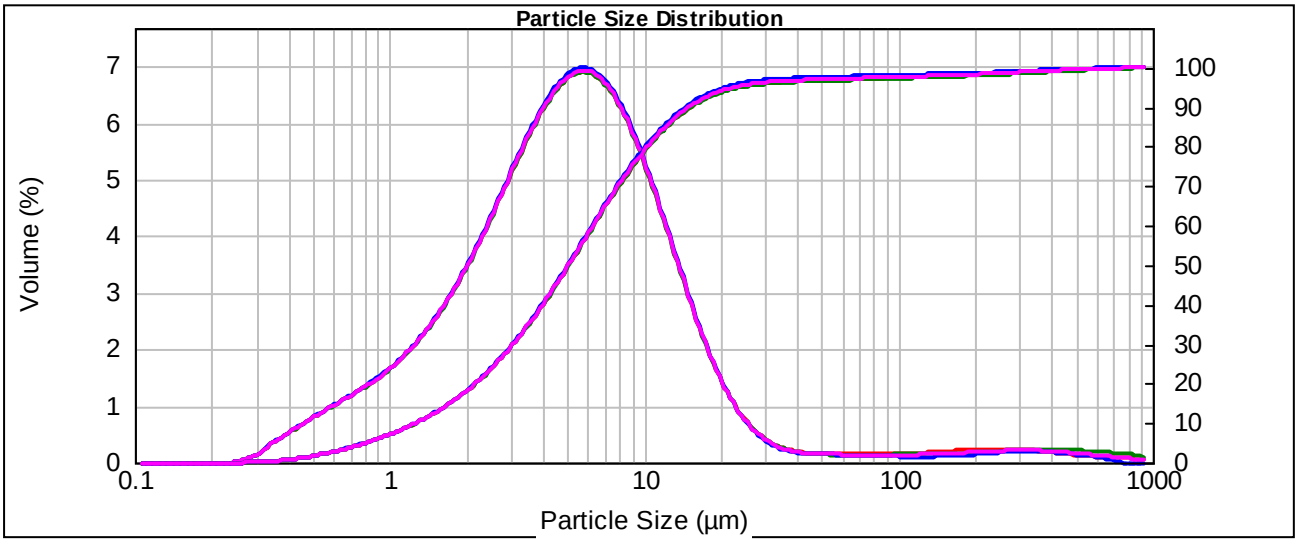
Concentration: 0.0070 %Vol
Specific Surface Area: 2.08 m²/g

Span : 2.723
Surface Weighted Mean D[3,2]: 2.884 um

Uniformity: 2.35
Vol. Weighted Mean D[4,3]: 14.501 um

Result units: Volume

d(0.1): 1.270 um d(0.5): 5.046 um **d(0.8): 10.297 um** d(0.9): 15.009 um d(0.98): 145.22 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.02
0.275	0.06
0.302	0.12
0.331	0.21
0.363	0.27
0.398	0.34
0.437	0.41
0.479	

Size (µm)	Volume In %
0.479	0.48
0.525	0.54
0.575	0.61
0.631	0.67
0.692	0.73
0.759	0.80
0.832	0.87
0.912	0.95
1.000	1.04
1.096	1.14
1.202	1.26
1.318	1.38
1.445	1.53
1.585	1.69
1.738	1.87
1.905	2.06
2.089	2.27
2.291	

Size (µm)	Volume In %
2.291	2.49
2.512	2.73
2.754	2.97
3.020	3.21
3.311	3.44
3.631	3.65
3.981	3.84
4.365	3.99
4.786	4.10
5.248	4.16
5.754	4.17
6.310	4.11
6.918	4.00
7.586	3.83
8.318	3.61
9.120	3.35
10.000	3.05
10.965	

Size (µm)	Volume In %
10.965	2.74
12.023	2.40
13.183	2.06
14.454	1.74
15.849	1.43
17.378	1.15
19.055	0.90
20.893	0.69
22.909	0.51
25.119	0.38
27.542	0.28
30.200	0.20
33.113	0.15
36.308	0.12
39.811	0.10
43.652	0.09
47.863	0.09
52.481	

Size (µm)	Volume In %
52.481	0.09
57.544	0.08
63.096	0.08
69.183	0.08
75.858	0.08
83.176	0.08
91.201	0.08
100.000	0.08
109.648	0.08
120.226	0.09
131.826	0.09
144.544	0.09
158.489	0.10
173.780	0.10
190.546	0.11
208.930	0.12
229.087	0.12
251.189	

Size (µm)	Volume In %
251.189	0.13
275.423	0.13
301.995	0.13
331.131	0.13
363.078	0.12
398.107	0.12
436.516	0.11
478.630	0.10
524.807	0.09
575.440	0.08
630.957	0.07
691.831	0.05
758.578	0.04
831.764	0.04
912.011	0.01
1000.000	

Operator notes:

G&T METALLURGICAL SERVICES LTD.

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM2721-31

Sample Name:
Bulk Regrind Discharge - Average

Measured by:
julie

Edited by:
julie

Measured:
Monday, November 01, 2010 8:29:14 AM

Analysed:
Monday, November 01, 2010 8:29:15 AM

Particle Name: Silica 0.01
Particle RI: 1.544
Dispersant Name: Water

Accessory Name: Hydro 2000MU (A)
Absorption: 0.01
Dispersant RI: 1.330

Analysis model: General purpose
Size range: 0.100 to 1000.000 um
Weighted Residual: 0.204 %

Sensitivity: Normal
Obscuration: 16.01 %
Result Emulation: Off

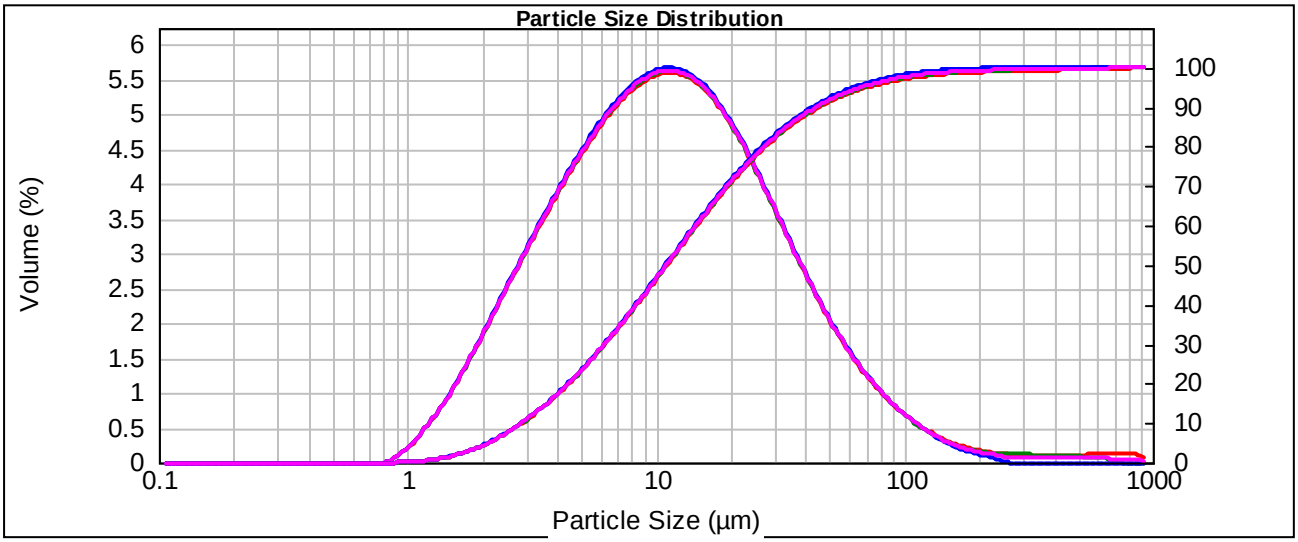
Concentration: 0.0140 %Vol
Specific Surface Area: 0.33 m²/g

Span : 3.748
Surface Weighted Mean D[3,2]: 6.851 um

Uniformity: 1.44
Vol. Weighted Mean D[4,3]: 21.364 um

Result units: Volume

d(0.1): 2.887 um d(0.5): 10.990 um **d(0.8): 27.211 um** d(0.9): 44.078 um d(0.98): 108.3 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.00
0.437	0.00
0.479	0.00

Size (µm)	Volume In %
0.479	0.00
0.525	0.00
0.575	0.00
0.631	0.00
0.692	0.00
0.759	0.00
0.832	0.02
0.912	0.10
1.000	0.15
1.096	0.27
1.202	0.37
1.318	0.49
1.445	0.63
1.585	0.78
1.738	0.93
1.905	1.09
2.089	1.26
2.291	1.43

Size (µm)	Volume In %
2.291	1.43
2.512	1.59
2.754	1.76
3.020	1.92
3.311	2.08
3.631	2.24
3.981	2.39
4.365	2.54
4.786	2.68
5.248	2.81
5.754	2.93
6.310	3.04
6.918	3.14
7.586	3.23
8.318	3.30
9.120	3.35
10.000	3.38
10.965	3.38

Size (µm)	Volume In %
10.965	3.38
12.023	3.37
13.183	3.33
14.454	3.27
15.849	3.18
17.378	3.07
19.055	2.94
20.893	2.79
22.909	2.62
25.119	2.45
27.542	2.27
30.200	2.09
33.113	1.90
36.308	1.72
39.811	1.55
43.652	1.39
47.863	1.23
52.481	1.23

Size (µm)	Volume In %
52.481	1.09
57.544	0.96
63.096	0.83
69.183	0.72
75.858	0.62
83.176	0.53
91.201	0.45
100.000	0.38
109.648	0.31
120.226	0.26
131.826	0.21
144.544	0.17
158.489	0.14
173.780	0.11
190.546	0.09
208.930	0.08
229.087	0.06
251.189	0.06

Size (µm)	Volume In %
251.189	0.05
275.423	0.04
301.995	0.04
331.131	0.04
363.078	0.04
398.107	0.04
436.516	0.04
478.630	0.04
524.807	0.04
575.440	0.04
630.957	0.04
691.831	0.03
758.578	0.02
831.764	0.02
912.011	0.01
1000.000	

Operator notes:

G&T METALLURGICAL SERVICES LTD.

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM2721-32

Measured by:
julie

Measured:
Monday, November 01, 2010 8:33:16 AM

Sample Name:
Bulk Regrind Discharge - Average

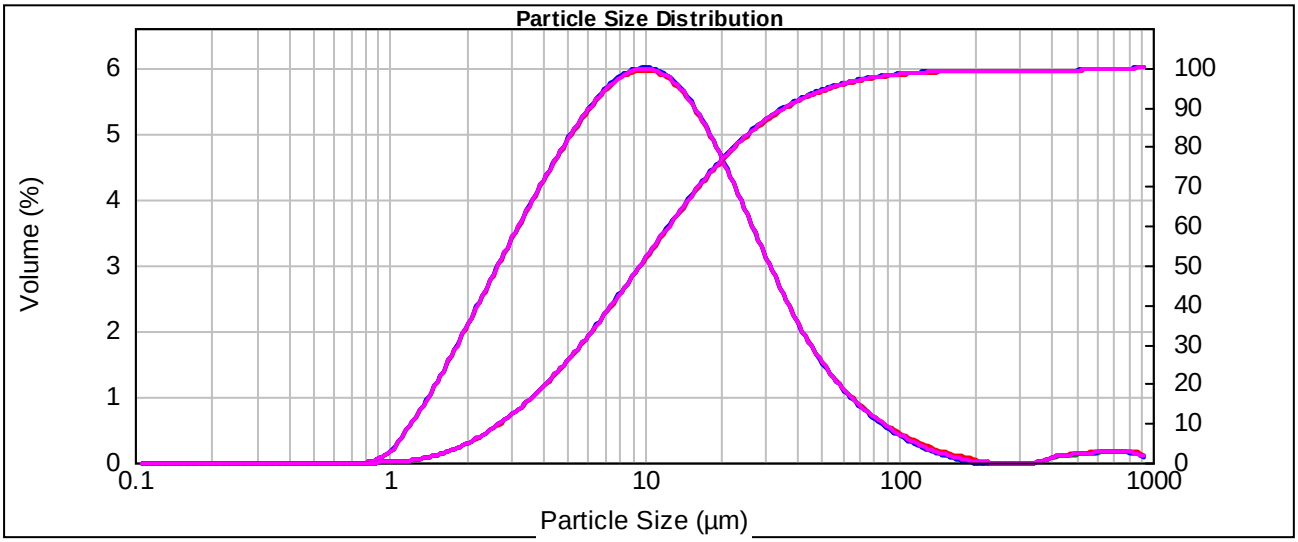
Edited by:
julie

Analysed:
Monday, November 01, 2010 8:33:17 AM

Particle Name: Silica 0.01
Accessory Name: Hydro 2000MU (A)
Analysis model: General purpose
Sensitivity: Normal
Particle RI: 1.544
Absorption: 0.01
Size range: 0.100 to 1000.000 um
Obscuration: 18.68 %
Dispersant Name: Water
Dispersant RI: 1.330
Weighted Residual: 0.135 %
Result Emulation: Off

Concentration: 0.0154 %Vol
Span : 3.417
Uniformity: 1.59
Result units: Volume
Specific Surface Area: 0.356 m²/g
Surface Weighted Mean D[3,2]: 6.367 um
Vol. Weighted Mean D[4,3]: 20.573 um

d(0.1): 2.744 um d(0.5): 9.711 um **d(0.8): 22.716 um** d(0.9): 35.928 um d(0.98): 89.31 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.00
0.437	0.00
0.479	0.00

Size (µm)	Volume In %
0.479	0.00
0.525	0.00
0.575	0.00
0.631	0.00
0.692	0.00
0.759	0.00
0.832	0.01
0.912	0.07
1.000	0.13
1.096	0.28
1.202	0.40
1.318	0.54
1.445	0.70
1.585	0.88
1.738	1.05
1.905	1.23
2.089	1.41
2.291	

Size (µm)	Volume In %
2.291	1.59
2.512	1.77
2.754	1.95
3.020	2.13
3.311	2.30
3.631	2.48
3.981	2.64
4.365	2.80
4.786	2.96
5.248	3.10
5.754	3.23
6.310	3.34
6.918	3.44
7.586	3.52
8.318	3.57
9.120	3.60
10.000	3.61
10.965	

Size (µm)	Volume In %
10.965	3.58
12.023	3.52
13.183	3.43
14.454	3.32
15.849	3.18
17.378	3.01
19.055	2.82
20.893	2.62
22.909	2.41
25.119	2.20
27.542	1.98
30.200	1.77
33.113	1.58
36.308	1.39
39.811	1.21
43.652	1.06
47.863	0.92
52.481	

Size (µm)	Volume In %
52.481	0.79
57.544	0.68
63.096	0.58
69.183	0.50
75.858	0.42
83.176	0.35
91.201	0.29
100.000	0.24
109.648	0.19
120.226	0.14
131.826	0.11
144.544	0.08
158.489	0.05
173.780	0.02
190.546	0.01
208.930	0.00
229.087	0.00
251.189	

Size (µm)	Volume In %
251.189	0.00
275.423	0.00
301.995	0.00
331.131	0.00
363.078	0.02
398.107	0.06
436.516	0.07
478.630	0.08
524.807	0.09
575.440	0.09
630.957	0.10
691.831	0.10
758.578	0.10
831.764	0.09
912.011	0.03
1000.000	

Operator notes:

G&T METALLURGICAL SERVICES LTD.

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM2721-33

Sample Name:
Bulk Regrind Discharge V - Average

Measured by:
titan

Edited by:
titan

Measured:
Tuesday, November 09, 2010 11:39:00 AM

Analysed:
Tuesday, November 09, 2010 11:39:01 AM

Particle Name: Silica 0.1
Particle RI: 1.544
Dispersant Name: Water

Accessory Name: Hydro 2000MU (A)
Absorption: 0.1
Dispersant RI: 1.330

Analysis model: General purpose
Size range: 0.100 to 1000.000 um
Weighted Residual: 0.783 %

Sensitivity: Normal
Obscuration: 18.40 %
Result Emulation: Off

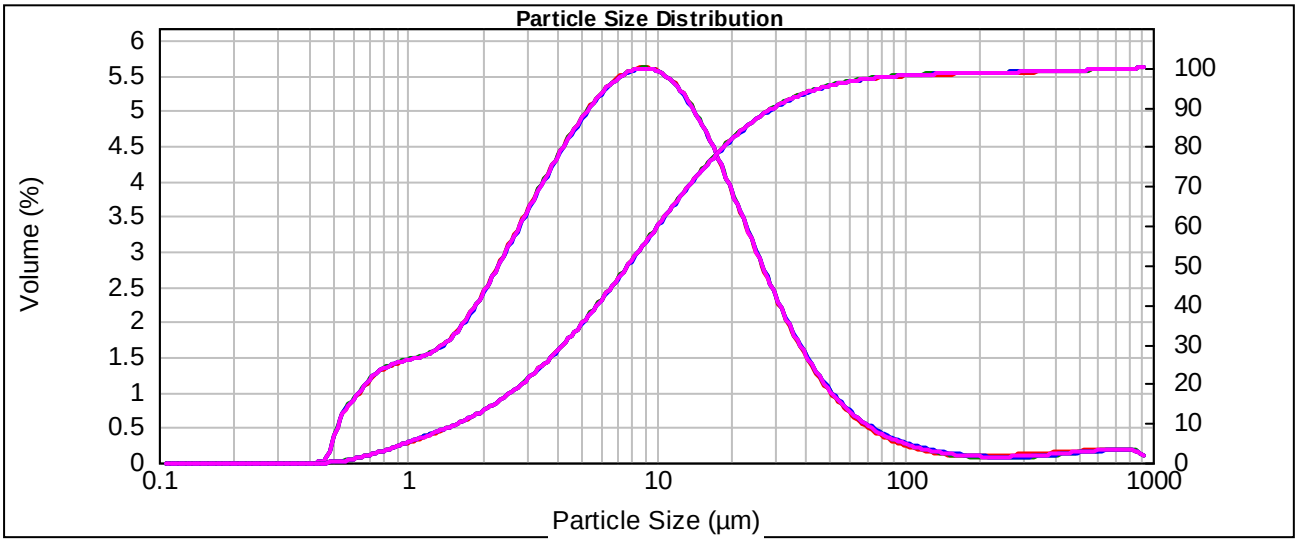
Concentration: 0.0114 %Vol
Specific Surface Area: 0.566 m²/g

Span : 3.676
Surface Weighted Mean D[3,2]: 4.003 um

Uniformity: 2.04
Vol. Weighted Mean D[4,3]: 19.511 um

Result units: Volume

d(0.1): 1.608 um d(0.5): 7.741 um **d(0.8): 18.779 um** d(0.9): 30.060 um d(0.98): 98.76 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.00
0.437	0.00
0.479	0.00

Size (µm)	Volume In %
0.479	0.18
0.525	0.43
0.575	0.53
0.631	0.64
0.692	0.74
0.759	0.80
0.832	0.84
0.912	0.87
1.000	0.89
1.096	0.91
1.202	0.94
1.318	1.00
1.445	1.07
1.585	1.17
1.738	1.29
1.905	1.43
2.089	1.58
2.291	1.74

Size (µm)	Volume In %
2.291	1.74
2.512	1.90
2.754	2.06
3.020	2.22
3.311	2.37
3.631	2.53
3.981	2.67
4.365	2.81
4.786	2.94
5.248	3.05
5.754	3.15
6.310	3.24
6.918	3.30
7.586	3.35
8.318	3.37
9.120	3.37
10.000	3.33
10.965	3.27

Size (µm)	Volume In %
10.965	3.27
12.023	3.18
13.183	3.06
14.454	2.91
15.849	2.74
17.378	2.55
19.055	2.35
20.893	2.14
22.909	1.93
25.119	1.73
27.542	1.53
30.200	1.34
33.113	1.16
36.308	1.00
39.811	0.86
43.652	0.73
47.863	0.61
52.481	0.52

Size (µm)	Volume In %
52.481	0.52
57.544	0.43
63.096	0.36
69.183	0.30
75.858	0.25
83.176	0.21
91.201	0.18
100.000	0.15
109.648	0.12
120.226	0.10
131.826	0.08
144.544	0.07
158.489	0.06
173.780	0.06
190.546	0.05
208.930	0.05
229.087	0.05
251.189	0.05

Size (µm)	Volume In %
251.189	0.05
275.423	0.05
301.995	0.06
331.131	0.06
363.078	0.07
398.107	0.07
436.516	0.08
478.630	0.09
524.807	0.10
575.440	0.10
630.957	0.11
691.831	0.11
758.578	0.11
831.764	0.10
912.011	0.03
1000.000	

Operator notes:

G&T METALLURGICAL SERVICES LTD.

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM2721-33

Sample Name:
Pyrite Rougher Concentrate - Average

Measured by:
david

Edited by:
david

Measured:
Tuesday, November 09, 2010 1:49:28 PM

Analysed:
Tuesday, November 09, 2010 1:49:29 PM

Particle Name:
Silica 1.0

Particle RI:
1.544

Dispersant Name:
Water

Accessory Name:
Hydro 2000MU (A)

Absorption:
1

Dispersant RI:
1.330

Analysis model:
General purpose

Size range:
0.100 to 1000.000 um

Weighted Residual:
0.321 %

Sensitivity:
Normal

Obscuration:
10.04 %

Result Emulation:
Off

Concentration:
0.0056 %Vol

Span :
9.969

Uniformity:
3.45

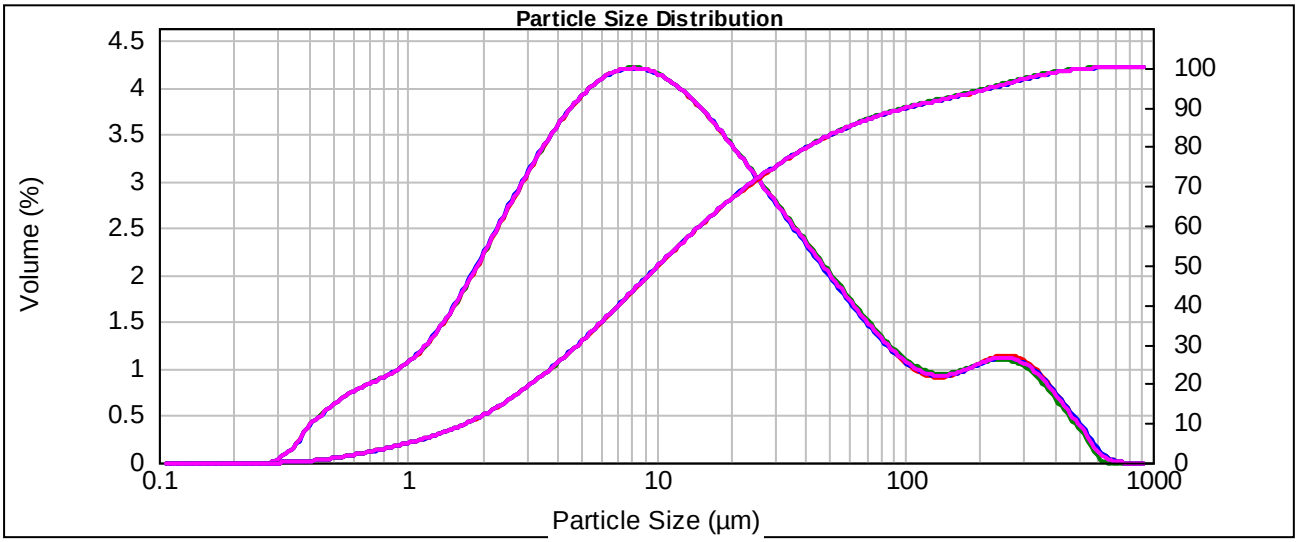
Result units:
Volume

Specific Surface Area:
1.4 m²/g

Surface Weighted Mean D[3,2]:
4.295 um

Vol. Weighted Mean D[4,3]:
39.813 um

d(0.1): 1.734 um d(0.5): 10.261 um **d(0.8): 40.826 um** d(0.9): 104.024 um d(0.98): 346.63 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.04
0.331	0.09
0.363	0.18
0.398	0.26
0.437	0.32
0.479	

Size (µm)	Volume In %
0.479	0.37
0.525	0.42
0.575	0.46
0.631	0.49
0.692	0.52
0.759	0.54
0.832	0.58
0.912	0.62
1.000	0.67
1.096	0.73
1.202	0.80
1.318	0.89
1.445	0.98
1.585	1.09
1.738	1.20
1.905	1.32
2.089	1.44
2.291	

Size (µm)	Volume In %
2.291	1.56
2.512	1.67
2.754	1.79
3.020	1.90
3.311	2.01
3.631	2.11
3.981	2.20
4.365	2.28
4.786	2.35
5.248	2.41
5.754	2.46
6.310	2.50
6.918	2.52
7.586	2.53
8.318	2.53
9.120	2.51
10.000	2.48
10.965	

Size (µm)	Volume In %
10.965	2.45
12.023	2.40
13.183	2.34
14.454	2.27
15.849	2.20
17.378	2.13
19.055	2.05
20.893	1.97
22.909	1.88
25.119	1.80
27.542	1.71
30.200	1.63
33.113	1.55
36.308	1.46
39.811	1.38
43.652	1.29
47.863	1.21
52.481	

Size (µm)	Volume In %
52.481	1.12
57.544	1.04
63.096	0.96
69.183	0.88
75.858	0.81
83.176	0.74
91.201	0.68
100.000	0.63
109.648	0.59
120.226	0.57
131.826	0.56
144.544	0.56
158.489	0.58
173.780	0.60
190.546	0.63
208.930	0.66
229.087	0.67
251.189	

Size (µm)	Volume In %
251.189	0.67
275.423	0.65
301.995	0.62
331.131	0.56
363.078	0.50
398.107	0.41
436.516	0.33
478.630	0.25
524.807	0.16
575.440	0.05
630.957	0.02
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes: *Average of 3 measurements from 2721*

TABLE III-31

G&T METALLURGICAL SERVICES LTD.

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM2721-34

Sample Name:
Bulk Regrind Discharge V - Average

Measured by:
Justin

Edited by:
Justin

Measured:
Thursday, November 18, 2010 12:28:48 PM

Analysed:
Thursday, November 18, 2010 12:28:49 PM

Particle Name: Silica 1.0
Particle RI: 1.544
Dispersant Name: Water

Accessory Name: Hydro 2000MU (A)
Absorption: 1
Dispersant RI: 1.330

Analysis model: General purpose
Size range: 0.100 to 1000.000 um
Weighted Residual: 0.263 %

Sensitivity: Normal
Obscuration: 15.73 %
Result Emulation: Off

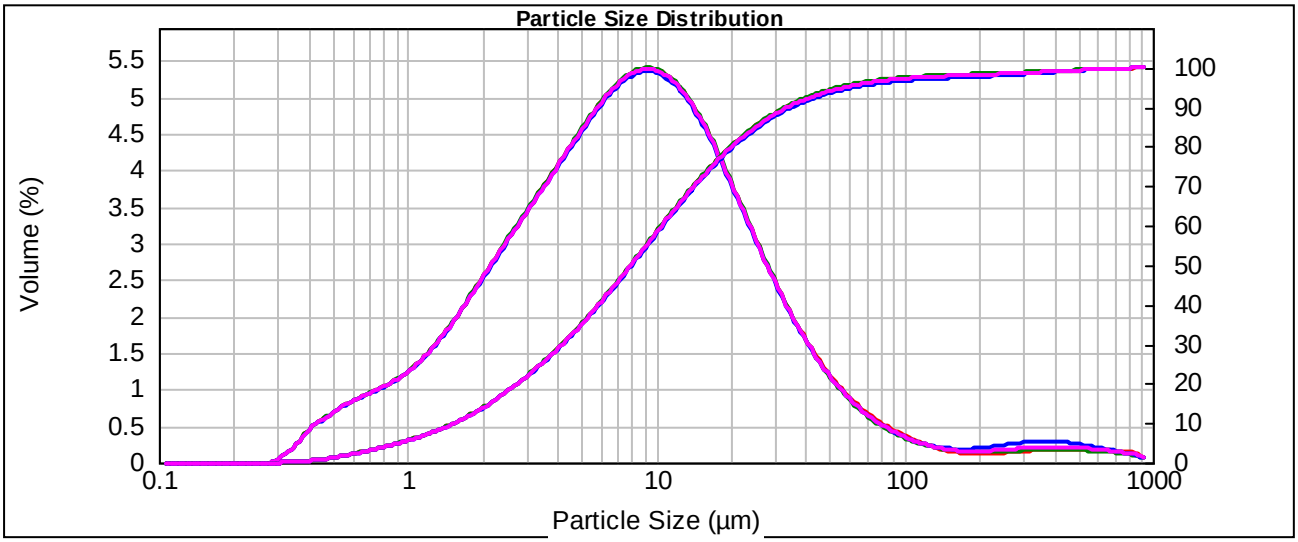
Concentration: 0.0079 %Vol
Specific Surface Area: 1.61 m²/g

Span : 4.083
Surface Weighted Mean D[3,2]: 3.726 um

Uniformity: 2.24
Vol. Weighted Mean D[4,3]: 21.505 um

Result units: Volume

d(0.1): 1.545 um d(0.5): 7.943 um **d(0.8): 20.192 um** d(0.9): 33.978 um d(0.98): 163.18 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.06
0.331	0.12
0.363	0.22
0.398	0.30
0.437	0.36
0.479	

Size (µm)	Volume In %
0.479	0.41
0.525	0.47
0.575	0.51
0.631	0.55
0.692	0.58
0.759	0.62
0.832	0.66
0.912	0.72
1.000	0.78
1.096	0.85
1.202	0.94
1.318	1.04
1.445	1.15
1.585	1.27
1.738	1.39
1.905	1.51
2.089	1.64
2.291	

Size (µm)	Volume In %
2.291	1.76
2.512	1.88
2.754	2.01
3.020	2.13
3.311	2.25
3.631	2.37
3.981	2.49
4.365	2.61
4.786	2.74
5.248	2.85
5.754	2.97
6.310	3.06
6.918	3.14
7.586	3.20
8.318	3.24
9.120	3.24
10.000	3.22
10.965	

Size (µm)	Volume In %
10.965	3.16
12.023	3.08
13.183	2.97
14.454	2.83
15.849	2.68
17.378	2.50
19.055	2.32
20.893	2.13
22.909	1.94
25.119	1.75
27.542	1.57
30.200	1.40
33.113	1.24
36.308	1.09
39.811	0.95
43.652	0.83
47.863	0.71
52.481	

Size (µm)	Volume In %
52.481	0.61
57.544	0.53
63.096	0.45
69.183	0.38
75.858	0.32
83.176	0.27
91.201	0.23
100.000	0.19
109.648	0.16
120.226	0.14
131.826	0.12
144.544	0.11
158.489	0.10
173.780	0.09
190.546	0.09
208.930	0.10
229.087	0.10
251.189	

Size (µm)	Volume In %
251.189	0.11
275.423	0.12
301.995	0.12
331.131	0.13
363.078	0.13
398.107	0.13
436.516	0.13
478.630	0.12
524.807	0.12
575.440	0.11
630.957	0.10
691.831	0.09
758.578	0.08
831.764	0.06
912.011	0.02
1000.000	

Operator notes:

G&T METALLURGICAL SERVICES LTD.

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM2721-34

Sample Name:
Pyrite Rougher Concentrate - Average

Measured by:
julie

Edited by:
julie

Measured:
Monday, November 22, 2010 1:34:13 PM

Analysed:
Monday, November 22, 2010 1:34:14 PM

Particle Name:
Silica 0.01

Particle RI:
1.544

Dispersant Name:
Water

Accessory Name:
Hydro 2000MU (A)

Absorption:
0.01

Dispersant RI:
1.330

Analysis model:
General purpose

Size range:
0.100 to 1000.000 um

Weighted Residual:
0.651 %

Sensitivity:
Normal

Obscuration:
10.42 %

Result Emulation:
Off

Concentration:
0.0103 %Vol

Span :
19.458

Uniformity:
5.68

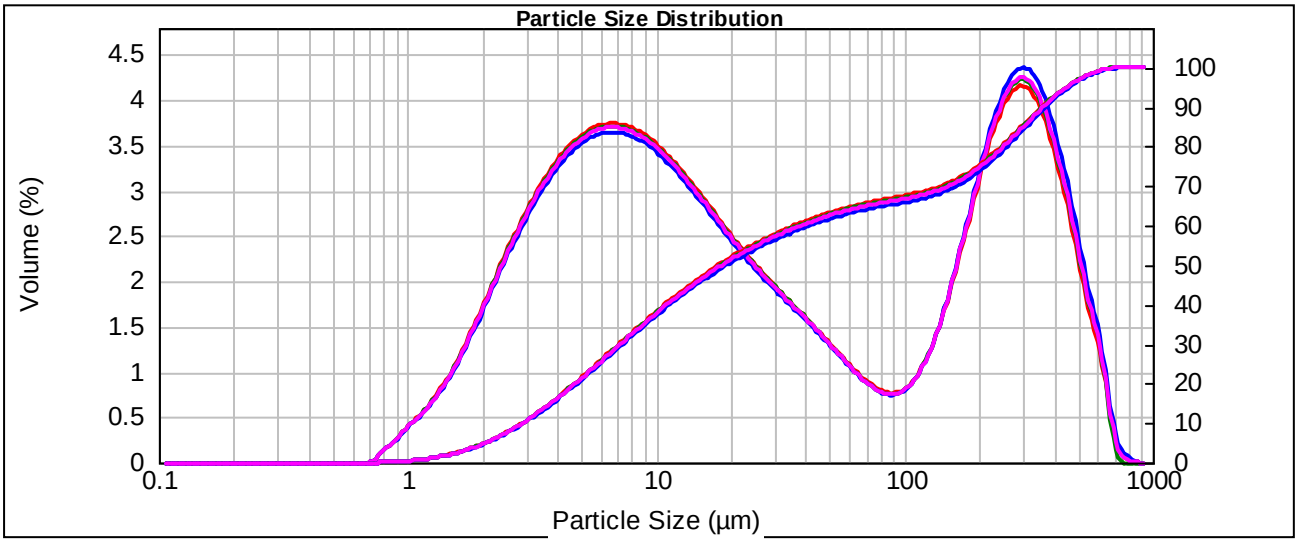
Result units:
Volume

Specific Surface Area:
0.28 m²/g

Surface Weighted Mean D[3,2]:
8.078 um

Vol. Weighted Mean D[4,3]:
111.719 um

d(0.1): 2.914 um d(0.5): 18.437 um **d(0.8): 250.435 um** d(0.9): 361.660 um d(0.98): 543.26 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.00
0.437	0.00
0.479	0.00

Size (µm)	Volume In %
0.479	0.00
0.525	0.00
0.575	0.00
0.631	0.00
0.692	0.00
0.759	0.08
0.832	0.13
0.912	0.20
1.000	0.27
1.096	0.32
1.202	0.40
1.318	0.50
1.445	0.60
1.585	0.73
1.738	0.87
1.905	1.01
2.089	1.16
2.291	1.31

Size (µm)	Volume In %
2.291	1.31
2.512	1.45
2.754	1.59
3.020	1.72
3.311	1.83
3.631	1.93
3.981	2.02
4.365	2.09
4.786	2.15
5.248	2.19
5.754	2.22
6.310	2.23
6.918	2.22
7.586	2.20
8.318	2.17
9.120	2.12
10.000	2.06
10.965	2.00

Size (µm)	Volume In %
10.965	2.00
12.023	1.92
13.183	1.84
14.454	1.76
15.849	1.67
17.378	1.58
19.055	1.50
20.893	1.42
22.909	1.34
25.119	1.27
27.542	1.19
30.200	1.13
33.113	1.06
36.308	0.99
39.811	0.93
43.652	0.86
47.863	0.78
52.481	0.71

Size (µm)	Volume In %
52.481	0.71
57.544	0.64
63.096	0.57
69.183	0.52
75.858	0.47
83.176	0.45
91.201	0.46
100.000	0.51
109.648	0.60
120.226	0.73
131.826	0.90
144.544	1.12
158.489	1.37
173.780	1.63
190.546	1.90
208.930	2.14
229.087	2.34
251.189	2.48

Size (µm)	Volume In %
251.189	2.48
275.423	2.55
301.995	2.54
331.131	2.44
363.078	2.27
398.107	2.03
436.516	1.74
478.630	1.42
524.807	1.09
575.440	0.83
630.957	0.44
691.831	0.06
758.578	0.01
831.764	0.00
912.011	0.00
1000.000	0.00

Operator notes:

G&T METALLURGICAL SERVICES LTD.

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM2721-35

Sample Name:
Bulk Regrind Discharge V - Average

Measured by:
Justin

Edited by:
Justin

Measured:
Thursday, November 25, 2010 1:00:03 PM

Analysed:
Thursday, November 25, 2010 1:00:04 PM

Particle Name: Silica 1.0
Particle RI: 1.544
Dispersant Name: Water

Accessory Name: Hydro 2000MU (A)
Absorption: 1
Dispersant RI: 1.330

Analysis model: General purpose
Size range: 0.100 to 1000.000 um
Weighted Residual: 0.271 %

Sensitivity: Normal
Obscuration: 18.59 %
Result Emulation: Off

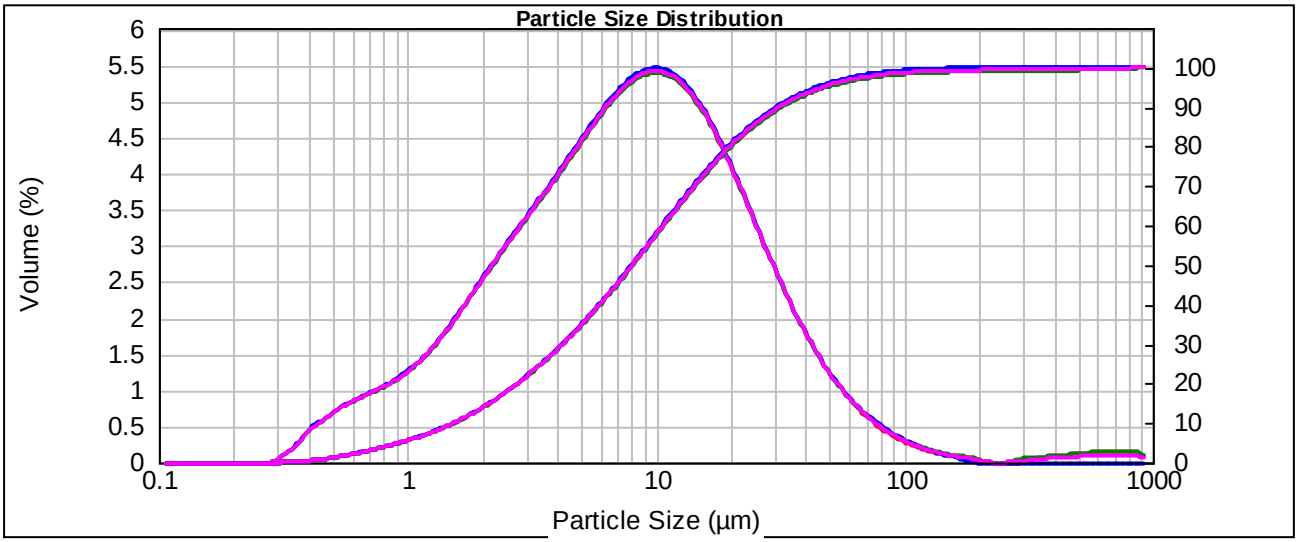
Concentration: 0.0095 %Vol
Specific Surface Area: 1.61 m²/g

Span : 3.707
Surface Weighted Mean D[3,2]: 3.715 um

Uniformity: 1.64
Vol. Weighted Mean D[4,3]: 16.860 um

Result units: Volume

d(0.1): 1.534 um d(0.5): 8.030 um **d(0.8): 19.818 um** d(0.9): 31.301 um d(0.98): 75.6 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.06
0.331	0.12
0.363	0.21
0.398	0.30
0.437	0.36
0.479	

Size (µm)	Volume In %
0.479	0.42
0.525	0.47
0.575	0.51
0.631	0.55
0.692	0.59
0.759	0.63
0.832	0.67
0.912	0.72
1.000	0.79
1.096	0.86
1.202	0.95
1.318	1.05
1.445	1.16
1.585	1.28
1.738	1.40
1.905	1.52
2.089	1.64
2.291	

Size (µm)	Volume In %
2.291	1.76
2.512	1.88
2.754	1.99
3.020	2.10
3.311	2.21
3.631	2.32
3.981	2.44
4.365	2.56
4.786	2.68
5.248	2.80
5.754	2.91
6.310	3.02
6.918	3.11
7.586	3.18
8.318	3.23
9.120	3.26
10.000	3.26
10.965	

Size (µm)	Volume In %
10.965	3.23
12.023	3.17
13.183	3.08
14.454	2.97
15.849	2.82
17.378	2.66
19.055	2.48
20.893	2.29
22.909	2.10
25.119	1.90
27.542	1.70
30.200	1.51
33.113	1.34
36.308	1.17
39.811	1.01
43.652	0.87
47.863	0.74
52.481	

Size (µm)	Volume In %
52.481	0.63
57.544	0.53
63.096	0.45
69.183	0.37
75.858	0.31
83.176	0.25
91.201	0.20
100.000	0.16
109.648	0.13
120.226	0.10
131.826	0.08
144.544	0.06
158.489	0.05
173.780	0.04
190.546	0.02
208.930	0.00
229.087	0.00
251.189	

Size (µm)	Volume In %
251.189	0.00
275.423	0.01
301.995	0.02
331.131	0.03
363.078	0.03
398.107	0.04
436.516	0.04
478.630	0.05
524.807	0.05
575.440	0.06
630.957	0.06
691.831	0.06
758.578	0.06
831.764	0.06
912.011	0.02
1000.000	

Operator notes:

TABLE III-34

G&T METALLURGICAL SERVICES LTD.

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM2721-36

Sample Name:
Bulk Regrind Discharge V - Average

Measured by:
Natasha

Edited by:
Natasha

Measured:
Tuesday, November 30, 2010 1:17:20 PM

Analysed:
Tuesday, November 30, 2010 1:17:21 PM

Particle Name: Silica 0.01
Particle RI: 1.544
Dispersant Name: Water

Accessory Name: Hydro 2000MU (A)
Absorption: 0.01
Dispersant RI: 1.330

Analysis model: General purpose
Size range: 0.100 to 1000.000 um
Weighted Residual: 0.318 %

Sensitivity: Normal
Obscuration: 15.56 %
Result Emulation: Off

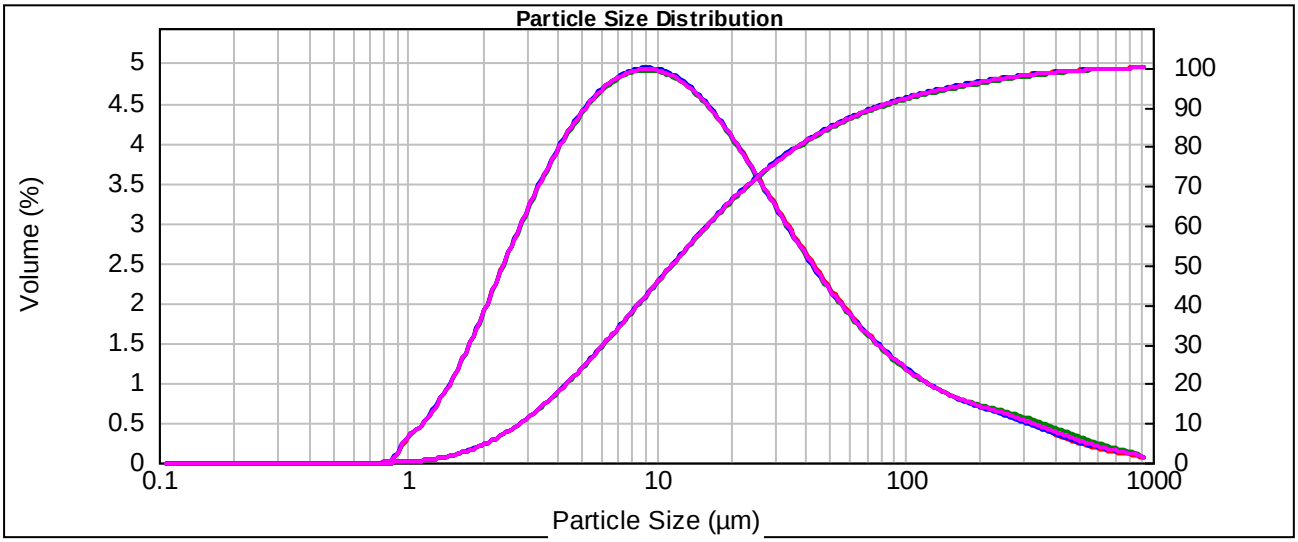
Concentration: 0.0138 %Vol
Specific Surface Area: 0.324 m²/g

Span : 6.460
Surface Weighted Mean D[3,2]: 6.994 um

Uniformity: 2.6
Vol. Weighted Mean D[4,3]: 35.730 um

Result units: Volume

d(0.1): 2.850 um d(0.5): 11.600 um **d(0.8): 37.135 um** d(0.9): 77.786 um d(0.98): 302.8 um



Size (µm)	Volume In %
0.010	0.00
0.011	0.00
0.013	0.00
0.015	0.00
0.017	0.00
0.020	0.00
0.023	0.00
0.026	0.00
0.030	0.00
0.035	0.00
0.040	0.00
0.046	0.00
0.052	0.00
0.060	0.00
0.069	0.00
0.079	0.00
0.091	0.00
0.105	0.00

Size (µm)	Volume In %
0.105	0.00
0.120	0.00
0.138	0.00
0.158	0.00
0.182	0.00
0.209	0.00
0.240	0.00
0.275	0.00
0.316	0.00
0.363	0.00
0.417	0.00
0.479	0.00
0.550	0.00
0.631	0.00
0.724	0.00
0.832	0.00
0.955	0.07
1.096	0.31

Size (µm)	Volume In %
1.096	0.46
1.259	0.70
1.445	0.99
1.660	1.34
1.905	1.72
2.188	2.12
2.512	2.52
2.884	2.89
3.311	3.25
3.802	3.56
4.365	3.83
5.012	4.05
5.754	4.23
6.607	4.35
7.586	4.42
8.710	4.44
10.000	4.41
11.482	

Size (µm)	Volume In %
11.482	4.33
13.183	4.20
15.136	4.03
17.378	3.81
19.953	3.57
22.909	3.31
26.303	3.04
30.200	2.76
34.674	2.49
39.811	2.24
45.709	2.00
52.481	1.78
60.256	1.58
69.183	1.40
79.433	1.24
91.201	1.10
104.713	0.97
120.226	

Size (µm)	Volume In %
120.226	0.87
138.038	0.78
158.489	0.71
181.970	0.65
208.930	0.60
239.883	0.55
275.423	0.49
316.228	0.43
363.078	0.36
416.869	0.30
478.630	0.24
549.541	0.19
630.957	0.15
724.436	0.11
831.764	0.08
954.993	0.00
1096.478	0.00
1258.925	

Size (µm)	Volume In %
1258.925	0.00
1445.440	0.00
1659.587	0.00
1905.461	0.00
2187.762	0.00
2511.886	0.00
2884.032	0.00
3311.311	0.00
3801.894	0.00
4365.158	0.00
5011.872	0.00
5754.399	0.00
6606.934	0.00
7585.776	0.00
8709.636	0.00
10000.000	0.00

Operator notes:

TABLE III-35

G&T METALLURGICAL SERVICES LTD.

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM2721-36

Sample Name:
Pyrite Rougher Concentrate - Average

Measured by:
natasha

Edited by:
natasha

Measured:
Tuesday, November 30, 2010 12:20:10 PM

Analysed:
Tuesday, November 30, 2010 12:20:11 PM

Particle Name: Silica 0.01
Particle RI: 1.544
Dispersant Name: Water

Accessory Name: Hydro 2000MU (A)
Absorption: 0.01
Dispersant RI: 1.330

Analysis model: General purpose
Size range: 0.100 to 1000.000 um
Weighted Residual: 0.804 %

Sensitivity: Normal
Obscuration: 12.41 %
Result Emulation: Off

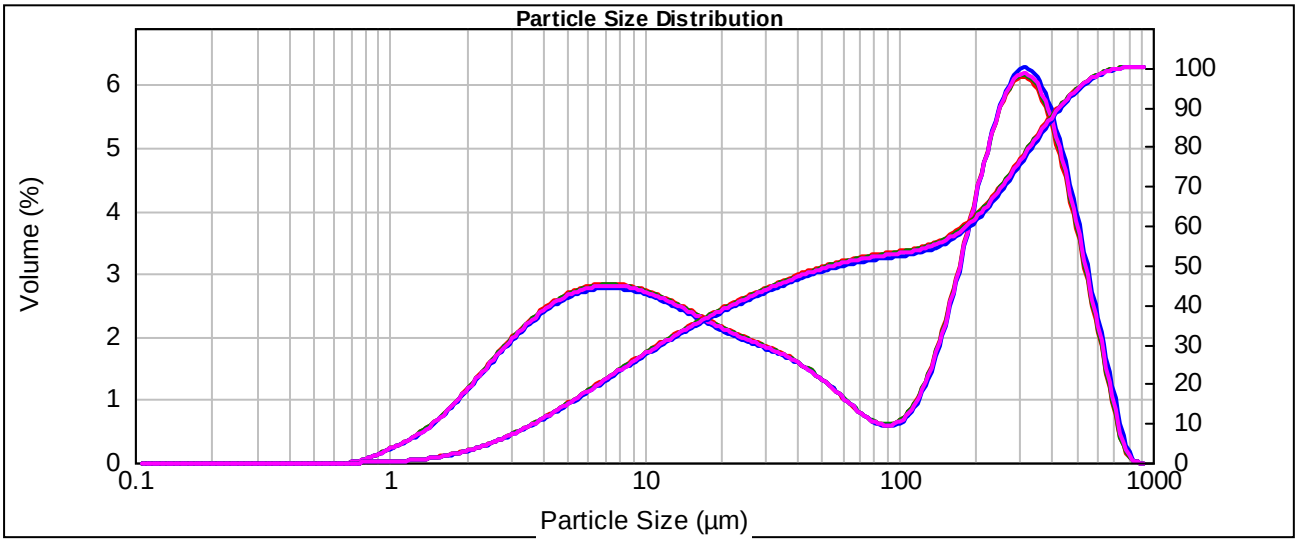
Concentration: 0.0175 %Vol
Specific Surface Area: 0.201 m²/g

Span : 7.622
Surface Weighted Mean D[3,2]: 11.262 um

Uniformity: 2.65
Vol. Weighted Mean D[4,3]: 162.102 um

Result units: Volume

d(0.1): 3.725 um d(0.5): 56.067 um **d(0.8): 329.584 um** d(0.9): 431.060 um d(0.98): 602.88 um



Size (µm)	Volume In %
0.010	0.00
0.011	0.00
0.013	0.00
0.015	0.00
0.017	0.00
0.020	0.00
0.023	0.00
0.026	0.00
0.030	0.00
0.035	0.00
0.040	0.00
0.046	0.00
0.052	0.00
0.060	0.00
0.069	0.00
0.079	0.00
0.091	0.00
0.105	0.00

Size (µm)	Volume In %
0.105	0.00
0.120	0.00
0.138	0.00
0.158	0.00
0.182	0.00
0.209	0.00
0.240	0.00
0.275	0.00
0.316	0.00
0.363	0.00
0.417	0.00
0.479	0.00
0.550	0.00
0.631	0.00
0.724	0.04
0.832	0.11
0.955	0.21
1.096	

Size (µm)	Volume In %
1.096	0.31
1.259	0.44
1.445	0.61
1.660	0.83
1.905	1.07
2.188	1.32
2.512	1.57
2.884	1.80
3.311	2.01
3.802	2.19
4.365	2.34
5.012	2.44
5.754	2.51
6.607	2.54
7.586	2.53
8.710	2.49
10.000	2.42
11.482	

Size (µm)	Volume In %
11.482	2.32
13.183	2.22
15.136	2.10
17.378	1.99
19.953	1.89
22.909	1.79
26.303	1.70
30.200	1.61
34.674	1.50
39.811	1.38
45.709	1.22
52.481	1.04
60.256	0.84
69.183	0.66
79.433	0.55
91.201	0.56
104.713	0.75
120.226	

Size (µm)	Volume In %
120.226	1.17
138.038	1.82
158.489	2.65
181.970	3.59
208.930	4.48
239.883	5.18
275.423	5.55
316.228	5.51
363.078	5.05
416.869	4.26
478.630	3.26
549.541	2.22
630.957	1.16
724.436	0.22
831.764	0.00
954.993	0.00
1096.478	0.00
1258.925	

Size (µm)	Volume In %
1258.925	0.00
1445.440	0.00
1659.587	0.00
1905.461	0.00
2187.762	0.00
2511.886	0.00
2884.032	0.00
3311.311	0.00
3801.894	0.00
4365.158	0.00
5011.872	0.00
5754.399	0.00
6606.934	0.00
7585.776	0.00
8709.636	0.00
10000.000	0.00

Operator notes:

G&T METALLURGICAL SERVICES LTD.

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM2721-37

Sample Name:
Bulk Regrind Discharge V - Average

Measured by:
melany

Edited by:
melany

Measured:
Thursday, December 02, 2010 2:01:22 PM

Analysed:
Thursday, December 02, 2010 2:01:23 PM

Particle Name: Silica 0.01
Particle RI: 1.544
Dispersant Name: Water

Accessory Name: Hydro 2000MU (A)
Absorption: 0.01
Dispersant RI: 1.330

Analysis model: General purpose
Size range: 0.100 to 1000.000 um
Weighted Residual: 0.321 %

Sensitivity: Normal
Obscuration: 18.88 %
Result Emulation: Off

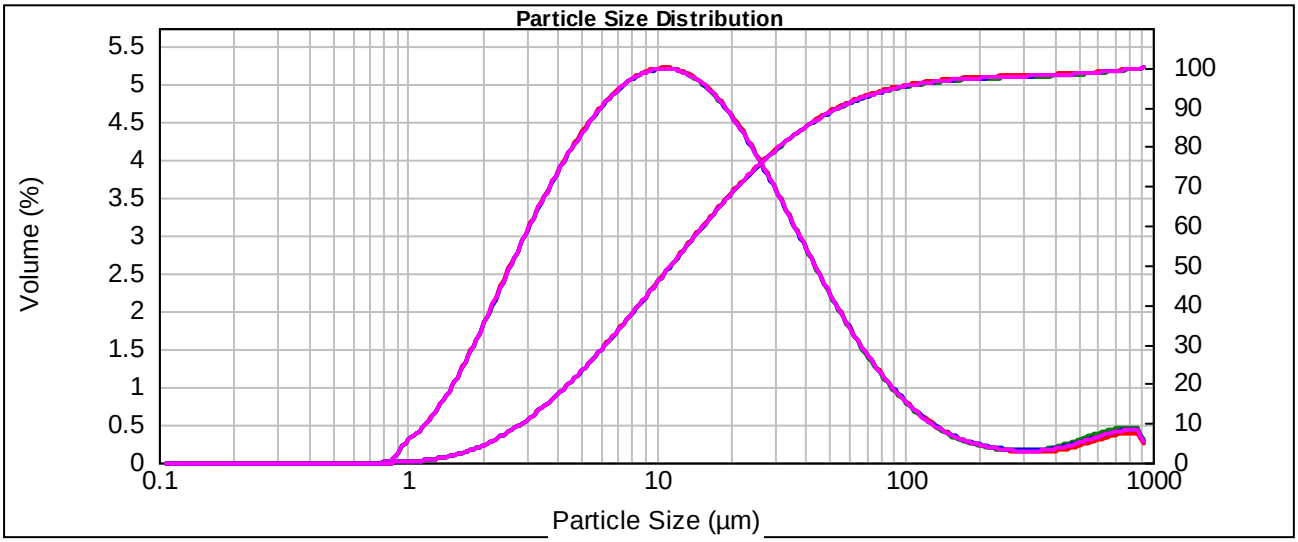
Concentration: 0.0173 %Vol
Specific Surface Area: 0.323 m²/g

Span : 4.526
Surface Weighted Mean D[3,2]: 7.001 um

Uniformity: 2.45
Vol. Weighted Mean D[4,3]: 33.988 um

Result units: Volume

d(0.1): 2.899 um d(0.5): 11.529 um **d(0.8): 31.468 um** d(0.9): 55.078 um d(0.98): 353.26 um



Size (µm)	Volume In %
0.010	0.00
0.011	0.00
0.013	0.00
0.015	0.00
0.017	0.00
0.020	0.00
0.023	0.00
0.026	0.00
0.030	0.00
0.035	0.00
0.040	0.00
0.046	0.00
0.052	0.00
0.060	0.00
0.069	0.00
0.079	0.00
0.091	0.00
0.105	0.00

Size (µm)	Volume In %
0.105	0.00
0.120	0.00
0.138	0.00
0.158	0.00
0.182	0.00
0.209	0.00
0.240	0.00
0.275	0.00
0.316	0.00
0.363	0.00
0.417	0.00
0.479	0.00
0.550	0.00
0.631	0.00
0.724	0.00
0.832	0.00
0.955	0.06
1.096	0.29

Size (µm)	Volume In %
1.096	0.45
1.259	0.68
1.445	0.96
1.660	1.30
1.905	1.67
2.188	2.05
2.512	2.44
2.884	2.81
3.311	3.16
3.802	3.49
4.365	3.79
5.012	4.05
5.754	4.27
6.607	4.45
7.586	4.58
8.710	4.67
10.000	4.70
11.482	

Size (µm)	Volume In %
11.482	4.67
13.183	4.59
15.136	4.46
17.378	4.26
19.953	4.03
22.909	3.74
26.303	3.43
30.200	3.09
34.674	2.75
39.811	2.40
45.709	2.07
52.481	1.75
60.256	1.46
69.183	1.20
79.433	0.97
91.201	0.77
104.713	0.60
120.226	

Size (µm)	Volume In %
120.226	0.46
138.038	0.35
158.489	0.27
181.970	0.22
208.930	0.18
239.883	0.15
275.423	0.14
316.228	0.14
363.078	0.16
416.869	0.19
478.630	0.24
549.541	0.30
630.957	0.35
724.436	0.38
831.764	0.34
954.993	0.00
1096.478	0.00
1258.925	

Size (µm)	Volume In %
1258.925	0.00
1445.440	0.00
1659.587	0.00
1905.461	0.00
2187.762	0.00
2511.886	0.00
2884.032	0.00
3311.311	0.00
3801.894	0.00
4365.158	0.00
5011.872	0.00
5754.399	0.00
6606.934	0.00
7585.776	0.00
8709.636	0.00
10000.000	0.00

Operator notes:

G&T METALLURGICAL SERVICES LTD.

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM2721-37

Sample Name:
Pyrite Rougher Concentrate - Average

Measured by:
melany

Edited by:
melany

Measured:
Thursday, December 02, 2010 1:50:39 PM

Analysed:
Thursday, December 02, 2010 1:50:40 PM

Particle Name:
Silica 0.01

Particle RI:
1.544

Dispersant Name:
Water

Accessory Name:
Hydro 2000MU (A)

Absorption:
0.01

Dispersant RI:
1.330

Analysis model:
General purpose

Size range:
0.100 to 1000.000 um

Weighted Residual:
0.434 %

Sensitivity:
Normal

Obscuration:
7.69 %

Result Emulation:
Off

Concentration:
0.0092 %Vol

Span :
9.609

Uniformity:
2.84

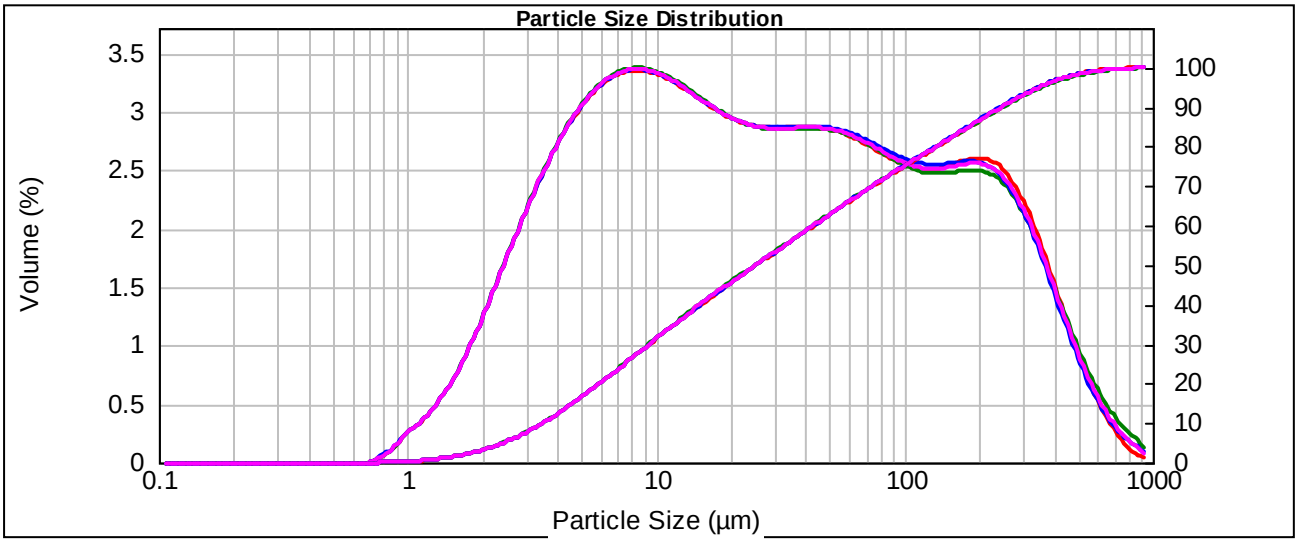
Result units:
Volume

Specific Surface Area:
0.234 m²/g

Surface Weighted Mean D[3,2]:
9.680 um

Vol. Weighted Mean D[4,3]:
80.871 um

d(0.1): 3.501 um d(0.5): 25.195 um **d(0.8): 134.226 um** d(0.9): 245.600 um d(0.98): 475.31 um



Size (µm)	Volume In %
0.010	0.00
0.011	0.00
0.013	0.00
0.015	0.00
0.017	0.00
0.020	0.00
0.023	0.00
0.026	0.00
0.030	0.00
0.035	0.00
0.040	0.00
0.046	0.00
0.052	0.00
0.060	0.00
0.069	0.00
0.079	0.00
0.091	0.00
0.105	0.00

Size (µm)	Volume In %
0.105	0.00
0.120	0.00
0.138	0.00
0.158	0.00
0.182	0.00
0.209	0.00
0.240	0.00
0.275	0.00
0.316	0.00
0.363	0.00
0.417	0.00
0.479	0.00
0.550	0.00
0.631	0.00
0.724	0.04
0.832	0.12
0.955	0.25
1.096	

Size (µm)	Volume In %
1.096	0.35
1.259	0.48
1.445	0.66
1.660	0.89
1.905	1.16
2.188	1.44
2.512	1.73
2.884	2.00
3.311	2.26
3.802	2.48
4.365	2.67
5.012	2.83
5.754	2.94
6.607	3.01
7.586	3.03
8.710	3.03
10.000	2.99
11.482	

Size (µm)	Volume In %
11.482	2.92
13.183	2.84
15.136	2.77
17.378	2.69
19.953	2.64
22.909	2.60
26.303	2.58
30.200	2.58
34.674	2.58
39.811	2.59
45.709	2.58
52.481	2.55
60.256	2.50
69.183	2.44
79.433	2.38
91.201	2.32
104.713	2.28
120.226	

Size (µm)	Volume In %
120.226	2.27
138.038	2.28
158.489	2.30
181.970	2.31
208.930	2.28
239.883	2.17
275.423	1.99
316.228	1.73
363.078	1.43
416.869	1.10
478.630	0.79
549.541	0.53
630.957	0.34
724.436	0.19
831.764	0.10
954.993	0.00
1096.478	0.00
1258.925	

Size (µm)	Volume In %
1258.925	0.00
1445.440	0.00
1659.587	0.00
1905.461	0.00
2187.762	0.00
2511.886	0.00
2884.032	0.00
3311.311	0.00
3801.894	0.00
4365.158	0.00
5011.872	0.00
5754.399	0.00
6606.934	0.00
7585.776	0.00
8709.636	0.00
10000.000	

Operator notes:

G&T METALLURGICAL SERVICES LTD.

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM2721-38

Sample Name:
Bulk Regrind Discharge - Average

Measured by:
Wendy

Edited by:
Wendy

Measured:
Thursday, December 09, 2010 10:32:16 AM

Analysed:
Thursday, December 09, 2010 10:32:17 AM

Particle Name: Silica 0.1
Particle RI: 1.544
Dispersant Name: Water

Accessory Name: Hydro 2000MU (A)
Absorption: 0.1
Dispersant RI: 1.330

Analysis model: General purpose
Size range: 0.100 to 1000.000 um
Weighted Residual: 0.765 %

Sensitivity: Normal
Obscuration: 18.94 %
Result Emulation: Off

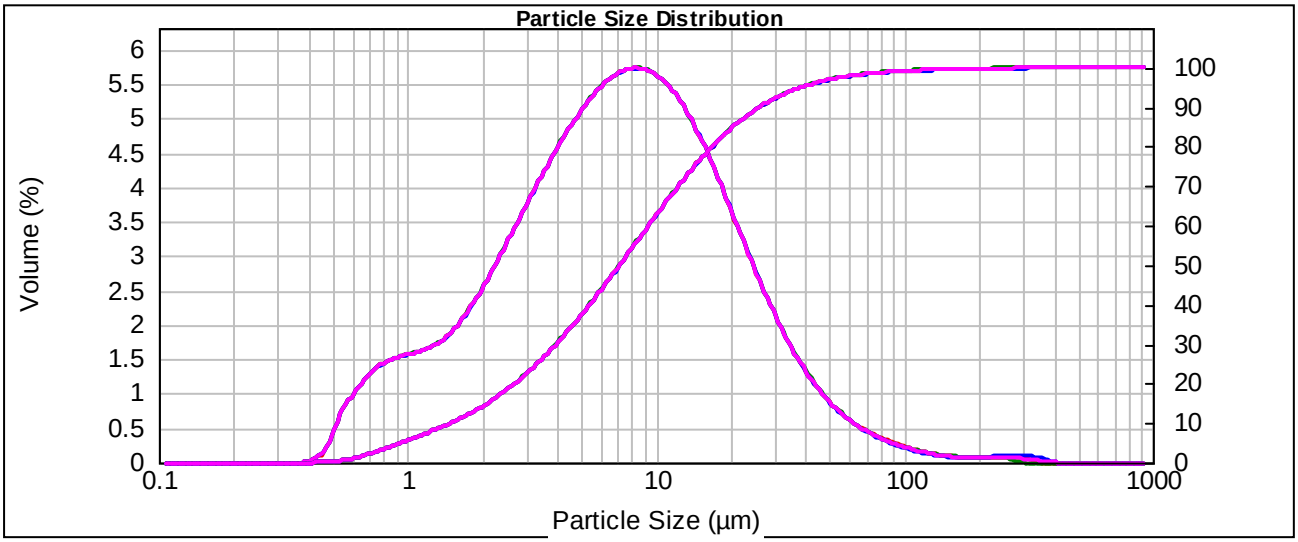
Concentration: 0.0110 %Vol
Specific Surface Area: 0.606 m²/g

Span : 3.447
Surface Weighted Mean D[3,2]: 3.733 um

Uniformity: 1.26
Vol. Weighted Mean D[4,3]: 12.424 um

Result units: Volume

d(0.1): 1.489 um d(0.5): 7.138 um **d(0.8): 16.850 um** d(0.9): 26.091 um d(0.98): 61.53 um



Size (µm)	Volume In %
0.010	0.00
0.011	0.00
0.013	0.00
0.015	0.00
0.017	0.00
0.020	0.00
0.023	0.00
0.026	0.00
0.030	0.00
0.035	0.00
0.040	0.00
0.046	0.00
0.052	0.00
0.060	0.00
0.069	0.00
0.079	0.00
0.091	0.00
0.105	0.00

Size (µm)	Volume In %
0.105	0.00
0.120	0.00
0.138	0.00
0.158	0.00
0.182	0.00
0.209	0.00
0.240	0.00
0.275	0.00
0.316	0.00
0.363	0.00
0.417	0.10
0.479	0.47
0.550	0.85
0.631	1.09
0.724	1.28
0.832	1.37
0.955	1.43
1.096	

Size (µm)	Volume In %
1.096	1.48
1.259	1.58
1.445	1.76
1.660	2.01
1.905	2.33
2.188	2.69
2.512	3.07
2.884	3.45
3.311	3.82
3.802	4.17
4.365	4.48
5.012	4.75
5.754	4.97
6.607	5.11
7.586	5.17
8.710	5.14
10.000	5.01
11.482	

Size (µm)	Volume In %
11.482	4.78
13.183	4.45
15.136	4.04
17.378	3.58
19.953	3.09
22.909	2.60
26.303	2.14
30.200	1.73
34.674	1.37
39.811	1.07
45.709	0.83
52.481	0.64
60.256	0.49
69.183	0.37
79.433	0.28
91.201	0.21
104.713	0.16
120.226	

Size (µm)	Volume In %
120.226	0.11
138.038	0.09
158.489	0.07
181.970	0.07
208.930	0.07
239.883	0.07
275.423	0.07
316.228	0.06
363.078	0.03
416.869	0.00
478.630	0.00
549.541	0.00
630.957	0.00
724.436	0.00
831.764	0.00
954.993	0.00
1096.478	0.00
1258.925	

Size (µm)	Volume In %
1258.925	0.00
1445.440	0.00
1659.587	0.00
1905.461	0.00
2187.762	0.00
2511.886	0.00
2884.032	0.00
3311.311	0.00
3801.894	0.00
4365.158	0.00
5011.872	0.00
5754.399	0.00
6606.934	0.00
7585.776	0.00
8709.636	0.00
10000.000	0.00

Operator notes:

G&T METALLURGICAL SERVICES LTD.

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM2721-39

Sample Name:
Bulk Regrind Discharge - Average

Measured by:
quentin

Edited by:
quentin

Measured:
Friday, December 10, 2010 1:44:00 PM

Analysed:
Friday, December 10, 2010 1:44:01 PM

Particle Name:
Silica 0.01

Particle RI:
1.544

Dispersant Name:
Water

Accessory Name:
Hydro 2000MU (A)

Absorption:
0.01

Dispersant RI:
1.330

Analysis model:
General purpose

Size range:
0.100 to 1000.000 um

Weighted Residual:
0.236 %

Sensitivity:
Normal

Obscuration:
15.42 %

Result Emulation:
Off

Concentration:
0.0098 %Vol

Span :
2.558

Uniformity:
0.842

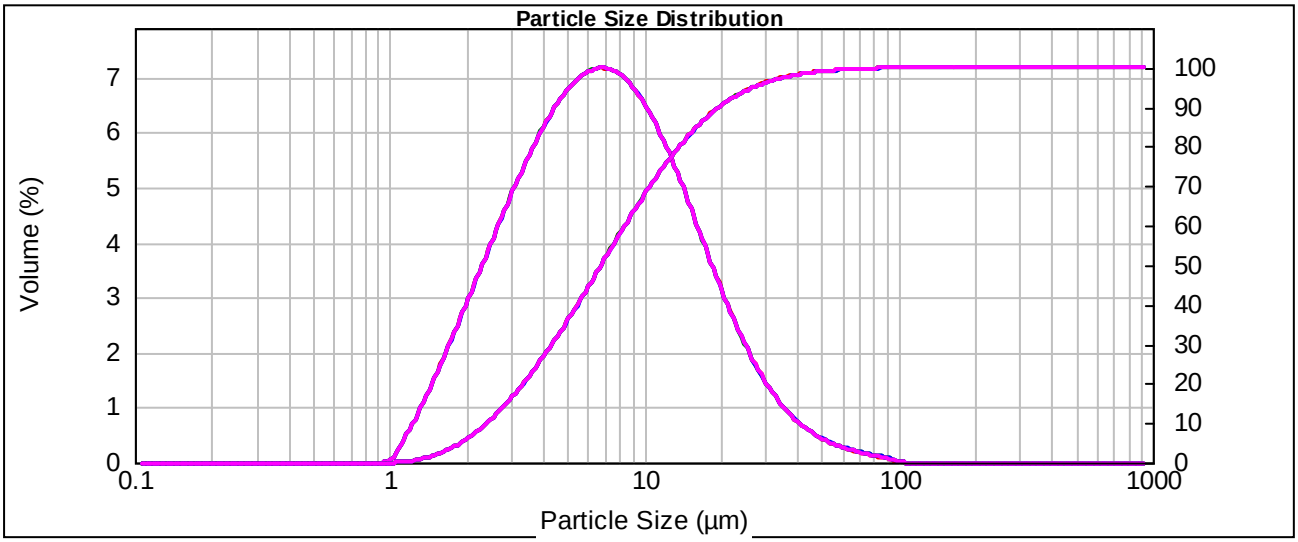
Result units:
Volume

Specific Surface Area:
0.444 m²/g

Surface Weighted Mean D[3,2]:
5.100 um

Vol. Weighted Mean D[4,3]:
9.643 um

d(0.1): 2.408 um d(0.5): 6.786 um **d(0.8): 13.754 um** d(0.9): 19.764 um d(0.98): 38.13 um



Size (µm)	Volume In %
0.010	0.00
0.011	0.00
0.013	0.00
0.015	0.00
0.017	0.00
0.020	0.00
0.023	0.00
0.026	0.00
0.030	0.00
0.035	0.00
0.040	0.00
0.046	0.00
0.052	0.00
0.060	0.00
0.069	0.00
0.079	0.00
0.091	0.00
0.105	0.00

Size (µm)	Volume In %
0.105	0.00
0.120	0.00
0.138	0.00
0.158	0.00
0.182	0.00
0.209	0.00
0.240	0.00
0.275	0.00
0.316	0.00
0.363	0.00
0.417	0.00
0.479	0.00
0.550	0.00
0.631	0.00
0.724	0.00
0.832	0.00
0.955	0.00
1.096	0.06

Size (µm)	Volume In %
1.096	0.48
1.259	0.95
1.445	1.50
1.660	2.09
1.905	2.69
2.188	3.30
2.512	3.91
2.884	4.50
3.311	5.06
3.802	5.55
4.365	5.96
5.012	6.26
5.754	6.44
6.607	6.48
7.586	6.36
8.710	6.10
10.000	5.69
11.482	

Size (µm)	Volume In %
11.482	5.17
13.183	4.55
15.136	3.89
17.378	3.22
19.953	2.58
22.909	2.00
26.303	1.51
30.200	1.12
34.674	0.81
39.811	0.58
45.709	0.42
52.481	0.30
60.256	0.21
69.183	0.15
79.433	0.10
91.201	0.03
104.713	0.00
120.226	

Size (µm)	Volume In %
120.226	0.00
138.038	0.00
158.489	0.00
181.970	0.00
208.930	0.00
239.883	0.00
275.423	0.00
316.228	0.00
363.078	0.00
416.869	0.00
478.630	0.00
549.541	0.00
630.957	0.00
724.436	0.00
831.764	0.00
954.993	0.00
1096.478	0.00
1258.925	

Size (µm)	Volume In %
1258.925	0.00
1445.440	0.00
1659.587	0.00
1905.461	0.00
2187.762	0.00
2511.886	0.00
2884.032	0.00
3311.311	0.00
3801.894	0.00
4365.158	0.00
5011.872	0.00
5754.399	0.00
6606.934	0.00
7585.776	0.00
8709.636	0.00
10000.000	

Operator notes:

G&T METALLURGICAL SERVICES LTD.

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM2721-39

Sample Name:
Pyrite Rougher Concentrate - Average

Measured by:
quentin

Edited by:
quentin

Measured:
Friday, December 10, 2010 1:51:36 PM

Analysed:
Friday, December 10, 2010 1:51:37 PM

Particle Name:
Silica 0.01

Particle RI:
1.544

Dispersant Name:
Water

Accessory Name:
Hydro 2000MU (A)

Absorption:
0.01

Dispersant RI:
1.330

Analysis model:
General purpose

Size range:
0.100 to 1000.000 um

Weighted Residual:
0.613 %

Sensitivity:
Normal

Obscuration:
11.69 %

Result Emulation:
Off

Concentration:
0.0117 %Vol

Span :
15.804

Uniformity:
4.23

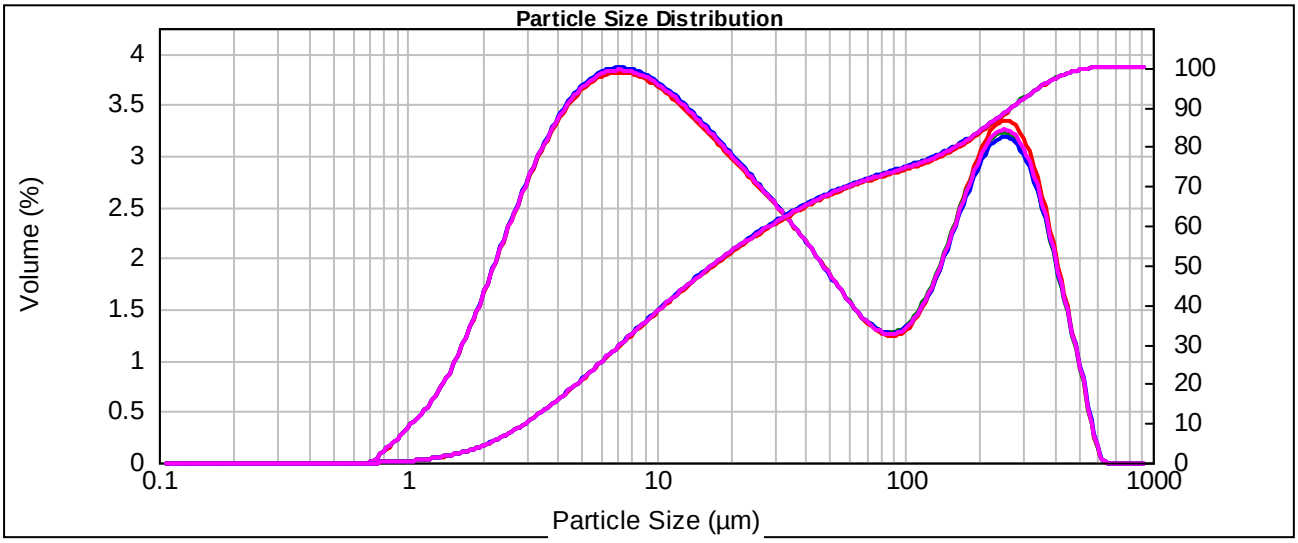
Result units:
Volume

Specific Surface Area:
0.281 m²/g

Surface Weighted Mean D[3,2]:
8.057 um

Vol. Weighted Mean D[4,3]:
78.656 um

d(0.1): 2.996 um d(0.5): 16.953 um **d(0.8): 161.896 um** d(0.9): 270.924 um d(0.98): 430.91 um



Size (µm)	Volume In %
0.010	0.00
0.011	0.00
0.013	0.00
0.015	0.00
0.017	0.00
0.020	0.00
0.023	0.00
0.026	0.00
0.030	0.00
0.035	0.00
0.040	0.00
0.046	0.00
0.052	0.00
0.060	0.00
0.069	0.00
0.079	0.00
0.091	0.00
0.105	0.00

Size (µm)	Volume In %
0.105	0.00
0.120	0.00
0.138	0.00
0.158	0.00
0.182	0.00
0.209	0.00
0.240	0.00
0.275	0.00
0.316	0.00
0.363	0.00
0.417	0.00
0.479	0.00
0.550	0.00
0.631	0.00
0.724	0.07
0.832	0.18
0.955	0.33
1.096	

Size (µm)	Volume In %
1.096	0.46
1.259	0.65
1.445	0.89
1.660	1.18
1.905	1.51
2.188	1.86
2.512	2.20
2.884	2.52
3.311	2.81
3.802	3.04
4.365	3.23
5.012	3.36
5.754	3.44
6.607	3.46
7.586	3.44
8.710	3.39
10.000	3.30
11.482	

Size (µm)	Volume In %
11.482	3.19
13.183	3.06
15.136	2.93
17.378	2.79
19.953	2.65
22.909	2.50
26.303	2.36
30.200	2.20
34.674	2.04
39.811	1.87
45.709	1.69
52.481	1.50
60.256	1.33
69.183	1.20
79.433	1.14
91.201	1.16
104.713	1.30
120.226	

Size (µm)	Volume In %
120.226	1.55
138.038	1.88
158.489	2.26
181.970	2.61
208.930	2.86
239.883	2.94
275.423	2.81
316.228	2.47
363.078	1.98
416.869	1.39
478.630	0.83
549.541	0.17
630.957	0.00
724.436	0.00
831.764	0.00
954.993	0.00
1096.478	0.00
1258.925	

Size (µm)	Volume In %
1258.925	0.00
1445.440	0.00
1659.587	0.00
1905.461	0.00
2187.762	0.00
2511.886	0.00
2884.032	0.00
3311.311	0.00
3801.894	0.00
4365.158	0.00
5011.872	0.00
5754.399	0.00
6606.934	0.00
7585.776	0.00
8709.636	0.00
10000.000	

Operator notes:

G&T METALLURGICAL SERVICES LTD.

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM2721-40

Sample Name:
Cyanide Tail - Average

Measured by:
Kent

Edited by:
Kent

Measured:
Friday, December 31, 2010 12:07:31 PM

Analysed:
Friday, December 31, 2010 12:07:32 PM

Particle Name:
Silica 0.01

Particle RI:
1.544

Dispersant Name:
Water

Accessory Name:
Hydro 2000MU (A)

Absorption:
0.01

Dispersant RI:
1.330

Analysis model:
General purpose

Size range:
0.100 to 1000.000 um

Weighted Residual:
0.350 %

Sensitivity:
Normal

Obscuration:
18.31 %

Result Emulation:
Off

Concentration:
0.0162 %Vol

Span :
7.729

Uniformity:
2.99

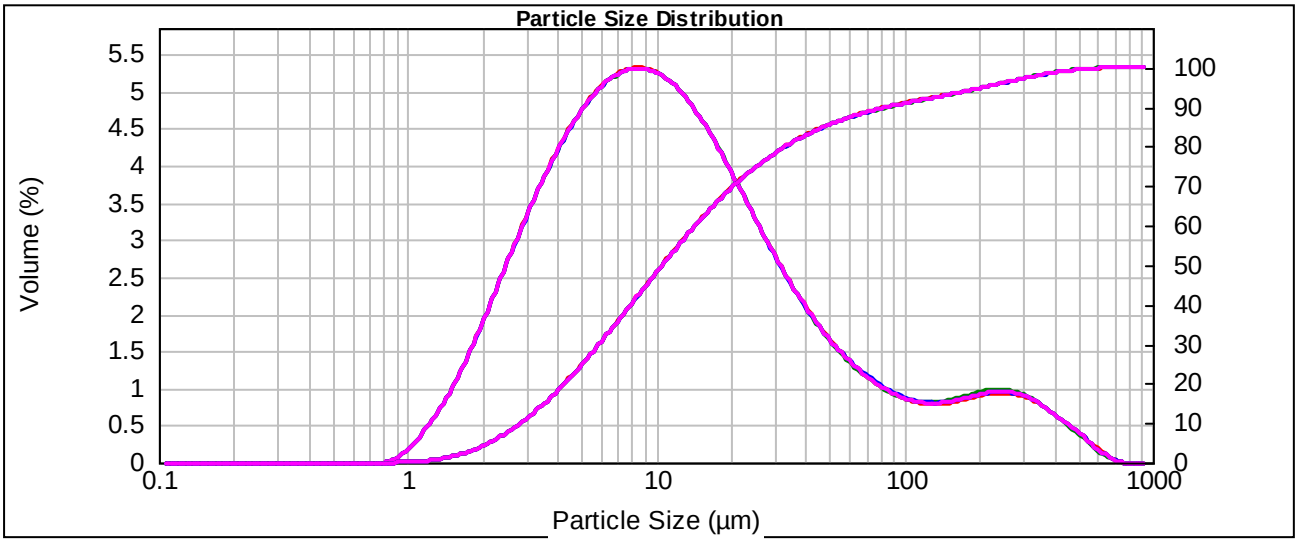
Result units:
Volume

Specific Surface Area:
0.33 m²/g

Surface Weighted Mean D[3,2]:
6.853 um

Vol. Weighted Mean D[4,3]:
37.060 um

d(0.1): 2.859 um d(0.5): 10.602 um **d(0.8): 33.081 um** d(0.9): 84.796 um d(0.98): 340.94 um



Size (µm)	Volume In %
0.010	0.00
0.011	0.00
0.013	0.00
0.015	0.00
0.017	0.00
0.020	0.00
0.023	0.00
0.026	0.00
0.030	0.00
0.035	0.00
0.040	0.00
0.046	0.00
0.052	0.00
0.060	0.00
0.069	0.00
0.079	0.00
0.091	0.00
0.105	0.00

Size (µm)	Volume In %
0.105	0.00
0.120	0.00
0.138	0.00
0.158	0.00
0.182	0.00
0.209	0.00
0.240	0.00
0.275	0.00
0.316	0.00
0.363	0.00
0.417	0.00
0.479	0.00
0.550	0.00
0.631	0.00
0.724	0.00
0.832	0.05
0.955	0.17
1.096	

Size (µm)	Volume In %
1.096	0.40
1.259	0.65
1.445	0.97
1.660	1.34
1.905	1.76
2.188	2.20
2.512	2.64
2.884	3.07
3.311	3.47
3.802	3.83
4.365	4.15
5.012	4.40
5.754	4.60
6.607	4.73
7.586	4.79
8.710	4.78
10.000	4.70
11.482	

Size (µm)	Volume In %
11.482	4.54
13.183	4.32
15.136	4.05
17.378	3.73
19.953	3.38
22.909	3.03
26.303	2.68
30.200	2.35
34.674	2.04
39.811	1.77
45.709	1.53
52.481	1.32
60.256	1.15
69.183	1.00
79.433	0.88
91.201	0.79
104.713	0.74
120.226	

Size (µm)	Volume In %
120.226	0.72
138.038	0.74
158.489	0.77
181.970	0.82
208.930	0.86
239.883	0.86
275.423	0.83
316.228	0.74
363.078	0.62
416.869	0.48
478.630	0.34
549.541	0.17
630.957	0.06
724.436	0.00
831.764	0.00
954.993	0.00
1096.478	0.00
1258.925	

Size (µm)	Volume In %
1258.925	0.00
1445.440	0.00
1659.587	0.00
1905.461	0.00
2187.762	0.00
2511.886	0.00
2884.032	0.00
3311.311	0.00
3801.894	0.00
4365.158	0.00
5011.872	0.00
5754.399	0.00
6606.934	0.00
7585.776	0.00
8709.636	0.00
10000.000	

Operator notes:

TABLE III-42

G&T METALLURGICAL SERVICES LTD.

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM2721-41

Sample Name:
Cyanide Tail - Average

Measured by:
Kent

Edited by:
Kent

Measured:
Friday, December 31, 2010 12:20:03 PM

Analysed:
Friday, December 31, 2010 12:20:04 PM

Particle Name: Silica 0.01
Particle RI: 1.544
Dispersant Name: Water

Accessory Name: Hydro 2000MU (A)
Absorption: 0.01
Dispersant RI: 1.330

Analysis model: General purpose
Size range: 0.100 to 1000.000 um
Weighted Residual: 0.413 %

Sensitivity: Normal
Obscuration: 15.03 %
Result Emulation: Off

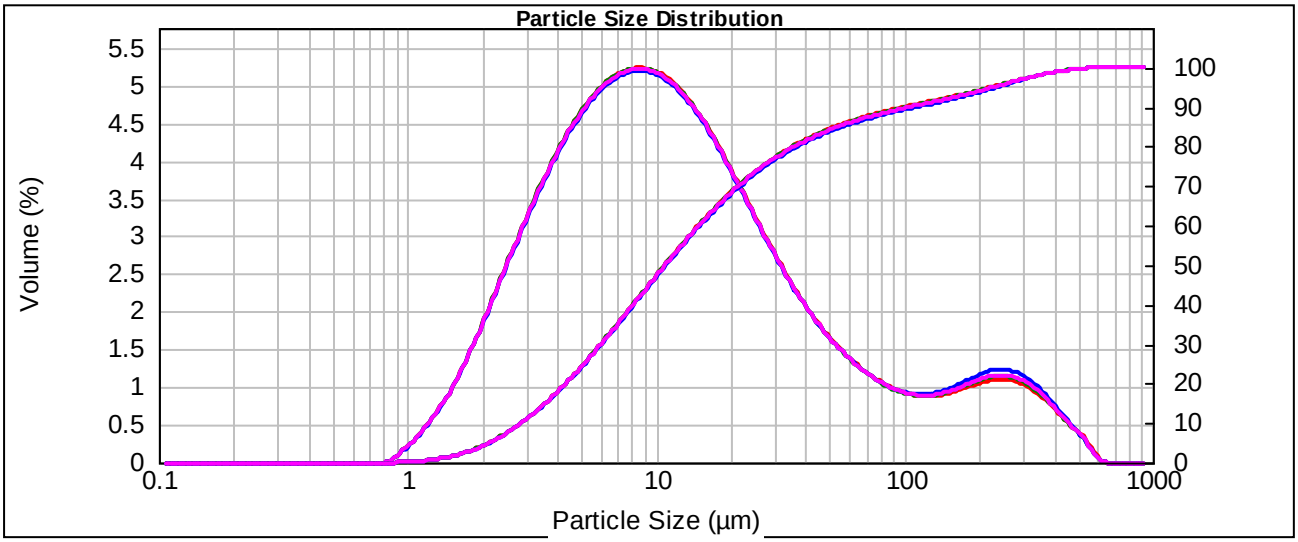
Concentration: 0.0132 %Vol
Specific Surface Area: 0.326 m²/g

Span : 9.259
Surface Weighted Mean D[3,2]: 6.940 um

Uniformity: 3.11
Vol. Weighted Mean D[4,3]: 39.299 um

Result units: Volume

d(0.1): 2.875 um d(0.5): 10.891 um **d(0.8): 35.907 um** d(0.9): 103.719 um d(0.98): 342.08 um



Size (µm)	Volume In %
0.010	0.00
0.011	0.00
0.013	0.00
0.015	0.00
0.017	0.00
0.020	0.00
0.023	0.00
0.026	0.00
0.030	0.00
0.035	0.00
0.040	0.00
0.046	0.00
0.052	0.00
0.060	0.00
0.069	0.00
0.079	0.00
0.091	0.00
0.105	0.00

Size (µm)	Volume In %
0.105	0.00
0.120	0.00
0.138	0.00
0.158	0.00
0.182	0.00
0.209	0.00
0.240	0.00
0.275	0.00
0.316	0.00
0.363	0.00
0.417	0.00
0.479	0.00
0.550	0.00
0.631	0.00
0.724	0.00
0.832	0.00
0.955	0.06
1.096	0.21

Size (µm)	Volume In %
1.096	0.42
1.259	0.65
1.445	0.95
1.660	1.31
1.905	1.72
2.188	2.15
2.512	2.58
2.884	3.00
3.311	3.39
3.802	3.75
4.365	4.06
5.012	4.31
5.754	4.51
6.607	4.64
7.586	4.70
8.710	4.70
10.000	4.62
11.482	

Size (µm)	Volume In %
11.482	4.47
13.183	4.26
15.136	3.99
17.378	3.68
19.953	3.34
22.909	2.99
26.303	2.65
30.200	2.32
34.674	2.02
39.811	1.76
45.709	1.53
52.481	1.33
60.256	1.16
69.183	1.03
79.433	0.92
91.201	0.85
104.713	0.81
120.226	

Size (µm)	Volume In %
120.226	0.81
138.038	0.84
158.489	0.91
181.970	0.98
208.930	1.04
239.883	1.05
275.423	1.00
316.228	0.88
363.078	0.71
416.869	0.51
478.630	0.34
549.541	0.08
630.957	0.00
724.436	0.00
831.764	0.00
954.993	0.00
1096.478	0.00
1258.925	

Size (µm)	Volume In %
1258.925	0.00
1445.440	0.00
1659.587	0.00
1905.461	0.00
2187.762	0.00
2511.886	0.00
2884.032	0.00
3311.311	0.00
3801.894	0.00
4365.158	0.00
5011.872	0.00
5754.399	0.00
6606.934	0.00
7585.776	0.00
8709.636	0.00
10000.000	0.00

Operator notes:

G&T METALLURGICAL SERVICES LTD.

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM2721-42

Sample Name:
Bulk Regrind Discharge 1 - Average

Measured by:
kent

Edited by:
kent

Measured:
Friday, December 31, 2010 8:50:05 AM

Analysed:
Friday, December 31, 2010 8:50:06 AM

Particle Name: Silica 0.01
Particle RI: 1.544
Dispersant Name: Water

Accessory Name: Hydro 2000MU (A)
Absorption: 0.01
Dispersant RI: 1.330

Analysis model: General purpose
Size range: 0.100 to 1000.000 um
Weighted Residual: 0.301 %

Sensitivity: Normal
Obscuration: 19.16 %
Result Emulation: Off

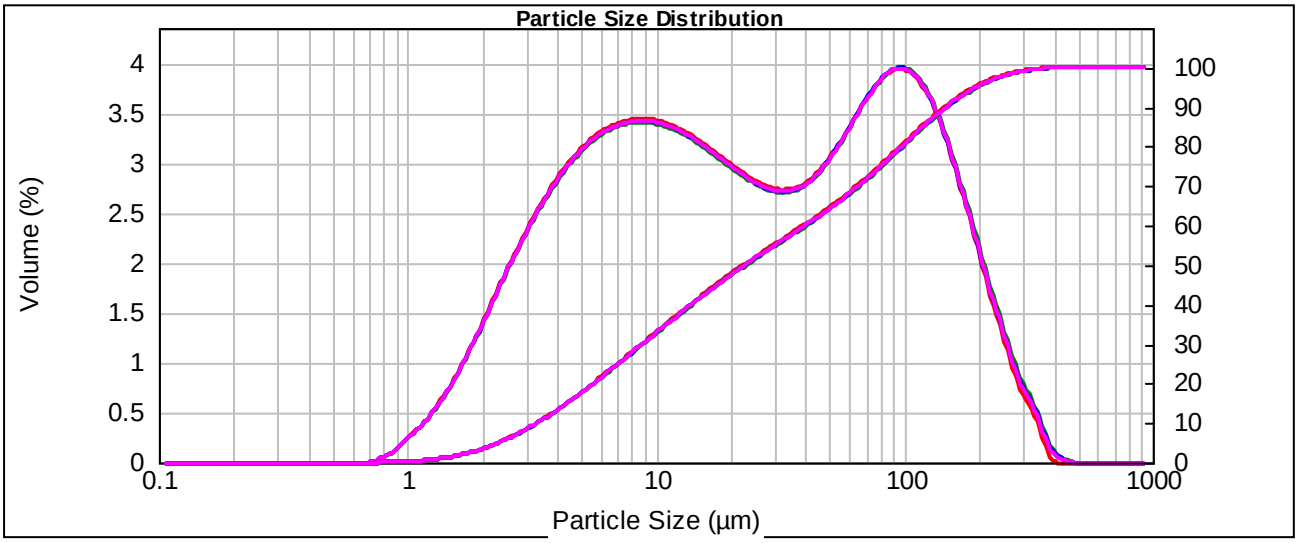
Concentration: 0.0229 %Vol
Specific Surface Area: 0.247 m²/g

Span : 6.286
Surface Weighted Mean D[3,2]: 9.153 um

Uniformity: 1.97
Vol. Weighted Mean D[4,3]: 53.359 um

Result units: Volume

d(0.1): 3.317 um d(0.5): 22.793 um **d(0.8): 97.246 um** d(0.9): 146.593 um d(0.98): 249.82 um



Size (µm)	Volume In %
0.010	0.00
0.011	0.00
0.013	0.00
0.015	0.00
0.017	0.00
0.020	0.00
0.023	0.00
0.026	0.00
0.030	0.00
0.035	0.00
0.040	0.00
0.046	0.00
0.052	0.00
0.060	0.00
0.069	0.00
0.079	0.00
0.091	0.00
0.105	0.00

Size (µm)	Volume In %
0.105	0.00
0.120	0.00
0.138	0.00
0.158	0.00
0.182	0.00
0.209	0.00
0.240	0.00
0.275	0.00
0.316	0.00
0.363	0.00
0.417	0.00
0.479	0.00
0.550	0.00
0.631	0.00
0.724	0.03
0.832	0.11
0.955	0.24
1.096	

Size (µm)	Volume In %
1.096	0.37
1.259	0.54
1.445	0.76
1.660	1.02
1.905	1.30
2.188	1.59
2.512	1.87
2.884	2.14
3.311	2.38
3.802	2.59
4.365	2.76
5.012	2.90
5.754	3.00
6.607	3.06
7.586	3.09
8.710	3.09
10.000	3.07
11.482	

Size (µm)	Volume In %
11.482	3.01
13.183	2.94
15.136	2.85
17.378	2.74
19.953	2.64
22.909	2.55
26.303	2.48
30.200	2.46
34.674	2.48
39.811	2.57
45.709	2.72
52.481	2.93
60.256	3.16
69.183	3.37
79.433	3.52
91.201	3.57
104.713	3.49
120.226	

Size (µm)	Volume In %
120.226	3.27
138.038	2.92
158.489	2.49
181.970	2.01
208.930	1.53
239.883	1.09
275.423	0.71
316.228	0.44
363.078	0.11
416.869	0.01
478.630	0.00
549.541	0.00
630.957	0.00
724.436	0.00
831.764	0.00
954.993	0.00
1096.478	0.00
1258.925	

Size (µm)	Volume In %
1258.925	0.00
1445.440	0.00
1659.587	0.00
1905.461	0.00
2187.762	0.00
2511.886	0.00
2884.032	0.00
3311.311	0.00
3801.894	0.00
4365.158	0.00
5011.872	0.00
5754.399	0.00
6606.934	0.00
7585.776	0.00
8709.636	0.00
10000.000	0.00

Operator notes:

G&T METALLURGICAL SERVICES LTD.

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM2721-42

Sample Name:
Bulk Regrind Discharge 2 - Average

Measured by:
kent

Edited by:
kent

Measured:
Friday, December 31, 2010 9:55:45 AM

Analysed:
Friday, December 31, 2010 9:55:46 AM

Particle Name: Silica 0.01
Particle RI: 1.544
Dispersant Name: Water

Accessory Name: Hydro 2000MU (A)
Absorption: 0.01
Dispersant RI: 1.330

Analysis model: General purpose
Size range: 0.100 to 1000.000 um
Weighted Residual: 0.292 %

Sensitivity: Normal
Obscuration: 6.64 %
Result Emulation: Off

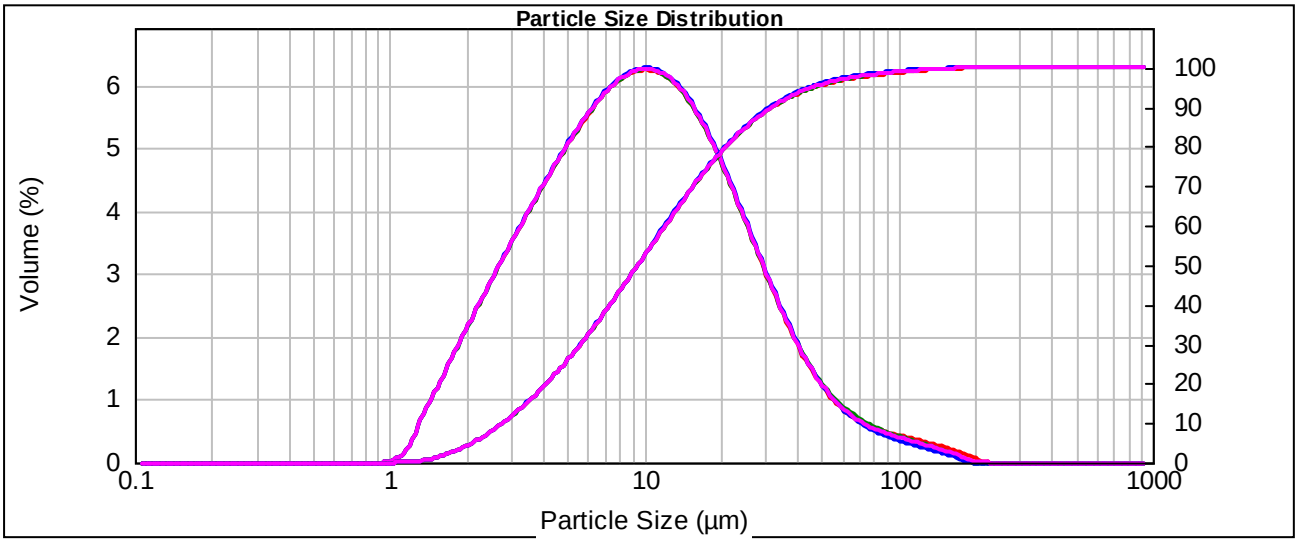
Concentration: 0.0051 %Vol
Specific Surface Area: 0.354 m²/g

Span : 3.059
Surface Weighted Mean D[3,2]: 6.398 um

Uniformity: 1.06
Vol. Weighted Mean D[4,3]: 15.072 um

Result units: Volume

d(0.1): 2.788 um d(0.5): 9.462 um **d(0.8): 21.011 um** d(0.9): 31.734 um d(0.98): 73.35 um



Size (µm)	Volume In %
0.010	0.00
0.011	0.00
0.013	0.00
0.015	0.00
0.017	0.00
0.020	0.00
0.023	0.00
0.026	0.00
0.030	0.00
0.035	0.00
0.040	0.00
0.046	0.00
0.052	0.00
0.060	0.00
0.069	0.00
0.079	0.00
0.091	0.00
0.105	0.00

Size (µm)	Volume In %
0.105	0.00
0.120	0.00
0.138	0.00
0.158	0.00
0.182	0.00
0.209	0.00
0.240	0.00
0.275	0.00
0.316	0.00
0.363	0.00
0.417	0.00
0.479	0.00
0.550	0.00
0.631	0.00
0.724	0.00
0.832	0.00
0.955	0.00
1.096	0.03

Size (µm)	Volume In %
1.096	0.19
1.259	0.68
1.445	1.09
1.660	1.54
1.905	1.98
2.188	2.40
2.512	2.82
2.884	3.23
3.311	3.63
3.802	4.02
4.365	4.39
5.012	4.74
5.754	5.06
6.607	5.32
7.586	5.52
8.710	5.63
10.000	5.64
11.482	

Size (µm)	Volume In %
11.482	5.55
13.183	5.34
15.136	5.02
17.378	4.59
19.953	4.10
22.909	3.56
26.303	3.00
30.200	2.46
34.674	1.96
39.811	1.53
45.709	1.17
52.481	0.89
60.256	0.69
69.183	0.55
79.433	0.45
91.201	0.37
104.713	0.31
120.226	

Size (µm)	Volume In %
120.226	0.25
138.038	0.18
158.489	0.12
181.970	0.02
208.930	0.00
239.883	0.00
275.423	0.00
316.228	0.00
363.078	0.00
416.869	0.00
478.630	0.00
549.541	0.00
630.957	0.00
724.436	0.00
831.764	0.00
954.993	0.00
1096.478	0.00
1258.925	

Size (µm)	Volume In %
1258.925	0.00
1445.440	0.00
1659.587	0.00
1905.461	0.00
2187.762	0.00
2511.886	0.00
2884.032	0.00
3311.311	0.00
3801.894	0.00
4365.158	0.00
5011.872	0.00
5754.399	0.00
6606.934	0.00
7585.776	0.00
8709.636	0.00
10000.000	0.00

Operator notes:

APPENDIX IV – KM2721

SPECIAL ASSAY DATA

INDEX

TABLE		PAGE
IV-1A	Variability Head Assay Data	1
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IV-2	Statistical Analysis of Head Assays	4
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CERTIFICATES AND FIGURES

Stewart Group Certificate	Et. File No. E10-2562
Figure IV-1	Ancillary Test Flowsheet and Test Data
Figure IV-2	Effect of Reagent on Copper Rougher Performance

TABLE I-1A
VARIABILITY HEAD ASSAY DATA

Sample	Assay - percent or g/tonne								
	Cu	Fe	Ag	Mo	S	Au	As	Cu(ox)	$Cu_{(CN)}$
Sample 1	0.29	1.9	4	0.031	2.22	0.34	0.004	0.01	0.05
Sample 2	0.40	2.7	4	0.019	3.61	0.34	0.003	0.03	0.19
Sample 3	0.38	1.8	5	0.035	1.70	0.47	0.003	0.02	0.05
Sample 4	0.30	2.4	3	0.063	2.39	0.38	0.002	0.02	0.17
Sample 5	0.56	1.5	3	0.073	2.09	0.54	0.002	0.04	0.33
Sample 6	0.24	1.6	2	0.086	1.97	0.25	<0.001	0.02	0.09
Sample 7	0.35	3.7	2	0.045	3.37	0.18	0.002	0.04	0.21
Sample 8	0.34	7.4	3	0.018	6.39	0.16	0.002	0.05	0.20
Sample 9	0.33	5.2	4	0.024	5.95	0.27	0.002	0.03	0.13
Sample 10	0.18	5.8	4	0.039	5.39	0.21	0.005	0.02	0.04
Sample 11	0.15	4.9	3	0.010	2.56	0.16	0.003	0.01	0.02
Sample 12	0.15	7.2	2	0.010	6.77	0.06	0.003	0.02	0.05
Sample 13	0.21	4.3	3	0.004	3.80	0.48	0.004	0.01	0.02
Sample 14	0.10	4.5	2	0.004	3.93	0.15	0.004	0.00	0.01
Sample 15	0.18	5.7	3	0.052	6.15	0.18	0.004	0.01	0.02
Sample 16	0.15	4.6	4	0.021	4.27	0.44	0.004	0.01	0.01
Sample 17	0.20	4.6	4	0.012	5.37	0.47	0.004	0.01	0.02
Sample 18	0.36	3.4	2	0.018	2.35	0.37	0.003	0.03	0.25
Sample 19	0.50	2.8	4	0.020	2.54	0.57	0.002	0.04	0.17
Sample 20	0.31	2.8	2	0.029	3.28	0.23	0.002	0.03	0.14
Sample 21	0.26	2.0	3	0.016	2.60	0.19	0.002	0.03	0.15
Sample 22	0.32	3.6	3	0.012	3.43	0.33	0.002	0.03	0.10
Sample 23	0.31	2.9	3	0.013	2.90	0.34	0.002	0.02	0.08
Sample 24	0.38	3.3	4	0.002	2.12	0.28	0.003	0.03	0.18
Sample 25	0.21	3.2	2	0.002	1.74	0.27	0.003	0.00	0.00
Sample 26	0.25	2.7	2	0.008	3.11	0.22	0.002	0.01	0.03
Sample 27	0.53	3.6	2	0.004	1.09	0.41	0.001	0.04	0.32
Sample 28	0.15	2.8	2	0.024	1.02	0.20	0.005	0.01	0.01
Sample 29	0.16	2.3	1	0.003	2.50	0.21	0.004	0.01	0.03
Sample 30	0.28	1.4	2	0.017	0.93	0.24	0.002	0.04	0.17
Sample 31	0.17	2.5	3	0.012	1.68	0.16	0.003	0.01	0.01
Sample 32	0.37	4.5	3	0.005	1.99	0.65	0.004	0.02	0.05
Sample 33	0.23	3.6	1	0.004	1.78	0.25	0.003	0.03	0.08
Sample 34	0.19	1.7	1	0.004	1.36	0.15	0.002	0.02	0.05

TABLE I-1A Continued
VARIABILITY HEAD ASSAY DATA

Sample	Assay - percent or g/tonne								
	Cu	Fe	Ag	Mo	S	Au	As	Cu(ox)	$Cu_{(CN)}$
Sample 35	0.22	3.3	2	0.016	1.60	0.18	0.003	0.05	0.06
Sample 36	0.38	2.9	2	0.011	1.62	0.30	0.002	0.04	0.21
Sample 37	0.34	3.4	2	0.042	1.67	0.26	0.003	0.02	0.11
Sample 38	0.20	4.8	4	0.007	4.17	0.15	0.006	0.00	0.00
Sample 39	0.26	1.7	2	0.019	1.77	0.22	0.002	0.04	0.15
Sample 40	0.18	1.6	2	0.032	1.44	0.27	0.002	0.01	0.02
Sample 41	0.16	1.7	1	0.024	1.43	0.15	0.002	0.01	0.04
Sample 42	0.15	2.7	2	0.014	2.08	0.16	0.002	0.01	0.01
Sample 44	0.14	4.5	2	0.008	2.26	0.25	0.007	0.02	0.03
Sample 46	0.39	4.5	2	0.012	3.92	0.22	0.009	0.08	0.19
Sample 47	0.30	0.8	1	0.042	0.64	0.15	0.004	0.03	0.10
Sample 48	0.32	1.0	1	0.038	0.87	0.25	0.003	0.03	0.11
Sample 49	0.32	1.1	1	0.029	0.76	0.19	0.003	0.03	0.05
Sample 50	0.10	3.0	2	0.002	3.49	0.21	0.002	0.01	0.05
Sample 51	0.32	1.9	2	0.022	1.91	0.12	0.003	0.06	0.07
Sample 52	0.21	4.3	2	0.021	0.87	0.25	0.004	0.01	0.00
Sample 53	0.21	2.3	1	0.023	1.09	0.15	0.005	0.02	0.03
Sample 54	0.26	4.0	2	0.013	1.02	0.19	0.002	0.04	0.09
Sample 55	0.26	3.0	2	0.002	1.22	0.26	0.003	0.03	0.12
Sample 56	0.32	3.6	3	0.550	4.31	0.10	0.003	0.06	0.16
Sample 57	0.62	5.6	2	0.176	6.12	0.09	0.001	0.08	0.46
Sample 58	0.17	3.9	3	0.070	2.85	0.15	0.002	0.01	0.01
Sample 59	0.64	3.6	5	0.084	3.82	0.27	0.003	0.07	0.14
Sample 60	0.30	4.0	3	0.027	4.30	0.13	0.001	0.03	0.14
Sample 61	0.22	3.5	2	0.031	2.16	0.20	0.001	0.01	0.05
Sample 62	0.32	1.6	2	0.042	2.17	0.22	0.002	0.03	0.16
Sample 63	0.46	2.6	2	0.078	3.53	0.10	0.003	0.07	0.30
Sample 64	0.34	5.2	3	0.011	6.51	0.25	0.003	0.04	0.22
Sample 65	0.44	3.8	4	0.068	5.04	0.29	0.002	0.04	0.23
Sample 66	0.41	1.8	4	0.040	2.13	0.26	0.001	0.03	0.18
Sample 67	0.16	4.1	2	0.024	2.36	0.16	0.002	0.01	0.01
Sample 68	0.30	4.1	2	0.015	3.61	0.07	0.001	0.04	0.20
Sample 69	0.25	3.9	2	0.006	3.96	0.30	0.001	0.04	0.12

TABLE IV-1B
REPLICATE HEAD ASSAY DATA
SUP Composite 2010

Sample	Assay - percent or g/tonne								
	Cu	Fe	Ag	Mo	S	Au	As	Cu(ox)	$Cu_{(CN)}$
SUP Composite 2010 Head 1	0.31	3.44	2	0.037	2.88	0.26	0.001	0.03	0.11
SUP Composite 2010 Head 2	0.29	3.49	3	0.035	2.87	0.24	0.001	0.03	0.10
Average	**0.30**	**3.47**	**2**	**0.036**	**2.88**	**0.25**	**0.001**	**0.03**	**0.11**

SUP Composite 2010-2

Sample	Assay - percent or g/tonne								
	Cu	Fe	Ag	Mo	S	Au	As	Cu(ox)	$Cu_{(CN)}$
SUP Composite 2010-2 Head 1	0.29	3.50	2	0.032	2.81	0.18	0.001	0.03	0.11
SUP Composite 2010-2 Head 2	0.28	3.50	3	0.032	2.94	0.20	0.001	0.03	0.11
Average	**0.29**	**3.50**	**2**	**0.032**	**2.88**	**0.19**	**0.001**	**0.03**	**0.11**

Note: Ag and Au assays in g/tonne, all other assays in percent.

TABLE IV-2A
STATISTICAL ANALYSIS OF HEAD ASSAYS
SUP Composite 2010

Test	Assay - percent or g/tonne					
	Cu	Mo	Fe	S	Ag	Au
1	0.30	0.033	3.42	2.6	2.18	0.24
2	0.28	0.038	3.62	2.8	1.96	0.24
3	0.30	0.032	3.60	2.9	2.02	0.25
4	0.28	0.037	3.38	2.8	2.13	0.27
5	0.30	0.036	3.55	2.6	2.20	0.22
6	0.28	0.035	3.54	2.6	2.15	0.22
7	0.30	0.031	3.51	2.6	1.97	0.24
8	0.28	0.035	3.37	2.5	4.12	0.20
9	0.29	0.038	3.49	2.6	2.40	0.20
10	0.29	0.032	3.56	2.7	3.02	0.25
11	0.28	0.033	3.78	2.9	2.19	0.23
12	0.29	0.035	3.35	2.8	2.06	0.23
13	0.27	0.033	3.70	2.5	2.14	0.24
14	0.28	0.030	3.82	2.5	1.97	0.27
15	0.28	0.034	3.74	2.5	2.23	0.27
16	0.30	0.032	3.64	2.5	1.88	0.23
17	0.27	0.032	3.58	2.5	2.09	0.23
18	0.29	0.035	3.63	2.6	2.33	0.21
19	0.29	0.036	3.48	2.7	2.03	0.24
21	0.28	0.032	3.58	2.7	2.14	0.18
22	0.29	0.038	3.74	2.6	2.23	0.25
23	0.29	0.037	3.70	2.6	2.19	0.21
24	0.29	0.037	3.61	2.6	2.29	0.24
25	0.29	0.034	3.56	2.7	2.29	0.26
26	0.29	0.038	3.74	2.6	2.23	0.25
27	0.29	0.034	3.67	2.6	2.37	0.21
29	0.29	0.033	3.60	2.7	2.62	0.25
31	0.29	0.032	3.56	2.5	2.49	0.21
32	0.29	0.034	3.57	2.7	2.30	0.25
33	0.28	0.033	3.39	2.6	2.47	0.22
34	0.28	0.031	3.38	2.7	2.29	0.27
35	0.28	0.032	3.80	2.6	2.37	0.23
36	0.29	0.033	3.71	2.6	2.08	0.23
37	0.28	0.033	3.61	2.7	2.26	0.21
Average Head	**0.29**	**0.03**	**3.59**	**2.63**	**2.29**	**0.23**
Measured Head	0.30	0.036	3.47	2.88	2.45	0.25

TABLE IV-2B
STATISTICAL ANALYSIS OF HEAD ASSAYS
SUP Composite 2010-2

Test	Assay - percent or grams/tonne					
	Cu	Mo	Fe	S	Ag	Au
38	0.30	0.035	3.89	2.9	2.40	0.20
39	0.29	0.030	3.73	2.6	2.33	0.21
42	0.29	0.032	3.77	2.8	2.96	0.22
Average Head	**0.29**	**0.032**	**3.80**	**2.76**	**2.56**	**0.21**
Measured Head	0.29	0.032	3.50	2.88	2.25	0.19

TABLE IV-3
COMPARATIVE BULK CONCENTRATE ASSAYS

Test		Copper - percent	
		AAS	Titre
10		32.9	34.3
19		34.1	33.9
20		31.4	31.3
21		33.3	31.9
22		23.7	24.7
23		25.0	25.4
24		25.1	25.8
25		29.5	29.9
26		35.6	35.8
27		31.8	31.9
29		25.8	25.6
31		26.2	26.8
32		26.4	26.8
33	Bulk Con I	24.4	24.7
	Bulk Con II	23.7	23.6
	Bulk Con III	32.5	32.3
	Bulk Con IV	31.6	30.8
	Bulk Con V	29.6	28.2
34	Bulk Con I	31.7	31.7
	Bulk Con II	27.9	26.3
	Bulk Con III	22.8	22.7
	Bulk Con IV	26.7	26.1
	Bulk Con V	26.0	25.7
35	Bulk Con I	26.4	27.8
	Bulk Con II	22.4	22.6
	Bulk Con III	24.4	25.0
	Bulk Con IV	26.6	26.3
	Bulk Con V	25.1	25.1
37	Bulk Con III	22.5	23.0
	Bulk Con IV	22.2	21.2
	Bulk Con V	20.6	20.8
38		26.6	27.0
39		33.7	33.2
42		29.2	29.9

TABLE IV-4
MINOR ELEMENT ASSAYS
Test 33

Element	Symbol	Units	Method	Bulk Concentrate III-V
Aluminum	Al	%	WR ICP-OES	0.48
Antimony	Sb	g/t	2 Acid ICP-OES	102
Arsenic	As	g/t	2 Acid ICP-OES	199
Bismuth	Bi	g/t	2 Acid ICP-OES	88
Cadmium	Cd	g/t	AR FAAS	32
Calcium	Ca	%	WR ICP-OES	0.13
Carbon	C	%	Leco	0.24
Cobalt	Co	g/t	AR FAAS	68
Copper	Cu	%	Titr	30.7
Fluorine	F	g/t	Fusion ISE	92
Gold	Au	g/t	FA FAAS	20.5
Iron	Fe	%	AR FAAS	24.3
Lead	Pb	%	AR FAAS	0.05
Magnesium	Mg	%	WR ICP-OES	0.06
Manganese	Mn	%	WR ICP-OES	0.002
Mercury	Hg	g/t	LeForte rt CV-AAS	<1
Molybdenum	Mo	%	2 Acid FAAS*	1.50
Nickel	Ni	g/t	AR FAAS	96
Phosphorus	P	g/t	3 Acid ICP-OES	83
Selenium	Se	g/t	ESHKA ICP-OES	46
Silicon	Si	%	Fusion ICP-OES	1
Sulphur	S	%	Leco	34.6
Silver	Ag	g/t	AR FAAS	179
Zinc	Zn	%	AR FAAS	0.13

Analytical Methods

CV-AAS	Cold vapour flameless atomic absorption spectrometry
FAAS	Flame atomic absorption spectrometry
ICP-OES	Inductively coupled plasma - optical emission spectroscopy
Leco	Leco induction furnace
ISE	ion selective electrode
Titr	Classical wet method titration

Digestion Methods

2 Acid	Hydrochloric acid and nitric acid
2 Acid*	Hydrochloric acid, nitric acid and potassium chlorate
2 Acid**	Nitric acid and bromine
3 Acid	Hydrochloric acid, nitric acid and perchloric acid
4 Acid	Hydrochloric acid, nitric acid, hydrofluoric acid and perchloric acid
AR	Aqua regia - 3:1 hydrochloric acid:nitric acid
ESHKA	Magnesium oxide, sodium carbonate sinter
FA	Fire assay fusion
Fusion	Sodium peroxide fusion
Leco	Combusion
LeForte rt	Reverse aqua regia - 1:3 hydrochloric acid:nitric acid, at room temperature
WR	Hydrochloric acid, nitric acid and hydrofluoric acid

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StewartGroup
Geochemical & Assay

CHEMICAL ANALYSIS REPORT

Date: 20-Oct-10

Et. File No. **E10-2562**

Report On: **Acid / Base Accounting**
No. of samples received:5
Sample type:Rock
Project #: KM2721

Report To: **G&T Metallurgical Services**
2957 Bowers Place
Kamloops, BC
V1S 1W5

Attention: **Simone Bawtree**

ECO TECH LABORATORY LTD.
per:

John Andrew, BSc.
Environmental Laboratory Manager

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StewartGroup
Geochemical & Assay

G&T Metallurgical Services 20-Oct-10
E10-2562

POTENTIAL ACID PRODUCTION / NEUTRALIZATION

Sample #		Paste pH	Total Sulfur (%)	Sulfate (S) (%)	Sulfide (%)	pH before Titration	Tonnes CaC03 Equivalent per 1000 Tonnes: Acid Production	Neutralization Potential	Net Neutralization Potential	NP/AP
1	KM2721-26 PylCT	7.98	1.3700	0.0430	1.3270	1.84	42.8	10.0	-32.8	0.2
2	KM2721-26 Py2CT	7.82	6.0500	0.0655	5.9845	2.35	189.1	12.5	-176.6	0.1
3	KM2721-26 PyROT1	9.55	0.0900	0.0117	0.0783	2.13	2.8	11.8	8.9	4.2
4	KM2721-1 Master CompHd 3	6.71	2.8800	0.0150	2.8650	2.01	90.0	6.0	-84.0	0.1
5	KM2721 Master Comp Hd 4	6.68	2.8700	0.0146	2.8554	2.02	89.7	5.8	-83.9	0.1
QC/DATA										
Repeat:										
5	KM2721 Master Comp Hd 4	6.68	2.8700	0.0150	2.8550	2.05	89.7	5.8	-83.9	0.1
Standard:										
KZK		8.80	0.8000	-	-	2.17	25.0	59.8	34.8	2.4
NBM		8.60	0.2980	-	-	2.12	9.3	51.1	41.8	5.5

XLS/10
JA/ap

End of Report

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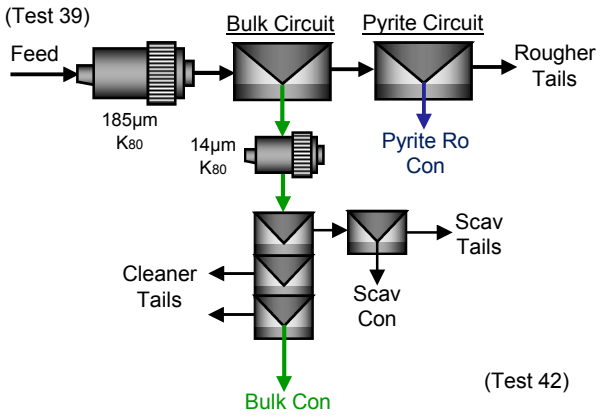
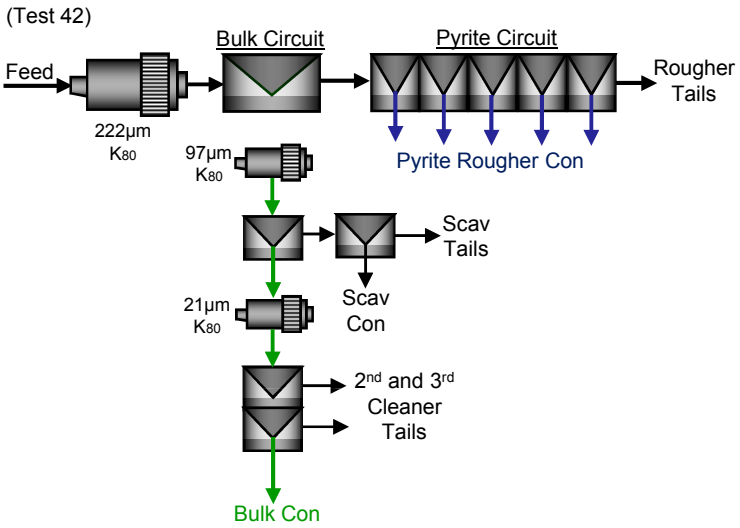
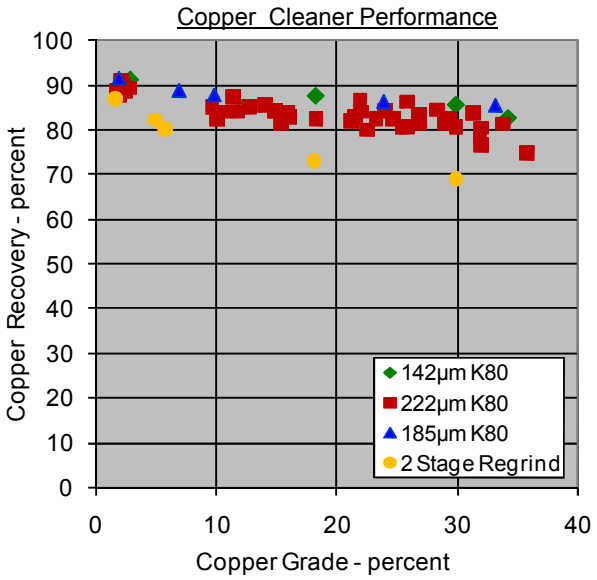
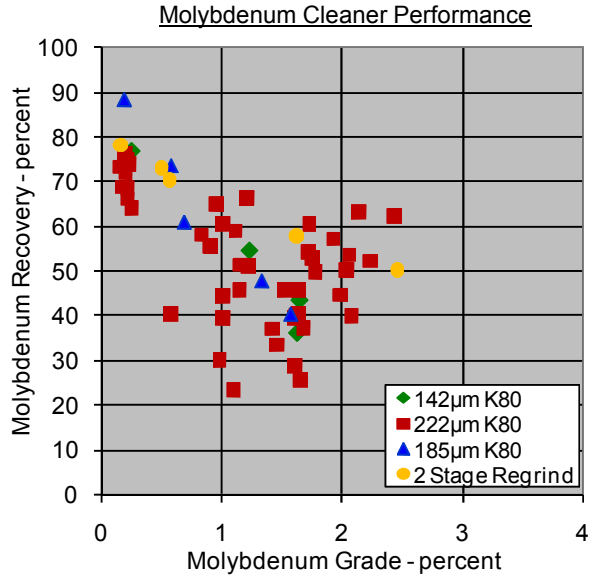
FIGURE IV-1

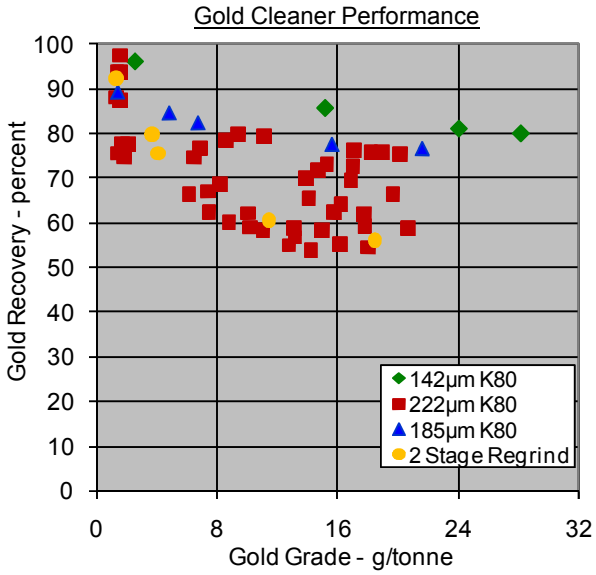
ANCILLARY TEST FLOWSHEET AND TEST DATA





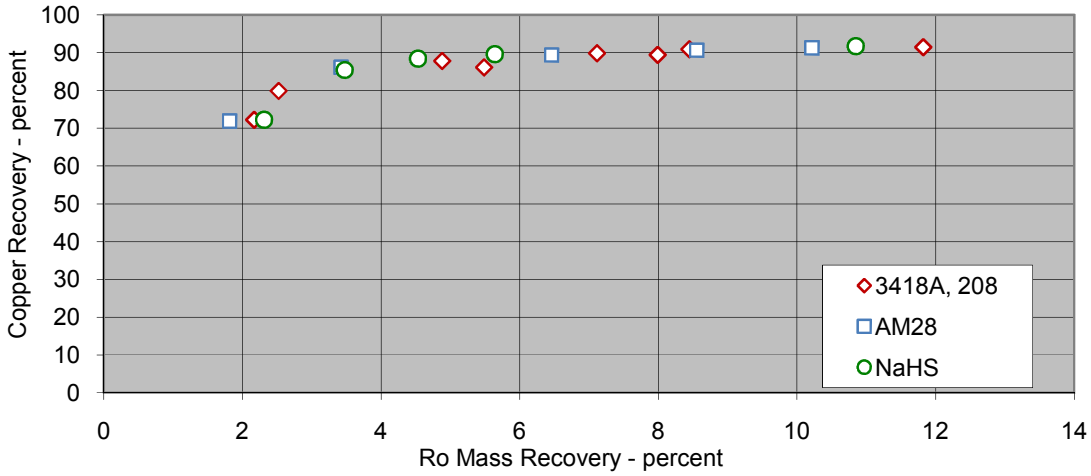






Notes: a) Detailed test conditions and results can be found in Appendix II.

FIGURE IV-2
EFFECT OF REAGENT ON COPPER ROUGHER PERFORMANCE



APPENDIX V – KM2721

MINERALOGICAL DATA

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TABLE 1A
SUMMARY OF PERCENT LIBERATION BY SIZE AND CLASS
SUP Composite 2010, 142µm K80
KM2721

Size Range	>150µm						<150>75µm						<75>C2					
Mineral Status	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	0.0	0.0	0.0	0.0	11.5	16.3	2.0	0.0	0.0	0.0	24.3	28.2	7.5	0.0	9.3	15.7	21.2	15.1
Binary - Cp		0.0	2.0	0.0	1.0	0.2		0.0	4.2	0.0	4.7	0.2		4.2	23.8	2.6	2.4	0.0
Binary - Bn	0.0		0.0	0.0	0.0	0.0	1.0		0.0	0.0	0.0	0.0	2.7		0.8	0.0	0.0	0.0
Binary - Ch	0.4	0.0		0.0	0.0	0.0	1.5	0.0		0.0	0.0	0.0	6.6	4.2		0.0	0.0	0.0
Binary - Md	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.3	0.0	0.0		0.1	0.0
Binary - Py	1.2	0.0	0.0	0.0		0.4	7.0	0.0	1.1	0.0		0.6	7.5	0.0	0.8	5.2		0.1
Binary - Gn	7.5	12.0	3.9	8.9	8.6		12.5	17.7	6.4	25.1	12.6		5.7	8.5	5.9	10.5	2.5	
Multiphase	0.4	0.0	0.0	0.0	0.2	0.0	3.0	0.0	2.1	0.0	0.8	0.0	0.9	2.1	1.7	0.0	0.3	0.0
Total	9.4	12.0	5.9	8.9	21.4	17.0	27.1	17.7	13.8	25.1	42.4	29.2	31.4	19.0	42.4	34.1	26.5	15.3

Size Range	<C2>C5						<C5					
Mineral Status	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	10.1	0.0	4.5	15.1	5.1	16.1	10.8	6.1	12.0	9.8	3.3	22.4
Binary - Cp		0.0	10.7	0.0	0.3	0.0		9.1	2.8	0.0	0.2	0.0
Binary - Bn	0.9		1.1	0.0	0.0	0.0	0.2		0.5	0.0	0.0	0.0
Binary - Ch	3.0	4.6		0.0	0.0	0.0	0.6	9.1		0.0	0.0	0.0
Binary - Md	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0
Binary - Py	2.3	0.0	0.0	0.0		0.0	0.2	0.0	0.0	0.0		0.0
Binary - Gn	2.1	7.0	2.8	4.3	0.4		1.5	15.2	2.4	2.8	0.3	
Multiphase	0.4	0.0	1.1	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.1	0.0
Total	18.8	11.6	20.3	19.4	5.9	16.1	13.3	39.6	17.6	12.6	3.9	22.4

SUMMARY OF MINERAL DISTRIBUTION BY CLASS OF ASSOCIATION

Mineral Status	Mineral Liberation-2 Dimensions						Mineral Liberation-3 Dimensions					
	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	30.5	6.1	25.8	40.6	65.4	98.1	13.1	0.0	7.3	25.8	56.8	97.6
Binary - Cp		13.4	43.5	2.6	8.7	0.5		14.3	54.4	3.3	10.8	0.7
Binary - Bn	4.8		2.4	0.0	0.0	0.1	6.0		3.1	0.0	0.0	0.1
Binary - Ch	12.1	18.0		0.0	0.1	0.0	15.1	19.2		0.0	0.1	0.1
Binary - Md	0.3	0.0	0.0		0.1	0.0	0.4	0.0	0.0		0.1	0.1
Binary - Py	18.2	0.0	1.9	5.2		1.1	22.8	0.0	2.4	6.6		1.4
Binary - Gn	29.3	60.4	21.4	51.5	24.4		36.6	64.3	26.7	64.4	30.5	
Multiphase	4.8	2.1	4.9	0.0	1.4	0.1	6.0	2.3	6.2	0.0	1.8	0.1
Total	100	100	100	100	100	100	100	100	100	100	100	100

Notes 1) Cp-Chalcopyrite and Tennantite/Tetrahedrite group minerals, Bn-Bornite, Ch-Chalcocite and Covellite, Md-Molybdenite, Py-Pyrite, Gn-Non-Sulphide minerals.

2) 0.0 Indicates these minerals were not observed during the counting procedure.

3) The 150µm and 75µm sizing fraction corresponds to the Tyler 100 and 200 mesh sieve. C1 to C5 indicates cyclones 1 to 5 on the cyclosizer.

4) The Total line is the distribution of mineral in the size fraction. Original data is from the size by assay and distribution tables.

5) The calculated liberation of the unsized product as measured in two dimensions has been converted to three dimensions using correction factors developed by G & T Metallurgical Services.

6) The three dimension liberation is zero if the liberation in two dimensions is less than 20 percent.

TABLE 1B
SIZE BY ASSAY AND DISTRIBUTION BASED ON METAL CONTENT
SUP Composite 2010, 142µm K80

Size Fraction	Mass %	Assays-percent						Distribution					
		Cu	Fe	Mo	S	Cu ox	Cu CN	Cu	Fe	Mo	S	Cu ox	Cu CN
>150µm	17.1	0.12	2.96	0.02	2.73	0.01	0.05	7.8	15.9	8.9	16.8	3.7	7.7
<150>75µm	29.7	0.19	3.52	0.03	3.94	0.01	0.10	21.5	32.8	25.1	42.0	10.7	25.3
<75>C2	15.9	0.59	4.61	0.07	5.28	0.03	0.26	35.8	23.0	34.1	30.1	17.7	36.3
<C2>C5	15.7	0.32	2.44	0.04	1.20	0.04	0.13	19.2	12.0	19.4	6.8	24.3	18.0
<C5	21.6	0.19	2.42	0.02	0.56	0.06	0.07	15.7	16.4	12.6	4.3	43.6	12.8
Total	100	0.26	3.19	0.03	2.79	0.03	0.11	100	100	100	100	100	100

Notes: 1) The assays shown in this table are utilized to determine the mineralogical distribution shown in Table C

TABLE 1C
SIZE BY ASSAY AND DISTRIBUTION BASED ON MINERAL CONTENT
SUP Composite 2010, 142µm K80

Size Fraction	Mass %	Assays-percent						Distribution					
		Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
>150µm	17.1	0.24	0.01	0.05	0.03	5.31	94.4	9.4	12.0	5.9	8.9	21.4	17.0
<150>75µm	29.7	0.39	0.01	0.07	0.04	6.06	93.4	27.1	17.7	13.8	25.1	42.4	29.2
<75>C2	15.9	0.85	0.01	0.39	0.11	7.07	91.6	31.4	19.0	42.4	34.1	26.5	15.3
<C2>C5	15.7	0.51	0.01	0.19	0.06	1.58	97.6	18.8	11.6	20.3	19.4	5.9	16.1
<C5	21.6	0.26	0.02	0.12	0.03	0.76	98.8	13.3	39.6	17.6	12.6	3.9	22.4
Total	100	0.43	0.01	0.15	0.05	4.24	95.1	100	100	100	100	100	100

Notes: 1) Cp-Chalcopyrite and Tennantite/Tetrahedrite group minerals, Bn-Bornite, Ch-Chalcocite and Covellite, Md-Molybdenite, Py-Pyrite, Gn-Non-Sulphide minerals.
2) Mineral assays are based on gravimetric factors to convert the metal to the pure mineral.
3) See appendix I for details of gravimetric factors.
4) An assay value of "0" indicates the assay value is less than the detection limit.

TABLE 1D
ESTIMATED RELATIVE PROPORTION AND COMPOSITION OF MINERAL GRAINS
SUP Composite 2010, 142µm K80

Binary	Proportion by Weight-2D						Proportion by Weight-3D						Composition of Grains					
Component	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	0.13	0.00	0.04	0.02	2.78	93.3	0.06	0.00	0.01	0.01	2.41	92.9	100	100	100	100	100	100
Binary - Cp		0.00	0.06	0.00	0.37	0.5		0.00	0.08	0.00	0.46	0.6		5	55	51	82	80
Binary - Bn	0.02		0.00	0.00	0.00	0.1	0.03		0.00	0.00	0.00	0.1	95		70	0	0	93
Binary - Ch	0.05	0.00		0.00	0.00	0.0	0.07	0.00		0.00	0.00	0.1	45	30		0	45	59
Binary - Md	0.00	0.00	0.00		0.00	0.0	0.00	0.00	0.00		0.00	0.0	49	0	0		50	60
Binary - Py	0.08	0.00	0.00	0.00		1.1	0.10	0.00	0.00	0.00		1.3	18	0	55	50		51
Binary - Gn	0.13	0.01	0.03	0.03	1.03		0.16	0.01	0.04	0.03	1.29		20	7	41	40	49	
Multiphase	0.02	0.00	0.01	0.00	0.06	0.1	0.03	0.00	0.01	0.00	0.08	0.1	14	0	5	0	41	40
Average Composition	0.43	0.01	0.15	0.05	4.24	95.1	0.43	0.01	0.15	0.05	4.24	95.1	24	3	32	18	73	98

Notes 1) The two-dimensional proportion of minerals is a weighted estimate which is based on the liberation and the mineral content of the unsized sample.
2) The three-dimensional data is based on converting the two dimensional liberation data using G & T Metallurgical Services correction factors.
3) Composition values of "0" represents values <2% and "100" represents values >98%.

TABLE 1E
DISTRIBUTION BY SIZE RANGE OF COPPER SULPHIDE MINERALS
SUP Composite 2010, 142µm K80

Size	Mass	% Copper Bearing Minerals						% Copper of Total Copper						% Iron of Total Iron			
Fraction	%	Cp	Bn	Ch	Cv	Te	Mal	Cp	Bn	Ch	Cv	Te	Mal	Cs	Py	Goe	Gn
>150µm	17.1	80.7	2.3	0.9	16.0	0.0	0.0	68.5	3.8	1.7	26.0	0.0	0.0	1.6	83.4	4.2	10.8
<150>75µm	29.7	84.2	1.2	8.6	5.8	0.1	0.0	71.7	2.1	16.8	9.4	0.1	0.0	3.9	80.1	6.8	9.2
<75>C2	15.9	68.0	0.9	18.7	12.4	0.0	0.0	50.1	1.4	30.9	17.5	0.0	0.0	5.5	71.3	13.4	9.8
<C2>C5	15.7	72.4	1.0	12.9	13.6	0.1	0.0	55.8	2.0	22.4	19.9	0.0	0.0	7.6	30.2	25.9	36.3
<C5	21.6	65.8	4.4	14.0	15.5	0.3	0.0	48.3	6.4	23.4	21.6	0.3	0.0	6.3	14.6	36.9	42.2
Total	100	75.2	2.0	10.7	11.9	0.1	0.0	60.2	3.2	18.7	17.8	0.1	0.0	4.9	57.3	16.9	21.0

Notes 1) Cp-Chalcopyrite, Bn-Bornite, Ch-Chalcocite, Cv-Covellite, Te-Tennantite/Tetrahedrite group minerals. Mal-Malachite, Azurite, Cuprite and Native Copper
2) Cs-Chalcopyrite and Bornite, Py-Pyrite, Ma-Magnetite, He-Hematite, Goe-Goethite, Gn-Non-Sulphide Gangue

TABLE 1F
COMPARATIVE ASSAY TABLE
SUP Composite 2010, 142µm K80

Methods	Cu	Fe	Mo	S
QEMSCAN	0.3	3.7	<0.1	3.0
Chemical	0.3	3.2	<0.1	2.8

Notes 1) This table compares the chemical composition of the samples determined by chemical analysis with the composition determined by QEMSCAN analysis.

TABLE 1G
THE WEIGHT PERCENT OF THE OBSERVED MINERALS
SUP Composite 2010, 142µm K80

Mineral	Mineral Assays (percent)					
	>150µm	<150>75µm	<75>C2	<C2>C5	<C5	Total
Chalcopyrite	0.20	0.62	0.83	0.52	0.49	0.54
Bornite	0.01	0.01	0.01	0.01	0.03	0.01
Chalcocite	0.00	0.06	0.23	0.09	0.10	0.09
Covellite	0.04	0.04	0.15	0.10	0.12	0.08
Tennantite	0.00	0.00	0.00	0.00	0.00	0.00
Malachite/Azurite	0.00	0.00	0.00	0.00	0.00	0.00
Molybdenite	0.01	0.01	0.11	0.09	0.03	0.04
Pyrite	6.75	8.31	7.17	1.37	0.76	5.14
Iron Oxides	0.24	0.52	0.96	0.87	1.42	0.79
Quartz	43.6	41.9	39.0	32.0	11.8	33.7
Feldspars	20.9	21.6	23.7	29.4	20.9	22.9
Muscovite	22.2	19.0	18.1	19.7	42.1	24.5
Biotite/Phlogopite	2.73	2.77	2.97	4.78	4.39	3.46
Kaolinite (clay)	0.57	1.18	2.37	4.15	10.2	3.67
Chlorite/Epidote	1.60	1.66	1.71	3.00	3.71	2.31
Pyrophyllite	0.36	0.62	1.03	1.56	0.86	0.84
Ti Mineral Group	0.19	0.29	0.42	0.58	0.58	0.40
Apatite	0.10	0.29	0.48	0.54	0.41	0.35
Tourmaline (Dravite)	0.11	0.35	0.21	0.29	0.18	0.24
Garnet	0.04	0.06	0.05	0.14	0.65	0.20
Ankerite	0.13	0.17	0.08	0.19	0.13	0.14
Amphibole (Hornblende)	0.06	0.14	0.04	0.10	0.42	0.16
Others	0.21	0.36	0.37	0.37	0.79	0.43
Total	100	100	100	100	100	100

Note: 1) Tennantite-Tennantite and Tetrahedrite.
2) Feldspars includes Plagioclase Feldspar, K-Feldspar, Feldspar-Albite, and Alkali-Feldspar.
3) Iron Oxides-Hematite and Goethite.
4) Ti-Minerals includes Rutile/Anatase, Ilmentite and Sphene.
5) Garnet includes Grossular and Almamdine.
6) Ankerite-Ankerite, Calcite and Dolomite.
7) Amphibole includes small amount of Pyroxene group minerals.
8) Others includes trace amounts of Barite, Sphalerite, Galena and unresolved mineral species.

TABLE 2A
SUMMARY OF PERCENT LIBERATION BY SIZE AND CLASS
Test 34 Bulk Concentrate I to V, 27µm K80
KM2721

Size Range	>150µm						<150>75µm						<75µm>C2					
Mineral Status	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.1	1.8	22.9	37.4	11.8
Binary - Cp		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		1.4	2.8	3.7	13.0	2.8
Binary - Bn	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.2		0.1	0.0	0.1	0.0
Binary - Ch	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.6	0.7		0.1	0.5	0.5
Binary - Md	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.1	0.0	0.1		0.8	0.2
Binary - Py	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	1.7	0.4	0.5	1.2		5.7
Binary - Gn	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.1	0.0	0.1	0.1	1.1	
Multiphase	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	3.5	1.3	0.3	1.8	2.5
Total	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.4	6.0	6.7	28.2	54.6	23.5

Size Range	<C2>C5						<C5					
Mineral Status	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	15.0	0.7	13.1	36.5	25.5	3.8	63.1	14.7	39.7	25.2	6.9	55.4
Binary - Cp		6.4	14.6	2.9	8.2	1.1		22.6	16.5	1.3	1.9	7.4
Binary - Bn	0.8		0.9	0.0	0.0	0.0	0.7		1.4	0.0	0.0	0.1
Binary - Ch	3.4	4.4		0.5	0.4	0.3	4.1	16.8		0.3	0.0	1.8
Binary - Md	0.1	0.0	0.1		0.3	0.1	0.1	0.0	0.2		0.1	0.2
Binary - Py	3.1	0.4	0.8	2.2		0.8	2.0	0.1	0.1	1.0		2.4
Binary - Gn	0.2	0.1	0.2	0.2	0.3		0.8	0.4	0.7	0.1	0.3	
Multiphase	0.8	11.3	2.9	0.5	1.2	0.9	0.6	16.2	2.0	1.1	0.3	2.1
Total	23.3	23.1	32.7	42.9	35.9	7.1	71.2	70.8	60.6	29.0	9.4	69.4

SUMMARY OF MINERAL DISTRIBUTION BY CLASS OF ASSOCIATION

Mineral Status	Mineral Liberation-2 Dimensions						Mineral Liberation-3 Dimensions					
	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	80.6	15.5	54.6	84.7	69.7	70.9	75.7	0.0	43.2	80.8	62.1	63.7
Binary - Cp		30.3	34.0	7.8	23.1	11.4		35.9	42.5	9.8	28.9	14.2
Binary - Bn	1.6		2.4	0.0	0.1	0.1	2.1		3.0	0.0	0.1	0.1
Binary - Ch	8.0	21.9		1.0	1.0	2.7	10.1	25.9		1.2	1.2	3.4
Binary - Md	0.2	0.0	0.5		1.3	0.5	0.3	0.0	0.6		1.6	0.6
Binary - Py	6.7	0.9	1.4	4.4		9.0	8.4	1.0	1.7	5.5		11.2
Binary - Gn	1.1	0.5	1.0	0.3	1.6		1.4	0.5	1.2	0.4	2.0	
Multiphase	1.7	31.0	6.2	1.9	3.2	5.5	2.1	36.6	7.8	2.3	4.0	6.8
Total	100	100	100	100	100	100	100	100	100	100	100	100

Notes 1) Cp-Chalcopyrite and Tennantite/Tetrahedrite group minerals, Bn-Bornite, Ch-Chalcocite and Covellite, Md-Molybdenite, Py-Pyrite, Gn-Non-Sulphide minerals.

2) 0.0 Indicates these minerals were not observed during the counting procedure.

3) The 150µm and 75µm sizing fraction corresponds to the Tyler 100 and 200 mesh sieve. C1 to C5 indicates cyclones 1 to 5 on the cyclosizer.

4) The Total line is the distribution of mineral in the size fraction. Original data is from the size by assay and distribution tables.

5) The calculated liberation of the unsized product as measured in two dimensions has been converted to three dimensions using correction factors developed by G & T Metallurgical Services.

6) The three dimension liberation is zero if the liberation in two dimensions is less than 20 percent.

TABLE 2B
SIZE BY ASSAY AND DISTRIBUTION BASED ON METAL CONTENT
Test 34 Bulk Concentrate I to V, 27µm K80

Size Fraction	Mass %	Assays-percent						Distribution					
		Cu	Fe	Mo	S			Cu	Fe	Mo	S		
>150µm	0.0	0.0	0.0	0.00	0.0			0.0	0.0	0.0	0.0		
<150>75µm	0.0	0.0	0.0	0.00	0.0			0.0	0.0	0.0	0.0		
<75µm>C2	20.5	7.7	35.7	1.91	43.3			6.0	28.0	28.2	25.1		
<C2>C5	26.5	26.6	28.5	2.25	37.6			26.8	28.9	42.9	28.2		
<C5	53.0	33.4	21.2	0.76	31.2			67.2	43.0	29.0	46.7		
Total	100	26.3	26.1	1.39	35.4			100	100	100	100		

Notes: 1) The assays shown in this table are utilized to determine the mineralogical distribution shown in Table C

TABLE 2C
SIZE BY ASSAY AND DISTRIBUTION BASED ON MINERAL CONTENT
Test 34 Bulk Concentrate I to V, 27µm K80

Size Fraction	Mass %	Assays-percent						Distribution					
		Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
>150µm	0.0	0.0	0.00	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<150>75µm	0.0	0.0	0.00	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<75µm>C2	20.5	12.9	0.30	4.1	3.19	67.8	11.7	5.4	6.0	6.7	28.2	54.6	23.5
<C2>C5	26.5	42.6	0.89	15.6	3.76	34.5	2.8	23.3	23.1	32.7	42.9	35.9	7.1
<C5	53.0	65.0	1.36	14.4	1.27	4.5	13.4	71.2	70.8	60.6	29.0	9.4	69.4
Total	100	48.4	1.02	12.6	2.32	25.4	10.2	100	100	100	100	100	100

Notes: 1) Cp-Chalcopyrite and Tennantite/Tetrahedrite group minerals, Bn-Bornite, Ch-Chalcocite and Covellite, Md-Molybdenite, Py-Pyrite, Gn-Non-Sulphide minerals.
2) Mineral assays are based on gravimetric factors to convert the metal to the pure mineral.
3) See appendix I for details of gravimetric factors.
4) An assay value of "0" indicates the assay value is less than the detection limit.

TABLE 2D
ESTIMATED RELATIVE PROPORTION AND COMPOSITION OF MINERAL GRAINS
Test 34 Bulk Concentrate I to V, 27µm K80

Binary	Proportion by Weight-2D						Proportion by Weight-3D						Composition of Grains					
Component	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	39.0	0.16	6.9	1.97	17.7	7.3	36.6	0.00	5.4	1.88	15.8	6.5	100	100	100	100	100	100
Binary - Cp		0.31	4.3	0.18	5.9	1.2		0.37	5.4	0.23	7.3	1.5		27	52	62	64	69
Binary - Bn	0.8		0.3	0.00	0.0	0.0	1.0		0.4	0.00	0.0	0.0	73		59	4	77	66
Binary - Ch	3.9	0.22		0.02	0.2	0.3	4.9	0.26		0.03	0.3	0.3	48	41		26	59	69
Binary - Md	0.1	0.00	0.1		0.3	0.0	0.1	0.00	0.1		0.4	0.1	38	96	74		77	87
Binary - Py	3.2	0.01	0.2	0.10		0.9	4.1	0.01	0.2	0.13		1.1	36	23	41	23		69
Binary - Gn	0.5	0.00	0.1	0.01	0.4		0.7	0.01	0.2	0.01	0.5		31	34	31	13	31	
Multiphase	0.8	0.32	0.8	0.04	0.8	0.6	1.0	0.37	1.0	0.05	1.0	0.7	25	9	24	1	24	17
Average Composition	48.4	1.02	12.6	2.32	25.4	10.2	48.4	1.02	12.6	2.32	25.4	10.2	71	16	58	33	75	68

Notes 1) The two-dimensional proportion of minerals is a weighted estimate which is based on the liberation and the mineral content of the unsized sample.
2) The three-dimensional data is based on converting the two dimensional liberation data using G & T Metallurgical Services correction factors.
3) Composition values of "0" represents values <2% and "100" represents values >98%.

TABLE 2E
DISTRIBUTION BY SIZE RANGE OF COPPER SULPHIDE MINERALS
Test 34 Bulk Concentrate I to V, 27µm K80

Size	Mass	% Copper Bearing Minerals						% Copper of Total Copper						% Iron of Total Iron			
Fraction	%	Cp	Bn	Ch	Cv	Te	Mal	Cp	Bn	Ch	Cv	Te	Mal	Cs	Py	Goe	Gn
>150µm	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<150>75µm	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<75µm>C2	20.5	74.2	1.7	12.0	11.9	0.1	0.1	57.9	2.5	21.5	17.8	0.1	0.3	10.9	88.3	0.4	0.4
<C2>C5	26.5	72.0	1.5	11.4	14.9	0.1	0.0	55.5	2.1	20.3	22.0	0.1	0.0	43.5	56.2	0.2	0.1
<C5	53.0	80.4	1.7	3.4	14.4	0.1	0.0	67.6	2.6	6.4	23.3	0.1	0.0	89.0	9.9	0.7	0.4
Total	100	76.9	1.6	7.3	14.0	0.1	0.0	62.4	2.4	13.2	21.8	0.1	0.1	60.9	38.3	0.5	0.3

Notes 1) Cp-Chalcopyrite, Bn-Bornite, Ch-Chalcocite, Cv-Covellite, Te-Tennantite/Tetrahedrite group minerals. Mal-Malachite, Azurite, Cuprite and Native Copper
2) Cs-Chalcopyrite and Bornite, Py-Pyrite, Ma-Magnetite, He-Hematite, Goe-Goethite, Gn-Non-Sulphide Gangue

TABLE 2F
COMPARATIVE ASSAY TABLE
Test 34 Bulk Concentrate I to V, 27µm K80

Methods	Cu	Fe	Mo	S
QEMSCAN	27.6	27.8	1.4	36.9
Chemical	26.3	26.1	1.4	35.4

Notes 1) This table compares the chemical composition of the samples determined by chemical analysis with the composition determined by QEMSCAN analysis.

TABLE 2G
THE WEIGHT PERCENT OF THE OBSERVED MINERALS
Test 34 Bulk Concentrate I to V, 27µm K80

Mineral	Mineral Assays (percent)					
	>150µm	<150>75µm	<75µm>C2	<C2>C5	<C5	Total
Chalcopyrite	0.00	0.00	12.1	42.0	70.4	50.9
Bornite	0.00	0.00	0.28	0.88	1.47	1.07
Chalcocite	0.00	0.00	1.96	6.67	2.99	3.75
Covellite	0.00	0.00	1.94	8.70	12.6	9.40
Tennantite	0.00	0.00	0.01	0.05	0.08	0.06
Malachite/Azurite	0.00	0.00	0.02	0.00	0.00	0.01
Molybdenite	0.00	0.00	4.87	4.06	1.28	2.75
Pyrite	0.00	0.00	65.0	35.8	5.19	25.6
Iron Oxides	0.00	0.00	0.21	0.07	0.23	0.18
Quartz	0.00	0.00	5.14	0.70	1.71	2.15
Feldspars	0.00	0.00	3.11	0.20	1.50	1.48
Muscovite	0.00	0.00	3.31	0.14	0.73	1.10
Biotite/Phlogopite	0.00	0.00	0.19	0.03	0.07	0.08
Kaolinite (clay)	0.00	0.00	0.27	0.04	0.17	0.15
Chlorite/Epidote	0.00	0.00	0.87	0.06	0.08	0.24
Pyrophyllite	0.00	0.00	0.12	0.01	0.07	0.07
Ti Mineral Group	0.00	0.00	0.13	0.06	0.06	0.08
Apatite	0.00	0.00	0.07	0.01	0.05	0.04
Tourmaline (Dravite)	0.00	0.00	0.04	0.01	0.10	0.06
Garnet	0.00	0.00	0.01	0.02	0.01	0.01
Ankerite	0.00	0.00	0.04	0.05	0.12	0.08
Amphibole (Hornblende)	0.00	0.00	0.02	0.00	0.05	0.03
Others	0.00	0.00	0.28	0.36	1.01	0.69
Total	0.00	0.00	100	100	100	100

Note: 1) Tennantite-Tennantite, Tetrahedrite and Enargite.
2) Iron Oxides includes Goethite, Limonite, Magnetite and Hematite.
3) Feldspars includes Plagioclase Feldspar, K-Feldspar, Feldspar-Albite, and Alkali-Feldspar.
4) Ti-Minerals includes Rutile/Anatase, Ilmentite and Sphene.
5) Garnet includes Grossular, Andradite and Almamdine.
6) Ankerite includes Calcite and Dolomite.
7) Amphibole includes a small amount of Pyroxene group minerals.
8) Others includes trace amounts of Sphalerite, Diaspore, Chromite and unresolved mineral species.

TABLE 3A
SUMMARY OF PERCENT LIBERATION BY SIZE AND CLASS
Test 34 Bulk Cleaner Scavenger Tailing IV & V, 16µm K80
KM2721

Size Range	>150µm						<150>75µm						<75µm>C2					
Mineral Status	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	1.7	4.6	16.8	4.9
Binary - Cp		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.8	0.0	0.3	0.3
Binary - Bn	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Binary - Ch	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.1	0.0		0.0	0.0	0.0
Binary - Md	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0
Binary - Py	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	5.0	0.0	1.7	0.0		0.2
Binary - Gn	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.5	0.0	0.0	0.8	0.5	
Multiphase	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	2.5	0.0	0.0	0.0
Total	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.2	0.1	6.7	5.4	17.6	5.4

Size Range	<C2>C5						<C5					
Mineral Status	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	2.0	0.0	1.1	40.4	42.5	11.4	53.9	14.0	45.1	45.1	36.7	80.9
Binary - Cp		4.0	0.0	3.2	0.4	0.2		41.9	15.0	0.0	0.3	0.0
Binary - Bn	0.2		0.0	0.0	0.0	0.0	4.1		2.5	0.0	0.0	0.0
Binary - Ch	0.0	0.0		0.0	0.0	0.0	4.9	14.0		0.0	0.0	0.0
Binary - Md	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0
Binary - Py	7.7	0.0	0.5	0.6		0.4	1.6	0.0	0.0	1.3		1.6
Binary - Gn	1.8	0.0	0.9	1.3	1.3		15.5	0.0	22.5	1.3	1.1	
Multiphase	0.6	12.0	0.7	0.0	0.0	0.0	1.6	14.0	5.0	1.3	0.0	0.0
Total	12.2	16.1	3.2	45.6	44.2	12.0	81.6	83.8	90.1	49.1	38.2	82.6

SUMMARY OF MINERAL DISTRIBUTION BY CLASS OF ASSOCIATION

Mineral Status	Mineral Liberation-2 Dimensions						Mineral Liberation-3 Dimensions					
	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	56.3	14.0	47.9	90.1	96.0	97.3	45.4	0.0	34.8	87.7	95.0	96.7
Binary - Cp		45.9	15.9	3.2	1.0	0.5		53.4	19.8	4.0	1.2	0.6
Binary - Bn	4.3		2.5	0.0	0.0	0.0	5.3		3.1	0.0	0.0	0.0
Binary - Ch	5.0	14.0		0.0	0.0	0.0	6.3	16.2		0.0	0.0	0.0
Binary - Md	0.0	0.0	0.0		0.1	0.0	0.0	0.0	0.0		0.1	0.0
Binary - Py	14.3	0.0	2.1	2.0		2.2	17.8	0.0	2.7	2.5		2.7
Binary - Gn	17.8	0.0	23.4	3.4	3.0		22.2	0.0	29.3	4.2	3.7	
Multiphase	2.3	26.0	8.2	1.3	0.0	0.0	2.9	30.2	10.3	1.7	0.0	0.0
Total	100	100	100	100	100	100	100	100	100	100	100	100

Notes 1) Cp-Chalcopyrite and Tennantite/Tetrahedrite group minerals, Bn-Bornite, Ch-Chalcocite and Covellite, Md-Molybdenite, Py-Pyrite, Gn-Non-Sulphide minerals.

2) 0.0 Indicates these minerals were not observed during the counting procedure.

3) The 150µm and 75µm sizing fraction corresponds to the Tyler 100 and 200 mesh sieve. C1 to C5 indicates cyclones 1 to 5 on the cyclosizer.

4) The Total line is the distribution of mineral in the size fraction. Original data is from the size by assay and distribution tables.

5) The calculated liberation of the unsized product as measured in two dimensions has been converted to three dimensions using correction factors developed by G & T Metallurgical Services.

6) The three dimension liberation is zero if the liberation in two dimensions is less than 20 percent.

TABLE 3B
SIZE BY ASSAY AND DISTRIBUTION BASED ON METAL CONTENT
Test 34 Bulk Cleaner Scavenger Tailing IV & V, 16µm K80

Size Fraction	Mass %	Assays-percent						Distribution					
		Cu	Fe	Mo	S			Cu	Fe	Mo	S		
>150µm	0.0	0.00	0.0	0.00	0.0			0.0	0.0	0.0	0.0		
<150>75µm	0.0	0.00	0.0	0.00	0.0			0.0	0.0	0.0	0.0		
<75µm>C2	8.2	0.08	23.5	0.03	24.2			7.5	15.7	5.4	16.2		
<C2>C5	19.4	0.04	25.3	0.10	27.5			9.4	40.0	45.6	43.5		
<C5	72.4	0.10	7.5	0.03	6.8			83.1	44.3	49.1	40.4		
Total	100	0.09	12.3	0.04	12.3			100	100	100	100		

Notes: 1) The assays shown in this table are utilized to determine the mineralogical distribution shown in Table C

TABLE 3C
SIZE BY ASSAY AND DISTRIBUTION BASED ON MINERAL CONTENT
Test 34 Bulk Cleaner Scavenger Tailing IV & V, 16µm K80

Size Fraction	Mass %	Assays-percent						Distribution					
		Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
>150µm	0.0	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<150>75µm	0.0	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<75µm>C2	8.2	0.11	0.00	0.03	0.05	49.3	50.5	6.2	0.1	6.7	5.4	17.6	5.4
<C2>C5	19.4	0.09	0.01	0.01	0.17	52.3	47.5	12.2	16.1	3.2	45.6	44.2	12.0
<C5	72.4	0.16	0.02	0.05	0.05	12.1	87.6	81.6	83.8	90.1	49.1	38.2	82.6
Total	100	0.14	0.01	0.04	0.07	22.9	76.8	100	100	100	100	100	100

Notes: 1) Cp-Chalcopyrite and Tennantite/Tetrahedrite group minerals, Bn-Bornite, Ch-Chalcocite and Covellite, Md-Molybdenite, Py-Pyrite, Gn-Non-Sulphide minerals.
2) Mineral assays are based on gravimetric factors to convert the metal to the pure mineral.
3) See appendix I for details of gravimetric factors.
4) An assay value of "0" indicates the assay value is less than the detection limit.

TABLE 3D
ESTIMATED RELATIVE PROPORTION AND COMPOSITION OF MINERAL GRAINS
Test 34 Bulk Cleaner Scavenger Tailing IV & V, 16µm K80

Binary	Proportion by Weight-2D						Proportion by Weight-3D						Composition of Grains					
Component	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	0.08	0.00	0.02	0.07	22.0	74.7	0.06	0.00	0.01	0.06	21.8	74.2	100	100	100	100	100	100
Binary - Cp		0.01	0.01	0.00	0.2	0.4		0.01	0.01	0.00	0.3	0.5		49	45	99	92	94
Binary - Bn	0.01		0.00	0.00	0.0	0.0	0.01		0.00	0.00	0.0	0.0	51		34	0	0	0
Binary - Ch	0.01	0.00		0.00	0.0	0.0	0.01	0.00		0.00	0.0	0.0	55	66		0	56	11
Binary - Md	0.00	0.00	0.00		0.0	0.0	0.00	0.00	0.00		0.0	0.0	1	0	0		89	88
Binary - Py	0.02	0.00	0.00	0.00		1.7	0.03	0.00	0.00	0.00		2.1	8	0	44	11		71
Binary - Gn	0.03	0.00	0.01	0.00	0.7		0.03	0.00	0.01	0.00	0.9		6	0	89	12	29	
Multiphase	0.00	0.00	0.00	0.00	0.0	0.0	0.00	0.00	0.00	0.00	0.0	0.0	17	17	16	5	5	39
Average Composition	0.14	0.01	0.04	0.07	22.9	76.8	0.14	0.01	0.04	0.07	22.9	76.8	15	32	52	55	92	99

Notes 1) The two-dimensional proportion of minerals is a weighted estimate which is based on the liberation and the mineral content of the unsized sample.
2) The three-dimensional data is based on converting the two dimensional liberation data using G & T Metallurgical Services correction factors.
3) Composition values of "0" represents values <2% and "100" represents values >98%.

TABLE 3E
DISTRIBUTION BY SIZE RANGE OF COPPER SULPHIDE MINERALS
Test 34 Bulk Cleaner Scavenger Tailing IV & V, 16µm K80

Size	Mass	% Copper Bearing Minerals						% Copper of Total Copper						% Iron of Total Iron			
Fraction	%	Cp	Bn	Ch	Cv	Te	Mal	Cp	Bn	Ch	Cv	Te	Mal	Cs	Py	Goe	Gn
>150µm	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<150>75µm	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<75µm>C2	8.2	59.4	0.1	8.1	8.3	23.8	0.3	46.6	0.2	14.5	12.5	26.1	0.2	0.1	97.6	0.8	1.5
<C2>C5	19.4	83.8	10.5	1.5	4.2	0.0	0.0	73.7	16.9	2.3	7.0	0.0	0.0	0.1	96.1	2.1	1.8
<C5	72.4	70.5	6.9	7.1	12.9	2.5	0.0	55.2	9.9	12.8	19.4	2.8	0.0	0.9	75.0	14.2	9.9
Total	100	72.2	7.1	6.1	10.9	3.8	0.0	58.0	10.4	10.9	16.4	4.1	0.0	0.7	80.9	10.7	7.6

Notes 1) Cp-Chalcopyrite, Bn-Bornite, Ch-Chalcocite, Cv-Covellite, Te-Tennantite/Tetrahedrite group minerals. Mal-Malachite, Azurite, Cuprite and Native Copper
2) Cs-Chalcopyrite and Bornite, Py-Pyrite, Ma-Magnetite, He-Hematite, Goe-Goethite, Gn-Non-Sulphide Gangue

TABLE 3F
COMPARATIVE ASSAY TABLE
Test 34 Bulk Cleaner Scavenger Tailing IV & V, 16µm K80

Methods	Cu	Fe	Mo	S
QEMSCAN	<0.1	11.2	<0.1	12.1
Chemical	<0.1	12.3	<0.1	12.3

Notes 1) This table compares the chemical composition of the samples determined by chemical analysis with the composition determined by QEMSCAN analysis.

TABLE 3G
THE WEIGHT PERCENT OF THE OBSERVED MINERALS
Test 34 Bulk Cleaner Scavenger Tailing IV & V, 16µm K80

Mineral	Mineral Assays (percent)					
	>150µm	<150>75µm	<75µm>C2	<C2>C5	<C5	Total
Chalcopyrite	0.00	0.00	0.08	0.06	0.19	0.15
Bornite	0.00	0.00	0.00	0.01	0.02	0.01
Chalcocite	0.00	0.00	0.01	0.00	0.02	0.01
Covellite	0.00	0.00	0.01	0.00	0.03	0.03
Tennantite	0.00	0.00	0.03	0.00	0.01	0.01
Malachite/Azurite	0.00	0.00	0.00	0.00	0.00	0.00
Molybdenite	0.00	0.00	0.12	0.22	0.09	0.12
Pyrite	0.00	0.00	41.7	52.2	10.4	21.1
Iron Oxides	0.00	0.00	0.22	0.75	1.38	1.16
Quartz	0.00	0.00	45.5	25.3	22.9	25.2
Feldspars	0.00	0.00	4.30	8.81	22.9	18.6
Muscovite	0.00	0.00	3.01	5.63	26.1	20.2
Biotite/Phlogopite	0.00	0.00	2.85	3.23	3.72	3.55
Kaolinite (clay)	0.00	0.00	0.20	0.65	2.50	1.95
Chlorite/Epidote	0.00	0.00	0.79	1.55	1.81	1.68
Pyrophyllite	0.00	0.00	0.09	0.14	0.53	0.42
Ti Mineral Group	0.00	0.00	0.11	0.50	0.71	0.62
Apatite	0.00	0.00	0.01	0.12	0.41	0.32
Tourmaline (Dravite)	0.00	0.00	0.03	0.20	3.45	2.54
Garnet	0.00	0.00	0.04	0.06	0.17	0.14
Ankerite	0.00	0.00	0.49	0.21	0.39	0.36
Amphibole (Hornblende)	0.00	0.00	0.04	0.05	0.20	0.16
Others	0.00	0.00	0.34	0.30	2.16	1.65
Total	0.00	0.00	100	100	100	100

Note: 1) Tennantite-Tennantite, Tetrahedrite and Enargite.
2) Iron Oxides includes Goethite, Limonite, Magnetite and Hematite.
3) Feldspars includes Plagioclase Feldspar, K-Feldspar, Feldspar-Albite, and Alkali-Feldspar.
4) Ti-Minerals includes Rutile/Anatase, Ilmentite and Sphene.
5) Garnet includes Grossular, Andradite and Almamdine.
6) Ankerite includes Calcite and Dolomite.
7) Amphibole includes a small amount of Pyroxene group minerals.
8) Others includes trace amounts of Sphalerite, Diaspore, Chromite and unresolved mineral species.

TABLE 4A
SUMMARY OF PERCENT LIBERATION BY SIZE AND CLASS
Test 34 Pyrite Rougher Concentrate III to V, 266µm K80
KM2721

Size Range	>150µm						<150>75µm						<75µm>C2					
Mineral Status	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	0.0	0.0	0.0	0.0	16.5	41.5	0.1	0.0	0.0	26.1	18.7	5.8	0.1	0.0	1.0	0.0	14.0	2.5
Binary - Cp		0.0	0.0	0.0	2.1	5.9		0.0	1.6	0.0	1.7	0.0		0.0	3.1	0.0	0.4	0.0
Binary - Bn	0.0		0.0	0.0	0.0	0.0	0.1		0.0	0.0	0.0	0.0	0.1		1.0	0.0	0.0	0.0
Binary - Ch	0.0	0.0		0.0	0.0	0.0	0.1	0.0		3.3	0.0	0.0	0.0	2.0		0.0	0.0	0.0
Binary - Md	0.0	0.0	0.0		0.0	0.0	0.0	0.0	1.6		0.0	0.0	0.0	0.0	0.0		0.0	0.0
Binary - Py	2.5	0.0	0.0	0.0		5.7	2.3	0.0	0.0	3.3		1.4	0.5	0.0	1.0	0.0		0.3
Binary - Gn	50.9	8.3	36.3	26.6	31.7		5.0	0.5	9.9	9.8	8.0		0.7	2.0	5.1	7.5	1.4	
Multiphase	5.1	0.0	0.0	0.0	0.0	0.0	0.9	0.0	3.3	0.0	0.0	0.0	0.1	1.0	2.1	0.0	0.0	0.0
Total	58.5	8.3	36.3	26.6	50.3	53.1	8.6	0.5	16.5	42.3	28.4	7.2	1.5	4.9	13.3	7.5	15.8	2.8

Size Range	<C2>C5						<C5					
Mineral Status	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	0.9	0.0	3.4	3.3	3.8	7.4	11.4	0.0	3.5	14.3	1.1	29.1
Binary - Cp		0.2	5.9	0.0	0.1	0.0		0.0	0.0	0.0	0.0	0.1
Binary - Bn	0.1		1.7	0.0	0.0	0.0	0.0		1.2	0.0	0.0	0.0
Binary - Ch	0.2	0.5		0.0	0.0	0.0	0.0	42.5		0.0	0.0	0.0
Binary - Md	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0
Binary - Py	0.3	0.0	1.7	0.5		0.1	0.4	0.0	0.0	3.6		0.1
Binary - Gn	0.7	0.0	6.8	1.9	0.4		15.8	0.0	4.6	0.0	0.1	
Multiphase	0.3	0.5	1.7	0.0	0.0	0.0	1.5	42.5	3.5	0.0	0.0	0.0
Total	2.4	1.2	21.1	5.6	4.2	7.5	29.0	85.1	12.8	17.9	1.3	29.3

SUMMARY OF MINERAL DISTRIBUTION BY CLASS OF ASSOCIATION

Mineral Status	Mineral Liberation-2 Dimensions						Mineral Liberation-3 Dimensions					
	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	12.5	0.0	7.9	43.7	54.1	86.3	0.0	0.0	0.0	29.6	42.6	82.8
Binary - Cp		0.2	10.6	0.0	4.4	6.1		0.2	11.6	0.0	5.4	7.6
Binary - Bn	0.3		3.9	0.0	0.0	0.0	0.3		4.2	0.0	0.0	0.0
Binary - Ch	0.4	45.0		3.3	0.0	0.0	0.4	45.0		4.1	0.0	0.0
Binary - Md	0.0	0.0	1.6		0.0	0.0	0.0	0.0	1.8		0.0	0.0
Binary - Py	6.0	0.0	2.7	7.3		7.6	6.9	0.0	2.9	9.1		9.5
Binary - Gn	73.1	10.8	62.7	45.8	41.5		83.5	10.8	68.1	57.2	51.9	
Multiphase	7.8	44.0	10.5	0.0	0.0	0.0	8.9	44.0	11.4	0.0	0.0	0.0
Total	100	100	100	100	100	100	100	100	100	100	100	100

Notes 1) Cp-Chalcopyrite and Tennantite/Tetrahedrite group minerals, Bn-Bornite, Ch-Chalcocite and Covellite, Md-Molybdenite, Py-Pyrite, Gn-Non-Sulphide minerals.

2) 0.0 Indicates these minerals were not observed during the counting procedure.

3) The 150µm and 75µm sizing fraction corresponds to the Tyler 100 and 200 mesh sieve. C1 to C5 indicates cyclones 1 to 5 on the cyclosizer.

4) The Total line is the distribution of mineral in the size fraction. Original data is from the size by assay and distribution tables.

5) The calculated liberation of the unsized product as measured in two dimensions has been converted to three dimensions using correction factors developed by G & T Metallurgical Services.

6) The three dimension liberation is zero if the liberation in two dimensions is less than 20 percent.

TABLE 4B
SIZE BY ASSAY AND DISTRIBUTION BASED ON METAL CONTENT
Test 34 Pyrite Rougher Concentrate III to V, 266µm K80

Size Fraction	Mass %	Assays-percent						Distribution					
		Cu	Fe	Mo	S			Cu	Fe	Mo	S		
>150µm	52.6	0.12	8.8	0.01	9.8			53.3	48.4	26.6	51.7		
<150>75µm	11.1	0.10	22.1	0.10	24.1			9.0	25.6	42.3	26.8		
<75µm>C2	5.2	0.07	26.6	0.04	28.1			2.9	14.5	7.5	14.6		
<C2>C5	6.9	0.07	6.4	0.02	6.0			4.3	4.6	5.6	4.1		
<C5	24.2	0.15	2.7	0.02	1.2			30.6	6.9	17.9	2.8		
Total	100	0.12	9.6	0.03	10.0			100	100	100	100		

Notes: 1) The assays shown in this table are utilized to determine the mineralogical distribution shown in Table C

TABLE 4C
SIZE BY ASSAY AND DISTRIBUTION BASED ON MINERAL CONTENT
Test 34 Pyrite Rougher Concentrate III to V, 266µm K80

Size Fraction	Mass %	Assays-percent						Distribution					
		Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
>150µm	52.6	0.32	0.00	0.01	0.02	17.4	82.2	58.5	8.3	36.3	26.6	50.3	53.1
<150>75µm	11.1	0.22	0.00	0.02	0.16	46.5	53.1	8.6	0.5	16.5	42.3	28.4	7.2
<75µm>C2	5.2	0.08	0.01	0.04	0.06	55.3	44.5	1.5	4.9	13.3	7.5	15.8	2.8
<C2>C5	6.9	0.10	0.00	0.05	0.04	11.0	88.8	2.4	1.2	21.1	5.6	4.2	7.5
<C5	24.2	0.34	0.04	0.01	0.03	0.9	98.6	29.0	85.1	12.8	17.9	1.3	29.3
Total	100	0.29	0.01	0.02	0.04	18.2	81.5	100	100	100	100	100	100

Notes: 1) Cp-Chalcopyrite and Tennantite/Tetrahedrite group minerals, Bn-Bornite, Ch-Chalcocite and Covellite, Md-Molybdenite, Py-Pyrite, Gn-Non-Sulphide minerals.
2) Mineral assays are based on gravimetric factors to convert the metal to the pure mineral.
3) See appendix I for details of gravimetric factors.
4) An assay value of "0" indicates the assay value is less than the detection limit.

TABLE 4D
ESTIMATED RELATIVE PROPORTION AND COMPOSITION OF MINERAL GRAINS
Test 34 Pyrite Rougher Concentrate III to V, 266µm K80

Binary	Proportion by Weight-2D						Proportion by Weight-3D						Composition of Grains					
Component	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	0.04	0.00	0.00	0.02	9.8	70.3	0.00	0.00	0.00	0.01	7.7	67.5	100	100	100	100	100	100
Binary - Cp		0.00	0.00	0.00	0.8	4.9		0.00	0.00	0.00	1.0	6.2		3	61	0	98	96
Binary - Bn	0.00		0.00	0.00	0.0	0.0	0.00		0.00	0.00	0.0	0.0	97		12	0	0	30
Binary - Ch	0.00	0.00		0.00	0.0	0.0	0.00	0.00		0.00	0.0	0.0	39	88		85	73	49
Binary - Md	0.00	0.00	0.00		0.0	0.0	0.00	0.00	0.00		0.0	0.0	0	0	15		13	40
Binary - Py	0.02	0.00	0.00	0.00		6.2	0.02	0.00	0.00	0.00		7.8	2	0	27	87		45
Binary - Gn	0.21	0.00	0.01	0.02	7.5		0.24	0.00	0.01	0.02	9.4		4	70	51	60	55	
Multiphase	0.02	0.00	0.00	0.00	0.0	0.0	0.03	0.00	0.00	0.00	0.0	0.0	47	9	4	0	16	24
Average Composition	0.29	0.01	0.02	0.04	18.2	81.5	0.29	0.01	0.02	0.04	18.2	81.5	4	18	19	38	70	89

Notes 1) The two-dimensional proportion of minerals is a weighted estimate which is based on the liberation and the mineral content of the unsized sample.
2) The three-dimensional data is based on converting the two dimensional liberation data using G & T Metallurgical Services correction factors.
3) Composition values of "0" represents values <2% and "100" represents values >98%.

TABLE 4E
DISTRIBUTION BY SIZE RANGE OF COPPER SULPHIDE MINERALS
Test 34 Pyrite Rougher Concentrate III to V, 266µm K80

Size	Mass	% Copper Bearing Minerals						% Copper of Total Copper						% Iron of Total Iron			
Fraction	%	Cp	Bn	Ch	Cv	Te	Mal	Cp	Bn	Ch	Cv	Te	Mal	Cs	Py	Goe	Gn
>150µm	52.6	95.9	0.5	2.3	1.2	0.1	0.0	91.7	0.9	5.1	2.1	0.2	0.0	1.1	92.0	2.3	4.6
<150>75µm	11.1	88.8	0.2	3.6	6.3	1.0	0.0	81.0	0.4	7.1	11.1	0.4	0.0	0.2	97.9	0.9	1.0
<75µm>C2	5.2	60.1	7.7	7.8	23.7	0.6	0.0	43.6	10.3	12.8	33.0	0.2	0.0	0.1	96.8	2.0	1.2
<C2>C5	6.9	64.9	1.2	14.2	19.0	0.7	0.0	47.7	1.6	23.6	26.8	0.3	0.0	0.6	80.3	9.5	9.7
<C5	24.2	87.7	10.0	2.3	0.0	0.0	0.0	78.9	16.4	4.7	0.0	0.0	0.0	1.7	16.1	35.8	46.4
Total	100	89.1	3.2	3.5	3.9	0.3	0.0	81.9	5.2	6.9	5.9	0.2	0.0	1.0	73.7	10.8	14.5

Notes 1) Cp-Chalcopyrite, Bn-Bornite, Ch-Chalcocite, Cv-Covellite, Te-Tennantite/Tetrahedrite group minerals. Mal-Malachite, Azurite, Cuprite and Native Copper
2) Cs-Chalcopyrite and Bornite, Py-Pyrite, Ma-Magnetite, He-Hematite, Goe-Goethite, Gn-Non-Sulphide Gangue

TABLE 4F
COMPARATIVE ASSAY TABLE
Test 34 Pyrite Rougher Concentrate III to V, 266µm K80

Methods	Cu	Fe	Mo	S
QEMSCAN	<0.1	9.6	<0.1	10.4
Chemical	0.1	9.6	<0.1	10.0

Notes 1) This table compares the chemical composition of the samples determined by chemical analysis with the composition determined by QEMSCAN analysis.

TABLE 4G
THE WEIGHT PERCENT OF THE OBSERVED MINERALS
Test 34 Pyrite Rougher Concentrate III to V, 266µm K80

Mineral	Mineral Assays (percent)					
	>150µm	<150>75µm	<75µm>C2	<C2>C5	<C5	Total
Chalcopyrite	0.29	0.18	0.10	0.12	0.07	0.20
Bornite	0.00	0.00	0.01	0.00	0.01	0.00
Chalcocite	0.01	0.01	0.01	0.03	0.00	0.01
Covellite	0.00	0.01	0.04	0.04	0.00	0.01
Tennantite	0.00	0.00	0.00	0.00	0.00	0.00
Malachite/Azurite	0.00	0.00	0.00	0.00	0.00	0.00
Molybdenite	0.00	0.10	0.05	0.03	0.01	0.02
Pyrite	15.9	51.8	56.7	11.7	0.47	18.9
Iron Oxides	0.30	0.34	0.85	1.00	0.77	0.51
Quartz	37.7	19.1	17.3	31.8	10.5	27.9
Feldspars	13.1	7.50	9.47	25.0	16.9	14.2
Muscovite	26.7	16.3	9.25	15.8	58.4	31.7
Biotite/Phlogopite	2.89	1.44	1.79	4.36	3.93	3.06
Kaolinite (clay)	0.74	0.91	1.13	3.45	2.24	1.35
Chlorite/Epidote	1.31	0.96	1.24	2.53	1.81	1.50
Pyrophyllite	0.22	0.28	0.41	1.50	1.07	0.54
Ti Mineral Group	0.35	0.41	0.41	0.61	0.65	0.46
Apatite	0.11	0.11	0.45	0.58	0.27	0.21
Tourmaline (Dravite)	0.08	0.12	0.26	0.56	1.26	0.42
Garnet	0.03	0.03	0.08	0.17	0.55	0.17
Ankerite	0.09	0.17	0.14	0.31	0.04	0.10
Amphibole (Hornblende)	0.03	0.02	0.02	0.06	0.25	0.08
Others	0.12	0.20	0.29	0.43	0.81	0.33
Total	100	100	100	100	100	102

Note: 1) Tennantite-Tennantite, Tetrahedrite and Enargite.
2) Iron Oxides includes Goethite, Limonite, Magnetite and Hematite.
3) Feldspars includes Plagioclase Feldspar, K-Feldspar, Feldspar-Albite, and Alkali-Feldspar.
4) Ti-Minerals includes Rutile/Anatase, Ilmentite and Sphene.
5) Garnet includes Grossular, Andradite and Almamdine.
6) Ankerite includes Calcite and Dolomite.
7) Amphibole includes a small amount of Pyroxene group minerals.
8) Others includes trace amounts of Sphalerite, Diaspore, Chromite and unresolved mineral species.

TABLE 5A
SUMMARY OF PERCENT LIBERATION BY SIZE AND CLASS
Test 34 Pyrite Rougher Tailing IV & V, 213µm K80
KM2721

Size Range	>150µm						<150>75µm						<75µm>C2					
Mineral Status	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	0.0	0.0	0.0	0.0	0.0	35.5	0.0	0.0	0.0	0.0	0.7	20.5	1.7	0.0	0.0	0.0	9.7	10.0
Binary - Cp		0.0	0.0	0.0	0.0	0.1		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	1.0	0.0
Binary - Bn	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Binary - Ch	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0
Binary - Md	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0
Binary - Py	0.0	0.0	0.0	0.0		0.1	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0
Binary - Gn	34.2	0.0	18.1	50.9	55.3		7.0	0.0	26.2	31.5	2.9		5.0	6.5	1.3	6.6	7.7	
Multiphase	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	34.2	0.0	18.1	50.9	55.3	35.7	7.0	0.0	26.2	31.5	3.7	20.5	6.6	6.5	1.3	6.6	18.4	10.0

Size Range	<C2>C5						<C5					
Mineral Status	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	2.4	0.0	4.4	2.1	0.9	12.5	25.7	89.7	17.3	7.0	16.2	21.3
Binary - Cp		0.0	4.4	0.0	0.0	0.0		0.0	17.3	0.0	0.5	0.0
Binary - Bn	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Binary - Ch	0.5	1.3		0.0	0.0	0.0	2.6	0.0		0.0	0.0	0.0
Binary - Md	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0
Binary - Py	0.0	0.0	0.0	0.0		0.0	1.3	0.0	0.0	0.0		0.0
Binary - Gn	2.4	0.0	0.0	2.1	0.6		15.4	0.0	0.0	0.0	4.5	
Multiphase	0.5	2.6	2.2	0.0	0.0	0.0	1.3	0.0	8.7	0.0	0.0	0.0
Total	5.8	3.9	11.1	4.1	1.5	12.5	46.3	89.7	43.3	7.0	21.2	21.3

SUMMARY OF MINERAL DISTRIBUTION BY CLASS OF ASSOCIATION

Mineral Status	Mineral Liberation-2 Dimensions						Mineral Liberation-3 Dimensions					
	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	29.8	89.7	21.8	9.1	27.5	99.7	12.3	87.1	2.2	0.0	9.4	99.7
Binary - Cp		0.0	21.8	0.0	1.4	0.1		0.0	27.2	0.0	1.8	0.1
Binary - Bn	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Binary - Ch	3.1	1.3		0.0	0.0	0.0	3.8	1.6		0.0	0.0	0.0
Binary - Md	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0
Binary - Py	1.3	0.0	0.0	0.0		0.1	1.6	0.0	0.0	0.0		0.2
Binary - Gn	64.1	6.5	45.6	90.9	71.1		80.1	8.1	57.0	100	88.8	
Multiphase	1.8	2.6	10.9	0.0	0.0	0.0	2.2	3.2	13.6	0.0	0.0	0.0
Total	100	100	100	100	100	100	100	100	100	100	100	100

Notes 1) Cp-Chalcopyrite and Tennantite/Tetrahedrite group minerals, Bn-Bornite, Ch-Chalcocite and Covellite, Md-Molybdenite, Py-Pyrite, Gn-Non-Sulphide minerals.

2) 0.0 Indicates these minerals were not observed during the counting procedure.

3) The 150µm and 75µm sizing fraction corresponds to the Tyler 100 and 200 mesh sieve. C1 to C5 indicates cyclones 1 to 5 on the cyclosizer.

4) The Total line is the distribution of mineral in the size fraction. Original data is from the size by assay and distribution tables.

5) The calculated liberation of the unsized product as measured in two dimensions has been converted to three dimensions using correction factors developed by G & T Metallurgical Services.

6) The three dimension liberation is zero if the liberation in two dimensions is less than 20 percent.

TABLE 5B
SIZE BY ASSAY AND DISTRIBUTION BASED ON METAL CONTENT
Test 34 Pyrite Rougher Tailing IV & V, 213µm K80

Size Fraction	Mass %	Assays-percent						Distribution					
		Cu	Fe	Mo	S			Cu	Fe	Mo	S		
>150µm	35.7	0.02	1.06	0.01	0.11			27.5	27.3	50.9	43.0		
<150>75µm	20.5	0.02	1.13	0.01	0.05			11.7	16.7	31.5	11.2		
<75µm>C2	10.0	0.02	1.51	0.01	0.13			5.4	10.9	6.6	14.2		
<C2>C5	12.5	0.02	1.58	0.00	0.06			7.5	14.3	4.1	8.2		
<C5	21.3	0.07	2.00	0.00	0.10			47.9	30.8	7.0	23.3		
Total	100	0.03	1.38	0.01	0.09			100	100	100	100		

Notes: 1) The assays shown in this table are utilized to determine the mineralogical distribution shown in Table C

TABLE 5C
SIZE BY ASSAY AND DISTRIBUTION BASED ON MINERAL CONTENT
Test 34 Pyrite Rougher Tailing IV & V, 213µm K80

Size Fraction	Mass %	Assays-percent						Distribution					
		Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
>150µm	35.7	0.06	0.00	0.01	0.02	0.21	99.7	34.2	0.0	18.1	50.9	55.3	35.7
<150>75µm	20.5	0.02	0.00	0.01	0.02	0.02	99.9	7.0	0.0	26.2	31.5	3.7	20.5
<75µm>C2	10.0	0.04	0.00	0.00	0.01	0.25	99.7	6.6	6.5	1.3	6.6	18.4	10.0
<C2>C5	12.5	0.03	0.00	0.01	0.01	0.02	99.9	5.8	3.9	11.1	4.1	1.5	12.5
<C5	21.3	0.13	0.01	0.02	0.01	0.14	99.7	46.3	89.7	43.3	7.0	21.2	21.3
Total	100	0.06	0.00	0.01	0.02	0.14	99.8	100	100	100	100	100	100

Notes: 1) Cp-Chalcopyrite and Tennantite/Tetrahedrite group minerals, Bn-Bornite, Ch-Chalcocite and Covellite, Md-Molybdenite, Py-Pyrite, Gn-Non-Sulphide minerals.
2) Mineral assays are based on gravimetric factors to convert the metal to the pure mineral.
3) See appendix I for details of gravimetric factors.
4) An assay value of "0" indicates the assay value is less than the detection limit.

TABLE 5D
ESTIMATED RELATIVE PROPORTION AND COMPOSITION OF MINERAL GRAINS
Test 34 Pyrite Rougher Tailing IV & V, 213µm K80

Binary	Proportion by Weight-2D						Proportion by Weight-3D						Composition of Grains					
Component	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	0.02	0.00	0.00	0.00	0.04	99.5	0.01	0.00	0.00	0.00	0.01	99.5	100	100	100	100	100	100
Binary - Cp		0.00	0.00	0.00	0.00	0.1		0.00	0.00	0.00	0.00	0.1		0	57	0	72	75
Binary - Bn	0.00		0.00	0.00	0.00	0.0	0.00		0.00	0.00	0.00	0.0	0		3	0	0	16
Binary - Ch	0.00	0.00		0.00	0.00	0.0	0.00	0.00		0.00	0.00	0.0	43	97		0	0	1
Binary - Md	0.00	0.00	0.00		0.00	0.0	0.00	0.00	0.00		0.00	0.0	0	0	0		0	53
Binary - Py	0.00	0.00	0.00	0.00		0.1	0.00	0.00	0.00	0.00		0.2	28	0	0	0		58
Binary - Gn	0.04	0.00	0.00	0.01	0.10		0.05	0.00	0.01	0.02	0.12		25	84	99	47	42	
Multiphase	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.0	35	3	40	0	0	22
Average Composition	0.06	0.00	0.01	0.02	0.14	99.8	0.06	0.00	0.01	0.02	0.14	99.8	28	44	71	43	44	100

Notes 1) The two-dimensional proportion of minerals is a weighted estimate which is based on the liberation and the mineral content of the unsized sample.
2) The three-dimensional data is based on converting the two dimensional liberation data using G & T Metallurgical Services correction factors.
3) Composition values of "0" represents values <2% and "100" represents values >98%.

TABLE 5E
DISTRIBUTION BY SIZE RANGE OF COPPER SULPHIDE MINERALS
Test 34 Pyrite Rougher Tailing IV & V, 213µm K80

Size	Mass	% Copper Bearing Minerals						% Copper of Total Copper						% Iron of Total Iron			
Fraction	%	Cp	Bn	Ch	Cv	Te	Mal	Cp	Bn	Ch	Cv	Te	Mal	Cs	Py	Goe	Gn
>150µm	35.7	91.1	0.0	0.0	8.9	0.0	0.0	84.1	0.0	0.0	15.9	0.0	0.0	1.6	9.2	22.3	66.8
<150>75µm	20.5	58.9	0.0	17.5	23.2	0.0	0.4	40.9	0.0	28.0	30.8	0.0	0.3	0.2	1.0	47.3	51.5
<75µm>C2	10.0	90.9	4.4	3.3	0.0	1.5	0.0	85.1	7.5	7.1	0.0	0.3	0.0	0.3	7.7	52.6	39.4
<C2>C5	12.5	67.6	2.2	10.8	13.2	6.1	0.0	52.0	3.1	18.8	19.5	6.5	0.0	0.5	0.5	50.9	48.1
<C5	21.3	78.8	7.5	3.6	10.0	0.0	0.0	65.6	11.4	7.0	16.0	0.0	0.0	1.4	3.1	41.8	53.7
Total	100	78.9	2.3	6.0	11.7	0.9	0.1	67.4	3.6	10.3	17.8	0.9	0.1	1.0	5.0	38.2	55.8

Notes 1) Cp-Chalcopyrite, Bn-Bornite, Ch-Chalcocite, Cv-Covellite, Te-Tennantite/Tetrahedrite group minerals. Mal-Malachite, Azurite, Cuprite and Native Copper
2) Cs-Chalcopyrite and Bornite, Py-Pyrite, Ma-Magnetite, He-Hematite, Goe-Goethite, Gn-Non-Sulphide Gangue

TABLE 5F
COMPARATIVE ASSAY TABLE
Test 34 Pyrite Rougher Tailing IV & V, 213µm K80

Methods	Cu	Fe	Mo	S
QEMSCAN	<0.1	1.1	<0.1	<0.1
Chemical	<0.1	1.4	<0.1	<0.1

Notes 1) This table compares the chemical composition of the samples determined by chemical analysis with the composition determined by QEMSCAN analysis.

TABLE 5G
THE WEIGHT PERCENT OF THE OBSERVED MINERALS
Test 34 Pyrite Rougher Tailing IV & V, 213µm K80

Mineral	Mineral Assays (percent)					
	>150µm	<150>75µm	<75µm>C2	<C2>C5	<C5	Total
Chalcopyrite	0.03	0.01	0.01	0.03	0.07	0.03
Bornite	0.00	0.00	0.00	0.00	0.01	0.00
Chalcocite	0.00	0.00	0.00	0.00	0.00	0.00
Covellite	0.00	0.00	0.00	0.01	0.01	0.00
Tennantite	0.00	0.00	0.00	0.00	0.00	0.00
Malachite/Azurite	0.00	0.00	0.00	0.00	0.00	0.00
Molybdenite	0.01	0.06	0.00	0.00	0.00	0.02
Pyrite	0.13	0.02	0.24	0.02	0.10	0.10
Iron Oxides	0.23	0.66	1.19	1.27	1.03	0.71
Quartz	49.6	42.0	41.4	34.6	11.7	37.3
Feldspars	22.9	27.7	27.9	33.2	21.3	25.3
Muscovite	19.7	20.5	17.8	15.5	48.6	25.3
Biotite/Phlogopite	2.90	3.36	3.13	4.94	4.34	3.58
Kaolinite (clay)	0.98	1.69	2.00	3.12	5.13	2.38
Chlorite/Epidote	1.68	1.74	2.23	2.71	3.27	2.21
Pyrophyllite	0.53	1.01	1.01	1.33	1.40	0.96
Ti Mineral Group	0.27	0.26	0.65	0.77	0.58	0.44
Apatite	0.16	0.07	0.65	0.64	0.43	0.31
Tourmaline (Dravite)	0.26	0.34	0.68	0.57	0.19	0.34
Garnet	0.10	0.10	0.11	0.16	0.53	0.20
Ankerite	0.22	0.17	0.49	0.59	0.21	0.28
Amphibole (Hornblende)	0.09	0.06	0.10	0.13	0.41	0.16
Others	0.21	0.34	0.37	0.44	0.67	0.38
Total	100	100	100	100	100	100

Note: 1) Tennantite-Tennantite, Tetrahedrite and Enargite.
2) Iron Oxides includes Goethite, Limonite, Magnetite and Hematite.
3) Feldspars includes Plagioclase Feldspar, K-Feldspar, Feldspar-Albite, and Alkali-Feldspar.
4) Ti-Minerals includes Rutile/Anatase, Ilmentite and Sphene.
5) Garnet includes Grossular, Andradite and Almamdine.
6) Ankerite includes Calcite and Dolomite.
7) Amphibole includes a small amount of Pyroxene group minerals.
8) Others includes trace amounts of Sphalerite, Diaspore, Chromite and unresolved mineral species.

TABLE 6A
LIBERATION UNITS TABLE BY STREAM AND SIZE RANGE AND MINERAL CLASS FOR TEST 34 OVERALL SUMMARY
KM2721

Bulk Cleaner Scavenger Tailing IV & V

Size Range	>150µm						<150>75µm						<75µm>C2					
Mineral Status	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.06	0.91	11.46	0.60
Binary - Cp		0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00		0.00	0.03	0.00	0.22	0.04
Binary - Bn	0.00		0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00
Binary - Ch	0.00	0.00		0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00
Binary - Md	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00		0.00	0.00
Binary - Py	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00		0.00	0.17	0.00	0.06	0.00		0.02
Binary - Gn	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00		0.02	0.00	0.00	0.15	0.35	
Multiphase	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.02	0.23	1.06	12.03	0.65

Size Range	<C2>C5						<C5						Bulk Cleaner Scavenger Tailing					
Mineral Status	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	0.07	0.00	0.04	8.02	28.99	1.38	0.45	0.00	1.10	8.63	25.04	9.52	0.53	0.00	1.20	17.56	65.48	11.50
Binary - Cp		0.50	0.00	0.64	0.24	0.02		2.60	0.00	0.68	0.21	0.15		3.10	0.03	1.32	0.68	0.20
Binary - Bn	0.01		0.00	0.00	0.00	0.00	0.04		0.00	0.00	0.00	0.00	0.05		0.00	0.00	0.00	0.00
Binary - Ch	0.00	0.00		0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00
Binary - Md	0.00	0.00	0.00		0.02	0.00	0.00	0.00	0.00		0.01	0.01	0.00	0.00	0.00		0.03	0.01
Binary - Py	0.26	0.00	0.02	0.13		0.04	1.73	0.00	0.45	0.14		0.30	2.16	0.00	0.52	0.26		0.36
Binary - Gn	0.06	0.00	0.03	0.25	0.91		0.40	0.00	0.90	0.27	0.78		0.48	0.00	0.93	0.68	2.04	
Multiphase	0.02	1.49	0.02	0.00	0.00	0.00	0.13	7.81	0.70	0.00	0.00	0.00	0.16	9.30	0.81	0.00	0.00	0.00
Total	0.41	1.99	0.11	9.03	30.16	1.45	2.76	10.41	3.15	9.72	26.05	9.97	3.38	12.40	3.49	19.82	68.24	12.07

Bulk Concentrate I to V

Size Range	>150µm						<150>75µm						<75µm>C2					
Mineral Status	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.18	0.05	1.62	11.28	2.03	0.02
Binary - Cp		0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00		0.96	2.56	1.81	0.71	0.00
Binary - Bn	0.00		0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.14		0.12	0.00	0.00	0.00
Binary - Ch	0.00	0.00		0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.52	0.50		0.04	0.03	0.00
Binary - Md	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.05	0.01	0.11		0.04	0.00
Binary - Py	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00		0.00	1.45	0.26	0.43	0.59		0.01
Binary - Gn	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00		0.09	0.01	0.08	0.04	0.06	
Multiphase	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29	2.43	1.20	0.13	0.10	0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.73	4.24	6.12	13.89	2.97	0.03

Size Range	<C2>C5						<C5						Bulk Concentrate					
Mineral Status	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	13.03	0.51	11.92	18.02	1.38	0.01	54.74	10.34	36.06	12.45	0.37	0.08	69.94	10.90	49.60	41.75	3.79	0.10
Binary - Cp		4.48	13.32	1.44	0.45	0.00		15.88	15.00	0.62	0.10	0.01		21.32	30.88	3.87	1.25	0.02
Binary - Bn	0.68		0.83	0.00	0.00	0.00	0.61	0.00	1.26	0.00	0.00	0.00	1.43		2.21	0.00	0.01	0.00
Binary - Ch	2.93	3.07		0.27	0.02	0.00	3.53	11.84		0.17	0.00	0.00	6.98	15.42		0.48	0.05	0.00
Binary - Md	0.06	0.00	0.13		0.02	0.00	0.08	0.00	0.22		0.01	0.00	0.20	0.01	0.45		0.07	0.00
Binary - Py	2.68	0.27	0.73	1.08		0.00	1.70	0.07	0.08	0.48		0.00	5.83	0.60	1.24	2.15		0.01
Binary - Gn	0.16	0.04	0.15	0.09	0.01		0.70	0.27	0.66	0.03	0.01		0.94	0.32	0.89	0.16	0.09	
Multiphase	0.70	7.91	2.66	0.25	0.06	0.00	0.49	11.43	1.78	0.54	0.01	0.00	1.48	21.78	5.64	0.92	0.17	0.01
Total	20.24	16.28	29.73	21.15	1.95	0.01	61.84	49.83	55.07	14.29	0.51	0.10	86.81	70.34	90.92	49.33	5.44	0.15

Pyrite Rougher Concentrate III to V TABLE 6A Continued

Size Range	>150µm						<150>75µm						<75µm>C2					
Mineral Status	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	0.00	0.00	0.00	0.00	3.98	2.06	0.00	0.00	0.00	1.29	4.50	0.29	0.00	0.00	0.01	0.00	3.35	0.12
Binary - Cp		0.00	0.00	0.00	0.51	0.29		0.00	0.00	0.00	0.41	0.00		0.00	0.02	0.00	0.10	0.00
Binary - Bn	0.00		0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00		0.01	0.00	0.00	0.00
Binary - Ch	0.00	0.00		0.00	0.00	0.00	0.00	0.00		0.16	0.00	0.00	0.00	0.00		0.00	0.00	0.00
Binary - Md	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00		0.00	0.00
Binary - Py	0.09	0.00	0.00	0.00		0.28	0.08	0.00	0.00	0.16		0.07	0.02	0.00	0.01	0.00		0.02
Binary - Gn	1.71	0.41	0.29	1.31	7.61		0.17	0.00	0.00	0.48	1.91		0.02	0.00	0.04	0.00	0.34	
Multiphase	0.17	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00
Total	1.96	0.41	0.29	1.31	12.10	2.64	0.29	0.03	0.13	2.09	6.82	0.36	0.05	0.25	0.10	0.37	3.80	0.14

Size Range	<C2>C5						<C5						Pyrite Rougher Concentrate					
Mineral Status	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	0.03	0.00	0.03	0.16	0.90	0.37	0.38	0.00	0.03	0.71	0.27	1.44	0.42	0.00	0.06	2.16	13.00	4.28
Binary - Cp		0.00	0.05	0.00	0.02	0.00		0.00	0.00	0.00	0.01	0.00		0.00	0.07	0.00	1.05	0.30
Binary - Bn	0.00		0.01	0.00	0.00	0.00	0.00		0.01	0.00	0.00	0.00	0.01		0.03	0.00	0.00	0.00
Binary - Ch	0.01	0.00		0.00	0.00	0.00	0.00	2.13		0.00	0.00	0.00	0.01	2.13		0.16	0.00	0.00
Binary - Md	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00		0.00	0.00
Binary - Py	0.01	0.00	0.01	0.02		0.00	0.01	0.00	0.00	0.18		0.01	0.20	0.00	0.02	0.36		0.38
Binary - Gn	0.02	0.00	0.05	0.09	0.09		0.53	0.00	0.04	0.00	0.03		2.45	0.41	0.42	1.89	9.98	
Multiphase	0.01	0.00	0.01	0.00	0.00	0.00	0.05	2.13	0.03	0.00	0.00	0.00	0.26	2.13	0.06	0.00	0.01	0.00
Total	0.08	0.06	0.17	0.28	1.01	0.37	0.97	4.27	0.10	0.88	0.30	1.45	3.36	4.68	0.66	4.57	24.04	4.96

Pyrite Rougher Tailing IV & V

Size Range	>150µm						<150>75µm						<75µm>C2					
Mineral Status	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	0.00	0.00	0.00	0.00	0.00	29.42	0.00	0.00	0.00	0.00	0.02	16.94	0.11	0.00	0.00	0.00	0.22	8.26
Binary - Cp		0.00	0.00	0.00	0.00	0.04		0.00	0.00	0.00	0.00	0.03		0.00	0.00	0.00	0.02	0.01
Binary - Bn	0.00		0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00
Binary - Ch	0.00	0.00		0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00
Binary - Md	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00		0.00	0.01	0.00	0.00	0.00		0.00	0.00
Binary - Py	0.00	0.00	0.00	0.00		0.09	0.00	0.00	0.00	0.00		0.01	0.00	0.00	0.00	0.00		0.00
Binary - Gn	2.21	0.00	0.87	13.18	1.26		0.45	0.00	1.26	8.15	0.07		0.32	0.79	0.06	1.70	0.18	
Multiphase	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	2.21	0.00	0.87	13.18	1.26	29.55	0.45	0.00	1.26	8.15	0.08	17.00	0.43	0.79	0.06	1.70	0.42	8.28

Size Range	<C2>C5						<C5						Pyrite Rougher Tailing					
Mineral Status	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	0.16	0.00	0.21	0.53	0.02	10.36	1.25	0.00	0.83	0.91	0.29	17.62	1.51	0.00	1.05	1.44	0.55	82.60
Binary - Cp		0.00	0.21	0.00	0.00	0.00		0.00	0.83	0.00	0.00	0.01		0.00	1.05	0.00	0.02	0.09
Binary - Bn	0.00		0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00
Binary - Ch	0.03	0.16		0.00	0.00	0.00	0.25	3.65		0.00	0.00	0.00	0.28	3.81		0.00	0.00	0.00
Binary - Md	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00		0.00	0.01
Binary - Py	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00		0.11
Binary - Gn	0.16	0.00	0.00	0.53	0.01		1.25	0.00	0.00	0.91	0.19		4.38	0.79	2.19	24.48	1.71	
Multiphase	0.03	0.32	0.11	0.00	0.00	0.00	0.25	7.31	0.41	0.00	0.00	0.00	0.28	7.62	0.52	0.00	0.00	0.00
Total	0.37	0.47	0.53	1.07	0.03	10.37	2.99	10.96	2.08	1.81	0.48	17.63	6.45	12.23	4.81	25.92	2.29	82.82

Recalculated Flotation Feed TABLE 6A Continued

Size Range	>150µm						<150>75µm						<75µm>C2					
Mineral Status	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	0.00	0.00	0.00	0.00	3.98	31.48	0.00	0.00	0.00	1.29	4.51	17.23	2.30	0.05	1.68	12.19	17.06	9.00
Binary - Cp		0.00	0.00	0.00	0.51	0.34		0.00	0.00	0.00	0.41	0.03		0.96	2.61	1.81	1.05	0.05
Binary - Bn	0.00		0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.15		0.13	0.00	0.00	0.00
Binary - Ch	0.00	0.00		0.00	0.00	0.00	0.00	0.00		0.16	0.00	0.00	0.53	0.50		0.04	0.03	0.00
Binary - Md	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00		0.00	0.01	0.05	0.01	0.11		0.05	0.00
Binary - Py	0.09	0.00	0.00	0.00		0.37	0.08	0.00	0.00	0.16		0.09	1.64	0.26	0.49	0.59		0.05
Binary - Gn	3.91	0.41	1.16	14.50	8.88		0.62	0.00	1.26	8.63	1.98		0.45	0.80	0.19	1.89	0.93	
Multiphase	0.17	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.30	2.43	1.31	0.13	0.10	0.00
Total	4.17	0.41	1.16	14.50	13.37	32.18	0.74	0.03	1.39	10.24	6.91	17.36	5.42	5.29	6.52	17.03	19.23	9.10

Size Range	<C2>C5						<C5						Recalculated Flotation Feed					
Mineral Status	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	13.28	0.51	12.20	26.73	31.29	12.12	56.81	10.34	38.02	22.69	25.98	28.66	72.40	10.90	51.91	62.91	82.82	98.49
Binary - Cp		4.97	13.58	2.07	0.71	0.03		18.48	15.84	1.31	0.32	0.17		24.42	32.03	5.19	3.00	0.61
Binary - Bn	0.69		0.84	0.00	0.00	0.00	0.65		1.27	0.00	0.00	0.00	1.49		2.24	0.00	0.01	0.00
Binary - Ch	2.97	3.23		0.27	0.02	0.00	3.78	17.63		0.17	0.00	0.00	7.28	21.37		0.64	0.06	0.00
Binary - Md	0.06	0.00	0.13		0.04	0.00	0.09	0.00	0.22		0.02	0.01	0.21	0.01	0.45		0.11	0.02
Binary - Py	2.95	0.27	0.76	1.23		0.05	3.44	0.07	0.53	0.79		0.31	8.19	0.60	1.78	2.78		0.86
Binary - Gn	0.40	0.04	0.23	0.97	1.02		2.87	0.27	1.60	1.21	1.01		8.26	1.52	4.43	27.20	13.82	
Multiphase	0.76	9.72	2.80	0.25	0.07	0.00	0.92	28.68	2.92	0.54	0.01	0.00	2.17	40.83	7.03	0.92	0.18	0.01
Total	21.10	18.80	30.54	31.53	33.15	12.20	68.56	75.47	60.40	26.71	27.35	29.16	100	100	100	100	100	100

TABLE 6B
DISTRIBUTION BY SIZE RANGE AND MINERAL CLASS FOR TEST 34 OVERALL SUMMARY
KM2721

Bulk Cleaner Scavenger Tailing IV & V

Size Range	>150µm						<150>75µm						<75µm>C2					
Mineral Status	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.5	13.8	0.6
Binary - Cp		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.1	0.0	7.4	5.9
Binary - Bn	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Binary - Ch	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.1	0.0		0.0	5.2	3.4
Binary - Md	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		2.8	0.8
Binary - Py	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	2.1	0.0	3.3	0.0		2.2
Binary - Gn	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.2	0.0	0.0	0.6	2.5	
Multiphase	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	1.2	0.0	1.6	1.8

Size Range	<C2>C5						<C5						Bulk Cleaner Scavenger Tailing					
Mineral Status	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	0.1	0.0	0.1	12.7	35.0	1.4	0.6	0.0	2.1	13.7	30.2	9.7	0.7	0.0	2.3	27.9	79.1	11.7
Binary - Cp		2.0	0.0	12.3	8.1	3.4		10.7	0.0	13.2	7.0	23.7		12.7	0.1	25.5	22.6	33.1
Binary - Bn	0.4		0.0	0.0	0.0	0.0	3.0		0.0	0.0	0.0	0.0	3.4		0.0	0.0	0.0	0.0
Binary - Ch	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.1	0.0		0.0	5.2	3.4
Binary - Md	0.2	0.0	0.0		16.0	4.0	1.3	0.0	0.0		13.8	27.8	1.5	0.0	0.0		32.5	32.6
Binary - Py	3.2	0.0	0.9	4.6		5.0	21.1	0.0	25.2	4.9		34.7	26.4	0.0	29.4	9.5		41.9
Binary - Gn	0.7	0.0	0.7	0.9	6.6		4.9	0.0	20.3	1.0	5.7		5.8	0.0	21.0	2.5	14.7	
Multiphase	0.9	3.7	0.4	0.0	0.0	0.0	6.1	19.1	9.9	0.0	0.0	0.0	7.3	22.8	11.5	0.0	1.6	1.8

Bulk Concentrate I to V

Size Range	>150µm						<150>75µm						<75µm>C2					
Mineral Status	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.5	3.1	17.9	2.5	0.0
Binary - Cp		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		3.9	8.0	34.8	23.5	0.7
Binary - Bn	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	9.7		5.2	100	56.4	0.0
Binary - Ch	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	7.2	2.4		6.1	49.1	16.1
Binary - Md	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	26.5	100	24.3		42.2	1.5
Binary - Py	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	17.7	43.7	23.9	21.4		1.0
Binary - Gn	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		1.1	0.7	1.9	0.1	0.4	
Multiphase	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.4	6.0	17.1	14.0	51.9	41.1

Size Range	<C2>C5						<C5						Bulk Concentrate					
Mineral Status	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	18.0	4.6	23.0	28.6	1.7	0.0	75.6	94.8	69.5	19.8	0.5	0.1	96.6	100	95.6	66.4	4.6	0.1
Binary - Cp		18.3	41.6	27.7	14.8	0.3		65.0	46.8	12.0	3.5	1.8		87.3	96.4	74.5	41.8	2.7
Binary - Bn	45.5		37.0	0.0	41.5	5.5	40.7		56.3	0.0	2.1	64.0	95.9		98.5	100	100	69.5
Binary - Ch	40.2	14.4		42.2	40.8	10.7	48.5	55.4		26.5	2.5	58.0	95.9	72.2		74.8	92.4	84.8
Binary - Md	31.4	0.0	28.3		17.5	0.9	40.5	0.0	47.5		7.2	1.1	98.5	100	100		66.9	3.5
Binary - Py	32.8	45.0	40.8	38.8		0.1	20.7	11.4	4.8	17.3		0.4	71.2	100	69.4	77.5		1.5
Binary - Gn	1.9	2.3	3.3	0.3	0.1		8.4	18.0	14.9	0.1	0.1		11.4	21.0	20.2	0.6	0.6	
Multiphase	32.1	19.4	37.8	27.7	34.3	15.4	22.4	28.0	25.3	58.3	7.4	34.7	67.9	53.3	80.3	100	93.5	91.2

Pyrite Rougher Concentrate III to V TABLE 6B Continued

Size Range	>150µm						<150>75µm						<75µm>C2					
Mineral Status	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	0.0	0.0	0.0	0.0	4.8	2.1	0.0	0.0	0.0	2.0	5.4	0.3	0.0	0.0	0.0	0.0	4.1	0.1
Binary - Cp		0.0	0.0	0.0	17.0	48.0		0.0	0.0	0.0	13.7	0.2		0.0	0.1	0.0	3.5	0.2
Binary - Bn	0.0		0.0	0.0	0.0	0.0	0.3		0.0	0.0	0.0	0.0	0.2		0.4	0.0	0.0	13.8
Binary - Ch	0.0	0.0		0.0	0.0	0.0	0.1	0.0		25.2	0.0	5.7	0.0	0.0		0.0	1.4	2.1
Binary - Md	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	2.0	0.0	0.0	0.0		0.0	1.3
Binary - Py	1.0	0.0	0.0	0.0		32.5	0.9	0.0	0.0	5.8		8.3	0.2	0.0	0.5	0.0		1.9
Binary - Gn	20.7	27.2	6.4	4.8	55.1		2.0	0.0	0.0	1.8	13.8		0.3	0.0	0.9	0.0	2.5	
Multiphase	7.9	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0	2.1	3.0	0.1	0.0	0.2	0.0	0.9	1.1

Size Range	<C2>C5						<C5						Pyrite Rougher Concentrate					
Mineral Status	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	0.0	0.0	0.1	0.3	1.1	0.4	0.5	0.0	0.1	1.1	0.3	1.5	0.6	0.0	0.1	3.4	15.7	4.3
Binary - Cp		0.0	0.1	0.0	0.6	0.2		0.0	0.0	0.0	0.2	0.6		0.0	0.2	0.0	34.9	49.1
Binary - Bn	0.2		0.6	0.0	0.0	0.0	0.0		0.4	0.0	0.0	0.0	0.7		1.4	0.0	0.0	13.8
Binary - Ch	0.1	0.0		0.0	0.8	1.3	0.0	10.0		0.0	0.2	2.1	0.2	10.0		25.2	2.5	11.2
Binary - Md	0.0	0.0	0.0		0.4	0.3	0.0	0.0	0.0		0.1	0.2	0.0	0.0	0.0		0.6	3.9
Binary - Py	0.1	0.0	0.7	0.8		0.5	0.2	0.0	0.0	6.4		0.6	2.5	0.0	1.2	13.0		43.8
Binary - Gn	0.3	0.0	1.2	0.3	0.6		6.4	0.0	0.8	0.0	0.2		29.7	27.2	9.4	6.9	72.2	
Multiphase	0.4	0.0	0.2	0.0	1.5	1.2	2.3	5.2	0.4	0.0	0.4	1.7	12.0	5.2	0.8	0.0	4.9	7.0

Pyrite Rougher Tailing IV & V

Size Range	>150µm						<150>75µm						<75µm>C2					
Mineral Status	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	0.0	0.0	0.0	0.0	0.0	29.9	0.0	0.0	0.0	0.0	0.0	17.2	0.1	0.0	0.0	0.0	0.3	8.4
Binary - Cp		0.0	0.0	0.0	0.0	7.0		0.0	0.0	0.0	0.0	5.2		0.0	0.0	0.0	0.7	1.4
Binary - Bn	0.0		0.0	0.0	0.0	16.7	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Binary - Ch	0.0	0.0		0.0	0.0	0.6	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0
Binary - Md	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	52.9	0.0	0.0	0.0		0.0	0.0
Binary - Py	0.0	0.0	0.0	0.0		10.0	0.0	0.0	0.0	0.0		1.6	0.0	0.0	0.0	0.0		0.3
Binary - Gn	26.7	0.0	19.6	48.5	9.2		5.5	0.0	28.4	30.0	0.5		3.9	51.8	1.4	6.3	1.3	
Multiphase	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Size Range	<C2>C5						<C5						Pyrite Rougher Tailing					
Mineral Status	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	0.2	0.0	0.4	0.8	0.0	10.5	1.7	0.0	1.6	1.4	0.4	17.9	2.1	0.0	2.0	2.3	0.7	83.9
Binary - Cp		0.0	0.7	0.0	0.0	0.5		0.0	2.6	0.0	0.0	0.9		0.0	3.3	0.0	0.7	15.1
Binary - Bn	0.0		0.0	0.0	0.0	0.0	0.0		0.1	0.0	0.0	0.0	0.0		0.1	0.0	0.0	16.7
Binary - Ch	0.4	0.7		0.0	0.0	0.0	3.4	17.1		0.0	0.0	0.0	3.9	17.8		0.0	0.0	0.6
Binary - Md	0.0	0.0	0.0		0.0	2.6	0.0	0.0	0.0		0.0	4.5	0.0	0.0	0.0		0.0	60.0
Binary - Py	0.0	0.0	0.0	0.0		0.3	0.0	0.0	0.0	0.0		0.5	0.0	0.0	0.0	0.0		12.7
Binary - Gn	1.9	0.0	0.0	2.0	0.1		15.1	0.0	0.0	3.3	1.4		53.1	51.8	49.5	90.0	12.4	
Multiphase	1.4	0.8	1.5	0.0	0.0	0.0	11.5	17.9	5.9	0.0	0.0	0.0	12.9	18.7	7.4	0.0	0.0	0.0

TABLE 6C
RECOVERY BY MINERAL CLASS BY SIZE RANGE FOR TEST 34 OVERALL SUMMARY
KM2721

>150µm Recovery Table

Product	Bulk Cleaner Scavenger Tailing						Bulk Concentrate						Pyrite Rougher Tailing						Pyrite Rougher Tailing					
Mineral Status	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100	6.5	0.0	0.0	0.0	0.0	0.0	93.5
Binary - Cp		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	100	87.2		0.0	0.0	0.0	0.0	12.8
Binary - Bn	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	100
Binary - Ch	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	100
Binary - Md	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0
Binary - Py	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	100	0.0	0.0	0.0		76.5	0.0	0.0	0.0	0.0		23.5
Binary - Gn	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		43.6	100	24.7	9.1	85.8		56.4	0.0	75.3	90.9	14.2	
Multiphase	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

<150>75µm Recovery Table

Product	Bulk Cleaner Scavenger Tailing						Bulk Concentrate						Pyrite Rougher Tailing						Pyrite Rougher Tailing					
Mineral Status	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100	0.0	0.0	100	100	1.7	0.0	0.0	0.0	0.0	0.4	98.3
Binary - Cp		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	100	2.8		0.0	0.0	0.0	0.0	97.2
Binary - Bn	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	100		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Binary - Ch	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	100	0.0		100	0.0	100	0.0	0.0		0.0	0.0	0.0
Binary - Md	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	3.6	0.0	0.0	0.0		0.0	96.4
Binary - Py	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	100	0.0	0.0	100		83.4	0.0	0.0	0.0	0.0		16.6
Binary - Gn	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		27.1	0.0	0.0	5.6	96.6		72.9	0.0	100	94.4	3.4	
Multiphase	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100	0.0	0.0	0.0	100	100	0.0	0.0	0.0	0.0	0.0	0.0

<75µm>C2 Recovery Table

Product	Bulk Cleaner Scavenger Tailing						Bulk Concentrate						Pyrite Rougher Tailing						Pyrite Rougher Tailing					
Mineral Status	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	0.7	0.0	3.5	7.5	67.1	6.6	94.5	100	96.1	92.5	11.9	0.2	0.2	0.0	0.5	0.0	19.7	1.4	4.6	0.0	0.0	0.0	1.3	91.8
Binary - Cp		0.0	1.1	0.0	21.1	71.6		100	98.0	100	66.9	8.2		0.0	0.9	0.0	9.8	2.9		0.0	0.0	0.0	2.1	17.3
Binary - Bn	0.0		0.0	0.0	0.0	0.0	98.4		93.6	100	100	0.0	1.6		6.4	0.0	0.0	100	0.0		0.0	0.0	0.0	0.0
Binary - Ch	0.8	0.0		0.0	9.3	15.7	98.9	100		100	88.2	74.7	0.3	0.0		0.0	2.5	9.7	0.0	0.0		0.0	0.0	0.0
Binary - Md	0.0	0.0	0.0		6.1	21.7	100	100	100		93.9	41.4	0.0	0.0	0.0		0.0	36.8	0.0	0.0	0.0		0.0	0.0
Binary - Py	10.3	0.0	11.9	0.0		40.9	88.7	100	86.5	100		18.4	1.1	0.0	1.6	0.0		35.9	0.0	0.0	0.0	0.0		4.8
Binary - Gn	3.7	0.0	0.0	8.0	37.3		20.2	1.4	45.0	2.0	6.5		4.9	0.0	21.7	0.0	37.0		71.1	98.6	33.4	89.9	19.1	
Multiphase	1.4	0.0	6.7	0.0	2.9	4.1	97.8	100	92.1	100	95.5	93.4	0.8	0.0	1.2	0.0	1.6	2.5	0.0	0.0	0.0	0.0	0.0	0.0

<C2>C5 Recovery Table

Product	Bulk Cleaner Scavenger Tailing						Bulk Concentrate						Pyrite Rougher Tailing						Pyrite Rougher Tailing					
Mineral Status	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	0.5	0.0	0.3	30.0	92.6	11.4	98.1	100	97.7	67.4	4.4	0.0	0.2	0.0	0.2	0.6	2.9	3.0	1.2	0.0	1.7	2.0	0.1	85.5
Binary - Cp		10.0	0.0	30.7	34.6	78.4		90.0	98.1	69.3	63.0	6.1		0.0	0.3	0.0	2.4	3.5		0.0	1.6	0.0	0.0	11.9
Binary - Bn	1.0		0.0	0.0	0.0	0.0	98.7		98.4	0.0	100	100	0.4		1.6	0.0	0.0	0.0	0.0		0.1	0.0	0.0	0.0
Binary - Ch	0.0	0.0		0.0	0.0	0.0	98.7	95.1		100	98.1	88.9	0.2	0.0		0.0	1.9	11.1	1.0	4.9		0.0	0.0	0.0
Binary - Md	0.6	0.0	0.0		47.1	51.3	99.4	0.0	100		51.6	11.1	0.0	0.0	0.0		1.3	3.9	0.0	0.0	0.0		0.0	33.6
Binary - Py	8.8	0.0	2.1	10.4		84.4	90.9	100	96.1	87.8		2.4	0.3	0.0	1.8	1.9		8.0	0.0	0.0	0.0	0.0		5.2
Binary - Gn	15.1	0.0	13.6	26.2	88.9		39.5	100	63.6	9.3	1.4		6.1	0.0	22.8	9.6	8.4		39.3	0.0	0.0	54.9	1.3	
Multiphase	2.6	15.4	0.9	0.0	0.0	0.0	92.1	81.4	94.9	100	95.9	92.9	1.2	0.0	0.5	0.0	4.1	7.1	4.1	3.2	3.8	0.0	0.0	0.0

<C5 Recovery Table

Product	Bulk Cleaner Scavenger Tailing						Bulk Concentrate						Pyrite Rougher Tailing						Pyrite Rougher Tailing					
Mineral Status	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
Liberated	0.8	0.0	2.9	38.0	96.4	33.2	96.4	100	94.8	54.9	1.4	0.3	0.7	0.0	0.1	3.1	1.0	5.0	2.2	0.0	2.2	4.0	1.1	61.5
Binary - Cp		14.1	0.0	52.4	66.0	88.0		85.9	94.7	47.6	32.4	6.6		0.0	0.0	0.0	1.6	2.1		0.0	5.3	0.0	0.0	3.3
Binary - Bn	6.8		0.0	0.0	0.0	0.0	93.2		99.1	0.0	100	100	0.0		0.7	0.0	0.0	0.0	0.0		0.2	0.0	0.0	0.0
Binary - Ch	0.0	0.0		0.0	0.0	0.0	93.4	67.2		100	91.1	96.5	0.0	12.1		0.0	8.9	3.5	6.6	20.7		0.0	0.0	0.0
Binary - Md	3.2	0.0	0.0		65.4	82.6	96.8	0.0	100		34.0	3.3	0.0	0.0	0.0		0.6	0.7	0.0	0.0	0.0		0.0	13.4
Binary - Py	50.3	0.0	84.2	17.3		95.7	49.3	100	15.8	60.5		1.1	0.4	0.0	0.0	22.3		1.7	0.0	0.0	0.0	0.0		1.5
Binary - Gn	13.9	0.0	56.3	22.6	77.4		24.2	100	41.4	2.3	1.4		18.4	0.0	2.3	0.0	2.5		43.4	0.0	0.0	75.0	18.7	
Multiphase	14.5	27.2	23.9	0.0	0.0	0.0	53.0	39.9	61.0	100	94.3	95.4	5.4	7.4	0.9	0.0	5.7	4.6	27.1	25.5	14.2	0.0	0.0	0.0

TABLE 6D
SIZE BY ASSAY AND DISTRIBUTION FOR TEST 34 OVERALL SUMMARY
KM2721

Bulk Cleaner Scavenger Tailing IV & V

Size	Mass	Metal Assays				Distribution			
Fraction	%	Cu	Mo	Fe	S	Cu	Mo	Fe	S
>150µm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<150>75µm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<75µm>C2	1.18	0.07	0.03	20.86	23.71	0.29	1.06	7.35	10.42
<C2>C5	2.80	0.04	0.09	22.46	26.94	0.36	9.03	18.72	28.01
<C5	10.46	0.08	0.03	6.66	6.70	3.21	9.72	20.71	26.00
Total	14.44	0.07	0.04	10.89	12.02	3.86	19.82	46.78	64.43

Size	Mass	Mineral Assays						Distribution					
Fraction	%	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
>150µm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<150>75µm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<75µm>C2	1.18	0.09	0.00	0.02	0.04	43.79	52.20	0.21	0.02	0.23	1.06	12.03	0.65
<C2>C5	2.80	0.07	0.01	0.01	0.16	46.39	49.08	0.41	1.99	0.11	9.03	30.16	1.45
<C5	10.46	0.13	0.01	0.04	0.05	10.74	90.61	2.76	10.41	3.15	9.72	26.05	9.97
Total	14.44	0.12	0.01	0.03	0.07	20.37	79.41	3.38	12.41	3.49	19.82	68.24	12.07

Bulk Concentrate I to V

Size	Wt	Metal Assays				Distribution			
Fraction	%	Cu	Mo	Fe	S	Cu	Mo	Fe	S
>150µm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<150>75µm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<75µm>C2	0.20	7.29	2.07	34.12	41.23	5.24	13.89	2.01	3.02
<C2>C5	0.26	25.18	2.44	27.24	35.80	23.41	21.15	2.07	3.39
<C5	0.51	31.61	0.82	20.26	29.71	58.79	14.29	3.08	5.63
Total	0.96	24.92	1.51	24.95	33.68	87.44	49.33	7.15	12.05

Size	Wt	Mineral Assays						Distribution					
Fraction	%	Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
>150µm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<150>75µm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<75µm>C2	0.20	12.17	0.28	3.92	3.46	64.80	16.58	4.73	4.24	6.12	13.89	2.97	0.03
<C2>C5	0.26	40.28	0.84	14.73	4.07	32.95	3.91	20.24	16.28	29.73	21.15	1.95	0.01
<C5	0.51	61.54	1.29	13.64	1.38	4.33	18.96	61.84	49.83	55.07	14.29	0.51	0.10
Total	0.96	45.79	0.96	11.94	2.52	24.31	14.48	86.81	70.34	90.92	49.33	5.44	0.15

Pyrite Rougher Concentrate III to V TABLE 6D Continued

Size Fraction	Mass %	Metal Assays				Distribution			
		Cu	Mo	Fe	S	Cu	Mo	Fe	S
>150µm	3.04	0.12	0.01	8.69	9.80	1.38	1.31	7.85	11.03
<150>75µm	0.64	0.10	0.10	21.82	24.01	0.23	2.09	4.16	5.71
<75µm>C2	0.30	0.07	0.04	26.27	28.00	0.07	0.37	2.34	3.12
<C2>C5	0.40	0.08	0.02	6.32	5.96	0.11	0.28	0.75	0.88
<C5	1.40	0.16	0.02	2.70	1.15	0.79	0.88	1.12	0.59
Total	5.77	0.12	0.03	9.45	9.96	2.58	4.93	16.22	21.33

Size Fraction	Mass %	Mineral Assays						Distribution					
		Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
>150µm	3.04	0.33	0.00	0.01	0.02	17.18	82.47	1.96	0.41	0.29	1.31	12.10	2.64
<150>75µm	0.64	0.23	0.00	0.03	0.16	45.92	53.23	0.29	0.03	0.13	2.09	6.82	0.36
<75µm>C2	0.30	0.08	0.01	0.04	0.06	54.64	44.59	0.05	0.25	0.10	0.37	3.80	0.14
<C2>C5	0.40	0.10	0.00	0.05	0.03	10.91	89.00	0.08	0.06	0.17	0.28	1.01	0.37
<C5	1.40	0.35	0.04	0.01	0.03	0.93	98.90	0.97	4.27	0.10	0.88	0.30	1.45
Total	5.77	0.30	0.01	0.02	0.04	17.95	81.68	3.36	5.02	0.79	4.93	24.04	4.96

Pyrite Rougher Tailing IV & V

Size Fraction	Mass %	Metal Assays				Distribution			
		Cu	Mo	Fe	S	Cu	Mo	Fe	S
>150µm	28.14	0.02	0.01	0.97	0.09	1.68	13.18	8.16	0.94
<150>75µm	16.16	0.01	0.01	1.04	0.04	0.71	8.15	5.00	0.25
<75µm>C2	7.88	0.01	0.01	1.39	0.11	0.33	1.70	3.26	0.31
<C2>C5	9.85	0.01	0.00	1.45	0.05	0.46	1.07	4.26	0.18
<C5	16.79	0.05	0.00	1.84	0.08	2.93	1.81	9.19	0.51
Total	78.82	0.02	0.01	1.27	0.07	6.11	25.92	29.86	2.19

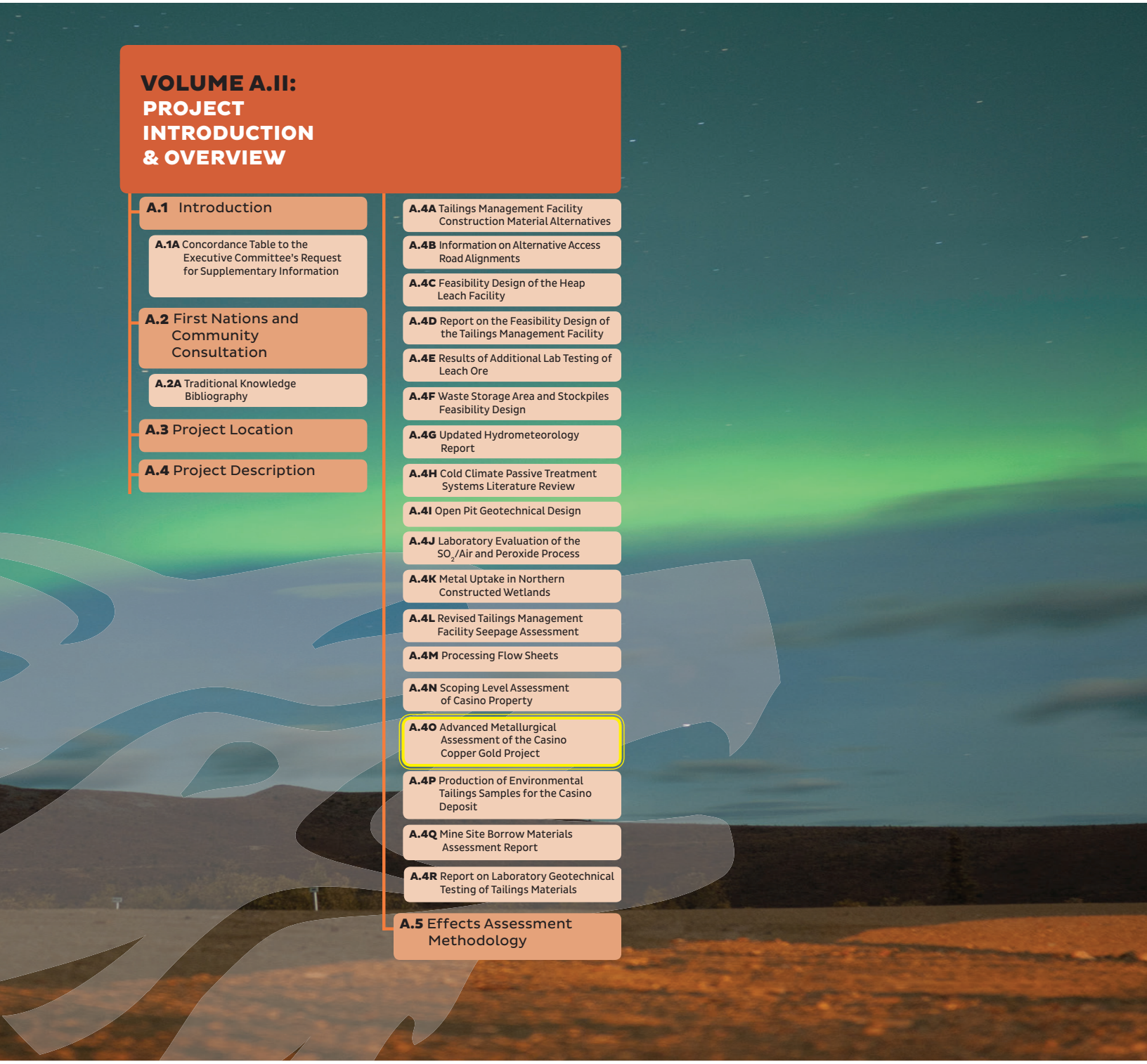
Size Fraction	Mass %	Mineral Assays						Distribution					
		Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
>150µm	28.14	0.04	0.00	0.00	0.02	0.19	99.74	2.21	0.00	0.87	13.18	1.26	29.55
<150>75µm	16.16	0.01	0.00	0.01	0.02	0.02	99.95	0.45	0.00	1.26	8.15	0.08	17.00
<75µm>C2	7.88	0.03	0.00	0.00	0.01	0.23	99.73	0.43	0.79	0.06	1.70	0.42	8.28
<C2>C5	9.85	0.02	0.00	0.01	0.01	0.02	99.97	0.37	0.47	0.53	1.07	0.03	10.37
<C5	16.79	0.09	0.01	0.02	0.01	0.12	99.73	2.99	10.96	2.08	1.81	0.48	17.63
Total	78.82	0.04	0.00	0.01	0.02	0.13	99.81	6.45	12.23	4.81	25.92	2.29	82.82

Recalculated Flotation Feed TABLE 6D Continued

Size Fraction	Mass %	Metal Assays				Distribution			
		Cu	Mo	Fe	S	Cu	Mo	Fe	S
>150µm	31.18	0.03	0.01	1.73	1.04	3.06	14.50	16.01	11.97
<150>75µm	16.80	0.02	0.02	1.83	0.96	0.95	10.24	9.15	5.95
<75µm>C2	9.56	0.17	0.05	5.26	4.75	5.93	17.03	14.95	16.87
<C2>C5	13.31	0.50	0.07	6.52	6.57	24.34	31.53	25.79	32.46
<C5	29.15	0.62	0.03	3.93	3.03	65.72	26.71	34.09	32.74
Total	100	0.27	0.03	3.36	2.69	100	100	100	100

Size Fraction	Mass %	Mineral Assays						Distribution					
		Cp	Bn	Ch	Md	Py	Gn	Cp	Bn	Ch	Md	Py	Gn
>150µm	31.18	0.07	0.00	0.00	0.02	1.85	98.06	4.17	0.41	1.16	14.50	13.37	32.18
<150>75µm	16.80	0.02	0.00	0.01	0.03	1.77	98.17	0.74	0.03	1.39	10.24	6.91	17.36
<75µm>C2	9.56	0.29	0.01	0.09	0.09	8.66	90.40	5.42	5.29	6.52	17.03	19.23	9.10
<C2>C5	13.31	0.81	0.02	0.29	0.12	10.74	87.09	21.10	18.80	30.54	31.53	33.15	12.20
<C5	29.15	1.20	0.03	0.26	0.05	4.04	95.01	68.56	75.47	60.40	26.71	27.35	29.16
Total	100	0.51	0.01	0.13	0.05	4.31	94.99	100	100	100	100	100	100

APPENDIX A.4O: Advanced Metallurgical Assessment of the Casino Copper Gold Project



ADVANCED METALLURGICAL ASSESSMENT OF THE CASINO COPPER GOLD PROJECT

WHITEHORSE, YUKON

KM3512

December 20, 2012

Work Performed on behalf of Western Copper and Gold Corporation

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December 20, 2012
KM3512

Report Distribution:
Paul West-Sells, Western Copper and Gold Corp., Vancouver, BC – 2 Copies

1.0 Introduction

Western Copper and Gold Corporation is currently conducting a feasibility assessment of the Casino Project, located 300 kilometres northwest of Whitehorse, Yukon. The deposit is described as porphyry mineralization with geological zones of oxide, supergene, and hypogene mineralization.

Previous test programs have developed a flotation process to extract a bulk copper-molybdenum and gold concentrate. This program of study was intended to produce tailings samples for environmental testing and investigate the copper-molybdenum separation process. The program also provided an opportunity to evaluate the process using fresh hyrogene drill core. Many of the previous test programs had been conducted on core sample that had been in storage for a long time and could have possibly oxidized.

This study was commissioned at the request of Dr. Paul West-Sells, President and CEO at Western Copper and Gold Corporation. On behalf of Western Copper and Gold Corporation, Mr. Jeff Austin of International Metallurgical and Environmental provided technical input on the design of the program. The objectives of this program, as described by Mr. Austin, were as follows:

- Prepare six composites for laboratory and pilot scale testing; three composites representing geological sub-types of the hypogene zone were designated for laboratory testing. Two separate composites of hypogene and supergene fresh drill core sample were prepared for pilot scale testing. A third commissioning composite for the pilot plant was also prepared from old reject sample.

- Evaluate the metallurgical performance of the hypogene composites using batch and locked cycle flotation tests.

- Process the pilot composites using the developed flowsheet. From the pilot testing, obtain samples of tailings and concentrate for subsequent testing.

- Conduct preliminary copper-molybdenum testing on the concentrate produced from the pilot campaign.

- Assay the concentrates for minor payable and deleterious elements.

The following technical brief summarizes the key technical points of the program. All of the test data generated through the execution of this program can be reviewed in a series of appendices attached to this brief. The appendices are arranged as follows:

Appendix I - Sample Origin
Appendix II - Flotation Test Data
Appendix III - Particle Sizing Data
Appendix IV - Special Assay Data
Appendix V - Pilot Plant Data

2.0 Properties of the Hypogene Composites

The chemical content of composite samples were determined by standard assaying techniques. The results are summarized in Table 1.

Copper averaged about 0.17 percent for all of the composites. This grade was slightly lower than some of the other samples previously investigated. Weak acid soluble copper was low for the hypogene composites, averaging about 3 percent of the total copper. This level is very low, indicating the samples should respond well to the developed copper flotation process.

Gold in the samples ranged between 0.18 and 0.22 g/tonne. Molybdenum in the sample was relatively high ranging from 0.019 to 0.071 percent by weight. The high relative levels of molybdenum to copper should result in high levels of molybdenum in the bulk copper concentrate.

The IX and WR samples averaged about 2.3 percent by weight sulphur. Comparatively, the PP Composite had relatively low levels of sulphur. Although no mineralogical analyses were conducted, past programs would suggest that pyrite would account for most of the remaining sulphur in the sample.

On this basis, anticipated pyrite levels in the IX and WR Composites would be high relative to the copper sulphides in the sample. Careful control of flotation pulp conditions will be required to optimize pyrite rejection from the concentrate.

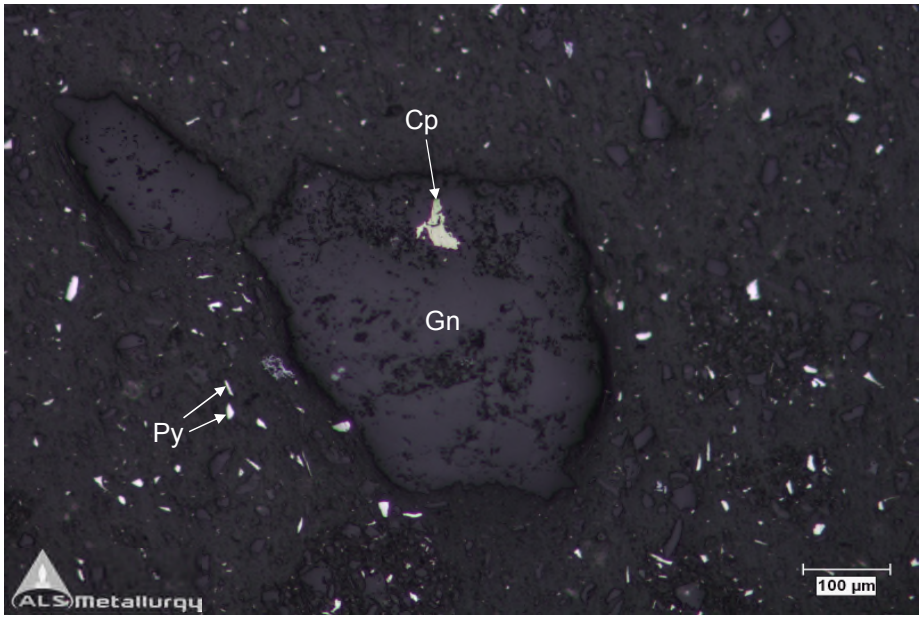
TABLE 1
CHEMICAL COMPOSITION – LABORATORY HYPOGENE COMPOSITES

Sample	Assay - percent or g/tonne								
	Cu	Mo	Fe	Au	CuOx	CuCN	S	C	Ag
PP Composite Head 1	0.13	0.031	2.97	0.22	0.004	0.008	0.74	0.46	1
PP Composite Head 2	0.14	0.029	2.92	0.22	0.003	0.007	0.74	0.45	1
Average	**0.14**	**0.030**	**2.95**	**0.22**	**0.004**	**0.008**	**0.74**	**0.45**	**1**
IX Composite Head 1	0.17	0.069	2.42	0.21	0.006	0.011	2.10	0.31	2
IX Composite Head 2	0.17	0.073	2.35	0.22	0.005	0.012	2.02	0.31	2
Average	**0.17**	**0.071**	**2.39**	**0.22**	**0.006**	**0.012**	**2.06**	**0.31**	**2**
WR Composite Head 1	0.19	0.018	2.53	0.20	0.004	0.013	2.49	0.16	1
WR Composite Head 2	0.18	0.019	2.47	0.15	0.005	0.013	2.42	0.16	1
Average	**0.19**	**0.019**	**2.50**	**0.18**	**0.005**	**0.013**	**2.46**	**0.16**	**1**

Note: Au and Ag are shown in g/tonne, all others are in percent.

PHOTOMICROGRAPH 1
CASINO – BULK 1ST CLEANER TAILING V
KM3512 Test 19

Unsized



*Cp-Chalcopyrite, Py-Pyrite, Gn-Gangue

3.0 Flotation Testing – Hypogene Composites

3.1 Rougher Test Results

A total of 14 rougher flotation tests were conducted in this program. The tests were used to establish the initial response of the composites using previously developed flotation conditions. Primary grind size and rougher pH were the two primary variables investigated. A summary of the test conditions and a graphical display of the results are shown in Figure 1. The following conclusions were reached when reviewing the test data:

- The results indicated that there was a negligible effect of primary grind size on copper rougher flotation response over the range of primary grind sizes tested; 150µm to 250µm K_{80}.

- For the hypogene composites, copper in the feed was about 88 to 95 percent recovered into the feed at a rougher mass recovery of about 8 to 10 percent. The performance of the samples appeared to be better than previously tested samples despite lower feed grades*.

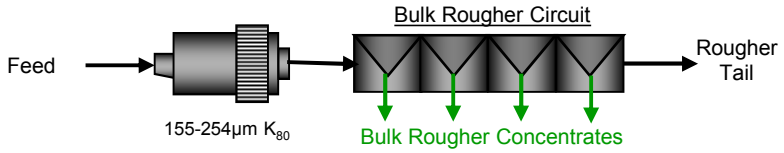
- Rougher pH appeared to have an effect on the metallurgical performance. Tests conducted at higher pH had better rougher response curves. It is assumed that the pyrite in the feed was better depressed at higher pH allowing more aggressive copper sulphide flotation.

- Molybdenum recovery to the rougher concentrate was also highly variable. The samples had superior performance when compared to the other composites. Molybdenum was about 80 percent recovered from the feed into the rougher concentrate at 9 percent rougher mass recovery. Molybdenum flotation data is graphically displayed in Appendix IV, Figure IV-1.

- Gold recovery data was not generated for the rougher tests.

* Quantitative mineralogy on ground feed samples should be conducted to determine if the fragmentation properties were more favourable for these samples.

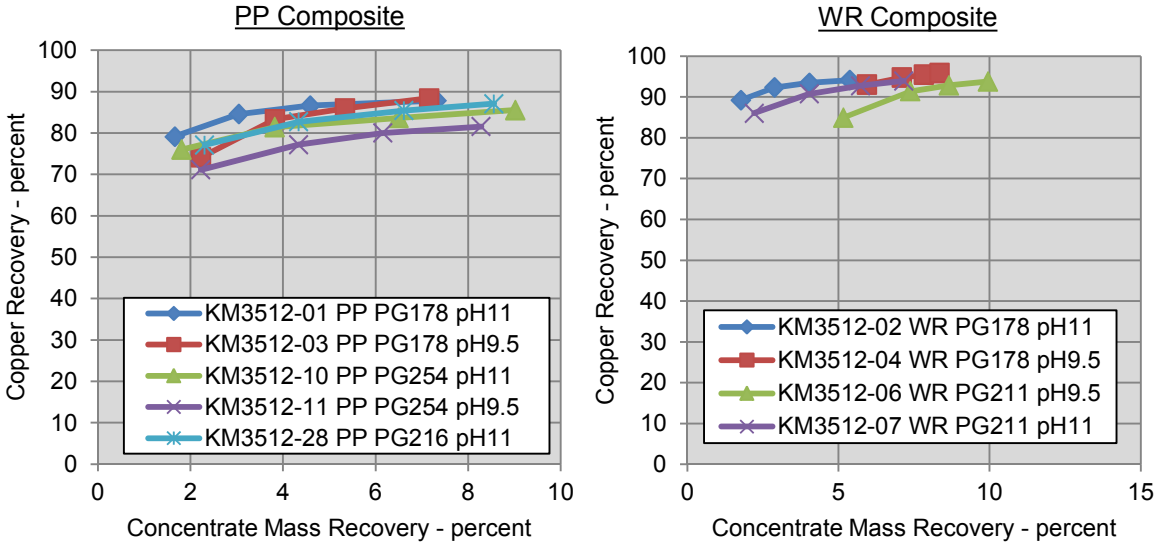
FIGURE 1
ROUGHER TEST METALLURGICAL RESPONSE

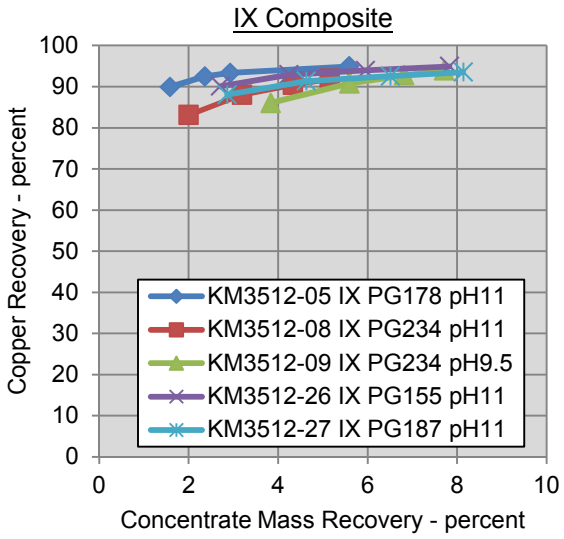


Nominal Rougher Test Conditions

Stage	pH	Reagents g/tonne		
		FO	3418A	208
Primary Grind	9.4 –11.5	10-30	-	-
Rougher	9.5 – 11.2	-	6-7	12-14

Note: Detailed test conditions can be found in Appendix II.





3.2 Cleaner Test Results

Based on the latest flowsheet configuration testing*, batch cleaner test utilized regrind on the first cleaner concentrate. The flowsheet is presented in Figure 2 along with a graphical presentation of the metallurgical results. The tests also investigated a lower pH in the cleaner circuit in an effort to improve molybdenum recovery.

As shown in the top graph of the figure, copper grade and recovery performance was negatively affected by the reduction of pH in the cleaner. For molybdenum, there was no clear benefit to metallurgical performance by operating at a lower pH. It was, therefore, recommended to perform a locked cycle test at pH 11 in the cleaner circuit.

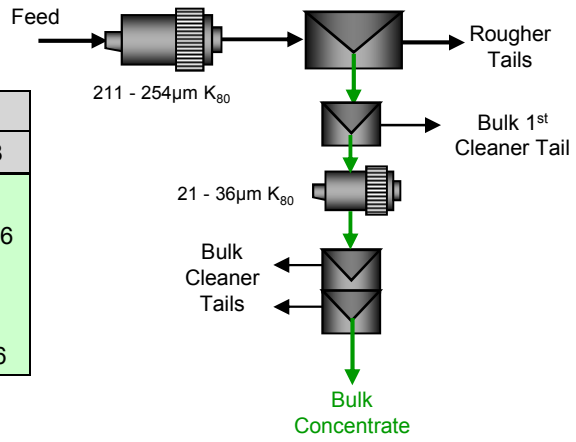
A series of tests on IX Composite were performed to optimize the chemical conditions for the first cleaner regrind (Test 22) and a comparison to rougher regrind (Test 21). Both tests indicated an improvement in metallurgical performance for copper and molybdenum over the baseline test. Test 21 also indicated a slight metallurgical performance gain with the rougher regrind circuit. The operating and capital cost will be higher for the rougher regrind flowsheet compared to the first cleaner regrind circuit. Further testing would be required to confirm these test results.

* KM3134 “Advance Process Development for Casino Copper Gold Project”, March 2012.

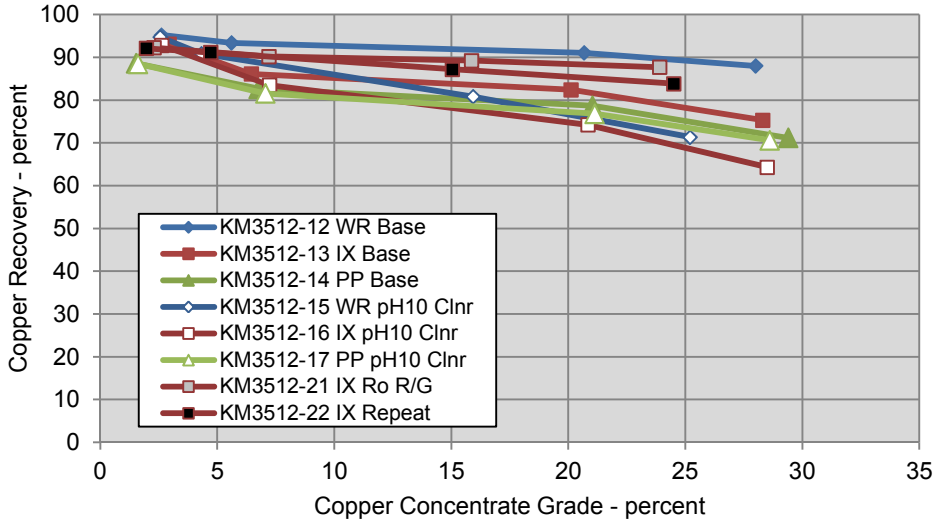
FIGURE 2
BATCH CLEANER METALLURGICAL PERFORMANCE

Cleaner Test Conditions

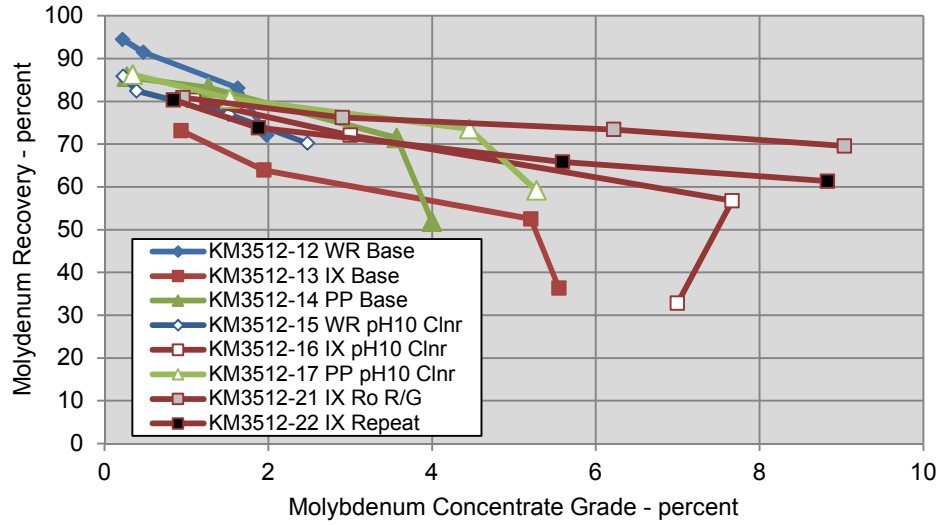
Stream	pH	Reagents g/tonne		
		FO	3418A	208
Primary Grind	10.9-11.5	10	-	-
Rougher	11.1-11.5	-	6-8	12-16
Cleaner 1	10.0-11.0	-	0-3	0-6
Regrind	10.0-11.1	10	-	-
Cleaner 2-3	10.0-11.4	0 - 4	3-8	6-16



Batch Cleaner Test Performance - Copper



Batch Cleaner Test Performance - Molybdenum



Note: Detailed test conditions can be found in Appendix II.

3.3 Locked Cycle Test Results

A series of locked cycle tests were conducted in this program to establish the estimates of metallurgical performance anticipated from a continuous process. Both the first cleaner regrind and rougher regrind flowsheets were tested in locked cycle for all three composites. Figure 3 displays the rougher regrind flowsheet schematic used in these samples, along with a summary of test results.

The first cleaner concentrate regrind data is displayed in Appendix IV, Figure IV-2. Overall the first cleaner regrind cycle tests did not perform as well. The reagent dosages in these tests did not appear to be full optimized as losses of copper were high in the cleaner tailings streams.

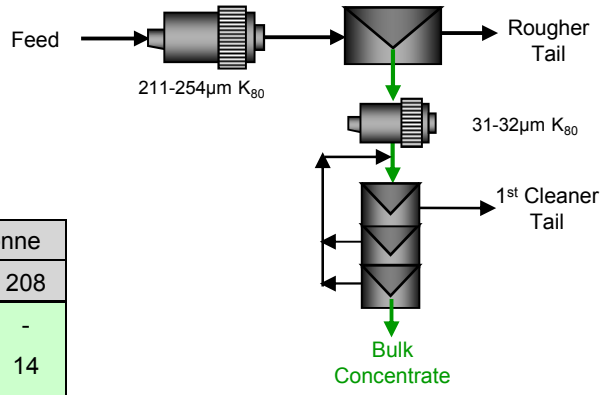
Overall, the metallurgical performance of the rougher regrind flowsheet was very good. Copper in the feed was 89.9, 87.2 and 91.9 percent recovered into the bulk concentrate for IX, PP and WR Composites, respectively. The concentrate grades range between 18 and 25 percent copper. The concentrate grades were lower for IX and PP samples due to high levels of molybdenum in the concentrate. The WR Composite was also lower due to higher levels of pyrite*.

Similarly, molybdenum was 78, 79 and 89 percent recovered into the bulk concentrates. Molybdenum grade ranged from 7.5 to 1.5 percent. Finally, gold recoveries ranged from 55 percent to 67 percent to the bulk concentrate.

The apparent use of recently drilled sample has resulted in arguably better overall metallurgical performance. Additional mineralogy on these ground feed samples should be performed to verify that the copper and molybdenum characteristics for these samples are similar to previously tested composites. If the characteristics are the same, this would increase confidence that a gain in metallurgical performance will be realized by treating fresh ore.

* The sulphur grades are high on this concentrate, perhaps indicating higher levels of pyrite.

FIGURE 3
LOCKED CYCLE TEST RESULTS
Global Composites



Summary of Conditions

Stream	pH	Reagents g/tonne		
		FO	3418A	208
Primary Grind	11.1-11.2	10-20	-	-
Rougher	11.0-11.2	-	7	14
Regrind	11.0-11.1	10	-	-
Cleaners	11.0	4	8-11	16-22

Locked Cycle Test Results

Product	Weight	Assay - percent or g/tonne						Distribution - percent					
	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
KM3512-23 IX Composite													
Flotation Feed	100.0	0.17	0.079	2.3	1.84	2.2	0.22	100	100	100	100	100	100
Bulk Con	0.8	18.6	7.484	27.0	34.8	126	15.6	89.9	77.9	9.4	15.5	46.5	57.3
Bulk 1st Clnr Tail	4.9	0.10	0.181	8.5	8.13	5.0	0.57	2.9	11.4	18.0	21.9	11.1	12.5
Bulk Ro Tail	94.2	0.01	0.009	1.8	1.22	1.0	0.07	7.2	10.7	72.6	62.6	42.4	30.1
KM3512-24 PP Composite													
Flotation Feed	100.0	0.14	0.027	2.9	0.71	1.2	0.22	100	100	100	100	100	100
Bulk Con	0.5	24.6	4.316	25.9	33.3	107	24.3	87.2	78.6	4.4	23.4	46.0	55.4
Bulk 1st Clnr Tail	6.5	0.06	0.034	4.6	2.09	2.5	0.29	2.6	8.0	10.1	19.1	14.0	8.6
Bulk Ro Tail	93.0	0.02	0.004	2.7	0.44	0.5	0.08	10.2	13.3	85.5	57.4	40.0	36.0
KM3512-25 WR Composite													
Flotation Feed	100.0	0.20	0.017	2.5	2.50	2	0.21	100	100	100	100	100	100
Bulk Con	1.0	17.5	1.502	24.9	38.8	82	13.5	91.9	89.4	10.5	16.1	53.8	67.2
Bulk 1st Clnr Tail	5.9	0.11	0.013	13.0	13.9	5	0.36	3.1	4.3	30.9	32.7	16.8	10.0
Bulk Ro Tail	93.1	0.01	0.001	1.6	1.37	1	0.05	4.9	6.4	58.6	51.2	29.4	22.8

Note: a) Detailed test conditions can be found in Appendix II.
b) Au and Ag are shown in g/tonne, all others are in percent.

4.0 Pilot Plant Testing

Pilot plant testing was performed on three composites of Casino mineralization. The initial pilot plant calibration was conducted on a composite constructed from old sample from previous programs. The main campaigns were performed on two composites constructed from fresh drill core sample. The samples represented hypogene and supergene mineralization. Pilot runs P2 and P3 were on the PP Hypogene Composite, runs P4 and P5 were completed on the PP Supergene Composite.

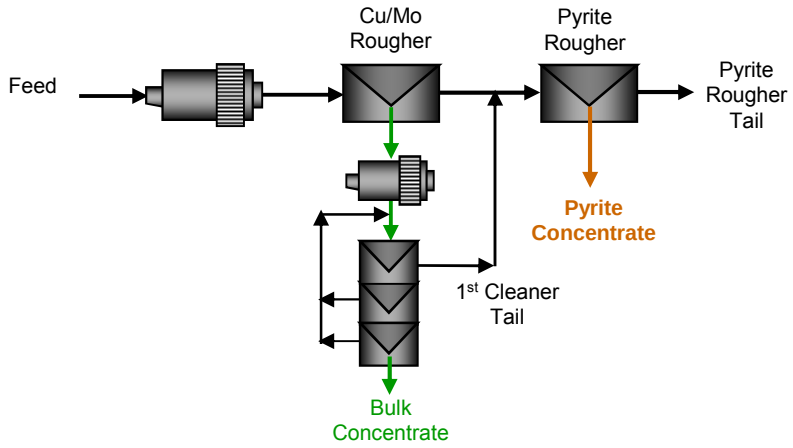
The primary objective of the pilot campaign was to produce tailings for environmental studies. Concentrate form the program was also used to investigate separation of copper and molybdenum. The flowsheet used to process the sample is shown in Figure 4, along with a summary of conditions and results.

The primary mill was operated at a nominal 100 kg per hour; copper rougher flotation was performed in 6, 12 litre flotation cells. Pyrite flotation was conducted in another 6, 12 litre cells. Rougher concentrate was reground in a 2 litre IsaMill and graded in a conventional first cleaner and column cell cleaner for stages two and three.

Overall, the performance copper flotation circuit never stabilized. Copper recoveries from the feed to bulk concentrate ranged between 73 and 87; however, the concentrate grades were very low. The concentrates were very high in iron and sulphur, indicating pyrite as the principle diluent.

The pyrite circuit used Potassium Amyl Xanthate (PAX) as the primary collector. The collector dosages were high to produce a low sulphur tailing required for the environmental sample. The PAX dosages were not optimized and it was likely that PAX was recycled to the copper circuit as part of the tailing water recycle. Elevated levels of PAX in the recycle would cause activation and flotation of pyrite in the copper circuit.

FIGURE 4
PILOT PLANT PRODUCTION OF CONCENTRATE AND TAILINGS
Pilot Plant Composites



Summary of Conditions

Stream	pH	Reagents g/tonne			
		FO	3418A	208	PAX
Primary Grind	8.3-11.4	9 – 16	-	-	-
Rougher	10.5-11.2	-	1-10	1-18	-
Regrind	10.5-11.4	9-15	-	-	-
Cleaners	9.2-11.4	-	1-8	0-17	-
Pyrite Rougher	10.2-10.8	-	-	-	88-419

Bulk Concentrate Performance – Survey Periods

Pilot Run	Grind Size mm K80		Assay - percent of g/tonne			Recovery - percent		
	PG	RG	Cu	Mo	Au	Cu	Mo	Au
P2	167	21	9.9	0.54	8.7	77	59	66
P2	216	31	16.5	0.53	14.8	73	43	56
P2	180	43	8.8	0.38	9.1	76	53	76
P2	221	129	21.5	0.59	22.5	75	24	62
P3	242	187	10.9	1.11	10.9	84	67	73
P3	253	51	7.5	1.05	9.7	86	75	80
P3	280	60	5.8	0.90	7.1	87	75	75
P3	-	-	7.5	1.10	7.7	85	81	64
P4	217	84	8.6	0.90	11	81	30	69
P4	256	65	12.7	1.64	15.9	79	74	64
P4	249	84	4.6	0.50	5.4	83	83	75
P4	300	68	7.4	0.60	7.2	79	75	71
P5	274	64	8.5	0.64	9.9	75	65	66
P5	253	62	10	0.89	12.7	75	61	67
P5	243	56	9.5	1.10	10.7	78	69	71
P5	228	38	4.4	0.69	6.8	81	80	82

Note: a) Detailed test conditions can be found in Appendix V.
b) Gold assays are in g/tonne, all others are in percent.

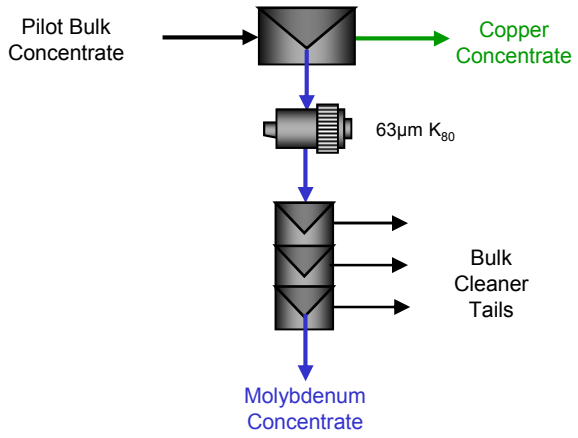
5.0 Copper – Molybdenum Separation

The concentrate from the pilot plant was retreated to remove excess pyrite ahead of copper-molybdenum testing. This work was reported in pilot runs P6 to P8. While the concentrate grade improved, the bulk concentrate would be considered low grade.

Despite the lower concentrate grade, the bulk concentrate from the P6 to P8 campaigns was combined and a single cleaner test was conducted to evaluate the copper-molybdenum process. Conventional copper depression with Sodium Hydrosulphide (NaHS) and flotation with nitrogen was conducted. The flowsheet, reagent conditions and metallurgical balance for the test is displayed in Figure 5.

As shown, the concentrate produced contained low levels of copper and was high grade. Molybdenum was 94 percent recovered into a concentrate grading 51 percent molybdenite. This data indicates the molybdenum would respond well to a conventional molybdenum separation process.

FIGURE 5
BATCH CLEANER METALLURGICAL PERFORMANCE



Cleaner Test Conditions

Stage	Reagents Added g/tonne			Time (minutes)			pH	Redox
	NaHS	Fuel Oil	MIBC	Grind	Cond.	Float		
Feed	-	-	-	-	-	-	8.4	130
Rougher 1	1680	20	-	-	10	11	11.2	-580
Regrind	-	-	-	5	-	-	8.9	-
Cleaner 1	1400	60	60	-	7	8	10.7	-580
Cleaner 2	1750	20	60	-	3	5	10.6	-575
Cleaner 3	1750	12	60	-	3	3	10.7	-580

Batch Cleaner Test Performance - Molybdenum

Product	Mass	Assay - percent				Distribution - percent			
	percent	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Moly Concentrate	**3.1**	**0.39**	**57.4**	**0.8**	**37.9**	**0.1**	**94.1**	**0.1**	**2.6**
Moly 2nd Clnr Tail	0.4	16.80	7.1	25.9	35.8	0.4	1.6	0.3	0.3
Moly 1st Clnr Tail	2.7	17.80	1.2	30.3	38.4	2.9	1.7	2.5	2.3
Moly Ro Concentrate	6.1	9.04	29.7	15.3	38.0	3.5	97.4	2.9	5.3
Copper Concentrate	**93.9**	**16.5**	**0.05**	**33.9**	**44.3**	**96.5**	**2.6**	**97.1**	**94.7**
Feed	100.0	16.0	1.87	32.8	43.9	100	100	100	100

Note: Detailed test conditions can be found in Appendix II.

6.0 Quality of the Concentrates

The minor element concentrations of the concentrates were measured with element specific analyses to increase the accuracy. The results of the analyses are displayed for the composites tested by locked cycle in Table 2. To have sufficient sample to assay, cycles IV and V were combined. The following comments may be relevant when reviewing the table:

- The bulk concentrates for some composites showed elevated levels of arsenic, lead and zinc. However, none of the levels measured would cause a significant barrier to marketability.

- Silver levels in the bulk concentrate ranged from 82 to 126 g/tonne. At these levels, payment of silver might be possible.

- The molybdenum concentrate was relatively free of deleterious elements. Arsenic, lead and zinc may be elements to reassess when more molybdenum concentrates become available. Rhenium in the concentrate was 134 g/tonne. See Appendix IV-Special Data for the Rhenium Certificate.

- Fluorine assays were not reproducible and therefore not reported. Additional fluorine assays should be conducted when sample becomes available.

- The minor element data should be reviewed by a specialist to provide specific advice on the current concentrate market.

TABLE 2
MINOR ELEMENTS OF THE CONCENTRATES

Element	Symbol	Units	Technique	Test 23 Bulk Con IV&V	Test 24 Bulk Con IV&V	Test 25 Bulk Con IV&V	Test 29 Mo Con
Aluminum	Al	%	Fusion ICP-OES	0.98	0.89	1.11	1.71
Antimony	Sb	g/t	2 Acid ICP-OES	200	1000	70	100
Arsenic	As	g/t	2 Acid ICP-OES	771	977	139	1659
Bismuth	Bi	g/t	2 Acid ICP-OES	126	120	60	68
Cadmium	Cd	g/t	AR FAAS	70	120	50	30
Calcium	Ca	%	WR ICP-OES	0.38	0.20	0.15	0.06
Carbon	C	%	Leco	0.27	0.22	0.16	4.00
Cobalt	Co	g/t	AR FAAS	110	80	150	10
Copper	Cu	%	Titre	18.6	24.6	17.5	0.39
Fluorine	F	g/t	Fusion ISE	150	ND	ND	ND
Gold	Au	g/t	FA FAAS	15.6	24.3	13.5	1.85
Iron	Fe	%	AR FAAS	27.0	25.9	24.9	0.8
Lead	Pb	g/t	AR FAAS	400	740	240	240
Magnesium	Mg	%	Fusion ICP-OES	0.16	0.10	0.09	<0.01
Manganese	Mn	%	Fusion ICP-OES	0.02	0.01	0.01	<0.01
Mercury	Hg	g/t	LeForte rt CV-AAS	<1	<1	<1	<1
Molybdenum	Mo	%	2 Acid FAAS*	7.48	4.32	1.50	57.4
Nickel	Ni	g/t	AR FAAS	280	180	180	120
Palladium	Pd	g/t	FA ICP-OES	0.09	0.11	0.02	-
Phosphorus	P	g/t	3 Acid ICP-OES	<20	<20	76	<20
Platinum	Pt	g/t	FA ICP-OES	0.02	0.13	<0.01	-
Rhenium	Re	g/t	Re-OG62	-	-	-	133.5
Selenium	Se	g/t	ESHKA ICP-OES	98	89	64	301
Silicon	Si	%	Fusion ICP-OES	2.21	2.15	2.32	1.74
Sulphur	S	%	Leco	34.8	33.3	38.8	37.9
Silver	Ag	g/t	AR FAAS	126	107	82	11
Zinc	Zn	g/t	AR FAAS	1080	930	350	280

Note: Analytical methods can be found in Appendix IV, Table IV-4.

7.0 Conclusions and Recommendations

The testing of three hypogene composites produced very good metallurgical performance, despite relatively low copper feed grades. On average, copper was 90, 87 and 92 percent recovered into bulk concentrates for the IX, PP and WR composites, respectively. The concentrate grades were within expected ranges considering the high levels of molybdenum in the bulk concentrate. The WR Composite had lower concentrate grade perhaps due to pyrite.

Molybdenum was also well recovered to the bulk concentrate at 78, 79 and 89 percent for the IX, PP and WR Composites, respectively. The high relative grade of molybdenum to copper in the feed resulted in concentrates containing between 1.5 and 7.5 percent molybdenum in the concentrate. The gold in the feed was 57, 55 and 67 percent recovered to the bulk concentrates for IX, PP and WR Composites, respectively. These results were in line with previous results.

The metallurgical performance of these fresh drill composites were better than previously tested hypogene composites constructed of old drill core sample. Mineralogical assessment of the ground feed samples is recommended. If the fragmentation properties are similar to previously tested samples performed on old core, this would increase confidence that these latest results should be expected when treating fresh ore.

The best metallurgical results (quoted above) were produced with a rougher regrind flowsheet. The first cleaner concentrate regrind circuit locked cycle tests produced inferior results; however, the tests were not fully optimized for reagents in the cleaner circuit. This first cleaner regrind circuit has lower capital and operating cost and, as previously shown, can provide similar metallurgical results when fully optimized.

The pilot recessing of the hypogene and supergene composites was completed to produce tailings sample for environmental testing. This objective was effectively completed with the addition of a pyrite rougher circuit after the bulk copper-

molybdenum and gold circuit. Tailings samples of each composite were shipped to the required third party testing groups.

Unfortunately, there was insufficient sample to stabilize bulk concentrate production for subsequent copper and molybdenum testing. The concentrate was consistently contaminated with pyrite, resulting in low concentrate grades.

As per normal plant practice, tailings water in the pilot was recycled to the primary grinding mill. The addition of a pyrite recovery circuit and reagent (PAX) to recover pyrite was believed to have been the source of the problem.

In an effort to derive some basic copper-molybdenum separation data, the bulk concentrate was further cleaned to reject pyrite. This concentrate was combined tested using a conventional copper-molybdenum separation process. The results should be used with caution as the bulk concentrate was essentially unrepresentative due to the additional cleaning stages.

APPENDIX I – KM3512

SAMPLE ORIGIN

1.0 Sample Origin

On July 19, 2012, half drill core intervals from several drill holes were received at ALS Metallurgy Kamloops for testing. The total weight of the shipment was approximately 3,524 kg. The drill core was identified by drill hole and sample ID number. Each sample was weighed; Table I-1 displays the details of the samples received and their respective weights.

Based on instructions from the client, select intervals were crushed and screened to 6 mesh in preparation for compositing. Five separate composites were constructed for testing; three hypogene composites for bench testing and two for pilot plant testing. The details of the composite construction are displayed in Table I-2.

Not all of the drill core was used, some intact drill core intervals were retained in storage.

The hypogene composites used for laboratory testing were homogenized and rotary split into 2 kg charges for metallurgical testing. The charges were sealed into plastic bags under nitrogen. These samples were stored frozen until their subsequent use in the test program. Representative head assays of the composites are displayed in Table I-3.

The pilot plant samples were crushed and screened to pass 5 mm. The samples were blended with a mechanical loader using a cone and quartering method. The samples were stored in plastic totes at ambient temperature prior to processing in the pilot plant.

A commissioning composite was constructed from old test sample. This material, approximately 1,353 kg, was used to calibrate the grinding and mass flow rates in the pilot plant.

TABLE I-1
MASS AND IDENTIFICATION OF SAMPLE RECEIVED

Sample	Hole	From	To	Length	Weight
I474982	CAS-088	91.00	92.62	1.62	4.0
I474983	CAS-088	92.62	95.00	2.38	6.3
I474984	CAS-088	95.00	98.00	3.00	7.7
I474985	CAS-088	98.00	101.00	3.00	8.0
I474986	CAS-088	101.00	102.31	1.31	3.7
I474987	CAS-088	102.31	105.00	2.69	6.8
I474988	CAS-088	105.00	108.00	3.00	7.7
I474989	CAS-088	108.00	111.00	3.00	7.8
I474990	CAS-088	111.00	114.00	3.00	7.5
I474991	CAS-088	114.00	117.00	3.00	7.6
I474992	CAS-088	117.00	120.00	3.00	7.8
I474993	CAS-088	120.00	123.00	3.00	7.3
I474994	CAS-088	123.00	125.00	2.00	5.5
I474995	CAS-088	125.00	126.50	1.50	3.2
I474996	CAS-088	126.50	129.00	2.50	6.9
I474997	CAS-088	129.00	132.00	3.00	8.4
I474998	CAS-088	132.00	135.00	3.00	7.8
I474999	CAS-088	135.00	138.00	3.00	7.7
I475000	CAS-088	138.00	141.00	3.00	8.4
I477803	CAS-088	141.00	144.00	3.00	7.2
I477804	CAS-088	144.00	147.00	3.00	9.0
I477805	CAS-088	147.00	150.00	3.00	8.6
I477806	CAS-088	150.00	153.00	3.00	7.0
I477807	CAS-088	153.00	156.00	3.00	8.4
I477808	CAS-088	156.00	159.00	3.00	7.1
I477809	CAS-088	159.00	162.00	3.00	7.9
I477810	CAS-088	162.00	165.00	3.00	7.5
I477811	CAS-088	165.00	168.00	3.00	7.7
I477812	CAS-088	168.00	171.00	3.00	8.1
I477813	CAS-088	171.00	174.00	3.00	8.1
I477814	CAS-088	174.00	177.00	3.00	8.1
I477815	CAS-088	177.00	180.00	3.00	8.1
I477816	CAS-088	180.00	183.00	3.00	7.9
I477817	CAS-088	183.00	186.00	3.00	7.5
I477818	CAS-088	186.00	189.00	3.00	7.5
I477819	CAS-088	189.00	192.00	3.00	8.9
I477820	CAS-088	192.00	195.00	3.00	8.0
I477821	CAS-088	195.00	198.00	3.00	7.8
I477822	CAS-088	198.00	201.00	3.00	7.4
I477823	CAS-088	201.00	204.00	3.00	8.4
I477824	CAS-088	204.00	207.00	3.00	8.2
I477825	CAS-088	207.00	210.00	3.00	8.2
I477826	CAS-088	210.00	213.00	3.00	7.6

TABLE I-1 Continued
MASS AND IDENTIFICATION OF SAMPLE RECEIVED

Sample	Hole	From	To	Length	Weight
I477827	CAS-088	213.00	216.00	3.00	7.4
I477828	CAS-088	216.00	219.00	3.00	7.5
I477829	CAS-088	219.00	222.00	3.00	8.1
I477830	CAS-088	222.00	225.00	3.00	7.9
I477831	CAS-088	225.00	228.00	3.00	8.4
I477832	CAS-088	228.00	231.00	3.00	8.2
I477833	CAS-088	231.00	234.00	3.00	8.3
I477834	CAS-088	234.00	237.00	3.00	8.2
I477835	CAS-088	237.00	240.00	3.00	8.6
I477836	CAS-088	240.00	243.00	3.00	8.7
I477837	CAS-088	243.00	246.00	3.00	8.3
I477838	CAS-088	246.00	249.00	3.00	7.0
I477839	CAS-088	249.00	252.00	3.00	8.8
I477840	CAS-088	252.00	255.00	3.00	9.2
I477841	CAS-088	255.00	258.00	3.00	8.1
I477842	CAS-088	258.00	261.00	3.00	7.8
I477843	CAS-088	261.00	264.00	3.00	7.9
I477844	CAS-088	264.00	267.00	3.00	7.5
I477846	CAS-088	270.00	273.00	3.00	8.8
I477847	CAS-088	273.00	276.00	3.00	8.5
I477848	CAS-088	276.00	279.00	3.00	8.2
I477849	CAS-088	279.00	282.00	3.00	8.3
I477850	CAS-088	282.00	285.00	3.00	9.3
I477853	CAS-088	285.00	288.00	3.00	7.9
I477854	CAS-088	288.00	291.00	3.00	9.0
I477855	CAS-088	291.00	294.00	3.00	8.4
I477856	CAS-088	294.00	297.00	3.00	9.0
I477857	CAS-088	297.00	300.00	3.00	7.7
I477858	CAS-088	300.00	303.00	3.00	8.9
I477859	CAS-088	303.00	306.00	3.00	7.6
I477860	CAS-088	306.00	309.00	3.00	7.7
I477861	CAS-088	309.00	311.81	2.81	7.7
I477867	CAS-089	15.00	18.00	3.00	13.7
I477868	CAS-089	18.00	21.00	3.00	13.7
I477869	CAS-089	21.00	24.00	3.00	12.1
I477870	CAS-089	24.00	27.00	3.00	14.9
I477871	CAS-089	27.00	30.00	3.00	13.4
I477872	CAS-089	30.00	33.00	3.00	13.2
I477873	CAS-089	33.00	36.00	3.00	13.8
I477874	CAS-089	36.00	39.00	3.00	13.8
I477875	CAS-089	39.00	42.00	3.00	12.8
I477876	CAS-089	42.00	45.00	3.00	7.5
I477877	CAS-089	45.00	48.00	3.00	8.9

TABLE I-1 Continued
MASS AND IDENTIFICATION OF SAMPLE RECEIVED

Sample	Hole	From	To	Length	Weight
I477878	CAS-089	48.00	51.00	3.00	8.1
I477879	CAS-089	51.00	54.00	3.00	8.3
I477880	CAS-089	54.00	57.00	3.00	6.6
I477881	CAS-089	57.00	60.00	3.00	9.6
I477882	CAS-089	60.00	63.00	3.00	7.7
I477883	CAS-089	63.00	66.00	3.00	7.0
I477884	CAS-089	66.00	69.00	3.00	7.3
I477885	CAS-089	69.00	72.00	3.00	8.0
I477886	CAS-089	72.00	75.00	3.00	5.0
I477887	CAS-089	75.00	78.00	3.00	8.2
I477888	CAS-089	78.00	81.00	3.00	7.6
I477889	CAS-089	81.00	84.00	3.00	6.8
I477890	CAS-089	84.00	87.00	3.00	7.7
I477891	CAS-089	87.00	90.00	3.00	8.7
I477892	CAS-089	90.00	93.00	3.00	8.1
I477893	CAS-089	93.00	96.00	3.00	8.2
I477894	CAS-089	96.00	99.00	3.00	7.9
I477895	CAS-089	99.00	102.00	3.00	7.4
I477896	CAS-089	102.00	105.00	3.00	7.8
I477897	CAS-089	105.00	108.00	3.00	7.8
I477898	CAS-089	108.00	111.00	3.00	7.8
I477899	CAS-089	111.00	114.00	3.00	9.0
I477900	CAS-089	114.00	117.00	3.00	7.0
I477903	CAS-089	117.00	120.00	3.00	11.4
I477904	CAS-089	120.00	123.00	3.00	6.3
I477905	CAS-089	123.00	126.00	3.00	7.1
I477906	CAS-089	126.00	129.00	3.00	7.9
I477907	CAS-089	129.00	132.00	3.00	7.4
I477908	CAS-089	132.00	135.00	3.00	7.7
I477909	CAS-089	135.00	138.00	3.00	8.8
I477910	CAS-089	138.00	141.00	3.00	8.0
I477911	CAS-089	141.00	144.00	3.00	8.2
I477912	CAS-089	144.00	147.00	3.00	7.5
I477913	CAS-089	147.00	150.00	3.00	8.5
I477914	CAS-089	150.00	153.00	3.00	7.8
I477915	CAS-089	153.00	156.00	3.00	7.4
I477916	CAS-089	156.00	159.00	3.00	8.4
I477917	CAS-089	159.00	162.00	3.00	8.1
I477918	CAS-089	162.00	165.00	3.00	7.9
I477920	CAS-089	168.00	171.00	3.00	8.3
I477921	CAS-089	171.00	174.00	3.00	7.5
I477922	CAS-089	174.00	177.00	3.00	8.2
I477923	CAS-089	177.00	180.00	3.00	8.4

TABLE I-1 Continued
MASS AND IDENTIFICATION OF SAMPLE RECEIVED

Sample	Hole	From	To	Length	Weight
I477924	CAS-089	180.00	183.00	3.00	7.5
I477925	CAS-089	183.00	186.00	3.00	8.5
I477926	CAS-089	186.00	189.00	3.00	9.1
I477927	CAS-089	189.00	190.50	1.50	3.6
I477928	CAS-089	190.50	193.50	3.00	7.9
I477929	CAS-089	193.50	196.50	3.00	9.0
I477930	CAS-089	196.50	199.50	3.00	7.7
I477931	CAS-089	199.50	202.50	3.00	8.5
I477932	CAS-089	202.50	205.50	3.00	7.8
I477933	CAS-089	205.50	208.50	3.00	8.3
I477934	CAS-089	208.50	211.50	3.00	8.4
I477935	CAS-089	211.50	214.50	3.00	8.1
I477936	CAS-089	214.50	217.50	3.00	8.2
I477937	CAS-089	217.50	220.50	3.00	7.5
I477938	CAS-089	220.50	223.50	3.00	7.9
I477939	CAS-089	223.50	226.50	3.00	8.8
I477940	CAS-089	226.50	229.50	3.00	7.7
I477941	CAS-089	229.50	232.50	3.00	7.4
I477942	CAS-089	232.50	235.50	3.00	9.0
I477943	CAS-089	235.50	238.50	3.00	7.9
I477944	CAS-089	238.50	241.50	3.00	8.9
I477945	CAS-089	241.50	244.50	3.00	8.3
I477946	CAS-089	244.50	246.25	1.75	5.4
I477947	CAS-089	246.25	248.00	1.75	3.9
I477948	CAS-089	248.00	251.00	3.00	8.6
I477949	CAS-089	251.00	254.00	3.00	8.1
I477950	CAS-089	254.00	257.00	3.00	7.9
I477953	CAS-089	257.00	260.00	3.00	7.8
I477954	CAS-089	260.00	263.00	3.00	8.6
I477956	CAS-089	266.00	269.00	3.00	8.2
I477957	CAS-089	269.00	272.00	3.00	7.3
I477958	CAS-089	272.00	275.00	3.00	8.9
I477959	CAS-089	275.00	278.00	3.00	8.3
I477960	CAS-089	278.00	281.00	3.00	9.0
I477961	CAS-089	281.00	284.00	3.00	8.3
I477962	CAS-089	284.00	287.00	3.00	8.0
I477963	CAS-089	287.00	290.00	3.00	8.5
I477964	CAS-089	290.00	293.00	3.00	8.7
I477965	CAS-089	293.00	296.00	3.00	7.6
I477966	CAS-089	296.00	299.00	3.00	8.4
I477967	CAS-089	299.00	302.00	3.00	9.2
I477968	CAS-089	302.00	305.00	3.00	9.0
I477969	CAS-089	305.00	308.00	3.00	8.0

TABLE I-1 Continued
MASS AND IDENTIFICATION OF SAMPLE RECEIVED

Sample	Hole	From	To	Length	Weight
I477970	CAS-089	308.00	311.00	3.00	8.1
I477971	CAS-089	311.00	314.00	3.00	7.8
I477972	CAS-089	314.00	317.00	3.00	8.5
I477973	CAS-089	317.00	320.00	3.00	8.6
I477974	CAS-089	320.00	323.00	3.00	8.5
I477975	CAS-089	323.00	326.00	3.00	9.1
I477976	CAS-089	326.00	329.00	3.00	9.1
I477977	CAS-089	329.00	330.50	1.50	4.0
I477978	CAS-089	330.50	332.23	1.73	4.9
I477992	CAS-090	40.00	43.00	3.00	7.9
I477995	CAS-090	49.00	52.00	3.00	8.2
I479328	CAS-090	141.10	144.00	2.90	8.0
I479329	CAS-090	144.00	147.00	3.00	8.3
I479330	CAS-090	147.00	150.00	3.00	8.9
I479331	CAS-090	150.00	153.00	3.00	8.9
I479332	CAS-090	153.00	156.00	3.00	13.2
I479333	CAS-090	156.00	159.00	3.00	5.9
I479334	CAS-090	159.00	162.00	3.00	9.2
I479335	CAS-090	162.00	165.00	3.00	8.7
I479336	CAS-090	165.00	168.00	3.00	9.1
I479337	CAS-090	168.00	171.00	3.00	9.5
I479338	CAS-090	171.00	174.00	3.00	6.6
I479339	CAS-090	174.00	177.00	3.00	9.9
I479340	CAS-090	177.00	180.00	3.00	8.5
I479341	CAS-090	180.00	183.00	3.00	9.7
I479342	CAS-090	183.00	186.00	3.00	9.1
I479343	CAS-090	186.00	189.00	3.00	8.6
I479344	CAS-090	189.00	192.00	3.00	9.1
I479345	CAS-090	192.00	195.00	3.00	8.8
I479346	CAS-090	195.00	198.00	3.00	8.4
I479347	CAS-090	198.00	201.00	3.00	8.7
I479348	CAS-090	201.00	204.00	3.00	9.0
I479349	CAS-090	204.00	207.00	3.00	9.2
I479350	CAS-090	207.00	209.00	2.00	5.2
I479353	CAS-090	209.00	212.00	3.00	10.4
I479354	CAS-090	212.00	215.00	3.00	9.5
I479355	CAS-090	215.00	218.00	3.00	8.6
I479356	CAS-090	218.00	221.00	3.00	8.5
I479357	CAS-090	221.00	224.00	3.00	8.7
I479358	CAS-090	224.00	227.00	3.00	8.5
I479359	CAS-090	227.00	230.00	3.00	9.4
I479360	CAS-090	230.00	233.00	3.00	8.3
I479361	CAS-090	233.00	236.00	3.00	9.3

TABLE I-1 Continued
MASS AND IDENTIFICATION OF SAMPLE RECEIVED

Sample	Hole	From	To	Length	Weight
I479362	CAS-090	236.00	239.00	3.00	8.2
I479363	CAS-090	239.00	242.00	3.00	9.5
I479364	CAS-090	242.00	245.00	3.00	9.1
I479365	CAS-090	245.00	248.00	3.00	8.8
I479366	CAS-090	248.00	250.50	2.50	7.3
I479367	CAS-090	250.50	253.50	3.00	9.4
I479368	CAS-090	253.50	256.50	3.00	9.0
I479369	CAS-090	256.50	259.50	3.00	9.5
I479370	CAS-090	259.50	262.50	3.00	9.6
I479371	CAS-090	262.50	265.50	3.00	9.3
I479372	CAS-090	265.50	268.50	3.00	9.6
I479373	CAS-090	268.50	271.50	3.00	9.2
I479374	CAS-090	271.50	274.50	3.00	8.5
I479375	CAS-090	274.50	276.00	1.50	4.3
I479376	CAS-090	276.00	279.00	3.00	9.5
I479377	CAS-090	279.00	282.00	3.00	8.8
I479378	CAS-090	282.00	285.00	3.00	8.0
I479379	CAS-090	285.00	288.00	3.00	8.5
I479380	CAS-090	288.00	291.00	3.00	9.0
I479381	CAS-090	291.00	294.00	3.00	8.4
I479382	CAS-090	294.00	297.00	3.00	8.9
I479383	CAS-090	297.00	300.00	3.00	9.5
I479384	CAS-090	300.00	303.00	3.00	9.2
I479385	CAS-090	303.00	306.00	3.00	9.5
I479386	CAS-090	306.00	309.00	3.00	8.6
I479387	CAS-090	309.00	312.00	3.00	8.7
I479388	CAS-090	312.00	315.00	3.00	8.5
I479389	CAS-090	315.00	318.00	3.00	9.0
I479390	CAS-090	318.00	321.00	3.00	9.7
I479391	CAS-090	321.00	324.00	3.00	9.3
I479392	CAS-090	324.00	327.00	3.00	9.2
I479393	CAS-090	327.00	330.00	3.00	8.2
I479394	CAS-090	330.00	333.00	3.00	9.5
I479395	CAS-090	333.00	335.28	2.28	6.4
I479429	CAS-091	93.00	96.00	3.00	8.4
I479430	CAS-091	96.00	99.00	3.00	9.3
I479431	CAS-091	99.00	102.00	3.00	8.3
I479432	CAS-091	102.00	105.00	3.00	8.9
I479433	CAS-091	105.00	108.00	3.00	8.4
I479434	CAS-091	108.00	111.00	3.00	8.6
I479435	CAS-091	111.00	114.00	3.00	7.4
I479436	CAS-091	114.00	116.00	2.00	5.6
I479437	CAS-091	116.00	118.00	2.00	6.0

TABLE I-1 Continued
MASS AND IDENTIFICATION OF SAMPLE RECEIVED

Sample	Hole	From	To	Length	Weight
I479438	CAS-091	118.00	121.00	3.00	8.5
I479439	CAS-091	121.00	124.00	3.00	8.2
I479440	CAS-091	124.00	127.00	3.00	9.4
I479441	CAS-091	127.00	130.00	3.00	9.2
I479442	CAS-091	130.00	133.00	3.00	9.3
I479443	CAS-091	133.00	136.00	3.00	8.8
I479444	CAS-091	136.00	138.00	2.00	5.9
I479445	CAS-091	138.00	141.00	3.00	8.9
I479446	CAS-091	141.00	144.00	3.00	10.2
I479448	CAS-091	144.00	147.00	3.00	9.2
I479449	CAS-091	147.00	150.00	3.00	8.3
I479450	CAS-091	150.00	153.00	3.00	8.6
I479453	CAS-091	153.00	156.00	3.00	8.4
I479454	CAS-091	156.00	159.00	3.00	8.8
I479455	CAS-091	159.00	162.00	3.00	8.9
I479456	CAS-091	162.00	165.00	3.00	8.4
I479457	CAS-091	165.00	168.00	3.00	9.2
I479458	CAS-091	168.00	171.00	3.00	7.9
I479459	CAS-091	171.00	174.00	3.00	8.2
I479460	CAS-091	174.00	177.00	3.00	7.0
I479461	CAS-091	177.00	180.00	3.00	8.4
I479462	CAS-091	180.00	183.00	3.00	8.7
I479463	CAS-091	183.00	186.00	3.00	8.6
I479464	CAS-091	186.00	188.00	2.00	5.0
I479465	CAS-091	188.00	190.00	2.00	6.3
I479466	CAS-091	190.00	193.00	3.00	8.2
I479467	CAS-091	193.00	196.00	3.00	9.3
I479468	CAS-091	196.00	199.00	3.00	8.7
I479469	CAS-091	199.00	202.00	3.00	8.5
I479470	CAS-091	202.00	205.00	3.00	8.6
I479471	CAS-091	205.00	208.00	3.00	9.1
I479472	CAS-091	208.00	211.00	3.00	8.7
I479473	CAS-091	211.00	214.00	3.00	9.3
I479474	CAS-091	214.00	217.00	3.00	8.1
I479475	CAS-091	217.00	220.00	3.00	8.6
I479476	CAS-091	220.00	223.00	3.00	8.5
I479477	CAS-091	223.00	226.00	3.00	8.5
I479478	CAS-091	226.00	229.00	3.00	8.5
I479479	CAS-091	229.00	232.00	3.00	8.4
I479480	CAS-091	232.00	235.00	3.00	9.0
I479481	CAS-091	235.00	238.00	3.00	8.8
I479482	CAS-091	238.00	241.00	3.00	8.8
I479483	CAS-091	241.00	244.00	3.00	9.2

TABLE I-1 Continued
MASS AND IDENTIFICATION OF SAMPLE RECEIVED

Sample	Hole	From	To	Length	Weight
I479484	CAS-091	244.00	247.00	3.00	8.4
I479485	CAS-091	247.00	250.00	3.00	8.6
I479486	CAS-091	250.00	253.00	3.00	9.0
I479487	CAS-091	253.00	256.00	3.00	8.4
I479488	CAS-091	256.00	259.00	3.00	9.3
I479489	CAS-091	259.00	262.00	3.00	9.0
I479490	CAS-091	262.00	265.00	3.00	9.0
I479491	CAS-091	265.00	268.00	3.00	8.5
I479492	CAS-091	268.00	271.00	3.00	9.0
I479493	CAS-091	271.00	274.00	3.00	8.3
I479494	CAS-091	274.00	277.00	3.00	9.3
I479495	CAS-091	277.00	280.00	3.00	8.6
I479496	CAS-091	280.00	283.00	3.00	9.2
I479497	CAS-091	283.00	286.00	3.00	9.0
I479498	CAS-091	286.00	289.00	3.00	8.5
I479499	CAS-091	289.00	292.00	3.00	9.0
I479500	CAS-091	292.00	295.00	3.00	8.8
I479503	CAS-091	295.00	297.18	2.18	6.6
I479504	CAS-092	5.10	8.10	3.00	12.3
I479505	CAS-092	8.10	11.10	3.00	10.1
I479506	CAS-092	11.10	14.10	3.00	13.7
I479507	CAS-092	14.10	17.10	3.00	14.0
I479508	CAS-092	17.10	19.40	2.30	10.9
I479509	CAS-092	19.40	22.40	3.00	14.1
I479510	CAS-092	22.40	25.40	3.00	14.1
I479511	CAS-092	25.40	28.40	3.00	12.3
I479512	CAS-092	28.40	31.40	3.00	8.5
I479513	CAS-092	31.40	34.40	3.00	8.0
I479514	CAS-092	34.40	37.40	3.00	8.4
I479515	CAS-092	37.40	40.40	3.00	8.7
I479516	CAS-092	40.40	43.30	2.90	8.3
I479517	CAS-092	43.30	46.30	3.00	9.2
I479518	CAS-092	46.30	49.30	3.00	8.2
I479519	CAS-092	49.30	52.30	3.00	9.4
I479520	CAS-092	52.30	53.30	1.00	2.4
I479521	CAS-092	53.30	56.30	3.00	8.5
I479522	CAS-092	56.30	59.30	3.00	7.4
I479523	CAS-092	59.30	62.30	3.00	8.7
I479524	CAS-092	62.30	65.30	3.00	8.8
I479525	CAS-092	65.30	68.30	3.00	8.5
I479526	CAS-092	68.30	71.30	3.00	8.5
I479527	CAS-092	71.30	74.30	3.00	8.2
I479528	CAS-092	74.30	77.30	3.00	9.3

TABLE I-1 Continued
MASS AND IDENTIFICATION OF SAMPLE RECEIVED

Sample	Hole	From	To	Length	Weight
I479529	CAS-092	77.30	80.30	3.00	8.5
I479530	CAS-092	80.30	83.30	3.00	7.7
I479531	CAS-092	83.30	86.30	3.00	8.2
I479532	CAS-092	86.30	89.30	3.00	8.5
I479533	CAS-092	89.30	92.30	3.00	7.4
I479534	CAS-092	92.30	95.30	3.00	8.0
I479535	CAS-092	95.30	98.30	3.00	8.3
I479536	CAS-092	98.30	101.30	3.00	8.2
I479537	CAS-092	101.30	104.30	3.00	8.3
I479538	CAS-092	104.30	107.30	3.00	9.0
I479539	CAS-092	107.30	110.30	3.00	8.6
i479540	CAS-092	110.30	113.30	3.00	8.6
I479541	CAS-092	113.30	116.30	3.00	8.8
I479542	CAS-092	116.30	119.30	3.00	8.1
I479543	CAS-092	119.30	122.30	3.00	9.4
I479544	CAS-092	122.30	125.30	3.00	7.1
I479545	CAS-092	125.30	128.30	3.00	8.5
I479546	CAS-092	128.30	131.30	3.00	8.1
I479547	CAS-092	131.30	134.30	3.00	8.3
I479548	CAS-092	134.30	137.30	3.00	7.6
I479549	CAS-092	137.30	140.30	3.00	7.8
I479550	CAS-092	140.30	143.30	3.00	7.9
I479553	CAS-092	143.30	146.30	3.00	7.8
I479554	CAS-092	146.30	149.30	3.00	8.9
I479555	CAS-092	149.30	152.30	3.00	7.8
I479556	CAS-092	152.30	155.30	3.00	8.3
I479557	CAS-092	155.30	158.30	3.00	8.6
I479558	CAS-092	158.30	161.30	3.00	8.3
I479559	CAS-092	161.30	164.30	3.00	8.8
I479560	CAS-092	164.30	167.30	3.00	8.5
I479561	CAS-092	167.30	170.30	3.00	9.1
I479562	CAS-092	170.30	173.30	3.00	9.3
I479563	CAS-092	173.30	176.30	3.00	8.5
I479564	CAS-092	176.30	178.00	1.70	5.4
I479565	CAS-092	178.00	181.00	3.00	7.9
I479566	CAS-092	181.00	184.00	3.00	8.4
I479567	CAS-092	184.00	187.00	3.00	8.9
I479568	CAS-092	187.00	190.00	3.00	9.3
I479569	CAS-092	190.00	193.00	3.00	8.8
I479570	CAS-092	193.00	196.00	3.00	8.7
I479571	CAS-092	196.00	199.00	3.00	9.1
I479572	CAS-092	199.00	202.00	3.00	8.8
I479573	CAS-092	202.00	205.00	3.00	10.4

TABLE I-1 Continued
MASS AND IDENTIFICATION OF SAMPLE RECEIVED

Sample	Hole	From	To	Length	Weight
I479574	CAS-092	205.00	207.00	2.00	4.8
I479575	CAS-092	207.00	210.00	3.00	9.1
I479576	CAS-092	210.00	213.00	3.00	8.2
I479577	CAS-092	213.00	216.00	3.00	9.8
I479578	CAS-092	216.00	219.00	3.00	9.2
I479579	CAS-092	219.00	222.00	3.00	8.6
I479580	CAS-092	222.00	225.00	3.00	8.7
I479581	CAS-092	225.00	228.00	3.00	9.0
I479582	CAS-092	228.00	231.00	3.00	8.6
I479583	CAS-092	231.00	234.00	3.00	9.1
I479584	CAS-092	234.00	237.00	3.00	9.3
I479585	CAS-092	237.00	240.00	3.00	8.7
I479586	CAS-092	240.00	243.00	3.00	9.0
I479587	CAS-092	243.00	246.00	3.00	8.5
I479588	CAS-092	246.00	249.00	3.00	9.5
I479589	CAS-092	249.00	252.00	3.00	9.1
I479590	CAS-092	252.00	255.00	3.00	8.6
I479591	CAS-092	255.00	258.00	3.00	8.0
I479592	CAS-092	258.00	261.00	3.00	9.3
I479593	CAS-092	261.00	264.00	3.00	8.7
I479594	CAS-092	264.00	267.00	3.00	9.1
I479595	CAS-092	267.00	270.00	3.00	9.1
I479596	CAS-092	270.00	273.00	3.00	7.9
I479597	CAS-092	273.00	276.00	3.00	7.6
I479598	CAS-092	276.00	279.00	3.00	9.7
I479599	CAS-092	279.00	282.00	3.00	8.5
I479600	CAS-092	282.00	285.00	3.00	8.9
I479603	CAS-092	285.00	288.00	3.00	9.6
I479604	CAS-092	288.00	291.00	3.00	8.5
I479605	CAS-092	291.00	292.50	1.50	5.2
I479606	CAS-092	292.50	294.13	1.63	5.2

TABLE I-2A
COMPOSITE CONSTRUCTION
IX Composite

Sample ID	Hole	From	To	Weight (kg)	Form
I477829	CAS-088	219.00	222.00	8.1	Half Core
I477835	CAS-088	237.00	240.00	8.6	Half Core
I477841	CAS-088	255.00	258.00	8.1	Half Core
I477847	CAS-088	273.00	276.00	8.5	Half Core
I477855	CAS-088	291.00	294.00	8.4	Half Core
I477861	CAS-088	309.00	311.81	7.7	Half Core
I479379	CAS-090	285.00	288.00	8.5	Half Core
I479381	CAS-090	291.00	294.00	8.4	Half Core
I479383	CAS-090	297.00	300.00	9.5	Half Core
I479385	CAS-090	303.00	306.00	9.5	Half Core
I479387	CAS-090	309.00	312.00	8.7	Half Core
I479389	CAS-090	315.00	318.00	9.0	Half Core
I479391	CAS-090	321.00	324.00	9.3	Half Core
I479393	CAS-090	327.00	330.00	8.2	Half Core
I479395	CAS-090	333.00	335.28	6.4	Half Core

TABLE I-2B
COMPOSITE CONSTRUCTION
WR Composite

Sample ID	Hole	From	To	Weight (kg)	Form
I479479	CAS-091	229.00	232.00	8.4	Half Core
I479483	CAS-091	241.00	244.00	9.2	Half Core
I479487	CAS-091	253.00	256.00	8.4	Half Core
I479491	CAS-091	265.00	268.00	8.5	Half Core
I479495	CAS-091	277.00	280.00	8.6	Half Core
I479499	CAS-091	289.00	292.00	9.0	Half Core
I479584	CAS-092	234.00	237.00	9.3	Half Core
I479588	CAS-092	246.00	249.00	9.5	Half Core
I479592	CAS-092	258.00	261.00	9.3	Half Core
I479596	CAS-092	270.00	273.00	7.9	Half Core
I479600	CAS-092	282.00	285.00	8.9	Half Core
I479606	CAS-092	292.50	294.13	5.2	Half Core

TABLE I-2C
COMPOSITE CONSTRUCTION
PP Composite

Sample ID	Hole	From	To	Weight (kg)	Form
I477957	CAS-089	269.00	272.00	7.3	Half Core
I477959	CAS-089	275.00	278.00	8.3	Half Core
I477962	CAS-089	284.00	287.00	8.0	Half Core
I477964	CAS-089	290.00	293.00	8.7	Half Core
I477966	CAS-089	296.00	299.00	8.4	Half Core
I477968	CAS-089	302.00	305.00	9.0	Half Core
I477970	CAS-089	308.00	311.00	8.1	Half Core
I477972	CAS-089	314.00	317.00	8.5	Half Core
I477974	CAS-089	320.00	323.00	8.5	Half Core
I477976	CAS-089	326.00	329.00	9.1	Half Core
I477978	CAS-089	330.50	332.23	4.9	Half Core

TABLE I-2D
COMPOSITE CONSTRUCTION
HYP PP Composite

Sample ID	Hole	From	To	Weight (kg)	Form
I477805	CAS-088	147.00	150.00	8.6	Half Core
I477806	CAS-088	150.00	153.00	7.0	Half Core
I477807	CAS-088	153.00	156.00	8.4	Half Core
I477808	CAS-088	156.00	159.00	7.1	Half Core
I477809	CAS-088	159.00	162.00	7.9	Half Core
I477810	CAS-088	162.00	165.00	7.5	Half Core
I477811	CAS-088	165.00	168.00	7.7	Half Core
I477812	CAS-088	168.00	171.00	8.1	Half Core
I477813	CAS-088	171.00	174.00	8.1	Half Core
I477814	CAS-088	174.00	177.00	8.1	Half Core
I477815	CAS-088	177.00	180.00	8.1	Half Core
I477816	CAS-088	180.00	183.00	7.9	Half Core
I477817	CAS-088	183.00	186.00	7.5	Half Core
I477818	CAS-088	186.00	189.00	7.5	Half Core
I477819	CAS-088	189.00	192.00	8.9	Half Core
I477820	CAS-088	192.00	195.00	8.0	Half Core
I477821	CAS-088	195.00	198.00	7.8	Half Core
I477822	CAS-088	198.00	201.00	7.4	Half Core
I477823	CAS-088	201.00	204.00	8.4	Half Core
I477824	CAS-088	204.00	207.00	8.2	Half Core
I477825	CAS-088	207.00	210.00	8.2	Half Core
I477826	CAS-088	210.00	213.00	7.6	Half Core
I477827	CAS-088	213.00	216.00	7.4	Half Core

TABLE I-2D Continued
COMPOSITE CONSTRUCTION
HYP PP Composite

Sample ID	Hole	From	To	Weight (kg)	Form
I477828	CAS-088	216.00	219.00	7.5	Half Core
I477830	CAS-088	222.00	225.00	7.9	Half Core
I477831	CAS-088	225.00	228.00	8.4	Half Core
I477832	CAS-088	228.00	231.00	8.2	Half Core
I477833	CAS-088	231.00	234.00	8.3	Half Core
I477834	CAS-088	234.00	237.00	8.2	Half Core
I477836	CAS-088	240.00	243.00	8.7	Half Core
I477837	CAS-088	243.00	246.00	8.3	Half Core
I477838	CAS-088	246.00	249.00	7.0	Half Core
I477839	CAS-088	249.00	252.00	8.8	Half Core
I477840	CAS-088	252.00	255.00	9.2	Half Core
I477842	CAS-088	258.00	261.00	7.8	Half Core
I477843	CAS-088	261.00	264.00	7.9	Half Core
I477844	CAS-088	264.00	267.00	7.5	Half Core
I477846	CAS-088	270.00	273.00	8.8	Half Core
I477848	CAS-088	276.00	279.00	8.2	Half Core
I477849	CAS-088	279.00	282.00	8.3	Half Core
I477850	CAS-088	282.00	285.00	9.3	Half Core
I477853	CAS-088	285.00	288.00	7.9	Half Core
I477854	CAS-088	288.00	291.00	9.0	Half Core
I477856	CAS-088	294.00	297.00	9.0	Half Core
I477857	CAS-088	297.00	300.00	7.7	Half Core
I477858	CAS-088	300.00	303.00	8.9	Half Core
I477859	CAS-088	303.00	306.00	7.6	Half Core
I477860	CAS-088	306.00	309.00	7.7	Half Core
I477948	CAS-089	248.00	251.00	8.6	Half Core
I477949	CAS-089	251.00	254.00	8.1	Half Core
I477950	CAS-089	254.00	257.00	7.9	Half Core
I477953	CAS-089	257.00	260.00	7.8	Half Core
I477954	CAS-089	260.00	263.00	8.6	Half Core
I477956	CAS-089	266.00	269.00	8.2	Half Core
I477958	CAS-089	272.00	275.00	8.9	Half Core
I477960	CAS-089	278.00	281.00	9.0	Half Core
I477961	CAS-089	281.00	284.00	8.3	Half Core
I477963	CAS-089	287.00	290.00	8.5	Half Core
I477965	CAS-089	293.00	296.00	7.6	Half Core
I477967	CAS-089	299.00	302.00	9.2	Half Core
I477969	CAS-089	305.00	308.00	8.0	Half Core
I477971	CAS-089	311.00	314.00	7.8	Half Core
I477973	CAS-089	317.00	320.00	8.6	Half Core
I477975	CAS-089	323.00	326.00	9.1	Half Core
I477977	CAS-089	329.00	330.50	4.0	Half Core

TABLE I-2D Continued
COMPOSITE CONSTRUCTION
HYP PP Composite

Sample ID	Hole	From	To	Weight (kg)	Form
I479376	CAS-090	276.00	279.00	9.5	Half Core
I479377	CAS-090	279.00	282.00	8.8	Half Core
I479378	CAS-090	282.00	285.00	8.0	Half Core
I479380	CAS-090	288.00	291.00	9.0	Half Core
I479382	CAS-090	294.00	297.00	8.9	Half Core
I479384	CAS-090	300.00	303.00	9.2	Half Core
I479386	CAS-090	306.00	309.00	8.6	Half Core
I479388	CAS-090	312.00	315.00	8.5	Half Core
I479390	CAS-090	318.00	321.00	9.7	Half Core
I479392	CAS-090	324.00	327.00	9.2	Half Core
I479394	CAS-090	330.00	333.00	9.5	Half Core
I479465	CAS-091	188.00	190.00	6.3	Half Core
I479466	CAS-091	190.00	193.00	8.2	Half Core
I479467	CAS-091	193.00	196.00	9.3	Half Core
I479468	CAS-091	196.00	199.00	8.7	Half Core
I479469	CAS-091	199.00	202.00	8.5	Half Core
I479470	CAS-091	202.00	205.00	8.6	Half Core
I479471	CAS-091	205.00	208.00	9.1	Half Core
I479472	CAS-091	208.00	211.00	8.7	Half Core
I479473	CAS-091	211.00	214.00	9.3	Half Core
I479474	CAS-091	214.00	217.00	8.1	Half Core
I479475	CAS-091	217.00	220.00	8.6	Half Core
I479476	CAS-091	220.00	223.00	8.5	Half Core
I479477	CAS-091	223.00	226.00	8.5	Half Core
I479478	CAS-091	226.00	229.00	8.5	Half Core
I479480	CAS-091	232.00	235.00	9.0	Half Core
I479481	CAS-091	235.00	238.00	8.8	Half Core
I479482	CAS-091	238.00	241.00	8.8	Half Core
I479484	CAS-091	244.00	247.00	8.4	Half Core
I479485	CAS-091	247.00	250.00	8.6	Half Core
I479486	CAS-091	250.00	253.00	9.0	Half Core
I479488	CAS-091	256.00	259.00	9.3	Half Core
I479489	CAS-091	259.00	262.00	9.0	Half Core
I479490	CAS-091	262.00	265.00	9.0	Half Core
I479492	CAS-091	268.00	271.00	9.0	Half Core
I479493	CAS-091	271.00	274.00	8.3	Half Core
I479494	CAS-091	274.00	277.00	9.3	Half Core
I479496	CAS-091	280.00	283.00	9.2	Half Core
I479497	CAS-091	283.00	286.00	9.0	Half Core
I479498	CAS-091	286.00	289.00	8.5	Half Core
I479500	CAS-091	292.00	295.00	8.8	Half Core
I479503	CAS-091	295.00	297.18	6.6	Half Core

TABLE I-2D Continued
COMPOSITE CONSTRUCTION
HYP PP Composite

Sample ID	Hole	From	To	Weight (kg)	Form
I479565	CAS-092	178.00	181.00	7.9	Half Core
I479566	CAS-092	181.00	184.00	8.4	Half Core
I479567	CAS-092	184.00	187.00	8.9	Half Core
I479568	CAS-092	187.00	190.00	9.3	Half Core
I479569	CAS-092	190.00	193.00	8.8	Half Core
I479570	CAS-092	193.00	196.00	8.7	Half Core
I479571	CAS-092	196.00	199.00	9.1	Half Core
I479572	CAS-092	199.00	202.00	8.8	Half Core
I479573	CAS-092	202.00	205.00	10.4	Half Core
I479574	CAS-092	205.00	207.00	4.8	Half Core
I479575	CAS-092	207.00	210.00	9.1	Half Core
I479576	CAS-092	210.00	213.00	8.2	Half Core
I479577	CAS-092	213.00	216.00	9.8	Half Core
I479578	CAS-092	216.00	219.00	9.2	Half Core
I479579	CAS-092	219.00	222.00	8.6	Half Core
I479580	CAS-092	222.00	225.00	8.7	Half Core
I479581	CAS-092	225.00	228.00	9.0	Half Core
I479582	CAS-092	228.00	231.00	8.6	Half Core
I479583	CAS-092	231.00	234.00	9.1	Half Core
I479585	CAS-092	237.00	240.00	8.7	Half Core
I479586	CAS-092	240.00	243.00	9.0	Half Core
I479587	CAS-092	243.00	246.00	8.5	Half Core
I479589	CAS-092	249.00	252.00	9.1	Half Core
I479590	CAS-092	252.00	255.00	8.6	Half Core
I479591	CAS-092	255.00	258.00	8.0	Half Core
I479593	CAS-092	261.00	264.00	8.7	Half Core
I479594	CAS-092	264.00	267.00	9.1	Half Core
I479595	CAS-092	267.00	270.00	9.1	Half Core
I479597	CAS-092	273.00	276.00	7.6	Half Core
I479598	CAS-092	276.00	279.00	9.7	Half Core
I479599	CAS-092	279.00	282.00	8.5	Half Core
I479603	CAS-092	285.00	288.00	9.6	Half Core
I479604	CAS-092	288.00	291.00	8.5	Half Core
I479605	CAS-092	291.00	292.50	5.2	Half Core

TABLE I-2E
COMPOSITE CONSTRUCTION
SUS PP Composite

Sample ID	Hole	From	To	Weight (kg)	Form
I474992	CAS-088	117.00	120.00	7.8	Half Core
I474993	CAS-088	120.00	123.00	7.3	Half Core
I474994	CAS-088	123.00	125.00	5.5	Half Core
I474996	CAS-088	126.50	129.00	6.9	Half Core
I474997	CAS-088	129.00	132.00	8.4	Half Core
I474998	CAS-088	132.00	135.00	7.8	Half Core
I475000	CAS-088	138.00	141.00	8.4	Half Core
I477803	CAS-088	141.00	144.00	7.2	Half Core
I477804	CAS-088	144.00	147.00	9.0	Half Core
I477927	CAS-089	189.00	190.50	3.6	Half Core
I477928	CAS-089	190.50	193.50	7.9	Half Core
I477929	CAS-089	193.50	196.50	9.0	Half Core
I477931	CAS-089	199.50	202.50	8.5	Half Core
I477932	CAS-089	202.50	205.50	7.8	Half Core
I477933	CAS-089	205.50	208.50	8.3	Half Core
I477935	CAS-089	211.50	214.50	8.1	Half Core
I477936	CAS-089	214.50	217.50	8.2	Half Core
I477937	CAS-089	217.50	220.50	7.5	Half Core
I477939	CAS-089	223.50	226.50	8.8	Half Core
I477940	CAS-089	226.50	229.50	7.7	Half Core
I477941	CAS-089	229.50	232.50	7.4	Half Core
I477943	CAS-089	235.50	238.50	7.9	Half Core
I477944	CAS-089	238.50	241.50	8.9	Half Core
I477945	CAS-089	241.50	244.50	8.3	Half Core
I477946	CAS-089	244.50	246.25	5.4	Half Core
I477947	CAS-089	246.25	248.00	3.9	Half Core
I479328	CAS-090	141.10	144.00	8.0	Half Core
I479329	CAS-090	144.00	147.00	8.3	Half Core
I479330	CAS-090	147.00	150.00	8.9	Half Core
I479331	CAS-090	150.00	153.00	8.9	Half Core
I479332	CAS-090	153.00	156.00	13.2	Half Core
I479333	CAS-090	156.00	159.00	5.9	Half Core
I479335	CAS-090	162.00	165.00	8.7	Half Core
I479336	CAS-090	165.00	168.00	9.1	Half Core
I479337	CAS-090	168.00	171.00	9.5	Half Core
I479338	CAS-090	171.00	174.00	6.6	Half Core
I479339	CAS-090	174.00	177.00	9.9	Half Core
I479340	CAS-090	177.00	180.00	8.5	Half Core
I479341	CAS-090	180.00	183.00	9.7	Half Core
I479342	CAS-090	183.00	186.00	9.1	Half Core
I479343	CAS-090	186.00	189.00	8.6	Half Core
I479344	CAS-090	189.00	192.00	9.1	Half Core

TABLE I-2E Continued
COMPOSITE CONSTRUCTION
SUS PP Composite

Sample ID	Hole	From	To	Weight (kg)	Form
I479345	CAS-090	192.00	195.00	8.8	Half Core
I479347	CAS-090	198.00	201.00	8.7	Half Core
I479348	CAS-090	201.00	204.00	9.0	Half Core
I479349	CAS-090	204.00	207.00	9.2	Half Core
I479350	CAS-090	207.00	209.00	5.2	Half Core
I479353	CAS-090	209.00	212.00	10.4	Half Core
I479354	CAS-090	212.00	215.00	9.5	Half Core
I479355	CAS-090	215.00	218.00	8.6	Half Core
I479356	CAS-090	218.00	221.00	8.5	Half Core
I479357	CAS-090	221.00	224.00	8.7	Half Core
I479358	CAS-090	224.00	227.00	8.5	Half Core
I479359	CAS-090	227.00	230.00	9.4	Half Core
I479360	CAS-090	230.00	233.00	8.3	Half Core
I479361	CAS-090	233.00	236.00	9.3	Half Core
I479362	CAS-090	236.00	239.00	8.2	Half Core
I479363	CAS-090	239.00	242.00	9.5	Half Core
I479364	CAS-090	242.00	245.00	9.1	Half Core
I479365	CAS-090	245.00	248.00	8.8	Half Core
I479367	CAS-090	250.50	253.50	9.4	Half Core
I479368	CAS-090	253.50	256.50	9.0	Half Core
I479369	CAS-090	256.50	259.50	9.5	Half Core
I479370	CAS-090	259.50	262.50	9.6	Half Core
I479371	CAS-090	262.50	265.50	9.3	Half Core
I479372	CAS-090	265.50	268.50	9.6	Half Core
I479373	CAS-090	268.50	271.50	9.2	Half Core
I479374	CAS-090	271.50	274.50	8.5	Half Core
I479375	CAS-090	274.50	276.00	4.3	Half Core
I479435	CAS-091	111.00	114.00	7.4	Half Core
I479436	CAS-091	114.00	116.00	5.6	Half Core
I479437	CAS-091	116.00	118.00	6.0	Half Core
I479438	CAS-091	118.00	121.00	8.5	Half Core
I479439	CAS-091	121.00	124.00	8.2	Half Core
I479440	CAS-091	124.00	127.00	9.4	Half Core
I479441	CAS-091	127.00	130.00	9.2	Half Core
I479442	CAS-091	130.00	133.00	9.3	Half Core
I479443	CAS-091	133.00	136.00	8.8	Half Core
I479444	CAS-091	136.00	138.00	5.9	Half Core
I479445	CAS-091	138.00	141.00	8.9	Half Core
I479446	CAS-091	141.00	144.00	10.2	Half Core
I479448	CAS-091	144.00	147.00	9.2	Half Core
I479450	CAS-091	150.00	153.00	8.6	Half Core
I479453	CAS-091	153.00	156.00	8.4	Half Core

TABLE I-2E Continued
COMPOSITE CONSTRUCTION
SUS PP Composite

Sample ID	Hole	From	To	Weight (kg)	Form
I479454	CAS-091	156.00	159.00	8.8	Half Core
I479455	CAS-091	159.00	162.00	8.9	Half Core
I479456	CAS-091	162.00	165.00	8.4	Half Core
I479457	CAS-091	165.00	168.00	9.2	Half Core
I479458	CAS-091	168.00	171.00	7.9	Half Core
I479459	CAS-091	171.00	174.00	8.2	Half Core
I479460	CAS-091	174.00	177.00	7.0	Half Core
I479461	CAS-091	177.00	180.00	8.4	Half Core
I479462	CAS-091	180.00	183.00	8.7	Half Core
I479463	CAS-091	183.00	186.00	8.6	Half Core
I479517	CAS-092	43.30	46.30	9.2	Half Core
I479518	CAS-092	46.30	49.30	8.2	Half Core
I479519	CAS-092	49.30	52.30	9.4	Half Core
I479520	CAS-092	52.30	53.30	2.4	Half Core
I479521	CAS-092	53.30	56.30	8.5	Half Core
I479522	CAS-092	56.30	59.30	7.4	Half Core
I479523	CAS-092	59.30	62.30	8.7	Half Core
I479524	CAS-092	62.30	65.30	8.8	Half Core
I479525	CAS-092	65.30	68.30	8.5	Half Core
I479526	CAS-092	68.30	71.30	8.5	Half Core
I479527	CAS-092	71.30	74.30	8.2	Half Core
I479528	CAS-092	74.30	77.30	9.3	Half Core
I479530	CAS-092	80.30	83.30	7.7	Half Core
I479531	CAS-092	83.30	86.30	8.2	Half Core
I479532	CAS-092	86.30	89.30	8.5	Half Core
I479533	CAS-092	89.30	92.30	7.4	Half Core
I479534	CAS-092	92.30	95.30	8.0	Half Core
I479535	CAS-092	95.30	98.30	8.3	Half Core
I479536	CAS-092	98.30	101.30	8.2	Half Core
I479537	CAS-092	101.30	104.30	8.3	Half Core
I479538	CAS-092	104.30	107.30	9.0	Half Core
I479539	CAS-092	107.30	110.30	8.6	Half Core
i479540	CAS-092	110.30	113.30	8.6	Half Core
I479541	CAS-092	113.30	116.30	8.8	Half Core
I479543	CAS-092	119.30	122.30	9.4	Half Core
I479544	CAS-092	122.30	125.30	7.1	Half Core
I479545	CAS-092	125.30	128.30	8.5	Half Core
I479546	CAS-092	128.30	131.30	8.1	Half Core
I479547	CAS-092	131.30	134.30	8.3	Half Core
I479548	CAS-092	134.30	137.30	7.6	Half Core
I479549	CAS-092	137.30	140.30	7.8	Half Core
I479550	CAS-092	140.30	143.30	7.9	Half Core

TABLE I-2E Continued
COMPOSITE CONSTRUCTION
SUS PP Composite

Sample ID	Hole	From	To	Weight (kg)	Form
I479553	CAS-092	143.30	146.30	7.8	Half Core
I479554	CAS-092	146.30	149.30	8.9	Half Core
I479555	CAS-092	149.30	152.30	7.8	Half Core
I479556	CAS-092	152.30	155.30	8.3	Half Core
I479558	CAS-092	158.30	161.30	8.3	Half Core
I479559	CAS-092	161.30	164.30	8.8	Half Core
I479560	CAS-092	164.30	167.30	8.5	Half Core
I479561	CAS-092	167.30	170.30	9.1	Half Core
I479562	CAS-092	170.30	173.30	9.3	Half Core
I479563	CAS-092	173.30	176.30	8.5	Half Core
I479564	CAS-092	176.30	178.00	5.4	Half Core

TABLE I-3
REPLICATE HEAD ASSAY DATA

Sample	Assay - percent or g/tonne								
	Cu	Mo	Fe	Au	CuOx	CuCN	S	C	Ag
PP Composite	0.14	0.030	2.95	0.22	0.004	0.008	0.74	0.45	1
IX Composite	0.17	0.071	2.39	0.22	0.006	0.012	2.06	0.31	2
WR Composite	0.19	0.019	2.50	0.18	0.005	0.013	2.46	0.16	1
HYP PP Composite	0.21	0.032	2.52	0.35	0.01	0.018	2.19	0.19	1
SUS PP Composite	0.29	0.028	4.01	0.38	0.027	0.093	3.22	0.18	1

APPENDIX II – KM3512

FLOTATION TEST DATA

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DATE: August 28, 2012

PROJECT NO: KM3512-01

PURPOSE: Preliminary Rougher Test.

PROCEDURE: Perform a standard one product rougher test.

FEED: 2 kg of PP Composite ore ground to a nominal 178μm K_{80}.

FLOWSHEET: 1

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	2000	10				11			11.1
BULK CIRCUIT:									
Rougher 1	-		2	4	8		1	2	11.0
Rougher 2	√		2	4	-		1	2	11.0
Rougher 3	√		2	4	-		1	2	11.0
Rougher 4	√		1	2	8		1	3	11.0

Flotation Data	Rougher	
Flotation Machine:	D2A	
Cell Size in liters:	4.4	
Aspiration:	Air	
Water Type:	Fresh	
Impeller Speed in rpm:	1100	

Grinding Data	Primary Grind
Mill:	M3-Mild
Charge/Material:	20kg-Mild
Water:	1000 ml

KM3512-01 PP Composite
Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Bulk Ro Con 1	1.7	32.9	6.90	1.099	10.2	11.00	79.1	65.1	5.7	24.6
Bulk Ro Con 2	1.4	27.5	0.57	0.157	4.3	2.55	5.5	7.8	2.0	4.8
Bulk Ro Con 3	1.5	30.5	0.19	0.031	3.2	1.21	2.0	1.7	1.7	2.5
Bulk Ro Con 4	2.7	54.2	0.06	0.011	3.0	0.60	1.2	1.1	2.8	2.2
Bulk RoTl	92.7	1837.3	0.02	0.007	2.8	0.53	12.2	24.3	87.8	65.9
Feed	100.0	1982	0.14	0.028	3.0	0.74	100	100	100	100

KM3512-01 PP Composite
Cumulative Metallurgical Balance

Cumulative Product	Cum. Weight		Assay - percent or g/t				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Product 1	1.7	32.9	6.90	1.099	10.2	11.00	79.1	65.1	5.7	24.6
Product 1 to 2	3.0	60.4	4.02	0.670	7.5	7.15	84.6	72.9	7.7	29.4
Product 1 to 3	4.6	90.9	2.73	0.456	6.1	5.16	86.6	74.6	9.4	31.9
Product 1 to 4	7.3	145.1	1.74	0.290	4.9	3.46	87.8	75.7	12.2	34.1
Product 5	92.7	1837.3	0.02	0.007	2.8	0.53	12.2	24.3	87.8	65.9
Feed	100.0	1982	0.14	0.028	3.0	0.74	100	100	100	100

DATE: August 28, 2012

PROJECT NO: KM3512-02

PURPOSE: Preliminary Rougher Test.

PROCEDURE: Perform a standard one product rougher test.

FEED: 2 kg of WR Composite ore ground to a nominal 178μm K_{80}.

FLOWSHEET: 1

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	2000	10				13			10.5
BULK CIRCUIT:									
Rougher 1	1000		2	4	8		1	2	11.0
Rougher 2	√		2	4	-		1	2	11.0
Rougher 3	-		1	2	8		1	2	11.0
Rougher 4	-		1	2	-		1	2	11.0

Flotation Data	Rougher	
Flotation Machine:	D2A	
Cell Size in liters:	4.4	
Aspiration:	Air	
Water Type:	Fresh	
Impeller Speed in rpm:	1100	

Grinding Data	Primary Grind
Mill:	M3-Mild
Charge/Material:	20kg-Mild
Water:	1000 ml

KM3512-02 WR Composite
Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Bulk Ro Con 1	1.8	35.4	9.70	0.807	15.7	19.10	89.2	76.2	11.2	14.1
Bulk Ro Con 2	1.1	22.1	0.54	0.079	9.9	8.41	3.1	4.7	4.4	3.9
Bulk Ro Con 3	1.2	23.1	0.19	0.020	4.5	4.46	1.1	1.3	2.1	2.2
Bulk Ro Con 4	1.3	26.6	0.09	0.013	2.4	2.30	0.6	0.9	1.3	1.3
Bulk RoTl	94.6	1887.5	0.01	0.003	2.1	1.99	5.9	17.0	81.1	78.5
Feed	100.0	1995	0.19	0.019	2.5	2.40	100	100	100	100

KM3512-02 WR Composite
Cumulative Metallurgical Balance

Cumulative Product	Cum. Weight		Assay - percent or g/t				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Product 1	1.8	35.4	9.70	0.807	15.7	19.10	89.2	76.2	11.2	14.1
Product 1 to 2	2.9	57.5	6.18	0.527	13.5	14.99	92.3	80.9	15.5	18.0
Product 1 to 3	4.0	80.6	4.46	0.382	10.9	11.97	93.5	82.1	17.6	20.2
Product 1 to 4	5.4	107.2	3.38	0.290	8.8	9.57	94.1	83.0	18.9	21.5
Product 5	94.6	1887.5	0.01	0.003	2.1	1.99	5.9	17.0	81.1	78.5
Feed	100.0	1995	0.19	0.019	2.5	2.40	100	100	100	100

DATE: August 30, 2012

PROJECT NO: KM3512-03

PURPOSE: To Repeat Test 1 at a pH of 9.5.

PROCEDURE: Perform a standard one product rougher test.

FEED: 2 kg of PP Composite ore ground to a nominal 178μm K_{80}.

FLOWSHEET: 1

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	800	10				11			10.4
BULK CIRCUIT:									
Rougher 1	-		2	4	23		1	2	9.8
Rougher 2	-		2	4	-		1	2	9.6
Rougher 3	-		2	4	-		1	2	9.5
Rougher 4	√		1	2	-		1	3	9.8

Flotation Data	Rougher	
Flotation Machine:	D2A	
Cell Size in liters:	4.4	
Aspiration:	Air	
Water Type:	Fresh	
Impeller Speed in rpm:	1100	

Grinding Data	Primary Grind
Mill:	M3-Mild
Charge/Material:	20kg-Mild
Water:	1000 ml

KM3512-03 PP Composite
Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Bulk Ro Con 1	2.2	44.3	4.00	0.93	10.3	13.0	74.1	76.3	7.6	38.3
Bulk Ro Con 2	1.6	31.9	0.69	0.06	11.1	11.2	9.2	3.6	5.9	23.8
Bulk Ro Con 3	1.5	30.1	0.21	0.02	7.2	5.48	2.6	0.9	3.6	11.0
Bulk Ro Con 4	1.8	36.2	0.16	0.009	4.4	1.73	2.4	0.6	2.6	4.2
Bulk RoTl	92.8	1846.8	0.02	0.005	2.6	0.19	11.6	18.5	80.2	22.7
Feed	100.0	1989	0.12	0.027	3.0	0.76	100	100	100	100

KM3512-03 PP Composite
Cumulative Metallurgical Balance

Cumulative Product	Cum. Weight		Assay - percent or g/t				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Product 1	2.2	44.3	4.00	0.93	10.3	13.0	74.1	76.3	7.6	38.3
Product 1 to 2	3.8	76.2	2.61	0.57	10.6	12.2	83.3	79.9	13.5	62.1
Product 1 to 3	5.3	106.3	1.93	0.41	9.7	10.3	86.0	80.8	17.2	73.1
Product 1 to 4	7.2	142.5	1.48	0.31	8.3	8.15	88.4	81.5	19.8	77.3
Product 5	92.8	1846.8	0.02	0.005	2.6	0.19	11.6	18.5	80.2	22.7
Feed	100.0	1989	0.12	0.03	3.0	0.76	100	100	100	100

DATE: August 30, 2012

PROJECT NO: KM3512-04

PURPOSE: To Repeat Test 2 at a pH of 9.5.

PROCEDURE: Perform a standard one product rougher test.

FEED: 2 kg of WR Composite ore ground to a nominal 178μm K_{80}.

FLOWSHEET: 1

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	600	10				13			9.5
BULK CIRCUIT:									
Rougher 1	25		2	4	15		1	2	9.5
Rougher 2	√		2	4	8		1	2	9.5
Rougher 3	-		1	2	-		1	2	9.5
Rougher 4	-		1	2	-		1	2	9.5

Flotation Data	Rougher	
Flotation Machine:	D2A	
Cell Size in liters:	4.4	
Aspiration:	Air	
Water Type:	Fresh	
Impeller Speed in rpm:	1100	

Grinding Data	Primary Grind
Mill:	M3-Mild
Charge/Material:	20kg-Mild
Water:	1000 ml

KM3512-04 WR Composite
Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Bulk Ro Con 1	5.9	118.5	3.11	0.30	25.2	36.3	93.0	88.5	58.8	80.5
Bulk Ro Con 2	1.2	23.1	0.30	0.02	12.2	12.6	1.7	1.2	5.6	5.4
Bulk Ro Con 3	0.7	14.5	0.19	0.01	12.0	14.0	0.7	0.4	3.4	3.8
Bulk Ro Con 4	0.5	10.3	0.15	0.009	11.4	12.6	0.4	0.2	2.3	2.4
Bulk RoTl	91.7	1826.9	0.01	0.002	0.8	0.23	4.1	9.6	29.9	7.8
Feed	100.0	1993	0.20	0.020	2.5	2.68	100	100	100	100

KM3512-04 WR Composite
Cumulative Metallurgical Balance

Cumulative Product	Cum. Weight		Assay - percent or g/t				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Product 1	5.9	118.5	3.11	0.30	25.2	36.3	93.0	88.5	58.8	80.5
Product 1 to 2	7.1	141.6	2.65	0.25	23.1	32.4	94.8	89.8	64.4	85.9
Product 1 to 3	7.8	156.1	2.42	0.23	22.1	30.7	95.5	90.2	67.8	89.7
Product 1 to 4	8.3	166.4	2.28	0.21	21.4	29.6	95.9	90.4	70.1	92.2
Product 5	91.7	1826.9	0.01	0.002	0.8	0.23	4.1	9.6	29.9	7.8
Feed	100.0	1993	0.20	0.02	2.5	2.68	100	100	100	100

DATE: August 30, 2012

PROJECT NO: KM3512-05

PURPOSE: Preliminary Rougher Test.

PROCEDURE: Perform a standard one product rougher test.

FEED: 2 kg of IX Composite ore ground to a nominal 155μm K_{80}.

FLOWSHEET: 1

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	2000	10				14.5			11.4
BULK CIRCUIT:									
Rougher 1	-		3	6	15		1	2	11.0
Rougher 2	-		2	4	-		1	2	11.0
Rougher 3	-		1	2	-		1	2	11.0
Rougher 4	√		20	40	-		1	2	11.0

Flotation Data	Rougher	
Flotation Machine:	D2A	
Cell Size in liters:	4.4	
Aspiration:	Air	
Water Type:	Fresh	
Impeller Speed in rpm:	1100	

Grinding Data	Primary Grind
Mill:	M3-Mild
Charge/Material:	20kg-Mild
Water:	1000 ml

KM3512-05 IX Composite
Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Bulk Ro Con 1	1.6	31.3	9.54	3.06	19.8	23.7	89.9	68.8	13.4	19.4
Bulk Ro Con 2	0.8	15.4	0.55	0.47	16.9	16.8	2.6	5.2	5.6	6.8
Bulk Ro Con 3	0.6	11.2	0.26	0.15	18.1	21.8	0.9	1.2	4.4	6.4
Bulk Ro Con 4	2.7	52.8	0.10	0.04	19.4	23.9	1.6	1.4	22.1	33.0
Bulk RoTl	94.4	1871.3	0.01	0.02	1.4	0.71	5.1	23.4	54.5	34.5
Feed	100.0	1982	0.17	0.070	2.3	1.93	100	100	100	100

KM3512-05 IX Composite
Cumulative Metallurgical Balance

Cumulative Product	Cum. Weight		Assay - percent or g/t				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Product 1	1.6	31.3	9.54	3.06	19.8	23.7	89.9	68.8	13.4	19.4
Product 1 to 2	2.4	46.7	6.58	2.21	18.8	21.4	92.5	74.1	19.0	26.1
Product 1 to 3	2.9	57.9	5.35	1.81	18.7	21.5	93.3	75.2	23.4	32.5
Product 1 to 4	5.6	110.7	2.85	0.96	19.0	22.6	94.9	76.6	45.5	65.5
Product 5	94.4	1871.3	0.01	0.02	1.4	0.71	5.1	23.4	54.5	34.5
Feed	100.0	1982	0.17	0.07	2.3	1.93	100	100	100	100

DATE: September 5, 2012

PROJECT NO: KM3512-06

PURPOSE: To Repeat Test 4 at a Coarser Primary Grind.

PROCEDURE: Perform a standard one product rougher test.

FEED: 2 kg of WR Composite ore ground to a nominal 211μm K_{80}.

FLOWSHEET: 1

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	600	10				11.5			9.4
BULK CIRCUIT:									
Rougher 1	25		2	4	23		1	2	9.5
Rougher 2	√		2	4	-		1	2	9.5
Rougher 3	√		1	2	-		1	2	9.5
Rougher 4	√		1	2	-		1	2	9.5

Flotation Data	Rougher	
Flotation Machine:	D2A	
Cell Size in liters:	4.4	
Aspiration:	Air	
Water Type:	Fresh	
Impeller Speed in rpm:	1100	

Grinding Data	Primary Grind
Mill:	M3-Mild
Charge/Material:	20kg-Mild
Water:	1000 ml

KM3512-06 WR Composite
Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Bulk Ro Con 1	5.2	102.8	3.33	0.268	29.7	35.8	84.9	80.4	56.9	71.8
Bulk Ro Con 2	2.2	44.1	0.59	0.032	13.3	15.5	6.5	4.1	10.9	13.3
Bulk Ro Con 3	1.3	25.4	0.23	0.009	6.2	6.42	1.4	0.6	2.9	3.2
Bulk Ro Con 4	1.3	25.8	0.15	0.007	4.6	4.32	1.0	0.5	2.2	2.2
Bulk RoTl	90.1	1793.2	0.01	0.003	0.8	0.27	6.2	14.4	27.1	9.5
Feed	100.0	1991	0.20	0.017	2.7	2.57	100	100	100	100

KM3512-06 WR Composite
Cumulative Metallurgical Balance

Cumulative Product	Cum. Weight		Assay - percent or g/t				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Product 1	5.2	102.8	3.33	0.268	29.7	35.8	84.9	80.4	56.9	71.8
Product 1 to 2	7.4	146.9	2.51	0.197	24.8	29.7	91.4	84.5	67.8	85.2
Product 1 to 3	8.7	172.3	2.17	0.169	22.0	26.3	92.8	85.1	70.7	88.4
Product 1 to 4	9.9	198.1	1.91	0.148	19.8	23.4	93.8	85.6	72.9	90.5
Product 5	90.1	1793.2	0.01	0.003	0.8	0.27	6.2	14.4	27.1	9.5
Feed	100.0	1991	0.20	0.017	2.7	2.57	100	100	100	100

DATE: September 5, 2012

PROJECT NO: KM3512-07

PURPOSE: To Repeat Test 6 at pH 11.0.

PROCEDURE: Perform a standard one product rougher test.

FEED: 2 kg of WR Composite ore ground to a nominal 211μm K_{80}.

FLOWSHEET: 1

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	2000	10				11.5			11.4
BULK CIRCUIT:									
Rougher 1	-		2	4	23		1	2	11.4
Rougher 2	√		2	4	-		1	2	11.3
Rougher 3	√		1	2	-		1	2	11.3
Rougher 4	√		1	2	-		1	2	11.2

Flotation Data	Rougher	
Flotation Machine:	D2A	
Cell Size in liters:	4.4	
Aspiration:	Air	
Water Type:	Fresh	
Impeller Speed in rpm:	1100	

Grinding Data	Primary Grind
Mill:	M3-Mild
Charge/Material:	20kg-Mild
Water:	1000 ml

KM3512-07 WR Composite
Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Bulk Ro Con 1	2.2	44.3	7.40	0.598	17.9	23.9	84.2	74.1	14.5	19.7
Bulk Ro Con 2	1.8	36.4	0.90	0.060	15.7	18.9	8.4	6.2	10.5	12.8
Bulk Ro Con 3	1.7	33.8	0.24	0.010	13.9	15.4	2.1	1.0	8.6	9.7
Bulk Ro Con 4	1.4	28.6	0.14	0.008	15.2	17.6	1.0	0.6	8.0	9.3
Bulk RoTl	92.8	1854.9	0.01	0.003	1.7	1.41	4.3	18.1	58.4	48.6
Feed	100.0	1998	0.19	0.018	2.7	2.70	100	100	100	100

KM3512-07 WR Composite
Cumulative Metallurgical Balance

Cumulative Product	Cum. Weight		Assay - percent or g/t				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Product 1	2.2	44.3	7.40	0.598	17.9	23.9	84.2	74.1	14.5	19.7
Product 1 to 2	4.0	80.7	4.47	0.355	16.9	21.6	92.6	80.3	25.0	32.4
Product 1 to 3	5.7	114.5	3.22	0.254	16.0	19.8	94.7	81.2	33.6	42.1
Product 1 to 4	7.2	143.1	2.60	0.204	15.9	19.4	95.7	81.9	41.6	51.4
Product 5	92.8	1854.9	0.01	0.003	1.7	1.41	4.3	18.1	58.4	48.6
Feed	100.0	1998	0.19	0.018	2.7	2.70	100	100	100	100

DATE: September 5, 2012

PROJECT NO: KM3512-08

PURPOSE: To Repeat Test 5 at a Coarser Primary Grind.

PROCEDURE: Perform a standard one product rougher test.

FEED: 2 kg of IX Composite ore ground to a nominal 234μm K_{80}.

FLOWSHEET: 1

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	2000	10				11			11.5
BULK CIRCUIT:									
Rougher 1	-		3	6	23		1	2	11.5
Rougher 2	-		2	4	-		1	2	11.4
Rougher 3	-		1	2	-		1	2	11.4
Rougher 4	-		1	2	8		1	2	11.2

Flotation Data	Rougher	
Flotation Machine:	D2A	
Cell Size in liters:	4.4	
Aspiration:	Air	
Water Type:	Fresh	
Impeller Speed in rpm:	1100	

Grinding Data	Primary Grind
Mill:	M3-Mild
Charge/Material:	20kg-Mild
Water:	1000 ml

KM3512-08 IX Composite
Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Bulk Ro Con 1	2.0	39.4	7.30	2.19	13.7	16.6	83.1	65.0	12.2	17.5
Bulk Ro Con 2	1.2	23.6	0.72	0.400	8.6	7.87	4.9	7.1	4.6	5.0
Bulk Ro Con 3	1.1	22.5	0.37	0.092	7.9	7.31	2.4	1.6	4.0	4.4
Bulk Ro Con 4	0.8	16.2	0.31	0.061	6.5	6.90	1.5	0.7	2.4	3.0
Bulk RoTl	94.9	1873.4	0.02	0.018	1.8	1.40	8.1	25.6	76.8	70.2
Feed	100.0	1975	0.18	0.067	2.2	1.89	100	100	100	100

KM3512-08 IX Composite
Cumulative Metallurgical Balance

Cumulative Product	Cum. Weight		Assay - percent or g/t				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Product 1	2.0	39.4	7.30	2.19	13.7	16.6	83.1	65.0	12.2	17.5
Product 1 to 2	3.2	63.0	4.84	1.52	11.8	13.3	88.0	72.1	16.8	22.5
Product 1 to 3	4.3	85.5	3.66	1.14	10.8	11.7	90.4	73.7	20.8	26.9
Product 1 to 4	5.1	101.7	3.13	0.970	10.1	11.0	91.9	74.4	23.2	29.8
Product 5	94.9	1873.4	0.02	0.018	1.8	1.40	8.1	25.6	76.8	70.2
Feed	100.0	1975	0.18	0.067	2.2	1.89	100	100	100	100

DATE: September 5, 2012

PROJECT NO: KM3512-09

PURPOSE: To Repeat Test 8 at pH 9.5.

PROCEDURE: Perform a standard one product rougher test.

FEED: 2 kg of IX Composite ore ground to a nominal 234μm K_{80}.

FLOWSHEET: 1

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	600	10				11			10.0
BULK CIRCUIT:									
Rougher 1	-		3	6	23		1	2	10.0
Rougher 2	-		2	4	-		1	2	9.6
Rougher 3	√		1	2	-		1	2	9.5
Rougher 4	√		1	2	-		1	2	9.5

Flotation Data	Rougher	
Flotation Machine:	D2A	
Cell Size in liters:	4.4	
Aspiration:	Air	
Water Type:	Fresh	
Impeller Speed in rpm:	1100	

Grinding Data	Primary Grind
Mill:	M3-Mild
Charge/Material:	20kg-Mild
Water:	1000 ml

KM3512-09 IX Composite
Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Bulk Ro Con 1	3.8	75.9	4.10	1.43	20.7	30.1	86.0	77.7	35.9	56.2
Bulk Ro Con 2	1.8	34.9	0.49	0.11	13.3	18.1	4.7	2.7	10.6	15.5
Bulk Ro Con 3	1.2	24.2	0.30	0.05	9.4	11.7	2.0	0.8	5.2	7.0
Bulk Ro Con 4	0.9	17.7	0.24	0.03	7.1	7.62	1.2	0.4	2.9	3.3
Bulk RoTl	92.3	1828.9	0.01	0.01	1.1	0.40	6.1	18.3	45.5	18.0
Feed	100.0	1982	0.18	0.070	2.2	2.05	100	100	100	100

KM3512-09 IX Composite
Cumulative Metallurgical Balance

Cumulative Product	Cum. Weight		Assay - percent or g/t				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Product 1	3.8	75.9	4.10	1.43	20.7	30.1	86.0	77.7	35.9	56.2
Product 1 to 2	5.6	110.8	2.96	1.01	18.4	26.3	90.8	80.5	46.4	71.7
Product 1 to 3	6.8	135.0	2.49	0.84	16.8	23.7	92.8	81.2	51.6	78.7
Product 1 to 4	7.7	152.7	2.23	0.75	15.6	21.8	93.9	81.7	54.5	82.0
Product 5	92.3	1828.9	0.01	0.01	1.1	0.40	6.1	18.3	45.5	18.0
Feed	100.0	1982	0.18	0.07	2.2	2.05	100	100	100	100

DATE: September 6, 2012

PROJECT NO: KM3212-10

PURPOSE: To Repeat Test 1 at a Coarser Primary Grind.

PROCEDURE: Perform a one product rougher test.

FEED: 2 kg of PP Composite ore ground to a nominal 254μm K_{80}.

FLOWSHEET: 1

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	2000	10				9.5			11.3
BULK CIRCUIT:									
Rougher 1	-		2	4	23		1	2	11.3
Rougher 2	-		2	4	-		1	2	11.2
Rougher 3	-		2	4	-		1	2	11.1
Rougher 4	-		1	2	8		1	2	11.0

Flotation Data	Rougher
Flotation Machine	D2A
Cell Size in liters	4.4
Aspiration	Air
Water Type	Fresh
Impeller Speed in rpm	1100

Grinding Data	Primary Grind
Mill:	M3-Mild
Charge/Material:	20kg-Mild
Water:	1000 ml

KM3512-10 PP Composite
Overall Metallurgical Balance

Product	Weight		Assay - percent or g/tonne				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Bulk Ro Con 1	1.8	35.9	6.10	1.180	10.7	10.40	76.0	75.3	6.7	27.3
Bulk Ro Con 2	2.0	40.0	0.39	0.084	4.4	2.51	5.4	6.0	3.0	7.3
Bulk Ro Con 3	2.7	53.3	0.12	0.017	3.7	1.27	2.2	1.6	3.4	4.9
Bulk Ro Con 4	2.5	50.2	0.11	0.011	3.4	0.94	1.9	1.0	3.0	3.4
Bulk Rougher Tail	91.0	1808.9	0.02	0.005	2.7	0.43	14.4	16.1	83.9	57.0
Feed	100.0	1988.3	0.14	0.028	2.9	0.69	100	100	100	100

KM3512-10 PP Composite
Cumulative Metallurgical Balance

Cumulative	Cum. Weight		Assay - percent or g/tonne				Distribution - percent			
Product	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Product 1	1.8	35.9	6.1	1.2	10.7	10	76.0	75.3	6.7	27.3
Product 1 to 2	3.8	75.9	3.1	0.6	7.4	6	81.4	81.3	9.7	34.6
Product 1 to 3	6.5	129.2	1.9	0.4	5.8	4	83.6	82.9	13.1	39.5
Product 1 to 4	9.0	179.4	1.4	0.26	5.14	3	85.6	83.9	16.1	43.0
Product 5	91.0	1808.9	0.0	0.01	2.66	0	14.4	16.1	83.9	57.0
Feed	100.0	1988.3	0.14	0.03	2.88	1	100	100	100	100

DATE: September 6, 2012

PROJECT NO: KM3212-11

PURPOSE: To Repeat Test 10 at pH 9.5.

PROCEDURE: Perform a one product rougher test.

FEED: 2 kg of PP Composite ore ground to a nominal 254μm K_{80}.

FLOWSHEET: 1

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	600	10				9.5			9.8
BULK CIRCUIT:									
Rougher 1	-		2	4	23		1	2	9.8
Rougher 2	-		2	4	-		1	2	9.6
Rougher 3	√		2	4	-		1	2	9.5
Rougher 4	√		1	2	8		1	2	9.5

Flotation Data	Rougher	
Flotation Machine	D2A	
Cell Size in liters	4.4	
Aspiration	Air	
Water Type	Fresh	
Impeller Speed in rpm	1100	

Grinding Data	Primary Grind
Mill:	M3-Mild
Charge/Material:	20kg-Mild
Water:	1000 ml

KM3512-11 PP Composite
Overall Metallurgical Balance

Product	Weight		Assay - percent or g/tonne				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Bulk Ro Con 1	2.2	44.2	4.78	1.090	14.2	15.30	71.1	80.4	10.7	46.4
Bulk Ro Con 2	2.1	42.1	0.43	0.040	9.0	4.86	6.1	2.8	6.4	14.0
Bulk Ro Con 3	1.8	36.2	0.23	0.015	5.6	4.01	2.8	0.9	3.4	10.0
Bulk Ro Con 4	2.1	42.2	0.11	0.009	4.8	2.73	1.6	0.6	3.4	7.9
Bulk Rougher Tail	91.7	1823.5	0.03	0.005	2.5	0.17	18.4	15.2	76.0	21.8
Feed	100.0	1988.2	0.15	0.030	3.0	0.73	100	100	100	100

KM3512-11 PP Composite
Cumulative Metallurgical Balance

Cumulative Product	Cum. Weight		Assay - percent or g/tonne				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Product 1	2.2	44.2	4.8	1.1	14.2	15	71.1	80.4	10.7	46.4
Product 1 to 2	4.3	86.3	2.7	0.6	11.7	10	77.2	83.2	17.1	60.4
Product 1 to 3	6.2	122.5	1.9	0.4	9.9	8	80.0	84.1	20.6	70.3
Product 1 to 4	8.3	164.7	1.5	0.31	8.6	7	81.6	84.8	24.0	78.2
Product 5	91.7	1823.5	0.0	0.01	2.5	0	18.4	15.2	76.0	21.8
Feed	100.0	1988.2	0.1	0.03	3.0	1	100	100	100	100

DATE: September 7, 2012

PROJECT NO: KM3512-12

PURPOSE: Preliminary Cleaner Test.

PROCEDURE: Perform a standard one product cleaner test.

FEED: 2 kg of WR Composite ore ground to a nominal 211µm K_{80}.
Bulk Regrind Discharge - 36µm K_{80}.

FLOWSHEET: 2

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	1800	10				11.5			10.9
BULK CIRCUIT:									
Rougher 1	25		2	4	15		1	2	11.1
Rougher 2	-		2	4	8		1	2	11.2
Rougher 3	-		1	2	-		1	2	11.2
Rougher 4	-		1	2	-		1	2	11.1
Cleaner 1	250		3	6	15		1	4	11.0
Regrind	250	10				10			11.3
Cleaner 2	-		2	4	8		1	3	11.3
Cleaner 3	√		1	2	8		1	2	11.0

Flotation Data	Rougher	Cleaner
Flotation Machine	D2A	D1B
Cell Size in liters	4.4	2.2
Aspiration	Air	
Water Type	Fresh	
Impeller Speed in rpm	1100	1200

Grinding Data	Primary Regrind	Bulk Regrind
Mill:	M3-Mild	RM3-Mild
Charge/Material:	20kg-Mild	6kg-Stainless Steel
Water:	1000 ml	estimated

KM3512-12 WR Composite
Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Bulk Concentrate	0.6	12.2	**28.0**	1.98	27.3	37.2	88.0	72.1	7.0	9.5
Bulk 3rd Clnr Tail	0.2	4.9	2.43	0.75	26.2	33.7	3.1	11.0	2.7	3.4
Bulk 2nd Clnr Tail	2.4	47.6	0.19	0.059	23.7	30.2	2.3	8.4	23.7	30.0
Bulk 1st Clnr Tail	3.8	76.9	0.09	0.013	3.1	3.29	1.8	3.0	5.0	5.3
Bulk Rougher Tail	92.9	1857.1	0.01	0.001	1.6	1.34	4.8	5.5	61.6	51.9
Feed	100.0	1998.7	0.19	0.017	2.4	2.40	100	100	100	100

KM3512-12 WR Composite
Cumulative Metallurgical Balance

Cumulative Product	Cum. Weight		Assay - percent or g/t				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Product 1	0.6	12.2	28.0	1.98	27.3	37.2	88.0	72.1	7.0	9.5
Product 1 to 2	0.9	17.1	20.7	1.63	27.0	36.2	91.0	83.1	9.7	12.9
Product 1 to 3	3.2	64.7	5.60	0.474	24.6	31.8	93.4	91.5	33.4	42.9
Product 1 to 4	7.1	141.6	2.61	0.224	12.9	16.3	95.2	94.5	38.4	48.1
Product 5	92.9	1857.1	0.01	0.001	1.6	1.34	4.8	5.5	61.6	51.9
Feed	100.0	1998.7	0.19	0.017	2.4	2.40	100	100	100	100

DATE: September 7, 2012

PROJECT NO: KM3512-13

PURPOSE: Preliminary Cleaner Test.

PROCEDURE: Perform a standard one product cleaner test.

FEED: 2 kg of IX Composite ore ground to a nominal 234µm K_{80}.
Bulk Regrind Discharge - 30µm K_{80}.

FLOWSHEET: 2

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	1800	10				11			11.4
BULK CIRCUIT:									
Rougher 1	-		3	6	23		1	2	11.4
Rougher 2	-		2	4	-		1	2	11.2
Rougher 3	-		1	2	-		1	2	11.2
Rougher 4	-		1	2	-		1	2	11.1
Cleaner 1	250		3	6	15		1	4	11.0
Regrind	250	10				10			11.2
Cleaner 2	-		2	4	8		1	3	11.2
Cleaner 3	√		1	2	8		1	2	11.0

Flotation Data	Rougher	Cleaner
Flotation Machine	D2A	D1B
Cell Size in liters	4.4	2.2
Aspiration	Air	
Water Type	Fresh	
Impeller Speed in rpm	1100	1200

Grinding Data	Primary Regrind	Bulk Regrind
Mill:	M3-Mild	RM3-Mild
Charge/Material:	20kg-Mild	6kg-Stainless Steel
Water:	1000 ml	estimated

KM3512-13 IX Composite
Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Bulk Concentrate	0.4	8.7	**28.3**	5.55	24.1	36.6	75.3	36.3	4.5	7.7
Bulk 3rd Clnr Tail	0.2	4.7	4.95	4.57	22.5	31.0	7.1	16.2	2.3	3.5
Bulk 2nd Clnr Tail	1.5	30.2	0.40	0.502	23.5	28.7	3.7	11.4	15.4	20.9
Bulk 1st Clnr Tail	3.0	60.2	0.38	0.204	4.5	5.11	7.0	9.2	5.9	7.4
Bulk Rougher Tail	94.8	1878.5	0.01	0.019	1.8	1.34	6.9	26.9	71.9	60.6
Feed	100.0	1982.3	0.16	0.067	2.3	2.10	100	100	100	100

KM3512-13 IX Composite
Cumulative Metallurgical Balance

Cumulative Product	Cum. Weight		Assay - percent or g/t				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Product 1	0.4	8.7	28.3	5.55	24.1	36.6	75.3	36.3	4.5	7.7
Product 1 to 2	0.7	13.4	20.1	5.21	23.5	34.6	82.4	52.5	6.8	11.2
Product 1 to 3	2.2	43.6	6.46	1.95	23.5	30.5	86.1	63.9	22.2	32.0
Product 1 to 4	5.2	103.8	2.93	0.936	12.5	15.8	93.1	73.1	28.1	39.4
Product 5	94.8	1878.5	0.01	0.019	1.8	1.34	6.9	26.9	71.9	60.6
Feed	100.0	1982.3	0.16	0.067	2.3	2.10	100	100	100	100

DATE: September 8, 2012

PROJECT NO: KM3512-14

PURPOSE: Preliminary Cleaner Test.

PROCEDURE: Perform a standard one product cleaner test.

FEED: 2 kg of PP Composite ore ground to a nominal 254µm K_{80}.
Bulk Regrind Discharge - 21µm K_{80}.

FLOWSHEET: 2

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	1800	10				9.5			11.4
BULK CIRCUIT:									
Rougher 1	-		2	4	23		1	2	11.4
Rougher 2	-		2	4	-		1	2	11.4
Rougher 3	-		2	4	-		1	2	11.3
Rougher 4	-		1	2	-		1	2	11.2
Cleaner 1	250		3	6	15		1	4	11.0
Regrind	250	10				10			11.4
Cleaner 2	-		2	4	8		1	3	11.4
Cleaner 3	√		1	2	8		1	2	11.0

Flotation Data	Rougher	Cleaner
Flotation Machine	D2A	D1B
Cell Size in liters	4.4	2.2
Aspiration	Air	
Water Type	Fresh	
Impeller Speed in rpm	1100	1200

Grinding Data	Primary Regrind	Bulk Regrind
Mill:	M3-Mild	RM3-Mild
Charge/Material:	20kg-Mild	6kg-Stainless Steel
Water:	1000 ml	estimated

KM3512-14 PP Composite
Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Bulk Concentrate	0.3	6.6	**29.4**	4.00	24.8	37.1	71.2	51.8	2.8	17.0
Bulk 3rd Clnr Tail	0.2	3.6	5.68	2.78	13.5	17.0	7.5	19.6	0.8	4.2
Bulk 2nd Clnr Tail	1.2	23.1	0.47	0.26	9.7	9.38	4.0	11.8	3.9	15.0
Bulk 1st Clnr Tail	6.3	124.7	0.13	0.010	3.2	1.06	5.9	2.4	7.0	9.2
Bulk Rougher Tail	92.0	1829.2	0.02	0.004	2.7	0.43	11.4	14.4	85.4	54.6
Feed	100.0	1987.2	0.14	0.026	2.9	0.73	100	100	100	100

KM3512-14 PP Composite
Cumulative Metallurgical Balance

Cumulative Product	Cum. Weight		Assay - percent or g/t				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Product 1	0.3	6.6	29.4	4.00	24.8	37.1	71.2	51.8	2.8	17.0
Product 1 to 2	0.5	10.2	21.0	3.57	20.8	30.0	78.7	71.4	3.7	21.2
Product 1 to 3	1.7	33.3	6.77	1.27	13.1	15.7	82.6	83.2	7.6	36.3
Product 1 to 4	8.0	158.0	1.53	0.28	5.3	4.15	88.6	85.6	14.6	45.4
Product 5	92.0	1829.2	0.02	0.004	2.7	0.43	11.4	14.4	85.4	54.6
Feed	100.0	1987.2	0.14	0.026	2.9	0.73	100	100	100	100

DATE: September 12, 2012

PROJECT NO: KM3512-15

PURPOSE: Preliminary Cleaner Test.

PROCEDURE: Perform a standard one product cleaner test.

FEED: 2 kg of WR Composite ore ground to a nominal 211µm K_{80}.
Bulk Regrind Discharge - 32µm K_{80}.

FLOWSHEET: 2

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	1800	10				11.5			11.3
BULK CIRCUIT:									
Rougher 1	-		2	4	15		1	2	11.3
Rougher 2	-		2	4	8		1	2	11.3
Rougher 3	-		1	2	-		1	2	11.1
Rougher 4	-		1	2	-		1	2	11.0
Cleaner 1	50		3	6	15		1	4	10.0
Regrind	100	10				18			10.0
Cleaner 2	-		2	4	15		1	3	10.0
Cleaner 3	√		1	2	8		1	2	10.0

Flotation Data	Rougher	Cleaner
Flotation Machine	D2A	D1B
Cell Size in liters	4.4	2.2
Aspiration	Air	
Water Type	Fresh	
Impeller Speed in rpm	1100	1200

Grinding Data	Primary Regrind	Bulk Regrind
Mill:	M3-Mild	RM3-Mild
Charge/Material:	20kg-Mild	6kg-Stainless Steel
Water:	1000 ml	estimated

KM3512-15 WR Composite
Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Bulk Concentrate	0.5	11.0	**25.2**	2.48	29.3	40.2	71.4	70.2	6.1	8.4
Bulk 3rd Clnr Tail	0.4	8.7	4.22	0.302	33.3	41.3	9.5	6.7	5.4	6.8
Bulk 2nd Clnr Tail	3.1	62.1	0.63	0.034	28.8	31.3	10.1	5.5	33.6	37.0
Bulk 1st Clnr Tail	3.1	62.5	0.24	0.021	5.4	5.47	3.9	3.4	6.3	6.5
Bulk Rougher Tail	92.8	1856.7	0.01	0.003	1.4	1.17	5.3	14.1	48.5	41.3
Feed	100.0	2001.0	0.19	0.019	2.7	2.63	100	100	100	100

KM3512-15 WR Composite
Cumulative Metallurgical Balance

Cumulative Product	Cum. Weight		Assay - percent or g/t				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Product 1	0.5	11.0	25.2	2.48	29.3	40.2	71.4	70.2	6.1	8.4
Product 1 to 2	1.0	19.7	15.9	1.52	31.1	40.7	80.8	76.9	11.5	15.2
Product 1 to 3	4.1	81.8	4.32	0.392	29.3	33.6	90.9	82.4	45.1	52.2
Product 1 to 4	7.2	144.3	2.55	0.231	19.0	21.4	94.7	85.9	51.5	58.7
Product 5	92.8	1856.7	0.01	0.003	1.4	1.17	5.3	14.1	48.5	41.3
Feed	100.0	2001.0	0.19	0.019	2.7	2.63	100	100	100	100

DATE: September 12, 2012

PROJECT NO: KM3512-16

PURPOSE: To Repeat Test 13 at pH 10 in the Cleaner.

PROCEDURE: Perform a standard one product cleaner test.

FEED: 2 kg of IX Composite ore ground to a nominal 234µm K_{80}.
Bulk Regrind Discharge - 30µm K_{80}.

FLOWSHEET: 2

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	1800	10				11			11.4
BULK CIRCUIT:									
Rougher 1	-		3	6	15		1	2	11.4
Rougher 2	-		2	4	-		1	2	11.2
Rougher 3	-		1	2	-		1	2	11.1
Rougher 4	√		1	2	8		1	2	11.0
Cleaner 1	100		3	6	15		1	4	10.0
Regrind	100	10				10			10.2
Cleaner 2	-		2	4	23		1	3	10.0
Cleaner 3	√		1	2	23		1	2	10.0

Flotation Data	Rougher	Cleaner
Flotation Machine	D2A	D1B
Cell Size in liters	4.4	2.2
Aspiration	Air	
Water Type	Fresh	
Impeller Speed in rpm	1100	1200

Grinding Data	Primary Regrind	Bulk Regrind
Mill:	M3-Mild	RM3-Mild
Charge/Material:	20kg-Mild	6kg-Stainless Steel
Water:	1000 ml	estimated

KM3512-16 IX Composite
Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Bulk Concentrate	0.4	7.6	**28.5**	7.00	24.2	28.7	64.3	32.8	4.2	5.8
Bulk 3rd Clnr Tail	0.2	4.4	7.60	8.82	21.9	26.0	9.9	24.0	2.2	3.0
Bulk 2nd Clnr Tail	1.4	26.9	1.16	0.921	20.7	22.4	9.3	15.3	12.6	16.0
Bulk 1st Clnr Tail	4.1	80.4	0.39	0.164	8.5	9.96	9.3	8.2	15.4	21.2
Bulk Rougher Tail	94.0	1865.2	0.01	0.017	1.6	1.09	7.2	19.8	65.7	53.9
Feed	100.0	1984.5	0.17	0.082	2.2	1.90	100	100	100	100

KM3512-16 IX Composite
Cumulative Metallurgical Balance

Cumulative Product	Cum. Weight		Assay - percent or g/t				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Product 1	0.4	7.6	28.5	7.00	24.2	28.7	64.3	32.8	4.2	5.8
Product 1 to 2	0.6	12.0	20.8	7.67	23.4	27.7	74.2	56.8	6.3	8.8
Product 1 to 3	2.0	38.9	7.23	3.00	21.5	24.0	83.5	72.1	18.9	24.8
Product 1 to 4	6.0	119.3	2.62	1.09	12.7	14.6	92.8	80.2	34.3	46.1
Product 5	94.0	1865.2	0.01	0.017	1.6	1.09	7.2	19.8	65.7	53.9
Feed	100.0	1984.5	0.17	0.082	2.2	1.90	100	100	100	100

DATE: September 8, 2012

PROJECT NO: KM3512-17

PURPOSE: To Repeat Test 14 at pH 10 in the Cleaner.

PROCEDURE: Perform a standard one product cleaner test.

FEED: 2 kg of PP Composite ore ground to a nominal 254µm K_{80}.
Bulk Regrind Discharge - 28µm K_{80}.

FLOWSHEET: 2

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	2000	10				9.5			11.5
BULK CIRCUIT:									
Rougher 1	-		2	4	15		1	2	11.5
Rougher 2	-		2	4	-		1	2	11.4
Rougher 3	-		2	4	8		1	2	11.3
Rougher 4	-		1	2	-		1	2	11.3
Cleaner 1	50		3	6	15		1	4	10.0
Regrind	100	10				6			10.2
Cleaner 2	-		2	4	30		1	3	10.0
Cleaner 3	√		1	2	30		1	2	10.0

Flotation Data	Rougher	Cleaner
Flotation Machine	D2A	D1B
Cell Size in liters	4.4	2.2
Aspiration	Air	
Water Type	Fresh	
Impeller Speed in rpm	1100	1200

Grinding Data	Primary Regrind	Bulk Regrind
Mill:	M3-Mild	RM3-Mild
Charge/Material:	20kg-Mild	6kg-Stainless Steel
Water:	1000 ml	estimated

KM3512-17 PP Composite
Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Bulk Concentrate	0.4	7.4	**28.6**	5.28	25.6	37.6	70.6	59.1	3.1	18.9
Bulk 3rd Clnr Tail	0.2	3.5	5.32	2.72	16.8	21.2	6.2	14.4	0.9	5.0
Bulk 2nd Clnr Tail	1.2	23.8	0.60	0.197	9.7	7.17	4.8	7.1	3.7	11.6
Bulk 1st Clnr Tail	6.5	129.4	0.16	0.029	3.4	1.16	6.9	5.6	7.1	10.2
Bulk Rougher Tail	91.7	1821.1	0.02	0.005	2.9	0.44	11.5	13.8	85.2	54.3
Feed	100.0	1985.2	0.15	0.033	3.1	0.74	100	100	100	100

KM3512-17 PP Composite
Cumulative Metallurgical Balance

Cumulative Product	Cum. Weight		Assay - percent or g/t				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Product 1	0.4	7.4	28.6	5.28	25.6	37.6	70.6	59.1	3.1	18.9
Product 1 to 2	0.5	10.9	21.1	4.46	22.8	32.3	76.8	73.5	4.0	23.9
Product 1 to 3	1.7	34.7	7.05	1.53	13.8	15.1	81.6	80.6	7.7	35.5
Product 1 to 4	8.3	164.1	1.62	0.347	5.6	4.10	88.5	86.2	14.8	45.7
Product 5	91.7	1821.1	0.02	0.005	2.9	0.44	11.5	13.8	85.2	54.3
Feed	100.0	1985.2	0.15	0.033	3.1	0.74	100	100	100	100

DATE: September 18, 2012

PROJECT NO: KM3512-18

PURPOSE: Preliminary Locked Cycle Test.

PROCEDURE: Perform a standard one product locked cycle test.

FEED: 5 x 2 kg of PP Composite ore ground to a nominal 254 μm K_{80}.
Bulk Regrind Discharge V - 27 μm K_{80}.

FLOWSHEET: 3

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	1600	10				9.5			11.1
BULK CIRCUIT:									
Rougher 1	-		2	4	15		1	2	11.1
Rougher 2	-		2	4	-		1	2	11.0
Rougher 3	√		2	4	8		1	2	11.0
Rougher 4	√		1	2	-		1	2	11.0
					W34				
Cleaner 1	150		3	6	15		1	4	11.0
Regrind	150	10				6			11.0
Cleaner 2	-	4	2	4	15		1	3	11.0
Cleaner 3	√	-	1	2	8		1	2	11.0

Grinding Data	Primary Grind	Bulk Regrind
Mill:	M3-Mild	RM3-Mild
Charge/Material:	20kg-Mild	6kg-Stainless Steel
Water:	1000 ml	estimated

Flotation Data	Rougher	Clnr 1+2	Clnr 3
Flotation Machine:	D1B	D1B	D1B
Cell Size in liters:	4.4	2.2	1
Aspiration:		Air	
Water Type:		Fresh	
Impeller Speed in rpm:	1100	1200	1200

KM3512-18
Estimated Dry Weight Table

Product	Cycles - Weight (gms)				
	I	II	III	IV	V
BULK CIRCUIT:					
Rougher Concentrate	170	170	170	171	168
Cleaner Tail 1	135	155	155	165	160
Cleaner Tail 2	25	34	31	25	27
Cleaner Tail 3	4	3	2	2	2
Bulk Concentrate	6	8	8	7	7
Primary Discharge pH	11.5	11.5	11.5	11.1	11.1

KM3512-18 PP Composite
OVERALL CYCLE TEST MASS AND METALLURGICAL BALANCE

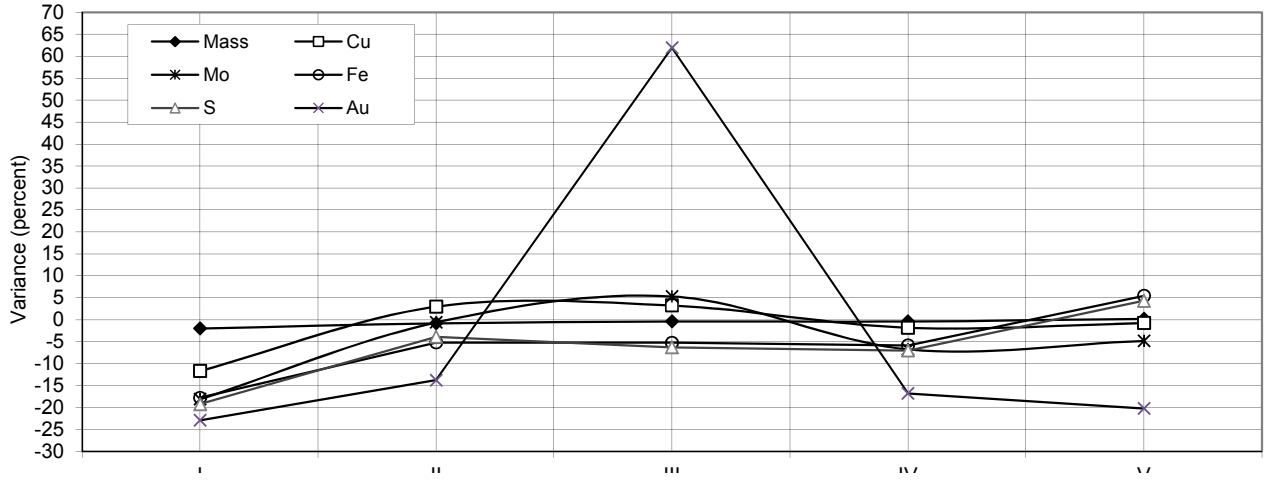
Product	Weight	Weight	Assay - percent or g/t						Distribution - percent					
	%	g	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Bulk Con I	0.1	6.8	**29.2**	4.89	24.8	35.8	112	29.6	13.8	11.7	0.6	3.2	7.2	8.7
Bulk Con II	0.1	8.9	**27.9**	4.83	25.2	37.6	108	30.0	17.2	15.1	0.8	4.4	9.1	11.6
Bulk Con III	0.1	8.0	**28.4**	5.21	24.9	37.0	104	31.3	15.8	14.6	0.7	3.9	7.9	10.9
Bulk Con IV	0.1	7.7	**28.8**	5.70	24.6	36.4	110	28.7	15.4	15.4	0.7	3.7	8.1	9.6
Bulk Con V	0.1	7.8	**28.2**	5.32	24.8	36.4	104	29.3	15.3	14.5	0.7	3.7	7.7	9.9
Bulk 3rd Clnr Tail	0.0	1.6	5.40	1.54	17.2	20.8	30	10.0	0.6	0.9	0.1	0.4	0.5	0.7
Bulk 2nd Clnr Tail	0.2	21.9	1.37	0.24	10.7	10.1	16	1.83	2.1	1.8	0.8	2.9	3.3	1.7
Bulk 1st Clnr Tail I	1.3	130.4	0.18	0.05	3.6	1.09	2	0.40	1.6	2.4	1.6	1.9	2.5	2.3
Bulk 1st Clnr Tail II	1.4	142.3	0.15	0.03	3.7	1.54	1	0.47	1.5	1.4	1.8	2.9	1.4	2.9
Bulk 1st Clnr Tail III	1.5	154.2	0.14	0.03	3.8	1.79	2	0.33	1.5	1.5	2.0	3.6	2.9	2.2
Bulk 1st Clnr Tail IV	1.6	162.7	0.20	0.04	4.1	2.18	1	0.39	2.3	2.2	2.3	4.6	1.5	2.8
Bulk 1st Clnr Tail V	1.5	150.6	0.20	0.04	4.0	2.34	3	0.39	2.1	2.2	2.1	4.6	4.3	2.6
Bulk Ro Tail I	18.4	1829.0	0.02	0.006	2.8	0.552	0.5	0.10	2.2	3.7	17.9	13.2	8.7	7.9
Bulk Ro Tail II	18.5	1836.1	0.02	0.005	2.7	0.493	0.5	0.08	2.3	3.1	16.9	11.8	8.7	6.4
Bulk Ro Tail III	18.4	1828.6	0.02	0.006	2.9	0.488	0.5	0.09	2.3	3.9	18.0	11.6	8.7	7.1
Bulk Ro Tail IV	18.3	1824.0	0.02	0.004	2.6	0.465	0.5	0.08	2.0	2.4	16.6	11.1	8.7	6.3
Bulk Ro Tail V	18.4	1829.8	0.02	0.005	2.7	0.531	0.5	0.08	2.2	3.4	16.7	12.7	8.7	6.4
FEED	100	9950	0.14	0.029	2.9	0.77	1	0.23	100.0	100.0	100.0	100.0	100.0	100.0

KM3512-18 PP Composite
METALLURGICAL BALANCES BY TEST CYCLES

Product	Weight	Weight	Assay - percent or g/t						Distribution - percent					
	%	g	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
CYCLE IV														
Flotation Feed	100.0	1994	0.14	0.03	2.8	0.74	1.0	0.22	100.0	100.0	100.0	100.0	100.0	100.0
Bulk Con	0.4	7.7	28.8	5.7	24.6	36.4	110	28.7	78.2	77.1	3.3	18.9	44.1	51.4
Bulk 1st Clnr Tail	8.2	162.7	0.20	0.04	4.1	2.2	1.0	0.39	11.5	10.9	11.7	23.9	8.5	14.7
Bulk Ro Tail	91.5	1824.0	0.02	0.00	2.6	0.47	0.5	0.08	10.3	12.0	84.9	57.2	47.5	33.9
CYCLE V														
Flotation Feed	100.0	1988	0.14	0.03	2.8	0.81	1.1	0.22	100.0	100.0	100.0	100.0	100.0	100.0
Bulk Con	0.4	7.8	28.2	5.3	24.8	36.4	104	29.3	78.2	72.2	3.4	17.7	37.2	52.7
Bulk 1st Clnr Tail	7.6	150.6	0.20	0.04	4.0	2.3	3.0	0.39	10.7	10.8	10.6	21.9	20.7	13.6
Bulk Ro Tail	92.0	1829.8	0.02	0.01	2.7	0.53	0.5	0.08	11.1	17.1	86.0	60.4	42.0	33.8
CYCLES IV and V														
Flotation Feed	100.0	3983	0.14	0.03	2.8	0.78	1.0	0.22	100.0	100.0	100.0	100.0	100.0	100.0
Bulk Con	0.4	15.5	28.5	5.5	24.7	36.4	107	29.0	78.2	74.6	3.4	18.3	40.4	52.0
Bulk 1st Clnr Tail	7.9	313.3	0.20	0.04	4.0	2.3	2.0	0.39	11.1	10.8	11.2	22.9	15.0	14.1
Bulk Ro Tail	91.7	3653.8	0.02	0.005	2.6	0.50	0.5	0.08	10.7	14.5	85.5	58.9	44.6	33.8

Cycle Test Stability Data

Cycles	Mass		Calculated Head						Metal Unit Variances (%)					
	%Var.	g/cycle	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
I	-1.2	1966.2	0.13	0.026	3.0	0.71	0.99	0.22	-12	-11	0	-9	-8	-5
II	-0.1	1987.3	0.15	0.028	2.9	0.73	1.02	0.24	5	-2	-2	-5	-4	4
III	0.0	1990.8	0.14	0.029	3.0	0.74	1.03	0.23	-2	0	3	-4	-2	1
IV	0.2	1994.4	0.14	0.029	2.8	0.74	0.96	0.22	-2	0	-3	-3	-9	-7
V	-0.1	1988.2	0.14	0.029	2.8	0.81	1.10	0.22	-2	1	-3	5	4	-6
Total	-	1990.1	0.14	0.029	2.9	0.77	1.06	0.23	-	-	-	-	-	-



KM3512-18 PP Composite

CYCLES (IV+V) MASS BALANCE FLOWSHEET AND METALLURGICAL BALANCE DATA

Flotation Stream		Weight	Assay (percent or g/t)						Distribution (percent)					
No.	Product	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
1	Bulk Ro Feed	100	0.14	0.029	2.8	0.78	1.0	0.22	100	100.0	100.0	100.0	100.0	100.0
2	Bulk Ro Tail	91.7	0.02	0.005	2.6	0.50	0.5	0.08	10.7	14.5	85.5	58.9	44.6	33.8
3	Bulk Ro Con	8.3	1.53	0.297	5.0	3.9	6.9	1.74	89.3	85.5	14.5	41.1	55.4	66.2
4	Bulk 1st Clnr Feed	9.4	1.55	0.301	5.8	4.7	8.2	1.82	103.0	98.8	19.2	57.6	74.9	79.2
5	Bulk 1st Clnr Tail	7.9	0.20	0.039	4.0	2.3	2.0	0.39	11.1	10.8	11.2	22.9	15.0	14.1
6	Bulk 1st Clnr Con	1.6	8.30	1.608	14.5	17.2	39.3	8.98	91.9	88.0	8.0	34.7	59.9	65.0
7	Bulk 2nd Clnr Tail	1.1	1.37	0.235	10.7	10.1	16.0	1.83	10.6	9.0	4.2	14.3	17.1	9.3
8	Bulk 2nd Clnr Con	0.5	24.5	4.83	23.4	33.7	93.8	25.7	81.3	78.9	3.9	20.4	42.8	55.7
9	Bulk 3rd Clnr Tail	0.1	5.40	1.535	17.2	20.8	30.0	10.00	3.1	4.3	0.5	2.2	2.3	3.7
10	Bulk 3rd Clnr Con	0.4	28.5	5.51	24.7	36.4	107.0	29.0	78.2	74.6	3.4	18.3	40.4	52.0
11	Final Tail	99.6	0.03	0.007	2.8	0.64	0.6	0.10	21.8	25.4	96.6	81.7	59.6	48.0

DATE: September 20, 2012

PROJECT NO: KM3512-19

PURPOSE: Preliminary Locked Cycle Test.

PROCEDURE: Perform a standard one product locked cycle test.

FEED: 5 x 2 kg of WR Composite ore ground to a nominal 211μm K_{80}.
Bulk Regrind Discharge V - 30μm K_{80}.

FLOWSHEET: 3

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	1500	10				11.5			11.4
BULK CIRCUIT:									
Rougher 1	-		2	4	15		1	2	11.4
Rougher 2	-		2	4	8		1	2	11.2
Rougher 3	-		1	2	-		1	2	11.1
Rougher 4	-		1	2	8		1	2	11.0
Cleaner 1	200		5	10	15		1	5	11.0
Regrind	250	10				10			11.4
Cleaner 2	-	4	4	8	23		1	4	11.0
Cleaner 3	√	-	2	4	23		1	3	11.0

Grinding Data	Primary Grind	Bulk Regrind
Mill:	M3-Mild	RM3-Mild
Charge/Material:	20kg-Mild	6kg-Stainless Steel
Water:	1000 ml	estimated

Flotation Data	Rougher	Clnr 1+2	Clnr 3
Flotation Machine:	D1B	D1B	D1B
Cell Size in liters:	4.4	2.2	1
Aspiration:		Air	
Water Type:		Fresh	
Impeller Speed in rpm:	1100	1200	1200

KM3512-19
Estimated Dry Weight Table

Product	Cycles - Weight (gms)				
	I	II	III	IV	V
BULK CIRCUIT:					
Rougher Concentrate	135	155	150	155	150
Cleaner Tail 1	92	140	140	150	150
Cleaner Tail 2	40	51	60	70	65
Cleaner Tail 3	7	11	11	10	10
Bulk Concentrate	10	13	14	14	14
Primary Discharge pH	11.6	11.5	11.2	11.4	11.4

KM3512-19 WR Composite

OVERALL CYCLE TEST MASS AND METALLURGICAL BALANCE

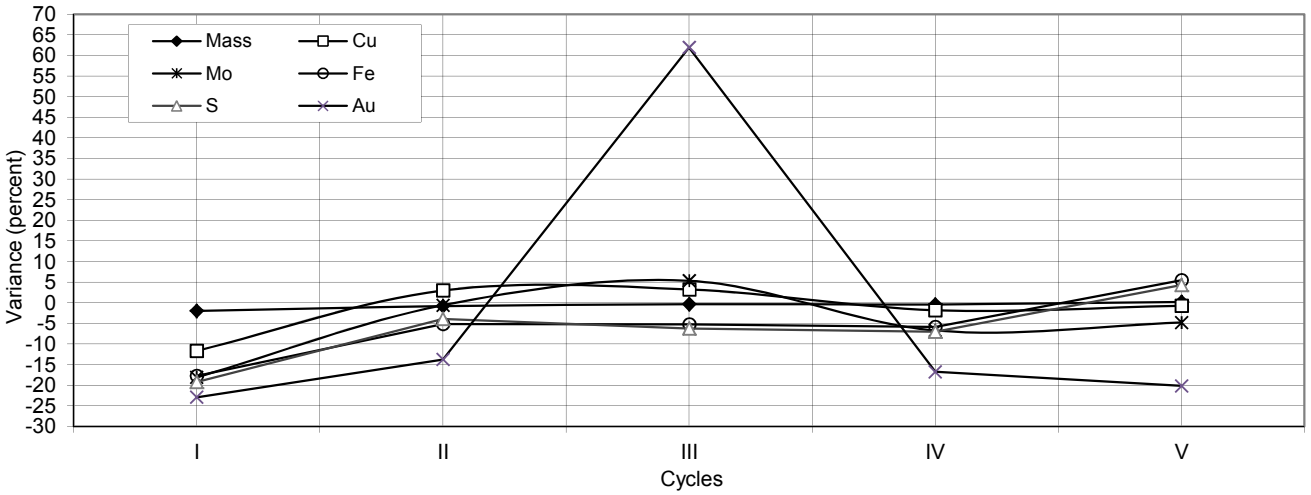
Product	Weight	Weight	Assay - percent or g/t						Distribution - percent					
	%	g	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Bulk Con I	0.1	10.5	**29.2**	2.21	29.4	35.5	104.0	24.9	15.6	11.5	1.1	1.4	7.1	9.5
Bulk Con II	0.1	13.9	**26.1**	2.05	29.4	36.1	112.0	21.5	18.5	14.1	1.5	1.9	10.2	10.9
Bulk Con III	0.2	15.4	**23.5**	1.99	31.1	36.1	102.0	39.6	18.4	15.2	1.8	2.1	10.3	22.2
Bulk Con IV	0.2	15.1	**22.6**	1.81	31.5	37.9	100.0	20.2	17.4	13.5	1.7	2.2	9.9	11.1
Bulk Con V	0.1	13.9	**24.6**	1.93	29.8	36.7	106.0	19.3	17.4	13.3	1.5	2.0	9.6	9.7
Bulk 3rd Clnr Tail	0.1	9.1	0.84	0.30	23.5	24.9	18.0	1.30	0.4	1.4	0.8	0.9	1.1	0.4
Bulk 2nd Clnr Tail	0.6	58.8	0.41	0.13	22.9	24.5	11.0	0.90	1.2	3.6	4.9	5.6	4.2	1.9
Bulk 1st Clnr Tail I	0.9	87.5	0.23	0.03	6.3	6.43	5.0	0.59	1.0	1.2	2.0	2.2	2.9	1.9
Bulk 1st Clnr Tail II	1.3	130.9	0.18	0.05	8.9	9.42	4.0	0.50	1.2	3.0	4.3	4.8	3.4	2.4
Bulk 1st Clnr Tail III	1.3	130.9	0.18	0.05	10.9	11.2	4.0	0.46	1.2	3.2	5.2	5.7	3.4	2.2
Bulk 1st Clnr Tail IV	1.5	153.9	0.16	0.03	9.7	10.1	4.0	0.40	1.3	2.4	5.5	6.0	4.0	2.2
Bulk 1st Clnr Tail V	1.5	153.3	0.17	0.03	11.0	11.5	4.0	0.40	1.3	2.5	6.2	6.8	4.0	2.2
Bulk Ro Tail I	18.6	1858.0	0.01	0.004	2.0	1.75	0.5	0.06	1.0	3.7	13.3	12.5	6.1	4.1
Bulk Ro Tail II	18.4	1834.3	0.01	0.003	2.0	1.77	0.5	0.06	0.9	2.7	13.2	12.5	6.0	4.0
Bulk Ro Tail III	18.5	1841.9	0.01	0.003	1.8	1.54	0.5	0.12	1.0	2.7	12.0	10.9	6.0	8.0
Bulk Ro Tail IV	18.2	1818.5	0.01	0.003	1.7	1.48	0.5	0.05	1.0	2.7	11.6	10.4	5.9	3.3
Bulk Ro Tail V	18.4	1832.7	0.01	0.004	2.0	1.71	0.5	0.06	1.1	3.2	13.4	12.1	6.0	4.0
FEED	100	9979	0.20	0.020	2.7	2.60	2	0.28	100.0	100.0	100.0	100.0	100.0	100.0

KM3512-19 WR Composite
METALLURGICAL BALANCES BY TEST CYCLES

Product	Weight	Weight	Assay - percent or g/t						Distribution - percent					
	%	g	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
CYCLE IV														
Flotation Feed	100.0	1988	0.19	0.02	2.6	2.42	1.5	0.23	100.0	100.0	100.0	100.0	100.0	100.0
Bulk Con	0.8	15.1	22.6	1.8	31.5	37.9	100	20.2	88.4	72.4	9.3	11.9	49.8	66.7
Bulk 1st Clnr Tail	7.7	153.9	0.16	0.03	9.7	10.1	4.0	0.40	6.4	13.1	29.1	32.3	20.3	13.4
Bulk Ro Tail	91.5	1818.5	0.01	0.00	1.7	1.48	0.5	0.05	5.2	14.5	61.6	55.9	30.0	19.9
CYCLE V														
Flotation Feed	100.0	2000	0.20	0.02	2.9	2.70	1.5	0.22	100.0	100.0	100.0	100.0	100.0	100.0
Bulk Con	0.7	13.9	24.6	1.9	29.8	36.7	106	19.3	87.7	69.8	7.2	9.4	49.1	61.0
Bulk 1st Clnr Tail	7.7	153.3	0.17	0.03	11.0	11.5	4.0	0.40	6.7	13.2	29.3	32.6	20.4	14.0
Bulk Ro Tail	91.6	1832.7	0.01	0.00	2.0	1.71	0.5	0.06	5.6	17.1	63.5	58.0	30.5	25.0
CYCLES IV and V														
Flotation Feed	100.0	3987	0.19	0.02	2.7	2.56	1.5	0.22	100.0	100.0	100.0	100.0	100.0	100.0
Bulk Con	0.7	29.0	23.6	1.9	30.7	37.3	103	19.8	88.1	71.1	8.2	10.6	49.4	63.9
Bulk 1st Clnr Tail	7.7	307.2	0.16	0.03	10.3	10.8	4.0	0.40	6.5	13.1	29.2	32.4	20.4	13.7
Bulk Ro Tail	91.6	3651.2	0.01	0.003	1.9	1.60	0.5	0.06	5.4	15.8	62.6	57.0	30.2	22.4

Cycle Test Stability Data

Cycles	Mass		Calculated Head						Metal Unit Variances (%)					
	%Var.	g/cycle	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
I	-2.0	1956.0	0.18	0.017	2.3	2.14	1.26	0.22	-12	-18	-18	-19	-20	-23
II	-0.8	1979.1	0.20	0.020	2.6	2.52	1.51	0.24	3	-1	-5	-4	-2	-14
III	-0.4	1988.2	0.20	0.021	2.6	2.44	1.52	0.45	3	5	-5	-6	-2	62
IV	-0.4	1987.5	0.19	0.019	2.6	2.42	1.53	0.23	-2	-7	-6	-7	-1	-17
V	0.2	1999.9	0.20	0.019	2.9	2.70	1.50	0.22	-1	-5	5	4	-2	-20
Total	-	1995.7	0.20	0.020	2.7	2.60	1.54	0.28	-	-	-	-	-	-



KM3512-19 WR Composite

CYCLES (IV+V) MASS BALANCE FLOWSHEET AND METALLURGICAL BALANCE DATA

Flotation Stream		Weight	Assay (percent or g/t)						Distribution (percent)					
No.	Product	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
1	Bulk Ro Feed	100	0.19	0.019	2.7	2.56	1.5	0.22	100	100.0	100.0	100.0	100.0	100.0
2	Bulk Ro Tail	91.6	0.01	0.003	1.9	1.60	0.5	0.06	5.4	15.8	62.6	57.0	30.2	22.4
3	Bulk Ro Con	8.4	2.18	0.191	12.1	13.1	12.5	2.07	94.6	84.2	37.4	43.0	69.8	77.6
4	Bulk 1st Clnr Feed	11.8	1.69	0.179	15.2	16.4	12.4	1.75	102.7	110.7	66.0	75.5	96.5	92.0
5	Bulk 1st Clnr Tail	7.7	0.16	0.032	10.3	10.8	4.0	0.40	6.5	13.1	29.2	32.4	20.4	13.7
6	Bulk 1st Clnr Con	4.1	4.54	0.451	24.3	26.8	28.0	4.27	96.2	97.6	36.8	43.1	76.2	78.3
7	Bulk 2nd Clnr Tail	2.9	0.41	0.125	22.9	24.5	11.0	0.90	6.2	19.3	24.7	28.1	21.4	11.8
8	Bulk 2nd Clnr Con	1.2	14.8	1.26	27.9	32.5	70.2	12.7	90.0	78.2	12.1	15.0	54.8	66.5
9	Bulk 3rd Clnr Tail	0.5	0.84	0.300	23.5	24.9	18.0	1.30	2.0	7.2	3.9	4.4	5.4	2.6
10	Bulk 3rd Clnr Con	0.7	23.6	1.86	30.7	37.3	102.9	19.8	88.1	71.1	8.2	10.6	49.4	63.9
11	Final Tail	99.3	0.02	0.006	2.5	2.31	0.8	0.08	11.9	28.9	91.8	89.4	50.6	36.1

DATE: September 21, 2012

PROJECT NO: KM3512-20

PURPOSE: Preliminary Locked Cycle Test.

PROCEDURE: Perform a standard one product locked cycle test.

FEED: 5 x 2 kg of IX Composite ore ground to a nominal 234μm K_{80}.
Bulk Regrind Discharge V - 22μm K_{80}.

FLOWSHEET: 3

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	1600	20				11			11.4
BULK CIRCUIT:									
Rougher 1	-		3	6	15		1	2	11.3
Rougher 2	-		2	4	8		1	2	11.3
Rougher 3	-		1	2	8		1	2	11.1
Rougher 4	-		1	2	-		1	2	11.0
Cleaner 1	200		5	10	15		1	5	11.0
Regrind	250	10				10			11.3
Cleaner 2	-	4	4	8	30		1	4	11.0
Cleaner 3	√	-	2	4	30		1	3	11.0

Grinding Data	Primary Grind	Bulk Regrind
Mill:	M3-Mild	RM3-Mild
Charge/Material:	20kg-Mild	6kg-Stainless Steel
Water:	1000 ml	estimated

Flotation Data	Rougher	Clnr 1+2	Clnr 3
Flotation Machine:	D1B	D1B	D1B
Cell Size in liters:	4.4	2.2	1.1
Aspiration:		Air	
Water Type:		Fresh	
Impeller Speed in rpm:	1100	1200	1200

KM3512-20
Estimated Dry Weight Table

Product	Cycles - Weight (gms)				
	I	II	III	IV	V
BULK CIRCUIT:					
Rougher Concentrate	135	135	125	140	135
Cleaner Tail 1	100	125	120	140	145
Cleaner Tail 2	32	32	32	39	37
Cleaner Tail 3	5	5	6	7	5
Bulk Concentrate	8	9	9	8	10
Primary Discharge pH	11.4	11.3	11.4	11.4	11.4

KM3512-20 IX Composite

OVERALL CYCLE TEST MASS AND METALLURGICAL BALANCE

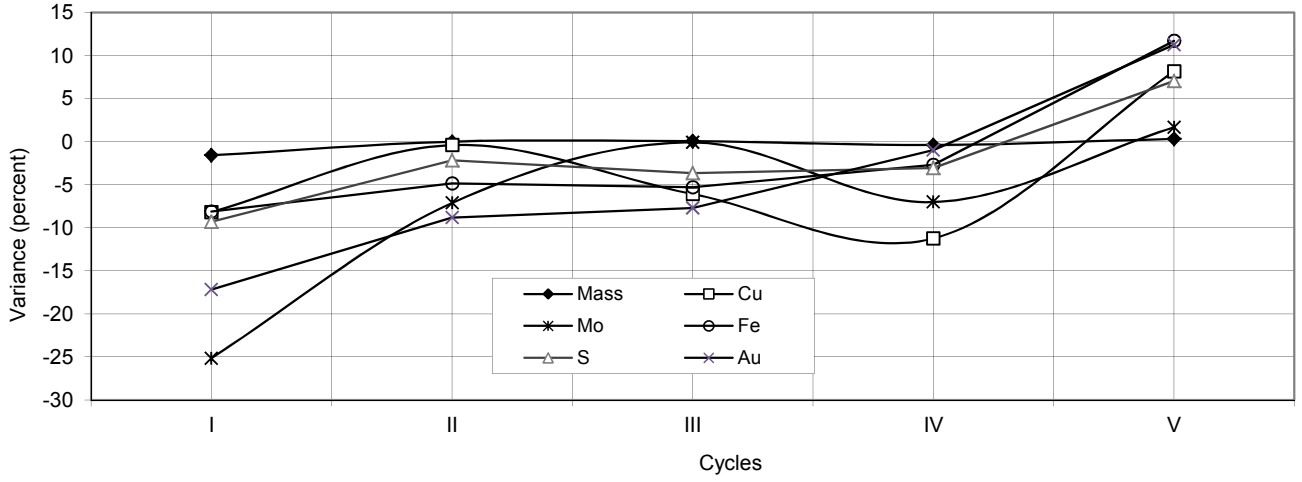
Product	Weight	Weight	Assay - percent or g/t						Distribution - percent					
	%	g	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Bulk Con I	0.1	8.3	**26.6**	6.33	23.7	34.8	130	22.5	13.9	7.7	0.9	1.5	6.3	8.3
Bulk Con II	0.1	9.1	**27.6**	5.58	24.1	34.2	150	24.1	15.8	7.5	1.0	1.6	8.0	9.7
Bulk Con III	0.1	8.3	**27.8**	5.45	24.4	34.6	148	22.6	14.5	6.7	0.9	1.5	7.2	8.3
Bulk Con IV	0.1	7.4	**28.3**	4.65	24.5	34.8	146	24.2	13.2	5.1	0.8	1.3	6.3	8.0
Bulk Con V	0.1	8.8	**28.8**	4.66	24.9	34.8	154	23.7	15.9	6.0	1.0	1.6	8.0	9.3
Bulk 3rd Clnr Tail	0.0	3.4	2.71	1.84	12.9	14.4	42	10.0	0.6	0.9	0.2	0.2	0.8	1.5
Bulk 2nd Clnr Tail	0.3	29.5	1.61	1.53	12.5	13.3	29	2.43	3.0	6.6	1.7	2.0	5.0	3.2
Bulk 1st Clnr Tail I	1.0	94.5	0.29	0.194	6.0	5.59	6	0.80	1.7	2.7	2.6	2.7	3.3	3.4
Bulk 1st Clnr Tail II	1.3	130.7	0.28	0.334	5.2	5.53	6	0.62	2.3	6.4	3.1	3.7	4.6	3.6
Bulk 1st Clnr Tail III	1.1	113.3	0.39	0.530	7.0	7.61	8	0.86	2.8	8.8	3.6	4.4	5.3	4.3
Bulk 1st Clnr Tail IV	1.3	130.0	0.38	0.494	7.2	7.73	8	1.07	3.1	9.4	4.2	5.1	6.1	6.2
Bulk 1st Clnr Tail V	1.4	140.3	0.40	0.440	8.7	8.33	8	1.17	3.5	9.1	5.5	5.9	6.6	7.3
Bulk Ro Tail I	18.6	1840.4	0.02	0.017	1.8	1.50	1	0.06	2.8	4.5	14.9	14.0	10.8	4.9
Bulk Ro Tail II	18.6	1834.6	0.02	0.017	1.8	1.54	1	0.06	1.8	4.7	15.0	14.3	5.4	4.9
Bulk Ro Tail III	18.8	1853.8	0.01	0.016	1.7	1.43	1	0.07	1.5	4.5	14.5	13.4	5.4	5.8
Bulk Ro Tail IV	18.5	1829.3	0.01	0.015	1.8	1.40	1	0.07	1.5	4.1	14.4	13.0	5.4	5.6
Bulk Ro Tail V	18.6	1831.7	0.02	0.019	1.9	1.50	1	0.07	2.2	5.2	15.8	13.9	5.4	5.7
FEED	100	9873	0.16	0.069	2.2	2.00	2	0.23	100.0	100.0	100.0	100.0	100.0	100.0

KM3512-20 IX Composite
METALLURGICAL BALANCES BY TEST CYCLES

Product	Weight	Weight	Assay - percent or g/t						Distribution - percent					
	%	g	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
CYCLE IV														
Flotation Feed	100.0	1967	0.14	0.064	2.2	1.94	2	0.23	100.0	100.0	100.0	100.0	100.0	100.0
Bulk Con	0.4	7.4	28.3	4.65	24.5	34.8	146	24.2	74.1	27.2	4.2	6.7	35.6	40.2
Bulk 1st Clnr Tail	6.6	130.0	0.38	0.494	7.2	7.73	8	1.07	17.5	50.8	21.7	26.3	34.3	31.3
Bulk Ro Tail	93.0	1829.3	0.01	0.015	1.8	1.40	1	0.07	8.4	22.0	74.1	67.0	30.1	28.5
CYCLE V														
Flotation Feed	100.0	1981	0.17	0.070	2.5	2.13	2	0.25	100.0	100.0	100.0	100.0	100.0	100.0
Bulk Con	0.4	8.8	28.8	4.66	24.9	34.8	154	23.7	73.6	29.7	4.4	7.3	39.9	41.7
Bulk 1st Clnr Tail	7.1	140.3	0.40	0.440	8.7	8.33	8	1.17	16.3	44.7	24.6	27.7	33.1	32.9
Bulk Ro Tail	92.5	1831.7	0.02	0.019	1.9	1.50	1	0.07	10.1	25.6	71.0	65.1	27.0	25.4
CYCLES IV and V														
Flotation Feed	100.0	3948	0.16	0.067	2.3	2.04	2	0.24	100.0	100.0	100.0	100.0	100.0	100.0
Bulk Con	0.4	16.2	28.6	4.66	24.7	34.8	150	23.9	73.8	28.5	4.3	7.0	37.9	41.0
Bulk 1st Clnr Tail	6.8	270.3	0.39	0.466	8.0	8.04	8	1.13	16.8	47.6	23.3	27.0	33.6	32.2
Bulk Ro Tail	92.7	3661.0	0.02	0.017	1.8	1.45	1	0.07	9.3	23.9	72.4	66.0	28.5	26.9

Cycle Test Stability Data

Cycles	Mass		Calculated Head						Metal Unit Variances (%)					
	%Var.	g/cycle	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
I	-1.6	1943.2	0.15	0.052	2.1	1.84	1.8	0.19	-8	-25	-8	-9	2	-17
II	0.0	1974.4	0.16	0.064	2.1	1.95	1.6	0.21	0	-7	-5	-2	-10	-9
III	0.0	1975.4	0.15	0.069	2.1	1.92	1.5	0.21	-6	0	-5	-4	-10	-8
IV	-0.4	1966.7	0.14	0.064	2.2	1.94	1.5	0.23	-11	-7	-3	-3	-11	-1
V	0.3	1980.8	0.17	0.070	2.5	2.13	1.7	0.25	8	2	12	7	0	11
Total	-	1974.7	0.16	0.069	2.2	2.00	1.7	0.23	-	-	-	-	-	-



KM3512-20 IX Composite

CYCLES (IV+V) MASS BALANCE FLOWSHEET AND METALLURGICAL BALANCE DATA

Flotation Stream		Weight	Assay (percent or g/t)						Distribution (percent)					
No.	Product	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
1	Bulk Ro Feed	100	0.16	0.067	2.3	2.04	2	0.24	100	100.0	100.0	100.0	100.0	100.0
2	Bulk Ro Tail	92.7	0.02	0.017	1.8	1.45	1	0.07	9.3	23.9	72.4	66.0	28.5	26.9
3	Bulk Ro Con	7.3	1.98	0.703	8.9	9.55	16	2.41	90.7	76.1	27.6	34.0	71.5	73.1
4	Bulk 1st Clnr Feed	8.9	1.94	0.863	9.6	10.3	19	2.56	108.7	114.8	36.4	45.0	102.5	95.4
5	Bulk 1st Clnr Tail	6.8	0.39	0.466	8.0	8.0	8	1.13	16.8	47.6	23.3	27.0	33.6	32.2
6	Bulk 1st Clnr Con	2.1	7.04	2.17	15.0	17.7	54	7.32	91.9	67.2	13.2	17.9	68.8	63.2
7	Bulk 2nd Clnr Tail	1.5	1.61	1.53	12.5	13.3	29	2.43	15.1	34.0	7.9	9.7	26.5	15.1
8	Bulk 2nd Clnr Con	0.6	20.9	3.83	21.2	28.8	118	19.8	76.8	33.2	5.3	8.2	42.3	48.1
9	Bulk 3rd Clnr Tail	0.2	2.71	1.84	12.9	14.4	42	10.0	2.9	4.7	0.9	1.2	4.4	7.2
10	Bulk 3rd Clnr Con	0.4	28.6	4.66	24.7	34.8	150	23.9	73.8	28.5	4.3	7.0	37.9	41.0
11	Final Tail	99.6	0.04	0.048	2.3	1.90	1	0.14	26.2	71.5	95.7	93.0	62.1	59.0

DATE: September 27, 2012

PROJECT NO: KM3512-21

PURPOSE: To Investigate Regrind of the Rougher Concentrate.

PROCEDURE: Perform a standard one product cleaner test.

FEED: 2 kg of IX Composite ore ground to a nominal 234µm K_{80}.
Bulk Regrind Discharge - 24µm K_{80}.

FLOWSHEET: 2

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	1800	20				11			11.5
BULK CIRCUIT:									
Rougher 1	-	-	3	6	15		1	2	11.5
Rougher 2	-	-	2	4	-		1	2	11.4
Rougher 3	-	-	1	2	8		1	2	11.3
Rougher 4	-	-	1	2	8		1	2	11.2
Regrind	200	10				15			11.1
Cleaner 1	-	-	5	10	30		1	6	11.0
Cleaner 2	√	4	2	4	30		1	5	11.0
Cleaner 3	√	-	1	2	30		1	3	11.0

Flotation Data	Rougher	Cleaner
Flotation Machine	D2A	D1B
Cell Size in liters	4.4	2.2
Aspiration	Air	
Water Type	Fresh	
Impeller Speed in rpm	1100	1200

Grinding Data	Primary Regrind	Bulk Regrind
Mill:	M3-Mild	RM3-Mild
Charge/Material:	20kg-Mild	6kg-Stainless Steel
Water:	1000 ml	estimated

KM3512-21 IX Composite
Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Bulk Concentrate	0.6	12.2	**23.9**	9.04	25.9	36.4	87.7	69.6	6.7	12.3
Bulk 3rd Clnr Tail	0.3	6.5	0.78	0.94	10.9	10.3	1.5	3.8	1.5	1.8
Bulk 2nd Clnr Tail	1.2	22.9	0.14	0.20	7.1	5.41	1.0	2.8	3.5	3.4
Bulk 1st Clnr Tail	4.6	91.9	0.07	0.08	7.0	5.62	2.0	4.6	13.7	14.3
Bulk Rougher Tail	93.3	1844.5	0.01	0.02	1.9	1.34	7.8	19.1	74.6	68.2
Feed	100.0	1978.0	0.17	0.080	2.4	1.83	100	100	100	100

KM3512-21 IX Composite
Cumulative Metallurgical Balance

Cumulative Product	Cum. Weight		Assay - percent or g/t				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Product 1	0.6	12.2	23.9	9.04	25.9	36.4	87.7	69.6	6.7	12.3
Product 1 to 2	0.9	18.7	15.9	6.22	20.7	27.3	89.2	73.4	8.2	14.1
Product 1 to 3	2.1	41.6	7.21	2.90	13.2	15.3	90.2	76.2	11.7	17.5
Product 1 to 4	6.7	133.5	2.30	0.96	8.9	8.62	92.2	80.9	25.4	31.8
Product 5	93.3	1844.5	0.01	0.02	1.9	1.34	7.8	19.1	74.6	68.2
Feed	100.0	1978.0	0.168	0.08	2.4	1.83	100	100	100	100

DATE: September 27, 2012

PROJECT NO: KM3512-22

PURPOSE: To Investigate No Filtration of the Rougher Concentrate.

PROCEDURE: Perform a standard one product cleaner test.

FEED: 2 kg of IX Composite ore ground to a nominal 234µm K_{80}.
Bulk Regrind Discharge - 25µm K_{80}.

FLOWSHEET: 2

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	1800	20				11			11.6
BULK CIRCUIT:									
Rougher 1	-	-	3	6	15		1	2	11.6
Rougher 2	-	-	2	4	-		1	2	11.5
Rougher 3	-	-	1	2	8		1	2	11.4
Rougher 4	-	-	1	2	8		1	2	11.3
Cleaner 1	-	-	-	-	8		1	8	11.0
Regrind	250	10				15			11.0
Cleaner 2	-	4	2	4	30		1	4	11.0
Cleaner 3	√	-	1	2	30		1	3	11.0

Flotation Data	Rougher	Cleaner
Flotation Machine	D2A	D1B
Cell Size in liters	4.4	2.2
Aspiration	Air	
Water Type	Fresh	
Impeller Speed in rpm	1100	1200

Grinding Data	Primary Regrind	Bulk Regrind
Mill:	M3-Mild	RM3-Mild
Charge/Material:	20kg-Mild	6kg-Stainless Steel
Water:	1000 ml	estimated

KM3512-22 IX Composite
Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Bulk Concentrate	0.6	11.1	**24.5**	8.83	26.0	35.8	83.8	61.3	6.1	10.3
Bulk 3rd Clnr Tail	0.4	7.7	1.41	0.93	13.2	12.9	3.3	4.5	2.1	2.6
Bulk 2nd Clnr Tail	2.2	43.9	0.29	0.29	12.7	11.7	3.9	8.0	11.8	13.3
Bulk 1st Clnr Tail	4.5	89.5	0.04	0.12	2.5	1.54	1.0	6.5	4.7	3.6
Bulk Rougher Tail	92.3	1828.8	0.01	0.02	2.0	1.48	7.9	19.7	75.3	70.2
Feed	100.0	1981.0	0.16	0.081	2.4	1.95	100	100	100	100

KM3512-22 IX Composite
Cumulative Metallurgical Balance

Cumulative Product	Cum. Weight		Assay - percent or g/t				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Product 1	0.6	11.1	24.5	8.83	26.0	35.8	83.8	61.3	6.1	10.3
Product 1 to 2	0.9	18.8	15.0	5.59	20.8	26.4	87.2	65.8	8.2	12.9
Product 1 to 3	3.2	62.7	4.71	1.88	15.1	16.1	91.1	73.8	20.0	26.2
Product 1 to 4	7.7	152.2	1.96	0.84	7.7	7.54	92.1	80.3	24.7	29.8
Product 5	92.3	1828.8	0.01	0.02	2.0	1.48	7.9	19.7	75.3	70.2
Feed	100.0	1981.0	0.164	0.08	2.4	1.95	100	100	100	100

DATE: October 2, 2012

PROJECT NO: KM3512-23

PURPOSE: Repeat Test 21 Using 4 kg Feed.

PROCEDURE: Perform a standard one product locked cycle test.

FEED: 5 x 4 kg of IX Composite ore ground to a nominal 234μm K_{80}.
Bulk Regrind Discharge V - 31μm K_{80}.

FLOWSHEET: 3

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	1200	20				11			11.1
BULK CIRCUIT:									
Rougher 1	-		3	6	23		1	2	11.0
Rougher 2	-		2	4	-		1	2	11.0
Rougher 3	√		1	2	-		1	2	11.0
Rougher 4	√		1	2	-		1	2	11.0
Regrind	100	10				21			11.0
Cleaner 1	-	-	5	10	15		1	7	11.0
Cleaner 2	√	4	2	4	8		1	5	11.0
Cleaner 3	√	-	1	2	8		1	3	11.0

Grinding Data	Primary Grind	Bulk Regrind
Mill:	M3-Mild	RM3-Mild
Charge/Material:	20kg-Mild	6kg-Stainless Steel
Water:	1000 ml	estimated

Flotation Data	Rougher	Cleaner
Flotation Machine:	D1B	D1B
Cell Size in liters:	4.4	2.2
Aspiration:	Air	
Water Type:	Fresh	
Impeller Speed in rpm:	1100	1200

KM3512-23
Estimated Dry Weight Table

Product	Cycles - Weight (gms)				
	I	II	III	IV	V
BULK CIRCUIT:					
Rougher Concentrate	210	230	225	225	235
Cleaner Tail 1	155	205	215	215	220
Cleaner Tail 2	46	71	72	73	85
Cleaner Tail 3	11	14	17	20	18
Bulk Concentrate	28	31	32	34	32
Primary Discharge pH	11.5	11.3	11.1	11.1	11.1

KM3512-23 IX Composite

OVERALL CYCLE TEST MASS AND METALLURGICAL BALANCE

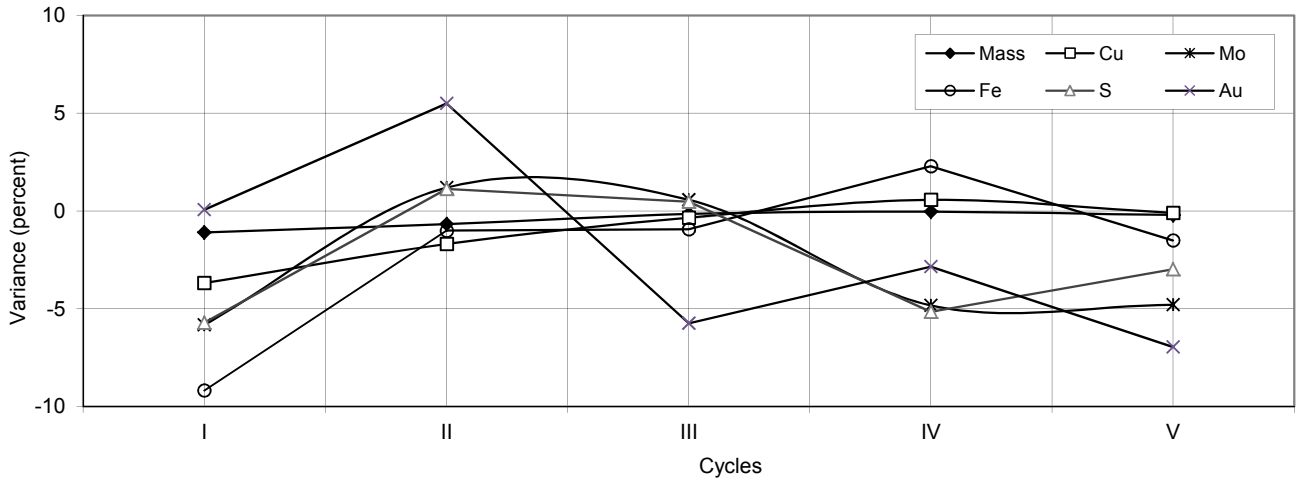
Product	Weight	Weight	Assay - percent or g/t						Distribution - percent					
	%	g	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Bulk Con I	0.1	29.2	**20.1**	8.23	25.9	35.2	130	18.8	17.5	14.7	1.6	2.7	8.7	11.8
Bulk Con II	0.2	31.6	18.8	8.19	26.5	33.7	126	17.0	17.7	15.8	1.8	2.8	9.1	11.6
Bulk Con III	0.2	32.2	18.6	7.98	27.9	37.5	122	16.5	17.9	15.7	1.9	3.2	9.0	11.4
Bulk Con IV	0.2	34.5	17.6	7.10	27.7	35.5	124	15.4	18.1	15.0	2.1	3.2	9.8	11.4
Bulk Con V	0.2	30.4	**19.8**	7.92	26.1	34.0	128	16.0	17.9	14.7	1.7	2.7	8.9	10.4
Bulk 3rd Clnr Tail	0.1	15.6	0.85	1.12	13.9	14.3	23	1.62	0.4	1.1	0.5	0.6	0.8	0.5
Bulk 2nd Clnr Tail	0.4	71.3	0.31	0.385	10.4	9.92	10	0.95	0.7	1.7	1.6	1.9	1.6	1.5
Bulk 1st Clnr Tail I	0.7	144.3	0.10	0.122	7.1	6.84	4	0.56	0.4	1.1	2.2	2.6	1.3	1.7
Bulk 1st Clnr Tail II	0.9	185.9	0.07	0.134	7.6	7.09	4	0.60	0.4	1.5	3.1	3.5	1.7	2.4
Bulk 1st Clnr Tail III	1.0	194.2	0.11	0.184	9.0	8.79	5	0.59	0.6	2.2	3.8	4.5	2.2	2.5
Bulk 1st Clnr Tail IV	1.0	191.0	0.10	0.183	8.8	8.53	5	0.55	0.6	2.1	3.6	4.3	2.2	2.3
Bulk 1st Clnr Tail V	1.0	200.3	0.10	0.179	8.3	7.75	5	0.58	0.6	2.2	3.6	4.1	2.3	2.5
Bulk Ro Tail I	18.9	3743.4	0.01	0.013	1.8	1.37	1	0.08	1.3	3.1	14.3	13.5	8.5	6.5
Bulk Ro Tail II	18.8	3716.8	0.01	0.013	1.9	1.42	1	0.09	1.6	2.9	14.9	13.9	8.5	7.2
Bulk Ro Tail III	18.8	3728.1	0.01	0.010	1.8	1.26	1	0.06	1.4	2.2	14.1	12.4	8.5	5.0
Bulk Ro Tail IV	18.9	3733.6	0.01	0.008	1.8	1.16	1	0.07	1.4	1.9	14.8	11.4	8.5	5.8
Bulk Ro Tail V	18.8	3721.8	0.01	0.009	1.8	1.28	1	0.07	1.4	2.1	14.4	12.6	8.5	5.7
FEED	100	19804	0.17	0.083	2.3	1.91	2	0.24	100.0	100.0	100.0	100.0	100.0	100.0

KM3512-23 IX Composite
METALLURGICAL BALANCES BY TEST CYCLES

Product	Weight	Weight	Assay - percent or g/t						Distribution - percent					
	%	g	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
CYCLE IV														
Flotation Feed	100.0	3959	0.17	0.079	2.4	1.81	2	0.23	100.0	100.0	100.0	100.0	100.0	100.0
Bulk Con	0.9	34.5	17.6	7.10	27.7	35.5	124	15.4	90.0	78.6	10.1	17.0	47.7	58.6
Bulk 1st Clnr Tail	4.8	191.0	0.10	0.183	8.8	8.53	5	0.55	2.8	11.2	17.8	22.7	10.7	11.7
Bulk Ro Tail	94.3	3733.6	0.01	0.008	1.8	1.16	1	0.07	7.2	10.1	72.2	60.3	41.6	29.7
CYCLE V														
Flotation Feed	100.0	3953	0.17	0.079	2.3	1.86	2	0.22	100.0	100.0	100.0	100.0	100.0	100.0
Bulk Con	0.8	30.4	19.8	7.92	26.1	34.0	128	16.0	89.8	77.2	8.7	14.1	45.2	56.0
Bulk 1st Clnr Tail	5.1	200.3	0.10	0.179	8.3	7.75	5	0.58	3.0	11.5	18.2	21.1	11.6	13.4
Bulk Ro Tail	94.2	3721.8	0.01	0.009	1.8	1.28	1	0.07	7.2	11.3	73.1	64.8	43.2	30.6
CYCLES IV and V														
Flotation Feed	100.0	7912	0.17	0.079	2.3	1.84	2	0.22	100.0	100.0	100.0	100.0	100.0	100.0
Bulk Con	0.8	64.9	18.6	7.48	27.0	34.8	126	15.6	89.9	77.9	9.4	15.5	46.5	57.3
Bulk 1st Clnr Tail	4.9	391.3	0.10	0.181	8.5	8.13	5	0.57	2.9	11.4	18.0	21.9	11.1	12.5
Bulk Ro Tail	94.2	7455.4	0.01	0.009	1.8	1.22	1	0.07	7.2	10.7	72.6	62.6	42.4	30.1

Cycle Test Stability Data

Cycles	Mass		Calculated Head						Metal Unit Variances (%)					
	%Var.	g/cycle	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
I	-1.1	3916.9	0.16	0.079	2.1	1.82	2	0.24	-4	-6	-9	-6	-7	0
II	-0.7	3934.3	0.17	0.084	2.3	1.95	2	0.25	-2	1	-1	1	-4	5
III	-0.2	3954.5	0.17	0.083	2.3	1.92	2	0.22	0	1	-1	0	-2	-6
IV	0.0	3959.1	0.17	0.079	2.4	1.81	2	0.23	1	-5	2	-5	2	-3
V	-0.2	3952.5	0.17	0.079	2.3	1.86	2	0.22	0	-5	-2	-3	-2	-7
Total	-	3960.8	0.17	0.083	2.3	1.91	2	0.24	-	-	-	-	-	-



KM3512-23 IX Composite

CYCLES (IV+V) MASS BALANCE FLOWSHEET AND METALLURGICAL BALANCE DATA

Flotation Stream		Weight	Assay (percent or g/t)						Distribution (percent)					
No.	Product	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
1	Bulk Ro Feed	100	0.17	0.079	2.3	1.84	2	0.22	100	100.0	100.0	100.0	100.0	100.0
2	Bulk Ro Tail	94.2	0.01	0.009	1.8	1.22	1	0.07	7.2	10.7	72.6	62.6	42.4	30.1
3	Bulk Ro Con	5.8	2.74	1.22	11.2	11.9	22	2.71	92.8	89.3	27.4	37.4	57.6	69.9
4	Bulk 1st Clnr Feed	8.0	2.09	1.03	11.1	11.6	19	2.26	98.1	103.7	37.7	50.2	69.8	80.4
5	Bulk 1st Clnr Tail	4.9	0.10	0.181	8.5	8.13	5	0.57	2.9	11.4	18.0	21.9	11.1	12.5
6	Bulk 1st Clnr Con	3.0	5.36	2.41	15.4	17.3	43	5.03	95.1	92.4	19.7	28.4	58.7	67.9
7	Bulk 2nd Clnr Tail	1.8	0.31	0.385	10.4	9.92	10	0.95	3.3	8.8	8.0	9.7	8.1	7.7
8	Bulk 2nd Clnr Con	1.2	12.9	5.42	22.7	28.1	92	11.1	91.9	83.5	11.7	18.6	50.6	60.2
9	Bulk 3rd Clnr Tail	0.4	0.85	1.12	13.9	14.3	23	1.62	2.0	5.6	2.3	3.1	4.1	2.9
10	Bulk 3rd Clnr Con	0.8	18.6	7.48	27.0	34.8	126	15.6	89.9	77.9	9.4	15.5	46.5	57.3
11	Final Tail	99.2	0.02	0.018	2.1	1.56	1	0.10	10.1	22.1	90.6	84.5	53.5	42.7

DATE: October 3, 2012

PROJECT NO: KM3512-24

PURPOSE: Repeat Test 18 With an Alternate Flowsheet.

PROCEDURE: Perform a standard one product locked cycle test.

FEED: 5 x 4 kg of PP Composite ore ground to a nominal 254μm K_{80}.
Bulk Regrind Discharge V - 32μm K_{80}.

FLOWSHEET: 3

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	1200	10				9.5			11.2
BULK CIRCUIT:									
Rougher 1	-		2	4	23		1	2	11.2
Rougher 2	-		2	4	-		1	2	11.1
Rougher 3	-		2	4	-		1	2	11.0
Rougher 4	√		1	2	-		1	2	11.0
Regrind	150	10				14			11.1
Cleaner 1	-	-	5	10	15		1	6	11.0
Cleaner 2	√	4	2	4	8		1	3	11.0
Cleaner 3	√	-	1	2	8		1	2	11.0

Grinding Data	Primary Grind	Bulk Regrind
Mill:	M3-Mild	RM3-Mild
Charge/Material:	20kg-Mild	6kg-Stainless Steel
Water:	1000 ml	estimated

Flotation Data	Rougher	Cleaner
Flotation Machine:	D1B	D1B
Cell Size in liters:	4.4	2.2
Aspiration:	Air	
Water Type:	Fresh	
Impeller Speed in rpm:	1100	1200

KM3512-24
Estimated Dry Weight Table

Product	Cycles - Weight (gms)				
	I	II	III	IV	V
BULK CIRCUIT:					
Rougher Concentrate	290	295	280	285	280
Cleaner Tail 1	240	285	270	275	280
Cleaner Tail 2	48	59	61	72	69
Cleaner Tail 3	8	9	19	11	11
Bulk Concentrate	19	19	20	20	20
Primary Discharge pH	11.5	11.2	11.1	11.2	11.2

KM3512-24 PP Composite

OVERALL CYCLE TEST MASS AND METALLURGICAL BALANCE

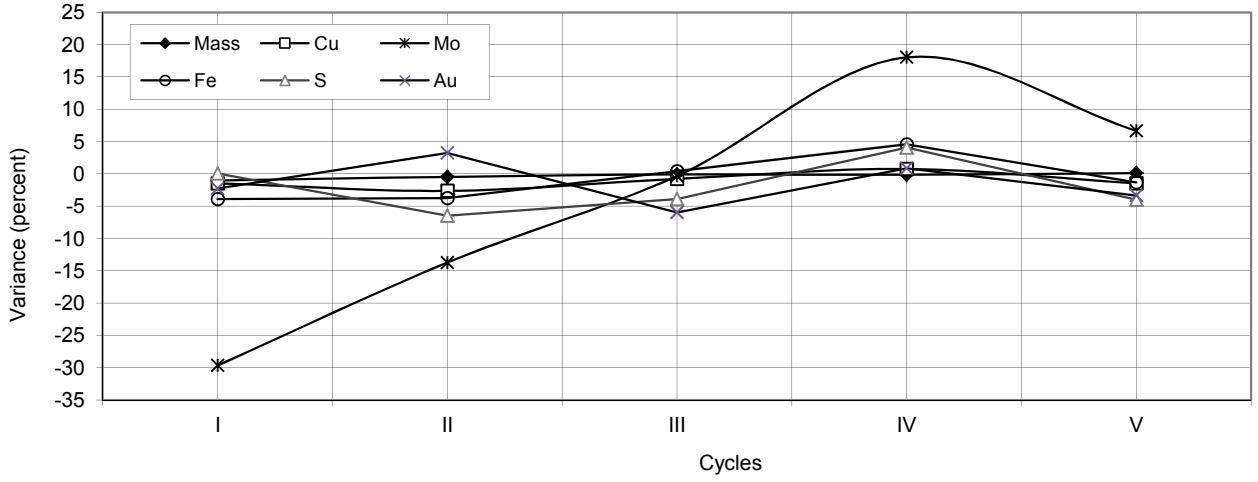
Product	Weight	Weight	Assay - percent or g/t						Distribution - percent					
	%	g	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Bulk Con I	0.1	20.1	**24.1**	2.34	25.4	36.1	92	22.1	17.3	9.7	0.9	5.1	8.2	10.1
Bulk Con II	0.1	18.9	**25.3**	3.53	25.8	33.5	106	28.6	17.0	13.7	0.8	4.5	8.9	12.2
Bulk Con III	0.1	20.2	**23.9**	3.90	25.1	31.2	100	24.1	17.2	16.2	0.9	4.5	9.0	11.0
Bulk Con IV	0.1	19.9	**24.7**	4.62	25.8	33.0	108	24.7	17.5	19.0	0.9	4.7	9.6	11.1
Bulk Con V	0.1	19.8	**24.4**	4.01	26.0	33.7	106	23.9	17.2	16.4	0.9	4.7	9.3	10.7
Bulk 3rd Clnr Tail	0.0	8.1	1.54	0.767	11.5	10.4	27	3.02	0.4	1.3	0.2	0.6	1.0	0.6
Bulk 2nd Clnr Tail	0.3	56.4	0.34	0.218	6.5	3.63	8	0.74	0.7	2.5	0.6	1.5	2.0	0.9
Bulk 1st Clnr Tail I	1.1	221.0	0.04	0.022	4.0	1.60	2	0.22	0.3	1.0	1.5	2.5	2.0	1.1
Bulk 1st Clnr Tail II	1.3	257.8	0.05	0.035	4.5	1.95	1	0.30	0.5	1.8	2.0	3.6	1.1	1.8
Bulk 1st Clnr Tail III	1.2	246.4	0.05	0.029	4.8	2.08	2	0.34	0.4	1.5	2.0	3.6	2.2	1.9
Bulk 1st Clnr Tail IV	1.3	255.3	0.06	0.038	4.7	2.15	3	0.26	0.5	2.0	2.1	3.9	3.4	1.5
Bulk 1st Clnr Tail V	1.3	261.7	0.06	0.030	4.5	2.03	2	0.32	0.5	1.6	2.0	3.8	2.3	1.9
Bulk Ro Tail I	18.6	3690.2	0.02	0.004	2.6	0.47	1	0.10	2.1	3.4	16.8	12.4	8.2	8.4
Bulk Ro Tail II	18.5	3676.1	0.02	0.002	2.6	0.41	1	0.08	2.0	1.7	16.4	10.7	8.2	6.7
Bulk Ro Tail III	18.6	3701.3	0.02	0.003	2.7	0.42	1	0.07	2.2	2.2	17.2	11.1	8.2	5.9
Bulk Ro Tail IV	18.6	3691.0	0.02	0.003	2.8	0.47	1	0.09	2.1	2.6	18.0	12.3	8.2	7.5
Bulk Ro Tail V	18.6	3695.2	0.02	0.004	2.6	0.41	1	0.08	2.0	3.4	16.8	10.7	8.2	6.7
FEED	100	19859	0.14	0.024	2.9	0.71	1	0.22	100.0	100.0	100.0	100.0	100.0	100.0

KM3512-24 PP Composite
METALLURGICAL BALANCES BY TEST CYCLES

Product	Weight	Weight	Assay - percent or g/t						Distribution - percent					
	%	g	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
CYCLE IV														
Flotation Feed	100.0	3966	0.14	0.029	3.0	0.74	1	0.22	100.0	100.0	100.0	100.0	100.0	100.0
Bulk Con	0.5	19.9	24.7	4.62	25.8	33.0	108	24.7	86.9	80.3	4.3	22.4	45.1	55.2
Bulk 1st Clnr Tail	6.4	255.3	0.06	0.038	4.7	2.15	3	0.26	2.6	8.5	9.9	18.7	16.1	7.5
Bulk Ro Tail	93.1	3691.0	0.02	0.003	2.8	0.47	1	0.09	10.4	11.2	85.8	58.9	38.8	37.3
CYCLE V														
Flotation Feed	100.0	3977	0.14	0.026	2.9	0.68	1	0.21	100.0	100.0	100.0	100.0	100.0	100.0
Bulk Con	0.5	19.8	24.4	4.01	26.0	33.7	106	23.9	87.4	76.8	4.5	24.6	47.0	55.5
Bulk 1st Clnr Tail	6.6	261.7	0.06	0.030	4.5	2.03	2	0.32	2.6	7.5	10.3	19.6	11.7	9.8
Bulk Ro Tail	92.9	3695.2	0.02	0.004	2.6	0.41	1	0.08	10.0	15.7	85.2	55.8	41.3	34.7
CYCLES IV and V														
Flotation Feed	100.0	7943	0.14	0.027	2.9	0.71	1	0.22	100.0	100.0	100.0	100.0	100.0	100.0
Bulk Con	0.5	39.7	24.6	4.32	25.9	33.3	107	24.3	87.2	78.6	4.4	23.4	46.0	55.4
Bulk 1st Clnr Tail	6.5	517.0	0.06	0.034	4.6	2.09	2	0.29	2.6	8.0	10.1	19.1	14.0	8.6
Bulk Ro Tail	93.0	7386.2	0.02	0.004	2.7	0.44	1	0.08	10.2	13.3	85.5	57.4	40.0	36.0

Cycle Test Stability Data

Cycles	Mass		Calculated Head						Metal Unit Variances (%)					
	%Var.	g/cycle	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
I	-1.0	3931.3	0.14	0.017	2.8	0.72	1	0.22	-1	-30	-4	0	-8	-2
II	-0.5	3952.8	0.14	0.021	2.8	0.67	1	0.23	-3	-14	-4	-6	-9	3
III	-0.1	3967.9	0.14	0.024	2.9	0.68	1	0.21	-1	0	0	-4	-3	-6
IV	-0.1	3966.2	0.14	0.029	3.0	0.74	1	0.22	1	18	5	4	6	1
V	0.1	3976.7	0.14	0.026	2.9	0.68	1	0.21	-1	7	-1	-4	-1	-3
Total	-	3971.9	0.14	0.024	2.9	0.71	1	0.22	-	-	-	-	-	-



KM3512-24 PP Composite

CYCLES (IV+V) MASS BALANCE FLOWSHEET AND METALLURGICAL BALANCE DATA

Flotation Stream		Weight	Assay (percent or g/t)						Distribution (percent)					
No.	Product	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
1	Bulk Ro Feed	100	0.14	0.027	2.9	0.71	1	0.22	100	100.0	100.0	100.0	100.0	100.0
2	Bulk Ro Tail	93.0	0.02	0.004	2.7	0.44	1	0.08	10.2	13.3	85.5	57.4	40.0	36.0
3	Bulk Ro Con	7.0	1.80	0.339	6.1	4.32	10	2.00	89.8	86.7	14.5	42.6	60.0	64.0
4	Bulk 1st Clnr Feed	8.6	1.56	0.329	6.3	4.35	10	1.82	95.4	103.6	18.4	52.8	74.5	71.6
5	Bulk 1st Clnr Tail	6.5	0.06	0.034	4.6	2.09	2	0.29	2.6	8.0	10.1	19.1	14.0	8.6
6	Bulk 1st Clnr Con	2.1	6.16	1.24	11.5	11.3	33	6.51	92.8	95.6	8.3	33.7	60.5	62.9
7	Bulk 2nd Clnr Tail	1.4	0.34	0.218	6.5	3.63	8	0.74	3.4	11.3	3.1	7.2	9.8	4.8
8	Bulk 2nd Clnr Con	0.7	17.9	3.29	21.7	26.7	84	18.1	89.4	84.3	5.2	26.4	50.8	58.2
9	Bulk 3rd Clnr Tail	0.2	1.54	0.767	11.5	10.4	27	3.02	2.2	5.7	0.8	3.0	4.7	2.8
10	Bulk 3rd Clnr Con	0.5	24.6	4.32	25.9	33.3	107	24.3	87.2	78.6	4.4	23.4	46.0	55.4
11	Final Tail	99.5	0.02	0.006	2.8	0.55	1	0.10	12.8	21.4	95.6	76.6	54.0	44.6

DATE: October 3, 2012

PROJECT NO: KM3512-25

PURPOSE: Repeat Test 19 With an Alternate Flowsheet.

PROCEDURE: Perform a standard one product locked cycle test.

FEED: 5 x 4 kg of WR Composite ore ground to a nominal 211μm K_{80}.
Bulk Regrind Discharge V - 31μm K_{80}.

FLOWSHEET: 3

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	1300	10				9.5			11.2
BULK CIRCUIT:									
Rougher 1	-		2	4	15		1	2	11.2
Rougher 2	-		2	4	8		1	2	11.1
Rougher 3	-		1	2	8		1	2	11.0
Rougher 4	√		1	2	15		1	2	11.0
Regrind	175	10				14			11.1
Cleaner 1	-	-	5	10	60		1	6	11.0
Cleaner 2	-	4	4	8	60		1	3	11.0
Cleaner 3	√	-	2	4	60		1	2	11.0

Grinding Data	Primary Grind	Bulk Regrind
Mill:	M3-Mild	RM3-Mild
Charge/Material:	20kg-Mild	6kg-Stainless Steel
Water:	1000 ml	estimated

Flotation Data	Rougher	Cleaner
Flotation Machine:	D1B	D1B
Cell Size in liters:	4.4	2.2
Aspiration:	Air	
Water Type:	Fresh	
Impeller Speed in rpm:	1100	1200

KM3512-25
Estimated Dry Weight Table

Product	Cycles - Weight (gms)				
	I	II	III	IV	V
BULK CIRCUIT:					
Rougher Concentrate	280	265	275	280	275
Cleaner Tail 1	210	220	220	255	245
Cleaner Tail 2	57	64	83	75	85
Cleaner Tail 3	17	20	29	28	28
Bulk Concentrate	30	42	38	43	41
Primary Discharge pH	11.4	11.2	11.1	11.2	11.2

KM3512-25 WR Composite

OVERALL CYCLE TEST MASS AND METALLURGICAL BALANCE

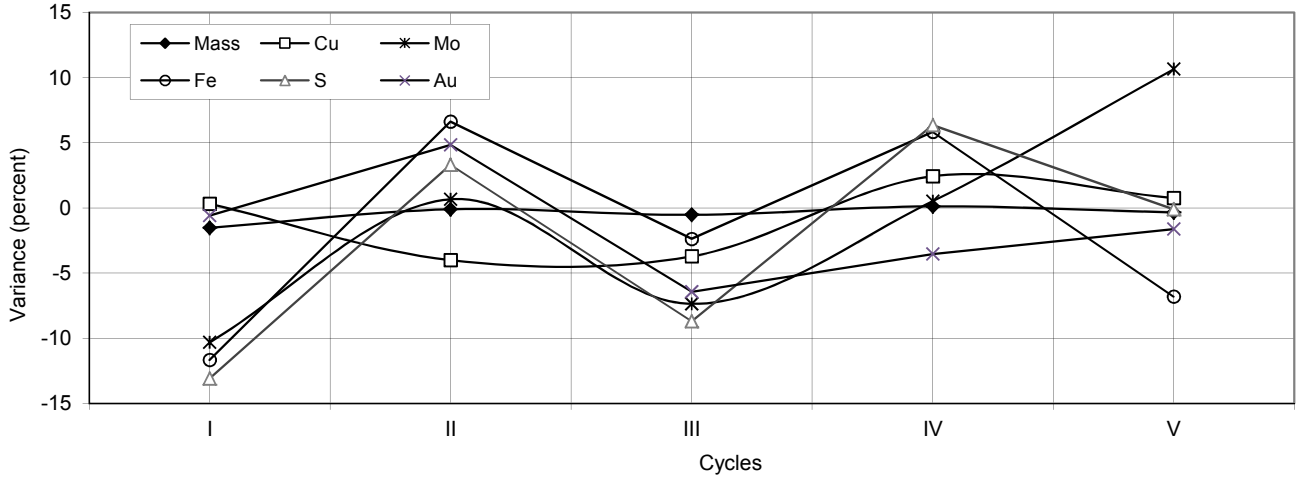
Product	Weight	Weight	Assay - percent or g/t						Distribution - percent					
	%	g	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
Bulk Con I	0.2	31.0	**23.3**	1.57	29.5	36.6	92	17.3	18.6	14.8	1.9	2.3	8.6	12.5
Bulk Con II	0.2	43.6	15.7	1.31	31.8	38.8	80	14.5	17.6	17.3	2.8	3.5	10.6	14.8
Bulk Con III	0.2	39.7	17.1	1.34	31.9	39.1	80	13.1	17.5	16.1	2.6	3.2	9.6	12.1
Bulk Con IV	0.2	41.3	17.6	1.41	31.2	38.1	84	13.2	18.7	17.6	2.6	3.3	10.5	12.7
Bulk Con V	0.2	41.5	17.4	1.60	18.7	39.5	80	13.9	18.6	20.1	1.6	3.4	10.1	13.5
Bulk 3rd Clnr Tail	0.1	23.2	0.70	0.075	7.7	20.7	14	1.11	0.4	0.5	0.4	1.0	1.0	0.6
Bulk 2nd Clnr Tail	0.4	72.2	0.23	0.030	9.0	9.72	7	0.52	0.4	0.6	1.3	1.5	1.5	0.9
Bulk 1st Clnr Tail I	0.9	186.1	0.10	0.020	9.3	12.7	4	0.42	0.5	1.1	3.5	4.9	2.3	1.8
Bulk 1st Clnr Tail II	1.0	207.1	0.11	0.013	13.0	14.6	4	0.36	0.6	0.8	5.5	6.3	2.5	1.7
Bulk 1st Clnr Tail III	1.0	208.4	0.13	0.017	12.2	13.1	5	0.44	0.7	1.1	5.1	5.7	3.2	2.1
Bulk 1st Clnr Tail IV	1.2	244.4	0.11	0.012	12.8	13.6	5	0.36	0.7	0.9	6.3	6.9	3.7	2.1
Bulk 1st Clnr Tail V	1.1	222.9	0.10	0.013	13.2	14.3	4	0.35	0.6	0.9	6.0	6.6	2.7	1.8
Bulk Ro Tail I	18.6	3708.6	0.01	0.002	1.6	1.32	1	0.06	1.0	2.0	12.3	10.1	11.2	5.6
Bulk Ro Tail II	18.7	3731.6	0.01	0.002	1.7	1.41	1	0.05	1.0	2.1	13.1	10.9	5.7	4.5
Bulk Ro Tail III	18.6	3717.2	0.01	0.001	1.6	1.22	1	0.05	1.1	1.3	11.8	9.4	5.6	4.4
Bulk Ro Tail IV	18.6	3705.4	0.01	0.001	1.6	1.45	1	0.05	1.1	1.5	12.2	11.1	5.6	4.5
Bulk Ro Tail V	18.6	3708.2	0.01	0.001	1.5	1.30	1	0.05	1.0	1.1	11.1	10.0	5.6	4.4
FEED	100	19932	0.19	0.017	2.5	2.42	2	0.21	100.0	100.0	100.0	100.0	100.0	100.0

KM3512-25 WR Composite
METALLURGICAL BALANCES BY TEST CYCLES

Product	Weight	Weight	Assay - percent or g/t						Distribution - percent					
	%	g	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
CYCLE IV														
Flotation Feed	100.0	3991	0.20	0.017	2.6	2.57	2	0.21	100.0	100.0	100.0	100.0	100.0	100.0
Bulk Con	1.0	41.3	17.6	1.41	31.2	38.1	84	13.2	91.5	87.7	12.3	15.3	53.0	65.8
Bulk 1st Clnr Tail	6.1	244.4	0.11	0.012	12.8	13.6	5	0.36	3.4	4.6	29.9	32.4	18.7	10.7
Bulk Ro Tail	92.8	3705.4	0.01	0.001	1.6	1.45	1	0.05	5.1	7.7	57.8	52.3	28.3	23.5
CYCLE V														
Flotation Feed	100.0	3973	0.20	0.018	2.3	2.43	2	0.21	100.0	100.0	100.0	100.0	100.0	100.0
Bulk Con	1.0	41.5	17.4	1.60	18.7	39.5	80	13.9	92.4	90.9	8.4	17.0	54.7	68.5
Bulk 1st Clnr Tail	5.6	222.9	0.10	0.013	13.2	14.3	4	0.35	2.9	3.9	32.0	33.0	14.7	9.3
Bulk Ro Tail	93.3	3708.2	0.01	0.001	1.5	1.30	1	0.05	4.7	5.2	59.6	50.0	30.6	22.2
CYCLES IV and V														
Flotation Feed	100.0	7964	0.20	0.017	2.5	2.50	2	0.21	100.0	100.0	100.0	100.0	100.0	100.0
Bulk Con	1.0	82.8	17.5	1.50	24.9	38.8	82	13.5	91.9	89.4	10.5	16.1	53.8	67.2
Bulk 1st Clnr Tail	5.9	467.3	0.11	0.013	13.0	13.9	5	0.36	3.1	4.3	30.9	32.7	16.8	10.0
Bulk Ro Tail	93.1	7413.6	0.01	0.001	1.6	1.37	1	0.05	4.9	6.4	58.6	51.2	29.4	22.8

Cycle Test Stability Data

Cycles	Mass		Calculated Head						Metal Unit Variances (%)					
	%Var.	g/cycle	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
I	-1.5	3925.7	0.20	0.015	2.2	2.14	2	0.22	0	-10	-12	-13	11	-1
II	-0.1	3982.3	0.19	0.017	2.6	2.51	2	0.23	-4	1	7	3	-6	5
III	-0.5	3965.3	0.19	0.015	2.4	2.22	2	0.20	-4	-7	-2	-9	-8	-6
IV	0.1	3991.1	0.20	0.017	2.6	2.57	2	0.21	2	1	6	6	-1	-4
V	-0.3	3972.6	0.20	0.018	2.3	2.43	2	0.21	1	11	-7	0	-8	-2
Total	-	3986.5	0.19	0.017	2.5	2.42	2	0.21	-	-	-	-	-	-



KM3512-25 WR Composite

CYCLES (IV+V) MASS BALANCE FLOWSHEET AND METALLURGICAL BALANCE DATA

Flotation Stream		Weight	Assay (percent or g/t)						Distribution (percent)					
No.	Product	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
1	Bulk Ro Feed	100	0.20	0.017	2.5	2.50	2	0.21	100	100.0	100.0	100.0	100.0	100.0
2	Bulk Ro Tail	93.1	0.01	0.001	1.6	1.37	1	0.05	4.9	6.4	58.6	51.2	29.4	22.8
3	Bulk Ro Con	6.9	2.72	0.237	14.8	17.7	16	2.34	95.1	93.6	41.4	48.8	70.6	77.2
4	Bulk 1st Clnr Feed	9.3	2.11	0.186	13.2	16.3	14	1.91	99.2	99.2	49.8	60.7	83.8	84.8
5	Bulk 1st Clnr Tail	5.9	0.11	0.013	13.0	13.93	5	0.36	3.1	4.3	30.9	32.7	16.8	10.0
6	Bulk 1st Clnr Con	3.4	5.53	0.482	13.6	20.4	31	4.55	96.1	94.9	18.9	28.0	67.0	74.8
7	Bulk 2nd Clnr Tail	1.8	0.23	0.030	9.0	9.72	7	0.52	2.1	3.1	6.6	7.1	8.0	4.5
8	Bulk 2nd Clnr Con	1.6	11.5	0.989	18.7	32.3	58	9.07	94.0	91.9	12.3	21.0	59.0	70.3
9	Bulk 3rd Clnr Tail	0.6	0.70	0.075	7.7	20.7	14	1.11	2.1	2.5	1.8	4.8	5.2	3.1
10	Bulk 3rd Clnr Con	1.0	17.5	1.50	24.9	38.8	82	13.5	91.9	89.4	10.5	16.1	53.8	67.2
11	Final Tail	99.0	0.02	0.002	2.2	2.12	1	0.07	8.1	10.6	89.5	83.9	46.2	32.8

DATE: October 17, 2012

PROJECT NO: KM3512-26

PURPOSE: To Repeat Test 5 With More Fuel Oil.

PROCEDURE: Perform a standard one product rougher test.

FEED: 2 kg of IX Composite ore ground to a nominal 155μm K_{80}.

FLOWSHEET: 1

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	1200	30				14.5			11.0
BULK CIRCUIT:									
Rougher 1	-		3	6	15		1	2	11.0
Rougher 2	√		2	4	8		1	2	11.0
Rougher 3	√		1	2	8		1	2	11.0
Rougher 4	-		1	2	8		1	2	11.0

Flotation Data	Rougher	
Flotation Machine:	D2A	
Cell Size in liters:	4.4	
Aspiration:	Air	
Water Type:	Fresh	
Impeller Speed in rpm:	1100	

Grinding Data	Primary Grind
Mill:	M3-Mild
Charge/Material:	20kg-Mild
Water:	1000 ml

KM3512-26 IX Composite
Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Bulk Ro Con 1	2.7	53.8	5.44	2.26	13.2	17.1	90.1	88.0	15.0	23.8
Bulk Ro Con 2	1.5	30.3	0.30	0.119	8.7	11.1	2.8	2.6	5.6	8.7
Bulk Ro Con 3	1.7	34.0	0.10	0.030	5.9	4.49	1.0	0.7	4.2	3.9
Bulk Ro Con 4	1.9	37.3	0.09	0.015	6.7	5.59	1.0	0.4	5.3	5.4
Bulk RoTl	92.2	1829.3	0.01	0.006	1.8	1.23	5.1	8.2	69.9	58.2
Feed	100.0	1985	0.16	0.070	2.4	1.95	100	100	100	100

KM3512-26 IX Composite
Cumulative Metallurgical Balance

Cumulative Product	Cum. Weight		Assay - percent or g/t				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Product 1	2.7	53.8	5.44	2.26	13.2	17.1	90.1	88.0	15.0	23.8
Product 1 to 2	4.2	84.1	3.59	1.49	11.6	14.9	92.9	90.6	20.6	32.5
Product 1 to 3	6.0	118.1	2.58	1.07	9.9	11.9	93.9	91.4	24.8	36.4
Product 1 to 4	7.8	155.4	1.98	0.817	9.2	10.4	94.9	91.8	30.1	41.8
Product 5	92.2	1829.3	0.01	0.006	1.8	1.23	5.1	8.2	69.9	58.2
Feed	100.0	1985	0.16	0.070	2.4	1.95	100	100	100	100

DATE: October 17, 2012

PROJECT NO: KM3512-27

PURPOSE: To Repeat Test 26 at a 200μm Primary Grind.

PROCEDURE: Perform a standard one product rougher test.

FEED: 2 kg of IX Composite ore ground to a nominal 187μm K_{80}.

FLOWSHEET: 1

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	1200	30				13			11.1
BULK CIRCUIT:									
Rougher 1	-		3	6	15		1	2	11.0
Rougher 2	-		2	4	8		1	2	11.0
Rougher 3	√		1	2	8		1	2	11.0
Rougher 4	√		1	2	8		1	2	11.0

Flotation Data	Rougher
Flotation Machine:	D2A
Cell Size in liters:	4.4
Aspiration:	Air
Water Type:	Fresh
Impeller Speed in rpm:	1100

Grinding Data	Primary Grind
Mill:	M3-Mild
Charge/Material:	20kg-Mild
Water:	1000 ml

KM3512-27 IX Composite
Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Bulk Ro Con 1	2.9	56.7	5.23	2.19	13.8	16.5	88.0	85.0	16.7	24.4
Bulk Ro Con 2	1.8	35.0	0.32	0.111	8.7	6.91	3.3	2.7	6.5	6.3
Bulk Ro Con 3	1.9	37.3	0.11	0.031	5.4	4.92	1.2	0.8	4.3	4.8
Bulk Ro Con 4	1.6	32.2	0.10	0.014	7.4	10.8	1.0	0.3	5.1	9.1
Bulk RoTl	91.9	1820.4	0.01	0.009	1.7	1.17	6.5	11.3	67.5	55.5
Feed	100.0	1982	0.17	0.074	2.4	1.94	100	100	100	100

KM3512-27 IX Composite
Cumulative Metallurgical Balance

Cumulative Product	Cum. Weight		Assay - percent or g/t				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Product 1	2.9	56.7	5.23	2.19	13.8	16.5	88.0	85.0	16.7	24.4
Product 1 to 2	4.6	91.7	3.36	1.40	11.9	12.8	91.3	87.6	23.1	30.7
Product 1 to 3	6.5	129.0	2.42	1.00	10.0	10.5	92.6	88.4	27.5	35.5
Product 1 to 4	8.1	161.2	1.95	0.804	9.5	10.6	93.5	88.7	32.5	44.5
Product 5	91.9	1820.4	0.01	0.009	1.7	1.17	6.5	11.3	67.5	55.5
Feed	100.0	1982	0.17	0.074	2.4	1.94	100	100	100	100

DATE: October 17, 2012

PROJECT NO: KM3512-28

PURPOSE: To Investigate a 200μm Primary Grind.

PROCEDURE: Perform a standard one product rougher test.

FEED: 2 kg of PP Composite ore ground to a nominal 216μm K_{80}.

FLOWSHEET: 1

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	1200	10				10			11.1
BULK CIRCUIT:									
Rougher 1	-		2	4	15		1	2	11.0
Rougher 2	-		2	4	8		1	2	11.0
Rougher 3	-		1	2	8		1	2	11.0
Rougher 4	√		1	2	8		1	2	11.0

Flotation Data	Rougher	
Flotation Machine:	D2A	
Cell Size in liters:	4.4	
Aspiration:	Air	
Water Type:	Fresh	
Impeller Speed in rpm:	1100	

Grinding Data	Primary Grind
Mill:	M3-Mild
Charge/Material:	20kg-Mild
Water:	1000 ml

KM3512-28 PP Composite
Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Bulk Ro Con 1	2.3	46.0	4.74	0.957	9.9	8.45	77.1	77.8	7.3	26.9
Bulk Ro Con 2	2.0	40.5	0.39	0.081	4.5	1.71	5.6	5.8	2.9	4.8
Bulk Ro Con 3	2.3	45.3	0.17	0.023	4.3	1.35	2.7	1.8	3.1	4.2
Bulk Ro Con 4	1.9	38.8	0.12	0.009	3.8	1.04	1.6	0.6	2.3	2.8
Bulk RoTl	91.4	1822.2	0.02	0.004	2.9	0.49	12.9	14.0	84.4	61.3
Feed	100.0	1993	0.14	0.028	3.1	0.73	100	100	100	100

KM3512-28 PP Composite
Cumulative Metallurgical Balance

Cumulative Product	Cum. Weight		Assay - percent or g/t				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Product 1	2.3	46.0	4.74	0.957	9.9	8.45	77.1	77.8	7.3	26.9
Product 1 to 2	4.3	86.5	2.70	0.547	7.4	5.29	82.7	83.6	10.2	31.7
Product 1 to 3	6.6	131.8	1.83	0.367	6.3	3.94	85.5	85.4	13.3	35.9
Product 1 to 4	8.6	170.6	1.44	0.285	5.7	3.28	87.1	86.0	15.6	38.7
Product 5	91.4	1822.2	0.02	0.004	2.9	0.49	12.9	14.0	84.4	61.3
Feed	100.0	1993	0.14	0.028	3.1	0.73	100	100	100	100

DATE: November 29, 2012

PROJECT NO: KM3512-29

PURPOSE: Preliminary Cleaner Test.

PROCEDURE: Perform a standard one product cleaner test.

FEED: ~1 kg of P6 to P8 Cleaner Concentrate.
Moly Regrind Discharge - 63µm K_{80}.

FLOWSHEET: 2

Stage	Reagents Added g/tonne			Time (minutes)			pH	Redox
	NaHS	Fuel Oil	MIBC	Grind	Cond.	Float		
Natural							8.4	130
MOLY CIRCUIT:								
Rougher 1	1680	20	-		10	11	11.2	-580
Regrind				5			8.9	
Cleaner 1	1400	60	60		7	8	10.7	-580
Cleaner 2	1750	20	60		3	5	10.6	-575
Cleaner 3	1750	12	60		3	3	10.7	-580

Flotation Data	Rougher	Cleaner
Flotation Machine	D2A	D1B
Cell Size in liters	4.4	2.2
Aspiration	N2	
Water Type	Fresh	
Impeller Speed in rpm	1100	1200

Grinding Data	Moly Regrind
Mill:	RM3-Mild
Charge/Material:	6kg-Stainless Steel
Water:	estimated

KM3512-29 P6 to P8 Cleaner Concentrate
Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Moly Concentrate	3.1	31.2	0.39	57.4	0.8	37.9	0.1	94.1	0.1	2.6
Moly 2nd Clnr Tail	0.4	4.3	16.8	7.13	25.9	35.8	0.4	1.6	0.3	0.3
Moly 1st Clnr Tail	2.7	27.0	17.8	1.20	30.3	38.4	2.9	1.7	2.5	2.3
Moly Rougher Tail	93.9	953.8	16.5	0.05	33.9	44.3	96.5	2.6	97.1	94.7
Feed	100.0	1016.3	16.0	1.87	32.8	43.9	100	100	100	100

KM3512-29 P6 to P8 Cleaner Concentrate
Cumulative Metallurgical Balance

Cumulative Product	Cum. Weight		Assay - percent or g/t				Distribution - percent			
	%	grams	Cu	Mo	Fe	S	Cu	Mo	Fe	S
Product 1	3.1	31.2	0.39	57.4	0.8	37.9	0.1	94.1	0.1	2.6
Product 1 to 2	3.5	35.5	2.38	51.3	3.8	37.6	0.5	95.7	0.4	3.0
Product 1 to 3	6.1	62.5	9.04	29.7	15.3	38.0	3.5	97.4	2.9	5.3
Product 4	93.9	953.8	16.5	0.05	33.9	44.3	96.5	2.6	97.1	94.7
Feed	100.0	1016.3	16.0	1.87	32.8	43.9	100	100	100	100

APPENDIX III – KM3512

PARTICLE SIZING DATA

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III-65	KM3512-P3 WSD Bulk Rougher Concentrate	206	65
III-66	KM3512-P3 WSD Flotation Feed	225	66
III-67	KM3512-P4 WSA Bulk Concentrate	89	67
III-68	KM3512-P4 WSA Bulk Regrind Discharge	84	68
III-69	KM3512-P4 WSA Bulk Rougher Concentrate	208	69
III-70	KM3512-P4 WSA Flotation Feed	217	70
III-71	KM3512-P4 WSB Bulk Concentrate	60	71
III-72	KM3512-P4 WSB Bulk Regrind Discharge	65	72
III-73	KM3512-P4 WSB Bulk Rougher Concentrate	196	73
III-74	KM3512-P4 WSB Flotation Feed	256	74
III-75	KM3512-P4 WSC Bulk Concentrate	66	75
III-76	KM3512-P4 WSC Bulk Regrind Discharge	84	76
III-77	KM3512-P4 WSC Bulk Rougher Concentrate	202	77
III-78	KM3512-P4 WSC Flotation Feed	249	78
III-79	KM3512-P4 WSD Bulk Concentrate	68	79
III-80	KM3512-P4 WSD Bulk Regrind Discharge	68	80
III-81	KM3512-P4 WSD Bulk Rougher Concentrate	246	81
III-82	KM3512-P4 WSD Flotation Feed	300	82
III-83	KM3512-P5 WSA Bulk Concentrate	57	83
III-84	KM3512-P5 WSA Bulk Regrind Discharge	64	84
III-85	KM3512-P5 WSA Bulk Rougher Concentrate	196	85
III-86	KM3512-P5 WSA Flotation Feed	274	86
III-87	KM3512-P5 WSB Bulk Concentrate	56	87

III-88 KM3512-P5 WSB Bulk Regrind Discharge 62 88
III-89 KM3512-P5 WSB Bulk Rougher Concentrate 183 89
III-90 KM3512-P5 WSB Flotation Feed 253 90
III-91 KM3512-P5 WSC Bulk Concentrate 53 91
III-92 KM3512-P5 WSC Bulk Regrind Discharge 56 92
III-93 KM3512-P5 WSC Bulk Rougher Concentrate 165 93
III-94 KM3512-P5 WSC Flotation Feed 243 94
III-95 KM3512-P5 WSD Bulk Concentrate 58 95
III-96 KM3512-P5 WSD Bulk Regrind Discharge 38 96
III-97 KM3512-P5 WSD Rougher Concentrate 158 97
III-98 KM3512-P5 WSD Flotation Feed 228 98

OPERATIONAL FEED SIZING

III-99 KM3512-P1 Flotation Feed 10:55 ..... 256 99
III-100 KM3512-P1 Flotation Feed 12:50 ..... 150 100
III-101 KM3512-P1 Flotation Feed 12:00 ..... 202 101
III-102 KM3512-P2 Flotation Feed 09:00 ..... 167 102
III-103 KM3512-P2 Flotation Feed 11:15 ..... 186 103
III-104 KM3512-P2 Flotation Feed 13:15 ..... 174 104
III-105 KM3512-P2 Flotation Feed 14:15 ..... 213 105
III-106 KM3512-P2 Flotation Feed 15:40 ..... 245 106
III-107 KM3512-P3 Flotation Feed 10:30 ..... 181 107
III-108 KM3512-P3 Flotation Feed 11:30 ..... 299 108
III-109 KM3512-P3 Flotation Feed 12:30 ..... 298 109
III-110 KM3512-P4 Flotation Feed 10:00 ..... 236 110
III-111 KM3512-P4 Flotation Feed 11:00 ..... 240 111
III-112 KM3512-P4 Flotation Feed 12:00 ..... 179 112
III-113 KM3512-P4 Flotation Feed 14:00 ..... 310 113
III-114 KM3512-P4 Flotation Feed 15:00 ..... 320 114
III-115 KM3512-P5 Flotation Feed 09:30 ..... 224 115
III-116 KM3512-P5 Flotation Feed 10:30 ..... 220 116
III-117 KM3512-P5 Flotation Feed 12:30 ..... 286 117
III-118 KM3512-P5 Flotation Feed 13:55 ..... 231 118

OPERATIONAL LASER SIZING

III-119	KM3512-P2 Bulk Regrind Discharge 09:20	20	119
III-120	KM3512-P2 Bulk Regrind Discharge 10:30	23	120
III-121	KM3512-P2 Bulk Regrind Discharge 12:00	26	121
III-122	KM3512-P2 Bulk Regrind Discharge 12:50	49	122
III-123	KM3512-P2 Bulk Regrind Discharge 15:30	39	123
III-124	KM3512-P3 Bulk Regrind Discharge 11:30	63	124
III-125	KM3512-P3 Bulk Regrind Discharge 12:45	46	125
III-126	KM3512-P3 Bulk Regrind Discharge 13:30	47	126
III-127	KM3512-P4 Bulk Regrind Discharge 09:45	33	127
III-128	KM3512-P4 Bulk Regrind Discharge 11:30	71	128
III-129	KM3512-P4 Bulk Regrind Discharge 13:30	78	129
III-130	KM3512-P4 Bulk Regrind Discharge 15:00	51	130
III-131	KM3512-P5 Bulk Regrind Discharge 09:30	98	131
III-132	KM3512-P5 Bulk Regrind Discharge 10:45	63	132
III-133	KM3512-P5 Bulk Regrind Discharge 13:00	50	133
III-134	KM3512-P5 Bulk Regrind Discharge 14:00	50	134

TABLE III-1
SCREEN ANALYSIS
KM3512 IX Composite - 10 Minute Grind Calibration

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	10.80	89.2
65 Mesh	212	17.90	71.3
100 Mesh	150	13.40	57.9
150 Mesh	106	9.90	48.0
200 Mesh	75	6.80	41.2
270 Mesh	53	7.80	33.4
400 Mesh	38	4.80	28.6
TOTAL		100.00	**

K80 =253µm

Note: 10 min. grind calibration using 2 kg. Ore, 1000 ml water and 20 kg. of Mild Steel rods in Mill: M3

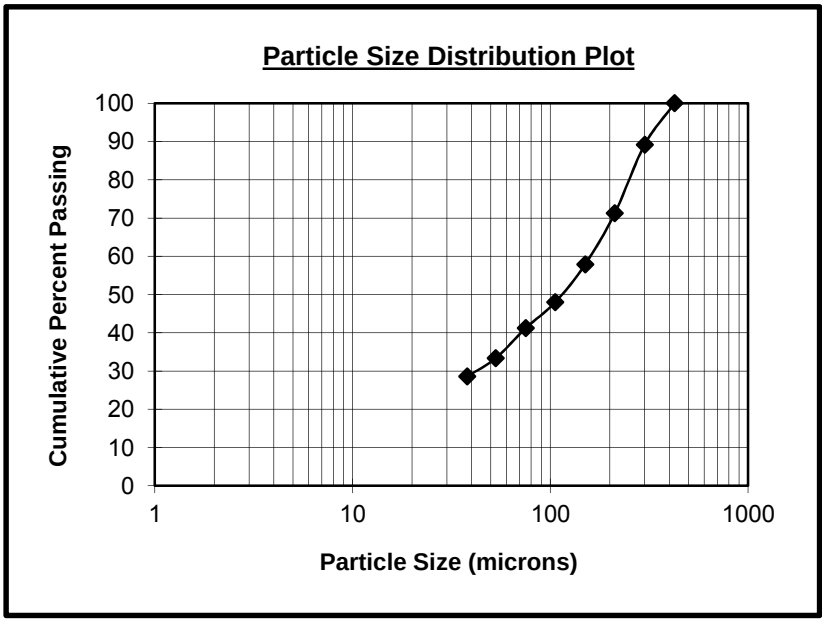


TABLE III-2
SCREEN ANALYSIS
KM3512 IX Composite - 11 Minute Grind Calibration

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	5.70	94.3
65 Mesh	212	19.30	75.0
100 Mesh	150	13.60	61.4
150 Mesh	106	10.30	51.1
200 Mesh	75	7.40	43.7
270 Mesh	53	6.70	37.0
400 Mesh	38	5.40	31.6
TOTAL		100.00	**

K80 =234µm

Note: 11 min. grind calibration using 2 kg. Ore, 1000 ml water and 20 kg. of Mild Steel rods in Mill: M3

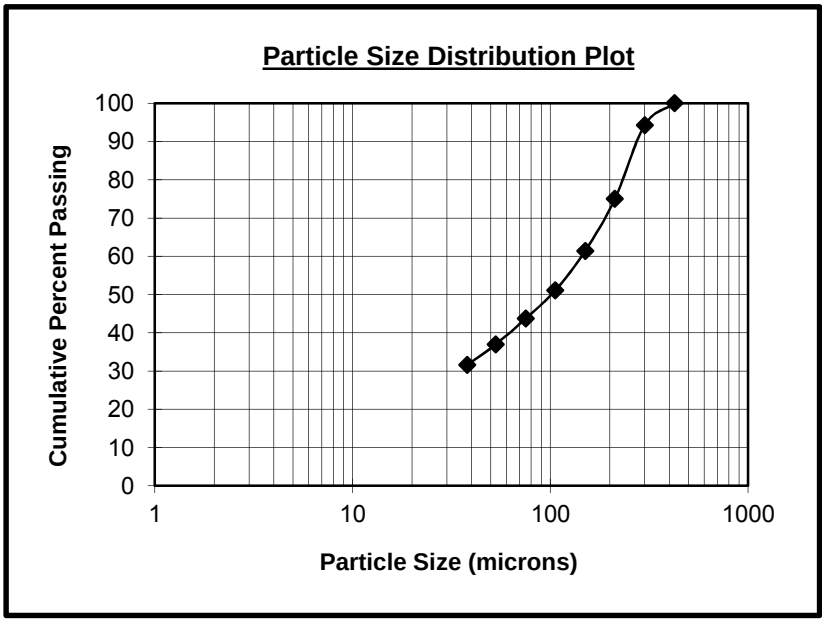


TABLE III-3
SCREEN ANALYSIS
KM3512 IX Composite - 13 Minute Grind Calibration

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	0.80	99.2
65 Mesh	212	12.20	87.0
100 Mesh	150	18.20	68.8
150 Mesh	106	13.10	55.7
200 Mesh	75	9.90	45.8
270 Mesh	53	7.80	38.0
400 Mesh	38	5.90	32.1
TOTAL		100.00	**

K80 =187µm

Note: 13 min. grind calibration using 2 kg. Ore, 1000 ml water and 20 kg. of Mild Steel rods in Mill: M3

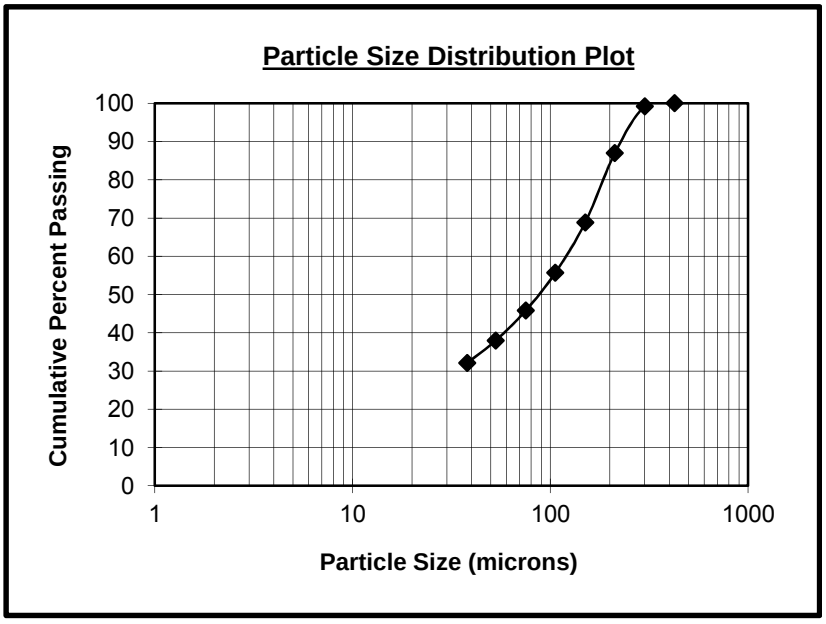


TABLE III-4
SCREEN ANALYSIS
KM3512 IX Composite - 13.5 Minute Grind Calibration

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	0.50	99.5
65 Mesh	212	10.60	88.9
100 Mesh	150	18.80	70.1
150 Mesh	106	14.00	56.1
200 Mesh	75	11.00	45.1
270 Mesh	53	8.40	36.7
400 Mesh	38	6.50	30.2
TOTAL		100.00	**

K80 =182µm

Note: 13.5 min. grind calibration using 2 kg. Ore, 1000 ml water and 20 kg. of Mild Steel rods in Mill: M3

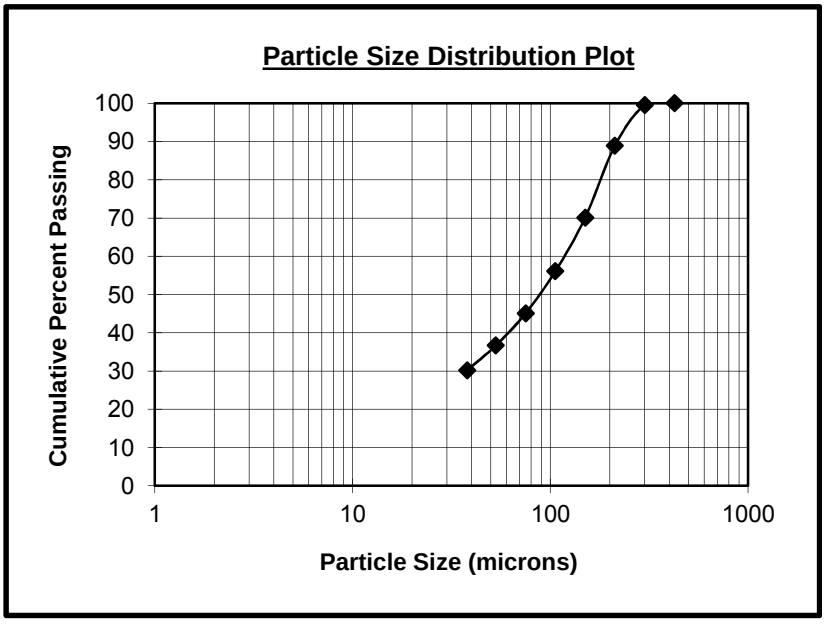


TABLE III-5
SCREEN ANALYSIS
KM3512 IX Composite - 14 Minute Grind Calibration

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	0.10	99.9
65 Mesh	212	6.90	93.0
100 Mesh	150	20.90	72.1
150 Mesh	106	17.60	54.5
200 Mesh	75	12.10	42.4
270 Mesh	53	8.40	34.0
400 Mesh	38	9.60	24.4
TOTAL		100.00	**

K80 =173µm

Note: 14 min. grind calibration using 2 kg. Ore, 1000 ml water and 20 kg. of Mild Steel rods in Mill: M3

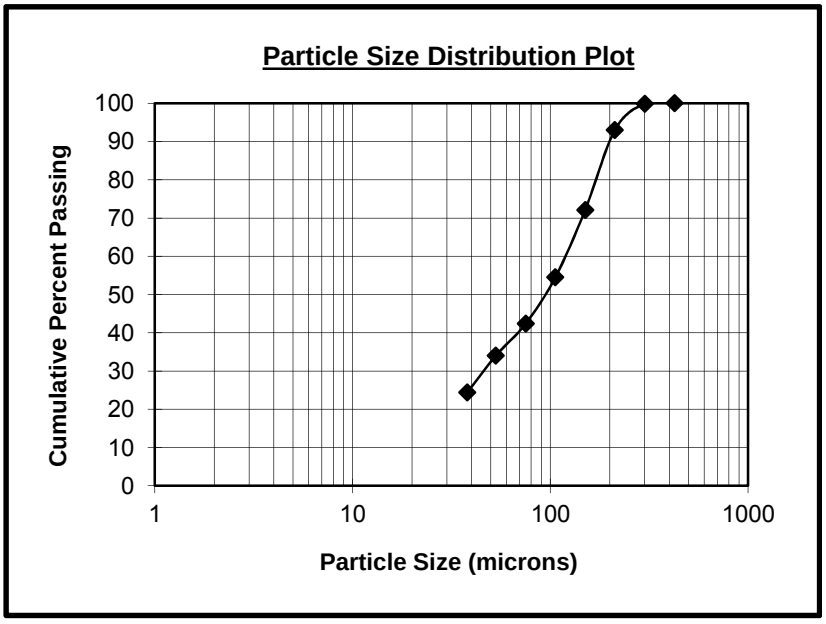


TABLE III-6
SCREEN ANALYSIS
KM3512 IX Composite - 15 Minute Grind Calibration

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
48 Mesh	300	0.00	100.0
65 Mesh	212	3.50	96.5
100 Mesh	150	16.90	79.6
150 Mesh	106	17.10	62.5
200 Mesh	75	10.50	52.0
270 Mesh	53	10.60	41.4
400 Mesh	38	6.20	35.2
TOTAL		100.00	**

K80 =151µm

Note: 15 min. grind calibration using 2 kg. Ore, 1000 ml water and 20 kg. of Mild Steel rods in Mill: M3

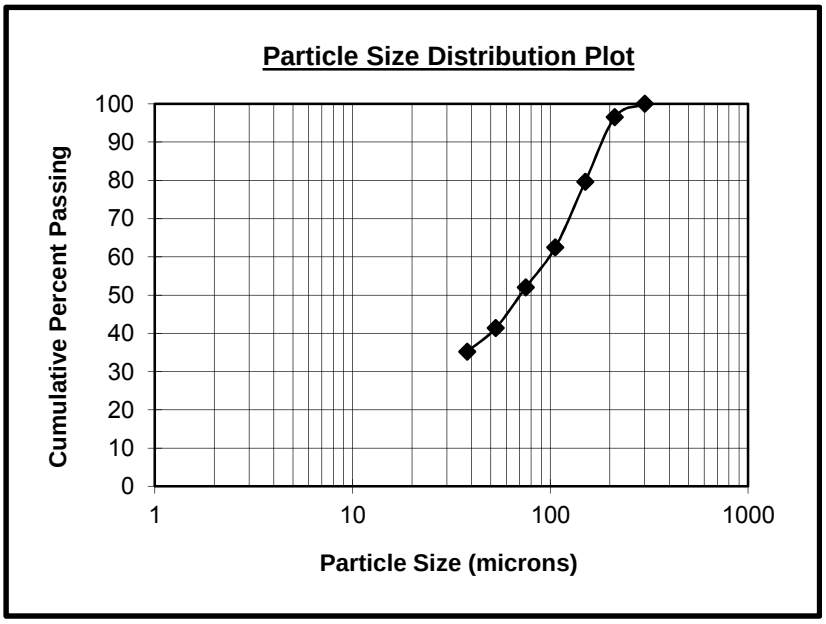


TABLE III-7
SCREEN ANALYSIS
KM3512 PP Composite - 8.5 Minute Grind Calibration

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	15.30	84.7
65 Mesh	212	17.10	67.6
100 Mesh	150	11.70	55.9
150 Mesh	106	8.10	47.8
200 Mesh	75	6.70	41.1
270 Mesh	53	6.10	35.0
400 Mesh	38	5.20	29.8
TOTAL		100.00	**

K80 =275µm

Note: 8.5 min. grind calibration using 2 kg. Ore, 1000 ml water and 20 kg. of Mild Steel rods in Mill: M3

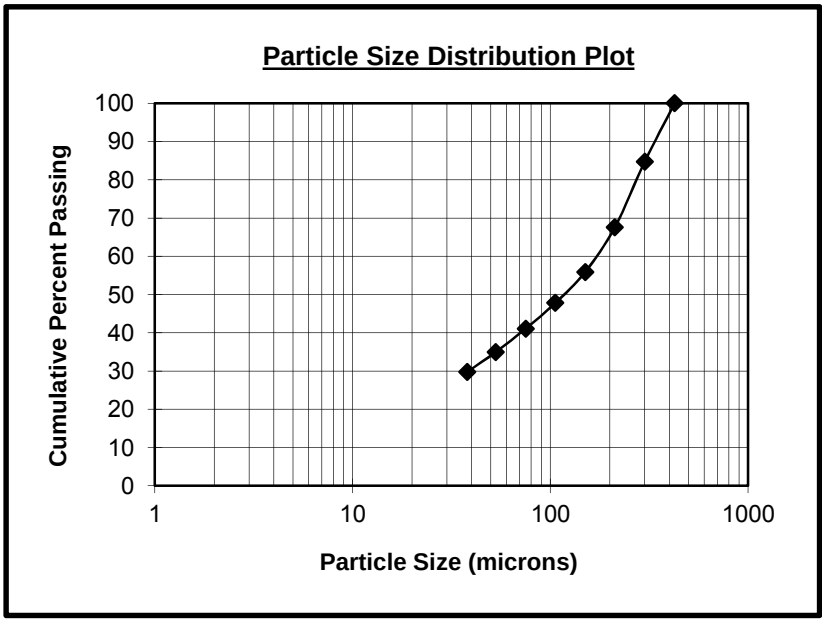


TABLE III-8
SCREEN ANALYSIS
KM3512 PP Composite - 9.5 Minute Grind Calibration

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	11.00	89.0
65 Mesh	212	17.90	71.1
100 Mesh	150	12.60	58.5
150 Mesh	106	8.60	49.9
200 Mesh	75	7.20	42.7
270 Mesh	53	6.40	36.3
400 Mesh	38	5.40	30.9
TOTAL		100.00	**

K80 =254µm

Note: 9.5 min. grind calibration using 2 kg. Ore, 1000 ml water and 20 kg. of Mild Steel rods in Mill: M3

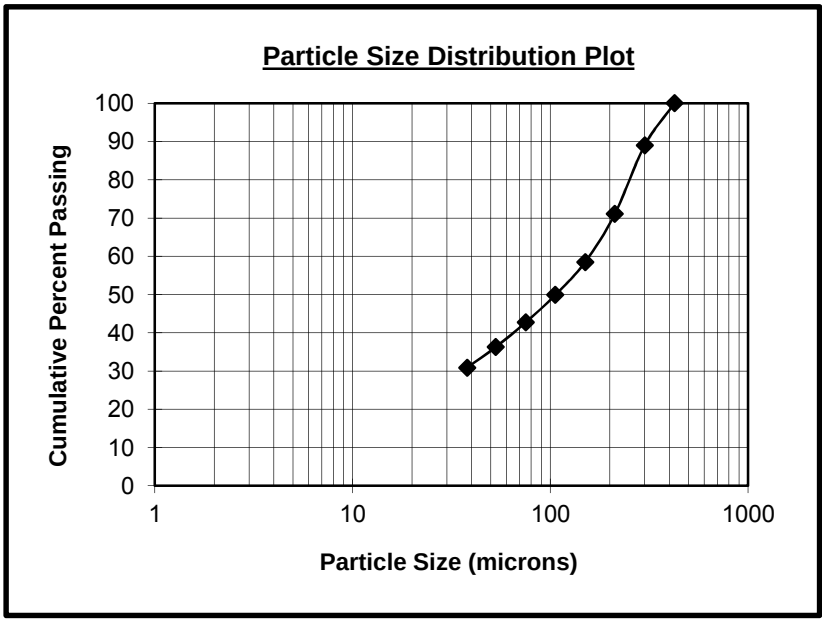


TABLE III-9
SCREEN ANALYSIS
KM3512 PP Composite - 10 Minute Grind Calibration

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	2.80	97.2
65 Mesh	212	18.00	79.2
100 Mesh	150	12.60	66.6
150 Mesh	106	10.00	56.6
200 Mesh	75	7.20	49.4
270 Mesh	53	6.50	42.9
400 Mesh	38	5.70	37.2
TOTAL		100.00	**

K80 =216µm

Note: 10 min. grind calibration using 2 kg. Ore, 1000 ml water and 20 kg. of Mild Steel rods in Mill: M3

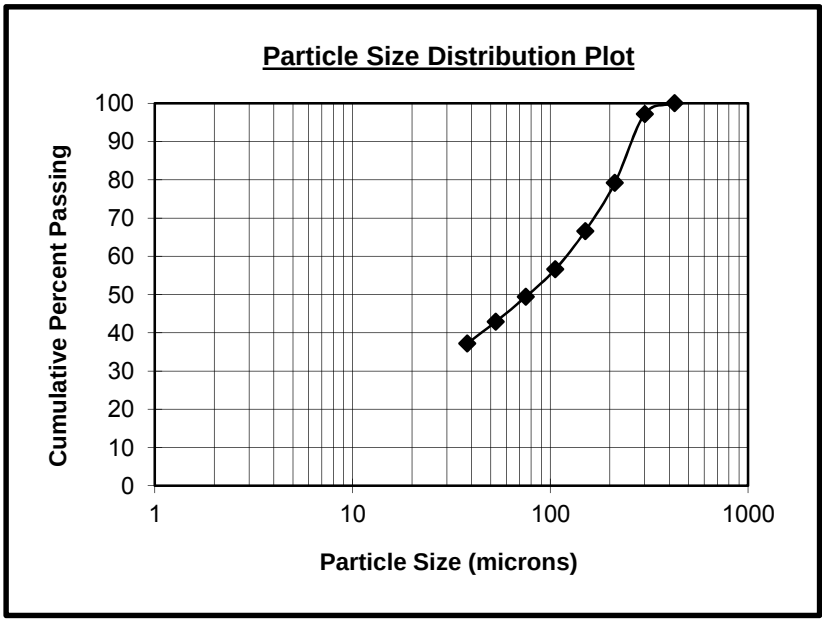


TABLE III-10
SCREEN ANALYSIS
KM3512 PP Composite - 11 Minute Grind Calibration

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	0.40	99.6
65 Mesh	212	10.30	89.3
100 Mesh	150	17.40	71.9
150 Mesh	106	12.80	59.1
200 Mesh	75	9.70	49.4
270 Mesh	53	7.40	42.0
400 Mesh	38	6.40	35.6
TOTAL		100.00	**

K80 =178µm

Note: 11 min. grind calibration using 2 kg. Ore, 1000 ml water and 20 kg. of Mild Steel rods in Mill: M3

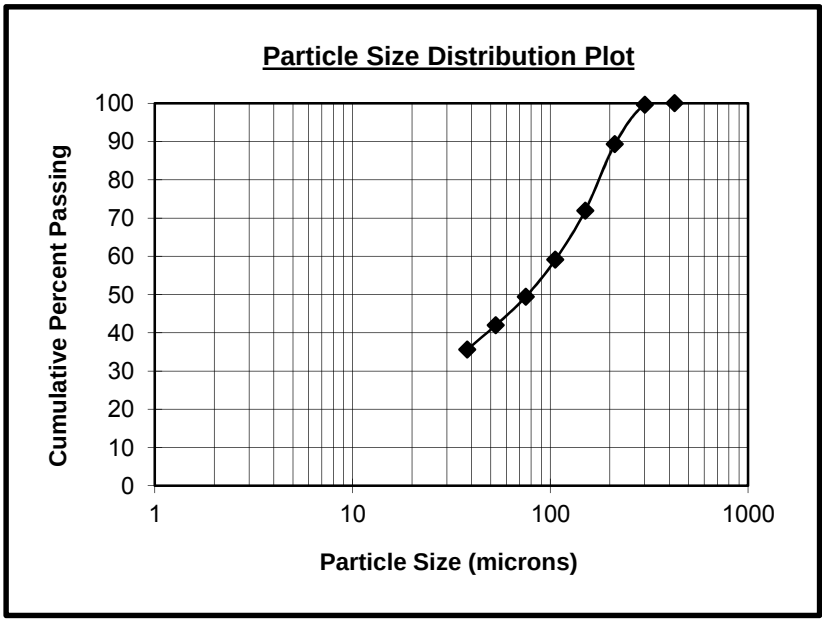


TABLE III-11
SCREEN ANALYSIS
KM3512 WR Composite - 10 Minute Grind Calibration

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	13.30	86.7
65 Mesh	212	19.40	67.3
100 Mesh	150	13.80	53.5
150 Mesh	106	9.50	44.0
200 Mesh	75	7.60	36.4
270 Mesh	53	5.70	30.7
400 Mesh	38	4.50	26.2
TOTAL		100.00	**

K80 =269µm

Note: 10 min. grind calibration using 2 kg. Ore, 1000 ml water and 20 kg. of Mild Steel rods in Mill: M3

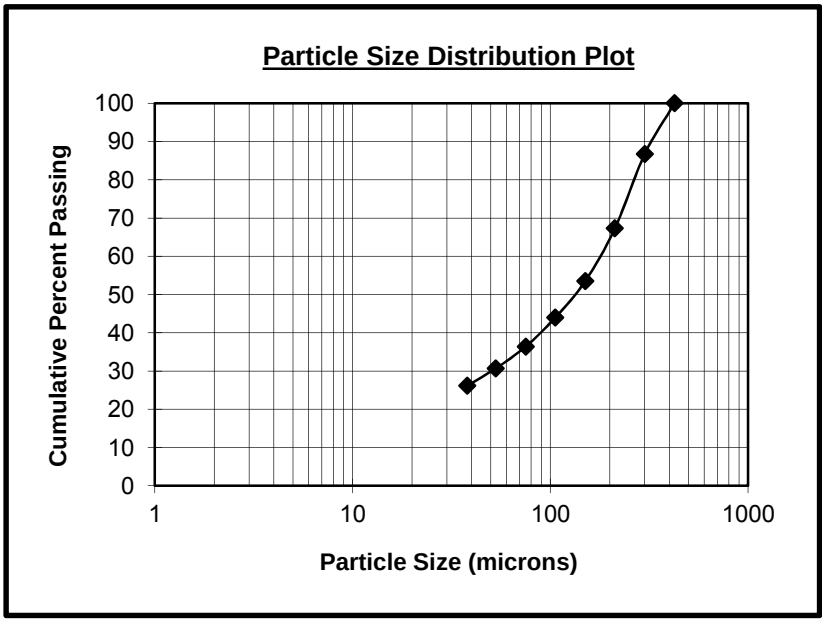


TABLE III-12
SCREEN ANALYSIS
KM3512 WR Composite - 11.5 Minute Grind Calibration

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	2.70	97.3
65 Mesh	212	17.00	80.3
100 Mesh	150	16.80	63.5
150 Mesh	106	11.80	51.7
200 Mesh	75	8.00	43.7
270 Mesh	53	7.00	36.7
400 Mesh	38	5.30	31.4
TOTAL		100.00	**

K80 =211µm

Note: 11.5 min. grind calibration using 2 kg. Ore, 1000 ml water and 20 kg. of Mild Steel rods in Mill: M3

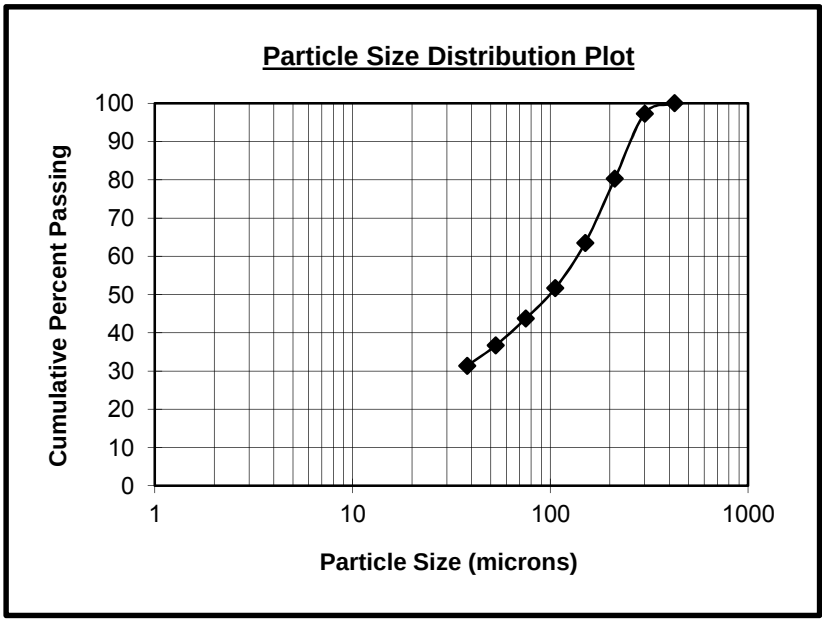


TABLE III-13
SCREEN ANALYSIS
KM3512 WR Composite - 13 Minute Grind Calibration

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	0.50	99.5
65 Mesh	212	9.80	89.7
100 Mesh	150	18.40	71.3
150 Mesh	106	13.60	57.7
200 Mesh	75	10.40	47.3
270 Mesh	53	8.00	39.3
400 Mesh	38	5.80	33.5
TOTAL		100.00	**

K80 =178µm

Note: 13 min. grind calibration using 2 kg. Ore, 1000 ml water and 20 kg. of Mild Steel rods in Mill: M3

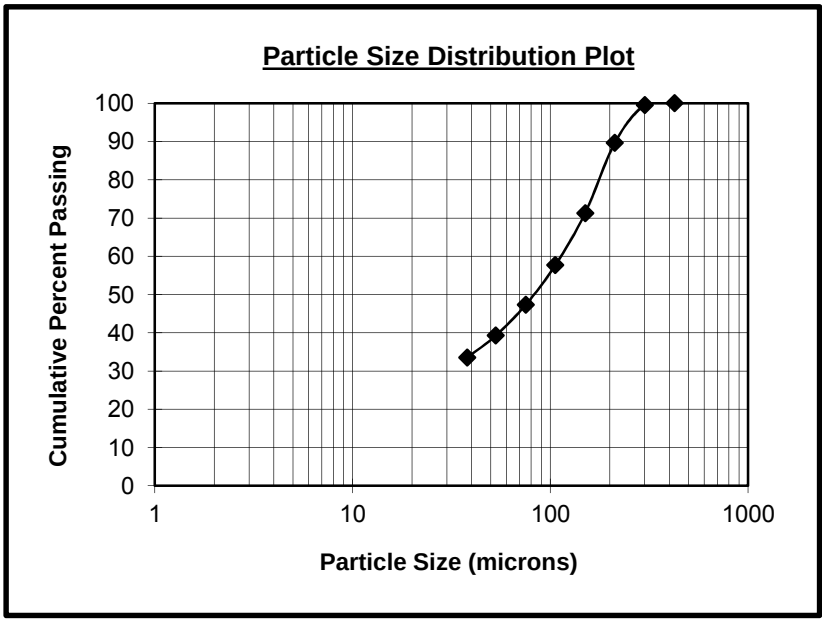


TABLE III-14
SCREEN ANALYSIS
KM3512 WR Composite - 14 Minute Grind Calibration

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
48 Mesh	300	0.00	100.0
65 Mesh	212	3.80	96.2
100 Mesh	150	16.00	80.2
150 Mesh	106	17.40	62.8
200 Mesh	75	11.80	51.0
270 Mesh	53	9.80	41.2
400 Mesh	38	6.40	34.8
TOTAL		100.00	**

K80 =149µm

Note: 14 min. grind calibration using 2 kg. Ore, 1000 ml water and 20 kg. of Mild Steel rods in Mill: M3

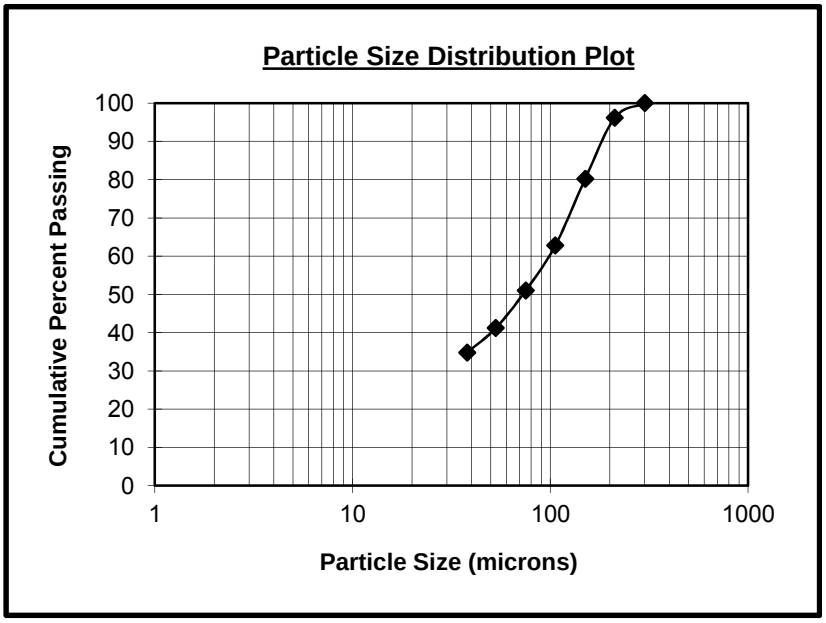
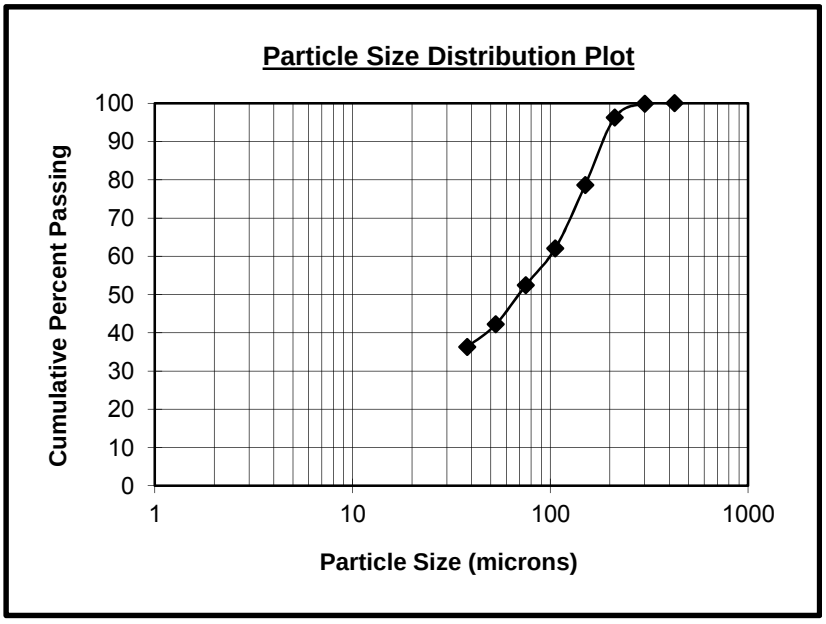


TABLE III-15
SCREEN ANALYSIS
KM3512-05 Flotation Feed

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	0.10	99.9
65 Mesh	212	3.60	96.3
100 Mesh	150	17.70	78.6
150 Mesh	106	16.50	62.1
200 Mesh	75	9.70	52.4
270 Mesh	53	10.20	42.2
400 Mesh	38	5.90	36.3
TOTAL		100.00	**

K80 =155µm



ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-12

Measured by:
tristan

Measured:
Wednesday, September 12, 2012 8:50:21 AM

Sample Name:
Bulk Regrind Discharge - Average

Edited by:
tristan

Analysed:
Wednesday, September 12, 2012 8:50:22 AM

Particle Name:
Silica 0.01

Accessory Name:
Hydro 2000MU (A)

Analysis model:
General purpose

Sensitivity:
Normal

Particle RI:
1.544

Absorption:
0.01

Size range:
0.100 to 1000.000 um

Obscuration:
16.53 %

Dispersant Name:
Water

Dispersant RI:
1.330

Weighted Residual:
0.157 %

Result Emulation:
Off

Concentration:
0.0231 %Vol

Span :
2.377

Uniformity:
0.74

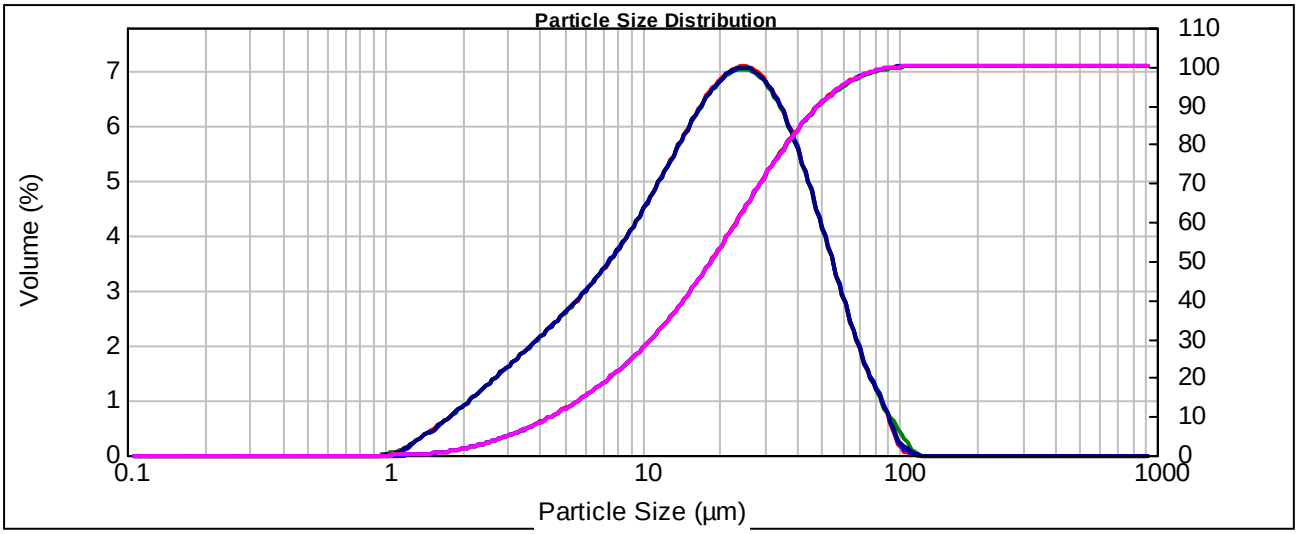
Result units:
Volume

Specific Surface Area:
0.216 m²/g

Surface Weighted Mean D[3,2]:
10.496 um

Vol. Weighted Mean D[4,3]:
23.221 um

d(0.1): 4.444 um d(0.5): 18.604 um **d(0.8): 36.451 um** d(0.9): 48.671 um d(0.98): 73.53 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.00
0.437	0.00
0.479	

Size (µm)	Volume In %
0.479	0.00
0.525	0.00
0.575	0.00
0.631	0.00
0.692	0.00
0.759	0.00
0.832	0.00
0.912	0.00
1.000	0.01
1.096	0.03
1.202	0.11
1.318	0.19
1.445	0.26
1.585	0.34
1.738	0.43
1.905	0.53
2.089	0.62
2.291	

Size (µm)	Volume In %
2.291	0.72
2.512	0.82
2.754	0.92
3.020	1.03
3.311	1.13
3.631	1.23
3.981	1.34
4.365	1.45
4.786	1.56
5.248	1.68
5.754	1.80
6.310	1.93
6.918	2.07
7.586	2.23
8.318	2.39
9.120	2.57
10.000	2.77
10.965	

Size (µm)	Volume In %
10.965	2.97
12.023	3.17
13.183	3.39
14.454	3.59
15.849	3.79
17.378	3.96
19.055	4.10
20.893	4.20
22.909	4.25
25.119	4.24
27.542	4.16
30.200	4.02
33.113	3.82
36.308	3.55
39.811	3.24
43.652	2.89
47.863	2.50
52.481	

Size (µm)	Volume In %
52.481	2.12
57.544	1.75
63.096	1.38
69.183	1.05
75.858	0.77
83.176	0.56
91.201	0.24
100.000	0.09
109.648	0.02
120.226	0.00
131.826	0.00
144.544	0.00
158.489	0.00
173.780	0.00
190.546	0.00
208.930	0.00
229.087	0.00
251.189	

Size (µm)	Volume In %
251.189	0.00
275.423	0.00
301.995	0.00
331.131	0.00
363.078	0.00
398.107	0.00
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-13

Sample Name:
Bulk Regrind Discharge - Average

Measured by:
Neville

Edited by:
Neville

Measured:
Monday, September 10, 2012 3:25:26 PM

Analysed:
Monday, September 10, 2012 3:25:27 PM

Particle Name: Silica 0.01
Particle RI: 1.544
Dispersant Name: Water

Accessory Name: Hydro 2000MU (A)
Absorption: 0.01
Dispersant RI: 1.330

Analysis model: General purpose
Size range: 0.100 to 1000.000 um
Weighted Residual: 1.436 %

Sensitivity: Normal
Obscuration: 4.76 %
Result Emulation: Off

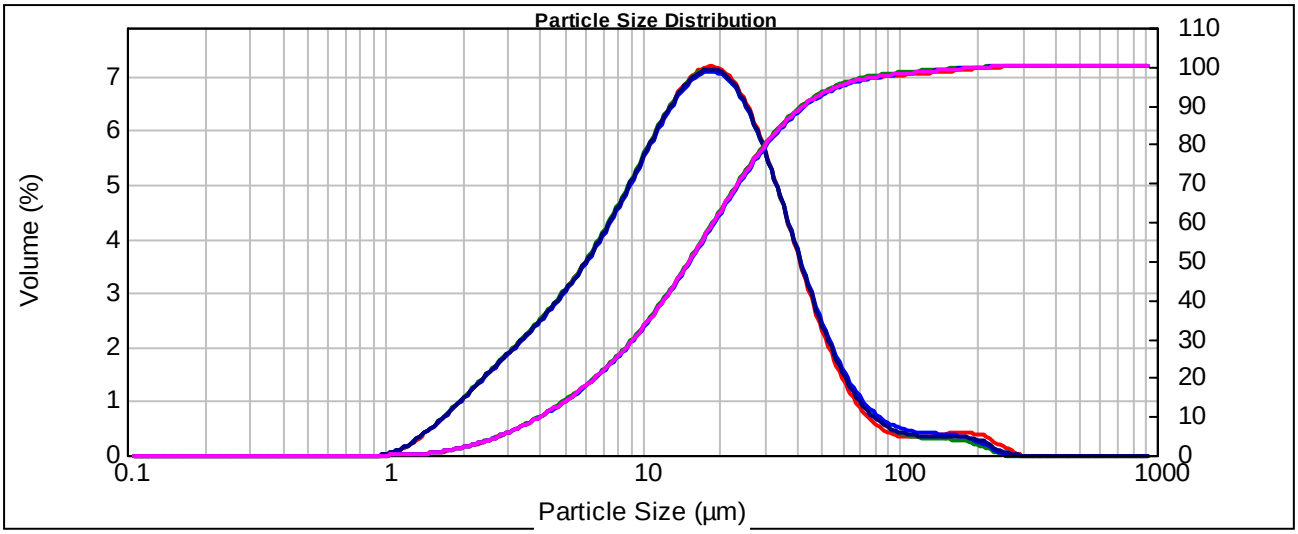
Concentration: 0.0055 %Vol
Specific Surface Area: 0.242 m²/g

Span : 2.515
Surface Weighted Mean D[3,2]: 9.343 um

Uniformity: 0.895
Vol. Weighted Mean D[4,3]: 21.790 um

Result units: Volume

d(0.1): 4.044 um d(0.5): 15.324 um **d(0.8): 30.300 um** d(0.9): 42.592 um d(0.98): 96.99 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.00
0.437	0.00
0.479	

Size (µm)	Volume In %
0.479	0.00
0.525	0.00
0.575	0.00
0.631	0.00
0.692	0.00
0.759	0.00
0.832	0.00
0.912	0.00
1.000	0.03
1.096	0.06
1.202	0.12
1.318	0.21
1.445	0.29
1.585	0.39
1.738	0.50
1.905	0.61
2.089	0.73
2.291	

Size (µm)	Volume In %
2.291	0.84
2.512	0.96
2.754	1.07
3.020	1.19
3.311	1.30
3.631	1.42
3.981	1.55
4.365	1.68
4.786	1.82
5.248	1.97
5.754	2.14
6.310	2.31
6.918	2.51
7.586	2.72
8.318	2.94
9.120	3.16
10.000	3.40
10.965	

Size (µm)	Volume In %
10.965	3.62
12.023	3.82
13.183	4.01
14.454	4.15
15.849	4.25
17.378	4.29
19.055	4.27
20.893	4.18
22.909	4.02
25.119	3.80
27.542	3.52
30.200	3.20
33.113	2.85
36.308	2.48
39.811	2.12
43.652	1.77
47.863	1.44
52.481	

Size (µm)	Volume In %
52.481	1.16
57.544	0.91
63.096	0.70
69.183	0.54
75.858	0.42
83.176	0.33
91.201	0.27
100.000	0.24
109.648	0.22
120.226	0.21
131.826	0.21
144.544	0.22
158.489	0.21
173.780	0.20
190.546	0.18
208.930	0.14
229.087	0.06
251.189	

Size (µm)	Volume In %
251.189	0.03
275.423	0.00
301.995	0.00
331.131	0.00
363.078	0.00
398.107	0.00
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-14

Measured by:
Neville

Measured:
Monday, September 10, 2012 3:33:58 PM

Sample Name:
Bulk Regrind Discharge - Average

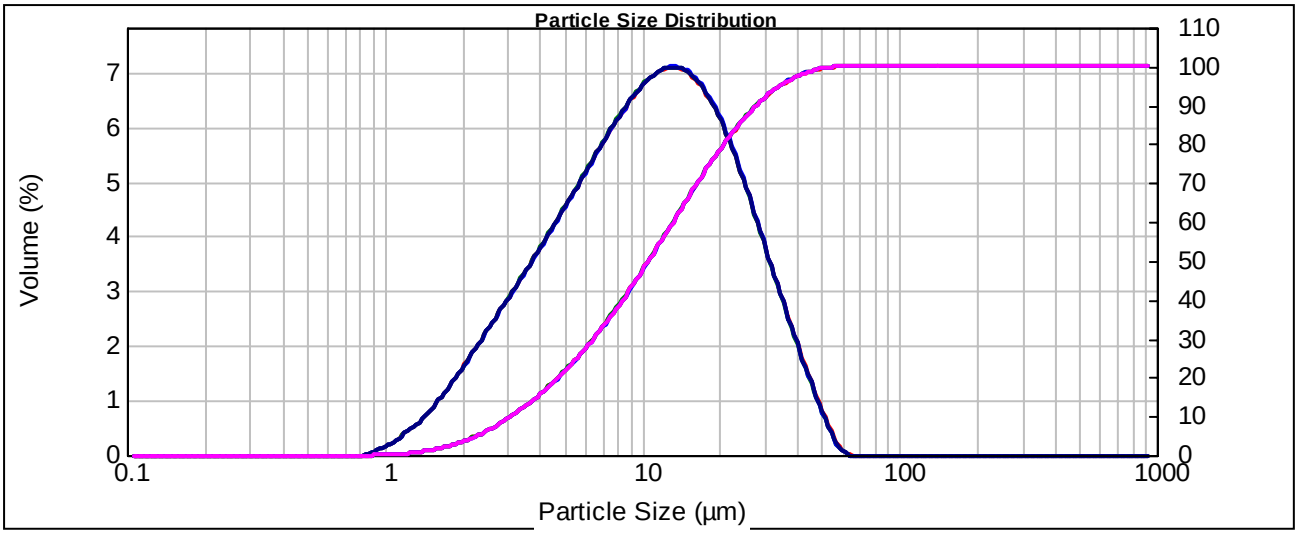
Edited by:
Neville

Analysed:
Monday, September 10, 2012 3:33:59 PM

Particle Name: Silica 0.01
Accessory Name: Hydro 2000MU (A)
Analysis model: General purpose
Sensitivity: Normal
Particle RI: 1.544
Absorption: 0.01
Size range: 0.100 to 1000.000 um
Obscuration: 3.87 %
Dispersant Name: Water
Dispersant RI: 1.330
Weighted Residual: 0.837 %
Result Emulation: Off

Concentration: 0.0033 %Vol
Span : 2.334
Uniformity: 0.721
Result units: Volume
Specific Surface Area: 0.327 m²/g
Surface Weighted Mean D[3,2]: 6.929 um
Vol. Weighted Mean D[4,3]: 13.395 um

d(0.1): 3.111 um d(0.5): 10.612 um **d(0.8): 20.779 um** d(0.9): 27.885 um d(0.98): 41.75 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.00
0.437	0.00
0.479	

Size (µm)	Volume In %
0.479	0.00
0.525	0.00
0.575	0.00
0.631	0.00
0.692	0.00
0.759	0.00
0.832	0.01
0.912	0.07
1.000	0.11
1.096	0.20
1.202	0.28
1.318	0.38
1.445	0.50
1.585	0.64
1.738	0.79
1.905	0.95
2.089	1.12
2.291	

Size (µm)	Volume In %
2.291	1.29
2.512	1.46
2.754	1.64
3.020	1.81
3.311	1.99
3.631	2.17
3.981	2.35
4.365	2.54
4.786	2.72
5.248	2.91
5.754	3.11
6.310	3.30
6.918	3.49
7.586	3.68
8.318	3.85
9.120	4.00
10.000	4.12
10.965	

Size (µm)	Volume In %
10.965	4.21
12.023	4.26
13.183	4.27
14.454	4.21
15.849	4.11
17.378	3.94
19.055	3.73
20.893	3.46
22.909	3.15
25.119	2.82
27.542	2.47
30.200	2.11
33.113	1.76
36.308	1.42
39.811	1.09
43.652	0.78
47.863	0.48
52.481	

Size (µm)	Volume In %
52.481	0.21
57.544	0.03
63.096	0.00
69.183	0.00
75.858	0.00
83.176	0.00
91.201	0.00
100.000	0.00
109.648	0.00
120.226	0.00
131.826	0.00
144.544	0.00
158.489	0.00
173.780	0.00
190.546	0.00
208.930	0.00
229.087	0.00
251.189	

Size (µm)	Volume In %
251.189	0.00
275.423	0.00
301.995	0.00
331.131	0.00
363.078	0.00
398.107	0.00
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-15

Sample Name:
Bulk Regrind Discharge - Average

Measured by:
tristan

Edited by:
tristan

Measured:
Wednesday, September 12, 2012 10:58:26 AM

Analysed:
Wednesday, September 12, 2012 10:58:27 AM

Particle Name: Silica 0.01
Particle RI: 1.544
Dispersant Name: Water

Accessory Name: Hydro 2000MU (A)
Absorption: 0.01
Dispersant RI: 1.330

Analysis model: General purpose
Size range: 0.100 to 1000.000 um
Weighted Residual: 0.175 %

Sensitivity: Normal
Obscuration: 14.41 %
Result Emulation: Off

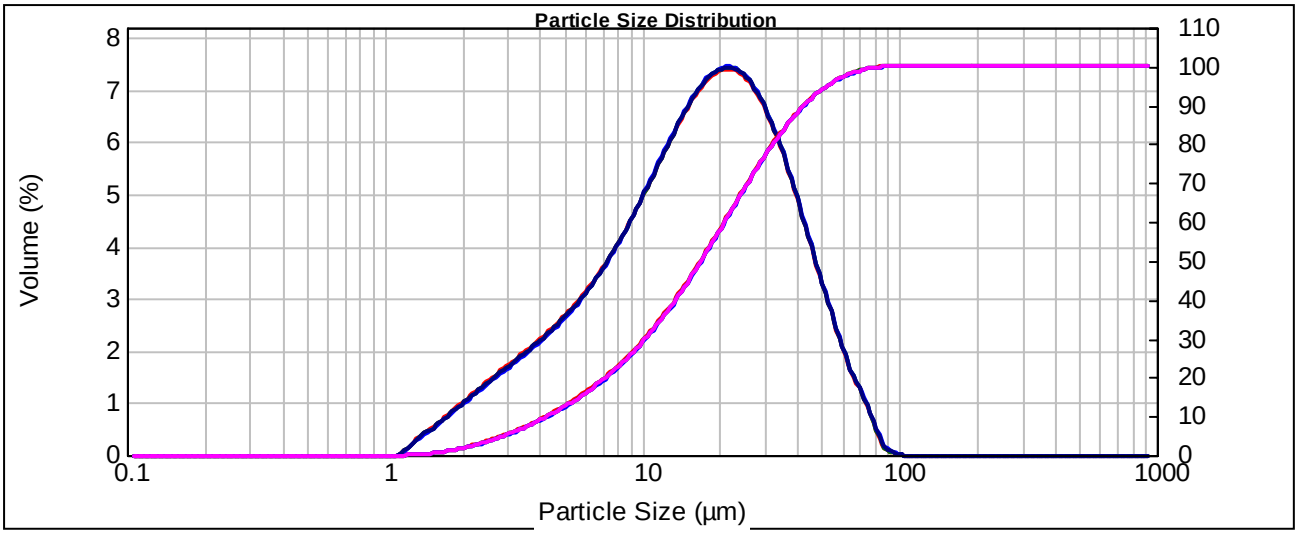
Concentration: 0.0188 %Vol
Specific Surface Area: 0.227 m²/g

Span : 2.260
Surface Weighted Mean D[3,2]: 9.953 um

Uniformity: 0.697
Vol. Weighted Mean D[4,3]: 20.743 um

Result units: Volume

d(0.1): 4.282 um d(0.5): 16.963 um **d(0.8): 32.200 um** d(0.9): 42.617 um d(0.98): 63.6 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.00
0.437	0.00
0.479	

Size (µm)	Volume In %
0.479	0.00
0.525	0.00
0.575	0.00
0.631	0.00
0.692	0.00
0.759	0.00
0.832	0.00
0.912	0.00
1.000	0.00
1.096	0.00
1.202	0.11
1.318	0.22
1.445	0.29
1.585	0.39
1.738	0.49
1.905	0.59
2.089	0.69
2.291	

Size (µm)	Volume In %
2.291	0.79
2.512	0.88
2.754	0.98
3.020	1.07
3.311	1.16
3.631	1.26
3.981	1.36
4.365	1.48
4.786	1.59
5.248	1.72
5.754	1.87
6.310	2.03
6.918	2.20
7.586	2.40
8.318	2.62
9.120	2.84
10.000	3.09
10.965	

Size (µm)	Volume In %
10.965	3.33
12.023	3.58
13.183	3.82
14.454	4.03
15.849	4.22
17.378	4.36
19.055	4.45
20.893	4.47
22.909	4.43
25.119	4.31
27.542	4.12
30.200	3.87
33.113	3.55
36.308	3.19
39.811	2.80
43.652	2.40
47.863	1.99
52.481	

Size (µm)	Volume In %
52.481	1.60
57.544	1.23
63.096	0.91
69.183	0.69
75.858	0.38
83.176	0.08
91.201	0.02
100.000	0.00
109.648	0.00
120.226	0.00
131.826	0.00
144.544	0.00
158.489	0.00
173.780	0.00
190.546	0.00
208.930	0.00
229.087	0.00
251.189	

Size (µm)	Volume In %
251.189	0.00
275.423	0.00
301.995	0.00
331.131	0.00
363.078	0.00
398.107	0.00
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-16

Measured by:
tristan

Measured:
Wednesday, September 12, 2012 12:14:33 PM

Sample Name:
Bulk Regrind Discharge - Average

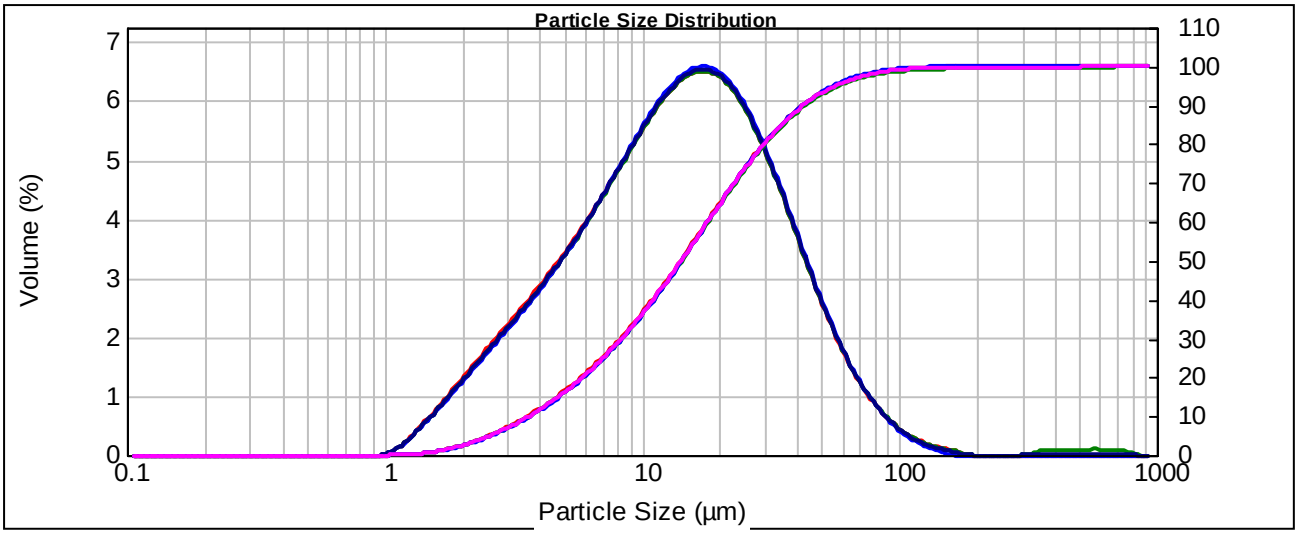
Edited by:
tristan

Analysed:
Wednesday, September 12, 2012 12:14:34 PM

Particle Name: Silica 0.01
Accessory Name: Hydro 2000MU (A)
Analysis model: General purpose
Sensitivity: Normal
Particle RI: 1.544
Absorption: 0.01
Size range: 0.100 to 1000.000 um
Obscuration: 10.91 %
Dispersant Name: Water
Dispersant RI: 1.330
Weighted Residual: 0.165 %
Result Emulation: Off

Concentration: 0.0118 %Vol
Span : 2.731
Uniformity: 0.93
Result units: Volume
Specific Surface Area: 0.264 m²/g
Surface Weighted Mean D[3,2]: 8.565 um
Vol. Weighted Mean D[4,3]: 20.538 um

d(0.1): 3.634 um d(0.5): 14.211 um **d(0.8): 29.827 um** d(0.9): 42.439 um d(0.98): 76.81 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.00
0.437	0.00
0.479	

Size (µm)	Volume In %
0.479	0.00
0.525	0.00
0.575	0.00
0.631	0.00
0.692	0.00
0.759	0.00
0.832	0.00
0.912	0.00
1.000	0.03
1.096	0.08
1.202	0.18
1.318	0.29
1.445	0.39
1.585	0.51
1.738	0.63
1.905	0.75
2.089	0.88
2.291	

Size (µm)	Volume In %
2.291	1.00
2.512	1.12
2.754	1.25
3.020	1.37
3.311	1.50
3.631	1.63
3.981	1.76
4.365	1.90
4.786	2.04
5.248	2.19
5.754	2.36
6.310	2.52
6.918	2.70
7.586	2.88
8.318	3.06
9.120	3.23
10.000	3.40
10.965	

Size (µm)	Volume In %
10.965	3.56
12.023	3.70
13.183	3.81
14.454	3.89
15.849	3.93
17.378	3.92
19.055	3.88
20.893	3.78
22.909	3.64
25.119	3.45
27.542	3.23
30.200	2.97
33.113	2.70
36.308	2.41
39.811	2.12
43.652	1.83
47.863	1.55
52.481	

Size (µm)	Volume In %
52.481	1.30
57.544	1.07
63.096	0.86
69.183	0.69
75.858	0.54
83.176	0.41
91.201	0.31
100.000	0.23
109.648	0.16
120.226	0.11
131.826	0.07
144.544	0.05
158.489	0.03
173.780	0.00
190.546	0.00
208.930	0.00
229.087	0.00
251.189	

Size (µm)	Volume In %
251.189	0.00
275.423	0.00
301.995	0.00
331.131	0.01
363.078	0.02
398.107	0.02
436.516	0.02
478.630	0.02
524.807	0.02
575.440	0.02
630.957	0.02
691.831	0.02
758.578	0.01
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-17

Measured by:
tristan

Measured:
Wednesday, September 12, 2012 1:00:08 PM

Sample Name:
Bulk Regrind Discharge - Average

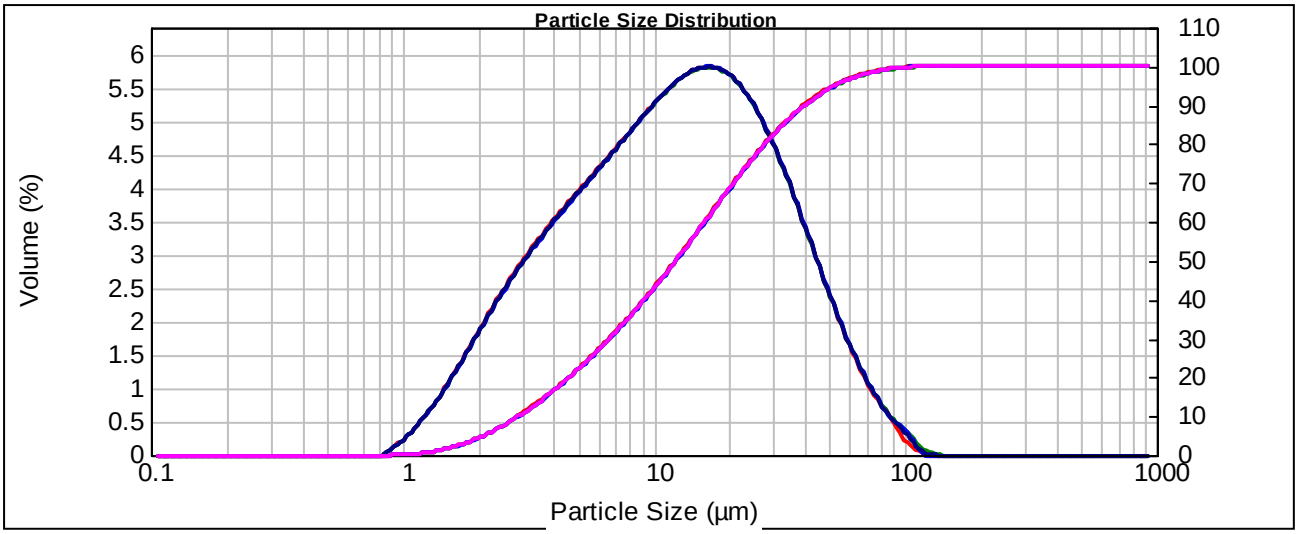
Edited by:
tristan

Analysed:
Wednesday, September 12, 2012 1:00:09 PM

Particle Name: Silica 0.01
Accessory Name: Hydro 2000MU (A)
Analysis model: General purpose
Sensitivity: Normal
Particle RI: 1.544
Absorption: 0.01
Size range: 0.100 to 1000.000 um
Obscuration: 13.46 %
Dispersant Name: Water
Dispersant RI: 1.330
Weighted Residual: 0.170 %
Result Emulation: Off

Concentration: 0.0119 %Vol
Span : 3.019
Uniformity: 0.952
Result units: Volume
Specific Surface Area: 0.322 m²/g
Surface Weighted Mean D[3,2]: 7.039 um
Vol. Weighted Mean D[4,3]: 17.570 um

d(0.1): 2.888 um d(0.5): 12.183 um **d(0.8): 27.631 um** d(0.9): 39.665 um d(0.98): 68 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.00
0.437	0.00
0.479	

Size (µm)	Volume In %
0.479	0.00
0.525	0.00
0.575	0.00
0.631	0.00
0.692	0.00
0.759	0.00
0.832	0.02
0.912	0.11
1.000	0.17
1.096	0.28
1.202	0.38
1.318	0.50
1.445	0.64
1.585	0.79
1.738	0.94
1.905	1.10
2.089	1.26
2.291	

Size (µm)	Volume In %
2.291	1.40
2.512	1.55
2.754	1.68
3.020	1.81
3.311	1.93
3.631	2.05
3.981	2.16
4.365	2.27
4.786	2.37
5.248	2.48
5.754	2.58
6.310	2.69
6.918	2.79
7.586	2.90
8.318	3.01
9.120	3.11
10.000	3.22
10.965	

Size (µm)	Volume In %
10.965	3.31
12.023	3.39
13.183	3.45
14.454	3.49
15.849	3.50
17.378	3.48
19.055	3.43
20.893	3.35
22.909	3.22
25.119	3.07
27.542	2.88
30.200	2.67
33.113	2.44
36.308	2.19
39.811	1.94
43.652	1.69
47.863	1.44
52.481	

Size (µm)	Volume In %
52.481	1.20
57.544	0.99
63.096	0.79
69.183	0.62
75.858	0.47
83.176	0.34
91.201	0.25
100.000	0.15
109.648	0.03
120.226	0.01
131.826	0.00
144.544	0.00
158.489	0.00
173.780	0.00
190.546	0.00
208.930	0.00
229.087	0.00
251.189	

Size (µm)	Volume In %
251.189	0.00
275.423	0.00
301.995	0.00
331.131	0.00
363.078	0.00
398.107	0.00
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-18

Sample Name:
Bulk Regrind Discharge V - Average

Measured by:
Dean

Edited by:
Dean

Measured:
Tuesday, September 18, 2012 1:46:21 PM

Analysed:
Tuesday, September 18, 2012 1:46:23 PM

Particle Name: Silica 0.01
Particle RI: 1.544
Dispersant Name: Water

Accessory Name: Hydro 2000MU (A)
Absorption: 0.01
Dispersant RI: 1.330

Analysis model: General purpose
Size range: 0.100 to 1000.000 um
Weighted Residual: 0.398 %

Sensitivity: Normal
Obscuration: 7.45 %
Result Emulation: Off

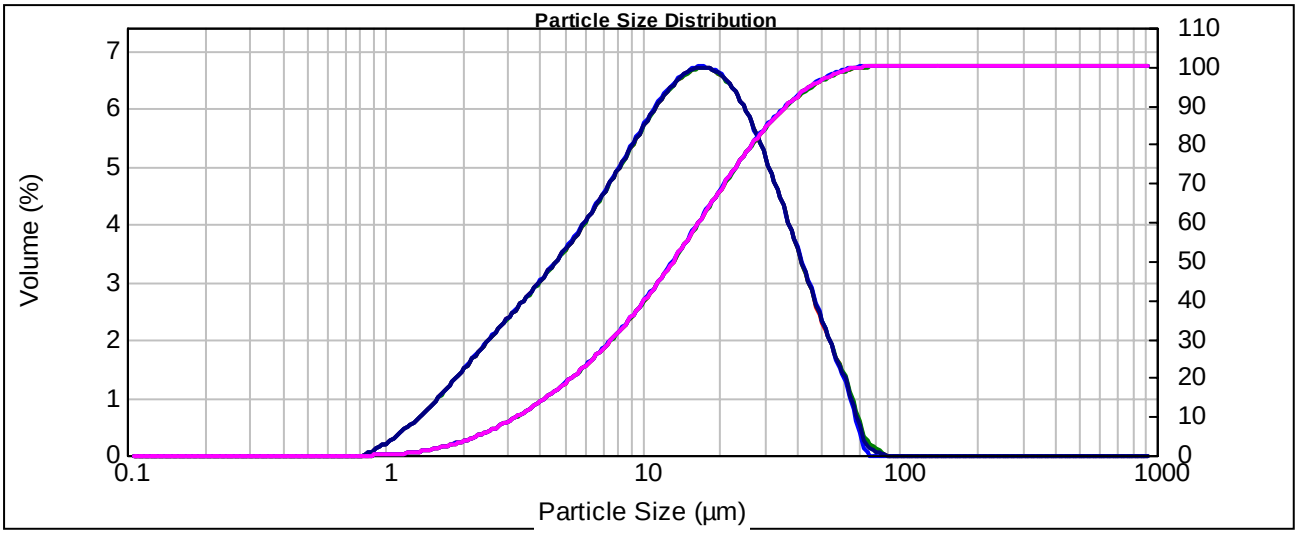
Concentration: 0.0071 %Vol
Specific Surface Area: 0.293 m²/g

Span : 2.520
Surface Weighted Mean D[3,2]: 7.730 um

Uniformity: 0.778
Vol. Weighted Mean D[4,3]: 17.033 um

Result units: Volume

d(0.1): 3.275 um d(0.5): 13.225 um **d(0.8): 26.883 um** d(0.9): 36.603 um d(0.98): 55.63 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.00
0.437	0.00
0.479	

Size (µm)	Volume In %
0.479	0.00
0.525	0.00
0.575	0.00
0.631	0.00
0.692	0.00
0.759	0.00
0.832	0.02
0.912	0.10
1.000	0.14
1.096	0.23
1.202	0.31
1.318	0.40
1.445	0.51
1.585	0.63
1.738	0.75
1.905	0.87
2.089	1.00
2.291	

Size (µm)	Volume In %
2.291	1.12
2.512	1.25
2.754	1.37
3.020	1.49
3.311	1.61
3.631	1.73
3.981	1.86
4.365	1.99
4.786	2.13
5.248	2.27
5.754	2.43
6.310	2.59
6.918	2.76
7.586	2.94
8.318	3.12
9.120	3.30
10.000	3.49
10.965	

Size (µm)	Volume In %
10.965	3.65
12.023	3.79
13.183	3.91
14.454	4.00
15.849	4.04
17.378	4.03
19.055	3.98
20.893	3.87
22.909	3.71
25.119	3.50
27.542	3.25
30.200	2.97
33.113	2.66
36.308	2.34
39.811	2.02
43.652	1.71
47.863	1.40
52.481	

Size (µm)	Volume In %
52.481	1.11
57.544	0.86
63.096	0.56
69.183	0.16
75.858	0.05
83.176	0.00
91.201	0.00
100.000	0.00
109.648	0.00
120.226	0.00
131.826	0.00
144.544	0.00
158.489	0.00
173.780	0.00
190.546	0.00
208.930	0.00
229.087	0.00
251.189	

Size (µm)	Volume In %
251.189	0.00
275.423	0.00
301.995	0.00
331.131	0.00
363.078	0.00
398.107	0.00
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-19

Measured by:
Mel

Measured:
Thursday, September 20, 2012 3:00:15 PM

Sample Name:
Bulk Regrind Discharge V - Average

Edited by:
Mel

Analysed:
Thursday, September 20, 2012 3:00:16 PM

Particle Name:
Silica 0.01

Accessory Name:
Hydro 2000MU (A)

Analysis model:
General purpose

Sensitivity:
Normal

Particle RI:
1.544

Absorption:
0.01

Size range:
0.100 to 1000.000 um

Obscuration:
12.77 %

Dispersant Name:
Water

Dispersant RI:
1.330

Weighted Residual:
0.340 %

Result Emulation:
Off

Concentration:
0.0132 %Vol

Span :
2.799

Uniformity:
0.871

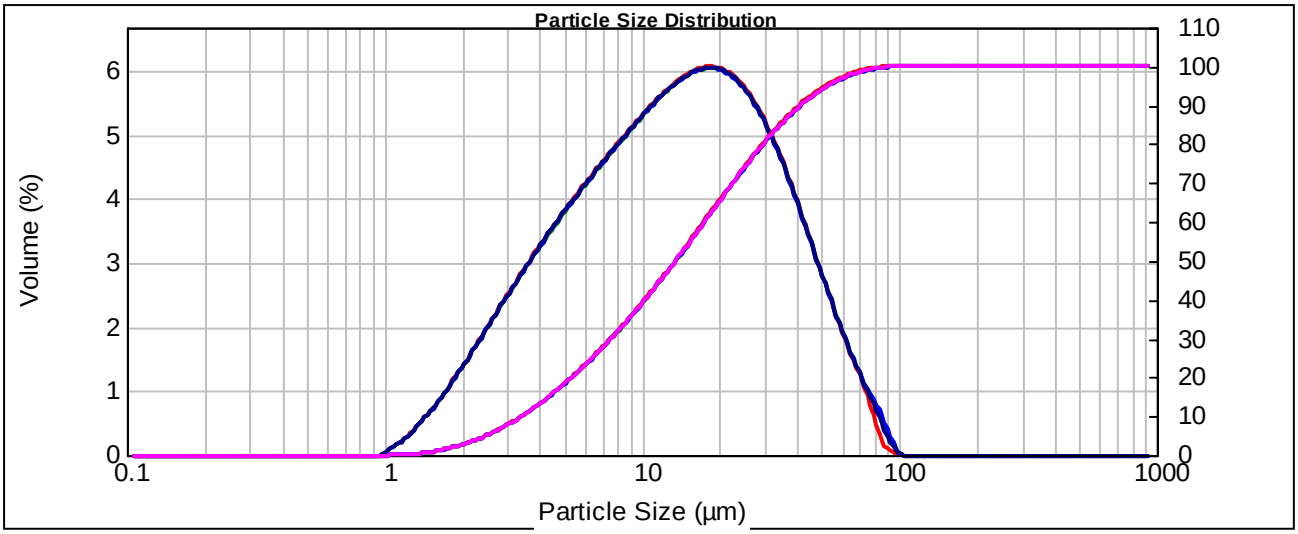
Result units:
Volume

Specific Surface Area:
0.28 m²/g

Surface Weighted Mean D[3,2]:
8.078 um

Vol. Weighted Mean D[4,3]:
18.532 um

d(0.1): 3.401 um d(0.5): 13.501 um **d(0.8): 29.523 um** d(0.9): 41.193 um d(0.98): 65.32 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.00
0.437	0.00
0.479	

Size (µm)	Volume In %
0.479	0.00
0.525	0.00
0.575	0.00
0.631	0.00
0.692	0.00
0.759	0.00
0.832	0.00
0.912	0.00
1.000	0.05
1.096	0.11
1.202	0.20
1.318	0.31
1.445	0.41
1.585	0.54
1.738	0.68
1.905	0.82
2.089	0.97
2.291	

Size (µm)	Volume In %
2.291	1.12
2.512	1.28
2.754	1.43
3.020	1.59
3.311	1.74
3.631	1.88
3.981	2.02
4.365	2.16
4.786	2.29
5.248	2.42
5.754	2.55
6.310	2.67
6.918	2.79
7.586	2.90
8.318	3.02
9.120	3.13
10.000	3.24
10.965	

Size (µm)	Volume In %
10.965	3.34
12.023	3.43
13.183	3.52
14.454	3.58
15.849	3.62
17.378	3.64
19.055	3.63
20.893	3.58
22.909	3.50
25.119	3.38
27.542	3.22
30.200	3.02
33.113	2.79
36.308	2.54
39.811	2.26
43.652	1.98
47.863	1.69
52.481	

Size (µm)	Volume In %
52.481	1.41
57.544	1.15
63.096	0.91
69.183	0.69
75.858	0.47
83.176	0.25
91.201	0.05
100.000	0.00
109.648	0.00
120.226	0.00
131.826	0.00
144.544	0.00
158.489	0.00
173.780	0.00
190.546	0.00
208.930	0.00
229.087	0.00
251.189	

Size (µm)	Volume In %
251.189	0.00
275.423	0.00
301.995	0.00
331.131	0.00
363.078	0.00
398.107	0.00
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-20

Measured by:
Mel

Measured:
Monday, September 24, 2012 3:41:37 PM

Sample Name:
Bulk Regrind Discharge V - Average

Edited by:
Mel

Analysed:
Monday, September 24, 2012 3:41:38 PM

Particle Name:
Silica 0.01

Accessory Name:
Hydro 2000MU (A)

Analysis model:
General purpose

Sensitivity:
Normal

Particle RI:
1.544

Absorption:
0.01

Size range:
0.100 to 1000.000 um

Obscuration:
9.08 %

Dispersant Name:
Water

Dispersant RI:
1.330

Weighted Residual:
0.355 %

Result Emulation:
Off

Concentration:
0.0073 %Vol

Span :
3.019

Uniformity:
0.961

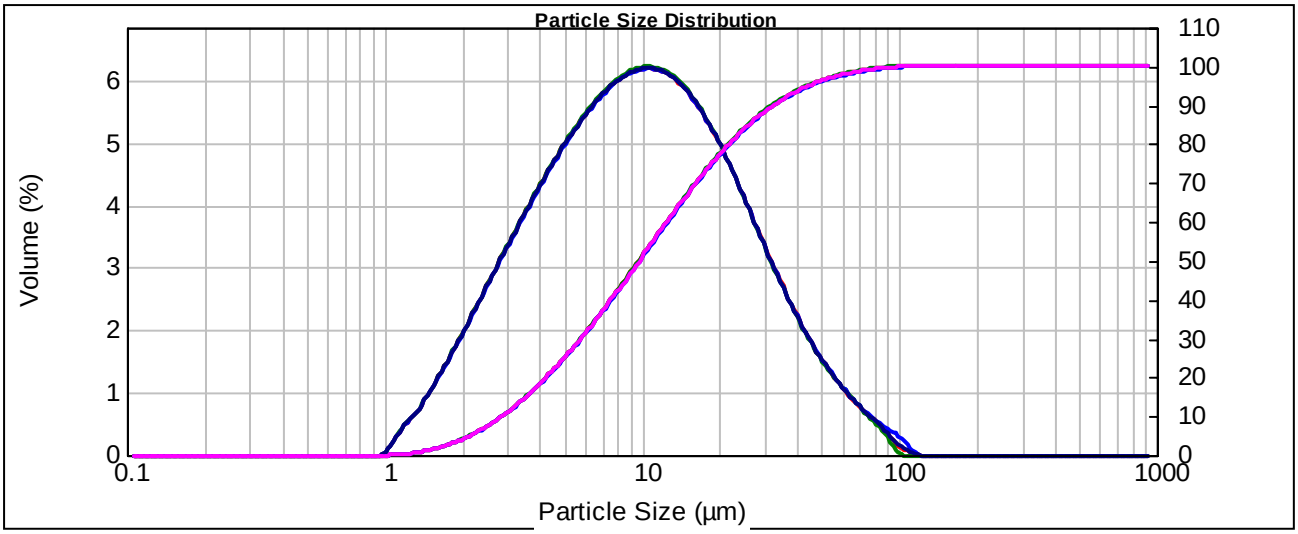
Result units:
Volume

Specific Surface Area:
0.348 m²/g

Surface Weighted Mean D[3,2]:
6.507 um

Vol. Weighted Mean D[4,3]:
14.566 um

d(0.1): 2.852 um d(0.5): 9.767 um **d(0.8): 21.753 um** d(0.9): 32.336 um d(0.98): 60.89 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.00
0.437	0.00
0.479	

Size (µm)	Volume In %
0.479	0.00
0.525	0.00
0.575	0.00
0.631	0.00
0.692	0.00
0.759	0.00
0.832	0.00
0.912	0.00
1.000	0.06
1.096	0.24
1.202	0.34
1.318	0.47
1.445	0.63
1.585	0.80
1.738	0.97
1.905	1.16
2.089	1.35
2.291	

Size (µm)	Volume In %
2.291	1.54
2.512	1.74
2.754	1.93
3.020	2.12
3.311	2.31
3.631	2.49
3.981	2.66
4.365	2.83
4.786	2.99
5.248	3.14
5.754	3.28
6.310	3.40
6.918	3.51
7.586	3.60
8.318	3.67
9.120	3.71
10.000	3.73
10.965	

Size (µm)	Volume In %
10.965	3.72
12.023	3.68
13.183	3.60
14.454	3.50
15.849	3.36
17.378	3.20
19.055	3.01
20.893	2.80
22.909	2.58
25.119	2.35
27.542	2.11
30.200	1.88
33.113	1.66
36.308	1.45
39.811	1.25
43.652	1.08
47.863	0.91
52.481	

Size (µm)	Volume In %
52.481	0.77
57.544	0.65
63.096	0.54
69.183	0.43
75.858	0.34
83.176	0.25
91.201	0.13
100.000	0.06
109.648	0.01
120.226	0.00
131.826	0.00
144.544	0.00
158.489	0.00
173.780	0.00
190.546	0.00
208.930	0.00
229.087	0.00
251.189	

Size (µm)	Volume In %
251.189	0.00
275.423	0.00
301.995	0.00
331.131	0.00
363.078	0.00
398.107	0.00
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-21

Measured by:
Neville

Measured:
Thursday, September 27, 2012 10:52:08 AM

Sample Name:
Bulk Regrind Discharge - Average

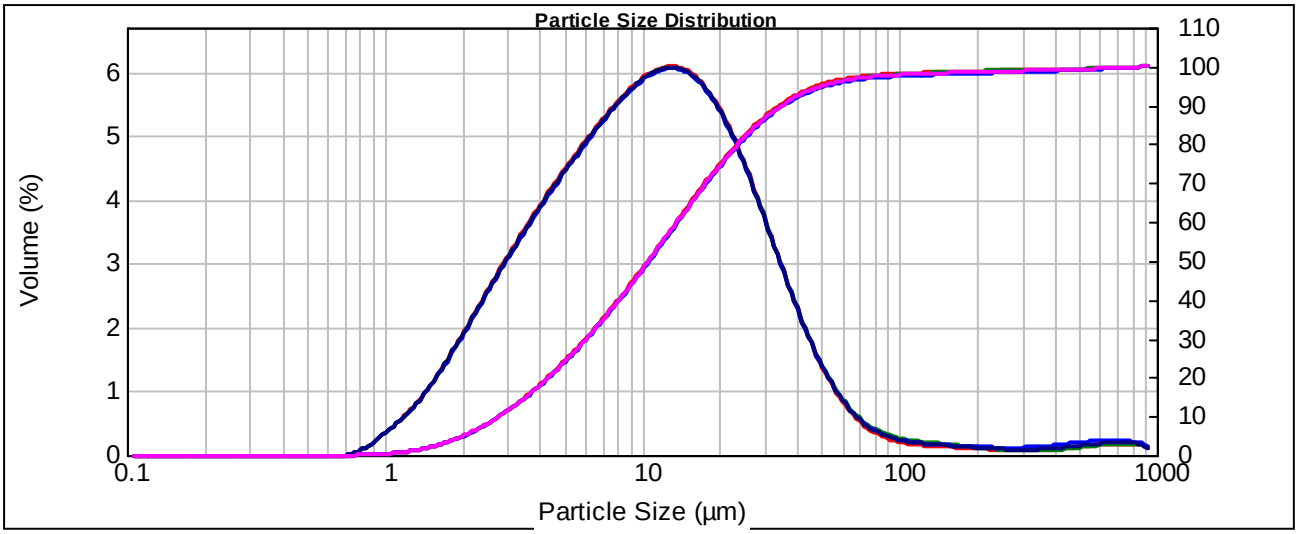
Edited by:
Neville

Analysed:
Thursday, September 27, 2012 10:52:09 AM

Particle Name: Silica 0.01
Accessory Name: Hydro 2000MU (A)
Analysis model: General purpose
Sensitivity: Normal
Particle RI: 1.544
Absorption: 0.01
Size range: 0.100 to 1000.000 um
Obscuration: 13.21 %
Dispersant Name: Water
Dispersant RI: 1.330
Weighted Residual: 0.324 %
Result Emulation: Off

Concentration: 0.0109 %Vol
Span : 3.022
Uniformity: 1.62
Result units: Volume
Specific Surface Area: 0.346 m²/g
Surface Weighted Mean D[3,2]: 6.538 um
Vol. Weighted Mean D[4,3]: 22.620 um

d(0.1): 2.795 um d(0.5): 10.626 um **d(0.8): 23.603 um** d(0.9): 34.908 um d(0.98): 108.6 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.00
0.437	0.00
0.479	

Size (µm)	Volume In %
0.479	0.00
0.525	0.00
0.575	0.00
0.631	0.00
0.692	0.00
0.759	0.00
0.832	0.05
0.912	0.08
1.000	0.17
1.096	0.25
1.202	0.32
1.318	0.42
1.445	0.53
1.585	0.66
1.738	0.80
1.905	0.96
2.089	1.12
2.291	1.29

Size (µm)	Volume In %
2.291	1.46
2.512	1.62
2.754	1.79
3.020	1.95
3.311	2.10
3.631	2.25
3.981	2.40
4.365	2.54
4.786	2.68
5.248	2.81
5.754	2.94
6.310	3.07
6.918	3.19
7.586	3.30
8.318	3.41
9.120	3.50
10.000	3.57
10.965	

Size (µm)	Volume In %
10.965	3.63
12.023	3.65
13.183	3.65
14.454	3.61
15.849	3.53
17.378	3.42
19.055	3.27
20.893	3.08
22.909	2.86
25.119	2.61
27.542	2.35
30.200	2.07
33.113	1.80
36.308	1.53
39.811	1.28
43.652	1.05
47.863	0.84
52.481	

Size (µm)	Volume In %
52.481	0.66
57.544	0.51
63.096	0.39
69.183	0.30
75.858	0.24
83.176	0.19
91.201	0.15
100.000	0.13
109.648	0.12
120.226	0.11
131.826	0.10
144.544	0.09
158.489	0.09
173.780	0.08
190.546	0.07
208.930	0.07
229.087	0.06
251.189	

Size (µm)	Volume In %
251.189	0.05
275.423	0.05
301.995	0.05
331.131	0.05
363.078	0.06
398.107	0.07
436.516	0.08
478.630	0.09
524.807	0.10
575.440	0.11
630.957	0.11
691.831	0.11
758.578	0.12
831.764	0.10
912.011	0.03
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-22

Sample Name:
Bulk Regrind Discharge - Average

Measured by:
Neville

Edited by:
Neville

Measured:
Thursday, September 27, 2012 11:56:29 AM

Analysed:
Thursday, September 27, 2012 11:56:30 AM

Particle Name: Silica 0.01
Particle RI: 1.544
Dispersant Name: Water

Accessory Name: Hydro 2000MU (A)
Absorption: 0.01
Dispersant RI: 1.330

Analysis model: General purpose
Size range: 0.100 to 1000.000 um
Weighted Residual: 0.594 %

Sensitivity: Normal
Obscuration: 8.69 %
Result Emulation: Off

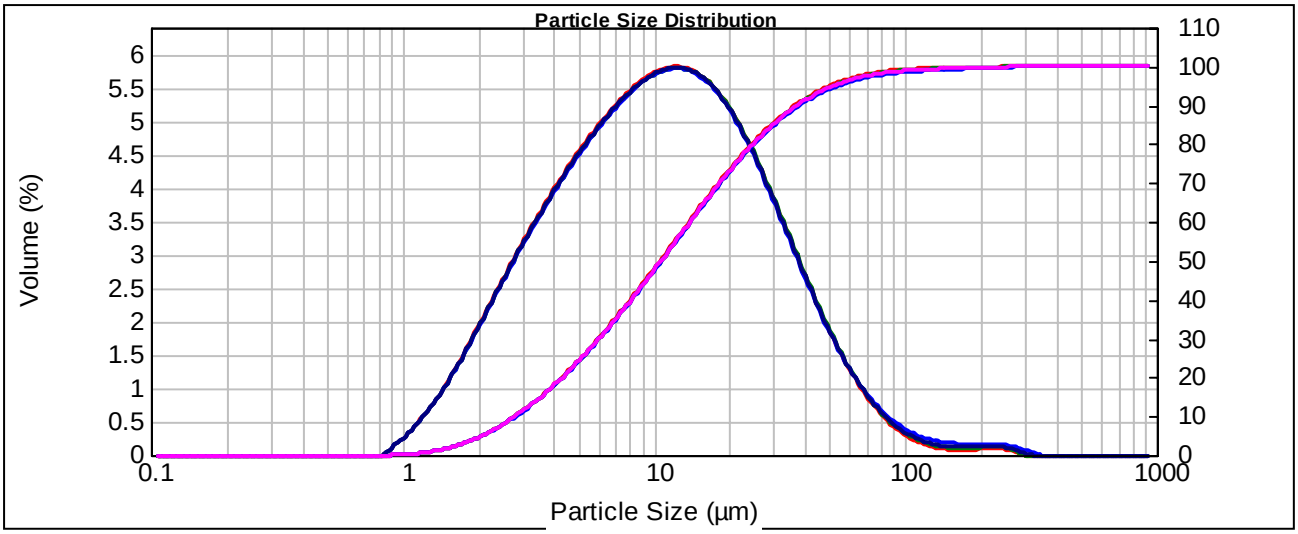
Concentration: 0.0071 %Vol
Specific Surface Area: 0.341 m²/g

Span : 3.224
Surface Weighted Mean D[3,2]: 6.633 um

Uniformity: 1.11
Vol. Weighted Mean D[4,3]: 17.220 um

Result units: Volume

d(0.1): 2.815 um d(0.5): 10.660 um **d(0.8): 24.765 um** d(0.9): 37.184 um d(0.98): 75.55 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.00
0.437	0.00
0.479	

Size (µm)	Volume In %
0.479	0.00
0.525	0.00
0.575	0.00
0.631	0.00
0.692	0.00
0.759	0.00
0.832	0.02
0.912	0.12
1.000	0.18
1.096	0.29
1.202	0.40
1.318	0.52
1.445	0.66
1.585	0.81
1.738	0.97
1.905	1.14
2.089	1.32
2.291	

Size (µm)	Volume In %
2.291	1.49
2.512	1.66
2.754	1.83
3.020	1.99
3.311	2.15
3.631	2.30
3.981	2.44
4.365	2.58
4.786	2.71
5.248	2.84
5.754	2.96
6.310	3.07
6.918	3.17
7.586	3.26
8.318	3.34
9.120	3.40
10.000	3.45
10.965	

Size (µm)	Volume In %
10.965	3.48
12.023	3.49
13.183	3.47
14.454	3.43
15.849	3.35
17.378	3.25
19.055	3.12
20.893	2.97
22.909	2.79
25.119	2.60
27.542	2.39
30.200	2.17
33.113	1.95
36.308	1.73
39.811	1.51
43.652	1.31
47.863	1.11
52.481	

Size (µm)	Volume In %
52.481	0.93
57.544	0.77
63.096	0.63
69.183	0.50
75.858	0.39
83.176	0.30
91.201	0.23
100.000	0.18
109.648	0.13
120.226	0.10
131.826	0.08
144.544	0.07
158.489	0.07
173.780	0.07
190.546	0.08
208.930	0.08
229.087	0.08
251.189	

Size (µm)	Volume In %
251.189	0.06
275.423	0.03
301.995	0.00
331.131	0.00
363.078	0.00
398.107	0.00
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-23

Sample Name:
Bulk Regrind Discharge V - Average

Measured by:
tristan

Edited by:
tristan

Measured:
Tuesday, October 02, 2012 11:47:56 AM

Analysed:
Tuesday, October 02, 2012 11:47:57 AM

Particle Name: Silica 0.01
Particle RI: 1.544
Dispersant Name: Water

Accessory Name: Hydro 2000MU (A)
Absorption: 0.01
Dispersant RI: 1.330

Analysis model: General purpose
Size range: 0.100 to 1000.000 um
Weighted Residual: 0.234 %

Sensitivity: Normal
Obscuration: 19.41 %
Result Emulation: Off

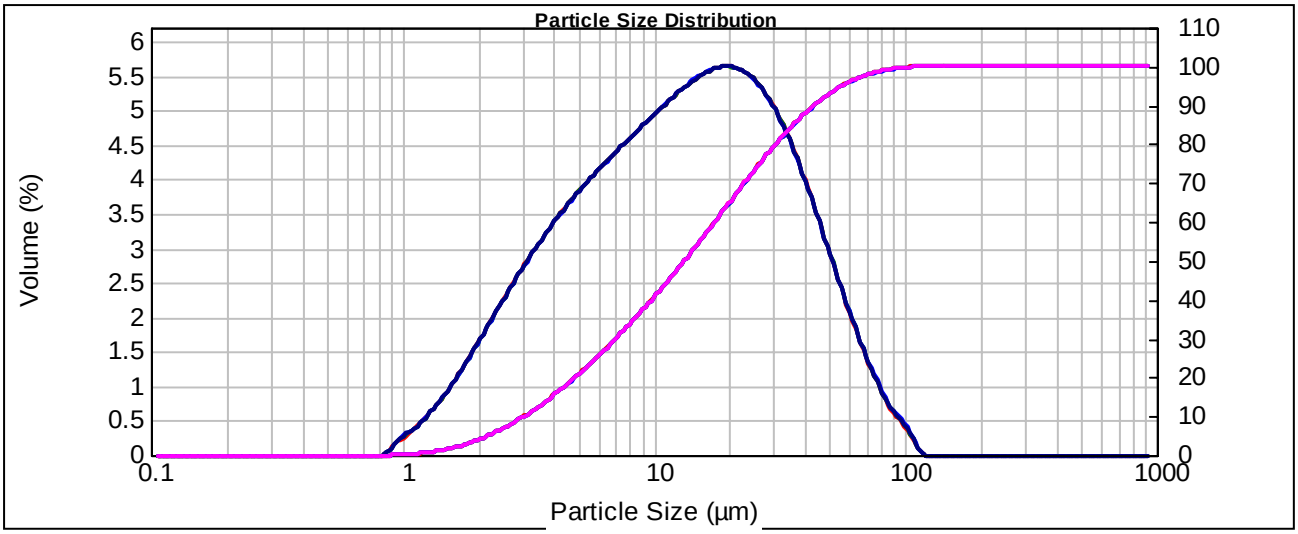
Concentration: 0.0189 %Vol
Specific Surface Area: 0.305 m²/g

Span : 3.050
Surface Weighted Mean D[3,2]: 7.419 um

Uniformity: 0.959
Vol. Weighted Mean D[4,3]: 19.006 um

Result units: Volume

d(0.1): 3.041 um d(0.5): 13.204 um **d(0.8): 30.508 um** d(0.9): 43.309 um d(0.98): 71.52 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.00
0.437	0.00
0.479	

Size (µm)	Volume In %
0.479	0.00
0.525	0.00
0.575	0.00
0.631	0.00
0.692	0.00
0.759	0.00
0.832	0.01
0.912	0.13
1.000	0.20
1.096	0.26
1.202	0.35
1.318	0.45
1.445	0.56
1.585	0.70
1.738	0.83
1.905	0.98
2.089	1.13
2.291	

Size (µm)	Volume In %
2.291	1.28
2.512	1.43
2.754	1.57
3.020	1.71
3.311	1.84
3.631	1.97
3.981	2.09
4.365	2.20
4.786	2.30
5.248	2.40
5.754	2.49
6.310	2.58
6.918	2.67
7.586	2.76
8.318	2.84
9.120	2.93
10.000	3.01
10.965	

Size (µm)	Volume In %
10.965	3.10
12.023	3.17
13.183	3.25
14.454	3.31
15.849	3.36
17.378	3.39
19.055	3.39
20.893	3.37
22.909	3.32
25.119	3.23
27.542	3.11
30.200	2.95
33.113	2.75
36.308	2.53
39.811	2.29
43.652	2.03
47.863	1.76
52.481	

Size (µm)	Volume In %
52.481	1.49
57.544	1.24
63.096	0.99
69.183	0.78
75.858	0.59
83.176	0.42
91.201	0.31
100.000	0.20
109.648	0.02
120.226	0.00
131.826	0.00
144.544	0.00
158.489	0.00
173.780	0.00
190.546	0.00
208.930	0.00
229.087	0.00
251.189	

Size (µm)	Volume In %
251.189	0.00
275.423	0.00
301.995	0.00
331.131	0.00
363.078	0.00
398.107	0.00
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-24

Measured by:
Mel

Measured:
Wednesday, October 03, 2012 9:33:35 AM

Sample Name:
Bulk Regrind Discharge V - Average

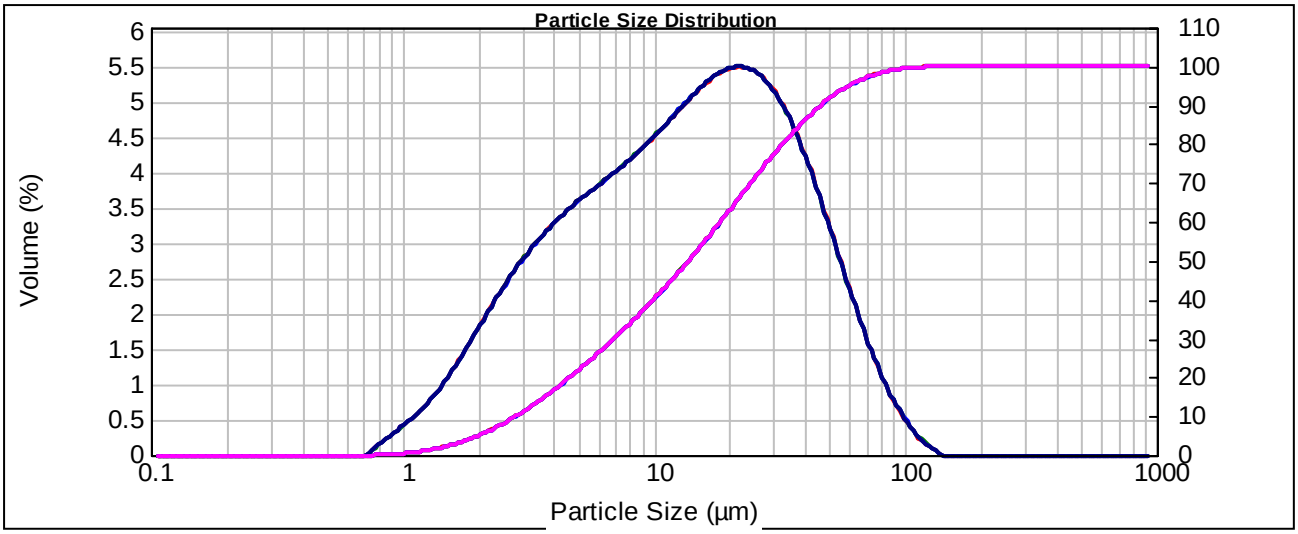
Edited by:
Mel

Analysed:
Wednesday, October 03, 2012 9:33:36 AM

Particle Name: Silica 0.01
Accessory Name: Hydro 2000MU (A)
Analysis model: General purpose
Sensitivity: Normal
Particle RI: 1.544
Absorption: 0.01
Size range: 0.100 to 1000.000 um
Obscuration: 17.30 %
Dispersant Name: Water
Dispersant RI: 1.330
Weighted Residual: 0.238 %
Result Emulation: Off

Concentration: 0.0158 %Vol
Span : 3.156
Uniformity: 0.997
Result units: Volume
Specific Surface Area: 0.32 m²/g
Surface Weighted Mean D[3,2]: 7.077 um
Vol. Weighted Mean D[4,3]: 19.967 um

d(0.1): 2.816 um d(0.5): 13.714 um **d(0.8): 32.424 um** d(0.9): 46.092 um d(0.98): 76.26 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.00
0.437	0.00
0.479	

Size (µm)	Volume In %
0.479	0.00
0.525	0.00
0.575	0.00
0.631	0.00
0.692	0.00
0.759	0.09
0.832	0.14
0.912	0.21
1.000	0.28
1.096	0.35
1.202	0.45
1.318	0.55
1.445	0.66
1.585	0.80
1.738	0.93
1.905	1.08
2.089	1.22
2.291	

Size (µm)	Volume In %
2.291	1.36
2.512	1.49
2.754	1.62
3.020	1.73
3.311	1.84
3.631	1.93
3.981	2.02
4.365	2.10
4.786	2.17
5.248	2.24
5.754	2.30
6.310	2.37
6.918	2.44
7.586	2.51
8.318	2.59
9.120	2.67
10.000	2.76
10.965	

Size (µm)	Volume In %
10.965	2.85
12.023	2.94
13.183	3.04
14.454	3.12
15.849	3.20
17.378	3.26
19.055	3.30
20.893	3.31
22.909	3.30
25.119	3.25
27.542	3.16
30.200	3.03
33.113	2.87
36.308	2.67
39.811	2.45
43.652	2.20
47.863	1.94
52.481	

Size (µm)	Volume In %
52.481	1.67
57.544	1.41
63.096	1.15
69.183	0.92
75.858	0.71
83.176	0.52
91.201	0.37
100.000	0.24
109.648	0.13
120.226	0.08
131.826	0.00
144.544	0.00
158.489	0.00
173.780	0.00
190.546	0.00
208.930	0.00
229.087	0.00
251.189	

Size (µm)	Volume In %
251.189	0.00
275.423	0.00
301.995	0.00
331.131	0.00
363.078	0.00
398.107	0.00
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes: *REDO*

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-25

Sample Name:
Bulk Regrind Discharge V - Average

Measured by:
quentin

Edited by:
quentin

Measured:
Thursday, October 04, 2012 7:34:08 AM

Analysed:
Thursday, October 04, 2012 7:34:10 AM

Particle Name: Silica 0.01
Particle RI: 1.544
Dispersant Name: Water

Accessory Name: Hydro 2000MU (A)
Absorption: 0.01
Dispersant RI: 1.330

Analysis model: General purpose
Size range: 0.100 to 1000.000 um
Weighted Residual: 0.348 %

Sensitivity: Normal
Obscuration: 18.16 %
Result Emulation: Off

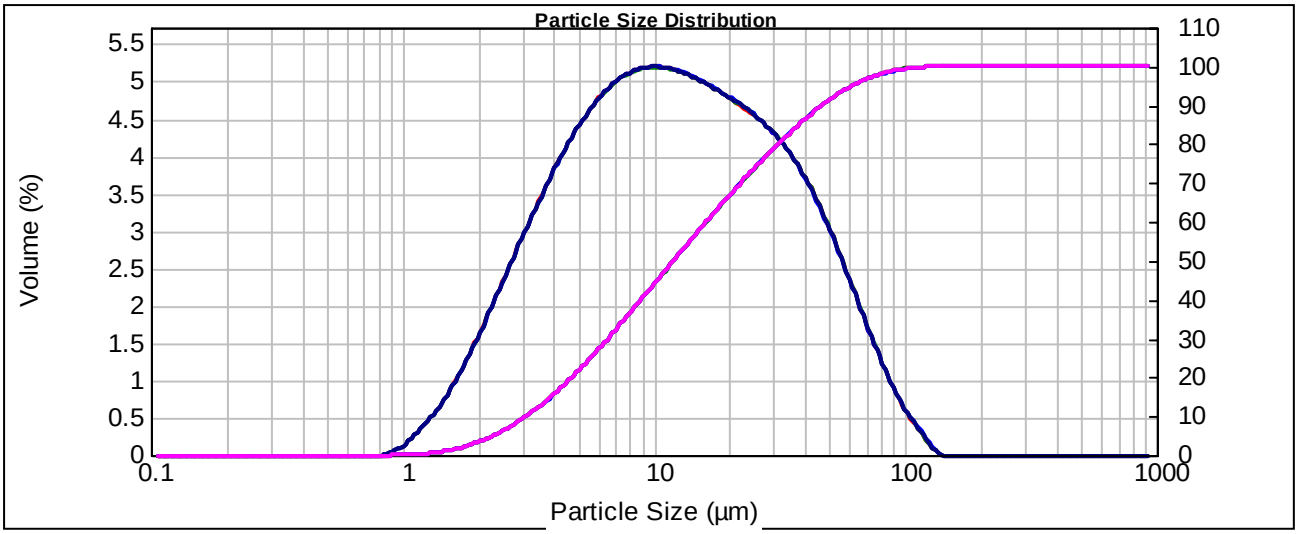
Concentration: 0.0175 %Vol
Specific Surface Area: 0.307 m²/g

Span : 3.639
Surface Weighted Mean D[3,2]: 7.368 um

Uniformity: 1.12
Vol. Weighted Mean D[4,3]: 19.318 um

Result units: Volume

d(0.1): 3.105 um d(0.5): 11.928 um **d(0.8): 31.131 um** d(0.9): 46.511 um d(0.98): 79.18 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.00
0.437	0.00
0.479	

Size (µm)	Volume In %
0.479	0.00
0.525	0.00
0.575	0.00
0.631	0.00
0.692	0.00
0.759	0.00
0.832	0.01
0.912	0.05
1.000	0.10
1.096	0.19
1.202	0.27
1.318	0.37
1.445	0.49
1.585	0.63
1.738	0.78
1.905	0.95
2.089	1.13
2.291	

Size (µm)	Volume In %
2.291	1.31
2.512	1.49
2.754	1.68
3.020	1.86
3.311	2.04
3.631	2.21
3.981	2.37
4.365	2.52
4.786	2.65
5.248	2.77
5.754	2.87
6.310	2.96
6.918	3.03
7.586	3.08
8.318	3.11
9.120	3.13
10.000	3.13
10.965	

Size (µm)	Volume In %
10.965	3.11
12.023	3.09
13.183	3.06
14.454	3.02
15.849	2.98
17.378	2.93
19.055	2.88
20.893	2.83
22.909	2.77
25.119	2.70
27.542	2.63
30.200	2.54
33.113	2.44
36.308	2.31
39.811	2.16
43.652	2.00
47.863	1.81
52.481	

Size (µm)	Volume In %
52.481	1.61
57.544	1.41
63.096	1.19
69.183	0.98
75.858	0.78
83.176	0.60
91.201	0.43
100.000	0.30
109.648	0.20
120.226	0.08
131.826	0.00
144.544	0.00
158.489	0.00
173.780	0.00
190.546	0.00
208.930	0.00
229.087	0.00
251.189	

Size (µm)	Volume In %
251.189	0.00
275.423	0.00
301.995	0.00
331.131	0.00
363.078	0.00
398.107	0.00
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-29

Measured by:
tristan

Measured:
Thursday, November 29, 2012 2:01:37 PM

Sample Name:
Molybdenum Regrind Discharge - Average

Edited by:
tristan

Analysed:
Thursday, November 29, 2012 2:01:38 PM

Particle Name:
Silica 0.1

Accessory Name:
Hydro 2000MU (A)

Analysis model:
General purpose

Sensitivity:
Normal

Particle RI:
1.544

Absorption:
0.1

Size range:
0.100 to 1000.000 um

Obscuration:
7.63 %

Dispersant Name:
Water

Dispersant RI:
1.330

Weighted Residual:
0.204 %

Result Emulation:
Off

Concentration:
0.0113 %Vol

Span :
3.077

Uniformity:
0.96

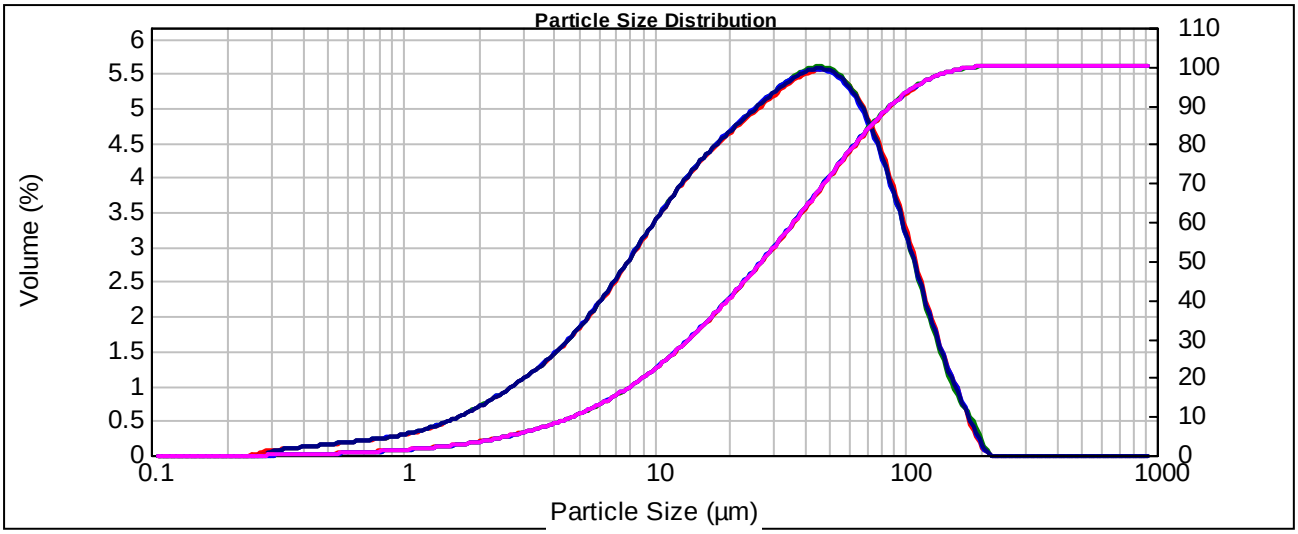
Result units:
Volume

Specific Surface Area:
0.231 m²/g

Surface Weighted Mean D[3,2]:
9.793 um

Vol. Weighted Mean D[4,3]:
38.102 um

d(0.1): 4.780 um d(0.5): 26.993 um **d(0.8): 63.107 um** d(0.9): 87.832 um d(0.98): 138.11 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.01
0.302	0.04
0.331	0.06
0.363	0.06
0.398	0.07
0.437	0.08
0.479	

Size (µm)	Volume In %
0.479	0.09
0.525	0.10
0.575	0.11
0.631	0.12
0.692	0.13
0.759	0.14
0.832	0.15
0.912	0.17
1.000	0.18
1.096	0.21
1.202	0.23
1.318	0.26
1.445	0.29
1.585	0.33
1.738	0.37
1.905	0.42
2.089	0.46
2.291	

Size (µm)	Volume In %
2.291	0.52
2.512	0.57
2.754	0.63
3.020	0.69
3.311	0.76
3.631	0.83
3.981	0.91
4.365	1.00
4.786	1.10
5.248	1.20
5.754	1.31
6.310	1.43
6.918	1.56
7.586	1.69
8.318	1.82
9.120	1.95
10.000	2.08
10.965	

Size (µm)	Volume In %
10.965	2.20
12.023	2.32
13.183	2.43
14.454	2.53
15.849	2.63
17.378	2.72
19.055	2.80
20.893	2.88
22.909	2.96
25.119	3.03
27.542	3.11
30.200	3.18
33.113	3.24
36.308	3.30
39.811	3.34
43.652	3.35
47.863	3.34
52.481	

Size (µm)	Volume In %
52.481	3.28
57.544	3.19
63.096	3.05
69.183	2.87
75.858	2.65
83.176	2.38
91.201	2.10
100.000	1.79
109.648	1.48
120.226	1.19
131.826	0.92
144.544	0.68
158.489	0.49
173.780	0.30
190.546	0.10
208.930	0.00
229.087	0.00
251.189	

Size (µm)	Volume In %
251.189	0.00
275.423	0.00
301.995	0.00
331.131	0.00
363.078	0.00
398.107	0.00
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P1

Measured by:
tristan

Measured:
Wednesday, October 17, 2012 1:32:27 PM

Sample Name:
WSA Bulk Concentrate - Average

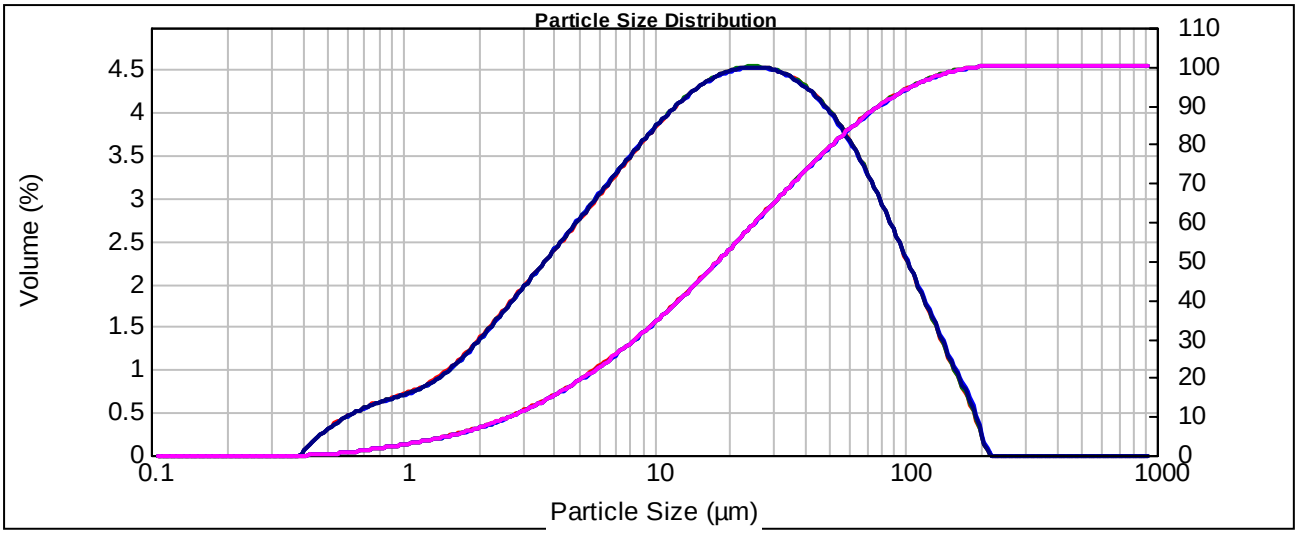
Edited by:
tristan

Analysed:
Wednesday, October 17, 2012 1:32:28 PM

Particle Name: Silica 0.1
Accessory Name: Hydro 2000MU (A)
Analysis model: General purpose
Sensitivity: Normal
Particle RI: 1.544
Absorption: 0.1
Size range: 0.100 to 1000.000 um
Obscuration: 11.50 %
Dispersant Name: Water
Dispersant RI: 1.330
Weighted Residual: 0.531 %
Result Emulation: Off

Concentration: 0.0113 %Vol
Span : 4.247
Uniformity: 1.31
Result units: Volume
Specific Surface Area: 0.345 m²/g
Surface Weighted Mean D[3,2]: 6.560 um
Vol. Weighted Mean D[4,3]: 31.142 um

d(0.1): 2.697 um d(0.5): 18.051 um **d(0.8): 51.343 um** d(0.9): 79.362 um d(0.98): 139.65 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.05
0.437	0.13
0.479	

Size (µm)	Volume In %
0.479	0.17
0.525	0.23
0.575	0.27
0.631	0.31
0.692	0.34
0.759	0.37
0.832	0.39
0.912	0.41
1.000	0.43
1.096	0.46
1.202	0.49
1.318	0.54
1.445	0.59
1.585	0.65
1.738	0.72
1.905	0.80
2.089	0.88
2.291	

Size (µm)	Volume In %
2.291	0.96
2.512	1.05
2.754	1.13
3.020	1.22
3.311	1.30
3.631	1.39
3.981	1.48
4.365	1.56
4.786	1.65
5.248	1.74
5.754	1.82
6.310	1.91
6.918	2.00
7.586	2.09
8.318	2.17
9.120	2.25
10.000	2.33
10.965	

Size (µm)	Volume In %
10.965	2.40
12.023	2.47
13.183	2.53
14.454	2.59
15.849	2.63
17.378	2.67
19.055	2.70
20.893	2.71
22.909	2.72
25.119	2.72
27.542	2.71
30.200	2.69
33.113	2.66
36.308	2.62
39.811	2.56
43.652	2.49
47.863	2.41
52.481	

Size (µm)	Volume In %
52.481	2.31
57.544	2.20
63.096	2.08
69.183	1.94
75.858	1.79
83.176	1.64
91.201	1.48
100.000	1.31
109.648	1.15
120.226	0.99
131.826	0.83
144.544	0.66
158.489	0.51
173.780	0.38
190.546	0.15
208.930	0.00
229.087	0.00
251.189	

Size (µm)	Volume In %
251.189	0.00
275.423	0.00
301.995	0.00
331.131	0.00
363.078	0.00
398.107	0.00
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P1

Measured by:
tristan

Measured:
Wednesday, October 17, 2012 1:24:53 PM

Sample Name:
WSA Bulk Regrind Discharge - Average

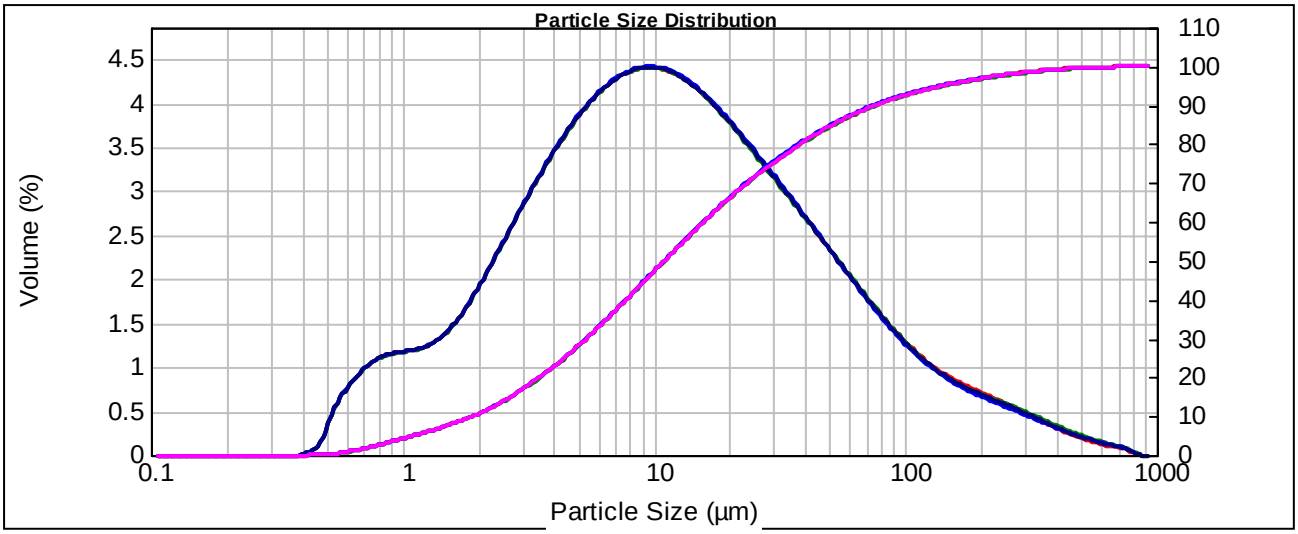
Edited by:
tristan

Analysed:
Wednesday, October 17, 2012 1:24:55 PM

Particle Name: Silica 0.1	**Accessory Name:** Hydro 2000MU (A)	**Analysis model:** General purpose	**Sensitivity:** Normal
Particle RI: 1.544	**Absorption:** 0.1	**Size range:** 0.100 to 1000.000 um	**Obscuration:** 13.68 %
Dispersant Name: Water	**Dispersant RI:** 1.330	**Weighted Residual:** 0.649 %	**Result Emulation:** Off

Concentration: 0.0100 %Vol	**Span :** 6.705	**Uniformity:** 2.53	**Result units:** Volume
Specific Surface Area: 0.47 m²/g	**Surface Weighted Mean D[3,2]:** 4.816 um	**Vol. Weighted Mean D[4,3]:** 32.647 um	

d(0.1): 1.897 um d(0.5): 10.991 um **d(0.8): 37.997 um** d(0.9): 75.590 um d(0.98): 260.12 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.01
0.437	0.05
0.479	

Size (µm)	Volume In %
0.479	0.19
0.525	0.37
0.575	0.46
0.631	0.54
0.692	0.62
0.759	0.66
0.832	0.69
0.912	0.70
1.000	0.71
1.096	0.72
1.202	0.75
1.318	0.79
1.445	0.85
1.585	0.93
1.738	1.03
1.905	1.14
2.089	1.26
2.291	

Size (µm)	Volume In %
2.291	1.39
2.512	1.52
2.754	1.65
3.020	1.77
3.311	1.90
3.631	2.01
3.981	2.12
4.365	2.23
4.786	2.32
5.248	2.40
5.754	2.48
6.310	2.54
6.918	2.59
7.586	2.62
8.318	2.64
9.120	2.65
10.000	2.65
10.965	

Size (µm)	Volume In %
10.965	2.63
12.023	2.60
13.183	2.55
14.454	2.49
15.849	2.43
17.378	2.36
19.055	2.28
20.893	2.20
22.909	2.11
25.119	2.03
27.542	1.94
30.200	1.85
33.113	1.76
36.308	1.67
39.811	1.58
43.652	1.50
47.863	1.40
52.481	

Size (µm)	Volume In %
52.481	1.31
57.544	1.22
63.096	1.13
69.183	1.05
75.858	0.96
83.176	0.88
91.201	0.80
100.000	0.73
109.648	0.67
120.226	0.61
131.826	0.56
144.544	0.52
158.489	0.48
173.780	0.45
190.546	0.42
208.930	0.39
229.087	0.36
251.189	

Size (µm)	Volume In %
251.189	0.33
275.423	0.30
301.995	0.27
331.131	0.24
363.078	0.21
398.107	0.18
436.516	0.15
478.630	0.13
524.807	0.10
575.440	0.08
630.957	0.07
691.831	0.06
758.578	0.02
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

TABLE III-33
SCREEN ANALYSIS
KM3512-P1 WSA Bulk Rougher Concentrate

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	1.10	98.9
65 Mesh	212	3.30	95.6
100 Mesh	150	5.10	90.5
150 Mesh	106	5.80	84.7
200 Mesh	75	6.80	77.9
270 Mesh	53	7.40	70.5
400 Mesh	38	6.70	63.8
TOTAL		100.00	**

K80 =84µm

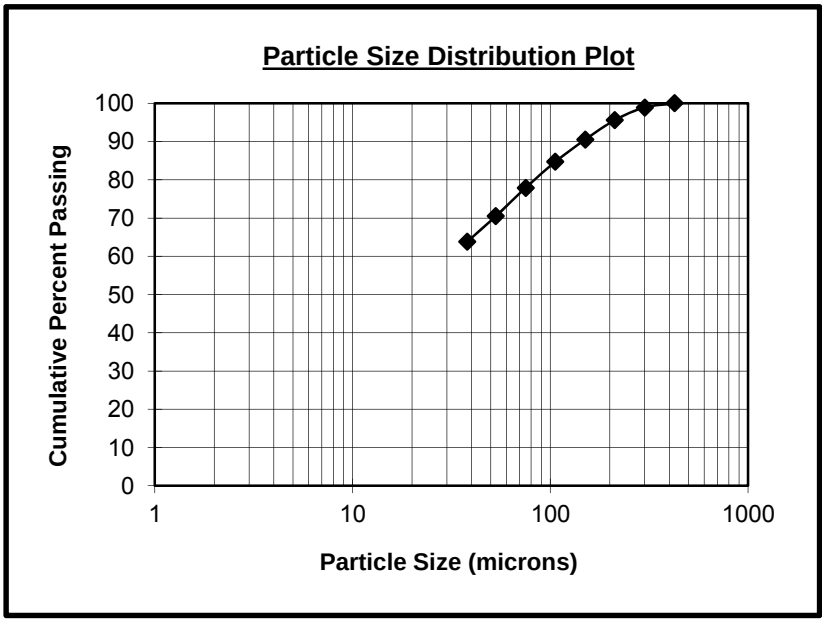
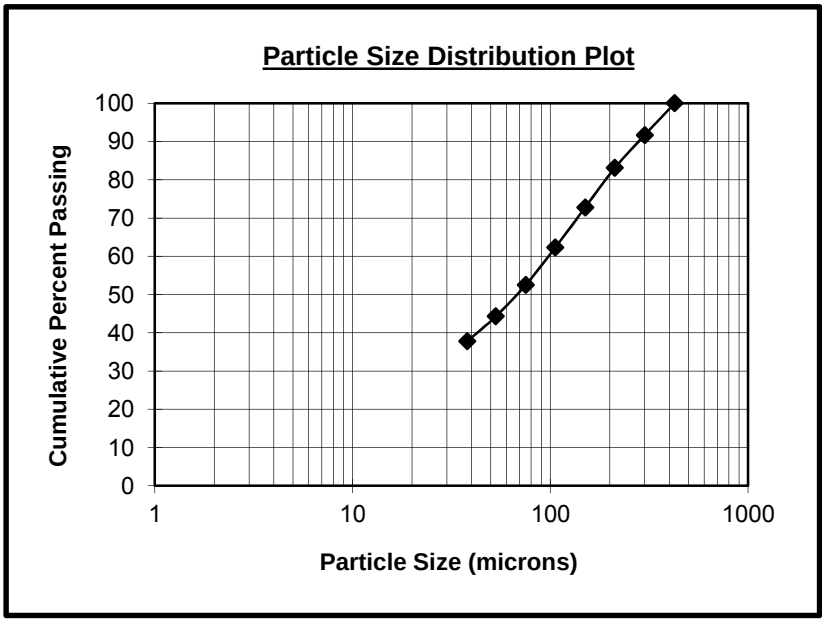


TABLE III-34
SCREEN ANALYSIS
KM3512-P1 WSA Flotation Feed

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	8.30	91.7
65 Mesh	212	8.60	83.1
100 Mesh	150	10.30	72.8
150 Mesh	106	10.50	62.3
200 Mesh	75	9.80	52.5
270 Mesh	53	8.20	44.3
400 Mesh	38	6.50	37.8
TOTAL		100.00	**

K80 =192µm



ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P2

Sample Name:
WSA Bulk Concentrate - Average

Measured by:
Hoang

Edited by:
Hoang

Measured:
Thursday, October 18, 2012 2:18:11 PM

Analysed:
Thursday, October 18, 2012 2:18:12 PM

Particle Name: Silica 0.1
Particle RI: 1.544
Dispersant Name: Water

Accessory Name: Hydro 2000MU (A)
Absorption: 0.1
Dispersant RI: 1.330

Analysis model: General purpose
Size range: 0.100 to 1000.000 um
Weighted Residual: 0.598 %

Sensitivity: Normal
Obscuration: 19.49 %
Result Emulation: Off

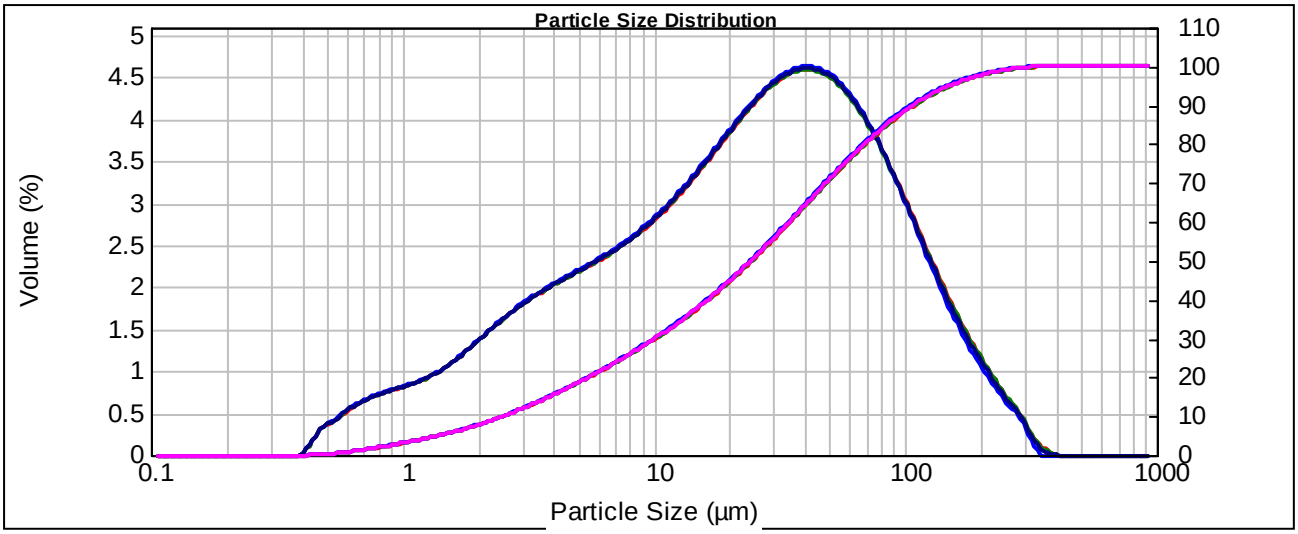
Concentration: 0.0205 %Vol
Specific Surface Area: 0.343 m²/g

Span : 4.283
Surface Weighted Mean D[3,2]: 6.609 um

Uniformity: 1.36
Vol. Weighted Mean D[4,3]: 42.381 um

Result units: Volume

d(0.1): 2.500 um d(0.5): 24.353 um **d(0.8): 68.643 um** d(0.9): 106.798 um d(0.98): 204.53 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.03
0.437	0.16
0.479	

Size (µm)	Volume In %
0.479	0.22
0.525	0.26
0.575	0.32
0.631	0.37
0.692	0.40
0.759	0.43
0.832	0.46
0.912	0.48
1.000	0.50
1.096	0.52
1.202	0.56
1.318	0.59
1.445	0.64
1.585	0.70
1.738	0.76
1.905	0.82
2.089	0.88
2.291	

Size (µm)	Volume In %
2.291	0.94
2.512	1.00
2.754	1.06
3.020	1.11
3.311	1.16
3.631	1.20
3.981	1.24
4.365	1.28
4.786	1.32
5.248	1.36
5.754	1.40
6.310	1.44
6.918	1.49
7.586	1.54
8.318	1.59
9.120	1.65
10.000	1.72
10.965	

Size (µm)	Volume In %
10.965	1.79
12.023	1.87
13.183	1.96
14.454	2.04
15.849	2.13
17.378	2.22
19.055	2.31
20.893	2.40
22.909	2.49
25.119	2.57
27.542	2.64
30.200	2.70
33.113	2.74
36.308	2.77
39.811	2.77
43.652	2.75
47.863	2.72
52.481	

Size (µm)	Volume In %
52.481	2.66
57.544	2.58
63.096	2.47
69.183	2.35
75.858	2.22
83.176	2.06
91.201	1.90
100.000	1.74
109.648	1.56
120.226	1.39
131.826	1.23
144.544	1.07
158.489	0.93
173.780	0.80
190.546	0.68
208.930	0.57
229.087	0.46
251.189	

Size (µm)	Volume In %
251.189	0.36
275.423	0.28
301.995	0.13
331.131	0.04
363.078	0.01
398.107	0.00
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P2

Sample Name:
WSA Bulk Regrind Discharge - Average

Measured by:
Hoang

Edited by:
Hoang

Measured:
Thursday, October 18, 2012 2:22:20 PM

Analysed:
Thursday, October 18, 2012 2:22:21 PM

Particle Name: Silica 0.1
Particle RI: 1.544
Dispersant Name: Water

Accessory Name: Hydro 2000MU (A)
Absorption: 0.1
Dispersant RI: 1.330

Analysis model: General purpose
Size range: 0.100 to 1000.000 um
Weighted Residual: 0.996 %

Sensitivity: Normal
Obscuration: 18.84 %
Result Emulation: Off

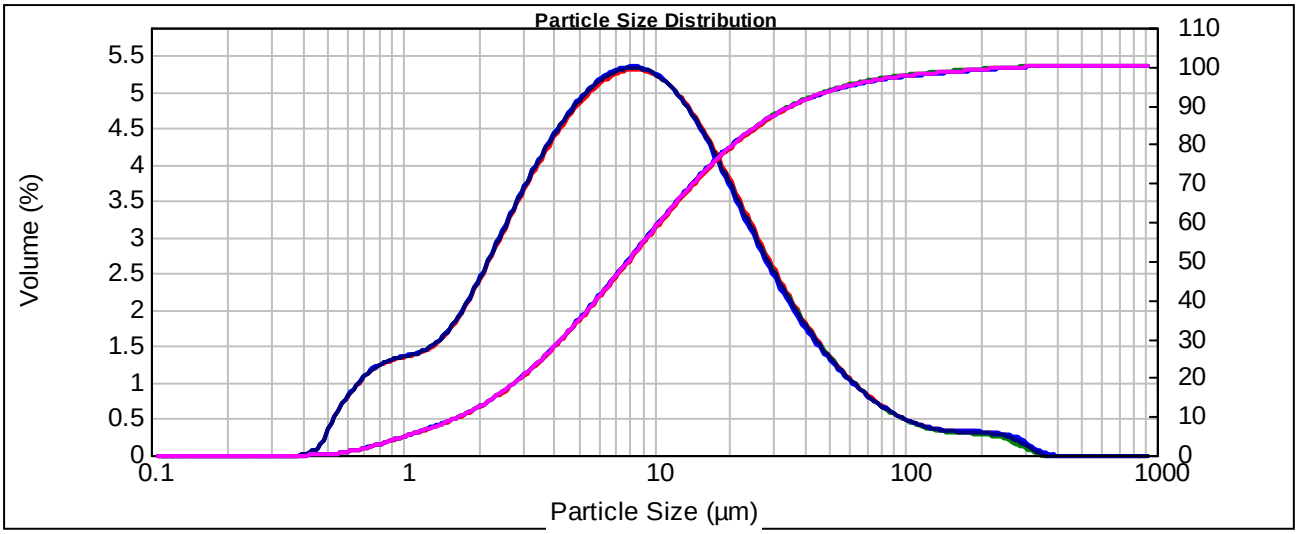
Concentration: 0.0120 %Vol
Specific Surface Area: 0.549 m²/g

Span : 4.288
Surface Weighted Mean D[3,2]: 4.127 um

Uniformity: 1.65
Vol. Weighted Mean D[4,3]: 16.823 um

Result units: Volume

d(0.1): 1.696 um d(0.5): 7.895 um **d(0.8): 20.683 um** d(0.9): 35.555 um d(0.98): 114.1 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.01
0.437	0.05
0.479	

Size (µm)	Volume In %
0.479	0.18
0.525	0.37
0.575	0.48
0.631	0.59
0.692	0.68
0.759	0.74
0.832	0.78
0.912	0.80
1.000	0.82
1.096	0.84
1.202	0.88
1.318	0.94
1.445	1.02
1.585	1.14
1.738	1.27
1.905	1.43
2.089	1.60
2.291	

Size (µm)	Volume In %
2.291	1.77
2.512	1.94
2.754	2.11
3.020	2.28
3.311	2.43
3.631	2.57
3.981	2.70
4.365	2.82
4.786	2.93
5.248	3.02
5.754	3.09
6.310	3.15
6.918	3.18
7.586	3.20
8.318	3.20
9.120	3.18
10.000	3.13
10.965	

Size (µm)	Volume In %
10.965	3.07
12.023	2.98
13.183	2.86
14.454	2.73
15.849	2.59
17.378	2.43
19.055	2.26
20.893	2.09
22.909	1.91
25.119	1.75
27.542	1.58
30.200	1.43
33.113	1.28
36.308	1.15
39.811	1.02
43.652	0.91
47.863	0.80
52.481	

Size (µm)	Volume In %
52.481	0.71
57.544	0.62
63.096	0.55
69.183	0.48
75.858	0.42
83.176	0.36
91.201	0.32
100.000	0.28
109.648	0.25
120.226	0.22
131.826	0.21
144.544	0.20
158.489	0.19
173.780	0.19
190.546	0.19
208.930	0.18
229.087	0.17
251.189	

Size (µm)	Volume In %
251.189	0.14
275.423	0.10
301.995	0.07
331.131	0.00
363.078	0.00
398.107	0.00
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

TABLE III-37
SCREEN ANALYSIS
KM3512-P2 WSA Bulk Rougher Concentrate

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	0.90	99.1
65 Mesh	212	3.30	95.8
100 Mesh	150	4.90	90.9
150 Mesh	106	4.60	86.3
200 Mesh	75	5.00	81.3
270 Mesh	53	5.10	76.2
400 Mesh	38	4.50	71.7
TOTAL		100.00	**

K80 =69µm

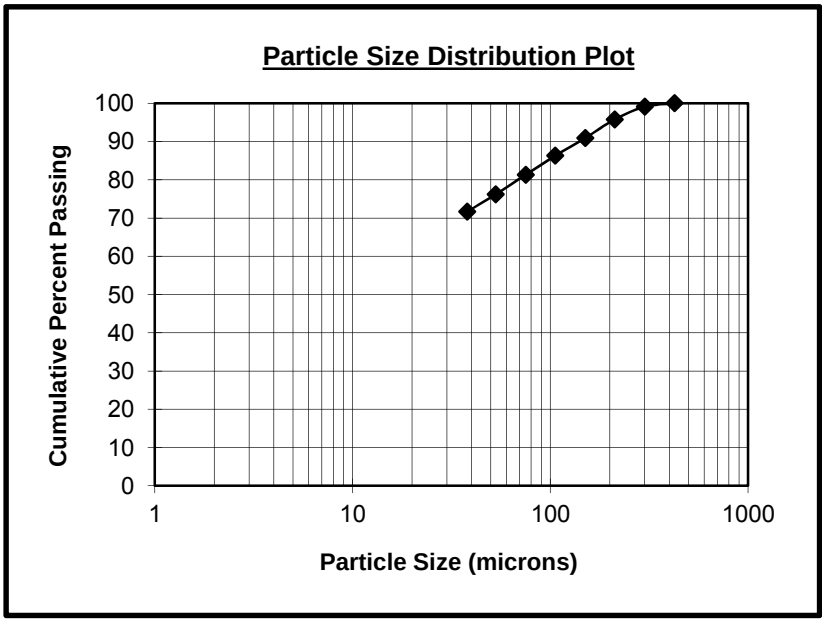
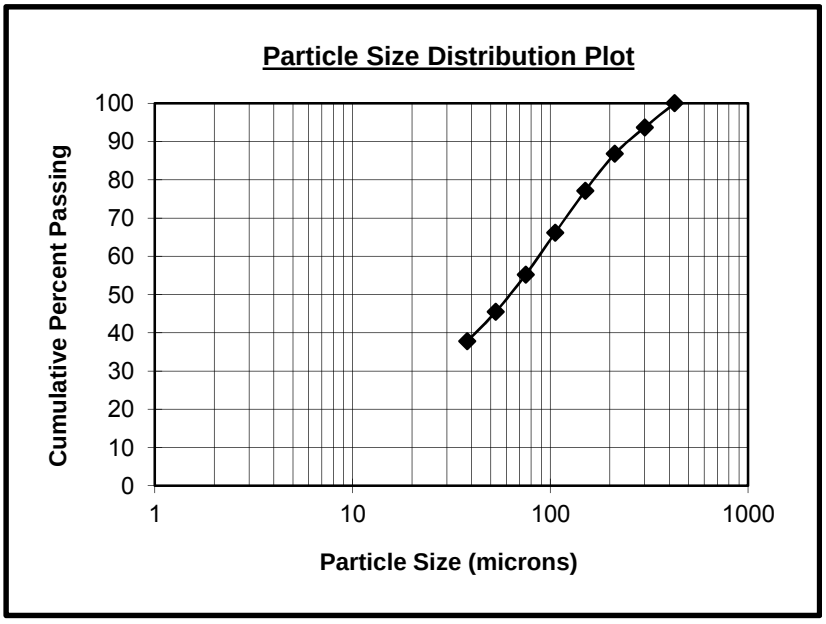


TABLE III-38
SCREEN ANALYSIS
KM3512-P2 WSA Flotation Feed

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	6.30	93.7
65 Mesh	212	6.90	86.8
100 Mesh	150	9.70	77.1
150 Mesh	106	10.90	66.2
200 Mesh	75	11.00	55.2
270 Mesh	53	9.70	45.5
400 Mesh	38	7.70	37.8
TOTAL		100.00	**

K80 =167µm



ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

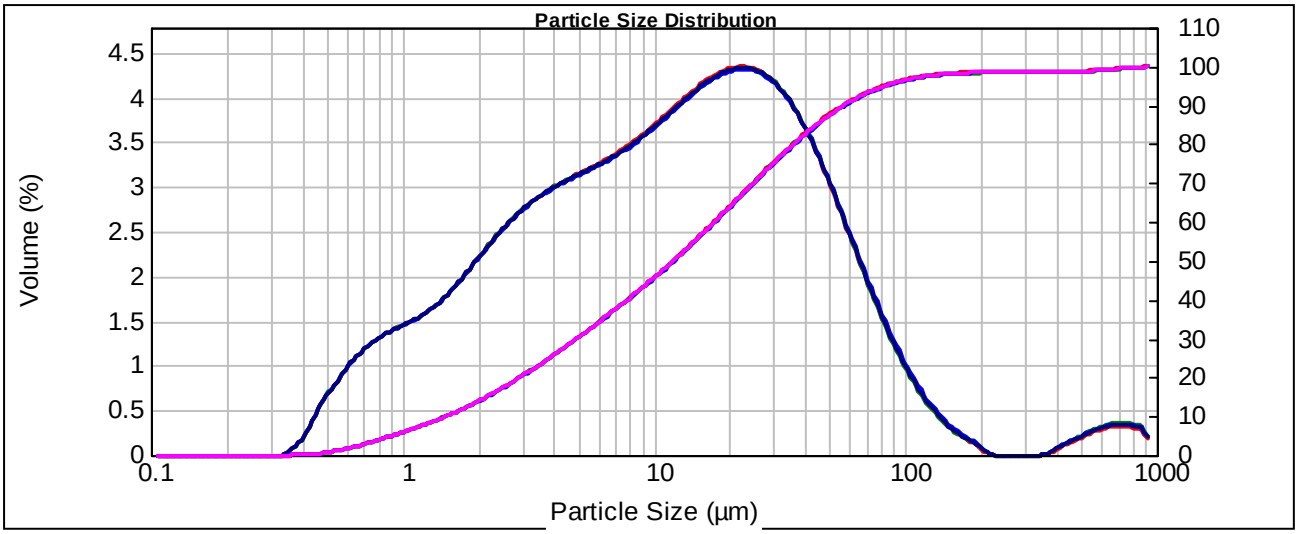
Result Analysis Report

Project and Test number: KM3512-P2
Measured by: Hoang
Measured: Thursday, October 18, 2012 1:47:35 PM
Sample Name: WSB Bulk Concentrate - Average
Edited by: Hoang
Analysed: Thursday, October 18, 2012 1:47:36 PM

Particle Name: Silica 0.1
Accessory Name: Hydro 2000MU (A)
Analysis model: General purpose
Sensitivity: Normal
Particle RI: 1.544
Absorption: 0.1
Size range: 0.100 to 1000.000 um
Obscuration: 17.06 %
Dispersant Name: Water
Dispersant RI: 1.330
Weighted Residual: 0.358 %
Result Emulation: Off

Concentration: 0.0115 %Vol
Span : 4.646
Uniformity: 2.18
Result units: Volume
Specific Surface Area: 0.545 m²/g
Surface Weighted Mean D[3,2]: 4.153 um
Vol. Weighted Mean D[4,3]: 30.617 um

d(0.1): 1.486 um d(0.5): 11.952 um **d(0.8): 35.936 um** d(0.9): 57.021 um d(0.98): 142.23 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.01
0.363	0.08
0.398	0.14
0.437	0.30
0.479	

Size (µm)	Volume In %
0.479	0.41
0.525	0.50
0.575	0.59
0.631	0.67
0.692	0.73
0.759	0.78
0.832	0.82
0.912	0.86
1.000	0.89
1.096	0.92
1.202	0.97
1.318	1.02
1.445	1.08
1.585	1.16
1.738	1.24
1.905	1.32
2.089	1.41
2.291	

Size (µm)	Volume In %
2.291	1.49
2.512	1.56
2.754	1.63
3.020	1.68
3.311	1.74
3.631	1.78
3.981	1.82
4.365	1.86
4.786	1.89
5.248	1.92
5.754	1.96
6.310	1.99
6.918	2.03
7.586	2.08
8.318	2.13
9.120	2.18
10.000	2.24
10.965	

Size (µm)	Volume In %
10.965	2.30
12.023	2.36
13.183	2.42
14.454	2.47
15.849	2.52
17.378	2.56
19.055	2.59
20.893	2.61
22.909	2.60
25.119	2.58
27.542	2.54
30.200	2.47
33.113	2.38
36.308	2.27
39.811	2.14
43.652	1.99
47.863	1.83
52.481	

Size (µm)	Volume In %
52.481	1.66
57.544	1.48
63.096	1.30
69.183	1.13
75.858	0.96
83.176	0.81
91.201	0.66
100.000	0.54
109.648	0.42
120.226	0.33
131.826	0.25
144.544	0.18
158.489	0.13
173.780	0.10
190.546	0.05
208.930	0.00
229.087	0.00
251.189	

Size (µm)	Volume In %
251.189	0.00
275.423	0.00
301.995	0.00
331.131	0.00
363.078	0.02
398.107	0.06
436.516	0.09
478.630	0.13
524.807	0.16
575.440	0.19
630.957	0.20
691.831	0.21
758.578	0.20
831.764	0.18
912.011	0.05
1000.000	

Operator notes: *Average of 3 measurements from 3512*

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P2

Sample Name:
WSB Bulk Regrind Discharge - Average

Measured by:
Hoang

Edited by:
Hoang

Measured:
Thursday, October 18, 2012 2:10:02 PM

Analysed:
Thursday, October 18, 2012 2:10:03 PM

Particle Name: Silica 0.1
Particle RI: 1.544
Dispersant Name: Water

Accessory Name: Hydro 2000MU (A)
Absorption: 0.1
Dispersant RI: 1.330

Analysis model: General purpose
Size range: 0.100 to 1000.000 um
Weighted Residual: 0.828 %

Sensitivity: Normal
Obscuration: 17.46 %
Result Emulation: Off

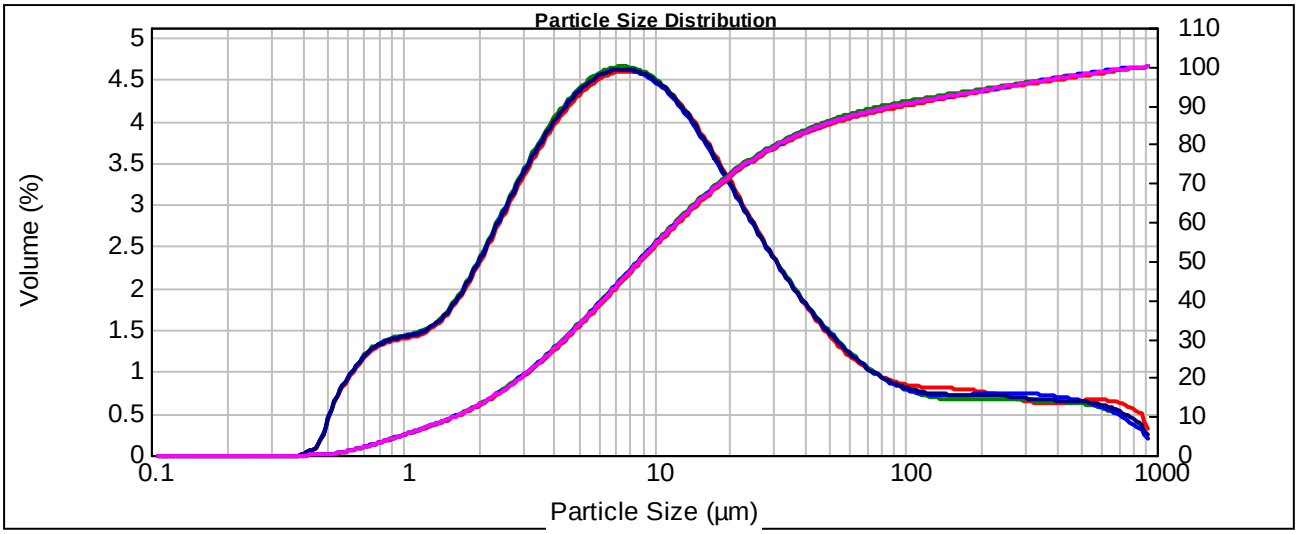
Concentration: 0.0114 %Vol
Specific Surface Area: 0.54 m²/g

Span : 10.360
Surface Weighted Mean D[3,2]: 4.195 um

Uniformity: 4.68
Vol. Weighted Mean D[4,3]: 44.921 um

Result units: Volume

d(0.1): 1.618 um d(0.5): 8.757 um **d(0.8): 31.397 um** d(0.9): 92.334 um d(0.98): 517.84 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.02
0.437	0.06
0.479	

Size (µm)	Volume In %
0.479	0.23
0.525	0.44
0.575	0.55
0.631	0.65
0.692	0.74
0.759	0.79
0.832	0.82
0.912	0.84
1.000	0.86
1.096	0.87
1.202	0.90
1.318	0.95
1.445	1.03
1.585	1.13
1.738	1.25
1.905	1.38
2.089	1.52
2.291	

Size (µm)	Volume In %
2.291	1.67
2.512	1.82
2.754	1.96
3.020	2.09
3.311	2.22
3.631	2.34
3.981	2.44
4.365	2.54
4.786	2.62
5.248	2.68
5.754	2.73
6.310	2.76
6.918	2.78
7.586	2.78
8.318	2.76
9.120	2.73
10.000	2.68
10.965	

Size (µm)	Volume In %
10.965	2.61
12.023	2.53
13.183	2.44
14.454	2.33
15.849	2.21
17.378	2.09
19.055	1.97
20.893	1.84
22.909	1.71
25.119	1.59
27.542	1.47
30.200	1.35
33.113	1.25
36.308	1.14
39.811	1.05
43.652	0.96
47.863	0.87
52.481	

Size (µm)	Volume In %
52.481	0.80
57.544	0.73
63.096	0.67
69.183	0.61
75.858	0.57
83.176	0.53
91.201	0.50
100.000	0.48
109.648	0.46
120.226	0.45
131.826	0.44
144.544	0.44
158.489	0.44
173.780	0.43
190.546	0.43
208.930	0.43
229.087	0.43
251.189	

Size (µm)	Volume In %
251.189	0.42
275.423	0.41
301.995	0.41
331.131	0.40
363.078	0.40
398.107	0.39
436.516	0.39
478.630	0.39
524.807	0.38
575.440	0.36
630.957	0.34
691.831	0.31
758.578	0.27
831.764	0.22
912.011	0.06
1000.000	

Operator notes:

TABLE III-41
SCREEN ANALYSIS
KM3512-P2 WSB Bulk Rougher Concentrate

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	1.10	98.9
65 Mesh	212	3.20	95.7
100 Mesh	150	5.00	90.7
150 Mesh	106	4.80	85.9
200 Mesh	75	4.20	81.7
270 Mesh	53	3.70	78.0
400 Mesh	38	3.40	74.6
TOTAL		100.00	**

K80 =64µm

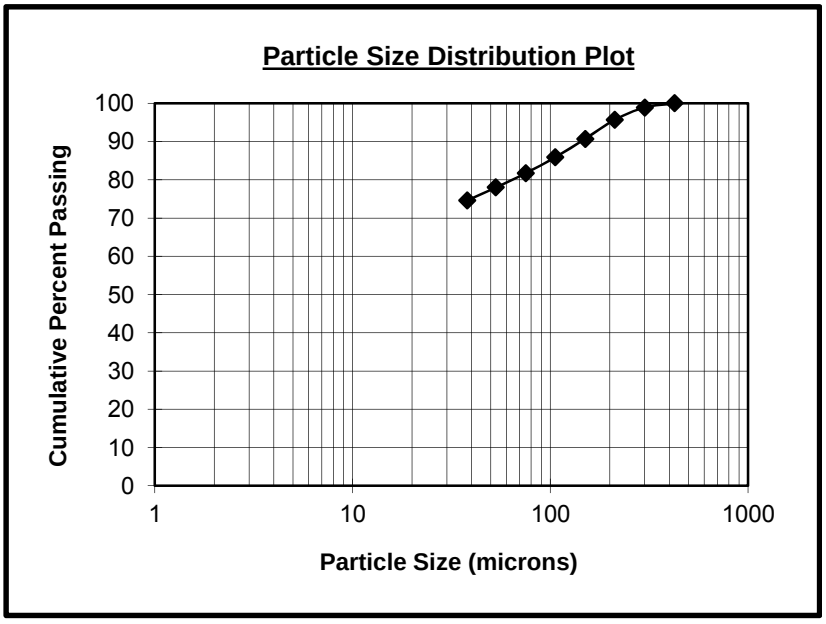
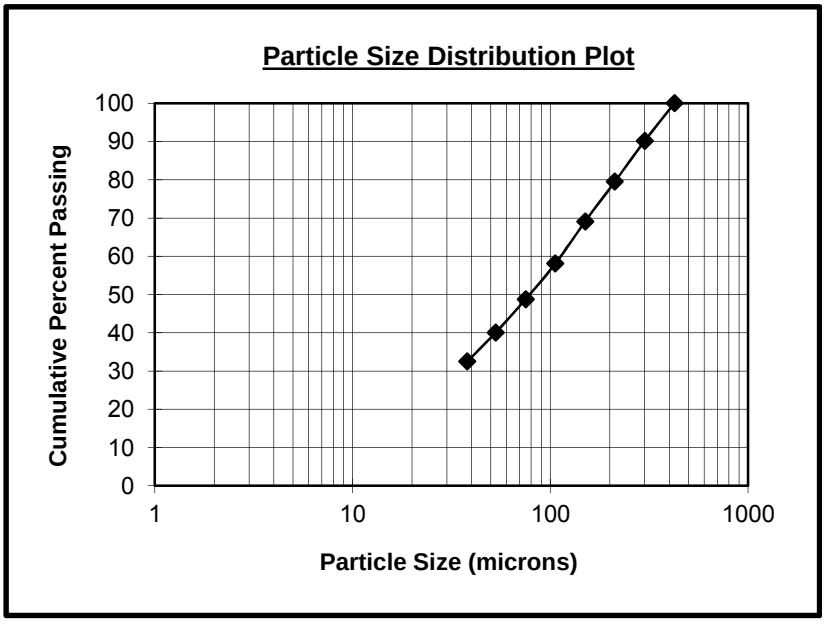


TABLE III-42
SCREEN ANALYSIS
KM3512-P2 WSB Flotation Feed

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	9.80	90.2
65 Mesh	212	10.70	79.5
100 Mesh	150	10.40	69.1
150 Mesh	106	11.00	58.1
200 Mesh	75	9.30	48.8
270 Mesh	53	8.70	40.1
400 Mesh	38	7.60	32.5
TOTAL		100.00	**

K80 =216µm



ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P2

Sample Name:
WSC Bulk Concentrate - Average

Measured by:
Hoang

Edited by:
Hoang

Measured:
Thursday, October 18, 2012 2:37:30 PM

Analysed:
Thursday, October 18, 2012 2:37:31 PM

Particle Name:
Silica 0.1

Particle RI:
1.544

Dispersant Name:
Water

Accessory Name:
Hydro 2000MU (A)

Absorption:
0.1

Dispersant RI:
1.330

Analysis model:
General purpose

Size range:
0.100 to 1000.000 um

Weighted Residual:
0.086 %

Sensitivity:
Normal

Obscuration:
21.30 %

Result Emulation:
Off

Concentration:
0.0174 %Vol

Span :
3.967

Uniformity:
1.42

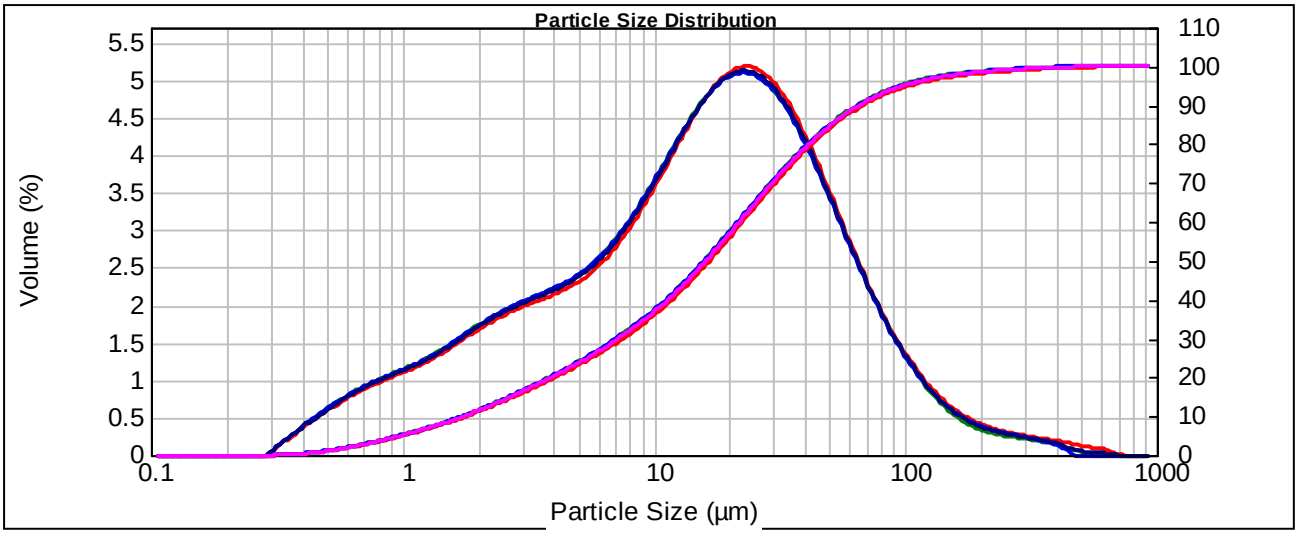
Result units:
Volume

Specific Surface Area:
0.478 m²/g

Surface Weighted Mean D[3,2]:
4.735 um

Vol. Weighted Mean D[4,3]:
29.270 um

d(0.1): 1.745 um d(0.5): 16.084 um **d(0.8): 41.338 um** d(0.9): 65.552 um d(0.98): 162.23 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.07
0.331	0.13
0.363	0.19
0.398	0.25
0.437	0.31
0.479	

Size (µm)	Volume In %
0.479	0.36
0.525	0.42
0.575	0.47
0.631	0.52
0.692	0.56
0.759	0.59
0.832	0.63
0.912	0.66
1.000	0.69
1.096	0.73
1.202	0.77
1.318	0.82
1.445	0.87
1.585	0.92
1.738	0.97
1.905	1.03
2.089	1.08
2.291	

Size (µm)	Volume In %
2.291	1.12
2.512	1.17
2.754	1.20
3.020	1.24
3.311	1.27
3.631	1.30
3.981	1.34
4.365	1.38
4.786	1.43
5.248	1.49
5.754	1.56
6.310	1.65
6.918	1.74
7.586	1.85
8.318	1.98
9.120	2.11
10.000	2.25
10.965	

Size (µm)	Volume In %
10.965	2.40
12.023	2.54
13.183	2.68
14.454	2.80
15.849	2.91
17.378	2.99
19.055	3.05
20.893	3.09
22.909	3.08
25.119	3.05
27.542	2.99
30.200	2.89
33.113	2.77
36.308	2.62
39.811	2.45
43.652	2.27
47.863	2.08
52.481	

Size (µm)	Volume In %
52.481	1.89
57.544	1.70
63.096	1.51
69.183	1.33
75.858	1.16
83.176	1.01
91.201	0.87
100.000	0.74
109.648	0.62
120.226	0.52
131.826	0.44
144.544	0.37
158.489	0.31
173.780	0.26
190.546	0.23
208.930	0.20
229.087	0.18
251.189	

Size (µm)	Volume In %
251.189	0.17
275.423	0.15
301.995	0.14
331.131	0.12
363.078	0.11
398.107	0.08
436.516	0.05
478.630	0.04
524.807	0.02
575.440	0.02
630.957	0.01
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P2

Sample Name:
WSC Bulk Regrind Discharge - Average

Measured by:
Hoang

Edited by:
Hoang

Measured:
Thursday, October 18, 2012 2:31:31 PM

Analysed:
Thursday, October 18, 2012 2:31:32 PM

Particle Name: Silica 0.1
Particle RI: 1.544
Dispersant Name: Water

Accessory Name: Hydro 2000MU (A)
Absorption: 0.1
Dispersant RI: 1.330

Analysis model: General purpose
Size range: 0.100 to 1000.000 um
Weighted Residual: 0.703 %

Sensitivity: Normal
Obscuration: 16.70 %
Result Emulation: Off

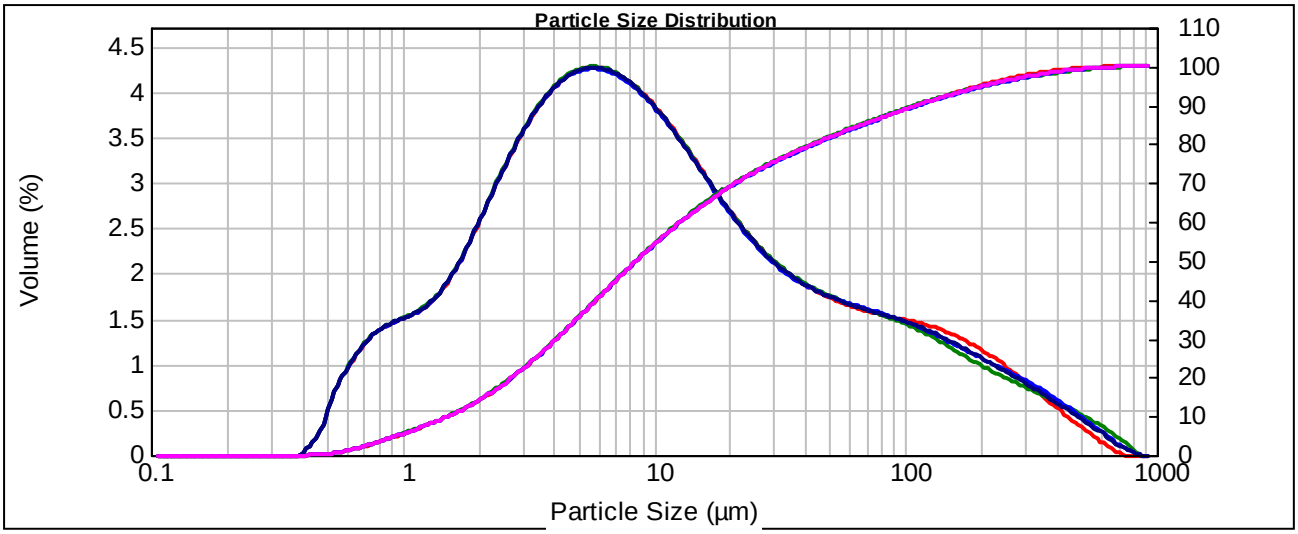
Concentration: 0.0104 %Vol
Specific Surface Area: 0.563 m²/g

Span : 12.826
Surface Weighted Mean D[3,2]: 4.024 um

Uniformity: 4.19
Vol. Weighted Mean D[4,3]: 39.305 um

Result units: Volume

d(0.1): 1.517 um d(0.5): 8.500 um **d(0.8): 42.885 um** d(0.9): 110.545 um d(0.98): 341.87 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.04
0.437	0.12
0.479	

Size (µm)	Volume In %
0.479	0.27
0.525	0.47
0.575	0.57
0.631	0.67
0.692	0.76
0.759	0.82
0.832	0.86
0.912	0.89
1.000	0.92
1.096	0.95
1.202	1.00
1.318	1.06
1.445	1.15
1.585	1.26
1.738	1.39
1.905	1.53
2.089	1.68
2.291	

Size (µm)	Volume In %
2.291	1.82
2.512	1.96
2.754	2.09
3.020	2.21
3.311	2.31
3.631	2.40
3.981	2.47
4.365	2.52
4.786	2.55
5.248	2.57
5.754	2.57
6.310	2.55
6.918	2.52
7.586	2.48
8.318	2.42
9.120	2.35
10.000	2.28
10.965	

Size (µm)	Volume In %
10.965	2.19
12.023	2.10
13.183	2.01
14.454	1.91
15.849	1.81
17.378	1.71
19.055	1.62
20.893	1.53
22.909	1.45
25.119	1.37
27.542	1.31
30.200	1.25
33.113	1.20
36.308	1.15
39.811	1.11
43.652	1.08
47.863	1.05
52.481	

Size (µm)	Volume In %
52.481	1.02
57.544	1.00
63.096	0.98
69.183	0.96
75.858	0.94
83.176	0.92
91.201	0.90
100.000	0.87
109.648	0.85
120.226	0.82
131.826	0.79
144.544	0.75
158.489	0.72
173.780	0.68
190.546	0.65
208.930	0.61
229.087	0.57
251.189	

Size (µm)	Volume In %
251.189	0.53
275.423	0.49
301.995	0.45
331.131	0.41
363.078	0.37
398.107	0.33
436.516	0.28
478.630	0.24
524.807	0.19
575.440	0.15
630.957	0.10
691.831	0.05
758.578	0.02
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

TABLE III-45
SCREEN ANALYSIS
KM3512-P2 WSC Bulk Rougher Concentrate

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	0.87	99.1
65 Mesh	212	4.62	94.5
100 Mesh	150	8.67	85.8
150 Mesh	106	8.38	77.5
200 Mesh	75	8.38	69.1
270 Mesh	53	7.23	61.8
400 Mesh	38	4.05	57.8
TOTAL		100.00	**

K80 =118µm

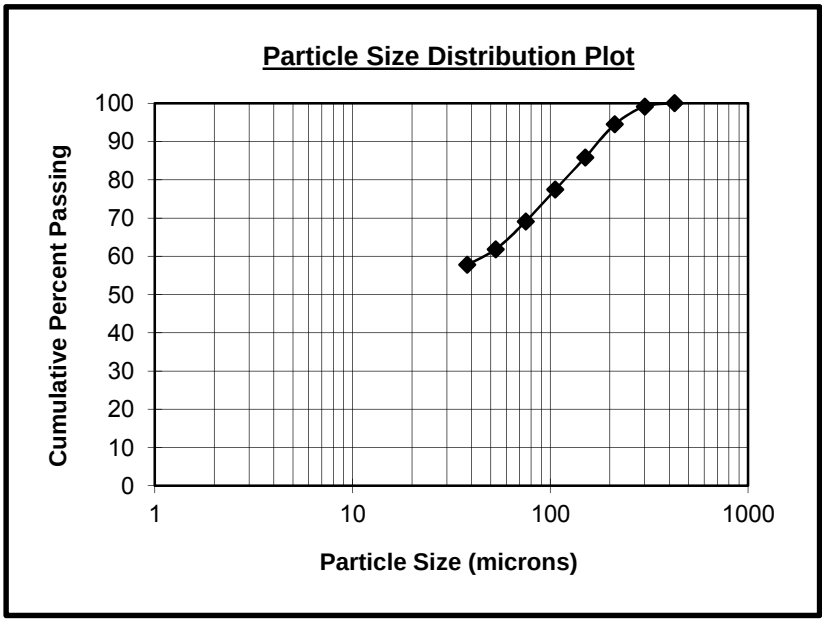
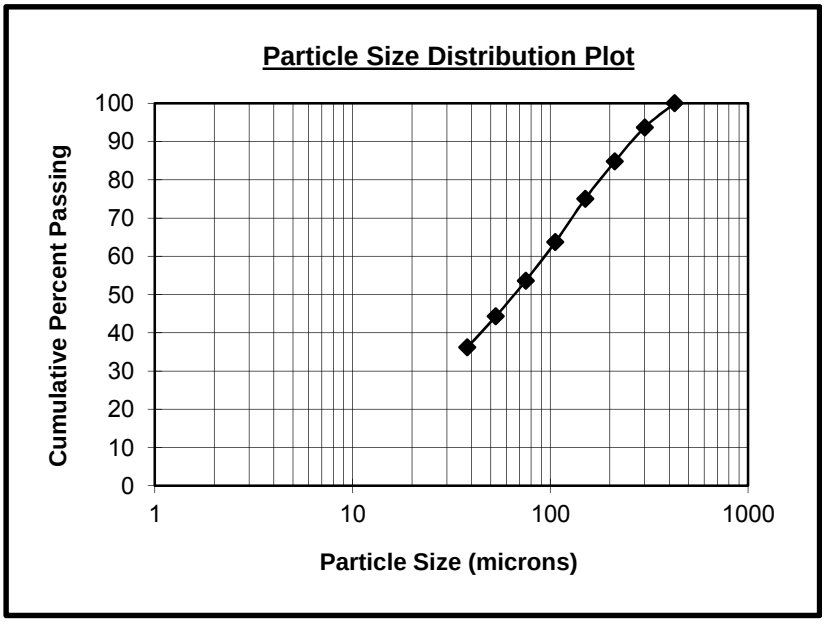


TABLE III-46
SCREEN ANALYSIS
KM3512-P2 WSC Flotation Feed

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	6.30	93.7
65 Mesh	212	8.90	84.8
100 Mesh	150	9.80	75.0
150 Mesh	106	11.30	63.7
200 Mesh	75	10.10	53.6
270 Mesh	53	9.30	44.3
400 Mesh	38	8.10	36.2
TOTAL		100.00	**

K80 =180µm



ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P2

Sample Name:
WSD Bulk Concentrate - Average

Measured by:
Hoang

Edited by:
Hoang

Measured:
Thursday, October 18, 2012 2:40:56 PM

Analysed:
Thursday, October 18, 2012 2:40:57 PM

Particle Name: Silica 0.1
Particle RI: 1.544
Dispersant Name: Water

Accessory Name: Hydro 2000MU (A)
Absorption: 0.1
Dispersant RI: 1.330

Analysis model: General purpose
Size range: 0.100 to 1000.000 um
Weighted Residual: 1.180 %

Sensitivity: Normal
Obscuration: 9.57 %
Result Emulation: Off

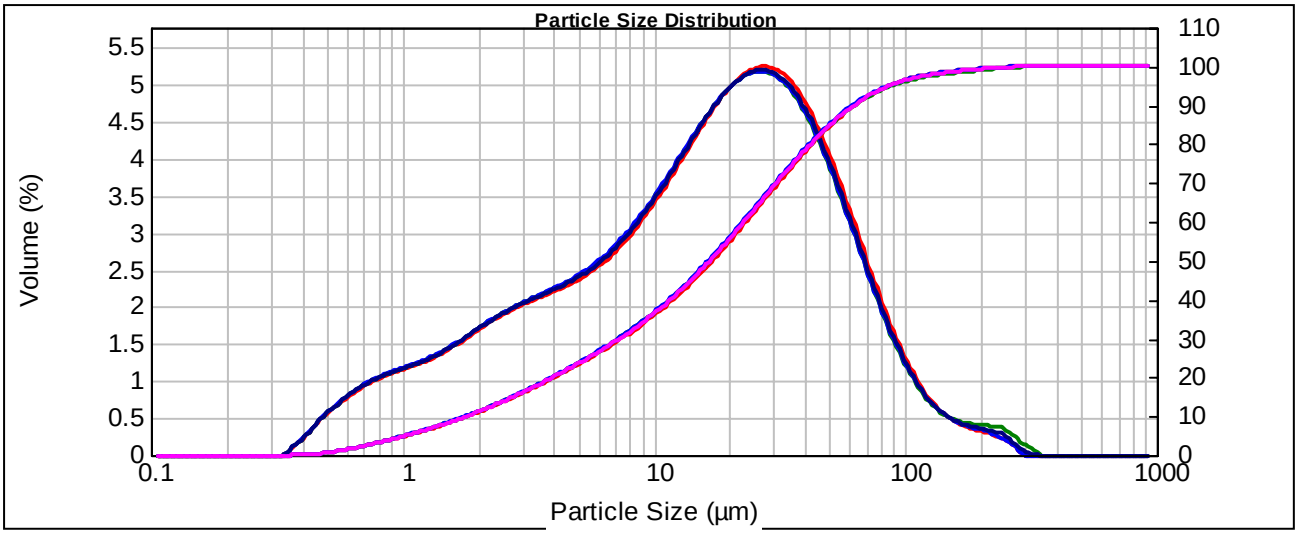
Concentration: 0.0074 %Vol
Specific Surface Area: 0.456 m²/g

Span : 3.631
Surface Weighted Mean D[3,2]: 4.963 um

Uniformity: 1.22
Vol. Weighted Mean D[4,3]: 26.992 um

Result units: Volume

d(0.1): 1.791 um d(0.5): 16.704 um **d(0.8): 41.895 um** d(0.9): 62.435 um d(0.98): 129.15 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.01
0.363	0.11
0.398	0.16
0.437	0.27
0.479	

Size (µm)	Volume In %
0.479	0.34
0.525	0.41
0.575	0.48
0.631	0.54
0.692	0.58
0.759	0.63
0.832	0.66
0.912	0.69
1.000	0.72
1.096	0.74
1.202	0.78
1.318	0.82
1.445	0.86
1.585	0.91
1.738	0.97
1.905	1.02
2.089	1.08
2.291	

Size (µm)	Volume In %
2.291	1.13
2.512	1.17
2.754	1.21
3.020	1.25
3.311	1.29
3.631	1.32
3.981	1.36
4.365	1.40
4.786	1.45
5.248	1.50
5.754	1.56
6.310	1.63
6.918	1.71
7.586	1.80
8.318	1.90
9.120	2.01
10.000	2.14
10.965	

Size (µm)	Volume In %
10.965	2.26
12.023	2.39
13.183	2.53
14.454	2.65
15.849	2.78
17.378	2.89
19.055	2.98
20.893	3.06
22.909	3.11
25.119	3.13
27.542	3.12
30.200	3.08
33.113	3.00
36.308	2.89
39.811	2.74
43.652	2.57
47.863	2.37
52.481	

Size (µm)	Volume In %
52.481	2.15
57.544	1.92
63.096	1.68
69.183	1.45
75.858	1.23
83.176	1.02
91.201	0.84
100.000	0.68
109.648	0.54
120.226	0.43
131.826	0.35
144.544	0.29
158.489	0.26
173.780	0.24
190.546	0.22
208.930	0.20
229.087	0.18
251.189	

Size (µm)	Volume In %
251.189	0.12
275.423	0.04
301.995	0.02
331.131	0.00
363.078	0.00
398.107	0.00
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P2

Sample Name:
WSD Bulk Regrind Discharge - Average

Measured by:
Hoang

Edited by:
Hoang

Measured:
Thursday, October 18, 2012 2:48:22 PM

Analysed:
Thursday, October 18, 2012 2:48:23 PM

Particle Name: Silica 1.0
Particle RI: 1.544
Dispersant Name: Water

Accessory Name: Hydro 2000MU (A)
Absorption: 1
Dispersant RI: 1.330

Analysis model: General purpose
Size range: 0.100 to 1000.000 um
Weighted Residual: 0.260 %

Sensitivity: Normal
Obscuration: 17.54 %
Result Emulation: Off

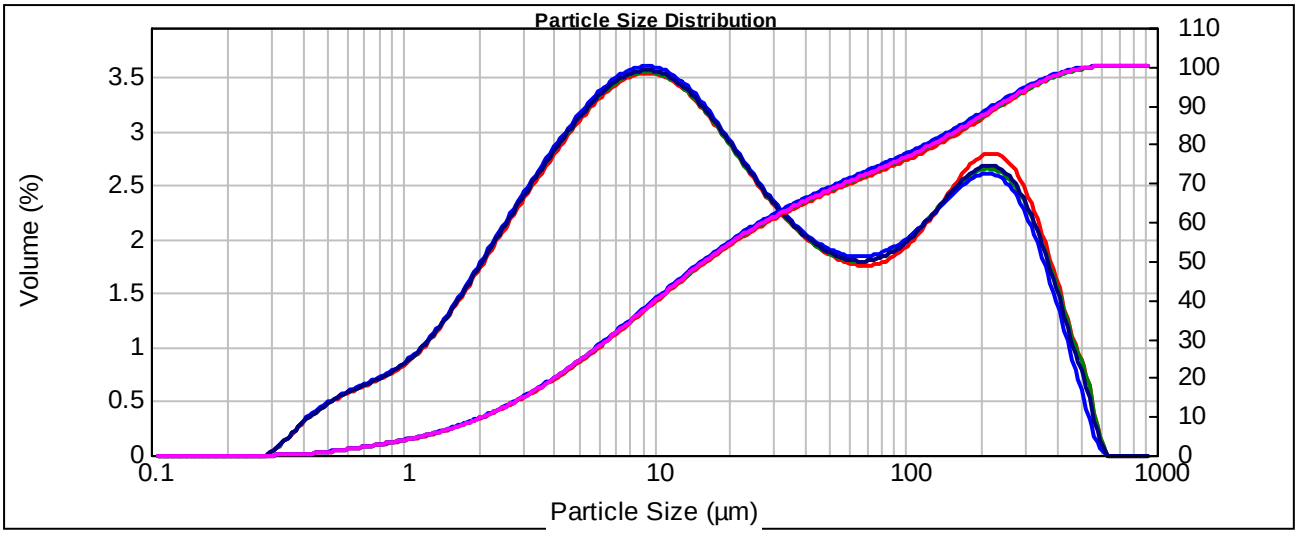
Concentration: 0.0128 %Vol
Specific Surface Area: 1.12 m²/g

Span : 14.550
Surface Weighted Mean D[3,2]: 5.356 um

Uniformity: 3.99
Vol. Weighted Mean D[4,3]: 69.821 um

Result units: Volume

d(0.1): 2.112 um d(0.5): 15.978 um **d(0.8): 128.171 um** d(0.9): 234.591 um d(0.98): 408.84 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.05
0.363	0.08
0.398	0.15
0.437	0.21
0.479	0.25

Size (µm)	Volume In %
0.479	0.29
0.525	0.32
0.575	0.35
0.631	0.37
0.692	0.40
0.759	0.42
0.832	0.45
0.912	0.48
1.000	0.52
1.096	0.57
1.202	0.63
1.318	0.70
1.445	0.78
1.585	0.86
1.738	0.95
1.905	1.04
2.089	1.13
2.291	

Size (µm)	Volume In %
2.291	1.22
2.512	1.31
2.754	1.40
3.020	1.48
3.311	1.57
3.631	1.65
3.981	1.73
4.365	1.80
4.786	1.88
5.248	1.94
5.754	2.00
6.310	2.05
6.918	2.09
7.586	2.12
8.318	2.14
9.120	2.14
10.000	2.13
10.965	

Size (µm)	Volume In %
10.965	2.11
12.023	2.08
13.183	2.03
14.454	1.97
15.849	1.90
17.378	1.82
19.055	1.74
20.893	1.66
22.909	1.58
25.119	1.51
27.542	1.43
30.200	1.36
33.113	1.30
36.308	1.25
39.811	1.20
43.652	1.16
47.863	1.13
52.481	

Size (µm)	Volume In %
52.481	1.10
57.544	1.09
63.096	1.08
69.183	1.08
75.858	1.10
83.176	1.12
91.201	1.16
100.000	1.21
109.648	1.26
120.226	1.33
131.826	1.39
144.544	1.46
158.489	1.52
173.780	1.57
190.546	1.61
208.930	1.62
229.087	1.60
251.189	

Size (µm)	Volume In %
251.189	1.54
275.423	1.46
301.995	1.34
331.131	1.19
363.078	1.02
398.107	0.83
436.516	0.64
478.630	0.47
524.807	0.28
575.440	0.04
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

TABLE III-49
SCREEN ANALYSIS
KM3512-P2 WSD Bulk Rougher Concentrate

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	3.66	96.3
65 Mesh	212	7.56	88.8
100 Mesh	150	9.88	78.9
150 Mesh	106	8.54	70.4
200 Mesh	75	7.44	62.9
270 Mesh	53	6.34	56.6
400 Mesh	38	5.37	51.2
TOTAL		100.00	**

K80 =156µm

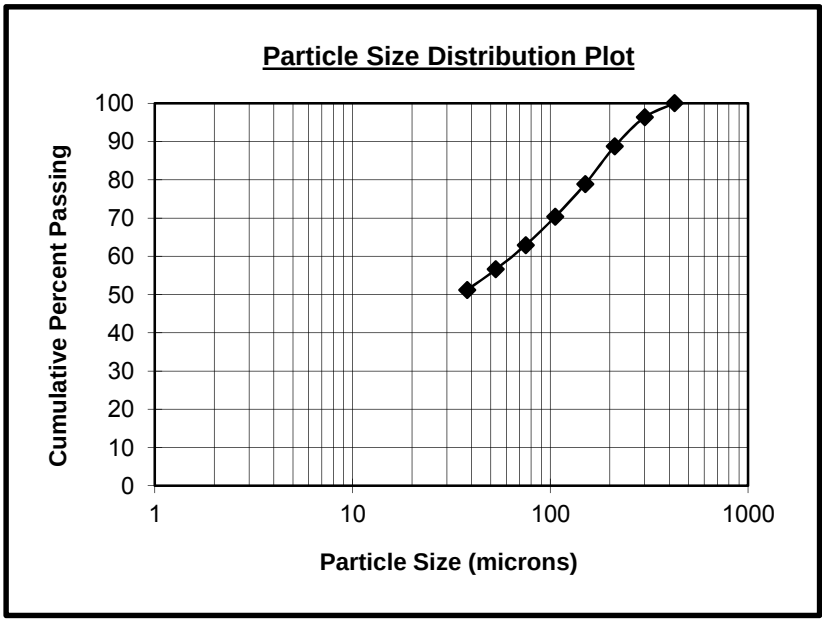
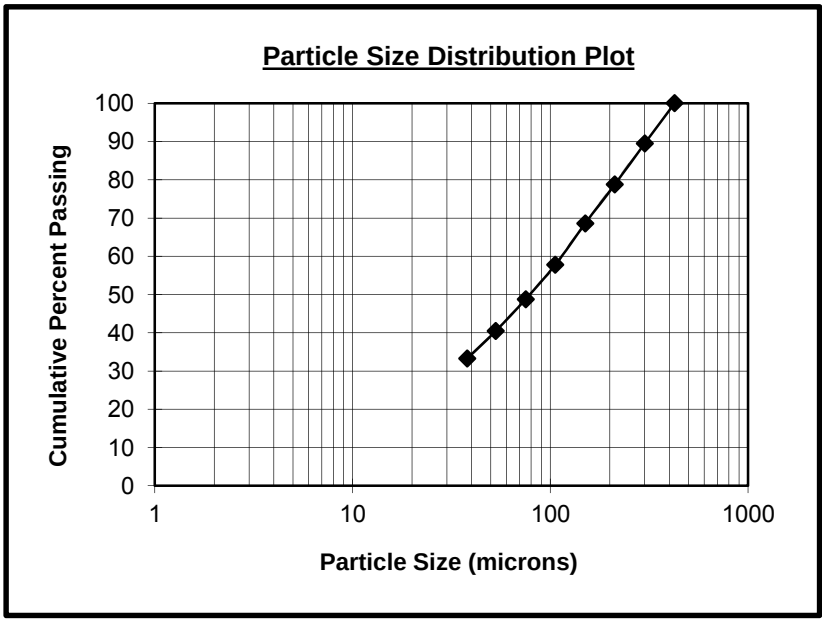


TABLE III-50
SCREEN ANALYSIS
KM3512-P2 WSD Flotation Feed

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	10.50	89.5
65 Mesh	212	10.70	78.8
100 Mesh	150	10.20	68.6
150 Mesh	106	10.80	57.8
200 Mesh	75	9.00	48.8
270 Mesh	53	8.30	40.5
400 Mesh	38	7.20	33.3
TOTAL		100.00	**

K80 =221µm



ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P3

Measured by:
Mel

Measured:
Monday, October 22, 2012 9:49:45 AM

Sample Name:
WSA Bulk Concentrate - Average

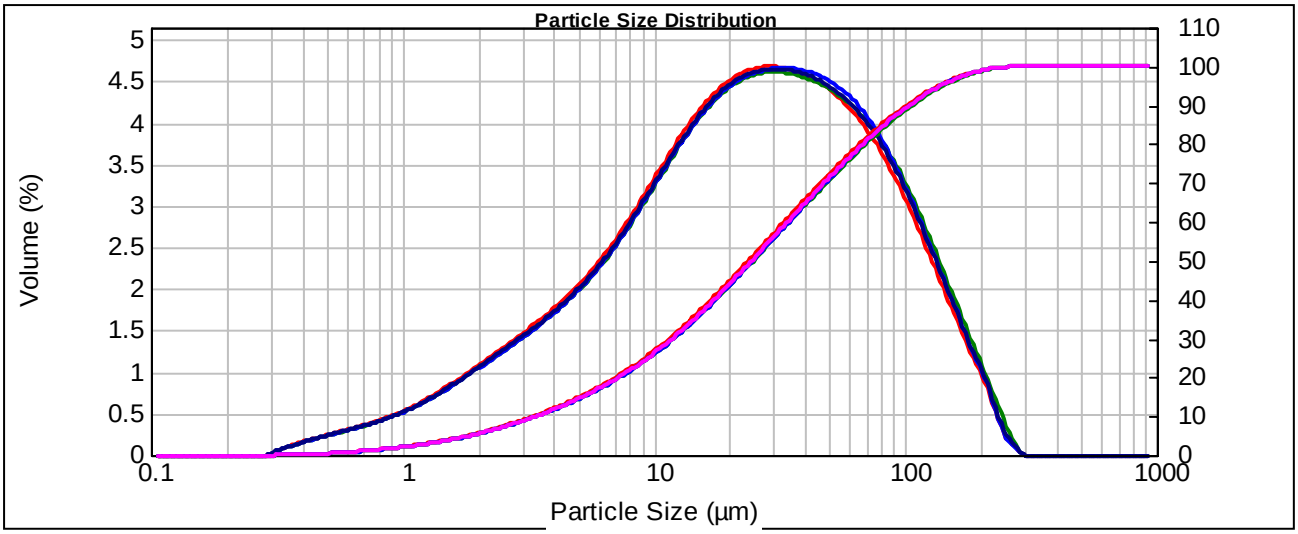
Edited by:
Mel

Analysed:
Monday, October 22, 2012 9:49:46 AM

Particle Name: Silica 1.0
Accessory Name: Hydro 2000MU (A)
Analysis model: General purpose
Sensitivity: Normal
Particle RI: 1.544
Absorption: 1
Size range: 0.100 to 1000.000 um
Obscuration: 12.77 %
Dispersant Name: Water
Dispersant RI: 1.330
Weighted Residual: 0.210 %
Result Emulation: Off

Concentration: 0.0134 %Vol
Span : 4.091
Uniformity: 1.25
Result units: Volume
Specific Surface Area: 0.766 m²/g
Surface Weighted Mean D[3,2]: 7.836 um
Vol. Weighted Mean D[4,3]: 40.921 um

d(0.1): 3.367 um d(0.5): 24.435 um **d(0.8): 67.801 um** d(0.9): 103.325 um d(0.98): 177.84 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.03
0.331	0.06
0.363	0.08
0.398	0.10
0.437	0.12
0.479	

Size (µm)	Volume In %
0.479	0.14
0.525	0.16
0.575	0.18
0.631	0.20
0.692	0.22
0.759	0.24
0.832	0.27
0.912	0.30
1.000	0.33
1.096	0.36
1.202	0.40
1.318	0.44
1.445	0.49
1.585	0.54
1.738	0.59
1.905	0.63
2.089	0.69
2.291	

Size (µm)	Volume In %
2.291	0.74
2.512	0.79
2.754	0.84
3.020	0.89
3.311	0.95
3.631	1.01
3.981	1.07
4.365	1.13
4.786	1.21
5.248	1.28
5.754	1.37
6.310	1.46
6.918	1.56
7.586	1.67
8.318	1.79
9.120	1.90
10.000	2.02
10.965	

Size (µm)	Volume In %
10.965	2.14
12.023	2.26
13.183	2.36
14.454	2.46
15.849	2.55
17.378	2.62
19.055	2.68
20.893	2.73
22.909	2.76
25.119	2.78
27.542	2.80
30.200	2.80
33.113	2.79
36.308	2.77
39.811	2.75
43.652	2.71
47.863	2.67
52.481	

Size (µm)	Volume In %
52.481	2.62
57.544	2.55
63.096	2.47
69.183	2.38
75.858	2.27
83.176	2.14
91.201	2.00
100.000	1.84
109.648	1.67
120.226	1.50
131.826	1.32
144.544	1.15
158.489	0.97
173.780	0.79
190.546	0.63
208.930	0.46
229.087	0.21
251.189	

Size (µm)	Volume In %
251.189	0.11
275.423	0.01
301.995	0.00
331.131	0.00
363.078	0.00
398.107	0.00
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P3

Measured by:
Neville

Measured:
Monday, October 22, 2012 9:26:10 AM

Sample Name:
WSA Bulk Regrind Discharge - Average

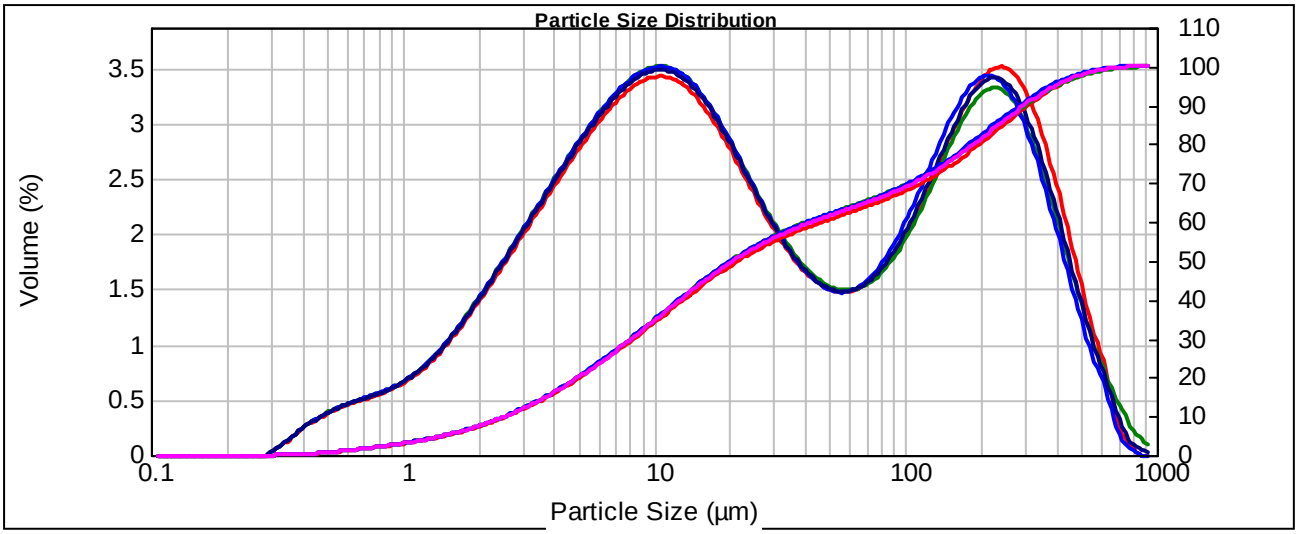
Edited by:
Neville

Analysed:
Monday, October 22, 2012 9:26:11 AM

Particle Name: Silica 1.0
Accessory Name: Hydro 2000MU (A)
Analysis model: General purpose
Sensitivity: Normal
Particle RI: 1.544
Absorption: 1
Size range: 0.100 to 1000.000 um
Obscuration: 11.89 %
Dispersant Name: Water
Dispersant RI: 1.330
Weighted Residual: 0.187 %
Result Emulation: Off

Concentration: 0.0100 %Vol
Span : 14.205
Uniformity: 4.21
Result units: Volume
Specific Surface Area: 0.944 m²/g
Surface Weighted Mean D[3,2]: 6.357 um
Vol. Weighted Mean D[4,3]: 94.646 um

d(0.1): 2.563 um d(0.5): 20.677 um **d(0.8): 187.432 um** d(0.9): 296.286 um d(0.98): 505.75 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.04
0.331	0.07
0.363	0.12
0.398	0.17
0.437	0.20
0.479	

Size (µm)	Volume In %
0.479	0.23
0.525	0.25
0.575	0.28
0.631	0.30
0.692	0.31
0.759	0.33
0.832	0.35
0.912	0.38
1.000	0.41
1.096	0.45
1.202	0.50
1.318	0.55
1.445	0.62
1.585	0.69
1.738	0.76
1.905	0.84
2.089	0.92
2.291	

Size (µm)	Volume In %
2.291	1.00
2.512	1.09
2.754	1.18
3.020	1.26
3.311	1.35
3.631	1.44
3.981	1.52
4.365	1.61
4.786	1.69
5.248	1.77
5.754	1.84
6.310	1.91
6.918	1.97
7.586	2.02
8.318	2.06
9.120	2.09
10.000	2.10
10.965	

Size (µm)	Volume In %
10.965	2.09
12.023	2.07
13.183	2.02
14.454	1.96
15.849	1.89
17.378	1.80
19.055	1.70
20.893	1.60
22.909	1.49
25.119	1.39
27.542	1.29
30.200	1.19
33.113	1.11
36.308	1.04
39.811	0.98
43.652	0.93
47.863	0.90
52.481	

Size (µm)	Volume In %
52.481	0.89
57.544	0.89
63.096	0.91
69.183	0.95
75.858	1.00
83.176	1.08
91.201	1.16
100.000	1.27
109.648	1.38
120.226	1.50
131.826	1.63
144.544	1.75
158.489	1.86
173.780	1.95
190.546	2.02
208.930	2.05
229.087	2.05
251.189	

Size (µm)	Volume In %
251.189	2.00
275.423	1.91
301.995	1.78
331.131	1.62
363.078	1.44
398.107	1.23
436.516	1.03
478.630	0.83
524.807	0.64
575.440	0.48
630.957	0.32
691.831	0.16
758.578	0.06
831.764	0.03
912.011	0.01
1000.000	

Operator notes:

TABLE III-53
SCREEN ANALYSIS
KM3512-P3 WSA Bulk Rougher Concentrate

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	5.43	94.6
65 Mesh	212	15.92	78.7
100 Mesh	150	17.42	61.2
150 Mesh	106	9.74	51.5
200 Mesh	75	6.37	45.1
270 Mesh	53	3.93	41.2
400 Mesh	38	2.43	38.8
TOTAL		100.00	**

K80 =219µm

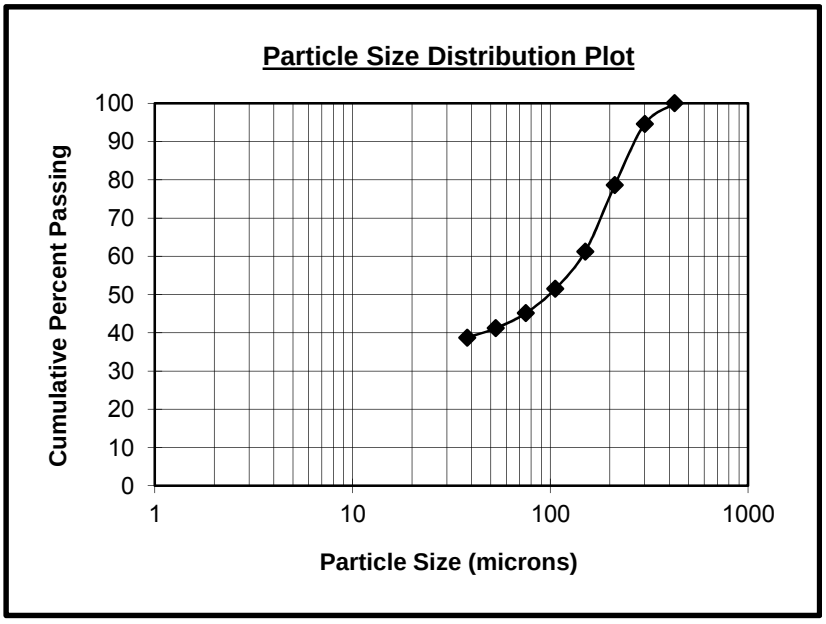
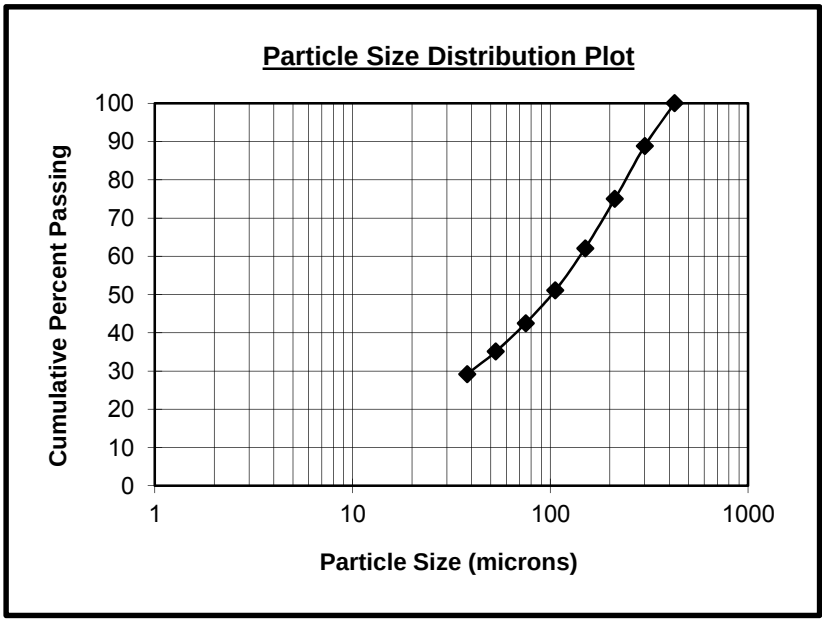


TABLE III-54
SCREEN ANALYSIS
KM3512-P3 WSA Flotation Feed

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	11.20	88.8
65 Mesh	212	13.80	75.0
100 Mesh	150	12.90	62.1
150 Mesh	106	11.00	51.1
200 Mesh	75	8.60	42.5
270 Mesh	53	7.40	35.1
400 Mesh	38	5.90	29.2
TOTAL		100.00	**

K80 =242µm



ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P3

Measured by:
Neville

Measured:
Monday, October 22, 2012 9:21:25 AM

Sample Name:
WSB Bulk Concentrate - Average

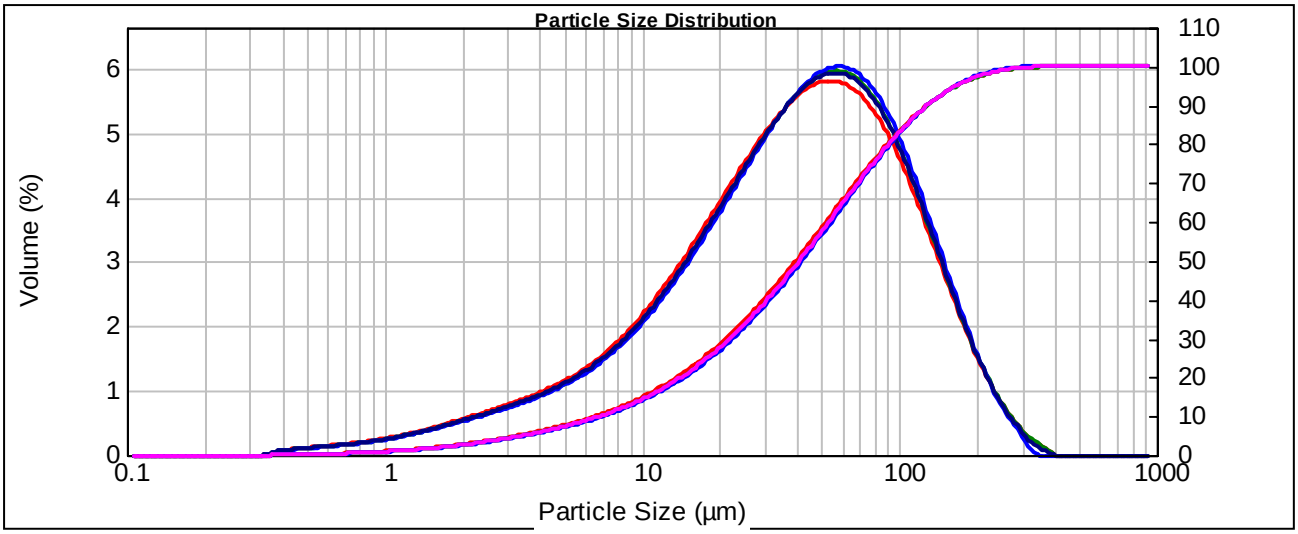
Edited by:
Neville

Analysed:
Monday, October 22, 2012 9:21:26 AM

Particle Name: Silica 1.0	**Accessory Name:** Hydro 2000MU (A)	**Analysis model:** General purpose	**Sensitivity:** Normal
Particle RI: 1.544	**Absorption:** 1	**Size range:** 0.100 to 1000.000 um	**Obscuration:** 12.61 %
Dispersant Name: Water	**Dispersant RI:** 1.330	**Weighted Residual:** 0.075 %	**Result Emulation:** Off

Concentration: 0.0230 %Vol	**Span :** 2.978	**Uniformity:** 0.931	**Result units:** Volume
Specific Surface Area: 0.449 m²/g	**Surface Weighted Mean D[3,2]:** 13.358 um	**Vol. Weighted Mean D[4,3]:** 56.765 um	

d(0.1): 6.799 um d(0.5): 40.847 um **d(0.8): 90.932 um** d(0.9): 128.456 um d(0.98): 212.84 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.04
0.437	0.05
0.479	0.06

Size (µm)	Volume In %
0.479	0.07
0.525	0.08
0.575	0.08
0.631	0.09
0.692	0.10
0.759	0.11
0.832	0.13
0.912	0.14
1.000	0.16
1.096	0.17
1.202	0.20
1.318	0.22
1.445	0.24
1.585	0.27
1.738	0.30
1.905	0.32
2.089	0.35
2.291	

Size (µm)	Volume In %
2.291	0.38
2.512	0.41
2.754	0.44
3.020	0.47
3.311	0.50
3.631	0.54
3.981	0.58
4.365	0.62
4.786	0.67
5.248	0.73
5.754	0.79
6.310	0.85
6.918	0.93
7.586	1.01
8.318	1.10
9.120	1.21
10.000	1.32
10.965	

Size (µm)	Volume In %
10.965	1.44
12.023	1.57
13.183	1.71
14.454	1.85
15.849	1.99
17.378	2.15
19.055	2.30
20.893	2.46
22.909	2.61
25.119	2.77
27.542	2.92
30.200	3.06
33.113	3.19
36.308	3.31
39.811	3.41
43.652	3.49
47.863	3.55
52.481	

Size (µm)	Volume In %
52.481	3.57
57.544	3.56
63.096	3.52
69.183	3.44
75.858	3.33
83.176	3.17
91.201	2.98
100.000	2.76
109.648	2.51
120.226	2.25
131.826	1.98
144.544	1.70
158.489	1.43
173.780	1.18
190.546	0.94
208.930	0.73
229.087	0.54
251.189	

Size (µm)	Volume In %
251.189	0.39
275.423	0.27
301.995	0.14
331.131	0.07
363.078	0.02
398.107	0.00
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P3

Measured by:
Mel

Measured:
Monday, October 22, 2012 10:04:51 AM

Sample Name:
WSB Bulk Regrind Discharge - Average

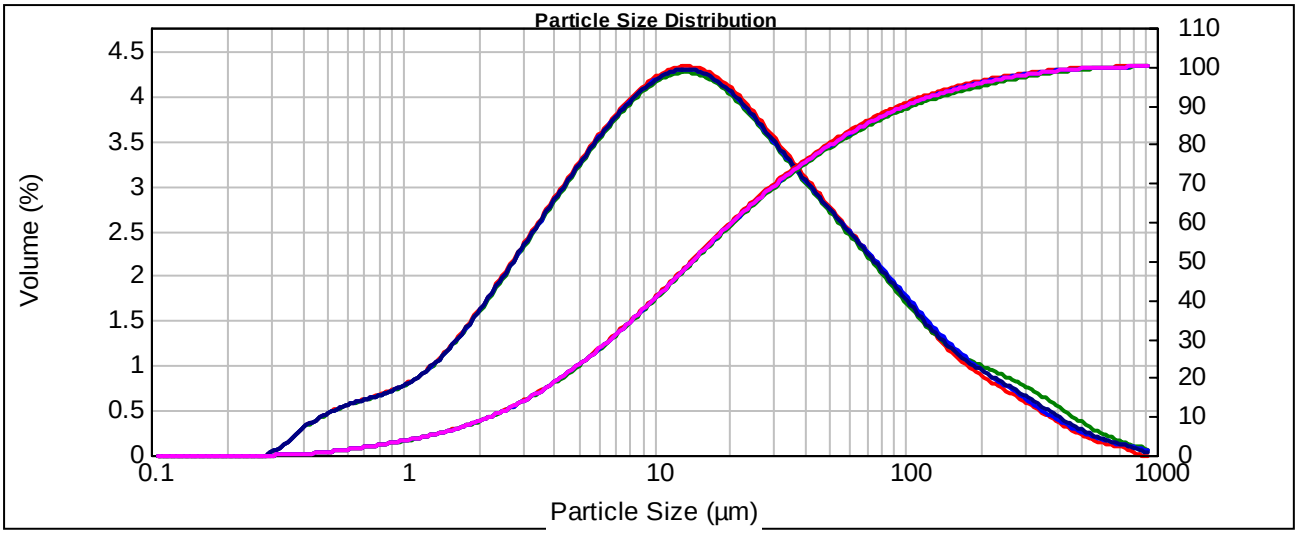
Edited by:
Mel

Analysed:
Monday, October 22, 2012 10:04:52 AM

Particle Name: Silica 1.0
Accessory Name: Hydro 2000MU (A)
Analysis model: General purpose
Sensitivity: Normal
Particle RI: 1.544
Absorption: 1
Size range: 0.100 to 1000.000 um
Obscuration: 16.67 %
Dispersant Name: Water
Dispersant RI: 1.330
Weighted Residual: 0.190 %
Result Emulation: Off

Concentration: 0.0122 %Vol
Span : 6.938
Uniformity: 2.47
Result units: Volume
Specific Surface Area: 1.12 m²/g
Surface Weighted Mean D[3,2]: 5.374 um
Vol. Weighted Mean D[4,3]: 41.303 um

d(0.1): 2.254 um d(0.5): 14.287 um **d(0.8): 50.919 um** d(0.9): 101.376 um d(0.98): 311.1 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.04
0.331	0.08
0.363	0.15
0.398	0.20
0.437	0.24
0.479	

Size (µm)	Volume In %
0.479	0.28
0.525	0.31
0.575	0.34
0.631	0.36
0.692	0.38
0.759	0.40
0.832	0.42
0.912	0.45
1.000	0.48
1.096	0.52
1.202	0.57
1.318	0.63
1.445	0.70
1.585	0.78
1.738	0.87
1.905	0.95
2.089	1.05
2.291	

Size (µm)	Volume In %
2.291	1.15
2.512	1.24
2.754	1.35
3.020	1.45
3.311	1.55
3.631	1.65
3.981	1.75
4.365	1.85
4.786	1.95
5.248	2.04
5.754	2.13
6.310	2.21
6.918	2.29
7.586	2.36
8.318	2.43
9.120	2.48
10.000	2.53
10.965	

Size (µm)	Volume In %
10.965	2.56
12.023	2.58
13.183	2.58
14.454	2.57
15.849	2.54
17.378	2.50
19.055	2.45
20.893	2.38
22.909	2.30
25.119	2.23
27.542	2.14
30.200	2.06
33.113	1.97
36.308	1.89
39.811	1.81
43.652	1.73
47.863	1.64
52.481	

Size (µm)	Volume In %
52.481	1.57
57.544	1.49
63.096	1.41
69.183	1.33
75.858	1.25
83.176	1.17
91.201	1.09
100.000	1.01
109.648	0.93
120.226	0.85
131.826	0.78
144.544	0.72
158.489	0.66
173.780	0.61
190.546	0.57
208.930	0.53
229.087	0.49
251.189	

Size (µm)	Volume In %
251.189	0.46
275.423	0.42
301.995	0.37
331.131	0.33
363.078	0.29
398.107	0.25
436.516	0.21
478.630	0.17
524.807	0.14
575.440	0.11
630.957	0.09
691.831	0.07
758.578	0.05
831.764	0.03
912.011	0.01
1000.000	

Operator notes:

TABLE III-57
SCREEN ANALYSIS
KM3512-P3 WSB Bulk Rougher Concentrate

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	4.80	95.2
65 Mesh	212	8.90	86.3
100 Mesh	150	8.20	78.1
150 Mesh	106	8.70	69.4
200 Mesh	75	7.50	61.9
270 Mesh	53	6.50	55.4
400 Mesh	38	5.80	49.6
TOTAL		100.00	**

K80 =163µm

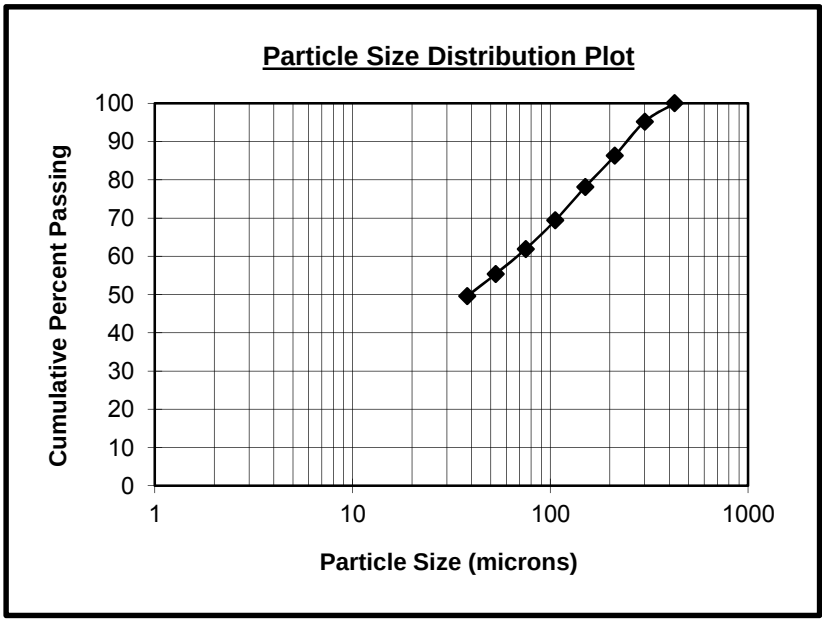
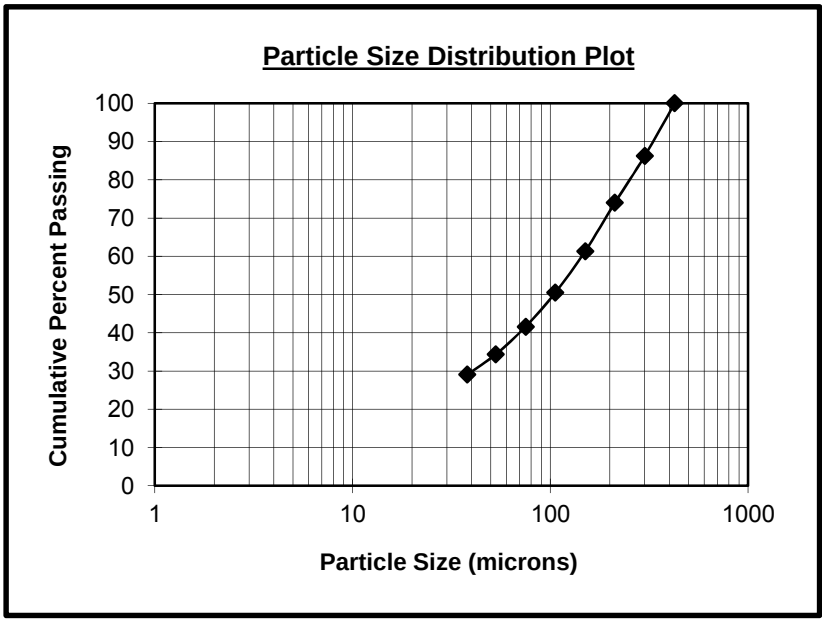


TABLE III-58
SCREEN ANALYSIS
KM3512-P3 WSB Flotation Feed

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	13.80	86.2
65 Mesh	212	12.20	74.0
100 Mesh	150	12.70	61.3
150 Mesh	106	10.80	50.5
200 Mesh	75	8.90	41.6
270 Mesh	53	7.20	34.4
400 Mesh	38	5.30	29.1
TOTAL		100.00	**

K80 =253µm



ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P3

Measured by:
Mel

Measured:
Monday, October 22, 2012 10:10:01 AM

Sample Name:
WSC Bulk Concentrate - Average

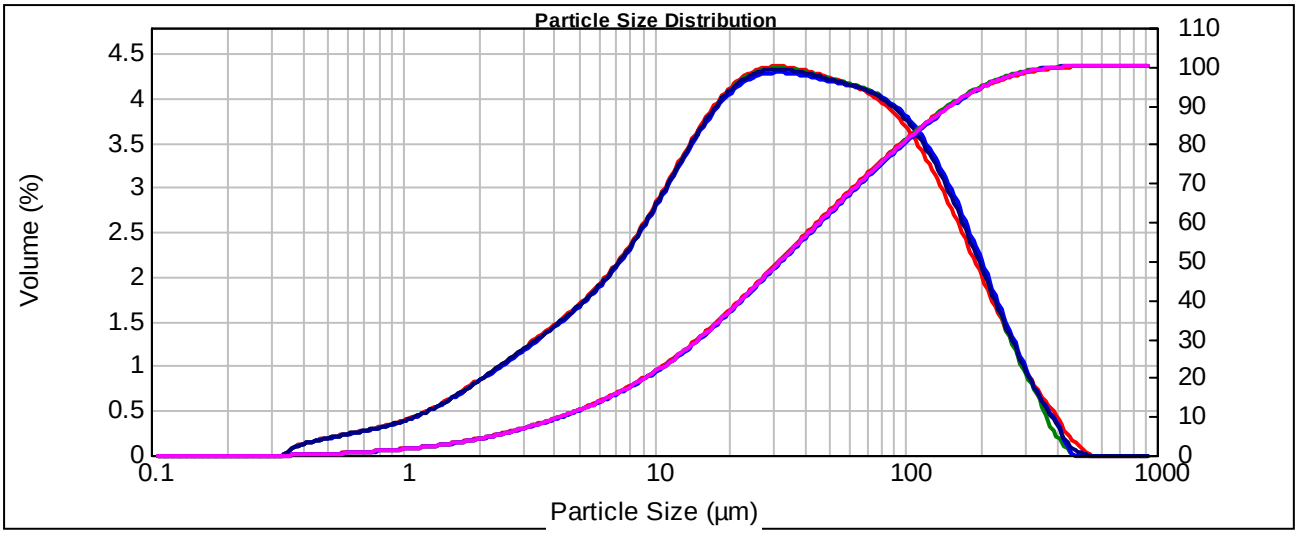
Edited by:
Mel

Analysed:
Monday, October 22, 2012 10:10:02 AM

Particle Name: Silica 1.0
Accessory Name: Hydro 2000MU (A)
Analysis model: General purpose
Sensitivity: Normal
Particle RI: 1.544
Absorption: 1
Size range: 0.100 to 1000.000 um
Obscuration: 12.50 %
Dispersant Name: Water
Dispersant RI: 1.330
Weighted Residual: 0.090 %
Result Emulation: Off

Concentration: 0.0165 %Vol
Span : 4.604
Uniformity: 1.42
Result units: Volume
Specific Surface Area: 0.615 m²/g
Surface Weighted Mean D[3,2]: 9.762 um
Vol. Weighted Mean D[4,3]: 58.615 um

d(0.1): 4.308 um d(0.5): 31.924 um **d(0.8): 96.579 um** d(0.9): 151.288 um d(0.98): 274.52 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.01
0.363	0.07
0.398	0.08
0.437	0.10
0.479	

Size (µm)	Volume In %
0.479	0.11
0.525	0.13
0.575	0.14
0.631	0.15
0.692	0.17
0.759	0.18
0.832	0.20
0.912	0.22
1.000	0.24
1.096	0.27
1.202	0.30
1.318	0.33
1.445	0.37
1.585	0.41
1.738	0.45
1.905	0.50
2.089	0.54
2.291	

Size (µm)	Volume In %
2.291	0.59
2.512	0.64
2.754	0.69
3.020	0.74
3.311	0.79
3.631	0.84
3.981	0.89
4.365	0.95
4.786	1.00
5.248	1.07
5.754	1.14
6.310	1.21
6.918	1.30
7.586	1.39
8.318	1.49
9.120	1.60
10.000	1.72
10.965	

Size (µm)	Volume In %
10.965	1.84
12.023	1.96
13.183	2.08
14.454	2.19
15.849	2.29
17.378	2.38
19.055	2.45
20.893	2.51
22.909	2.56
25.119	2.58
27.542	2.60
30.200	2.60
33.113	2.59
36.308	2.58
39.811	2.57
43.652	2.55
47.863	2.53
52.481	

Size (µm)	Volume In %
52.481	2.51
57.544	2.50
63.096	2.47
69.183	2.45
75.858	2.41
83.176	2.36
91.201	2.30
100.000	2.22
109.648	2.13
120.226	2.02
131.826	1.89
144.544	1.75
158.489	1.60
173.780	1.44
190.546	1.28
208.930	1.11
229.087	0.95
251.189	

Size (µm)	Volume In %
251.189	0.79
275.423	0.64
301.995	0.49
331.131	0.37
363.078	0.27
398.107	0.15
436.516	0.04
478.630	0.01
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P3

Measured by:
Neville

Measured:
Monday, October 22, 2012 9:31:53 AM

Sample Name:
WSC Bulk Regrind Discharge - Average

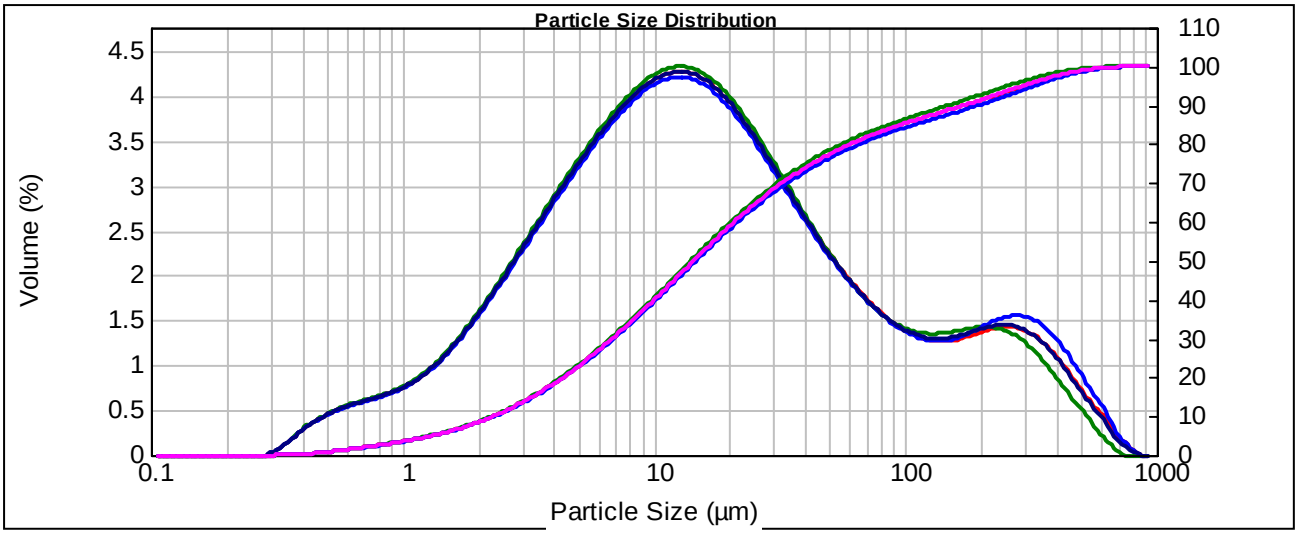
Edited by:
Neville

Analysed:
Monday, October 22, 2012 9:31:54 AM

Particle Name: Silica 1.0
Accessory Name: Hydro 2000MU (A)
Analysis model: General purpose
Sensitivity: Normal
Particle RI: 1.544
Absorption: 1
Size range: 0.100 to 1000.000 um
Obscuration: 14.84 %
Dispersant Name: Water
Dispersant RI: 1.330
Weighted Residual: 0.196 %
Result Emulation: Off

Concentration: 0.0109 %Vol
Span : 11.700
Uniformity: 3.36
Result units: Volume
Specific Surface Area: 1.1 m²/g
Surface Weighted Mean D[3,2]: 5.459 um
Vol. Weighted Mean D[4,3]: 54.345 um

d(0.1): 2.290 um d(0.5): 14.344 um **d(0.8): 60.134 um** d(0.9): 170.114 um d(0.98): 422.62 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.04
0.331	0.08
0.363	0.14
0.398	0.20
0.437	0.23
0.479	

Size (µm)	Volume In %
0.479	0.27
0.525	0.30
0.575	0.33
0.631	0.35
0.692	0.37
0.759	0.39
0.832	0.41
0.912	0.44
1.000	0.47
1.096	0.51
1.202	0.56
1.318	0.62
1.445	0.69
1.585	0.77
1.738	0.85
1.905	0.94
2.089	1.04
2.291	

Size (µm)	Volume In %
2.291	1.14
2.512	1.24
2.754	1.34
3.020	1.45
3.311	1.55
3.631	1.66
3.981	1.76
4.365	1.86
4.786	1.96
5.248	2.05
5.754	2.14
6.310	2.23
6.918	2.30
7.586	2.38
8.318	2.44
9.120	2.49
10.000	2.53
10.965	

Size (µm)	Volume In %
10.965	2.56
12.023	2.57
13.183	2.56
14.454	2.54
15.849	2.50
17.378	2.44
19.055	2.37
20.893	2.28
22.909	2.19
25.119	2.09
27.542	1.98
30.200	1.87
33.113	1.76
36.308	1.65
39.811	1.54
43.652	1.44
47.863	1.34
52.481	

Size (µm)	Volume In %
52.481	1.25
57.544	1.17
63.096	1.09
69.183	1.02
75.858	0.96
83.176	0.90
91.201	0.86
100.000	0.82
109.648	0.80
120.226	0.78
131.826	0.78
144.544	0.79
158.489	0.80
173.780	0.82
190.546	0.85
208.930	0.86
229.087	0.87
251.189	

Size (µm)	Volume In %
251.189	0.87
275.423	0.85
301.995	0.82
331.131	0.76
363.078	0.69
398.107	0.61
436.516	0.52
478.630	0.43
524.807	0.34
575.440	0.26
630.957	0.16
691.831	0.07
758.578	0.03
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

TABLE III-61
SCREEN ANALYSIS
KM3512-P3 WSC Bulk Rougher Concentrate

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	5.90	94.1
65 Mesh	212	7.80	86.3
100 Mesh	150	7.90	78.4
150 Mesh	106	7.20	71.2
200 Mesh	75	6.60	64.6
270 Mesh	53	5.80	58.8
400 Mesh	38	5.20	53.6
TOTAL		100.00	**

K80 =161µm

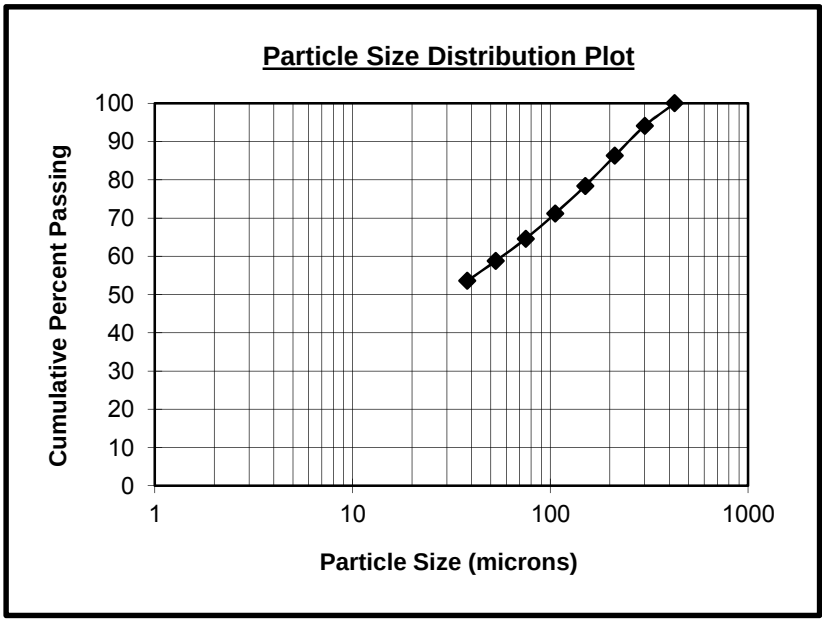
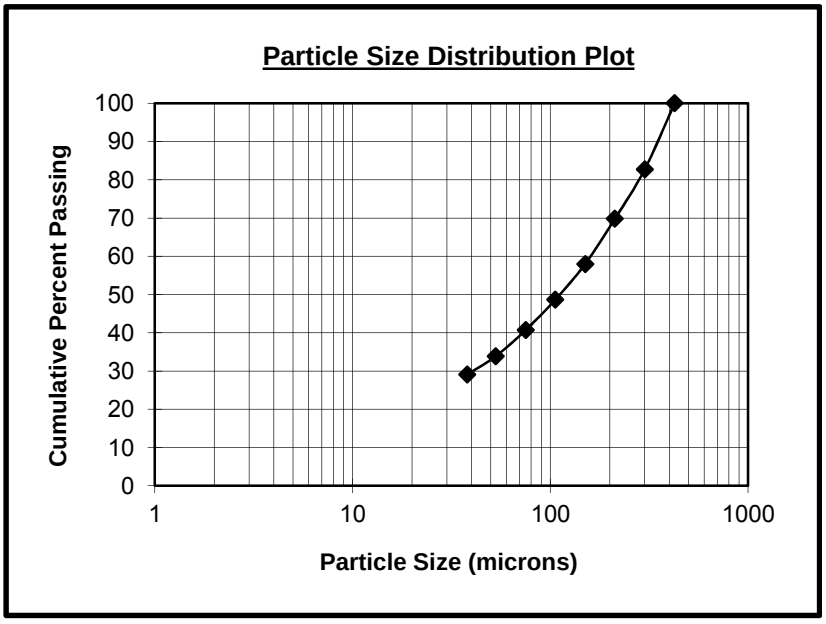


TABLE III-62
SCREEN ANALYSIS
KM3512-P3 WSC Flotation Feed

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	17.30	82.7
65 Mesh	212	12.90	69.8
100 Mesh	150	11.80	58.0
150 Mesh	106	9.30	48.7
200 Mesh	75	8.00	40.7
270 Mesh	53	6.80	33.9
400 Mesh	38	4.80	29.1
TOTAL		100.00	**

K80 =280µm



ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P3

Measured by:
Mel

Measured:
Monday, October 22, 2012 9:53:55 AM

Sample Name:
WSD Bulk Concentrate - Average

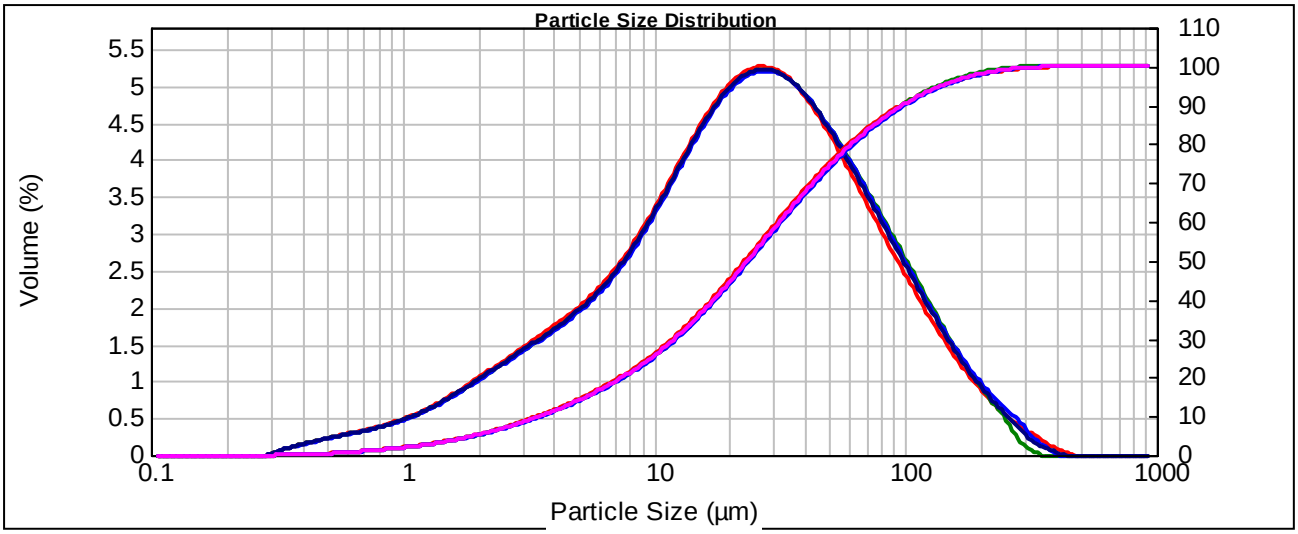
Edited by:
Mel

Analysed:
Monday, October 22, 2012 9:53:56 AM

Particle Name: Silica 1.0
Accessory Name: Hydro 2000MU (A)
Analysis model: General purpose
Sensitivity: Normal
Particle RI: 1.544
Absorption: 1
Size range: 0.100 to 1000.000 um
Obscuration: 11.92 %
Dispersant Name: Water
Dispersant RI: 1.330
Weighted Residual: 0.079 %
Result Emulation: Off

Concentration: 0.0128 %Vol
Span : 3.980
Uniformity: 1.26
Result units: Volume
Specific Surface Area: 0.748 m²/g
Surface Weighted Mean D[3,2]: 8.019 um
Vol. Weighted Mean D[4,3]: 39.939 um

d(0.1): 3.496 um d(0.5): 23.532 um **d(0.8): 60.958 um** d(0.9): 97.151 um d(0.98): 194.24 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.03
0.331	0.05
0.363	0.08
0.398	0.10
0.437	0.12
0.479	

Size (µm)	Volume In %
0.479	0.14
0.525	0.15
0.575	0.17
0.631	0.19
0.692	0.21
0.759	0.23
0.832	0.25
0.912	0.27
1.000	0.30
1.096	0.34
1.202	0.37
1.318	0.42
1.445	0.46
1.585	0.51
1.738	0.56
1.905	0.62
2.089	0.67
2.291	

Size (µm)	Volume In %
2.291	0.72
2.512	0.78
2.754	0.83
3.020	0.89
3.311	0.94
3.631	1.00
3.981	1.06
4.365	1.12
4.786	1.18
5.248	1.25
5.754	1.34
6.310	1.43
6.918	1.53
7.586	1.64
8.318	1.77
9.120	1.90
10.000	2.05
10.965	

Size (µm)	Volume In %
10.965	2.20
12.023	2.35
13.183	2.50
14.454	2.65
15.849	2.78
17.378	2.90
19.055	3.00
20.893	3.07
22.909	3.12
25.119	3.15
27.542	3.14
30.200	3.12
33.113	3.06
36.308	2.99
39.811	2.89
43.652	2.78
47.863	2.65
52.481	

Size (µm)	Volume In %
52.481	2.51
57.544	2.37
63.096	2.22
69.183	2.08
75.858	1.93
83.176	1.77
91.201	1.62
100.000	1.48
109.648	1.33
120.226	1.18
131.826	1.04
144.544	0.91
158.489	0.78
173.780	0.67
190.546	0.56
208.930	0.46
229.087	0.37
251.189	

Size (µm)	Volume In %
251.189	0.29
275.423	0.20
301.995	0.12
331.131	0.07
363.078	0.04
398.107	0.01
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P3

Measured by:
Mel

Measured:
Monday, October 22, 2012 9:57:33 AM

Sample Name:
WSD Bulk Regrind Discharge - Average

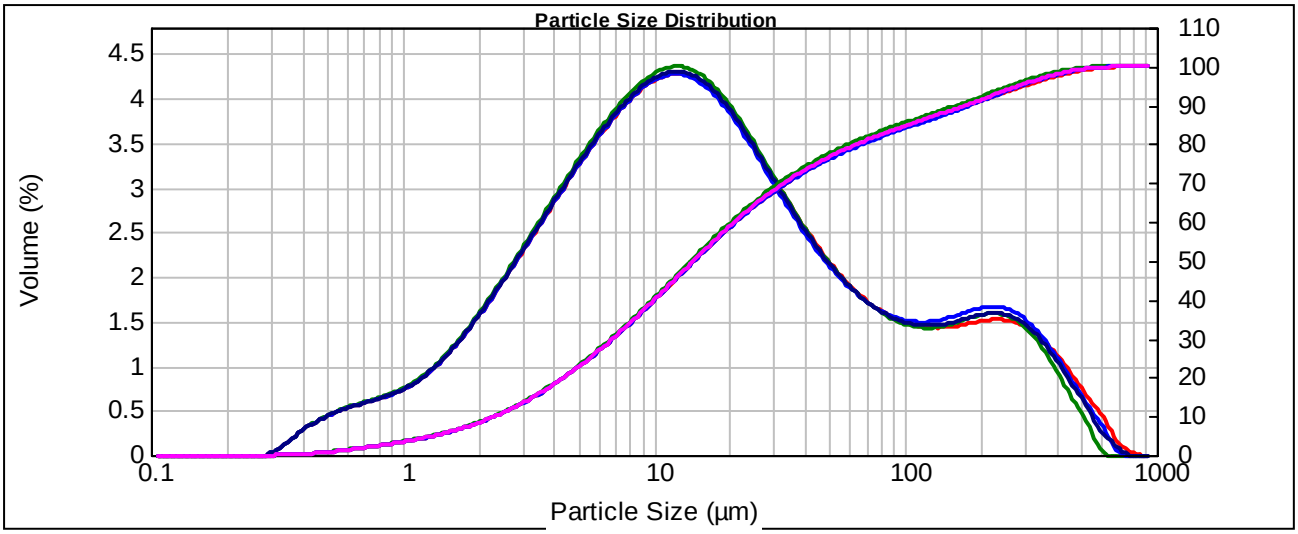
Edited by:
Mel

Analysed:
Monday, October 22, 2012 9:57:34 AM

Particle Name: Silica 1.0
Accessory Name: Hydro 2000MU (A)
Analysis model: General purpose
Sensitivity: Normal
Particle RI: 1.544
Absorption: 1
Size range: 0.100 to 1000.000 um
Obscuration: 16.36 %
Dispersant Name: Water
Dispersant RI: 1.330
Weighted Residual: 0.190 %
Result Emulation: Off

Concentration: 0.0123 %Vol
Span : 11.899
Uniformity: 3.32
Result units: Volume
Specific Surface Area: 1.09 m²/g
Surface Weighted Mean D[3,2]: 5.517 um
Vol. Weighted Mean D[4,3]: 53.735 um

d(0.1): 2.322 um d(0.5): 14.329 um **d(0.8): 63.975 um** d(0.9): 172.830 um d(0.98): 398.23 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.04
0.331	0.08
0.363	0.14
0.398	0.19
0.437	0.23
0.479	

Size (µm)	Volume In %
0.479	0.26
0.525	0.30
0.575	0.32
0.631	0.34
0.692	0.36
0.759	0.38
0.832	0.40
0.912	0.43
1.000	0.46
1.096	0.50
1.202	0.55
1.318	0.61
1.445	0.68
1.585	0.76
1.738	0.84
1.905	0.93
2.089	1.03
2.291	

Size (µm)	Volume In %
2.291	1.13
2.512	1.23
2.754	1.33
3.020	1.44
3.311	1.55
3.631	1.65
3.981	1.76
4.365	1.86
4.786	1.97
5.248	2.06
5.754	2.16
6.310	2.25
6.918	2.33
7.586	2.40
8.318	2.47
9.120	2.52
10.000	2.56
10.965	

Size (µm)	Volume In %
10.965	2.58
12.023	2.59
13.183	2.57
14.454	2.54
15.849	2.49
17.378	2.42
19.055	2.34
20.893	2.24
22.909	2.13
25.119	2.02
27.542	1.91
30.200	1.79
33.113	1.68
36.308	1.57
39.811	1.47
43.652	1.37
47.863	1.29
52.481	

Size (µm)	Volume In %
52.481	1.21
57.544	1.14
63.096	1.07
69.183	1.02
75.858	0.97
83.176	0.93
91.201	0.91
100.000	0.89
109.648	0.87
120.226	0.87
131.826	0.88
144.544	0.89
158.489	0.91
173.780	0.93
190.546	0.95
208.930	0.96
229.087	0.95
251.189	

Size (µm)	Volume In %
251.189	0.94
275.423	0.90
301.995	0.85
331.131	0.78
363.078	0.69
398.107	0.59
436.516	0.48
478.630	0.39
524.807	0.28
575.440	0.15
630.957	0.09
691.831	0.02
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

TABLE III-65
SCREEN ANALYSIS
KM3512-P3 WSD Bulk Rougher Concentrate

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	7.70	92.3
65 Mesh	212	11.40	80.9
100 Mesh	150	10.10	70.8
150 Mesh	106	7.60	63.2
200 Mesh	75	7.20	56.0
270 Mesh	53	5.90	50.1
400 Mesh	38	3.70	46.4
TOTAL		100.00	**

K80 =206µm

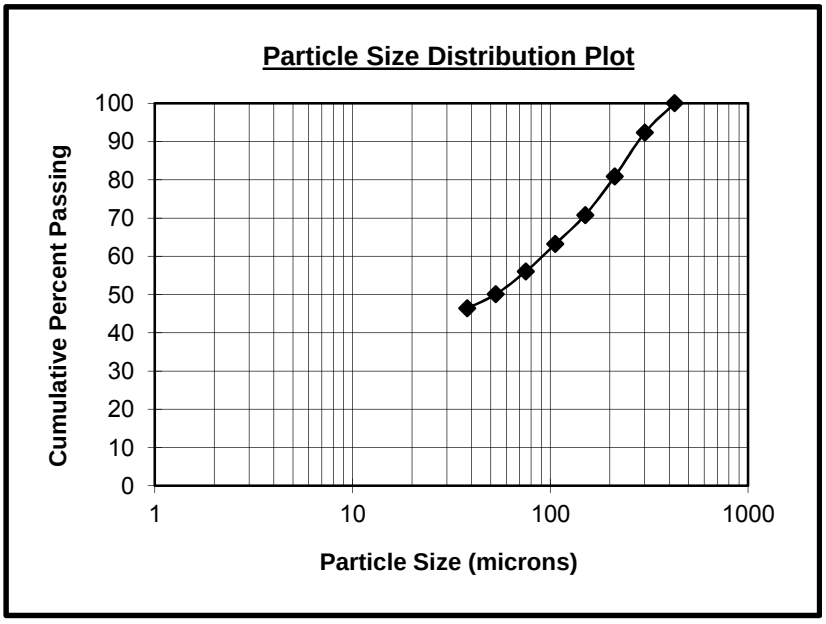
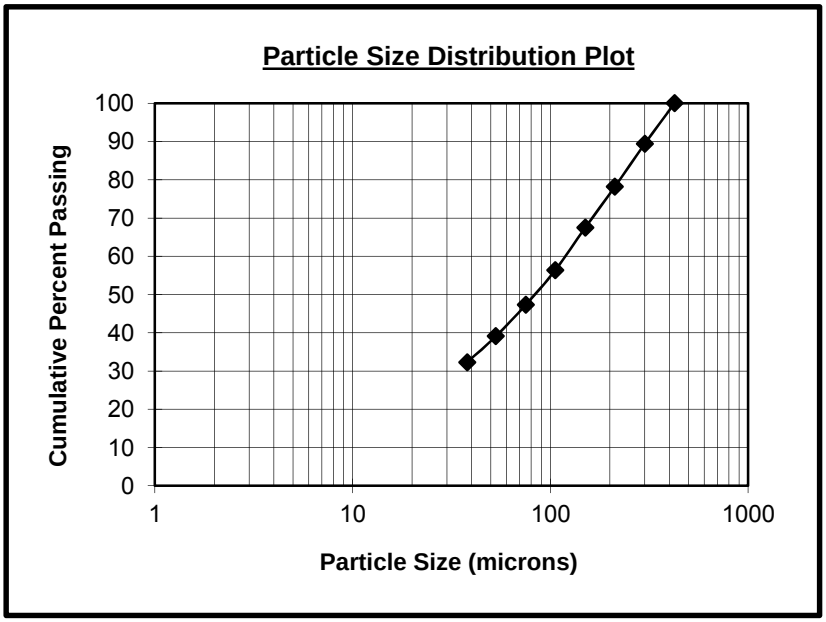


TABLE III-66
SCREEN ANALYSIS
KM3512-P3 WSD Flotation Feed

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	10.60	89.4
65 Mesh	212	11.20	78.2
100 Mesh	150	10.70	67.5
150 Mesh	106	11.10	56.4
200 Mesh	75	9.10	47.3
270 Mesh	53	8.20	39.1
400 Mesh	38	6.80	32.3
TOTAL		100.00	**

K80 =225µm



ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P4

Measured by:
Mel

Measured:
Monday, October 22, 2012 2:17:52 PM

Sample Name:
WSA Bulk Concentrate - Average

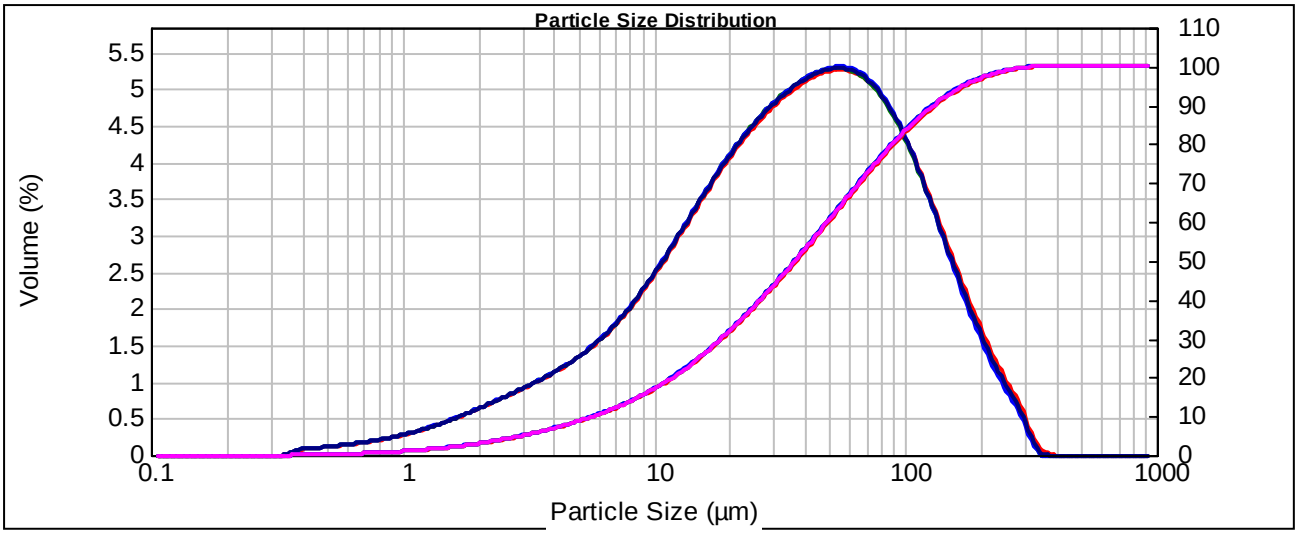
Edited by:
Mel

Analysed:
Monday, October 22, 2012 2:17:53 PM

Particle Name: Silica 1.0
Accessory Name: Hydro 2000MU (A)
Analysis model: General purpose
Sensitivity: Normal
Particle RI: 1.544
Absorption: 1
Size range: 0.100 to 1000.000 um
Obscuration: 12.15 %
Dispersant Name: Water
Dispersant RI: 1.330
Weighted Residual: 0.221 %
Result Emulation: Off

Concentration: 0.0199 %Vol
Span : 3.398
Uniformity: 1.06
Result units: Volume
Specific Surface Area: 0.499 m²/g
Surface Weighted Mean D[3,2]: 12.023 um
Vol. Weighted Mean D[4,3]: 54.608 um

d(0.1): 5.715 um d(0.5): 36.390 um **d(0.8): 88.825 um** d(0.9): 129.355 um d(0.98): 220.36 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.05
0.437	0.05
0.479	0.06

Size (µm)	Volume In %
0.479	0.07
0.525	0.08
0.575	0.09
0.631	0.10
0.692	0.11
0.759	0.12
0.832	0.14
0.912	0.16
1.000	0.18
1.096	0.20
1.202	0.22
1.318	0.25
1.445	0.28
1.585	0.31
1.738	0.35
1.905	0.38
2.089	0.42
2.291	

Size (µm)	Volume In %
2.291	0.45
2.512	0.49
2.754	0.53
3.020	0.57
3.311	0.61
3.631	0.66
3.981	0.70
4.365	0.75
4.786	0.81
5.248	0.87
5.754	0.94
6.310	1.02
6.918	1.10
7.586	1.20
8.318	1.31
9.120	1.42
10.000	1.55
10.965	

Size (µm)	Volume In %
10.965	1.68
12.023	1.81
13.183	1.95
14.454	2.08
15.849	2.21
17.378	2.34
19.055	2.46
20.893	2.57
22.909	2.67
25.119	2.77
27.542	2.86
30.200	2.93
33.113	3.00
36.308	3.06
39.811	3.11
43.652	3.15
47.863	3.17
52.481	

Size (µm)	Volume In %
52.481	3.18
57.544	3.17
63.096	3.13
69.183	3.07
75.858	2.98
83.176	2.85
91.201	2.70
100.000	2.52
109.648	2.31
120.226	2.09
131.826	1.86
144.544	1.63
158.489	1.41
173.780	1.20
190.546	1.00
208.930	0.82
229.087	0.65
251.189	

Size (µm)	Volume In %
251.189	0.50
275.423	0.37
301.995	0.15
331.131	0.01
363.078	0.00
398.107	0.00
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P4

Measured by:
Mel

Measured:
Monday, October 22, 2012 2:03:19 PM

Sample Name:
WSA Bulk Regrind Discharge - Average

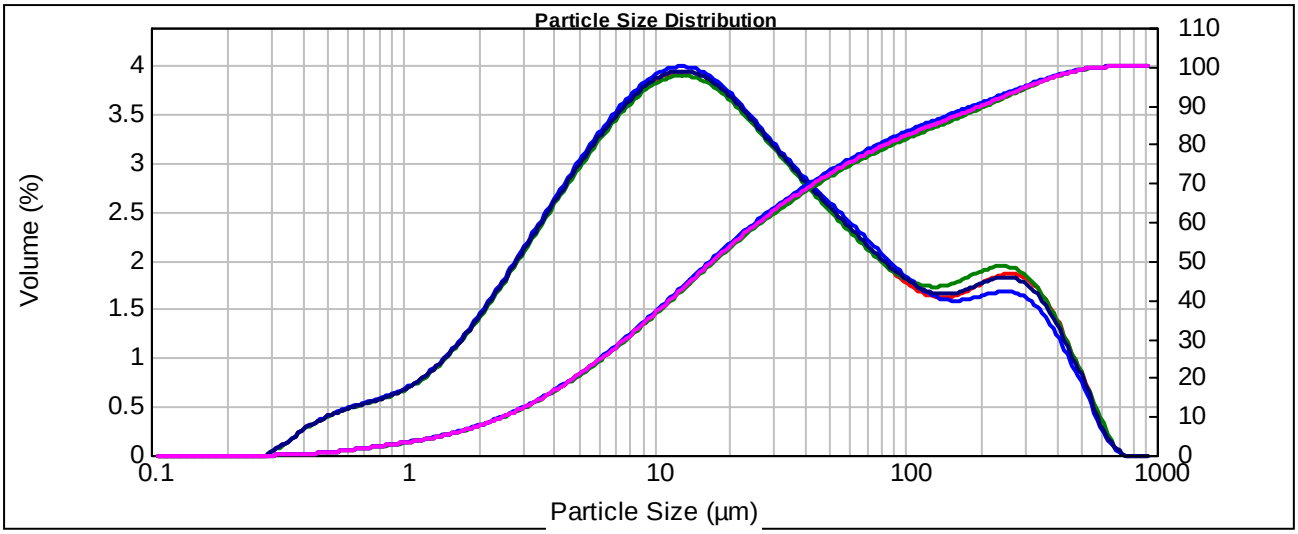
Edited by:
Mel

Analysed:
Monday, October 22, 2012 2:03:20 PM

Particle Name: Silica 1.0
Accessory Name: Hydro 2000MU (A)
Analysis model: General purpose
Sensitivity: Normal
Particle RI: 1.544
Absorption: 1
Size range: 0.100 to 1000.000 um
Obscuration: 19.00 %
Dispersant Name: Water
Dispersant RI: 1.330
Weighted Residual: 0.225 %
Result Emulation: Off

Concentration: 0.0158 %Vol
Span : 11.684
Uniformity: 3.2
Result units: Volume
Specific Surface Area: 0.994 m²/g
Surface Weighted Mean D[3,2]: 6.034 um
Vol. Weighted Mean D[4,3]: 61.910 um

d(0.1): 2.533 um d(0.5): 17.156 um **d(0.8): 83.961 um** d(0.9): 202.980 um d(0.98): 420.08 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.04
0.331	0.07
0.363	0.13
0.398	0.17
0.437	0.21
0.479	

Size (µm)	Volume In %
0.479	0.24
0.525	0.27
0.575	0.29
0.631	0.31
0.692	0.32
0.759	0.34
0.832	0.36
0.912	0.39
1.000	0.42
1.096	0.45
1.202	0.50
1.318	0.55
1.445	0.61
1.585	0.69
1.738	0.76
1.905	0.84
2.089	0.93
2.291	

Size (µm)	Volume In %
2.291	1.02
2.512	1.11
2.754	1.21
3.020	1.31
3.311	1.41
3.631	1.50
3.981	1.60
4.365	1.69
4.786	1.79
5.248	1.87
5.754	1.96
6.310	2.04
6.918	2.11
7.586	2.18
8.318	2.24
9.120	2.29
10.000	2.33
10.965	

Size (µm)	Volume In %
10.965	2.36
12.023	2.37
13.183	2.37
14.454	2.35
15.849	2.32
17.378	2.27
19.055	2.22
20.893	2.15
22.909	2.09
25.119	2.01
27.542	1.94
30.200	1.87
33.113	1.79
36.308	1.72
39.811	1.66
43.652	1.59
47.863	1.53
52.481	

Size (µm)	Volume In %
52.481	1.47
57.544	1.40
63.096	1.34
69.183	1.28
75.858	1.22
83.176	1.16
91.201	1.11
100.000	1.06
109.648	1.03
120.226	1.00
131.826	0.99
144.544	1.00
158.489	1.01
173.780	1.03
190.546	1.06
208.930	1.08
229.087	1.10
251.189	

Size (µm)	Volume In %
251.189	1.10
275.423	1.08
301.995	1.03
331.131	0.96
363.078	0.87
398.107	0.75
436.516	0.61
478.630	0.49
524.807	0.35
575.440	0.16
630.957	0.09
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

TABLE III-69
SCREEN ANALYSIS
KM3512-P4 WSA Bulk Rougher Concentrate

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	8.80	91.2
65 Mesh	212	10.60	80.6
100 Mesh	150	10.30	70.3
150 Mesh	106	9.30	61.0
200 Mesh	75	8.80	52.2
270 Mesh	53	7.00	45.2
400 Mesh	38	5.30	39.9
TOTAL		100.00	**

K80 =208µm

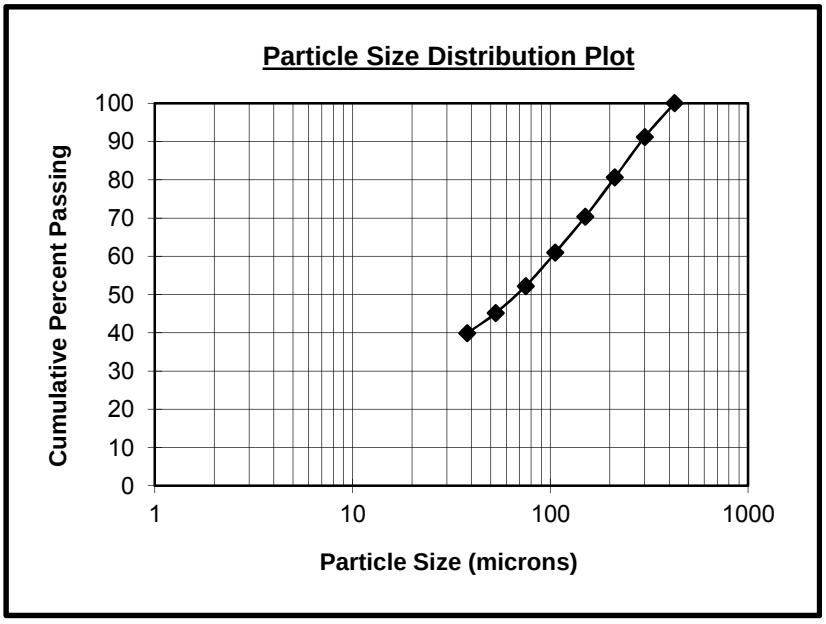
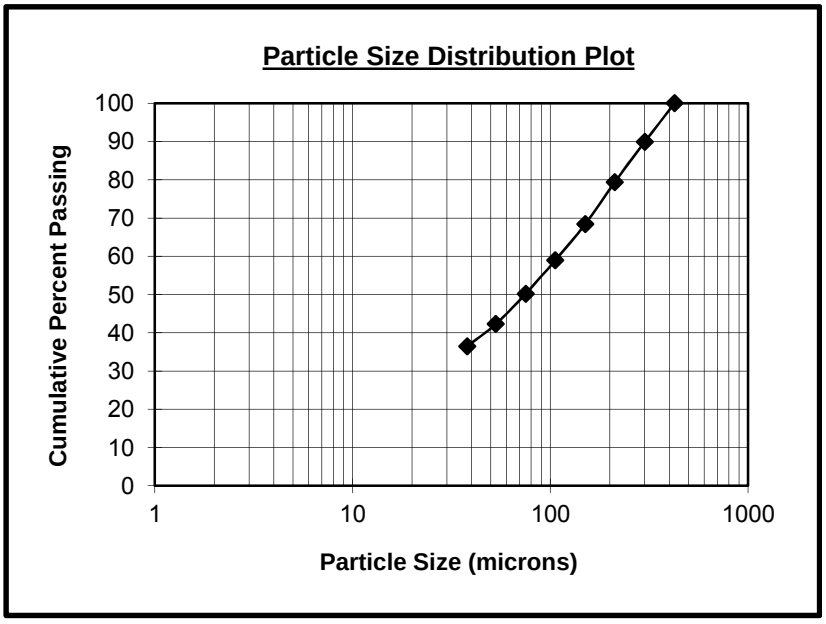


TABLE III-70
SCREEN ANALYSIS
KM3512-P4 WSA Flotation Feed

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	10.10	89.9
65 Mesh	212	10.50	79.4
100 Mesh	150	11.00	68.4
150 Mesh	106	9.40	59.0
200 Mesh	75	8.80	50.2
270 Mesh	53	7.90	42.3
400 Mesh	38	5.80	36.5
TOTAL		100.00	**

K80 =217µm



ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P4

Measured by:
Mel

Measured:
Monday, October 22, 2012 2:21:21 PM

Sample Name:
WSB Bulk Concentrate - Average

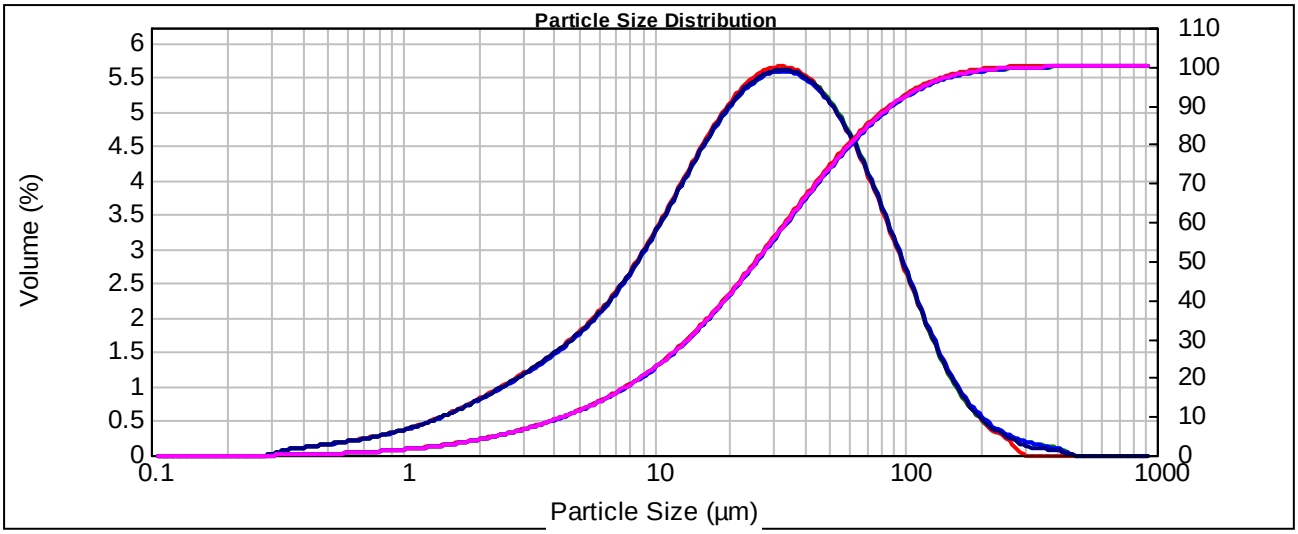
Edited by:
Mel

Analysed:
Monday, October 22, 2012 2:21:22 PM

Particle Name: Silica 1.0
Accessory Name: Hydro 2000MU (A)
Analysis model: General purpose
Sensitivity: Normal
Particle RI: 1.544
Absorption: 1
Size range: 0.100 to 1000.000 um
Obscuration: 10.82 %
Dispersant Name: Water
Dispersant RI: 1.330
Weighted Residual: 0.130 %
Result Emulation: Off

Concentration: 0.0136 %Vol
Span : 3.275
Uniformity: 1.05
Result units: Volume
Specific Surface Area: 0.64 m²/g
Surface Weighted Mean D[3,2]: 9.375 um
Vol. Weighted Mean D[4,3]: 38.822 um

d(0.1): 4.388 um d(0.5): 25.660 um **d(0.8): 60.272 um** d(0.9): 88.415 um d(0.98): 163.04 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.03
0.331	0.05
0.363	0.06
0.398	0.07
0.437	0.08
0.479	

Size (µm)	Volume In %
0.479	0.09
0.525	0.11
0.575	0.12
0.631	0.13
0.692	0.15
0.759	0.17
0.832	0.19
0.912	0.21
1.000	0.23
1.096	0.26
1.202	0.29
1.318	0.32
1.445	0.36
1.585	0.40
1.738	0.44
1.905	0.48
2.089	0.53
2.291	

Size (µm)	Volume In %
2.291	0.58
2.512	0.63
2.754	0.68
3.020	0.74
3.311	0.79
3.631	0.85
3.981	0.92
4.365	0.99
4.786	1.07
5.248	1.15
5.754	1.24
6.310	1.34
6.918	1.45
7.586	1.58
8.318	1.72
9.120	1.86
10.000	2.02
10.965	

Size (µm)	Volume In %
10.965	2.17
12.023	2.33
13.183	2.50
14.454	2.65
15.849	2.80
17.378	2.94
19.055	3.06
20.893	3.17
22.909	3.25
25.119	3.32
27.542	3.36
30.200	3.38
33.113	3.37
36.308	3.34
39.811	3.29
43.652	3.21
47.863	3.10
52.481	

Size (µm)	Volume In %
52.481	2.97
57.544	2.81
63.096	2.63
69.183	2.43
75.858	2.22
83.176	1.99
91.201	1.75
100.000	1.52
109.648	1.28
120.226	1.07
131.826	0.87
144.544	0.69
158.489	0.54
173.780	0.42
190.546	0.32
208.930	0.25
229.087	0.19
251.189	

Size (µm)	Volume In %
251.189	0.15
275.423	0.09
301.995	0.07
331.131	0.06
363.078	0.05
398.107	0.04
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P4

Measured by:
Mel

Measured:
Monday, October 22, 2012 2:07:01 PM

Sample Name:
WSB Bulk Regrind Discharge - Average

Edited by:
Mel

Analysed:
Monday, October 22, 2012 2:07:02 PM

Particle Name:
Silica 1.0

Accessory Name:
Hydro 2000MU (A)

Analysis model:
General purpose

Sensitivity:
Normal

Particle RI:
1.544

Absorption:
1

Size range:
0.100 to 1000.000 um

Obscuration:
13.50 %

Dispersant Name:
Water

Dispersant RI:
1.330

Weighted Residual:
0.234 %

Result Emulation:
Off

Concentration:
0.0108 %Vol

Span :
9.956

Uniformity:
2.92

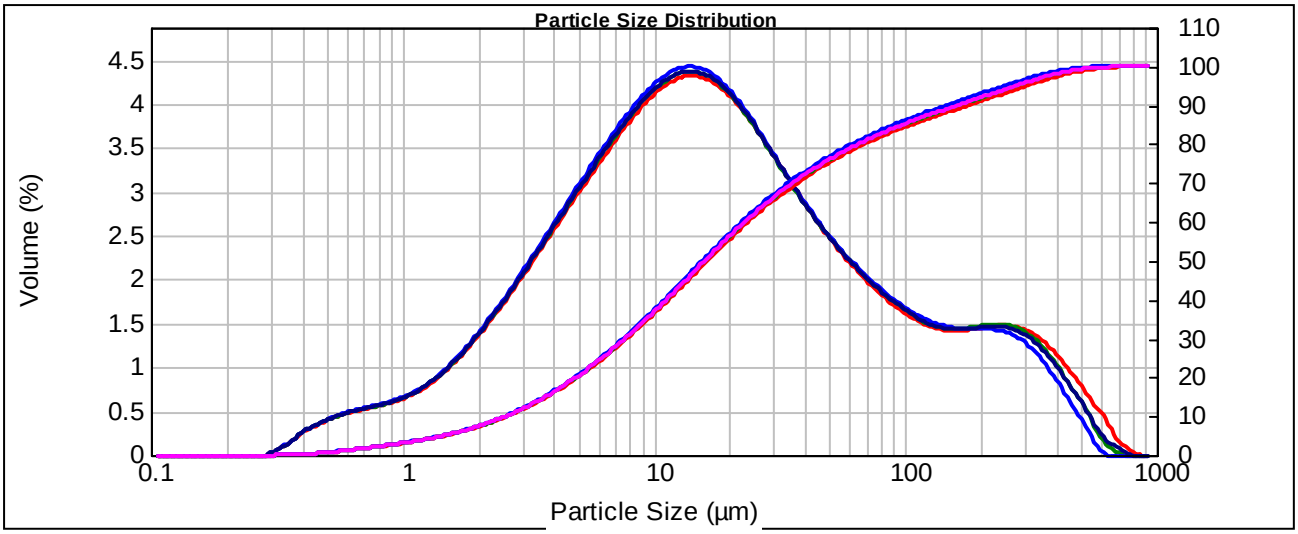
Result units:
Volume

Specific Surface Area:
1 m²/g

Surface Weighted Mean D[3,2]:
5.972 um

Vol. Weighted Mean D[4,3]:
53.257 um

d(0.1): 2.570 um d(0.5): 15.908 um **d(0.8): 64.631 um** d(0.9): 160.946 um d(0.98): 391.02 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.04
0.331	0.07
0.363	0.13
0.398	0.18
0.437	0.21
0.479	

Size (µm)	Volume In %
0.479	0.24
0.525	0.27
0.575	0.29
0.631	0.31
0.692	0.32
0.759	0.34
0.832	0.36
0.912	0.38
1.000	0.40
1.096	0.44
1.202	0.48
1.318	0.54
1.445	0.60
1.585	0.67
1.738	0.74
1.905	0.82
2.089	0.91
2.291	

Size (µm)	Volume In %
2.291	1.00
2.512	1.10
2.754	1.20
3.020	1.30
3.311	1.40
3.631	1.51
3.981	1.61
4.365	1.72
4.786	1.82
5.248	1.93
5.754	2.03
6.310	2.13
6.918	2.22
7.586	2.31
8.318	2.40
9.120	2.47
10.000	2.54
10.965	

Size (µm)	Volume In %
10.965	2.59
12.023	2.62
13.183	2.63
14.454	2.62
15.849	2.60
17.378	2.55
19.055	2.48
20.893	2.40
22.909	2.31
25.119	2.21
27.542	2.10
30.200	1.99
33.113	1.88
36.308	1.77
39.811	1.67
43.652	1.58
47.863	1.49
52.481	

Size (µm)	Volume In %
52.481	1.41
57.544	1.33
63.096	1.26
69.183	1.19
75.858	1.13
83.176	1.07
91.201	1.02
100.000	0.97
109.648	0.93
120.226	0.90
131.826	0.88
144.544	0.86
158.489	0.86
173.780	0.87
190.546	0.87
208.930	0.88
229.087	0.88
251.189	

Size (µm)	Volume In %
251.189	0.87
275.423	0.84
301.995	0.80
331.131	0.74
363.078	0.66
398.107	0.56
436.516	0.46
478.630	0.36
524.807	0.25
575.440	0.13
630.957	0.08
691.831	0.03
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

TABLE III-73
SCREEN ANALYSIS
KM3512-P4 WSB Bulk Rougher Concentrate

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	8.10	91.9
65 Mesh	212	9.90	82.0
100 Mesh	150	8.50	73.5
150 Mesh	106	7.10	66.4
200 Mesh	75	7.00	59.4
270 Mesh	53	6.60	52.8
400 Mesh	38	5.20	47.6
TOTAL		100.00	**

K80 =196µm

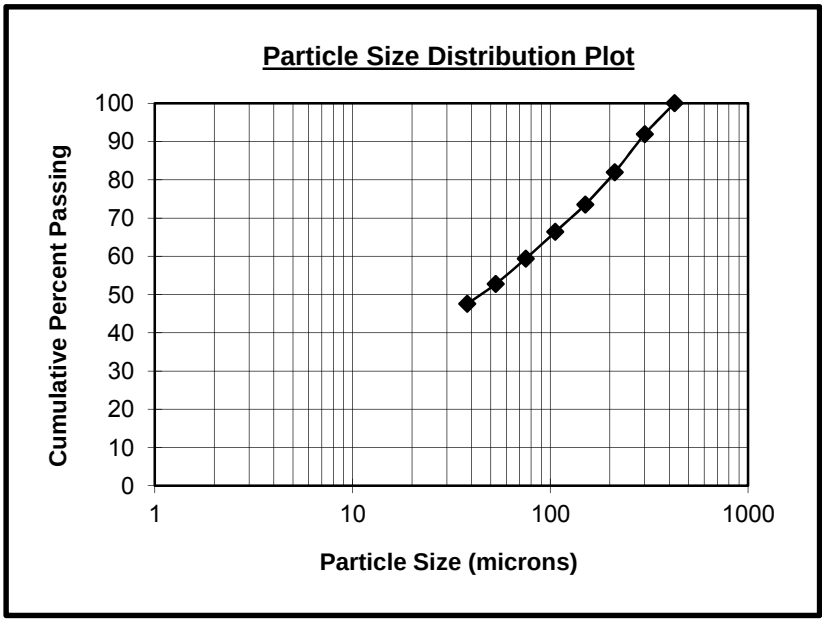
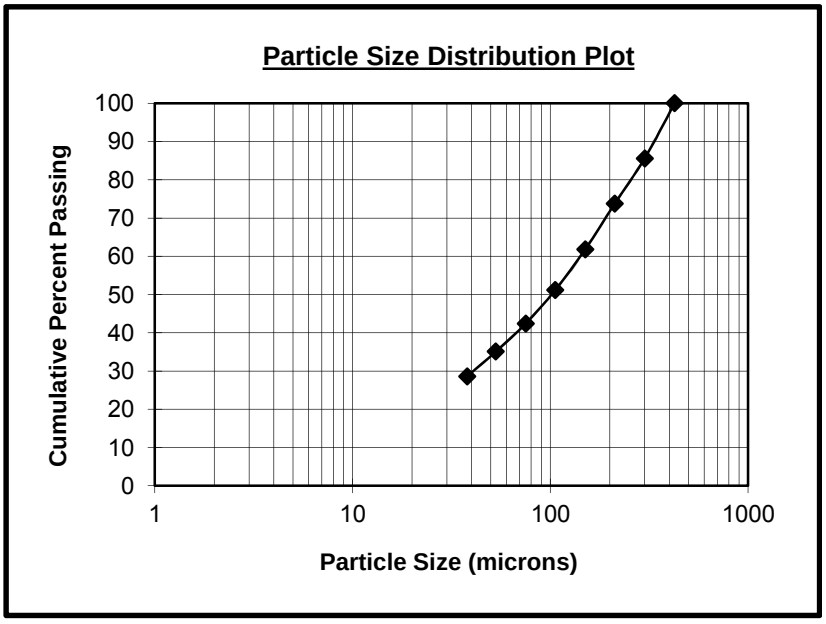


TABLE III-74
SCREEN ANALYSIS
KM3512-P4 WSB Flotation Feed

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	14.40	85.6
65 Mesh	212	11.80	73.8
100 Mesh	150	12.00	61.8
150 Mesh	106	10.60	51.2
200 Mesh	75	8.80	42.4
270 Mesh	53	7.30	35.1
400 Mesh	38	6.50	28.6
TOTAL		100.00	**

K80 =256µm



ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P4

Measured by:
Mel

Measured:
Monday, October 22, 2012 2:25:05 PM

Sample Name:
WSC Bulk Concentrate - Average

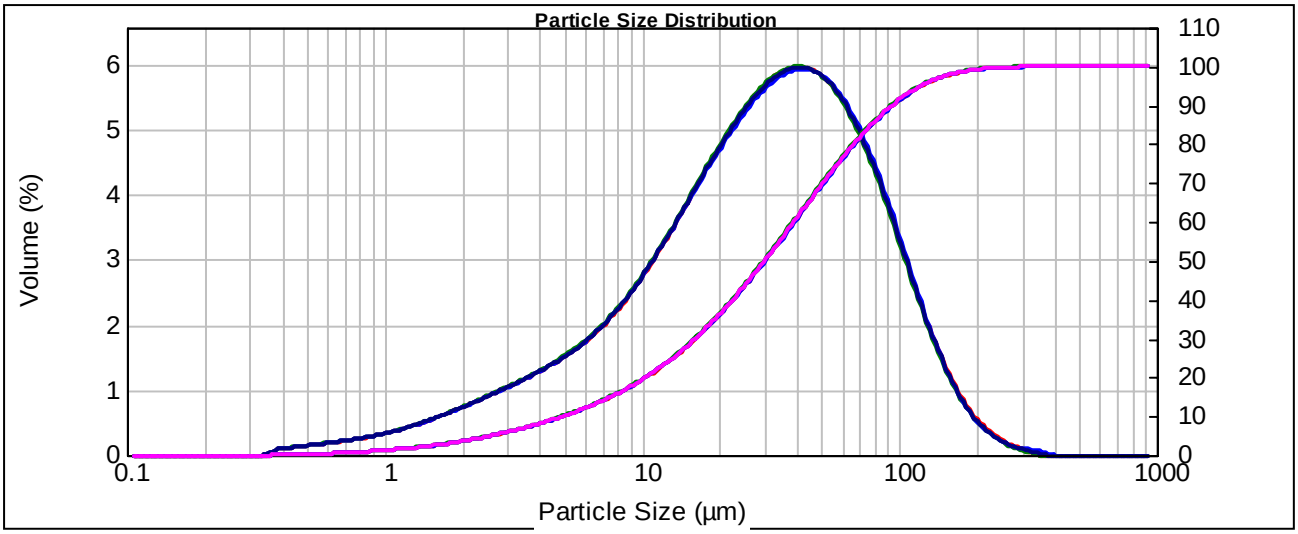
Edited by:
Mel

Analysed:
Monday, October 22, 2012 2:25:06 PM

Particle Name: Silica 1.0
Accessory Name: Hydro 2000MU (A)
Analysis model: General purpose
Sensitivity: Normal
Particle RI: 1.544
Absorption: 1
Size range: 0.100 to 1000.000 um
Obscuration: 12.53 %
Dispersant Name: Water
Dispersant RI: 1.330
Weighted Residual: 0.150 %
Result Emulation: Off

Concentration: 0.0177 %Vol
Span : 2.966
Uniformity: 0.937
Result units: Volume
Specific Surface Area: 0.575 m²/g
Surface Weighted Mean D[3,2]: 10.438 um
Vol. Weighted Mean D[4,3]: 41.791 um

d(0.1): 4.910 um d(0.5): 29.928 um **d(0.8): 66.430 um** d(0.9): 93.678 um d(0.98): 158.13 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.01
0.363	0.05
0.398	0.07
0.437	0.08
0.479	

Size (µm)	Volume In %
0.479	0.09
0.525	0.10
0.575	0.11
0.631	0.13
0.692	0.14
0.759	0.15
0.832	0.17
0.912	0.19
1.000	0.21
1.096	0.24
1.202	0.26
1.318	0.29
1.445	0.33
1.585	0.36
1.738	0.40
1.905	0.44
2.089	0.48
2.291	

Size (µm)	Volume In %
2.291	0.52
2.512	0.57
2.754	0.61
3.020	0.65
3.311	0.70
3.631	0.75
3.981	0.80
4.365	0.85
4.786	0.91
5.248	0.98
5.754	1.05
6.310	1.13
6.918	1.23
7.586	1.33
8.318	1.45
9.120	1.58
10.000	1.72
10.965	

Size (µm)	Volume In %
10.965	1.87
12.023	2.02
13.183	2.19
14.454	2.35
15.849	2.52
17.378	2.68
19.055	2.84
20.893	2.99
22.909	3.13
25.119	3.26
27.542	3.37
30.200	3.46
33.113	3.53
36.308	3.57
39.811	3.58
43.652	3.56
47.863	3.50
52.481	

Size (µm)	Volume In %
52.481	3.41
57.544	3.28
63.096	3.11
69.183	2.91
75.858	2.68
83.176	2.41
91.201	2.14
100.000	1.85
109.648	1.56
120.226	1.29
131.826	1.03
144.544	0.80
158.489	0.61
173.780	0.45
190.546	0.32
208.930	0.23
229.087	0.15
251.189	

Size (µm)	Volume In %
251.189	0.10
275.423	0.06
301.995	0.04
331.131	0.01
363.078	0.00
398.107	0.00
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P4

Measured by:
Mel

Measured:
Monday, October 22, 2012 2:10:35 PM

Sample Name:
WSC Bulk Regrind Discharge - Average

Edited by:
Mel

Analysed:
Monday, October 22, 2012 2:10:36 PM

Particle Name:
Silica 1.0

Accessory Name:
Hydro 2000MU (A)

Analysis model:
General purpose

Sensitivity:
Normal

Particle RI:
1.544

Absorption:
1

Size range:
0.100 to 1000.000 um

Obscuration:
11.88 %

Dispersant Name:
Water

Dispersant RI:
1.330

Weighted Residual:
0.426 %

Result Emulation:
Off

Concentration:
0.0121 %Vol

Span :
5.685

Uniformity:
1.73

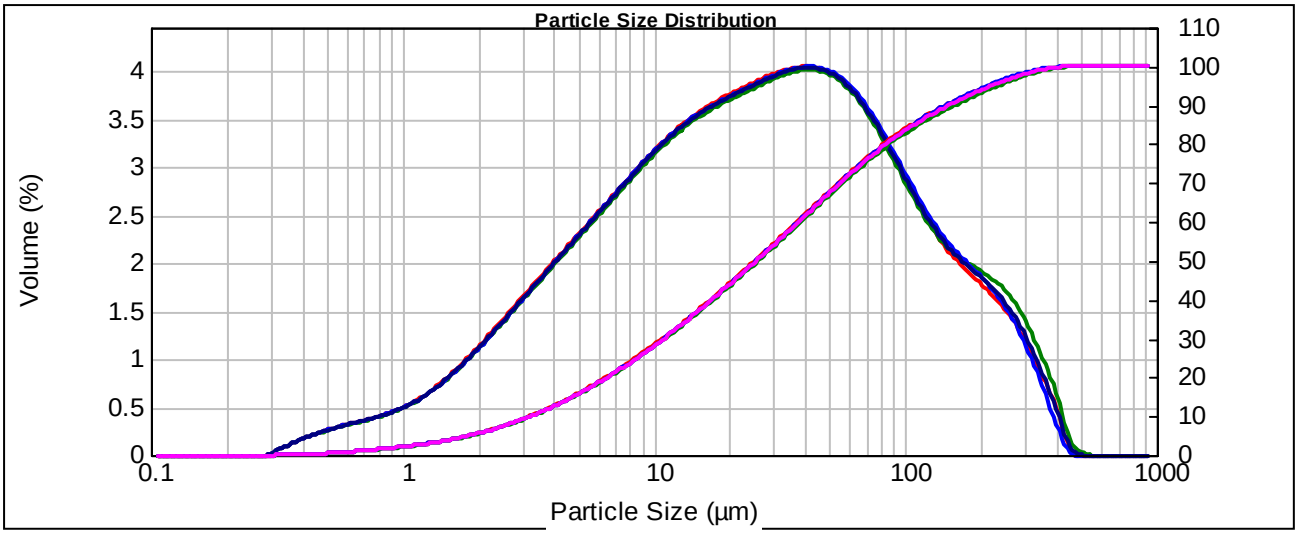
Result units:
Volume

Specific Surface Area:
0.783 m²/g

Surface Weighted Mean D[3,2]:
7.663 um

Vol. Weighted Mean D[4,3]:
54.179 um

d(0.1): 3.217 um d(0.5): 25.550 um **d(0.8): 83.799 um** d(0.9): 148.468 um d(0.98): 295.18 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.03
0.331	0.06
0.363	0.09
0.398	0.12
0.437	0.14
0.479	

Size (µm)	Volume In %
0.479	0.16
0.525	0.18
0.575	0.19
0.631	0.21
0.692	0.22
0.759	0.24
0.832	0.26
0.912	0.28
1.000	0.31
1.096	0.35
1.202	0.39
1.318	0.43
1.445	0.48
1.585	0.54
1.738	0.60
1.905	0.67
2.089	0.74
2.291	

Size (µm)	Volume In %
2.291	0.81
2.512	0.88
2.754	0.95
3.020	1.02
3.311	1.09
3.631	1.17
3.981	1.24
4.365	1.31
4.786	1.38
5.248	1.45
5.754	1.52
6.310	1.59
6.918	1.66
7.586	1.73
8.318	1.80
9.120	1.87
10.000	1.93
10.965	

Size (µm)	Volume In %
10.965	1.99
12.023	2.05
13.183	2.10
14.454	2.14
15.849	2.18
17.378	2.22
19.055	2.25
20.893	2.28
22.909	2.31
25.119	2.34
27.542	2.37
30.200	2.39
33.113	2.41
36.308	2.43
39.811	2.43
43.652	2.42
47.863	2.40
52.481	

Size (µm)	Volume In %
52.481	2.36
57.544	2.31
63.096	2.23
69.183	2.14
75.858	2.04
83.176	1.92
91.201	1.80
100.000	1.68
109.648	1.56
120.226	1.46
131.826	1.37
144.544	1.29
158.489	1.23
173.780	1.17
190.546	1.12
208.930	1.06
229.087	0.99
251.189	

Size (µm)	Volume In %
251.189	0.91
275.423	0.80
301.995	0.67
331.131	0.53
363.078	0.38
398.107	0.19
436.516	0.03
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

TABLE III-77
SCREEN ANALYSIS
KM3512-P4 WSC Bulk Rougher Concentrate

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	8.50	91.5
65 Mesh	212	10.30	81.2
100 Mesh	150	8.20	73.0
150 Mesh	106	8.00	65.0
200 Mesh	75	7.30	57.7
270 Mesh	53	7.00	50.7
400 Mesh	38	6.30	44.4
TOTAL		100.00	**

K80 =202µm

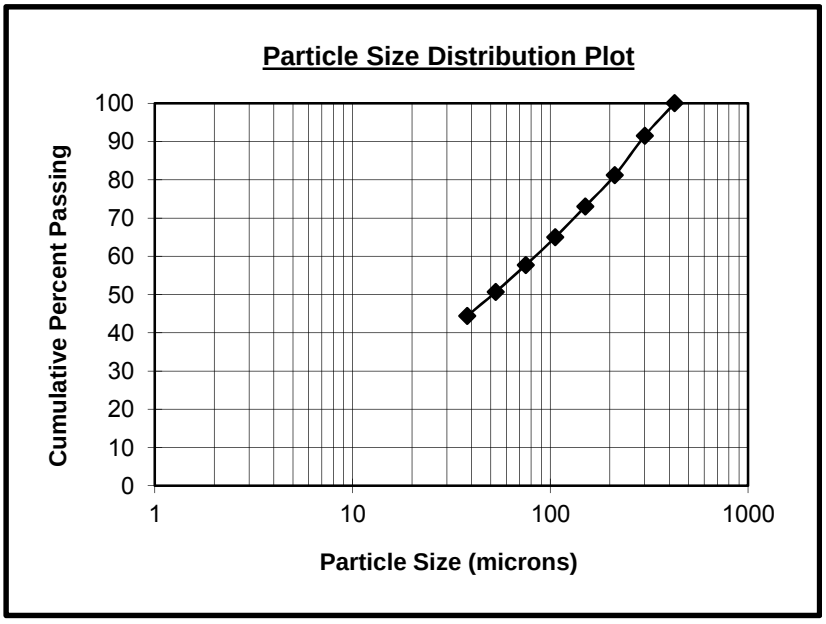
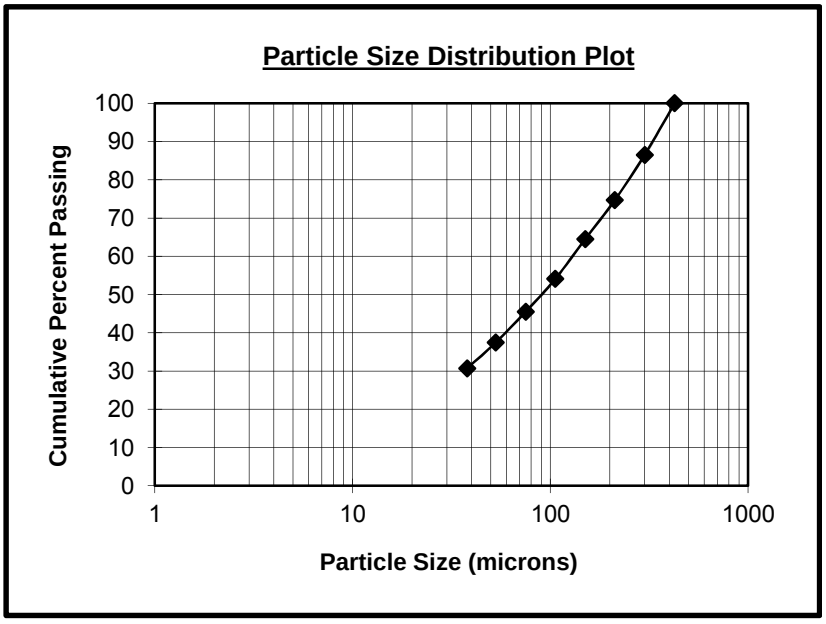


TABLE III-78
SCREEN ANALYSIS
KM3512-P4 WSC Flotation Feed

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	13.50	86.5
65 Mesh	212	11.80	74.7
100 Mesh	150	10.20	64.5
150 Mesh	106	10.40	54.1
200 Mesh	75	8.60	45.5
270 Mesh	53	8.00	37.5
400 Mesh	38	6.80	30.7
TOTAL		100.00	**

K80 =249µm



ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

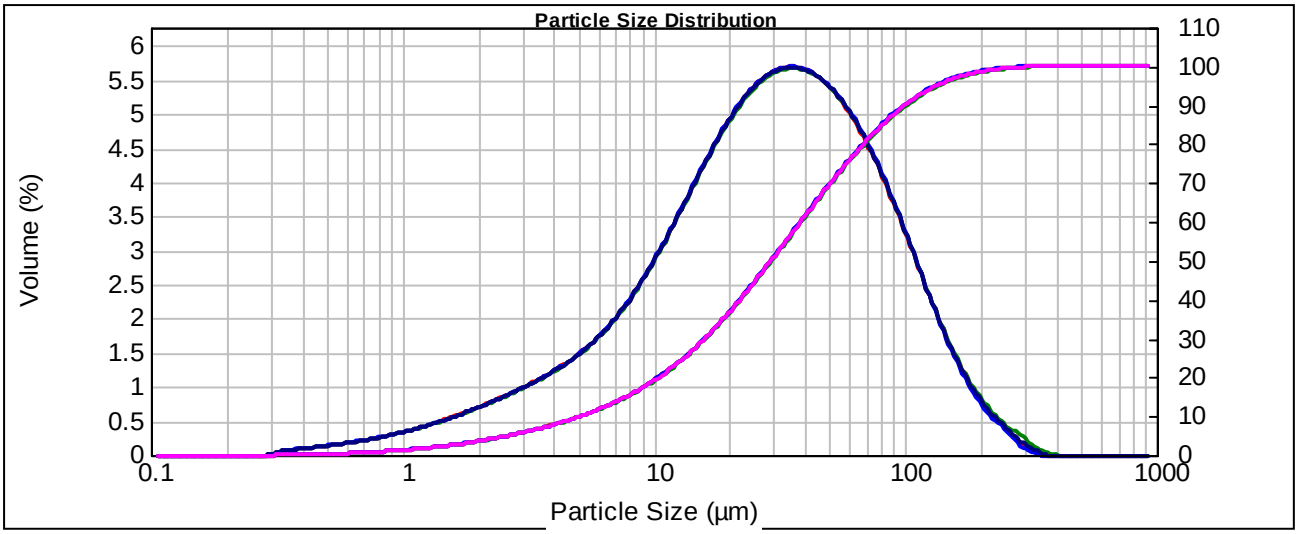
Result Analysis Report

Project and Test number: KM3512-P4
Measured by: Mel
Measured: Monday, October 22, 2012 1:58:17 PM
Sample Name: WSD Bulk Concentrate - Average
Edited by: Mel
Analysed: Monday, October 22, 2012 1:58:18 PM

Particle Name: Silica 1.0
Accessory Name: Hydro 2000MU (A)
Analysis model: General purpose
Sensitivity: Normal
Particle RI: 1.544
Absorption: 1
Size range: 0.100 to 1000.000 um
Obscuration: 16.14 %
Dispersant Name: Water
Dispersant RI: 1.330
Weighted Residual: 0.126 %
Result Emulation: Off

Concentration: 0.0232 %Vol
Span : 3.234
Uniformity: 1.02
Result units: Volume
Specific Surface Area: 0.577 m²/g
Surface Weighted Mean D[3,2]: 10.393 um
Vol. Weighted Mean D[4,3]: 43.273 um

d(0.1): 5.076 um d(0.5): 29.190 um **d(0.8): 68.060 um** d(0.9): 99.463 um d(0.98): 177.38 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.02
0.331	0.05
0.363	0.05
0.398	0.06
0.437	0.07
0.479	

Size (µm)	Volume In %
0.479	0.08
0.525	0.10
0.575	0.11
0.631	0.12
0.692	0.14
0.759	0.15
0.832	0.17
0.912	0.19
1.000	0.21
1.096	0.24
1.202	0.26
1.318	0.29
1.445	0.32
1.585	0.35
1.738	0.38
1.905	0.42
2.089	0.46
2.291	

Size (µm)	Volume In %
2.291	0.49
2.512	0.53
2.754	0.58
3.020	0.62
3.311	0.66
3.631	0.71
3.981	0.77
4.365	0.83
4.786	0.89
5.248	0.96
5.754	1.04
6.310	1.14
6.918	1.24
7.586	1.36
8.318	1.49
9.120	1.64
10.000	1.79
10.965	

Size (µm)	Volume In %
10.965	1.96
12.023	2.13
13.183	2.31
14.454	2.48
15.849	2.65
17.378	2.81
19.055	2.96
20.893	3.09
22.909	3.20
25.119	3.29
27.542	3.36
30.200	3.41
33.113	3.42
36.308	3.42
39.811	3.38
43.652	3.33
47.863	3.25
52.481	

Size (µm)	Volume In %
52.481	3.15
57.544	3.02
63.096	2.87
69.183	2.71
75.858	2.52
83.176	2.31
91.201	2.09
100.000	1.85
109.648	1.61
120.226	1.38
131.826	1.16
144.544	0.95
158.489	0.77
173.780	0.62
190.546	0.48
208.930	0.37
229.087	0.29
251.189	

Size (µm)	Volume In %
251.189	0.20
275.423	0.11
301.995	0.07
331.131	0.01
363.078	0.00
398.107	0.00
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P4

Measured by:
Mel

Measured:
Monday, October 22, 2012 2:14:16 PM

Sample Name:
WSD Bulk Regrind Discharge - Average

Edited by:
Mel

Analysed:
Monday, October 22, 2012 2:14:17 PM

Particle Name:
Silica 1.0

Accessory Name:
Hydro 2000MU (A)

Analysis model:
General purpose

Sensitivity:
Normal

Particle RI:
1.544

Absorption:
1

Size range:
0.100 to 1000.000 um

Obscuration:
13.17 %

Dispersant Name:
Water

Dispersant RI:
1.330

Weighted Residual:
0.164 %

Result Emulation:
Off

Concentration:
0.0146 %Vol

Span :
4.278

Uniformity:
1.46

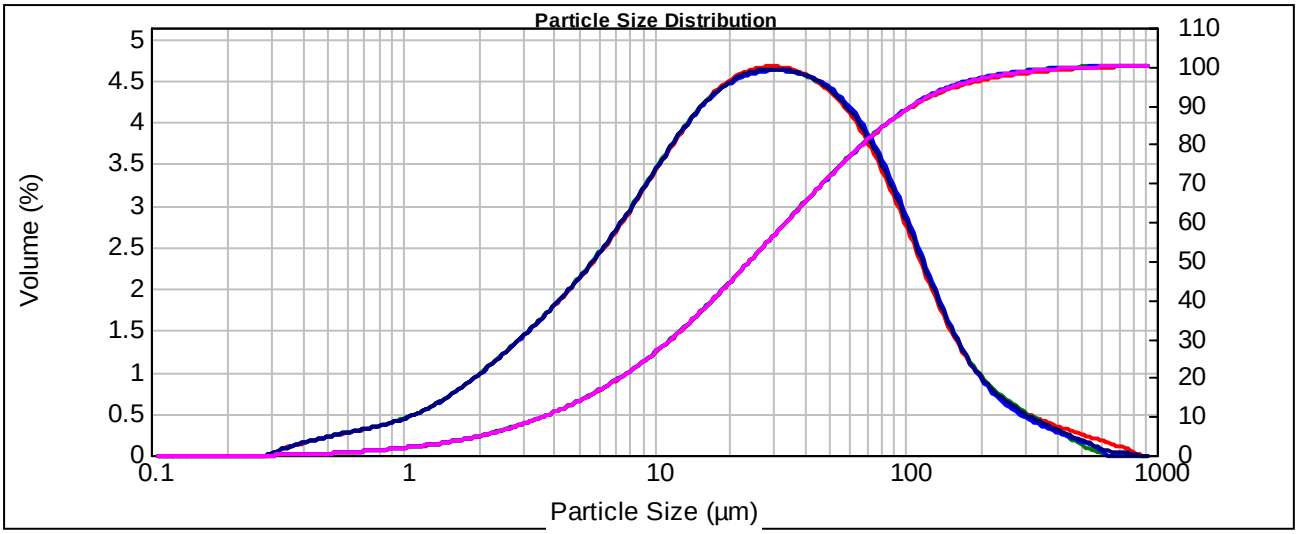
Result units:
Volume

Specific Surface Area:
0.729 m²/g

Surface Weighted Mean D[3,2]:
8.231 um

Vol. Weighted Mean D[4,3]:
45.702 um

d(0.1): 3.652 um d(0.5): 24.157 um **d(0.8): 67.528 um** d(0.9): 106.994 um d(0.98): 250.35 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.03
0.331	0.05
0.363	0.08
0.398	0.10
0.437	0.12
0.479	

Size (µm)	Volume In %
0.479	0.13
0.525	0.15
0.575	0.16
0.631	0.18
0.692	0.19
0.759	0.21
0.832	0.23
0.912	0.25
1.000	0.27
1.096	0.30
1.202	0.34
1.318	0.38
1.445	0.42
1.585	0.47
1.738	0.52
1.905	0.58
2.089	0.64
2.291	

Size (µm)	Volume In %
2.291	0.70
2.512	0.76
2.754	0.83
3.020	0.89
3.311	0.97
3.631	1.04
3.981	1.11
4.365	1.19
4.786	1.27
5.248	1.36
5.754	1.45
6.310	1.55
6.918	1.65
7.586	1.76
8.318	1.87
9.120	1.99
10.000	2.10
10.965	

Size (µm)	Volume In %
10.965	2.21
12.023	2.32
13.183	2.42
14.454	2.50
15.849	2.58
17.378	2.65
19.055	2.70
20.893	2.74
22.909	2.77
25.119	2.78
27.542	2.79
30.200	2.79
33.113	2.78
36.308	2.76
39.811	2.73
43.652	2.70
47.863	2.64
52.481	

Size (µm)	Volume In %
52.481	2.58
57.544	2.49
63.096	2.39
69.183	2.27
75.858	2.13
83.176	1.97
91.201	1.80
100.000	1.62
109.648	1.43
120.226	1.25
131.826	1.08
144.544	0.92
158.489	0.78
173.780	0.66
190.546	0.56
208.930	0.48
229.087	0.42
251.189	

Size (µm)	Volume In %
251.189	0.36
275.423	0.31
301.995	0.27
331.131	0.24
363.078	0.20
398.107	0.17
436.516	0.14
478.630	0.11
524.807	0.08
575.440	0.04
630.957	0.03
691.831	0.02
758.578	0.01
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

TABLE III-81
SCREEN ANALYSIS
KM3512-P4 WSD Bulk Rougher Concentrate

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	12.80	87.2
65 Mesh	212	12.20	75.0
100 Mesh	150	11.40	63.6
150 Mesh	106	9.80	53.8
200 Mesh	75	8.50	45.3
270 Mesh	53	6.40	38.9
400 Mesh	38	4.50	34.4
TOTAL		100.00	**

K80 =246µm

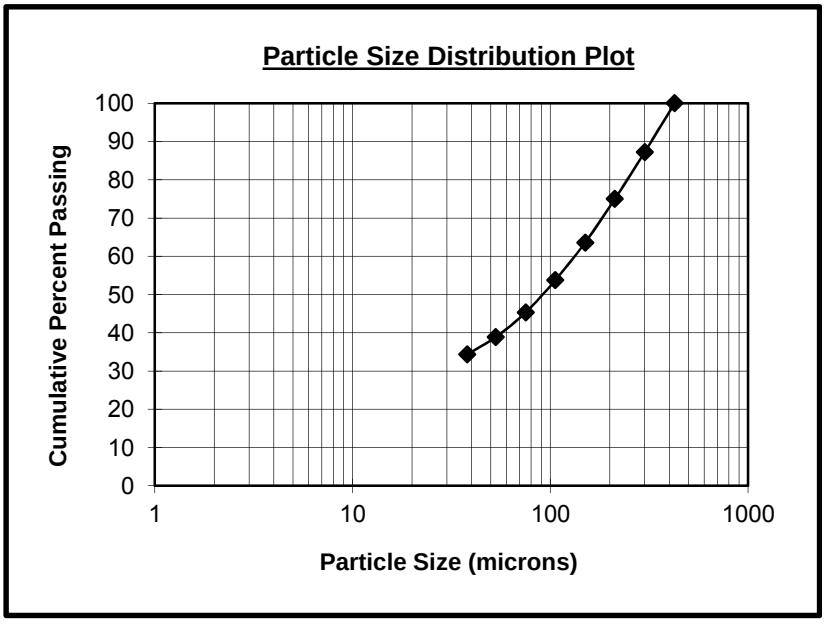
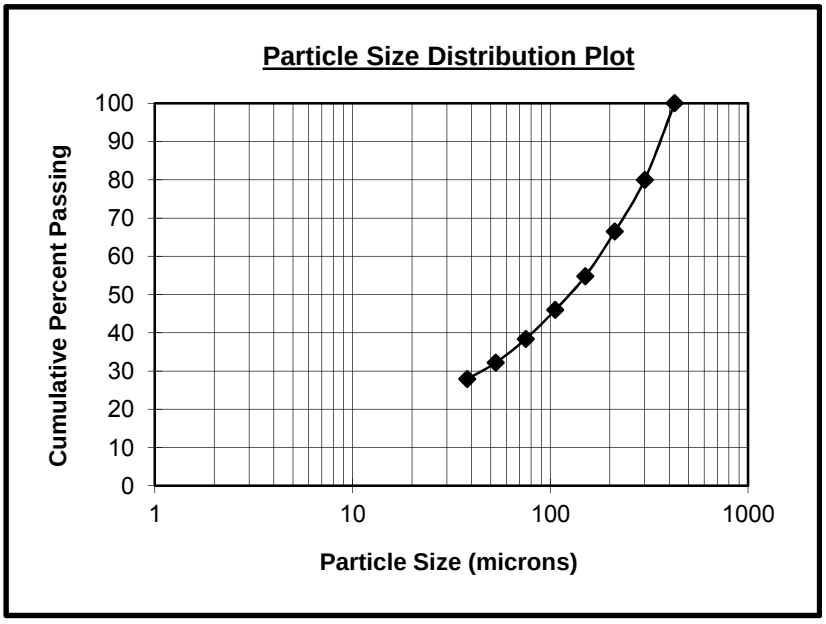


TABLE III-82
SCREEN ANALYSIS
KM3512-P4 WSD Flotation Feed

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	20.00	80.0
65 Mesh	212	13.50	66.5
100 Mesh	150	11.70	54.8
150 Mesh	106	8.80	46.0
200 Mesh	75	7.60	38.4
270 Mesh	53	6.20	32.2
400 Mesh	38	4.30	27.9
TOTAL		100.00	**

K80 =300µm



ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P5

Sample Name:
WSA Bulk Concentrate

Measured by:
Dean

Edited by:

Measured:
Tuesday, October 23, 2012 9:23:02 AM

Analysed:
Tuesday, October 23, 2012 9:23:04 AM

Particle Name: Silica 1.0
Particle RI: 1.544
Dispersant Name: Water

Accessory Name: Hydro 2000MU (A)
Absorption: 1
Dispersant RI: 1.330

Analysis model: General purpose
Size range: 0.100 to 1000.000 um
Weighted Residual: 0.565 %

Sensitivity: Normal
Obscuration: 13.27 %
Result Emulation: Off

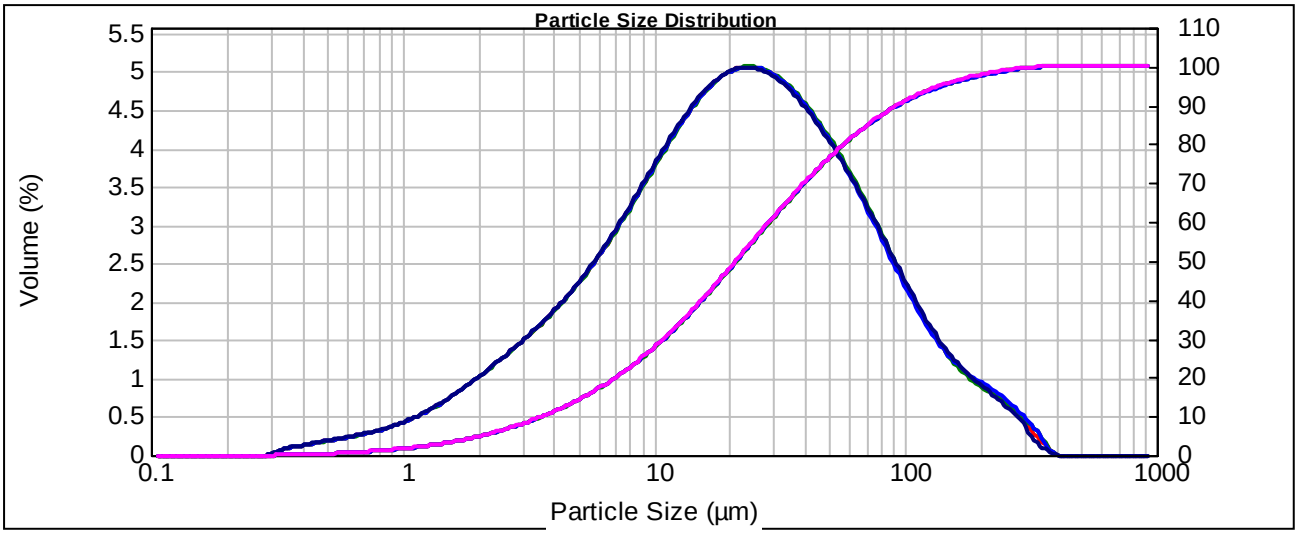
Concentration: 0.0145 %Vol
Specific Surface Area: 0.744 m²/g

Span : 4.187
Surface Weighted Mean D[3,2]: 8.062 um

Uniformity: 1.35
Vol. Weighted Mean D[4,3]: 38.033 um

Result units: Volume

d(0.1): 3.582 um d(0.5): 21.173 um **d(0.8): 56.868 um** d(0.9): 92.241 um d(0.98): 200.59 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.03
0.331	0.06
0.363	0.07
0.398	0.08
0.437	0.10
0.479	

Size (µm)	Volume In %
0.479	0.11
0.525	0.13
0.575	0.14
0.631	0.16
0.692	0.17
0.759	0.19
0.832	0.22
0.912	0.24
1.000	0.27
1.096	0.31
1.202	0.35
1.318	0.39
1.445	0.44
1.585	0.50
1.738	0.55
1.905	0.61
2.089	0.67
2.291	

Size (µm)	Volume In %
2.291	0.74
2.512	0.80
2.754	0.87
3.020	0.94
3.311	1.01
3.631	1.09
3.981	1.17
4.365	1.26
4.786	1.35
5.248	1.46
5.754	1.57
6.310	1.68
6.918	1.81
7.586	1.94
8.318	2.07
9.120	2.21
10.000	2.34
10.965	

Size (µm)	Volume In %
10.965	2.47
12.023	2.60
13.183	2.71
14.454	2.81
15.849	2.90
17.378	2.96
19.055	3.01
20.893	3.04
22.909	3.04
25.119	3.03
27.542	2.99
30.200	2.94
33.113	2.87
36.308	2.78
39.811	2.68
43.652	2.58
47.863	2.46
52.481	

Size (µm)	Volume In %
52.481	2.33
57.544	2.20
63.096	2.06
69.183	1.91
75.858	1.76
83.176	1.60
91.201	1.44
100.000	1.29
109.648	1.14
120.226	1.01
131.826	0.89
144.544	0.78
158.489	0.69
173.780	0.62
190.546	0.55
208.930	0.49
229.087	0.42
251.189	

Size (µm)	Volume In %
251.189	0.35
275.423	0.28
301.995	0.15
331.131	0.07
363.078	0.02
398.107	0.00
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P5

Measured by:
Dean

Measured:
Tuesday, October 23, 2012 9:17:45 AM

Sample Name:
WSA Bulk Regrind Discharge - Average

Edited by:
Dean

Analysed:
Tuesday, October 23, 2012 9:17:46 AM

Particle Name: Silica 1.0
Accessory Name: Hydro 2000MU (A)
Analysis model: General purpose
Sensitivity: Normal

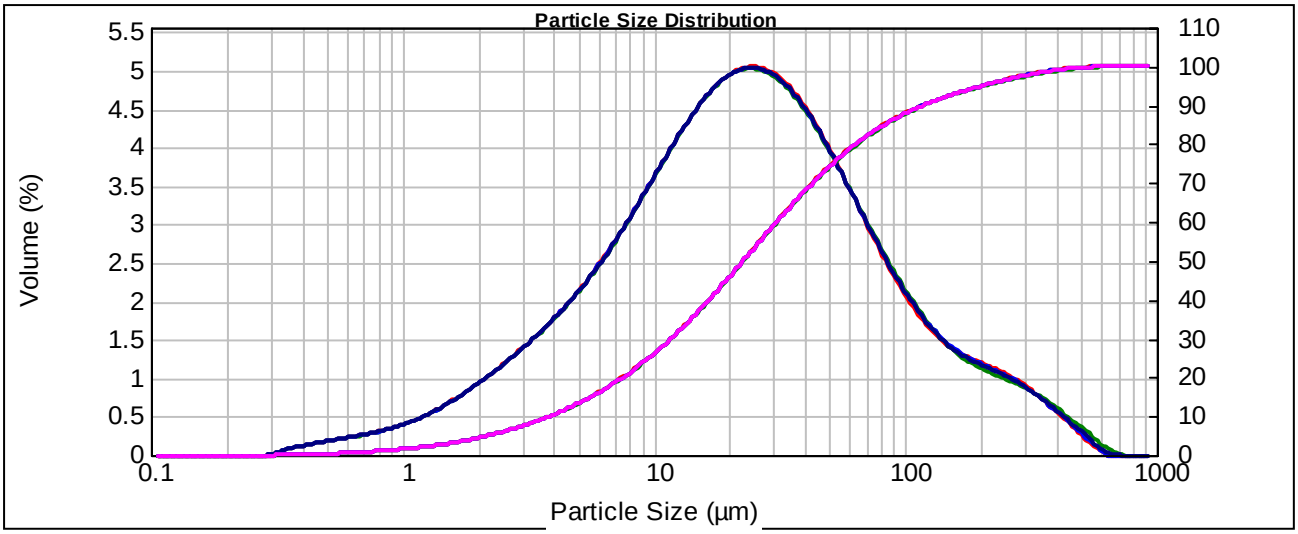
Particle RI: 1.544
Absorption: 1
Size range: 0.100 to 1000.000 um
Obscuration: 17.52 %

Dispersant Name: Water
Dispersant RI: 1.330
Weighted Residual: 0.067 %
Result Emulation: Off

Concentration: 0.0208 %Vol
Span : 5.011
Uniformity: 1.69
Result units: Volume

Specific Surface Area: 0.702 m²/g
Surface Weighted Mean D[3,2]: 8.545 um
Vol. Weighted Mean D[4,3]: 48.475 um

d(0.1): 3.834 um d(0.5): 22.672 um **d(0.8): 63.547 um** d(0.9): 117.452 um d(0.98): 316.61 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.02
0.331	0.05
0.363	0.06
0.398	0.08
0.437	0.10
0.479	

Size (µm)	Volume In %
0.479	0.11
0.525	0.12
0.575	0.14
0.631	0.15
0.692	0.17
0.759	0.18
0.832	0.20
0.912	0.22
1.000	0.25
1.096	0.28
1.202	0.32
1.318	0.36
1.445	0.40
1.585	0.45
1.738	0.51
1.905	0.56
2.089	0.62
2.291	

Size (µm)	Volume In %
2.291	0.68
2.512	0.74
2.754	0.81
3.020	0.88
3.311	0.95
3.631	1.02
3.981	1.10
4.365	1.19
4.786	1.28
5.248	1.38
5.754	1.48
6.310	1.60
6.918	1.71
7.586	1.84
8.318	1.97
9.120	2.11
10.000	2.24
10.965	

Size (µm)	Volume In %
10.965	2.38
12.023	2.51
13.183	2.63
14.454	2.74
15.849	2.84
17.378	2.92
19.055	2.98
20.893	3.02
22.909	3.03
25.119	3.03
27.542	3.00
30.200	2.94
33.113	2.87
36.308	2.77
39.811	2.65
43.652	2.53
47.863	2.38
52.481	

Size (µm)	Volume In %
52.481	2.23
57.544	2.08
63.096	1.92
69.183	1.77
75.858	1.62
83.176	1.47
91.201	1.34
100.000	1.21
109.648	1.10
120.226	1.00
131.826	0.92
144.544	0.85
158.489	0.79
173.780	0.74
190.546	0.71
208.930	0.67
229.087	0.64
251.189	

Size (µm)	Volume In %
251.189	0.60
275.423	0.56
301.995	0.50
331.131	0.45
363.078	0.38
398.107	0.32
436.516	0.25
478.630	0.19
524.807	0.12
575.440	0.04
630.957	0.01
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

TABLE III-85
SCREEN ANALYSIS
KM3512-P5 WSA Bulk Rougher Concentrate

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	7.70	92.3
65 Mesh	212	10.00	82.3
100 Mesh	150	9.47	72.8
150 Mesh	106	8.50	64.3
200 Mesh	75	8.40	55.9
270 Mesh	53	7.90	48.0
400 Mesh	38	5.50	42.5
TOTAL		100.00	**

K80 =196µm

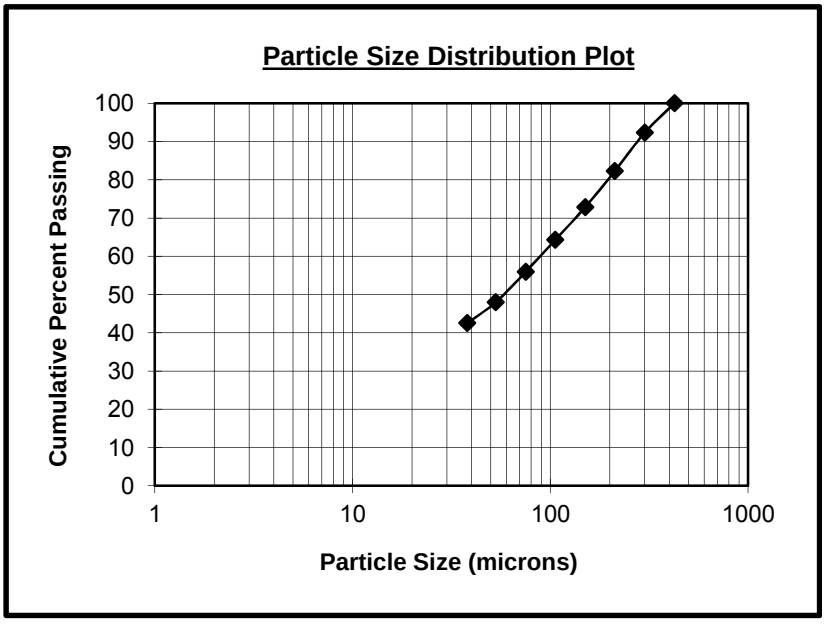
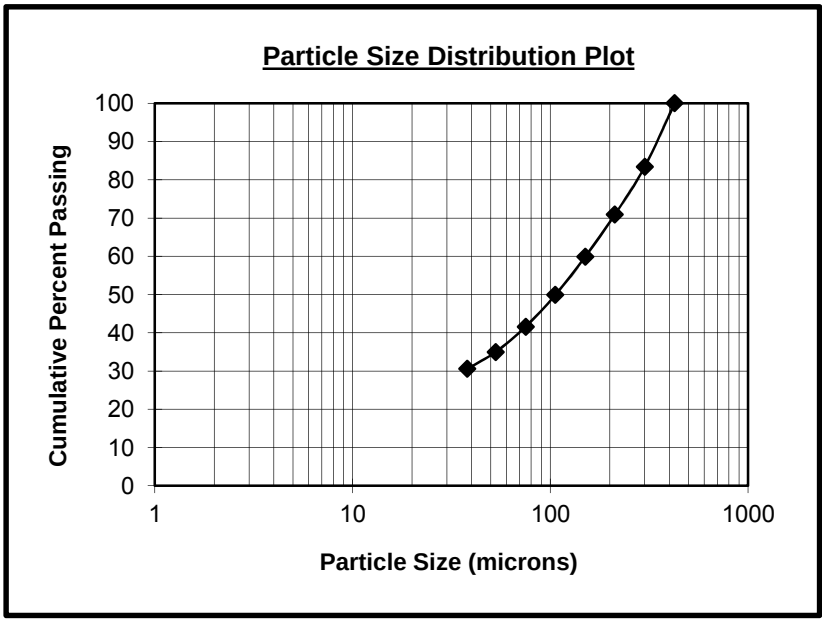


TABLE III-86
SCREEN ANALYSIS
KM3512-P5 WSA Flotation Feed

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	16.60	83.4
65 Mesh	212	12.50	70.9
100 Mesh	150	11.00	59.9
150 Mesh	106	10.00	49.9
200 Mesh	75	8.30	41.6
270 Mesh	53	6.60	35.0
400 Mesh	38	4.40	30.6
TOTAL		100.00	**

K80 =274µm



ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P5

Measured by:
Dean

Measured:
Tuesday, October 23, 2012 9:48:43 AM

Sample Name:
WSB Bulk Concentrate - Average

Edited by:
Dean

Analysed:
Tuesday, October 23, 2012 9:48:44 AM

Particle Name:
Silica 1.0

Accessory Name:
Hydro 2000MU (A)

Analysis model:
General purpose

Sensitivity:
Normal

Particle RI:
1.544

Absorption:
1

Size range:
0.100 to 1000.000 um

Obscuration:
14.06 %

Dispersant Name:
Water

Dispersant RI:
1.330

Weighted Residual:
0.145 %

Result Emulation:
Off

Concentration:
0.0179 %Vol

Span :
2.912

Uniformity:
0.92

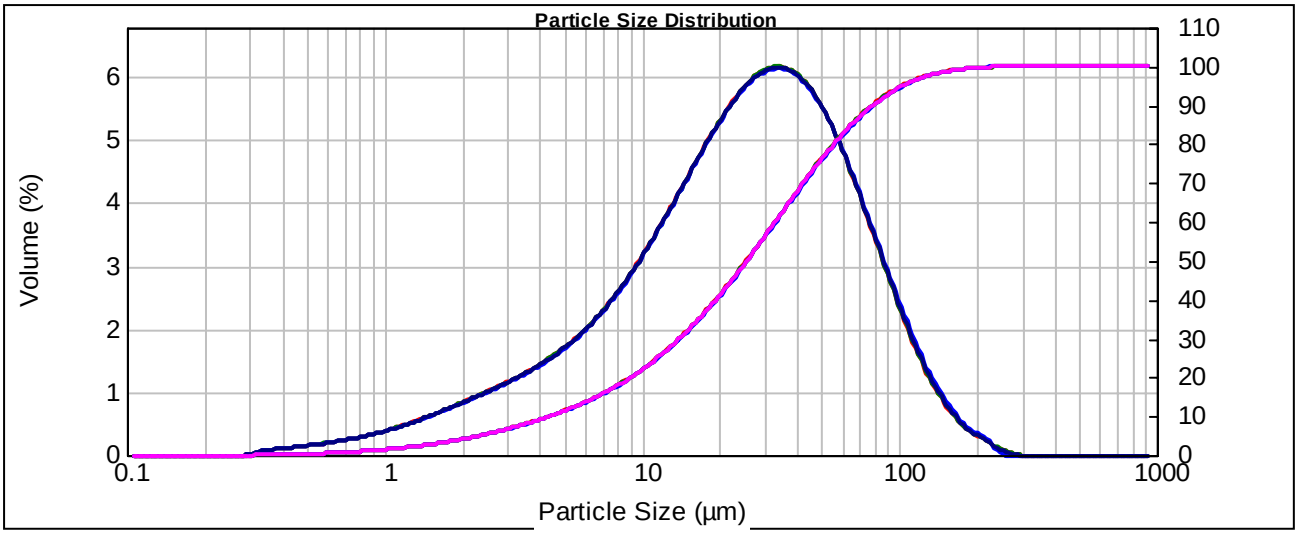
Result units:
Volume

Specific Surface Area:
0.644 m²/g

Surface Weighted Mean D[3,2]:
9.323 um

Vol. Weighted Mean D[4,3]:
35.383 um

d(0.1): 4.369 um d(0.5): 25.542 um **d(0.8): 55.582 um** d(0.9): 78.754 um d(0.98): 135.07 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.03
0.331	0.05
0.363	0.06
0.398	0.07
0.437	0.08
0.479	

Size (µm)	Volume In %
0.479	0.09
0.525	0.10
0.575	0.12
0.631	0.13
0.692	0.15
0.759	0.17
0.832	0.19
0.912	0.21
1.000	0.24
1.096	0.27
1.202	0.31
1.318	0.34
1.445	0.38
1.585	0.42
1.738	0.46
1.905	0.50
2.089	0.54
2.291	

Size (µm)	Volume In %
2.291	0.58
2.512	0.63
2.754	0.67
3.020	0.72
3.311	0.77
3.631	0.83
3.981	0.89
4.365	0.95
4.786	1.02
5.248	1.10
5.754	1.20
6.310	1.30
6.918	1.41
7.586	1.53
8.318	1.67
9.120	1.81
10.000	1.97
10.965	

Size (µm)	Volume In %
10.965	2.14
12.023	2.31
13.183	2.49
14.454	2.66
15.849	2.84
17.378	3.01
19.055	3.18
20.893	3.33
22.909	3.46
25.119	3.57
27.542	3.65
30.200	3.69
33.113	3.70
36.308	3.67
39.811	3.59
43.652	3.48
47.863	3.32
52.481	

Size (µm)	Volume In %
52.481	3.13
57.544	2.91
63.096	2.66
69.183	2.39
75.858	2.12
83.176	1.83
91.201	1.56
100.000	1.30
109.648	1.06
120.226	0.84
131.826	0.65
144.544	0.49
158.489	0.36
173.780	0.26
190.546	0.19
208.930	0.15
229.087	0.06
251.189	

Size (µm)	Volume In %
251.189	0.03
275.423	0.00
301.995	0.00
331.131	0.00
363.078	0.00
398.107	0.00
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P5

Measured by:
Dean

Measured:
Tuesday, October 23, 2012 9:28:36 AM

Sample Name:
WSB Bulk Regrind Discharge - Average

Edited by:
Dean

Analysed:
Tuesday, October 23, 2012 9:28:37 AM

Particle Name:
Silica 1.0

Accessory Name:
Hydro 2000MU (A)

Analysis model:
General purpose

Sensitivity:
Normal

Particle RI:
1.544

Absorption:
1

Size range:
0.100 to 1000.000 um

Obscuration:
14.30 %

Dispersant Name:
Water

Dispersant RI:
1.330

Weighted Residual:
0.059 %

Result Emulation:
Off

Concentration:
0.0194 %Vol

Span :
3.513

Uniformity:
1.15

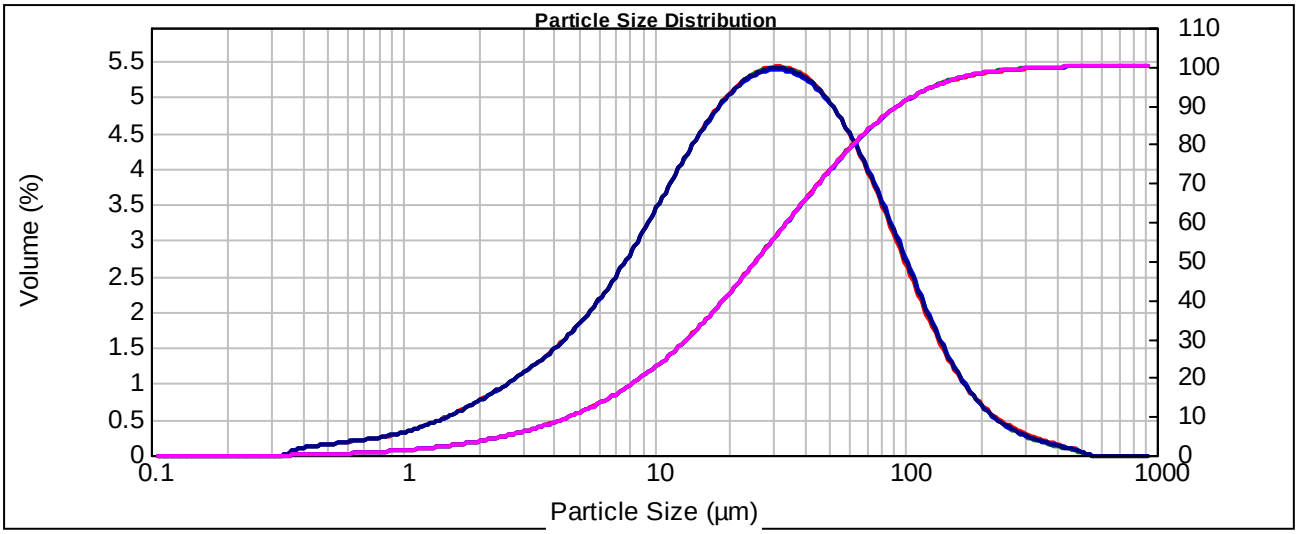
Result units:
Volume

Specific Surface Area:
0.607 m²/g

Surface Weighted Mean D[3,2]:
9.890 um

Vol. Weighted Mean D[4,3]:
41.209 um

d(0.1): 4.638 um d(0.5): 25.503 um **d(0.8): 62.337 um** d(0.9): 94.223 um d(0.98): 189.49 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.01
0.363	0.05
0.398	0.07
0.437	0.08
0.479	

Size (µm)	Volume In %
0.479	0.09
0.525	0.10
0.575	0.11
0.631	0.12
0.692	0.13
0.759	0.15
0.832	0.16
0.912	0.18
1.000	0.20
1.096	0.23
1.202	0.26
1.318	0.29
1.445	0.32
1.585	0.36
1.738	0.41
1.905	0.45
2.089	0.50
2.291	

Size (µm)	Volume In %
2.291	0.55
2.512	0.60
2.754	0.66
3.020	0.72
3.311	0.78
3.631	0.85
3.981	0.92
4.365	1.01
4.786	1.09
5.248	1.19
5.754	1.30
6.310	1.42
6.918	1.54
7.586	1.67
8.318	1.82
9.120	1.96
10.000	2.12
10.965	

Size (µm)	Volume In %
10.965	2.27
12.023	2.41
13.183	2.56
14.454	2.70
15.849	2.82
17.378	2.93
19.055	3.03
20.893	3.11
22.909	3.18
25.119	3.22
27.542	3.25
30.200	3.25
33.113	3.24
36.308	3.20
39.811	3.14
43.652	3.07
47.863	2.96
52.481	

Size (µm)	Volume In %
52.481	2.84
57.544	2.70
63.096	2.53
69.183	2.36
75.858	2.16
83.176	1.96
91.201	1.75
100.000	1.54
109.648	1.33
120.226	1.14
131.826	0.95
144.544	0.79
158.489	0.65
173.780	0.53
190.546	0.43
208.930	0.34
229.087	0.28
251.189	

Size (µm)	Volume In %
251.189	0.23
275.423	0.18
301.995	0.15
331.131	0.12
363.078	0.10
398.107	0.07
436.516	0.05
478.630	0.03
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

TABLE III-89
SCREEN ANALYSIS
KM3512-P5 WSB Bulk Rougher Concetrate

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	6.80	93.2
65 Mesh	212	9.50	83.7
100 Mesh	150	8.50	75.2
150 Mesh	106	9.40	65.8
200 Mesh	75	8.80	57.0
270 Mesh	53	8.40	48.6
400 Mesh	38	7.00	41.6
TOTAL		100.00	**

K80 =183µm

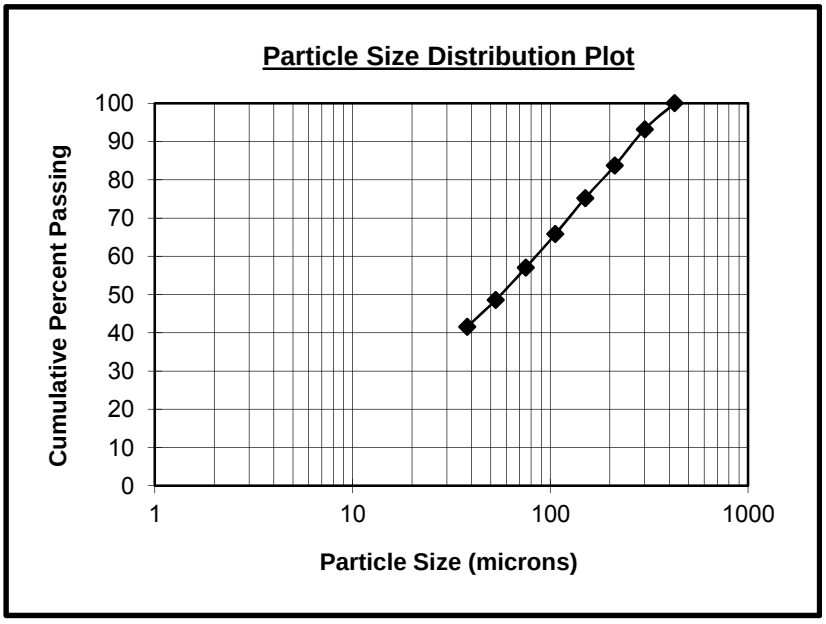
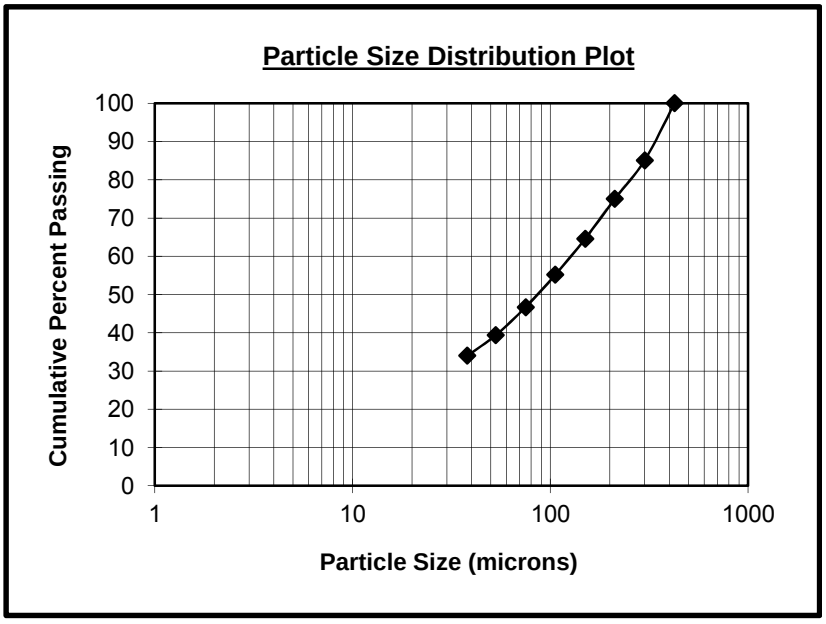


TABLE III-90
SCREEN ANALYSIS
KM3512-P5 WSB Flotation Feed

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	14.90	85.1
65 Mesh	212	10.10	75.0
100 Mesh	150	10.40	64.6
150 Mesh	106	9.40	55.2
200 Mesh	75	8.50	46.7
270 Mesh	53	7.30	39.4
400 Mesh	38	5.40	34.0
TOTAL		100.00	**

K80 =253µm



ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P5

Measured by:
Dean

Measured:
Tuesday, October 23, 2012 9:53:07 AM

Sample Name:
WSC Bulk Concentrate - Average

Edited by:
Dean

Analysed:
Tuesday, October 23, 2012 9:53:08 AM

Particle Name:
Silica 1.0

Accessory Name:
Hydro 2000MU (A)

Analysis model:
General purpose

Sensitivity:
Normal

Particle RI:
1.544

Absorption:
1

Size range:
0.100 to 1000.000 um

Obscuration:
15.84 %

Dispersant Name:
Water

Dispersant RI:
1.330

Weighted Residual:
0.240 %

Result Emulation:
Off

Concentration:
0.0201 %Vol

Span :
3.088

Uniformity:
1.02

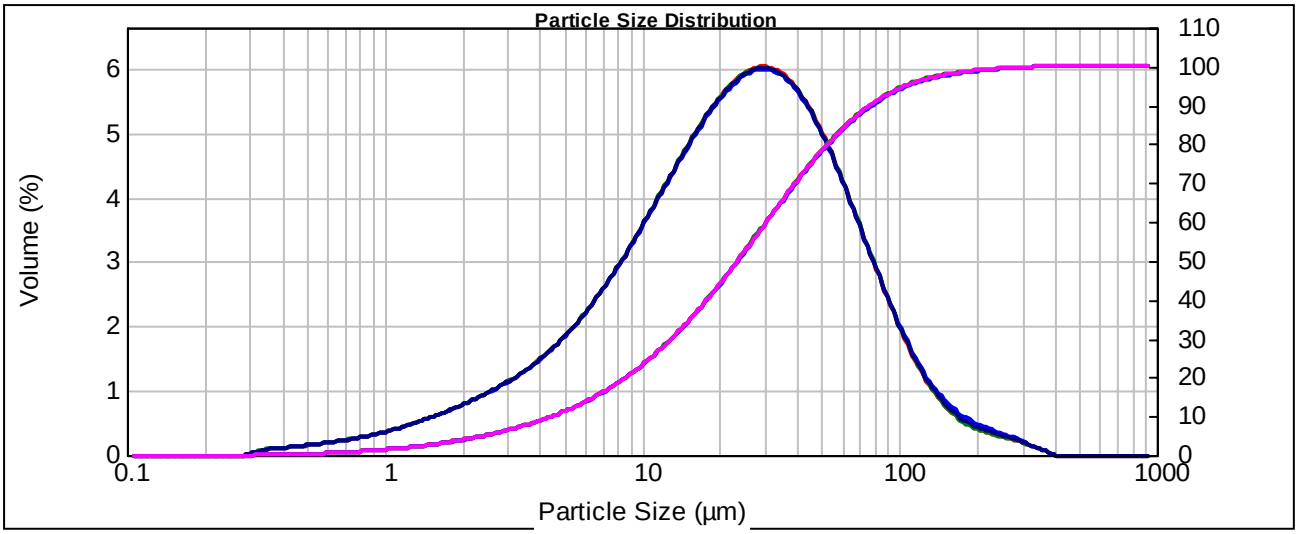
Result units:
Volume

Specific Surface Area:
0.652 m²/g

Surface Weighted Mean D[3,2]:
9.197 um

Vol. Weighted Mean D[4,3]:
35.208 um

d(0.1): 4.457 um d(0.5): 23.532 um **d(0.8): 52.582 um** d(0.9): 77.133 um d(0.98): 154.45 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.03
0.331	0.06
0.363	0.06
0.398	0.07
0.437	0.08
0.479	

Size (µm)	Volume In %
0.479	0.09
0.525	0.10
0.575	0.12
0.631	0.13
0.692	0.15
0.759	0.16
0.832	0.18
0.912	0.20
1.000	0.23
1.096	0.26
1.202	0.29
1.318	0.32
1.445	0.35
1.585	0.39
1.738	0.43
1.905	0.47
2.089	0.51
2.291	

Size (µm)	Volume In %
2.291	0.56
2.512	0.61
2.754	0.66
3.020	0.72
3.311	0.78
3.631	0.85
3.981	0.93
4.365	1.01
4.786	1.11
5.248	1.21
5.754	1.33
6.310	1.45
6.918	1.59
7.586	1.74
8.318	1.89
9.120	2.05
10.000	2.22
10.965	

Size (µm)	Volume In %
10.965	2.39
12.023	2.56
13.183	2.73
14.454	2.90
15.849	3.05
17.378	3.20
19.055	3.33
20.893	3.44
22.909	3.53
25.119	3.59
27.542	3.62
30.200	3.61
33.113	3.57
36.308	3.48
39.811	3.36
43.652	3.20
47.863	3.01
52.481	

Size (µm)	Volume In %
52.481	2.79
57.544	2.56
63.096	2.31
69.183	2.06
75.858	1.80
83.176	1.55
91.201	1.32
100.000	1.10
109.648	0.90
120.226	0.73
131.826	0.59
144.544	0.47
158.489	0.38
173.780	0.31
190.546	0.26
208.930	0.23
229.087	0.20
251.189	

Size (µm)	Volume In %
251.189	0.17
275.423	0.14
301.995	0.10
331.131	0.07
363.078	0.02
398.107	0.00
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P5

Measured by:
Dean

Measured:
Tuesday, October 23, 2012 9:35:47 AM

Sample Name:
WSC Bulk Regrind Discharge - Average

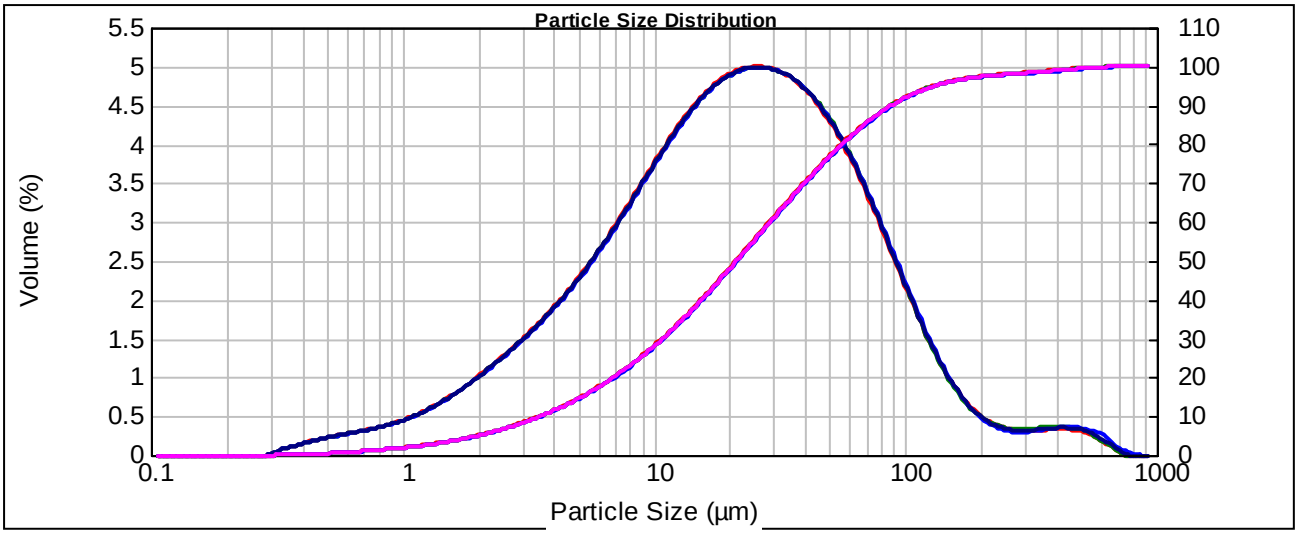
Edited by:
Dean

Analysed:
Tuesday, October 23, 2012 9:35:48 AM

Particle Name: Silica 1.0
Accessory Name: Hydro 2000MU (A)
Analysis model: General purpose
Sensitivity: Normal
Particle RI: 1.544
Absorption: 1
Size range: 0.100 to 1000.000 um
Obscuration: 14.18 %
Dispersant Name: Water
Dispersant RI: 1.330
Weighted Residual: 0.317 %
Result Emulation: Off

Concentration: 0.0151 %Vol
Span : 3.973
Uniformity: 1.49
Result units: Volume
Specific Surface Area: 0.766 m²/g
Surface Weighted Mean D[3,2]: 7.835 um
Vol. Weighted Mean D[4,3]: 41.134 um

d(0.1): 3.518 um d(0.5): 21.316 um **d(0.8): 56.077 um** d(0.9): 88.211 um d(0.98): 252.94 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.03
0.331	0.06
0.363	0.08
0.398	0.10
0.437	0.12
0.479	

Size (µm)	Volume In %
0.479	0.14
0.525	0.15
0.575	0.17
0.631	0.18
0.692	0.20
0.759	0.21
0.832	0.23
0.912	0.26
1.000	0.28
1.096	0.31
1.202	0.35
1.318	0.39
1.445	0.44
1.585	0.49
1.738	0.55
1.905	0.60
2.089	0.67
2.291	

Size (µm)	Volume In %
2.291	0.73
2.512	0.79
2.754	0.86
3.020	0.94
3.311	1.01
3.631	1.09
3.981	1.18
4.365	1.27
4.786	1.37
5.248	1.47
5.754	1.58
6.310	1.69
6.918	1.81
7.586	1.94
8.318	2.06
9.120	2.19
10.000	2.31
10.965	

Size (µm)	Volume In %
10.965	2.43
12.023	2.55
13.183	2.65
14.454	2.75
15.849	2.83
17.378	2.89
19.055	2.94
20.893	2.98
22.909	3.00
25.119	3.01
27.542	3.00
30.200	2.97
33.113	2.93
36.308	2.87
39.811	2.80
43.652	2.71
47.863	2.59
52.481	

Size (µm)	Volume In %
52.481	2.47
57.544	2.32
63.096	2.16
69.183	1.99
75.858	1.80
83.176	1.61
91.201	1.42
100.000	1.23
109.648	1.04
120.226	0.87
131.826	0.71
144.544	0.57
158.489	0.46
173.780	0.37
190.546	0.30
208.930	0.25
229.087	0.21
251.189	

Size (µm)	Volume In %
251.189	0.20
275.423	0.19
301.995	0.19
331.131	0.20
363.078	0.21
398.107	0.21
436.516	0.21
478.630	0.20
524.807	0.17
575.440	0.12
630.957	0.09
691.831	0.02
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

TABLE III-93
SCREEN ANALYSIS
KM3512-P5 WSC Bulk Rougher Concentrate

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	4.70	95.3
65 Mesh	212	8.50	86.8
100 Mesh	150	9.30	77.5
150 Mesh	106	8.90	68.6
200 Mesh	75	9.60	59.0
270 Mesh	53	9.60	49.4
400 Mesh	38	7.00	42.4
TOTAL		100.00	**

K80 =165µm

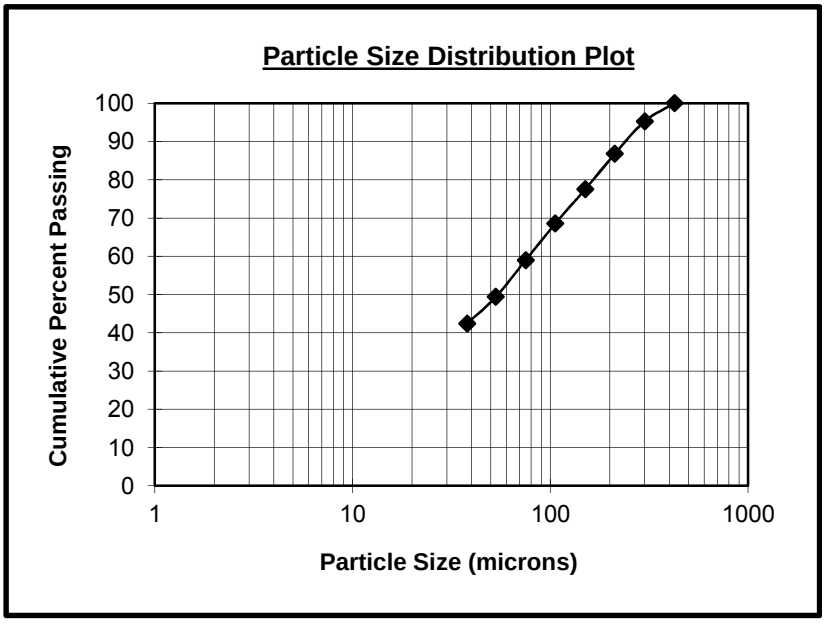
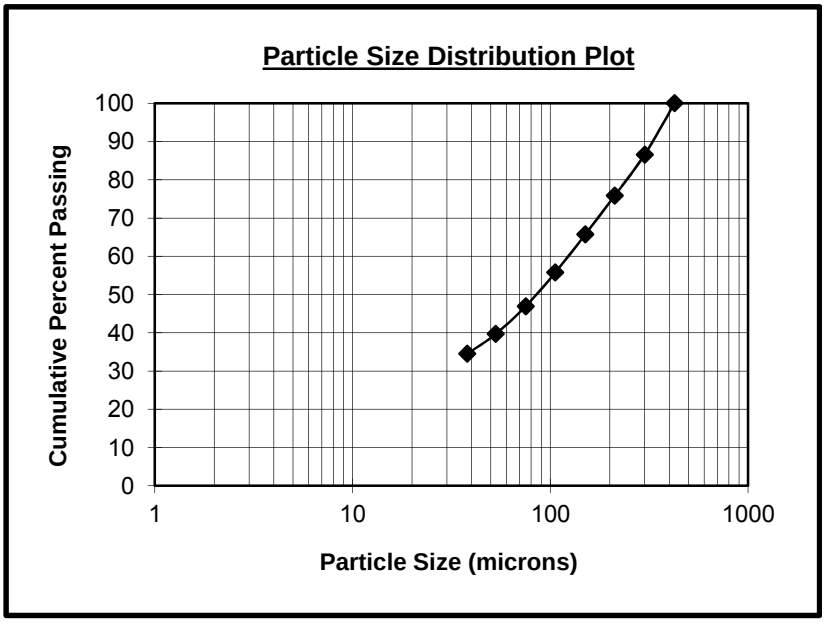


TABLE III-94
SCREEN ANALYSIS
KM3512-P5 WSC Flotation Feed

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	13.40	86.6
65 Mesh	212	10.70	75.9
100 Mesh	150	10.20	65.7
150 Mesh	106	9.90	55.8
200 Mesh	75	8.90	46.9
270 Mesh	53	7.20	39.7
400 Mesh	38	5.20	34.5
TOTAL		100.00	**

K80 =243µm



ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P5

Measured by:
Dean

Measured:
Tuesday, October 23, 2012 9:45:21 AM

Sample Name:
WSD Bulk Concentrate - Average

Edited by:
Dean

Analysed:
Tuesday, October 23, 2012 9:45:23 AM

Particle Name:
Silica 1.0

Accessory Name:
Hydro 2000MU (A)

Analysis model:
General purpose

Sensitivity:
Normal

Particle RI:
1.544

Absorption:
1

Size range:
0.100 to 1000.000 um

Obscuration:
12.05 %

Dispersant Name:
Water

Dispersant RI:
1.330

Weighted Residual:
0.090 %

Result Emulation:
Off

Concentration:
0.0135 %Vol

Span :
3.298

Uniformity:
1.06

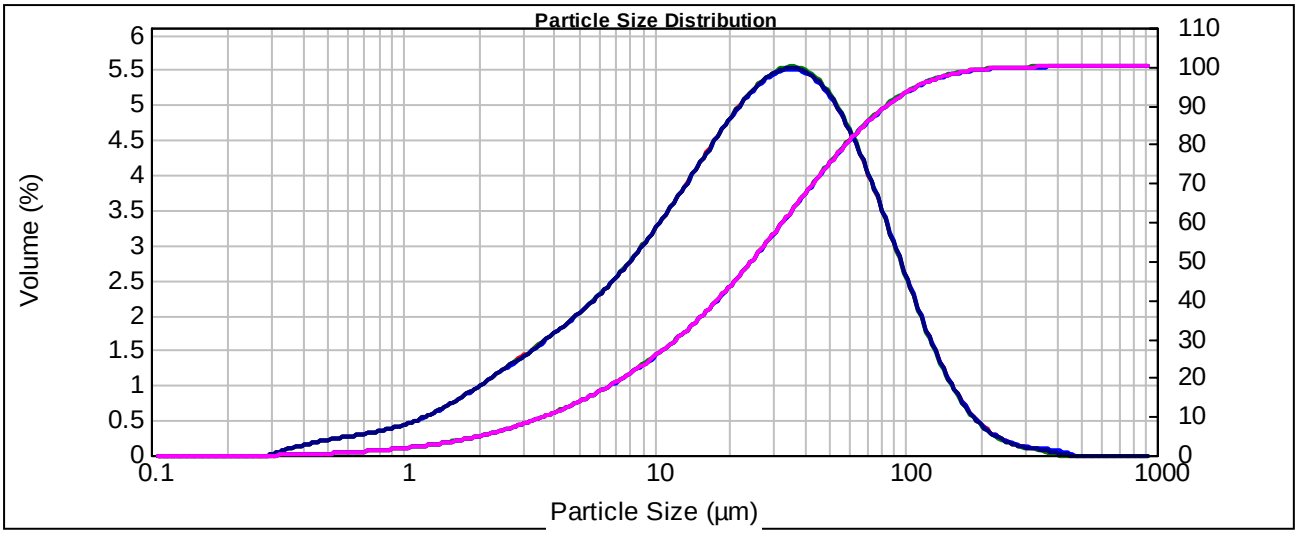
Result units:
Volume

Specific Surface Area:
0.721 m²/g

Surface Weighted Mean D[3,2]:
8.323 um

Vol. Weighted Mean D[4,3]:
36.763 um

d(0.1): 3.676 um d(0.5): 24.527 um **d(0.8): 58.058 um** d(0.9): 84.577 um d(0.98): 152.11 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.02
0.331	0.05
0.363	0.07
0.398	0.09
0.437	0.11
0.479	

Size (µm)	Volume In %
0.479	0.13
0.525	0.14
0.575	0.16
0.631	0.17
0.692	0.19
0.759	0.20
0.832	0.22
0.912	0.24
1.000	0.27
1.096	0.30
1.202	0.34
1.318	0.38
1.445	0.43
1.585	0.48
1.738	0.53
1.905	0.59
2.089	0.64
2.291	

Size (µm)	Volume In %
2.291	0.70
2.512	0.76
2.754	0.82
3.020	0.88
3.311	0.94
3.631	1.01
3.981	1.07
4.365	1.14
4.786	1.21
5.248	1.29
5.754	1.37
6.310	1.46
6.918	1.55
7.586	1.65
8.318	1.76
9.120	1.87
10.000	1.99
10.965	

Size (µm)	Volume In %
10.965	2.11
12.023	2.24
13.183	2.37
14.454	2.50
15.849	2.63
17.378	2.76
19.055	2.88
20.893	3.00
22.909	3.10
25.119	3.19
27.542	3.26
30.200	3.31
33.113	3.33
36.308	3.32
39.811	3.27
43.652	3.20
47.863	3.09
52.481	

Size (µm)	Volume In %
52.481	2.95
57.544	2.79
63.096	2.59
69.183	2.38
75.858	2.15
83.176	1.91
91.201	1.67
100.000	1.43
109.648	1.20
120.226	0.99
131.826	0.79
144.544	0.62
158.489	0.47
173.780	0.36
190.546	0.26
208.930	0.19
229.087	0.14
251.189	

Size (µm)	Volume In %
251.189	0.10
275.423	0.08
301.995	0.06
331.131	0.05
363.078	0.03
398.107	0.01
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P5

Measured by:
Dean

Measured:
Tuesday, October 23, 2012 9:40:33 AM

Sample Name:
WSD Bulk Regrind Discharge - Average

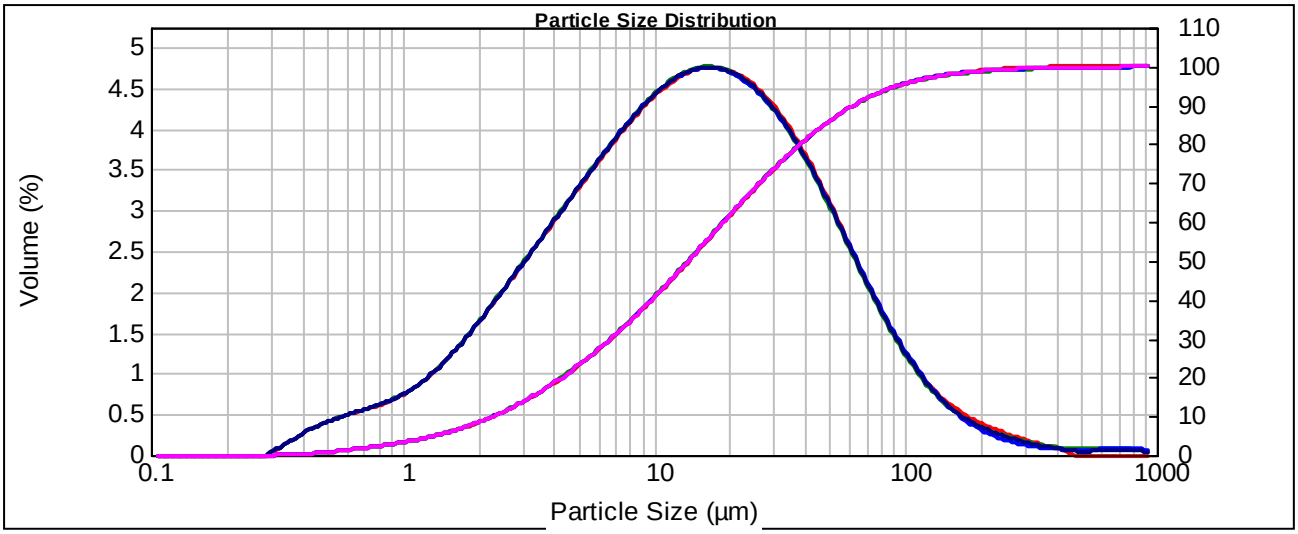
Edited by:
Dean

Analysed:
Tuesday, October 23, 2012 9:40:34 AM

Particle Name: Silica 1.0
Accessory Name: Hydro 2000MU (A)
Analysis model: General purpose
Sensitivity: Normal
Particle RI: 1.544
Absorption: 1
Size range: 0.100 to 1000.000 um
Obscuration: 18.89 %
Dispersant Name: Water
Dispersant RI: 1.330
Weighted Residual: 0.131 %
Result Emulation: Off

Concentration: 0.0141 %Vol
Span : 4.378
Uniformity: 1.58
Result units: Volume
Specific Surface Area: 1.11 m²/g
Surface Weighted Mean D[3,2]: 5.401 um
Vol. Weighted Mean D[4,3]: 27.710 um

d(0.1): 2.298 um d(0.5): 13.708 um **d(0.8): 38.198 um** d(0.9): 62.308 um d(0.98): 150.86 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.05
0.331	0.09
0.363	0.14
0.398	0.18
0.437	0.21
0.479	

Size (µm)	Volume In %
0.479	0.25
0.525	0.27
0.575	0.30
0.631	0.32
0.692	0.34
0.759	0.37
0.832	0.39
0.912	0.43
1.000	0.47
1.096	0.51
1.202	0.57
1.318	0.64
1.445	0.71
1.585	0.80
1.738	0.88
1.905	0.97
2.089	1.07
2.291	

Size (µm)	Volume In %
2.291	1.17
2.512	1.27
2.754	1.37
3.020	1.47
3.311	1.57
3.631	1.67
3.981	1.77
4.365	1.87
4.786	1.97
5.248	2.07
5.754	2.17
6.310	2.27
6.918	2.36
7.586	2.45
8.318	2.54
9.120	2.62
10.000	2.69
10.965	

Size (µm)	Volume In %
10.965	2.75
12.023	2.80
13.183	2.83
14.454	2.85
15.849	2.86
17.378	2.85
19.055	2.83
20.893	2.79
22.909	2.74
25.119	2.68
27.542	2.60
30.200	2.50
33.113	2.39
36.308	2.27
39.811	2.14
43.652	2.00
47.863	1.84
52.481	

Size (µm)	Volume In %
52.481	1.69
57.544	1.53
63.096	1.37
69.183	1.22
75.858	1.08
83.176	0.94
91.201	0.81
100.000	0.70
109.648	0.59
120.226	0.50
131.826	0.42
144.544	0.35
158.489	0.30
173.780	0.25
190.546	0.21
208.930	0.18
229.087	0.15
251.189	

Size (µm)	Volume In %
251.189	0.12
275.423	0.10
301.995	0.08
331.131	0.07
363.078	0.06
398.107	0.05
436.516	0.03
478.630	0.03
524.807	0.03
575.440	0.03
630.957	0.03
691.831	0.03
758.578	0.03
831.764	0.03
912.011	0.01
1000.000	

Operator notes:

TABLE III-97
SCREEN ANALYSIS
KM3512-P5 WSD Bulk Rougher Concentrate

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	5.10	94.9
65 Mesh	212	8.20	86.7
100 Mesh	150	7.80	78.9
150 Mesh	106	9.10	69.8
200 Mesh	75	8.50	61.3
270 Mesh	53	8.20	53.1
400 Mesh	38	6.80	46.3
TOTAL		100.00	**

K80 =158µm

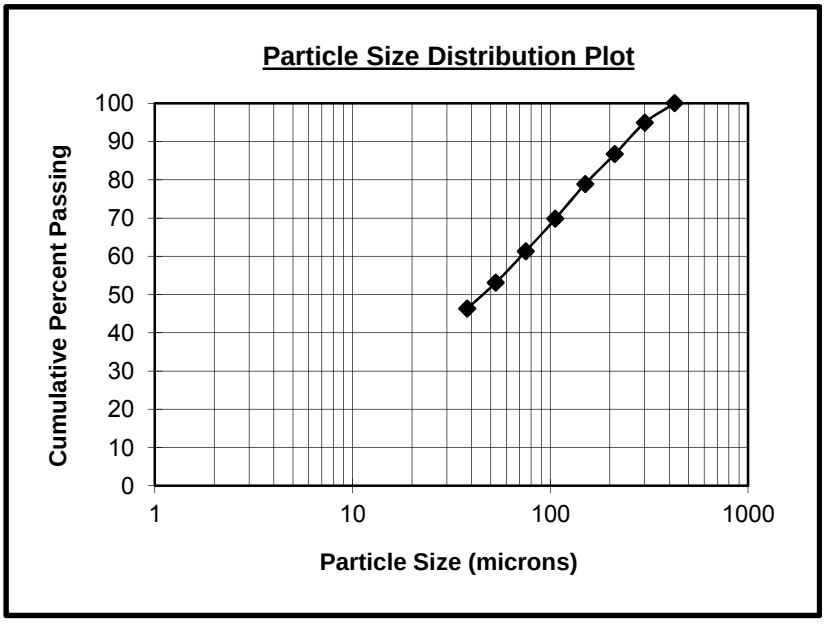


TABLE III-98
SCREEN ANALYSIS
KM3512-P5 WSD Flotation Feed

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	12.20	87.8
65 Mesh	212	9.80	78.0
100 Mesh	150	10.60	67.4
150 Mesh	106	9.70	57.7
200 Mesh	75	8.60	49.1
270 Mesh	53	7.50	41.6
400 Mesh	38	5.70	35.9
TOTAL		100.00	**

K80 =228µm

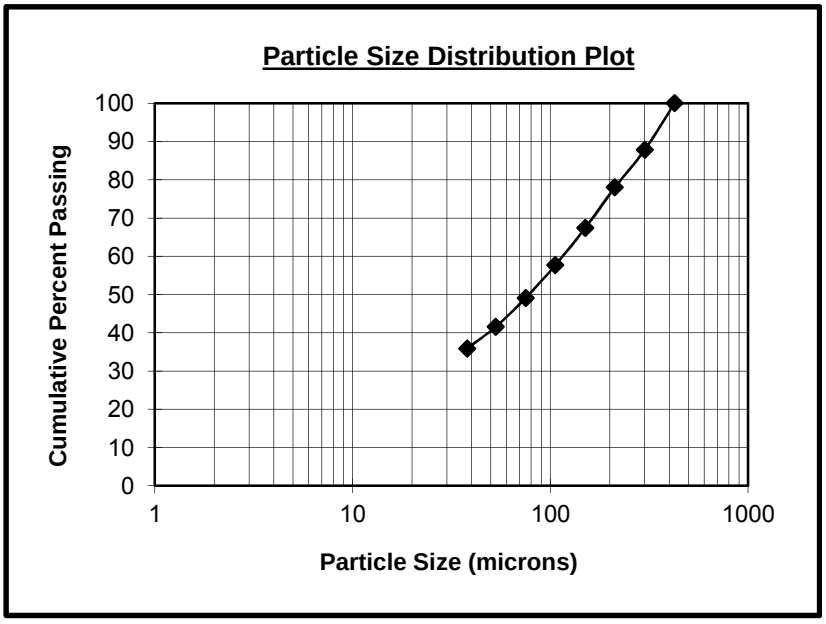


TABLE III-99
SCREEN ANALYSIS
KM3512-P1 Flotation Feed 10:55

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
28 Mesh	600	0.00	100.0
35 Mesh	425	6.80	93.2
48 Mesh	300	8.38	84.8
65 Mesh	212	10.23	74.6
100 Mesh	150	11.83	62.8
150 Mesh	106	11.02	51.7
200 Mesh	75	8.18	43.6
TOTAL		100.00	**

K80 =256µm

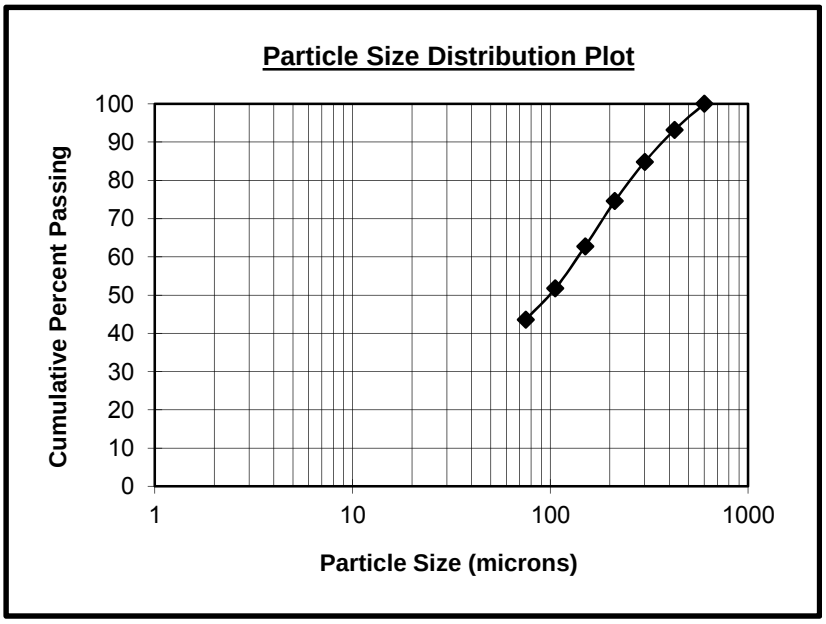


TABLE III-100
SCREEN ANALYSIS
KM3512-P1 Flotation Feed 12:50

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
28 Mesh	600	0.00	100.0
35 Mesh	425	1.09	98.9
48 Mesh	300	3.42	95.5
65 Mesh	212	6.14	89.3
100 Mesh	150	9.26	80.1
150 Mesh	106	11.77	68.3
200 Mesh	75	10.47	57.9
TOTAL		100.00	**

K80 =150µm

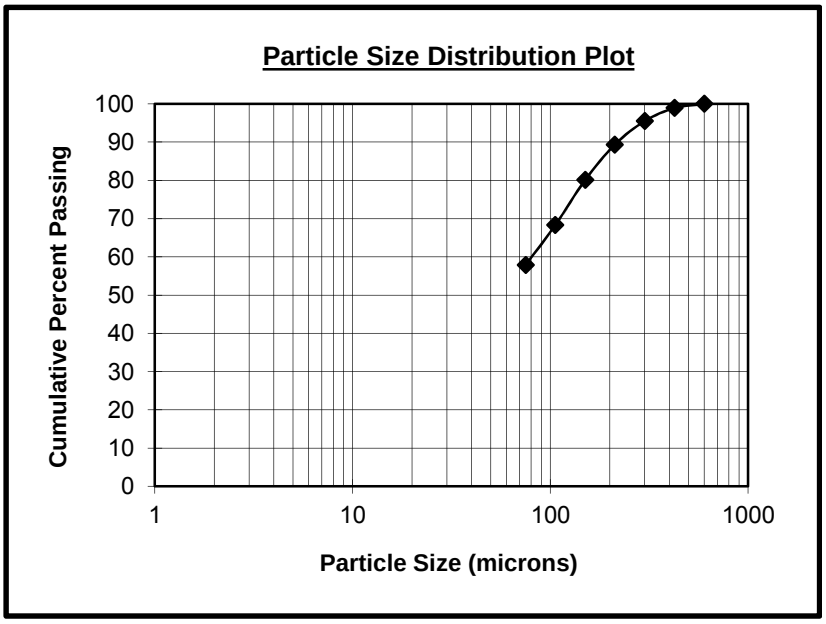


TABLE III-101
SCREEN ANALYSIS
KM3512-P1 Flotation Feed 14:00

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
28 Mesh	600	0.00	100.0
35 Mesh	425	3.35	96.6
48 Mesh	300	6.30	90.3
65 Mesh	212	8.67	81.7
100 Mesh	150	10.95	70.7
150 Mesh	106	11.30	59.4
200 Mesh	75	9.42	50.0
TOTAL		100.00	**

K80 =202µm

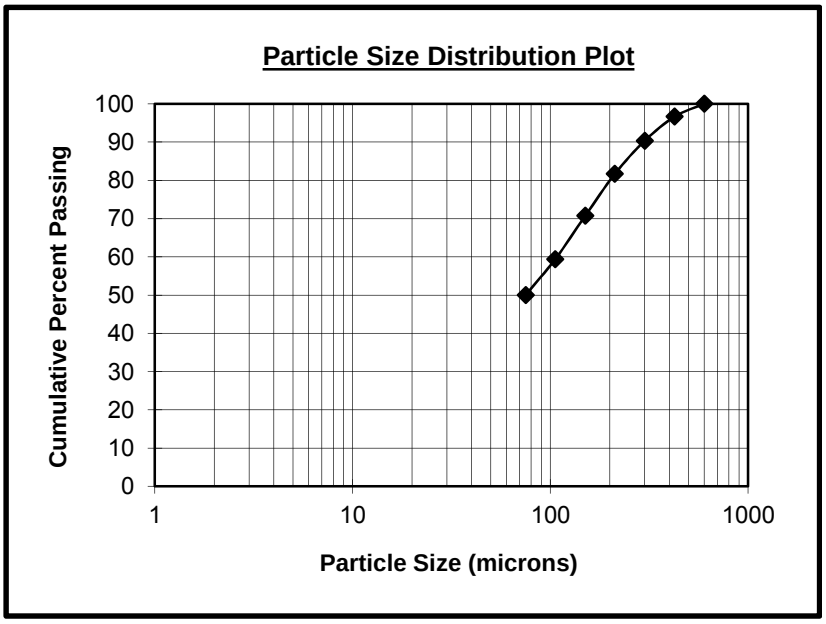


TABLE III-102
SCREEN ANALYSIS
KM3512-P2 Flotation Feed 09:00

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
28 Mesh	600	0.00	100.0
35 Mesh	425	2.19	97.8
48 Mesh	300	4.48	93.3
65 Mesh	212	6.77	86.6
100 Mesh	150	9.36	77.2
150 Mesh	106	11.55	65.6
200 Mesh	75	10.16	55.5
TOTAL		100.00	**

K80 =167µm

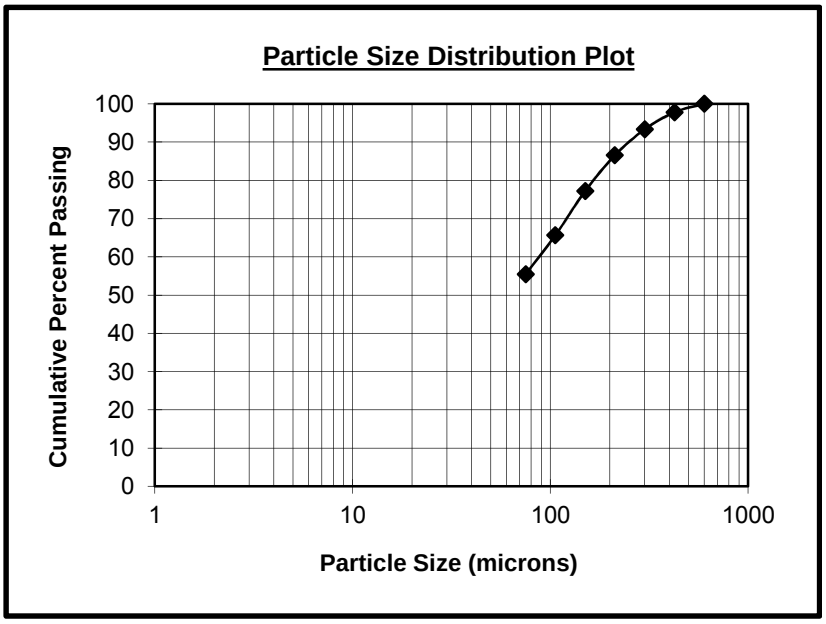


TABLE III-103
SCREEN ANALYSIS
KM3512-P2 Flotation Feed 11:15

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
28 Mesh	600	0.00	100.0
35 Mesh	425	2.65	97.4
48 Mesh	300	5.28	92.1
65 Mesh	212	7.98	84.1
100 Mesh	150	10.55	73.5
150 Mesh	106	12.27	61.3
200 Mesh	75	9.84	51.4
TOTAL		100.00	**

K80 =186µm

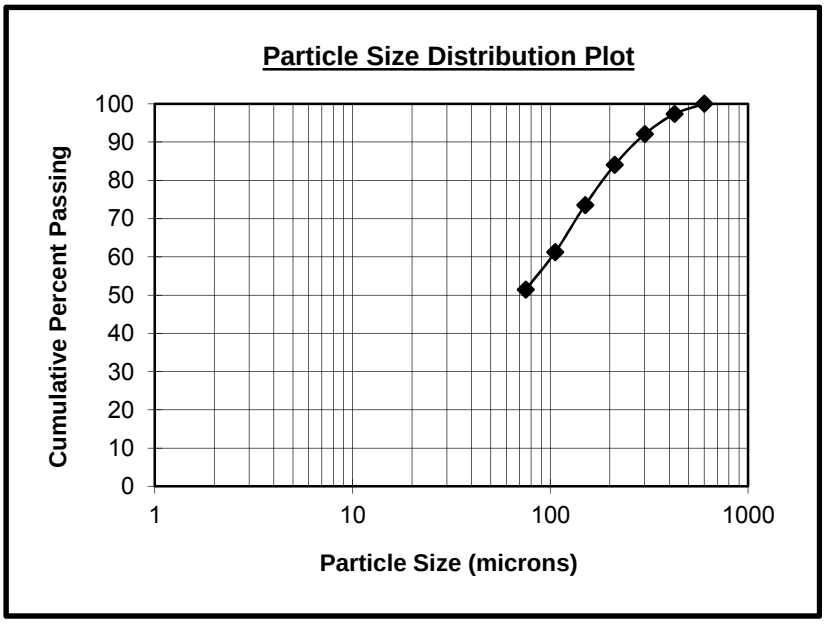


TABLE III-104
SCREEN ANALYSIS
KM3512-P2 Flotation Feed 13:15

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
28 Mesh	600	0.00	100.0
35 Mesh	425	1.37	98.6
48 Mesh	300	4.34	94.3
65 Mesh	212	7.89	86.4
100 Mesh	150	10.97	75.4
150 Mesh	106	12.46	63.0
200 Mesh	75	10.40	52.6
TOTAL		100.00	**

K80 =174µm

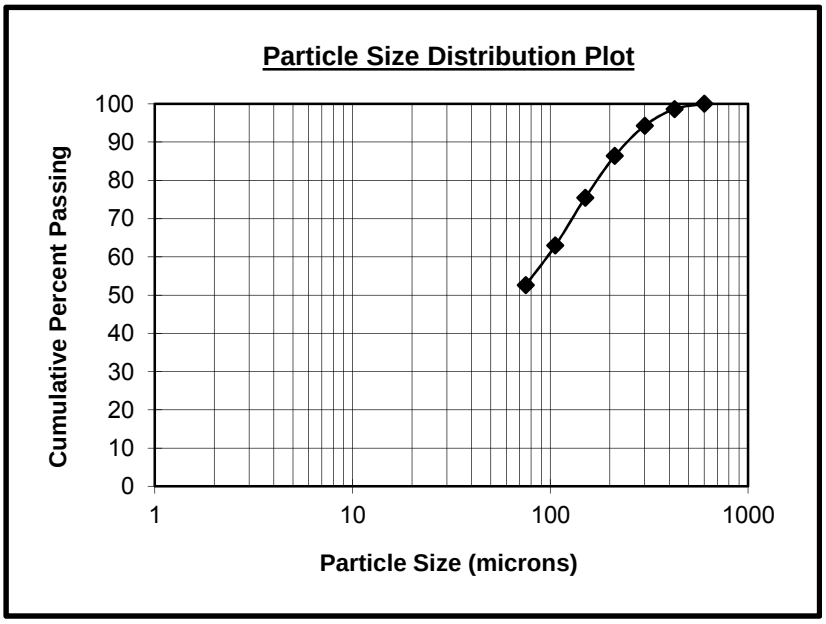


TABLE III-105
SCREEN ANALYSIS
KM3512-P2 Flotation Feed 14:15

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
28 Mesh	600	0.00	100.0
35 Mesh	425	3.46	96.5
48 Mesh	300	7.12	89.4
65 Mesh	212	9.53	79.9
100 Mesh	150	11.73	68.2
150 Mesh	106	12.04	56.1
200 Mesh	75	9.32	46.8
TOTAL		100.00	**

K80 =213µm

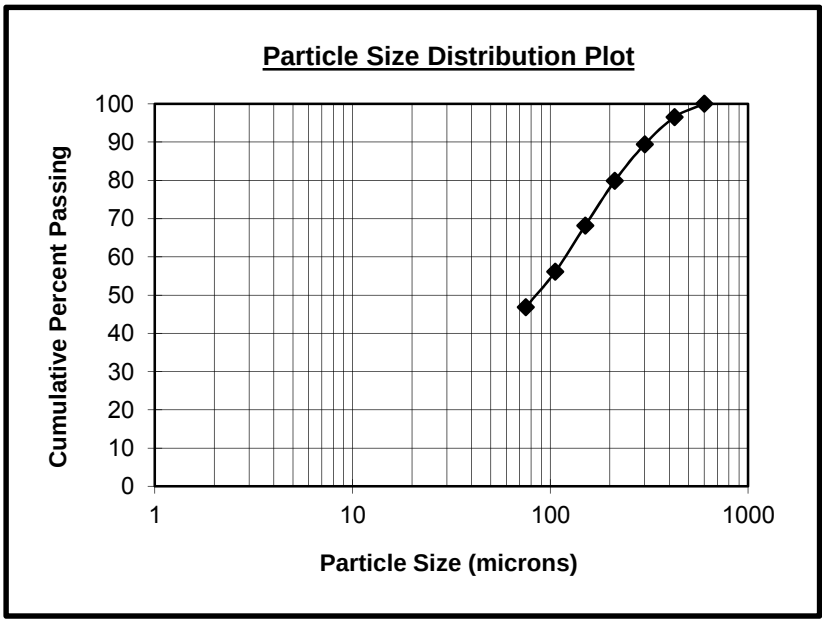


TABLE III-106
SCREEN ANALYSIS
KM3512-P2 Flotation Feed 15:40

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
28 Mesh	600	0.00	100.0
35 Mesh	425	5.20	94.8
48 Mesh	300	8.71	86.1
65 Mesh	212	10.22	75.9
100 Mesh	150	11.39	64.5
150 Mesh	106	11.26	53.2
200 Mesh	75	8.33	44.9
TOTAL		100.00	**

K80 =245µm

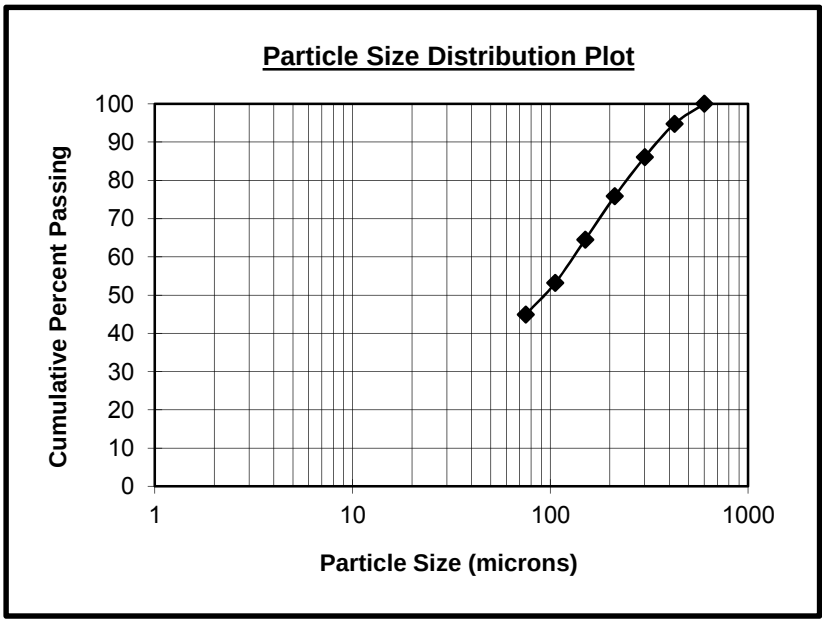


TABLE III-107
SCREEN ANALYSIS
KM3512-P3 Flotation Feed 10:30

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
28 Mesh	600	0.00	100.0
35 Mesh	425	0.76	99.2
48 Mesh	300	3.70	95.5
65 Mesh	212	9.11	86.4
100 Mesh	150	13.47	73.0
150 Mesh	106	13.82	59.1
200 Mesh	75	10.16	49.0
TOTAL		100.00	**

K80 =181µm

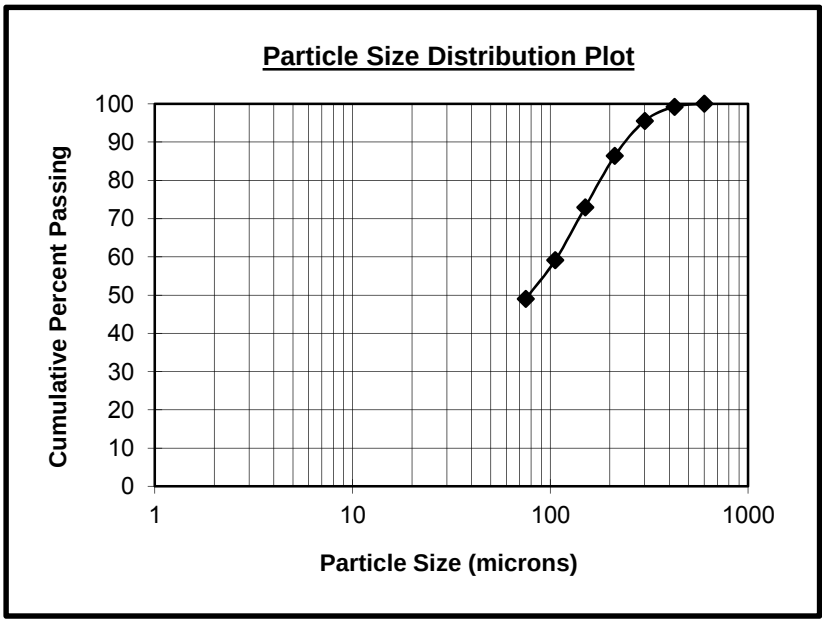


TABLE III-108
SCREEN ANALYSIS
KM3512-P3 Flotation Feed 11:30

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
28 Mesh	600	0.00	100.0
35 Mesh	425	7.04	93.0
48 Mesh	300	12.82	80.1
65 Mesh	212	13.22	66.9
100 Mesh	150	13.11	53.8
150 Mesh	106	11.56	42.2
200 Mesh	75	7.93	34.3
TOTAL		100.00	**

K80 =299µm

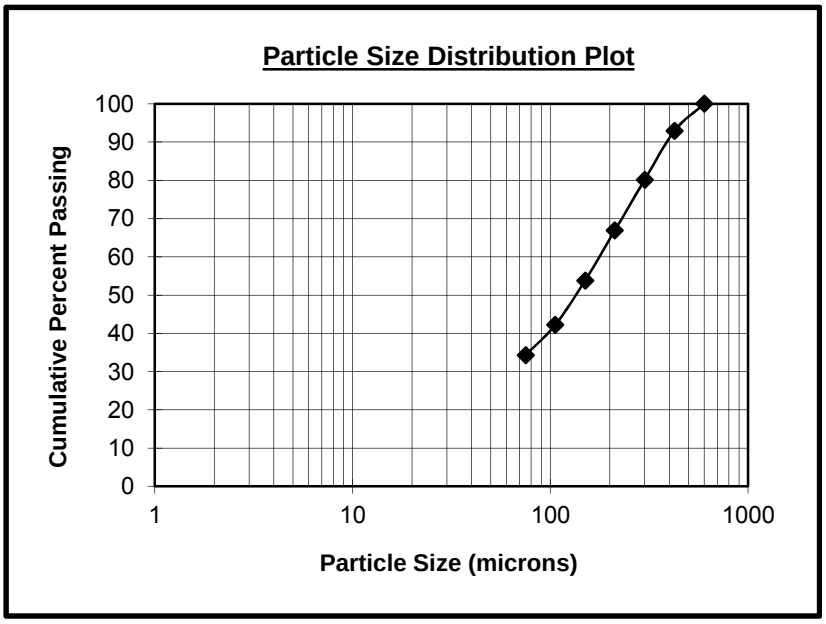


TABLE III-109
SCREEN ANALYSIS
KM3512-P3 Flotation Feed 12:30

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
28 Mesh	600	0.00	100.0
35 Mesh	425	7.11	92.9
48 Mesh	300	12.62	80.3
65 Mesh	212	13.08	67.2
100 Mesh	150	12.57	54.6
150 Mesh	106	10.65	44.0
200 Mesh	75	7.75	36.2
TOTAL		100.00	**

K80 =298µm

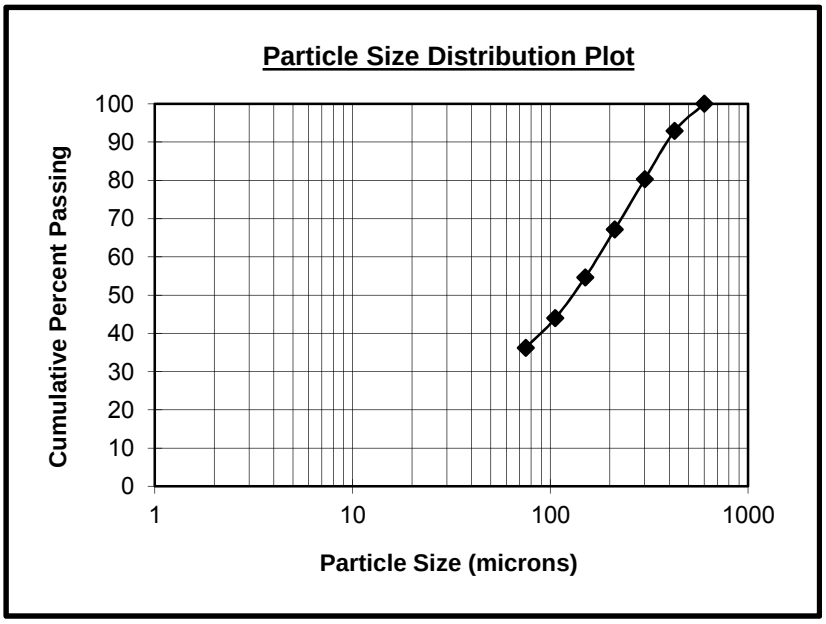


TABLE III-110
SCREEN ANALYSIS
KM3512-P4 Flotation Feed 10:00

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
28 Mesh	600	0.00	100.0
35 Mesh	425	3.01	97.0
48 Mesh	300	8.73	88.3
65 Mesh	212	11.75	76.5
100 Mesh	150	13.25	63.3
150 Mesh	106	12.85	50.4
200 Mesh	75	9.14	41.3
TOTAL		100.00	**

K80 =236µm

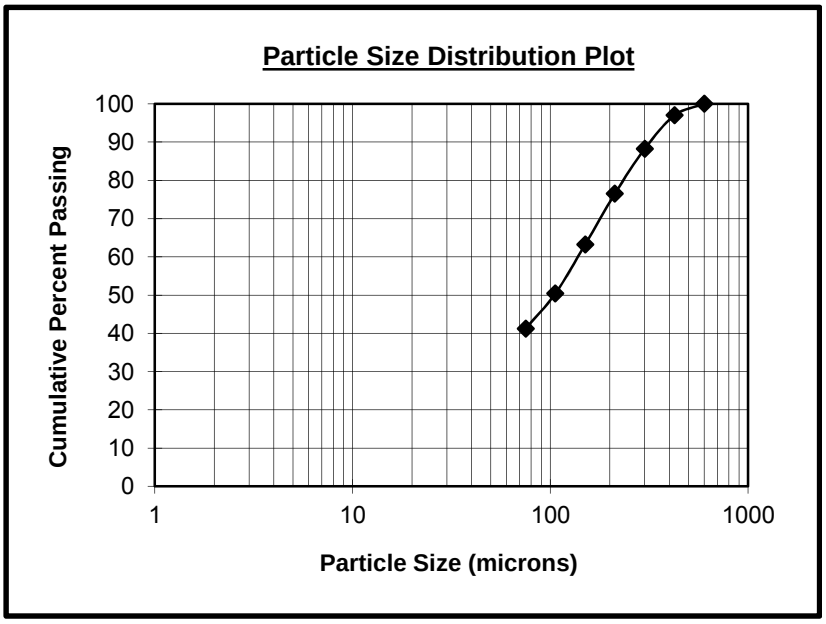


TABLE III-111
SCREEN ANALYSIS
KM3512-P4 Flotation Feed 11:00

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
28 Mesh	600	0.00	100.0
35 Mesh	425	4.06	95.9
48 Mesh	300	8.79	87.1
65 Mesh	212	10.82	76.3
100 Mesh	150	11.98	64.3
150 Mesh	106	11.79	52.6
200 Mesh	75	8.89	43.7
TOTAL		100.00	**

K80 =240µm

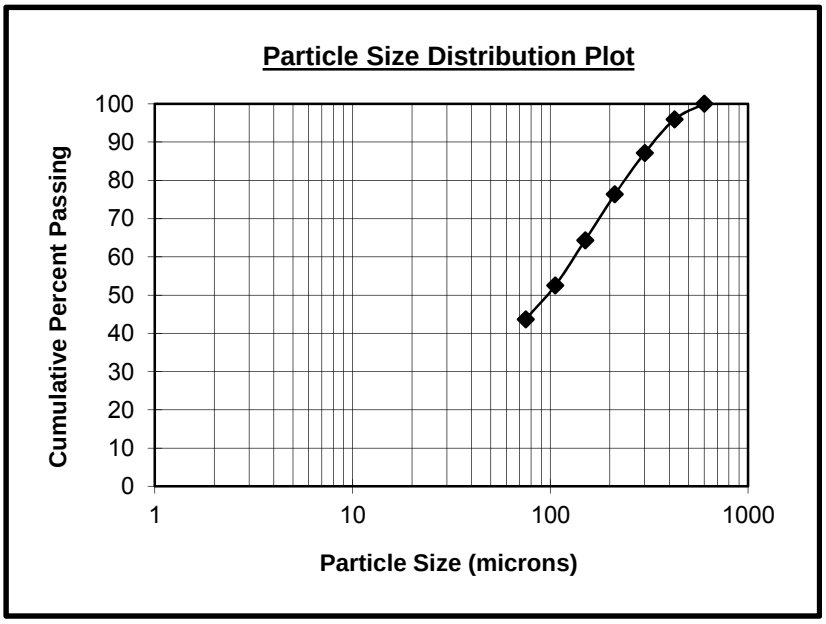


TABLE III-112
SCREEN ANALYSIS
KM3512-P4 Flotation Feed 12:00

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
28 Mesh	600	0.00	100.0
35 Mesh	425	1.57	98.4
48 Mesh	300	5.35	93.1
65 Mesh	212	8.09	85.0
100 Mesh	150	9.79	75.2
150 Mesh	106	11.49	63.7
200 Mesh	75	10.44	53.3
TOTAL		100.00	**

K80 =179µm

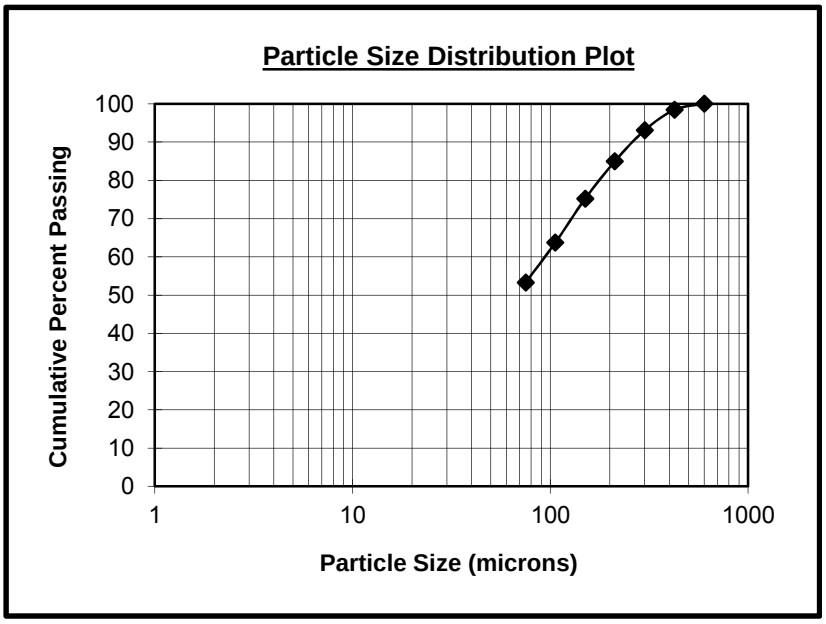


TABLE III-113
SCREEN ANALYSIS
KM3512-P4 Flotation Feed 14:00

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
28 Mesh	600	0.00	100.0
35 Mesh	425	8.82	91.2
48 Mesh	300	12.31	78.9
65 Mesh	212	11.52	67.4
100 Mesh	150	10.88	56.5
150 Mesh	106	9.85	46.6
200 Mesh	75	7.47	39.2
TOTAL		100.00	**

K80 =310µm

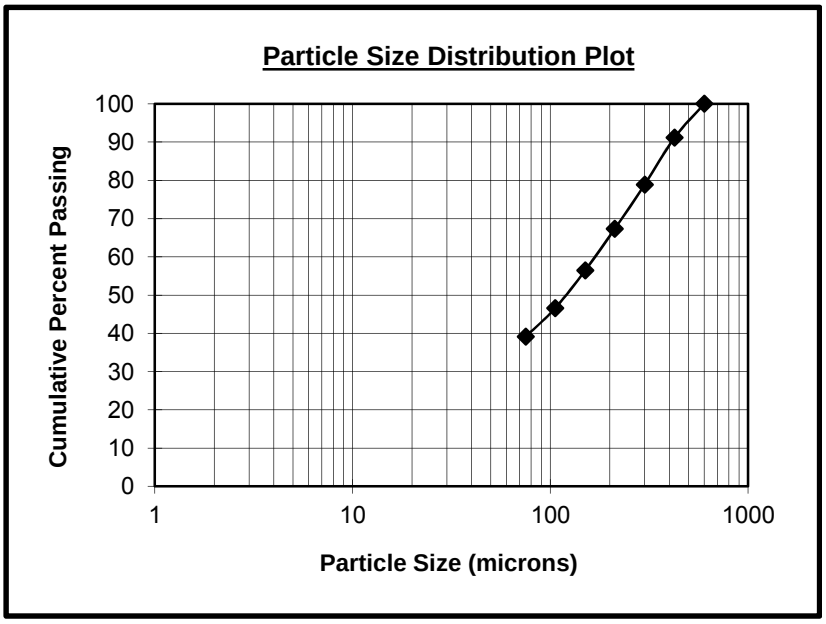


TABLE III-114
SCREEN ANALYSIS
KM3512-P4 Flotation Feed 15:00

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
28 Mesh	600	0.00	100.0
35 Mesh	425	8.22	91.8
48 Mesh	300	14.24	77.5
65 Mesh	212	14.48	63.1
100 Mesh	150	14.01	49.1
150 Mesh	106	11.82	37.2
200 Mesh	75	8.06	29.2
TOTAL		100.00	**

K80 =320µm

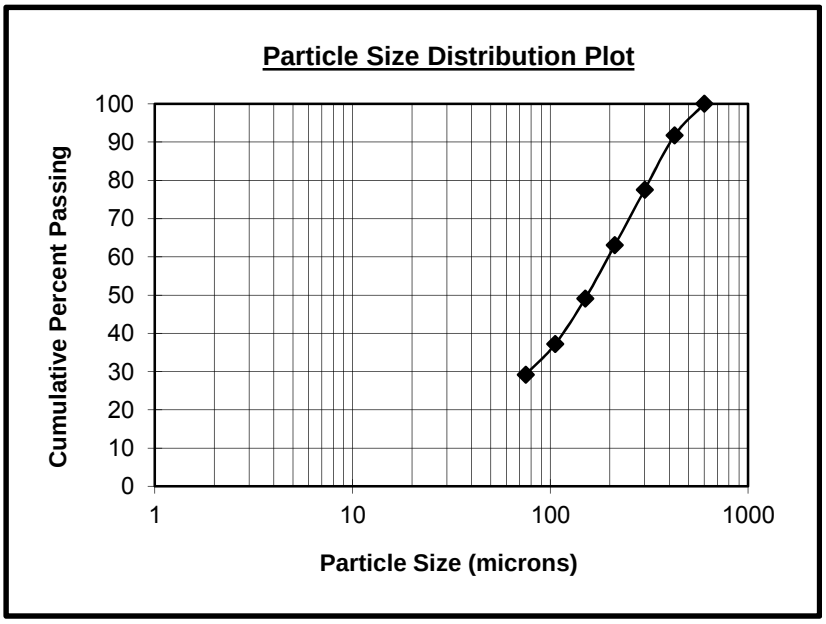


TABLE III-115
SCREEN ANALYSIS
KM3512-P5 Flotation Feed 09:30

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
28 Mesh	600	0.00	100.0
35 Mesh	425	4.30	95.7
48 Mesh	300	7.87	87.8
65 Mesh	212	9.21	78.6
100 Mesh	150	9.90	68.7
150 Mesh	106	10.52	58.2
200 Mesh	75	8.51	49.7
TOTAL		100.00	**

K80 =224µm

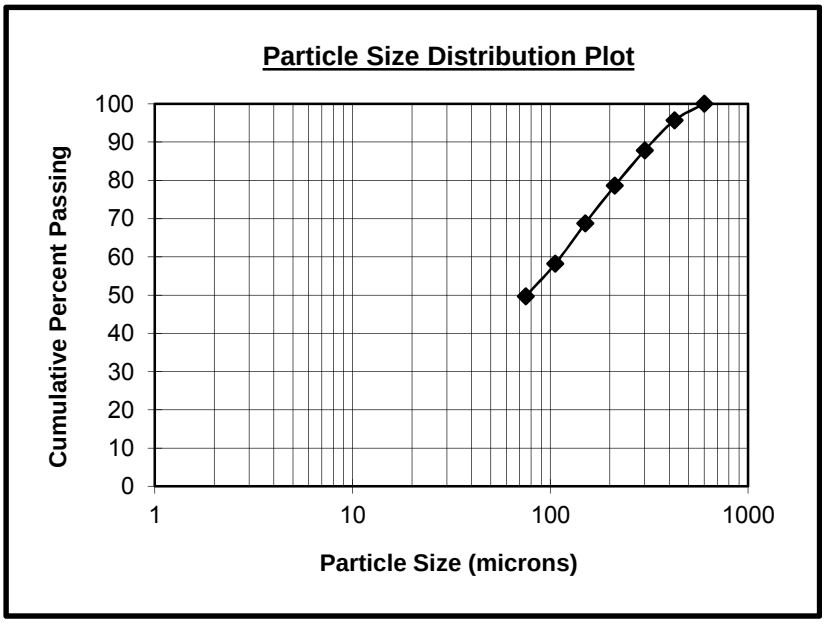


TABLE III-116
SCREEN ANALYSIS
KM3512-P5 Flotation Feed 10:30

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
28 Mesh	600	0.00	100.0
35 Mesh	425	4.81	95.2
48 Mesh	300	7.41	87.8
65 Mesh	212	8.70	79.1
100 Mesh	150	9.72	69.4
150 Mesh	106	10.37	59.0
200 Mesh	75	8.61	50.4
TOTAL		100.00	**

K80 =220µm

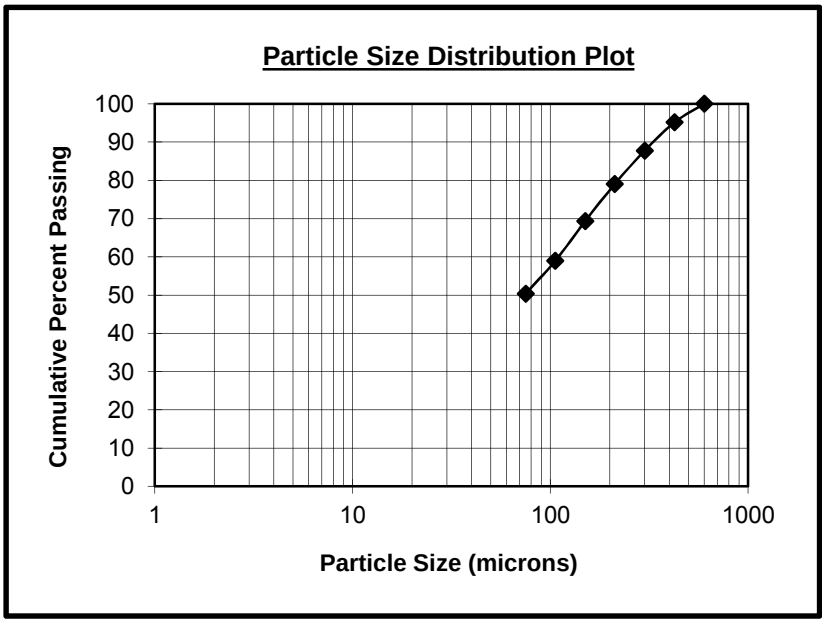


TABLE III-117
SCREEN ANALYSIS
KM3512-P5 Flotation Feed 12:30

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
28 Mesh	600	0.00	100.0
35 Mesh	425	6.98	93.0
48 Mesh	300	11.36	81.7
65 Mesh	212	11.09	70.6
100 Mesh	150	10.75	59.8
150 Mesh	106	9.59	50.2
200 Mesh	75	7.58	42.6
TOTAL		100.00	**

K80 =286µm

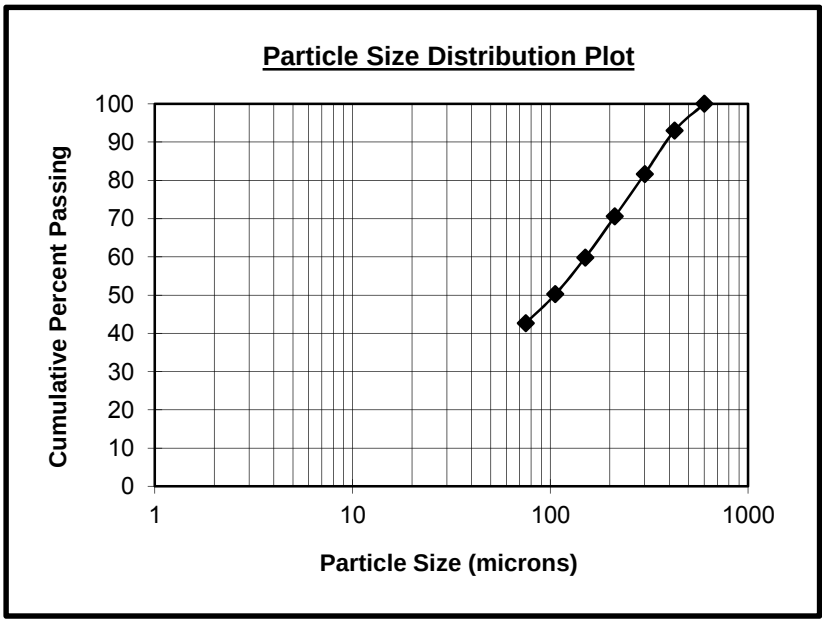
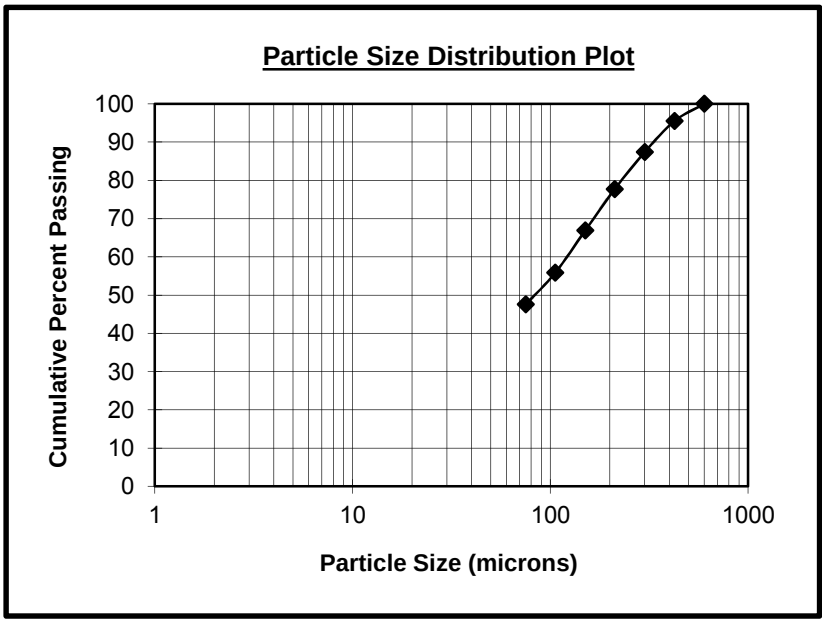


TABLE III-118
SCREEN ANALYSIS
KM3512-P5 Flotation Feed 13:55

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
28 Mesh	600	0.00	100.0
35 Mesh	425	4.48	95.5
48 Mesh	300	8.14	87.4
65 Mesh	212	9.64	77.7
100 Mesh	150	10.86	66.9
150 Mesh	106	11.02	55.9
200 Mesh	75	8.28	47.6
TOTAL		100.00	**

K80 =231µm



ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P2

Measured by:
ALKMM.LaserSizer

Measured:
Wednesday, October 17, 2012 9:30:46 AM

Sample Name:
Bulk Regrind Discharge 0920 - Average

Edited by:
ALKMM.LaserSizer

Analysed:
Wednesday, October 17, 2012 9:30:47 AM

Particle Name:
Silica 1.0

Accessory Name:
Hydro 2000MU (A)

Analysis model:
General purpose

Sensitivity:
Normal

Particle RI:
1.544

Absorption:
1

Size range:
0.100 to 1000.000 um

Obscuration:
18.57 %

Dispersant Name:
Water

Dispersant RI:
1.330

Weighted Residual:
0.331 %

Result Emulation:
Off

Concentration:
0.0075 %Vol

Span :
6.012

Uniformity:
3.06

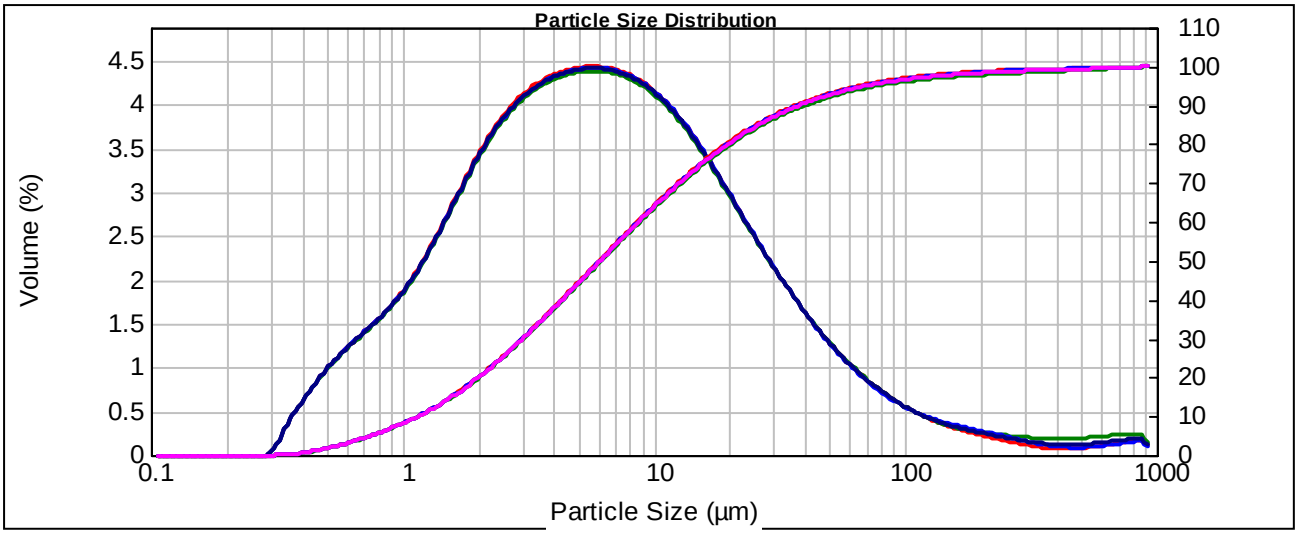
Result units:
Volume

Specific Surface Area:
2.03 m²/g

Surface Weighted Mean D[3,2]:
2.962 um

Vol. Weighted Mean D[4,3]:
21.385 um

d(0.1): 1.152 um d(0.5): 6.108 um **d(0.8): 19.682 um** d(0.9): 37.877 um d(0.98): 164.71 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.07
0.331	0.21
0.363	0.31
0.398	0.41
0.437	0.51
0.479	

Size (µm)	Volume In %
0.479	0.59
0.525	0.67
0.575	0.74
0.631	0.80
0.692	0.86
0.759	0.93
0.832	0.99
0.912	1.07
1.000	1.16
1.096	1.27
1.202	1.39
1.318	1.51
1.445	1.65
1.585	1.79
1.738	1.92
1.905	2.05
2.089	2.16
2.291	

Size (µm)	Volume In %
2.291	2.27
2.512	2.36
2.754	2.43
3.020	2.49
3.311	2.54
3.631	2.58
3.981	2.61
4.365	2.63
4.786	2.65
5.248	2.66
5.754	2.66
6.310	2.65
6.918	2.63
7.586	2.60
8.318	2.57
9.120	2.52
10.000	2.46
10.965	

Size (µm)	Volume In %
10.965	2.39
12.023	2.31
13.183	2.22
14.454	2.13
15.849	2.02
17.378	1.91
19.055	1.79
20.893	1.68
22.909	1.56
25.119	1.45
27.542	1.33
30.200	1.23
33.113	1.13
36.308	1.03
39.811	0.93
43.652	0.85
47.863	0.77
52.481	

Size (µm)	Volume In %
52.481	0.69
57.544	0.62
63.096	0.56
69.183	0.50
75.858	0.44
83.176	0.40
91.201	0.35
100.000	0.31
109.648	0.28
120.226	0.25
131.826	0.22
144.544	0.20
158.489	0.18
173.780	0.17
190.546	0.15
208.930	0.14
229.087	0.13
251.189	

Size (µm)	Volume In %
251.189	0.11
275.423	0.10
301.995	0.09
331.131	0.08
363.078	0.08
398.107	0.07
436.516	0.07
478.630	0.07
524.807	0.08
575.440	0.09
630.957	0.10
691.831	0.10
758.578	0.11
831.764	0.11
912.011	0.03
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P2

Sample Name:
Bulk Regrind Discharge 1030 - Average

Measured by:
Alan

Edited by:
Alan

Measured:
Wednesday, October 17, 2012 10:39:43 AM

Analysed:
Wednesday, October 17, 2012 10:39:44 AM

Particle Name: Silica 1.0
Particle RI: 1.544
Dispersant Name: Water

Accessory Name: Hydro 2000MU (A)
Absorption: 1
Dispersant RI: 1.330

Analysis model: General purpose
Size range: 0.100 to 1000.000 um
Weighted Residual: 0.300 %

Sensitivity: Normal
Obscuration: 19.81 %
Result Emulation: Off

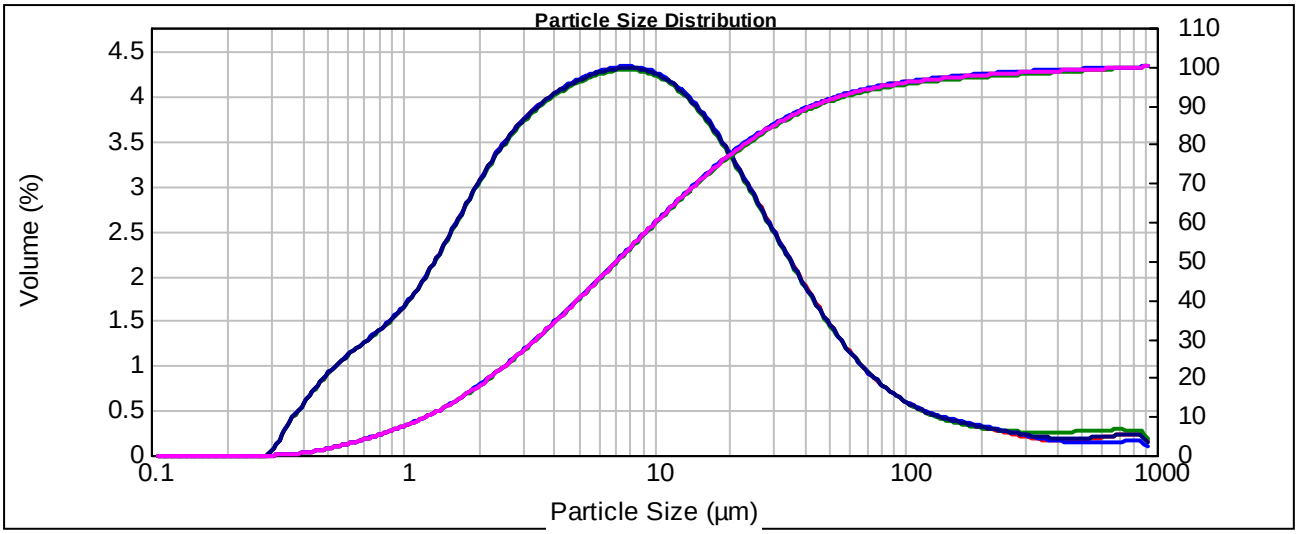
Concentration: 0.0088 %Vol
Specific Surface Area: 1.86 m²/g

Span : 5.912
Surface Weighted Mean D[3,2]: 3.227 um

Uniformity: 3.12
Vol. Weighted Mean D[4,3]: 25.397 um

Result units: Volume

d(0.1): 1.249 um d(0.5): 7.146 um **d(0.8): 22.920 um** d(0.9): 43.498 um d(0.98): 227.35 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.06
0.331	0.20
0.363	0.29
0.398	0.38
0.437	0.47
0.479	

Size (µm)	Volume In %
0.479	0.54
0.525	0.61
0.575	0.67
0.631	0.72
0.692	0.77
0.759	0.83
0.832	0.88
0.912	0.95
1.000	1.03
1.096	1.12
1.202	1.22
1.318	1.33
1.445	1.45
1.585	1.58
1.738	1.70
1.905	1.82
2.089	1.93
2.291	

Size (µm)	Volume In %
2.291	2.04
2.512	2.13
2.754	2.21
3.020	2.28
3.311	2.34
3.631	2.40
3.981	2.44
4.365	2.48
4.786	2.52
5.248	2.54
5.754	2.57
6.310	2.59
6.918	2.60
7.586	2.60
8.318	2.59
9.120	2.58
10.000	2.55
10.965	

Size (µm)	Volume In %
10.965	2.51
12.023	2.46
13.183	2.39
14.454	2.32
15.849	2.23
17.378	2.13
19.055	2.03
20.893	1.91
22.909	1.80
25.119	1.68
27.542	1.55
30.200	1.43
33.113	1.31
36.308	1.20
39.811	1.08
43.652	0.98
47.863	0.87
52.481	

Size (µm)	Volume In %
52.481	0.78
57.544	0.69
63.096	0.61
69.183	0.54
75.858	0.48
83.176	0.43
91.201	0.38
100.000	0.34
109.648	0.31
120.226	0.28
131.826	0.25
144.544	0.24
158.489	0.22
173.780	0.20
190.546	0.19
208.930	0.18
229.087	0.17
251.189	

Size (µm)	Volume In %
251.189	0.15
275.423	0.14
301.995	0.13
331.131	0.12
363.078	0.12
398.107	0.11
436.516	0.11
478.630	0.12
524.807	0.12
575.440	0.12
630.957	0.13
691.831	0.13
758.578	0.13
831.764	0.13
912.011	0.04
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P2

Sample Name:
Bulk Regrind Discharge 1200 - Average

Measured by:
Alan

Edited by:
Alan

Measured:
Wednesday, October 17, 2012 12:05:19 PM

Analysed:
Wednesday, October 17, 2012 12:05:20 PM

Particle Name: Silica 1.0
Particle RI: 1.544
Dispersant Name: Water

Accessory Name: Hydro 2000MU (A)
Absorption: 1
Dispersant RI: 1.330

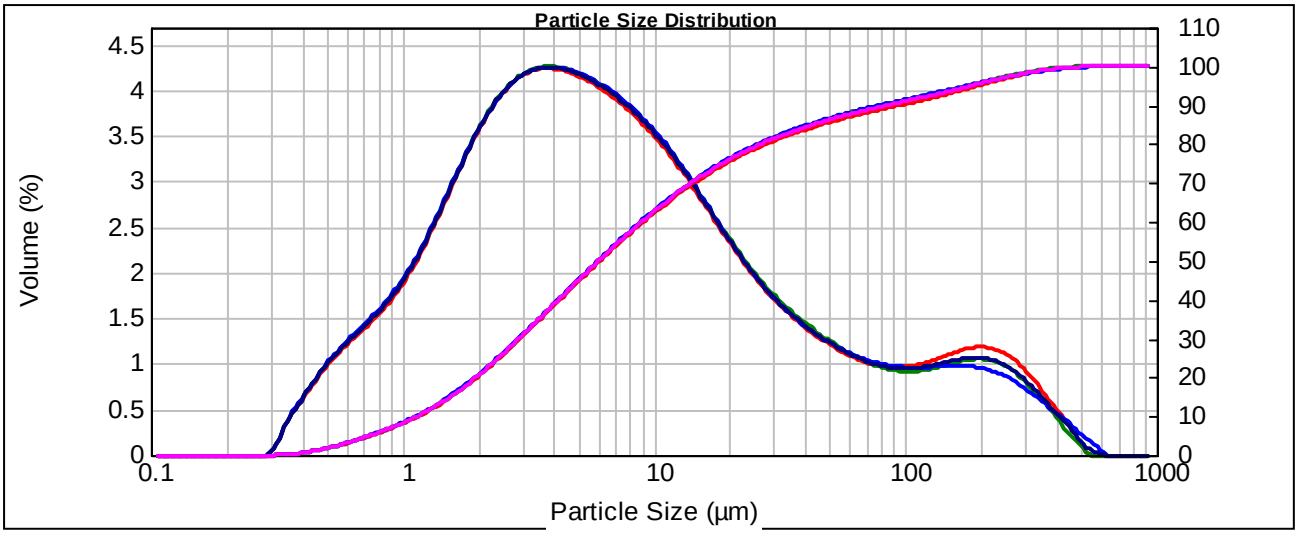
Analysis model: General purpose
Size range: 0.100 to 1000.000 um
Weighted Residual: 0.327 %

Sensitivity: Normal
Obscuration: 13.19 %
Result Emulation: Off

Concentration: 0.0051 %Vol
Span : 13.739
Uniformity: 4.59
Result units: Volume

Specific Surface Area: 2.03 m²/g
Surface Weighted Mean D[3,2]: 2.952 um
Vol. Weighted Mean D[4,3]: 30.288 um

d(0.1): 1.139 um d(0.5): 6.024 um **d(0.8): 26.454 um** d(0.9): 83.896 um d(0.98): 285.63 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.07
0.331	0.22
0.363	0.32
0.398	0.42
0.437	0.52
0.479	

Size (µm)	Volume In %
0.479	0.60
0.525	0.67
0.575	0.74
0.631	0.81
0.692	0.87
0.759	0.94
0.832	1.01
0.912	1.10
1.000	1.19
1.096	1.31
1.202	1.44
1.318	1.58
1.445	1.72
1.585	1.87
1.738	2.01
1.905	2.14
2.089	2.26
2.291	

Size (µm)	Volume In %
2.291	2.35
2.512	2.43
2.754	2.49
3.020	2.53
3.311	2.55
3.631	2.56
3.981	2.55
4.365	2.54
4.786	2.51
5.248	2.48
5.754	2.44
6.310	2.40
6.918	2.35
7.586	2.30
8.318	2.23
9.120	2.17
10.000	2.09
10.965	

Size (µm)	Volume In %
10.965	2.01
12.023	1.92
13.183	1.82
14.454	1.72
15.849	1.62
17.378	1.52
19.055	1.42
20.893	1.32
22.909	1.23
25.119	1.15
27.542	1.07
30.200	1.00
33.113	0.94
36.308	0.88
39.811	0.83
43.652	0.78
47.863	0.74
52.481	

Size (µm)	Volume In %
52.481	0.70
57.544	0.67
63.096	0.64
69.183	0.61
75.858	0.59
83.176	0.58
91.201	0.57
100.000	0.57
109.648	0.58
120.226	0.59
131.826	0.60
144.544	0.62
158.489	0.63
173.780	0.64
190.546	0.64
208.930	0.63
229.087	0.61
251.189	

Size (µm)	Volume In %
251.189	0.57
275.423	0.52
301.995	0.46
331.131	0.39
363.078	0.31
398.107	0.24
436.516	0.18
478.630	0.08
524.807	0.04
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes: *1200g 3.5mm 1380RPM*

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P2

Measured by:
Alan

Measured:
Wednesday, October 17, 2012 12:58:29 PM

Sample Name:
Bulk Regrind Discharge 1250 - Average

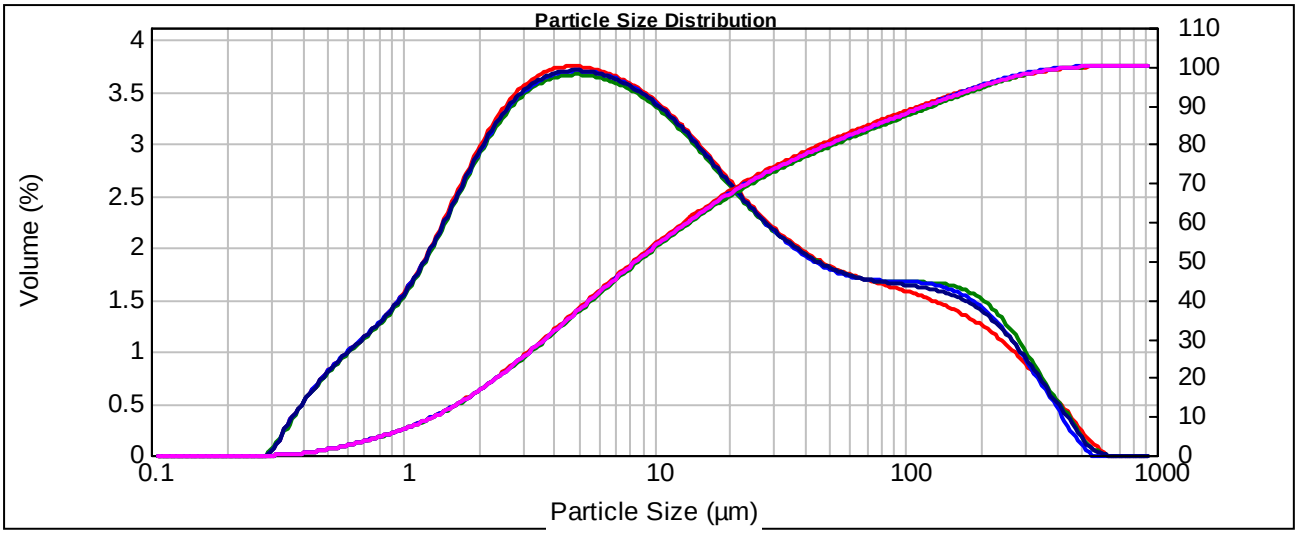
Edited by:
Alan

Analysed:
Wednesday, October 17, 2012 12:58:31 PM

Particle Name: Silica 1.0
Accessory Name: Hydro 2000MU (A)
Analysis model: General purpose
Sensitivity: Normal
Particle RI: 1.544
Absorption: 1
Size range: 0.100 to 1000.000 um
Obscuration: 18.68 %
Dispersant Name: Water
Dispersant RI: 1.330
Weighted Residual: 0.258 %
Result Emulation: Off

Concentration: 0.0090 %Vol
Span : 14.158
Uniformity: 4.13
Result units: Volume
Specific Surface Area: 1.7 m²/g
Surface Weighted Mean D[3,2]: 3.540 um
Vol. Weighted Mean D[4,3]: 38.755 um

d(0.1): 1.338 um d(0.5): 8.551 um **d(0.8): 49.348 um** d(0.9): 122.406 um d(0.98): 297.61 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.06
0.331	0.18
0.363	0.25
0.398	0.33
0.437	0.41
0.479	

Size (µm)	Volume In %
0.479	0.48
0.525	0.54
0.575	0.59
0.631	0.65
0.692	0.70
0.759	0.75
0.832	0.81
0.912	0.88
1.000	0.96
1.096	1.05
1.202	1.16
1.318	1.27
1.445	1.39
1.585	1.51
1.738	1.63
1.905	1.74
2.089	1.85
2.291	

Size (µm)	Volume In %
2.291	1.94
2.512	2.02
2.754	2.08
3.020	2.13
3.311	2.17
3.631	2.20
3.981	2.22
4.365	2.23
4.786	2.23
5.248	2.22
5.754	2.21
6.310	2.19
6.918	2.17
7.586	2.14
8.318	2.11
9.120	2.07
10.000	2.02
10.965	

Size (µm)	Volume In %
10.965	1.97
12.023	1.91
13.183	1.85
14.454	1.79
15.849	1.72
17.378	1.65
19.055	1.58
20.893	1.51
22.909	1.45
25.119	1.38
27.542	1.33
30.200	1.27
33.113	1.23
36.308	1.18
39.811	1.15
43.652	1.11
47.863	1.08
52.481	

Size (µm)	Volume In %
52.481	1.06
57.544	1.04
63.096	1.03
69.183	1.01
75.858	1.00
83.176	1.00
91.201	0.99
100.000	0.98
109.648	0.97
120.226	0.96
131.826	0.95
144.544	0.93
158.489	0.91
173.780	0.88
190.546	0.84
208.930	0.80
229.087	0.74
251.189	

Size (µm)	Volume In %
251.189	0.67
275.423	0.60
301.995	0.52
331.131	0.43
363.078	0.35
398.107	0.27
436.516	0.20
478.630	0.10
524.807	0.04
575.440	0.01
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes: *1200g 3.5mm 1380RPM*

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P2

Measured by:
ALKMM.LaserSizer

Measured:
Wednesday, October 17, 2012 3:47:28 PM

Sample Name:
Bulk Regrind Discharge 1530 - Average

Edited by:
ALKMM.LaserSizer

Analysed:
Wednesday, October 17, 2012 3:47:29 PM

Particle Name: Silica 1.0
Accessory Name: Hydro 2000MU (A)
Analysis model: General purpose
Sensitivity: Normal

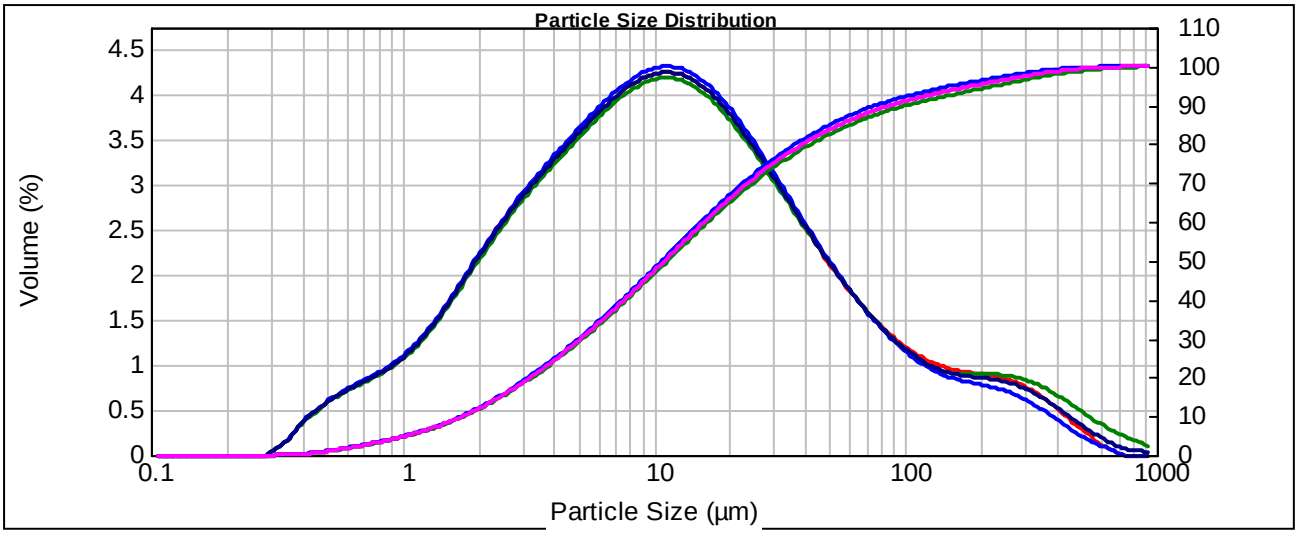
Particle RI: 1.544
Absorption: 1
Size range: 0.100 to 1000.000 um
Obscuration: 12.87 %

Dispersant Name: Water
Dispersant RI: 1.330
Weighted Residual: 0.260 %
Result Emulation: Off

Concentration: 0.0075 %Vol
Span : 7.785
Uniformity: 2.97
Result units: Volume

Specific Surface Area: 1.37 m²/g
Surface Weighted Mean D[3,2]: 4.377 um
Vol. Weighted Mean D[4,3]: 37.280 um

d(0.1): 1.734 um d(0.5): 11.003 um **d(0.8): 39.029 um** d(0.9): 87.388 um d(0.98): 326.25 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.05
0.331	0.09
0.363	0.18
0.398	0.25
0.437	0.30
0.479	

Size (µm)	Volume In %
0.479	0.35
0.525	0.40
0.575	0.44
0.631	0.47
0.692	0.50
0.759	0.54
0.832	0.58
0.912	0.62
1.000	0.68
1.096	0.74
1.202	0.82
1.318	0.91
1.445	1.01
1.585	1.11
1.738	1.21
1.905	1.31
2.089	1.42
2.291	

Size (µm)	Volume In %
2.291	1.51
2.512	1.60
2.754	1.69
3.020	1.78
3.311	1.85
3.631	1.93
3.981	2.01
4.365	2.08
4.786	2.15
5.248	2.22
5.754	2.29
6.310	2.35
6.918	2.41
7.586	2.46
8.318	2.50
9.120	2.53
10.000	2.55
10.965	

Size (µm)	Volume In %
10.965	2.56
12.023	2.55
13.183	2.52
14.454	2.48
15.849	2.43
17.378	2.36
19.055	2.28
20.893	2.19
22.909	2.10
25.119	2.00
27.542	1.90
30.200	1.79
33.113	1.69
36.308	1.58
39.811	1.48
43.652	1.38
47.863	1.28
52.481	

Size (µm)	Volume In %
52.481	1.19
57.544	1.10
63.096	1.01
69.183	0.93
75.858	0.86
83.176	0.79
91.201	0.73
100.000	0.68
109.648	0.63
120.226	0.60
131.826	0.57
144.544	0.55
158.489	0.53
173.780	0.52
190.546	0.52
208.930	0.51
229.087	0.50
251.189	

Size (µm)	Volume In %
251.189	0.48
275.423	0.46
301.995	0.43
331.131	0.39
363.078	0.34
398.107	0.29
436.516	0.25
478.630	0.20
524.807	0.15
575.440	0.12
630.957	0.08
691.831	0.05
758.578	0.03
831.764	0.03
912.011	0.01
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P3

Measured by:
lloyd

Measured:
Thursday, October 18, 2012 12:05:29 PM

Sample Name:
Bulk Regrind Discharge 1130 - Average

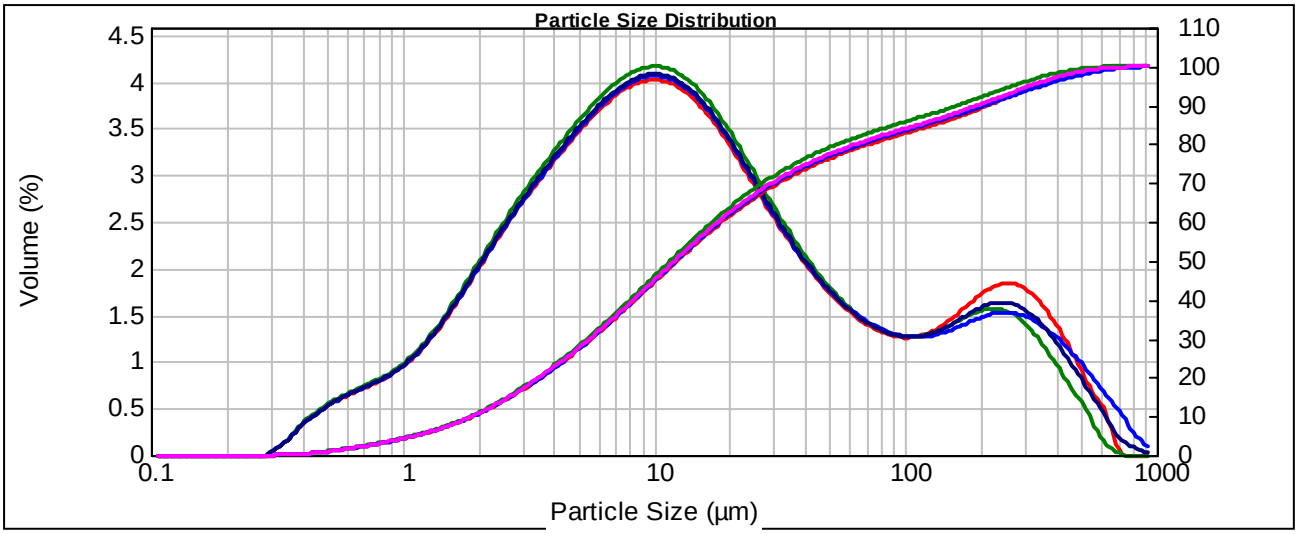
Edited by:
lloyd

Analysed:
Thursday, October 18, 2012 12:05:30 PM

Particle Name: Silica 1.0	**Accessory Name:** Hydro 2000MU (A)	**Analysis model:** General purpose	**Sensitivity:** Normal
Particle RI: 1.544	**Absorption:** 1	**Size range:** 0.100 to 1000.000 um	**Obscuration:** 9.94 %
Dispersant Name: Water	**Dispersant RI:** 1.330	**Weighted Residual:** 0.281 %	**Result Emulation:** Off

Concentration: 0.0061 %Vol	**Span :** 15.932	**Uniformity:** 4.31	**Result units:** Volume
Specific Surface Area: 1.27 m²/g	**Surface Weighted Mean D[3,2]:** 4.737 um	**Vol. Weighted Mean D[4,3]:** 56.977 um	

d(0.1): 1.891 um d(0.5): 12.063 um **d(0.8): 63.192 um** d(0.9): 194.079 um d(0.98): 444.41 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.05
0.331	0.09
0.363	0.16
0.398	0.23
0.437	0.27
0.479	

Size (µm)	Volume In %
0.479	0.32
0.525	0.36
0.575	0.39
0.631	0.42
0.692	0.45
0.759	0.48
0.832	0.51
0.912	0.55
1.000	0.60
1.096	0.66
1.202	0.73
1.318	0.82
1.445	0.91
1.585	1.01
1.738	1.11
1.905	1.21
2.089	1.31
2.291	

Size (µm)	Volume In %
2.291	1.41
2.512	1.51
2.754	1.61
3.020	1.70
3.311	1.79
3.631	1.87
3.981	1.95
4.365	2.03
4.786	2.11
5.248	2.18
5.754	2.25
6.310	2.31
6.918	2.37
7.586	2.41
8.318	2.44
9.120	2.45
10.000	2.45
10.965	

Size (µm)	Volume In %
10.965	2.44
12.023	2.41
13.183	2.36
14.454	2.30
15.849	2.22
17.378	2.14
19.055	2.04
20.893	1.93
22.909	1.82
25.119	1.72
27.542	1.61
30.200	1.50
33.113	1.40
36.308	1.30
39.811	1.21
43.652	1.13
47.863	1.06
52.481	

Size (µm)	Volume In %
52.481	0.99
57.544	0.93
63.096	0.88
69.183	0.84
75.858	0.81
83.176	0.78
91.201	0.77
100.000	0.76
109.648	0.77
120.226	0.78
131.826	0.81
144.544	0.84
158.489	0.88
173.780	0.92
190.546	0.95
208.930	0.98
229.087	0.99
251.189	

Size (µm)	Volume In %
251.189	0.98
275.423	0.96
301.995	0.91
331.131	0.85
363.078	0.77
398.107	0.68
436.516	0.59
478.630	0.49
524.807	0.39
575.440	0.29
630.957	0.18
691.831	0.09
758.578	0.06
831.764	0.03
912.011	0.01
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P3

Measured by:
lloyd

Measured:
Thursday, October 18, 2012 1:02:04 PM

Sample Name:
Bulk Regrind Discharge 1245 - Average

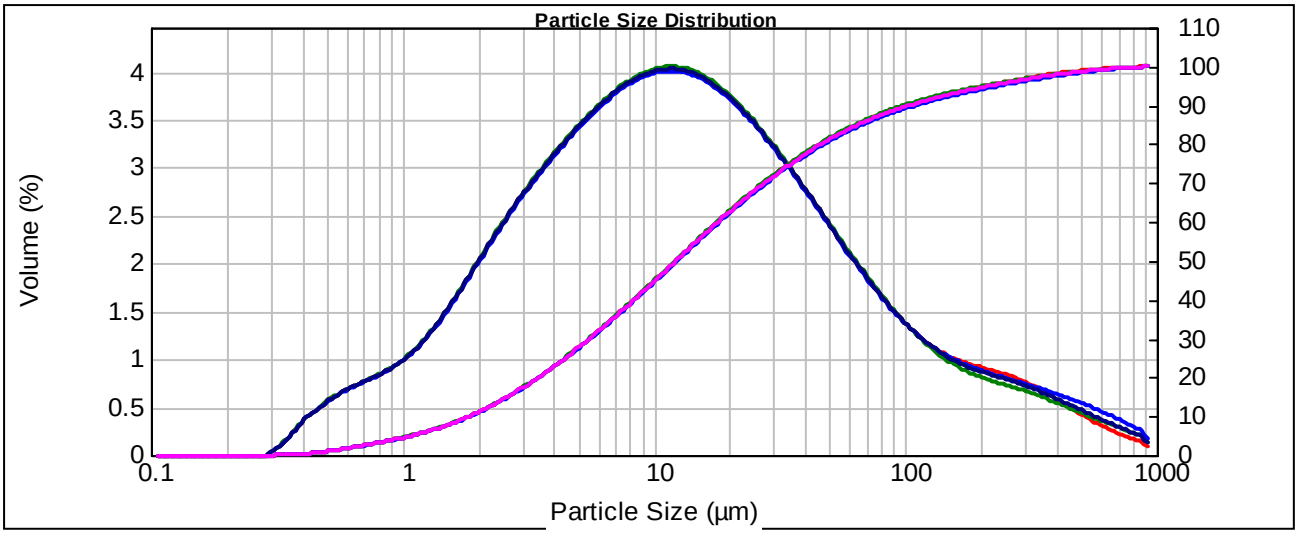
Edited by:
lloyd

Analysed:
Thursday, October 18, 2012 1:02:05 PM

Particle Name: Silica 1.0
Accessory Name: Hydro 2000MU (A)
Analysis model: General purpose
Sensitivity: Normal
Particle RI: 1.544
Absorption: 1
Size range: 0.100 to 1000.000 um
Obscuration: 18.27 %
Dispersant Name: Water
Dispersant RI: 1.330
Weighted Residual: 0.238 %
Result Emulation: Off

Concentration: 0.0116 %Vol
Span : 8.299
Uniformity: 3.24
Result units: Volume
Specific Surface Area: 1.3 m²/g
Surface Weighted Mean D[3,2]: 4.630 um
Vol. Weighted Mean D[4,3]: 44.641 um

d(0.1): 1.844 um d(0.5): 12.227 um **d(0.8): 46.183 um** d(0.9): 103.310 um d(0.98): 406.91 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.05
0.363	0.09
0.398	0.17
0.437	0.24
0.479	0.29

Size (µm)	Volume In %
0.479	0.34
0.525	0.38
0.575	0.41
0.631	0.44
0.692	0.47
0.759	0.50
0.832	0.53
0.912	0.57
1.000	0.62
1.096	0.68
1.202	0.75
1.318	0.83
1.445	0.92
1.585	1.01
1.738	1.11
1.905	1.21
2.089	1.31
2.291	

Size (µm)	Volume In %
2.291	1.41
2.512	1.51
2.754	1.60
3.020	1.68
3.311	1.77
3.631	1.85
3.981	1.92
4.365	1.99
4.786	2.06
5.248	2.13
5.754	2.19
6.310	2.25
6.918	2.30
7.586	2.34
8.318	2.38
9.120	2.40
10.000	2.42
10.965	

Size (µm)	Volume In %
10.965	2.43
12.023	2.42
13.183	2.41
14.454	2.39
15.849	2.35
17.378	2.30
19.055	2.25
20.893	2.19
22.909	2.12
25.119	2.05
27.542	1.97
30.200	1.89
33.113	1.80
36.308	1.72
39.811	1.63
43.652	1.54
47.863	1.44
52.481	

Size (µm)	Volume In %
52.481	1.35
57.544	1.26
63.096	1.17
69.183	1.09
75.858	1.01
83.176	0.93
91.201	0.86
100.000	0.80
109.648	0.74
120.226	0.69
131.826	0.64
144.544	0.60
158.489	0.57
173.780	0.55
190.546	0.53
208.930	0.51
229.087	0.49
251.189	

Size (µm)	Volume In %
251.189	0.47
275.423	0.45
301.995	0.42
331.131	0.40
363.078	0.37
398.107	0.34
436.516	0.31
478.630	0.28
524.807	0.25
575.440	0.23
630.957	0.20
691.831	0.17
758.578	0.14
831.764	0.12
912.011	0.03
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P3

Measured by:
lloyd

Measured:
Thursday, October 18, 2012 2:02:01 PM

Sample Name:
Bulk Regrind Discharge 1330 - Average

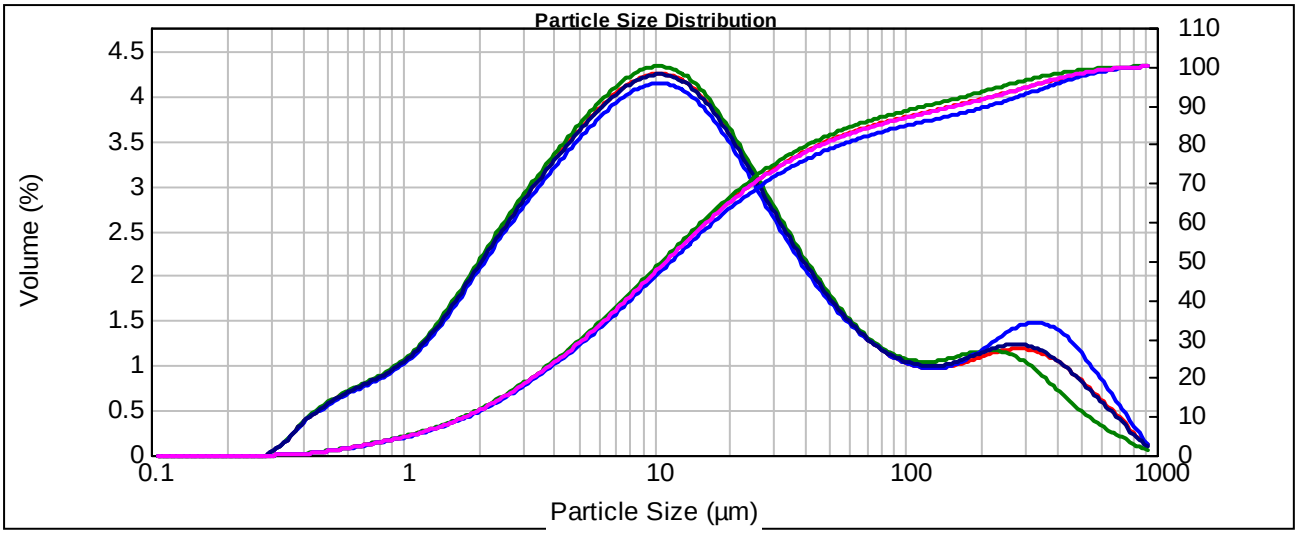
Edited by:
lloyd

Analysed:
Thursday, October 18, 2012 2:02:02 PM

Particle Name: Silica 1.0	**Accessory Name:** Hydro 2000MU (A)	**Analysis model:** General purpose	**Sensitivity:** Normal
Particle RI: 1.544	**Absorption:** 1	**Size range:** 0.100 to 1000.000 um	**Obscuration:** 14.88 %
Dispersant Name: Water	**Dispersant RI:** 1.330	**Weighted Residual:** 0.247 %	**Result Emulation:** Off

Concentration: 0.0090 %Vol	**Span :** 14.454	**Uniformity:** 4.36	**Result units:** Volume
Specific Surface Area: 1.33 m²/g	**Surface Weighted Mean D[3,2]:** 4.502 um	**Vol. Weighted Mean D[4,3]:** 53.754 um	

d(0.1): 1.795 um d(0.5): 11.235 um **d(0.8): 47.087 um** d(0.9): 164.186 um d(0.98): 483.51 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.05
0.331	0.10
0.363	0.18
0.398	0.25
0.437	0.29
0.479	

Size (µm)	Volume In %
0.479	0.34
0.525	0.38
0.575	0.42
0.631	0.45
0.692	0.48
0.759	0.51
0.832	0.55
0.912	0.59
1.000	0.64
1.096	0.71
1.202	0.78
1.318	0.86
1.445	0.96
1.585	1.06
1.738	1.16
1.905	1.26
2.089	1.37
2.291	

Size (µm)	Volume In %
2.291	1.47
2.512	1.56
2.754	1.66
3.020	1.75
3.311	1.84
3.631	1.93
3.981	2.01
4.365	2.09
4.786	2.17
5.248	2.24
5.754	2.31
6.310	2.38
6.918	2.43
7.586	2.48
8.318	2.52
9.120	2.54
10.000	2.55
10.965	

Size (µm)	Volume In %
10.965	2.54
12.023	2.52
13.183	2.48
14.454	2.42
15.849	2.34
17.378	2.25
19.055	2.15
20.893	2.04
22.909	1.92
25.119	1.80
27.542	1.68
30.200	1.56
33.113	1.45
36.308	1.34
39.811	1.24
43.652	1.14
47.863	1.05
52.481	

Size (µm)	Volume In %
52.481	0.97
57.544	0.89
63.096	0.82
69.183	0.77
75.858	0.72
83.176	0.67
91.201	0.64
100.000	0.62
109.648	0.60
120.226	0.60
131.826	0.60
144.544	0.61
158.489	0.63
173.780	0.66
190.546	0.69
208.930	0.71
229.087	0.73
251.189	

Size (µm)	Volume In %
251.189	0.74
275.423	0.74
301.995	0.73
331.131	0.70
363.078	0.67
398.107	0.62
436.516	0.56
478.630	0.49
524.807	0.42
575.440	0.35
630.957	0.29
691.831	0.23
758.578	0.14
831.764	0.09
912.011	0.03
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P4

Measured by:
lloyd

Measured:
Friday, October 19, 2012 10:15:06 AM

Sample Name:
Bulk Regrind Discharge 0945 - Average

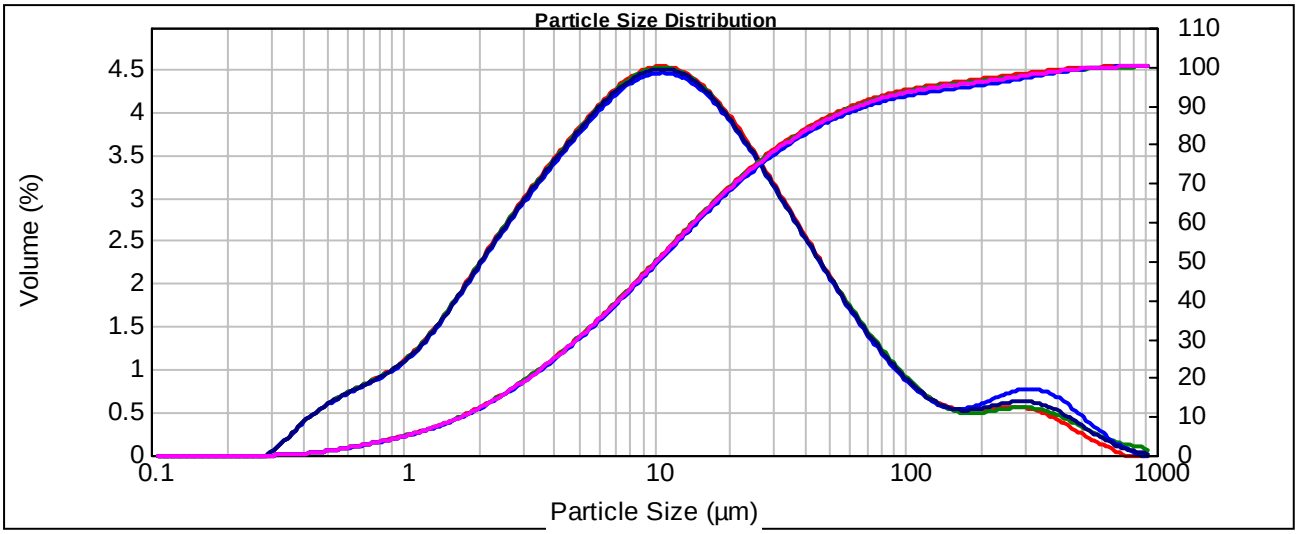
Edited by:
lloyd

Analysed:
Friday, October 19, 2012 10:15:08 AM

Particle Name: Silica 1.0	**Accessory Name:** Hydro 2000MU (A)	**Analysis model:** General purpose	**Sensitivity:** Normal
Particle RI: 1.544	**Absorption:** 1	**Size range:** 0.100 to 1000.000 um	**Obscuration:** 16.11 %
Dispersant Name: Water	**Dispersant RI:** 1.330	**Weighted Residual:** 0.236 %	**Result Emulation:** Off

Concentration: 0.0093 %Vol	**Span :** 6.238	**Uniformity:** 2.79	**Result units:** Volume
Specific Surface Area: 1.4 m²/g	**Surface Weighted Mean D[3,2]:** 4.283 um	**Vol. Weighted Mean D[4,3]:** 33.241 um	

d(0.1): 1.728 um d(0.5): 10.324 um **d(0.8): 33.168 um** d(0.9): 66.130 um d(0.98): 325.7 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.06
0.331	0.11
0.363	0.19
0.398	0.26
0.437	0.30
0.479	

Size (µm)	Volume In %
0.479	0.35
0.525	0.40
0.575	0.44
0.631	0.47
0.692	0.50
0.759	0.54
0.832	0.58
0.912	0.62
1.000	0.68
1.096	0.74
1.202	0.82
1.318	0.91
1.445	1.00
1.585	1.11
1.738	1.21
1.905	1.32
2.089	1.43
2.291	

Size (µm)	Volume In %
2.291	1.53
2.512	1.63
2.754	1.73
3.020	1.83
3.311	1.92
3.631	2.01
3.981	2.10
4.365	2.19
4.786	2.27
5.248	2.35
5.754	2.43
6.310	2.50
6.918	2.57
7.586	2.62
8.318	2.66
9.120	2.69
10.000	2.70
10.965	

Size (µm)	Volume In %
10.965	2.70
12.023	2.68
13.183	2.65
14.454	2.59
15.849	2.53
17.378	2.45
19.055	2.36
20.893	2.26
22.909	2.16
25.119	2.05
27.542	1.94
30.200	1.82
33.113	1.71
36.308	1.59
39.811	1.47
43.652	1.36
47.863	1.25
52.481	

Size (µm)	Volume In %
52.481	1.14
57.544	1.03
63.096	0.93
69.183	0.84
75.858	0.74
83.176	0.66
91.201	0.58
100.000	0.51
109.648	0.44
120.226	0.39
131.826	0.35
144.544	0.33
158.489	0.31
173.780	0.32
190.546	0.33
208.930	0.34
229.087	0.36
251.189	

Size (µm)	Volume In %
251.189	0.37
275.423	0.38
301.995	0.37
331.131	0.36
363.078	0.33
398.107	0.30
436.516	0.26
478.630	0.21
524.807	0.16
575.440	0.13
630.957	0.08
691.831	0.05
758.578	0.03
831.764	0.02
912.011	0.00
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P4

Measured by:
lloyd

Measured:
Friday, October 19, 2012 12:15:55 PM

Sample Name:
Bulk Regrind Discharge 1130 - Average

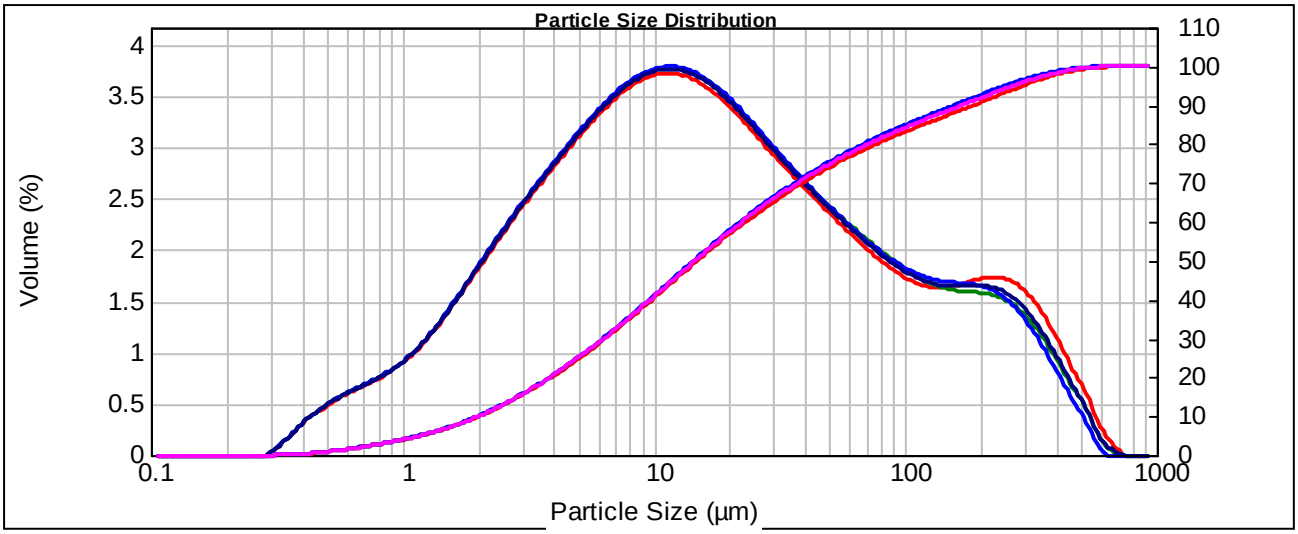
Edited by:
lloyd

Analysed:
Friday, October 19, 2012 12:15:56 PM

Particle Name: Silica 1.0
Accessory Name: Hydro 2000MU (A)
Analysis model: General purpose
Sensitivity: Normal
Particle RI: 1.544
Absorption: 1
Size range: 0.100 to 1000.000 um
Obscuration: 17.04 %
Dispersant Name: Water
Dispersant RI: 1.330
Weighted Residual: 0.223 %
Result Emulation: Off

Concentration: 0.0117 %Vol
Span : 11.358
Uniformity: 3.25
Result units: Volume
Specific Surface Area: 1.18 m²/g
Surface Weighted Mean D[3,2]: 5.083 um
Vol. Weighted Mean D[4,3]: 53.077 um

d(0.1): 1.997 um d(0.5): 14.537 um **d(0.8): 70.731 um** d(0.9): 167.101 um d(0.98): 375.94 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.05
0.331	0.09
0.363	0.15
0.398	0.21
0.437	0.25
0.479	

Size (µm)	Volume In %
0.479	0.30
0.525	0.33
0.575	0.36
0.631	0.39
0.692	0.42
0.759	0.45
0.832	0.48
0.912	0.52
1.000	0.57
1.096	0.62
1.202	0.69
1.318	0.76
1.445	0.84
1.585	0.93
1.738	1.01
1.905	1.10
2.089	1.19
2.291	

Size (µm)	Volume In %
2.291	1.27
2.512	1.36
2.754	1.44
3.020	1.52
3.311	1.59
3.631	1.67
3.981	1.74
4.365	1.81
4.786	1.88
5.248	1.95
5.754	2.02
6.310	2.08
6.918	2.13
7.586	2.18
8.318	2.21
9.120	2.24
10.000	2.26
10.965	

Size (µm)	Volume In %
10.965	2.27
12.023	2.26
13.183	2.24
14.454	2.22
15.849	2.18
17.378	2.13
19.055	2.08
20.893	2.02
22.909	1.95
25.119	1.88
27.542	1.82
30.200	1.75
33.113	1.68
36.308	1.62
39.811	1.56
43.652	1.50
47.863	1.44
52.481	

Size (µm)	Volume In %
52.481	1.39
57.544	1.33
63.096	1.28
69.183	1.23
75.858	1.18
83.176	1.14
91.201	1.09
100.000	1.06
109.648	1.03
120.226	1.01
131.826	1.00
144.544	0.99
158.489	0.99
173.780	0.99
190.546	0.99
208.930	0.99
229.087	0.97
251.189	

Size (µm)	Volume In %
251.189	0.94
275.423	0.89
301.995	0.82
331.131	0.73
363.078	0.64
398.107	0.53
436.516	0.42
478.630	0.33
524.807	0.22
575.440	0.08
630.957	0.04
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P4

Measured by:
lloyd

Measured:
Friday, October 19, 2012 2:02:50 PM

Sample Name:
Bulk Regrind Discharge 1330 - Average

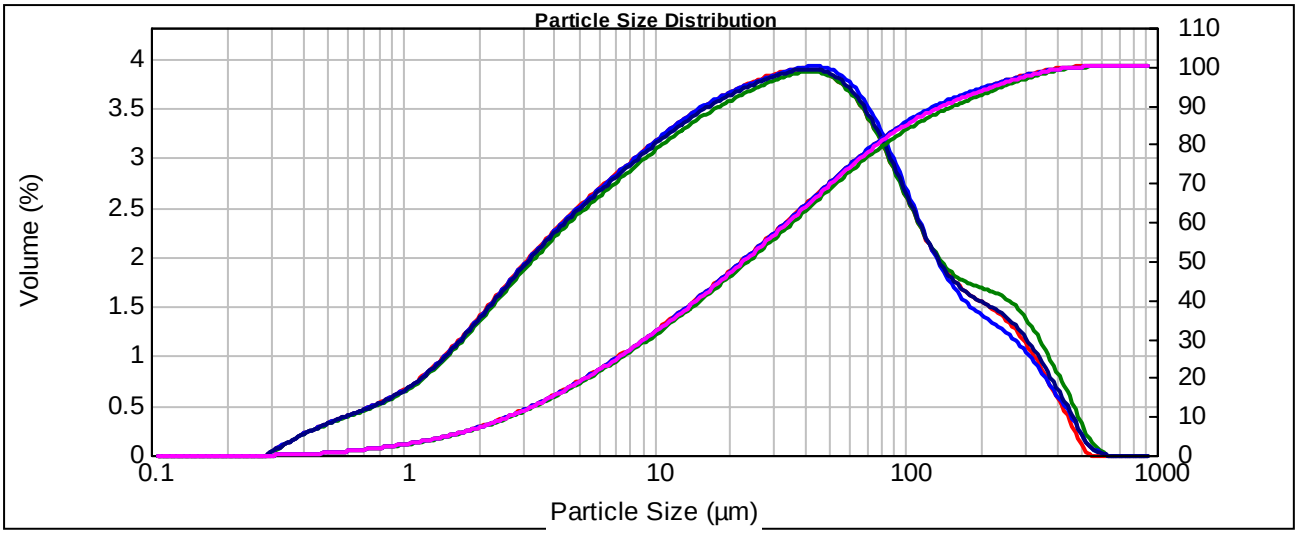
Edited by:
lloyd

Analysed:
Friday, October 19, 2012 2:02:51 PM

Particle Name: Silica 1.0	**Accessory Name:** Hydro 2000MU (A)	**Analysis model:** General purpose	**Sensitivity:** Normal
Particle RI: 1.544	**Absorption:** 1	**Size range:** 0.100 to 1000.000 um	**Obscuration:** 16.72 %
Dispersant Name: Water	**Dispersant RI:** 1.330	**Weighted Residual:** 0.192 %	**Result Emulation:** Off

Concentration: 0.0152 %Vol	**Span :** 6.097	**Uniformity:** 1.94	**Result units:** Volume
Specific Surface Area: 0.901 m²/g	**Surface Weighted Mean D[3,2]:** 6.658 um	**Vol. Weighted Mean D[4,3]:** 53.085 um	

d(0.1): 2.671 um d(0.5): 22.911 um **d(0.8): 77.879 um** d(0.9): 142.368 um d(0.98): 323.09 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.04
0.331	0.07
0.363	0.11
0.398	0.14
0.437	0.16
0.479	

Size (µm)	Volume In %
0.479	0.19
0.525	0.22
0.575	0.24
0.631	0.26
0.692	0.28
0.759	0.31
0.832	0.34
0.912	0.37
1.000	0.40
1.096	0.45
1.202	0.50
1.318	0.55
1.445	0.61
1.585	0.68
1.738	0.75
1.905	0.82
2.089	0.89
2.291	

Size (µm)	Volume In %
2.291	0.96
2.512	1.03
2.754	1.11
3.020	1.18
3.311	1.24
3.631	1.31
3.981	1.37
4.365	1.43
4.786	1.49
5.248	1.54
5.754	1.60
6.310	1.65
6.918	1.70
7.586	1.75
8.318	1.80
9.120	1.85
10.000	1.90
10.965	

Size (µm)	Volume In %
10.965	1.95
12.023	2.00
13.183	2.04
14.454	2.08
15.849	2.12
17.378	2.15
19.055	2.18
20.893	2.21
22.909	2.24
25.119	2.26
27.542	2.29
30.200	2.31
33.113	2.32
36.308	2.34
39.811	2.34
43.652	2.33
47.863	2.31
52.481	

Size (µm)	Volume In %
52.481	2.28
57.544	2.22
63.096	2.15
69.183	2.05
75.858	1.94
83.176	1.80
91.201	1.67
100.000	1.53
109.648	1.39
120.226	1.27
131.826	1.16
144.544	1.08
158.489	1.02
173.780	0.97
190.546	0.93
208.930	0.90
229.087	0.86
251.189	

Size (µm)	Volume In %
251.189	0.81
275.423	0.75
301.995	0.67
331.131	0.57
363.078	0.47
398.107	0.36
436.516	0.26
478.630	0.12
524.807	0.04
575.440	0.01
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P4

Measured by:
lloyd

Measured:
Friday, October 19, 2012 3:29:14 PM

Sample Name:
Bulk Regrind Discharge 1500 - Average

Edited by:
lloyd

Analysed:
Friday, October 19, 2012 3:29:15 PM

Particle Name: Silica 1.0
Particle RI: 1.544
Dispersant Name: Water

Accessory Name: Hydro 2000MU (A)
Absorption: 1
Dispersant RI: 1.330

Analysis model: General purpose
Size range: 0.100 to 1000.000 um
Weighted Residual: 0.475 %

Sensitivity: Normal
Obscuration: 18.38 %
Result Emulation: Off

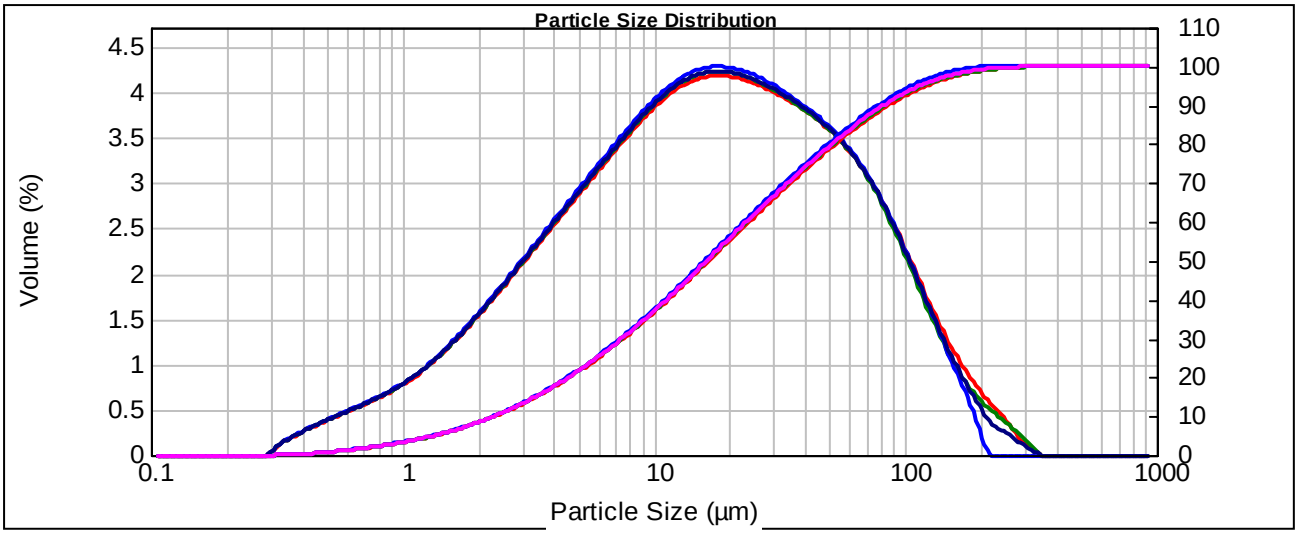
Concentration: 0.0142 %Vol
Specific Surface Area: 1.06 m²/g

Span : 4.910
Surface Weighted Mean D[3,2]: 5.637 um

Uniformity: 1.53
Vol. Weighted Mean D[4,3]: 31.509 um

Result units: Volume

d(0.1): 2.307 um d(0.5): 16.219 um **d(0.8): 50.936 um** d(0.9): 81.943 um d(0.98): 155.98 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.06
0.331	0.10
0.363	0.14
0.398	0.17
0.437	0.20
0.479	

Size (µm)	Volume In %
0.479	0.23
0.525	0.26
0.575	0.29
0.631	0.32
0.692	0.35
0.759	0.38
0.832	0.41
0.912	0.45
1.000	0.49
1.096	0.54
1.202	0.59
1.318	0.65
1.445	0.71
1.585	0.78
1.738	0.85
1.905	0.93
2.089	1.01
2.291	

Size (µm)	Volume In %
2.291	1.08
2.512	1.16
2.754	1.25
3.020	1.33
3.311	1.41
3.631	1.50
3.981	1.58
4.365	1.66
4.786	1.74
5.248	1.82
5.754	1.91
6.310	1.99
6.918	2.07
7.586	2.15
8.318	2.22
9.120	2.29
10.000	2.36
10.965	

Size (µm)	Volume In %
10.965	2.42
12.023	2.47
13.183	2.50
14.454	2.53
15.849	2.54
17.378	2.55
19.055	2.54
20.893	2.53
22.909	2.50
25.119	2.48
27.542	2.44
30.200	2.41
33.113	2.37
36.308	2.32
39.811	2.27
43.652	2.22
47.863	2.16
52.481	

Size (µm)	Volume In %
52.481	2.10
57.544	2.02
63.096	1.93
69.183	1.83
75.858	1.71
83.176	1.57
91.201	1.43
100.000	1.28
109.648	1.12
120.226	0.96
131.826	0.81
144.544	0.67
158.489	0.54
173.780	0.42
190.546	0.31
208.930	0.21
229.087	0.17
251.189	

Size (µm)	Volume In %
251.189	0.13
275.423	0.07
301.995	0.04
331.131	0.00
363.078	0.00
398.107	0.00
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P5

Sample Name:
Bulk Regrind Discharge 0930 - Average

Measured by:
Neville

Edited by:
Neville

Measured:
Monday, October 22, 2012 9:39:49 AM

Analysed:
Monday, October 22, 2012 9:39:50 AM

Particle Name: Silica 1.0
Particle RI: 1.544
Dispersant Name: Water

Accessory Name: Hydro 2000MU (A)
Absorption: 1
Dispersant RI: 1.330

Analysis model: General purpose
Size range: 0.100 to 1000.000 um
Weighted Residual: 0.081 %

Sensitivity: Normal
Obscuration: 18.84 %
Result Emulation: Off

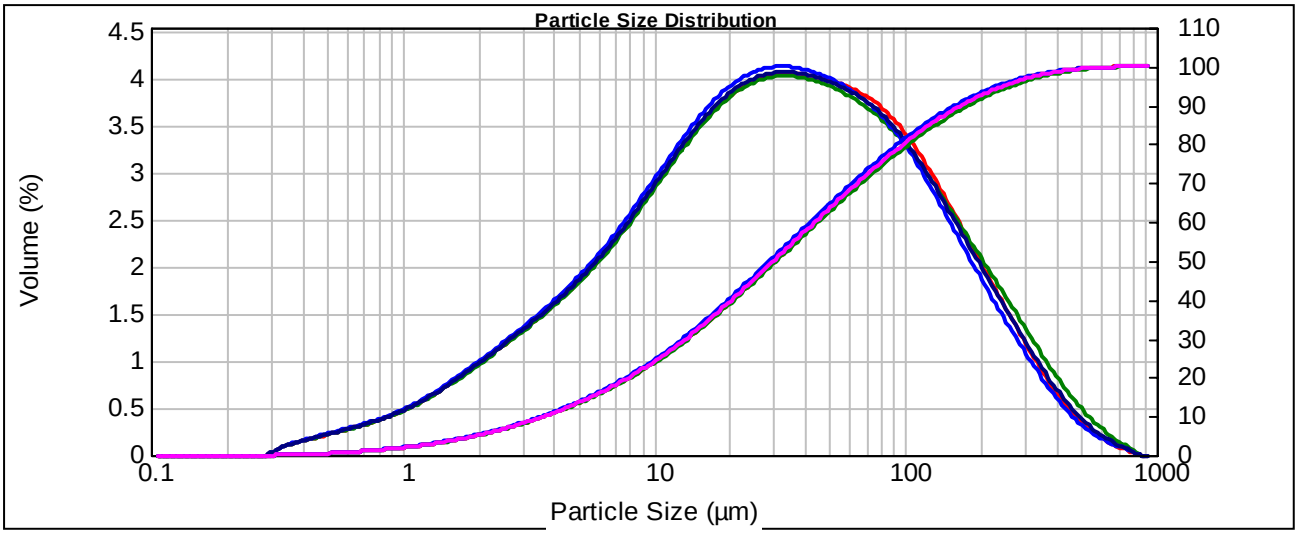
Concentration: 0.0223 %Vol
Specific Surface Area: 0.706 m²/g

Span : 5.443
Surface Weighted Mean D[3,2]: 8.500 um

Uniformity: 1.73
Vol. Weighted Mean D[4,3]: 63.917 um

Result units: Volume

d(0.1): 3.637 um d(0.5): 29.989 um **d(0.8): 98.330 um** d(0.9): 166.881 um d(0.98): 354.77 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.04
0.331	0.06
0.363	0.08
0.398	0.10
0.437	0.12
0.479	

Size (µm)	Volume In %
0.479	0.13
0.525	0.15
0.575	0.17
0.631	0.18
0.692	0.20
0.759	0.22
0.832	0.25
0.912	0.27
1.000	0.30
1.096	0.33
1.202	0.37
1.318	0.41
1.445	0.45
1.585	0.49
1.738	0.54
1.905	0.58
2.089	0.63
2.291	

Size (µm)	Volume In %
2.291	0.68
2.512	0.73
2.754	0.78
3.020	0.83
3.311	0.88
3.631	0.94
3.981	1.00
4.365	1.06
4.786	1.12
5.248	1.18
5.754	1.26
6.310	1.33
6.918	1.41
7.586	1.50
8.318	1.59
9.120	1.68
10.000	1.77
10.965	

Size (µm)	Volume In %
10.965	1.86
12.023	1.95
13.183	2.04
14.454	2.12
15.849	2.19
17.378	2.26
19.055	2.32
20.893	2.36
22.909	2.40
25.119	2.42
27.542	2.44
30.200	2.45
33.113	2.45
36.308	2.44
39.811	2.43
43.652	2.41
47.863	2.39
52.481	

Size (µm)	Volume In %
52.481	2.36
57.544	2.33
63.096	2.29
69.183	2.25
75.858	2.19
83.176	2.13
91.201	2.05
100.000	1.97
109.648	1.87
120.226	1.77
131.826	1.66
144.544	1.55
158.489	1.44
173.780	1.32
190.546	1.21
208.930	1.10
229.087	0.99
251.189	

Size (µm)	Volume In %
251.189	0.88
275.423	0.77
301.995	0.67
331.131	0.57
363.078	0.47
398.107	0.38
436.516	0.30
478.630	0.23
524.807	0.18
575.440	0.13
630.957	0.09
691.831	0.06
758.578	0.03
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P5

Measured by:
ALKMM.LaserSizer

Measured:
Monday, October 22, 2012 10:51:39 AM

Sample Name:
Bulk Regrind Discharge 1045 - Average

Edited by:
ALKMM.LaserSizer

Analysed:
Monday, October 22, 2012 10:51:41 AM

Particle Name:
Silica 1.0

Accessory Name:
Hydro 2000MU (A)

Analysis model:
General purpose

Sensitivity:
Normal

Particle RI:
1.544

Absorption:
1

Size range:
0.100 to 1000.000 um

Obscuration:
15.93 %

Dispersant Name:
Water

Dispersant RI:
1.330

Weighted Residual:
0.247 %

Result Emulation:
Off

Concentration:
0.0165 %Vol

Span :
3.961

Uniformity:
1.27

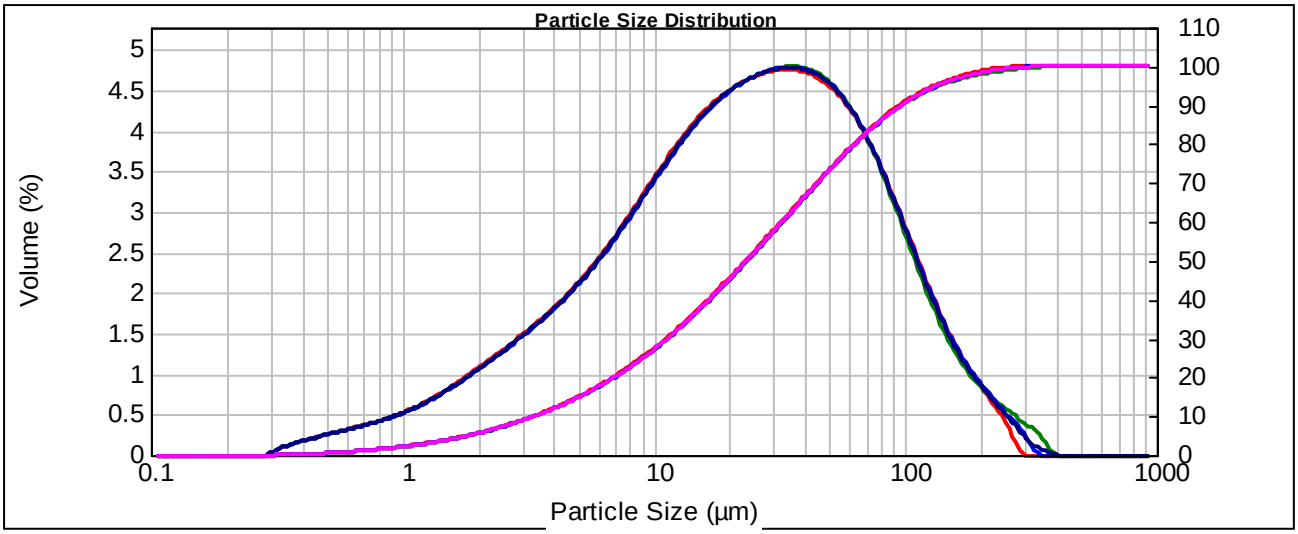
Result units:
Volume

Specific Surface Area:
0.791 m²/g

Surface Weighted Mean D[3,2]:
7.587 um

Vol. Weighted Mean D[4,3]:
39.483 um

d(0.1): 3.310 um d(0.5): 23.354 um **d(0.8): 62.745 um** d(0.9): 95.814 um d(0.98): 185.82 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.04
0.331	0.07
0.363	0.09
0.398	0.12
0.437	0.13
0.479	

Size (µm)	Volume In %
0.479	0.15
0.525	0.17
0.575	0.19
0.631	0.21
0.692	0.23
0.759	0.25
0.832	0.27
0.912	0.30
1.000	0.33
1.096	0.36
1.202	0.40
1.318	0.44
1.445	0.48
1.585	0.53
1.738	0.58
1.905	0.64
2.089	0.69
2.291	

Size (µm)	Volume In %
2.291	0.74
2.512	0.80
2.754	0.86
3.020	0.92
3.311	0.98
3.631	1.05
3.981	1.12
4.365	1.19
4.786	1.27
5.248	1.36
5.754	1.45
6.310	1.55
6.918	1.65
7.586	1.76
8.318	1.87
9.120	1.98
10.000	2.10
10.965	

Size (µm)	Volume In %
10.965	2.21
12.023	2.31
13.183	2.41
14.454	2.49
15.849	2.57
17.378	2.64
19.055	2.70
20.893	2.75
22.909	2.79
25.119	2.83
27.542	2.85
30.200	2.87
33.113	2.87
36.308	2.87
39.811	2.85
43.652	2.81
47.863	2.75
52.481	

Size (µm)	Volume In %
52.481	2.68
57.544	2.58
63.096	2.45
69.183	2.31
75.858	2.15
83.176	1.96
91.201	1.77
100.000	1.57
109.648	1.38
120.226	1.19
131.826	1.02
144.544	0.86
158.489	0.73
173.780	0.62
190.546	0.52
208.930	0.43
229.087	0.34
251.189	

Size (µm)	Volume In %
251.189	0.25
275.423	0.16
301.995	0.08
331.131	0.05
363.078	0.01
398.107	0.00
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P5

Measured by:
ALKMM.LaserSizer

Measured:
Monday, October 22, 2012 1:50:12 PM

Sample Name:
Bulk Regrind Discharge 1300 - Average

Edited by:
ALKMM.LaserSizer

Analysed:
Monday, October 22, 2012 1:50:13 PM

Particle Name: Silica 1.0
Accessory Name: Hydro 2000MU (A)
Analysis model: General purpose
Sensitivity: Normal

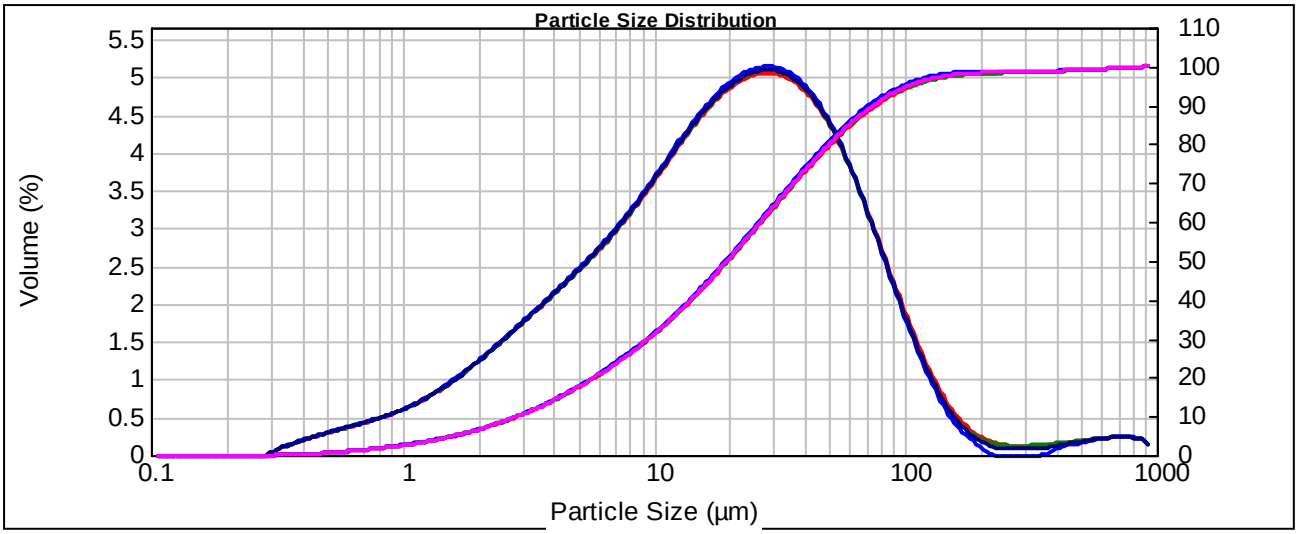
Particle RI: 1.544
Absorption: 1
Size range: 0.100 to 1000.000 um
Obscuration: 16.74 %

Dispersant Name: Water
Dispersant RI: 1.330
Weighted Residual: 0.102 %
Result Emulation: Off

Concentration: 0.0154 %Vol
Span : 3.656
Uniformity: 1.48
Result units: Volume

Specific Surface Area: 0.895 m²/g
Surface Weighted Mean D[3,2]: 6.700 um
Vol. Weighted Mean D[4,3]: 37.306 um

d(0.1): 2.858 um d(0.5): 19.542 um **d(0.8): 49.532 um** d(0.9): 74.306 um d(0.98): 161.67 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.04
0.331	0.08
0.363	0.10
0.398	0.13
0.437	0.15
0.479	

Size (µm)	Volume In %
0.479	0.18
0.525	0.20
0.575	0.22
0.631	0.24
0.692	0.27
0.759	0.29
0.832	0.32
0.912	0.35
1.000	0.38
1.096	0.42
1.202	0.46
1.318	0.51
1.445	0.56
1.585	0.62
1.738	0.68
1.905	0.75
2.089	0.81
2.291	

Size (µm)	Volume In %
2.291	0.88
2.512	0.95
2.754	1.02
3.020	1.10
3.311	1.17
3.631	1.25
3.981	1.32
4.365	1.40
4.786	1.47
5.248	1.55
5.754	1.64
6.310	1.73
6.918	1.82
7.586	1.92
8.318	2.03
9.120	2.14
10.000	2.25
10.965	

Size (µm)	Volume In %
10.965	2.37
12.023	2.48
13.183	2.59
14.454	2.69
15.849	2.79
17.378	2.87
19.055	2.94
20.893	3.00
22.909	3.04
25.119	3.06
27.542	3.07
30.200	3.06
33.113	3.02
36.308	2.96
39.811	2.88
43.652	2.77
47.863	2.64
52.481	

Size (µm)	Volume In %
52.481	2.48
57.544	2.30
63.096	2.10
69.183	1.89
75.858	1.66
83.176	1.43
91.201	1.21
100.000	1.00
109.648	0.80
120.226	0.62
131.826	0.47
144.544	0.34
158.489	0.24
173.780	0.17
190.546	0.11
208.930	0.07
229.087	0.05
251.189	

Size (µm)	Volume In %
251.189	0.05
275.423	0.05
301.995	0.05
331.131	0.05
363.078	0.07
398.107	0.09
436.516	0.10
478.630	0.11
524.807	0.12
575.440	0.13
630.957	0.14
691.831	0.15
758.578	0.14
831.764	0.13
912.011	0.04
1000.000	

Operator notes:

ALS Metallurgy

ISO9001:2008
Certificate No. FS63170

Result Analysis Report

Project and Test number:
KM3512-P5

Measured by:
Mel

Measured:
Monday, October 22, 2012 2:32:38 PM

Sample Name:
Bulk Regrind Discharge 1400 - Average

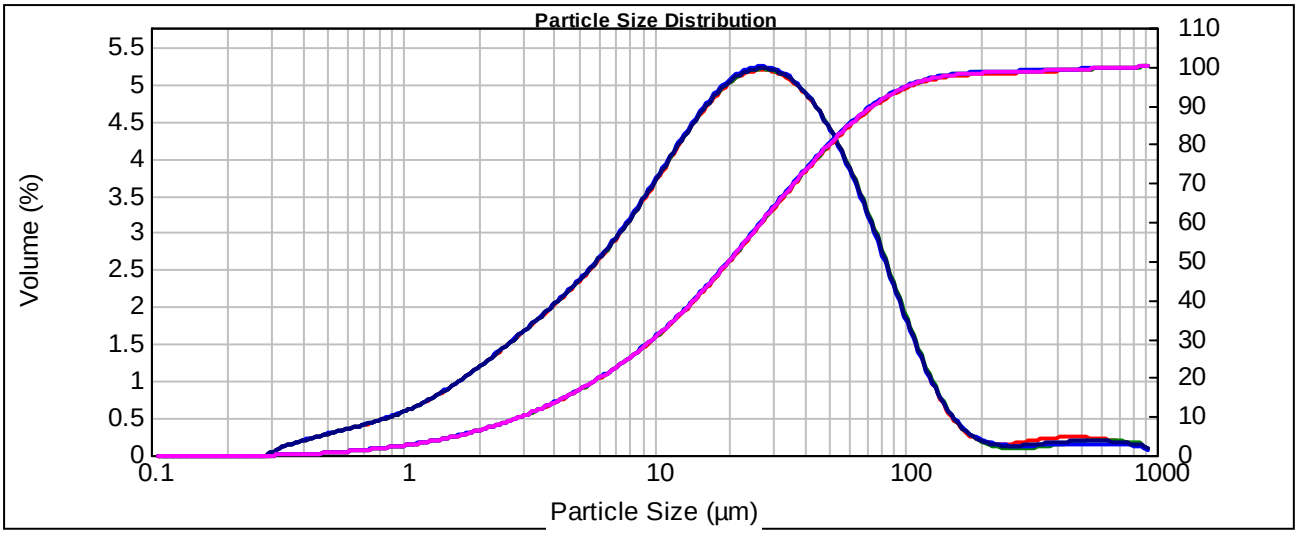
Edited by:
Mel

Analysed:
Monday, October 22, 2012 2:32:39 PM

Particle Name: Silica 1.0
Accessory Name: Hydro 2000MU (A)
Analysis model: General purpose
Sensitivity: Normal
Particle RI: 1.544
Absorption: 1
Size range: 0.100 to 1000.000 um
Obscuration: 18.37 %
Dispersant Name: Water
Dispersant RI: 1.330
Weighted Residual: 0.131 %
Result Emulation: Off

Concentration: 0.0176 %Vol
Span : 3.598
Uniformity: 1.4
Result units: Volume
Specific Surface Area: 0.87 m²/g
Surface Weighted Mean D[3,2]: 6.900 um
Vol. Weighted Mean D[4,3]: 36.743 um

d(0.1): 2.983 um d(0.5): 19.965 um **d(0.8): 49.903 um** d(0.9): 74.813 um d(0.98): 163.36 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.05
0.331	0.08
0.363	0.10
0.398	0.13
0.437	0.15
0.479	

Size (µm)	Volume In %
0.479	0.17
0.525	0.19
0.575	0.21
0.631	0.23
0.692	0.25
0.759	0.28
0.832	0.30
0.912	0.33
1.000	0.37
1.096	0.40
1.202	0.44
1.318	0.49
1.445	0.54
1.585	0.59
1.738	0.65
1.905	0.71
2.089	0.77
2.291	

Size (µm)	Volume In %
2.291	0.83
2.512	0.90
2.754	0.97
3.020	1.03
3.311	1.11
3.631	1.18
3.981	1.25
4.365	1.33
4.786	1.41
5.248	1.50
5.754	1.59
6.310	1.68
6.918	1.79
7.586	1.90
8.318	2.02
9.120	2.14
10.000	2.27
10.965	

Size (µm)	Volume In %
10.965	2.40
12.023	2.52
13.183	2.65
14.454	2.76
15.849	2.86
17.378	2.95
19.055	3.03
20.893	3.08
22.909	3.12
25.119	3.14
27.542	3.13
30.200	3.10
33.113	3.06
36.308	2.98
39.811	2.89
43.652	2.78
47.863	2.64
52.481	

Size (µm)	Volume In %
52.481	2.49
57.544	2.32
63.096	2.12
69.183	1.92
75.858	1.70
83.176	1.47
91.201	1.24
100.000	1.02
109.648	0.81
120.226	0.62
131.826	0.46
144.544	0.33
158.489	0.23
173.780	0.16
190.546	0.12
208.930	0.09
229.087	0.08
251.189	

Size (µm)	Volume In %
251.189	0.08
275.423	0.08
301.995	0.09
331.131	0.09
363.078	0.10
398.107	0.11
436.516	0.11
478.630	0.12
524.807	0.12
575.440	0.11
630.957	0.11
691.831	0.10
758.578	0.09
831.764	0.08
912.011	0.02
1000.000	

Operator notes:

APPENDIX IV – KM3512

SPECIAL DATA

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IV-2 Statistical Analysis of Head Assays 2

IV-3 Comparative Copper Concentrate Assays 4

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IV-2 Locked Cycle Test Results 7

REFERENCE

ALS Minerals Certificate VA12196487

ALS Minerals Certificate VA12288466

TABLE IV-1
REPLICATE HEAD ASSAY DATA

Sample	Assay - percent or g/tonne								
	Cu	Mo	Fe	Au	CuOx	CuCN	S	C	Ag
PP Composite Head 1	0.13	0.031	2.97	0.22	0.004	0.008	0.74	0.46	1
PP Composite Head 2	0.14	0.029	2.92	0.22	0.003	0.007	0.74	0.45	1
Average	**0.14**	**0.030**	**2.95**	**0.22**	**0.004**	**0.008**	**0.74**	**0.45**	**1**
IX Composite Head 1	0.17	0.069	2.42	0.21	0.006	0.011	2.10	0.31	2
IX Composite Head 2	0.17	0.073	2.35	0.22	0.005	0.012	2.02	0.31	2
Average	**0.17**	**0.071**	**2.39**	**0.22**	**0.006**	**0.012**	**2.06**	**0.31**	**2**
WR Composite Head 1	0.19	0.018	2.53	0.20	0.004	0.013	2.49	0.16	1
WR Composite Head 2	0.18	0.019	2.47	0.15	0.005	0.013	2.42	0.16	1
Average	**0.19**	**0.019**	**2.50**	**0.18**	**0.005**	**0.013**	**2.46**	**0.16**	**1**
HYP PP Composite Head 1	0.21	0.034	2.46	0.33	0.009	0.017	2.17	0.18	<1
HYP PP Composite Head 2	0.21	0.030	2.57	0.41	0.010	0.018	2.21	0.19	1
HYP PP Composite Head 3	-	-	-	0.34	-	-	-	-	
HYP PP Composite Head 4	-	-	-	0.30	-	-	-	-	
Average	**0.21**	**0.032**	**2.52**	**0.35**	**0.010**	**0.018**	**2.19**	**0.19**	**1**
SUS PP Composite Head 1	0.29	0.028	4.01	0.37	0.027	0.093	3.29	0.18	1
SUS PP Composite Head 2	0.29	0.027	4.00	0.23	0.026	0.092	3.15	0.17	1
SUS PP Composite Head 3	-	-	-	0.35	-	-	-	-	-
SUS PP Composite Head 4	-	-	-	0.35	-	-	-	-	-
SUS PP Composite Head 5	-	-	-	0.44	-	-	-	-	-
SUS PP Composite Head 6	-	-	-	0.51	-	-	-	-	-
Average	**0.29**	**0.028**	**4.01**	**0.38**	**0.027**	**0.093**	**3.22**	**0.18**	**1**

TABLE IV-2A
STATISTICAL ANALYSIS OF HEAD ASSAYS
PP Composite

Test	Assays - percent or g/tonne					
	Cu	Mo	Fe	S	Ag	Au
1	0.14	0.028	3.0	0.74	-	-
3	0.12	0.027	3.0	0.76	-	-
10	0.14	0.028	2.9	0.69	-	-
11	0.15	0.030	3.0	0.73	-	-
14	0.14	0.026	2.9	0.73	-	-
17	0.15	0.033	3.1	0.74	-	-
18	0.14	0.029	2.9	0.77	-	0.23
24	0.14	0.024	2.9	0.71	1	0.22
28	0.14	0.028	3.1	0.73	-	-
Calculated Head	0.14	0.028	3.0	0.73	1	0.23
Measured Head	0.14	0.030	3.0	0.74	1	0.22

TABLE IV-2B
STATISTICAL ANALYSIS OF HEAD ASSAYS
WR Composite

Test	Assays - percent or g/tonne					
	Cu	Mo	Fe	S	Ag	Au
2	0.19	0.019	2.5	2.40	-	-
4	0.20	0.020	2.5	2.68	-	-
6	0.20	0.017	2.7	2.57	-	-
7	0.19	0.018	2.7	2.70	-	-
12	0.19	0.017	2.4	2.40	-	-
15	0.19	0.019	2.7	2.63	-	-
19	0.20	0.020	2.7	2.60	2	0.28
25	0.19	0.017	2.5	2.42	2	0.21
Calculated Head	0.19	0.018	2.6	2.55	2	0.25
Measured Head	0.19	0.019	2.5	2.46	1	0.18

TABLE IV-2C
STATISTICAL ANALYSIS OF HEAD ASSAYS
IX Composite

Test	Assays - percent or g/tonne					
	Cu	Mo	Fe	S	Ag	Au
5	0.17	0.070	2.3	1.93	-	-
8	0.18	0.067	2.2	1.89	-	-
9	0.18	0.070	2.2	2.05	-	-
13	0.16	0.067	2.3	2.10	-	-
16	0.17	0.082	2.2	1.90	-	-
20	0.16	0.069	2.2	2.00	2	0.23
21	0.17	0.080	2.4	1.83	-	-
22	0.16	0.081	2.4	1.95	-	-
23	0.17	0.083	2.3	1.91	2	0.24
26	0.16	0.070	2.4	1.95	-	-
27	0.17	0.074	2.4	1.94	-	-
Calculated Head	0.17	0.074	2.3	1.95	2	0.24
Measured Head	0.17	0.071	2.4	2.06	2	0.22

TABLE IV-3
COMPARATIVE COPPER CONCENTRATE ASSAYS

Test		Copper - percent	
		AAS	Titre
12		28.0	28.2
13		27.7	28.3
14		29.4	29.7
15		23.8	25.2
16		26.9	28.5
17		28.0	28.6
18	Con I	29.2	28.9
	Con II	27.9	27.6
	Con III	28.4	27.3
	Con IV	28.8	28.1
	Con V	28.2	28.0
19	Con I	28.8	29.2
	Con II	25.2	26.1
	Con III	22.9	23.5
	Con IV	21.7	22.6
	Con V	23.9	24.6
20	Con I	25.4	26.6
	Con II	26.5	27.6
	Con III	27.7	27.8
	Con IV	27.5	28.3
	Con V	27.9	28.8
21		23.7	23.9
22		24.3	24.5
23	Con I	19.9	20.1
	Con V	19.4	19.8
24	Con I	23.4	24.1
	Con II	24.4	25.3
	Con III	23.5	23.9
	Con IV	23.9	24.7
	Con V	24.0	24.4
25	Con I	21.2	23.3
P2	WSC Con	26.3	26.0
P2	WSD Con	21.8	21.8

TABLE IV-4
MINOR ELEMENTS OF THE CONCENTRATES

Element	Symbol	Units	Technique	Test 23 Bulk Con IV&V	Test 24 Bulk Con IV&V	Test 25 Bulk Con IV&V	Test 29 Mo Con
Aluminum	Al	%	Fusion ICP-OES	0.98	0.89	1.11	1.71
Antimony	Sb	g/t	2 Acid ICP-OES	200	1000	70	100
Arsenic	As	g/t	2 Acid ICP-OES	771	977	139	1659
Bismuth	Bi	g/t	2 Acid ICP-OES	126	120	60	68
Cadmium	Cd	g/t	AR FAAS	70	120	50	30
Calcium	Ca	%	WR ICP-OES	0.38	0.20	0.15	0.06
Carbon	C	%	Leco	0.27	0.22	0.16	4.00
Cobalt	Co	g/t	AR FAAS	110	80	150	10
Copper	Cu	%	Titre	18.6	24.6	17.5	0.39
Fluorine	F	g/t	Fusion ISE	150	ND	ND	ND
Gold	Au	g/t	FA FAAS	15.6	24.3	13.5	1.85
Iron	Fe	%	AR FAAS	27.0	25.9	24.9	0.8
Lead	Pb	g/t	AR FAAS	400	740	240	240
Magnesium	Mg	%	Fusion ICP-OES	0.16	0.10	0.09	<0.01
Manganese	Mn	%	Fusion ICP-OES	0.02	0.01	0.01	<0.01
Mercury	Hg	g/t	LeForte rt CV-AAS	<1	<1	<1	<1
Molybdenum	Mo	%	2 Acid FAAS*	7.48	4.32	1.50	57.4
Nickel	Ni	g/t	AR FAAS	280	180	180	120
Palladium	Pd	g/t	FA ICP-OES	0.09	0.11	0.02	-
Phosphorus	P	g/t	3 Acid ICP-OES	<20	<20	76	<20
Platinum	Pt	g/t	FA ICP-OES	0.02	0.13	<0.01	-
Rhenium	Re	g/t	Re-OG62	-	-	-	133.5
Selenium	Se	g/t	ESHKA ICP-OES	98	89	64	301
Silicon	Si	%	Fusion ICP-OES	2.21	2.15	2.32	1.74
Sulphur	S	%	Leco	34.8	33.3	38.8	37.9
Silver	Ag	g/t	AR FAAS	126	107	82	11
Zinc	Zn	g/t	AR FAAS	1080	930	350	280

Analytical Methods

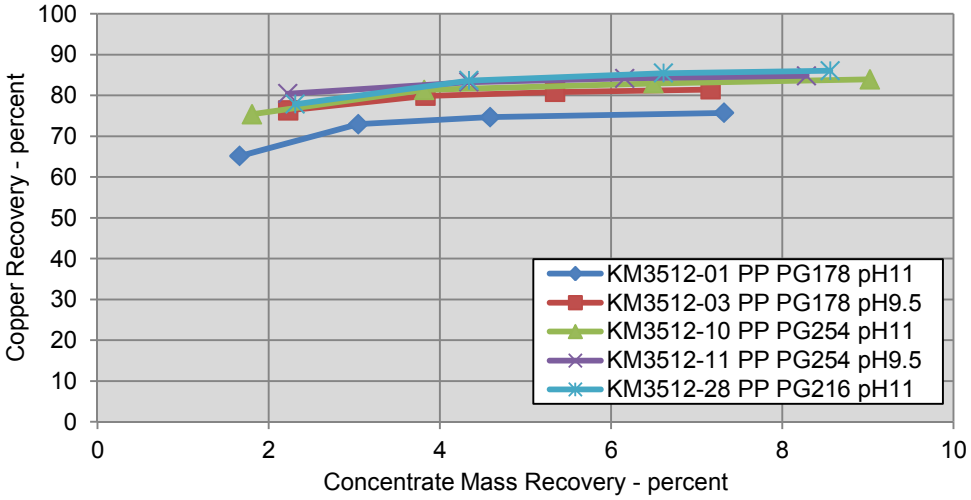
CV-AAS	Cold vapour flameless atomic absorption spectrometry
FAAS	Flame atomic absorption spectrometry
ICP-OES	Inductively coupled plasma - optical emission spectroscopy
Leco	Leco induction furnace
ISE	ion selective electrode
Titr	Classical wet method titration

Digestion Methods

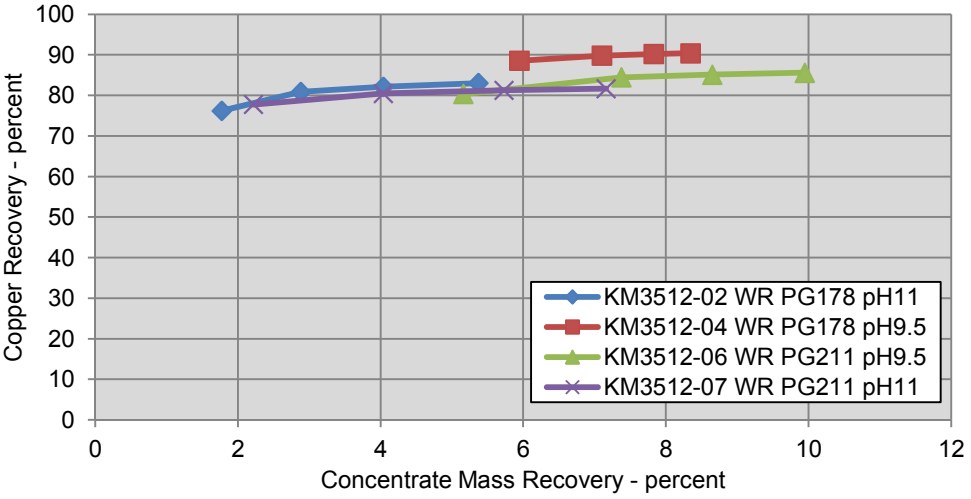
2 Acid	Hydrochloric acid and nitric acid
2 Acid*	Hydrochloric acid, nitric acid and potassium chlorate
2 Acid**	Nitric acid and bromine
3 Acid	Hydrochloric acid, nitric acid and perchloric acid
4 Acid	Hydrochloric acid, nitric acid, hydrofluoric acid and perchloric acid
AR	Aqua regia - 3:1 hydrochloric acid:nitric acid
ESHKA	Magnesium oxide, sodium carbonate sinter
FA	Fire assay fusion
Fusion	Sodium peroxide fusion
Leco	Combusion
LeForte rt	Reverse aqua regia - 1:3 hydrochloric acid:nitric acid, at room temperature
WR	Hydrochloric acid, nitric acid and hydrofluoric acid

FIGURE IV-1
MOLYBDENUM ROUGHER FLOTATION PERFORMANCE

PP Composite



WR Composite



IX Composite

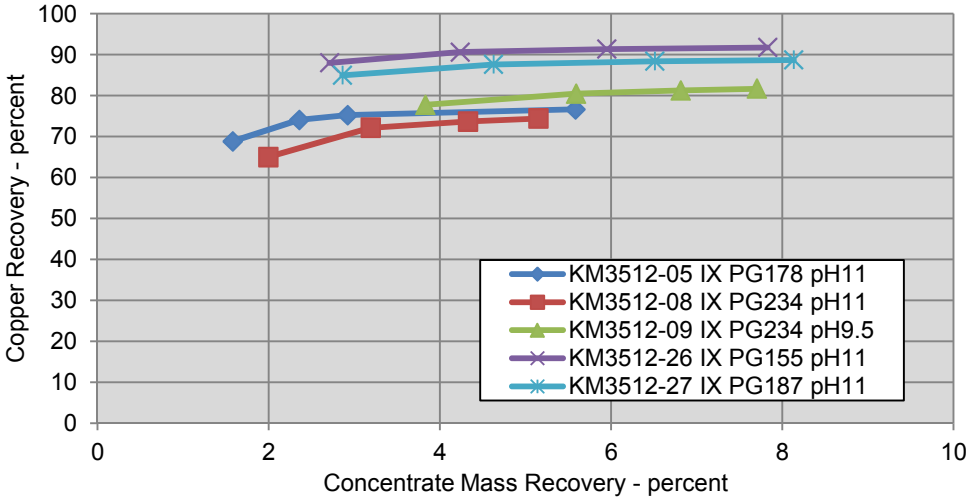
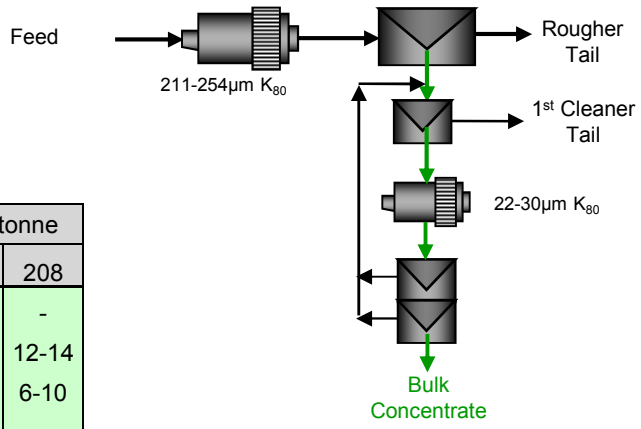


FIGURE IV-2
LOCKED CYCLE TEST RESULTS
Global Composites



REAGENT SUMMARY

Stream	pH	Reagents g/tonne		
		FO	3418A	208
Primary Grind	11.1-11.4	10-20	-	-
Rougher	11.0-11.4	-	6-7	12-14
Cleaner 1	11.0	-	3-5	6-10
Regrind	11.0-11.4	10	-	-
Cleaner 2-3	11.0	4	3-6	6-12

LOCKED CYCLE TEST RESULTS

Product	Weight	Assay - percent or g/t						Distribution - percent					
	%	Cu	Mo	Fe	S	Ag	Au	Cu	Mo	Fe	S	Ag	Au
KM3512-18 PP Composite													
Flotation Feed	100.0	0.14	0.03	2.8	0.78	1.0	0.22	100	100	100	100	100	100
Bulk Con	0.4	28.5	5.5	24.7	36.4	107	29.0	78.2	74.6	3.4	18.3	40.4	52.0
Bulk 1st Clnr Tail	7.9	0.20	0.04	4.0	2.3	2.0	0.39	11.1	10.8	11.2	22.9	15.0	14.1
Bulk Ro Tail	91.7	0.02	0.005	2.6	0.50	0.5	0.08	10.7	14.5	85.5	58.9	44.6	33.8
KM3512-19 WR Composite													
Flotation Feed	100.0	0.19	0.02	2.7	2.56	1.5	0.22	100	100	100	100	100	100
Bulk Con	0.7	23.6	1.9	30.7	37.3	103	19.8	88.1	71.1	8.2	10.6	49.4	63.9
Bulk 1st Clnr Tail	7.7	0.16	0.03	10.3	10.8	4.0	0.40	6.5	13.1	29.2	32.4	20.4	13.7
Bulk Ro Tail	91.6	0.01	0.003	1.9	1.60	0.5	0.06	5.4	15.8	62.6	57.0	30.2	22.4
KM3512-20 IX Composite													
Flotation Feed	100.0	0.16	0.067	2.3	2.04	2	0.24	100	100	100	100	100	100
Bulk Con	0.4	28.6	4.66	24.7	34.8	150	23.9	73.8	28.5	4.3	7.0	37.9	41.0
Bulk 1st Clnr Tail	6.8	0.39	0.466	8.0	8.04	8	1.13	16.8	47.6	23.3	27.0	33.6	32.2
Bulk Ro Tail	92.7	0.02	0.017	1.8	1.45	1	0.07	9.3	23.9	72.4	66.0	28.5	26.9

Note: a) Detailed test conditions can be found in Appendix II.
b) Gold assays are in g/tonne, all others are in percent.

ALS Canada Ltd.
2103 Dollarton Hwy
North Vancouver BC V7H 0A7
Phone: 604 984 0221 Fax: 604 984 0218 www.alsglobal.com

To: ALS METALLURGY, DIV OF ALS CANADA LTD
SS2 COMP #7, 2957 BOWERS PL
KAMLOOPS BC V1S 1W5

Finalized Date: 29- AUG- 2012
Account: KRL

CERTIFICATE VA12196487

Project: KM3512

P.O. No.: A9063

This report is for 3 Pulp samples submitted to our lab in Vancouver, BC, Canada on 23- AUG- 2012.

The following have access to data associated with this certificate:

G AND T METALLURGICAL	SIMONE BAWTREE	BRENDA TREMBLAY

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
WEI- 21	Received Sample Weight
LOG- 24	Pulp Login - Rcd w/o Barcode

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION
ME- MS61	48 element four acid ICP- MS

To: ALS METALLURGY, DIV OF ALS CANADA LTD
ATTN: BRENDA TREMBLAY
SS2 COMP #7, 2957 BOWERS PL
KAMLOOPS BC V1S 1W5

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Signature:
Colin Ramshaw, Vancouver Laboratory Manager

ALS Canada Ltd.
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North Vancouver BC V7H 0A7
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To: ALS METALLURGY, DIV OF ALS CANADA LTD
SS2 COMP #7, 2957 BOWERS PL
KAMLOOPS BC V1S 1W5

Finalized Date: 29- AUG- 2012
Account: KRL

Project: KM3512

CERTIFICATE OF ANALYSIS VA12196487

Sample Description	Method	WEI-21	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61
	Analyte	Recvd Wt.	Ag	Al	As	Ba	Be	Bi	Ca	Cd	Ce	Co	Cr	Cs	Cu	Fe
	Units	kg	ppm	%	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	%
	LOR	0.02	0.01	0.01	0.2	10	0.05	0.01	0.01	0.02	0.01	0.1	1	0.05	0.2	0.01
KM3512 WR Comp Hd 1		0.02	1.39	6.97	6.4	930	0.89	0.98	0.36	0.21	60.4	19.2	186	2.34	1795	3.20
KM3512 IX Comp Hd 1		0.02	1.74	6.99	16.3	1150	1.10	1.87	1.05	<0.5	69.8	18.8	178	4.33	1650	2.89
KM3512 PP Comp Hd 1		0.02	1.54	7.27	15.3	1520	1.28	1.08	0.96	0.28	72.9	13.3	187	3.95	1400	3.59

***** See Appendix Page for comments regarding this certificate *****

ALS Canada Ltd.
2103 Dollarton Hwy
North Vancouver BC V7H 0A7
Phone: 604 984 0221 Fax: 604 984 0218 www.alsglobal.com

To: ALS METALLURGY, DIV OF ALS CANADA LTD
SS2 COMP #7, 2957 BOWERS PL
KAMLOOPS BC V1S 1W5

Finalized Date: 29- AUG- 2012
Account: KRL

Project: KM3512

CERTIFICATE OF ANALYSIS VA12196487

Sample Description	Method	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61
	Analyte	Ga	Ge	Hf	In	K	La	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb
	Units	ppm	ppm	ppm	ppm	%	ppm	ppm	%	ppm	ppm	%	ppm	ppm	ppm	ppm
	LOR	0.05	0.05	0.1	0.005	0.01	0.5	0.2	0.01	5	0.05	0.01	0.1	0.2	10	0.5
KM3512 WR Comp Hd 1		12.55	0.17	0.7	0.050	4.82	36.3	10.4	0.50	108	171.5	0.22	2.5	7.8	520	15.1
KM3512 IX Comp Hd 1		13.80	0.19	0.8	0.083	4.71	41.4	11.9	0.61	203	733	0.57	3.6	13.2	470	14.9
KM3512 PP Comp Hd 1		17.25	0.20	0.8	0.044	4.84	41.0	8.6	0.66	230	315	0.39	4.0	15.7	580	21.2

***** See Appendix Page for comments regarding this certificate *****

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2103 Dollarton Hwy
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To: ALS METALLURGY, DIV OF ALS CANADA LTD
SS2 COMP #7, 2957 BOWERS PL
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Finalized Date: 29- AUG- 2012
Account: KRL

Project: KM3512

CERTIFICATE OF ANALYSIS VA12196487

Sample Description	Method	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61
	Analyte	Rb	Re	S	Sb	Sc	Se	Sn	Sr	Ta	Te	Th	Ti	Tl	U	V
	Units	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm
	LOR	0.1	0.002	0.01	0.05	0.1	1	0.2	0.2	0.05	0.05	0.2	0.005	0.02	0.1	1
KM3512 WR Comp Hd 1		183.0	0.040	2.53	1.31	9.9	3	5.7	99.6	0.20	0.22	13.4	0.117	1.28	4.9	73
KM3512 IX Comp Hd 1		193.5	0.157	2.19	3.23	7.1	4	3.3	171.0	0.26	0.39	14.1	0.113	1.34	5.0	54
KM3512 PP Comp Hd 1		159.5	0.079	0.79	7.54	7.5	2	2.6	203	0.28	0.15	12.6	0.126	1.24	4.4	58

***** See Appendix Page for comments regarding this certificate *****

ALS Canada Ltd.
2103 Dollarton Hwy
North Vancouver BC V7H 0A7
Phone: 604 984 0221 Fax: 604 984 0218 www.alsglobal.com

To: ALS METALLURGY, DIV OF ALS CANADA LTD
SS2 COMP #7, 2957 BOWERS PL
KAMLOOPS BC V1S 1W5

Finalized Date: 29- AUG- 2012
Account: KRL

Project: KM3512

CERTIFICATE OF ANALYSIS VA12196487

Sample Description	Method Analyte Units LOR	ME-MS61 W ppm 0.1	ME-MS61 Y ppm 0.1	ME-MS61 Zn ppm 2	ME-MS61 Zr ppm 0.5
KM3512 WR Comp Hd 1		32.2	8.3	20	17.5
KM3512 IX Comp Hd 1		25.7	11.6	40	22.0
KM3512 PP Comp Hd 1		24.9	12.9	58	24.5

***** See Appendix Page for comments regarding this certificate *****

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2103 Dollarton Hwy
North Vancouver BC V7H 0A7
Phone: 604 984 0221 Fax: 604 984 0218 www.alsglobal.com

To: ALS METALLURGY, DIV OF ALS CANADA LTD
SS2 COMP #7, 2957 BOWERS PL
KAMLOOPS BC V1S 1W5

Finalized Date: 29- AUG- 2012
Account: KRL

Project: KM3512

CERTIFICATE OF ANALYSIS VA12196487

Method	CERTIFICATE COMMENTS
ME- MS61	Interference: Mo> 400ppm on ICP- MS Cd,ICP- AES results shown.
ME- MS61	REE's may not be totally soluble in this method.

ALS Canada Ltd.
2103 Dollarton Hwy
North Vancouver BC V7H 0A7
Phone: 604 984 0221 Fax: 604 984 0218 www.alsglobal.com

To: ALS METALLURGY, DIV OF ALS CANADA LTD
SS2 COMP #7, 2957 BOWERS PL
KAMLOOPS BC V1S 1W5

Finalized Date: 18- DEC- 2012
Account: KRL

CERTIFICATE VA12288466

Project: KM3512

P.O. No.: A0107

This report is for 1 Pulp sample submitted to our lab in Vancouver, BC, Canada on 10- DEC- 2012.

The following have access to data associated with this certificate:

G AND T METALLURGICAL	SIMONE BAWTREE	BRENDA TREMBLAY

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
WEI- 21	Received Sample Weight
LOG- 24	Pulp Login - Rcd w/o Barcode

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	INSTRUMENT
Re- OG62	Ore Grade Re - 4- Acid	ICP- MS

To: ALS METALLURGY, DIV OF ALS CANADA LTD
ATTN: BRENDA TREMBLAY
SS2 COMP #7, 2957 BOWERS PL
KAMLOOPS BC V1S 1W5

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

Signature:
Colin Ramshaw, Vancouver Laboratory Manager

ALS Canada Ltd.
2103 Dollarton Hwy
North Vancouver BC V7H 0A7
Phone: 604 984 0221 Fax: 604 984 0218 www.alsglobal.com

To: ALS METALLURGY, DIV OF ALS CANADA LTD
SS2 COMP #7, 2957 BOWERS PL
KAMLOOPS BC V1S 1W5

Finalized Date: 18- DEC- 2012
Account: KRL

Project: KM3512

CERTIFICATE OF ANALYSIS VA12288466

Sample Description	Method Analyte Units LOR	WEI- 21 Recvd Wt. kg 0.02	Re- OG62 Re ppm 0.01
KM3512- 29 Mo Con		0.02	133.5

APPENDIX V – KM3512

PILOT PLANT DATA

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TABLE V-1A
SUMMARY OF GRINDING CONDITIONS
KM3512-P1 HYP PP Composite

Time	Rod Mill 1			Flotation Feed		
	Mass kg/hr	Feed H_2O L/min	Mill Density	Pumpbox H_2O L/min	Feed Density	Size µm K_{80}
Target	100	1.1	60	2.3	33	
7:00						
7:30						
8:00						
8:30	99	-	-	-	-	-
9:00	104	-	-	-	-	-
9:30						
10:00						
10:30	97	-	55	-	28	-
11:00	105	-	-	-	40	256
11:30	101	-	58	-	-	-
12:00	101	1.2	60	2.2	27	-
12:30						
12:45	102	1.2	54	2.2	34	150
13:15	98	-	59	-	29	-
14:00	105	-	60	-	32	202
14:30						
15:00						
15:30	-	-	-	-	-	-
16:00						
16:30						
17:00						
17:30						
18:00						
Average	101	1.2	58	2.2	32	203

Mass Start	1018	kg	Time Start	8:34	am
Mass Finish	559	kg	Time Finish	15:20	pm
Total Feed	459	kg	Moisture	0.73	%

Notes:
1. Float Feed Density taken with Marcy Cup and Scale.
2. Sizings reported above are on Operational grab samples.
3. Mill stopped at 9:30 and started back up at 10:10.
4. Mill stopped at 12:17 and started back up at 12:40.
5. Mill stopped at 14:15 and started back up at 15:05.
6. At11:13 sped mill up to 1500rpm.

Grinding Mill Data

Parameters	Rod Mill 1
Mill Dimensions	24" dia x 30" Mild
RPM	As above
Motor HP	3
No Load Power (amps)	Varies with speed
Starting Mill Charge (kg)	180 kg mild steel rods

Notes:
1. Recycled water was used in grinding circuit.

TABLE V-1B
SUMMARY OF REGRINDING CONDITIONS
KM3512-P1 HYP PP Composite

Time	Cu Ro Con	Ro Con Regrind		
	Mass Pull (%)	RG Speed RPM	RG1 Power kW	Disch. µm K80
7:00				
7:30				
8:00				
8:30	-	-	-	-
9:00	-	-	-	-
9:30				
10:00				
10:30	-	-	-	-
11:00	-	1530	0.91	-
11:30	-	-	-	-
12:00	-	-	-	-
12:30				
13:00	-	1530	0.91	-
13:30	-	-	-	-
14:00	-	-	-	-
14:30				
15:00				
15:30	-	-	-	-
16:00				
16:30				
17:00				
17:30				
18:00				
Average	-	1530	0.91	-

Note: Sizings reported above are on Operational grab samples.

Grinding Mill Data

Parameters	Ro Con Regrind
Mill Type	2.5 L Vertical Stirred Mill
RPM	See Above
Motor HP	1
No Load Power (amps)	Varies on Speed
Mill Charge	1200g of 3.5 mm ceramic media

TABLE V-1C
SUMMARY OF STREAM SIZING DATA
KM3512-P1 HYP PP Composite

Time	Particle Size - μm K_{80}			
	Flotation Feed	Rougher Concentrate	Regrind Discharge	Bulk Concentrate
12:00-13:40	192	84	38	51

Note: Sizings conducted on Survey Samples.

TABLE V-1D
SUMMARY OF REAGENT ADDITIONS
KM3512-P1 HYP PP Composite

Time	pH										
	Prim Dis	Ro 1	Ro 2	Ro 3	Ro4	RG	Clnr1-A	Clnr1-C	Clnr Tl	Py Ro 1	Py Ro Tl
7:30											
8:00											
8:30	-	-	-	-	-	-	-	-	-	-	-
9:00	-	-	-	-	-	-	-	-	-	-	-
9:30											
10:00											
10:30	-	-	-	-	-	-	-	-	-	-	-
11:00	11.2	10.9	10.8	10.6	10.5	11.2	11.1	10.3	9.5	10.1	10.1
11:30	0.0	-	-	-	-	-	-	-	-	-	-
12:00	10.9	11.0	11.0	10.8	10.5	11.2	11.2	10.5	9.5	10.2	10.1
12:30											
13:00	9.3	11.1	11.0	10.9	10.6	11.4	10.8	9.0	8.4	10.2	10.1
13:30	-	-	-	-	-	-	-	-	-	-	-
14:00	10.2	10.2	10.1	10.2	10.4	11.3	10.9	10.0	9.3	10.2	10.2
14:30											
15:00											
15:30	-	-	-	-	-	-	-	-	-	-	-
16:00											
16:30											
17:00											
17:30											
18:00											
Average	8.3	10.8	10.7	10.6	10.5	11.3	11.0	10.0	9.2	10.2	10.1

Note: pH contolling pump used at primary grind discharge.

TABLE V-1D Continued
SUMMARY OF REAGENT ADDITIONS
KM3512-P1 HYP PP Composite

Time	g/tonne								
	PG Feed Lime	PG Feed F.O.	P.B. Lime	Ro1 MIBC	Ro1 3418A	Ro1 208	Ro3 3418A	Ro 3 208	RG Lime
7:30									
8:00									
8:30	-	-	-	-	-	-	-	-	-
9:00	-	-	-	-	-	-	-	-	-
9:30									
10:00									
10:30	-	-	-	-	-	-	-	-	-
11:00	-	-	-	-	-	-	-	-	-
11:30	1580	9	0	23	3	4	3	5	0
12:00	-	-	-	-	-	-	-	-	-
12:30									
13:00	-	-	-	-	-	-	-	-	-
13:30	1643	9	4359	30	2	3	1	3	0
14:00	-	-	-	-	-	-	-	-	-
14:30									
15:00									
15:30	-	-	-	-	-	-	-	-	-
16:00									
16:30									
17:00									
17:30									
18:00									
Average	1611	9	2180	27	2	3	2	4	0

Reagents	Solution Strength		Location
Lime	0.1	g/ml	PG
Lime	0.005	g/ml	RG
F.O	0.86	g/ml	All
MIBC	0.0120	g/drop	All
3418A	0.00025	g/ml	All
208	0.0005	g/ml	All
PAX	0.005	g/ml	Py Ro
Floc	0.001	g/ml	Thickener

TABLE V-1D Continued
SUMMARY OF REAGENT ADDITIONS
KM3512-P1 HYP PP Composite

Time	g/tonne									
	RG Lime/pH	RG F.O.	Cl1-A MIBC	Cl1-A 3418A	Cl1-A 208	Cl1-C 3418A	Cl1-C 208	Py Ro1 MIBC	Py Ro1 PAX	Thick Fd Floc
7:30										
8:00										
8:30	-	-	-	-	-	-	-	-	-	-
9:00	-	-	-	-	-	-	-	-	-	-
9:30										
10:00										
10:30	-	-	-	-	-	-	-	-	-	-
11:00	-	-	-	-	-	-	-	-	-	-
11:30	0	14	15	3	6	0	0	23	88	15
12:00	-	-	-	-	-	-	-	-	-	-
12:30										
13:00	-	-	-	-	-	-	-	-	-	-
13:30	0	14	8	2	3	0	0	15	88	0
14:00	-	-	-	-	-	-	-	-	-	-
14:30										
15:00										
15:30	-	-	-	-	-	-	-	-	-	-
16:00										
16:30										
17:00										
17:30										
18:00										
Average	0	14	11	2	4	0	0	19	88	8

TABLE V-1E
KM3512-P1 HYP PP Composite
Raw Data - Sample Survey 12:00 - 13:40

Product	Mass	Assay - percent or g/tonne					Time	Mass	Wet Wt	Density
	Dry - g	Cu	Mo	Fe	S	Au	s	kg/hr	g	percent
Feed	505.4	0.31	0.019	3.5	1.67	0.30	20	91.0	1615.4	31.3
Bulk Ro Con	141.1	3.13	0.21	18.3	17.9	3.30	80	6.3	1039.6	13.6
Bulk Ro Tails	432.6	0.06	0.007	2.7	0.48	0.09	20	77.9	1144.4	37.8
Bulk Rgd Dis	177.2	3.12	0.21	18.6	19.1	3.72	80	8.0	1232.5	14.4
Bulk Clnr Tail	62.2	0.36	0.022	8.2	5.24	0.49	80	2.8	1259.9	4.9
Py Ro Feed	520.0	0.07	0.012	2.8	0.63	0.10	20	93.6	1598.9	32.5
Py Ro Con	56.3	0.66	0.087	15.0	15.1	1.20	80	2.5	449.1	12.5
Py Ro Tail	393.2	0.06	0.007	2.3	0.15	0.17	20	70.8	1185	33.2
Bulk Con	1757.2	10.8	0.57	32.1	38.2	8.22	6000	1.1	27330	6.4
Startup Bulk Con	1785.6	10.5	0.55	33.6	40.1	9.17	9960	0.6	16080	11.1

TABLE V-1F
KM3512-P1 HYP PP Composite
Metallurgical Balance - Sample Survey 12:00 - 13:40

Product	Mass		Assay - percent or g/tonne					Distribution - percent				
	kg/hr	percent	Cu	Mo	Fe	S	Au	Cu	Mo	Fe	S	Au
Feed	95.0	100	0.30	0.022	3.5	1.61	0.31	100	100	100	100	100
Bulk Ro Con	6.8	7.2	3.45	0.19	16.7	16.8	3.13	82.5	63.8	34.1	75.0	72.5
Bulk Ro Tails	88.1	92.8	0.06	0.008	2.5	0.43	0.09	17.5	36.2	65.9	25.0	27.5
Bulk Rgd Dis	6.8	7.2	3.45	0.19	16.7	16.8	3.13	82.5	63.8	34.1	75.0	72.5
Bulk Clnr Tail	4.6	4.9	0.35	0.023	8.6	5.11	0.50	5.7	5.2	11.8	15.4	7.9
Py Ro Feed	92.8	97.7	0.1	0.009	2.8	0.67	0.11	23.2	41.3	77.7	40.4	35.3
Py Ro Con	3.1	3.3	0.64	0.085	15.1	15.5	1.04	7.0	13.1	14.1	31.8	11.1
Py Ro Tail	89.6	94.4	0.05	0.006	2.4	0.15	0.08	16.2	28.2	63.6	8.6	24.2
Bulk Con	2.2	2.3	9.94	0.54	33.8	41.4	8.63	76.8	58.7	22.3	59.6	64.7

TABLE V-2A
SUMMARY OF GRINDING CONDITIONS
KM3512-P2 HYP PP Composite

Time	Rod Mill 1			Flotation Feed		
	Mass kg/hr	Feed H_2O L/min	Mill Density	Pumpbox H_2O L/min	Feed Density	Size µm K_{80}
Target	100	1.1	60	2.3	33	
7:00						
7:30						
8:00	106	1.1	-	2.3	-	-
8:30	-	-	-	-	-	-
9:00	88	-	58	-	31	-
9:30	92	-	-	-	-	-
10:00	111	-	59	-	39	-
10:30	101	-	-	-	-	-
11:00	-	-	54	-	37	-
11:30	99	-	-	-	-	-
12:00	-	-	-	-	-	-
12:30	104	1.3	-	2.2	-	-
13:00	106	-	50	-	32	174
13:30	92	-	-	-	-	-
14:00	-	-	52	-	35	213
14:30	100	-	-	-	-	-
15:00	92	-	53	-	34	-
15:30	-	-	-	-	-	-
16:00						
16:30						
17:00						
17:30						
18:00						
Average	99	1.2	54	2.3	35	194

Mass Start	1755	kg	Time Start	8:00	am
Mass Finish	1079	kg	Time Finish	15:40	pm
Total Feed	676	kg	Moisture	-	%

Notes: 1. Float Feed Density taken with Marcy Cup and Scale.
2. Sizings reported above are on Operational grab samples.

Grinding Mill Data

Parameters	Rod Mill 1
Mill Dimensions	24" dia x 30" Mild
RPM	As above
Motor HP	3
No Load Power (amps)	Varies with speed
Starting Mill Charge (kg)	180 kg mild steel rods

Notes: 1. Recycled water was used in grinding circuit.

TABLE V-2B
SUMMARY OF REGRINDING CONDITIONS
KM3512-P2 HYP PP Composite

Time	Cu Ro Con	Ro Con Regrind		
	Mass Pull (%)	RG Speed RPM	RG1 Power kW	Disch. µm K80
7:00				
7:30				
8:00	17.3	-	-	-
8:30	-	-	-	-
9:00	15.9	1530	0.87	-
9:30	-	-	-	-
10:00	12.5	-	-	-
10:30	-	-	-	-
11:00	15.9	1380	-	-
11:30	-	-	-	-
12:00	14.2	-	-	26
12:30	-	-	-	-
13:00	13.8	-	-	-
13:30	-	-	-	-
14:00	16.7	1380	0.86	-
14:30	-	-	-	-
15:00	-	-	-	-
15:30	-	1380	0.90	-
16:00				
16:30				
17:00				
17:30				
18:00				
Average	15.2	1418	0.88	26

Note: Sizings reported above are on Operational grab samples.

Grinding Mill Data

Parameters	Ro Con Regrind
Mill Type	2.5 L Vertical Stirred Mill
RPM	See Above
Motor HP	1
No Load Power (amps)	Varies on Speed
Mill Charge	1200g of 3.5 mm ceramic media

TABLE V-2C
SUMMARY OF STREAM SIZING DATA
KM3512-P2 HYP PP Composite

Time	Particle Size - μm K_{80}			
	Flotation Feed	Rougher Concentrate	Regrind Discharge	Bulk Concentrate
7:40-10:00	167	69	21	69
10:00-12:00	216	64	31	36
12:20-14:20	180	118	43	41
14:20-18:20	221	156	129	42

Note: Sizings conducted on Survey Samples.

TABLE V-2D
SUMMARY OF REAGENT ADDITIONS
KM3512-P2 HYP PP Composite

Time	pH										
	Prim Dis	Ro 1	Ro 2	Ro 3	Ro4	RG	Clnr1-A	Clnr1-C	Clnr Tl	Py Ro 1	Py Ro Tl
7:30											
8:00	8.8	-	-	-	-	-	-	-	-	-	-
8:15	-	-	-	-	-	-	-	-	-	-	-
8:30	10.8	10.7	10.6	10.5	10.3	11.0	10.8	10.3	9.1	10.0	9.6
8:45	11.1	-	-	-	-	-	-	-	-	-	-
9:00	11.4	-	-	-	-	-	-	-	-	-	-
9:15	11.4	-	-	-	-	-	-	-	-	-	-
9:30	11.0	10.7	10.6	10.8	10.6	11.1	10.8	10.4	9.9	10.4	10.5
9:45	11.1	-	-	-	-	-	-	-	-	-	-
10:00	11.4	-	-	-	-	-	-	-	-	-	-
10:15	11.2	-	-	-	-	-	-	-	-	-	-
10:30	11.3	11.2	11.1	11.0	11.0	11.3	11.4	10.9	10.1	10.9	10.9
10:45	11.4	-	-	-	-	-	-	-	-	-	-
11:00	11.2	-	-	-	-	-	-	-	-	-	-
11:15	11.3	-	-	-	-	-	-	-	-	-	-
11:30	-	11.1	11.2	11.1	11.1	11.5	11.2	10.2	9.3	10.9	10.9
11:45	11.3	-	-	-	-	-	-	-	-	-	-
12:00	11.3	-	-	-	-	-	-	-	-	-	-
12:15	11.3	-	-	-	-	-	-	-	-	-	-
12:30	11.2	11.0	11.0	10.9	10.9	11.7	11.5	11.4	10.5	10.9	10.9
12:45	11.7	-	-	-	-	-	-	-	-	-	-
13:00	11.5	-	-	-	-	-	-	-	-	-	-
13:15	11.5	-	-	-	-	-	-	-	-	-	-
13:30	11.5	11.7	11.6	11.6	11.5	12.2	11.6	10.9	9.6	11.3	11.3
13:45	12.3	-	-	-	-	-	-	-	-	-	-
14:00	12.0	-	-	-	-	-	-	-	-	-	-
14:15	12.1	-	-	-	-	-	-	-	-	-	-
14:30	11.7	11.3	11.3	11.3	11.2	11.4	11.3	11.0	10.0	11.1	11.1
14:45	11.7	-	-	-	-	-	-	-	-	-	-
15:00	11.7	-	-	-	-	-	-	-	-	-	-
15:15	11.4	-	-	-	-	-	-	-	-	-	-
15:30	11.5	11.2	11.2	11.2	11.1	11.3	11.0	10.9	10.6	11.0	11.0
16:00											
16:30											
17:00											
17:30											
18:00											
Average	11.3	11.1	11.1	11.1	11.0	11.4	11.2	10.8	9.9	10.8	10.8

Note: pH Contolling pump used at PG Dis.

TABLE V-2D Continued
SUMMARY OF REAGENT ADDITIONS
KM3512-P2 HYP PP Composite

Time	g/tonne								
	PG Feed Lime	PG Feed F.O.	P.B. Lime	Ro1 MIBC	Ro1 3418A	Ro1 208	Ro3 3418A	Ro 3 208	RG Lime
7:30									
8:00	3407	-	0	25	3	4	2	4	0
8:15	-	-	-	-	-	-	-	-	-
8:30	-	-	-	-	-	-	-	-	-
8:45	-	-	-	-	-	-	-	-	-
9:00	3198	-	0	25	3	2	2	4	0
9:15	-	-	-	-	-	0	-	0	-
9:30	-	-	-	-	-	5	-	3	-
9:45	-	-	-	-	-	0	-	0	-
10:00	3198	20	0	25	3	4	2	3	0
10:15	-	-	-	-	-	-	-	-	-
10:30	-	-	-	-	-	-	-	-	-
10:45	-	-	-	-	-	-	-	-	-
11:00	2781	20	0	33	3	2	0.2	1	0
11:15	-	-	-	-	-	-	-	-	-
11:30	-	-	-	-	-	-	-	-	-
11:45	-	-	-	-	-	-	-	-	-
12:00	3198	10	0	33	0.3	1	0.0	1	320
12:15	-	-	-	-	-	-	-	-	-
12:30	-	-	-	-	5	9	4	9	-
12:45	-	-	-	-	-	-	-	-	-
13:00	3059	-	0	33	5	9	5	8	0
13:15	-	-	-	-	-	-	-	-	-
13:30	-	-	-	-	-	-	-	-	-
13:45	-	-	-	-	-	-	-	-	-
14:00	2642	-	0	25	5	9	4	9	0
14:15	-	-	-	-	-	-	-	-	-
14:30	-	-	-	-	-	-	-	-	-
14:45	-	-	-	-	-	-	-	-	-
15:00	-	-	-	-	6	12	5	12	-
15:15	2364	15	0	25	-	-	-	-	0
15:30	-	-	-	33	-	-	-	-	-
16:00									
16:30									
17:00									
17:30									
18:00									
Average	2981	16	0	29	3	5	3	5	40

Reagents	Solution Strength		Location
Lime	0.1	g/ml	PG
Lime	0.005	g/ml	RG
F.O	0.86	g/ml	All
MIBC	0.0120	g/drop	All
3418A	0.00025	g/ml	All
208	0.0005	g/ml	All
PAX	0.005	g/ml	Py Ro
Floc	0.001	g/ml	Thickener

TABLE V-2D Continued
SUMMARY OF REAGENT ADDITIONS
KM3512-P2 HYP PP Composite

Time	g/tonne									
	RG Lime/pH	RG F.O.	Cl1-A MIBC	Cl1-A 3418A	Cl1-A 208	Cl1-C 3418A	Cl1-C 208	Py Ro1 MIBC	Py Ro1 PAX	Thick Fd Floc
7:30										
8:00	0	-	33	3	3	3	0	33	229	23
8:15	-	-	-			-				
8:30	-	-	-	-	-	-	-	-	-	-
8:45	-	-	-			-				
9:00	0	15	33	2	3	2	0	17	243	22
9:15	-	-	-			-				
9:30	-	-	-	-	-	-	-	-	-	-
9:45	-	-	-			-				
10:00	0	10	29	2	3	2	0	21	240	22
10:15	-	-				-				
10:30	-	-	-	-	-	-	-	-	-	-
10:45	-	-				-				
11:00	0	20	33	2	3	2	0	21	243	22
11:15	-	-				-				
11:30	-	-	-	-	-	-	-	-	-	-
11:45	-	-				-				
12:00	320	10	33	2	3	2	0	33	243	24
12:15	-	-				-				
12:30	-	-	-	-	-	-	-	-	-	-
12:45	-	-				-				
13:00	0	-	-	2	3	2	0	33	243	15
13:15	-	-				-				
13:30	-	-	-	-	-	-	-	-	-	-
13:45	-	-				-				
14:00	0	5	-	2	3	2	0	29	236	15
14:15	-	-				-				
14:30	-	-	-	-	-	-	-	-	-	-
14:45	-	-	-	-	-	-	-	-	-	-
15:00	-	-				17				
15:15	0	15	-	18	34	-	1	29	236	22
15:30	-	-	-	-	-	-	-	-	-	-
-										
-										
-										
-										
-										
Average	40	12	33	4	7	4	0	27	239	21

TABLE V-2E
KM3512-P2 HYP PP Composite
Raw Data - Sample Survey 07:40-10:00

Product	Mass Dry - g	Assay - percent or g/tonne					Time s	Mass kg/hr	Wet Wt g	Density percent
		Cu	Mo	Fe	S	Au				
Feed	505.4	0.32	0.021	3.6	1.72	0.32	30	60.6	2642.1	19.1
Bulk Ro Con	141.1	3.84	0.202	14.0	12.2	3.98	120	4.2	1403.1	10.1
Bulk Ro Tails	432.6	0.08	0.006	2.6	0.85	0.11	30	51.9	2444.7	17.7
Bulk Rgd Dis	177.2	3.97	0.212	13.7	12.5	4.10	120	5.3	1409.6	12.6
Bulk Clnr Tail	62.2	0.19	0.006	6.5	3.90	0.34	120	1.9	1617	3.8
Py Ro Feed	520.0	0.08	0.008	2.7	0.78	0.11	30	62.4	2712.3	19.2
Py Ro Con	56.3	0.66	0.037	16.8	17.2	1.11	120	1.7	894.2	6.3
Py Ro Tail	393.2	0.07	0.005	2.1	0.15	0.09	30	47.2	2566.5	15.3
Bulk Con	4381.8	9.40	0.505	31.3	35.8	8.94	7200	2.2	17550	25.0

TABLE V-2E
KM3512-P2 HYP PP Composite
Raw Data - Sample Survey 10:00-12:00

Product	Mass Dry - g	Assay - percent or g/tonne					Time s	Mass kg/hr	Wet Wt g	Density percent
		Cu	Mo	Fe	S	Au				
Feed	773.0	0.30	0.018	3.3	1.66	0.37	30	92.8	2587.4	29.9
Bulk Ro Con	129.8	4.26	0.228	13.2	13.0	3.93	120	3.9	1249.2	10.4
Bulk Ro Tails	784.4	0.08	0.008	2.9	1.14	0.12	30	94.1	2326.8	33.7
Bulk Rgd Dis	142.1	3.82	0.192	12.0	11.7	3.72	120	4.3	1377.2	10.3
Bulk Clnr Tail	103.5	0.23	0.012	6.3	3.37	0.29	120	3.1	1741.8	5.9
Py Ro Feed	832.4	0.08	0.009	2.9	1.29	0.18	30	99.9	2835.7	29.4
Py Ro Con	215.8	0.32	0.050	12.6	13.1	0.75	120	6.5	1668.5	12.9
Py Ro Tail	728.9	0.06	0.006	2.0	0.19	0.09	30	87.5	2342	31.1
Bulk Con	1621.3	17.1	0.444	26.6	34.5	14.6	7200	0.8	15790	10.3

TABLE V-2E Continued
KM3512-P2 HYP PP Composite
Raw Data - Sample Survey 12:20-14:20

Product	Mass	Assay - percent or g/tonne					Time	Mass	Wet Wt	Density
	Dry - g	Cu	Mo	Fe	S	Au	s	kg/hr	g	percent
Feed	535.6	0.32	0.020	3.6	2.15	0.35	25	77.1	2053.9	26.1
Bulk Ro Con	82.8	5.15	0.225	24.3	25.1	5.73	100	3.0	696	11.9
Bulk Ro Tails	563.2	0.08	0.010	2.6	1.07	0.13	25	81.1	2159	26.1
Bulk Rgd Dis	86.2	5.06	0.230	19.7	24.0	4.86	100	3.1	820.5	10.5
Bulk Clnr Tail	35.2	0.38	0.033	10.7	10.4	0.7	100	1.3	763.9	4.6
Py Ro Feed	516.3	0.08	0.009	2.9	1.16	0.07	25	74.3	2136	24.2
Py Ro Con	41.1	0.64	0.155	25.7	29.2	1.60	100	1.5	245.9	16.7
Py Ro Tail	583.5	0.06	0.005	2.3	0.20	0.06	25	84.0	2360.3	24.7
Bulk Con	655.7	26.0	0.171	24.4	31.0	10.7	7200	0.3	21620	3.0

TABLE V-2E Continued
KM3512-P2 HYP PP Composite
Raw Data - Sample Survey 14:20-18:20

Product	Mass	Assay - percent or g/tonne					Time	Mass	Wet Wt	Density
	Dry - g	Cu	Mo	Fe	S	Au	s	kg/hr	g	percent
Feed	638.0	0.24	0.031	3.0	2.03	0.35	25	91.9	2284.6	27.9
Bulk Ro Con	140.7	3.53	0.331	13.5	14.4	4.17	100	5.1	1218.7	11.5
Bulk Ro Tails	601.1	0.04	0.013	2.3	1.20	0.09	25	86.6	1959.7	30.7
Bulk Rgd Dis	99.8	3.40	0.289	13.7	14.3	3.89	100	3.6	1022.6	9.8
Bulk Clnr Tail	108.6	0.46	0.029	11.2	10.8	0.74	100	3.9	1546.2	7.0
Py Ro Feed	697.0	0.05	0.015	2.6	1.5	0.1	25	100.4	2572.3	27.1
Py Ro Con	140.0	0.47	0.175	25.1	29.8	1.25	100	5.0	2179	6.4
Py Ro Tail	586.0	0.05	0.007	1.9	0.26	0.07	25	84.4	2234.6	26.2
Bulk Con	758.9	21.8	0.497	27.7	33.8	20.9	7200	0.4	13760	5.5

TABLE V-2F
KM3512-P2 HYP PP Composite
Metallurgical Balance - Sample Survey 07:40-10:00

Product	Mass		Assay - percent or g/tonne					Distribution - percent				
	kg/hr	percent	Cu	Mo	Fe	S	Au	Cu	Mo	Fe	S	Au
Feed	86	100.0	0.32	0.020	3.4	1.61	0.35	100.0	100.0	100.0	100.0	100.0
Bulk Ro Con	5.9	6.9	3.68	0.198	14.8	13.9	3.55	78.5	67.7	30.0	59.2	70.1
Bulk Ro Tails	80.4	93.1	0.07	0.007	2.5	0.71	0.11	21.5	32.3	70.0	40.8	29.9
Bulk Rgd Dis	5.9	6.9	3.68	0.198	14.8	13.9	3.55	78.5	67.7	30.0	59.2	70.1
Bulk Clnr Tail	3.8	4.4	0.19	0.006	6.2	3.57	0.35	2.6	1.3	8.0	9.7	4.3
Py Ro Feed	84.1	97.5	0.08	0.007	2.7	0.83	0.12	24.1	33.6	78.0	50.5	34.3
Py Ro Con	3.2	3.8	0.62	0.039	16.9	17.9	0.96	7.3	7.4	18.8	41.8	10.4
Py Ro Tail	80.9	93.7	0.06	0.006	2.1	0.15	0.09	16.8	26.2	59.2	8.7	23.9
Bulk con	2.2	2.5	9.77	0.532	29.7	31.8	9.15	75.9	66.4	22.0	49.5	65.7

TABLE V-2F
KM3512-P2 HYP PP Composite
Metallurgical Balance - Sample Survey 10:00-12:00

Product	Mass		Assay - percent or g/tonne					Distribution - percent				
	kg/hr	percent	Cu	Mo	Fe	S	Au	Cu	Mo	Fe	S	Au
Feed	86	100.0	0.30	0.016	3.2	1.71	0.35	100.0	100.0	100.0	100.0	100.0
Bulk Ro Con	4.6	5.3	4.23	0.140	11.8	11.5	3.88	75.8	46.2	19.2	35.6	59.6
Bulk Ro Tails	81.7	94.7	0.08	0.009	2.8	1.16	0.15	24.2	53.8	80.8	64.4	40.4
Bulk Rgd Dis	4.6	5.3	4.23	0.140	11.8	11.5	3.88	75.8	46.2	19.2	35.6	59.6
Bulk Clnr Tail	3.4	4.0	0.23	0.013	6.6	3.47	0.30	3.1	3.2	8.1	8.1	3.4
Py Ro Feed	85.2	98.7	0.08	0.009	2.9	1.26	0.15	27.2	57.0	88.9	72.5	43.8
Py Ro Con	7.1	8.2	0.32	0.049	12.7	13.0	0.76	8.9	24.9	32.0	62.3	18.1
Py Ro Tail	78.1	90.5	0.06	0.006	2.0	0.19	0.10	18.3	32.0	56.9	10.2	25.8
Bulk Con	1.1	1.3	16.5	0.529	27.6	36.0	14.8	72.8	43.0	11.1	27.5	56.2

TABLE V-2F Continued
KM3512-P2 HYP PP Composite
Metallurgical Balance - Sample Survey 12:20-14:20

Product	Mass	Assay - percent or g/tonne						Distribution - percent				
	kg/hr	percent	Cu	Mo	Fe	S	Au	Cu	Mo	Fe	S	Au
Feed	86	100.0	0.33	0.019	3.3	1.66	0.19	100.0	100.0	100.0	100.0	100.0
Bulk Ro Con	4.0	4.6	5.61	0.230	15.8	16.8	2.86	79.9	54.9	22.1	47.1	68.6
Bulk Ro Tails	82.3	95.4	0.07	0.009	2.7	0.92	0.06	20.1	45.1	77.9	52.9	31.4
Bulk Rgd Dis	4.0	4.6	5.61	0.230	15.8	16.8	2.86	79.9	54.9	22.1	47.1	68.6
Bulk Clnr Tail	3.2	3.7	0.37	0.033	13.0	12.03	0.68	4.1	6.2	14.4	26.6	12.9
Py Ro Feed	85.5	99.0	0.08	0.010	3.1	1.33	0.09	24.3	51.3	92.3	79.5	44.4
Py Ro Con	3.1	3.6	0.64	0.152	25.5	30.9	1.53	7.1	28.4	27.9	67.6	28.7
Py Ro Tail	82.3	95.4	0.06	0.005	2.2	0.21	0.03	17.1	23.0	64.4	11.9	15.7
Bulk Con	0.8	1.0	25.3	0.970	26.2	34.9	11.0	75.7	48.7	7.7	20.5	55.6

TABLE V-2F Continued
KM3512-P2 HYP PP Composite
Metallurgical Balance - Sample Survey 14:20-18:20

Product	Mass		Assay - percent or g/tonne					Distribution - percent				
	kg/hr	percent	Cu	Mo	Fe	S	Au	Cu	Mo	Fe	S	Au
Feed	86	100.0	0.24	0.020	3.0	1.85	0.30	100.0	100.0	100.0	100.0	100.0
Bulk Ro Con	4.8	5.6	3.56	0.115	13.6	14.2	3.95	84.1	31.6	25.7	42.9	73.7
Bulk Ro Tails	81.5	94.4	0.04	0.015	2.3	1.12	0.08	15.9	68.4	74.3	57.1	26.3
Bulk Rgd Dis	4.8	5.6	3.56	0.115	13.6	14.2	3.95	84.1	31.6	25.7	42.9	73.7
Bulk Clnr Tail	4.1	4.8	0.43	0.033	11.2	10.64	0.72	8.7	7.7	18.0	27.5	11.4
Py Ro Feed	85.6	99.2	0.06	0.016	2.8	1.58	0.11	24.6	76.1	92.3	84.6	37.7
Py Ro Con	3.7	4.3	0.45	0.191	24.3	30.9	1.24	8.1	40.1	34.8	71.2	17.6
Py Ro Tail	81.9	94.9	0.04	0.008	1.8	0.26	0.06	16.5	35.9	57.5	13.4	20.0
Bulk Con	0.7	0.8	21.5	0.586	27.7	34.4	22.5	75.4	23.9	7.7	15.4	62.3

TABLE V-3A
SUMMARY OF GRINDING CONDITIONS
KM3512-P3 HYP PP Composite

Time	Rod Mill 1			Flotation Feed		
	Mass kg/hr	Feed H_2O L/min	Mill Density	Pumpbox H_2O L/min	Feed Density	Size µm K_{80}
Target	100	1.1	60	2.3	33	
7:00						
7:30						
8:00	-	1.6	-	1.6	-	-
8:30	94	-	-	-	-	-
9:00	101	-	-	-	-	-
9:30						
10:00	-	-	-	-	-	-
10:30	104	-	45	-	32	181
11:00	99	-	-	-	-	-
11:30	94	-	52	-	34	290
12:00	-	-	-	-	-	-
12:30	109	-	55	-	40	298
13:00	101	-	56	-	39	-
13:30	107	-	54	-	40	-
14:00	97	-	54	-	39	-
14:30	-	-	-	-	-	-
15:00	96	-	55	-	32	-
15:30	110	-	54	-	32	-
16:00						
16:30						
17:00						
17:30						
18:00						
Average	101	1.6	53	1.6	36	256

Mass Start	975	kg	Time Start	7:50	am
Mass Finish	284	kg	Time Finish	15:50	pm
Total Feed	691	kg	Moisture	-	%

Notes:
1. Float Feed Density taken with Marcy Cup and Scale.
2. Sizings reported above are on Operational grab samples.
3. Mill was down from 9:00-9:40 because of sanding in cells.

Grinding Mill Data

Parameters	Rod Mill 1
Mill Dimensions	24" dia x 30" Mild
RPM	As above
Motor HP	3
No Load Power (amps)	Varies with speed
Starting Mill Charge (kg)	180 kg mild steel rods

Notes:
1. Recycled water was used in grinding circuit.

TABLE V-3B
SUMMARY OF REGRINDING CONDITIONS
KM3512-P3 HYP PP Composite

Time	Cu Ro Con	Ro Con Regrind				
	Mass Pull (%)	RG Speed RPM	RG1 Power kW	RG2 Speed RPM	RG2 Power kW	Disch. µm K80
7:00						
7:30						
8:00	16.9	-	-	-	-	-
8:30	-	-	-	-	-	-
9:00	15.5	1530	0.89	-	-	-
9:30						
10:00	12.2	-	-	-	-	-
10:30	-	-	-	-	-	-
11:00	15.5	1530	0.89	-	-	-
11:30	-	-	-	-	-	63
12:00	13.9	-	-	-	-	-
12:30	-	-	-	-	-	46
13:00	13.5	-	-	1530	0.85	-
13:30	-	-	-	-	-	47
14:00	16.3	-	-	-	-	-
14:30	-	1380	-	1380	-	-
15:00	-	-	-	-	0.83	-
15:30	-	-	-	-	-	-
16:00						
16:30						
17:00						
17:30						
18:00						
Average	14.8	1480	0.89	1455	0.84	52

Note: Sizings reported above are on Operational grab samples
One regrind mill with 1200g until 1220, then media was added to 1400g
Two regrind mills at 1420 with 1600g in RG1 and 1400 in RG2.

Grinding Mill Data

Parameters	Ro Con Regrind
Mill Type	2.5 L Vertical Stirred Mill
RPM	See Above
Motor HP	1
No Load Power (amps)	Varies on Speed
Mill Charge	1200g of 3.5 mm ceramic media

TABLE V-3C
SUMMARY OF STREAM SIZING DATA
KM3512-P3 HYP PP Composite

Time	Particle Size - μm K_{80}			
	Flotation Feed	Rougher Concentrate	Regrind Discharge	Bulk Concentrate
7:40-10:00	242	218	187	68
10:00-12:00	253	163	51	91
12:20-14:20	280	161	60	97

Note: Sizings conducted on Survey Samples.

TABLE V-3D
SUMMARY OF REAGENT ADDITIONS
KM3512-P3 HYP PP Composite

Time	pH										
	Prim Dis	Ro 1	Ro 2	Ro 3	Ro4	RG	Clnr1-A	Clnr1-C	Clnr Tl	Py Ro 1	Py Ro Tl
7:30											
8:00	11.1	-	-	-	-	-	-	-	-	-	-
8:15	11.3	-	-	-	-	-	-	-	-	-	-
8:30	11.5	11.2	11.2	11.1	11.0	11.6	11.5	9.5	9.2	10.8	10.7
8:45	10.9	-	-	-	-	-	-	-	-	-	-
9:00	10.8	-	-	-	-	-	-	-	-	-	-
9:15	-	-	-	-	-	-	-	-	-	-	-
9:30											
9:45	11.1	-	-	-	-	-	-	-	-	-	-
10:00	11.2	-	-	-	-	-	-	-	-	-	-
10:15	11.3	-	-	-	-	-	-	-	-	-	-
10:30	11.5	11.2	11.1	10.9	10.7	11.3	11.0	10.5	9.3	10.3	10.2
10:45	11.4	-	-	-	-	-	-	-	-	-	-
11:00	-	-	-	-	-	-	-	-	-	-	-
11:15	11.0	-	-	-	-	-	-	-	-	-	-
11:30	11.5	11.1	11.0	10.9	10.8	11.5	11.2	10.4	9.4	10.5	10.5
11:45	11.6	-	-	-	-	-	-	-	-	-	-
12:00	11.6	-	-	-	-	-	-	-	-	-	-
12:15	11.6	-	-	-	-	-	-	-	-	-	-
12:30	11.6	11.4	11.4	11.3	11.2	11.9	11.5	8.7	8.5	10.6	10.6
12:45	11.7	-	-	-	-	-	-	-	-	-	-
13:00	11.6	-	-	-	-	-	-	-	-	-	-
13:15	11.6	-	-	-	-	-	-	-	-	-	-
13:30	11.5	11.2	11.2	11.1	11.0	11.6	11.3	10.3	9.2	10.7	10.7
13:45	11.5	-	-	-	-	-	-	-	-	-	-
14:00	11.5	-	-	-	-	-	-	-	-	-	-
14:15	11.3	-	-	-	-	-	-	-	-	-	-
14:30	11.5	11.2	11.1	11.0	10.9	11.9	11.5	11.2	10.3	10.6	10.6
14:45	11.4	-	-	-	-	-	-	-	-	-	-
15:00	11.4	-	-	-	-	-	-	-	-	-	-
15:15	11.6	-	-	-	-	-	-	-	-	-	-
15:30	11.6	11.3	11.2	11.1	11.1	11.9	11.8	11.7	11.4	11.0	10.8
15:45	11.6	-	-	-	-	-	-	-	-	-	-
16:00											
16:30											
17:00											
17:30											
18:00											
Average	11.4	11.2	11.2	11.1	11.0	11.7	11.4	10.3	9.6	10.6	10.6

Note: pH contolling pump used at primary grind discharge.

TABLE V-3D Continued
SUMMARY OF REAGENT ADDITIONS
KM3512-P3 HYP PP Composite

Time	g/tonne									
	PG Feed Lime	PG Feed F.O.	P.B. Lime	Ro1 MIBC	Ro1 3418A	Ro1 208	Ro3 3418A	Ro 3 208	RG Lime	RG Lime/pH
7:30										
8:00	1496	-	0	33	9	19	8	19	0	0
8:15	-	-	-	-	-	-	-	-	-	-
8:30	-	-	-	-	-	-	-	-	-	-
8:45	-	-	-	-	-	-	-	-	-	-
9:00	-	-	-	-	11	22	10	-	-	-
9:15	-	-	-	-	-	-	-	-	-	-
9:30										
9:45	-	-	-	-	-	-	-	-	-	-
10:00	2177	34	0	82	11	22	11	22	0	0
10:15	-	-	-	-	-	-	-	-	-	-
10:30	-	-	-	-	-	-	-	-	-	-
10:45	-	-	-	-	-	-	-	-	-	-
11:00	2177	10	748	82	10	10	1.8	4	0	0
11:15	-	-	-	-	-	-	-	-	-	-
11:30	-	-	-	-	-	-	-	-	-	-
11:45	-	-	-	-	-	-	-	-	-	-
12:00	2177	10	0	82	1.1	2	1.0	2	0	0
12:15	-	-	-	-	-	-	-	-	-	-
12:30	-	-	-	-	-	-	-	-	-	-
12:45	-	-	-	-	-	-	-	-	-	-
13:00	2177	10	0	82	1	2	1	2	0	0
13:15	-	-	-	-	-	-	-	-	-	-
13:30	-	-	-	-	-	-	-	-	-	-
13:45	-	-	-	-	-	-	-	-	-	-
14:00	2177	10	0	82	3	7	3	7	0	0
14:15	-	-	-	-	-	-	-	-	-	-
14:30	-	-	-	-	-	-	-	-	-	-
14:45	-	-	-	-	3	-	2	-	-	-
15:00	-	-	-	-	3	7	2	7	-	-
15:15	-	-	-	-	-	-	-	-	-	-
15:30	-	-	-	-	-	6	-	4	-	-
15:45	-	-	-	-	-	6	-	4	-	-
16:00										
16:30										
17:00										
17:30										
18:00										
Average	2063	15	125	73	6	10	4	8	0	0

Reagents	Solution Strength		Location
Lime	0.1	g/ml	PG
Lime	0.005	g/ml	RG
F.O	0.86	g/ml	All
MIBC	0.0120	g/drop	All
3418A	0.00025	g/ml	All
208	0.0005	g/ml	All
PAX	0.005	g/ml	Py Ro
Floc	0.001	g/ml	Thickener

TABLE V-3D Continued
SUMMARY OF REAGENT ADDITIONS
KM3512-P3 HYP PP Composite

Time	g/tonne									
	RG F.O.	Cl1-A MIBC	Cl1-A 3418A	Cl1-A 208	Cl1-B lime	Cl1-C 3418A	Cl1-C 208	Py Ro1 MIBC	Py Ro1 PAX	Thick Fd Floc
7:30										
8:00	-	-	17	33	-	17	1	33	224	20
8:15	-	-	-	-	-	-	-	-	-	-
8:30	-	-	-	-	-	-	-	-	-	-
8:45	-	-	-	-	-	-	-	-	-	-
9:00	-	-	-	22	-	-	-	-	-	-
9:15	-	-	-	-	-	-	-	-	-	-
9:30										
9:45	-	-	-	-	-	-	-	-	-	-
10:00	15	-	11	22	-	11	0	33	221	20
10:15	-	-	-	-	-	-	-	-	-	-
10:30	-	-	-	-	-	-	-	-	-	-
10:45	-	-	-	-	-	-	-	-	-	-
11:00	10	-	11	23	-	11	0	24	231	15
11:15	-	-	-	-	-	-	-	-	-	-
11:30	-	-	-	-	-	-	-	-	-	-
11:45	-	-	-	-	-	-	-	-	-	-
12:00	19	-	7	13	-	6	0	24	197	22
12:15	-	-	-	-	-	-	-	-	-	-
12:30	-	-	-	-	-	-	-	-	-	-
12:45	-	-	-	-	-	-	-	-	-	-
13:00	15	-	7	14	-	6	0	27	238	22
13:15	-	-	-	-	-	-	-	-	-	-
13:30	-	-	-	-	-	-	-	-	-	-
13:45	-	-	-	-	-	-	-	-	-	-
14:00	15	-	6	14	82	6	0	25	238	22
14:15	-	-	-	-	-	-	-	-	-	-
14:30	-	-	3	7	-	3	0	-	-	-
14:45	-	-	-	-	-	-	-	-	-	-
15:00	-	-	3	7	34	3	0	24	238	21
15:15	-	-	-	-	-	-	-	-	-	-
15:30	-	-	-	-	-	-	-	-	-	-
15:45	-	-	-	-	-	-	-	-	-	-
16:00										
16:30										
17:00										
17:30										
18:00										
Average	15	-	8	17	58	8	0	27	227	20

TABLE V-3E
KM3512-P3 HYP PP Composite
Raw Data - Sample Survey 07:40-10:00

Product	Mass	Assay - percent or g/tonne					Time	Mass	Wet Wt	Density
	Dry - g	Cu	Mo	Fe	S	Au	s	kg/hr	g	percent
Feed	512.2	0.20	0.032	2.7	1.98	0.33	15	122.9	1504.3	34.0
Bulk Ro Con	80.7	3.20	0.520	15.4	17.7	3.29	60	4.8	573.5	14.1
Bulk Ro Tails	376.1	0.04	0.011	1.8	0.61	0.06	20	67.7	1261.2	29.8
Bulk Rgd Dis	57.2	2.72	0.369	14.7	18.4	2.67	80	2.6	471.6	12.1
Bulk Clnr Tail	30.9	0.25	0.021	5.9	4.48	0.36	80	1.4	650.6	4.7
Py Ro Feed	467.0	0.03	0.008	1.7	0.67	0.06	20	84.1	1725.5	27.1
Py Ro Con	51.1	0.29	0.093	12.4	14.4	0.70	40	4.6	809.4	6.3
Py Ro Tail	432.4	0.03	0.006	1.5	0.26	0.06	20	77.8	1537.6	28.1
Bulk Con	2119.2	13.0	0.933	31.3	38.9	10.6	7200	1.1	6720	31.5

TABLE V-3E
KM3512-P3 HYP PP Composite
Raw Data - Sample Survey 10:00-12:00

Product	Mass	Assay - percent or g/tonne					Time	Mass	Wet Wt	Density
	Dry - g	Cu	Mo	Fe	S	Au	s	kg/hr	g	percent
Feed	952.4	0.25	0.036	2.7	1.66	0.28	30	114.3	2619.1	36.4
Bulk Ro Con	213.9	2.62	0.433	15.1	17.1	4.18	120	6.4	1688.5	12.7
Bulk Ro Tails	794.4	0.03	0.010	1.7	0.68	0.10	30	95.3	2152.7	36.9
Bulk Rgd Dis	289.4	2.42	0.372	17.4	20.6	ip	120	8.7	1991.5	14.5
Bulk Clnr Tail	166.9	0.19	0.021	4.4	3.11	0.28	120	5.0	2383.6	7.0
Py Ro Feed	742.3	0.03	0.009	1.9	0.77	0.06	30	89.1	2591.5	28.6
Py Ro Con	131.0	0.31	0.082	11.6	14.3	0.67	120	3.9	1948.4	6.7
Py Ro Tail	785.8	0.02	0.005	1.4	0.18	0.09	30	94.3	2611.3	30.1
Bulk Con	4675.4	7.60	1.00	36.7	43.5	9.60	7200	2.3	28330	16.5

TABLE V-3E Continued
KM3512-P3 HYP PP Composite
Raw Data - Sample Survey 12:20-14:20

Product	Mass	Assay - percent or g/tonne					Time	Mass	Wet Wt	Density
	Dry - g	Cu	Mo	Fe	S	Au	s	kg/hr	g	percent
Feed	865.3	0.21	0.038	3.2	1.93	0.35	30	103.8	2504.9	34.5
Bulk Ro Con	266.3	1.93	0.262	12.9	13.7	2.37	120	8.0	1841.6	14.5
Bulk Ro Tails	923.8	0.03	0.012	1.8	0.68	0.07	30	110.9	2240.3	41.2
Bulk Rgd Dis	229.5	2.22	0.325	13.7	14.8	2.71	120	6.9	1581.6	14.5
Bulk Clnr Tail	117.2	0.2	0.010	3.4	1.7	0.3	120	3.5	1616.1	7.3
Py Ro Feed	949.1	0.0	0.010	1.9	0.7	0.12	30	113.9	2648.7	35.8
Py Ro Con	168.6	0.3	0.060	13.6	13.9	0.67	120	5.1	2120	8.0
Py Ro Tail	865.1	0.0	0.009	1.5	0.2	0.06	30	103.8	2338.9	37.0
Bulk Con	4590.8	6.70	0.991	32.2	19.8	7.30	7200	2.3	38970	11.8

TABLE V-3E
KM3512-P3 HYP PP Composite
Raw Data - Sample Survey 14:20-18:20

Product	Mass	Assay - percent or g/tonne					Time	Mass	Wet Wt	Density
	Dry - g	Cu	Mo	Fe	S	Au	s	kg/hr	g	percent
Feed	596.1	0.22	0.035	3.0	1.82	0.43	25	85.8	2009.3	29.7
Bulk Ro Con	149.5	2.26	0.337	16.9	37.1	2.89	100	5.4	1191.5	12.5
Bulk Ro Tails	716.5	0.03	0.007	1.7	0.33	0.08	25	103.2	2057.6	34.8
Bulk Rgd Dis	164.6	1.94	0.307	15.5	17.2	2.67	100	5.9	1464.8	11.2
Bulk Clnr Tail	101.5	0.23	0.013	6.3	5.26	0.42	100	3.7	1630.2	6.2
Py Ro Feed	695.7	0.0	0.006	1.7	0.5	0.08	25	100.2	2370.5	29.3
Py Ro Con	144.2	0.23	0.043	8.5	7.86	0.60	100	5.2	2249.2	6.4
Py Ro Tail	717.1	0.02	0.005	1.5	0.13	0.08	25	103.3	2153.2	33.3
Bulk Con	2933.5	8.90	1.041	33.5	39.9	6.62	7200	1.5	19540	15.0

TABLE V-3F
KM3512-P3 HYP PP Composite
Metallurgical Balance - Sample Survey 07:40-10:00

Product	Mass		Assay - percent or g/tonne					Distribution - percent				
	kg/hr	percent	Cu	Mo	Fe	S	Au	Cu	Mo	Fe	S	Au
Feed	88	100.0	0.22	0.028	2.4	1.44	0.24	100.0	100.0	100.0	100.0	100.0
Bulk Ro Con	5.3	6.0	3.29	0.264	13.3	15.1	3.13	90.1	55.5	33.2	62.6	78.8
Bulk Ro Tails	83.0	94.0	0.02	0.013	1.7	0.57	0.05	9.9	44.5	66.8	37.4	21.2
Bulk Rgd Dis	5.3	6.0	3.29	0.264	13.3	15.1	3.13	90.1	55.5	33.2	62.6	78.8
Bulk Clnr Tail	3.9	4.5	0.24	0.022	6.2	4.66	0.34	5.0	3.5	11.6	14.4	6.5
Py Ro Feed	86.9	98.5	0.03	0.014	1.9	0.76	0.07	14.9	48.0	78.4	51.8	27.7
Py Ro Con	3.0	3.4	0.28	0.131	12.4	14.5	0.69	4.4	15.7	17.8	34.4	10.0
Py Ro Tail	83.9	95.1	0.02	0.010	1.5	0.26	0.04	10.6	32.3	60.5	17.5	17.7
Bulk con	1.3	1.5	12.3	0.980	34.1	46.0	11.4	85.1	52.0	21.6	48.2	72.3

TABLE V-3F
KM3512-P3 HYP PP Composite
Metallurgical Balance - Sample Survey 10:00-12:00

Product	Mass		Assay - percent or g/tonne					Distribution - percent				
	kg/hr	percent	Cu	Mo	Fe	S	Au	Cu	Mo	Fe	S	Au
Feed	88	100.0	0.23	0.036	2.8	1.86	0.31	100.0	100.0	100.0	100.0	100.0
Bulk Ro Con	6.7	7.6	2.71	0.373	15.8	16.9	3.49	89.6	77.9	43.3	68.6	83.7
Bulk Ro Tails	81.5	92.4	0.03	0.009	1.7	0.63	0.06	10.4	22.1	56.7	31.4	16.3
Bulk Rgd Dis	6.7	7.6	2.71	0.373	15.8	16.9	3.49	89.6	77.9	43.3	68.6	83.7
Bulk Clnr Tail	4.4	5.0	0.19	0.021	4.5	3.12	0.27	4.0	2.8	8.0	8.3	4.2
Py Ro Feed	85.9	97.4	0.03	0.009	1.8	0.76	0.07	14.4	24.9	64.8	39.7	20.4
Py Ro Con	3.5	3.9	0.30	0.095	11.7	14.4	0.67	5.2	10.4	16.8	30.5	8.4
Py Ro Tail	82.4	93.5	0.02	0.006	1.4	0.18	0.04	9.2	14.6	47.9	9.2	12.0
Bulk Con	2.3	2.6	7.54	1.05	37.3	43.3	9.65	85.6	75.1	35.2	60.3	79.6

TABLE V-3F Continued
KM3512-P3 HYP PP Composite
Metallurgical Balance - Sample Survey 12:20-14:20

Product	Mass		Assay - percent or g/tonne					Distribution - percent				
	kg/hr	percent	Cu	Mo	Fe	S	Au	Cu	Mo	Fe	S	Au
Feed	88	100.0	0.22	0.039	3.0	1.54	0.32	100.0	100.0	100.0	100.0	100.0
Bulk Ro Con	7.9	8.9	2.23	0.336	13.7	10.0	2.74	90.4	76.2	41.3	58.1	76.0
Bulk Ro Tails	80.4	91.1	0.02	0.010	1.9	0.71	0.08	9.6	23.8	58.7	41.9	24.0
Bulk Rgd Dis	7.9	8.9	2.23	0.336	13.7	10.0	2.74	90.4	76.2	41.3	58.1	76.0
Bulk Clnr Tail	5.0	5.7	0.18	0.010	3.3	1.80	0.26	4.6	1.4	6.4	6.6	4.6
Py Ro Feed	85.4	96.8	0.03	0.010	2.0	0.77	0.09	14.2	25.2	65.1	48.5	28.6
Py Ro Con	3.9	4.5	0.22	0.058	13.5	13.6	0.70	4.4	6.6	20.4	39.5	9.8
Py Ro Tail	81.4	92.3	0.02	0.008	1.4	0.15	0.07	9.8	18.6	44.7	9.0	18.8
Bulk Con	2.9	3.2	5.81	0.908	31.9	24.5	7.10	85.8	74.8	34.9	51.5	71.4

TABLE V-3F
KM3512-P3 HYP PP Composite
Metallurgical Balance - Sample Survey 14:20-18:20

Product	Mass		Assay - percent or g/tonne					Distribution - percent				
	kg/hr	percent	Cu	Mo	Fe	S	Au	Cu	Mo	Fe	S	Au
Feed	88	100.0	0.22	0.033	2.7	1.69	0.29	100.0	100.0	100.0	100.0	100.0
Bulk Ro Con	7.3	8.3	2.37	0.326	15.1	17.0	2.58	90.4	82.9	46.3	83.7	72.8
Bulk Ro Tails	80.9	91.7	0.02	0.006	1.6	0.30	0.09	9.6	17.1	53.7	16.3	27.2
Bulk Rgd Dis	7.3	8.3	2.37	0.326	15.1	17.0	2.58	90.4	82.9	46.3	83.7	72.8
Bulk Clnr Tail	5.2	5.9	0.21	0.013	6.4	5.12	0.44	5.7	2.4	13.9	17.7	8.7
Py Ro Feed	86.0	97.5	0.03	0.007	1.9	0.59	0.11	15.4	19.5	67.6	34.1	36.0
Py Ro Con	5.2	5.8	0.23	0.040	8.5	7.8	0.60	6.3	7.2	18.3	26.9	11.9
Py Ro Tail	80.9	91.7	0.02	0.004	1.5	0.13	0.08	9.1	12.3	49.3	7.2	24.1
Bulk Con	2.2	2.5	7.53	1.07	35.8	45.4	7.69	84.6	80.5	32.4	65.9	64.0

TABLE V-4A
SUMMARY OF GRINDING CONDITIONS
KM3512-P4 SUS PP Composite

Time	Rod Mill 1			Flotation Feed		
	Mass kg/hr	Feed H_2O L/min	Mill Density	Pumpbox H_2O L/min	Feed Density	Size µm K_{80}
Target	100	1.1	60	2.3	33	
7:00						
7:30						
8:00						
8:30						
9:00	91	1.2	52	1.7	33	-
9:30	90	-	50	-	32	-
10:00	98	-	52	-	37	236
10:30	105	-	51	-	33	-
11:00	100	-	53	-	31	240
11:30	96	-	53	-	42	-
12:00	92	-	51	-	35	179
12:30	103	-	51	-	33	-
13:00	97	-	50	-	34	-
13:30	111	-	-	-	-	-
14:00	103	-	54	-	34	310
14:30	100	-	-	-	-	-
15:00	98	-	54	-	34	-
15:30	-	-	-	-	-	-
16:00						
16:30						
17:00						
17:30						
18:00						
Average	99	1.2	52	1.7	34	241

Mass Start	1437	kg	Time Start	8:50	am
Mass Finish	770	kg	Time Finish	15:40	pm
Total Feed	667	kg	Moisture	-	%

Notes: 1. Float Feed Density taken with Marcy Cup and Scale.
2. Sizings reported above are on Operational grab samples.

Grinding Mill Data

Parameters	Rod Mill 1
Mill Dimensions	24" dia x 30" Mild
RPM	As above
Motor HP	3
No Load Power (amps)	Varies with speed
Starting Mill Charge (kg)	180 kg mild steel rods

Notes: 1. Recycled water was used in grinding circuit.

TABLE V-4B
SUMMARY OF REGRINDING CONDITIONS
KM3512-P4 SUS PP Composite

Time	Cu Ro Con	Ro Con Regrind				
	Mass Pull (%)	RG Speed RPM	RG1 Power kW	RG2 Speed RPM	RG2 Power kW	Disch. µm K80
7:00						
7:30						
8:00						
8:30						
9:00	16.1	1380	0.82	-	-	-
9:30	-	-	-	-	-	33
10:00	12.7	-	-	-	-	-
10:30	-	-	-	-	-	-
11:00	16.1	1380	0.82	1530	0.89	-
11:30	-	-	-	-	-	71
12:00	14.4	-	-	-	-	-
12:30	-	-	-	-	-	-
13:00	14.0	1380	0.83	1530	0.89	-
13:30	-	-	-	-	-	78
14:00	16.9	-	-	-	-	-
14:30	-	1530	0.86	1530	0.89	-
15:00	-	1530	0.85	1530	0.89	51
15:30	-	-	-	-	-	-
16:00						
16:30						
17:00						
17:30						
18:00						
Average	15.0	1440	0.83	1530	0.89	58

Notes: 1.Sizings reported above are on Operational grab samples.

2. At 14:30 increased speed on RG2 from 1380rpm to 1530 rpm.

Grinding Mill Data

Parameters	Ro Con Regrind
Mill Type	2x2.5 L Vertical Stirred Mill
RPM	See Above
Motor HP	1
No Load Power (amps)	Varies on Speed
Mill Charge	1600g and 1400g of 3.5 mm ceramic media

TABLE V-4C
SUMMARY OF STREAM SIZING DATA
KM3512-P4 SUS PP Composite

Time	Particle Size - μm K_{80}			
	Flotation Feed	Rougher Concentrate	Regrind Discharge	Bulk Concentrate
7:40-10:00	217	208	84	89
10:00-12:00	256	196	65	60
12:20-14:20	249	202	84	66
14:20-18:20	300	246	68	68

Note: Sizings conducted on Survey Samples.

TABLE V-4D
SUMMARY OF REAGENT ADDITIONS
KM3512-P4 SUS PP Composite

Time	pH											
	Prim Dis	Ro 1	Ro 2	Ro 3	Ro4	RG	Clnr1-A	Clnr1-C	Clnr Tl	Py Ro 1	Py Ro Tl	Clnr1-B
7:30												
8:00												
8:15												
8:30												
8:45												
9:00	11.4	-	-	-	-	-	-	-	-	-	-	-
9:15	11.6	-	-	-	-	-	-	-	-	-	-	-
9:30	11.7	11.6	11.4	11.2	11.0	11.7	11.6	11.3	10.5	10.8	10.7	11.3
9:45	11.8	-	-	-	-	-	-	-	-	-	-	-
10:00	11.8	-	-	-	-	-	-	-	-	-	-	-
10:15	11.7	-	-	-	-	-	-	-	-	-	-	-
10:30	11.7	11.4	11.4	11.3	11.3	11.7	11.6	11.4	11.0	11.1	11.0	11.5
10:45	11.8	-	-	-	-	-	-	-	-	-	-	-
11:00	11.7	-	-	-	-	-	-	-	-	-	-	-
11:15	11.7	-	-	-	-	-	-	-	-	-	-	-
11:30	11.6	11.4	11.4	11.3	11.2	11.6	11.6	11.4	11.0	11.1	11.0	11.5
11:45	11.3	-	-	-	-	-	-	-	-	-	0.0	0.0
12:00	11.3	-	-	-	-	-	-	-	-	-	-	-
12:15	10.9	-	-	-	-	-	-	-	-	-	-	-
12:30	10.8	10.6	10.6	10.7	10.7	9.4	11.2	11.2	10.5	10.7	10.7	11.2
12:45	10.8	-	-	-	-	-	-	-	-	-	-	-
13:00	10.9	-	-	-	-	-	-	-	-	-	-	-
13:15	11.1	-	-	-	-	-	-	-	-	-	-	-
13:30	11.1	11.0	10.8	10.6	10.3	10.1	11.2	11.1	10.7	10.3	10.1	11.1
13:45	11.1	-	-	-	-	-	-	-	-	-	-	-
14:00	11.2	-	-	-	-	-	-	-	-	-	-	-
14:15	11.2	-	-	-	-	-	-	-	-	-	-	-
14:30	11.2	11.0	10.8	10.7	10.6	10.5	11.3	11.2	10.7	10.5	10.4	11.3
14:45	11.2	-	-	-	-	-	-	-	-	-	-	-
15:00	11.2	-	-	-	-	-	-	-	-	-	-	-
15:15	11.1	-	-	-	-	-	-	-	-	-	-	-
15:30	11.1	11.0	10.8	10.7	10.6	10.0	11.6	11.4	10.9	10.7	10.7	11.6
15:45	-	-	-	-	-	-	-	-	-	-	-	-
16:00												
16:30												
17:00												
17:30												
18:00												
Average	11.3	11.1	11.0	10.9	10.8	10.7	11.4	11.3	10.8	10.7	9.3	9.9

Note: pH contolling pump used at primary grind discharge.

TABLE V-4D Continued
SUMMARY OF REAGENT ADDITIONS
KM3512-P4 SUS PP Composite

Time	g/tonne									
	PG Feed Lime	PG Feed F.O.	P.B. Lime	Ro1 MIBC	Ro1 3418A	Ro1 208	Ro3 3418A	Ro 3 208	RG Lime	RG Lime/pH
7:30										
8:00										
8:15										
8:30										
8:45										
9:00	2255	-	0	85	4	7	-	-	-	-
9:15	-	-	-	-	-	-	-	-	-	-
9:30	-	-	-	-	-	-	-	-	-	-
9:45	-	-	-	-	-	-	-	-	-	-
10:00	2184	10	0	101	2	-	-	-	-	-
10:15	-	-	-	-	-	-	-	-	-	-
10:30	-	-	-	-	-	-	-	-	-	-
10:45	-	-	-	-	-	-	-	-	-	-
11:00	2396	10	0	85	2	-	-	-	-	-
11:15	-	-	-	-	-	-	-	-	-	-
11:30	-	-	-	-	-	-	-	-	-	-
11:45	-	-	-	-	-	-	-	-	-	-
12:00	2325	10	0	59	0.5	-	-	-	-	-
12:15	-	-	-	-	-	-	-	-	-	-
12:30	2678	-	-	-	-	-	-	-	-	-
12:45	-	-	-	-	-	-	-	-	-	-
13:00	2748	10	2255	85	0	-	-	-	-	-
13:15	-	-	-	-	-	-	-	-	-	-
13:30	3030	-	-	-	-	-	0	-	-	-
13:45	-	-	-	-	-	-	-	-	-	-
14:00	3030	10	0	85	-	-	1	-	-	-
14:15	-	-	-	-	-	-	-	-	-	-
14:30	-	-	-	-	-	-	-	-	-	-
14:45	-	-	-	-	-	-	-	-	-	-
15:00	-	-	-	-	-	-	1	-	-	-
15:15	-	-	-	-	-	-	-	-	-	-
15:30	-	-	-	-	-	-	-	-	-	-
15:45	-	-	-	-	-	-	-	-	-	-
16:00										
16:30										
17:00										
17:30										
18:00										
Average	2581	10	376	83	2	7	0	-	-	-

Reagents	Solution Strength		Location
Lime	0.1	g/ml	PG
Lime	0.005	g/ml	RG
F.O	0.86	g/ml	All
MIBC	0.0120	g/drop	All
3418A	0.00025	g/ml	All
208	0.0005	g/ml	All
PAX	0.005	g/ml	Py Ro
Floc	0.001	g/ml	Thickener

TABLE V-4D Continued
SUMMARY OF REAGENT ADDITIONS
KM3512-P4 SUS PP Composite

Time	g/tonne										
	RG F.O.	Cl1-A MIBC	Cl1-A 3418A	Cl1-A 208	Cl1-B lime	Cl1-C lime	Cl1-C 3418A	Cl1-C 208	Py Ro1 MIBC	Py Ro1 PAX	Thick Fd Floc
7:30											
8:00											
8:15											
8:30											
8:45											
9:00	-	-	-	-	0	42	4	0	42	240	23
9:15	-	-	-	-	-	-	-	-	-	-	-
9:30	-	-	-	-	-	-	-	-	-	-	-
9:45	-	-	-	-	-	-	-	-	-	-	-
10:00	10	-	-	-	-	42	4	-	34	247	23
10:15	-	-	-	-	-	-	-	-	-	-	-
10:30	-	-	-	-	-	-	-	-	-	-	-
10:45	-	-	-	-	-	-	-	-	-	-	-
11:00	10	-	-	-	-	18	-	-	59	247	23
11:15	-	-	-	-	-	-	-	-	-	-	-
11:30	-	-	-	-	-	-	-	-	-	-	-
11:45	-	-	-	-	-	-	-	-	-	-	-
12:00	10	-	-	-	-	25	-	-	42	416	23
12:15	-	-	-	-	-	-	-	-	-	-	-
12:30	-	-	-	-	-	-	-	-	-	-	-
12:45	-	-	-	-	-	-	-	-	-	-	-
13:00	10	-	-	-	-	35	-	-	51	409	23
13:15	-	-	-	-	-	-	-	-	-	-	-
13:30	-	-	-	-	-	-	-	-	-	-	-
13:45	-	-	-	-	-	-	-	-	-	-	-
14:00	15	-	-	-	-	25	-	-	0	416	23
14:15	-	-	-	-	-	-	-	-	-	-	-
14:30	-	-	-	-	-	-	-	-	-	-	-
14:45	-	-	-	-	-	-	-	-	-	-	-
15:00	-	-	-	-	-	-	-	-	59	423	24
15:15	-	-	-	-	-	-	-	-	-	-	-
15:30	-	-	-	-	-	-	-	-	-	-	-
15:45	-	-	-	-	-	-	-	-	-	-	-
16:00											
16:30											
17:00											
17:30											
18:00											
Average	11	-	-	-	0	31	4	0	41	342	23

TABLE V-4E
KM3512-P4 SUS PP Composite
Raw Data - Sample Survey 07:40-10:00

Product	Mass	Assay - percent or g/tonne					Time	Mass	Wet Wt	Density
	Dry - g	Cu	Mo	Fe	S	Au	s	kg/hr	g	percent
Feed	881.0	0.20	0.037	2.7	1.68	0.28	30	105.7	2721.3	32.4
Bulk Ro Con	184.3	2.45	0.417	19.2	22.5	3.32	120	5.5	1965	9.4
Bulk Ro Tails	648.9	0.02	0.004	1.6	0.17	0.06	30	77.9	1888.8	34.4
Bulk Rgd Dis	256.4	2.51	0.430	19.6	23.2	3.89	120	7.7	2550.4	10.1
Bulk Clnr Tail	146.9	0.44	0.018	7.8	7.41	0.71	120	4.4	2492.8	5.9
Py Ro Feed	822.5	0.04	0.010	1.7	0.50	0.10	30	98.7	2948.1	27.9
Py Ro Con	106.9	0.47	0.048	11.0	11.4	0.92	120	3.2	1506.7	7.1
Py Ro Tail	732.7	0.02	0.004	1.5	0.14	0.08	30	87.9	2529.1	29.0
Bulk Con	1747.4	9.60	0.712	38.4	46.1	12.6	7200	0.9	8010	21.8

TABLE V-4E
KM3512-P4 SUS PP Composite
Raw Data - Sample Survey 10:00-12:00

Product	Mass	Assay - percent or g/tonne					Time	Mass	Wet Wt	Density
	Dry - g	Cu	Mo	Fe	S	Au	s	kg/hr	g	percent
Feed	1350.4	0.19	0.032	2.6	1.56	0.30	40	121.5	3847.6	35.1
Bulk Ro Con	322.4	1.97	0.310	16.1	18.0	2.89	160	7.3	3549.3	9.1
Bulk Ro Tails	982.6	0.02	0.005	1.6	0.22	0.05	40	88.4	2683.4	36.6
Bulk Rgd Dis	324.5	2.29	0.366	16.8	18.8	2.78	160	7.3	3601.4	9.0
Bulk Clnr Tail	234.2	0.36	0.038	11.9	12.1	0.84	160	5.3	3668.4	6.4
Py Ro Feed	1102.0	0.04	0.005	2.1	0.80	0.10	40	99.2	3813.1	28.9
Py Ro Con	127.1	0.53	0.090	20.3	23.0	0.85	160	2.9	1603.6	7.9
Py Ro Tail	988.2	0.02	0.006	1.6	0.19	0.06	40	88.9	3405.9	29.0
Bulk Con	1144.6	14.2	1.348	36.3	42.4	16.3	7200	0.6	7400	15.5

TABLE V-4E Continued
KM3512-P4 SUS PP Composite
Raw Data - Sample Survey 12:20-14:20

Product	Mass	Assay - percent or g/tonne					Time	Mass	Wet Wt	Density
	Dry - g	Cu	Mo	Fe	S	Au	s	kg/hr	g	percent
Feed	629.9	0.29	0.032	4.8	3.49	0.38	25	90.7	2243.5	28.1
Bulk Ro Con	323.0	1.72	0.174	18.8	20.7	2.28	100	11.6	2854.9	11.3
Bulk Ro Tails	494.0	0.03	0.004	1.7	0.15	0.06	25	71.1	1474	33.5
Bulk 1st Clnr Con	274.0	2.72	0.325	31.6	37.2	3.99	100	9.9	2103	13.0
Bulk Rgd Dis	256.5	2.56	0.367	31.3	37.7	4.24	100	9.2	1934.1	13.3
Bulk 1st Clnr Tail	215.0	0.28	0.013	9.4	8.09	0.53	25	31.0	2730.2	7.9
Py Ro Feed	643.5	0.05	0.006	2.5	0.88	0.06	25	92.7	2455.2	26.2
Py Ro Con	88.3	0.40	0.045	16.1	17.6	1.04	100	3.2	1083.6	8.1
Py Ro Tail	628.3	0.03	0.005	1.8	0.28	0.06	25	90.5	2360	26.6
Bulk Con	4771.1	4.62	0.515	39.3	46.3	5.27	7200	2.4	15870	30.1

TABLE V-4E Continued
KM3512-P4 SUS PP Composite
Raw Data - Sample Survey 14:20-18:20

Product	Mass	Assay - percent or g/tonne					Time	Mass	Wet Wt	Density
	Dry - g	Cu	Mo	Fe	S	Au	s	kg/hr	g	percent
Feed	586.6	0.33	0.030	4.0	2.50	0.31	20	105.6	2007.4	29.2
Bulk Ro Con	239.4	2.23	0.217	18.0	19.7	2.74	80	10.8	1910.9	12.5
Bulk Ro Tails	524.3	0.05	0.010	1.9	0.20	0.08	20	94.4	1461.1	35.9
Bulk 1st Clnr Con	350.6	3.32	0.517	35.6	43.0	4.38	80	15.8	1719.2	20.4
Bulk Rgd Dis	122.7	3.23	0.552	34.1	40.4	4.06	80	5.5	632.9	19.4
Bulk 1st Clnr Tail	169.9	0.26	0.014	9.1	7.64	0.45	20	30.6	2122.3	8.0
Py Ro Feed	585.7	0.08	0.007	2.4	0.76	0.12	20	105.4	2077	28.2
Py Ro Con	101.6	0.37	0.040	12.0	11.6	0.86	80	4.6	1129.7	9.0
Py Ro Tail	561.0	0.05	0.005	2.1	0.37	0.07	20	101.0	1953.3	28.7
Bulk Con	4187.5	7.40	0.617	40.0	47.2	7.35	7200	2.1	15370	27.2

TABLE V-4F
KM3512-P4 SUS PP Composite
Metallurgical Balance - Sample Survey 07:40-10:00

Product	Mass		Assay - percent or g/tonne					Distribution - percent				
	kg/hr	percent	Cu	Mo	Fe	S	Au	Cu	Mo	Fe	S	Au
Feed	85	100.0	0.20	0.023	2.6	1.48	0.30	100	100	100	100	100
Bulk Ro Con	5.5	6.4	2.77	0.278	17.7	20.5	3.70	90.2	76.8	44.4	89.1	79.9
Bulk Ro Tails	79.7	93.6	0.02	0.006	1.5	0.17	0.06	9.8	23.2	55.6	10.9	20.1
Bulk Rgd Dis	5.5	6.4	2.77	0.278	17.7	20.5	3.70	90.2	76.8	44.4	89.1	79.9
Bulk Clnr Tail	3.9	4.6	0.39	0.019	8.1	7.67	0.72	8.9	3.8	14.4	23.6	11.1
Py Ro Feed	83.6	98.1	0.04	0.01	1.8	0.52	0.1	18.8	27.0	70.0	34.5	31.2
Py Ro Con	2.9	3.4	0.46	0.050	11.1	11.4	0.92	7.9	7.3	14.5	25.8	10.3
Py Ro Tail	80.7	94.8	0.02	0.005	1.5	0.14	0.07	10.9	19.7	55.5	8.8	20.9
Bulk Con	1.6	1.9	8.60	0.911	41.2	52.0	11.0	81.2	73.0	30.0	65.5	68.8

TABLE V-4F
KM3512-P4 SUS PP Composite
Metallurgical Balance - Sample Survey 10:00-12:00

Product	Mass		Assay - percent or g/tonne					Distribution - percent				
	kg/hr	percent	Cu	Mo	Fe	S	Au	Cu	Mo	Fe	S	Au
Feed	85	100.0	0.18	0.023	2.6	1.39	0.26	100	100	100	100	100
Bulk Ro Con	6.0	7.0	2.29	0.272	15.9	17.0	3.01	88.9	82.8	43.7	85.9	82.4
Bulk Ro Tails	79.2	93.0	0.02	0.004	1.5	0.21	0.05	11.1	17.2	56.3	14.1	17.6
Bulk Rgd Dis	6.0	7.0	2.29	0.272	15.9	17.0	3.01	88.9	82.8	43.7	85.9	82.4
Bulk Clnr Tail	5.1	6.0	0.32	0.036	12.3	12.1	0.79	10.5	9.3	28.8	52.4	18.4
Py Ro Feed	84.3	99.0	0.04	0.006	2.2	0.93	0.09	21.5	26.5	85.0	66.4	36.0
Py Ro Con	2.9	3.4	0.55	0.072	20.3	21.8	0.90	10.5	10.7	27.1	53.7	11.9
Py Ro Tail	81.4	95.5	0.02	0.004	1.5	0.19	0.06	11.1	15.7	57.9	12.8	24.0
Bulk Con	0.9	1.0	13.7	1.64	36.9	45.0	15.9	78.5	73.5	15.0	33.6	64.0

TABLE V-4F Continued
KM3512-P4 SUS PP Composite
Metallurgical Balance - Sample Survey 12:20-14:20

Product	Mass		Assay - percent or g/tonne					Distribution - percent				
	kg/hr	percent	Cu	Mo	Fe	S	Au	Cu	Mo	Fe	S	Au
Feed	85	100.0	0.29	0.032	4.4	3.32	0.37	100.0	100.0	100.0	100.0	100.0
Bulk Ro Con	12.3	14.5	1.81	0.190	20.2	22.0	2.25	91.5	87.1	66.5	96.2	87.3
Bulk Ro Tails	72.8	85.5	0.03	0.005	1.7	0.15	0.06	8.5	12.9	33.5	3.8	12.7
Bulk Clnr Tail	7.9	9.2	0.25	0.014	9.2	8.20	0.49	8.1	4.1	19.4	22.9	12.1
Py Ro Feed	80.7	94.8	0.05	0.006	2.5	0.93	0.10	16.6	17.0	53.0	26.6	24.8
Py Ro Con	3.2	3.8	0.43	0.042	16.3	16.6	0.99	5.7	5.0	14.1	19.1	10.1
Py Ro Tail	77.5	91.0	0.03	0.004	1.9	0.28	0.06	10.9	11.9	38.8	7.6	14.7
Bulk Con	4.5	5.2	4.57	0.501	39.5	46.5	5.36	83.4	83.0	47.0	73.4	75.2

TABLE V-4F
KM3512-P4 SUS PP Composite
Metallurgical Balance - Sample Survey 14:20-18:20

Product	Mass		Assay - percent or g/tonne					Distribution - percent				
	kg/hr	percent	Cu	Mo	Fe	S	Au	Cu	Mo	Fe	S	Au
Feed	85	100.0	0.32	0.029	3.8	2.45	0.35	100	100	100	100	100
Bulk Ro Con	10.1	11.8	2.33	0.197	18.2	19.2	2.40	85.9	79.5	56.4	93.0	81.3
Bulk Ro Tails	75.1	88.2	0.05	0.007	1.9	0.20	0.07	14.1	20.5	43.6	7.0	18.7
Bulk Clnr Tail	7.2	8.4	0.27	0.014	9.0	7.37	0.45	7.0	3.9	19.9	25.3	10.8
Py Ro Feed	82.2	96.6	0.07	0.007	2.5	0.82	0.11	21.1	24.4	63.5	32.4	29.5
Py Ro Con	3.5	4.1	0.38	0.041	12.0	11.3	0.88	4.8	5.7	12.8	18.8	10.3
Py Ro Tail	78.8	92.5	0.06	0.006	2.1	0.36	0.07	16.3	18.7	50.7	13.6	19.2
Bulk Con	2.9	3.4	7.40	0.646	40.6	48.3	7.20	78.9	75.6	36.5	67.6	70.5

TABLE V-5A
SUMMARY OF GRINDING CONDITIONS
KM3512-P5 SUS PP Composite

Time	Rod Mill 1			Flotation Feed		
	Mass kg/hr	Feed H_2O L/min	Mill Density	Pumpbox H_2O L/min	Feed Density	Size µm K_{80}
Target	100	1.1	60	2.3	33	
7:00						
7:30						
8:00	94	1.4	55	2.7	34	-
8:30						
9:00	95	-	56	-	35	-
9:30	97	-	56	-	33	224
10:00	104	-	56	-	33	-
10:30	109	-	-	-	-	220
11:00	105	-	55	-	33	-
11:30	92	-	-	-	-	-
12:00	107	-	57	-	33	-
12:30	96	-	-	-	-	286
13:00	100	-	54	-	33	-
13:30	103	-	-	-	-	-
14:00	109	-	55	-	31	-
14:30	102	-	-	-	-	-
15:00	97	-	53	-	35	-
15:30	-	-	55	-	-	-
16:00						
16:30						
17:00						
17:30						
18:00						
Average	101	1.4	55	2.7	33	243

Mass Start	725	kg	Time Start	7:50	am
Mass Finish	47	kg	Time Finish	15:20	pm
Total Feed	678	kg	Moisture	-	%

Notes:
1. Float Feed Density taken with Marcy Cup and Scale.
2. Sizings reported above are on Operational grab samples.
3. Mill went down at 8:25 and back up at 8:40 because of cells sanding.
4. At 8:40 sped mill up to 1200rpm .
5. At 15:20 ran out of rock.

Grinding Mill Data

Parameters	Rod Mill 1
Mill Dimensions	24" dia x 30" Mild
RPM	As above
Motor HP	3
No Load Power (amps)	Varies with speed
Starting Mill Charge (kg)	180 kg mild steel rods

Notes:
1. Recycled water was used in grinding circuit.

TABLE V-5B
SUMMARY OF REGRINDING CONDITIONS
KM3512-P5 SUS PP Composite

Time	Cu Ro Con	Ro Con Regrind				
	Mass Pull (%)	RG Speed RPM	RG1 Power kW	RG2 Speed RPM	RG2 Power kW	Disch. µm K80
7:00						
7:30						
8:00	17.2	-	-	-	-	-
8:30						
9:00	15.8	1530	0.89	1530	0.84	-
9:30	-	-	-	-	-	98
10:00	12.5	-	-	-	-	-
10:30	-	-	-	-	-	62
11:00	15.8	1530	0.89	1530	0.84	-
11:30	-	-	-	-	-	-
12:00	14.1	-	-	-	-	-
12:30	-	1530	0.90	-	-	-
13:00	13.7	1530	0.90	1530	0.85	49
13:30	-	-	-	-	-	-
14:00	16.6	-	-	-	-	49
14:30	-	-	-	-	-	-
15:00	-	1530	0.89	1530	0.85	-
15:30	-	-	-	-	-	-
16:00						
16:30						
17:00						
17:30						
18:00						
Average	15.1	1530	0.89	1530	0.85	65

Notes: 1.Sizings reported above are on Operational grab samples.

2. At 12:00 increased media for RG1 and RG2 to 1800g.

Grinding Mill Data

Parameters	Ro Con Regrind
Mill Type	2x2.5 L Vertical Stirred Mill
RPM	See Above
Motor HP	1
No Load Power (amps)	Varies on Speed
Mill Charge	1800g of 3.5 mm ceramic media in each

TABLE V-5C
SUMMARY OF STREAM SIZING DATA
KM3512-P5 SUS PP Composite

Time	Particle Size - μm K_{80}			
	Flotation Feed	Rougher Concentrate	Regrind Discharge	Bulk Concentrate
8:20-10:00	274	196	64	57
10:20-12:00	253	183	62	56
12:20-14:00	243	166	56	53
14:20-15:00	228	158	38	58

Note: Sizings conducted on Survey Samples.

TABLE V-5D
SUMMARY OF REAGENT ADDITIONS
KM3512-P5 SUS PP Composite

Time	pH											
	Prim Dis	Ro 1	Ro 2	Ro 3	Ro4	RG	Clnr1-A	Clnr1-C	Clnr Tl	Py Ro 1	Py Ro Tl	Clnr1-B
7:30												
8:00	11.5	-	-	-	-	-	-	-	-	-	-	-
8:15	11.6	-	-	-	-	-	-	-	-	-	-	-
8:30												
8:45	11.2	-	-	-	-	-	-	-	-	-	-	-
9:00	11.1	-	-	-	-	-	-	-	-	-	-	-
9:15	11.2	-	-	-	-	-	-	-	-	-	-	-
9:30	11.1	11.0	10.8	10.7	10.6	11.1	11.2	10.7	10.2	10.5	10.5	11.1
9:45	11.1	-	-	-	-	-	-	-	-	-	-	-
10:00	11.0	-	-	-	-	-	-	-	-	-	-	-
10:15	10.9	-	-	-	-	-	-	-	-	-	-	-
10:30	10.9	10.9	10.9	10.8	10.6	10.4	11.2	10.8	10.4	10.6	10.5	11.1
10:45	10.9	-	-	-	-	-	-	-	-	-	-	-
11:00	11.1	-	-	-	-	-	-	-	-	-	-	-
11:15	10.9	-	-	-	-	-	-	-	-	-	-	-
11:30	10.8	11.3	11.0	10.9	10.8	11.0	11.5	11.3	10.7	10.8	10.7	11.4
11:45	10.6	-	-	-	-	-	-	-	-	-	-	-
12:00	10.8	-	-	-	-	-	-	-	-	-	-	-
12:15	10.8	-	-	-	-	-	-	-	-	-	-	-
12:30	10.8	11.3	11.0	10.8	10.7	10.6	11.3	10.9	10.3	10.8	10.4	11.2
12:45	10.6	-	-	-	-	-	-	-	-	-	-	-
13:00	10.5	-	-	-	-	-	-	-	-	-	-	-
13:15	8.2	-	-	-	-	-	-	-	-	-	-	-
13:30	8.7	11.2	10.9	10.7	10.6	9.5	11.6	10.8	9.6	10.4	10.2	11.1
13:45	10.5	-	-	-	-	-	-	-	-	-	-	-
14:00	11.0	-	-	-	-	-	-	-	-	-	-	-
14:15	11.2	-	-	-	-	-	-	-	-	-	-	-
14:30	11.2	11.2	10.9	10.5	10.3	10.6	11.1	11.1	10.9	10.2	10.0	10.3
14:45	11.1	-	-	-	-	-	-	-	-	-	-	-
15:00	11.3	-	-	-	-	-	-	-	-	-	-	-
15:15	11.3	-	-	-	-	-	-	-	-	-	-	-
15:30	11.6	11.0	10.9	10.7	10.6	10.2	11.0	10.5	10.0	10.5	10.4	10.8
15:45												
16:00												
16:30												
17:00												
17:30												
18:00												
Average	10.9	11.1	10.9	10.7	10.6	10.5	11.3	10.9	10.3	10.5	10.4	11.0

Notes: 1. pH contolling pump used at primary grind discharge.
2. At 12:00 two cells added to Pyrite Circuit.

TABLE V-5D Continued
SUMMARY OF REAGENT ADDITIONS
KM3512-P5 SUS PP Composite

Time	g/tonne									
	PG Feed Lime	PG Feed F.O.	P.B. Lime	Ro1 MIBC	Ro1 3418A	Ro1 208	Ro3 3418A	Ro 3 208	RG Lime	RG Lime/pH
7:30										
8:00	3050	-	0	87	-	-	1	-	-	-
8:15	-	-	-	-	-	-	-	-	-	-
8:30										
8:45	-	-	-	-	-	-	-	-	-	-
9:00	3119	8	0	108	-	-	1	-	-	-
9:15	-	-	-	-	-	-	-	-	-	-
9:30	-	-	-	-	-	-	-	-	-	-
9:45	-	-	-	-	-	-	-	-	-	-
10:00	3258	7	0	92	-	-	1	-	-	-
10:15	-	-	-	-	-	-	-	-	-	-
10:30	-	-	-	-	-	-	-	-	-	-
10:45	-	-	-	-	-	-	-	-	-	-
11:00	3119	15	0	92	-	-	0.2	-	-	-
11:15	-	-	-	-	-	-	-	-	-	-
11:30	-	-	-	-	-	-	-	0	-	-
11:45	-	-	-	-	-	-	-	-	-	-
12:00	3258	5	763	75	-	-	0.2	0	-	-
12:15	-	-	-	-	-	-	-	-	-	-
12:30	-	-	-	-	-	-	-	-	-	-
12:45	-	-	-	-	-	-	-	-	-	-
13:00	3466	15	4575	36	-	-	0	0	-	-
13:15	-	-	-	-	-	-	-	-	-	-
13:30	-	-	-	-	-	-	-	-	-	-
13:45	-	-	-	-	-	-	-	-	-	-
14:00	3189	10	347	108	-	-	1	1	-	-
14:15	-	-	-	-	-	-	-	-	-	-
14:30	-	-	-	-	-	-	-	-	-	-
14:45	-	-	-	-	-	-	-	-	-	-
15:00	-	-	-	-	-	-	1	1	-	-
15:15	-	-	-	-	-	-	-	-	-	-
15:30	-	-	-	-	-	-	-	-	-	-
15:45										
16:00										
16:30										
17:00										
17:30										
18:00										
Average	3209	10	812	85	-	-	1	1	-	-

Reagents	Solution Strength		Location
Lime	0.1	g/ml	PG
Lime	0.005	g/ml	RG
F.O	0.86	g/ml	All
MIBC	0.0120	g/drop	All
3418A	0.00025	g/ml	All
208	0.0005	g/ml	All
PAX	0.005	g/ml	Py Ro
Floc	0.001	g/ml	Thickener

TABLE V-5D Continued
SUMMARY OF REAGENT ADDITIONS
KM3512-P5 SUS PP Composite

Time	g/tonne										
	RG F.O.	Cl1-A MIBC	Cl1-A 3418A	Cl1-A 208	Cl1-B lime	Cl1-C lime	Cl1-C 3418A	Cl1-C 208	Py Ro1 MIBC	Py Ro1 PAX	Thick Fd Floc
7:30											
8:00	-	34	-	-	-	0	-	-	58	367	22
8:15	-	-	-	-	-	-	-	-	-	-	-
8:30											
8:45	-	-	-	-	-	-	-	-	-	-	-
9:00	-	0	-	-	-	0	-	-	58	395	22
9:15	-	-	-	-	-	-	-	-	-	-	-
9:30	-	-	-	-	-	-	-	-	-	-	-
9:45	-	-	-	-	-	-	-	-	-	-	-
10:00	11	0	-	-	-	0	-	-	36	416	31
10:15	-	-	-	-	-	-	-	-	-	-	-
10:30	-	-	-	-	-	-	-	-	-	-	-
10:45	-	-	-	-	-	-	-	-	-	-	-
11:00	11	0	-	-	-	0	-	-	42	402	22
11:15	-	-	-	-	-	-	-	-	-	-	-
11:30	-	-	-	-	-	-	-	-	-	-	-
11:45	-	-	-	-	-	-	-	-	-	-	-
12:00	10	0	-	-	-	0	1	0	40	402	22
12:15	-	-	-	-	-	-	-	-	-	458	-
12:30	-	-	-	-	-	-	-	-	-	-	-
12:45	-	-	-	-	-	-	-	-	-	-	-
13:00	10	0	-	-	-	0	1	0	58	451	24
13:15	-	-	-	-	-	-	-	-	-	-	-
13:30	-	-	-	-	-	-	-	-	-	-	-
13:45	-	-	-	-	-	-	-	-	-	-	-
14:00	10	0	-	-	-	0	1	0	47	444	22
14:15	-	-	-	-	-	-	-	-	-	-	-
14:30	-	-	-	-	-	-	-	-	-	-	-
14:45	-	-	-	-	-	-	-	-	-	-	-
15:00	-	0	-	-	-	0	1	0	47	437	21
15:15	-	-	-	-	-	-	-	-	-	-	-
15:30	-	-	-	-	-	-	-	-	-	-	-
15:45											
16:00											
16:30											
17:00											
17:30											
18:00											
Average	10	4	-	-	-	0	1	0	48	419	23

TABLE V-5E
KM3512-P5 SUS PP Composite
Raw Data - Sample Survey 08:20-10:00

Product	Mass Dry - g	Assay - percent or g/tonne					Time s	Mass kg/hr	Wet Wt g	Density percent
		Cu	Mo	Fe	S	Au				
Feed	898.5	0.33	0.037	4.1	2.74	0.46	25	129.4	2744.4	32.7
Bulk Ro Con	271.8	2.66	0.301	21.7	25.7	3.68	100	9.8	2206.4	12.3
Bulk Ro Tails	730.7	0.08	0.009	2.0	0.20	0.09	25	105.2	2345.3	31.2
Bulk 1st Clnr Con	504.9	4.37	0.808	35.5	43.4	4.82	100	18.2	1969.7	25.6
Bulk Rgd Dis	409.1	4.70	0.775	35.9	43.3	5.05	100	14.7	1633.8	25.0
Bulk 1st Clnr Tail	209.3	0.43	0.019	12.5	12.8	0.88	25	30.1	2170.8	9.6
Py Ro Feed	674.6	0.08	0.011	2.9	1.19	0.25	100	24.3	2537.8	26.6
Py Ro Con	339.4	0.30	0.026	8.0	6.43	0.49	100	12.2	2994.8	11.3
Py Ro Tail	639.3	0.06	0.008	2.0	0.26	0.09	25	92.1	2173.3	29.4
Bulk Con	3207.6	8.90	0.548	36.5	43.8	9.72	7200	1.6	15550	20.6

TABLE V-5E
KM3512-P5 SUS PP Composite
Raw Data - Sample Survey 10:20-12:00

Product	Mass Dry - g	Assay - percent or g/tonne					Time s	Mass kg/hr	Wet Wt g	Density percent
		Cu	Mo	Fe	S	Au				
Feed	622.3	0.32	0.046	3.8	2.95	0.46	25	89.6	2305.9	27.0
Bulk Ro Con	312.7	2.60	0.314	24.9	27.0	3.95	100	11.3	2305.7	13.6
Bulk Ro Tails	815.9	0.06	0.010	1.9	0.22	0.08	30	97.9	2479.6	32.9
Bulk 1st Clnr Con	812.0	4.23	1.28	35.2	44.0	4.88	120	24.4	4134.7	19.6
Bulk Rgd Dis	658.3	4.25	1.21	36.4	44.2	6.00	120	19.7	3068	21.5
Bulk 1st Clnr Tail	288.9	0.40	0.064	17.1	17.7	1.02	30	34.7	3166.1	9.1
Py Ro Feed	885.1	0.09	0.013	2.9	1.65	0.21	120	26.6	3335.2	26.5
Py Ro Con	598.1	0.26	0.039	8.5	7.71	0.42	120	17.9	4919.3	12.2
Py Ro Tail	672.9	0.05	0.009	1.8	0.26	0.08	30	80.7	2175.5	30.9
Bulk Con	5530.9	10.3	0.768	36.7	45.8	12.4	7200	2.8	19580	28.2

TABLE V-5E Continued
KM3512-P5 SUS PP Composite
Raw Data - Sample Survey 12:20-14:00

Product	Mass	Assay - percent or g/tonne					Time	Mass	Wet Wt	Density
	Dry - g	Cu	Mo	Fe	S	Au	s	kg/hr	g	percent
Feed	344.4	0.34	0.051	3.8	3.49	0.20	30	41.3	2970.3	11.6
Bulk Ro Con	376.9	2.48	0.377	25.5	29.1	3.86	120	11.3	2680.8	14.1
Bulk Ro Tails	748.9	0.05	0.014	1.6	0.23	0.08	30	89.9	2321.1	32.3
Bulk 1st Clnr Con	671.6	3.47	1.153	37.4	44.6	4.98	120	20.1	3522.2	19.1
Bulk Rgd Dis	604.3	3.47	1.117	36.2	43.7	5.17	120	18.1	3304	18.3
Bulk 1st Clnr Tail	295.4	0.37	0.032	17.2	17.5	0.76	30	35.4	3277	9.0
Py Ro Feed	955.2	0.08	0.014	2.6	1.53	0.16	120	28.7	3587.2	26.6
Py Ro Con	738.9	0.19	0.025	6.5	5.07	0.22	100	26.6	4846.7	15.2
Py Ro Tail	526.0	0.05	0.008	1.6	0.22	0.07	30	63.1	1721	30.6
Bulk Con	2903.1	10.2	0.977	37.1	46.6	9.89	7200	1.5	12220	23.8

TABLE V-5E
KM3512-P5 SUS PP Composite
Raw Data - Sample Survey 14:20-15:20

Product	Mass	Assay - percent or g/tonne					Time	Mass	Wet Wt	Density
	Dry - g	Cu	Mo	Fe	S	Au	s	kg/hr	g	percent
Feed	603.5	0.35	0.049	3.9	3.29	0.38	20	108.6	2021.2	29.9
Bulk Ro Con	307.9	2.12	0.274	21.1	24.6	2.92	80	13.9	2354	13.1
Bulk Ro Tails	509.3	0.05	0.013	1.6	0.18	0.07	20	91.7	1524.7	33.4
Bulk 1st Clnr Con	345.6	2.72	0.430	30.8	38.6	3.94	80	15.6	3084.7	11.2
Bulk Rgd Dis	229.7	2.46	0.399	30.1	33.0	3.11	80	10.3	3052.9	7.5
Bulk 1st Clnr Tail	212.8	0.25	0.014	8.9	7.66	0.39	20	38.3	2175.6	9.8
Py Ro Feed	570.9	0.06	0.011	2.2	1.02	0.12	80	25.7	2139.8	26.7
Py Ro Con	341.0	0.25	0.038	6.0	4.87	0.28	80	15.3	2425	14.1
Py Ro Tail	463.8	0.04	0.009	1.6	0.18	0.06	20	83.5	1473.7	31.5
Bulk Con	7371.7	4.21	0.827	35.9	44.5	7.17	7200	3.7	32700	22.5

TABLE V-5F
KM3512-P5 SUS PP Composite
Metallurgical Balance - Sample Survey 08:20-10:00

Product	Mass		Assay - percent or g/tonne					Distribution - percent				
	kg/hr	percent	Cu	Mo	Fe	S	Au	Cu	Mo	Fe	S	Au
Feed	87	100.0	0.34	0.030	3.9	2.52	0.45	100	100	100	100	100
Bulk Ro Con	8.5	9.9	2.83	0.207	20.6	23.7	3.66	82.8	69.3	51.8	92.9	80.5
Bulk Ro Tails	78.0	90.1	0.06	0.010	2.1	0.20	0.10	17.2	30.7	48.2	7.1	19.5
Bulk Clnr Tail	6.0	6.9	0.39	0.020	13.2	13.9	0.93	7.9	4.6	23.2	37.8	14.3
Py Ro Feed	84.0	97.0	0.09	0.011	2.9	1.17	0.16	25.2	35.3	71.3	44.9	33.7
Py Ro Con	12.3	14.2	0.28	0.026	8.0	6.50	0.51	11.6	12.6	28.8	36.5	16.2
Py Ro Tail	71.7	82.9	0.06	0.008	2.0	0.26	0.09	13.6	22.7	42.5	8.4	17.5
Bulk Con	2.6	3.0	8.47	0.640	37.6	46.5	9.93	74.8	64.7	28.7	55.1	66.3

TABLE V-5F
KM3512-P5 SUS PP Composite
Metallurgical Balance - Sample Survey 10:20-12:00

Product	Mass		Assay - percent or g/tonne					Distribution - percent				
	kg/hr	percent	Cu	Mo	Fe	S	Au	Cu	Mo	Fe	S	Au
Feed	87	100.0	0.33	0.035	3.9	2.81	0.46	100	100	100	100	100
Bulk Ro Con	8.9	10.3	2.67	0.257	22.1	25.3	3.79	84.2	75.6	58.5	93.1	84.4
Bulk Ro Tails	77.6	89.7	0.06	0.010	1.8	0.22	0.08	15.8	24.4	41.5	6.9	15.6
Bulk Clnr Tail	6.8	7.9	0.40	0.065	17.5	18.5	1.04	9.7	14.5	35.2	52.0	17.7
Py Ro Feed	84.4	97.6	0.09	0.014	3.1	1.70	0.16	25.5	38.9	76.8	59.0	33.3
Py Ro Con	16.6	19.1	0.25	0.036	8.4	7.61	0.46	14.4	19.7	40.9	51.8	18.8
Py Ro Tail	67.9	78.4	0.05	0.009	1.8	0.26	0.09	11.1	19.2	35.8	7.2	14.4
Bulk Con	2.1	2.4	10.0	0.877	37.2	47.3	12.7	74.5	61.1	23.2	41.0	66.7

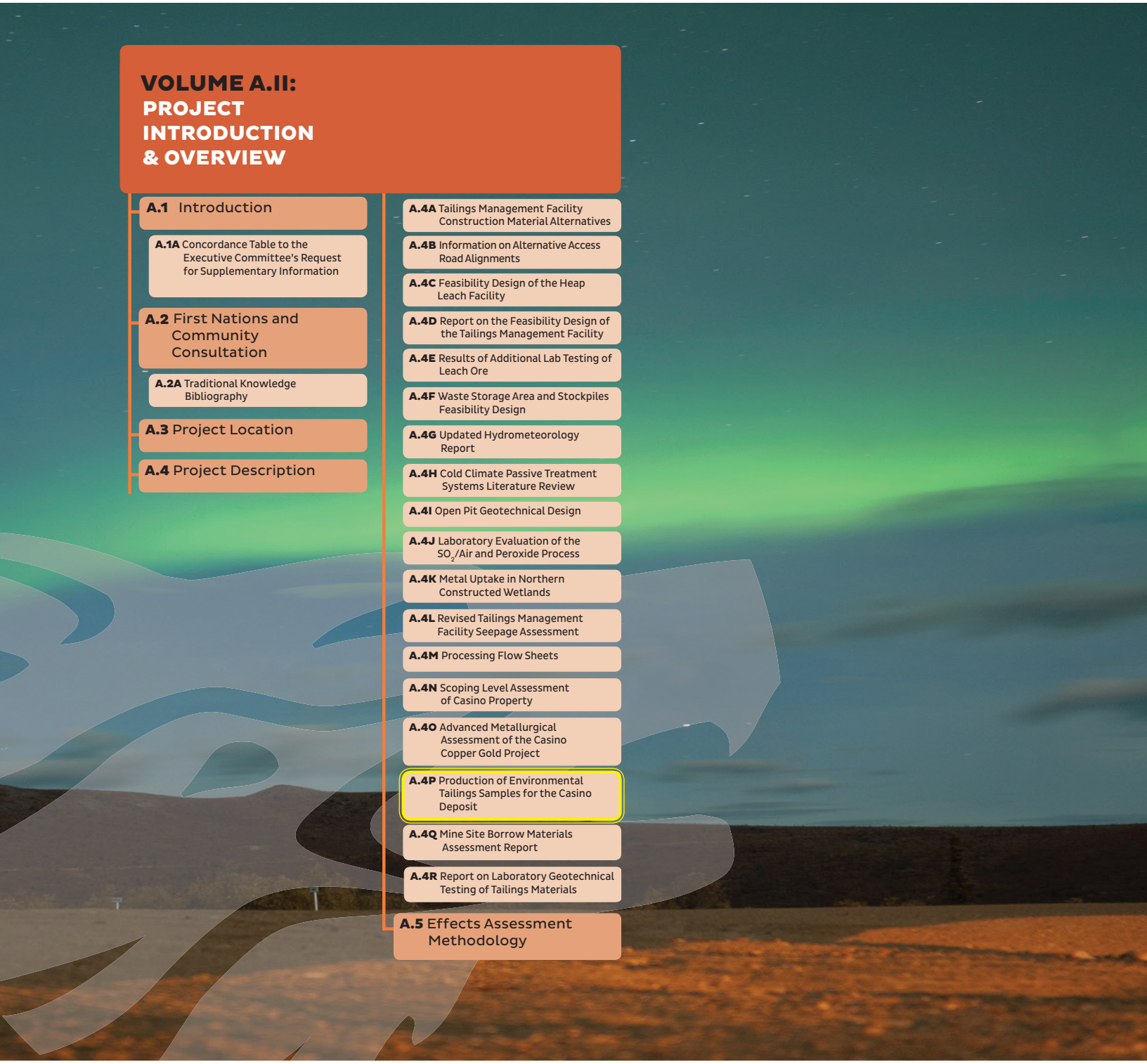
TABLE V-5F Continued
KM3512-P5 SUS PP Composite
Metallurgical Balance - Sample Survey 12:20-14:00

Product	Mass		Assay - percent or g/tonne					Distribution - percent				
	kg/hr	percent	Cu	Mo	Fe	S	Au	Cu	Mo	Fe	S	Au
Feed	87	100.0	0.34	0.045	3.9	3.00	0.43	100	100	100	100	100
Bulk Ro Con	9.2	10.6	2.79	0.315	23.1	26.3	3.39	86.1	74.2	63.7	93.1	84.4
Bulk Ro Tails	77.4	89.4	0.05	0.013	1.6	0.23	0.07	13.9	25.8	36.3	6.9	15.6
Bulk Clnr Tail	6.7	7.8	0.37	0.032	17.8	17.6	0.73	8.4	5.6	35.9	45.8	13.3
Py Ro Feed	84.1	97.2	0.08	0.015	2.9	1.63	0.13	22.3	31.4	72.3	52.7	28.9
Py Ro Con	24.1	27.8	0.17	0.028	6.1	5.15	0.25	13.8	17.3	44.1	47.7	16.3
Py Ro Tail	60.0	69.3	0.04	0.009	1.6	0.22	0.08	8.5	14.1	28.2	5.0	12.6
Bulk Con	2.5	2.8	9.45	1.09	37.7	50.1	10.7	77.7	68.6	27.7	47.3	71.1

TABLE V-5F
KM3512-P5 SUS PP Composite
Metallurgical Balance - Sample Survey 14:20-15:20

Product	Mass		Assay - percent or g/tonne					Distribution - percent				
	kg/hr	percent	Cu	Mo	Fe	S	Au	Cu	Mo	Fe	S	Au
Feed	87	100.0	0.34	0.054	4.2	3.53	0.51	100.0	100.0	100.0	100.0	100.0
Bulk Ro Con	12.7	14.7	2.00	0.300	19.9	23.0	3.08	87.2	81.7	69.0	95.5	88.2
Bulk Ro Tails	73.9	85.3	0.05	0.012	1.5	0.19	0.07	12.8	18.3	31.0	4.5	11.8
Bulk Clnr Tail	7.4	8.5	0.24	0.014	9.0	8.30	0.39	6.2	2.2	18.1	20.0	6.5
Py Ro Feed	81.2	93.8	0.07	0.012	2.2	0.92	0.10	18.9	20.5	49.1	24.5	18.3
Py Ro Con	12.7	14.7	0.23	0.034	5.8	4.93	0.29	10.2	9.3	20.2	20.5	8.5
Py Ro Tail	68.5	79.2	0.04	0.01	1.5	0.18	0.06	8.7	11.2	28.9	4.0	9.9
Bulk Con	5.3	6.2	4.42	0.694	34.9	43.1	6.77	81.1	79.5	50.9	75.5	81.7

APPENDIX A.4P: Production of Environmental Tailings Samples for the Casino Deposit



PRODUCTION OF ENVIRONMENTAL TAILINGS SAMPLES FOR THE CASINO DEPOSIT

WESTERN COPPER CORPORATION

KM2459

December 3, 2009

G&T METALLURGICAL SERVICES LTD.

2957 Bowers Place, Kamloops, B.C. Canada V1S 1W5

E-mail: info@gtmet.com , Website: www.gtmet.com

ISO 9001:2000
Certificate No. FS 63170

G&T METALLURGICAL
SERVICES LTD.

December 3, 2009

Dr. Paul West-Sells
Senior Metallurgist
Western Copper Corporation
2050 – 1111 West Georgia St.
Vancouver, BC
V6E 4M3

Dear Dr. West-Sells:

Re: Production of Environmental Tailings Samples for the Casino Deposit – KM2459

We are pleased to inform you that a program to produce tailings from samples of the Casino Deposit is now complete. The program was initiated in September 2009 and was completed by November 2009. The tailing samples generated were intended for environmental testing.

Three composites were tested in this program and reportedly represent three ore types from the Casino deposit. The samples for each composite were taken from single drill holes and were provided as half drill core from the 2008 drilling season.

A few standardized batch cleaner tests were performed on each composite using test protocols established in KM2084 "Metallurgical Assessment of the Casino Deposit". Once the performance of the samples was deemed acceptable, additional tests were performed to produce the required tailings samples. The samples were not dried, but shipped to CEMI for environmental testing on November 20, 2009. CEMI will provide an independent report on the environmental testing.

The flotation response of the samples, particularly Composites 2 and 3 was very good. Composite 1 had inferior flotation performance, but available data would suggest this composite may have elevated levels of non-sulphide copper.

There is a possibility that the fresh drill core samples produced better metallurgical response when compared to the data generated in the previous study. This study utilized old samples of drill core. Further mineralogical and flotation testing would be required to verify this hypothesis.

Thank you for choosing G & T Metallurgical for your testing needs. If you have any questions, please don't hesitate to contact us.

Thank you,

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December 3, 2009
KM2459

Report Distribution:
Dr. Paul West-Sells, Western Copper Corporation, Vancouver, BC – 2 Copies
G&T Metallurgical Services Ltd., Kamloops, BC – 1 Copy

1. Metallurgical Flotation Response

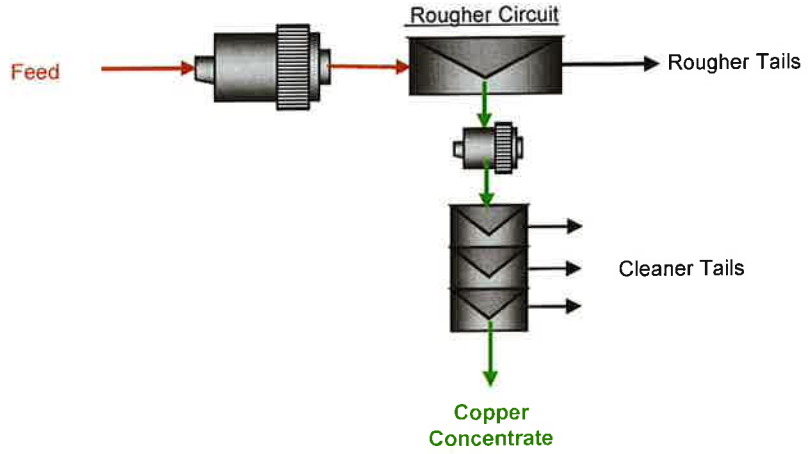
A total of ten batch cleaner tests were performed using conditions previously developed in KM2084. This conventional process utilized a primary grind size of about 150μm K_{80} and regrind size of 30μm K_{80}. The flotation pulp was modulated to pH 11.0 to control the activation and flotation of pyrite. Copper collectors selective against pyrite were also used. Finally, molybdenum in the feed was collected with fuel oil.

Figure 1 displays a schematic of the flowsheet summary of reagents used. Shown at the bottom of the figure are graphs indicating the metallurgical performance of the composites. The following comments may be of interest:

- Composites 2 and 3 performed very well in batch cleaner tests. Composite 2 had 92 percent copper recovery into a concentrate grading about 28 percent copper. Similarly, Composite 3 had 87 percent of the copper in the feed recovered into a concentrate grading 26 percent copper. Molybdenum was also very well recovered into the concentrates for these composites; about 90 percent of the molybdenum was recovered from the feed into the concentrate. Final molybdenum grade was about 7 to 9 percent.

- The flotation performance of Composite 1 was inferior to the other composites. Copper in the feed was about 70 percent recovered into a concentrate grading 28 percent copper. The cause of inferior performance was not determined. However, this sample had elevated levels of weak acid soluble copper, suggesting perhaps non-sulphide forms of copper were contained in this sample.

FIGURE 1
COPPER CLEANER TEST FLOWSHEET AND TEST CONDITIONS
Composite

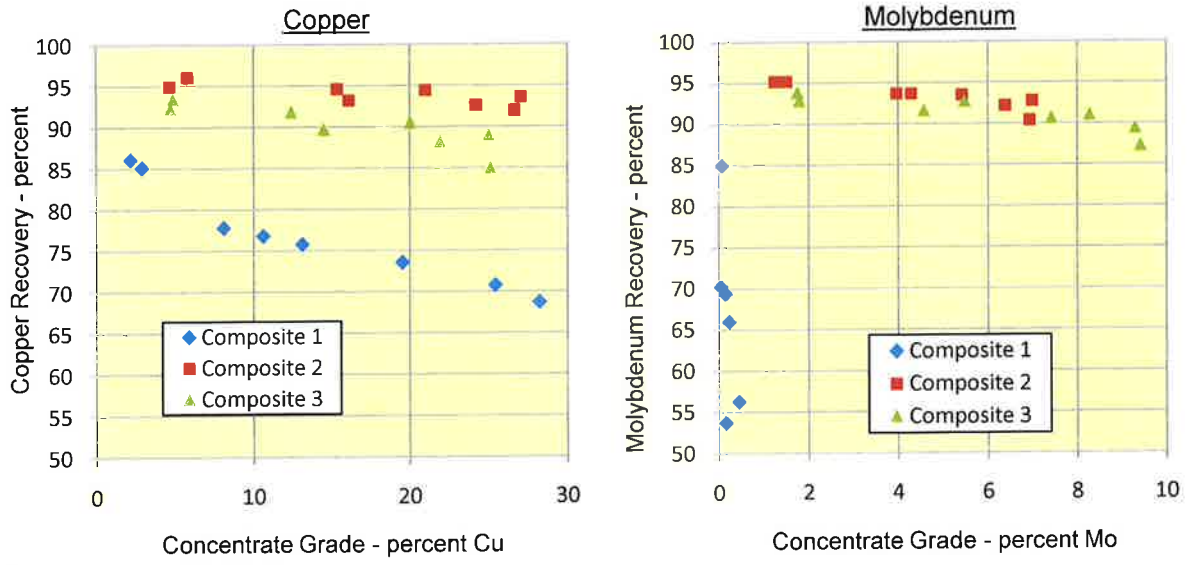


SUMMARY OF TEST CONDITIONS

Composite	Grind Size um K80		pH	Rougher - g/t			Cleaner - g/t		
	Primary	Regrind		Fuel Oil	3418A	AP208	Fuel Oil	3418A	AP208
1	130	20-29	11	20	7	7	6-26	7-12	7-12
2	166	28-33	11	20	5	5	26	7	7
3	167	30-31	11	20	7	7	26	7	7

Note a) Detailed test data can be found in Appendix III

BATCH CLEANER TEST PEFORMANCE



APPENDIX I – KM2459

SAMPLE ORIGIN

1.0 Sample Origin

Drill core samples from the Casino project were received on August 27, 2009. The samples were received as half drill core; a listing of drill core inventory is displayed in Table I-1.

TABLE I-1
INVENTORY OF DRILL CORE RECEIVED

Composite	Drill Hole	Interval (m)	Mass (kg)
Composite 1	CAS 002	206.10 – 211.06	6.8
	CAS 002	211.06 – 216.94	12.4
	CAS 002	216.33 – 220.59	2.0
Composite 2	CAS 002	632.25 – 636.13	7.5
	CAS 002	637.03 – 640.55	6.1
	CAS 002	640.43 – 643.13	4.4
Composite 3	CAS 003	182.88 – 183.42	3.2
	CAS 003	183.42 – 189.68	16.6
	CAS 003	189.68 – 192.68	8.7

The drill core was stage crushed and prepared into composites as shown in Table I-1. Representative head assay samples were pulverized and assayed for the elements of interest in this project. These assays are summarized in Table I-2. All test charges were kept in the freezer.

TABLE I-2
REPLICATE HEAD ASSAY DATA

Composite	Assays – percent or g/tonne						
	Cu	Fe	Mo	Au	Ag	Cuox	CuCN
Composite 1	0.19	5.15	0.001	0.25	1.3	0.020	0.062
Composite 2	0.22	0.84	0.048	0.26	1.0	0.005	0.014
Composite 3	0.16	1.06	0.046	0.15	0.9	0.001	0.006

APPENDIX II – KM2459

FLOTATION TEST DATA

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TEST		PAGE
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11	Rougher Test – Composite 2	21
12	Rougher Test – Composite 3	23

PROJECT NO: KM2459-01

PURPOSE: Preliminary Cleaner Test.

PROCEDURE: Perform a standard one product cleaner test.

FEED: 2 kg of Composite 3 ore ground to a nominal 167μm K_{80}.
Copper Regrind Discharge - 30μm K_{80}.

FLOWSHEET: 2

Stage	Reagents Added g/tonne						Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	H_2SO_4	MIBC	Grind	Cond.	Float	
Primary Grind	2500	20					14			11.6
COPPER CIRCUIT:										
Rougher 1	700		3	3	1900			5	2	11.0
Rougher 2	-		2	2				1	2	11.0
Regrind	50	20					4			9.0
Cleaner 1	700	2	5	5		30		1	4	11.0
Cleaner 2	-	2	1	1		15		1	3	11.0
Cleaner 3	-	2	1	1		15		1	2	11.0

Flotation Data	Rougher	Cleaner
Flotation Machine:	D2B	D1C
Cell Size in liters:	4.4	2.2
Aspiration:	Air	
Impeller Speed in rpm:	1100	1200

Grinding Data	Primary Grind	Copper Regrind
Mill:	M5-Mild	RM2-Mild
Charge/Material:	20kg-Mild	6kg-Steel
Water:	1000ml	estimated

KM2459-01 Composite 3
Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t				Distribution - percent			
	grams	%	Cu	Mo	Fe	Au	Cu	Mo	Fe	Au
Cu Concentrate	10.4	0.5	25.0	9.30	24.7	20.3	89.0	89.4	10.7	47.9
Cu 3rd Cleaner Tail *	2.8	0.1	1.60	0.47	7.70	0.96	1.5	1.2	0.9	0.6
Cu 2nd Cleaner Tail	8.4	0.4	0.46	0.12	4.58	0.96	1.3	1.0	1.6	1.8
Cu 1st Cleaner Tail	34.4	1.7	0.13	0.04	4.16	0.54	1.5	1.2	6.0	4.2
Cu Rougher Tail	1934.9	97.2	0.01	0.004	1.00	0.10	6.6	7.2	80.8	45.4
Feed	1990.9	100	0.15	0.054	1.20	0.22	100	100	100	100

* Not enough sample for assay, Au values estimated.

KM2459-01 Composite 3
Cumulative Metallurgical Balance

Cumulative Product	Cum. Weight		Assay - percent or g/t				Distribution - percent			
	grams	%	Cu	Mo	Fe	Au	Cu	Mo	Fe	Au
Product 1	10.4	0.5	25.0	9.30	24.7	20.3	89.0	89.4	10.7	47.9
Product 1 to 2	13.2	0.7	20.0	7.43	21.1	16.2	90.5	90.6	11.6	48.5
Product 1 to 3	21.6	1.1	12.4	4.59	14.7	10.3	91.8	91.6	13.2	50.4
Product 1 to 4	56.0	2.8	4.87	1.79	8.21	4.29	93.4	92.8	19.2	54.6
Product 5	1934.9	97.2	0.01	0.004	1.00	0.10	6.6	7.2	80.8	45.4
Feed	1990.9	100	0.15	0.054	1.20	0.22	100	100	100	100

PROJECT NO: KM2459-02

PURPOSE: Preliminary Cleaner Test.

PROCEDURE: Perform a standard one product cleaner test.

FEED: 2 kg of Composite 2 ore ground to a nominal 166µm K_{80}.
Copper Regrind Discharge - 28µm K_{80}.

FLOWSHEET: 2

Stage	Reagents Added g/tonne						Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	H_2SO_4	MIBC	Grind	Cond.	Float	
Primary Grind	2500	20					14			11.8
COPPER CIRCUIT:										
Rougher 1			3	3	1800	15		4	2	11.0
Rougher 2			2	2	-	-		1	2	11.0
Regrind	50	20					4			9.0
Cleaner 1	700	2	5	5		30		1	4	11.0
Cleaner 2		2	1	1		15		1	3	11.0
Cleaner 3		2	1	1		15		1	2	11.0

Flotation Data	Rougher	Cleaner
Flotation Machine:	D2B	D1C
Cell Size in liters:	4.4	2.2
Aspiration:	Air	
Impeller Speed in rpm:	1100	1200

Grinding Data	Primary Grind	Copper Regrind
Mill:	M5-Mild	RM2-Mild
Charge/Material:	20kg-Mild	6kg-Steel
Water:	1000ml	estimated

KM2459-02 Composite 2

Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t				Distribution - percent			
	grams	%	Cu	Mo	Fe	Au	Cu	Mo	Fe	Au
Cu Concentrate	13.4	0.7	27.0	7.00	27.2	22.2	93.6	92.8	17.3	55.7
Cu 3rd Cleaner Tail	4.0	0.2	0.90	0.18	6.90	1.33	0.9	0.7	1.3	1.0
Cu 2nd Cleaner Tail	6.4	0.3	0.10	0.03	4.08	0.63	0.2	0.2	1.2	0.8
Cu 1st Cleaner Tail	40.4	2.0	0.13	0.04	4.48	1.33	1.4	1.5	8.6	10.1
Cu Rougher Tail	1930.1	96.8	0.01	0.003	0.78	0.09	4.0	4.8	71.5	32.5
Feed	1994.3	100	0.19	0.051	1.06	0.27	100	100	100	100

KM2459-02 Composite 2

Cumulative Metallurgical Balance

Cumulative Product	Cum. Weight		Assay - percent or g/t				Distribution - percent			
	grams	%	Cu	Mo	Fe	Au	Cu	Mo	Fe	Au
Product 1	13.4	0.7	27.0	7.00	27.2	22.2	93.6	92.8	17.3	55.7
Product 1 to 2	17.4	0.9	21.0	5.43	22.5	17.4	94.5	93.5	18.6	56.7
Product 1 to 3	23.8	1.2	15.4	3.98	17.6	12.9	94.6	93.7	19.9	57.4
Product 1 to 4	64.2	3.2	5.78	1.50	9.33	5.62	96.0	95.2	28.5	67.5
Product 5	1930.1	96.8	0.01	0.003	0.78	0.09	4.0	4.8	71.5	32.5
Feed	1994.3	100	0.19	0.051	1.06	0.27	100	100	100	100

PROJECT NO: KM2459-03

PURPOSE: Preliminary Cleaner Test.

PROCEDURE: Perform a standard one product cleaner test.

FEED: 2 kg of Composite 1 ore ground to a nominal 130μm K_{80}.
Copper Regrind Discharge - 20μm K_{80}.

FLOWSHEET: 2

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	2500	20				17			8.8
COPPER CIRCUIT:									
Rougher 1	1600		5	5	15		2	2	11.0
Rougher 2	√		2	2	-		2	2	11.0
Regrind	400	20				8			10.5
Cleaner 1	500	2	5	5	30		1	4	11.0
Cleaner 2		2	1	1	15		1	3	11.0
Cleaner 3		2	1	1	15		1	2	11.0

Flotation Data	Rougher	Cleaner
Flotation Machine:	D2B	D1C
Cell Size in liters:	4.4	2.2
Aspiration:	Air	
Impeller Speed in rpm:	1100	1200

Grinding Data	Primary Grind	Copper Regrind
Mill:	M5-Mild	RM2-Mild
Charge/Material:	20kg-Mild	6kg-Steel
Water:	1000ml	estimated

KM2459-03 Composite 1

Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t				Distribution - percent			
	grams	%	Cu	Mo	Fe	Au	Cu	Mo	Fe	Au
Cu Concentrate	8.1	0.4	28.2	0.44	24.4	24.6	68.7	56.3	1.8	38.5
Cu 3rd Cleaner Tail	11.1	0.6	2.13	0.06	13.0	1.69	7.1	9.7	1.3	3.6
Cu 2nd Cleaner Tail	12.7	0.6	0.53	0.02	11.1	0.71	2.0	3.4	1.3	1.7
Cu 1st Cleaner Tail	65.7	3.3	0.37	0.02	10.8	1.09	7.3	15.6	6.4	13.8
Cu Rougher Tail	1902.9	95.1	0.03	0.001	5.16	0.12	14.9	15.1	89.2	42.3
Feed	2000.5	100	0.17	0.003	5.50	0.26	100	100	100	100

KM2459-03 Composite 1

Cumulative Metallurgical Balance

Cumulative Product	Cum. Weight		Assay - percent or g/t				Distribution - percent			
	grams	%	Cu	Mo	Fe	Au	Cu	Mo	Fe	Au
Product 1	8.1	0.4	28.2	0.44	24.4	24.6	68.7	56.3	1.8	38.5
Product 1 to 2	19.2	1.0	13.1	0.22	17.8	11.4	75.8	65.9	3.1	42.1
Product 1 to 3	31.9	1.6	8.11	0.14	15.1	7.12	77.8	69.3	4.4	43.9
Product 1 to 4	97.6	4.9	2.90	0.05	12.2	3.06	85.1	84.9	10.8	57.7
Product 5	1902.9	95.1	0.03	0.001	5.16	0.12	14.9	15.1	89.2	42.3
Feed	2000.5	100	0.17	0.003	5.50	0.26	100	100	100	100

PROJECT NO: KM2459-04

PURPOSE: Repeat Test 1, Optimize Metallurgy.

PROCEDURE: Perform a standard one product cleaner test.

FEED: 2 kg of Composite 3 ore ground to a nominal 167μm K_{80}.
Copper Regrind Discharge - 31μm K_{80}.

FLOWSHEET: 2

Stage	Reagents Added g/tonne						Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	H_2SO_4	MIBC	Grind	Cond.	Float	
Primary Grind	1000	20					14			11.0
COPPER CIRCUIT:										
Rougher 1			3	3		15		2	2	11.0
Rougher 2	√		2	2		0		1	2	11.0
Regrind	400	20					4			11.5
Cleaner 1	0	2	5	5	125	30		1	4	11.0
Cleaner 2	√	2	1	1	0	15		1	3	11.0
Cleaner 3	√	2	1	1	0			1	2	11.0

Flotation Data	Rougher	Cleaner
Flotation Machine:	D2B	D1C
Cell Size in liters:	4.4	2.2
Aspiration:	Air	
Impeller Speed in rpm:	1100	1200

Grinding Data	Primary Grind	Copper Regrind
Mill:	M5-Mild	RM2-Mild
Charge/Material:	20kg-Mild	6kg-Steel
Water:	1000ml	estimated

KM2459-04 Composite 3

Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t				Distribution - percent			
	grams	%	Cu	Mo	Fe	Au	Cu	Mo	Fe	Au
Cu Concentrate	10.2	0.5	25.1	9.42	25.1	18.4	85.1	87.3	10.6	54.1
Cu 3rd Cleaner Tail *	1.9	0.1	5.00	2.18	15.5	1.73	3.2	3.8	1.2	0.9
Cu 2nd Cleaner Tail	6.5	0.3	0.68	0.29	7.40	1.73	1.5	1.7	2.0	3.2
Cu 1st Cleaner Tail	40.3	2.0	0.19	0.03	5.43	0.73	2.5	1.1	9.1	8.4
Cu Rougher Tail	1939.3	97.1	0.01	0.004	0.96	0.06	7.7	6.2	77.1	33.3
Feed	1998.2	100	0.15	0.055	1.21	0.17	100	100	100	100

* Not enough sample for assay, Au values estimated.

KM2459-04 Composite 3

Cumulative Metallurgical Balance

Cumulative Product	Cum. Weight		Assay - percent or g/t				Distribution - percent			
	grams	%	Cu	Mo	Fe	Au	Cu	Mo	Fe	Au
Product 1	10.2	0.5	25.1	9.42	25.1	18.4	85.1	87.3	10.6	54.1
Product 1 to 2	12.1	0.6	21.9	8.28	23.6	15.8	88.3	91.0	11.8	55.0
Product 1 to 3	18.6	0.9	14.5	5.49	17.9	10.9	89.7	92.7	13.8	58.3
Product 1 to 4	58.9	2.9	4.71	1.75	9.38	3.93	92.3	93.8	22.9	66.7
Product 5	1939.3	97.1	0.01	0.004	0.96	0.06	7.7	6.2	77.1	33.3
Feed	1998.2	100	0.15	0.055	1.21	0.17	100	100	100	100

PROJECT NO: KM2459-05

PURPOSE: Repeat Test 2, Optimize Metallurgy.

PROCEDURE: Perform a standard one product cleaner test.

FEED: 2 kg of Composite 2 ore ground to a nominal 166µm K_{80}.
Copper Regrind Discharge - 33µm K_{80}.

FLOWSHEET: 2

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	1000	20				14			10.8
COPPER CIRCUIT:									
Rougher 1	150		3	3	15		2	2	11.0
Rougher 2	√		2	2	0		1	2	11.0
Regrind	400	20				4			11.1
Cleaner 1	0	2	5	5	30		1	4	11.0
Cleaner 2	√	2	1	1	15		1	3	11.0
Cleaner 3	√	2	1	1	15		1	2	11.0

Flotation Data	Rougher	Cleaner
Flotation Machine:	D2B	D1C
Cell Size in liters:	4.4	2.2
Aspiration:	Air	
Impeller Speed in rpm:	1100	1200

Grinding Data	Primary Grind	Copper Regrind
Mill:	M5-Mild	RM2-Mild
Charge/Material:	20kg-Mild	6kg-Steel
Water:	1000ml	estimated

KM2459-05 Composite 2

Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t				Distribution - percent			
	grams	%	Cu	Mo	Fe	Au	Cu	Mo	Fe	Au
Cu Concentrate	13.1	0.7	26.6	6.94	26.0	22.5	92.0	90.4	17.1	61.8
Cu 3rd Cleaner Tail *	1.4	0.1	1.62	1.28	13.4	2.47	0.6	1.8	0.9	0.7
Cu 2nd Cleaner Tail	7.4	0.4	0.34	0.20	6.30	2.47	0.7	1.5	2.3	3.8
Cu 1st Cleaner Tail	55.2	2.8	0.12	0.03	4.68	0.82	1.7	1.5	13.0	9.5
Cu Rougher Tail	1920.4	96.1	0.01	0.003	0.69	0.06	5.1	4.8	66.6	24.2
Feed	1997.5	100	0.19	0.050	1.00	0.24	100	100	100	100

* Not enough sample for assay, Au values estimated.

KM2459-05 Composite 2

Cumulative Metallurgical Balance

Cumulative Product	Cum. Weight		Assay - percent or g/t				Distribution - percent			
	grams	%	Cu	Mo	Fe	Au	Cu	Mo	Fe	Au
Product 1	13.1	0.7	26.6	6.94	26.0	22.5	92.0	90.4	17.1	61.8
Product 1 to 2	14.5	0.7	24.2	6.39	24.8	20.6	92.6	92.2	18.1	62.5
Product 1 to 3	21.9	1.1	16.1	4.30	18.5	14.5	93.3	93.7	20.4	66.4
Product 1 to 4	77.1	3.9	4.66	1.24	8.62	4.69	94.9	95.2	33.4	75.8
Product 5	1920.4	96.1	0.01	0.003	0.69	0.06	5.1	4.8	66.6	24.2
Feed	1997.5	100	0.19	0.050	1.00	0.24	100	100	100	100

PROJECT NO: KM2459-06

PURPOSE: Repeat Test 3, Optimize Metallurgy.

PROCEDURE: Perform a standard one product cleaner test.

FEED: 2 kg of Composite 1 ore ground to a nominal 130μm K_{80}.
Copper Regrind Discharge - 89μm K_{80}.

FLOWSHEET: 2

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	1000	20				17			7.3
COPPER CIRCUIT:									
Rougher 1	2250		5	5			2	2	11.0
Rougher 2			2	2			2	2	11.0
Regrind	400	20				6			11.0
Cleaner 1	0	2	8	8	15		1	4	11.0
Cleaner 2	√	2	2	2	15		1	3	11.0
Cleaner 3	√	2	2	2	15		1	2	11.0

Flotation Data	Rougher	Cleaner
Flotation Machine:	D2B	D1C
Cell Size in liters:	4.4	2.2
Aspiration:	Air	
Impeller Speed in rpm:	1100	1200

Grinding Data	Primary Grind	Copper Regrind
Mill:	M5-Mild	RM2-Mild
Charge/Material:	20kg-Mild	6kg-Steel
Water:	1000ml	estimated

KM2459-06 Composite 1

Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t				Distribution - percent			
	grams	%	Cu	Mo	Fe	Au	Cu	Mo	Fe	Au
Cu Concentrate	123.2	6.2	1.94	0.03	45.1	2.81	77.2	61.0	56.9	74.6
Cu 3rd Cleaner Tail	18.3	0.9	0.14	0.01	44.6	0.80	0.8	2.5	8.4	3.1
Cu 2nd Cleaner Tail	18.6	0.9	0.13	0.01	40.0	0.69	0.8	1.9	7.6	2.8
Cu 1st Cleaner Tail	27.5	1.4	0.15	0.01	29.6	0.41	1.3	3.8	8.3	2.4
Cu Rougher Tail	1809.5	90.6	0.03	0.001	1.01	0.04	19.9	30.9	18.7	17.0
Feed	1997.1	100	0.16	0.003	4.89	0.23	100	100	100	100

KM2459-06 Composite 1

Cumulative Metallurgical Balance

Cumulative Product	Cum. Weight		Assay - percent or g/t				Distribution - percent			
	grams	%	Cu	Mo	Fe	Au	Cu	Mo	Fe	Au
Product 1	123.2	6.2	1.94	0.03	45.1	2.81	77.2	61.0	56.9	74.6
Product 1 to 2	141.5	7.1	1.71	0.03	45.0	2.55	78.0	63.5	65.3	77.7
Product 1 to 3	160.1	8.0	1.52	0.02	44.5	2.33	78.8	65.4	72.9	80.5
Product 1 to 4	187.6	9.4	1.32	0.02	42.3	2.05	80.1	69.1	81.3	83.0
Product 5	1809.5	90.6	0.03	0.001	1.01	0.04	19.9	30.9	18.7	17.0
Feed	1997.1	100	0.16	0.003	4.89	0.23	100	100	100	100

PROJECT NO: KM2459-07

PURPOSE: Repeat Test 3, with More Lime in the Primary Grind.

PROCEDURE: Perform a standard one product cleaner test.

FEED: 2 kg of Composite 1 ore ground to a nominal 130μm K_{80}.
Copper Regrind Discharge - 29μm K_{80}.

FLOWSHEET: 2

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	4000	20				17			10.3
COPPER CIRCUIT:									
Rougher 1	400		5	5	15		2	2	11.0
Rougher 2			2	2	0		2	2	11.0
Regrind	400					8			11.2
Cleaner 1	0	2	8	8	30		1	5	11.0
Cleaner 2	√	2	2	2			1	4	11.0
Cleaner 3	√	2	2	2			1	3	11.0

Flotation Data	Rougher	Cleaner
Flotation Machine:	D2B	D1C
Cell Size in liters:	4.4	2.2
Aspiration:	Air	
Impeller Speed in rpm:	1100	1200

Grinding Data	Primary Grind	Copper Regrind
Mill:	M5-Mild	RM2-Mild
Charge/Material:	20kg-Mild	6kg-Steel
Water:	1000ml	estimated

KM2459-07 Composite 1

Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t				Distribution - percent			
	grams	%	Cu	Mo	Fe	Au	Cu	Mo	Fe	Au
Cu Concentrate	9.1	0.5	25.4	0.28	30.6	21.0	70.8	40.8	2.6	42.3
Cu 3rd Cleaner Tail *	3.2	0.2	2.83	0.13	37.3	2.70	2.8	6.4	1.1	1.9
Cu 2nd Cleaner Tail	11.3	0.6	0.94	0.04	27.8	2.70	3.3	6.6	3.0	6.8
Cu 1st Cleaner Tail	104.7	5.2	0.29	0.01	24.1	0.76	9.3	16.5	23.9	17.7
Cu Rougher Tail	1888.7	93.6	0.02	0.001	3.88	0.08	13.9	29.8	69.4	31.4
Feed	2017.0	100	0.16	0.003	5.24	0.22	100	100	100	100

* Not enough sample for assay, Au values are estimated.

KM2459-07 Composite 1

Cumulative Metallurgical Balance

Cumulative Product	Cum. Weight		Assay - percent or g/t				Distribution - percent			
	grams	%	Cu	Mo	Fe	Au	Cu	Mo	Fe	Au
Product 1	9.1	0.5	25.4	0.28	30.6	21.0	70.8	40.8	2.6	42.3
Product 1 to 2	12.3	0.6	19.5	0.24	32.3	16.2	73.6	47.1	3.8	44.2
Product 1 to 3	23.6	1.2	10.6	0.14	30.2	9.75	76.8	53.7	6.7	50.9
Product 1 to 4	128.3	6.4	2.19	0.03	25.2	2.42	86.1	70.2	30.6	68.6
Product 5	1888.7	93.6	0.02	0.001	3.88	0.08	13.9	29.8	69.4	31.4
Feed	2017.0	100	0.16	0.003	5.24	0.22	100	100	100	100

PROJECT NO: KM2459-08

PURPOSE: To Produce Tailings for Environmental Analysis.

PROCEDURE: Perform a standard one product cleaner test.

FEED: 6 kg of Composite 3 ore ground to a nominal 167μm K_{80}.
Copper Regrind Discharge - 32μm K_{80}.

FLOWSHEET: 2

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	1000	20				14			11.1
COPPER CIRCUIT:									
Rougher 1			3	3	7.5		2	2	11.1
Rougher 2			2	2	0		1	2	11.0
Rougher 3			2	2	0		1	2	11.0
Regrind	200	20				14			11.0
Cleaner 1		2	5	5	30		1	4	11.2
Cleaner 2		2	2	2	8		1	3	11.0
Cleaner 3		2	2	2	8		1	2	11.0

Flotation Data	Rougher	Cleaner
Flotation Machine:	D2B	D1C
Cell Size in liters:	8.8	1.2
Aspiration:	Air	
Impeller Speed in rpm:	1100	1200

Grinding Data	Primary Grind	Copper Regrind
Mill:	M5-Mild	RM2-Mild
Charge/Material:	20kg-Mild	6kg-Steel
Water:	1000ml	estimated

KM2459-08 Composite 3

Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t				Distribution - percent			
	grams	%	Cu	Mo	Fe	Au	Cu	Mo	Fe	Au
Cu Concentrate	38.3	0.6	21.9	7.76	20.3	20.1	76.6	96.1	11.0	63.7
Cu Rougher Tail	5961.7	99.4	0.04	0.002	1.06	0.07	23.4	3.9	89.0	36.3
Feed	6000.0	100	0.18	0.052	1.18	0.20	100	100	100	100

KM2459-08 Composite 3

Cumulative Metallurgical Balance

Cumulative Product	Cum. Weight		Assay - percent or g/t				Distribution - percent			
	grams	%	Cu	Mo	Fe	Au	Cu	Mo	Fe	Au
Product 1	38.3	0.6	21.9	7.76	20.3	20.1	76.6	96.1	11.0	63.7
Product 2	5961.7	99.4	0.04	0.002	1.06	0.07	23.4	3.9	89.0	36.3
Feed	6000.0	100	0.18	0.052	1.18	0.20	100	100	100	100

PROJECT NO: KM2459-09

PURPOSE: To Produce Tailings for Environmental Analysis.

PROCEDURE: Perform a standard one product cleaner test.

FEED: 6 kg of Composite 2 ore ground to a nominal 166μm K_{80}.
Copper Regrind Discharge - 27μm K_{80}.

FLOWSHEET: 2

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	1000	20				14			11.0
COPPER CIRCUIT:									
Rougher 1			3	3	7.5		2	2	11.0
Rougher 2	√		2	2	0		1	2	11.0
Rougher 3	√		2	2	0		1	2	11.0
Regrind	200	20				14			11.5
Cleaner 1	0	2	5	5	15		1	4	11.5
Cleaner 2	0	2	1	1	8		1	3	11.4
Cleaner 3	0	2	1	1			1	2	11.0

Flotation Data	Rougher	Cleaner
Flotation Machine:	D2B	D1C
Cell Size in liters:	8.8	1.2
Aspiration:	Air	
Impeller Speed in rpm:	1100	1200

Grinding Data	Primary Grind	Copper Regrind
Mill:	M5-Mild	RM2-Mild
Charge/Material:	20kg-Mild	6kg-Steel
Water:	1000ml	estimated

KM2459-09 Composite 2

Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t				Distribution - percent			
	grams	%	Cu	Mo	Fe	Au	Cu	Mo	Fe	Au
Cu Concentrate	44.3	0.7	25.2	6.32	21.1	24.6	84.6	87.9	16.2	75.5
Cu Rougher Tail	5955.7	99.3	0.03	0.007	0.81	0.06	15.4	12.1	83.8	24.5
Feed	6000.0	100	0.22	0.053	0.96	0.24	100	100	100	100

KM2459-09 Composite 2

Cumulative Metallurgical Balance

Cumulative Product	Cum. Weight		Assay - percent or g/t				Distribution - percent			
	grams	%	Cu	Mo	Fe	Au	Cu	Mo	Fe	Au
Product 1	44.3	0.7	25.2	6.32	21.1	24.6	84.6	87.9	16.2	75.5
Product 2	5955.7	99.3	0.03	0.007	0.81	0.06	15.4	12.1	83.8	24.5
Feed	6000.0	100	0.22	0.053	0.96	0.24	100	100	100	100

PROJECT NO: KM2459-10

PURPOSE: To Produce Tailings for Environmental Analysis.

PROCEDURE: Perform a standard one product cleaner test.

FEED: 6 kg of Composite 1 ore ground to a nominal 130μm K_{80}.
Copper Regrind Discharge - 22μm K_{80}.

FLOWSHEET: 2

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	4000	20				17			10.0
COPPER CIRCUIT:									
Rougher 1	880		5	5	7.5		2	2	11.0
Rougher 2	√		2	2	0		2	2	11.0
Rougher 3	√		2	2	0		2	2	11.0
Regrind	200	20				4			11.0
Cleaner 1	0	2	8	8	15		1	4	11.0
Cleaner 2	√	2	2	2	8		1	3	11.0
Cleaner 3		2	2	2	8		1	2	11.0

Flotation Data	Rougher	Cleaner
Flotation Machine:	D2B	D1C
Cell Size in liters:	8.8	1.2
Aspiration:	Air	
Impeller Speed in rpm:	1100	1200

Grinding Data	Primary Grind	Copper Regrind
Mill:	M5-Mild	Stirred Mill
Charge/Material:	20kg-Mild	1.2kg-Beads
Water:	1000ml	estimated

KM2459-10 Composite 1
Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t				Distribution - percent			
	grams	%	Cu	Mo	Fe	Au	Cu	Mo	Fe	Au
Cu Concentrate	25.1	0.4	30.8	0.31	23.8	31.2	68.0	24.7	2.1	52.0
Cu Rougher Tail	5974.9	99.6	0.06	0.004	4.70	0.12	32.0	75.3	97.9	48.0
Feed	6000.0	100	0.19	0.005	4.78	0.25	100	100	100	100

KM2459-10 Composite 1
Cumulative Metallurgical Balance

Cumulative Product	Cum. Weight		Assay - percent or g/t				Distribution - percent			
	grams	%	Cu	Mo	Fe	Au	Cu	Mo	Fe	Au
Product 1	25.1	0.4	30.8	0.31	23.8	31.2	68.0	24.7	2.1	52.0
Product 2	5974.9	99.6	0.06	0.004	4.70	0.12	32.0	75.3	97.9	48.0
Feed	6000.0	100	0.19	0.005	4.78	0.25	100	100	100	100

PROJECT NO: KM2459-11

PURPOSE: Investigate the Effect of Scavenging Pyrite.

PROCEDURE: Perform a two product rougher test at pH 11.0.

FEED: 2 kg of Composite 2 ore ground to a nominal 166µm K_{80}.

FLOWSHEET: 1

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	1000	20				17			10.1
COPPER CIRCUIT:									
Rougher 1	300		3	3	15		2	2	11.0
Rougher 2	√		2	2	0		1	4	11.0
PYRITE CIRCUIT:			PAX						
Rougher 1	-		15		15		1	1	10.2
Rougher 2	-		5		0		1	2	10.0
Rougher 3	-		5		0		1	4	9.6

Flotation Data	Rougher
Flotation Machine:	D2B
Cell Size in liters:	4.4
Aspiration:	Air
Impeller Speed in rpm:	1100

Grinding Data	Primary Grind
Mill:	M5-Mild
Charge/Material:	20kg-Mild
Water:	1000ml

KM2459-11 Composite 2
Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t				Distribution - percent			
	grams	%	Cu	Mo	Fe	Au	Cu	Mo	Fe	Au
Cu Rougher 1	23.8	1.2	14.0	3.11	20.8	14.9	83.1	78.4	26.4	68.5
Cu Rougher 2	43.9	2.2	1.18	0.28	3.7	1.50	12.9	12.9	8.6	12.7
Pyrite Rougher 1	7.8	0.4	0.16	0.04	15.0	1.31	0.3	0.3	6.2	2.0
Pyrite Rougher 2	15.9	0.8	0.08	0.02	1.8	0.18	0.3	0.4	1.5	0.6
Pyrite Rougher 3	6.9	0.4	0.04	0.01	1.2	0.08	0.1	0.1	0.4	0.1
Pyrite Rougher Tail	1872.6	95.0	0.01	0.004	0.6	0.04	3.3	7.9	56.9	16.1
Feed	1970.9	100	0.20	0.048	1.0	0.26	100	100	100	100

KM2459-11 Composite 2
Cumulative Metallurgical Balance

Cumulative Product	Cum. Weight		Assay - percent or g/t				Distribution - percent			
	grams	%	Cu	Mo	Fe	Au	Cu	Mo	Fe	Au
Product 1	23.8	1.2	14.0	3.11	20.8	14.9	83.1	78.4	26.4	68.5
Product 1 to 2	67.7	3.4	5.69	1.27	9.7	6.21	96.0	91.3	35.0	81.2
Product 1 to 3	75.5	3.8	5.12	1.15	10.2	5.70	96.4	91.6	41.2	83.2
Product 1 to 4	91.4	4.6	4.24	0.95	8.8	4.74	96.7	92.0	42.7	83.8
Product 1 to 5	98.3	5.0	3.94	0.88	8.2	4.42	96.7	92.1	43.1	83.9
Product 6	1872.6	95.0	0.01	0.004	0.6	0.04	3.3	7.9	56.9	16.1
Feed	1970.9	100	0.20	0.048	1.0	0.26	100	100	100	100

PROJECT NO: KM2459-12

PURPOSE: Investigate the Effect of Scavenging Pyrite.

PROCEDURE: Perform a two product rougher test at pH 11.0.

FEED: 2 kg of Composite 3 ore ground to a nominal 167μm K_{80}.

FLOWSHEET: 1

Stage	Reagents Added g/tonne					Time (minutes)			pH
	Lime	Fuel Oil	3418A	208	MIBC	Grind	Cond.	Float	
Primary Grind	1000	20				14			10.6
COPPER CIRCUIT:									
Rougher 1	300		3	3	15		2	2	11.0
Rougher 2	√		2	2	0		1	4	11.0
PYRITE CIRCUIT:			PAX						
Rougher 1	-		20		15		2	1	10.1
Rougher 2	-		15		0		1	2	9.9
Rougher 3	-		10		0		1	4	9.5

Flotation Data	Rougher
Flotation Machine:	D2B
Cell Size in liters:	4.4
Aspiration:	Air
Impeller Speed in rpm:	1100

Grinding Data	Primary Grind
Mill:	M5-Mild
Charge/Material:	20kg-Mild
Water:	1000ml

KM2459-12 Composite 3

Overall Metallurgical Balance

Product	Weight		Assay - percent or g/t				Distribution - percent			
	grams	%	Cu	Mo	Fe	Au	Cu	Mo	Fe	Au
Cu Rougher 1	19.3	1.0	13.5	4.90	15.9	12.1	84.6	88.1	13.8	58.9
Cu Rougher 2	32.0	1.6	0.81	0.20	3.3	1.87	8.4	5.9	4.7	15.0
Pyrite Rougher 1	5.2	0.3	0.23	0.03	22.9	2.00	0.4	0.1	5.3	2.6
Pyrite Rougher 2	6.3	0.3	0.17	0.03	2.7	0.52	0.3	0.2	0.8	0.8
Pyrite Rougher 3	58.1	2.9	0.04	0.01	1.5	0.12	0.8	0.5	3.8	1.8
Pyrite Rougher Tail	1878.9	94.0	0.01	0.003	0.9	0.04	5.5	5.2	71.6	20.9
Feed	1999.8	100	0.15	0.054	1.1	0.20	100	100	100	100

KM2459-12 Composite 3

Cumulative Metallurgical Balance

Cumulative Product	Cum. Weight		Assay - percent or g/t				Distribution - percent			
	grams	%	Cu	Mo	Fe	Au	Cu	Mo	Fe	Au
Product 1	19.3	1.0	13.5	4.90	15.9	12.1	84.6	88.1	13.8	58.9
Product 1 to 2	51.3	2.6	5.58	1.97	8.0	5.73	93.0	93.9	18.5	73.9
Product 1 to 3	56.5	2.8	5.09	1.79	9.4	5.39	93.4	94.1	23.8	76.5
Product 1 to 4	62.8	3.1	4.60	1.61	8.7	4.90	93.7	94.3	24.6	77.3
Product 1 to 5	120.9	6.0	2.41	0.84	5.2	2.60	94.5	94.8	28.4	79.1
Product 6	1878.9	94.0	0.01	0.003	0.9	0.04	5.5	5.2	71.6	20.9
Feed	1999.8	100	0.15	0.054	1.1	0.20	100	100	100	100

APPENDIX III – KM2459

PARTICLE SIZING DATA

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TABLE III-1
SCREEN ANALYSIS
KM2459 Composite 1 2009 - 14 Minute Grind Calibration

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	2.80	97.2
65 Mesh	212	18.70	78.5
100 Mesh	150	16.00	62.5
150 Mesh	106	11.90	50.6
200 Mesh	75	9.10	41.5
270 Mesh	53	6.60	34.9
400 Mesh	38	4.80	30.1
TOTAL		100.00	**

K80 =219µm

Note: 11 min. grind calibration using 1 kg. Ore, 500 ml water and 20 kg. of Mild Steel rods in Mill: M4

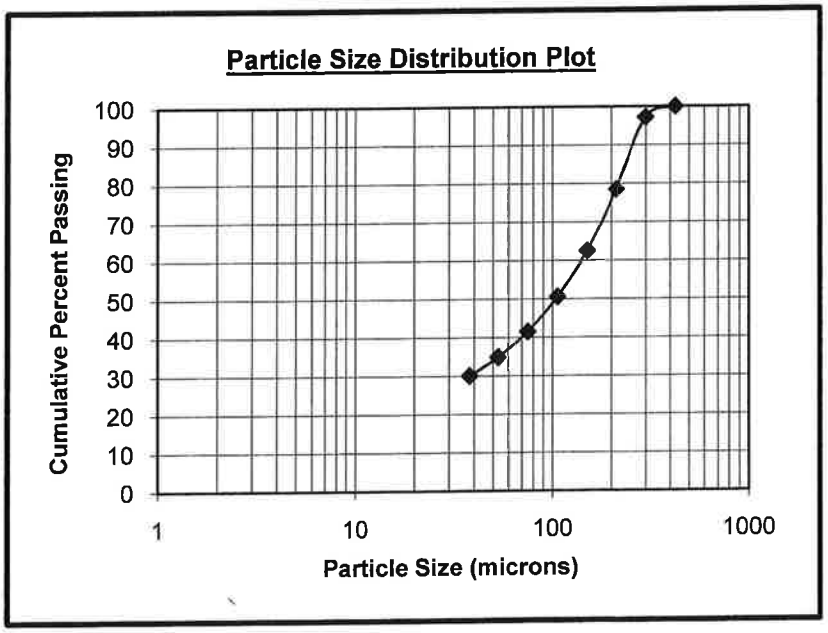


TABLE III-2
SCREEN ANALYSIS
KM2459 Composite 1 2009 - 17 Minute Grind Calibration

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
48 Mesh	300	0.00	100.0
65 Mesh	212	0.50	99.5
100 Mesh	150	10.60	88.9
150 Mesh	106	19.90	69.0
200 Mesh	75	15.80	53.2
270 Mesh	53	10.40	42.8
400 Mesh	38	6.00	36.8
TOTAL		100.00	**

K80 =130µm

Note: 17 min. grind calibration using 1 kg. Ore, 500 ml water and 20 kg. of Mild Steel rods in Mill: M4

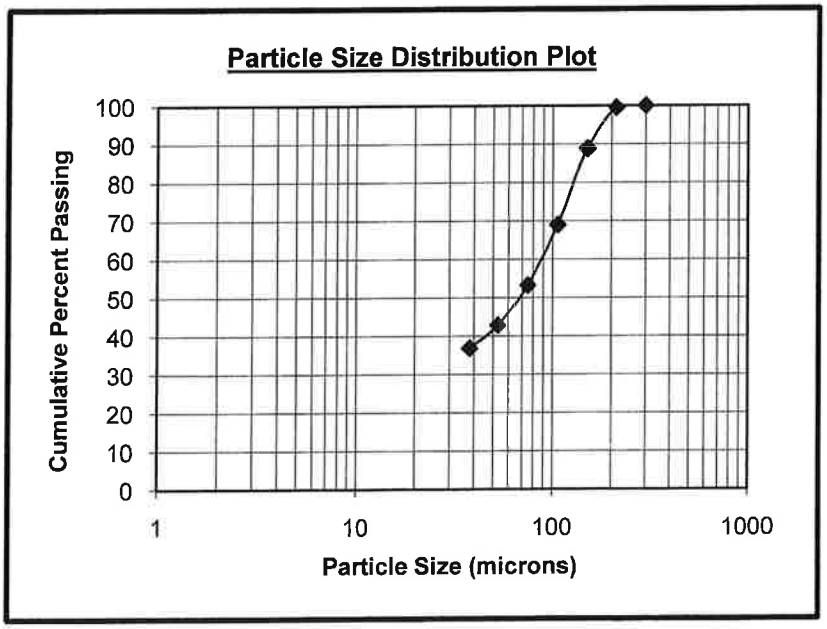


TABLE III-3

SCREEN ANALYSIS

KM2459 Composite 1 2009 - 20 Minute Grind Calibration

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
48 Mesh	300	0.00	100.0
65 Mesh	212	0.00	100.0
100 Mesh	150	2.30	97.7
150 Mesh	106	16.30	81.4
200 Mesh	75	18.50	62.9
270 Mesh	53	12.30	50.6
400 Mesh	38	7.00	43.6
TOTAL		100.00	**

K80 =104µm

Note: 20 min. grind calibration using 1 kg. Ore, 500 ml water and 20 kg. of Mild Steel rods in Mill: M4

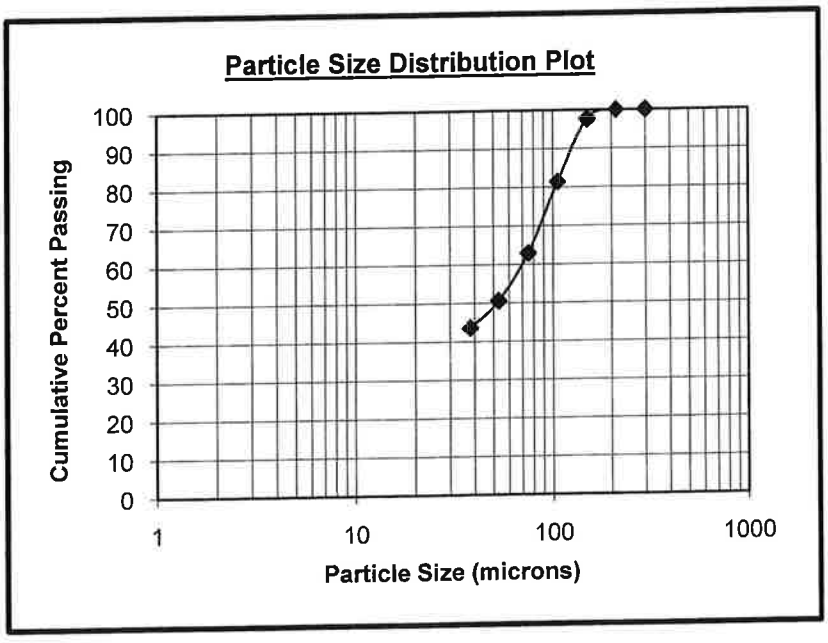


TABLE III-4
SCREEN ANALYSIS
KM2459 Composite 2 2009 - 14 Minute Grind Calibration

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	0.10	99.9
65 Mesh	212	6.40	93.5
100 Mesh	150	18.50	75.0
150 Mesh	106	13.90	61.1
200 Mesh	75	10.40	50.7
270 Mesh	53	8.30	42.4
400 Mesh	38	6.20	36.2
TOTAL		100.00	**

K80 =166µm

Note: 11 min. grind calibration using 1 kg. Ore, 500 ml water and 20 kg. of Mild Steel rods in Mill: M4

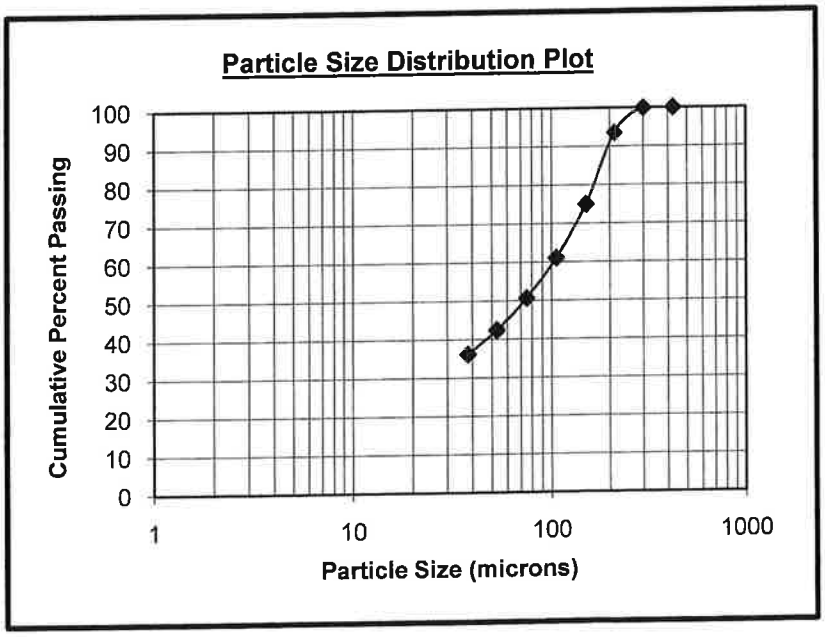


TABLE III-5
SCREEN ANALYSIS
KM2459 Composite 2 2009 - 15 Minute Grind Calibration

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
48 Mesh	300	0.00	100.0
65 Mesh	212	0.70	99.3
100 Mesh	150	9.20	90.1
150 Mesh	106	18.40	71.7
200 Mesh	75	13.20	58.5
270 Mesh	53	11.10	47.4
400 Mesh	38	8.40	39.0
TOTAL		100.00	**

K80 =125µm

Note: 15 min. grind calibration using 1 kg. Ore, 500 ml water and 20 kg. of Mild Steel rods in Mill: M4

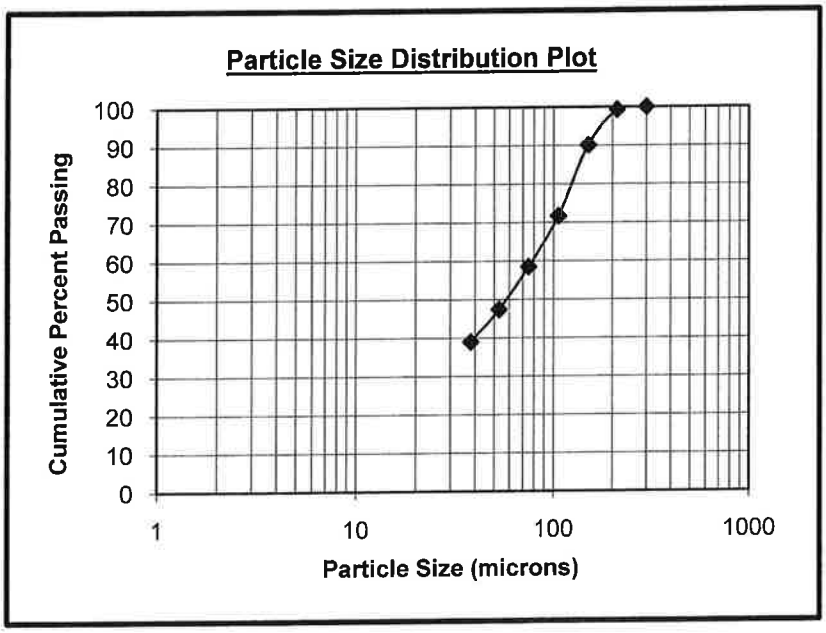


TABLE III-6
SCREEN ANALYSIS
KM2459 Composite 3 2009 - 14 Minute Grind Calibration

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
35 Mesh	425	0.00	100.0
48 Mesh	300	0.30	99.7
65 Mesh	212	7.70	92.0
100 Mesh	150	16.70	75.3
150 Mesh	106	16.40	58.9
200 Mesh	75	10.80	48.1
270 Mesh	53	9.10	39.0
400 Mesh	38	6.10	32.9
TOTAL		100.00	**

K80 =167µm

Note: 11 min. grind calibration using 1 kg. Ore, 500 ml water and 20 kg. of Mild Steel rods in Mill: M4

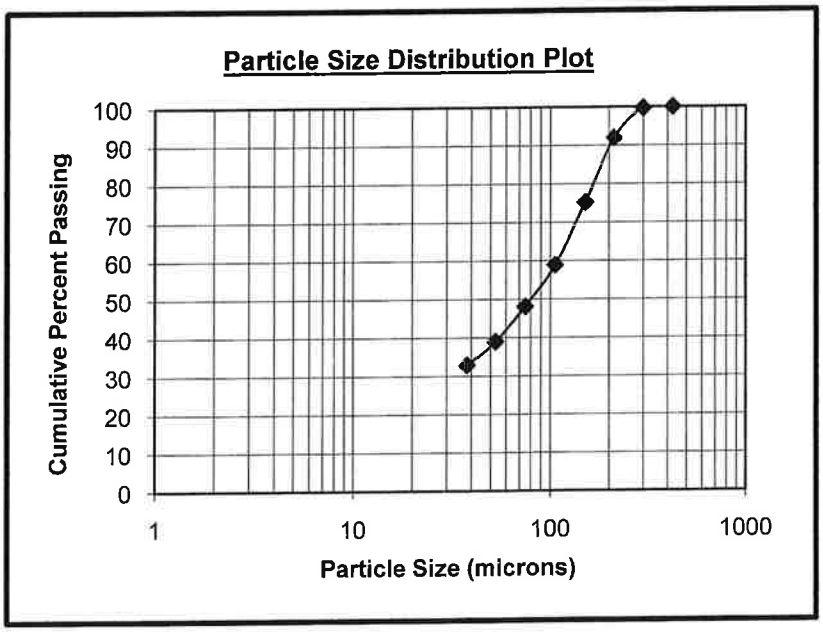
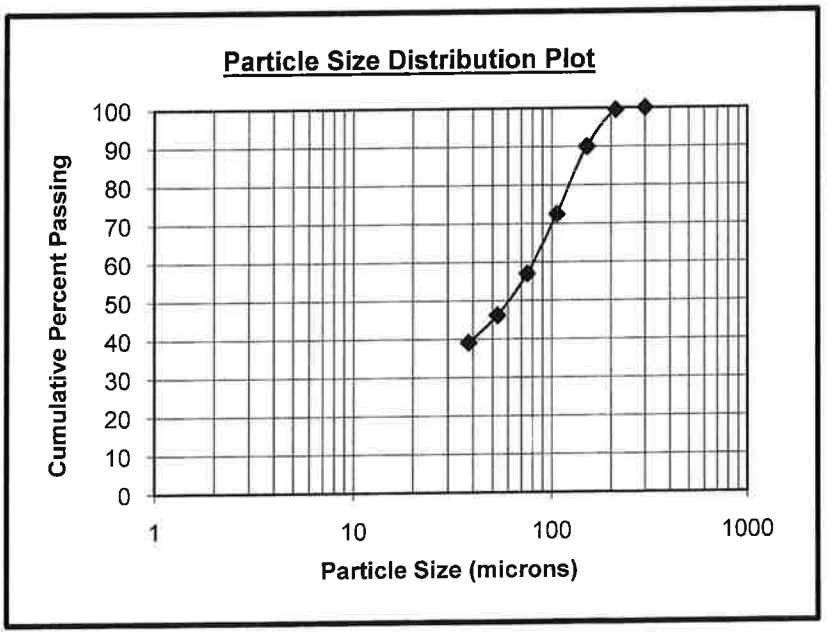


TABLE III-7
SCREEN ANALYSIS
KM2459 Composite 3 2009 - 15 Minute Grind Calibration

Product	Particle Size µm	Weight % Retained	Cumulative % Passing
48 Mesh	300	0.00	100.0
65 Mesh	212	0.50	99.5
100 Mesh	150	9.50	90.0
150 Mesh	106	17.50	72.5
200 Mesh	75	15.50	57.0
270 Mesh	53	10.80	46.2
400 Mesh	38	7.10	39.1
TOTAL		100.00	**

K80 =124µm

Note: 15 min. grind calibration using 1 kg. Ore, 500 ml water and 20 kg. of Mild Steel rods in Mill: M4



G&T Metallurgical Services Ltd.

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FS 63170

Result Analysis Report

Project and Test number:
KM2459-01

Sample Name:
Copper Regrind Discharge - Average

Measured by:
ryanm

Edited by:
ryanm

Measured:
Tuesday, September 15, 2009 4:32:28 PM

Analysed:
Tuesday, September 15, 2009 4:32:29 PM

Particle Name:
Silica 0.01

Particle RI:
1.544

Dispersant Name:
Water

Accessory Name:
Hydro 2000MU (A)

Absorption:
0.01

Dispersant RI:
1.330

Analysis model:
General purpose

Size range:
0.100 to 1000.000 um

Weighted Residual:
0.362 %

Sensitivity:
Normal

Obscuration:
9.09 %

Result Emulation:
Off

Concentration:
0.0081 %Vol

Specific Surface Area:
0.315 m²/g

Span :
3.239

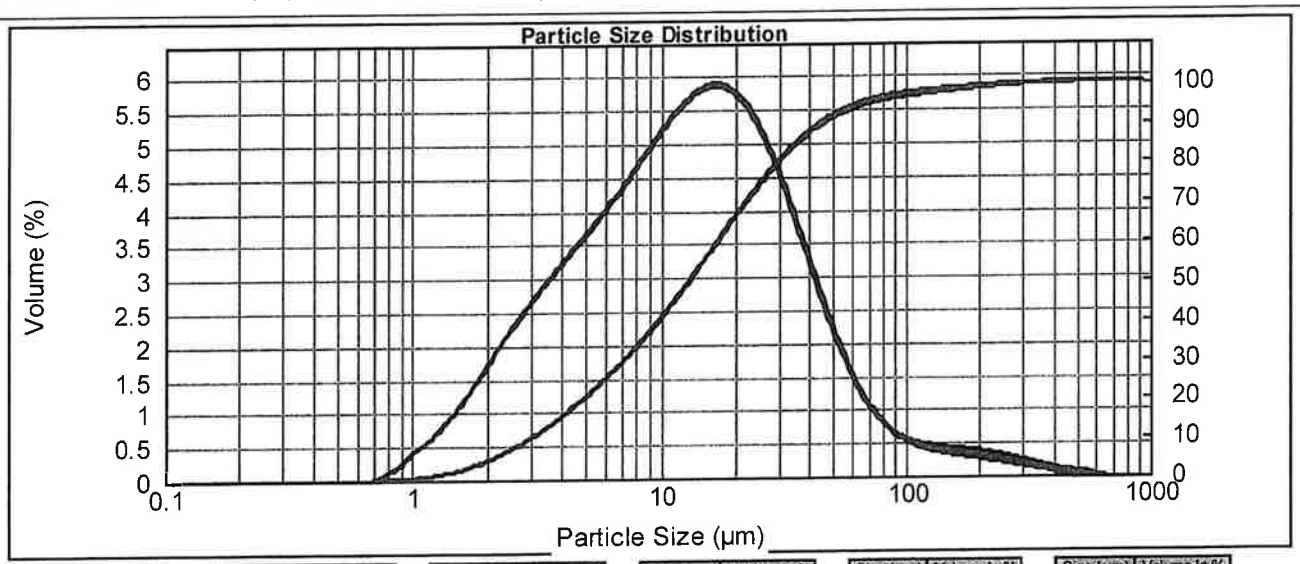
Surface Weighted Mean D[3,2]:
7.197 um

Uniformity:
1.28

Vol. Weighted Mean D[4,3]:
22.964 um

Result units:
Volume

d(0.1): 2.937 um **d(0.5):** 13.006 um **d(0.8):** 29.678 um **d(0.9):** 45.062 um **d(0.98):** 137.37 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.00
0.437	0.00
0.479	0.00

Size (µm)	Volume In %
0.479	0.00
0.525	0.00
0.575	0.00
0.631	0.00
0.692	0.00
0.759	0.06
0.832	0.10
0.912	0.19
1.000	0.27
1.096	0.33
1.202	0.42
1.318	0.51
1.445	0.62
1.585	0.74
1.738	0.87
1.905	1.01
2.089	1.14
2.291	

Size (µm)	Volume In %
2.291	1.27
2.512	1.40
2.754	1.53
3.020	1.64
3.311	1.76
3.631	1.87
3.981	1.98
4.365	2.08
4.786	2.19
5.248	2.30
5.754	2.42
6.310	2.54
6.918	2.66
7.586	2.79
8.318	2.92
9.120	3.05
10.000	3.17
10.965	

Size (µm)	Volume In %
10.965	3.29
12.023	3.39
13.183	3.47
14.454	3.52
15.849	3.54
17.378	3.52
19.055	3.47
20.893	3.37
22.909	3.23
25.119	3.06
27.542	2.85
30.200	2.61
33.113	2.36
36.308	2.10
39.811	1.83
43.652	1.58
47.863	1.33
52.481	

Size (µm)	Volume In %
52.481	1.11
57.544	0.92
63.096	0.75
69.183	0.62
75.858	0.51
83.176	0.42
91.201	0.36
100.000	0.31
109.648	0.28
120.226	0.26
131.826	0.24
144.544	0.23
158.489	0.22
173.780	0.21
190.546	0.20
208.930	0.18
229.087	0.17
251.189	

Size (µm)	Volume In %
251.189	0.15
275.423	0.13
301.995	0.11
331.131	0.09
363.078	0.07
398.107	0.05
436.516	0.04
478.630	0.02
524.807	0.01
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

G&T Metallurgical Services Ltd.

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FS 63170

Result Analysis Report

Project and Test number:
KM2459-02

Sample Name:
Copper Regrind Discharge - Average

Measured by:
ryanm

Edited by:
ryanm

Measured:
Wednesday, September 16, 2009 8:02:39 AM

Analysed:
Wednesday, September 16, 2009 8:02:40 AM

Particle Name:
Silica 0.01

Particle RI:
1.544

Dispersant Name:
Water

Accessory Name:
Hydro 2000MU (A)

Absorption:
0.01

Dispersant RI:
1.330

Analysis model:
General purpose

Size range:
0.100 to 1000.000 um

Weighted Residual:
0.382 %

Sensitivity:
Normal

Obscuration:
9.41 %

Result Emulation:
Off

Concentration:
0.0085 %Vol

Specific Surface Area:
0.312 m²/g

Span :
2.826

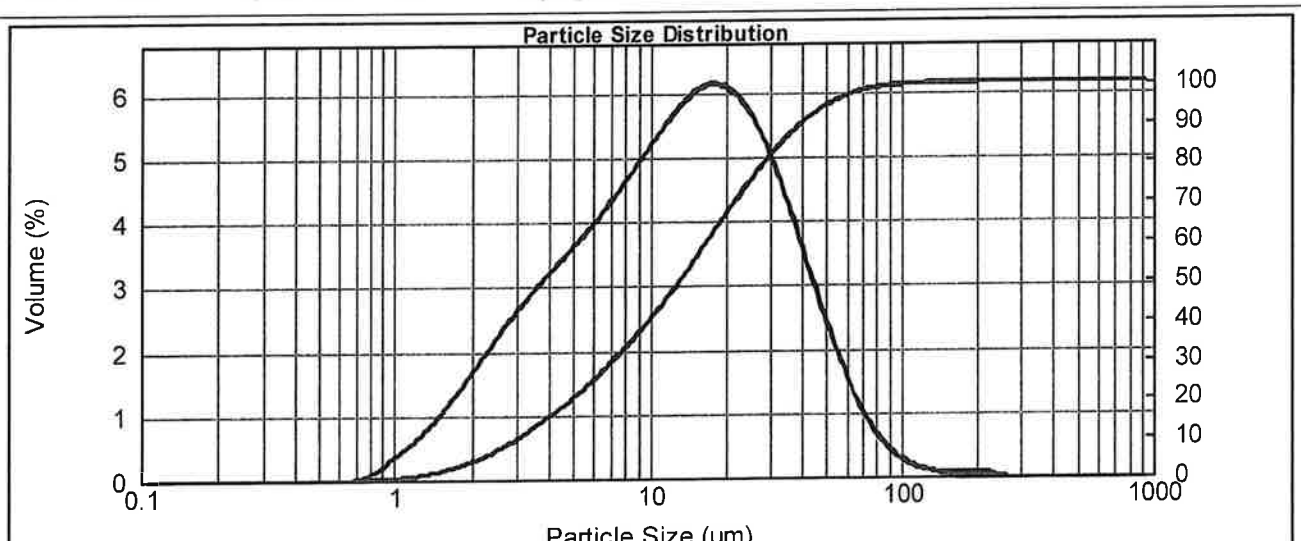
Surface Weighted Mean D[3,2]:
7.251 um

Uniformity:
0.911

Vol. Weighted Mean D[4,3]:
18.333 um

Result units:
Volume

d(0.1): 2.979 um **d(0.5):** 13.113 um **d(0.8):** 28.445 um **d(0.9):** 40.032 um **d(0.98):** 68.78 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.00
0.437	0.00
0.479	0.00

Size (µm)	Volume In %
0.479	0.00
0.525	0.00
0.575	0.00
0.631	0.00
0.692	0.00
0.759	0.00
0.832	0.05
0.912	0.08
1.000	0.17
1.096	0.25
1.202	0.31
1.318	0.40
1.445	0.49
1.585	0.60
1.738	0.72
1.905	0.85
2.089	0.99
2.291	1.13

Size (µm)	Volume In %
2.291	1.26
2.512	1.40
2.754	1.52
3.020	1.64
3.311	1.75
3.631	1.86
3.981	1.97
4.365	2.08
4.786	2.18
5.248	2.29
5.754	2.40
6.310	2.51
6.918	2.64
7.586	2.77
8.318	2.90
9.120	3.04
10.000	3.18
10.965	3.32

Size (µm)	Volume In %
10.965	3.32
12.023	3.44
13.183	3.55
14.454	3.63
15.849	3.69
17.378	3.70
19.055	3.68
20.893	3.61
22.909	3.49
25.119	3.33
27.542	3.13
30.200	2.89
33.113	2.63
36.308	2.34
39.811	2.04
43.652	1.75
47.863	1.47
52.481	1.20

Size (µm)	Volume In %
52.481	1.20
57.544	0.96
63.096	0.75
69.183	0.57
75.858	0.42
83.176	0.30
91.201	0.21
100.000	0.15
109.648	0.10
120.226	0.07
131.826	0.05
144.544	0.03
158.489	0.01
173.780	0.01
190.546	0.02
208.930	0.02
229.087	0.01
251.189	0.00

Size (µm)	Volume In %
251.189	0.00
275.423	0.00
301.995	0.00
331.131	0.00
363.078	0.00
398.107	0.00
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

G&T Metallurgical Services Ltd.

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FS 63170

Result Analysis Report

Project and Test number:
KM2459-03

Sample Name:
Copper Regrind Discharge - Average

Measured by:
ryanm

Edited by:
ryanm

Measured:
Wednesday, September 16, 2009 8:07:26 AM

Analysed:
Wednesday, September 16, 2009 8:07:27 AM

Particle Name:
Silica 0.01

Particle RI:
1.544

Dispersant Name:
Water

Accessory Name:
Hydro 2000MU (A)

Absorption:
0.01

Dispersant RI:
1.330

Analysis model:
General purpose

Size range:
0.100 to 1000.000 um

Weighted Residual:
0.465 %

Sensitivity:
Normal

Obscuration:
16.69 %

Result Emulation:
Off

Concentration:
0.0142 %Vol

Specific Surface Area:
0.347 m²/g

Span :
2.594

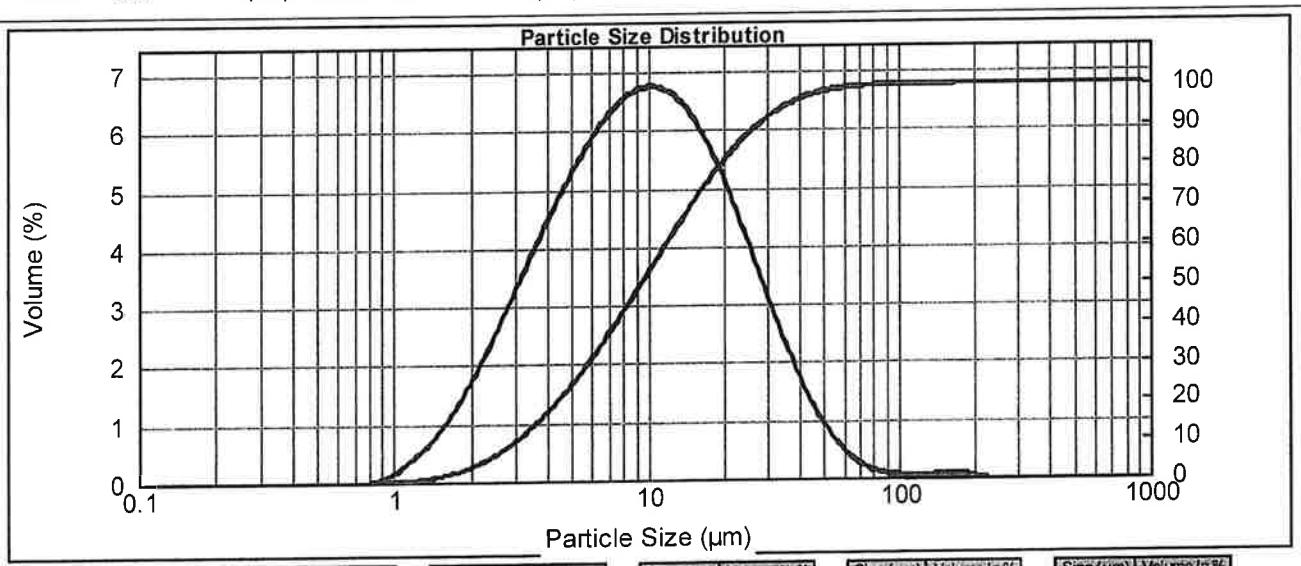
Surface Weighted Mean D[3,2]:
6.526 um

Uniformity:
0.832

Vol. Weighted Mean D[4,3]:
13.082 um

Result units:
Volume

d(0.1): 2.996 um d(0.5): 9.452 um d(0.8): 19.538 um d(0.9): 27.517 um d(0.98): 47.25 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.00
0.437	0.00
0.479	0.00

Size (µm)	Volume In %
0.479	0.00
0.525	0.00
0.575	0.00
0.631	0.00
0.692	0.00
0.759	0.00
0.832	0.01
0.912	0.06
1.000	0.11
1.096	0.20
1.202	0.28
1.318	0.38
1.445	0.51
1.585	0.66
1.738	0.82
1.905	1.01
2.089	1.21
2.291	

Size (µm)	Volume In %
2.291	1.42
2.512	1.64
2.754	1.86
3.020	2.09
3.311	2.32
3.631	2.55
3.981	2.77
4.365	2.98
4.786	3.18
5.248	3.37
5.754	3.54
6.310	3.69
6.918	3.82
7.586	3.93
8.318	4.01
9.120	4.05
10.000	4.06
10.965	

Size (µm)	Volume In %
10.965	4.04
12.023	3.98
13.183	3.88
14.454	3.74
15.849	3.57
17.378	3.36
19.055	3.13
20.893	2.87
22.909	2.59
25.119	2.31
27.542	2.01
30.200	1.72
33.113	1.45
36.308	1.19
39.811	0.95
43.652	0.75
47.863	0.57
52.481	

Size (µm)	Volume In %
52.481	0.42
57.544	0.30
63.096	0.20
69.183	0.14
75.858	0.09
83.176	0.06
91.201	0.04
100.000	0.01
109.648	0.01
120.226	0.01
131.826	0.01
144.544	0.01
158.489	0.01
173.780	0.02
190.546	0.01
208.930	0.00
229.087	0.00
251.189	

Size (µm)	Volume In %
251.189	0.00
275.423	0.00
301.995	0.00
331.131	0.00
363.078	0.00
398.107	0.00
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

G&T Metallurgical Services Ltd.

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FS 63170

Result Analysis Report

Project and Test number:
KM2459-04

Sample Name:
Copper Regrind Discharge - Average

Measured by:
Wendy

Edited by:
Wendy

Measured:
Monday, September 21, 2009 2:22:01 PM

Analysed:
Monday, September 21, 2009 2:22:02 PM

Particle Name:
Silica 0.1

Particle RI:
1.544

Dispersant Name:
Water

Accessory Name:
Hydro 2000MU (A)

Absorption:
0.1

Dispersant RI:
1.330

Analysis model:
General purpose

Size range:
0.100 to 1000.000 um

Weighted Residual:
0.992 %

Sensitivity:
Normal

Obscuration:
6.16 %

Result Emulation:
Off

Concentration:
0.0051 %Vol

Specific Surface Area:
0.391 m²/g

Span :
3.013

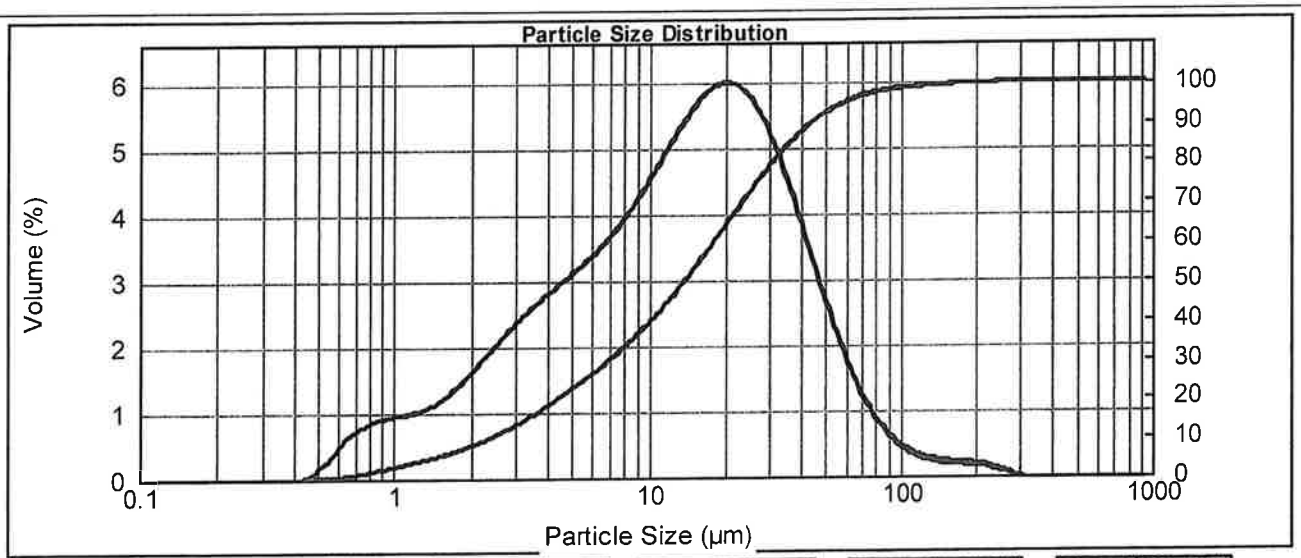
Surface Weighted Mean D[3,2]:
5.794 um

Uniformity:
1.04

Vol. Weighted Mean D[4,3]:
20.602 um

Result units:
Volume

d(0.1): 2.349 um **d(0.5):** 13.907 um **d(0.8):** 30.906 um **d(0.9):** 44.257 um **d(0.98):** 87.81 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.00
0.437	0.00
0.479	0.00

Size (µm)	Volume In %
0.479	0.09
0.525	0.15
0.575	0.28
0.631	0.38
0.692	0.44
0.759	0.50
0.832	0.53
0.912	0.56
1.000	0.57
1.096	0.59
1.202	0.61
1.318	0.65
1.445	0.70
1.585	0.77
1.738	0.86
1.905	0.96
2.089	1.06
2.291	

Size (µm)	Volume In %
2.291	1.16
2.512	1.27
2.754	1.37
3.020	1.46
3.311	1.55
3.631	1.63
3.981	1.71
4.365	1.79
4.786	1.87
5.248	1.94
5.754	2.03
6.310	2.13
6.918	2.23
7.586	2.35
8.318	2.48
9.120	2.63
10.000	2.79
10.965	

Size (µm)	Volume In %
10.965	2.94
12.023	3.10
13.183	3.26
14.454	3.39
15.849	3.50
17.378	3.57
19.055	3.61
20.893	3.59
22.909	3.53
25.119	3.41
27.542	3.24
30.200	3.02
33.113	2.77
36.308	2.49
39.811	2.19
43.652	1.90
47.863	1.61
52.481	

Size (µm)	Volume In %
52.481	1.34
57.544	1.09
63.096	0.87
69.183	0.69
75.858	0.54
83.176	0.42
91.201	0.33
100.000	0.26
109.648	0.21
120.226	0.17
131.826	0.15
144.544	0.13
158.489	0.13
173.780	0.12
190.546	0.11
208.930	0.10
229.087	0.07
251.189	

Size (µm)	Volume In %
251.189	0.05
275.423	0.01
301.995	0.00
331.131	0.00
363.078	0.00
398.107	0.00
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

G&T Metallurgical Services Ltd.

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Result Analysis Report

Project and Test number:
KM2459-05

Sample Name:
Copper Regrind Discharge - Average

Measured by:
Wendy

Edited by:
Wendy

Measured:
Monday, September 21, 2009 2:29:20 PM

Analysed:
Monday, September 21, 2009 2:29:21 PM

Particle Name:
Silica 0.1

Particle RI:
1.544

Dispersant Name:
Water

Accessory Name:
Hydro 2000MU (A)

Absorption:
0.1

Dispersant RI:
1.330

Analysis model:
General purpose

Size range:
0.100 to 1000.000 um

Weighted Residual:
0.784 %

Sensitivity:
Normal

Obscuration:
8.39 %

Result Emulation:
Off

Concentration:
0.0063 %Vol

Specific Surface Area:
0.435 m²/g

Span :
3.610

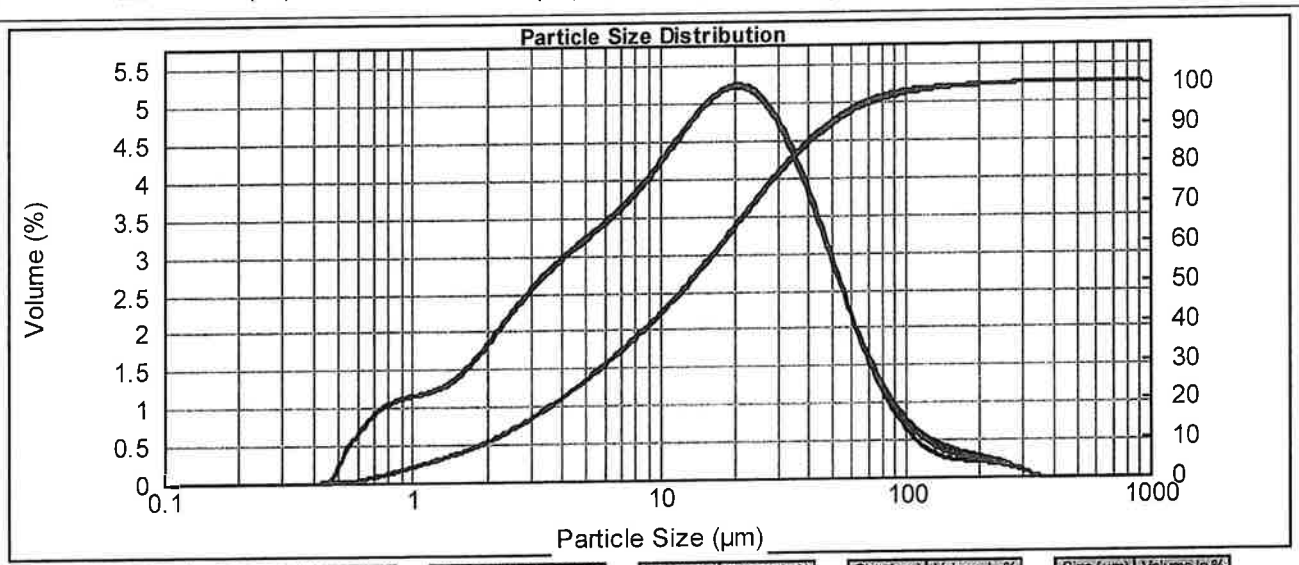
Surface Weighted Mean D[3,2]:
5.211 um

Uniformity:
1.25

Vol. Weighted Mean D[4,3]:
22.120 um

Result units:
Volume

d(0.1): 2.011 um d(0.5): 13.229 um d(0.8): 33.077 um d(0.9): 49.772 um d(0.98): 107.35 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.00
0.437	0.00
0.479	0.00

Size (µm)	Volume In %
0.479	0.10
0.525	0.28
0.575	0.38
0.631	0.48
0.692	0.56
0.759	0.62
0.832	0.65
0.912	0.68
1.000	0.69
1.096	0.71
1.202	0.74
1.318	0.77
1.445	0.83
1.585	0.90
1.738	0.99
1.905	1.00
2.089	1.18
2.291	

Size (µm)	Volume In %
2.291	1.28
2.512	1.38
2.754	1.48
3.020	1.57
3.311	1.65
3.631	1.73
3.981	1.80
4.365	1.87
4.786	1.93
5.248	1.99
5.754	2.06
6.310	2.13
6.918	2.20
7.586	2.28
8.318	2.37
9.120	2.47
10.000	2.58
10.965	

Size (µm)	Volume In %
10.965	2.68
12.023	2.79
13.183	2.89
14.454	2.98
15.849	3.05
17.378	3.11
19.055	3.14
20.893	3.14
22.909	3.10
25.119	3.03
27.542	2.92
30.200	2.78
33.113	2.61
36.308	2.41
39.811	2.20
43.652	1.98
47.863	1.74
52.481	

Size (µm)	Volume In %
52.481	1.52
57.544	1.30
63.096	1.10
69.183	0.92
75.858	0.76
83.176	0.61
91.201	0.50
100.000	0.40
109.648	0.32
120.226	0.27
131.826	0.22
144.544	0.19
158.489	0.17
173.780	0.16
190.546	0.14
208.930	0.13
229.087	0.12
251.189	

Size (µm)	Volume In %
251.189	0.09
275.423	0.07
301.995	0.04
331.131	0.00
363.078	0.00
398.107	0.00
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

G&T Metallurgical Services Ltd.

We Identify and Solve Complex Mineral Processing Problems

ISO9001:2000
FS 63170

Result Analysis Report

Project and Test number:
KM2459-06

Sample Name:
Copper Regrind Discharge - Average

Measured by:
julie

Edited by:
julie

Measured:
Thursday, September 24, 2009 1:59:35 PM

Analysed:
Thursday, September 24, 2009 1:59:36 PM

Particle Name:
Silica 0.01

Particle RI:
1.544

Dispersant Name:
Water

Accessory Name:
Hydro 2000MU (A)

Absorption:
0.01

Dispersant RI:
1.330

Analysis model:
General purpose

Size range:
0.100 to 1000.000 um

Weighted Residual:
0.393 %

Sensitivity:
Normal

Obscuration:
12.42 %

Result Emulation:
Off

Concentration:
0.0300 %Vol

Specific Surface Area:
0.125 m²/g

Span :
2.248

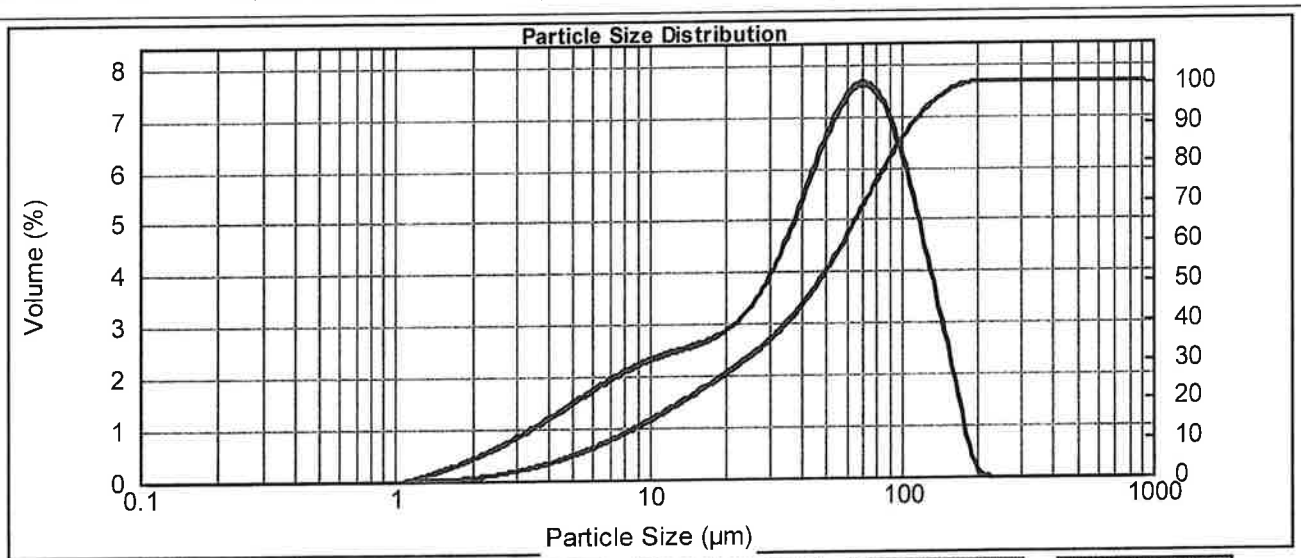
Surface Weighted Mean D[3,2]:
18.181 um

Uniformity:
0.705

Vol. Weighted Mean D[4,3]:
54.153 um

Result units:
Volume

d(0.1): 7.058 um **d(0.5):** 47.179 um **d(0.8):** 88.793 um **d(0.9):** 113.128 um **d(0.98):** 154.67 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.00
0.437	0.00
0.479	

Size (µm)	Volume In %
0.479	0.00
0.525	0.00
0.575	0.00
0.631	0.00
0.692	0.00
0.759	0.00
0.832	0.00
0.912	0.00
1.000	0.00
1.096	0.00
1.202	0.05
1.318	0.08
1.445	0.12
1.585	0.16
1.738	0.20
1.905	0.25
2.089	0.30
2.291	

Size (µm)	Volume In %
2.291	0.35
2.512	0.41
2.754	0.47
3.020	0.53
3.311	0.60
3.631	0.67
3.981	0.74
4.365	0.82
4.786	0.89
5.248	0.97
5.754	1.04
6.310	1.12
6.918	1.18
7.586	1.25
8.318	1.31
9.120	1.38
10.000	1.41
10.965	

Size (µm)	Volume In %
10.965	1.45
12.023	1.49
13.183	1.52
14.454	1.55
15.849	1.59
17.378	1.64
19.055	1.71
20.893	1.80
22.909	1.92
25.119	2.07
27.542	2.26
30.200	2.49
33.113	2.75
36.308	3.05
39.811	3.36
43.652	3.67
47.863	3.97
52.481	

Size (µm)	Volume In %
52.481	4.24
57.544	4.44
63.096	4.57
69.183	4.59
75.858	4.51
83.176	4.32
91.201	4.02
100.000	3.63
109.648	3.15
120.226	2.64
131.826	2.11
144.544	1.59
158.489	1.06
173.780	0.48
190.546	0.09
208.930	0.00
229.087	0.00
251.189	

Size (µm)	Volume In %
251.189	0.00
275.423	0.00
301.995	0.00
331.131	0.00
363.078	0.00
398.107	0.00
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

G&T Metallurgical Services Ltd.

We Identify and Solve Complex Mineral Processing Problems

ISO9001:2000
FS 63170

Result Analysis Report

Project and Test number:
KM2459-07

Sample Name:
Copper Regrind Discharge - Average

Measured by:
ryanm

Edited by:
ryanm

Measured:
Wednesday, September 23, 2009 4:18:14 PM

Analysed:
Wednesday, September 23, 2009 4:18:15 PM

Particle Name:
Silica 0.01

Particle RI:
1.544

Dispersant Name:
Water

Accessory Name:
Hydro 2000MU (A)

Absorption:
0.01

Dispersant RI:
1.330

Analysis model:
General purpose

Size range:
0.100 to 1000.000 um

Weighted Residual:
0.492 %

Sensitivity:
Normal

Obscuration:
6.61 %

Result Emulation:
Off

Concentration:
0.0060 %Vol

Specific Surface Area:
0.308 m²/g

Span :
3.511

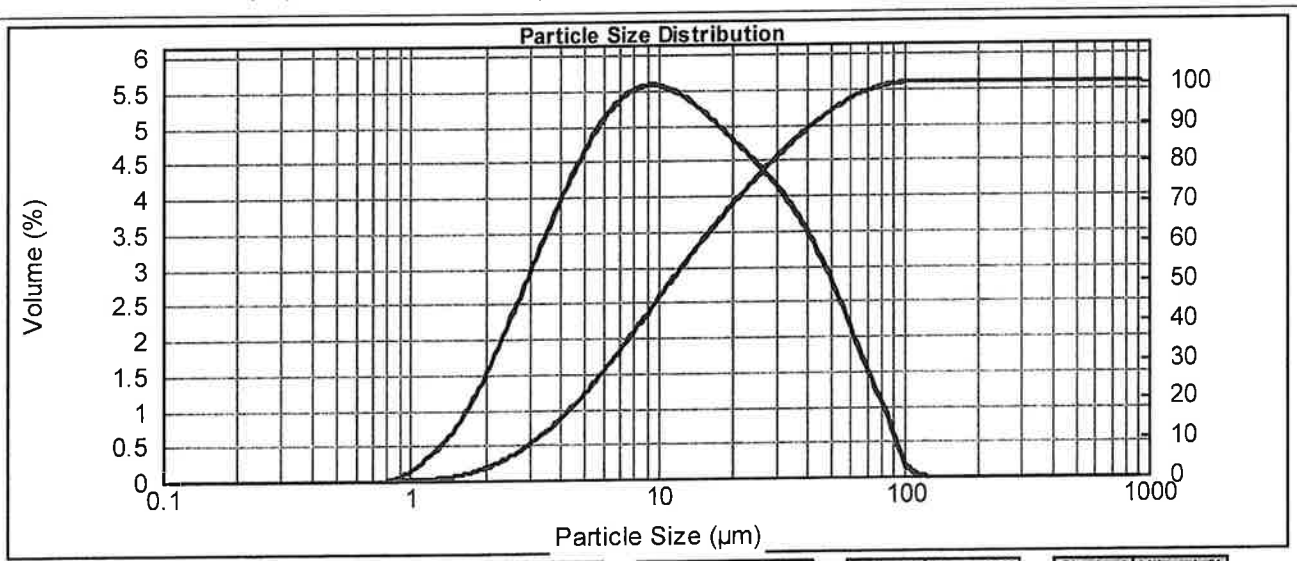
Surface Weighted Mean D[3,2]:
7.343 um

Uniformity:
1.06

Vol. Weighted Mean D[4,3]:
17.938 um

Result units:
Volume

d(0.1): 3.190 um **d(0.5):** 11.349 um **d(0.8):** 28.761 um **d(0.9):** 43.033 um **d(0.98):** 71.24 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.00
0.437	0.00
0.479	

Size (µm)	Volume In %
0.479	0.00
0.525	0.00
0.575	0.00
0.631	0.00
0.692	0.00
0.759	0.00
0.832	0.01
0.912	0.06
1.000	0.10
1.096	0.18
1.202	0.25
1.318	0.33
1.445	0.44
1.585	0.57
1.738	0.71
1.905	0.88
2.089	1.06
2.291	

Size (µm)	Volume In %
2.291	1.25
2.512	1.45
2.754	1.65
3.020	1.85
3.311	2.06
3.631	2.26
3.981	2.45
4.365	2.63
4.786	2.79
5.248	2.94
5.754	3.07
6.310	3.17
6.918	3.25
7.586	3.31
8.318	3.35
9.120	3.36
10.000	3.34
10.965	

Size (µm)	Volume In %
10.965	3.31
12.023	3.27
13.183	3.20
14.454	3.14
15.849	3.06
17.378	2.98
19.055	2.90
20.893	2.81
22.909	2.73
25.119	2.64
27.542	2.54
30.200	2.44
33.113	2.32
36.308	2.18
39.811	2.03
43.652	1.87
47.863	1.68
52.481	

Size (µm)	Volume In %
52.481	1.49
57.544	1.29
63.096	1.08
69.183	0.87
75.858	0.68
83.176	0.49
91.201	0.20
100.000	0.06
109.648	0.01
120.226	0.00
131.826	0.00
144.544	0.00
158.489	0.00
173.780	0.00
190.546	0.00
208.930	0.00
229.087	0.00
251.189	

Size (µm)	Volume In %
251.189	0.00
275.423	0.00
301.995	0.00
331.131	0.00
363.078	0.00
398.107	0.00
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

G&T Metallurgical Services Ltd.

We Identify and Solve Complex Mineral Processing Problems

ISO9001:2000
FS 63170

Result Analysis Report

Project and Test number:
KM2459-08

Sample Name:
Copper Regrind Discharge - Average

Measured by:
ryanm

Edited by:
ryanm

Measured:
Thursday, September 24, 2009 8:52:27 AM

Analysed:
Thursday, September 24, 2009 8:52:28 AM

Particle Name:
Silica 0.01

Particle RI:
1.544

Dispersant Name:
Water

Accessory Name:
Hydro 2000MU (A)

Absorption:
0.01

Dispersant RI:
1.330

Analysis model:
General purpose

Size range:
0.100 to 1000.000 um

Weighted Residual:
0.329 %

Sensitivity:
Normal

Obscuration:
14.13 %

Result Emulation:
Off

Concentration:
0.0134 %Vol

Specific Surface Area:
0.304 m²/g

Span :
2.936

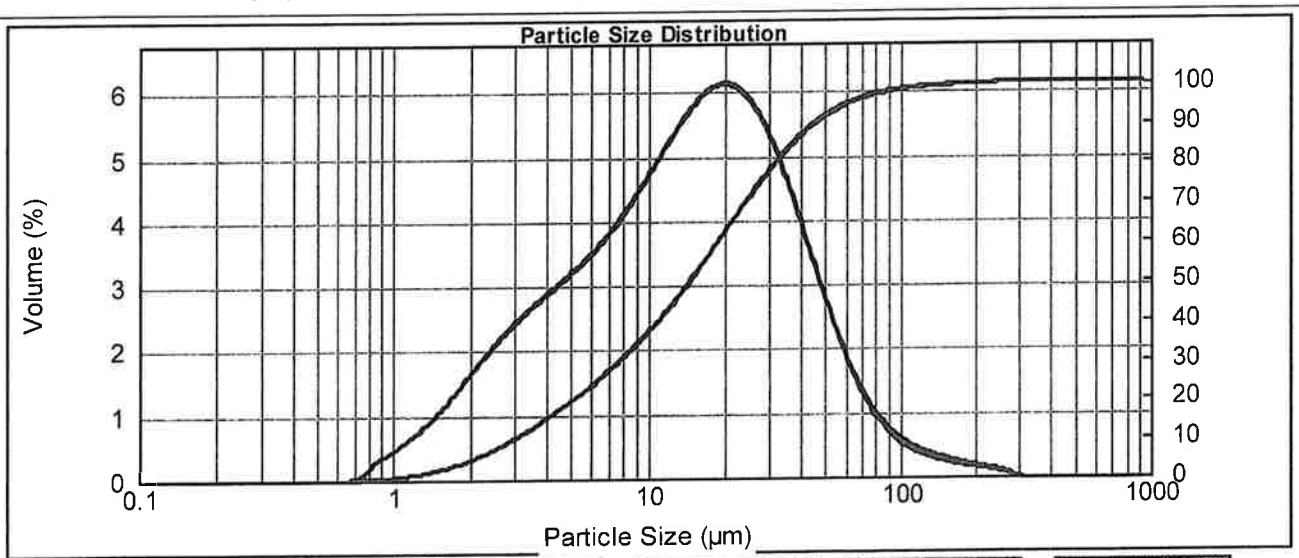
Surface Weighted Mean D[3,2]:
7.436 um

Uniformity:
1

Vol. Weighted Mean D[4,3]:
21.595 um

Result units:
Volume

d(0.1): 2.964 um **d(0.5):** 14.612 um **d(0.8):** 31.906 um **d(0.9):** 45.870 um **d(0.98):** 93.71 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.00
0.437	0.00
0.479	

Size (µm)	Volume In %
0.479	0.00
0.525	0.00
0.575	0.00
0.631	0.00
0.692	0.00
0.759	0.00
0.832	0.18
0.912	0.23
1.000	0.29
1.096	0.36
1.202	0.44
1.318	0.52
1.445	0.62
1.585	0.73
1.738	0.85
1.905	0.97
2.089	1.09
2.291	

Size (µm)	Volume In %
2.291	1.20
2.512	1.31
2.754	1.41
3.020	1.50
3.311	1.59
3.631	1.68
3.981	1.76
4.365	1.84
4.786	1.92
5.248	2.01
5.754	2.11
6.310	2.21
6.918	2.33
7.586	2.46
8.318	2.60
9.120	2.74
10.000	2.91
10.965	

Size (µm)	Volume In %
10.965	3.06
12.023	3.22
13.183	3.37
14.454	3.50
15.849	3.60
17.378	3.67
19.055	3.69
20.893	3.67
22.909	3.60
25.119	3.48
27.542	3.31
30.200	3.10
33.113	2.85
36.308	2.57
39.811	2.27
43.652	1.97
47.863	1.68
52.481	

Size (µm)	Volume In %
52.481	1.41
57.544	1.16
63.096	0.93
69.183	0.75
75.858	0.60
83.176	0.48
91.201	0.38
100.000	0.31
109.648	0.26
120.226	0.22
131.826	0.19
144.544	0.17
158.489	0.14
173.780	0.12
190.546	0.11
208.930	0.09
229.087	0.07
251.189	

Size (µm)	Volume In %
251.189	0.05
275.423	0.01
301.995	0.00
331.131	0.00
363.078	0.00
398.107	0.00
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

G&T Metallurgical Services Ltd.

We Identify and Solve Complex Mineral Processing Problems

ISO9001:2000
FS 63170

Result Analysis Report

Project and Test number:
KM2459-09

Sample Name:
Copper Regrind Discharge - Average

Measured by:
ryanm

Edited by:
ryanm

Measured:
Thursday, September 24, 2009 9:27:49 AM

Analysed:
Thursday, September 24, 2009 9:27:50 AM

Particle Name:
Silica 0.01

Particle RI:
1.544

Dispersant Name:
Water

Accessory Name:
Hydro 2000MU (A)

Absorption:
0.01

Dispersant RI:
1.330

Analysis model:
General purpose

Size range:
0.100 to 1000.000 um

Weighted Residual:
0.297 %

Sensitivity:
Normal

Obscuration:
17.73 %

Result Emulation:
Off

Concentration:
0.0166 %Vol

Specific Surface Area:
0.313 m²/g

Span :
2.603

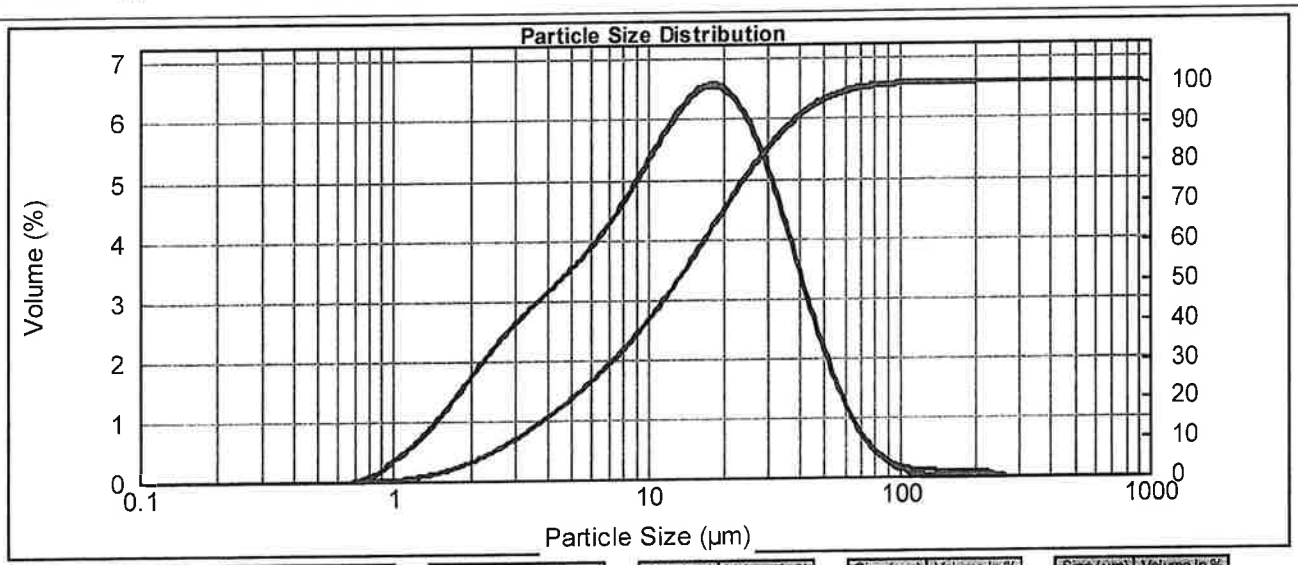
Surface Weighted Mean D[3,2]:
7.231 um

Uniformity:
0.839

Vol. Weighted Mean D[4,3]:
17.426 um

Result units:
Volume

d(0.1): 2.961 um d(0.5): 13.116 um d(0.8): 27.072 um d(0.9): 37.097 um d(0.98): 60.83 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.00
0.437	0.00
0.479	

Size (µm)	Volume In %
0.479	0.00
0.525	0.00
0.575	0.00
0.631	0.00
0.692	0.00
0.759	0.04
0.832	0.07
0.912	0.16
1.000	0.24
1.096	0.31
1.202	0.40
1.318	0.51
1.445	0.62
1.585	0.75
1.738	0.88
1.905	1.02
2.089	1.15
2.291	

Size (µm)	Volume In %
2.291	1.28
2.512	1.40
2.754	1.51
3.020	1.62
3.311	1.72
3.631	1.82
3.981	1.92
4.365	2.01
4.786	2.11
5.248	2.22
5.754	2.33
6.310	2.46
6.918	2.60
7.586	2.75
8.318	2.91
9.120	3.08
10.000	3.26
10.965	

Size (µm)	Volume In %
10.965	3.43
12.023	3.60
13.183	3.74
14.454	3.85
15.849	3.93
17.378	3.95
19.055	3.93
20.893	3.84
22.909	3.70
25.119	3.49
27.542	3.24
30.200	2.94
33.113	2.62
36.308	2.27
39.811	1.93
43.652	1.60
47.863	1.28
52.481	

Size (µm)	Volume In %
52.481	1.00
57.544	0.76
63.096	0.55
69.183	0.39
75.858	0.26
83.176	0.17
91.201	0.11
100.000	0.07
109.648	0.03
120.226	0.02
131.826	0.02
144.544	0.02
158.489	0.02
173.780	0.02
190.546	0.02
208.930	0.02
229.087	0.01
251.189	

Size (µm)	Volume In %
251.189	0.00
275.423	0.00
301.995	0.00
331.131	0.00
363.078	0.00
398.107	0.00
436.516	0.00
478.630	0.00
524.807	0.00
575.440	0.00
630.957	0.00
691.831	0.00
758.578	0.00
831.764	0.00
912.011	0.00
1000.000	

Operator notes:

G&T Metallurgical Services Ltd.

We Identify and Solve Complex Mineral Processing Problems

ISO9001:2000
FS 63170

Result Analysis Report

Project and Test number:
KM2459-10

Sample Name:
Copper Regrind Discharge - Average

Measured by:
ryanm

Edited by:
ryanm

Measured:
Thursday, September 24, 2009 10:19:10 AM

Analysed:
Thursday, September 24, 2009 10:19:11 AM

Particle Name:
Silica 0.01

Particle RI:
1.544

Dispersant Name:
Water

Accessory Name:
Hydro 2000MU (A)

Absorption:
0.01

Dispersant RI:
1.330

Analysis model:
General purpose

Size range:
0.100 to 1000.000 um

Weighted Residual:
0.240 %

Sensitivity:
Normal

Obscuration:
19.99 %

Result Emulation:
Off

Concentration:
0.0179 %Vol

Specific Surface Area:
0.335 m²/g

Span :
3.091

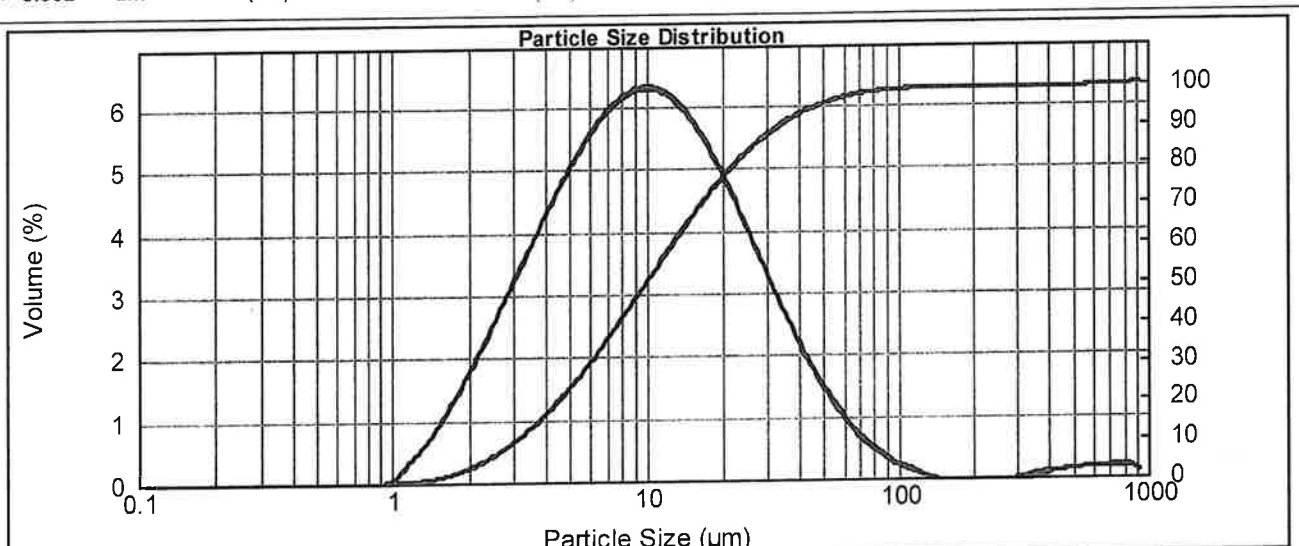
Surface Weighted Mean D[3,2]:
6.759 um

Uniformity:
1.54

Vol. Weighted Mean D[4,3]:
20.624 um

Result units:
Volume

d(0.1): 3.002 um **d(0.5):** 9.933 um **d(0.8):** 22.234 um **d(0.9):** 33.700 um **d(0.98):** 73.5 um



Size (µm)	Volume In %
0.100	0.00
0.110	0.00
0.120	0.00
0.132	0.00
0.145	0.00
0.158	0.00
0.174	0.00
0.191	0.00
0.209	0.00
0.229	0.00
0.251	0.00
0.275	0.00
0.302	0.00
0.331	0.00
0.363	0.00
0.398	0.00
0.437	0.00
0.479	

Size (µm)	Volume In %
0.479	0.00
0.525	0.00
0.575	0.00
0.631	0.00
0.692	0.00
0.759	0.00
0.832	0.00
0.912	0.00
1.000	0.05
1.096	0.18
1.202	0.26
1.318	0.39
1.445	0.54
1.585	0.69
1.738	0.86
1.905	1.04
2.089	1.23
2.291	

Size (µm)	Volume In %
2.291	1.42
2.512	1.62
2.754	1.83
3.020	2.04
3.311	2.24
3.631	2.45
3.981	2.65
4.365	2.84
4.786	3.03
5.248	3.20
5.754	3.35
6.310	3.49
6.918	3.60
7.586	3.70
8.318	3.76
9.120	3.79
10.000	3.79
10.965	

Size (µm)	Volume In %
10.965	3.76
12.023	3.70
13.183	3.61
14.454	3.49
15.849	3.34
17.378	3.16
19.055	2.97
20.893	2.76
22.909	2.54
25.119	2.31
27.542	2.08
30.200	1.86
33.113	1.64
36.308	1.43
39.811	1.23
43.652	1.05
47.863	0.88
52.481	

Size (µm)	Volume In %
52.481	0.74
57.544	0.60
63.096	0.48
69.183	0.38
75.858	0.30
83.176	0.22
91.201	0.16
100.000	0.12
109.648	0.08
120.226	0.04
131.826	0.00
144.544	0.00
158.489	0.00
173.780	0.00
190.546	0.00
208.930	0.00
229.087	0.00
251.189	

Size (µm)	Volume In %
251.189	0.00
275.423	0.00
301.995	0.00
331.131	0.01
363.078	0.04
398.107	0.06
436.516	0.07
478.630	0.08
524.807	0.10
575.440	0.11
630.957	0.11
691.831	0.11
758.578	0.12
831.764	0.11
912.011	0.03
1000.000	

Operator notes:

APPENDIX IV – KM2459

SPECIAL ASSAYS AND STATISTICAL INFORMATION

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TABLE IV-1
REPLICATE HEAD ASSAY DATA

Composite	Assays - percent or g/tonne						
	Cu	Fe	Mo	Au	Ag	Cuox	CuCN
Composite 1 2009 Head 1	0.20	5.54	0.001	0.25	1.4	0.021	0.065
Composite 1 2009 Head 2	0.19	4.76	0.001	0.25	1.2	0.018	0.059
Composite 1 2009 Head 3	0.19	-	-	-	-	-	-
Composite 1 2009 Head 4	0.18	-	-	-	-	-	-
Average	**0.19**	**5.15**	**0.001**	**0.25**	**1.3**	**0.020**	**0.062**
Composite 2 2009 Head 1	0.22	0.87	0.049	0.37	0.9	0.006	0.013
Composite 2 2009 Head 2	0.21	0.81	0.046	0.32	1.0	0.004	0.014
Composite 2 2009 Head 3	-	-	-	0.17	-	-	-
Composite 2 2009 Head 4	-	-	-	0.16	-	-	-
Composite 2 2009 Head 5	-	-	-	0.28	-	-	-
Composite 2 2009 Head 6	-	-	-	0.27	-	-	-
Average	**0.22**	**0.84**	**0.048**	**0.26**	**1.0**	**0.005**	**0.014**
Composite 3 2009 Head 1	0.15	1.01	0.045	0.13	0.8	0.001	0.006
Composite 3 2009 Head 2	0.17	1.10	0.049	0.17	0.9	0.001	0.006
Composite 3 2009 Head 3	-	-	0.041	-	-	-	-
Composite 3 2009 Head 4	-	-	0.050	-	-	-	-
Average	**0.16**	**1.06**	**0.046**	**0.15**	**0.9**	**0.001**	**0.006**

TABLE IV-2A
STATISTICAL ANALYSIS OF HEAD ASSAYS
Composite 1

Test	Assays - percent or g/tonne			
	Cu	Mo	Fe	Au
3	0.17	0.003	5.50	0.26
6	0.16	0.003	4.89	0.23
7	0.16	0.003	5.24	0.22
10	0.19	0.005	4.78	0.25
Calculated	0.17	0.004	5.10	0.24
Measured	0.19	0.001	5.15	0.25

TABLE IV-2B
STATISTICAL ANALYSIS OF HEAD ASSAYS
Composite 2

Test	Assays - percent or g/tonne			
	Cu	Mo	Fe	Au
2	0.19	0.051	1.06	0.27
5	0.19	0.050	1.00	0.24
9	0.22	0.053	0.96	0.24
11	0.20	0.048	0.95	0.26
Calculated	0.2	0.051	0.99	0.25
Measured	0.22	0.050	0.84	0.22

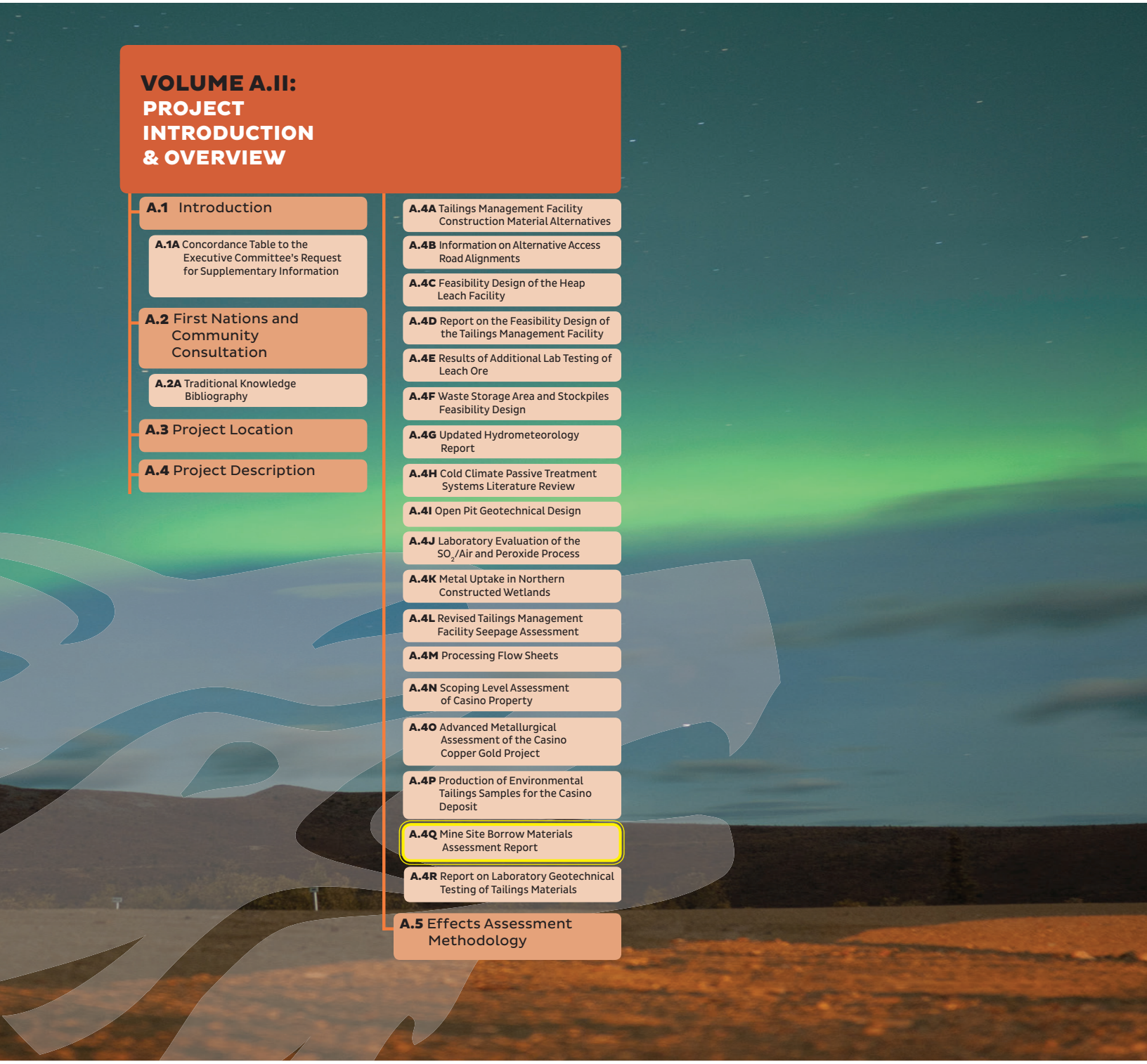
TABLE IV-2C
STATISTICAL ANALYSIS OF HEAD ASSAYS
Composite 3

Test	Assays - percent or g/tonne			
	Cu	Mo	Fe	Au
1	0.15	0.054	1.20	0.22
4	0.15	0.055	1.21	0.17
8	0.18	0.052	1.18	0.20
12	0.15	0.054	1.12	0.20
Calculated	0.16	0.054	1.18	0.20
Measured	0.16	0.046	1.06	0.15

TABLE IV-3
COMPARATIVE COPPER CONCENTRATE ASSAYS

Test	Copper - percent	
	AAS	Titre
1	25.5	25.0
2	27.9	27.0
3	29.1	28.2
4	25.5	25.1
5	27.6	26.6
7	25.3	25.4
8	21.5	21.9
9	25.1	25.2
10	31.2	30.8

APPENDIX A.4Q: Mine Site Borrow Materials Assessment Report



CASINO MINING CORPORATION
CASINO PROJECT





MINE SITE BORROW MATERIALS ASSESSMENT REPORT

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VA101-325/16-3
Rev 0
March 11, 2015

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ISO 9001 - FS 64925
ISO 14001 - EMS 550121
OHSAS 18001 - OHS 550122

CASINO MINING CORPORATION
CASINO PROJECT

MINE SITE BORROW MATERIALS ASSESSMENT REPORT
VA101-325/16-3

Rev	Description	Date
0	Issued in Final	March 11, 2015

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EXECUTIVE SUMMARY

Casino Mining Corporation proposes to build an Open Pit copper-gold-molybdenum mine in the southwestern Yukon. The purpose of this report is to identify potential borrow sources to provide construction materials for project facilities at the Mine Site.

All borrow materials must be free of organics, geochemically innocuous, and thaw stable. Based on geochemical characterization by Lorax, it is expected that geochemically innocuous borrow materials can be derived from all areas, except within the proposed Open Pit limits. The materials also have to be well-graded within specified limits, and comply with other requirements that are set for the specific type of borrow material. Borrow sources are not considered feasible if the targeted material is overlain by a thick layer of unsuitable material.

The material quantities required for construction of the mine site were derived from the Feasibility study. The quantity of available borrow materials was derived by assessing the extent of the borrow areas and the thickness of suitable layers using site investigation data.

Borrow sources were identified and evaluated for the following construction materials:

Low Permeability Soils

Residual soils having at least 15% fines are considered potentially suitable for use as low permeability borrow material. The findings from the hydraulic conductivity tests indicate that residual soil needs to have a fines content of at least 20% to provide a sufficiently low permeability (1×10^{-5} cm/s or less). Processing will be required to increase the fines content from 15% to 20%, by removing gravel and cobbles from the borrow material.

The borrow sources contain insufficient low permeability material for construction of the proposed mine site facilities. Alternative methods to mitigate the shortage of low permeability material include addition of bentonite to borrow materials with low fines content, import of Glacial Till from outside the project area, optimisation of the tailings dam design to reduce the size of the low permeability core zone, and redesign the tailings dam using alternative seepage control measures, such as geosynthetic liners and an asphalt core.

Filter and Transition Zone Material

The filter and transition zone materials will comprise sand and gravel with little fines and no cobbles or boulders, in order to satisfy the filter relationship between low permeability soil and coarse material. The primary borrow materials for the filter and transition zones are coarse residual soils and highly weathered bedrock. These materials are present below the low permeability material borrow materials. Locations with surficial residual soils that are too coarse for use as low permeability material may also be suitable filter and transition zone borrow areas.

The coarse residual soils may be supplemented with alluvial channel deposits located in Casino Creek valley. The presence of shallow permafrost in the valley bottom necessitates extensive stripping, melting and stockpiling to provide access to and facilitate drainage of the coarse grained alluvial materials. The coarse alluvium underlying the embankment may be used despite these unfavorable conditions, as all overburden in this area will be excavated to provide a competent dam foundation.

The borrow materials will require screening in order to comply with the grading limits. Rejected material that is too fine may be suitable for use as low permeability material, and particles that are too coarse may be used as general fill. It is recommended that the effects of compaction and high confining stress on the gradation and strength of residual soils are investigated.

The identified borrow sources are expected to contain sufficient filter and transition zone material for construction of the proposed mine site facilities.

General Fill

General fill has to be free draining, durable, coarse grained material. General fill is expected to be sourced primarily from bedrock on site, as well as residual soils and alluvial channel deposits that are too coarse for use as core or filter zone material. Waste rock from the proposed Open Pit may also be used, provided that this material is geochemically innocuous.

Large boulders will have to be removed from general fill to allow for proper compaction. The general fill borrow source is limited to the upper layer of bedrock where the rock can be excavated with modest effort. Unaltered Granodiorite and Quartzite are expected to be suitable rock types for use as general fill. Highly altered Granodiorite and other types of bedrock are not considered for use as general fill, due to the presence of clay minerals and the potential for acid rock drainage and metal leaching.

The identified borrow sources contain sufficient general fill for construction of the mine site facilities.

Aggregates

Aggregates are required for the production of concrete and for use as bedding material in foundations. Samples of fine and coarse aggregates were tested at the Levelton Consultants laboratory in Richmond, B.C., for concrete aggregate suitability as per CSA standard A23.1/2-09.

The alluvial channel deposits that are located on a ridge along the Britannia Creek Access Road were identified as a suitable fine aggregate source. Processing will be required to meet the specified gradations, including removal of material greater than 5mm, and washing to remove fines. The alluvium contained trace organic impurities but within the allowable range specified by the CSA. Petrographic analysis revealed some minerals in the alluvium that have the potential for alkali-aggregate reactivity with Portland cement. However, the mortar bar test indicated a reactivity that is below the specified maximum.

Alluvial channel deposits at Casino Creek are considered less suitable for use as fine aggregate as these are typically frozen or saturated, and contain slightly more organics than the alluvium along Britannia Creek Access Road. It is recommended to conduct test CSA A23.2-8A “Measuring mortar-strength properties of fine aggregate” on alluvial samples to determine the effect of organic impurities on mortar strength.

Field observations suggest that sufficient material may be present at the borrow source along Britannia Creek Access Road to satisfy the fine aggregate requirements for the mine site. Additional site investigations are required to confirm the depth and areal extent of this proposed borrow source, and to determine the variability of this material.

Fresh, unaltered Granodiorite was identified as a suitable source of coarse aggregate. Crushing and screening will be required to satisfy the gradations specified in the CSA. Laboratory tests indicate

that crushed Granodiorite is a durable and sound material that complies with all CSA specifications for coarse aggregate. The aggregate is interpreted to have a low reactivity, however, some minerals were identified that may promote an alkalicarbonate reaction in concrete. The mortar bar test indicated a very low reactivity that is far below the specified maximum. Therefore alkali-reactivity of the Granodiorite is not of concern.

An area with fresh, unaltered Granodiorite approximately 3km to the North of the proposed Gold Ore Stockpile has been identified as a potential borrow source for use as coarse aggregate. This borrow area is expected to provide sufficient coarse aggregate, but additional site investigations are required to determine the extent of this borrow source.

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Appendix B Summary of Soil Laboratory Test Results
Appendix C Concrete Aggregate Laboratory Test Results

ABBREVIATIONS

ARD ..... Acid Rock Drainage
CSA ..... Canadian Standards Association
KP ..... Knight Piésold Ltd.
ML ..... Metal Leaching
SPMDD ..... Standard Proctor Maximum Dry Density

1 – INTRODUCTION

Casino Mining Corporation proposes to build an Open Pit copper-gold-molybdenum mine in the southwestern Yukon. The purpose of this report is to identify potential borrow sources to provide construction materials for project facilities at the Mine Site.

This report provides an overview of general suitability criteria for borrow materials and describes the geotechnical units and conditions encountered on site. The geotechnical units are characterized and their properties are determined based on findings from site investigations and laboratory tests. This information is used to identify potential borrow sources for specific types of construction materials, including low permeability material, filter and transition zone materials, general fill, and aggregates. The available quantities of suitable borrow material are compared to the estimated quantities required for construction of the mine (based on the Feasibility design study) to determine if sufficient materials are available or if additional site investigations or alternatives should be pursued.

The borrow materials assessment is based on previous geotechnical information collected by Knight Piésold (KP) for the mine site area between 1993 and 2013. Details of the previous investigations are available in the following KP reports:

- Report on Preliminary Surficial Geotechnical Investigations (Ref. No. 1831/1, March 1994).
- Data Compilation Report on 1994 Geotechnical and Hydrogeotechnical Investigations (Ref. No. 1832/2, February 1995).
- KP report “2010 Geotechnical Site Investigation Data Report” (Ref. No. VA101-325/3-4, November 2010).
- KP report “2011 Geotechnical Site Investigation Data Report – Plant Site” (Ref. No. VA101-325/8-4, December 2012).
- KP report “2011 Geotechnical Site Investigation Data Report – Waste Management Facilities” (Ref. No. VA101-325/8-5, December 2012).
- KP report “2011 Geomechanical Site Investigation Data Report – Open Pit” (Ref. No. VA101-325/8-6, December 2012).
- KP report “2012 Geotechnical Site Investigation Data Report” (Ref. No. VA101-325/8-14, December 2012).
- KP report “2013 Geotechnical Site Investigation Data Report – Mine Site” (Ref. No. VA101-325/16-1, January 2014).

An overview of the site investigations at the mine site area is presented on Figure A.1 in Appendix A.

2 – GENERAL SUITABILITY CRITERIA AND DERIVATION OF QUANTITIES

Potential borrow sources have been identified based on a comprehensive review of site investigation data collected to date. Soils and rock throughout the mine site area were evaluated using both general criteria and specific requirements for the intended purpose of the borrow source, such as a minimum required fines content for low permeability material. Borrow material must meet the following general criteria to be considered potentially suitable:

- The material shall be free of organic material. Organic material can oxidize over time, potentially causing settlements and leading to preferential seepage paths.
- All materials shall be well-graded within specified limits, gap-graded soils are not acceptable.
- All materials shall be durable.
- The maximum dimension of any particle shall not be greater than two-thirds the required thickness of the layer in which it is to be placed. This requirement is met by removing coarse particles such as cobbles and boulders from the borrow materials, if necessary.
- All frozen materials shall be thaw stable. Frozen soils are thaw unstable if the amount of ice present will produce more water upon thawing than can be held in the voids. Thaw unstable soils are unsuitable as melting ice results in loss of soil strength and difficult handling. The soil is considered thaw stable if all the melt water can be absorbed by the soil voids without significant settlement and loss of strength.
- All materials shall be geochemically innocuous. Geochemical test results indicate that there is some potential for metal leaching (ML) and acid rock drainage (ARD) from borrow materials in the Open Pit area and low to no ML/ARD potential from other areas (Lorax, 2014). Based on these findings, it is expected that geochemically innocuous borrow materials can be derived from all areas, except within the proposed Open Pit limits. Lorax recommends implementation of a ML/ARD Management Plan to be developed prior to excavation of the borrow sources to confirm suitability.

Additionally, potential borrow sources are rejected if excessive amounts of unsuitable material overlie the targeted borrow material. The thickness of the potential borrow material has to be greater than the overlying unsuitable material in order to be acceptable.

The material quantities required for the construction of the mine site are derived from the Feasibility study. The majority of the earthworks at the mine site are required for the Tailings Management Facility and the Heap Leach Facility. Additional information on the material requirements for construction of the mine site facilities is provided in the following reports:

- M3 Engineering and Technology Corporation, “Casino Project Feasibiltiy Study Volume II”, January 2013.
- KP report “Report on Feasibility Design of the Tailings Management Facility” (Ref. No. VA101-325/8-10, December 2012).
- KP report “Feasibility Design of the Heap Leach Facility” (Ref. No. VA101-325/8-9, December 2012).

The quantity of available borrow materials was derived by identifying potentially suitable areas using the results of terrain mapping. These areas were assessed in detail by studying site investigation data (primarily drillhole and test pits logs) and laboratory test results. This was used to determine the extent of the borrow areas, the thickness of suitable layers, and the thickness of overlying unsuitable soil requiring excavation.

3 – GEOTECHNICAL CHARACTERIZATION

This section provides an overview of the geotechnical conditions encountered at the Mine Site. The geotechnical units are defined and their characteristics and properties are discussed, including the findings of laboratory index tests and hydraulic conductivity tests. Geotechnical units at the site include topsoil, colluvium, residual soil, alluvium and bedrock. Considerations for permafrost and frost susceptibility are also discussed.

3.1 GEOTECHNICAL UNITS

3.1.1 Topsoil

The composition of the topsoil varies throughout the Mine Site area. It is generally silty, and has a high organic content with peaty layers, roots, and plant remains. The high organic content makes topsoil unsuitable for use as a construction material. Topsoil should be carefully stripped from borrow sources and stockpiled for use in reclamation.

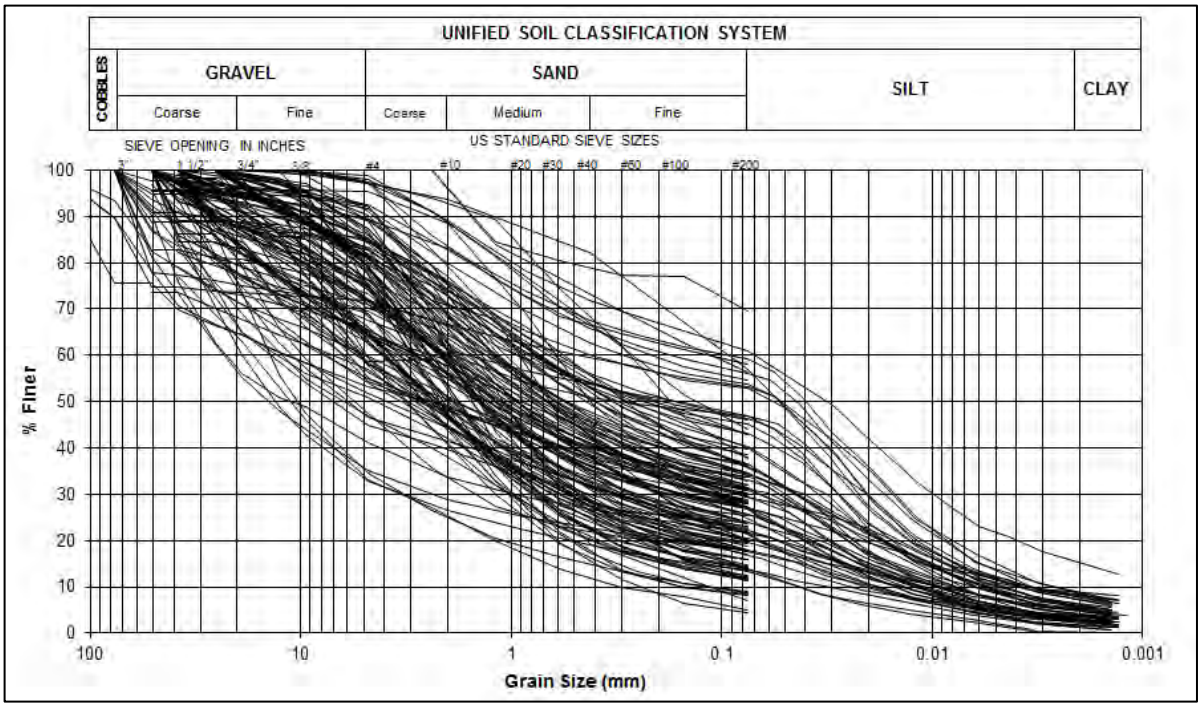
3.1.2 Colluvium

Surficial colluvium is typically found along the slopes of valleys. The colluvium is thin along the upper part of particularly south facing slopes, and generally absent on ridges where residual soils predominate.

The colluvium veneer along the slopes of Casino Creek valley comprises a fine to medium grained sand with some silt supporting coarse gravel and cobble sized broken rock fragments. The thickness generally increases down-slope. On North facing slopes, the colluvial veneer is mostly frozen and ice-rich, and not considered to be a suitable borrow source. Some of the colluvial veneer on south facing slopes may be suitable for use as borrow material. However, the nature of colluvium, i.e. material that has been transported down slopes, causes local variations in the composition. The downslope migration also causes organic material to be included at some locations. The organic content generally increases down-slope. Colluvial veneer is not considered as a potential borrow material in this assessment, due to its inherent variability and organic inclusions.

The colluvial material located towards the valley bottom, where the slope is gentler, is classified as colluvial apron. In the Casino Creek valley the colluvial apron is organic-rich, saturated and frozen, and is not suitable for use as borrow material. The colluvium at the base of the slopes in the Open Pit area consists of coarse blocky talus (scree).

The gradations of colluvium samples collected during previous site investigations are presented in Figure 3.1.



NOTES:

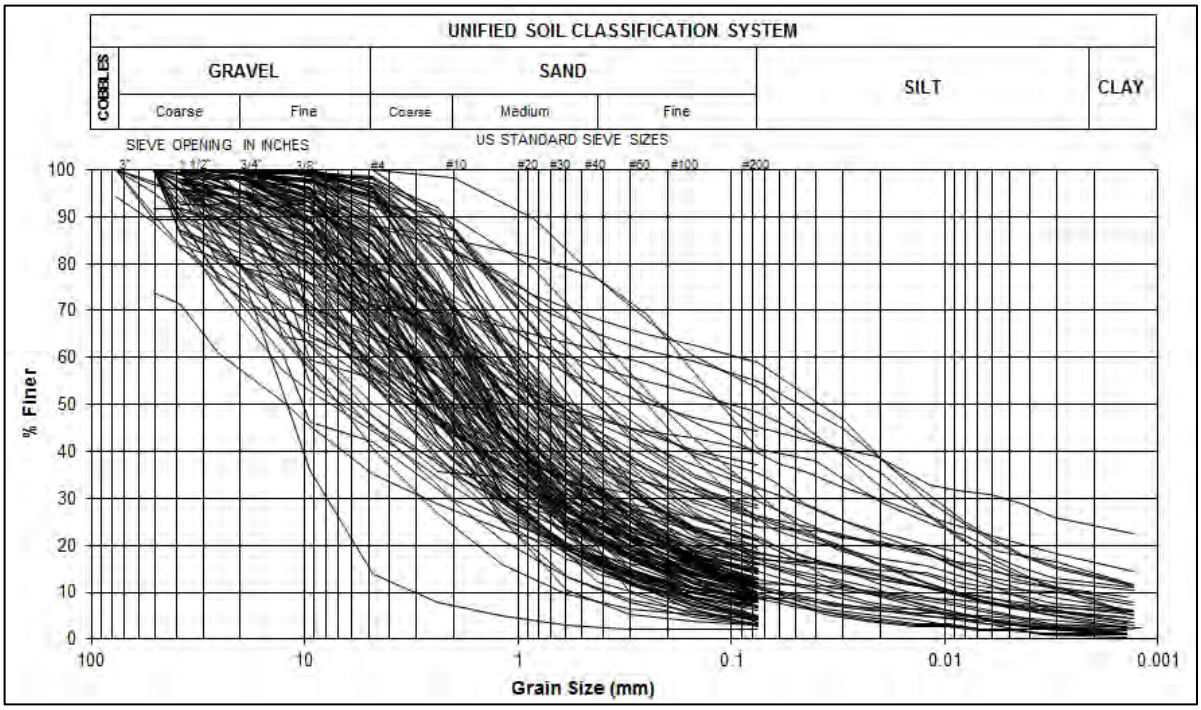
1. Cobbles and boulders are excluded from samples.

Figure 3.1 Gradations of Colluvium

3.1.3 Residual Soil

Residual soils typically comprise heavily weathered, iron oxidized and decomposed sand with some fine gravel and silt. The material is derived from in-situ weathering of host granodiorite bedrock. Weathering is dominated by frost action rather than chemical weathering, and as a result little clay is present. The residual soils coarsen with depth to broken rock as the weathering processes decrease. The material is locally silt rich due to windblown loess enrichment. Residual soils are mainly present along ridges at higher elevations and along the upper parts of some slopes, with thicknesses of less than five meters. Residual soils are locally thicker in the Open Pit area, due to the presence of alteration zones and preferential weathering along shear and fault structures. Residual soils are considered to be a potentially suitable borrow source.

The gradations of residual soil samples collected during previous site investigations are presented in Figure 3.2.



NOTES:

1. Cobbles and boulders are excluded from samples.

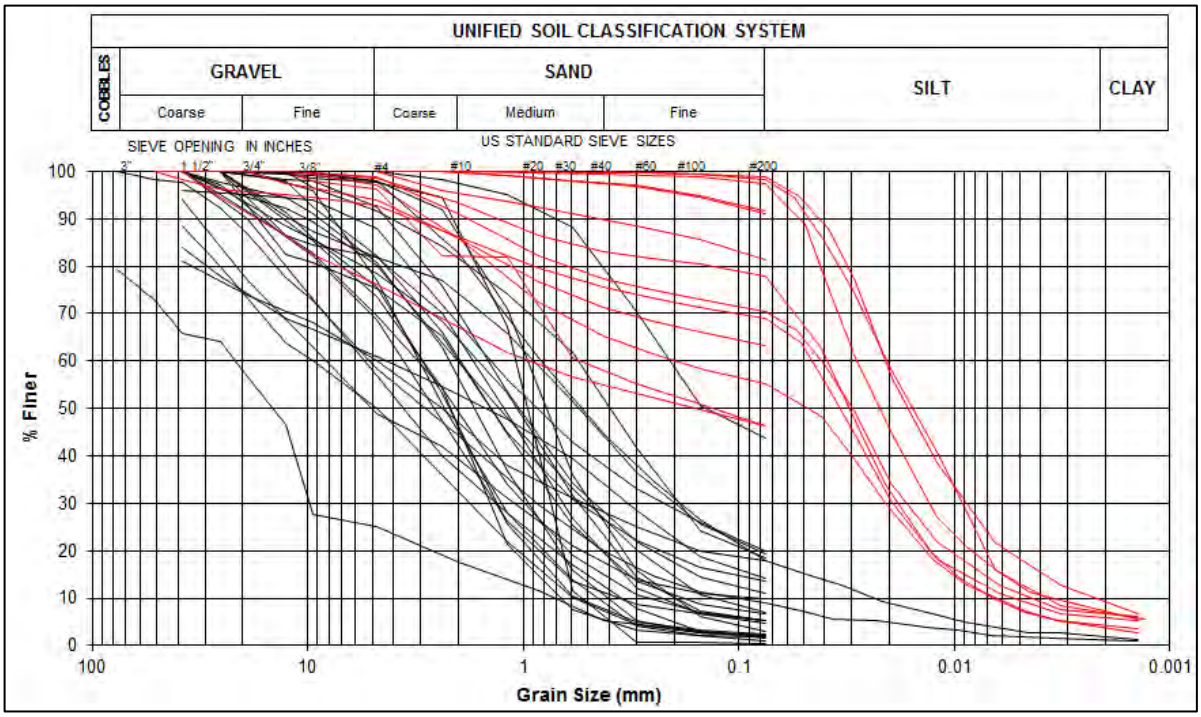
Figure 3.2 Gradations of Residual Soil

3.1.4 Alluvium

Alluvial materials in the project area are found adjacent to creeks in valley bottoms. The alluvium near Casino Creek is coarse grained and comprises interbedded sands and gravelly sands with cobbles and small boulders, and is classified as an alluvial channel deposit. These coarse materials are typically overlain by alluvial flood deposits comprising interbedded ice-rich silts, peats and sandy gravels. In tributary valleys the alluvium is generally present at surface and consists of stratified fine grained sands and silts that are ice-rich or saturated.

The alluvial flood deposits are considered unsuitable for use as construction materials due to interbedded organic layers, and thaw unstable behaviour due to a high ice content. The channel deposits are typically frozen or saturated but the free draining nature of this material makes it a potentially suitable borrow material. Organic matter has occasionally been observed in the channel deposits as a result of historical meandering of the stream; any material containing organic matter should be discarded. The alluvial channel deposits are typically over five metres thick in the vicinity of Casino Creek.

The gradations of alluvial flood deposits and channel deposits sampled during previous site investigations are presented in Figure 3.3.



NOTES:

1. Cobbles and boulders are excluded from samples.
2. Alluvial channel deposits indicated in black.
3. Alluvial floodplain deposits indicated in red.

Figure 3.3 Gradations of Alluvium

3.1.5 Bedrock

Bedrock in and surrounding Casino Creek valley comprises primarily Dawson Range Granodiorite, with minor quartz Diorite. Some quartzite and gneiss of the older Yukon Metamorphic complex were encountered as well. The depth to bedrock is typically between 1 to 4 m along slopes and ridges of the valley, where it is overlain by residual soils and colluvium. Depths to bedrock of over 20m are present in the valley bottom.

Bedrock in the deposit area comprises Granodiorite, Quartz Monzonite, Patton Porphyry (dacite) and latite breccias. Depth to bedrock varies considerably due to local variations in preferential weathering along shear, alteration and fault zones.

3.2 INDEX PROPERTIES

The database with lab test results for each geotechnical overburden unit is included in Appendix B. A summary of the index properties is presented in Table 3.1. The median values are used to characterize the geotechnical units, as certain conditions may skew the properties' average. For example, ice-rich frozen soils have very high moisture contents (over 100%), leading to unrepresentative average values.

Table 3.1 Summary of Index Tests

Sample ID	Moisture Content	Specific Gravity	Organic Content	Atterberg Limits			Particle Size Distribution				Modified Proctor Compaction	
				LL	PL	PI	% Gravel	% Sand	% Silt	% Clay	Maximum Dry Density (tonne/m^3)	Optimum Moisture Content (%)
Colluvium	12.4	2.70	6.3	23.0	19.0	4.0	25	46	25	4	2.13	7.0
Residual Soil	9.2	2.69	2.2	24.0	18.0	6.0	24	62	11	3	2.03	9.7
Alluvium – Channel Deposits	13.3	-	4.8	NP	NP	NP	23	68	8	1	-	-
Alluvium – Floodplain Deposits	34.8	2.71	4.4	25.0	22.0	3.0	3	22	69	6	-	-

NOTES:

1. Median values reported.
2. Particle Size Distribution by percent of sample weight. Cobbles and boulders removed from samples.
3. NP = Non Plastic, LL= Liquid Limit, PL = Plastic Limit, PI = Plasticity Index.
4. Modified proctor includes an oversize correction as per ASTM D4718.

The values in Table 3.1 confirm that residual soils contain little organic matter. Colluvium has the highest organic content due to intermixing of the topsoil layer. All soil types are non-plastic to low plasticity, and contain only trace clay. The residual soils have a natural moisture content that is typically slightly below optimum, which indicates favorable conditions to achieve compaction. Colluvium has a natural moisture content several percent above the optimum moisture content, which is less favorable.

3.3 HYDRAULIC CONDUCTIVITY

Saturated hydraulic conductivity testing was completed between 2010 and 2013 on selected samples in the Knight Piésold soil laboratory in Denver, Colorado. The tests were conducted on colluvial and residual soils using a flexible wall permeameter. The results are presented on Figure 3.4.

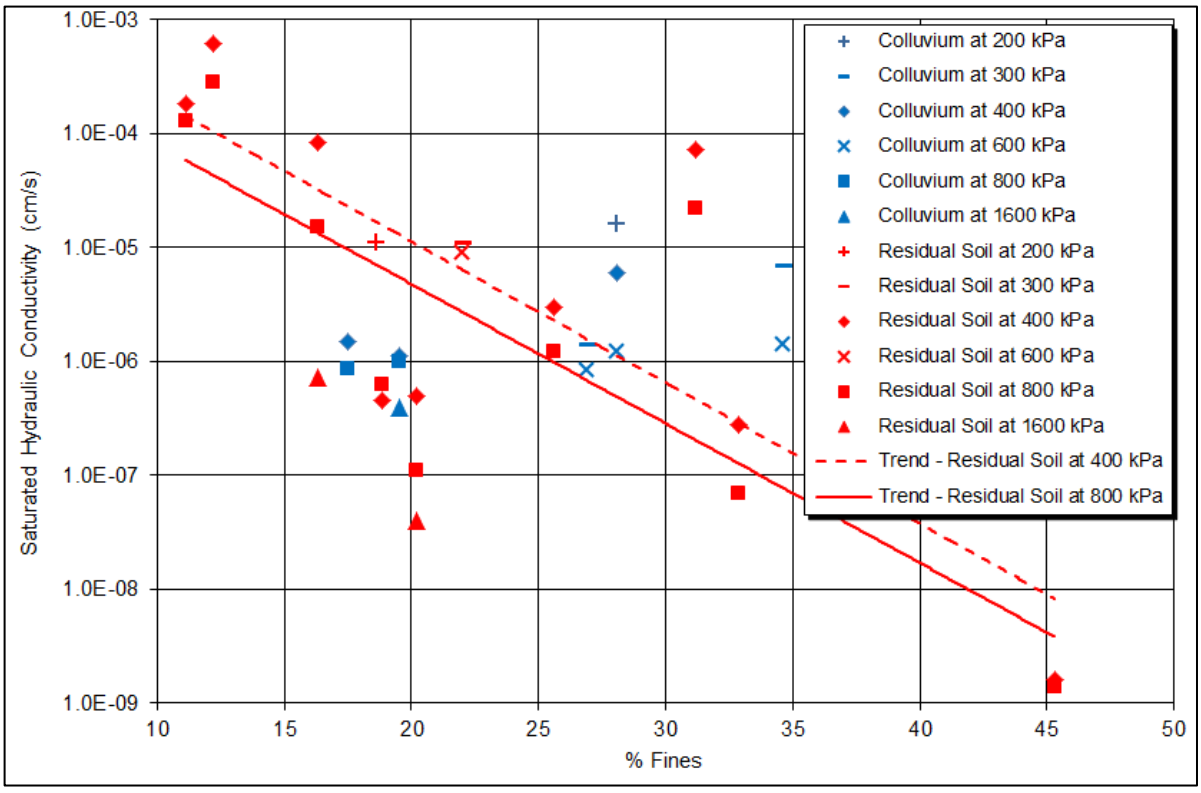
Residual soil samples compacted to 95% Standard Proctor Maximum Dry Density (SPMDD) have saturated hydraulic conductivity values ranging from approximately 1×10^{-3} cm/s (low fines content) to 1×10^{-9} cm/s (high fines content), depending on material gradation and confining pressure. The saturated hydraulic conductivity of the colluvium ranges from 5×10^{-5} cm/s to 5×10^{-7} cm/s for 95% SPMDD.

The saturated hydraulic conductivity of residual soil generally decreases with increasing fines content. This trend is not observed for the colluvial samples.

Tests in which the same sample was subjected to various levels of confining stress indicate a reduction in hydraulic conductivity for higher stress levels. The trend line in Figure 3.4 indicates that residual soils with 20% fines have a saturated hydraulic conductivity of approximately 1×10^{-5} cm/s at 400 kPa, reducing by about half an order of magnitude at 800 kPa.

A common specification for embankment core zone and soil liner materials is compaction to 95% SPMDD. Laboratory tests indicate that increasing the compaction to 98% SPMDD leads to a

small reduction in permeability (less than half an order of magnitude). Proctor tests conducted on residual soils in 1993 indicate that compaction may result in particle crushing. It is recommended that the effects of compaction and high confining stress on the gradation and strength of the residual soils be investigated in more detail.



NOTES:

1. Fines are defined as material passing the #200 sieve (0.075 mm).
2. All samples are compacted to 95% Standard Proctor Maximum Dry Density.

Figure 3.4 Saturated Hydraulic Conductivity for Colluvium and Residual Soil

The findings from the hydraulic conductivity tests indicate that residual soil with a fines content of at least 20% is suitable for use as low permeability borrow material (1 x 10^{-5} cm/s or less). Applications of low permeability materials at low confining stresses may require residual soil with a higher fines content. Alternatively, the residual soil may be enriched with bentonite to reduce the permeability. This has been done for the Charlot River Dam, where the addition of 3% bentonite by weight to the silty sand core material decreased the permeability by one order of magnitude (Solymar and Nunn, 1983). Controlled mixing of the bentonite and silty sand proved difficult during construction, and additional studies will be required if admixing bentonite is pursued.

3.4 PERMAFROST AND FROST SUSCEPTIBILITY

Frost susceptible soils can display frost heaving and thaw weakening behaviour. Frost heaving is the result of ice segregation during the freezing process and the formation of alternating bands of soil and ice. Thaw weakening occurs when these ice bands melt, providing an excess of water. When

this water cannot escape due to remaining frozen layers or low permeability soil, excess pore pressures build up causing a reduction in soil strength. Frost heave and thaw weakening can cause differential settlements, instability, increase in void ratio, and preferential seepage paths.

The frost susceptibility classification is based on the guidelines by the U.S. Army Corps of Engineers (Johnson et al., 1986). Gravels with less than 1.5% finer than 0.02mm and sands with less than 3% finer than 0.02mm are classified to have negligible to low frost susceptibility. All other soils have a wide range of possible frost susceptibility, with a tendency to be more frost susceptible for higher fines content. A frost heave laboratory test can be performed when precise information on soil frost susceptibility is required. As a first approximation, soils having more than 10% of material passing the #200 sieve (0.075mm) can be assumed frost susceptible (Barker and Thomas, 2013).

Most natural soils present on site are frost susceptible, based on the above criteria. Soils that contain sufficient moisture are likely to accumulate excess ice when they freeze, and may become thaw unstable. Excess ice has been observed in all geotechnical units present on site. Thaw unstable soils are unsuitable for use as borrow material as they lose strength when they are allowed to thaw before placement, which may result in instability. Areas with permafrost are therefore less likely to provide suitable borrow material.

Permafrost is extensive yet discontinuous in the Casino mine site area. In Casino Creek valley, it is primarily present in the valley bottom and along North facing slopes. Permafrost is also prevalent in the Plant Site and Open Pit areas. The most suitable locations for borrow materials are typically permafrost-free areas located on south facing slopes and hilltops.

Frost heaving and thaw weakening may occur in frost susceptible borrow materials after final placement as a construction material. Measures to mitigate or prevent frost heave effects include:

- Apply a cover of insulation or non-frost susceptible material to the depth of frost penetration,
- Limit the supply of water to the freezing front using drainage measures,
- Apply a surcharge pressure to prevent or reduce frost heave to tolerable levels, and
- Limit the construction season to select months in order to reduce the effects of seasonal frost.

Care should be taken in handling and stockpiling frost susceptible materials to avoid saturation and freezing of these materials. A comprehensive strategy to mitigate frost heave effects will be developed as part of detailed design.

4 – LOW PERMEABILITY SOIL

4.1 CRITERIA

The following criteria have been used to determine suitability for use as low permeability borrow material, in addition to the general criteria presented in Section 2:

- Material shall have at least 15% fines. Laboratory tests have indicated that residual soil is required to have at least 20% fines to have a sufficiently low permeability. However, the fines content can be increased by removing the coarse fraction of the borrow material. The coarse material may be suitable for use as filter material or general fill.
- Material shall be close to or dry of optimum moisture content. Limited moisture conditioning of soils containing fines is possible, however, it is problematic and impractical to drain and dry the soil due to its low permeability. Wet and saturated soil is considered unsuitable as a low permeability material, as well as thaw unstable (ice-rich) frozen soils.

4.2 POTENTIAL BORROW AREAS

A common borrow source for low permeability soils in Canada is glacial till. However, the Casino mine site was not glaciated during the Wisconsin advance and consequently no till is present in the area. Residual soil was identified as an alternative source for low permeability borrow material, provided sufficient fines are present. Colluvium is not considered to be suitable due to its inherent variability and organic inclusions. Alluvial channel deposits are also not considered for this purpose as these primarily comprise coarse grained soils. Alluvial floodplain deposits are fine grained but contain organics and are ice-rich or saturated.

Areas with fine grained residual soils that meet the criteria were identified as potential sources for low permeability borrow material, and are presented on Figure A.2 in Appendix A.

4.3 QUANTITIES

The estimated quantity of low permeability material that is required for construction of the proposed mine site facilities is summarized in Table 4.1. The material is mainly required for the core zone of the proposed tailings dam. Low permeability borrow is also required for the soil liner of the proposed Heap Leach Facility, although in much smaller quantities. The total amount required for construction of the proposed mine site facilities is approximately 11.2 Mm^3.

Table 4.1 Required Quantity of Low Permeability Material

Line Item	Volume (m^3)
Tailings Management Facility – Starter Dam	3,400,000
Tailings Management Facility – Final Dam (excluding Starter Dam)	6,800,000
Heap Leach Facility	530,000
Miscellaneous (allowance for small ponds and other structures)	500,000
Total Required	**11,230,000**

NOTES:
1. Includes 10% overbuild.

The borrow material assessment indicates that approximately 4,600,000 m^3 of suitable low permeability material is present in the mine site area. Processing is required for some of this material to increase the fines content from 15% to 20%. This may be achieved by removing gravel and cobbles from the soil, i.e. any material greater than the #4 sieve (4.75mm). Removing the coarse fraction leads to a reduction of the available quantity of borrow material by approximately 20% to 3,700,000 m^3.

The available quantity of low permeability material is presented in Table 4.2. This table also includes the amount of unsuitable material that is overlying the intended borrow source, including topsoil and colluvium. The amount of unsuitable material that needs to be removed is relatively large compared to the quantity of borrow material. This is due to the relatively thin layer of fine grained residual soil (average between 1.5 and 2 meter thick), leading to a large disturbance area.

Table 4.2 Available Quantity of Low Permeability Material

Line Item	Volume (m^3)
Suitable Low Permeability Material – Fine Grained Residual Soil	3,700,000
Total Available	**3,700,000**
Overlying Unsuitable Material - to be removed	1,700,000

NOTES:
1. Assumes removal of coarse material (20% by weight) to produce suitable low permeability material

The borrow sources contain insufficient low permeability material for construction of the proposed project facilities at the Mine Site. The available quantities are slightly less than the amount required to construct the proposed Stage 1 (starter) dam of the Tailings Management Facility and the soil liner for the Heap Leach Facility.

4.4 METHODS TO MITIGATE SHORTAGE OF LOW PERMEABILITY MATERIAL

The site investigations completed to date have covered most of the mine site, as illustrated in Figure A.1 in Appendix A. Additional borrow areas may be explored outside the mine site area, but these will have longer hauling distances. Alternative methods to mitigate the shortage of low permeability material may be more cost-effective or have other benefits (for example, the alternative may use non-frost susceptible materials). These alternatives include:

- Addition of bentonite to the low permeability material, as described in Section 3.3, thereby lowering the required fines content and increasing the amount of suitable material.
- Use Glacial Till from other locations as low permeability material. Bond and Lipovsky (2011) indicate localized glacial deposits near Mount Cockfield, approximately 20km straight line distance from the mine site area. These are likely the glacial deposits that are closest to the mine site. The suitability of these glacial deposits has not been assessed to date.
- Optimise the tailings dam design to reduce the size of the low permeability core zone.
- Redesign the tailings dam using seepage control measures other than an earthfill core, such as:
  - Geosynthetic liners
  - Asphalt core

5 – FILTER AND TRANSITION ZONE MATERIAL

5.1 CRITERIA

One or more filter and transition zones are required to avoid migration of fines from low permeability material to adjacent coarse material (such as the shell zone in the embankment dam). The primary requirement for this material is to provide a filter relationship between the low permeability soil and the coarse material, in addition to general borrow material requirements.

The filter and transition zone materials will comprise sand and gravel with little fines and no cobbles or boulders, in order to satisfy the filter relationship. Grading limits have not been specified at this stage and will be established during detailed design.

5.2 POTENTIAL BORROW AREAS

The borrow sources for the filter and transition zones are expected to be coarse residual soils and highly weathered bedrock, or alluvial channel deposits comprising sands, gravels and cobbles in valley bottoms. These materials will require screening in order to comply with the grading limits. Rejected material that is too fine may be suitable for use as low permeability material, and particles that are too coarse may be used as general fill.

Historical laboratory test work indicates that compaction of residual soils may result in particle crushing. It is recommended that the effects of compaction and high confining stress on the gradation and strength of residual soils are investigated, to confirm suitability for use as filter material.

The primary source of coarse alluvial channel deposits is located in Casino Creek valley. The presence of shallow permafrost in the valley bottom necessitates extensive stripping, melting and stockpiling to provide access to and facilitate drainage of the coarse grained alluvial materials. These unfavorable conditions make alluvial channel deposits an unattractive borrow source for the majority of Casino Creek valley. The coarse alluvium underlying the embankment may be used despite these unfavorable conditions, as all overburden in this area must be excavated to provide a competent dam foundation.

The residual soils that are present on site are generally coarsening with depth, as the degree of weathering decreases. Coarse residual soils and highly weathered bedrock that are suitable for use as filter and transition zone materials are therefore present below the low permeability material borrow sources. Locations with surficial residual soils that are too coarse for use as low permeability material may also be suitable filter and transition zone borrow areas.

The locations of filter and transition zone borrow areas are presented on Figure A.3 in Appendix A. Materials in the proposed Open Pit area have not been considered due to their ML/ARD potential.

5.3 QUANTITIES

An estimate of filter and transition zone material that is required for the construction of the mine is provided in Table 5.1. The material is mainly used for the filter and transition zone of the tailings dam, and overliner material for the Heap Leach Facility. The total amount required for construction of the mine is approximately 3.6 Mm^3.

Table 5.1 Required Quantity of Filter and Transition Zone Material

Line Item	Volume (m^3)
Tailings Management Facility – Starter Dam	250,000
Tailings Management Facility – Final Dam (excluding Starter Dam)	1,350,000
Heap Leach Facility	1,840,000
Miscellaneous (allowance for small ponds and other structures)	200,000
Total Required	**3,640,000**

NOTES:
1. Includes 10% overbuild.

The available quantity of filter and transition zone material is presented in Table 5.2. It is estimated that on average at least one meter of suitable filter and transition material is present in the identified borrow areas with residual soils and highly weathered bedrock. The coarse grained alluvium in the valley bottom is also estimated to comprise on average at least one meter of suitable filter and transition zone material.

Table 5.2 also includes the amount of unsuitable material in the borrow areas. Unsuitable material that was already listed as part of the low permeability material has been excluded from Table 5.2.

The identified borrow sources contain sufficient filter and transition zone material for construction of the mine.

Table 5.2 Available Quantity of Filter and Transition Zone Material

Line Item	Volume (m^3)
Suitable Filter and Transition Zone Material – Coarse Grained Residual Soil	6,440,000
Suitable Filter and Transition Zone Material – Coarse Grained Alluvial Soil below Tailings Dam	60,000
Total Available	**6,500,000**
Overlying Unsuitable Material - to be removed (1)	3,000,000

NOTES:
1. Excluding unsuitable materials that are to be removed from low permeability borrow areas (Table 4.2).

6 – GENERAL FILL

6.1 CRITERIA

General fill has to be free draining, in addition to the general requirements presented in Section 2. This is achieved by limiting the fines content to a maximum of 10% by weight.

6.2 POTENTIAL BORROW AREAS

General fill is expected to be sourced primarily from bedrock on site, as well as residual soils and alluvial channel deposits that are too coarse for use as core or filter zone materials. Waste rock from the proposed Open Pit may also be used, provided that this material is geochemically innocuous.

The general fill is sourced from the same borrow areas as the filter and transition zone material, as presented on Figure A.3 in Appendix A. A small amount of general fill is expected to be obtained from the alluvial channel deposits underlying the tailings dam. The main sources of general fill are the coarse residual soils and fractured bedrock underlying the filter borrow material. Large boulders will have to be removed from general fill to allow for proper compaction. Competent bedrock with few joints and fractures may be suitable, but would require costly methods such as drilling and blasting to remove the rock and to reduce it to an acceptable size. The general fill borrow source is therefore limited to the upper layer of bedrock where the rock can be excavated with modest effort. Unaltered Granodiorite and Quartzite are expected to be suitable rock types for use as general fill. Highly altered Granodiorite and other types of bedrock are not considered for use as general fill, due to the presence of clay minerals and the potential for acid rock drainage and metal leaching.

6.3 QUANTITIES

The required quantity of general fill is provided in Table 6.1. General fill is mainly required for construction of the shell zone of the starter dam. The shell zone of the final dam is made of cyclone sand. A contingency of 1,000,000 m^3 of general fill is included to compensate any shortfall of cyclone sand. A substantial amount of general fill is required for embankments, ponds and grading at the Heap Leach Facility. The total amount required for construction of the proposed mine site facilities is approximately 11.1 Mm^3.

Table 6.1 Required Quantity of General Fill Material

Line Item	Volume (m^3)
Tailings Management Facility – Starter Dam	7,300,000
Tailings Management Facility – Contingency for Shortfall of Cyclone Sand	1,000,000
Heap Leach Facility	2,290,000
Miscellaneous (allowance for small ponds and other structures)	500,000
Total Required	**11,090,000**

NOTES:
1. Includes 10% overbuild.

The available quantity of general fill borrow material is presented in Table 6.2. The quantity is determined using an estimated five meters of suitable residual soils and bedrock. The coarse grained alluvium in the valley bottom is estimated to comprise at least three meters of suitable general fill.

The quantities were determined assuming no general fill would be sourced from the proposed Open Pit area, as this material has potential for ML/ARD.

Unsuitable material overlying the targeted borrow materials are already included as part of the low permeability and filter borrow materials presented in Table 4.2 and Table 5.2.

The identified borrow sources contain sufficient general fill for construction of the proposed mine site facilities.

Table 6.2 Available Quantity of General Fill Material

Line Item	Volume (m^3)
Suitable General Fill Material – Coarse Grained Residual Soil	32,190,000
Suitable General Fill Material – Coarse Grained Alluvial Soil below Tailings Dam	180,000
Total Available	**32,370,000**

NOTES:

1. For unsuitable materials that are to be removed, refer to Table 4.2 and Table 5.2.

7 – AGGREGATE

7.1 CRITERIA

Aggregates are required for the production of concrete and for use as bedding material in foundations. Canadian Standard Association (CSA) standard A23.1/2-09 provides criteria for concrete aggregate, and standard test methods to determine the aggregate properties. The standard includes specific requirements for fine and coarse aggregates. Materials are tested to determine properties including the particle size distribution, density, organic impurities, durability, and petrographic examination for deleterious substances. Coarse aggregates that are suitable for concrete production are also suitable for bedding material (structural fill) in foundations. Similarly, fine concrete aggregate can also be used as bedding sand. The concrete aggregate criteria and corresponding laboratory test results are presented in Section 7.3.

7.2 POTENTIAL BORROW AREAS

Alluvium and rock sources with fresh unaltered bedrock have been investigated for use as potential sources of aggregate.

One alluvial source was identified on a ridge along the Britannia Creek Access Road (TP13-01). This material comprised subrounded sand and gravel, with some to many cobbles, and trace silt. The material was sampled from a trench that was originally frozen but thawed out after being exposed several years ago. Other alluvial sources were found along Casino Creek (e.g. TP13-14 and TP13-19). These materials are similar to the soils in Test Pit TP13-01 but typically frozen or saturated. Traces of roots and plant remains were occasionally observed in the alluvium along Casino Creek.

Two types of bedrock were considered potentially suitable for use as aggregate based on field observations: Granodiorite and Quartzite. The fresh Quartzite was strong and fractured along pre-existing planes of weakness. Fresh Granodiorite was very strong and less prone to breaking.

The locations of aggregate borrow areas are presented on Figure A.4 in Appendix A.

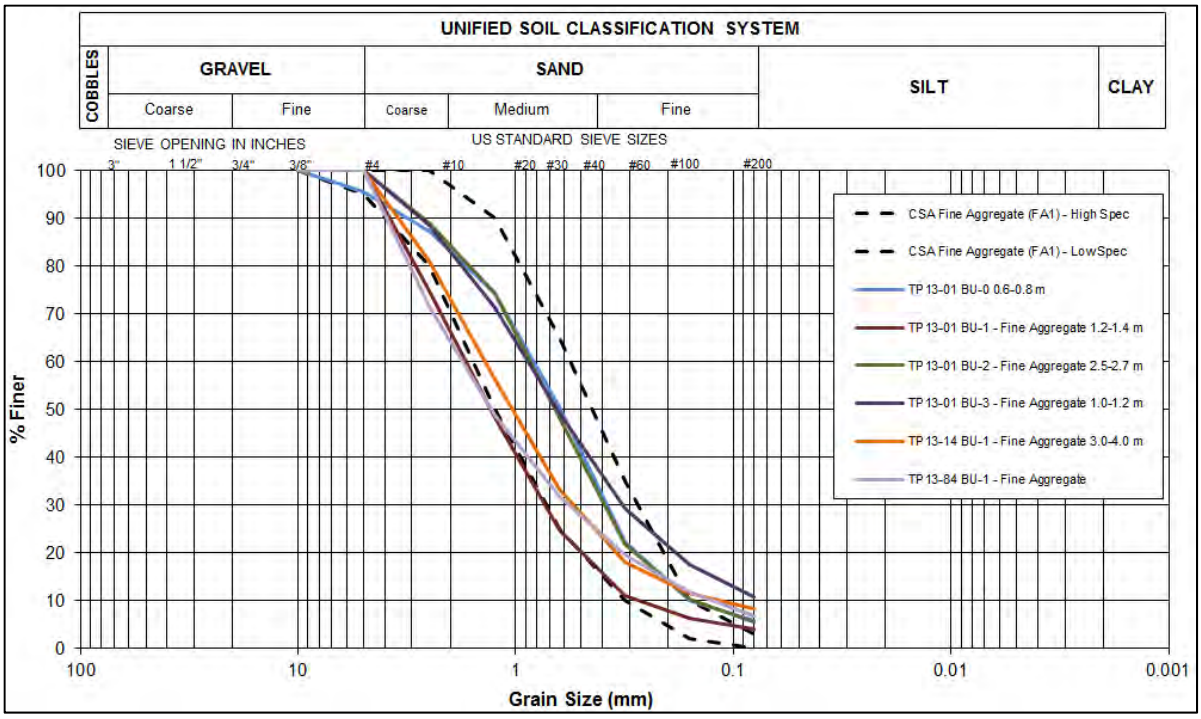
7.3 CONCRETE AGGREGATE LABORATORY TESTING

Alluvial test pit samples from TP13-01 and TP13-14, and fresh Grandiorite samples from TP13-84 were sent to the Levelton Consultants laboratory in Richmond, B.C., for concrete aggregate suitability testing as per CSA standard A23.1/2-09. The Granodiorite (TP13-84) was crushed using a jaw crusher with a 28mm opening and tested for suitability as coarse aggregate. Samples were collected from various horizons in the alluvium along Britannia Creek Access road (TP13-01). The gradation was determined for each of the samples, before combining them into a representative bulk sample. The bulk sample was then split into a coarse and a fine fraction. The fine fraction was subjected to a full suite of tests, and select tests were conducted on the coarse fraction. A sample was also collected from the alluvium along Casino Creek (TP13-14). The fine fraction of this sample was subjected to select tests for fine aggregate suitability.

The gradations of the test pit samples for fine and coarse aggregate are presented in Figure 7.1 and Figure 7.2, respectively. The aggregate testing results are summarized in Table 7.1 and Table 7.2, and detailed test results are provided in Appendix C.

7.3.1 Fine Aggregate

The particle size distributions presented in Figure 7.1 indicate that the alluvial samples from TP13-01 and TP13-14 mostly satisfy the CSA gradation criteria for fine aggregate after removing material greater than 5 mm. However, the samples contain too many fines (silt and clay) to be acceptable.



NOTES:

1. No processing was required for TP13-01 BU-1 to satisfy the CSA specification for fine aggregate (FA1).
2. All other fine aggregate samples were produced by removing material greater than 5mm.
3. TP13-01 and TP13-14 comprise alluvium.
4. TP13-84 comprises Granodiorite.

Figure 7.1 Fine Aggregate Gradations

The petrographic examination indicates that the alluvial samples from TP13-01 are made up of quartz, feldspar, quartz-feldspar intergrowths, amphibole, clay, biotite, white mica, epidote, iron oxides, metamorphic schist, quartz breccia, carbonate, magnetite and chlorite.

The alluvial sample from TP13-14 is made up of feldspar, feldspar and quartz intergrowths, quartz, clay, biotite, iron oxides, amphibole, brecciated feldspar and quartz, white mica, titanite, magnetite, epidote, pyrite, carbonate and chlorite.

The two samples show different mineral compositions, which can be summarised as more abundant quartz in sample TP13-01 and more abundant feldspar in sample TP13-14. Sample TP13-01 Composite hosts more abundant amphibole, and subordinate fragments of metamorphic schists. The source rocks of this aggregate are quartzo-feldspathic plutonic rocks (Granodiorite) and schists.

Some of the minerals identified in the two samples, namely clay, feldspar and strained quartz have the potential for alkali-aggregate reactivity with Portland cement. The test CSA A23.2-25A

"Detection of alkali-silica reactive aggregate by accelerated expansion of mortar bars" indicated a reactivity that is below the specified maximum for TP13-01. The material in TP13-14 is not tested for alkali-reactivity.

Table 7.1 Summary of Fine Aggregate Tests Results

Test Method	Standard	CSA Specification Maximum Percentage	Alluvium TP13-01 Composite	Alluvium TP13-14 BU-1
Sieve analysis of fine aggregate	CSA A23.2-2A	See Figure 7.1		
Clay lumps in natural aggregate (%)	CSA A23.2-3A	1.0	0.0	0.0
Low-density granular material in aggregates (%)	CSA A23.2-4A	0.5	0.0	Not tested
Amount of material finer than 80 µm in aggregates (%)	CSA A23.2-5A	3.0	8.6	6.0
Relative density (saturated surface-dry basis) and absorption (%) in fine aggregate	CSA A23.2-6A	N/A	Density: 2.563 Absorption: 1.24	Not tested
Organic impurities in fine aggregates for concrete (color plate index)	CSA A23.2-7A	No. 3 or less	No. 3	No. 4
Petrographic examination of aggregates	CSA A23.2-15A	Identification of deleterious substances, discussed separately		
Resistance of fine aggregate to degradation by abrasion in the Micro-Deval apparatus (% loss)	CSA A23.2-23A	20.0	13.0	Not tested
Detection of alkali-silica reactive aggregate by accelerated expansion of mortar bars (% expansion at 14 days)	CSA A23.2-25A	0.150	0.102	Not tested

NOTES:

1. Specifications as per CSA A23.1 Table 12.

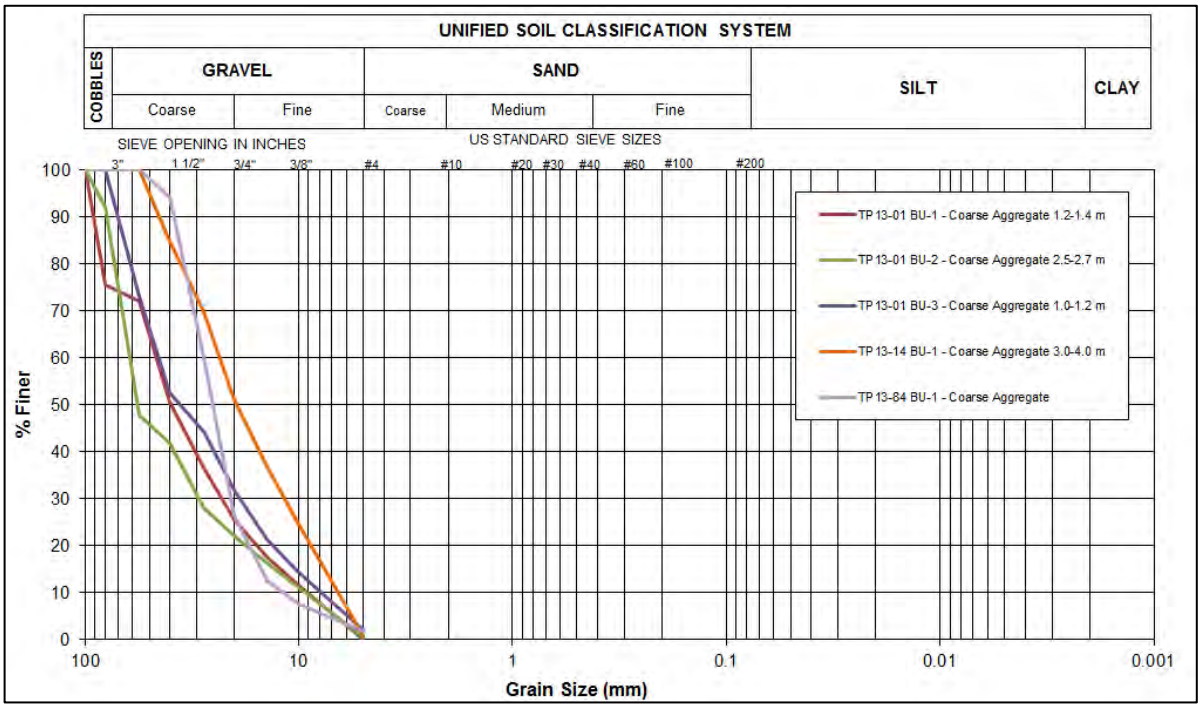
The results of the testing program indicate that alluvium is overall a good source of fine aggregate. It was determined to be a durable and sound material, with the following deficiencies:

- Amount of fines. The gradations in Figure 7.1 and the results from test CSA A23.2-4A indicate that too much fines are present in the aggregate samples. Silt coating on particles may affect the strength of the concrete by weakening the bond between the cement and the particles. It may also cause frost susceptibility of fine aggregates used as bedding sand. It is recommended to wash the alluvium to remove the silt coating prior to use as fine aggregate.
- Organic impurities. The alluvium at TP13-01 contained some organic impurities, but within the allowable range. The organic impurities at TP13-14 exceeded the CSA specifications. A fine aggregate failing the test may be used, provided that can be demonstrated that the organic impurities do not have a detrimental effect on the compressive strength of mortar produced using

this aggregate. It is recommended to conduct test CSA A23.2-8A "Measuring mortar-strength properties of fine aggregate" on alluvium from TP13-01 and TP13-14 to determine the effect of organic impurities on mortar strength.

7.3.2 Coarse Aggregate

The gradations of alluvium and crushed Granodiorite after removal of material smaller than 5mm are presented in Figure 7.2. The gradations are not within the specified limits for coarse aggregate listed in CSA A23.2-09 Table 11. Additional crushing and screening is required before these materials can be used as coarse aggregate.



NOTES:

1. Coarse aggregate samples produced by removing material smaller than 5mm.
2. TP13-01 and TP13-14 comprise alluvium.
3. TP13-84 comprises Granodiorite.

Figure 7.2 Coarse Aggregate Gradations

Table 7.2 Summary of Coarse Aggregate Tests Results

Test Method	Standard	CSA Specification Maximum Percentage	Alluvium TP13-01 Composite	Granodiorite TP13-84 BU-1
Sieve analysis of coarse aggregate	CSA A23.2-2A	See Figure 7.2		
Clay lumps in natural aggregate (%)	CSA A23.2-3A	0.3	Not tested	0.0
Low-density granular material in aggregates (%)	CSA A23.2-4A	0.5	Not tested	0.0
Amount of material finer than 80 µm in aggregates (%)	CSA A23.2-5A	1.0	Not tested	0.6
Relative density (saturated surface-dry basis) and absorption (%) of coarse aggregate	CSA A23.2-12A	N/A	Not tested	Density: 2.668 Absorption: 0.60
Flat and elongated particles in coarse aggregate - Procedure A, ratio 4:1 (% Flat, Elongated, and Flat and Elongated)	CSA A23.2-13A	20.0	8.3	2.8
Petrographic examination of aggregates	CSA A23.2-15A	Identification of deleterious substances, discussed separately		
Resistance to degradation of small-size aggregate by abrasion and impact in the Los Angeles machine (% loss)	CSA A23.2-16A	50.0	Not tested	41.9
Resistance of unconfined coarse aggregate to freezing and thawing (% total weighted loss)	CSA A23.2-24A	6.0	3.3	0.0
Detection of alkali-silica reactive aggregate by accelerated expansion of mortar bars (% expansion at 14 days)	CSA A23.2-25A	0.150	Not tested	0.030
Resistance of coarse aggregate to degradation by abrasion in the Micro-Deval apparatus (% loss)	CSA A23.2-29A	17.0	Not tested	14.2

NOTES:

1. Specifications as per CSA A23.1 Table 12.
2. CSA coarse aggregate specification listed for concrete exposed to freezing and thawing.

Coarse aggregate samples are classified on the basis of the petrographic number (PN) method as specified by CSA A23.2-15A. The crushed Granodiorite has a PN of 100 and is judged to be of "good" physical-mechanical quality for all types of aggregate use, including concrete.

The rock is made up of plagioclase, quartz, biotite, magnetite and probably hornblende. Subordinate and sub-ellipsoidal masses of fine-grained microdiorite are dispersed as inclusions within the Granodiorite. The microdiorite is made up of biotite/hornblende, plagioclase and quartz. The Granodiorite has a very high strength. Apart from the subordinate microdiorite, which is richer in mica and can be scratched and scraped with some difficulty, the aggregate cannot be scratched. The sample is fresh and does not show coatings.

The aggregate is interpreted to have a low reactivity, however, some minerals were identified that may promote an alkalicarbonate reaction in concrete. The test CSA A23.2-25A "Detection of alkali-silica reactive aggregate by accelerated expansion of mortar bars" indicated a very low reactivity that is far below the specified maximum. Therefore alkali-reactivity of the Granodiorite is not of concern.

The results of the testing program indicate that crushed granodiorite is a durable, sound material that complies with all CSA specifications for coarse aggregate.

7.4 QUANTITIES

Approximate quantities of fine and coarse aggregate required for construction of the Mine Site facilities are presented in Table 7.3 and Table 7.4. The quantities are derived from take-offs from the Feasibility study and estimates provided by the client. A total of approximately 65,000 m^3 fine aggregate and 260,000 m^3 coarse aggregate is required.

Table 7.3 Required Quantity of Fine Aggregate

Line Item	Volume (m^3)
Fine Concrete Aggregate	20,000
Bedding Sand	45,000
Total Required	**65,000**

NOTES:
1. Includes 10% overbuild.
2. Includes 5% overpour for concrete.

Table 7.4 Required Quantity of Coarse Aggregate

Line Item	Volume (m^3)
Coarse Concrete Aggregate	40,000
Structural Fill	220,000
Total Required	**260,000**

NOTES:
1. Includes 10% overbuild.
2. Includes 5% overpour for concrete.

The preferred borrow source for fine concrete aggregate is alluvium located along the Britannia Creek Access Road near TP13-01. This material is preferred over alluvium along Casino Creek due to its lower moisture and organic content. The alluvial borrow source along Britannia Creek is estimated to be approximately ten meters thick, based on nearby exposures. A relatively small borrow area would suffice to provide the required amount of fine aggregate, as indicated on Figure A.4 in Appendix A. This borrow area provides approximately 100,000 m^3 of alluvium. Assuming 30% reject of coarse material would result in sufficient fine aggregate material. The rejected material may be suitable for use as filter and transition zone material, general fill or coarse

concrete aggregate. Additional site investigations are required to determine the depth and areal extent of the proposed borrow source, and to determine variability of material. It is recommended to conduct test CSA A23.2-8A “Measuring mortar-strength properties of fine aggregate” on the alluvium to determine the effect of organic impurities on mortar strength.

Fresh Granodiorite is the most suitable borrow source for coarse aggregate. Abundant Granodiorite is present at the mine site, with varying degrees of alteration, metamorphism and weathering. The material at TP13-84 is fresh, unaltered and suitable for use as coarse aggregate. A borrow area for coarse aggregate is indicated on Figure A.4 in Appendix A. This borrow area assumes a quarry depth of ten meters, to provide approximately 300,000 m^3 of Granodiorite. Assuming 10% reject due to unsuitable size after drilling, blasting and processing, would leave sufficient coarse aggregate material. The extent of this borrow source is to be confirmed using additional site investigations. There is no need to investigate the possibility of other rock sources (such as Quartzite) for coarse aggregate, based on the excellent properties and abundance of Granodiorite.

The results of the coarse aggregate testing of Granodiorite suggest that this borrow source may also be suitable for use as fine aggregate. However, this requires additional crushing and screening that likely makes this option less cost effective than using the alluvium.

The identified borrow sources contain sufficient fine and coarse aggregate for construction of the mine site facilities. Additional site investigations are required if aggregate borrow sources closer to the mine site are to be pursued.

8 – RECOMMENDATIONS

It is recommended that the following work be undertaken:

- Develop measures to mitigate the shortage of low permeability material. These measures may include addition of bentonite to borrow materials with low fines content, import of Glacial Till from outside the project area, optimisation of the tailings dam design to reduce the size of the low permeability core zone, and redesign the tailings dam using alternative seepage control measures, such as geosynthetic liners and an asphalt core.
- Confirm that the proposed borrow sources are geochemically innocuous, by implementing a ML/ARD Management Plan prior to excavation of the borrow materials.
- Establish gradation limits for construction materials.
- Determine the effects of compaction and high confining stress on the gradation and strength of the residual soils.
- Conduct test CSA A23.2-8A “Measuring mortar-strength properties of fine aggregate” on alluvial samples from the fine aggregate borrow area to determine the effect of organic impurities on mortar strength.
- Conduct additional site investigations to confirm the depth and areal extent of the proposed aggregate borrow sources, and to determine the variability of this material.

9 – REFERENCES

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10 – CERTIFICATION

This report was prepared, reviewed and approved by the undersigned.

Prepared:

Sanne Brinkman, M.Sc.
Geological Engineering

Reviewed:

Graham R. Greenaway, P.Eng.
Specialist Geotechnical Engineer

PROFESSIONAL GEOSCIENTIST
PROVINCE OF BRITISH COLUMBIA
D. J. GRIMES

11 Mar. 15

Reviewed:

Doug Grimes, M.Sc. P.Geo., PMP
Specialist Scientist/Project Manager

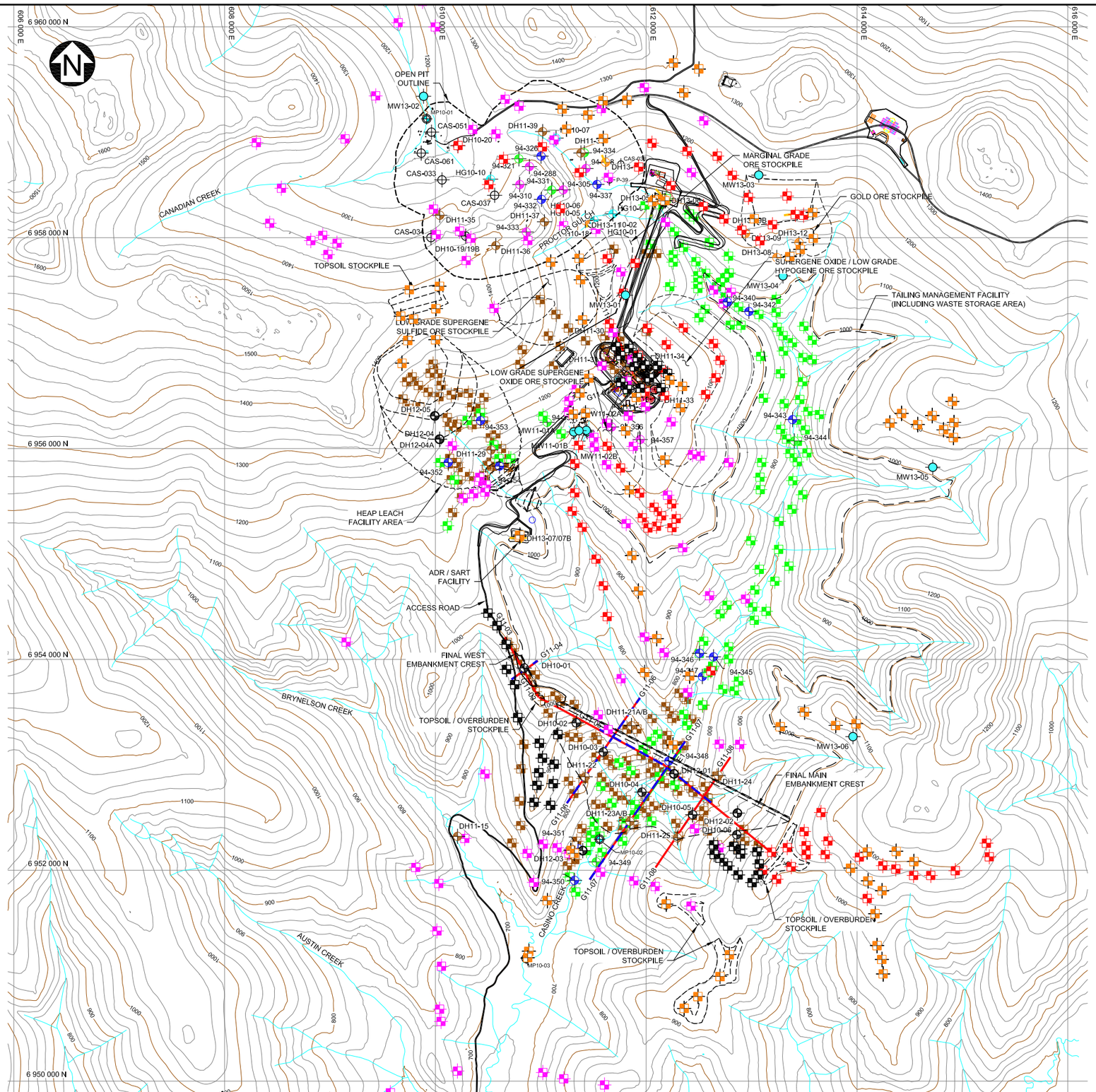
This report was prepared by Knight Piésold Ltd. for the account of Casino Mining Corporation. Report content reflects Knight Piésold's best judgement based on the information available at the time of preparation. Any use a third party makes of this report, or any reliance on or decisions made based on it is the responsibility of such third parties. Knight Piésold Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report. This numbered report is a controlled document. Any reproductions of this report are uncontrolled and might not be the most recent revision.

Approval that this document adheres to Knight Piésold Quality Systems:

APPENDIX A

REFERENCE FIGURES

(Pages A-1 to A-4)



LEGEND:

- DH13-10 — 2013 GEOTECHNICAL DRILLHOLE
- DH12-01 — 2012 GEOTECHNICAL DRILLHOLE
- DH11-30 — 2011 GEOTECHNICAL DRILLHOLE
- MW11-01A — 2011 MONITORING WELL
- MP10-01 — MINI PIEZOMETER
- HG10-01 — 2010 HYDROGEOLOGICAL DRILLHOLE
- DH10-01 — 2010 GEOTECHNICAL DRILLHOLE
- CAS-033 — EXPLORATION DRILLHOLE WITH PIEZOMETER OR THERMISTOR
- 94-305 — 1994 GEOTECHNICAL DRILLHOLE
- 94-344 — 1994 GEOTECHNICAL DRILLHOLE WITH THERMISTOR
- 94-350 — 1994 GEOTECHNICAL DRILLHOLE WITH 50 mm DIA. WELL
- 2013 TEST PIT LOCATION
- 2012 TEST PIT LOCATION
- 2011 TEST PIT LOCATION
- 2010 TEST PIT LOCATION
- 1994 TEST PIT LOCATION
- 1993 TEST TRENCH LOCATION
- 2013 GEOPHYSICS SURVEY LINE
- 2011 SEISMIC REFRACTION LINE
- 2011 GROUND PENETRATING RADAR (GPR) LINE
- 2011 EM31 LINE

NOTES:

1. COORDINATE GRID IS UTM (WGS84/NAD83) ZONE 7 (m).
2. CONTOUR INTERVAL IS 25 METRES.
3. DIMENSIONS ARE IN METRES UNLESS NOTED.
4. OPEN PIT IS SHOWN AT ITS FINAL OUTLINE AS PROVIDED BY CASINO MINING CORPORATION (NOVEMBER 2012).
5. PLANT SITE AND CRUSHER LAYOUT PROVIDED BY M3 ENGINEERING AND TECHNOLOGY CORPORATION (OCTOBER 4, 2012).
6. HEAP LEACH PAD IS SHOWN AT ITS MAXIMUM SIZE.
7. ORE AND TOPSOIL STOCKPILES ARE SHOWN AT THEIR MAXIMUM SIZE DURING OPERATIONS.
8. TEST PIT ID'S ARE NOT SHOWN TO IMPROVE CLARITY.

SCALE A: 400 200 0 400 800 1200 1600 2000 m

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	10MAR'15	ISSUED WITH REPORT	SB	TAM	GRG

CASINO MINING CORPORATION

CASINO PROJECT

GEOTECHNICAL SITE INVESTIGATIONS MINE SITE

Knight Piésold CONSULTING

P/A NO. VA101-325/16 | REF NO. 3

FIGURE A.1 | REV 0

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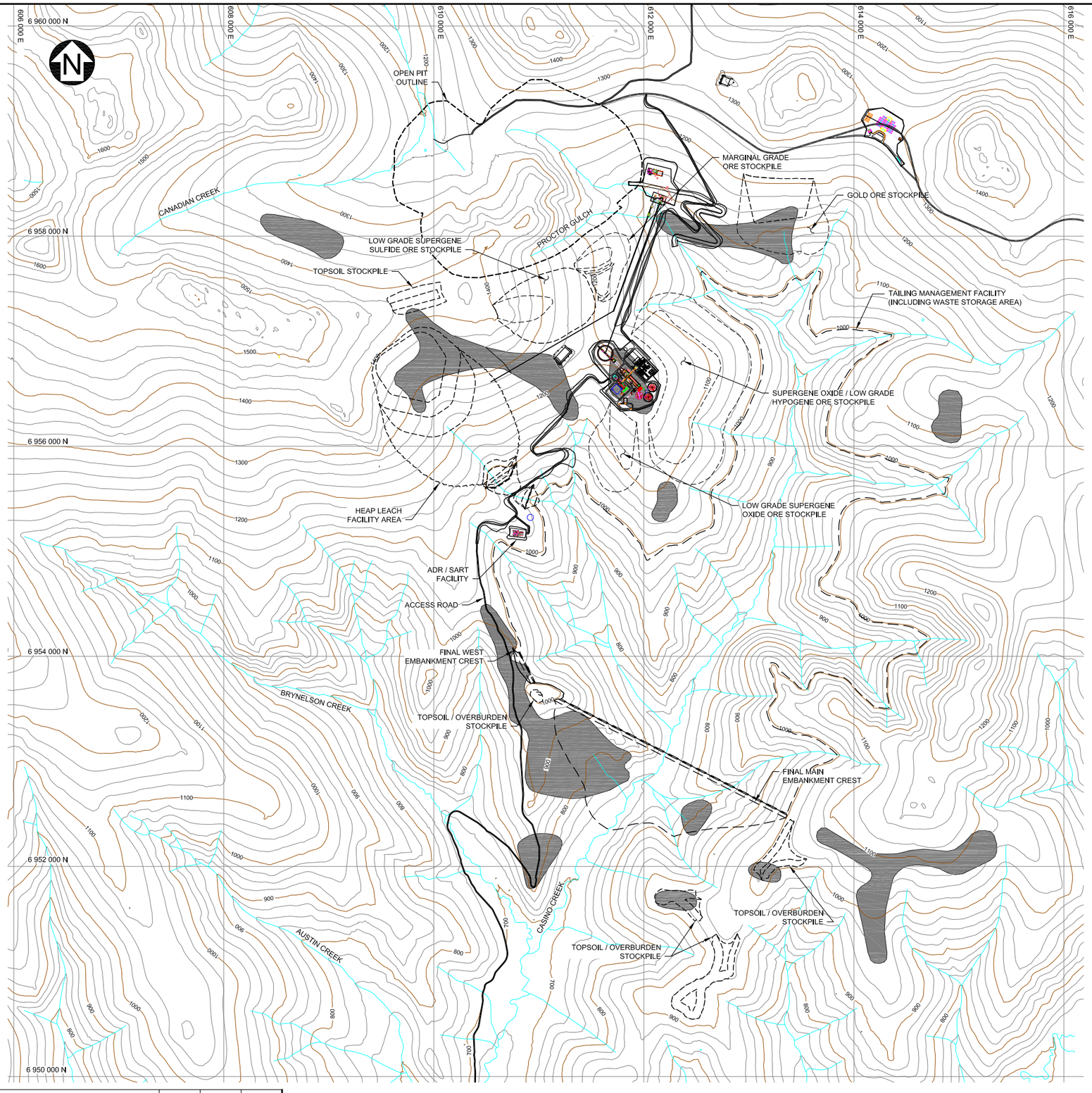

LEGEND:

LOW PERMEABILITY MATERIAL BORROW AREA

NOTES:

1. COORDINATE GRID IS UTM (WGS84/NAD83) ZONE 7 (m).
2. CONTOUR INTERVAL IS 25 METRES.
3. DIMENSIONS ARE IN METRES UNLESS NOTED.
4. OPEN PIT IS SHOWN AT ITS FINAL OUTLINE AS PROVIDED BY CASINO MINING CORPORATION (NOVEMBER 2012).
5. PLANT SITE AND CRUSHER LAYOUT PROVIDED BY M3 ENGINEERING AND TECHNOLOGY CORPORATION (OCTOBER 4, 2012).
6. HEAP LEACH PAD IS SHOWN AT ITS MAXIMUM SIZE.
7. ORE AND TOPSOIL STOCKPILES ARE SHOWN AT THEIR MAXIMUM SIZE DURING OPERATIONS.

SCALE A: 400 200 0 400 800 1200 1600 2000 m

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	10MAR'15	ISSUED WITH REPORT	SB	TAM	GRG

CASINO MINING CORPORATION

CASINO PROJECT

LOW PERMEABILITY MATERIAL BORROW AREAS

Knight Piésold CONSULTING

P/A NO. VA101-325/16 | REF NO. 3

FIGURE A.2 | REV 0

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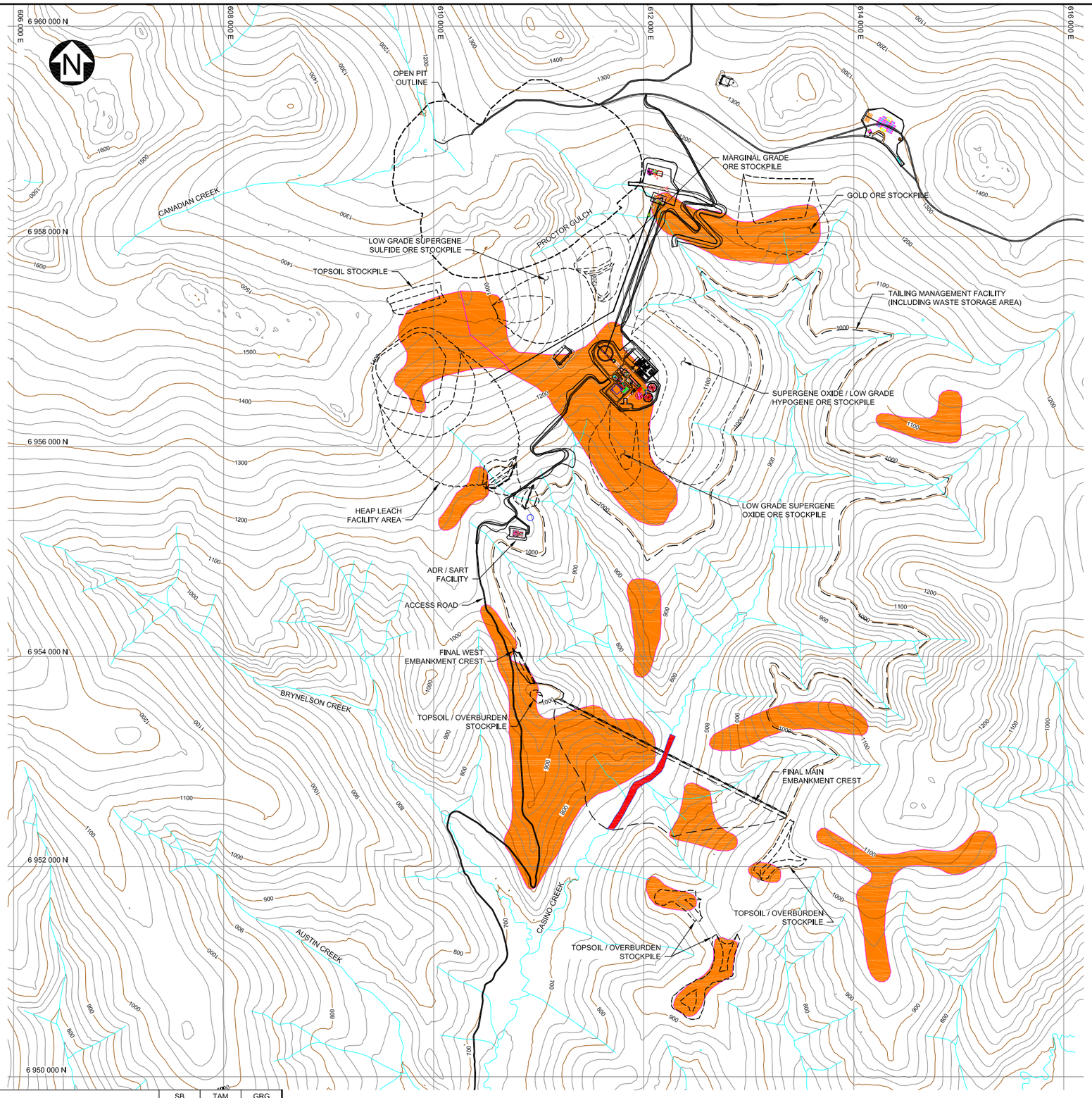

LEGEND:

FILTER AND TRANSITION ZONE MATERIAL AND GENERAL FILL BORROW AREA - RESIDUAL SOIL AND BEDROCK

FILTER AND TRANSITION ZONE MATERIAL AND GENERAL FILL BORROW AREA - ALLUVIAL CHANNEL DEPOSIT

NOTES:

1. COORDINATE GRID IS UTM (WGS84/NAD83) ZONE 7 (m).
2. CONTOUR INTERVAL IS 25 METRES.
3. DIMENSIONS ARE IN METRES UNLESS NOTED.
4. OPEN PIT IS SHOWN AT ITS FINAL OUTLINE AS PROVIDED BY CASINO MINING CORPORATION (NOVEMBER 2012).
5. PLANT SITE AND CRUSHER LAYOUT PROVIDED BY M3 ENGINEERING AND TECHNOLOGY CORPORATION (OCTOBER 4, 2012).
6. HEAP LEACH PAD IS SHOWN AT ITS MAXIMUM SIZE.
7. ORE AND TOPSOIL STOCKPILES ARE SHOWN AT THEIR MAXIMUM SIZE DURING OPERATIONS.

SCALE A 400 200 0 400 800 1200 1600 2000 m

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0	10MAR'15	ISSUED WITH REPORT	SB	TAM	GRG

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CASINO PROJECT

FILTER AND TRANSITION ZONE MATERIAL AND GENERAL FILL BORROW AREAS

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P/A NO. VA101-325/16 | REF NO. 3

FIGURE A.3 | REV 0

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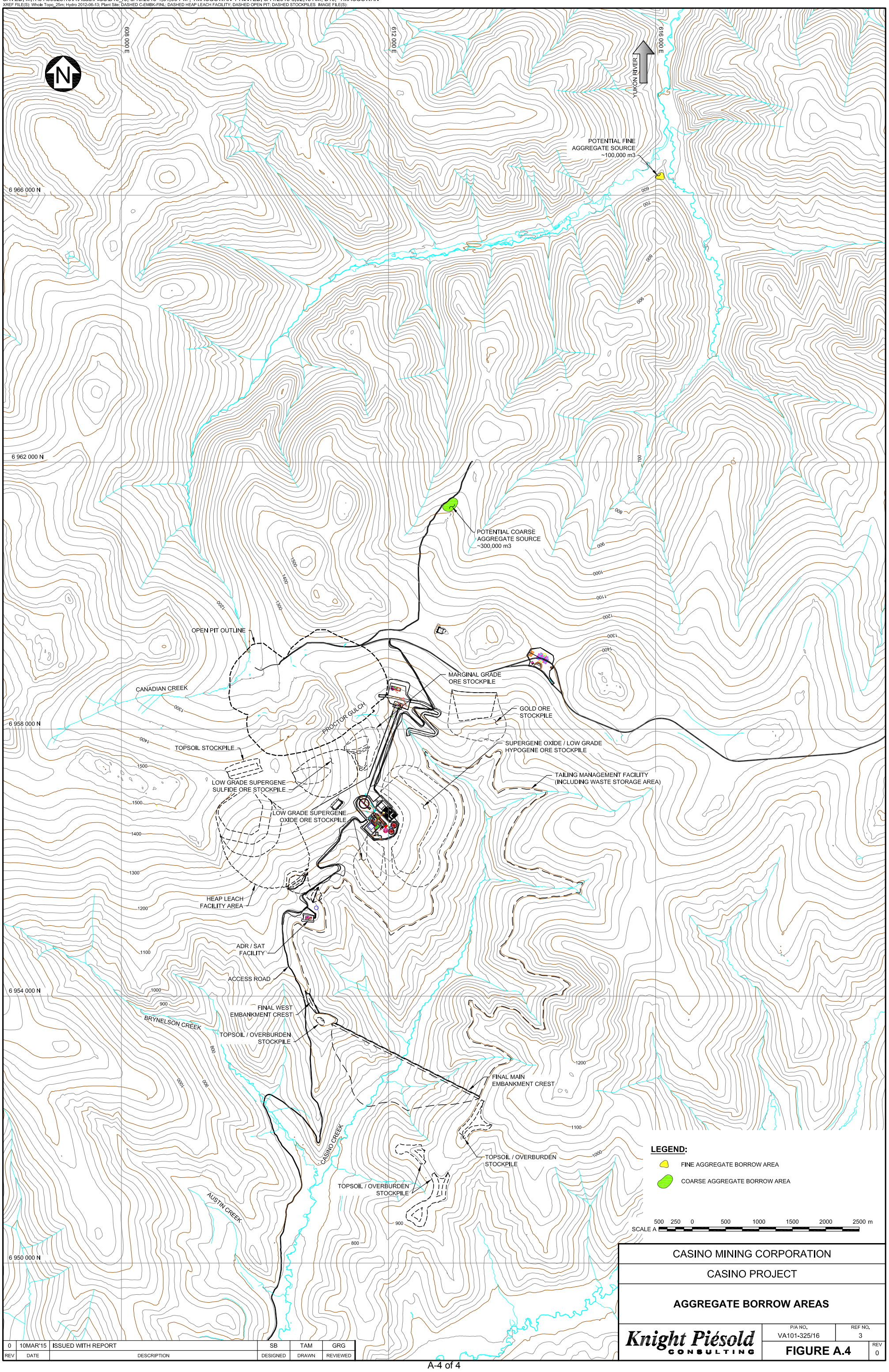

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0	10MAR'15	ISSUED WITH REPORT	SB	TAM	GRG

CASINO MINING CORPORATION

CASINO PROJECT

AGGREGATE BORROW AREAS

Knight Piésold CONSULTING

P/A NO. VA101-325/16

REF NO. 3

FIGURE A.4

REV 0

APPENDIX B

SUMMARY OF SOIL LABORATORY TEST RESULTS

(Pages B-1 to B-9)

Knight Piésold CONSULTING

TABLE B.1

CASINO MINING CORPORATION
CASINO PROJECT

MINE SITE BORROW MATERIALS ASSESSMENT REPORT
LABORATORY SOIL TEST RESULTS - COLLUVIUM

Print Mar/11/2015 10:41:02

Sample ID	Area	Depth		Natural Moisture Content (%)	Soil Specific Gravity (-)	Organic Content (%)	Atterberg Limits			Particle Size Distribution												Compaction Standard Proctor		Soil Type
		From (m)	To (m)				LL	PL	PI	% Cobbles	% Gravel			% Sand				% Fines				Max. Dry Density (t/m^3)	Optimum Moisture Content (%)	
										+3"	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total			
9008-D1	Tailings Impoundment	0.65	1.00	16.8	-	-	-	-	-	-	18.0	16.0	34.0	16.2	20.8	11.0	48.0	-	-	18.0	-	-	Colluvium
9035-A1	Heap Leach Facility	0.20	0.40	10.2	-	-	-	-	-	-	31.0	22.0	53.0	9.6	16.9	8.6	35.0	-	-	12.0	-	-	Colluvium
9036-D2	South of TMF Embankment	1.10	1.60	7.5	-	-	-	-	-	-	37.0	30.0	67.0	8.2	13.0	6.7	28.0	-	-	5.0	-	-	Colluvium
9036-E1	South of TMF Embankment	0.15	0.55	16.1	-	-	-	-	-	-	5.0	9.0	14.0	13.8	18.4	7.7	40.0	-	-	46.0	-	-	Colluvium
9038-A1	North of Open Pit	0.40	1.20	15.1	-	-	-	-	-	-	35.0	14.0	49.0	9.6	16.9	8.6	35.0	-	-	16.0	-	-	Colluvium
9040-B1	South of TMF Embankment	0.20	0.60	13.8	-	-	26	21	4	-	7.0	11.0	18.0	13.2	15.1	10.7	39.0	-	-	43.0	-	-	Colluvium
9041-E1	South of TMF Embankment	0.20	0.40	10.3	-	-	28	20	8	-	12.0	17.0	29.0	14.8	20.6	7.6	43.0	-	-	28.0	-	-	Colluvium
9042-A1	TMF Embankment	0.50	1.00	16.4	-	-	-	-	-	-	9.0	27.0	36.0	13.8	17.0	9.1	40.0	-	-	24.0	-	-	Colluvium
9051-A1	West of Open Pit	1.25	1.45	14.4	-	-	-	-	-	-	6.0	9.0	15.0	10.5	22.1	16.4	49.0	-	-	36.0	-	-	Colluvium
9051-C1	West of Open Pit	2.00	2.50	11.2	-	-	-	-	-	-	29.0	16.0	45.0	6.6	10.7	7.7	25.0	-	-	30.0	-	-	Colluvium
9053-D1	Open Pit	1.00	1.60	13.7	-	-	25	21	4	-	14.0	22.0	36.0	8.9	15.4	7.7	32.0	-	-	32.0	-	-	Colluvium
9053-E1	Open Pit	1.20	1.60	15.5	-	-	28	22	6	-	18.0	24.0	42.0	12.5	19.5	12.0	44.0	-	-	14.0	-	-	Colluvium
9056-C1	East of Crusher Area	0.90	1.30	16	-	-	31	21	10	-	21.0	8.0	29.0	12.2	25.4	13.4	51.0	-	-	20.0	-	-	Colluvium
9063-A1	Open Pit	1.45	1.55	13.7	-	-	-	-	-	-	5.0	14.0	19.0	8.9	19.7	14.4	43.0	-	-	38.0	-	-	Colluvium
9074-A1	North of Open Pit	1.00	1.50	14.5	-	-	21	16	4	-	12.0	18.0	30.0	6.2	17.9	13.9	38.0	-	-	32.0	-	-	Colluvium
9076-B1	West of Open Pit	0.70	1.10	14.3	-	-	-	-	-	-	2.0	26.0	28.0	11.5	19.9	9.6	41.0	-	-	31.0	-	-	Colluvium
9076-C1	West of Open Pit	0.50	1.00	15.5	-	-	28	23	6	-	12.0	16.0	28.0	12.9	19.1	12.0	44.0	-	-	28.0	-	-	Colluvium
9220-D1	Tailings Impoundment	0.55	1.00	9.2	-	-	-	-	-	-	4.0	21.0	25.0	17.8	25.2	12.0	55.0	-	-	20.0	-	-	Colluvium
9223-E1	Tailings Impoundment	0.30	0.65	12.4	-	-	-	-	-	-	35.0	20.0	55.0	5.6	9.7	7.7	23.0	-	-	22.0	-	-	Colluvium
TP94-01A	Crusher Area	1.20	1.80	15.9	-	-	27	23	5	-	0.0	23.9	23.9	14.0	19.2	11.9	45.1	-	-	31.0	-	-	Colluvium
TP94-05A	Southeast of Crusher Area	0.80	1.80	11.4	-	-	-	-	-	-	0.0	25.7	25.7	19.8	26.7	12.0	58.4	-	-	15.9	-	-	Colluvium
TP94-06A	Southeast of Crusher Area	0.30	1.05	8.2	-	-	-	-	-	-	0.0	43.0	43.0	12.8	18.1	8.1	39.0	-	-	18.0	-	-	Colluvium
TP94-07A	East of Marginal Grade Ore Stockpile	0.70	1.10	11.5	-	-	-	-	-	-	0.0	12.5	12.5	19.8	26.1	10.8	56.8	-	-	30.7	-	-	Colluvium
TP94-100A	Tailings Impoundment	1.50	1.60	11.1	-	-	-	-	-	-	0.0	32.5	32.5	8.1	22.1	13.5	43.7	-	-	23.8	-	-	Colluvium
TP94-108A	Southeast of Crusher Area	0.40	0.60	9.0	-	-	NP	NP	NP	-	0.0	41.3	41.3	3.4	27.8	15.2	46.4	-	-	12.3	-	-	Colluvium
TP94-108B	Southeast of Crusher Area	1.20	1.40	9.6	-	-	NP	NP	NP	-	0.0	21.4	21.4	18.9	31.6	16.9	67.4	-	-	11.2	-	-	Colluvium
TP94-109A	Southeast of Crusher Area	0.40	0.60	17.0	-	-	-	-	-	-	0.0	25.4	25.4	22.8	29.7	11.0	63.4	-	-	11.2	-	-	Colluvium
TP94-110A	East of Heap Leach Facility	1.50	1.60	10.3	-	-	NP	NP	NP	-	0.0	8.8	8.8	17.5	32.2	21.5	71.2	-	-	20.0	-	-	Colluvium
TP94-111A	East of Heap Leach Facility	0.40	0.60	5.7	-	-	-	-	-	-	0.0	24.9	24.9	27.8	32.3	10.7	70.8	-	-	4.3	-	-	Colluvium
TP94-112A	Heap Leach Facility	0.60	0.80	11.4	-	-	-	-	-	-	0.0	18.3	18.3	20.3	26.8	11.8	59.0	-	-	22.7	-	-	Colluvium
TP94-113A	Heap Leach Facility	0.80	0.90	27.6	-	-	-	-	-	-	0.0	2.0	2.0	9.9	22.0	22.0	53.9	-	-	44.1	-	-	Colluvium
TP94-113B	Heap Leach Facility	1.70	1.80	16.0	-	-	-	-	-	-	0.0	2.6	2.6	4.8	25.2	29.7	59.7	-	-	37.7	-	-	Colluvium
TP94-115A	Heap Leach Facility	1.20	1.40	15.1	-	-	-	-	-	-	0.0	12.6	12.6	20.2	26.9	11.9	59.0	-	-	28.4	-	-	Colluvium
TP94-116A	Heap Leach Facility	1.20	1.40	11.1	-	-	-	-	-	-	0.0	13.9	13.9	21.4	27.4	13.4	62.2	-	-	23.9	-	-	Colluvium
TP94-117A	South of Heap Leach Facility	0.70	0.90	6.9	-	-	-	-	-	-	0.0	42.3	42.3	17.9	24.0	7.4	49.3	-	-	8.4	-	-	Colluvium
TP94-16A	Southeast of Crusher Area	Unknown	Unknown	10.2	-	-	-	-	-	-	0.0	23.9	23.9	10.0	21.3	16.7	48.1	-	-	28.0	-	-	Colluvium
TP94-17A	Tailings Impoundment	0.55	0.85	14.0	-	-	-	-	-	-	0.0	19.0	19.0	18.0	20.0	9.4	47.4	-	-	33.6	-	-	Colluvial Topsoil
TP94-19A	Tailings Impoundment	0.20	1.10	10.1	-	-	-	-	-	-	0.0	31.5	31.5	14.2	20.4	14.1	48.7	-	-	19.8	-	-	Colluvium
TP94-20A	Tailings Impoundment	0.60	1.05	7.9	-	-	-	-	-	-	0.0	34.6	34.6	19.1	21.0	10.5	50.6	-	-	14.8	-	-	Colluvium

Knight Piésold CONSULTING

TABLE B.1

CASINO MINING CORPORATION
CASINO PROJECT

MINE SITE BORROW MATERIALS ASSESSMENT REPORT
LABORATORY SOIL TEST RESULTS - COLLUVIUM

Print Mar/11/2015 10:41:02

Sample ID	Area	Depth		Natural Moisture Content (%)	Soil Specific Gravity (-)	Organic Content (%)	Atterberg Limits			Particle Size Distribution												Compaction Standard Proctor		Soil Type
		From (m)	To (m)				LL	PL	PI	% Cobbles	% Gravel			% Sand				% Fines				Max. Dry Density (t/m^3)	Optimum Moisture Content (%)	
										+3"	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total			
TP94-21A	Tailings Impoundment	0.40	0.80	11.1	-	-	-	-	-	-	0.0	20.8	20.8	22.2	30.0	9.9	62.1	-	-	17.1	-	-	Colluvium
TP94-21B	Tailings Impoundment	1.10	1.40	9.4	-	-	-	-	-	-	0.0	17.2	17.2	23.9	27.4	12.6	63.9	-	-	18.9	-	-	Colluvium
TP94-22A	Low Grade Ore Stockpile East	0.55	0.65	23.1	-	-	-	-	-	-	0.0	28.4	28.4	13.0	19.4	11.2	43.5	-	-	28.1	-	-	Colluvium
TP94-24B	Tailings Impoundment	0.37	0.42	21.6	-	-	-	-	-	-	0.0	2.7	2.7	19.1	23.1	12.3	54.5	-	-	42.8	-	-	Colluvium
TP94-27A	Tailings Impoundment	0.23	0.70	8.5	-	-	-	-	-	-	0.0	18.7	18.7	20.9	22.9	8.6	52.4	-	-	28.9	-	-	Colluvium
TP94-28A	Tailings Impoundment	0.40	1.00	7.6	-	-	-	-	-	-	0.0	40.5	40.5	15.7	18.9	6.8	41.5	-	-	18.0	-	-	Colluvial Topsoil
TP94-30A	Tailings Impoundment	Unknown	Unknown	13.9	-	-	-	-	-	-	0.0	15.9	15.9	15.9	20.8	8.8	45.5	-	-	38.6	-	-	Colluvium
TP94-31A	Tailings Impoundment	0.30	0.58	10.8	-	-	-	-	-	-	0.0	34.5	34.5	19.4	18.0	5.1	42.5	-	-	23.0	-	-	Colluvium
TP94-31B	Tailings Impoundment	0.30	0.58	19.5	-	-	-	-	-	-	0.0	2.7	2.7	14.5	16.4	8.3	39.2	-	-	58.1	-	-	Colluvium
TP94-32A	Tailings Impoundment	Unknown	Unknown	14.4	-	-	-	-	-	-	0.0	27.9	27.9	17.2	18.9	8.6	44.8	-	-	27.3	-	-	Colluvium
TP94-33B	Tailings Impoundment	0.52	0.74	11.9	-	-	-	-	-	-	0.0	40.6	40.6	19.2	20.6	7.6	47.4	-	-	12.0	-	-	Colluvium
TP94-36B	Tailings Impoundment	0.50	0.90	9.2	-	-	NP	NP	NP	-	0.0	31.0	31.0	23.0	28.9	9.0	60.9	-	-	8.1	-	-	Colluvium
TP94-37A	Tailings Impoundment	0.05	0.25	12.3	-	-	-	-	-	-	0.0	25.4	25.4	16.6	18.0	6.4	41.0	-	-	33.6	-	-	Colluvium
TP94-38A	Tailings Impoundment	Unknown	Unknown	7.9	-	-	-	-	-	-	0.0	65.4	65.4	9.9	9.9	5.8	25.6	-	-	9.0	-	-	Colluvium
TP94-41A	Tailings Impoundment	0.25	0.45	10.3	-	-	-	-	-	-	0.0	35.8	35.8	18.2	17.7	8.0	43.9	-	-	20.3	-	-	Colluvium
TP94-42A	Tailings Impoundment	0.50	0.65	5.5	-	-	-	-	-	-	0.0	37.1	37.1	16.8	24.2	9.4	50.4	-	-	12.5	-	-	Colluvium
TP94-46A	Tailings Impoundment	0.75	0.90	11.3	-	-	-	-	-	-	0.0	20.6	20.6	21.7	27.3	12.7	61.8	-	-	17.6	-	-	Colluvium
TP94-51A	Tailings Impoundment	0.30	0.50	8.9	-	-	NP	NP	NP	-	0.0	21.8	21.8	22.8	24.5	12.9	60.2	-	-	18.0	-	-	Colluvium
TP94-53A	Tailings Impoundment	0.50	0.70	11.8	-	-	-	-	-	-	0.0	19.3	19.3	10.1	28.2	12.6	50.9	-	-	29.8	-	-	Colluvium
TP94-55A	Tailings Impoundment	0.45	0.55	41.9	-	-	-	-	-	-	0.0	20.3	20.3	12.3	22.1	12.5	46.9	-	-	32.8	-	-	Colluvium
TP94-59A	Tailings Impoundment	0.90	1.10	11.4	-	-	-	-	-	-	0.0	41.8	41.8	8.2	13.1	10.2	31.4	-	-	26.8	-	-	Colluvium
TP94-60A	Tailings Impoundment	0.30	0.50	18.4	-	-	-	-	-	-	0.0	15.1	15.1	12.8	20.6	15.0	48.4	-	-	36.5	-	-	Colluvium
TP94-62A	TMF Embankment	0.70	0.90	6.5	-	-	-	-	-	-	0.0	36.8	36.8	19.8	23.5	8.4	51.7	-	-	11.5	-	-	Colluvium
TP94-72A	TMF Embankment	Unknown	Unknown	10.8	-	-	-	-	-	-	0.0	52.5	52.5	14.4	11.3	3.9	29.6	-	-	17.9	-	-	Colluvium
TP94-72B	TMF Embankment	1.10	1.20	56.3	-	-	-	-	-	-	0.0	0.0	0.0	4.9	16.3	9.2	30.4	-	-	69.6	-	-	Colluvium
TP94-74A	TMF Embankment	1.23	1.33	105.8	-	-	-	-	-	-	0.0	0.0	0.0	5.1	22.2	16.3	43.6	-	-	56.4	-	-	Colluvium
TP94-78A	TMF Embankment	0.80	1.00	89.3	-	-	-	-	-	-	0.0	10.4	10.4	16.4	23.4	13.5	53.2	-	-	36.4	-	-	Colluvium
TP94-82A	TMF Embankment	0.40	0.60	14.4	-	-	-	-	-	-	0.0	9.7	9.7	18.4	27.9	12.5	58.8	-	-	31.5	-	-	Colluvium
TP94-83A	TMF Embankment	0.85	0.95	54.7	-	-	-	-	-	-	0.0	22.8	22.8	28.7	26.4	7.4	62.6	-	-	14.6	-	-	Colluvium
TP94-87A	Tailings Impoundment	0.60	0.70	16.0	-	-	-	-	-	-	0.0	41.7	41.7	10.6	16.1	7.9	34.6	-	-	23.7	-	-	Colluvium
TP94-87B	Tailings Impoundment	1.15	1.25	16.8	-	-	-	-	-	-	0.0	36.9	36.9	16.6	24.0	8.4	49.0	-	-	14.1	-	-	Colluvium
TP94-87C	Tailings Impoundment	1.60	1.70	21.5	-	-	-	-	-	-	0.0	3.0	3.0	9.1	22.1	11.4	42.5	-	-	54.5	-	-	Colluvium
TP94-90A	Tailings Impoundment	0.75	1.00	18.1	-	-	-	-	-	-	0.0	19.8	19.8	15.2	19.8	10.6	45.6	-	-	34.6	-	-	Colluvium
TP94-91A	Tailings Impoundment	1.30	1.50	10.7	-	-	-	-	-	-	0.0	21.3	21.3	20.8	25.6	9.8	56.2	-	-	22.5	-	-	Colluvium
TP94-92A	Tailings Impoundment	1.20	1.30	14.8	-	-	-	-	-	-	0.0	34.8	34.8	19.0	19.2	7.6	45.8	-	-	19.4	-	-	Colluvium
TP94-93A	Tailings Impoundment	0.60	0.80	7.4	-	-	-	-	-	-	0.0	10.8	10.8	28.2	36.9	10.3	75.3	-	-	13.9	-	-	Colluvium
TP94-94A	Tailings Impoundment	0.60	0.80	21.6	-	-	-	-	-	-	0.0	10.6	10.6	15.0	24.4	10.3	49.7	-	-	39.7	-	-	Colluvium
TP94-96A	Tailings Impoundment	0.50	0.70	6.7	-	-	-	-	-	-	0.0	20.9	20.9	27.0	30.4	9.7	67.1	-	-	12.0	-	-	Colluvium
TP94-98A	Tailings Impoundment	0.60	0.80	9.6	-	-	-	-	-	-	0.0	23.5	23.5	19.5	24.4	7.2	51.1	-	-	25.4	-	-	Colluvium

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TABLE B.1

CASINO MINING CORPORATION
CASINO PROJECT

MINE SITE BORROW MATERIALS ASSESSMENT REPORT
LABORATORY SOIL TEST RESULTS - COLLUVIUM

Print Mar/11/2015 10:41:02

Sample ID	Area	Depth		Natural Moisture Content (%)	Soil Specific Gravity (-)	Organic Content (%)	Atterberg Limits			Particle Size Distribution												Compaction Standard Proctor		Soil Type
		From (m)	To (m)				LL	PL	PI	% Cobbles	% Gravel			% Sand				% Fines				Max. Dry Density (t/m^3)	Optimum Moisture Content (%)	
										+3"	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total			
TP94-99A	Tailings Impoundment	0.50	0.70	15.5	-	-	-	-	-	-	0.0	22.4	22.4	26.5	27.5	7.7	61.6	-	-	16.0	-	-	Colluvium
TP10-04 AND TP10-11	Tailings Management Facility	-	-	-	-	-	-	-	-	0.0	20.8	14.7	35.5	9.5	15.8	11.1	36.4	-	-	28.1	2.16	6.9	Colluvium
TP10-04-1	Tailings Management Facility	0.80	0.90	103.0	2.71	-	22	19	3	0.0	27.1	7.4	34.5	9.0	15.3	10.5	34.8	22.6	8.1	30.7	-	-	Colluvium
TP10-09-1	Tailings Management Facility	2.00	2.10	12.3	-	-	-	-	-	0.0	0.5	12.8	13.3	24.2	20.9	12.3	57.4	20.5	8.8	29.3	-	-	Colluvium
TP10-11-1	Tailings Management Facility	1.80	1.90	8.3	2.66	-	15	18	NP	0.0	15.5	20.7	36.2	10.1	16.3	11.7	38.1	20.8	4.9	25.7	-	-	Colluvium
TP10-18-1	Tailings Management Facility	1.00	1.10	9.4	-	-	-	-	-	0.0	12.1	12.2	24.3	17.7	21.9	9.0	48.6	18.8	8.3	27.1	-	-	Colluvium
TP10-31-1	Plant Site	0.60	0.70	22.2	-	-	-	-	-	0.0	0.0	1.1	1.1	9.7	17.2	11.0	37.9	46.3	14.7	61.0	-	-	Colluvium
DH11-38-2	Open Pit	11.58	13.72	16.7	2.71	95.8	34	NP	NP	0.0	1.3	19.7	21.0	17.3	23.1	17.3	57.7	20.3	1.0	21.3			Colluvium
DH11-38-3	Open Pit	15.24	16.76	14.6	-	-	-	-	-	0.0	4.1	0.6	4.7	6.9	38.4	23.2	68.5	25.5	1.3	26.8			Colluvium
DH11-39-1	Open Pit	7.62	7.80	2.3	2.72	-	24	19	5	0.0	20.1	23.6	43.7	9.7	15.1	9.4	34.2	19.6	2.5	22.1			Colluvium
TP11-04	Plant Site	0.77	0.97	27.8	-		-	-	-	0.0	4.8	3.5	8.3	11.8	17.1	9.0	37.9	46.1	7.7	53.8			Colluvium
TP11-05	Plant Site	0.53	0.73	41.9	2.70		33	14	19	0.0	3.4	4.0	7.4	9.8	16.9	9.9	36.6	48.6	7.4	56.0			Colluvium
TP11-06	Plant Site	0.84	1.04	64.7	-		41	37	4	0.0	5.4	5.2	10.6	6.3	15.5	8.3	30.1	50.6	8.7	59.3			Colluvium
TP11-10	Plant Site	0.30	0.65	19.5	2.63		29	22	7	0.0	7.6	7.9	15.5	10.5	14.0	6.8	31.3	45.0	8.2	53.2			Colluvium
TP11-11	Plant Site	1.10	1.30	11.3	2.65		-	-	-	0.0	16.8	20.8	37.6	13.7	19.9	11.9	45.5	14.0	2.9	16.9			Colluvium
TP11-HLF-01	Heap Leach Facility	2.00	2.10	19.3	-	-	-	-	-	0.0	5.9	5.0	10.9	12.1	24.0	12.8	48.9	34.7	5.5	40.2	-	-	Colluvium
TP11-HLF-05	Heap Leach Facility	1.50	1.90	7.7	-	-	NP	NP	NP	0.0	10.8	15.0	25.8	15.9	32.2	12.7	60.8	13.1	0.3	13.4	-	-	Colluvium
TP11-HLF-09	Heap Leach Facility	2.10	2.30	13.9	-	-	25	22	3	0.0	23.1	11.3	34.4	9.6	15.1	14.0	38.7	23.9	3.0	26.9	2.09	8.8	Colluvium
TP11-HLF-10	Heap Leach Facility	1.30	1.50	9.9	-	-	-	-	-	0.0	29.0	11.2	40.2	8.5	16.1	8.1	32.7	24.9	2.2	27.1	-	-	Colluvium
TP11-HLF-13	Heap Leach Facility	1.80	2.00	8.7	-	-	-	-	-	0.0	12.7	12.6	25.3	15.9	24.2	13.0	53.1	17.7	3.9	21.6	-	-	Colluvium
TP11-HLF-21	Heap Leach Facility	0.80	1.00	12.6	-	-	-	-	-	0.0	4.5	14.7	19.2	12.1	24.2	13.0	49.3	29.1	2.4	31.5	-	-	Colluvium
TP11-HLF-28	Heap Leach Facility	1.20	1.30	15.6	2.76	-	NP	NP	NP	0.0	5.8	9.2	15.0	9.0	25.2	16.8	51.0	31.4	2.6	34.0	-	-	Colluvium
TP11-HLF-30	Heap Leach Facility	1.50	1.70	17.5	-	-	NP	NP	NP	0.0	5.9	8.8	14.7	18.3	19.9	11.2	49.4	32.8	3.1	35.9	-	-	Colluvium
TP11-NAG-02	Ore Stockpile Area	1.20	1.40	19.1	2.68	-	31	NP	NP	0.0	5.8	12.8	18.6	16.5	20.9	10.8	48.2	29.1	4.1	33.2	-	-	Colluvium
TP11-NAG-03	Ore Stockpile Area	1.20	1.40	12.4	2.70	-	24	20	4	0.0	11.5	6.9	18.4	10.6	17.0	8.8	36.4	40.0	5.2	45.2	-	-	Colluvium
TP11-NAG-04	Ore Stockpile Area	1.40	1.60	12.0	-	-	-	-	-	0.0	7.2	9.7	16.9	12.7	20.9	14.9	48.5	31.6	3.0	34.6	2.03	9.5	Colluvium
TP11-NAG-07	Ore Stockpile Area	0.70	0.90	47.5	-	-	29	23	6	0.0	11.0	6.3	17.3	11.4	18.2	9.8	39.4	37.1	6.2	43.3	-	-	Colluvium
TP11-NAG-08	Ore Stockpile Area	0.60	0.80	13.6	-	-	27	24	3	6.6	12.7	7.5	20.2	14.9	19.0	8.2	42.1	27.4	3.7	31.1	-	-	Colluvium
TP11-TMF-01	Tailings Management Facility	1.22	1.42	7.5	-	-	25	21	4	0.0	39.9	27.3	67.2	6.3	7.5	5.5	19.3	11.9	1.6	13.5	-	-	Colluvium
TP11-TMF-07	Tailings Management Facility	0.58	0.78	51.9	-	-	23	NP	NP	0.0	0.0	2.8	2.8	3.6	11.5	25.1	40.2	50.0	7.0	57.0	-	-	Colluvium
TP11-TMF-10	Tailings Management Facility	1.00	1.20	8.8	-	-	-	-	-	0.0	43.9	15.0	58.9	7.3	7.0	5.1	19.4	19.2	2.5	21.7	-	-	Colluvium
TP11-TMF-103	Tailings Management Facility	0.60	0.80	6.9	-	-	-	-	-	0.0	16.5	28.3	44.8	10.3	17.1	10.3	37.7	15.9	1.6	17.5	2.13	7.0	Colluvium
TP11-TMF-14	Tailings Management Facility	0.20	0.40	55.5	-	6.6	-	-	-	0.0	12.1	4.5	16.6	9.2	19.6	14.6	43.4	35.4	4.6	40.0	-	-	Colluvium
TP11-TMF-16-1	Tailings Management Facility	0.85	1.05	18.6	-	-	20	NP	NP	0.0	9.2	18.7	27.9	10.8	7.6	6.7	25.1	41.5	5.5	47.0	-	-	Colluvium
TP11-TMF-34	Tailings Management Facility	0.80	1.00	65.3	-	5.6	-	-	-	0.0	11.2	3.8	15.0	8.7	20.1	9.8	38.6	39.3	7.1	46.4	-	-	Colluvium
TP11-TMF-42	Tailings Management Facility	1.05	1.25	11.0	-	-	32	27	5	0.0	44.7	20.1	64.8	6.5	6.0	4.8	17.3	15.1	2.8	17.9	-	-	Colluvium
TP11-TMF-43	Tailings Management Facility	0.80	1.00	19.7	-	-	41	NP	NP	10.3	25.4	11.1	36.5	4.1	13.6	9.8	27.5	22.2	3.5	25.7	-	-	Colluvium
TP11-TMF-46	Tailings Management Facility	0.65	0.85	37.1	-	-	-	-	-	0.0	1.9	13.6	15.5	8.8	20.0	19.9	48.7	31.0	4.8	35.8	-	-	Colluvium
TP11-TMF-68	Tailings Management Facility	0.80	1.00	17.8	-	-	-	-	-	24.4	11.3	12.6	23.9	7.4	15.7	8.2	31.3	18.0	2.4	20.4	-	-	Colluvium

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TABLE B.1

CASINO MINING CORPORATION
CASINO PROJECT

MINE SITE BORROW MATERIALS ASSESSMENT REPORT
LABORATORY SOIL TEST RESULTS - COLLUVIUM

Print Mar/11/2015 10:41:02

Sample ID	Area	Depth		Natural Moisture Content (%)	Soil Specific Gravity (-)	Organic Content (%)	Atterberg Limits			Particle Size Distribution												Compaction Standard Proctor		Soil Type
		From (m)	To (m)				LL	PL	PI	% Cobbles	% Gravel			% Sand				% Fines				Max. Dry Density (t/m^3)	Optimum Moisture Content (%)	
										+3"	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total			
TP11-TMF-79	Tailings Management Facility	1.30	1.50	25.3	2.60	6.3	39	NP	NP	0.0	22.6	7.7	30.3	9.3	9.4	4.2	22.9	43.4	3.4	46.8	-	-	Colluvium
TP11-TMF-86	Tailings Management Facility	0.40	0.70	6.1	-	-	-	-	-	0.0	9.0	31.5	40.5	13.3	18.9	13.3	45.5	13.7	0.3	14.0	-	-	Colluvium
TP11-TMF-94	Tailings Management Facility	1.30	1.50	10.2	2.74	-	-	-	-	0.0	16.7	28.9	45.6	6.3	9.5	11.4	27.2	22.5	4.7	27.2	-	-	Colluvium
TP11-TMF-96	Tailings Management Facility	1.00	1.20	8.3	-	-	-	-	-	0.0	27.1	26.4	53.5	5.2	9.3	10.3	24.8	18.0	3.7	21.7	-	-	Colluvium
TP11-TMF-98-1	Tailings Management Facility	0.20	0.50	24.2	-	-	-	-	-	0.0	13.0	15.0	28.0	5.4	7.0	6.7	19.1	47.7	5.2	52.9	-	-	Colluvium
TP11-TMF-99	Tailings Management Facility	0.50	0.70	8.4	-	-	-	-	-	0.0	8.9	26.7	35.6	5.4	16.7	17.6	39.7	21.7	3.0	24.7	-	-	Colluvium
TP12-58	LGO Stockpile South	1.00	1.20	8.9	-	-	-	-	-	0.0	25.0	5.9	30.9	19.0	21.8	8.8	49.6	15.7	3.8	19.5	2.15	6.7	Colluvium
TP12-65	LGO Stockpile South	1.00	1.20	8.6	-	-	-	-	-	0.0	23.2	11.7	34.9	21.3	26.6	8.6	56.5	-	-	8.6	-	-	Colluvium
DH13-11 BU-1	Open Pit	3.50	3.70	28.3	-	-	-	-	-	0.0	11.3	25.9	37.2	14.1	11.8	6.6	32.5	30.3	0.0	30.3	-	-	Colluvium
DH13-11 FC-1	Open Pit	1.80	2.00	30.7	-	-	-	-	-	0.0	5.3	19.4	24.7	28.2	27.7	12.5	68.5	6.9	0.0	6.9	-	-	Colluvium
TP13-12 BU-1	Tailing Management Facility	0.50	0.70	9.8	-	-	25	19	6	0.0	25.2	20.7	45.9	9.8	12.6	7.8	30.2	20.3	3.6	23.9	-	-	Colluvium
TP13-13 BU-1	Tailing Management Facility	1.40	1.60	14.6	-	-	31	22	9	0.0	16.8	18.9	35.7	6.6	14.0	9.5	30.1	28.7	5.5	34.2	-	-	Colluvium
TP13-69 BU-1	Topsoil Stockpile North of HLF	1.30	1.50	16.6	-	-	29	20	9	10.2	16.3	1.7	18.0	5.5	19.6	12.1	37.2	28.1	6.5	34.6	-	-	Colluvium
TP13-73 BU-1	Heap Leach Facility	1.60	1.80	12.4	-	-	-	-	-	0.0	1.9	5.8	7.7	19.6	30.1	13.2	62.9	24.7	4.7	29.4	-	-	Colluvium
TP13-86 BU-1	Crusher Area	1.20	1.40	14.1	-	3.1	27	21	6	0.0	3.6	4.3	7.9	21.4	25.8	8.3	55.5	30.8	5.8	36.6	-	-	Colluvium

M:\1\01\00325\16\A\Report\3 - Borrow Source Assessment\Rev 0\Appendix B\[Appendix B - Lab Tests Results_rev A.xlsm]Table B.1

NOTES:

1. Particle size distribution by percent of sample weight.
2. Organic content according to ASTM D 2974, method C.
3. Cobble content may vary in the field.
4. Standard proctor includes an oversize correction as per ASTM D 4718-87.

REV	DATE	DESCRIPTION	PREP'D	REV'D
0	11MAR'15	ISSUED WITH REPORT VA101-325/16-3	SB	GRG

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TABLE B.2

CASINO MINING CORPORATION
CASINO PROJECT

MINE SITE BORROW MATERIALS ASSESSMENT REPORT
LABORATORY SOIL TEST RESULTS - RESIDUAL SOIL

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Sample ID	Area	Depth		Natural Moisture Content (%)	Soil Specific Gravity (-)	Organic Content (%)	Atterberg Limits			Particle Size Distribution												Compaction Standard Proctor		Soil Type
		From (m)	To (m)				LL	PL	PI	% Cobbles	% Gravel			% Sand				% Fines				Max. Dry Density (t/m^3)	Optimum Moisture Content (%)	
										+3"	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total			
9008-B1	Open Pit	1.90	2.10	14.7	-	-	-	-	-	-	7.0	17.0	24.0	13.5	24.2	17.3	55.0	-	-	21.0	-	-	Residual Soil
9008-C1	South of Crusher Area	0.70	1.20	19.6	-	-	-	-	-	-	11.0	27.0	38.0	14.2	21.8	12.0	48.0	-	-	14.0	-	-	Residual Soil
9034-C1	Low Grade Ore Stockpile South	2.10	2.90	7.2	-	-	-	-	-	-	1.0	1.0	2.0	22.7	44.3	21.0	88.0	-	-	10.0	-	-	Residual Soil
9034-D1	Low Grade Ore Stockpile South	1.20	2.20	6.8	-	-	-	-	-	-	0.0	5.0	5.0	25.3	45.5	17.2	88.0	-	-	7.0	-	-	Residual Soil
9035-A2	Heap Leach Facility	1.00	1.20	11.4	-	-	-	-	-	-	0.0	0.0	0.0	18.9	49.5	21.6	90.0	-	-	10.0	-	-	Residual Soil
9035-F1	Heap Leach Facility	0.70	1.20	7.4	-	-	-	-	-	-	9.0	27.0	36.0	22.8	24.6	9.6	57.0	-	-	7.0	-	-	Residual Soil
9039-A1	South of TMF Embankment	0.30	0.60	10.1	-	-	-	-	-	-	5.0	9.0	14.0	22.4	32.2	15.4	70.0	-	-	16.0	-	-	Residual Soil
9039-B1	South of TMF Embankment	Unknown	Unknown	6.9	-	-	33	25	8	-	14.0	22.0	36.0	17.8	22.6	11.6	52.0	-	-	12.0	-	-	Residual Soil
9039-C1	TMF Embankment	0.50	1.00	6.9	-	-	-	-	-	-	2.0	31.0	33.0	22.4	26.6	11.0	60.0	-	-	7.0	-	-	Residual Soil
9040-A1	South of TMF Embankment	0.40	0.80	7.1	-	-	-	-	-	-	12.0	23.0	35.0	13.5	23.7	16.9	54.0	-	-	11.0	-	-	Residual Soil
9040-B2	South of TMF Embankment	Unknown	Unknown	6.6	-	-	-	-	-	-	13.0	29.0	42.0	14.5	17.8	8.7	41.0	-	-	17.0	-	-	Residual Soil
9041-G1	South of TMF Embankment	0.50	0.80	11.7	-	-	-	-	-	-	13.0	16.0	29.0	8.6	16.9	13.6	39.0	-	-	32.0	-	-	Residual Soil
9041-H1	South of TMF Embankment	0.10	0.85	8.8	-	-	NP	NP	NP	-	6.0	17.0	23.0	21.4	25.0	9.6	56.0	-	-	21.0	-	-	Residual Soil
9042-A2	TMF Embankment	1.10	1.70	8.4	-	-	-	-	-	-	2.0	18.0	20.0	15.1	35.8	19.2	70.0	-	-	10.0	-	-	Residual Soil
9042-B1	Topsoil South of Embankment	0.80	1.10	34.6	-	-	-	-	-	-	21.0	8.0	29.0	9.9	14.4	6.7	31.0	-	-	40.0	-	-	Residual Soil
9042-B2	Topsoil South of Embankment	0.30	0.80	6.5	-	-	-	-	-	-	7.0	13.0	20.0	22.7	29.8	14.4	67.0	-	-	13.0	-	-	Residual Soil
9042-D1	South of TMF Embankment	0.35	1.25	7.3	-	-	-	-	-	-	3.0	19.0	22.0	24.1	30.5	12.4	67.0	-	-	11.0	-	-	Residual Soil
9042-D2	South of TMF Embankment	1.00	1.60	7.8	-	-	-	-	-	-	16.0	23.0	39.0	18.2	21.8	11.0	51.0	-	-	10.0	-	-	Residual Soil
9042-E2	South of TMF Embankment	0.50	0.80	7.6	-	-	-	-	-	-	0.0	11.0	11.0	29.0	36.7	14.3	80.0	-	-	9.0	-	-	Residual Soil
9042-F1	South of TMF Embankment	0.45	0.95	8.4	-	-	-	-	-	-	1.0	9.0	10.0	23.4	35.9	16.7	76.0	-	-	14.0	-	-	Residual Soil
9043-C1	South of TMF Embankment	0.50	0.80	6.8	-	-	-	-	-	-	0.0	6.0	6.0	26.3	40.5	17.2	84.0	-	-	10.0	-	-	Residual Soil
9043-C2	South of TMF Embankment	1.00	1.35	6.3	-	-	-	-	-	-	13.0	32.0	45.0	19.8	19.0	8.1	47.0	-	-	8.0	-	-	Residual Soil
9043-D1	Tailings Impoundment	1.10	1.60	8.1	-	-	-	-	-	-	2.0	37.0	39.0	15.5	24.5	13.0	53.0	-	-	8.0	-	-	Residual Soil
9043-G1	Topsoil South of Embankment	0.20	0.40	6.2	-	-	-	-	-	-	8.0	26.0	34.0	21.4	26.6	11.0	59.0	-	-	7.0	-	-	Residual Soil
9043-G2	Topsoil South of Embankment	0.60	0.80	8.3	-	-	-	-	-	-	0.0	26.0	26.0	21.4	29.6	11.0	62.0	-	-	12.0	-	-	Residual Soil
9043-H1	South of TMF Embankment	0.50	1.00	5.2	-	-	-	-	-	-	1.0	21.0	22.0	26.7	35.0	12.3	74.0	-	-	4.0	-	-	Residual Soil
9044-A1	South of TMF Embankment	0.90	1.15	15.7	-	-	-	-	-	-	8.0	36.0	44.0	18.8	21.6	9.6	50.0	-	-	6.0	-	-	Residual Soil
9044-A2	South of TMF Embankment	0.35	0.70	7.3	-	-	-	-	-	-	24.0	31.0	55.0	9.2	12.0	10.7	32.0	-	-	13.0	-	-	Residual Soil
9044-C1	South of TMF Embankment	0.50	1.00	7.1	-	-	-	-	-	-	21.0	21.0	42.0	20.5	21.4	9.1	51.0	-	-	7.0	-	-	Residual Soil
9044-D1	South of TMF Embankment	0.30	0.60	10.7	-	-	31	25	5	-	18.0	16.0	34.0	13.2	16.7	8.1	38.0	-	-	28.0	-	-	Residual Soil
9045-B1	South of TMF Embankment	1.30	1.80	6.3	-	-	-	-	-	-	9.0	25.0	34.0	15.1	30.0	12.9	58.0	-	-	8.0	-	-	Residual Soil
9046-A1	South of TMF Embankment	0.90	1.60	5.5	-	-	-	-	-	-	2.0	14.0	16.0	17.1	36.3	19.6	73.0	-	-	11.0	-	-	Residual Soil
9047-A1	South of TMF Embankment	1.50	2.50	10.8	-	-	40	17	23	-	0.0	2.0	2.0	11.4	37.6	24.0	73.0	-	-	25.0	-	-	Residual Soil
9047-A2	South of TMF Embankment	0.50	1.40	6.7	-	-	-	-	-	-	15.0	20.0	35.0	26.2	22.3	8.6	57.0	-	-	8.0	-	-	Residual Soil
9047-B1	South of TMF Embankment	0.55	1.00	4.1	-	-	-	-	-	-	24.0	62.0	86.0	7.0	4.6	0.4	12.0	-	-	2.0	-	-	Residual Soil
9047-B2	South of TMF Embankment	0.10	0.35	11	-	-	-	-	-	-	3.0	11.0	14.0	24.1	30.1	16.9	71.0	-	-	15.0	-	-	Residual Soil
9047-B3	South of TMF Embankment	0.45	1.40	6.6	-	-	-	-	-	-	1.0	32.0	33.0	25.4	25.0	8.6	59.0	-	-	8.0	-	-	Residual Soil
9052-A1	South of TMF Embankment	1.00	1.20	5.4	-	-	-	-	-	-	22.0	28.0	50.0	12.2	18.2	11.6	42.0	-	-	8.0	-	-	Residual Soil
9052-A1*	South of TMF Embankment	1.00	1.20	7.6	-	-	-	-	-	-	3.0	14.0	17.0	12.8	26.4	24.7	64.0	-	-	19.0	-	-	Residual Soil
9052-B1	South of TMF Embankment	0.45	1.45	6.4	-	-	24	23	0	-	2.0	19.0	21.0	23.4	34.7	12.9	71.0	-	-	8.0	-	-	Residual Soil

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TABLE B.2

CASINO MINING CORPORATION
CASINO PROJECT

MINE SITE BORROW MATERIALS ASSESSMENT REPORT
LABORATORY SOIL TEST RESULTS - RESIDUAL SOIL

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Sample ID	Area	Depth		Natural Moisture Content (%)	Soil Specific Gravity (-)	Organic Content (%)	Atterberg Limits			Particle Size Distribution												Compaction Standard Proctor		Soil Type
		From (m)	To (m)				LL	PL	PI	% Cobbles	% Gravel			% Sand				% Fines				Max. Dry Density (t/m^3)	Optimum Moisture Content (%)	
										+3"	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total			
9053-A1	West of Open Pit	0.50	3.50	15.6	-	-	37	26	11	-	6.0	28.0	34.0	20.1	25.3	8.6	54.0	-	-	12.0	-	-	Residual Soil
9053-D2	Open Pit	2.00	2.40	13.3	-	-	-	-	-	-	0.0	31.0	31.0	15.5	26.1	15.4	57.0	-	-	12.0	-	-	Residual Soil
9056-C2	East of Crusher Area	Unknown	Unknown	15.3	-	-	-	-	-	-	5.0	29.0	34.0	13.8	26.8	10.4	51.0	-	-	15.0	-	-	Residual Soil
9057-A1	South of TMF Embankment	0.60	1.80	7.1	-	-	-	-	-	-	0.0	16.0	16.0	22.4	33.7	15.9	72.0	-	-	12.0	-	-	Residual Soil
9057-A2	South of TMF Embankment	0.60	1.10	9.3	-	-	-	-	-	-	2.0	22.0	24.0	16.4	30.7	12.9	60.0	-	-	16.0	-	-	Residual Soil
9057-A3	South of TMF Embankment	0.60	1.10	9.0	-	-	-	-	-	-	0.0	3.0	3.0	20.4	38.0	21.6	80.0	-	-	17.0	-	-	Residual Soil
9057-A4	South of TMF Embankment	1.40	1.80	5.4	-	-	-	-	-	-	2.0	27.0	29.0	26.1	24.9	12.0	63.0	-	-	8.0	-	-	Residual Soil
9057-B1	South of TMF Embankment	0.35	0.55	11.6	-	-	-	-	-	-	1.0	2.0	3.0	11.4	34.6	21.0	67.0	-	-	30.0	-	-	Residual Soil
9057-B2	South of TMF Embankment	0.60	1.60	7.2	-	-	-	-	-	-	0.0	4.0	4.0	19.0	40.4	18.6	78.0	-	-	18.0	-	-	Residual Soil
9058-A1	Plant Site	1.00	1.10	11.2	-	-	-	-	-	-	0.0	21.0	21.0	23.3	35.8	11.9	71.0	-	-	8.0	-	-	Residual Soil
9058-B2	Low Grade Ore SUS Stockpile	1.30	1.40	19.1	-	-	NP	NP	NP	-	0.0	4.0	4.0	28.3	41.0	16.7	86.0	-	-	10.0	-	-	Residual Soil
9059-A1	South of TMF Embankment	0.45	1.45	9.4	-	-	-	-	-	-	4.0	28.0	32.0	13.8	29.9	16.3	60.0	-	-	8.0	-	-	Residual Soil
9062-A1	Plant Site	1.10	2.20	10.0	-	-	-	-	-	-	1.0	19.0	20.0	25.4	31.2	13.4	70.0	-	-	10.0	-	-	Residual Soil
9062-B1	Open Pit	2.10	2.90	9.1	-	-	-	-	-	-	5.0	25.0	30.0	23.1	24.9	10.0	58.0	-	-	12.0	-	-	Residual Soil
9076-C2	West of Open Pit	1.80	2.20	13.3	-	-	46	22	23	-	1.0	28.0	29.0	19.2	22.3	9.6	51.0	-	-	20.0	-	-	Residual Soil
9076-E1	West of Open Pit	0.90	1.10	17.3	-	-	-	-	-	-	2.0	10.0	12.0	5.9	22.1	35.0	63.0	-	-	25.0	-	-	Residual Soil
9219-D1	Tailings Impoundment	0.40	0.90	8.1	-	-	-	-	-	-	0.0	13.0	13.0	26.7	40.6	14.7	82.0	-	-	5.0	-	-	Residual Soil
9220-A1	Plant Site	0.75	1.00	8.1	-	-	-	-	-	-	5.0	36.0	41.0	17.8	24.6	7.6	50.0	-	-	9.0	-	-	Residual Soil
9220-B1	Plant Site	0.90	1.40	9.0	-	-	-	-	-	-	0.0	16.0	16.0	27.0	34.7	14.3	76.0	-	-	8.0	-	-	Residual Soil
9220-D2	Tailings Impoundment	1.10	1.90	5	-	-	-	-	-	-	0.0	24.0	24.0	29.7	31.3	10.0	71.0	-	-	5.0	-	-	Residual Soil
9221-A1	West of Plant Site	0.50	2.00	8.8	-	-	-	-	-	-	0.0	3.0	3.0	17.0	46.0	26.0	89.0	-	-	8.0	-	-	Residual Soil
9221-B1	Low Grade Ore Stockpile South	1.10	1.65	5.0	-	-	-	-	-	-	0.0	24.0	24.0	30.7	30.3	10.0	71.0	-	-	5.0	-	-	Residual Soil
9222-A1	Plant Site	0.60	1.20	9.0	-	-	-	-	-	-	0.0	16.0	16.0	22.7	35.6	16.7	75.0	-	-	9.0	-	-	Residual Soil
9222-D1	Low Grade Ore Stockpile East	0.55	0.95	7.0	-	-	-	-	-	-	0.0	10.0	10.0	25.9	41.8	14.3	82.0	-	-	8.0	-	-	Residual Soil
9223-E2	Tailings Impoundment	1.05	1.40	7.4	-	-	-	-	-	-	1.0	19.0	20.0	21.4	31.7	12.9	66.0	-	-	14.0	-	-	Residual Soil
TP94-01B	Crusher Area	3.20	4.00	17.3	-	-	-	-	-	-	0.0	18.9	18.9	16.2	23.9	12.4	52.5	-	-	28.6	-	-	Residual Soil
TP94-02A	Crusher Area	Unknown	Unknown	9.8	-	-	-	-	-	-	0.0	32.6	32.6	28.3	22.0	8.6	58.9	-	-	8.5	-	-	Residual Soil
TP94-03A	Crusher Area	2.50	2.80	12.7	-	-	-	-	-	-	0.0	59.5	59.5	17.3	15.4	3.5	36.2	-	-	4.3	-	-	Residual Soil
TP94-05B	Southeast of Crusher Area	Unknown	Unknown	11.3	-	-	-	-	-	-	0.0	55.8	55.8	12.4	14.9	8.3	35.6	-	-	8.6	-	-	Residual Soil
TP94-06B	Southeast of Crusher Area	1.20	1.50	8.5	-	-	-	-	-	-	0.0	52.5	52.5	12.1	11.1	10.2	33.4	-	-	14.1	-	-	Residual Soil
TP94-07B	East of Marginal Grade Ore Stockpile	1.60	1.85	6.5	-	-	-	-	-	-	0.0	57.9	57.9	13.5	18.0	6.5	38.0	-	-	4.1	-	-	Residual Soil
TP94-08B	Southeast of Crusher Area	0.80	0.95	11.2	-	-	-	-	-	-	0.0	27.1	27.1	24.8	27.5	10.8	63.2	-	-	9.7	-	-	Residual Soil
TP94-104A	Tailings Impoundment	1.60	2.00	11.3	-	-	-	-	-	-	0.0	27.8	27.8	21.3	30.4	9.6	61.3	-	-	10.9	-	-	Residual Soil
TP94-119A	Heap Leach Facility	0.60	0.70	12.1	-	-	-	-	-	-	0.0	4.6	4.6	20.6	42.6	20.7	83.9	-	-	11.5	-	-	Residual Soil
TP94-13A	Tailings Impoundment	1.10	2.60	5.7	-	-	NP	NP	NP	-	0.0	9.5	9.5	26.7	47.1	13.7	87.5	-	-	3.0	-	-	Residual Soil
TP94-18A	Tailings Impoundment	1.10	1.50	10.5	-	-	-	-	-	-	0.0	31.7	31.7	17.5	18.6	12.6	48.8	-	-	19.5	-	-	Residual Soil
TP94-20B	Tailings Impoundment	1.20	1.60	10.4	-	-	-	-	-	-	0.0	13.8	13.8	22.8	32.0	15.7	70.4	-	-	15.8	-	-	Residual Soil
TP94-24E	Tailings Impoundment	0.92	0.98	19.1	-	-	-	-	-	-	0.0	14.2	14.2	34.4	36.1	8.5	79.1	-	-	6.7	-	-	Residual Soil
TP94-25A	Tailings Impoundment	0.90	1.05	6.0	-	-	-	-	-	-	0.0	45.6	45.6	20.5	19.6	5.5	45.5	-	-	8.9	-	-	Residual Soil
TP94-27B	Tailings Impoundment	0.88	1.20	5.6	-	-	-	-	-	-	0.0	21.3	21.3	38.3	30.2	7.2	75.6	-	-	3.1	-	-	Residual Soil

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		From (m)	To (m)				LL	PL	PI	% Cobbles	% Gravel			% Sand				% Fines				Max. Dry Density (t/m^3)	Optimum Moisture Content (%)	
										+3"	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total			
TP94-28B	Tailings Impoundment	1.18	1.39	6.0	-	-	-	-	-	-	0.0	18.8	18.8	37.7	35.9	4.7	78.3	-	-	2.9	-	-	Residual Soil
TP94-32B	Tailings Impoundment	Unknown	Unknown	27.0	-	-	-	-	-	-	0.0	14.3	14.3	16.0	16.0	9.4	41.4	-	-	44.3	-	-	Residual Soil
TP94-33C	Tailings Impoundment	0.81	0.85	9.7	-	-	-	-	-	-	0.0	30.3	30.3	20.5	18.3	7.0	45.8	-	-	23.9	-	-	Residual Soil
TP94-33D	Tailings Impoundment	1.03	1.18	9.2	-	-	-	-	-	-	0.0	15.4	15.4	27.6	31.5	10.8	69.9	-	-	14.7	-	-	Residual Soil
TP94-41B	Tailings Impoundment	0.70	0.80	11.1	-	-	-	-	-	-	0.0	4.0	4.0	34.1	36.6	13.3	84.1	-	-	11.9	-	-	Residual Soil
TP94-43A	Tailings Impoundment	2.90	3.10	11.7	-	-	-	-	-	-	0.0	8.0	8.0	30.4	43.7	14.8	88.8	-	-	3.2	-	-	Bedrock - Completely Weathered
TP94-47A	Tailings Impoundment	1.10	1.20	9.7	-	-	-	-	-	-	0.0	26.9	26.9	29.9	28.7	9.9	68.5	-	-	4.6	-	-	Residual Soil
TP94-64A	TMF Embankment	0.90	1.10	5.7	-	-	NP	NP	NP	-	0.0	64.9	64.9	8.0	9.4	6.4	23.9	-	-	11.2	-	-	Residual Soil
TP94-65A	TMF Embankment	1.00	1.20	5.0	-	-	-	-	-	-	0.0	24.0	24.0	24.8	30.2	11.7	66.7	-	-	9.3	-	-	Residual Soil
TP94-68B	TMF Embankment	0.35	0.45	4.7	-	-	-	-	-	-	0.0	3.7	3.7	29.7	48.8	13.5	92.0	-	-	4.3	-	-	Residual Soil
TP94-75A	TMF Embankment	0.40	0.60	6.5	-	-	-	-	-	-	0.0	6.6	6.6	23.9	36.5	21.0	81.4	-	-	12.0	-	-	Residual Soil
TP94-89A	Tailings Impoundment	0.70	0.90	6.7	-	-	-	-	-	-	0.0	39.3	39.3	11.4	24.9	9.9	46.2	-	-	14.5	-	-	Residual Soil
TP10-13 AND TP10-14	Tailings Management Facility	-	-	-	-	-	-	-		0.0	4.6	13.9	18.5	16.5	17.5	10.5	44.5	-	-	37.0	2.10	7.9	Residual Soil
TP10-13-1	Tailings Management Facility	2.00	2.10	9.1	-	-	-	-	-	0.0	9.2	15.9	25.1	17.6	19.0	12.6	49.2	19.4	6.3	25.7	-	-	Residual Soil
TP10-14-1	Tailings Management Facility	1.30	1.40	13.5	2.67	-	23	18	5	0.0	0.0	11.9	11.9	15.0	15.3	9.4	39.7	36.9	11.5	48.4	-	-	Residual Soil
TP10-19-1	Tailings Management Facility	1.50	1.60	6.6	2.68	-	24	18	6	0.0	19.3	23.9	43.2	13.4	15.2	10.0	38.6	12.2	6.0	18.2	-	-	Residual Soil
TP10-22 AND TP10-25	Tailings Management Facility	-	-	-	-	-	-	-	-	0.0	21.4	22.7	44.1	10.7	13.8	12.8	37.3	-	-	18.6	2.16	7.3	Residual Soil
TP10-22-1	Tailings Management Facility	2.50	2.60	5.2	-	-	-	-	-	0.0	21.4	31.2	52.6	12.5	14.3	8.6	35.4	6.8	5.2	12.0	-	-	Residual Soil
TP10-25-1	Tailings Management Facility	1.20	1.30	10.8	-	-	-	-	-	0.0	21.3	14.7	36.0	7.6	12.2	17.9	37.7	19.7	6.6	26.3	-	-	Residual Soil
TP10-28-1	Plant Site	2.90	3.00	8.8	-	-	-	-	-	0.0	4.6	16.0	20.6	20.9	28.6	12.9	62.4	7.9	9.1	17.0	-	-	Residual Soil
TP10-32-1	Plant Site	1.30	1.40	13.2	-	-	-	-	-	0.0	0.7	5.3	6.0	17.1	34.7	18.4	70.2	12.5	11.3	23.8	-	-	Residual Soil
TP10-38-1	Plant Site	1.20	1.30	17.4	-	-	-	-	-	0.0	0.0	3.4	3.4	14.2	17.3	10.2	41.7	41.5	13.4	54.9	-	-	Residual Soil
TP10-39-1	Plant Site	1.50	1.60	15.8	-	-	-	-	-	0.0	0.9	4.3	5.2	11.6	15.2	9.1	35.9	46.0	12.9	58.9	-	-	Residual Soil
DH11-32 SPT #3	Plant Site	4.57	5.03	7.7	-		40	15	25	0.0	0.0	8.0	8.0	4.8	28.7	18.7	52.2	23.4	16.4	39.8			Residual Soil
DH11-38-4	Open Pit	18.29	19.81	23.9	-	-	49	28	21	0.0	0.0	0.0	0.0	1.8	21.4	23.4	46.6	45.6	7.8	53.4			Residual Soil
TP11-18	Plant Site	1.20	1.40	89.6	-		30	20	10	0.0	0.0	4.1	4.1	17.3	27.8	15.4	60.5	27.9	7.5	35.4			Residual Soil
TP11-HLF-25	Heap Leach Facility	1.40	1.60	10.3	2.74	-	-	-	-	0.0	10.5	14.9	25.4	12.1	22.6	17.9	52.6	19.5	2.5	22.0	2.16	7.4	Residual Soil
TP11-NAG-06	Ore Stockpile Area	3.20	3.40	9.2	2.69	-	35	21	14	0.0	8.2	19.2	27.4	10.6	26.0	14.7	51.3	17.1	4.2	21.3	-	-	Granodiorite - Completely Weathered
TP11-TMF-05	Tailings Management Facility	2.10	2.30	6.8	-	-	-	-	-	0.0	0.0	5.8	5.8	14.2	41.5	21.4	77.1	15.0	2.1	17.1	-	-	Residual Soil
TP11-TMF-12	Tailings Management Facility	0.90	1.10	22.7	-	-	-	-	-	0.0	10.5	10.1	20.6	7.2	29.5	21.9	58.6	19.3	1.5	20.8	-	-	Residual Soil
TP11-TMF-89	Tailings Management Facility	1.60	1.80	7.9	-	-	-	-	-	0.0	1.4	5.4	6.8	3.5	25.2	33.3	62.0	27.6	3.6	31.2	2.00	9.9	Residual Soil
TP11-TMF-92	Tailings Management Facility	3.60	3.80	6.7	2.68	-	31	18	13	0.0	10.5	17.2	27.7	6.1	23.0	17.6	46.7	21.2	4.4	25.6	2.07	8.5	Granodiorite - Completely Weathered
TP12-23	Gold Ore Stockpile	1.50	1.70	8.2	-	-	NP	NP	NP	0.0	27.9	14.3	42.2	13.1	22.7	10.9	46.7	-	-	11.1	2.14	7.3	Residual Soil
TP12-24-1	Gold Ore Stockpile	2.00	2.20	26.9	-	2.7	61	18	43	0.0	2.2	26.4	28.6	2.1	7.9	16.1	26.1	21.6	23.7	45.3	1.66	19.3	Residual Soil
TP12-26	Gold Ore Stockpile	0.50	0.70	31.8	-	-	45	21	24	0.0	2.4	9.3	11.7	3.1	8.4	36.2	47.7	27.1	13.5	40.6	-	-	Residual Soil
TP12-30	Gold Ore Stockpile	1.00	1.20	12.0	-	-	26	18	8	0.0	10.0	13.1	23.1	11.9	21.8	17.1	50.8	17.1	9.0	26.1	-	-	Residual Soil
TP12-40	TMF Embankment East	0.80	1.00	13.5	-	1.9	NP	NP	NP	0.0	2.1	8.4	10.5	22.1	40.2	14.6	76.9	-	-	12.6	-	-	Residual Soil
TP12-42	TMF Embankment East	1.20	1.40	7.6	-	-	NP	NP	NP	5.7	19.2	15.7	34.9	14.9	20.6	11.3	46.8	10.8	1.8	12.6	-	-	Residual Soil
TP12-57	LGO Stockpile South	1.00	1.20	8.0	-	-	-	-	-	0.0	0.0	4.8	4.8	29.8	43.4	13.8	87.0	-	-	8.2	-	-	Residual Soil
DH13-08 BU-1	Gold Ore Stockpile	2.60	2.80	10.0	-	-	-	-	-	0.0	0.0	25.1	25.1	27.4	31.7	12.1	71.2	3.7	0.0	3.7	-	-	Granodiorite - Completely Weathered

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TABLE B.2

CASINO MINING CORPORATION
CASINO PROJECT

MINE SITE BORROW MATERIALS ASSESSMENT REPORT
LABORATORY SOIL TEST RESULTS - RESIDUAL SOIL

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Sample ID	Area	Depth		Natural Moisture Content (%)	Soil Specific Gravity (-)	Organic Content (%)	Atterberg Limits			Particle Size Distribution												Compaction Standard Proctor		Soil Type
		From (m)	To (m)				LL	PL	PI	% Cobbles	% Gravel			% Sand				% Fines				Max. Dry Density (t/m^3)	Optimum Moisture Content (%)	
										+3"	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total			
DH13-08 BU-2	Gold Ore Stockpile	3.20	3.50	7.4	-	-	-	-	-	0.0	13.5	31.8	45.3	19.4	23.1	9.5	52.1	2.7	0.0	2.7		-	-	Granodiorite - Completely Weathered
DH13-09B BU-1	Gold Ore Stockpile	2.00	2.20	2.1	-	-	-	-	-	0.0	0.0	41.5	41.5	14.9	21.2	15.4	51.5	-	-	7.0		-	-	Residual Soil
DH13-10 BU-1	Open Pit	2.55	2.65	12.3	-	-	-	-	-	0.0	16.7	21.6	38.4	15.0	19.9	14.4	49.4	12.2	0.0	12.2		-	-	Residual Soil
DH13-10 BU-2	Open Pit	3.70	3.90	13.0	-	-	-	-	-	0.0	20.9	33.6	54.5	15.8	15.7	9.3	40.7	4.8	0.0	4.8		-	-	Residual Soil
DH13-11 BU-2	Open Pit	7.60	7.80	16.4	-	-	-	-	-	0.0	0.0	16.2	16.2	19.8	37.2	22.6	79.6	-	-	4.2		-	-	Residual Soil
DH13-12 BU-1	Gold Ore Stockpile	1.20	1.50	7.7	-	-	-	-	-	0.0	0.0	44.5	44.5	15.0	24.3	12.8	52.0	-	-	3.5		-	-	Granodiorite - Completely Weathered
TP13-03 BU-1	West of Plant Site	2.00	2.20	11.0	-	3.6	26	20	6	0.0	4.8	17.0	21.8	14.4	29.1	16.1	59.6	13.7	4.9	18.6		-	-	Residual Soil
TP13-04 BU-1	West of Plant Site	2.80	3.00	3.1	2.73	-	NP	NP	NP	0.0	0.0	0.0	0.0	12.5	44.7	34.0	91.2	6.7	2.1	8.8		1.79	10.6	Granodiorite - Completely Weathered
TP13-04 BU-2	West of Plant Site	Loose	Material	7.9	-	-	NP	NP	NP	0.0	0.5	1.3	1.8	14.6	45.3	28.5	88.4	8.7	1.1	9.8		-	-	Granodiorite - Completely Weathered
TP13-07 BU-1	Northeast of Open Pit	1.20	1.40	18.6	-	-	30	22	8	0.0	1.6	9.5	11.1	18.6	33.4	19.5	71.5	12.4	5.0	17.4		-	-	Residual Soil
TP13-10 BU-1	Tailing Management Facility	0.60	0.80	11.3	-	-	NP	NP	NP	0.0	16.7	25.3	42.0	7.6	19.4	21.6	48.6	8.1	1.3	9.4		-	-	Residual Soil
TP13-27 BU-1	Southeast of TMF Main Embankment	2.60	2.80	5.0	-	-	26	18	8	0.0	10.9	31.5	42.4	19.5	21.6	7.7	48.8	5.9	2.9	8.8		2.13	7.7	Granodiorite - Completely Weathered
TP13-28 BU-1	Southeast of TMF Main Embankment	1.40	1.60	6.7	-	2.2	22	18	4	0.0	5.6	25.3	30.9	19.5	25.4	8.0	52.9	12.8	3.4	16.2		2.02	10.1	Residual Soil
TP13-33 BU-1	Southeast of TMF Main Embankment	2.00	2.30	9.3	2.74	-	21	22	NP	0.0	1.7	11.4	13.1	16.9	32.3	21.5	70.7	14.2	2.0	16.2		-	-	Residual Soil
TP13-41 BU-1	Southeast of Gold Ore Stockpile	2.00	2.20	12.0	-	-	34	19	15	0.0	0.6	5.1	5.7	9.3	30.8	22.0	62.1	23.7	8.5	32.2		1.90	12.3	Residual Soil
TP13-43 BU-1	Southeast of Gold Ore Stockpile	1.80	2.00	7.4	-	1.4	25	24	1	0.0	11.0	35.3	46.3	9.9	18.9	13.5	42.3	9.7	1.7	11.4		2.03	9.7	Residual Soil
TP13-48 BU-1	Gold Ore Stockpile	2.50	2.70	6.3	2.73	-	NP	NP	NP	0.0	5.9	16.5	22.4	20.1	32.3	14.4	66.8	8.4	2.4	10.8		1.97	11.2	Residual Soil
TP13-63 BU-1	Northeast of Open Pit	1.50	2.00	10.7	-	-	NP	NP	NP	0.0	15.3	14.0	29.3	21.1	21.1	14.1	56.3	12.8	1.6	14.4		-	-	Residual Soil
TP13-65 BU-1	Northeast of Open Pit	2.50	3.00	8.3	-	-	-	-	-	0.0	6.0	9.4	15.4	27.3	26.5	19.8	73.6	10.3	0.7	11.0		-	-	Granodiorite - Completely Weathered
TP13-81 BU-1	ADR/SART Facility	1.00	1.20	11.5	2.66	-	30	19	11	0.0	0.0	1.4	1.4	11.2	37.7	20.3	69.2	19.4	10.0	29.4		-	-	Residual Soil

M:\1\01\00325\16\A\Report\3 - Borrow Source Assessment\Rev 0\Appendix B\[Appendix B - Lab Tests Results_rev A.xlsm]Table B.2

NOTES:

1. Particle size distribution by percent of sample weight.
2. Organic content according to ASTM D 2974, method C.
3. Cobble content may vary in the field.
4. Standard proctor includes an oversize correction as per ASTM D 4718-87.

REV	DATE	DESCRIPTION	PREP'D	REV'D
0	11MAR'15	ISSUED WITH REPORT VA101-325/16-3	SB	GRG

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TABLE B.3

CASINO MINING CORPORATION
CASINO PROJECT

MINE SITE BORROW MATERIALS ASSESSMENT REPORT
LABORATORY SOIL TEST RESULTS - ALLUVIUM

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Sample ID	Area	Depth		Natural Moisture Content (%)	Soil Specific Gravity (-)	Organic Content (%)	Atterberg Limits			Particle Size Distribution												Compaction Standard Proctor		Soil Type
		From (m)	To (m)				LL	PL	PI	% Cobbles	% Gravel			% Sand				% Fines				Max. Dry Density (t/m^3)	Optimum Moisture Content (%)	
										+3"	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total			
9008-F1	Tailings Impoundment	Unknown	Unknown	9.9	-	-	-	-	-	-	26.0	14.0	40.0	13.8	18.6	9.6	42.0	-	-	18.0	-	-	Alluvium - Channel Deposit
9033-A1	West of Open Pit	Unknown	Unknown	16.8	-	-	-	-	-	-	5.0	7.0	12.0	21.1	29.6	17.3	68.0	-	-	20.0	-	-	Alluvium - Channel Deposit
9036-H1	South of TMF Embankment	0.30	0.70	6.4	-	-	-	-	-	-	0.0	2.0	2.0	12.7	60.7	21.6	95.0	-	-	3.0	-	-	Alluvium - Channel Deposit
9036-H2	South of TMF Embankment	1.30	2.40	4.8	-	-	-	-	-	-	10.0	33.0	43.0	20.8	24.3	9.9	55.0	-	-	2.0	-	-	Alluvium - Channel Deposit
9038-A2	North of Open Pit	1.90	2.30	8.8	-	-	-	-	-	-	23.0	28.0	51.0	10.5	21.5	7.0	39.0	-	-	10.0	-	-	Alluvium - Channel Deposit
GS1	Tailings Impoundment	Unknown	Unknown	10.7	-	-	-	-	-	-	0.0	23.0	23.0	33.3	35.4	7.3	76.0	-	-	1.0	-	-	Alluvium - Channel Deposit
TP94-26A	Tailings Impoundment	2.40	2.60	20.0	-	-	-	-	-	-	0.0	31.3	31.3	28.0	29.8	5.5	63.3	-	-	5.4	-	-	Alluvium - Channel Deposit
TP94-35A	Tailings Impoundment	Unknown	Unknown	9.2	-	-	-	-	-	-	0.0	50.0	50.0	18.5	24.6	4.9	48.0	-	-	2.0	-	-	Alluvium - Channel Deposit
TP94-40A	Tailings Impoundment	1.80	2.40	15.4	-	-	-	-	-	-	0.0	39.0	39.0	8.6	19.1	19.0	46.8	-	-	14.2	-	-	Alluvium - Channel Deposit
TP94-50A	Tailings Impoundment	0.90	1.10	11.2	-	-	-	-	-	-	0.0	7.5	7.5	23.7	41.6	16.1	81.4	-	-	11.1	-	-	Alluvium - Channel Deposit
TP94-52A	Tailings Impoundment	1.20	1.40	19.8	-	-	-	-	-	-	0.0	18.1	18.1	8.4	30.6	23.5	62.5	-	-	19.4	-	-	Alluvium - Channel Deposit
TP94-54A	Tailings Impoundment	0.90	1.10	11.5	-	-	-	-	-	-	0.0	17.8	17.8	23.1	40.5	12.1	75.6	-	-	6.6	-	-	Alluvium - Channel Deposit
TP94-57A	Tailings Impoundment	3.40	3.60	15.1	-	-	-	-	-	-	0.0	30.3	30.3	21.9	33.5	8.9	64.3	-	-	5.4	-	-	Alluvium - Channel Deposit
TP94-61A	TMF Embankment	3.80	4.20	23.3	-	-	-	-	-	-	0.0	18.1	18.1	18.6	44.8	13.8	77.2	-	-	4.7	-	-	Alluvium - Channel Deposit
TP94-67A	TMF Embankment	0.60	0.80	30.0	-	-	-	-	-	-	0.0	8.2	8.2	10.8	30.6	31.9	73.4	-	-	18.4	-	-	Alluvium - Channel Deposit
TP94-67B	TMF Embankment	2.60	2.80	17.9	-	-	-	-	-	-	0.0	19.7	19.7	21.6	33.0	18.7	73.3	-	-	7.0	-	-	Alluvium - Channel Deposit
TP94-70A	TMF Embankment	1.10	1.30	9.8	-	-	-	-	-	-	0.0	19.2	19.2	26.1	44.8	7.7	78.6	-	-	2.2	-	-	Alluvium - Channel Deposit
TP94-77A	TMF Embankment	2.20	2.40	13.3	-	-	-	-	-	-	0.0	24.3	24.3	31.2	37.2	4.9	73.3	-	-	2.4	-	-	Alluvium - Channel Deposit
TP94-84A	South of TMF Embankment	1.40	1.80	17.2	-	-	-	-	-	-	0.0	21.4	21.4	15.1	41.6	16.7	73.4	-	-	5.2	-	-	Alluvium - Channel Deposit
TP94-85A	South of TMF Embankment	0.40	0.45	3.4	-	-	-	-	-	-	0.0	2.3	2.3	11.8	80.5	5.0	97.3	-	-	0.4	-	-	Alluvium - Channel Deposit
TP94-85B	South of TMF Embankment	0.50	0.55	39.3	-	-	-	-	-	-	0.0	0.0	0.0	2.6	19.4	34.2	56.2	-	-	43.8	-	-	Alluvium - Channel Deposit
TP94-94B	Tailings Impoundment	1.10	1.30	10.8	-	-	-	-	-	-	0.0	24.8	24.8	16.4	32.9	12.4	61.7	-	-	13.5	-	-	Alluvium - Channel Deposit
TP94-94C	Tailings Impoundment	1.80	2.00	4.7	-	-	-	-	-	-	0.0	26.5	26.5	29.7	38.6	3.4	71.7	-	-	1.8	-	-	Alluvium - Channel Deposit
DH12-01-2	TMF Embankment	19.50	19.80	19.2	-	-	-	-	-	0.0	0.0	1.9	1.9	15.3	38.3	26.7	80.3	16.1	1.7	17.8	-	-	Alluvium - Channel Deposit
DH13-05 BU-1	Crusher Area	3.40	3.50	14.3	-	-	-	-	-	20.6	22.6	31.6	54.2	7.7	12.4	3.7	23.8	-	-	1.5	-	-	Alluvium - Channel Deposit
TP13-86 BU-2	Crusher Area	2.60	2.70	10.7	-	4.8	NP	NP	NP	0.0	13.1	28.6	41.7	14.1	24.4	10.9	49.4	7.9	1.0	8.9	-	-	Alluvium - Channel Deposit
TP94-24D	Tailings Impoundment	0.63	0.68	89.2	-	-	-	-	-	-	0.0	3.6	3.6	14.3	24.6	11.1	50.0	-	-	46.4	-	-	Alluvium - Floodplain Dep. (Interbedded Peat)
TP94-79A	TMF Embankment	1.60	1.80	35.2	-	-	25	19	7	-	0.0	0.0	0.0	0.3	2.4	6.1	8.8	-	-	91.2	-	-	Alluvium - Floodplain Deposit (Organics)
TP94-79B	TMF Embankment	4.30	4.50	34.8	-	-	-	-	-	-	0.0	0.0	0.0	0.3	2.2	5.7	8.2	-	-	91.8	-	-	Alluvium - Floodplain Deposit (Organics)
TP94-87D	Tailings Impoundment	2.10	2.20	53.7	-	-	-	-	-	-	0.0	0.0	0.0	4.7	5.8	8.2	18.6	-	-	81.4	-	-	Alluvium - Floodplain Deposit
TP94-90B	Tailings Impoundment	2.25	2.50	24.0	-	-	-	-	-	-	0.0	23.7	23.7	9.7	12.0	8.4	30.1	-	-	46.2	-	-	Alluvium - Floodplain Deposit
DH11-23A SPT#6	Tailings Management Facility	9.35	9.80	211.1	-	-	NP	NP	NP	0.0	0.0	0.0	0.0	0.0	0.2	1.4	1.6	91.4	7.0	98.4	-	-	Alluvium - Floodplain Deposit
TP11-TMF-09	Tailings Management Facility	0.85	1.05	131.7	-	-	40	33	7	0.0	0.0	0.0	0.0	0.0	0.0	1.3	1.3	89.4	9.3	98.7	-	-	Alluvium - Floodplain Deposit
TP11-TMF-23-2	Tailings Management Facility	4.50	4.70	27.4	2.71	3.2	28	NP	NP	0.0	0.0	1.3	1.3	7.6	13.8	6.8	28.2	64.0	6.5	70.5	-	-	Alluvium - Floodplain Deposit
TP11-TMF-26	Tailings Management Facility	1.99	2.19	26.1	-	-	28	NP	NP	0.0	4.3	3.0	7.3	6.6	10.5	6.5	23.6	63.6	5.5	69.1	-	-	Alluvium - Floodplain Deposit
DH12-01-1	TMF Embankment	5.70	6.10	38.3	-	3.7	-	-	-	0.0	0.0	0.0	0.0	0.1	0.5	2.1	2.7	90.5	6.8	97.3	-	-	Alluvium - Floodplain Deposit
DH12-03	TMF Embankment	3.10	3.30	26.7	-	5.8	37	30	7	0.0	0.0	6.1	6.1	7.9	14.8	8.0	30.7	-	-	63.2	-	-	Alluvium - Floodplain Deposit
TP13-16 BU-1	South of Tailing Management Facility	3.00	3.20	22.7	-	-	24	22	2	0.0	0.0	1.4	1.4	5.3	10.1	5.4	20.8	73.8	4.0	77.8	-	-	Alluvium - Floodplain Deposit
TP13-16 BU-2	South of Tailing Management Facility	5.00	5.70	23.9	-	5.1	32	30	2	0.0	0.0	2.9	2.9	11.3	20.6	10.0	41.9	51.7	3.5	55.2	-	-	Alluvium - Floodplain Deposit

M:\1\01\00325\16\A\Report\3 - Borrow Source Assessment\Rev 0\Appendix B\[Appendix B - Lab Tests Results_rev A.xlsm]Table B.3

NOTES:

1. Particle size distribution by percent of sample weight.
2. Organic content according to ASTM D 2974, method C.
3. Cobble content may vary in the field.
4. Standard proctor includes an oversize correction as per ASTM D 4718-87.

REV	DATE	DESCRIPTION	PREP'D	CHK'D
0	11MAR'15	ISSUED WITH REPORT VA101-325/16-3	SB	GRG

APPENDIX C

CONCRETE AGGREGATE LABORATORY TEST RESULTS

(Pages C-1 to C-67)

SIEVE ANALYSIS REPORT

Levelton Consultants Ltd.

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Tel.: 604-278-1411
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To: **Knight Piesold Ltd.**
Suite 1400 - 750 West Pender St.
Vancouver, BC V6C 2T8

File No: R814-0178-00
Report No: 1

Attention: Mr. Sanne Brinkman, M.Sc

Project: KP - Yukon Mine Aggregate Qualification

Date Issued: February 18, 2014

SAMPLING INFORMATION

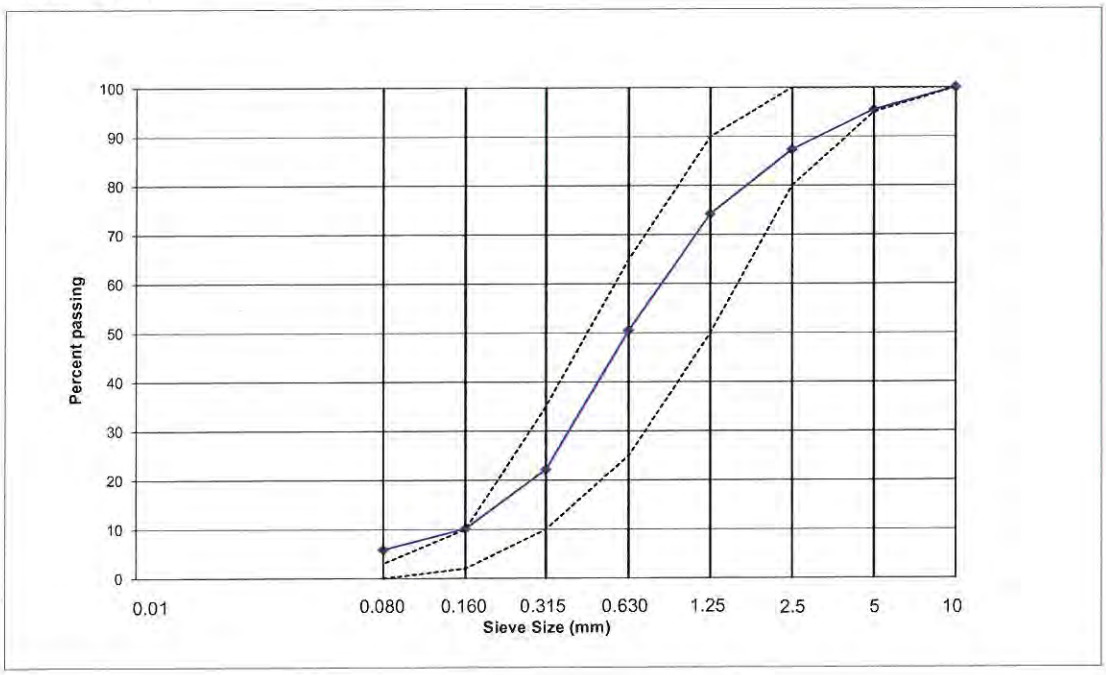
Source: TP13-01 BU - 0 (0.6-0.8 m)
Material: Fine Aggregate

Specification: CSA A23.1 Table 10 grading limits for fine aggregate

Date Sampled: August, 2013
Date Tested: January, 2014
Sample No: 1
Sampled by: Client
Tested by: NC

Material Specification			Sieve Analysis	
Sieve	HIGH SPEC	LOW SPEC	Sieve	% Passing
10	100	100	10	100.0
5	100	95	5	95.4
2.5	100	80	2.5	87.3
1.25	90	50	1.25	74.2
0.630	65	25	0.630	50.5
0.315	35	10	0.315	22.2
0.160	10	2	0.160	10.1
0.08	3	0	0.08	5.8

Fineness Modulus: **2.60**



REMARKS: Sample tested in accordance with CSA A23.2-2A and 5A.

LEVELTON CONSULTANTS LTD.

Per: _____
Norman Chang, AScT

Reviewed By: _____
Damien O'Brien, EIT.

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File No: R814-0178-00
Report No: 2

Attention: Mr. Sanne Brinkman, M.Sc

Project: KP - Yukon Mine Aggregate Qualification

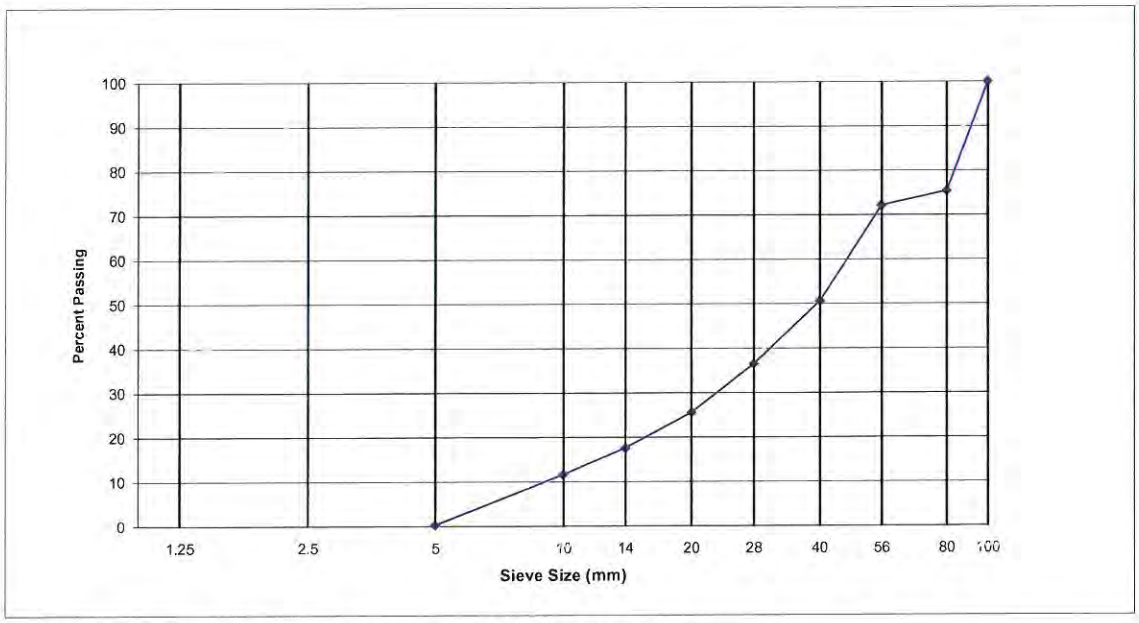
Date Issued: February 18, 2014

SAMPLING INFORMATION
Source: TP13-01 BU - 1 (1.2-1.4 m)
Material: Coarse Aggregate

Specification:

Date Sampled: August, 2013
Date Tested: January, 2014
Sample No: 2
Sampled by: Client
Tested by: NC

Material Specification			Sieve Analysis	
Sieve	HIGH SPEC	LOW SPEC	Sieve	% Passing
100			100	100.0
80			80	75.4
56			56	72.1
40			40	50.6
28			28	36.5
20			20	25.5
14			14	17.6
10			10	11.6
5			5	0.2



REMARKS: Sample tested in accordance with CSA A23.2-2A and 5A.

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File No: R814-0178-00
Report No: 6

Attention: Mr. Sanne Brinkman, M.Sc.

Project: KP - Yukon Mine Aggregate Qualification

Date Issued: February 18, 2014

SAMPLING INFORMATION

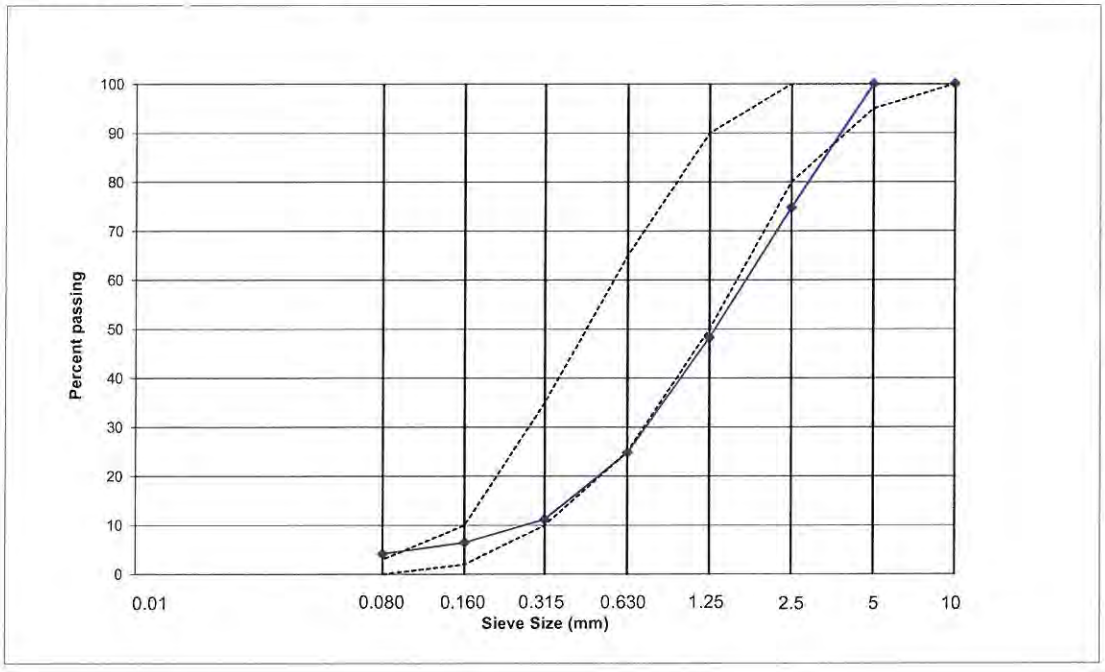
Source: TP13-01 BU - 1 (1.2-1.4 m)
Material: Fine Aggregate

Specification: CSA A23.1 Table 10 grading limits for fine aggregate

Date Sampled: August, 2013
Date Tested: January, 2014
Sample No: 2
Sampled by: Client
Tested by: NC

Material Specification			Sieve Analysis	
Sieve	HIGH SPEC	LOW SPEC	Sieve	% Passing
10	100	100	10	100.0
5	100	95	5	100.0
2.5	100	80	2.5	74.8
1.25	90	50	1.25	48.3
0.630	65	25	0.630	24.8
0.315	35	10	0.315	11.1
0.160	10	2	0.160	6.4
0.08	3	0	0.08	4.1

Fineness Modulus: 3.35



REMARKS: Sample tested in accordance with CSA A23.2-2A and 5A.

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Reviewed By: _____
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Attention: Mr. Sanne Brinkman, M.Sc.

Project: KP - Yukon Mine Aggregate Qualification

File No: R814-0178-00
Report No: 10

Date Issued: February 18, 2014

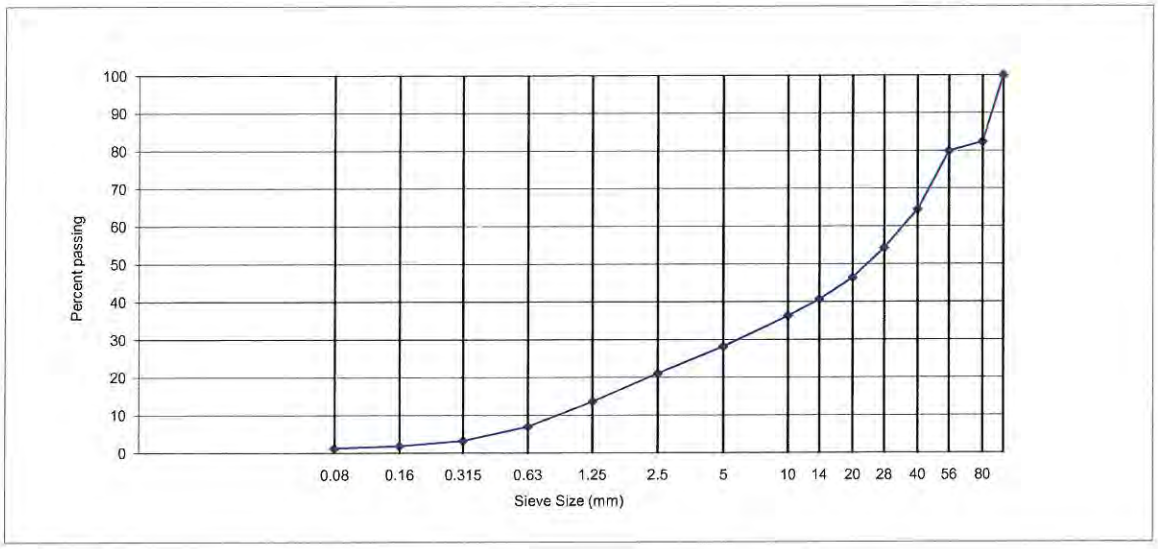
SAMPLING INFORMATION

Source: TP13-01 BU - 1 (1.2-1.4 m)
Material: Combined - Coarse and Fine Aggregate

Specification:

Date Sampled: August, 2013
Date Tested: January, 2014
Sample No: 2
Sampled by: Client
Tested by: NC

Material Specification			Sieve Analysis	
Sieve	HIGH SPEC	LOW SPEC	Sieve	% Passing
100			100	100.0
80			80	82.3
56			56	79.9
40			40	64.4
28			28	54.2
20			20	46.3
14			14	40.6
10			10	36.3
5			5	28.1
2.5			2.5	21.0
1.25			1.25	13.6
0.630			0.630	7.0
0.315			0.315	3.1
0.160			0.160	1.8
0.080			0.080	1.2



REMARKS: Sample tested in accordance with CSA A23.2-2A and 5A.

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Per: _____ Reviewed By: _____
Norman Chang, AScT — Damien O'Brien, EIT.

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Attention: Mr. Sanne Brinkman, M.Sc

File No: R814-0178-00
Report No: 4

Project: KP - Yukon Mine Aggregate Qualification

Date Issued: February 18, 2014

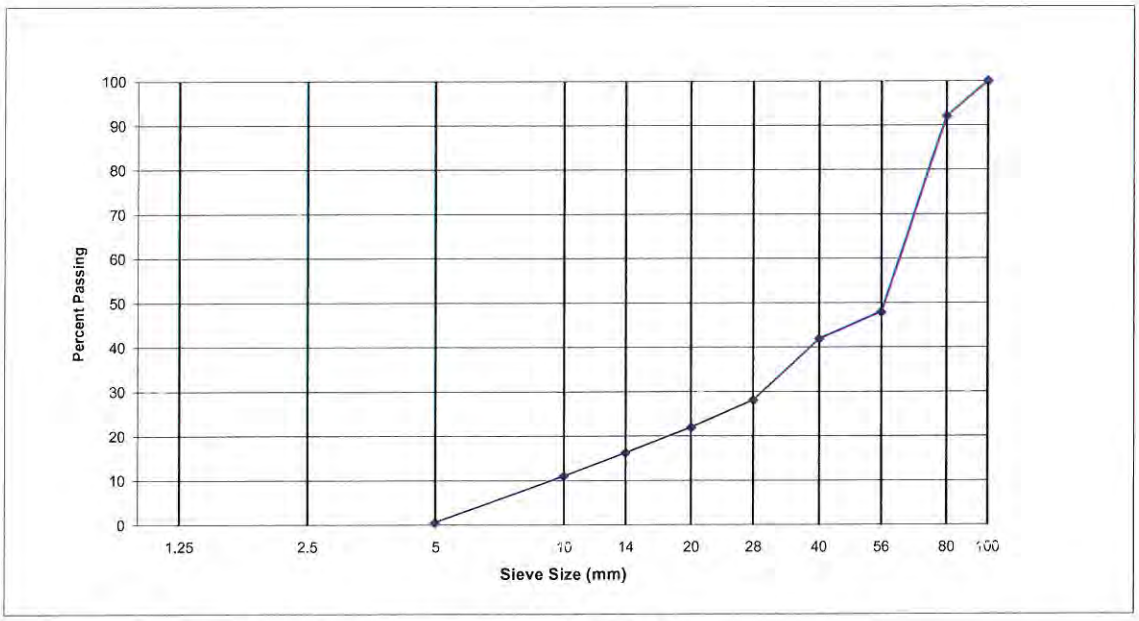
SAMPLING INFORMATION

Source: TP13-01 BU - 2 (2.5-2.7 m)
Material: Coarse Aggregate

Specification:

Date Sampled: August, 2013
Date Tested: January, 2014
Sample No: 4
Sampled by: Client
Tested by: NC

Material Specification			Sieve Analysis	
Sieve	HIGH SPEC	LOW SPEC	Sieve	% Passing
100			100	100.0
80			80	92.1
56			56	47.9
40			40	41.9
28			28	28.1
20			20	22.0
14			14	16.3
10			10	11.0
5			5	0.5



REMARKS: Sample tested in accordance with CSA A23.2-2A and 5A.

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File No: R814-0178-00
Report No: 8

Attention: Mr. Sanne Brinkman, M.Sc

Project: KP - Yukon Mine Aggregate Qualification

Date Issued: February 18, 2014

SAMPLING INFORMATION

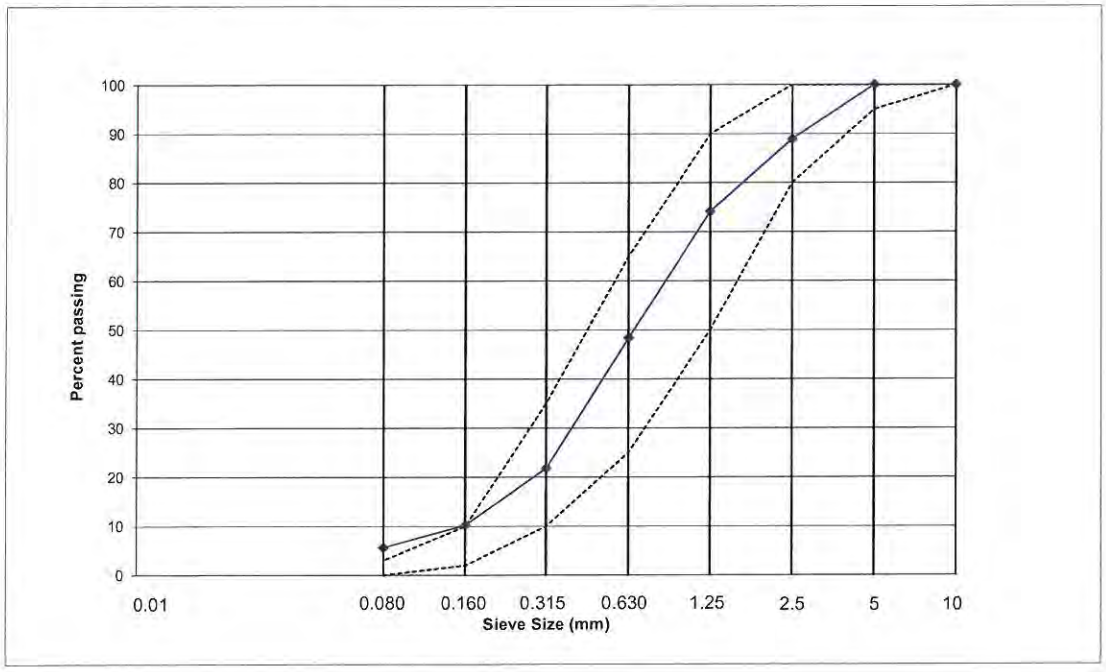
Source: TP13-01 BU - 2 (2.5-2.7 m)
Material: Fine Aggregate

Specification: CSA A23.1 Table 10 grading limits for fine aggregate

Date Sampled: August, 2013
Date Tested: January, 2014
Sample No: 4
Sampled by: Client
Tested by: NC

Material Specification			Sieve Analysis	
Sieve	HIGH SPEC	LOW SPEC	Sieve	% Passing
10	100	100	10	100.0
5	100	95	5	100.0
2.5	100	80	2.5	88.9
1.25	90	50	1.25	74.2
0.630	65	25	0.630	48.4
0.315	35	10	0.315	21.8
0.160	10	2	0.160	10.2
0.08	3	0	0.08	5.6

Fineness Modulus: **2.56**



REMARKS: Sample tested in accordance with CSA A23.2-2A and 5A.

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Attention: Mr. Sanne Brinkman, M.Sc.

Project: KP - Yukon Mine Aggregate Qualification

File No: R814-0178-00
Report No: 12

Date Issued: February 18, 2014

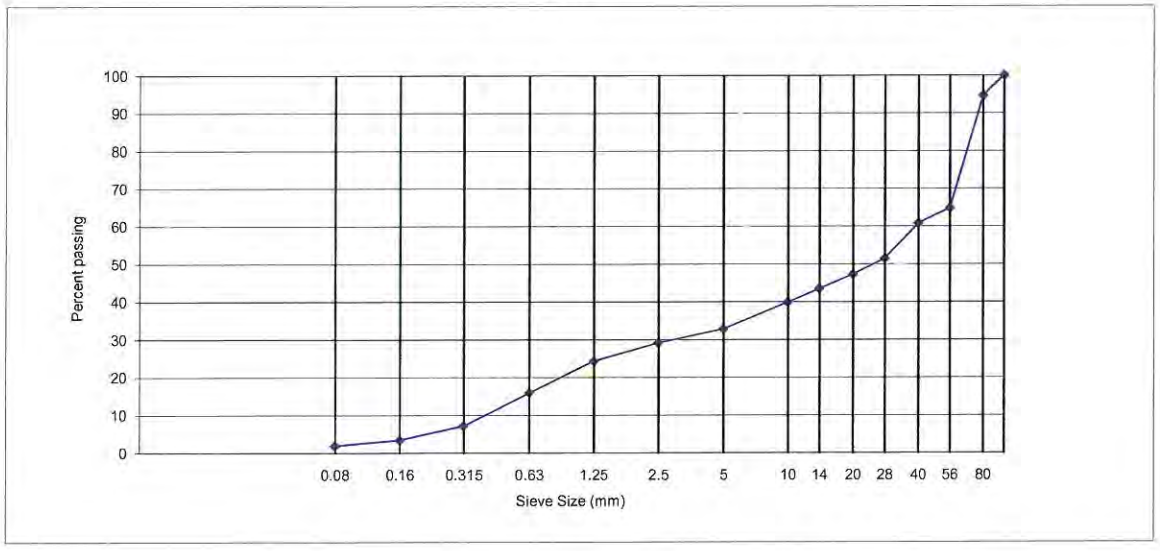
SAMPLING INFORMATION

Source: TP13-01 BU - 2 (2.5-2.7 m)
Material: Combined - Coarse and Fine Aggregate

Specification:

Date Sampled: August, 2013
Date Tested: January, 2014
Sample No: 4
Sampled by: Client
Tested by: NC

Material Specification			Sieve Analysis	
Sieve	HIGH SPEC	LOW SPEC	Sieve	% Passing
100			100	100.0
80			80	94.6
56			56	64.8
40			40	60.8
28			28	51.5
20			20	47.3
14			14	43.5
10			10	39.9
5			5	32.7
2.5			2.5	29.1
1.25			1.25	24.3
0.630			0.630	15.9
0.315			0.315	7.2
0.160			0.160	3.4
0.080			0.080	1.8



REMARKS: Sample tested in accordance with CSA A23.2-2A and 5A.

LEVELTON CONSULTANTS LTD.

Per: _____
Norman Chang, AScT

Reviewed By: _____
Damien O'Brien, EIT.

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File No: R814-0178-00
Report No: 5

Attention: Mr. Sanne Brinkman, M.Sc

Project: KP - Yukon Mine Aggregate Qualification

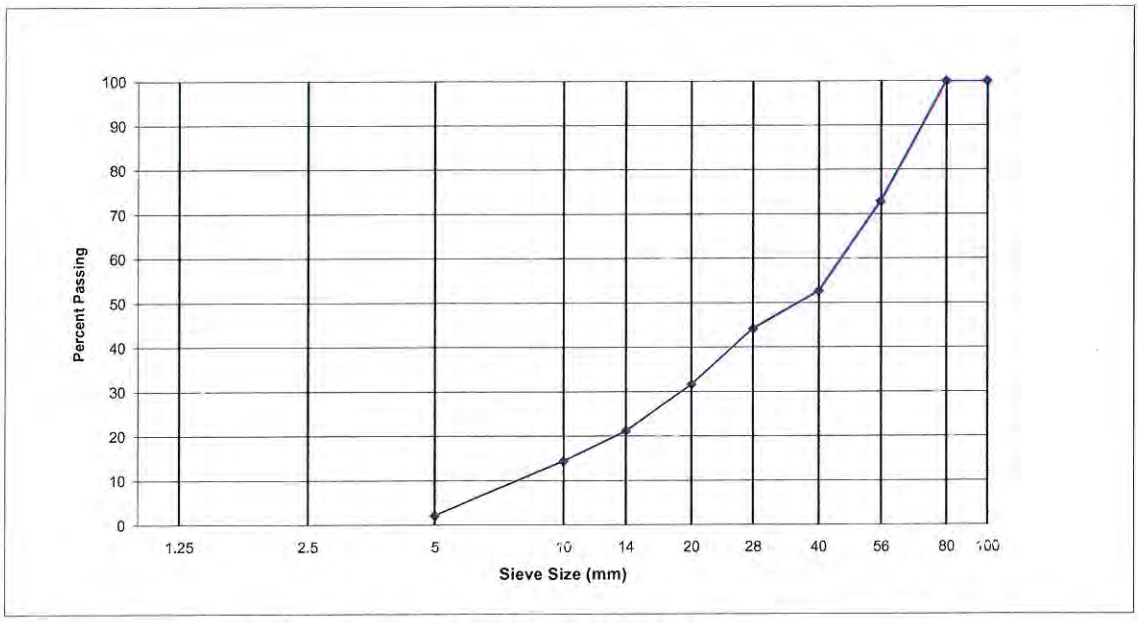
Date Issued: February 18, 2014

SAMPLING INFORMATION
Source: TP13-01 BU - 3 (1.0-1.2 m)
Material: Coarse Aggregate

Specification:

Date Sampled: August, 2013
Date Tested: January, 2014
Sample No: 5
Sampled by: Client
Tested by: NC

Material Specification			Sieve Analysis	
Sieve	HIGH SPEC	LOW SPEC	Sieve	% Passing
100			100	100.0
80			80	100.0
56			56	73.0
40			40	52.6
28			28	44.2
20			20	31.7
14			14	21.2
10			10	14.4
5			5	2.1



REMARKS: Sample tested in accordance with CSA A23.2-2A and 5A.

LEVELTON CONSULTANTS LTD.

Per: _____
Norman Chang, AScT

Reviewed By: _____
Damien O'Brien, EIT.

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File No: R814-0178-00
Report No: 9

Attention: Mr. Sanne Brinkman, M.Sc

Project: KP - Yukon Mine Aggregate Qualification

Date Issued: February 18, 2014

SAMPLING INFORMATION

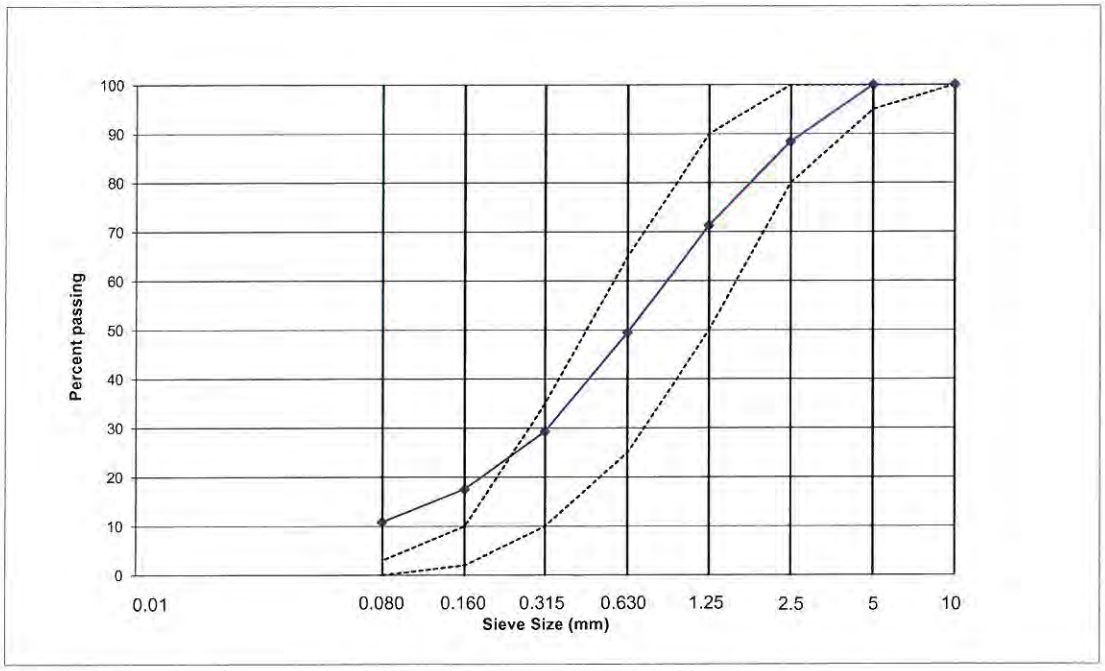
Source: TP13-01 BU - 3 (1.0-1.2 m)
Material: Fine Aggregate

Specification: CSA A23.1 Table 10 grading limits for fine aggregate

Date Sampled: August, 2013
Date Tested: January, 2014
Sample No: 5
Sampled by: Client
Tested by: NC

Material Specification			Sieve Analysis	
Sieve	HIGH SPEC	LOW SPEC	Sieve	% Passing
10	100	100	10	100.0
5	100	95	5	100.0
2.5	100	80	2.5	88.4
1.25	90	50	1.25	71.3
0.630	65	25	0.630	49.4
0.315	35	10	0.315	29.2
0.160	10	2	0.160	17.5
0.08	3	0	0.08	10.8

Fineness Modulus: **2.44**



REMARKS: Sample tested in accordance with CSA A23.2-2A and 5A.

LEVELTON CONSULTANTS LTD.

Per: _____
Norman Chang, AScT

Reviewed By: _____
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Attention: Mr. Sanne Brinkman, M.Sc.

Project: KP - Yukon Mine Aggregate Qualification

File No: R814-0178-00
Report No: 13

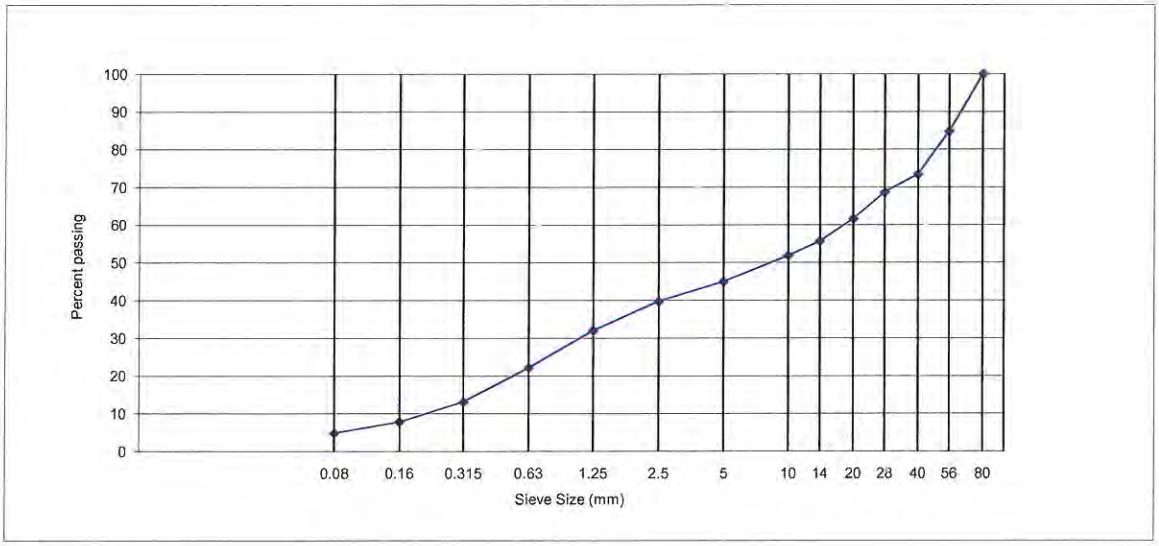
Date Issued: February 18, 2014

SAMPLING INFORMATION
Source: TP13-01 BU - 3 (1.0-1.2 m)
Material: Combined - Coarse and Fine Aggregate

Specification:

Date Sampled: August, 2013
Date Tested: January, 2014
Sample No: 5
Sampled by: Client
Tested by: NC

Material Specification			Sieve Analysis	
Sieve	HIGH SPEC	LOW SPEC	Sieve	% Passing
80			80	100.0
56			56	84.8
40			40	73.4
28			28	68.6
20			20	61.6
14			14	55.7
10			10	51.9
5			5	44.9
2.5			2.5	39.7
1.25			1.25	32.0
0.630			0.630	22.2
0.315			0.315	13.1
0.160			0.160	7.9
0.080			0.080	4.8



REMARKS: Sample tested in accordance with CSA A23.2-2A and 5A.

LEVELTON CONSULTANTS LTD.

Per: _____
Norman Chang, AScT

Reviewed By: _____
Damien O'Brien, EIT.

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To: **Knight Piesold Ltd.**
Suite 1400 - 750 West Pender St.
Vancouver, BC V6C 2T8

File No: R813-0178-00
Report No: 3

Attention: Mr. Sanne Brinkman, M.Sc

Project: KP - Yukon Mine Aggregate Qualification

Date Issued: February 18, 2014

SAMPLING INFORMATION
Source: TP13-14 BU - 1 (3.0-4.0 m)
Material: Coarse Aggregate

Specification:

Date Sampled: August, 2013
Date Tested: January, 2014
Sample No: 3
Sampled by: Client
Tested by: NC

Material Specification			Sieve Analysis	
Sieve	HIGH SPEC	LOW SPEC	Sieve	% Passing
100			100	100.0
80			80	100.0
56			56	100.0
40			40	84.8
28			28	69.7
20			20	51.1
14			14	36.7
10			10	24.5
5			5	0.9



REMARKS: Sample tested in accordance with CSA A23.2-2A and 5A.

LEVELTON CONSULTANTS LTD.

Per: _____
Norman Chang, AScT

Reviewed By: _____
Damien O'Brien, EIT.

This report constitutes a testing service only. No engineering interpretation opinion is expressed or implied. Engineering review and interpretation can be provided on written request.

SIEVE ANALYSIS REPORT

Levelton Consultants Ltd.

#150 - 12791 Clarke Place
Richmond, B.C.
Canada V6V 2H9
Tel.: 604-278-1411
Fax.: 604-278-1042
E-mail: cmd@levelton.com

To: **Knight Piesold Ltd.**
Suite 1400 - 750 West Pender St.
Vancouver, BC V6C 2T8

File No: R814-0178-00
Report No: 7

Attention: Mr. Sanne Brinkman, M.Sc

Project: KP - Yukon Mine Aggregate Qualification

Date Issued: February 18, 2014

SAMPLING INFORMATION

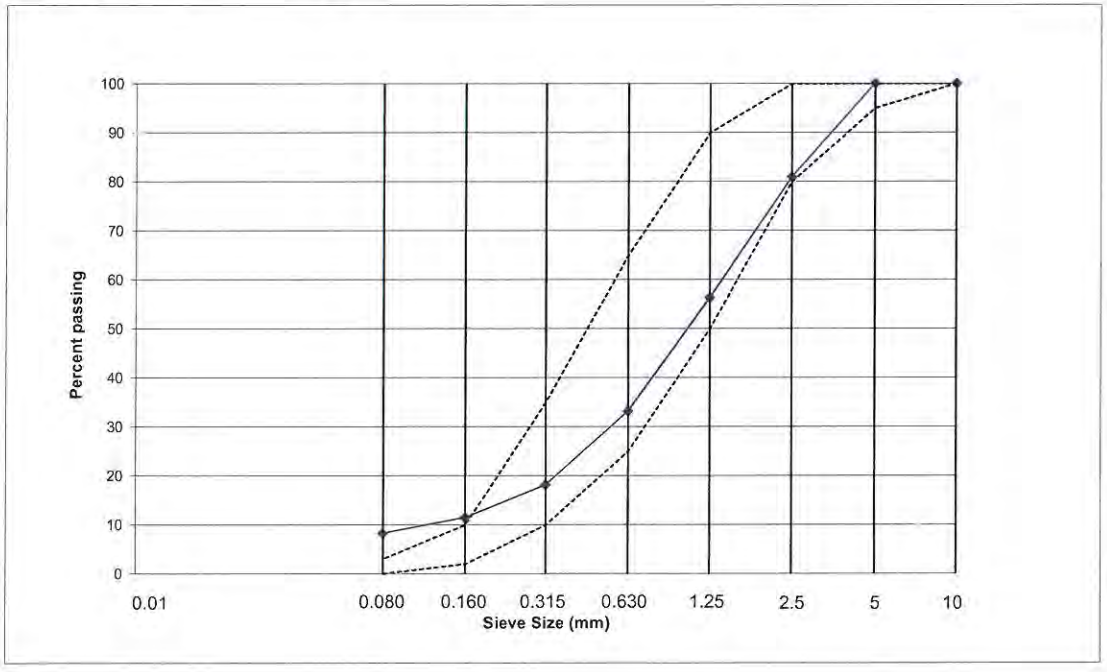
Source: TP13-14 BU - 1 (3.0-4.0 m)
Material: Fine Aggregate

Specification: CSA A23.1 Table 10 grading limits for fine aggregate

Date Sampled: August, 2013
Date Tested: January, 2014
Sample No: 3
Sampled by: Client
Tested by: NC

Material Specification			Sieve Analysis	
Sieve	HIGH SPEC	LOW SPEC	Sieve	% Passing
10	100	100	10	100.0
5	100	95	5	100.0
2.5	100	80	2.5	80.9
1.25	90	50	1.25	56.3
0.630	65	25	0.630	33.2
0.315	35	10	0.315	18.1
0.160	10	2	0.160	11.5
0.08	3	0	0.08	8.2

Fineness Modulus: **3.00**



REMARKS: Sample tested in accordance with CSA A23.2-2A and 5A.

LEVELTON CONSULTANTS LTD.

Per: _____
Norman Chang, AScT

Reviewed By: _____
Damien O'Brien, EIT.

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SIEVE ANALYSIS REPORT

Levelton Consultants Ltd.

#150 - 12791 Clarke Place
Richmond, B.C.
Canada V6V 2H9
Tel.: 604-278-1411
Fax.: 604-278-1042
E-mail: cmd@levelton.com

To: **Knight Piesold Ltd.**
Suite 1400 - 750 West Pender St.
Vancouver, BC V6C 2T8

Attention: Mr. Sanne Brinkman, M.Sc.

Project: KP - Yukon Mine Aggregate Qualification

File No: R814-0178-00
Report No: 11

Date Issued: February 18, 2014

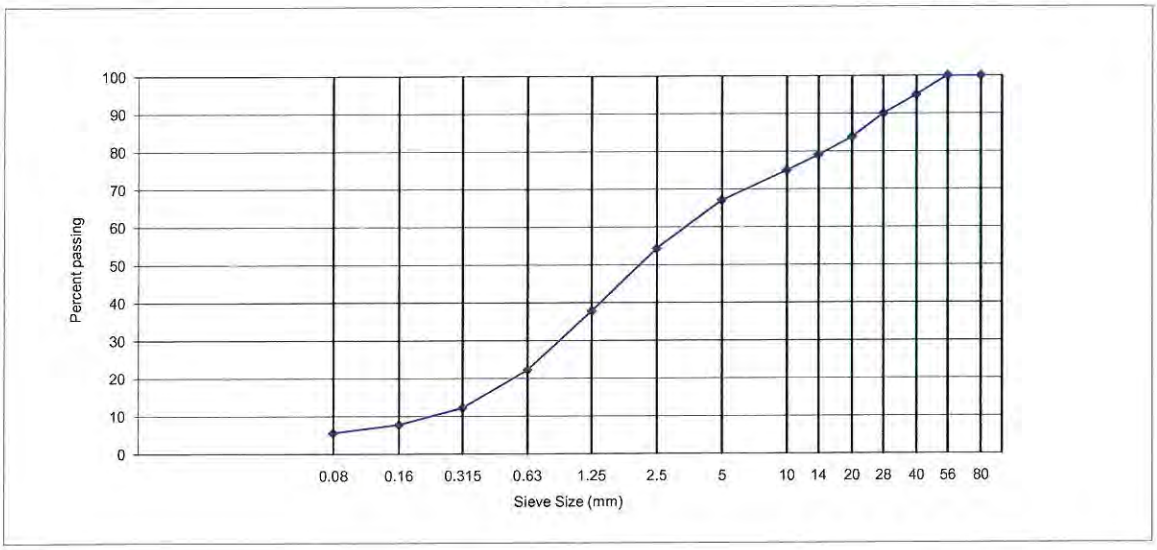
SAMPLING INFORMATION

Source: TP13-14 BU -1 (3.0-4.0 m)
Material: Combined - Coarse and Fine Aggregate

Specification:

Date Sampled: August, 2013
Date Tested: January, 2014
Sample No: 3
Sampled by: Client
Tested by: NC

Material Specification			Sieve Analysis	
Sieve	HIGH SPEC	LOW SPEC	Sieve	% Passing
80			80	100.0
56			56	100.0
40			40	95.0
28			28	89.9
20			20	83.8
14			14	79.0
10			10	74.9
5			5	67.1
2.5			2.5	54.3
1.25			1.25	37.8
0.630			0.630	22.3
0.315			0.315	12.2
0.160			0.160	7.7
0.080			0.080	5.5



REMARKS: Sample tested in accordance with CSA A23.2-2A and 5A.

LEVELTON CONSULTANTS LTD.

Per: _____
Norman Chang, AScT

Reviewed By: _____
Damien O'Brien, EIT.

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SIEVE ANALYSIS REPORT

Levelton Consultants Ltd.

#150 - 12791 Clarke Place
Richmond, B.C.
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Tel.: 604-278-1411
Fax.: 604-278-1042
E-mail: cmd@levelton.com

To: **Knight Piesold Ltd.**
Suite 1400 - 750 West Pender St.
Vancouver, BC V6C 2T8

File No: R814-0178-00
Report No: 14

Attention: Mr. Sanne Brinkman, M.Sc

Project: KP - Yukon Mine Aggregate Qualification

Date Issued: February 18, 2014

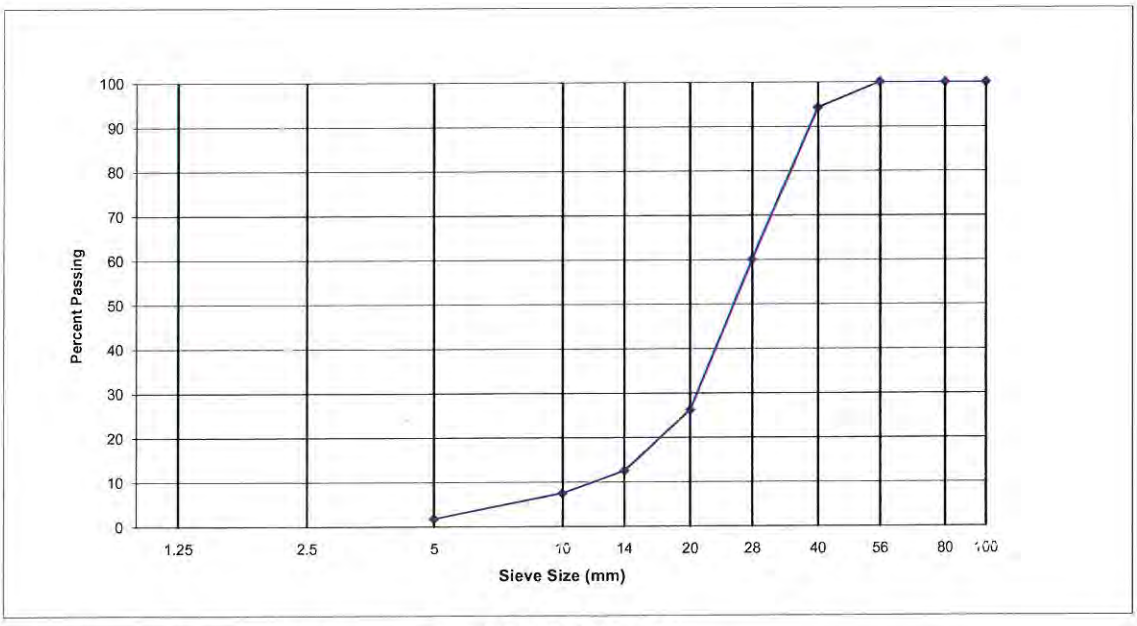
SAMPLING INFORMATION

Source: TP - 13-84
Material: Crushed -28 mm Coarse Blasted Rock (Granodiorite)

Specification:

Date Sampled: August, 2013
Date Tested: January 20, 2014
Sample No: 6
Sampled by: Client
Tested by: NC

Material Specification			Sieve Analysis	
Sieve	HIGH SPEC	LOW SPEC	Sieve	% Passing
100			100	100.0
80			80	100.0
56			56	100.0
40			40	94.3
28			28	60.0
20			20	26.2
14			14	12.5
10			10	7.5
5			5	1.8



REMARKS: Sample tested in accordance with CSA A23.2-2A and 5A.

LEVELTON CONSULTANTS LTD.

Per: _____
Norman Chang, AScT

Reviewed By: _____
Damien O'Brien, EIT.

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SIEVE ANALYSIS REPORT

Levelton Consultants Ltd.

#150 - 12791 Clarke Place
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Tel.: 604-278-1411
Fax.: 604-278-1042
E-mail: cmd@levelton.com

To: **Knight Piesold Ltd.**
Suite 1400 - 750 West Pender St.
Vancouver, BC V6C 2T8

File No: R814-0178-00
Report No: 15

Attention: Mr. Sanne Brinkman, M.Sc

Project: KP - Yukon Mine Aggregate Qualification

Date Issued: February 18, 2014

SAMPLING INFORMATION

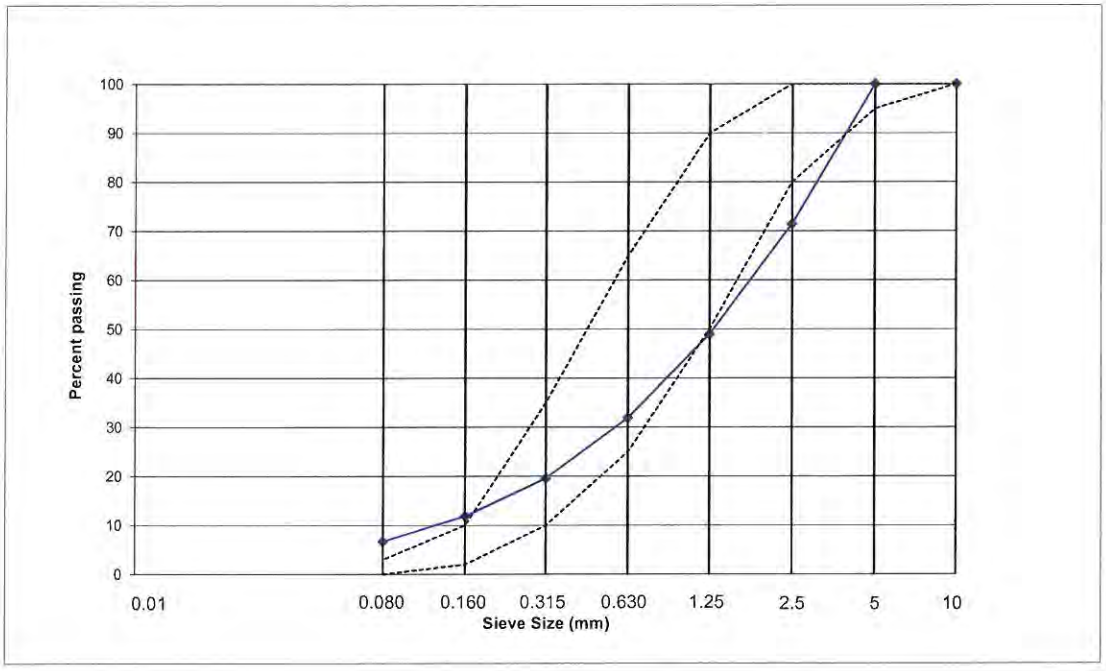
Source: TP - 13-84
Material: Crushed Fine Blasted Rock (Granodiorite)

Specification: CSA A23.1 Table 10 grading limits for fine aggregate

Date Sampled: August, 2013
Date Tested: January, 2014
Sample No: 6
Sampled by: Client
Tested by: NC

Material Specification			Sieve Analysis	
Sieve	HIGH SPEC	LOW SPEC	Sieve	% Passing
10	100	100	10	100.0
5	100	95	5	100.0
2.5	100	80	2.5	71.4
1.25	90	50	1.25	48.9
0.630	65	25	0.630	31.8
0.315	35	10	0.315	19.5
0.160	10	2	0.160	11.9
0.08	3	0	0.08	6.7

Fineness Modulus: **3.16**



REMARKS: Sample tested in accordance with CSA A23.2-2A and 5A.

LEVELTON CONSULTANTS LTD.

Per: _____
Norman Chang, AScT

Reviewed By: _____
Damien O'Brien, EIT.

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SIEVE ANALYSIS REPORT

Levelton Consultants Ltd.

#150 - 12791 Clarke Place
Richmond, B.C.
Canada V6V 2H9
Tel.: 604-278-1411
Fax.: 604-278-1042
E-mail: cmd@levelton.com

To: **Knight Piesold Ltd.**
Suite 1400 - 750 West Pender St.
Vancouver, BC V6C 2T8

Attention: Mr. Sanne Brinkman, M.Sc.

Project: KP - Yukon Mine Aggregate Qualification

File No: R814-0178-00
Report No: 16

Date Issued: February 18, 2014

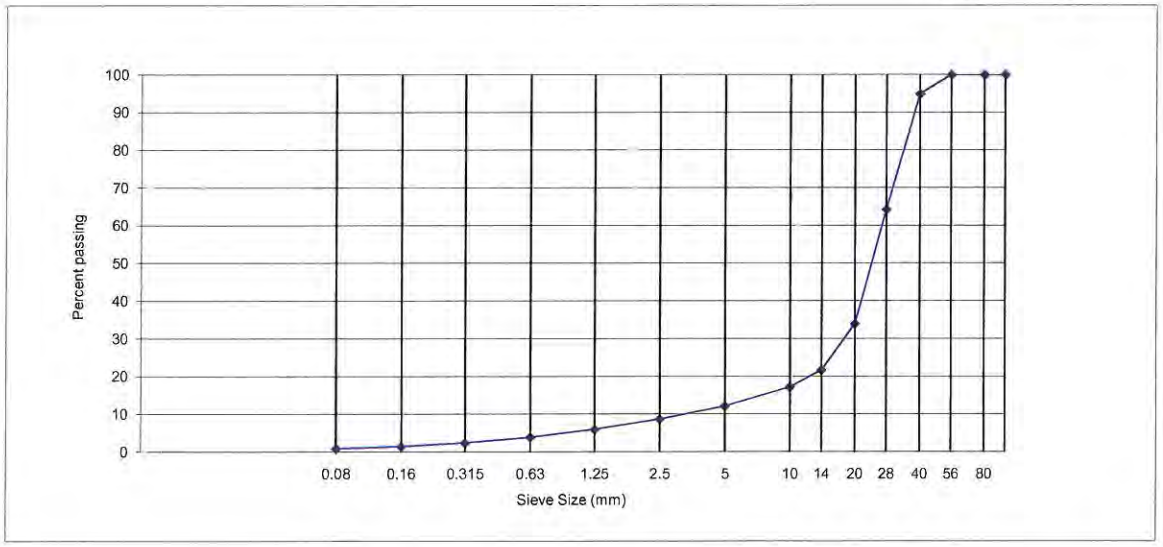
SAMPLING INFORMATION

Source: TP - 13-84
Material: Crushed -28 mm - Coarse and Fine Aggregate Blasted Rock (Granodiorite)

Specification:

Date Sampled: August, 2013
Date Tested: January, 2014
Sample No: 6
Sampled by: Client
Tested by: NC

Material Specification			Sieve Analysis	
Sieve	HIGH SPEC	LOW SPEC	Sieve	% Passing
100			100	100.0
80			80	100.0
56			56	100.0
40			40	94.9
28			28	64.2
20			20	33.9
14			14	21.7
10			10	17.2
5			5	12.1
2.5			2.5	8.6
1.25			1.25	5.9
0.630			0.630	3.9
0.315			0.315	2.4
0.160			0.160	1.5
0.080			0.080	0.8



REMARKS: Sample tested in accordance with CSA A23.2-2A and 5A.

LEVELTON CONSULTANTS LTD.

Per: _____ Reviewed By: _____
Norman Chang, AScT Damien O'Brien, EIT.

This report constitutes a testing service only. No engineering interpretation opinion is expressed or implied. Engineering review and interpretation can be provided on written request.

LEVELTON CONSULTANTS LTD.

150-12791 Clarke Place
Richmond, BC V6V 2H9
T: 604.278.1411 F: 604.278.1042
info@levelton.com
www.levelton.com

April 08, 2014

Levelton File R814-0178-00

Knight Piesold Ltd.
Suite 1400 – 750 West Pender Street
Vancouver, BC V6C 2T8

Attention: Mr. Sanne Brinkman, M.Sc.

Project: KP – Yukon Mine Aggregate Qualification
Subject: Aggregate Test Results

Dear Mr. Sanne Brinkman, MSc.;

Knight Piesold Ltd. retained Levelton Consultants Ltd. to complete testing of aggregate samples obtained by the client from Alluvium and Granodiorite test pits. Prior to further testing for aggregate qualification, samples were initially tested for sieve analysis. Based on the results from the sieve analysis, Knight Piesold has grouped and selected the following samples to be tested for aggregate qualification: *Alluvium TP13-01 Composite Fine Aggregate, Alluvium TP13-01 Composite Coarse Aggregate, Alluvium TP13-14 BU1 3.0-4.0 m Fine Aggregate, and Granodiorite TP13-84 BU-1 Coarse Aggregate*. The tests requested by Knight Piesold are as outlined in Tables 1 and 2. Test results are summarized in Tables 3 and 4 and formal test reports are appended to this letter.

Table 1: Coarse Aggregate Tests

Test Procedure
Material Finer than 80 μm (CSA A23.2-5A)
Relative Density & Absorption of Coarse Aggregate (CSA A23.2-12A)
Clay Lumps & Friable Particles in Aggregates (CSA A23.2-3A)
Flat & Elongated Particles (CSA A23.2-13A)
Resistance to Degradation of Small-Size Aggregate by Abrasion and Impact in the Los Angeles Machine (CSA A23.2-16A)
Potential Alkali Reactivity of Aggregates (Mortar-Bar Method) (CSA A23.2-25A)
Low Density Granular Materials in Aggregate (CSA A23.2-4A)
Resistance of Coarse Aggregate to Degradation by Abrasion in the Micro-Deval Apparatus (CSA A23.2-29A)
Resistance of Unconfined Coarse Aggregate to Freezing and Thawing (CSA A23.2-24A)
Petrographic (CSA A23.2-15A)

Table 2: Fine Aggregate Tests

Test Procedure
Material Finer than 80 μm (CSA A23.2-5A)
Relative Density & Absorption of Fine Aggregate (CSA A23.2-6A)
Clay Lumps & Friable Particles in Aggregates (CSA A23.2-3A)
Potential Alkali Reactivity of Aggregates (Mortar-Bar Method) (CSA A23.2-25A)
Low Density Granular Materials in Aggregate (CSA A23.2-4A)
Organic Impurities in Fine Aggregate (CSA 23.2-7A)
Resistance of Coarse Aggregate to Degradation by Abrasion in the Micro-Deval Apparatus (CSA A23.2-23A)
Petrographic (CSA A23.2-15A)

Table 3: Summary of Coarse Aggregate Test Results

Test Method	CSA Specifications A23.1 – Table 12 (See Clauses 4.2.3.2.2, .3.3.3, .3.4.3, .3.6, and .3.9.1) Maximum %	Alluvium TP13-01 Composite	Granodiorite TP13-84 BU-1 Composite
Material Finer than 80 µm (Percent Passing, %) (CSA A23.2-5A) CA	1.0	-	0.6
Relative Density (kg/m^3) and Absorption (%) of Coarse Aggregate (SSD) (CSA A23.2-12A)	N/A	-	Density:2668 Absorption: 0.60
Clay Lumps & Friable Particles in Aggregates (%) (CSA A23.2-3A)	0.3	-	0.0
Flat & Elongated Particles (Neither Flat nor Elongated, %) (CSA A23.2-13A)	N/A	91.7*	97.2
Degradation of Small-Size Aggregate by Abrasion and Impact in the Los Angeles Machine (Percent Loss, %) (CSA A23.2-16A)	50.0	-	41.9
Potential Alkali Reactivity of Aggregates (Mortar-Bar Method) (Expansion at 14 days, %) (CSA A23.2-25A)	0.150	-	0.030
Low Density Granular Materials in Aggregate, %) (CSA A23.2-4A)	0.5	-	0.0
Resistance of Coarse Aggregate to Degradation by Abrasion in the Micro-Deval Apparatus (Percent Loss, %) (CSA A23.2-29A)	17.0	-	14.2
Resistance of Unconfined Coarse Aggregate to Freezing and Thawing (Total Weighted Percent Loss, %) (CSA A23.2-24A)	6.0	3.3*	0.0
Petrographic (CSA A23.2-15A)	N/A	-	Petrographic Report is Enclosed

Note: *Knight Piesold only requested the following tests to be conducted on the Alluvium TP13-01 Composite coarse sample

Table 4: Summary of Fine Aggregate Test Results

Test Method	CSA Specifications A23.1 – Table 12 (See Clauses 4.2.3.2.2, 4.2.3.3.3, 4.2.3.4.3, 4.2.3.6, and 4.2.3.9.1)	Alluvium TP13-01 Composite	Alluvium TP13-14 BU-1 3.0-4.0 m
Material Finer than 80 µm (Percent Passing, %) (CSA A23.2-5A)	3.0	8.6	6.0*
Relative Density (kg/m^3) and Absorption (%) of Fine Aggregate (SSD) (CSA A23.2-6A)	N/A	Density: 2563 Absorption: 1.24	-
Clay Lumps & Friable Particles in Aggregates (%) (CSA A23.2-3A)	1.0	0.0	0.0*
Potential Alkali Reactivity of Aggregates (Mortar-Bar Method) (Expansion at 14 days, %) (CSA A23.2-25A)	0.150	0.102	-
Low Density Granular Materials in Aggregate (%) (CSA A23.2-4A)	0.5	0.0	-
Resistance of Fine Aggregate to Degradation by Abrasion in the Micro-Deval Apparatus (Percent Loss, %) (CSA A23.2-23A)	20.0	13.0	-
Organic Impurities in Fine Aggregates (Color Plate Index) (CSA A23.2-7A)	< No. 3	No.3	No. 4*
Petrographic (CSA A23.2-15A)	N/A	Petrographic Report is Enclosed	Petrographic Report is Enclosed*

Note: *Knight Piesold only requested the following tests to be conducted on the Alluvium TP13-14 BU-1 3.0-4.0 m fine sample.

We trust this meets your current needs. Please contact us if you require anything further. Thank you for retaining Levelton.

Yours truly,

Levelton Consultants Ltd.

Norman Chang, AScT
Laboratory Technologist
Construction Materials Laboratory
Materials Division, BC Region
Phone: 602-278-1411 ext. 302
Email: nchange@levelton.com

Reviewed by

David Smith, MScE, P.Eng.
Principal & Group Leader
Construction Materials Laboratory
Materials Division, BC Region
Direct Line: 604-207-6855
Email: dsmith@levelton.com

NJC:lgi

Attachment(s): Aggregate Test Reports

TECHNICAL REPORT

LEVELTON

Date: April 8, 2014

File: R814-0178-00

To: Knight Piesold Ltd.
Suite 1400 – 750 West Pender St.
Vancouver, BC V6C 2T8

Attention: Mr. Sanne Brinkman, M.Sc.

PROJECT: KP – Yukon Mine Aggregate Qualification

SUBJECT: Standard Test Method for Materials Finer than 80-µm (CSA A23.2-5A)

Product Tested: Alluvium – Natural Sand

Source: TP13-01 Composite **Sampled by:** Client

Date Received: December, 2013 **Date Tested:** March 13, 2014

Percentage of Material Finer than 80-µm	8.6%

LEVELTON CONSULTANTS LTD.

Per: _____
Norman Chang, AScT

Reviewed By: _____
Damien O'Brien, EIT.

Notice: The test data given herein pertain to the samples provided, and may not be applicable to material from other production zones. Reporting of these data constitutes a testing service. Interpretation of the data given may be provided upon request.

TECHNICAL REPORT

LEVELTON

Date: April 8, 2014

File: R814-0178-00

To: Knight Piesold Ltd.
Suite 1400 – 750 West Pender St.
Surrey, BC V4N 4X8

Attention: Mr. Sanne Brinkman, M.Sc.

PROJECT: KP – Yukon Mine Aggregate Qualification

SUBJECT: Clay Lumps and Friable Particles in Aggregates (CSA A23.2-3A)

Product Tested: Alluvium - Natural Sand

Source: 13-01 Composite **Sampled by:** Client

Date Received: December, 2013 **Date Tested:** February 20, 2014

Size of Particles (mm)	Mass of Sample (g)	Mass of Sample with Clay Lumps Removed (g)	Loss in Mass (g)	% Loss	% Retained in Original Gradation	Weighted % Loss
Fine Aggregate Portion						
5 - 1.25						
TOTAL LOSS (FINE PORTION)						**0.0**

Remarks: None per visual examination or readily apparent during S.G. preparation.

CCIL

LEVELTON CONSULTANTS LTD.

Per: _____
Norman Chang, AScT

Reviewed By: _____
Damien O'Brien, EIT.

Notice: The test data given herein pertain to the samples provided, and may not be applicable to material from other production zones. Reporting of these data constitutes a testing service. Interpretation of the data given may be provided upon request.

TECHNICAL REPORT

LEVELTON

Date: April 8, 2014

File: R814-0178-00

To: Knight Piesold Ltd.
Suite 1400 – 750 West Pender St.
Vancouver, BC V6C 2T8

Attention: Mr. Sanne Brinkman, M.Sc.

PROJECT: KP – Yukon Mine Aggregate Qualification

SUBJECT: Low-density Granular Material in Aggregate (CSA A23.2-4A)

Product Tested Alluvium - Natural Sand

Source: TP13-01 Composite **Sampled by:** Client

Date Received: December, 2013 **Date Tested:** March 10, 2014

FINE AGGREGATE	
Percentage of low-density pieces	0.0%

LEVELTON CONSULTANTS LTD.

Per: _____
Norman Chang, AScT

Reviewed By: _____
Damien O'Brien, EIT.

Notice: The data given in this report pertain to the sample provided only, and may not be applicable to material other than that represented by the sample. This report constitutes a testing service only. Interpretation of these data may be provided upon request.

TECHNICAL REPORT

LEVELTON

Date: April 8, 2014

File: R814-0178-00

To: Knight Piesold Ltd.
Suite 1400 – 750 West Pender St.
Vancouver, BC V6C 2T8

Attention: Mr. Sanne Brinkman, M.Sc.

PROJECT: KP – Yukon Mine Aggregate Qualification

SUBJECT: Relative Density and Absorption of Fine Aggregate (CSA 23.2-6A)

Product Tested Alluvium - Natural Sand

Source: TP13-01 Composite **Sampled by:** Client

Date Received: December, 2013 **Date Tested:** February 20, 2014

Sample	Bulk G_s (Dry Basis)	Bulk G_s (SSD Basis)	Absorption (%)
Natural Sand	2.531	2.563	1.24

LEVELTON CONSULTANTS LTD.

Per: _____
Norman Chang, AScT

Reviewed By: _____
Damien O'Brien, EIT.

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TECHNICAL REPORT

Date: April 8, 2014

File: R814-0178-00

To: Knight Piesold Ltd.
Suite 1400 – 750 West Pender St.
Vancouver, BC V6C 2T8

Attention: Mr. Sanne Brinkman, M.Sc.

PROJECT: KP – Yukon Mine Aggregate Qualification
SUBJECT: Test for Organic Impurities in Fine Aggregates for Concrete (CSA A23.2-7A)

Product Tested: Alluvium - Natural Sand

Source: TP13-01 Composite **Sampled by:** Client

Date Received: December, 2013 **Date Tested:** February 20, 2014

Colour Plate Index	No. 3

NOTES: 1. 3% NaOH solution used.

LEVELTON CONSULTANTS LTD.

Per: _____
Norman Chang, AScT

Reviewed By: _____
Damien O'Brien, EIT.

Note: The data given in this report pertain to the sample provided only, and may not be applicable to material other than that represented by the sample. This report constitutes a testing service. Interpretation may be provided upon request.

TECHNICAL REPORT

Date: April 8, 2014

File: R814-0178-00

To: Knight Piesold Ltd.
Suite 1400 - 750 West Pender St.
Vancouver, BC

Attention: Mr. Sanne Brinkman, M.Sc

PROJECT: KP - Yukon Mine Aggregate Qualification

SUBJECT: Detection of Alkali-Silica Reactive Aggregate by Accelerated Expansion of Mortar Bars (CSA A23.2-25A)

Product Tested: Alluvium - Natural Sand

Source: TP13-01 Composite **Sampled by:** Client

Date Received: December, 2013 **Cast Date:** February 26, 2014

Percent Expansion (measured at test ages in days)										
Sample	3	5	7	10	12	14				
Natural Sand	0.007	0.012	0.022	0.039	0.057	0.102				
	0.005	0.008	0.019	0.038	0.054	0.099				
	0.005	0.008	0.015	0.037	0.060	0.103				
	0.005	0.007	0.021	0.035	0.057	0.102				
	0.006	**0.009**	**0.019**	**0.037**	**0.057**	**0.102**				
CSA Recommended Expansion Limits						0.150				
Spratt Limestone Control Aggregate						0.356				

NOTES:
1. Stock cement (ESSROC, Picton, Type GU, Na_2O eq. of 0.85%) used in mix.
2. Water/cement ratio was 0.44.
3. Spratt Limestone Control Aggregate range after 14 days shall be between 0.30% and 0.55% and after 28 days shall be between 0.47% and 0.98%.

LEVELTON CONSULTANTS LTD.

Per: _____
Norman Chang, AScT

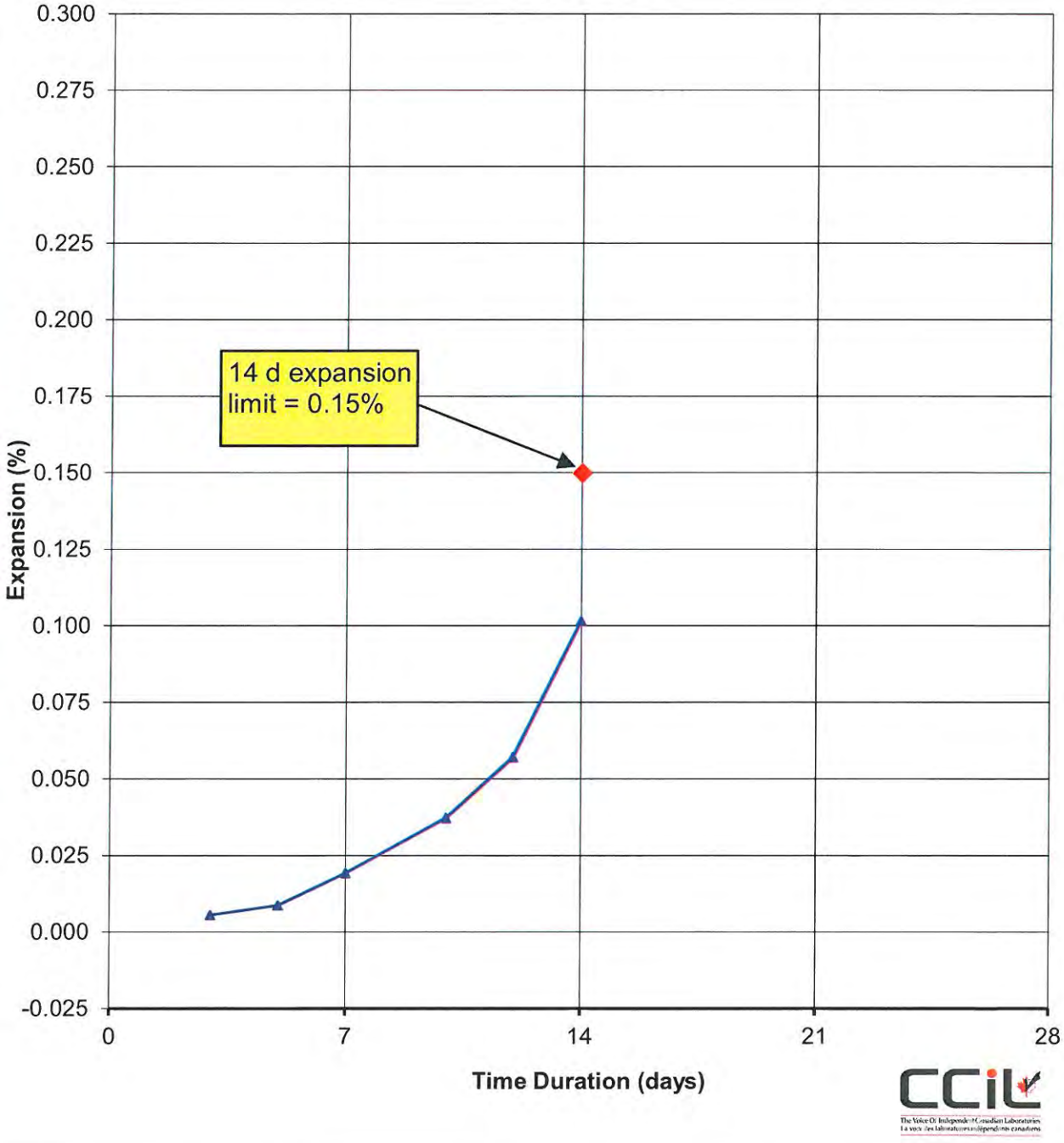
Reviewed by: _____
Damien O'Brien, EIT.

Notice: The test data given herein pertain to the sample provided, and may not be applicable to material from earlier or subsequent production. Reporting of these data constitutes a testing service. Interpretation may be provided upon request.

Levelton Consultants Ltd.
150 - 12791 Clarke Place., Richmond, B.C. Canada V6V 2H9 Tel: 604-278-1411 Fax: 604-278-1042

KP - Yukon Mine Aggregate Qualification
Alluvium - Natural Sand
TP13-01 Composite
File No.: R814-0178-00
April 8, 2014
Accelerated Alkali-Silica Reactivity Test
CSA A23.2-25A

LEVELTON



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TECHNICAL REPORT

LEVELTON

Date: April 8, 2014

File: R814-0178-00

To: Knight Piesold Ltd.
Suite 1400 – 750 West Pender St.
Vancouver, BC V6C 2T8

Attention: Mr. Sanne Brinkman, M.Sc.

PROJECT: KP – Yukon Mine Aggregate Qualification

SUBJECT: Micro-Deval Abrasion Test of Fine Aggregate (CSA A23.2-23A)

Product Tested: Alluvium - Natural Sand

Source: TP13-01 Composite **Sampled by:** Client

Date Received: December, 2013 **Date Tested:** March 11, 2014

Grading	Per Table 1
Initial mass of sample (g)	500.0
Final mass of sample (g)	434.8
Mass of charge (g)	1250.2
Loss (per run)	13.0%

NOTE: 1. Sutherland sand used as a control aggregate. Average loss: 18.6% (required range for Sutherland sand control aggregate = 15.0 – 25.0%).

CCIL

LEVELTON CONSULTANTS LTD.

Per: _____
Norman Chang, AScT

Reviewed By: _____
Damien O'Brien, EIT.

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Suite 1400 – 750 West Pender St.
Vancouver, BC V6C 2T8

Attention: Mr. Sanne Brinkman, M.Sc.

PROJECT: KP – Yukon Mine Aggregate Qualification

SUBJECT: Flat and Elongated Particles in Coarse Aggregate (CSA A23.2-13A)

Product Tested: Alluvium - Coarse Aggregate

Source: TP13-01 Composite **Sampled by:** Client

Date Received: December, 2013 **Date Tested:** March 10, 2014

SIZE Coarse Aggregate	FLAT	ELONGATED	FLAT AND ELONGATED	NEITHER FLAT NOR ELONGATED
	% mass	% mass	% mass	% mass
28 mm	0.0	0.0	9.6	90.4
20 mm	0.2	0.0	7.6	92.2
14 mm	0.9	0.0	8.1	91.0
10 mm	0.0	0.0	6.3	93.7
Weighted Average	0.3	0.0	8.0	91.7

Notes: Procedure A, ratio 4:1.

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Norman Chang, AScT

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Suite 1400 – 750 West Pender St.
Vancouver, BC V6C 2T8

Attention: Mr. Sanne Brinkman, M.Sc.

PROJECT: KP – Yukon Mine Aggregate Qualification

SUBJECT: Resistance of Unconfined Coarse Aggregate to Freezing and Thawing (CSA A23.2-24A)

Product Tested: Alluvium - Coarse Aggregate

Source: TP13-01 Composite **Sampled by:** Client

Date Received: December, 2013 **Date Tested:** March 18, 19, 21, 24, 25, 2014

Sieve Fraction	Retained (%)	Loss per Sieve (%)	Weighted Loss (%)
28 mm	15.1	0.3	0.1
20 mm	18.6	0.7	0.2
14 mm	14.4	0.6	0.1
10 mm	12.2	4.0	0.6
5 mm	23.6	8.1	2.3
Total Weighted Loss (%)			**3.3**

Note: 2. Control aggregate (Drain Bros. Aggregate) tested in this series gave a weighted loss of 13.7%. (Range of 8.5-15.3%)

LEVELTON CONSULTANTS LTD.

Per: _____
Norman Chang, AScT

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File: R814-0178-00

To: Knight Piesold Ltd.
Suite 1400 – 750 West Pender St.
Vancouver, BC V6C 2T8

Attention: Mr. Sanne Brinkman, M.Sc.

PROJECT: KP – Yukon Mine Aggregate Qualification

SUBJECT: Standard Test Method for Materials Finer than 80-µm (CSA A23.2-5A)

Product Tested: Alluvium – Natural Sand

Source: TP13-14 Composite **Sampled by:** Client

Date Received: December, 2013 **Date Tested:** March 13, 2014

Percentage of Material Finer than 80-µm	6.0%

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Per: _____
Norman Chang, AScT

Reviewed By: _____
Damien O'Brien, EIT.

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TECHNICAL REPORT

LEVELTON

Date: April 8, 2014

File: R814-0178-00

To: Knight Piesold Ltd.
Suite 1400 – 750 West Pender St.
Surrey, BC V4N 4X8

Attention: Mr. Sanne Brinkman, M.Sc.

PROJECT: KP – Yukon Mine Aggregate Qualification

SUBJECT: Clay Lumps and Friable Particles in Aggregates (CSA A23.2-3A)

Product Tested: Alluvium - Natural Sand

Source: TP13-14 BU-1 3.0-4.0 m **Sampled by:** Client

Date Received: December, 2013 **Date Tested:** February 20, 2014

Size of Particles (mm)	Mass of Sample (g)	Mass of Sample with Clay Lumps Removed (g)	Loss in Mass (g)	% Loss	% Retained in Original Gradation	Weighted % Loss
Fine Aggregate Portion						
5 - 1.25						
TOTAL LOSS (FINE PORTION)						**0.0**

Remarks: None per visual examination or readily apparent during S.G. preparation.

CCIL

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Per: _____
Norman Chang, AScT

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Date: April 8, 2014

File: R814-0178-00

To: Knight Piesold Ltd.
Suite 1400 – 750 West Pender St.
Vancouver, BC V6C 2T8

Attention: Mr. Sanne Brinkman, M.Sc.

PROJECT: KP – Yukon Mine Aggregate Qualification
SUBJECT: Test for Organic Impurities in Fine Aggregates for Concrete (CSA A23.2-7A)

Product Tested: Alluvium - Natural Sand

Source: TP13-14 Composite **Sampled by:** Client

Date Received: December, 2013 **Date Tested:** February 20, 2014

Colour Plate Index	No. 4

NOTES: 1. 3% NaOH solution used.

LEVELTON CONSULTANTS LTD.

Per: _____
Norman Chang, AScT

Reviewed By: _____
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Date: April 8, 2014

File: R814-0178-00

To: Knight Piesold Ltd.
Suite 1400 – 750 West Pender St.
Vancouver, BC V6C 2T8

Attention: Mr. Sanne Brinkman, M.Sc.

PROJECT: KP – Yukon Mine Aggregate Qualification

SUBJECT: Standard Test Method for Materials Finer than 80-µm (CSA A23.2-5A)

Product Tested: Granodiorite - Coarse Aggregate

Source: TP13-84 BU-1 **Sampled by:** Client

Date Received: December, 2013 **Date Tested:** March 13, 2014

Percentage of Material Finer than 80-µm	0.6%

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Per: _____
Norman Chang, AScT

Reviewed By: _____
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Date: April 8, 2014

File: R814-0178-00

To: Knight Piesold Ltd.
Suite 1400 – 750 West Pender St.
Surrey, BC V4N 4X8

Attention: Mr. Sanne Brinkman, M.Sc.

PROJECT: KP – Yukon Mine Aggregate Qualification

SUBJECT: Clay Lumps and Friable Particles in Aggregates (CSA A23.2-3A)

Product Tested: Granodiorite - Coarse Aggregate

Source: TP13-84 BU-1 **Sampled by:** Client

Date Received: December, 2013 **Date Tested:** February 20, 2014

Size of Particles (mm)	Mass of Sample (g)	Mass of Sample with Clay Lumps Removed (g)	Loss in Mass (g)	% Loss	% Retained in Original Gradation	Weighted % Loss
Coarse Aggregate Portion						
40 - 20						
20 - 10						
10 - 5						
TOTAL LOSS (COARSE PORTION)						**0.0**

Remarks: None per visual examination or readily apparent during S.G. preparation.

CCIL

LEVELTON CONSULTANTS LTD.

Per: _____ Reviewed By: _____

Norman Chang, AScT Damien O'Brien, EIT.

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Date: April 8, 2014

File: R814-0178-00

To: Knight Piesold Ltd.
Suite 1400 – 750 West Pender St.
Vancouver, BC V6C 2T8

Attention: Mr. Sanne Brinkman, M.Sc.

PROJECT: KP – Yukon Mine Aggregate Qualification

SUBJECT: Low-density Granular Material in Aggregate (CSA A23.2-4A)

Product Tested Granodiorite - Coarse Aggregate

Source: TP13-84 BU-1 **Sampled by:** Client

Date Received: December, 2013 **Date Tested:** March 10, 2014

COARSE AGGREGATE	
Percentage of low-density pieces	0.0%

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Per: _____
Norman Chang, AScT

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TECHNICAL REPORT

LEVELTON

Date: April 8, 2014

To: Knight Piesold Ltd.
Suite 1400 – 750 West Pender St.
Vancouver, BC V6C 2T8

Attention: Mr. Sanne Brinkman, M.Sc.

PROJECT: KP – Yukon Mine Aggregate Qualification

SUBJECT: Relative Density and Absorption of Coarse Aggregate (CSA 23.2-12A)

Product Tested Granodiorite - Coarse Aggregate

Source: TP13-84 BU-1 **Sampled by:** Client

Date Received: December, 2013 **Date Tested:** February 20, 2014

Sample	Bulk G_s (Dry Basis)	Bulk G_s (SSD Basis)	Absorption (%)
Coarse Aggregate	2.652	2.668	0.60

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To: Knight Piesold Ltd.
Suite 1400 – 750 West Pender St.
Vancouver, BC V6C 2T8

Attention: Mr. Sanne Brinkman, M.Sc.

PROJECT: KP – Yukon Mine Aggregate Qualification

SUBJECT: Flat and Elongated Particles in Coarse Aggregate (CSA A23.2-13A)

Product Tested: Granodiorite – Coarse Aggregate

Source: TP13-84 BU-1 **Sampled by:** Client

Date Received: December, 2013 **Date Tested:** March 10, 2014

SIZE Coarse Aggregate	FLAT	ELONGATED	FLAT AND ELONGATED	NEITHER FLAT NOR ELONGATED
	% mass	% mass	% mass	% mass
28 mm	0.0	0.0	0.0	100.0
20 mm	0.0	0.0	0.5	99.5
14 mm	5.8	0.0	7.5	86.7
10 mm	0.0	0.0	8.5	91.5
Weighted Average	0.9	0.0	1.9	97.2

Notes: Procedure A, ratio 4:1.

LEVELTON CONSULTANTS LTD.

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Norman Chang, AScT

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File: R814-0178-00

To: Knight Piesold Ltd.
Suite 1400 – 750 West Pender St.
Vancouver, BC V6C 2T8

Attention: Mr. Sanne Brinkman, M.Sc.

PROJECT: KP – Yukon Mine Aggregate Qualification

SUBJECT: Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine (CSA A23.2-16A)

Product Tested: Granodiorite – Coarse Aggregate

Source: TP13-84 BU-1 **Sampled by:** Client

Date Received: December, 2013 **Date Tested:** March 11, 2014

Sample	Coarse Aggregate
Grading	A
Revolutions	500
No. of Spheres	12
Initial Mass (g)	5001.2
Final Mass (g)	2907.2
Percent Loss	**41.9%**

LEVELTON CONSULTANTS LTD.

Per: Norman Chang, AScT

Reviewed by: Damien O'Brien, EIT.

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Vancouver, BC V6C 2T8

Attention: Mr. Sanne Brinkman, M.Sc.

PROJECT: KP – Yukon Mine Aggregate Qualification

SUBJECT: Resistance of Unconfined Coarse Aggregate to Freezing and Thawing (CSA A23.2-24A)

Product Tested: Granodiorite – Coarse Aggregate

Source: TP13-84 BU-1 **Sampled by:** Client

Date Received: December, 2013 **Date Tested:** March 18, 19, 21, 24, 25, 2014

Sieve Fraction	Retained (%)	Loss per Sieve (%)	Weighted Loss (%)
28 mm	34.3	0.1	0.0
20 mm	33.8	0.1	0.0
14 mm	13.7	0.2	0.0
10 mm	5.0	0.8	0.0
5 mm	5.7	0.5	0.0
Total Weighted Loss (%)			**0.0**

Note: 2. Control aggregate (Drain Bros. Aggregate) tested in this series gave a weighted loss of 13.7%. (Range of 8.5-15.3%)

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File: R814-0178-00

To: Knight Piesold Ltd.
Suite 1400 - 750 West Pender St.
Vancouver, BC

Attention: Mr. Sanne Brinkman, M.Sc

PROJECT: KP - Yukon Mine Aggregate Qualification

SUBJECT: Detection of Alkali-Silica Reactive Aggregate by Accelerated Expansion of Mortar Bars (CSA A23.2-25A)

Product Tested: Granodiorite - Coarse Aggregate

Source: TP13-84 BU-1 **Sampled by:** Client

Date Received: December, 2013 **Cast Date:** February 26, 2014

Percent Expansion (measured at test ages in days)										
Sample	3	5	7	10	12	14				
Crushed Coarse Aggregate	-0.002	0.007	0.013	0.017	0.021	0.028				
	-0.001	0.013	0.016	0.019	0.025	0.031				
	-0.001	0.011	0.014	0.016	0.022	0.030				
	-0.003	0.009	0.013	0.016	0.021	0.030				
	-0.002	**0.010**	**0.014**	**0.017**	**0.022**	**0.030**				
CSA Recommended Expansion Limits						0.150				
Spratt Limestone Control Aggregate						0.356				0.605

NOTES:

1. Stock cement (ESSROC, Picton, Type GU, Na_2O eq. of 0.85%) used in mix.
2. Water/cement ratio was 0.50.
3. Spratt Limestone Control Aggregate range after 14 days shall be between 0.30% and 0.55% and after 28 days shall be between 0.47% and 0.98%.

LEVELTON CONSULTANTS LTD.

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Norman Chang, AScT

Reviewed by: _____
Damien O'Brien, EIT.

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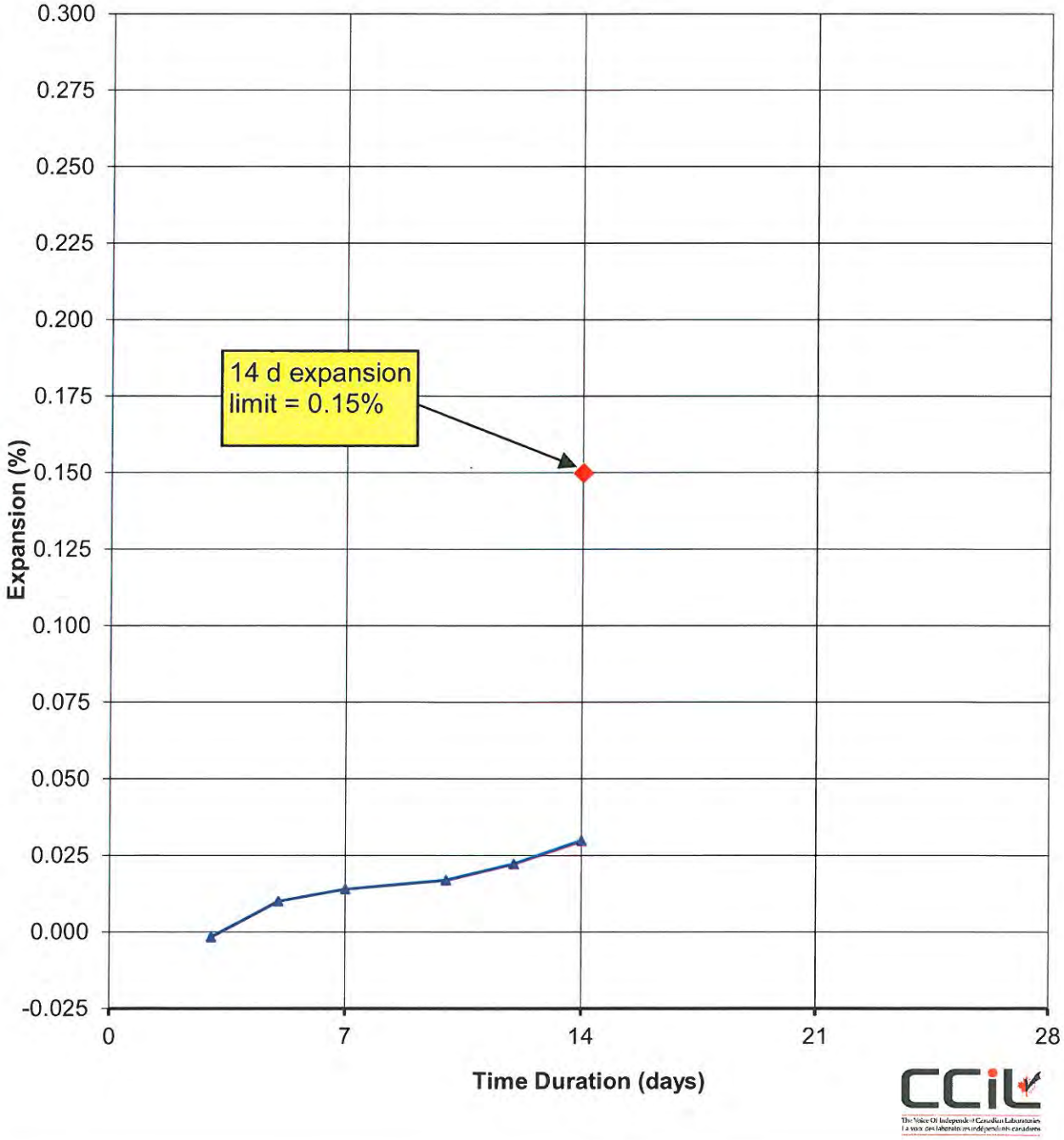
Levelton Consultants Ltd.
150 - 12791 Clarke Place., Richmond, B.C. Canada V6V 2H9 Tel: 604-278-1411 Fax: 604-278-1042

KP - Yukon Mine Aggregate Qualification
Granodiorite - Coarse Aggregate
TP13-84 BU-1
File No.: R814-0178-00
April 8, 2014
Accelerated Alkali-Silica Reactivity Test
CSA A23.2-25A

LEVELTON



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The Voice Of Independent Canadian Laboratories
La voix des laboratoires indépendants canadiens

TECHNICAL REPORT

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Date: April 8, 2014

File: R814-0178-00

To: Knight Piesold Ltd.
Suite 1400 – 750 West Pender St.
Vancouver, BC V6C 2T8

Attention: Mr. Sanne Brinkman, M.Sc.

PROJECT: KP – Yukon Mine Aggregate Qualification

SUBJECT: Micro-Deval Abrasion Test of Coarse Aggregate (CSA A23.2-29A)

Product Tested: Coarse Aggregate

Source: Granodiorite – Coarse Aggregate **Sampled by:** Client

Date Received: December, 2013 **Date Tested:** March 10, 2014

Grading	6.2
Initial mass of sample (g)	1553.3
Final mass of sample (g)	1332.4
Mass of charge (g)	5002.5
Loss (per run)	14.2%

NOTE: 1. Drain Bros stone used as a control aggregate. Average loss: 18.1% (required range for Drain Bros control aggregate = 17.5 – 20.7%).

LEVELTON CONSULTANTS LTD.

Per: _____
Norman Chang, AScT

Reviewed By: _____
Damien O'Brien, EIT.

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Vancouver Petrographics Ltd.
8080 GLOVER ROAD, LANGLEY, B.C. V1M 3S3
PHONE: 604-888-1323 • FAX: 604-888-3642
email: vanpetro@vanpetro.com
Website: www.vanpetro.com

Sample 13-01 Natural Sand

Report for: Mr. Norman Chang
Levelton Consultant Ltd.
150-12791 Clarke Place
Richmond, B.C V6V 2H9

Sent to: Mr. Norman Chang
nchang@levelton.com

Report 140200

March 31, 2014

Petrographic Examination of the Aggregate Samples Granodiorite (TP13-84 BU-1) Coarse Aggregate, Alluvium (TP13-01 Composite) Natural Sand, and Alluvium (TP13-14 BU-1 3.0-4.0 m) Natural Sand

Fabrizio Colombo, Ph.D., P.Geo.

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1. Introduction

Mr. Norman Chang of Levelton Consultants Ltd. submitted one coarse aggregate (Granodiorite (TP13-84 BU-1) Coarse Aggregate) and two fine aggregates (Alluvium (TP13-01 Composite) Natural Sand, and Alluvium (TP13-14 BU-1 3.0-4.0 m) Natural Sand) to Vancouver Petrographics for petrographic examination according to the Standard CSA A23.2-15A.

2. Detailed Petrographic Examination of Coarse Aggregate "Granodiorite (TP13-84 BU-1) Coarse Aggregate"

2.1. Methodology

The sample was examined as received. It was washed and dried, then was examined with the naked eyes. In some cases a 10× lens was used. No thin section was prepared in the identification of the coarse aggregate.

2.2. Petrographic quality

In accordance with methods in use in the aggregate industry, the coarse size fractions were classified on the basis of the petrographic number (PN) method (see Table 1). Using standard petrographic quality multipliers for the various quality classifications of each rock type, a PN of 100 was calculated for the sample. The PN indicates a "good" rating. Table 1 details the rock types classified as "good", "fair", or "poor", according to the specifications of CSA 23.2-15A. The coarse aggregate sample did not present significant coating.

2.3. Results

The 5–14 mm coarse aggregate is made up of the plutonic rock "Granodiorite (TP13-84 BU-1) Coarse Aggregate", and its PN of 100 is judged to be "good" in its physical-mechanical quality for concrete production. The rock is made up of plagioclase, quartz, biotite, magnetite and probably hornblende. Subordinate and sub-ellipsoidal masses of fine-grained microdiorite are dispersed as inclusions within the granodiorite. The microdiorite is made up of biotite/hornblende, plagioclase and quartz. The granodiorite shows very high strength. Apart from the subordinate subordinate microdiorite, which is richer in mica and can be scratched and scraped with some difficulty, the aggregate cannot be scratched. The sample is fresh and does not show coatings.

Concerning chemical stability, the aggregate is interpreted to have a low reactivity (Ingham, 2012); however, feldspar, biotite, chlorite, and clay have been reported as promoting an alkali-carbonate reaction in concrete (Stark and Bhatty, 1986), therefore it is recommended that the

alkali-aggregate reactivity (AAR) potential of the aggregate be assessed. The biotite may affect the compressive strenght of the concrete (Schmitt, 1990).

Table 1: Detailed petrographic examination of Sample Granodiorite (TP13-84 BU-1) Coarse Aggregate.

Sample ID: "Granodiorite (TP13-84 BU-1) Coarse Aggregate"		**Sieve fraction: 5–14 mm**
Petrographer: Fabrizio Colombo Ph.D., P.Geo.		**Date tested: March 26, 2014**
Petrographic description and quality	**Per cent by mass**	**Petrographic number contribution**
Good (PN Multiplier: 1)		
Granodiorite	100	100
Fair (PN Multiplier: 3)		
Poor (PN Multiplier: 6)		
Total	100	100
Notes:		
1 The Petrographic Number (PN) is not related to the potential for alkali-aggregate reactivity (AAR) of this aggregate when used in Portland cement concrete. AAR potential must be separately assessed.		
2 Rock types indicated by * may have potential for alkali-aggregate reaction (AAR).		
See CSA A23.1 and CSA A23.2 for information on the assessment of AAR in new concrete construction.		

Table 2: Suggested limits of the petrographic number (PN) for aggregate quality classifications (from CSA 23.2 15A).

Product type	***PN limits***
Concrete class C1, C2, F1	*125 max*
Other concrete classes	*140 max*
Shotcrete	*125 max*
Railroad ballast	*125 max*
Granular base	*150 max*
Select granular sub base	*160 max*

3. Detailed Petrographic Examination of Fine Aggregates " Alluvium (TP13-01 Composite) Natural Sand" and "Alluvium (TP13-14 BU-1 3.0-4.0 m) Natural Sand"

3.1. Methodology

The fine aggregates were examined with a stereomicroscope, and 12 polished thin sections were prepared from a representative portion of each size fraction. A minimum of 300 particles were examined for each size fraction under the stereomicroscope or a petrographic microscope, and the results are summarized in Table 3a and 3b (Sample Alluvium (TP13-01 Composite) Natural Sand and Sample Alluvium (TP13-14 BU-1 3.0-4.0 m) Natural Sand, respectively) and Figure 1a and 1b. The petrographic features of each rock type and mineral are listed in Table 4 and are shown in the photomicrographs attached in Appendix A.

3.2. Alkali-aggregate reactivity

Some of the minerals identified in the two samples, namely clay, and feldspar (see Table 3a and 3b for their relative abundance), have a reactivity potential for AAR with the alkali compounds in Portland cement (Ingham, 2013). If the aggregate has not been previously evaluated for AAR in accordance with the test methods and criteria given in CSA A23.1, it is recommended that such assessment be carried out.

3.3. Results

3.3.1 Sample Alluvium (TP13-01 Composite) Natural Sand

This sample is made up of quartz, feldspar, quartz-feldspar intergrowths, amphibole, clay, biotite, white mica, epidote, iron oxides, metamorphic schist, quartz breccia, carbonate, magnetite and chlorite. Aggregates rich in quartz, feldspar, and amphibole are intergrown with and enclose subordinate amounts of minerals, which are listed in Table 3a and Table 4 and are documented by photomicrographs in Appendix A.

3.3.2 Sample Alluvium (TP13-14 BU-1 3.0-4.0 m) Natural Sand

This sample is made up of feldspar, feldspar and quartz intergrowths, quartz, clay, biotite, iron oxides, amphibole, brecciated feldspar and quartz, white mica, titanite, magnetite, epidote, pyrite, carbonate and chlorite. The feldspar- and quartz-rich fragments are intergrown with and enclose subordinate amounts of minerals, which are listed in Table 3a and Table 4.

3.4. Discussion

The two samples show different mineral compositions, which can be summarised as more abundant quartz in Sample Alluvium (TP13-01 Composite) Natural Sand and more abundant feldspar in Sample Alluvium (TP13-14 BU-1 3.0-4.0 m) Natural Sand. In both samples, the feldspar-quartz intergrowths are liberated in the size fraction 0.630–0.315 mm. Sample Alluvium (TP13-01 Composite) Natural Sand hosts more abundant amphibole, and subordinate fragments of metamorphic schists, which must be considered one of the protoliths from which this aggregate, in association with quartzo-feldspathic plutonic rocks, was generated.

Both samples contain fragments of brecciated quartz. The strained quartz contained within the brecciated fragments is reported as having a potential AAR (Ingham, 2013). Despite the small amount of these brecciated fragments, it must be considered that some of the quartz and the feldspar-quartz intergrowths show different degrees of strain, which is indicated by strong undulose extinction of the quartz under crossed Nicols in transmitted polarized light. The AAR potential must be separately assessed in these two samples.

Table 3a: Detailed petrographic examination of fine aggregate—Alluvium (TP13-01 Composite) Natural Sand.

Sample Number: *Alluvium (TP13-01 Composite) Natural Sand* Sieve fraction:0.080–5.00 mm

Petrographer: Fabrizio Colombo Ph.D., P.Geo. Date tested: 27 March, 2014

	Total per sieve fraction						
	5.00–2.50 mm	2.50–1.25 mm	1.25–0.630 mm	0.630–0.315 mm	0.315–0.160 mm	0.160–0.080 mm	Weighted content (%)
	g						
	105.0	**216.0**	**198.0**	**194.0**	**90.0**	**46.0**	
	%						
Mineral type	**12.4**	**25.4**	**23.3**	**22.9**	**10.6**	**5.4**	
quartz ±biotite±amphibole±white mica±clay±iron oxides	18.0	27.4	39.7	44.3	29.2	24.1	33.0
feldspar ±amphibole±biotite±quartz±white mica±clay±chlorite±iron oxides	6.8	13.7	49.1	40.2	37.5	29.3	30.5
feldspar-quartz ±clay±epidote±amphibole±iron oxides±biotite±white mica±pyrite	58.6	41.7	1.3				18.2
amphibole ±epidote±quartz±iron oxides	1.5	5	6.0	3.3	7.9	12.5	5.1
clay	3.8	7.2	2.0	3.3	4.6	3.6	4.2
biotite±clay				3.3	9.9	16.2	2.7
quartz and clay	4.5						0.6
white mica		2.2	1.3	3.0	2.6	1.7	1.9
epidote±biotite±quartz±magnetite	3.0			0.3	5.0	5.0	1.2
iron oxides			0.3	2.0	2.6	5.3	1.1
quartz±amphibole±epidote±feldspar±biotite schist	3.8						0.5
clay and iron oxides		1.4	0.3				0.4
quartz breccia		1.4					0.4
carbonate					0.7	1.0	0.1
magnetite						1.3	0.1
chlorite				0.3			0.1
Totals	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 3b: Detailed petrographic examination of fine aggregate—Sample Alluvium (TP13-14 BU-1 3.0-4.0 m) Natural Sand.

Sample Number: Alluvium (TP13-14 BU-1 3.0-4.0 m) Natural Sand
Petrographer: Fabrizio Colombo Ph.D., P.Geo.
Sieve fraction:0.080–5.00 mm
Date tested: 26 March, 2014

	Total per sieve fraction						
	5.00–2.50 mm	2.50–1.25 mm	1.25–0.630 mm	0.630–0.315 mm	0.315–0.160 mm	0.160–0.080 mm	Weighted content (%)
	g						
	45.0	**89.0**	**160.0**	**148.0**	**139.0**	**281.0**	
	%						
Mineral/rock type	**5.2**	**10.3**	**18.6**	**17.2**	**16.1**	**32.6**	
feldspar ±white mica±clay±epidote	14.1	14.8	30.1	46.6	49.4	40.0	36.9
quartz ±clay±iron oxides	28.6	29.5	24.8	30.2	18.3	18.2	23.2
feldspar-quartz ±amphibole±biotite±chlorite±magnetite	52.2	45.4	31.4				13.2
biotite±clay		1.6	1.7	6.0	14.4	21.0	10.7
clay	2.2	4.9	7.3	12.6	6.1	1.6	5.6
iron oxides±hematite	1.5	1.1	0.7	4.0	4.5	6.7	3.9
amphibole		1.6	1.7	0.3	4.5	7.8	3.8
white mica			1.0		0.3	1.6	0.8
titanite					0.3	1.9	0.7
magnetite					2.2	0.6	0.5
feldspar and quartz breccia	0.7	1.0	1.0				0.3
epidote				0.3			0.1
clay-iron oxide	0.7		0.3				0.1
carbonate						0.3	0.1
chlorite						0.3	0.1
pyrite		0.1					traces
Totals	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Figure 1a: Mineral content in the different sieve fractions of the Sample Alluvium (TP13-01 Composite) Natural Sand.

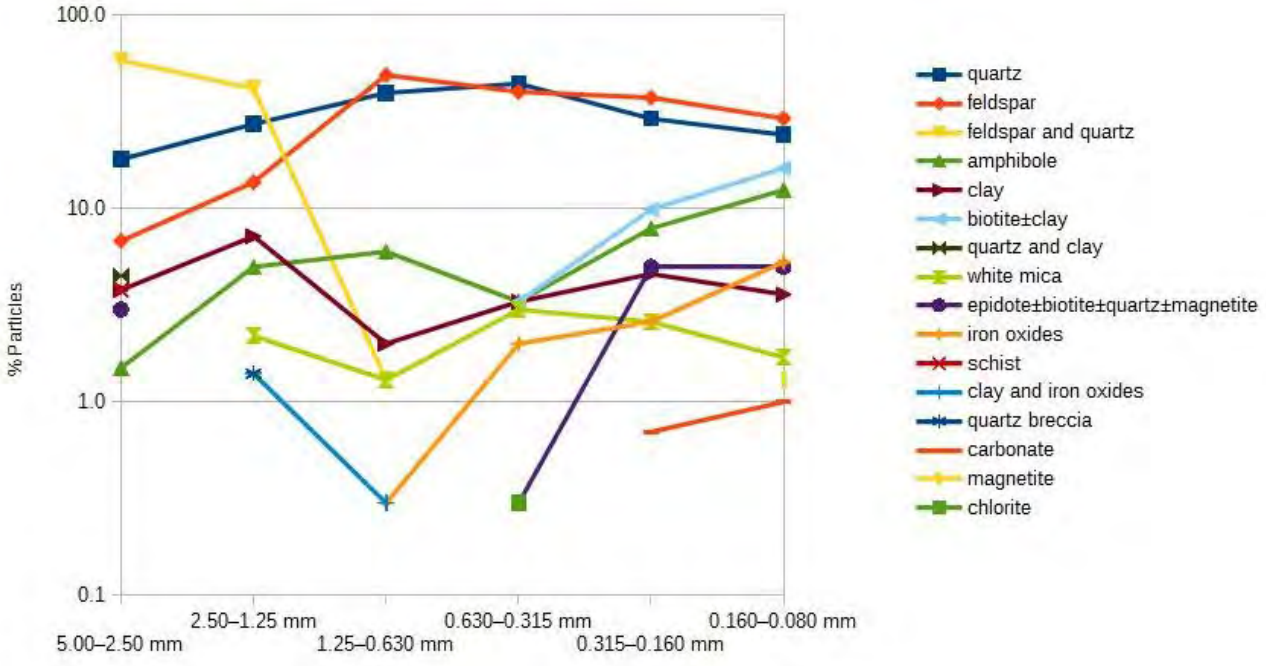

Figure 1b: Mineral content in the different sieve fractions of the Sample Alluvium (TP13-14 BU-1 3.0-4.0 m) Natural Sand.

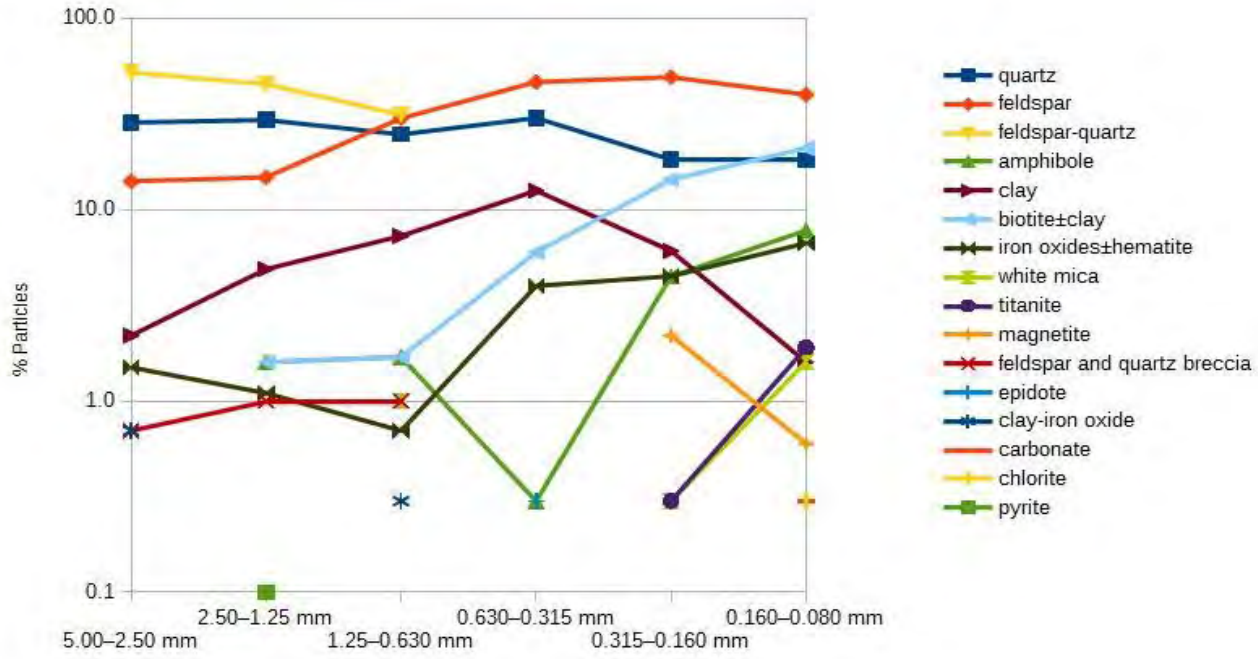

Table 4a: Petrographic Analysis of the Aggregate Sample Alluvium (TP13-01 Composite) Natural Sand.

Mineral type	Physical Quality	Chemical Quality	In whole sample (%)	Photomicrographs
quartz and subordinate inclusions/intergrowths of biotite±amphibole±white mica±clay±iron oxides	Good; it cannot be scratched. It may be brittle.	Mostly innocuous; strained quartz may have a potential AAR.	33.0	1, 7, 8
feldspar and subordinate inclusions/intergrowths of amphibole±biotite±quartz±white mica±clay±chlorite±iron oxides	Good; some of the feldspar may be altered by clay and white mica.	Mostly innocuous; feldspar may have a potential AAR; it may contain varying amounts of clay.	30.5	6, 7, 8
feldspar, quartz and subordinate inclusions/intergrowths of clay±epidote±amphibole±iron oxides±biotite±white mica±pyrite	Good; in some cases the aggregate may be brittle.	Mostly innocuous; strained quartz and feldspar may have a potential AAR; it may contain varying amounts of clay; rare pyrite.	18.2	2, 5, 6
amphibole and subordinate inclusions/intergrowths of epidote±quartz±iron oxides	Good; prismatic shape.	Innocuous.	5.1	7, 8
clay	Fair to poor; it is soft and can be scratched.	Potentially deleterious. Clay may promote AAR.	4.2	7
biotite±clay	Good to fair; crystals are mostly flat.	Biotite may reduce the compressive strenght.	2.7	7, 8
quartz and clay	Fair to poor; the clay-rich aggregate are soft and can be scratched.	Potentially deleterious. Clay may promote AAR	0.6	
white mica	Fair; it can be soft and can be scratched.	White mica may promote AAR.	1.9	
epidote±biotite±quartz ±magnetite	Good to fair; the aggregate may be brittle.	Innocuous.	1.2	8
iron oxides	Fair to poor; the aggregate may be brittle.	Potentially deleterious.	1.1	8
quartz±amphibole±epidote ±feldspar±biotite **schist**	Good to fair; aggregates may be flat.	Mostly innocuous, feldspar may have a potential AAR; it may contain varying amounts of clay.	0.5	3, 4
clay and iron oxides	Poor; soft and brittle.	Potentially deleterious.	0.4	5, 6
quartz breccia	Fair; the aggregate may be brittle.	Potentially deleterious. Strained quartz may have a potential AAR.	0.4	
carbonate	Fair. The crystals are soft and can be scratched.	Innocuous.	0.1	
magnetite	Good to fair; some crystals are variably altered by hematite.	Potentially deleterious, as it promotes oxidation.	0.1	
chlorite	Fair. The crystals are soft, can be scratched, and may occur as flat particles.	Potentially deleterious, as it may contain varying amounts of clay and it may promote oxidation.	0.1	

Table 4b: Petrographic Analysis of the Aggregate Sample Alluvium (TP13-14 BU-1 3.0-4.0 m) Natural Sand.

Mineral type	Physical Quality	Chemical Quality	In whole sample (%)	Photomicrographs
feldspar and subordinate inclusions/intergrowths of white mica±clay ±epidote	Good; some of the feldspar may be altered by clay and white mica.	Mostly innocuous; feldspar may have a potential AAR; it may contain varying amounts of clay.	36.9	11, 13, 14
quartz and subordinate inclusions/intergrowths of clay±iron oxides	Good; it cannot be scratched. It may be brittle.	Mostly innocuous; strained quartz may have a potential AAR.	23.2	11, 13, 14
feldspar-quartz and subordinate inclusions/intergrowths of amphibole± biotite±chlorite±magnetite	Good; in some cases the aggregate may be brittle.	Mostly innocuous; strained quartz and feldspar may have a potential AAR; it may contain varying amounts of clay; rare pyrite.	13.2	9, 12
biotite±clay	Good to fair; crystals are mostly flat.	Biotite may reduce the compressive strenght.	10.7	11, 13, 14
clay	Fair to poor; it is soft and can be scratched.	Potentially deleterious. Clay may promote AAR.	5.6	10, 13
iron oxides±hematite	Fair to poor; the aggregate may be brittle.	Potentially deleterious.	3.9	13, 14
amphibole	Good; prismatic shape.	Innocuous.	3.8	12, 14
white mica	Fair; it can be soft and can be scratched.	White mica may promote AAR.	0.8	
titanite	Good.	Innocuous.	0.7	
magnetite	Good to fair; some crystals are variably altered by hematite.	Potentially deleterious, as it promotes oxidation.	0.5	
feldspar and quartz breccia	Fair; the aggregate may be brittle.	Potentially deleterious. Strained quartz and feldspar may have a potential AAR; the particles may contain varying amounts of clay.	0.3	
epidote	Good to fair; the aggregate may be brittle.	Innocuous.	0.1	
clay-iron oxide	Poor; soft and brittle.	Potentially deleterious.	0.1	11
carbonate	Fair. The crystals are soft and can be scratched.	Innocuous.	0.1	
chlorite	Fair. The crystals are soft, can be scratched, and may occur as flat particles.	Potentially deleterious, as it may contain varying amounts of clay and it may promote oxidation.	0.1	
pyrite	Fair; some crystals are variably altered by iron oxides.	Potentially deleterious, as it promotes oxidation.	traces	

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Signed by

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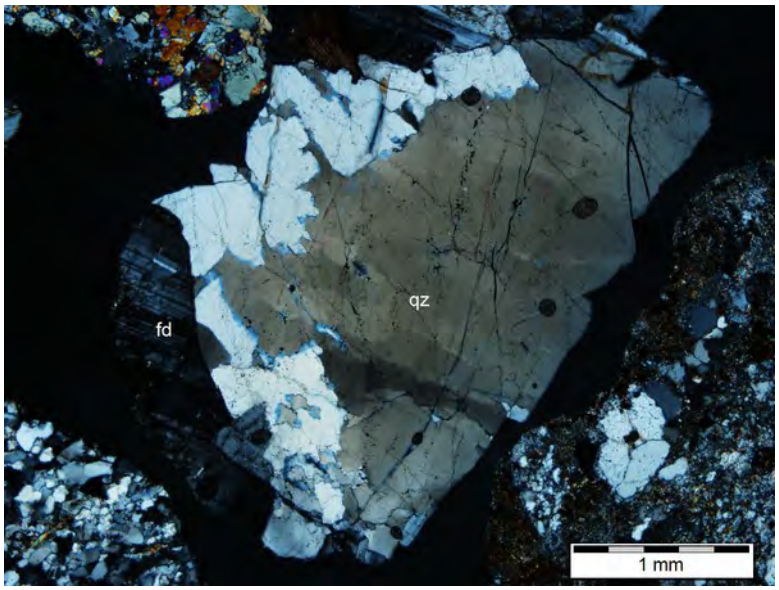
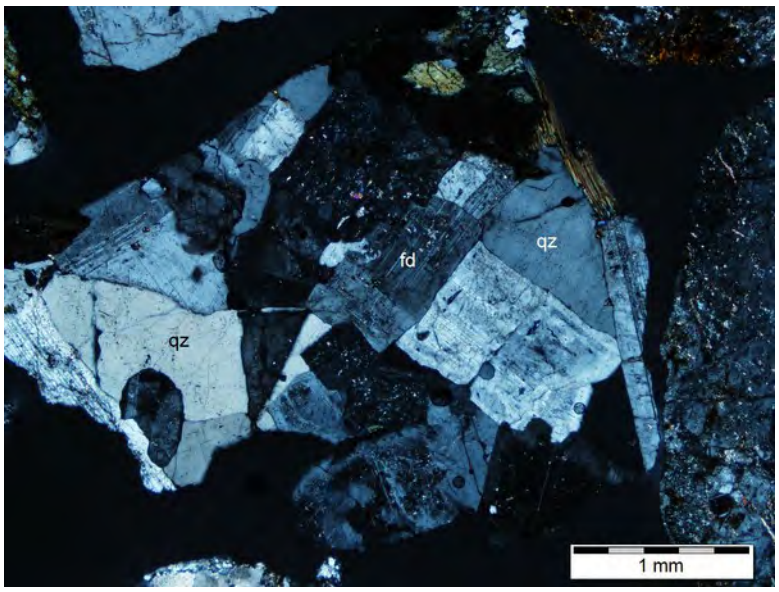
Appendix A

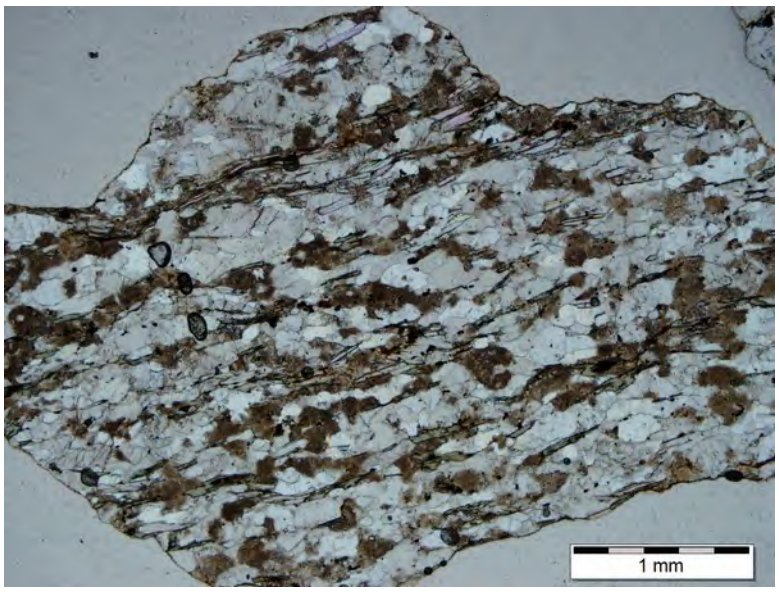
Photomicrographs of Sample Alluvium (TP13-01 Composite) Natural Sand



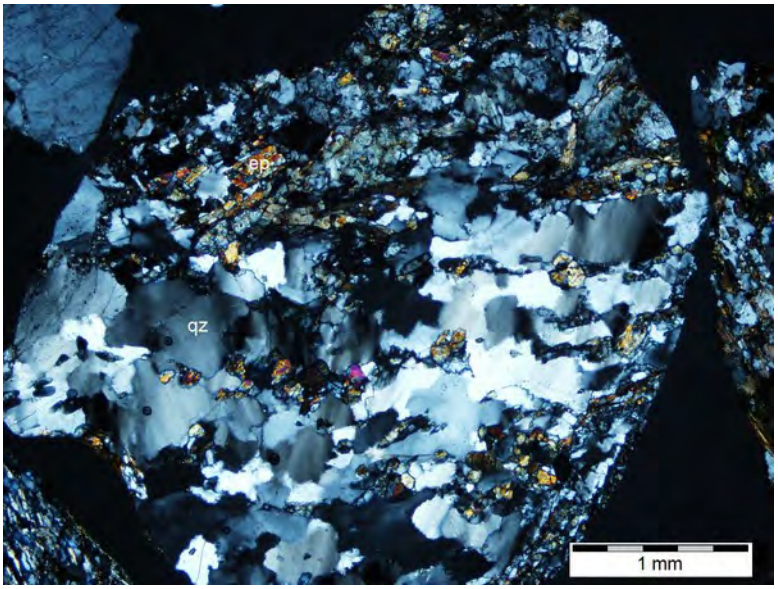
Photomicrograph 1. Sample Alluvium (TP13-01 Composite) Natural Sand, sieve fraction 5.00–2.50 mm*: Angular fragments of quartz (qz) are fractured and show varying amount of internal deformation. In this fragment the quartz is intergrown with subordinate plagioclase (fd). Crossed Nicols transmitted light.*



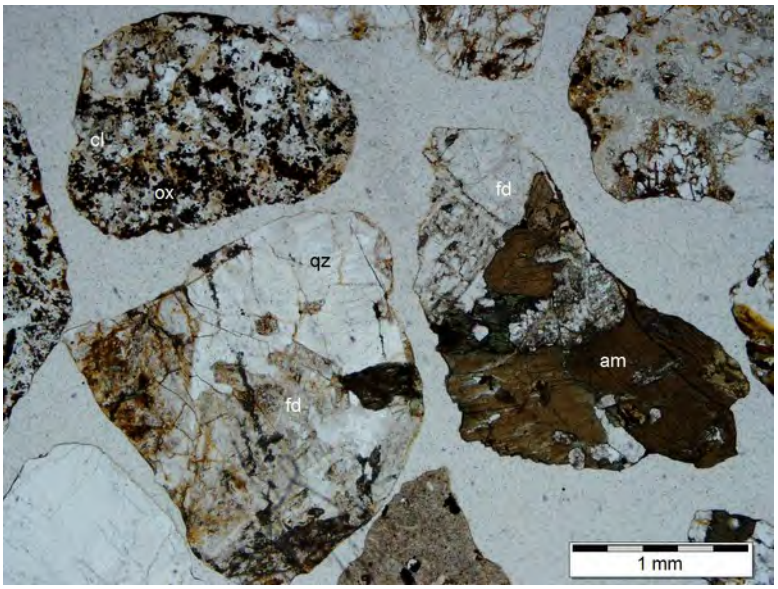
Photomicrograph 2. Sample Alluvium (TP13-01 Composite) Natural Sand, sieve fraction 5.00–2.50 mm*: Angular fragments of quartz (qz) and feldspar (fd) are intergrown and form the most abundant fragment type in this sieve fraction. The shape of the feldspar indicate this fragment is a plutonic rock (granitoid?). Crossed Nicols transmitted light.*



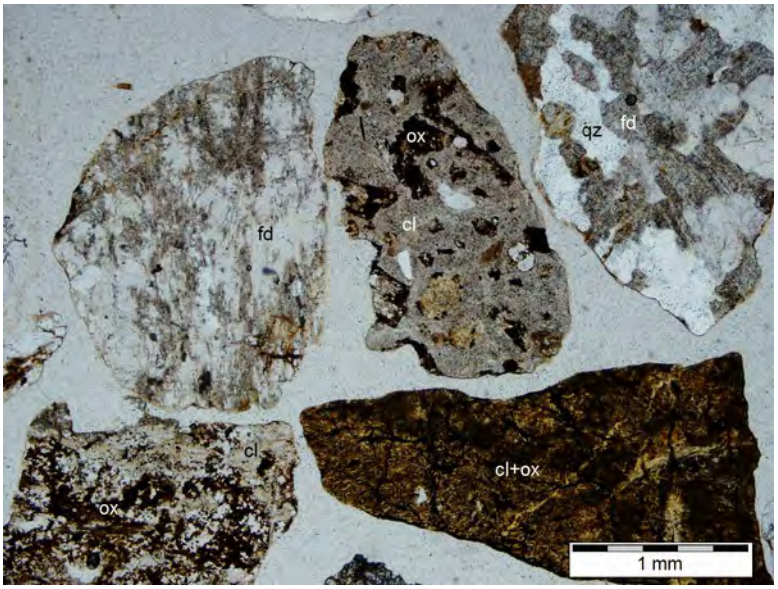
Photomicrograph 3. Sample Alluvium (TP13-01 Composite) Natural Sand, sieve fraction 5.00–2.50 mm*: The angular fragment of schist is made up of quartz (white), feldspar (earthy appearence) and shows a sub-planar foliation defined by iso-oriented white mica (lamellar crystals). Plane-polarized transmitted light.*



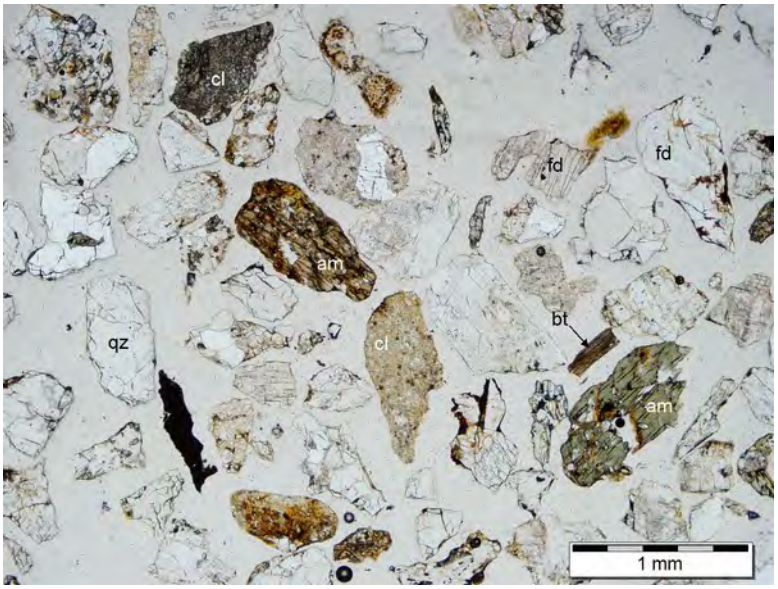
Photomicrograph 4. Sample Alluvium (TP13-01 Composite) Natural Sand, sieve fraction 5.00–2.50 mm*: The sub-rounded fragment of quartz (qz), epidote (ep) and amphibole was probably generated during a metamorphic event. The quartz shows undulose extinction. Crossed Nicols transmitted light.*



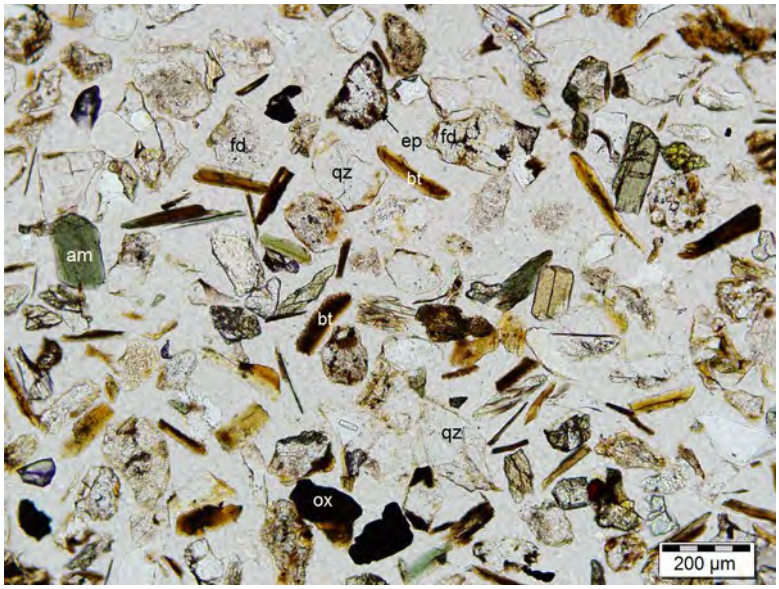
Photomicrograph 5. Sample Alluvium (TP13-01 Composite) Natural Sand, sieve fraction 2.50–1.25 mm*: Two of the fragments in this photomicrographs are made up of feldspar (fd), quartz (qz), amphibole (am), and are probably derived from a intrusive granitoid. In the upper left of the photomicrograph the sub-rounded fragment is made up of very fine-grained clay (cl) and iron oxides (ox). Plane-polarized transmitted light.*



Photomicrograph 6. Sample Alluvium (TP13-01 Composite) Natural Sand, sieve fraction 2.50–1.25 mm*: The fragments in the lower part of this photomicrograph are made up of varying amount of clay (cl) and iron oxides (ox). A crystal fragment of feldspar (fd) is slightly altered by clay (on the left). A volcanic fragment (center-right) is replaced by clay (cl) and iron oxides (ox), and in the upper right a granitic rock is distinguished by the intergrowth of feldspar (fd) and quartz (qz). Plane-polarized transmitted light.*

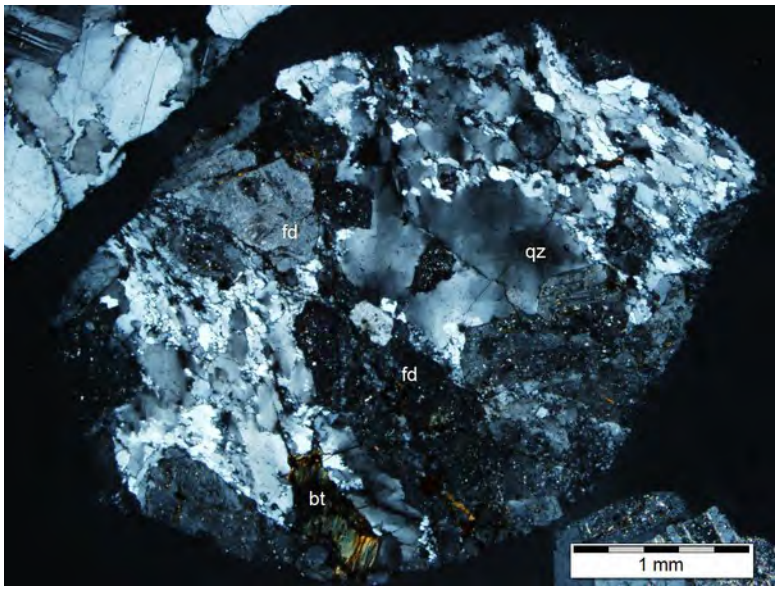


Photomicrograph 7. Sample Alluvium (TP13-01 Composite) Natural Sand, sieve fraction 0.630–0.315 mm*: In this sieve fraction the quartz (qz) and feldspar are mostly liberated and the percentage of clay-rich fragments (cl) and lamellar biotite (bt) increases. Plane-polarized transmitted light.*

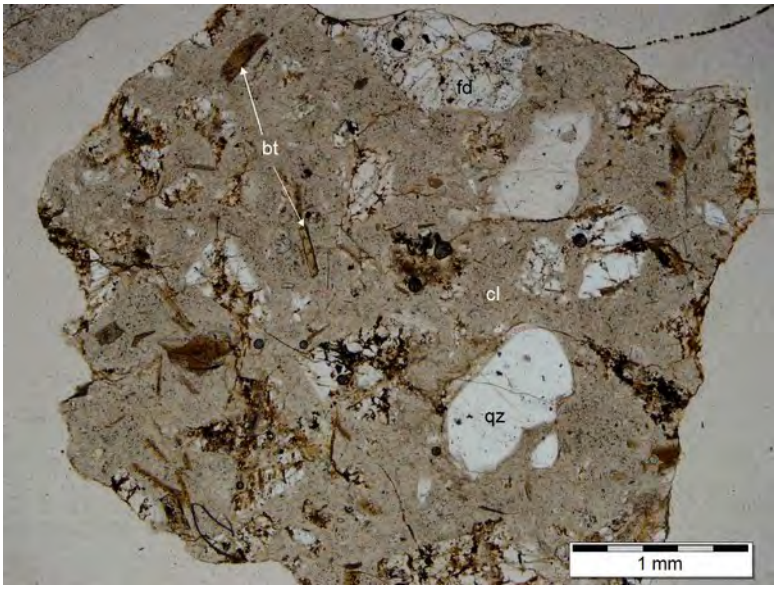


Photomicrograph 8. Sample Alluvium (TP13-01 Composite) Natural Sand, sieve fraction 0.160–0.080 mm*: The crystal fragments of quartz (qz), feldspar (fd) and biotite (bt) prevail in the finest sieve fraction. Fragments of epidote (ep), amphibole (am) and iron oxides are also distinguished in this photomicrograph. Plane-polarized transmitted light.*

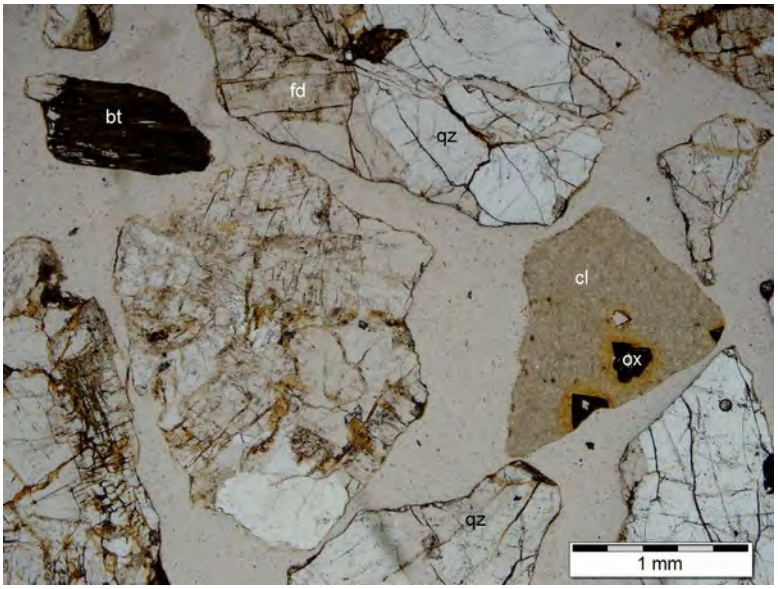
Photomicrographs of Sample Alluvium (TP13-14 BU-1 3.0-4.0 m) Natural Sand



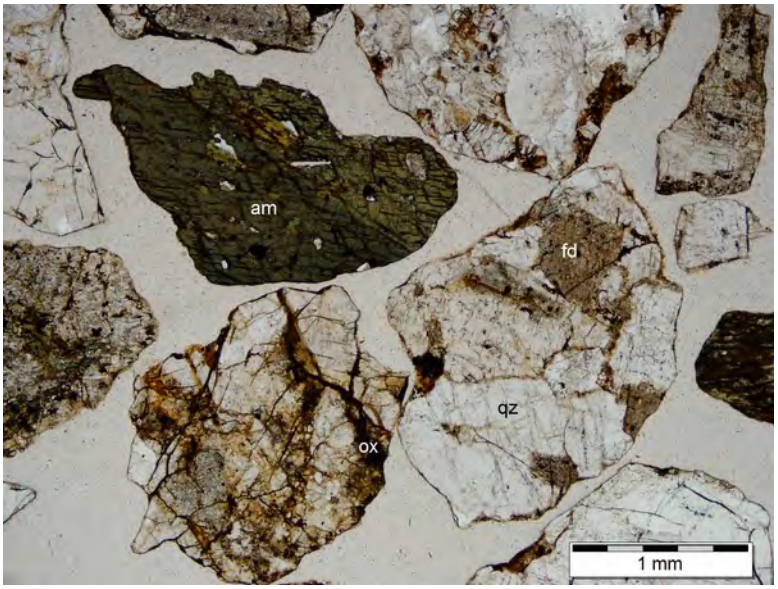
Photomicrograph 9. Sample Alluvium (TP13-14 BU-1 3.0-4.0 m) Natural Sand, sieve fraction 5.00–2.50 mm*: Feldspar (fd) and quartz (qz) are intergrown with subordinate biotite (bt) within this sub-rounded fragment. Crossed Nicols transmitted light.*



Photomicrograph 10. Sample Alluvium (TP13-14 BU-1 3.0-4.0 m) Natural Sand, sieve fraction 5.00–2.50 mm*: Quartz (qz), feldspar (fd) and biotite (bt) are immersed within a clay-rich aggregate within this altered fragment of volcanic rock. Plane-polarized transmitted light.*



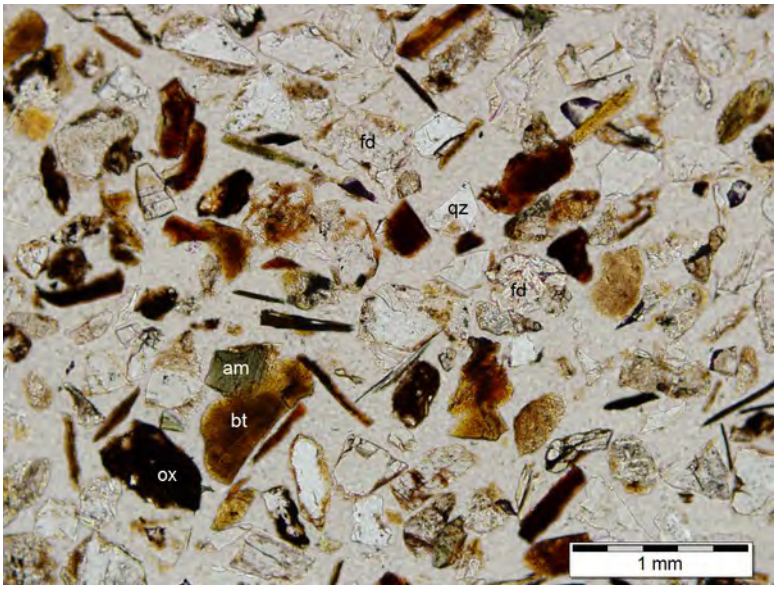
Photomicrograph 11. Sample Alluvium (TP13-14 BU-1 3.0-4.0 m) Natural Sand, sieve fraction 2.50–1.25 mm*: Angular fragments of feldspar (fd) and quartz (qz) are associated with fragments of quartz (qz), clay (cl) and iron oxides (ox) and biotite in this photomicrograph. Plane-polarized transmitted light.*



Photomicrograph 12. Sample Alluvium (TP13-14 BU-1 3.0-4.0 m) Natural Sand, sieve fraction 2.50–1.25 mm*: The fragments of feldspar (fd) and quartz (qz) host varying amounts of iron oxides (ox), which are probably generated by the weathering of ferromagnesian minerals. Angular fragments of amphibole (am) and the microstructure of the feldspar and quartz aggregates indicate that most of the fragments are derived from plutonic rock. Plane-polarized transmitted light.*



Photomicrograph 13. Sample Alluvium (TP13-14 BU-1 3.0-4.0 m) Natural Sand, sieve fraction 0.630–0.315 mm*: Most of the quartz (qz) and the feldspar (fd) are liberated in this sieve fraction, and are associated with subordinate biotite (bt), amphibole (am), clay (cl) and iron oxides (ox). Plane-polarized transmitted light.*



Photomicrograph 14. Sample Alluvium (TP13-14 BU-1 3.0-4.0 m) Natural Sand, sieve fraction 0.160–0.080 mm*: Within this sieve fraction the feldspar (fd) is the most abundant mineral, and is associated with biotite (bt), quartz (qz), amphibole (am), and iron oxides (ox). The biotite tends to occur as lamellar crystals. Plane-polarized transmitted light.*

APPENDIX A.4R: Report on Laboratory Geotechnical Testing of Tailings Materials



CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT





REPORT ON LABORATORY GEOTECHNICAL TESTING OF TAILINGS MATERIALS

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VA101-325/8-1
Rev 0
December 21, 2012

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CASINO COPPER-GOLD PROJECT

REPORT ON LABORATORY GEOTECHNICAL TESTING OF TAILINGS MATERIALS
VA101-325/8-1

Rev	Description	Date	Approved
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EXECUTIVE SUMMARY

A laboratory testing program has been conducted to determine the geotechnical characteristics of the Casino tailings materials. The tailings sample provided by Casino Mining Corporation for testing represents Non Acid Generating (NAG) Whole Tailings. This sample was used to generate representative samples of tailings Cyclone Overflow (fine tailings) and Cyclone Underflow (sand) materials. A sample of Potentially Acid Generating (PAG) tailings (with pyrite) was not available for testing at this time.

The test program included index testing to enable geotechnical classification of the materials, and slurry settling, air drying, consolidation and permeability testing to determine the characteristics of the Whole Tailings and Cyclone Overflow following deposition and for a range of conditions (representative of expected field conditions).

The Whole Tailings material can generally be described as non-plastic sand and silt with trace clay. The particle size distribution of the Whole Tailings sample comprises approximately 58% fine sand, 35% silt and 7% clay. The Cyclone Overflow sample was generated to a target particle size distribution with approximately 75% fines (silt and clay fractions). The resulting cyclone overflow material comprised approximately 23% sand, 69% silt and 8% clay (77% total fines). Similarly, the Cyclone Underflow sample was generated for a target particle size distribution with a maximum of 15% fines. The resulting cyclone underflow material comprised approximately 85% sand, 13% silt and 2% clay (15% total fines).

The specific gravity of the tailings solids was determined to be 2.70 for the Whole Tailings sample, 2.71 for the Cyclone Overflow sample, and 2.80 for the Cyclone Underflow sample.

Undrained settling, drained settling and air drying tests were carried out on slurry samples of the Whole Tailings and Cyclone Overflow. The Whole Tailings slurry was tested at a target solids content of 55%, corresponding to the current design value. The Cyclone Overflow slurry was tested at three solids contents (approximately 25%, 40% and 55%) to provide information on the effect of initial slurry solids content on the settling and permeability characteristics of the material and the effect on water recovery and achieved density. Slurry settling (sedimentation) tests provide an estimate of the density to which the tailings slurry will settle in a sub-aqueous environment, under undrained and drained conditions. These tests provide an indication of the tailings dry density achieved in a storage facility after settling and before any significant consolidation or air drying occurs. Air drying tests were carried out on the tailings samples to determine the effect of air drying after initial slurry settling and removal of supernatant water.

The undrained settled dry density of the Whole Tailings slurry is 1.0 tonnes/m^3. The drained settled dry density is 1.09 tonnes/m^3. The undrained settled dry density of the Cyclone Overflow varies from 0.8 tonnes/m^3 (initial slurry solids content of 25%) to 1.07 tonnes/m^3 (initial solids content of 55%). The drained settled dry density varies from 0.95 tonnes/m^3 to 1.2 tonnes/m^3. The dry densities achieved for drained settling are approximately 10% to 20% higher than those for undrained settling, with the larger increase occurring for Cyclone Overflow slurry with lower initial solids content.

Air drying of the tailings materials produces a significant increase in dry density over those from the undrained and drained settling tests. The highest densities are achieved for slurries with higher initial solids content (dry densities of 1.35 tonnes/m^3 for the Whole Tailings and 1.44 tonnes/m^3 for

the Cyclone Overflow sample with an initial slurry solids content of 55%). As expected, the amount of water recovered is highest for tailings slurries with lower initial solids content (higher initial water content). Supernatant water recovery from settled Cyclone Overflow with an initial slurry solids content of 25% is expected to be approximately 75%.

Laboratory tests carried out to determine the consolidation and permeability characteristics of the Whole Tailings and Cyclone Overflow included Slurry Consolidometer testing, Low Stress Slurry Consolidation tests and Falling Head Permeability tests (conducted on settled tailings after completion of drained settling tests). Relationships between coefficient of consolidation, void ratio and vertical coefficient of permeability to effective stress have been developed for both of these tailings materials. Calculated coefficients of consolidation for the Whole Tailings range from 100 m^2/year at very low stresses to over 1000 m^2/year at high stresses. Calculated coefficients of consolidation for the Cyclone Overflow range from 25 m^2/year at very low stresses to over 1000 m^2/year at high stresses.

Measured vertical permeability values for the Whole Tailings and Cyclone Overflow decrease with increasing effective stress. The permeability of the Whole Tailings ranges from approximately 1×10^{-4} cm/sec at low stresses (representing unconsolidated or fresher tailings near surface) to about 1×10^{-6} cm/sec at high stresses, corresponding to a reduction in void ratio (representing more consolidated or deeper tailings within the deposit). Similarly, the permeability of the Cyclone Overflow ranges from approximately 5×10^{-5} cm/sec at low stresses to about 1×10^{-6} cm/sec at high stresses.

Compaction, shear strength and permeability tests were carried out on the laboratory manufactured Cyclone Underflow sample. The shear strength and permeability tests were carried out over a large range of confining stresses to examine the influence of high confining stresses (corresponding to a large dam height) on the strength and permeability values. The optimum moisture content of the Cyclone Underflow sample was determined to be 16.7% and the maximum dry density was 1,559 kg/m^3. The shear strength of the cyclone sand is defined by an average effective friction angle of 36 degrees and zero cohesion. The potential strength characteristics of the cyclone sand over a large stress range have been examined by comparison of the laboratory test data to published information on the non-linear strength characteristics of similar granular materials (angular sands). This information suggests that the effective friction angle of the cyclone sand may be greater than 36 degrees at low confining stresses but potentially lower at very high stresses. However, the laboratory test results for the Cyclone Underflow sample suggest that there is no apparent loss of strength at the higher stresses, over the stress range tested.

Permeability values determined for the Cyclone Underflow show a general trend of reducing permeability with increasing confining stress. This decrease is the result of the decrease in material density and potentially from the generation of finer particles due to particle crushing. However, the results do not appear to indicate a dramatic decrease in permeability at high stresses, which would be indicative of significant particle crushing and changes to the fines content of the material. The permeability of the Cyclone Underflow ranges from approximately 2×10^{-3} cm/sec at lower stresses to about 5×10^{-4} cm/sec at high stresses (approximately 3000 kPa). Extrapolation of these results suggests that the permeability of the Cyclone Underflow will remain greater than 1×10^{-4} cm/sec at very high stresses of about 4000 to 5000 kPa.

It is recommended that laboratory testing is also carried out on a representative sample of PAG tailings for future design studies.

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APPENDICES

Appendix A Detailed Results of Tailings Laboratory Tests (Provided by Knight Piesold Denver)

1 – INTRODUCTION

This report presents the details and findings of a laboratory testing program to determine the geotechnical characteristics of the Casino tailings materials. The laboratory testing was carried out at the Knight Piésold laboratory in Denver, Colorado.

A sample of the Casino tailings was provided by Casino Mining Corporation for testing. The tailings sample represents Non Acid Generating (NAG) whole tailings. This sample was used to generate representative samples of Cyclone Overflow (fine tailings) and Cyclone Underflow materials. A sample of Potentially Acid Generating (PAG) tailings (with pyrite) was not available for testing at this time.

The Cyclone Overflow sample was generated to a target particle size distribution with approximately 75% fines (silt and clay fractions). Similarly, the Cyclone Underflow sample was generated for a target particle size distribution with a maximum of 15% fines. The target particle size distributions used for generation of the cyclone overflow and underflow materials were based on the anticipated material products from cycloning of the Casino whole tailings and information provided by cyclone manufacturers.

The laboratory test program included index testing to enable geotechnical classification of the materials, and slurry settling, air drying, consolidation and permeability testing to determine the characteristics of the Whole Tailings and Cyclone Overflow following deposition and for a range of conditions (representative of expected field conditions). The following is a list of the geotechnical tests conducted on the Whole Tailings and Cyclone Overflow samples:

Index Tests

- Specific Gravity of solids
- Atterberg Limits (Plastic and Liquid Limits), and
- Particle size distribution by mechanical sieve and hydrometer.

Slurry Settling and Air Drying Tests

- Undrained Settling
- Drained Settling (with Falling Head permeability measurement), and
- Air drying.

Slurry Consolidation Tests

- Slurry Consolidometer Test (with permeability measurement), and
- Low Stress Slurry Consolidation (Burette) Test.

The slurry settling (sedimentation) tests provide an estimate of the density to which the tailings slurry will settle in a sub-aqueous environment, under undrained and drained conditions. These tests provide an estimate of expected tailings density in a storage facility after settling and before any significant consolidation or air drying occurs. The air drying test provides the geotechnical characteristics of the tailings for expected conditions on exposed beaches following deposition. The effect of air drying on moisture loss and tailings density is determined by this test.

The slurry consolidometer test is used to determine the consolidation, compressibility and permeability characteristics of the tailings over a wide range of confining pressures (typically corresponding to expected conditions in the field). These parameters can be used to determine the

amount and rate of consolidation, seepage rates, settlement and density increase for the tailings. The slurry consolidation cylinder test provides a measure of the consolidation characteristics of the tailings at very low effective stresses (representing freshly deposited tailings immediately following settling).

The following is a list of the geotechnical tests conducted on the Cyclone Underflow sample:

Index Tests

- Specific Gravity of solids, and
- Particle size distribution by mechanical sieve and hydrometer.

Strength and Permeability Tests

- Compaction (Proctor) Test
- Tri-axial Shear Strength, and
- Flexible Wall Permeability.

The compaction test provide information on the expected density of the cyclone sand following placement as compacted sand fill for embankment construction. The shear strength test provides information on the strength of the compacted sand over a range of confining stresses, and is used for embankment stability assessment. Similarly, the Flexible Wall permeability test provides information on the expected permeability of the cyclone sand fill over a range of confining stresses. The permeability characteristics of the cyclone sand are an important consideration in the design of free-draining cyclone sand embankment dams.

It is recommended that laboratory testing is also carried out on a representative sample of PAG tailings for future design studies.

2 – INDEX TESTS

2.1 GENERAL

Index testing was carried out on the tailings solids for the Whole Tailings sample and the laboratory generated Cyclone Overflow (fine tailings) and Cyclone Underflow (cyclone) samples.

The Specific Gravity, Atterberg Limits (Plastic and Liquid Limits), and particle size distribution (screen and hydrometer) of the tailings were determined. These tests provide a measure of the type and condition of the material, specifically the particle density, composition (size and distribution) and plasticity characteristics. The index properties can provide a relationship to material structural properties, including compressibility, permeability and strength.

A summary of the tailings index test results is presented in Table 2.1. Detailed results of the index tests are included in Appendix A.

2.2 PARTICLE SIZE DISTRIBUTION

Mechanical sieve and hydrometer particle size analyses were carried out on each of the tailings samples in accordance with ASTM standard D422 procedures. The hydrometer analysis is used to determine the silt and clay fraction particle sizes.

The particle size distribution of the Whole Tailings sample comprises approximately 58% fine sand, 35% silt and 7% clay. The Cyclone Overflow sample was generated to a target particle size distribution with approximately 75% fines (silt and clay fractions). The resulting cyclone overflow material comprised approximately 23% sand, 69% silt and 8% clay (77% total fines). Similarly, the Cyclone Underflow sample was generated for a target particle size distribution with a maximum of 15% fines. The resulting cyclone underflow material comprised approximately 85% sand, 13% silt and 2% clay (15% total fines).

The particle size distributions of the three tailings samples tested are presented on Figure 2.1.

2.3 SPECIFIC GRAVITY

The specific gravity of the tailings solids was determined in accordance with ASTM standard D854. The measured specific gravity is 2.70 for the Whole Tailings sample, 2.71 for the Cyclone Overflow sample, and 2.80 for the Cyclone Underflow sample.

2.4 ATTERBERG LIMITS (PLASTICITY)

The Atterberg Limits (Plastic and Liquid Limits) of the tailings samples were determined in accordance with the ASTM standard D4318 test procedure. Examination of each of the three sample indicated that the tailings materials are non-plastic. A Liquid Limit (LL) of 24% was determined for the Cyclone Overflow sample. The liquid limit is the moisture content at which a soil material starts to exhibit liquid behaviour.

2.5 MATERIAL CLASSIFICATION

The Whole Tailings material can generally be described as non-plastic Silty Sand with trace Clay, and classifies as SM (sand with non-plastic fines) under the Unified Soil Classification System.

The Cyclone Overflow material is described as Silt with Sand, and classifies as ML (inorganic silts of slight or no plasticity).

The Cyclone Underflow material is described as a non-plastic Sand with some Silt and a trace Clay, and classifies as SM (sand with non-plastic fines). The fines content of the Cyclone Sand sample (15%) is significantly lower than for the Whole Tailings (42%).

3 – SLURRY SETTLING & AIR DRYING TESTS

3.1 GENERAL

Undrained Settling, Drained Settling and Air Drying tests were carried out on the Whole Tailings and Cyclone Overflow samples.

The Whole Tailings slurry sample was prepared at an initial target solids content of approximately 55%, corresponding to the current design discharge value for the project. For the Cyclone Overflow the tests were conducted on slurry samples prepared at initial solids contents of approximately 25%, 40% and 55%. The design solids content of the cyclone overflow material was unknown at the time of testing. Testing the slurry at different solids contents provides information on the effect of slurry solids content on the settling and permeability characteristics of the material, and also the effect on water recovery and achieved density.

Slurry settling (sedimentation) tests provide an estimate of the density to which the tailings slurry will settle in a sub-aqueous environment, under undrained and drained conditions. These tests provide an indication of the tailings dry density achieved in a storage facility after settling and before any significant consolidation or air drying occurs. The actual settled density achieved in the field, prior to commencement of consolidation or air-drying, is likely to be within the range bounded by the densities obtained from the Undrained and Drained Settling tests.

Air Drying tests are carried out to determine the effect of air drying after initial slurry settling and removal of supernatant water, thereby simulating expected conditions on exposed tailings beaches following deposition.

Complete results of the slurry settling and air drying tests are included in Appendix A.

3.2 UNDRAINED SETTLING TESTS

The Undrained Settling test estimates the density to which the tailings slurry will settle in an undrained sub-aqueous environment.

Undrained Settling tests were performed by placing the slurry into a one litre graduated cylinder and recording the rate of settling and change in volume of the tailings sample as supernatant water bleeds to the surface. The final dry density of the settled solids is determined once the change in settled volume remains essentially constant.

The Whole Tailings and Cyclone Overflow slurries took one to two days to complete undrained settling. The settled dry densities increase with increasing initial slurry solids content. For the Whole Tailings sample the settled dry density is 1.0 tonnes/m^3. The undrained settled dry density of the Cyclone Overflow sample is 0.80 tonnes/m^3 for an initial slurry solids content of 25% solids, 0.99 tonnes/m^3 for 40% solids, and 1.07 tonnes/m^3 for 55% solids.

The initial and final settled dry densities achieved for the Undrained Settling tests are included in Table 3.1. Also included in Table 3.1 are the corresponding initial and final void ratios (ratio of voids volume to volume of solids) and the corresponding total water recovery from the slurry (as a percentage of total water in initial slurry) after settling is complete.

3.3 DRAINED SETTLING TESTS

The Drained Settling test provides an indication of the tailings dry density that will be achieved from settling with free drainage from the base of the sample.

The Drained Settling tests were performed by placing the tailings slurry into a one litre graduated cylinder with provision for bottom drainage and recovery of downward seepage. The rate of settling and change in volume of the sample is recorded with time, as supernatant water bleeds to the surface and drains from the base. Supernatant water is continually decanted from the surface, whenever possible, to minimize development of a vertical seepage gradient across the sample. The final dry density of the settled solids is calculated once the change in settled volume remains constant.

Similar to the Undrained Settling tests, the tailings slurries took one to two days to complete drained settling. For the Whole Tailings sample, the settled dry density is 1.09 tonnes/m^3 (initial slurry solids content of 55%). For the Cyclone Overflow sample, the settled dry densities are 0.95 tonnes/m^3 for an initial slurry solids content of 25%, 1.13 tonnes/m^3 for 40% solids, and 1.20 tonnes/m^3 for 55% solids.

The initial and final settled dry densities achieved for the Drained Settling tests are included in Table 3.1. Also included in Table 3.1 are the corresponding initial and final void ratios and the corresponding total water recovery from the slurry after settling is complete.

Permeability measurements of the tailings samples were taken after completion of the Drained Settling tests. Details and results of Falling Head permeability tests conducted on the drained settled samples are provided in Section 4.4.

3.4 AIR DRYING TESTS

The Air Drying tests were conducted by allowing the tailings slurry samples to settle and air dry under monitored conditions in order to investigate the relationship between density, moisture content, and degree of saturation in a drying environment. Partially saturated conditions are achieved as the amount of moisture loss through evaporation exceeds the reduction in volume of the sample. An absolute relationship between dry density and moisture content exists up to a point at which the degree of saturation falls below 100%. At this stage negative pore pressures (suction pressures) develop and act to further consolidate the sample (reducing the volume). Further drying below a limiting moisture content (the shrinkage limit) produces no further consolidation and the dry density at this point represents the maximum that can be achieved by air drying of the material.

The Air Drying tests are performed by introducing a sample of tailings slurry into a one litre container with no underdrainage and allowing the slurry to settle while decanting supernatant water. Routine measurements are taken of sample weight and volume. Once the slurry has completely settled and all surface water has been removed, air drying commences causing moisture loss and consolidation. An evaporation control, subjected to the same drying environment as the slurry sample, is also monitored in order to estimate the rate and amount of evaporation (from a free water surface) applied to the sample. However, in the field, greater evaporation rates and correspondingly faster consolidation rates may occur than in the laboratory due to the effects of wind, advection and solar radiation.

The Whole Tailings and Cyclone Overflow samples required approximately one to two weeks to complete air drying (achieving the shrinkage limit) under laboratory conditions. For the Whole Tailings sample the air dried dry density was 1.35 tonnes/m^3 (initial slurry solids content of 55%). For the Cyclone Overflow sample the air dried dry densities achieved were 1.29 tonnes/m^3 for an initial slurry solids content of 25%, 1.43 tonnes/m^3 for 40% solids, and 1.44 tonnes/m^3 for 55% solids.

The dry densities achieved for each of the Air Drying tests are included in Table 3.1. Also included in Table 3.1 are the corresponding initial and final void ratios after settling and air drying is complete.

Complete results of the Air Drying tests are provided in Appendix A, including plots showing the relationship between tailings dry density, volume reduction, moisture content, degree of saturation and evaporation.

3.5 SUMMARY OF SETTLING AND AIR DRYING TESTS

The settled dry density of the Whole Tailings is approximately 1.0 tonnes/m^3 for undrained settling and 1.09 tonnes/m^3 for drained settling. The dry density achieved for drained settling is approximately 10% higher than for undrained settling. Supernatant water recovery from settled Whole Tailings with an initial slurry solids content of 55% is expected to be approximately 26% for undrained conditions and about 43% for drained settling conditions.

Using the results of the Undrained and Drained Settling tests, the final dry densities and corresponding total water recovery for the Cyclone Overflow slurry are plotted as functions of initial slurry solids content on Figures 3.1 and 3.2, respectively.

Figure 3.1 illustrates the higher dry density for slurries with higher initial solids content, and the increase in dry density for drained settling compared to undrained settling. The undrained settled dry density of the Cyclone Overflow varies from approximately 0.8 to 1.07 tonnes/m^3. The drained settled dry density varies from approximately 0.95 tonnes/m^3 to 1.2 tonnes/m^3. The dry densities achieved for drained settling are approximately 10% to 20% higher than those for undrained settling, with the larger increase occurring for slurries with lower initial solids content.

The final dry densities from the Air Drying tests are also plotted on Figure 3.1. Air drying of the Cyclone Overflow material produces a significant increase in dry density over those from the Undrained and Drained Settling tests. The highest densities are achieved for slurries with higher initial solids content (up to a dry density of about 1.44 tonnes/m^3 for an initial slurry solids content of 55%).

Figure 3.2 illustrates the relationship between total water recovery (supernatant water recovered from the tailings slurry) and initial solids content of the Cyclone Overflow slurry. As expected, the amount of water recovered is highest for slurries with lower initial solids content (higher initial water content). Supernatant water recovery from settled Cyclone Overflow with an initial slurry solids content of about 25% is expected to be approximately 75% or higher, depending on actual drainage conditions during settling.

4 – SLURRY CONSOLIDATION AND PERMEABILITY TESTS

4.1 GENERAL

Laboratory tests have been carried out to determine the consolidation and permeability characteristics of the Whole Tailings and laboratory generated Cyclone Overflow. Material consolidation, compressibility and permeability (hydraulic conductivity) parameters derived from the laboratory testing can be used in design studies to determine the amount and rate of tailings consolidation, to predict seepage rates from and through the tailings, and to predict tailings settlements and density increase with time.

The consolidation and permeability parameters have been provided by Slurry Consolidometer testing, Low Stress Slurry Consolidation tests and Falling Head Permeability tests (conducted on settled tailings after completion of Drained Settling tests).

4.2 SLURRY CONSOLIDOMETER TEST

A specialized slurry consolidometer device was used to determine the consolidation, compressibility and permeability characteristics of the tailings over a range of effective confining stresses. The slurry consolidometer apparatus is designed to evaluate the consolidation characteristics of slurries that initially have high void ratios and high moisture contents at low effective stresses.

The tests were conducted by placing a slurry sample into the consolidometer and allowing the tailings to settle and consolidate under self weight. Confining stresses ranging from very low (about 14 kPa) to over 800 kPa were then applied in incremental loading stages. Routine measurements of settlement with time were recorded during each loading stage. Once settlement ceased or became negligible during loading the confining stress was increased to the next loading stage. The permeability of the tailings was measured at the end of each loading stage. Two-way drainage conditions were facilitated in the test. Detailed results of the testing are provided in Appendix A.

The results of the Slurry Consolidometer test were used to calculate the coefficient of consolidation (c_v) for each loading stage. The coefficient of consolidation is a measure of the consolidation characteristics (rate of consolidation) of a material. A high coefficient of consolidation corresponds to a high rate of consolidation while a low value indicates a slow rate of consolidation. The coefficients of consolidation and void ratios determined for the tailings are presented for each loading stage in Table 4.1 for Whole Tailings and Table 4.2 for Cyclone Overflow. Calculated tailings dry densities and measured vertical permeability (k_v) values are also included in Tables 4.1 and 4.2.

Coefficients of consolidation determined for the Whole Tailings and Cyclone Overflow are generally similar and increase with increasing effective confining stress, ranging from approximately 200 m^2/year at low stresses to over 1000 m^2/year at high stresses. Measured void ratios decrease from about 1.0 at low stresses to less than 0.7 at high stresses. Calculated values of the coefficient of consolidation and void ratio for the Whole Tailings are included on Figures 4.1 and 4.2, respectively. Calculated values of the coefficient of consolidation and void ratio for the Cyclone Overflow are included on Figures 4.3 and 4.4, respectively.

The calculated tailings dry density for each loading stage is included in Tables 4.1 and 4.2. The dry density of the tailings materials increases with increasing effective stress, with a value of about 1.6 tonne/m3 achieved at high effective stresses.

Measured vertical permeabilities for the Whole Tailings and Cyclone Overflow are included on Figures 4.5 and 4.6 respectively.

4.3 LOW STRESS SLURRY CONSOLIDATION TEST

The Low Stress Slurry Consolidation (burette) test provides a measure of the consolidation characteristics of the tailings at very low effective stresses (approximately 1 to 2 kPa), representing freshly deposited tailings immediately following initial settling. The test is used to estimate the coefficient of consolidation of the tailings at a very low effective stress (and corresponding high void ratio).

The test is carried out by introducing a pre-measured quantity of the tailings slurry sample into a one litre burette with the bottom stopcock closed. After initial settling (sedimentation) of the slurry, the bottom stopcock is opened to permit drainage and dissipation of pore pressures, causing an increase in the effective stress within the sample. Observations of the decrease in slurry volume (settlement) with time are recorded, and used to estimate the coefficient of consolidation. Estimates of initial and final sample void ratio, dry density, permeability and the corresponding effective stresses (due to the self-weight of the sample) are calculated.

Tests were conducted for both the Whole Tailings and Cyclone Overflow samples. A summary of the Low Stress Slurry Consolidation test results, including calculated values of void ratio, dry density, coefficient of vertical permeability and the coefficient of consolidation are presented in Table 4.3 for both samples. The calculated values of coefficient of consolidation are 100 m^2/year for the Whole Tailings and 25 m^2/year for the Cyclone Overflow. Calculated permeability values are approximately 2 x 10^{-4} cm/sec for the Whole Tailings and 3 x 10^{-5} cm/sec for the Cyclone Overflow.

Detailed results of the testing are included in Appendix A.

4.4 FALLING HEAD TESTS ON SETTLED TAILINGS

Falling Head permeability tests were performed on the settled tailings samples, after completion of each of the drained settling tests (see Section 3.3). This test provides an indication of the vertical permeability of the tailings material at very low effective stresses (approximately 1 kPa) and corresponding low density (high void ratio). In practice, the permeability will decrease as consolidation increases the density and reduces the void ratio.

The test is conducted by applying water to the surface of the settled tailings, imposing a vertical gradient across the sample. The drainage rate and drop in water level were recorded with time to provide a value of vertical permeability (hydraulic conductivity). The test is repeated several times to provide an average permeability value.

The average permeability values provided by the Falling Head tests for each of the drained settling test samples are included in Table 3.1. The average permeability measured for the Whole Tailings is approximately 1 x 10^{-4} cm/sec. The average permeability measured for the Cyclone Overflow ranges from approximately 3 x 10^{-5} cm/sec to 6 x 10^{-5} cm/sec.

Detailed results of the testing are included in Appendix A.

4.5 SUMMARY OF CONSOLIDATION AND PERMEABILITY TESTS

Calculated coefficients of consolidation for the Whole tailings range from about 100 m^2/year at very low stresses (representing freshly settled tailings) to over 1000 m^2/year at high stresses (representing consolidated tailings at depth within the deposit). This indicates that the rate of tailings consolidation has the potential to increase as effective stress conditions increase with depth, but will be dependent on in situ pore water pressure conditions. The relationship between coefficient of consolidation and effective stress for the Whole Tailings is shown on Figure 4.1, including calculated coefficient of consolidation values provided by the Slurry Consolidometer test and the Low Stress Slurry Consolidation test. Similarly, calculated coefficients of consolidation for the Cyclone Overflow range from about 25 m^2/year at very low stresses to over 1000 m^2/year at high stresses. The relationship between coefficient of consolidation and effective stress for the Cyclone Overflow is shown on Figure 4.2.

The relationship between tailings void ratio and effective stress is shown for the Whole Tailings and Cyclone Overflow materials on Figures 4.3 and Figure 4.4 respectively. These relationships were developed using calculated void ratios provided by the Slurry Consolidometer tests and the Low Stress Slurry Consolidation tests. The data presented on Figures 4.2 and 4.3 suggests a bilinear relationship between void ratio and effective stress for both materials. At low effective stress levels the steep line is indicative of the large volume change which occurs during the tailings sedimentation and initial consolidation process. The shallower line exhibited for higher stresses is indicative of the consolidation process, whereby smaller volume changes occur under increased loading as the structure of the tailings material becomes more compact. This bilinear relationship is typical for sedimented tailings materials.

The vertical coefficient of permeability of the Whole Tailings is shown as a function of effective stress on Figure 4.5. These relationships were developed using permeability values provided by the Slurry Consolidometer tests, Low Stress Slurry Consolidation tests and Falling Head tests performed on the drained settled samples. As expected, a general trend of decreasing permeability with increasing effective stress (decreasing void ratio) is observed. The relationship presented on Figure 4.5 indicates that the permeability of the Whole Tailings will generally range from approximately 1×10^{-4} cm/sec (representing unconsolidated or fresher tailings near surface) to about 1×10^{-6} cm/sec or less, corresponding to an increase in effective stress and reduction in void ratio (representing more consolidated or deeper tailings within the deposit).

The vertical coefficient of permeability of the Cyclone Overflow is shown as a function of effective stress on Figure 4.6. The relationship presented on Figure 4.6 indicates that the permeability of the Cyclone Overflow will generally range from approximately 5×10^{-5} cm/sec to about 1×10^{-6} cm/sec.

5 – CYCLONE SAND TESTS

5.1 GENERAL

Compaction, shear strength and permeability tests were carried out on the laboratory manufactured Cyclone Underflow (cyclone sand) sample. The test samples used for shear strength and permeability testing were prepared to target density and moisture content conditions representative of compacted cyclone sand fill material used for embankment construction.

The shear strength and permeability tests were carried out over a large range of confining stresses to examine the influence of a large dam height (and corresponding high confining stress) on the strength and permeability values.

Complete results of the compaction, shear strength and permeability tests are included in Appendix A.

5.2 COMPACTION TEST

The maximum dry density and optimum moisture content of the Cyclone Underflow sample were determined from a Standard Proctor test (ASTM D-698-07 Method A Standard). The optimum moisture content was determined to be 16.7% and the maximum (ultimate) dry density was 1,559 kg/m^3. Test samples used for shear strength and permeability testing were prepared to 95% of the maximum dry density.

5.3 SHEAR STRENGTH TEST

Consolidated Undrained triaxial compression tests were carried out on the Cyclone Underflow sample to determine the shear strength of the material over a range of confining stresses. The tests were performed at effective confining stresses of approximately 350 kPa, 700 kPa, 1650 kPa and 2760 kPa.

The effective shear strength of the cyclone sand is defined by the effective friction angle and cohesion. The test results indicate an average effective friction angle of 36 degrees with zero cohesion.

The potential strength characteristics of the cyclone sand over a large stress range has also been examined, including estimation of the shear strength (effective friction angle) at low and very high stresses. The strength of granular materials is typically higher at low stresses due to the dilatant behaviour of the material under shearing, while a lower strength may occur at high stresses due to particle crushing and reduced dilation of the material. The shear strength test results for the Cyclone Underflow have been compared to published information on the strength characteristics of granular materials (rockfill and angular sands) provided by Leps (“Review of Shearing Strength of Rockfill, Journal of the Soil Mechanics and Foundations Division, ASCE, Vol. 96, No. SM4, July 1970). Specifically, a relationship between friction angle and effective stress provided for angular sands has been used for comparison to the Cyclone Underflow test results. This relationship suggests that the effective friction angle of the cyclone sand will be greater than 36 degrees at low confining stresses (approximately 40 degrees for a normal effective stress of 100 kPa), but potentially lower at very high stresses (about 30 degrees for very high effective stresses of about 4000 to 5000 kPa). However, it

is noted that the laboratory test results for the Cyclone Underflow sample suggest that there is no apparent loss of strength at the higher stresses, over the stress range tested. This is an important consideration for stability assessment of large cyclone sand dams where confining stresses can be very high.

5.4 PERMEABILITY TEST

Flexible Wall Permeability tests were carried out at applied confining stresses of approximately 350 kPa, 700 kPa, 1650 kPa and 2760 kPa. The tests were carried out at these confining stresses to investigate the influence of increasing confining stress (and corresponding embankment height) on the permeability of the material.

The permeability values determined for the Cyclone Underflow sample are presented on Figure 5.2, which shows a general trend of reducing permeability with increasing confining stress. This decrease is the result of the increase in material density (decrease in void ratio) and potentially from the generation of finer particles due to particle crushing. However, the results do not appear to indicate a dramatic decrease in permeability at high stresses, which would be indicative of significant particle crushing and changes to the fines content of the material. The particle size distribution of the sample was determined following completion of the permeability test to investigate the potential for increased fines content due to particle crushing. The measured fines content (% passing #200 sieve) of the sample increased by only one percent, from 15% to 16%. This is not enough to suggest any significant particle crushing under the very high confining pressures imposed during the permeability testing.

The relationship presented on Figure 5.2 indicates that the permeability of the Cyclone Underflow will generally range from approximately 2×10^{-3} cm/sec at lower stresses to about 5×10^{-4} cm/sec at higher stresses (approximately 3000 kPa). Extrapolation of these results suggests that the permeability of the Cyclone Underflow will remain greater than 1×10^{-4} cm/sec at very high stresses of about 4000 to 5000 kPa.

6 – CERTIFICATION

This report was prepared and approved by the undersigned.



Prepared by:

Graham R. Greenaway, P.Eng.
Specialist Geotechnical Engineer

Approved by:

Ken J. Brouwer, P.Eng.
Managing Director

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TABLE 2.1

CASINO MINING CORP.
CASINO COPPER AND GOLD PROJECT

SUMMARY OF TAILINGS INDEX TESTS

Print Sep/13/12 16:08:23

Sample	Specific Gravity of Solids	Atterburg Limits			Particle Size Distribution		
		Plastic Limit (%)	Liquid Limit (%)	Plasticity Index (%)	Sand (%) 4.75 mm to 0.075 mm	Silt (%) 0.075 mm to 0.002 mm	Clay (%) <0.002 mm
Whole tailings	2.70	Non-Plastic	Non-Plastic	Non-Plastic	58	35.5	6.5
Manufactured Cyclone Overflow	2.71	Non-Plastic	24	Non-Plastic	23.4	68.7	7.9
Manufactured Cyclone Underflow	2.80	Non-Plastic	Non-Plastic	Non-Plastic	85	13.1	1.9

M:\1\01\00325\08\A\Data\Task 300 - TMF Design\Tailings laboratory testing\Tailings Lab Test Results\[Table 2.1 Rev 0- Summary of Index Tests.xlsx]Table 2.1

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	13AUG'12	ISSUED WITH REPORT VA101-325/8-1	MGP	AMM	KJB

Knight Piésold CONSULTING

TABLE 3.1

CASINO MINING CORP.
CASINO COPPER AND GOLD PROJECT

SUMMARY OF SLURRY SETTLING AND AIR DRYING TESTS

Print Sep/13/12 16:09:13

Tailings Sample	Target Percent Solids	Undrained Settling Test					Drained Settling Test						Air Drying Test			
		Initial Void Ratio	Final Void Ratio	Initial Dry Density (tonne/m^3)	Final Dry Density (tonne/m^3)	Total Water Recovery[1] (%)	Initial Void Ratio	Final Void Ratio	Initial Dry Density (tonne/m^3)	Final Dry Density (tonne/m^3)	Total Water Recovery[1] (%)	Falling Head Permeability (cm/s)	Initial Void Ratio	Final Void Ratio	Initial Dry Density (tonne/m^3)	Final Dry Density (tonne/m^3)
Whole Tailings	55	2.29	1.70	0.82	1.00	26	2.29	1.47	0.82	1.09	43	1.E-04	2.21	1.00	0.84	1.35
Manufactured Cyclone Overflow	25	9.42	2.39	0.26	0.80	75	9.42	1.85	0.26	0.95	78	6.E-05	8.68	1.10	0.28	1.29
	40	4.02	1.74	0.54	0.99	57	4.11	1.40	0.53	1.13	67	3.E-05	4.02	0.90	0.54	1.43
	55	2.23	1.53	0.84	1.07	32	2.23	1.26	0.84	1.20	44	4.E-05	2.23	0.88	0.84	1.44

M:\1\01\00325\08\A\Data\Task 300 - TMF Design\Tailings laboratory testing\Tailings Lab Test Results\[Table 3.1, Figure 3.1, 3.2, 3.3, 3.4 Rev 0- Summary of Settling Tests.xlsx]Table 3.1

NOTE:

1. TOTAL WATER RECOVERY IS DEFINED AS THE PERCENTAGE OF WATER RECOVERED FROM THE SLURRY DURING SETTLING.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	13AUG'12	ISSUED WITH REPORT VA101-325/8-1	MGP	AMM	KJB

Knight Piésold CONSULTING

TABLE 4.1

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

SUMMARY OF SLURRY CONSOLIDOMETER TEST FOR WHOLE TAILINGS

Print Sep/13/12 16:25:06

Load Increment (psi)	Load Increment (kPa)	Average Effective Stress (kPa)	Void Ratio (e)	Dry Density (Note 1) (tonne/m^3)	C_V (m^2/year)	k_v (Note 3) (cm/sec)
					--	
2	14		0.95	1.39		--
		24			240	
5	34		0.88	1.44		4.9E-06
		52			340	
10	69		0.84	1.47		3.9E-06
		103			780	
20	138		0.79	1.51		2.9E-06
		207			880	
40	276		0.74	1.56		2.9E-06
		414			910	
80	552		0.68	1.61		2.0E-06
		690			1030	
120	827		0.65	1.64		1.0E-06

M:\1\01\00325\08\A\Data\Task 300 - TMF Design\Tailings laboratory testing\Tailings Lab Test Results\[Table 4.1, 4.2 Figure 4.1, 4.2, 4.3, 4.4, 4.5, 4.6 Rev 0 - Summary of Consolidation Tests.xlsx]TABLE 4.1

NOTES:

1. DRY DENSITY CALCULATED USING VOID RATIO AND MEASURED TAILINGS SPECIFIC GRAVITY (SG = 2.70) .
2. C_v = COEFFICIENT OF CONSOLIDATION.
3. k_v = COEFFICIENT OF VERTICAL PERMEABILITY. PERMEABILITY MEASURED AT THE END OF EACH LOADING STAGE.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	2JAUG12	ISSUED WITH REPORT VA101-325/8-1	AMM	GRG	KJB

Knight Piésold CONSULTING

TABLE 4.2

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

SUMMARY OF SLURRY CONSOLIDOMETER TEST FOR MANUFACTURED CYCLONE OVERFLOW

Print Sep/13/12 16:25:06

Load Increment (psi)	Load Increment (kPa)	Average Effective Stress (kPa)	Void Ratio (e)	Dry Density (Note 1) (tonne/m^3)	C_V (m^2/year)	m_v (m^2/kN)	k_v (Note 3) (cm/sec)
						--	
2	14		1.02	1.34			--
		24			190	2.1E-03	
5	34		0.93	1.40			1.1E-05
		52			410	8.7E-04	
10	69		0.88	1.45			9.1E-06
		103			540	4.0E-04	
20	138		0.82	1.49			6.8E-06
		207			690	1.9E-04	
40	276		0.78	1.53			2.8E-06
		414			1850	1.1E-04	
80	552		0.72	1.57			2.2E-06
		690			1420	6.7E-05	
120	827		0.69	1.60			1.9E-06

M:\1\01\00325\08\A\Data\Task 300 - TMF Design\Tailings laboratory testing\Tailings Lab Test Results\[Table 4.1, 4.2 Figure 4.1, 4.2, 4.3, 4.4, 4.5, 4.6 Rev 0 - Summary of Consolidation Tests.xlsx]Table 4.2

NOTES:

1. DRY DENSITY CALCULATED USING VOID RATIO AND MEASURED TAILINGS SPECIFIC GRAVITY (SG = 2.71) .
2. C_v = COEFFICIENT OF CONSOLIDATION.
3. k_v = COEFFICIENT OF VERTICAL PERMEABILITY. PERMEABILITY MEASURED AT THE END OF EACH LOADING STAGE.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	12JUL'12	ISSUED WITH REPORT VA101-325/1.8-1	MD	AMM	KJB

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TABLE 4.3

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

SUMMARY OF LOW STRESS SLURRY CONSOLIDATION TESTS

Print Sep/13/12 15:28:10

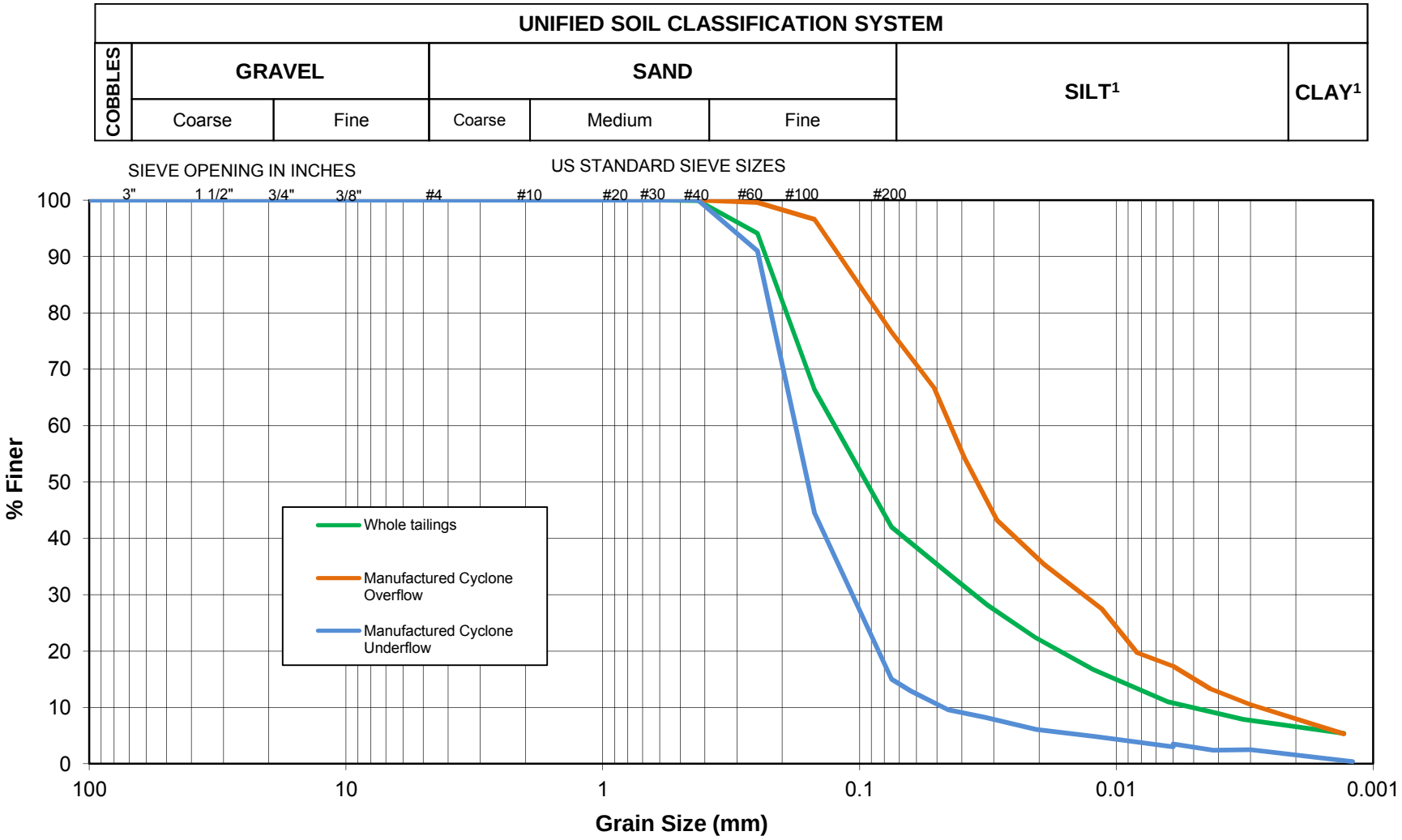
Sample	Self-Weight Loading (kPa)	Average Effective Stress (kPa)	Void Ratio (e)	Dry Density (tonne/m^3)	k_v (Note 1) (cm/sec)	C_v (Note 2) (m/year)
WHOLE TAILINGS						
	0.7		1.49	1.07		
		2.7			2E-04	100
	2.0		1.26	1.18		
		2.7				
MANUFACTURED CYCLONE OVERFLOW						
	0.8	1.5	1.57	1.06		
		1.7			3E-05	25
	2.6	0.8	1.40	1.13		

M:\1\01\00325\08\A\Data\Task 300 - TMF Design\Tailings laboratory testing\Tailings Lab Test Results\[Table 4.1, 4.2 Figure 4.1, 4.2, 4.3, 4.4, 4.5, 4.6 Rev 0 - Summary of Consolidation Tests.xlsx]TABLE 4.3

NOTES:

1. k_v = COEFFICIENT OF VERTICAL PERMEABILITY.
2. C_v = COEFFICIENT OF CONSOLIDATION.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	2AUG'12	ISSUED WITH REPORT VA101-325/8-1	AMM	GRG	KJB



NOTE:

1. SILT AND CLAY LIMITS FROM THE US DEPARTMENT OF AGRICULTURE DEFINITION. THE UNIFIED SOIL CLASSIFICATION SYSTEM DEFINES ALL PARTICLES WITH DIAMETERS <0.075 MM AS FINES WITH SILT AND CLAY DEFINED ONLY BY PLASTICITY.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	13AUG'12	ISSUED WITH REPORT	MGP	AMM	KJB

CASINO MINING CORP.

CASINO COPPER AND GOLD PROJECT

PARTICLE SIZE DISTRIBUTION FOR TAILINGS SAMPLES

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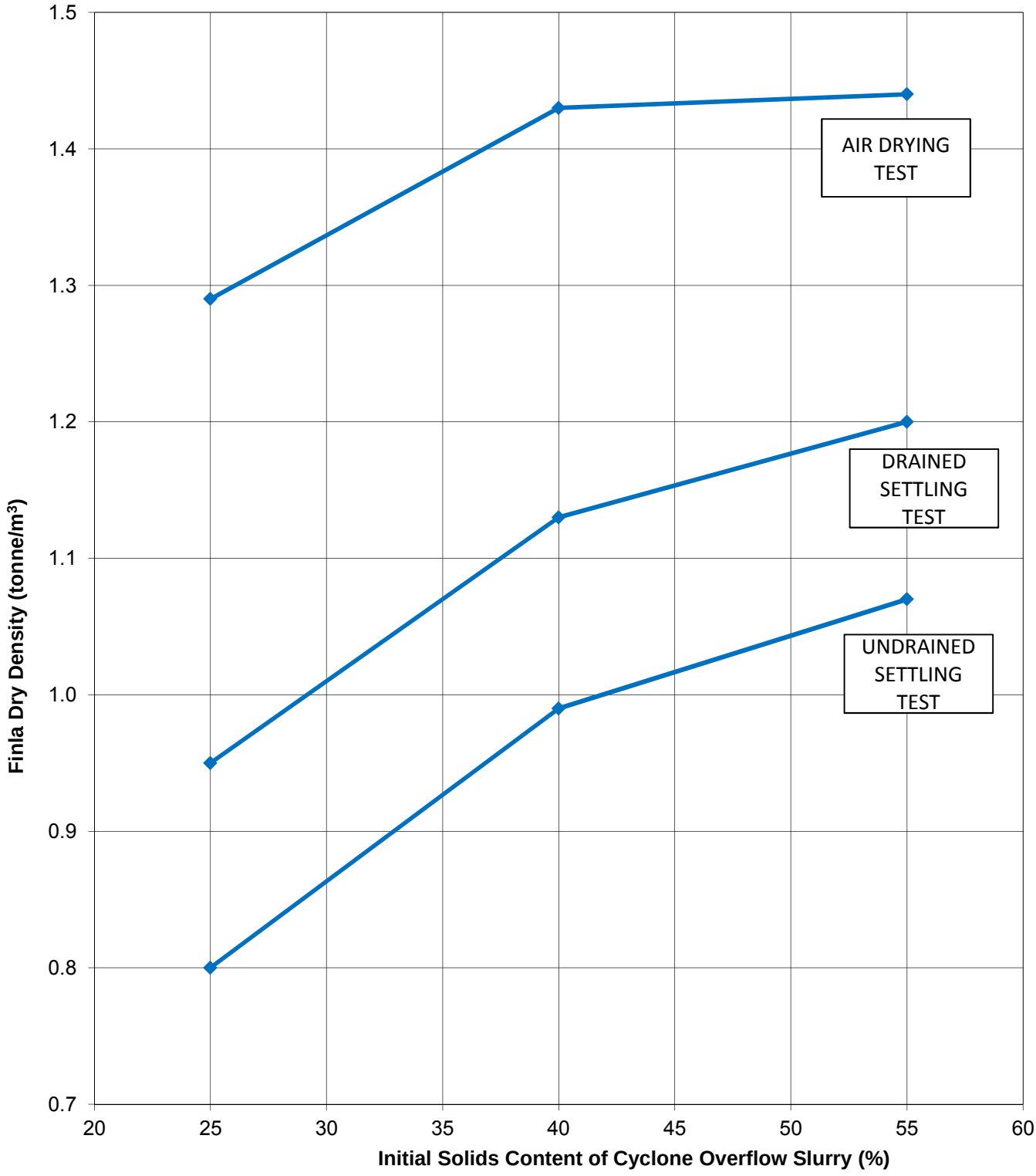
P/A NO. VA101-325/8

REF NO. 1

FIGURE 2.1

REV. 0



CASINO MINING CORP.

CASINO COPPER AND GOLD PROJECT

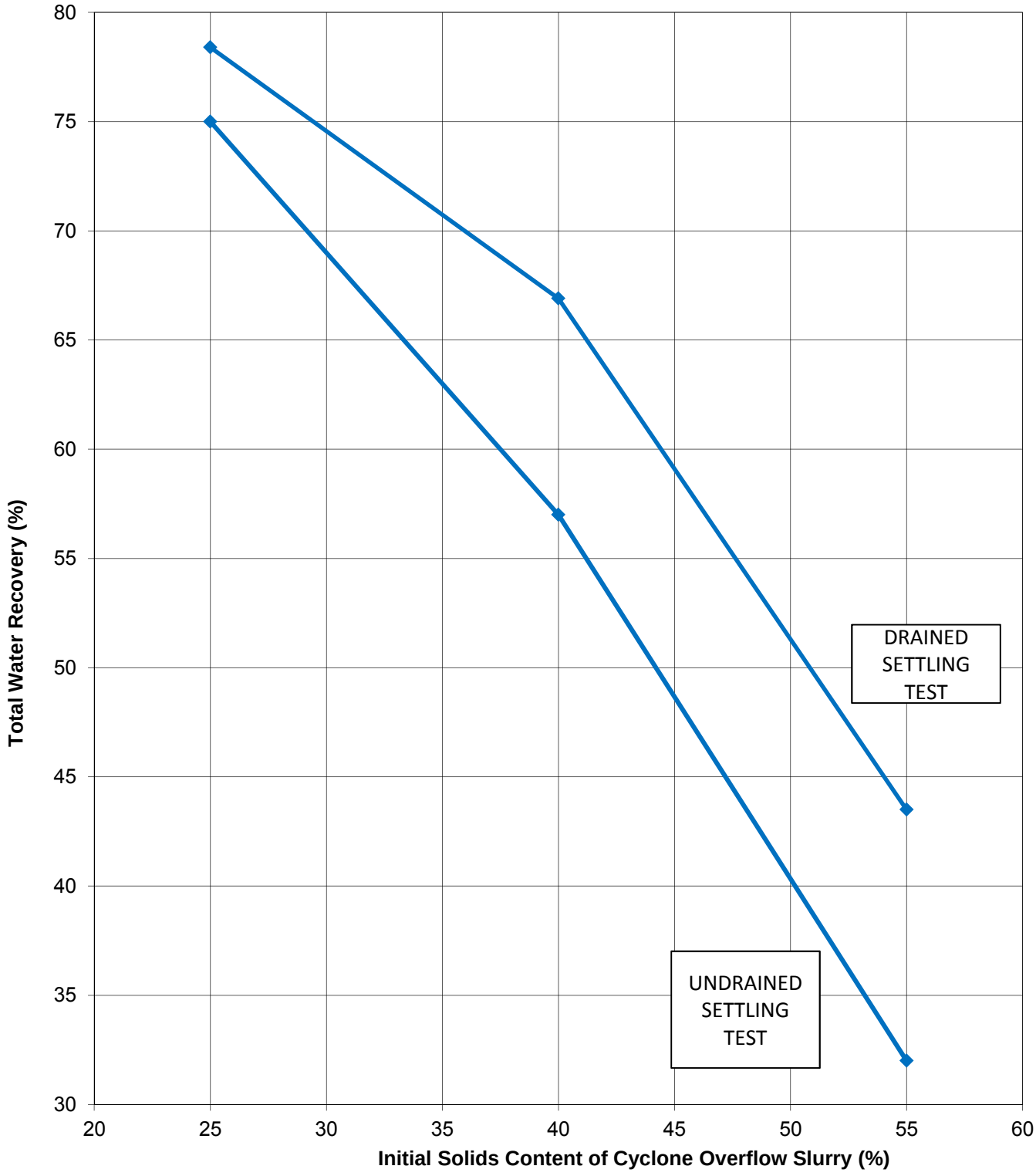
RELATIONSHIP BETWEEN FINAL DRY DENSITY AND INITIAL SOLIDS CONTENT OF MANUFACTURED CYCLONE OVERFLOW

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	13AUG'12	ISSUED WITH REPORT	MGP	AMM	KJB

Knight Piésold CONSULTING

P/A NO. VA101-325/8 | REF. NO. 1

FIGURE 3.1 | REV 0



NOTE:

1. TOTAL WATER RECOVERY IS DEFINED AS THE PERCENTAGE OF WATER RECOVERED FROM THE SLURRY VIA SETTLING.

CASINO MINING CORP.

CASINO COPPER AND GOLD PROJECT

RELATIONSHIP BETWEEN TOTAL WATER RECOVERY AND INITIAL SOLIDS CONTENT OF MANUFATURED CYCLONE OVERFLOW

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P/A NO. VA101-325/8 | REF. NO. 1

FIGURE 3.2 | REV 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
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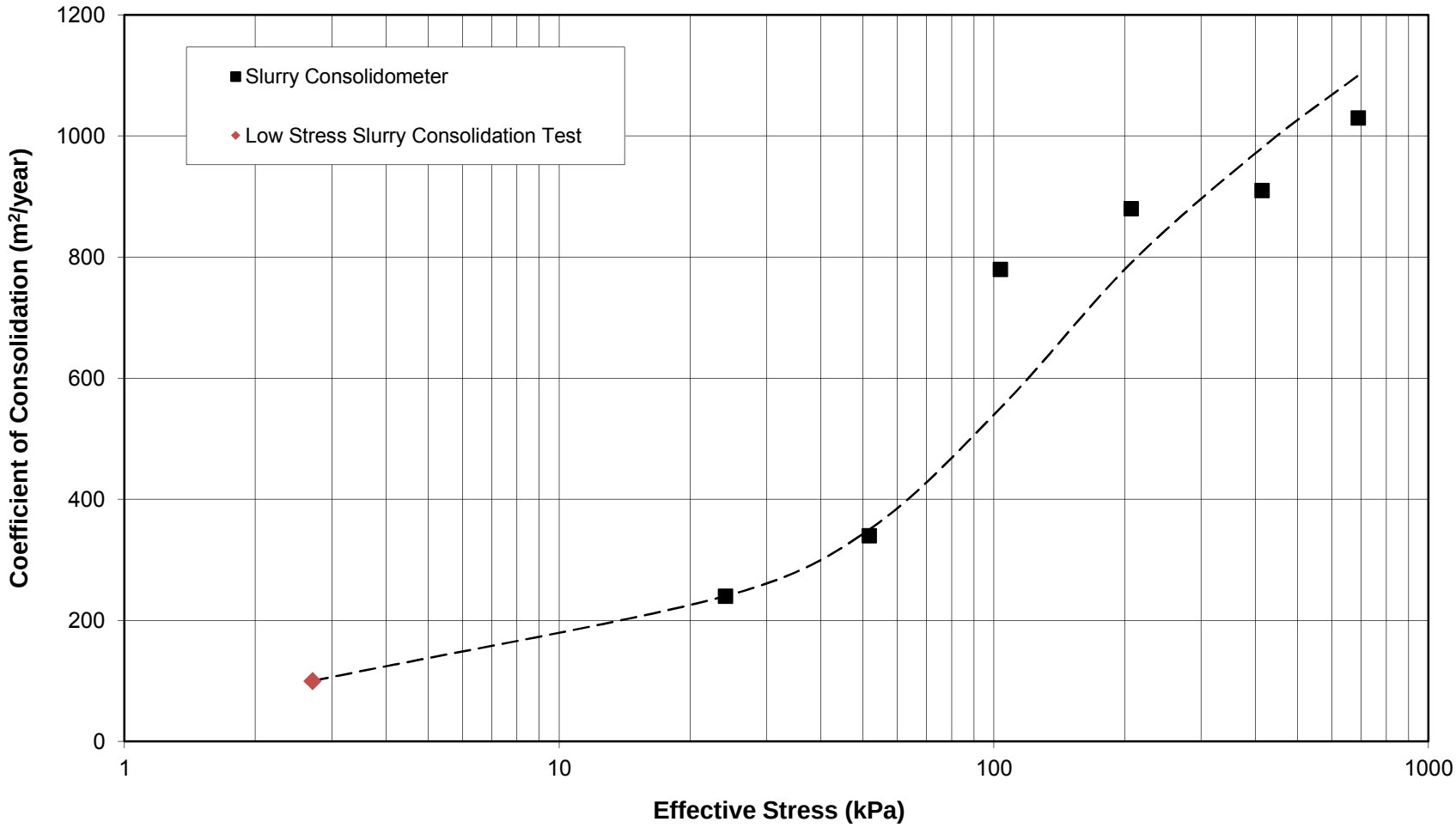


REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	3AUG'12	ISSUED WITH REPORT	AMM	GRG	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

RELATIONSHIP BETWEEN TAILINGS COEFFICIENT OF CONSOLIDATION AND EFFECTIVE STRESS FOR WHOLE TAILINGS

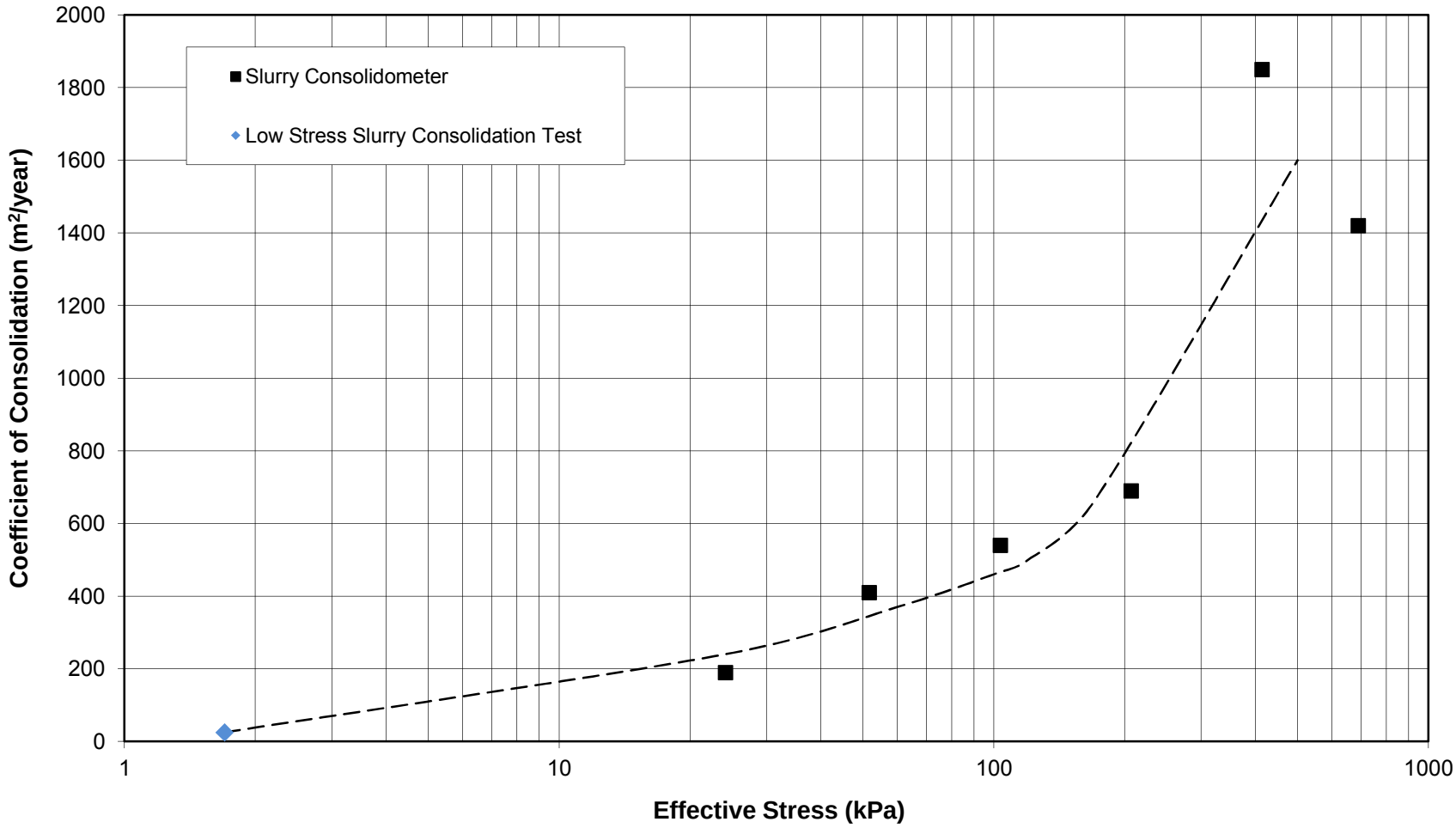
Knight Piésold CONSULTING

P/A NO. VA101-325/8

REF NO. 1

FIGURE 4.1

REV 0



0	01AUG'12	ISSUED WITH REPORT	AMM	GRG	KJB
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

RELATIONSHIP BETWEEN TAILINGS COEFFICIENT OF CONSOLIDATION AND EFFECTIVE STRESS FOR MANUFACTURED CYCLONE OVERFLOW

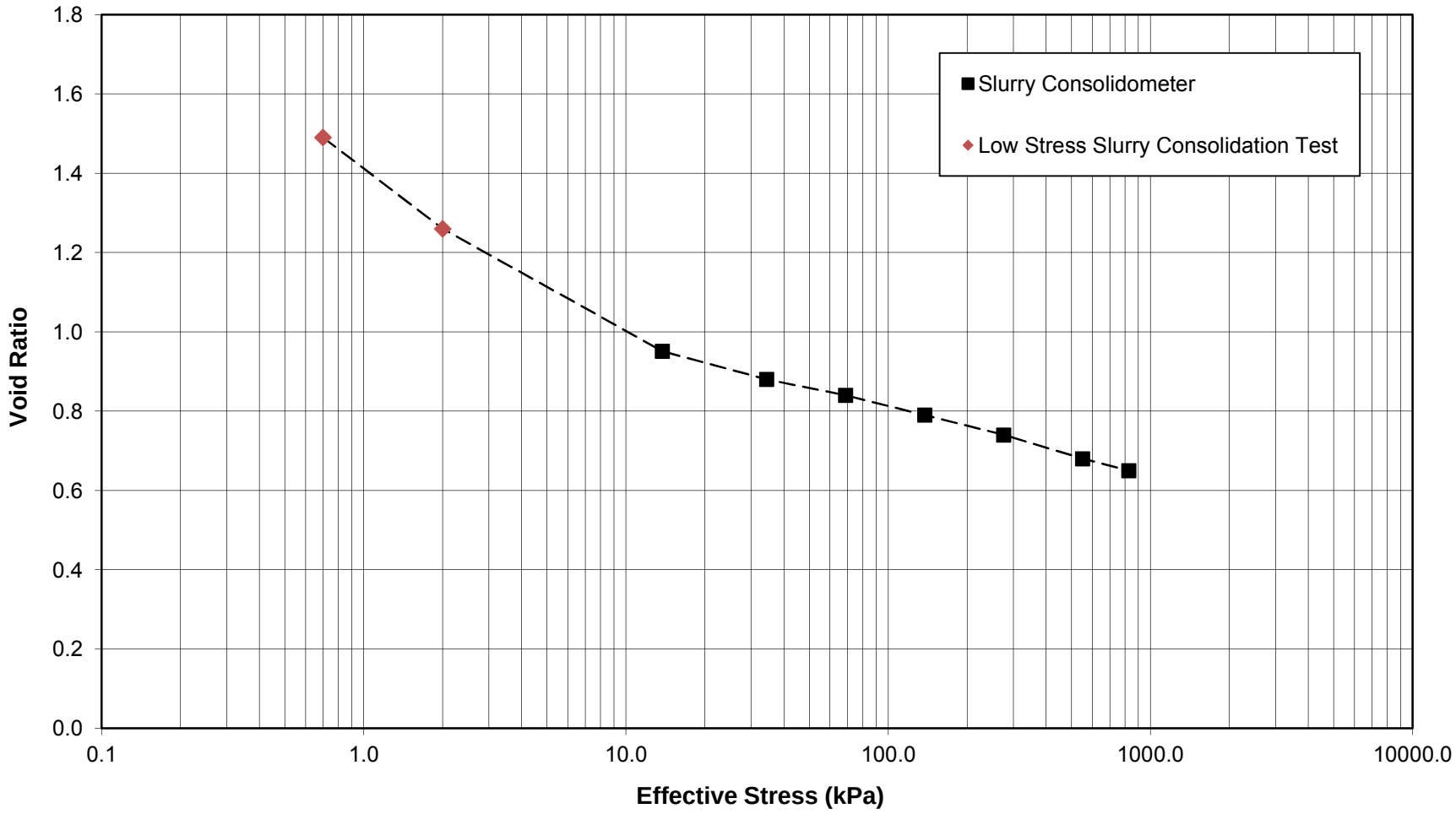
Knight Piésold CONSULTING

P/A NO. VA101-325/8

REF NO. 1

FIGURE 4.2

REV. 0



CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

RELATIONSHIP BETWEEN VOID RATIO AND EFFECTIVE STRESS FOR WHOLE TAILINGS

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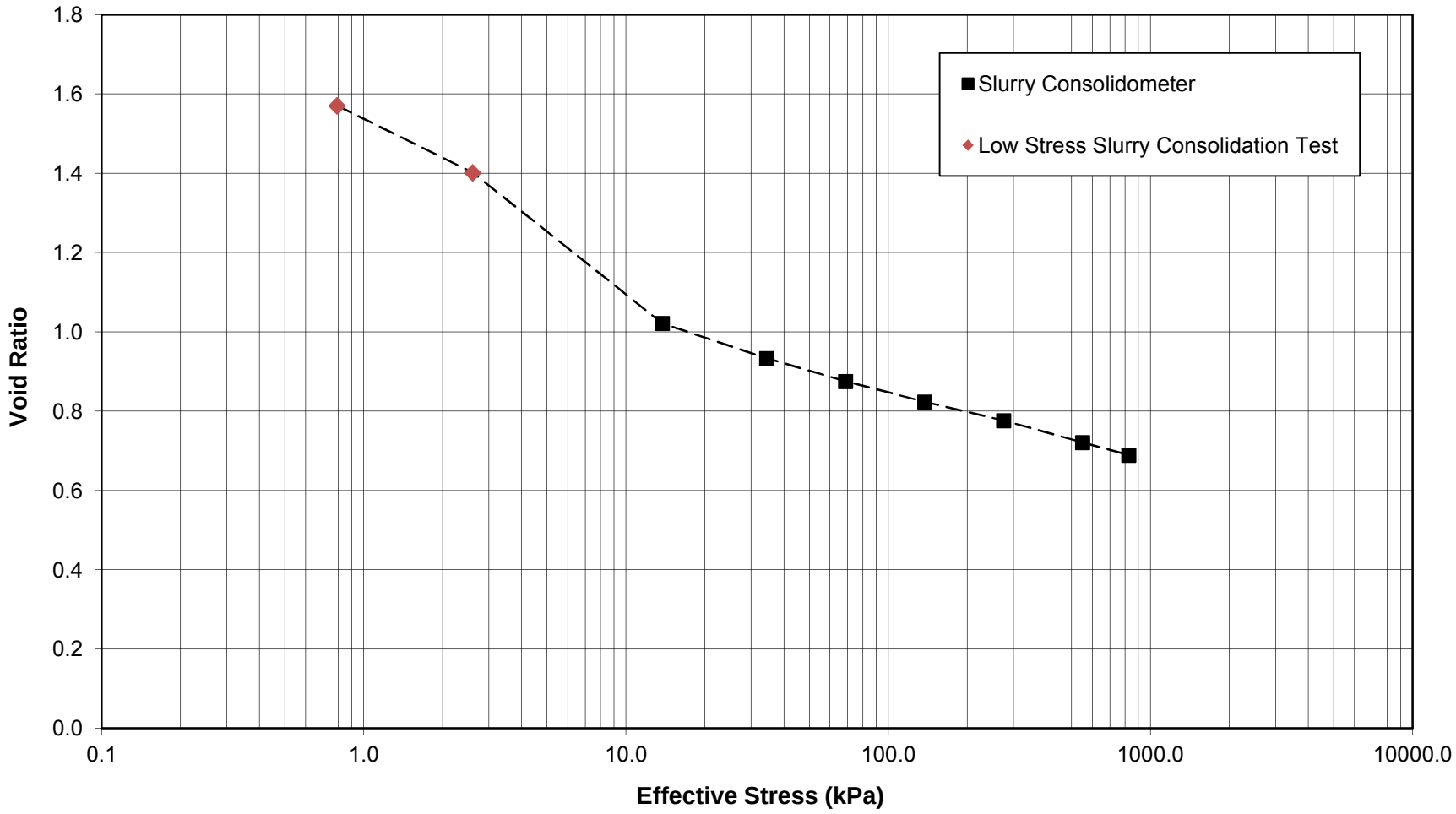
P/ A NO. VA101-325//8

REF NO. 1

FIGURE 4.3

REV. 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	02AUG'12	ISSUED WITH REPORT	AMM	GRG	KJB



REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	02AUG'12	ISSUED WITH REPORT	AMM	GRG	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

RELATIONSHIP BETWEEN VOID RATIO AND EFFECTIVE STRESS FOR MANUFACTURED CYCLONE OVERFLOW

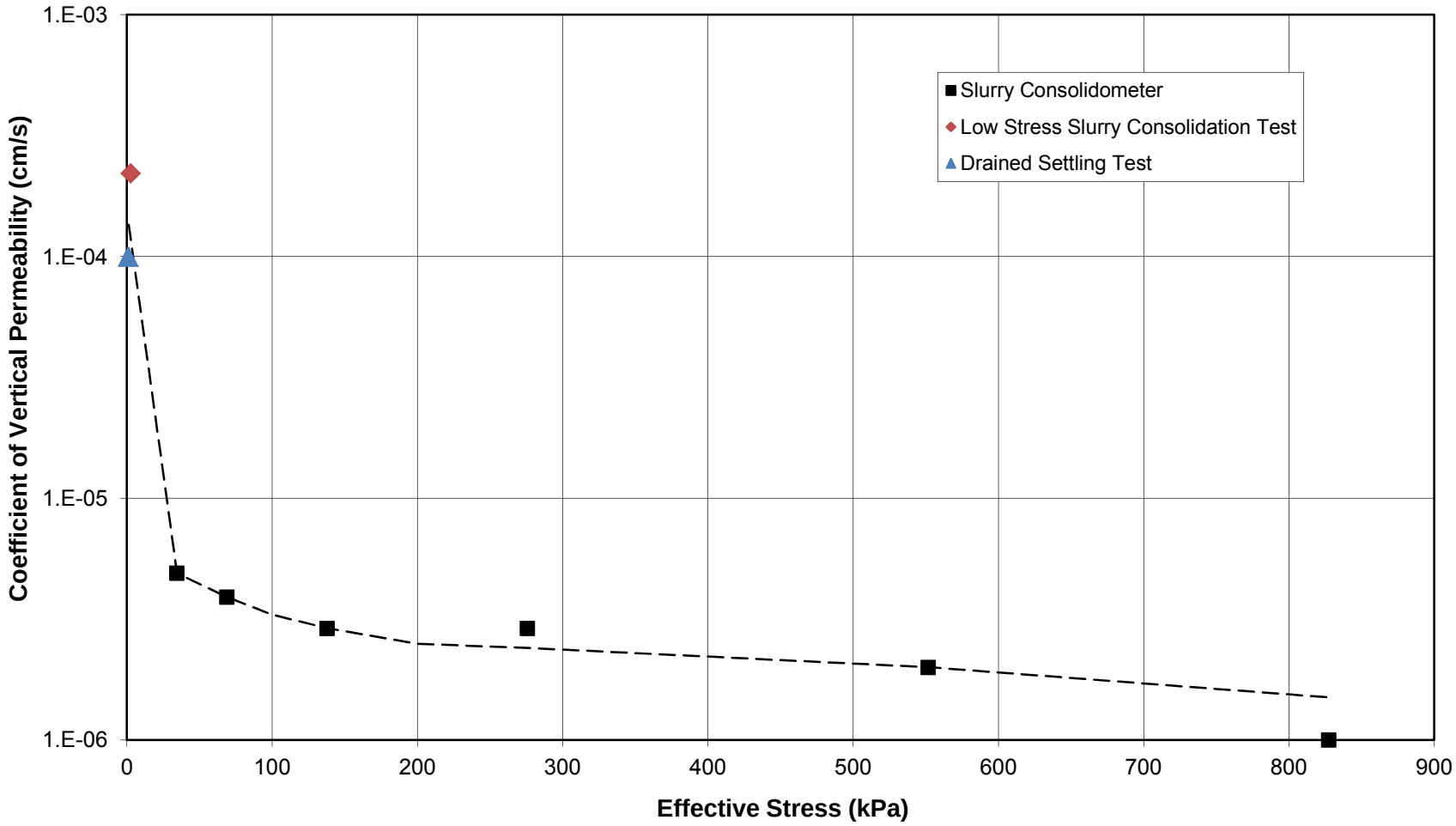
Knight Piésold CONSULTING

P/ A NO. VA101-325//8

REF NO. 1

FIGURE 4.4

REV. 0



REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	2AUG'12	ISSUED WITH REPORT	AMM	GRG	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

RELATIONSHIP BETWEEN COEFFICIENT OF VERTICAL PERMEABILITY AND EFFECTIVE STRESS FOR WHOLE TAILINGS

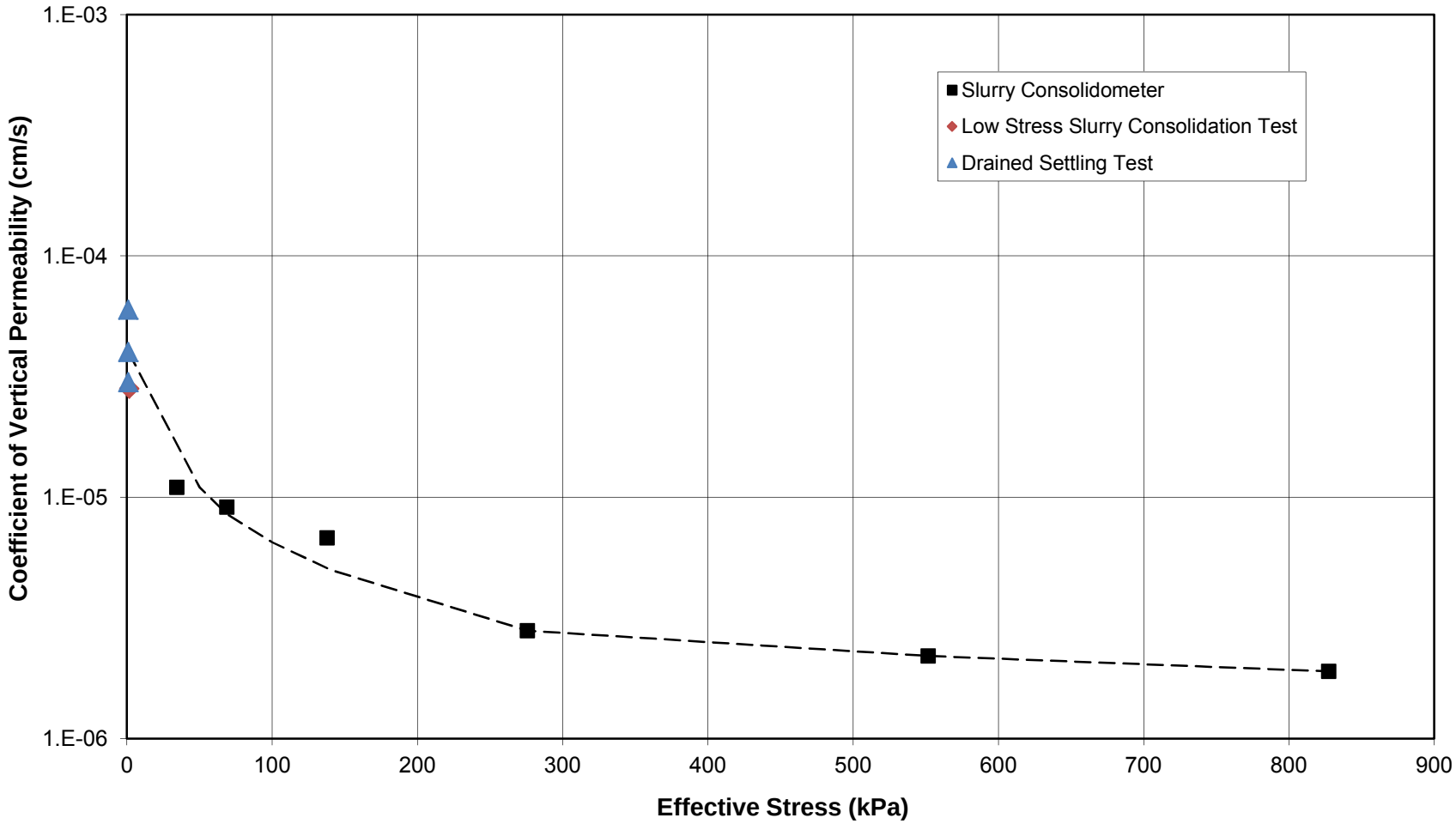
Knight Piésold CONSULTING

P/ A NO. VA101-325//8

REF NO. 1

FIGURE 4.5

REV 0



REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	2AUG'12	ISSUED WITH REPORT	AMM	GRG	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

RELATIONSHIP BETWEEN COEFFICIENT OF VERTICAL PERMEABILITY AND EFFECTIVE STRESS FOR MANUFACTURED CYCLONE OVERFLOW

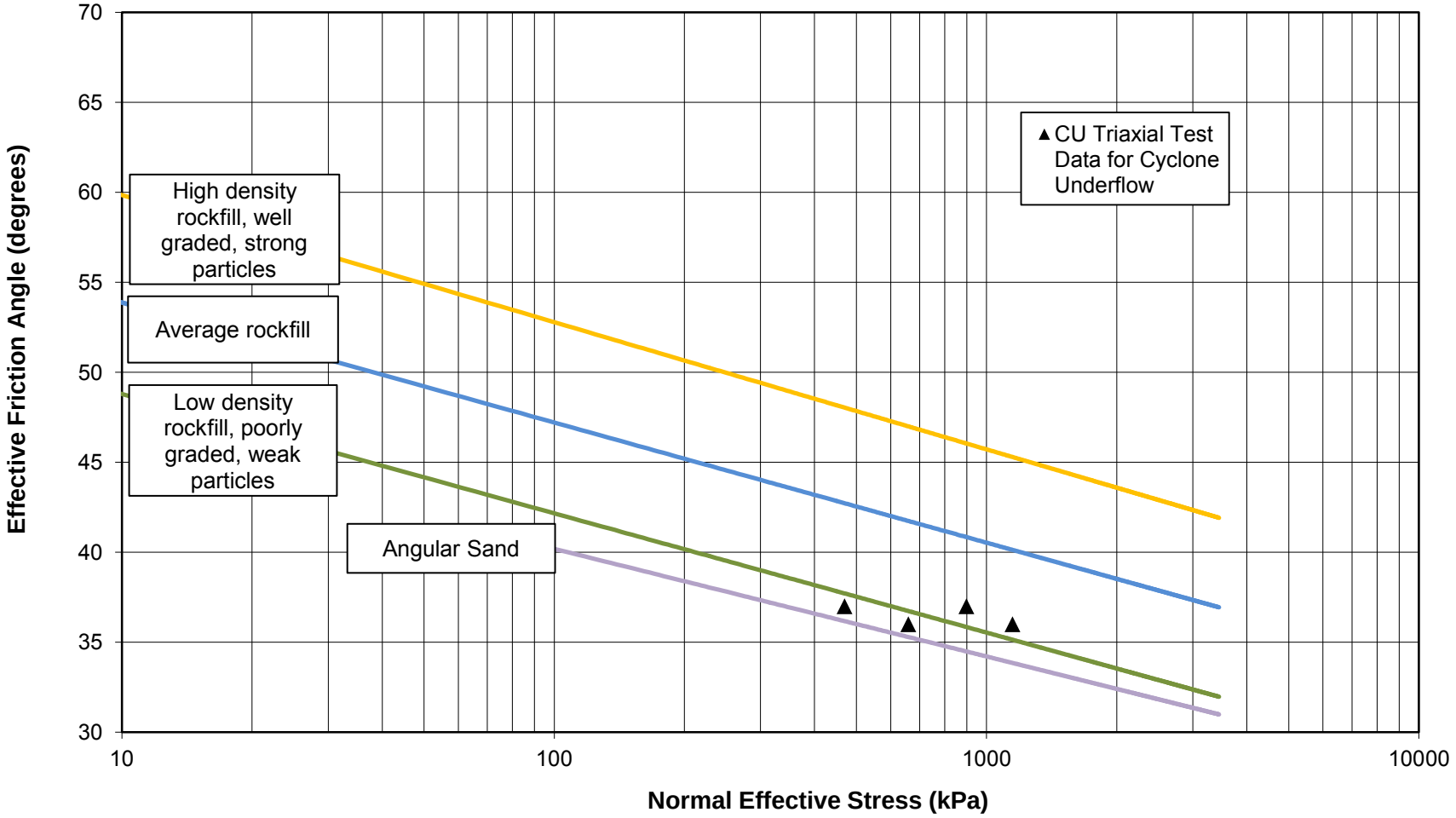
Knight Piésold CONSULTING

P/ A NO. VA101-325//8

REF NO. 1

FIGURE 4.6

REV 0



NOTE:
1. RESULTS PRESENTED WITH THE RELATIONSHIP BETWEEN NORMAL STRESS ACROSS THE FAILURE PLANE OF ROCKFILL AND FRICTION ANGLE (SHOWN AS FOUR RELATIONSHIPS FOR 1) HIGH DENSITY, WELL GRADED, STRONG PARTICLES; 2) AVERAGE ROCKFILL; 3) LOW DENSITY, POORLY GRADED, WEAK PARTICLES; AND 4) ANGULAR SAND) AFTER LEPS, 1970.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
1	20DEC'12	ISSUED WITH REPORT	AMM	GRG	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

RELATIONSHIP BETWEEN EFFECTIVE FRICTION ANGLE AND NORMAL EFFECTIVE STRESS FOR MANUFACTURED CYCLONE UNDERFLOW

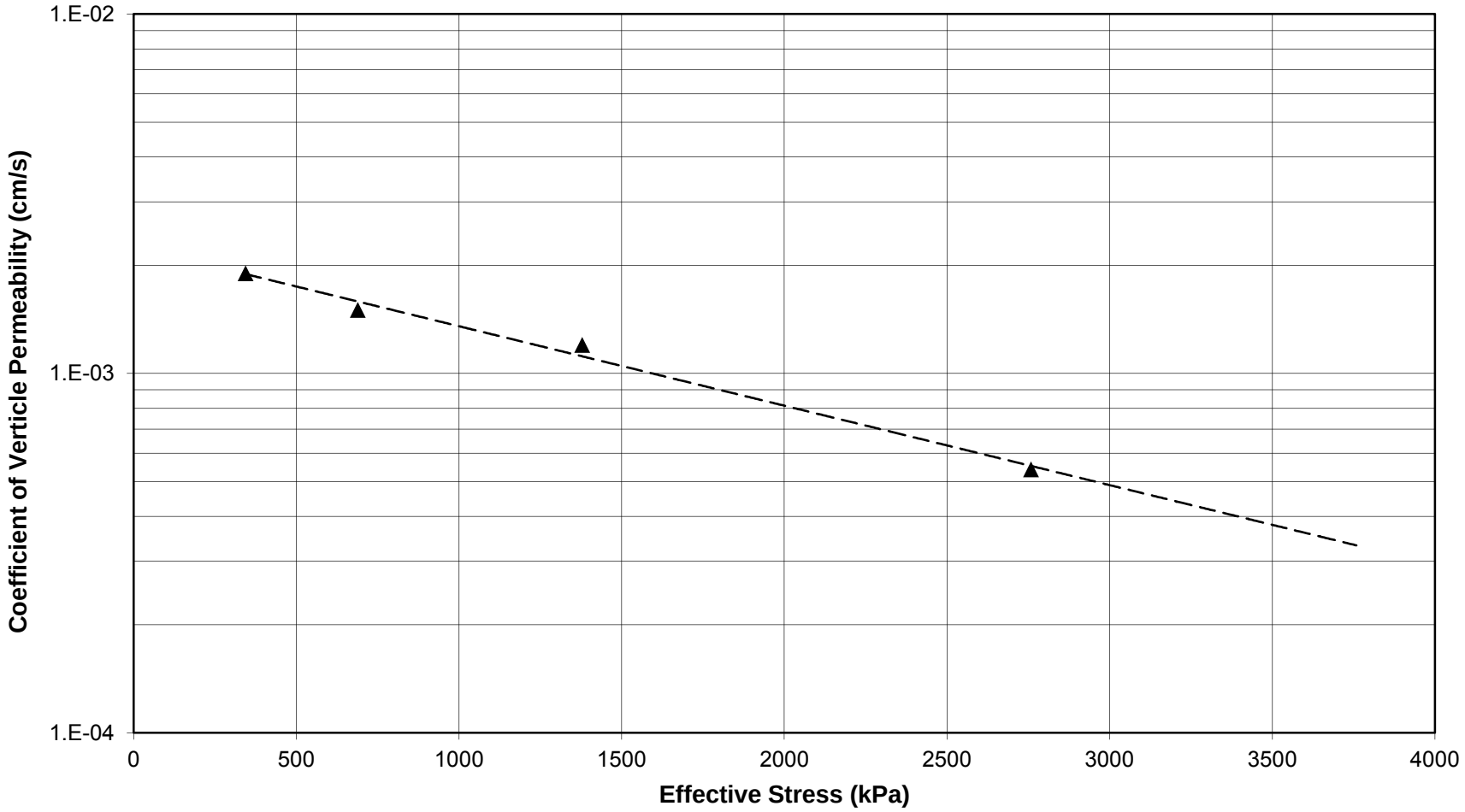
Knight Piésold CONSULTING

P/A NO. VA101-325/8

REF NO. 1

FIGURE 5.1

REV. 1



CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

RELATIONSHIP BETWEEN COEFFICIENT OF VERTICLE PERMEABILITY AND EFFECTIVE STRESS FOR MANUFACTURED CYCLONE UNDERFLOW

Knight Piésold CONSULTING

P/A NO. VA101-325/8

REF NO.. 1

FIGURE 5.2

REV. 0

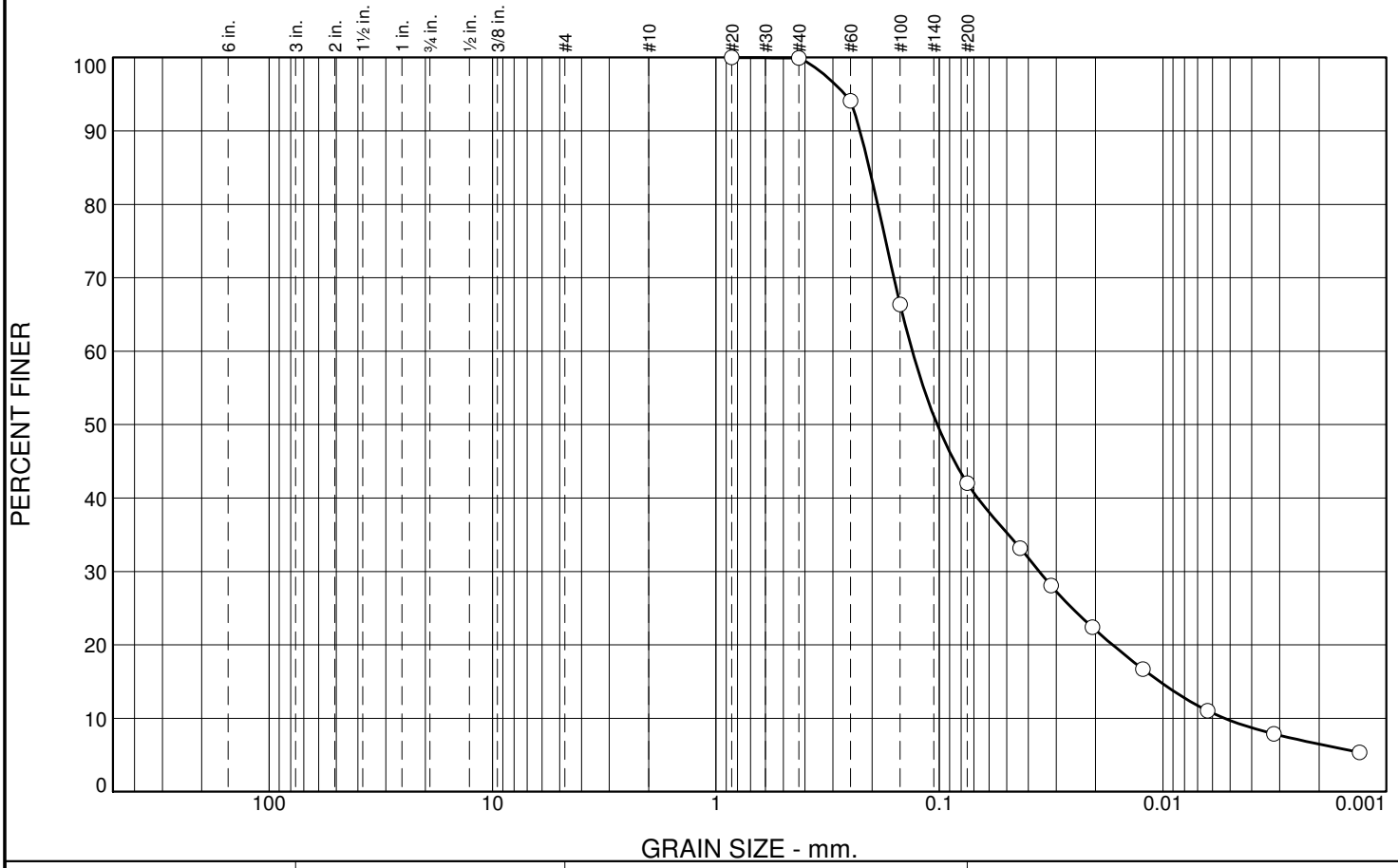
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	30AUG'12	ISSUED WITH REPORT	AMM	GRG	KJB

APPENDIX A

DETAILED RESULTS OF TAILINGS LABORATORY TESTS (PROVIDED BY KNIGHT PIESOLD DENVER)

(Pages A-1 to A-77)

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.1	57.9	35.5	6.5

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#20	100.0		
#40	99.9		
#60	94.1		
#100	66.4		
#200	42.0		
0.0435 mm.	33.2		
0.0317 mm.	28.1		
0.0207 mm.	22.4		
0.0123 mm.	16.7		
0.0063 mm.	11.0		
0.0032 mm.	7.9		
0.0013 mm.	5.4		

* (no specification provided)

Soil Description

silty sand

Atterberg Limits

PL= NP LL= NP PI= NP

Coefficients

D_{90}= 0.2268 D_{85}= 0.2060 D_{60}= 0.1322
D_{50}= 0.1022 D_{30}= 0.0357 D_{15}= 0.0103
D_{10}= 0.0053 C_u= 24.97 C_c= 1.82

Classification

USCS= SM AASHTO= A-4(0)

Remarks

Composite Gs - 2.695

Location: Composite of Samples KM3134-44 thru 47

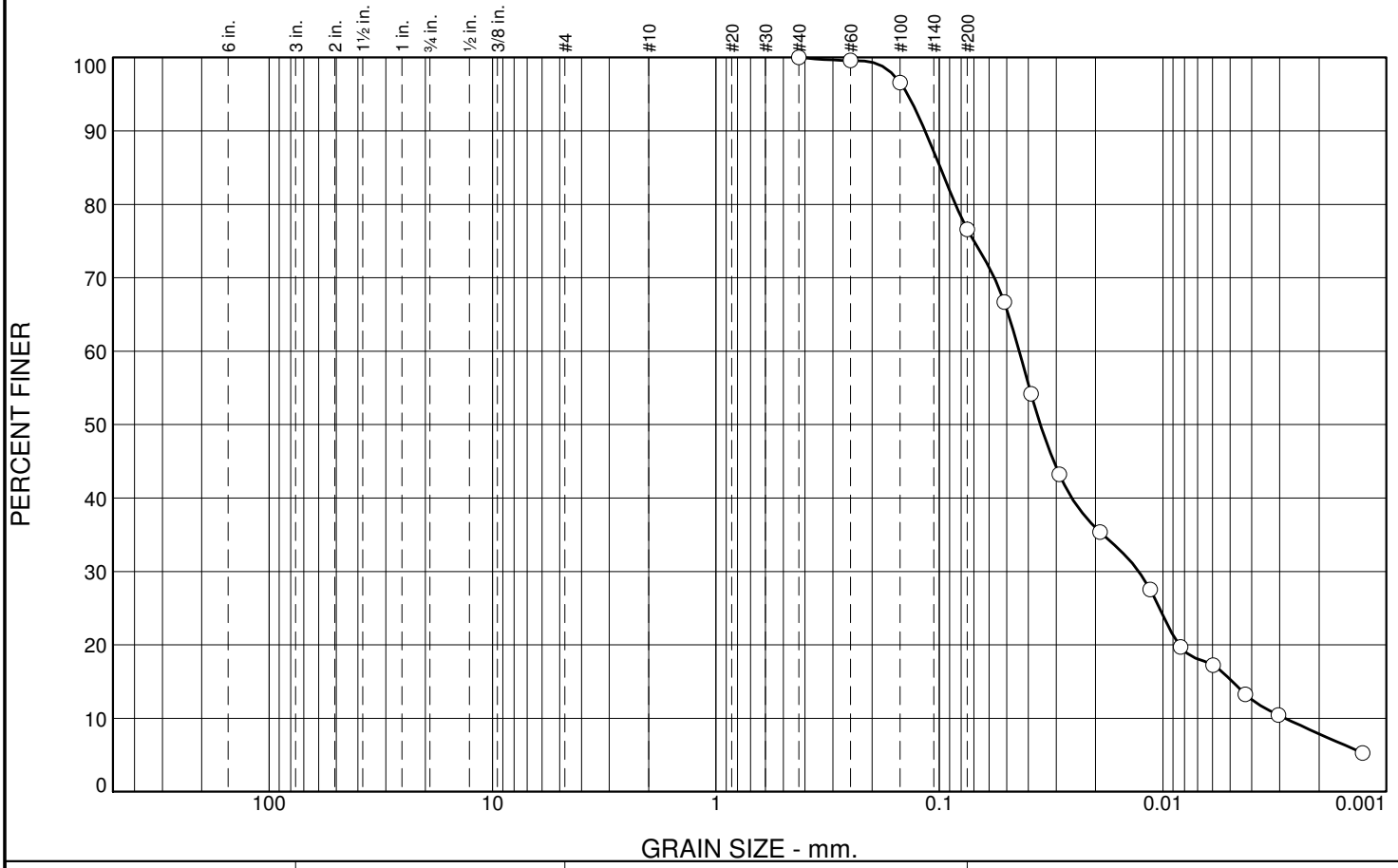
Date: 4/2/12

Knight Piésold CONSULTING

Client: Knight Piésold Ltd.
Project: Casino

Project No: 101-77/13 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.0	23.4	68.7	7.9

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#40	100.0		
#60	99.6		
#100	96.6		
#200	76.6		
0.0512 mm.	66.7		
0.0389 mm.	54.2		
0.0291 mm.	43.2		
0.0191 mm.	35.4		
0.0114 mm.	27.5		
0.0083 mm.	19.7		
0.0060 mm.	17.3		
0.0043 mm.	13.3		
0.0030 mm.	10.5		
0.0013 mm.	5.3		

* (no specification provided)

Soil Description

silt with sand

Atterberg Limits

PL= NP LL= 24 PI= NP

Coefficients

D_{90}= 0.1158 D_{85}= 0.0991 D_{60}= 0.0439
D_{50}= 0.0353 D_{30}= 0.0128 D_{15}= 0.0049
D_{10}= 0.0028 C_u= 15.51 C_c= 1.32

Classification

USCS= ML AASHTO= A-4(0)

Remarks

Gs = 2.711

Location: Manufactured O/F

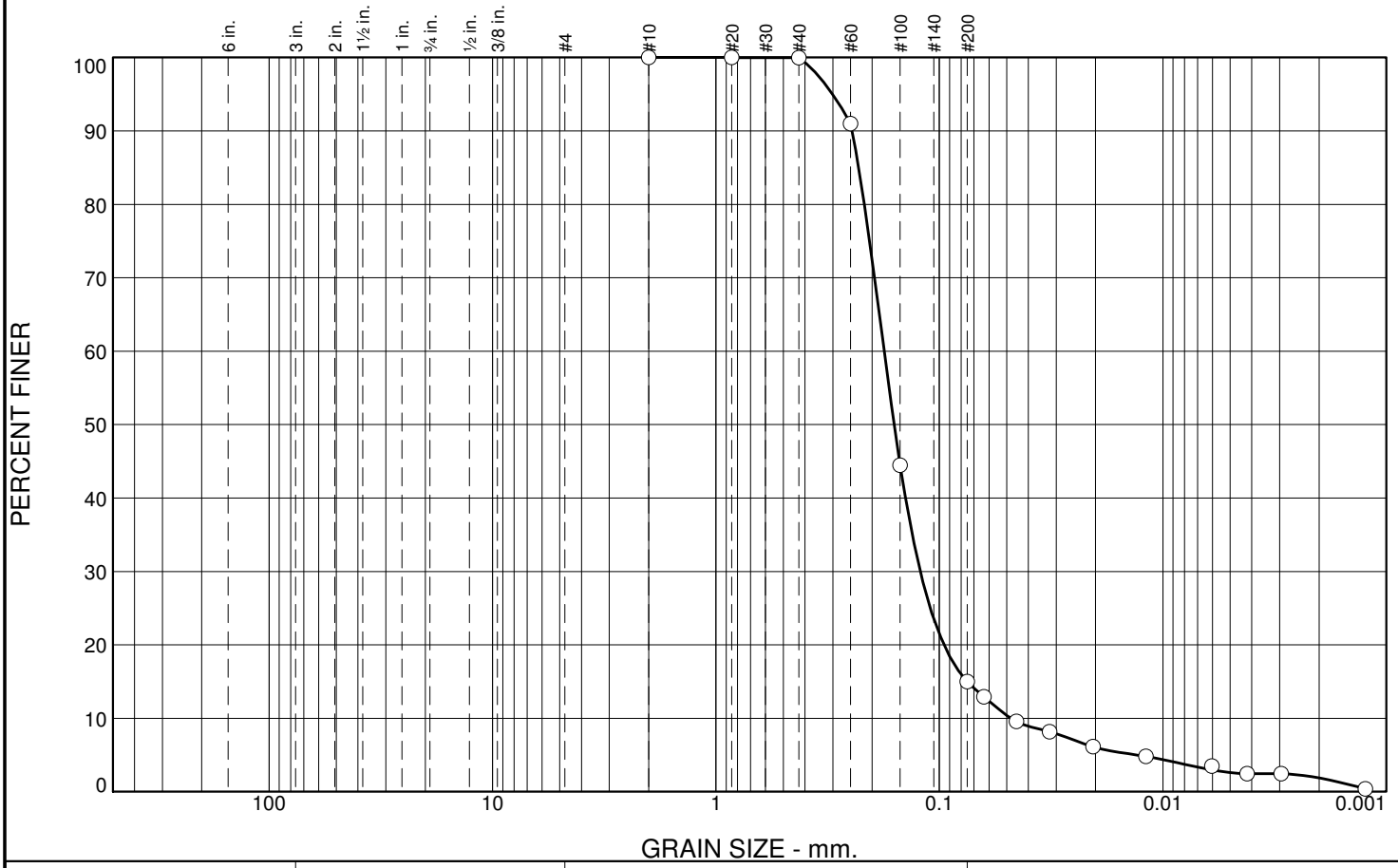
Date:

Knight Piésold CONSULTING

Client: Knight Piésold Ltd.
Project: Casino

Project No: 101-77/13 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.0	85.0	13.1	1.9

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	100.0		
#40	100.0		
#60	91.0		
#100	44.5		
#200	15.0		
0.0631 mm.	12.9		
0.0452 mm.	9.6		
0.0322 mm.	8.2		
0.0205 mm.	6.1		
0.0119 mm.	4.8		
0.0060 mm.	3.0		
0.0060 mm.	3.5		
0.0042 mm.	2.4		
0.0030 mm.	2.5		
0.0012 mm.	0.4		

* (no specification provided)

Soil Description

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.2461 D_{85}= 0.2298 D_{60}= 0.1767
D_{50}= 0.1595 D_{30}= 0.1217 D_{15}= 0.0750
D_{10}= 0.0478 C_u= 3.70 C_c= 1.75

Classification

USCS= AASHTO=

Remarks

Location: Manufactured U/F

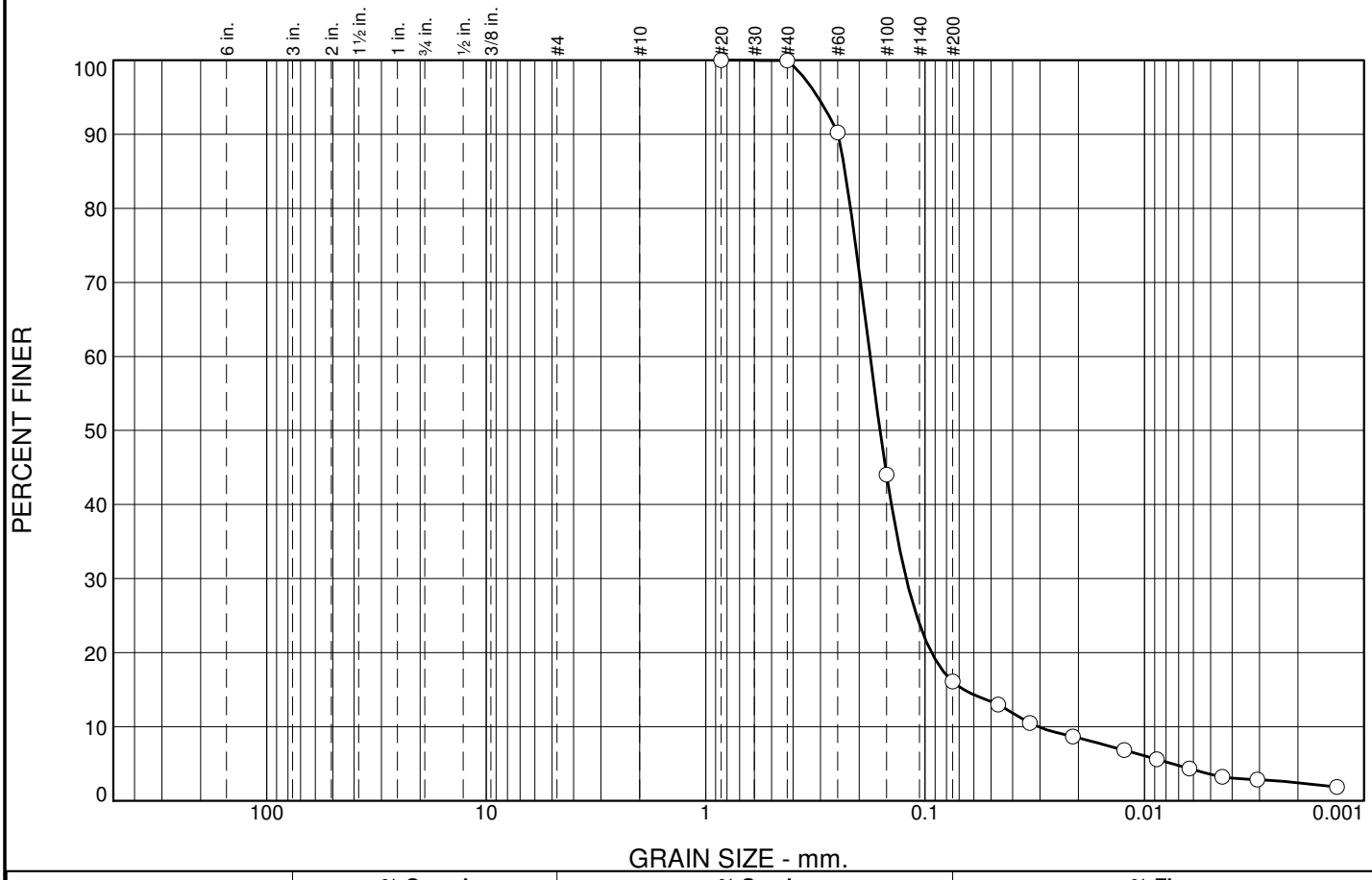
Date: 6/29/12

Knight Piésold CONSULTING

Client: Knight Piésold Ltd.
Project: Casino

Project No: 101-77/13 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.1	83.8	13.7	2.4

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#20	100.0		
#40	99.9		
#60	90.2		
#100	44.0		
#200	16.1		
0.0465 mm.	13.0		
0.0333 mm.	10.5		
0.0213 mm.	8.7		
0.0124 mm.	6.8		
0.0088 mm.	5.6		
0.0063 mm.	4.4		
0.0044 mm.	3.2		
0.0031 mm.	2.9		
0.0013 mm.	1.9		

* (no specification provided)

Soil Description

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.2491 D_{85}= 0.2321 D_{60}= 0.1779
D_{50}= 0.1605 D_{30}= 0.1218 D_{15}= 0.0666
D_{10}= 0.0304 C_u= 5.85 C_c= 2.74

Classification

USCS= AASHTO=

Remarks

Sample No.: **Source of Sample:** **Date:** 9/13/12
Location: Manufactured UF post shear **Elev./Depth:**

Knight Piésold CONSULTING

Client: Knight Piésold Ltd.
Project: Casino
Project No: 101-325/08 **Figure**

Knight Piésold CONSULTING	FLOW CONE VISCOSITY & SOLIDS CONTENT DETERMINATION	Project No. VA101-325/08

Project:	Casino	Sample No.:	55%
	Whole Tailings	Location:	KM3134-44,-45,-46,-47 Comp
Test Date:	29-May-12 10:57 AM	Tested By:	JK

FLOW CONE WATER DISCHARGE CALIBRATION

Trial No.	1.	2.	3.	Average
Time for complete water discharge (sec)				

FLOW CONE TAILINGS DISCHARGE TESTS

Trial No.	1	2	3	
Time for tailings discharge (sec)				

PERCENT SOLIDS AND MOISTURE CONTENT DETERMINATION

	Trial No.	1.	2.	3.	4.	Average
	Origin of Sample		Target 55%			
	Tare No.					
a.	Tare Weight (g)		396			
b.	Tare + Wet Sample Weight (g)		977			
c.	Tare + Dry Sample Weight (g)		718			
	Drying Time - From		29-May-12			
	- To		30-May-12			
d.	Moisture Loss [b-c] (g)		259.6			
e.	Dry Sample Weight [c-a] (g)		322.1			
	Initial Parameters from Previous Test					
f.	Tare (Cylinder or Beaker) Weight (g)		396			
g.	Tare + Initial Slurry Weight (g)		977			
h.	Initial Slurry Weight (g)		582			
i.	True Moisture Loss [h-e] (g)		260			
	PERCENT SOLIDS [e/h*100] (%)		55.4			
	MOISTURE CONTENT [i/e*100] (%)		80.6			

Comments:

Solids content percentages reported in trials 1, 2 & 3 will vary slightly for each specific test.

Knight Piésold CONSULTING

UNDRAINED SETTLING TEST

Project No. VA101-325/08

Project:	Casino	Sample No.:		Test Date:	5/30/2012-6/6/2012
		Location:	KM3134-44,-45,-46,-47 Comp	Tested By:	JK

Initial Parameters

a.	Cylinder (Tare) Weight =	195	g	d. Moisture Content (from drying test) =	**82.1**	%
b.	Initial Slurry Volume =	740	ml	e. Initial Slurry Bulk Density [(c-a)/b] =	1.49	g/cm³
c.	Tare + Initial Slurry Weight =	1299	g	f. Weight of Water [(c-a)/(1+1/(d/100))] =	498	g
	Time of Readings 30-May-12	10:52 AM		g. Weight of Solids [(c-a)/(1+d/100)] =	606	g

On-going Readings

			A.	B.	C.	D.	E.	F.	G.	H.
	Date of Reading	Time of Reading	Total Cylinder Weight (g)	Total Cylinder Volume (ml)	Settled Slurry Volume (ml)	Water Recovery [(B-C)/f] (%)	Volume Reduction of Solids [1-C/b] (%)	Slurry Bulk Density [(A-a-(B-C))/C] (g/cm³)	Slurry Dry Density [g/C] (g/cm³)	Moisture Content [(f-(B-C))/g] (%)
1	30-May-12	11:48 AM	1299	740	670	14	9	1.54	0.90	70.54
2	30-May-12	12:32 PM	1299	740	640	20	14	1.57	0.95	65.59
3	30-May-12	02:03 PM	1299	740	610	26	18	1.60	0.99	60.64
4	30-May-12	04:32 PM	1299	740	605	27	18	1.60	1.00	59.82
5	31-May-12	08:08 AM	1299	735	605	26	18	1.61	1.00	60.64
6	01-Jun-12	08:28 AM	1298	735	602	27	19	1.61	1.01	60.15
7	02-Jun-12	11:00 AM	1298	735	602	27	19	1.61	1.01	60.15
8	04-Jun-12	08:24 AM	1298	730	600	26	19	1.62	1.01	60.64
9	05-Jun-12	08:50 AM	1298	730	600	26	19	1.62	1.01	60.64
10	06-Jun-12	09:53 AM	1297	730	600	26	19	1.62	1.01	60.64

Knight Piésold CONSULTING

DRAINED SETTLING TEST AND FALLING HEAD PERMEABILITY TEST

Project No. VA101-325/08

Project:	Casino	Sample No.:		Test Date:	5/30/2012-6/9/2012
		Location:	KM3134-44,-45,-46,-47 Comp	Tested By:	JK

Initial Parameters

a. Cylinder (Tare) Weight =	272	g	d. Moisture Content (from drying test) =	**82.6**	%
b. Initial Slurry Volume =	710	ml	e. Initial Slurry Bulk Density [(c-a)/b] =	1.50	g/cm³
c. Tare + Initial Slurry Weight =	1338	g	f. Weight of Water [(c-a)/(1+1/(d/100))] =	482	g
Time of Readings 30-May-12	10:56 AM		g. Weight of Solids [(c-a)/(1+d/100)] =	584	g

On-going Readings

			A.	B.	C.	D.	E.	F.	G.	H.
	Date of Reading	Time of Reading	Total Cylinder Weight (before decant) (g)	Total Cylinder Volume (ml)	Settled Slurry Volume (ml)	Water Volume [B-C] (ml)	Drainage Volume Collected (ml)	Decanted Water Volume (ml)	Slurry Bulk Density [(A-a-(B-C))/C] (g/cm³)	Slurry Dry Density [g/C] (g/cm³)
1	30-May-12	11:47 AM	1310	680	620	60	28	57	1.58	0.94
2	30-May-12	12:31 PM	1239	610	580	30	42	30	1.62	1.01
3	30-May-12	02:02 PM	1191	565	550	15	61	5	1.64	1.06
4	30-May-12	04:31 PM	1164	538	538	0	82	0	1.66	1.09
5	31-May-12	08:07 AM	1144	535	535	0	102	0	1.63	1.09
6	01-Jun-12	08:27 AM	1130	500	500	0	116	0	1.72	1.17
7	02-Jun-12	11:00 AM	1130	500	500	0	116	0	1.72	1.17

Falling Head Permeability Test

	Data Readings, Ti (hours)	Initial Water Height, hi (cm)	Initial Solids Height, Hi (cm)	Finishing Time, Tf (hours)	Final Water Height, hf (cm)	Final Solids Height, Hf (cm)	Drainage Collected (ml)	Elapsed Time, T (hours)	Ave. Solids Thickness, H (cm)	Permeability k H/3600T*ln(hi/hf) (cm/sec)
1	0.00	32.6	17.9	0.00	22.2	17.8	299	16.38	17.9	1.2E-04
2	0.00	31.6	17.8	0.00	21.7	17.8	284	16.28	17.8	1.1E-04
3	0.00	32.2	17.8	0.00	21.4	17.8	311	17.70	17.8	1.1E-04
4	0.00	31.9	17.8	0.00	20.8	17.8	320	17.97	17.8	1.2E-04
									AVG.	1.2E-04

Knight Piésold CONSULTING

SETTLING AND DRYING TEST (including Evaporation Control)

Project No. VA101-325/08

Project: Casino
Sample No.:
Test Date: 5/30/2012-6/14/2012
Location: KM3134-44,-45,-46,-47 Comp
Tested By: JK

Initial Parameters for Settling and Drying Test

a.	Beaker (Tare) Weight =	402.49 g	d. Moisture Content (from drying test) =	**81.8** %	
b.	Initial Slurry Volume =	860 cm³	e. Initial Slurry Bulk Density [(c-a)/b] =	1.53 g/cm³	
c.	Tare + Initial Slurry Weight =	1714.9 g	f. Weight of Water [(c-a)/(1+1/(d/100))] =	591 g	
	Time of Readings	30-May-12	g. Weight of Solids [(c-a)/(1+d/100)] =	722 g	
		11:01 AM	h. Tailings Solids Specific Gravity =	2.668	
			i. Solids Volume [g/h] =	270.5 cm³	

Initial Parameters for Evaporation Control

x.	Beaker Tare Weight =	398 g
y.	Initial Weight of Beaker =	1447 g
z.	Beaker Cross-Sectional Area =	84.46 cm²

On-going Readings

			A.	B.	C.	D.	E.	F.	G.	H.	I.	J.		Evaporation Control		
	Date of Reading	Time of Reading	Total Remaining Weight (g)	Total Remaining Volume (cm³)	Settled Slurry Volume (cm³)	Decanted Water Volume (if any) (cm³)	Shrinkage Crack Volume (estimated) (cm³)	Net. Slurry Volume [C-E] (cm³)	Volume Reduction [(b-F)/b] (%)	Slurry Dry Density [g/F] (g/cm³)	Moisture Content [(A-a)/g]-1 (%)	Saturation (A-a-g)/(B-i) (%)	Comments	Total Weight After Decant (g)	Decanted Weight (if any) (g)	Evap. (mm)
1	30-May-12	11:45 AM	1714	860.0	750.0	99.4		750.0	12.8	0.96	81.7	100.0	Water Decanted	1446	0	0
2	30-May-12	12:30 PM	1614	765.0	700.0	47.9		700.0	18.6	1.03	67.9	100.0	Water Decanted	1445	0	0
3	30-May-12	2:00 PM	1565	720.0	690.0	18.0		690.0	19.8	1.05	61.0	100.0	Water Decanted	1443	0	0
4	30-May-12	4:29 PM	1544	700.0	685.0	7.0		685.0	20.3	1.05	58.1	100.0	Water Decanted	1440	0	1
5	31-May-12	8:05 AM	1520	675.0	650.0	7.4		650.0	24.4	1.11	54.8	100.0	Water Decanted	1419	0	3
6	01-Jun-12	8:26 AM	1490	630.0	630.0	0.0		630.0	26.7	1.15	50.7	100.0	No free water	1393	0	6
7	02-Jun-12	11:00 AM	1466	610.0	610.0	0.0		610.0	29.1	1.18	47.4	100.0	No free water	1364	0	10
8	04-Jun-12	8:20 AM	1431		601.2		4.6	596.6	30.6	1.21	42.4	93.9	No free water	1319	0	15
9	05-Jun-12	8:45 AM	1409		598.6		10.3	588.3	31.6	1.23	39.4	89.5	Specimen pulling from sides	1291	0	18
10	06-Jun-12	9:50 AM	1389		591.0		18.0	573.0	33.4	1.26	36.6	87.4	measured in jar	1264	0	22
11	07-Jun-12	11:03 AM	1369		589.3		23.5	565.7	34.2	1.28	33.8	82.7	measured in jar	1238	0	25
12	08-Jun-12	9:23 AM	1353		587.5		29.0	558.6	35.0	1.29	31.7	79.5	measured in jar	1218	0	27
13	09-Jun-12	10:14 AM	1333		584.1		36.4	547.7	36.3	1.32	28.9	75.2	measured in jar	1191	0	30
14	11-Jun-12	10:11 AM	1284		627.6		94.9	532.7	38.1	1.35	22.1	60.9	Specimen measured	1126	0	38
15	12-Jun-12	8:46 AM	1263		625.1		98.9	526.1	38.8	1.37	19.2	54.1	Specimen measured	1098	0	41
16	14-Jun-12	7:49 AM	1218		625.1		100.0	525.0	38.9	1.37	13.0	36.9	Specimen measured	1041	0	48
17	15-Jun-12	8:21 AM	1198		623.4		101.9	521.4	39.4	1.38	10.2	29.4	Specimen measured	1013	0	51
18	16-Jun-12	8:44 AM	1180		623.4		101.9	521.4	39.4	1.38	7.8	22.4	Specimen measured	989	0	54
19	18-Jun-12	8:26 AM	1153		623.4		101.9	521.4	39.4	1.38	4.0	11.5	Specimen measured	938	0	60
20	19-Jun-12	9:26 AM	1145		623.4		101.9	521.4	39.4	1.38	2.9	8.4	Specimen measured	907	1	64
21	21-Jun-12	10:49 AM	1137		623.4		101.9	521.4	39.4	1.38	1.8	5.1	Specimen measured	851	1	70

Notes:

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TABLE 1.0

Casino
VA101-325/08
KM3134-44,-45,-46,-47 Comp

SUMMARY OF TAILINGS SEDIMENTATION TEST RESULTS
55%

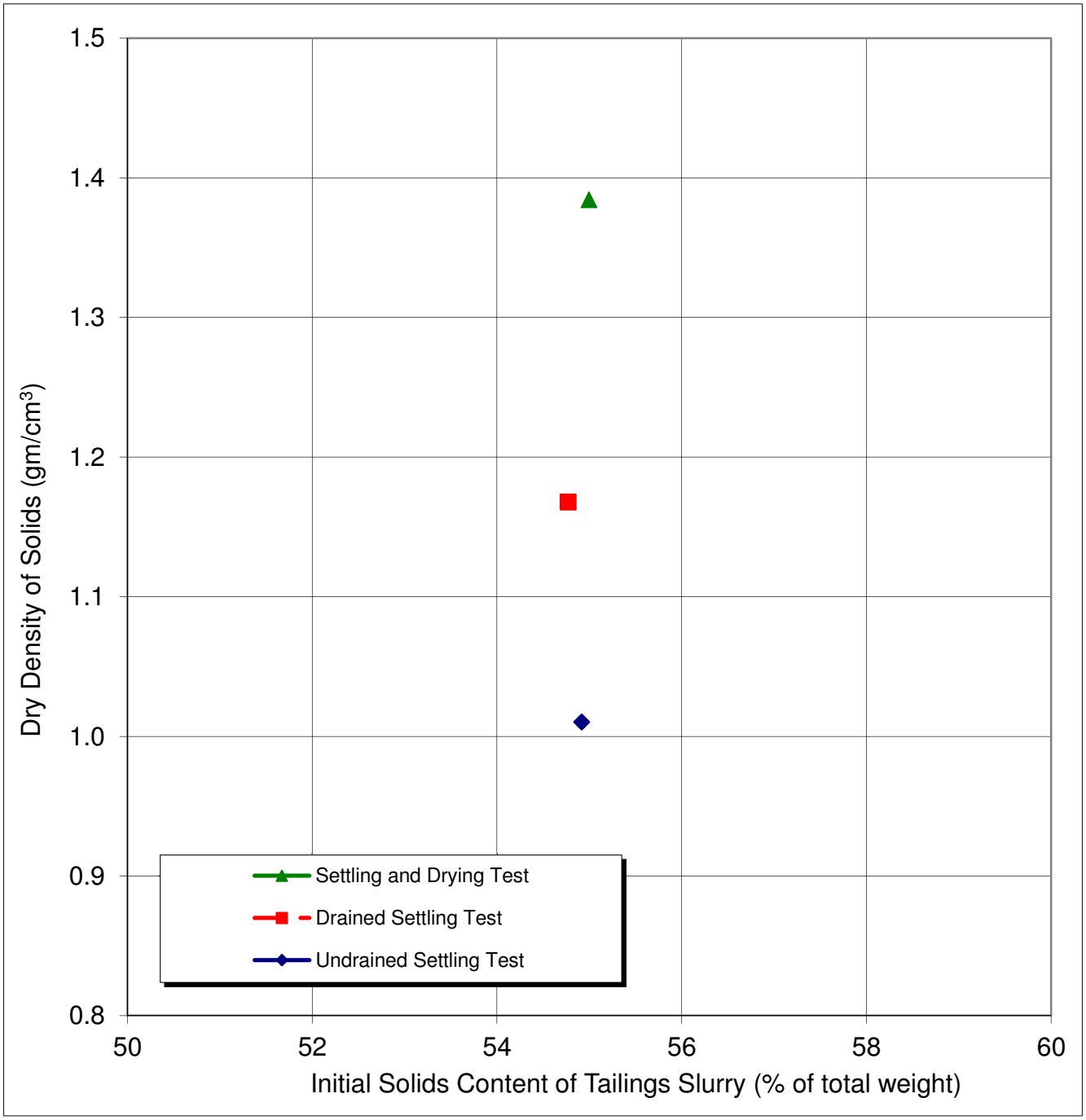
Undrained Settling Test				Drained Settling Test					Settling and Drying Test			Additional
Solids Content	Slurry Dry Density	Total Water Recovery	Portion of Initial Water Retained in Tailings prior to Onset of Evaporation	Solids Content	Slurry Dry Density	Total Water Recovery	Portion of Initial Water Retained in Tailings prior to Onset of Evaporation	Average Permeability	Solids Content	Slurry Dry Density	Total Evaporation	Water Recovered in Drained Test
(%)	(g/cm³)	(%)	(%)	(%)	(g/cm³)	(%)	(%)	(cm/sec)	(%)	(g/cm³)	(mm)	(%)
54.9	1.01	27.1	72.9	54.8	1.17	43.2	56.8	1.2E-04	55.0	1.38	70.4	16.0

Knight Piésold CONSULTING

FIGURE 1.1

Casino
VA101-325/08
KM3134-44,-45,-46,-47 Comp

TAILINGS DEPOSITION METHOD VS. DRY DENSITY
55.0%



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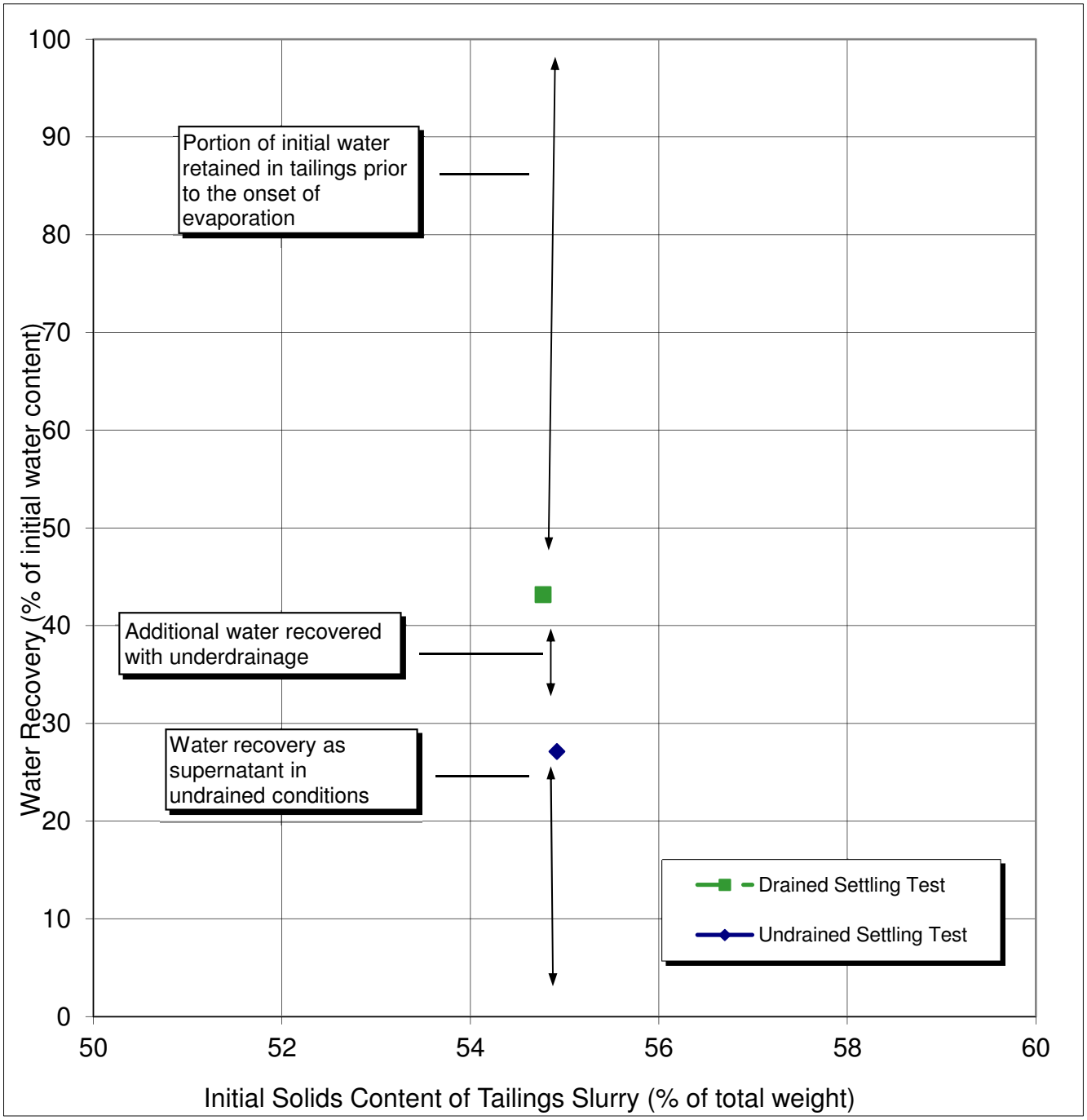
Knight Piésold CONSULTING

FIGURE 1.2

Casino
VA101-325/08
KM3134-44,-45,-46,-47 Comp

TAILINGS DEPOSITION METHOD VS. WATER RECOVERY
55%



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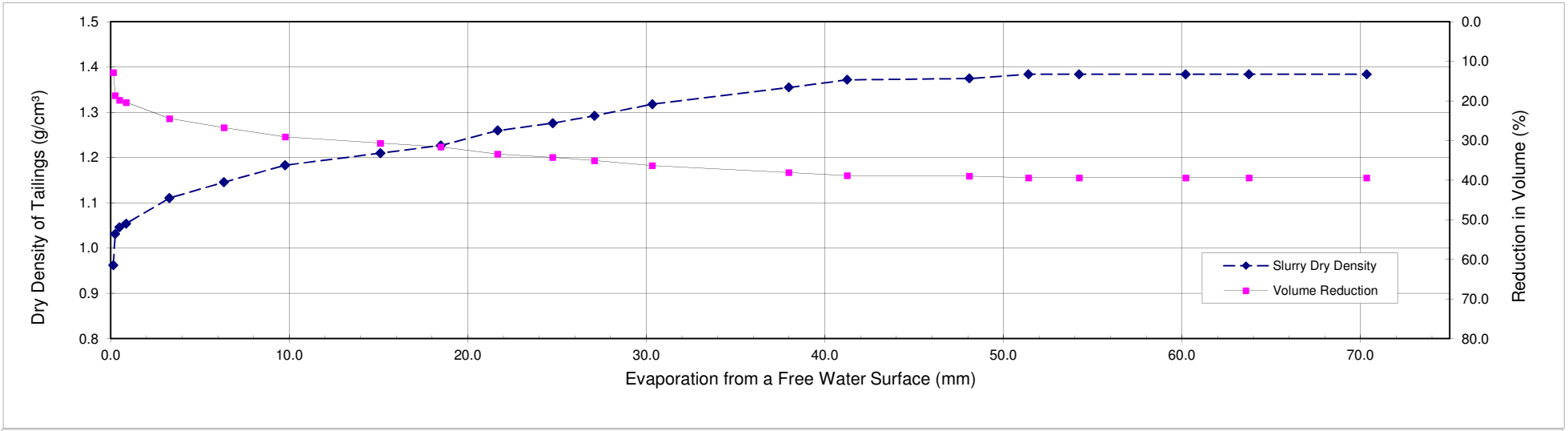
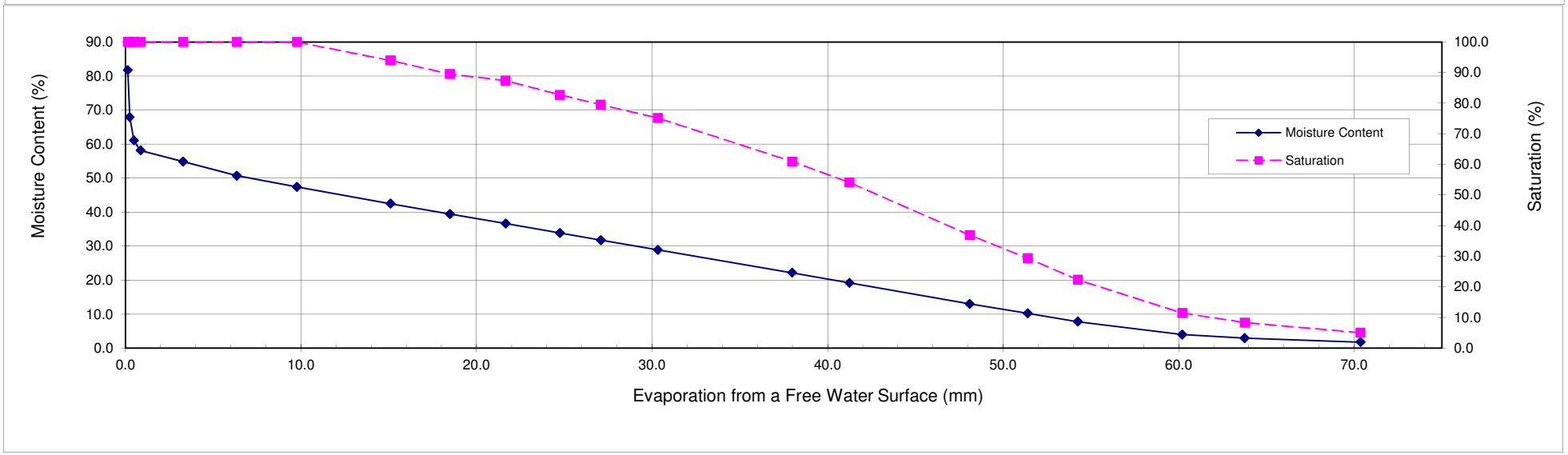
Knight Piésold CONSULTING

FIGURE 1.3

Casino
VA101-325/08

KM3134-44,-45,-46,-47 Comp
VARIATION OF TAILINGS PARAMETERS WITH ONGOING EVAPORATION
55%





SLURRY CONSOLIDOMETER TEST RESULTS
CASINO WHOLE TAILINGS
VA101-325/08

		Consolidation Test Data - Double Ended Drainage								
STRESS	psi	Free	0.5	2	5	10	20	40	80	120
	psf		72	288	720	1440	2880	5760	11520	17280
	kPa		3	14	34	69	138	276	552	827
Volume Change, cc		300.3	9.8	40.0	14.1	9.1	10.3	10.7	11.1	6.4
Cumulative Volume Change, cc		313.3	310.1	350.1	364.2	373.3	383.6	394.3	405.4	411.8
Consolidated Slurry Volume, cm^3		453.8	444.0	404.0	389.9	380.8	370.5	359.8	348.7	342.3
Settled Void Ratio, e_c		1.191	1.144	0.951	0.883	0.839	0.789	0.737	0.684	0.653
Dry Unit Weight, pcf		76.8	78.5	86.2	89.4	91.5	94.0	96.8	99.9	101.8
Slurry Height, cm		5.438	5.321	4.842	4.673	4.564	4.440	4.312	4.179	4.102
Mean Slurry Height, H^2 mm			723.5	645.5	565.7	533.2	506.7	478.7	450.6	428.6
Total Ht. Change, cm		3.599	3.716	4.196	4.365	4.474	4.597	4.725	4.859	4.935
Cumulative change in height, in.		1.417	1.463	1.652	1.718	1.761	1.810	1.860	1.913	1.943
Individual change in height, in.		1.417	0.046	0.189	0.067	0.043	0.049	0.050	0.052	0.030

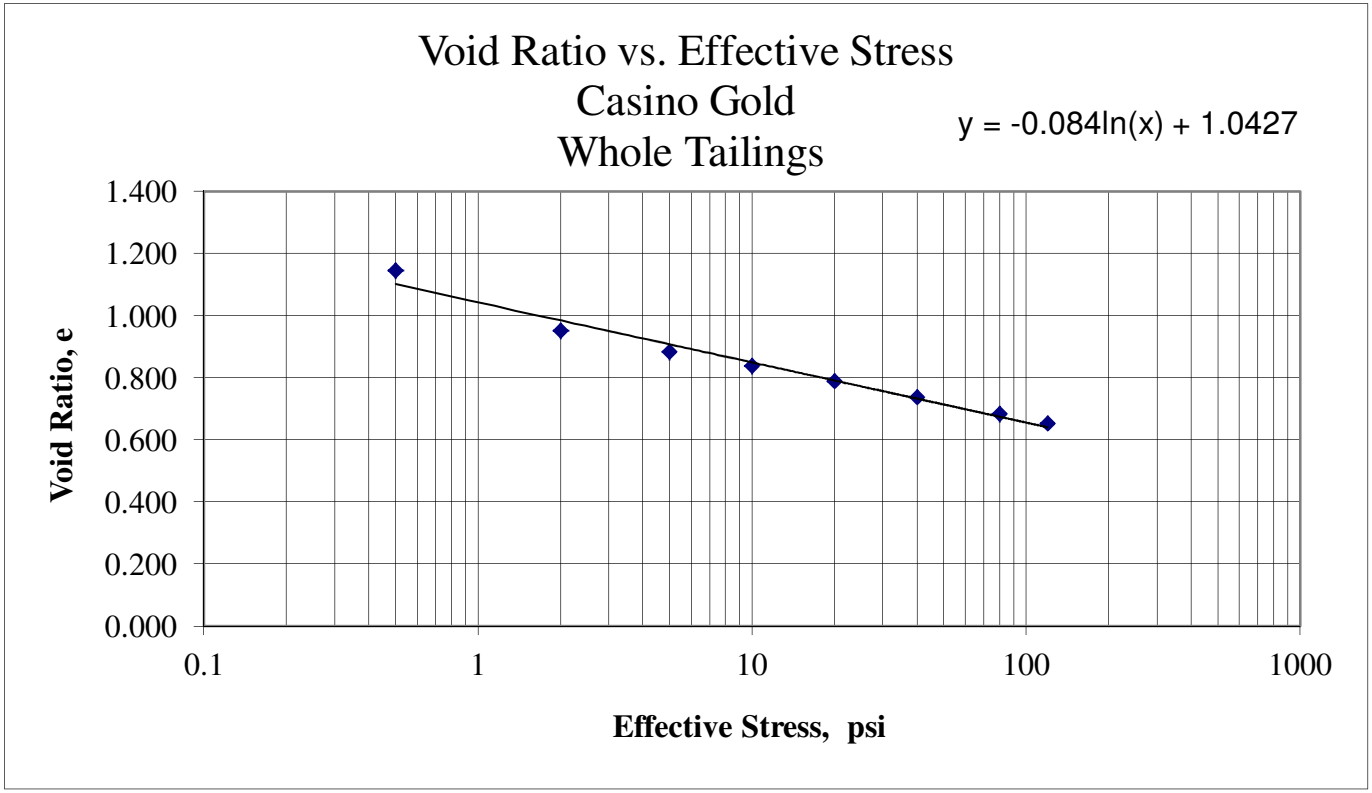
SAMPLE PARAMETERS

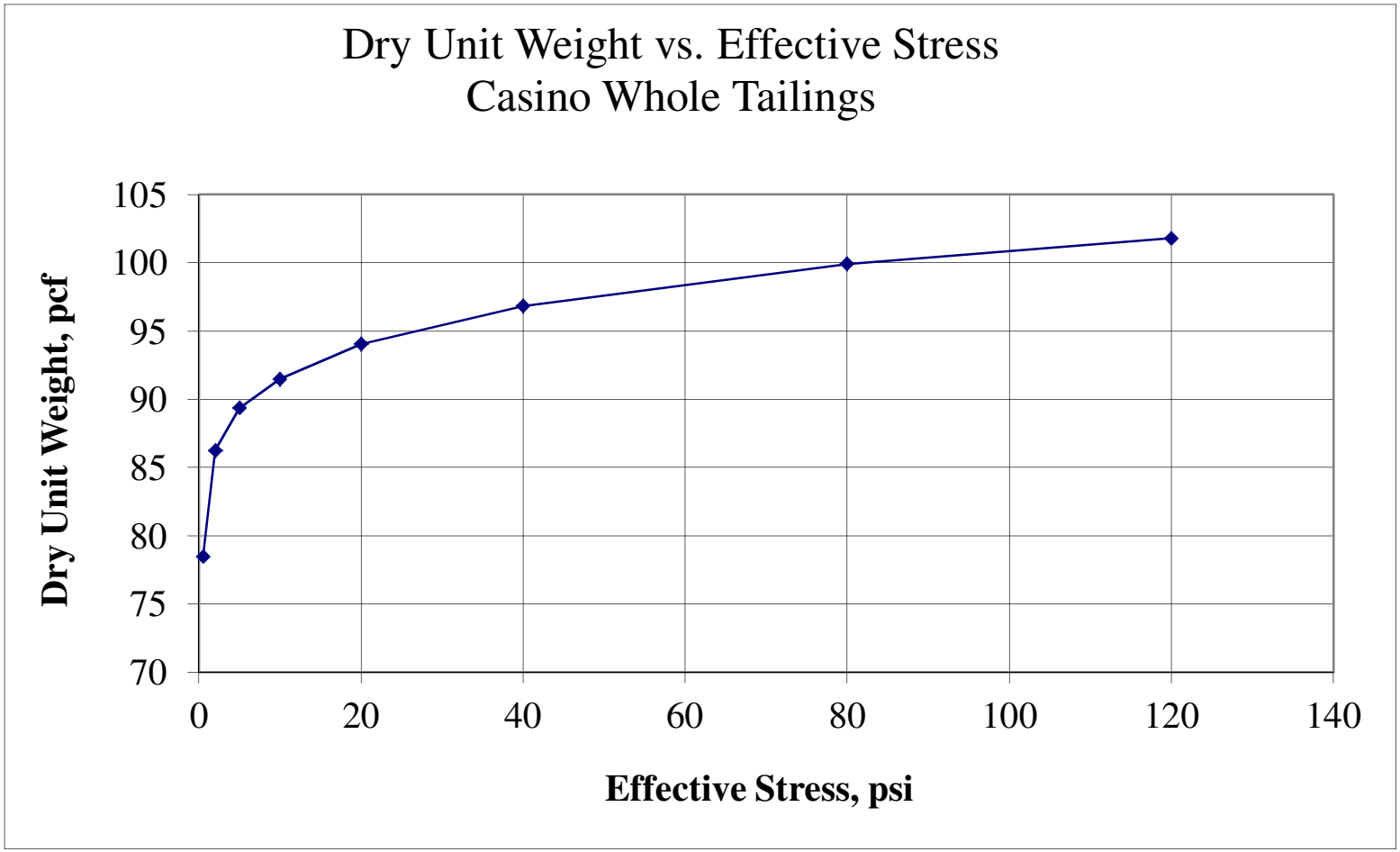
Specific Gravity	2.695	
Slurry Mass w/tare, g	1395.90	
Tare, g	273.00	
Slurry Mass, g	1122.90	
Height of Slurry (in./cm)	3.558	9.04
Volume of Slurry, cc		754.09
Solids Content, %	49.7	
Wt. of Solids, g	558.1	
Ht. of Solids, cm		2.482
Volume of Solids, cc	207.09	
Intial Void Ratio, e	2.641	

Ring Diameter (in./cm)	4.058	10.31
Ring Area, cm^2		83.441
Ring Height (in./cm)	4.058	10.31
Ring Volume, cm^3		860.06

Post Test Specimen Data

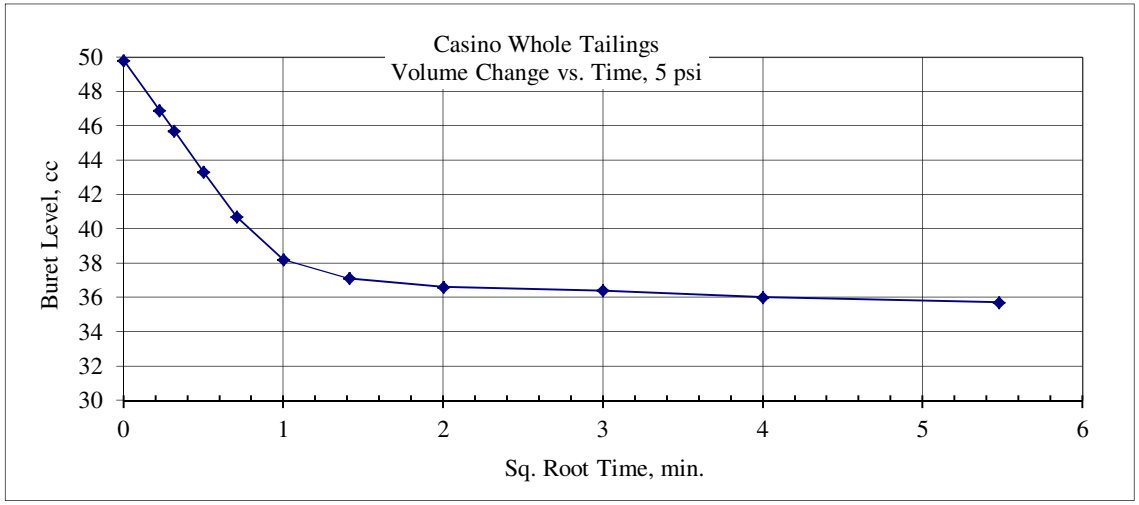
Wet + Tare, g	820.00
Dry + Tare, g	676.20
Tare, g	118.10
Wt. of Water, g	144.80
Wt. of Dry Solids, g	558.10
Moisture Content, %	25.95


Void Ratio vs. Effective Stress
Casino Gold
Whole Tailings
y = -0.084ln(x) + 1.0427
1.400
1.200
1.000
0.800
0.600
0.400
0.200
0.000
Void Ratio, e
0.1
1
10
100
1000
Effective Stress, psi

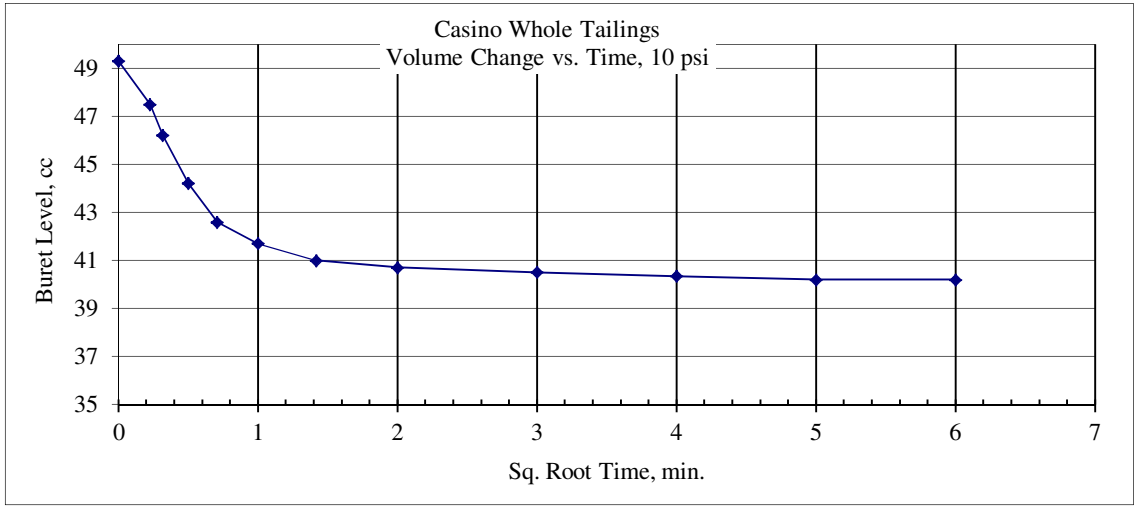

Dry Unit Weight vs. Effective Stress
Casino Whole Tailings
Dry Unit Weight, pcf
105
100
95
90
85
80
75
70
0
20
40
60
80
100
120
140
Effective Stress, psi

Casino Gold Project
Whole Tailings Composite
High Stress Consolidation Test

elapsed time min.	sq. root time min.	Change in Volume (50 - cc)	Cell Buret Level cc
0.00	0.00	49.8	0.2
0.05	0.22	46.9	3.1
0.10	0.32	45.7	4.3
0.25	0.50	43.3	6.7
0.50	0.71	40.7	9.3
1.00	1.00	38.2	11.8
2.00	1.41	37.1	12.9
4.00	2.00	36.6	13.4
9.00	3.00	36.4	13.6
16.00	4.00	36.0	14.0
30.00	5.48	35.7	14.3

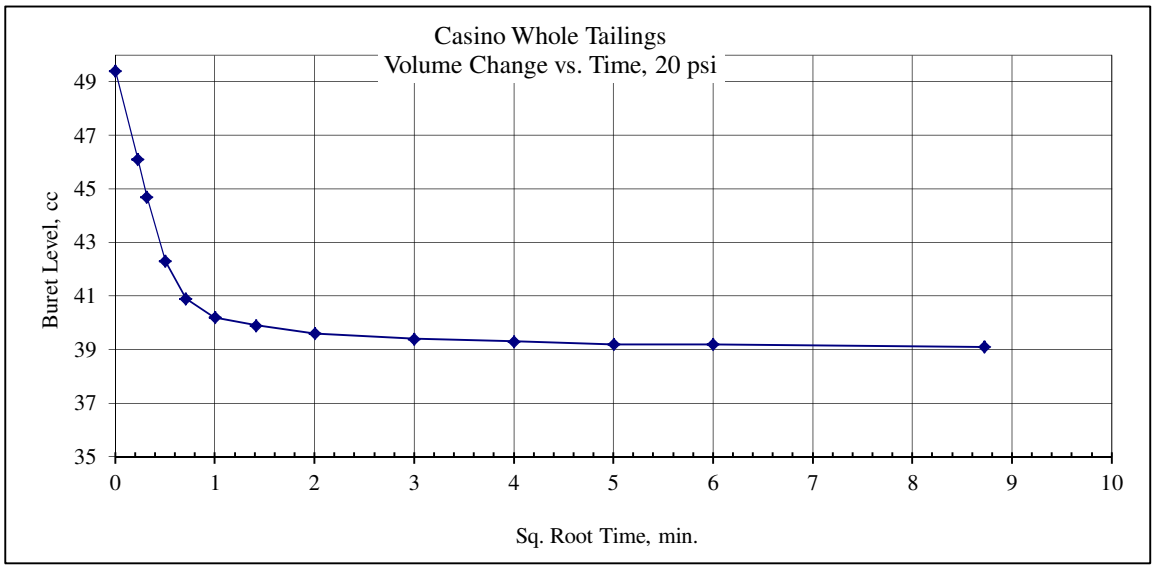


elapsed time min.	sq. root time min.	Change in Volume (50 - cc)	Cell Buret Level cc
0.00	0.00	49.3	0.7
0.05	0.22	47.5	2.5
0.10	0.32	46.2	3.8
0.25	0.50	44.2	5.8
0.50	0.71	42.6	7.4
1.00	1.00	41.7	8.3
2.00	1.41	41.0	9.0
4.00	2.00	40.7	9.3
9.00	3.00	40.5	9.5
16.00	4.00	40.4	9.7
25.00	5.00	40.2	9.8
36.00	6.00	40.2	9.8

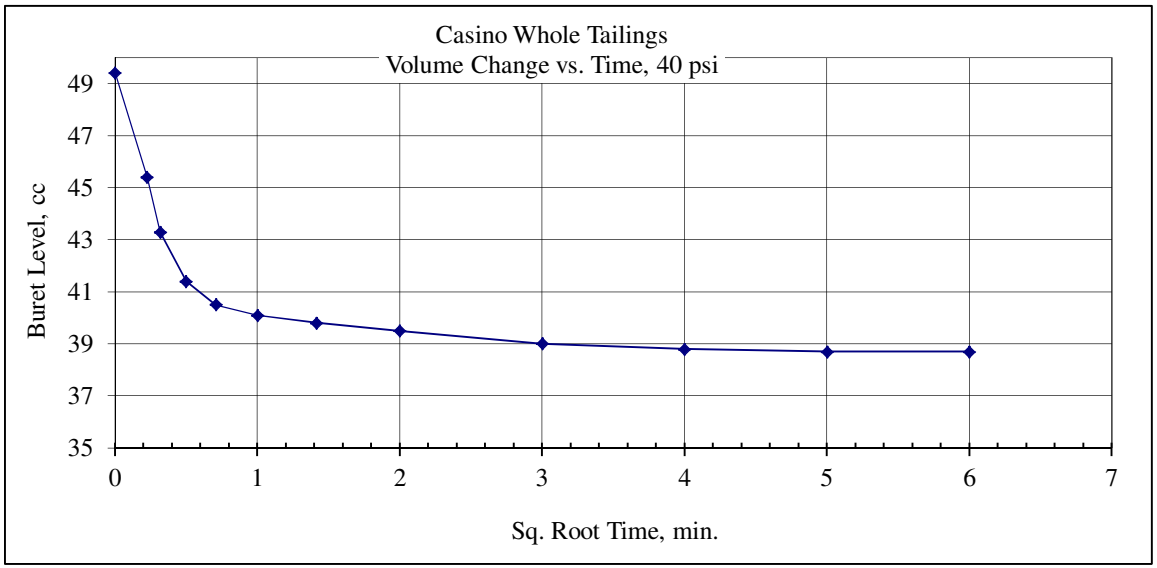


Casino Gold Project
Whole Tailings Composite
High Stress Consolidation Test

elapsed time min.	sq. root time min.	Change in Volume (50 - cc)	Cell Buret Level cc
0.00	0.00	49.4	0.6
0.05	0.22	46.1	3.9
0.10	0.32	44.7	5.3
0.25	0.50	42.3	7.7
0.50	0.71	40.9	9.1
1.00	1.00	40.2	9.8
2.00	1.41	39.9	10.1
4.00	2.00	39.6	10.4
9.00	3.00	39.4	10.6
16.00	4.00	39.3	10.7
25.00	5.00	39.2	10.8
36.00	6.00	39.2	10.8
76.00	8.72	39.1	10.9

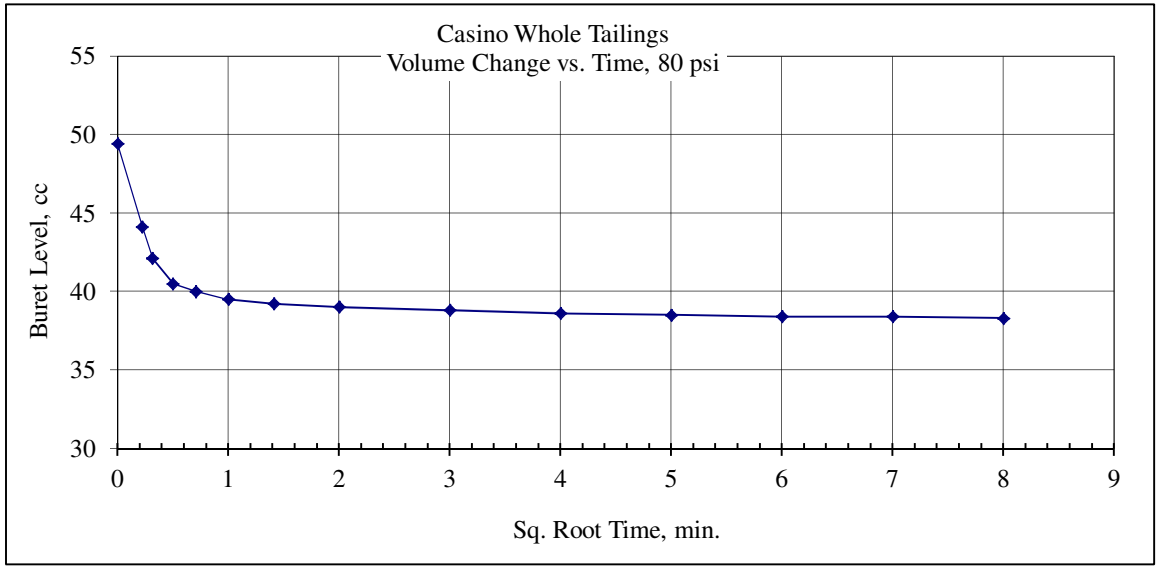


elapsed time min.	sq. root time min.	Change in Volume (50 - cc)	Cell Buret Level cc
0.00	0.00	49.4	0.6
0.05	0.22	45.4	4.6
0.10	0.32	43.3	6.7
0.25	0.50	41.4	8.6
0.50	0.71	40.5	9.5
1.00	1.00	40.1	9.9
2.00	1.41	39.8	10.2
4.00	2.00	39.5	10.5
9.00	3.00	39.0	11.0
16.00	4.00	38.8	11.2
25.00	5.00	38.7	11.3
36.00	6.00	38.7	11.3

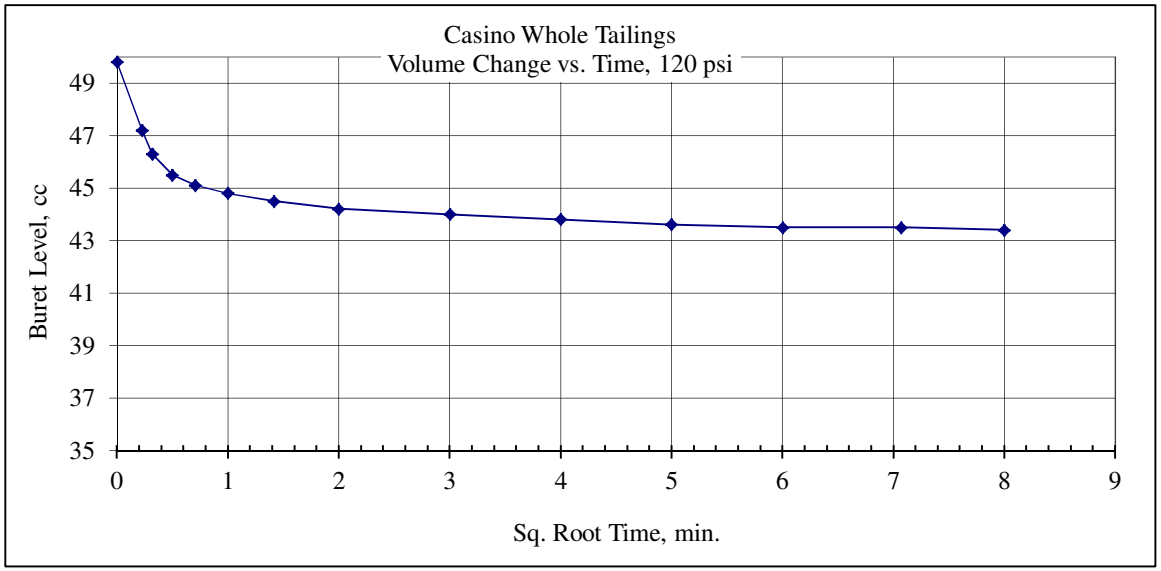


Casino Gold Project
Whole Tailings Composite
High Stress Consolidation Test

elapsed time min.	sq. root time min.	Change in Volume (50 - cc)	Cell Buret Level cc
0.00	0.00	49.4	0.6
0.05	0.22	44.1	5.9
0.10	0.32	42.1	7.9
0.25	0.50	40.5	9.5
0.50	0.71	40.0	10.0
1.00	1.00	39.5	10.5
2.00	1.41	39.2	10.8
4.00	2.00	39.0	11.0
9.00	3.00	38.8	11.2
16.00	4.00	38.6	11.4
25.00	5.00	38.5	11.5
36.00	6.00	38.4	11.6
49.00	7.00	38.4	11.6
64.00	8.00	38.3	11.7



elapsed time min.	sq. root time min.	Change in Volume (50 - cc)	Cell Buret Level cc
0.00	0.00	49.8	0.2
0.05	0.22	47.2	2.8
0.10	0.32	46.3	3.7
0.25	0.50	45.5	4.5
0.50	0.71	45.1	4.9
1.00	1.00	44.8	5.2
2.00	1.41	44.5	5.5
4.00	2.00	44.2	5.8
9.00	3.00	44.0	6.0
16.00	4.00	43.8	6.2
25.00	5.00	43.6	6.4
36.00	6.00	43.5	6.5
50.00	7.07	43.5	6.5
64.00	8.00	43.4	6.6



RIGID WALL PERMEABILITY TEST

ASTM D 5856-02

Falling Head / Increasing Tailwater Pressure

CLIENT:	Casino Copper-Gold		
PROJECT:	Casino	PROJECT NO. :	VA101-325.08
SAMPLE NO.	Whole Tailings Composite	LAB NO. :	L2012-056
DEPTH		SAMPLE ID:	2012-056
SAMPLE ID:		TEST STARTED :	07/24/12
SAMPLE TYPE		TEST FINISHED :	07/28/12
CONF. PRESSURE. (psi)	5	SATURATED TEST:	YES

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	1122.90	758.70
Wt. Wet Soil & Pan (g)	1122.90	758.70
Wt. Dry Soil & Pan (g)	558.10	558.10
Wt. Moisture Lost (g)	564.80	200.60
Wt. of Pan Only (g)	0.00	0.00
Wt. of Dry Soil (g)	558.10	558.10
Moisture Content %	101.2	35.9
Wet Density (pcf)	93.0	121.5
Dry Density (pcf)	46.2	89.4

Init. Diameter (in)	4.058	(cm)	10.307
Init. Area (sq in)	12.933	(sq cm)	83.441
Init. Height (in)	3.558	(cm)	9.037
Height Change (in)	1.718	(cm)	4.364
Consol. Height (in)	1.840	(cm)	4.674
Area After Consol. (sq in)	12.933	(sq cm)	83.423

Vol. Before Consol. (cu ft)	0.02663	Specific Gravity	2.695
Vol. Before Consol. (cc)	754.1	Assumed?	No
Change in Vol. (cc)	364.2		
Cell Exp. (cc)	0.0	Init. Saturation	100.0
Vol. After Consol. (cc)	389.9	Init. Void Ratio	2.641
Vol. After Consol. (cu ft)	0.01377	Final Saturation	100.0
Effective Porosity %	72.54	Final Void Ratio	0.883
Pressure Difference (psi):	0.00		
C =	0.02031	Buret Constant, a	0.315
k, cm/s = C/t*log(h1/h2)		Buret Stand	20

Permeability Test Trials

Time	Cap Elevation	Pedestal Elevation	Elevation Head	Total Head	Permeability k
min.	cm	cm	cm	cm	cm/sec
0.0	39.4	2.9	36.5	36.5	
1.0	38.2	4.0	34.2	34.2	9.6E-06
2.0	35.5	6.4	29.1	29.1	1.2E-05
9.0	31.7	10.7	21.0	21.0	5.3E-06
3.0	31.2	11.0	20.2	20.2	1.9E-06
4.0	30.6	11.7	18.9	18.9	2.4E-06
7.0	29.8	12.5	17.3	17.3	1.9E-06
8.0	29.0	13.2	15.8	15.8	1.7E-06
			Avg.of All Rdgs.		**4.9E-06**
			Max.Hyd.Gradient:	7.6	

RIGID WALL PERMEABILITY TEST

ASTM D 5856-02

Falling Head / Increasing Tailwater Pressure

CLIENT:	Casino Copper-Gold		
PROJECT:	Casino	PROJECT NO. :	VA101-325.08
SAMPLE NO.	Whole Tailings Composite	LAB NO. :	L2012-056
DEPTH		SAMPLE ID:	2012-056
SAMPLE ID:		TEST STARTED :	07/24/12
SAMPLE TYPE		TEST FINISHED :	07/28/12
CONF. PRESSURE. (psi)	10	SATURATED TEST:	YES

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	1122.90	749.60
Wt. Wet Soil & Pan (g)	1122.90	749.60
Wt. Dry Soil & Pan (g)	558.10	558.10
Wt. Moisture Lost (g)	564.80	191.50
Wt. of Pan Only (g)	0.00	0.00
Wt. of Dry Soil (g)	558.10	558.10
Moisture Content %	101.2	34.3
Wet Density (pcf)	93.0	122.9
Dry Density (pcf)	46.2	91.5

Init. Diameter (in)	4.058	(cm)	10.307
Init. Area (sq in)	12.933	(sq cm)	83.441
Init. Height (in)	3.558	(cm)	9.037
Height Change (in)	1.761	(cm)	4.473
Consol. Height (in)	1.797	(cm)	4.564
Area After Consol. (sq in)	12.933	(sq cm)	83.426

Vol. Before Consol. (cu ft)	0.02663	Specific Gravity	2.695
Vol. Before Consol. (cc)	754.1	Assumed?	No
Change in Vol. (cc)	373.3		
Cell Exp. (cc)	0.0	Init. Saturation	100.0
Vol. After Consol. (cc)	380.8	Init. Void Ratio	2.641
Vol. After Consol. (cu ft)	0.01345	Final Saturation	100.0
Effective Porosity %	72.54	Final Void Ratio	0.839
Pressure Difference (psi):	0.00		
C =	0.01984	Buret Constant, a	0.315
k, cm/s = C/t*log(h1/h2)		Buret Stand	20

Permeability Test Trials

Time	Cap Elevation	Pedestal Elevation	Elevation Head	Total Head	Permeability k
min.	cm	cm	cm	cm	cm/sec
0.0	43.4	3.2	40.2	40.2	
1.0	42.8	3.8	39.1	39.1	4.2E-06
1.0	42.3	4.3	38.0	38.0	3.9E-06
1.0	41.8	4.8	37.0	37.0	3.8E-06
1.0	41.3	5.3	36.1	36.1	3.7E-06
			Avg.of All Rdgs.		**3.9E-06**
			Max.Hyd.Gradient:	8.7	

RIGID WALL PERMEABILITY TEST

ASTM D 5856-02

Falling Head / Increasing Tailwater Pressure

CLIENT:	Casino Copper-Gold		
PROJECT:	Casino	PROJECT NO. :	VA101-325.08
SAMPLE NO.	Whole Tailings Composite	LAB NO. :	L2012-056
DEPTH		SAMPLE ID:	2012-056
SAMPLE ID:		TEST STARTED :	07/24/12
SAMPLE TYPE		TEST FINISHED :	07/28/12
CONF. PRESSURE. (psi)	20	SATURATED TEST:	YES

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	1122.90	739.30
Wt. Wet Soil & Pan (g)	1122.90	739.30
Wt. Dry Soil & Pan (g)	558.10	558.10
Wt. Moisture Lost (g)	564.80	181.20
Wt. of Pan Only (g)	0.00	0.00
Wt. of Dry Soil (g)	558.10	558.10
Moisture Content %	101.2	32.5
Wet Density (pcf)	93.0	124.6
Dry Density (pcf)	46.2	94.0

Init. Diameter (in)	4.058	(cm)	10.307
Init. Area (sq in)	12.933	(sq cm)	83.441
Init. Height (in)	3.558	(cm)	9.037
Height Change (in)	1.810	(cm)	4.597
Consol. Height (in)	1.748	(cm)	4.440
Area After Consol. (sq in)	12.933	(sq cm)	83.444

Vol. Before Consol. (cu ft)	0.02663	Specific Gravity	2.695
Vol. Before Consol. (cc)	754.1	Assumed?	No
Change in Vol. (cc)	383.6		
Cell Exp. (cc)	0.0	Init. Saturation	100.0
Vol. After Consol. (cc)	370.5	Init. Void Ratio	2.641
Vol. After Consol. (cu ft)	0.01308	Final Saturation	100.0
Effective Porosity %	72.54	Final Void Ratio	0.789
Pressure Difference (psi):	0.00		
C =	0.01929	Buret Constant, a	0.315
k, cm/s = C/t*log(h1/h2)		Buret Stand	20

Permeability Test Trials

Time	Cap Elevation	Pedestal Elevation	Elevation Head	Total Head	Permeability k
min.	cm	cm	cm	cm	cm/sec
0.0	46.6	2.1	44.5	44.5	
2.0	45.6	3.0	42.6	42.6	3.0E-06
2.0	44.7	3.9	40.8	40.8	3.0E-06
2.0	43.9	4.7	39.2	39.2	2.8E-06
2.0	43.1	5.5	37.6	37.6	2.9E-06
		6.2			
			Avg.of All Rdgs.		**2.9E-06**
			Max.Hyd.Gradient:	9.8	

RIGID WALL PERMEABILITY TEST

ASTM D 5856-02

Falling Head / Increasing Tailwater Pressure

CLIENT:	Casino Copper-Gold		
PROJECT:	Casino	PROJECT NO. :	VA101-325.08
SAMPLE NO.	Whole Tailings Composite	LAB NO. :	L2012-056
DEPTH		SAMPLE ID:	2012-056
SAMPLE ID:		TEST STARTED :	07/24/12
SAMPLE TYPE		TEST FINISHED :	07/28/12
CONF. PRESSURE. (psi)	40	SATURATED TEST:	YES

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	1122.90	728.60
Wt. Wet Soil & Pan (g)	1122.90	728.60
Wt. Dry Soil & Pan (g)	558.10	558.10
Wt. Moisture Lost (g)	564.80	170.50
Wt. of Pan Only (g)	0.00	0.00
Wt. of Dry Soil (g)	558.10	558.10
Moisture Content %	101.2	30.6
Wet Density (pcf)	93.0	126.4
Dry Density (pcf)	46.2	96.8

Init. Diameter (in)	4.058	(cm)	10.307
Init. Area (sq in)	12.933	(sq cm)	83.441
Init. Height (in)	3.558	(cm)	9.037
Height Change (in)	1.860	(cm)	4.724
Consol. Height (in)	1.698	(cm)	4.313
Area After Consol. (sq in)	12.933	(sq cm)	83.421

Vol. Before Consol. (cu ft)	0.02663	Specific Gravity	2.695
Vol. Before Consol. (cc)	754.1	Assumed?	No
Change in Vol. (cc)	394.3		
Cell Exp. (cc)	0.0	Init. Saturation	100.0
Vol. After Consol. (cc)	359.8	Init. Void Ratio	2.641
Vol. After Consol. (cu ft)	0.01271	Final Saturation	100.0
Effective Porosity %	72.54	Final Void Ratio	0.737
Pressure Difference (psi):	0.00		
C =	0.01874	Buret Constant, a	0.315
k, cm/s = C/t*log(h1/h2)		Buret Stand	20

Permeability Test Trials

Time	Cap Elevation	Pedestal Elevation	Elevation Head	Total Head	Permeability k
min.	cm	cm	cm	cm	cm/sec
0.0	46.8	3.0	43.8	43.8	
3.0	45.4	4.3	41.1	41.1	2.9E-06
3.0	44.1	5.7	38.4	38.4	3.1E-06
3.0	42.9	7.0	35.9	35.9	3.0E-06
3.0	41.9	8.1	33.8	33.8	2.7E-06
3.0	40.8	9.1	31.7	31.7	2.9E-06
			Avg.of All Rdgs.		**2.9E-06**
			Max.Hyd.Gradient:	9.8	

RIGID WALL PERMEABILITY TEST

ASTM D 5856-02

Falling Head / Increasing Tailwater Pressure

CLIENT:	Casino Copper-Gold		
PROJECT:	Casino	PROJECT NO. :	VA101-325.08
SAMPLE NO.	Whole Tailings Composite	LAB NO. :	L2012-056
DEPTH		SAMPLE ID:	2012-056
SAMPLE ID:		TEST STARTED :	07/24/12
SAMPLE TYPE		TEST FINISHED :	07/28/12
CONF. PRESSURE. (psi)	40	SATURATED TEST:	YES

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	1122.90	717.50
Wt. Wet Soil & Pan (g)	1122.90	717.50
Wt. Dry Soil & Pan (g)	558.10	558.10
Wt. Moisture Lost (g)	564.80	159.40
Wt. of Pan Only (g)	0.00	0.00
Wt. of Dry Soil (g)	558.10	558.10
Moisture Content %	101.2	28.6
Wet Density (pcf)	93.0	128.5
Dry Density (pcf)	46.2	99.9

Init. Diameter (in)	4.058	(cm)	10.307
Init. Area (sq in)	12.933	(sq cm)	83.441
Init. Height (in)	3.558	(cm)	9.037
Height Change (in)	1.913	(cm)	4.859
Consol. Height (in)	1.645	(cm)	4.178
Area After Consol. (sq in)	12.933	(sq cm)	83.452

Vol. Before Consol. (cu ft)	0.02663	Specific Gravity	2.695
Vol. Before Consol. (cc)	754.1	Assumed?	No
Change in Vol. (cc)	405.4		
Cell Exp. (cc)	0.0	Init. Saturation	100.0
Vol. After Consol. (cc)	348.7	Init. Void Ratio	2.641
Vol. After Consol. (cu ft)	0.01231	Final Saturation	100.0
Effective Porosity %	72.54	Final Void Ratio	0.684
Pressure Difference (psi):	0.00		
C =	0.01815	Buret Constant, a	0.315
k, cm/s = C/t*log(h1/h2)		Buret Stand	20

Permeability Test Trials

Time	Cap Elevation	Pedestal Elevation	Elevation Head	Total Head	Permeability k
min.	cm	cm	cm	cm	cm/sec
0.0	48.0	1.8	46.2	46.2	
2.0	47.4	2.5	44.9	44.9	1.9E-06
2.0	46.4	3.3	43.1	43.1	2.7E-06
2.0	45.9	3.9	42.0	42.0	1.7E-06
2.0	45.4	4.4	41.0	41.0	1.6E-06
2.0	44.9	4.9	40.0	40.0	1.6E-06
2.0	44.4	5.4	39.0	39.0	1.7E-06
			Avg.of All Rdgs.		**2.0E-06**
			Max.Hyd.Gradient:	10.9	

RIGID WALL PERMEABILITY TEST

ASTM D 5856-02

Falling Head / Increasing Tailwater Pressure

CLIENT:	Casino Copper-Gold		
PROJECT:	Casino	PROJECT NO. :	VA101-325.08
SAMPLE NO.	Whole Tailings Composite	LAB NO. :	L2012-056
DEPTH		SAMPLE ID:	2012-056
SAMPLE ID:		TEST STARTED :	07/24/12
SAMPLE TYPE		TEST FINISHED :	07/28/12
CONF. PRESSURE. (psi)	40	SATURATED TEST:	YES

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	1122.90	711.10
Wt. Wet Soil & Pan (g)	1122.90	711.10
Wt. Dry Soil & Pan (g)	558.10	558.10
Wt. Moisture Lost (g)	564.80	153.00
Wt. of Pan Only (g)	0.00	0.00
Wt. of Dry Soil (g)	558.10	558.10
Moisture Content %	101.2	27.4
Wet Density (pcf)	93.0	129.7
Dry Density (pcf)	46.2	101.8

Init. Diameter (in)	4.058	(cm)	10.307
Init. Area (sq in)	12.933	(sq cm)	83.441
Init. Height (in)	3.558	(cm)	9.037
Height Change (in)	1.943	(cm)	4.935
Consol. Height (in)	1.615	(cm)	4.102
Area After Consol. (sq in)	12.933	(sq cm)	83.442

Vol. Before Consol. (cu ft)	0.02663	Specific Gravity	2.695
Vol. Before Consol. (cc)	754.1	Assumed?	No
Change in Vol. (cc)	411.8		
Cell Exp. (cc)	0.0	Init. Saturation	100.0
Vol. After Consol. (cc)	342.3	Init. Void Ratio	2.641
Vol. After Consol. (cu ft)	0.01209	Final Saturation	100.0
Effective Porosity %	72.54	Final Void Ratio	0.653
Pressure Difference (psi):	0.00		
C =	0.01782	Buret Constant, a	0.315
k, cm/s = C/t*log(h1/h2)		Buret Stand	20

Permeability Test Trials

Time	Cap Elevation	Pedestal Elevation	Elevation Head	Total Head	Permeability k
min.	cm	cm	cm	cm	cm/sec
0.0	47.6	2.1	45.5	45.5	
5.0	46.8	3.0	43.8	43.8	9.8E-07
5.0	45.8	3.8	42.0	42.0	1.1E-06
5.0	45.0	4.7	40.3	40.3	1.1E-06
5.0	44.3	5.4	38.9	38.9	9.1E-07
5.0	43.6	6.1	37.5	37.5	9.5E-07
			Avg.of All Rdgs.		**1.0E-06**
			Max.Hyd.Gradient:	10.9	

PROJECT NO. VA201-325/08
PROJECT: Casino Copper-Gold 20 12
TESTED BY: jhk Denver
DATE: 14/06/12 S.G. SOLIDS : 2.67
Whole Tailings Composite S.G. LIQUOR: 1.0000
pH LIQUOR: 7.00

CONSOLIDATION TESTS

CYLINDER:	A
Weight of Container:	0.0
Weight of Slurry + Cont.:	1128.0
Height to Bottom of Slurry:	0.0
Height to Top of Slurry:	270.0
Diameter of Container:	59.0
Settled Top of Slurry Heights:	214
BEFORE CONSOLIDATION:	214.0
AFTER CONSOLIDATION:	194.0
AFTER COMPLETE DRAINAGE:	194.0

DATE		TIME			SLURRY HEIGHT	WEIGHT OF WATER +	WEIGHT OF	Water Level
DAY	MONTH	HOUR	MINUTE	SECOND	READING	CONTAINER	CONTAINER	
18	6	8	13	0	214.0	399.2	399.2	293.0
18	6	8	13	6	212.0			293.0
18	6	8	13	15	212.0			293.0
18	6	8	13	30	212.0	407.3	399.2	293.0
18	6	8	14	0	211.0	408.7	407.3	293.0
18	6	8	15	0	210.5	410.5	408.7	293.0
18	6	8	18	0	209.0	414.0	410.5	293.0
18	6	8	23	0	208.0	417.9	414.0	293.0
18	6	8	33	0	206.0	423.4	417.9	293.0
18	6	8	43	0	205.0	427.5	423.4	293.0
18	6	9	13	0	202.5	437.4	427.5	293.0
18	6	9	43	0	201.0	445.6	437.4	293.0
18	6	10	13	0	200.5	454.0	445.6	293.0
18	6	11	13	0	200.5	469.7	454.0	293.0
18	6	12	13	0	200.5	485.5	469.7	293.0
18	6	16	18	0	200.0	550.0	485.5	293.0
19	6	8	10	0	194.0	771.2	550.0	

NOTES: Water had completely drained at 24 hour reading.

ISOLIDATION TEST

PROJECT: Casino Copper-Gold
SAMPLE: Whole Tailings Composite
DATE: 14-Jun-12
TESTED BY: jhk Denver

*	Weight of Container	:	0.0		PULP DENSITY	:	1.531
*	Weight of Slurry + Container	:	1128.0	*	S.G. SOLIDS	:	2.67
	Weight of Slurry	:	1128.0	*	S.G. LIQUOR	:	1.00
*	Height to Bottom of Slurry	:	0.0		% WT. SOLIDS	:	55.46
*	Height to Top of Slurry	:	270.0		Weight of Solids	:	625.5
	Height of Slurry	:	270.0		Volume of water	:	502.5
*	Internal dia. of Container	:	59.0				
	Volume of Slurry	:	736.9				

BEFORE CONSOLIDATION			AFTER CONSOLIDATION			AFTER COMPLETE DRAINAGE		
* Settled Slurry Ht	:	214.0	* Settled Slurry Ht	:	194.0	* Settled Slurry Ht	:	194.0
Ht of Water	:	56.0	Ht of Water	:	76.0	Ht of Water	:	-
Vol of Slurry	:	584.1	Vol of Slurry	:	529.5	Vol of Slurry	:	529.5
Vol of Water	:	152.8	Vol of Water	:	207.4	Vol of Water	:	-
Dry Density	:	1.071	Dry Density	:	1.181	Dry Density	:	1.181
Pulp Density	:	1.670	Pulp Density	:	1.739	Pulp Density	:	1.739
Void Ratio	:	1.491	Void Ratio	:	1.258	Void Ratio	:	1.258
Total Stress at Base	:	4.053	Total Stress at Ba	:	4.053	Total Stress at Ba	:	3.308
Eff. Stress at Base	:	1.405	Eff. Stress at Bas	:	4.053	Eff. Stress at Bas	:	5.210
Average Eff. Stress	:	0.703	Average Eff. Stres	:	2.027	Average Eff. Stres	:	2.605

DAY	TIME	ELAPSED TIME (hours)	(min)	(sec)	* SLURRY HEIGHT READING	SETTLEMENT OF SLURRY	* WEIGHT OF WATER & CONT	* WEIGHT OF CONT	VOLUME OF WATER	CUMUL. VOLUME OF WATER	HEIGHT OF SLURRY	VOLUME OF SLURRY	DRY DENSITY t/m^3	i VALUE (av ht)	PERMEABILITY (m/s)
18/06/12	08:13:00	< START TIME		0	214.0	0.00	399.2	399.2	0.0	0.0	214.0	584.1	1.071		
18/06/12	08:13:06	0.00	0.10	6	212.0	2.00	0.0	0.0	0.0	0.0	212.0	578.6	1.081	1.27	0.000E+00
18/06/12	08:13:15	0.00	0.25	15	212.0	2.00	0.0	0.0	0.0	0.0	212.0	578.6	1.081	1.27	--
18/06/12	08:13:30	0.01	0.50	30	212.0	2.00	407.3	399.2	8.1	8.1	212.0	578.6	1.081	1.27	7.796E-05
18/06/12	08:14:00	0.02	1.00	60	211.0	3.00	408.7	407.3	1.4	9.5	211.0	575.9	1.086	1.28	1.311E-05
18/06/12	08:15:00	0.03	2.00	120	210.5	3.50	410.5	408.7	1.8	11.3	210.5	574.5	1.089	1.28	8.389E-06
18/06/12	08:18:00	0.08	5.00	300	209.0	5.00	414.0	410.5	3.6	14.8	209.0	570.4	1.097	1.29	5.645E-06
18/06/12	08:23:00	0.17	10.00	600	208.0	6.00	417.9	414.0	3.8	18.7	208.0	567.7	1.102	1.29	3.622E-06
18/06/12	08:33:00	0.33	20.00	1200	206.0	8.00	423.4	417.9	5.5	24.2	206.0	562.2	1.113	1.30	2.580E-06
18/06/12	08:43:00	0.50	30.00	1800	205.0	9.00	427.5	423.4	4.1	28.3	205.0	559.5	1.118	1.31	1.920E-06
18/06/12	09:13:00	1.00	60.00	3600	202.5	11.50	437.4	427.5	9.9	38.2	202.5	552.7	1.132	1.33	1.516E-06
18/06/12	09:43:00	1.50	90.00	5400	201.0	13.00	445.6	437.4	8.3	46.4	201.0	548.6	1.140	1.34	1.255E-06
18/06/12	10:13:00	2.00	120.00	7200	200.5	13.50	454.0	445.6	8.4	54.8	200.5	547.2	1.143	1.34	1.264E-06
18/06/12	11:13:00	3.00	180.00	10800	200.5	13.50	469.7	454.0	15.7	70.5	200.5	547.2	1.143	1.35	1.187E-06
18/06/12	12:13:00	4.00	240.00	14400	200.5	13.50	485.5	469.7	15.8	86.3	200.5	547.2	1.143	1.35	1.191E-06
18/06/12	16:18:00	8.08	485.00	29100	200.0	14.00	550.0	485.5	64.6	150.8	200.0	545.9	1.146	1.35	1.193E-06
19/06/12	08:10:00	23.95	1437.00	86220	194.0	20.00	771.2	550.0	221.2	372.0	194.0	529.5	1.181	1.37	1.035E-06

ENT OF CONSOLIDATION

U value	Tv	leasured Value	ROW	X values	Y values	L values	H values	A	B	C	Time(h)	Cv	
													Mv
0.5	0.197	7.00	7	6.000	-0.778			0.009	0.031	-1.272	0.231	82.71	0.0706
				8.000	-0.477	14.000	0.151						Kv
				9.000	-0.301	15.000	0.159						1.676E-06
													Cc
0.6	0.287	8.40	8	8.000	-0.477			-0.016	0.447	-3.031	0.395	69.95	0.5061
				9.000	-0.301	17.000	0.176						
				11.500	0.000	19.500	0.136					76.33	

Knight Piésold CONSULTING

FLOW CONE VISCOSITY & SOLIDS CONTENT DETERMINATION

Project No. VA101-325/08

Project:	Casino	Sample No.:	25%	40%	55%
		Location:	Manufactured O/F		
Test Date:	15-Jun-12 10:57 AM	Tested By:	jk/db		

FLOW CONE WATER DISCHARGE CALIBRATION

Trial No.	1.	2.	3.	Average
Time for complete water discharge (sec)	7.67	7.77	7.77	7.74

FLOW CONE TAILINGS DISCHARGE TESTS

Trial No.	1	2	3	
Time for tailings discharge (sec)	8.07	8.13	8.91	8.37

PERCENT SOLIDS AND MOISTURE CONTENT DETERMINATION

	Trial No.	1.	2.	3.	4.	Average
	Origin of Sample	Target 25%	Target 40%	Target 55%		
	Tare No.					
a.	Tare Weight (g)	113	113	118		
b.	Tare + Wet Sample Weight (g)	926	503	479		
c.	Tare + Dry Sample Weight (g)	287	268	317		
	Drying Time - From	15-Jun-12	15-Jun-12	15-Jun-12		
	- To	16-Jun-12	16-Jun-12	16-Jun-12		
d.	Moisture Loss [b-c] (g)	638.5	234.3	162		
e.	Dry Sample Weight [c-a] (g)	173.8	155.6	198.8		
	Initial Parameters from Previous Test					
f.	Tare (Cylinder or Beaker) Weight (g)	113	113	118		
g.	Tare + Initial Slurry Weight (g)	926	503	479		
h.	Initial Slurry Weight (g)	812	390	361		
i.	True Moisture Loss [h-e] (g)	639	234	162		
	PERCENT SOLIDS [e/h*100] (%)	21.4	39.9	55.1		
	MOISTURE CONTENT [i/e*100] (%)	367.4	150.6	81.5		

Comments:

30.7

Solids content percentages reported in trials 1, 2 & 3 will vary slightly for each specific test.

Knight Piésold CONSULTING

UNDRAINED SETTLING TEST

Project No. VA101-325/08

Project: Casino | Sample No.: 25% | Test Date: 6/15/2012-6/19/2012

Location: Manufactured O/F | Tested By: jhk/db

Initial Parameters

a. Cylinder (Tare) Weight =	185	g	d. Moisture Content (from drying test) =	**353.6**	%
b. Initial Slurry Volume =	780	ml	e. Initial Slurry Bulk Density [(c-a)/b] =	1.16	g/cm³
c. Tare + Initial Slurry Weight =	1090	g	f. Weight of Water [(c-a)/(1+1/(d/100))] =	706	g
Time of Readings 15-Jun-12	09:33 AM		g. Weight of Solids [(c-a)/(1+d/100)] =	200	g

On-going Readings

			A.	B.	C.	D.	E.	F.	G.	H.
	Date of Reading	Time of Reading	Total Cylinder Weight (g)	Total Cylinder Volume (ml)	Settled Slurry Volume (ml)	Water Recovery [(B-C)/f] (%)	Volume Reduction of Solids [1-C/b] (%)	Slurry Bulk Density [(A-a-(B-C))/C] (g/cm³)	Slurry Dry Density [g/C] (g/cm³)	Moisture Content [(f-(B-C))/g] (%)
1.	15-Jun-12	09:48 AM	1090	780	620	23	21	1.20	0.32	273.4
2.	15-Jun-12	09:56 AM	1090	780	550	33	29	1.23	0.36	238.3
3.	15-Jun-12	10:09 AM	1090	780	430	50	45	1.29	0.46	178.2
4.	15-Jun-12	10:33 AM	1090	780	325	64	58	1.39	0.61	125.6
5.	15-Jun-12	11:07 AM	1090	780	295	69	62	1.42	0.68	110.6
6.	15-Jun-12	12:26 PM	1090	780	265	73	66	1.47	0.75	95.5
7.	15-Jun-12	04:30 PM	1090	780	250	75	68	1.50	0.80	88.0
8.	16-Jun-12	09:03 AM	1090	780	250	75	68	1.50	0.80	88.0
9.	17-Jun-12	01:15 PM	1090	780	240	77	69	1.52	0.83	83.0
10	18-Jun-12	08:40 AM	1090	780	240	77	69	1.52	0.83	83.01
11	19-Jun-12	08:45 AM	1089	780	240	77	69	1.52	0.83	83.01

Knight Piésold CONSULTING

UNDRAINED SETTLING TEST

Project No. VA101-325/08

Project:	Casino	Sample No.:	40%	Test Date:	6/15-6/21/12
		Location:	Manufactured O/F	Tested By:	jhk/db

Initial Parameters

a.	Cylinder (Tare) Weight =	185	g	d. Moisture Content (from drying test) =	**149.0**	%
b.	Initial Slurry Volume =	1000	ml	e. Initial Slurry Bulk Density [(c-a)/b] =	1.34	g/cm³
c.	Tare + Initial Slurry Weight =	1523	g	f. Weight of Water [(c-a)/(1+1/(d/100))] =	800	g
	Time of Readings 15-Jun-12	09:18 AM		g. Weight of Solids [(c-a)/(1+d/100)] =	537	g

On-going Readings

			A.	B.	C.	D.	E.	F.	G.	H.
	Date of Reading	Time of Reading	Total Cylinder Weight (g)	Total Cylinder Volume (ml)	Settled Slurry Volume (ml)	Water Recovery [(B-C)/f] (%)	Volume Reduction of Solids [1-C/b] (%)	Slurry Bulk Density [(A-a-(B-C))/C] (g/cm³)	Slurry Dry Density [g/C] (g/cm³)	Moisture Content [(f-(B-C))/g] (%)
1.	15-Jun-12	09:48 AM	1523	1000	870	16	13	1.39	0.62	124.83
2.	15-Jun-12	09:56 AM	1523	1000	835	21	17	1.40	0.64	118.31
3.	15-Jun-12	10:09 AM	1523	1000	770	29	23	1.44	0.70	106.21
4.	15-Jun-12	10:33 AM	1523	1000	650	44	35	1.52	0.83	83.86
5.	15-Jun-12	11:07 AM	1523	1000	610	49	39	1.55	0.88	76.42
6.	15-Jun-12	12:26 PM	1523	1000	570	54	43	1.59	0.94	68.97
7.	15-Jun-12	04:30 PM	1523	1000	540	57	46	1.62	0.99	63.38
8.	16-Jun-12	09:03 AM	1523	1000	540	57	46	1.62	0.99	63.38
9.	17-Jun-12	01:15 PM	1523	1000	540	57	46	1.62	0.99	63.38
10	18-Jun-12	08:40 AM	1522	1000	535	58	47	1.63	1.00	62.45
11	19-Jun-12	08:45 AM	1522	1000	530	59	47	1.64	1.01	61.52
12	20-Jun-12	10:13 AM	1522	1000	530	59	47	1.63	1.01	61.52
13	21-Jun-12	10:46 AM	1522	1000	530	59	47	1.63	1.01	61.52

Knight Piésold CONSULTING

UNDRAINED SETTLING TEST

Project No. VA101-325/08

Project:	Casino	Sample No.:	55%	Test Date:	6/15/2012-6/19/2012
		Location:	Manufactured O/F	Tested By:	jhk/db

Initial Parameters

a.	Cylinder (Tare) Weight =	195	g	d. Moisture Content (from drying test) =	**81.3**	%
b.	Initial Slurry Volume =	945	ml	e. Initial Slurry Bulk Density [(c-a)/b] =	1.52	g/cm³
c.	Tare + Initial Slurry Weight =	1632	g	f. Weight of Water [(c-a)/(1+1/(d/100))] =	644	g
	Time of Readings 15-Jun-12	08:58 AM		g. Weight of Solids [(c-a)/(1+d/100)] =	793	g

On-going Readings

			A.	B.	C.	D.	E.	F.	G.	H.
	Date of Reading	Time of Reading	Total Cylinder Weight (g)	Total Cylinder Volume (ml)	Settled Slurry Volume (ml)	Water Recovery [(B-C)/f] (%)	Volume Reduction of Solids [1-C/b] (%)	Slurry Bulk Density [(A-a-(B-C))/C] (g/cm³)	Slurry Dry Density [g/C] (g/cm³)	Moisture Content [(f-(B-C))/g] (%)
1.	15-Jun-12	09:48 AM	1632	945	880	10	7	1.56	0.90	73.08
2.	15-Jun-12	10:09 AM	1632	945	860	13	9	1.57	0.92	70.56
3.	15-Jun-12	10:33 AM	1632	945	840	16	11	1.59	0.94	68.04
4.	15-Jun-12	11:07 AM	1632	945	820	19	13	1.60	0.97	65.51
5.	15-Jun-12	12:26 PM	1632	945	790	24	16	1.62	1.00	61.73
6.	15-Jun-12	05:00 PM	1632	945	740	32	22	1.66	1.07	55.42
7.	16-Jun-12	09:03 AM	1632	945	720	35	24	1.68	1.10	52.90
8.	17-Jun-12	01:15 PM	1632	945	720	35	24	1.68	1.10	52.90
9.	18-Jun-12	08:40 AM	1632	945	720	35	24	1.68	1.10	52.90
10	19-Jun-12	08:45 AM	1631	945	720	35	24	1.68	1.10	52.90

Knight Piésold CONSULTING

DRAINED SETTLING TEST AND FALLING HEAD PERMEABILITY TEST

Project No. VA101-325/08

Project:	Casino	Sample No.:	25%	Test Date:	6/15-6/26/12
		Location:	Manufactured O/F	Tested By:	jhk/db

Initial Parameters

a. Cylinder (Tare) Weight =	272	g	d. Moisture Content (from drying test) =	**351.5**	%
b. Initial Slurry Volume =	760	ml	e. Initial Slurry Bulk Density [(c-a)/b] =	1.18	g/cm³
c. Tare + Initial Slurry Weight =	1172	g	f. Weight of Water [(c-a)/(1+1/(d/100))] =	701	g
Time of Readings 15-Jun-12	09:34 AM		g. Weight of Solids [(c-a)/(1+d/100)] =	199	g

On-going Readings

			A.	B.	C.	D.	E.	F.	G.	H.
	Date of Reading	Time of Reading	Total Cylinder Weight (before decant) (g)	Total Cylinder Volume (ml)	Settled Slurry Volume (ml)	Water Volume [B-C] (ml)	Drainage Volume Collected (ml)	Decanted Water Volume (ml)	Slurry Bulk Density [(A-a-(B-C))/C] (g/cm³)	Slurry Dry Density [g/C] (g/cm³)
1.	15-Jun-12	09:43 AM	1156	740	650	90	16	84	1.22	0.31
2.	15-Jun-12	09:53 AM	1058	645	545	100	30	94	1.26	0.37
3.	15-Jun-12	10:04 AM	954	540	450	90	41	91	1.31	0.44
4.	15-Jun-12	10:14 AM	855	440	360	80	48	75	1.40	0.55
5.	15-Jun-12	10:32 AM	771	360	300	60	57	44	1.46	0.66
6.	15-Jun-12	11:00 AM	716	300	270	30	67	28	1.53	0.74
7	15-Jun-12	12:19 PM	669	255	230	25	86	22	1.62	0.87
8	15-Jun-12	04:13 PM	624	210	210	0	110	0	1.67	0.95
9	16-Jun-12	08:54 AM	623	210	210	0	110	0	1.67	0.95
10	17-Jun-12	01:15 PM	623	210	210	0	111	0	1.67	0.95

Falling Head Permeability Test

	Data Readings, Ti (hours)	Initial Water Height, hi (cm)	Initial Solids Height, Hi (cm)	Finishing Time, Tf (hours)	Final Water Height, hf (cm)	Final Solids Height, Hf (cm)	Drainage Collected (ml)	Elapsed Time, T (hours)	Ave. Solids Thickness, H (cm)	Permeability k H/3600T*ln(hi/hf) (cm/sec)
1.	0.00	22.2	7.7	7.82	17.5	7.6	134	7.82	7.7	6.5E-05
2.	0.00	22.9	7.6	8.12	17.8	7.6	146	8.12	7.6	6.6E-05
3.	0.00	22.2	7.6	6.13	18.5	7.6	102	6.13	7.6	6.3E-05
4.	0.00	21.8	7.6	5.85	18.3	7.6	98	5.85	7.6	6.3E-05
5.	0.00	22.6	7.6	1.62	21.6	7.6	31	1.62	7.6	5.9E-05
									AVG.	**6.3E-05**

Knight Piésold CONSULTING

DRAINED SETTLING TEST AND FALLING HEAD PERMEABILITY TEST

Project No. VA101-325/08

Project: Casino | Sample No.: 40% | Test Date: 6/15-6/20/2012

Location: Manufactured O/F | Tested By: jhk/db

Initial Parameters

a. Cylinder (Tare) Weight =	269	g	d. Moisture Content (from drying test) =	**151.5**	%
b. Initial Slurry Volume =	980	ml	e. Initial Slurry Bulk Density [(c-a)/b] =	1.34	g/cm³
c. Tare + Initial Slurry Weight =	1581	g	f. Weight of Water [(c-a)/(1+1/(d/100))] =	790	g
Time of Readings 15-Jun-12	09:21 AM		g. Weight of Solids [(c-a)/(1+d/100)] =	522	g

On-going Readings

			A.	B.	C.	D.	E.	F.	G.	H.
	Date of Reading	Time of Reading	Total Cylinder Weight (before decant) (g)	Total Cylinder Volume (ml)	Settled Slurry Volume (ml)	Water Volume [B-C] (ml)	Drainage Volume Collected (ml)	Decanted Water Volume (ml)	Slurry Bulk Density [(A-a-(B-C))/C] (g/cm³)	Slurry Dry Density [g/C] (g/cm³)
1.	15-Jun-12	09:46 AM	1573	970	870	100	7	94	1.38	0.60
2.	15-Jun-12	10:07 AM	1475	875	780	95	12	84	1.42	0.67
3.	15-Jun-12	10:28 AM	1387	790	685	105	15	95	1.48	0.76
4.	15-Jun-12	11:03 AM	1286	690	595	95	21	83	1.55	0.88
5.	15-Jun-12	12:22 PM	1194	595	540	55	30	53	1.61	0.97
6.	15-Jun-12	04:16 PM	1123	525	490	35	49	28	1.67	1.06
7.	16-Jun-12	08:59 AM	1056	460	460	0	88	0	1.71	1.13
8	17-Jun-12	01:15 PM	1054	460	460	0	90	0	1.71	1.13
9	18-Jun-12	08:34 AM	1052	455	455	0	92	0	1.72	1.15

Falling Head Permeability Test

	Data Readings, Ti (hours)	Initial Water Height, hi (cm)	Initial Solids Height, Hi (cm)	Finishing Time, Tf (hours)	Final Water Height, hf (cm)	Final Solids Height, Hf (cm)	Drainage Collected (ml)	Elapsed Time, T (hours)	Ave. Solids Thickness, H (cm)	Permeability k H/3600T*ln(hi/hf) (cm/sec)
1.	0.00	37.4	16.1	16.30	33.2	16.1	110	16.30	16.1	3.3E-05
2.	0.00	33.2	16.1	8.12	31.4	16.1	50	8.12	16.1	3.1E-05
3.	0.00	31.4	16.1	17.40	27.9	16.1	96	17.40	16.1	3.0E-05
4.	0.00	27.9	16.1	5.67	26.8	16.1	27	5.67	16.1	3.2E-05
									AVG.	**3.1E-05**

Knight Piésold CONSULTING

DRAINED SETTLING TEST AND FALLING HEAD PERMEABILITY TEST

Project No. VA101-325/08

Project:	Casino	Sample No.:	55%	Test Date:	6/15-6/20/2012
		Location:	Manufactured O/F	Tested By:	jhk/db

Initial Parameters

a. Cylinder (Tare) Weight =	273	g	d. Moisture Content (from drying test) =	**81.9**	%
b. Initial Slurry Volume =	945	ml	e. Initial Slurry Bulk Density [(c-a)/b] =	1.53	g/cm³
c. Tare + Initial Slurry Weight =	1718	g	f. Weight of Water [(c-a)/(1+1/(d/100))] =	650	g
Time of Readings 15-Jun-12	09:00 AM		g. Weight of Solids [(c-a)/(1+d/100)] =	794	g

On-going Readings

			A.	B.	C.	D.	E.	F.	G.	H.
	Date of Reading	Time of Reading	Total Cylinder Weight (before decant) (g)	Total Cylinder Volume (ml)	Settled Slurry Volume (ml)	Water Volume [B-C] (ml)	Drainage Volume Collected (ml)	Decanted Water Volume (ml)	Slurry Bulk Density [(A-a-(B-C))/C] (g/cm³)	Slurry Dry Density [g/C] (g/cm³)
1.	15-Jun-12	09:50 AM	1696	920	900	20	22	17	1.56	0.88
2.	15-Jun-12	10:12 AM	1672	900	860	40	28	31	1.58	0.92
3.	15-Jun-12	11:06 AM	1628	855	800	55	42	49	1.62	0.99
4.	15-Jun-12	12:25 PM	1565	790	750	40	56	35	1.67	1.06
5.	15-Jun-12	04:20 PM	1503	730	690	40	83	37	1.72	1.15
6.	16-Jun-12	09:01 AM	1436	660	660	0	113	0	1.76	1.20
7.	17-Jun-12	01:15 PM	1435	660	660	0	114	0	1.76	1.20

Falling Head Permeability Test

	Data Readings, Ti (hours)	Initial Water Height, hi (cm)	Initial Solids Height, Hi (cm)	Finishing Time, Tf (hours)	Final Water Height, hf (cm)	Final Solids Height, Hf (cm)	Drainage Collected (ml)	Elapsed Time, T (hours)	Ave. Solids Thickness, H (cm)	Permeability k H/3600T*ln(hi/hf) (cm/sec)
1.	0.00	36.4	23.0	7.78	34.8	23.0	43	7.78	23.0	3.7E-05
2.	0.00	34.8	23.0	16.30	31.5	23.0	87	16.30	23.0	3.9E-05
3.	0.00	31.5	23.0	8.12	30.0	23.0	40	8.12	23.0	3.8E-05
4.	0.00	30.0	23.0	17.35	27.1	23.0	78	17.53	23.0	3.7E-05
									AVG.	**3.8E-05**

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Knight Piésold CONSULTING

SETTLING AND DRYING TEST (including Evaporation Control)

Project No. VA101-325/08

Project: Casino
Sample No.: 25%
Test Date: 6/15-6/26/12
Location: Manufactured O/F
Tested By: jk/db

Initial Parameters for Settling and Drying Test

a.	Beaker (Tare) Weight =	398	g	d. Moisture Content (from drying test) =	**326.7**	%
b.	Initial Slurry Volume =	820	cm³	e. Initial Slurry Bulk Density [(c-a)/b] =	1.18	g/cm³
c.	Tare + Initial Slurry Weight =	1370	g	f. Weight of Water [(c-a)/(1+1/(d/100))] =	744	g
	Time of Readings	15-Jun-12		g. Weight of Solids [(c-a)/(1+d/100)] =	228	g
		09:35 AM		h. Tailings Solids Specific Gravity =	2.71	
				i. Solids Volume [g/h] =	84.0	cm³

Initial Parameters for Evaporation Control

x.	Beaker Tare Weight =	398	g
y.	Initial Weight of Beaker =	1012	g
z.	Beaker Cross-Sectional Area =	84.46	cm²

On-going Readings

			A.	B.	C.	D.	E.	F.	G.	H.	I.	J.		Evaporation Control		
	Date of Reading	Time of Reading	Total Remaining Weight (g)	Total Remaining Volume (cm³)	Settled Slurry Volume (cm³)	Decanted Water Volume (if any) (cm³)	Shrinkage Crack Volume (estimated) (cm³)	Net. Slurry Volume [C-E] (cm³)	Volume Reduction [(b-F)/b] (%)	Slurry Dry Density [g/F] (g/cm³)	Moisture Content [(A-a)/g]-1 (%)	Saturation (A-a-g)/(B-i) (%)	Comments	Total Weight After Decant (g)	Decanted Weight (if any) (g)	Evap. (mm)
1	15-Jun-12	9:41 AM	1370	820.0	650.0	159.0		650.0	20.7	0.35	326.6	100.0	Water Decanted	1011	0	0
2	15-Jun-12	9:51 AM	1210	660.0	420.0	234.8		420.0	48.8	0.54	256.7	100.0	Water Decanted	1011	0	0
3	15-Jun-12	10:02 AM	975	445.0	390.0	35.2		390.0	52.4	0.58	153.4	100.0	Water Decanted	1011	0	0
4	15-Jun-12	10:13 AM	940	400.0	350.0	32.5		350.0	57.3	0.65	137.9	100.0	Water Decanted	1011	0	0
5	15-Jun-12	10:30 AM	907	360.0	310.0	31.7		310.0	62.2	0.73	123.5	100.0	Water Decanted	1011	0	0
6	15-Jun-12	10:59 AM	875	345.0	260.0	46.1		260.0	68.3	0.88	109.4	100.0	Water Decanted	1010	0	0
7	15-Jun-12	12:18 PM	828	300.0	245.0	31.4		245.0	70.1	0.93	88.7	100.0	Water Decanted	1009	0	0
8	15-Jun-12	4:11 PM	794	255.0	215.0	17.3		215.0	73.8	1.06	73.5	100.0	Water Decanted	1005	0	1
9	16-Jun-12	8:53 AM	763	210.0	205.0	0.0		205.0	75.0	1.11	60.1	100.0	No free water	988	0	3
10	17-Jun-12	1:15 PM	741	200.0	200.0			200.0	75.6	1.14	50.6	99.4	No free water	962	0	6
11	18-Jun-12	8:29 AM	722	190.0	190.0			190.0	76.8	1.20	42.3	90.8	No free water	938	0	9
12	19-Jun-12	8:34 AM	698		194.5		5.2	189.3	76.9	1.20	31.4	67.8	specimen pulling from sides of	907	0	12
13	20-Jun-12	9:52 AM	673		193.7		17.5	176.2	78.5	1.29	20.6	50.7	specimen measured	874	0	16
14	21-Jun-12	10:36 AM	655		191.1		18.3	172.8	78.9	1.32	12.8	32.7	specimen measured	851	0	19
15	22-Jun-12	9:36 AM	640		191.1		18.6	172.5	79.0	1.32	6.0	15.4	specimen measured	828	0	22
16	23-Jun-12	10:09 AM	628		191.1		18.6	172.5	79.0	1.32	1.0	2.6	specimen measured	799	0	25
17	25-Jun-12	11:09 AM	628		191.1		18.6	172.5	79.0	1.32	0.7	1.8	specimen measured	742	0	32

Notes:

Knight Piésold CONSULTING

SETTLING AND DRYING TEST (including Evaporation Control)

Project No. VA101-325/08

Project: Casino
Sample No.: 40%
Test Date: 6/15-
Location: Manufactured O/F
Tested By: jk/db

Initial Parameters for Settling and Drying Test

a.	Beaker (Tare) Weight =	391	g	d. Moisture Content (from drying test) =	**152.4**	%
b.	Initial Slurry Volume =	850	cm³	e. Initial Slurry Bulk Density [(c-a)/b] =	1.37	g/cm³
c.	Tare + Initial Slurry Weight =	1556	g	f. Weight of Water [(c-a)/(1+1/(d/100))] =	703	g
	Time of Readings	15-Jun-12		g. Weight of Solids [(c-a)/(1+d/100)] =	462	g
		09:23 AM		h. Tailings Solids Specific Gravity =	2.711	
				i. Solids Volume [g/h] =	170.3	cm³

Initial Parameters for Evaporation Control

x.	Beaker Tare Weight =	398	g
y.	Initial Weight of Beaker =	1012	g
z.	Beaker Cross-Sectional Area =	84.46	cm²

On-going Readings

			A.	B.	C.	D.	E.	F.	G.	H.	I.	J.		Evaporation Control		
	Date of Reading	Time of Reading	Total Remaining Weight	Total Remaining Volume	Settled Slurry Volume	Decanted Water Volume (if any)	Shrinkage Crack Volume (estimated)	Net. Slurry Volume [C-E]	Volume Reduction	Slurry Dry Density [g/F]	Moisture Content	Saturation	Comments	Total Weight After Decant	Decanted Weight (if any)	Evap.
			(g)	(cm³)	(cm³)	(cm³)	(cm³)	(cm³)	[(b-F)/b] (%)	(g/cm³)	[(A-a)/g]-1 (%)	(A-a-g)/(B-i) (%)		(g)	(g)	(mm)
1	15-Jun-12	9:44 AM	1555	850.0	600.0	252.7		600.0	29.4	0.77	152.2	100.0	Water Decanted	1011	0	0
2	15-Jun-12	10:05 AM	1302	610.0	550.0	39.7		550.0	35.3	0.84	97.4	100.0	Water Decanted	1011	0	0
3	15-Jun-12	10:27 AM	1262	575.0	525.0	34.1		525.0	38.2	0.88	88.7	100.0	Water Decanted	1011	0	0
4	15-Jun-12	11:01 AM	1227	545.0	485.0	40.8		485.0	42.9	0.95	81.2	100.0	Water Decanted	1010	0	0
5	15-Jun-12	12:21 PM	1186	500.0	425.0	50.3		425.0	50.0	1.09	72.1	100.0	Water Decanted	1009	0	0
6	15-Jun-12	4:14 PM	1132	445.0	410.0	16.1		410.0	51.8	1.13	60.6	100.0	Water Decanted	1005	0	1
7	16-Jun-12	8:58 AM	1102	410.0	395.0	10.2		395.0	53.5	1.17	54.0	100.0	Water Decanted	988	0	3
8	17-Jun-12	1:15 PM	1068	375.0	375.0	0.0		375.0	55.9	1.23	46.7	100.0	No free water	962	0	6
9	18-Jun-12	8:32 AM	1048	350.0	350.0	0.0		350.0	58.8	1.32	42.3	100.0	No free water	938	0	9
10	19-Jun-12	8:39 AM	1021	340.0	340.0	0.0		340.0	60.0	1.36	36.5	99.1	No free water	907	0	12
11	20-Jun-12	10:09 AM	993		359.0		21.1	337.8	60.3	1.37	30.4	83.7	Specimen pulling from sides of jar	874	0	16
12	21-Jun-12	10:41 AM	973		364.0		34.9	329.1	61.3	1.40	26.2	76.0	Specimen measured	851	0	19
13	22-Jun-12	9:45 AM	955		359.0		37.1	321.9	62.1	1.43	22.3	67.8	Specimen measured	828	0	22
14	23-Jun-12	10:14 AM	932		358.1		37.6	320.5	62.3	1.44	17.2	52.8	Specimen measured	799	0	25
15	25-Jun-12	9:59 AM	887		358.1		37.6	320.5	62.3	1.44	7.5	23.1	Specimen measured	742	0	32
16	26-Jun-12	9:57 AM	870		358.1		37.6	320.5	62.3	1.44	3.7	11.5	Specimen measured	711	0	36
17	27-Jun-12	9:37 AM	863		358.1		37.6	320.5	62.3	1.44	2.3	6.9	Specimen measured	679	0	39
18	18-Jun-12	1:01 PM	859		358.1		37.6	320.5	62.3	1.44	1.4	4.4	Specimen measured	652	0	43
18	29-Jun-12	9:16 AM	857		358.1		37.6	320.5	62.3	1.44	1.0	3.1	Specimen measured	632	0	45

Notes:

Knight Piésold CONSULTING

SETTLING AND DRYING TEST
(including Evaporation Control)

Project No. VA101-325/08

Project: Casino
Sample No.: 55%
Test Date: 6/15/2012-6/
Location: Manufactured O/F
Tested By: jk/db

Initial Parameters for Settling and Drying Test

a.	Beaker (Tare) Weight =	402	g	d. Moisture Content (from drying test) =	**82.2**	%
b.	Initial Slurry Volume =	1000	cm³	e. Initial Slurry Bulk Density [(c-a)/b] =	1.54	g/cm³
c.	Tare + Initial Slurry Weight =	1937	g	f. Weight of Water [(c-a)/(1+1/(d/100))] =	693	g
	Time of Readings	15-Jun-12		g. Weight of Solids [(c-a)/(1+d/100)] =	842	g
		09:01 AM		h. Tailings Solids Specific Gravity =	2.71	
				i. Solids Volume [g/h] =	310.7	cm³

Initial Parameters for Evaporation Control

x.	Beaker Tare Weight =	398	g
y.	Initial Weight of Beaker =	1012	g
z.	Beaker Cross-Sectional Area =	84.46	cm²

On-going Readings

			A.	B.	C.	D.	E.	F.	G.	H.	I.	J.		Evaporation Control		
	Date of Reading	Time of Reading	Total Remaining Weight (g)	Total Remaining Volume (cm³)	Settled Slurry Volume (cm³)	Decanted Water Volume (if any) (cm³)	Shrinkage Crack Volume (estimated) (cm³)	Net. Slurry Volume [C-E] (cm³)	Volume Reduction [(b-F)/b] (%)	Slurry Dry Density [g/F] (g/cm³)	Moisture Content [(A-a)/g]-1 (%)	Saturation (A-a-g)/(B-i) (%)	Comments	Total Weight After Decant (g)	Decanted Weight (if any) (g)	Evap. (mm)
1	15-Jun-12	9:48 AM	1936	1000.0	950.0	41.1		950.0	5.0	0.89	82.1	100.0	Water Decanted	1011	0	0
2	15-Jun-12	10:10 AM	1895	950.0	920.0	23.6		920.0	8.0	0.92	77.2	100.0	Water Decanted	1011	0	0
3	15-Jun-12	11:04 AM	1870	940.0	855.0	57.3		855.0	14.5	0.99	74.3	100.0	Water Decanted	1010	0	0
4	15-Jun-12	12:23 PM	1812	880.0	800.0	58.3		800.0	20.0	1.05	67.4	100.0	Water Decanted	1009	0	0
5	15-Jun-12	4:17 PM	1750	815.0	750.0	47.9		750.0	25.0	1.12	60.1	100.0	Water Decanted	1005	0	1
6	16-Jun-12	9:00 AM	1687	750.0	750.0	0.0		750.0	25.0	1.12	52.5	100.0	No free water observed	988	0	3
7	17-Jun-12	1:15 PM	1663	725.0	725.0			725.0	27.5	1.16	49.7	100.0	No free water observed	962	0	6
8	18-Jun-12	8:35 AM	1642	700.0	700.0			700.0	30.0	1.20	47.2	100.0	No free water observed	938	0	9
9	19-Jun-12	8:41 AM	1614	680.0	680.0			680.0	32.0	1.24	43.9	100.0	No free water observed	907	0	12
10	20-Jun-12	10:18 AM	1584		705.4		45.4	660.0	34.0	1.28	40.3	97.2	Specimen pulling from sides of jar	874	0	16
11	21-Jun-12	10:47 AM	1563		696.9		55.2	641.7	35.8	1.31	37.9	96.4	measured in jar	851	0	19
12	22-Jun-12	9:49 AM	1544		692.7		58.7	634.0	36.6	1.33	35.6	92.6	measured in jar	828	0	22
13	23-Jun-12	10:12 AM	1519		686.8		62.0	624.8	37.5	1.35	32.6	87.4	Specimen measured	799	0	25
14	25-Jun-12	9:54 AM	1472		685.9		100.3	585.6	41.4	1.44	27.0	82.8	Specimen measured	742	0	32
15	26-Jun-12	9:54 AM	1445		683.4		103.6	579.8	42.0	1.45	23.9	74.7	Specimen measured	711	0	36
16	27-Jun-12	9:34 AM	1416		681.7		105.8	575.9	42.4	1.46	20.4	64.7	Specimen measured	679	0	39
17	28-Jun-12	12:57 PM	1392		680.0		106.7	573.3	42.7	1.47	17.5	56.1	Specimen measured	652	0	43
18	29-Jun-12	9:11 AM	1373		680.0		106.7	573.3	42.7	1.47	15.3	49.2	Specimen measured	632	0	45
19	30-Jun-12	9:24 AM	1351		680.0		106.7	573.3	42.7	1.47	12.7	40.7	Specimen measured	606	0	48
20	02-Jul-12	6:00 PM	1300		680.0		106.7	573.3	42.7	1.47	6.6	21.2	Specimen measured	552	0	54
21	03-Jul-12	11:24 AM	1291		680.0		106.7	573.3	42.7	1.47	5.5	17.6	Specimen measured	524	0	58
22	05-Jul-12	8:28 AM	1276		680.0		106.7	573.3	42.7	1.47	3.8	12.2	Specimen measured	478	0	63
23	07-Jul-12	10:51 AM	1268		680.0		106.7	573.3	42.7	1.47	2.8	9.1	Specimen measured	432	0	69

Notes:

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TABLE 1.0

Knight Piésold Ltd.
CASINO COPPER AND GOLD PROJECT
VA101-325/08

SUMMARY OF TAILINGS SEDIMENTATION TEST RESULTS
TAILINGS COMPOSITE

Undrained Settling Test				Drained Settling Test					Settling and Drying Test			Additional
Solids Content	Slurry Dry Density	Total Water Recovery	Portion of Initial Water Retained in Tailings prior to Onset of Evaporation	Solids Content	Slurry Dry Density	Total Water Recovery	Portion of Initial Water Retained in Tailings prior to Onset of Evaporation	Average Permeability	Solids Content	Slurry Dry Density	Total Evaporation	Water Recovered in Drained Test
(%)	(g/cm³)	(%)	(%)	(%)	(g/cm³)	(%)	(%)	(cm/sec)	(%)	(g/cm³)	(mm)	(%)
22.0	0.83	76.5	23.5	22.1	0.95	78.4	21.6	6.3E-05	23.4	1.32	31.9	1.8
40.2	1.01	58.7	41.3	39.8	1.15	66.9	33.1	3.1E-05	39.6	1.44	45.0	8.1
55.2	1.10	34.9	65.1	55.0	1.20	43.5	56.5	3.8E-05	54.9	1.47	68.6	8.5

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FIGURE 1.1

Knight Piésold Ltd.
CASINO COPPER AND GOLD PROJECT
VA101-325/08

TAILINGS DEPOSITION METHOD VS. DRY DENSITY
TAILINGS COMPOSITE

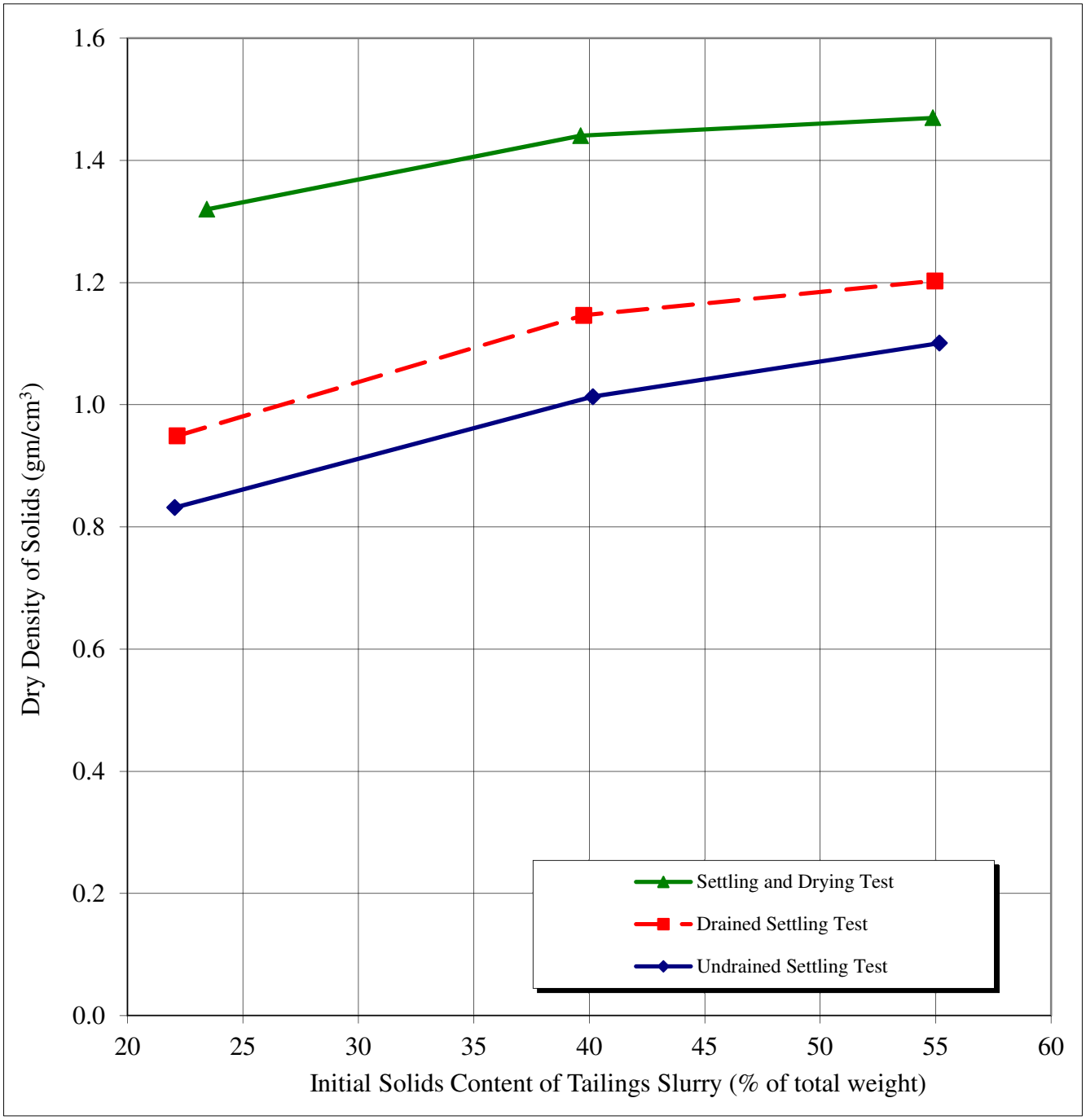

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FIGURE 1.2

Knight Piésold Ltd.
CASINO COPPER AND GOLD PROJECT
VA101-325/08

TAILINGS DEPOSITION METHOD VS. WATER RECOVERY
TAILINGS COMPOSITE

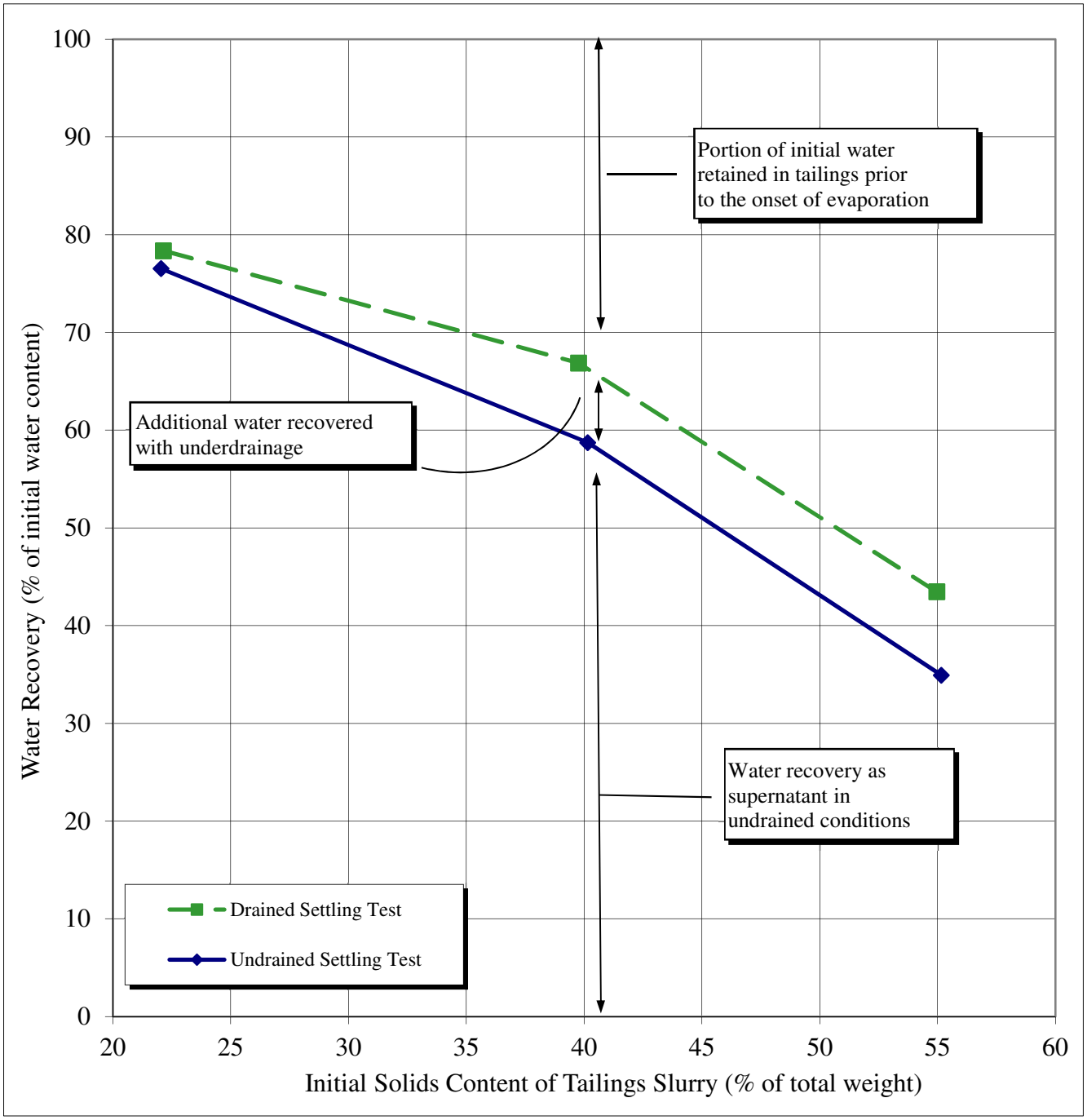

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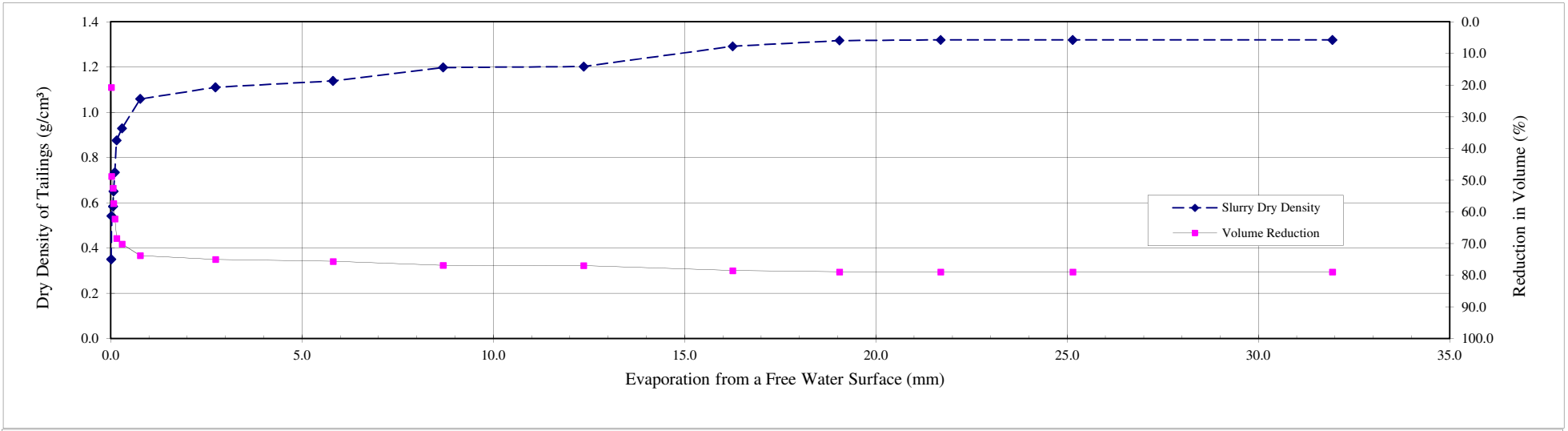
FIGURE 1.3

Knight Piésold Ltd.
CASINO COPPER AND GOLD PROJECT
VA101-325/08
MANUFACTURED OVERFLOW
VARIATION OF TAILINGS PARAMETERS WITH ONGOING EVAPORATION
0.25



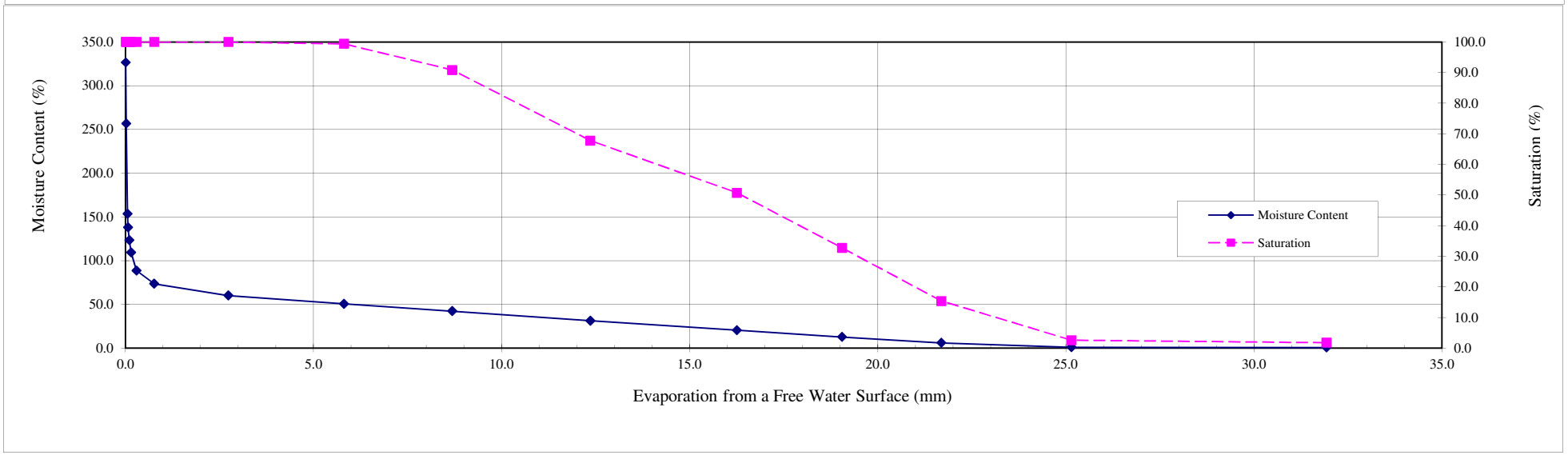


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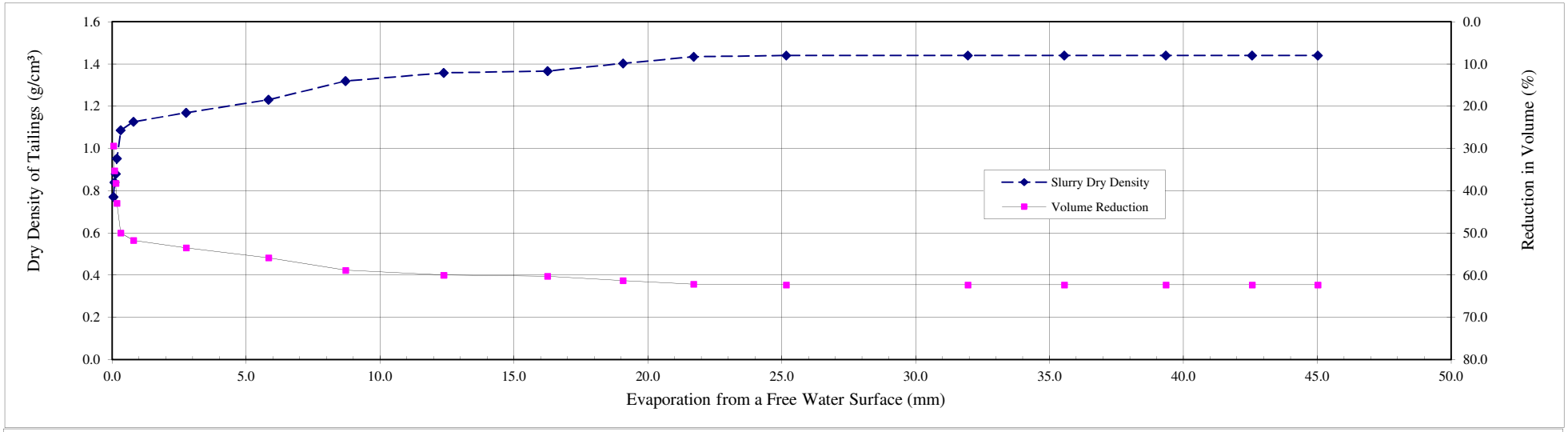
FIGURE 1.4

Knight Piésold Ltd.
CASINO COPPER AND GOLD PROJECT
VA101-325/08

VARIATION OF TAILINGS PARAMETERS WITH ONGOING EVAPORATION
0.4



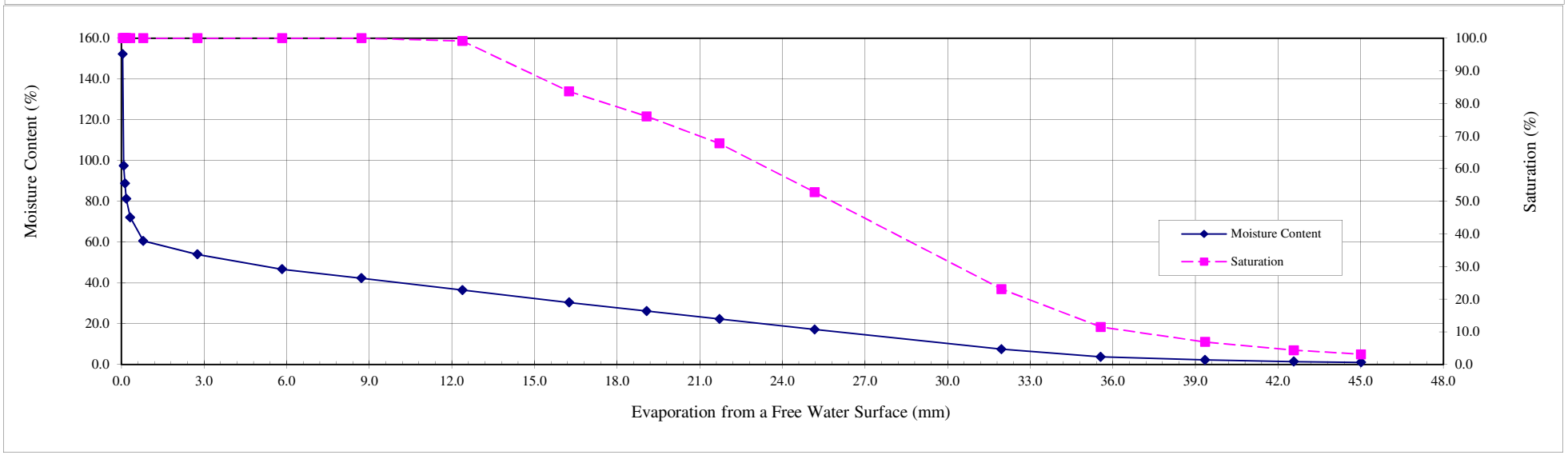


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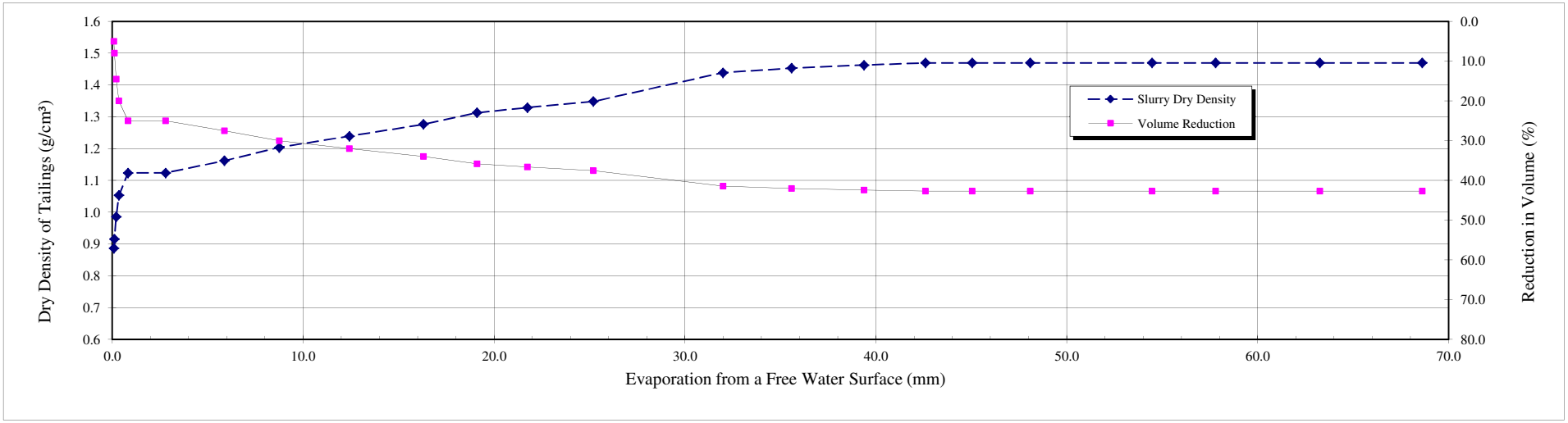
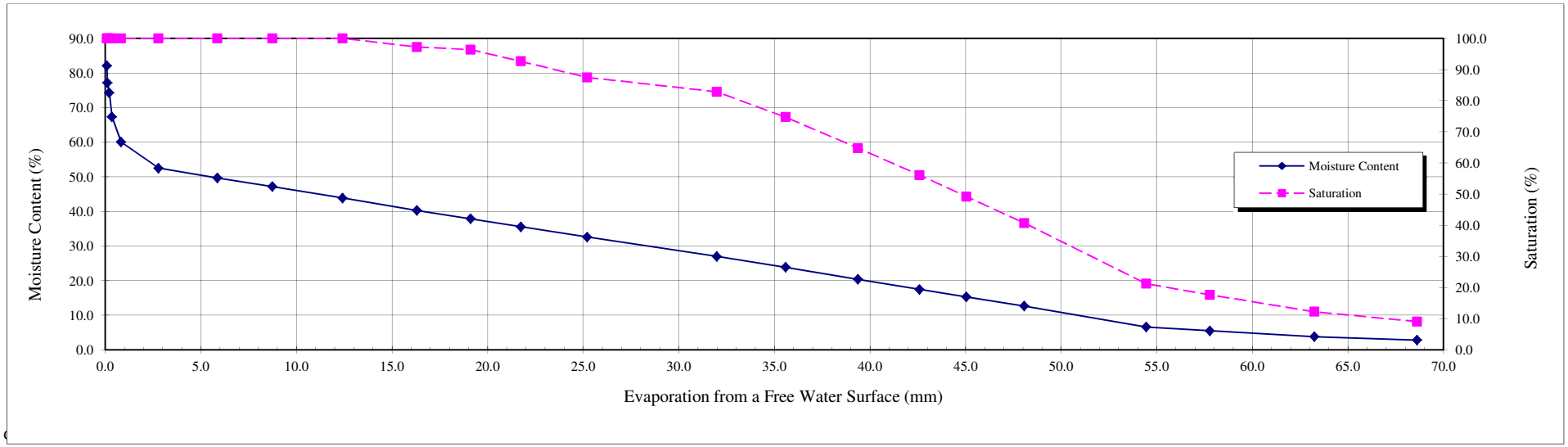
FIGURE 1.5

Knight Piésold Ltd.
CASINO COPPER AND GOLD PROJECT
VA101-325/08

VARIATION OF TAILINGS PARAMETERS WITH ONGOING EVAPORATION
0.55





Note:

SLURRY CONSOLIDOMETER TEST RESULTS
CASINO
MANUFACTURED OVERFLOW TAILINGS
VA101-325/08

		Consolidation Test Data - Double Ended Drainage								
STRESS	psi	Free	0.5	2	5	10	20	40	80	120
	psf		72	288	720	1440	2880	5760	11520	17280
	kPa		3	14	34	69	138	276	552	827
Volume Change, cc		343.6	10.0	34.0	18.7	12.4	10.9	10.1	11.7	6.7
Cumulative Volume Change, cc		343.6	353.6	387.6	406.3	418.7	429.6	439.7	451.4	458.1
Consolidated Slurry Volume, cm^3		473.3	463.3	429.3	410.6	398.2	387.3	377.2	365.5	358.8
Settled Void Ratio, e_c		1.228	1.181	1.021	0.933	0.875	0.823	0.776	0.721	0.689
Dry Unit Weight, pcf		76.0	77.6	83.7	87.6	90.3	92.8	95.3	98.4	100.2
Slurry Height, cm		5.678	5.558	5.150	4.926	4.777	4.646	4.525	4.385	4.304
Mean Slurry Height, H^2 mm			789.0	716.6	634.5	588.4	555.0	525.7	496.1	471.9
Total Ht. Change, cm		4.121	4.241	4.649	4.874	5.022	5.153	5.274	5.415	5.495
Cumulative change in height, in.		1.623	1.670	1.830	1.919	1.977	2.029	2.076	2.132	2.163
Individual change in height, in.		1.623	0.047	0.161	0.088	0.059	0.051	0.048	0.055	0.032

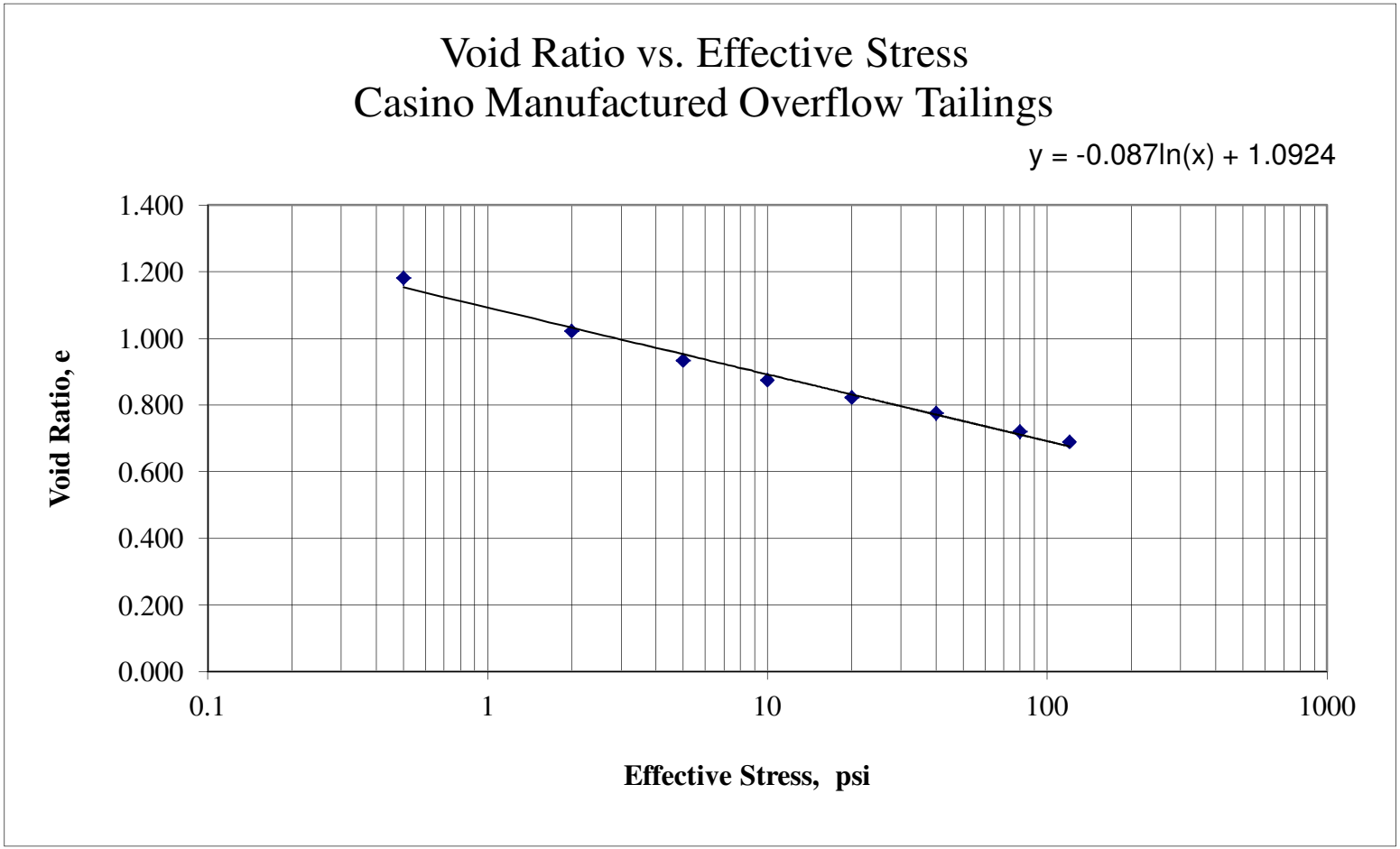
SAMPLE PARAMETERS

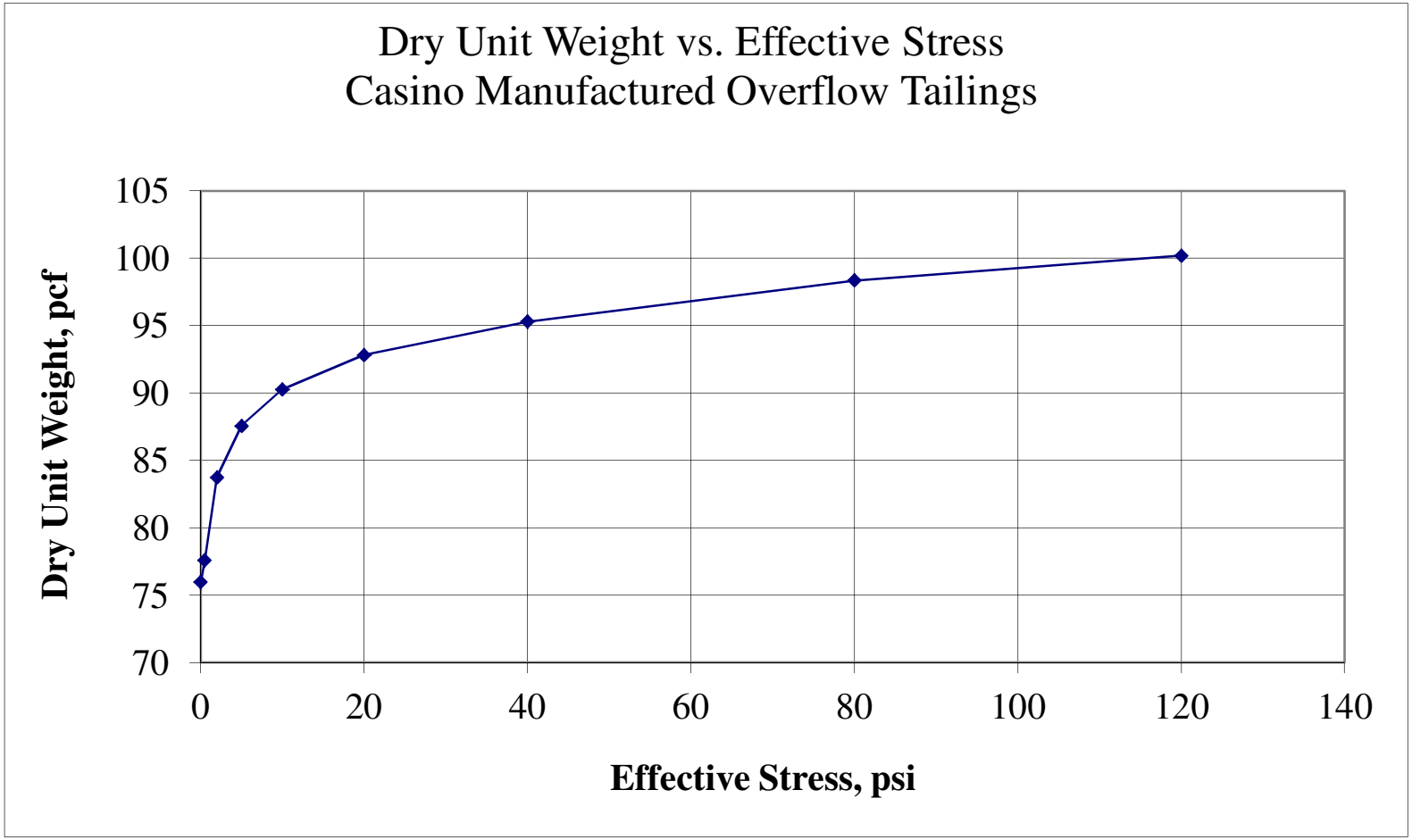
Specific Gravity	2.711	
Slurry Mass w/tare, g	1400.50	
Tare, g	217.90	
Slurry Mass, g	1182.60	
Height of Slurry (in./cm)	3.858	9.80
Volume of Slurry, cc		816.86
Solids Content, %	48.0	
Wt. of Solids, g	575.9	
Ht. of Solids, cm		2.548
Volume of Solids, cc	212.42	
Intial Void Ratio, e	2.846	

Ring Diameter (in./cm)	4.056	10.30
Ring Area, cm^2		83.359
Ring Height (in./cm)	4.058	10.31
Ring Volume, cm^3		859.21

Post Test Specimen Data

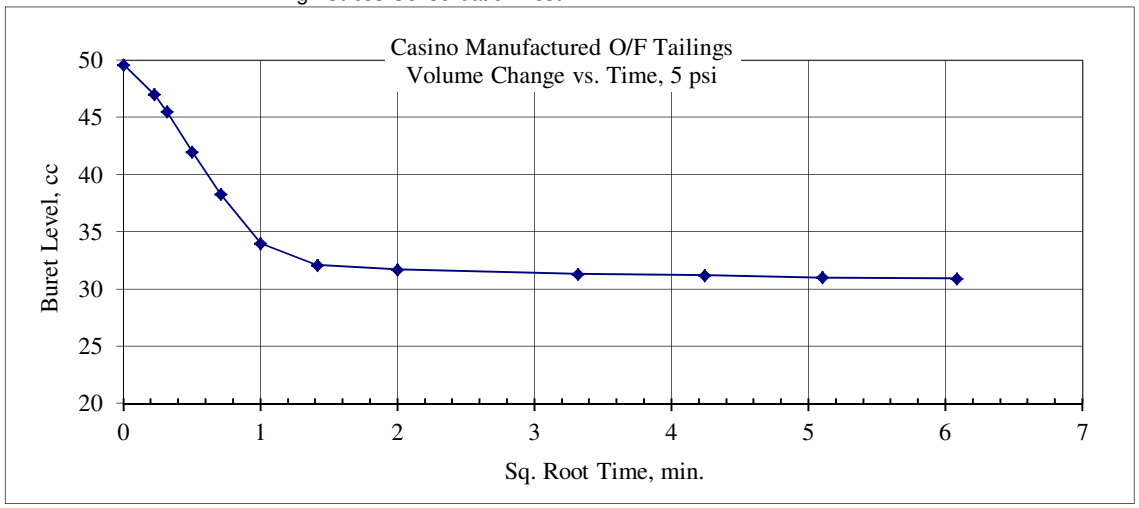
Wet + Tare, g	828.50
Dry + Tare, g	686.50
Tare, g	110.63
Wt. of Water, g	142.00
Wt. of Dry Solids, g	575.87
Moisture Content, %	24.66


Void Ratio vs. Effective Stress
Casino Manufactured Overflow Tailings
y = -0.087ln(x) + 1.0924
1.400
1.200
1.000
0.800
0.600
0.400
0.200
0.000
Void Ratio, e
0.1
1
10
100
1000
Effective Stress, psi

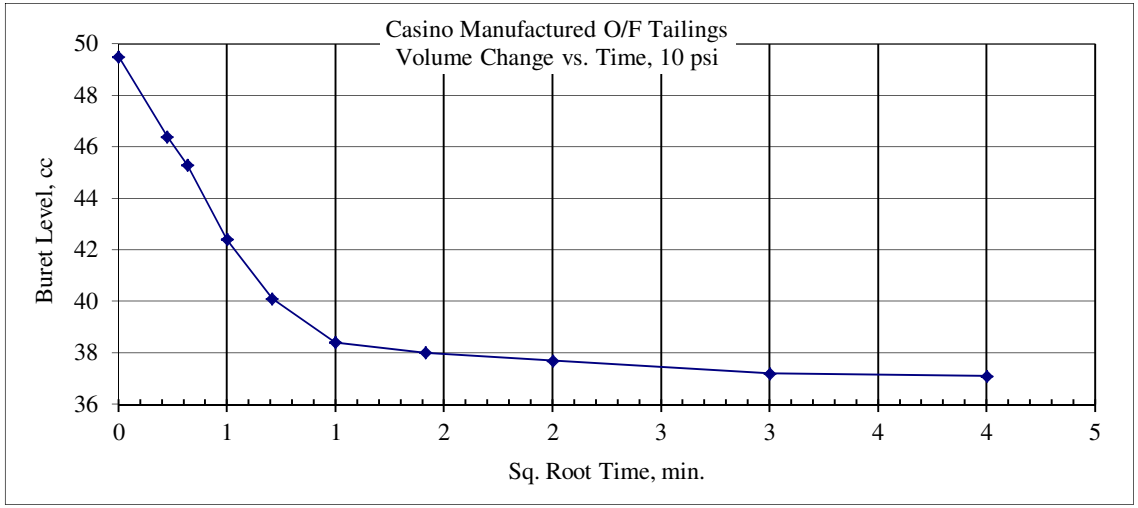

Dry Unit Weight vs. Effective Stress
Casino Manufactured Overflow Tailings
Dry Unit Weight, pcf
105
100
95
90
85
80
75
70
0
20
40
60
80
100
120
140
Effective Stress, psi

VA101-325/08
Casino
Manufactured Overflow
High Stress Consolidation Test

elapsed time min.	sq. root time min.	Change in Volume (50 - cc)	Cell Buret Level cc
0.00	0.00	49.6	0.4
0.05	0.22	47.0	3.0
0.10	0.32	45.5	4.5
0.25	0.50	42.0	8.0
0.50	0.71	38.3	11.7
1.00	1.00	34.0	16.0
2.00	1.41	32.1	17.9
4.00	2.00	31.7	18.3
11.00	3.32	31.3	18.7
18.00	4.24	31.2	18.8
26.00	5.10	31.0	19.0
37.00	6.08	30.9	19.1

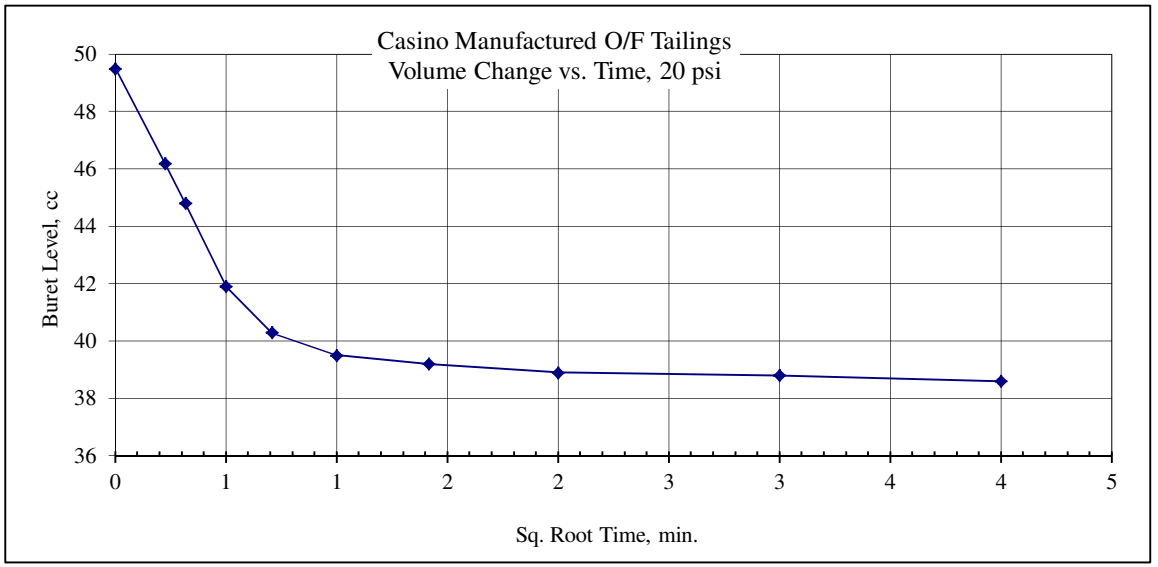


elapsed time min.	sq. root time min.	Change in Volume (50 - cc)	Cell Buret Level cc
0.00	0.00	49.5	0.5
0.05	0.22	46.4	3.6
0.10	0.32	45.3	4.7
0.25	0.50	42.4	7.6
0.50	0.71	40.1	9.9
1.00	1.00	38.4	11.6
2.00	1.41	38.0	12.0
4.00	2.00	37.7	12.3
9.00	3.00	37.2	12.8
16.00	4.00	37.1	12.9

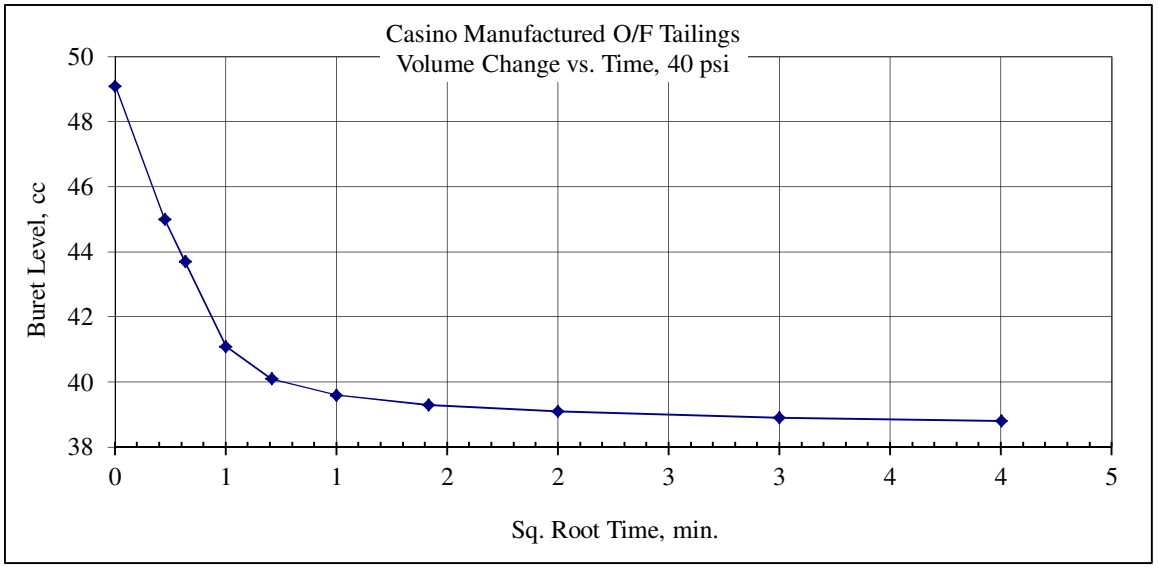


VA101-325/08
Casino
Manufactured Overflow
High Stress Consolidation Test

elapsed time min.	sq. root time min.	Change in Volume (50 - cc)	Cell Buret Level cc
0.00	0.00	49.5	0.5
0.05	0.22	46.2	3.8
0.10	0.32	44.8	5.2
0.25	0.50	41.9	8.1
0.50	0.71	40.3	9.7
1.00	1.00	39.5	10.5
2.00	1.41	39.2	10.8
4.00	2.00	38.9	11.1
9.00	3.00	38.8	11.2
16.00	4.00	38.6	11.4

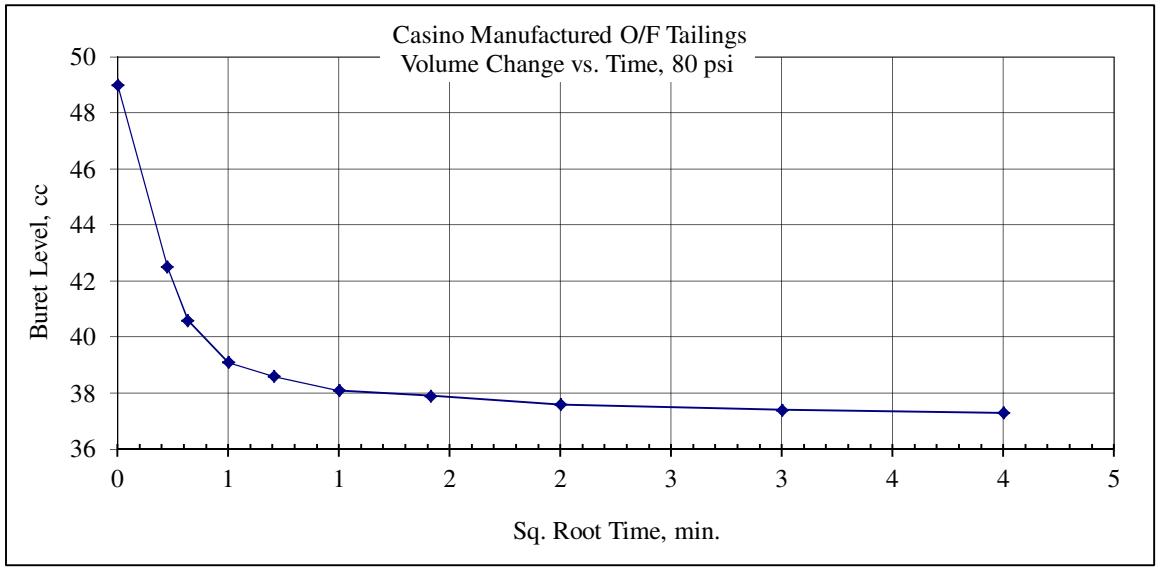


elapsed time min.	sq. root time min.	Change in Volume (50 - cc)	Cell Buret Level cc
0.00	0.00	49.1	0.9
0.05	0.22	45.0	5.0
0.10	0.32	43.7	6.3
0.25	0.50	41.1	8.9
0.50	0.71	40.1	9.9
1.00	1.00	39.6	10.4
2.00	1.41	39.3	10.7
4.00	2.00	39.1	10.9
9.00	3.00	38.9	11.1
16.00	4.00	38.8	11.2

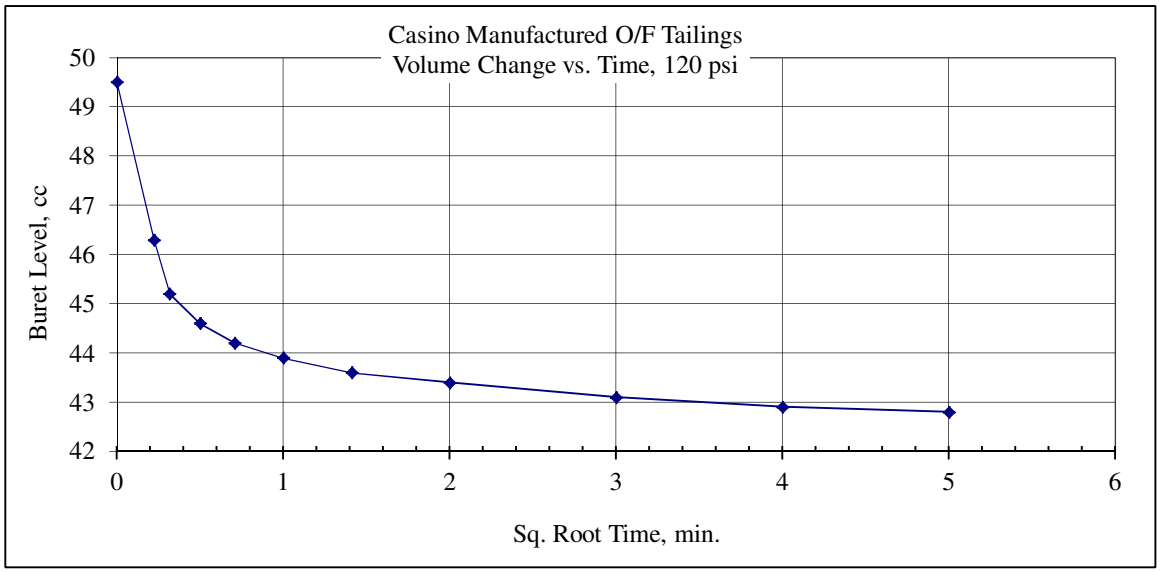


VA101-325/08
Casino
Manufactured Overflow
High Stress Consolidation Test

elapsed time min.	sq. root time min.	Change in Volume (50 - cc)	Cell Buret Level cc
0.00	0.00	49.0	1.0
0.05	0.22	42.5	7.5
0.10	0.32	40.6	9.4
0.25	0.50	39.1	10.9
0.50	0.71	38.6	11.4
1.00	1.00	38.1	11.9
2.00	1.41	37.9	12.1
4.00	2.00	37.6	12.4
9.00	3.00	37.4	12.6
16.00	4.00	37.3	12.7



elapsed time min.	sq. root time min.	Change in Volume (50 - cc)	Cell Buret Level cc
0.00	0.00	49.5	0.5
0.05	0.22	46.3	3.7
0.10	0.32	45.2	4.8
0.25	0.50	44.6	5.4
0.50	0.71	44.2	5.8
1.00	1.00	43.9	6.1
2.00	1.41	43.6	6.4
4.00	2.00	43.4	6.6
9.00	3.00	43.1	6.9
16.00	4.00	42.9	7.1
25.00	5.00	42.8	7.2



RIGID WALL PERMEABILITY TEST

ASTM D 5856-02

Falling Head / Increasing Tailwater Pressure

CLIENT:	Casino		
PROJECT:	Casino Copper-Gold	PROJECT NO. :	VA101-325.08
SAMPLE NO.	Manufactured O/F	LAB NO. :	L2012-056
DEPTH		SAMPLE ID:	2012-056-02
SAMPLE ID:		TEST STARTED :	06/25/12
SAMPLE TYPE	slurry	TEST FINISHED :	07/03/12
CONF. PRESSURE. (psi)	5	SATURATED TEST:	YES

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	1182.60	776.30
Wt. Wet Soil & Pan (g)	1182.60	776.30
Wt. Dry Soil & Pan (g)	575.90	575.90
Wt. Moisture Lost (g)	606.70	200.40
Wt. of Pan Only (g)	0.00	0.00
Wt. of Dry Soil (g)	575.90	575.90
Moisture Content %	105.3	34.8
Wet Density (pcf)	90.4	118.0
Dry Density (pcf)	44.0	87.6

Init. Diameter (in)	4.056	(cm)	10.302
Init. Area (sq in)	12.921	(sq cm)	83.359
Init. Height (in)	3.858	(cm)	9.799
Height Change (in)	1.919	(cm)	4.874
Consol. Height (in)	1.939	(cm)	4.925
Area After Consol. (sq in)	12.920	(sq cm)	83.359

Vol. Before Consol. (cu ft)	0.02885	Specific Gravity	2.711
Vol. Before Consol. (cc)	816.9	Assumed?	No
Change in Vol. (cc)	406.3		
Cell Exp. (cc)	0.0	Init. Saturation	100.0
Vol. After Consol. (cc)	410.6	Init. Void Ratio	2.845
Vol. After Consol. (cu ft)	0.01450	Final Saturation	100.0
Effective Porosity %	73.99	Final Void Ratio	0.933
Pressure Difference (psi):	0.00		
C =	0.02142	Buret Constant, a	0.315
k, cm/s = C/t*log(h1/h2)		Buret Stand	20

Permeability Test Trials

Time	Cap Elevation	Pedestal Elevation	Elevation Head	Total Head	Permeability k
min.	cm	cm	cm	cm	cm/sec
0.0	43.4	1.9	41.5	41.5	
1.5	41.3	4.0	37.3	37.3	1.1E-05
1.5	39.6	5.9	33.7	33.7	1.0E-05
2.0	37.3	8.1	29.2	29.2	1.1E-05
4.0	33.9	11.6	22.3	22.3	1.0E-05
			Avg.of All Rdgs.		**1.1E-05**
			Max.Hyd.Gradient:	8.0	

RIGID WALL PERMEABILITY TEST

ASTM D 5856-02

Falling Head / Increasing Tailwater Pressure

CLIENT:	Casino		
PROJECT:	Casino Copper-Gold	PROJECT NO. :	VA101-325.08
SAMPLE NO.	Manufactured O/F	LAB NO. :	L2012-056
DEPTH		SAMPLE ID:	2012-056-02
SAMPLE ID:		TEST STARTED :	06/25/12
SAMPLE TYPE	slurry	TEST FINISHED :	07/03/12
CONF. PRESSURE. (psi)	10	SATURATED TEST:	YES

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	1182.60	763.90
Wt. Wet Soil & Pan (g)	1182.60	763.90
Wt. Dry Soil & Pan (g)	575.90	575.90
Wt. Moisture Lost (g)	606.70	188.00
Wt. of Pan Only (g)	0.00	0.00
Wt. of Dry Soil (g)	575.90	575.90
Moisture Content %	105.3	32.6
Wet Density (pcf)	90.4	119.8
Dry Density (pcf)	44.0	90.3

Init. Diameter (in)	4.056	(cm)	10.302
Init. Area (sq in)	12.921	(sq cm)	83.359
Init. Height (in)	3.858	(cm)	9.799
Height Change (in)	1.977	(cm)	5.022
Consol. Height (in)	1.881	(cm)	4.778
Area After Consol. (sq in)	12.920	(sq cm)	83.359
Vol. Before Consol. (cu ft)	0.02885	Specific Gravity	2.711
Vol. Before Consol. (cc)	816.9	Assumed?	No
Change in Vol. (cc)	418.7		
Cell Exp. (cc)	0.0	Init. Saturation	100.0
Vol. After Consol. (cc)	398.2	Init. Void Ratio	2.845
Vol. After Consol. (cu ft)	0.01406	Final Saturation	100.0
Effective Porosity %	73.99	Final Void Ratio	0.874
Pressure Difference (psi):	0.00		
C =	0.02078	Buret Constant, a	0.315
k, cm/s = C/t*log(h1/h2)		Buret Stand	20

Permeability Test Trials

Time	Cap Elevation	Pedestal Elevation	Elevation Head	Total Head	Permeability k
min.	cm	cm	cm	cm	cm/sec
0.0	41.9	1.6	40.3	40.3	
0.5	41.2	2.3	38.9	38.9	1.1E-05
0.5	40.7	2.9	37.8	37.8	8.6E-06
1.0	39.7	4.0	35.7	35.7	8.6E-06
2.0	37.6	6.1	31.5	31.5	9.4E-06
4.0	34.7	9.3	25.4	25.4	8.1E-06
			Avg.of All Rdgs.		**9.1E-06**
			Max.Hyd.Gradient:	8.3	

RIGID WALL PERMEABILITY TEST

ASTM D 5856-02

Falling Head / Increasing Tailwater Pressure

CLIENT:	Casino		
PROJECT:	Casino Copper-Gold	PROJECT NO. :	VA101-325.08
SAMPLE NO.	Manufactured O/F	LAB NO. :	L2012-056
DEPTH		SAMPLE ID:	2012-056-02
SAMPLE ID:		TEST STARTED :	06/25/12
SAMPLE TYPE	slurry	TEST FINISHED :	07/03/12
CONF. PRESSURE. (psi)	20	SATURATED TEST:	YES

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	1182.60	753.00
Wt. Wet Soil & Pan (g)	1182.60	753.00
Wt. Dry Soil & Pan (g)	575.90	575.90
Wt. Moisture Lost (g)	606.70	177.10
Wt. of Pan Only (g)	0.00	0.00
Wt. of Dry Soil (g)	575.90	575.90
Moisture Content %	105.3	30.8
Wet Density (pcf)	90.4	121.4
Dry Density (pcf)	44.0	92.8

Init. Diameter (in)	4.056	(cm)	10.302
Init. Area (sq in)	12.921	(sq cm)	83.359
Init. Height (in)	3.858	(cm)	9.799
Height Change (in)	2.029	(cm)	5.154
Consol. Height (in)	1.829	(cm)	4.646
Area After Consol. (sq in)	12.920	(sq cm)	83.359
Vol. Before Consol. (cu ft)	0.02885	Specific Gravity	2.711
Vol. Before Consol. (cc)	816.9	Assumed?	No
Change in Vol. (cc)	429.6		
Cell Exp. (cc)	0.0	Init. Saturation	100.0
Vol. After Consol. (cc)	387.3	Init. Void Ratio	2.845
Vol. After Consol. (cu ft)	0.01368	Final Saturation	100.0
Effective Porosity %	73.99	Final Void Ratio	0.823
Pressure Difference (psi):	0.00		
C =	0.02021	Buret Constant, a	0.315
k, cm/s = C/t*log(h1/h2)		Buret Stand	20

Permeability Test Trials

Time	Cap Elevation	Pedestal Elevation	Elevation Head	Total Head	Permeability k
min.	cm	cm	cm	cm	cm/sec
0.0	43.5	1.9	41.6	41.6	
3.0	41.1	4.9	36.2	36.2	6.8E-06
4.0	38.1	8.0	30.1	30.1	6.7E-06
8.0	33.3	12.9	20.4	20.4	7.1E-06
16.0	28.2	18.4	9.8	9.8	6.7E-06
			Avg.of All Rdgs.		**6.8E-06**
			Max.Hyd.Gradient:	8.4	

RIGID WALL PERMEABILITY TEST

ASTM D 5856-02

Falling Head / Increasing Tailwater Pressure

CLIENT:	Casino		
PROJECT:	Casino Copper-Gold	PROJECT NO. :	VA101-325.08
SAMPLE NO.	Manufactured O/F	LAB NO. :	L2012-056
DEPTH		SAMPLE ID:	2012-056-02
SAMPLE ID:		TEST STARTED :	06/25/12
SAMPLE TYPE	slurry	TEST FINISHED :	07/03/12
CONF. PRESSURE. (psi)	40	SATURATED TEST:	YES

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	1182.60	742.90
Wt. Wet Soil & Pan (g)	1182.60	742.90
Wt. Dry Soil & Pan (g)	575.90	575.90
Wt. Moisture Lost (g)	606.70	167.00
Wt. of Pan Only (g)	0.00	0.00
Wt. of Dry Soil (g)	575.90	575.90
Moisture Content %	105.3	29.0
Wet Density (pcf)	90.4	123.0
Dry Density (pcf)	44.0	95.3

Init. Diameter (in)	4.056	(cm)	10.302
Init. Area (sq in)	12.921	(sq cm)	83.359
Init. Height (in)	3.858	(cm)	9.799
Height Change (in)	2.076	(cm)	5.273
Consol. Height (in)	1.782	(cm)	4.526
Area After Consol. (sq in)	12.920	(sq cm)	83.359
Vol. Before Consol. (cu ft)	0.02885	Specific Gravity	2.711
Vol. Before Consol. (cc)	816.9	Assumed?	No
Change in Vol. (cc)	439.7		
Cell Exp. (cc)	0.0	Init. Saturation	100.0
Vol. After Consol. (cc)	377.2	Init. Void Ratio	2.845
Vol. After Consol. (cu ft)	0.01332	Final Saturation	100.0
Effective Porosity %	73.99	Final Void Ratio	0.775
Pressure Difference (psi):	0.00		
C =	0.01969	Buret Constant, a	0.315
k, cm/s = C/t*log(h1/h2)		Buret Stand	20

Permeability Test Trials

Time	Cap Elevation	Pedestal Elevation	Elevation Head	Total Head	Permeability k
min.	cm	cm	cm	cm	cm/sec
0.0	47.3	2.6	44.7	44.7	
1.0	46.8	3.0	43.8	43.8	2.9E-06
2.0	46.0	3.9	42.1	42.1	2.8E-06
4.0	44.4	5.6	38.8	38.8	2.9E-06
8.0	41.6	8.3	33.3	33.3	2.7E-06
			Avg.of All Rdgs.		**2.8E-06**
			Max.Hyd.Gradient:	9.8	

RIGID WALL PERMEABILITY TEST

ASTM D 5856-02

Falling Head / Increasing Tailwater Pressure

CLIENT:	Casino		
PROJECT:	Casino Copper-Gold	PROJECT NO. :	VA101-325.08
SAMPLE NO.	Manufactured O/F	LAB NO. :	L2012-056
DEPTH		SAMPLE ID:	2012-056-02
SAMPLE ID:		TEST STARTED :	06/25/12
SAMPLE TYPE	slurry	TEST FINISHED :	07/03/12
CONF. PRESSURE. (psi)	80	SATURATED TEST:	YES

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	1182.60	731.20
Wt. Wet Soil & Pan (g)	1182.60	731.20
Wt. Dry Soil & Pan (g)	575.90	575.90
Wt. Moisture Lost (g)	606.70	155.30
Wt. of Pan Only (g)	0.00	0.00
Wt. of Dry Soil (g)	575.90	575.90
Moisture Content %	105.3	27.0
Wet Density (pcf)	90.4	124.9
Dry Density (pcf)	44.0	98.4

Init. Diameter (in)	4.056	(cm)	10.302
Init. Area (sq in)	12.921	(sq cm)	83.359
Init. Height (in)	3.858	(cm)	9.799
Height Change (in)	2.132	(cm)	5.415
Consol. Height (in)	1.726	(cm)	4.384
Area After Consol. (sq in)	12.920	(sq cm)	83.359
Vol. Before Consol. (cu ft)	0.02885	Specific Gravity	2.711
Vol. Before Consol. (cc)	816.9	Assumed?	No
Change in Vol. (cc)	451.4		
Cell Exp. (cc)	0.0	Init. Saturation	100.0
Vol. After Consol. (cc)	365.5	Init. Void Ratio	2.845
Vol. After Consol. (cu ft)	0.01291	Final Saturation	100.0
Effective Porosity %	73.99	Final Void Ratio	0.720
Pressure Difference (psi):	0.00		
C =	0.01907	Buret Constant, a	0.315
k, cm/s = C/t*log(h1/h2)		Buret Stand	20

Permeability Test Trials

Time	Cap Elevation	Pedestal Elevation	Elevation Head	Total Head	Permeability k
min.	cm	cm	cm	cm	cm/sec
0.0	42.3	2.7	39.6	39.6	
2.0	41.8	3.3	38.5	38.5	1.9E-06
4.0	40.6	4.6	36.0	36.0	2.3E-06
8.0	38.5	6.9	31.6	31.6	2.2E-06
16.0	35.1	10.4	24.7	24.7	2.1E-06
			Avg.of All Rdgs.		**2.2E-06**
			Max.Hyd.Gradient:	8.9	

RIGID WALL PERMEABILITY TEST

ASTM D 5856-02

Falling Head / Increasing Tailwater Pressure

CLIENT:	Casino		
PROJECT:	Casino Copper-Gold	PROJECT NO. :	VA101-325.08
SAMPLE NO.	Manufactured O/F	LAB NO. :	L2012-056
DEPTH		SAMPLE ID:	2012-056-02
SAMPLE ID:		TEST STARTED :	06/25/12
SAMPLE TYPE	slurry	TEST FINISHED :	07/03/12
CONF. PRESSURE. (psi)	120	SATURATED TEST:	YES

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	1182.60	724.50
Wt. Wet Soil & Pan (g)	1182.60	724.50
Wt. Dry Soil & Pan (g)	575.90	575.90
Wt. Moisture Lost (g)	606.70	148.60
Wt. of Pan Only (g)	0.00	0.00
Wt. of Dry Soil (g)	575.90	575.90
Moisture Content %	105.3	25.8
Wet Density (pcf)	90.4	126.1
Dry Density (pcf)	44.0	100.2

Init. Diameter (in)	4.056	(cm)	10.302
Init. Area (sq in)	12.921	(sq cm)	83.359
Init. Height (in)	3.858	(cm)	9.799
Height Change (in)	2.163	(cm)	5.494
Consol. Height (in)	1.695	(cm)	4.305
Area After Consol. (sq in)	12.920	(sq cm)	83.359
Vol. Before Consol. (cu ft)	0.02885	Specific Gravity	2.711
Vol. Before Consol. (cc)	816.9	Assumed?	No
Change in Vol. (cc)	458.1		
Cell Exp. (cc)	0.0	Init. Saturation	100.0
Vol. After Consol. (cc)	358.8	Init. Void Ratio	2.845
Vol. After Consol. (cu ft)	0.01267	Final Saturation	100.0
Effective Porosity %	73.99	Final Void Ratio	0.689
Pressure Difference (psi):	0.00		
C =	0.01873	Buret Constant, a	0.315
k, cm/s = C/t*log(h1/h2)		Buret Stand	20

Permeability Test Trials

Time	Cap Elevation	Pedestal Elevation	Elevation Head	Total Head	Permeability k
min.	cm	cm	cm	cm	cm/sec
0.0	41.1	2.5	38.6	38.6	
2.0	40.6	3.0	37.6	37.6	1.8E-06
4.0	39.5	4.1	35.4	35.4	2.0E-06
8.0	37.8	6.0	31.8	31.8	1.8E-06
16.0	34.7	9.0	25.7	25.7	1.8E-06
			Avg.of All Rdgs.		**1.9E-06**
			Max.Hyd.Gradient:	8.8	

PROJECT NO. VA201-325/08
PROJECT: Casino Copper-Gold 20 12
TESTED BY: jhk Denver
DATE: 16/06/12 S.G. SOLIDS : 2.71
Manufactured Overflow S.G. LIQUOR: 1.0000
pH LIQUOR: 7.00

CONSOLIDATION TESTS

CYLINDER:	B
Weight of Container:	0.0
Weight of Slurry + Cont.:	1442.0
Height to Bottom of Slurry:	0.0
Height to Top of Slurry:	370.0
Diameter of Container:	58.8
Settled Top of Slurry Heights:	243
BEFORE CONSOLIDATION:	243.0
AFTER CONSOLIDATION:	227.0
AFTER COMPLETE DRAINAGE:	227.0

DATE		TIME			SLURRY HEIGHT	WEIGHT OF WATER +	WEIGHT OF	Water Level
DAY	MONTH	HOUR	MINUTE	SECOND	READING	CONTAINER	CONTAINER	
19	6	8	17	0	243.0	391.4	391.4	370.0
19	6	8	17	6	242.0			370.0
19	6	8	17	15	242.0			370.0
19	6	8	17	30	242.0	399.7	391.4	370.0
19	6	8	18	0	242.0	401.0	399.7	370.0
19	6	8	19	0	241.0	403.6	401.0	370.0
19	6	8	22	0	240.0	406.8	403.6	370.0
19	6	8	27	0	239.0	411.4	406.8	370.0
19	6	8	37	0	238.0	415.0	411.4	370.0
19	6	8	47	0	236.5	423.1	415.0	370.0
19	6	9	15	0	234.5	430.6	423.1	370.0
19	6	9	47	0	232.5	436.6	430.6	370.0
19	6	10	17	0	231.0	449.8	436.6	370.0
19	6	11	17	0	229.0	462.9	449.8	370.0
19	6	12	17	0	227.0	517.0	462.9	370.0
19	6	16	20	0	227.0	705.4	517.0	370.0
20	6	8	17	0	227.0	981.7	705.4	361.0

ISOLIDATION TEST

PROJECT : Casino Copper-Gold
SAMPLE : Manufactured Overflow

DATE : 16-Jun-12
TESTED BY : jhk Denver

*	Weight of Container	:	0.0		PULP DENSITY	:	1.437
*	Weight of Slurry + Container	:	1442.0	*	S.G. SOLIDS	:	2.71
	Weight of Slurry	:	1442.0	*	S.G. LIQUOR	:	1.00
*	Height to Bottom of Slurry	:	0.0		% WT. SOLIDS	:	48.20
*	Height to Top of Slurry	:	370.0		Weight of Solids	:	695.0
	Height of Slurry	:	370.0		Volume of water	:	747.0
*	Internal dia. of Container	:	58.8				
	Volume of Slurry	:	1003.4				

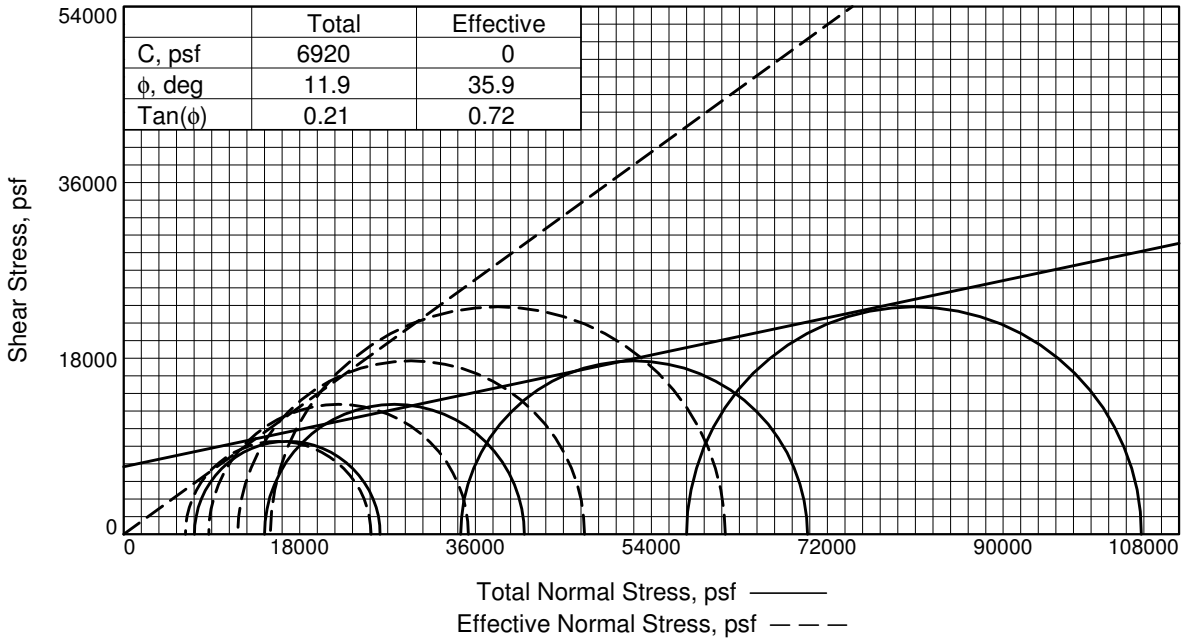
BEFORE CONSOLIDATION			AFTER CONSOLIDATION			AFTER COMPLETE DRAINAGE		
* Settled Slurry Ht	:	243.0	* Settled Slurry Ht	:	227.0	* Settled Slurry Ht	:	227.0
Ht of Water	:	127.0	Ht of Water	:	143.0	Ht of Water	:	-
Vol of Slurry	:	659.0	Vol of Slurry	:	615.6	Vol of Slurry	:	615.6
Vol of Water	:	344.4	Vol of Water	:	387.8	Vol of Water	:	-
Dry Density	:	1.055	Dry Density	:	1.129	Dry Density	:	1.129
Pulp Density	:	1.666	Pulp Density	:	1.713	Pulp Density	:	1.713
Void Ratio	:	1.570	Void Ratio	:	1.401	Void Ratio	:	1.401
Total Stress at Base	:	5.215	Total Stress at Ba	:	5.215	Total Stress at Ba	:	3.813
Eff. Stress at Base	:	1.586	Eff. Stress at Bas	:	5.215	Eff. Stress at Bas	:	6.039
Average Eff. Stress	:	0.793	Average Eff. Stres	:	2.607	Average Eff. Stres	:	3.019

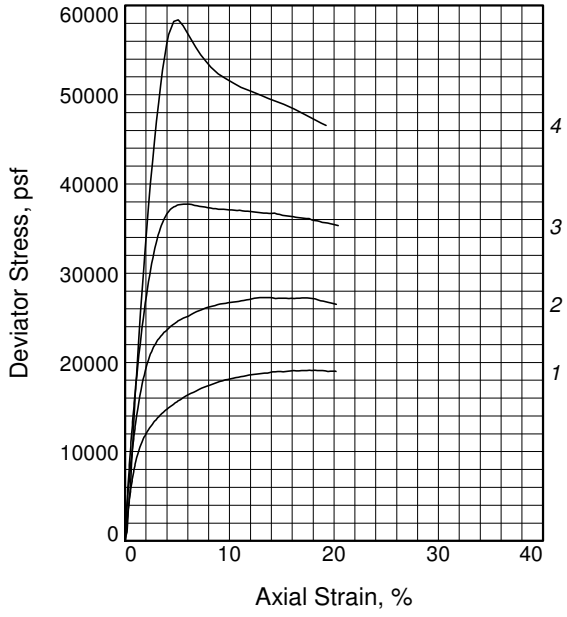
DAY	TIME	ELAPSED TIME (hours)	(min)	(sec)	* SLURRY HEIGHT READING	SETTLEMENT OF SLURRY	* WEIGHT OF WATER & CONT	* WEIGHT OF CONT	VOLUME OF WATER	CUMUL. VOLUME OF WATER	HEIGHT OF SLURRY	VOLUME OF SLURRY	DRY DENSITY t/m^3	i VALUE (av ht)	PERMEABILITY (m/s)
19/06/12	08:17:00	< START TIME		0	243.0	0.00	391.4	391.4	0.0	0.0	243.0	659.0	1.055		
19/06/12	08:17:06	0.00	0.10	6	242.0	1.00	0.0	0.0	0.0	0.0	242.0	656.2	1.059	1.53	0.000E+00
19/06/12	08:17:15	0.00	0.25	15	242.0	1.00	0.0	0.0	0.0	0.0	242.0	656.2	1.059	1.53	--
19/06/12	08:17:30	0.01	0.50	30	242.0	1.00	399.7	391.4	8.4	8.4	242.0	656.2	1.059	1.53	6.721E-05
19/06/12	08:18:00	0.02	1.00	60	242.0	1.00	401.0	399.7	1.3	9.6	242.0	656.2	1.059	1.53	1.021E-05
19/06/12	08:19:00	0.03	2.00	120	241.0	2.00	403.6	401.0	2.6	12.3	241.0	653.5	1.063	1.53	1.059E-05
19/06/12	08:22:00	0.08	5.00	300	240.0	3.00	406.8	403.6	3.1	15.4	240.0	650.8	1.068	1.54	4.168E-06
19/06/12	08:27:00	0.17	10.00	600	239.0	4.00	411.4	406.8	4.6	20.0	239.0	648.1	1.072	1.54	3.692E-06
19/06/12	08:37:00	0.33	20.00	1200	238.0	5.00	415.0	411.4	3.6	23.7	238.0	645.4	1.077	1.55	1.434E-06
19/06/12	08:47:00	0.50	30.00	1800	236.5	6.50	423.1	415.0	8.1	31.7	236.5	641.3	1.084	1.56	3.172E-06
19/06/12	09:15:00	0.97	58.00	3480	234.5	8.50	430.6	423.1	7.5	39.2	234.5	635.9	1.093	1.57	1.051E-06
19/06/12	09:47:00	1.50	90.00	5400	232.5	10.50	436.6	430.6	6.0	45.3	232.5	630.5	1.102	1.58	7.297E-07
19/06/12	10:17:00	2.00	120.00	7200	231.0	12.00	449.8	436.6	13.2	58.4	231.0	626.4	1.109	1.60	1.691E-06
19/06/12	11:17:00	3.00	180.00	10800	229.0	14.00	462.9	449.8	13.1	71.5	229.0	621.0	1.119	1.61	8.322E-07
19/06/12	12:17:00	4.00	240.00	14400	227.0	16.00	517.0	462.9	54.1	125.6	227.0	615.6	1.129	1.62	3.416E-06
19/06/12	16:20:00	8.05	483.00	28980	227.0	16.00	705.4	517.0	188.4	314.0	227.0	615.6	1.129	1.63	2.924E-06
20/06/12	08:17:00	24.00	1440.00	86400	227.0	16.00	981.7	705.4	276.3	590.3	227.0	615.6	1.129	1.63	1.089E-06

ENT OF CONSOLIDATION

U value	Tv	leasured Value	ROW	X values	Y values	L values	H values	A	B	C	Time(h)	Cv	
													Mv
0.5	0.197	8.00	9	6.500	-0.301			-0.012	0.322	-1.891	0.837	29.45	0.0363
				8.500	-0.015	15.000	0.143						Kv
				10.500	0.176	17.000	0.119						3.284E-07
													Cc
0.6	0.287	9.60	10	8.500	-0.015			-0.003	0.161	-1.135	1.241	28.74	0.3274
				10.500	0.176	19.000	0.095						
				12.000	0.301	20.500	0.090					29.10	

Cursory interpretations provided require review by a professional engineer. Knight Piesold accepts no responsibility in subsequent analyses.





Sample No.		1	2	3	4
Initial	Water Content, %	16.5	16.5	16.5	16.5
	Dry Density, pcf	93.0	92.7	92.2	92.8
	Saturation, %	52.5	52.1	51.5	52.3
	Void Ratio	0.8768	0.8843	0.8937	0.8809
	Diameter, in.	2.41	2.41	2.42	2.41
	Height, in.	5.00	5.00	5.00	5.00
At Test	Water Content, %	24.4	23.7	22.5	22.1
	Dry Density, pcf	103.8	105.0	107.2	107.9
	Saturation, %	100.0	100.0	100.0	100.0
	Void Ratio	0.6818	0.6631	0.6293	0.6184
	Diameter, in.	2.29	2.28	2.26	2.27
	Height, in.	4.96	4.95	4.90	4.87
Strain rate, %/min.		0.03	0.03	0.03	0.03
Eff. Cell Pressure, kPa		346.4	689.6	1650.9	2757.9
Fail. Stress, psf		19004	26580	35484	46543
Excess Pore Pr., psf		933	5710	22812	42595
Strain, %		19.9	20.0	19.9	19.2
Ult. Stress, psf					
Excess Pore Pr., psf					
Strain, %					
$\bar{\sigma}_1$ Failure, psf		25305	35273	47150	61548
$\bar{\sigma}_3$ Failure, psf		6302	8693	11667	15005

Type of Test:
CU with Pore Pressures

Sample Type: Remolded

Description:

Specific Gravity= 2.797

Remarks: Failure tangents drawn at approximately 20% strain.

Figure _____

Client: Knight Piésold Ltd.

Project: Casino

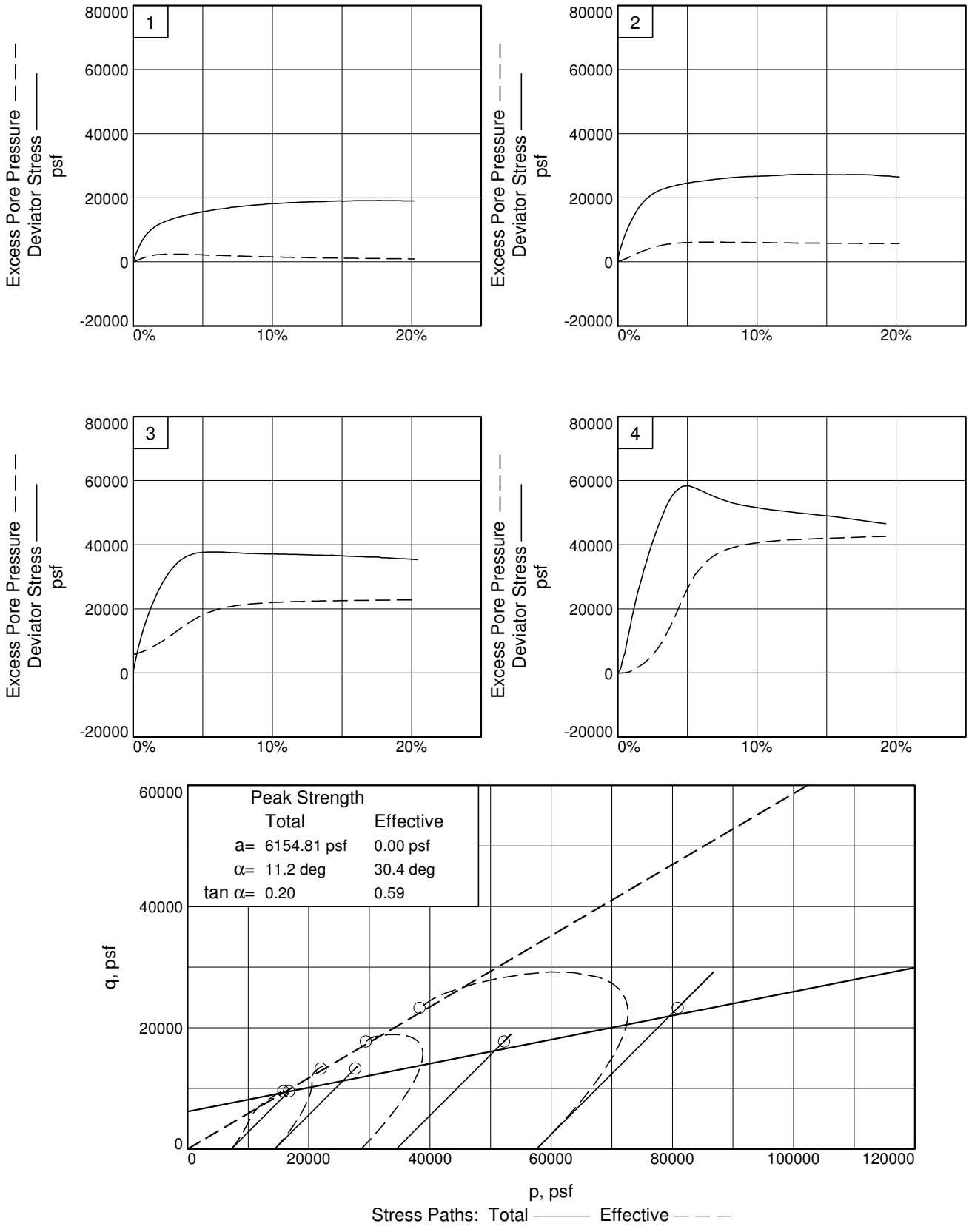
Location: Manufactured U/F

Proj. No.: 101-325/08 **Date Sampled:** 6/29/12

Knight Piésold CONSULTING

Tested By: rsh **Checked By:** jdb

Cursory interpretations provided require review by a professional engineer. Knight Piesold accepts no responsibility in subsequent analyses.



Client: Knight Piésold Ltd.
Project: Casino
Location: Manufactured U/F
Project No.: 101-325/08

Figure _____

Knight Piesold Geotechnical Lab.

Tested By: rsh _____ **Checked By:** jdb _____

TRIAXIAL COMPRESSION TEST

CU with Pore Pressures

8/14/2012
1:29 PM

Date: 6/29/12
Client: Knight Piésold Ltd.
Project: Casino
Project No.: 101-325/08
Location: Manufactured U/F
Description:
Remarks: Failure tangents drawn at approximately 20% strain.
Type of Sample: Remolded
Specific Gravity=2.797 **LL=** **PL=** **PI=**
Test Method: ASTM D 4767 Method A

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	906.600			891.900
Moisture content: Dry soil+tare, gms.	797.000			755.800
Moisture content: Tare, gms.	131.300			197.500
Moisture, %	16.5	31.3	24.4	24.4
Moist specimen weight, gms.	648.2			
Diameter, in.	2.41	2.41	2.29	
Area, in.²	4.56	4.56	4.12	
Height, in.	5.00	5.00	4.96	
Net decrease in height, in.		0.00	0.04	
Net decrease in water volume, cc.			38.80	
Wet density, pcf	108.4	122.2	129.1	
Dry density, pcf	93.0	93.0	103.8	
Void ratio	0.8768	0.8768	0.6818	
Saturation, %	52.5	100.0	100.0	

Test Readings for Specimen No. 1

Membrane modulus = 0.124105 kN/cm²
Membrane thickness = 0.064 cm
Consolidation cell pressure = 90.24 psi (12995 psf)
Consolidation back pressure = 40.00 psi (5760 psf)
Consolidation effective confining stress = 7235 psf
Strain rate, %/min. = 0.03
Fail. Stress = 19004 psf **at reading no.** 139

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psf	Minor Eff. Stress psf	Major Eff. Stress psf	1:3 Ratio	Pore Press. psi	P psf	Q psf
0	-1.6853	2.958	0.0	0.0	0	7203	7203	1.00	40.22	7203	0
1	-1.6841	10.484	7.5	0.0	263	7196	7459	1.04	40.27	7327	132
2	-1.6828	20.580	17.6	0.1	616	7178	7794	1.09	40.39	7486	308
3	-1.6816	30.712	27.8	0.1	970	7150	8120	1.14	40.59	7635	485
4	-1.6803	40.496	37.5	0.1	1312	7114	8426	1.18	40.84	7770	656
5	-1.6791	49.623	46.7	0.1	1630	7076	8706	1.23	41.10	7891	815
6	-1.6778	58.628	55.7	0.2	1944	7039	8983	1.28	41.36	8011	972
7	-1.6766	67.042	64.1	0.2	2237	6993	9231	1.32	41.68	8112	1119
8	-1.6753	76.052	73.1	0.2	2551	6945	9496	1.37	42.01	8220	1276
9	-1.6741	83.356	80.4	0.2	2806	6897	9703	1.41	42.34	8300	1403
10	-1.6728	91.377	88.4	0.3	3085	6852	9937	1.45	42.66	8394	1542
11	-1.6715	99.668	96.7	0.3	3373	6804	10177	1.50	42.99	8491	1686
12	-1.6703	107.630	104.7	0.3	3650	6756	10406	1.54	43.32	8581	1825
13	-1.6690	114.988	112.0	0.3	3905	6715	10620	1.58	43.61	8667	1953
14	-1.6678	121.865	118.9	0.4	4144	6668	10812	1.62	43.93	8740	2072
15	-1.6665	129.871	126.9	0.4	4422	6624	11046	1.67	44.24	8835	2211
16	-1.6653	136.582	133.6	0.4	4655	6576	11231	1.71	44.57	8903	2327
17	-1.6640	142.356	139.4	0.4	4854	6525	11380	1.74	44.92	8953	2427
18	-1.6628	148.406	145.4	0.5	5064	6475	11539	1.78	45.28	9007	2532
19	-1.6615	155.794	152.8	0.5	5320	6429	11749	1.83	45.59	9089	2660
20	-1.6603	161.344	158.4	0.5	5511	6385	11896	1.86	45.90	9140	2756
21	-1.6590	167.627	164.7	0.5	5729	6346	12074	1.90	46.17	9210	2864
22	-1.6577	173.026	170.1	0.6	5915	6296	12211	1.94	46.52	9253	2957
23	-1.6565	179.453	176.5	0.6	6137	6251	12388	1.98	46.83	9320	3068
24	-1.6552	185.199	182.2	0.6	6335	6208	12543	2.02	47.13	9376	3168
25	-1.6540	190.317	187.4	0.6	6511	6167	12679	2.06	47.41	9423	3256
26	-1.6527	195.048	192.1	0.7	6674	6123	12797	2.09	47.72	9460	3337
27	-1.6515	201.276	198.3	0.7	6889	6082	12970	2.13	48.01	9526	3444
28	-1.6502	205.932	203.0	0.7	7049	6045	13094	2.17	48.26	9570	3524
29	-1.6490	210.965	208.0	0.7	7222	6003	13224	2.20	48.56	9613	3611
30	-1.6477	216.091	213.1	0.8	7398	5962	13360	2.24	48.83	9661	3699
31	-1.6465	220.981	218.0	0.8	7565	5923	13489	2.28	49.11	9706	3783
32	-1.6452	226.205	223.2	0.8	7745	5885	13630	2.32	49.37	9758	3872
33	-1.6440	230.165	227.2	0.8	7880	5857	13738	2.35	49.56	9797	3940
34	-1.6427	234.218	231.3	0.9	8019	5822	13841	2.38	49.81	9832	4009
35	-1.6414	239.089	236.1	0.9	8185	5792	13978	2.41	50.02	9885	4093
36	-1.6402	242.694	239.7	0.9	8308	5763	14072	2.44	50.22	9917	4154
37	-1.6389	247.124	244.2	0.9	8460	5723	14183	2.48	50.49	9953	4230
38	-1.6377	250.962	248.0	1.0	8590	5683	14273	2.51	50.78	9978	4295
39	-1.6364	254.852	251.9	1.0	8723	5650	14373	2.54	51.01	10011	4362
40	-1.6352	258.910	256.0	1.0	8861	5618	14480	2.58	51.22	10049	4431
41	-1.6302	272.547	269.6	1.1	9324	5501	14825	2.70	52.04	10163	4662
42	-1.6252	285.665	282.7	1.2	9768	5393	15160	2.81	52.79	10277	4884
43	-1.6202	296.347	293.4	1.3	10126	5300	15426	2.91	53.44	10363	5063
44	-1.6152	306.483	303.5	1.4	10465	5244	15709	3.00	53.83	10476	5233
45	-1.6102	317.699	314.7	1.5	10841	5151	15992	3.10	54.47	10572	5421
46	-1.6052	325.548	322.6	1.6	11100	5093	16194	3.18	54.87	10644	5550

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psf	Minor Eff. Stress psf	Major Eff. Stress psf	1:3 Ratio	Pore Press. psi	P psf	Q psf
47	-1.6002	334.138	331.2	1.7	11384	5032	16416	3.26	55.30	10724	5692
48	-1.5952	341.177	338.2	1.8	11614	4985	16599	3.33	55.62	10792	5807
49	-1.5901	347.381	344.4	1.9	11815	4966	16780	3.38	55.76	10873	5907
50	-1.5851	354.972	352.0	2.0	12063	4915	16978	3.45	56.11	10947	6031
51	-1.5801	360.645	357.7	2.1	12245	4889	17133	3.50	56.29	11011	6122
52	-1.5751	366.929	364.0	2.2	12447	4864	17311	3.56	56.46	11087	6223
53	-1.5701	373.307	370.3	2.3	12652	4845	17497	3.61	56.59	11171	6326
54	-1.5651	377.399	374.4	2.4	12779	4850	17628	3.63	56.56	11239	6389
55	-1.5601	383.034	380.1	2.5	12957	4824	17782	3.69	56.74	11303	6479
56	-1.5551	387.719	384.8	2.6	13104	4822	17926	3.72	56.75	11374	6552
57	-1.5501	393.447	390.5	2.7	13285	4810	18095	3.76	56.83	11453	6642
58	-1.5451	397.433	394.5	2.8	13407	4811	18217	3.79	56.83	11514	6703
59	-1.5401	401.990	399.0	2.9	13547	4822	18369	3.81	56.76	11595	6774
60	-1.5351	406.303	403.3	3.0	13680	4818	18497	3.84	56.78	11658	6840
61	-1.5301	410.517	407.6	3.1	13808	4825	18633	3.86	56.73	11729	6904
62	-1.5251	414.912	412.0	3.2	13943	4829	18771	3.89	56.71	11800	6971
63	-1.5201	418.770	415.8	3.3	14058	4836	18895	3.91	56.65	11866	7029
64	-1.5151	422.332	419.4	3.4	14164	4850	19014	3.92	56.56	11932	7082
65	-1.5101	425.967	423.0	3.5	14272	4857	19129	3.94	56.51	11993	7136
66	-1.5051	429.792	426.8	3.6	14386	4863	19249	3.96	56.47	12056	7193
67	-1.5001	433.553	430.6	3.7	14497	4876	19374	3.97	56.38	12125	7249
68	-1.4951	437.101	434.1	3.8	14602	4880	19482	3.99	56.35	12181	7301
69	-1.4901	440.641	437.7	3.9	14705	4904	19610	4.00	56.18	12257	7353
70	-1.4851	443.841	440.9	4.0	14797	4909	19706	4.01	56.15	12307	7399
71	-1.4801	447.004	444.0	4.1	14888	4930	19818	4.02	56.00	12374	7444
72	-1.4751	450.182	447.2	4.2	14978	4935	19914	4.03	55.97	12424	7489
73	-1.4701	453.411	450.5	4.3	15071	4950	20021	4.04	55.86	12486	7535
74	-1.4651	456.084	453.1	4.4	15144	4965	20110	4.05	55.76	12538	7572
75	-1.4601	458.516	455.6	4.5	15209	5000	20209	4.04	55.52	12605	7605
76	-1.4551	462.773	459.8	4.6	15335	4997	20332	4.07	55.54	12664	7668
77	-1.4501	465.845	462.9	4.7	15421	5012	20433	4.08	55.44	12722	7711
78	-1.4451	468.657	465.7	4.8	15499	5022	20521	4.09	55.36	12772	7749
79	-1.4401	471.516	468.6	4.9	15577	5039	20616	4.09	55.25	12828	7789
80	-1.4351	475.405	472.4	5.0	15690	5053	20743	4.11	55.15	12898	7845
81	-1.4226	480.429	477.5	5.3	15815	5124	20938	4.09	54.66	13031	7907
82	-1.4100	488.054	485.1	5.6	16024	5139	21163	4.12	54.55	13151	8012
83	-1.3975	495.113	492.2	5.8	16214	5176	21390	4.13	54.30	13283	8107
84	-1.3850	501.895	498.9	6.1	16394	5213	21607	4.14	54.04	13410	8197
85	-1.3725	507.307	504.3	6.3	16527	5247	21774	4.15	53.80	13511	8263
86	-1.3600	512.130	509.2	6.6	16640	5299	21940	4.14	53.44	13619	8320
87	-1.3475	518.199	515.2	6.8	16793	5323	22116	4.15	53.27	13720	8397
88	-1.3350	525.564	522.6	7.1	16987	5357	22344	4.17	53.04	13851	8493
89	-1.3225	530.481	527.5	7.3	17100	5390	22490	4.17	52.81	13940	8550
90	-1.3100	535.467	532.5	7.6	17215	5424	22639	4.17	52.57	14032	8607
91	-1.2975	540.708	537.8	7.8	17337	5462	22799	4.17	52.31	14131	8668
92	-1.2850	545.378	542.4	8.1	17440	5498	22938	4.17	52.06	14218	8720
93	-1.2725	550.458	547.5	8.3	17555	5532	23087	4.17	51.82	14309	8777

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psf	Minor Eff. Stress psf	Major Eff. Stress psf	1:3 Ratio	Pore Press. psi	P psf	Q psf
94	-1.2600	555.125	552.2	8.6	17656	5558	23213	4.18	51.65	14385	8828
95	-1.2475	559.652	556.7	8.8	17751	5579	23330	4.18	51.50	14455	8876
96	-1.2350	564.752	561.8	9.1	17864	5611	23476	4.18	51.27	14543	8932
97	-1.2225	568.480	565.5	9.3	17933	5641	23575	4.18	51.06	14608	8967
98	-1.2100	573.736	570.8	9.6	18050	5654	23704	4.19	50.98	14679	9025
99	-1.1975	576.923	574.0	9.8	18100	5685	23785	4.18	50.76	14735	9050
100	-1.1850	580.658	577.7	10.1	18167	5712	23878	4.18	50.58	14795	9083
101	-1.1725	584.219	581.3	10.3	18227	5736	23963	4.18	50.41	14849	9114
102	-1.1600	587.925	585.0	10.6	18292	5759	24050	4.18	50.25	14905	9146
103	-1.1475	591.446	588.5	10.8	18350	5789	24139	4.17	50.04	14964	9175
104	-1.1349	595.017	592.1	11.1	18409	5804	24213	4.17	49.94	15008	9205
105	-1.1224	598.385	595.4	11.3	18462	5827	24289	4.17	49.77	15058	9231
106	-1.1099	601.862	598.9	11.6	18516	5848	24365	4.17	49.63	15107	9258
107	-1.0974	605.976	603.0	11.9	18590	5871	24462	4.17	49.47	15167	9295
108	-1.0849	608.530	605.6	12.1	18616	5903	24519	4.15	49.25	15211	9308
109	-1.0724	611.242	608.3	12.4	18646	5917	24562	4.15	49.15	15240	9323
110	-1.0599	614.829	611.9	12.6	18702	5936	24637	4.15	49.02	15287	9351
111	-1.0474	617.459	614.5	12.9	18728	5950	24678	4.15	48.92	15314	9364
112	-1.0349	620.473	617.5	13.1	18765	5964	24729	4.15	48.82	15346	9383
113	-1.0224	623.199	620.2	13.4	18793	5984	24778	4.14	48.68	15381	9397
114	-1.0099	625.041	622.1	13.6	18794	6020	24814	4.12	48.44	15417	9397
115	-0.9974	629.141	626.2	13.9	18863	6024	24887	4.13	48.40	15456	9431
116	-0.9849	633.211	630.3	14.1	18930	6033	24963	4.14	48.34	15498	9465
117	-0.9724	635.310	632.4	14.4	18937	6041	24979	4.13	48.29	15510	9469
118	-0.9599	638.454	635.5	14.6	18975	6057	25033	4.13	48.17	15545	9488
119	-0.9474	640.980	638.0	14.9	18995	6068	25062	4.13	48.10	15565	9497
120	-0.9349	640.921	638.0	15.1	18937	6115	25052	4.10	47.77	15583	9468
121	-0.9224	644.855	641.9	15.4	18997	6107	25104	4.11	47.83	15605	9498
122	-0.9099	647.557	644.6	15.6	19020	6116	25135	4.11	47.77	15625	9510
123	-0.8974	650.544	647.6	15.9	19051	6127	25177	4.11	47.69	15652	9525
124	-0.8848	653.455	650.5	16.1	19079	6145	25224	4.10	47.56	15685	9540
125	-0.8723	654.835	651.9	16.4	19062	6163	25225	4.09	47.44	15694	9531
126	-0.8598	656.637	653.7	16.6	19057	6163	25220	4.09	47.44	15692	9529
127	-0.8473	659.305	656.3	16.9	19077	6175	25252	4.09	47.36	15713	9539
128	-0.8348	662.065	659.1	17.1	19099	6188	25287	4.09	47.27	15738	9550
129	-0.8223	664.277	661.3	17.4	19105	6193	25298	4.08	47.23	15745	9552
130	-0.8098	667.011	664.1	17.7	19125	6208	25333	4.08	47.13	15771	9563
131	-0.7973	668.330	665.4	17.9	19105	6233	25338	4.06	46.95	15786	9552
132	-0.7848	670.708	667.8	18.2	19114	6237	25351	4.06	46.93	15794	9557
133	-0.7723	672.125	669.2	18.4	19096	6239	25335	4.06	46.91	15787	9548
134	-0.7598	674.446	671.5	18.7	19103	6252	25354	4.06	46.83	15803	9551
135	-0.7473	675.864	672.9	18.9	19084	6261	25345	4.05	46.76	15803	9542
136	-0.7348	676.938	674.0	19.2	19055	6267	25322	4.04	46.72	15794	9527
137	-0.7223	676.882	673.9	19.4	18994	6303	25297	4.01	46.47	15800	9497
138	-0.7098	679.426	676.5	19.7	19006	6290	25296	4.02	46.56	15793	9503
139	-0.6973	681.480	678.5	19.9	19004	6302	25305	4.02	46.48	15803	9502
140	-0.6848	683.535	680.6	20.2	19001	6308	25309	4.01	46.44	15808	9501

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psf	Minor Eff. Stress psf	Major Eff. Stress psf	1:3 Ratio	Pore Press. psi	P psf	Q psf
141	-0.6846	683.441	680.5	20.2	18998	6308	25305	4.01	46.44	15806	9499

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	906.600			822.700
Moisture content: Dry soil+tare, gms.	797.000			690.300
Moisture content: Tare, gms.	131.300			131.600
Moisture, %	16.5	31.6	23.7	23.7
Moist specimen weight, gms.	647.2			
Diameter, in.	2.41	2.41	2.28	
Area, in.²	4.57	4.57	4.08	
Height, in.	5.00	5.00	4.95	
Net decrease in height, in.		0.00	0.05	
Net decrease in water volume, cc.			43.95	
Wet density, pcf	107.9	122.0	129.9	
Dry density, pcf	92.7	92.7	105.0	
Void ratio	0.8843	0.8843	0.6631	
Saturation, %	52.1	100.0	100.0	

Test Readings for Specimen No. 2

Membrane modulus = 0.124105 kN/cm²
Membrane thickness = 0.064 cm
Consolidation cell pressure = 140.02 psi (20163 psf)
Consolidation back pressure = 40.00 psi (5760 psf)
Consolidation effective confining stress = 14403 psf
Strain rate, %/min. = 0.03
Fail. Stress = 26580 psf **at reading no.** 139

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psf	Minor Eff. Stress psf	Major Eff. Stress psf	1:3 Ratio	Pore Press. psi	P psf	Q psf
0	-1.7320	2.409	0.0	0.0	0	14365	14365	1.00	40.26	14365	0
1	-1.7308	41.946	39.5	0.0	1396	14325	15721	1.10	40.54	15023	698
2	-1.7295	56.084	53.7	0.1	1895	14299	16194	1.13	40.72	15246	948
3	-1.7283	70.034	67.6	0.1	2387	14267	16654	1.17	40.94	15461	1194
4	-1.7270	83.172	80.8	0.1	2850	14234	17084	1.20	41.17	15659	1425
5	-1.7258	94.901	92.5	0.1	3263	14197	17461	1.23	41.43	15829	1632
6	-1.7245	105.955	103.5	0.2	3653	14159	17811	1.26	41.70	15985	1826
7	-1.7233	116.574	114.2	0.2	4026	14123	18149	1.29	41.94	16136	2013
8	-1.7220	127.152	124.7	0.2	4398	14079	18477	1.31	42.25	16278	2199
9	-1.7208	136.952	134.5	0.2	4742	14038	18780	1.34	42.54	16409	2371
10	-1.7195	147.490	145.1	0.3	5113	13995	19107	1.37	42.84	16551	2556
11	-1.7183	156.843	154.4	0.3	5441	13953	19394	1.39	43.12	16674	2720
12	-1.7170	166.946	164.5	0.3	5795	13907	19702	1.42	43.44	16805	2898
13	-1.7158	175.981	173.6	0.3	6112	13864	19976	1.44	43.74	16920	3056
14	-1.7145	185.282	182.9	0.4	6438	13819	20257	1.47	44.06	17038	3219
15	-1.7133	193.714	191.3	0.4	6733	13772	20505	1.49	44.38	17139	3366
16	-1.7120	202.793	200.4	0.4	7051	13726	20776	1.51	44.70	17251	3525
17	-1.7108	211.582	209.2	0.4	7358	13681	21039	1.54	45.01	17360	3679
18	-1.7095	219.712	217.3	0.5	7642	13632	21275	1.56	45.35	17453	3821

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psf	Minor Eff. Stress psf	Major Eff. Stress psf	1:3 Ratio	Pore Press. psi	P psf	Q psf
19	-1.7083	228.941	226.5	0.5	7965	13582	21547	1.59	45.70	17565	3982
20	-1.7070	237.024	234.6	0.5	8247	13535	21781	1.61	46.03	17658	4123
21	-1.7058	245.982	243.6	0.5	8559	13485	22045	1.63	46.37	17765	4280
22	-1.7045	253.438	251.0	0.6	8819	13437	22256	1.66	46.71	17846	4410
23	-1.7033	261.785	259.4	0.6	9110	13386	22496	1.68	47.06	17941	4555
24	-1.7020	269.134	266.7	0.6	9366	13340	22706	1.70	47.38	18023	4683
25	-1.7008	277.068	274.7	0.6	9642	13290	22932	1.73	47.73	18111	4821
26	-1.6995	284.709	282.3	0.7	9908	13243	23150	1.75	48.06	18196	4954
27	-1.6983	291.972	289.6	0.7	10160	13193	23353	1.77	48.40	18273	5080
28	-1.6970	299.186	296.8	0.7	10410	13144	23555	1.79	48.74	18350	5205
29	-1.6958	307.479	305.1	0.7	10699	13093	23792	1.82	49.09	18443	5349
30	-1.6945	314.616	312.2	0.8	10946	13044	23990	1.84	49.44	18517	5473
31	-1.6933	321.189	318.8	0.8	11174	12994	24167	1.86	49.79	18580	5587
32	-1.6920	328.284	325.9	0.8	11419	12944	24364	1.88	50.13	18654	5710
33	-1.6907	334.834	332.4	0.8	11646	12896	24542	1.90	50.47	18719	5823
34	-1.6895	341.495	339.1	0.9	11876	12846	24723	1.92	50.81	18785	5938
35	-1.6882	348.107	345.7	0.9	12105	12796	24901	1.95	51.16	18849	6052
36	-1.6870	354.805	352.4	0.9	12336	12745	25081	1.97	51.52	18913	6168
37	-1.6857	361.005	358.6	0.9	12550	12696	25246	1.99	51.85	18971	6275
38	-1.6845	368.413	366.0	1.0	12806	12644	25450	2.01	52.21	19047	6403
39	-1.6832	374.255	371.8	1.0	13007	12595	25602	2.03	52.56	19098	6504
40	-1.6820	380.809	378.4	1.0	13233	12544	25777	2.05	52.91	19160	6617
41	-1.6770	404.583	402.2	1.1	14050	12343	26393	2.14	54.30	19368	7025
42	-1.6720	427.964	425.6	1.2	14852	12139	26991	2.22	55.72	19565	7426
43	-1.6670	449.009	446.6	1.3	15570	11942	27512	2.30	57.09	19727	7785
44	-1.6620	469.628	467.2	1.4	16272	11745	28018	2.39	58.45	19882	8136
45	-1.6570	489.127	486.7	1.5	16934	11551	28485	2.47	59.81	20018	8467
46	-1.6520	507.238	504.8	1.6	17546	11364	28910	2.54	61.11	20137	8773
47	-1.6470	522.945	520.5	1.7	18073	11174	29247	2.62	62.42	20211	9037
48	-1.6419	537.777	535.4	1.8	18569	10995	29564	2.69	63.67	20280	9285
49	-1.6369	552.405	550.0	1.9	19057	10820	29877	2.76	64.88	20349	9529
50	-1.6319	565.506	563.1	2.0	19491	10654	30145	2.83	66.03	20400	9745
51	-1.6269	577.137	574.7	2.1	19873	10493	30366	2.89	67.15	20430	9936
52	-1.6219	589.491	587.1	2.2	20279	10332	30611	2.96	68.27	20472	10140
53	-1.6169	600.424	598.0	2.3	20635	10185	30820	3.03	69.29	20503	10318
54	-1.6119	609.896	607.5	2.4	20941	10043	30984	3.09	70.28	20513	10470
55	-1.6069	618.366	616.0	2.5	21210	9909	31119	3.14	71.21	20514	10605
56	-1.6019	627.103	624.7	2.6	21489	9781	31270	3.20	72.09	20526	10744
57	-1.5969	635.115	632.7	2.7	21742	9662	31404	3.25	72.92	20533	10871
58	-1.5919	642.099	639.7	2.8	21959	9546	31505	3.30	73.73	20525	10980
59	-1.5869	648.492	646.1	2.9	22156	9439	31595	3.35	74.47	20517	11078
60	-1.5819	654.622	652.2	3.0	22342	9341	31684	3.39	75.15	20513	11171
61	-1.5769	660.635	658.2	3.1	22525	9250	31775	3.44	75.78	20513	11262
62	-1.5719	665.624	663.2	3.2	22672	9166	31838	3.47	76.37	20502	11336
63	-1.5669	670.387	668.0	3.3	22811	9083	31893	3.51	76.95	20488	11405
64	-1.5619	675.369	673.0	3.4	22957	9008	31965	3.55	77.46	20487	11478
65	-1.5569	680.723	678.3	3.5	23115	8937	32052	3.59	77.96	20494	11558

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psf	Minor Eff. Stress psf	Major Eff. Stress psf	1:3 Ratio	Pore Press. psi	P psf	Q psf
66	-1.5519	685.203	682.8	3.6	23244	8872	32116	3.62	78.41	20494	11622
67	-1.5469	690.153	687.7	3.7	23388	8814	32202	3.65	78.81	20508	11694
68	-1.5419	693.525	691.1	3.8	23478	8762	32239	3.68	79.17	20501	11739
69	-1.5369	697.358	694.9	3.9	23583	8709	32292	3.71	79.54	20501	11791
70	-1.5319	701.157	698.7	4.0	23687	8665	32352	3.73	79.85	20508	11843
71	-1.5269	705.330	702.9	4.1	23803	8620	32423	3.76	80.16	20522	11902
72	-1.5219	709.931	707.5	4.2	23934	8583	32517	3.79	80.42	20550	11967
73	-1.5169	714.001	711.6	4.3	24046	8545	32591	3.81	80.68	20568	12023
74	-1.5119	717.070	714.7	4.5	24124	8515	32639	3.83	80.89	20577	12062
75	-1.5069	720.617	718.2	4.6	24218	8483	32701	3.85	81.11	20592	12109
76	-1.5019	723.477	721.1	4.7	24289	8458	32747	3.87	81.28	20603	12144
77	-1.4969	726.930	724.5	4.8	24379	8433	32812	3.89	81.46	20622	12190
78	-1.4919	730.635	728.2	4.9	24478	8410	32888	3.91	81.62	20649	12239
79	-1.4869	733.613	731.2	5.0	24552	8389	32941	3.93	81.76	20665	12276
80	-1.4819	736.917	734.5	5.1	24637	8371	33008	3.94	81.88	20690	12318
81	-1.4693	743.297	740.9	5.3	24784	8335	33120	3.97	82.14	20727	12392
82	-1.4568	750.952	748.5	5.6	24974	8307	33281	4.01	82.33	20794	12487
83	-1.4443	755.654	753.2	5.8	25063	8286	33350	4.02	82.48	20818	12532
84	-1.4318	761.883	759.5	6.1	25203	8272	33475	4.05	82.57	20874	12601
85	-1.4193	769.115	766.7	6.3	25374	8266	33641	4.07	82.62	20953	12687
86	-1.4068	776.187	773.8	6.6	25539	8262	33801	4.09	82.65	21031	12770
87	-1.3943	782.549	780.1	6.8	25680	8261	33940	4.11	82.65	21101	12840
88	-1.3818	787.811	785.4	7.1	25783	8265	34048	4.12	82.62	21157	12891
89	-1.3693	793.979	791.6	7.3	25915	8270	34184	4.13	82.59	21227	12957
90	-1.3568	800.381	798.0	7.6	26053	8277	34330	4.15	82.54	21304	13026
91	-1.3443	805.198	802.8	7.8	26138	8288	34427	4.15	82.46	21358	13069
92	-1.3318	810.138	807.7	8.1	26227	8295	34522	4.16	82.41	21409	13114
93	-1.3193	814.863	812.5	8.3	26308	8306	34614	4.17	82.34	21460	13154
94	-1.3068	819.523	817.1	8.6	26386	8319	34705	4.17	82.25	21512	13193
95	-1.2943	824.553	822.1	8.8	26475	8333	34808	4.18	82.15	21571	13238
96	-1.2818	829.206	826.8	9.1	26551	8345	34896	4.18	82.07	21621	13276
97	-1.2693	832.948	830.5	9.4	26597	8357	34954	4.18	81.98	21656	13299
98	-1.2568	836.431	834.0	9.6	26634	8370	35004	4.18	81.89	21687	13317
99	-1.2443	840.760	838.4	9.9	26698	8381	35079	4.19	81.82	21730	13349
100	-1.2318	844.064	841.7	10.1	26728	8397	35124	4.18	81.71	21761	13364
101	-1.2193	847.160	844.8	10.4	26751	8410	35160	4.18	81.62	21785	13375
102	-1.2068	850.886	848.5	10.6	26793	8424	35217	4.18	81.52	21820	13396
103	-1.1943	854.487	852.1	10.9	26830	8435	35265	4.18	81.44	21850	13415
104	-1.1818	858.935	856.5	11.1	26894	8448	35342	4.18	81.35	21895	13447
105	-1.1693	862.612	860.2	11.4	26933	8462	35394	4.18	81.26	21928	13466
106	-1.1568	867.752	865.3	11.6	27016	8472	35489	4.19	81.18	21980	13508
107	-1.1443	871.471	869.1	11.9	27055	8483	35538	4.19	81.11	22010	13527
108	-1.1318	876.508	874.1	12.1	27134	8493	35627	4.19	81.04	22060	13567
109	-1.1193	880.937	878.5	12.4	27193	8507	35699	4.20	80.95	22103	13596
110	-1.1068	884.178	881.8	12.6	27214	8515	35729	4.20	80.89	22122	13607
111	-1.0943	888.135	885.7	12.9	27257	8525	35782	4.20	80.82	22153	13629
112	-1.0818	890.809	888.4	13.1	27260	8535	35795	4.19	80.75	22165	13630

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psf	Minor Eff. Stress psf	Major Eff. Stress psf	1:3 Ratio	Pore Press. psi	P psf	Q psf
113	-1.0693	894.182	891.8	13.4	27284	8544	35828	4.19	80.69	22186	13642
114	-1.0567	896.251	893.8	13.7	27267	8555	35823	4.19	80.61	22189	13634
115	-1.0442	898.707	896.3	13.9	27262	8564	35827	4.18	80.55	22195	13631
116	-1.0317	899.774	897.4	14.2	27215	8572	35787	4.17	80.49	22180	13607
117	-1.0192	901.124	898.7	14.4	27175	8580	35755	4.17	80.44	22168	13588
118	-1.0067	904.528	902.1	14.7	27198	8586	35784	4.17	80.39	22185	13599
119	-0.9942	906.637	904.2	14.9	27181	8594	35774	4.16	80.34	22184	13590
120	-0.9817	909.781	907.4	15.2	27194	8601	35795	4.16	80.29	22198	13597
121	-0.9692	912.249	909.8	15.4	27187	8608	35795	4.16	80.24	22201	13593
122	-0.9567	914.443	912.0	15.7	27171	8616	35787	4.15	80.19	22201	13585
123	-0.9442	917.396	915.0	15.9	27177	8621	35799	4.15	80.15	22210	13589
124	-0.9317	919.760	917.4	16.2	27166	8628	35794	4.15	80.10	22211	13583
125	-0.9192	923.453	921.0	16.4	27193	8634	35827	4.15	80.06	22230	13596
126	-0.9067	926.170	923.8	16.7	27190	8642	35832	4.15	80.01	22237	13595
127	-0.8942	930.081	927.7	16.9	27223	8648	35870	4.15	79.97	22259	13611
128	-0.8817	933.132	930.7	17.2	27229	8652	35881	4.15	79.94	22266	13615
129	-0.8692	935.956	933.5	17.4	27228	8657	35886	4.15	79.90	22272	13614
130	-0.8567	938.070	935.7	17.7	27207	8661	35867	4.14	79.88	22264	13603
131	-0.8442	939.098	936.7	17.9	27153	8667	35820	4.13	79.83	22244	13576
132	-0.8317	940.511	938.1	18.2	27110	8672	35782	4.13	79.80	22227	13555
133	-0.8192	940.094	937.7	18.5	27014	8678	35692	4.11	79.76	22185	13507
134	-0.8067	939.079	936.7	18.7	26901	8683	35585	4.10	79.72	22134	13451
135	-0.7942	940.500	938.1	19.0	26858	8687	35546	4.09	79.69	22116	13429
136	-0.7817	941.579	939.2	19.2	26805	8691	35497	4.08	79.66	22094	13403
137	-0.7692	942.197	939.8	19.5	26739	8690	35429	4.08	79.67	22059	13370
138	-0.7567	941.994	939.6	19.7	26649	8693	35343	4.07	79.65	22018	13325
139	-0.7442	942.510	940.1	20.0	26580	8693	35273	4.06	79.66	21983	13290
140	-0.7320	942.628	940.2	20.2	26501	8689	35190	4.05	79.68	21940	13251

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	906.600			793.800
Moisture content: Dry soil+tare, gms.	797.000			670.200
Moisture content: Tare, gms.	131.300			120.800
Moisture, %	16.5	32.0	22.5	22.5
Moist specimen weight, gms.	645.6			
Diameter, in.	2.42	2.42	2.26	
Area, in.²	4.58	4.58	4.02	
Height, in.	5.00	5.00	4.90	
Net decrease in height, in.		0.00	0.10	
Net decrease in water volume, cc.			52.40	
Wet density, pcf	107.4	121.7	131.3	
Dry density, pcf	92.2	92.2	107.2	
Void ratio	0.8937	0.8937	0.6293	
Saturation, %	51.5	100.0	100.0	

Test Readings for Specimen No. 3

Membrane modulus = 0.124105 kN/cm²
Membrane thickness = 0.064 cm
Consolidation cell pressure = 239.44 psi (34479 psf)
Consolidation back pressure = 0.00 psi (0 psf)
Strain rate, %/min. = 0.03
Fail. Stress = 35484 psf **at reading no.** 138

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psf	Minor Eff. Stress psf	Major Eff. Stress psf	1:3 Ratio	Pore Press. psi	P psf	Q psf
0	-1.3739	1.957	0.0	0.0	0	28662	28662	1.00	40.40	28662	0
1	-1.3726	24.657	22.7	0.0	813	28649	29462	1.03	40.49	29055	406
2	-1.3714	41.165	39.2	0.1	1403	28637	30040	1.05	40.57	29339	702
3	-1.3701	57.195	55.2	0.1	1976	28619	30596	1.07	40.70	29607	988
4	-1.3689	72.532	70.6	0.1	2525	28605	31130	1.09	40.79	29868	1262
5	-1.3676	88.608	86.7	0.1	3099	28580	31679	1.11	40.97	30129	1549
6	-1.3664	103.405	101.4	0.2	3627	28561	32188	1.13	41.10	30374	1814
7	-1.3651	118.505	116.5	0.2	4166	28537	32703	1.15	41.26	30620	2083
8	-1.3639	132.823	130.9	0.2	4676	28506	33183	1.16	41.48	30845	2338
9	-1.3626	147.395	145.4	0.2	5196	28482	33677	1.18	41.65	31080	2598
10	-1.3614	161.863	159.9	0.3	5711	28445	34157	1.20	41.90	31301	2856
11	-1.3601	175.243	173.3	0.3	6187	28413	34601	1.22	42.13	31507	3094
12	-1.3589	189.175	187.2	0.3	6683	28388	35072	1.24	42.30	31730	3342
13	-1.3576	201.752	199.8	0.3	7130	28350	35480	1.25	42.57	31915	3565
14	-1.3564	215.714	213.8	0.4	7627	28318	35945	1.27	42.78	32132	3813
15	-1.3551	228.148	226.2	0.4	8068	28283	36351	1.29	43.03	32317	4034
16	-1.3539	240.869	238.9	0.4	8520	28244	36764	1.30	43.30	32504	4260
17	-1.3526	252.952	251.0	0.4	8948	28213	37161	1.32	43.52	32687	4474
18	-1.3514	264.878	262.9	0.5	9371	28167	37538	1.33	43.83	32853	4686
19	-1.3501	276.991	275.0	0.5	9800	28129	37930	1.35	44.10	33029	4900
20	-1.3489	289.304	287.3	0.5	10237	28089	38326	1.36	44.38	33207	5118
21	-1.3476	300.641	298.7	0.5	10638	28056	38694	1.38	44.61	33375	5319
22	-1.3464	312.235	310.3	0.6	11048	28012	39059	1.39	44.91	33535	5524
23	-1.3451	323.532	321.6	0.6	11447	27971	39418	1.41	45.19	33695	5724
24	-1.3438	335.329	333.4	0.6	11864	27924	39788	1.42	45.53	33856	5932

Test Readings for Specimen No. 3

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psf	Minor Eff. Stress psf	Major Eff. Stress psf	1:3 Ratio	Pore Press. psi	P psf	Q psf
25	-1.3426	345.670	343.7	0.6	12229	27880	40108	1.44	45.83	33994	6114
26	-1.3413	356.065	354.1	0.7	12595	27842	40438	1.45	46.09	34140	6298
27	-1.3401	366.231	364.3	0.7	12954	27792	40746	1.47	46.44	34269	6477
28	-1.3388	376.791	374.8	0.7	13326	27752	41077	1.48	46.72	34414	6663
29	-1.3376	387.453	385.5	0.7	13701	27704	41405	1.49	47.05	34554	6851
30	-1.3363	397.718	395.8	0.8	14063	27656	41718	1.51	47.39	34687	7031
31	-1.3351	408.012	406.1	0.8	14425	27613	42038	1.52	47.68	34825	7212
32	-1.3338	417.258	415.3	0.8	14749	27561	42310	1.54	48.04	34936	7375
33	-1.3326	427.825	425.9	0.8	15121	27519	42640	1.55	48.34	35079	7560
34	-1.3313	436.915	435.0	0.9	15439	27469	42909	1.56	48.68	35189	7720
35	-1.3301	446.378	444.4	0.9	15771	27417	43189	1.58	49.04	35303	7886
36	-1.3288	455.672	453.7	0.9	16097	27376	43473	1.59	49.33	35424	8048
37	-1.3276	464.688	462.7	0.9	16413	27320	43733	1.60	49.72	35526	8206
38	-1.3263	473.562	471.6	1.0	16723	27277	44000	1.61	50.02	35639	8362
39	-1.3251	483.303	481.3	1.0	17064	27222	44286	1.63	50.40	35754	8532
40	-1.3238	492.450	490.5	1.0	17384	27168	44551	1.64	50.78	35860	8692
41	-1.3188	527.093	525.1	1.1	18592	26961	45554	1.69	52.21	36257	9296
42	-1.3138	560.660	558.7	1.2	19760	26736	46497	1.74	53.77	36617	9880
43	-1.3088	592.855	590.9	1.3	20878	26518	47395	1.79	55.29	36956	10439
44	-1.3038	623.415	621.5	1.4	21935	26281	48215	1.83	56.93	37248	10967
45	-1.2988	653.021	651.1	1.5	22956	26044	48999	1.88	58.58	37522	11478
46	-1.2938	682.064	680.1	1.6	23955	25795	49750	1.93	60.31	37773	11977
47	-1.2888	710.142	708.2	1.7	24918	25538	50456	1.98	62.09	37997	12459
48	-1.2838	735.713	733.8	1.8	25791	25275	51066	2.02	63.92	38170	12895
49	-1.2788	761.921	760.0	1.9	26684	25009	51693	2.07	65.77	38351	13342
50	-1.2738	786.221	784.3	2.0	27509	24733	52242	2.11	67.68	38488	13754
51	-1.2688	809.437	807.5	2.1	28294	24455	52748	2.16	69.62	38601	14147
52	-1.2638	832.073	830.1	2.2	29056	24161	53218	2.20	71.65	38689	14528
53	-1.2588	853.759	851.8	2.3	29784	23866	53650	2.25	73.70	38758	14892
54	-1.2538	873.818	871.9	2.5	30454	23564	54018	2.29	75.80	38791	15227
55	-1.2488	893.200	891.2	2.6	31098	23266	54364	2.34	77.87	38815	15549
56	-1.2438	911.413	909.5	2.7	31701	22955	54656	2.38	80.03	38805	15850
57	-1.2388	929.727	927.8	2.8	32305	22646	54951	2.43	82.17	38799	16153
58	-1.2338	945.766	943.8	2.9	32829	22323	55152	2.47	84.42	38738	16414
59	-1.2288	962.099	960.1	3.0	33362	22008	55370	2.52	86.61	38689	16681
60	-1.2238	975.708	973.8	3.1	33799	21681	55480	2.56	88.88	38580	16900
61	-1.2188	990.141	988.2	3.2	34264	21373	55637	2.60	91.02	38505	17132
62	-1.21381	002.225	1000.3	3.3	34647	21047	55693	2.65	93.28	38370	17323
63	-1.20881	014.062	1012.1	3.4	35020	20730	55750	2.69	95.48	38240	17510
64	-1.20381	024.283	1022.3	3.5	35336	20408	55744	2.73	97.72	38076	17668
65	-1.19881	034.849	1032.9	3.6	35663	20095	55759	2.77	99.89	37927	17832
66	-1.19381	043.281	1041.3	3.7	35916	19789	55705	2.81	102.02	37747	17958
67	-1.18881	051.957	1050.0	3.8	36177	19478	55655	2.86	104.17	37567	18089
68	-1.18381	060.097	1058.1	3.9	36419	19184	55603	2.90	106.22	37393	18210
69	-1.17881	066.864	1064.9	4.0	36613	18886	55499	2.94	108.29	37192	18307
70	-1.17381	072.950	1071.0	4.1	36783	18599	55383	2.98	110.28	36991	18392
71	-1.16881	078.517	1076.6	4.2	36935	18318	55253	3.02	112.23	36786	18468

Test Readings for Specimen No. 3

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psf	Minor Eff. Stress psf	Major Eff. Stress psf	1:3 Ratio	Pore Press. psi	P psf	Q psf
72	-1.16381	084.265	1082.3	4.3	37093	18044	55137	3.06	114.13	36591	18546
73	-1.15881	088.422	1086.5	4.4	37195	17782	54977	3.09	115.96	36379	18598
74	-1.15381	092.924	1091.0	4.5	37310	17526	54835	3.13	117.73	36180	18655
75	-1.14871	096.290	1094.3	4.6	37385	17274	54659	3.16	119.48	35966	18692
76	-1.14371	099.512	1097.6	4.7	37455	17033	54487	3.20	121.16	35760	18727
77	-1.13871	102.045	1100.1	4.8	37501	16811	54312	3.23	122.70	35561	18750
78	-1.13371	105.137	1103.2	4.9	37566	16592	54158	3.26	124.21	35375	18783
79	-1.12871	107.994	1106.0	5.0	37623	16377	54000	3.30	125.71	35189	18811
80	-1.12371	110.406	1108.4	5.1	37664	16177	53841	3.33	127.10	35009	18832
81	-1.11121	114.415	1112.5	5.4	37699	15710	53409	3.40	130.34	34560	18849
82	-1.09871	118.786	1116.8	5.6	37745	15292	53037	3.47	133.25	34164	18872
83	-1.08621	121.404	1119.4	5.9	37731	14927	52658	3.53	135.78	33793	18866
84	-1.07371	124.203	1122.2	6.1	37723	14606	52329	3.58	138.01	33467	18862
85	-1.06121	126.337	1124.4	6.4	37692	14318	52010	3.63	140.01	33164	18846
86	-1.04871	126.817	1124.9	6.6	37605	14067	51673	3.67	141.75	32870	18803
87	-1.03621	128.715	1126.8	6.9	37566	13846	51412	3.71	143.29	32629	18783
88	-1.02371	129.312	1127.4	7.1	37483	13654	51137	3.75	144.62	32396	18741
89	-1.01121	131.931	1130.0	7.4	37467	13478	50944	3.78	145.84	32211	18733
90	-0.99871	133.410	1131.5	7.7	37412	13327	50739	3.81	146.89	32033	18706
91	-0.98621	134.868	1132.9	7.9	37357	13191	50548	3.83	147.84	31869	18678
92	-0.97371	136.092	1134.1	8.2	37294	13069	50362	3.85	148.69	31715	18647
93	-0.96121	137.840	1135.9	8.4	37247	12962	50210	3.87	149.42	31586	18624
94	-0.94871	140.602	1138.6	8.7	37234	12862	50096	3.89	150.12	31479	18617
95	-0.93621	142.048	1140.1	8.9	37177	12771	49948	3.91	150.75	31359	18589
96	-0.92371	145.193	1143.2	9.2	37175	12695	49870	3.93	151.28	31282	18588
97	-0.91121	147.565	1145.6	9.4	37148	12621	49769	3.94	151.79	31195	18574
98	-0.89871	150.267	1148.3	9.7	37130	12559	49689	3.96	152.23	31124	18565
99	-0.88621	152.870	1150.9	10.0	37109	12497	49607	3.97	152.65	31052	18555
100	-0.87371	155.606	1153.6	10.2	37092	12447	49539	3.98	153.01	30993	18546
101	-0.86121	157.372	1155.4	10.5	37043	12398	49442	3.99	153.34	30920	18522
102	-0.84871	159.865	1157.9	10.7	37017	12354	49371	4.00	153.65	30863	18509
103	-0.83621	164.025	1162.1	11.0	37044	12313	49358	4.01	153.93	30835	18522
104	-0.82371	165.532	1163.6	11.2	36986	12276	49262	4.01	154.19	30769	18493
105	-0.81121	167.759	1165.8	11.5	36950	12242	49192	4.02	154.43	30717	18475
106	-0.79871	170.720	1168.8	11.7	36937	12208	49146	4.03	154.66	30677	18469
107	-0.78621	172.933	1171.0	12.0	36900	12179	49080	4.03	154.86	30629	18450
108	-0.77371	175.777	1173.8	12.2	36883	12149	49032	4.04	155.07	30591	18441
109	-0.76121	177.933	1176.0	12.5	36843	12124	48967	4.04	155.24	30546	18422
110	-0.74871	179.952	1178.0	12.8	36799	12097	48896	4.04	155.43	30496	18399
111	-0.73611	182.935	1181.0	13.0	36784	12072	48856	4.05	155.61	30464	18392
112	-0.72361	184.726	1182.8	13.3	36732	12048	48780	4.05	155.77	30414	18366
113	-0.71111	188.714	1186.8	13.5	36747	12026	48773	4.06	155.93	30400	18373
114	-0.69861	191.037	1189.1	13.8	36710	12007	48717	4.06	156.06	30362	18355
115	-0.68611	194.181	1192.2	14.0	36698	11989	48687	4.06	156.18	30338	18349
116	-0.67361	199.044	1197.1	14.3	36739	11968	48707	4.07	156.33	30338	18369
117	-0.66111	198.616	1196.7	14.5	36616	11954	48570	4.06	156.43	30262	18308
118	-0.64861	200.805	1198.8	14.8	36574	11936	48509	4.06	156.55	30223	18287

Test Readings for Specimen No. 3

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psf	Minor Eff. Stress psf	Major Eff. Stress psf	1:3 Ratio	Pore Press. psi	P psf	Q psf
119	-0.63611	201.828	1199.9	15.1	36495	11920	48415	4.06	156.66	30168	18248
120	-0.62361	204.207	1202.3	15.3	36458	11905	48363	4.06	156.77	30134	18229
121	-0.61111	206.172	1204.2	15.6	36407	11887	48294	4.06	156.89	30091	18204
122	-0.59861	208.820	1206.9	15.8	36377	11873	48251	4.06	156.99	30062	18189
123	-0.58611	210.702	1208.7	16.1	36323	11856	48179	4.06	157.11	30017	18162
124	-0.57361	212.973	1211.0	16.3	36281	11845	48126	4.06	157.18	29986	18140
125	-0.56111	215.065	1213.1	16.6	36233	11830	48063	4.06	157.29	29946	18116
126	-0.54861	217.300	1215.3	16.8	36189	11820	48009	4.06	157.36	29914	18094
127	-0.53611	219.987	1218.0	17.1	36157	11807	47965	4.06	157.44	29886	18079
128	-0.52361	223.050	1221.1	17.4	36137	11794	47930	4.06	157.54	29862	18068
129	-0.51111	226.442	1224.5	17.6	36125	11781	47906	4.07	157.63	29843	18063
130	-0.49861	224.755	1222.8	17.9	35964	11763	47726	4.06	157.75	29745	17982
131	-0.48611	226.526	1224.6	18.1	35904	11751	47655	4.06	157.83	29703	17952
132	-0.47361	228.946	1227.0	18.4	35863	11738	47601	4.06	157.92	29670	17931
133	-0.46111	230.798	1228.8	18.6	35805	11726	47531	4.05	158.01	29629	17902
134	-0.44861	231.276	1229.3	18.9	35706	11714	47421	4.05	158.09	29568	17853
135	-0.43611	233.779	1231.8	19.1	35666	11698	47365	4.05	158.20	29531	17833
136	-0.42361	236.305	1234.3	19.4	35627	11690	47316	4.05	158.26	29503	17813
137	-0.41111	237.363	1235.4	19.6	35544	11677	47221	4.04	158.35	29449	17772
138	-0.39861	239.184	1237.2	19.9	35484	11667	47150	4.04	158.42	29409	17742
139	-0.38611	240.473	1238.5	20.2	35407	11656	47063	4.04	158.49	29360	17704
140	-0.37371	241.817	1239.9	20.4	35334	11641	46975	4.04	158.60	29308	17667

Parameters for Specimen No. 4

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	906.600			824.200
Moisture content: Dry soil+tare, gms.	797.000			701.100
Moisture content: Tare, gms.	131.300			144.500
Moisture, %	16.5	31.5	22.1	22.1
Moist specimen weight, gms.	649.1			
Diameter, in.	2.41	2.41	2.27	
Area, in.²	4.57	4.57	4.05	
Height, in.	5.00	5.00	4.87	
Net decrease in height, in.		0.00	0.14	
Net decrease in water volume, cc.			52.30	
Wet density, pcf	108.1	122.1	131.8	
Dry density, pcf	92.8	92.8	107.9	
Void ratio	0.8809	0.8809	0.6184	
Saturation, %	52.3	100.0	100.0	

Test Readings for Specimen No. 4

Membrane modulus = 0.124105 kN/cm²
Membrane thickness = 0.064 cm
Consolidation cell pressure = 440.00 psi (63360 psf)
Consolidation back pressure = 40.00 psi (5760 psf)
Consolidation effective confining stress = 57600 psf
Strain rate, %/min. = 0.03
Fail. Stress = 46543 psf **at reading no.** 51

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psf	Minor Eff. Stress psf	Major Eff. Stress psf	1:3 Ratio	Pore Press. psi	P psf	Q psf
0	0.0000	78.900	0.0	0.0	0	57629	57629	1.00	39.80	57629	0
1	0.0040	96.700	17.8	0.1	633	57629	58262	1.01	39.80	57945	317
2	0.0080	106.400	27.5	0.2	977	57629	58606	1.02	39.80	58117	489
3	0.0120	138.800	59.9	0.2	2127	57614	59742	1.04	39.90	58678	1064
4	0.0150	176.000	97.1	0.3	3446	57600	61046	1.06	40.00	59323	1723
5	0.0200	221.900	143.0	0.4	5070	57571	62641	1.09	40.20	60106	2535
6	0.0250	253.700	174.8	0.5	6191	57542	63733	1.11	40.40	60638	3095
7	0.0300	322.500	243.6	0.6	8618	57456	66074	1.15	41.00	61765	4309
8	0.0350	384.300	305.4	0.7	10794	57370	68163	1.19	41.60	62766	5397
9	0.0390	435.400	356.5	0.8	12589	57254	69844	1.22	42.40	63549	6295
10	0.0450	510.600	431.7	0.9	15226	57082	72307	1.27	43.60	64695	7613
11	0.0480	554.900	476.0	1.0	16778	56923	73701	1.29	44.70	65312	8389
12	0.0530	608.500	529.6	1.1	18648	56736	75384	1.33	46.00	66060	9324
13	0.0620	711.500	632.6	1.3	22233	56304	78537	1.39	49.00	67420	11116
14	0.0710	809.600	730.7	1.5	25632	55800	81432	1.46	52.50	68616	12816
15	0.0860	946.700	867.8	1.8	30347	54950	85297	1.55	58.40	70124	15173
16	0.0900	991.400	912.5	1.8	31883	54634	86517	1.58	60.60	70575	15941
17	0.0950	1033.300	954.4	2.0	33312	54288	87600	1.61	63.00	70944	16656
18	0.1000	1074.000	995.1	2.1	34696	53914	88610	1.64	65.60	71262	17348
19	0.1090	1155.800	1076.9	2.2	37477	53150	90628	1.71	70.90	71889	18739
20	0.1180	1232.700	1153.8	2.4	40078	52286	92364	1.77	76.90	72325	20039
21	0.1280	1306.100	1227.2	2.6	42537	51322	93859	1.83	83.60	72590	21269
22	0.1370	1376.200	1297.3	2.8	44882	50242	95123	1.89	91.10	72683	22441
23	0.1460	1441.400	1362.5	3.0	47048	49075	96123	1.96	99.20	72599	23524

Test Readings for Specimen No. 4

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psf	Minor Eff. Stress psf	Major Eff. Stress psf	1:3 Ratio	Pore Press. psi	P psf	Q psf
24	0.15601	504.600	1425.7	3.2	49126	47765	96891	2.03	108.30	72328	24563
25	0.16501	563.000	1484.1	3.4	51040	46339	97380	2.10	118.20	71859	25520
26	0.17401	617.400	1538.5	3.6	52810	44770	97580	2.18	129.10	71175	26405
27	0.18401	665.600	1586.7	3.8	54348	43070	97419	2.26	140.90	70245	27174
28	0.19301	707.900	1629.0	4.0	55690	41299	96989	2.35	153.20	69144	27845
29	0.20301	742.000	1663.1	4.2	56734	39398	96132	2.44	166.40	67765	28367
30	0.22601	794.000	1715.1	4.6	58219	34589	92808	2.68	199.80	63698	29110
31	0.24701	807.100	1728.2	5.1	58398	30629	89027	2.91	227.30	59828	29199
32	0.27001	796.000	1717.1	5.5	57734	26986	84720	3.14	252.60	55853	28867
33	0.30601	766.300	1687.4	6.3	56291	23126	79418	3.43	279.40	51272	28146
34	0.32901	745.700	1666.8	6.8	55323	21442	76765	3.58	291.10	49103	27662
35	0.35201	729.200	1650.3	7.2	54498	20160	74658	3.70	300.00	47409	27249
36	0.37601	715.400	1636.5	7.7	53755	19238	72993	3.79	306.40	46116	26877
37	0.39901	703.100	1624.2	8.2	53078	18547	71625	3.86	311.20	45086	26539
38	0.43401	693.300	1614.4	8.9	52344	17755	70099	3.95	316.70	43927	26172
39	0.46901	689.200	1610.3	9.6	51798	17208	69006	4.01	320.50	43107	25899
40	0.50501	686.700	1607.8	10.4	51295	16790	68085	4.05	323.40	42438	25647
41	0.54001	685.500	1606.6	11.1	50845	16502	67347	4.08	325.40	41925	25422
42	0.58601	688.300	1609.4	12.0	50392	16157	66548	4.12	327.80	41353	25196
43	0.63301	691.500	1612.6	13.0	49937	15955	65892	4.13	329.20	40924	24969
44	0.66801	693.600	1614.7	13.7	49589	15797	65386	4.14	330.30	40591	24794
45	0.70401	696.700	1617.8	14.5	49258	15682	64939	4.14	331.10	40310	24629
46	0.73901	700.000	1621.1	15.2	48943	15566	64509	4.14	331.90	40038	24472
47	0.78501	700.500	1621.6	16.1	48412	15451	63864	4.13	332.70	39657	24206
48	0.83201	699.800	1620.9	17.1	47834	15293	63127	4.13	333.80	39210	23917
49	0.89101	698.300	1619.4	18.3	47091	15120	62211	4.11	335.00	38665	23545
50	0.91401	697.600	1618.7	18.8	46798	15077	61875	4.10	335.30	38476	23399
51	0.93601	697.800	1618.9	19.2	46543	15005	61548	4.10	335.80	38276	23272

FLEXIBLE WALL PERMEABILITY TEST
ASTM D 5084-03
Falling Head/Increasing Tailwater Pressure

CLIENT:	Casino		
PROJECT:	Casino	PROJECT NO. :	VA101-325.08
BORING NO.	Manufactured UF	LAB NO. :	L2012-056PPQ
DEPTH		SAMPLE ID:	2012-056-03
SAMPLE NO.		TEST STARTED :	07/10/12
SAMPLE TYPE	Remolded	TEST FINISHED :	07/12/12
CONF. PRESSURE. (psi)	50	SATURATED TEST:	YES

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	648.20	694.40
Wt. Wet Soil & Pan (g)	906.60	891.90
Wt. Dry Soil & Pan (g)	797.00	755.80
Wt. Moisture Lost (g)	109.60	136.10
Wt. of Pan Only (g)	131.30	197.50
Wt. of Dry Soil (g)	665.70	558.30
Moisture Content %	16.5	24.4
Wet Density (pcf)	108.4	129.5
Dry Density (pcf)	93.0	104.1

Init. Diameter (in)	2.409	(cm)	6.119
Init. Area (sq in)	4.558	(sq cm)	29.406
Init. Height (in)	5.000	(cm)	12.700
Height Change (in)	0.040	(cm)	0.102
Consol. Height (in)	4.960	(cm)	12.598
Area After Consol. (sq in)	4.117	(sq cm)	26.563

Vol. Before Consol. (cu ft)	0.01319	Specific Gravity	2.797
Vol. Before Consol. (cc)	373.5	Assumed?	No
Change in Vol. (cc)	38.8		
Cell Exp. (cc)	0.0	Init. Saturation	51.7
Vol. After Consol. (cc)	334.7	Init. Void Ratio	0.871
Vol. After Consol. (cu ft)	0.01182	Final Saturation	100.0
Effective Porosity %	46.72	Final Void Ratio	0.677
Pressure Difference (psi):	0.01		
C =	0.50223	Buret Constant, a	0.920
k, cm/s = (C/t)*log(h1/h2)		Buret Stand	3

Permeability Test Trials

Time	Cap Elevation	Pedestal Elevation	Elevation Head	Total Head	Permeability k
sec.	cc	cc	cm	cm	cm/sec
0.0	49.0	1.0	51.8	52.5	
9.8	47.0	3.0	47.5	48.2	1.9E-03
0.0	49.0	1.0	51.8	52.5	
9.4	47.0	3.0	47.5	48.2	2.0E-03
0.0	49.0	1.0	51.8	52.5	
10.0	47.0	3.0	47.5	48.2	1.9E-03
0.0	49.0	1.0	51.8	52.5	
9.8	47.0	3.0	47.5	48.2	1.9E-03
0.0	49.0	1.0	51.8	52.5	
9.9	47.0	3.0	47.5	48.2	1.9E-03
			Avg.of Last 4 Rdgs.		1.9E-03

General Test Notes:
1) Tap water was used as the permeant.
2) Back pressure saturation continued until 'B' parameter a minimum of 0.95.
3) Target remolding parameters: 92.4 pcf @ 16.7% moisture.

FLEXIBLE WALL PERMEABILITY TEST
ASTM D 5084-03
Falling Head/Increasing Tailwater Pressure

CLIENT:	Casino		
PROJECT:	Casino	PROJECT NO. :	VA101-325.08
BORING NO.	Manufactured UF	LAB NO. :	L2012-056PPQ
DEPTH		SAMPLE ID:	2012-056-03
SAMPLE NO.		TEST STARTED :	07/10/12
SAMPLE TYPE	Remolded	TEST FINISHED :	07/13/12
CONF. PRESSURE. (psi)	100	SATURATED TEST:	YES

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	647.20	691.10
Wt. Wet Soil & Pan (g)	906.60	822.70
Wt. Dry Soil & Pan (g)	797.00	690.30
Wt. Moisture Lost (g)	109.60	132.40
Wt. of Pan Only (g)	131.30	131.60
Wt. of Dry Soil (g)	665.70	558.70
Moisture Content %	16.5	23.7
Wet Density (pcf)	107.9	130.6
Dry Density (pcf)	92.7	105.6

Init. Diameter	(in)	2.412	(cm)	6.126
Init. Area	(sq in)	4.569	(sq cm)	29.479
Init. Height	(in)	5.000	(cm)	12.700
Height Change	(in)	0.053	(cm)	0.135
Consol. Height	(in)	4.947	(cm)	12.565
Area After Consol.	(sq in)	4.076	(sq cm)	26.297

Vol. Before Consol.	(cu ft)	0.01322	Specific Gravity 2.797
Vol. Before Consol.	(cc)	374.4	Assumed? No
Change in Vol.	(cc)	44.0	
Cell Exp.	(cc)	0.0	Init. Saturation 50.7
Vol. After Consol.	(cc)	330.4	Init. Void Ratio 0.874
Vol. After Consol.	(cu ft)	0.01167	Final Saturation 100.0
Effective Porosity %		46.93	Final Void Ratio 0.654
Pressure Difference (psi):		0.01	
C =		0.50598	Buret Constant, a 0.920
k, cm/s = (C/t)*log(h1/h2)			Buret Stand 6

Permeability Test Trials

Time	Cap Elevation	Pedestal Elevation	Elevation Head	Total Head	Permeability k
sec.	cc	cc	cm	cm	cm/sec
0.0	49.0	1.0	51.8	52.5	
13.0	47.0	3.0	47.5	48.2	1.5E-03
0.0	49.0	1.0	51.8	52.5	
12.7	47.0	3.0	47.5	48.2	1.5E-03
0.0	49.0	1.0	51.8	52.5	
13.0	47.0	3.0	47.5	48.2	1.5E-03
0.0	49.0	1.0	51.8	52.5	
13.1	47.0	3.0	47.5	48.2	1.4E-03
0.0	49.0	1.0	51.8	52.5	
12.8	47.0	3.0	47.5	48.2	1.5E-03
			Avg.of Last 4 Rdgs.		1.5E-03

General Test Notes:
1) Tap water was used as the permeant.
2) Back pressure saturation continued until 'B' parameter a minimum of 0.95.
3) Target remolding parameters: 92.4 pcf @ 16.7% moisture.

FLEXIBLE WALL PERMEABILITY TEST
ASTM D 5084-03
Falling Head/Increasing Tailwater Pressure

CLIENT:	Casino		
PROJECT:	Casino	PROJECT NO. :	VA101-325.08
BORING NO.	Manufactured UF	LAB NO. :	L2012-056PPQ
DEPTH		SAMPLE ID:	2012-056-03
SAMPLE NO.		TEST STARTED :	07/10/12
SAMPLE TYPE	Remolded	TEST FINISHED :	07/13/12
CONF. PRESSURE. (psi)	200	SATURATED TEST:	YES

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	645.60	673.00
Wt. Wet Soil & Pan (g)	906.60	793.80
Wt. Dry Soil & Pan (g)	797.00	670.20
Wt. Moisture Lost (g)	109.60	123.60
Wt. of Pan Only (g)	131.30	120.80
Wt. of Dry Soil (g)	665.70	549.40
Moisture Content %	16.5	22.5
Wet Density (pcf)	107.4	130.1
Dry Density (pcf)	92.2	106.2

Init. Diameter (in)	2.415	(cm)	6.134
Init. Area (sq in)	4.581	(sq cm)	29.552
Init. Height (in)	5.000	(cm)	12.700
Height Change (in)	0.100	(cm)	0.254
Consol. Height (in)	4.900	(cm)	12.446
Area After Consol. (sq in)	4.021	(sq cm)	25.945

Vol. Before Consol. (cu ft)	0.01325	Specific Gravity	2.797
Vol. Before Consol. (cc)	375.3	Assumed?	No
Change in Vol. (cc)	52.4		
Cell Exp. (cc)	0.0	Init. Saturation	53.8
Vol. After Consol. (cc)	322.9	Init. Void Ratio	0.911
Vol. After Consol. (cu ft)	0.01140	Final Saturation	97.7
Effective Porosity %	47.19	Final Void Ratio	0.644
Pressure Difference (psi):	0.01		
C =	0.50797	Buret Constant, a	0.920
k, cm/s = (C/t)*log(h1/h2)		Buret Stand	5

Permeability Test Trials

Time	Cap Elevation	Pedestal Elevation	Elevation Head	Total Head	Permeability k
sec.	cc	cc	cm	cm	cm/sec
0.0	49.0	1.0	51.8	52.5	
15.8	47.0	3.0	47.5	48.2	1.2E-03
0.0	49.0	1.0	51.8	52.5	
15.2	47.0	3.0	47.5	48.2	1.2E-03
0.0	49.0	1.0	51.8	52.5	
15.3	47.0	3.0	47.5	48.2	1.2E-03
0.0	49.0	1.0	51.8	52.5	
15.2	47.0	3.0	47.5	48.2	1.2E-03
0.0	49.0	1.0	51.8	52.5	
15.2	47.0	3.0	47.5	48.2	1.2E-03
			Avg.of Last 4 Rdgs.		1.2E-03

General Test Notes:
1) Tap water was used as the permeant.
2) Back pressure saturation continued until 'B' parameter a minimum of 0.95.
3) Target remolding parameters: 92.4 pcf @ 16.7% moisture.

FLEXIBLE WALL PERMEABILITY TEST

ASTM D 5084-03

Falling Head/Increasing Tailwater Pressure

CLIENT:	Casino		
PROJECT:	Casino	PROJECT NO. :	VA101-325.08
BORING NO.	Manufactured UF	LAB NO. :	L2012-056PPQ
DEPTH		SAMPLE ID:	2012-056-03
SAMPLE NO.		TEST STARTED :	07/10/12
SAMPLE TYPE	Remolded	TEST FINISHED :	07/14/12
CONF. PRESSURE. (psi)	400	SATURATED TEST:	YES

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	649.10	679.70
Wt. Wet Soil & Pan (g)	906.60	824.20
Wt. Dry Soil & Pan (g)	797.00	701.10
Wt. Moisture Lost (g)	109.60	123.10
Wt. of Pan Only (g)	131.30	144.50
Wt. of Dry Soil (g)	665.70	556.60
Moisture Content %	16.5	22.1
Wet Density (pcf)	108.1	131.6
Dry Density (pcf)	92.8	107.7

Init. Diameter (in)	2.413	(cm)	6.130
Init. Area (sq in)	4.574	(sq cm)	29.511
Init. Height (in)	5.000	(cm)	12.700
Height Change (in)	0.135	(cm)	0.343
Consol. Height (in)	4.865	(cm)	12.357
Area After Consol. (sq in)	4.045	(sq cm)	26.097

Vol. Before Consol. (cu ft)	0.01324	Specific Gravity	2.797
Vol. Before Consol. (cc)	374.8	Assumed?	No
Change in Vol. (cc)	52.3		
Cell Exp. (cc)	0.0	Init. Saturation	52.6
Vol. After Consol. (cc)	322.5	Init. Void Ratio	0.883
Vol. After Consol. (cu ft)	0.01139	Final Saturation	99.7
Effective Porosity %	46.83	Final Void Ratio	0.621
Pressure Difference (psi):	0.01		
C =	0.50140	Buret Constant, a	0.920
k, cm/s = (C/t)*log(h1/h2)		Buret Stand Delta	

Permeability Test Trials

Time	Cap Elevation	Pedestal Elevation	Elevation Head	Total Head	Permeability k
sec.	cc	cc	cm	cm	cm/sec
0.0	49.1	1.0	51.9	52.7	
15.9	48.2	2.0	49.9	50.6	5.4E-04
0.0	47.2	3.0	47.7	48.4	
17.5	46.2	4.0	45.6	46.3	5.7E-04
0.0	45.3	5.0	43.5	44.2	
20.3	44.3	6.0	41.4	42.1	5.4E-04
0.0	43.3	7.0	39.2	39.9	
22.9	42.3	8.0	37.0	37.7	5.3E-04
			Avg.of Last 4 Rdgs.		5.4E-04

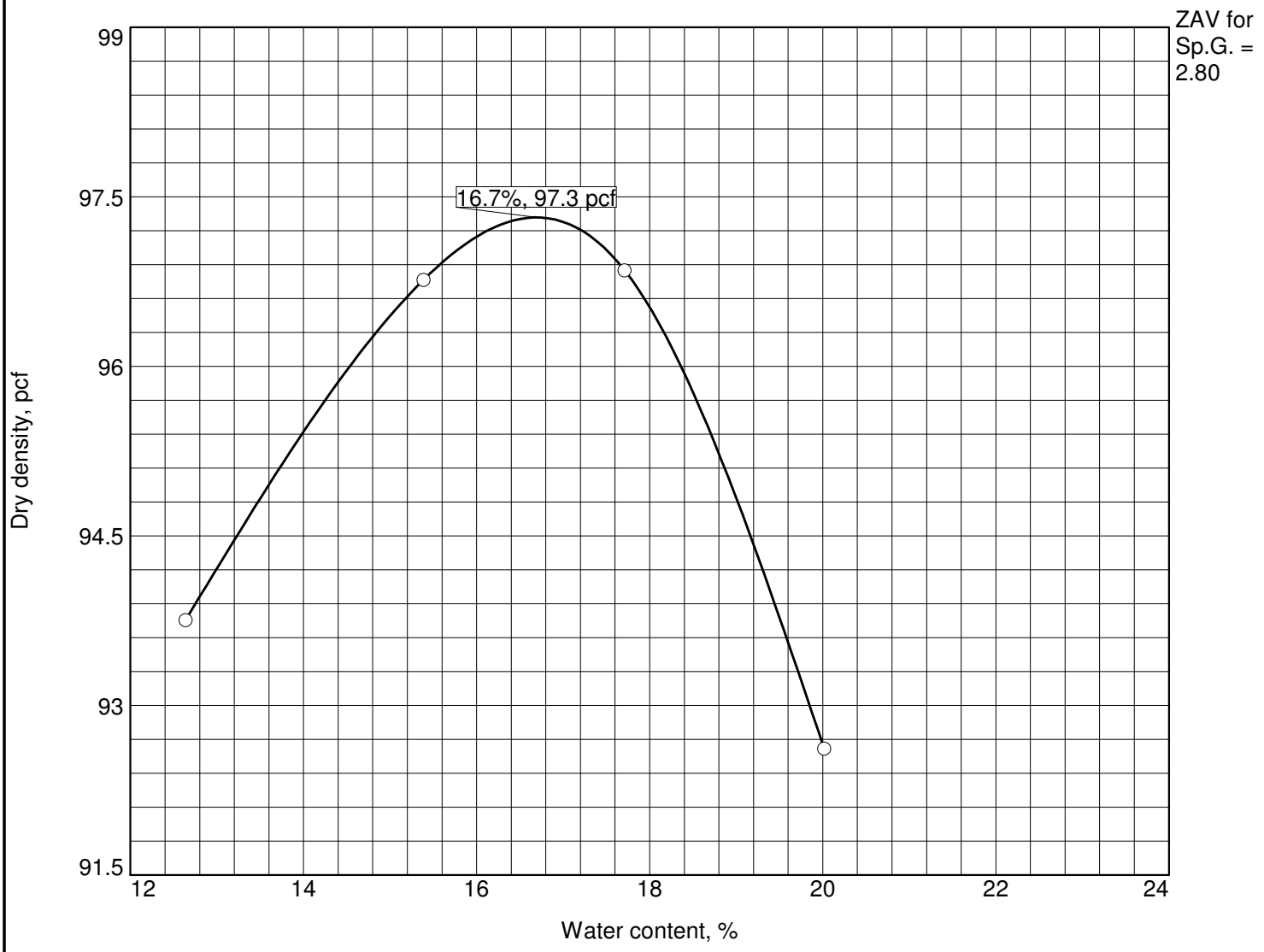
General Test Notes:

1) Tap water was used as the permeant.

2) Back pressure saturation continued until 'B' parameter a minimum of 0.95.

3) Target remolding parameters: 92.4 pcf @ 16.7% moisture.

COMPACTION TEST REPORT



Test specification: ASTM D 698-07 Method A Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > #4	% < No.200
	USCS	AASHTO						
				2.797			0.0	15.0

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 97.3 pcf Optimum moisture = 16.7 %	

Project No. 101-77/13 **Client:** Knight Piésold Ltd.
Project: Casino

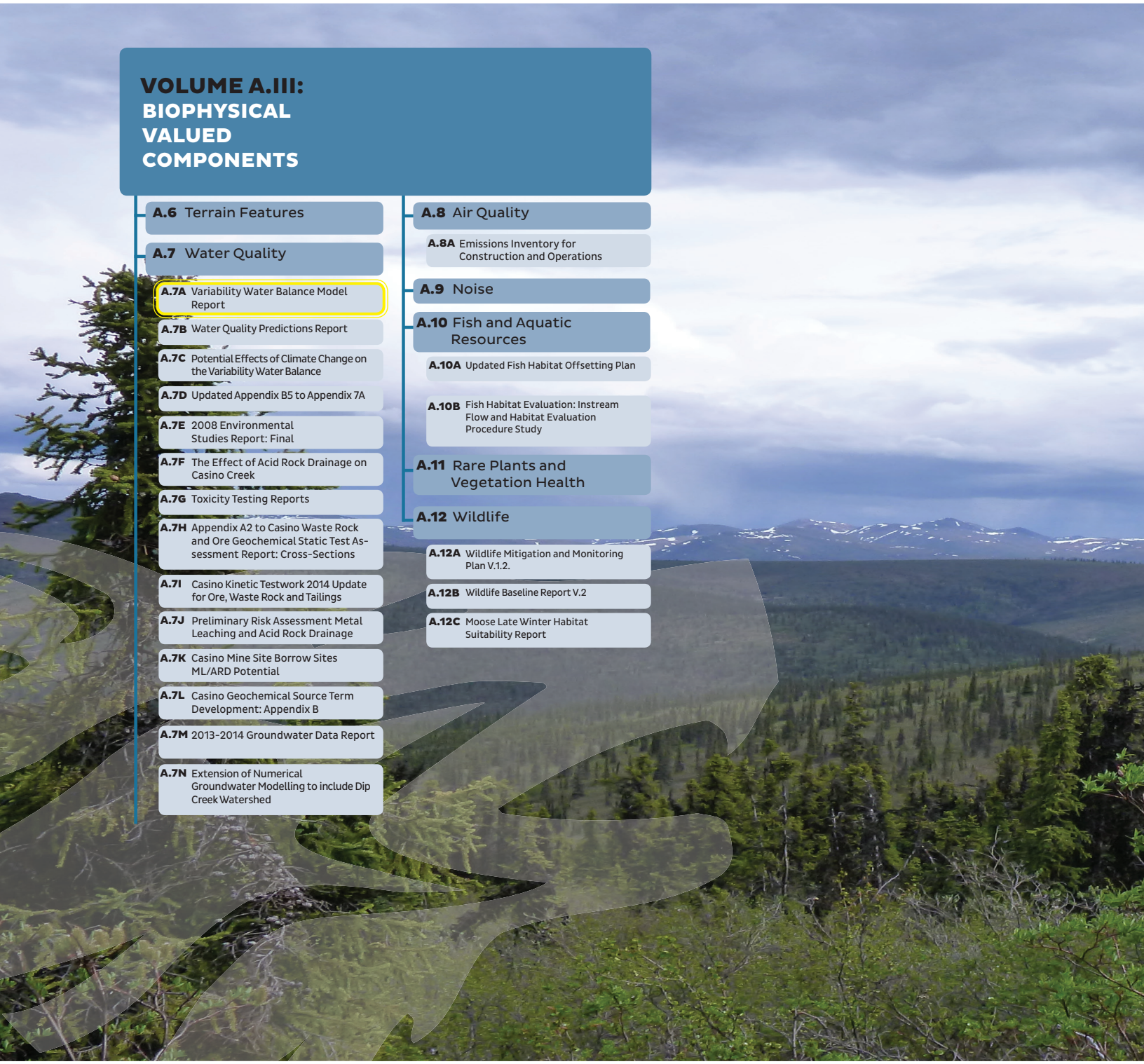
○ **Location:** Manufactured U/F

Remarks:

Knight Piésold CONSULTING

Figure

APPENDIX A.7A: Variability Water Balance Model Report



February 5, 2015

File No.:VA101-325/17-A.01
Cont. No.:VA15-01998

Ms. Mary Mioska
Senior Environmental Manager
Casino Mining Corporation
570 Granville Street, Suite 1800
Vancouver, British Columbia
Canada, V6C 3P1

Dear Mary,

Re: Casino Project –YESAB Water Balance to Include Climate Variability

1 – INTRODUCTION

The water balance submitted to the Yukon Environmental and Socio-Economic Assessment Board (YESAB) for the Casino Project (the project) has been updated to determine the potential impact of climate variability on modelled results. The objective of the water balance modelling exercise was to evaluate the quantity of flow of water in the ground, in the streams, and in various mine facilities under a variety of climate conditions. The water balance model also provided the platform on which the water quality model was developed.

The purpose of this letter is to outline the climate inputs and water management assumptions that were used for climate variability water balance modelling, and to present the results of the study. Only the water quantity model and results are discussed in this letter. The water quality model has been prepared by Source Environmental Associates Inc. (SEA) and will be documented separately.

2 – BACKGROUND AND MODELLING PHILOSOPHY

The water balance model submitted as part of the YESAB Proposal (the Proposal) was a deterministic model created using the GoldSim© software package based on mean monthly climate inputs. The deterministic water balance was based on the water management plan developed for the Proposal, as presented in the Knight Piésold (KP) report “Water Management Plan” (2013a). The deterministic water balance integrated the results of various models created to define the groundwater and surface water management plan for the site and these models included a watershed model, a numerical groundwater model, and the feasibility level operational mine site water balance model. The modelling methodology, assumptions and input parameters used to develop the deterministic water balance are presented in the KP report “YESAB Water Balance Model Report” (2013b), along with the results of the modelling. The water balance model presented in this letter involves variable climate inputs, but also includes modifications to the Proposal water management plan that were made in response to updated water quality predictions resulting from assessing the effects of the variable inputs.

Climate variability was modelled by systematically varying climatic inputs based on a 52 year historical climate record (precipitation and temperature) developed for the project site. The historical climate record was based on correlating available project site data with the measured data from the regional climate station at Pelly Ranch (ID 2100880), which is operated by Environment Canada (EC). Details of the development of the precipitation and temperature record for the project site are included in the KP Report “Casino Project – Baseline Climate Report” (2013c).

The water balance timeline included four years of baseline conditions (Year -8 to Year -5), four years of pre-production (Year -4 to Year -1), 22 years of operations (Year 1 to Year 22), 91 years of closure (Year 23 to Year 113), and 87 years of post-closure (Year 114 to Year 200). The 52 year net precipitation

sequence therefore had to be repeated four times to produce a time series long enough for the 208 year simulation timeline. This approach maintained the inherent cyclical nature of the climate record. The climate variability model was run with 52 iterations for each year of simulated mine life, enabling a large number of combinations of resulting wet, dry, and median months and years of precipitation to be considered. The climate inputs were essentially cycled through the model, such that the monthly climate inputs for year 2 in the first run became the inputs for year 1 in the second run, and the inputs for year 3 in the first run became the inputs for year 2 in the second run, and so on. Each year of monthly climate values that was displaced was then tacked onto the end of the 208 year (4 x 52 years) time series. Model outputs, and in particular flow volumes, were then compiled as distributions for each month in each year, from which probabilities of occurrence could be determined. The probabilities of occurrence presented for the water balance results represent the following conditions:

- Median scenario – 50% chance of being equaled or exceeded in any given month or year;
- 95th percentile scenario – 95% chance of the water volume or flow rate not being equaled or exceeded in any given month or year (5% chance that it will be); also referred to as the 95th percentile wet; and
- 5th percentile scenario – 5% chance of a water volume or flow rate not being equaled or exceeded in any given month or year (95% chance that it will be); also referred to as the 95th percentile dry.

The climate variability water balance model was used to assess the effects of the variable climatic inputs on the project, and provided a range of water quantity predictions over the operations, closure and post-closure phases. The flow outputs from the climate variability water balance were used as the inputs to the corresponding water quality model prepared by SEA. The general arrangement for the maximum footprint of the project used for the water balance is shown on Figure 1.

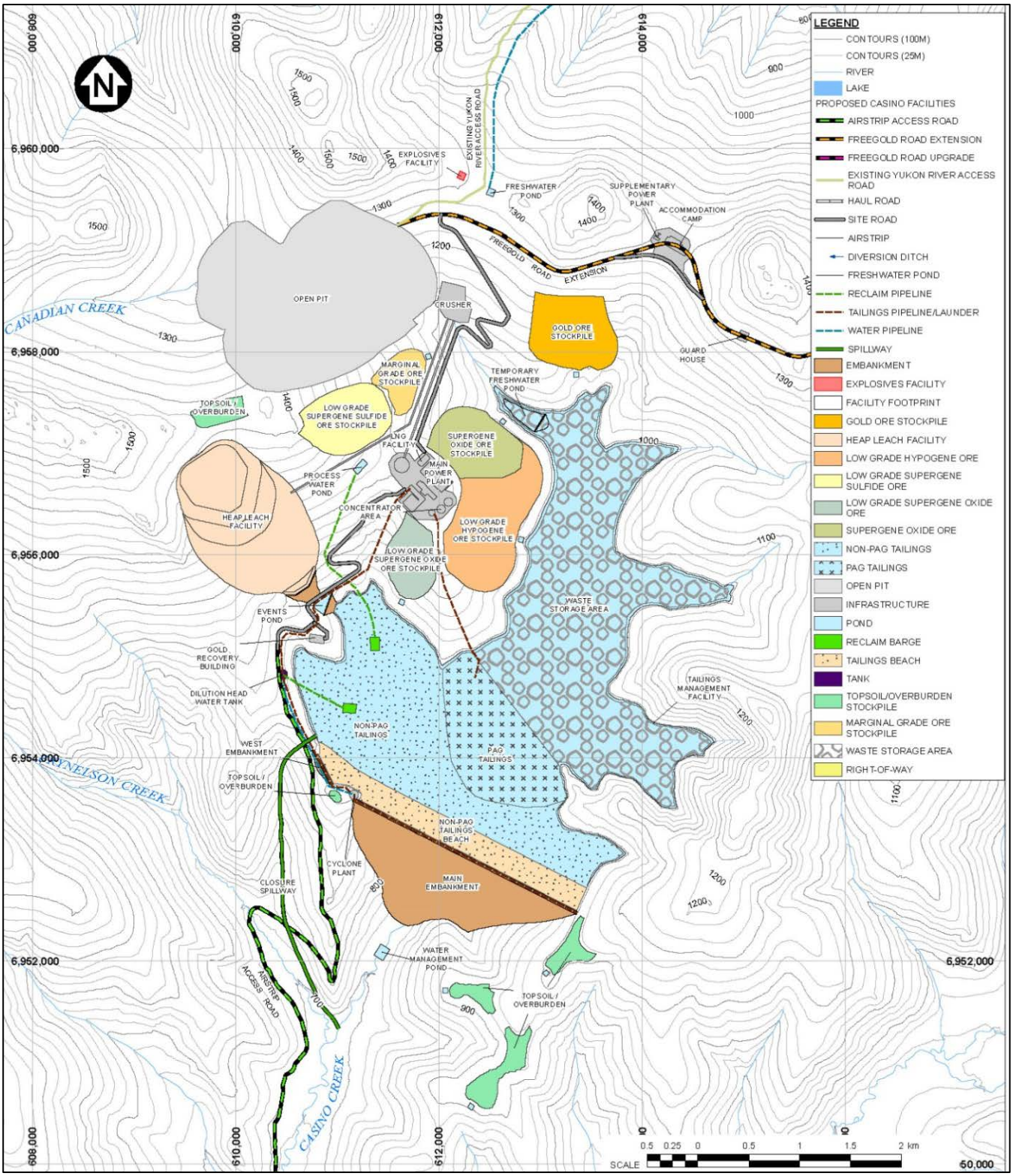


Figure 1 General Arrangement for the Maximum Footprint

3 – WATER MANAGEMENT ASSUMPTION UPDATES

The basic components of the water balance remain unchanged from those in the Proposal, but the water management plan was modified to address potential water quality issues identified by climate variability water quality modelling. The water management plan was modified as follows:

3.1 TAILINGS MANAGEMENT FACILITY AND OPEN PIT

Operations (Years 1 to 22):

- The water management pond (WMP) to be constructed downstream of the TMF embankment will include a seepage cut-off wall keyed into bedrock. The purpose of the cut-off wall will be to intercept all seepage from the TMF and force it to surface where it will collect in the storage pond. Previously, this seepage cut-off was to be implemented only at closure but now it will be constructed prior to operations in order to improve the capture of seepage from the TMF.

Closure Water Management Phase I (Years 23 to 34):

- During the first 5 years of closure (Year 23 to 27), while the TMF pond water is being pumped to the Open Pit, the seepage and runoff collected in the WMP will also be pumped directly to the Open Pit. Pumping of the WMP water directly to the Open Pit will help to facilitate ongoing improvement of water quality in the TMF pond.
- Following the 5 years of pumping TMF pond water to the Open Pit, the TMF pond will be allowed to fill naturally to the closure spillway elevation and then discharge to Casino Creek. Pumping of seepage from the WMP to the Open Pit will continue until the TMF pond reaches the approximate spillway elevation, which is predicted to occur in approximately Year 34 (under median conditions). The TMF filling time predicted in the climate variability water balance is similar to that predicted in the Proposal water balance; that is, approximately 10 to 15 years after the end of operations.
- The WMP will be expanded in closure to 600,000 m^3 (unchanged from the Proposal) in order to accommodate runoff and seepage water collected from the TMF and store it during the winter months. In the Proposal, this pond was referred to as the “winter seepage mitigation pond” in closure. For simplicity, in the climate variability model this pond will be referred to as the “water management pond” in closure, since the pond features largely remain the same as in operations (i.e. seepage cut-off wall), with the exception of the increase in volume.
- The closure cover on the Heap Leach Facility (HLF) was assumed to be 80% effective at reducing infiltration for the climate variability water balance, as opposed to an assumption of 50% in the deterministic water balance. This increase in effectiveness is based on re-contouring of the heap surface slopes and the placement of a low permeability material on top of the heap, as described in the “Conceptual Closure and Reclamation Plan” (Brodie, 2013) submitted with the Proposal.

Closure Water Management Phase II (Years 35 to 109):

- Seasonal discharge from the WMP will commence once the TMF is spilling and when natural flows in Brynelson Creek are sufficient to provide substantial dilution. This constraint was implemented as a mitigation measure in order to prevent the discharge of seepage from the project at times when there is little to no dilution available from surface runoff. The seasonal timing and associated discharge rates from the WMP will be as follows:
  - In April, the WMP will be allowed to discharge naturally as required.
  - In May, once Brynelson Creek is flowing at a rate of 20 L/s or more, the WMP will discharge at a ratio of 0.8 times the Brynelson Creek flow.
  - From June to November the WMP will discharge at a ratio of 0.8 times the Brynelson Creek flow or 200 L/s, whichever is greater. This condition will ensure that the pond will be emptied by the end of November each year.

- An additional mitigation measure adopted in the climate variability model included the discharge of surface water from the TMF to Casino Creek at the onset of freshet and through April and May to supplement the dilution of the seepage discharge from the WMP. A low-level outlet was incorporated into the TMF spillway and was assumed to discharge water at a ratio of 2.0 times the WMP seepage discharge in April and May, and then at a ratio of 1.2 until November, while still maintaining adequate water cover over the wetlands, tailings and waste rock stored in the TMF, under all climatic conditions.
- The TMF will continue to discharge excess water via the closure spillway under wet conditions, as necessary.

Closure Water Management Phase III (Year 109+):

- The Open Pit is predicted to be full as of Year 109 (under median conditions), approximately 87 years after the end of operations. This filling time is approximately 5 years less than the 92 years (Year 114) that was predicted with the deterministic water balance.
- Once the Open pit is completely flooded and discharging to the TMF, the TMF seasonal discharge (April through to November) ratio was assumed to increase to 2.5 times the WMP discharge.

4 – VARIABLE CLIMATE INPUTS AND ASSUMPTIONS

4.1 NET PRECIPITATION INPUTS

Climate variability was modelled using the net precipitation values from the calibrated watershed model described in Appendix A of the *Casino Project – YESAB Water Balance Model Report* (KP, 2013b). Net precipitation is the water available for groundwater recharge and runoff, determined as the total amount of precipitation (rainfall and snowmelt) less losses to the environment (e.g. evapotranspiration and soil moisture losses). The watershed model produced a 52 year time series of net precipitation values for baseline and mine development conditions, as presented in Appendices A and B (attached), respectively.

4.2 LAKE EVAPORATION

The deterministic water balance used an annual lake evaporation value of 300 mm for the project site, based on mean monthly values calculated using the Thornthwaite equation (without latitude correction), as presented in the baseline climate report (KP, 2013c). A subsequent review of lake evaporation for the project suggested that the annual value should be greater, and more in the range of 350 mm to 400 mm. Therefore the lake evaporation values in the climate variability water balance were revised to equate to an average annual value of approximately 390 mm, which was achieved by applying a latitude adjustment factor to the monthly values calculated using the Thornthwaite equation. The revised lake evaporation estimates are considered appropriate based on regional evaporation information currently available from the Yukon and Alaska. The estimated monthly lake evaporation values for the TMF pond and the Pit Lake, at an assumed elevation of 1400 m, are shown in Table C.1 in Appendix C.

4.3 DOWNSTREAM WATER QUALITY COMPLIANCE NODE

Flows at an additional node (W16) located downstream of the water balance model footprint were calculated for water quality purposes. Flows at this node were simulated by prorating flows from the upstream water balance model on the basis of drainage area.

5 – WATER BALANCE RESULTS

5.1 OVERVIEW

Using the climate variability approach, 52 different simulated flow values were generated for each node in the model. The water balance flow schematics, as previously developed for the deterministic water balance (KP, 2013b), were updated and are included in Appendix D. The annual flow volumes that correspond to the

nodes presented in the flow schematics for each water management phase have also been summarized in Table D.1, based on the median case results.

The following sections present discussions of detailed water balance results for the TMF, Open Pit, Water Management Pond (WMP), and Heap Leach Facility (HLF). The results are presented as monthly and annual probabilistic values (median, 95th percentile wet and 5th percentile dry), as well as mean, maximum and minimum values derived from the 52 model iterations.

5.2 TAILINGS MANAGEMENT FACILITY

The water balance was used to determine the likelihood of having a surplus or a deficit water condition for mill operations. A deficit condition pertains to when the TMF pond volume is insufficient to maintain mill operations. The minimum required TMF pond volume during operations was assumed to be 15 Mm^3, which is equal to approximately three months of mill requirements. Makeup water from the Yukon River was used to supplement the mill process water when deficit conditions occurred during years of mill operations (Years 1 to 22). The annual makeup flow requirements for the mill during operations are summarized in Table 1.

Prior to mill start up in Year 1, water from the Yukon River will be required to supplement the TMF pond to establish the minimum starting pond volume of 15 Mm^3. The start-up water requirements from the Yukon River are summarized in Table 2. The Yukon River freshwater pipeline will be adequately sized to convey the makeup water requirements for all phases of the Project. Figure 2 presents the possible range of pond volumes in the TMF, for both pre-production and operations of the mine, under variable climate conditions.

The TMF makeup water requirements at start-up and during operations that are predicted by the climate variability water balance are consistent with but slightly lower than those predicted by the deterministic water balance. There is no makeup water required under all scenarios for Year 22 because the TMF is in a surplus condition and can supply all the required process water required by the mill.

Table 1 Annual Process Water Makeup Requirements

Mine Year	Process Water Makeup Requirements (m^3/yr)					
	Mean	Maximum	5th Percentile Dry	Median	95th Percentile Wet	Minimum
1	4,527,000	8,080,000	7,494,000	4,227,000	2,533,000	2,314,000
2	9,301,000	13,150,000	12,670,000	9,512,000	5,330,000	880,000
3	7,311,000	11,540,000	10,740,000	7,351,000	4,516,000	1,632,000
4	5,295,000	8,686,000	8,476,000	4,939,000	3,189,000	0
5	5,013,000	8,557,000	8,335,000	4,891,000	1,902,000	0
6	5,188,000	8,910,000	8,650,000	5,091,000	2,181,000	0
7	4,889,000	8,284,000	8,125,000	4,859,000	1,751,000	0
8	4,917,000	8,598,000	8,337,000	4,838,000	1,159,000	0
9	5,226,000	8,914,000	8,773,000	5,150,000	1,958,000	0
10	4,546,000	8,297,000	7,859,000	4,472,000	1,333,000	0
11	4,422,000	8,245,000	7,746,000	4,391,000	629,000	0
12	4,760,000	8,624,000	8,260,000	4,774,000	1,132,000	0
13	4,876,000	8,716,000	8,354,000	4,849,000	1,378,000	0
14	4,453,000	8,214,000	7,888,000	4,388,000	934,000	0
15	4,303,000	8,376,000	7,864,000	4,132,000	324,000	0
16	4,119,000	8,107,000	7,682,000	4,125,000	218,000	0
17	6,278,000	10,770,000	10,380,000	6,241,000	2,549,000	0
18	6,996,000	11,230,000	10,810,000	7,024,000	3,487,000	0
19	4,771,000	8,048,000	7,851,000	4,613,000	1,750,000	0
20	4,436,000	8,167,000	7,875,000	4,358,000	493,000	0
21	4,916,000	8,632,000	8,315,000	4,832,000	1,828,000	0
22	0	0	0	0	0	0

Table 2 Start-Up Makeup Water Requirements for the TMF

	Start-Up Water Requirements from the Yukon River to the TMF (Mm^3)
Mean	8.5
Maximum	14.5
5th Percentile Dry	12.6
Median	9.0
95th Percentile Wet	4.0
Minimum	0.0

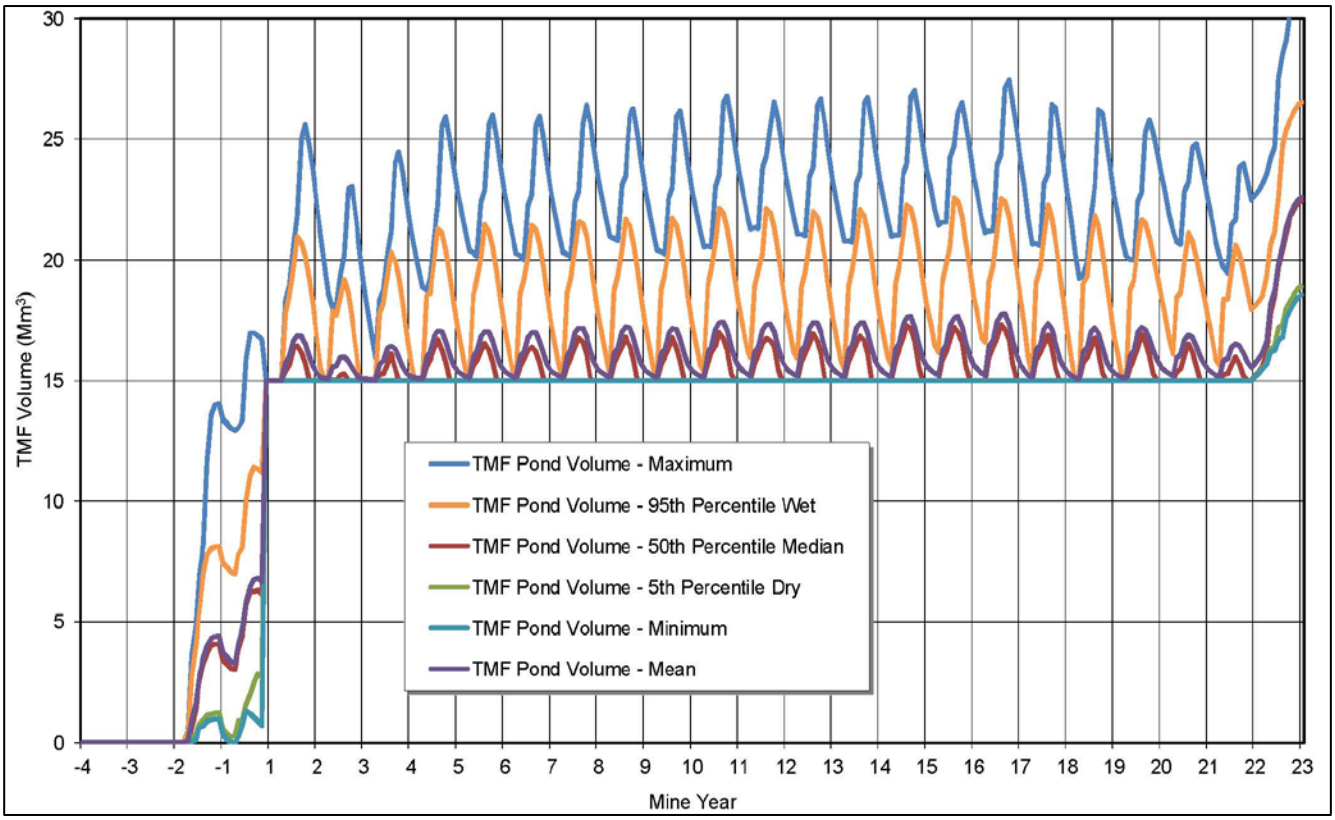


Figure 2 Tailings Management Facility Simulated Pond Volumes for Operations

Following the cessation of milling activities, water in the TMF pond will be pumped to the Open Pit to allow for the construction of the North and South TMF wetlands. The range of possible TMF pond water depths resulting from pumping under various climate scenarios are summarized in Table 3. Following the wetland establishment, the TMF pond will then fill at its natural inflow rate, and will take between 10 and 15 years to completely fill and begin spilling, depending on climate conditions.

Table 3 TMF Water Depth as a Result of Pumping to the Open Pit

	TMF Pond Depth (m)
Mean	1.0
Minimum	0.5
5th Percentile	0.5
Median	1.0
95th Percentile	1.8
Maximum	2.0

Discharge from the TMF pond in closure will be via the constructed TMF spillway to Casino Creek downstream of the WMP. The discharge from the TMF pond will be a combination of the water released through the low-level outlet in the spillway and the excess flow through the main spillway during wet periods. The predicted total combined monthly and annual discharges through the TMF spillway (low-level + main spillway) are summarized in Table 6 for the varying climate conditions. The monthly and annual flow rates for Years 60 and 120 are shown, which represent the periods prior to the Open Pit spilling and after the Open Pit spilling.

Table 4 TMF Spillway Flows

		Flow (L/s)												
		Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Closure Water Management Phase II (prior to Open Pit spilling) Year 60	**Mean**	0	0	0	70	515	140	303	199	154	79	32	0	124
	Minimum	0	0	0	0	76	43	53	31	34	33	0	0	64
	5th Percentile Dry	0	0	0	0	100	57	55	50	48	42	5	0	69
	Median	0	0	0	37	570	103	220	92	83	62	32	0	111
	95th Percentile Wet	0	0	0	255	1,244	345	999	729	458	215	57	0	232
	Maximum	8	6	3	357	1,537	604	1,292	925	1,372	352	62	0	352
Closure Water Management Phase III (after Open Pit spilling) Year 120	**Mean**	0	0	0	52	582	258	472	320	285	139	69	0	182
	Minimum	0	0	0	0	98	85	112	69	70	74	0	0	109
	5th Percentile Dry	0	0	0	0	127	120	115	106	104	81	11	0	118
	Median	0	0	0	38	708	220	437	203	222	131	70	0	173
	95th Percentile Wet	0	0	0	167	1,260	480	1,082	915	640	224	118	0	303
	Maximum	0	0	2	318	1,400	841	1,335	1,067	1,521	368	128	0	435

5.3 OPEN PIT

During closure, the Open Pit will be allowed to fill and become a pit lake. The annual Pit Lake discharge volume will be released to the North TMF Wetland at a controlled rate through a gravity controlled discharge system during the warmest months of the year (June through September). The climate variability water balance was used to determine the Pit Lake filling time under variable climatic conditions. The climate variability water balance simulation shows that the Pit Lake will take approximately 87 years (Year 109) to fill after the end of operations for the median case, and 83 to 88 years to fill based on 95th percentile wet and 5th percentile dry scenarios, respectively.

Once pit filling is achieved, a controlled release flow averaging 180 L/s (June through September) will be required to maintain lake levels in the Pit at or below an elevation of 1095 masl, based on average climate conditions. Flows in excess of the controlled flow rate will be allowed to spill to the North TMF Wetland. Table 5 summarizes the release rates from the Pit Lake to the North TMF Wetland for Year 110. The climate variability water balance results show that the assumed release rate from the deterministic water balance of 180 L/s will still able to maintain the maximum Pit water level elevation of 1095 masl in closure, for the median and dry scenarios. For the 95th percentile wet scenario, the climate variability model predicts excess release rates to occur in the first 11 years (Years 109 to 119) following the commencement of the Pit Lake release. The surplus flows will be discharged downstream to the North TMF Wetland.

Table 5 Pit Lake Release Rates

		Flow (L/s)												
		Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Controlled Release Year 110	**Mean**	0	0	0	0	0	170	179	180	180	0	0	0	59
	Minimum	0	0	0	0	0	0	122	180	180	0	0	0	40
	5th Percentile Dry	0	0	0	0	0	24	180	180	180	0	0	0	47
	Median	0	0	0	0	0	180	180	180	180	0	0	0	60
	95th Percentile Wet	0	0	0	0	0	180	180	180	180	0	0	0	60
	Maximum	0	0	0	0	0	180	180	180	180	0	0	0	60
Excess Release Year 110	**Mean**	0	0	0	0	0	16	4	1	0	0	0	0	2
	Minimum	0	0	0	0	0	0	0	0	0	0	0	0	0
	5th Percentile Dry	0	0	0	0	0	0	0	0	0	0	0	0	0
	Median	0	0	0	0	0	0	0	0	0	0	0	0	0
	95th Percentile Wet	0	0	0	0	0	172	24	0	0	0	0	0	17
	Maximum	9	2	1	0	11	221	81	58	0	0	0	0	25

5.4 WATER MANAGEMENT POND

The Water Management Pond (WMP) that will be constructed prior to operations, downstream of the TMF main embankment, includes a groundwater seepage cut-off wall keyed into bedrock, which will function to collect seepage and embankment runoff. In closure, the WMP will be expanded to a volume of 600,000 m^3 to allow for

the collection and storage of all runoff and seepage over the winter. Initially in closure, the water collected will be pumped directly to the Open Pit for the duration of Closure Water Management Phase I. Once the TMF begins spilling (Closure Water Management Phase II), flows collected in the WMP will be stored during the low flow months (December through March) and discharged during the spring to coincide with periods of flows in Brynelson Creek and and/or discharge from TMF spillway (April through November). Discharge from the WMP will continue in Closure Water Management Phase III, once the Open Pit is full and spilling to the TMF pond. The flow releases from the WMP are summarized in Table 6 for Years 60 and 120, which represent the periods prior to and after the Open Pit is spilling to the TMF pond.

The water management pond flow release rates for the closure period predicted by both the climate variability and deterministic water balances are consistent on an annual basis, for the median scenario. However, the monthly distributions of the flow releases differ, as those for the climate variability water balance were modified to match the timing of higher flows in Brynelson Creek in order to achieve better dilution of the winter seepage releases. This modification results in higher discharges from the pond in May, compared to the deterministic water balance, with minimal releases in April and November. Overall, the water management pond in closure is still predicted to empty by the end of each year and provide adequate storage for the winter seepage and runoff.

Table 6 Water Management Pond Flow Releases in Closure

		Flow (L/s)												
		Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Closure Water Management Phase II (prior to Open Pit spilling) Year 60	**Mean**	0	0	0	14	219	90	128	77	65	51	27	0	56
	Minimum	0	0	0	0	38	35	45	26	28	28	0	0	43
	5th Percentile Dry	0	0	0	0	50	47	46	42	40	35	4	0	48
	Median	0	0	0	11	285	75	94	72	63	51	27	0	56
	95th Percentile Wet	0	0	0	42	341	186	324	135	94	66	47	0	66
	Maximum	0	0	0	69	364	338	346	171	124	74	51	0	72
Closure Water Management Phase III (after Open Pit spilling) Year 120	**Mean**	0	0	0	14	218	90	127	77	66	52	28	0	56
	Minimum	0	0	0	0	39	34	45	27	28	29	0	0	43
	5th Percentile Dry	0	0	0	0	51	47	46	42	41	32	4	0	47
	Median	0	0	0	8	283	75	94	72	63	52	28	0	56
	95th Percentile Wet	0	0	0	41	341	190	321	146	94	67	47	0	66
	Maximum	0	0	0	67	364	336	343	178	124	74	51	0	72

5.5 HEAP LEACH FACILITY

The results of the climate variability water balance indicate that the Heap Leach Facility (HLF) will operate in a water deficit condition during all months of operations when ore stacking is active (Years -3 to 15). Table 7 summarizes the annual makeup water requirements during operations when ore is being actively irrigated with cyanide solution. As shown in Table 7, the makeup water requirements will decrease each year as water released from inactive areas becomes available and the environmental contributions will increase due to the increasing heap footprint. The makeup requirements predicted by the climate variability water balance are slightly lower than those predicted by the deterministic water balance; however, this also results in more

discharge from the heap to the TMF pond and/or Open Pit in the active closure phases of heap operations, as shown on Figure 3.

Figure 3 presents estimates of the surplus water generated from the heap as well as the accumulated water stored in the heap, for the median and 95th percentile wet cases. The heap will be in a surplus condition from July to September, in Years 15 to 23 (median case), because the environmental inputs will exceed the leaching water requirements during these months. The surplus water from Years 15 to 18 (blue line) is assumed to be recycled to inactive areas of the heap, therefore adding to the water inventory in the heap. During the rinsing phase (Years 19 to 23) no additional water will accumulate in the heap because the surplus water (orange line) will be pumped to the Open Pit to aid in pit filling. Once the heap draindown commences in Year 24, the stacked ore is assumed to drain to the long-term residual moisture content of 5% (by mass) over 5 years until Year 29. During the heap draindown phase, the draindown water will be discharged from the heap at a constant rate of 52,535 m^3/mon (1726 m^3/day) plus whatever environmental inputs occur (rain plus snowmelt), which will result in the seasonal discharge pattern illustrated by the red line on Figure 3. The surplus water during this phase is assumed to be pumped to the Open Pit. Once the draindown flow reaches manageable levels, as of Year 29, the closure cover on the heap is assumed to become effective by reducing the infiltration through the heap by 80% of net precipitation, and accordingly the water discharged from the heap will be reduced, as shown by the green line. From this time onwards, in perpetuity, the heap discharge as well as the runoff from the closure cover will be routed naturally downstream to the TMF pond.

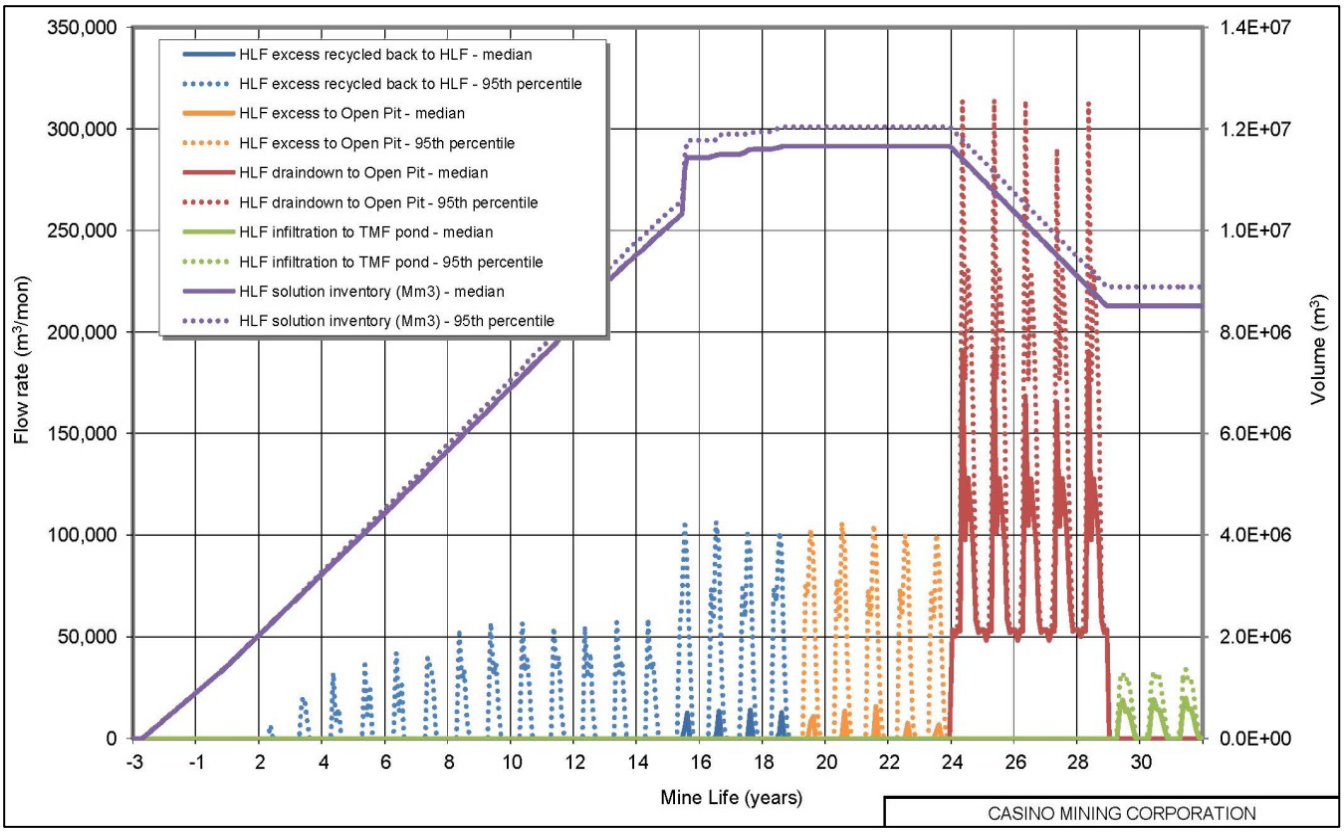


Figure 3 Heap Leach Facility – Accumulated Water and Monthly Surplus

Table 7 Annual Process Water Makeup Requirements for HLF

Mine Year	Process Water Makeup Requirements (m^3/yr)					
	Mean	Maximum	5th Percentile Dry	Median	95th Percentile Wet	Minimum
-3	166,700	467,500	342,500	143,600	112,400	94,500
-2	33,800	186,900	169,600	0	0	0
-1	7,500	147,900	80,400	0	0	0
1	497,900	623,800	599,300	492,800	377,800	250,700
2	463,200	605,700	577,600	462,800	329,200	192,800
3	429,400	593,700	551,500	420,800	301,800	179,200
4	421,200	578,500	547,800	408,100	290,000	189,800
5	409,900	564,300	536,700	394,700	276,600	183,200
6	401,700	562,300	535,100	388,900	263,000	181,400
7	385,100	561,700	521,600	373,300	243,900	169,700
8	381,100	553,400	515,200	369,400	250,800	181,100
9	372,500	547,600	516,400	357,100	248,000	179,400
10	367,800	541,500	504,800	354,700	246,400	179,800
11	362,500	529,100	500,100	355,600	234,500	159,200
12	318,400	493,200	457,000	306,000	187,700	118,200
13	383,800	565,000	522,300	371,500	257,100	187,300
14	379,600	569,900	518,700	367,800	255,400	189,200
15	216,100	329,200	298,400	208,100	175,400	170,200
16	240,200	356,200	315,000	229,500	197,400	192,200
17	239,400	352,700	320,000	226,800	195,800	190,600
18	237,400	357,600	315,100	226,600	193,800	190,700
19	235,300	355,600	311,700	225,000	191,800	189,600
20	240,500	357,400	313,500	229,900	199,500	194,500
21	239,800	348,400	315,100	226,900	198,700	193,400
22	238,700	348,300	313,300	229,900	195,600	190,600
23	239,500	352,700	320,200	228,900	194,800	192,800

6 – SUMMARY

The deterministic (Proposal) water balance was updated to include climate variability. The purpose of the climate variability model was to evaluate the quantities and rates of flow of water in the ground, in the streams, and in various mine facilities under a variety of climate conditions. The climate variability water balance results were also used by SEA to develop a water quality model for the project. The key results of the water balance for varying climate conditions are as follows:

- The project mine will be in a water deficit condition during operations; therefore, makeup water from the Yukon River freshwater pipeline will be required to supplement the mill process. Makeup water requirements for dry conditions (5th percentile) will range from 12.6 Mm^3/yr at the start of operations to 8.3 Mm^3/yr at the end of operations, while for wet conditions (95th percentile) they will range from 5.3 Mm^3/yr at the start of operations to 1.8 Mm^3/yr at the end of operations.
- Prior to mill start up in Year 1, water from the Yukon River will be required to supplement the TMF pond to establish the minimum starting pond volume of 15 Mm^3. The start-up water requirements from the Yukon River range from 12.6 Mm^3 (5th percentile dry) to 4.0 Mm^3 (95th percentile wet).
- Water in the TMF pond will be pumped to the Open Pit for five years following the end of operations, which will draw down the TMF pond level by approximately 0.5 m to 1.8 m, depending on the climate variability.
- The TMF will take approximately 10 to 15 years after the end of operations to begin spilling through the constructed spillway.
- Annual discharges from the TMF spillway will range from approximately 69 to 232 L/s (5th and 95th percentiles) following the TMF reaching its maximum capacity in closure, and range from approximately 118 to 303 L/s (5th and 95th percentiles) once the Pit Lake begins discharging.
- It will take approximately 83 to 88 years after the end of operations to establish the Pit Lake in the Open Pit, with an outlet elevation of 1095 masl.
- The release from the Pit Lake to the North TMF Wetland will have an average outflow of 180 L/s during June through September in order to maintain the Pit Lake elevation. For the 95th percentile wet scenario, additional water will be need to be released in the first 11 years after the Pit is full to maintain the Pit Lake elevation at 1095 m. Releases are not required under the median and dry scenarios.
- The water management pond (WMP) constructed downstream of the TMF will begin releasing flows when the TMF has reached its maximum capacity and begins spilling. The WMP will release flow from April to November, with the flow rates varying per month to match the flow in Brynelson Creek in order to provide the necessary dilution to maintain water quality standards. There will be no flow releases from December through March and the pond has been sized to collect and store seepage and runoff during the winter months.
- The heap leach facility will be in a water deficit condition during operations, with makeup water consistently required from the Yukon River. Makeup water requirements for dry conditions (5th percentile) will range from 0.08 Mm^3/yr to 0.6 Mm^3/yr, while for wet conditions (95th percentile) they will range from 0.1 Mm^3/yr to 0.4 M m^3/yr. After operations, the heap leach facility will be in a surplus condition and water will be discharged to the Open Pit until draindown is complete, after which it will be discharged to the TMF.

7 – REFERENCES

Brodie Consulting Ltd. (2013). *Casino Project – Conceptual Closure and Reclamation Plan*, December 17, 2013.

EcoMetrix (2014). Casino Mine Proposal: Suggested requests for supplementary Information relating to hydrology and aquatic resources and engineering design and geotechnical considerations. March 18, 2014.

KP (2013a). *Casino Project – Water Management Plan*, Ref. No. VA101-325/14-2 Rev 0, December 12, 2013.

KP (2013b). *Casino Project – YESAB Water Balance Model Report*, Ref. No. VA101-325/14-10 Rev 1, December 13, 2013.

KP (2013c). *Casino Project – Baseline Climate Report*, Ref. No. VA101-325/14-7 Rev 0, June 14, 2013.

We trust that this letter meets your requirements at this time. Please direct any questions or comments to the undersigned.

Yours truly,

KNIGHT PIESOLD LTD.

PROFESSIONAL ENGINEER YUKON TERRITORY ERIN RAINEY Feb 5/15

Prepared: _____
Erin Rainey, P. Eng.
Senior Engineer

Reviewed: _____
Jaime Cathcart, Ph.D., P.Eng.
Hydrotechnical Specialist Engineer

Approval that this document adheres to Knight Piésold Quality Systems:

Attachments:

Appendix A	Baseline Net Precipitation Values from Watershed Model
Appendix B	Operational Net Precipitation Values for Mine Facilities
Appendix C	Lake Evaporation Values – TMF Pond and Open Pit Lake
Appendix D	Climate variability YESAB Water Balance Model Flow Schematics with Annual Flow Values

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APPENDIX A

BASELINE NET PRECIPITATION VALUES FROM WATERSHED MODEL

(Pages A-1 to A-8)

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TABLE A.1

CASINO MINING CORPORATION
CASINO PROJECT

BASELINE NET PRECIPTIATON VALUES
NODE W3 - CANADIAN CREEEK

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Year	Monthly Net Precipitation (mm/mon)												Annual Net Precipitation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	0	8	15	1	20	55	10	0	0	0	109
2	0	0	0	0	103	17	0	10	14	0	0	0	144
3	0	0	0	6	19	0	109	12	21	1	0	0	167
4	0	0	0	0	41	13	8	2	5	0	0	0	69
5	0	0	0	9	96	37	2	9	3	0	0	0	156
6	0	0	0	0	66	60	76	5	8	5	0	0	220
7	0	0	0	4	23	3	6	0	18	0	0	0	53
8	0	0	0	1	59	3	0	0	0	0	0	0	64
9	0	0	0	0	104	36	42	38	20	1	0	0	241
10	0	0	0	9	68	0	0	0	44	0	0	0	122
11	0	0	0	19	31	0	23	0	5	0	0	0	78
12	0	0	0	4	60	0	0	0	33	0	0	0	97
13	0	0	0	4	46	1	0	4	7	0	0	0	63
14	0	0	0	0	83	57	11	0	9	0	0	0	160
15	0	0	0	37	63	25	11	38	0	0	0	0	174
16	0	0	0	4	64	4	18	5	0	0	0	0	95
17	0	0	0	5	40	0	23	5	26	0	0	0	98
18	0	0	0	18	95	7	9	0	0	0	0	0	129
19	0	0	0	12	56	13	1	0	0	0	0	0	82
20	0	0	0	3	13	4	77	25	13	2	0	0	136
21	0	0	0	5	100	22	21	0	6	0	0	0	154
22	0	0	0	14	6	0	3	7	50	6	0	0	85
23	0	0	0	0	15	4	66	22	61	8	0	0	176
24	0	0	0	1	95	2	12	1	15	0	0	0	127
25	0	0	0	30	52	18	20	83	22	2	0	0	227
26	0	0	0	19	48	0	8	23	18	0	0	0	116
27	0	0	0	0	62	54	72	32	24	0	0	0	244
28	0	0	0	0	70	20	46	26	0	0	0	0	162
29	0	0	0	7	34	0	12	7	43	14	0	0	117
30	0	0	0	26	55	0	30	3	1	0	0	0	115
31	0	0	0	11	37	19	0	0	0	0	0	0	68
32	0	0	0	10	55	30	0	3	32	0	0	0	131
33	0	0	0	32	70	0	10	9	40	0	0	0	162
34	0	0	0	13	133	22	7	20	34	0	0	0	227
35	0	0	0	43	106	1	12	14	12	8	0	0	197
36	0	0	0	31	52	27	3	0	0	0	0	0	114
37	0	0	0	9	3	1	45	78	0	0	0	0	136
38	0	0	0	10	136	21	60	10	21	0	0	0	258
39	0	0	0	21	6	2	0	0	7	0	0	0	37
40	0	0	0	8	37	34	0	25	33	4	0	0	141
41	0	0	0	6	122	14	61	80	109	0	0	0	392
42	0	0	0	11	26	17	91	8	13	1	0	0	168
43	0	0	0	0	66	0	36	71	0	1	0	0	175
44	0	0	0	1	30	4	11	2	9	1	0	0	60
45	0	0	0	54	100	0	3	0	38	1	0	0	197
46	0	0	0	36	49	20	70	0	12	11	0	0	198
47	0	0	0	11	56	1	6	10	0	0	0	0	84
48	0	0	0	19	25	3	10	1	54	1	0	0	113
49	0	0	0	16	47	0	27	117	28	1	0	0	236
50	0	0	0	14	69	0	0	58	7	4	0	0	152
51	0	0	0	17	8	2	63	12	1	1	0	0	104
52	0	0	0	4	18	90	95	39	2	1	0	0	248
Average	**0**	**0**	**0**	**12**	**56**	**14**	**26**	**19**	**18**	**1**	**0**	**0**	**146**
Minimum	**0**	**0**	**0**	**0**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**37**
Maximum	**0**	**0**	**0**	**54**	**136**	**90**	**109**	**117**	**109**	**14**	**0**	**0**	**392**

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REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	13JAN'15	ISSUED WITH LETTER VA15-01945	EER	JGC	KJB

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TABLE A.2

CASINO MINING CORPORATION
CASINO PROJECT

BASELINE NET PRECIPTIATON VALUES
NODE W14 - BRITIANNIA CREEK

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Year	Monthly Net Precipitation (mm/mon)												Annual Net Precipitation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	0	16	8	1	23	58	10	0	0	0	116
2	0	0	0	1	104	15	0	13	15	0	0	0	146
3	0	0	0	10	14	0	116	14	22	1	0	0	176
4	0	0	0	0	39	15	10	3	6	0	0	0	72
5	0	0	0	14	91	35	3	11	3	1	0	0	158
6	0	0	0	1	86	38	81	6	8	7	0	0	227
7	0	0	0	7	16	2	7	0	21	0	0	0	53
8	0	0	0	2	58	0	0	0	0	0	0	0	60
9	0	0	0	0	117	21	45	41	21	1	0	0	247
10	0	0	0	13	61	0	0	0	51	0	0	0	126
11	0	0	0	26	20	0	27	0	6	1	0	0	80
12	0	0	0	7	56	0	0	0	39	0	0	0	103
13	0	0	0	6	42	0	0	5	9	0	0	0	62
14	0	0	0	0	83	57	13	0	12	0	0	0	165
15	0	0	0	53	47	21	13	41	0	0	0	0	176
16	0	0	0	5	63	0	20	7	0	0	0	0	96
17	0	0	0	7	33	0	27	6	27	0	0	0	100
18	0	0	0	27	85	7	12	0	0	0	0	0	131
19	0	0	0	20	45	14	1	0	0	1	0	0	81
20	0	0	0	6	11	5	82	27	13	3	0	0	146
21	0	0	0	6	95	23	24	0	7	0	0	0	156
22	0	0	0	18	1	0	3	9	54	8	0	0	94
23	0	0	0	1	10	6	70	24	65	11	0	0	185
24	0	0	0	1	93	0	14	1	17	0	0	0	126
25	0	0	0	45	34	20	23	87	26	2	0	0	237
26	0	0	0	29	32	0	10	26	18	0	0	0	115
27	0	0	0	1	60	57	77	34	26	0	0	0	254
28	0	0	0	0	70	19	50	28	0	0	0	0	167
29	0	0	0	11	26	0	15	9	44	20	0	0	127
30	0	0	0	39	32	0	34	4	0	0	0	0	110
31	0	0	0	19	27	21	0	0	0	0	0	0	67
32	0	0	0	19	45	33	0	3	35	0	0	0	136
33	0	0	0	48	50	0	13	11	41	0	0	0	163
34	0	0	0	17	141	6	9	21	48	0	0	0	244
35	0	0	0	63	72	0	16	16	12	12	0	0	190
36	0	0	0	41	35	30	3	0	0	1	0	0	110
37	0	0	0	12	1	0	49	82	0	1	0	0	145
38	0	0	0	16	130	24	64	11	22	0	0	0	267
39	0	0	0	28	1	1	0	0	9	0	0	0	40
40	0	0	0	15	26	36	0	28	34	5	0	0	145
41	0	0	0	9	120	12	65	84	116	1	0	0	406
42	0	0	0	17	19	15	96	9	14	2	0	0	171
43	0	0	0	0	64	0	41	75	0	1	0	0	181
44	0	0	0	2	26	5	15	3	10	2	0	0	62
45	0	0	0	78	70	0	3	0	47	2	0	0	200
46	0	0	0	52	25	22	74	0	13	16	0	0	203
47	0	0	0	16	42	1	8	13	0	1	0	0	81
48	0	0	0	30	14	3	12	1	56	1	0	0	117
49	0	0	0	23	37	0	31	123	29	1	0	0	244
50	0	0	0	20	58	0	0	64	7	6	0	0	155
51	0	0	0	22	1	2	67	14	1	1	0	0	107
52	0	0	0	7	13	95	101	41	2	2	0	0	260
Average	**0**	**0**	**0**	**18**	**49**	**13**	**28**	**20**	**19**	**2**	**0**	**0**	**150**
Minimum	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**40**
Maximum	**0**	**0**	**0**	**78**	**141**	**95**	**116**	**123**	**116**	**20**	**0**	**0**	**406**

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REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	13JAN'15	ISSUED WITH LETTER VA15-01945	EER	JGC	KJB

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TABLE A.3

CASINO MINING CORPORATION
CASINO PROJECT

BASELINE NET PRECIPTIATON VALUES
NODE W11 - UPPER CASINO CREEK

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Year	Monthly Net Precipitation (mm/mon)												Annual Net Precipitation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	0	14	24	2	33	68	13	0	0	0	155
2	0	0	0	0	128	21	0	18	20	0	0	0	187
3	0	0	0	6	29	0	132	18	26	0	0	0	211
4	0	0	0	0	56	20	14	4	9	0	0	0	103
5	0	0	0	4	127	43	5	16	5	1	0	0	201
6	0	0	0	0	86	69	89	9	12	5	0	0	270
7	0	0	0	4	35	4	10	0	29	0	0	0	82
8	0	0	0	0	81	1	0	0	0	0	0	0	83
9	0	0	0	0	144	39	52	46	24	0	0	0	306
10	0	0	0	5	92	0	0	0	63	0	0	0	161
11	0	0	0	29	37	0	36	0	9	0	0	0	110
12	0	0	0	4	78	0	0	1	51	0	0	0	133
13	0	0	0	1	64	0	0	9	13	0	0	0	86
14	0	0	0	0	110	65	18	0	16	0	0	0	210
15	0	0	0	31	88	32	18	48	0	0	0	0	217
16	0	0	0	0	89	1	29	10	0	0	0	0	130
17	0	0	0	3	57	0	37	8	32	0	0	0	138
18	0	0	0	13	124	10	16	0	1	0	0	0	164
19	0	0	0	11	80	20	2	0	0	0	0	0	114
20	0	0	0	4	25	7	97	32	16	1	0	0	183
21	0	0	0	1	128	29	30	0	10	1	0	0	198
22	0	0	0	27	4	0	6	13	65	8	0	0	122
23	0	0	0	0	20	8	83	29	70	5	0	0	215
24	0	0	0	0	123	0	21	1	24	0	0	0	169
25	0	0	0	33	69	26	28	95	28	1	0	0	280
26	0	0	0	26	59	0	14	33	22	0	0	0	154
27	0	0	0	0	80	64	85	39	29	0	0	0	299
28	0	0	0	0	90	24	57	33	0	0	0	0	205
29	0	0	0	6	50	0	21	13	51	13	0	0	155
30	0	0	0	30	72	0	45	6	1	0	0	0	154
31	0	0	0	16	50	27	0	0	0	0	0	0	94
32	0	0	0	18	75	39	0	5	44	0	0	0	181
33	0	0	0	28	95	1	18	15	48	0	0	0	206
34	0	0	0	5	174	19	13	29	31	0	0	0	270
35	0	0	0	41	142	0	23	22	16	8	0	0	251
36	0	0	0	45	59	36	5	0	0	0	0	0	145
37	0	0	0	21	3	1	66	90	0	0	0	0	181
38	0	0	0	8	166	29	72	15	25	0	0	0	316
39	0	0	0	35	5	4	0	0	14	0	0	0	58
40	0	0	0	12	53	45	0	37	39	1	0	0	188
41	0	0	0	2	157	18	74	92	125	0	0	0	466
42	0	0	0	12	39	21	107	13	17	0	0	0	210
43	0	0	0	0	85	0	51	83	0	1	0	0	220
44	0	0	0	0	44	8	20	4	14	2	0	0	93
45	0	0	0	47	134	0	5	0	57	0	0	0	243
46	0	0	0	46	57	28	83	0	19	10	0	0	243
47	0	0	0	8	76	3	11	18	0	0	0	0	117
48	0	0	0	23	34	6	19	2	68	0	0	0	152
49	0	0	0	11	65	0	42	133	34	0	0	0	286
50	0	0	0	8	94	0	0	78	10	4	0	0	192
51	0	0	0	30	6	5	81	18	2	0	0	0	142
52	0	0	0	5	28	107	111	47	3	1	0	0	303
Average	**0**	**0**	**0**	**13**	**75**	**17**	**34**	**24**	**23**	**1**	**0**	**0**	**187**
Minimum	**0**	**0**	**0**	**0**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**58**
Maximum	**0**	**0**	**0**	**47**	**174**	**107**	**132**	**133**	**125**	**13**	**0**	**0**	**466**

M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 511 - Water Balance Model updates\02_Inputs\from Watershed Model\GoldSim11\[WatershedSurplusWater_20130802_ER.xlsx]Table_W11Inputs

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	13JAN'15	ISSUED WITH LETTER VA15-01945	EER	JGC	KJB

Knight Piésold CONSULTING

TABLE A.4

CASINO MINING CORPORATION
CASINO PROJECT

BASELINE NET PRECIPTIATON VALUES
NODE W18 - BRYNELSON CREEK

Print Jan/13/15 11:06:50

Year	Monthly Net Precipitation (mm/mon)												Annual Net Precipitation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	0	12	31	3	33	68	13	0	0	0	161
2	0	0	0	0	126	30	0	18	20	0	0	0	195
3	0	0	0	6	33	0	132	18	26	0	0	0	216
4	0	0	0	0	61	20	14	4	9	0	0	0	108
5	0	0	0	4	126	52	5	16	5	1	0	0	208
6	0	0	0	0	70	93	89	9	13	4	0	0	278
7	0	0	0	4	38	6	10	0	30	0	0	0	88
8	0	0	0	0	80	7	0	0	0	0	0	0	88
9	0	0	0	0	130	63	52	47	25	0	0	0	317
10	0	0	0	5	97	0	0	1	62	0	0	0	165
11	0	0	0	23	49	0	36	0	9	0	0	0	118
12	0	0	0	4	82	0	0	1	48	0	0	0	136
13	0	0	0	1	68	3	0	9	13	0	0	0	94
14	0	0	0	0	110	73	18	0	15	0	0	0	217
15	0	0	0	29	91	42	18	48	0	0	0	0	227
16	0	0	0	1	86	8	31	10	0	0	0	0	136
17	0	0	0	3	63	0	37	9	33	0	0	0	145
18	0	0	0	13	127	13	16	0	1	0	0	0	171
19	0	0	0	12	86	20	2	0	1	0	0	0	121
20	0	0	0	4	28	7	99	32	17	1	0	0	188
21	0	0	0	1	132	31	30	0	11	0	0	0	205
22	0	0	0	21	11	0	7	13	63	6	0	0	121
23	0	0	0	0	28	8	83	29	70	5	0	0	223
24	0	0	0	0	122	5	23	1	25	0	0	0	176
25	0	0	0	27	81	26	29	96	25	1	0	0	284
26	0	0	0	21	72	1	14	33	22	0	0	0	164
27	0	0	0	0	84	66	85	40	29	0	0	0	304
28	0	0	0	0	90	30	57	33	0	0	0	0	212
29	0	0	0	7	55	0	22	13	52	11	0	0	160
30	0	0	0	24	86	0	46	6	1	0	0	0	163
31	0	0	0	13	59	28	0	0	1	0	0	0	100
32	0	0	0	14	84	40	0	5	45	0	0	0	188
33	0	0	0	26	105	1	18	16	49	0	0	0	214
34	0	0	0	5	159	41	13	30	27	0	0	0	275
35	0	0	0	36	155	3	23	22	16	7	0	0	262
36	0	0	0	35	77	36	5	0	0	0	0	0	153
37	0	0	0	18	8	1	67	91	0	0	0	0	185
38	0	0	0	9	171	30	73	16	26	0	0	0	324
39	0	0	0	27	13	6	0	0	15	0	0	0	60
40	0	0	0	11	60	47	0	38	39	2	0	0	197
41	0	0	0	2	155	27	74	92	120	0	0	0	470
42	0	0	0	11	43	29	107	13	18	0	0	0	221
43	0	0	0	0	89	1	51	83	0	1	0	0	225
44	0	0	0	0	49	9	21	5	14	1	0	0	99
45	0	0	0	41	148	1	6	0	52	1	0	0	249
46	0	0	0	36	79	28	83	0	20	9	0	0	256
47	0	0	0	9	84	3	11	18	1	0	0	0	125
48	0	0	0	19	43	7	19	2	69	0	0	0	159
49	0	0	0	12	71	0	43	133	34	0	0	0	293
50	0	0	0	8	100	0	0	79	10	3	0	0	200
51	0	0	0	23	15	6	83	18	2	1	0	0	147
52	0	0	0	5	33	108	111	47	3	1	0	0	308
Average	**0**	**0**	**0**	**11**	**80**	**20**	**35**	**24**	**23**	**1**	**0**	**0**	**194**
Minimum	**0**	**0**	**0**	**0**	**8**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**60**
Maximum	**0**	**0**	**0**	**41**	**171**	**108**	**132**	**133**	**120**	**11**	**0**	**0**	**470**

M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 511 - Water Balance Model updates\02_Inputs\from Watershed Model\GoldSim11\[WatershedSurplusWater_20130802_ER.xlsx]Table_W18Inputs

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	13JAN'15	ISSUED WITH LETTER VA15-01945	EER	JGC	KJB

Knight Piésold CONSULTING

TABLE A.5

CASINO MINING CORPORATION
CASINO PROJECT

BASELINE NET PRECIPTIATON VALUES
NODE H18 - CASINO CREEK BELOW BRYNELSON

Print Jan/13/15 11:06:50

Year	Monthly Net Precipitation (mm/mon)												Annual Net Precipitation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	0	28	1	0	28	61	10	0	0	0	128
2	0	0	0	1	102	17	0	17	16	0	0	0	152
3	0	0	0	22	5	0	124	16	23	2	0	0	192
4	0	0	0	1	37	18	13	3	7	0	0	0	79
5	0	0	0	22	79	38	4	15	3	1	0	0	162
6	0	0	0	1	97	28	87	8	9	10	0	0	240
7	0	0	0	16	5	2	10	0	25	0	0	0	57
8	0	0	0	3	53	0	0	0	0	0	0	0	56
9	0	0	0	0	122	19	50	45	22	2	0	0	260
10	0	0	0	22	49	0	0	0	58	0	0	0	129
11	0	0	0	30	15	0	34	0	6	2	0	0	86
12	0	0	0	16	48	0	0	0	46	0	0	0	110
13	0	0	0	7	37	0	0	6	12	0	0	0	62
14	0	0	0	0	82	61	16	0	14	0	0	0	173
15	0	0	0	89	13	20	17	44	0	0	0	0	183
16	0	0	0	7	58	0	26	9	0	0	0	0	99
17	0	0	0	15	23	0	31	7	28	0	0	0	106
18	0	0	0	53	57	9	15	0	0	0	0	0	134
19	0	0	0	43	21	17	1	0	0	2	0	0	83
20	0	0	0	14	4	5	90	30	14	5	0	0	162
21	0	0	0	8	90	26	28	0	9	0	0	0	160
22	0	0	0	18	0	0	3	12	58	10	0	0	101
23	0	0	0	1	8	7	76	27	68	18	0	0	205
24	0	0	0	2	84	0	18	0	20	0	0	0	125
25	0	0	0	62	14	24	27	93	28	4	0	0	251
26	0	0	0	37	20	0	13	30	19	0	0	0	119
27	0	0	0	1	58	62	84	38	27	0	0	0	269
28	0	0	0	0	69	22	56	31	0	0	0	0	178
29	0	0	0	27	11	0	20	12	46	30	0	0	145
30	0	0	0	49	7	0	40	5	0	0	0	0	102
31	0	0	0	27	16	24	0	0	0	0	0	0	68
32	0	0	0	31	35	37	0	3	40	1	0	0	146
33	0	0	0	79	17	0	17	14	43	0	0	0	170
34	0	0	0	25	136	2	12	25	73	0	0	0	274
35	0	0	0	96	17	0	20	18	12	17	0	0	179
36	0	0	0	41	27	33	4	0	0	2	0	0	107
37	0	0	0	11	0	0	56	88	0	2	0	0	157
38	0	0	0	36	111	27	70	13	23	0	0	0	281
39	0	0	0	28	0	0	0	0	10	1	0	0	39
40	0	0	0	32	10	40	0	33	36	8	0	0	160
41	0	0	0	11	113	14	71	90	122	1	0	0	422
42	0	0	0	32	5	16	103	12	14	3	0	0	185
43	0	0	0	0	62	0	48	81	0	1	0	0	191
44	0	0	0	3	22	6	19	3	11	3	0	0	68
45	0	0	0	119	25	0	3	0	54	3	0	0	205
46	0	0	0	64	11	25	80	0	15	25	0	0	220
47	0	0	0	35	13	1	10	16	0	1	0	0	78
48	0	0	0	46	2	1	14	1	60	2	0	0	126
49	0	0	0	44	16	0	35	131	31	1	0	0	257
50	0	0	0	36	39	0	0	72	7	11	0	0	164
51	0	0	0	17	0	0	75	16	0	3	0	0	111
52	0	0	0	14	4	101	108	45	2	3	0	0	278
Average	**0**	**0**	**0**	**27**	**37**	**14**	**32**	**22**	**22**	**3**	**0**	**0**	**158**
Minimum	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**39**
Maximum	**0**	**0**	**0**	**119**	**136**	**101**	**124**	**131**	**122**	**30**	**0**	**0**	**422**

M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 511 - Water Balance Model updates\02_Inputs\from Watershed Model\GoldSim11\[WatershedSurplusWater_20130802_ER.xlsx]Table_H18Inputs

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	13JAN'15	ISSUED WITH LETTER VA15-01945	EER	JGC	KJB

Knight Piésold CONSULTING

TABLE A.6

CASINO MINING CORPORATION
CASINO PROJECT

BASELINE NET PRECIPTIATON VALUES
NODE W4 - LOWER CASINO CREEK

Print Jan/13/15 11:06:50

Year	Monthly Net Precipitation (mm/mon)												Annual Net Precipitation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	0	25	3	1	28	62	10	0	0	0	130
2	0	0	0	1	103	18	0	17	16	0	0	0	154
3	0	0	0	18	8	0	125	16	23	2	0	0	192
4	0	0	0	1	38	18	13	3	7	0	0	0	80
5	0	0	0	25	79	38	4	15	3	1	0	0	165
6	0	0	0	1	96	31	88	8	9	9	0	0	242
7	0	0	0	13	9	2	10	0	25	0	0	0	59
8	0	0	0	4	54	0	0	0	0	0	0	0	58
9	0	0	0	0	123	20	50	45	22	2	0	0	262
10	0	0	0	22	51	0	0	0	58	0	0	0	132
11	0	0	0	29	16	0	34	0	7	1	0	0	87
12	0	0	0	14	51	0	0	0	46	0	0	0	111
13	0	0	0	11	37	0	0	6	12	0	0	0	66
14	0	0	0	0	83	61	16	0	14	0	0	0	175
15	0	0	0	79	24	21	17	44	0	0	0	0	185
16	0	0	0	10	58	0	26	9	0	0	0	0	103
17	0	0	0	14	26	0	32	7	28	1	0	0	108
18	0	0	0	46	66	9	15	0	0	0	0	0	136
19	0	0	0	37	29	17	1	0	0	1	0	0	85
20	0	0	0	11	7	5	90	30	14	5	0	0	164
21	0	0	0	12	88	26	28	0	9	0	0	0	162
22	0	0	0	19	0	0	3	12	59	10	0	0	102
23	0	0	0	1	8	7	76	27	68	17	0	0	205
24	0	0	0	2	86	0	18	0	20	0	0	0	128
25	0	0	0	57	20	24	27	93	28	4	0	0	253
26	0	0	0	35	23	0	13	30	19	0	0	0	121
27	0	0	0	1	59	62	84	38	27	0	0	0	271
28	0	0	0	0	70	22	56	31	0	0	0	0	179
29	0	0	0	22	16	0	20	12	46	28	0	0	144
30	0	0	0	47	14	0	40	5	0	1	0	0	108
31	0	0	0	26	20	24	0	0	0	0	0	0	70
32	0	0	0	29	39	37	0	3	40	1	0	0	149
33	0	0	0	70	28	0	17	14	43	0	0	0	172
34	0	0	0	29	134	3	12	26	68	0	0	0	270
35	0	0	0	87	33	0	20	18	12	16	0	0	186
36	0	0	0	42	29	33	4	0	0	2	0	0	110
37	0	0	0	12	0	0	57	88	0	2	0	0	158
38	0	0	0	30	119	27	70	13	23	0	0	0	283
39	0	0	0	29	0	0	0	0	10	1	0	0	41
40	0	0	0	28	15	40	0	33	36	9	0	0	162
41	0	0	0	15	110	14	71	90	122	1	0	0	424
42	0	0	0	27	10	17	103	12	14	3	0	0	186
43	0	0	0	0	63	0	48	81	0	1	0	0	193
44	0	0	0	5	23	6	19	4	12	3	0	0	70
45	0	0	0	108	38	0	3	0	55	4	0	0	207
46	0	0	0	61	15	25	80	0	15	23	0	0	220
47	0	0	0	29	22	1	10	17	0	1	0	0	81
48	0	0	0	41	5	2	14	1	61	3	0	0	127
49	0	0	0	38	22	0	36	131	31	2	0	0	259
50	0	0	0	34	44	0	0	71	7	10	0	0	166
51	0	0	0	19	0	1	75	16	1	2	0	0	114
52	0	0	0	12	8	102	108	45	2	3	0	0	280
Average	**0**	**0**	**0**	**26**	**41**	**14**	**32**	**23**	**22**	**3**	**0**	**0**	**160**
Minimum	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**41**
Maximum	**0**	**0**	**0**	**108**	**134**	**102**	**125**	**131**	**122**	**28**	**0**	**0**	**424**

M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 511 - Water Balance Model updates\02_Inputs\from Watershed Model\GoldSim11\[WatershedSurplusWater_20130802_ER.xlsx]Table_W4Inputs

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	13JAN'15	ISSUED WITH LETTER VA15-01945	EER	JGC	KJB

Knight Piésold CONSULTING

TABLE A.7

CASINO MINING CORPORATION
CASINO PROJECT

BASELINE NET PRECIPTIATON VALUES
NODE W9 - UPPER DIP CREEK

Print Jan/13/15 11:06:50

Year	Monthly Net Precipitation (mm/mon)												Annual Net Precipitation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	0	20	16	2	31	66	12	0	0	0	146
2	0	0	0	0	118	22	0	18	18	0	0	0	176
3	0	0	0	9	23	0	129	17	25	1	0	0	204
4	0	0	0	0	50	19	14	4	8	0	0	0	95
5	0	0	0	10	111	43	4	15	4	1	0	0	189
6	0	0	0	0	91	55	89	8	11	7	0	0	262
7	0	0	0	7	25	4	10	0	28	0	0	0	74
8	0	0	0	1	71	2	0	0	0	0	0	0	75
9	0	0	0	0	135	35	52	46	24	1	0	0	292
10	0	0	0	10	79	0	0	0	61	0	0	0	151
11	0	0	0	30	29	0	35	0	8	1	0	0	103
12	0	0	0	7	70	0	0	1	49	0	0	0	126
13	0	0	0	3	55	1	0	8	13	0	0	0	80
14	0	0	0	0	100	65	17	0	16	0	0	0	199
15	0	0	0	47	65	30	18	47	0	0	0	0	207
16	0	0	0	3	78	2	28	10	0	0	0	0	121
17	0	0	0	6	48	0	35	8	31	0	0	0	128
18	0	0	0	23	106	11	16	0	0	0	0	0	155
19	0	0	0	19	64	19	2	0	0	1	0	0	105
20	0	0	0	6	19	7	95	32	16	2	0	0	176
21	0	0	0	4	115	28	29	0	10	1	0	0	187
22	0	0	0	23	3	0	5	12	62	9	0	0	115
23	0	0	0	0	17	8	80	28	69	9	0	0	212
24	0	0	0	1	110	1	20	1	23	0	0	0	156
25	0	0	0	44	50	25	28	95	28	2	0	0	271
26	0	0	0	33	44	0	14	32	21	0	0	0	144
27	0	0	0	0	73	64	85	39	29	0	0	0	289
28	0	0	0	0	82	25	57	32	0	0	0	0	197
29	0	0	0	11	39	0	21	12	50	18	0	0	152
30	0	0	0	39	49	0	43	6	1	0	0	0	138
31	0	0	0	22	38	26	0	0	0	0	0	0	86
32	0	0	0	23	61	38	0	4	43	0	0	0	170
33	0	0	0	43	72	1	17	15	47	0	0	0	194
34	0	0	0	12	160	16	12	28	43	0	0	0	271
35	0	0	0	58	102	1	22	20	15	11	0	0	229
36	0	0	0	45	48	35	5	0	0	1	0	0	134
37	0	0	0	17	2	0	63	89	0	1	0	0	173
38	0	0	0	14	152	28	72	15	25	0	0	0	306
39	0	0	0	33	4	2	0	0	13	0	0	0	52
40	0	0	0	18	40	44	0	36	38	3	0	0	179
41	0	0	0	5	141	18	73	91	123	0	0	0	452
42	0	0	0	17	29	22	106	13	16	1	0	0	203
43	0	0	0	0	78	0	50	82	0	1	0	0	211
44	0	0	0	1	37	8	20	4	13	2	0	0	85
45	0	0	0	69	99	0	4	0	56	1	0	0	230
46	0	0	0	54	41	27	82	0	18	15	0	0	237
47	0	0	0	14	59	2	11	17	0	1	0	0	105
48	0	0	0	31	23	5	17	2	65	1	0	0	144
49	0	0	0	20	52	0	40	132	33	1	0	0	277
50	0	0	0	15	78	0	0	76	9	6	0	0	184
51	0	0	0	26	5	3	79	17	1	1	0	0	133
52	0	0	0	7	22	105	110	46	3	2	0	0	295
Average	**0**	**0**	**0**	**17**	**63**	**16**	**33**	**24**	**23**	**2**	**0**	**0**	**178**
Minimum	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**52**
Maximum	**0**	**0**	**0**	**69**	**160**	**105**	**129**	**132**	**123**	**18**	**0**	**0**	**452**

M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 511 - Water Balance Model updates\02_Inputs\from Watershed Model\GoldSim11\[WatershedSurplusWater_20130802_ER.xlsx]Table_W9Inputs

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	13JAN'15	ISSUED WITH LETTER VA15-01945	EER	JGC	KJB

Knight Piésold CONSULTING

TABLE A.8

CASINO MINING CORPORATION
CASINO PROJECT

BASELINE NET PRECIPTIATON VALUES
NODE W16 - LOWER DIP CREEK

Print Jan/13/15 11:06:50

Year	Monthly Net Precipitation (mm/mon)												Annual Net Precipitation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	0	22	8	1	29	62	11	0	0	0	133
2	0	0	0	1	107	18	0	17	16	0	0	0	159
3	0	0	0	14	13	0	126	16	24	2	0	0	194
4	0	0	0	1	41	18	13	3	7	0	0	0	84
5	0	0	0	27	82	38	4	15	4	1	0	0	170
6	0	0	0	1	91	40	88	8	10	8	0	0	246
7	0	0	0	10	15	2	10	0	26	0	0	0	63
8	0	0	0	5	57	0	0	0	0	0	0	0	62
9	0	0	0	0	125	24	50	45	22	2	0	0	269
10	0	0	0	21	56	0	0	0	59	0	0	0	137
11	0	0	0	28	21	0	34	0	7	1	0	0	91
12	0	0	0	11	57	0	0	0	47	0	0	0	114
13	0	0	0	14	39	0	0	6	12	0	0	0	71
14	0	0	0	0	87	62	17	0	15	0	0	0	180
15	0	0	0	67	39	22	17	45	0	0	0	0	190
16	0	0	0	12	60	0	26	9	0	1	0	0	108
17	0	0	0	13	31	0	32	8	28	1	0	0	113
18	0	0	0	37	79	9	15	0	0	0	0	0	141
19	0	0	0	30	40	17	1	0	0	1	0	0	90
20	0	0	0	9	11	6	91	30	15	5	0	0	167
21	0	0	0	15	88	27	28	0	9	0	0	0	167
22	0	0	0	20	1	0	4	12	60	9	0	0	105
23	0	0	0	1	10	7	77	27	68	15	0	0	207
24	0	0	0	2	92	0	19	1	21	0	0	0	134
25	0	0	0	49	31	24	27	94	28	4	0	0	257
26	0	0	0	31	32	0	13	31	20	0	0	0	126
27	0	0	0	1	62	63	84	38	27	0	0	0	275
28	0	0	0	0	73	22	56	31	0	0	0	0	183
29	0	0	0	17	24	0	20	12	47	25	0	0	145
30	0	0	0	41	28	0	41	5	0	1	0	0	117
31	0	0	0	22	27	24	0	0	0	0	0	0	73
32	0	0	0	25	47	37	0	3	41	1	0	0	154
33	0	0	0	58	43	0	17	14	44	0	0	0	177
34	0	0	0	31	133	6	12	26	59	0	0	0	268
35	0	0	0	74	59	0	20	19	13	14	0	0	199
36	0	0	0	41	36	34	4	0	0	2	0	0	117
37	0	0	0	13	1	0	58	88	0	2	0	0	161
38	0	0	0	23	130	27	70	14	23	0	0	0	288
39	0	0	0	30	1	1	0	0	11	1	0	0	44
40	0	0	0	24	24	40	0	34	37	9	0	0	167
41	0	0	0	18	111	15	72	90	123	1	0	0	430
42	0	0	0	22	16	18	103	12	15	3	0	0	189
43	0	0	0	0	66	0	48	81	0	1	0	0	196
44	0	0	0	6	25	6	19	4	12	2	0	0	75
45	0	0	0	93	59	0	3	0	55	4	0	0	213
46	0	0	0	55	24	26	81	0	16	20	0	0	222
47	0	0	0	23	35	1	10	17	0	1	0	0	87
48	0	0	0	35	12	3	15	1	62	3	0	0	131
49	0	0	0	31	31	0	36	131	31	2	0	0	264
50	0	0	0	31	52	0	0	72	8	8	0	0	171
51	0	0	0	21	1	2	76	16	1	2	0	0	119
52	0	0	0	10	12	102	109	45	2	3	0	0	283
Average	**0**	**0**	**0**	**23**	**47**	**14**	**32**	**23**	**22**	**3**	**0**	**0**	**164**
Minimum	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**44**
Maximum	**0**	**0**	**0**	**93**	**133**	**102**	**126**	**131**	**123**	**25**	**0**	**0**	**430**

M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 511 - Water Balance Model updates\02_Inputs\from Watershed Model\GoldSim11\[WatershedSurplusWater_20130802_ER.xlsx]ReadMe_First

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	13JAN'15	ISSUED WITH LETTER VA15-01945	EER	JGC	KJB

Knight Piésold
CONSULTING

APPENDIX B

OPERATIONAL NET PRECIPITATION VALUES FOR MINE FACILITIES

(Pages B-1 to B-13)

Knight Piésold
CONSULTING

TABLE B.1

CASINO MINING CORPORATION
CASINO PROJECT

OPERATIONAL NET PRECIPATION VALUES
OPEN PIT

Print Jan/13/15 11:10:07

Year	Monthly Net Precipitation (mm/mon)												Annual Net Precipitation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	0	1	135	25	72	91	22	0	0	0	346
2	0	0	0	0	197	76	19	43	32	0	0	0	369
3	0	0	0	0	123	18	167	39	37	0	0	0	385
4	0	0	0	0	145	47	44	22	22	0	0	0	279
5	0	0	0	0	204	95	28	42	15	0	0	0	385
6	0	0	0	0	50	226	117	29	25	1	0	0	448
7	0	0	0	0	128	24	38	8	58	0	0	0	256
8	0	0	0	0	151	43	0	24	17	0	0	0	235
9	0	0	0	0	196	151	80	70	36	0	0	0	534
10	0	0	0	0	191	8	19	21	92	0	0	0	331
11	0	0	0	15	142	0	127	5	28	0	0	0	317
12	0	0	0	1	171	14	0	62	77	0	0	0	326
13	0	0	0	0	155	0	17	53	29	0	0	0	254
14	0	0	0	0	188	116	48	15	29	0	0	0	396
15	0	0	0	5	189	89	48	69	7	0	0	0	407
16	0	0	0	0	155	33	79	31	5	0	0	0	304
17	0	0	0	0	158	0	89	28	44	0	0	0	319
18	0	0	0	1	228	35	47	10	14	0	0	0	335
19	0	0	0	2	193	47	23	6	16	0	0	0	286
20	0	0	0	0	121	30	136	55	29	0	0	0	370
21	0	0	0	0	223	54	60	0	47	0	0	0	384
22	0	0	0	36	65	12	44	35	84	4	0	0	280
23	0	0	0	0	113	31	116	51	80	0	0	0	391
24	0	0	0	0	197	21	76	17	43	0	0	0	353
25	0	0	0	2	196	55	59	116	29	0	0	0	456
26	0	0	0	3	183	16	45	60	32	0	0	0	340
27	0	0	0	0	172	90	115	60	40	0	0	0	477
28	0	0	0	0	163	66	89	54	4	0	0	0	376
29	0	0	0	1	150	17	58	36	63	2	0	0	327
30	0	0	0	1	209	16	85	25	9	0	0	0	345
31	0	0	0	0	162	55	0	16	31	0	0	0	265
32	0	0	0	1	203	67	0	51	65	0	0	0	386
33	0	0	0	1	221	21	50	38	61	0	0	0	392
34	0	0	0	0	197	124	42	57	5	0	0	0	425
35	0	0	0	3	313	0	72	45	26	1	0	0	461
36	0	0	0	25	180	63	30	0	31	0	0	0	329
37	0	0	0	61	51	24	111	110	5	0	0	0	361
38	0	0	0	1	272	57	103	38	38	0	0	0	508
39	0	0	0	30	79	39	1	16	42	0	0	0	208
40	0	0	0	2	165	75	18	71	49	0	0	0	380
41	0	0	0	0	231	73	104	111	134	0	0	0	653
42	0	0	0	2	134	52	136	37	29	0	0	0	388
43	0	0	0	0	175	11	94	103	5	2	0	0	390
44	0	0	0	0	138	32	55	23	28	0	0	0	275
45	0	0	0	2	287	3	44	0	102	0	0	0	437
46	0	0	0	13	201	57	111	14	37	1	0	0	434
47	0	0	0	0	186	24	40	44	9	0	0	0	303
48	0	0	0	3	144	32	53	19	87	0	0	0	338
49	0	0	0	1	170	10	85	154	44	0	0	0	464
50	0	0	0	0	197	9	0	153	21	0	0	0	380
51	0	0	0	29	87	34	119	41	10	0	0	0	320
52	0	0	0	1	124	136	140	68	13	0	0	0	482
Average	**0**	**0**	**0**	**5**	**169**	**47**	**64**	**46**	**37**	**0**	**0**	**0**	**369**
Minimum	**0**	**0**	**0**	**0**	**50**	**0**	**0**	**0**	**4**	**0**	**0**	**0**	**208**
Maximum	**0**	**0**	**0**	**61**	**313**	**226**	**167**	**154**	**134**	**4**	**0**	**0**	**653**

M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 511 - Water Balance Model updates\02_Inputs\from Watershed Model\GoldSim11\[FacilitiesSurplusWater_20131015_ER.xlsx]Table_OpenPit

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	13JAN'15	ISSUED WITH LETTER VA15-01945	EER	JGC	KJB

Knight Piésold CONSULTING

TABLE B.2

CASINO MINING CORPORATION
CASINO PROJECT

OPERATIONAL NET PRECIPATION VALUES
PIT LAKE (CLOSURE)

Print Jan/13/15 11:10:07

Year	Monthly Net Precipitation (mm/mon)												Annual Net Precipitation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	0	0	157	55	103	111	28	0	0	0	455
2	0	0	0	0	193	134	48	62	42	0	0	0	479
3	0	0	0	0	147	44	195	61	47	0	0	0	494
4	0	0	0	0	165	75	74	43	30	0	0	0	387
5	0	0	0	0	200	149	59	65	22	0	0	0	494
6	0	0	0	0	17	300	146	51	35	0	0	0	549
7	0	0	0	0	146	50	69	29	67	0	0	0	361
8	0	0	0	0	147	95	12	34	27	0	0	0	314
9	0	0	0	0	165	236	108	93	47	0	0	0	648
10	0	0	0	0	214	35	49	43	99	0	0	0	440
11	0	0	0	4	175	5	135	20	38	0	0	0	378
12	0	0	0	0	193	40	9	71	83	0	0	0	397
13	0	0	0	0	177	19	40	75	37	0	0	0	347
14	0	0	0	0	185	168	78	38	26	0	0	0	496
15	0	0	0	0	193	148	79	90	14	0	0	0	524
16	0	0	0	0	143	92	109	53	14	0	0	0	411
17	0	0	0	0	181	27	119	48	54	0	0	0	429
18	0	0	0	0	250	62	77	32	24	0	0	0	445
19	0	0	0	0	218	74	50	30	25	0	0	0	398
20	0	0	0	0	142	55	166	77	39	0	0	0	479
21	0	0	0	0	246	79	90	17	55	0	0	0	487
22	0	0	0	2	126	41	74	55	88	0	0	0	386
23	0	0	0	0	143	55	146	72	88	0	0	0	504
24	0	0	0	0	193	70	104	37	53	0	0	0	457
25	0	0	0	1	221	83	89	136	20	0	0	0	550
26	0	0	0	2	218	45	74	81	41	0	0	0	461
27	0	0	0	0	194	116	146	81	47	0	0	0	584
28	0	0	0	0	166	108	121	74	13	0	0	0	482
29	0	0	0	0	173	44	88	57	71	0	0	0	434
30	0	0	0	1	238	43	114	47	16	0	0	0	460
31	0	0	0	0	185	81	22	34	39	0	0	0	361
32	0	0	0	0	228	94	22	68	75	0	0	0	487
33	0	0	0	0	249	50	79	57	71	0	0	0	507
34	0	0	0	0	163	210	73	79	0	0	0	0	525
35	0	0	0	1	348	28	103	66	34	0	0	0	580
36	0	0	0	4	227	89	60	14	36	0	0	0	430
37	0	0	0	29	110	53	140	130	18	0	0	0	479
38	0	0	0	0	295	84	134	60	49	0	0	0	621
39	0	0	0	1	136	67	32	35	51	0	0	0	323
40	0	0	0	0	186	104	47	95	58	0	0	0	490
41	0	0	0	0	227	131	135	130	140	0	0	0	763
42	0	0	0	0	151	81	165	60	38	0	0	0	495
43	0	0	0	0	196	39	124	124	15	0	0	0	497
44	0	0	0	0	159	58	87	44	34	0	0	0	382
45	0	0	0	1	319	34	74	6	92	0	0	0	526
46	0	0	0	1	257	84	139	36	47	0	0	0	563
47	0	0	0	0	212	52	71	64	19	0	0	0	418
48	0	0	0	0	171	61	84	41	96	0	0	0	452
49	0	0	0	0	197	38	113	175	53	0	0	0	576
50	0	0	0	0	223	37	19	166	31	0	0	0	476
51	0	0	0	2	140	62	147	64	18	0	0	0	433
52	0	0	0	0	148	164	169	89	24	0	0	0	593
Average	**0**	**0**	**0**	**1**	**190**	**82**	**92**	**66**	**45**	**0**	**0**	**0**	**475**
Minimum	**0**	**0**	**0**	**0**	**17**	**5**	**9**	**6**	**0**	**0**	**0**	**0**	**314**
Maximum	**0**	**0**	**0**	**29**	**348**	**300**	**195**	**175**	**140**	**0**	**0**	**0**	**763**

M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 511 - Water Balance Model updates\02_Inputs\from Watershed Model\GoldSim11\[FacilitiesSurplusWater_20131015_ER.xlsx]Table_PitLake

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	13JAN'15	ISSUED WITH LETTER VA15-01945	EER	JGC	KJB

Knight Piésold CONSULTING

TABLE B.3

CASINO MINING CORPORATION
CASINO PROJECT

OPERATIONAL NET PRECIPATION VALUES
GOLD ORE STOCKPILE

Print Jan/13/15 11:10:07

Year	Monthly Net Precipitation (mm/mon)												Annual Net Precipitation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	0	44	22	24	71	90	20	0	0	0	272
2	0	0	0	0	139	48	19	43	31	0	0	0	279
3	0	0	0	2	46	17	166	39	36	0	0	0	307
4	0	0	0	0	68	47	43	21	20	0	0	0	199
5	0	0	0	5	139	66	28	41	13	2	0	0	295
6	0	0	0	0	115	72	117	29	24	6	0	0	363
7	0	0	0	1	44	24	38	7	56	0	0	0	170
8	0	0	0	0	91	18	0	24	16	0	0	0	149
9	0	0	0	0	203	48	79	69	35	0	0	0	435
10	0	0	0	3	106	7	19	20	90	0	0	0	246
11	0	0	0	42	40	0	127	4	27	0	0	0	241
12	0	0	0	3	94	14	0	62	75	0	0	0	248
13	0	0	0	1	74	0	17	52	28	0	0	0	171
14	0	0	0	0	127	90	48	14	31	0	0	0	309
15	0	0	0	29	99	57	48	68	5	0	0	0	307
16	0	0	0	1	104	0	80	31	4	0	0	0	219
17	0	0	0	4	74	0	89	27	43	0	0	0	237
18	0	0	0	5	141	34	47	9	12	0	0	0	249
19	0	0	0	10	102	47	22	5	15	1	0	0	202
20	0	0	0	4	41	29	135	54	28	0	0	0	291
21	0	0	0	1	138	53	59	0	46	2	0	0	299
22	0	0	0	38	0	17	43	34	81	10	0	0	224
23	0	0	0	0	31	30	116	50	79	5	0	0	310
24	0	0	0	0	133	0	79	16	42	0	0	0	269
25	0	0	0	54	59	54	58	115	35	0	0	0	375
26	0	0	0	45	54	16	45	59	31	0	0	0	250
27	0	0	0	0	92	89	115	60	38	0	0	0	394
28	0	0	0	0	98	51	89	53	3	0	0	0	293
29	0	0	0	9	64	16	57	35	61	15	0	0	258
30	0	0	0	53	57	15	84	25	7	0	0	0	241
31	0	0	0	39	50	54	0	16	30	0	0	0	189
32	0	0	0	49	79	66	0	50	64	0	0	0	308
33	0	0	0	32	104	20	49	38	59	0	0	0	302
34	0	0	0	4	198	24	42	56	33	0	0	0	357
35	0	0	0	52	138	0	72	44	25	10	0	0	342
36	0	0	0	62	56	62	29	0	30	0	0	0	238
37	0	0	0	34	8	23	110	109	4	1	0	0	289
38	0	0	0	5	187	56	102	37	37	0	0	0	423
39	0	0	0	48	0	51	0	15	41	0	0	0	156
40	0	0	0	24	62	74	17	70	48	0	0	0	295
41	0	0	0	2	168	45	103	110	132	0	0	0	560
42	0	0	0	11	47	50	135	36	27	0	0	0	306
43	0	0	0	0	96	11	93	102	4	7	0	0	312
44	0	0	0	0	55	31	54	22	26	3	0	0	191
45	0	0	0	58	132	2	42	0	112	0	0	0	345
46	0	0	0	72	51	56	110	14	36	12	0	0	350
47	0	0	0	2	91	23	39	43	7	0	0	0	206
48	0	0	0	37	27	31	52	18	86	0	0	0	252
49	0	0	0	6	83	9	85	153	43	0	0	0	379
50	0	0	0	3	109	8	0	152	20	3	0	0	296
51	0	0	0	44	0	38	118	40	9	0	0	0	249
52	0	0	0	7	42	135	139	68	12	3	0	0	406
Average	**0**	**0**	**0**	**18**	**84**	**36**	**64**	**45**	**37**	**2**	**0**	**0**	**286**
Minimum	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**0**	**0**	**0**	**149**
Maximum	**0**	**0**	**0**	**72**	**203**	**135**	**166**	**153**	**132**	**15**	**0**	**0**	**560**

M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 511 - Water Balance Model updates\02_Inputs\from Watershed Model\GoldSim11\[FacilitiesSurplusWater_20131015_ER.xlsx]Table_GoldOre

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	13JAN'15	ISSUED WITH LETTER VA15-01945	EER	JGC	KJB

Knight Piésold CONSULTING

TABLE B.4

CASINO MINING CORPORATION
CASINO PROJECT

OPERATIONAL NET PRECIPATION VALUES
LOW GRADE ORE STOCKPILE - SUPERGENE SULFIDE

Print Jan/13/15 11:10:07

Year	Monthly Net Precipitation (mm/mon)												Annual Net Precipitation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	0	1	79	25	72	91	20	0	0	0	287
2	0	0	0	0	165	48	19	43	32	0	0	0	308
3	0	0	0	0	62	18	167	39	37	0	0	0	324
4	0	0	0	0	84	47	44	22	22	0	0	0	218
5	0	0	0	0	171	67	28	42	13	0	0	0	322
6	0	0	0	0	50	158	117	29	25	1	0	0	380
7	0	0	0	0	67	24	38	8	58	0	0	0	195
8	0	0	0	0	114	18	0	24	17	0	0	0	174
9	0	0	0	0	188	95	80	70	36	0	0	0	469
10	0	0	0	0	130	8	19	21	88	0	0	0	266
11	0	0	0	15	81	0	127	5	28	0	0	0	257
12	0	0	0	1	111	14	0	62	74	0	0	0	261
13	0	0	0	0	95	0	17	53	28	0	0	0	192
14	0	0	0	0	152	91	48	15	26	0	0	0	332
15	0	0	0	5	156	57	48	69	6	0	0	0	341
16	0	0	0	0	125	0	80	31	5	0	0	0	241
17	0	0	0	0	97	0	89	28	44	0	0	0	258
18	0	0	0	1	167	35	47	10	14	0	0	0	274
19	0	0	0	2	132	47	23	6	16	0	0	0	226
20	0	0	0	0	60	30	136	55	29	0	0	0	309
21	0	0	0	0	162	54	60	0	47	0	0	0	323
22	0	0	0	24	25	14	44	35	80	4	0	0	226
23	0	0	0	0	52	31	116	51	77	0	0	0	327
24	0	0	0	0	160	0	78	17	43	0	0	0	298
25	0	0	0	2	135	55	59	116	25	0	0	0	391
26	0	0	0	3	119	16	45	60	32	0	0	0	276
27	0	0	0	0	111	90	115	60	36	0	0	0	413
28	0	0	0	0	116	52	89	54	4	0	0	0	315
29	0	0	0	1	90	17	58	36	63	2	0	0	266
30	0	0	0	1	148	16	85	25	9	0	0	0	284
31	0	0	0	0	102	55	0	16	31	0	0	0	204
32	0	0	0	1	142	67	0	51	65	0	0	0	326
33	0	0	0	1	161	21	50	38	61	0	0	0	331
34	0	0	0	0	187	69	42	57	5	0	0	0	360
35	0	0	0	3	245	0	72	45	26	1	0	0	393
36	0	0	0	25	119	63	30	0	30	0	0	0	267
37	0	0	0	34	20	24	111	110	5	0	0	0	304
38	0	0	0	1	211	57	103	38	38	0	0	0	447
39	0	0	0	30	28	45	1	16	42	0	0	0	162
40	0	0	0	2	104	75	18	71	49	0	0	0	319
41	0	0	0	0	197	46	104	111	130	0	0	0	588
42	0	0	0	2	74	51	136	37	29	0	0	0	328
43	0	0	0	0	114	11	94	103	5	2	0	0	329
44	0	0	0	0	77	32	55	23	24	0	0	0	210
45	0	0	0	2	226	3	44	0	98	0	0	0	372
46	0	0	0	13	137	57	111	14	37	1	0	0	370
47	0	0	0	0	125	24	40	44	9	0	0	0	242
48	0	0	0	3	83	32	53	19	87	0	0	0	278
49	0	0	0	1	109	10	85	154	44	0	0	0	403
50	0	0	0	0	137	9	0	153	21	0	0	0	319
51	0	0	0	29	30	36	119	41	10	0	0	0	265
52	0	0	0	1	63	136	140	68	13	0	0	0	421
Average	**0**	**0**	**0**	**4**	**117**	**39**	**65**	**46**	**36**	**0**	**0**	**0**	**308**
Minimum	**0**	**0**	**0**	**0**	**20**	**0**	**0**	**0**	**4**	**0**	**0**	**0**	**162**
Maximum	**0**	**0**	**0**	**34**	**245**	**158**	**167**	**154**	**130**	**4**	**0**	**0**	**588**

M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 511 - Water Balance Model updates\02_Inputs\from Watershed Model\GoldSim11\[FacilitiesSurplusWater_20131015_ER.xlsx]Table_SGS

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	13JAN'15	ISSUED WITH LETTER VA15-01945	EER	JGC	KJB

Knight Piésold CONSULTING

TABLE B.5

CASINO MINING CORPORATION
CASINO PROJECT

OPERATIONAL NET PRECIPATION VALUES
LOW GRADE ORE STOCKPILE - SUPERGENE OXIDE

Print Jan/13/15 11:10:07

Year	Monthly Net Precipitation (mm/mon)												Annual Net Precipitation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	0	44	22	24	71	90	20	0	0	0	272
2	0	0	0	0	139	48	19	43	31	0	0	0	279
3	0	0	0	2	46	17	166	39	36	0	0	0	307
4	0	0	0	0	68	47	43	21	20	0	0	0	199
5	0	0	0	5	139	66	28	41	13	2	0	0	295
6	0	0	0	0	115	72	117	29	24	6	0	0	363
7	0	0	0	1	44	24	38	7	56	0	0	0	170
8	0	0	0	0	91	18	0	24	16	0	0	0	149
9	0	0	0	0	203	48	79	69	35	0	0	0	435
10	0	0	0	3	106	7	19	20	90	0	0	0	246
11	0	0	0	42	40	0	127	4	27	0	0	0	241
12	0	0	0	3	94	14	0	62	75	0	0	0	248
13	0	0	0	1	74	0	17	52	28	0	0	0	171
14	0	0	0	0	127	90	48	14	31	0	0	0	309
15	0	0	0	29	99	57	48	68	5	0	0	0	307
16	0	0	0	1	104	0	80	31	4	0	0	0	219
17	0	0	0	4	74	0	89	27	43	0	0	0	237
18	0	0	0	5	141	34	47	9	12	0	0	0	249
19	0	0	0	10	102	47	22	5	15	1	0	0	202
20	0	0	0	4	41	29	135	54	28	0	0	0	291
21	0	0	0	1	138	53	59	0	46	2	0	0	299
22	0	0	0	38	0	17	43	34	81	10	0	0	224
23	0	0	0	0	31	30	116	50	79	5	0	0	310
24	0	0	0	0	133	0	79	16	42	0	0	0	269
25	0	0	0	54	59	54	58	115	35	0	0	0	375
26	0	0	0	45	54	16	45	59	31	0	0	0	250
27	0	0	0	0	92	89	115	60	38	0	0	0	394
28	0	0	0	0	98	51	89	53	3	0	0	0	293
29	0	0	0	9	64	16	57	35	61	15	0	0	258
30	0	0	0	53	57	15	84	25	7	0	0	0	241
31	0	0	0	39	50	54	0	16	30	0	0	0	189
32	0	0	0	49	79	66	0	50	64	0	0	0	308
33	0	0	0	32	104	20	49	38	59	0	0	0	302
34	0	0	0	4	198	24	42	56	33	0	0	0	357
35	0	0	0	52	138	0	72	44	25	10	0	0	342
36	0	0	0	62	56	62	29	0	30	0	0	0	238
37	0	0	0	34	8	23	110	109	4	1	0	0	289
38	0	0	0	5	187	56	102	37	37	0	0	0	423
39	0	0	0	48	0	51	0	15	41	0	0	0	156
40	0	0	0	24	62	74	17	70	48	0	0	0	295
41	0	0	0	2	168	45	103	110	132	0	0	0	560
42	0	0	0	11	47	50	135	36	27	0	0	0	306
43	0	0	0	0	96	11	93	102	4	7	0	0	312
44	0	0	0	0	55	31	54	22	26	3	0	0	191
45	0	0	0	58	132	2	42	0	112	0	0	0	345
46	0	0	0	72	51	56	110	14	36	12	0	0	350
47	0	0	0	2	91	23	39	43	7	0	0	0	206
48	0	0	0	37	27	31	52	18	86	0	0	0	252
49	0	0	0	6	83	9	85	153	43	0	0	0	379
50	0	0	0	3	109	8	0	152	20	3	0	0	296
51	0	0	0	44	0	38	118	40	9	0	0	0	249
52	0	0	0	7	42	135	139	68	12	3	0	0	406
Average	**0**	**0**	**0**	**18**	**84**	**36**	**64**	**45**	**37**	**2**	**0**	**0**	**286**
Minimum	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**0**	**0**	**0**	**149**
Maximum	**0**	**0**	**0**	**72**	**203**	**135**	**166**	**153**	**132**	**15**	**0**	**0**	**560**

M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 511 - Water Balance Model updates\02_Inputs\from Watershed Model\GoldSim11\[FacilitiesSurplusWater_20131015_ER.xlsx]Table_LG_SGO

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	13JAN'15	ISSUED WITH LETTER VA15-01945	EER	JGC	KJB

Knight Piésold CONSULTING

TABLE B.6

CASINO MINING CORPORATION
CASINO PROJECT

OPERATIONAL NET PRECIPATION VALUES
LOW GRADE ORE STOCKPILE - HYPOGENE

Print Jan/13/15 11:10:07

Year	Monthly Net Precipitation (mm/mon)												Annual Net Precipitation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	0	44	22	24	71	90	20	0	0	0	272
2	0	0	0	0	139	48	19	43	31	0	0	0	279
3	0	0	0	2	46	17	166	39	36	0	0	0	307
4	0	0	0	0	68	47	43	21	20	0	0	0	199
5	0	0	0	5	139	66	28	41	13	2	0	0	295
6	0	0	0	0	115	72	117	29	24	6	0	0	363
7	0	0	0	1	44	24	38	7	56	0	0	0	170
8	0	0	0	0	91	18	0	24	16	0	0	0	149
9	0	0	0	0	203	48	79	69	35	0	0	0	435
10	0	0	0	3	106	7	19	20	90	0	0	0	246
11	0	0	0	42	40	0	127	4	27	0	0	0	241
12	0	0	0	3	94	14	0	62	75	0	0	0	248
13	0	0	0	1	74	0	17	52	28	0	0	0	171
14	0	0	0	0	127	90	48	14	31	0	0	0	309
15	0	0	0	29	99	57	48	68	5	0	0	0	307
16	0	0	0	1	104	0	80	31	4	0	0	0	219
17	0	0	0	4	74	0	89	27	43	0	0	0	237
18	0	0	0	5	141	34	47	9	12	0	0	0	249
19	0	0	0	10	102	47	22	5	15	1	0	0	202
20	0	0	0	4	41	29	135	54	28	0	0	0	291
21	0	0	0	1	138	53	59	0	46	2	0	0	299
22	0	0	0	38	0	17	43	34	81	10	0	0	224
23	0	0	0	0	31	30	116	50	79	5	0	0	310
24	0	0	0	0	133	0	79	16	42	0	0	0	269
25	0	0	0	54	59	54	58	115	35	0	0	0	375
26	0	0	0	45	54	16	45	59	31	0	0	0	250
27	0	0	0	0	92	89	115	60	38	0	0	0	394
28	0	0	0	0	98	51	89	53	3	0	0	0	293
29	0	0	0	9	64	16	57	35	61	15	0	0	258
30	0	0	0	53	57	15	84	25	7	0	0	0	241
31	0	0	0	39	50	54	0	16	30	0	0	0	189
32	0	0	0	49	79	66	0	50	64	0	0	0	308
33	0	0	0	32	104	20	49	38	59	0	0	0	302
34	0	0	0	4	198	24	42	56	33	0	0	0	357
35	0	0	0	52	138	0	72	44	25	10	0	0	342
36	0	0	0	62	56	62	29	0	30	0	0	0	238
37	0	0	0	34	8	23	110	109	4	1	0	0	289
38	0	0	0	5	187	56	102	37	37	0	0	0	423
39	0	0	0	48	0	51	0	15	41	0	0	0	156
40	0	0	0	24	62	74	17	70	48	0	0	0	295
41	0	0	0	2	168	45	103	110	132	0	0	0	560
42	0	0	0	11	47	50	135	36	27	0	0	0	306
43	0	0	0	0	96	11	93	102	4	7	0	0	312
44	0	0	0	0	55	31	54	22	26	3	0	0	191
45	0	0	0	58	132	2	42	0	112	0	0	0	345
46	0	0	0	72	51	56	110	14	36	12	0	0	350
47	0	0	0	2	91	23	39	43	7	0	0	0	206
48	0	0	0	37	27	31	52	18	86	0	0	0	252
49	0	0	0	6	83	9	85	153	43	0	0	0	379
50	0	0	0	3	109	8	0	152	20	3	0	0	296
51	0	0	0	44	0	38	118	40	9	0	0	0	249
52	0	0	0	7	42	135	139	68	12	3	0	0	406
Average	**0**	**0**	**0**	**18**	**84**	**36**	**64**	**45**	**37**	**2**	**0**	**0**	**286**
Minimum	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**0**	**0**	**0**	**149**
Maximum	**0**	**0**	**0**	**72**	**203**	**135**	**166**	**153**	**132**	**15**	**0**	**0**	**560**

M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 511 - Water Balance Model updates\02_Inputs\from Watershed Model\GoldSim11\[FacilitiesSurplusWater_20131015_ER.xlsx]Table_HG

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	13JAN'15	ISSUED WITH LETTER VA15-01945	EER	JGC	KJB

Knight Piésold CONSULTING

TABLE B.7

CASINO MINING CORPORATION
CASINO PROJECT

OPERATIONAL NET PRECIPATION VALUES
SUPERGENE OXIDE STOCKPILE

Print Jan/13/15 11:10:07

Year	Monthly Net Precipitation (mm/mon)												Annual Net Precipitation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	0	44	22	24	71	90	20	0	0	0	272
2	0	0	0	0	139	48	19	43	31	0	0	0	279
3	0	0	0	2	46	17	166	39	36	0	0	0	307
4	0	0	0	0	68	47	43	21	20	0	0	0	199
5	0	0	0	5	139	66	28	41	13	2	0	0	295
6	0	0	0	0	115	72	117	29	24	6	0	0	363
7	0	0	0	1	44	24	38	7	56	0	0	0	170
8	0	0	0	0	91	18	0	24	16	0	0	0	149
9	0	0	0	0	203	48	79	69	35	0	0	0	435
10	0	0	0	3	106	7	19	20	90	0	0	0	246
11	0	0	0	42	40	0	127	4	27	0	0	0	241
12	0	0	0	3	94	14	0	62	75	0	0	0	248
13	0	0	0	1	74	0	17	52	28	0	0	0	171
14	0	0	0	0	127	90	48	14	31	0	0	0	309
15	0	0	0	29	99	57	48	68	5	0	0	0	307
16	0	0	0	1	104	0	80	31	4	0	0	0	219
17	0	0	0	4	74	0	89	27	43	0	0	0	237
18	0	0	0	5	141	34	47	9	12	0	0	0	249
19	0	0	0	10	102	47	22	5	15	1	0	0	202
20	0	0	0	4	41	29	135	54	28	0	0	0	291
21	0	0	0	1	138	53	59	0	46	2	0	0	299
22	0	0	0	38	0	17	43	34	81	10	0	0	224
23	0	0	0	0	31	30	116	50	79	5	0	0	310
24	0	0	0	0	133	0	79	16	42	0	0	0	269
25	0	0	0	54	59	54	58	115	35	0	0	0	375
26	0	0	0	45	54	16	45	59	31	0	0	0	250
27	0	0	0	0	92	89	115	60	38	0	0	0	394
28	0	0	0	0	98	51	89	53	3	0	0	0	293
29	0	0	0	9	64	16	57	35	61	15	0	0	258
30	0	0	0	53	57	15	84	25	7	0	0	0	241
31	0	0	0	39	50	54	0	16	30	0	0	0	189
32	0	0	0	49	79	66	0	50	64	0	0	0	308
33	0	0	0	32	104	20	49	38	59	0	0	0	302
34	0	0	0	4	198	24	42	56	33	0	0	0	357
35	0	0	0	52	138	0	72	44	25	10	0	0	342
36	0	0	0	62	56	62	29	0	30	0	0	0	238
37	0	0	0	34	8	23	110	109	4	1	0	0	289
38	0	0	0	5	187	56	102	37	37	0	0	0	423
39	0	0	0	48	0	51	0	15	41	0	0	0	156
40	0	0	0	24	62	74	17	70	48	0	0	0	295
41	0	0	0	2	168	45	103	110	132	0	0	0	560
42	0	0	0	11	47	50	135	36	27	0	0	0	306
43	0	0	0	0	96	11	93	102	4	7	0	0	312
44	0	0	0	0	55	31	54	22	26	3	0	0	191
45	0	0	0	58	132	2	42	0	112	0	0	0	345
46	0	0	0	72	51	56	110	14	36	12	0	0	350
47	0	0	0	2	91	23	39	43	7	0	0	0	206
48	0	0	0	37	27	31	52	18	86	0	0	0	252
49	0	0	0	6	83	9	85	153	43	0	0	0	379
50	0	0	0	3	109	8	0	152	20	3	0	0	296
51	0	0	0	44	0	38	118	40	9	0	0	0	249
52	0	0	0	7	42	135	139	68	12	3	0	0	406
Average	**0**	**0**	**0**	**18**	**84**	**36**	**64**	**45**	**37**	**2**	**0**	**0**	**286**
Minimum	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**0**	**0**	**0**	**149**
Maximum	**0**	**0**	**0**	**72**	**203**	**135**	**166**	**153**	**132**	**15**	**0**	**0**	**560**

M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 511 - Water Balance Model updates\02_Inputs\from Watershed Model\GoldSim11\[FacilitiesSurplusWater_20131015_ER.xlsx]Table_SGO

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	13JAN'15	ISSUED WITH LETTER VA15-01945	EER	JGC	KJB

Knight Piésold
CONSULTING

TABLE B.8

CASINO MINING CORPORATION
CASINO PROJECT

OPERATIONAL NET PRECIPATION VALUES
MARGINAL GRADE ORE STOCKPILE

Print Jan/13/15 11:10:07

Year	Monthly Net Precipitation (mm/mon)												Annual Net Precipitation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	0	1	36	13	36	45	11	0	0	0	141
2	0	0	0	0	77	24	10	22	16	0	0	0	148
3	0	0	0	0	28	9	83	20	18	0	0	0	158
4	0	0	0	0	39	24	22	11	10	0	0	0	105
5	0	0	0	0	80	33	14	21	7	0	0	0	156
6	0	0	0	0	41	57	59	15	12	1	0	0	184
7	0	0	0	0	30	12	19	4	28	0	0	0	93
8	0	0	0	0	52	9	0	12	8	0	0	0	82
9	0	0	0	0	111	24	40	35	18	0	0	0	229
10	0	0	0	0	60	4	10	10	46	0	0	0	130
11	0	0	0	13	31	0	64	2	14	0	0	0	124
12	0	0	0	1	52	7	0	31	38	0	0	0	129
13	0	0	0	0	43	0	8	26	14	0	0	0	92
14	0	0	0	0	71	45	24	7	14	0	0	0	161
15	0	0	0	5	68	29	24	34	3	0	0	0	163
16	0	0	0	0	59	0	40	15	2	0	0	0	117
17	0	0	0	0	44	0	44	14	22	0	0	0	125
18	0	0	0	1	78	18	24	5	7	0	0	0	132
19	0	0	0	2	61	24	11	3	8	0	0	0	108
20	0	0	0	0	27	15	68	27	14	0	0	0	151
21	0	0	0	0	76	27	30	0	23	0	0	0	157
22	0	0	0	23	0	8	22	17	41	4	0	0	116
23	0	0	0	0	21	15	58	25	40	0	0	0	160
24	0	0	0	0	75	0	39	8	21	0	0	0	144
25	0	0	0	2	62	27	29	58	16	0	0	0	194
26	0	0	0	2	51	8	22	30	16	0	0	0	130
27	0	0	0	0	51	45	58	30	20	0	0	0	203
28	0	0	0	0	54	26	44	27	2	0	0	0	153
29	0	0	0	1	41	8	29	18	31	2	0	0	130
30	0	0	0	1	68	8	42	13	4	0	0	0	135
31	0	0	0	0	47	27	0	8	15	0	0	0	98
32	0	0	0	0	67	33	0	25	32	0	0	0	159
33	0	0	0	1	75	10	25	19	30	0	0	0	160
34	0	0	0	0	110	12	21	28	5	0	0	0	177
35	0	0	0	2	113	0	36	22	13	1	0	0	188
36	0	0	0	24	43	31	15	0	15	0	0	0	128
37	0	0	0	21	4	12	55	55	2	0	0	0	150
38	0	0	0	1	101	28	51	19	19	0	0	0	219
39	0	0	0	29	0	25	0	8	21	0	0	0	84
40	0	0	0	2	47	37	9	35	24	0	0	0	155
41	0	0	0	0	93	23	52	55	66	0	0	0	289
42	0	0	0	2	32	25	68	18	14	0	0	0	159
43	0	0	0	0	53	6	47	51	2	2	0	0	161
44	0	0	0	0	34	16	27	11	14	0	0	0	102
45	0	0	0	1	106	1	22	0	53	0	0	0	183
46	0	0	0	13	53	28	55	7	18	1	0	0	175
47	0	0	0	0	57	12	20	22	4	0	0	0	115
48	0	0	0	2	36	16	26	9	43	0	0	0	134
49	0	0	0	1	50	5	43	77	22	0	0	0	197
50	0	0	0	0	63	4	0	76	10	0	0	0	154
51	0	0	0	28	0	19	59	20	5	0	0	0	131
52	0	0	0	1	28	68	70	34	6	0	0	0	207
Average	**0**	**0**	**0**	**3**	**54**	**18**	**32**	**23**	**18**	**0**	**0**	**0**	**149**
Minimum	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**82**
Maximum	**0**	**0**	**0**	**29**	**113**	**68**	**83**	**77**	**66**	**4**	**0**	**0**	**289**

M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 511 - Water Balance Model updates\02_Inputs\from Watershed Model\GoldSim11\[FacilitiesSurplusWater_20131015_ER.xlsx]Table_MGO

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	13JAN'15	ISSUED WITH LETTER VA15-01945	EER	JGC	KJB

Knight Piésold
CONSULTING

TABLE B.9

CASINO MINING CORPORATION
CASINO PROJECT

OPERATIONAL NET PRECIPATION VALUES
HEAP LEACH FACILITY

Print Jan/13/15 11:10:07

Year	Monthly Net Precipitation (mm/mon)												Annual Net Precipitation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	0	1	79	25	72	91	20	0	0	0	287
2	0	0	0	0	165	48	19	43	32	0	0	0	308
3	0	0	0	0	62	18	167	39	37	0	0	0	324
4	0	0	0	0	84	47	44	22	22	0	0	0	218
5	0	0	0	0	171	67	28	42	13	0	0	0	322
6	0	0	0	0	50	158	117	29	25	1	0	0	380
7	0	0	0	0	67	24	38	8	58	0	0	0	195
8	0	0	0	0	114	18	0	24	17	0	0	0	174
9	0	0	0	0	188	95	80	70	36	0	0	0	469
10	0	0	0	0	130	8	19	21	88	0	0	0	266
11	0	0	0	15	81	0	127	5	28	0	0	0	257
12	0	0	0	1	111	14	0	62	74	0	0	0	261
13	0	0	0	0	95	0	17	53	28	0	0	0	192
14	0	0	0	0	152	91	48	15	26	0	0	0	332
15	0	0	0	5	156	57	48	69	6	0	0	0	341
16	0	0	0	0	125	0	80	31	5	0	0	0	241
17	0	0	0	0	97	0	89	28	44	0	0	0	258
18	0	0	0	1	167	35	47	10	14	0	0	0	274
19	0	0	0	2	132	47	23	6	16	0	0	0	226
20	0	0	0	0	60	30	136	55	29	0	0	0	309
21	0	0	0	0	162	54	60	0	47	0	0	0	323
22	0	0	0	24	25	14	44	35	80	4	0	0	226
23	0	0	0	0	52	31	116	51	77	0	0	0	327
24	0	0	0	0	160	0	78	17	43	0	0	0	298
25	0	0	0	2	135	55	59	116	25	0	0	0	391
26	0	0	0	3	119	16	45	60	32	0	0	0	276
27	0	0	0	0	111	90	115	60	36	0	0	0	413
28	0	0	0	0	116	52	89	54	4	0	0	0	315
29	0	0	0	1	90	17	58	36	63	2	0	0	266
30	0	0	0	1	148	16	85	25	9	0	0	0	284
31	0	0	0	0	102	55	0	16	31	0	0	0	204
32	0	0	0	1	142	67	0	51	65	0	0	0	326
33	0	0	0	1	161	21	50	38	61	0	0	0	331
34	0	0	0	0	187	69	42	57	5	0	0	0	360
35	0	0	0	3	245	0	72	45	26	1	0	0	393
36	0	0	0	25	119	63	30	0	30	0	0	0	267
37	0	0	0	34	20	24	111	110	5	0	0	0	304
38	0	0	0	1	211	57	103	38	38	0	0	0	447
39	0	0	0	30	28	45	1	16	42	0	0	0	162
40	0	0	0	2	104	75	18	71	49	0	0	0	319
41	0	0	0	0	197	46	104	111	130	0	0	0	588
42	0	0	0	2	74	51	136	37	29	0	0	0	328
43	0	0	0	0	114	11	94	103	5	2	0	0	329
44	0	0	0	0	77	32	55	23	24	0	0	0	210
45	0	0	0	2	226	3	44	0	98	0	0	0	372
46	0	0	0	13	137	57	111	14	37	1	0	0	370
47	0	0	0	0	125	24	40	44	9	0	0	0	242
48	0	0	0	3	83	32	53	19	87	0	0	0	278
49	0	0	0	1	109	10	85	154	44	0	0	0	403
50	0	0	0	0	137	9	0	153	21	0	0	0	319
51	0	0	0	29	30	36	119	41	10	0	0	0	265
52	0	0	0	1	63	136	140	68	13	0	0	0	421
Average	**0**	**0**	**0**	**4**	**117**	**39**	**65**	**46**	**36**	**0**	**0**	**0**	**308**
Minimum	**0**	**0**	**0**	**0**	**20**	**0**	**0**	**0**	**4**	**0**	**0**	**0**	**162**
Maximum	**0**	**0**	**0**	**34**	**245**	**158**	**167**	**154**	**130**	**4**	**0**	**0**	**588**

M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 511 - Water Balance Model updates\02_Inputs\from Watershed Model\GoldSim11\[FacilitiesSurplusWater_20131015_ER.xlsx]Table_HLF

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	13JAN'15	ISSUED WITH LETTER VA15-01945	EER	JGC	KJB

Knight Piésold CONSULTING

TABLE B.10

CASINO MINING CORPORATION
CASINO PROJECT

OPERATIONAL NET PRECIPATION VALUES
TAILINGS MANAGEMENT FACILITY - BEACH

Print Jan/13/15 11:10:07

Year	Monthly Net Precipitation (mm/mon)												Annual Net Precipitation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	0	32	0	0	13	59	8	0	0	0	111
2	0	0	0	0	111	5	0	1	15	0	0	0	133
3	0	0	0	3	15	0	114	7	19	0	0	0	158
4	0	0	0	0	41	7	0	0	0	0	0	0	48
5	0	0	0	4	110	28	0	0	0	2	0	0	144
6	0	0	0	0	113	16	75	0	5	8	0	0	217
7	0	0	0	2	18	0	0	0	18	0	0	0	38
8	0	0	0	0	66	0	0	0	0	0	0	0	66
9	0	0	0	0	146	8	39	35	18	0	0	0	245
10	0	0	0	4	76	0	0	0	54	0	0	0	133
11	0	0	0	39	9	0	31	0	0	0	0	0	79
12	0	0	0	1	64	0	0	0	46	0	0	0	111
13	0	0	0	1	47	0	0	0	7	0	0	0	54
14	0	0	0	0	99	50	4	0	8	0	0	0	161
15	0	0	0	33	63	18	4	38	0	0	0	0	156
16	0	0	0	0	71	0	16	0	0	0	0	0	87
17	0	0	0	0	39	0	25	0	25	0	0	0	88
18	0	0	0	6	114	0	0	0	0	0	0	0	120
19	0	0	0	0	67	7	0	0	0	0	0	0	73
20	0	0	0	0	0	0	86	21	10	0	0	0	117
21	0	0	0	1	110	16	15	0	0	1	0	0	143
22	0	0	0	25	0	0	0	0	64	9	0	0	98
23	0	0	0	0	0	0	68	18	65	6	0	0	157
24	0	0	0	0	106	0	5	0	15	0	0	0	126
25	0	0	0	65	11	12	14	84	28	0	0	0	214
26	0	0	0	52	14	0	0	23	16	0	0	0	105
27	0	0	0	0	63	51	70	29	24	0	0	0	238
28	0	0	0	0	74	11	42	23	0	0	0	0	150
29	0	0	0	0	34	0	1	3	46	19	0	0	103
30	0	0	0	64	3	0	29	0	0	0	0	0	96
31	0	0	0	37	9	14	0	0	0	0	0	0	60
32	0	0	0	42	32	26	0	0	37	0	0	0	136
33	0	0	0	38	61	0	0	6	42	0	0	0	147
34	0	0	0	5	169	0	0	17	41	0	0	0	233
35	0	0	0	63	81	0	8	12	10	12	0	0	188
36	0	0	0	59	21	23	0	0	0	0	0	0	103
37	0	0	0	1	0	0	52	79	0	0	0	0	133
38	0	0	0	0	152	16	57	4	19	0	0	0	249
39	0	0	0	36	0	0	0	0	0	0	0	0	36
40	0	0	0	24	30	30	0	21	33	0	0	0	138
41	0	0	0	2	140	1	59	81	119	0	0	0	402
42	0	0	0	12	21	8	92	2	11	0	0	0	147
43	0	0	0	0	69	0	35	72	0	0	0	0	175
44	0	0	0	0	25	0	3	0	6	4	0	0	38
45	0	0	0	71	77	0	0	0	58	0	0	0	205
46	0	0	0	80	1	14	68	0	7	16	0	0	186
47	0	0	0	3	58	0	0	4	0	0	0	0	65
48	0	0	0	36	0	0	0	0	60	0	0	0	96
49	0	0	0	8	49	0	28	122	27	0	0	0	235
50	0	0	0	5	78	0	0	73	4	4	0	0	163
51	0	0	0	31	0	0	64	7	0	0	0	0	102
52	0	0	0	3	9	95	95	36	0	0	0	0	238
Average	**0**	**0**	**0**	**17**	**53**	**9**	**23**	**17**	**19**	**2**	**0**	**0**	**139**
Minimum	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**36**
Maximum	**0**	**0**	**0**	**80**	**169**	**95**	**114**	**122**	**119**	**19**	**0**	**0**	**402**

M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 511 - Water Balance Model updates\02_Inputs\from Watershed Model\GoldSim11\[FacilitiesSurplusWater_20131015_ER.xlsx]Table_TMFBeach

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	13JAN'15	ISSUED WITH LETTER VA15-01945	EER	JGC	KJB

Knight Piésold
CONSULTING

TABLE B.11

CASINO MINING CORPORATION
CASINO PROJECT

OPERATIONAL NET PRECIPATION VALUES
TAILINGS MANAGEMENT FACILITY - EMBANKMENT

Print Jan/13/15 11:10:07

Year	Monthly Net Precipitation (mm/mon)												Annual Net Precipitation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	0	55	5	24	71	89	20	0	0	0	264
2	0	0	0	0	129	47	19	42	30	0	0	0	268
3	0	0	0	11	33	17	166	38	35	1	0	0	302
4	0	0	0	0	61	46	43	21	20	0	0	0	191
5	0	0	0	11	122	66	28	41	12	3	0	0	283
6	0	0	0	1	121	59	116	28	23	9	0	0	357
7	0	0	0	8	29	23	38	7	56	0	0	0	161
8	0	0	0	1	82	17	0	8	15	0	0	0	122
9	0	0	0	0	189	48	79	69	35	1	0	0	420
10	0	0	0	10	90	7	18	20	89	0	0	0	234
11	0	0	0	44	33	0	102	3	27	1	0	0	210
12	0	0	0	11	82	13	0	43	74	0	0	0	223
13	0	0	0	1	65	0	7	52	27	0	0	0	153
14	0	0	0	0	117	89	47	14	31	0	0	0	299
15	0	0	0	61	61	56	48	68	4	0	0	0	298
16	0	0	0	3	92	0	78	30	3	1	0	0	207
17	0	0	0	11	58	0	87	27	42	0	0	0	226
18	0	0	0	27	112	34	46	9	12	0	0	0	240
19	0	0	0	31	74	46	21	5	14	3	0	0	195
20	0	0	0	10	29	29	134	54	27	2	0	0	284
21	0	0	0	1	126	53	59	0	40	2	0	0	281
22	0	0	0	33	0	10	43	34	80	12	0	0	212
23	0	0	0	0	24	29	115	50	78	10	0	0	307
24	0	0	0	1	117	0	71	15	41	0	0	0	246
25	0	0	0	71	34	54	58	115	36	1	0	0	369
26	0	0	0	53	38	15	44	59	31	0	0	0	240
27	0	0	0	0	84	89	115	59	37	0	0	0	384
28	0	0	0	0	91	50	88	52	2	1	0	0	285
29	0	0	0	21	47	16	57	35	61	24	0	0	259
30	0	0	0	65	27	14	84	24	6	0	0	0	221
31	0	0	0	48	35	53	0	7	29	0	0	0	172
32	0	0	0	61	60	66	0	42	63	0	0	0	292
33	0	0	0	58	68	20	49	37	59	0	0	0	291
34	0	0	0	10	179	24	41	55	53	0	0	0	363
35	0	0	0	81	79	0	71	44	24	14	0	0	313
36	0	0	0	60	45	61	28	0	21	2	0	0	218
37	0	0	0	26	7	22	109	109	4	4	0	0	281
38	0	0	0	20	162	55	102	37	36	0	0	0	412
39	0	0	0	42	0	35	0	15	40	0	0	0	133
40	0	0	0	38	41	74	16	70	47	2	0	0	288
41	0	0	0	3	154	45	103	110	131	0	0	0	545
42	0	0	0	22	30	50	135	36	27	1	0	0	300
43	0	0	0	0	87	10	93	102	3	8	0	0	304
44	0	0	0	1	47	30	54	21	25	4	0	0	183
45	0	0	0	99	77	1	42	0	102	1	0	0	321
46	0	0	0	82	33	55	109	13	35	19	0	0	347
47	0	0	0	16	63	22	39	42	7	1	0	0	190
48	0	0	0	52	8	30	52	18	85	1	0	0	245
49	0	0	0	24	56	9	84	153	42	0	0	0	368
50	0	0	0	15	87	7	0	140	20	7	0	0	277
51	0	0	0	34	0	32	118	40	8	2	0	0	233
52	0	0	0	13	31	135	138	67	12	4	0	0	400
Average	**0**	**0**	**0**	**26**	**68**	**34**	**63**	**44**	**36**	**3**	**0**	**0**	**273**
Minimum	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**122**
Maximum	**0**	**0**	**0**	**99**	**189**	**135**	**166**	**153**	**131**	**24**	**0**	**0**	**545**

M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 511 - Water Balance Model updates\02_Inputs\from Watershed Model\GoldSim11\[FacilitiesSurplusWater_20131015_ER.xlsx]Table_TMFEmbk

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	13JAN'15	ISSUED WITH LETTER VA15-01945	EER	JGC	KJB

Knight Piésold CONSULTING

TABLE B.12

CASINO MINING CORPORATION
CASINO PROJECT

OPERATIONAL NET PRECIPATION VALUES
TAILINGS MANAGEMENT FACILITY - POND

Print Jan/13/15 11:10:07

Year	Monthly Net Precipitation (mm/mon)												Annual Net Precipitation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	0	61	24	55	103	111	28	0	0	0	382
2	0	0	0	0	151	77	48	62	42	0	0	0	380
3	0	0	0	3	63	44	195	61	47	0	0	0	413
4	0	0	0	0	82	75	74	43	30	0	0	0	304
5	0	0	0	6	149	93	59	65	22	3	0	0	396
6	0	0	0	0	135	89	146	51	35	8	0	0	464
7	0	0	0	2	54	50	69	29	67	0	0	0	270
8	0	0	0	0	102	47	12	34	27	0	0	0	220
9	0	0	0	0	210	77	108	93	47	0	0	0	535
10	0	0	0	4	119	35	49	43	99	0	0	0	349
11	0	0	0	53	51	5	135	20	38	1	0	0	303
12	0	0	0	4	108	40	9	71	83	0	0	0	315
13	0	0	0	1	86	19	40	75	37	0	0	0	257
14	0	0	0	0	138	117	78	38	39	0	0	0	410
15	0	0	0	38	104	84	79	90	14	0	0	0	408
16	0	0	0	1	114	24	109	53	14	0	0	0	315
17	0	0	0	5	88	27	119	48	54	0	0	0	340
18	0	0	0	6	152	62	77	32	24	0	0	0	353
19	0	0	0	12	114	74	50	30	25	2	0	0	307
20	0	0	0	5	55	55	166	77	39	0	0	0	397
21	0	0	0	1	150	79	90	17	55	2	0	0	394
22	0	0	0	43	15	41	74	55	88	13	0	0	329
23	0	0	0	0	49	55	146	72	88	6	0	0	416
24	0	0	0	0	141	22	104	37	53	0	0	0	357
25	0	0	0	75	55	83	89	136	43	0	0	0	482
26	0	0	0	63	55	45	74	81	41	0	0	0	359
27	0	0	0	0	105	116	146	81	47	0	0	0	495
28	0	0	0	0	109	79	121	74	13	0	0	0	395
29	0	0	0	12	76	44	88	57	71	19	0	0	368
30	0	0	0	74	50	43	114	47	16	0	0	0	345
31	0	0	0	55	54	81	22	34	39	0	0	0	285
32	0	0	0	69	80	94	22	68	75	0	0	0	408
33	0	0	0	44	107	50	79	57	71	0	0	0	409
34	0	0	0	5	205	53	73	79	41	0	0	0	456
35	0	0	0	72	128	28	103	66	34	12	0	0	444
36	0	0	0	73	63	89	60	14	36	0	0	0	334
37	0	0	0	39	28	53	140	130	18	2	0	0	408
38	0	0	0	6	199	84	134	60	49	0	0	0	530
39	0	0	0	51	11	67	32	35	51	0	0	0	247
40	0	0	0	32	66	104	47	95	58	0	0	0	402
41	0	0	0	2	179	76	135	130	140	0	0	0	661
42	0	0	0	14	55	79	165	60	38	0	0	0	411
43	0	0	0	0	108	39	124	124	15	8	0	0	418
44	0	0	0	0	66	58	87	44	34	4	0	0	293
45	0	0	0	80	125	34	74	6	117	0	0	0	436
46	0	0	0	92	56	84	139	36	47	16	0	0	469
47	0	0	0	3	101	52	71	64	19	0	0	0	310
48	0	0	0	50	30	61	84	41	96	0	0	0	362
49	0	0	0	8	97	38	113	175	53	0	0	0	485
50	0	0	0	5	122	37	19	166	31	4	0	0	384
51	0	0	0	46	16	62	147	64	18	0	0	0	353
52	0	0	0	9	58	164	169	89	24	3	0	0	516
Average	**0**	**0**	**0**	**24**	**93**	**62**	**92**	**66**	**47**	**2**	**0**	**0**	**386**
Minimum	**0**	**0**	**0**	**0**	**11**	**5**	**9**	**6**	**13**	**0**	**0**	**0**	**220**
Maximum	**0**	**0**	**0**	**92**	**210**	**164**	**195**	**175**	**140**	**19**	**0**	**0**	**661**

M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 511 - Water Balance Model updates\02_Inputs\from Watershed Model\GoldSim11\[FacilitiesSurplusWater_20131015_ER.xlsx]Table_TMFPond

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	13JAN'15	ISSUED WITH LETTER VA15-01945	EER	JGC	KJB

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TABLE B.13

CASINO MINING CORPORATION
CASINO PROJECT

OPERATIONAL NET PRECIPATION VALUES
TAILINGS MANAGEMENT FACILITY - WASTE ROCK

Print Jan/13/15 11:10:07

Year	Monthly Net Precipitation (mm/mon)												Annual Net Precipitation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	0	58	6	24	71	89	20	0	0	0	269
2	0	0	0	0	134	48	19	42	31	0	0	0	274
3	0	0	0	3	43	17	166	39	36	0	0	0	303
4	0	0	0	0	65	47	43	21	20	0	0	0	195
5	0	0	0	6	133	66	28	41	13	3	0	0	290
6	0	0	0	0	126	59	117	28	24	8	0	0	362
7	0	0	0	2	39	24	38	7	56	0	0	0	165
8	0	0	0	0	87	17	0	24	15	0	0	0	144
9	0	0	0	0	196	48	79	69	35	0	0	0	428
10	0	0	0	4	101	7	19	20	90	0	0	0	241
11	0	0	0	47	33	0	127	3	27	1	0	0	238
12	0	0	0	4	90	14	0	62	75	0	0	0	244
13	0	0	0	1	70	0	17	52	27	0	0	0	167
14	0	0	0	0	122	90	47	14	32	0	0	0	305
15	0	0	0	36	87	57	48	68	5	0	0	0	301
16	0	0	0	1	99	0	80	30	4	0	0	0	214
17	0	0	0	5	69	0	89	27	43	0	0	0	233
18	0	0	0	6	136	34	46	9	12	0	0	0	244
19	0	0	0	12	96	46	22	5	14	2	0	0	197
20	0	0	0	5	37	29	135	54	27	0	0	0	287
21	0	0	0	1	133	53	59	0	46	2	0	0	294
22	0	0	0	36	0	17	43	34	81	11	0	0	222
23	0	0	0	0	27	30	116	50	78	6	0	0	306
24	0	0	0	0	127	0	79	16	41	0	0	0	263
25	0	0	0	71	37	54	58	115	37	0	0	0	371
26	0	0	0	58	38	16	45	59	31	0	0	0	247
27	0	0	0	0	88	89	115	60	38	0	0	0	389
28	0	0	0	0	94	51	88	53	3	0	0	0	289
29	0	0	0	11	59	16	57	35	61	19	0	0	258
30	0	0	0	70	30	15	84	25	7	0	0	0	230
31	0	0	0	52	36	54	0	16	29	0	0	0	187
32	0	0	0	65	60	66	0	50	64	0	0	0	305
33	0	0	0	42	88	20	49	37	59	0	0	0	296
34	0	0	0	5	190	24	41	56	41	0	0	0	358
35	0	0	0	68	109	0	72	44	25	12	0	0	330
36	0	0	0	67	46	61	29	0	30	0	0	0	233
37	0	0	0	31	8	23	110	109	4	2	0	0	286
38	0	0	0	6	181	56	102	37	36	0	0	0	418
39	0	0	0	45	0	51	0	15	41	0	0	0	152
40	0	0	0	31	51	74	16	70	48	0	0	0	290
41	0	0	0	2	163	45	103	110	131	0	0	0	554
42	0	0	0	13	41	50	135	36	27	0	0	0	302
43	0	0	0	0	92	10	93	102	4	8	0	0	309
44	0	0	0	0	50	31	54	22	26	4	0	0	186
45	0	0	0	76	105	1	42	0	114	0	0	0	338
46	0	0	0	87	33	56	110	13	36	16	0	0	350
47	0	0	0	3	84	23	39	43	7	0	0	0	198
48	0	0	0	48	12	31	52	18	85	0	0	0	246
49	0	0	0	8	78	9	85	153	43	0	0	0	375
50	0	0	0	5	104	8	0	152	20	4	0	0	292
51	0	0	0	40	0	39	118	40	8	0	0	0	245
52	0	0	0	9	38	135	139	67	12	3	0	0	403
Average	**0**	**0**	**0**	**22**	**76**	**35**	**64**	**45**	**37**	**2**	**0**	**0**	**281**
Minimum	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**0**	**0**	**0**	**144**
Maximum	**0**	**0**	**0**	**87**	**196**	**135**	**166**	**153**	**131**	**19**	**0**	**0**	**554**

M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 511 - Water Balance Model updates\02_Inputs\from Watershed Model\GoldSim11\[FacilitiesSurplusWater_20131015_ER.xlsx]Table_TMF_WR

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	13JAN'15	ISSUED WITH LETTER VA15-01945	EER	JGC	KJB

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APPENDIX C

LAKE EVAPORATION VALUES – TMF POND AND OPEN PIT LAKE

(Page C-1)

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TABLE C.1

CASINO MINING CORPORATION
CASINO PROJECT

LAKE EVAPORATION VALUES
TMF POND AND OPEN PIT LAKE

Print Jan/13/15 11:11:47

Year	Monthly Lake Evaporation (mm/mon)												Annual Lake Evaporation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	0	0	56	95	112	86	24	0	0	0	372
2	0	0	0	0	50	109	102	56	35	0	0	0	351
3	0	0	0	0	53	85	105	79	17	0	0	0	338
4	0	0	0	0	48	93	114	85	26	0	0	0	367
5	0	0	0	0	44	92	111	92	4	0	0	0	342
6	0	0	0	0	48	88	108	78	25	0	0	0	347
7	0	0	0	0	39	84	108	81	30	0	0	0	342
8	0	0	0	0	59	98	114	80	37	0	0	0	388
9	0	0	0	0	47	95	115	92	43	0	0	0	392
10	0	0	0	0	57	96	105	103	34	0	0	0	395
11	0	0	0	0	58	92	116	93	45	0	0	0	404
12	0	0	0	0	53	89	114	97	45	0	0	0	397
13	0	0	0	0	67	103	112	80	15	0	0	0	376
14	0	0	0	0	76	85	109	86	26	0	0	0	382
15	0	0	0	0	39	98	118	83	37	0	0	0	376
16	0	0	0	0	57	100	113	80	0	0	0	0	350
17	0	0	0	0	52	98	106	81	34	0	0	0	371
18	0	0	0	0	50	85	111	77	23	0	0	0	345
19	0	0	0	0	36	92	118	78	33	0	0	0	357
20	0	0	0	0	56	97	117	87	35	0	0	0	391
21	0	0	0	0	67	100	111	91	30	0	0	0	398
22	0	0	0	0	67	100	125	102	36	0	0	0	430
23	0	0	0	0	74	102	117	96	42	0	0	0	431
24	0	0	0	0	65	103	114	78	45	0	0	0	404
25	0	0	0	0	36	96	114	86	0	0	0	0	332
26	0	0	0	0	68	100	118	88	33	0	0	0	407
27	0	0	0	0	59	98	121	107	29	0	0	0	413
28	0	0	0	12	78	111	119	87	59	0	0	0	466
29	0	0	0	0	58	99	120	93	48	0	0	0	418
30	0	0	0	0	82	108	124	83	36	0	0	0	433
31	0	0	0	0	46	109	116	102	38	0	0	0	410
32	0	0	0	0	46	103	114	74	21	0	0	0	358
33	0	0	0	0	39	102	111	97	39	0	0	0	387
34	0	0	0	0	50	97	114	82	39	0	0	0	381
35	0	0	0	0	46	92	122	88	19	0	0	0	367
36	0	0	0	0	75	120	123	96	11	0	0	0	425
37	0	0	0	0	85	104	111	93	44	0	0	0	437
38	0	0	0	0	61	104	121	87	47	0	0	0	420
39	0	0	0	0	67	109	124	97	37	0	0	0	434
40	0	0	0	0	67	100	103	84	36	0	0	0	390
41	0	0	0	0	65	107	125	91	44	0	0	0	431
42	0	0	0	0	73	101	113	95	33	0	0	0	415
43	0	0	0	0	72	101	115	88	44	0	0	0	420
44	0	0	0	0	62	106	111	90	46	0	0	0	415
45	0	0	0	0	61	111	120	87	22	0	0	0	400
46	0	0	0	0	44	97	102	69	32	0	0	0	344
47	0	0	0	0	67	89	105	84	39	0	0	0	385
48	0	0	0	0	53	94	112	85	33	0	0	0	376
49	0	0	0	0	46	87	114	93	22	0	0	0	361
50	0	0	0	0	0	99	102	83	36	0	0	0	320
51	0	0	0	0	39	85	114	83	35	0	0	0	354
52	0	0	0	0	39	98	115	75	36	0	0	0	364
Average	**0**	**0**	**0**	**0**	**56**	**98**	**114**	**87**	**32**	**0**	**0**	**0**	**387**
Minimum	**0**	**0**	**0**	**0**	**0**	**84**	**102**	**56**	**0**	**0**	**0**	**0**	**320**
Maximum	**0**	**0**	**0**	**12**	**85**	**120**	**125**	**107**	**59**	**0**	**0**	**0**	**466**

M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 511 - Water Balance Model updates\02_Inputs\from Watershed Model\GoldSim11\[Temperature String for Variability Evap Modelling_20141119.xlsx]Table_Evap

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	13JAN'15	ISSUED WITH LETTER VA15-01945	EER	JGC	KJB

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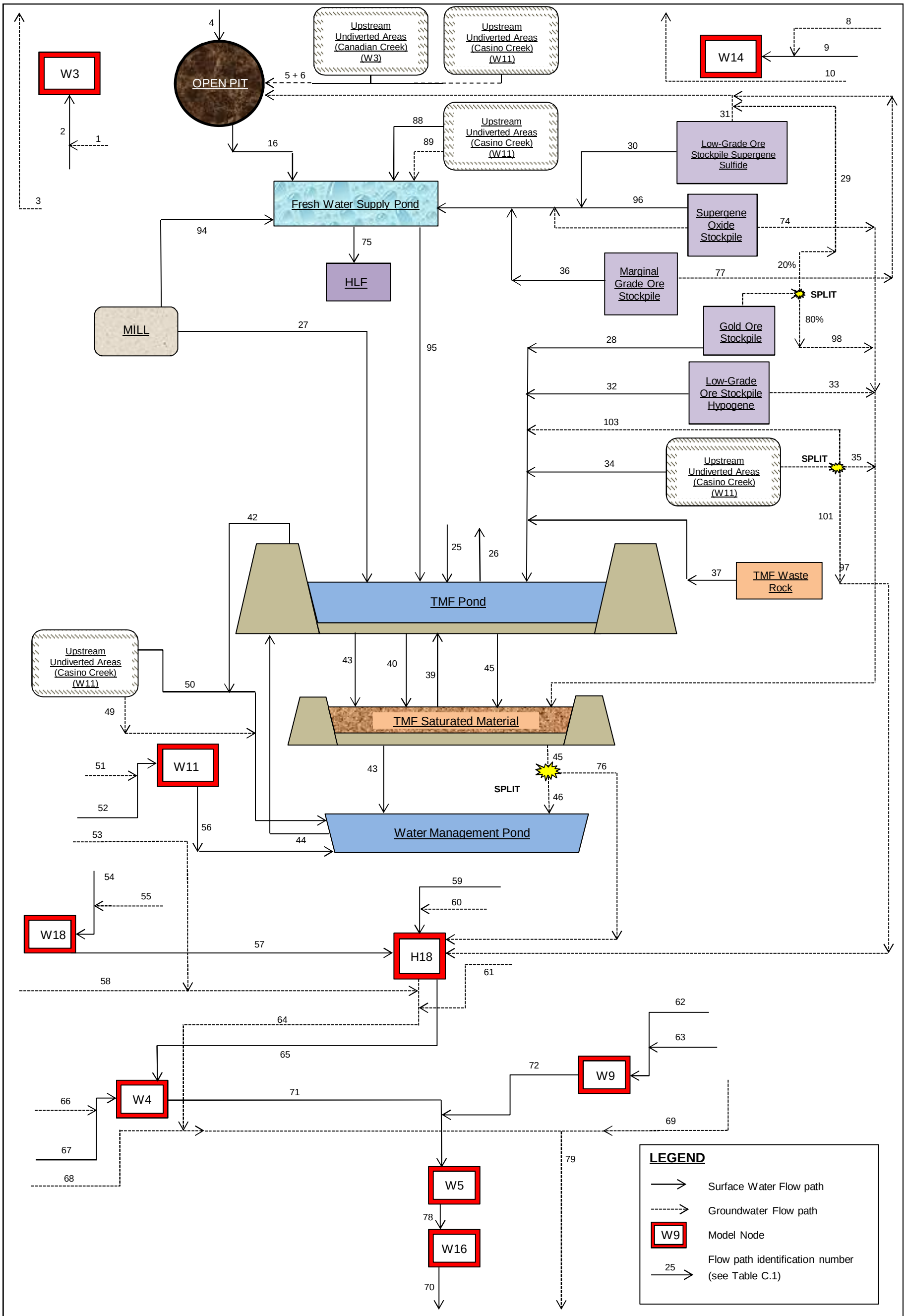
APPENDIX D

CLIMATE VARIABILITY YESAB WATER BALANCE MODEL FLOW SCHEMATICS WITH ANNUAL FLOW VALUES

(Pages D-1 to D-7)



LEGEND

- Surface Water Flow path
- Groundwater Flow path
- W9 — Model Node
- 25 — Flow path identification number (see Table C.1)

NOTES:

1. TMF AS SHOWN IS ASSUMED TO INLCUDE FRESH WATER SUPPLY POND CONTRIBUTIONS.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	13JAN'15	ISSUED WITH LETTER VA15-01945	ER	JGC	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

SITE WATER MANAGEMENT YEAR -1

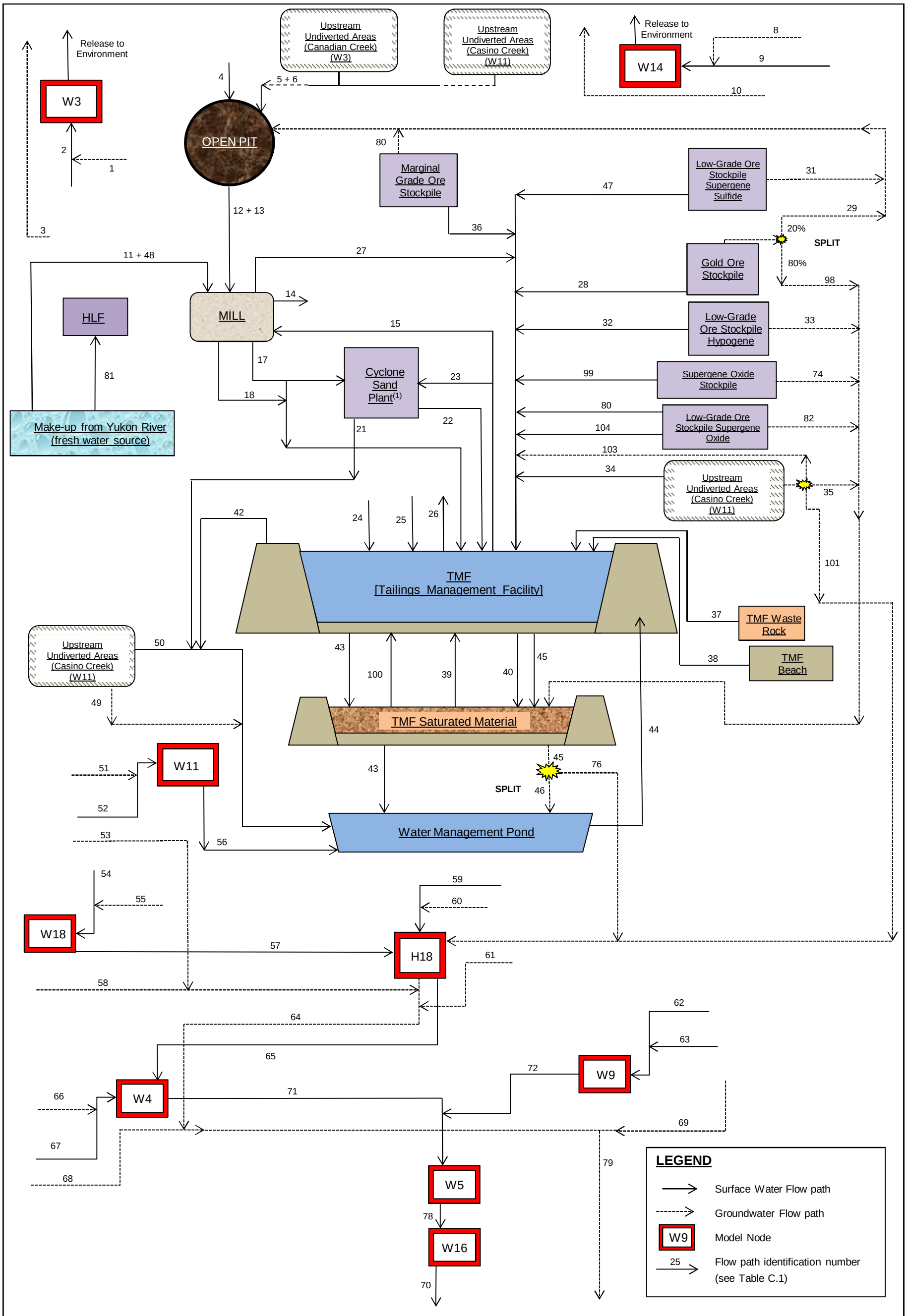
Knight Piésold CONSULTING

P/A NO. VA101-325/14

REF. NO. VA15-01945

FIGURE D.1

REV 0



NOTES:

1. THE CYCLONE SAND PLANT IS OPERATIONAL OVER A PERIOD OF 9 MONTHS DURING EACH YEAR OF OPERATIONS (TYPICALLY FROM FEBRUARY TO NOVEMBER). CYCLONING OPERATIONS ARE ASSUMED TO BE SUSPENDED OR REDUCED DURING THE COLDEST WINTER MONTHS (IN PARTICULAR DECEMBER AND JANUARY).

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	13JAN'15	ISSUED WITH LETTER VA15-01945	ER	JGC	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

WATER BALANCE MODEL SCHEMATIC YEAR 10 OF OPERATIONS

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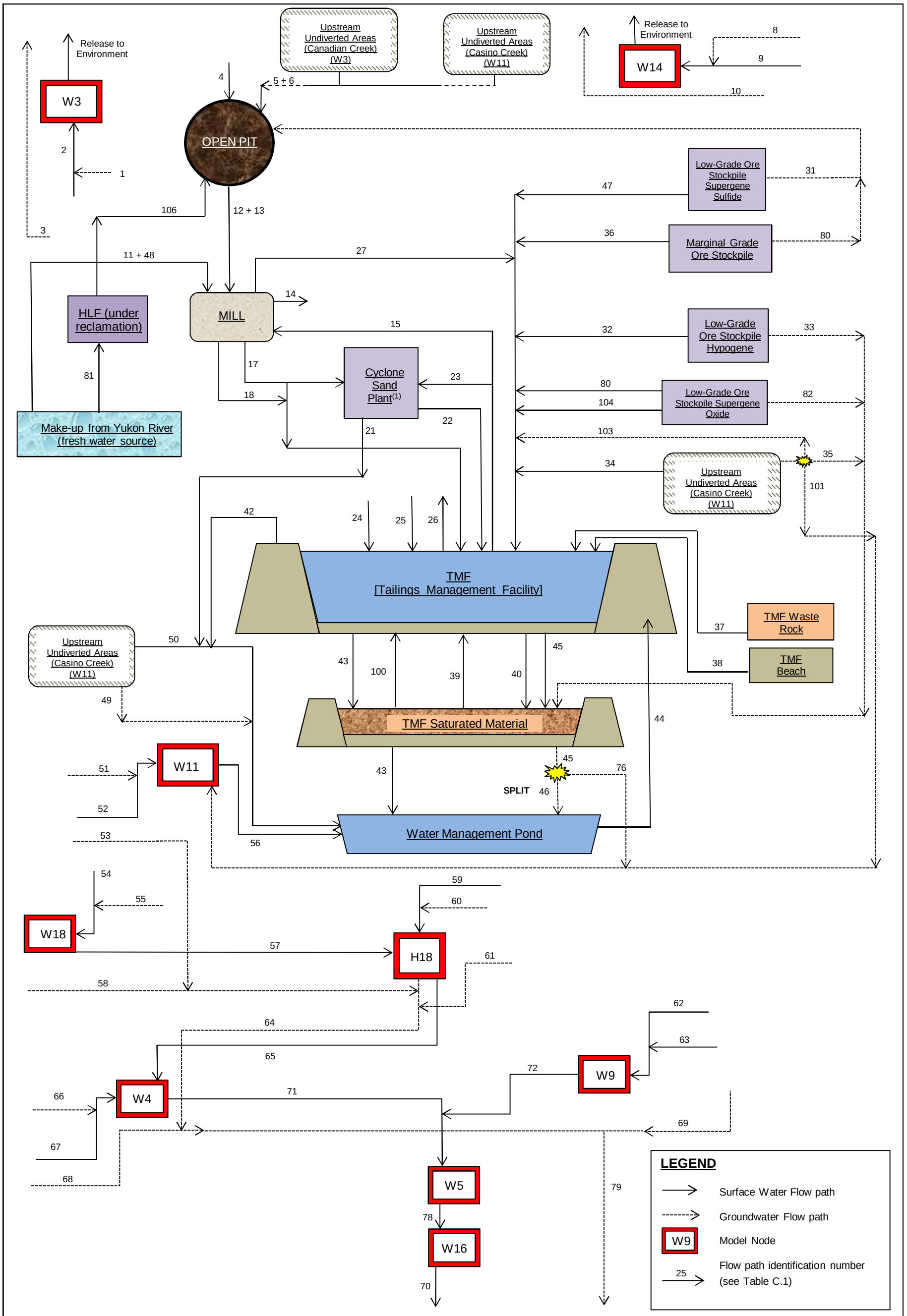
P/A NO. VA101-325/14

REF. NO. VA15-01945

FIGURE D.2

REV 0



NOTES:

1. THE CYCLONE SAND PLANT IS OPERATIONAL OVER A PERIOD OF 9 MONTHS DURING EACH YEAR OF OPERATIONS (TYPICALLY FROM FEBRUARY TO NOVEMBER). CYCLONING OPERATIONS ARE ASSUMED TO BE SUSPENDED OR REDUCED DURING THE COLDEST WINTER MONTHS (IN PARTICULAR DECEMBER AND JANUARY).

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	13JAN'15	ISSUED WITH LETTER VA15-01945	ER	JGC	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

WATER BALANCE MODEL SCHEMATIC YEAR 21 OF OPERATIONS

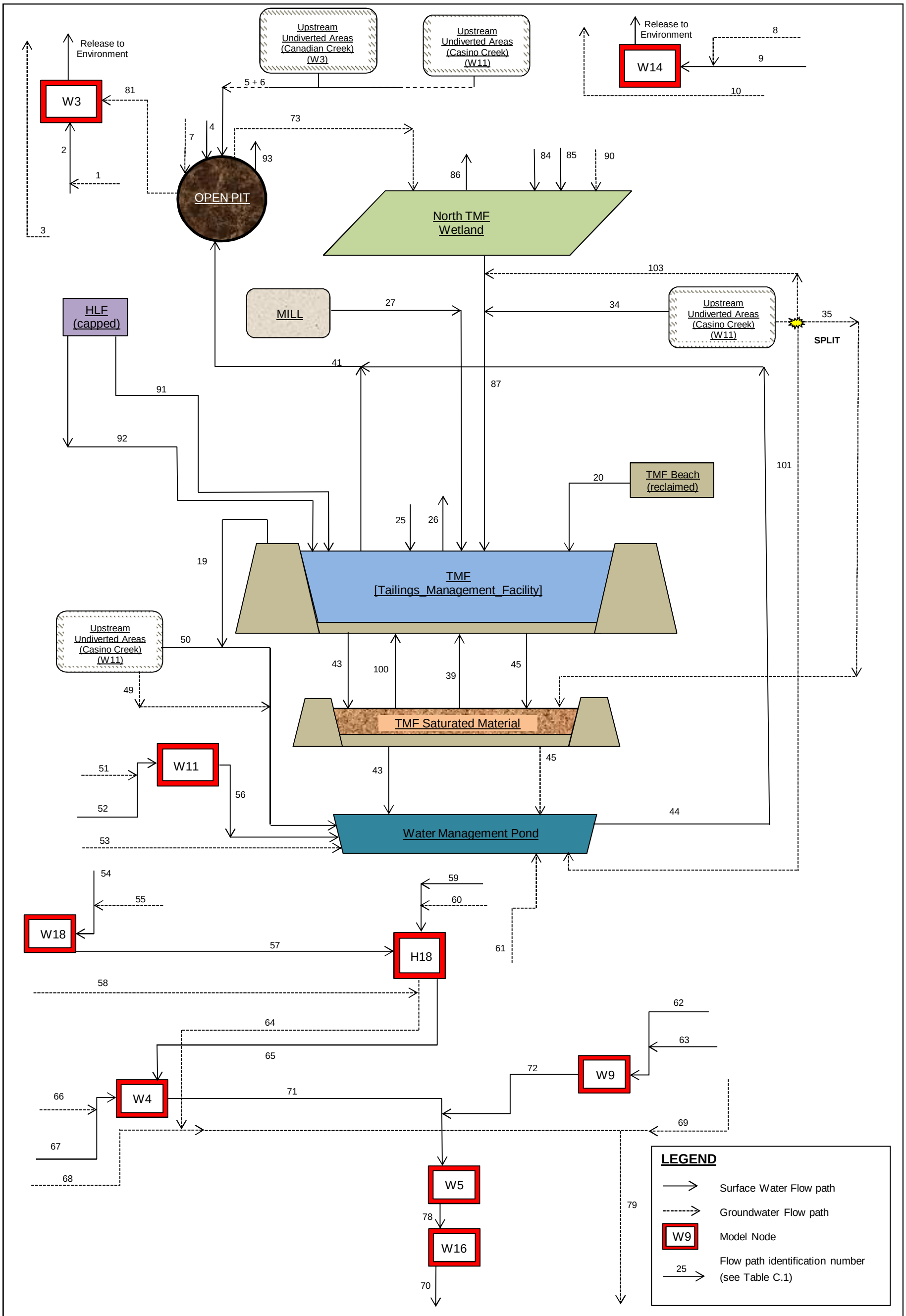
Knight Piésold CONSULTING

P/A NO. VA101-325/14

REF. NO. VA15-01945

FIGURE D.3

REV 0



NOTES:
1. THE MARGINAL GRADE ORE STOCKPILE WILL BE HAULED TO THE OPEN PIT AT CLOSURE.
2. WATER FROM THE TMF POND WILL BE PUMPED TO THE OPEN PIT FOR THE FIRST 5 YEARS OF CLOSURE.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	13JAN'15	ISSUED WITH LETTER VA15-01945	ER	JGC	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

WATER BALANCE MODEL SCHEMATIC
CLOSURE WATER MANAGEMENT PHASE I

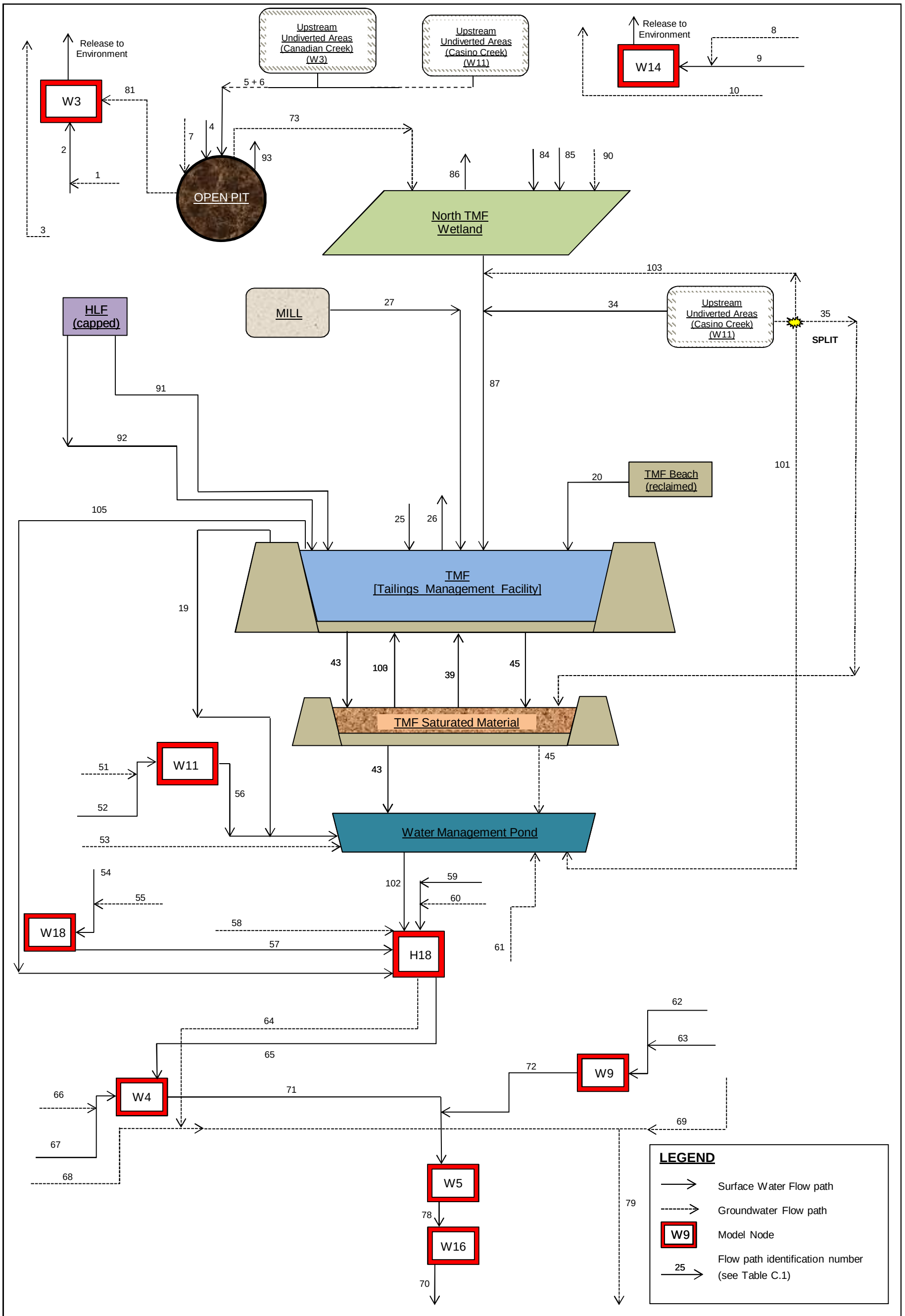
Knight Piésold CONSULTING

P/A NO. VA101-325/14

REF. NO. VA15-01945

FIGURE D.4

REV 0



NOTES:
1. THE MARGINAL GRADE ORE STOCKPILE WILL BE HAULED TO THE OPEN PIT AT CLOSURE.

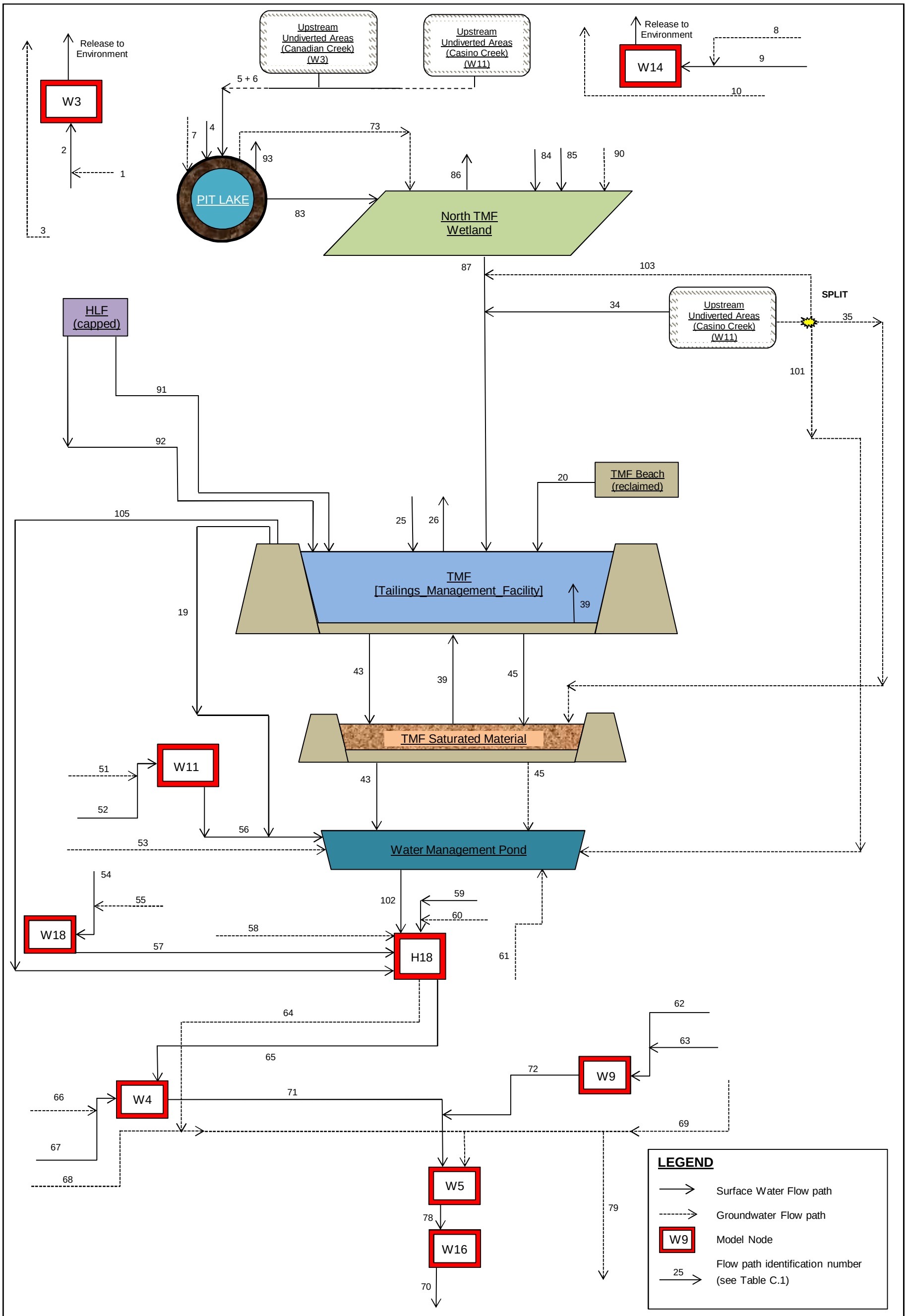
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	13JAN'15	ISSUED WITH LETTER VA15-01945	ER	JGC	KJB

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT
WATER BALANCE MODEL SCHEMATIC CLOSURE WATER MANAGEMENT PHASE II

Knight Piésold CONSULTING

P/A NO. VA101-325/14 | REF. NO. VA15-01945

FIGURE D.5 | REV 0



NOTES:
1. THE SEEPAGE COLLECTION SYSTEM IS MAINTAINED UNTIL THE SEEPAGE WATER QUALITY IS ACCEPABLE FOR DISCHARGE DOWNSTREAM INTO CASINO CREEK. AT THIS POINT THE WATER MANAGEMENT POND WILL BE DECOMMISSIONED AND ALL FLOWS WILL BE RELEASED DIRECTLY INTO CASINO CREEK.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	13JAN'15	ISSUED WITH LETTER VA15-01945	ER	JGC	KJB

CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

WATER BALANCE MODEL SCHEMATIC
CLOSURE WATER MANAGEMENT PHASE III

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P/A NO. VA101-325/14

REF. NO. VA15-01945

FIGURE D.6

REV 0

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TABLE D.1

CASINO MINING CORPORATION
CASINO COPPER-GOLD PROJECT

UPDATED WATER BALANCE MODEL
MODEL SCHEMATIC FLOW PATHS

Print Jan/13/15 10:41:24

Flow path number	Flow Routing Description	Average Annual Flow Volume (m^3/year)														
		Pre-production	Operations		Closure Phase I		Closure Phase II								Closure Phase III	
		Year -1	Year 10	Year 20	Year 25	Year 30	Year 40	Year 50	Year 60	Year 70	Year 80	Year 90	Year 100		Year 110	Year 120
1	Shallow groundwater discharge to surface water at W3	1,450,000	1,204,000	1,184,000	1,175,000	1,180,000	1,198,000	1,188,000	1,226,000	1,213,000	1,213,000	1,207,000	1,220,000		1,234,000	1,265,000
2	W3 upstream surface runoff + diverted water at W3	7,021,000	5,922,000	5,952,000	5,959,000	5,935,000	5,865,000	5,868,000	5,938,000	5,949,000	5,855,000	5,901,000	5,895,000		5,990,000	5,930,000
3	Deep groundwater to environment at W3	877,140	698,580	696,800	757,790	792,470	816,620	816,670	833,230	835,690	844,460	846,250	852,640		861,390	866,680
4	Direct precipitation on Open Pit walls	438,190	990,630	1,161,000	993,700	828,690	687,920	630,430	601,250	569,250	524,910	497,180	468,910		457,840	448,260
5	Surface runoff from W3 and W11 basins to Open Pit	149,220	99,580	1,129,000	1,130,000	1,125,000	1,100,000	1,095,000	1,112,000	1,129,000	1,104,000	1,101,000	1,102,000		1,135,000	1,123,000
6	Undiverted upstream catchment groundwater inflows from W3 and W11 basins to Open Pit	92,620	756,130	835,700	633,660	544,880	506,610	479,390	459,470	437,910	420,830	402,660	387,290		376,090	378,800
7	Direct precipitation on Pit Lake	0	0	63,780	296,650	506,700	656,220	706,270	769,790	823,290	851,750	893,380	930,240		980,990	955,980
8	Shallow groundwater discharge to surface water at W14	947,200	944,320	969,710	948,480	942,180	950,830	940,570	964,580	947,360	944,170	939,080	946,360		948,990	973,080
9	Surface water runoff at W14	5,131,000	5,153,000	5,135,000	5,171,000	5,149,000	5,125,000	5,078,000	5,155,000	5,157,000	5,095,000	5,150,000	5,132,000		5,212,000	5,137,000
10	Deep groundwater to environment at W14	763,340	758,490	762,670	758,250	757,820	763,200	757,810	761,620	757,820	759,950	757,370	757,550		759,040	763,070
11	Fresh water source to Mill via Yukon River pipeline	0	1,174,000	1,177,000	0	0	0	0	0	0	0	0	0		0	0
12	Open Pit dewatering to Mill	0	1,912,000	0	0	0	0	0	0	0	0	0	0		0	0
13	Water in ore	0	1,772,000	1,788,000	0	0	0	0	0	0	0	0	0		0	0
14	Water retained in concentrate	0	49,220	49,660	0	0	0	0	0	0	0	0	0		0	0
15	Reclaim water from TMF to Mill	0	26,890,000	29,220,000	0	0	0	0	0	0	0	0	0		0	0
16	Open Pit dewatering - during pre-production to FWSP	686,660	0	0	0	0	0	0	0	0	0	0	0		0	0
17	NAG Slurry water	0	31,890,000	32,180,000	0	0	0	0	0	0	0	0	0		0	0
18	PAG Slurry water	0	7,249,000	7,314,000	0	0	0	0	0	0	0	0	0		0	0
19	Runoff from reclaimed TMF embankment to Water Management Pond	0	0	0	343,130	340,450	341,990	339,240	342,530	342,240	341,300	343,280	341,990		344,520	341,990
20	Runoff from reclaimed TMF beach	0	0	0	98,900	98,540	98,040	96,660	98,430	98,390	97,300	98,350	98,040		99,650	98,040
21	Water in cyclone sand underflow slurry to WMP via TMF embankment	0	5,823,000	1,986,000	0	0	0	0	0	0	0	0	0		0	0
22	Water in cyclone sand overflow to TMF pond	0	35,780,000	12,130,000	0	0	0	0	0	0	0	0	0		0	0
23	Water required for sand plant during cycloning operation from TMF pond	0	22,690,000	7,693,000	0	0	0	0	0	0	0	0	0		0	0
24	Domestic waste water from camp to TMF pond	0	39,790	39,900	0	0	0	0	0	0	0	0	0		0	0
25	Direct precipitation on TMF pond	64,810	712,570	2,203,000	2,809,000	2,779,000	2,818,000	2,793,000	2,825,000	2,826,000	2,812,000	2,826,000	2,819,000		2,849,000	2,818,000
26	TMF pond evaporation	67,120	701,360	2,209,000	2,769,000	2,749,000	2,798,000	2,785,000	2,804,000	2,797,000	2,813,000	2,799,000	2,804,000		2,804,000	2,805,000
27	Mill site runoff to TMF pond	3,950	68,490	68,570	0	0	0	0	0	0	0	0	0		0	0
28	Surface runoff from Gold Ore stockpile to TMF Pond	41,030	97,530	0	0	0	0	0	0	0	0	0	0		0	0
29	Groundwater from Gold Ore stockpile to Open Pit	3,390	9,260	0	0	0	0	0	0	0	0	0	0		0	0
30	Surface water runoff from Low Grade Ore Supergene Sulfide stockpile to FWSP	690	0	0	0	0	0	0	0	0	0	0	0		0	0
31	Groundwater from Low Grade Ore Supergene Sulfide stockpile to Open Pit	1,260	37,260	24,010	0	0	0	0	0	0	0	0	0		0	0
32	Surface runoff from Low Grade Ore Hypogene stockpile to TMF pond	0	177,040	99,520	0	0	0	0	0	0	0	0	0		0	0
33	Groundwater from Low Grade Ore Hypogene stockpile to TMF saturated materials	0	84,030	54,860	0	0	0	0	0	0	0	0	0		0	0
34	Surface runoff from Casino Creek undiverted catchment to TMF pond	3,459,000	3,254,000	3,206,000	3,096,000	3,080,000	3,024,000	2,987,000	3,055,000	3,080,000	3,022,000	3,037,000	3,027,000		3,096,000	3,073,000
35	Undiverted upstream groundwater to TMF saturated material	55,210	679,070	685,140	654,920	666,310	676,900	668,810	678,910	673,940	677,200	673,210	675,210		681,970	689,200
36	Surface runoff from Marginal Grade Ore Stockpile	0	43,050	23,670	0	0	0	0	0	0	0	0	0		0	0
37	Runoff from TMF waste rock to TMF pond	118,760	824,360	604,380	0	0	0	0	0	0	0	0	0		0	0
38	TMF beach runoff to TMF pond	0	71,350	94,900	0	0	0	0	0	0	0	0	0		0	0
39	TMF saturated material pore water to TMF pond	87,100	699,020	652,390	596,890	606,510	616,150	608,680	617,450	612,860	616,000	612,250	613,930		619,410	625,500
40	Water lost from TMF pond to TMF saturated material voids	2,843,000	25,500,000	25,490,000	0	0	0	0	0	0	0	0	0		0	0
41	TMF Pond pumped to Open Pit	0	0	0	10,590,000	0	0	0	0	0	0	0	0		0	0
42	TMF embankment runoff to Water Management Pond	0	228,730	334,250	0	0	0	0	0	0	0	0	0		0	0
43	TMF embankment seepage	0	240,530	453,590	441,500	441,500	442,710	441,500	442,710	441,500	442,710	441,500	441,500		441,500	442,710
44	Water Management Pond recycle (pumped)	494,050	7,220,000	3,977,000	1,765,000	1,763,000	0	0	0	0	0	0	0		0	0
45	TMF foundation seepage	0	430,900	705,070	693,790	693,790	695,690	693,790	695,690	693,790	695,690	693,790	693,790		693,790	695,690
46	TMF foundation and embankment seepage collected in Water Management Pond	0	671,430	1,159,000	1,135,000	1,135,000	1,138,000	1,135,000	1,138,000	1,135,000	1,138,000	1,135,000	1,135,000		1,135,000	1,138,000
47	Surface water runoff from Low Grade Ore Stockpile Supergene Sulfide to TMF	0	84,120	48,230	0	0	0	0	0	0	0	0	0		0	0
48	Make-up water from Yukon River to Mill	0	4,546,000	4,436,000	0	0	0	0	0	0	0	0	0		0	0
49	Casino Creek undiverted upstream catchment groundwater to Water Management Pond	6,870	7,520	8,470	0	0	0	0	0	0	0	0	0		0	0
50	Casino Creek undiverted upstream catchment surface runoff to Water Management Pond	195,930	198,590	200,590	0	0	0	0	0	0	0	0	0		0	0
51	Shallow groundwater discharge to surface water to W11	0	0	0	0	0	0	0	0	0	0	0	0		0	0
52	Upstream surface runoff and diverted site flows to W11	17,330	14,370	11,250	10,750	10,650	10,720	10,640	10,840	10,730	10,690	10,830	10,790		10,740	10,780
53	Deep groundwater from W11 to downstream	0	0	0	0	0	0	0	0	0	0	0	0		0	0
54	Upstream surface runoff to W18	4,381,000	4,326,000	4,423,000	4,266,000	4,241,000	4,212,000	4,139,000	4,231,000	4,255,000	4,195,000	4,202,000	4,186,000		4,283,000	4,266,000
55	Shallow groundwater discharge to surface water at W18	674,380	658,220	686,830	659,100	653,800	659,040	643,480	658,690	656,500	651,060	638,380	639,120		661,420	675,600
56	Surface water from W11 to WMP	17,330	14,370	11,250	10,750	10,650	10,720	10,640	10,840	10,730	10,690	10,830	10,790		10,740	10,780
57	Surface water from W18 to H18	3,706,000	3,668,000	3,736,000	3,607,000	3,587,000	3,552,000	3,496,000	3,573,000	3,599,000	3,544,000	3,564,000	3,547,000		3,622,000	3,590,000
58	Deep groundwater from W18 to downstream	599,980	597,760	600,360	597,300	597,120	600,090	596,990	599,390	597,010	598,430	596,290	596,650		597,770	599,880
59	Upstream surface runoff from H18	202,800	206,110	209,070	208,840	206,250	208,180	205,930	210,890	208,250	207,750	210,410	209,700		208,400	209,610
60	Shallow groundwater discharge to surface water from H18	6,870	7,520	8,470	8,310	8,250	8,280	8,070	8,310	8,280	8,290	8,240	8,210		8,230	8,500
61	Deep groundwater from H18 to Water Management Pond	179,060	181,460	182,510	180,870	181,900	180,870	181,260	181,090	181,080	179,650	180,210	179,360		182,230	181,830
62	Upstream surface runoff to W9	26,400,000	26,370,000	26,670,000	26,690,000	26,510,000	26,350,000	26,160,000	26,610,000	26,640,000	26,320,000	26,520,000	26,430,000		26,750,000	26,640,000
63	Shallow groundwater discharge to surface water to W9	8,318,000	8,336,000	8,417,000	8,365,000	8,392,000	8,312,000	8,318,000	8,318,000	8,367,000	8,295,000	8,273,000	8,241,000		8,422,000	8,441,000
64	Deep groundwater from H18 to downstream	583,890	582,100	584,880	582,930	582,760	585,210	582,690	584,550	582,470	584,080	581,790	582,370		583,140	585,770
65	Surface Water from H18 to W4	4,387,000	4,333,000	4,432,000	4,600,000	4,571,000	9,782,000	9,313,000	10,260,000	10,250,000	10,080,000	10,110,000	10,050,000		12,180,000	12,090,000
66	Shallow groundwater discharge to surface water at W4	0	0	0	0	0	0	0	0	0	0	0	0		0	0
67	Upstream surface runoff to W4	1,786,000	1,800,000	1,794,000	1,791,000	1,778,000	1,783,000	1,775,000	1,801,000	1,788,000	1,778,000	1,798,000	1,792,000		1,795,000	1,792,000
68	Deep groundwater from W4 to downstream	1,246,000	1,250,000	1,254,000	1,250,000	1,252,000	1,246,000	1,248,000	1,248,000	1,249,000	1,244,000	1,243,000	1,242,000		1,254,000	1,256,000
69	Deep groundwater from W9 to downstream	453,210	451,900	453,400	451,740	451,800	453,420	451,590	453,240	451,720	452,810	451,560	451,640		451,960	453,400
70	Release to environment/surplus from W16	57,740,000	57,660,000	58,340,000	58,530,000	58,250,000	65,270,000	64,340,000	66,350,000	66,430,000	65,620,000	65,950,000	65,680,000		69,400,000	69,140,000
71	Surface water from W4 to W5	6,174,000	6,133,000	6,226,000	6,392,000	6,349,000	11,560,000	11,090,000	12,060,000	12,040,000	11,860,000	11,910,000	11,840,000		13,980,000	13,880,000
72	Surface water from W9 to W5	34,720,000	34,700,000	35,090,000	35,060,000	34,900,000	34,660,000	34,480,000	34,930,000	35,010,000	34,610,000	34,800,000	34,670,000		35,170,000	35,080,000
73	Pit Lake seepage losses to TMF Wetland - Closure and Post-Closure	0	0	0	0	0	57,750	116,500	168,820	214,720	257,620	295,440	330,810		357,630	355,650
74	Groundwater from Supergene Oxide stockpile to TMF saturated material	18,240	12,880	0	0	0	0	0	0	0	0	0	0		0	0
75	FWSP to HLF - Year -1 only	583,930	0	0	0	0	0	0	0	0	0	0	0		0	0
76	TMF foundation and embankment seepage that bypasses Water Management Pond and shows up as surface water at H18	0	0	0	0	0	0	0	0	0	0	0	0		0	0
77	Groundwater from Marginal Grade Ore Stockpile to Open Pit	1,980	19,520	12,170	0	0	0	0	0	0	0	0	0		0	0
78	Surface water from W5 to W16	40,890,000	40,840,000	41,310,000	41,450,000	41,250,000	46,220,000	45,570,000	46,990,000	47,040,000	46,470,000	46,710,000	46,510,000		49,150,000	48,970,000
79	Deep groundwater from W5 to downstream	1,699,000	1,702,000	1,707,000	1,701,000	1,704,000	1,700,000	1,699,000	1,701,000	1,700,000	1,697,000	1,694,000	1,693,000		1,706,000	1,709,000
80	Surface water runoff from Low Grade Ore Supergene Oxide stockpile to TMF pond	0	24,180	0	0	0	0	0	0	0	0	0	0		0	0
81	Fresh water source to HLF	7,540	367,810	240,540	0	0	0	0	0	0	0	0	0		0	0
82	Groundwater collection well bypass from Low Grade Ore Supergene Oxide	110	2,620	1,600	0	0	0	0	0	0	0	0	0		0	0
83	Pit Lake discharge to TMF wetland - Post Closure only	0	0	0	0	0	0	0	0	0	0	0	0		1,926,000	1,912,000
84	Upstream catchment runoff to TMF wetland	0	0	0	235,400	234,190	231,770	230,760	233,850	234,980	232,050	233,540	232,210		235,660	234,980
85	Direct precipitation on TMF wetland	0	0	0	394,190	392,100	391,820	388,760	392,740	392,890	390,970	392,810	391,820		396,030	391,820
86	Evaporation from TMF wetland	0	0	0	388,570	387,870	389,130	387,630	389,700	388,790	391,070	389,060	389,850		389,760	389,960
87	TMF wetland overflow to TMF pond	0	0	0	184,180	238,520	292,650	347,670	405,450	453,810	489,560	532,730	564,990		2,525,000	2,505,000
88	Runoff from Casino Creek undiverted catchment to FWSP - Year -1 only	632,360	0	0	0	0	0	0	0	0	0	0	0		0	0
89	Shallow groundwater from Casino Creek undiverted catchment to FWSP - Year -1 only	0	0	0	0	0	0	0	0	0	0	0	0		0	0
90	Shallow groundwater from undiverted catchment to wetland - Closure and Post-Closure	0	0	0	0	0	0	0	0	0	0	0	0		0	0
91	Non-contact surface runoff from reclaimed HLF - Closure and Post-Closure	0	0	0	0	419,320	414,540	410,530	416,410	418,690	412,860	415,300	414,830		423,390	415,870
92	HLF drain down water (Closure), HLF infiltration discharge (Post-Closure)	0	0	0	1,050,000	0	0	0	0	0	0	0	0		0	0
93	Evaporation from Pit Lake surface - Closure and Post-Closure	0	0	52,510	238,190	400,960	527,530	572,910	617,870	653,700	691,180	718,230	748,960		771,570	769,560
94	Runoff from Mill to FWSP - Year -1 only	59,040	0	0	0	0	0	0	0	0	0	0	0		0	0
95	Overflow from FWSP to TMF pond - Year -1 only	729,960	0	0	0	0	0	0	0	0	0	0	0		0	0
96	Surface runoff from Supergene Oxide stockpile to FWSP	12,220	0	0	0	0	0	0	0	0	0	0	0		0	0
97	Shallow groundwater from Supergene Oxide stockpile to FWSP	0	0	0	0	0	0	0	0	0	0	0	0		0	0
98	Groundwater from Gold Ore stockpile to TMF saturated material	13,540	37,050	0	0	0	0	0	0	0	0	0	0		0	0
99	Surface runoff from Supergene Oxide stockpile to TMF pond	2,530	55,460	29,920	0	0	0	0	0	0	0	0	0		0	0
100	Tailings pore water from TMF saturated material to TMF pond	0	10,630,000	12,370,000	2,660,000	1,546,000	1,044,000	536,600	360,690	292,610	226,130	158,410	94,610		94,610	94,870
101	Undiverted upstream groundwater that bypasses the TMF	0	0	0	0	0	0	0	0	0	0	0	0		0	0
102	Total release from Water Management Pond to H18	0	0	0	0	0	1,764,000	1,765,000	1,762,000	1,765,000	1,760,000	1,765,000	1,761,000		1,765,000	1,765,000
103	Undiverted upstream groundwater to TMF Pond	1,909,000	537,990	482,450	534,860	564,690	561,720	564,900	574,010	592,150	586,410	583,320	581,610		610,960	618,920
104	Groundwater collection well from Low Grade Ore Supergene Oxide to TMF Pond	1,000	23,570	14,380	0	0	0	0	0	0	0	0	0		0	0
105	TMF Spillway flows to H18	0	0	0	0	0	3,473,000	3,080,000	3,925,000	3,896,000	3,795,000	3,809,000	3,769,000		5,801,000	5,724,000
106	HLF surplus rinse water to Open Pit	0	0	85,180	0	0	0	0	0	0	0	0	0		0	0

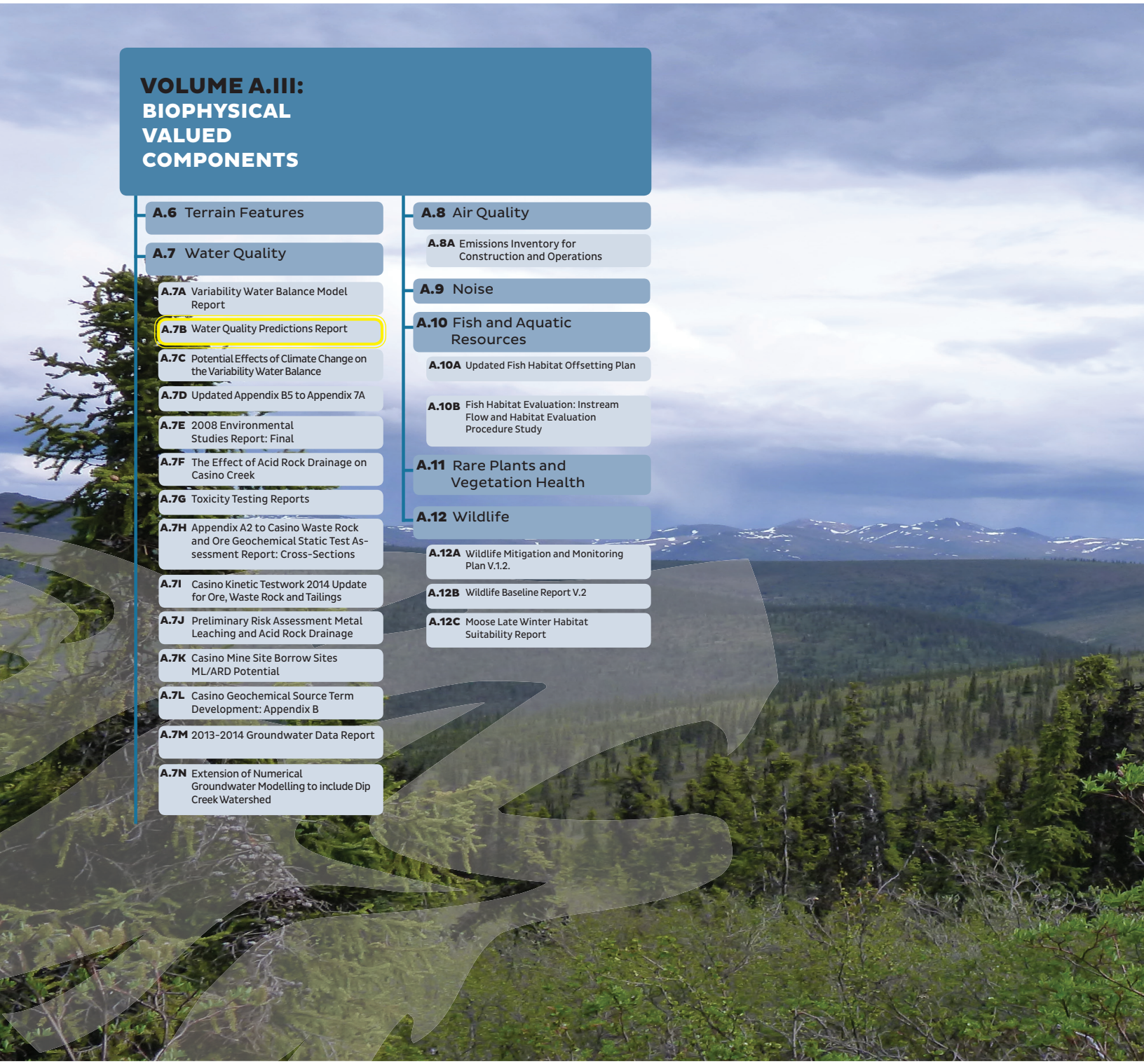
M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 511 - Water Balance Model updates\03_Results\Flow schematics_WB_025\[Master Table for all Schematics_20141218.xlsx]Table

NOTES:

1. FRESH WATER SUPPLY POND IS ASSUMED PART OF TMF.
2. TMF - TAILINGS MANAGEMENT FACILITY, WMP - WATER MANAGEMENT POND, FWSP - FRESH WATER SUPPLY POND.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	13JAN'15	ISSUED WITH LETTER VA15-01945	ER	JGC	KJB

APPENDIX A.7B: Water Quality Predictions Report



Casino Project

Water Quality Predictions

Prepared for:

CASINO
COPPER AND GOLD

Prepared by:

Source
ENVIRONMENTAL ASSOCIATES INC.

February 2015

Executive Summary

Introduction

A site-wide water quality model was developed for the proposed Casino Project. The model simulates water quality in the mine discharge and receiving environment. The model was used as a planning tool to help select water quality mitigation systems.

The site-wide water quality model is organized by the following six model components:

- Open Pit Lake
- Ore Stockpile Drainage
- Heap Leach Facility
- TMF Pond and Treatment Wetlands
- Seepage Management Pond
- Receiving Environment

The water quality model was developed within the GoldSim modelling platform, and includes 27 water quality parameters (i.e. potential contaminants). The model was run with a monthly time step for a time period beginning a few years prior to Construction, and continued for 200 years following the beginning of Operations.

A site-wide water balance was developed by Knight Piésold Limited (KPL) and was used as the basis for the water quality model. The water balance and the water quality models were fully integrated in GoldSim.

A water balance model was initially developed by KPL in 2013 and is described in KP (2013c). The 2013 water balance was representative of average annual hydrologic conditions at the site. Water quality modelling for the average annual water balance was carried out by SEA. Modelling methodology and results were reported in SEA (2013).

In 2014, a climate variability water balance model was developed by KPL (KPL, 2015) to account for the expected variability in hydrological conditions (i.e. wet and dry periods) from year to year. SEA used the climate variability water balance as the basis for the water quality model that is described herein. This report contains all information relevant to the water quality model, and repeats the pertinent information previously provided in the December 2013 report (SEA, 2013).

Input to the climate variability water balance model was developed by correlating existing site hydrology data with regional data to derive a long-term synthetic dataset of monthly site conditions. A dataset of monthly hydrological conditions (e.g. streamflow, temperature, precipitation) was developed from 52 years of continuous regional data. A

correlation was established between the regional data and data collected at the Project site. The correlation was used to convert the regional dataset to a 52-year synthetic dataset of weather conditions at the Project site. Because the model was run over a simulation period of ~200 years, the 52-year input dataset repeats approximately four times during a given simulation.

Geochemical source terms for the water quality model were developed by Lorax Environmental Services Ltd. (Lorax) and were incorporated into the GoldSim model as the basis for mass loading calculations. The source terms for the climate variability water quality model are consistent with the source terms used in the model presented in the 2013 water quality modelling report.

Geochemical modelling was integrated into the site-wide water quality model by use of dynamic links between GoldSim and PHREEQC software. The model nodes with geochemical solubility controls include the following:

- Pit Lake;
- TMF pond; and
- TMF Seepage Water Management Pond.

These nodes are locations where mixing of water streams would occur and solubility controls are expected to affect the concentrations of some water quality parameters (such as aluminum, copper and iron).

Mine drainage will enter Casino Creek (to the south) and will not enter Canadian Creek (to the north). Because there will be no mine derived sources of contaminants entering the Canadian Creek drainage basin, model predictions were limited to the Casino and Dip Creek basins.

Water Quality Mitigations

The water quality model results were used as a rationale for the selection of a number of water quality mitigation systems. Initially, copper was used as the contaminant of concern (CoC) for mitigation planning because copper was predicted to potentially exceed water quality targets by orders of magnitude based on the source terms. Once desired copper concentrations were achieved in model results, mitigations were considered for other CoCs including sulphate, fluoride, cyanide, cadmium, molybdenum, selenium, uranium, and iron.

Key Project mitigation plans for the Open Pit are as follows:

- The North TMF wetland was designed to passively treat the Pit Lake discharge. The Pit Lake water quality model results indicated that the discharge will be at

acceptable concentrations and pH for successful treatment in the North TMF wetland.

Key project mitigations included in the water quality modeling for the HLF are as follows:

- Following HLF operations, surplus water will be treated and pumped to the Open Pit until the HLF cover is in place by year 29. Treatment will include cyanide destruction and removal of selenium and mercury. Further cyanide degradation of the HLF discharge will occur as the Open Pit is filled.

- Surplus water will be directed to the Pit Lake following cyanide destruction and selenium and mercury treatment. Following drain-down, the HLF will be re-contoured and covered to promote runoff and minimize infiltration. The soil cover placed over the HLF is expected to reduce seepage from the toe of the HLF to 20% of the total net surplus water.

Key Project mitigation plans for the TMF are as follows:

- The upward migration of groundwater through the submerged waste rock in the TMF is expected to impact the water quality of the TMF Pond water. The South TMF wetland will be in place to passively treat TMF Pond water prior to discharge to Casino Creek.

- TMF pumping to the Pit Lake at closure will lower the water level in the TMF and will create suitable working conditions for the construction of the TMF wetlands.

- The placement of waste rock in the upstream (northern) end of the TMF where there will be minimal loading contribution to the foundation seepage.

The wetland passive treatment systems were designed by Clear Coast Consulting Inc. Passive treatment by the North and South wetlands was modelled as follows:

- The wetlands treat Cd, Cu, Mo, Hg, Ag, Zn to the CCME guideline;

- The wetlands treat SO_4 to 85% of the inflow concentration (i.e., 15% removal).

Key Project mitigation plans for seepage water quality management:

- Source control for one of the six ore stockpiles was identified as an appropriate Project mitigation. The groundwater seepage pathway from the southern-most ore pile was estimated to have the greatest potential influence on Casino Creek water quality. As a result, the Project proposal incorporates mitigation (e.g., groundwater seepage collection) to intercept 90% of potentially contaminated stockpile seepage. The collected discharge will be directed to the TMF pond.

- Water collected in the TMF seepage Water Management Pond (WMP) will be pumped back into the TMF Pond until the end of operations. Following

Operations, the WMP will be temporarily pumped to the Open Pit until discharge of the TMF Pond commences.

- Following mine closure, the WMP will store winter seepage and release it during the open water season when it will be mixed with the TMF Pond discharge prior to release to Casino Creek. Mixing the discharges will allow for dilution of the WMP release, especially when there is little-to-no flow expected in Brynelson Creek, a tributary to Casino Creek.

Model Results

The water quality model results for Casino Creek and Dip Creek are summarized by CoC and compared to CCME water quality guidelines. As there is no CCME water quality guideline for sulphate, the BC Water Quality Guideline (BCWQG) was adopted. Water quality guidelines are presented in this report as a point of reference and do not represent the water quality objectives adopted for the Project.

The model results are presented in two ways in this report:

1) Single Model Realization
   Results generated when one realization of the input hydrology dataset was run with the model. Single realization results provide a time-series of model output which shows a representation of water quality that would result from a realistic range in hydrological conditions at the site. The output provides an indication of how high (or low) water quality concentrations may get, and how often those results are expected to occur. Time-series plots and summary tables of water quality results for a single realization are presented throughout this report.

2) Monte-Carlo Summary (52 Realizations)
   The model was run 52 times. Each model run used a unique input hydrology dataset. The combined output from the 52 model runs (i.e., realizations) represents the range in all possible model outputs resulting from all the possible permutations of the input hydrology dataset. A statistical summary of the model output for the 52 realizations was generated to be used as the basis for the aquatic impact assesment.

The water quality results in this report do not represent an impact assessment. Palmer Environmental Consulting Group (PECG) completed the aquatic impact assessment of the Casino Project including the effects of the Project on the receiving environment downstream of the Project. EDI Consulting Services completed the wildlife impact assessment of the Casino Project including the effects of the Project resulting from the two long-term wetlands and two water bodies (Open Pit and TMF Pond) following mine closure, as presented in the Project Proposal (CMC, 2014).

The results showed that the water bodies on site (Pit Lake, TMF Pond, and WMP) will be able to produce more or less consistent inter-annual water quality in the receiving environment by balancing mine derived water between wet and dry years such that it can be released to the receiving environment when sufficient assimilative capacity is available.

The largest factor driving variation in Casino Creek water quality is the flow in Brynelson Creek because it will make up the majority of background flow in Casino Creek immediately downstream from the Project site. In low-flow years, higher concentrations can be expected in Casino Creek. The model results showed some exceedances of water quality guidelines in Casino Creek. This list includes sulphate, fluoride, cadmium, copper, iron, molybdenum, selenium, and uranium.

Site discharge water was calculated (using PHREEQC) to be pH neutral. Similarly, the resulting streamflow in Casino and Dip Creeks were calculated to be pH neutral. The model results showed some exceedances of generic water quality guidelines in Dip Creek. This list includes fluoride, cadmium, and copper. Molybdenum and sulphate guidelines were exceeded infrequently (i.e. about 3 times over the 200 year simulation). Exceedances of the water quality parameters are discussed in the impact assessment.

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Glossary

Abbreviation	Definition
BCL	Brodie Consulting Ltd
BCWQG	BC Water Quality Guideline
CAP	Leached Cap
CCME	Canadian Council of Ministers of the Environment
CMC	Casino Mining Corporation
CoC	Contaminant of Concern
HLF	Heap Leach Facility
HYP	Hypogene
KPL	Knight Piésold Ltd.
Lorax	Lorax Environmental Services Ltd.
mbgs	Metres below ground surface
MMER	Metal Mining Effluent Regulations
NAG	Non-Acid Generating
PAG	Potentially Acid Generating
PECG	Palmer Environmental Consulting Group
Project	Casino Project
SART	Sulphidization, acidification, recycling and thickening
SEA	Source Environmental Associates Inc.
SOX	Supergene oxide
SUS	Supergene sulphide
TDS	Total Dissolved Solids
TMF	Tailings Management Facility
WMP	Water Management Pond
YESAB	Yukon Environmental and Socio-economic Assessment Board

1 Introduction

The Casino Project (the Project) is a proposed open pit copper-gold-molybdenum mine in the Yukon Territory owned by Casino Mining Corporation (CMC). The Project is located at 62.74°N and 138.82°W, approximately 300 km northwest of Whitehorse, Yukon. A location map is provided in Figure 1-1. The deposit will be mined by open pit methods and processed on-site using conventional flotation cell milling methods, with an estimated nominal mill throughput of 120,000 tonnes/day of ore, over a 22 year operating life. The Project also includes a heap leach facility for cyanide leaching of gold ore.

A water quality model was developed to predict mine drainage water quality and the potential for effects on the receiving environment of the proposed Casino Mine. A site-wide water balance was developed by Knight Piésold Limited (KPL) and was used by Source Environmental Associates Inc. (SEA) as the basis for the water quality model. The water balance and the water quality models were fully integrated in GoldSim.

A water balance model was initially developed by KPL in 2013 and is described in KP (2013c). The 2013 water balance was run using average annual estimates for hydrologic conditions at the site. Water quality modelling for the average annual water balance was carried out by SEA. Modelling methodology and results were reported in SEA (2013).

In 2014, a climate variability water balance model was developed by KPL (and is described in KPL, 2015) to account for the expected variability in hydrological conditions (i.e. wet and dry periods) from year to year. SEA used the climate variability water balance as the basis for the water quality model that is described herein.

A comparison between the SEA (2013) water quality modelling report and this report is provided in Table 1-1.

Mine drainage and naturally occurring sources of potential contaminants within the hydrologic system of the Project site were characterized, and the rate of mass transport (mass loading) from each source was estimated. Flow rate (hydrologic) estimates were combined with mass loading rates to predict water quality concentrations of potential contaminants in the Project receiving waters.

This report presents the methodology and results of the water quality predictions. The main body of this report presents a summary of the water quality predictions in the mine drainage and in the receiving environment. Additional information related to modelling methodology and results are presented in Appendices to this report. This report contains all information relevant to the water quality model, and repeats the pertinent information previously provided in the December 2013 report (SEA, 2013).



Source: M3 Engineering and Technology, 2013.

Figure 1-1. Location Map

Table 1-1 Comparison between 2013 and 2015 Modelling Reports

Concept	SEA (2013) Report	Applies to this Report
Water Balance Input Dataset	Average monthly hydrologic conditions (e.g. precipitation, temperature, streamflow, etc.) were used as input for every year of the model simulation.	Inter-annual variation in hydrologic conditions was applied throughout the model simulation. Water balance output flows were calculated from a synthetic, long-term (52 year) input dataset of monthly hydrologic conditions. The synthetic dataset was derived from regional and site data. **Rationale:** Using the range of monthly flows is more conservative (compared to using average annual flows) because realistic wet and dry periods can be simulated.
Estimation of Wet and Dry Years	n/a - wet and dry years were not simulated.	1-in-10 year wet and dry years were identified in the water quality output time-series plots. **Rationale:** To illustrate how the water quality management system will perform as a results of infrequent wet/dry periods.
Monte-Carlo Analysis (Stochastic Modelling)	Stochastic modelling was not carried out.	Model simulations included 52 unique input hydrology datasets. A statistical summary was generated from the water quality model output for the 52 realizations. **Rationale:** To account for all possible water balance flow scenarios that could result from the input hydrology dataset.
Project Phase Start Dates for TMF Discharge Phase and Pit Discharge Phase	Project dates were based on KPL (2013) water balance model output.	Project dates were based on KPL (2015) water balance model results.
TMF Seepage Cut-Off System	The TMF seepage cut-off system was to be constructed after Operations. As a result, during Operations, the WMP was assumed to have a 90% capture efficiency with 10% seepage by-pass to Casino Creek. Following Operations, the seepage cut-off system was to be constructed, resulting in 100% seepage capture efficiency (i.e. 0% by-pass).	The seepage cut-off system will be constructed prior to Operations. The seepage collection system was assumed to have 100% capture efficiency during Operations and for all subsequent mine phases. **Rationale**: Reduce the potential for seepage water to enter Casino Creek during Operations.

Concept	SEA (2013) Report	Applies to this Report
Water Management Pond (WMP) / Winter Seepage Mitigation Pond (WSMP)	WMP was to be online for seepage collection during Operations. Following operations, the WSMP was to be used for seepage collection in winter and release during summer. Both facilities were essentially situated in the same location.	For all phases, the seepage collection pond(s) will be referred to as the WMP. **Rationale**: Simplification of terminology.
WMP Pumping to the Open Pit (Wetland Construction Phase)	During the Wetland Construction Phase, the WMP was assumed to be pumped to the TMF Pond.	During the wetland construction phase, the WMP will be pumped to the Open Pit. **Rationale:** Mass load from the WMP by-passes the TMF Pond by pumping directly to the Open Pit.
WMP Release to Casino Creek	Release from the seepage pond was set at a constant rate of 130 L/s from May to August with flows gradually reduced to 50 L/s by November.	Release of WMP was set to 0.8 times flow in Brynelson for typical conditions. To ensure sufficient seepage storage capacity for the following winter an increased release rate (above 0.8 times Brynelson flow) will be used during exceptionally dry periods, to drain-down the WMP. **Rationale:** The available dilution in Brynelson will be utilized by proportioning the release of WMP to the natural hydrograph.
TMF Pond Release to Casino Creek	TMF Pond was allowed to naturally overflow seasonally with no control of the flow rate.	The TMF pond will be released in a controlled manner. The ratio of TMF pond release to WMP release will be set between 1.2 to 2.5, depending on the Project Phase and the month. The ratio increases when there is little flow in Brynelson to provide dilution of the seepage released. **Rationale**: The available dilution in Brynelson is utilized by tying the release of WMP to the natural hydrograph.

Concept	SEA (2013) Report	Applies to this Report
Location of GoldSim-PHREEQC modelling nodes Embedded in the Water Quality Model	Solubility limits were calculated (using PHREEQC) for the following nodes: • Open Pit • TMF Pond • "Mixing Point" (upstream from H18 – where TMF Pond and WMP water mix)	Solubility limits were calculated (using PHREEQC) for the following nodes: • Open Pit • TMF Pond • WMP **Rationale:** Contact of WMP seepage with atmospheric conditions will occur in the WMP and chemical precipitation is more likely to occur in the WMP, rather than at the mixing point.
Pit Water Quality PHREEQC Input Assumptions	Assumption was that all available NP in the pit walls was released during submergence and fully mixed in the pit. This results in neutral pH and low copper concentration (~0.4 mg/L).	Assumption is that the available NP in the pit walls will be a source of buffering. Only the NP required for buffering is released. This change in the assumptions resulted in a predicted Pit Lake pH of about pH 6.2 and higher copper concentrations (about 5 mg/L rather than 0.4 mg/L). **Rationale:** The updated assumption used in 2015 is more conservative because not all the NP in the wall rock will be released and mixed with the pit lake during initial submergence of wall rock.
pH Prediction	pH was calculated for mine contact water (TMF Pond, WMP, Open Pit) using PHREEQC. pH was not calculated for Casino and Dip Creeks.	pH was calculated (using PHREEQC) for mine contact water, Casino Creek and Dip Creek modelling points.
CoC List	7 CoCs were reported. The CoC list did not include fluoride.	Fluoride was added as a CoC, so 8 CoCs are reported. **Rationale**: Fluoride was added as it exceeded a generic water quality guideline

2 Overview of the Proposed Mine Facilities

The following section provides a discussion of the proposed mine components and activities as they are relevant to water quality modelling. Additional information related to design and operation of the facility is provided in the Project Proposal (CMC, 2014), as well as updated information provided in the Supplementary Information Report (SIR) (CMC, 2015).

2.1 Mine System Components

The following Project facilities are proposed for the Casino Project and are described in the following sub-sections:

- Open Pit;
- Ore Stockpiles;
- Heap Leach Facility (HLF); and
- Processing Facility (mill);
- Tailings Management Facility (TMF).

2.1.1 Open Pit

Mining will be carried out by conventional open pit methods. The Open Pit will be situated between the headwaters of Casino Creek and Canadian Creek and will be up to 600 m deep and up to 2400 m wide, with an ultimate footprint area of approximately 3 km^2. The four main mineralization types found in the Open Pit are summarized in Table 2-1.

Table 2-1. Mineralization Types in the Open Pit

Mineralization Type	Acronym	Characteristics
Leached Cap (oxide gold zone)	CAP	Gold-enriched and copper-depleted. Forms the top layer (average 70 m thick) of the mineralization types in the Open Pit.
Supergene Oxide	SOX	Copper-enriched, with trace molybdenite. Generally occurs as a thin layer (10 m) above the Supergene Sulphide zone.
Supergene Sulphide	SUS	Copper mineralization occurs in an up to 200 m deep weathered zone below the leached cap and above the hypogene. Average thickness of 60 m.
Hypogene	HYP	Below the other mineralization types, also occurs throughout the various alteration zones as mineralized stock-work veins and breccias.

2.1.2 Ore Stockpiles

Temporary storage of ore will be required to provide a steady input to the mill and to the HLF throughout Operations. Ore types will be separated and placed into six stockpiles based on ore grade and mineralization type (Table 2-2).

Mitigation measures to reduce groundwater seepage will be installed for the Low Grade Supergene Oxide pile to reduce loading to the environment. The seepage reduction mitigation was assumed to have 90% load reduction efficiency in the water quality model.

Table 2-2. Casino Ore Stockpiles

Ore Stockpile Name	Project Years [1]	
	Stockpiling	Processing
Supergene Oxide Ore	-3 to 1	4 to 12
Gold[2]	-2 to 3 & 8 to 10	4 to 7 & 11 to 15
Low Grade Supergene Oxide	-1 to 15	19 to 22
Low Grade Hypogene	2 to 17	19 to 22
Low Grade Supergene Sulphide	-1 to 16	19 to 22
Marginal Grade	-2 to 4	Backfilled to Open Pit

1. Project Years are relative to the first year of ore processing in the Mill, described in Section 2.2.
2. Leached Cap (CAP) rock to be processed in the HLF.

2.1.3 Ore Processing Facility (Mill)

Ore processing consists of primary crushing followed by a mill circuit and conventional copper/molybdenum flotation to produce molybdenum and copper concentrates. Process water will be supplied by reclaim from the TMF Pond with makeup water supplied from the Yukon River. The process will produce two tailings slurry streams: Non-Acid Generating (NAG) and Potentially Acid Generating (PAG). M3 Engineering and Technology (2013) estimated that 80% (by mass) of the total tailings will be NAG, and the remaining 20% will be PAG.

2.1.4 Heap Leach Facility (HLF)

The HLF will process crushed gold ore using a cyanide leach system. The HLF will be constructed in a small valley upslope from Casino Creek, 1 km south of the Open Pit. An earthen embankment at the eastern end of the pad will provide structural support. A composite liner system will be constructed below the HLF to minimize seepage into groundwater. A spill and runoff control collection system (Events Pond) will be constructed immediately down slope from the heap leach pad. The completed HLF and associated infrastructure will encompass approximately 1.3 km^2 (KPL, 2013a).

2.1.5 Tailings Management Facility (TMF)

Tailings and waste rock will be stored in the TMF, located in the Casino Creek valley southeast of the open pit. Two embankments, the Main Embankment, and the West Saddle Embankment will be constructed across the Casino Creek valley to create the storage impoundment. The finished TMF will have a footprint area of approximately 11 km^2, and a final water surface elevation of approximately 990 m.

Waste rock and PAG tailings will be stored subaqueously to maintain a saturated state and inhibit oxidation and potential reactivity. A portion of the NAG tailings will be processed in the cyclone sand plant to produce material for construction of the TMF embankments. The remainder of the NAG tailings will be stored in the TMF.

The TMF Water Management Pond (WMP) will be constructed downstream from the embankments to recover seepage and runoff from the embankments. The recovered seepage will be pumped back into the TMF Pond during mine Operations, and to the Open Pit for a few years following Operations, and will discharge to Casino Creek following Closure.

2.2 Project Water Management Phases

The Casino Project life was sub-divided into five water management phases (Table 2-3) in this document. Project years are described relative to the beginning of milling Operations. For example, Year -2 refers to the second year before Operations begins, and Year 2 refers to the second year of Operations. Relevant information related to water quality modeling is provided in the following sub-sections.

Project phases are based on the best estimate years provided by KPL in the climate variability water balance model report (KPL, 2015). Water balance model results indicated that the pit will most likely fill to its storage capacity and discharge to the North Wetland between Year 105 and Year 110, however, KPL has established Year 109 as the best estimate for the beginning of the Pit Discharge Phase. Therefore, Year 109 is used in Table 2-3.

Table 2-3 shows the project years that were presented in the 2013 report (SEA, 2013), for comparison. Mine years for the beginning of the TMF Discharge Phase and the Open Pit Discharge Phase differ slightly from those reported in the SEA (2013) report. The reason for this difference comes from a revision to WMP pump-out during the Wetland Construction Phase. In the 2013 version, the WMP was assumed to be pumped to the TMF Pond. In the 2015 revision, the WMP was assumed to be pumped to the Open Pit. As a result, reduced inflow to the TMF Pond led to a slightly longer time until initial discharge of the TMF Pond. Conversely, the increased inflow to the Open Pit led to a slightly shorter time to pit filling, and initial discharge, compared to the 2013 model results.

Table 2-3. Water Management Phases

Water Management Phase	Abbreviation	Project Year	
		SEA (2013) Report	Applies to this Report
Construction Water Management	Construction	-4 to -1	-4 to -1
Operations Water Management	Operations	1 to 22	1 to 22
Wetland Construction Phase (zero discharge from the mine site to Casino Creek continues during this phase)	Wetland Construction	23 to 30	23 to 34
TMF Discharge Phase (the TMF Pond and WMP will discharge to Casino Creek during this phase)	TMF Discharge	31 to 112	35 to 109
Open Pit Discharge Phase (the Pit Lake will have filled and discharges to the TMF Pond during this phase)	Pit Discharge	>113	> 109

2.2.1 Construction (Year -4 to Year -1)

Project construction is expected to take four years to complete. Activities relevant to water quality modelling include:

- Open Pit stripping of overburden and mining the top layer of ore;
- ore stockpile development;
- construction and operation of a fresh water supply pond (for interim use);
- construction of the fresh water supply pipeline from the Yukon River;
- construction of the Mill;
- construction and operation of the WMP downstream from the TMF footprint;
- construction of the cyclone sand plant;
- TMF embankment development; and
- construction and operation of the HLF.

Open Pit construction will begin by overburden stripping and stockpiling, followed by mining of the CAP rock from the Open Pit. The gold ore (from the CAP rock) that is removed from the Open Pit during the construction phase will be placed in a temporary stockpile (Gold Ore Stockpile), and processing by heap leaching will begin in Year -3.

The fresh water supply pipeline from the Yukon River will be constructed and operational by the end of the Construction Phase. While the water supply pipeline is under construction, a fresh

water supply pond will be constructed on Casino Creek (at the north end of the TMF area) to provide an interim source of fresh water for use by the HLF.

Local borrow material and suitable waste rock from Open Pit stripping will be used for initial construction of the TMF starter Main Embankment and the West Saddle Embankment. A reclaim water pond upstream from the Main Embankment will collect surface runoff and precipitation to provide mill start-up water for initial ore processing.

2.2.2 Operations (Year 1 to Year 22)

Milling Operations will commence in Year 1 and will continue to the end of Year 22. A portion of the NAG tailings produced in the milling process will be cycloned in the Cyclone Sand Plant for construction of the TMF embankments. During Operations, unused NAG tailings (including overflow from the Cyclone Sand Plant), PAG tailings, and waste rock will be disposed of in the TMF. Waste rock will be placed at the north end of the TMF at an elevation above the level of the supernatant pond to provide a dry, stable placement surface for machine access and waste rock deposition. Seepage water losses from the TMF will be collected in the WMP (downstream of the embankments) and pumped back to the TMF throughout Operations.

Mining of the Open Pit will be carried out from Year 1 until the end of Year 19. The pit will be dewatered by pump and pipeline systems and the water will be used as make-up water in the Mill.

The low grade ore stockpiles will be processed during the final four years of Operations (Year 19 to Year 22). The waste rock area will be covered by a layer (approximately 3 m thick) of NAG tailings produced by the processing of the low grade ore.

Ore stacked in the HLF will be processed until the end of Year 14. Crushed oxide gold ore sequentially piled in the HLF will be leached with an aqueous cyanide solution and the pregnant solution extracted for gold and copper using a SART facility, until the end of Year 18. Surplus barren solution will be treated in a cyanide destruction facility. Supplementary water will be supplied from the fresh water pipeline.

A general layout of the Project is provided in Figure 2-1 to illustrate the site conditions during Operations.

2.2.3 Wetland Construction Phase (Year 23 to Year 34)

The primary objective of the mine closure and reclamation initiative will be to achieve long-term physical and geochemical stability of the reclaimed mine components to ensure acceptable water quality in the receiving environment. The proposed closure plan is to flood waste rock and tailings stored in the TMF and to allow the Open Pit to flood to create a Pit Lake. Additional information related to mine closure activities are provided in the *Casino Project Conceptual Reclamation and Closure Plan* (BCL, 2013), included as part of the Project Proposal.

The Wetland Construction Phase is presented in this document as the period of time immediately following ore processing, when water will be actively managed at some locations and the site will remain a zero discharge facility.

Closure of the Open Pit will begin prior to Year 23. Mining of the Open Pit will be completed by the end of Year 19. Dewatering will be discontinued, and the Open Pit will be allowed to fill with groundwater, overland runoff, and direct precipitation.

Water from the TMF will be pumped to the Open Pit from Year 23 to Year 27 (inclusive). Pumping to the Open Pit will stop at the beginning of Year 28, and the TMF Pond will be allowed to fill with surface runoff, precipitation and groundwater inflow to its maximum storage capacity. Filling of the TMF Pond was predicted by KPL (2015) to be complete by the end of Year 34.

Water from the WMP (mostly tailings embankment runoff and TMF seepage) will be pumped to the Open Pit until the time when TMF Pond discharges to Casino Creek.

Closure of the HLF will begin before Year 23 with an ore rinsing process (Year 19 to Year 23), followed by drain down (Year 24 to Year 28). Surplus rinse water and drain down water will be treated in a cyanide destruction facility and then pumped to the Open Pit. The final slopes of the HLF ore will be graded, covered, and re-vegetated to provide adequate drainage and erosion protection from surface runoff. Surface runoff and seepage from the toe of the HLF will flow to the TMF beginning in Year 28.

Some residual ore may be present in the surface ore stockpiles following mine closure if the ore is not economical to process. Unprocessed ore will be placed in the Open Pit. For closure planning purposes, BCL (2013) assumed that the Gold Ore and Supergene Oxide Ore would be processed completely, while 5% of the low grade ores would remain at the end of mining. BCL (2013) conservatively assumed that none of the Marginal Ore will be processed. The 5% low grade ore remainder and 100% of the Marginal Grade Ore will be disposed of in the Open Pit. The reclaimed stockpile footprints will be covered with stockpiled overburden and re-vegetated.

Construction of two engineered wetlands within the TMF will begin during this phase. The wetlands are intended to perform as long-term passive water treatment systems for removal of contaminants by chemical precipitation and biological processes. The North TMF Wetland will be constructed for treatment of the discharge from the Pit Lake. The South TMF Wetland will be constructed immediately upstream of the TMF spillway for removal of contaminants from the TMF Pond prior to discharge to Casino Creek.

2.2.4 TMF Discharge Phase (Year 35 to 109)

The TMF Discharge Phase will begin immediately after the TMF Pond reaches its maximum capacity and overflows to Casino Creek via the TMF Closure Spillway. KPL (2015) predicted

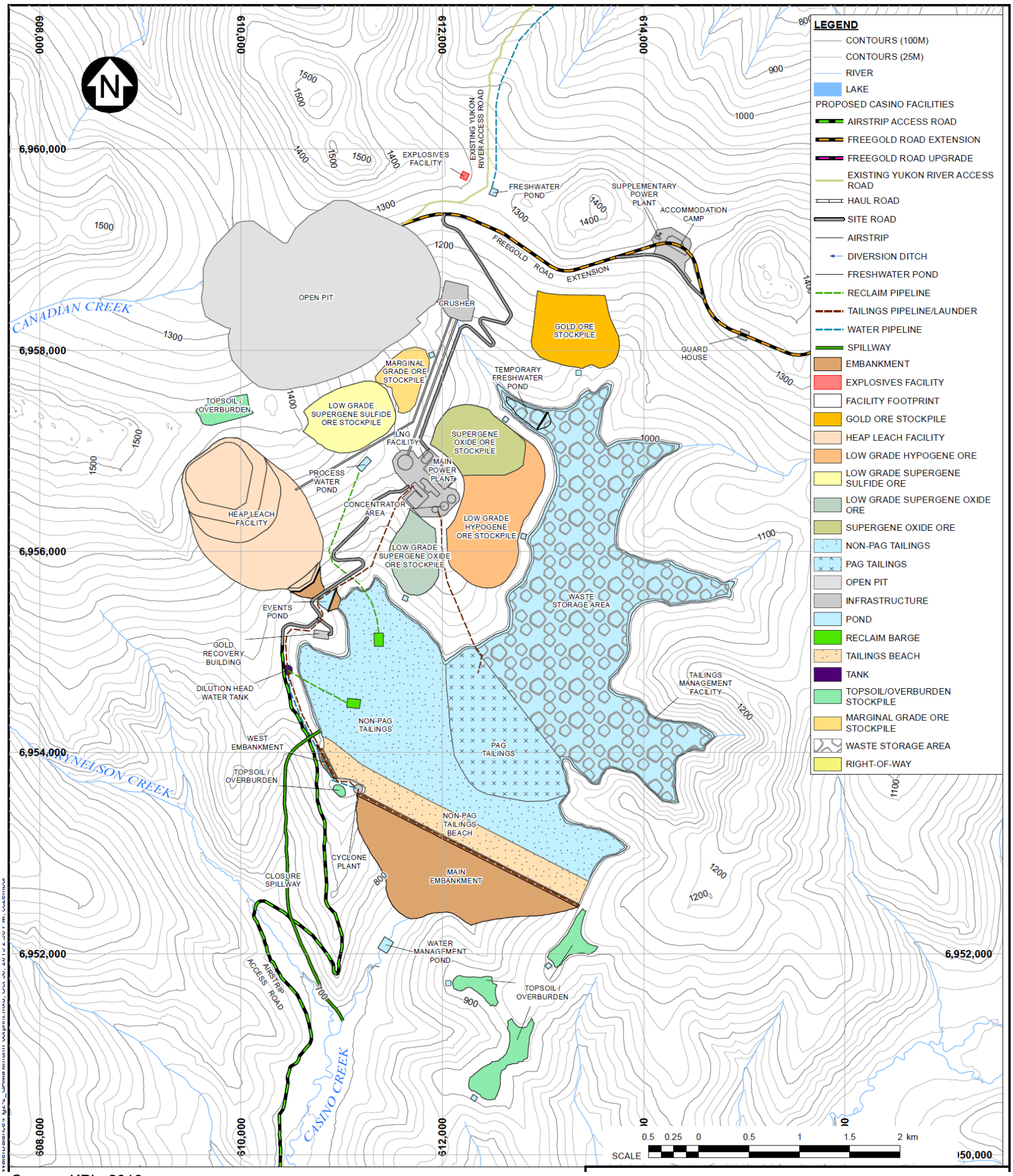
initial discharge of the TMF to occur during Year 35. The TMF Pond water will travel through the TMF South Wetland for passive treatment prior to release into Casino Creek.

Starting in Year 35, seepage recovered downstream from the TMF embankments will be stored in the Water Management Pond (WMP) through the low flow months of the year (winter), and released during the remaining months when the TMF Pond water discharges via the Closure Spillway, such that the seepage water quality will be less influential on the water quality in Casino Creek.

2.2.5 Pit Discharge Phase (Year 109+)

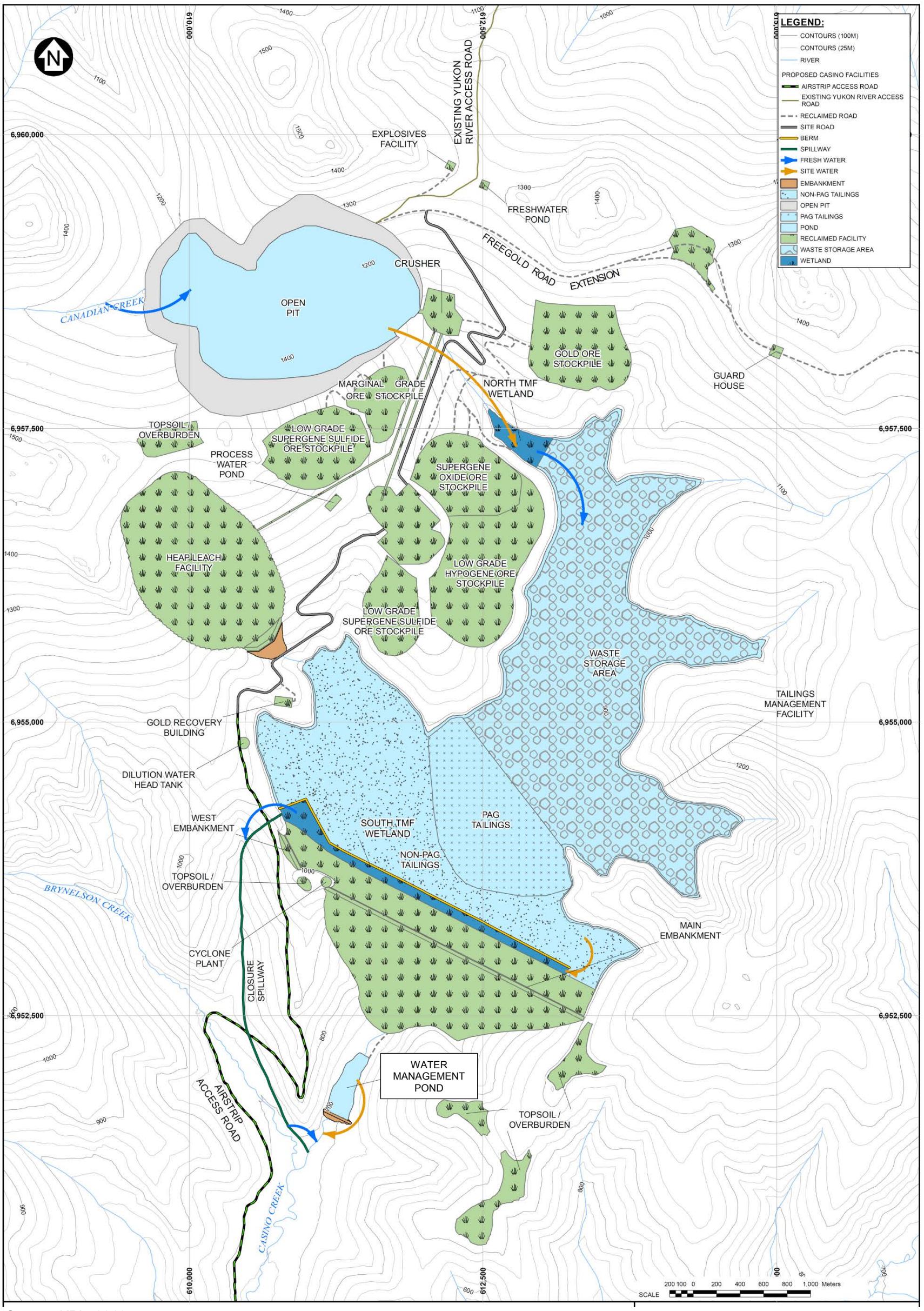
Eventually (approximately 90 years following the cessation of mining), the Pit Lake will fill to its maximum water storage capacity and will discharge to the North TMF Wetland treatment system, which will be constructed at the northern end of the TMF. Treated effluent from the wetland will discharge to the TMF Pond.

Layout of the Project site during Pit Discharge is provided in Figure 2-2 to illustrate the long-term site conditions including: the final Open Pit Lake, reclaimed HLF and stockpile areas, TMF pond, and wetland treatment systems.



Source: KPL, 2013c

Figure 2-1. Site Plan Showing Proposed Mine Components (Operations)



Source: KPL, 2013c

Figure 2-2. Site Plan Showing Proposed Mine Components (Pit Discharge Phase)

3 Existing Site Conditions at the Casino Project

A discussion of the existing environmental conditions as they are relevant to water quality modelling is provided in the following section. This section is unchanged from Section 3 of SEA (2013).

3.1 Physiography

The Casino Project property is located in the west central Yukon, in the north-westerly trending Dawson Range Mountains. The Dawson Range forms a series of rounded ridges and hills that reach a maximum elevation of 1675 m with moderate to deeply incised valleys. Major drainage channels extend below 1000 m elevation. The Yukon River is about 16 km north of the Project site and flows to the west. Most of the Casino Project lies between the 650 m elevation at Dip Creek and an elevation of approximately 1400 m on Patton Hill near the proposed open pit (M3 Engineering, 2013).

3.2 Climate

The climate at the Casino Project area is continental and cold. Winters are long, cold and dry, with snow typically on the ground from September through June. Summers are short, mild, and wet, with the greatest monthly precipitation falling in July.

Site weather data was initially collected by KPL (previously Hallam Knight Piesold) from 1993 to 1995. A new weather station was established in 2008 at approximately the same location at an elevation of approximately 1200 m (Figure 3-1) and has been operational since that time. Monthly average climate conditions at Casino (for an elevation of 1200 m) were derived by KPL (2013d), and are presented in Table 3-1.

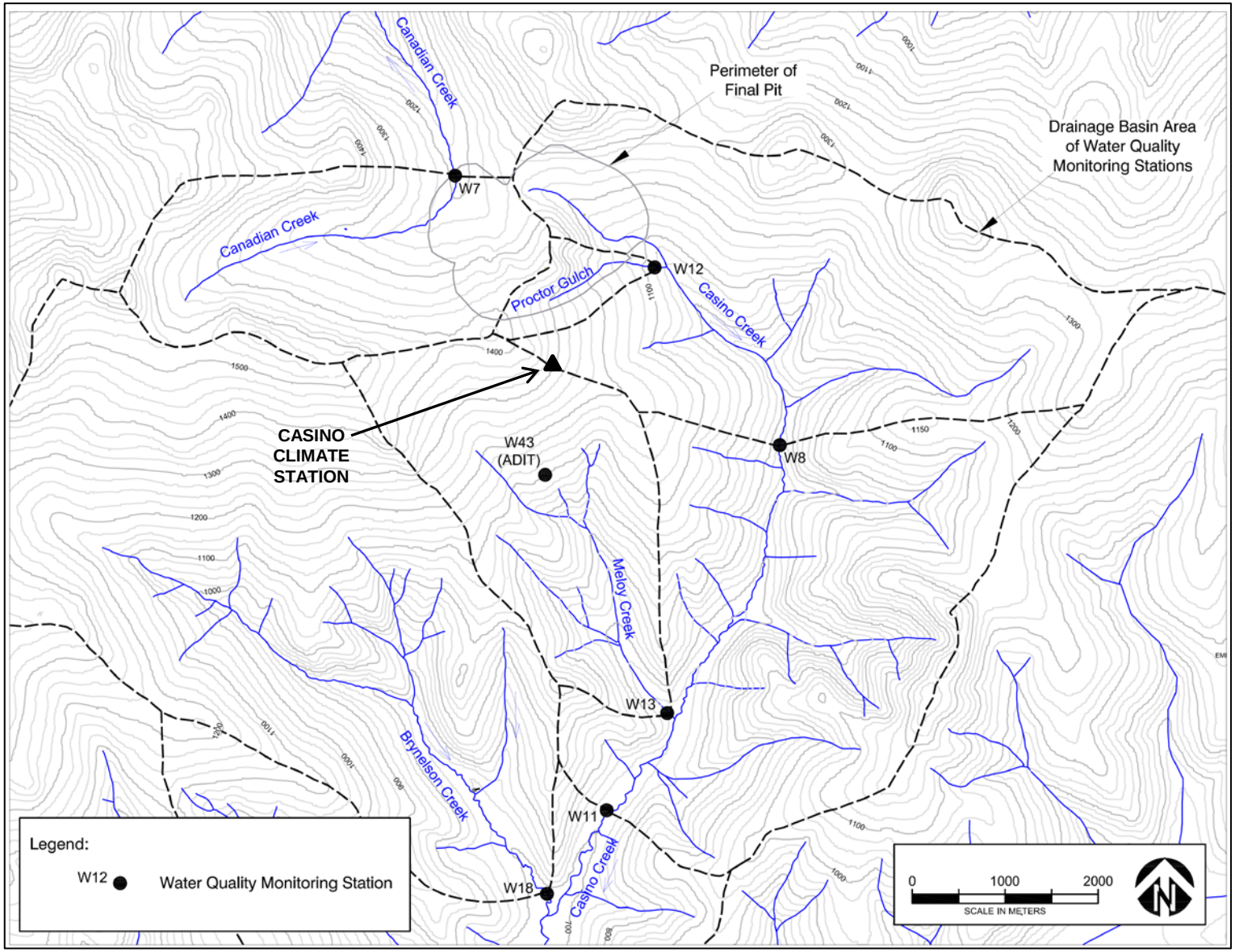


Figure 3-1. Climate and Water Quality Monitoring Stations at the Project Site

Table 3-1. Average Monthly Climate Conditions at the Casino Project Site

Month	Temp-erature (°C)	Evap-oration (mm)	Precip-itation (mm)	Rainfall (mm)	Snowfall (mm)	Snowmelt (mm)
Jan	-18.0	0	25	0	25	0
Feb	-14.2	0	19	0	19	0
Mar	-9.7	0	15	0	15	0
Apr	-1.9	2	13	0	13	15
May	4.9	43	37	37	0	85
Jun	9.9	72	62	62	0	0
Jul	11.4	79	91	91	0	0
Aug	9.0	68	67	67	0	0
Sep	3.7	37	48	48	0	0
Oct	-4.4	1	28	0	28	0
Nov	-12.1	0	31	0	31	0
Dec	-16.3	0	24	0	24	0
Average	**-3.2**		**38**			
Total		**303**	**460**	**305**	**155**	**100**

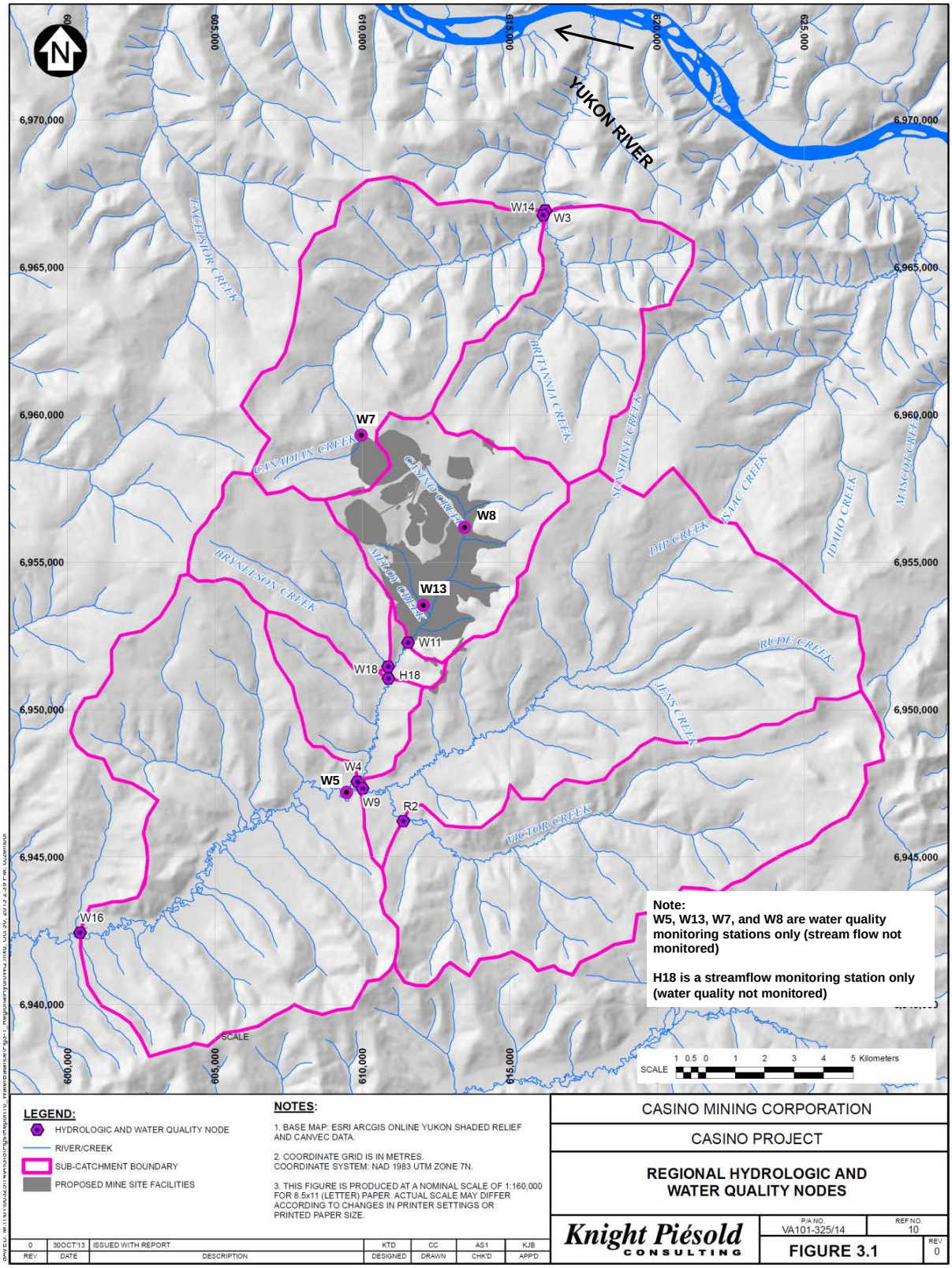
1. Average monthly values apply for an elevation of 1200 m.

3.3 Hydrology

The property is within the Yukon River drainage basin. The Project is situated in the Dip Creek and Britannia Creek watersheds. Casino Creek is a tributary to Dip Creek. Dip Creek drains southwest, eventually flowing into the White River, a tributary of the Yukon River. Canadian Creek is a tributary to Britannia Creek. Britannia Creek drains north, and discharges into the Yukon River. The footprint of the proposed Open Pit is situated along the existing watershed divide between Canadian Creek and Casino Creek.

The majority of creeks in the area observe peak discharges during May, and daily fluctuations in discharge due to permafrost active layer melt, and rainfall events from June to September. The annual hydrograph typically has a bimodal shape, with high flows resulting from snowmelt in the spring freshet period and a secondary peak in mid-summer from rainfall and permafrost melt events.

Stream flow data were collected from 1993 to 1994, and from 2008 to present at several locations around the Project area. Hydrometric (stream flow) monitoring station locations are presented on Figure 3-2. KPL combined site and regional hydrology data to characterise baseline hydrology conditions and summarized the results in the *Casino Baseline Hydrology Report* (KPL, 2013e).



Source: KPL, 2013c

Figure 3-2. Hydrology and Water Quality Monitoring Stations Surrounding the Project

3.4 Hydrogeology

The following section summarizes the results of *the 2012 Baseline Hydrogeology Report* that was completed by KPL (2013g). The Casino Project is situated within a region of discontinuous permafrost. Permafrost is inferred to be present at shallow depths on north-facing slopes and below organic soils in portions of the Casino Creek valley, and generally absent, or deeper, on south-facing slopes. The groundwater flow systems that develop within the Project area are controlled by the extent and spatial distribution of the permafrost in addition to topography and geology.

A surface and inferred groundwater flow divide bisects the deposit area, directing surface water and groundwater flow north toward Canadian Creek or south and east toward Casino Creek. Groundwater is inferred to discharge to surface throughout the year in creek valleys and sustains winter flows in Casino Creek and Canadian Creek. Four hydrostratigraphic units have been identified at the Project site, consisting of overburden, weathered bedrock, fresh bedrock, and fault zones. Each of the hydrostratigraphic units may be frozen or unfrozen based on the presence or absence of permafrost.

Groundwater elevations are lowest in April and May immediately preceding the spring freshet and are typically highest in August following snowmelt and summer rainfall. Relatively strong downward vertical hydraulic gradients have been observed within the upland areas of the proposed Open Pit where the water table is more than 100 m deep. Within the southeast lowlands of the proposed Open Pit, upward vertical hydraulic gradients and artesian conditions are present upslope of faults adjacent to Proctor Gulch at the head of Casino Creek. These artesian pressures suggest that faults may act as barriers to groundwater flow. Depth to groundwater along the hillslope is between 6 mbgs and 20 mbgs. Groundwater elevations are artesian within the Casino Creek valley.

3.5 Baseline Water Quality

Description of surface water quality was provided in the *Water and Sediment Quality Baseline Report* (PECG, 2013). Groundwater quality was summarized by KPL (2013g).

3.5.1 Surface Water Quality

A total of 26 sites were sampled for water quality between 2008 and 2012. Sites were concentrated in the Casino Creek (a tributary to Dip Creek) and Britannia Creek watersheds. Water quality station locations are shown on Figure 3-1 and Figure 3-2.

Water samples were collected and analyzed for a full suite of physical parameters, anions, nutrients and total and dissolved metals. Exceedances of the Canadian Council of Ministers of the Environment (CCME) guidelines for the protection of freshwater aquatic life were observed for a total of ten parameters (cadmium, copper, aluminum, iron, uranium, fluoride, zinc, lead, pH

and silver) throughout the Project area. The number of exceedances was highest for aluminum, cadmium, copper and iron. With the exception of uranium, exceedances were most numerous in the summer season (May to October), indicating a seasonal trend related to hydrological factors such as snow melt and stream flow.

In general, hardness, conductivity and nitrogen-based nutrients were higher in the winter months. Conversely, TSS, phosphorus-based nutrients, organic matter and metal concentrations were higher in the summer months for all sites, indicating a seasonal trend most likely directly related to hydrological factors such as surface runoff and stream flow.

The 2008-2012 water quality program confirmed the unique water chemistry of Proctor Gulch (W12) originally documented by Himmelright (1994). Exceedances of CCME guidelines for pH, copper, aluminum and iron were found in 100% of the 16 samples from Proctor Gulch. Fluoride, cadmium, lead and zinc were also elevated in samples from Proctor Gulch. Additionally, water quality at this site exhibited highest values for acidity (and lowest pH), hardness, conductivity, total dissolved solids and turbidity, as well as lowest values for alkalinity.

Spatially, it was observed that copper, aluminum and iron concentrations were highest at Proctor Gulch (W12) and decreased with successive sites downstream at W8, W11 and W4. This indicates that inflows from Casino Creek tributaries, Meloy Creek, Brynelson Creek and Austin Creek, effectively dilute the Casino Creek water.

Proctor Gulch consistently showed higher concentrations in the winter than in the summer for all the metals when groundwater was the major source of flow in the winter months. Some effects from Proctor Gulch are observed in Dip Creek at site W5, just downstream of Casino Creek, particularly for copper, cadmium, lead and zinc, as background levels upstream in the Dip Creek watershed at sites W22, R2 and W9 had lower concentrations of those metals.

A historical adit established to access a lead/zinc/silver deposit in the upper Meloy Creek watershed discharges groundwater in the spring and summer months (approximately May to August). This site (W43) was found to have the highest concentrations of cadmium, lead, silver and zinc of all the sites sampled. Never the less, of these four metals, only one cadmium sample (0.00004 mg/L in April 2011) exceeded CCME guidelines in the lower reach of Casino Creek at W4, due to the small flow from the adit relative to the total Casino Creek discharge.

Table 3-2 provides a summary of parameters that exceeded CCME guidelines in the upper Dip Creek (including Casino Creek) drainage basin.

Table 3-2. Parameters with Median Water Quality Exceeding CCME Guidelines

Station	Watercourse	Water Quality Parameters Exceeding CCME Guidelines in Baseline Discharge		
		Summer	Winter	Year-Round
W12	Proctor Gulch	Al, Cd, Cu, Fe, F, pH, Zn	Al, Cd, Cu, Fe, F, pH, U, Zn	Al, Cd, Cu, Fe, F, pH, Zn
W8	Upper Casino Creek	Al, Cd, Cu, Fe	Al, Cd, Cu	Al, Cd, Cu, Fe
W43	Adit	Ag, Cd, Cu, Pb, Zn	(no flow)	(no year-round flow)
W13	Meloy Creek	Cd, Pb	Cd, Cu, U	Cd
W11	Mid-Casino Creek	Al, Cd, Cu, Fe	Cd, Cu, U	Al, Cd, Cu, Fe
W18	Brynelson	Al	-	-
W4	Lower Casino Creek	Al, Cu	-	Cu
W9	Upper Dip Creek	Al	-	-
W5	Mid-Dip Creek	Al, Cu	-	Cu

Summer was defined by PECG as May to October (inclusive) and winter was November to April.

Although less pronounced, an overall similar spatial pattern for cadmium, zinc, copper, aluminum, iron and lead were observed for Canadian Creek and Britannia Creek. The uppermost site on Canadian Creek (W7) is situated in close proximity to the ore body and therefore may receive some base flow with similar water quality to Proctor Gulch. This site exhibits the highest concentration of these metals in the Britannia Creek watershed, decreasing downstream to the Yukon River.

3.5.2 Groundwater Quality

Groundwater chemistry is variable throughout the Project area and has been characterized in terms of the proposed Open Pit area, the hillslope area, and the Casino Creek valley area. Groundwater samples from the proposed Open Pit area were dominantly calcium-sulphate type, and from the hillslope area were dominantly calcium-bicarbonate type. Groundwater chemistry of samples collected from the Casino Creek valley area can generally be interpreted as intermediate to that of the hillslope and proposed Open Pit areas. The groundwater types vary along the Casino Creek valley but are generally characterized as calcium-bicarbonate-sulphate in the upper limits of the valley, calcium-magnesium-bicarbonate-sulphate type through the middle of the proposed TMF area, and calcium-bicarbonate in the vicinity of the proposed TMF embankment.

The deposit area is a sulphidic ore body that has been subjected to considerable weathering and oxidation. Sulphate is present in the mineralization (as gypsum/anhydrite) and as a result sulphate has been measured at very high concentrations in this area (up to 1,100 mg/L). Mean total dissolved solids (TDS) concentrations are indicative of groundwater that is moderately to highly mineralized. In the proposed Open Pit area, significant variability in groundwater metals

and metalloid concentrations was observed between samples collected from the Proctor Gulch monitoring wells and from monitoring well 94-337. The variability in the ore body geochemistry results in groundwater with low pH and low hardness in the vicinity of 94-337 and neutral pH and very hard water in the Proctor Gulch area. In the samples from 94-337, cadmium, cobalt, copper and zinc were detected at concentrations that exceeded the Yukon Contaminated Sites Regulation (YCSR) limits, and aluminum and iron were detected at concentrations that exceeded the CCME guidelines. In the Proctor Gulch area groundwater samples, cadmium and cobalt were detected at concentrations that exceeded the YCSR limits and arsenic, iron, uranium and zinc were detected at concentrations that exceeded the CCME guidelines.

In the hillslope area, mean TDS values in water collected from monitoring wells were indicative of slight to moderately mineralized groundwater. Samples from monitoring wells installed near the historic Meloy Creek mine adit reported higher mean TDS values than others from the hillslope area.

Slightly higher mean TDS and higher concentrations of sulphate, sodium, fluoride, and chloride were reported in water samples obtained from the shallow groundwater well compared to the deep well. In samples from the hillslope area, cadmium, copper, and zinc were the only metals detected at concentrations that exceed the CCME guidelines on a regular basis.

In the Casino Creek valley, mean TDS values for groundwater samples were indicative of slightly-to-highly mineralized conditions. Cadmium, copper, iron, and uranium were the only metals that were detected at concentrations exceeding the CCME guidelines on a regular basis from the vicinity of the proposed TMF in the Casino Creek valley area. The elevated concentrations were not widespread and are reflective of relatively heterogeneous groundwater chemistry conditions that may result from localized variability in mineralization and from mixing with groundwater originating from the deposit area. Arsenic and zinc were also reported at concentrations that exceeded the CCME guideline, but the exceedances were infrequent.

4 Mine Sources of Geochemical Mass Loading

Development of the proposed mine is expected to introduce sources of geochemical mass loading to the hydrologic and water management system of the Project site and downstream environment. Sources of geochemical mass loading at the Casino Project are described in the following sections. Source terms were developed by Lorax to predict the rate of mass loading from each source into the water management system of the Casino Project (Lorax, 2013). This section is unchanged from Section 4 of SEA (2013).

4.1 Open Pit Wall Rock

Blasting in the Open Pit leaves the wall rock fractured and exposed to weathering processes. The fractured rock will contribute mass loading into the Pit Lake via runoff from the pit walls. As the Pit Lake reaches its maximum storage capacity, exposed wall rock will be submerged, inhibiting potential oxidation and reactivity. A portion of the pit wall (i.e. the “high wall”) that is above the elevation of the final Pit Lake will remain un-submerged in perpetuity. Runoff from the high wall will be an on-going source of mass loading into the Pit Lake.

Pit wall runoff is expected to travel along preferential flow paths through the fractures of the unsubmerged pit wall rock. As a result, oxidation products could build-up on the the poorly drained wall rock surfaces. When the Pit Lake level rises and submerges the wall rock, those built-up oxidation products may be flushed into the Pit Lake. After submergence of the wall rock, oxidation products will no longer form on the saturated rock surfaces and no additional leaching is predicted to occur.

4.2 Ore Stockpiles

While the ore stockpiles are present during Operations, contact water (from rainfall and snowmelt) will drain from the rock as runoff or infiltration to groundwater. Runoff from the stockpiles will be captured by the TMF Pond. Hydrogeological modelling (KPL, 2013h) indicated that depending on the stockpile location, infiltrated contact water will flow to one or more of the following receptors: the TMF Pond, Open Pit, through the TMF Embankment, or through the TMF foundation.

Some residual ore may be present in the stockpiles following Operations if the ore is not economical to process. Unprocessed ore will be placed in the Open Pit at the end of Operations and during Closure. Upon submergence of the ore in the Pit Lake, the oxidation products that have built up on the ore during Operations are assumed to flush into the Pit Lake.

4.3 Processing Facility (Mill)

NAG and PAG tailings will be pumped from the Mill to the TMF as slurry. The water content of the tailings slurry will be process water from the Mill. Mass load in the slurry water will enter the TMF Pond.

Lorax (2013) assumed that select parameters (Sb, As, Mo, Se, and U) will accumulate in the process/reclaim water throughout Operations. That is, those water quality parameters will continue to build up in the TMF pond water, while others will be removed from reclaim water in the milling process.

4.4 Heap Leach Facility

Ore contact water from the HLF will be a source of loading. During Operations and rinsing of the HLF, the ore contact water will be kept within a closed system and will therefore not be a source of loading to other Project components, or to the receiving environment. During rinsing and draindown, the contact water will be treated and pumped to the Pit Lake. Following draindown, HLF toe seepage and surface runoff will discharge to the TMF Pond.

4.5 TMF Waste Rock and Tailings

Tailings and waste rock will be deposited in the TMF for long-term storage. Temporary and perpetual mass loading mechanisms from the stored mine wastes are described in the following sections.

4.5.1 Unsaturated Tailings

NAG tailings will remain unsaturated in the tailings beach and the TMF embankments. Contact water (runoff) from the tailings beach will drain into the TMF Pond, and runoff from the downstream face of the TMF embankments will drain downstream to be collected in the WMP.

4.5.2 Unsaturated Waste Rock

Waste rock will be placed at the upstream (north) end of the TMF. During Operations, the surface of the waste rock will be maintained above the operating level of the supernatant pond to provide a dry, stable placement surface for machine access to facilitate waste rock placement. Runoff from and infiltration through the unsubmerged portion of waste rock will carry a mass load into the TMF Pond.

Built up oxidation products that are not transported by runoff from the unsubmerged waste rock surfaces are assumed to be flushed into the TMF Pond when the supernatent pond level rises and submerges the waste rock.

4.5.3 Saturated Tailings and Waste Rock

Tailings and waste rock that are stored below the water surface in the TMF will be in chemical equilibrium with their porewater. Fluxes of water through the stored mine waste will lead to displacement of the porewater and mass transport from the deposited material into the TMF Pond, groundwater table, or TMF embankment.

4.6 Summary of Mine Loading Sources by Project Phase

Table 4-1 illustrates the mine sources of loading by Project phase. Following closure of the mine the following loading sources are expected to contribute some mass loading in perpetuity: Open Pit high wall rock, tailings beach runoff, TMF embankment runoff, runoff from spent HLF ore and displaced porewater from saturated tailings and waste rock.

Table 4-1. Loading Sources by Project Phase

Source of Loading	Casino Project Water Management Phase				
	Construction	Operations	Wetland Construction	TMF Discharge	Pit Discharge
Open Pit wall rock (runoff)	■	■	■	■	■
Open Pit wall rock (flushing upon submergence)			■	■	
Ore Stockpile (runoff and infiltration)	■	■	■	(note 2)	
Ore Stockpile (flushing)			■		
Heap Leach Facility (rinsing and drain down)		■	■		
Heap Leach Facility (runoff from covered ore)				■	■
Saturated Tailings and Waste Rock (TMF seepage)		■	■	■	■
Unsaturated (NAG) Tailings (embankment and beach runoff)		■	■	■	■
Unsaturated Waste Rock (runoff and flushing)		■			

1. Shaded cells indicate a loading source during that Project phase.
2. Because ore stockpile seepage will enter the groundwater table, a lag time can be expected from when the contact water enters the groundwater and when it reaches its point of discharge.

5 Water Quality Model Overview

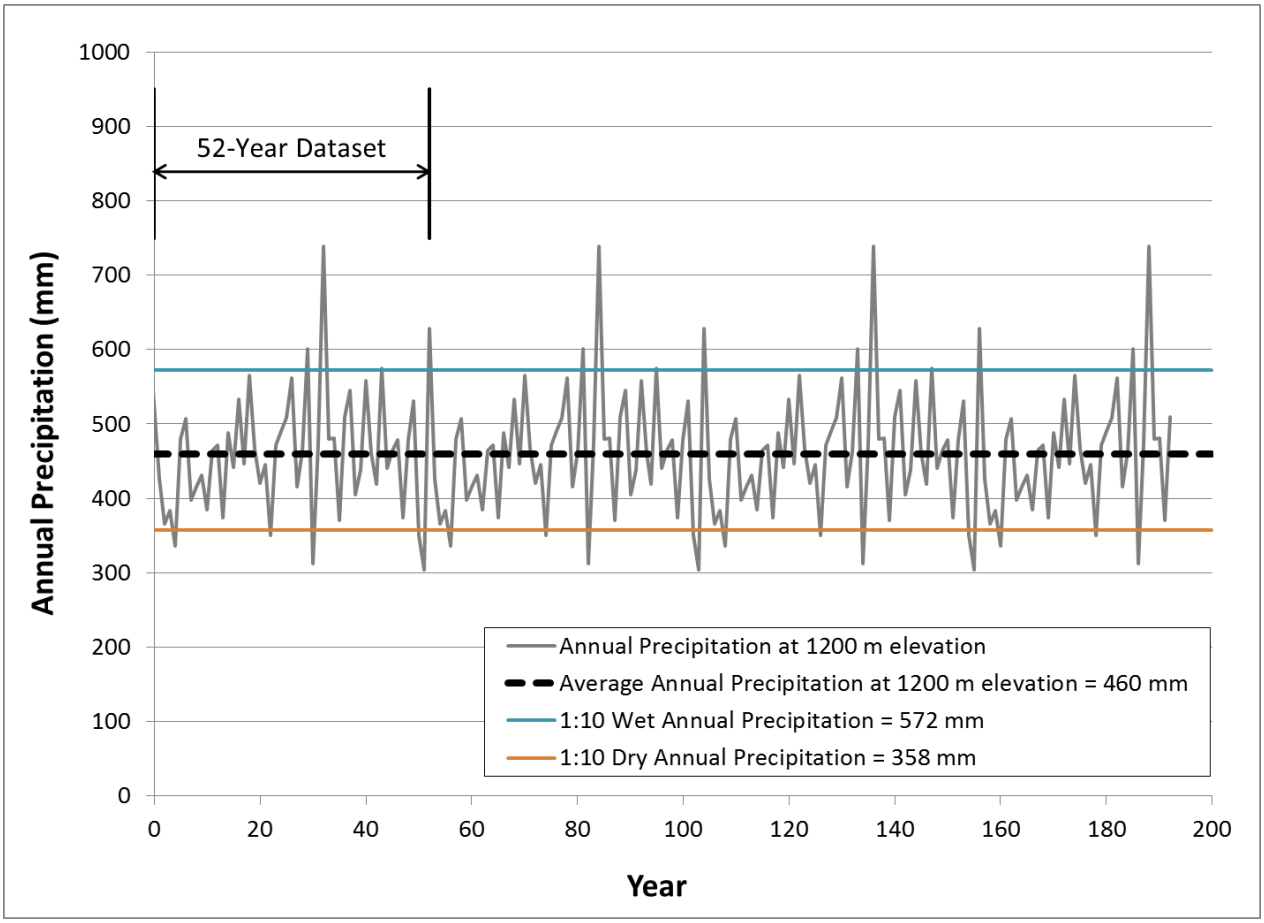
A water quality model was developed to predict mine drainage water quality for various components for each Project phase to evaluate the potential impact on water quality in the receiving environment. Mass transport (mass loading) rates were estimated for potential sources of contamination within the water management system. Flow rate (water balance) estimates were combined with mass loading rates, to predict water quality concentrations of substances at the Project site and in the receiving waters of the Project site. A water quality model was developed in 2013 which evaluated water quality given average annual hydrologic conditions, and was presented in SEA (2013). The water quality model was updated to account for inter-annual variability in site hydrology. The updated water quality model is described in the following sections.

5.1 Water Balance Model

A site-wide water balance model was developed by KPL and was used as the basis for the water quality model. A 52-year, continuous dataset of monthly weather conditions was developed by KPL in order to simulate the natural variability in hydrologic conditions (i.e. wet and dry periods) that can be expected at the site.

The input dataset to the water balance model was developed by correlating existing site weather data with regional weather data to derive a long-term synthetic dataset of monthly site conditions. A dataset of monthly hydrologic conditions (e.g. temperature, precipitation, streamflow) was developed from 52 years of continuous regional data. A correlation was established between the regional data and data collected at the Project site. The correlation was used to convert the regional dataset to a 52-year synthetic dataset for the Project site. Because the model was run over a simulation period of ~200 years, the 52-year input dataset repeated approximately four times during a given simulation. Figure 5-1 shows the synthetic dataset for annual precipitation over a 200 year simulation.

SEA carried out a frequency analysis on the 52 year dataset of annual precipitation values to estimate wet and dry years with 10-year return period (1:10). The results from the frequency analysis are shown on Figure 5-1.



Note: Annual values shown in this figure were calculated as annual the sum of monthly values from the input dataset.

Figure 5-1. Input Dataset of Annual Precipitation

5.2 Water Quality Model

SEA developed a mass load balance to predict the rate of contaminant transport through the modelled system. Source terms (Lorax, 2013) were combined with flow rates from the water balance to predict contaminant concentrations throughout the mine water management system and in the receiving (downstream) environment of the Casino Project.

A total of 27 water quality parameters (i.e. potential contaminants) were modelled and the full set of water quality model input values and results are provided in the Appendices of this document. This document summarizes input and output values for sulphate, fluoride, cadmium, copper, iron, molybdenum, selenium, and uranium to illustrate modelling methodology and results. Modelling results for the full set of water quality parameters are presented in the Appendices of this report.

The performance of the water quality management system was evaluated by plotting time-series of water quality model results (single realization) during infrequent wet and dry periods. 1:10 wet

and 1:10 dry years were selected for the evaluation. 1:10 wet and dry years are identified in the water quality output plots for Casino Creek and Dip Creek in Section 11.

5.3 Modelling Time-Steps and Timeline

The model simulation was run for a time period beginning a few years prior to Construction, and continued for 200 years following the beginning of Operations using monthly time steps. The Project timeline with respect to relevant Project activities are provided in Table 5-1.

Table 5-1. Milestone Dates for Water Quality Modelling

Project Year	Project Activity
-4	start of construction
-3	start of HLF processing and mining the Open Pit
1	start of milling (start of Operations)
18	final year of Open Pit mining
19	Open Pit dewatering stops, Pit Lake begins to form
19	end of waste rock placement and begin covering waste rock with tailings layer
19	begin rinsing HLF (pump surplus water to Open Pit)
22	final year of milling (end of Operations)
23	start of pumping TMF Pond to Open Pit
23	end of pumping of WMP to TMF, and begin pumping WMP to Open Pit
24	end of HLF rinsing and start of HLF drain down (pump to Open Pit)
27	end of pumping TMF to Open Pit
28	start of TMF filling by natural recharge
28	end of HLF drain down
29	HLF drainage directed to TMF Pond
35	end of pumping of WMP to Open Pit
35	initial discharge of TMF Pond and WMP (seasonal) to Casino Creek
109	initial discharge of Pit Lake to TMF (into North TMF Wetland)

5.4 Simplified Site-Wide Mass Loading Schematic

A simplified representation of the Casino Project water management system and receiving environment are presented schematically to illustrate the general flow paths of water and

potential contaminants through the system during Operations (Figure 5-2) and for long-term conditions (Pit Discharge Phase, Figure 5-3).

Descriptions of each of the drainage system components are presented in Section 6 (Open Pit), Section 7 (Heap Leach Facility), Section 8 (TMF Pond), Section 9 (Downstream Seepage), and Section 11 (Receiving Environment).

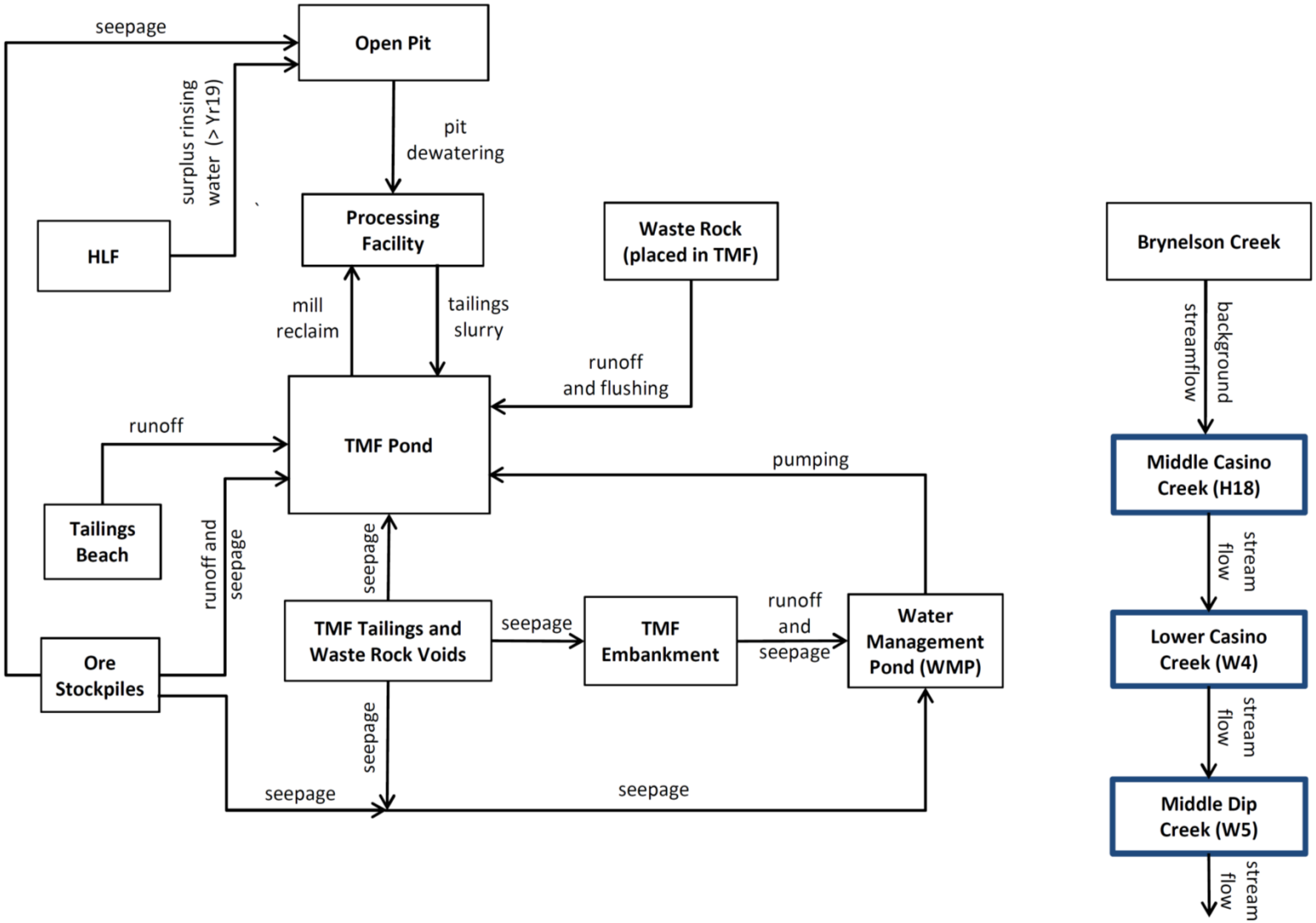


Figure 5-2. Simplified Mass Loading Schematic Casino Mine System (Operations)

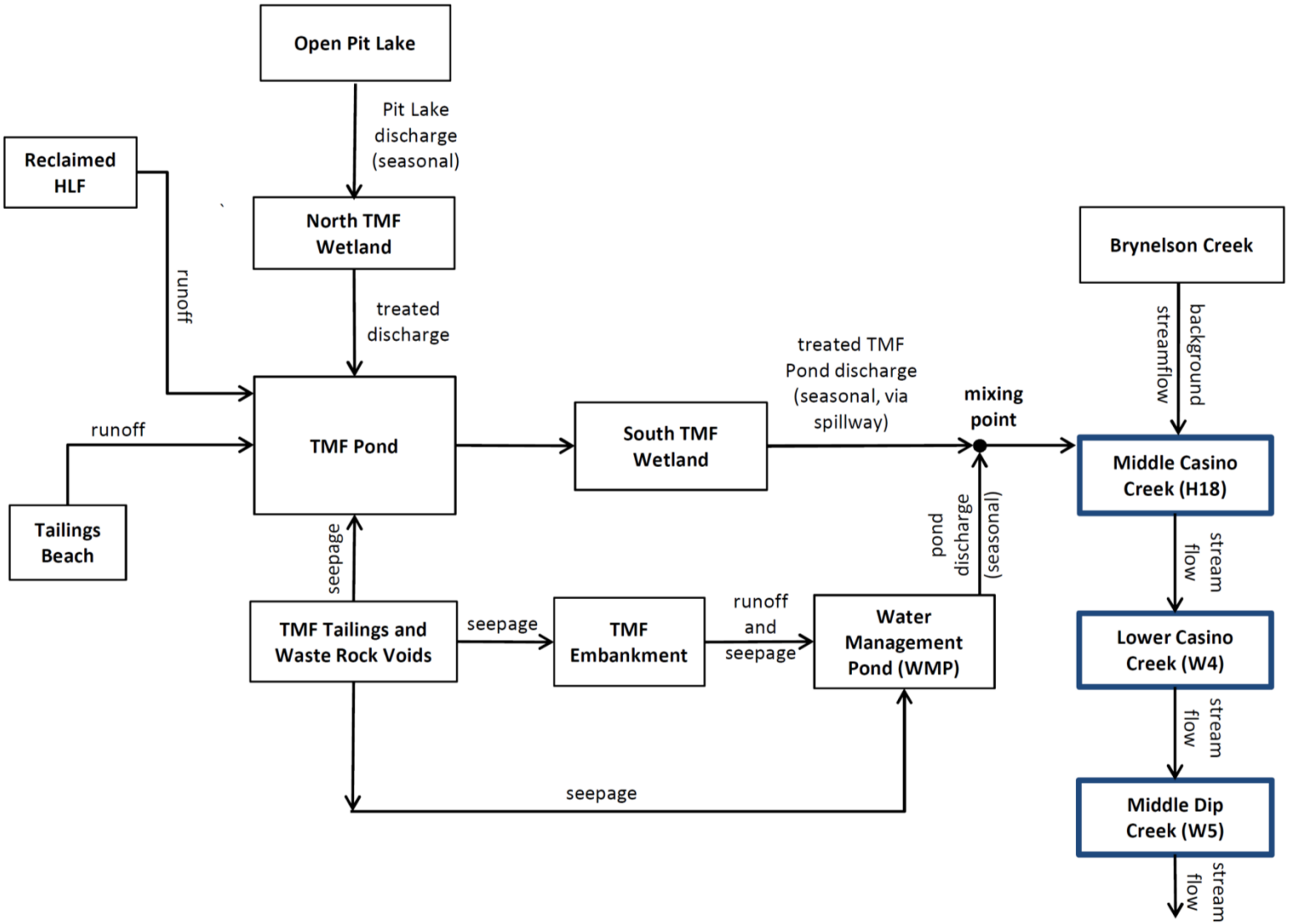


Figure 5-3. Simplified Mass Loading Schematic Casino Mine System (Pit Discharge Phase)

5.5 Modelling Platform

The model was developed using GoldSim modelling software. GoldSim is a standard platform for developing detailed water balance and water quality models for mine sites. A schematic view of one of the GoldSim model sub-components is provided in Figure 5-4 for illustration. The example includes four sub-containers (yellow boxes), one cell pathway (TMF_wq), four expressions ("f_x" icons), and one Dynamic Link Library element ("DLL" icon). Other types of GoldSim elements are incorporated into the model but are not part of this particular example. Information about GoldSim software can be readily obtained (GoldSim Technology Group LLC, 2013).

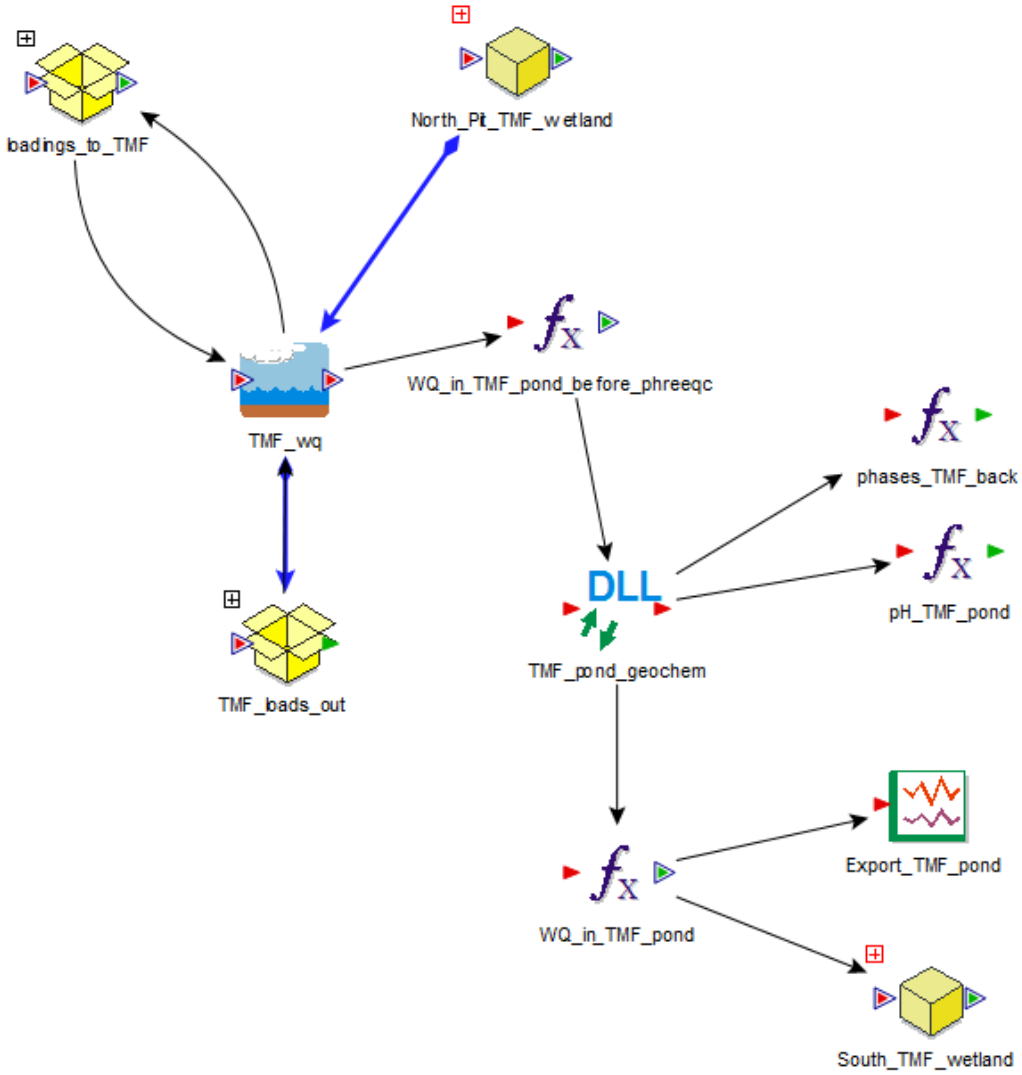


Figure 5-4. Example of the Casino Water Quality Model in GoldSim

5.6 GoldSim and PHREEQC Linkages

PHREEQC is geochemical modelling software developed by the United States Geological Survey. The mixing model in GoldSim was linked dynamically with PHREEQC at three model nodes: the Pit Lake, the TMF Pond, and the WMP. At each model node, a C++ DLL (dynamic link library) element was developed to represent the particular geochemical environment. Additional information related to geochemical modelling using PHREEQC is provided in Appendix I (Open Pit), Appendix IV (TMF Pond), and Appendix V (WMP).

During each timestep, GoldSim ran PHREEQC and the resulting concentrations returned from PHREEQC replaced the initial mixed concentrations. For example, as iron moves from a reducing enviromnment (groundwater seepage) to an oxiding environment (surface water), iron precipitates out of solution, and the concentration in water shifts accordingly. Without the dynamic link of GoldSim to PHREEQC, the water quality concentrations in the various water streams would be mis-represented. In GoldSim water quality is based purely on loads and flows, which does not incorporate the solubilities of each parameter.

5.7 Model Simulations

The model results are presented in two ways in this report:

1) Single Model Realization

   Results generated when one permutation (i.e. realization) of the input hydrology dataset was run with the model. Single realization results provide a time-series of model output which shows a representation of water quality that would result from a realistic range in hydrological conditions at the site. The output provides an indication of how high (or low) water quality concentrations may get, and how often those results are expected to occur. Time-series plots, and summary tables of water quality results for a single realization are presented throughout this report.

2) Monte-Carlo Summary (52 Realizations)

   The model was run 52 times. Each model run used a unique permutation (i.e. realization) of the input hydrology dataset. Of the 52 realizations run in the model, the first realization used the input dataset of monthly hydrology beginning from Year 1 of the synthetic dataset. The second realization began at Year 2, the next one began at Year 3, and so on. This continued until the 52nd realization, which began at Year 52 of the dataset. Figure 5-5 shows streamflow in Brynelson Creek for the first three model realizations as an example. A peak in monthly flow can be seen in Year 8 in Realization 1 (black line). That peak occurs in Year 7 in Realization 2 (dashed line), in Year 6 in Realization 3 (grey line), and so on (not shown in this example).

   The combined output from the 52 model runs represents the range in all possible model outputs resulting from all the possible permutations of the input hydrology dataset. A

statistical summary of the model output for the 52 realizations was generated for Casino and Dip Creek to be used as the basis for the aquatic impact assesment.

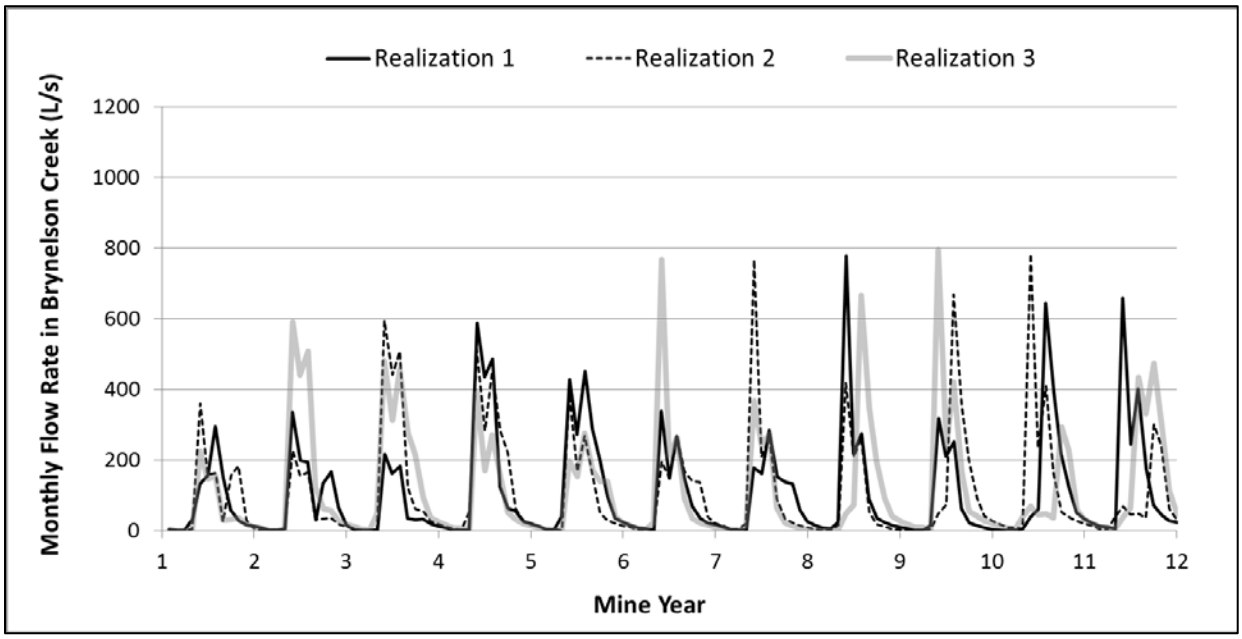


Figure 5-5. Brynelson Creek Streamflow for three Model Realizations

6 Open Pit Water Quality

Mining of the open pit will begin 4 years before the mill starts operating and will continue through the first 19 years of Operations. Dewatering will continue until Year 19 and collected water will be pumped to the mill as makeup. Pit water pumped to the Mill will take on the water quality of process water and will ultimately be discharged to the TMF Pond within the tailings slurry. Mill process water from the Open Pit dewatering was accounted for in TMF Pond water quality model (Section 8).

Following the cessation of dewatering in Year 19, the formation of the Pit Lake will commence by groundwater recharge, overland runoff, and direct precipitation on the water surface in the Open Pit. During the Wetland Construction Phase (Year 23 to Year 34), unused ore present in the surface ore stockpiles will be placed in the pit and TMF Pond water will be pumped to the Open Pit. Eventually (approximately Year 109), the Pit Lake will fill to its maximum water storage capacity. After that time, the Pit Lake will seasonally discharge to the TMF North Wetland for treatment prior to discharge to the TMF Pond.

A water quality model was developed for the Pit Lake (Year 19 and beyond). Pit Lake inflow and outflow sources of mass loading are summarized in Figure 6-1.

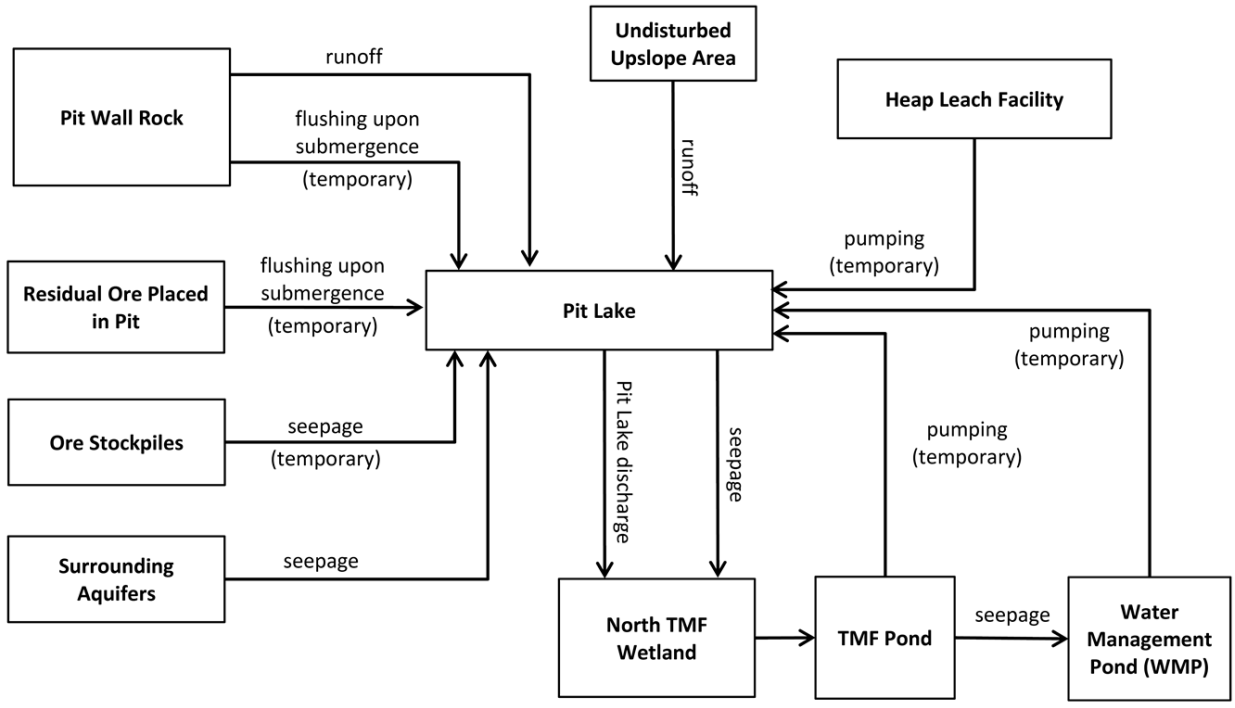


Figure 6-1. Mass Loading Flow Paths through the Pit Lake System

6.1 Water Balance Model Results

Based on the 52 realizations of the water balance simulation, the pit will most likely fill to its storage capacity and discharge to the North Wetland between Year 105 and Year 110. However, KPL (2015) established Year 109 as the best estimate for the beginning of the Pit Discharge Phase.

Average model output among the 52 model realizations are presented in Table 6-1 for 1) Wetland Construction Phase, 2) TMF Discharge Phase, and 3) Pit Discharge Phase.

Table 6-1. Pit Lake Water Balance Results

	Average Annual Discharge (L/s)		
	Wetland Construction Phase	TMF Discharge Phase	Pit Discharge Phase
INFLOWS			
Precipitation on Lake Surface	14	26	31
Groundwater Seepage	18	14	12
Ore Stokcpile Seepage	< 1	0	0
Pit Wall Runoff	28	18	15
Upslope Overland Runoff	35	35	36
Pumping from WMP	52	0	0
Pumping from TMF Pond	0 to 336 [2]	0	0
Pumping from the HLF	0 to 33 [3]	0	0
Total Inflow	123 to 522 [4]	93	95
OUTFLOWS			
Evaporation	11	21	24
Groundwater Seepage	0	7	11
Pit Lake Discharge	0	0	60
Total Outflow	11	28	95
Net (Inflow - Outflow)	112 to 511 [4]	65	0

1. Flow rates reported in this table are average results from 52 model realizations over the duration of each water management phase.
2. Constant pumping rate of 336 L/s for Year 23 to 27. Pumping ceases in Year 28 and beyond.
3. Constant pumping rate of 33 L/s for Year 24 to 28. Pumping ceases in Year 29 and beyond.
4. Range of inflow, resulting from temporary pumping from TMF and HLF.

According to the *Conceptual Reclamation and Closure Plan* (BCL, 2013), the total annual Pit Lake overflow volume will be discharged to the TMF wetland at a controlled rate during the warmest months of the year (June through September, inclusive) for optimal operation of the TMF wetland treatment system. KPL (2015) modelled the discharge as a flow of approximately 180 l/s over the four month period.

6.2 Mass Load Balance and Water Quality Model Results

Water balance flows (KPL, 2015) were combined with mine loading source terms (Lorax, 2013) and background water quality to predict mass loading rates of inflow and outflow of potential contaminants in the Pit Lake water. Water quality in the Pit Lake was calculated as the cumulative mass of a given substance in the Pit Lake water, divided by the water volume stored in the Pit Lake over a given time step interval. The Pit Lake mixing model output concentrations were assessed for solubility controls at each time step of the model simulation by coupling GoldSim and PHREEQC. This section provides a summary of the Pit Lake water quality model results. Modelling methodology and results are provided in Appendix I of this report.

As the Pit Lake water level rises, all wall rock below the water surface will become submerged, and loading was assumed to cease for that submerged portion of the wall rock. The total planar area of un-submerged wall rock was calculated for each model time-step. From that, the relative proportions of acidic and neutral un-submerged wall rock were calculated, and their respective loading rates into the Pit Lake were applied.

The mass loading balance between Pit Lake acidity loading and available alkalinity in the water (including neutralization potential available from the submerged wall rock) indicated that over the duration of the model simulation, the available alkalinity exceeds the acidity. Geochemical modelling indicated the pH of the Pit Lake will be near neutral.

The Pit Lake will discharge to the North TMF Wetland, an engineered wetland for the removal of certain contaminants. The wetland layout was designed by BCL (2013) and is illustrated on Figure 2-2. Clear Coast Consulting Inc. (2013) provided maximum water quality concentrations for water quality parameters (Table 6-2) from the North TMF Wetland.

In the water quality modelling, if the modelled TMF Pond water quality in the North TMF Wetland discharge was higher than the maximum treatment system concentrations, then water quality in North TMF Wetland discharge was set equal to the maximum effluent water quality (Table 6-2). If no treatment was specified, the modelled water quality loading from the Open Pit was assumed to report to the TMF Pond via the wetland.

Table 6-2. North TMF Wetland Maximum Effluent Water Quality

Water Quality Parameter		Maximum Effluent Water Quality (mg/L)
Sulphate	(SO_4)	15% reduction
Cadmium	(Cd)	0.000080
Copper	(Cu)	0.0040
Molybdenum	(Mo)	0.073
Mercury	(Hg)	0.000026
Selenium	(Se)	-
Silver	(Ag)	0.00010
Uranium	(U)	0.015
Zinc	(Zn)	0.030

Average annual water quality in the Pit Lake, and predicted North TMF Wetland discharge concentrations are provided in Table 6-1 for intial discharge of the Pit Lake (Year 109), and long-term conditions (Year 200) for a single model realization. Model output concentrations for all modelled water quality parameters are provided in Appendix I.

Table 6-3. Pit Lake Water Quality Model Results

Water Quality		Pit Lake Water Quality (mg/L)		North TMF Wetland Water Quality (mg/L)	
		Initial Pit Lake Discharge (Year 109)	Long-Term (Year 200)	Initial Pit Lake Discharge (Year 109)	Long-Term (Year 200)
pH		6.2	6.2		
Sulphate	(SO_4)	501	368	315	221
Fluoride	(F)	1.2	0.88	0.88	0.62
Cadmium	(Cd)	0.0038	0.0035	0.000080	0.000080
Copper	(Cu)	5.0	4.9	0.0040	0.0040
Iron	(Fe)	0.00090	0.00089	0.059	0.080
Molybdenum	(Mo)	0.19	0.10	0.068	0.063
Selenium	(Se)	0.0084	0.0052	0.0061	0.0036
Uranium	(U)	0.060	0.054	0.015	0.015

Individual contributions of each mass loading source are presented in Table 6-4 (initial pit discharge) and Table 6-5 for a typical year following discharge of the Pit Lake. Model output concentrations and individual contributions of mass loading sources are provided in Appendix I for all modelled water quality parameters.

Closure activities such as pumping from the HLF, TMF, and WMP, and disposal of residual ore stockpile rock will influence Pit Lake water quality upon initial discharge. However, those loading contributions will be temporary and will not affect the long-term water quality in the Pit Lake.

A portion of the pit wall (i.e. the "high wall") that is above the elevation of the final Pit Lake will remain un-submerged in perpetuity. Runoff from the high wall will be a perpetual source of mass loading into the Pit Lake. Generally, the acidic portion (Supergene Acidic or Hypogene Acidic) of the Open Pit high wall rock is expected to be the largest contributor of mass load into the Pit Lake in the long-term.

Table 6-4. Loading Source Contributions to the Pit Lake (Initial Discharge)

Pit Lake Loading Source	Fraction Contributing (%)							
	SO_4	F	Cd	Cu	Fe	Mo	Se	U
Runoff	3	2	2	0	0	0	0	0
Groundwater	15	7	7	1	27	1	0	9
Ore Stockpile Seepage	0	1	2	2	1	0	1	1
Pit Wall Rock	23	37	43	55	49	16	18	50
Ore Rock Flushing upon Submergence	10	18	37	41	22	5	51	28
WMP Pumping	10	9	2	0	0	11	5	4
TMF Pond Pumping	31	23	4	0	0	26	20	9
HLF Draindown	7	4	4	1	2	42	5	0
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

1. Total loading into the Pit Lake until initial discharge (Year 109).
2. Shaded cells are for sources that contribute >10% to the overall load.
3. Values are rounded to the nearest 1 and the total of individual values may not add to exactly 100.

Table 6-5. Loading Source Contributions to the Pit Lake (Long-Term)

Pit Lake Loading Source	Fraction Contributing (%)							
	SO_4	F	Cd	Cu	Fe	Mo	Se	U
Runoff	9	6	3	0	0	1	2	0
Groundwater	40	19	10	1	30	12	1	13
Pit Wall Rock	50	75	87	99	70	87	98	87
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

1. Year 200 was selected as the representative year for long-term conditions.
2. Shaded cells are for sources that contribute >10% to the overall load.
3. Values are rounded to the nearest 1 and the total of individual values may not add to exactly 100.

7 Heap Leach Facility Water Quality Model

Crushed oxide gold ore will be placed on the HLF until end of Year 14. The ore will be leached with an aqueous cyanide solution and the pregnant solution extracted for gold and copper. The leaching will continue until recovery is no longer profitable. For modelling purposes, KPL (2013c) assumed leaching would continue until end of Year 18 and predicted that during that time the system will operate in a water deficit. That is, no surplus water will be produced by the HLF until after the end of Year 18.

After operations of the HLF, rinsing occurs from Year 19 to Year 23 and draindown occurs from Year 24 to Year 28. Surplus water will be directed to the Pit Lake, after treatment with a cyanide destruction circuit and a bioreactor for selenium and mercury (Clear Coast Consulting, 2013). A bioreactor is currently the preferred treatment method for selenium and mercury. Alternate treatment methods may also be considered to remove selenium and mercury during the rinsing and draindown phase.

Following draindown, the final slopes of the HLF will be graded, covered, and re-vegetated. The water quality model assumes that 20% of surplus water (i.e. 20% of net precipitation) infiltrates and becomes seepage at the toe of the HLF while the remaining 80% of surplus water is non-contact runoff. The non-contact runoff is modelled as background water quality (W13), similar to runoff from the land adjacent to the HLF. Both the toe seepage and the surface runoff from the HLF will be directed downslope to the TMF Pond. Table 7-1 provides a timeline of surplus HLF water management with predicted average annual flow rates from the KPL water balance (KPL, 2015).

Table 7-1. HLF Surplus Water Management

Project Year	Activity	Average Annual Surplus Water (l/s)	Surplus Water Management
-3 to 18	Processing	0	-
19 to 23	Rinsing	1.6	Treated and Pump to Open Pit
24 to 28	Drain Down	33	Treated and Pump to Open Pit
29 and beyond	Reclaimed Site	10.4	Non-contact runoff to TMF Pond
29 and beyond	Reclaimed Site	2.6	HLF seepage to TMF Pond

The HLF will be underlain by a Linear Low Density Polyethylene (LLDPE) liner (KPL, 2013a). As a result, a groundwater pathway from the HLF was assumed to be negligible. Discharge from the HLF toe seepage is incorporated into the water quality model.

Lorax (2013) provided a source term for three time periods: 1) rinsing and draindown; 2) 10 years following draindown; and, 3) long-term. The first set of source terms was applied during the rinsing and draindown period. The second set was applied for ten years following draindown (Year 29 to Year 38) while the water quality stabilizes to long-term conditions. Long-term water quality was applied for Year 39 and beyond.

Mass loading from the HLF to the Pit Lake during rinsing and draindown was adjusted for treatment by the bioreactor (Table 7-2). Following treatment in the bioreactor, the selenium and mercury levels are reduced to 0.02 mg/L and 0.00026 mg/L, respectively. This mitigation was designed to reduce selenium levels in the North TMF wetland (Clear Coast Consulting, 2013).

The bioreactor treatment may also remove other constituents of concern in addition to selenium and mercury (e.g. uranium, silver, copper, cadmium, arsenic), however the water quality model did not account for these reductions to allow for flexibility in the treatment method as more detailed designs are developed. The cyanide destruction circuit was accounted for in the source terms provided by Lorax.

Mass loading from the HLF to the TMF Pond was accounted for by SEA in the water quality modelling by multiplying the estimated HLF toe seepage flow rate by the estimated water quality (Table 7-2). The full set of HLF surplus water quality data is provided in Appendix III.

Table 7-2. HLF Surplus Water Quality

Water Quality Parameter	HLF Surplus Water Quality (mg/L)			
	Rinsing and Drain Down (Year 19 to 28)	Bioreactor Treatment* (Year 19 to 28)	10 Years Post Drain Down (Year 29 to 38)	Long Term (Year 39 and beyond)
WAD-Cyanide	5.0	5.0	0.030	
Sulphate (SO_4)	1,920	1,920	2,100	424
Fluoride (F)	2.1	2.1	3.0	1.3
Cadmium (Cd)	0.0084	0.0084	0.0050	0.00028
Copper (Cu)	2.8	2.8	0.016	0.0011
Iron (Fe)	9.5	9.5	0.0040	0.0040
Molybdenum (Mo)	4.2	4.2	4.2	0.94
Selenium (Se)	0.40	0.02**	0.23	0.098
Uranium (U)	0.0018	0.0018	0.63	0.17

* Mercury is also treated for in the bioreactor to the CCME guideline level (0.026 ug/L)

** This treatment level is based on Yukon Zinc (2010)

8 TMF Pond Water Quality

The Tailings Management Facility (TMF) will be the primary water and waste management component of the Project, and was designed by KPL to store approximately 956 million tonnes of tailings and up to 649 million tonnes waste rock and overburden (KPL, 2012). The TMF will be situated in the Casino Creek valley southeast of the Open Pit.

During Operations, waste rock and tailings slurry will be deposited in the TMF with the tailings supernatant water reclaimed via the reclaim system for reuse by the mill or by the cyclone sand plant. Site runoff, including runoff from the ore stockpiles will drain to the pond. During Operations, the WMP will collect the TMF embankment runoff and seepage and pump it back to the TMF pond.

Starting in year 23, the WMP will be pumped to the Open Pit rather than to the TMF, and the TMF Pond will be pumped to the Open Pit for a 5 year period and then the TMF will be allowed to refill by natural recharge. Once full, the TMF Pond will discharge to Casino Creek via an engineered spillway. The final phase will begin when the Open Pit discharges to the TMF Pond.

A water quality model was developed for the TMF Pond from Construction through to the Pit Discharge Phase. TMF Pond mass loading inflows and outflows are summarized for Operations (Figure 8-1), and the Pit Discharge Phase (Figure 8-2).

8.1 Water Balance Model Results

The TMF Pond will be pumped to the Open Pit for five years during Wetland Construction, and will refill by natural recharge and will discharge to Casino Creek in approximately Year 35. Inflow from tailings pore water will be highest during Operations due to tailings consolidation, and will gradually reduce during closure and post-closure as the tailings consolidation process slows and eventually stops. After that time, tailings and waste rock pore water displacement will be the result of groundwater fluxes through the tailings and waste rock voids.

A summary of annual inflows and outflows of water to the TMF Pond (derived from the KPL water balance model) is provided in Appendix IV (TMF Pond Water Quality Modelling).

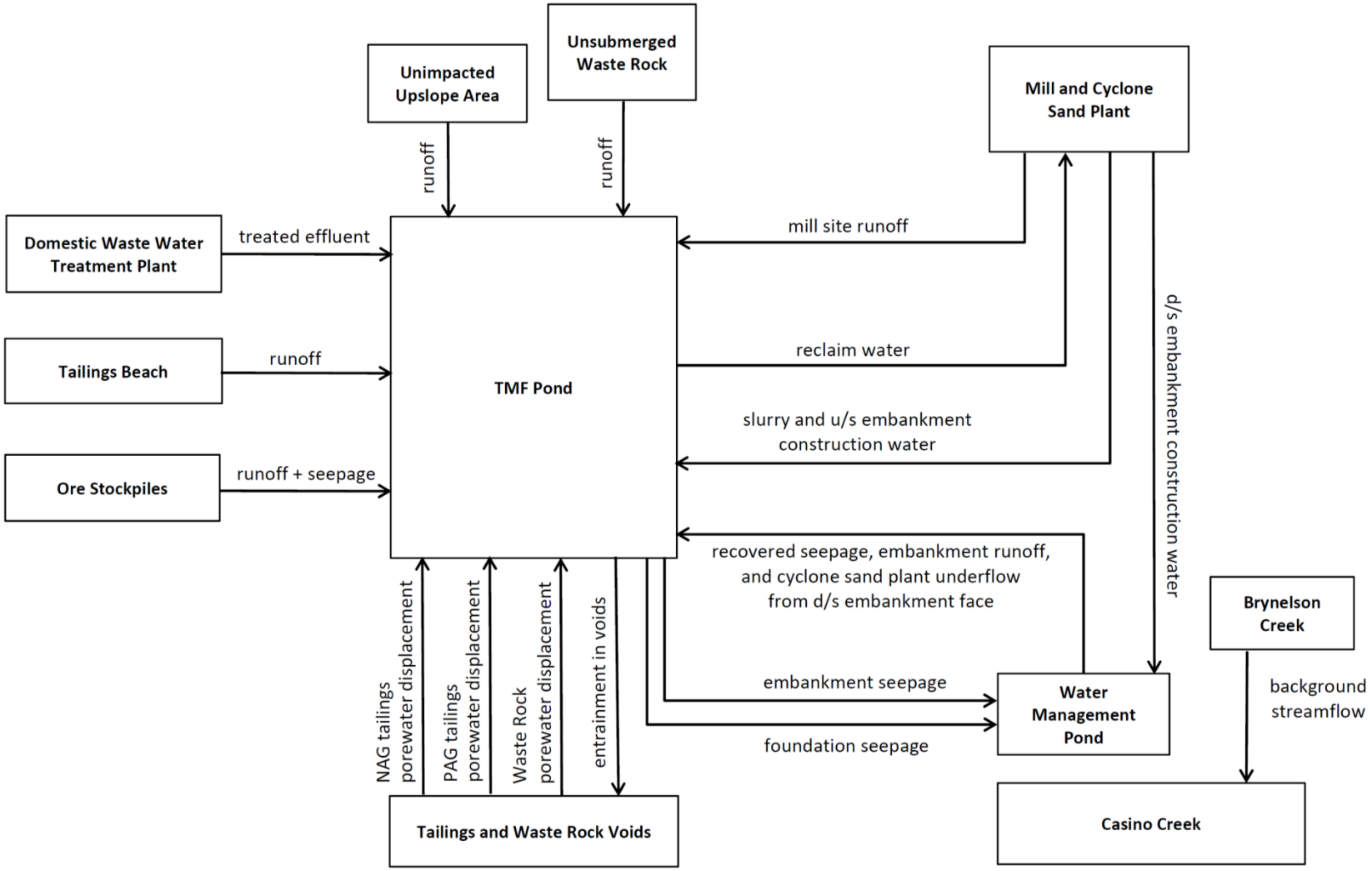


Figure 8-1. Mass Loading Flow Paths through the TMF Pond System (Operations Phase)

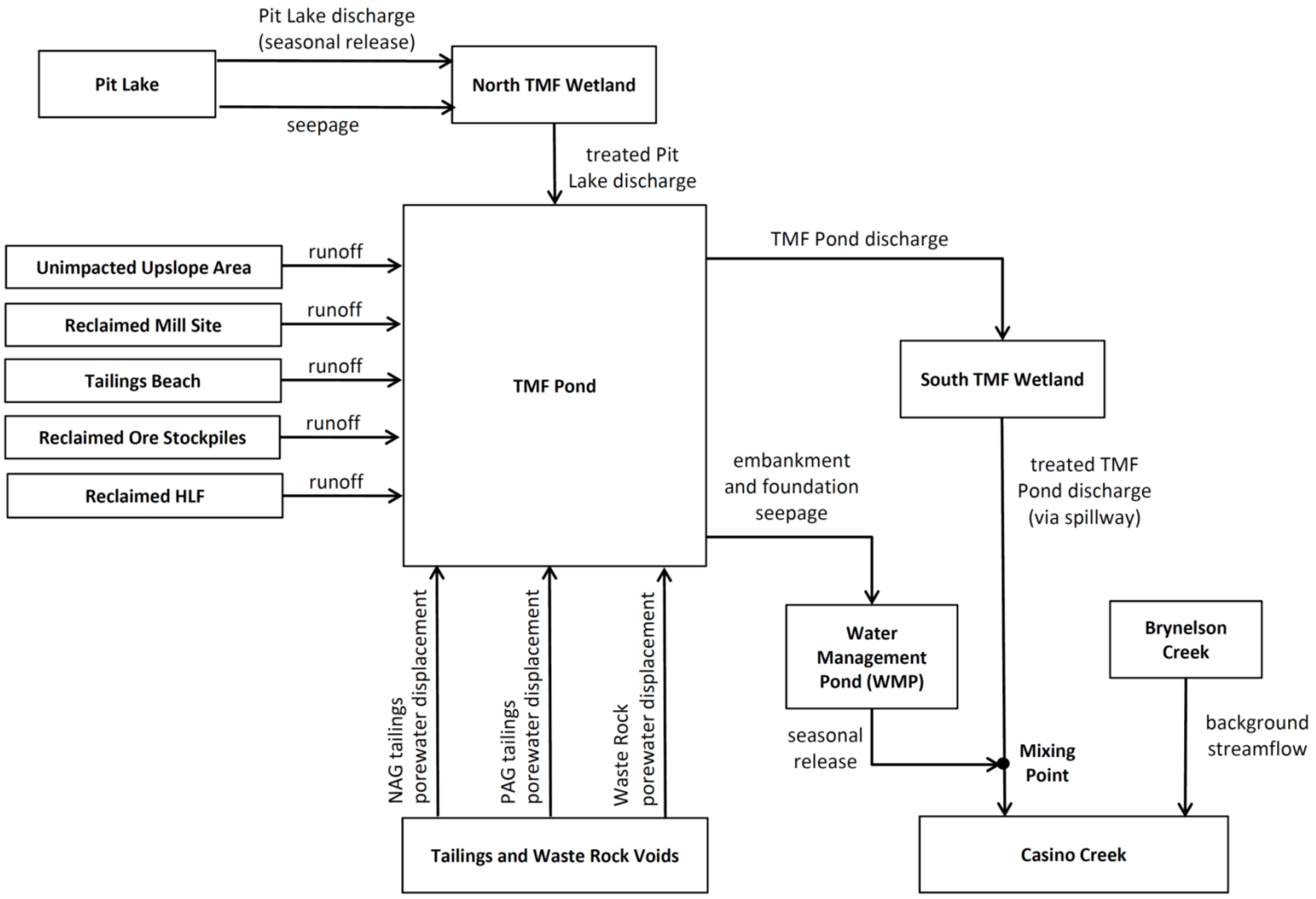


Figure 8-2. Mass Loading Flow Paths through the TMF Pond System (Pit Discharge Phase)

8.2 Mass Load Balance and Water Quality Prediction

Water balance flows (KPL, 2015) were combined with mine loading source terms (Lorax, 2013), and background water quality to predict mass loading rates of inflow and outflow of potential contaminants in the TMF Pond. Water quality in the TMF Pond was calculated as the cumulative mass of a given substance in the TMF Pond water, divided by the water volume stored in the TMF Pond in a given time step interval. The TMF Pond mixing model output concentrations were assessed for solubility controls at each time step of the model simulation by coupling GoldSim and PHREEQC. This section provides a summary of the model results. Modelling methodology and results are provided in Appendix IV.

After the Wetland Construction Phase, surplus TMF Pond water will discharge over the TMF spillway and into Casino Creek. Prior to discharge over the spillway, the TMF Pond water will travel through the South TMF Wetland, an engineered wetland for the removal of some contaminants. The wetland layout was designed by BCL (2013) and is illustrated on Figure 2-2.

Clear Coast Consultants (2013) provided maximum water quality concentrations for the South TMF Wetland effluent (Table 8-1). In the water quality modelling, if the modelled TMF Pond water quality in the spillway discharge was higher than the maximum treatment system concentrations, then water quality in the spillway discharge was set equal to the maximum water quality concentration of the wetland. If no treatment was specified, the modelled TMF Pond water quality was assumed to report to Casino Creek via the spillway, unchanged.

Table 8-1. South TMF Wetland Maximum Effluent Water Quality

Water Quality Parameter		Maximum Effluent Water Quality (mg/L)
Sulphate	(SO_4)	15% reduction
Cadmium	(Cd)	0.000080
Copper	(Cu)	0.0040
Molybdenum	(Mo)	0.073
Mercury	(Hg)	0.000026
Selenium	(Se)	-
Silver	(Ag)	0.00010
Uranium	(U)	0.015
Zinc	(Zn)	0.030

Annual TMF Pond water quality from one model realization, for select parameters, are provided for a typical year during Operations (Year 15), initial discharge of the TMF to Casino Creek (Year 35), and long-term, post Pit Lake discharge (Year 120) conditions. Model output concentrations are provided in Appendix IV for all modelled water quality parameters.

Water quality is provided (Table 8-2) for the TMF Pond water, and TMF Spillway discharge to illustrate the modelled effects of the treatment wetland.

Table 8-2. TMF Pond Water Quality Model Results

Water Quality Parameter		Average TMF Pond Water Quality (mg/L) [1]			
		Operations	Wetland Construction Phase	TMF Discharge Phase	Pit Discharge Phase
pH		6.1	6.8	6.9	6.9
Sulphate	(SO_4)	1,242	695	335	266
Fluoride	(F)	2.1	1.2	0.65	0.63
Cadmium	(Cd)	0.00064	0.00065	0.00034	0.00016
Copper	(Cu)	0.33	0.067	0.11	0.073
Iron	(Fe)	0.0012	0.00030	0.00022	0.00023
Molybdenum	(Mo)	0.37	0.20	0.085	0.066
Selenium	(Se)	0.015	0.0069	0.0043	0.0043
Uranium	(U)	0.018	0.033	0.048	0.042
Water Quality Parameter		**Average TMF Spillway Water Quality (mg/L)**			
		Operations [2]	**Wetland Construction Phase [2]**	**Initial TMF Pond Discharge**	**Pit Discharge Phase**
pH		-	-	6.9	6.9
Sulphate	(SO_4)	-	-	283	225
Fluoride	(F)	-	-	0.65	0.63
Cadmium	(Cd)	-	-	0.000080	0.000080
Copper	(Cu)	-	-	0.0040	0.0040
Iron	(Fe)	-	-	0.00022	0.00023
Molybdenum	(Mo)	-	-	0.085	0.066
Selenium	(Se)	-	-	0.0043	0.0043
Uranium	(U)	-	-	0.015	0.015

1. Values represent average water quality results over the duration of each mining phase for a single model realization (realization #1).
2. TMF Spillway will have zero discharge during the Operations and Wetland Discharge Phases.

Individual contributions of each mass loading source are presented for each phase of mining in Table 8-3 to Table 8-6. Individual contributions of mass loading sources are provided in Appendix IV for all modelled water quality parameters.

In general, during TMF Discharge Phase, upward fluxes from porewater in the tailings and waste rock are the dominant loads to the TMF Pond. Once the Pit Discharge Phase begins, North Wetland discharge makes up a large portion of the overall load to the TMF Pond for some water quality parameters.

Table 8-3. Loading Source Contributions to the TMF Pond (Operations)

Source of Loading	Fraction Contributing (%)							
	SO_4	F	Cd	Cu	Fe	Mo	Se	U
Background Runoff	0	0	1	0	0	0	0	3
Stockpile (runoff + seepage)	1	3	44	93	20	2	9	20
Waste Rock Runoff	0	0	7	1	0	0	5	4
Tailings Beach Runoff	0	0	1	0	0	1	0	0
HLF Drainage	0	0	0	0	0	0	0	0
Tailings Slurry	73	72	5	1	3	78	72	54
PAG Tailings Pore Water	1	1	1	0	3	1	1	2
NAG Tailings Pore Water	15	14	36	1	72	11	8	4
Waste Rock Pore Water	1	1	1	3	2	1	1	10
WMP Pump Back	8	8	6	0	0	7	5	3
North TMF Wetland Discharge	0	0	0	0	0	0	0	0
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

1. Average of all year during Operations, calculated from output from model Realization #1.
2. Shaded cells are for sources that contribute >10% to the overall load.
3. Values are rounded to the nearest 1 and the total of individual values may not add to exactly 100.

Table 8-4. Loading Source Contributions to the TMF Pond (Wetland Construction Phase)

Source of Loading	Fraction Contributing (%)							
	SO_4	F	Cd	Cu	Fe	Mo	Se	U
Background Runoff	3	4	8	1	2	0	1	19
Stockpile (runoff + seepage)	0	0	0	1	0	0	0	0
Waste Rock Runoff	0	0	0	0	0	0	0	0
Tailings Beach Runoff	0	7	0	0	0	5	1	2
HLF Drainage	1	1	2	0	0	9	14	5
Tailings Slurry	0	0	0	0	0	0	0	0
PAG Tailings Pore Water	3	2	1	0	1	2	2	1
NAG Tailings Pore Water	71	65	79	9	73	67	57	5
Waste Rock Pore Water	22	21	8	88	23	17	25	68
WMP Pump Back	0	0	0	0	0	0	0	0
North TMF Wetland Discharge	0	0	0	0	1	0	0	0
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

1. Average of all years during the Wetland Construction Phase, calculated from output from model Realization #1.
2. Shaded cells are for sources that contribute >10% to the overall load.
3. Values are rounded to the nearest 1 and the total of individual values may not add to exactly 100.

Table 8-5. Loading Source Contributions to the TMF Pond (TMF Discharge Phase)

Source of Loading	Fraction Contributing (%)							
	SO_4	F	Cd	Cu	Fe	Mo	Se	U
Background Runoff	6	7	21	1	3	0	1	17
Stockpile (runoff + seepage)	0	0	4	13	1	0	0	0
Waste Rock Runoff	0	0	0	0	0	0	0	0
Tailings Beach Runoff	1	12	1	0	0	9	1	2
HLF Drainage	3	4	4	0	0	22	39	8
Tailings Slurry	0	0	0	0	0	0	0	0
PAG Tailings Pore Water	1	1	1	0	1	1	1	0
NAG Tailings Pore Water	31	25	42	2	35	26	15	1
Waste Rock Pore Water	50	42	24	84	57	35	34	70
WMP Pump Back	0	0	0	0	0	0	0	0
North TMF Wetland Discharge	7	9	2	0	3	7	10	3
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

1. Average of all years during TMF Discharge Phase, calculated from output from model Realization #1.
2. Shaded cells are for sources that contribute >10% to the overall load.
3. Values are rounded to the nearest 1 and the total of individual values may not add to exactly 100.

Table 8-6. Loading Source Contributions to the TMF Pond (Pit Discharge Phase)

Source of Loading	Fraction Contributing (%)							
	SO_4	F	Cd	Cu	Fe	Mo	Se	U
Background Runoff	5	5	30	1	5	0	1	16
Stockpile (runoff + seepage)	0	0	0	0	0	0	0	0
Waste Rock Runoff	0	0	0	0	0	0	0	0
Tailings Beach Runoff	1	9	2	0	0	8	1	2
HLF Drainage	2	3	4	0	0	17	26	6
Tailings Slurry	0	0	0	0	0	0	0	0
PAG Tailings Pore Water	0	0	0	0	0	0	0	0
NAG Tailings Pore Water	6	4	14	0	11	6	2	0
Waste Rock Pore Water	43	30	32	96	79	31	24	63
WMP Pump Back	0	0	0	0	0	0	0	0
North TMF Wetland Discharge	42	49	18	2	4	38	46	13
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

1. Average of all years during Pit Discharge Phase, calculated from output from model Realization #1.
2. Shaded cells are for sources that contribute >10% to the overall load.
3. Values are rounded to the nearest 1 and the total of individual values may not add to exactly 100.

9 TMF Water Management Pond Water Quality Model

The Water Management Pond (WMP) will collect surface runoff and seepage from the TMF embankments and the collected water will be pumped back to the TMF Pond during Operations and to the Open Pit during Wetland Construction Phase. Mass loading inflows and outflows to the WMP are presented in Figure 9-1 (Operations), and Figure 9-2 (Wetland Construction Phase).

Starting in the TMF Discharge Phase, seepage recovered downstream from the TMF embankments will be stored in the WMP through the low flow months of the year (winter), and released during those months when the TMF Spillway is discharging, and when Brynelson Creek flows are higher (spring, summer, and fall) such that the seepage water quality will be less influential on the water quality in Casino Creek. Mass loading inflows and outflows to the WMP during TMF Discharge and Pit Discharge Phases are presented in Figure 9-3.

9.1 Water Balance Model Results

KPL assumed in the water balance that 100% of the total TMF seepage, embankment runoff, and embankment construction water (i.e. Sand Plant underflow) will be captured in the WMP. Because the WMP water will be pumped back to the TMF Pond (Operations), or Open Pit (Wetland Construction Phase), the mine site will have zero discharge to Casino Creek during those phases.

Following the wetland construction phase, withdrawal and discharge from the WMP pond will occur from May to November through the following controls:

- In May, once Brynelson Creek is discharging at 20 L/s or more, the WMP will discharge at a ratio of 0.8 times the Brynelson Creek Flow. From June to November under typical conditions in Brynelson, the WMP will discharge at this ratio. However, for years with exceptionally low flow in Brynelson, the WMP will need to be discharged at a rate of up to 200 L/s to drain down stored water in the WMP in order to ensure there is storage capacity available for the following winter months.
- The release of the TMF pond will be controlled to further mitigate water quality in Casino Creek. This is especially important for drier periods when there is little-to-no water in Brynelson Creek. The ratio of TMF pond release to WMP release is set at 1.2 for June to November and 2.0 for May for the TMF Discharge Phase. These ratios were determined to avoid excess draw-down in the TMF pond and provide for a sufficient water cover over waste rock and tailings. The ratio of TMF pond release to WMP release varies from 1.2 to 2.5 for the Pit Discharge Phase as there is more water available in the TMF once the pit starts to discharge.

A summary of annual inflows and outflows of water to the WMP is provided in Appendix V.

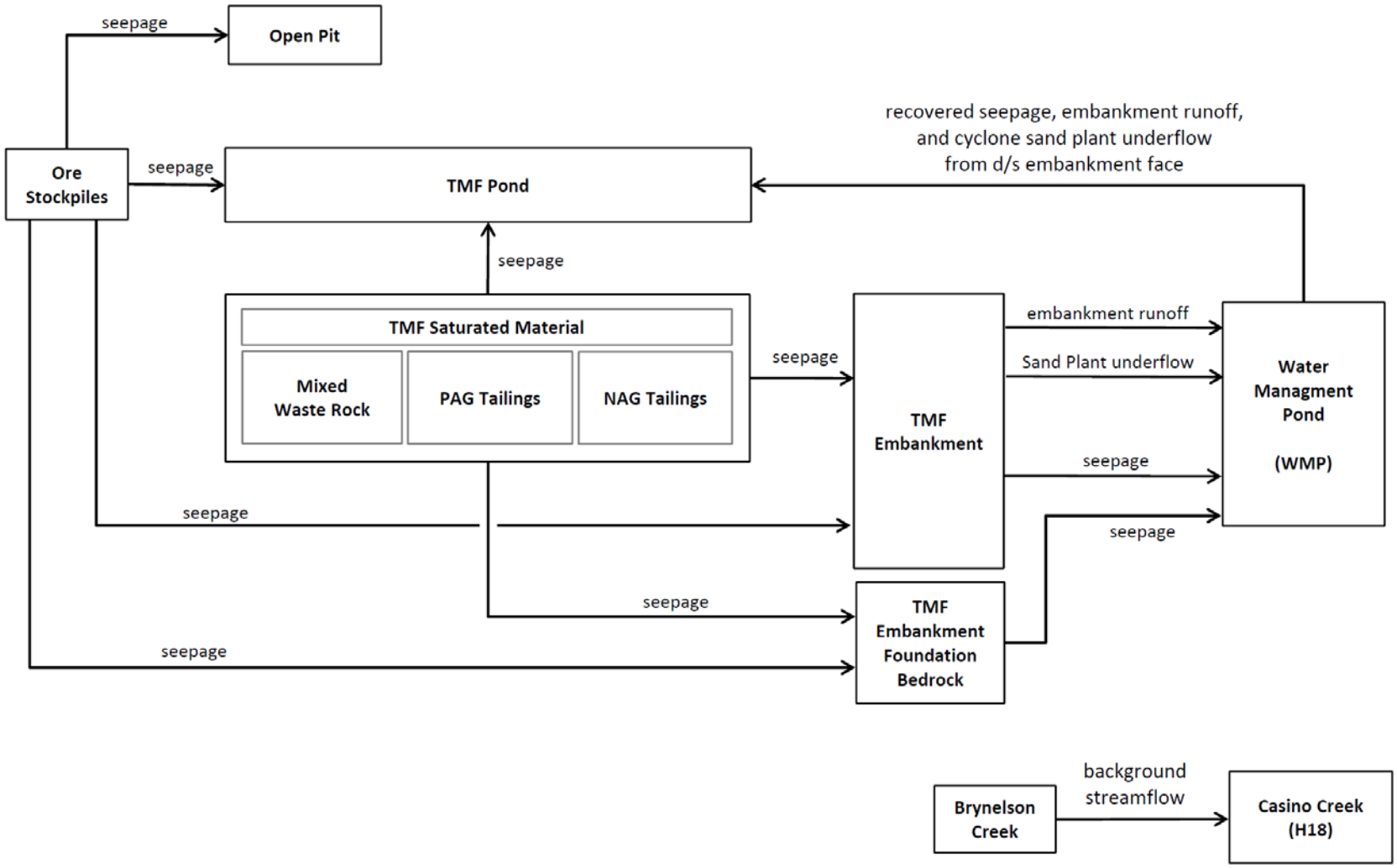


Figure 9-1. WMP Mass Loading Diagram (Operations Phase)

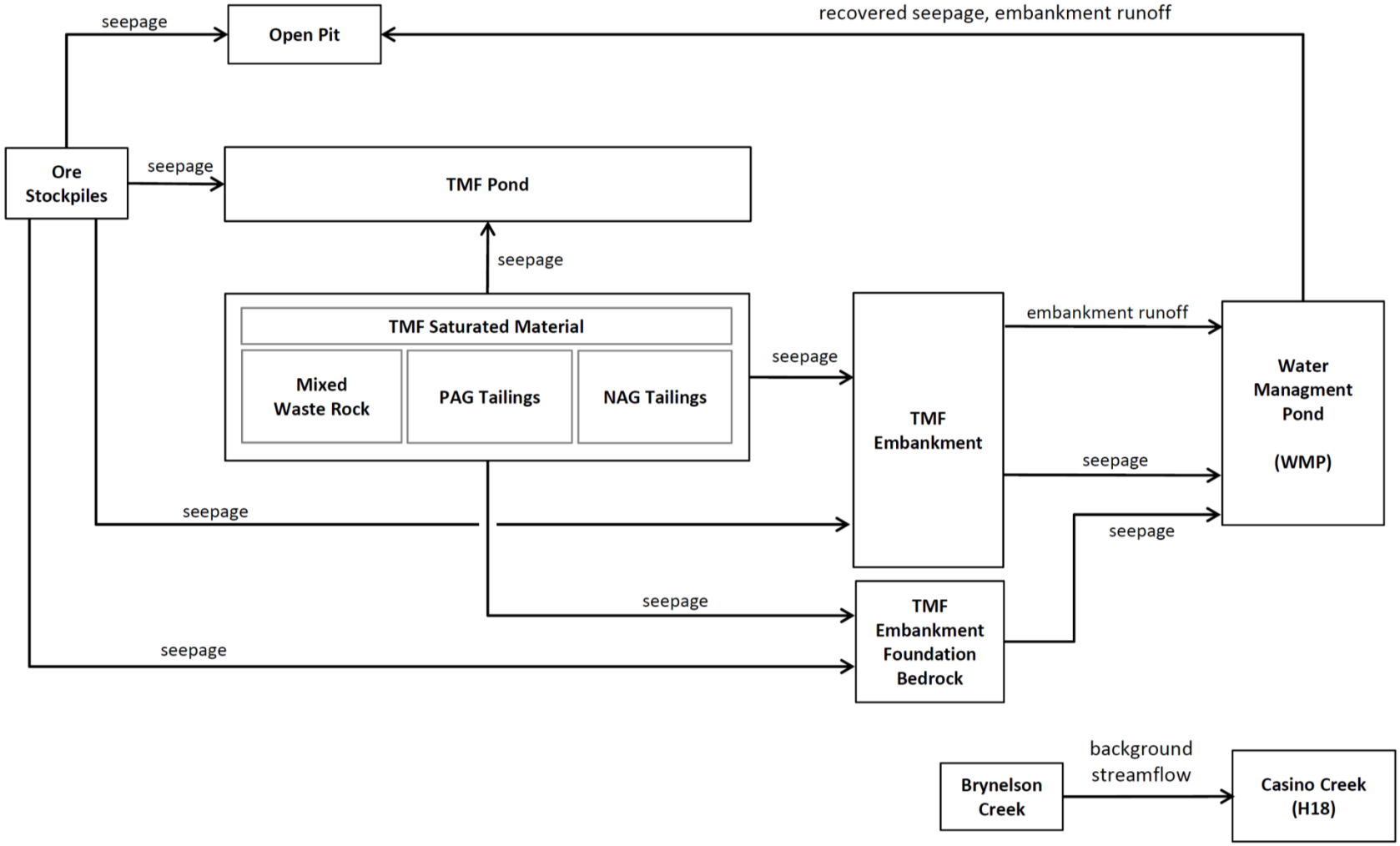


Figure 9-2. WMP Mass Loading Diagram (Wetland Construction Phase)

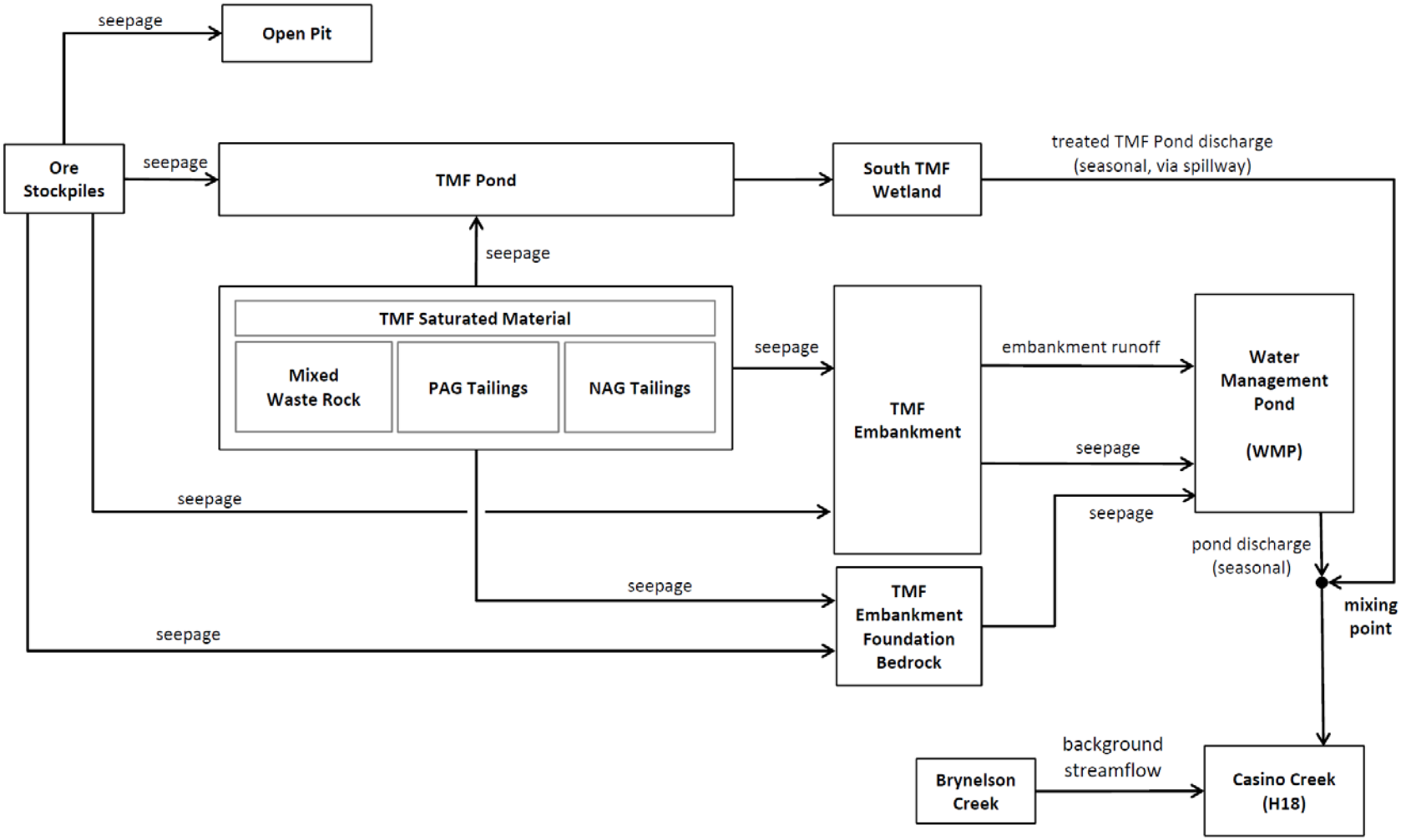


Figure 9-3. WMP Mass Loading Diagram (TMF Discharge and Pit Discharge Phases)

9.2 Mass Load Balance and Water Quality Prediction

Water balance flows (KPL, 2015) were combined with mine loading source terms (Lorax, 2013), and background water quality to predict mass loading rates of inflow and outflow of potential contaminants in the WMP. The WMP mixing model output concentrations were assessed for solubility controls at each time step of the model simulation by coupling GoldSim and PHREEQC. The pH of the WMP was predicted by PHREEQC to be near neutral. Water quality model results for select parameters are presented in Table 9-1. Modelling methodology and results are presented in detail in Appendix V of this report.

Table 9-1. Water Quality Results for the WMP

Water Quality Model Parameter		WMP Quality (mg/L) [1]		
		Pumped Back to TMF (Operations Phase)	Pumped Back to Pit (Wetland Construction Phase)	Released to Casino Creek (TMF Discharge and Pit Discharge Phases)
pH		6.2	6.4	6.4
Sulphate	(SO_4)	1,137	947	979
Fluoride	(F)	1.9	1.8	1.8
Cadmium	(Cd)	0.00063	0.0014	0.0012
Copper	(Cu)	0.021	0.044	0.038
Iron	(Fe)	0.0011	0.00056	0.00059
Molybdenum	(Mo)	0.27	0.32	0.24
Selenium	(Se)	0.0075	0.0072	0.0072
Uranium	(U)	0.0095	0.036	0.036

1. Values represent average water quality results over the duration of each mining phase for a single model realization (Realization #1).

Individual contributions of each mass loading source are presented in Table 9-2 (Operations) and Table 9-3 (TMF Discharge and Pit Discharge). Individual contributions of mass loading sources are provided in Appendix V for all modelled water quality parameters.

Table 9-2. Loading Source Contributions to WMP (Operations)

Source of Loading	Fraction Contributing (%)							
	SO_4	F	Cd	Cu	Fe	Mo	Se	U
Background Runoff	0	0	0	1	1	0	0	5
Embankment Runoff	1	1	48	14	0	22	2	25
Stockpile Seepage	0	0	1	17	0	0	0	1
Tailings and Waste Rock Seepage	13	12	42	38	92	12	13	34
Sand Plant Slurry Underflow	86	86	8	31	7	66	85	36
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

1. Average of all years during Operations, calculated from output from model Realization #1.
2. Shaded cells are for sources that contribute >10% to the overall load.
3. Values are rounded to the nearest 1 and the total of individual values may not add to exactly 100.

Table 9-3. Loading Source Contributions to WMP (TMF Discharge and Pit Discharge Phases)

Source of Loading	Fraction Contributing (%)							
	SO_4	F	Cd	Cu	Fe	Mo	Se	U
Background Runoff	0	0	0	1	0	0	0	2
Embankment Runoff	4	26	20	12	0	30	13	47
Stockpile Seepage	0	0	0	1	0	0	0	0
Tailings and Waste Rock Seepage	96	73	80	86	100	70	87	51
Sand Plant Slurry Underflow	0	0	0	0	0	0	0	0
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

1. Average of all years during TMF Discharge and Pit Discharge Phases, calculated from output from model Realization #1.
2. Shaded cells are for sources that contribute >10% to the overall load.
3. Values are rounded to the nearest 1 and the total of individual values may not add to exactly 100.

10 Mine Sources of Loading to the Receiving Environment

Total loading from mine sources were calculated and used as input to the receiving environment water quality modeling (Section 11). Loadings from mine sources, into the receiving environment, are expected to change throughout the Project life based on water management systems that are in place at a given time. The most notable milestone will be the transition from Wetland Construction Phase to TMF Discharge Phase, when the active water management systems will be discontinued. At that time, assuming acceptable water quality, pump-back of seepage from the WMP will stop, and the TMF Pond will discharge into Casino Creek. After that time, seepage that is collected in the WMP will be mixed with the TMF Spillway discharge during the open water season.

Mine loading sources are described in the following sections for the active water management phases (Operations and Wetland Construction), and passive water management phases (TMF Discharge and Pit Discharge).

10.1 Operations and Wetland Construction Phases

During Operations the WMP will be pumped back to the TMF Pond, and during Wetland Construction, the WMP will be pumped back to the Open Pit. As a result, there will be no mine sources of loading to Casino Creek during those phases.

10.2 TMF Discharge and Pit Discharge Phases

During TMF Discharge and Pit Discharge Phases, the WMP will be released during the open water season and will be allowed to mix with the TMF spillway discharge prior to entering Casino Creek. Background runoff from an area of about 1 km^2 is also expected to enter the total flow by the mixing point. The mixing point is shown schematically on Figure 9-3.

Monthly discharges at the mixing point are shown on Figure 10-1. Average, 5th percentile (P5), and 95th percentile (P95) from 52 realizations of the water balance are presented to show the expected range of flows at the mixing point.

Modelled water quality values for CoCs at the mixing point are presented in Table 10-1, by project phase. Metal Mining Effluent Regulation (MMER) values are presented in the table because the mixing point represents the point of discharge from the mine site into the receiving environment. The combined streamflow at the mixing point was calculated to be pH neutral using PHREEQC.

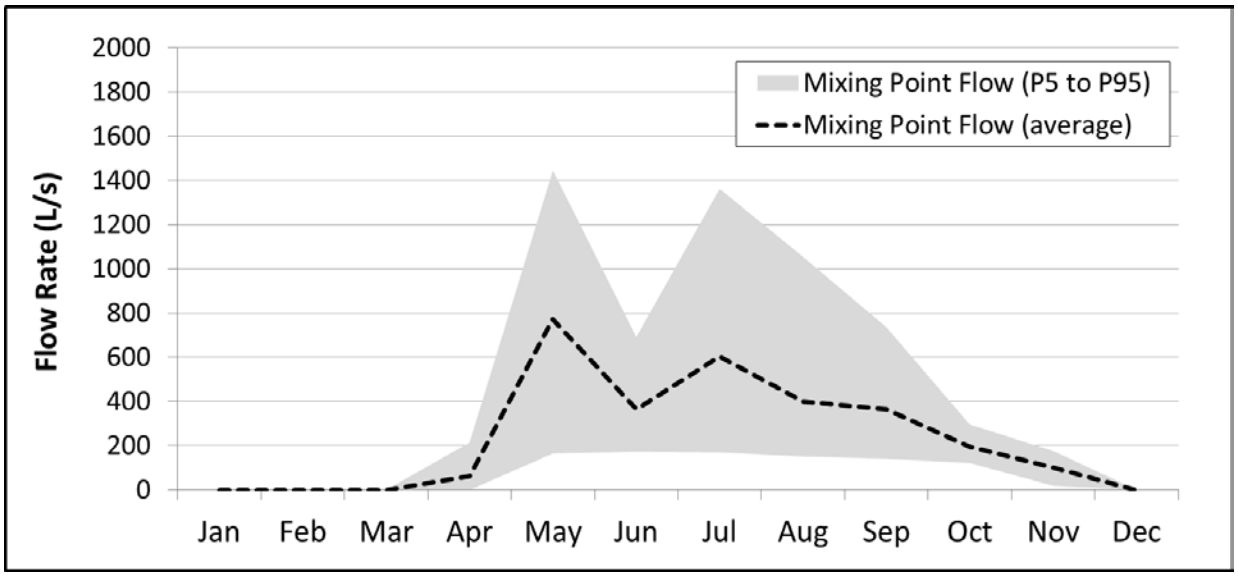


Figure 10-1. Monthly Flow of Mine Derived Water entering Casino Creek from the Mixing Point (Pit Discharge Phase)

Table 10-1. Water Quality of Mine Derived Water Entering Casino Creek

Water Quality Parameter		MMER (mg/L)	Mine Discharge Water Quality at the Mixing Point (mg/L) [1]					
			Operations and Wetland Construction Phase [2]		TMF Discharge Phase [3]		Pit Discharge Phase [3]	
pH		-	-		7.5		7.5	
Sulphate	(SO_4)	-	-		518		394	
Fluoride	(F)	-	-		1.1		0.93	
Cadmium	(Cd)	-	-		0.00050		0.00036	
Copper	(Cu)	0.3	-		0.017		0.012	
Iron	(Fe)	-	-		0.0029		0.0023	
Molybdenum	(Mo)	-	-		0.14		0.11	
Selenium	(Se)	-	-		0.0052		0.0049	
Uranium	(U)	-	-		0.024		0.021	
Annual Flow Components (L/s) [4]								
Background Runoff			0	(0)	4	(6)	4	(6)
TMF Pond Discharge			0	(0)	121	(197)	181	(301)
WMP Discharge			0	(0)	56	(93)	56	(93)
Total Flow at Mixing Point			**0**	**(0)**	**181**	**(296)**	**241**	**(400)**

1. Results in this table were generated from model output of a single model realization (Realization #1).
2. Zero discharge of mine derived water into Casino Creek during Operations, and Wetland Construction Phases.
3. Average of months when TMF and WMP water is released to Casino Creek (May to November). Average calculated from all years during each of the TMF Discharge and Pit Discharge Phases.
4. Annual flow components are presented in terms of average annual flow rate (presented without brackets), and average flow rate from May to November when TMF and WMP discharge occur (presented in brackets).

11 Receiving Environment Water Quality Model

Water quality was calculated for select locations downstream from the proposed mine. Selection of water quality prediction points, sources of loading, modelling methodology, and modelling results are presented in the following section.

11.1 Water Quality Prediction Points

All mine sources of loading are expected to report to Dip Creek watershed via Casino Creek. The following receiving environment water quality prediction points were selected:

- **Middle Casino Creek (H18)** – an existing stream flow monitoring station located immediately downstream from the confluence of Casino Creek and Brynelson Creek. The spillway discharge location is planned for approximately 250 m upstream of H18.
- **Lower Casino Creek (W4)** – an existing water quality and stream flow monitoring station located upstream of the confluence with Dip Creek.
- **Middle Dip Creek (W5)** – an existing water quality monitoring station, located a short distance downstream from the confluence of Casino Creek and Dip Creek.

11.2 Baseline (Pre-Mining) Stream Flow

Monthly baseline stream flow (existing conditions) for the water quality prediction points were calculated by KPL (2013a) in the water balance. Table 11-1 represents monthly streamflow averages of all (52) model realizations.

Table 11-1. Baseline Monthly Streamflow Estimates for Local Watercourses

Month	Middle Casino Creek (H18)	Lower Casino Creek (W4)	Middle Dip Creek (W5)
	Monthly Stream Flow (m^3/s)		
Jan	0.056	0.056	0.15
Feb	0.028	0.028	0.07
Mar	0.025	0.025	0.05
Apr	0.078	0.13	0.47
May	0.87	1.00	3.3
Jun	0.63	0.72	2.7
Jul	1.04	1.2	4.0
Aug	0.67	0.78	2.9
Sep	0.52	0.60	2.3
Oct	0.34	0.39	1.5
Nov	0.14	0.16	0.56
Dec	0.09	0.09	0.28
Mean Annual	**0.37**	**0.43**	**1.5**
Drainage Basin Area (km^2)	67	82	276
Mean Annual Runoff Depth (mm)	176	165	174

11.3 Post-Mining Streamflow

Water balance output for monthly flow rates in Casino Creek at H18 are presented on Figure 11-1 for a single model realization (Realization #1) to illustrate the expected variation in streamflow through the different mine water management phases. The total flow is broken down into components of background streamflow, and mine derived water entering Casino Creek. A ten year blow-up is included with the figure to illustrate the seasonal range observed within that 10 year period. A 1:10 year wet year and 1:10 dry year is identified on the water quality plot. The wet and dry years are labelled on the figure in terms of hydrologic years, rather than calendar years. Hydrologic year was assumed to run from November 1 to October 31 because precipitation begins to accumulate as snow and ice around the beginning of November.

Water balance output, of annual streamflow following the beginning of mining, are presented Table 11-2. Statistics were generated from the 52 model realizations to show the expected variation in annual flow in Casino and Dip Creeks.

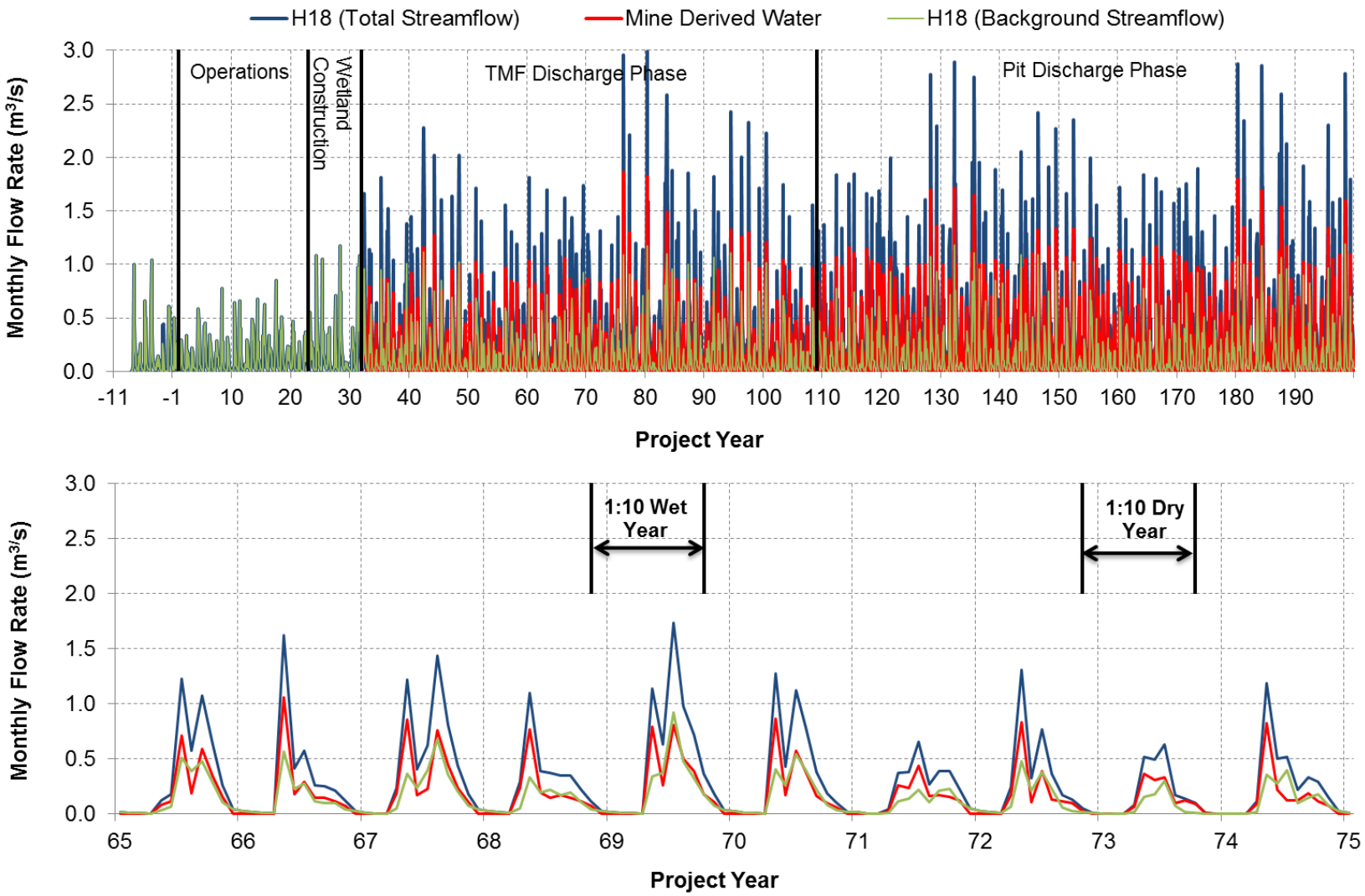


Figure 11-1. Monthly Flow Rate in Casino Creek at H18 (Realization #1)

Table 11-2. Post-Mining Streamflow Estimates for Casino and Dip Creek

	Annual Flow (m^3/s)											
	Operations and and Wetland Construction Phase				TMF Discharge Phase				Pit Discharge Phase			
	P5	P50	Mean	P95	P5	P50	Mean	P95	P5	P50	Mean	P95
H18 (Casino Creek)												
background streamflow	0.06	0.13	0.14	0.23	0.06	0.14	0.14	0.24	0.06	0.14	0.14	0.24
mine derived water	0	0	0	0	0.12	0.16	0.18	0.30	0.17	0.22	0.24	0.37
total streamflow	0.06	0.13	0.14	0.23	0.17	0.29	0.32	0.54	0.22	0.36	0.38	0.61
W4 (Casino Creek)												
background streamflow	0.07	0.18	0.20	0.34	0.07	0.19	0.20	0.35	0.07	0.19	0.20	0.35
mine derived water	0	0	0	0	0.12	0.16	0.18	0.30	0.17	0.22	0.24	0.37
total streamflow	0.07	0.18	0.20	0.34	0.19	0.35	0.38	0.65	0.24	0.41	0.44	0.72
W5 (Middle Dip Creek)												
background streamflow	0.55	1.3	1.3	2.2	0.55	1.3	1.3	2.2	0.54	1.3	1.3	2.2
mine derived water	0	0	0	0	0.12	0.16	0.18	0.30	0.17	0.22	0.24	0.37
total streamflow	0.55	1.3	1.3	2.2	0.67	1.4	1.5	2.5	0.71	1.5	1.5	2.5

1. Annual flow was calculated from 52 realizations of the model.
2. Mine derived flow is the combined discharge from the TMF Pond (via spillway) and WMP discharge.

11.4 Baseline Water Quality

Baseline water quality was grouped by PECG (2013) into winter (November to April) and summer (May to October) seasons. For water quality modelling, SEA subdivided the summer water quality data into two sub-seasons: Spring (May and June), and Summer (July to October). SEA used the seasonal median water quality to represent baseline water quality for modelling. Baseline water quality data are presented for W18 (Table 11-3), W4 (Table 11-4), W9 (Table 11-5), and W5 (Table 11-6). CCME guidelines for the protection of aquatic life are presented beside the water quality data for reference. All values are presented in total metal concentrations, not dissolved.

Table 11-3. Baseline Water Quality at Brynelson Creek (W18)

Water Quality		CCME Guideline (mg/L)	W18 Median Water Quality (mg/L)			
			All Data	Winter	Spring	Summer
Sulphate	(SO_4)	218	23	38	20	20
Fluoride	(F)	0.12	0.040	0.050	0.040	0.040
Cadmium	(Cd)	0.00012	0.000013	0.000011	0.000015	0.000015
Copper	(Cu)	0.0020	0.0012	0.00056	0.0016	0.0016
Iron	(Fe)	0.30	0.053	0.010	0.11	0.11
Molybdenum	(Mo)	0.073	0.0012	0.0019	0.0011	0.0011
Selenium	(Se)	0.0010	0.000040	0.000040	0.000020	0.000020
Uranium	(U)	0.015	0.0034	0.0073	0.0026	0.0026

1. CCME guidelines for the protection of Aquatic Life (BCWQG for SO_4) are presented for reference. Guidelines for SO_4, Cd, and Cu are hardness dependent. Values presented in this table were calculated using the median baseline hardness of Brynelson Creek at W18 (74 mg/L as $CaCO_3$).

Table 11-4. Baseline Water Quality at Casino Creek (W4)

Water Quality		CCME Guideline (mg/L)	W4 Median Water Quality (mg/L)			
			All Data	Winter	Spring	Summer
Sulphate	(SO_4)	309	41	60	20	41
Fluoride	(F)	0.12	0.070	0.070	0.060	0.070
Cadmium	(Cd)	0.00017	0.000027	0.000030	0.000046	0.000025
Copper	(Cu)	0.0026	0.0059	0.0019	0.014	0.0067
Iron	(Fe)	0.30	0.13	0.030	0.30	0.12
Molybdenum	(Mo)	0.073	0.0011	0.0013	0.00070	0.0011
Selenium	(Se)	0.0010	0.000070	0.000080	0.000065	0.000060
Uranium	(U)	0.015	0.0066	0.013	0.0036	0.0066

1. CCME guidelines for the protection of Aquatic Life (BCWQG for SO_4) are presented for reference. Guidelines for SO_4, Cd, and Cu are hardness dependent. Values presented in this table were calculated using the median baseline hardness of Casino Creek at W4 (111 mg/L as $CaCO_3$).
2. Shaded cells exceed CCME guidelines.

Table 11-5. Baseline Water Quality at Dip Creek (W9)

Water Quality		CCME Guideline (mg/L)	W9 Median Water Quality (mg/L)			
			All Data	Winter	Spring	Summer
Sulphate	(SO_4)	309	15	22	3.5	13
Fluoride	(F)	0.12	0.050	0.050	0.050	0.050
Cadmium	(Cd)	0.00013	0.000012	0.0000080	0.000043	0.0000090
Copper	(Cu)	0.0020	0.00091	0.00068	0.0024	0.0012
Iron	(Fe)	0.30	0.084	0.043	0.90	0.12
Molybdenum	(Mo)	0.073	0.00059	0.00058	0.00042	0.00071
Selenium	(Se)	0.0010	0.000040	0.000020	0.000055	0.000030
Uranium	(U)	0.015	0.0053	0.0086	0.0035	0.0046

1. CCME guidelines for the protection of Aquatic Life (BCWQG for SO_4) are presented for reference. Guidelines for SO_4, Cd, and Cu are hardness dependent. Values presented in this table were calculated using the median baseline hardness of Dip Creek at W9 (81 mg/L as $CaCO_3$).
2. Shaded cells exceed CCME guidelines.

Table 11-6. Baseline Water Quality at Dip Creek (W5)

Water Quality		CCME Guideline (mg/L)	W5 Median Water Quality (mg/L)			
			All Data	Winter	Spring	Summer
Sulphate	(SO_4)	309	24	34	8.1	23
Fluoride	(F)	0.12	0.060	0.060	0.055	0.060
Cadmium	(Cd)	0.00015	0.000017	0.000017	0.000054	0.000015
Copper	(Cu)	0.0022	0.0023	0.0011	0.0067	0.0023
Iron	(Fe)	0.30	0.089	0.052	0.72	0.078
Molybdenum	(Mo)	0.073	0.00081	0.00084	0.00049	0.00082
Selenium	(Se)	0.0010	0.000050	0.000055	0.000060	0.000050
Uranium	(U)	0.015	0.0056	0.0099	0.0030	0.0055

1. CCME guidelines for the protection of Aquatic Life (BCWQG for SO_4) are presented for reference. Guidelines for SO_4, Cd, and Cu are hardness dependent. Values presented in this table were calculated using the median baseline hardness of Dip Creek at W9 (81 mg/L as $CaCO_3$).
2. Shaded cells exceed CCME guidelines.

11.5 Mass Loading Sources

Mass loading of contaminants from mine sources and naturally occurring sources were accounted for in the modelling and are described in the following section.

11.5.1 Mine Sources

Loadings from the mine sources into the receiving environment are expected to change throughout the Project life based on water management systems that are in place at a given time. Calculation of loading from mine sources within the modelling timeframe is described in Section 10.

11.5.2 Background Loading

Naturally occurring loading present in the surface water from non-mining impacted areas was accounted for in the modelling. In this document, this source of mass loading is referred to as "background" loading.

At the proposed Casino mine site, the Upper Casino Creek drainage basin would be altered by mining from the development of the open pit and the construction of the TMF. Station W11 is located at the downstream-most location of the TMF. It was concluded by SEA that all area downstream from station W11 (except for the WMP) would remain essentially unaltered from pre-mining conditions. As a result, all areas downstream from, (i.e. outside of the W11 drainage basin) would contribute background loading to the modelled water quality prediction points.

This report presents background concentrations in total metal concentrations, not dissolved.

11.6 Mass Balance and Water Quality Modelling Equations

A mixing model was developed where the concentration of a given substance at each modelling point was calculated by adding the mass flow rate from each of the incoming loading sources, and dividing by the total volumetric flow rate at that modelling point.

The mass loading rate from each load source was calculated as the product of the concentration and the volumetric flow rate of water, as follows:

$$L = C * Q$$

Where:

- L is the mass loading rate for a given contaminant (mass of substance / time)
- C is the water quality concentration (mass of substance / volume of water); and
- Q is the flow rate of water in the modelled watercourse (volume of water / time)

Mass loading equations that were used to predict water quality in the receiving environment are presented in the following sub-sections for each modelling point.

11.6.1 Casino Creek (H18)

The total loading to H18 was calculated with the following relationship:

$$L_{H18} = L_{MINE} + L_{H18\ (BG)}$$

- L_{H18} total mass loading at H18
- L_{MINE} total mass load from mine derived sources
- $L_{H18\ (BG)}$ background mass loading at H18

Calculation of mine sources of mass loading is described in Section 10. The background loading was calculated as the naturally occurring loading in the stream flow downstream from the TMF, and upstream from the H18 monitoring point. The equation for background loading is as follows:

$$L_{H18\ (BG)} = Q_{H18\ (BG)} * C_{H18\ (BG)}$$

- $Q_{H18\ (BG)}$ background stream flow at H18
- $C_{H18\ (BG)}$ background water quality (concentration) at H18

Background stream flow at H18 was calculated in the water balance model (KP 2013a). Background water quality was assumed to be equal to baseline water quality from Brynelson Creek (W18) monitoring station because W18 makes up approximately 90% of the H18 background drainage basin.

11.6.2 Casino Creek (W4)

The total loading to W4 was calculated with the following relationship:

$$L_{W4} = L_{H18} + L_{W4\ (BG)}$$

L_{W4} total mass loading at W4
$L_{W4\ (BG)}$ background mass loading at W4

The background loading was calculated as the naturally occurring loading in the stream flow downstream from H18, and upstream from the W4 monitoring point. The equation for background loading was calculated as:

$$L_{W4\ (BG)} = Q_{W4\ (BG)} * C_{W4\ (BG)}$$

$Q_{W4\ (BG)}$ background stream flow at W4
$C_{W4\ (BG)}$ background water quality W4

Background stream flow at H18 was calculated as the difference between baseline stream flows station W4 and H18. Background water quality at W4 was assumed to be equal to baseline water quality at W18 because W18 makes up a large portion of the W4 background drainage basin, once the TMF is constructed.

11.6.3 Middle Dip Creek (W5)

Middle Dip Creek (W5) is immediately downstream from the confluence between Casino Creek (at W4) and Dip Creek (at W9). Because the Dip Creek drainage basin at W9 will not be impacted by the casino Project, baseline loading at W9 is combined with the predicted loading at W4, to calculate total mass loading at W5. Water quality predictions for W5 were based on the following mass balance relationship:

$$L_{W5} = L_{W4} + L_{W9\ (BL)}$$
$$L_{W9\ (BL)} = Q_{W9\ (BL)} * C_{W9\ (BL)}$$

L_{W5} predicted mass loading at W5
$L_{W9\ (BL)}$ baseline loading at W9
$Q_{W9\ (BL)}$ baseline stream flow at W9
$C_{W9\ (BL)}$ baseline water quality at W9

11.7 Water Quality Model Results – Single Model Realization

Single model realization results were generated when one permutation (i.e. realization) of the input hydrology dataset was run with the model. Single realization results provide a time-series of model output which shows a representation of water quality that would result from a realistic range in hydrological conditions at the site. The output provides an indication of how high (or low) water quality concentrations may get, and how often those results are expected to occur.

Water quality model results are tabulated in Table 11-7 for the eight parameters that were predicted to exceed CCME guidelines at least once during the model simulation. Water quality results are presented for all modelled parameters in Appendix VI. The predicted water quality was compared to CCME guidelines for all parameters with the exception of sulphate. There is no CCME guideline for sulphate and as a result the BCWQG was used. Hardness based guidelines were derived from median baseline hardness. CCME guidelines have not been defined as the target maximum water quality for the Casino Project; they have been compared to the water quality model results as a point of reference.

Time-series water quality plots are also presented in the following sections. Because there is a large amount of information plotted over the 200 year simulation, a ten year blow-up is included with the figures to illustrate the seasonal range observed within this period. A 1:10 year wet year and 1:10 dry year is identified on the water quality plots.

11.7.1 Casino Creek (H18 and W4)

Time series plots of Casino Creek results are presented for one model realization in Figure 11-2 to Figure 11-9. Water quality at model node H18 and W4 are plotted on the same figures as they are very similar.

The pH in Casino Creek was calculated (using PHREEQC) to be neutral.

Fraction contributing tables are presented for H18 (Table 11-8) to illustrate the relative proportions of mass loading from the TMF Pond, WMP, and background streamflow to the water quality modelling points. Values in Table 11-8 can be considered representative of W4 because there is no other significant source of loading between W4 and H18.

Table 11-7. Annual and Seasonal Water Quality Predictions in the Receiving Environment – Single Model Realization

Water Quality Parameter		CCME Guideline (mg/L)	Operations and Wetland Construction Phase (mg/L)				TMF Discharge Phase (mg/L)				Pit Discharge Phase (mg/L)			
			Annual	Winter	Spring	Summer	Annual	Winter	Spring	Summer	Annual	Winter	Spring	Summer
Casino Creek (H18)														
pH			7.3	7.4	7.2	7.2	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.5
Sulphate	(SO_4)	309	27	32	19	19	205	141	341	266	179	122	298	233
Fluoride	(F)	0.12	0.044	0.047	0.040	0.040	0.42	0.26	0.69	0.60	0.40	0.25	0.66	0.58
Cadmium	(Cd)	0.00017	0.000013	0.000012	0.000014	0.000014	0.00018	0.00011	0.00032	0.00026	0.00015	0.000092	0.00027	0.00021
Copper	(Cu)	0.0026	0.0012	0.00086	0.0016	0.0016	0.0065	0.0042	0.011	0.0089	0.0055	0.0035	0.0097	0.0073
Iron	(Fe)	0.30	0.069	0.039	0.11	0.11	0.033	0.022	0.045	0.051	0.029	0.022	0.039	0.040
Molybdenum	(Mo)	0.073	0.0014	0.0017	0.0011	0.0011	0.049	0.029	0.084	0.073	0.045	0.026	0.078	0.068
Selenium	(Se)	0.0010	0.000028	0.000034	0.000020	0.000020	0.0019	0.0012	0.0032	0.0027	0.0020	0.0012	0.0034	0.0030
Uranium	(U)	0.015	0.0045	0.0060	0.0026	0.0026	0.012	0.0095	0.015	0.015	0.012	0.0093	0.015	0.014
Casino Creek (W4)														
pH			7.3	7.4	7.2	7.2	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
Sulphate	(SO_4)	309	27	33	19	19	184	128	300	236	163	112	267	211
Fluoride	(F)	0.12	0.044	0.047	0.040	0.040	0.37	0.24	0.60	0.53	0.36	0.23	0.59	0.53
Cadmium	(Cd)	0.00017	0.000013	0.000012	0.000014	0.000014	0.00016	0.00010	0.00028	0.00023	0.00014	0.000084	0.00024	0.00019
Copper	(Cu)	0.0026	0.0012	0.00087	0.0016	0.0016	0.0059	0.0038	0.010	0.0080	0.0050	0.0032	0.0088	0.0067
Iron	(Fe)	0.30	0.069	0.039	0.11	0.11	0.039	0.026	0.054	0.059	0.034	0.025	0.047	0.048
Molybdenum	(Mo)	0.073	0.0014	0.0017	0.0011	0.0011	0.043	0.026	0.073	0.064	0.041	0.024	0.069	0.061
Selenium	(Se)	0.0010	0.000028	0.000034	0.000020	0.000020	0.0017	0.0010	0.0028	0.0024	0.0018	0.0010	0.0030	0.0027
Uranium	(U)	0.015	0.0046	0.0060	0.0026	0.0026	0.011	0.0091	0.013	0.013	0.011	0.0090	0.013	0.013
Casino Creek (W5)														
pH			7.4	7.5	7.2	7.3	7.4	7.5	7.3	7.3	7.4	7.5	7.3	7.4
Sulphate	(SO_4)	309	17	22	5.9	14	62	49	94	73	62	48	91	76
Fluoride	(F)	0.12	0.049	0.050	0.048	0.049	0.14	0.10	0.22	0.18	0.15	0.10	0.23	0.20
Cadmium	(Cd)	0.00015	0.000014	0.0000087	0.000038	0.0000097	0.000055	0.000033	0.00012	0.000069	0.000053	0.000031	0.00011	0.000066
Copper	(Cu)	0.0022	0.0012	0.00078	0.0022	0.0013	0.0025	0.0016	0.0047	0.0031	0.0024	0.0015	0.0045	0.0030
Iron	(Fe)	0.30	0.19	0.053	0.78	0.12	0.17	0.049	0.66	0.11	0.16	0.048	0.64	0.10
Molybdenum	(Mo)	0.073	0.00071	0.00074	0.00052	0.00076	0.012	0.0072	0.022	0.017	0.013	0.0076	0.023	0.020
Selenium	(Se)	0.0010	0.000029	0.000023	0.000050	0.000029	0.00048	0.00029	0.00090	0.00065	0.00058	0.00034	0.0010	0.00087
Uranium	(U)	0.015	0.0061	0.0077	0.0033	0.0043	0.0077	0.0084	0.0064	0.0068	0.0079	0.0085	0.0067	0.0072

1. Results presented in this table were generated from model output of a single model realization (Realization #1).
2. Results presented in this table represent average water quality for all years (or seasons) that fall within each phase of mining.
3. Shaded cells are modelled concentrations that exceed the CCME Guidelines for the protection of freshwater aquatic life. Water quality limits have not been established and the CCME guidelines are provided as a point of reference only.
4. BC Water Quality guideline for sulphate was used because CCME guidelines are not available.
5. Water quality guidelines for SO_4, Cd, Cu, Pb, and Ni are hardness dependent. Values presented in this table were calculated using the median baseline hardness of 111 mg/L as $CaCO_3$ (H18 and W4) and 90 mg/L as $CaCO_3$ (W5).

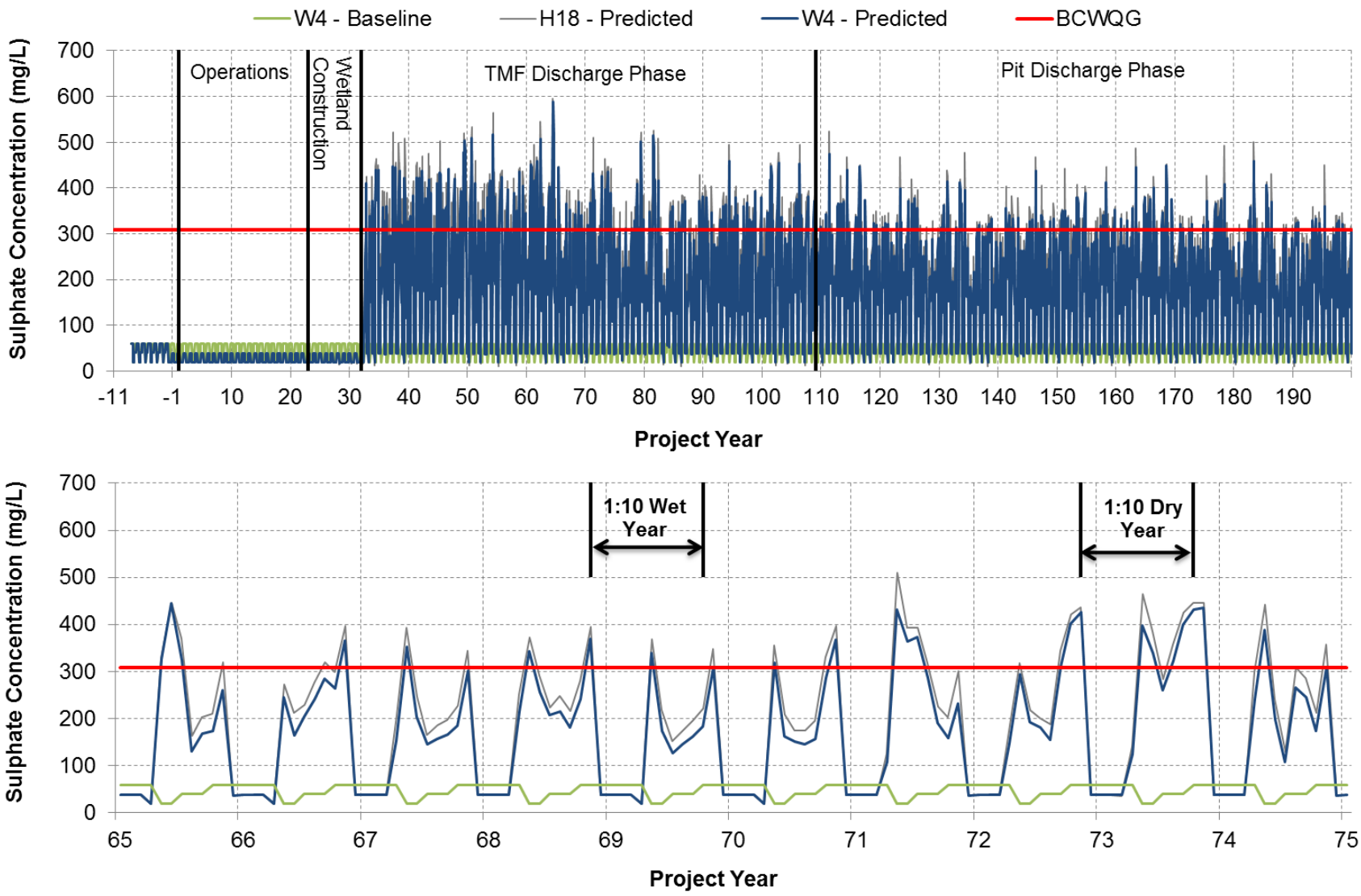


Figure 11-2. Modelled Sulphate Concentration at H18 and W4

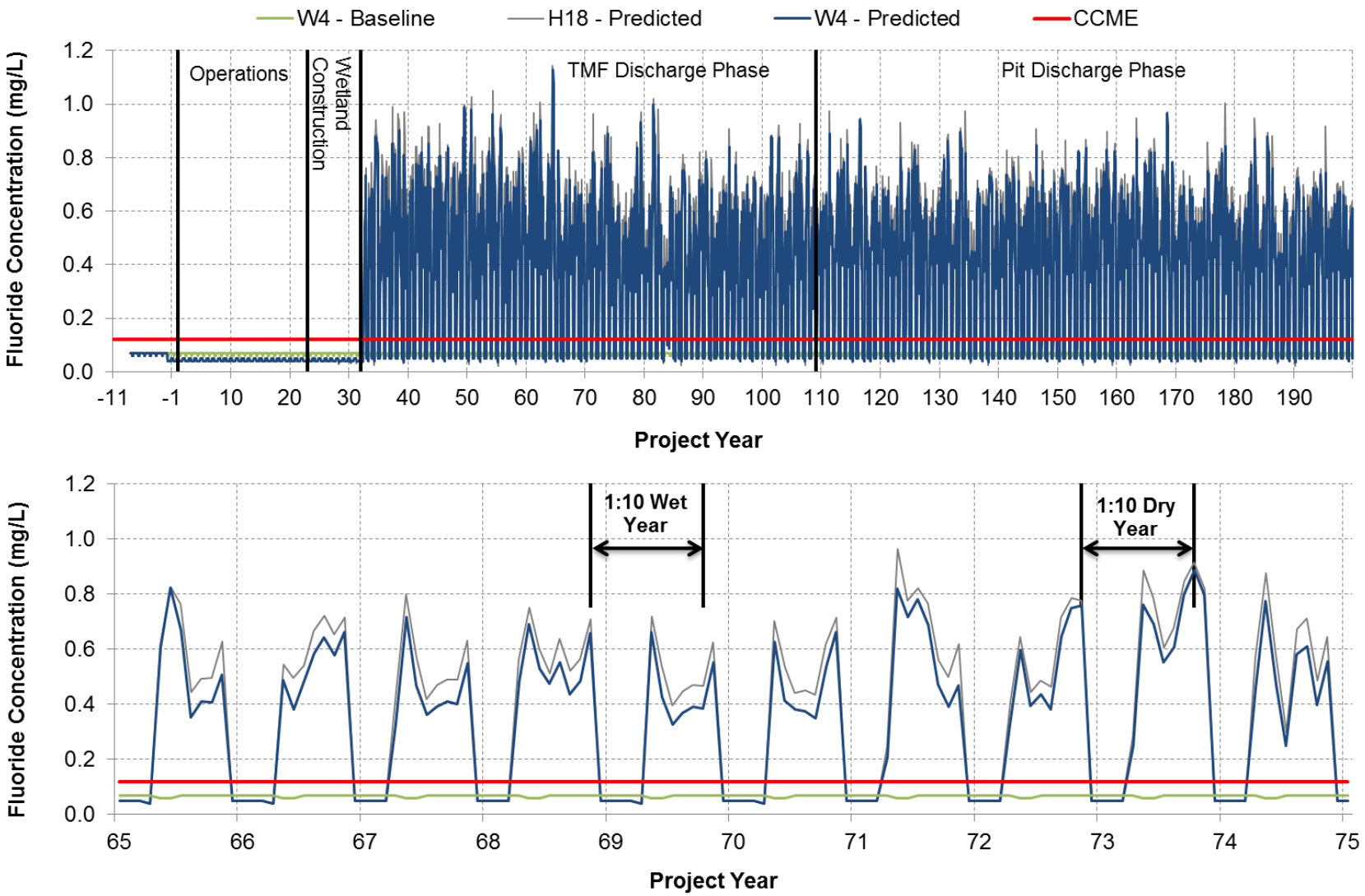


Figure 11-3. Modelled Fluoride Concentration at H18 and W4

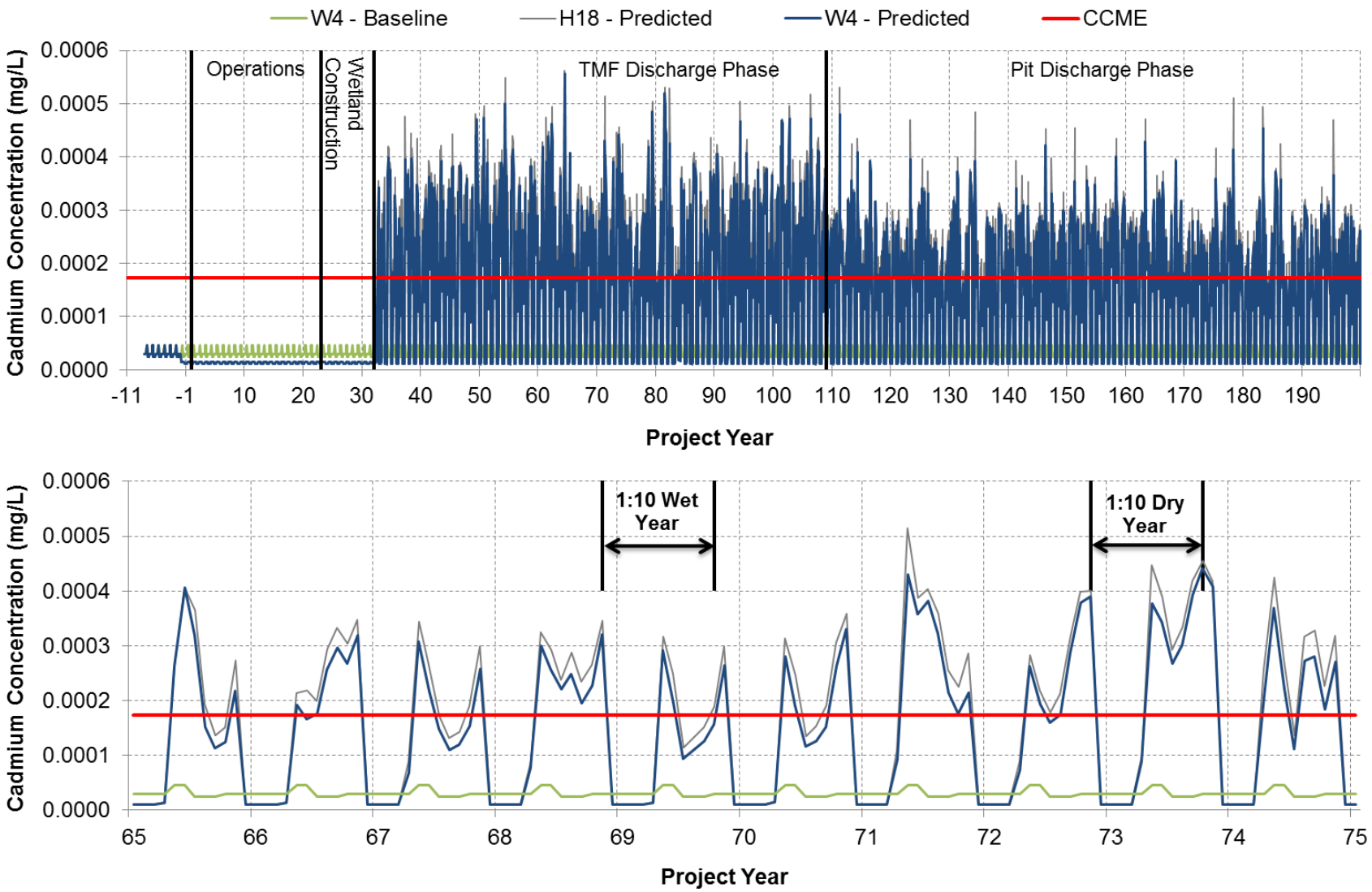


Figure 11-4. Modelled Cadmium Concentration at H18 and W4

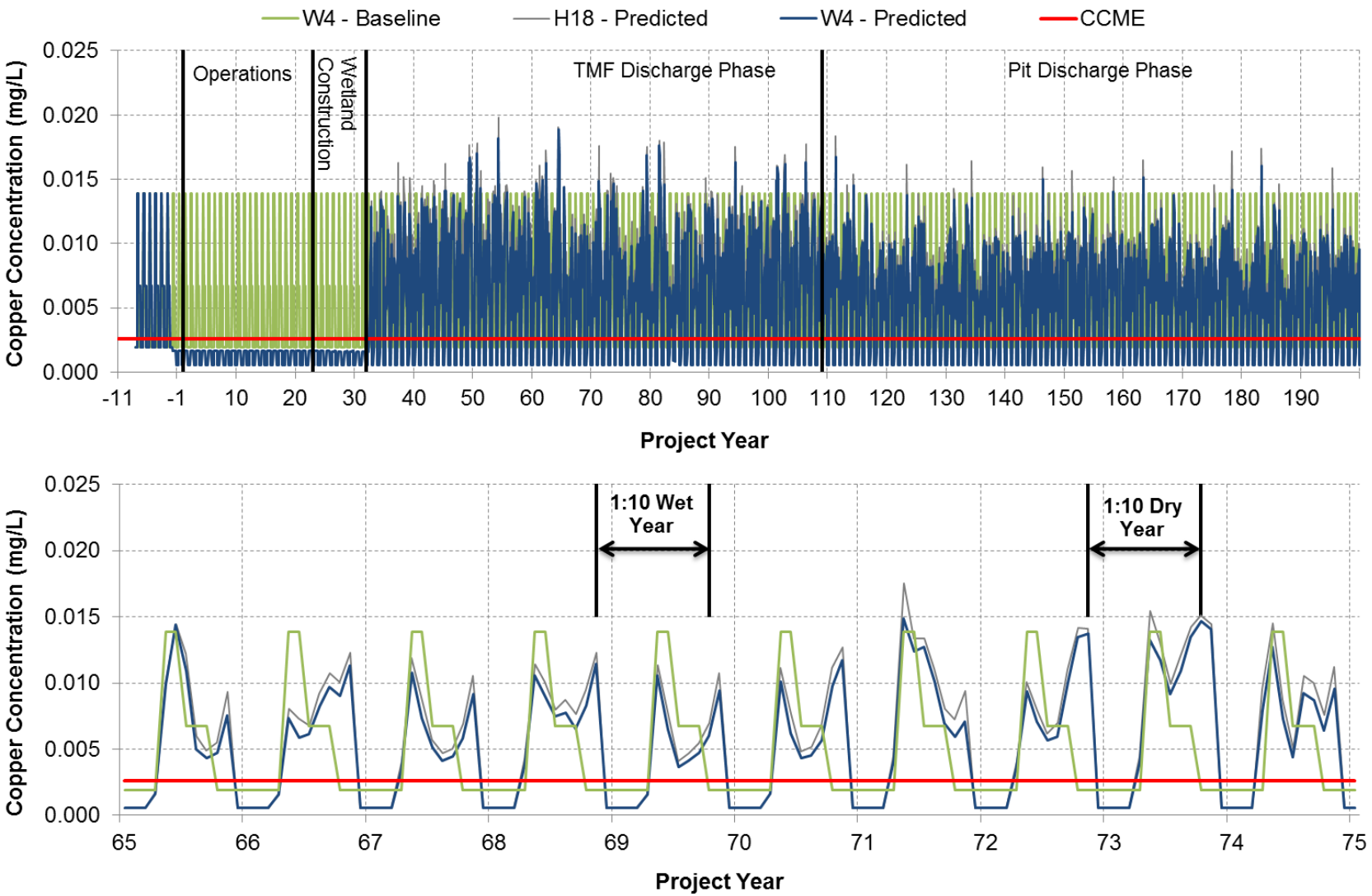


Figure 11-5. Modelled Copper Concentration at H18 and W4

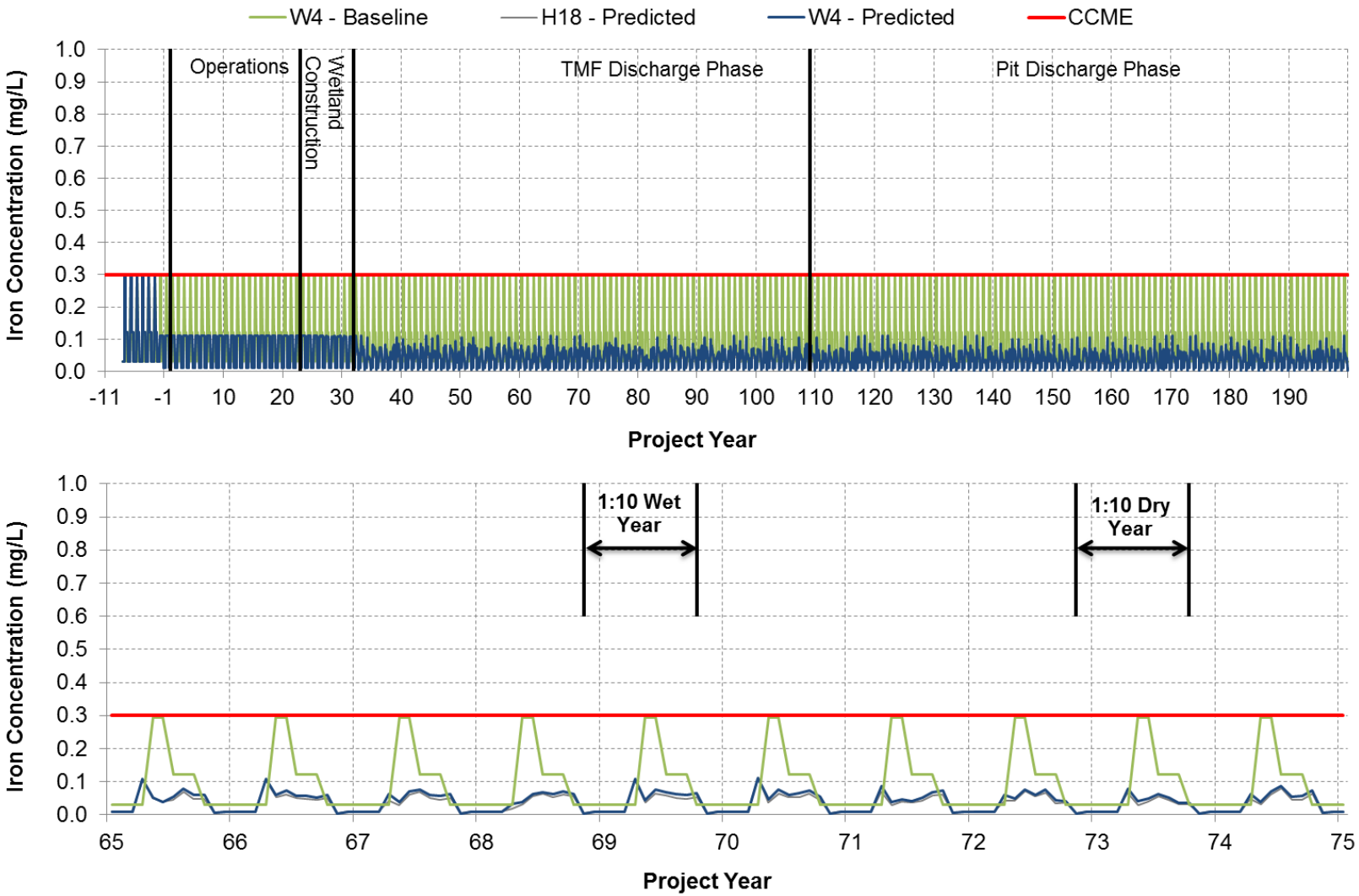


Figure 11-6. Modelled Iron Concentration at H18 and W4

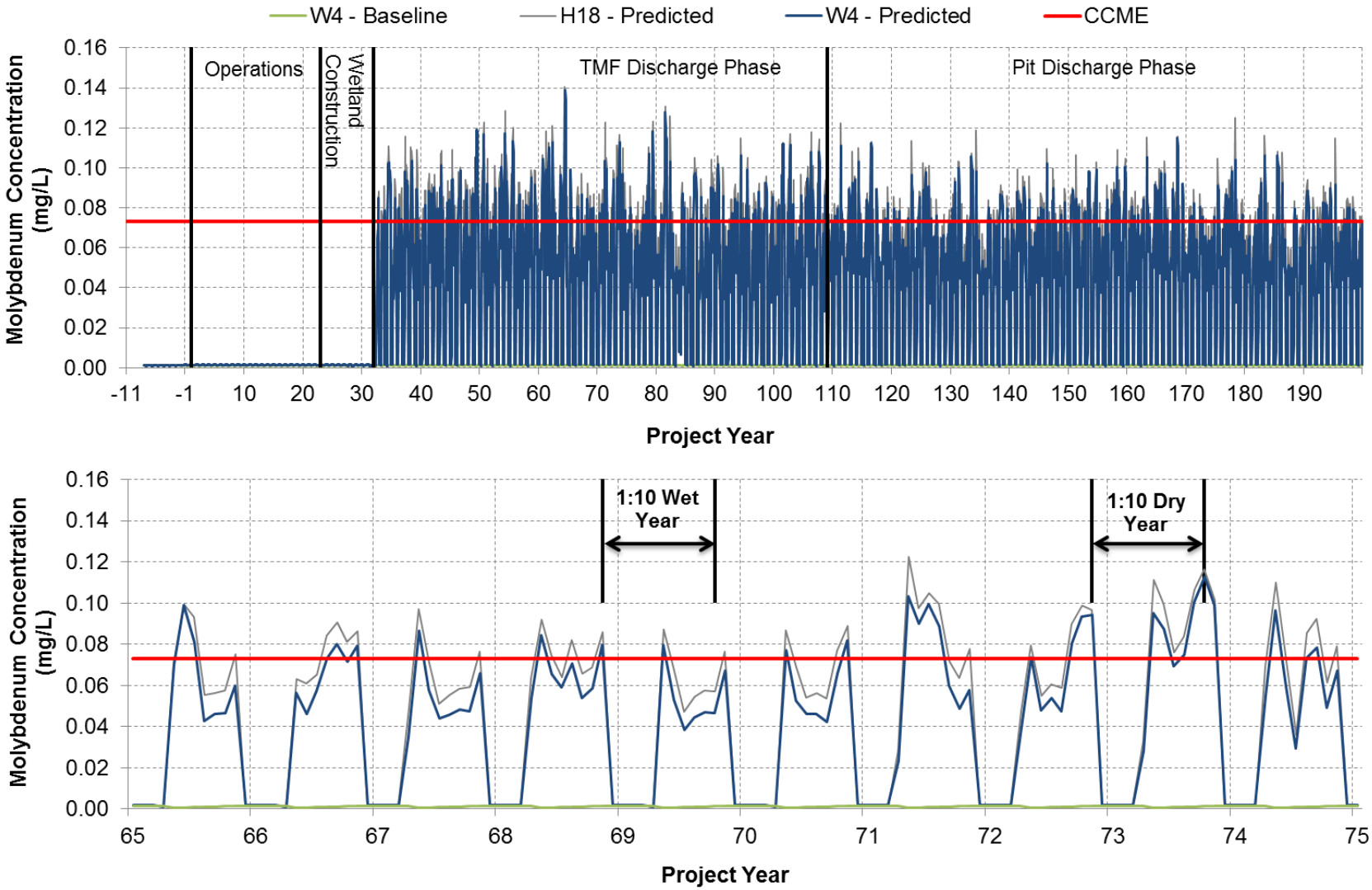


Figure 11-7. Modelled Molybdenum Concentration at H18 and W4

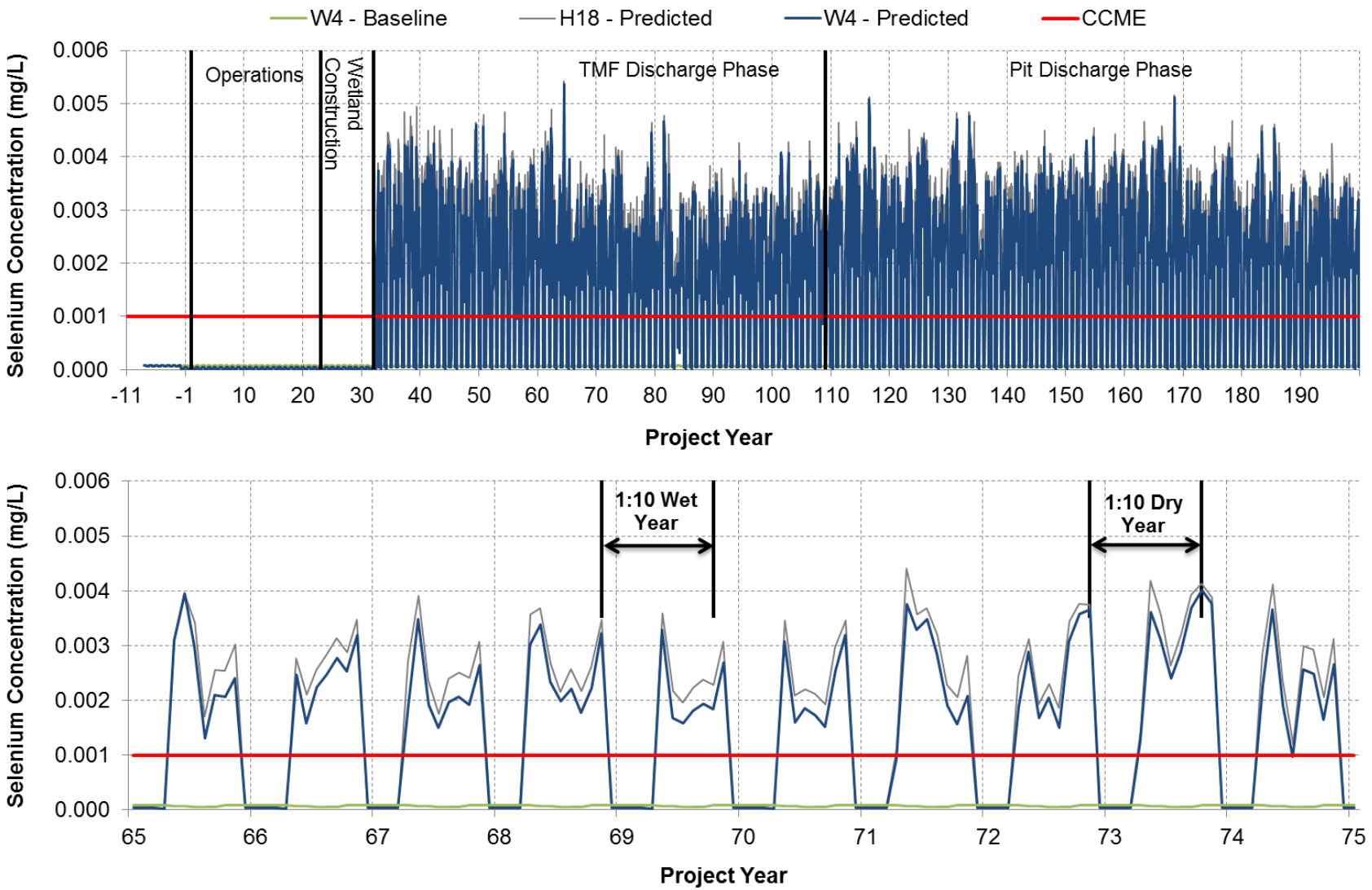


Figure 11-8. Modelled Selenium Concentration at H18 and W4

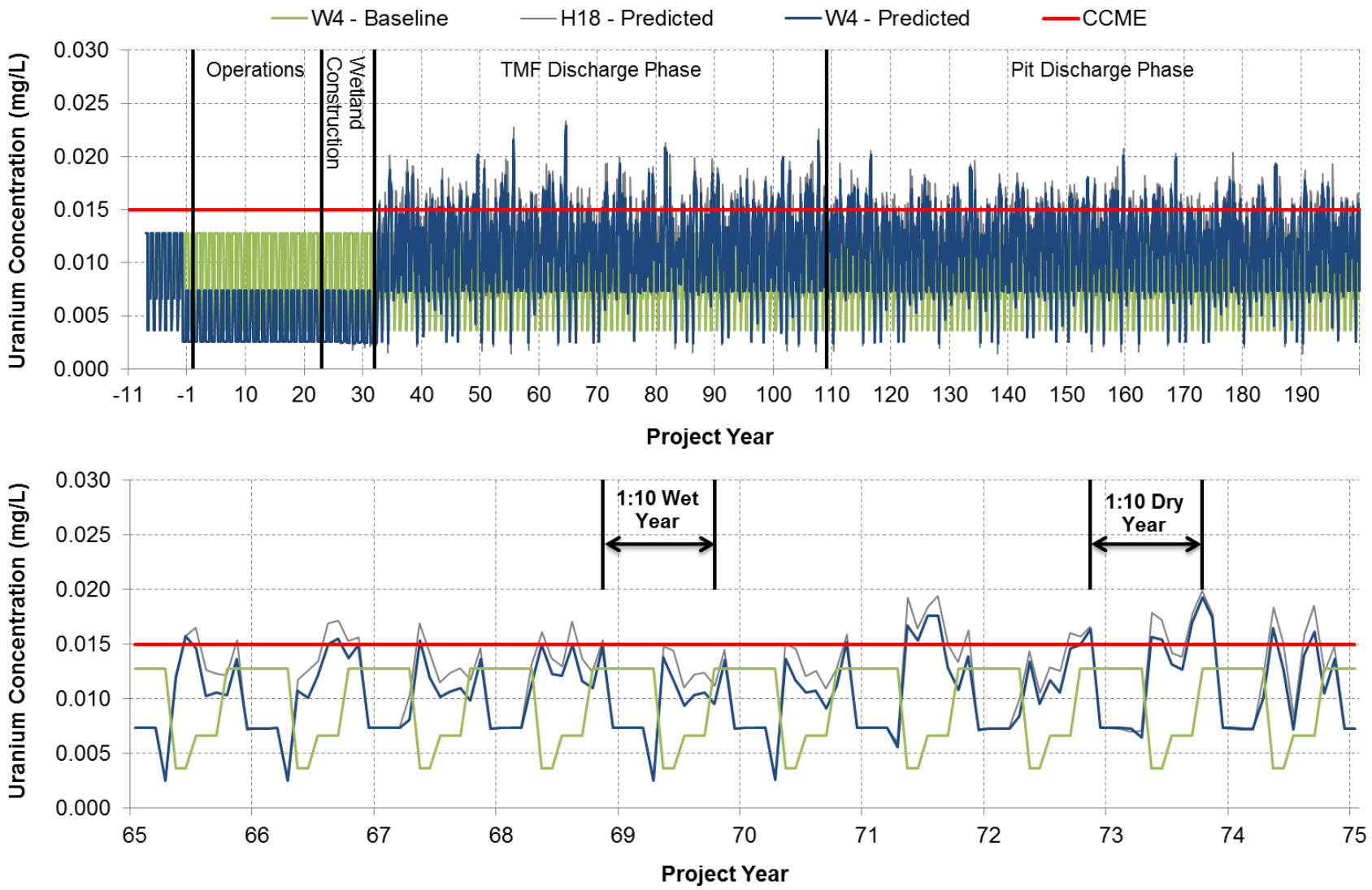


Figure 11-9. Modelled Uranium Concentration at H18 and W4

Table 11-8. Loading Source Contributions to H18 (TMF and Pit Discharge Phases)

Source of Loading	Fraction Contributing (%)							
	SO_4	F	Cd	Cu	Fe	Mo	Se	U
TMF Discharge Phase								
Background Streamflow	3	3	2	7	100	1	0	10
TMF Pond Discharge	39	42	12	17	0	37	58	39
WMP Pond Discharge	58	55	86	76	0	63	42	51
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Pit Discharge Phase								
Background Streamflow	3	2	2	7	99	1	0	8
TMF Pond Discharge	45	53	18	24	0	47	69	50
WMP Pond Discharge	52	45	80	69	0	53	31	42
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

1. Average of all years during each phase, calculated from output from model Realization #1.
2. Shaded cells are for sources that contribute >10% to the overall load.
3. Values are rounded and the total of individual values may not add to exactly 100.

11.7.2 Middle Dip Creek (W5)

Middle Dip Creek (W5) model results for one realization are presented in Figure 11-10 to Figure 11-17 for the eight parameters of interest. Fractions contributing from individual loading sources are presented in Table 11-9.

At W5, there is sufficient dilution that the water quality guidelines are met with the exception of cadmium, copper, fluoride, iron and selenium. For iron, the baseline/background water quality is higher than the predicted water quality. Molybdenum and sulphate guidelines were exceeded infrequently (i.e. about 3 times over the 200 year simulation). For copper, the baseline/ background is generally higher than the predicted post-mining water quality. Cadmium, copper, fluoride and selenium are discussed in more detail in the impact assessment. The pH was determined (using PHREEQC) to be neutral.

Table 11-9. Loading Source Contributions to W5 (TMF and Pit Discharge Phases)

Source of Loading	Fraction Contributing (%)							
	SO_4	F	Cd	Cu	Fe	Mo	Se	U
TMF Discharge Phase								
Background Streamflow	18	25	20	40	100	4	4	60
TMF Pond Discharge	33	32	10	11	0	36	56	17
WMP Pond Discharge	49	43	71	49	0	61	40	22
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Pit Discharge Phase								
Background Streamflow	17	22	19	39	100	3	3	56
TMF Pond Discharge	39	42	15	16	0	45	67	24
WMP Pond Discharge	44	36	66	46	0	51	30	20
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

1. Average of all years during each phase, calculated from output from model Realization #1.
2. Shaded cells are for sources that contribute >10% to the overall load.
3. Values are rounded and the total of individual values may not add to exactly 100.

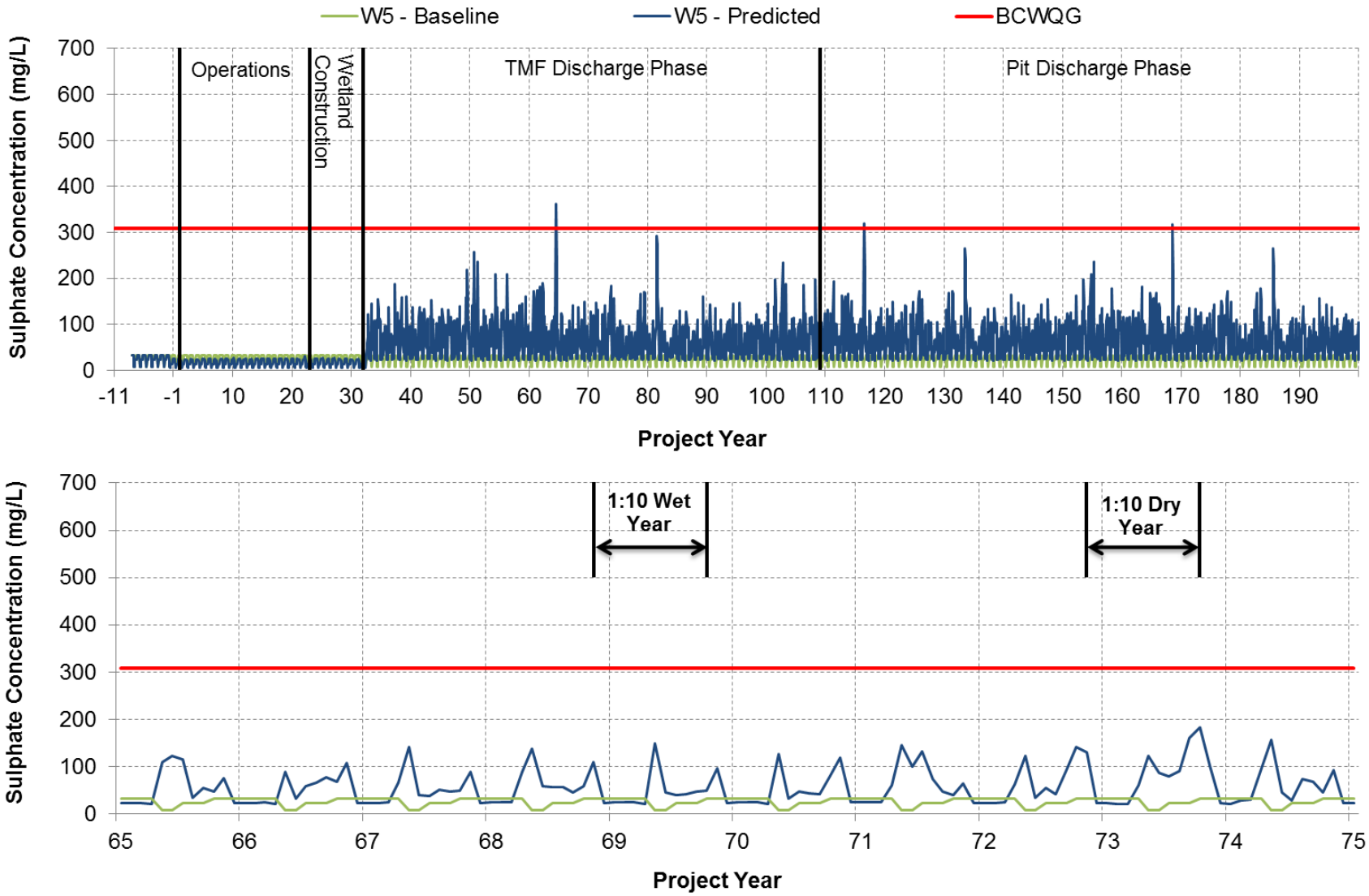


Figure 11-10. Modelled Sulphate Concentration at W5

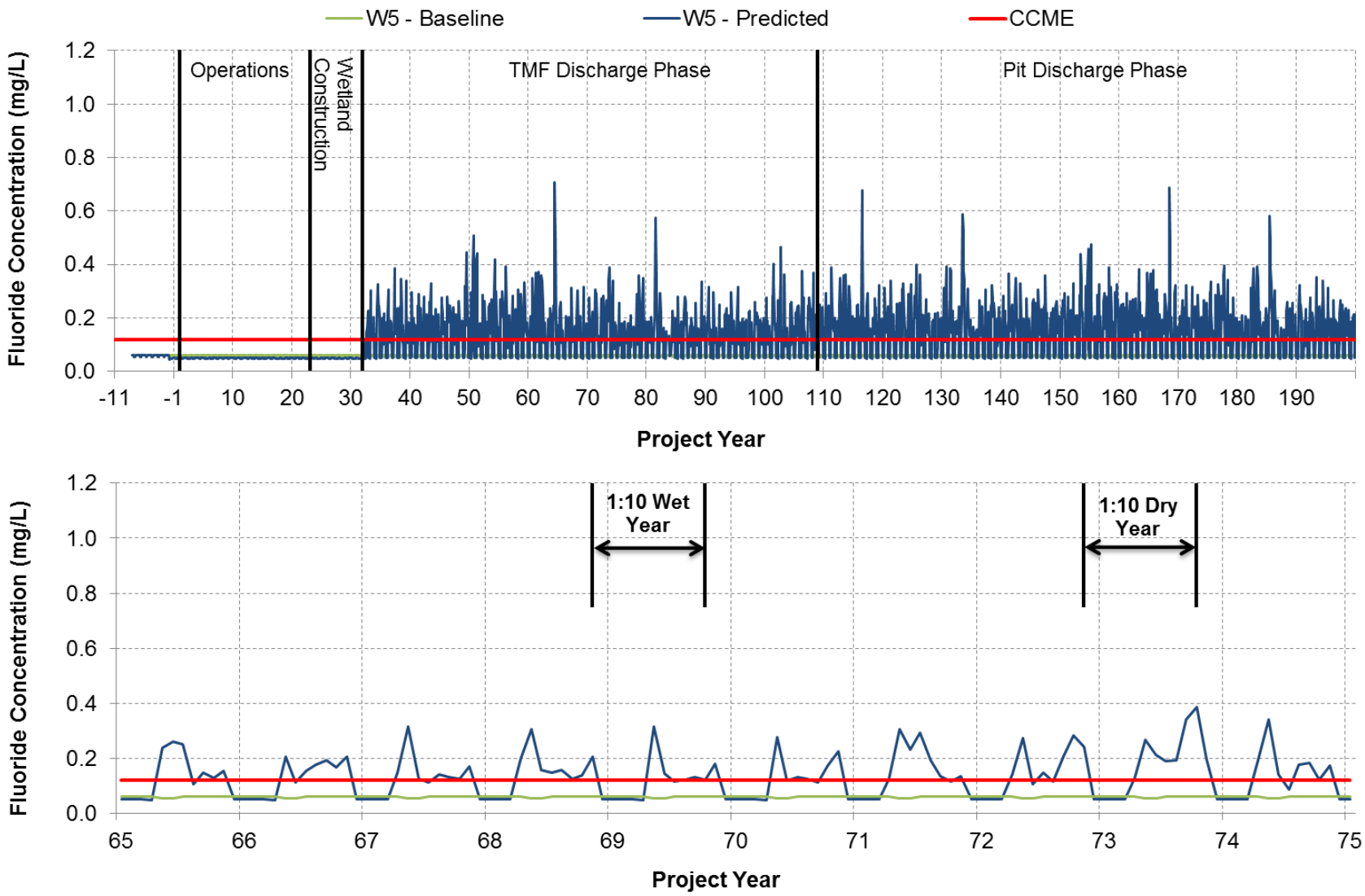


Figure 11-11. Modelled Fluoride Concentration at W5

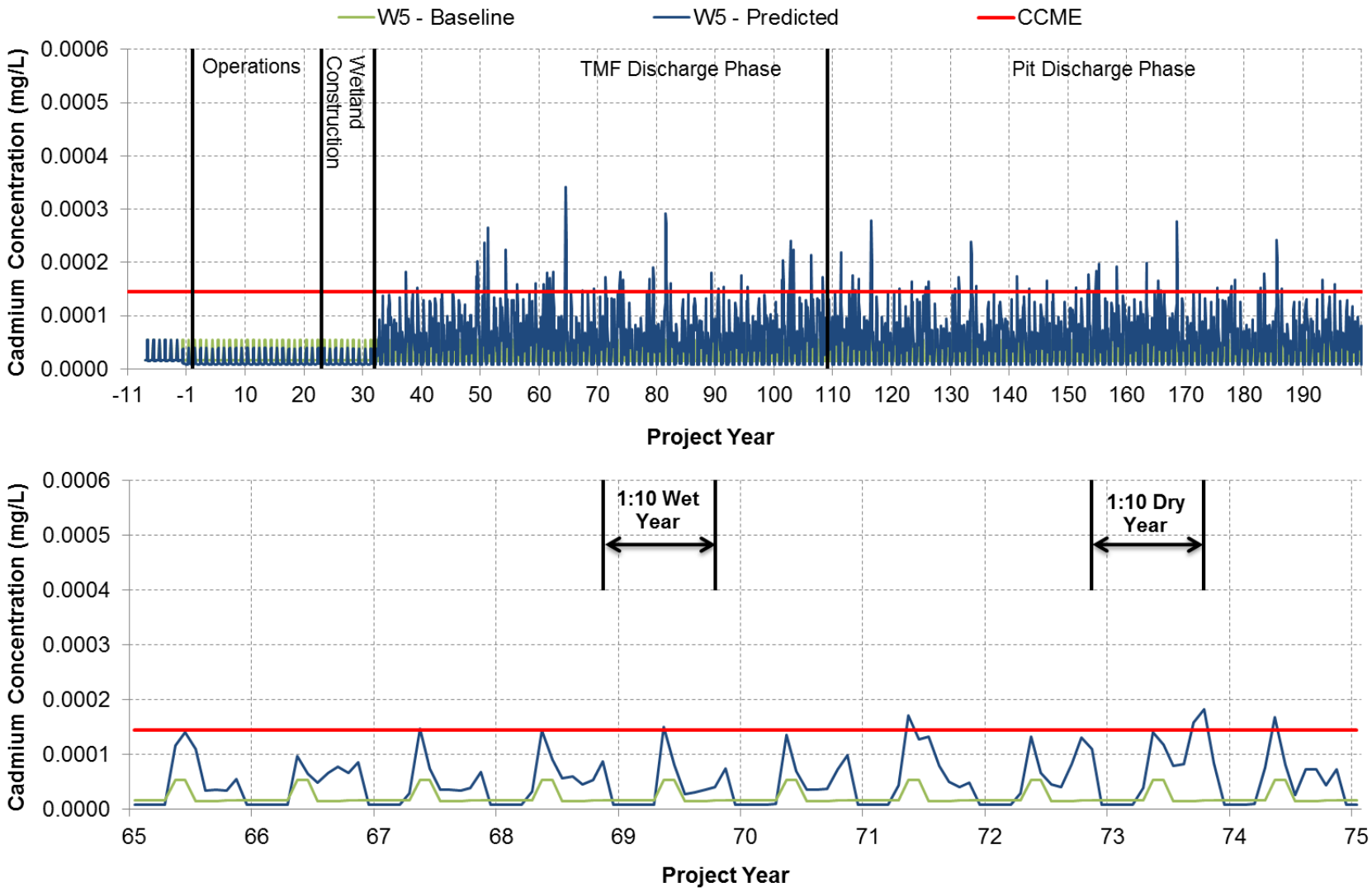


Figure 11-12. Modelled Cadmium Concentration at W5

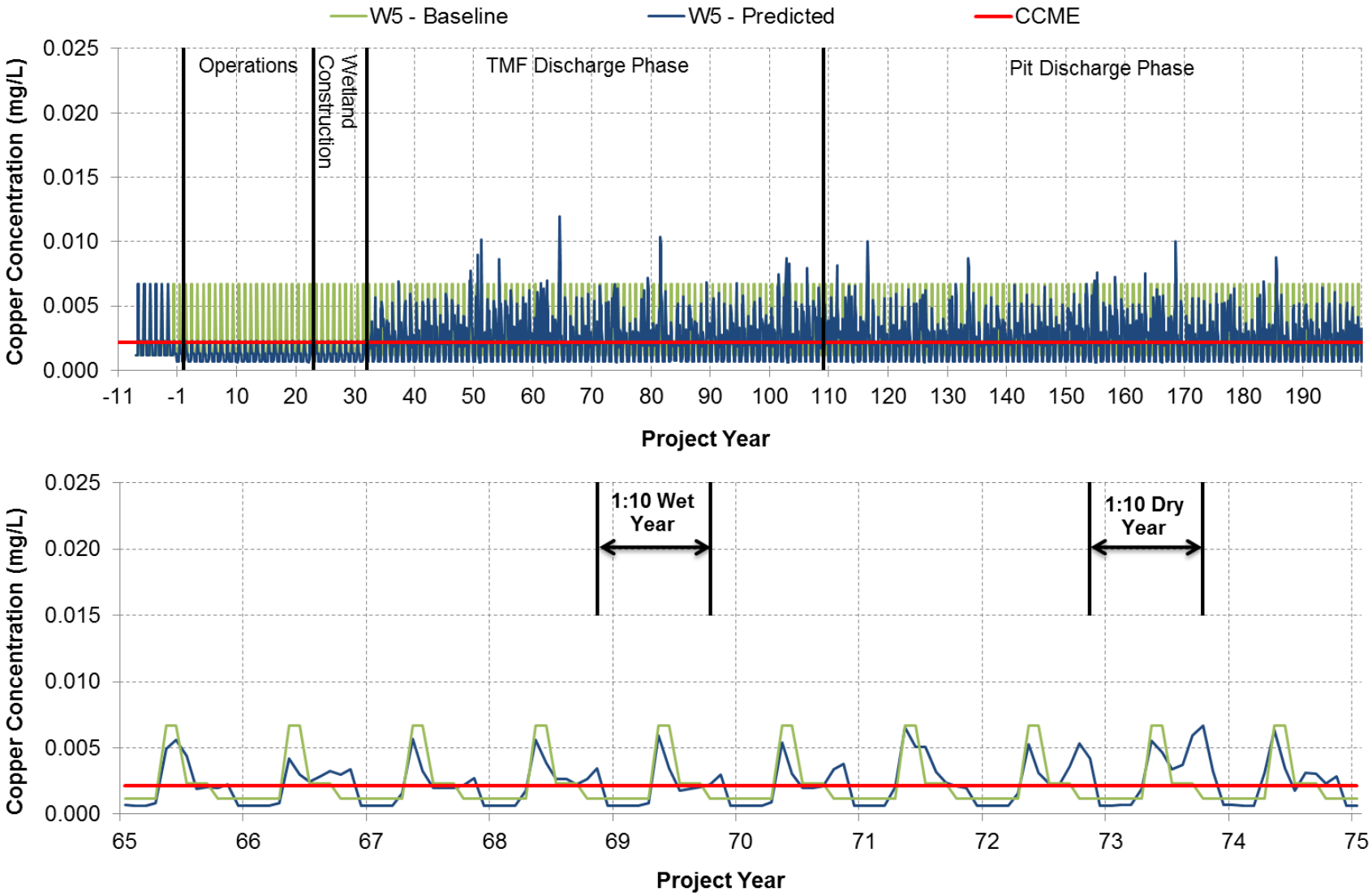


Figure 11-13. Modelled Copper Concentration at W5

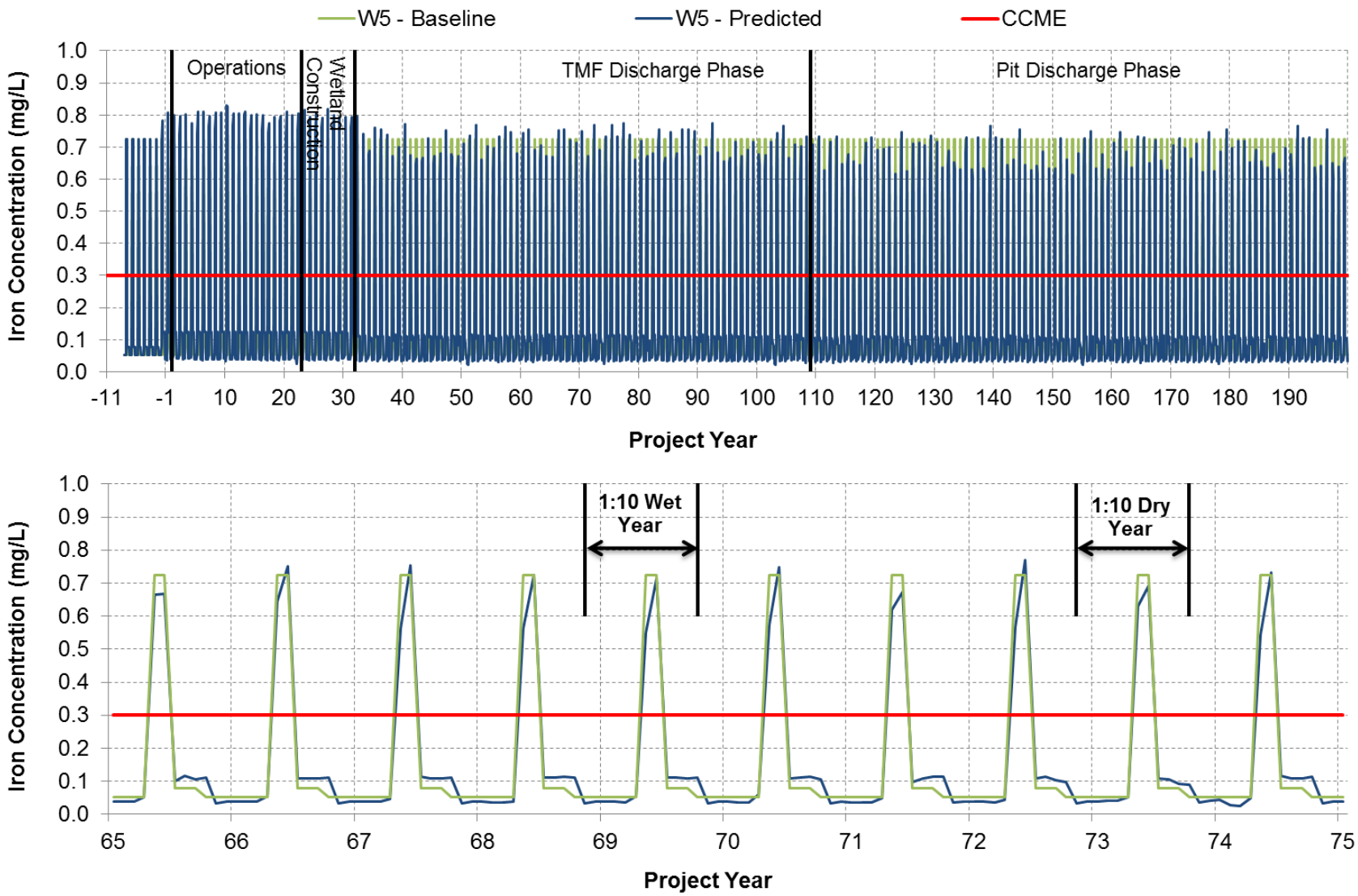


Figure 11-14. Modelled Iron Concentration at W5

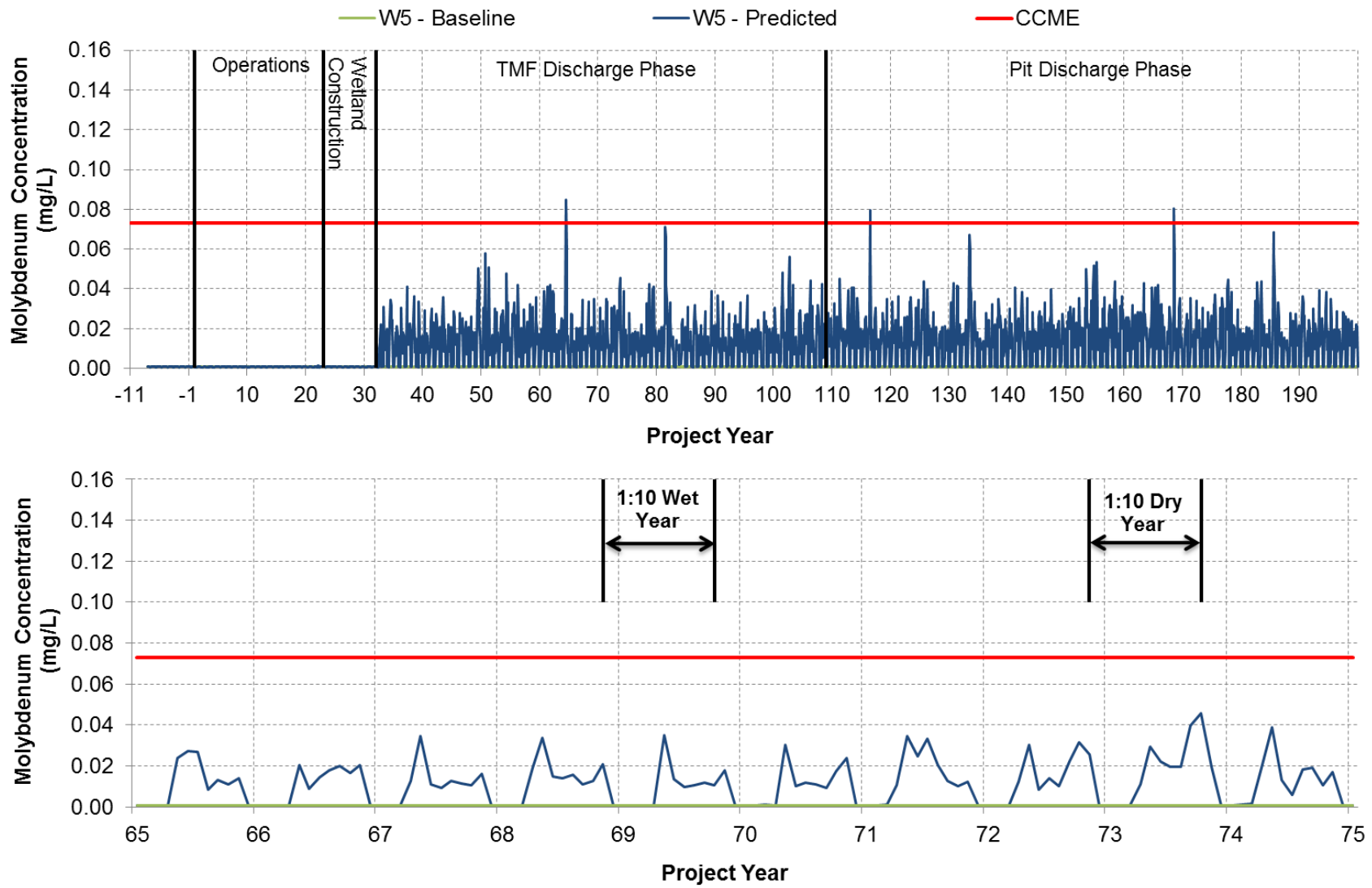


Figure 11-15. Modelled Molybdenum Concentration at W5

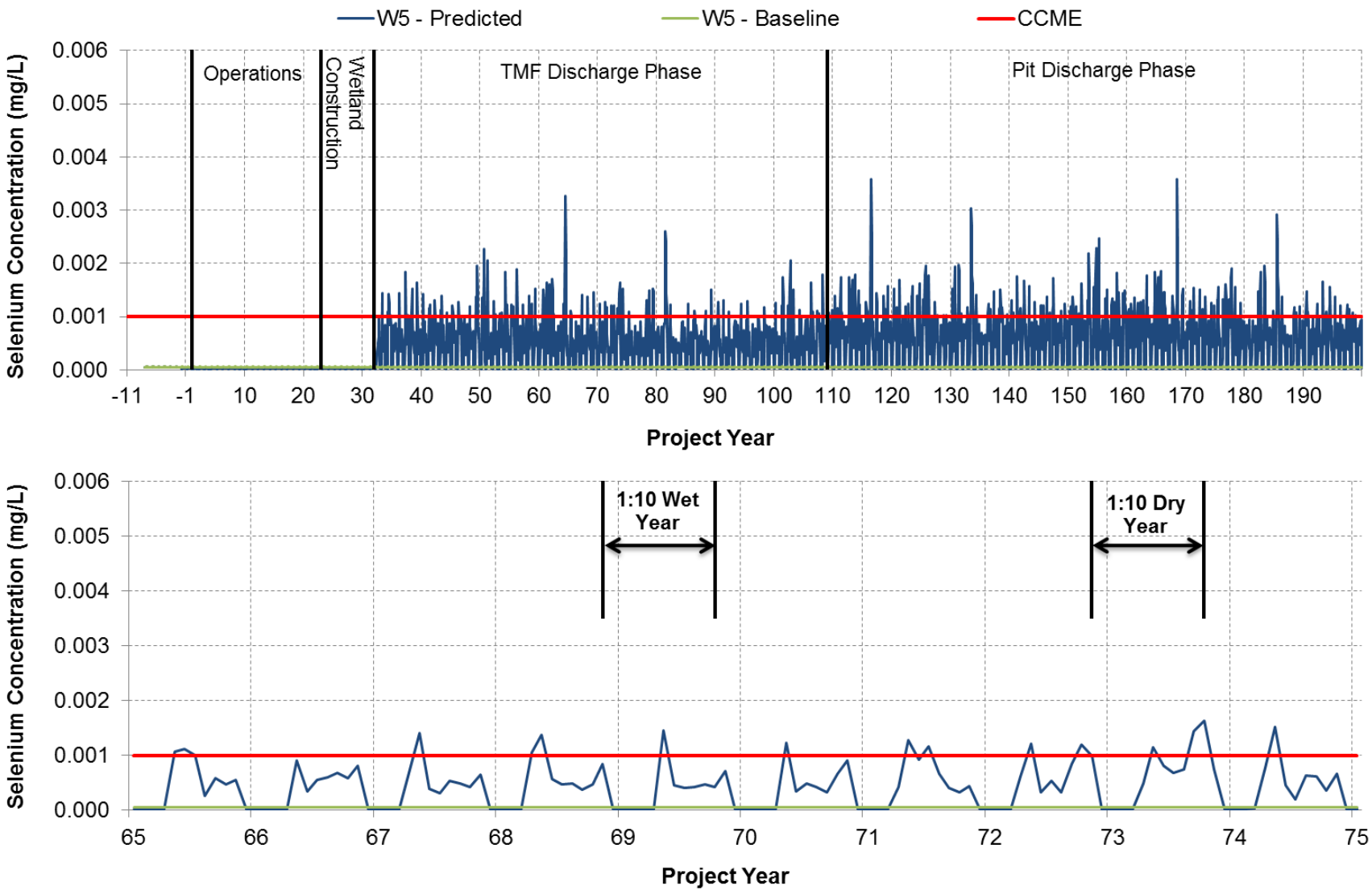


Figure 11-16. Modelled Selenium Concentration at W5

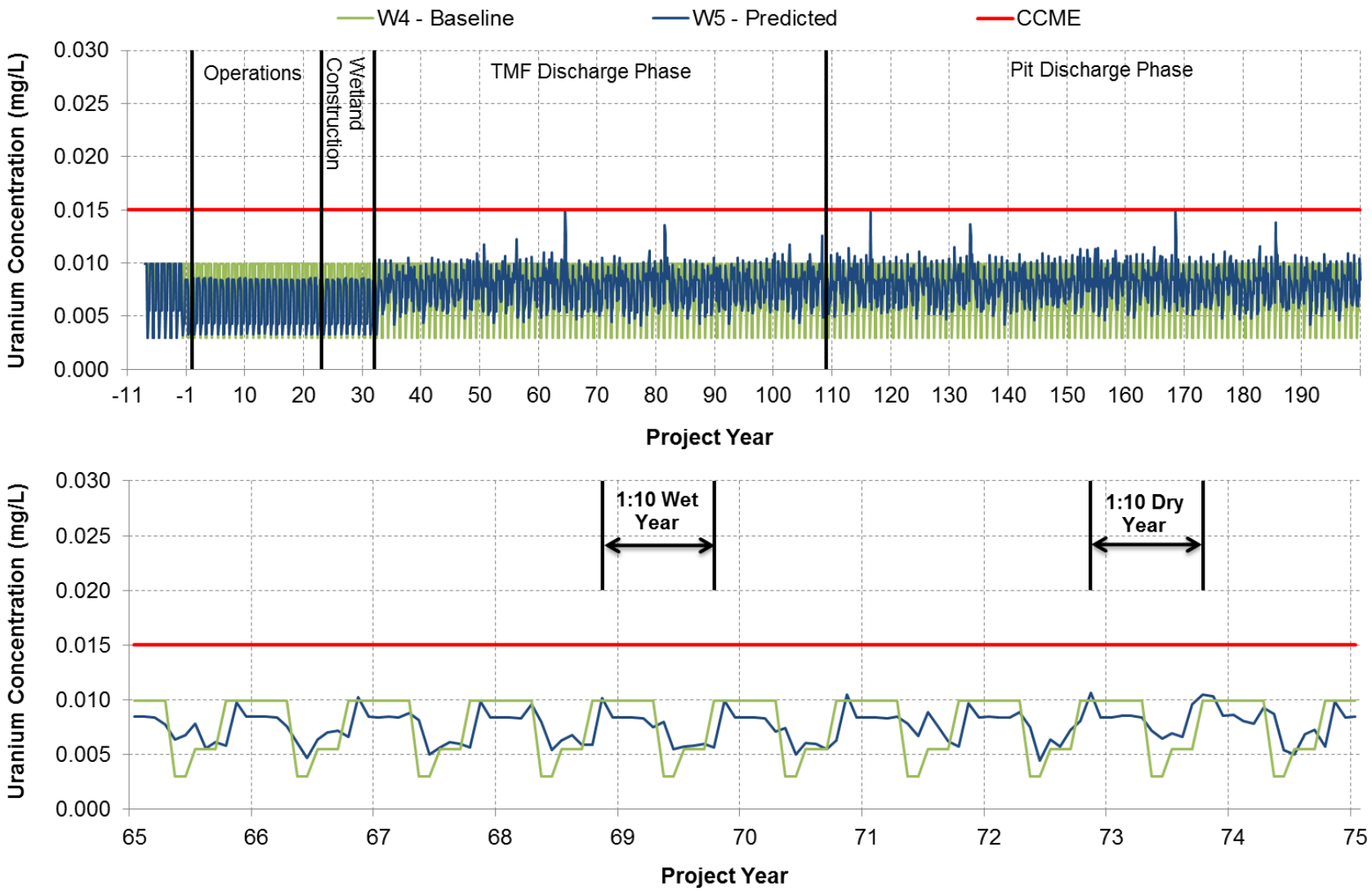


Figure 11-17. Modelled Uranium Concentration at W5

11.8 Water Quality Model Results – Monte-Carlo Summary

The model was run 52 times. Each model run used a unique permutation (i.e. realization) of the input hydrology dataset. The combined output from the 52 model runs represents the range in all possible model outputs resulting from all the possible permutations of the input hydrology dataset. A statistical summary of the model output for the 52 realizations was generated to be used as the basis for the aquatic impact assessment. A summary of the monthly median (50th percentile) water quality results for all modelled parameters is presented in Appendix IV (Table VI-11 to Table VI-13).

12 Summary and Discussion

A site-wide water quality model was developed for the proposed Casino Project. The model simulated water quality in the mine discharge and receiving environment and was based on a climate variability water balance model to account for inter-annual variability in hydrologic conditions. The model was used as a planning tool to help select water quality mitigation systems. This report documents updates to the previous model that was presented in the December 13, 2013 SEA report, with minor modifications resulting from the climate variability model.

The water quality model was developed within the GoldSim modelling platform, and included 27 water quality parameters (i.e. potential contaminants). The model simulation was run for a time period beginning a few years prior to Construction, and continued for 200 years following the beginning of Operations using monthly time steps. A synthetic dataset of monthly weather and hydrologic conditions was developed by KPL and was used as input to the model in order to simulate the natural variability in hydrologic conditions (i.e. wet and dry periods) that can be expected at the site.

Source terms were developed by Lorax (2013) and used as model input to calculate the mass loading rates from mine loading sources.

Geochemical modelling was integrated into the site-wide water quality model by use of dynamic links between GoldSim and PHREEQC software packages. The model nodes where geochemical solubility controls were calculated are as follows:

- Pit Lake;
- TMF pond; and
- WMP.

These nodes are locations where mixing of water streams occurs and solubility controls affect the concentrations of some water quality parameters (such as aluminum, copper and iron). PHREEQC was also used to determine pH in Casino and Dip Creek.

12.1 Water Quality Mitigations

The water quality model results were used as a rationale for the selection of a number of water quality mitigation systems. Initially, copper was used as the contaminant of concern (CoC) for mitigation planning because copper was predicted to exceed water quality targets by orders of magnitude based on the source terms. Once desired copper concentrations were achieved in model results, mitigations were considered for other CoCs including sulphate, fluoride, cyanide, cadmium, molybdenum, selenium, uranium, and iron.

Key Project mitigation plans for the Open Pit are as follows:

- The North TMF wetland was designed to passively treat the Pit Lake discharge. The Pit Lake water quality model results indicated that the discharge will be at tolerable concentrations and pH for successful treatment in the North TMF wetland.

Key project mitigations included in the water quality modeling for the HLF are as follows:

- Following HLF operations, surplus water will be treated and pumped to the Open Pit until the HLF cover is in place by year 29. Treatment will include cyanide destruction and removal of selenium and mercury in a bioreactor. Further cyanide degradation of the HLF discharge will occur as the Open Pit is filled.

- Surplus water will be directed to the Pit Lake following cyanide destruction and selenium and mercury treatment. Following drain-down, the HLF will be re-contoured and covered to promote runoff and minimize infiltration. The soil cover placed over the HLF is expected to reduce seepage from the toe of the HLF to 20% of the total net surplus water.

Key Project mitigation plans for the TMF are as follows:

- The upward migration of groundwater through the submerged waste rock in the TMF is expected to impact the water quality of the TMF Pond water. The South TMF wetland will be in place to passively treat TMF Pond water prior to discharge to Casino Creek.

- TMF pumping to the Pit Lake at closure will lower the water level in the TMF and will create suitable working conditions for the construction of the TMF wetlands.

- The placement of waste rock in the upstream (northern) end of the TMF where there will be minimal loading contribution to the foundation seepage.

The wetland passive treatment systems were designed by Clear Coast Consulting Inc. Passive treatment by the North and South wetlands was modelled as follows:

- The wetlands treat Cd, Cu, Mo, Hg, Ag, Zn to the CCME guideline;

- The wetlands treat SO4 to 85% of the inflow concentration (i.e., 15% removal).

Key Project mitigation plans for seepage water quality management:

- Source control for one of the six ore stockpiles was identified as an appropriate Project mitigation. The groundwater seepage pathway from the southern-most ore pile was estimated to have the greatest potential influence on Casino Creek water quality. As a result, the Project proposal incorporates mitigation (e.g., groundwater seepage collection) to intercept 90% of potentially contaminated stockpile drainage. The collected discharge will be directed to the TMF pond.

- Water collected in the TMF seepage Water Management Pond (WMP) will be pumped back into the TMF Pond until the end of operations. Following Operations, the WMP will be temporarily pumped to the Open Pit until discharge of the TMF Pond commences.

- Following mine closure, the WMP will store winter seepage and release it during the open water season when it will mix with the TMF Pond discharge prior to release to Casino Creek. Mixing the discharges will allow for dilution of the WMP release, especially when there is little-to-no flow expected in Brynelson Creek, a tributary to Casino Creek.

12.2 Results of the Model

Time series model results of a single realization of the model were plotted for the CoCs to illustrate the variability in water quality that can be expected as a result of a realistic range of site hydrologic conditions. For reference, baseline water quality at the Casino Creek and Dip Creek modelling nodes are presented (Section 11) with the predicted water quality and the CCME guideline.

Modelled years corresponding to 1:10-year wet and 1:10-year dry conditions were identified on the water quality output plots for the CoCs to illustrate how water quality can be expected to result from those infrequent events. The results showed that the water bodies on site (Pit Lake, TMF Pond, and WMP) will be able to produce more or less consistent inter-annual water quality in the receiving environment by balancing mine derived water between wet and dry years such that it can be released to the receiving environment when sufficient assimilative capacity is available.

The model results show some exceedances of water quality guidelines in Casino Creek. This list includes sulphate, fluoride, cadmium, copper, iron, molybdenum, selenium, and uranium. At Middle Dip Creek (W5), guidelines were exceeded for fluoride, cadmium, copper, iron, and selenium. For iron, the baseline water quality exceeds guidelines, and is higher than the predicted water quality. Molybdenum and sulphate concentrations were exceeded infrequently (i.e. about 3 times over the 200 year simulation).

Mine discharge water, and the resulting streamflow in Casino and Dip Creeks were predicted (using PHREEQC) to be pH neutral.

13 Closure

This document was prepared by SEA for Casino Mining Corporation. The material in it reflects SEA's judgement in light of the information available to SEA at the time of document preparation. Any use which a third party makes of this document or any reliance on decisions to be based on it is the responsibility of such third parties.

We trust this water quality assessment meets your requirements for the Casino Project. If you have any questions, please contact the undersigned.

Yours truly,

Source Environmental Associates Inc.





Rina Freed, Ph.D., P.Eng.
Senior Environmental Engineer

Rob Griffith, P.Eng.
Water Resources Engineer

Reviewed by



Rob Marsland, M.Sc., P.Eng
Senior Environmental Engineer

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Casino Project

Water Quality Predictions

Appendix I
Open Pit Water Quality Modelling

Prepared by:

Source
ENVIRONMENTAL ASSOCIATES INC.

February 2015

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1 Introduction

The Casino Project (the Project) is a proposed mining project in the west-central Yukon. The deposit will be mined using open pit methods, with a nominal mill throughput of approximately 120,000 tonnes/day of ore over a 22 year operating life. Milling operations will produce molybdenum and copper concentrates through conventional flotation circuit milling and gold and silver doré will be produced by cyanide heap leaching.

The open pit will be up to 600 m deep and up to 2400 m wide when finished. After mining, dewatering of the open pit will cease and a Pit Lake will form by groundwater recharge, overland runoff, and direct precipitation on the water surface. During mine decommissioning, any unused ore present in the stockpiles will be placed in the pit. Surplus water from the Water Management Pond (WMP), Tailings Management Facility (TMF) Pond, and Heap Leach Facility (HLF) will be temporarily pumped to the Open Pit to mitigate water quality concerns for Casino and Dip Creeks.

A water quality model was developed to predict mine drainage water quality and the potential for effects on the receiving environment of the proposed Casino Mine. A site-wide water balance was developed by Knight Piésold Limited (KPL) and was used by Source Environmental Associates Inc. (SEA) as the basis for the water quality model. The water balance and the water quality models were fully integrated in GoldSim.

A water balance model was initially developed by KPL in 2013 (and is described in KP. 2013a). The 2013 water balance was run using average annual estimates for hydrologic conditions at the site. Water quality modelling for the average annual water balance was carried out by SEA. Modelling methodology and results were reported in SEA (2013).

In 2014, a climate variability water balance model was developed by KPL (and is described in KPL, 2015) to account for the expected variability in hydrological conditions (i.e. wet and dry periods) from year to year. SEA used the climate variability water balance as the basis for the water quality model that is described herein.

This report presents the methodology and results of the water quality predictions for the Pit Lake model. This report contains all information relevant to the water quality model, and repeats the pertinent information previously provided in the December 2013 report (SEA, 2013). A comparison between the SEA (2013) Pit Lake water quality modelling report and this report is provided in Table 1-1.

Table 1-1. Comparison between 2013 and 2015 Modelling Reports

Concept	SEA (2013) Report	Applies to this Report
Water Balance Input Dataset	Average monthly hydrologic conditions (e.g. precipitation, temperature, streamflow, etc.) were used as input for every year of the model simulation.	Inter-annual variation in hydrologic conditions was applied throughout the model simulation. Water balance output flows were calculated from a synthetic, long-term (52 year) input dataset of monthly hydrologic conditions. The synthetic dataset was derived from regional and site data. **Rationale:** Using the range of monthly flows is more conservative (compared to using average annual flows) because realistic wet and dry periods can be simulated.
Estimation of Wet and Dry Years	n/a - wet and dry years were not simulated.	1-in-10 year wet and dry years were identified in the water quality output time-series plots. **Rationale:** To illustrate how the water quality management system will perform as a results of infrequent wet/dry periods.
Monte-Carlo Analysis (Stochastic Modelling)	Stochastic modelling was not carried out.	Model simulations included 52 unique input hydrology datasets. A statistical summary was generated from the water quality model output for the 52 realizations. **Rationale:** To account for all possible water balance flow scenarios that could result from the input hydrology dataset.
Project Phase Start Dates for TMF Discharge Phase and Pit Discharge Phase	Project dates were based on KPL (2013) water balance model output.	Project dates were based on KPL (2015) water balance model results.
WMP Pumping to the Open Pit (Wetland Construction Phase)	During the Wetland Construction Phase, the WMP was assumed to be pumped to and mixed with the TMF Pond.	During the wetland construction phase, the WMP will be pumped to the Open Pit. **Rationale:** Mass load from the WMP by-passes the TMF Pond by pumping directly to the Open Pit.

Concept	SEA (2013) Report	Applies to this Report
Pit Water Quality PHREEQC Input Assumptions	Assumption was that all available NP in the pit walls was released during submergence and fully mixed in the pit. This results in neutral pH and low copper concentration (~0.4 mg/L).	Assumption is that the available NP in the pit walls will be a source of buffering. Only the NP required for buffering is released. This change in the assumptions resulted in a predicted Pit Lake pH of about pH 6.2 and higher copper concentrations (about 5 mg/L rather than 0.4 mg/L). **Rationale:** The updated assumption used in 2015 is more conservative because not all the NP in the wall rock will be released and mixed with the pit lake during initial submergence of wall rock.
CoC List	7 CoCs were reported. The CoC list did not include fluoride.	Fluoride was added as a CoC, so 8 CoCs are reported. **Rationale**: Fluoride was added as it exceeded a generic water quality guideline in Casino and Dip Creeks.

2 Casino Project Water Management Phases

The Casino Project life was sub-divided into five water management phases (Table 2-1) in this document. Project years are described in years relative to the beginning of milling operations. For example, Year -2 refers to the second year before Operations begins, and Year 2 refers to the second year of Operations. Relevant project activities related to water quality modeling are provided in Table 2-1.

Table 2-1. Water Management Phases

Water Management Phase	Project Year	Water Management Activities
Construction	-4 to -1	• overburden stripping • mining and stockpiling of ore
Operations	1 to 22	• Final year of Open Pit Mining, year 18 • Final year of milling, year 22 • Dewatering from Open Pit will be pumped to mill to be used as make up water until end of Year 18. • Beginning in Year 19, dewatering will be discontinued, and the Open Pit will be allowed to fill with water by groundwater recharge, overland runoff, and direct precipitation. Pit Lake will begin to form. • Beginning Year 19, Surplus HLF ore rinsing water will be pumped to the Pit Lake.
Wetland Construction	23 to 34	• Any unprocessed ore will be placed in the Open Pit. • Construction of the North TMF Wetland that will eventually be used for treatment of the discharge from the Pit Lake. • WMP water will be pumped to the Open Pit • Year 24 to Year 28 – HLF drain down water pumped to Pit Lake • Year 23 to Year 27 – TMF Pond water will be pumped to Pit Lake • Year 28 to 34 – TMF fills with natural recharge
TMF Pond Discharge	35 to 109	• TMF Pond will discharge to Casino Creek via South TMF Wetland • No changes to Pit Lake water management
Pit Lake Discharge	>109	• Pit Lake will discharge to the North TMF Wetland treatment system. Treated effluent from the wetland will discharge to the TMF Pond.

3 Model Overview

A site-wide water balance model was developed by KPL and was used as the basis for the water quality model. The water balance and the water quality models were fully integrated in GoldSim. SEA combined the water balance flows with mine loading source terms (Lorax, 2013), and background water quality to predict water quality in the Pit Lake for 27 water quality parameters. A schematic showing the mass transport flow paths through the Pit Lake system is presented in Figure 3-1.

A 52-year model input dataset of monthly weather conditions was developed by KPL in order to simulate the natural variability in hydrologic conditions (i.e. wet and dry periods) that can be expected at the site. The model was run over a time-frame from beginning of Pit Lake formation, to 200 years after the beginning of Operations. Because the model was run over a simulation period of ~200 years, the 52-year input dataset repeats approximately four times during a given simulation.

The model results are presented in two ways in this report:

1) Single Model Realization

   Results generated when one realization of the input hydrology dataset was run with the model. Single realization results provide a time-series of model output which shows a representation of water quality that would result from a realistic range in hydrological conditions at the site. The output provides an indication of how high (or low) water quality concentrations may get, and how often those results are expected to occur. Time-series plots and summary tables of water quality results for a single realization are presented throughout this report.

2) Monte-Carlo Summary (52 Realizations)

   The model was run 52 times. Each model run used a unique input hydrology dataset. The combined output from the 52 model runs (i.e. realizations) represents the range in all possible model outputs resulting from all the possible permutations of the input hydrology dataset. Average annual water balance results presented in this report were generated from the Monte-Carlo Summary results.

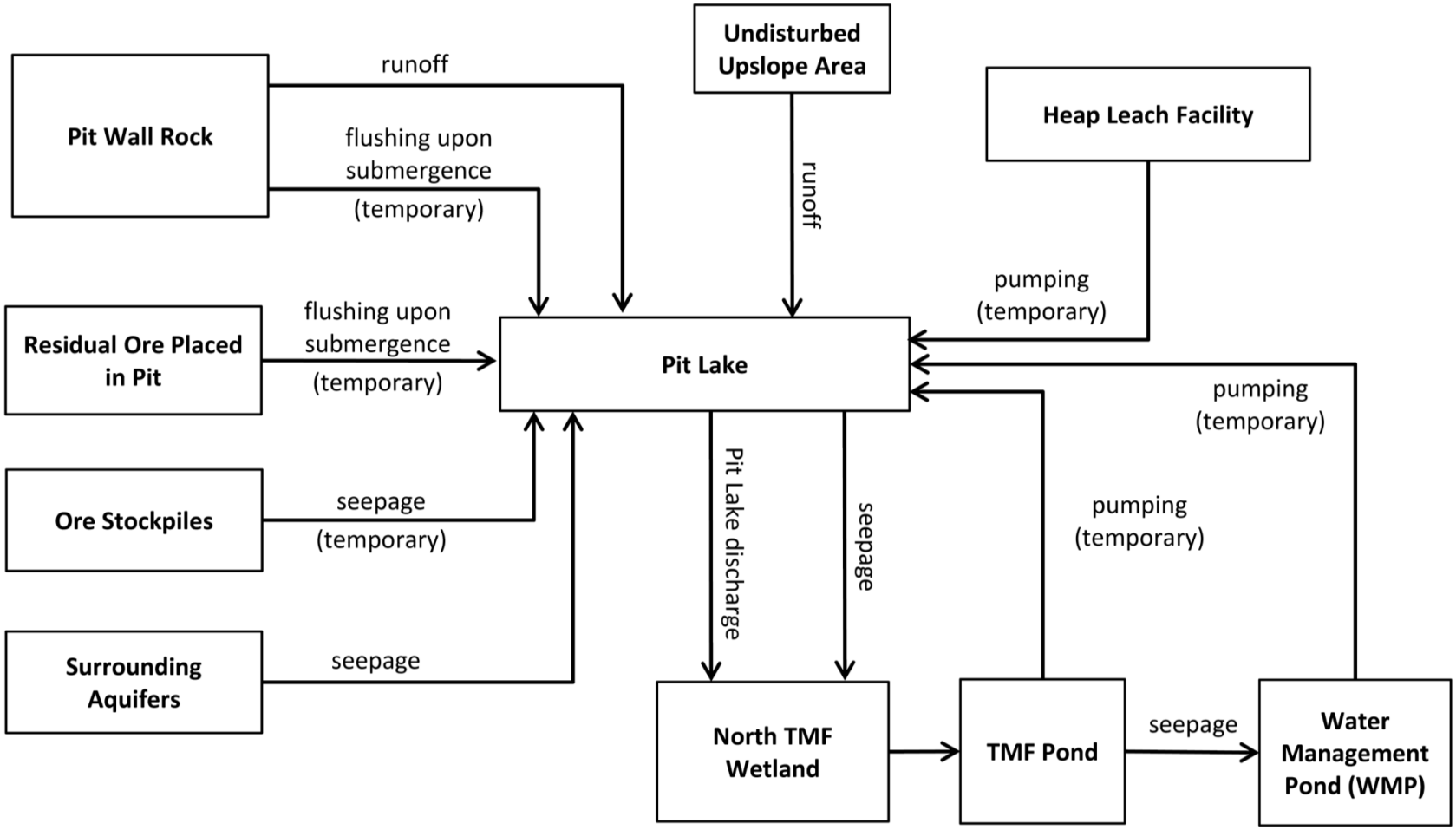

Figure 3-1. Mass Transport Flow Paths through the Post-Closure Pit Lake System

4 Pit Lake Water Balance Model

The KPL (2015) water balance model was developed to estimate the Pit Lake inflow and outflow rates, and the time required for the Pit Lake to fill and overflow. The following characeristics of the Open Pit were provided to SEA from KPL:

- maximum storage capacity of the pit = 280 Mm^3
- maximum water surface elevation of the Pit Lake = 1095 m
- total planar area of exposed pit walls (Pit Lake empty) = 3.14 km^2
- total planar area of exposed pit walls (Pit Lake full) = 1.16 km^2
- final planar area of the Pit Lake = 1.98 km^2

As the Pit Lake fills with water, the total water volume and surface area of water stored within the Pit Lake will vary. Pit Lake water surface elevation versus storage capacity and surface area (Figure 4-1) were provided to SEA by KPL with their Goldsim water balance model.

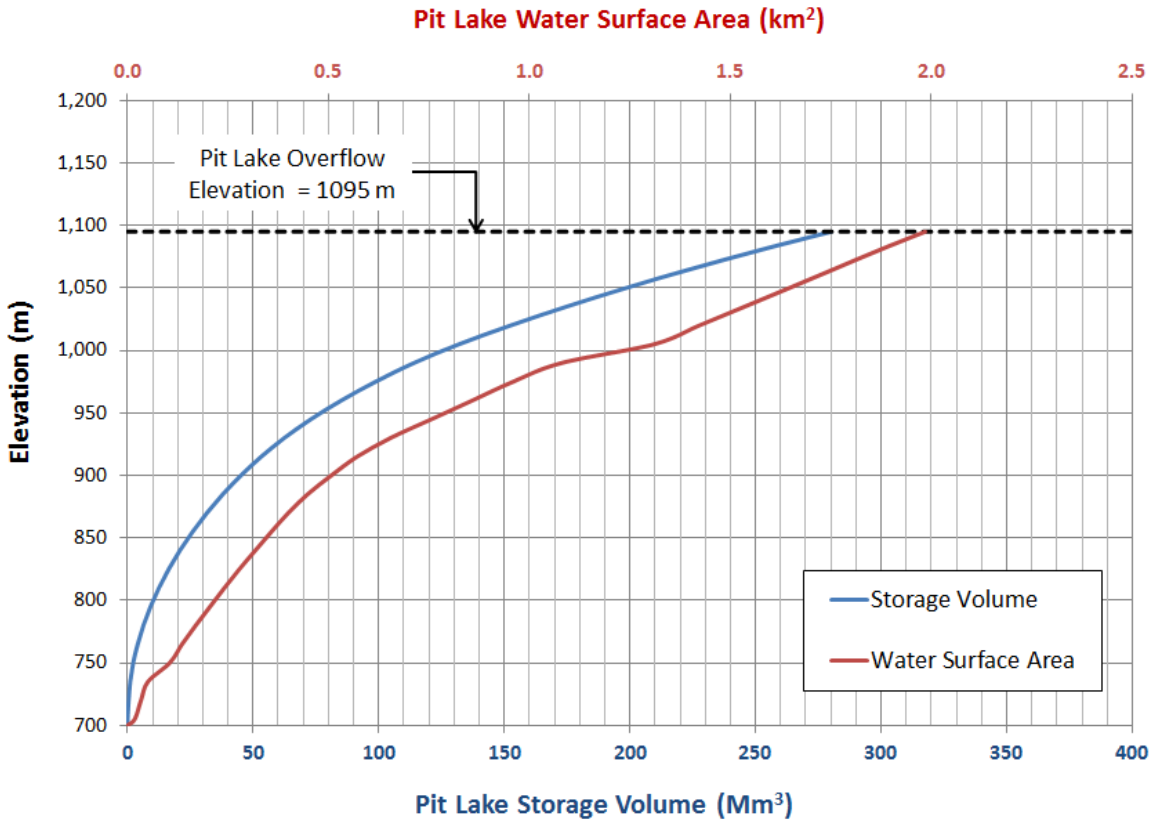

Figure 4-1. Pit Storage-Elevation and Area-Elevation Curves

The 52 realizations of the water balance (KPL, 2015) simulation showed that the Pit will likely fill to its storage capacity and discharge to the North Wetland between Year 105 and Year 110. KPL established Year 109 as the best estimate of the beginning of the Pit Discharge Phase. A summary of annual Pit Lake inflows and outflows from the 52 model realizations are presented in Table 4-1 for each water management phase. Some description of the water balance flows are provided in Section 5 as they are related to the development of the Pit Lake mass balance and water quality model.

Table 4-1. Pit Lake Water Balance Model Results

	Average Annual Discharge (L/s)		
	Wetland Construction Phase	TMF Discharge Phase	Pit Discharge Phase
INFLOWS			
Precipitation on Lake Surface	14	26	31
Groundwater Seepage	18	14	12
Ore Stokcpile Seepage	< 1	0	0
Pit Wall Runoff	28	18	15
Upslope Overland Runoff	35	35	36
Pumping from WMP	52	0	0
Pumping from TMF Pond	0 to 336 [2]	0	0
Pumping from the HLF	0 to 33 [3]	0	0
Total Inflow	123 to 522 [4]	93	95
OUTFLOWS			
Evaporation	11	21	24
Groundwater Seepage	0	7	11
Pit Lake Discharge	0	0	60
Total Outflow	11	28	95
Net (Inflow - Outflow)	112 to 511 [4]	65	0

1. Flow rates reported in this table are average results from 52 model realizations over the duration of each water management phase.
2. Constant pumping rate of 336 L/s for Year 23 to 27. Pumping ceases in Year 28 and beyond.
3. Constant pumping rate of 33 L/s for Year 24 to 28. Pumping ceases in Year 29 and beyond.
4. Range of inflow, resulting from temporary pumping from TMF and HLF.

According to the *Conceptual Reclamation and Closure Plan* (BCL, 2013), the total annual Pit Lake overflow volume will be discharged to the TMF wetland at a controlled rate during the warmest months of the year (June through September, inclusive) for optimal operation of the TMF wetland treatment system. KPL (2015) modelled the discharge as a flow of approximately 180 l/s over the four month period.

5 Pit Lake Water Quality Model

A mixing model was developed to predict water quality for 27 water quality parameters in the Pit Lake as it fills and eventually discharges to the North TMF Wetland treatment system. Water balance flows (from KPL) were combined with mine loading source terms (from Lorax, 2013) and background water quality (from SEA) to predict mass loading rates of inflow and outflow of potential contaminants in the Pit Lake water. This section provides a summary of the Pit Lake water quality modelling methodology.

Tables of model input and output values are provided for each modelled water quality parameter in Appendix I - A (model input) and Appendix I - B (model results).

5.1 Mass Load Inflows

5.1.1 Precipitation

The monthly inflow of precipitation into the Pit Lake was calculated as the top surface area of the Pit Lake, multiplied by the monthly depth of precipitation. The Pit Lake surface area varied from 0 km^2 (immediately following mine closure), to 1.98 km^2 (when the Pit Lake level was at its maximum elevation of 1095 m). As a result, the inflow of precipitation to the Pit Lake water surface varied during the period of time when the Pit Lake was filling. Average annual inflow to the final Pit Lake from the KPL (2015) water balance model is provided in Table 4-1.

While precipitation was accounted for in the water balance, no load was associated with precipitation in the water quality model.

5.1.2 Background Runoff

Runoff from the upslope undisturbed area was calculated as the monthly surplus water multiplied by drainage area. Annual surplus water was calculated by KPL (2015) to be 150 mm (average of all model realizations). The final pit will intercept runoff from approximately 6.8 km^2, and 0.6 km^2 of undisturbed areas within the Canadian Creek, and Casino Creek drainage basins, respectively (total area of 7.4 km^2).

The mass loading rate into the Pit Lake from overland runoff was calculated as the monthly rate of overland runoff inflow, multiplied by the monthly water quality concentrations of the overland runoff.

A total of 18 water quality samples were collected at the Upper Canadian Creek (W7) monitoring station between 2008 and 2012 (PECG, 2013). The median value of all water quality samples from station W7 (Appendix I - A, Table I-A1) was used to represent average annual

overland runoff water quality draining to the Pit Lake from undisturbed areas surrounding the perimeter of the pit.

5.1.3 Background Groundwater

KPL (2015) calculated the groundwater inflow into the pit from the surrounding upslope groundwater catchments to be 33 l/s at the end of operations and 12 l/s once the pit reaches its maximum Pit Lake elevation (1095 m). In the KPL water balance model, groundwater inflow decreased linearly from 33 l/s to 12 l/s proportionally to water surface elevation in the pit as the Pit Lake water surface elevation varied from 700 m (Pit Lake empty) to 1095 m (Pit Lake full).

The load contributions to the Pit Lake from background groundwater were calculated as the monthly rate of groundwater inflow, multiplied by the estimated groundwater inflow water quality. The *2012 Baseline Hydrogeology Report* (KPL, 2013b) provides groundwater monitoring station information and water quality analysis results. Median water quality from each of the monitoring wells in the vicinity of the Open Pit (94-337, HG10-01, HG10-02, HG10-04, HG10-07) were combined by SEA to represent average annual water quality of the groundwater entering the Pit Lake. The representative background groundwater water quality that was used by SEA in the water quality modelling is provided in Appendix I - A (Table I-A1).

5.1.4 Seepage from Ore Stockpiles

While the ore stockpiles are present during Operations, contact water (from rainfall and snowmelt) will drain from the rock as runoff or infiltration to groundwater. Runoff from the stockpiles will be captured by the TMF Pond. Hydrogeological modelling (KPL, 2013c) indicated that depending on the stockpile location, infiltrated contact water will flow towards either the TMF Pond or the Open Pit and seepage from the Hypogene Low Grade Ore, Supergene Sulphide Low Grade Ore, and Marginal Grade Ore Stockpile would continue to flow into the Open Pit for a few years after the Pit Lake begins to form (i.e. after Year 19).

Seepage concentrations into the Open Pit Lake were calculated by combining the seepage flow rates with mass loading rates, and mass of rock in the stockpiles. Calculation methodology of stockpile mass loading to the Open Pit is described in Appendix II (Ore Stockpile Water Quality Modelling).

5.1.5 Pit Wall Runoff

Pit wall runoff for a given time-step was calculated as the monthly surplus water multiplied by the planar area of un-submerged pit walls. The planar area of un-submerged pit wall decreased incrementally from the maximum value (immediately following closure) to the minimum value (at final Pit Lake level) in each monthly time-step as the Pit Lake surface elevation increased and submerged the wall rock.

Fracturing of open pit mine walls due to blasting exposes the wall rock to the process of weathering. The fractured rock can be expected to contribute mass loading into the Pit Lake following mine closure. Source terms were developed by Lorax (2013) for each of mineralization zones that are expected to be exposed on the Casino pit wall, including: Oxide Cap (CAP), Supergene (SUP), and Hypogene (HYP).

The estimated planar areas of each mineralization zone were provided by Lorax (2013) and were subdivided into pit wall areas above and below the ultimate pit water surface elevation of 1095 m. The values used in the model are given in Table 5-1.

Table 5-1. Pit Wall Planar Area by Mineralization Zone

Mineralization Zone	Planar (Horizontal Projection) Area (m^2)		
	Below 1095 m Elevation	Above 1095 m Elevation	Total
Hypogene (HYP)	1,900,064	351,665	2,251,729
Supergene (SUP)	65,496	493,435	558,931
Oxide Cap (CAP)	0	320,340	320,340
Total	**1,965,560**	**1,165,440**	**3,131,000**

After Lorax (2013)

Lorax (2013) provided a derivation of geochemical source terms for the exposed Casino pit wall rock. The source terms were developed by scaling loading rates measured in laboratory-based kinetic tests (unsaturated columns and standard humidity cells) to field conditions. Average annual source term loading rates were provided based on a horizontal planar 1 m^2 unit area of exposed pit wall to allow for the terms to be applied in a dynamic water quality prediction model with time integrated wall exposures. Loading rates are presented in Appendix I – A (Table I-A2).

Results of acid-base accounting (ABA) analyses by Lorax indicated that a large portion of the SUP and HYP zones are potentially acid generating (PAG). Therefore, both acidic and neutral source terms were provided for the HYP and SUP mineralization zones in addition to the single CAP source term.

The rate at which the HYP and SUP pit wall rock acidifies will influence the Pit Lake chemistry. Weathering rates observed in neutral pH humidity cells were used by Lorax to estimate NP depletion rates and predict time until acidification. Lorax (2013) developed the following relationships to estimate the proportion of acidic and neutral pit wall for 200 years following initial exposure of the pit wall rock (t is in years):

$$\text{Fraction NP Depletion (HYP)} = 0.00258t + 0.08$$

$$\text{Fraction NP Depletion (SUP)} = -1.31\times10^{-9}\,t^4 + 6.24\times10^{-7}\,t^3 - 1.04\times10^{-4}\,t^2 + 0.00838t + 0.45$$

Figure 5-1 illustrates the component parts of acidic and neutral wall rock that were calculated using the equations (from Lorax) for the duration of the model simulation. Beyond the model simulation time frame, a portion of supergene and hypogene wall rock will remain neutral even after long-term exposure.

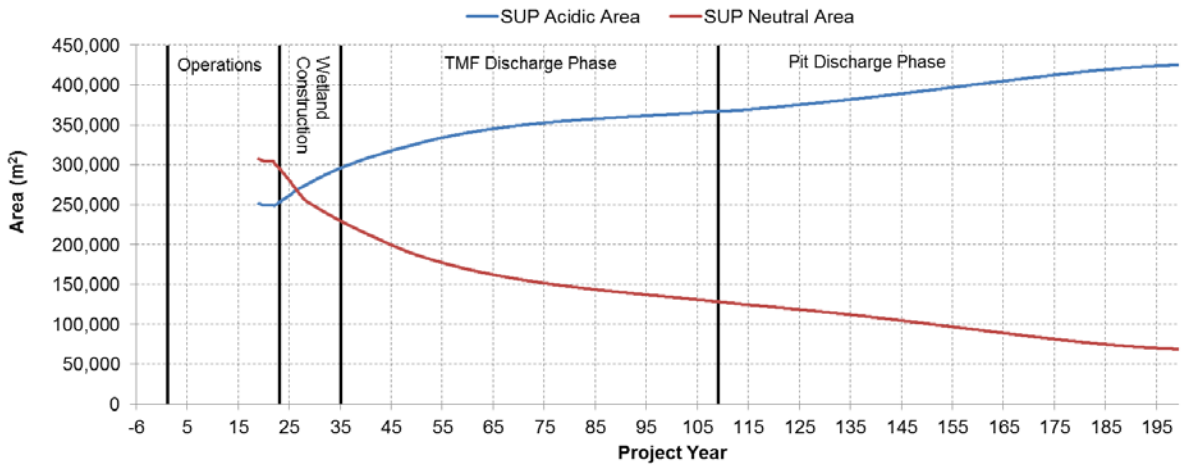

Figure 5-1. Areas of Supergene Acidic and Supergene Neutral wall rock in the Pit Wall with time

5.1.6 Pit Wall Rock Submergence

Pit wall runoff can be expected to travel along preferential flow paths through the fractures of the pit wall rock. As a result, a portion of the oxidation products that form on the walls would not be regularly flushed from those poorly drained portions of the wall rock surfaces. However, as the Pit Lake elevation rises and submerges the wall rock, those built-up oxidation products could be flushed into the Pit Lake. Lorax (2013) derived source terms to account for the build-up and flushing of oxidation products from the wall rock as follows:

$$L = m / (A * t)$$

Where:

L is the wall rock build-up source term (mg/m^2/year)
m is mass of oxidation products built up on the wall rock (mg);
A is the planar area of exposed wall rock (m^2); and
t is the length of time the wall rock is exposed to the atmosphere (years).

The wall rock build-up source term values derived by Lorax are presented in Appendix I-A (Table I-A2) of this document.

In a given time step of the model, the mass of built-up substance flushed from wall rock into the Pit Lake were calculated as the product between the wall rock flushing source term (in $mg/m^2/year$), planar area of wall rock submerged during that time step (m^2), and the duration (years) the wall rock was exposed to the atmosphere prior to submergence. The model conservatively assumes that all of the accumulated oxidation product could dissolve in to the pit lake during the timestep when the rock becomes flooded.

In order to assess the time of exposure at the time of wall rock submergence, the pit shell was sub-divided into elevation bands of equal exposure times (from the time they were mined) at the end of open pit mining. The higher elevations have a longer exposure time than the lower elevation bands that were mined out last. Table 5-2 shows a breakdown of the incremental exposure times that were assumed by SEA.

Table 5-2. Time of Exposure of Pit Wall Rock at the End of Mining

Elevation Band	Incremental Average Wall Rock Exposure Time (yr)
700 m – 800 m	1
800 m – 900 m	2
900 m – 1000 m	6
1000 m – 1050 m	11
1050 m – 1095 m	16
> 1095 m	20

The modelling approach used to estimate the geochemical effect of the mine walls on the Pit Lake water quality generally follows *The Minewall Approach*, developed as a formal standardized technique for the MEND program, which is documented by Morin and Hutt (2004). As the Pit Lake level rises, all wall rock below the water surface is submerged, and loading ceases for that submerged portion of the wall rock. The total planar area of un-submerged wall rock was calculated for each model time-step. From that, the relative proportions of acidic and neutral un-submerged wall rock were calculated, and their respective loading rates into the Pit Lake were applied.

The total exposure time for a submerged band of wall rock was calculated as the average wall rock exposure time prior to the start of pit filling (i.e., during mining) (Table 5-2), plus the number of years that elapsed after the Pit Lake filling began and until submergence of that elevation band of wall rock.

5.1.7 Flushing from LGO Placed in Open Pit

It was assumed that following mining, 5% of the low grade ore and 100% of the Marginal Ore Stockpile would be backfilled into the pit. The Gold Ore and Supergene Oxide Ore were assumed to be processed completely. Table 5-3 shows the total ore masses, and estimated

mass of each pile that was assumed by SEA to be placed in the Pit Lake after mining. The total mass of gold ore was incorrectly reported in the SEA (2013) report as 35,000,000 tonnes. The corrected value is presented in Table 5-3. The discrepancy was the result of a typographical error in the report and did not result in any error in the 2013 modelling results.

Table 5-3. Summary of Ore Stockpiles Placed in the Open Pit

Stockpile	Mass (tonnes)	
	Total Ore to Pile	Unused Ore Placed in Pit
Gold Ore	56,674,000	0
Supergene Oxide Ore	32,410,000	0
Supergene Oxide LGO	14,043,000	702,150
Supergene Sulphide LGO	39,351,000	1,967,550
Hypogene LGO	90,433,000	4,521,650
Marginal Ore	8,837,100	8,837,100
Total	**241,748,100**	**16,028,450**

In KPL's water balance, a specific gravity of 2.8 was assumed for ore for displacing volume in the pit water balance. The total volume of ore in the Pit Lake would account for a reduction in available water storage volume of 5.7 Mm^3.

When the ore is placed in the Open Pit, the built-up oxidation products from the rock surfaces could be flushed into the Pit Lake. Lorax (2013) estimated the loading from each ore type going to the Pit Lake (Appendix I-A, Table I – A2).

5.1.8 Pumping from the TMF

Water in the TMF pond will be pumped to the Open Pit from Year 23 to Year 27 at an average pumping rate of 336 L/s (total volume of 53 Mm^3) to lower the TMF Pond level and create suitable working conditions for the construction of the TMF wetlands and TMF closure spillway. Pumping to the Open Pit will also help fill the pit faster.

Mass transport from the TMF Pond was calculated as the concentration in the TMF Pond, multipled by the pumping rate over a given time-step. Water quality of the TMF Pond water was calculated by SEA in the water quality model. Development of the TMF Pond model is described in Appendix IV (TMF Pond Water Quality). Average TMF Pond water quality over the five year duration of pumping to the Open Pit is provided in Appendix I - A (Table IA-1).

5.1.9 Pumping from the Heap Leach Facility

Closure of the facility will begin by rinsing (Year 19 to Year 23) and drain down (Year 24 to Year 28). Surplus water will be directed to the Pit Lake, after treatment for cyanide destruction and removal of selenium and mercury (Clear Coast Consulting, 2013).

KPL estimated that the rinsing will take place from Year 19 to Year 23 with an average annual pumping rate of 1.6 L/s to the Pit Lake from the HLF. Draindown was estimated to take place from Year 24 to Year 28 at an average flow rate of 33 L/s. After drain down (Year 29 and beyond), pumping to the Pit Lake will stop, and drainage from the HLF will be directed down slope to the TMF Pond.

Mass transport from the HLF to the Pit Lake was calculated as the concentration in pumped surplus water, multiplied by the pumping rate over a given time-step. Water quality of the rinsing and drain down water was estimated by Lorax (2013) prior to treatment and is summarized in Appendix I - A (Table IA-1). Following treatment, the selenium and mercury levels are reduced to 0.02 mg/L and 0.00026 mg/L, respectively. This mitigation was designed to reduce selenium levels in the North TMF wetland (Clear Coast Consulting, 2013).

5.1.10 Pumping from the Water Management Pond

During the Wetland Construction Phase (Year 23 to 34), water collected in the WMP will be pumped directly to the Open Pit. The WMP water quality will be a function of background overland runoff, TMF embankment runoff, TMF embankment seepage and TMF foundation seepage. Prediction of the WMP water quality is described in Appendix V. Water quality of the WMP water pumped to the Open Pit is summarized in Appendix I – A (Table IA-1).

5.2 Mass Load Outflow

5.2.1 Evaporation

The monthly outflow from the Pit Lake due to evaporation was calculated as the top surface area of the Pit Lake for a given time-step, multiplied by the monthly depth of evaporation. Average annual lake evaporation was estimated by KPL (2015) to be 390 mm.

While evaporation was accounted for in the water balance, no load was associated with evaporation in the water quality model.

5.2.2 Groundwater

KPL (2015) estimated the net groundwater outflow from the pit to the surrounding down gradient catchments would be 0 l/s before the pit level reached the tailings pond elevation of approximately 990 m and would increase to about 11 l/s by the time the pit reaches its maximum Pit Lake elevation (approximately 1095 m).

The rate of mass transport exiting the Pit Lake for a given time-step was calculated as the concentration in the Pit Lake, multipled by the groundwater outflow rate.

5.2.3 Pit Lake Discharge

After the pit fills to its maximum storage capacity, surplus Pit Lake water will be released into the TMF where it will initially flow through the North TMF Wetland treatment system prior to discharge to the main TMF Pond. On an annual basis, the total volume of overflow would equal the total Pit Lake inflow volume, minus evaporation and seepage losses. The pit discharge will be regulated such that flow will only occur during the open water season when the North TMF Wetland is the most biologically productive. KPL predicted that for average annual conditions, the Pit Lake would be released at an average rate of 180 L/s over a four month period in the summer.

The rate of mass transport exiting the Pit Lake discharge for a given time-step was calculated as the concentration in the Pit Lake, multipled by the rate of release of Pit Lake water.

5.3 Calculation of Pit Lake Water Quality

Water quality in the Pit Lake was calculated in Goldsim with a “cell pathway” modelling component. The Pit Lake mixing model output concentrations were assessed for solubility controls at each time step of the model simulation by coupling GoldSim and PHREEQC. PHREEQC is a geochemical modelling software developed by the United States Geological Survey. To accurately predict pH, all water quality inputs to PHREEQC were charge balanced, and the residual balance was placed on either chloride or sodium. During each timestep, Goldsim ran PHREEQC and the resulting concentrations were returned from PHREEQC. The calculated water quality from PHREEQC at each time step became the input concentration to the North TMF wetland. The assumptions used in the PHREEQC pit lake model are listed in Table 5-4.

Additional available NP is associated with submerged rock, and was conservatively based on equations developed by Lorax (2013) for HYP wall rock and SUP wall rock. For modelling purposes, it was assumed that available NP was consumed to maintain near neutral pH conditions within the Pit Lake. The amount of remaining wall rock NP was calculated at each time-step.

Full mixing throughout the water column was assumed, such that geochemical conditions would be the same throughout the pit. This is considered to be a worst case assumption. Typically, pit lake stratification results from the denser water near the bottom of the pit lake having the worse water quality and the lighter overlying water near the lake discharge elevation having better quality water. Assuming fully-mixed conditions is typically considered a conservative assumption.

Table 5-4. PHREEQC Assumptions used in the Pit Lake Model

PHREEQC Input Assumptions	
Equilibrium Phases (minerals form solid phase - precipitate forms at some point during the simulation)	$Fe(OH)_3(a)$, $Al(OH)_3(a)$, Jarosite ($KFe^{3+}{}_3(OH)_6(SO_4)_2$) Malachite ($Cu_2CO_3(OH)_2$),
Equilibrium Phases (no mineral formation)	$Cd(OH)_2(a)$, $Cu(OH)_2$, $CuCO_3$, $Zn(OH)_2$, $ZnCO_3$:H_2O, Alunite ($KAl_3(SO_4)_2(OH)_6$) Gypsum ($CaSO_4$)$2H_20$, Otavite ($CdCO_3$), Smithsonite ($ZnCO_3$), Tenorite (CuO),
Database	wateq4f
pH	Charge balance (PHREEQC determines pH of solution and alkalinity)
PE	14 (oxidizing)
Temperature	5^0C
Oxygen	Atmospheric conditions
CO_2	pCO_2 = -2
Stratification	Full mixing throughout the water column was assumed, such that geochemical conditions would be the same throughout the pit.

6 Results and Discussion

6.1 Water Quality Predictions

Annual water quality in the Pit Lake is provided for select parameters in Table 6-1 for intial discharge of the Pit Lake (Year 109) to the North TMF wetland, and long-term conditions (Year 200). Model output concentrations for all modelled water quality parameters are provided in Appendix I - B.

Table 6-1. Pit Lake Water Quality Model Results

Water Quality		Pit Lake Water Quality (mg/L)	
		Initial Pit Lake Discharge (Year 109)	Long-Term (Year 200)
pH		6.2	6.2
Sulphate	(SO_4)	504	368
Fluoride	(F)	1.2	0.88
Cadmium	(Cd)	0.0038	0.0035
Copper	(Cu)	5.0	4.9
Iron	(Fe)	0.00090	0.00089
Molybdenum	(Mo)	0.19	0.10
Selenium	(Se)	0.0084	0.0052
Uranium	(U)	0.060	0.054

Time-series plots of Pit Lake water quality model output concentrations are provided for select parameters (Figure 6-1 to Figure 6-8) to illustrate water quality variations over the duration of the model simulation. Negligable inter-annual variation in pit lake water quality occurred as a result of dry and wet hydrologic conditions because the pit lake is a very large storage reservoir and fluctuations in water and mass loading will be attenuated.

6.2 Post Closure Pit Lake pH

The PHREEQC results (Figure 6-9) show a near neutral pH over the duration of the simulation. There is excess NP in the hypogene wall rock that will be a source of buffering for the Pit Lake water.

Results presented in the SEA (2013) report were generated under the assumption that all available NP in the pit walls would be released during initial submergence of the wall rock, and would become fully mixed with the Pit Lake water at that time. The resulting model output was neutral pH (~pH 7.1 to pH 7.2) water and low copper (~0.4 mg/L). However, not all of the NP can be expected to be released from the wall rock upon initial submergence. The assumption was conservatively revised in this assessment, such that only the NP required for buffering will be released from the submerged wall rock. This results in a Pit Lake pH of about pH 6.2 (pH 6.0 to pH 6.5) with higher copper concentrations (~5 mg/L).

Furthermore, in both the 2013 and 2015 simulations, the pit lake was assumed to be supersaturated with CO_2, shown in Table 5-4 (pCO_2= -2), instead of atmospheric (pCO_2 = -3.45). Superstation of CO_2 results in a slightly higher concentration in copper than would result from atmospheric conditions.

6.3 Natural Degradation of Cyanide

HLF operations were assumed to be complete in Year 19. Surplus rinsing and drain down water will be pumped to the Open Pit after that time. Numerous gold mining operations located in Canada make use of the natural degradation processes for removal of cyanide from site water. Generally WAD-CN is removed rapidly – essentially all WAD-CN dissipates during a single open water season. The half-life of WAD-CD is very short – as little as a few hours, as the solution pH drops below pH 8. For the purposes of the model, it has been conservatively assumed the half-life is 0.05 years (18 days). Total cyanide was assumed to degrade more slowly, with a half-life of 0.5 years. Because the Pit Lake will not discharge for approximately 85 years after the final year of drain down pumping to Pit Lake (Year 28), cyanide degradation will remove this source prior to initial discharge of the Pit Lake.

6.4 Individual Contributions from Loading Sources

Individual contributions of each mass loading source are presented for select water quality parameters. Table 6-2 represents cumulative loading contributions at the time of initial discharge of the Pit Lake.

Table 6-3 represents the long-term (perpetual) contributions and was calculated from annual mass loading inflows at the end of the simulation (Year 200). Loading contributions for all water quality parameters are presented in Appendix I-B.

Closure activities carried out during the Wetland Construction Phase (pumping from the HLF, TMF and WMP, and disposal of residual stockpile ore rock) will influence Pit Lake water quality upon intial discharge, but those loading contributions will be temporary and will not affect the long-term water quality in the Pit Lake.

A portion of the pit wall (i.e., the “high wall”) that is above the elevation of the final Pit Lake will remain un-submerged. Runoff from the high wall will be a perpetual source of mass loading into the Pit Lake. The acidic portion (Supergene Acidic or Hypogene Acidic) of the Open Pit high wall rock is expected to be the largest contributor of mass load into the Pit Lake in the long-term.

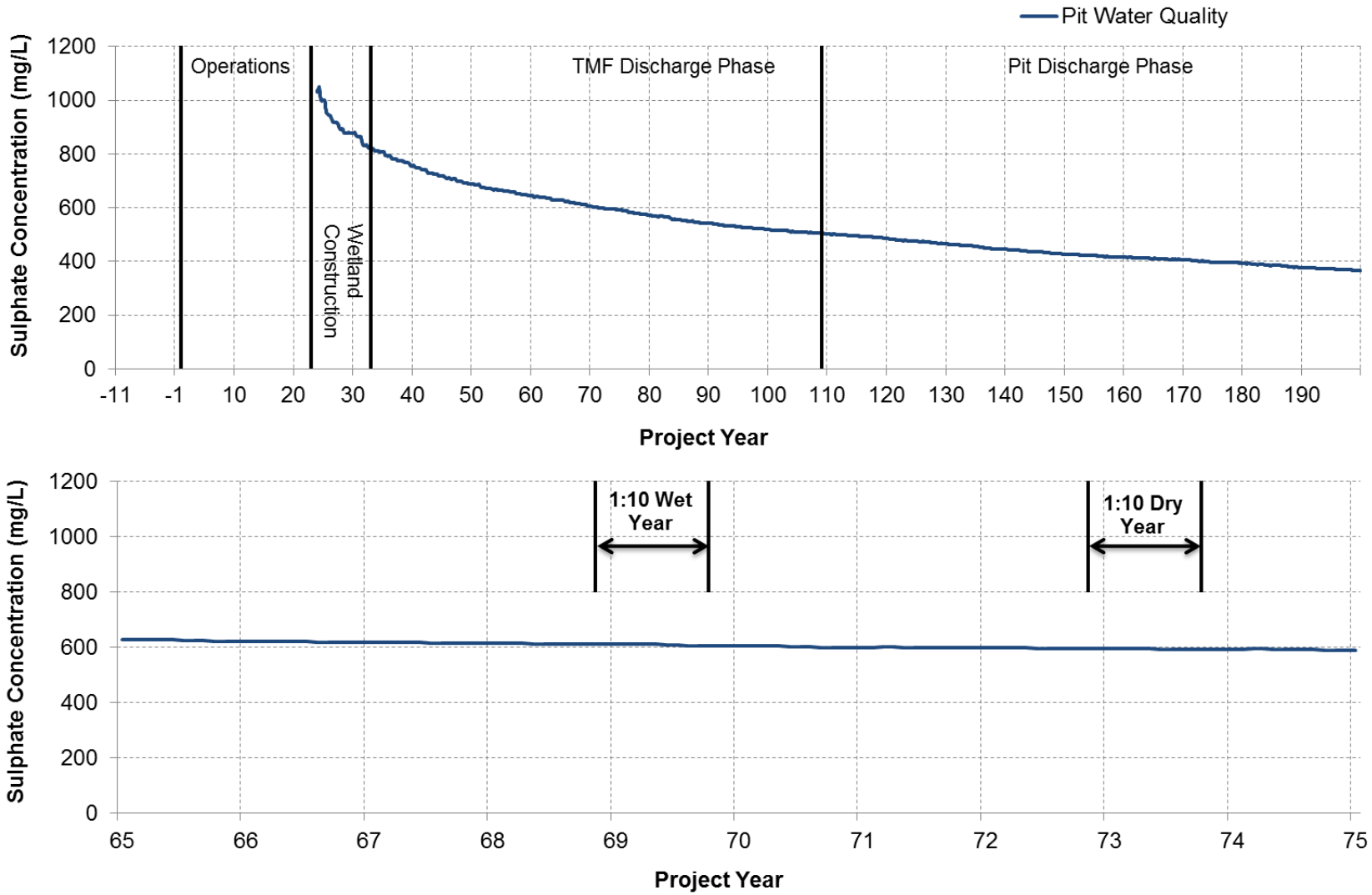

Figure 6-1. Modelled Sulphate Concentration in the Pit Lake

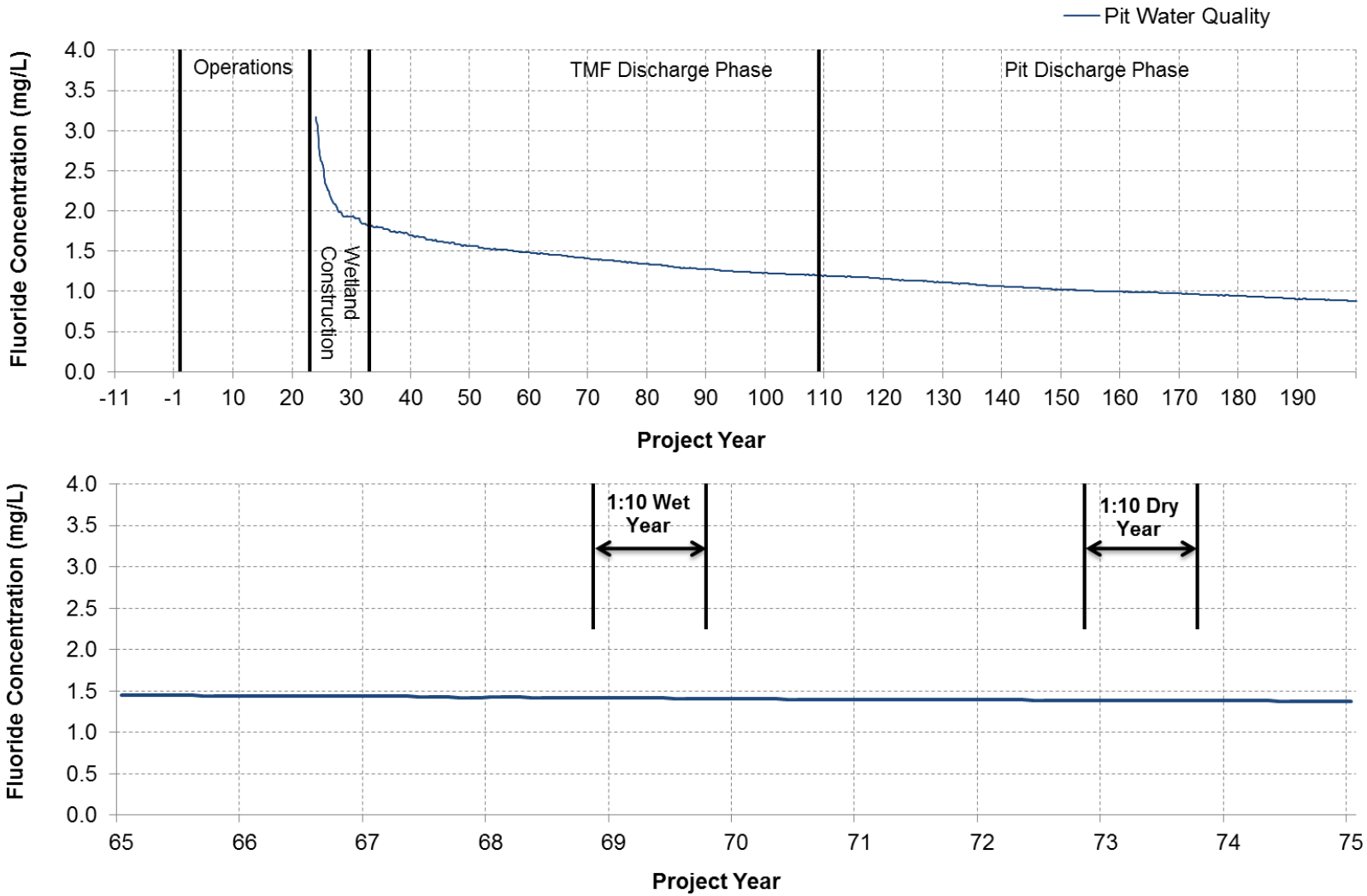

Figure 6-2. Modelled Fluoride Concentration in the Pit Lake

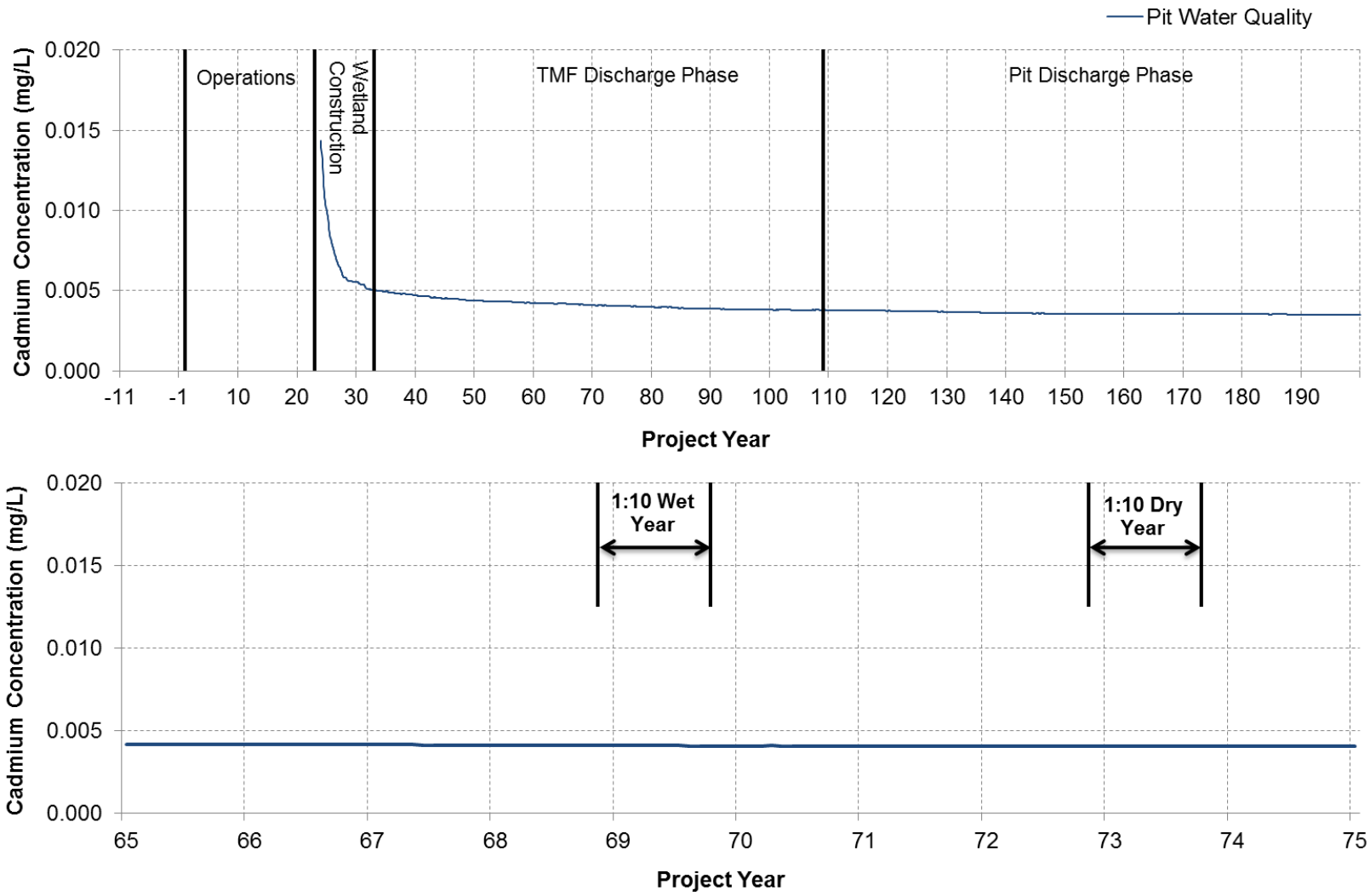

Figure 6-3. Modelled Cadmium Concentration in the Pit Lake

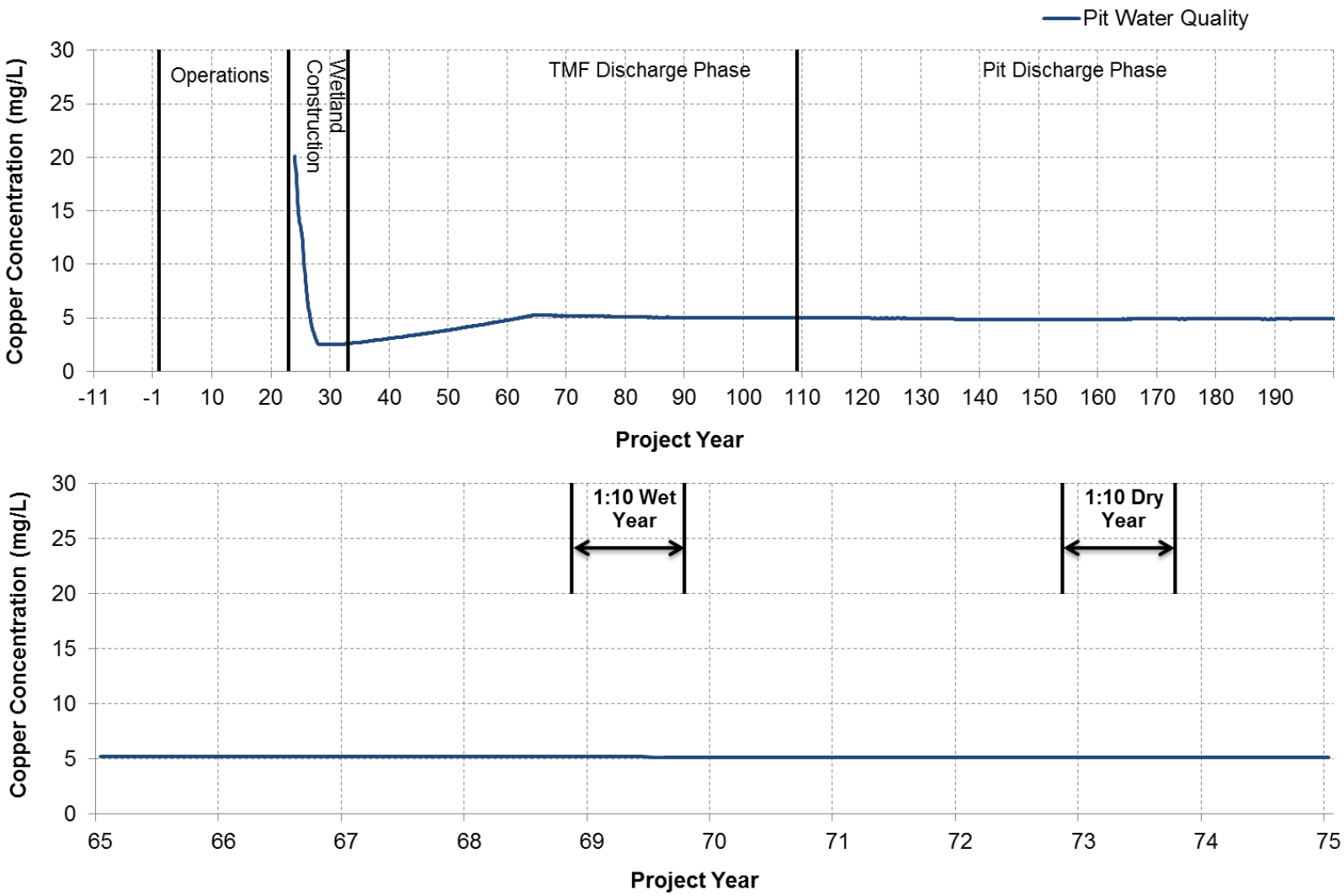

Figure 6-4. Modelled Copper Concentration in the Pit Lake

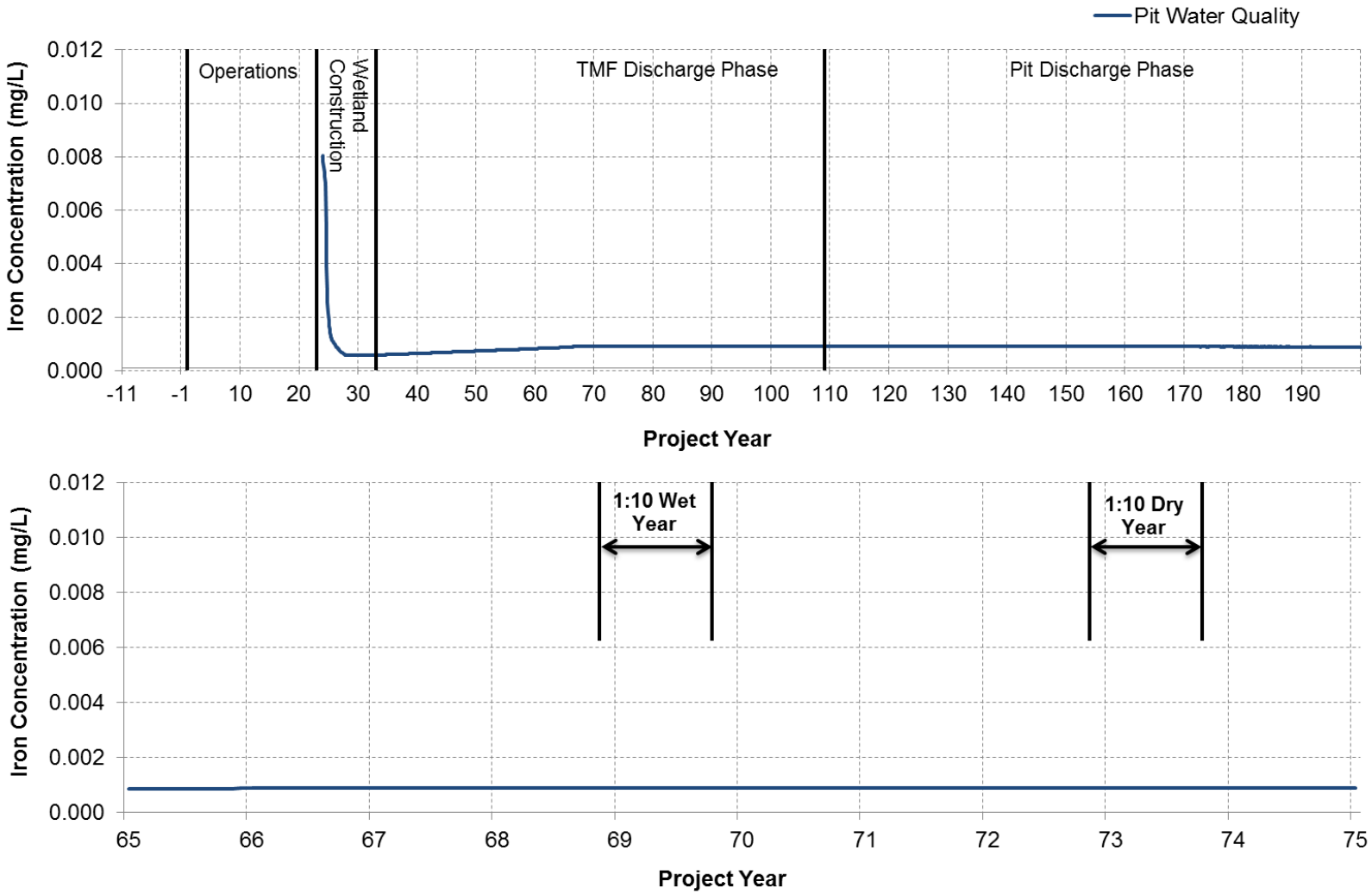

Figure 6-5. Modelled Iron Concentration in the Pit Lake

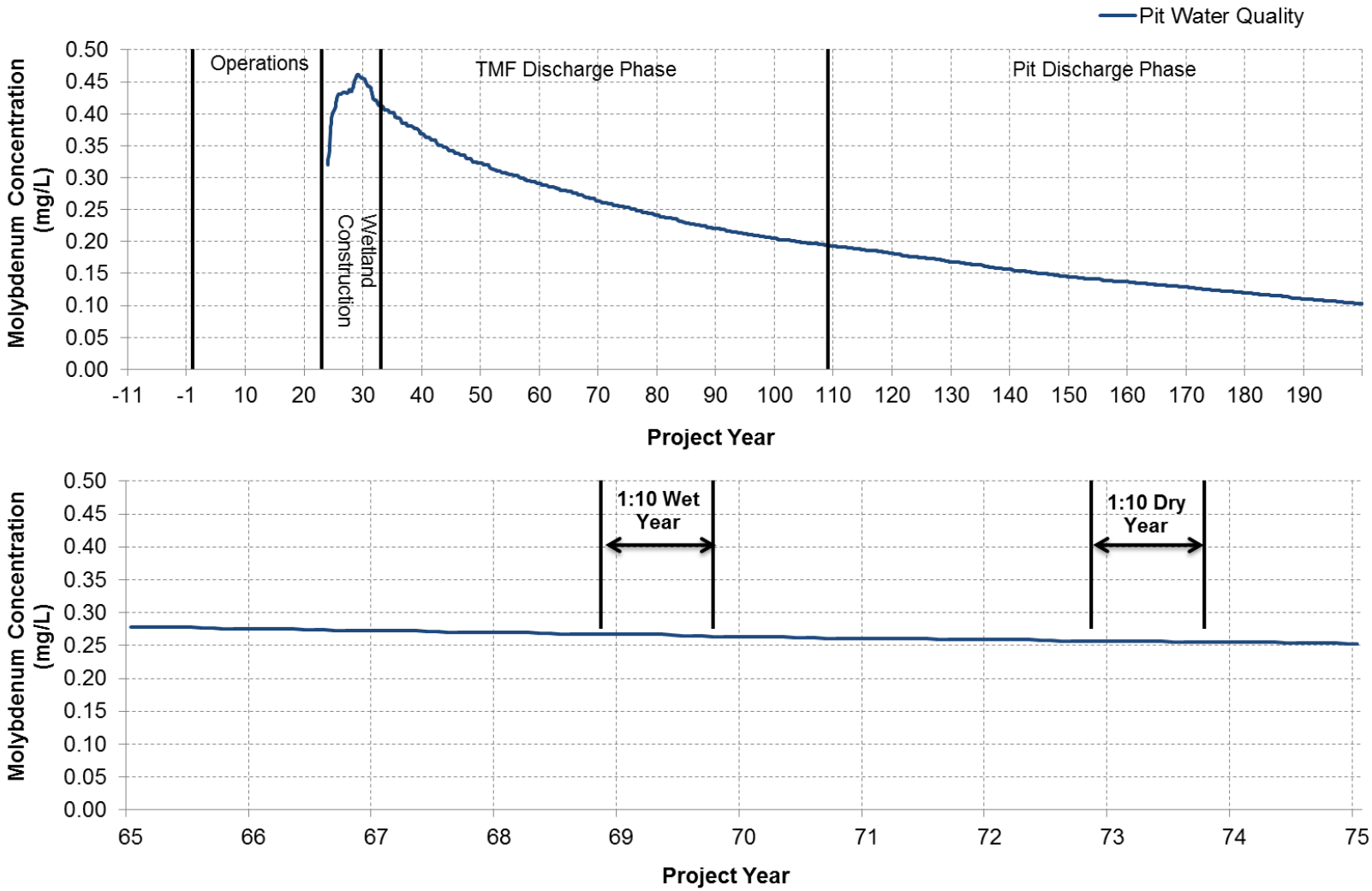

Figure 6-6. Modelled Molybdenum Concentration in the Pit Lake

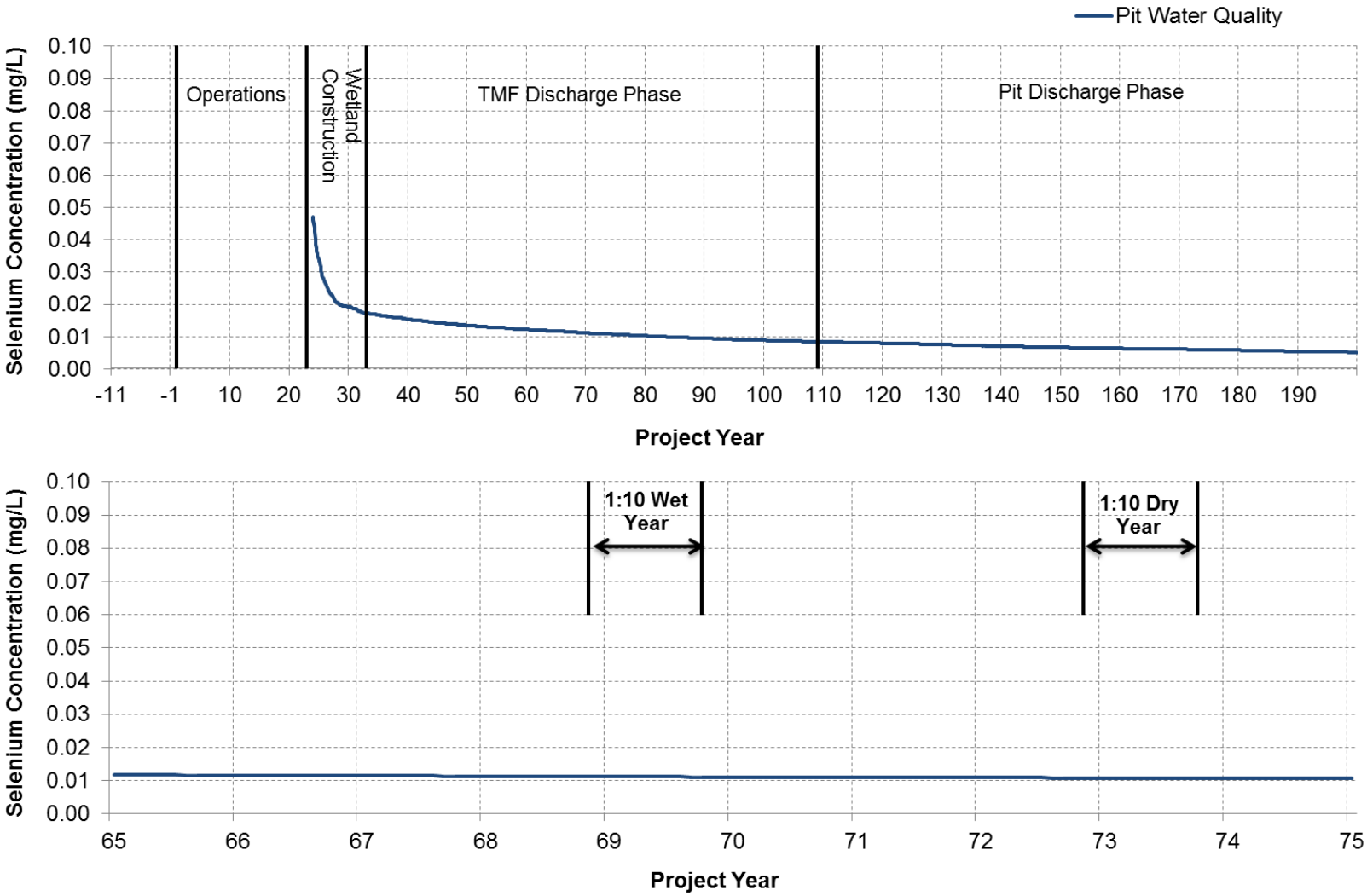

Figure 6-7. Modelled Selenium Concentration in the Pit Lake

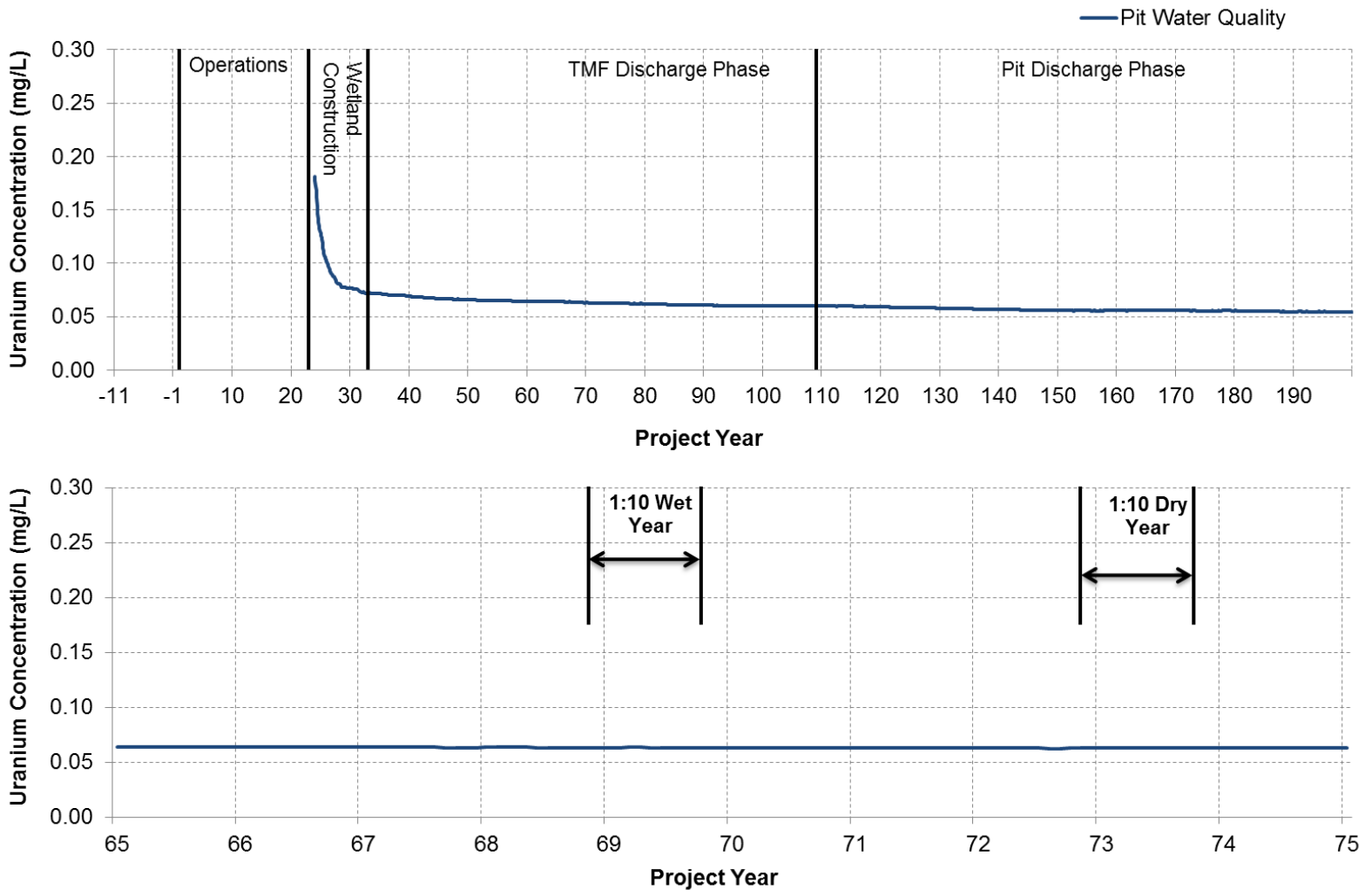

Figure 6-8. Modelled Uranium Concentration in the Pit Lake

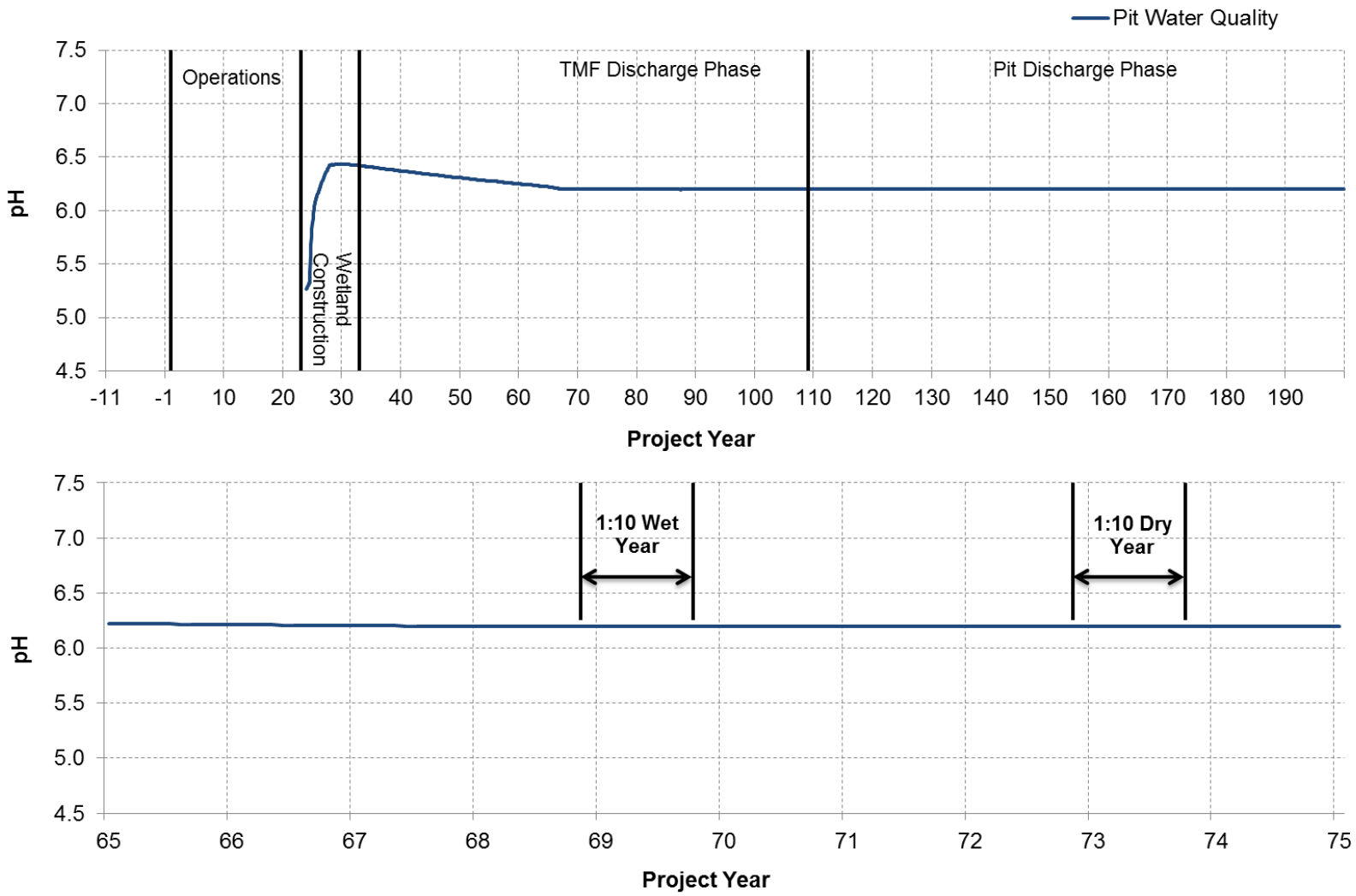

Figure 6-9. Modelled pH in the Pit Lake

Table 6-2. Cumulative Fraction Contributing to Pit Lake Water Quality – Initial Pit Lake Discharge (Year 109)

Pit Lake Loading Source	Fraction Contributing (%)							
	SO_4	F	Cd	Cu	Fe	Mo	Se	U
Runoff	3	2	2	0	0	0	0	0
Groundwater	15	7	7	1	27	1	0	9
Ore Stockpile Seepage								
Hypogene	0	0	0	0	0	0	0	0
Supergene Sulphide	0	1	2	2	1	0	1	1
Marginal Ore	0	0	0	0	0	0	0	0
Pit Wall Runoff								
CAP	1	1	1	1	0	0	3	0
Hypogene (neutral)	7	12	1	0	0	12	4	7
Hypogene (acidic)	5	4	8	14	22	0	2	13
Supergene (neutral)	2	7	0	0	0	1	1	2
Supergene (acidic)	4	7	30	34	18	0	6	21
Pit Wall Flushing upon Submergence								
CAP	0	0	0	0	0	0	0	0
Hypogene (neutral)	2	3	0	0	0	3	1	2
Hypogene (acidic)	2	2	3	5	8	0	1	5
Supergene (neutral)	0	0	0	0	0	0	0	0
Supergene (acidic)	0	0	0	1	0	0	0	0
Ore Rock Flushing upon Submergence								
Supergene Oxide LGO	0	1	2	2	1	0	2	1
Supergene Sulphide LGO	1	4	6	5	3	0	4	3
Hypogene LGO	5	6	1	2	1	5	13	3
Marginal Ore	4	7	28	32	17	0	31	20
WMP Pumping	10	9	2	0	0	11	5	4
TMF Pond Pumping	31	23	4	0	0	26	20	9
HLF Draindown	7	4	4	1	2	42	5	0
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

1. Values were calculated from total load into the Pit Lake until initial discharge (Year 109).
2. Shaded cells are for sources that contribute >10% to the overall load.
3. Values are rounded and the total of individual values may not add to exactly 100.

Table 6-3. Annual Fraction Contributing to Pit Lake Water Quality – Long-Term Conditions (Year 200)

Pit Lake Loading Source	Fraction Contributing (%)							
	SO_4	F	Cd	Cu	Fe	Mo	Se	U
Runoff	9	6	3	0	0	1	2	0
Groundwater	40	19	10	1	30	12	1	13
Ore Stockpile Seepage	0	0	0	0	0	0	0	0
Pit Wall Runoff								
CAP	3	3	1	2	0	0	18	0
Hypogene (neutral)	7	12	0	0	0	73	8	4
Hypogene (acidic)	21	17	19	29	39	1	16	30
Supergene (neutral)	3	13	0	0	0	13	4	2
Supergene (acidic)	17	29	67	68	31	0	52	50
Pit Wall Flushing	0	0	0	0	0	0	0	0
Ore Rock Flushing	0	0	0	0	0	0	0	0
WMP Pumping	0	0	0	0	0	0	0	0
TMF Pond Pumping	0	0	0	0	0	0	0	0
HLF Draindown	0	0	0	0	0	0	0	0
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

1. Values were calculated from loading entering the Pit Lake in Year 200.
2. Shaded cells are for sources that contribute >10% to the overall load.
3. Values are rounded and the total of individual values may not add to exactly 100.

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Appendix I - A

Water Quality Modelling Input Source Terms

Table I-A1. Pit Lake Water Quality Model Inflow Concentration

Water Quality Parameter	Overland Runoff (W7)	Background Groundwater	Ore Stockpile Seepage (max concentration)[1]			Pumped from TMF Pond [2]	Pumped from HLF	Pumped from WMP [3]
			Hypogene LGO	Supergene Sulphide LGO	Marginal Grade Ore			
	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
Hardness (as $CaCO_3$)	44	691	1,919	1,107	645	901	1,695	974
Alkalinity (as $CaCO_3$)	7.1	123	68	0	0	64	70	37
Sulphate (SO_4)	47	578	1,890	2,220	1,590	899	1,920	954
Chloride (Cl)	0.25	0.91	37	16	3.0	26	638	0.033
Fluoride (F)	0.065	0.63	2.4	25	6.3	1.5	2.1	1.8
Aluminum (Al)	0.057	0.15	0.0023	121	98	0.84	0.069	0.014
Antimony (Sb)	0.000065	0.00015	0.28	0.080	0.0027	0.0035	0.77	0.019
Arsenic (As)	0.00024	0.0088	0.030	0.046	0.0087	0.0054	0.036	0.0074
Barium (Ba)	0.049	0.011	0.0056	0.0053	0.023	0.093	0.0064	0.085
Cadmium (Cd)	0.00017	0.0019	0.0093	0.12	0.079	0.00077	0.0084	0.0014
Calcium (Ca)	13	218	609	302	211	347	666	373
Chromium (Cr)	0.00015	0.00036	0.014	0.021	0.015	0.0019	0.0010	0.0036
Cobalt (Co)	0.000079	0.034	0.052	0.34	0.24	0.0035	5.7	0.0057
Copper (Cu)	0.0023	0.37	0.056	147	119	0.059	2.8	0.043
Iron (Fe)	0.047	16	0.0099	125	107	0.00037	9.5	0.00057
Lead (Pb)	0.000076	0.00051	0.0024	0.040	0.040	0.0021	0.0015	0.00089
Magnesium (Mg)	2.7	36	97	86	29	8.5	7.8	10
Manganese (Mn)	0.0047	1.2	0.13	4.1	0.46	1.3	0.0036	1.6
Mercury (Hg)	0.0000050	0.000015	0.00060	0.00040	0.00014	0.000011	0.000026	0.000026
Molybdenum (Mo)	0.00026	0.010	2.5	0.0090	0.0010	0.28	4.2	0.30
Nickel (Ni)	0.00097	0.0050	0.071	2.0	2.0	0.0030	0.24	0.0052
Selenium (Se)	0.000060	0.000076	0.30	0.20	0.20	0.0092	0.020	0.0073
Silver (Ag)	0.0000025	0.0000095	0.00070	0.00085	0.00054	0.000042	0.053	0.000064
Sodium (Na)	4.0	11	8.2	7.9	1.2	58	432	63
Thallium (Tl)	0.0000025	0.000027	0.00050	0.00094	0.00027	0.00034	0.0018	0.00039
Uranium (U)	0.000074	0.037	0.50	1.1	0.90	0.028	0.0018	0.036
Zinc (Zn)	0.014	0.15	0.57	9.5	7.7	0.014	0.072	0.022

1. Concentration of stockpile seepage will vary depending on the mass of ore in the stockpile at the time of infiltration through the stockpile. Contact water quality is expected to be equal to or less than the concentrations shown (Lorax, 2013).
2. Average TMF Pond concentration over the duration of pumping from the TMF to the Pit (Year 23 to Year 27).
3. Average WMP concentration over the duration of pumping from the WMP to the Pit (Year 23 to Year 34).

Table I-A2. Loading Rates for Pit Wall Runoff, Flushing (from Submergence) of Pit Wall Rock and Flushing of Ore Stockpile Rock

Water Quality Parameter	Pit Wall Runoff (mg/m^2/year) [2]					Rate of Buildup of Substances on the Pit Walls (mg/m^2/year) [2]					Flushing of Ore When Placed in the Pit (mg/tonne)			
	Hypogene		Supergene		CAP	Hypogene		Supergene		CAP	Supergene Oxide LGO	Supergene Sulphide LGO	Hypogene LGO	Marginal Ore
	Neutral	Acidic	Neutral	Acidic		Neutral	Acidic	Neutral	Acidic					
Hardness (as $CaCO_3$)	153,468	663,200	157,172	619,840	36,495	86,960	375,320	88,939	351,050	20,751	272,350	280,470	1,762,580	282,500
Alkalinity (as $CaCO_3$)	18,000	0	10,300	0	530	(note 3)	(note 3)	(note 3)	(note 3)	(note 3)	0	0	439,000	0
Sulphate (SO_4)	129,000	1,150,000	139,000	764,000	43,200	73,200	653,000	78,600	433,000	24,500	545,000	562,000	1,690,000	693,000
Chloride (Cl)	1,840	4,300	1,810	867	359	1,040	2,440	1,020	491	203	3,960	4,080	9,180	1,300
Fluoride (F)	717	1,200	1,710	910	117	406	677	971	515	66	6,080	6,260	4,510	2,730
Aluminum (Al)	1.3	63,700	1.9	14,300	503	0.75	36,100	1.1	8,110	285	29,700	30,500	14,800	43,000
Antimony (Sb)	4.4	1.6	2.4	0.79	0.35	2.5	0.91	1.4	0.45	0.20	31	32	68	1.2
Arsenic (As)	4.5	5.9	1.1	1.3	0.39	2.5	3.4	0.61	0.72	0.22	11	12	7.4	3.8
Barium (Ba)	75	20	162	3.3	43	43	11	92	1.9	24	202	208	190	10
Cadmium (Cd)	0.16	7.2	0.085	12	0.24	0.089	4.1	0.048	6.5	0.14	30	31	2.3	35
Calcium (Ca)	52,400	98,000	54,800	203,000	11,400	29,700	55,500	31,000	115,000	6,480	74,500	76,600	666,000	92,500
Chromium (Cr)	0.27	19	0.74	2.2	0.57	0.15	11	0.42	1.2	0.32	5.1	5.2	3.4	6.5
Cobalt (Co)	0.91	148	2.7	35	8.0	0.52	84	1.5	20	4.6	84	87	13	104
Copper (Cu)	13	16,600	45	17,400	653	7.2	9,390	25	9,830	370	36,200	37,200	5,810	52,100
Iron (Fe)	8.0	43,800	8.0	15,500	25	4.5	24,800	4.5	8,800	14	32,200	33,100	4,520	46,600
Lead (Pb)	0.34	1.1	0.33	0.47	0.22	0.19	0.63	0.19	0.27	0.12	17	10	0.59	18
Magnesium (Mg)	5,480	102,000	4,920	27,400	1,950	3,100	57,700	2,790	15,500	1,110	21,000	21,700	23,800	12,500
Manganese (Mn)	54	560	128	67	102	31	317	73	38	58	1,000	1,030	1,020	200
Mercury (Hg)	0.0080	0.043	0.013	0.040	0.0096	0.0045	0.024	0.0075	0.022	0.0055	0.099	0.10	0.16	0.059
Molybdenum (Mo)	85	1.2	31	0.12	0.47	48	0.65	18	0.067	0.27	3.8	2.3	612	0.35
Nickel (Ni)	1.4	83	2.0	13	2.6	0.78	47	1.1	7.1	1.5	842	506	18	876
Selenium (Se)	1.7	3.9	2.0	5.6	2.5	0.96	2.2	1.1	3.2	1.4	84	51	74	88
Silver (Ag)	0.0053	0.16	0.013	0.078	0.049	0.0030	0.090	0.0075	0.044	0.028	0.21	0.22	0.17	0.24
Sodium (Na)	351	6,900	430	5,710	1,450	199	3,910	244	3,240	821	1,030	1,990	2,020	520
Thallium (Tl)	0.10	0.18	0.100	0.079	0.087	0.057	0.10	0.057	0.045	0.049	0.23	0.24	0.12	0.12
Uranium (U)	32	179	24	131	0.80	18	102	13	74	0.45	271	279	121	393
Zinc (Zn)	17	1,390	30	1,120	24	9.4	788	17	634	13	2,340	2,410	140	3,360

1. Values presented in this table were provided by Lorax (2013).
2. Loading units are in terms of horizontal (planar) unit area.
3. Alkalinity loading is solved for in PHREEQC based on available NP in wall rock.

Appendix I - B

Water Quality Modelling Results

Table I-B1. Pit Lake Water Quality Model Results

Water Quality Model Parameter	Pit Lake Water Quality	
	Initial Pit Lake Discharge (Year 109)	Long Term Post-Closure (Year 200)
pH	6.2	6.2
Hardness (as $CaCO_3$)	502	378
Alkalinity (as $CaCO_3$)	21	21
Sulphate (SO_4)	504	368
Chloride (Cl)	26	16
Fluoride (F)	1.2	0.88
Aluminum (Al)	0.24	0.19
Antimony (Sb)	0.020	0.011
Arsenic (As)	0.0059	0.0045
Barium (Ba)	0.078	0.064
Cadmium (Cd)	0.0038	0.0035
Calcium (Ca)	178	130
Chromium (Cr)	0.0026	0.0024
Cobalt (Co)	0.13	0.079
Copper (Cu)	5.0	4.9
Iron (Fe)	0.00090	0.00089
Lead (Pb)	0.0014	0.00091
Magnesium (Mg)	14	13
Manganese (Mn)	0.59	0.44
Mercury (Hg)	0.000025	0.000022
Molybdenum (Mo)	0.19	0.10
Nickel (Ni)	0.046	0.029
Selenium (Se)	0.0084	0.0052
Silver (Ag)	0.0011	0.00056
Sodium (Na)	27	16
Thallium (Tl)	0.00018	0.00012
Uranium (U)	0.060	0.054
Zinc (Zn)	0.37	0.37

Table I-B2. Cumulative Fraction Contributing to Pit Lake Water Quality for Initial Pit Lake Discharge (Year 109)

Pit Lake Loading Source	Hard-ness	Alk	SO4	Cl	F	Al	Sb	As	Ba	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Na	Tl	U	Zn
Runoff	3	1	3	0	2	0	0	1	20	2	2	2	0	0	0	2	6	0	7	0	1	0	0	5	1	0	1
Groundwater	19	10	15	3	7	0	0	21	2	7	17	2	4	1	27	5	36	28	8	1	1	0	0	6	2	9	6
Ore Stockpile Seepage																											
Hypogene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Supergene Sulphide	0	0	0	0	1	1	0	0	0	2	0	0	0	2	1	2	0	0	1	0	2	1	0	0	0	1	1
Marginal Ore	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pit Wall Runoff																											
CAP	1	5	1	1	1	1	0	1	5	1	1	2	1	1	0	1	1	2	4	0	1	3	0	0	4	0	1
Hypogene (neutral)	8	2	7	2	12	0	4	15	19	1	8	3	0	0	0	4	11	2	9	12	1	4	0	0	10	7	1
Hypogene (acidic)	1	0	5	1	4	37	0	4	1	8	1	31	5	14	22	3	8	4	7	0	7	2	1	0	4	13	16
Supergene (neutral)	2	0	2	0	7	0	3	5	11	0	2	2	0	0	0	1	3	1	4	1	0	1	0	0	3	2	0
Supergene (acidic)	2	0	4	7	7	19	0	2	0	30	2	8	2	34	18	3	3	1	16	0	3	6	1	0	4	21	30
Pit Wall Flushing upon Submergence																											
CAP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hypogene (neutral)	2	66	2	4	3	0	1	4	5	0	2	1	0	0	0	1	3	1	2	3	0	1	0	0	1	2	0
Hypogene (acidic)	2	0	2	2	2	14	0	2	0	3	0	11	2	5	8	1	3	1	3	0	3	1	0	0	2	5	6
Supergene (neutral)	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Supergene (acidic)	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Ore Rock Flushing upon Submergence																											
Supergene Oxide LGO	0	0	0	0	1	1	0	0	1	2	0	0	0	2	1	3	0	0	1	0	4	2	0	0	0	1	2
Supergene Sulphide LGO	0	0	1	0	4	3	1	1	2	6	0	1	0	5	3	5	1	1	3	0	7	4	0	0	1	3	5
Hypogene LGO	6	3	5	1	6	3	5	2	4	1	6	2	0	2	1	1	3	3	10	5	1	13	0	0	1	3	1
Marginal Ore	2	0	4	0	7	18	0	2	0	28	2	8	2	32	17	36	3	1	7	0	57	31	1	0	2	20	28
WMP Pumping	11	2	10	12	9	0	7	9	6	2	12	11	0	0	0	3	5	14	8	11	1	5	0	14	12	4	0
TMF Pond Pumping	33	8	31	18	23	2	3	17	22	4	37	14	0	0	0	26	12	40	9	26	1	20	1	41	33	9	1
HLF Draindown	7	0	7	48	4	0	73	12	0	4	8	1	83	1	2	2	1	0	2	42	10	5	95	33	19	0	0
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

1. Values were calculated from total load into the Pit Lake until initial discharge (Year 109).
2. Shaded cells are for sources that contribute >10% to the overall load.
3. Values are rounded and the total of individual values may not add to exactly 100.

Table I-B2. Cumulative Fraction Contributing to Pit Lake Water Quality for Long Term Conditions (Year 200)

Pit Lake Loading Source	Hard	Alk	SO4	Cl	F	Al	Sb	As	Ba	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Na	Tl	U	Zn
Runoff	10	6	9	2	6	0	3	4	50	3	10	4	0	0	0	10	11	1	14	1	5	2	3	48	3	0	2
Groundwater	58	54	40	18	19	0	2	49	4	10	59	3	23	1	30	23	53	71	13	12	8	1	4	46	8	13	7
Ore Stockpile Seepage	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pit Wall Runoff																											
CAP	3	33	3	6	3	1	4	2	13	1	3	4	5	2	0	8	3	5	7	0	3	18	18	4	21	0	1
Hypogene (neutral)	9	5	7	4	12	0	33	14	14	0	10	2	0	0	0	8	6	2	5	73	1	8	2	1	15	4	0
Hypogene (acidic)	7	0	21	12	17	66	11	16	3	19	3	69	47	29	39	24	18	15	18	1	62	16	33	1	24	30	32
Supergene (neutral)	4	2	3	1	13	0	35	8	14	0	5	2	0	0	0	4	2	2	4	13	1	4	2	1	7	2	0
Supergene (acidic)	8	0	17	57	29	33	12	7	1	67	9	18	24	68	31	22	7	4	38	0	21	52	37	1	23	50	57
Pit Wall Flushing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ore Rock Flushing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WMP Pumping	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TMF Pond Pumping	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HLF Draindown	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

1. Values were calculated from loading entering the Pit Lake in Year 200.
2. Shaded cells are for sources that contribute >10% to the overall load.
3. Values are rounded and the total of individual values may not add to exactly 100.

Casino Project
Water Quality Predictions

Appendix II
Ore Stockpiles Water Quality Modelling

Prepared by:

Source
ENVIRONMENTAL ASSOCIATES INC.

February 2015

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1 Introduction

During Operations of the Casino Project (the Project), six types of ore will be temporarily stockpiled on surface. The stockpiles include:

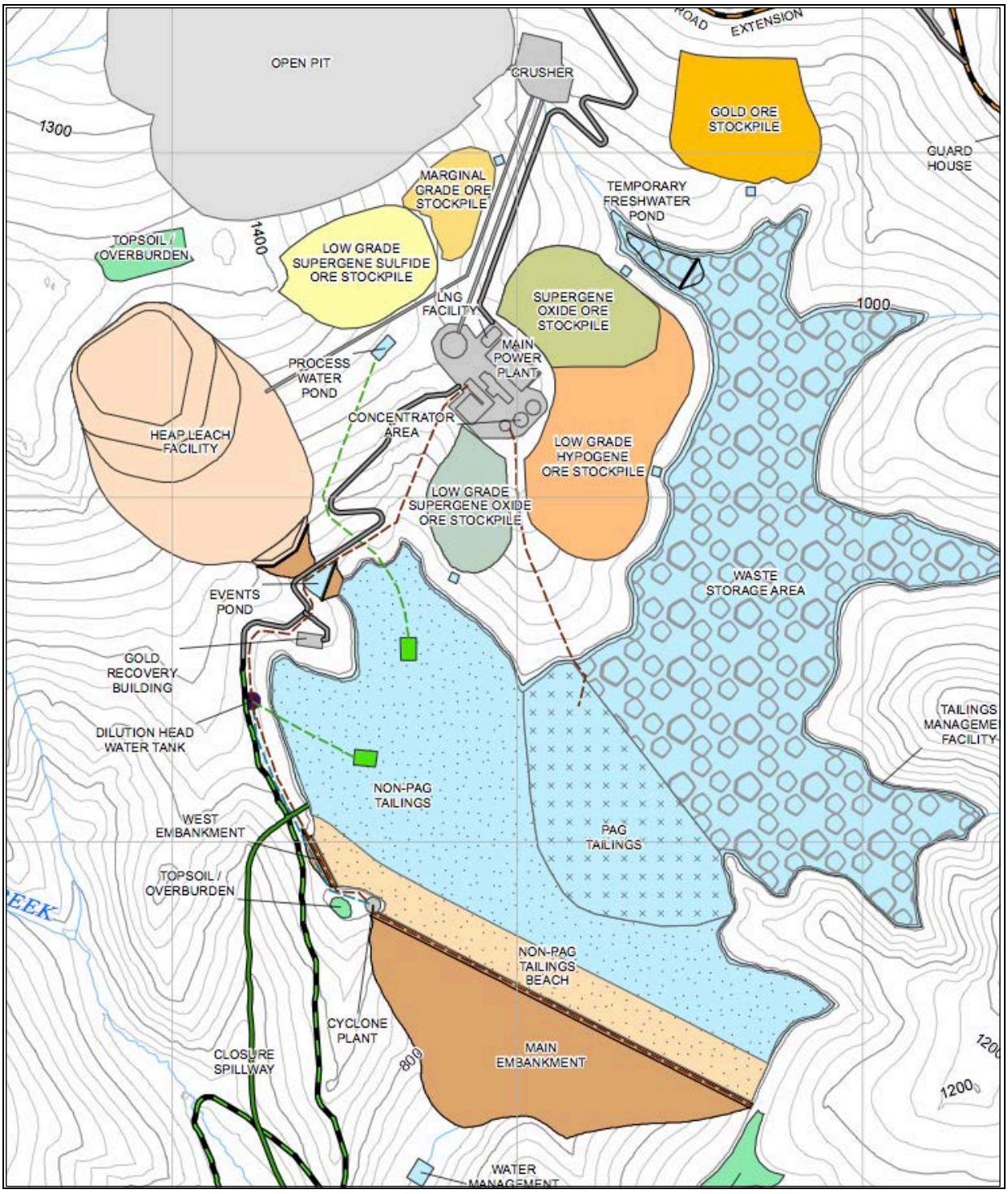
- Gold Ore;
- Supergene Oxide Ore;
- Low Grade Supergene Oxide;
- Low Grade Hypogene;
- Low Grade Supergene Sulphide; and,
- Marginal Grade Ore (MGO).

The gold ore will be crushed then processed in the Heap Leach Facility (HLF), and the marginal ore, should it not be economical to mill, will be backfilled to the Open Pit. The remaining 4 piles will be milled in the processing facility throughout the life of the mine. Stockpile locations are shown on Figure 1-1. The schedule of ore stockpiling rock is provided in Appendix II-A (Table II - A 1).

While the ore stockpiles are present during Operations, contact water (from rainfall and snowmelt) will drain from the rock as runoff or will infiltrate to groundwater. Runoff from the stockpiles will be captured by the TMF Pond. Prior to construction of the TMF, runoff water from the stockpiles will be conveyed to the temporary Freshwater Storage Pond (FWSP) in the northern upper reach of the final TMF footprint. The FWSP water will be used to supply makeup water to the HLF (KPL, 2013a). Hydrogeological modelling results (KPL, 2013b) indicated that depending on the stockpile location, infiltrated contact water will flow to one or more of the following receptors: the TMF Pond; Open Pit; TMF Embankment; or TMF Foundation bedrock.

Because the stockpiles will be temporary structures, they will be temporary sources of loading. The transient effect of the stockpiles on the site-wide water quality was accounted for by Source Environmental Associates Inc. (SEA) in the water quality model.

This document summarizes the calculation methodology and results of mass loading from the stockpiles to the various receptors around the project site. Mass transport rates were calculated using flow rates from the KPL (2015) water balance model, combined with geochemical source terms provided by Lorax (2013), and the stockpile schedule from KPL (2013c). Hydrogeological modelling results from KPL (2013b) were used to predict average travel times of groundwater from the stockpiles to their receptors.



Adapted from KPL, 2013a

Figure 1-1. Ore Stockpile General Arrangement at Maximum Footprint

2 Water Quality Model

A site-wide water quality model was developed by SEA. The model simulation was run with monthly time steps for a timeline beginning a few years prior to Construction, through to 200 years following the beginning of Operations.

Project years are described in this document relative to the beginning of milling Operations. For example, Year -2 refers to the second year before Operations begins, and Year 2 refers to the second year of Operations. Construction will span from Year -4 to Year -1, and Operations from Year 1 to Year 22. Modelling methodology and results are presented in the following sections.

2.1 Modelling Approach

The rate of mass transport from the ore (via contact water) was calculated for 27 water quality parameters using source terms from Lorax (2013) and water balance flows from KPL (2015). Ore stockpile source terms from Lorax include both a loading rate based on the amount of rock present in the stockpile (i.e. mass of constituents per mass of rock) and a maximum concentration limit based on solubility controls. In the GoldSim model, development of the total loadings in mass flow rate per time (e.g. kg/month) for each ore pile was the first step in a multi-step process.

Once the total load for each constituent was determined for an ore pile, this total load was then partitioned by the annual quantity of flow to surface water and groundwater. Surface water runoff was directed to the TMF pond. Groundwater loadings were further partitioned into the following four pathways shown on Figure 2-1.

- Seepage to the TMF Pond
- Seepage to the Open Pit
- Seepage to the TMF Embankment
- Seepage to the TMF Foundation

Once the total load (Section 2.2) was partitioned to a groundwater pathway (Section 2.3), a delay was applied in the water quality model to simulate the travel time (Section 2.4) for the loading from the stockpile to the receptor.

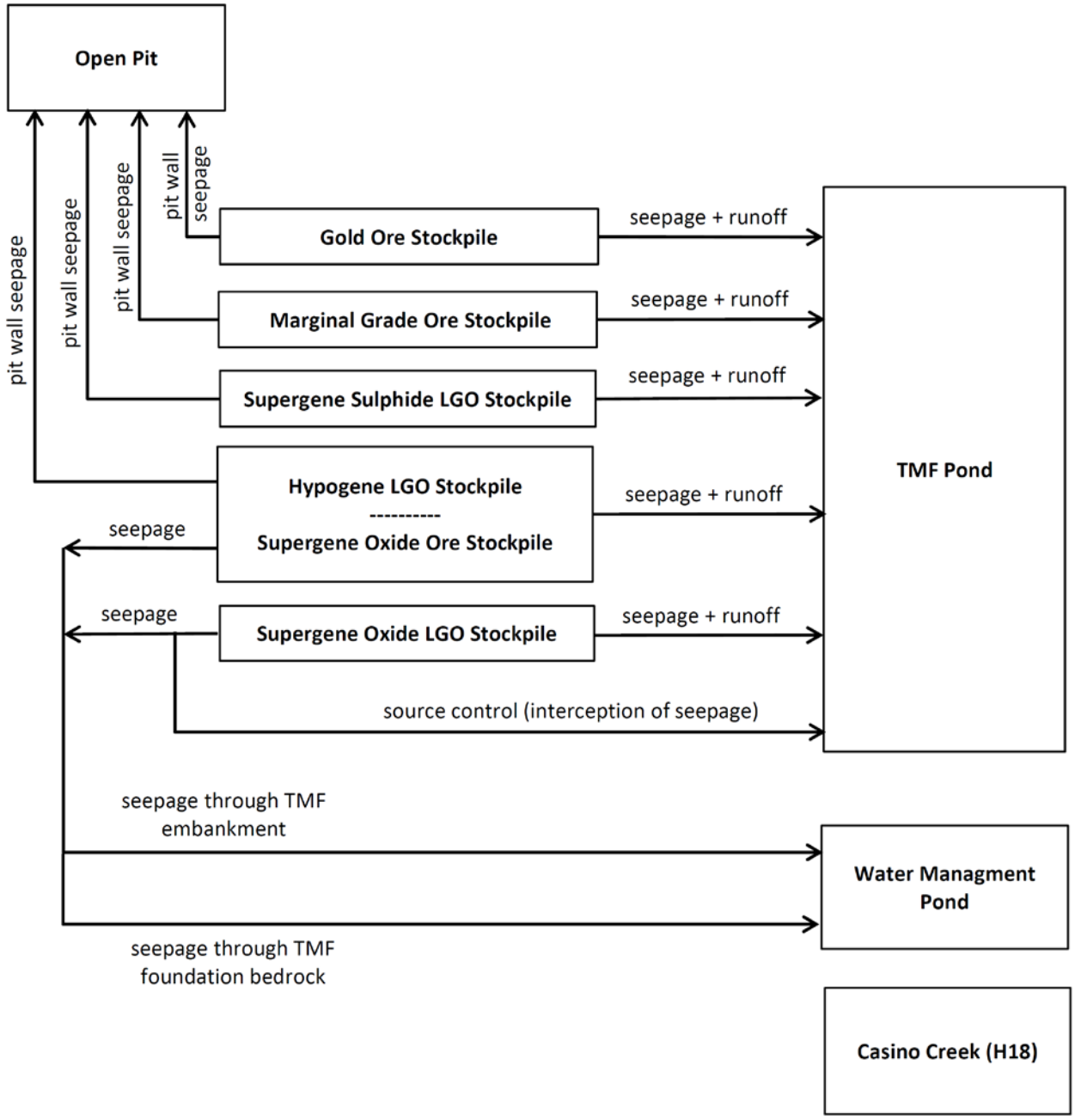


Figure 2-1. Mass Loading Pathways from the Ore Stockpiles

2.2 Mass Loading from Ore Stockpiles

The amount of rock stockpiled on surface directly affects the quantity and quality of the ore stockpile contact water. The ore deposition schedule is summarized in Appendix II-A (Table II - A1). Mass loading rate source terms for the six ore stockpiles were developed by Lorax (2013) on an annual basis and are presented in Appendix II-A (Table II - A 2). The source term loading rates were multiplied by the total rock mass stored in the stockpiles to calculate total load from the ore piles during a given model time-step. The loading concentrations from the ore piles were compared to solubility controls for the suite of parameters. Lorax (2013) provided maximum allowable contact water concentrations (Appendix II-A, Table II - A 3) based on water availability and solubility constraints. The total mass load in the contact water was reduced if the resulting contact water concentration exceeded the maximum allowable concentration provided by Lorax (2013).

Lorax predicted the pH of the contact water to be pH 4.7 for the Gold Ore, pH 7.2 for the Low Grade Hypogene Ore, and pH 3.2 for the other stockpiles (Table II - A 4). Water quality modeling indicated that only the Low Grade Hypogene Ore stockpile would be affected by solubility controls (the solubility controls apply to copper, iron and other parameters that are relatively insoluble at neutral pH). Time series plots of copper mass loading rates from the Supergene Oxide Ore (Figure 2-2) and the Low Grade Hypogene stockpile (Figure 2-3) illustrate the calculated total mass loading from the stockpiles.

Once the mass loadings from each stockpile were determined, the next step in the model was to partition the total load into the flow pathways to receptors (Section 2.3).

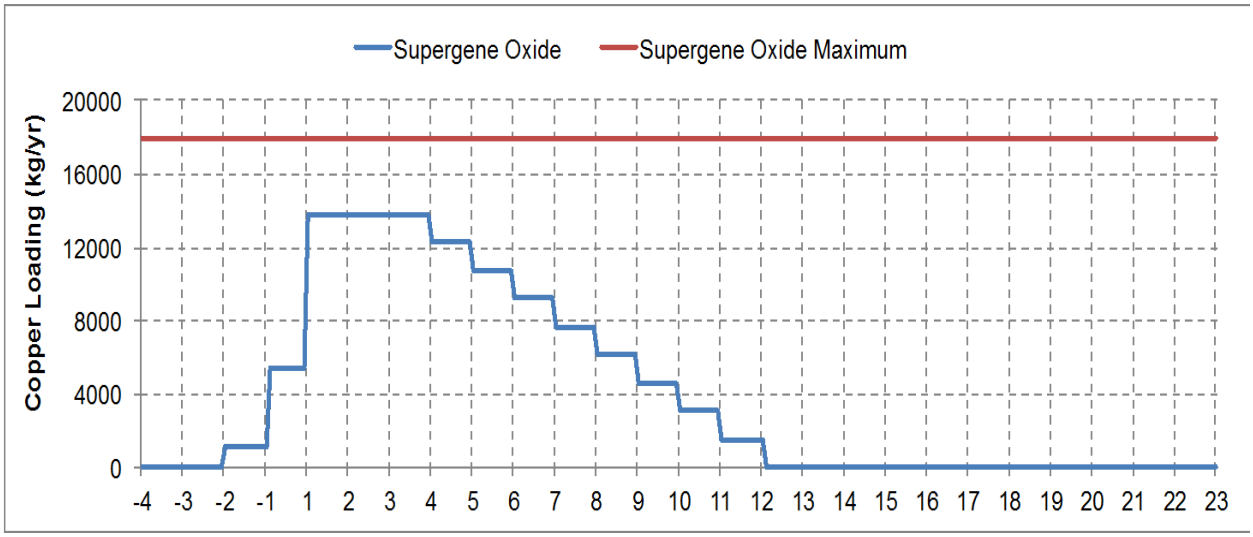


Figure 2-2. Copper Loadings and Maximum Solubility in the Supergene Oxide Ore Stockpile Drainage

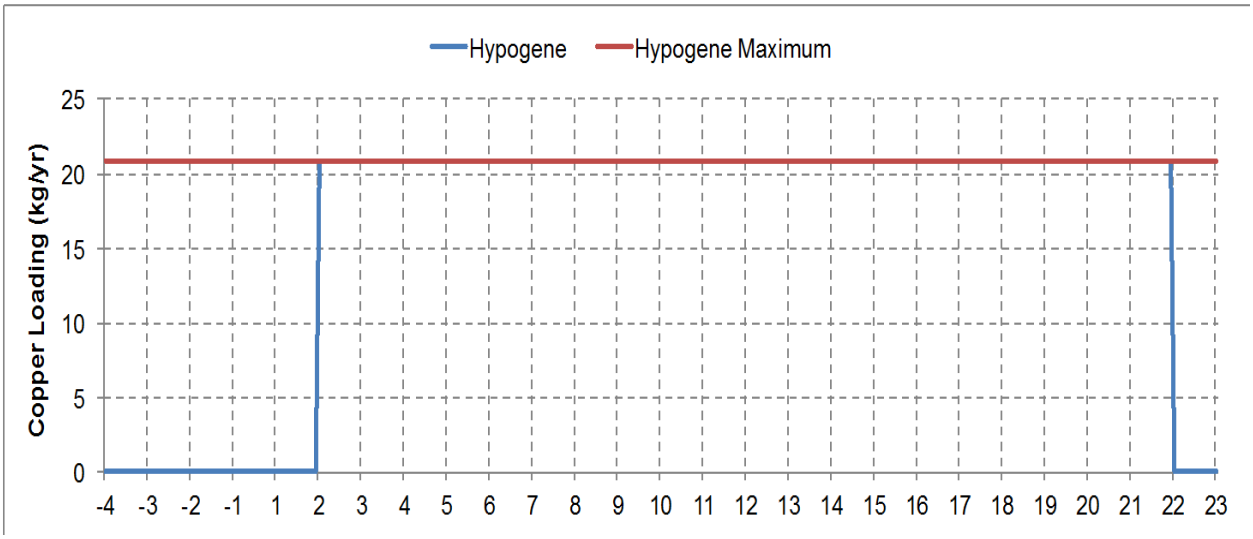


Figure 2-3. Copper Loadings and Maximum Solubility in the Hypogene Low Grade Ore Stockpile Drainage

2.3 Partition Loadings by Pathway

The ore contact water is expected to follow several possible pathways from the stockpiles. Surface water (runoff) from all stockpiles will report to the TMF Pond. The ratio of the annual surface water flow to the total contact water flow was used to partition the loading to surface water for each stockpile. The remainder of the loading was allocated as seepage between up to four groundwater pathways.

KPL (2013b) provided relative proportions of the total seepage by individual flow pathways for three snapshots in time: Year 4, Year 10, and Year 19. Because the values were fairly similar among the three snapshots in time, constant ratios for partitioning were used for the duration of the model. Table 2-1 shows the assumption used in the SEA model. Year 19 was used to represent the flow (and load) partitioning for all years of the model simulation, with the following exceptions:

- Year 10 was used for the Supergene Oxide Ore as it does not exist at year 19 (it is replaced by the Hypogene pile) and
- Year 10 was used for the Low Grade Supergene Sulphide and Marginal Grade Ore as to be more conservative because by year 19 there is no seepage to the TMF pond.

Initial modelling results indicated that seepage from the Low Grade Supergene Oxide stockpile could potentially have a noticeable (albeit temporary) effect on Casino Creek water quality. Interception of seepage (i.e., source control) was integrated into the project description to mitigate the potential impacts of the Low Grade Supergene Oxide seepage on water quality in Casino Creek. KPL (2013b) assumed that 90% of the seepage will be recovered and conveyed to the TMF Pond.

Table 2-1. Stockpile Seepage Partitioning by Receptor in the Water Quality Model

Stockpile Receptor	Fraction of Total Seepage Discharge (%)
Gold Ore Stockpile	
Open Pit	20%
TMF Pond	80%
Supergene Oxide	
Open Pit	4%
TMF Pond	95%
TMF Embankment Seepage	1%
TMF Foundation Seepage	0%
Low Grade Supergene Oxide Ore Stockpile [2]	
TMF Pond (via overland runoff)	65%
TMF Pond (via intercepted seepage) [2]	31.5%
TMF Embankment Seepage [2]	2.5%
TMF Foundation Seepage [2]	1.0%
Low Grade Hypogene Ore Stockpile	
Open Pit	3%
TMF Pond	95%
TMF Embankment Seepage	1%
TMF Foundation Seepage	1%
Low Grade Supergene Sulfide Ore Stockpile	
Open Pit	95%
TMF Pond	5%
Marginal Grade Ore Stockpile	
Open Pit	95%
TMF Pond	5%

1. Values in this table were adapted from KPL (2013b).
2. Values in the table represent the seepage partitioning with the proposed seepage interception system in place. Without the system in place, 25% of total seepage would result in embankment seepage, and 10% of the total seepage would result in foundation seepage. With the interception system in place, 31.5% of the total seepage will be intercepted and discharged to the TMF Pond during Operations.

2.4 Delay of Seepage along Pathway

To simulate groundwater flow velocities in the seepage, a time delay was applied to the seepage mass loading in the water quality model. The seepage was assumed to report to its receptor after a period of time equal to an estimated seepage travel time. Median, minimum, and maximum seepage travel times from the stockpiles to their receptors were approximated by KPL (2013b).

SEA calculated an average travel time in the GoldSim model using a triangular probability distribution to produce a base case value. Travel time calculation from the gold ore stockpile to the Open Pit is shown on Figure 2-4. The resulting mean time delay was calculated to be 3.8 years, based on minimum (1.3 years), maximum (7.3 years) and median (2.8 years) delays that were provided by KPL (2013b).

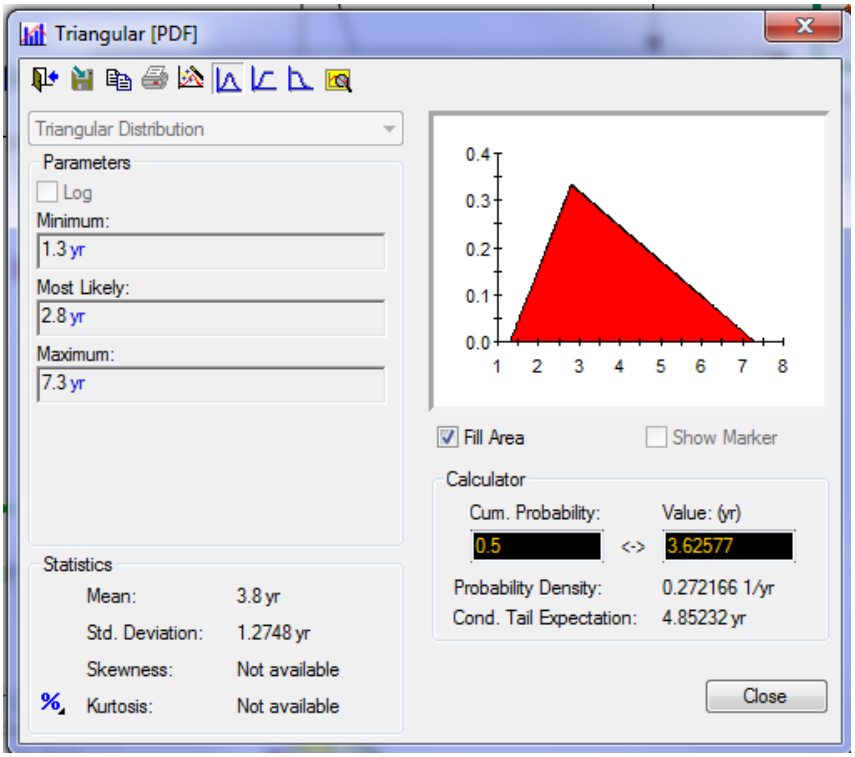


Figure 2-4. Gold Ore Stockpile Time Delay GoldSim Calculations

The calculated average values used in the model are presented in Table 2-2.

Table 2-2. Average Travel Time from Stockpile to Receptor

Stockpile Receptor	Average Travel Time to Discharge Location (Years)
Gold Ore Stockpile	
Open Pit	3.8
TMF Pond	1.8
Supergene Oxide	
Open Pit	2.7
TMF Pond	3.8
TMF Embankment Seepage	8.3
TMF Foundation Seepage	15.0
Low Grade Supergene Oxide Ore Stockpile	
TMF Pond	9.2
TMF Embankment Seepage	7.7
TMF Foundation Seepage	27.7
Low Grade Hypogene Ore Stockpile	
Open Pit	2.7
TMF Pond	3.8
TMF Embankment Seepage	8.3
TMF Foundation Seepage	15.0
Low Grade Supergene Sulfide Ore Stockpile	
Open Pit	3.4
TMF Pond	33.2
Marginal Grade Ore Stockpile	
Open Pit	3.4
TMF Pond	33.2

Adapted from KPL (2013b)

3 Summary and Results

The ore stockpile water quality modelling methodology respected the principal of mass conservation. The total loading from each ore pile was partitioned to the appropriate receptors in the fully-integrated water quality model.

Loadings from the ore stockpiles to the various receptors will vary over time. Generally, the rate of loading from the ore stockpiles will vary proportionally to the stockpile mass.

During Operations, the majority of the loads will be captured by runoff to the TMF Pond, or by groundwater intercepted by the TMF Pond or Open Pit. A lag time was applied to the stockpile seepage water to simulate the travel time that it will take for the stockpile contact water to reach the receptors as seepage. Application of the time delay resulted in some seepage reaching the TMF Pond, TMF Embankment and TMF Foundation after Operations.

Because the stockpiles will be temporary structures, they will be temporary sources of loading. Based on the stockpile schedule (Table II-A1), combined with the estimates for average travel times (Table 2-2), all water quality effects to the receptors were predicted to cease by Year 55 of the model simulation.

The water quality model was used to evaluate where mitigation measures can be implemented to minimize the influence of stockpile loading on the receiving environment water quality. Interception of seepage (i.e. source control) from the Low Grade Supergene Oxide stockpile was incorporated into the input assumptions for partitioning of loads to the receptors, such that most of the load from this stockpile was directed to the TMF Pond.

Calculated rates of mass transport at the stockpile loading receptors are presented (in kg/year) in Appendix, II-B for Years 5, 15, 25 and 35. The mass loading calculations showed that the Supergene Oxide and Low Grade Supergene Sulphide stockpiles will be largest sources of stockpile mass loading for most parameters during the Operations phase. The Low Grade Supergene Oxide and the Marginal Ore stockpiles produce lower loading, and the Gold Ore stockpile loadings are lower still. The copper loadings from the Hypogene stockpile were calculated to be the lowest as they are limited by the maximum solubility of copper in the neutral pH drainage from this ore pile as predicted by Lorax (2013).

4 References

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Appendix II - A

Model Inputs

Table II - A1. Ore Stockpile Schedule

YEAR	Gold Ore		Supergene Oxide Ore		Low Grade Supergene Oxide Ore		Low Grade Hypogene Ore		Low Grade Supergene Sulphide Ore		Marginal Grade Ore
	Gold Ore to Stockpile (tonnes)	Gold Ore Stockpile to Crusher (tonnes)	To Stockpile (tonnes)	From Stockpile to Mill (tonnes)	To Stockpile (tonnes)	From Stockpile to Mill (tonnes)	To Stockpile (tonnes)	From Stockpile to Mill (tonnes)	To Stockpile (tonnes)	From Stockpile to Mill (tonnes)	Ore to Stockpile (tonnes)
-3	0	0	20,000	0	0	0	0	0	0	0	0
-2	5,072,000	0	2,806,000	0	0	0	0	0	0	0	4050
-1	12,529,000	0	9,950,000	0	31,000	0	0	0	153,000	0	17,550
1	9,542,000	0	19,634,000	0	387,000	0	0	0	452,000	0	421,200
2	8,454,000	0	0	0	2,034,000	0	1,186,000	0	3,967,000	0	1,319,850
3	3,754,000	0	0	0	742,000	0	1,010,000	0	1,643,000	0	1,642,050
4	0	1,316,000	0	3,600,000	3,739,000	0	1,300,000	0	5,733,000	0	5,432,400
5	0	8,630,000	0	3,600,000	3,320,000	0	6,511,000	0	6,681,000	0	0
6	0	8,053,000	0	3,600,000	1,209,000	0	19,141,000	0	1,883,000	0	0
7	0	352,000	0	3,600,000	0	0	11,948,000	0	25,000	0	0
8	3,986,000	0	0	3,600,000	107,000	0	6,524,000	0	144,000	0	0
9	4,227,000	0	0	3,600,000	276,000	0	6,267,000	0	1,757,000	0	0
10	9,110,000	0	0	3,600,000	280,000	0	1,321,000	0	3,974,000	0	0
11	0	7,862,000	0	3,600,000	105,000	0	1,642,000	0	3,196,000	0	0
12	0	8,500,000	0	3,610,000	397,000	0	5,768,000	0	3,296,000	0	0
13	0	8,200,000	0	0	767,000	0	6,930,000	0	1,332,000	0	0
14	0	8,887,000	0	0	606,000	0	4,343,000	0	1,721,000	0	0
15	0	4,874,000	0	0	43,000	0	5,742,000	0	2,835,000	0	0
16	0	0	0	0	0	0	6,584,000	0	559,000	0	0
17	0	0	0	0	0	0	4,216,000	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	1,011,000	0	24,160,000	0	5,744,000	0
20	0	0	0	0	0	1,570,000	0	30,404,000	0	13,081,000	0
21	0	0	0	0	0	4,429,000	0	32,177,000	0	8,377,000	0
22	0	0	0	0	0	7,033,000	0	3,692,000	0	12,149,000	0
TOTALS	**56,674,000**	**56,674,000**	**32,410,000**	**32,410,000**	**14,043,000**	**14,043,000**	**90,433,000**	**90,433,000**	**39,351,000**	**39,351,000**	**8,837,100**

Table II - A 2. Mass Loading Rates of Ore Stockpiles

Water Quality Parameter	Stockpile Mass Loading Rates (mg/tonne/year)					
	Gold Ore	Supergene Oxide Ore	Low Grade Supergene Oxide Ore	Low Grade Hypogene Ore	Low Grade Supergene Sulphide Ore	Marginal Grade Ore
Hardness ($CaCO_3$)	3,428	4,363	3,953	29,351	4,065	4,092
Alkalinity ($CaCO_3$)	0	0	0	7,320	0	0
Sulphate (SO_4)	10,300	7,558	7,900	28,200	8,140	10,040
Chloride (Cl)	363	68	57	153	59	19
Fluoride (F)	17	101	88	75	91	40
Aluminum (Al)	26	393	430	247	442	623
Antimony (Sb)	0.15	0.55	0.44	1.1	0.46	0.017
Arsenic (As)	0.098	0.19	0.16	0.12	0.17	0.055
Barium (Ba)	11	3.6	2.9	3.2	3.0	0.15
Cadmium (Cd)	0.053	0.43	0.44	0.038	0.45	0.50
Calcium (Ca)	1,010	1,180	1,080	11,100	1,110	1,340
Chromium (Cr)	0.16	0.070	0.073	0.056	0.076	0.094
Cobalt (Co)	1.1	1.2	1.2	0.21	1.3	1.5
Copper (Cu)	68	480	524	97	539	755
Iron (Fe)	3.3	426	466	75	480	676
Lead (Pb)	0.12	0.17	0.24	0.0099	0.15	0.25
Magnesium (Mg)	220	344	305	396	314	181
Manganese (Mn)	26	18	15	17	15	2.9
Mercury (Hg)	0.0021	0.0016	0.0014	0.0026	0.0015	0.00086
Molybdenum (Mo)	0.13	0.038	0.055	10	0.033	0.0051
Nickel (Ni)	0.33	8.5	12	0.29	7.3	13
Selenium (Se)	0.37	0.85	1.2	1.2	0.73	1.3
Silver (Ag)	0.013	0.0030	0.0030	0.0028	0.0031	0.0034
Sodium (Na)	2,810	17	15	34	29	7.5
Thallium (Tl)	0.019	0.0038	0.0033	0.0020	0.0034	0.0017
Uranium (U)	0.093	3.6	3.9	2.0	4.1	5.7
Zinc (Zn)	5.8	31	34	2.3	35	49

Source terms provided by Lorax (2013)

Table II - A 3. Maximum Allowable Concentration of Ore Stockpile Contact Water

Water Quality Parameter	Maximum Allowable Concentration (mg/L)					
	Gold Ore	Supergene Oxide Ore	Low Grade Supergene Oxide Ore	Low Grade Hypogene Ore	Low Grade Supergene Sulphide Ore	Marginal Grade Ore
Hardness ($CaCO_3$)	878	1,029	662	1,919	1,106	645
Alkalinity ($CaCO_3$)	10	0	0	68	0	0
Sulphate (SO_4)	2,310	1,780	1,300	1,890	2,220	1,590
Chloride (Cl)	81	16	9.3	37	16	3.0
Fluoride (F)	3.7	24	14	2.4	25	6.3
Aluminum (Al)	5.8	92	71	0.0023	121	98
Antimony (Sb)	0.034	0.13	0.072	0.28	0.080	0.0027
Arsenic (As)	0.022	0.045	0.027	0.030	0.046	0.0087
Barium (Ba)	0.0043	0.0060	0.0067	0.0056	0.0053	0.023
Cadmium (Cd)	0.012	0.10	0.072	0.0093	0.12	0.079
Calcium (Ca)	259	279	181	609	302	211
Chromium (Cr)	0.035	0.016	0.012	0.014	0.021	0.015
Cobalt (Co)	0.25	0.28	0.20	0.052	0.34	0.24
Copper (Cu)	15	113	87	0.056	147	119
Iron (Fe)	0.30	100	77	0.0099	125	107
Lead (Pb)	0.027	0.040	0.040	0.0024	0.040	0.040
Magnesium (Mg)	56	81	51	97	86	29
Manganese (Mn)	5.7	4.1	2.4	0.13	4.1	0.46
Mercury (Hg)	0.00050	0.00038	0.00023	0.00060	0.00040	0.00014
Molybdenum (Mo)	0.030	0.0090	0.0090	2.5	0.0090	0.0010
Nickel (Ni)	0.074	2.0	2.0	0.071	2.0	2.0
Selenium (Se)	0.082	0.20	0.20	0.30	0.20	0.20
Silver (Ag)	0.0028	0.00070	0.00050	0.00070	0.00085	0.00054
Sodium (Na)	628	4.0	2.4	8.2	7.9	1.2
Thallium (Tl)	0.0042	0.00090	0.00055	0.00050	0.00094	0.00027
Uranium (U)	0.021	0.85	0.65	0.50	1.1	0.90
Zinc (Zn)	1.3	7.3	5.6	0.57	9.5	7.7

Source terms provided by Lorax (2013)

Table II - A 4. pH of Stockpile Contact Water

Water Quality Parameter	pH of Stockpile Contact Water					
	Gold Ore	Supergene Oxide Ore	Low Grade Supergene Oxide Ore	Low Grade Hypogene Ore	Low Grade Supergene Sulphide Ore	Marginal Grade Ore
pH	4.7	3.2	3.2	7.2	3.2	3.2

Provided by Lorax (2013)

Appendix II - B

Ore Stockpile Loading Results

Table II - B 1. Ore Stockpile Loadings to Receptors – Year 5

Parameter	Annual Loading (kg)																										
	Hard-ness	Alkalin-ity	SO4	Cl	F	Al	Sb	As	Ba	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Na	Tl	U	Zn
Source of Loading																											
Receptor																											
Gold Ore Stockpile																											
Groundwater to Open Pit	1348	0	4051	158	6	10	0	0	0	0	397	0	0	27	1	0	87	10	0	0	0	0	0	1105	0	0	2
Groundwater to TMF Pond	31533	0	93765	3525	150	237	1	1	0	0	9293	1	10	614	13	1	2024	232	0	1	3	3	0	25504	0	1	53
Runoff to TMF Pond	66509	0	199895	7787	320	507	3	2	0	1	19601	3	22	1316	31	2	4270	495	0	3	6	7	0	54535	0	2	113
Low Grade Supergene Oxide Ore Stockpile																											
Groundwater to TMF Pond	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Runoff to TMF Pond	41063	0	80900	3228	892	4407	4	2	1	4	11222	1	13	5376	4785	2	3173	146	0	1	125	12	0	5652	0	40	348
Groundwater to Embankment	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Groundwater to Foundation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Low Grade Hypogene Ore Stockpile																											
Groundwater to Open Pit	998	280	959	5	3	0	0	0	0	0	377	0	0	0	0	0	13	1	0	0	0	0	0	91	0	0	0
Groundwater to TMF Pond	25258	7077	24249	132	65	0	1	0	1	0	9545	0	0	7	1	0	341	13	0	9	0	1	0	2311	0	2	2
Runoff to TMF Pond	191062	23003	183428	999	489	1	7	1	1	0	72201	0	1	14	2	0	2576	31	0	66	2	8	0	13005	0	13	15
Groundwater to Embankment	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Groundwater to Foundation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Low Grade Supergene Sulfide Ore Stockpile																											
Groundwater to Open Pit	1084	0	2172	74	24	118	0	0	0	0	296	0	0	144	128	0	84	4	0	0	2	0	0	8	0	1	9
Groundwater to TMF Pond	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Runoff to TMF Pond	50705	0	101599	3480	1132	5517	6	2	1	6	13854	1	16	6727	5991	2	3919	186	0	0	91	9	0	360	0	51	436
Marginal Ore Stockpile																											
Groundwater to Open Pit	627	0	1539	17	6	96	0	0	0	0	205	0	0	116	104	0	28	0	0	0	2	0	0	1	0	1	7
Groundwater to TMF Pond	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Runoff to TMF Pond	25387	0	62604	117	246	3874	0	0	1	3	8308	1	9	4685	4213	2	1126	18	0	0	79	8	0	47	0	35	303
Supergene Oxide Ore Stockpile																											
Groundwater to Open Pit	1126	0	1960	148	26	102	0	0	0	0	306	0	0	125	111	0	88	4	0	0	2	0	0	4	0	1	8
Groundwater to TMF Pond	17466	0	30346	2397	406	1578	2	1	0	2	4738	0	5	1927	1710	1	1367	70	0	0	34	3	0	68	0	14	125
Runoff to TMF Pond	94536	0	163862	15855	2190	8520	12	4	1	9	25583	2	26	10407	9236	4	7458	379	0	1	184	18	0	369	0	78	674
Groundwater to Embankment	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table II - B 2. Ore Stockpile Loadings to Receptors – Year 15

Parameter	Annual Loading (kg)																										
	Hard-ness	Alkalin-ity	SO4	Cl	F	Al	Sb	As	Ba	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Na	Tl	U	Zn
Source of Loading																											
Receptor																											
Gold Ore Stockpile																											
Groundwater to Open Pit	7133	0	21308	828	34	54	0	0	0	0	2102	0	2	140	3	0	458	53	0	0	1	1	0	5812	0	0	12
Groundwater to TMF Pond	21840	0	65641	2557	105	166	1	1	0	0	6437	1	7	432	13	1	1402	163	0	1	2	2	0	17908	0	1	37
Runoff to TMF Pond	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Low Grade Supergene Oxide Ore Stockpile																											
Groundwater to TMF Pond	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Runoff to TMF Pond	56242	0	110594	4421	1221	6036	6	2	1	6	15370	1	17	7359	6551	3	4339	200	0	1	170	17	0	7741	0	55	477
Groundwater to Embankment	32	0	62	2	1	3	0	0	0	0	9	0	0	4	4	0	2	0	0	0	0	0	0	4	0	0	0
Groundwater to Foundation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Low Grade Hypogene Ore Stockpile																											
Groundwater to Open Pit	8508	425	8358	132	10	0	1	0	0	0	2717	0	0	0	0	0	341	1	0	9	0	1	0	240	0	2	2
Groundwater to TMF Pond	233981	11678	229858	3595	286	0	26	3	1	1	74704	1	5	7	1	0	9266	16	0	239	7	29	0	6602	0	47	55
Runoff to TMF Pond	460872	23003	452751	7952	564	1	58	6	1	2	147144	3	11	14	2	1	20498	31	0	528	15	64	0	13005	0	105	121
Groundwater to Embankment	2836	142	2786	32	3	0	0	0	0	0	906	0	0	0	0	0	81	0	0	2	0	0	0	80	0	0	0
Groundwater to Foundation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Low Grade Supergene Sulfide Ore Stockpile																											
Groundwater to Open Pit	37497	0	75135	2574	837	4080	4	2	0	4	10246	1	12	4975	4431	1	2898	138	0	0	68	7	0	266	0	37	322
Groundwater to TMF Pond	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Runoff to TMF Pond	105584	0	211564	7247	2357	11488	8	4	1	12	28850	2	33	14009	12084	4	8161	386	0	1	191	19	0	749	0	105	907
Marginal Ore Stockpile																											
Groundwater to Open Pit	11345	0	27843	56	110	1727	0	0	0	1	3715	0	4	2093	1875	1	502	8	0	0	35	4	0	21	0	16	135
Groundwater to TMF Pond	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Runoff to TMF Pond	7422	0	18211	117	72	1130	0	0	0	1	2431	0	3	1369	1226	0	328	5	0	0	23	2	0	14	0	10	88
Supergene Oxide Ore Stockpile																											
Groundwater to Open Pit	117	0	203	22	3	11	0	0	0	0	32	0	0	13	11	0	9	0	0	0	0	0	0	0	0	0	1
Groundwater to TMF Pond	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Runoff to TMF Pond	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Groundwater to Embankment	162	0	281	30	4	15	0	0	0	0	44	0	0	18	16	0	13	1	0	0	0	0	0	1	0	0	1

Table II - B 3. Ore Stockpile Loadings to Receptors – Year 25

Parameter	Annual Loading (kg)																									
	Hard-ness	Alkalin-ity	SO4	Cl	F	Al	Sb	As	Ba	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Na	Tl	U	Zn
Source of Loading																											
Receptor																											
Gold Ore Stockpile																											
Groundwater to Open Pit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Groundwater to TMF Pond	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Runoff to TMF Pond	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Low Grade Supergene Oxide Ore Stockpile																											
Groundwater to TMF Pond	3	0	6	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Runoff to TMF Pond	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Groundwater to Embankment	70	0	138	5	2	8	0	0	0	0	19	0	0	9	8	0	5	0	0	0	0	0	0	10	0	0	1
Groundwater to Foundation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Low Grade Hypogene Ore Stockpile																											
Groundwater to Open Pit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Groundwater to TMF Pond	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Runoff to TMF Pond	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Groundwater to Embankment	2836	142	2786	47	3	0	0	0	0	0	906	0	0	0	0	0	119	0	0	3	0	0	0	80	0	1	1
Groundwater to Foundation	2836	142	2786	35	3	0	0	0	0	0	906	0	0	0	0	0	89	0	0	2	0	0	0	80	0	0	1
Low Grade Supergene Sulfide Ore Stockpile																											
Groundwater to Open Pit	14314	0	28681	982	320	1557	2	1	0	2	3911	0	4	1899	1691	1	1106	53	0	0	26	3	0	102	0	14	123
Groundwater to TMF Pond	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Runoff to TMF Pond	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Marginal Ore Stockpile																											
Groundwater to Open Pit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Groundwater to TMF Pond	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Runoff to TMF Pond	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Supergene Oxide Ore Stockpile																											
Groundwater to Open Pit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Groundwater to TMF Pond	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Runoff to TMF Pond	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Groundwater to Embankment	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table II - B 4. Ore Stockpile Loadings to Receptors – Year 35

Parameter	Annual Loading (kg)																										
	Hard-ness	Alkalin-ity	SO4	Cl	F	Al	Sb	As	Ba	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Na	Tl	U	Zn
Source of Loading																											
Receptor																											
Gold Ore Stockpile																											
Groundwater to Open Pit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Groundwater to TMF Pond	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Runoff to TMF Pond	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Low Grade Supergene Oxide Ore Stockpile																											
Groundwater to TMF Pond	184	0	361	14	4	20	0	0	0	0	50	0	0	24	21	0	14	1	0	0	1	0	0	25	0	0	2
Runoff to TMF Pond	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Groundwater to Embankment	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Groundwater to Foundation	17.560	0	35	1	0	2	0	0	0	0	5	0	0	2	2	0	1	0	0	0	0	0	0	2	0	0	0
Low Grade Hypogene Ore Stockpile																											
Groundwater to Open Pit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Groundwater to TMF Pond	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Runoff to TMF Pond	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Groundwater to Embankment	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Groundwater to Foundation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Low Grade Supergene Sulfide Ore Stockpile																											
Groundwater to Open Pit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Groundwater to TMF Pond	219	0	439	15	5	24	0	0	0	0	60	0	0	29	26	0	17	1	0	0	0	0	0	2	0	0	2
Runoff to TMF Pond	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Marginal Ore Stockpile																											
Groundwater to Open Pit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Groundwater to TMF Pond	43	0	105	1	0	7	0	0	0	0	14	0	0	8	7	0	2	0	0	0	0	0	0	0	0	0	1
Runoff to TMF Pond	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Supergene Oxide Ore Stockpile																											
Groundwater to Open Pit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Groundwater to TMF Pond	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Runoff to TMF Pond	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Groundwater to Embankment	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Casino Project
Water Quality Predictions

Appendix III
Heap Leach Facility Water Quality Modelling

Prepared by:

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ENVIRONMENTAL ASSOCIATES INC.

February 2015

Table III-1. HLF Surplus Water Quality

Water Quality Parameter		HLF Surplus Water Quality (mg/L)		
		Rinsing and Drain Down (Year 19 to 28)	10 Years Post Drain Down (Year 29 to 38)	Long Term (Year 39 and beyond)
Hardness		1,695	3,502	2,395
Alkalinity		70	47	47
Sulphate	(SO_4)	1,920	2,100	424
Cyanide (Total)		11	0.20	
Cyanide (WAD)		5.0	0.030	
Chloride	(Cl)	638	240	38
Fluoride	(F)	2.1	3.0	1.3
Aluminum	(Al)	0.069	0.0070	0.0060
Antimony	(Sb)	0.77	0.77	0.47
Arsenic	(As)	0.036	0.036	0.036
Barium	(Ba)	0.0064	0.0077	0.0077
Cadmium	(Cd)	0.0084	0.0050	0.00028
Calcium	(Ca)	666	756	532
Chromium	(Cr)	0.0010	0.0010	0.0010
Cobalt	(Co)	5.7	2.6	0.49
Copper	(Cu)	2.8	0.016	0.0011
Iron	(Fe)	9.5	0.0040	0.0040
Lead	(Pb)	0.0015	0.00028	0.00028
Magnesium	(Mg)	7.8	392	259
Manganese	(Mn)	0.0036	0.0045	0.00031
Mercury	(Hg)	0.018	0.000020	0.000020
Molybdenum	(Mo)	4.2	4.2	0.94
Nickel	(Ni)	0.24	0.093	0.0073
Potassium	(K)	214	170	97.8
Selenium	(Se)	0.40	0.23	0.098
Silver	(Ag)	0.053	0.00078	0.00062
Sodium	(Na)	432	15	0.56
Thallium	(Tl)	0.0018	0.00011	0.00011
Uranium	(U)	0.0018	0.63	0.17
Zinc	(Zn)	0.072	0.39	0.22

Concentrations provided by Lorax (2013)

Casino Project

Water Quality Predictions

Appendix IV
TMF Pond Water Quality Modelling

Prepared by:

Source
ENVIRONMENTAL ASSOCIATES INC.

February 2015

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Appendix IV - A Water Quality Modelling Input
Appendix IV - B Water Quality Modelling Results

1 Introduction

The Casino Project (the Project) is a proposed mining project in the west-central Yukon. The deposit will be mined using open pit methods, with a nominal mill throughput of approximately 120,000 tonnes/day of ore over a 22 year operating life. Milling operations will produce molybdenum and copper concentrates through conventional flotation circuit milling and gold and silver doré will be produced by cyanide heap leaching.

The Tailings Management Facility (TMF) will be the primary water and waste management component of the Project. The TMF was designed by Knight Piesold Ltd (KPL) to store approximately 956 million tonnes of tailings and up to 649 million tonnes of waste rock and overburden (KPL, 2012). The TMF will be situated in the Casino Creek valley southeast of the Open Pit. Two embankments, the Main Embankment, and the West Saddle Embankment will be constructed across the Casino Creek valley to create the storage impoundment.

A water quality model was developed to predict mine drainage water quality and the potential for effects on the receiving environment of the proposed Casino Mine. A site-wide water balance was developed by KPL and was used by Source Environmental Associates Inc. (SEA) as the basis for the water quality model. The water balance and the water quality models were fully integrated in GoldSim.

A water balance model was initially developed by KPL in 2013 (and is described in KP, 2013a). The 2013 water balance was run using average annual estimates for hydrologic conditions at the site. Water quality modelling for the average annual water balance was carried out by SEA. Modelling methodology and results were reported in SEA (2013).

In 2014, a climate variability water balance model was developed by KPL (and is described in KPL, 2015) to account for the expected variability in hydrological conditions (i.e. wet and dry periods) from year to year. SEA used the climate variability water balance as the basis for the water quality model that is described herein.

This report presents the methodology and results of the water quality predictions for the TMF Pond model. This report contains all information relevant to the water quality model, and repeats the pertinent information previously provided in the December 2013 report (SEA, 2013). A comparison between the SEA (2013) Pit Lake water quality modelling report and this report is provided Table 1-1.

Table 1-1. Comparison between 2013 and 2015 Modelling Reports

Concept	SEA (2013) Report	Applies to this Report
Water Balance Input Dataset	Average monthly hydrologic conditions (e.g. precipitation, temperature, streamflow, etc.) were used as input for every year of the model simulation.	Inter-annual variation in hydrologic conditions was applied throughout the model simulation. Water balance output flows were calculated from a synthetic, long-term (52 year) input dataset of monthly hydrologic conditions. The synthetic dataset was derived from regional and site data. **Rationale:** Using the range of monthly flows is more conservative (compared to using average annual flows) because realistic wet and dry periods can be simulated.
Estimation of Wet and Dry Years	n/a - wet and dry years were not simulated.	1-in-10 year wet and dry years were identified in the water quality output time-series plots. **Rationale:** To illustrate how the water quality management system will perform as a results of infrequent wet/dry periods.
Monte-Carlo Analysis (Stochastic Modelling)	Stochastic modelling was not carried out.	Model simulations included 52 unique input hydrology datasets. A statistical summary was generated from the water quality model output for the 52 realizations. **Rationale:** To account for all possible water balance flow scenarios that could result from the input hydrology dataset.
Project Phase Start Dates for TMF Discharge Phase and Pit Discharge Phase	Project dates were based on KPL (2013) water balance model output.	Project dates were based on KPL (2015) water balance model results.
TMF Seepage Cut-Off System	The TMF seepage cut-off system was to be constructed after Operations. As a result, during Operations, the WMP was assumed to have a 90% capture efficiency with 10% seepage by-pass to Casino Creek. Following Operations, the seepage cut-off system was to be constructed, resulting in 100% seepage capture efficiency (i.e. 0% by-pass).	The seepage cut-off system will be constructed prior to Operations. The seepage collection system was assumed to have 100% capture efficiency during Operations and for all subsequent mine phases. **Rationale**: Reduce the potential for seepage water to enter Casino Creek during Operations.

Concept	SEA (2013) Report	Applies to this Report
WMP Pumping to the Open Pit (Wetland Construction Phase)	During the Wetland Construction Phase, the WMP was assumed to be pumped to the TMF Pond.	During the wetland construction phase, the WMP will be pumped to the Open Pit. **Rationale:** Mass load from the WMP by-passes the TMF Pond by pumping directly to the Open Pit.
TMF Pond Release to Casino Creek	TMF Pond was allowed to naturally overflow seasonally with no control of the flow rate.	The TMF pond will be released in a controlled manner. The ratio of TMF pond release to WMP release will be set between 1.2 to 2.5, depending on the Project Phase and the month. The ratio increases when there is little flow in Brynelson to provide dilution of the seepage released. **Rationale**: The available dilution in Brynelson is utilized by tying the release of WMP to the natural hydrograph.
CoC List	7 CoCs were reported. The CoC list did not include fluoride.	Fluoride was added as a CoC, so 8 CoCs are reported. **Rationale**: Fluoride was added as it exceeded a generic water quality guideline in Casino and Dip Creeks.

2 Casino Project Water Management Phases

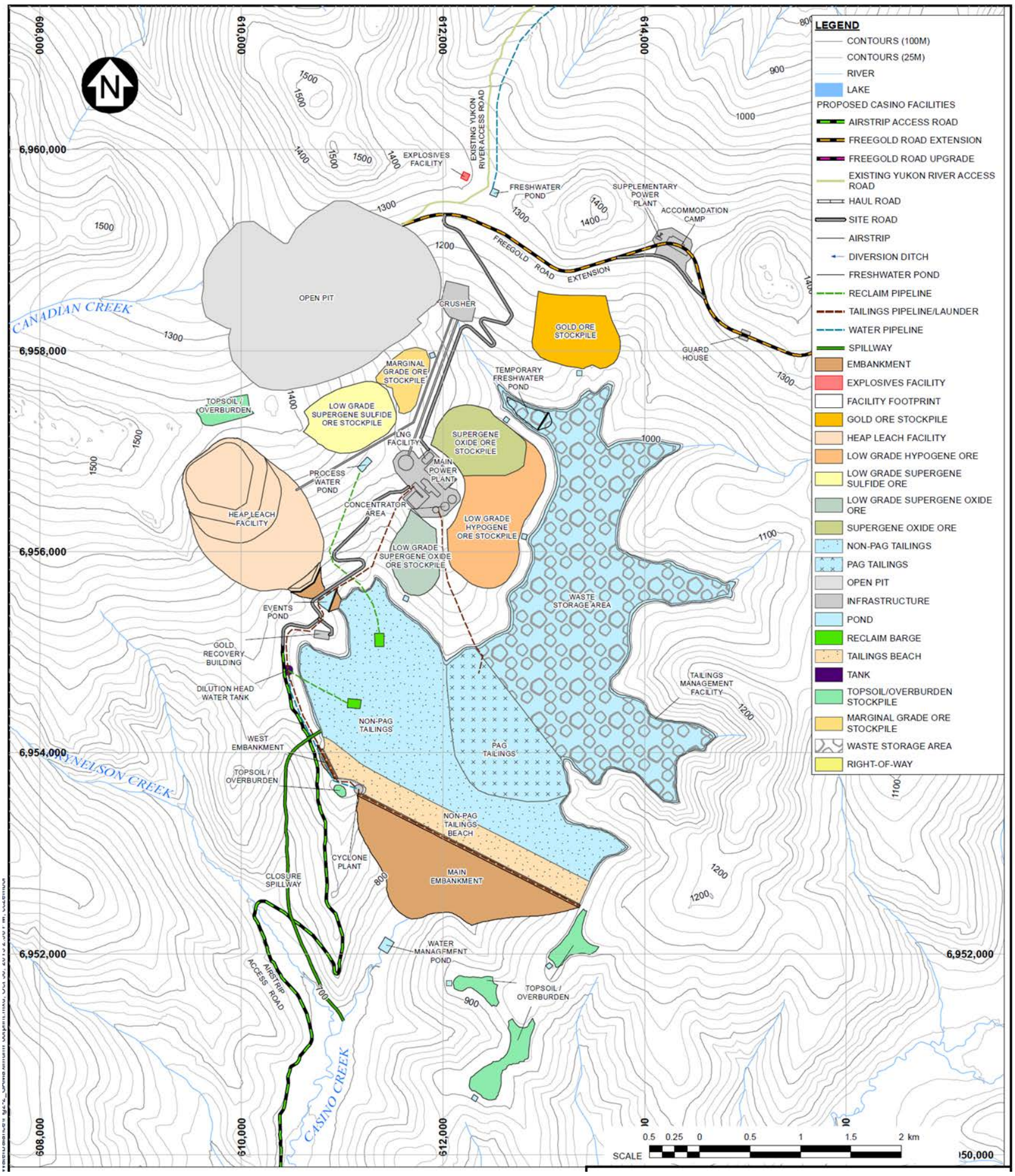
For the purposes of water quality modeling, the Casino Project has been sub-divided into five water management phases. Project years are described in years relative to the beginning of milling operations. For example, Year -2 refers to the second year before Operations begins, and Year 2 refers to the second year of Operations.

Water management phases and relevant project activities related to water quality modeling are provided in Table 2-1. Layout of the Project site is illustrated in Figure 2-1 for Operations. Development of the TMF during Operations is provided in Figure 2-2. Long-term site conditions following mine closure are shown on Figure 2-3.

Table 2-1. Water Management Phases

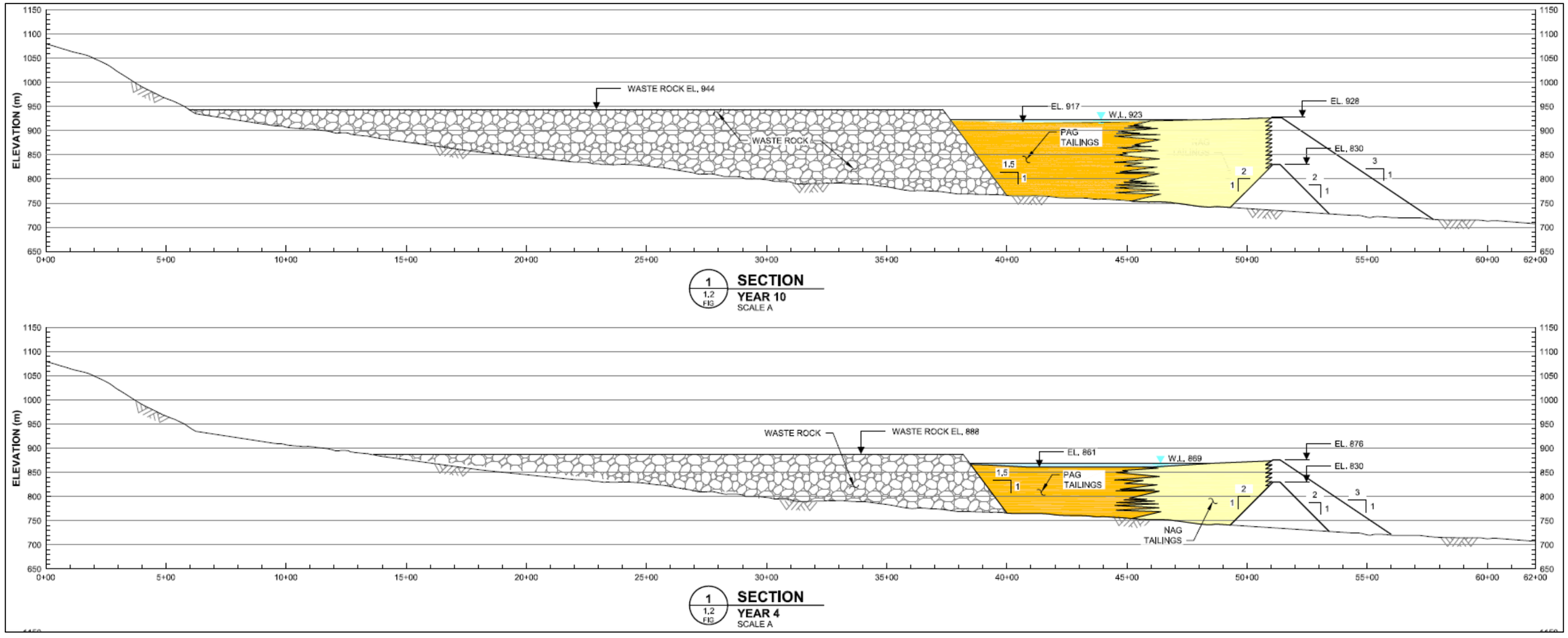
Water Management Phase	Project Year	Water Management Activities
Construction	-4 to -1	• TMF starter embankment construction. • Construction of TMF Water Management Pond (WMP) downstream from the embankments to recover seepage and embankment runoff. • Open Pit construction. • Construction of the Fresh Water Supply Pond (FWSP) at the north end of the TMF to be used as an interim source of fresh water. • Construction of the freshwater supply pipeline to draw fresh water from the Yukon River.
Operations	1 to 22	• Mill operations. • Tailings discharge to the TMF. Approximately 80% of the total tailings produced will be non-acid generating (NAG) material, and 20% will be potentially acid generating (PAG). • Waste Rock placed at the north end of TMF. • Some of the NAG tailings will be processed in the Cyclone Sand Plant to produce embankment construction material. • Runoff from the ore stockpiles and mill site will be directed into the TMF Pond. • Water recovered in WMP will be pumped to TMF Pond. • TMF Pond water will be reclaimed to the mill. • Makeup water will be supplied to the mill from the Yukon River via the freshwater supply pipeline. • No interaction between Heap Leach Facility (HLF) water management system and TMF water management system throughout Operations.
Wetland Construction	23 to 34	• Seepage collected in the WMP will be pumped to the Open Pit. • Year 23 to Year 28 – TMF Pond water will be pumped to Pit Lake. • North TMF Wetland and South TMF Wetland will be constructed and commissioned.

Water Management Phase	Project Year	Water Management Activities
		• Any unprocessed low or marginal grade ore will be placed in the Pit Lake. • Following wetland construction, the TMF Pond will be allowed to fill through natural recharge. • The tailings beach, stockpile areas, HLF, mill site, and other disturbed surfaces will be covered and re-vegetated. • Year 29 (and beyond) – drainage from reclaimed HLF will be directed into the TMF Pond.
TMF Discharge	35 to 109	• Assuming acceptable water quality, the TMF Pond will discharge to Casino Creek via an engineered spillway, following treatment in the South TMF wetland. • Seepage recovered downstream from the TMF embankments will be stored in the WMP through the low-flow months of the year (winter), and release during with warmer months when the TMF Pond water discharges via the Closure Spillway.
Pit Discharge	>109	• Pit Lake will discharge to the North TMF Wetland treatment system. Treated effluent from the wetland will discharge to the TMF Pond. • WMP will continue to operate as in the TMF Discharge Phase.



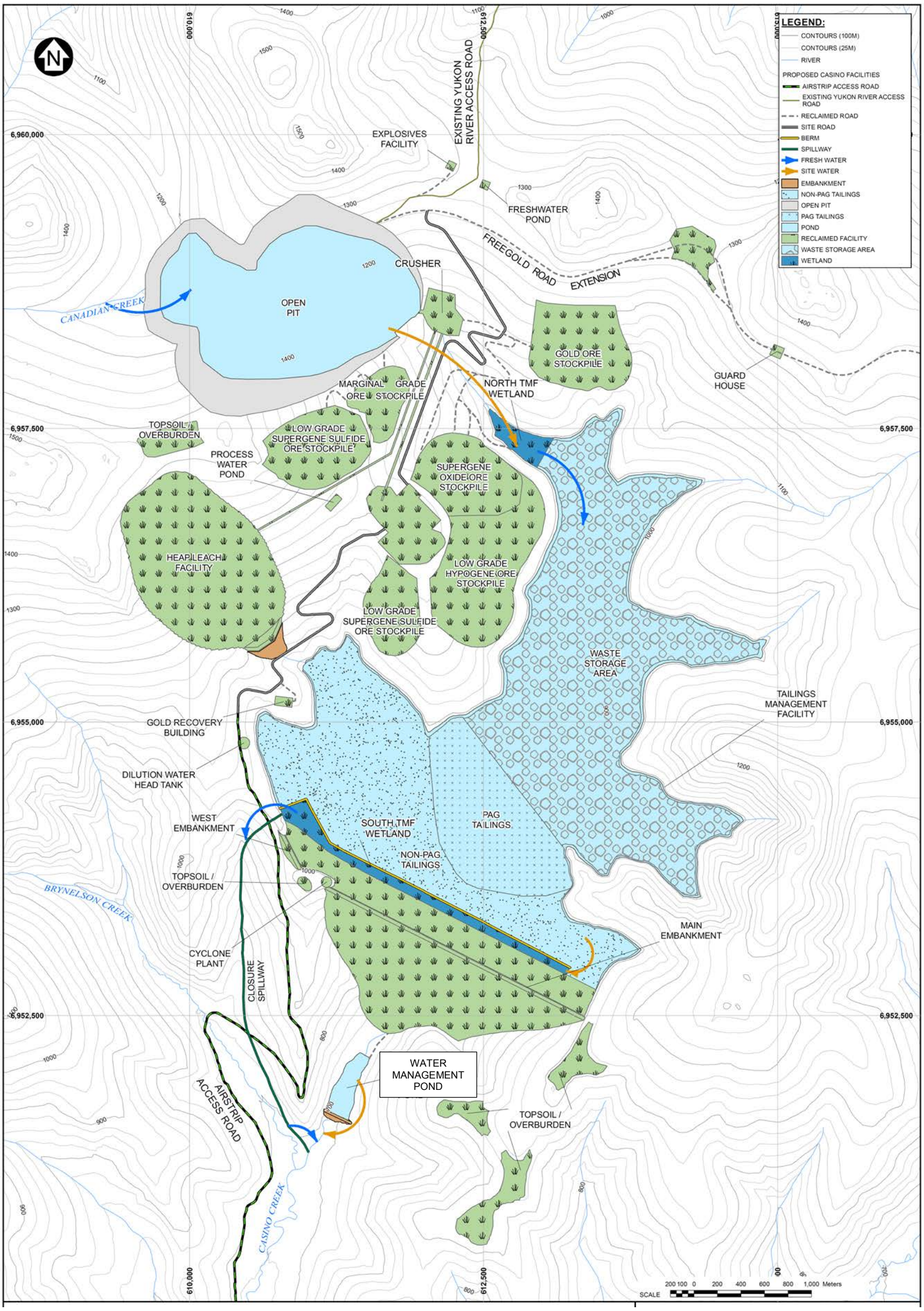
Source: Casino YESAB Water Balance Report (KPL, 2013a)

Figure 2-1. Casino Project Overview (Operations)



Source: Revised Waste Deposition Strategy to Improve Water Quality (KPL, 2013b)

Figure 2-2. TMF Waste Deposition Strategy – Typical Sections (Years 4 and 10)



Source: Casino YESAB Water Balance Report (KPL, 2013a)

Figure 2-3. Casino Project Overview (Pit Discharge Phase)

3 Model Overview

A site-wide water balance model was developed by KPL and was used as the basis for the water quality model. The water balance and the water quality models were fully integrated in GoldSim. SEA combined the water balance flows with mine loading source terms (Lorax, 2013), and background water quality to predict water quality in the TMF Pond for 27 water quality parameters.

A 52-year model input dataset of monthly weather conditions was developed by KPL in order to simulate the natural variability in hydrologic conditions (i.e. wet and dry periods) that can be expected at the site. The model was run over a time-frame from beginning of Pit Lake formation, to 200 years after the beginning of Operations. Because the model was run over a simulation period of ~200 years, the 52-year input dataset repeated approximately four times during a given simulation.

The model results are presented in two ways in this report:

1) Single Model Realization

   Results generated when one realization of the input hydrology dataset was run with the model. Single realization results provide a time-series of model output which shows a representation of water quality that would result from a realistic range in hydrological conditions at the site. The output provides an indication of how high (or low) water quality concentrations may get, and how often those results are expected to occur. Time-series plots and summary tables of water quality results for a single realization are presented throughout this report.

2) Monte-Carlo Summary (52 Realizations)

   The model was run 52 times. Each model run used a unique input hydrology dataset. The combined output from the 52 model runs (i.e. realizations) represents the range in all possible model outputs resulting from all the possible permutations of the input hydrology dataset. Average annual water balance results presented in this report were generated from the Monte-Carlo Summary results.

Project timelines for activities relevant to TMF Pond water management are provided in Table 3-1. Schematics are provided to illustrate the mass transport pathways associated with the TMF Pond during Operations (Figure 3-1) and long term conditions following mine closure (i.e. Pit Discharge Phase - Figure 3-2). Tables of model input and output values are provided for each modelled water quality parameter in Appendix IV - A (model input) and Appendix IV - B (model results).

Table 3-1. Project Timeline

Project Year	Project Activity
-4	start of construction
-3	Start of mining the Open Pit
1	start of milling (start of Operations Phase)
18	final year of Open Pit Mining
19	Open Pit dewatering stops, Pit Lake begins to form
19	end of waste rock placement in TMF and begin covering waste rock with tailings layer
22	final year of milling (end of Operations Phase)
23	start of pumping TMF Pond to Open Pit (start Wetland Construction Phase)
23	start of pumping WMP to Open Pit
24	end of HLF rinsing and start of HLF drain down (pump to Open Pit)
27	end of pumping TMF to Open Pit
28	start of TMF filling by natural recharge
29	HLF drainage directed to TMF Pond
35	initial discharge of TMF Pond and WMP to Casino Creek
35	end of pumping WMP to Open Pit and initial discharge of WMP to Casino Creek
109	initial discharge of Pit Lake to TMF (into North TMF Wetland)

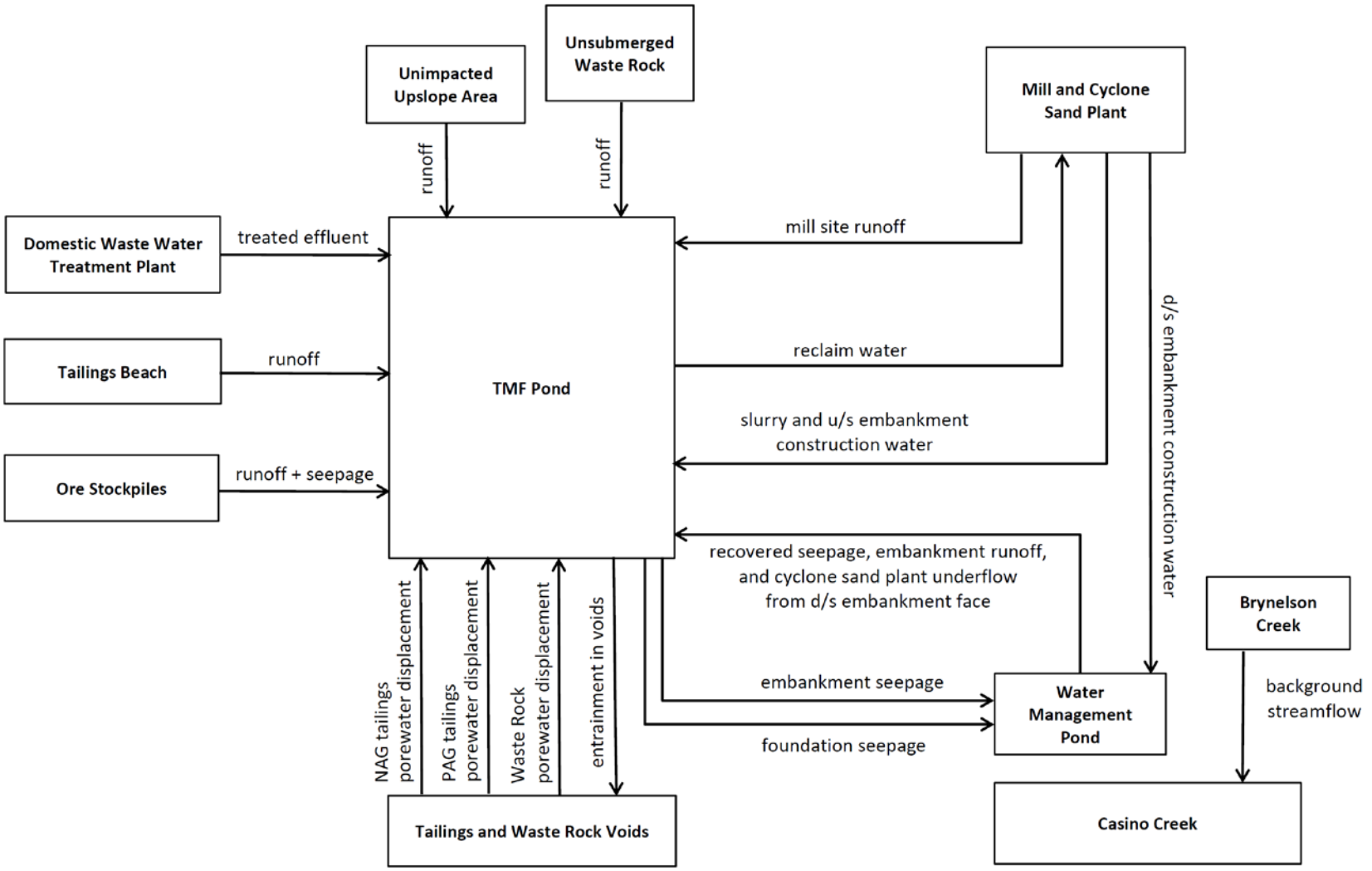


Figure 3-1. Mass Transport Flow Paths through the TMF Pond (Operations)

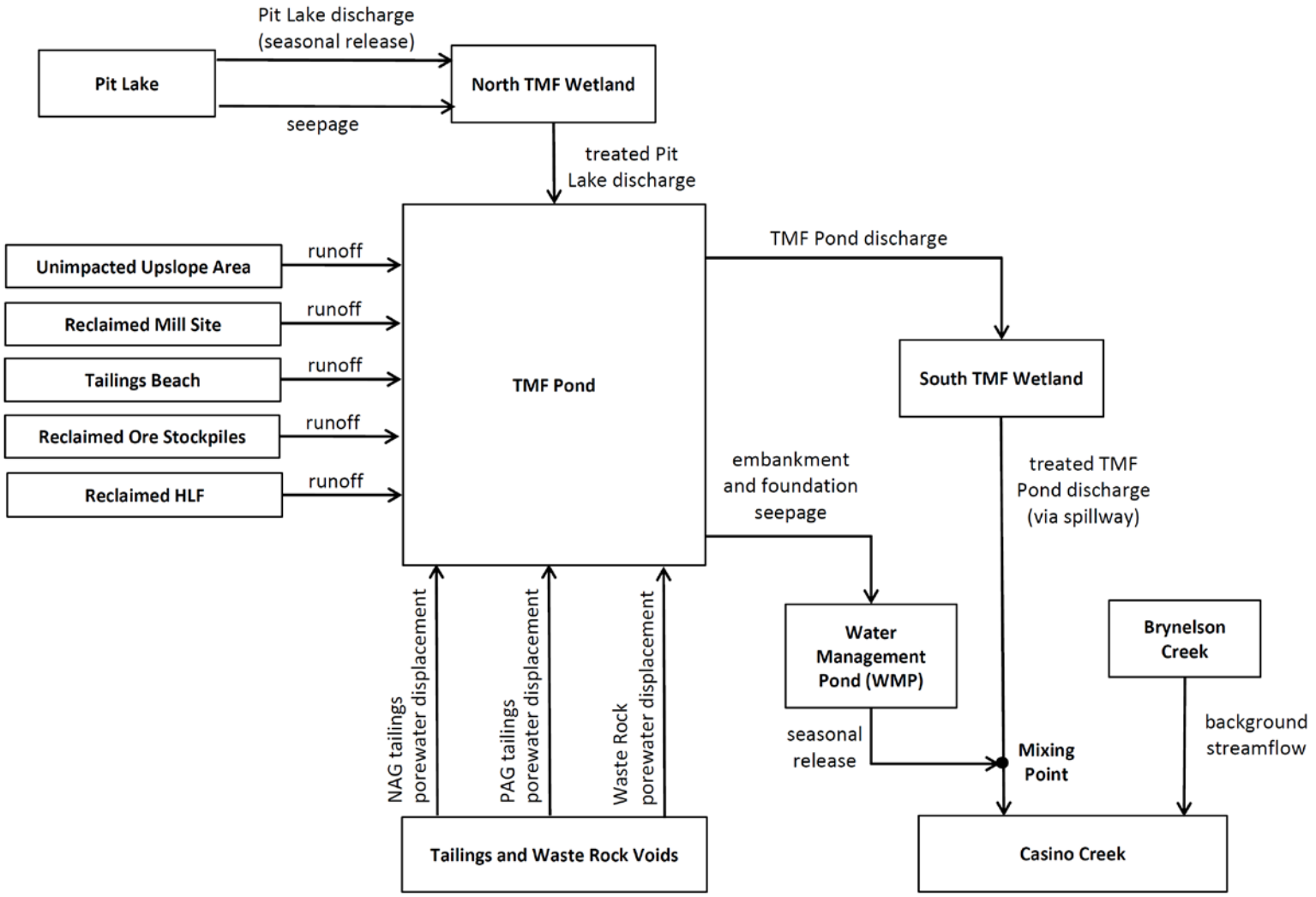


Figure 3-2. Mass Transport Flow Paths through the TMF Pond (Pit Discharge Phase)

4 Water Balance Model

The KPL (2015) water balance model was developed to estimate the TMF Pond inflow and outflow rates for water quality modelling, water management and waste deposition planning. A summary of water balance assumptions and results are provided in the following section.

The TMF Pond will not discharge to the receiving environment during Operations or the Wetland Construction Phase. During the Wetland Construction Phase, the TMF Pond will be pumped to the Pit Lake for five years (Year 23 to Year 27), then will be allowed to fill by natural recharge. The TMF Discharge Phase will begin when the TMF Pond fills to its maximum storage capacity and then discharges to Casino Creek via the engineered closure spillway.

The water balance (KPL, 2015) simulation showed that the TMF will fill to its storage capacity and discharge to Casino Creek about 10 to 15 years following the end of Operations. KP established Year 35 as the best estimate of the beginning of the TMF Discharge Phase. The beginning of the TMF Discharge Phase differs slightly from those reported in the SEA (2013) report. The reason for this difference comes from a revision to WMP pump-out during the Wetland Construction Phase. In the 2013 version, the WMP was assumed to be pumped to the TMF Pond. In the 2015 revision, the WMP was assumed to be pumped to the Open Pit. As a result, reduced inflow to the TMF Pond led to a slightly longer time until filling and initial discharge of the TMF Pond. The 2013 version reported initial TMF Pond discharge to be at Year 31, where the 2015 version has initial discharge occurring in Year 35.

Conversely, the increased inflow to the Open Pit led to a slightly shorter time to pit filling. The 2013 version reported initial Pit Lake discharge after Year 113, where the 2015 version has initial discharge occurring after Year 109. Additional information related to the Pit Lake water balance and water quality model is provided in Appendix I (Open Pit Water Quality Modelling).

Inflow and outflow of water to the TMF Pond from the KPL (2015) water balance model are summarized in Table IV - A 1 to illustrate the average annual conditions over the duration of the water quality model.

5 Water Quality Model

This section provides a description of the modelling methodology that was used for the prediction of mass transport of substances through the TMF Pond and the resulting water quality. Relevant water balance components are discussed where applicable to the water quality modelling calculations. Tables of model input for each modelled water quality parameter are provided in Appendix IV - A.

5.1 TMF Pond Inflows

5.1.1 Precipitation on TMF Pond Surface

The monthly inflow of water to the TMF Pond by precipitation was calculated as the top surface area of the TMF Pond for a given time-step, multiplied by the monthly depth of precipitation. Consequently, calculated inflows from precipitation increased throughout Operations as pond surface area increased. Modelled pond area remained more or less constant following the beginning of the TMF Discharge Phase.

While precipitation was accounted for in the water balance, no load was associated with precipitation in the water quality model.

5.1.2 Background Runoff

Areas not disturbed by mining activities will contribute a load (i.e. background load) to the TMF Pond via overland runoff. The mass loading rate into the TMF Pond from overland runoff was calculated as the monthly rate of runoff, multiplied by the average annual water quality concentrations of the overland runoff.

Water quality monitoring data was available for Casino Creek (monitoring stations W12, W8, and W11) within the drainage basin of the TMF Pond (Figure 5-1). However, the water quality at those sites has been impacted by drainage from Proctor Gulch, where groundwater comes into contact with the Casino ore body (PECG, 2013). During Operations the ore body will be mined out and overland runoff will no longer be impacted by the presence of the ore body. Therefore, the Casino Creek water quality stations do not provide an appropriate representation of background runoff after the open pit excavation is complete.

The Meloy Creek (W13) water quality dataset was selected by SEA to represent background water quality to the TMF Pond because it was the nearest watercourse to the TMF Pond that is not impacted by the presence of the Casino ore body. The median values from 12 water quality

samples collected between 2008 and 2012 at W13 were used to represent average annual overland runoff water quality. Median water quality at W13 is presented in Appendix IV - A (Table IV - A 2).

Meloy Creek (W13) water quality data may be somewhat impacted by the presence of a historical adit. The adit, from lead/zinc/silver exploration between 1965 and 1980 was partially sealed by CMC in 2008. What remains today is a pipe that discharges at surface in upper Meloy Creek watershed. This water (site W43) was included in the 2008-2012 baseline studies (PEGC, 2013). Discharge occurs only during the spring and summer months and is frozen from October to April. At the point of discharge, it travels down the watershed for roughly two kilometres before joining Meloy Creek. Because the flow rate from the adit is relatively low compared to total stream flow at Meloy Creek, the loading from the adit is quite small at W13 for most parameters. However, cadmium (Cd), barium (Ba), lead (Pb), silver (Ag) and zinc (Zn) in the W13 data appeared to be mildly elevated and may result in a slight over-prediction of long-term concentrations in background runoff entering the TMF Pond.

Runoff from the mill site (approximately 0.3 km^2) during operations will be affected by the land disturbance created by the construction of the mill. However, the potential load from the disturbed area is considered by SEA to be negligible compared to major sources of loading to the TMF Pond during Operations (e.g., waste rock, tailings slurry, ore stockpiles, etc.). Therefore, drainage from the mill site was assumed by SEA to have background runoff water quality (from W13) for modelling.

5.1.3 Surplus Fresh Water Supply Pond Discharge

The Fresh Water Supply Pond (FWSP) will be constructed in upper Casino Creek and used during Construction and early Operations. During that time, upper Casino Creek will feed the pond and surplus FWSP water not required for processing will discharge to the TMF Pond (once the TMF has been constructed). Average annual discharge from the FWSP to the TMF Pond is presented in Table IV - A 1.

Proctor Gulch will still be in place during Construction (i.e. it will not have been mined out by the Open Pit by that time) and will therefore still contribute mass loading to Casino Creek. Water quality data from Casino Creek at W8 (median of 13 samples collected between 2008 and 2012) were selected to represent FWSP discharge in the modelling and is presented in Appendix IV - A (Table IV - A 2).

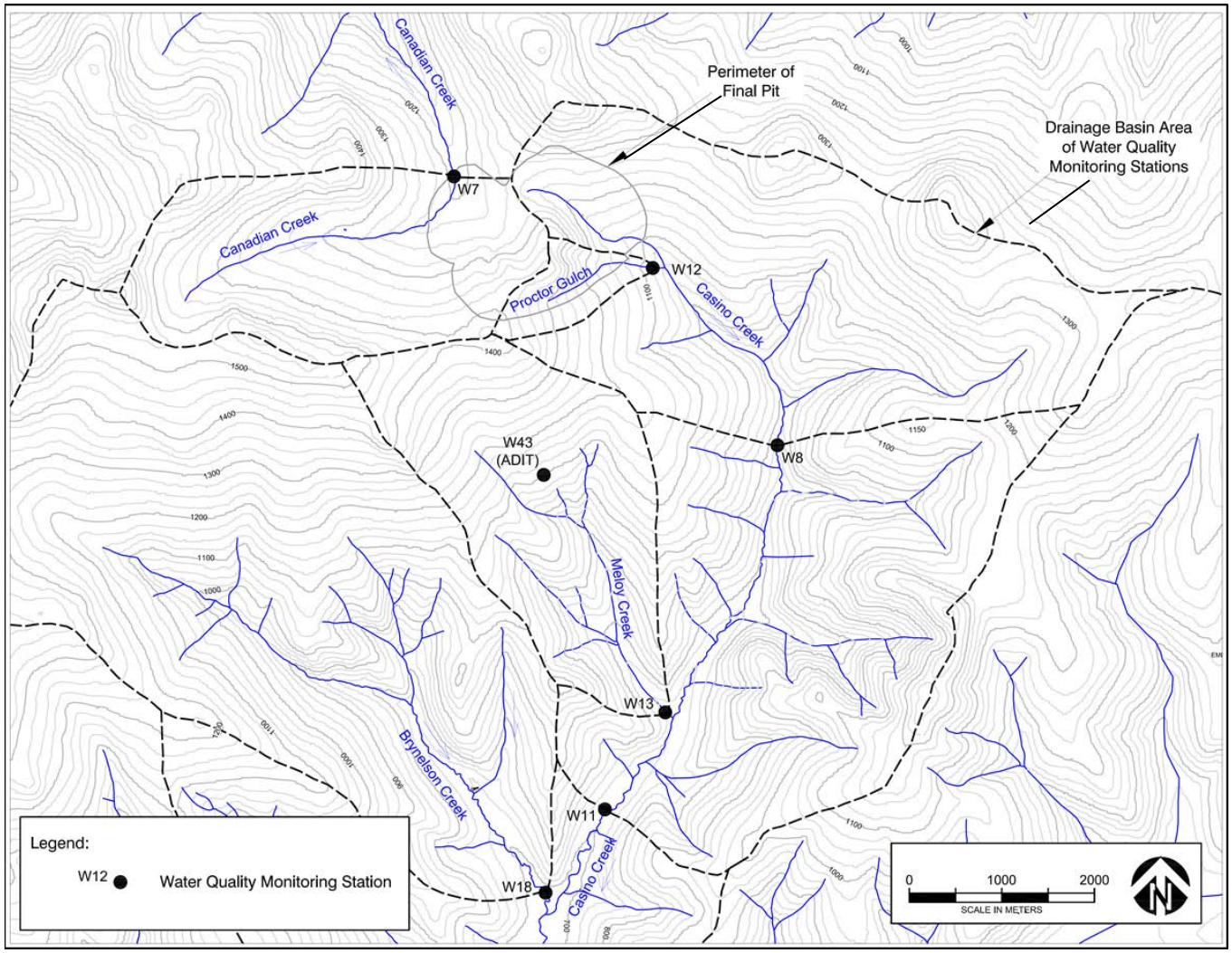


Figure 5-1. Water Quality Monitoring Stations in the Vicinity of the TMF

5.1.4 Treated Domestic Wastewater

Treated domestic wastewater from the water treatment plant will discharge to the TMF Pond during Operations. Mass loading was calculated as the flow rate multiplied by the water quality of the effluent. The average effluent discharge rate was 1.3 L/s in the KPL (2014) water balance.

Prior to its use for domestic purposes, the water supply will be suitable for human consumption and will not contain significant levels of heavy metals. SEA assumed the treated wastewater quality to be equal to the background runoff water quality. The impact of this simplifying assumption on water quality model results is considered by SEA to be negligible.

5.1.5 Ore Stockpile Runoff and Seepage

While the ore stockpiles are present during Operations, contact water (from rainfall and snowmelt) will drain from the rock as runoff or infiltration to groundwater. Runoff from the stockpiles will be captured by the TMF Pond.

Hydrogeological modelling results (KPL, 2013c) indicated that depending on the stockpile location, infiltrated contact water will flow to one or more of the following receptors: the TMF Pond, Open Pit, TMF Embankment (towards the WMP) or TMF Foundation bedrock (towards Casino Creek). SEA estimated an average travel time from a range of travel times provided by KPL (2013c) and assumed that the mass load associated with the stockpile seepage will report to the TMF Pond after a lag-time equal to the seepage travel time (Table 5-1). Methodology of the travel time estimate is provided in Appendix II (Ore Stockpile Water Quality Modelling).

Table 5-1. Seepage Travel Time from Stockpiles to TMF Pond

Stockpile	Seepage Travel time to TMF Pond (years)
Gold Ore	1.8
Marginal Grade Ore	33.2
Supergene Oxide Ore	3.8
Low Grade Supergene Oxide Ore	9.2
Low Grade Supergene Sulphide Ore	33.2
Low Grade Hypogene Ore	3.8

Seepage and runoff concentrations into the TMF Pond were calculated by combining the seepage flow rates with mass loading rates, and mass of rock in the stockpiles. Calculation methodology of stockpile mass loading is described in Appendix II (Ore Stockpile Water Quality Modelling).

During the Wetland Construction Phase, any residual stockpile rock will be placed in the pit, and the stockpile areas will be reclaimed (covered with overburden and re-vegetated). Loading from the reclaimed stockpile areas during the Wetland Construction Phase and beyond were calculated by multiplying the monthly overland runoff by background overland runoff water quality.

5.1.6 Drainage from Unsubmerged Waste Rock

Waste rock will be placed at the north end of the TMF. When the waste rock is placed during Operations, the top surface will be maintained above the normal operating pond level of the supernatant pond to provide a dry, stable placement surface for machine access and waste rock deposition.

Drainage water from the unsubmerged portion of waste rock will carry a mass load into the TMF Pond. Total drainage from the waste rock area to the TMF Pond will increase proportionally with the footprint area throughout operations, with the ultimate waste rock footprint area achieved in Year 17. After that time, waste rock drainage will decrease as the waste rock is covered with tailings, beginning in Year 19. The waste rock and tailings will be submerged after Operations and waste rock runoff will no longer be a source of mass load to the TMF Pond.

Lorax (2013) provided loading rates to calculate mass loading from the unsubmerged waste rock during a given time step. The mass load was calculated by multiplying the mass of unsubmerged waste rock (tonnes) from the KPL water balance, by the loading rates. Total mass load and volume of runoff water were combined at each time step to calculate contact water concentration.

Lorax provided maximum allowable concentrations for the waste rock drainage water to take into consideration water availability and solubility constraints. If the calculated waste rock runoff water quality exceeded the maximum allowable concentrations, waste rock drainage water quality was set equal to the maximum allowable concentrations for that time step.

Loading rates and maximum allowable concentrations are provided in Appendix IV - A (Table IV – A 3).

5.1.7 Tailings Beach Runoff

The footprint area of the tailings beach will increase from 0 km^2 to 0.7 km^2 during Operations. After that time, the tailings beach area will remain constant at 0.7 km^2. Average annual tailings beach runoff rates (from the KPL water balance) are provided in Table IV - A 1.

Runoff from the tailings beach will contribute a mass load to the TMF Pond in Operations and will continue into Post-Closure. Mass loading into the TMF Pond was calculated as the runoff flow rate multiplied by the tailings beach runoff water quality.

Lorax (2013) developed two sets of runoff concentrations for the tailings beach. The first was intended to be used for Operations and the second for Post-Closure conditions (Wetland Construction Phase and beyond). Concentrations in the runoff are expected to be lowest after Operations because by then, the tailings slurry (process) water will have been flushed out and the tailings beach will also be covered and vegetated. Tailings beach runoff water quality values are presented in Appendix IV - A (Table IV - A 2).

5.1.8 Surplus Heap Leach Facility Discharge

The Heap Leach Facility (HLF) will process oxide gold ore by leaching it with an aqueous cyanide solution. The HLF will be situated upslope from the TMF, but will operate independently from the TMF during Operations. That is, there will be no interaction of water or waste between the TMF Pond and the HLF throughout Operations.

During rinsing (Year 19 to Year 23) and drain-down (Year 24 to Year 28) of the HLF, surplus water will be directed to the Pit Lake. Following drain down, the final slopes of the HLF will be graded, covered, and re-vegetated. The water quality model assumes that 20% of surplus water (i.e. 20% of net precipitation) infiltrates and becomes seepage at the toe of the HLF while the remaining 80% of surplus water is non-contact runoff. Both the toe seepage and the surface runoff from the HLF will be directed downslope to the TMF Pond. The average annual flow from the HLF to the TMF Pond was estimated by KPL (2013a) to be 13 L/s. This flow combines the non-contact runoff and the HLF toe seepage.

Lorax (2013) provided a source term for three time periods; 1) rinsing and drain-down, 2) 10 years following drain-down and 3) long-term. The first set of source terms was applied during the drain down period and this loading was allocated to the pit lake (as described in Appendix I). The second set was applied for ten years following drain down (Year 29 to Year 38) while the water quality stabilizes to long-term conditions. Long-term water quality was applied for Year 39 and beyond.

Mass loading from the HLF to the TMF Pond was accounted for in the water quality modelling by multiplying the estimated HLF toe seepage flow rate by the estimated water quality. HLF drainage water quality values are presented in Appendix IV - A (Table IV - A 2).

5.1.9 Tailings Slurry Water

NAG and PAG tailings will be transported from the Mill to the TMF as slurry. A portion of the NAG tailings slurry will be conveyed to the Cyclone Sand Plant. Overflow from the sand plant will be discharged to the TMF Pond. The water content that drains from the upstream side of the embankment construction sand (i.e. Sand Plant underflow slurry water) will also report to the TMF Pond. The sand plant will also draw water from the TMF Pond as supplemental feed water. The sand plant process will not introduce additional mass load or water to the TMF Pond system. Average annual inflow rates of slurry water inflow (Table IV - A 1) represent the net rate of slurry water inflow to the TMF Pond (i.e. tailings slurry + sand plant overflow + upstream embankment construction water, minus sand plant feed water).

The water component of the tailings slurry will be process water from the Mill. Slurry water quality was estimated by Lorax (2013). Loading into the TMF Pond was calculated as the concentration in the slurry water multiplied by the total slurry water inflow rate.

TMF Pond water will be reclaimed to the Mill for re-use. Certain water quality parameters are expected to accumulate within the process water over time as the TMF Pond water is recirculated through the mill. Loading rates were provided by Lorax (2013) for those parameters (Sb, As, Mo, Se and U) as g/tonne (i.e., gram of loading per tonne of ore processed). In the water quality model, an incremental mass of those accumulating substances was added to the slurry water quality at each time step based on the mine production schedule (approximately 120,000 tonne/day) from the KPL (2013a) water balance. Slurry water source terms are provided in Appendix IV - A (Table IV - A 2).

5.1.10 Tailings and Waste Rock Porewater Displacement

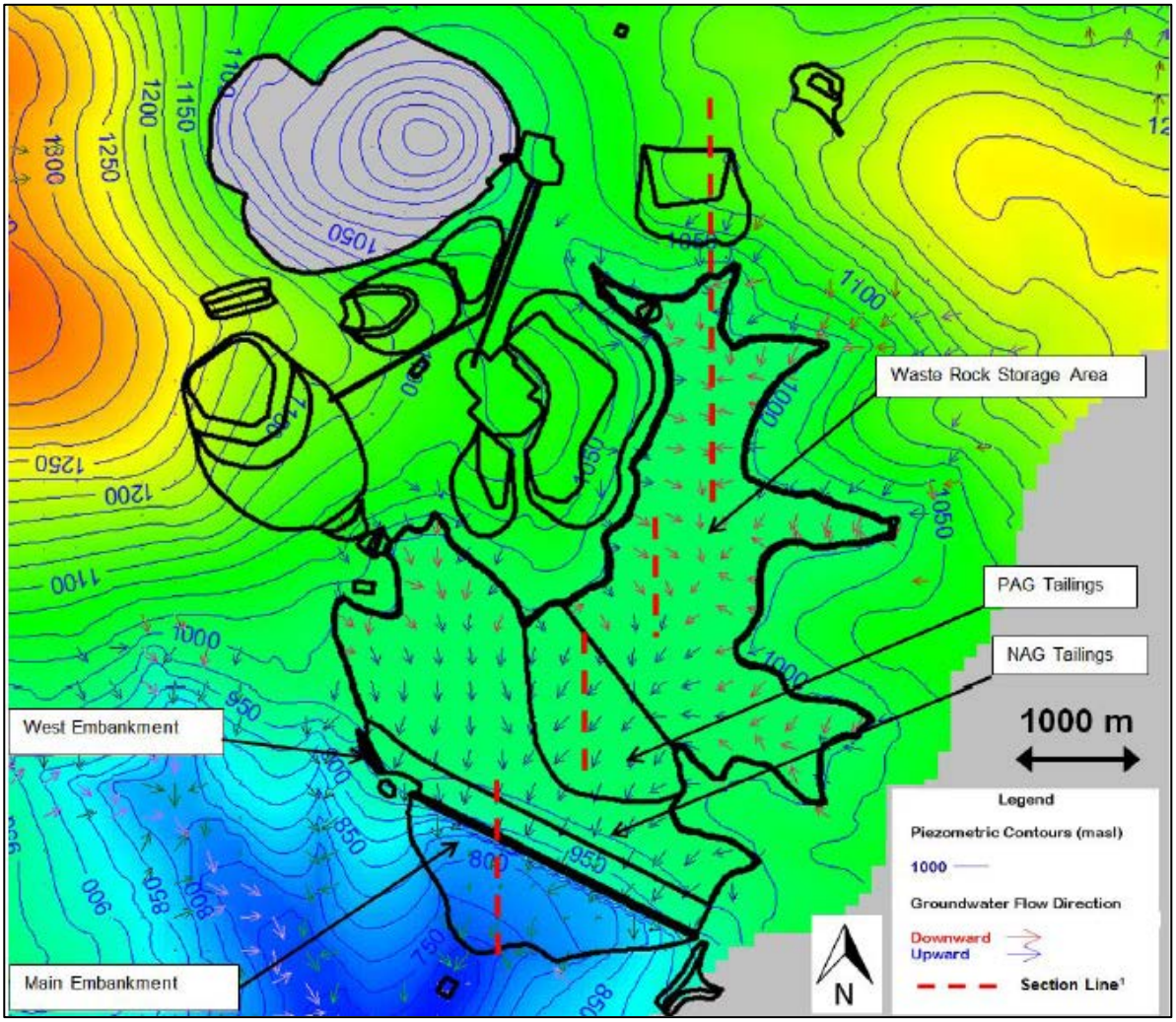
KPL (2013c) predicted that there will be upward groundwater flow from a portion of the saturated PAG tailings into the TMF Pond. The majority of the waste rock is also expected to have upward groundwater flow (Figure 5-2).

Inflow to the TMF Pond from tailings pore water will be highest during Operations due to tailings consolidation, and will gradually reduce following Operations as the tailings consolidation process slows. When tailings consolidation stops, the on-going tailings and waste rock pore water displacement will be the result of groundwater flow through the tailings and waste rock voids. Average annual flow from the tailings and waste rock into the TMF Pond are summarized in Table IV - A 1.

The KPL water balance provided the total flow rate of tailings pore water displacement which was the sum of groundwater flow and tailings consolidation flow from the combined NAG and PAG tailings. SEA subdivided the total flow into NAG and PAG components. KPL (2013c, Table 5.1) provided estimates of groundwater seepage from the tailings to the TMF Pond for various snapshots in time. The relative proportions of NAG and PAG seepage were adopted by SEA and used to sub-divide the total seepage flow rates. Relative proportions of PAG and NAG seepage are presented in Table 5-2.

Table 5-2. Components of Total Tailings Porewater to the TMF Pond

Year	Fraction of Total Tailings Pore Water Flow from Tailings to TMF Pond (%)	
	PAG	NAG
4	11	89
10	12	88
19	5	95
22	4	96
>22	4	96



Source: KPL (2013c)

Figure 5-2. Numerical Hydrogeological Model of TMF, Hydraulic Gradients

Lorax (2013) estimated the porewater quality of the Waste Rock, NAG Tailings and PAG Tailings (provided in Appendix IV - A, Table IV - A 4). Mass loading into the TMF Pond was calculated in the water quality model by multiplying the water quality by the flow rate for the given time steps. Water quality for years not provided by Lorax were assumed by SEA to be equal to the nearest later year (i.e., years 0-3 were equal to year 4, years 5-9 were equal to year 10, etc.). During operations, it would be reasonable to assume the tailings consolidation portion of the porewater would be similar to tailings slurry water, or pond water (for subaqueously deposited tailings (e.g., PAG tailings)) however, once mill operations cease, all tailings pore water would be expected to be of the characteristics assigned by Lorax and included in the water quality model. This simplifying assumption does not have an effect on long term TMF pond water quality – i.e., once the TMF commences discharge.

Following Operations, the North TMF Wetland will be constructed over the waste rock. A portion of the total upward flow of pore water from the waste rock will enter the North TMF Wetland. Some mass load will be removed in the North TMF Wetland prior to entering the TMF Pond via the wetland discharge. However, as it is not possible to predict what fraction of the upward flow will be treated, the total mass load associated with the upward flow through waste rock was conservatively assumed to enter the TMF Pond rather than part of it entering the North TMF Wetland for treatment.

A layer of tailings (approximately 3 m thick) will be placed over waste rock in the last few years of Operations and will act as a growth medium for the wetland and an attenuation barrier for metals transport from waste rock. The attenuation associated with this tailings layer was not accounted for in the development of the source terms or in the water quality model input assumptions.

5.1.11 Water Management Pond

The Water Management Pond (WMP) will be in place downstream from the TMF embankment. The WMP will collect seepage that travels through the TMF embankment and foundation. The WMP will also collect runoff from the downstream (south) faces of the TMF embankments, and water that drains from the embankment sands during embankment construction (i.e., Sand Plant underflow slurry water). During Operations, the WMP water will be recovered by pumping back to the TMF Pond. During the Wetland Construction Phase, the WMP water will be pumped to the Open Pit.

A description of the water balance and water quality model for the WMP is provided in Appendix V (Seepage Pond Water Quality Modelling). Loading from the WMP into the TMF Pond (during Operations) was calculated as the pumping flow rate, multiplied by the water quality in the WMP. Modelled flow rate is presented in Appendix IV – A (Table IV – A 1). Annual water quality of the WMP is presented in Appendix IV - A (Table IV - A 2) for Operations.

5.1.12 Treated Pit Lake Discharge (North TMF Wetland Discharge)

The KPL (2014) water balance simulation showed that the Pit Lake is expected to reach its maximum storage capacity and discharge to the TMF after approximately Year 109. Before entering the TMF Pond, the Pit Lake discharge will be directed to the North TMF Wetland, an engineered wetland located at the northern edge of the TMF (on Figure 2-3). After the pit lake discharge flows through the wetland system, the treated Pit Lake discharge will enter the TMF Pond.

According to the *Conceptual Reclamation and Closure Plan* (BCL, 2013), the total annual Pit Lake overflow volume will be discharged to the TMF wetland at a controlled rate during the warmest months of the year (June through September, inclusive) for optimal operation of the

TMF wetland treatment system. KPL (2014) modelled the discharge as a constant flow of approximately 180 l/s over the four month period. Inflow of water to the wetland system will be composed of direct precipitation, background runoff, Pit Lake discharge, and seepage (up to 11 L/s) from the Pit Lake. Outflow will include evaporation and discharge via the outlet into the TMF Pond. The estimated average annual discharge from the wetland system is provided in Table IV - A 1.

Clear Coast Consultants (2013) provided the maximum expected water quality concentrations in effluent, and 15% removal for sulphate (Table 5-3) from the North TMF Wetland. Water quality was calculated as the balance of inflows and outflows of water and loadings to the North TMF Wetland. If the calculated water quality in the wetland effluent exceeded the maximum effluent concentrations (Table 5-3) then water quality in the effluent was set equal to the maximum effluent concentrations.

Average annual inflow water quality from the North TMF Wetland to the TMF Pond is provided in Appendix IV - A (Table IV - A 2) for initial discharge of the Pit Lake (Year 109), and long-term conditions (Year 200).

Table 5-3. Maximum Effluent Water Quality from the North TMF Wetland

Water Quality Parameter		Maximum Effluent Water Quality (mg/L)
Sulphate	(SO_4)	15% reduction
Cadmium	(Cd)	0.000080
Copper	(Cu)	0.0040
Molybdenum	(Mo)	0.073
Mercury	(Hg)	0.000026
Selenium	(Se)	-
Silver	(Ag)	0.00010
Uranium	(U)	0.015
Zinc	(Zn)	0.030

5.2 TMF Pond Outflows

The rate of mass exiting the TMF Pond for a given pond outflow rate was calculated as the concentration in the TMF Pond, multiplied by the outflow rate of water over a given time-step. TMF Pond outflows are summarized in the following section.

5.2.1 Evaporation

The monthly outflow of water from the TMF Pond due to evaporation was calculated for a given time step as the pond area, multiplied by the monthly depth of evaporation. Calculated losses to evaporation increased throughout Operations and Wetland Construction Phases as pond surface area increased. Modelled evaporation rates are presented in Table IV - A 1.

While evaporation was accounted for in the water balance, no outflow of mass load was associated with evaporation in the water quality model.

5.2.2 Tailings and Waste Rock Void Entrainment

When tailings and waste rock are deposited in the TMF, the pond water will become entrained in the voids of the deposited solids. Losses to voids will only take place during Operations, because waste rock and tailings will be saturated following Operations. The modelled rate of entrainment is provided in Table IV - A 1.

5.2.3 Mill Reclaim

Water will be reclaimed to the mill for processing during Operations. Average annual reclaim rate from the KP (2014) water balance model is presented in Table IV - A 1.

5.2.4 Pumping to Open Pit

Water from the TMF pond will be pumped to the Open Pit from Year 23 to Year 28 during the Wetland Construction Phase to provide suitable working conditions for wetland construction. The mass load pumped from the TMF Pond was accounted for in the Pit Lake water quality model (Appendix I - Open Pit Water Quality Modelling).

5.2.5 Foundation and Embankment Seepage

KPL (2013c) predicted that toward the south end of the TMF, vertical hydraulic gradients within the tailings will be primarily downward (Figure 5-2). That is, water from the TMF supernatant pond will infiltrate the tailings and flow downward into the foundation material and/or the TMF Embankment. Flow rates will increase throughout operations as the height of the embankment increases, and will stabilize following completion of the embankments. Modelled flows from the TMF Pond to the foundation and embankment are summarized in Table IV - A 1.

5.2.6 Spillway Discharge

In the TMF Discharge Phase and beyond, surplus TMF Pond water will discharge through the South TMF Wetland and into Casino Creek via the TMF Spillway. The South TMF Wetland will be an engineered wetland for the removal of some contaminants. The wetland layout was designed by BCL (2013) and is illustrated on Figure 2-3. South TMF Wetland water quality is described in Section 5.4.

5.3 Calculation of TMF Pond Water Quality

Water quality in the TMF Pond was calculated as the cumulative mass of a given substance in the pond water, divided by the free water volume stored in the pond over a given time step interval.

The TMF Pond mixing model output concentrations were assessed for solubility controls at each time step of the model simulation by coupling GoldSim and PHREEQC. PHREEQC is a geochemical modelling software developed by the United States Geological Survey. To predict pH, all water quality inputs to PHREEQC were charge balanced, and the residual balance was placed on either chloride or sodium. During each timestep, GoldSim ran PHREEQC and the resulting concentrations returned from PHREEQC were linked to the South TMF wetland. Input assumptions are provided in Table 5-4.

Table 5-4. PHREEQC Assumptions for TMF Pond Water Quality Modelling

PHREEQC Input Assumptions	
Equilibrium Phases (minerals form solid phase - precipitate forms)	$Fe(OH)_3(a)$ $Al(OH)_3(a)$
Database	wateq4f
pH	Charge balance (PHREEQC determines pH of solution and alkalinity)
PE	10 (oxidizing)
Temperature	5°C
Oxygen	Atmospheric conditions
CO_2	Atmospheric conditions

5.4 South TMF Wetland Discharge Water Quality

In the TMF Discharge Phase (and beyond), TMF Pond water will be released through the TMF spillway and into Casino Creek. Prior to discharge to the spillway, the TMF Pond water will travel through the South TMF Wetland, an engineered wetland for the removal of certain contaminants. The wetland layout was designed by BCL (2013) and is illustrated on Figure 2-3.

Clear Coast Consultants (2013) provided maximum water quality concentrations for the South TMF Wetland effluent (Table 5-5), and this treatment was included in the water quality model. 15% removal efficiency was incorporated into the wetland for sulphate. If no treatment was specified, the modelled TMF Pond water quality for that parameter was assumed to report to Casino Creek via the spillway.

Table 5-5. Maximum Effluent Water Quality from the South TMF Wetland

Water Quality Parameter		Maximum Effluent Water Quality (mg/L)
Sulphate	(SO_4)	15% reduction
Cadmium	(Cd)	0.000080
Copper	(Cu)	0.0040
Molybdenum	(Mo)	0.073
Mercury	(Hg)	0.000026
Selenium	(Se)	-
Silver	(Ag)	0.00010
Uranium	(U)	0.015
Zinc	(Zn)	0.030

6 Results and Discussion

6.1 Water Quality Predictions

Average annual TMF Pond water quality for select parameters are provided in Table 6-1 for each water management phase for select water quality parameters. Water quality model results are also provided for the TMF Spillway discharge to illustrate the modelled effects of the treatment wetland on TMF Pond water quality prior to discharge to Casino Creek. Tables of water quality model results are provided for all modelled parameters in Appendix IV - B (Table IV - B 1).

Time series plots for select parameters are provided on Figure 6-1 to Figure 6-8 for a single realization of the model (Realization #1). Wet and dry years with 10 year return period are identified on the plots to help illustrate the effects of inter-annual variation in hydrologic conditions. Because the TMF Pond is a large water body, fluctuations in water and mass loading are well attenuated and the resulting variation in TMF Pond water quality from wet and dry years is relatively small.

PHREEQC results indicated that the TMF Pond will be at near neutral pH during all phases of mining. A time-series plot of TMF Pond pH is presented on Figure 6-9.

Table 6-1. TMF Pond Water Quality Model Results

Water Quality Parameter		TMF Pond Water Quality (mg/L)			
		Operations	Wetland Construction Phase	TMF Discharge Phase	Pit Discharge Phase
pH		6.1	6.8	6.9	6.9
Sulphate	(SO_4)	1,242	695	335	266
Fluoride	(F)	2.1	1.2	0.65	0.63
Cadmium	(Cd)	0.00064	0.00065	0.00034	0.00016
Copper	(Cu)	0.33	0.067	0.11	0.073
Iron	(Fe)	0.0012	0.00030	0.00022	0.00023
Molybdenum	(Mo)	0.37	0.20	0.085	0.066
Selenium	(Se)	0.015	0.0069	0.0043	0.0043
Uranium	(U)	0.018	0.033	0.048	0.042
Water Quality Parameter		**TMF Spillway Water Quality (mg/L)**			
		Operations	**Wetland Construction Phase**	**Initial TMF Pond Discharge**	**Pit Discharge Phase**
pH		-	-	6.9	6.9
Sulphate	(SO_4)	-	-	283	225
Fluoride	(F)	-	-	0.65	0.63
Cadmium	(Cd)	-	-	0.000080	0.000080
Copper	(Cu)	-	-	0.0040	0.0040
Iron	(Fe)	-	-	0.00022	0.00023
Molybdenum	(Mo)	-	-	0.085	0.066
Selenium	(Se)	-	-	0.0043	0.0043
Uranium	(U)	-	-	0.015	0.015

1. Values represent average water quality results over the duration of each mining phase for a single model realization (Realization #1).
2. TMF Spillway will have zero discharge during the Operations and Wetland Discharge Phases.

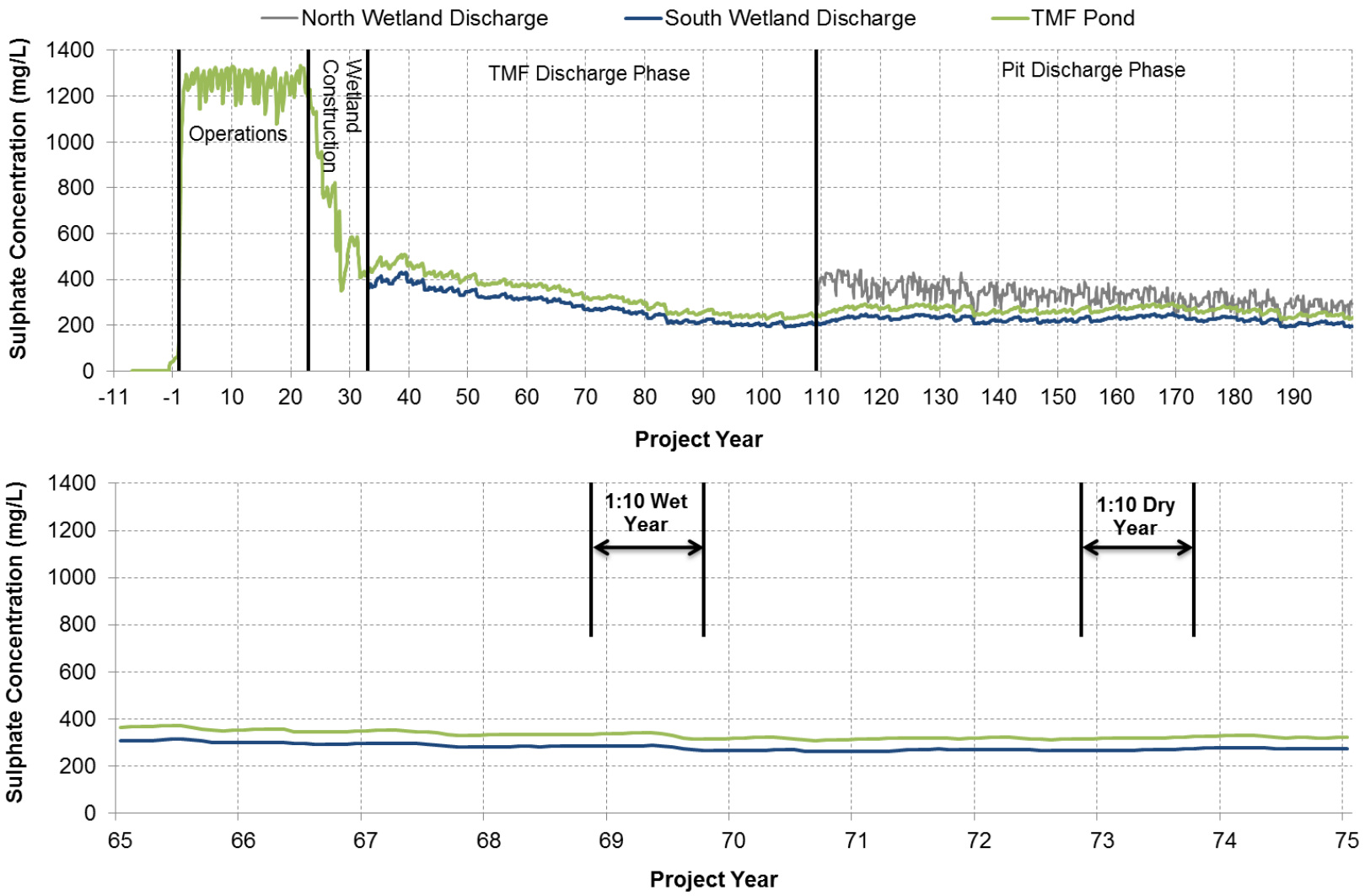


Figure 6-1. Modelled Sulphate Water Quality in the TMF Pond and Wetlands

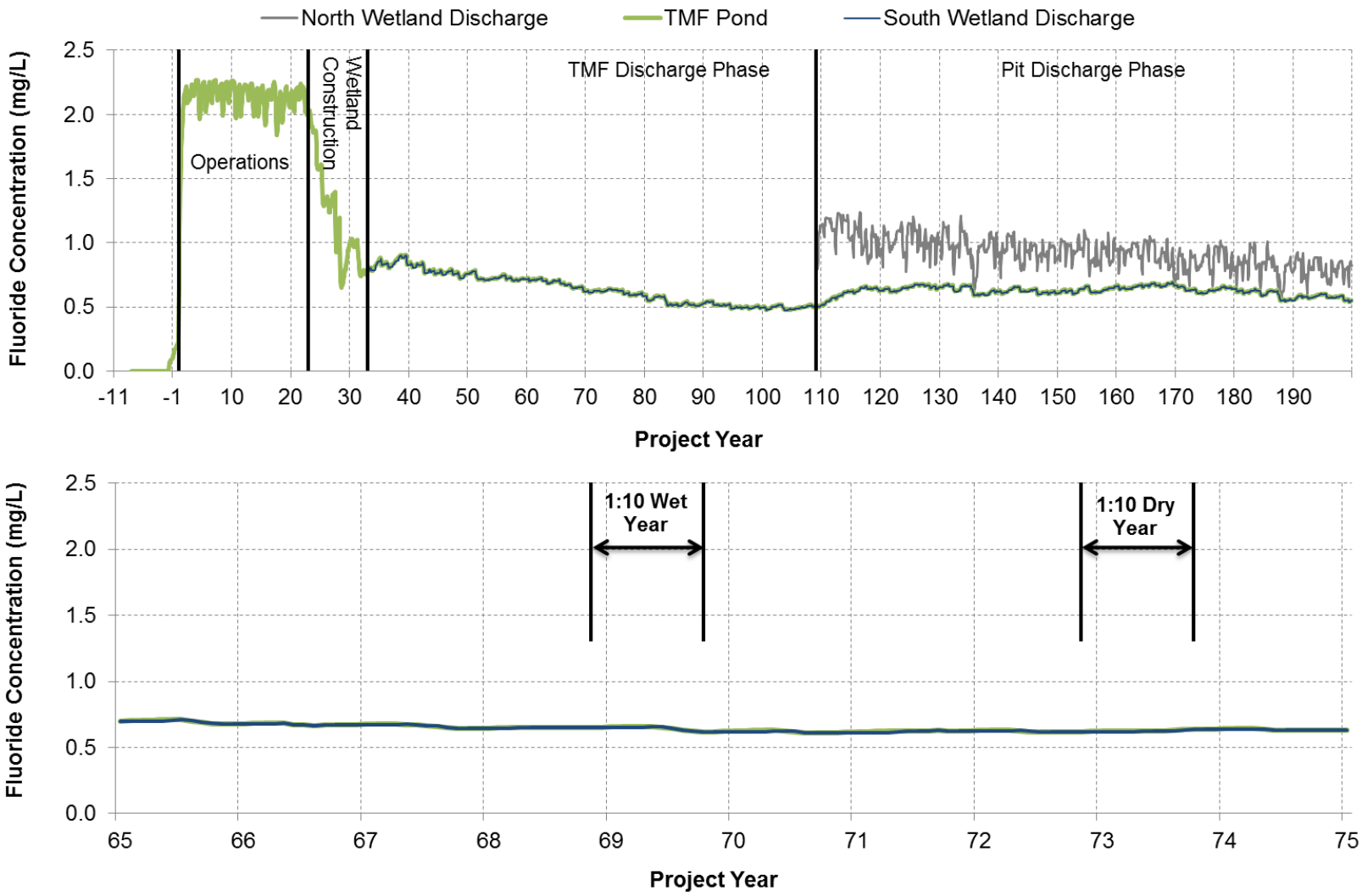


Figure 6-2. Modelled Fluoride Water Quality in the TMF Pond and Wetlands

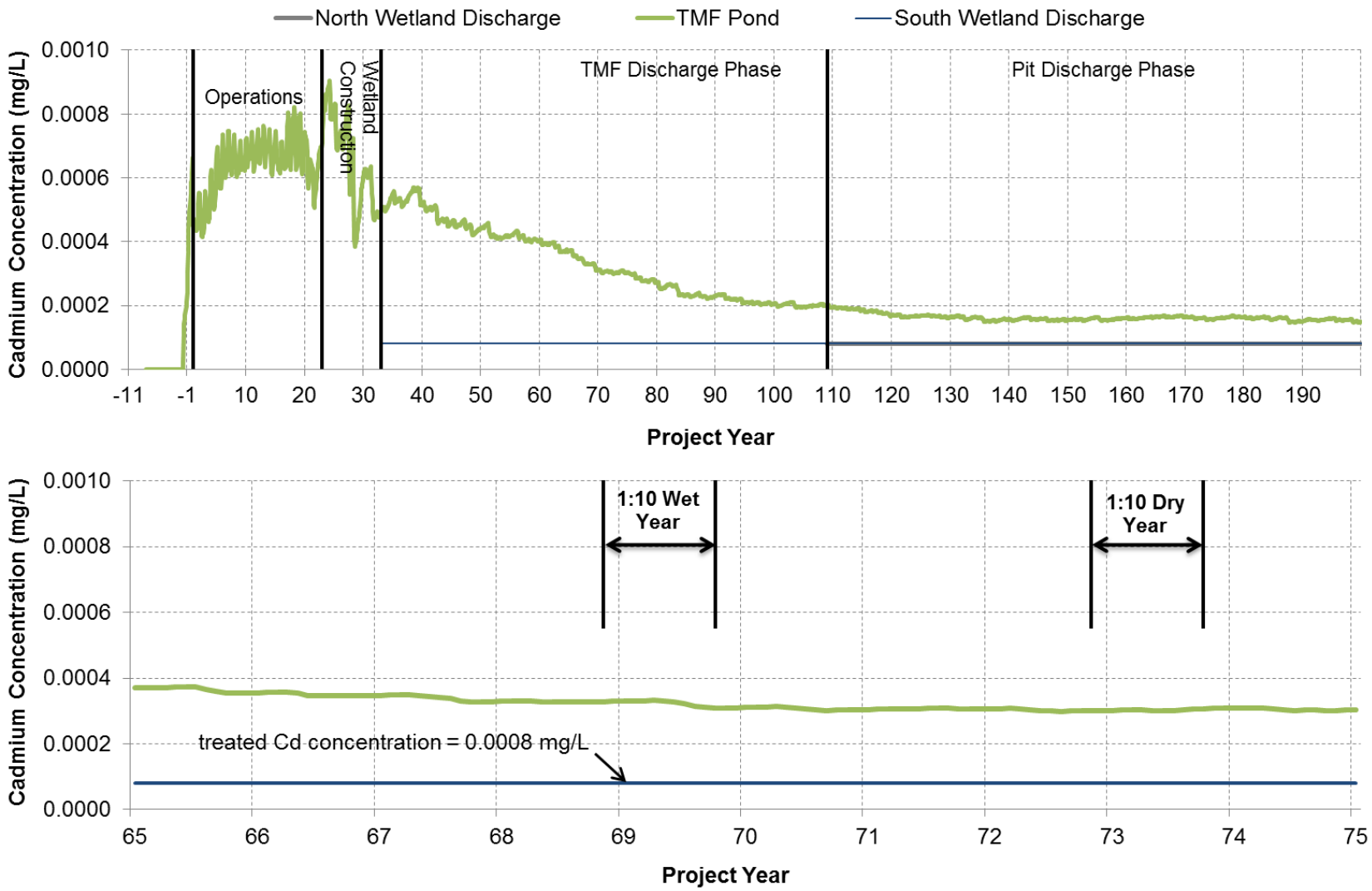


Figure 6-3. Modelled Cadmium Water Quality in the TMF Pond and Wetlands

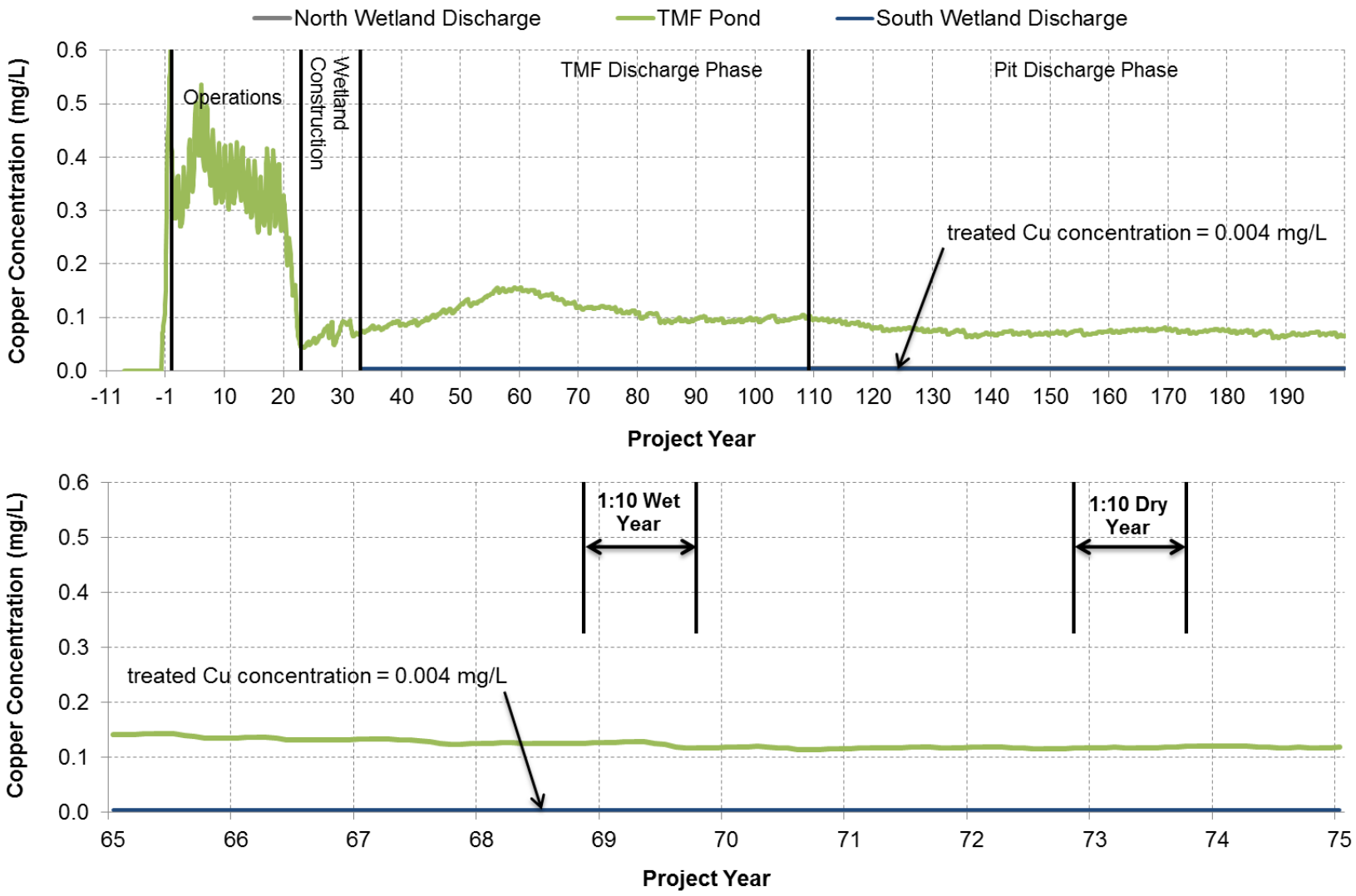


Figure 6-4. Modelled Copper Water Quality in the TMF Pond and Wetlands

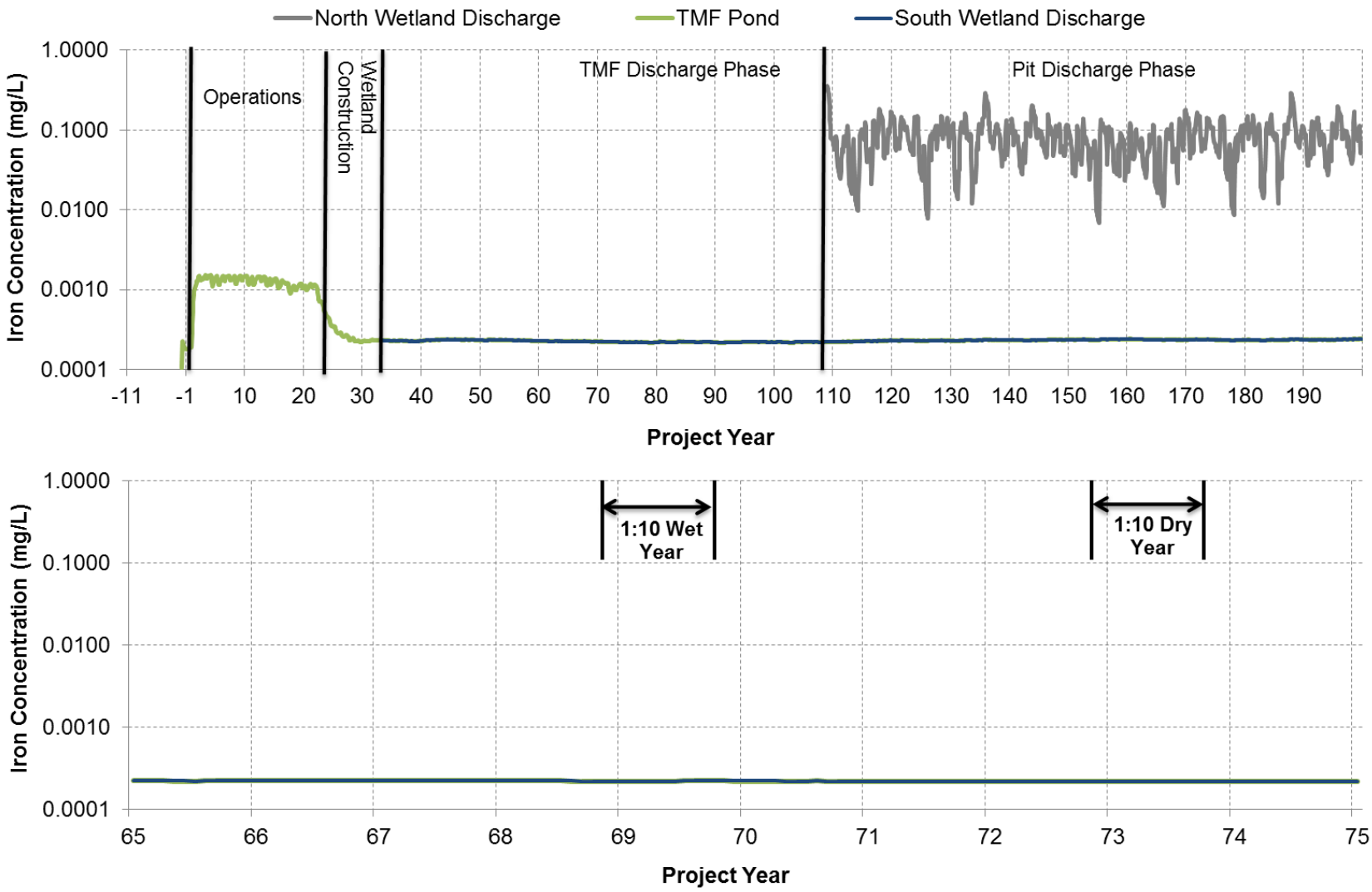


Figure 6-5. Modelled Iron Water Quality in the TMF Pond and Wetlands

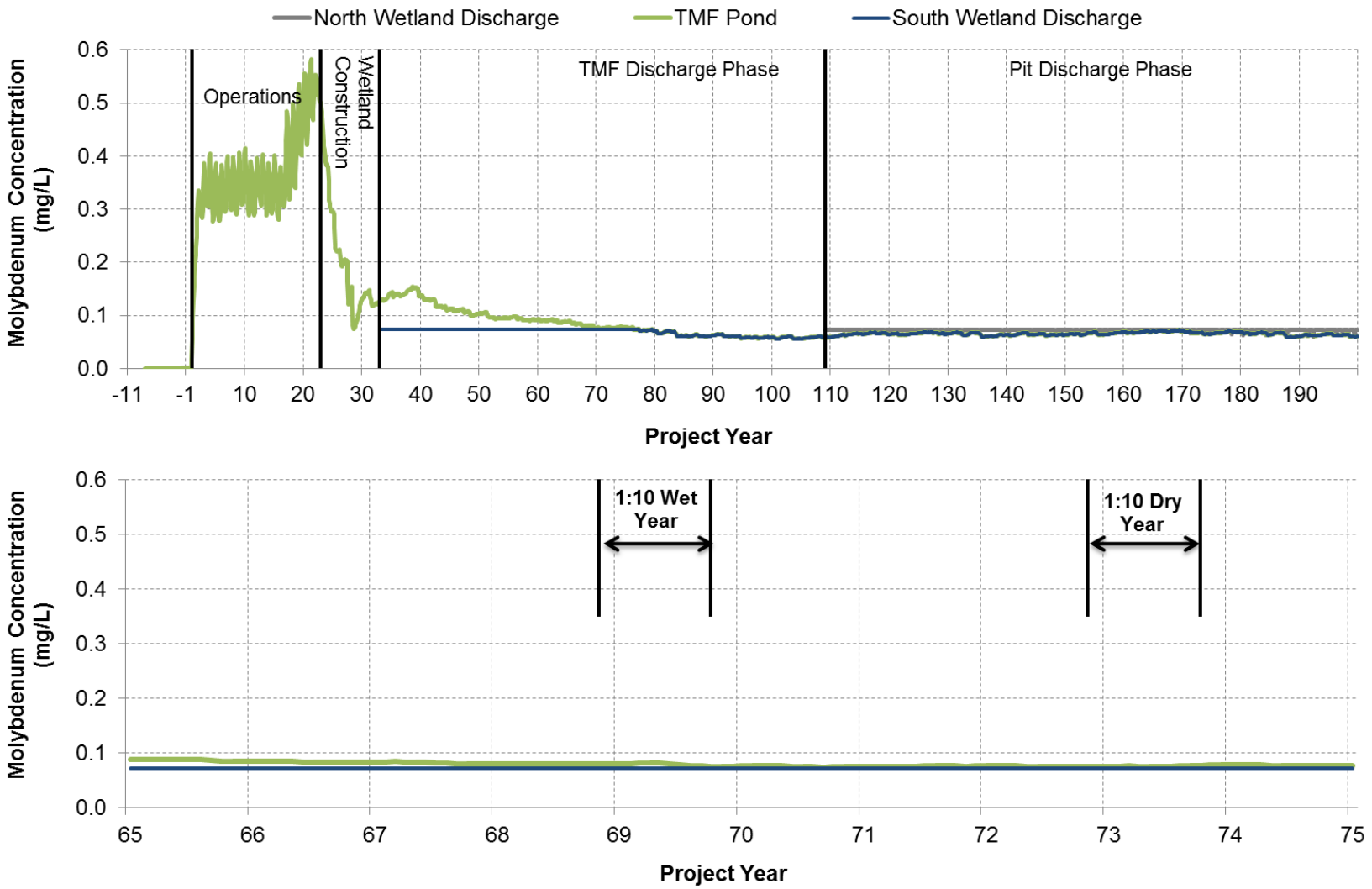


Figure 6-6. Modelled Molybdenum Water Quality in the TMF Pond and Wetlands

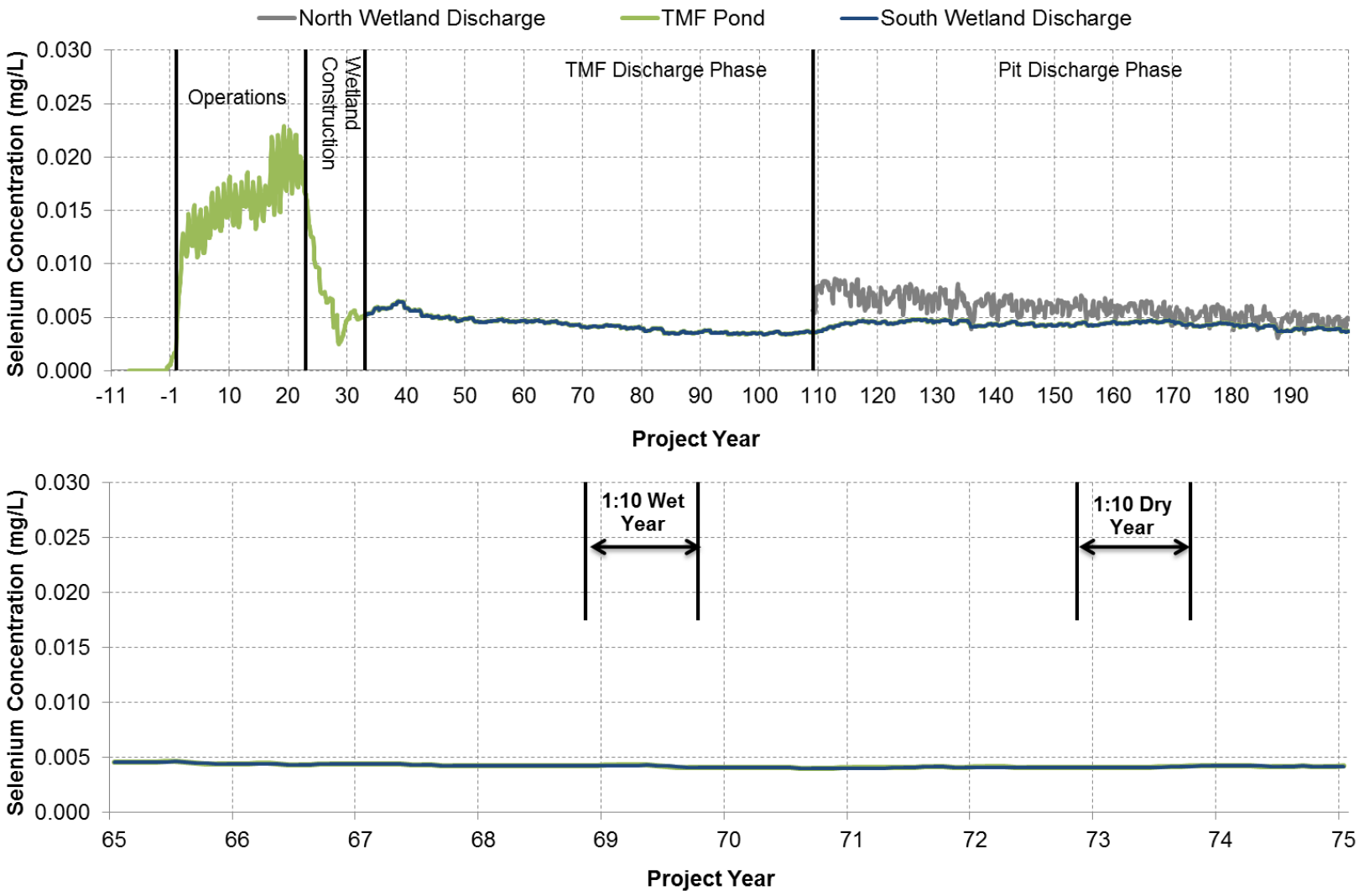


Figure 6-7. Modelled Selenium Water Quality in the TMF Pond and Wetlands

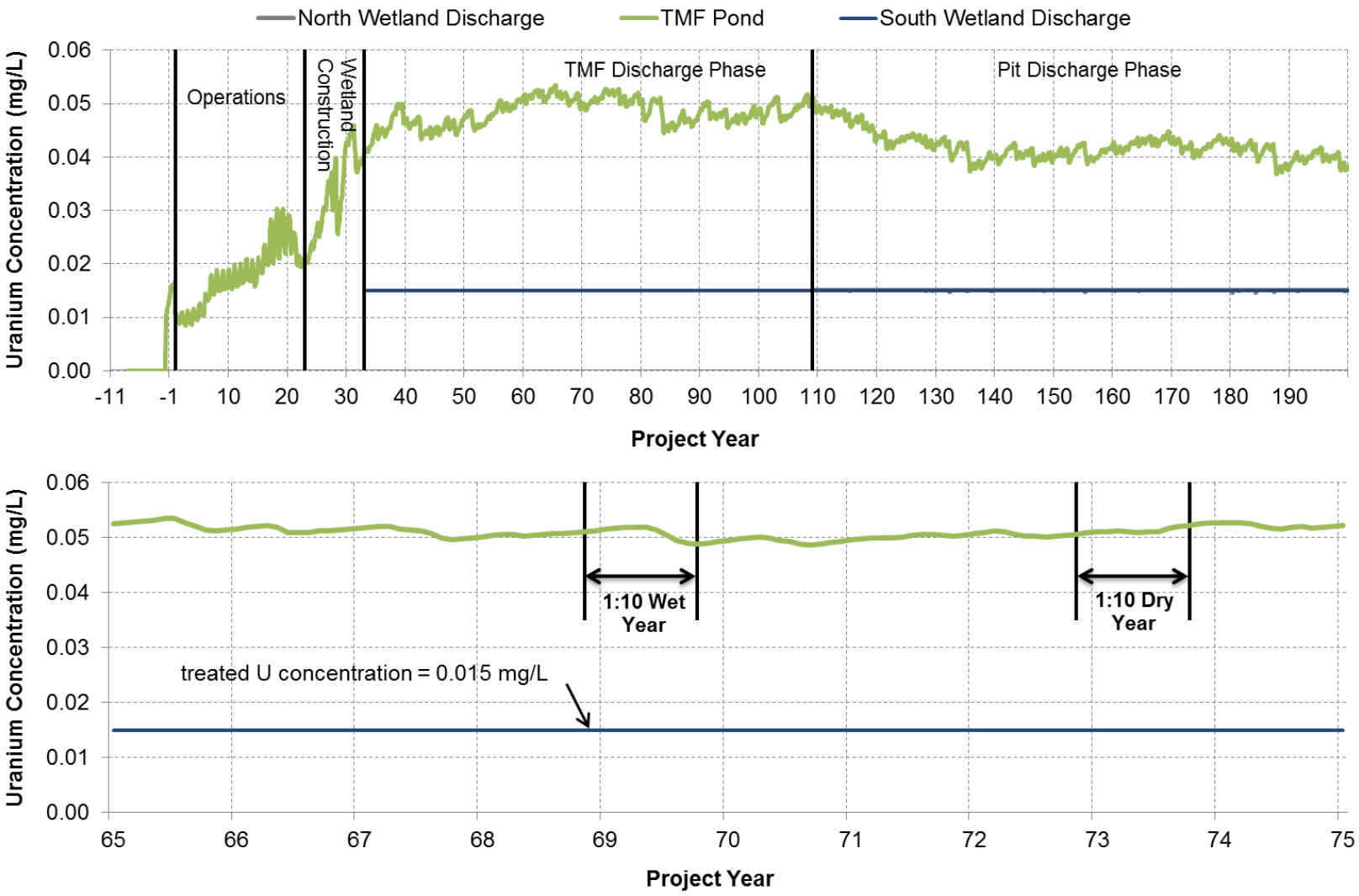


Figure 6-8. Modelled Uranium Water Quality in the TMF Pond and Wetlands

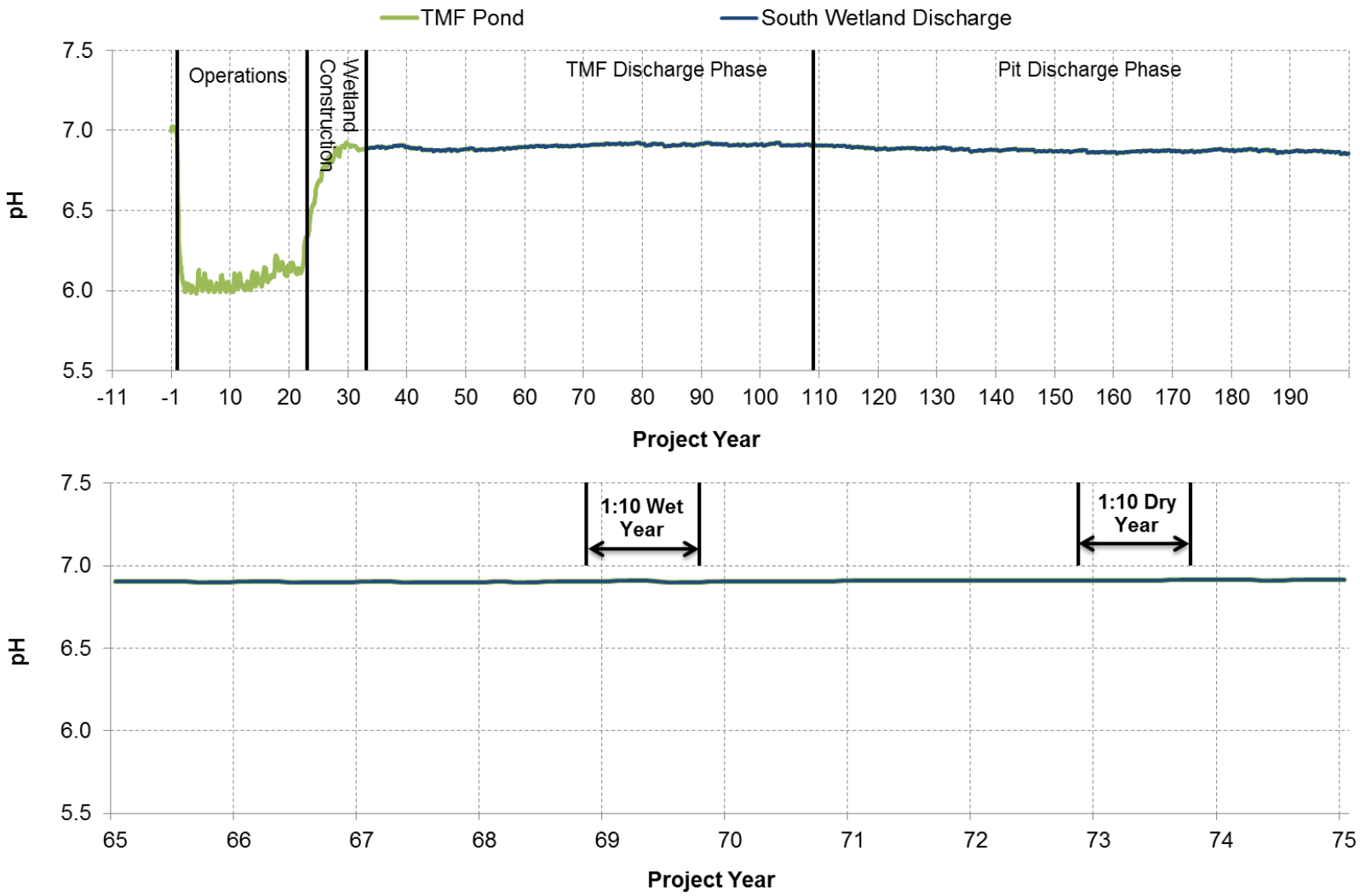


Figure 6-9. Modelled pH of the TMF Pond

Figure 6-10 shows an example of the accumulation of selenium in the process water quality for a single model realization to illustrate the influence of the process water on the TMF Pond water quality. The blue line is the process water quality and the green line is the TMF Pond water quality. Because the TMF pond experiences seasonal dilution, the reclaim water concentration also varies, and thus so will the process water.

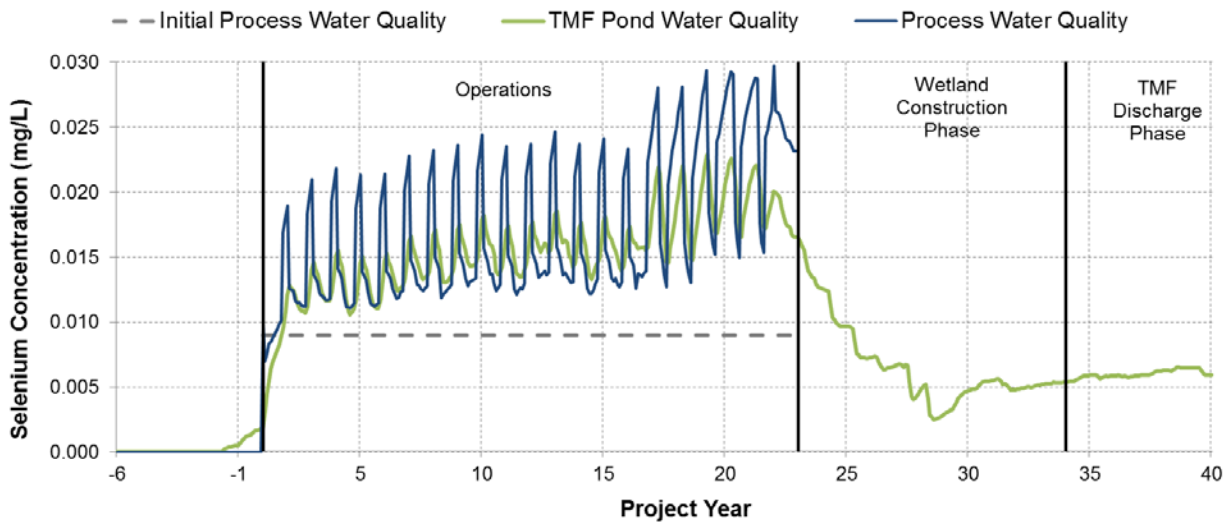


Figure 6-10. Example of Process Water Quality and TMF Pond Quality for Selenium

6.2 Individual Contributions of Mass Loading Sources to the TMF

Individual contributions of each mass loading source are presented in Table 6-2 (Operations), Table 6-3 (Wetland Construction Phase), Table 6-4 (TMF Discharge Phase), and Table 6-5 (Pit Discharge Phase). Individual contributions of mass loading sources are provided in Appendix IV – B (Table IV-B2 to Table IV-B5) for all modelled water quality parameters.

In general, during TMF Discharge, upward fluxes of CoCs in the porewater from the tailings and waste rock are the dominant loads to the TMF Pond. Once the Pit Discharge Phase begins (via the North TMF Wetland), this source is a large proportion of the overall load to the TMF Pond for some water quality parameters.

Table 6-2. Loading Source Contributions to the TMF Pond (Operations)

Source of Loading	Fraction Contributing (%)							
	SO_4	F	Cd	Cu	Fe	Mo	Se	U
Background Runoff	0	0	1	0	0	0	0	3
Stockpile (runoff + seepage)	1	3	44	93	20	2	9	20
Waste Rock Runoff	0	0	7	1	0	0	5	4
Tailings Beach Runoff	0	0	1	0	0	1	0	0
HLF Drainage	0	0	0	0	0	0	0	0
Tailings Slurry	73	72	5	1	3	78	72	54
PAG Tailings Pore Water	1	1	1	0	3	1	1	2
NAG Tailings Pore Water	15	14	36	1	72	11	8	4
Waste Rock Pore Water	1	1	1	3	2	1	1	10
WMP Pump Back	8	8	6	0	0	7	5	3
North TMF Wetland Discharge	0	0	0	0	0	0	0	0
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

1. Average of all years during Operations, calculated from output from model Realization #1.
2. Shaded cells are for sources that contribute >10% to the overall load.
3. Values are rounded to the nearest 1 and the total of individual values may not add to exactly 100.

Table 6-3. Loading Source Contributions to the TMF Pond (Wetland Construction Phase)

Source of Loading	Fraction Contributing (%)							
	SO_4	F	Cd	Cu	Fe	Mo	Se	U
Background Runoff	3	4	8	1	2	0	1	19
Stockpile (runoff + seepage)	0	0	0	1	0	0	0	0
Waste Rock Runoff	0	0	0	0	0	0	0	0
Tailings Beach Runoff	0	7	0	0	0	5	1	2
HLF Drainage	1	1	2	0	0	9	14	5
Tailings Slurry	0	0	0	0	0	0	0	0
PAG Tailings Pore Water	3	2	1	0	1	2	2	1
NAG Tailings Pore Water	71	65	79	9	73	67	57	5
Waste Rock Pore Water	22	21	8	88	23	17	25	68
WMP Pump Back	0	0	0	0	0	0	0	0
North TMF Wetland Discharge	0	0	0	0	1	0	0	0
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

1. Average of all years during the Wetland Construction Phase, calculated from output from model Realization #1.
2. Shaded cells are for sources that contribute >10% to the overall load.
3. Values are rounded to the nearest 1 and the total of individual values may not add to exactly 100.

Table 6-4. Loading Source Contributions to the TMF Pond (TMF Discharge Phase)

Source of Loading	Fraction Contributing (%)							
	SO_4	F	Cd	Cu	Fe	Mo	Se	U
Background Runoff	6	7	21	1	3	0	1	17
Stockpile (runoff + seepage)	0	0	4	13	1	0	0	0
Waste Rock Runoff	0	0	0	0	0	0	0	0
Tailings Beach Runoff	1	12	1	0	0	9	1	2
HLF Drainage	3	4	4	0	0	22	39	8
Tailings Slurry	0	0	0	0	0	0	0	0
PAG Tailings Pore Water	1	1	1	0	1	1	1	0
NAG Tailings Pore Water	31	25	42	2	35	26	15	1
Waste Rock Pore Water	50	42	24	84	57	35	34	70
WMP Pump Back	0	0	0	0	0	0	0	0
North TMF Wetland Discharge	7	9	2	0	3	7	10	3
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

1. Average of all years during TMF Discharge Phase, calculated from output from model Realization #1.
2. Shaded cells are for sources that contribute >10% to the overall load.
3. Values are rounded to the nearest 1 and the total of individual values may not add to exactly 100.

Table 6-5. Loading Source Contributions to the TMF Pond (Pit Discharge Phase)

Source of Loading	Fraction Contributing (%)							
	SO_4	F	Cd	Cu	Fe	Mo	Se	U
Background Runoff	5	5	30	1	5	0	1	16
Stockpile (runoff + seepage)	0	0	0	0	0	0	0	0
Waste Rock Runoff	0	0	0	0	0	0	0	0
Tailings Beach Runoff	1	9	2	0	0	8	1	2
HLF Drainage	2	3	4	0	0	17	26	6
Tailings Slurry	0	0	0	0	0	0	0	0
PAG Tailings Pore Water	0	0	0	0	0	0	0	0
NAG Tailings Pore Water	6	4	14	0	11	6	2	0
Waste Rock Pore Water	43	30	32	96	79	31	24	63
WMP Pump Back	0	0	0	0	0	0	0	0
North TMF Wetland Discharge	42	49	18	2	4	38	46	13
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

1. Average of all years during Pit Discharge Phase, calculated from output from model Realization #1.
2. Shaded cells are for sources that contribute >10% to the overall load.
3. Values are rounded to the nearest 1 and the total of individual values may not add to exactly 100.

7 References

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Appendix IV - A

Water Quality Modelling Input Data

Table IV - A 1 Average Annual Inflow and Outflow of Water for the TMF Pond

Water Management Phase	Project Year	Average Annual Inflow (L/s)															Average Annual Outflow (L/s)								
											Tailings Porewater														
		Precipit-ation	Back-ground Runoff (1)	FWSP	Stockpile Runoff (2)	Waste Rock Runoff	Tailings Beach	HLF Runoff	Tailings Slurry	Sand Plant (3)	NAG (4)	PAG (4)	Waste Rock Porewater (4)	WMP	North TMF Wetland Discharge	Total Inflow	Evapor-ation	Reclaim to Mill	Tailings and WR Voids	Sand Plant Makeup	Pump to Open Pit	Embank-ment Seepage	Founda-tion Seepage	Spillway Discharge	Total
Construction	-3	0	116	5	0	0.6	0	0	0	0	0	0	0	16	0	137	0	0	0	0	0	0	0	137	137
	-2	0	113	10	0	1.9	0	0	0	0	0	0	0	15.7	0	141	0	0	0	0	0	0	0	1	1
	-1	2	110	23	1.4	3.8	0	0	0	0	0	0	3	15.6	0	158	2	0	90	0	0	0	0	0	92
Operations	1	6	127	17	7.4	6.1	1.1	0	409	874	182	14	8	160	0	1,811	5.6	772	604	554	0	0.7	0	0	1,936
	2	10	125	0	9.3	8.4	1.4	0	544	1,199	211	16	14	179	0	2,317	9.5	1,044	834	738	0	2.0	0	0	2,628
	3	13	123	0	11	11	1.7	0	543	1,192	241	18	18	187	0	2,359	12.4	1,034	797	736	0	3.5	0.9	0	2,584
	4	14	118	0	12	13	1.8	0	540	1,177	270	21	20	200	0	2,387	14	1,024	765	734	0	4.8	1.8	0	2,544
	5	16	115	0	13	15	1.9	0	536	1,161	287	22	20	206	0	2,392	16	1,014	786	727	0	5.3	3.2	0	2,551
	6	17	113	0	14	17	1.9	0	535	1,165	292	22	21	203	0	2,400	17	1,013	799	726	0	5.8	4.5	0	2,565
	7	17	113	0	15	20	2.1	0	535	1,163	297	23	21	206	0	2,414	17	1,010	800	726	0	6.2	5.8	0	2,565
	8	19	112	0	15	22	2.1	0	542	1,174	303	23	22	215	0	2,449	19	1,025	812	736	0	6.6	7.2	0	2,606
	9	21	109	0	16	24	2.2	0	546	1,182	308	24	22	218	0	2,472	21	1,034	829	741	0	7.1	8.6	0	2,640
	10	23	107	0	16	26	2.3	0	530	1,149	311	26	22	215	0	2,427	22	997	809	719	0	7.6	10.0	0	2,565
	11	23	104	0	15	28	2.3	0	529	1,144	316	26	22	219	0	2,428	23	994	815	718	0	8.3	11.0	0	2,570
	12	24	106	0	14	30	2.4	0	543	1,174	321	27	22	226	0	2,489	24	1,021	839	738	0	9.0	12	0	2,642
	13	25	107	0	14	33	2.5	0	548	1,185	327	27	22	228	0	2,516	25	1,029	852	743	0	9.6	13	0	2,671
	14	27	107	0	13	35	2.6	0	542	1,171	331	27	22	231	0	2,508	26	1,017	842	736	0	10	14	0	2,645
	15	27	101	0	12	36	2.6	0	535	1,154	337	28	22	231	0	2,485	27	1,003	839	726	0	11	15	0	2,622
	16	30	102	0	13	37	2.7	0	533	1,154	342	28	22	231	0	2,494	30	998	844	725	0	12	16	0	2,625
	17	33	101	0	13	38	2.8	0	871	516	347	29	21	137	0	2,107	33	991	945	324	0	12	17	0	2,323
	18	38	102	0	13	38	2.9	0	874	524	352	29	21	133	0	2,126	37	993	967	325	0	13	18	0	2,353
	19	50	105	0	11	32	3.0	0	887	532	373	13	21	135	0	2,163	49	1,077	813	330	0	14	19	0	2,302
	20	70	105	0	6.8	19	3.0	0	947	392	378	13	21	118	0	2,072	70	1,064	806	243	0	14	19	0	2,217
	21	90	103	0	2.1	6.5	3.1	0	945	394	383	13	19	118	0	2,077	90	1,063	807	244	0	15	20	0	2,238
	22	100	102	0	0	0	3.1	0	587	0	387	14	19	64	0	1,275	99	522	399	0	0	15	20	0	1,055
Wetland Construction Phase	23	89	94	0	0	0	3.0	0	0	0	247	8.7	19	0	0.5	461	89	0	0	0	336	14	20	0	459
	24	89	97	0	0	0	3.1	0	0	0	94	3.3	19	0	3.1	308	88	0	0	0	336	14	20	0	458
	25	89	98	0	0	0	3.1	0	0	0	81	2.9	19	0	5.8	299	88	0	0	0	336	14	20	0	458
	26	87	96	0	0	0	3.1	0	0	0	69	2.4	19	0	7.3	285	86	0	0	0	336	14	20	0	456
	27	88	95	0	0	0	3.1	0	0	0	57	2.0	19	0	7.6	272	86	0	0	0	285	14	20	0	406
	28	87	96	0	0	0	3.1	0	0	0	50	1.8	19	0	7.4	266	87	0	0	0	0	14	20	0	121
	29	88	97	0	0	0	3.1	13	0	0	49	1.7	19	0	7.4	278	87	0	0	0	0	14	20	0	121
	30 - 34	88	98	0	0	0	3.1	13	0	0	47	1.7	19	0	7.6	278	87	0	0	0	0	14	20	0	121
TMF Discharge	35 - 109	89	96	0	0	0	3.1	13	0	0	7	0.3	19	0	15	244	89	0	0	0	0	14	20	121	244
Pit Discharge	> 109	89	96	0	0	0	3.1	13	0	0	2.9	0.1	20	0	79	303	88	0	0	0	0	14	20	181	303

1. Includes domestic wastewater treatment plant effluent (average rate = 1.3 L/s during Operations) and mill site runoff
2. Following Operations, runoff from the reclaimed stockpile areas was accounted for as “Background Runoff” in the water balance.
3. Includes sand plant overflow, embankment construction water from the upstream face, minus the sand plant make-up water.
4. Porewater displacement from NAG Tailings, PAG Tailings, and Waste Rock includes tailings consolidation seepage (tailings only) and seepage from ore stockpiles.
5. Values reported in this table represent average model results from 52 model realizations.

Table IV - A 2 Source Terms for Inflows to the TMF Pond

Water Quality Model Parameter		Background Runoff (W13) [1] (mg/L)	FWSP Inflow (W8) [1] (mg/L)	Tailngs Beach Runoff		HLF Drainage		WMP Pumping [2] (mg/L)	Tailings Slurry Water [3]		N TMF Wetland [4] Pit Discharge Phase (mg/L)
				Operations (mg/L)	> Year 23 (mg/L)	Year 29 - Year 38 (mg/L)	> Year 39 (mg/L)		Water Quality (mg/L)	Accumulation (g/tonne)	
Hardness (as $CaCO_3$)		124	107	110	179	3,502	2,395	1,084	1,246		300
Alkalinity (as $CaCO_3$)		105	38	68	75	47	47	25	63		29
Sulphate	(SO_4)	28	73	101	150	2,100	424	1,137	1,320		250
Chloride	(Cl)	0.25	0.25	0.054	7.8	240	38	31	36		14
Fluoride	(F)	0.060	0.10	0.56	4.1	3.0	1.3	1.9	2.2		0.70
Aluminum	(Al)	0.074	0.53	0.038	0.00019	0.0070	0.0060	2.1	4.8		0.19
Antimony	(Sb)	0.00023	0.000090	0.044	0.029	0.77	0.47	0.0038	0.0025	0.0020	0.0099
Arsenic	(As)	0.0014	0.00030	0.054	0.029	0.036	0.036	0.0050	0.0041	0.0033	0.0035
Barium	(Ba)	0.090	0.052	0.029	0.023	0.0077	0.0077	0.070	0.058		0.052
Cadmium	(Cd)	0.000087	0.00025	0.0048	0.00019	0.0050	0.00028	0.00063	0.000043		0.000080
Calcium	(Ca)	34	31	40	60	756	532	428	497		104
Chromium	(Cr)	0.00015	0.00010	0.043	0.0082	0.0010	0.0010	0.0030	0.0025		0.0017
Cobalt	(Co)	0.000074	0.0023	0.0056	0.0016	2.6	0.49	0.0022	0.00075		0.069
Copper	(Cu)	0.0011	0.058	0.038	0.0099	0.016	0.0011	0.021	0.0050		0.0040
Iron	(Fe)	0.071	0.87	0.0050	0.0051	0.0040	0.0040	0.0011	0.060		0.083
Lead	(Pb)	0.0036	0.00029	0.0073	0.00020	0.00028	0.00028	0.0011	0.0013		0.00079
Magnesium	(Mg)	9.7	7.0	2.3	7.4	392	259	3.7	1.3		9.6
Manganese	(Mn)	0.040	0.068	0.0060	0.0065	0.0045	0.00031	0.64	0.0015		0.35
Mercury	(Hg)	0.0000050	0.0000050	0.00043	0.000074	0.000020	0.000020	0.000012	0.0000050		0.000016
Molybdenum	(Mo)	0.00053	0.00023	2.8	0.18	4.2	0.94	0.27	0.24	0.20	0.066
Nickel	(Ni)	0.00036	0.00092	0.018	0.0041	0.093	0.0073	0.0035	0.0025		0.024
Selenium	(Se)	0.000047	0.000060	0.0022	0.0022	0.23	0.098	0.0075	0.0085	0.0070	0.0044
Silver	(Ag)	0.000016	0.0000025	0.00047	0.00012	0.00078	0.00062	0.000055	0.000050		0.000096
Sodium	(Na)	3.9	3.5	4.3	2.4	15	0.56	48	35		14
Thallium	(Tl)	0.0000030	0.0000070	0.00020	0.000068	0.00011	0.00011	0.00044	0.00050		0.00010
Uranium	(U)	0.012	0.0019	0.017	0.042	0.63	0.17	0.0095	0.0031	0.0025	0.014
Zinc	(Zn)	0.0061	0.018	0.14	0.015	0.39	0.22	0.013	0.0061		0.029

1. Median water quality from water quality data collected at W13 and W8.
2. Average water quality during the Operations Phase.
3. Represents the water quality of the slurry water. For parameters where a “mass accumulation” source term was provided, the “water quality” value represents the initial water quality in the slurry water at the beginning of the model simulation.
4. Average water quality during the Pit Discharge Phase.

Table IV - A 3 **Source Terms for Inflows to the TMF Pond - Loading Rates and Maximum Concentrations for Unsubmerged Waste Rock in the TMF during Operations**

Water Quality Parameter	Mass Loading Rate (mg/tonne/year)			Maximum Concentration (mg/L)		
	Year -3 to Year 4	Year 5 to Year 14	Year 15 to Year 20	Year -3 to Year 4	Year 5 to Year 14	Year 15 to Year 20
Hardness (as $CaCO_3$)	1,985	4,860	3,697	201	793	611
Alkalinity (as $CaCO_3$)	0	0	58	0	0	68
Sulphate (SO_4)	5,700	5,900	5,300	590	980	840
Chloride (Cl)	230	140	260	23	23	42
Fluoride (F)	17	16	19	1.8	2.6	3.1
Aluminum (Al)	19	4.1	0.020	1.9	0.69	0.0023
Antimony (Sb)	0.13	0.21	0.18	0.014	0.035	0.029
Arsenic (As)	0.080	0.18	0.24	0.0083	0.030	0.038
Barium (Ba)	0.076	0.042	0.040	0.0079	0.0069	0.0069
Cadmium (Cd)	0.027	0.12	0.060	0.0028	0.020	0.0089
Calcium (Ca)	630	1,600	1,200	64	260	200
Chromium (Cr)	0.12	0.20	0.29	0.012	0.034	0.046
Cobalt (Co)	0.53	0.68	0.55	0.054	0.11	0.087
Copper (Cu)	31	9.5	0.29	3.2	1.6	0.046
Iron (Fe)	3.2	0.69	0.060	0.33	0.11	0.0094
Lead (Pb)	0.051	0.033	0.020	0.0052	0.0054	0.0038
Magnesium (Mg)	100	210	170	10	35	27
Manganese (Mn)	12	5.3	0.56	1.2	0.87	0.089
Mercury (Hg)	0.0020	0.0036	0	0.00020	0.00059	0.00076
Molybdenum (Mo)	0.60	0.47	0.64	0.062	0.078	0.10
Nickel (Ni)	0.16	0.30	0.34	0.016	0.049	0.055
Selenium (Se)	0.78	1.8	1.9	0.080	0.30	0.30
Silver (Ag)	0.0071	0.0073	0.010	0.00073	0.0012	0.0013
Sodium (Na)	1,700	580	46	170	96	7.3
Thallium (Tl)	0.016	0.0084	0.010	0.0016	0.0014	0.00081
Uranium (U)	0.17	1.8	1.6	0.017	0.30	0.25
Zinc (Zn)	3.0	13	7.2	0.31	2.1	1.1

From Lorax (2013)

Table IV - A 4 Source Terms for Inflows to the TMF Pond - Seepage from Saturated Tailings and Waste Rock

Water Quality Parameter	Flux from Submerged Waste Rock to TMF Pond (mg/L)					Flux from PAG Tailings to TMF Pond (mg/L)					Flux from NAG Tailings to TMF Pond (mg/L)				
	Year 4	Year 9	Year 19	Year 22	> Year 22	Year 4	Year 9	Year 19	Year 22	> Year 22	Year 4	Year 9	Year 19	Year 22	> Year 22
Hardness (as $CaCO_3$)	1,266	1,397	1,480	1,480	1,480	1,277	1,288	1,292	1,298	1,296	1,255	1,255	1,257	1,257	1,260
Alkalinity (as $CaCO_3$)	0	0	329	329	329	75	75	75	75	75	58	58	58	58	58
Sulphate (SO_4)	1,320	1,320	1,320	1,320	1,320	1,320	1,320	1,320	1,320	1,320	1,320	1,320	1,320	1,320	1,320
Chloride (Cl)	36	36	36	36	36	35	38	38	38	38	36	36	36	36	36
Fluoride (F)	2.2	2.2	2.2	2.2	2.2	2.1	2.2	2.2	2.2	2.2	2.1	2.1	2.1	2.1	2.1
Aluminum (Al)	4.8	1.4	0.0020	0.0020	0.0020	0.0086	0.0086	0.0086	0.0086	0.0086	0.0058	0.0058	0.0058	0.0058	0.0058
Antimony (Sb)	0.0046	0.0040	0.0025	0.0025	0.0025	0.0029	0.0029	0.0029	0.0029	0.0029	0.0025	0.0025	0.0026	0.0025	0.0026
Arsenic (As)	0.0041	0.0041	0.0063	0.0063	0.0063	0.0044	0.0044	0.0043	0.0044	0.0044	0.0043	0.0043	0.0043	0.0043	0.0043
Barium (Ba)	0.21	0.15	0.067	0.067	0.067	0.077	0.074	0.074	0.074	0.074	0.11	0.11	0.11	0.11	0.11
Cadmium (Cd)	0.00044	0.00085	0.00056	0.00056	0.00056	0.00077	0.00077	0.00077	0.00077	0.00077	0.0016	0.0016	0.0016	0.0016	0.0016
Calcium (Ca)	498	498	498	498	498	498	498	498	498	498	498	498	498	498	498
Chromium (Cr)	0.0026	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025
Cobalt (Co)	0.015	0.038	0.042	0.042	0.042	0.0021	0.0051	0.0061	0.0071	0.0067	0.0016	0.0016	0.0019	0.0020	0.0023
Copper (Cu)	2.5	1.0	0.76	0.75	0.75	0.0088	0.018	0.018	0.018	0.018	0.017	0.020	0.024	0.024	0.024
Iron (Fe)	0.58	0.87	6.9	6.8	6.8	3.5	3.5	3.5	3.5	3.5	6.7	6.7	6.7	6.7	6.7
Lead (Pb)	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013
Magnesium (Mg)	5.5	37	57	57	57	8.0	11	12	13	13	2.9	2.7	3.3	3.3	4.1
Manganese (Mn)	0.46	1.3	2.9	2.9	2.9	1.4	1.4	1.4	1.4	1.4	2.7	2.7	2.7	2.7	2.7
Mercury (Hg)	0.000024	0.000029	0.000042	0.000042	0.000042	0.000040	0.000039	0.000039	0.000039	0.000039	0.000010	0.0000085	0.000010	0.000010	0.000013
Molybdenum (Mo)	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.29	0.29	0.29	0.29	0.29
Nickel (Ni)	0.0047	0.013	0.017	0.017	0.017	0.0027	0.0038	0.0041	0.0045	0.0044	0.0025	0.0026	0.0027	0.0027	0.0028
Selenium (Se)	0.0085	0.013	0.012	0.012	0.012	0.0085	0.0088	0.0089	0.0090	0.0090	0.0085	0.0085	0.0086	0.0086	0.0086
Silver (Ag)	0.000072	0.000056	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050
Sodium (Na)	36	57	66	66	66	37	41	41	41	41	38	38	38	38	39
Thallium (Tl)	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050
Uranium (U)	0.011	0.16	0.28	0.28	0.28	0.014	0.028	0.034	0.042	0.039	0.0040	0.0039	0.0059	0.0063	0.0089
Zinc (Zn)	0.054	0.073	0.067	0.067	0.067	0.021	0.025	0.026	0.027	0.026	0.011	0.011	0.012	0.012	0.013

From Lorax (2013)

Appendix IV - B

Water Quality Modelling Results

Table IV - B 1 TMF Pond Water Quality Model Results

Water Quality Model Parameter	TMF Pond Water Quality (mg/L)				TMF Spillway Water Quality (mg/L)			
	Operations	Wetland Construction Phase	TMF Discharge Phase	Pit Discharge Phase	Operations [2]	Wetland Construction Phase [2]	TMF Discharge Phase	Pit Discharge Phase
pH	6.1	6.8	6.9	6.9	-	-	6.9	6.9
Hardness (as $CaCO_3$)	1,178	730	452	381	-	-	452	381
Alkalinity (as $CaCO_3$)	47	106	122	115	-	-	122	115
Sulphate (SO_4)	1,242	695	335	266	-	-	283	225
Chloride (Cl)	34	22	35	31	-	-	35	31
Fluoride (F)	2.1	1.2	0.65	0.63	-	-	0.65	0.63
Aluminum (Al)	2.9	0.47	0.096	0.12	-	-	0.096	0.12
Antimony (Sb)	0.0056	0.0043	0.0096	0.011	-	-	0.0096	0.011
Arsenic (As)	0.0066	0.0043	0.0034	0.0037	-	-	0.0034	0.0037
Barium (Ba)	0.068	0.092	0.089	0.081	-	-	0.089	0.081
Cadmium (Cd)	0.00064	0.00065	0.00034	0.00016	-	-	0.000080	0.000080
Calcium (Ca)	467	273	149	123	-	-	149	123
Chromium (Cr)	0.0026	0.0015	0.00086	0.0011	-	-	0.00086	0.0011
Cobalt (Co)	0.0026	0.0100	0.018	0.038	-	-	0.018	0.038
Copper (Cu)	0.33	0.067	0.11	0.073	-	-	0.0040	0.0040
Iron (Fe)	0.0012	0.00030	0.00022	0.00023	-	-	0.00022	0.00023
Lead (Pb)	0.0015	0.0024	0.0030	0.0025	-	-	0.0030	0.0025
Magnesium (Mg)	3.1	11	19	18	-	-	19	18
Manganese (Mn)	0.47	1.1	0.66	0.47	-	-	0.66	0.47
Mercury (Hg)	0.000011	0.000011	0.000012	0.000015	-	-	0.000012	0.000015
Molybdenum (Mo)	0.37	0.20	0.085	0.066	-	-	0.085	0.066
Nickel (Ni)	0.0080	0.0030	0.0033	0.012	-	-	0.0033	0.012

Water Quality Model Parameter		TMF Pond Water Quality (mg/L)				TMF Spillway Water Quality (mg/L)			
		Operations	Wetland Construction Phase	TMF Discharge Phase	Pit Discharge Phase	Operations [2]	Wetland Construction Phase [2]	TMF Discharge Phase	Pit Discharge Phase
Selenium	(Se)	0.015	0.0069	0.0043	0.0043	-	-	0.0043	0.0043
Silver	(Ag)	0.000058	0.000038	0.000036	0.000059	-	-	0.000036	0.000059
Sodium	(Na)	45	49	29	21	-	-	29	21
Thallium	(Tl)	0.00048	0.00026	0.00012	0.000099	-	-	0.00012	0.000099
Uranium	(U)	0.018	0.033	0.048	0.042	-	-	0.015	0.015
Zinc	(Zn)	0.034	0.015	0.020	0.023	-	-	0.020	0.023

1. Values in this table represent average water quality results over the duration of each mining phase for a single model realization (Realization #1).
2. TMF Spillway will have zero discharge during the Operations and Wetland Discharge Phases.

Table IV - B 2 Fraction Contributing to TMF Pond Water Quality – Operations Phase

Source of Loading	Hard-ness	Alk	SO_4	Cl	F	Al	Sb	As	Ba	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Na	Tl	U	Zn
Background Runoff	1	15	0	86	0	0	0	1	7	1	0	0	0	0	0	12	16	0	2	0	0	0	1	0	0	3	1
Stockpile (runoff + seepage)	1	1	1	0	3	6	17	3	0	44	1	4	40	93	20	9	15	3	26	2	66	9	10	2	2	20	63
Waste Rock Runoff	0	0	0	0	0	0	2	1	0	7	0	4	11	1	0	1	3	0	9	0	2	5	6	1	1	4	13
Tailings Beach Runoff	0	0	0	0	0	0	1	1	0	1	0	1	0	0	0	0	0	0	4	1	0	0	1	0	0	0	0
HLF Drainage	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tailings Slurry	73	35	73	0	72	87	67	76	60	5	74	65	20	1	3	58	30	0	32	78	22	72	59	55	72	54	12
PAG Tailings Pore Water	1	2	1	0	1	0	1	1	1	1	1	1	2	0	3	1	3	3	4	1	0	1	1	1	1	2	1
NAG Tailings Pore Water	15	27	15	0	14	0	7	9	23	36	15	13	9	1	72	12	14	84	12	11	5	8	12	32	15	4	5
Waste Rock Pore Water	1	5	1	0	1	0	1	1	2	1	1	1	12	3	2	1	12	3	3	1	1	1	1	1	1	10	2
WMP Pump Back	8	14	8	14	8	6	6	7	8	6	8	10	5	0	0	7	7	5	8	7	4	5	9	8	8	3	3
North TMF Wetland Discharge	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

1. Average of all years during the Operations Phase, calculated from output from model Realization #1.
2. Shaded cells are for sources that contribute >10% to the overall load.
3. Values are rounded to the nearest 1 and the total of individual values may not add to exactly 100.

Table IV - B 3 Fraction Contributing to TMF Pond Water Quality – Wetland Construction Phase

Source of Loading	Hard-ness	Alk	SO_4	Cl	F	Al	Sb	As	Ba	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Na	Tl	U	Zn
Background Runoff	12	46	3	21	4	68	3	24	55	8	9	7	0	1	2	79	42	2	25	0	7	1	28	5	1	19	23
Stockpile (runoff + seepage)	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0
Waste Rock Runoff	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tailings Beach Runoff	0	1	0	0	7	0	12	14	0	0	0	11	0	0	0	0	1	0	10	5	2	1	6	0	1	2	2
HLF Drainage	2	1	1	79	1	1	57	3	1	2	1	0	60	0	0	1	9	0	1	9	9	14	7	0	0	5	7
Tailings Slurry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PAG Tailings Pore Water	2	1	3	0	2	0	1	1	1	1	2	2	1	0	1	1	1	1	4	2	2	2	2	1	3	1	2
NAG Tailings Pore Water	61	15	71	0	65	3	20	39	34	79	67	61	5	9	73	14	7	73	26	67	27	57	44	68	73	5	23
Waste Rock Pore Water	22	36	22	0	21	0	6	17	6	8	20	19	33	88	23	4	39	23	33	17	52	25	14	25	22	68	39
WMP Pump Back	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
North TMF Wetland Discharge	1	1	0	0	0	26	0	0	2	0	0	0	1	0	1	0	2	0	1	0	1	0	0	0	0	0	4
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

1. Average of all years during the Wetland Construction Phase, calculated from output from model Realization #1.
2. Shaded cells are for sources that contribute >10% to the overall load.
3. Values are rounded to the nearest 1 and the total of individual values may not add to exactly 100.

Table IV - B 4 Fraction Contributing to TMF Pond Water Quality – TMF Discharge Phase

Source of Loading	Hard-ness	Alk	SO_4	Cl	F	Al	Sb	As	Ba	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Na	Tl	U	Zn
Background Runoff	20	48	6	46	7	51	2	27	71	21	17	12	0	1	3	84	34	5	28	0	5	1	26	10	2	17	20
Stockpile (runoff + seepage)	0	0	0	0	0	12	0	0	0	4	0	0	0	13	1	0	0	0	0	0	4	0	0	0	0	0	4
Waste Rock Runoff	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tailings Beach Runoff	1	1	1	0	12	0	5	16	0	1	1	18	0	0	0	0	1	0	11	9	1	1	5	0	1	2	1
HLF Drainage	10	3	3	52	4	3	78	18	4	4	7	3	45	0	0	5	24	0	4	22	4	39	25	1	2	8	19
Tailings Slurry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PAG Tailings Pore Water	1	0	1	0	1	0	0	0	0	1	1	1	0	0	1	0	0	1	1	1	0	1	0	0	1	0	0
NAG Tailings Pore Water	21	3	31	0	25	0	2	9	9	42	26	21	1	2	35	3	1	33	6	26	4	15	9	28	33	1	4
Waste Rock Pore Water	41	41	50	0	42	0	3	22	9	24	42	34	23	84	57	5	35	56	40	35	38	34	14	55	53	70	38
WMP Pump Back	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
North TMF Wetland Discharge	6	3	7	1	9	34	10	8	6	2	7	12	31	0	3	3	4	5	10	7	44	10	20	6	8	3	12
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

1. Average of all years during the TMF Discharge Phase, calculated from output from model Realization #1.
2. Shaded cells are for sources that contribute >10% to the overall load.
3. Values are rounded to the nearest 1 and the total of individual values may not add to exactly 100.

Table IV - B 5 Fraction Contributing to TMF Pond Water Quality – Pit Discharge Phase

Source of Loading	Hard-ness	Alk	SO_4	Cl	F	Al	Sb	As	Ba	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Na	Tl	U	Zn
Background Runoff	17	43	5	90	5	31	1	19	58	30	14	6	0	1	5	76	28	4	17	0	1	1	14	10	2	16	14
Stockpile (runoff + seepage)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Waste Rock Runoff	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tailings Beach Runoff	1	1	1	0	9	0	4	11	0	2	1	10	0	0	0	0	1	0	7	8	0	1	3	0	1	2	1
HLF Drainage	9	3	2	5	3	2	51	12	3	4	6	1	14	0	0	4	19	0	3	17	1	26	14	1	1	6	12
Tailings Slurry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PAG Tailings Pore Water	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NAG Tailings Pore Water	4	1	6	0	4	0	0	1	2	14	5	3	0	0	11	1	0	7	1	6	0	2	1	6	6	0	1
Waste Rock Pore Water	34	36	43	0	30	0	2	15	7	32	35	18	9	96	79	4	28	53	24	31	11	24	8	52	43	63	26
WMP Pump Back	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
North TMF Wetland Discharge	35	16	42	5	49	67	42	42	29	18	39	62	77	2	4	15	24	34	48	38	86	46	60	31	46	13	46
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

1. Average of all years during the Pit Discharge Phase, calculated from output from model Realization #1.
2. Shaded cells are for sources that contribute >10% to the overall load.
3. Values are rounded to the nearest 1 and the total of individual values may not add to exactly 100.

Casino Project
Water Quality Predictions

Appendix V
Seepage Water Management Pond
Water Quality Modelling

Prepared by:

Source
ENVIRONMENTAL ASSOCIATES INC.

February 2015

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1 Introduction

The Casino Project (the Project) is a proposed mining project in the west-central Yukon. The deposit will be mined using open pit methods, with a nominal mill throughput of approximately 120,000 tonnes/day of ore over a 22 year operating life. Milling operations will produce molybdenum and copper concentrates through conventional flotation circuit milling and gold and silver doré will be produced by cyanide heap leaching.

Seepage water and runoff from the TMF embankment and foundation will be collected by an underdrain system and a surface ditch system that discharge into a Water Management Pond (WMP) located downstream of the TMF main embankment (KPL, 2012). Additionally, the WMP will collect hydrocyclone underflow from the tailings sand used to construct the TMF Embankment. All water collected in the WMP will be pumped back to the TMF Pond during Operations.

Following mine closure, seepage recovered downstream from the TMF embankments will be stored in the WMP through the low flow months of the year (winter), and released during months when Casino Creek flows are higher (spring, summer, and fall) when the seepage water can mix with the TMF Spillway discharge prior to entering Casino Creek.

A water quality model was developed to predict mine drainage water quality and the potential for effects on the receiving environment of the proposed Casino Mine. A site-wide water balance was developed by Knight Piésold Limited (KPL) and was used by Source Environmental Associates Inc. (SEA) as the basis for the water quality model. The water balance and the water quality models were fully integrated in GoldSim.

A water balance model was initially developed by KPL in 2013 (and is described in KP. 2013a). The 2013 water balance was run using average annual estimates for hydrologic conditions at the site. Water quality modelling for the average annual water balance was carried out by SEA. Modelling methodology and results were reported in SEA (2013).

In 2014, a climate variability water balance model was developed by KPL (and is described in KPL, 2015) to account for the expected variability in hydrological conditions (i.e. wet and dry periods) from year to year. SEA used the climate variability water balance as the basis for the water quality model that is described herein.

This report presents the methodology and results of the water quality predictions for the WMP model. This report contains all information relevant to the water quality model, and repeats the pertinent information previously provided in the December 2013 report (SEA, 2013). A comparison between the SEA (2013) Pit Lake water quality modelling report and this report is provided in Table 1-1.

Table 1-1. Comparison between 2013 and 2015 Modelling Reports

Concept	SEA (2013) Report	Applies to this Report
Water Balance Input Dataset	Average monthly hydrologic conditions (e.g. precipitation, temperature, streamflow, etc.) were used as input for every year of the model simulation.	Inter-annual variation in hydrologic conditions was applied throughout the model simulation. Water balance output flows were calculated from a synthetic, long-term (52 year) input dataset of monthly hydrologic conditions. The synthetic dataset was derived from regional and site data. **Rationale:** Using the range of monthly flows is more conservative (compared to using average annual flows) because realistic wet and dry periods can be simulated.
Estimation of Wet and Dry Years	n/a - wet and dry years were not simulated.	1-in-10 year wet and dry years were identified in the water quality output time-series plots. **Rationale:** To illustrate how the water quality management system will perform as a results of infrequent wet/dry periods.
Monte-Carlo Analysis (Stochastic Modelling)	Stochastic modelling was not carried out.	Model simulations included 52 unique input hydrology datasets. A statistical summary was generated from the water quality model output for the 52 realizations. **Rationale:** To account for all possible water balance flow scenarios that could result from the input hydrology dataset.
Project Phase Start Dates for TMF Discharge Phase and Pit Discharge Phase	Project dates were based on KPL (2013) water balance model output.	Project dates were based on KPL (2015) water balance model results.
TMF Seepage Cut-Off System	The TMF seepage cut-off system was to be constructed after Operations. As a result, during Operations, the WMP was assumed to have a 90% capture efficiency with 10% seepage by-pass to Casino Creek. Following Operations, the seepage cut-off system was to be constructed, resulting in 100% seepage capture efficiency (i.e. 0% by-pass).	The seepage cut-off system will be constructed prior to Operations. The seepage collection system was assumed to have 100% capture efficiency during Operations and for all subsequent mine phases. **Rationale**: Reduce the potential for seepage water to enter Casino Creek during Operations.

Concept	SEA (2013) Report	Applies to this Report
Water Management Pond (WMP) / Winter Seepage Mitigation Pond (WSMP)	WMP was to be online for seepage collection during Operations. Following operations, the WSMP was to be used for seepage collection in winter and release during summer. Both facilities were essentially situated in the same location.	For all phases, the seepage collection pond(s) will be referred to as the WMP. **Rationale**: Simplification of terminology.
WMP Pumping to the Open Pit (Wetland Construction Phase)	During the Wetland Construction Phase, the WMP was assumed to be pumped to the TMF Pond.	During the wetland construction phase, the WMP will be pumped to the Open Pit. **Rationale:** Mass load from the WMP by-passes the TMF Pond by pumping directly to the Open Pit.
WMP Release to Casino Creek	Release from the seepage pond was set at a constant rate of 130 L/s from May to August with flows gradually reduced to 50 L/s by November.	Release of WMP was set to 0.8 times flow in Brynelson for typical conditions. To ensure sufficient seepage storage capacity for the following winter an increased release rate (above 0.8 times Brynelson flow) will be used during exceptionally dry periods, to drain-down the WMP. **Rationale:** The available dilution in Brynelson will be utilized by proportioning the release of WMP to the natural hydrograph.
TMF Pond Release to Casino Creek	TMF Pond was allowed to naturally overflow seasonally with no control of the flow rate.	The TMF pond will be released in a controlled manner. The ratio of TMF pond release to WMP release will be set between 1.2 to 2.5, depending on the Project Phase and the month. The ratio increases when there is little flow in Brynelson to provide dilution of the seepage released. **Rationale**: The available dilution in Brynelson is utilized by tying the release of WMP to the natural hydrograph.

Concept	SEA (2013) Report	Applies to this Report
Location of GoldSim-PHREEQC modelling nodes Embedded in the Water Quality Model	Solubility limits were calculated (using PHREEQC) for the following nodes: • Open Pit • TMF Pond • "Mixing Point" (upstream from H18 – where TMF Pond and WMP water mix)	Solubility limits were calculated (using PHREEQC) for the following nodes: • Open Pit • TMF Pond • WMP **Rationale:** Contact of WMP seepage with atmospheric conditions will occur in the WMP and chemical precipitation is more likely to occur in the WMP, rather than at the mixing point.
pH Prediction	pH was calculated for mine contact water (TMF Pond, WMP, Open Pit) using PHREEQC. pH was not calculated for Casino and Dip Creeks.	pH was calculated (using PHREEQC) for mine contact water, Casino Creek and Dip Creek modelling points.
CoC List	7 CoCs were reported. The CoC list did not include fluoride.	Fluoride was added as a CoC, so 8 CoCs are reported. **Rationale**: Fluoride was added as it exceeded a generic water quality guideline

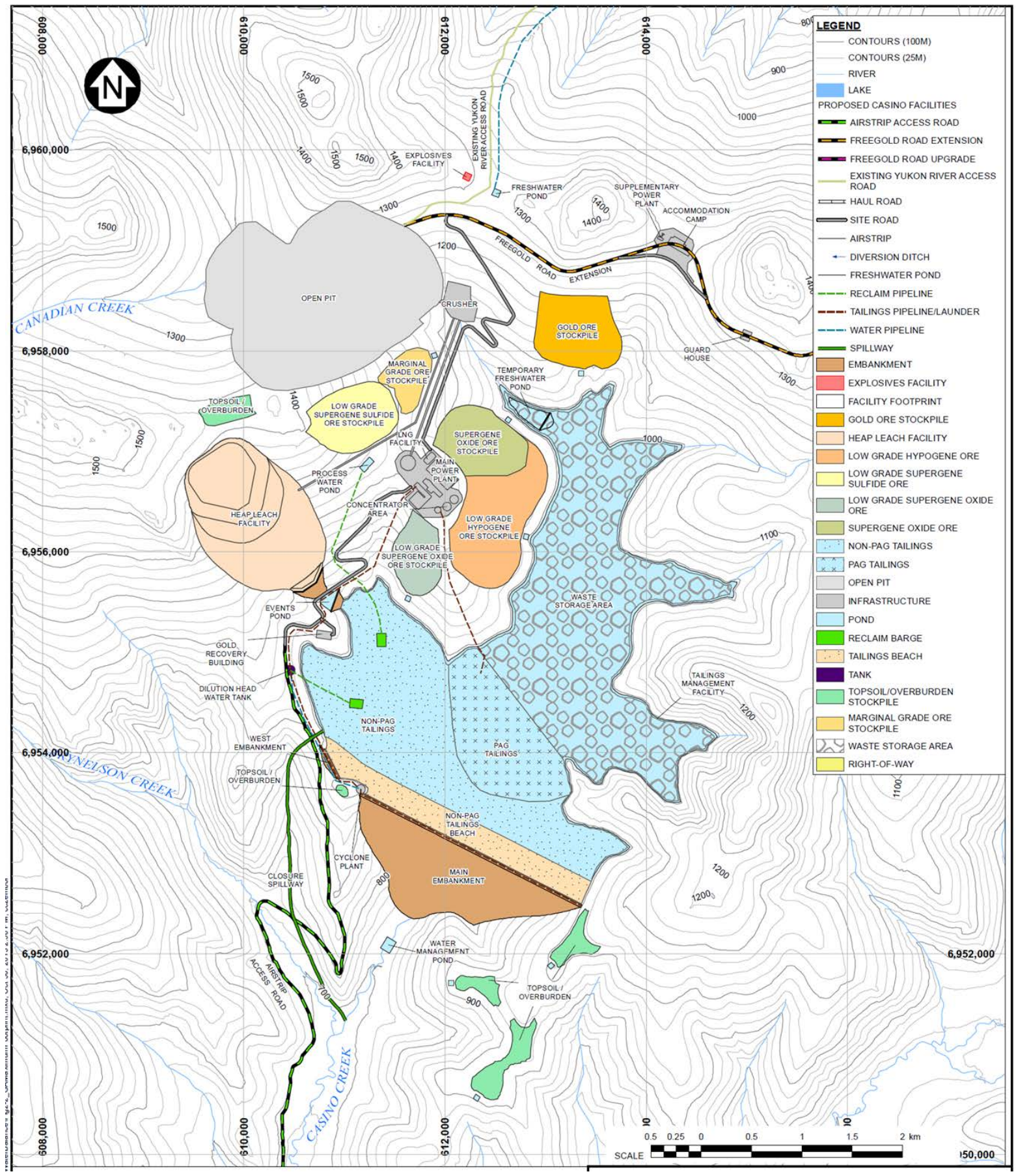
2 Casino Project Water Management Phases

For the purposes of water quality modeling, the Casino Project was sub-divided into five water management phases in (Table 2-1). Project years are described in years relative to the beginning of milling operations. For example, Year -2 refers to the second year before Operations begins, and Year 2 refers to the second year of Operations.

Layout of the Project site is illustrated in Figure 2-1 for Operations. Long-term conditions following mine closure are shown on Figure 2-2.

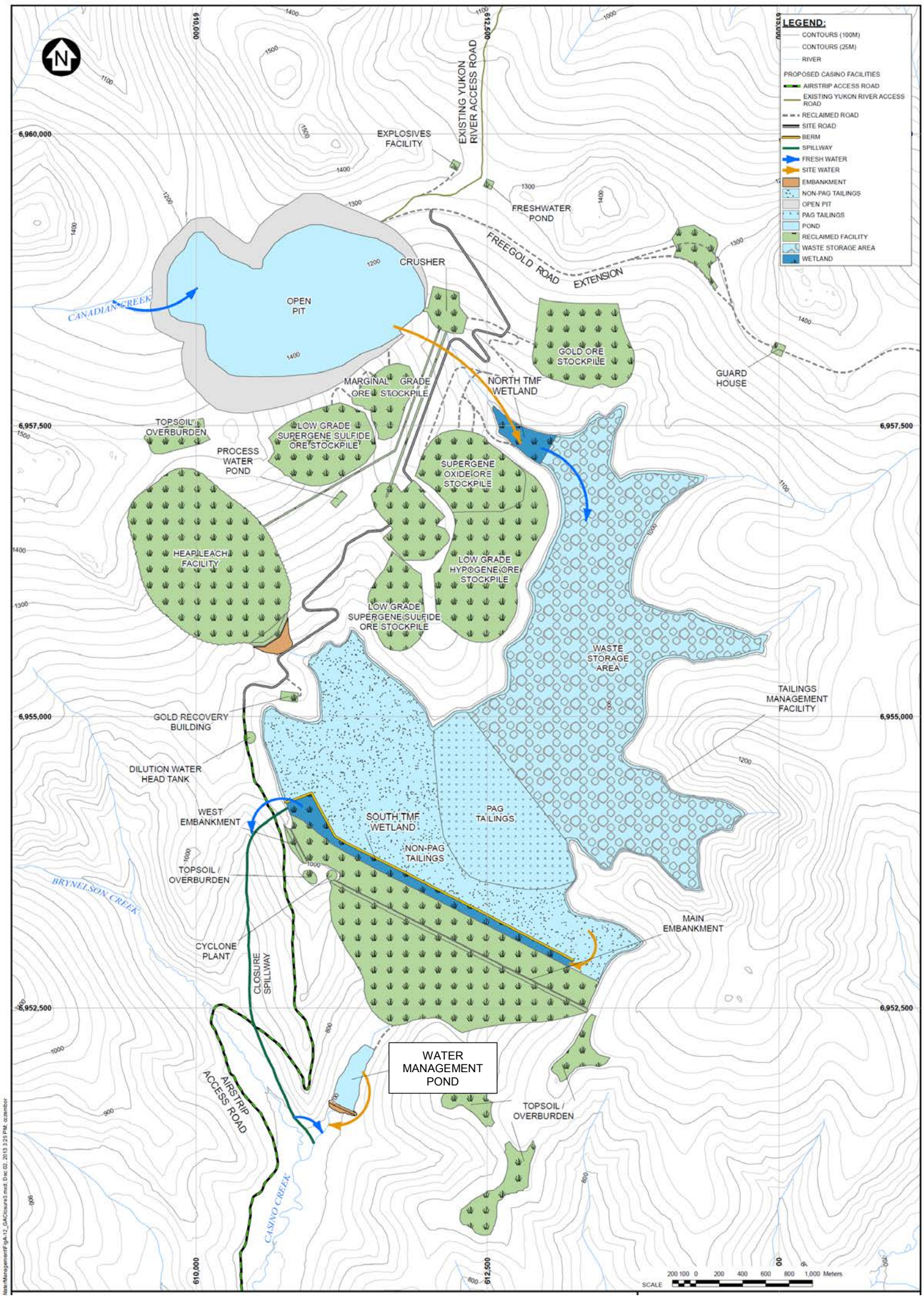
Table 2-1. Water Management Phases

Water Management Phase	Project Year	Project Activities Relevant to WMP and WSMP
Construction	-4 to -1	• Construction of the TMF and associated mining infrastructure. • WMP constructed downstream of the TMF to control sediment and detain runoff from disturbed areas. • Water collected in WMP pumped to TMF Pond.
Operations	1 to 22	• Mining and processing of ore. • Water from TMF embankment and foundation seepage, surface runoff, and embankment construction water collected in the WMP and pumped back to the TMF Pond.
Wetland Construction	23 to 34	• Cessation of milling. • Pump back from the WMP the Open Pit. • Re-vegetation of the TMF Embankment.
TMF Discharge	35 to 109	• Storage of recovered seepage downstream from the TMF embankments in the WMP through the low flow months of the year (winter) and release to Casino Creek during the open water season.
Pit Discharge	> 109	



Source: Casino YESAB Water Balance Report (KPL, 2013a)

Figure 2-1. Casino Project Overview (Operations)



Source: Casino YESAB Water Balance Report (KPL, 2013a)

Figure 2-2. Casino Project Overview (Pit Discharge Phase)

3 Model Overview

A site-wide water balance model was developed by KPL and was used as the basis for the water quality model. The water balance and the water quality models were fully integrated in GoldSim. SEA combined the water balance flows with mine loading source terms (Lorax, 2013), and background water quality to predict water quality in the WMP for 27 water quality parameters.

A 52-year model input dataset of monthly weather conditions was developed by KPL in order to simulate the natural variability in hydrologic conditions (i.e. wet and dry periods) that can be expected at the site. The model was run over a time-frame from beginning of Pit Lake formation, to 200 years after the beginning of Operations. Because the model was run over a simulation period of ~200 years, the 52-year input dataset repeated approximately four times during a given simulation.

The model results are presented in two ways in this report:

1) Single Model Realization

   Results generated when one realization of the input hydrology dataset was run with the model. Single realization results provide a time-series of model output which shows a representation of water quality that would result from a realistic range in hydrological conditions at the site. The output provides an indication of how high (or low) water quality concentrations may get, and how often those results are expected to occur. Time-series plots and summary tables of water quality results for a single realization are presented throughout this report.

2) Monte-Carlo Summary (52 Realizations)

   The model was run 52 times. Each model run used a unique input hydrology dataset. The combined output from the 52 model runs (i.e. realizations) represents the range in all possible model outputs resulting from all the possible permutations of the input hydrology dataset. Average annual water balance results presented in this report were generated from the Monte-Carlo Summary results.

Schematics are provided to illustrate the mass transport pathways associated with the WMP during Operations (Figure 3-1), Wetland Construction Phase (Figure 3-2), and the TMF and Pit Discharge Phases (Figure 3-3). Tables of model input and output values are provided for each modelled water quality parameter in Appendix V - A (model input) and Appendix V - B (model results).

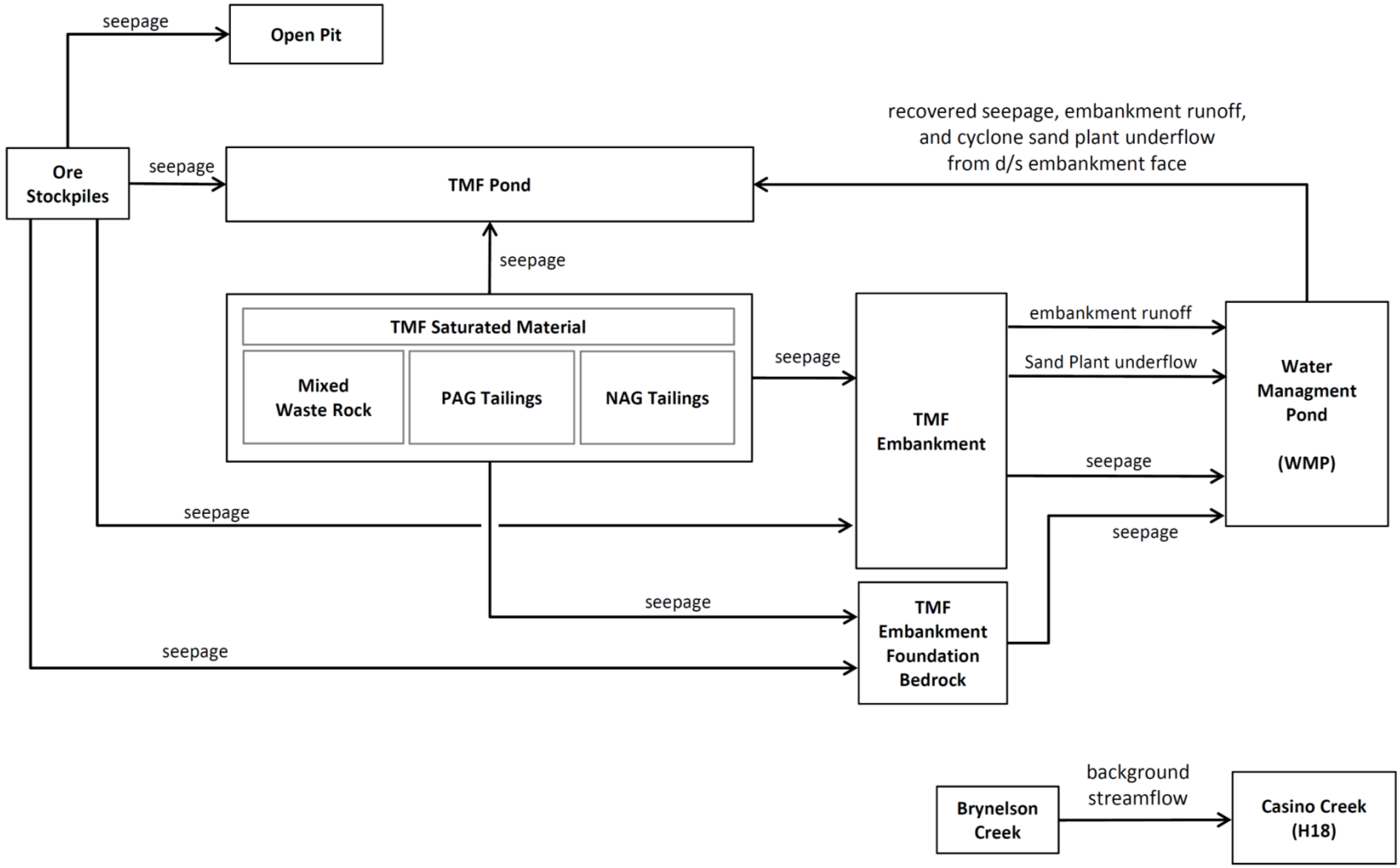


Figure 3-1. Mass Transport Flow Paths Associated with the WMP (Operations Phase)

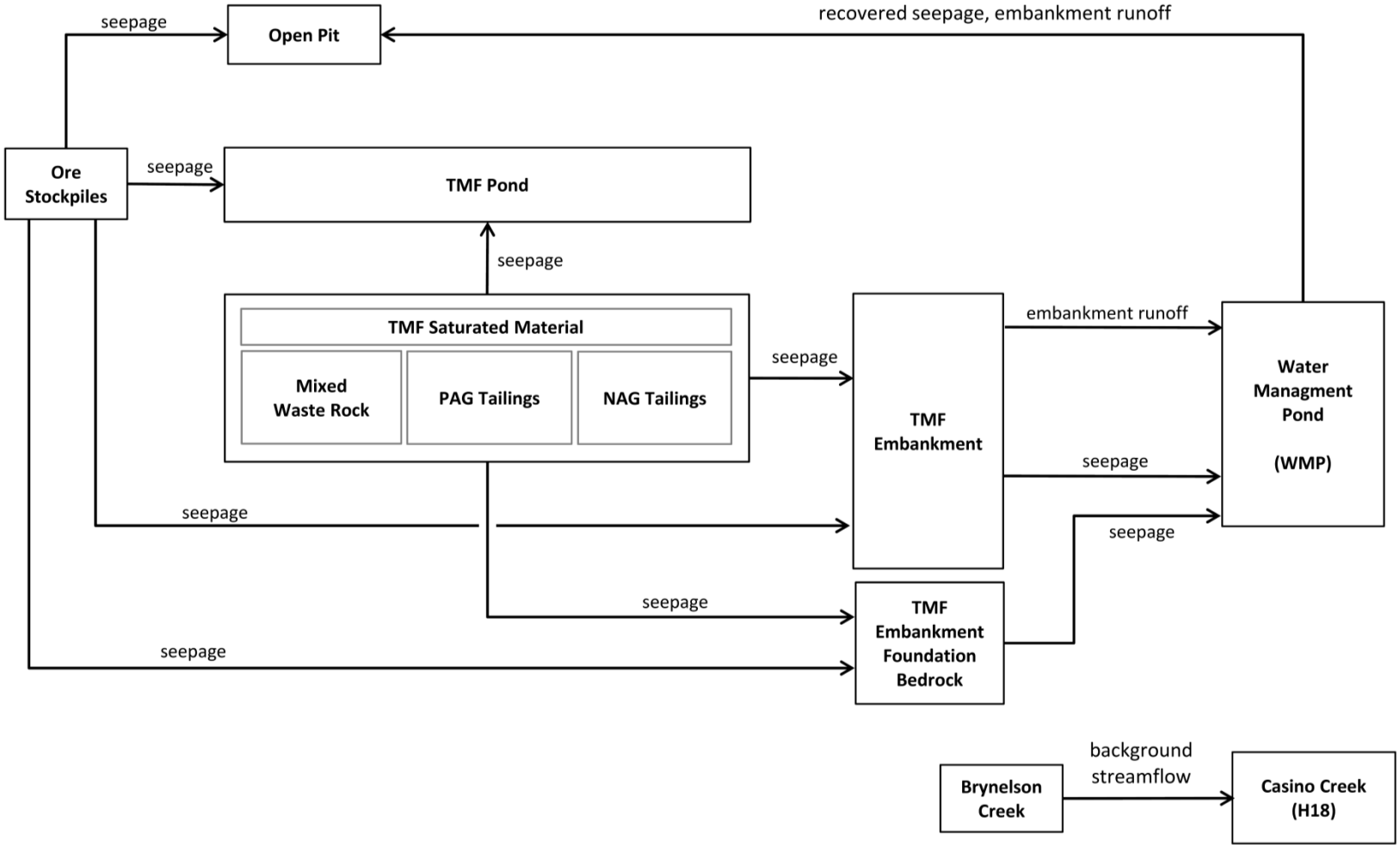


Figure 3-2. Mass Transport Flow Paths Associated with the WMP (Wetland Construction Phase)

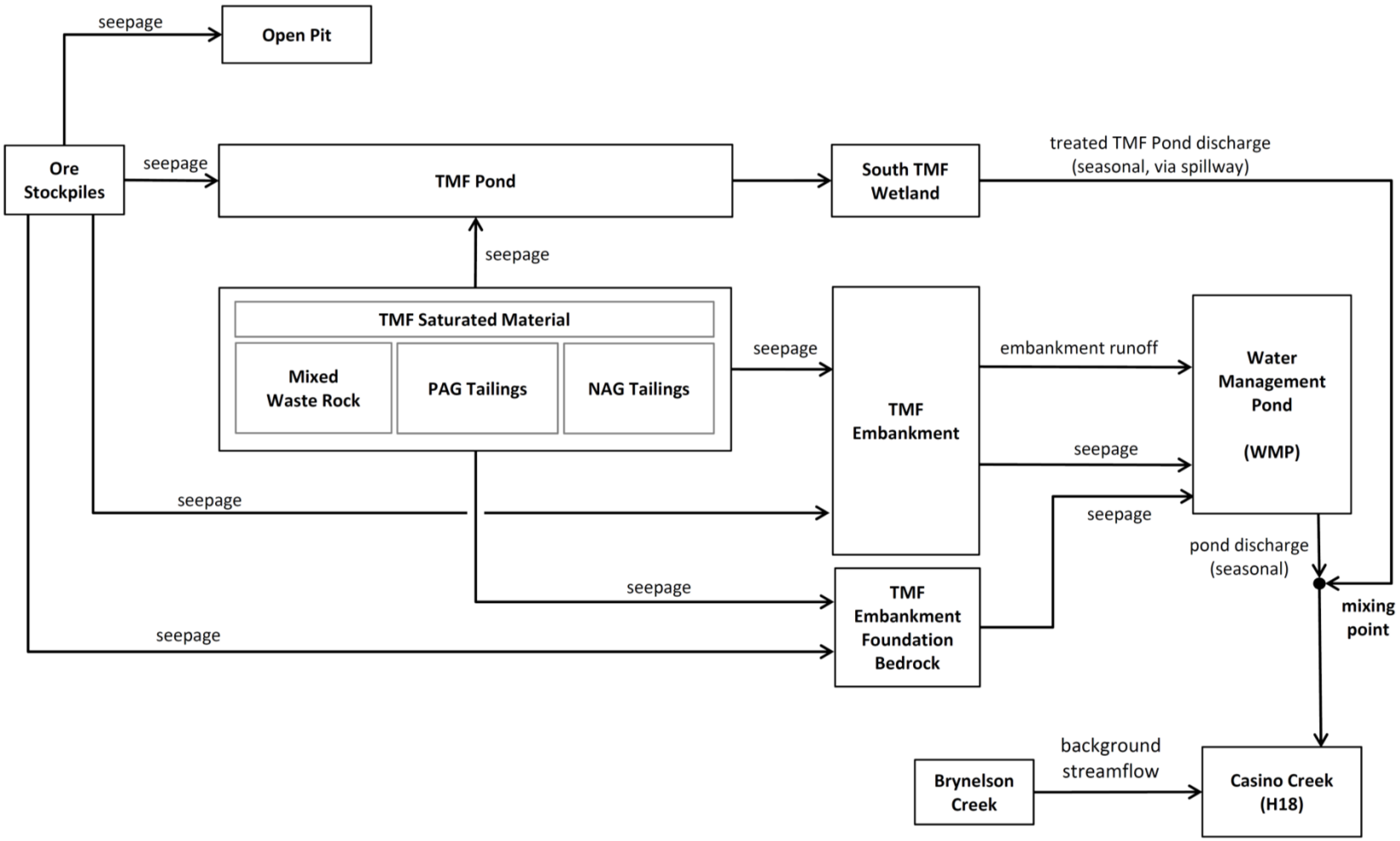


Figure 3-3. Mass Transport Flow Paths Associated with the WMP (TMF Discharge and Pit Discharge Phases)

4 Water Balance Model

WMP inflow and outflow rates from the KPL water balance (2015) are summarized by SEA in Table 4-1 to illustrate the annual flow rates over the duration of the water quality model. The results represent the average results between 52 model realizations.

Foundation and embankment seepage are expected to increase with the size of the TMF embankment. Seepage rates through the embankment and foundation were predicted by KPL (2013b) using numerical groundwater modelling, and were accounted for by KPL in their water balance model (KPL 2015).

In the TMF Discharge Phase (and beyond), seepage recovered downstream from the TMF embankments will be stored in the WMP through the low flow months of the year (winter), and seepage will be released concurrently with the TMF Spillway discharge. Withdrawal and discharge from the WMP pond will occur May to November through the following controls:

- In May, once Brynelson Creek is discharging at 20 L/s or more, the WMP will discharge at a ratio of 0.8 times the Brynelson Creek Flow. From June to November under typical conditions in Brynelson, the WMP will discharge at this ratio until the WMP is empty and water is released as it comes in (minimum flow expected to be 36 L/s of TMF seepage). However, for years with exceptionally low flow in Brynelson, the WMP will need to be discharged at a rate of up to 200 L/s to drain down stored water in the WMP in order to ensure there is storage capacity available for the following winter months.

- The release of the TMF pond will be controlled to further mitigate water quality in Casino Creek. This is especially important for drier periods when there is little-to-no water in Brynelson Creek. The ratio of TMF pond release to WMP release is set at 1.2 for June to November and 2.0 for May for the TMF Discharge Phase. These ratios were determined to avoid excess draw-down in the TMF pond and provide for a sufficient water cover over waste rock and tailings. The ratio of TMF pond release to WMP release varies from 1.2 to 2.5 for the Pit Discharge Phase as there is more water available in the TMF once the pit starts to discharge.

Table 4-1. WMP Water Balance Results

Water Management Phase	Project Year	Average Annual Inflow (L/s) [1]						Outflow (L/s) [1]		
		Overland Runoff	Embank-ment Runoff	Embank-ment Seepage	Founda-tion Seepage	Sand Plant Underflow	Total	Pump-back to TMF Pond	Pump-back to Pit	Seasonal Release
Operations	1	15.6	1.8	0.8	0.8	141	160	160	0	0
	2	15.6	2.7	2.3	2.4	156	179	179	0	0
	3	15.7	3.7	3.9	4.0	159	187	187	0	0
	4	15.7	4.4	4.9	5.5	170	200	200	0	0
	5	15.6	4.8	5.3	6.9	173	205	206	0	0
	6	15.6	5.3	5.8	8.3	168	203	203	0	0
	7	15.6	5.7	6.2	9.7	169	206	206	0	0
	8	15.7	6.2	6.6	11	175	215	215	0	0
	9	15.7	6.7	7.1	12	176	218	218	0	0
	10	15.7	7.3	7.6	14	171	215	215	0	0
	11	15.5	7.4	8.3	15	173	219	219	0	0
	12	15.6	7.9	9.0	16	178	226	226	0	0
	13	15.7	8.2	9.6	17	178	228	228	0	0
	14	15.7	8.7	10	17	179	231	231	0	0
	15	15.6	9.1	11	18	177	231	231	0	0
	16	15.8	9.4	12	19	175	231	231	0	0
	17	15.6	9.7	12	20	79	137	137	0	0
	18	15.6	10.1	13	21	73	133	133	0	0
	19	15.7	10.4	14	22	74	135	135	0	0
	20	15.7	10.6	14	22	55	117	118	0	0
	21	15.7	10.9	15	23	53	118	118	0	0
	22	15.6	10.8	15	22	0	64	64	0	0
Wetland Construction	23 - 34	9.1	10.9	14	22	0	56	0	56	0
TMF Discharge	35 - 109	9.1	10.8	14	22	0	56	0	0	56
Pit Discharge	> 109	9.1	10.8	14	22	0	56	0	0	56

1. Flow rates reported in this table are average results from 52 model realizations over the duration of each water management phase.

5 Water Quality Model

This section provides a description of the modelling methodology that was used for the prediction of mass transport of substances to the WMP and the resulting water quality. Relevant water balance components are discussed where applicable to the water quality modelling calculations.

5.1 WMP Inflows

Inflows to the WMP include: overland runoff; TMF embankment runoff; TMF embankment and foundation seepage collected by the seepage collection system; Cyclone Sand Plant underflow water; and, groundwater impacted by ore stockpile seepage.

5.1.1 Background Overland Runoff

Runoff from the undisturbed upslope area (i.e. background runoff) of the WMP will be collected in the pond. Mean annual runoff into the WMP is presented in Table 4-1. Median annual water quality from baseline sampling station at Brynelson Creek (W18) was used to calculate the mass loading to the WMP. Input water quality values are provided in Appendix V - A (Table V - A 1).

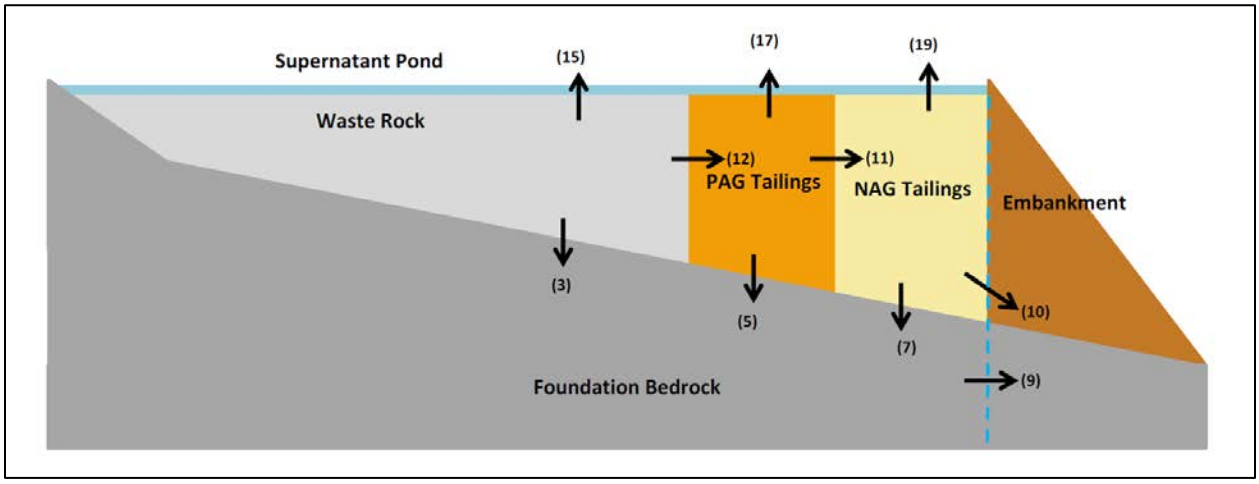
5.1.2 TMF Embankment Runoff

NAG tailings will be used for the production of cyclone sand for construction of the TMF Embankments (KPL, 2012). According to KPL (2013a), the final drainage area of the embankments will be 1.2 km^2. Runoff from the downstream face of the embankments will be intercepted by collection ditches and directed to the WMP. Average annual runoff from the embankment is provided in Table 4-1.

The mass loading rate of the embankment runoff into the WMP was calculated as the monthly flow rate, multiplied by the runoff concentration. The embankment face will be re-vegetated upon mine closure. As a result, metal and sulphate leaching rates are expected to be lower following Operations because the re-vegetation will reduce contact of water with the embankment sand. Lorax (2013) provided runoff concentrations for Operations and for a reclaimed embankment surface (Appendix V-A, Table V - A 1). The reclaimed embankment concentrations were assumed to commence in Year 26, which corresponds to a few years following the end of Operations after vegetation becomes established on the reclaimed surface.

5.1.3 TMF Embankment and Foundation Seepage

Seepage through the TMF foundation and embankment will be collected in the WMP. Lorax provided a schematic of TMF seepage flow paths to illustrate the sources and receptors of TMF seepage (Figure 5-1). Embankment seepage to the WMP is represented by flow path (10), and foundation seepage to the WMP is represented by flow path (9). The foundation and embankment seepage flow rates are expected to increase with the size of the TMF facility and embankment footprint. Average annual seepage rates are provided in Table 4-1.



Source: Lorax (2013), Figure 7-2

Figure 5-1. TMF Seepage Flow Paths

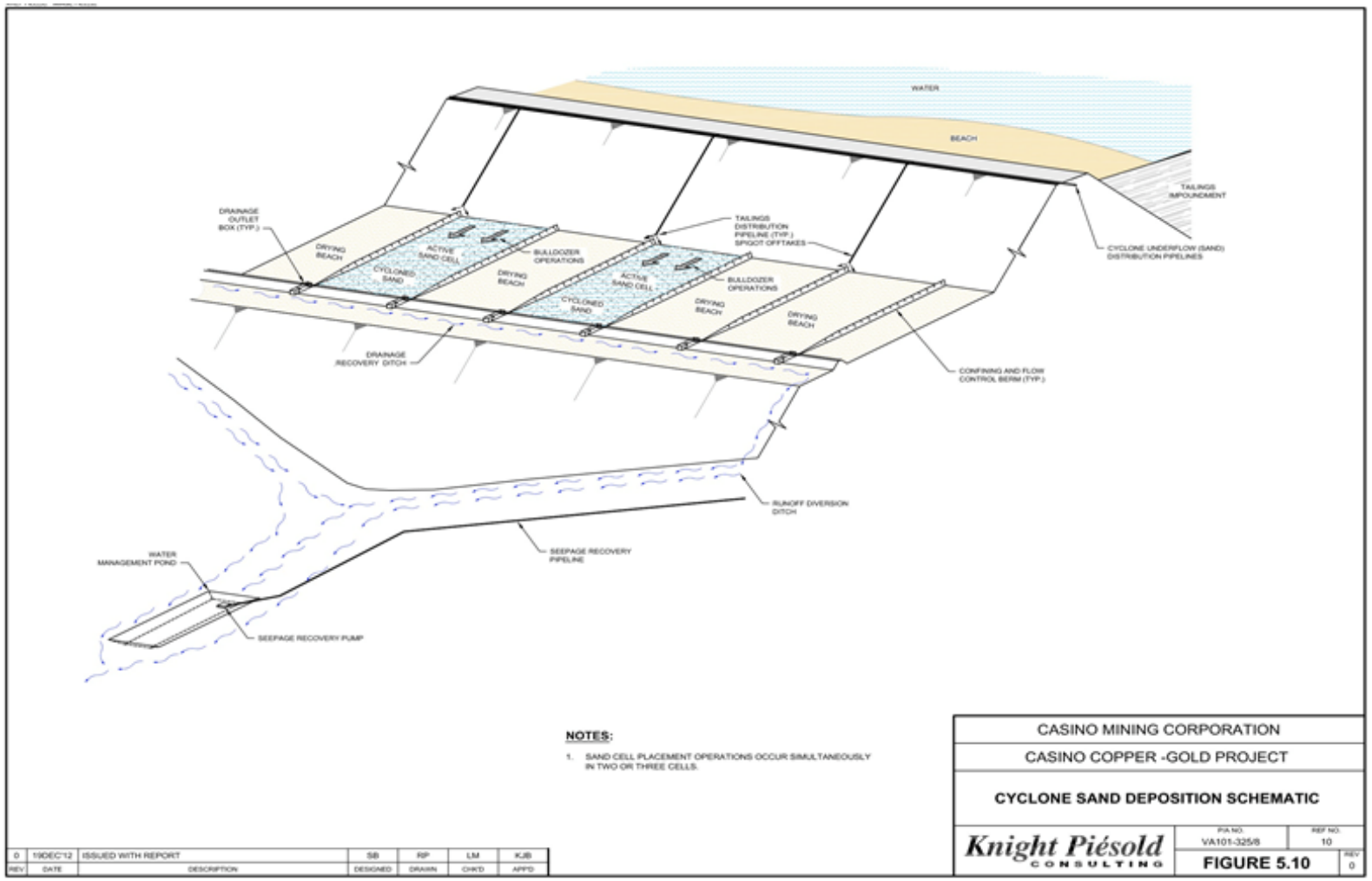
According to Lorax (2013), the seepage water quality will change throughout Operations because it will be affected by the quantity of the waste rock and tailings deposited in the TMF. Lorax provided source terms for the following stages of TMF Development: Year 4, 9, 19, 22, and >22 (Appendix V - A, Table V - A 1). Mass loading into the WMP was calculated by multiplying the seepage water quality by the seepage flow rate over a given time step. Seepage concentrations for years not explicitly provided by Lorax were assumed to be equal to the nearest later year (i.e., Years 0-4 were equal to Year 4, Years 5-9 were equal to Year 9, etc.).

TMF seepage was assumed to travel instantaneously from the source to receptor (i.e. through the embankment and through the foundation).

5.1.4 Cyclone Sand Plant Underflow (Embankment Construction Water)

During Operations, cyclone sand will be produced from bulk NAG tailings and discharged to the embankment for construction. Water expelled from the sand will be collected in the WMP (Figure 5-2).

Mill process (tailings slurry) water was used to represent the water quality of the embankment construction water. Loading into the WMP Pond was calculated as the concentration in the slurry water multiplied by the total slurry water inflow rate. Tailings slurry water quality changes over time for certain parameters, as discussed in Appendix IV – TMF Pond Water Quality Modelling.



Source: KPL (2012)

Figure 5-2. Cyclone Sand Deposition Schematic

5.1.5 Ore Stockpile Seepage

While the ore stockpiles are present during Operations, contact water (from rainfall and snowmelt) will drain from the rock as runoff or infiltration to groundwater. Runoff from the stockpiles will be captured by the TMF Pond.

Hydrogeological modelling (KPL, 2013b) indicated that depending on the stockpile location, infiltrated contact water will flow to one or more of the following receptors: the TMF Pond; Open Pit; TMF Embankment (towards the WMP); or TMF Foundation bedrock (towards the WMP). SEA estimated an average travel time from a range of seepage travel times provided by KPL (2013b) and assumed that the mass load associated with the stockpile seepage will report to the WMP after a lag-time equal to the seepage travel time (Table 5-1).

Table 5-1. Seepage Travel Time from Stockpiles to WMP

Stockpile	Seepage Travel time to WMP via TMF Embankment [1] (years)	Seepage Travel time to WMP via TMF Foundation [1] (years)
Gold Ore	(note 2)	(note 2)
Marginal Grade Ore	(note 2)	(note 2)
Supergene Oxide Ore	8.3	(note 2)
Low Grade Supergene Oxide Ore[3]	7.7	28
Low Grade Supergene Sulphide Ore	(note 2)	(note 2)
Low Grade Hypogene Ore	8.3	15

1. Average estimated travel time from KPL (2013b) hydrogeological modelling assessment.
2. Not expected to report to the TMF Embankment or Foundation
3. Seepage interception at the source (with 90% efficiency) is planned for this pile

Seepage and runoff concentrations into the groundwater were calculated by combining the seepage flow rates with mass loading rates. Calculation methodology of stockpile mass loading is described in Appendix II - Ore Stockpile Water Quality Modelling.

5.2 WMP Outflow

5.2.1 WMP Pump-back (Operations and Wetland Construction Phases)

KPL (2015) assumed that 100% of water collected in the WMP will be pumped back to the TMF during Operations and to the Open Pit during the Wetland Construction Phase. Average annual flow is presented in Table 4-1. Water quality in the WMP was multiplied by the monthly pumping rate to calculate mass loading from the WMP to the TMF Pond and Open Pit.

5.2.2 WMP Seasonal Release to Casino Creek (TMF Discharge and Pit Discharge Phases)

The KPL (2015) water balance simulated the release of water from WMP to Casino Creek from May to November (inclusive), and flow rate would be proportional to the flow rate in Brynelson Creek, the main tributary to Casino Creek immediately downstream from the Project site. The WMP will collect seepage (i.e. no discharge to Casino Creek) from December to April. Logic used in the water balance for release of WMP water is described in Section 4 (Water Balance). WMP water quality was multiplied by the monthly discharge rate to calculate mass loading into Casino Creek during a given time-step.

5.3 Calculation of Water Quality in the WMP

Water quality in the WMP was calculated in GoldSim with a cell pathway. The WMP Pond mixing model output concentrations were assessed for solubility controls at each time step of the model simulation by coupling GoldSim and PHREEQC. PHREEQC is a geochemical modelling software developed by the United States Geological Survey. To accurately predict pH, all water quality inputs to PHREEQC were charge balanced, and the residual balance was placed on either chloride or sodium. During each timestep, Goldsim ran PHREEQC and the resulting concentrations returned from PHREEQC were linked to the WMP water quality. Input assumptions are provided in Table 5-2.

Table 5-2. PHREEQC Assumptions used in the WMP Model

PHREEQC Input Assumptions	
Equilibrium Phases (minerals form solid phase - precipitate forms)	$Fe(OH)_3(a)$, $Al(OH)_3(a)$
Database	wateq4f
pH	Charge balance (PHREEQC determines pH of solution and alkalinity)
PE	10 (oxidizing)
Temperature	5^0C
Oxygen	atmospheric conditions
CO2	atmospheric conditions

6 Results and Discussion

WMP water quality results are provided for select parameters in Table 6-1 and for the full set of modelled parameters in Appendix V - B (Table V – B1).

Time series plots for select parameters are provided on Figure 6-1 to Figure 6-9 for a single realization of the model. Wet and dry years with 10 year return periods are identified on the plots to help illustrate the effects of inter-annual variation in hydrologic conditions on water quality. The model results show that wet and dry hydrologic conditions result in minimal inter-annual variation in WMP water quality during the TMF Discharge Phase and the Pit Discharge Phase. WMP water quality is dominated by seepage water which was modelled as a constant, year-round flow rate (i.e. it does not vary during wet and dry periods).

Seasonal variation in WMP water quality is most noticeable in the model results because seepage water inflow is constant, and surface water only enters during the warmer months. In general (following Operations), concentrations increase throughout the winter months when seepage alone enters the WMP, and concentrations reduce through the open water season as surface water enters the WMP and water is released to Casino Creek.

The WMP water quality is higher for some parameters such as cadmium (Figure 6-36-4) and molybdenum (Figure 6-7) during the first few years following Operations. This is a result of the source terms that were applied to represent embankment runoff water quality. The post-closure source term for embankment runoff was applied beginning in Year 26. Prior to that, the Operations source term was applied. Source terms are presented in Appendix V - B (Table V-A1).

The pH of the WMP was determined with PHREEQC to be near neutral. A time-series plot of modelled pH is provided in Figure 6-10.

Table 6-1. Water Quality Model Results for the WMP

Water Quality Model Parameter	WMP Quality (mg/L)		
	Recovered to TMF (Operations Phase)	Recovered to Pit (Wetland Construction Phase)	Released to Casino Creek (TMF Discharge and Pit Discharge Phases)
pH	6.2	6.4	6.4
Sulphate (SO_4)	1,137	954	979
Fluoride (F)	1.9	1.8	1.8
Cadmium (Cd)	0.00063	0.0014	0.0012
Copper (Cu)	0.021	0.043	0.038
Iron (Fe)	0.0011	0.00057	0.00059
Molybdenum (Mo)	0.27	0.30	0.24
Selenium (Se)	0.0075	0.0073	0.0072
Uranium (U)	0.0095	0.036	0.036

1. Values represent average water quality results over the duration of each mining phase for a single model realization (Realization #1).

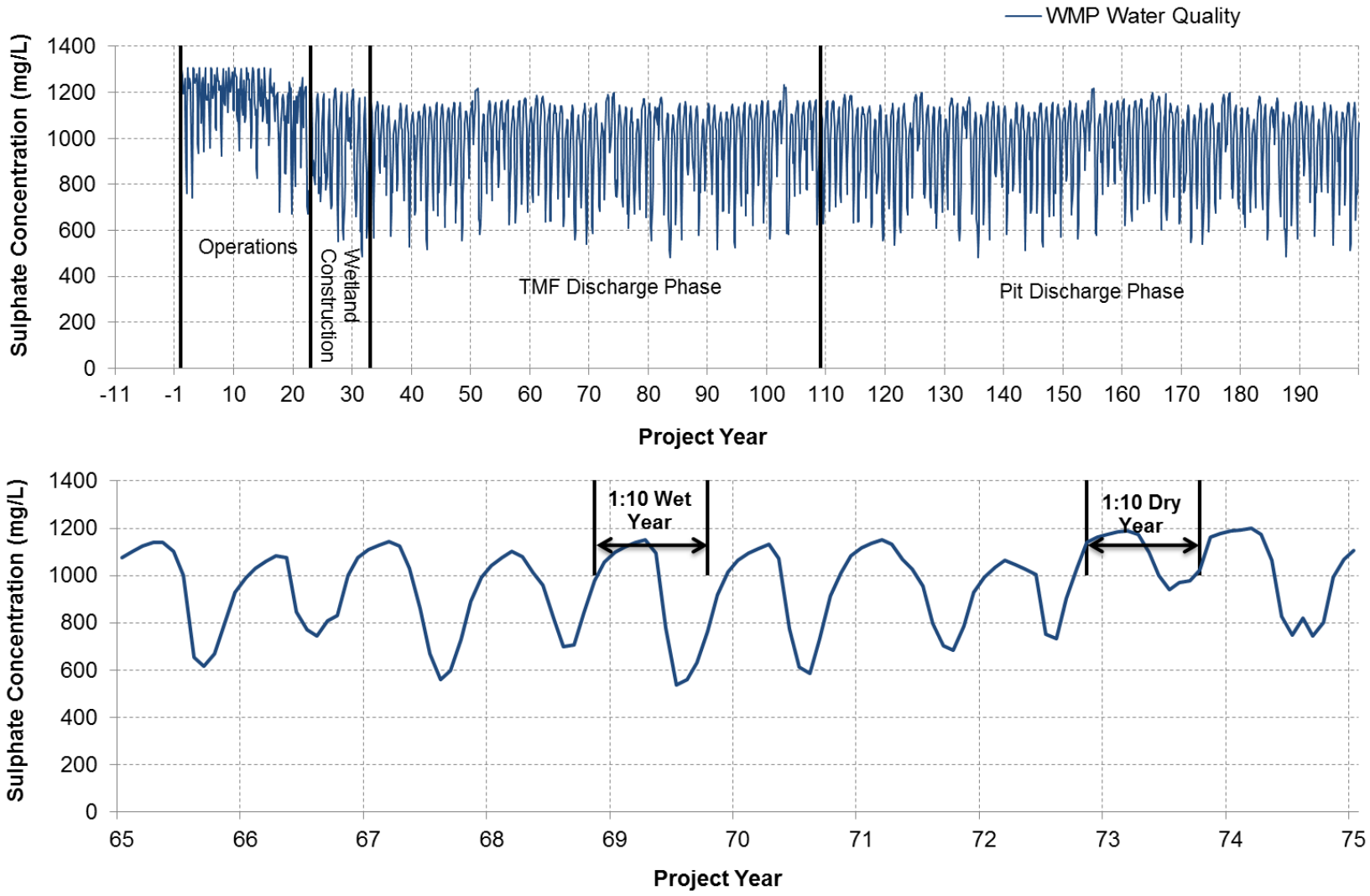


Figure 6-1. Modelled Sulphate Water Quality in the WMP

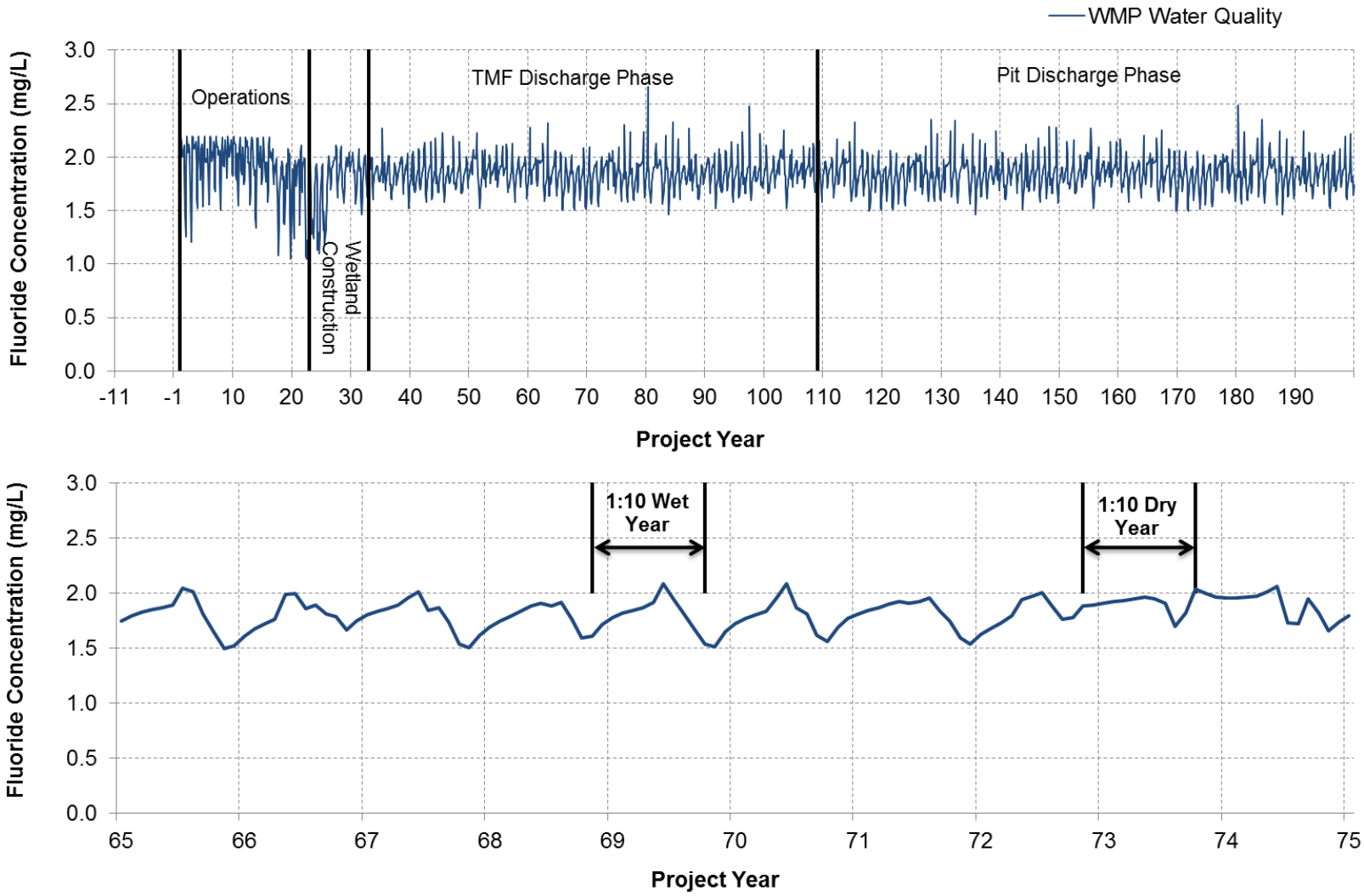


Figure 6-2. Modelled Fluoride Water Quality in the WMP

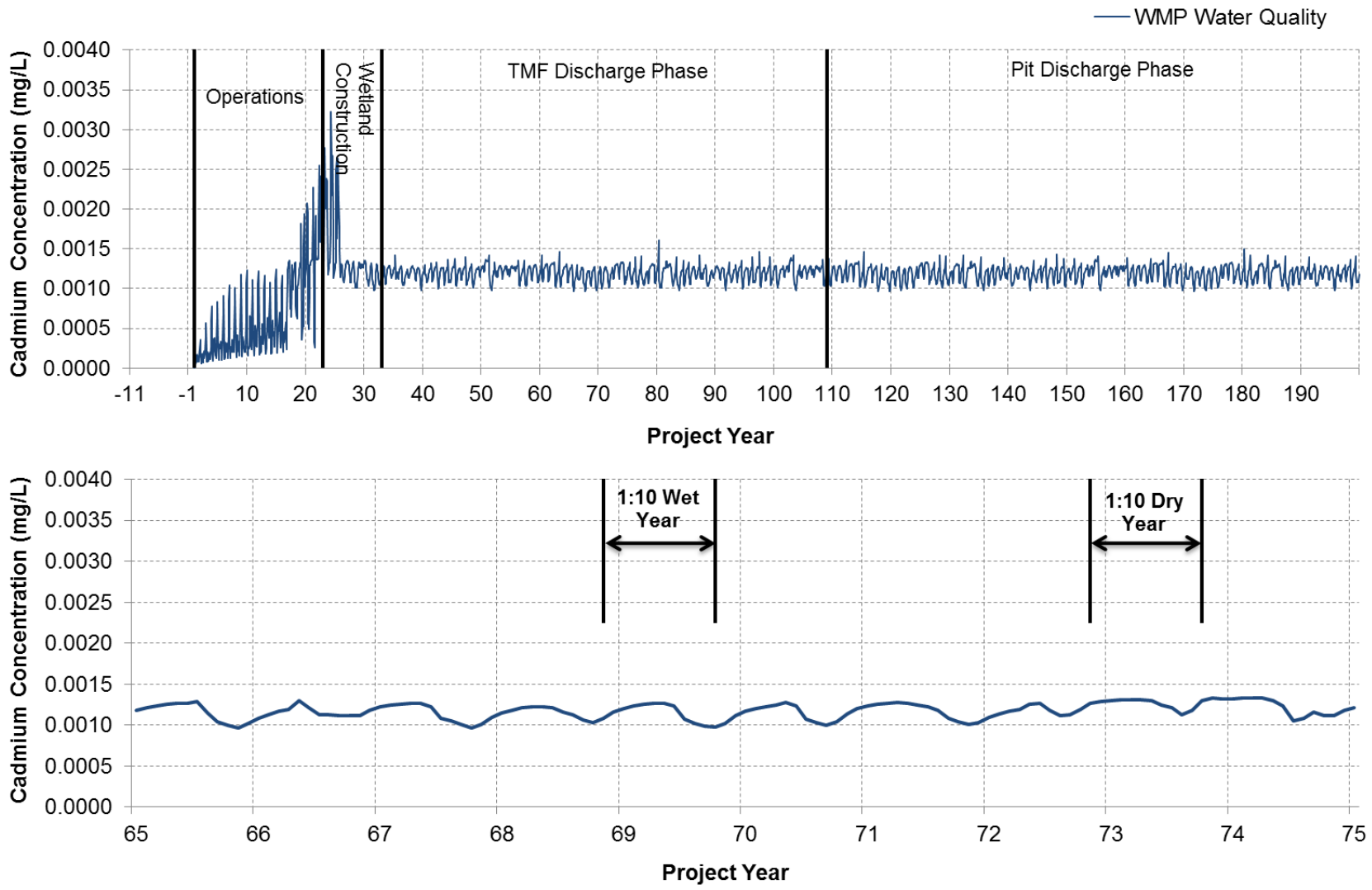


Figure 6-36-4.Modelled Cadmium Water Quality in the WMP

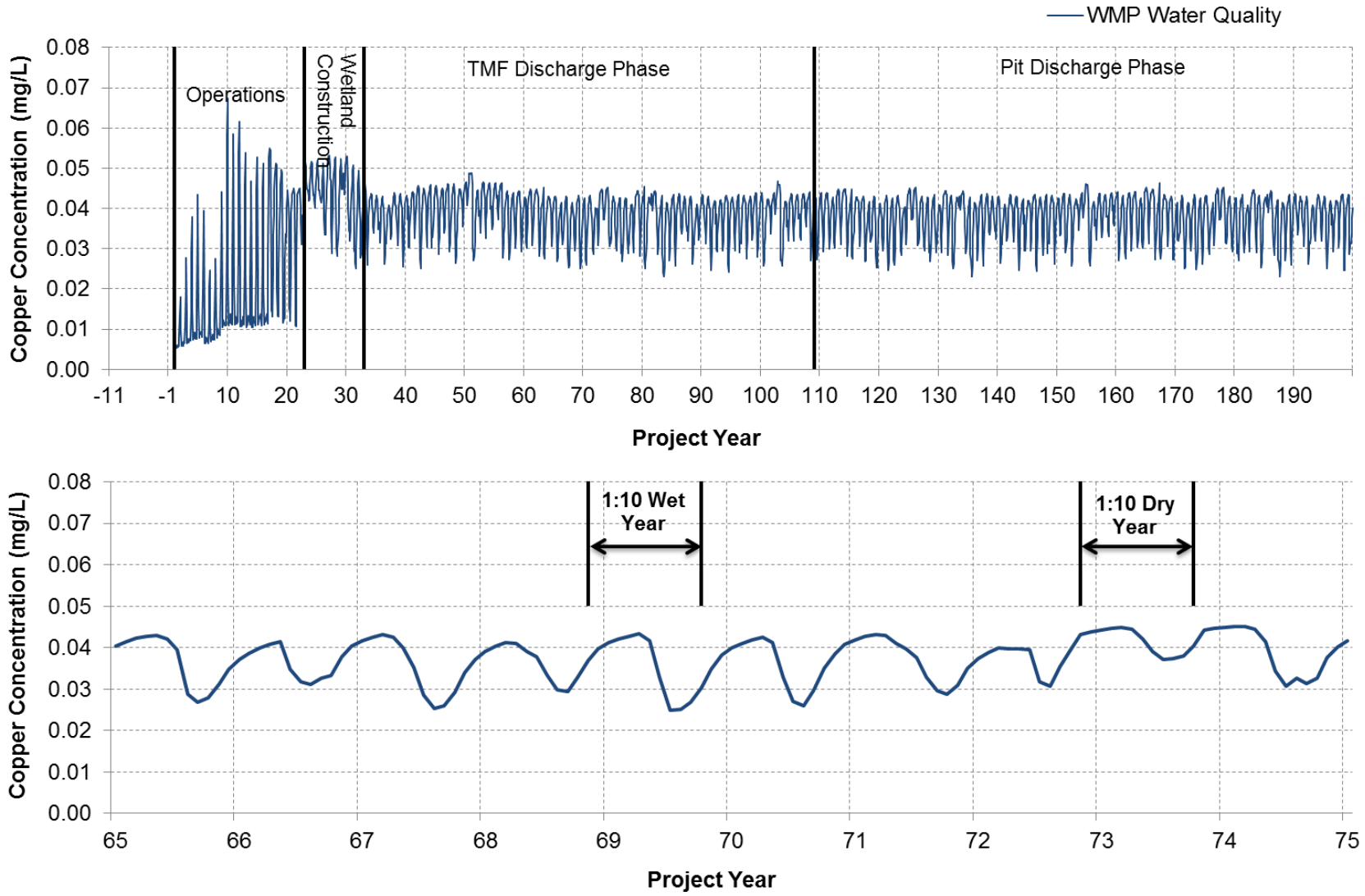


Figure 6-5. Modelled Copper Water Quality in the WMP

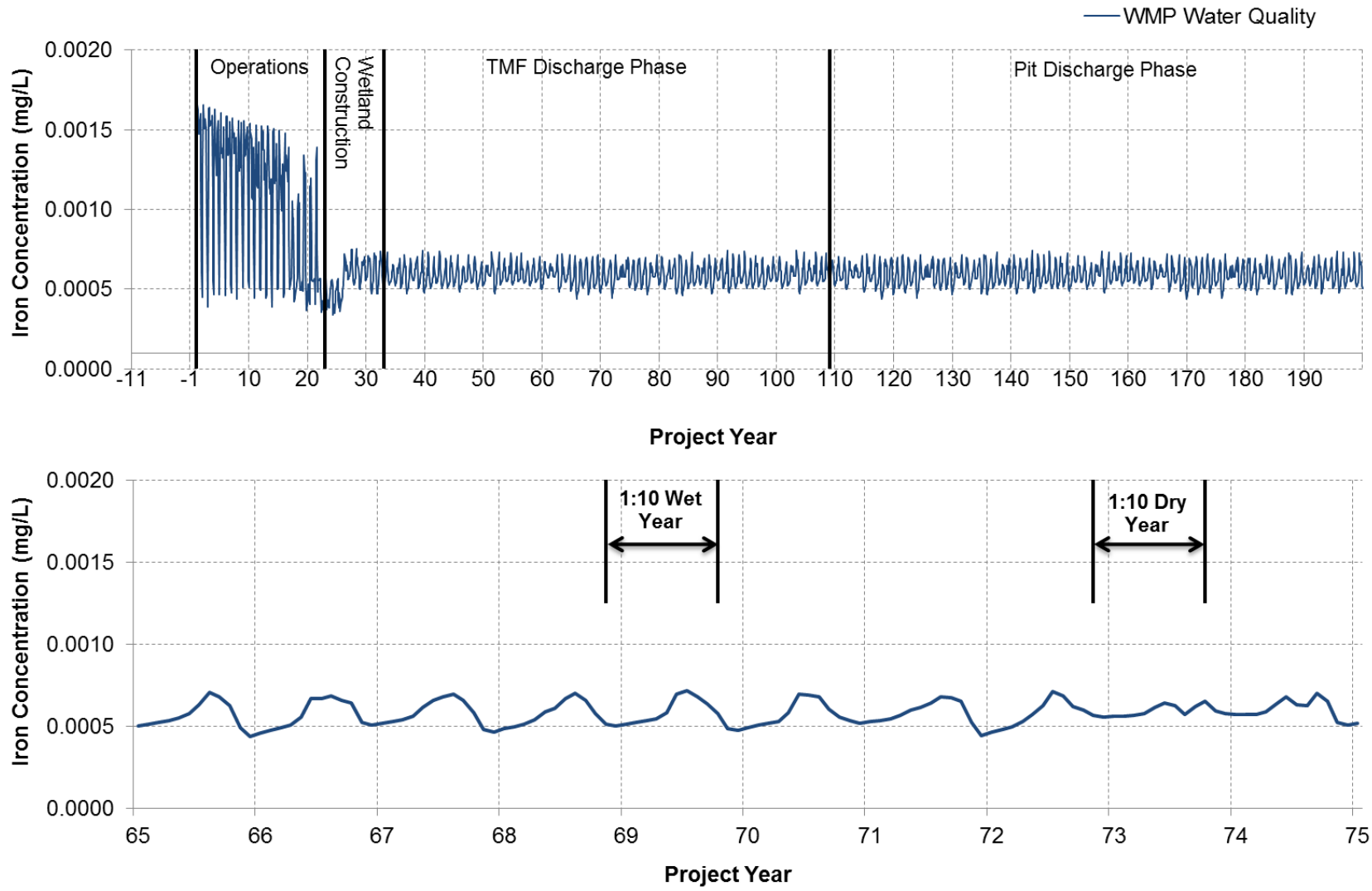


Figure 6-6. Modelled Iron Water Quality in the WMP

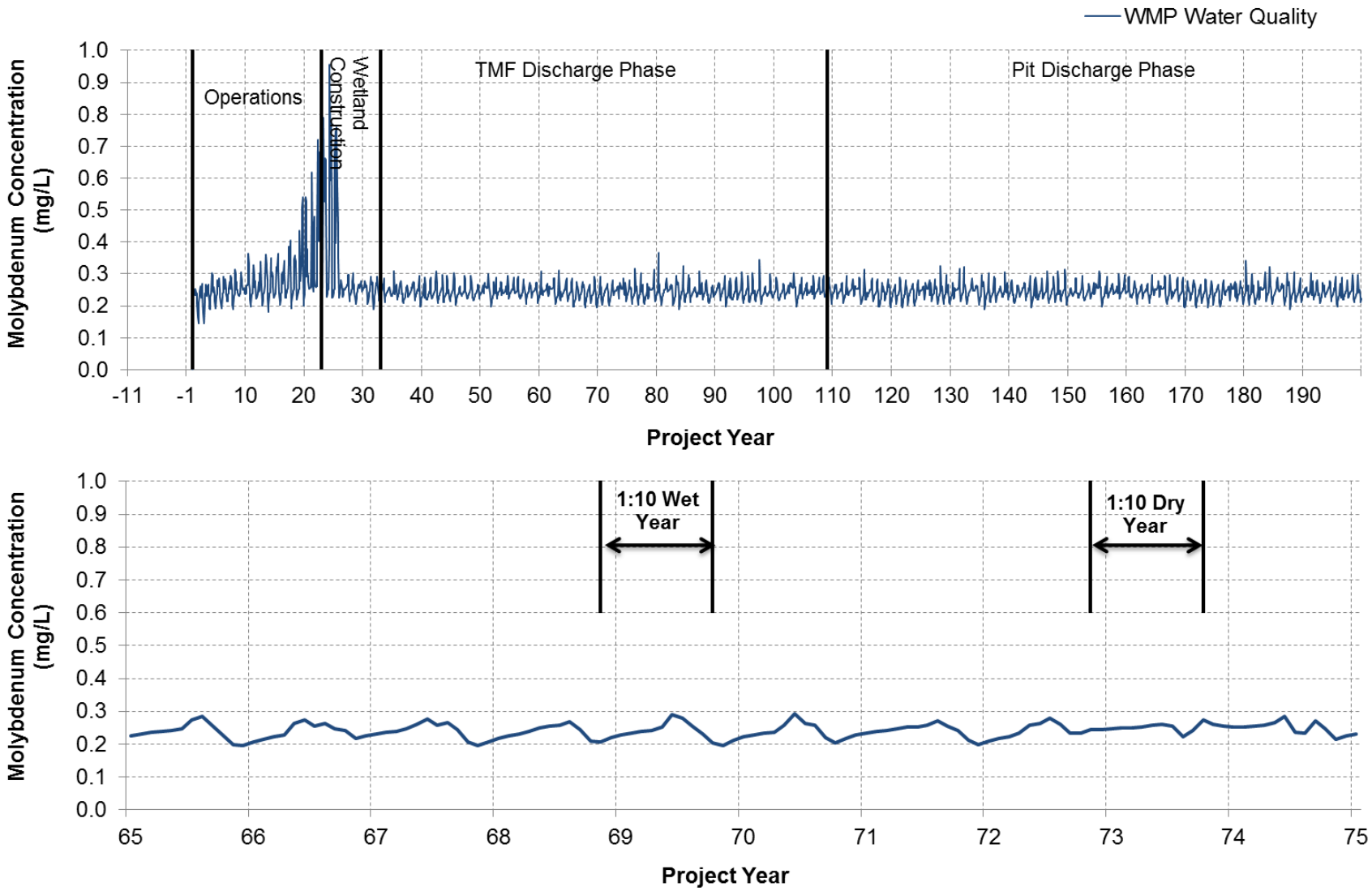


Figure 6-7. Modelled Molybdenum Water Quality in the WMP

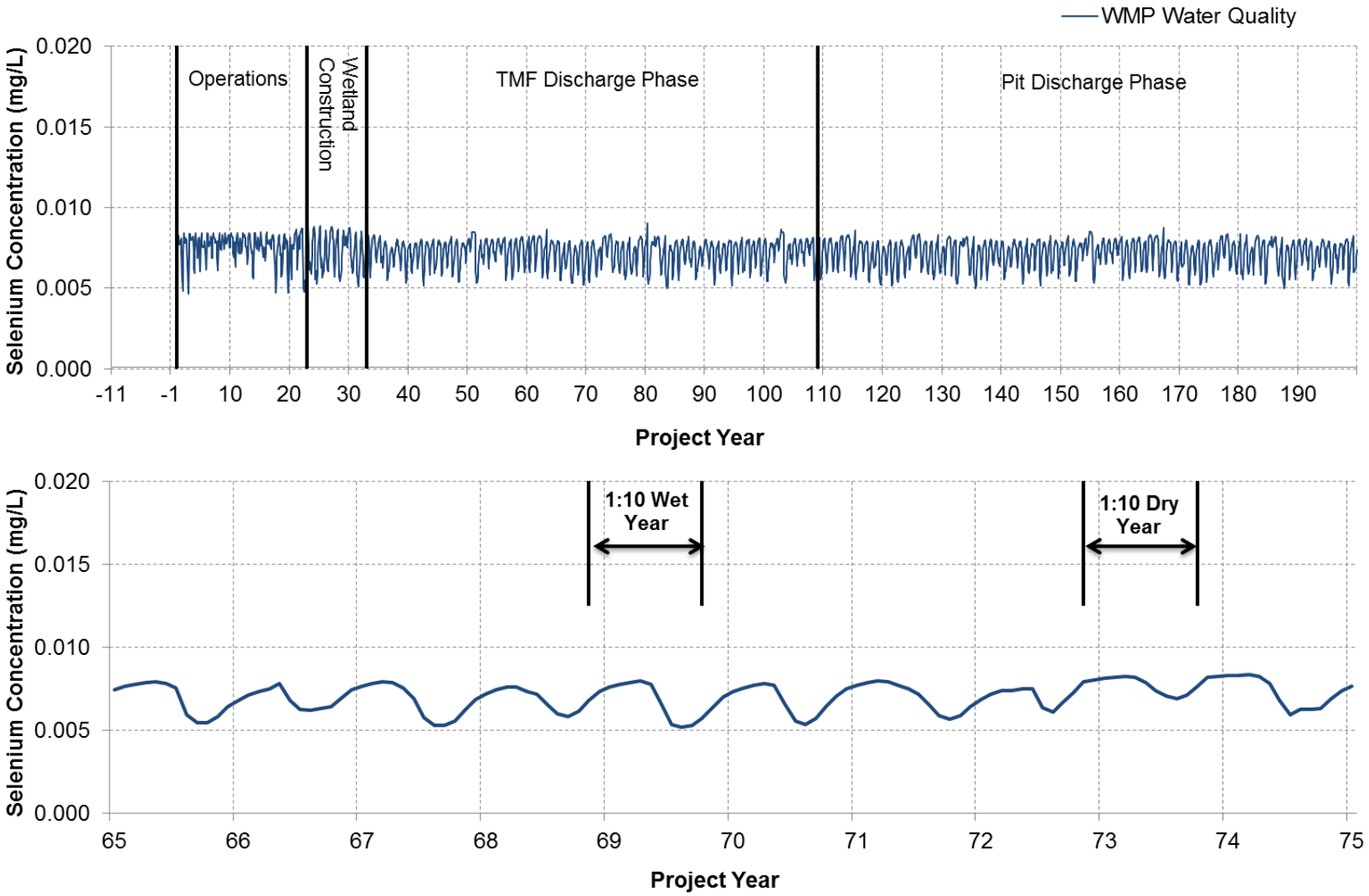


Figure 6-8. Modelled Selenium Water Quality in the WMP

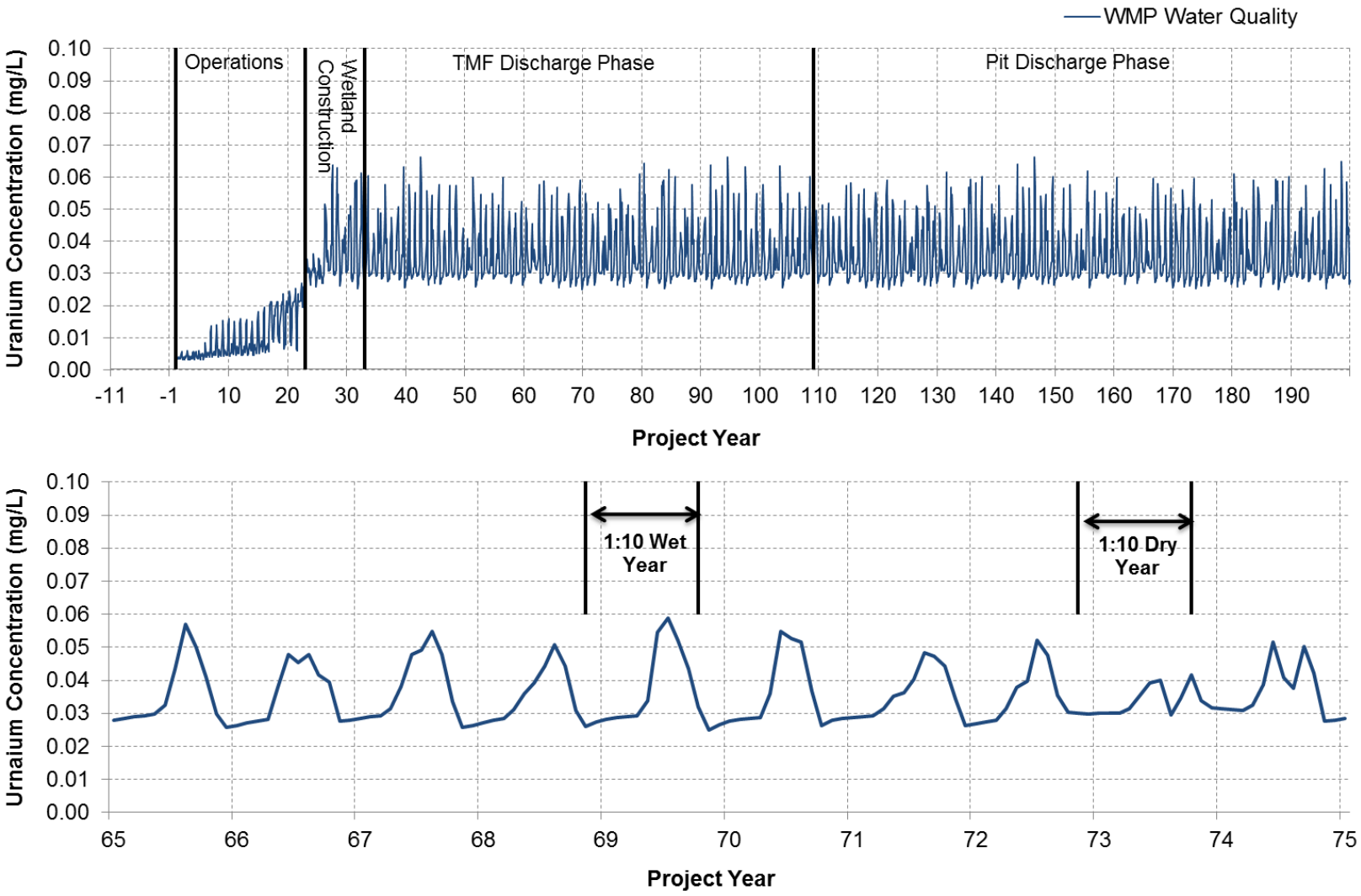


Figure 6-9. Modelled Uranium Water Quality in the WMP

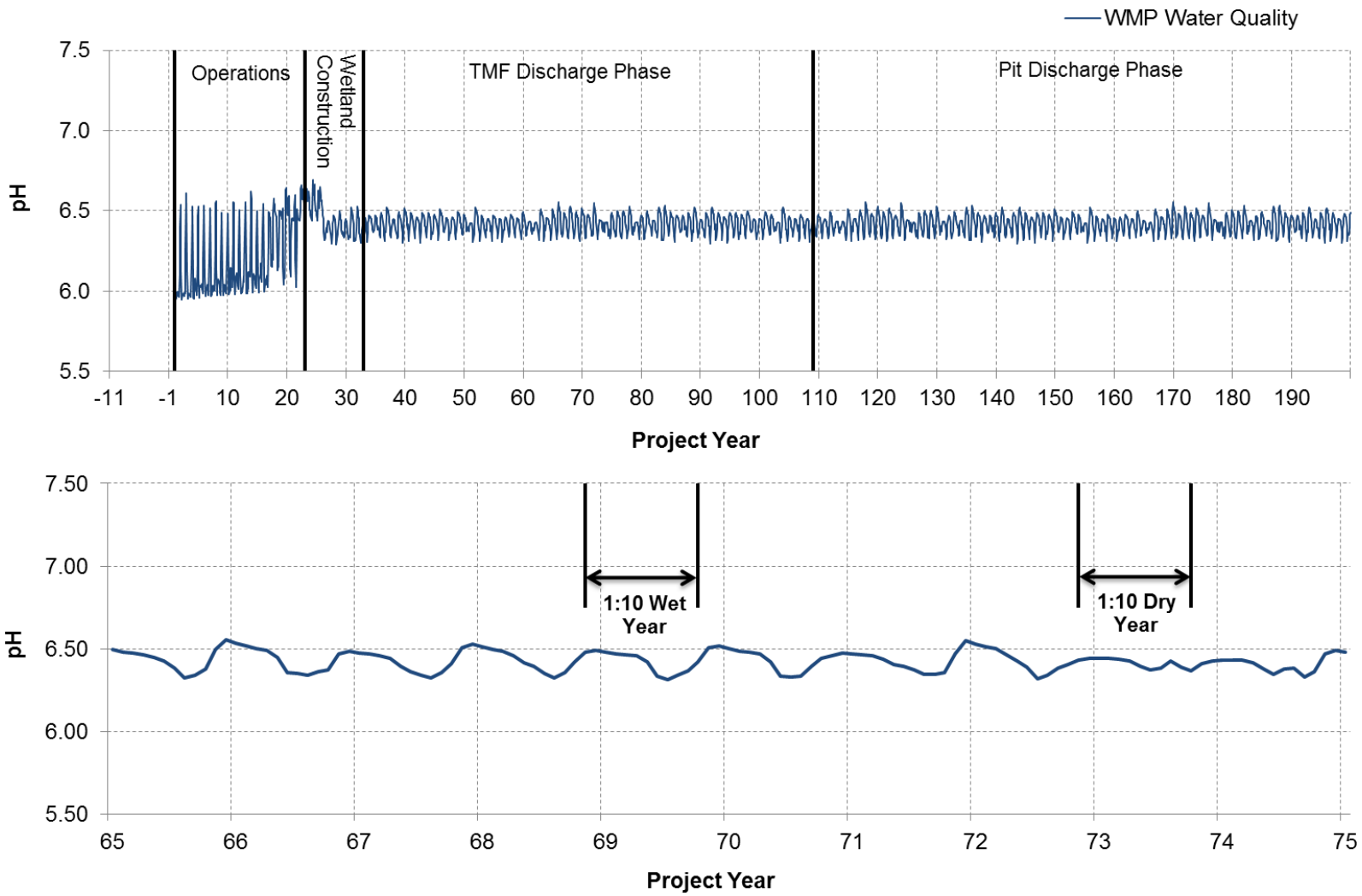


Figure 6-10. Modelled pH in the WMP

Individual contributions of mass loading sources are presented for select parameters during Operations (Table 6-2) and TMF Discharge and Pit Discharge Phases (Table 6-3). The mass loading contributions for all model parameters are presented in Appendix V - B. During Operations, the majority of the loadings to the WMP come from seepage or the sand plant underflow. During TMF Discharge and Pit Discharge phases, seepage is generally the highest contributor to mass loading to the WMP, with embankment runoff providing the majority of the remaining load.

Table 6-2. Loading Contributions to the WMP (Operations)

Source of Loading	Fraction Contributing (%)							
	SO_4	F	Cd	Cu	Fe	Mo	Se	U
Background Runoff	0	0	0	1	1	0	0	5
Embankment Runoff	1	1	48	14	0	22	2	25
Stockpile Seepage	0	0	1	17	0	0	0	1
Tailings and Waste Rock Seepage	13	12	42	38	92	12	13	34
Sand Plant Slurry Underflow	86	86	8	31	7	66	85	36
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

1. Average of all years during Operations, calculated from output from model Realization #1.
2. Shaded cells are for sources that contribute >10% to the overall load.
3. Values are rounded to the nearest 1 and the total of individual values may not add to exactly 100.

Table 6-3. Loading Contributions to the WMP (TMF Discharge / Pit Discharge Phases)

Source of Loading	Fraction Contributing (%)							
	SO_4	F	Cd	Cu	Fe	Mo	Se	U
Background Runoff	1	0	0	1	0	0	0	2
Embankment Runoff	4	26	20	13	0	30	13	47
Stockpile Seepage	0	0	0	1	0	0	0	0
Tailings and Waste Rock Seepage	96	73	80	86	100	70	87	51
Sand Plant Slurry Underflow	0	0	0	0	0	0	0	0
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

1. Average of all years during TMF Discharge and Pit Discharge Phases, calculated from output from model Realization #1.
2. Shaded cells are for sources that contribute >10% to the overall load.
3. Values are rounded to the nearest 1 and the total of individual values may not add to exactly 100.

7 References

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Source Environmental Associates Inc, 2013. Casino Project – Water Quality Predictions. December 2013.

Appendix V - A

Water Quality Modelling Input Data

Table V - A 1 Source Terms for Inflows to the WMP

Water Quality Model Parameter		Background Runoff (W18) [1]	Embankment Runoff [2]		Foundation Seepage (mg/L) [2]					Embankment Seepage (mg/L) [2]					Sand Plant Underflow [2]	
			Operations	Post Closure	Year 4	Year 9	Year 19	Year 22	> Year 22	Year 4	Year 9	Year 19	Year 22	> Year 22	Water Quality	Mass Accum-ulation [3]
		(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(g/tonne)
Hardness (as $CaCO_3$)		74	333	571	1,261	1,276	1,282	1,288	1,296	1,255	1,255	1,257	1,257	1,260	1,246	
Alkalinity (as $CaCO_3$)		63	95	124	45	56	54	53	51	64	64	64	64	64	63	
Sulphate	(SO_4)	23	463	170	1,320	1,320	1,320	1,320	1,320	1,320	1,320	1,320	1,320	1,320	1,320	
Chloride	(Cl)	0.25	8.2	69	36	36	36	36	36	36	36	36	36	36	36	
Fluoride	(F)	0.040	0.55	2.5	2.2	2.1	2.2	2.2	2.2	2.1	2.1	2.1	2.1	2.1	2.2	
Aluminum	(Al)	0.036	0.0040	0.0040	0.0020	0.0037	0.0033	0.0032	0.0028	0.0057	0.0057	0.0057	0.0057	0.0058	4.8	
Antimony	(Sb)	0.00014	0.045	0.15	0.0031	0.0028	0.0028	0.0027	0.0028	0.0025	0.0025	0.0026	0.0025	0.0026	0.0025	0.0020
Arsenic	(As)	0.00039	0.041	0.026	0.0043	0.0043	0.0043	0.0043	0.0043	0.0043	0.0043	0.0043	0.0043	0.0043	0.0041	0.0033
Barium	(Ba)	0.044	0.010	0.031	0.13	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.058	
Cadmium	(Cd)	0.000013	0.0054	0.0012	0.0012	0.0014	0.0014	0.0014	0.0014	0.0016	0.0016	0.0016	0.0016	0.0016	0.000043	
Calcium	(Ca)	20	120	193	498	498	498	498	498	498	498	498	498	498	497	
Chromium	(Cr)	0.00015	0.026	0.0080	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	
Cobalt	(Co)	0.000054	0.0089	0.0043	0.0048	0.0064	0.0077	0.0086	0.010	0.0016	0.0016	0.0019	0.0020	0.0023	0.00075	
Copper	(Cu)	0.0012	0.048	0.016	0.12	0.044	0.052	0.054	0.065	0.017	0.020	0.027	0.027	0.027	0.0050	
Iron	(Fe)	0.053	0.0052	0.0052	4.3	5.0	4.9	4.9	4.7	5.9	5.9	6.0	6.0	6.0	0.060	
Lead	(Pb)	0.000061	0.000055	0.000092	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	
Magnesium	(Mg)	5.8	8.1	22	4.2	7.8	9.4	11	13	2.9	2.7	3.3	3.3	4.1	1.3	
Manganese	(Mn)	0.0037	0.0087	0.0073	1.8	2.2	2.1	2.2	2.1	2.4	2.4	2.4	2.4	2.5	0.0015	
Mercury	(Hg)	0.0000050	0.00012	0.000080	0.000018	0.000015	0.000017	0.000017	0.000020	0.000010	0.0000085	0.000010	0.000010	0.000013	0.0000050	
Molybdenum	(Mo)	0.0012	1.7	0.39	0.27	0.28	0.27	0.27	0.27	0.29	0.29	0.29	0.29	0.29	0.24	0.20
Nickel	(Ni)	0.00030	0.027	0.0088	0.0031	0.0039	0.0043	0.0047	0.0052	0.0025	0.0026	0.0027	0.0027	0.0028	0.0025	
Potassium	(K)	1.0	184	26											86	
Selenium	(Se)	0.000040	0.0033	0.0046	0.0085	0.0090	0.0092	0.0094	0.0096	0.0085	0.0085	0.0086	0.0086	0.0086	0.0085	0.0070
Silver	(Ag)	0.0000025	0.00036	0.00013	0.000056	0.000051	0.000051	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	
Sodium	(Na)	3.3	9.1	1.1	37	40	40	40	41	38	38	38	38	38	35	
Thallium	(Tl)	0.0000030	0.00052	0.00019	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	
Uranium	(U)	0.0034	0.046	0.100	0.0071	0.026	0.032	0.040	0.048	0.0040	0.0039	0.0059	0.0063	0.0089	0.0031	0.0025
Zinc	(Zn)	0.0014	0.11	0.024	0.023	0.020	0.023	0.023	0.026	0.011	0.011	0.012	0.012	0.013	0.0061	

1. Median water quality from water quality data collected at W18.
2. Source terms provided by Lorax (2013)
3. Represents the water quality of the slurry water. For parameters where a “mass accumulation” source term was provided, the “water quality” value represents the initial water quality in the slurry water at the beginning of the model simulation.

Appendix V - B

Water Quality Modelling Results

Table V - B 1 WMP Water Quality Model Results

Water Quality Model Parameter	WMP Quality (mg/L)		
	Recovered to TMF (Operations Phase)	Recovered to Pit (Wetland Construction Phase)	Released to Casino Creek (TMF Discharge and Pit Discharge Phases)
pH	6.2	6.4	6.4
Hardness (as $CaCO_3$)	1,084	974	1,007
Alkalinity (as $CaCO_3$)	25	37	35
Sulphate (SO_4)	1,137	954	979
Chloride (Cl)	0.023	0.033	0.035
Fluoride (F)	1.9	1.8	1.8
Aluminum (Al)	2.1	0.014	0.011
Antimony (Sb)	0.0038	0.019	0.019
Arsenic (As)	0.0050	0.0074	0.0061
Barium (Ba)	0.070	0.085	0.089
Cadmium (Cd)	0.00063	0.0014	0.0012
Calcium (Ca)	428	373	386
Chromium (Cr)	0.0030	0.0036	0.0027
Cobalt (Co)	0.0022	0.0057	0.0056
Copper (Cu)	0.021	0.043	0.038
Iron (Fe)	0.0011	0.00057	0.00059
Lead (Pb)	0.0011	0.00089	0.00092
Magnesium (Mg)	3.7	10	10
Manganese (Mn)	0.64	1.6	1.6
Mercury (Hg)	0.000012	0.000026	0.000022
Molybdenum (Mo)	0.27	0.30	0.24
Nickel (Ni)	0.0035	0.0052	0.0041
Selenium (Se)	0.0075	0.0073	0.0072
Silver (Ag)	0.000055	0.000064	0.000051
Sodium (Na)	48	63	66
Thallium (Tl)	0.00044	0.00039	0.00038
Uranium (U)	0.0095	0.036	0.036
Zinc (Zn)	0.013	0.022	0.018

1. Values represent average water quality results over the duration of each mining phase for a single model realization (Realization #1).

Table V - B 2 Fraction Contributing to WMP Water Quality – Operations Phase

Parameter	Hard-ness	Alk	SO4	Cl	F	Al	Sb	As	Ba	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Na	Tl	U	Zn
Background Runoff	1	15	0	0	0	0	0	1	5	0	0	0	0	1	1	0	19	0	4	0	1	0	0	1	0	5	1
Embankment Runoff	1	15	1	1	1	0	41	29	1	48	1	29	21	14	0	0	12	0	43	22	29	2	22	1	4	25	36
Stockpile Seepage	0	0	0	0	0	0	1	0	0	1	0	0	1	17	0	0	0	0	1	0	1	0	0	0	0	1	2
Tailings and Waste Rock Seepage	13	27	13	13	12	0	8	10	21	42	13	9	39	38	92	13	29	99	15	12	12	13	10	29	13	34	19
Sand Plant Slurry Underflow	85	44	86	86	86	100	50	61	73	8	86	61	39	31	7	86	40	0	38	66	57	85	67	70	83	36	43
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

1. Average of all years during Operations, calculated from output from model Realization #1.
2. Shaded cells are for sources that contribute >10% to the overall load.
3. Values are rounded to the nearest 1 and the total of individual values may not add to exactly 100.

Table V - B 3 Fraction Contributing to WMP Water Quality – TMF Discharge and Pit Discharge Phases

Parameter	Hard-ness	Alk	SO4	Cl	F	Al	Sb	As	Ba	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Na	Tl	U	Zn
Background Runoff	1	12	1	0	0	66	0	1	9	0	1	1	0	1	0	1	10	0	3	0	1	0	1	1	0	2	1
Embankment Runoff	12	36	4	64	26	8	94	64	7	20	10	49	15	13	0	2	37	0	57	30	38	13	43	0	10	47	26
Stockpile Seepage	0	0	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Tailings and Waste Rock Seepage	87	51	96	36	73	25	6	35	83	80	89	51	84	86	100	97	53	100	40	70	61	87	56	99	90	51	73
Sand Plant Slurry Underflow	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

1. Average of all years during TMF Discharge and Pit Discharge Phases, calculated from output from model Realization #1.
2. Shaded cells are for sources that contribute >10% to the overall load.
3. Values are rounded to the nearest 1 and the total of individual values may not add to exactly 100.

Casino Project
Water Quality Predictions

Appendix VI
Receiving Environment Water Quality Modelling

Prepared by:

Source
ENVIRONMENTAL ASSOCIATES INC.

February 2015

Table VI-1 Baseline Water Quality in Brynelson Creek (W18)

Water Quality Model Parameter	CCME Guideline (mg/L)	W18 Median Water Quality (mg/L)			
		All Data	Winter	Spring	Summer
Hardness (as $CaCO_3$)		74	116	63	63
Alkalinity (as $CaCO_3$)		63	88	51	51
Sulphate (SO_4)	218	23	38	20	20
Chloride (Cl)	640	0.25	0.25	0.25	0.25
Fluoride (F)	0.12	0.040	0.050	0.040	0.040
Aluminum (Al)	0.10	0.036	0.0079	0.066	0.066
Antimony (Sb)		0.00014	0.00015	0.00014	0.00014
Arsenic (As)	0.0050	0.00039	0.00036	0.00043	0.00043
Barium (Ba)		0.044	0.058	0.040	0.040
Cadmium (Cd)	0.00012	0.000013	0.000011	0.000015	0.000015
Calcium (Ca)		20	31	17	17
Chromium (Cr)	0.0089	0.00015	0.000050	0.00020	0.00020
Cobalt (Co)		0.000054	0.000015	0.000065	0.000065
Copper (Cu)	0.0020	0.0012	0.00056	0.0016	0.0016
Iron (Fe)	0.30	0.053	0.010	0.11	0.11
Lead (Pb)	0.0022	0.000061	0.000016	0.000073	0.000073
Magnesium (Mg)		5.8	9.7	4.9	4.9
Manganese (Mn)		0.0037	0.0036	0.0037	0.0037
Mercury (Hg)	0.000026	0.0000050	0.0000050	0.0000050	0.0000050
Molybdenum (Mo)	0.073	0.0012	0.0019	0.0011	0.0011
Nickel (Ni)	0.08	0.00030	0.00015	0.00039	0.00039
Selenium (Se)	0.0010	0.000040	0.000040	0.000020	0.000020
Silver (Ag)	0.00010	0.0000025	0.0000025	0.0000025	0.0000025
Sodium (Na)		3.3	4.8	2.7	2.7
Thallium (Tl)	0.00080	0.0000030	0.0000010	0.0000040	0.0000040
Uranium (U)	0.015	0.0034	0.0073	0.0026	0.0026
Zinc (Zn)	0.030	0.0014	0.0011	0.0015	0.0015

1. CCME Guidelines for protection of aquatic life are shown for reference. The BC Water Quality Guideline for sulphate was used because CCME guidelines are not available.
2. Water quality guidelines for SO4, Cd, Cu, Pb, and Ni are hardness dependent. Values presented in this table were calculated using the median baseline hardness of Brynelson Creek at W18 (74 mg/L as $CaCO_3$).

Table VI-2 Baseline Water Quality in Casino Creek (W4)

Water Quality Model Parameter	CCME Guideline (mg/L)	W4 Median Water Quality (mg/L)			
		All Data	Winter	Spring	Summer
Hardness (as $CaCO_3$)		111	162	64	111
Alkalinity (as $CaCO_3$)		79	110	44	79
Sulphate (SO_4)	309	41	60	20	41
Chloride (Cl)	640	0.25	0.25	1.1	0.25
Fluoride (F)	0.12	0.070	0.070	0.060	0.070
Aluminum (Al)	0.10	0.081	0.019	0.24	0.067
Antimony (Sb)		0.00013	0.00013	0.00013	0.00014
Arsenic (As)	0.0050	0.00043	0.00038	0.00063	0.00042
Barium (Ba)		0.059	0.078	0.051	0.055
Cadmium (Cd)	0.00017	0.000027	0.000030	0.000046	0.000025
Calcium (Ca)		29	42	17	29
Chromium (Cr)	0.0089	0.00010	0.000050	0.00040	0.00020
Cobalt (Co)		0.000079	0.000031	0.00021	0.000083
Copper (Cu)	0.0026	0.0059	0.0019	0.014	0.0067
Iron (Fe)	0.30	0.13	0.030	0.30	0.12
Lead (Pb)	0.0036	0.00018	0.00010	0.00021	0.00021
Magnesium (Mg)		9.0	14	5.2	9.0
Manganese (Mn)		0.011	0.011	0.023	0.0095
Mercury (Hg)	0.000026	0.0000050	0.0000050	0.0000050	0.0000050
Molybdenum (Mo)	0.073	0.0011	0.0013	0.00070	0.0011
Nickel (Ni)	0.10	0.00037	0.00019	0.00072	0.00036
Selenium (Se)	0.0010	0.000070	0.000080	0.000065	0.000060
Silver (Ag)	0.00010	0.0000025	0.0000025	0.0000068	0.0000025
Sodium (Na)		4.1	5.8	2.4	4.1
Thallium (Tl)	0.00080	0.0000020	0.0000010	0.0000045	0.0000015
Uranium (U)	0.015	0.0066	0.013	0.0036	0.0066
Zinc (Zn)	0.030	0.0018	0.0014	0.0035	0.0021

1. Shaded cells exceed the CCME guideline for protection of aquatic life.
2. BC Water Quality guideline for sulphate was used because CCME guidelines are not available.
3. Water quality guidelines for SO4, Cd, Cu, Pb, and Ni are hardness dependent. Values presented in this table were calculated using the median baseline hardness of Casino Creek at W4 (111 mg/L as $CaCO_3$).

Table VI-3 Baseline Water Quality in Dip Creek (W9)

Water Quality Model Parameter	CCME Guideline (mg/L)	W9 Median Water Quality (mg/L)			
		All Data	Winter	Spring	Summer
Hardness (as $CaCO_3$)		81	120	54	73
Alkalinity (as $CaCO_3$)		74	110	46	66
Sulphate (SO_4)	309	15	22	3.5	13
Chloride (Cl)	640	0.25	0.25	1.0	0.25
Fluoride (F)	0.12	0.050	0.050	0.050	0.050
Aluminum (Al)	0.10	0.024	0.0071	0.10	0.032
Antimony (Sb)		0.000080	0.000060	0.000080	0.000080
Arsenic (As)	0.0050	0.00031	0.00020	0.00080	0.00032
Barium (Ba)		0.053	0.076	0.049	0.047
Cadmium (Cd)	0.00013	0.000012	0.0000080	0.000043	0.0000090
Calcium (Ca)		21	31	14	19
Chromium (Cr)	0.0089	0.00010	0.000050	0.00068	0.00020
Cobalt (Co)		0.000071	0.000042	0.00050	0.000081
Copper (Cu)	0.0020	0.00091	0.00068	0.0024	0.0012
Iron (Fe)	0.30	0.084	0.043	0.90	0.12
Lead (Pb)	0.0024	0.000084	0.000023	0.00066	0.000089
Magnesium (Mg)		7.0	10	4.8	6.3
Manganese (Mn)		0.022	0.025	0.068	0.015
Mercury (Hg)	0.000026	0.0000050	0.0000050	0.0000050	0.0000050
Molybdenum (Mo)	0.073	0.00059	0.00058	0.00042	0.00071
Nickel (Ni)	0.08	0.00034	0.00027	0.0011	0.00046
Selenium (Se)	0.0010	0.000040	0.000020	0.000055	0.000030
Silver (Ag)	0.00010	0.0000025	0.0000025	0.0000048	0.0000025
Sodium (Na)		3.6	5.0	2.4	3.3
Thallium (Tl)	0.00080	0.0000010	0.0000010	0.0000069	0.0000015
Uranium (U)	0.015	0.0053	0.0086	0.0035	0.0046
Zinc (Zn)	0.030	0.00070	0.00050	0.0034	0.00070

1. Shaded cells exceed the CCME guideline for protection of aquatic life.
2. BC Water Quality guideline for sulphate was used because CCME guidelines are not available.
3. Water quality guidelines for SO4, Cd, Cu, Pb, and Ni are hardness dependent. Values presented in this table were calculated using the median baseline hardness of Dip Creek at W9 (81 mg/L as $CaCO_3$).

Table VI-4 Baseline Water Quality in Dip Creek (W5)

Water Quality Model Parameter	CCME Guideline (mg/L) [2,3]	W5 Median Water Quality (mg/L) [1]			
		All Data	Winter	Spring	Summer
Hardness (as $CaCO_3$)		90	135	56	88
Alkalinity (as $CaCO_3$)		75	105	41	74
Sulphate (SO_4)	309	24	34	8.1	23
Chloride (Cl)	640	0.43	0.25	1.0	0.25
Fluoride (F)	0.12	0.060	0.060	0.055	0.060
Aluminum (Al)	0.10	0.037	0.021	0.47	0.033
Antimony (Sb)		0.00010	0.000080	0.000090	0.00010
Arsenic (As)	0.0050	0.00036	0.00031	0.00077	0.00035
Barium (Ba)		0.053	0.074	0.047	0.052
Cadmium (Cd)	0.00015	0.000017	0.000017	0.000054	0.000015
Calcium (Ca)		24	35	15	23
Chromium (Cr)	0.0089	0.00015	0.000050	0.00060	0.00020
Cobalt (Co)		0.000093	0.000052	0.00041	0.000093
Copper (Cu)	0.0022	0.0023	0.0011	0.0067	0.0023
Iron (Fe)	0.30	0.089	0.052	0.72	0.078
Lead (Pb)	0.0028	0.00012	0.000072	0.0015	0.000094
Magnesium (Mg)		7.5	11	4.6	7.5
Manganese (Mn)		0.025	0.030	0.041	0.015
Mercury (Hg)	0.000026	0.0000050	0.0000050	0.0000050	0.0000050
Molybdenum (Mo)	0.073	0.00081	0.00084	0.00049	0.00082
Nickel (Ni)	0.09	0.00032	0.00024	0.0011	0.00033
Selenium (Se)	0.0010	0.000050	0.000055	0.000060	0.000050
Silver (Ag)	0.00010	0.0000025	0.0000025	0.000010	0.0000025
Sodium (Na)		3.7	5.1	2.3	3.7
Thallium (Tl)	0.00080	0.0000020	0.0000010	0.0000070	0.0000020
Uranium (U)	0.015	0.0056	0.0099	0.0030	0.0055
Zinc (Zn)	0.030	0.0012	0.00095	0.0042	0.0010

1. Shaded cells exceed the CCME guideline for protection of aquatic life.
2. BC Water Quality guideline for sulphate was used because CCME guidelines are not available.
3. Water quality guidelines for SO4, Cd, Cu, Pb, and Ni are hardness dependent. Values presented in this table were calculated using the median baseline hardness of Dip Creek at W5 (90 mg/L as $CaCO_3$).

Model Results

Single Model Realization (Realization #1)

Table VI-5 Water Quality of Mine Derived Water Entering Casino Creek

Water Quality Model Parameter	MMER (mg/L)	Water Quality at the Mixing Point (mg/L) [1]		
		Operations and Wetland Construction Phases [2]	TMF Discharge Phase [3]	Pit Discharge Phase [3]
pH			7.5	7.6
Hardness (as $CaCO_3$)		-	637	520
Alkalinity (as $CaCO_3$)		-	92	96
Sulphate (SO_4)		-	518	394
Chloride (Cl)		-	44	38
Fluoride (F)		-	1.1	0.93
Aluminum (Al)		-	0.063	0.091
Antimony (Sb)		-	0.016	0.015
Arsenic (As)	0.50	-	0.0048	0.0045
Barium (Ba)		-	0.086	0.081
Cadmium (Cd)		-	0.00050	0.00036
Calcium (Ca)		-	229	182
Chromium (Cr)		-	0.0017	0.0016
Cobalt (Co)		-	0.013	0.029
Copper (Cu)	0.30	-	0.017	0.012
Iron (Fe)		-	0.0029	0.0023
Lead (Pb)	0.20	-	0.0021	0.0021
Magnesium (Mg)		-	16	16
Manganese (Mn)		-	0.96	0.72
Mercury (Hg)		-	0.000017	0.000017
Molybdenum (Mo)		-	0.14	0.11
Nickel (Ni)	0.50	-	0.0036	0.0096
Selenium (Se)		-	0.0052	0.0049
Silver (Ag)		-	0.000043	0.000057
Sodium (Na)		-	40	31
Thallium (Tl)		-	0.00021	0.00016
Uranium (U)		-	0.024	0.021
Zinc (Zn)	0.50	-	0.019	0.022

1. Results in this table were generated from model output of a single model realization (Realization #1).
2. Zero discharge of mine derived water into Casino Creek during Operations, and Wetland Construction Phases.
3. Average of months when TMF and WMP water is released to Casino Creek (May to November). Average calculated from all years during each of the TMF Discharge and Pit Discharge Phases.

Table VI-6 Water Quality Predictions for Casino Creek (H18) – Single Model Realization

Water Quality Model Parameter		CCME Guideline (mg/L) [4,5]	Operations and Wetland Construction Phase (mg/L)				TMF Discharge Phase (mg/L)				Pit Discharge Phase (mg/L)			
			Annual	Winter	Spring	Summer	Annual	Winter	Spring	Summer	Annual	Winter	Spring	Summer
pH			7.3	7.4	7.2	7.2	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.5
TDS			200	200	100	100	500	400	700	600	500	400	700	600
Hardness (as $CaCO_3$)			85	101	63	63	287	219	424	355	267	202	389	335
Alkalinity (as $CaCO_3$)			50	59	36	36	67	67	69	66	71	69	74	75
Sulphate	(SO_4)	309	27	32	19	19	205	141	341	266	179	122	298	233
Chloride	(Cl)	640	0.25	0.25	0.25	0.25	15	8.2	25	25	15	8.1	25	26
Fluoride	(F)	0.12	0.044	0.047	0.040	0.040	0.42	0.26	0.69	0.60	0.40	0.25	0.66	0.58
Aluminum	(Al)	0.10	0.041	0.024	0.065	0.065	0.043	0.028	0.062	0.064	0.054	0.035	0.078	0.083
Antimony	(Sb)		0.00014	0.00014	0.00013	0.00013	0.0054	0.0025	0.0083	0.010	0.0058	0.0028	0.0090	0.011
Arsenic	(As)	0.0050	0.00039	0.00037	0.00042	0.00042	0.0019	0.0011	0.0029	0.0030	0.0020	0.0012	0.0031	0.0032
Barium	(Ba)		0.047	0.053	0.040	0.040	0.062	0.061	0.068	0.063	0.062	0.060	0.067	0.064
Cadmium	(Cd)	0.00017	0.000013	0.000012	0.000014	0.000014	0.00018	0.00011	0.00032	0.00026	0.00015	0.000092	0.00027	0.00021
Calcium	(Ca)		23	27	17	17	98	71	151	124	89	64	136	114
Chromium	(Cr)	0.0089	0.00014	0.000092	0.00020	0.00020	0.00065	0.00037	0.0011	0.0010	0.00070	0.00040	0.0011	0.0011
Cobalt	(Co)		0.000044	0.000029	0.000065	0.000065	0.0046	0.0028	0.0077	0.0068	0.012	0.0067	0.018	0.019
Copper	(Cu)	0.0026	0.0012	0.00086	0.0016	0.0016	0.0065	0.0042	0.011	0.0089	0.0055	0.0035	0.0097	0.0073
Iron	(Fe)	0.30	0.069	0.039	0.11	0.11	0.033	0.022	0.045	0.051	0.029	0.022	0.039	0.040
Lead	(Pb)	0.0036	0.000049	0.000032	0.000072	0.000072	0.00078	0.00048	0.0013	0.0011	0.00085	0.00050	0.0013	0.0014
Magnesium	(Mg)		6.8	8.3	4.8	4.8	10	10	11	11	11	10	12	12
Manganese	(Mn)		0.0036	0.0036	0.0036	0.0036	0.35	0.22	0.62	0.48	0.30	0.18	0.53	0.41
Mercury	(Hg)	0.000026	0.0000050	0.0000050	0.0000050	0.0000050	0.0000090	0.0000070	0.000012	0.000012	0.0000097	0.0000074	0.000013	0.000013
Molybdenum	(Mo)	0.073	0.0014	0.0017	0.0011	0.0011	0.049	0.029	0.084	0.073	0.045	0.026	0.078	0.068
Nickel	(Ni)	0.10	0.00029	0.00021	0.00039	0.00039	0.0014	0.00088	0.0023	0.0022	0.0040	0.0023	0.0062	0.0064
Selenium	(Se)	0.0010	0.000028	0.000034	0.000020	0.000020	0.0019	0.0012	0.0032	0.0027	0.0020	0.0012	0.0034	0.0030
Silver	(Ag)	0.00010	0.0000025	0.0000025	0.0000025	0.0000025	0.000017	0.000010	0.000026	0.000025	0.000024	0.000015	0.000037	0.000038
Sodium	(Na)		3.6	4.2	2.7	2.7	17	12	27	21	15	11	23	19
Thallium	(Tl)	0.00080	0.0000027	0.0000018	0.0000040	0.0000040	0.000077	0.000047	0.00013	0.00011	0.000068	0.000040	0.00012	0.000097
Uranium	(U)	0.015	0.0045	0.0060	0.0026	0.0026	0.012	0.0095	0.015	0.015	0.012	0.0093	0.015	0.014
Zinc	(Zn)	0.030	0.0013	0.0012	0.0014	0.0014	0.0075	0.0049	0.012	0.011	0.0094	0.0058	0.015	0.014

1. Results presented in this table were generated from model output of a single model realization (Realization #1).
2. Results presented in this table represent average water quality for all years (or seasons) that fall within each phase of mining.
3. Shaded cells are modelled concentrations that exceed the CCME Guidelines for the protection of freshwater aquatic life. Water quality limits have not been established and the CCME guidelines are provided as a point of reference only.
4. BC Water Quality guideline for sulphate was used because CCME guidelines are not available.
5. Water quality guidelines for SO_4, Cd, Cu, Pb, and Ni are hardness dependent. Values presented in this table were calculated using the median baseline hardness of Casino Creek at W4 (111 mg/L as $CaCO_3$).

Table VI-7 Water Quality Predictions for Casino Creek (W4) – Single Model Realization

Water Quality Model Parameter		CCME Guideline (mg/L) [4,5]	Operations and Wetland Construction Phase (mg/L)				TMF Discharge Phase (mg/L)				Pit Discharge Phase (mg/L)			
			Annual	Winter	Spring	Summer	Annual	Winter	Spring	Summer	Annual	Winter	Spring	Summer
pH			7.3	7.4	7.2	7.2	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
TDS			200	200	100	100	500	400	600	500	500	400	600	500
Hardness (as $CaCO_3$)			85	101	63	63	262	205	378	319	247	192	352	307
Alkalinity (as $CaCO_3$)			50	59	37	37	65	67	65	62	69	68	70	71
Sulphate	(SO_4)	309	27	33	19	19	184	128	300	236	163	112	267	211
Chloride	(Cl)	640	0.25	0.25	0.25	0.25	13	7.2	21	22	14	7.2	22	23
Fluoride	(F)	0.12	0.044	0.047	0.040	0.040	0.37	0.24	0.60	0.53	0.36	0.23	0.59	0.53
Aluminum	(Al)	0.10	0.041	0.024	0.065	0.065	0.043	0.028	0.063	0.064	0.053	0.034	0.077	0.081
Antimony	(Sb)		0.00014	0.00014	0.00013	0.00013	0.0047	0.0022	0.0071	0.0089	0.0051	0.0025	0.0079	0.0094
Arsenic	(As)	0.0050	0.00039	0.00037	0.00042	0.00042	0.0017	0.0011	0.0025	0.0026	0.0018	0.0011	0.0028	0.0029
Barium	(Ba)		0.047	0.053	0.040	0.040	0.061	0.060	0.065	0.060	0.061	0.059	0.064	0.062
Cadmium	(Cd)	0.00017	0.000013	0.000012	0.000014	0.000014	0.00016	0.00010	0.00028	0.00023	0.00014	0.000084	0.00024	0.00019
Calcium	(Ca)		23	27	17	17	89	66	134	111	82	60	123	104
Chromium	(Cr)	0.0089	0.00014	0.000093	0.00020	0.00020	0.00059	0.00034	0.00094	0.00093	0.00064	0.00037	0.0010	0.0010
Cobalt	(Co)		0.000044	0.000029	0.000065	0.000065	0.0040	0.0024	0.0067	0.0059	0.010	0.0059	0.016	0.017
Copper	(Cu)	0.0026	0.0012	0.00087	0.0016	0.0016	0.0059	0.0038	0.010	0.0080	0.0050	0.0032	0.0088	0.0067
Iron	(Fe)	0.30	0.069	0.039	0.11	0.11	0.039	0.026	0.054	0.059	0.034	0.025	0.047	0.048
Lead	(Pb)	0.0036	0.000049	0.000032	0.000073	0.000073	0.00069	0.00042	0.0011	0.0010	0.00076	0.00044	0.0012	0.0012
Magnesium	(Mg)		6.9	8.3	4.8	4.8	10.0	9.8	10	10.0	11	10	11	11
Manganese	(Mn)		0.0036	0.0036	0.0037	0.0037	0.31	0.19	0.54	0.42	0.26	0.16	0.47	0.37
Mercury	(Hg)	0.000026	0.0000050	0.0000050	0.0000050	0.0000050	0.0000085	0.0000068	0.000011	0.000011	0.0000092	0.0000072	0.000012	0.000012
Molybdenum	(Mo)	0.073	0.0014	0.0017	0.0011	0.0011	0.043	0.026	0.073	0.064	0.041	0.024	0.069	0.061
Nickel	(Ni)	0.10	0.00029	0.00021	0.00039	0.00039	0.0013	0.00080	0.0021	0.0019	0.0036	0.0021	0.0056	0.0058
Selenium	(Se)	0.0010	0.000028	0.000034	0.000020	0.000020	0.0017	0.0010	0.0028	0.0024	0.0018	0.0010	0.0030	0.0027
Silver	(Ag)	0.00010	0.0000025	0.0000025	0.0000025	0.0000025	0.000015	0.0000094	0.000023	0.000022	0.000022	0.000013	0.000033	0.000034
Sodium	(Na)		3.6	4.2	2.7	2.7	15	11	24	19	14	10	21	17
Thallium	(Tl)	0.00080	0.0000027	0.0000019	0.0000040	0.0000040	0.000068	0.000041	0.00012	0.000095	0.000061	0.000036	0.00011	0.000088
Uranium	(U)	0.015	0.0046	0.0060	0.0026	0.0026	0.011	0.0091	0.013	0.013	0.011	0.0090	0.013	0.013
Zinc	(Zn)	0.030	0.0013	0.0012	0.0014	0.0014	0.0067	0.0044	0.011	0.0096	0.0085	0.0053	0.013	0.013

1. Results presented in this table were generated from model output of a single model realization (Realization #1).
2. Results presented in this table represent average water quality for all years (or seasons) that fall within each phase of mining.
3. Shaded cells are modelled concentrations that exceed the CCME Guidelines for the protection of freshwater aquatic life. Water quality limits have not been established and the CCME guidelines are provided as a point of reference only.
4. BC Water Quality guideline for sulphate was used because CCME guidelines are not available.
5. Water quality guidelines for SO_4, Cd, Cu, Pb, and Ni are hardness dependent. Values presented in this table were calculated using the median baseline hardness of Casino Creek at W4 (111 mg/L as $CaCO_3$).

Table VI-8 Water Quality Predictions for Dip Creek (W5) – Single Model Realization

Water Quality Model Parameter		CCME Guideline (mg/L) [4,5]	Operations and Wetland Construction Phase (mg/L)				TMF Discharge Phase (mg/L)				Pit Discharge Phase (mg/L)			
			Annual	Winter	Spring	Summer	Annual	Winter	Spring	Summer	Annual	Winter	Spring	Summer
pH			7.4	7.5	7.2	7.3	7.4	7.5	7.3	7.3	7.4	7.5	7.3	7.4
TDS			200	300	100	200	300	300	300	300	300	300	300	300
Hardness (as $CaCO_3$)			92	111	55	72	141	138	153	139	143	138	153	147
Alkalinity (as $CaCO_3$)			63	78	34	48	67	79	43	53	68	79	45	57
Sulphate	(SO_4)	309	17	22	5.9	14	62	49	94	73	62	48	91	76
Chloride	(Cl)	640	0.36	0.25	0.89	0.25	3.9	2.1	7.1	5.9	4.5	2.4	7.7	7.2
Fluoride	(F)	0.12	0.049	0.050	0.048	0.049	0.14	0.10	0.22	0.18	0.15	0.10	0.23	0.20
Aluminum	(Al)	0.10	0.033	0.013	0.096	0.037	0.034	0.015	0.091	0.040	0.037	0.017	0.094	0.047
Antimony	(Sb)		0.000079	0.000073	0.000088	0.000087	0.0013	0.00062	0.0021	0.0023	0.0016	0.00079	0.0025	0.0029
Arsenic	(As)	0.0050	0.00035	0.00024	0.00074	0.00033	0.00070	0.00043	0.0013	0.00092	0.00079	0.00048	0.0014	0.0011
Barium	(Ba)		0.060	0.069	0.048	0.046	0.063	0.070	0.054	0.051	0.063	0.070	0.054	0.052
Cadmium	(Cd)	0.00015	0.000014	0.0000087	0.000038	0.0000097	0.000055	0.000033	0.00012	0.000069	0.000053	0.000031	0.00011	0.000066
Calcium	(Ca)		24	28	14	19	42	39	50	44	42	39	50	46
Chromium	(Cr)	0.0089	0.00019	0.000075	0.00060	0.00020	0.00031	0.00014	0.00076	0.00039	0.00034	0.00016	0.00080	0.00045
Cobalt	(Co)		0.00012	0.000045	0.00043	0.000078	0.0012	0.00070	0.0024	0.0016	0.0033	0.0019	0.0056	0.0053
Copper	(Cu)	0.0022	0.0012	0.00078	0.0022	0.0013	0.0025	0.0016	0.0047	0.0031	0.0024	0.0015	0.0045	0.0030
Iron	(Fe)	0.30	0.19	0.053	0.78	0.12	0.17	0.049	0.66	0.11	0.16	0.048	0.64	0.10
Lead	(Pb)	0.0028	0.00014	0.000033	0.00057	0.000087	0.00030	0.00014	0.00082	0.00033	0.00034	0.00016	0.00085	0.00044
Magnesium	(Mg)		7.9	9.6	4.8	6.1	8.7	9.9	6.5	7.3	9.0	10	6.9	7.9
Manganese	(Mn)		0.025	0.021	0.058	0.013	0.11	0.071	0.22	0.12	0.11	0.068	0.20	0.13
Mercury	(Hg)	0.000026	0.0000050	0.0000050	0.0000050	0.0000050	0.0000059	0.0000055	0.0000067	0.0000066	0.0000063	0.0000057	0.0000072	0.0000072
Molybdenum	(Mo)	0.073	0.00071	0.00074	0.00052	0.00076	0.012	0.0072	0.022	0.017	0.013	0.0076	0.023	0.020
Nickel	(Ni)	0.088	0.00044	0.00029	0.00098	0.00045	0.00070	0.00044	0.0014	0.00084	0.0015	0.00087	0.0026	0.0021
Selenium	(Se)	0.0010	0.000029	0.000023	0.000050	0.000029	0.00048	0.00029	0.00090	0.00065	0.00058	0.00034	0.0010	0.00087
Silver	(Ag)	0.00010	0.0000028	0.0000025	0.0000044	0.0000025	0.0000062	0.0000044	0.000010	0.0000075	0.0000088	0.0000058	0.000014	0.000012
Sodium	(Na)		3.9	4.7	2.4	3.2	7.2	6.6	8.9	7.5	7.1	6.5	8.5	7.7
Thallium	(Tl)	0.00080	0.0000022	0.0000012	0.0000065	0.0000018	0.000020	0.000012	0.000041	0.000026	0.000021	0.000012	0.000040	0.000029
Uranium	(U)	0.015	0.0061	0.0077	0.0033	0.0043	0.0077	0.0084	0.0064	0.0068	0.0079	0.0085	0.0067	0.0072
Zinc	(Zn)	0.030	0.0011	0.00061	0.0031	0.00080	0.0026	0.0015	0.0057	0.0030	0.0034	0.0019	0.0067	0.0045

1. Results presented in this table were generated from model output of a single model realization (Realization #1).
2. Results presented in this table represent average water quality for all years (or seasons) that fall within each phase of mining.
3. Shaded cells are modelled concentrations that exceed the CCME Guidelines for the protection of freshwater aquatic life. Water quality limits have not been established and the CCME guidelines are provided as a point of reference only.
4. BC Water Quality guideline for sulphate was used because CCME guidelines are not available.
5. Water quality guidelines for SO_4, Cd, Cu, Pb, and Ni are hardness dependent. Values presented in this table were calculated using the median baseline hardness of Casino Creek at W5 (90 mg/L as $CaCO_3$).

Table VI-9 Fraction Contributing of Individual Loading Sources at H18 (TMF Discharge Phase and Pit Discharge Phase)

Parameter	Alk	SO4	Cl	F	Al	Sb	As	Ba	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Na	Tl	U	Zn
TMF Discharge Phase																										
Background Streamflow	26	3	0	3	38	1	6	27	2	6	8	0	7	100	2	20	0	19	1	5	0	4	6	1	10	5
TMF Pond Discharge	60	39	54	42	59	42	46	50	12	43	35	90	17	0	86	63	48	41	37	67	58	59	47	41	39	67
WMP Pond Discharge	14	58	46	55	3	57	48	22	86	50	57	10	76	0	12	17	51	41	63	28	42	37	47	58	51	28
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Pit Discharge Phase																										
Background Streamflow	20	3	0	2	25	0	5	23	2	6	6	0	7	99	2	16	0	14	1	2	0	2	5	1	8	3
TMF Pond Discharge	69	45	62	53	74	56	60	59	18	51	53	96	24	0	89	71	52	57	47	89	69	75	52	48	50	78
WMP Pond Discharge	11	52	38	45	2	44	36	18	80	44	41	4	69	0	9	13	48	30	53	9	31	22	43	50	42	19
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

1. Average of all years during each phase, calculated from output from model Realization #1.
2. Shaded cells are for sources that contribute >10% to the overall load.
3. Values are rounded and the total of individual values may not add to exactly 100.

Table VI-10 Fraction Contributing of Individual Loading Sources at W5 (TMF Discharge Phase and Pit Discharge Phase)

Parameter	Alk	SO4	Cl	F	Al	Sb	As	Ba	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Na	Tl	U	Zn
TMF Discharge Phase																										
Background Streamflow	80	18	6	25	81	4	37	81	20	40	52	5	40	100	34	74	15	68	4	43	4	30	39	8	60	30
TMF Pond Discharge	16	33	51	32	18	41	31	13	10	28	18	85	11	0	58	20	41	16	36	40	56	42	31	38	17	49
WMP Pond Discharge	4	49	44	43	1	55	32	6	71	32	30	10	49	0	8	6	44	16	61	17	40	27	30	54	22	21
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Pit Discharge Phase																										
Background Streamflow	75	17	5	22	69	3	30	77	19	37	44	2	39	100	28	68	14	60	3	19	3	21	37	8	56	22
TMF Pond Discharge	22	39	59	42	30	54	44	18	15	34	32	94	16	0	65	27	45	26	45	73	67	61	34	45	24	63
WMP Pond Discharge	3	44	36	36	1	43	26	5	66	29	24	4	46	0	7	5	41	14	51	7	30	18	28	47	20	15
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

1. Average of all years during each phase, calculated from output from model Realization #1.
2. Shaded cells are for sources that contribute >10% to the overall load.
3. Values are rounded and the total of individual values may not add to exactly 100.

Model Results

Monte-Carlo Summary
(52 Realizations)

Table VI-11 Water Quality Predictions for Dip Creek (H18) – Median (P50) from 52 Model Realizations

Water Quality Model Parameter		CCME Guideline (mg/L) [2,3,4]	Operations and Wetland Construction Phase (mg/L)				TMF Discharge Phase (mg/L)				Pit Discharge Phase (mg/L)				Max P50 (all phases) mg/L
			Annual	Winter	Spring	Summer	Annual	Winter	Spring	Summer	Annual	Winter	Spring	Summer	
pH			7.3	7.4	7.2	7.2	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.5	
TDS			200	300	100	100	500	400	700	600	500	400	700	600	1,200
Hardness (as $CaCO_3$)			85	101	63	63	279	223	401	328	265	207	379	325	531
Alkalinity (as $CaCO_3$)			50	59	37	36	68	67	71	66	72	69	75	75	91
Sulphate	(SO_4)	309	27	32	19	19	196	145	313	238	176	125	285	223	449
Chloride	(Cl)	640	0.25	0.25	0.25	0.25	15	8.0	25	25	15	8.1	25	25	29
Fluoride	(F)	0.12	0.044	0.047	0.040	0.040	0.40	0.27	0.65	0.56	0.40	0.25	0.65	0.57	0.84
Aluminum	(Al)	0.10	0.041	0.024	0.065	0.065	0.041	0.027	0.062	0.062	0.054	0.035	0.079	0.083	0.089
Antimony	(Sb)		0.00014	0.00014	0.00013	0.00013	0.0052	0.0023	0.0081	0.0102	0.0057	0.0027	0.0089	0.011	0.012
Arsenic	(As)	0.0050	0.00039	0.00037	0.00042	0.00042	0.0019	0.0011	0.0029	0.0029	0.0020	0.0012	0.0031	0.0032	0.0035
Barium	(Ba)		0.047	0.053	0.040	0.040	0.062	0.061	0.068	0.061	0.062	0.060	0.067	0.063	0.080
Cadmium	(Cd)	0.00017	0.000013	0.000012	0.000014	0.000014	0.00018	0.00011	0.00029	0.00025	0.00015	0.000093	0.00026	0.00020	0.00036
Calcium	(Ca)		23	27	17	17	94	73	142	114	88	66	132	110	192
Chromium	(Cr)	0.0089	0.00014	0.000092	0.00020	0.00020	0.00064	0.00037	0.0010	0.00101	0.00070	0.00040	0.0011	0.0011	0.0013
Cobalt	(Co)		0.000044	0.000029	0.000065	0.000065	0.0047	0.0027	0.0081	0.0069	0.012	0.0067	0.018	0.019	0.023
Copper	(Cu)	0.0026	0.0012	0.00086	0.0016	0.0016	0.0062	0.0042	0.0102	0.0082	0.0054	0.0036	0.0093	0.0070	0.013
Iron	(Fe)	0.30	0.069	0.038	0.11	0.11	0.033	0.021	0.043	0.052	0.028	0.021	0.037	0.041	0.11
Lead	(Pb)	0.0036	0.000049	0.000032	0.000073	0.000073	0.00079	0.00048	0.0014	0.0012	0.00087	0.00051	0.0014	0.0014	0.0017
Magnesium	(Mg)		6.8	8.3	4.8	4.8	10	10.0	12	11	11	10	12	12	15
Manganese	(Mn)		0.0036	0.0036	0.0036	0.0036	0.33	0.22	0.57	0.42	0.29	0.18	0.50	0.39	0.83
Mercury	(Hg)	0.000026	0.0000050	0.0000050	0.0000050	0.0000050	0.0000089	0.0000069	0.000012	0.000012	0.0000098	0.0000074	0.000013	0.000013	0.000014
Molybdenum	(Mo)	0.073	0.0014	0.0017	0.0011	0.0011	0.048	0.030	0.079	0.069	0.045	0.027	0.077	0.067	0.091
Nickel	(Ni)	0.10	0.00029	0.00021	0.00039	0.00039	0.0014	0.00087	0.0023	0.0021	0.0040	0.0024	0.0064	0.0064	0.0078
Selenium	(Se)	0.0010	0.000028	0.000034	0.000020	0.000020	0.0018	0.0012	0.0031	0.0025	0.0020	0.0012	0.0034	0.0029	0.0045
Silver	(Ag)	0.00010	0.0000025	0.0000025	0.0000025	0.0000025	0.000016	0.000010	0.000026	0.000024	0.000024	0.000015	0.000038	0.000038	0.000042
Sodium	(Na)		3.6	4.2	2.7	2.7	16	13	25	19	15	11	22	18	35
Thallium	(Tl)	0.00080	0.0000027	0.0000018	0.0000040	0.0000040	0.000073	0.000048	0.00012	0.000098	0.000067	0.000042	0.00012	0.000094	0.00017
Uranium	(U)	0.015	0.0045	0.0060	0.0026	0.0026	0.012	0.0095	0.015	0.014	0.012	0.0094	0.01503	0.01428	0.016
Zinc	(Zn)	0.030	0.0013	0.0012	0.0014	0.0014	0.0074	0.0048	0.012	0.010	0.0095	0.0059	0.01496	0.01422	0.016

1. Results were generated from median water quality model results from 52 model realizations. Median values were averaged by mine phase.
2. Shaded cells are modelled concentrations that exceed the CCME Guidelines for the protection of freshwater aquatic life. Water quality limits have not been established and the CCME guidelines are provided as a point of reference only.
3. BC Water Quality guideline for sulphate was used because CCME guidelines are not available.
4. Water quality guidelines for SO4, Cd, Cu, Pb, and Ni are hardness dependent. Values presented in this table were calculated using the median baseline hardness of Dip Creek at W4 (111 mg/L as $CaCO_3$).

Table VI-12 Water Quality Predictions for Dip Creek (W4) – Median (P50) from 52 Model Realizations

Water Quality Model Parameter		CCME Guideline (mg/L) [2,3,4]	Operations and Wetland Construction Phase (mg/L)				TMF Discharge Phase (mg/L)				Pit Discharge Phase (mg/L)				Max P50 (all phases) mg/L
			Annual	Winter	Spring	Summer	Annual	Winter	Spring	Summer	Annual	Winter	Spring	Summer	
pH			7.3	7.4	7.2	7.2	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	
TDS			200	300	100	100	500	400	700	500	500	400	600	600	1,100
Hardness (as $CaCO_3$)			85	101	63	63	252	207	356	290	245	196	341	295	488
Alkalinity (as $CaCO_3$)			50	59	37	37	65	67	67	62	69	68	70	71	89
Sulphate	(SO_4)	309	27	33	19	19	174	131	274	207	160	116	254	200	407
Chloride	(Cl)	640	0.25	0.25	0.25	0.25	13	6.8	22	21	13	7.2	22	22	27
Fluoride	(F)	0.12	0.044	0.047	0.040	0.040	0.35	0.24	0.57	0.48	0.36	0.23	0.57	0.51	0.75
Aluminum	(Al)	0.10	0.041	0.024	0.066	0.065	0.042	0.027	0.063	0.063	0.054	0.035	0.078	0.082	0.087
Antimony	(Sb)		0.00014	0.00014	0.00013	0.00013	0.0045	0.0020	0.0071	0.0087	0.0051	0.0025	0.0080	0.0093	0.010
Arsenic	(As)	0.0050	0.00039	0.00037	0.00042	0.00042	0.0017	0.0010	0.0026	0.0026	0.0018	0.0011	0.0028	0.0029	0.0032
Barium	(Ba)		0.047	0.053	0.040	0.040	0.060	0.060	0.064	0.058	0.061	0.060	0.064	0.060	0.078
Cadmium	(Cd)	0.00017	0.000013	0.000012	0.000014	0.000014	0.00015	0.00010	0.00025	0.00021	0.00013	0.000085	0.00023	0.00018	0.00033
Calcium	(Ca)		23	27	17	17	85	67	125	99	81	62	118	100	175
Chromium	(Cr)	0.0089	0.00014	0.000092	0.00020	0.00020	0.00057	0.00034	0.00091	0.00090	0.00064	0.00037	0.0010	0.00100	0.0011
Cobalt	(Co)		0.000044	0.000029	0.000065	0.000065	0.0041	0.0024	0.0071	0.0060	0.010	0.0059	0.016	0.017	0.021
Copper	(Cu)	0.0026	0.0012	0.00087	0.0016	0.0016	0.0055	0.0038	0.0090	0.0072	0.0049	0.0033	0.0084	0.0064	0.012
Iron	(Fe)	0.30	0.069	0.039	0.11	0.11	0.039	0.026	0.053	0.061	0.034	0.024	0.047	0.049	0.11
Lead	(Pb)	0.0036	0.000049	0.000032	0.000073	0.000073	0.00069	0.00041	0.0012	0.0010	0.00077	0.00046	0.0012	0.0012	0.0016
Magnesium	(Mg)		6.9	8.3	4.8	4.8	10.0	9.8	11	10.0	11	10	11	11	14
Manganese	(Mn)		0.0036	0.0036	0.0037	0.0037	0.29	0.20	0.50	0.36	0.26	0.17	0.44	0.35	0.74
Mercury	(Hg)	0.000026	0.0000050	0.0000050	0.0000050	0.0000050	0.0000084	0.0000067	0.000011	0.000011	0.0000092	0.0000072	0.000012	0.000012	0.000013
Molybdenum	(Mo)	0.073	0.0014	0.0017	0.0011	0.0011	0.041	0.026	0.068	0.059	0.040	0.024	0.067	0.059	0.082
Nickel	(Ni)	0.10	0.00029	0.00021	0.00039	0.00039	0.0012	0.00078	0.0020	0.0018	0.0036	0.0021	0.0056	0.0057	0.0071
Selenium	(Se)	0.0010	0.000028	0.000034	0.000020	0.000020	0.0016	0.0010	0.0027	0.0021	0.0018	0.0011	0.0029	0.0026	0.0040
Silver	(Ag)	0.00010	0.0000025	0.0000025	0.0000025	0.0000025	0.000014	0.0000093	0.000023	0.000021	0.000022	0.000013	0.000034	0.000034	0.000039
Sodium	(Na)		3.6	4.2	2.7	2.7	15	11	22	17	13	10	20	16	32
Thallium	(Tl)	0.00080	0.0000027	0.0000018	0.0000040	0.0000040	0.000064	0.000042	0.00011	0.000084	0.000060	0.000037	0.00010	0.000083	0.00015
Uranium	(U)	0.015	0.0046	0.0060	0.0026	0.0026	0.011	0.0090	0.013	0.012	0.011	0.0090	0.013	0.013	0.015
Zinc	(Zn)	0.030	0.0013	0.0012	0.0014	0.0014	0.0065	0.0043	0.011	0.0091	0.0085	0.0054	0.013	0.013	0.015

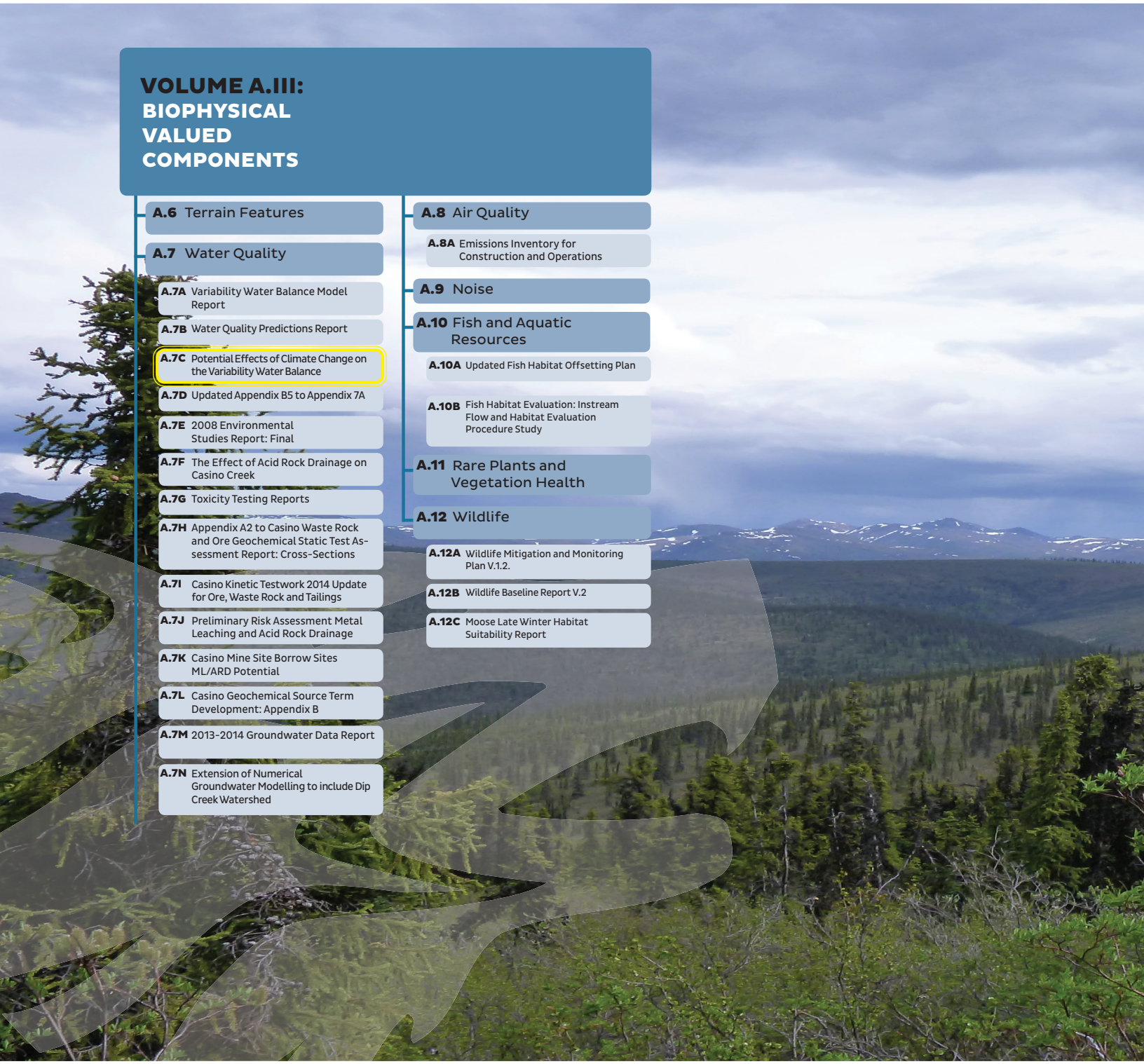
1. Results were generated from median water quality model results from 52 model realizations. Median values were averaged by mine phase.
2. Shaded cells are modelled concentrations that exceed the CCME Guidelines for the protection of freshwater aquatic life. Water quality limits have not been established and the CCME guidelines are provided as a point of reference only.
3. BC Water Quality guideline for sulphate was used because CCME guidelines are not available.
4. Water quality guidelines for SO4, Cd, Cu, Pb, and Ni are hardness dependent. Values presented in this table were calculated using the median baseline hardness of Dip Creek at W4 (111 mg/L as $CaCO_3$).

Table VI-13 Water Quality Predictions for Dip Creek (W5) – Median (P50) from 52 Model Realizations

Water Quality Model Parameter		CCME Guideline (mg/L) [2,3,4]	Operations and Wetland Construction Phase (mg/L)				TMF Discharge Phase (mg/L)				Pit Discharge Phase (mg/L)				Max P50 (all phases) mg/L
			Annual	Winter	Spring	Summer	Annual	Winter	Spring	Summer	Annual	Winter	Spring	Summer	
pH			7.4	7.5	7.2	7.3	7.4	7.5	7.3	7.3	7.4	7.5	7.3	7.4	
TDS			200	300	100	200	300	300	300	300	300	300	300	300	800
Hardness (as $CaCO_3$)			92	111	55	72	133	136	140	121	138	137	146	132	209
Alkalinity (as $CaCO_3$)			63	78	34	48	66	79	43	53	68	79	45	56	86
Sulphate	(SO_4)	309	17	22	5.9	14	54	47	80	55	57	47	84	62	142
Chloride	(Cl)	640	0.36	0.25	0.88	0.25	3.5	1.9	6.8	5.1	4.2	2.3	7.5	6.3	9.3
Fluoride	(F)	0.12	0.049	0.050	0.048	0.049	0.13	0.097	0.20	0.15	0.14	0.10	0.22	0.17	0.30
Aluminum	(Al)	0.10	0.033	0.013	0.096	0.037	0.034	0.015	0.092	0.039	0.037	0.017	0.095	0.046	0.098
Antimony	(Sb)		0.000080	0.000074	0.000088	0.000088	0.0012	0.00055	0.0020	0.0021	0.0015	0.00075	0.0025	0.0026	0.0030
Arsenic	(As)	0.0050	0.00035	0.00024	0.00074	0.00033	0.00066	0.00041	0.0013	0.00083	0.00076	0.00047	0.0014	0.0010	0.0016
Barium	(Ba)		0.060	0.069	0.048	0.046	0.062	0.070	0.054	0.050	0.063	0.070	0.054	0.051	0.077
Cadmium	(Cd)	0.00015	0.000014	0.0000087	0.000038	0.0000098	0.000048	0.000030	0.00010	0.000052	0.000048	0.000030	0.00010	0.000054	0.00013
Calcium	(Ca)		24	28	14	19	39	38	45	37	40	38	47	40	69
Chromium	(Cr)	0.0089	0.00019	0.000075	0.00060	0.00020	0.00029	0.00014	0.00074	0.00035	0.00033	0.00016	0.00079	0.00042	0.00084
Cobalt	(Co)		0.00012	0.000045	0.00043	0.000078	0.0011	0.00065	0.0024	0.0014	0.0031	0.0018	0.0055	0.0045	0.0072
Copper	(Cu)	0.0022	0.0012	0.00078	0.0022	0.0013	0.0022	0.0015	0.0042	0.0025	0.0022	0.0015	0.0043	0.0026	0.0054
Iron	(Fe)	0.30	0.19	0.053	0.78	0.12	0.17	0.050	0.67	0.11	0.16	0.048	0.65	0.10	0.81
Lead	(Pb)	0.0028	0.00014	0.000033	0.00057	0.000087	0.00029	0.00013	0.00083	0.00030	0.00033	0.00016	0.00085	0.00039	0.00097
Magnesium	(Mg)		7.9	9.6	4.8	6.1	8.6	9.9	6.5	7.2	8.9	10.0	6.8	7.6	12
Manganese	(Mn)		0.025	0.021	0.058	0.013	0.095	0.068	0.19	0.092	0.097	0.067	0.19	0.10	0.31
Mercury	(Hg)	0.000026	0.0000050	0.0000050	0.0000050	0.0000050	0.0000058	0.0000054	0.0000066	0.0000063	0.0000062	0.0000057	0.0000072	0.0000069	0.0000077
Molybdenum	(Mo)	0.073	0.00071	0.00075	0.00052	0.00076	0.011	0.0068	0.019	0.013	0.012	0.0073	0.022	0.017	0.030
Nickel	(Ni)	0.088	0.00044	0.00029	0.00097	0.00045	0.00067	0.00043	0.0014	0.00077	0.0014	0.00085	0.0025	0.0019	0.0031
Selenium	(Se)	0.0010	0.000029	0.000023	0.000050	0.000029	0.00042	0.00027	0.00082	0.00051	0.00054	0.00033	0.00098	0.00073	0.0015
Silver	(Ag)	0.00010	0.0000028	0.0000025	0.0000044	0.0000025	0.0000058	0.0000042	0.0000100	0.0000067	0.0000084	0.0000057	0.000014	0.000011	0.000017
Sodium	(Na)		3.9	4.7	2.4	3.2	6.7	6.4	8.0	6.2	6.7	6.4	8.0	6.7	13
Thallium	(Tl)	0.00080	0.0000022	0.0000012	0.0000064	0.0000018	0.000017	0.000011	0.000036	0.000019	0.000019	0.000012	0.000038	0.000023	0.000059
Uranium	(U)	0.015	0.0061	0.0077	0.0033	0.0043	0.0075	0.0084	0.0061	0.0063	0.0078	0.0085	0.0066	0.0069	0.011
Zinc	(Zn)	0.030	0.0011	0.00062	0.0031	0.00080	0.0024	0.0014	0.0055	0.0027	0.0032	0.0019	0.0065	0.0040	0.0076

1. Results were generated from median water quality model results from 52 model realizations. Median values were averaged by mine phase.
2. Shaded cells are modelled concentrations that exceed the CCME Guidelines for the protection of freshwater aquatic life. Water quality limits have not been established and the CCME guidelines are provided as a point of reference only.
3. BC Water Quality guideline for sulphate was used because CCME guidelines are not available.
4. Water quality guidelines for SO4, Cd, Cu, Pb, and Ni are hardness dependent. Values presented in this table were calculated using the median baseline hardness of Dip Creek at W5 (90 mg/L as $CaCO_3$).

APPENDIX A.7C: Potential Effects of Climate Change on the Variability Water Balance



February 5, 2015

File No.:VA101-325/17-A.01
Cont. No.:VA15-02003

Ms. Mary Mioska
Senior Environmental Manager
Casino Mining Corporation
570 Granville Street, Suite 1800
Vancouver, British Columbia
Canada, V6C 3P1

Dear Mary,

Re: Casino Project – Potential Effects of Climate Change on the YESAB Water Balance

1 – INTRODUCTION

The water balance submitted to the Yukon Environmental and Socio-Economic Assessment Board (YESAB) for the Casino Project (the project) has been updated to consider potential climate change effects. The objective of the water balance was to evaluate the quantity of water flowing in the ground, in the streams, and in various mine facilities, as well as provide a platform for development of the water quality model. The water balance submitted as part of the YESAB Proposal (the Proposal) in December 2013 was based on mean monthly climate conditions and was subsequently updated in January 2015 to include climate variability. The details of the climate variability water balance and results are described in the Knight Piésold (KP) letter "Casino Project – YESAB Water Balance to Include Climate Variability" (2015). For the purposes of this letter, the climate variability water balance model will be used as the "base case" water balance to provide a means of comparison for the projected climate change effects on estimates of flow quantity for the project.

The purposes of this letter are to outline changes to inputs and assumptions in the base case water balance that were made in order to model projected climate change effects, and to present the flow quantity results of the modelling. Based on the climate change model results, it was determined that the projected climate change effects on flow quantity were within the range of conditions already predicted by the base case water balance for which mitigation measures have been developed (KP, 2015). Therefore, climate change is not expected to adversely affect the water quality impact of the project. The results of the water quality modelling for the base case model are discussed separately in Section A.7 of the Supplementary Information Report (SIR).

2 – CLIMATE CHANGE ASSUMPTIONS

The base case water balance was developed using the net precipitation values produced by the calibrated watershed model (KP, 2013a). Net precipitation is defined as the water available for groundwater recharge and runoff from the total amount of precipitation (rainfall and snowmelt) after considering losses to the environment (e.g. evapotranspiration and soil moisture losses). The watershed model net precipitation results were developed using climatic inputs based on a 52 year long-term baseline monthly record (precipitation and temperature) developed for the project site (KP, 2013b).

In order to develop the projected climate change net precipitation inputs for the base case water balance, the long-term baseline monthly temperature and precipitation series used in the watershed model were adjusted to be representative of conditions in 2025, 2055 and 2085. The adjustments were determined on the basis of projected future annual and seasonal temperature values using the ClimateWNA program (CFCG, 2014) developed by the Department of Forest Sciences at the University of British Columbia. This program

downscales and integrates historical datasets (1901-2009) and future climate datasets (2020s, 2050s and 2080s) generated by various global circulation models.

Values were calculated for the CanEWM2_RCP85 model scenario, which appears to have the most substantial climate change effects of all the scenarios offered by the program. The magnitudes of the projected changes are shown in Table 1, which are shown relative to the climate normal for the reference period 1961-1990 used by the ClimateWNA program (CFCG, 2014). For example, differences between the 1961-1990 climate normal temperature and precipitation values and the projected 2055 values equate to +5.2 °C for temperature and +18% for precipitation. Adjusting the model input values of temperature and precipitation results in changes to the other components of the water cycle in the watershed model, as summarized in Table 2 for the reference elevation of 1200 m. A general increase in temperature and precipitation corresponds to greater rainfall but less snowfall, greater evapotranspiration but less sublimation, and higher annual runoff. Based on the three climate scenarios (2025, 2055, 2085), the 2055 scenario was projected to generate the largest increases in resulting runoff; therefore, the 2055 conditions were chosen as the representative scenario for evaluating the effects of climate change on the updated water balance model.

Table 1 Projected Climate Change Scenarios

	Climate Change Scenario	Temperature (°C)					Precipitation (mm)				
		Annual	Winter	Spring	Summer	Fall	Annual	Winter	Spring	Summer	Fall
Change Relative to 1961-1990	2025	2.7	2.5	2.6	2.9	3.1	8%	0%	16%	9%	7%
	2055	5.2	6.5	4.6	4.9	5.0	18%	15%	23%	11%	26%
	2085	8.0	9.4	7.1	7.8	7.7	20%	34%	41%	5%	22%

Table 2 Climate Change Effects Summary (elevation 1200 m)

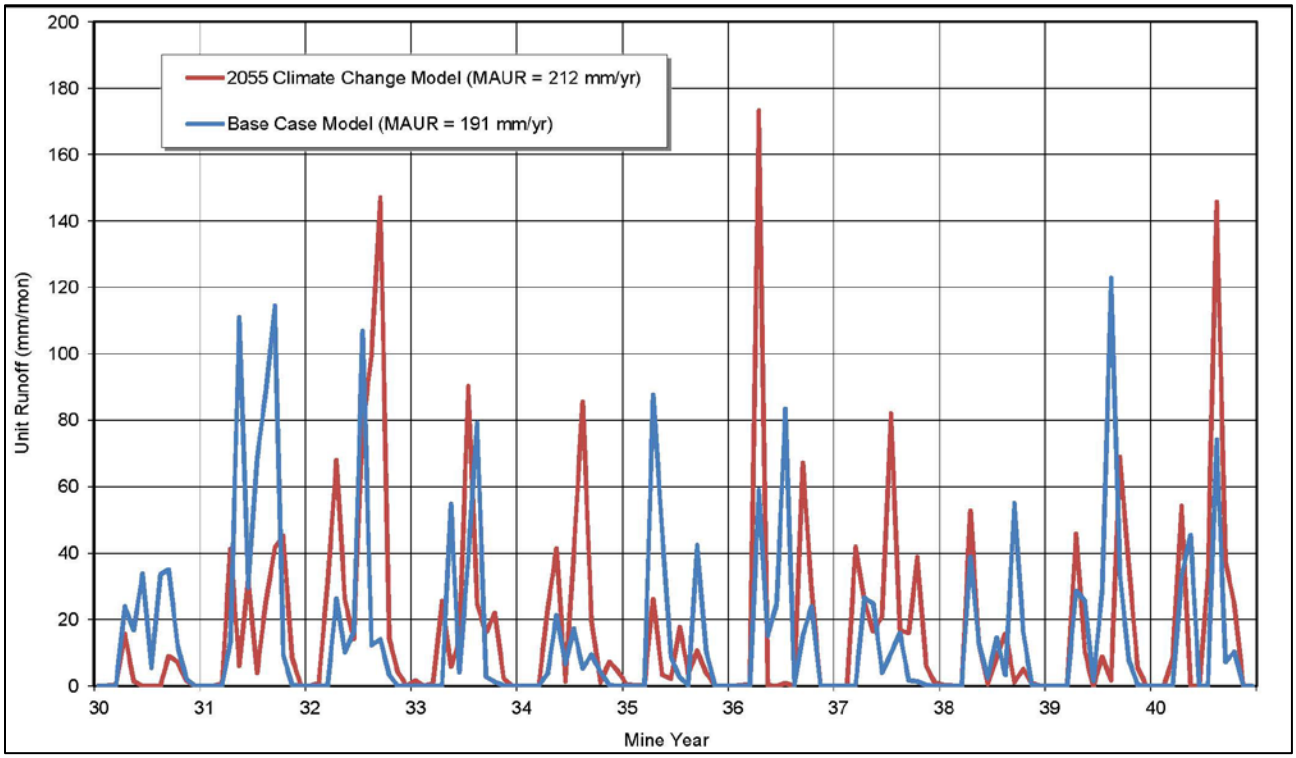
Parameter	Watershed Model Scenario			
	Base Case	2025	2055	2085
Mean Annual Precipitation (mm)	461	499	538	546
Mean Annual Rainfall (mm)	305	352	385	399
Mean Annual Snowfall (mm)	156	147	153	147
Mean Annual Sublimation (mm)	61	56	52	47
Mean Annual Actual Evapotranspiration (mm)	204	230	251	281
Mean Annual Unit Runoff (mm)	184	199	220	203

3 – CLIMATE CHANGE MODEL INPUTS

3.1 NET PRECIPITATION INPUTS

The water balance timeline includes four years of baseline conditions (Year -8 to Year -5), four years of pre-production (Year -4 to Year -1), 22 years of operations (Year 1 to Year 22), 91 years of closure (Year 23 to Year 113), and 87 years of post-closure (Year 114 to Year 200). The 52 years of net precipitation values therefore had to be repeated four times to produce a time series long enough for the simulated 208 year timeline. The watershed model produced a 52 year time series record of net precipitation for each model node; the resulting 2055 climate change scenario monthly values for each baseline watershed node and mine facility node are presented in Appendices A and B, respectively.

Figure 1 presents a comparison of the resulting baseline runoff values for the 2055 climate change scenario and base case models for model node W4 (Lower Casino Creek), for an example 11-year period (Years 30 to 40 of the model simulation). Based on this 11-year period, the mean annual unit runoff (MAUR) for the climate change scenario is approximately 11% higher than for the base case scenario. However, on a monthly basis there appears to be no consistent difference between the high flows for the base case and climate change scenarios, both in terms of timing and magnitude. In some years the base case scenario has higher flows (Years 30, 31, 35, 38 and 39) and in other years the climate change scenario has higher flows (Years 32, 33, 34, 36, 37 and 40).



NOTES

1. MAUR (mm/yr) = MEAN ANNUAL UNIT RUNOFF.
2. THE MAUR VALUES PRESENTED ON THE FIGURE FOR EACH MODEL ARE BASED ON THE AVERAGE OF THE 10 YEAR PERIOD PRESENTED FROM YEAR 30 TO YEAR 40.

Figure 1 **Climate Change Water Balance Model – Comparison of Monthly Runoff at W4**

3.2 LAKE EVAPORATION

The monthly long term temperature time series for the 52 years of record was adjusted based on the 2055 climate change scenario and then used as input to the Thornthwaite equation to estimate lake evaporation for the project site. The resulting 52 years of monthly lake evaporation values for the TMF pond and the Pit Lake at the assumed elevation of 1400 m are shown in Table C.1 in Appendix C. The mean average annual lake evaporation for the climate change scenario was estimated to be 397 mm, which is only a 3% increase from the base case scenario value of 387 mm. The negligible increase in the lake evaporation values as a result of the 2055 climate change scenario, coupled with the larger increase in precipitation values, is likely why the corresponding runoff for this scenario is more substantial compared to the other projected climate change scenarios.

4 – WATER BALANCE RESULTS

4.1 OVERVIEW

Using the climate variability approach, 52 unique sets of water balance results were developed for each node in the model. The following sections present detailed water balance results over the life of the model for the TMF, Open Pit, Water Management Pond (WMP) and Heap Leach Facility (HLF). The climate change model results are presented as monthly and annual median values (50th percentile) for comparison with the base case model results.

4.2 TAILINGS MANAGEMENT FACILITY

The water balance was used to determine the likelihood of having a surplus or deficit condition during mill operations. The TMF pond was assumed to be maintained at a minimum pond volume of 15 Mm^3 (approximately 3 months of slurry water requirements) in all months throughout operations. A deficit condition was defined when the TMF pond volume was at the minimum volume of 15 Mm^3 and the TMF and surrounding catchments were not able to supply enough process water to meet the mill process water needs. Figure 2 presents the range of possible cumulative TMF pond volumes for the base case and climate change models, as defined by the median results. The climate change model shows a larger accumulated pond volume initially prior to operations and in some years during operations. Overall, the climate change scenario pond volumes during operations are projected to be ~4% greater on a monthly basis, which is due to the higher runoff values generated by the projected climate change scenarios compared to the base case scenario.

The TMF operates in a deficit condition during the entire operation period (Years 1 to 22), with the exception of Year 22. There is no makeup water required under all scenarios for Year 22 since the TMF is in a surplus condition and can supply all the required process water required by the mill. Makeup water from the Yukon River will be used to supplement the mill process water during deficit conditions when the mill is operating. The annual makeup flow requirements during operations are summarized in Table 3. Comparison of the annual makeup water requirements for the baseline and climate change models indicate that climate change conditions result in 10% to 50% less makeup water being required on an annual basis to support mill operations. The lower makeup water requirements are due to the projections of greater precipitation in the future and associated increases in water available to satisfy the mill requirements.

Similarly, under climate change conditions less makeup water is required from the Yukon River to supplement the TMF pond prior to operations to establish the minimum pond volume. The median start-up water requirements from the Yukon River are 6.4 Mm^3 and 9.0 Mm^3 for the climate change and base case scenarios, respectively.

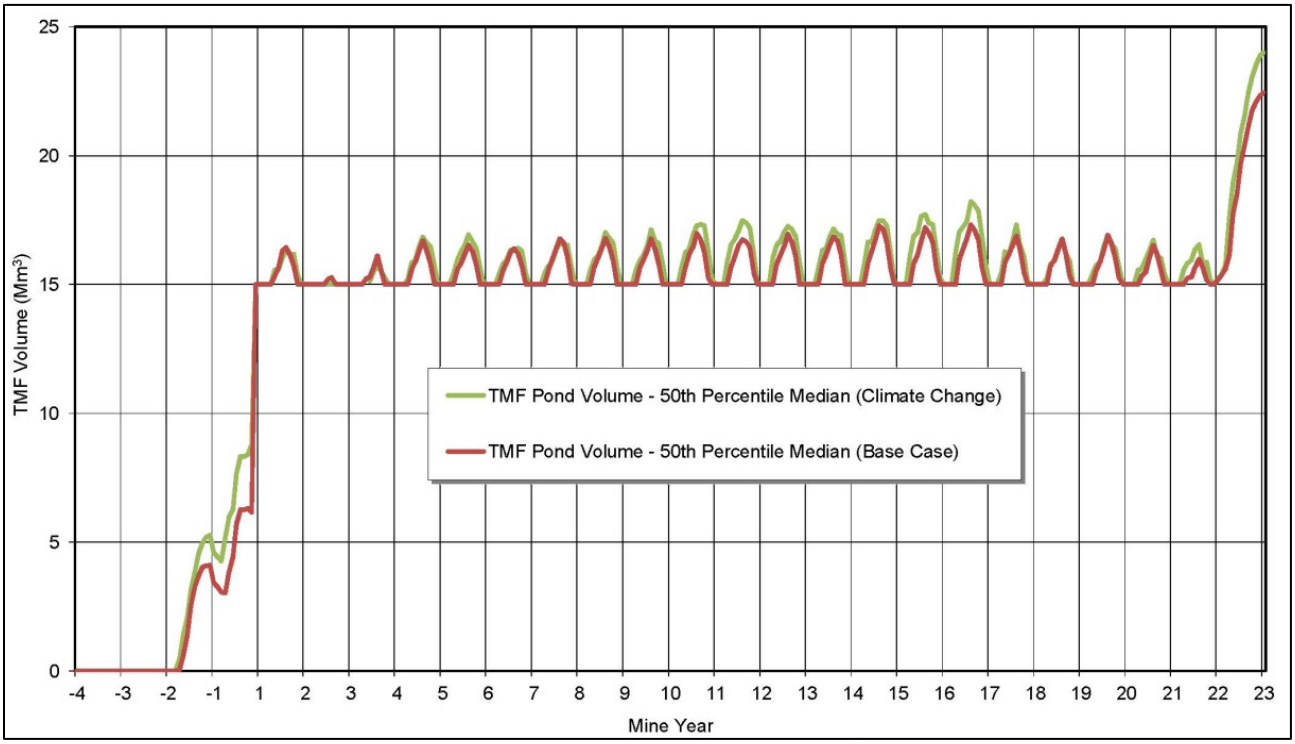


Figure 2: Tailings Management Facility Simulated Pond Volumes for Operations

Following the cessation of milling activities, the TMF pond will be pumped to the Open Pit to allow for the construction of the North and South TMF wetlands. The TMF median pond water depth for the climate change scenario, with pumping, is projected to be 1.7 m, compared to a median TMF pond water depth of 1.0 m for the base case scenario. Therefore, an increased pumping rate would be required for the climate change condition to maintain the desired water level for wetland development.

Following the wetland establishment, the TMF pond will be allowed to fill at its natural inflow rate until it begins to spill. The median results of the climate change model indicate that it takes approximately 10 years for the TMF pond to begin spilling following the end of operations, compared to 12 years for the base case model. Discharge from the TMF pond in closure will be via the constructed TMF spillway to Casino Creek downstream of the WMP. The discharge from the TMF pond will be a combination of the water released through the low-level outlet in the spillway plus any excess flow that discharges through the main spillway during wet periods. The total combined flow (low-level + main spillway) discharges through the TMF spillway are summarized in Table 6 for both models, for Years 60 and 120. These two years represent periods prior to and after filling of the Open Pit; once full, the Pit will spill water into the TMF pond and thereby increase TMF spillway flows. On an annual basis the climate change scenario indicates greater spill volumes than the base case due to overall wetter conditions, but on a monthly basis the relative spill volumes vary greatly due to differences in the hydrologic patterns. For instance, the climate change model predicts much higher spill volumes in April but lower spill volumes in May because of the earlier onset of freshet resulting from warmer temperatures.

Table 3 Annual Mill Process Water Makeup Requirements

Mine Year	Process Water Requirements (m^3/yr)	
	Base Case Model	Climate Change Model
	Median	Median
1	4,227,000	3,205,000
2	9,512,000	8,659,000
3	7,351,000	6,125,000
4	4,939,000	3,830,000
5	4,891,000	3,608,000
6	5,091,000	3,695,000
7	4,859,000	3,642,000
8	4,838,000	3,574,000
9	5,150,000	3,799,000
10	4,472,000	2,968,000
11	4,391,000	3,063,000
12	4,774,000	3,288,000
13	4,849,000	3,527,000
14	4,388,000	3,039,000
15	4,132,000	2,839,000
16	4,125,000	2,784,000
17	6,241,000	4,530,000
18	7,024,000	5,411,000
19	4,613,000	3,757,000
20	4,358,000	3,434,000
21	4,832,000	3,487,000
22	0	0

Table 4 TMF Spillway Flows

		Flow (L/s)												
		Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Closure Water Management Phase II (prior to Open Pit spilling) Year 60	Base Case Model	0	0	0	37	570	103	220	92	83	62	32	0	111
	Climate Change Model	0	0	0	327	332	129	231	84	93	113	55	0	135
Closure Water Management Phase III (after Open Pit spilling) Year 120	Base Case Model	0	0	0	38	708	220	437	203	222	131	70	0	173
	Climate Change Model	0	0	0	302	410	282	482	216	234	178	113	0	210

4.3 OPEN PIT

During closure, the Open Pit will be allowed to fill and become a pit lake. The annual Pit Lake discharge volume will be released to the North TMF Wetland at a controlled rate through a gravity controlled discharge system during the warmest months of the year (June through September). The modelling indicates that the Pit Lake will fill to the spill level 13 years faster for the climate change scenario than for the base case scenario.

Once pit filling is achieved, a controlled release flow averaging 180 L/s (June through September) will be required to maintain lake levels in the Pit at or below an elevation of 1095 masl, based on average climate conditions. Flows in excess of the controlled flow rate will be allowed to spill to the North TMF Wetland. Table 5 summarizes the release rates from the Pit Lake to the North TMF Wetland for Year 110. Results for this year are presented as an example of a "typical" year and indicate that there are expected to be no excess releases under median conditions for both the base case and the climate change scenario. The model results indicate that once full, the open pit will spill flows to the TMF pond (via the North Wetland).

Table 5 Pit Lake Release Rates

		Flow (L/s)												
		Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Controlled Release (Year 110)	Base Case Model	0	0	0	0	0	180	180	180	180	0	0	0	60
	Climate Change Model	0	0	0	0	0	180	180	180	180	0	0	0	60
Excess Release (Year 110)	Base Case Model	0	0	0	0	0	0	0	0	0	0	0	0	0
	Climate Change Model	0	0	0	0	0	0	0	0	0	0	0	0	0

4.4 WATER MANAGEMENT POND

Once the TMF begins spilling, flows collected in the water management pond (WMP), which were previously pumped to the Open Pit, will be stored during the low flow months (December through March) and discharged during the spring to coincide with periods of high flows in Brynelson Creek and discharge from TMF spillway (April through November). Discharge from the WMP will continue in Closure Water Management Phase III, once the Open Pit is full and spilling to the TMF pond. The flow releases from the WMP are summarized in Table 6 for median conditions, for both the base case and the climate change scenario. Results are shown for Years 60 and 120, which represent periods prior to and after filling of the Open Pit. The results are very similar for both periods, with the base case and the climate change scenario having similar annual flows, but substantially different monthly distributions. The climate change scenario results indicate a more even monthly distribution of flows, which reflects the change in flow pattern of the receiving waters, with an increase in winter flows and a decrease in freshet flows, resulting from an increase in winter rainfall and snowmelt and a decrease in the spring snowpack melt.

Overall, the water management pond in closure is predicted to empty by the end of each year and provide adequate storage for the winter seepage and runoff, for both the base case and the climate change scenario.

Table 6 Water Management Pond Flow Releases in Closure

		Flow (L/s)												
		Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Closure Water Management Phase II (prior to Open Pit spilling) Year 60	Base Case Model	0	0	0	11	285	75	94	72	63	51	27	0	56
	Climate Change Model	0	0	0	19	166	85	123	67	66	64	46	0	58
Closure Water Management Phase III (after Open Pit spilling) Year 120	Base Case Model	0	0	0	8	283	75	94	72	63	52	28	0	56
	Climate Change Model	0	0	0	23	164	87	129	70	64	66	45	0	59

4.5 HEAP LEACH FACILITY

The results of the updated water balance indicate that the Heap Leach Facility (HLF) operates in a water deficit condition during all months of operations when ore stacking is active (Years -3 to 15). Table 7 summarizes the annual makeup water requirements during operations, which are lower for the climate change scenario because of overall wetter climatic conditions. These wetter conditions result in an increase in the accumulated water in the heap, as indicated on Figure 3. The monthly surplus flow rates for the climate change scenario are generally lower compared to the base case, as presented on Figure 3; however, due to the modified monthly distribution of flows for the climate change scenario, more water is discharged from the heap on an annual basis, as summarized in Table 8.

Table 7 Annual Process Water Makeup Requirements for HLF

Mine Year	Process Water Requirements (m^3/yr)	
	Base Case Model	Climate Change Model
	Median	Median
-3	143,600	88,700
-2	0	0
-1	0	0
1	492,800	450,300
2	462,800	403,900
3	420,800	374,700
4	408,100	353,300
5	394,700	340,600
6	388,900	328,900
7	373,300	320,100
8	369,400	307,700
9	357,100	292,800
10	354,700	286,700
11	355,600	284,900
12	306,000	242,600
13	371,500	314,100
14	367,800	308,200
15	208,100	131,000
16	229,500	177,500
17	226,800	177,100
18	226,600	175,300
19	225,000	172,800
20	229,900	175,200
21	226,900	172,000
22	229,900	177,800
23	228,900	173,100

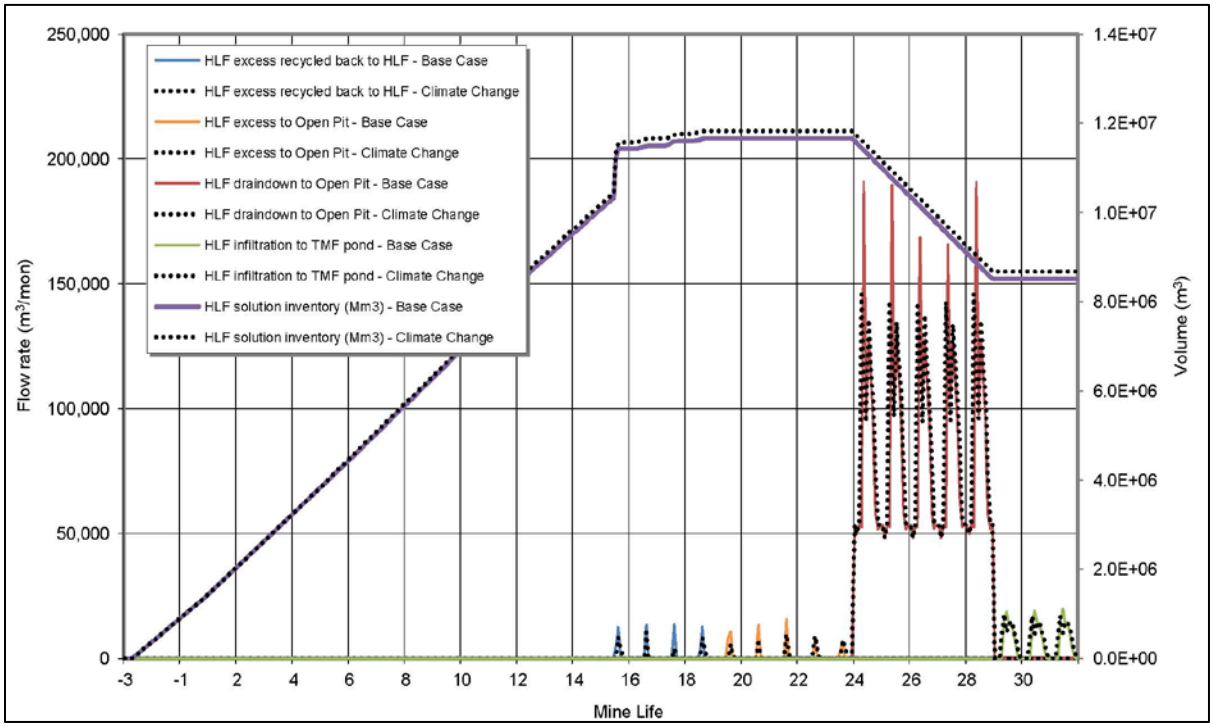


Figure 3 **Heap Leach Facility – Accumulated Water and Monthly Surplus, Median Results**

Table 8 **Heap Leach Facility – Annual Surplus Volumes**

Year	HLF excess recycled back to HLF (m^3/yr)		HLF excess to Open Pit (m^3/yr)		HLF draindown to Open Pit (m^3/yr)		HLF infiltration to TMF Pond (m^3/yr)	
	Base Case	Climate Change	Base Case	Climate Change	Base Case	Climate Change	Base Case	Climate Change
15	64,200	68,700	0	0	0	0	0	0
16	71,000	77,100	0	0	0	0	0	0
17	67,700	71,000	0	0	0	0	0	0
18	67,400	76,200	0	0	0	0	0	0
19	0	0	71,000	70,600	0	0	0	0
20	0	0	73,900	73,400	0	0	0	0
21	0	0	69,800	82,100	0	0	0	0
22	0	0	67,900	72,400	0	0	0	0
23	0	0	64,400	79,500	0	0	0	0
24	0	0	0	0	1,050,000	1,129,000	0	0
25	0	0	0	0	1,048,000	1,114,000	0	0
26	0	0	0	0	1,037,000	1,126,000	0	0
27	0	0	0	0	1,042,000	1,134,000	0	0
28	0	0	0	0	1,049,000	1,132,000	0	0
29	0	0	0	0	0	0	84,200	99,400
30	0	0	0	0	0	0	83,900	99,100
31	0	0	0	0	0	0	86,600	97,300
32	0	0	0	0	0	0	84,300	100,000

5 – SUMMARY

Predicted climate change scenarios for the Casino Project are projected to be both warmer and wetter, resulting in increased annual runoff (~20%) and a more even monthly distribution of runoff. These conditions, in turn, produce the following likely changes in the project operational water balance mine development components, when comparing the median climate change model results with the corresponding base case model results:

- Tailings Management Facility (TMF):
  - Pond volumes during operations are ~ 4% greater.
  - ~ 30% less make-up water from the Yukon River is required for start-up.
  - ~ 10% to 50% less make-up water from the Yukon River is required for operations.
  - A greater pumping rate may be required to facilitate TMF wetland development at closure.
  - After closure, the TMF pond will fill to its spill level approximately 2 years faster (10 years vs. 12 years).
- Open Pit:
  - In closure the Open Pit Lake will fill to the spill level 13 years faster (74 years vs. 87 years).
  - Once full, the Open Pit Lake is projected to spill under the controlled release rate of 180 L/s during June to September without any uncontrolled discharge for median conditions.
- Water Management Pond (WMP):
  - Flows released from the WMP will be very similar on an annual flow basis, but substantially different on a monthly basis. There will be a more even monthly distribution of flows, which reflects the change in flow pattern of the receiving waters, with an increase in winter flows and a decrease in freshet flows resulting from an increase in winter rainfall and snowmelt and a decrease in the spring snowpack melt.
- Heap Leach Facility:
  - Increases in both the surplus water from the heap and accumulated water in the heap.

6 – REFERENCES

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KP (2013b). *Casino Project – Baseline Climate Report*, Ref. No. VA101-325/14-7 Rev 0, June 14, 2013.

Yours truly,

KNIGHT PIESOLD LTD.



Prepared: _____
Erin Rainey, P. Eng.
Project Engineer

Reviewed: _____
Jaime Cathcart, Ph.D., P.Eng.
Hydrotechnical Specialist Engineer

Approval that this document adheres to Knight Piésold Quality Systems: ☐

Attachments:

Appendix A	Climate Change 2055 Scenario: Net Precipitation Values from Watershed Model
Appendix B	Climate Change 2055 Scenario: Operational Net Precipitation Values for Mine Facilities
Appendix C	Climate Change 2055 Scenario: Lake Evaporation Values – TMF Pond and Open Pit Lake

/er

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APPENDIX A

CLIMATE CHANGE 2055 SCENARIO: NET PRECIPITATION VALUES FROM WATERSHED MODEL

(Pages A-1 to A-8)

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TABLE A.1

CASINO MINING CORPORATION
CASINO PROJECT

CLIMATE CHANGE NET PRECIPTIATON VALUES - 2055 SCENARIO
NODE W3 - CANADIAN CREEEK

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Year	Monthly Net Precipitation (mm/mon)												Annual Net Precipitation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	1	27	7	0	0	0	1	0	0	0	36
2	0	0	0	34	1	0	18	57	9	13	0	0	131
3	0	0	0	56	78	12	0	10	15	1	0	0	173
4	0	0	0	40	1	0	114	12	26	4	0	0	198
5	0	0	0	31	28	12	8	2	5	14	0	0	100
6	0	0	0	99	31	28	3	9	2	1	0	0	173
7	0	0	0	53	68	23	83	5	9	16	0	0	257
8	0	0	3	27	2	1	6	0	22	22	0	0	83
9	0	0	0	48	32	0	0	0	0	0	0	0	81
10	0	0	0	37	127	14	43	40	24	9	0	0	294
11	0	0	20	56	19	0	0	0	58	8	0	0	161
12	0	0	0	43	16	0	26	0	5	2	0	0	93
13	0	0	5	28	47	0	0	1	45	16	0	0	144
14	0	0	0	53	16	0	0	3	8	5	0	0	85
15	0	0	0	6	103	55	11	0	11	24	0	0	209
16	0	0	0	121	7	10	11	39	0	3	0	0	191
17	0	0	0	76	30	0	15	6	0	10	0	0	137
18	0	0	0	49	7	0	19	4	28	14	0	0	122
19	0	0	0	81	49	5	10	0	0	4	3	0	152
20	0	1	0	69	11	12	1	0	0	5	0	0	100
21	0	0	0	17	3	3	83	25	15	22	0	0	169
22	0	0	3	71	42	20	22	0	8	0	0	0	165
23	0	0	0	27	0	0	3	7	62	12	2	0	113
24	2	0	5	15	9	2	67	22	76	48	6	0	253
25	0	0	0	37	51	0	11	0	18	10	0	0	128
26	0	0	0	80	12	18	21	89	29	17	0	0	268
27	0	0	13	35	19	0	8	23	20	8	0	0	126
28	3	0	0	37	40	54	79	33	29	10	0	0	286
29	0	0	0	9	78	17	50	27	0	1	0	0	181
30	0	0	0	47	5	0	12	8	51	48	2	0	174
31	0	0	9	60	4	0	31	3	0	12	0	0	118
32	0	0	0	32	17	18	0	0	1	3	0	0	72
33	0	0	1	41	43	30	0	2	40	25	0	0	182
34	0	0	0	94	12	0	10	9	48	11	0	0	184
35	0	0	16	116	65	2	7	19	93	14	2	0	334
36	0	0	2	120	7	0	13	12	12	28	0	0	194
37	0	0	5	55	28	27	2	0	0	10	0	0	128
38	0	0	0	10	0	0	48	83	0	12	0	0	153
39	0	1	0	58	115	20	64	9	25	11	2	0	305
40	0	0	0	38	0	0	0	0	8	3	0	0	51
41	0	0	0	51	5	33	0	24	40	38	0	0	191
42	0	0	13	70	52	10	66	86	138	11	2	0	446
43	1	0	0	44	1	10	96	8	15	19	0	0	193
44	0	0	0	13	63	0	38	76	0	2	2	1	196
45	0	0	0	35	8	3	13	2	9	4	0	0	74
46	0	0	0	175	13	0	2	0	56	23	0	0	269
47	0	0	20	58	12	18	73	0	14	41	0	0	237
48	0	0	0	60	4	1	6	10	0	5	0	0	85
49	0	0	0	68	1	0	8	1	61	21	1	0	161
50	0	0	3	65	6	0	22	126	34	19	0	0	277
51	0	0	0	89	14	0	0	55	7	19	0	0	185
52	0	0	10	24	0	1	62	11	1	8	0	0	117
Average	**0**	**0**	**3**	**54**	**27**	**9**	**25**	**18**	**23**	**13**	**0**	**0**	**172**
Minimum	**0**	**0**	**0**	**6**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**36**
Maximum	**3**	**1**	**20**	**175**	**127**	**55**	**114**	**126**	**138**	**48**	**6**	**1**	**446**

M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 513 - Climate change scenarios\GoldSim\[Appendix A tables_WatershedSurplusWater.xlsx]Table_W3Inputs

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	09DEC'14	ISSUED WITH LETTER VA15-01946	EER	JGC	KJB

Knight Piésold CONSULTING

TABLE A.2

CASINO MINING CORPORATION
CASINO PROJECT

CLIMATE CHANGE NET PRECIPTIATON VALUES - 2055 SCENARIO
NODE W14 - BRITIANNIA CREEK

Print Jan/15/15 18:01:48

Year	Monthly Net Precipitation (mm/mon)												Annual Net Precipitation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	1	32	1	0	0	0	0	0	0	0	35
2	0	0	0	33	0	0	22	59	9	18	0	0	142
3	0	0	0	78	45	14	0	13	16	2	0	0	168
4	0	0	0	38	0	0	122	13	27	4	0	0	203
5	0	0	0	42	15	13	10	2	7	21	0	0	110
6	0	0	0	109	8	30	3	12	3	0	0	0	165
7	0	0	0	73	43	25	88	6	10	14	0	0	260
8	0	0	4	25	0	1	7	0	25	31	0	0	93
9	0	0	0	62	10	0	0	0	0	1	0	0	72
10	0	0	0	56	100	15	46	43	26	10	0	0	295
11	0	0	29	54	9	0	0	0	63	11	0	0	165
12	0	0	0	36	17	0	30	0	6	2	0	0	92
13	0	0	8	23	48	0	0	0	50	23	0	0	153
14	0	0	0	59	3	0	0	2	11	9	0	0	84
15	0	0	0	8	91	58	13	0	12	34	0	0	216
16	0	0	0	112	1	10	13	41	0	5	0	0	183
17	0	0	0	94	8	0	17	7	0	14	0	0	140
18	0	0	0	49	1	0	23	5	29	18	0	0	125
19	0	0	0	79	44	7	12	0	0	5	6	0	153
20	0	2	1	65	6	13	1	0	0	6	0	0	94
21	0	0	0	17	0	4	88	27	16	25	0	0	178
22	0	0	4	83	22	22	24	0	10	0	1	0	165
23	0	0	0	22	0	0	3	9	66	11	3	0	114
24	3	0	8	19	3	1	70	24	79	48	9	0	266
25	0	0	0	47	35	0	14	0	20	15	0	0	131
26	0	0	0	71	12	20	24	94	30	19	0	0	271
27	0	0	19	25	19	0	10	25	21	11	0	0	130
28	4	0	0	53	19	57	84	36	30	14	0	0	296
29	0	0	0	14	67	18	54	28	0	0	0	0	182
30	0	0	0	44	5	0	15	9	52	47	3	0	176
31	0	0	12	52	4	0	34	4	0	16	0	0	122
32	0	0	0	25	18	20	0	0	0	6	0	0	69
33	0	0	2	36	44	33	0	2	44	32	0	0	193
34	0	0	0	88	7	0	12	11	49	15	0	0	182
35	0	0	23	134	31	1	9	21	96	21	3	0	339
36	0	0	3	113	1	0	16	14	12	26	0	0	185
37	0	0	7	49	30	29	2	0	0	13	0	0	130
38	0	0	0	7	0	0	52	87	0	12	0	0	158
39	0	1	0	57	116	22	68	10	26	16	2	0	319
40	0	0	0	29	0	0	0	0	10	5	0	0	44
41	0	0	0	48	4	36	0	27	42	42	0	0	199
42	0	1	18	79	29	12	70	90	143	13	2	0	456
43	1	0	0	39	0	12	100	9	15	22	0	0	198
44	0	0	0	18	52	0	42	80	0	2	4	1	201
45	0	0	0	38	1	3	15	2	10	3	0	0	73
46	0	0	0	179	3	0	1	0	61	27	0	0	271
47	0	0	28	44	12	20	77	0	15	39	0	1	237
48	0	0	0	58	2	1	7	13	0	6	0	0	87
49	0	0	0	64	0	0	9	0	66	25	2	0	166
50	0	0	4	63	1	0	26	132	36	23	0	0	284
51	0	0	0	96	2	0	0	60	8	19	0	0	185
52	0	0	16	17	0	0	67	12	0	8	1	0	121
Average	**0**	**0**	**4**	**55**	**19**	**10**	**27**	**20**	**24**	**16**	**1**	**0**	**174**
Minimum	**0**	**0**	**0**	**7**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**35**
Maximum	**4**	**2**	**29**	**179**	**116**	**58**	**122**	**132**	**143**	**48**	**9**	**1**	**456**

M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 513 - Climate change scenarios\GoldSim\[Appendix A tables_WatershedSurplusWater.xlsx]Table_W14Inputs

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	09DEC'14	ISSUED WITH LETTER VA15-01946	EER	JGC	KJB

Knight Piésold CONSULTING

TABLE A.3

CASINO MINING CORPORATION
CASINO PROJECT

CLIMATE CHANGE NET PRECIPTIATON VALUES - 2055 SCENARIO
NODE W11 - UPPER CASINO CREEK

Print Jan/15/15 18:01:48

Year	Monthly Net Precipitation (mm/mon)												Annual Net Precipitation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	0	40	5	0	0	0	1	0	0	0	47
2	0	0	0	54	0	0	32	72	13	9	0	0	180
3	0	0	0	61	101	20	0	18	22	1	0	0	224
4	0	0	0	54	0	0	140	18	31	6	0	0	249
5	0	0	0	40	34	20	15	3	10	16	0	0	138
6	0	0	0	129	26	39	5	17	4	1	0	0	221
7	0	0	0	66	81	33	98	9	14	20	0	0	320
8	0	0	1	40	0	3	11	0	35	24	0	0	114
9	0	0	0	67	30	0	0	0	0	0	0	0	98
10	0	0	0	31	174	21	55	50	30	12	0	0	373
11	0	0	13	84	17	0	0	0	79	9	0	0	202
12	0	0	0	55	22	0	41	0	10	3	0	0	131
13	0	0	4	41	57	0	0	1	64	16	0	0	183
14	0	0	0	76	10	0	0	6	15	8	0	0	115
15	0	0	0	1	132	68	19	0	18	23	0	0	262
16	0	0	0	152	3	16	19	50	0	6	0	0	247
17	0	0	0	99	25	0	27	10	0	19	0	0	180
18	0	0	0	66	4	0	33	8	37	16	0	0	164
19	0	0	0	101	53	10	17	0	0	8	4	0	194
20	0	0	0	93	11	19	1	0	0	11	0	0	137
21	0	0	0	29	1	7	106	33	20	27	0	0	224
22	0	0	1	94	41	29	31	0	14	0	0	0	210
23	0	0	0	38	0	0	6	13	79	15	1	0	152
24	2	0	4	25	10	4	86	30	86	56	2	0	307
25	0	0	0	53	56	0	21	0	29	11	0	0	170
26	0	0	0	99	17	27	31	103	34	21	0	0	333
27	0	0	9	46	27	0	15	35	26	10	0	0	167
28	1	0	0	48	48	67	94	42	35	10	0	0	345
29	0	0	0	5	103	25	63	34	0	1	0	0	232
30	0	0	0	64	7	0	23	13	61	55	1	0	224
31	0	0	4	79	7	0	47	6	0	21	0	0	164
32	0	0	0	40	23	27	0	0	1	7	0	0	98
33	0	0	0	61	52	40	0	4	55	29	0	0	242
34	0	0	0	115	12	1	18	15	58	11	0	0	230
35	0	0	7	155	67	3	14	30	104	11	1	0	392
36	0	0	1	153	4	0	24	20	17	33	0	0	252
37	0	0	1	71	37	36	5	0	0	19	0	0	169
38	0	0	0	14	0	0	70	96	0	18	0	0	200
39	0	0	0	75	126	29	78	15	31	9	1	0	365
40	0	0	0	53	0	0	0	0	16	7	0	0	75
41	0	0	0	72	6	46	0	37	47	46	0	0	254
42	0	0	5	100	51	17	80	99	154	14	1	0	520
43	0	0	0	58	0	18	114	13	20	23	0	0	247
44	0	0	0	8	83	0	54	89	0	4	3	0	242
45	0	0	0	54	5	6	22	4	15	5	0	0	110
46	0	0	0	209	10	0	3	0	77	29	0	0	328
47	0	0	11	76	18	28	89	0	22	47	0	0	291
48	0	0	0	76	4	2	11	18	0	9	0	0	120
49	0	0	0	88	0	0	15	1	80	26	0	0	211
50	0	0	0	86	2	0	37	145	40	24	0	0	335
51	0	0	0	113	8	0	0	77	11	23	0	0	231
52	0	0	8	33	0	1	84	18	1	12	0	0	157
Average	**0**	**0**	**1**	**70**	**31**	**13**	**34**	**24**	**29**	**16**	**0**	**0**	**219**
Minimum	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**47**
Maximum	**2**	**0**	**13**	**209**	**174**	**68**	**140**	**145**	**154**	**56**	**4**	**0**	**520**

M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 513 - Climate change scenarios\GoldSim\[Appendix A tables_WatershedSurplusWater.xlsx]Table_W11Inputs

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	09DEC'14	ISSUED WITH LETTER VA15-01946	EER	JGC	KJB

Knight Piésold
CONSULTING

TABLE A.4

CASINO MINING CORPORATION
CASINO PROJECT

CLIMATE CHANGE NET PRECIPTIATON VALUES - 2055 SCENARIO
NODE W18 - BRYNELSON CREEK

Print Jan/15/15 18:01:48

Year	Monthly Net Precipitation (mm/mon)												Annual Net Precipitation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	0	33	13	0	0	0	2	0	0	0	50
2	0	0	0	59	1	1	33	72	13	9	0	0	189
3	0	0	0	50	121	21	1	19	23	1	0	0	236
4	0	0	0	56	3	0	141	19	32	6	0	0	256
5	0	0	0	32	47	20	16	4	10	14	0	0	143
6	0	0	0	112	53	41	5	17	5	2	0	0	235
7	0	0	0	54	100	34	99	9	15	21	0	0	331
8	0	0	1	40	4	3	12	0	36	20	0	0	116
9	0	0	0	53	54	0	0	0	0	1	0	0	107
10	0	0	0	29	188	24	56	50	30	11	0	0	388
11	0	0	13	74	34	0	0	1	80	8	0	0	210
12	0	0	0	62	23	0	42	0	10	4	0	0	140
13	0	0	4	43	60	0	0	2	65	14	0	0	188
14	0	0	0	64	28	0	0	7	15	6	0	0	121
15	0	0	0	1	143	69	20	0	19	20	0	0	272
16	0	0	0	150	14	19	20	51	0	5	0	0	259
17	0	0	0	81	50	0	29	11	0	16	0	0	186
18	0	0	0	63	15	0	35	8	38	13	0	0	173
19	0	0	0	100	64	10	18	0	1	7	4	0	204
20	0	0	0	93	20	20	2	0	0	11	0	0	147
21	0	0	0	30	5	7	107	34	21	25	0	0	229
22	0	0	1	79	66	30	32	0	15	0	0	0	223
23	0	0	0	44	0	0	6	13	80	16	1	0	160
24	2	0	4	19	18	5	88	30	87	55	3	0	312
25	0	0	0	42	75	0	22	1	30	9	0	0	178
26	0	0	0	104	20	28	31	104	35	19	0	0	342
27	0	0	9	53	28	0	15	36	26	8	0	0	175
28	1	0	0	39	66	68	95	42	35	8	0	0	354
29	0	0	0	6	110	26	64	35	0	1	0	0	241
30	0	0	0	66	11	0	23	14	62	58	1	0	235
31	0	0	4	83	9	0	48	6	0	18	0	0	168
32	0	0	0	48	25	28	0	0	1	6	0	0	108
33	0	0	0	68	55	41	0	4	56	24	0	0	248
34	0	0	0	116	23	1	19	16	59	9	0	0	244
35	0	0	8	131	104	3	14	31	105	10	1	0	407
36	0	0	1	150	15	0	24	21	18	35	0	0	264
37	0	0	1	76	37	37	5	0	1	19	0	0	177
38	0	0	0	19	0	1	72	97	0	18	0	0	207
39	0	1	0	74	133	30	79	15	32	8	1	0	373
40	0	0	0	59	0	1	0	0	17	6	0	0	82
41	0	0	0	75	10	47	0	39	48	42	0	0	260
42	0	0	6	84	80	18	81	99	154	12	1	0	535
43	0	0	0	62	3	19	115	14	20	21	0	0	254
44	0	0	0	8	92	0	56	90	0	5	3	0	254
45	0	0	0	46	16	7	23	4	15	6	0	0	118
46	0	0	0	200	29	0	4	0	78	26	0	0	337
47	0	0	12	83	20	29	89	0	23	49	0	0	307
48	0	0	0	76	8	2	12	19	0	9	0	0	126
49	0	0	0	92	2	1	16	1	81	23	1	0	216
50	0	0	0	84	12	0	40	146	41	21	0	0	344
51	0	0	0	102	27	0	0	79	12	23	0	0	242
52	0	0	8	38	0	2	85	18	1	12	0	0	164
Average	**0**	**0**	**1**	**67**	**41**	**13**	**34**	**25**	**30**	**15**	**0**	**0**	**228**
Minimum	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**50**
Maximum	**2**	**1**	**13**	**200**	**188**	**69**	**141**	**146**	**154**	**58**	**4**	**0**	**535**

M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 513 - Climate change scenarios\GoldSim\[Appendix A tables_WatershedSurplusWater.xlsx]Table_W18Inputs

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	09DEC'14	ISSUED WITH LETTER VA15-01946	EER	JGC	KJB

Knight Piésold CONSULTING

TABLE A.5

CASINO MINING CORPORATION
CASINO PROJECT

CLIMATE CHANGE NET PRECIPTIATON VALUES - 2055 SCENARIO
NODE H18 - CASINO CREEK BELOW BRYNELSON

Print Jan/15/15 18:01:48

Year	Monthly Net Precipitation (mm/mon)												Annual Net Precipitation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	2	30	0	0	0	0	0	0	0	0	32
2	0	0	0	34	0	0	28	63	10	30	0	0	164
3	0	0	0	101	9	17	0	16	17	3	0	0	163
4	0	0	0	35	0	0	132	15	29	3	0	0	213
5	0	0	0	50	6	16	13	2	8	33	0	0	129
6	0	0	0	100	0	33	3	15	3	0	0	0	155
7	0	0	0	91	23	29	94	7	11	13	0	0	269
8	0	0	6	20	0	0	9	0	30	41	0	0	106
9	0	0	0	61	0	0	0	0	0	2	0	0	63
10	0	0	0	102	48	17	49	46	28	9	0	0	300
11	0	0	52	29	8	0	0	0	70	13	0	0	173
12	0	0	0	32	19	0	35	0	8	1	0	0	96
13	0	0	18	12	50	0	0	0	57	33	0	0	171
14	0	0	0	50	0	0	0	1	14	16	0	0	80
15	0	0	0	10	79	63	16	0	15	52	0	0	235
16	0	0	0	89	0	12	17	44	0	8	0	0	171
17	0	0	0	99	0	0	20	9	0	15	0	0	143
18	0	0	0	45	0	0	28	6	31	21	0	0	133
19	0	0	0	74	47	8	15	0	0	6	13	0	162
20	0	3	1	53	7	16	0	0	0	6	0	0	87
21	0	0	0	17	0	4	96	30	18	25	0	0	190
22	0	0	6	83	17	25	27	0	12	0	1	0	172
23	0	0	0	19	0	0	2	11	72	10	4	0	119
24	7	0	17	11	0	0	77	27	84	47	15	0	285
25	0	0	0	46	29	0	18	0	24	21	0	0	137
26	0	0	0	61	14	23	27	100	32	19	0	0	276
27	0	0	38	7	17	0	11	30	23	13	0	0	140
28	7	0	0	63	3	61	90	39	32	20	0	0	316
29	0	0	0	25	48	21	59	31	0	0	0	0	185
30	0	0	0	41	5	0	19	11	55	45	6	0	183
31	0	0	20	38	5	0	39	4	0	18	0	0	124
32	0	0	0	21	19	23	0	0	0	8	0	0	72
33	0	0	3	33	47	36	0	1	50	39	0	0	209
34	0	0	0	80	7	0	15	14	52	21	0	0	189
35	0	0	36	125	17	1	12	25	100	36	4	0	357
36	0	0	4	91	0	0	20	17	13	25	0	0	170
37	0	0	10	43	32	32	2	0	0	15	0	0	135
38	0	0	0	6	0	0	58	93	0	11	0	0	168
39	0	3	0	52	123	25	73	12	28	27	4	0	347
40	0	0	0	15	0	0	0	0	11	6	0	0	32
41	0	0	1	45	4	40	0	31	44	43	0	0	208
42	0	1	28	70	24	14	75	96	151	14	4	0	478
43	1	0	1	33	0	15	108	11	16	22	0	0	207
44	0	0	0	33	37	0	48	86	0	1	9	2	215
45	0	0	0	30	0	3	20	2	13	2	0	0	70
46	0	0	0	176	0	0	0	0	69	28	0	0	274
47	0	0	55	17	13	22	83	0	18	38	0	1	246
48	0	0	0	55	2	0	9	16	0	6	0	0	88
49	0	0	0	60	0	0	11	0	73	25	3	0	172
50	0	0	5	57	0	0	31	140	38	24	0	0	296
51	0	0	0	95	0	0	0	67	9	17	0	0	189
52	0	0	33	5	0	0	71	14	0	8	1	0	133
Average	**0**	**0**	**6**	**51**	**15**	**11**	**30**	**22**	**26**	**18**	**1**	**0**	**181**
Minimum	**0**	**0**	**0**	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**32**
Maximum	**7**	**3**	**55**	**176**	**123**	**63**	**132**	**140**	**151**	**52**	**15**	**2**	**478**

M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 513 - Climate change scenarios\GoldSim\[Appendix A tables_WatershedSurplusWater.xlsx]Table_H18Inputs

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	09DEC'14	ISSUED WITH LETTER VA15-01946	EER	JGC	KJB

Knight Piésold CONSULTING

TABLE A.6

CASINO MINING CORPORATION
CASINO PROJECT

CLIMATE CHANGE NET PRECIPTIATON VALUES - 2055 SCENARIO
NODE W4 - LOWER CASINO CREEK

Print Jan/15/15 18:01:48

Year	Monthly Net Precipitation (mm/mon)												Annual Net Precipitation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	2	31	0	0	0	0	0	0	0	0	33
2	0	0	0	35	0	0	28	63	10	28	0	0	164
3	0	0	0	94	20	17	0	16	18	3	0	0	167
4	0	0	0	36	0	0	132	15	29	3	0	0	215
5	0	0	0	49	9	16	13	2	8	31	0	0	128
6	0	0	0	104	1	34	3	15	3	0	0	0	161
7	0	0	0	87	28	29	95	8	12	13	0	0	272
8	0	0	8	21	0	1	8	0	31	38	0	0	107
9	0	0	0	63	2	0	0	0	0	2	0	0	66
10	0	0	0	92	63	18	49	47	28	9	0	0	306
11	0	0	46	37	8	0	0	0	71	12	0	0	174
12	0	0	0	33	19	0	36	0	8	2	0	0	98
13	0	0	16	16	50	0	0	0	57	31	0	0	170
14	0	0	0	54	0	0	0	1	14	15	0	0	83
15	0	0	0	14	79	63	16	0	15	48	0	0	236
16	0	0	0	97	0	12	17	45	0	8	0	0	179
17	0	0	0	99	1	0	21	9	0	16	0	0	146
18	0	0	0	46	0	0	29	7	32	20	0	0	133
19	0	0	0	76	47	8	15	0	0	6	12	0	164
20	0	5	1	55	7	16	0	0	0	6	0	0	91
21	0	0	0	18	0	4	96	30	18	25	0	0	192
22	0	0	6	84	18	25	27	0	12	0	1	0	175
23	0	0	0	20	0	0	2	11	73	10	5	0	121
24	6	0	14	14	1	0	78	27	84	47	16	0	287
25	0	0	0	46	31	0	18	0	24	19	0	0	138
26	0	0	0	64	14	23	27	101	32	19	0	0	281
27	0	0	32	13	18	0	12	30	23	13	0	0	141
28	8	0	0	60	7	62	91	39	32	18	0	0	317
29	0	0	0	23	54	21	59	31	0	0	0	0	189
30	0	0	0	42	5	0	19	12	56	45	6	0	186
31	0	0	21	41	5	0	39	4	0	18	0	0	127
32	0	0	0	23	20	23	0	0	0	8	0	0	73
33	0	0	4	34	47	36	0	1	50	38	0	0	210
34	0	0	0	82	7	0	15	14	52	20	0	0	191
35	0	0	38	125	20	1	12	26	101	32	5	0	358
36	0	0	5	96	0	0	20	18	13	25	0	0	177
37	0	0	12	43	32	33	2	0	0	15	0	0	137
38	0	0	0	6	0	0	59	93	0	12	0	0	170
39	0	3	0	53	123	25	73	12	28	25	4	1	348
40	0	0	0	19	0	0	0	0	11	7	0	0	37
41	0	0	1	47	4	40	0	32	44	43	0	0	211
42	0	1	30	70	25	15	76	96	151	14	4	0	482
43	1	0	1	34	0	15	108	11	17	22	0	0	209
44	0	0	0	30	41	0	48	86	0	1	8	3	217
45	0	0	0	32	0	3	20	3	13	2	0	0	73
46	0	0	0	178	0	0	1	0	69	28	0	0	277
47	0	0	48	25	13	23	83	0	18	38	0	1	249
48	0	0	0	56	2	0	9	17	0	6	0	0	90
49	0	0	0	61	0	0	11	0	73	26	3	0	175
50	0	0	8	56	0	0	32	140	38	24	0	0	298
51	0	0	0	97	0	0	0	68	9	18	1	0	192
52	0	0	27	9	0	0	73	15	0	8	1	0	134
Average	**0**	**0**	**6**	**53**	**16**	**11**	**30**	**22**	**27**	**18**	**1**	**0**	**184**
Minimum	**0**	**0**	**0**	**6**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**33**
Maximum	**8**	**5**	**48**	**178**	**123**	**63**	**132**	**140**	**151**	**48**	**16**	**3**	**482**

M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 513 - Climate change scenarios\GoldSim\[Appendix A tables_WatershedSurplusWater.xlsx]Table_W4Inputs

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	09DEC'14	ISSUED WITH LETTER VA15-01946	EER	JGC	KJB

Knight Piésold CONSULTING

TABLE A.7

CASINO MINING CORPORATION
CASINO PROJECT

CLIMATE CHANGE NET PRECIPTIATON VALUES - 2055 SCENARIO
NODE W9 - UPPER DIP CREEK

Print Jan/15/15 18:01:48

Year	Monthly Net Precipitation (mm/mon)												Annual Net Precipitation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	1	36	4	0	0	0	1	0	0	0	42
2	0	0	0	47	0	0	31	69	12	15	0	0	175
3	0	0	0	76	70	19	0	18	20	2	0	0	205
4	0	0	0	47	1	0	137	17	31	5	0	0	238
5	0	0	0	45	24	18	14	3	9	21	0	0	136
6	0	0	0	119	19	37	4	16	4	1	0	0	201
7	0	0	0	76	60	32	97	8	13	17	0	0	304
8	0	0	3	33	1	2	10	0	33	30	0	0	112
9	0	0	0	66	21	0	0	0	0	1	0	0	88
10	0	0	0	51	137	21	54	49	29	11	0	0	351
11	0	0	23	67	16	0	0	0	76	10	0	0	194
12	0	0	0	48	21	0	39	0	9	3	0	0	120
13	0	0	7	33	56	0	0	1	62	22	0	0	179
14	0	0	0	67	8	0	0	4	15	10	0	0	105
15	0	0	0	5	115	66	18	0	17	32	0	0	254
16	0	0	0	131	4	15	19	48	0	7	0	0	224
17	0	0	0	99	18	0	25	10	0	18	0	0	169
18	0	0	0	58	4	0	32	8	35	18	0	0	155
19	0	0	0	91	53	9	17	0	0	8	7	0	184
20	0	2	0	80	11	18	1	0	0	9	0	0	122
21	0	0	0	25	2	6	103	32	20	26	0	0	214
22	0	0	2	90	35	28	30	0	14	0	0	0	199
23	0	0	0	32	0	0	4	13	77	13	2	0	141
24	3	0	7	23	7	3	83	29	86	53	6	0	300
25	0	0	0	52	48	0	20	0	27	14	0	0	162
26	0	0	0	87	17	26	30	103	34	21	0	0	316
27	0	0	16	36	24	0	14	33	25	11	0	0	159
28	3	0	0	56	31	65	93	41	34	13	0	0	336
29	0	0	0	10	87	24	62	33	0	1	0	0	217
30	0	0	0	56	7	0	21	13	59	52	2	0	212
31	0	0	9	67	6	0	44	5	0	20	0	0	152
32	0	0	0	35	22	26	0	0	0	7	0	0	91
33	0	0	1	51	51	39	0	3	53	32	0	0	232
34	0	0	0	102	12	0	17	15	56	14	0	0	217
35	0	0	16	147	51	2	13	28	103	18	2	0	381
36	0	0	2	133	5	0	23	19	16	30	0	0	227
37	0	0	4	63	35	35	4	0	0	18	0	0	159
38	0	0	0	12	0	0	67	95	0	16	0	0	190
39	0	1	0	67	127	28	76	14	30	14	2	0	360
40	0	0	0	41	0	0	0	0	14	7	0	0	63
41	0	0	0	63	6	44	0	36	46	45	0	0	240
42	0	0	12	90	44	16	79	98	153	14	2	0	509
43	0	0	0	50	1	17	112	13	19	23	0	0	235
44	0	0	0	14	71	0	52	88	0	3	5	1	235
45	0	0	0	45	5	5	21	4	14	4	0	0	98
46	0	0	0	197	9	0	2	0	74	29	0	0	312
47	0	0	22	60	17	26	87	0	21	44	0	0	278
48	0	0	0	69	4	1	10	18	0	8	0	0	110
49	0	0	0	79	0	0	14	1	78	26	1	0	199
50	0	0	2	75	3	0	36	144	40	24	0	0	324
51	0	0	0	106	8	0	0	74	10	21	0	0	219
52	0	0	14	25	0	1	81	17	1	11	0	0	149
Average	**0**	**0**	**3**	**64**	**27**	**12**	**33**	**23**	**28**	**17**	**1**	**0**	**208**
Minimum	**0**	**0**	**0**	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**42**
Maximum	**3**	**2**	**23**	**197**	**137**	**66**	**137**	**144**	**153**	**53**	**7**	**1**	**509**

M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 513 - Climate change scenarios\GoldSim\[Appendix A tables_WatershedSurplusWater.xlsx]Table_W9Inputs

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	09DEC'14	ISSUED WITH LETTER VA15-01946	EER	JGC	KJB

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TABLE A.8

CASINO MINING CORPORATION
CASINO PROJECT

CLIMATE CHANGE NET PRECIPTIATON VALUES - 2055 SCENARIO
NODE W16 - LOWER DIP CREEK

Print Jan/15/15 18:01:48

Year	Monthly Net Precipitation (mm/mon)												Annual Net Precipitation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	2	32	1	0	0	0	0	0	0	0	35
2	0	0	0	38	0	0	29	64	11	25	0	0	166
3	0	0	0	83	39	18	0	16	18	2	0	0	176
4	0	0	0	38	0	0	133	16	29	4	0	0	221
5	0	0	0	45	15	17	13	2	9	27	0	0	128
6	0	0	0	108	7	34	3	16	3	0	0	0	172
7	0	0	0	80	41	29	95	8	12	14	0	0	279
8	0	0	9	23	0	1	8	0	31	35	0	0	108
9	0	0	0	62	8	0	0	0	0	1	0	0	72
10	0	0	0	79	85	18	50	47	28	10	1	0	318
11	0	0	39	46	10	0	0	0	72	11	0	0	178
12	0	0	1	37	20	0	36	0	8	2	0	0	103
13	0	0	13	21	51	0	0	0	58	28	0	0	171
14	0	0	0	58	2	0	0	2	14	13	0	0	89
15	0	0	0	17	85	63	17	0	16	42	0	0	239
16	0	0	1	108	1	13	17	45	0	7	0	0	192
17	0	0	0	97	6	0	22	9	0	16	1	0	151
18	0	0	0	49	1	0	29	7	33	19	0	0	137
19	0	0	0	80	48	8	15	0	0	6	10	0	168
20	0	6	1	60	8	17	1	0	0	7	0	0	99
21	0	0	0	20	0	4	98	31	18	25	0	0	197
22	0	0	7	83	23	26	28	0	13	0	2	0	180
23	0	0	0	23	0	0	3	11	73	11	5	0	126
24	4	0	11	16	3	1	79	27	84	49	15	0	291
25	0	0	0	44	36	0	18	0	25	17	0	0	140
26	0	0	0	71	14	24	28	101	32	19	0	0	290
27	0	0	26	20	20	0	12	31	23	12	0	0	145
28	8	0	1	54	16	63	91	39	33	17	0	1	321
29	0	0	0	20	63	22	60	32	0	0	0	0	197
30	0	0	0	46	6	0	20	12	57	47	6	0	193
31	0	0	20	46	5	0	40	4	0	18	0	0	134
32	0	0	0	26	20	23	0	0	0	7	0	0	76
33	0	0	5	37	47	37	0	2	51	35	0	0	214
34	0	0	1	88	8	0	16	14	53	18	0	0	198
35	0	0	37	123	31	2	12	27	101	26	5	0	364
36	0	0	5	105	1	0	21	18	14	26	0	0	190
37	0	0	14	45	32	33	3	0	0	15	0	0	142
38	0	0	0	8	0	0	61	93	0	13	0	0	175
39	0	3	0	56	123	26	74	13	29	21	4	1	350
40	0	0	0	26	0	0	0	0	12	6	0	0	44
41	0	0	1	52	5	40	0	33	45	44	0	0	218
42	0	1	30	70	30	15	76	96	152	13	5	0	489
43	2	0	1	37	0	15	109	12	17	22	0	0	214
44	0	0	0	26	49	0	49	87	0	2	7	3	222
45	0	0	0	36	1	3	20	3	13	3	0	0	79
46	0	1	1	182	2	0	1	0	70	28	0	0	285
47	0	0	40	36	13	24	84	0	19	40	0	1	256
48	0	0	0	59	2	1	9	17	0	7	0	0	94
49	0	0	0	66	0	0	11	0	74	25	3	0	180
50	0	0	11	57	0	0	33	141	39	23	0	0	304
51	0	0	0	99	2	0	0	69	9	18	1	0	198
52	0	0	22	14	0	0	75	15	0	9	1	0	137
Average	**0**	**0**	**6**	**55**	**19**	**11**	**31**	**22**	**27**	**17**	**1**	**0**	**189**
Minimum	**0**	**0**	**0**	**8**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**35**
Maximum	**8**	**6**	**40**	**182**	**123**	**63**	**133**	**141**	**152**	**49**	**15**	**3**	**489**

M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 513 - Climate change scenarios\GoldSim\[Appendix A tables_WatershedSurplusWater.xlsx]ReadMe_First

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	09DEC'14	ISSUED WITH LETTER VA15-01946	EER	JGC	KJB

Knight Piésold
CONSULTING

APPENDIX B

CLIMATE CHANGE 2055 SCENARIO: OPERATIONAL NET PRECIPITATION VALUES FOR MINE FACILITIES

(Pages B-1 to B-13)

Knight Piésold
CONSULTING

TABLE B.1

CASINO MINING CORPORATION
CASINO PROJECT

CLIMATE CHANGE NET PRECIPATION VALUES - 2055 SCENARIO
OPEN PIT

Print Jan/15/15 18:10:37

Year	Monthly Net Precipitation (mm/mon)												Annual Net Precipitation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	0	50	52	0	40	9	27	1	0	0	180
2	0	0	0	144	9	28	79	99	25	0	0	0	384
3	0	0	0	13	262	54	22	47	39	0	0	0	436
4	0	0	0	125	19	19	185	43	46	12	0	0	449
5	0	0	0	16	143	52	49	23	25	5	0	0	313
6	0	0	0	128	142	74	32	46	16	7	0	0	445
7	0	0	0	26	212	66	130	32	31	29	0	0	526
8	0	0	0	97	17	27	43	8	71	6	0	0	270
9	0	0	0	41	160	20	0	27	20	5	0	0	272
10	0	0	0	5	351	54	88	77	45	14	0	0	634
11	0	0	0	120	89	9	21	23	113	4	0	0	379
12	0	0	0	136	43	0	141	3	35	11	0	0	369
13	0	0	0	110	79	16	0	69	94	4	0	0	371
14	0	0	0	84	97	0	19	58	34	3	0	0	294
15	0	0	0	0	252	100	54	16	39	4	0	0	464
16	0	0	0	219	40	70	55	76	6	6	0	0	472
17	0	0	0	71	145	0	90	34	5	29	0	0	374
18	0	0	0	103	53	0	99	30	54	9	0	0	347
19	0	0	0	157	104	38	52	10	16	16	0	0	394
20	0	0	0	157	56	52	25	6	19	28	0	0	342
21	0	0	0	95	18	32	150	60	36	29	0	0	419
22	0	0	0	84	151	59	66	0	59	2	0	0	421
23	0	0	0	111	0	17	49	38	101	24	0	0	340
24	0	0	0	16	98	33	129	56	99	68	0	0	498
25	0	0	0	31	166	0	87	17	53	2	0	0	357
26	0	0	0	188	39	60	66	127	45	23	0	0	548
27	0	0	0	127	49	18	50	66	39	5	0	0	356
28	0	0	0	15	184	99	129	66	48	2	0	0	542
29	0	0	0	0	210	57	99	59	4	13	0	0	441
30	0	0	0	135	26	18	64	39	77	67	0	0	427
31	0	0	0	153	27	17	94	28	9	27	0	0	355
32	0	0	0	117	46	59	0	18	37	6	0	0	283
33	0	0	0	158	76	73	0	56	81	14	0	0	459
34	0	0	0	184	62	23	55	41	76	3	0	0	444
35	0	0	0	123	226	28	47	62	112	0	0	0	597
36	0	0	0	222	48	0	80	49	31	43	0	0	474
37	0	0	0	141	58	68	32	0	38	40	0	0	376
38	0	0	0	80	12	25	122	120	7	36	0	0	402
39	0	0	0	128	160	62	114	41	47	0	0	0	552
40	0	0	0	138	0	55	1	17	52	13	0	0	275
41	0	0	0	154	23	82	19	78	61	45	0	0	462
42	0	0	0	93	168	51	115	122	165	16	0	0	730
43	0	0	0	131	9	56	150	40	35	24	0	0	445
44	0	0	0	0	186	12	104	113	5	18	0	0	438
45	0	0	0	81	59	34	61	24	32	13	0	0	305
46	0	0	0	248	74	2	47	0	143	28	0	0	542
47	0	0	0	165	44	62	122	15	46	58	0	0	512
48	0	0	0	131	32	26	44	47	10	22	0	0	312
49	0	0	0	160	0	54	58	20	108	25	0	0	426
50	0	0	0	133	42	11	94	169	54	24	0	0	527
51	0	0	0	136	73	9	0	168	26	31	0	0	443
52	0	0	0	103	0	41	131	45	11	23	0	0	353
Average	**0**	**0**	**0**	**107**	**90**	**37**	**69**	**49**	**48**	**18**	**0**	**0**	**419**
Minimum	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**0**	**0**	**0**	**180**
Maximum	**0**	**0**	**0**	**248**	**351**	**100**	**185**	**169**	**165**	**68**	**0**	**0**	**730**

M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 513 - Climate change scenarios\GoldSim\[Appendix B tables_FacilitiesSurplusWater.xlsx]Table_OpenPit

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	09DEC'14	ISSUED WITH LETTER VA15-01946	EER	JGC	KJB

Knight Piésold CONSULTING

TABLE B.2

CASINO MINING CORPORATION
CASINO PROJECT

CLIMATE CHANGE NET PRECIPATION VALUES - 2055 SCENARIO
PIT LAKE (CLOSURE)

Print Jan/15/15 18:10:37

Year	Monthly Net Precipitation (mm/mon)												Annual Net Precipitation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	0	17	111	23	64	36	41	1	0	0	293
2	0	0	0	159	29	61	114	123	35	0	0	0	521
3	0	0	0	4	302	86	53	69	52	0	0	0	565
4	0	0	0	134	44	48	216	67	59	14	0	0	583
5	0	0	0	3	183	82	82	47	38	0	0	0	435
6	0	0	0	86	224	102	65	72	27	11	0	0	587
7	0	0	0	8	254	98	161	56	44	34	0	0	655
8	0	0	0	102	41	55	77	32	84	0	0	0	391
9	0	0	0	7	229	52	13	37	33	0	0	0	372
10	0	0	0	1	393	85	119	103	59	10	0	0	770
11	0	0	0	81	167	39	54	47	124	1	0	0	514
12	0	0	0	156	62	6	149	22	48	14	0	0	457
13	0	0	0	122	99	45	10	78	105	0	0	0	458
14	0	0	0	44	171	21	44	82	46	0	0	0	409
15	0	0	0	0	284	130	86	42	49	0	0	0	592
16	0	0	0	200	98	93	87	99	18	2	0	0	597
17	0	0	0	27	224	27	121	58	18	17	0	0	491
18	0	0	0	84	118	30	131	53	67	4	0	0	487
19	0	0	0	143	156	68	86	35	30	10	0	0	528
20	0	0	0	153	102	82	55	34	31	31	0	0	488
21	0	0	0	103	39	61	183	86	50	20	0	0	542
22	0	0	0	43	233	87	99	19	70	7	0	0	558
23	0	0	0	127	19	45	81	60	111	30	0	0	474
24	0	0	0	5	139	61	161	80	110	74	0	0	630
25	0	0	0	8	214	24	115	41	66	0	0	0	468
26	0	0	0	208	59	92	99	151	54	16	0	0	679
27	0	0	0	152	68	49	82	89	52	1	0	0	494
28	0	0	0	4	227	128	162	89	59	0	0	0	669
29	0	0	0	0	237	87	134	82	17	16	0	0	571
30	0	0	0	147	45	49	98	63	90	74	0	0	566
31	0	0	0	169	48	48	126	52	20	14	0	0	478
32	0	0	0	145	66	90	24	37	50	1	0	0	413
33	0	0	0	179	98	104	24	75	94	6	0	0	580
34	0	0	0	178	116	55	88	64	90	0	0	0	589
35	0	0	0	74	313	59	81	87	118	0	0	0	732
36	0	0	0	209	102	31	113	73	43	48	0	0	621
37	0	0	0	157	77	98	66	16	45	39	0	0	498
38	0	0	0	98	34	58	155	143	22	39	0	0	550
39	0	0	0	127	192	93	148	66	61	0	0	0	687
40	0	0	0	154	13	74	36	39	64	8	0	0	388
41	0	0	0	174	40	115	52	105	73	32	0	0	592
42	0	0	0	52	258	84	149	144	176	8	0	0	871
43	0	0	0	153	25	88	182	67	48	15	0	0	577
44	0	0	0	0	223	43	137	137	19	23	0	0	581
45	0	0	0	42	126	64	96	49	43	17	0	0	437
46	0	0	0	213	153	38	81	7	147	17	0	0	657
47	0	0	0	195	68	93	153	40	59	64	0	0	672
48	0	0	0	133	62	58	78	71	24	25	0	0	451
49	0	0	0	174	6	67	93	45	120	14	0	0	521
50	0	0	0	124	99	42	125	193	67	12	0	0	662
51	0	0	0	97	160	41	21	184	39	35	0	0	576
52	0	0	0	118	20	69	163	70	23	26	0	0	487
Average	**0**	**0**	**0**	**102**	**132**	**66**	**100**	**72**	**60**	**16**	**0**	**0**	**547**
Minimum	**0**	**0**	**0**	**0**	**6**	**6**	**10**	**7**	**17**	**0**	**0**	**0**	**293**
Maximum	**0**	**0**	**0**	**213**	**393**	**130**	**216**	**193**	**176**	**74**	**0**	**0**	**871**

M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 513 - Climate change scenarios\GoldSim\[Appendix B tables_FacilitiesSurplusWater.xlsx]Table_PitLake

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	09DEC'14	ISSUED WITH LETTER VA15-01946	EER	JGC	KJB

Knight Piésold CONSULTING

TABLE B.3

CASINO MINING CORPORATION
CASINO PROJECT

CLIMATE CHANGE NET PRECIPATION VALUES - 2055 SCENARIO
GOLD ORE STOCKPILE

Print Jan/15/15 18:10:37

Year	Monthly Net Precipitation (mm/mon)												Annual Net Precipitation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	0	50	10	0	40	8	27	1	0	0	136
2	0	0	0	81	8	26	78	98	24	6	0	0	321
3	0	0	0	64	117	53	21	46	38	1	0	0	340
4	0	0	0	60	15	18	184	42	45	9	0	0	372
5	0	0	0	47	48	51	47	22	25	19	0	0	258
6	0	0	0	157	15	73	31	45	15	5	0	0	340
7	0	0	0	83	84	65	129	31	30	24	0	0	447
8	0	0	1	46	10	25	42	7	70	24	0	0	226
9	0	0	0	83	24	24	0	27	19	17	0	0	193
10	0	0	0	36	212	53	87	76	44	15	0	0	523
11	0	0	5	103	30	7	20	22	112	10	0	0	310
12	0	0	0	62	42	0	141	3	34	8	0	0	290
13	0	0	0	52	78	15	0	69	93	15	0	0	322
14	0	0	0	100	0	0	13	57	33	11	0	0	215
15	0	0	0	1	157	98	52	15	38	20	0	0	381
16	0	0	0	168	0	75	53	75	5	13	0	0	389
17	0	0	0	118	11	1	88	33	4	36	0	0	291
18	0	0	0	73	6	0	99	29	53	17	0	0	277
19	0	0	0	108	68	37	51	9	16	17	5	0	311
20	0	0	0	106	28	51	23	5	18	24	0	0	256
21	0	0	0	40	15	31	148	59	35	31	0	0	359
22	0	0	0	117	40	58	65	0	59	1	0	0	340
23	0	0	0	53	0	17	48	37	100	21	0	0	276
24	1	0	1	35	14	32	128	55	98	60	0	0	424
25	0	0	0	66	65	0	87	16	52	10	0	0	297
26	0	0	0	108	38	59	64	126	44	25	0	0	464
27	0	0	3	57	48	17	49	65	39	11	0	0	288
28	0	0	0	56	59	98	127	65	47	9	0	0	462
29	0	0	0	1	124	56	98	58	3	10	0	0	349
30	0	0	0	75	25	17	63	38	77	59	0	0	354
31	0	0	2	90	26	16	93	27	8	33	0	0	293
32	0	0	0	44	44	58	0	18	37	14	0	0	215
33	0	0	0	79	75	72	0	56	80	31	0	0	393
34	0	0	0	122	29	22	54	40	75	11	0	0	352
35	0	0	3	182	66	26	46	61	110	7	0	0	501
36	0	0	0	169	15	0	80	48	31	37	0	0	380
37	0	0	0	81	56	67	31	0	37	36	0	0	308
38	0	0	0	21	11	24	120	119	6	31	0	0	332
39	0	0	0	81	145	61	112	40	46	6	0	0	491
40	0	0	0	64	0	55	0	16	51	14	0	0	199
41	0	0	0	87	22	81	17	77	60	51	0	0	395
42	0	0	2	127	47	50	114	121	164	17	0	0	641
43	0	0	0	63	7	55	149	39	34	27	0	0	374
44	0	0	0	2	105	11	103	112	5	15	4	0	356
45	0	0	0	67	8	33	60	23	31	10	0	0	233
46	0	0	0	229	16	1	46	0	143	33	0	0	467
47	0	0	1	89	43	61	120	14	45	51	0	0	425
48	0	0	0	82	20	24	42	46	9	18	0	0	242
49	0	0	0	98	0	54	57	19	107	30	0	0	365
50	0	0	0	92	6	10	93	168	54	28	0	0	451
51	0	0	0	125	4	7	0	168	25	27	0	0	356
52	0	0	2	45	0	41	130	44	10	18	0	0	289
Average	**0**	**0**	**0**	**82**	**41**	**36**	**68**	**48**	**47**	**21**	**0**	**0**	**344**
Minimum	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**3**	**1**	**0**	**0**	**136**
Maximum	**1**	**0**	**5**	**229**	**212**	**98**	**184**	**168**	**164**	**60**	**5**	**0**	**641**

M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 513 - Climate change scenarios\GoldSim\[Appendix B tables_FacilitiesSurplusWater.xlsx]Table_GoldOre

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	09DEC'14	ISSUED WITH LETTER VA15-01946	EER	JGC	KJB

Knight Piésold
CONSULTING

TABLE B.4

CASINO MINING CORPORATION
CASINO PROJECT

CLIMATE CHANGE NET PRECIPATION VALUES - 2055 SCENARIO
LOW GRADE ORE STOCKPILE - SUPERGENE SULFIDE

Print Jan/15/15 18:10:37

Year	Monthly Net Precipitation (mm/mon)												Annual Net Precipitation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	0	35	33	0	40	9	27	1	0	0	146
2	0	0	0	96	9	28	79	99	25	0	0	0	336
3	0	0	0	13	201	54	22	47	39	0	0	0	376
4	0	0	0	75	16	19	185	43	46	8	0	0	391
5	0	0	0	16	90	52	49	23	25	5	0	0	260
6	0	0	0	128	81	74	32	46	16	7	0	0	384
7	0	0	0	26	159	66	130	32	31	28	0	0	472
8	0	0	0	58	11	27	43	8	71	6	0	0	225
9	0	0	0	41	99	20	0	27	20	5	0	0	212
10	0	0	0	5	290	54	88	77	45	12	0	0	571
11	0	0	0	97	59	9	21	23	113	4	0	0	326
12	0	0	0	83	43	0	141	3	35	8	0	0	314
13	0	0	0	65	79	16	0	69	94	4	0	0	326
14	0	0	0	79	46	0	16	58	34	3	0	0	237
15	0	0	0	0	191	100	54	16	39	4	0	0	403
16	0	0	0	193	10	70	55	76	6	6	0	0	415
17	0	0	0	71	84	0	90	34	5	26	0	0	309
18	0	0	0	80	22	0	99	30	54	9	0	0	294
19	0	0	0	130	73	38	52	10	16	12	0	0	333
20	0	0	0	134	30	52	25	6	19	24	0	0	289
21	0	0	0	51	16	32	150	60	36	25	0	0	370
22	0	0	0	84	97	59	66	0	59	2	0	0	368
23	0	0	0	66	0	17	49	38	101	24	0	0	295
24	0	0	0	16	45	33	129	56	99	64	0	0	441
25	0	0	0	31	113	0	87	17	53	2	0	0	304
26	0	0	0	135	39	60	66	127	45	20	0	0	492
27	0	0	0	78	49	18	50	66	39	5	0	0	306
28	0	0	0	15	123	99	129	66	48	2	0	0	481
29	0	0	0	0	149	57	99	59	4	9	0	0	377
30	0	0	0	89	26	18	64	39	77	67	0	0	381
31	0	0	0	108	27	17	94	28	9	23	0	0	305
32	0	0	0	68	46	59	0	18	37	6	0	0	234
33	0	0	0	105	76	73	0	56	81	14	0	0	406
34	0	0	0	157	32	23	55	41	76	3	0	0	387
35	0	0	0	123	165	28	47	62	112	0	0	0	536
36	0	0	0	195	18	0	80	49	31	42	0	0	417
37	0	0	0	96	58	68	32	0	38	37	0	0	328
38	0	0	0	31	12	25	122	120	7	32	0	0	348
39	0	0	0	96	147	62	114	41	47	0	0	0	506
40	0	0	0	85	0	55	1	17	52	10	0	0	219
41	0	0	0	105	23	82	19	78	61	41	0	0	409
42	0	0	0	93	113	51	115	122	165	12	0	0	671
43	0	0	0	82	9	56	150	40	35	20	0	0	392
44	0	0	0	0	129	12	104	113	5	18	0	0	381
45	0	0	0	59	32	34	61	24	32	12	0	0	255
46	0	0	0	225	47	2	47	0	143	24	0	0	489
47	0	0	0	116	44	62	122	15	46	57	0	0	462
48	0	0	0	97	21	26	44	47	10	17	0	0	262
49	0	0	0	115	0	54	58	20	108	21	0	0	377
50	0	0	0	110	12	11	94	169	54	20	0	0	470
51	0	0	0	114	42	9	0	168	26	27	0	0	386
52	0	0	0	58	0	41	131	45	11	18	0	0	303
Average	**0**	**0**	**0**	**81**	**64**	**37**	**69**	**49**	**48**	**16**	**0**	**0**	**365**
Minimum	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**0**	**0**	**0**	**146**
Maximum	**0**	**0**	**0**	**225**	**290**	**100**	**185**	**169**	**165**	**67**	**0**	**0**	**671**

M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 513 - Climate change scenarios\GoldSim\[Appendix B tables_FacilitiesSurplusWater.xlsx]Table_SGS

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	09DEC'14	ISSUED WITH LETTER VA15-01946	EER	JGC	KJB

Knight Piésold
CONSULTING

TABLE B.5

CASINO MINING CORPORATION
CASINO PROJECT

CLIMATE CHANGE NET PRECIPATION VALUES - 2055 SCENARIO
LOW GRADE ORE STOCKPILE - SUPERGENE OXIDE

Print Jan/15/15 18:10:37

Year	Monthly Net Precipitation (mm/mon)												Annual Net Precipitation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	0	50	10	0	40	8	27	1	0	0	136
2	0	0	0	81	8	26	78	98	24	6	0	0	321
3	0	0	0	64	117	53	21	46	38	1	0	0	340
4	0	0	0	60	15	18	184	42	45	9	0	0	372
5	0	0	0	47	48	51	47	22	25	19	0	0	258
6	0	0	0	157	15	73	31	45	15	5	0	0	340
7	0	0	0	83	84	65	129	31	30	24	0	0	447
8	0	0	1	46	10	25	42	7	70	24	0	0	226
9	0	0	0	83	24	24	0	27	19	17	0	0	193
10	0	0	0	36	212	53	87	76	44	15	0	0	523
11	0	0	5	103	30	7	20	22	112	10	0	0	310
12	0	0	0	62	42	0	141	3	34	8	0	0	290
13	0	0	0	52	78	15	0	69	93	15	0	0	322
14	0	0	0	100	0	0	13	57	33	11	0	0	215
15	0	0	0	1	157	98	52	15	38	20	0	0	381
16	0	0	0	168	0	75	53	75	5	13	0	0	389
17	0	0	0	118	11	1	88	33	4	36	0	0	291
18	0	0	0	73	6	0	99	29	53	17	0	0	277
19	0	0	0	108	68	37	51	9	16	17	5	0	311
20	0	0	0	106	28	51	23	5	18	24	0	0	256
21	0	0	0	40	15	31	148	59	35	31	0	0	359
22	0	0	0	117	40	58	65	0	59	1	0	0	340
23	0	0	0	53	0	17	48	37	100	21	0	0	276
24	1	0	1	35	14	32	128	55	98	60	0	0	424
25	0	0	0	66	65	0	87	16	52	10	0	0	297
26	0	0	0	108	38	59	64	126	44	25	0	0	464
27	0	0	3	57	48	17	49	65	39	11	0	0	288
28	0	0	0	56	59	98	127	65	47	9	0	0	462
29	0	0	0	1	124	56	98	58	3	10	0	0	349
30	0	0	0	75	25	17	63	38	77	59	0	0	354
31	0	0	2	90	26	16	93	27	8	33	0	0	293
32	0	0	0	44	44	58	0	18	37	14	0	0	215
33	0	0	0	79	75	72	0	56	80	31	0	0	393
34	0	0	0	122	29	22	54	40	75	11	0	0	352
35	0	0	3	182	66	26	46	61	110	7	0	0	501
36	0	0	0	169	15	0	80	48	31	37	0	0	380
37	0	0	0	81	56	67	31	0	37	36	0	0	308
38	0	0	0	21	11	24	120	119	6	31	0	0	332
39	0	0	0	81	145	61	112	40	46	6	0	0	491
40	0	0	0	64	0	55	0	16	51	14	0	0	199
41	0	0	0	87	22	81	17	77	60	51	0	0	395
42	0	0	2	127	47	50	114	121	164	17	0	0	641
43	0	0	0	63	7	55	149	39	34	27	0	0	374
44	0	0	0	2	105	11	103	112	5	15	4	0	356
45	0	0	0	67	8	33	60	23	31	10	0	0	233
46	0	0	0	229	16	1	46	0	143	33	0	0	467
47	0	0	1	89	43	61	120	14	45	51	0	0	425
48	0	0	0	82	20	24	42	46	9	18	0	0	242
49	0	0	0	98	0	54	57	19	107	30	0	0	365
50	0	0	0	92	6	10	93	168	54	28	0	0	451
51	0	0	0	125	4	7	0	168	25	27	0	0	356
52	0	0	2	45	0	41	130	44	10	18	0	0	289
Average	**0**	**0**	**0**	**82**	**41**	**36**	**68**	**48**	**47**	**21**	**0**	**0**	**344**
Minimum	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**3**	**1**	**0**	**0**	**136**
Maximum	**1**	**0**	**5**	**229**	**212**	**98**	**184**	**168**	**164**	**60**	**5**	**0**	**641**

M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 513 - Climate change scenarios\GoldSim\[Appendix B tables_FacilitiesSurplusWater.xlsx]Table_LG_SGO

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	09DEC'14	ISSUED WITH LETTER VA15-01946	EER	JGC	KJB

Knight Piésold CONSULTING

TABLE B.6

CASINO MINING CORPORATION
CASINO PROJECT

CLIMATE CHANGE NET PRECIPATION VALUES - 2055 SCENARIO
LOW GRADE ORE STOCKPILE - HYPOGENE

Print Jan/15/15 18:10:37

Year	Monthly Net Precipitation (mm/mon)												Annual Net Precipitation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	0	50	10	0	40	8	27	1	0	0	136
2	0	0	0	81	8	26	78	98	24	6	0	0	321
3	0	0	0	64	117	53	21	46	38	1	0	0	340
4	0	0	0	60	15	18	184	42	45	9	0	0	372
5	0	0	0	47	48	51	47	22	25	19	0	0	258
6	0	0	0	157	15	73	31	45	15	5	0	0	340
7	0	0	0	83	84	65	129	31	30	24	0	0	447
8	0	0	1	46	10	25	42	7	70	24	0	0	226
9	0	0	0	83	24	24	0	27	19	17	0	0	193
10	0	0	0	36	212	53	87	76	44	15	0	0	523
11	0	0	5	103	30	7	20	22	112	10	0	0	310
12	0	0	0	62	42	0	141	3	34	8	0	0	290
13	0	0	0	52	78	15	0	69	93	15	0	0	322
14	0	0	0	100	0	0	13	57	33	11	0	0	215
15	0	0	0	1	157	98	52	15	38	20	0	0	381
16	0	0	0	168	0	75	53	75	5	13	0	0	389
17	0	0	0	118	11	1	88	33	4	36	0	0	291
18	0	0	0	73	6	0	99	29	53	17	0	0	277
19	0	0	0	108	68	37	51	9	16	17	5	0	311
20	0	0	0	106	28	51	23	5	18	24	0	0	256
21	0	0	0	40	15	31	148	59	35	31	0	0	359
22	0	0	0	117	40	58	65	0	59	1	0	0	340
23	0	0	0	53	0	17	48	37	100	21	0	0	276
24	1	0	1	35	14	32	128	55	98	60	0	0	424
25	0	0	0	66	65	0	87	16	52	10	0	0	297
26	0	0	0	108	38	59	64	126	44	25	0	0	464
27	0	0	3	57	48	17	49	65	39	11	0	0	288
28	0	0	0	56	59	98	127	65	47	9	0	0	462
29	0	0	0	1	124	56	98	58	3	10	0	0	349
30	0	0	0	75	25	17	63	38	77	59	0	0	354
31	0	0	2	90	26	16	93	27	8	33	0	0	293
32	0	0	0	44	44	58	0	18	37	14	0	0	215
33	0	0	0	79	75	72	0	56	80	31	0	0	393
34	0	0	0	122	29	22	54	40	75	11	0	0	352
35	0	0	3	182	66	26	46	61	110	7	0	0	501
36	0	0	0	169	15	0	80	48	31	37	0	0	380
37	0	0	0	81	56	67	31	0	37	36	0	0	308
38	0	0	0	21	11	24	120	119	6	31	0	0	332
39	0	0	0	81	145	61	112	40	46	6	0	0	491
40	0	0	0	64	0	55	0	16	51	14	0	0	199
41	0	0	0	87	22	81	17	77	60	51	0	0	395
42	0	0	2	127	47	50	114	121	164	17	0	0	641
43	0	0	0	63	7	55	149	39	34	27	0	0	374
44	0	0	0	2	105	11	103	112	5	15	4	0	356
45	0	0	0	67	8	33	60	23	31	10	0	0	233
46	0	0	0	229	16	1	46	0	143	33	0	0	467
47	0	0	1	89	43	61	120	14	45	51	0	0	425
48	0	0	0	82	20	24	42	46	9	18	0	0	242
49	0	0	0	98	0	54	57	19	107	30	0	0	365
50	0	0	0	92	6	10	93	168	54	28	0	0	451
51	0	0	0	125	4	7	0	168	25	27	0	0	356
52	0	0	2	45	0	41	130	44	10	18	0	0	289
Average	**0**	**0**	**0**	**82**	**41**	**36**	**68**	**48**	**47**	**21**	**0**	**0**	**344**
Minimum	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**3**	**1**	**0**	**0**	**136**
Maximum	**1**	**0**	**5**	**229**	**212**	**98**	**184**	**168**	**164**	**60**	**5**	**0**	**641**

M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 513 - Climate change scenarios\GoldSim\[Appendix B tables_FacilitiesSurplusWater.xlsx]Table_HG

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	09DEC'14	ISSUED WITH LETTER VA15-01946	EER	JGC	KJB

Knight Piésold
CONSULTING

TABLE B.7

CASINO MINING CORPORATION
CASINO PROJECT

CLIMATE CHANGE NET PRECIPATION VALUES - 2055 SCENARIO
SUPERGENE OXIDE STOCKPILE

Print Jan/15/15 18:10:37

Year	Monthly Net Precipitation (mm/mon)												Annual Net Precipitation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	0	50	10	0	40	8	27	1	0	0	136
2	0	0	0	81	8	26	78	98	24	6	0	0	321
3	0	0	0	64	117	53	21	46	38	1	0	0	340
4	0	0	0	60	15	18	184	42	45	9	0	0	372
5	0	0	0	47	48	51	47	22	25	19	0	0	258
6	0	0	0	157	15	73	31	45	15	5	0	0	340
7	0	0	0	83	84	65	129	31	30	24	0	0	447
8	0	0	1	46	10	25	42	7	70	24	0	0	226
9	0	0	0	83	24	24	0	27	19	17	0	0	193
10	0	0	0	36	212	53	87	76	44	15	0	0	523
11	0	0	5	103	30	7	20	22	112	10	0	0	310
12	0	0	0	62	42	0	141	3	34	8	0	0	290
13	0	0	0	52	78	15	0	69	93	15	0	0	322
14	0	0	0	100	0	0	13	57	33	11	0	0	215
15	0	0	0	1	157	98	52	15	38	20	0	0	381
16	0	0	0	168	0	75	53	75	5	13	0	0	389
17	0	0	0	118	11	1	88	33	4	36	0	0	291
18	0	0	0	73	6	0	99	29	53	17	0	0	277
19	0	0	0	108	68	37	51	9	16	17	5	0	311
20	0	0	0	106	28	51	23	5	18	24	0	0	256
21	0	0	0	40	15	31	148	59	35	31	0	0	359
22	0	0	0	117	40	58	65	0	59	1	0	0	340
23	0	0	0	53	0	17	48	37	100	21	0	0	276
24	1	0	1	35	14	32	128	55	98	60	0	0	424
25	0	0	0	66	65	0	87	16	52	10	0	0	297
26	0	0	0	108	38	59	64	126	44	25	0	0	464
27	0	0	3	57	48	17	49	65	39	11	0	0	288
28	0	0	0	56	59	98	127	65	47	9	0	0	462
29	0	0	0	1	124	56	98	58	3	10	0	0	349
30	0	0	0	75	25	17	63	38	77	59	0	0	354
31	0	0	2	90	26	16	93	27	8	33	0	0	293
32	0	0	0	44	44	58	0	18	37	14	0	0	215
33	0	0	0	79	75	72	0	56	80	31	0	0	393
34	0	0	0	122	29	22	54	40	75	11	0	0	352
35	0	0	3	182	66	26	46	61	110	7	0	0	501
36	0	0	0	169	15	0	80	48	31	37	0	0	380
37	0	0	0	81	56	67	31	0	37	36	0	0	308
38	0	0	0	21	11	24	120	119	6	31	0	0	332
39	0	0	0	81	145	61	112	40	46	6	0	0	491
40	0	0	0	64	0	55	0	16	51	14	0	0	199
41	0	0	0	87	22	81	17	77	60	51	0	0	395
42	0	0	2	127	47	50	114	121	164	17	0	0	641
43	0	0	0	63	7	55	149	39	34	27	0	0	374
44	0	0	0	2	105	11	103	112	5	15	4	0	356
45	0	0	0	67	8	33	60	23	31	10	0	0	233
46	0	0	0	229	16	1	46	0	143	33	0	0	467
47	0	0	1	89	43	61	120	14	45	51	0	0	425
48	0	0	0	82	20	24	42	46	9	18	0	0	242
49	0	0	0	98	0	54	57	19	107	30	0	0	365
50	0	0	0	92	6	10	93	168	54	28	0	0	451
51	0	0	0	125	4	7	0	168	25	27	0	0	356
52	0	0	2	45	0	41	130	44	10	18	0	0	289
Average	**0**	**0**	**0**	**82**	**41**	**36**	**68**	**48**	**47**	**21**	**0**	**0**	**344**
Minimum	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**3**	**1**	**0**	**0**	**136**
Maximum	**1**	**0**	**5**	**229**	**212**	**98**	**184**	**168**	**164**	**60**	**5**	**0**	**641**

M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 513 - Climate change scenarios\GoldSim\[Appendix B tables_FacilitiesSurplusWater.xlsx]Table_SGO

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	09DEC'14	ISSUED WITH LETTER VA15-01946	EER	JGC	KJB

Knight Piésold CONSULTING

TABLE B.8

CASINO MINING CORPORATION
CASINO PROJECT

CLIMATE CHANGE NET PRECIPATION VALUES - 2055 SCENARIO
MARGINAL GRADE ORE STOCKPILE

Print Jan/15/15 18:10:37

Year	Monthly Net Precipitation (mm/mon)												Annual Net Precipitation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	0	35	33	0	40	9	27	1	0	0	146
2	0	0	0	96	9	28	79	99	25	0	0	0	336
3	0	0	0	13	201	54	22	47	39	0	0	0	376
4	0	0	0	75	16	19	185	43	46	8	0	0	391
5	0	0	0	16	90	52	49	23	25	5	0	0	260
6	0	0	0	128	81	74	32	46	16	7	0	0	384
7	0	0	0	26	159	66	130	32	31	28	0	0	472
8	0	0	0	58	11	27	43	8	71	6	0	0	225
9	0	0	0	41	99	20	0	27	20	5	0	0	212
10	0	0	0	5	290	54	88	77	45	12	0	0	571
11	0	0	0	97	59	9	21	23	113	4	0	0	326
12	0	0	0	83	43	0	141	3	35	8	0	0	314
13	0	0	0	65	79	16	0	69	94	4	0	0	326
14	0	0	0	79	46	0	16	58	34	3	0	0	237
15	0	0	0	0	191	100	54	16	39	4	0	0	403
16	0	0	0	193	10	70	55	76	6	6	0	0	415
17	0	0	0	71	84	0	90	34	5	26	0	0	309
18	0	0	0	80	22	0	99	30	54	9	0	0	294
19	0	0	0	130	73	38	52	10	16	12	0	0	333
20	0	0	0	134	30	52	25	6	19	24	0	0	289
21	0	0	0	51	16	32	150	60	36	25	0	0	370
22	0	0	0	84	97	59	66	0	59	2	0	0	368
23	0	0	0	66	0	17	49	38	101	24	0	0	295
24	0	0	0	16	45	33	129	56	99	64	0	0	441
25	0	0	0	31	113	0	87	17	53	2	0	0	304
26	0	0	0	135	39	60	66	127	45	20	0	0	492
27	0	0	0	78	49	18	50	66	39	5	0	0	306
28	0	0	0	15	123	99	129	66	48	2	0	0	481
29	0	0	0	0	149	57	99	59	4	9	0	0	377
30	0	0	0	89	26	18	64	39	77	67	0	0	381
31	0	0	0	108	27	17	94	28	9	23	0	0	305
32	0	0	0	68	46	59	0	18	37	6	0	0	234
33	0	0	0	105	76	73	0	56	81	14	0	0	406
34	0	0	0	157	32	23	55	41	76	3	0	0	387
35	0	0	0	123	165	28	47	62	112	0	0	0	536
36	0	0	0	195	18	0	80	49	31	42	0	0	417
37	0	0	0	96	58	68	32	0	38	37	0	0	328
38	0	0	0	31	12	25	122	120	7	32	0	0	348
39	0	0	0	96	147	62	114	41	47	0	0	0	506
40	0	0	0	85	0	55	1	17	52	10	0	0	219
41	0	0	0	105	23	82	19	78	61	41	0	0	409
42	0	0	0	93	113	51	115	122	165	12	0	0	671
43	0	0	0	82	9	56	150	40	35	20	0	0	392
44	0	0	0	0	129	12	104	113	5	18	0	0	381
45	0	0	0	59	32	34	61	24	32	12	0	0	255
46	0	0	0	225	47	2	47	0	143	24	0	0	489
47	0	0	0	116	44	62	122	15	46	57	0	0	462
48	0	0	0	97	21	26	44	47	10	17	0	0	262
49	0	0	0	115	0	54	58	20	108	21	0	0	377
50	0	0	0	110	12	11	94	169	54	20	0	0	470
51	0	0	0	114	42	9	0	168	26	27	0	0	386
52	0	0	0	58	0	41	131	45	11	18	0	0	303
Average	**0**	**0**	**0**	**81**	**64**	**37**	**69**	**49**	**48**	**16**	**0**	**0**	**365**
Minimum	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**0**	**0**	**0**	**146**
Maximum	**0**	**0**	**0**	**225**	**290**	**100**	**185**	**169**	**165**	**67**	**0**	**0**	**671**

M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 513 - Climate change scenarios\GoldSim\[Appendix B tables_FacilitiesSurplusWater.xlsx]Table_MGO

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	09DEC'14	ISSUED WITH LETTER VA15-01946	EER	JGC	KJB

Knight Piésold
CONSULTING

TABLE B.9

CASINO MINING CORPORATION
CASINO PROJECT

CLIMATE CHANGE NET PRECIPATION VALUES - 2055 SCENARIO
HEAP LEACH FACILITY

Print Jan/15/15 18:10:37

Year	Monthly Net Precipitation (mm/mon)												Annual Net Precipitation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	0	35	33	0	40	9	27	1	0	0	146
2	0	0	0	96	9	28	79	99	25	0	0	0	336
3	0	0	0	13	201	54	22	47	39	0	0	0	376
4	0	0	0	75	16	19	185	43	46	8	0	0	391
5	0	0	0	16	90	52	49	23	25	5	0	0	260
6	0	0	0	128	81	74	32	46	16	7	0	0	384
7	0	0	0	26	159	66	130	32	31	28	0	0	472
8	0	0	0	58	11	27	43	8	71	6	0	0	225
9	0	0	0	41	99	20	0	27	20	5	0	0	212
10	0	0	0	5	290	54	88	77	45	12	0	0	571
11	0	0	0	97	59	9	21	23	113	4	0	0	326
12	0	0	0	83	43	0	141	3	35	8	0	0	314
13	0	0	0	65	79	16	0	69	94	4	0	0	326
14	0	0	0	79	46	0	16	58	34	3	0	0	237
15	0	0	0	0	191	100	54	16	39	4	0	0	403
16	0	0	0	193	10	70	55	76	6	6	0	0	415
17	0	0	0	71	84	0	90	34	5	26	0	0	309
18	0	0	0	80	22	0	99	30	54	9	0	0	294
19	0	0	0	130	73	38	52	10	16	12	0	0	333
20	0	0	0	134	30	52	25	6	19	24	0	0	289
21	0	0	0	51	16	32	150	60	36	25	0	0	370
22	0	0	0	84	97	59	66	0	59	2	0	0	368
23	0	0	0	66	0	17	49	38	101	24	0	0	295
24	0	0	0	16	45	33	129	56	99	64	0	0	441
25	0	0	0	31	113	0	87	17	53	2	0	0	304
26	0	0	0	135	39	60	66	127	45	20	0	0	492
27	0	0	0	78	49	18	50	66	39	5	0	0	306
28	0	0	0	15	123	99	129	66	48	2	0	0	481
29	0	0	0	0	149	57	99	59	4	9	0	0	377
30	0	0	0	89	26	18	64	39	77	67	0	0	381
31	0	0	0	108	27	17	94	28	9	23	0	0	305
32	0	0	0	68	46	59	0	18	37	6	0	0	234
33	0	0	0	105	76	73	0	56	81	14	0	0	406
34	0	0	0	157	32	23	55	41	76	3	0	0	387
35	0	0	0	123	165	28	47	62	112	0	0	0	536
36	0	0	0	195	18	0	80	49	31	42	0	0	417
37	0	0	0	96	58	68	32	0	38	37	0	0	328
38	0	0	0	31	12	25	122	120	7	32	0	0	348
39	0	0	0	96	147	62	114	41	47	0	0	0	506
40	0	0	0	85	0	55	1	17	52	10	0	0	219
41	0	0	0	105	23	82	19	78	61	41	0	0	409
42	0	0	0	93	113	51	115	122	165	12	0	0	671
43	0	0	0	82	9	56	150	40	35	20	0	0	392
44	0	0	0	0	129	12	104	113	5	18	0	0	381
45	0	0	0	59	32	34	61	24	32	12	0	0	255
46	0	0	0	225	47	2	47	0	143	24	0	0	489
47	0	0	0	116	44	62	122	15	46	57	0	0	462
48	0	0	0	97	21	26	44	47	10	17	0	0	262
49	0	0	0	115	0	54	58	20	108	21	0	0	377
50	0	0	0	110	12	11	94	169	54	20	0	0	470
51	0	0	0	114	42	9	0	168	26	27	0	0	386
52	0	0	0	58	0	41	131	45	11	18	0	0	303
Average	**0**	**0**	**0**	**81**	**64**	**37**	**69**	**49**	**48**	**16**	**0**	**0**	**365**
Minimum	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**0**	**0**	**0**	**146**
Maximum	**0**	**0**	**0**	**225**	**290**	**100**	**185**	**169**	**165**	**67**	**0**	**0**	**671**

M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 513 - Climate change scenarios\GoldSim\[Appendix B tables_FacilitiesSurplusWater.xlsx]Table_HLF

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	09DEC'14	ISSUED WITH LETTER VA15-01946	EER	JGC	KJB

Knight Piésold CONSULTING

TABLE B.10

CASINO MINING CORPORATION
CASINO PROJECT

CLIMATE CHANGE NET PRECIPATION VALUES - 2055 SCENARIO
TAILINGS MANAGEMENT FACILITY - BEACH

Print Jan/15/15 18:10:37

Year	Monthly Net Precipitation (mm/mon)												Annual Net Precipitation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	0	38	0	0	0	0	0	0	0	0	38
2	0	0	0	40	0	0	11	61	6	12	0	0	130
3	0	0	0	102	26	4	0	0	17	3	0	0	152
4	0	0	0	41	0	0	120	6	24	4	0	0	195
5	0	0	0	60	0	2	0	0	0	22	0	0	85
6	0	0	0	131	0	21	0	0	0	0	0	0	152
7	0	0	0	110	17	16	81	0	5	15	0	0	244
8	0	0	1	29	0	0	0	0	24	36	0	0	90
9	0	0	0	84	0	0	0	0	0	0	0	0	84
10	0	0	0	48	133	5	40	36	22	11	0	0	295
11	0	0	10	81	0	0	0	0	69	11	0	0	171
12	0	0	0	38	12	0	36	0	0	0	0	0	86
13	0	0	0	33	46	0	0	0	59	23	0	0	161
14	0	0	0	74	0	0	0	0	5	18	0	0	97
15	0	0	0	2	109	52	2	0	5	32	0	0	202
16	0	0	0	130	0	0	3	39	0	2	0	0	175
17	0	0	0	112	0	0	10	0	0	18	0	0	140
18	0	0	0	57	0	0	21	0	29	19	0	0	125
19	0	0	0	84	40	0	0	0	0	0	4	0	127
20	0	1	0	82	0	3	0	0	0	0	0	0	86
21	0	0	0	17	0	0	88	20	12	28	0	0	166
22	0	0	0	101	10	14	14	0	3	0	0	0	143
23	0	0	0	25	0	0	0	0	77	10	0	0	113
24	2	0	2	39	0	0	66	17	79	51	0	0	256
25	0	0	0	72	22	0	4	0	18	16	0	0	132
26	0	0	0	79	6	11	14	91	28	22	0	0	250
27	0	0	4	35	18	0	0	23	18	12	0	0	110
28	0	0	0	82	0	49	77	29	28	14	0	0	279
29	0	0	0	2	83	9	45	22	0	0	0	0	162
30	0	0	0	48	0	0	0	0	57	49	0	0	153
31	0	0	4	66	0	0	28	0	0	15	0	0	114
32	0	0	0	26	12	11	0	0	0	0	0	0	49
33	0	0	0	53	40	24	0	0	47	38	0	0	201
34	0	0	0	90	0	0	0	1	53	16	0	0	160
35	0	0	6	182	11	0	0	16	99	13	0	0	326
36	0	0	0	138	0	0	4	11	11	28	0	0	191
37	0	0	0	59	26	21	0	0	0	9	0	0	115
38	0	0	0	1	0	0	54	83	0	10	0	0	148
39	0	0	0	64	114	13	60	1	23	13	0	0	288
40	0	0	0	36	0	0	0	0	0	10	0	0	46
41	0	0	0	68	0	27	0	20	40	48	0	0	202
42	0	0	3	109	17	0	63	86	146	15	0	0	440
43	0	0	0	46	0	0	98	0	12	25	0	0	181
44	0	0	0	5	66	0	37	76	0	0	0	0	184
45	0	0	0	49	0	0	0	0	3	2	0	0	54
46	0	0	0	202	0	0	0	0	74	31	0	0	307
47	0	0	2	67	5	12	72	0	9	42	0	0	209
48	0	0	0	64	0	0	0	0	0	1	0	0	66
49	0	0	0	78	0	0	0	0	71	29	0	0	178
50	0	0	0	74	0	0	24	132	33	26	0	0	288
51	0	0	0	107	0	0	0	78	4	19	0	0	208
52	0	0	3	22	0	0	68	4	0	6	0	0	104
Average	**0**	**0**	**1**	**67**	**16**	**6**	**22**	**16**	**23**	**16**	**0**	**0**	**166**
Minimum	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**38**
Maximum	**2**	**1**	**10**	**202**	**133**	**52**	**120**	**132**	**146**	**51**	**4**	**0**	**440**

M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 513 - Climate change scenarios\GoldSim\[Appendix B tables_FacilitiesSurplusWater.xlsx]Table_TMFBeach

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	09DEC'14	ISSUED WITH LETTER VA15-01946	EER	JGC	KJB

Knight Piésold
CONSULTING

TABLE B.11

CASINO MINING CORPORATION
CASINO PROJECT

CLIMATE CHANGE NET PRECIPATION VALUES - 2055 SCENARIO
TAILINGS MANAGEMENT FACILITY - EMBANKMENT

Print Jan/15/15 18:10:37

Year	Monthly Net Precipitation (mm/mon)												Annual Net Precipitation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	1	40	9	0	29	7	26	1	0	0	112
2	0	0	0	67	6	24	76	97	23	22	0	0	316
3	0	0	0	108	36	51	19	45	38	4	0	0	301
4	0	0	0	47	13	17	182	41	44	8	0	0	352
5	0	0	0	59	26	49	46	21	24	36	0	0	261
6	0	0	0	120	13	71	29	44	14	3	0	0	295
7	0	0	0	113	38	64	128	30	29	21	0	0	423
8	0	0	2	34	9	24	40	6	70	41	0	0	225
9	0	0	0	76	0	17	0	8	18	30	0	0	150
10	0	0	0	107	95	51	86	75	43	14	0	0	471
11	0	0	37	55	29	6	19	21	111	14	0	0	291
12	0	0	0	48	41	0	113	2	33	6	0	0	243
13	0	0	15	27	77	14	0	48	92	29	0	0	301
14	0	0	0	67	0	0	7	56	33	23	0	0	185
15	0	0	0	5	120	97	51	14	37	46	0	0	369
16	0	0	0	116	0	60	52	74	4	18	0	0	324
17	0	0	0	111	0	0	85	32	4	34	0	0	267
18	0	0	0	60	5	0	95	28	53	23	0	0	263
19	0	0	0	87	67	36	49	8	15	18	16	0	296
20	0	1	0	77	27	49	22	4	17	20	0	0	218
21	0	0	0	30	14	29	147	58	34	30	0	0	343
22	0	0	3	98	39	56	63	0	51	0	2	0	313
23	0	0	0	39	0	11	46	36	100	17	2	0	251
24	5	0	12	26	1	30	126	53	97	54	8	0	412
25	0	0	0	63	49	0	77	15	51	20	0	0	275
26	0	0	0	80	37	58	63	125	43	24	0	0	429
27	0	0	27	25	47	15	48	64	38	15	0	0	277
28	3	0	0	77	20	97	126	64	46	18	0	0	450
29	0	0	0	16	84	54	96	56	2	8	0	0	317
30	0	0	0	62	24	16	61	37	76	53	3	0	331
31	0	0	12	62	25	14	91	25	7	32	0	0	269
32	0	0	0	34	43	57	0	6	36	20	0	0	195
33	0	0	1	60	74	70	0	45	79	40	0	0	370
34	0	0	0	95	28	20	52	39	74	19	0	0	327
35	0	0	21	159	37	25	44	60	109	28	2	0	485
36	0	0	2	121	14	0	77	47	30	33	0	0	323
37	0	0	3	64	55	65	29	0	26	34	0	0	277
38	0	0	0	13	9	22	118	118	5	27	0	0	313
39	0	2	0	66	144	59	110	39	45	22	2	0	488
40	0	0	0	33	0	38	0	14	50	14	0	0	149
41	0	0	1	72	21	79	16	75	59	49	0	0	372
42	0	0	15	96	46	48	113	120	163	18	2	0	621
43	0	0	0	49	6	53	147	38	33	27	0	0	354
44	0	0	0	22	72	9	101	111	4	12	11	1	344
45	0	0	0	46	7	32	58	22	30	8	0	0	203
46	0	0	0	202	14	0	44	0	128	32	0	0	420
47	0	0	38	41	41	59	119	13	44	45	0	0	400
48	0	0	0	68	18	23	41	45	8	16	0	0	219
49	0	0	0	83	0	31	55	17	106	30	1	0	323
50	0	0	1	75	5	8	92	167	53	28	0	0	428
51	0	0	0	107	3	6	0	154	24	23	0	0	317
52	0	0	24	19	0	34	128	43	9	16	1	0	274
Average	**0**	**0**	**4**	**68**	**31**	**34**	**66**	**46**	**46**	**23**	**1**	**0**	**318**
Minimum	**0**	**0**	**0**	**5**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**112**
Maximum	**5**	**2**	**38**	**202**	**144**	**97**	**182**	**167**	**163**	**54**	**16**	**1**	**621**

M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 513 - Climate change scenarios\GoldSim\[Appendix B tables_FacilitiesSurplusWater.xlsx]Table_TMFEmbk

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	09DEC'14	ISSUED WITH LETTER VA15-01946	EER	JGC	KJB

Knight Piésold CONSULTING

TABLE B.12

CASINO MINING CORPORATION
CASINO PROJECT

CLIMATE CHANGE NET PRECIPATION VALUES - 2055 SCENARIO
TAILINGS MANAGEMENT FACILITY - POND

Print Jan/15/15 18:10:37

Year	Monthly Net Precipitation (mm/mon)												Annual Net Precipitation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	0	50	31	23	64	36	41	3	0	0	248
2	0	0	0	83	29	61	114	123	35	12	0	0	457
3	0	0	0	110	75	86	53	69	52	3	0	0	448
4	0	0	0	61	38	48	216	67	59	12	0	0	501
5	0	0	0	68	48	82	82	47	38	28	0	0	393
6	0	0	0	147	33	102	65	72	27	9	0	0	456
7	0	0	0	126	53	98	161	56	44	28	0	0	567
8	0	0	1	48	28	55	77	32	84	36	0	0	361
9	0	0	0	96	12	52	13	37	33	25	0	0	267
10	0	0	0	65	179	85	119	103	59	18	0	0	629
11	0	0	10	97	51	39	54	47	124	14	0	0	436
12	0	0	0	64	62	6	149	22	48	11	0	0	362
13	0	0	1	54	99	45	10	78	105	23	0	0	414
14	0	0	0	89	15	21	44	82	46	18	0	0	316
15	0	0	0	2	158	130	86	42	49	32	0	0	500
16	0	0	0	152	10	93	87	99	18	17	0	0	476
17	0	0	0	125	15	27	121	58	18	39	0	0	404
18	0	0	0	72	28	30	131	53	67	22	0	0	404
19	0	0	0	102	87	68	86	35	30	22	9	0	440
20	0	1	0	100	49	82	55	34	31	26	0	0	378
21	0	0	0	42	36	61	183	86	50	35	0	0	492
22	0	0	0	115	60	87	99	19	70	6	0	0	455
23	0	0	0	59	19	45	81	60	111	25	0	0	401
24	2	0	2	47	27	61	161	80	110	61	0	0	551
25	0	0	0	81	69	24	115	41	66	16	0	0	412
26	0	0	0	102	59	92	99	151	54	29	0	0	586
27	0	0	4	59	68	49	82	89	52	14	0	0	419
28	0	0	0	91	42	128	162	89	59	14	0	0	585
29	0	0	0	2	129	87	134	82	17	13	0	0	462
30	0	0	0	76	45	49	98	63	90	61	0	0	482
31	0	0	4	89	48	48	126	52	20	36	0	0	424
32	0	0	0	48	66	90	24	37	50	19	0	0	333
33	0	0	0	76	98	104	24	75	94	40	0	0	512
34	0	0	0	111	51	55	88	64	90	16	0	0	474
35	0	0	6	197	57	59	81	87	118	13	0	0	617
36	0	0	0	159	37	31	113	73	43	40	0	0	498
37	0	0	0	84	77	98	66	16	45	39	0	0	425
38	0	0	0	29	34	58	155	143	22	32	0	0	473
39	0	0	0	81	166	93	148	66	61	13	0	0	627
40	0	0	0	61	13	74	36	39	64	17	0	0	304
41	0	0	0	87	40	115	52	105	73	54	0	0	527
42	0	0	3	124	66	84	149	144	176	21	0	0	767
43	0	0	0	65	25	88	182	67	48	31	0	0	506
44	0	0	0	5	116	43	137	137	19	19	7	0	483
45	0	0	0	63	28	64	96	49	43	14	0	0	356
46	0	0	0	223	39	38	81	7	147	37	0	0	572
47	0	0	2	91	68	93	153	40	59	53	0	0	559
48	0	0	0	82	40	58	78	71	24	20	0	0	374
49	0	0	0	98	6	67	93	45	120	34	0	0	464
50	0	0	0	91	29	42	125	193	67	31	0	0	579
51	0	0	0	122	26	41	21	184	39	29	0	0	461
52	0	0	3	48	20	69	163	70	23	21	0	0	417
Average	**0**	**0**	**1**	**85**	**54**	**66**	**100**	**72**	**60**	**25**	**0**	**0**	**463**
Minimum	**0**	**0**	**0**	**2**	**6**	**6**	**10**	**7**	**17**	**3**	**0**	**0**	**248**
Maximum	**2**	**1**	**10**	**223**	**179**	**130**	**216**	**193**	**176**	**61**	**9**	**0**	**767**

M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 513 - Climate change scenarios\GoldSim\[Appendix B tables_FacilitiesSurplusWater.xlsx]Table_TMFPond

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	09DEC'14	ISSUED WITH LETTER VA15-01946	EER	JGC	KJB

Knight Piésold
CONSULTING

TABLE B.13

CASINO MINING CORPORATION
CASINO PROJECT

CLIMATE CHANGE NET PRECIPATION VALUES - 2055 SCENARIO
TAILINGS MANAGEMENT FACILITY - WASTE ROCK

Print Jan/15/15 18:10:37

Year	Monthly Net Precipitation (mm/mon)												Annual Net Precipitation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	0	45	10	0	40	7	26	1	0	0	129
2	0	0	0	74	7	25	77	97	23	12	0	0	316
3	0	0	0	107	55	52	20	46	38	3	0	0	321
4	0	0	0	53	14	18	183	42	45	9	0	0	362
5	0	0	0	65	26	50	47	22	24	28	0	0	262
6	0	0	0	140	13	72	30	45	15	4	0	0	319
7	0	0	0	122	38	64	128	31	29	23	0	0	436
8	0	0	1	40	9	25	41	7	70	36	0	0	229
9	0	0	0	91	0	29	0	26	19	25	0	0	190
10	0	0	0	63	160	52	86	76	44	15	0	0	497
11	0	0	10	90	29	7	20	21	112	13	0	0	301
12	0	0	0	53	41	0	141	2	34	7	0	0	278
13	0	0	1	46	77	14	0	69	92	23	0	0	322
14	0	0	0	83	0	0	12	57	33	18	0	0	202
15	0	0	0	2	138	98	52	15	37	32	0	0	373
16	0	0	0	143	0	75	53	74	5	16	0	0	366
17	0	0	0	120	0	2	86	33	4	37	0	0	282
18	0	0	0	66	6	0	99	29	53	21	0	0	273
19	0	0	0	95	68	36	50	9	15	19	9	0	301
20	0	1	0	93	28	50	23	4	17	22	0	0	238
21	0	0	0	35	15	30	148	59	34	32	0	0	352
22	0	0	0	109	40	57	64	0	59	0	0	0	329
23	0	0	0	48	0	17	47	36	100	19	0	0	267
24	2	0	2	43	1	31	127	54	97	57	0	0	415
25	0	0	0	77	50	0	87	16	52	16	0	0	297
26	0	0	0	93	37	59	64	126	44	26	0	0	447
27	0	0	4	49	47	16	48	64	38	13	0	0	281
28	0	0	0	87	20	97	127	65	46	14	0	0	457
29	0	0	0	2	110	55	97	57	3	9	0	0	333
30	0	0	0	68	24	16	62	38	76	56	0	0	341
31	0	0	4	80	25	15	92	26	7	34	0	0	283
32	0	0	0	39	44	57	0	18	36	18	0	0	212
33	0	0	0	67	74	71	0	56	79	39	0	0	387
34	0	0	0	102	28	21	53	40	74	16	0	0	335
35	0	0	6	190	38	26	45	61	110	13	0	0	489
36	0	0	0	150	14	0	80	48	30	35	0	0	357
37	0	0	0	73	56	66	30	0	37	36	0	0	299
38	0	0	0	17	10	23	119	119	5	29	0	0	323
39	0	0	0	74	145	60	111	39	46	13	0	0	488
40	0	0	0	51	0	55	0	16	50	15	0	0	187
41	0	0	0	79	21	80	17	76	59	52	0	0	385
42	0	0	3	118	46	49	113	120	164	19	0	0	632
43	0	0	0	57	7	54	148	39	34	29	0	0	367
44	0	0	0	5	95	10	102	112	4	13	7	0	349
45	0	0	0	57	8	32	59	23	30	9	0	0	219
46	0	0	0	215	15	0	45	0	143	34	0	0	452
47	0	0	2	81	42	60	120	13	44	48	0	0	411
48	0	0	0	75	19	24	42	46	9	17	0	0	231
49	0	0	0	90	0	54	56	18	107	32	0	0	357
50	0	0	0	84	6	9	92	168	53	29	0	0	441
51	0	0	0	116	4	7	0	168	25	25	0	0	343
52	0	0	3	37	0	41	129	43	10	18	0	0	281
Average	**0**	**0**	**1**	**78**	**34**	**36**	**68**	**48**	**47**	**23**	**0**	**0**	**333**
Minimum	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**3**	**0**	**0**	**0**	**129**
Maximum	**2**	**1**	**10**	**215**	**160**	**98**	**183**	**168**	**164**	**57**	**9**	**0**	**632**

M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 513 - Climate change scenarios\GoldSim\[Appendix B tables_FacilitiesSurplusWater.xlsx]Table_TMF_WR

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	09DEC'14	ISSUED WITH LETTER VA15-01946	EER	JGC	KJB

Knight Piésold
CONSULTING

APPENDIX C

CLIMATE CHANGE 2055 SCENARIO: LAKE EVAPORATION VALUES – TMF POND AND OPEN PIT LAKE

(Page C-1)

Knight Piésold CONSULTING

TABLE C.1

CASINO MINING CORPORATION
CASINO PROJECT

CLIMATE CHANGE LAKE EVAPORATION VALUES - 2055 SCENARIO
TMF POND AND OPEN PIT LAKE

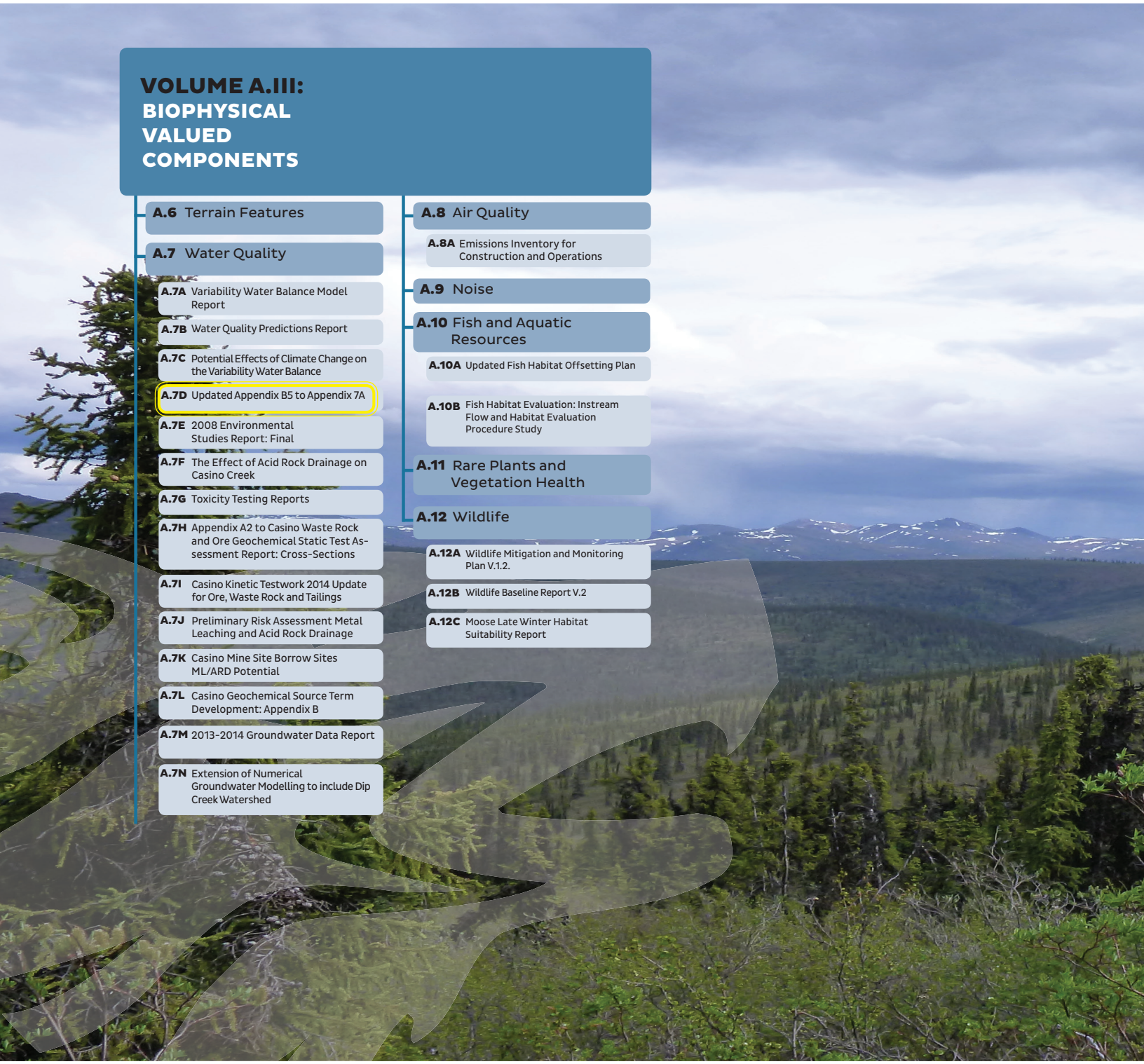
Print Jan/15/15 18:03:23

Year	Monthly Lake Evaporation (mm/mon)												Annual Lake Evaporation (mm/yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	0	0	49	82	94	84	58	9	0	0	376
2	0	0	0	9	53	78	97	88	45	18	0	0	388
3	0	0	0	0	32	78	90	83	57	20	3	0	362
4	0	0	0	13	41	73	97	84	55	2	0	0	364
5	0	0	0	0	40	83	98	79	55	13	0	0	368
6	0	0	0	0	49	85	90	90	58	0	0	0	373
7	0	0	0	8	53	77	95	84	53	6	0	0	376
8	0	0	0	25	53	86	90	63	54	11	2	0	384
9	0	0	0	14	55	73	90	81	47	3	0	0	363
10	0	0	0	6	54	83	98	82	47	0	0	0	371
11	0	0	0	0	43	80	93	89	40	8	0	0	352
12	0	0	0	16	49	78	91	79	53	8	0	0	374
13	0	0	0	2	44	69	91	81	56	7	0	0	349
14	0	0	0	9	60	86	97	79	54	0	0	0	385
15	0	0	0	16	45	79	98	90	61	2	0	0	391
16	0	0	0	15	51	82	91	96	55	18	1	0	409
17	0	0	0	9	52	80	96	90	61	12	0	0	401
18	0	0	0	6	56	79	98	92	60	20	0	0	412
19	0	0	0	29	63	84	96	79	48	27	6	0	432
20	0	0	0	0	69	75	93	86	52	12	2	0	388
21	0	0	0	0	38	81	100	85	57	2	0	0	364
22	0	0	0	25	59	88	97	79	36	0	0	0	384
23	0	0	0	20	52	85	91	81	58	9	0	0	397
24	0	0	0	0	49	71	93	78	51	6	0	0	349
25	0	0	0	0	44	75	99	78	56	9	1	0	362
26	0	0	0	18	58	85	100	84	53	18	0	0	416
27	0	0	0	24	57	85	96	88	52	12	0	0	415
28	0	0	0	18	58	86	103	98	55	11	0	0	429
29	0	0	0	20	64	88	99	92	65	10	0	0	438
30	0	0	0	22	64	90	97	77	60	0	0	0	410
31	0	0	0	4	46	78	97	86	27	1	0	0	340
32	0	0	0	23	57	84	100	88	55	19	3	0	429
33	0	0	0	30	55	83	103	101	52	13	0	0	437
34	0	0	0	38	72	96	102	84	71	7	0	0	470
35	0	0	0	12	55	80	101	89	67	8	0	0	413
36	0	0	0	28	73	89	104	82	58	5	0	0	439
37	0	0	0	18	51	87	99	97	60	4	0	0	417
38	0	0	0	6	53	90	97	75	44	0	0	0	365
39	0	0	0	14	44	86	95	92	57	11	0	0	399
40	0	0	0	0	48	84	96	82	61	28	1	0	400
41	0	0	0	5	48	75	101	86	51	19	1	0	387
42	0	0	0	26	71	104	105	91	40	0	0	0	435
43	0	0	0	27	67	89	96	90	62	18	3	0	451
44	0	0	0	16	53	88	103	88	63	18	1	0	429
45	0	0	0	17	58	92	104	94	56	11	0	0	431
46	0	0	0	14	65	88	90	82	53	0	0	0	392
47	0	0	0	10	60	87	105	88	64	16	3	0	433
48	0	0	0	29	68	85	96	92	57	8	1	0	436
49	0	0	0	17	57	85	98	88	62	15	2	0	424
50	0	20	10	28	62	92	96	87	61	0	0	0	456
51	0	0	0	2	51	86	90	94	67	10	0	0	401
52	0	0	0	20	58	87	102	85	52	6	0	0	411
Average	**0**	**0**	**0**	**14**	**54**	**83**	**97**	**86**	**55**	**9**	**1**	**0**	**399**
Minimum	**0**	**0**	**0**	**0**	**32**	**69**	**90**	**63**	**27**	**0**	**0**	**0**	**340**
Maximum	**0**	**20**	**10**	**38**	**73**	**104**	**105**	**101**	**71**	**28**	**6**	**0**	**470**

M:\1\01\00325\17\A\Data\Task 500 - Water Balance Variability\Task 513 - Climate change scenarios\GoldSim\[Appendix C table_LakeEvap.xlsx]Table_Evap

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	09DEC'14	ISSUED WITH LETTER VA15-01946	EER	JGC	KJB

APPENDIX A.7D: Updated Appendix B5 to Appendix 7A



Appendix B5. Surface Water Quality Statistics: All sites all parameters, Casino Project, 2008-2012

Parameters	CCME[1] Guideline	unit	W12											W8									
			n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL	n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL
pH	6.5 - 9.0	pH unit	16	3.06	4.25	3.51	3.43	0.36	0.09	9.70	0	16	100	13	6.90	7.80	7.48	7.60	0.31	0.08	24.42	0	0	0
Conductivity	-	µS/cm	16	209	1610	875	930	379	95	2.31	0	0	0	13	72	373	244	265	95	26	2.56	0	0	0
Total Hardness CaCO3	-	mg/L	16	56	521	294	286	143	36	2.06	0	0	0	13	30	156	106	107	41	11	2.61	0	0	0
Dissolved Hardness CaCO3	-	mg/L	5	57	589	353	397	212	95	1.67	0	0	0	6	31	164	115	131	50	20	2.31	0	0	0
Ion Balance	-	no unit	4	0.87	1.10	0.99	1.00	0.09	0.05	10.53	0	0	0	4	0.89	1.00	0.95	0.95	0.06	0.03	14.88	0	0	0
Total Dissolved Solids	-	mg/L	16	120	1120	590	610	273	68	2.16	0	0	0	13	54	238	166	160	53	15	3.13	0	0	0
Total Suspended Solids	-	mg/L	15	2.0	77.6	18.7	11.0	21.2	5.5	0.88	0	0	0	13	2.0	30.9	8.3	5.0	7.8	2.2	1.07	0	0	0
Turbidity	-	NTU	16	2.5	59.6	19.4	15.4	15.5	3.9	1.25	0	0	0	13	1.0	13.4	5.3	3.4	3.7	1.0	1.40	0	0	0
Ammonia as N	0.499[a]	mg/L	16	0.007	0.180	0.061	0.050	0.049	0.012	1.25	0	0	0	13	0.005	0.048	0.017	0.014	0.012	0.003	1.39	2	0	0
Alkalinity, Total (as CaCO3)	-	mg/L	16	0.25	0.25	0.25	0.25	0	-	-	16	0	0	13	8.19	59.0	37.37	38.0	16.42	4.55	2.28	0	0	0
Acidity (pH 4.5) as CaCO3	-	mg/L	5	2.43	130.00	51.17	33.70	51.94	23.23	0.99	0	0	0	6	0.25	0.25	0.25	0.25	0	-	-	6	0	0
Acidity (pH8.3) as CaCO3	-	mg/L	14	22.20	229.00	110.15	113.00	56.28	15.04	1.96	0	0	0	9	0.25	4.60	2.01	2.10	1.40	0.47	1.44	2	0	0
Bromide (Br)	-	mg/L	12	0.01	0.20	0.17	0.20	0.07	0.02	2.35	12	0	0	10	0.01	0.20	0.16	0.20	0.08	0.03	1.96	10	0	0
Chloride (Cl)	120	mg/L	16	0.25	1.10	0.53	0.55	0.29	0.07	1.82	7	0	0	13	0.25	2.00	0.56	0.25	0.53	0.15	1.07	8	0	0
Fluoride (F)	0.12	mg/L	12	0.066	0.410	0.241	0.220	0.104	0.030	2.33	0	11	92	10	0.049	0.140	0.098	0.100	0.026	0.008	3.84	0	1	10
Sulphate (SO4)	-	mg/L	16	79.20	820.00	370.76	380.00	203.61	50.90	1.82	0	0	0	13	18.90	126.00	75.45	73.00	31.52	8.74	2.39	0	0	0
Total Nitrogen (N)	-	mg/L	5	0.16	0.58	0.32	0.30	0.17	0.07	1.90	0	0	0	6	0.21	0.60	0.29	0.23	0.15	0.06	1.85	0	0	0
Nitrate (as N)	13	mg/L	16	0.014	0.105	0.048	0.031	0.031	0.008	1.56	0	0	0	13	0.011	0.165	0.088	0.090	0.049	0.013	1.81	0	0	0
Nitrate plus Nitrite (N)	-	mg/L	5	0.014	0.105	0.057	0.042	0.041	0.018	1.40	0	0	0	6	0.032	0.165	0.109	0.114	0.051	0.021	2.14	0	0	0
Nitrite (as N)	0.06	mg/L	16	0.001	0.010	0.004	0.003	0.003	0.001	1.28	6	0	0	13	0.001	0.010	0.002	0.001	0.003	0.001	0.91	10	0	0
Total Kjeldahl Nitrogen	-	mg/L	16	0.05	0.56	0.24	0.19000	0.1552	0.0388	1.56	0	0	0	13	0.05	0.57	0.18	0.12000	0.1443	0.0400	1.25	0	0	0
Ortho Phosphate as P	-	mg/L	16	0.0005	0.0150	0.0027	0.0020	0.0035	0.0009	0.77	3	0	0	13	0.0005	0.0070	0.0017	0.0010	0.0017	0.0005	1.02	3	0	0
Cyanide, Total	0.005	mg/L	15	0.00025	0.00130	0.00034	0.00025	0.00027	0.00007	1.23	13	1	7	13	0.00025	0.00140	0.00048	0.00025	0.00036	0.00010	1.34	8	0	0
Cyanide, Weak Acid Diss	-	mg/L	15	0.00025	0.00070	0.00028	0.00025	0.00012	0.00003	2.41	14	0	0	13	0.00025	0.00110	0.00043	0.00025	0.00030	0.00008	1.43	9	0	0
Dissolved Organic Carbon	-	mg/L	9	1.70	7.00	3.08	2.20	1.98	0.66	1.56	0	0	0	8	1.40	12.20	4.67	3.75	3.63	1.28	1.29	0	0	0
Total Organic Carbon	-	mg/L	13	1.50	14.20	5.56	3.00	4.76	1.32	1.17	0	0	0	10	1.50	18.20	6.18	4.30	6.00	1.90	1.03	0	0	0
Total Aluminum	0.1[b]	mg/L	16	2.26	18.50	8.97	8.04	4.79	1.20	1.87	0	16	100	13	0.3580	0.9870	0.5746	0.5340	0.1820	0.0505	3.16	0	13	100
Total Antimony	-	mg/L	16	0.00009	0.00035	0.00016	0.00016	0.00006	0.00002	2.62	0	0	0	13	0.00006	0.00014	0.00009	0.00009	0.00002	0.00001	4.15	0	0	0
Total Arsenic	0.005	mg/L	16	0.00027	0.00235	0.00070	0.00042	0.00062	0.00016	1.12	0	0	0	13	0.00023	0.00090	0.00037	0.00030	0.00019	0.00005	2.02	0	0	0
Total Barium	-	mg/L	16	0.01	0.04	0.02	0.02510	0.0114	0.0029	1.90	0	0	0	13	0.04	0.07	0.05	0.05240	0.0103	0.0029	5.24	0	0	0
Total Beryllium	-	mg/L	16	0.00010	0.00088	0.00046	0.00049	0.00022	0.00006	2.05	0	0	0	13	0.000020	0.000050	0.000036	0.000040	0.000010	0.000003	3.64	0	0	0
Total Bismuth	-	mg/L	16	0.0000025	0.0000820	0.0000149	0.0000060	0.0000214	0.0000053	0.70	9	0	0	13	0.0000025	0.0000307	0.0000057	0.0000025	0.0000078	0.0000022	0.73	9	0	0
Total Boron	1.5	mg/L	16	0.03	0.15	0.04	0.02500	0.0427	0.0107	0.95	16	0	0	13	0.03	0.03	0.03	0.02500	0	-	-	13	0	0
Total Cadmium	0.000032 [c]	mg/L	16	0.000520	0.004600	0.002355	0.002355	0.001155	0.000289	2.04	0	16	100	13	0.000152	0.000382	0.000242	0.000252	0.000068	0.000019	3.58	0	13	100
Total Calcium	-	mg/L	16	16.50	151.00	87.16	84.80	41.93	10.48	2.08	0	0	0	13	9.08	46.40	31.51	31.30	12.00	3.33	2.63	0	0	0
Total Chromium	0.001	mg/L	16	0.00030	0.00080	0.00059	0.00060	0.00015	0.00004	3.99	0	0	0	13	0.00005	0.00051	0.00017	0.00010	0.00015	0.00004	1.16	5	0	0
Total Cobalt	-	mg/L	16	0.007200	0.079700	0.035865	0.036000	0.019245	0.004811	1.86	0	0	0	13	0.001130	0.005020	0.002349	0.002310	0.001015	0.000281	2.31	0	0	0
Total Copper	0.0023[d]	mg/L	16	0.1790	1.4300	0.7808	0.7905	0.3697	0.0924	2.11	0	16	100	13	0.0317	0.0922	0.0573	0.0581	0.0155	0.0043	3.70	0	13	100
Total Iron	0.3	mg/L	16	6.480	39.100	21.694	19.850	10.591	2.648	2.05	0	16	100	13	0.076	1.650	0.873	0.873	0.508	0.141	1.72	0	11	85
Total Lead	0.003[e]	mg/L	16	0.000661	0.002730	0.001487	0.001500	0.000518	0.000129	2.87	0	1	6	13	0.000176	0.001370	0.000501	0.000293	0.000437	0.000121	1.14	0	1	8
Total Lithium	-	mg/L	16	0.00093	0.00800	0.00472	0.00530	0.00208	0.00052	2.27	0	0	0	13	0.00025	0.00140	0.00092	0.00100	0.00035	0.00010	2.65	2	0	0
Total Magnesium	-	mg/L	16	3.67	37.20	18.60	17.90	9.31	2.33	2.00	0	0	0	13	1.87	10.30	6.65	7.03	2.61	0.73	2.55	0	0	0
Total Manganese	-	mg/L	16	0.2430	1.9700	0.9774	1.0105	0.4688	0.1172	2.08	0	0	0	13	0.0539	0.1570	0.0780	0.0679	0.0278	0.0077	2.80	0	0	0
Total Mercury	0.000026	mg/L	14	0.0000050	0.0000250	0.0000093	0.0000050	0.0000078	0.0000021	1.19	12	0	0	10	0.0000050	0.0000050	0.0000050	0.0000050	0	-	-	10	0	0
Total Molybdenum	0.073	mg/L	16	0.00003	0.00034	0.00019	0.00017	0.00009	0.00002	2.09	3	0	0	13	0.00014	0.00078	0.00027	0.00023	0.00016	0.00004	1.65	0	0	0
Total Nickel	0.0033[f]	mg/L	16	0.00176	0.01230	0.00596	0.00575	0.00269	0.00067	2.22	0	0	0	13	0.00071	0.00126	0.00093	0.00092	0.00018	0.00005	5.27	0	0	0
Total Phosphorus	-	mg/L	14	0.0040	0.1110	0.0213	0.0095	0.0314	0.0084	0.68	1	0	0	10	0.0010	0.0310	0.0107	0.0045	0.0117	0.0037	0.91	3	0	0
Total Potassium	-	mg/L	16	1.05	2.50	1.71	1.80	0.47	0.12	3.67	0	0	0	13	0.73	1.16	0.89	0.88	0.13	0.04	7.05	0	0	0
Total Selenium	0.001	mg/L	16	0.00008	0.00040	0.00022	0.00023	0.00008	0.00002	2.82	0	0	0	13	0.00002	0.00009	0.00005	0.00006	0.00002	0.00001	2.69	2	0	0
Total Silicon	-	mg/L	16	2.78	13.00	7.88	8.35	2.74	0.69	2.88	0	0	0	13	2.84	6.90	5.45	5.80	1.34	0.37	4.07	0	0	0

Note:

1) Canadian water quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2007
a) Ammonia (NH3) guideline based on ph=8 and temp=20
b) Aluminum (AL-T)= 0.005 mg/L at pH < 6.5: 0.1 mg/L at pH ≥ 6.5
c) Cadmium (Cd) mg/L: 10^(0.86*(log(hardness))-3.2)/1000
d) Copper (Cu) mg/L: (e^0.8545[ln(hardness)]-1.465)*0.2/1000; minimum is 0.002mg/L regardless of water hardness
e) Lead (Pb) mg/L: (e^1.273[ln(hardness)]-4.705)/1000; minimum is 0.001mg/L regardless of water hardness
f) Nickel (Ni) mg/L: (e^0.76[(ln(hardness)]+1.06)/1000; minimum is 0.025mg/L regardless of water hardness
Highlighted cells indicate updates from Project Proposal

"n"	Count
"min"	Minimum Value
"max"	Maximum Value
"sd"	Standard Deviation
"se"	Standard Error
"cov"	Covariance
"<DL"	# of Non-detectable Values
">GL"	# of Exceedances of CCME Guic
"%>GL"	% of Parameters that Exceed CCME Guidelin
"-"	No Data Available

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

Appendix B5. Surface Water Quality Statistics: All sites all parameters, Casino Project, 2008-2012

Parameters	CCME[1] Guideline	unit	W12										W8									
			n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL	n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL
Total Silver	0.0001	mg/L	16	0.000008	0.000096	0.000026	0.000020	0.000021	0.000005	1.24	2	0	0	13	0.000003	0.000063	0.000009	0.000003	0.000017	0.000005	0.52	10	0	0
Total Sodium	-	mg/L	16	1.24	10.40	5.61	5.43	2.64	0.66	2.12	0	0	0	13	1.01	4.88	3.33	3.53	1.18	0.33	2.82	0	0	0
Total Strontium	-	mg/L	16	0.051	0.457	0.252	0.266	0.118	0.030	2.14	0	0	0	13	0.059	0.361	0.220	0.217	0.091	0.025	2.41	0	0	0
Total Sulphur	-	mg/L	5	27.00	280.00	162.00	183.00	97.74	43.71	1.66	0	0	0	6	5.00	45.00	29.00	32.00	14.46	5.90	2.01	1	0	0
Total Thallium	0.0008	mg/L	16	0.0000226	0.0001200	0.0000652	0.0000665	0.0000267	0.0000067	2.44	0	0	0	13	0.0000040	0.0000100	0.0000071	0.0000070	0.0000020	0.0000006	3.54	0	0	0
Total Tin	-	mg/L	16	0.000005	0.000500	0.000047	0.000005	0.000124	0.000031	0.38	15	0	0	13	0.000005	0.000100	0.000027	0.000005	0.000039	0.000011	0.71	11	0	0
Total Titanium	-	mg/L	16	0.00025	0.01050	0.00269	0.00145	0.00343	0.00086	0.78	7	0	0	13	0.00025	0.01260	0.00223	0.00025	0.00365	0.00101	0.61	8	0	0
Total Uranium	0.015	mg/L	16	0.00276	0.02280	0.01110	0.01140	0.00534	0.00134	2.08	0	0	0	13	0.00098	0.00429	0.00224	0.00193	0.00100	0.00028	2.24	0	0	0
Total Vanadium	-	mg/L	16	0.00010	0.00160	0.00045	0.00035	0.00044	0.00011	1.03	8	0	0	13	0.00010	0.00094	0.00022	0.00010	0.00024	0.00007	0.91	9	0	0
Total Zinc	0.03	mg/L	16	0.04120	0.37700	0.17698	0.17500	0.09062	0.02266	1.95	0	16	100	13	0.01240	0.03160	0.01880	0.01830	0.00530	0.00147	3.55	0	1	8
Total Zirconium	-	mg/L	16	0.00005	0.00050	0.00020	0.00020	0.00014	0.00004	1.41	8	0	0	13	0.00005	0.00042	0.00013	0.00005	0.00012	0.00003	1.08	7	0	0
Dissolved Aluminum	0.1	mg/L	16	1.78	18.80	8.52	7.36	5.15	1.29	1.65	0	16	100	13	0.0275	0.4340	0.1125	0.0569	0.1208	0.0335	0.93	0	3	23
Dissolved Antimony	-	mg/L	16	0.00004	0.00020	0.00012	0.00011	0.00006	0.000014	2.00	3	0	0	13	0.00005	0.00011	0.00008	0.00008	0.00002	0.000005	4.96	0	0	0
Dissolved Arsenic	-	mg/L	16	0.00010	0.00060	0.00034	0.00031	0.00012	0.000030	2.80	0	0	0	13	0.00007	0.00035	0.00021	0.00018	0.00008	0.000023	2.52	0	0	0
Dissolved Barium	-	mg/L	16	0.007900	0.043600	0.020372	0.022600	0.011002	0.002750	1.85	0	0	0	13	0.030500	0.067800	0.051415	0.049800	0.011700	0.003245	4.39	0	0	0
Dissolved Beryllium	-	mg/L	16	0.000025	0.000880	0.000414	0.000440	0.000237	0.000059	1.75	1	0	0	13	0.000005	0.000030	0.000012	0.000010	0.000008	0.000002	1.38	6	0	0
Dissolved Bismuth	-	mg/L	16	0.0000025	0.0000150	0.0000064	0.0000025	0.0000056	0.0000014	1.16	14	0	0	13	0.0000025	0.0000025	0.0000025	0.0000025	0	-	-	13	0	0
Dissolved Boron	-	mg/L	16	0.025	0.150	0.056	0.025	0.056	0.014	1.01	16	0	0	13	0.025	0.025	0.025	0.025	0	-	-	13	0	0
Dissolved Cadmium	-	mg/L	16	0.000050	0.004620	0.002167	0.002090	0.001270	0.000317	1.71	0	0	0	13	0.000117	0.000316	0.000200	0.000190	0.000058	0.000016	3.42	0	0	0
Dissolved Calcium	-	mg/L	16	17.00	175.00	87.88	85.20	43.51	10.88	2.02	0	0	0	13	9.38	49.50	32.22	34.00	12.48	3.46	2.58	0	0	0
Dissolved Chromium	-	mg/L	16	0.00024	0.00080	0.00046	0.00045	0.00018	0.00004	2.56	3	0	0	13	0.00005	0.00030	0.00010	0.00005	0.00008	0.00002	1.30	7	0	0
Dissolved Cobalt	-	mg/L	16	0.000630	0.076100	0.033396	0.030000	0.020648	0.005162	1.62	0	0	0	13	0.000914	0.004760	0.002251	0.002270	0.001020	0.000283	2.21	0	0	0
Dissolved Copper	-	mg/L	16	0.0162	1.3400	0.7236	0.7295	0.4078	0.1019	1.77	0	0	0	13	0.0097	0.0493	0.0272	0.0278	0.0100	0.0028	2.73	0	0	0
Dissolved Iron	-	mg/L	16	0.355	35.100	16.522	15.300	12.214	3.053	1.35	0	0	0	13	0.001	0.423	0.219	0.203	0.150	0.042	1.46	0	0	0
Dissolved Lead	-	mg/L	16	0.000050	0.001900	0.001162	0.001185	0.000497	0.000124	2.34	0	0	0	13	0.000003	0.000712	0.000136	0.000092	0.000180	0.000050	0.76	1	0	0
Dissolved Lithium	-	mg/L	16	0.00089	0.00800	0.00459	0.00520	0.00202	0.00050	2.27	0	0	0	13	0.00025	0.00150	0.00091	0.00100	0.00032	0.00009	2.83	1	0	0
Dissolved Magnesium	-	mg/L	16	0.34	37.20	17.83	15.90	10.70	2.67	1.67	0	0	0	13	1.74	10.10	6.77	7.47	2.66	0.74	2.54	0	0	0
Dissolved Manganese	-	mg/L	16	0.0154	1.8800	0.9172	0.8595	0.5196	0.1299	1.77	0	0	0	13	0.0374	0.1510	0.0738	0.0683	0.0295	0.0082	2.50	0	0	0
Dissolved Mercury	-	mg/L	13	0.0000050	0.0000250	0.0000096	0.0000050	0.0000088	0.0000024	1.10	13	0	0	9	0.0000050	0.0000050	0.0000050	0.0000050	0	-	-	9	0	0
Dissolved Molybdenum	-	mg/L	16	0.00003	0.00031	0.00014	0.00013	0.00009	0.00002	1.46	7	0	0	13	0.00014	0.00028	0.00022	0.00021	0.00004	0.00001	5.36	0	0	0
Dissolved Nickel	-	mg/L	16	0.00020	0.01160	0.00566	0.00520	0.00300	0.00075	1.88	0	0	0	13	0.00072	0.00110	0.00088	0.00081	0.00013	0.00004	6.92	0	0	0
Dissolved Phosphorus	-	mg/L	13	0.0010	0.0160	0.0066	0.0050	0.0039	0.0011	1.67	4	0	0	9	0.0010	0.0115	0.0046	0.0020	0.0047	0.0016	0.98	4	0	0
Dissolved Potassium	-	mg/L	16	0.99	2.60	1.76	1.80	0.50	0.13	3.51	0	0	0	13	0.66	1.20	0.89	0.88	0.14	0.04	6.17	0	0	0
Dissolved Selenium	-	mg/L	16	0.00007	0.00050	0.00022	0.00019	0.00011	0.00003	2.01	1	0	0	13	0.00002	0.00009	0.00006	0.00006	0.00002	0.00001	2.67	2	0	0
Dissolved Silicon	-	mg/L	16	2.60	14.10	7.96	8.90	3.21	0.80	2.47	0	0	0	13	2.69	7.30	5.55	5.90	1.49	0.41	3.73	0	0	0
Dissolved Silver	-	mg/L	16	0.000003	0.000030	0.000016	0.000016	0.000007	0.000002	2.26	4	0	0	13	0.000003	0.000018	0.000004	0.000003	0.000005	0.000001	0.93	11	0	0
Dissolved Sodium	-	mg/L	15	1.19	10.30	5.76	6.10	2.79	0.72	2.06	0	0	0	13	0.99	4.89	3.40	3.72	1.21	0.34	2.82	0	0	0
Dissolved Strontium	-	mg/L	16	0.050	0.444	0.248	0.257	0.113	0.028	2.20	0	0	0	13	0.056	0.350	0.219	0.210	0.091	0.025	2.40	0	0	0
Dissolved Sulphur	-	mg/L	5	26.00	278.00	164.20	199.00	98.13	43.88	1.67	0	0	0	6	5.00	44.00	29.00	32.00	14.81	6.04	1.96	1	0	0
Dissolved Thallium	-	mg/L	16	0.0000164	0.0001000	0.0000643	0.0000700	0.0000266	0.0000067	2.42	0	0	0	13	0.0000030	0.0000090	0.0000061	0.0000060	0.0000018	0.0000005	3.48	0	0	0
Dissolved Tin	-	mg/L	16	0.000005	0.000500	0.000057	0.000005	0.000124	0.000031	0.46	13	0	0	13	0.000005	0.000100	0.000025	0.000005	0.000039	0.000011	0.65	12	0	0
Dissolved Titanium	-	mg/L	16	0.00025	0.00250	0.00107	0.00110	0.00072	0.00018	1.48	9	0	0	13	0.00025	0.00140	0.00057	0.00025	0.00044	0.00012	1.28	8	0	0
Dissolved Uranium	-	mg/L	16	0.00033	0.02090	0.01008	0.00996	0.00592	0.00148	1.70	0	0	0	13	0.00064	0.00220	0.00150	0.00135	0.00054	0.00015	2.75	0	0	0
Dissolved Vanadium	-	mg/L	16	0.00010	0.00060	0.00027	0.00015	0.00020	0.00005	1.37	12	0	0	13	0.00010	0.00035	0.00013	0.00010	0.00007	0.00002	1.75	11	0	0
Dissolved Zinc	-	mg/L	16	0.00340	0.32800	0.16683	0.15200	0.09664	0.02416	1.73	0	0	0	13	0.00630	0.02180	0.01349	0.01300	0.00448	0.00124	3.01	0	0	0
Dissolved Zirconium	-	mg/L	16	0.00005	0.00030	0.00018	0.00021	0.00010	0.00002	1.85	8	0	0	13	0.00005	0.00030	0.00010	0.00005	0.00008	0.00002	1.22	8	0	0

Note:

1) Canadian water quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2007
a) Ammonia (NH3) guideline based on ph=8 and temp=20
b) Aluminum (AL-T)= 0.005 mg/L at pH < 6.5: 0.1 mg/L at pH ≥ 6.5
c) Cadmium (Cd) mg/L: 10^(0.86*(log(hardness))-3.2)/1000
d) Copper (Cu) mg/L: (e^0.8545[ln(hardness)]-1.465)*0.2/1000; minimum is 0.002mg/L regardless of water hardness
e) Lead (Pb) mg/L: (e^1.273[ln(hardness)]-4.705)/1000; minimum is 0.001mg/L regardless of water hardness
f) Nickel (Ni) mg/L: (e^0.76[(ln(hardness)]+1.06)/1000; minimum is 0.025mg/L regardless of water hardness

Highlighted cells indicate updates from Project Proposal

"n"	Count
"min"	Minimum Value
"max"	Maximum Value
"sd"	Standard Deviation
"se"	Standard Error
"cov"	Covariance
"<DL"	# of Non-detectable Values
">GL"	# of Exceedances of CCME Gui
"%>GL"	% of Parameters that Exceed CCME Guidelin
"-"	No Data Available

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

Appendix B5. Surface Water Quality Statistics: All sites all parameters, Casino Project, 2008-2012

Parameters	CCME[1] Guideline	unit	W43										W13									
			n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL	n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL
pH	6.5 - 9.0	pH unit	10	6.90	7.64	7.40	7.48	0.22	0.07	34.21	0	0	0	12	7.46	8.20	7.89	7.80	0.25	0.07	31.22	0	0	0
Conductivity	-	µS/cm	10	208	300	236	222	30	9	7.93	0	0	0	12	76	444	253	259	104	30	2.44	0	0	0
Total Hardness CaCO3	-	mg/L	11	80	141	104	100	18	5	5.86	0	0	0	12	41	214	123	125	49	14	2.52	0	0	0
Dissolved Hardness CaCO3	-	mg/L	2	90	100	95	95	7	5	13.44	0	0	0	5	38	223	126	115	72	32	1.76	0	0	0
Ion Balance	-	no unit	2	1.00	1.10	1.05	1.05	0.07	0.05	14.85	0	0	0	4	0.87	1.00	0.94	0.94	0.06	0.03	15.51	0	0	0
Total Dissolved Solids	-	mg/L	10	110	210	151	150	29	9	5.20	0	0	0	12	70	260	154	145	57	17	2.68	0	0	0
Total Suspended Solids	-	mg/L	8	0.5	4.0	1.1	0.5	1.3	0.5	0.88	6	0	0	12	0.5	91.5	15.0	5.8	25.3	7.3	0.59	3	0	0
Turbidity	-	NTU	10	0.2	3.7	0.8	0.4	1.0	0.3	0.78	0	0	0	12	0.1	13.3	2.1	0.5	4.0	1.1	0.54	0	0	0
Ammonia as N	0.499[a]	mg/L	8	0.003	0.016	0.009	0.005	0.006	0.002	1.51	5	0	0	12	0.003	0.047	0.017	0.009	0.016	0.005	1.04	3	0	0
Alkalinity, Total (as CaCO3)	-	mg/L	10	59.0	93.0	73.88	70.0	11.11	3.51	6.65	0	0	0	12	28.8	141.0	96.48	105.0	34.78	10.04	2.77	0	0	0
Acidity (pH 4.5) as CaCO3	-	mg/L	4	0.25	0.25	0.25	0.25	0	-	-	4	0	0	5	0.25	0.25	0.25	0.25	0	-	-	5	0	0
Acidity (pH8.3) as CaCO3	-	mg/L	8	4.60	22.10	11.16	10.74	5.97	2.11	1.87	0	0	0	7	0.25	5.70	2.43	1.90	2.25	0.85	1.08	2	0	0
Bromide (Br)	-	mg/L	6	0.01	0.20	0.14	0.20	0.10	0.04	1.34	6	0	0	9	0.01	0.20	0.16	0.20	0.09	0.03	1.82	9	0	0
Chloride (Cl)	120	mg/L	10	0.25	5.00	0.85	0.25	1.47	0.47	0.58	6	0	0	12	0.25	1.10	0.56	0.43	0.35	0.10	1.60	6	0	0
Fluoride (F)	0.12	mg/L	6	0.080	0.092	0.087	0.090	0.005	0.002	16.13	0	0	0	9	0.034	0.110	0.065	0.060	0.022	0.007	2.99	0	0	0
Sulphate (SO4)	-	mg/L	10	34.00	54.00	40.95	38.50	6.62	2.09	6.19	0	0	0	12	0.25	110.00	33.50	28.00	30.04	8.67	1.12	1	0	0
Total Nitrogen (N)	-	mg/L	4	0.18	0.58	0.31	0.24	0.18	0.09	1.67	0	0	0	5	0.30	0.74	0.53	0.53	0.16	0.07	3.25	0	0	0
Nitrate (as N)	13	mg/L	10	0.128	0.479	0.236	0.173	0.128	0.041	1.84	0	0	0	12	0.082	0.419	0.272	0.291	0.103	0.030	2.65	0	0	0
Nitrate plus Nitrite (N)	-	mg/L	4	0.138	0.479	0.238	0.168	0.162	0.081	1.47	0	0	0	5	0.084	0.419	0.277	0.297	0.130	0.058	2.13	0	0	0
Nitrite (as N)	0.06	mg/L	10	0.001	0.002	0.001	0.001	0.000	0.000	2.69	7	0	0	12	0.001	0.003	0.001	0.001	0.001	0.000	1.93	10	0	0
Total Kjeldahl Nitrogen	-	mg/L	10	0.01	0.10	0.06	0.06400	0.0258	0.0082	2.16	1	0	0	12	0.03	0.66	0.18	0.13500	0.1691	0.0488	1.09	0	0	0
Ortho Phosphate as P	-	mg/L	10	0.0005	0.0630	0.0086	0.0020	0.0192	0.0061	0.45	1	0	0	12	0.0005	0.0040	0.0015	0.0012	0.0010	0.0003	1.48	4	0	0
Cyanide, Total	0.005	mg/L	8	0.00025	0.00025	0.00025	0.00025	0	-	-	8	0	0	12	0.00025	0.00150	0.00057	0.00025	0.00047	0.00014	1.22	7	0	0
Cyanide, Weak Acid Diss	-	mg/L	8	0.00025	0.00025	0.00025	0.00025	0	-	-	8	0	0	12	0.00025	0.00130	0.00045	0.00025	0.00038	0.00011	1.17	9	0	0
Dissolved Organic Carbon	-	mg/L	2	1.00	2.00	1.50	1.50	0.71	0.50	2.12	0	0	0	6	1.31	11.50	4.30	3.15	3.68	1.50	1.17	0	0	0
Total Organic Carbon	-	mg/L	5	0.90	2.00	1.26	1.00	0.46	0.20	2.76	0	0	0	9	1.20	10.80	4.01	3.00	2.92	0.97	1.37	0	0	0
Total Aluminum	0.1[b]	mg/L	11	0.0023	0.0269	0.0126	0.0139	0.0097	0.0029	1.30	0	0	0	12	0.0132	0.7190	0.1577	0.0743	0.2058	0.0594	0.77	0	5	42
Total Antimony	-	mg/L	11	0.00201	0.00366	0.00286	0.00294	0.00049	0.0001	5.88	0	0	0	12	0.00010	0.00033	0.00023	0.00023	0.00006	0.00002	3.87	0	0	0
Total Arsenic	0.005	mg/L	11	0.00043	0.00152	0.00069	0.00068	0.00031	0.0001	2.25	0	0	0	12	0.00047	0.00190	0.00132	0.00136	0.00043	0.00012	3.09	0	0	0
Total Barium	-	mg/L	11	0.04	0.07	0.05	0.04750	0.0090	0.0027	5.75	0	0	0	12	0.05	0.11	0.09	0.08955	0.0153	0.0044	5.65	0	0	0
Total Beryllium	-	mg/L	11	0.000005	0.000005	0.000005	0.000005	0.000000	-	-	11	0	0	12	0.000005	0.000047	0.000012	0.000005	0.000013	0.000004	0.96	8	0	0
Total Bismuth	-	mg/L	11	0.0000025	0.0000100	0.0000032	0.0000025	0.0000023	0.0000007	1.41	10	0	0	12	0.0000025	0.0000140	0.0000050	0.0000025	0.0000043	0.0000012	1.17	8	0	0
Total Boron	1.5	mg/L	11	0.03	0.03	0.03	0.02500	0	-	-	11	0	0	12	0.025	0.025	0.025	0.025	0.000	-	-	12	0	0
Total Cadmium	0.000032 [c]	mg/L	11	0.039600	0.068000	0.047400	0.045800	0.008143	0.002455	5.82	0	11	100	12	0.000026	0.000519	0.000124	0.000087	0.000134	0.000039	0.93	0	10	83
Total Calcium	-	mg/L	11	21.40	38.90	28.50	27.40	5.08	1.53	5.61	0	0	0	12	11.40	56.60	33.05	33.60	12.47	3.60	2.65	0	0	0
Total Chromium	0.001	mg/L	11	0.00005	0.00005	0.00005	0.00005	0	-	-	11	0	0	12	0.00005	0.00190	0.00042	0.00015	0.00061	0.00018	0.69	4	2	17
Total Cobalt	-	mg/L	11	0.000162	0.000524	0.000254	0.000221	0.000110	0.000033	2.30	0	0	0	12	0.000018	0.000645	0.000161	0.000074	0.000195	0.000056	0.83	0	0	0
Total Copper	0.0023[d]	mg/L	11	0.0463	0.0909	0.0671	0.0686	0.0128	0.0039	5.25	0	11	100	12	0.0005	0.0092	0.0024	0.0011	0.0028	0.0008	0.88	0	4	33
Total Iron	0.3	mg/L	11	0.021	0.112	0.050	0.047	0.028	0.008	1.80	0	0	0	12	0.021	0.906	0.206	0.071	0.272	0.079	0.76	0	3	25
Total Lead	0.003[e]	mg/L	11	0.004290	0.018300	0.011422	0.009910	0.005099	0.001537	2.24	0	11	100	12	0.000025	0.073000	0.010740	0.003560	0.020573	0.005939	0.52	0	5	42
Total Lithium	-	mg/L	11	0.00160	0.00300	0.00222	0.00220	0.00041	0.00012	5.45	0	0	0	12	0.00070	0.00270	0.00153	0.00150	0.00064	0.00019	2.39	0	0	0
Total Magnesium	-	mg/L	11	6.38	10.70	7.89	7.57	1.24	0.37	6.37	0	0	0	12	3.07	17.60	9.80	9.67	4.35	1.26	2.25	0	0	0
Total Manganese	-	mg/L	11	0.2470	1.0700	0.4135	0.3510	0.2336	0.0704	1.77	0	0	0	12	0.0045	0.1730	0.0517	0.0401	0.0518	0.0149	1.00	0	0	0
Total Mercury	0.000026	mg/L	10	0.0000050	0.0000050	0.0000050	0.0000050	0	-	-	10	0	0	10	0.0000050	0.0000050	0.0000050	0.0000050	0	-	-	10	0	0
Total Molybdenum	0.073	mg/L	11	0.00003	0.00003	0.00003	0.00003	0	-	-	11	0	0	12	0.00034	0.00088	0.00058	0.00053	0.00019	0.00005	3.07	0	0	0
Total Nickel	0.0033[f]	mg/L	11	0.00039	0.00062	0.00050	0.00049	0.00007	0.00002	6.98	0	0	0	12	0.00016	0.00146	0.00056	0.00036	0.00042	0.00012	1.33	0	0	0
Total Phosphorus	-	mg/L	10	0.0010	0.0050	0.0028	0.0030	0.0013	0.0004	2.16	2	0	0	10	0.0020	0.0647	0.0132	0.0070	0.0189	0.0060	0.70	0	0	0
Total Potassium	-	mg/L	11	1.10	1.62	1.34	1.35	0.13	0.04	10.03	0	0	0	12	0.89	1.41	1.09	1.08	0.14	0.04	7.54	0	0	0
Total Selenium	0.001	mg/L	11	0.00002	0.00002	0.00002	0.00002	0	-	-	11	0	0	12	0.00002	0.00028	0.00006	0.00005	0.00007	0.00002	0.86	4	0	0
Total Silicon	-	mg/L	11	4.60	6.60	5.65	5.80	0.51	0.15	11.12	0	0	0	12	3.02	6.00	5.06	5.35	1.01	0.29	5.00	0	0	0

Note:

1) Canadian water quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2007
a) Ammonia (NH3) guideline based on ph=8 and temp=20
b) Aluminum (AL-T)= 0.005 mg/L at pH < 6.5: 0.1 mg/L at pH ≥ 6.5
c) Cadmium (Cd) mg/L: 10^(0.86*(log(hardness))-3.2)/1000
d) Copper (Cu) mg/L: (e^0.8545[ln(hardness)]-1.465)*0.2/1000; minimum is 0.002mg/L regardless of water hardness
e) Lead (Pb) mg/L: (e^1.273[ln(hardness)]-4.705)/1000; minimum is 0.001mg/L regardless of water hardness
f) Nickel (Ni) mg/L: (e^0.76[(ln(hardness)]+1.06)/1000; minimum is 0.025mg/L regardless of water hardness

Highlighted cells indicate updates from Project Proposal

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"min"	Minimum Value
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"-"	No Data Available

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

Appendix B5. Surface Water Quality Statistics: All sites all parameters, Casino Project, 2008-2012

Parameters	CCME[1] Guideline	unit	W43											W13										
			n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL	n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL
Total Silver	0.0001	mg/L	11	0.000045	0.000215	0.000118	0.000105	0.000053	0.000016	2.24	0	6	55	12	0.000003	0.000152	0.000027	0.000016	0.000042	0.000012	0.63	5	1	8
Total Sodium	-	mg/L	11	2.74	3.75	3.26	3.28	0.30	0.09	10.96	0	0	0	12	1.17	5.59	3.71	3.85	1.32	0.38	2.80	0	0	0
Total Strontium	-	mg/L	11	0.195	0.342	0.255	0.245	0.044	0.013	5.77	0	0	0	12	0.072	0.380	0.214	0.222	0.087	0.025	2.47	0	0	0
Total Sulphur	-	mg/L	5	11.00	16.00	13.40	14.00	2.30	1.03	5.82	0	0	0	5	5.00	39.00	15.40	5.00	15.32	6.85	1.01	3	0	0
Total Thallium	0.0008	mg/L	11	0.0000220	0.0000293	0.0000256	0.0000250	0.0000023	0.0000007	10.92	0	0	0	12	0.0000010	0.0000249	0.0000064	0.0000030	0.0000076	0.0000022	0.84	2	0	0
Total Tin	-	mg/L	11	0.000005	0.000120	0.000033	0.000005	0.000048	0.000014	0.69	10	0	0	12	0.000005	0.000300	0.000038	0.000005	0.000087	0.000025	0.43	11	0	0
Total Titanium	-	mg/L	11	0.00025	0.00060	0.00031	0.00025	0.00014	0.00004	2.22	9	0	0	12	0.00025	0.02890	0.00723	0.00195	0.01034	0.00299	0.70	3	0	0
Total Uranium	0.015	mg/L	11	0.00077	0.00238	0.00136	0.00126	0.00051	0.00015	2.68	0	0	0	12	0.00369	0.02440	0.01217	0.01195	0.00685	0.00198	1.78	0	0	0
Total Vanadium	-	mg/L	11	0.00010	0.00030	0.00012	0.00010	0.00006	0.00002	1.96	10	0	0	12	0.00010	0.00231	0.00058	0.00035	0.00068	0.00020	0.85	5	0	0
Total Zinc	0.03	mg/L	11	2.22000	3.62000	2.62909	2.55000	0.39513	0.11914	6.65	0	11	100	12	0.00140	0.03290	0.00770	0.00610	0.00864	0.00249	0.89	0	1	8
Total Zirconium	-	mg/L	11	0.00005	0.00005	0.00005	0.00005	0	-	-	11	0	0	12	0.00005	0.00030	0.00011	0.00005	0.00010	0.00003	1.10	8	0	0
Dissolved Aluminum	0.1	mg/L	8	0.0013	0.0062	0.0034	0.0031	0.0021	0.0007	1.64	0	0	0	12	0.0023	0.1390	0.0348	0.0153	0.0484	0.0140	0.72	0	2	17
Dissolved Antimony	-	mg/L	8	0.00180	0.00360	0.00278	0.00270	0.00060	0.000214	4.60	0	0	0	12	0.00009	0.00026	0.00020	0.00021	0.00005	0.000014	4.18	0	0	0
Dissolved Arsenic	-	mg/L	8	0.00028	0.00047	0.00033	0.00031	0.00006	0.000022	5.30	0	0	0	12	0.00045	0.00178	0.00112	0.00111	0.00044	0.000128	2.53	0	0	0
Dissolved Barium	-	mg/L	8	0.045100	0.063100	0.053550	0.052250	0.006799	0.002404	7.88	0	0	0	12	0.039800	0.107000	0.078408	0.084350	0.018685	0.005394	4.20	0	0	0
Dissolved Beryllium	-	mg/L	8	0.000005	0.000005	0.000005	0.000005	0	-	-	8	0	0	12	0.000005	0.000020	0.000007	0.000005	0.000004	0.000001	1.50	10	0	0
Dissolved Bismuth	-	mg/L	8	0.0000025	0.0000025	0.0000025	0.0000025	0	-	-	8	0	0	12	0.0000025	0.0000025	0.0000025	0.0000025	0	-	-	12	0	0
Dissolved Boron	-	mg/L	8	0.025	0.025	0.025	0.025	0	-	-	8	0	0	12	0.025	0.025	0.025	0.025	0	-	-	12	0	0
Dissolved Cadmium	-	mg/L	8	0.041100	0.070500	0.048175	0.045100	0.009808	0.003467	4.91	0	0	0	12	0.000023	0.000120	0.000062	0.000049	0.000037	0.000011	1.67	0	0	0
Dissolved Calcium	-	mg/L	8	24.70	40.40	30.20	28.70	5.39	1.91	5.60	0	0	0	12	10.60	58.60	32.81	33.30	12.94	3.74	2.53	0	0	0
Dissolved Chromium	-	mg/L	8	0.00005	0.00030	0.00008	0.00005	0.00009	0.00003	0.92	7	0	0	12	0.00005	0.00030	0.00010	0.00005	0.00009	0.00002	1.17	8	0	0
Dissolved Cobalt	-	mg/L	8	0.000157	0.000488	0.000264	0.000236	0.000111	0.000039	2.37	0	0	0	12	0.000010	0.000253	0.000041	0.000018	0.000068	0.000020	0.60	0	0	0
Dissolved Copper	-	mg/L	8	0.0447	0.0709	0.0589	0.0589	0.0097	0.0034	6.10	0	0	0	12	0.0003	0.0069	0.0015	0.0008	0.0018	0.0005	0.81	0	0	0
Dissolved Iron	-	mg/L	8	0.007	0.034	0.017	0.013	0.010	0.004	1.74	0	0	0	12	0.001	0.108	0.028	0.012	0.034	0.010	0.81	0	0	0
Dissolved Lead	-	mg/L	8	0.002050	0.012600	0.006218	0.005205	0.004047	0.001431	1.54	0	0	0	12	0.000007	0.002730	0.000580	0.000122	0.000878	0.000253	0.66	0	0	0
Dissolved Lithium	-	mg/L	8	0.00180	0.00320	0.00231	0.00215	0.00045	0.00016	5.15	0	0	0	12	0.00025	0.00270	0.00140	0.00135	0.00071	0.00021	1.96	1	0	0
Dissolved Magnesium	-	mg/L	8	6.81	11.00	8.18	7.97	1.41	0.50	5.79	0	0	0	12	2.80	18.60	9.86	9.89	4.47	1.29	2.20	0	0	0
Dissolved Manganese	-	mg/L	8	0.2490	1.0800	0.4458	0.3645	0.2738	0.0968	1.63	0	0	0	12	0.0015	0.0939	0.0214	0.0117	0.0279	0.0080	0.77	0	0	0
Dissolved Mercury	-	mg/L	6	0.0000050	0.0000050	0.0000050	0.0000050	0	-	-	6	0	0	9	0.0000050	0.0000050	0.0000050	0.0000050	0	-	-	9	0	0
Dissolved Molybdenum	-	mg/L	8	0.00003	0.00035	0.00008	0.00003	0.00011	0.00004	0.72	5	0	0	12	0.00018	0.00099	0.00060	0.00056	0.00022	0.00006	2.71	0	0	0
Dissolved Nickel	-	mg/L	8	0.00039	0.00061	0.00051	0.00050	0.00008	0.00003	6.49	0	0	0	12	0.00015	0.00097	0.00040	0.00031	0.00025	0.00007	1.57	0	0	0
Dissolved Phosphorus	-	mg/L	6	0.0010	0.0050	0.0018	0.0010	0.0016	0.0007	1.14	4	0	0	9	0.0010	0.0110	0.0038	0.0030	0.0039	0.0013	0.96	4	0	0
Dissolved Potassium	-	mg/L	8	1.18	1.68	1.40	1.38	0.14	0.05	9.81	0	0	0	12	0.80	1.38	1.09	1.15	0.15	0.04	7.21	0	0	0
Dissolved Selenium	-	mg/L	8	0.00002	0.00002	0.00002	0.00002	0	-	-	8	0	0	12	0.00002	0.00031	0.00007	0.00005	0.00008	0.00002	0.79	5	0	0
Dissolved Silicon	-	mg/L	8	5.20	6.60	5.70	5.65	0.47	0.17	12.15	0	0	0	12	2.49	6.50	4.96	5.20	1.15	0.33	4.31	0	0	0
Dissolved Silver	-	mg/L	8	0.000008	0.000090	0.000029	0.000023	0.000025	0.000009	1.16	0	0	0	12	0.000003	0.000020	0.000005	0.000003	0.000005	0.000002	0.92	9	0	0
Dissolved Sodium	-	mg/L	8	2.89	3.95	3.32	3.35	0.35	0.12	9.59	0	0	0	12	1.16	5.39	3.77	3.99	1.35	0.39	2.80	0	0	0
Dissolved Strontium	-	mg/L	8	0.226	0.362	0.266	0.251	0.048	0.017	5.48	0	0	0	12	0.065	0.366	0.210	0.217	0.085	0.024	2.48	0	0	0
Dissolved Sulphur	-	mg/L	2	16.00	17.00	16.50	16.50	0.71	0.50	23.33	0	0	0	5	5.00	42.00	17.00	10.00	15.80	7.06	1.08	2	0	0
Dissolved Thallium	-	mg/L	8	0.0000210	0.0000270	0.0000244	0.0000250	0.0000020	0.0000007	12.21	0	0	0	12	0.0000010	0.0000030	0.0000014	0.0000010	0.0000008	0.0000002	1.79	9	0	0
Dissolved Tin	-	mg/L	8	0.000005	0.000080	0.000014	0.000005	0.000027	0.000009	0.54	7	0	0	12	0.000005	0.000100	0.000022	0.000005	0.000037	0.000011	0.60	11	0	0
Dissolved Titanium	-	mg/L	8	0.00025	0.00100	0.00034	0.00025	0.00027	0.00009	1.30	7	0	0	12	0.00025	0.00144	0.00049	0.00025	0.00046	0.00013	1.06	9	0	0
Dissolved Uranium	-	mg/L	8	0.00081	0.00229	0.00145	0.00128	0.00051	0.00018	2.85	0	0	0	12	0.00243	0.02390	0.01188	0.01182	0.00690	0.00199	1.72	0	0	0
Dissolved Vanadium	-	mg/L	8	0.00010	0.00010	0.00010	0.00010	0	-	-	8	0	0	12	0.00010	0.00035	0.00015	0.00010	0.00009	0.00003	1.64	9	0	0
Dissolved Zinc	-	mg/L	8	2.26000	3.73000	2.65000	2.52000	0.47401	0.16759	5.59	0	0	0	12	0.00110	0.00840	0.00379	0.00280	0.00247	0.00071	1.53	0	0	0
Dissolved Zirconium	-	mg/L	8	0.00005	0.00005	0.00005	0.00005	0	-	-	8	0	0	12	0.00005	0.00020	0.00008	0.00005	0.00005	0.00001	1.59	8	0	0

Note:

1) Canadian water quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2007
a) Ammonia (NH3) guideline based on ph=8 and temp=20
b) Aluminum (AL-T)= 0.005 mg/L at pH < 6.5: 0.1 mg/L at pH ≥ 6.5
c) Cadmium (Cd) mg/L: 10^(0.86*(log(hardness))-3.2)/1000
d) Copper (Cu) mg/L: (e^0.8545[ln(hardness)]-1.465)*0.2/1000; minimum is 0.002mg/L regardless of water hardness
e) Lead (Pb) mg/L: (e^1.273[ln(hardness)]-4.705)/1000; minimum is 0.001mg/L regardless of water hardness
f) Nickel (Ni) mg/L: (e^0.76[(ln(hardness)]+1.06)/1000; minimum is 0.025mg/L regardless of water hardness

Highlighted cells indicate updates from Project Proposal

"n"	Count
"min"	Minimum Value
"max"	Maximum Value
"sd"	Standard Deviation
"se"	Standard Error
"cov"	Covariance
"<DL"	# of Non-detectable Values
">GL"	# of Exceedances of CCME Guic
"%>GL"	% of Parameters that Exceed CCME Guidelin
"-"	No Data Available

Appendix B5. Surface Water Quality Statistics: All sites all parameters, Casino Project, 2008-2012

Parameters	CCME[1] Guideline	unit	W11										W18									
			n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL	n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL
pH	6.5 - 9.0	pH unit	24	7.20	8.12	7.86	7.90	0.24	0.05	33.30	0	0	0	22	7.20	8.20	7.79	7.82	0.23	0.05	34.37	0	0	0
Conductivity	-	µS/cm	24	85	450	262	275	95	19	2.76	0	0	0	22	53	267	168	162	66	14	2.56	0	0	0
Total Hardness CaCO3	-	mg/L	24	45	204	129	137	46	9	2.80	0	0	0	22	25	124	78	74	29	6	2.66	0	0	0
Dissolved Hardness CaCO3	-	mg/L	6	47	207	140	147	58	24	2.41	0	0	0	6	26	124	90	100	37	15	2.41	0	0	0
Ion Balance	-	no unit	4	0.84	1.00	0.96	0.99	0.08	0.04	12.43	0	0	0	4	0.79	1.10	0.97	0.99	0.13	0.06	7.47	0	0	0
Total Dissolved Solids	-	mg/L	24	78	278	174	195	50	10	3.51	0	0	0	22	54	170	108	105	37	8	2.95	0	0	0
Total Suspended Solids	-	mg/L	24	0.5	53.0	9.4	2.5	15.0	3.1	0.62	6	0	0	22	0.5	46.0	6.4	1.0	11.8	2.5	0.55	10	0	0
Turbidity	-	NTU	24	0.4	22.5	3.1	1.6	4.8	1.0	0.65	0	0	0	22	0.1	4.6	0.8	0.3	1.2	0.2	0.65	0	0	0
Ammonia as N	0.499[a]	mg/L	24	0.003	0.260	0.029	0.006	0.053	0.011	0.54	12	0	0	22	0.003	0.190	0.029	0.010	0.042	0.009	0.68	8	0	0
Alkalinity, Total (as CaCO3)	-	mg/L	24	25.0	127.0	76.86	82.0	28.89	5.90	2.66	0	0	0	22	15.5	98.0	61.75	62.5	23.50	5.01	2.63	0	0	0
Acidity (pH 4.5) as CaCO3	-	mg/L	6	0.25	0.25	0.25	0.25	0	-	-	6	0	0	6	0.25	0.25	0.25	0.25	0	-	-	6	0	0
Acidity (pH8.3) as CaCO3	-	mg/L	13	0.25	3.90	1.56	1.60	1.11	0.31	1.40	3	0	0	13	0.25	4.30	1.58	1.40	1.19	0.33	1.33	3	0	0
Bromide (Br)	-	mg/L	20	0.01	0.20	0.17	0.20	0.07	0.01	2.60	20	0	0	20	0.01	0.20	0.17	0.20	0.07	0.01	2.60	20	0	0
Chloride (Cl)	120	mg/L	23	0.25	1.40	0.50	0.25	0.37	0.08	1.36	14	0	0	22	0.25	2.50	0.61	0.25	0.60	0.13	1.03	12	0	0
Fluoride (F)	0.12	mg/L	20	0.055	0.100	0.082	0.080	0.013	0.003	6.52	0	0	0	20	0.028	0.060	0.044	0.040	0.009	0.002	5.11	0	0	0
Sulphate (SO4)	-	mg/L	24	9.30	107.00	57.15	62.00	22.05	4.50	2.59	0	0	0	22	0.25	49.00	23.23	23.00	13.04	2.78	1.78	2	0	0
Total Nitrogen (N)	-	mg/L	6	0.21	0.57	0.38	0.38	0.12	0.05	3.22	0	0	0	6	0.18	0.62	0.40	0.39	0.14	0.06	2.75	0	0	0
Nitrate (as N)	13	mg/L	24	0.031	0.289	0.169	0.180	0.083	0.017	2.03	0	0	0	22	0.037	0.333	0.191	0.181	0.092	0.020	2.07	0	0	0
Nitrate plus Nitrite (N)	-	mg/L	6	0.062	0.289	0.213	0.247	0.089	0.036	2.39	0	0	0	6	0.105	0.320	0.200	0.179	0.084	0.034	2.38	0	0	0
Nitrite (as N)	0.06	mg/L	24	0.001	0.010	0.002	0.001	0.002	0.000	0.99	17	0	0	22	0.001	0.010	0.002	0.001	0.002	0.000	0.90	18	0	0
Total Kjeldahl Nitrogen	-	mg/L	24	0.01	0.51	0.20	0.16000	0.1402	0.0286	1.44	1	0	0	22	0.01	0.52	0.20	0.17000	0.1408	0.0300	1.41	2	0	0
Ortho Phosphate as P	-	mg/L	24	0.0005	0.0420	0.0037	0.0010	0.0087	0.0018	0.42	8	0	0	22	0.0005	0.0420	0.0033	0.0010	0.0087	0.0019	0.38	6	0	0
Cyanide, Total	0.005	mg/L	24	0.00025	0.00160	0.00045	0.00025	0.00035	0.00007	1.27	17	0	0	22	0.00025	0.00150	0.00050	0.00025	0.00038	0.00008	1.34	13	0	0
Cyanide, Weak Acid Diss	-	mg/L	24	0.00025	0.00110	0.00039	0.00025	0.00025	0.00005	1.56	17	0	0	22	0.00025	0.00120	0.00044	0.00025	0.00029	0.00006	1.53	14	0	0
Dissolved Organic Carbon	-	mg/L	12	1.44	13.60	6.30	5.30	3.82	1.10	1.65	0	0	0	12	1.84	21.00	8.03	6.70	5.77	1.67	1.39	0	0	0
Total Organic Carbon	-	mg/L	20	1.72	19.90	6.58	5.20	5.01	1.12	1.31	0	0	0	20	1.80	21.80	7.84	5.40	5.87	1.31	1.34	0	0	0
Total Aluminum	0.1[b]	mg/L	24	0.0417	0.6300	0.2154	0.1680	0.1685	0.0344	1.28	0	16	67	22	0.0060	0.7090	0.1323	0.0694	0.1777	0.0379	0.74	0	9	41
Total Antimony	-	mg/L	24	0.000110	0.000390	0.000152	0.000145	0.000054	0.000011	2.82	0	0	0	22	0.000068	0.000180	0.000139	0.000140	0.000026	0.000006	5.33	0	0	0
Total Arsenic	0.005	mg/L	24	0.000540	0.001520	0.000772	0.000690	0.000252	0.000051	3.07	0	0	0	22	0.000300	0.001100	0.000458	0.000390	0.000183	0.000039	2.51	0	0	0
Total Barium	-	mg/L	24	0.04	0.09	0.06	0.06220	0.0126	0.0026	5.03	0	0	0	22	0.03	0.06	0.05	0.04355	0.0095	0.0020	4.80	0	0	0
Total Beryllium	-	mg/L	24	0.0000050	0.0000500	0.0000168	0.0000100	0.0000150	0.0000031	1.13	9	0	0	22	0.0000050	0.0000300	0.0000100	0.0000050	0.0000083	0.0000018	1.20	14	0	0
Total Bismuth	-	mg/L	24	0.0000025	0.0000310	0.0000053	0.0000025	0.0000077	0.0000016	0.68	20	0	0	22	0.0000025	0.0000140	0.0000030	0.0000025	0.0000025	0.0000005	1.23	21	0	0
Total Boron	1.5	mg/L	24	0.03	0.03	0.03	0.02500	0	-	-	24	0	0	22	0.03	0.03	0.03	0.02500	0	-	-	22	0	0
Total Cadmium	0.000032 [c]	mg/L	24	0.000041	0.000278	0.000094	0.000085	0.000050	0.000010	1.90	0	21	88	22	0.000003	0.000064	0.000021	0.000013	0.000018	0.000004	1.19	2	9	41
Total Calcium	-	mg/L	24	12.50	54.60	34.80	36.45	11.99	2.45	2.90	0	0	0	22	6.71	34.00	21.19	20.05	7.77	1.66	2.73	0	0	0
Total Chromium	0.001	mg/L	24	0.00005	0.00100	0.00024	0.00010	0.00027	0.00005	0.88	9	0	0	22	0.00005	0.00070	0.00021	0.00015	0.00019	0.00004	1.07	8	0	0
Total Cobalt	-	mg/L	24	0.000045	0.000973	0.000394	0.000330	0.000289	0.000059	1.37	0	0	0	22	0.000009	0.000421	0.000098	0.000054	0.000118	0.000025	0.83	0	0	0
Total Copper	0.0023[d]	mg/L	24	0.0044	0.0328	0.0161	0.0161	0.0085	0.0017	1.90	0	24	100	22	0.0004	0.0079	0.0019	0.0012	0.0020	0.0004	0.92	0	5	23
Total Iron	0.3	mg/L	24	0.032	1.040	0.339	0.307	0.256	0.052	1.32	0	13	54	22	0.004	0.617	0.139	0.053	0.192	0.041	0.73	0	4	18
Total Lead	0.003[e]	mg/L	23	0.000041	0.010000	0.001363	0.000671	0.002075	0.000433	0.66	0	2	9	22	0.000003	0.000711	0.000154	0.000061	0.000205	0.000044	0.75	4	0	0
Total Lithium	-	mg/L	24	0.00060	0.00260	0.00133	0.00130	0.00045	0.00009	2.95	0	0	0	22	0.00025	0.00200	0.00077	0.00070	0.00037	0.00008	2.06	2	0	0
Total Magnesium	-	mg/L	24	3.28	18.60	10.28	10.80	4.01	0.82	2.56	0	0	0	22	1.95	9.96	6.20	5.82	2.48	0.53	2.50	0	0	0
Total Manganese	-	mg/L	24	0.0145	0.1340	0.0468	0.0331	0.0307	0.0063	1.53	0	0	0	22	0.0015	0.0330	0.0091	0.0037	0.0099	0.0021	0.92	0	0	0
Total Mercury	0.000026	mg/L	21	0.0000050	0.0000100	0.0000057	0.0000050	0.0000018	0.0000004	3.19	18	0	0	19	0.0000050	0.0000100	0.0000053	0.0000050	0.0000011	0.0000003	4.59	18	0	0
Total Molybdenum	0.073	mg/L	24	0.00025	0.00101	0.00065	0.00066	0.00023	0.00005	2.86	0	0	0	22	0.00045	0.00239	0.00127	0.00119	0.00053	0.00011	2.41	0	0	0
Total Nickel	0.0033[f]	mg/L	24	0.00024	0.00167	0.00062	0.00052	0.00039	0.00008	1.61	0	0	0	22	0.00011	0.00109	0.00041	0.00030	0.00030	0.00006	1.38	0	0	0
Total Phosphorus	-	mg/L	21	0.0010	0.0310	0.0097	0.0050	0.0099	0.0022	0.98	5	0	0	19	0.0010	0.0320	0.0079	0.0030	0.0088	0.0020	0.90	5	0	0
Total Potassium	-	mg/L	24	0.50	1.41	0.98	0.96	0.21	0.04	4.65	0	0	0	22	0.64	1.50	1.06	1.02	0.25	0.05	4.24	0	0	0
Total Selenium	0.001	mg/L	24	0.00002	0.00028	0.00012	0.00012	0.00005	0.00001	2.26	1	0	0	22	0.00002	0.00009	0.00004	0.00004	0.00002	0.00000	1.83	10	0	0
Total Silicon	-	mg/L	24	2.83	6.50	5.06	5.25	0.98	0.20	5.17	0	0	0	22	2.30	5.90	4.97	5.30	0.90	0.19	5.51	0	0	0

Note:

1) Canadian water quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2007
a) Ammonia (NH3) guideline based on ph=8 and temp=20
b) Aluminum (AL-T)= 0.005 mg/L at pH < 6.5: 0.1 mg/L at pH ≥ 6.5
c) Cadmium (Cd) mg/L: 10^(0.86*(log(hardness))-3.2)/1000
d) Copper (Cu) mg/L: (e^0.8545[ln(hardness)]-1.465)*0.2/1000; minimum is 0.002mg/L regardless of water hardness
e) Lead (Pb) mg/L: (e^1.273[ln(hardness)]-4.705)/1000; minimum is 0.001mg/L regardless of water hardness
f) Nickel (Ni) mg/L: (e^0.76[(ln(hardness)]+1.06)/1000; minimum is 0.025mg/L regardless of water hardness

Highlighted cells indicate updates from Project Proposal

"n"	Count
"min"	Minimum Value
"max"	Maximum Value
"sd"	Standard Deviation
"se"	Standard Error
"cov"	Covariance
"<DL"	# of Non-detectable Values
">GL"	# of Exceedances of CCME Guic
"%>GL"	% of Parameters that Exceed CCME Guidelin
"-"	No Data Available

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

Appendix B5. Surface Water Quality Statistics: All sites all parameters, Casino Project, 2008-2012

Parameters	CCME[1] Guideline	unit	W11										W18									
			n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL	n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL
Total Silver	0.0001	mg/L	24	0.000003	0.000091	0.000010	0.000003	0.000019	0.000004	0.51	15	0	0	22	0.000003	0.000010	0.000003	0.000003	0.000002	0.000000	1.73	19	0	0
Total Sodium	-	mg/L	24	1.33	5.53	3.54	3.73	1.12	0.23	3.15	0	0	0	22	1.07	6.42	3.37	3.26	1.24	0.26	2.72	0	0	0
Total Strontium	-	mg/L	24	0.073	0.367	0.220	0.232	0.076	0.015	2.90	0	0	0	22	0.041	0.231	0.118	0.112	0.049	0.010	2.42	0	0	0
Total Sulphur	-	mg/L	6	5.00	39.00	23.17	24.00	11.81	4.82	1.96	1	0	0	6	5.00	17.00	11.00	12.00	5.06	2.07	2.17	2	0	0
Total Thallium	0.0008	mg/L	24	0.0000010	0.0000220	0.0000047	0.0000030	0.0000043	0.0000009	1.08	3	0	0	22	0.0000010	0.0000100	0.0000035	0.0000030	0.0000026	0.0000006	1.37	6	0	0
Total Tin	-	mg/L	24	0.000005	0.000100	0.000013	0.000005	0.000027	0.000005	0.48	24	0	0	22	0.000005	0.000500	0.000041	0.000005	0.000118	0.000025	0.35	19	0	0
Total Titanium	-	mg/L	24	0.00025	0.02050	0.00406	0.00110	0.00574	0.00117	0.71	7	0	0	22	0.00025	0.02040	0.00375	0.00065	0.00591	0.00126	0.64	10	0	0
Total Uranium	0.015	mg/L	24	0.00209	0.02400	0.00975	0.00970	0.00565	0.00115	1.73	0	0	0	22	0.00121	0.00826	0.00399	0.00336	0.00228	0.00049	1.75	0	0	0
Total Vanadium	-	mg/L	24	0.00010	0.00260	0.00050	0.00020	0.00064	0.00013	0.78	11	0	0	22	0.00010	0.00210	0.00059	0.00035	0.00059	0.00013	0.99	4	0	0
Total Zinc	0.03	mg/L	24	0.00180	0.02110	0.00648	0.00550	0.00406	0.00083	1.60	0	0	0	22	0.00020	0.00770	0.00204	0.00140	0.00212	0.00045	0.96	0	0	0
Total Zirconium	-	mg/L	24	0.00005	0.00070	0.00016	0.00015	0.00014	0.00003	1.14	9	0	0	22	0.00005	0.00060	0.00017	0.00015	0.00014	0.00003	1.21	8	0	0
Dissolved Aluminum	0.1	mg/L	24	0.0093	0.2680	0.0696	0.0339	0.0787	0.0161	0.88	0	5	21	22	0.0048	0.3460	0.0729	0.0356	0.0877	0.0187	0.83	0	6	27
Dissolved Antimony	-	mg/L	24	0.00009	0.00019	0.00014	0.00014	0.00002	0.000005	5.95	0	0	0	22	0.00006	0.00021	0.00014	0.00014	0.00003	0.000007	4.27	0	0	0
Dissolved Arsenic	-	mg/L	24	0.00035	0.00091	0.00058	0.00054	0.00014	0.000028	4.22	0	0	0	22	0.00027	0.00069	0.00039	0.00037	0.00010	0.000020	4.07	0	0	0
Dissolved Barium	-	mg/L	24	0.032900	0.091700	0.059238	0.060150	0.014441	0.002948	4.10	0	0	0	22	0.025200	0.061900	0.043814	0.041100	0.011115	0.002370	3.94	0	0	0
Dissolved Beryllium	-	mg/L	24	0.000005	0.000030	0.000010	0.000005	0.000009	0.000002	1.10	17	0	0	22	0.000005	0.000020	0.000007	0.000005	0.000004	0.000001	1.82	16	0	0
Dissolved Bismuth	-	mg/L	24	0.0000025	0.0000150	0.0000033	0.0000025	0.0000028	0.0000006	1.17	22	0	0	22	0.0000025	0.0000025	0.0000025	0.0000025	0	-	-	22	0	0
Dissolved Boron	-	mg/L	24	0.025	0.025	0.025	0.025	0	-	-	24	0	0	22	0.025	0.025	0.025	0.025	0	-	-	22	0	0
Dissolved Cadmium	-	mg/L	24	0.000023	0.000130	0.000069	0.000068	0.000027	0.000005	2.57	0	0	0	22	0.000003	0.000063	0.000015	0.000011	0.000016	0.000003	0.98	4	0	0
Dissolved Calcium	-	mg/L	24	12.50	55.20	34.33	37.20	11.52	2.35	2.98	0	0	0	22	7.21	32.90	21.11	19.45	7.89	1.68	2.68	0	0	0
Dissolved Chromium	-	mg/L	24	0.00005	0.00030	0.00011	0.00010	0.00008	0.00002	1.41	10	0	0	22	0.00005	0.00050	0.00016	0.00010	0.00012	0.00003	1.30	7	0	0
Dissolved Cobalt	-	mg/L	24	0.000033	0.000572	0.000260	0.000248	0.000160	0.000033	1.63	0	0	0	22	0.000010	0.000131	0.000041	0.000032	0.000031	0.000007	1.35	0	0	0
Dissolved Copper	-	mg/L	24	0.0034	0.0292	0.0116	0.0085	0.0076	0.0016	1.52	0	0	0	22	0.0004	0.0078	0.0016	0.0010	0.0018	0.0004	0.91	0	0	0
Dissolved Iron	-	mg/L	24	0.002	0.376	0.106	0.065	0.099	0.020	1.07	0	0	0	22	0.002	0.192	0.049	0.028	0.053	0.011	0.91	0	0	0
Dissolved Lead	-	mg/L	23	0.000009	0.000703	0.000175	0.000114	0.000185	0.000039	0.94	0	0	0	22	0.000003	0.000388	0.000063	0.000018	0.000106	0.000023	0.60	1	0	0
Dissolved Lithium	-	mg/L	24	0.00025	0.00240	0.00125	0.00130	0.00048	0.00010	2.62	1	0	0	22	0.00025	0.00220	0.00064	0.00060	0.00046	0.00010	1.40	8	0	0
Dissolved Magnesium	-	mg/L	24	3.23	17.60	10.01	10.55	3.75	0.77	2.67	0	0	0	22	1.89	10.20	6.09	5.68	2.44	0.52	2.49	0	0	0
Dissolved Manganese	-	mg/L	24	0.0136	0.1110	0.0346	0.0269	0.0230	0.0047	1.50	0	0	0	22	0.0011	0.0266	0.0050	0.0027	0.0067	0.0014	0.74	0	0	0
Dissolved Mercury	-	mg/L	20	0.0000050	0.0000200	0.0000063	0.0000050	0.0000036	0.0000008	1.74	17	0	0	18	0.0000050	0.0000100	0.0000053	0.0000050	0.0000012	0.0000003	4.48	17	0	0
Dissolved Molybdenum	-	mg/L	24	0.00025	0.00099	0.00064	0.00063	0.00021	0.00004	3.01	0	0	0	22	0.00045	0.00239	0.00126	0.00116	0.00054	0.00011	2.34	0	0	0
Dissolved Nickel	-	mg/L	24	0.00019	0.00112	0.00050	0.00045	0.00024	0.00005	2.12	0	0	0	22	0.00010	0.00076	0.00033	0.00025	0.00021	0.00004	1.61	0	0	0
Dissolved Phosphorus	-	mg/L	20	0.0010	0.0100	0.0033	0.0010	0.0033	0.0007	1.01	11	0	0	17	0.0010	0.0094	0.0030	0.0010	0.0028	0.0007	1.04	9	0	0
Dissolved Potassium	-	mg/L	24	0.45	1.47	0.96	0.94	0.22	0.05	4.35	0	0	0	22	0.63	1.53	1.05	1.05	0.24	0.05	4.28	0	0	0
Dissolved Selenium	-	mg/L	24	0.00007	0.00028	0.00012	0.00012	0.00005	0.00001	2.55	0	0	0	22	0.00002	0.00012	0.00004	0.00002	0.00003	0.00001	1.42	12	0	0
Dissolved Silicon	-	mg/L	24	2.74	6.40	4.97	5.20	0.92	0.19	5.38	0	0	0	22	2.34	6.10	4.87	5.00	0.94	0.20	5.21	0	0	0
Dissolved Silver	-	mg/L	24	0.000003	0.000013	0.000005	0.000003	0.000004	0.000001	1.29	17	0	0	22	0.000003	0.000007	0.000003	0.000003	0.000001	0.000000	2.58	20	0	0
Dissolved Sodium	-	mg/L	24	1.37	5.33	3.47	3.66	1.06	0.22	3.28	0	0	0	22	1.10	6.46	3.31	3.20	1.19	0.25	2.77	0	0	0
Dissolved Strontium	-	mg/L	24	0.072	0.365	0.217	0.228	0.074	0.015	2.92	0	0	0	22	0.041	0.250	0.117	0.113	0.051	0.011	2.29	0	0	0
Dissolved Sulphur	-	mg/L	6	5.00	40.00	23.67	24.00	12.40	5.06	1.91	1	0	0	6	5.00	16.00	10.50	12.00	4.55	1.86	2.31	2	0	0
Dissolved Thallium	-	mg/L	24	0.0000010	0.0000050	0.0000030	0.0000030	0.0000012	0.0000002	2.44	4	0	0	22	0.0000010	0.0000050	0.0000024	0.0000030	0.0000011	0.0000002	2.08	7	0	0
Dissolved Tin	-	mg/L	24	0.000005	0.000100	0.000013	0.000005	0.000027	0.000005	0.48	24	0	0	22	0.000005	0.000100	0.000014	0.000005	0.000028	0.000006	0.51	20	0	0
Dissolved Titanium	-	mg/L	24	0.00025	0.00210	0.00060	0.00025	0.00061	0.00013	0.97	16	0	0	22	0.00025	0.00260	0.00062	0.00025	0.00065	0.00014	0.95	15	0	0
Dissolved Uranium	-	mg/L	24	0.00144	0.02370	0.00946	0.00934	0.00556	0.00113	1.70	0	0	0	22	0.00102	0.00863	0.00393	0.00324	0.00238	0.00051	1.65	0	0	0
Dissolved Vanadium	-	mg/L	24	0.00010	0.00060	0.00018	0.00010	0.00014	0.00003	1.29	16	0	0	22	0.00010	0.00100	0.00034	0.00030	0.00021	0.00005	1.58	4	0	0
Dissolved Zinc	-	mg/L	24	0.00110	0.00980	0.00420	0.00430	0.00190	0.00039	2.21	0	0	0	22	0.00020	0.00520	0.00112	0.00060	0.00120	0.00026	0.93	0	0	0
Dissolved Zirconium	-	mg/L	24	0.00005	0.00050	0.00012	0.00010	0.00011	0.00002	1.14	11	0	0	22	0.00005	0.00050	0.00017	0.00020	0.00013	0.00003	1.35	8	0	0

Note:

1) Canadian water quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2007
a) Ammonia (NH3) guideline based on ph=8 and temp=20
b) Aluminum (AL-T)= 0.005 mg/L at pH < 6.5: 0.1 mg/L at pH ≥ 6.5
c) Cadmium (Cd) mg/L: 10^(0.86*(log(hardness))-3.2)/1000
d) Copper (Cu) mg/L: (e^0.8545[ln(hardness)]-1.465)*0.2/1000; minimum is 0.002mg/L regardless of water hardness
e) Lead (Pb) mg/L: (e^1.273[ln(hardness)]-4.705)/1000; minimum is 0.001mg/L regardless of water hardness
f) Nickel (Ni) mg/L: (e^0.76[(ln(hardness)]+1.06)/1000; minimum is 0.025mg/L regardless of water hardness

Highlighted cells indicate updates from Project Proposal

"n"	Count
"min"	Minimum Value
"max"	Maximum Value
"sd"	Standard Deviation
"se"	Standard Error
"cov"	Covariance
"<DL"	# of Non-detectable Values
">GL"	# of Exceedances of CCME Gui
"%>GL"	% of Parameters that Exceed CCME Guidelin
"-"	No Data Available

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

Appendix B5. Surface Water Quality Statistics: All sites all parameters, Casino Project, 2008-2012

Parameters	CCME[1] Guideline	unit	W4											W24										
			n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL	n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL
pH	6.5 - 9.0	pH unit	24	7.30	8.20	7.84	7.90	0.24	0.05	32.03	0	0	0	1	7.69	7.69	7.69	7.69	0	-	-	0	0	0
Conductivity	-	µS/cm	24	71	387	234	236	82	17	2.85	0	0	0	1	132	132	132	132	0	-	-	0	0	0
Total Hardness CaCO3	-	mg/L	24	37	176	111	111	39	8	2.87	0	0	0	1	62	62	62	62	0	-	-	0	0	0
Dissolved Hardness CaCO3	-	mg/L	6	33	176	123	129	52	21	2.36	0	0	0	1	58	58	58	58	0	-	-	0	0	0
Moisture	-	%	-	-	-	-	-	-	-	-	-	-	-	1	75	75	75	75	0	-	-	0	0	0
Ion Balance	-	no unit	4	0.93	1.00	0.98	1.00	0.03	0.02	28.07	0	0	0	1	0.97	0.97	0.97	0.97	0	-	-	0	0	0
Total Dissolved Solids	-	mg/L	24	72	232	154	150	44	9	3.52	0	0	0	1	74	74	74	74	0	-	-	0	0	0
Total Suspended Solids	-	mg/L	24	0.5	130.0	13.9	2.0	32.8	6.7	0.43	7	0	0	1	0.5	0.5	0.5	0.5	0	-	-	1	0	0
Turbidity	-	NTU	24	0.2	51.0	3.5	0.8	10.4	2.1	0.33	0	0	0	1	0.4	0.4	0.4	0.4	0	-	-	0	0	0
Ammonia as N	0.499[a]	mg/L	24	0.003	0.250	0.033	0.010	0.053	0.011	0.62	10	0	0	1	0.043	0.043	0.043	0.043	0	-	-	0	0	0
Alkalinity, Total (as CaCO3)	-	mg/L	24	22.0	125.0	78.04	79.0	27.81	5.68	2.81	0	0	0	1	40.0	40.0	40.0	40.0	0	-	-	0	0	0
Acidity (pH 4.5) as CaCO3	-	mg/L	6	0.25	0.25	0.25	0.25	0	-	-	6	0	0	1	0.25	0.25	0.25	0.25	0	-	-	1	0	0
Acidity (pH8.3) as CaCO3	-	mg/L	13	0.25	4.50	1.64	1.40	1.29	0.36	1.27	3	0	0	1	1.80	1.80	1.80	1.80	0	-	-	0	0	0
Bromide (Br)	-	mg/L	20	0.01	0.20	0.17	0.20	0.07	0.01	2.60	20	0	0	1	0.20	0.20	0.20	0.20	0	-	-	1	0	0
Chloride (Cl)	120	mg/L	24	0.25	6.40	0.83	0.25	1.27	0.26	0.65	13	0	0	1	0.25	0.25	0.25	0.25	0	-	-	1	0	0
Fluoride (F)	0.12	mg/L	20	0.040	0.100	0.068	0.070	0.013	0.003	5.19	0	0	0	1	0.060	0.060	0.060	0.060	0	-	-	0	0	0
Sulphate (SO4)	-	mg/L	24	7.16	70.50	39.02	41.00	16.68	3.40	2.34	0	0	0	1	21.00	21.00	21.00	21.00	0	-	-	0	0	0
Total Nitrogen (N)	-	mg/L	6	0.16	0.74	0.39	0.36	0.19	0.08	2.08	0	0	0	1	0.24	0.24	0.24	0.24	0	-	-	0	0	0
Nitrate (as N)	13	mg/L	24	0.022	0.264	0.145	0.158	0.080	0.016	1.81	0	0	0	1	0.205	0.205	0.205	0.205	0	-	-	0	0	0
Nitrate plus Nitrite (N)	-	mg/L	6	0.052	0.264	0.174	0.182	0.082	0.034	2.11	0	0	0	1	0.205	0.205	0.205	0.205	0	-	-	0	0	0
Nitrite (as N)	0.06	mg/L	24	0.001	0.004	0.001	0.001	0.001	0.000	1.72	18	0	0	1	0.001	0.001	0.001	0.001	0	-	-	1	0	0
Total Kjeldahl Nitrogen	-	mg/L	23	0.01	0.69	0.21	0.17000	0.1604	0.0334	1.30	1	0	0	1	0.03	0.03	0.03	0.03000	0	-	-	0	0	0
Ortho Phosphate as P	-	mg/L	24	0.0005	0.0480	0.0036	0.0010	0.0097	0.0020	0.37	7	0	0	1	0.0010	0.0010	0.0010	0.0010	0	-	-	0	0	0
Cyanide, Total	0.005	mg/L	23	0.00025	0.00210	0.00053	0.00025	0.00044	0.00009	1.20	13	1	4	1	0.00025	0.00025	0.00025	0.00025	0	-	-	1	0	0
Cyanide, Weak Acid Diss	-	mg/L	24	0.00025	0.00170	0.00049	0.00025	0.00036	0.00007	1.36	14	0	0	1	0.00025	0.00025	0.00025	0.00025	0	-	-	1	0	0
Dissolved Organic Carbon	-	mg/L	12	2.10	13.40	6.76	7.00	3.63	1.05	1.86	0	0	0	1	8.80	8.80	8.80	8.80	0	-	-	0	0	0
Total Organic Carbon	-	mg/L	20	1.80	19.80	7.18	5.65	4.80	1.07	1.50	0	0	0	1	9.20	9.20	9.20	9.20	0	-	-	0	0	0
Total Aluminum	0.1[b]	mg/L	24	0.0120	0.9450	0.1589	0.0811	0.2397	0.0489	0.66	0	9	38	1	0.0436	0.0436	0.0436	0.0436	0	-	-	0	0	0
Total Antimony	-	mg/L	24	0.000100	0.000460	0.000146	0.000131	0.000069	0.000014	2.12	0	0	0	1	0.00030	0.00030	0.00030	0.00030	0	-	-	0	0	0
Total Arsenic	0.005	mg/L	24	0.000290	0.002430	0.000587	0.000430	0.000466	0.000095	1.26	0	0	0	1	0.00063	0.00063	0.00063	0.00063	0	-	-	0	0	0
Total Barium	-	mg/L	24	0.04	0.10	0.06	0.05850	0.0151	0.0031	4.07	0	0	0	1	0.04	0.04	0.04	0.03960	0	-	-	0	0	0
Total Beryllium	-	mg/L	24	0.000005	0.000073	0.000013	0.000005	0.000019	0.000004	0.71	16	0	0	1	0.000010	0.000010	0.000010	0.000010	0	-	-	0	0	0
Total Bismuth	-	mg/L	24	0.0000025	0.0000177	0.0000044	0.0000025	0.0000048	0.0000010	0.92	20	0	0	1	0.0000025	0.0000025	0.0000025	0.0000025	0	-	-	1	0	0
Total Boron	1.5	mg/L	24	0.03	0.03	0.03	0.02500	0	-	-	24	0	0	1	0.03	0.03	0.03	0.02500	0	-	-	1	0	0
Total Cadmium	0.000032 [c]	mg/L	24	0.000012	0.000271	0.000048	0.000027	0.000067	0.000014	0.73	0	8	33	1	0.000013	0.000013	0.000013	0.000013	0	-	-	0	0	0
Total Calcium	-	mg/L	24	10.10	47.20	29.55	29.40	10.02	2.05	2.95	0	0	0	1	16.30	16.30	16.30	16.30	0	-	-	0	0	0
Total Chromium	0.001	mg/L	24	0.00005	0.00126	0.00023	0.00010	0.00027	0.00006	0.83	9	1	4	1	0.00030	0.00030	0.00030	0.00030	0	-	-	0	0	0
Total Cobalt	-	mg/L	24	0.000017	0.001700	0.000227	0.000079	0.000403	0.000082	0.56	0	0	0	1	0.000043	0.000043	0.000043	0.000043	0	-	-	0	0	0
Total Copper	0.0023[d]	mg/L	24	0.0015	0.0278	0.0079	0.0059	0.0070	0.0014	1.13	0	18	75	1	0.0014	0.0014	0.0014	0.0014	0	-	-	0	0	0
Total Iron	0.3	mg/L	24	0.011	1.930	0.258	0.126	0.422	0.086	0.61	0	4	17	1	0.039	0.039	0.039	0.039	0	-	-	0	0	0
Total Lead	0.003[e]	mg/L	23	0.000028	0.010700	0.000751	0.000182	0.002194	0.000457	0.34	0	2	9	1	0.000081	0.000081	0.000081	0.000081	0	-	-	0	0	0
Total Lithium	-	mg/L	24	0.00060	0.00160	0.00109	0.00100	0.00026	0.00005	4.19	0	0	0	1	0.00025	0.00025	0.00025	0.00025	0	-	-	1	0	0
Total Magnesium	-	mg/L	24	2.85	15.10	9.13	9.03	3.37	0.69	2.71	0	0	0	1	5.19	5.19	5.19	5.19	0	-	-	0	0	0
Total Manganese	-	mg/L	24	0.0038	0.2150	0.0275	0.0115	0.0474	0.0097	0.58	0	0	0	1	0.0006	0.0006	0.0006	0.0006	0	-	-	0	0	0
Total Mercury	0.000026	mg/L	21	0.0000050	0.0000100	0.0000055	0.0000050	0.0000015	0.0000003	3.64	19	0	0	1	0.0000050	0.0000050	0.0000050	0.0000050	0	-	-	1	0	0
Total Molybdenum	0.073	mg/L	24	0.00037	0.00138	0.00103	0.00113	0.00030	0.00006	3.50	0	0	0	1	0.00028	0.00028	0.00028	0.00028	0	-	-	0	0	0
Total Nickel	0.0033[f]	mg/L	24	0.00016	0.00171	0.00047	0.00037	0.00039	0.00008	1.21	0	0	0	1	0.00064	0.00064	0.00064	0.00064	0	-	-	0	0	0
Total Phosphorus	-	mg/L	21	0.0010	0.0910	0.0136	0.0060	0.0234	0.0051	0.58	2	0	0	1	0.0040	0.0040	0.0040	0.0040	0	-	-	0	0	0
Total Potassium	-	mg/L	24	0.59	1.54	1.04	1.01	0.23	0.05	4.52	0	0	0	1	0.43	0.43	0.43	0.43	0	-	-	0	0	0
Total Selenium	0.001	mg/L	24	0.00002	0.00015	0.00007	0.00007	0.00002	0.00000	2.98	1	0	0	1	0.00043	0.00043	0.00043	0.00043	0	-	-	0	0	0

Note:

1) Canadian water quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2007
a) Ammonia (NH3) guideline based on ph=8 and temp=20
b) Aluminum (AL-T)= 0.005 mg/L at pH < 6.5: 0.1 mg/L at pH ≥ 6.5
c) Cadmium (Cd) mg/L: 10^(0.86*(log(hardness))-3.2)/1000
d) Copper (Cu) mg/L: (e^0.8545[ln(hardness)]-1.465)*0.2/1000; minimum is 0.002mg/L regardless of water hardness
e) Lead (Pb) mg/L: (e^1.273[ln(hardness)]-4.705)/1000; minimum is 0.001mg/L regardless of water hardness
f) Nickel (Ni) mg/L: (e^0.76[(ln(hardness)]+1.06)/1000; minimum is 0.025mg/L regardless of water hardness

Highlighted cells indicate updates from Project Proposal

"n"	Count
"min"	Minimum Value
"max"	Maximum Value
"sd"	Standard Deviation
"se"	Standard Error
"cov"	Covariance
"<DL"	# of Non-detectable Values
">GL"	# of Exceedances of CCME Guic
"%>GL"	% of Parameters that Exceed CCME Guidelin
"-"	No Data Available

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

Appendix B5. Surface Water Quality Statistics: All sites all parameters, Casino Project, 2008-2012

Parameters	CCME[1] Guideline	unit	W4										W24									
			n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL	n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL
Total Silicon	-	mg/L	24	3.07	6.10	4.97	5.10	0.82	0.17	6.04	0	0	0	1	2.80	2.80	2.80	2.80	0	-	-	0	0	0
Total Silver	0.0001	mg/L	24	0.000003	0.000090	0.000009	0.000003	0.000021	0.000004	0.43	21	0	0	1	0.000003	0.000003	0.000003	0.000003	0	-	-	1	0	0
Total Sodium	-	mg/L	24	1.22	6.02	4.00	4.08	1.33	0.27	2.99	0	0	0	1	0.90	0.90	0.90	0.90	0	-	-	0	0	0
Total Strontium	-	mg/L	24	0.065	0.309	0.184	0.179	0.065	0.013	2.83	0	0	0	1	0.044	0.044	0.044	0.044	0	-	-	0	0	0
Total Sulphur	-	mg/L	6	5.00	26.00	16.83	17.00	7.47	3.05	2.25	1	0	0	1	5.00	5.00	5.00	5.00	0	-	-	1	0	0
Total Thallium	0.0008	mg/L	24	0.0000010	0.0000300	0.0000040	0.0000020	0.0000066	0.0000013	0.61	11	0	0	1	0.0000040	0.0000040	0.0000040	0.0000040	0	-	-	0	0	0
Total Tin	-	mg/L	24	0.000005	0.000100	0.000013	0.000005	0.000027	0.000005	0.48	24	0	0	1	0.000005	0.000005	0.000005	0.000005	0	-	-	1	0	0
Total Titanium	-	mg/L	24	0.00025	0.03130	0.00394	0.00145	0.00702	0.00143	0.56	7	0	0	1	0.00110	0.00110	0.00110	0.00110	0	-	-	0	0	0
Total Uranium	0.015	mg/L	24	0.00222	0.01850	0.00746	0.00663	0.00428	0.00087	1.74	0	0	0	1	0.00031	0.00031	0.00031	0.00031	0	-	-	0	0	0
Total Vanadium	-	mg/L	24	0.00010	0.00389	0.00067	0.00040	0.00097	0.00020	0.69	8	0	0	1	0.00010	0.00010	0.00010	0.00010	0	-	-	1	0	0
Total Zinc	0.03	mg/L	24	0.00050	0.02380	0.00379	0.00180	0.00553	0.00113	0.69	0	0	0	1	0.00310	0.00310	0.00310	0.00310	0	-	-	0	0	0
Total Zirconium	-	mg/L	24	0.00005	0.00070	0.00018	0.00015	0.00016	0.00003	1.11	9	0	0	1	0.00020	0.00020	0.00020	0.00020	0	-	-	0	0	0
Dissolved Aluminum	0.1	mg/L	24	0.0060	0.2470	0.0569	0.0270	0.0655	0.0134	0.87	0	4	17	1	0.0395	0.0395	0.0395	0.0395	0	-	-	0	0	0
Dissolved Antimony	-	mg/L	24	0.00007	0.00022	0.00013	0.00013	0.00003	0.000006	4.79	0	0	0	1	0.00030	0.00030	0.00030	0.00030	0	-	-	0	0	0
Dissolved Arsenic	-	mg/L	24	0.00030	0.00075	0.00041	0.00039	0.00010	0.000020	4.24	0	0	0	1	0.00060	0.00060	0.00060	0.00060	0	-	-	0	0	0
Dissolved Barium	-	mg/L	24	0.027	0.099	0.057	0.054	0.017	0.004	3.28	0	0	0	1	0.039	0.039	0.039	0.039	0	-	-	0	0	0
Dissolved Beryllium	-	mg/L	24	0.000005	0.000020	0.000007	0.000005	0.000004	0.000001	1.64	17	0	0	1	0.000005	0.000005	0.000005	0.000005	0	-	-	1	0	0
Dissolved Bismuth	-	mg/L	24	0.0000025	0.0000050	0.0000026	0.0000025	0.0000005	0.0000001	5.10	23	0	0	1	0.0000025	0.0000025	0.0000025	0.0000025	0	-	-	1	0	0
Dissolved Boron	-	mg/L	24	0.025	0.025	0.025	0.025	0	-	-	24	0	0	1	0.025	0.025	0.025	0.025	0	-	-	1	0	0
Dissolved Cadmium	-	mg/L	24	0.000006	0.000047	0.000023	0.000021	0.000010	0.000002	2.23	0	0	0	1	0.000003	0.000003	0.000003	0.000003	0	-	-	1	0	0
Dissolved Calcium	-	mg/L	24	8.91	46.60	29.06	28.45	9.94	2.03	2.92	0	0	0	1	14.40	14.40	14.40	14.40	0	-	-	0	0	0
Dissolved Chromium	-	mg/L	24	0.00005	0.00030	0.00012	0.00008	0.00009	0.00002	1.33	12	0	0	1	0.00030	0.00030	0.00030	0.00030	0	-	-	0	0	0
Dissolved Cobalt	-	mg/L	24	0.000014	0.000174	0.000071	0.000062	0.000048	0.000010	1.50	0	0	0	1	0.000029	0.000029	0.000029	0.000029	0	-	-	0	0	0
Dissolved Copper	-	mg/L	24	0.0014	0.0147	0.0056	0.0041	0.0040	0.0008	1.41	0	0	0	1	0.0013	0.0013	0.0013	0.0013	0	-	-	0	0	0
Dissolved Iron	-	mg/L	24	0.003	0.201	0.066	0.043	0.060	0.012	1.09	0	0	0	1	0.026	0.026	0.026	0.026	0	-	-	0	0	0
Dissolved Lead	-	mg/L	23	0.000006	0.000495	0.000077	0.000029	0.000106	0.000022	0.73	0	0	0	1	0.000012	0.000012	0.000012	0.000012	0	-	-	0	0	0
Dissolved Lithium	-	mg/L	24	0.00025	0.00150	0.00102	0.00100	0.00032	0.00007	3.14	1	0	0	1	0.00025	0.00025	0.00025	0.00025	0	-	-	1	0	0
Dissolved Magnesium	-	mg/L	24	2.54	15.30	9.08	8.52	3.33	0.68	2.73	0	0	0	1	5.41	5.41	5.41	5.41	0	-	-	0	0	0
Dissolved Manganese	-	mg/L	24	0.0034	0.0233	0.0093	0.0076	0.0054	0.0011	1.73	0	0	0	1	0.0002	0.0002	0.0002	0.0002	0	-	-	0	0	0
Dissolved Mercury	-	mg/L	20	0.0000050	0.0000100	0.0000053	0.0000050	0.0000011	0.0000003	4.70	19	0	0	-	-	-	-	-	-	-	-	-	-	-
Dissolved Molybdenum	-	mg/L	24	0.00033	0.00141	0.00106	0.00110	0.00029	0.00006	3.68	0	0	0	1	0.00030	0.00030	0.00030	0.00030	0	-	-	0	0	0
Dissolved Nickel	-	mg/L	24	0.00015	0.00089	0.00037	0.00032	0.00021	0.00004	1.75	0	0	0	1	0.00054	0.00054	0.00054	0.00054	0	-	-	0	0	0
Dissolved Phosphorus	-	mg/L	20	0.0010	0.0120	0.0040	0.0030	0.0034	0.0008	1.17	6	0	0	-	-	-	-	-	-	-	-	-	-	-
Dissolved Potassium	-	mg/L	24	0.59	1.57	1.03	1.02	0.23	0.05	4.50	0	0	0	1	0.45	0.45	0.45	0.45	0	-	-	0	0	0
Dissolved Selenium	-	mg/L	24	0.00002	0.00015	0.00007	0.00007	0.00003	0.00001	2.52	1	0	0	1	0.00036	0.00036	0.00036	0.00036	0	-	-	0	0	0
Dissolved Silicon	-	mg/L	24	2.24	6.40	4.90	5.10	0.97	0.20	5.03	0	0	0	1	2.60	2.60	2.60	2.60	0	-	-	0	0	0
Dissolved Silver	-	mg/L	24	0.000003	0.000028	0.000004	0.000003	0.000005	0.000001	0.73	21	0	0	1	0.000003	0.000003	0.000003	0.000003	0	-	-	1	0	0
Dissolved Sodium	-	mg/L	24	1.19	6.16	3.99	3.82	1.29	0.26	3.08	0	0	0	1	0.90	0.90	0.90	0.90	0	-	-	0	0	0
Dissolved Strontium	-	mg/L	24	0.057	0.299	0.183	0.179	0.064	0.013	2.83	0	0	0	1	0.044	0.044	0.044	0.044	0	-	-	0	0	0
Dissolved Sulphur	-	mg/L	6	5.00	27.00	17.17	17.00	8.26	3.37	2.08	1	0	0	1	5.00	5.00	5.00	5.00	0	-	-	1	0	0
Dissolved Thallium	-	mg/L	24	0.0000010	0.0000050	0.0000019	0.0000010	0.0000011	0.0000002	1.66	13	0	0	1	0.0000050	0.0000050	0.0000050	0.0000050	0	-	-	0	0	0
Dissolved Tin	-	mg/L	24	0.000005	0.000100	0.000014	0.000005	0.000027	0.000006	0.52	23	0	0	1	0.000005	0.000005	0.000005	0.000005	0	-	-	1	0	0
Dissolved Titanium	-	mg/L	24	0.00025	0.00230	0.00060	0.00025	0.00062	0.00013	0.96	16	0	0	1	0.00110	0.00110	0.00110	0.00110	0	-	-	0	0	0
Dissolved Uranium	-	mg/L	24	0.00150	0.01820	0.00734	0.00639	0.00440	0.00090	1.67	0	0	0	1	0.00028	0.00028	0.00028	0.00028	0	-	-	0	0	0
Dissolved Vanadium	-	mg/L	24	0.00010	0.00080	0.00027	0.00025	0.00018	0.00004	1.48	9	0	0	1	0.00040	0.00040	0.00040	0.00040	0	-	-	0	0	0
Dissolved Zinc	-	mg/L	24	0.00050	0.00690	0.00212	0.00155	0.00173	0.00035	1.23	0	0	0	1	0.00040	0.00040	0.00040	0.00040	0	-	-	0	0	0
Dissolved Zirconium	-	mg/L	24	0.00005	0.00050	0.00014	0.00010	0.00011	0.00002	1.28	9	0	0	1	0.00020	0.00020	0.00020	0.00020	0	-	-	0	0	0

Note:

1) Canadian water quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2007
a) Ammonia (NH3) guideline based on ph=8 and temp=20
b) Aluminum (AL-T)= 0.005 mg/L at pH < 6.5: 0.1 mg/L at pH ≥ 6.5
c) Cadmium (Cd) mg/L: 10^(0.86*(log(hardness))-3.2)/1000
d) Copper (Cu) mg/L: (e^0.8545[ln(hardness)]-1.465)*0.2/1000; minimum is 0.002mg/L regardless of water hardness
e) Lead (Pb) mg/L: (e^1.273[ln(hardness)]-4.705)/1000; minimum is 0.001mg/L regardless of water hardness
f) Nickel (Ni) mg/L: (e^0.76[(ln(hardness)]+1.06)/1000; minimum is 0.025mg/L regardless of water hardness

"n"	Count
"min"	Minimum Value
"max"	Maximum Value
"sd"	Standard Deviation
"se"	Standard Error
"cov"	Covariance
"<DL"	# of Non-detectable Values
">GL"	# of Exceedances of CCME Guic
"%>GL"	% of Parameters that Exceed CCME Guidelin
"-"	No Data Available

Highlighted cells indicate updates from Project Proposal

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

Appendix B5. Surface Water Quality Statistics: All sites all parameters, Casino Project, 2008-2012

Parameters	CCME[1] Guideline	unit	W22										R2									
			n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL	n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL
pH	6.5 - 9.0	pH unit	5	7.26	8.00	7.71	7.92	0.34	0.15	22.83	0	0	0	19	7.37	7.90	7.70	7.70	0.15	0.03	50.81	0	0	0
Conductivity	-	µS/cm	5	69	289	179	220	100	45	1.80	0	0	0	19	51	263	159	163	50	11	3.18	0	0	0
Total Hardness CaCO3	-	mg/L	5	28	132	75	71	43	19	1.73	0	0	0	5	26	125	83	93	37	16	2.26	0	0	0
Dissolved Hardness CaCO3	-	mg/L	5	30	128	74	70	41	19	1.79	0	0	0	19	27	118	75	76	22	5	3.45	0	0	0
Ion Balance	-	no unit	3	0.92	1.00	0.97	0.99	0.04	0.03	22.25	0	0	0	3	0.91	1.00	0.96	0.98	0.05	0.03	20.38	0	0	0
Total Dissolved Solids	-	mg/L	5	54	164	100	82	46	20	2.19	0	0	0	19	70	150	102	100	24	6	4.20	0	0	0
Total Suspended Solids	-	mg/L	5	0.5	10.0	4.1	0.5	4.9	2.2	0.83	3	0	0	19	0.5	31.1	3.2	0.5	7.1	1.6	0.45	11	0	0
Turbidity	-	NTU	5	0.2	2.2	1.1	1.1	0.9	0.4	1.21	0	0	0	19	0.1	3.1	0.5	0.2	0.7	0.2	0.68	1	0	0
Ammonia as N	0.499[a]	mg/L	5	0.010	0.046	0.022	0.020	0.014	0.006	1.58	0	0	0	19	0.003	0.070	0.013	0.005	0.016	0.004	0.80	11	0	0
Alkalinity, Total (as CaCO3)	-	mg/L	5	16.0	137.0	70.68	65.0	48.80	21.82	1.45	0	0	0	19	21.3	88.0	63.70	67.0	17.08	3.92	3.73	0	0	0
Acidity (pH 4.5) as CaCO3	-	mg/L	5	0.25	0.25	0.25	0.25	0	-	-	5	0	0	5	0.25	0.25	0.25	0.25	0	-	-	5	0	0
Acidity (pH8.3) as CaCO3	-	mg/L	5	0.25	7.50	2.47	2.10	2.97	1.33	0.83	2	0	0	13	0.70	7.30	2.48	1.60	1.88	0.52	1.32	0	0	0
Bromide (Br)	-	mg/L	5	0.01	0.20	0.12	0.20	0.11	0.05	1.14	5	0	0	19	0.01	0.20	0.18	0.20	0.06	0.01	2.92	19	0	0
Chloride (Cl)	120	mg/L	5	0.25	0.80	0.47	0.25	0.30	0.13	1.56	3	0	0	19	0.25	1.10	0.36	0.25	0.22	0.05	1.63	14	0	0
Fluoride (F)	0.12	mg/L	5	0.038	0.062	0.046	0.040	0.010	0.005	4.55	0	0	0	19	0.037	0.080	0.053	0.050	0.009	0.002	5.86	0	0	0
Sulphate (SO4)	-	mg/L	5	8.10	15.00	11.11	9.86	2.94	1.32	3.78	0	0	0	19	0.25	43.00	17.31	17.00	9.14	2.10	1.89	1	0	0
Total Nitrogen (N)	-	mg/L	5	0.22	0.54	0.38	0.38	0.12	0.05	3.30	0	0	0	5	0.37	0.61	0.44	0.41	0.10	0.04	4.62	0	0	0
Nitrate (as N)	13	mg/L	5	0.092	0.296	0.188	0.196	0.090	0.040	2.08	0	0	0	19	0.009	0.403	0.207	0.199	0.133	0.030	1.56	0	0	0
Nitrate plus Nitrite (N)	-	mg/L	5	0.092	0.296	0.189	0.199	0.090	0.040	2.10	0	0	0	5	0.011	0.359	0.229	0.268	0.142	0.063	1.61	0	0	0
Nitrite (as N)	0.06	mg/L	5	0.001	0.002	0.001	0.001	0.001	0.000	2.20	3	0	0	19	0.001	0.005	0.002	0.001	0.001	0.000	1.32	14	0	0
Total Kjeldahl Nitrogen	-	mg/L	5	0.02	0.44	0.19	0.16000	0.1628	0.0728	1.18	0	0	0	18	0.0200	0.5940	0.1869	0.1700	0.1311	0.0309	1.43	0	0	0
Ortho Phosphate as P	-	mg/L	5	0.0005	0.0030	0.0015	0.0010	0.0010	0.0004	1.50	1	0	0	19	0.0005	0.0310	0.0029	0.0010	0.0068	0.0016	0.42	4	0	0
Cyanide, Total	0.005	mg/L	5	0.00025	0.00135	0.00047	0.00025	0.00049	0.00022	0.96	4	0	0	19	0.00025	0.00150	0.00040	0.00025	0.00034	0.00008	1.18	15	0	0
Cyanide, Weak Acid Diss	-	mg/L	5	0.00025	0.00070	0.00043	0.00025	0.00025	0.00011	1.74	3	0	0	19	0.00025	0.00110	0.00040	0.00025	0.00028	0.00006	1.45	14	0	0
Dissolved Organic Carbon	-	mg/L	5	2.04	7.40	5.21	6.30	2.51	1.12	2.07	0	0	0	12	2.24	15.70	8.04	6.55	4.91	1.42	1.64	0	0	0
Total Organic Carbon	-	mg/L	5	2.00	7.40	4.38	4.10	2.28	1.02	1.93	1	0	0	19	2.40	19.50	7.34	6.10	4.71	1.08	1.56	0	0	0
Total Aluminum	0.1[b]	mg/L	5	0.0098	0.1980	0.0841	0.0874	0.0771	0.0345	1.09	0	2	40	19	0.0093	0.3700	0.0658	0.0238	0.1007	0.0231	0.65	0	3	16
Total Antimony	-	mg/L	5	0.000050	0.000080	0.000063	0.000060	0.000011	0.000005	5.75	0	0	0	19	0.000020	0.000060	0.000035	0.000032	0.000010	0.000002	3.69	0	0	0
Total Arsenic	0.005	mg/L	5	0.000260	0.000542	0.000332	0.000290	0.000119	0.000053	2.79	0	0	0	19	0.000100	0.000475	0.000216	0.000200	0.000087	0.000020	2.47	0	0	0
Total Barium	-	mg/L	5	0.01	0.10	0.06	0.06380	0.0350	0.0156	1.69	0	0	0	19	0.04	0.07	0.05	0.04980	0.0105	0.0024	4.82	0	0	0
Total Beryllium	-	mg/L	5	0.0000050	0.0000170	0.0000084	0.0000050	0.0000053	0.0000024	1.59	3	0	0	19	0.0000050	0.0000320	0.0000085	0.0000050	0.0000074	0.0000017	1.15	14	0	0
Total Bismuth	-	mg/L	5	0.0000025	0.0000025	0.0000025	0.0000025	0	-	-	5	0	0	19	0.0000025	0.0000077	0.0000028	0.0000025	0.0000012	0.0000003	2.33	18	0	0
Total Boron	1.5	mg/L	5	0.03	0.03	0.03	0.02500	0	-	-	5	0	0	19	0.03	0.03	0.03	0.02500	0	-	-	19	0	0
Total Cadmium	0.000032 [c]	mg/L	5	0.000003	0.000022	0.000013	0.000014	0.000007	0.000003	1.82	1	2	40	19	0.000003	0.000038	0.000007	0.000005	0.000008	0.000002	0.87	8	1	5
Total Calcium	-	mg/L	5	8.29	34.50	20.00	19.00	10.90	4.87	1.84	0	0	0	19	6.74	26.20	18.08	18.20	4.90	1.12	3.69	0	0	0
Total Chromium	0.001	mg/L	5	0.00005	0.00029	0.00016	0.00020	0.00011	0.00005	1.50	2	0	0	19	0.00005	0.00060	0.00018	0.00010	0.00017	0.00004	1.07	7	0	0
Total Cobalt	-	mg/L	5	0.000041	0.000149	0.000091	0.000071	0.000045	0.000020	2.00	0	0	0	19	0.000013	0.000319	0.000057	0.000030	0.000073	0.000017	0.77	0	0	0
Total Copper	0.0023[d]	mg/L	5	0.0003	0.0017	0.0010	0.0009	0.0006	0.0003	1.71	0	0	0	19	0.0005	0.0026	0.0011	0.0009	0.0006	0.0001	1.86	0	2	11
Total Iron	0.3	mg/L	5	0.056	0.371	0.161	0.094	0.131	0.059	1.23	0	1	20	19	0.006	0.625	0.088	0.029	0.153	0.035	0.58	0	2	11
Total Lead	0.003[e]	mg/L	5	0.000012	0.000438	0.000146	0.000121	0.000172	0.000077	0.85	0	0	0	19	0.000003	0.000232	0.000047	0.000018	0.000063	0.000015	0.75	1	0	0
Total Lithium	-	mg/L	5	0.00107	0.00470	0.00263	0.00240	0.00145	0.00065	1.81	0	0	0	19	0.00060	0.00130	0.00099	0.00100	0.00021	0.00005	4.81	0	0	0
Total Magnesium	-	mg/L	5	1.71	11.30	6.03	5.74	3.91	1.75	1.54	0	0	0	19	2.43	12.70	7.35	7.35	2.37	0.54	3.09	0	0	0
Total Manganese	-	mg/L	5	0.0011	0.0771	0.0419	0.0419	0.0277	0.0124	1.52	0	0	0	19	0.0032	0.0371	0.0068	0.0049	0.0075	0.0017	0.90	0	0	0
Total Mercury	0.000026	mg/L	4	0.0000050	0.0000050	0.0000050	0.0000050	0	-	-	4	0	0	16	0.0000050	0.0000100	0.0000053	0.0000050	0.0000013	0.0000003	4.25	15	0	0
Total Molybdenum	0.073	mg/L	5	0.00023	0.00052	0.00038	0.00037	0.00011	0.00005	3.41	0	0	0	19	0.00029	0.00098	0.00075	0.00076	0.00017	0.00004	4.48	0	0	0
Total Nickel	0.0033[f]	mg/L	5	0.00021	0.00057	0.00032	0.00027	0.00014	0.00006	2.25	0	0	0	19	0.00020	0.00108	0.00041	0.00031	0.00023	0.00005	1.78	0	0	0
Total Phosphorus	-	mg/L	4	0.0030	0.0208	0.0087	0.0055	0.0084	0.0042	1.04	0	0	0	16	0.0010	0.0400	0.0062	0.0040	0.0093	0.0023	0.66	2	0	0
Total Potassium	-	mg/L	5	0.36	1.16	0.75	0.69	0.29	0.13	2.57	0	0	0	19	0.41	0.85	0.64	0.66	0.11	0.03	5.56	0	0	0
Total Selenium	0.001	mg/L	5	0.00002	0.00004	0.00002	0.00002	0.00001	0.00000	2.68	4	0	0	19	0.00002	0.00010	0.00006	0.00006	0.00002	0.00000	3.03	2	0	0
Total Silicon	-	mg/L	5	3.09	5.80	4.88	5.10	1.10	0.49	4.45	0	0	0	19	2.20	5.00	4.42	4.60	0.71	0.16	6.26	0	0	0

Note:

1) Canadian water quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2007
a) Ammonia (NH3) guideline based on ph=8 and temp=20
b) Aluminum (AL-T)= 0.005 mg/L at pH < 6.5: 0.1 mg/L at pH ≥ 6.5
c) Cadmium (Cd) mg/L: 10^(0.86*(log(hardness))-3.2)/1000
d) Copper (Cu) mg/L: (e^0.8545[ln(hardness)]-1.465)*0.2/1000; minimum is 0.002mg/L regardless of water hardness
e) Lead (Pb) mg/L: (e^1.273[ln(hardness)]-4.705)/1000; minimum is 0.001mg/L regardless of water hardness
f) Nickel (Ni) mg/L: (e^0.76[(ln(hardness)]+1.06)/1000; minimum is 0.025mg/L regardless of water hardness

Highlighted cells indicate updates from Project Proposal

"n"	Count
"min"	Minimum Value
"max"	Maximum Value
"sd"	Standard Deviation
"se"	Standard Error
"cov"	Covariance
"<DL"	# of Non-detectable Values
">GL"	# of Exceedances of CCME Guic
"%>GL"	% of Parameters that Exceed CCME Guidelin
"-"	No Data Available

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

Appendix B5. Surface Water Quality Statistics: All sites all parameters, Casino Project, 2008-2012

Parameters	CCME[1] Guideline	unit	W22										R2									
			n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL	n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL
Total Silver	0.0001	mg/L	5	0.000003	0.000007	0.000003	0.000003	0.000002	0.000001	1.84	4	0	0	19	0.000003	0.000007	0.000003	0.000003	0.000001	0.000000	2.65	18	0	0
Total Sodium	-	mg/L	5	1.56	5.07	3.04	2.82	1.45	0.65	2.10	0	0	0	19	0.89	4.04	2.88	3.00	0.80	0.18	3.59	0	0	0
Total Strontium	-	mg/L	5	0.052	0.339	0.175	0.153	0.116	0.052	1.50	0	0	0	19	0.052	0.229	0.151	0.155	0.043	0.010	3.49	0	0	0
Total Sulphur	-	mg/L	5	5.00	5.00	5.00	5.00	0	-	-	5	0	0	5	5.00	16.00	7.20	5.00	4.92	2.20	1.46	4	0	0
Total Thallium	0.0008	mg/L	5	0.0000010	0.0000038	0.0000024	0.0000020	0.0000011	0.0000005	2.20	1	0	0	19	0.0000010	0.0000058	0.0000015	0.0000010	0.0000013	0.0000003	1.19	15	0	0
Total Tin	-	mg/L	5	0.000005	0.000300	0.000092	0.000050	0.000123	0.000055	0.75	3	0	0	19	0.000005	0.000100	0.000015	0.000005	0.000030	0.000007	0.50	19	0	0
Total Titanium	-	mg/L	5	0.00025	0.00692	0.00228	0.00090	0.00284	0.00127	0.80	2	0	0	19	0.00025	0.01120	0.00165	0.00025	0.00324	0.00074	0.51	10	0	0
Total Uranium	0.015	mg/L	5	0.00163	0.01440	0.00608	0.00371	0.00536	0.00240	1.13	0	0	0	19	0.00111	0.00569	0.00236	0.00227	0.00123	0.00028	1.92	0	0	0
Total Vanadium	-	mg/L	5	0.00010	0.00078	0.00036	0.00020	0.00028	0.00013	1.27	1	0	0	19	0.00010	0.00131	0.00030	0.00010	0.00034	0.00008	0.86	11	0	0
Total Zinc	0.03	mg/L	5	0.00030	0.00360	0.00139	0.00096	0.00128	0.00057	1.09	0	0	0	19	0.00020	0.00244	0.00065	0.00050	0.00055	0.00013	1.18	0	0	0
Total Zirconium	-	mg/L	5	0.00005	0.00021	0.00010	0.00010	0.00007	0.00003	1.56	2	0	0	19	0.00005	0.00040	0.00016	0.00010	0.00012	0.00003	1.40	5	0	0
Dissolved Aluminum	0.1	mg/L	5	0.0035	0.1140	0.0532	0.0256	0.0552	0.0247	0.96	0	2	40	19	0.0079	0.1660	0.0373	0.0225	0.0394	0.0090	0.95	0	1	5
Dissolved Antimony	-	mg/L	5	0.00005	0.00007	0.00006	0.00006	0.00001	0.000003	8.42	0	0	0	19	0.00001	0.00005	0.00003	0.00003	0.00001	0.000002	3.13	1	0	0
Dissolved Arsenic	-	mg/L	5	0.00020	0.00034	0.00027	0.00025	0.00006	0.000028	4.37	0	0	0	19	0.00014	0.00029	0.00020	0.00020	0.00004	0.000009	4.89	0	0	0
Dissolved Barium	-	mg/L	5	0.0101	0.1040	0.0589	0.0586	0.0365	0.0163	1.61	0	0	0	19	0.0264	0.0687	0.0496	0.0495	0.0122	0.0028	4.07	0	0	0
Dissolved Beryllium	-	mg/L	5	0.000005	0.000013	0.000008	0.000005	0.000004	0.000002	2.05	3	0	0	19	0.000005	0.000020	0.000007	0.000005	0.000004	0.000001	1.58	15	0	0
Dissolved Bismuth	-	mg/L	5	0.0000025	0.0000025	0.0000025	0.0000025	0	-	-	5	0	0	19	0.0000025	0.0000025	0.0000025	0.0000025	0	-	-	19	0	0
Dissolved Boron	-	mg/L	5	0.025	0.025	0.025	0.025	0	-	-	5	0	0	19	0.025	0.025	0.025	0.025	0	-	-	19	0	0
Dissolved Cadmium	-	mg/L	5	0.000003	0.000019	0.000010	0.000010	0.000007	0.000003	1.51	1	0	0	19	0.000003	0.000024	0.000006	0.000003	0.000006	0.000001	1.04	11	0	0
Dissolved Calcium	-	mg/L	5	9.05	32.80	19.51	18.60	10.15	4.54	1.92	0	0	0	19	6.24	29.00	17.92	18.20	5.48	1.26	3.27	0	0	0
Dissolved Chromium	-	mg/L	5	0.00005	0.00020	0.00012	0.00010	0.00007	0.00003	1.64	2	0	0	19	0.00005	0.00050	0.00016	0.00010	0.00012	0.00003	1.33	5	0	0
Dissolved Cobalt	-	mg/L	5	0.000035	0.000061	0.000048	0.000047	0.000012	0.000005	4.15	0	0	0	19	0.000015	0.000129	0.000037	0.000030	0.000026	0.000006	1.42	0	0	0
Dissolved Copper	-	mg/L	5	0.0002	0.0017	0.0008	0.0007	0.0006	0.0003	1.36	0	0	0	19	0.0004	0.0019	0.0010	0.0009	0.0004	0.0001	2.35	0	0	0
Dissolved Iron	-	mg/L	5	0.013	0.122	0.060	0.058	0.039	0.018	1.53	0	0	0	19	0.004	0.213	0.041	0.024	0.049	0.011	0.84	0	0	0
Dissolved Lead	-	mg/L	5	0.000003	0.000124	0.000034	0.000015	0.000051	0.000023	0.67	1	0	0	19	0.000003	0.000133	0.000025	0.000010	0.000036	0.000008	0.70	6	0	0
Dissolved Lithium	-	mg/L	5	0.00108	0.00470	0.00266	0.00270	0.00152	0.00068	1.75	0	0	0	19	0.00058	0.00120	0.00094	0.00100	0.00019	0.00004	4.89	0	0	0
Dissolved Magnesium	-	mg/L	5	1.84	11.20	6.17	5.68	3.93	1.76	1.57	0	0	0	19	2.46	12.70	7.32	7.49	2.30	0.53	3.19	0	0	0
Dissolved Manganese	-	mg/L	5	0.0010	0.0704	0.0293	0.0120	0.0309	0.0138	0.95	0	0	0	19	0.0025	0.0107	0.0047	0.0046	0.0018	0.0004	2.61	0	0	0
Dissolved Mercury	-	mg/L	2	0.0000050	0.0000050	0.0000050	0.0000050	0	-	-	2	0	0	16	0.0000050	0.0000050	0.0000050	0.0000050	0	-	-	16	0	0
Dissolved Molybdenum	-	mg/L	5	0.00033	0.00049	0.00042	0.00042	0.00007	0.00003	5.68	0	0	0	19	0.00028	0.00101	0.00075	0.00077	0.00018	0.00004	4.23	0	0	0
Dissolved Nickel	-	mg/L	5	0.00019	0.00047	0.00028	0.00024	0.00011	0.00005	2.51	0	0	0	19	0.00020	0.00090	0.00041	0.00033	0.00017	0.00004	2.35	0	0	0
Dissolved Phosphorus	-	mg/L	2	0.0020	0.0090	0.0055	0.0055	0.0049	0.0035	1.11	0	0	0	16	0.0010	0.0099	0.0031	0.0030	0.0024	0.0006	1.29	6	0	0
Dissolved Potassium	-	mg/L	5	0.38	1.11	0.77	0.70	0.28	0.13	2.70	0	0	0	19	0.44	0.84	0.64	0.64	0.11	0.03	5.75	0	0	0
Dissolved Selenium	-	mg/L	5	0.00002	0.00004	0.00002	0.00002	0.00001	0.00000	2.68	4	0	0	19	0.00002	0.00012	0.00006	0.00006	0.00002	0.00001	2.65	1	0	0
Dissolved Silicon	-	mg/L	5	2.98	5.70	4.86	5.10	1.09	0.49	4.47	0	0	0	19	1.98	5.70	4.31	4.40	0.86	0.20	5.01	0	0	0
Dissolved Silver	-	mg/L	5	0.000003	0.000003	0.000003	0.000003	0	-	-	5	0	0	19	0.000003	0.000003	0.000003	0.000003	0	-	-	19	0	0
Dissolved Sodium	-	mg/L	5	1.57	5.01	3.08	2.82	1.42	0.64	2.17	0	0	0	19	0.96	4.90	3.00	3.01	0.88	0.20	3.42	0	0	0
Dissolved Strontium	-	mg/L	5	0.055	0.330	0.175	0.155	0.113	0.051	1.54	0	0	0	19	0.051	0.233	0.151	0.159	0.045	0.010	3.33	0	0	0
Dissolved Sulphur	-	mg/L	5	5.00	5.00	5.00	5.00	0	-	-	5	0	0	5	5.00	14.00	6.80	5.00	4.02	1.80	1.69	4	0	0
Dissolved Thallium	-	mg/L	5	0.0000010	0.0000030	0.0000014	0.0000010	0.0000009	0.0000004	1.57	4	0	0	19	0.0000010	0.0000010	0.0000010	0.0000010	0	-	-	19	0	0
Dissolved Tin	-	mg/L	5	0.000005	0.000100	0.000043	0.000005	0.000052	0.000023	0.83	5	0	0	19	0.000005	0.000100	0.000016	0.000005	0.000030	0.000007	0.53	18	0	0
Dissolved Titanium	-	mg/L	5	0.00025	0.00122	0.00051	0.00025	0.00042	0.00019	1.22	3	0	0	19	0.00025	0.00164	0.00044	0.00025	0.00038	0.00009	1.15	14	0	0
Dissolved Uranium	-	mg/L	5	0.00170	0.01460	0.00619	0.00398	0.00547	0.00244	1.13	0	0	0	19	0.00104	0.00601	0.00235	0.00219	0.00132	0.00030	1.79	0	0	0
Dissolved Vanadium	-	mg/L	5	0.00010	0.00060	0.00033	0.00030	0.00020	0.00009	1.66	1	0	0	19	0.00010	0.00063	0.00024	0.00020	0.00017	0.00004	1.42	9	0	0
Dissolved Zinc	-	mg/L	5	0.00040	0.00120	0.00084	0.00090	0.00037	0.00017	2.26	0	0	0	19	0.00010	0.00296	0.00056	0.00050	0.00062	0.00014	0.91	0	0	0
Dissolved Zirconium	-	mg/L	5	0.00005	0.00020	0.00011	0.00010	0.00007	0.00003	1.68	2	0	0	19	0.00005	0.00030	0.00015	0.00010	0.00008	0.00002	1.83	3	0	0

Note:

1) Canadian water quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2007
a) Ammonia (NH3) guideline based on ph=8 and temp=20
b) Aluminum (AL-T)= 0.005 mg/L at pH < 6.5: 0.1 mg/L at pH ≥ 6.5
c) Cadmium (Cd) mg/L: 10^(0.86*(log(hardness))-3.2)/1000
d) Copper (Cu) mg/L: (e^0.8545[ln(hardness)]-1.465)*0.2/1000; minimum is 0.002mg/L regardless of water hardness
e) Lead (Pb) mg/L: (e^1.273[ln(hardness)]-4.705)/1000; minimum is 0.001mg/L regardless of water hardness
f) Nickel (Ni) mg/L: (e^0.76[(ln(hardness)]+1.06)/1000; minimum is 0.025mg/L regardless of water hardness

Highlighted cells indicate updates from Project Proposal

"n"	Count
"min"	Minimum Value
"max"	Maximum Value
"sd"	Standard Deviation
"se"	Standard Error
"cov"	Covariance
"<DL"	# of Non-detectable Values
">GL"	# of Exceedances of CCME Gui
"%>GL"	% of Parameters that Exceed CCME Guidelin
"-"	No Data Available

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

Appendix B5. Surface Water Quality Statistics: All sites all parameters, Casino Project, 2008-2012

Parameters	CCME[1] Guideline	unit	W9										W5									
			n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL	n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL
pH	6.5 - 9.0	pH unit	27	7.20	8.30	7.78	7.80	0.22	0.04	35.72	0	0	0	22	7.30	8.20	7.81	7.87	0.22	0.05	35.74	0	0	0
Conductivity	-	µS/cm	27	65	265	176	172	62	12	2.81	0	0	0	22	68	305	189	194	70	15	2.72	0	0	0
Total Hardness CaCO3	-	mg/L	27	33	128	84	81	29	6	2.93	0	0	0	22	33	140	91	90	32	7	2.81	0	0	0
Dissolved Hardness CaCO3	-	mg/L	6	31	118	88	99	34	14	2.57	0	0	0	6	33	134	100	112	38	16	2.61	0	0	0
Ion Balance	-	no unit	4	0.88	1.00	0.96	0.98	0.05	0.03	17.73	0	0	0	4	0.91	1.10	1.00	0.99	0.08	0.04	12.54	0	0	0
Total Dissolved Solids	-	mg/L	27	56	180	110	110	30	6	3.66	0	0	0	22	68	180	120	115	30	6	4.04	0	0	0
Total Suspended Solids	-	mg/L	27	0.5	160.0	17.7	3.0	35.3	6.8	0.50	9	0	0	22	0.5	96.0	15.3	3.5	25.7	5.5	0.59	9	0	0
Turbidity	-	NTU	27	0.2	29.0	2.7	0.6	5.8	1.1	0.46	0	0	0	22	0.2	7.8	1.7	1.1	2.1	0.5	0.79	0	0	0
Ammonia as N	0.499[a]	mg/L	27	0.003	0.083	0.016	0.005	0.022	0.004	0.74	15	0	0	22	0.003	0.260	0.030	0.005	0.058	0.012	0.51	12	0	0
Alkalinity, Total (as CaCO3)	-	mg/L	27	22.0	113.0	74.73	74.0	26.95	5.19	2.77	0	0	0	22	24.0	115.0	73.28	74.5	26.66	5.68	2.75	0	0	0
Acidity (pH 4.5) as CaCO3	-	mg/L	6	0.25	0.25	0.25	0.25	0	-	-	6	0	0	6	0.25	0.25	0.25	0.25	0	-	-	6	0	0
Acidity (pH8.3) as CaCO3	-	mg/L	15	0.25	11.10	2.84	1.60	2.89	0.75	0.98	3	0	0	11	0.25	4.90	2.28	2.50	1.64	0.49	1.40	3	0	0
Bromide (Br)	-	mg/L	23	0.01	0.20	0.18	0.20	0.06	0.01	2.83	23	0	0	18	0.01	0.20	0.17	0.20	0.07	0.02	2.44	18	0	0
Chloride (Cl)	120	mg/L	27	0.25	1.60	0.59	0.50	0.42	0.08	1.42	13	0	0	22	0.25	2.50	0.68	0.65	0.52	0.11	1.31	9	0	0
Fluoride (F)	0.12	mg/L	23	0.041	0.060	0.053	0.050	0.005	0.001	9.78	0	0	0	18	0.040	0.070	0.059	0.060	0.008	0.002	7.76	0	0	0
Sulphate (SO4)	-	mg/L	27	0.25	33.00	14.62	15.00	7.88	1.52	1.86	2	0	0	22	0.25	45.00	22.05	23.50	11.26	2.40	1.96	2	0	0
Total Nitrogen (N)	-	mg/L	6	0.16	0.61	0.40	0.41	0.15	0.06	2.72	0	0	0	6	0.16	0.56	0.36	0.37	0.13	0.05	2.89	0	0	0
Nitrate (as N)	13	mg/L	27	0.016	0.317	0.137	0.130	0.092	0.018	1.49	0	0	0	22	0.006	0.300	0.142	0.143	0.085	0.018	1.67	0	0	0
Nitrate plus Nitrite (N)	-	mg/L	6	0.037	0.317	0.197	0.198	0.105	0.043	1.88	0	0	0	6	0.046	0.300	0.191	0.186	0.096	0.039	2.00	0	0	0
Nitrite (as N)	0.06	mg/L	27	0.001	0.005	0.002	0.001	0.001	0.000	1.52	20	0	0	22	0.001	0.004	0.001	0.001	0.001	0.000	1.81	17	0	0
Total Kjeldahl Nitrogen	-	mg/L	26	0.01	0.58	0.20	0.16500	0.1266	0.0248	1.54	1	0	0	21	0.02	0.51	0.21	0.18000	0.1369	0.0299	1.53	0	0	0
Ortho Phosphate as P	-	mg/L	27	0.0005	0.0070	0.0019	0.0020	0.0014	0.0003	1.35	4	0	0	22	0.0005	0.0030	0.0017	0.0020	0.0008	0.0002	2.17	5	0	0
Cyanide, Total	0.005	mg/L	27	0.00025	0.00130	0.00053	0.00025	0.00037	0.00007	1.44	15	0	0	22	0.00025	0.00150	0.00054	0.00025	0.00037	0.00008	1.45	12	0	0
Cyanide, Weak Acid Diss	-	mg/L	27	0.00025	0.00110	0.00045	0.00025	0.00028	0.00005	1.60	17	0	0	22	0.00025	0.00130	0.00045	0.00025	0.00029	0.00006	1.57	13	0	0
Dissolved Organic Carbon	-	mg/L	14	2.62	14.10	6.64	5.15	3.58	0.96	1.85	0	0	0	10	2.50	14.10	6.71	5.65	3.95	1.25	1.70	0	0	0
Total Organic Carbon	-	mg/L	23	2.92	17.30	6.94	5.20	3.84	0.80	1.81	0	0	0	18	2.70	16.40	6.83	5.45	4.18	0.99	1.63	0	0	0
Total Aluminum	0.1[b]	mg/L	27	0.0073	0.7770	0.1439	0.0349	0.2047	0.0394	0.70	0	11	41	22	0.0105	0.5690	0.1452	0.0368	0.1751	0.0373	0.83	0	9	41
Total Antimony	-	mg/L	27	0.0000500	0.0001200	0.0000777	0.0000800	0.0000140	0.0000027	5.56	0	0	0	22	0.0000700	0.0001400	0.0000967	0.0001000	0.0000162	0.0000035	5.97	0	0	0
Total Arsenic	0.005	mg/L	27	0.0001900	0.0014100	0.0004153	0.0003100	0.0002778	0.0000535	1.50	0	0	0	22	0.0002600	0.0010600	0.0004545	0.0003550	0.0002148	0.0000458	2.12	0	0	0
Total Barium	-	mg/L	27	0.04	0.09	0.06	0.05260	0.0142	0.0027	4.14	0	0	0	22	0.04	0.09	0.06	0.05315	0.0134	0.0029	4.27	0	0	0
Total Beryllium	-	mg/L	27	0.0000050	0.0000700	0.0000160	0.0000050	0.0000178	0.0000034	0.90	15	0	0	22	0.0000050	0.0000500	0.0000148	0.0000050	0.0000143	0.0000031	1.03	12	0	0
Total Bismuth	-	mg/L	27	0.0000025	0.0000120	0.0000041	0.0000025	0.0000029	0.0000006	1.42	19	0	0	22	0.0000025	0.0000123	0.0000039	0.0000025	0.0000026	0.0000006	1.47	16	0	0
Total Boron	1.5	mg/L	27	0.03	0.03	0.03	0.02500	0	-	-	27	0	0	22	0.03	0.03	0.03	0.02500	0	-	-	22	0	0
Total Cadmium	0.000032 [c]	mg/L	27	0.000003	0.000057	0.000016	0.000012	0.000016	0.000003	0.96	7	4	15	22	0.000003	0.000101	0.000024	0.000017	0.000023	0.000005	1.05	2	7	32
Total Calcium	-	mg/L	27	8.38	32.00	21.62	21.20	7.28	1.40	2.97	0	0	0	22	8.44	36.10	23.67	23.65	8.32	1.77	2.85	0	0	0
Total Chromium	0.001	mg/L	27	0.00005	0.00100	0.00025	0.00010	0.00026	0.00005	0.96	9	0	0	22	0.00005	0.00079	0.00025	0.00015	0.00024	0.00005	1.04	9	0	0
Total Cobalt	-	mg/L	27	0.000016	0.000825	0.000157	0.000071	0.000198	0.000038	0.79	0	0	0	22	0.000029	0.000645	0.000166	0.000093	0.000171	0.000036	0.97	0	0	0
Total Copper	0.0023[d]	mg/L	27	0.0005	0.0053	0.0014	0.0009	0.0010	0.0002	1.33	0	4	15	22	0.0008	0.0093	0.0032	0.0023	0.0025	0.0005	1.31	0	12	55
Total Iron	0.3	mg/L	27	0.008	1.440	0.267	0.084	0.364	0.070	0.73	0	7	26	22	0.039	0.973	0.252	0.089	0.278	0.059	0.91	0	7	32
Total Lead	0.003[e]	mg/L	27	0.000012	0.002130	0.000281	0.000084	0.000479	0.000092	0.59	0	1	4	22	0.000018	0.004120	0.000573	0.000124	0.001033	0.000220	0.55	0	3	14
Total Lithium	-	mg/L	27	0.00145	0.00310	0.00231	0.00230	0.00045	0.00009	5.18	0	0	0	22	0.00130	0.00250	0.00186	0.00190	0.00031	0.00007	6.03	0	0	0
Total Magnesium	-	mg/L	27	2.83	12.60	7.41	6.96	2.64	0.51	2.81	0	0	0	22	2.77	12.90	7.72	7.52	2.88	0.61	2.69	0	0	0
Total Manganese	-	mg/L	27	0.0025	0.1070	0.0307	0.0220	0.0243	0.0047	1.26	0	0	0	22	0.0104	0.0785	0.0287	0.0247	0.0186	0.0040	1.55	0	0	0
Total Mercury	0.000026	mg/L	23	0.0000050	0.0000050	0.0000050	0.0000050	0	-	-	23	0	0	19	0.0000050	0.0000100	0.0000053	0.0000050	0.0000011	0.0000003	4.59	18	0	0
Total Molybdenum	0.073	mg/L	27	0.00028	0.00081	0.00059	0.00059	0.00014	0.00003	4.28	0	0	0	22	0.00040	0.00099	0.00075	0.00081	0.00017	0.00004	4.53	0	0	0
Total Nickel	0.0033[f]	mg/L	27	0.00022	0.00210	0.00055	0.00034	0.00044	0.00009	1.25	0	0	0	22	0.00020	0.00122	0.00050	0.00032	0.00033	0.00007	1.52	0	0	0
Total Phosphorus	-	mg/L	24	0.0020	0.1260	0.0190	0.0055	0.0293	0.0060	0.65	0	0	0	19	0.0010	0.0530	0.0147	0.0090	0.0176	0.0040	0.84	2	0	0
Total Potassium	-	mg/L	27	0.51	1.30	0.76	0.71	0.20	0.04	3.87	0	0	0	22	0.57	1.37	0.84	0.77	0.22	0.05	3.75	0	0	0
Total Selenium	0.001	mg/L	27	0.00002	0.00007	0.00004	0.00004	0.00002	0.00000	2.14	12	0	0	22	0.00002	0.00009	0.00005	0.00005	0.00002	0.00000	3.02	3	0	0
Total Silicon	-	mg/L	27	2.58	5.60	4.73	5.00	0.81	0.16	5.83	0	0	0	22	2.63	5.90	4.81	5.15	0.86	0.18	5.61	0	0	0

Note:

1) Canadian water quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2007
a) Ammonia (NH3) guideline based on ph=8 and temp=20
b) Aluminum (AL-T)= 0.005 mg/L at pH < 6.5: 0.1 mg/L at pH ≥ 6.5
c) Cadmium (Cd) mg/L: 10^(0.86*(log(hardness))-3.2)/1000
d) Copper (Cu) mg/L: (e^0.8545[ln(hardness)]-1.465)*0.2/1000; minimum is 0.002mg/L regardless of water hardness
e) Lead (Pb) mg/L: (e^1.273[ln(hardness)]-4.705)/1000; minimum is 0.001mg/L regardless of water hardness
f) Nickel (Ni) mg/L: (e^0.76[(ln(hardness)]+1.06)/1000; minimum is 0.025mg/L regardless of water hardness

Highlighted cells indicate updates from Project Proposal

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PALMER ENVIRONMENTAL CONSULTING GROUP INC.

Appendix B5. Surface Water Quality Statistics: All sites all parameters, Casino Project, 2008-2012

Parameters	CCME[1] Guideline	unit	W9											W5									
			n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL	n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL
Total Silver	0.0001	mg/L	27	0.000003	0.000010	0.000003	0.000003	0.000002	0.000000	1.65	23	0	0	22	0.000003	0.000023	0.000005	0.000003	0.000005	0.000001	0.97	16	0	0
Total Sodium	-	mg/L	27	1.31	5.86	3.71	3.64	1.23	0.24	3.02	0	0	0	22	1.25	5.85	3.71	3.74	1.25	0.27	2.96	0	0	0
Total Strontium	-	mg/L	27	0.069	0.263	0.175	0.170	0.059	0.011	2.95	0	0	0	22	0.068	0.281	0.171	0.174	0.061	0.013	2.83	0	0	0
Total Sulphur	-	mg/L	6	5.00	5.00	5.00	5.00	0	-	-	6	0	0	6	5.00	14.00	10.00	11.50	4.10	1.67	2.44	2	0	0
Total Thallium	0.0008	mg/L	27	0.0000010	0.0000080	0.0000026	0.0000010	0.0000024	0.0000005	1.09	15	0	0	22	0.0000010	0.0000104	0.0000031	0.0000020	0.0000028	0.0000006	1.11	10	0	0
Total Tin	-	mg/L	27	0.000005	0.000100	0.000012	0.000005	0.000025	0.000005	0.47	27	0	0	22	0.000005	0.000200	0.000021	0.000005	0.000046	0.000010	0.45	20	0	0
Total Titanium	-	mg/L	27	0.00025	0.02710	0.00547	0.00150	0.00782	0.00151	0.70	10	0	0	22	0.00025	0.02190	0.00506	0.00170	0.00672	0.00143	0.75	8	0	0
Total Uranium	0.015	mg/L	27	0.00232	0.01140	0.00576	0.00529	0.00261	0.00050	2.21	0	0	0	22	0.00234	0.01320	0.00607	0.00556	0.00320	0.00068	1.89	0	0	0
Total Vanadium	-	mg/L	27	0.00010	0.00500	0.00078	0.00030	0.00108	0.00021	0.73	8	0	0	22	0.00010	0.00216	0.00068	0.00035	0.00067	0.00014	1.02	5	0	0
Total Zinc	0.03	mg/L	27	0.00030	0.00600	0.00141	0.00070	0.00150	0.00029	0.94	0	0	0	22	0.00030	0.00734	0.00201	0.00120	0.00188	0.00040	1.07	0	0	0
Total Zirconium	-	mg/L	27	0.00005	0.00080	0.00022	0.00020	0.00017	0.00003	1.26	5	0	0	22	0.00005	0.00050	0.00020	0.00020	0.00014	0.00003	1.44	6	0	0
Dissolved Aluminum	0.1	mg/L	27	0.0065	0.1820	0.0431	0.0239	0.0448	0.0086	0.96	0	4	15	22	0.0068	0.3550	0.0600	0.0206	0.0826	0.0176	0.73	0	5	23
Dissolved Antimony	-	mg/L	27	0.00005	0.00012	0.00007	0.00007	0.00002	0.000003	4.77	1	0	0	22	0.00006	0.00012	0.00009	0.00009	0.00002	0.000003	5.82	0	0	0
Dissolved Arsenic	-	mg/L	27	0.00019	0.00055	0.00030	0.00031	0.00008	0.000015	3.81	0	0	0	22	0.00022	0.00052	0.00033	0.00033	0.00007	0.000014	5.02	0	0	0
Dissolved Barium	-	mg/L	27	0.028	0.087	0.055	0.050	0.018	0.003	3.07	0	0	0	22	0.029	0.089	0.054	0.050	0.016	0.003	3.31	0	0	0
Dissolved Beryllium	-	mg/L	27	0.000005	0.000030	0.000010	0.000005	0.000008	0.000001	1.30	18	0	0	22	0.000005	0.000030	0.000009	0.000005	0.000006	0.000001	1.39	13	0	0
Dissolved Bismuth	-	mg/L	27	0.0000025	0.0000150	0.0000030	0.0000025	0.0000024	0.0000005	1.23	27	0	0	22	0.0000025	0.0000080	0.0000028	0.0000025	0.0000012	0.0000003	2.35	21	0	0
Dissolved Boron	-	mg/L	27	0.025	0.150	0.030	0.025	0.024	0.005	1.23	27	0	0	22	0.025	0.025	0.025	0.025	0	-	-	22	0	0
Dissolved Cadmium	-	mg/L	27	0.000003	0.000016	0.000007	0.000006	0.000005	0.000001	1.47	11	0	0	22	0.000003	0.000042	0.000013	0.000011	0.000009	0.000002	1.44	2	0	0
Dissolved Calcium	-	mg/L	27	7.81	34.10	21.37	20.20	7.36	1.42	2.90	0	0	0	22	8.82	35.00	23.09	23.00	7.78	1.66	2.97	0	0	0
Dissolved Chromium	-	mg/L	27	0.00005	0.00030	0.00014	0.00010	0.00009	0.00002	1.59	10	0	0	22	0.00005	0.00030	0.00015	0.00010	0.00011	0.00002	1.39	10	0	0
Dissolved Cobalt	-	mg/L	27	0.000017	0.000110	0.000054	0.000048	0.000024	0.000005	2.25	0	0	0	22	0.000037	0.000362	0.000071	0.000052	0.000068	0.000015	1.04	0	0	0
Dissolved Copper	-	mg/L	27	0.0005	0.0019	0.0010	0.0009	0.0004	0.0001	2.44	0	0	0	22	0.0007	0.0080	0.0025	0.0019	0.0017	0.0004	1.45	0	0	0
Dissolved Iron	-	mg/L	27	0.006	0.220	0.079	0.044	0.063	0.012	1.26	0	0	0	22	0.013	0.581	0.094	0.042	0.120	0.026	0.78	0	0	0
Dissolved Lead	-	mg/L	27	0.000003	0.000172	0.000042	0.000021	0.000046	0.000009	0.91	4	0	0	22	0.000003	0.000760	0.000079	0.000032	0.000161	0.000034	0.49	3	0	0
Dissolved Lithium	-	mg/L	27	0.00120	0.00310	0.00221	0.00210	0.00049	0.00009	4.52	0	0	0	22	0.00092	0.00250	0.00178	0.00185	0.00037	0.00008	4.77	0	0	0
Dissolved Magnesium	-	mg/L	27	2.75	12.80	7.32	6.81	2.63	0.51	2.78	0	0	0	22	2.77	12.80	7.64	7.27	2.79	0.60	2.74	0	0	0
Dissolved Manganese	-	mg/L	27	0.0015	0.0486	0.0175	0.0122	0.0128	0.0025	1.36	0	0	0	22	0.0014	0.0410	0.0161	0.0117	0.0100	0.0021	1.61	0	0	0
Dissolved Mercury	-	mg/L	23	0.0000050	0.0000250	0.0000059	0.0000050	0.0000042	0.0000009	1.41	23	0	0	18	0.0000050	0.0000050	0.0000050	0.0000050	0	-	-	18	0	0
Dissolved Molybdenum	-	mg/L	27	0.00029	0.00084	0.00062	0.00061	0.00014	0.00003	4.49	0	0	0	22	0.00033	0.00099	0.00076	0.00082	0.00017	0.00004	4.36	0	0	0
Dissolved Nickel	-	mg/L	27	0.00022	0.00073	0.00041	0.00037	0.00017	0.00003	2.39	0	0	0	22	0.00020	0.00087	0.00040	0.00033	0.00019	0.00004	2.06	0	0	0
Dissolved Phosphorus	-	mg/L	23	0.0010	0.0120	0.0042	0.0040	0.0027	0.0006	1.54	4	0	0	18	0.0010	0.0170	0.0048	0.0035	0.0045	0.0011	1.06	4	0	0
Dissolved Potassium	-	mg/L	27	0.50	1.27	0.75	0.71	0.20	0.04	3.78	0	0	0	22	0.55	1.34	0.83	0.77	0.21	0.05	3.93	0	0	0
Dissolved Selenium	-	mg/L	27	0.00002	0.00010	0.00004	0.00004	0.00002	0.00000	1.85	14	0	0	22	0.00002	0.00007	0.00005	0.00005	0.00001	0.00000	3.89	2	0	0
Dissolved Silicon	-	mg/L	27	2.22	6.20	4.54	4.70	0.83	0.16	5.44	0	0	0	22	2.34	5.70	4.67	4.90	0.87	0.19	5.35	0	0	0
Dissolved Silver	-	mg/L	27	0.000003	0.000015	0.000003	0.000003	0.000002	0.000000	1.23	27	0	0	22	0.000003	0.000009	0.000003	0.000003	0.000002	0.000000	1.73	19	0	0
Dissolved Sodium	-	mg/L	27	1.34	5.90	3.71	3.49	1.23	0.24	3.01	0	0	0	22	1.34	5.90	3.67	3.59	1.21	0.26	3.04	0	0	0
Dissolved Strontium	-	mg/L	27	0.066	0.270	0.175	0.172	0.062	0.012	2.83	0	0	0	22	0.065	0.270	0.171	0.176	0.060	0.013	2.87	0	0	0
Dissolved Sulphur	-	mg/L	6	5.00	5.00	5.00	5.00	0	-	-	6	0	0	6	5.00	13.00	9.50	11.00	3.56	1.45	2.67	2	0	0
Dissolved Thallium	-	mg/L	27	0.0000010	0.0000050	0.0000013	0.0000010	0.0000009	0.0000002	1.47	24	0	0	22	0.0000010	0.0000070	0.0000017	0.0000010	0.0000014	0.0000003	1.22	14	0	0
Dissolved Tin	-	mg/L	27	0.000005	0.000100	0.000013	0.000005	0.000025	0.000005	0.50	27	0	0	22	0.000005	0.000100	0.000021	0.000005	0.000034	0.000007	0.60	19	0	0
Dissolved Titanium	-	mg/L	27	0.00025	0.00230	0.00063	0.00025	0.00059	0.00011	1.07	18	0	0	21	0.00025	0.00220	0.00063	0.00025	0.00065	0.00014	0.98	14	0	0
Dissolved Uranium	-	mg/L	27	0.00161	0.01190	0.00561	0.00543	0.00280	0.00054	2.01	0	0	0	22	0.00163	0.01300	0.00595	0.00567	0.00327	0.00070	1.82	0	0	0
Dissolved Vanadium	-	mg/L	27	0.00010	0.00080	0.00032	0.00030	0.00020	0.00004	1.60	8	0	0	22	0.00010	0.00140	0.00036	0.00030	0.00030	0.00006	1.17	6	0	0
Dissolved Zinc	-	mg/L	27	0.00010	0.00590	0.00105	0.00050	0.00153	0.00029	0.69	0	0	0	22	0.00040	0.00530	0.00148	0.00070	0.00157	0.00034	0.94	0	0	0
Dissolved Zirconium	-	mg/L	27	0.00005	0.00040	0.00017	0.00020	0.00009	0.00002	1.89	4	0	0	22	0.00005	0.00040	0.00017	0.00020	0.00010	0.00002	1.73	4	0	0

Note:

1) Canadian water quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2007
a) Ammonia (NH3) guideline based on ph=8 and temp=20
b) Aluminum (AL-T)= 0.005 mg/L at pH < 6.5: 0.1 mg/L at pH ≥ 6.5
c) Cadmium (Cd) mg/L: 10^(0.86*(log(hardness))-3.2)/1000
d) Copper (Cu) mg/L: (e^0.8545[ln(hardness)]-1.465)*0.2/1000; minimum is 0.002mg/L regardless of water hardness
e) Lead (Pb) mg/L: (e^1.273[ln(hardness)]-4.705)/1000; minimum is 0.001mg/L regardless of water hardness
f) Nickel (Ni) mg/L: (e^0.76[(ln(hardness)]+1.06)/1000; minimum is 0.025mg/L regardless of water hardness
Highlighted cells indicate updates from Project Proposal

"n"	Count
"min"	Minimum Value
"max"	Maximum Value
"sd"	Standard Deviation
"se"	Standard Error
"cov"	Covariance
"<DL"	# of Non-detectable Values
">GL"	# of Exceedances of CCME Gui
"%>GL"	% of Parameters that Exceed CCME Guidelin
"-"	No Data Available

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

Appendix B5. Surface Water Quality Statistics: All sites all parameters, Casino Project, 2008-2012

Parameters	CCME[1] Guideline	unit	W16										W19										
			n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL	n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL
pH	6.5 - 9.0	pH unit	22	7.40	8.30	7.83	7.90	0.20	0.04	39.62	0	0	0	5	7.48	7.91	7.72	7.79	0.18	0.08	42.47	0	0	0
Conductivity	-	µS/cm	22	108	327	200	190	60	13	3.35	0	0	0	5	101	248	171	174	66	30	2.58	0	0	0
Total Hardness CaCO3	-	mg/L	22	57	154	96	93	28	6	3.39	0	0	0	5	53	105	80	80	25	11	3.12	0	0	0
Dissolved Hardness CaCO3	-	mg/L	5	54	136	102	112	35	16	2.93	0	0	0	5	50	105	78	78	27	12	2.92	0	0	0
Moisture	-	%	1	20	20	20	20	0	-	-	0	0	0	-	-	-	-	-	-	-	-	-	-	-
Ion Balance	-	no unit	3	0.94	1.10	1.01	1.00	0.08	0.05	12.54	0	0	0	3	0.95	1.00	0.98	1.00	0.03	0.02	34.06	0	0	0
Total Dissolved Solids	-	mg/L	22	92	180	135	140	25	5	5.37	0	0	0	5	84	158	122	130	30	13	4.07	0	0	0
Total Suspended Solids	-	mg/L	22	0.5	74.0	11.4	3.5	17.4	3.7	0.65	4	0	0	5	1.1	123.0	41.2	12.0	53.4	23.9	0.77	0	0	0
Turbidity	-	NTU	22	0.3	12.6	2.7	0.9	3.6	0.8	0.75	0	0	0	5	1.1	16.5	8.7	5.4	6.8	3.0	1.28	0	0	0
Ammonia as N	0.499[a]	mg/L	22	0.003	0.260	0.029	0.016	0.054	0.011	0.54	9	0	0	5	0.014	0.059	0.031	0.027	0.018	0.008	1.72	0	0	0
Alkalinity, Total (as CaCO3)	-	mg/L	22	38.0	120.0	74.41	71.5	23.13	4.93	3.22	0	0	0	5	34.0	92.7	65.04	67.0	25.27	11.30	2.57	0	0	0
Acidity (pH 4.5) as CaCO3	-	mg/L	5	0.25	0.25	0.25	0.25	0	-	-	5	0	0	5	0.25	0.25	0.25	0.25	0	-	-	5	0	0
Acidity (pH8.3) as CaCO3	-	mg/L	12	0.25	6.00	1.55	0.90	1.75	0.51	0.88	5	0	0	5	0.25	12.10	3.19	1.60	5.03	2.25	0.63	2	0	0
Bromide (Br)	-	mg/L	19	0.05	0.20	0.19	0.20	0.03	0.01	5.58	19	0	0	5	0.01	0.20	0.12	0.20	0.11	0.05	1.14	5	0	0
Chloride (Cl)	120	mg/L	22	0.25	5.00	0.77	0.43	1.03	0.22	0.74	11	0	0	5	0.25	0.90	0.51	0.25	0.36	0.16	1.43	3	0	0
Fluoride (F)	0.12	mg/L	19	0.050	0.080	0.061	0.060	0.008	0.002	7.14	0	0	0	5	0.059	0.070	0.063	0.060	0.005	0.002	13.73	0	0	0
Sulphate (SO4)	-	mg/L	22	15.00	62.00	28.16	28.00	10.92	2.33	2.58	0	0	0	5	12.00	31.00	20.10	20.00	8.16	3.65	2.46	0	0	0
Total Nitrogen (N)	-	mg/L	5	0.15	0.51	0.35	0.38	0.14	0.06	2.48	0	0	0	5	0.19	0.74	0.41	0.31	0.22	0.10	1.89	0	0	0
Nitrate (as N)	13	mg/L	22	0.001	0.274	0.104	0.089	0.077	0.016	1.35	1	0	0	5	0.036	0.104	0.071	0.081	0.029	0.013	2.41	0	0	0
Nitrate plus Nitrite (N)	-	mg/L	5	0.054	0.274	0.153	0.145	0.080	0.036	1.91	0	0	0	5	0.039	0.106	0.072	0.081	0.029	0.013	2.53	0	0	0
Nitrite (as N)	0.06	mg/L	22	0.001	0.008	0.002	0.001	0.002	0.000	1.19	12	0	0	5	0.001	0.003	0.002	0.002	0.001	0.000	2.16	2	0	0
Total Kjeldahl Nitrogen	-	mg/L	21	0.01	4.00	0.41	0.20000	0.8328	0.1817	0.49	1	0	0	5	0.08	0.69	0.34	0.22800	0.2412	0.1079	1.39	0	0	0
Ortho Phosphate as P	-	mg/L	22	0.0005	0.0110	0.0021	0.0020	0.0021	0.0005	0.99	3	0	0	5	0.0019	0.0110	0.0050	0.0050	0.0037	0.0017	1.35	0	0	0
Cyanide, Total	0.005	mg/L	22	0.00025	0.00170	0.00056	0.00025	0.00043	0.00009	1.30	12	0	0	5	0.00025	0.00055	0.00031	0.00025	0.00013	0.00006	2.31	4	0	0
Cyanide, Weak Acid Diss	-	mg/L	22	0.00025	0.00120	0.00055	0.00050	0.00033	0.00007	1.67	10	0	0	5	0.00025	0.00110	0.00049	0.00025	0.00037	0.00017	1.32	3	0	0
Dissolved Organic Carbon	-	mg/L	11	3.50	15.50	8.36	7.70	3.78	1.14	2.21	0	0	0	5	5.44	17.80	10.89	10.20	5.21	2.33	2.09	0	0	0
Total Organic Carbon	-	mg/L	18	3.60	15.50	8.20	7.20	3.58	0.84	2.29	0	0	0	5	5.58	17.80	11.42	11.10	5.41	2.42	2.11	0	0	0
Total Aluminum	0.1[b]	mg/L	22	0.0102	0.4670	0.1418	0.0828	0.1422	0.0303	1.00	0	10	45	5	0.0111	0.7810	0.3424	0.2260	0.3500	0.1565	0.98	0	3	60
Total Antimony	-	mg/L	22	0.000060	0.000160	0.000093	0.000090	0.000019	0.000004	4.81	0	0	0	5	0.000050	0.000090	0.000077	0.000080	0.000016	0.000007	4.89	0	0	0
Total Arsenic	0.005	mg/L	22	0.000310	0.001230	0.000586	0.000535	0.000217	0.000046	2.69	0	0	0	5	0.000900	0.002300	0.001330	0.001120	0.000578	0.000258	2.30	0	0	0
Total Barium	-	mg/L	22	0.04	0.08	0.06	0.05390	0.0124	0.0026	4.59	0	0	0	5	0.05	0.09	0.06	0.06420	0.0160	0.0072	4.02	0	0	0
Total Beryllium	-	mg/L	22	0.0000050	0.0000400	0.0000132	0.0000100	0.0000108	0.0000023	1.23	10	0	0	5	0.0000050	0.0000520	0.0000274	0.0000200	0.0000222	0.0000099	1.23	1	0	0
Total Bismuth	-	mg/L	22	0.0000025	0.0000100	0.0000035	0.0000025	0.0000021	0.0000005	1.66	17	0	0	5	0.0000025	0.0000103	0.0000056	0.0000025	0.0000042	0.0000019	1.33	3	0	0
Total Boron	1.5	mg/L	22	0.03	0.03	0.03	0.02500	0	-	-	22	0	0	5	0.03	0.03	0.03	0.02500	0	-	-	5	0	0
Total Cadmium	0.000032 [c]	mg/L	22	0.000003	0.000073	0.000021	0.000017	0.000017	0.000004	1.21	2	4	18	5	0.000013	0.000091	0.000036	0.000018	0.000033	0.000015	1.09	0	2	40
Total Calcium	-	mg/L	22	14.20	36.40	23.86	23.95	6.88	1.47	3.47	0	0	0	5	13.10	25.90	19.90	20.70	5.99	2.68	3.32	0	0	0
Total Chromium	0.001	mg/L	22	0.00005	0.00070	0.00031	0.00025	0.00023	0.00005	1.35	3	0	0	5	0.00010	0.00120	0.00065	0.00060	0.00052	0.00023	1.26	0	2	40
Total Cobalt	-	mg/L	22	0.000063	0.000575	0.000191	0.000131	0.000142	0.000030	1.35	0	0	0	5	0.000207	0.001000	0.000514	0.000411	0.000327	0.000146	1.57	0	0	0
Total Copper	0.0023[d]	mg/L	22	0.0008	0.0089	0.0028	0.0022	0.0019	0.0004	1.48	0	10	45	5	0.0008	0.0083	0.0038	0.0031	0.0030	0.0013	1.26	0	3	60
Total Iron	0.3	mg/L	22	0.078	1.090	0.353	0.265	0.266	0.057	1.33	0	10	45	5	0.748	2.680	1.377	1.210	0.794	0.355	1.73	0	5	100
Total Lead	0.003[e]	mg/L	22	0.000015	0.003010	0.000363	0.000128	0.000652	0.000139	0.56	0	1	5	5	0.000015	0.002220	0.000741	0.000375	0.000918	0.000411	0.81	0	1	20
Total Lithium	-	mg/L	22	0.00110	0.00190	0.00140	0.00140	0.00017	0.00004	8.47	0	0	0	5	0.00060	0.00130	0.00107	0.00110	0.00028	0.00012	3.84	0	0	0
Total Magnesium	-	mg/L	22	5.15	15.40	8.72	8.17	2.75	0.59	3.17	0	0	0	5	4.71	10.10	7.29	7.01	2.57	1.15	2.84	0	0	0
Total Manganese	-	mg/L	22	0.0204	0.1330	0.0410	0.0329	0.0240	0.0051	1.70	0	0	0	5	0.0474	0.2750	0.1428	0.0965	0.0976	0.0437	1.46	0	0	0
Total Mercury	0.000026	mg/L	19	0.0000050	0.0000050	0.0000050	0.0000050	0	-	-	19	0	0	4	0.0000050	0.0000050	0.0000050	0.0000050	0	-	-	4	0	0
Total Molybdenum	0.073	mg/L	22	0.00049	0.00104	0.00079	0.00083	0.00017	0.00004	4.53	0	0	0	5	0.00048	0.00101	0.00069	0.00065	0.00021	0.00009	3.32	0	0	0
Total Nickel	0.0033[f]	mg/L	22	0.00032	0.00151	0.00075	0.00065	0.00038	0.00008	1.97	0	0	0	5	0.00060	0.00207	0.00124	0.00105	0.00068	0.00030	1.83	0	0	0
Total Phosphorus	-	mg/L	19	0.0030	0.0520	0.0133	0.0090	0.0119	0.0027	1.11	0	0	0	4	0.0120	0.0817	0.0409	0.0350	0.0324	0.0162	1.26	0	0	0
Total Potassium	-	mg/L	22	0.60	1.52	0.90	0.86	0.23	0.05	3.89	0	0	0	5	0.65	1.22	0.91	0.82	0.23	0.10	4.01	0	0	0
Total Selenium	0.001	mg/L	22	0.00002	0.00009	0.00006	0.00006	0.00002	0.00000	3.11	2	0	0	5	0.00002	0.00010	0.00006	0.00006	0.00003	0.00001	2.03	1	0	0

Note:

1) Canadian water quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2007
a) Ammonia (NH3) guideline based on ph=8 and temp=20
b) Aluminum (AL-T)= 0.005 mg/L at pH < 6.5: 0.1 mg/L at pH ≥ 6.5
c) Cadmium (Cd) mg/L: 10^(0.86*(log(hardness))-3.2)/1000
d) Copper (Cu) mg/L: (e^0.8545[ln(hardness)]-1.465)*0.2/1000; minimum is 0.002mg/L regardless of water hardness
e) Lead (Pb) mg/L: (e^1.273[ln(hardness)]-4.705)/1000; minimum is 0.001mg/L regardless of water hardness
f) Nickel (Ni) mg/L: (e^0.76[(ln(hardness)]+1.06)/1000; minimum is 0.025mg/L regardless of water hardness
Highlighted cells indicate updates from Project Proposal

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PALMER ENVIRONMENTAL CONSULTING GROUP INC.

Appendix B5. Surface Water Quality Statistics: All sites all parameters, Casino Project, 2008-2012

Parameters	CCME[1] Guideline	unit	W16											W19									
			n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL	n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL
Total Silicon	-	mg/L	22	3.50	5.70	4.64	4.65	0.67	0.14	6.94	0	0	0	5	3.80	5.40	4.68	4.80	0.64	0.29	7.34	0	0	0
Total Silver	0.0001	mg/L	22	0.000003	0.000010	0.000003	0.000003	0.000002	0.000000	1.57	19	0	0	5	0.000003	0.000023	0.000009	0.000007	0.000008	0.000004	1.04	2	0	0
Total Sodium	-	mg/L	22	2.30	6.72	3.95	3.79	1.18	0.25	3.34	0	0	0	5	2.19	5.19	3.71	3.76	1.44	0.64	2.58	0	0	0
Total Strontium	-	mg/L	22	0.091	0.245	0.161	0.151	0.047	0.010	3.41	0	0	0	5	0.082	0.190	0.136	0.135	0.049	0.022	2.75	0	0	0
Total Sulphur	-	mg/L	5	5.00	18.00	10.40	11.00	5.55	2.48	1.87	2	0	0	5	5.00	12.00	7.60	5.00	3.58	1.60	2.12	3	0	0
Total Thallium	0.0008	mg/L	22	0.0000010	0.0000090	0.0000025	0.0000010	0.0000022	0.0000005	1.14	12	0	0	5	0.0000010	0.0000090	0.0000045	0.0000030	0.0000039	0.0000018	1.14	2	0	0
Total Tin	-	mg/L	22	0.000005	0.000005	0.000005	0.000005	0	-	-	22	0	0	5	0.000005	0.000100	0.000043	0.000005	0.000052	0.000023	0.83	5	0	0
Total Titanium	-	mg/L	22	0.00025	0.01830	0.00499	0.00260	0.00557	0.00119	0.90	4	0	0	5	0.00025	0.02800	0.01325	0.01080	0.01277	0.00571	1.04	1	0	0
Total Uranium	0.015	mg/L	22	0.00178	0.00971	0.00456	0.00438	0.00224	0.00048	2.03	0	0	0	5	0.00161	0.00580	0.00315	0.00265	0.00162	0.00072	1.95	0	0	0
Total Vanadium	-	mg/L	22	0.00010	0.00250	0.00090	0.00070	0.00074	0.00016	1.23	3	0	0	5	0.00060	0.00437	0.00221	0.00160	0.00160	0.00072	1.38	0	0	0
Total Zinc	0.03	mg/L	22	0.00040	0.00580	0.00171	0.00125	0.00140	0.00030	1.22	0	0	0	5	0.00050	0.00640	0.00300	0.00290	0.00260	0.00116	1.16	0	0	0
Total Zirconium	-	mg/L	22	0.00005	0.00050	0.00028	0.00020	0.00015	0.00003	1.78	1	0	0	5	0.00020	0.00060	0.00042	0.00040	0.00018	0.00008	2.37	0	0	0
Dissolved Aluminum	0.1	mg/L	22	0.0062	0.1170	0.0444	0.0384	0.0358	0.0076	1.24	0	16	73	5	0.0078	0.1210	0.0538	0.0389	0.0471	0.0211	1.14	0	1	20
Dissolved Antimony	-	mg/L	22	0.00005	0.00013	0.00009	0.00009	0.00002	0.000003	5.50	0	0	0	5	0.00005	0.00008	0.00007	0.00008	0.00001	0.000006	5.49	0	0	0
Dissolved Arsenic	-	mg/L	22	0.00030	0.00053	0.00044	0.00045	0.00007	0.000014	6.74	0	0	0	5	0.00052	0.00082	0.00066	0.00063	0.00013	0.000056	5.21	0	0	0
Dissolved Barium	-	mg/L	22	0.031	0.082	0.053	0.051	0.014	0.003	3.80	0	0	0	5	0.031	0.088	0.052	0.042	0.023	0.010	2.26	0	0	0
Dissolved Beryllium	-	mg/L	22	0.000005	0.000030	0.000008	0.000005	0.000006	0.000001	1.30	15	0	0	5	0.000005	0.000020	0.000010	0.000010	0.000006	0.000003	1.66	2	0	0
Dissolved Bismuth	-	mg/L	22	0.0000025	0.0000050	0.0000026	0.0000025	0.0000005	0.0000001	4.90	21	0	0	5	0.0000025	0.0000025	0.0000025	0.0000025	0	-	-	5	0	0
Dissolved Boron	-	mg/L	22	0.025	0.025	0.025	0.025	0	-	-	22	0	0	5	0.025	0.025	0.025	0.025	0	-	-	5	0	0
Dissolved Cadmium	-	mg/L	22	0.000003	0.000022	0.000010	0.000010	0.000006	0.000001	1.72	5	0	0	5	0.000007	0.000015	0.000012	0.000013	0.000003	0.000001	3.54	0	0	0
Dissolved Calcium	-	mg/L	22	13.40	36.00	23.39	21.90	6.59	1.41	3.55	0	0	0	5	12.90	25.80	19.42	20.00	6.33	2.83	3.07	0	0	0
Dissolved Chromium	-	mg/L	22	0.00005	0.00040	0.00018	0.00015	0.00013	0.00003	1.43	6	0	0	5	0.00020	0.00040	0.00027	0.00025	0.00008	0.00004	3.23	0	0	0
Dissolved Cobalt	-	mg/L	22	0.000043	0.000133	0.000085	0.000084	0.000024	0.000005	3.56	0	0	0	5	0.000044	0.000414	0.000171	0.000123	0.000142	0.000064	1.20	0	0	0
Dissolved Copper	-	mg/L	22	0.0008	0.0062	0.0022	0.0020	0.0012	0.0003	1.81	0	0	0	5	0.0006	0.0039	0.0023	0.0022	0.0013	0.0006	1.72	0	0	0
Dissolved Iron	-	mg/L	22	0.063	0.240	0.144	0.143	0.053	0.011	2.71	0	0	0	5	0.241	0.585	0.416	0.345	0.158	0.071	2.64	0	0	0
Dissolved Lead	-	mg/L	22	0.000003	0.000399	0.000051	0.000030	0.000081	0.000017	0.63	1	0	0	5	0.000012	0.000126	0.000059	0.000057	0.000046	0.000021	1.28	0	0	0
Dissolved Lithium	-	mg/L	22	0.00090	0.00200	0.00135	0.00130	0.00020	0.00004	6.61	0	0	0	5	0.00060	0.00120	0.00087	0.00080	0.00023	0.00010	3.78	0	0	0
Dissolved Magnesium	-	mg/L	22	5.03	14.90	8.68	8.18	2.59	0.55	3.36	0	0	0	5	4.34	9.75	7.06	6.86	2.60	1.16	2.71	0	0	0
Dissolved Manganese	-	mg/L	22	0.0008	0.0529	0.0268	0.0207	0.0148	0.0032	1.81	0	0	0	5	0.0024	0.2650	0.0798	0.0295	0.1078	0.0482	0.74	0	0	0
Dissolved Mercury	-	mg/L	17	0.0000050	0.0000050	0.0000050	0.0000050	0	-	-	17	0	0	2	0.0000050	0.0000050	0.0000050	0.0000050	0	-	-	2	0	0
Dissolved Molybdenum	-	mg/L	22	0.00056	0.00104	0.00081	0.00077	0.00014	0.00003	5.59	0	0	0	5	0.00062	0.00104	0.00085	0.00095	0.00020	0.00009	4.20	0	0	0
Dissolved Nickel	-	mg/L	22	0.00030	0.00116	0.00057	0.00051	0.00023	0.00005	2.47	0	0	0	5	0.00056	0.00120	0.00081	0.00074	0.00024	0.00011	3.35	0	0	0
Dissolved Phosphorus	-	mg/L	17	0.0020	0.0070	0.0046	0.0050	0.0017	0.0004	2.65	0	0	0	2	0.0060	0.0121	0.0091	0.0091	0.0043	0.0031	2.10	0	0	0
Dissolved Potassium	-	mg/L	22	0.57	1.49	0.89	0.86	0.23	0.05	3.92	0	0	0	5	0.60	1.16	0.87	0.77	0.23	0.10	3.76	0	0	0
Dissolved Selenium	-	mg/L	22	0.00002	0.00009	0.00006	0.00006	0.00002	0.00000	2.86	3	0	0	5	0.00002	0.00009	0.00005	0.00005	0.00003	0.00001	1.58	2	0	0
Dissolved Silicon	-	mg/L	22	3.30	5.50	4.59	4.75	0.62	0.13	7.36	0	0	0	5	2.93	4.90	4.27	4.90	0.91	0.41	4.69	0	0	0
Dissolved Silver	-	mg/L	22	0.000003	0.000003	0.000003	0.000003	0	-	-	22	0	0	5	0.000003	0.000003	0.000003	0.000003	0	-	-	5	0	0
Dissolved Sodium	-	mg/L	22	2.32	6.44	3.93	3.80	1.08	0.23	3.63	0	0	0	5	2.14	5.14	3.67	3.67	1.40	0.62	2.63	0	0	0
Dissolved Strontium	-	mg/L	22	0.089	0.248	0.162	0.153	0.047	0.010	3.46	0	0	0	5	0.081	0.185	0.133	0.132	0.051	0.023	2.61	0	0	0
Dissolved Sulphur	-	mg/L	5	5.00	19.00	10.80	12.00	5.93	2.65	1.82	2	0	0	5	5.00	11.00	6.20	5.00	2.68	1.20	2.31	4	0	0
Dissolved Thallium	-	mg/L	22	0.0000010	0.0000020	0.0000012	0.0000010	0.0000004	0.0000001	2.99	18	0	0	5	0.0000010	0.0000010	0.0000010	0.0000010	0	-	-	5	0	0
Dissolved Tin	-	mg/L	22	0.000005	0.000005	0.000005	0.000005	0	-	-	22	0	0	5	0.000005	0.000100	0.000043	0.000005	0.000052	0.000023	0.83	5	0	0
Dissolved Titanium	-	mg/L	22	0.00025	0.00170	0.00070	0.00060	0.00050	0.00011	1.39	10	0	0	5	0.00025	0.00200	0.00111	0.00137	0.00082	0.00037	1.36	2	0	0
Dissolved Uranium	-	mg/L	22	0.00162	0.00998	0.00447	0.00459	0.00229	0.00049	1.95	0	0	0	5	0.00114	0.00580	0.00281	0.00226	0.00189	0.00085	1.48	0	0	0
Dissolved Vanadium	-	mg/L	22	0.00010	0.00120	0.00044	0.00040	0.00027	0.00006	1.63	4	0	0	5	0.00050	0.00110	0.00080	0.00080	0.00022	0.00010	3.60	0	0	0
Dissolved Zinc	-	mg/L	22	0.00020	0.00640	0.00105	0.00050	0.00142	0.00030	0.74	0	0	0	5	0.00030	0.00080	0.00064	0.00070	0.00021	0.00009	3.10	0	0	0
Dissolved Zirconium	-	mg/L	22	0.00005	0.00040	0.00023	0.00020	0.00012	0.00003	1.90	3	0	0	5	0.00020	0.00040	0.00029	0.00025	0.00010	0.00005	2.83	0	0	0

Note:

1) Canadian water quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2007
a) Ammonia (NH3) guideline based on ph=8 and temp=20
b) Aluminum (AL-T)= 0.005 mg/L at pH < 6.5: 0.1 mg/L at pH ≥ 6.5
c) Cadmium (Cd) mg/L: 10^(0.86*(log(hardness))-3.2)/1000
d) Copper (Cu) mg/L: (e^0.8545[ln(hardness)]-1.465)*0.2/1000; minimum is 0.002mg/L regardless of water hardness
e) Lead (Pb) mg/L: (e^1.273[ln(hardness)]-4.705)/1000; minimum is 0.001mg/L regardless of water hardness
f) Nickel (Ni) mg/L: (e^0.76[(ln(hardness)]+1.06)/1000; minimum is 0.025mg/L regardless of water hardness

"n"	Count
"min"	Minimum Value
"max"	Maximum Value
"sd"	Standard Deviation
"se"	Standard Error
"cov"	Covariance
"<DL"	# of Non-detectable Values
">GL"	# of Exceedances of CCME Guic
"%>GL"	% of Parameters that Exceed CCME Guidelin
"-"	No Data Available

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

Appendix B5. Surface Water Quality Statistics: All sites all parameters, Casino Project, 2008-2012

Parameters	CCME[1] Guideline	unit	W20											W21									
			n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL	n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL
pH	6.5 - 9.0	pH unit	19	7.25	8.10	7.76	7.74	0.19	0.04	41.44	0	0	0	17	7.31	8.10	7.76	7.79	0.20	0.05	38.68	0	0	0
Conductivity	-	µS/cm	19	106	201	159	165	24	5	6.68	0	0	0	17	131	242	173	171	27	7	6.34	0	0	0
Total Hardness CaCO3	-	mg/L	19	54	86	74	75	10	2	7.12	0	0	0	17	57	108	80	82	13	3	6.26	0	0	0
Dissolved Hardness CaCO3	-	mg/L	6	51	88	71	74	15	6	4.79	0	0	0	4	63	95	80	82	13	7	5.95	0	0	0
Moisture	-	%	-	-	-	-	-	-	-	-	-	-	-	1	18	18	18	18	0	-	-	0	0	0
Ion Balance	-	no unit	4	0.94	1.00	0.98	0.99	0.03	0.01	34.65	0	0	0	3	0.99	1.10	1.03	1.00	0.06	0.04	16.93	0	0	0
Total Dissolved Solids	-	mg/L	19	76	130	100	100	16	4	6.32	0	0	0	17	84	160	111	110	19	4	5.96	0	0	0
Total Suspended Solids	-	mg/L	19	0.5	59.5	5.3	1.0	13.4	3.1	0.39	6	0	0	17	0.5	9.0	3.1	1.0	3.0	0.7	1.02	4	0	0
Turbidity	-	NTU	19	0.3	6.6	2.1	1.2	2.0	0.5	1.03	0	0	0	17	0.4	6.2	2.5	1.8	2.0	0.5	1.28	0	0	0
Ammonia as N	0.499[a]	mg/L	19	0.003	0.170	0.030	0.021	0.038	0.009	0.79	5	0	0	17	0.003	0.200	0.034	0.025	0.046	0.011	0.73	6	0	0
Alkalinity, Total (as CaCO3)	-	mg/L	19	42.7	74.0	64.13	66.0	7.63	1.75	8.40	0	0	0	17	53.0	91.0	69.0	69.0	8.98	2.18	7.68	0	0	0
Acidity (pH 4.5) as CaCO3	-	mg/L	6	0.25	0.25	0.25	0.25	0	-	-	6	0	0	4	0.25	0.25	0.25	0.25	0	-	-	4	0	0
Acidity (pH8.3) as CaCO3	-	mg/L	14	0.25	4.90	1.73	1.45	1.30	0.35	1.33	2	0	0	11	0.25	4.40	1.50	1.60	1.21	0.37	1.24	3	0	0
Bromide (Br)	-	mg/L	19	0.01	0.20	0.18	0.20	0.06	0.01	2.92	19	0	0	17	0.20	0.20	0.20	0.20	0	-	-	17	0	0
Chloride (Cl)	120	mg/L	19	0.25	1.00	0.34	0.25	0.21	0.05	1.66	15	0	0	16	0.25	1.40	0.44	0.25	0.37	0.09	1.19	12	0	0
Fluoride (F)	0.12	mg/L	19	0.120	0.160	0.132	0.130	0.013	0.003	10.04	0	11	58	17	0.100	0.140	0.118	0.120	0.011	0.003	10.25	0	5	29
Sulphate (SO4)	-	mg/L	19	8.01	28.00	17.28	17.00	5.40	1.24	3.20	0	0	0	17	11.00	39.00	20.29	18.00	6.80	1.65	2.99	0	0	0
Total Nitrogen (N)	-	mg/L	6	0.09	0.56	0.31	0.29	0.15	0.06	2.00	0	0	0	4	0.11	0.27	0.21	0.24	0.07	0.04	3.02	0	0	0
Nitrate (as N)	13	mg/L	19	0.008	0.154	0.083	0.083	0.039	0.009	2.11	0	0	0	17	0.001	0.135	0.073	0.081	0.034	0.008	2.14	1	0	0
Nitrate plus Nitrite (N)	-	mg/L	6	0.008	0.154	0.094	0.104	0.059	0.024	1.60	0	0	0	4	0.001	0.121	0.067	0.073	0.050	0.025	1.33	1	0	0
Nitrite (as N)	0.06	mg/L	19	0.001	0.006	0.002	0.001	0.001	0.000	1.23	15	0	0	17	0.001	0.003	0.001	0.001	0.001	0.000	2.06	15	0	0
Total Kjeldahl Nitrogen	-	mg/L	19	0.04	0.49	0.17	0.15000	0.1089	0.0250	1.56	0	0	0	17	0.05	0.47	0.18	0.15000	0.1091	0.0265	1.63	0	0	0
Ortho Phosphate as P	-	mg/L	19	0.0005	0.0080	0.0022	0.0012	0.0020	0.0005	1.06	2	0	0	17	0.0005	0.0070	0.0019	0.0020	0.0015	0.0004	1.27	2	0	0
Cyanide, Total	0.005	mg/L	19	0.00025	0.00150	0.00041	0.00025	0.00031	0.00007	1.32	13	0	0	17	0.00025	0.00150	0.00042	0.00025	0.00033	0.00008	1.27	12	0	0
Cyanide, Weak Acid Diss	-	mg/L	19	0.00025	0.00110	0.00036	0.00025	0.00026	0.00006	1.37	16	0	0	17	0.00025	0.00120	0.00041	0.00025	0.00032	0.00008	1.30	13	0	0
Dissolved Organic Carbon	-	mg/L	14	3.00	8.90	5.53	5.10	2.19	0.58	2.53	0	0	0	11	3.40	9.80	5.85	4.90	2.19	0.66	2.67	0	0	0
Total Organic Carbon	-	mg/L	19	2.50	9.70	5.06	4.40	1.99	0.46	2.54	1	0	0	17	3.20	10.10	6.12	5.70	2.08	0.50	2.94	0	0	0
Total Aluminum	0.1[b]	mg/L	19	0.0049	0.4870	0.0636	0.0214	0.1116	0.0256	0.57	0	3	16	17	0.0048	0.2220	0.0470	0.0204	0.0596	0.0144	0.79	0	3	18
Total Antimony	-	mg/L	19	0.000020	0.000050	0.000037	0.000040	0.000009	0.000002	4.28	0	0	0	17	0.00003	0.00006	0.00004	0.00004	0.00001	0.00000	3.98	0	0	0
Total Arsenic	0.005	mg/L	19	0.000290	0.001920	0.000658	0.000440	0.000450	0.000103	1.46	0	0	0	17	0.00039	0.00117	0.00062	0.00053	0.00023	0.00006	2.64	0	0	0
Total Barium	-	mg/L	19	0.03	0.06	0.04	0.04010	0.0072	0.0017	5.96	0	0	0	17	0.04	0.06	0.05	0.04590	0.0078	0.0019	6.01	0	0	0
Total Beryllium	-	mg/L	19	0.000005	0.000045	0.000010	0.000005	0.000010	0.000002	1.02	12	0	0	17	0.000005	0.000020	0.000009	0.000005	0.000006	0.000002	1.42	11	0	0
Total Bismuth	-	mg/L	19	0.0000025	0.0000050	0.0000026	0.0000025	0.0000006	0.0000001	4.59	18	0	0	17	0.0000025	0.0000070	0.0000028	0.0000025	0.0000011	0.0000003	2.53	16	0	0
Total Boron	1.5	mg/L	19	0.03	0.03	0.03	0.03	0	-	-	19	0	0	17	0.03	0.03	0.03	0.03	0	-	-	17	0	0
Total Cadmium	0.000032 [c]	mg/L	19	0.000003	0.000054	0.000012	0.000011	0.000011	0.000003	1.09	4	1	5	17	0.000003	0.000026	0.000011	0.000009	0.000006	0.000002	1.68	1	0	0
Total Calcium	-	mg/L	19	13.10	20.60	17.74	18.40	2.48	0.57	7.15	0	0	0	17	13.40	26.00	19.52	20.20	3.13	0.76	6.24	0	0	0
Total Chromium	0.001	mg/L	19	0.00005	0.00150	0.00029	0.00020	0.00033	0.00007	0.91	2	1	5	17	0.00010	0.00070	0.00025	0.00020	0.00015	0.00004	1.64	0	0	0
Total Cobalt	-	mg/L	19	0.000058	0.000604	0.000152	0.000126	0.000117	0.000027	1.30	0	0	0	17	0.000073	0.000256	0.000162	0.000158	0.000056	0.000013	2.91	0	0	0
Total Copper	0.0023[d]	mg/L	19	0.0006	0.0028	0.0012	0.0010	0.0006	0.0001	1.94	0	1	5	17	0.0006	0.0024	0.0012	0.0010	0.0006	0.0001	2.08	0	3	18
Total Iron	0.3	mg/L	19	0.150	1.900	0.550	0.348	0.478	0.110	1.15	0	10	53	17	0.226	1.180	0.491	0.393	0.272	0.066	1.81	0	13	76
Total Lead	0.003[e]	mg/L	19	0.000006	0.000430	0.000077	0.000061	0.000095	0.000022	0.82	0	0	0	17	0.000011	0.000178	0.000064	0.000040	0.000054	0.000013	1.18	0	0	0
Total Lithium	-	mg/L	19	0.00025	0.00060	0.00030	0.00025	0.00012	0.00003	2.54	16	0	0	17	0.00025	0.00090	0.00045	0.00050	0.00022	0.00005	2.10	8	0	0
Total Magnesium	-	mg/L	19	4.78	8.87	7.09	7.34	1.08	0.25	6.55	0	0	0	17	5.37	10.50	7.57	7.68	1.26	0.31	6.00	0	0	0
Total Manganese	-	mg/L	19	0.0198	0.1530	0.0627	0.0563	0.0438	0.0101	1.43	0	0	0	17	0.0254	0.1540	0.0787	0.0530	0.0515	0.0125	1.53	0	0	0
Total Mercury	0.000026	mg/L	16	0.0000050	0.0000050	0.0000050	0.0000050	0	-	-	16	0	0	14	0.0000050	0.0000050	0.0000050	0.0000050	0	-	-	14	0	0
Total Molybdenum	0.073	mg/L	19	0.00043	0.00064	0.00056	0.00058	0.00007	0.00002	8.60	0	0	0	17	0.00048	0.00108	0.00067	0.00067	0.00013	0.00003	5.27	0	0	0
Total Nickel	0.0033[f]	mg/L	19	0.00043	0.00183	0.00068	0.00053	0.00034	0.00008	1.99	0	0	0	17	0.00047	0.00120	0.00067	0.00057	0.00024	0.00006	2.75	0	0	0
Total Phosphorus	-	mg/L	16	0.0030	0.0573	0.0136	0.0100	0.0127	0.0032	1.07	0	0	0	14	0.0030	0.0180	0.0096	0.0090	0.0047	0.0012	2.07	0	0	0
Total Potassium	-	mg/L	19	0.58	0.85	0.74	0.73	0.07	0.02	10.09	0	0	0	17	0.58	1.33	0.83	0.79	0.18	0.04	4.67	0	0	0
Total Selenium	0.001	mg/L	19	0.00008	0.00029	0.00014	0.00012	0.00005	0.00001	2.62	0	0	0	17	0.00007	0.00022	0.00012	0.00012	0.00004	0.00001	3.22	0	0	0

Note:

1) Canadian water quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2007
a) Ammonia (NH3) guideline based on ph=8 and temp=20
b) Aluminum (AL-T)= 0.005 mg/L at pH < 6.5: 0.1 mg/L at pH ≥ 6.5
c) Cadmium (Cd) mg/L: 10^(0.86*(log(hardness))-3.2)/1000
d) Copper (Cu) mg/L: (e^0.8545[ln(hardness)]-1.465)*0.2/1000; minimum is 0.002mg/L regardless of water hardness
e) Lead (Pb) mg/L: (e^1.273[ln(hardness)]-4.705)/1000; minimum is 0.001mg/L regardless of water hardness
f) Nickel (Ni) mg/L: (e^0.76[(ln(hardness)]+1.06)/1000; minimum is 0.025mg/L regardless of water hardness
Highlighted cells indicate updates from Project Proposal

"n"	Count
"min"	Minimum Value
"max"	Maximum Value
"sd"	Standard Deviation
"se"	Standard Error
"cov"	Covariance
"<DL"	# of Non-detectable Values
">GL"	# of Exceedances of CCME Guic
"%>GL"	% of Parameters that Exceed CCME Guidelin
"-"	No Data Available

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

Appendix B5. Surface Water Quality Statistics: All sites all parameters, Casino Project, 2008-2012

Parameters	CCME[1] Guideline	unit	W20										W21									
			n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL	n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL
Total Silicon	-	mg/L	19	3.50	5.60	4.66	4.80	0.50	0.12	9.23	0	0	0	17	3.50	5.40	4.76	4.80	0.54	0.13	8.78	0	0	0
Total Silver	0.0001	mg/L	19	0.000003	0.000011	0.000003	0.000003	0.000002	0.000000	1.51	18	0	0	17	0.000003	0.000003	0.000003	0.000003	0	-	-	17	0	0
Total Sodium	-	mg/L	19	2.43	4.01	3.44	3.56	0.40	0.09	8.54	0	0	0	17	2.86	6.22	3.87	3.77	0.77	0.19	5.04	0	0	0
Total Strontium	-	mg/L	19	0.104	0.173	0.146	0.148	0.017	0.004	8.41	0	0	0	17	0.123	0.187	0.150	0.153	0.018	0.004	8.55	0	0	0
Total Sulphur	-	mg/L	6	5.00	5.00	5.00	5.00	0	-	-	6	0	0	4	5.00	11.00	6.50	5.00	3.00	1.50	2.17	3	0	0
Total Thallium	0.0008	mg/L	19	0.0000010	0.0000033	0.0000011	0.0000010	0.0000005	0.0000001	2.12	18	0	0	17	0.0000010	0.0000020	0.0000011	0.0000010	0.0000002	0.0000001	4.37	16	0	0
Total Tin	-	mg/L	19	0.000005	0.000100	0.000015	0.000005	0.000030	0.000007	0.50	19	0	0	17	0.000005	0.000010	0.000005	0.000005	0.000001	0.000000	4.37	16	0	0
Total Titanium	-	mg/L	19	0.00025	0.01770	0.00212	0.00070	0.00407	0.00093	0.52	8	0	0	17	0.00025	0.00970	0.00161	0.00060	0.00238	0.00058	0.68	7	0	0
Total Uranium	0.015	mg/L	19	0.00012	0.00050	0.00025	0.00024	0.00010	0.00002	2.62	0	0	0	17	0.00015	0.00340	0.00090	0.00081	0.00077	0.00019	1.16	0	0	0
Total Vanadium	-	mg/L	19	0.00010	0.00262	0.00056	0.00040	0.00056	0.00013	1.00	2	0	0	17	0.00010	0.00130	0.00044	0.00030	0.00035	0.00009	1.25	4	0	0
Total Zinc	0.03	mg/L	19	0.00020	0.00370	0.00094	0.00060	0.00098	0.00022	0.96	0	0	0	17	0.00030	0.00220	0.00084	0.00050	0.00058	0.00014	1.45	0	0	0
Total Zirconium	-	mg/L	19	0.00010	0.00049	0.00017	0.00010	0.00010	0.00002	1.68	0	0	0	17	0.00010	0.00040	0.00021	0.00020	0.00008	0.00002	2.71	0	0	0
Dissolved Aluminum	0.1	mg/L	19	0.0036	0.0475	0.0152	0.0099	0.0129	0.0030	1.18	0	0	0	17	0.0043	0.0419	0.0164	0.0124	0.0128	0.0031	1.28	0	0	0
Dissolved Antimony	-	mg/L	19	0.00001	0.00005	0.00003	0.00003	0.00001	0.000002	3.44	1	0	0	17	0.00002	0.00017	0.00005	0.00005	0.00003	0.000008	1.50	0	0	0
Dissolved Arsenic	-	mg/L	19	0.00027	0.00145	0.00052	0.00037	0.00036	0.000082	1.45	0	0	0	17	0.00035	0.00074	0.00049	0.00042	0.00013	0.000032	3.69	0	0	0
Dissolved Barium	-	mg/L	19	0.026300	0.056400	0.041274	0.039100	0.008816	0.002023	4.68	0	0	0	17	0.031900	0.061200	0.045982	0.047400	0.008188	0.001986	5.62	0	0	0
Dissolved Beryllium	-	mg/L	19	0.000005	0.000015	0.000007	0.000005	0.000003	0.000001	2.34	12	0	0	17	0.000005	0.000010	0.000006	0.000005	0.000002	0.000001	2.83	13	0	0
Dissolved Bismuth	-	mg/L	19	0.0000025	0.0000025	0.0000025	0.0000025	0	-	-	19	0	0	17	0.0000025	0.0000025	0.0000025	0.0000025	0	-	-	17	0	0
Dissolved Boron	-	mg/L	19	0.025	0.025	0.025	0.025	0	-	-	19	0	0	17	0.025	0.025	0.025	0.025	0	-	-	17	0	0
Dissolved Cadmium	-	mg/L	19	0.000003	0.000021	0.000007	0.000008	0.000005	0.000001	1.45	7	0	0	17	0.000003	0.000011	0.000007	0.000007	0.000003	0.000001	2.15	5	0	0
Dissolved Calcium	-	mg/L	19	12.80	20.50	17.53	17.80	2.31	0.53	7.57	0	0	0	17	14.70	27.40	19.81	19.80	3.16	0.77	6.27	0	0	0
Dissolved Chromium	-	mg/L	19	0.00005	0.00030	0.00017	0.00020	0.00008	0.00002	2.17	3	0	0	17	0.00005	0.00030	0.00019	0.00020	0.00009	0.00002	2.11	3	0	0
Dissolved Cobalt	-	mg/L	19	0.000025	0.000193	0.000095	0.000079	0.000049	0.000011	1.95	0	0	0	17	0.000027	0.000209	0.000121	0.000093	0.000058	0.000014	2.09	0	0	0
Dissolved Copper	-	mg/L	19	0.0005	0.0016	0.0010	0.0009	0.0004	0.0001	2.61	0	0	0	17	0.0005	0.0018	0.0011	0.0009	0.0005	0.0001	2.38	0	0	0
Dissolved Iron	-	mg/L	19	0.085	1.150	0.312	0.136	0.328	0.075	0.95	0	0	0	17	0.017	0.424	0.248	0.197	0.119	0.029	2.09	0	0	0
Dissolved Lead	-	mg/L	19	0.000003	0.000117	0.000026	0.000008	0.000034	0.000008	0.76	4	0	0	17	0.000003	0.000314	0.000042	0.000017	0.000075	0.000018	0.56	4	0	0
Dissolved Lithium	-	mg/L	19	0.00025	0.00050	0.00026	0.00025	0.00006	0.00001	4.59	18	0	0	17	0.00025	0.00090	0.00043	0.00050	0.00020	0.00005	2.15	8	0	0
Dissolved Magnesium	-	mg/L	19	4.53	9.09	7.06	7.18	1.16	0.27	6.09	0	0	0	17	5.63	10.90	7.58	7.57	1.29	0.31	5.88	0	0	0
Dissolved Manganese	-	mg/L	19	0.0008	0.1550	0.0564	0.0340	0.0475	0.0109	1.19	0	0	0	17	0.0025	0.1570	0.0735	0.0438	0.0573	0.0139	1.28	0	0	0
Dissolved Mercury	-	mg/L	15	0.0000050	0.0000050	0.0000050	0.0000050	0	-	-	15	0	0	13	0.0000050	0.0000100	0.0000054	0.0000050	0.0000014	0.0000004	3.88	12	0	0
Dissolved Molybdenum	-	mg/L	19	0.00046	0.00078	0.00057	0.00054	0.00008	0.00002	7.34	0	0	0	17	0.00052	0.00144	0.00072	0.00069	0.00023	0.00006	3.17	0	0	0
Dissolved Nickel	-	mg/L	19	0.00042	0.00083	0.00057	0.00052	0.00013	0.00003	4.54	0	0	0	17	0.00021	0.00084	0.00058	0.00055	0.00015	0.00004	3.89	0	0	0
Dissolved Phosphorus	-	mg/L	15	0.0010	0.0140	0.0059	0.0050	0.0039	0.0010	1.51	2	0	0	13	0.0020	0.0080	0.0048	0.0050	0.0018	0.0005	2.66	0	0	0
Dissolved Potassium	-	mg/L	19	0.55	0.86	0.74	0.75	0.08	0.02	8.75	0	0	0	17	0.60	1.39	0.86	0.82	0.20	0.05	4.33	0	0	0
Dissolved Selenium	-	mg/L	19	0.00008	0.00028	0.00014	0.00012	0.00005	0.00001	2.63	0	0	0	17	0.00002	0.00020	0.00011	0.00012	0.00004	0.00001	2.66	1	0	0
Dissolved Silicon	-	mg/L	19	3.41	5.40	4.46	4.40	0.53	0.12	8.45	0	0	0	17	3.30	5.70	4.71	4.90	0.60	0.15	7.79	0	0	0
Dissolved Silver	-	mg/L	19	0.000003	0.000003	0.000003	0.000003	0	-	-	19	0	0	17	0.000003	0.000003	0.000003	0.000003	0	-	-	17	0	0
Dissolved Sodium	-	mg/L	19	2.39	5.70	3.56	3.56	0.64	0.15	5.58	0	0	0	17	2.98	6.42	3.99	3.87	0.84	0.20	4.73	0	0	0
Dissolved Strontium	-	mg/L	19	0.101	0.170	0.145	0.149	0.018	0.004	7.92	0	0	0	17	0.119	0.190	0.149	0.151	0.020	0.005	7.37	0	0	0
Dissolved Sulphur	-	mg/L	6	5.00	5.00	5.00	5.00	0	-	-	6	0	0	4	5.00	10.00	6.25	5.00	2.50	1.25	2.50	3	0	0
Dissolved Thallium	-	mg/L	19	0.0000010	0.0000010	0.0000010	0.0000010	0	-	-	19	0	0	17	0.0000010	0.0000030	0.0000011	0.0000010	0.0000005	0.0000001	2.30	16	0	0
Dissolved Tin	-	mg/L	19	0.000005	0.000100	0.000015	0.000005	0.000030	0.000007	0.51	18	0	0	17	0.000005	0.000005	0.000005	0.000005	0	-	-	17	0	0
Dissolved Titanium	-	mg/L	19	0.00025	0.00110	0.00034	0.00025	0.00023	0.00005	1.49	16	0	0	17	0.00025	0.00090	0.00032	0.00025	0.00017	0.00004	1.85	14	0	0
Dissolved Uranium	-	mg/L	19	0.00012	0.00037	0.00023	0.00023	0.00007	0.00002	3.12	0	0	0	17	0.00016	0.00425	0.00108	0.00083	0.00114	0.00028	0.94	0	0	0
Dissolved Vanadium	-	mg/L	19	0.00010	0.00080	0.00036	0.00030	0.00022	0.00005	1.68	4	0	0	17	0.00010	0.00080	0.00034	0.00030	0.00021	0.00005	1.63	3	0	0
Dissolved Zinc	-	mg/L	19	0.00020	0.00110	0.00047	0.00040	0.00023	0.00005	2.01	0	0	0	17	0.00020	0.00070	0.00041	0.00040	0.00015	0.00004	2.67	0	0	0
Dissolved Zirconium	-	mg/L	19	0.00005	0.00020	0.00015	0.00015	0.00005	0.00001	2.73	1	0	0	17	0.00010	0.00030	0.00018	0.00020	0.00006	0.00002	2.87	0	0	0

Note:

1) Canadian water quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2007
a) Ammonia (NH3) guideline based on ph=8 and temp=20
b) Aluminum (AL-T)= 0.005 mg/L at pH < 6.5: 0.1 mg/L at pH ≥ 6.5
c) Cadmium (Cd) mg/L: 10^(0.86*(log(hardness))-3.2)/1000
d) Copper (Cu) mg/L: (e^0.8545[ln(hardness)]-1.465)*0.2/1000; minimum is 0.002mg/L regardless of water hardness
e) Lead (Pb) mg/L: (e^1.273[ln(hardness)]-4.705)/1000; minimum is 0.001mg/L regardless of water hardness
f) Nickel (Ni) mg/L: (e^0.76[(ln(hardness)]+1.06)/1000; minimum is 0.025mg/L regardless of water hardness

"n"	Count
"min"	Minimum Value
"max"	Maximum Value
"sd"	Standard Deviation
"se"	Standard Error
"cov"	Covariance
"<DL"	# of Non-detectable Values
">GL"	# of Exceedances of CCME Guic
"%>GL"	% of Parameters that Exceed CCME Guidelin
"-"	No Data Available

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

Appendix B5. Surface Water Quality Statistics: All sites all parameters, Casino Project, 2008-2012

Parameters	CCME[1] Guideline	unit	W7											W3										
			n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL	n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL
pH	6.5 - 9.0	pH unit	18	5.50	8.00	6.87	6.89	0.51	0.12	13.58	0	3	17	27	7.40	8.21	7.83	7.89	0.20	0.04	38.61	0	0	0
Conductivity	-	µS/cm	18	34	217	121	125	44	10	2.75	0	0	0	27	89	435	276	263	92	18	3.01	0	0	0
Total Hardness CaCO3	-	mg/L	18	15	61	42	42	13	3	3.28	0	0	0	27	46	189	129	126	44	8	2.97	0	0	0
Dissolved Hardness CaCO3	-	mg/L	4	32	63	49	51	13	7	3.78	0	0	0	6	48	197	146	170	58	24	2.51	0	0	0
Ion Balance	-	no unit	3	0.93	1.10	1.01	1.00	0.09	0.05	11.82	0	0	0	4	0.62	1.10	0.90	0.95	0.21	0.10	4.36	0	0	0
Total Dissolved Solids	-	mg/L	17	32	130	90	98	30	7	3.04	0	0	0	27	74	306	184	180	59	11	3.10	0	0	0
Total Suspended Solids	-	mg/L	18	0.5	40.0	8.9	1.0	14.0	3.3	0.64	5	0	0	27	0.5	34.0	4.2	0.5	7.8	1.5	0.54	14	0	0
Turbidity	-	NTU	18	0.1	15.5	2.5	0.4	4.2	1.0	0.59	0	0	0	27	0.1	7.5	0.9	0.3	1.6	0.3	0.59	0	0	0
Ammonia as N	0.499[a]	mg/L	18	0.003	0.250	0.037	0.015	0.062	0.015	0.59	6	0	0	27	0.003	0.052	0.016	0.010	0.015	0.003	1.09	10	0	0
Alkalinity, Total (as CaCO3)	-	mg/L	18	0.6	15.0	7.23	7.05	3.40	0.80	2.13	0	0	0	27	22.0	130.0	75.18	72.0	26.26	5.05	2.86	0	0	0
Acidity (pH 4.5) as CaCO3	-	mg/L	4	0.25	0.25	0.25	0.25	0	-	-	4	0	0	6	0.25	0.25	0.25	0.25	0	-	-	6	0	0
Acidity (pH8.3) as CaCO3	-	mg/L	11	0.25	7.60	2.78	1.30	2.86	0.86	0.97	2	0	0	15	0.25	5.00	1.79	1.39	1.51	0.39	1.19	3	0	0
Bromide (Br)	-	mg/L	14	0.20	0.20	0.20	0.20	0	-	-	14	0	0	23	0.01	0.20	0.18	0.20	0.06	0.01	2.83	23	0	0
Chloride (Cl)	120	mg/L	18	0.25	1.90	0.47	0.25	0.43	0.10	1.10	12	0	0	27	0.25	1.50	0.56	0.50	0.38	0.07	1.47	13	0	0
Fluoride (F)	0.12	mg/L	14	0.030	0.130	0.066	0.065	0.024	0.007	2.73	0	1	7	23	0.059	0.120	0.096	0.100	0.018	0.004	5.20	0	0	0
Sulphate (SO4)	-	mg/L	18	0.25	54.00	39.85	44.50	15.26	3.60	2.61	1	0	0	27	15.00	121.00	61.67	58.00	25.96	5.00	2.38	0	0	0
Total Nitrogen (N)	-	mg/L	4	0.07	0.64	0.24	0.13	0.27	0.13	0.91	0	0	0	6	0.37	0.68	0.53	0.54	0.12	0.05	4.25	0	0	0
Nitrate (as N)	13	mg/L	18	0.001	0.011	0.003	0.001	0.004	0.001	0.92	13	0	0	27	0.050	0.487	0.228	0.236	0.115	0.022	1.99	0	0	0
Nitrate plus Nitrite (N)	-	mg/L	4	0.001	0.012	0.006	0.006	0.006	0.003	1.03	2	0	0	6	0.111	0.487	0.300	0.290	0.132	0.054	2.27	0	0	0
Nitrite (as N)	0.06	mg/L	18	0.001	0.010	0.002	0.001	0.002	0.001	0.90	15	0	0	27	0.001	0.004	0.002	0.001	0.001	0.000	1.69	19	0	0
Total Kjeldahl Nitrogen	-	mg/L	18	0.07	0.63	0.22	0.17000	0.1575	0.0371	1.40	0	0	0	27	0.08	0.56	0.22	0.21000	0.1117	0.0215	2.00	0	0	0
Ortho Phosphate as P	-	mg/L	18	0.0005	0.0040	0.0015	0.0010	0.0009	0.0002	1.68	4	0	0	27	0.0005	0.0460	0.0031	0.0010	0.0086	0.0017	0.36	6	0	0
Cyanide, Total	0.005	mg/L	18	0.00025	0.00150	0.00053	0.00025	0.00042	0.00010	1.25	11	0	0	27	0.00025	0.00150	0.00057	0.00025	0.00038	0.00007	1.48	14	0	0
Cyanide, Weak Acid Diss	-	mg/L	18	0.00025	0.00130	0.00049	0.00025	0.00038	0.00009	1.28	12	0	0	27	0.00025	0.00180	0.00054	0.00025	0.00042	0.00008	1.28	16	0	0
Dissolved Organic Carbon	-	mg/L	10	1.70	17.40	6.26	4.20	4.91	1.55	1.28	0	0	0	14	2.00	15.30	6.95	6.70	3.33	0.89	2.09	0	0	0
Total Organic Carbon	-	mg/L	15	1.90	18.50	5.96	4.00	4.67	1.21	1.28	0	0	0	23	1.50	17.40	7.22	6.40	3.48	0.73	2.08	0	0	0
Total Aluminum	0.1[b]	mg/L	18	0.0195	0.5890	0.1494	0.0619	0.1794	0.0423	0.83	0	7	39	27	0.0063	0.4150	0.0702	0.0237	0.1022	0.0197	0.69	0	5	19
Total Antimony	-	mg/L	18	0.000040	0.000110	0.000068	0.000070	0.000016	0.000004	4.32	0	0	0	27	0.000200	0.000490	0.000337	0.000320	0.000087	0.000017	3.86	0	0	0
Total Arsenic	0.005	mg/L	18	0.000150	0.000990	0.000371	0.000250	0.000272	0.000064	1.36	0	0	0	27	0.000380	0.001380	0.000692	0.000660	0.000269	0.000052	2.57	0	0	0
Total Barium	-	mg/L	18	0.03	0.07	0.05	0.04785	0.0097	0.0023	4.99	0	0	0	27	0.04	0.09	0.06	0.05440	0.0135	0.0026	4.23	0	0	0
Total Beryllium	-	mg/L	18	0.000005	0.000050	0.000018	0.000010	0.000015	0.000004	1.17	5	0	0	27	0.000005	0.000040	0.000009	0.000005	0.000009	0.000002	1.01	19	0	0
Total Bismuth	-	mg/L	18	0.0000025	0.0000400	0.0000105	0.0000025	0.0000123	0.0000029	0.85	11	0	0	27	0.0000025	0.0000130	0.0000038	0.0000025	0.0000030	0.0000006	1.29	22	0	0
Total Boron	1.5	mg/L	18	0.03	0.03	0.03	0.03	0	-	-	18	0	0	27	0.03	0.03	0.03	0.03	0	-	-	27	0	0
Total Cadmium	0.000032 [c]	mg/L	18	0.000087	0.000505	0.000213	0.000172	0.000114	0.000027	1.86	0	18	100	27	0.000008	0.000084	0.000029	0.000021	0.000020	0.000004	1.40	0	5	19
Total Calcium	-	mg/L	18	4.49	18.30	12.66	12.50	3.92	0.93	3.23	0	0	0	27	11.40	48.20	33.44	32.60	11.32	2.18	2.95	0	0	0
Total Chromium	0.001	mg/L	18	0.00005	0.00050	0.00019	0.00015	0.00015	0.00003	1.31	6	0	0	27	0.00005	0.00080	0.00021	0.00020	0.00019	0.00004	1.12	5	0	0
Total Cobalt	-	mg/L	18	0.000024	0.000793	0.000184	0.000079	0.000234	0.000055	0.79	0	0	0	27	0.000020	0.000545	0.000103	0.000045	0.000131	0.000025	0.78	0	0	0
Total Copper	0.0023[d]	mg/L	18	0.0009	0.0107	0.0037	0.0025	0.0029	0.0007	1.26	0	14	78	27	0.0013	0.0081	0.0030	0.0024	0.0017	0.0003	1.69	0	11	41
Total Iron	0.3	mg/L	18	0.010	0.646	0.159	0.047	0.206	0.049	0.77	0	4	22	27	0.004	0.540	0.091	0.028	0.145	0.028	0.63	0	3	11
Total Lead	0.003[e]	mg/L	18	0.000017	0.000856	0.000248	0.000076	0.000292	0.000069	0.85	0	0	0	27	0.000009	0.001470	0.000141	0.000040	0.000295	0.000057	0.48	0	0	0
Total Lithium	-	mg/L	18	0.00025	0.00130	0.00069	0.00070	0.00028	0.00007	2.46	3	0	0	27	0.00025	0.00080	0.00045	0.00050	0.00019	0.00004	2.39	11	0	0
Total Magnesium	-	mg/L	18	0.93	3.81	2.60	2.58	0.77	0.18	3.38	0	0	0	27	4.18	17.30	11.15	10.80	3.77	0.72	2.96	0	0	0
Total Manganese	-	mg/L	18	0.0008	0.0845	0.0157	0.0047	0.0247	0.0058	0.64	0	0	0	27	0.0002	0.0369	0.0091	0.0046	0.0115	0.0022	0.79	0	0	0
Total Mercury	0.000026	mg/L	15	0.0000050	0.0000100	0.0000053	0.0000050	0.0000013	0.0000003	4.13	14	0	0	24	0.0000050	0.0000100	0.0000052	0.0000050	0.0000010	0.0000002	5.10	23	0	0
Total Molybdenum	0.073	mg/L	18	0.00007	0.00049	0.00026	0.00026	0.00010	0.00002	2.71	0	0	0	27	0.00037	0.00143	0.00089	0.00088	0.00028	0.00005	3.13	0	0	0
Total Nickel	0.0033[f]	mg/L	18	0.00063	0.00217	0.00107	0.00097	0.00044	0.00010	2.41	0	0	0	27	0.00045	0.00211	0.00085	0.00069	0.00038	0.00007	2.21	0	0	0
Total Phosphorus	-	mg/L	15	0.0010	0.0480	0.0121	0.0050	0.0158	0.0041	0.76	2	0	0	24	0.0010	0.0300	0.0071	0.0035	0.0089	0.0018	0.80	7	0	0
Total Potassium	-	mg/L	18	0.34	2.53	0.76	0.55	0.54	0.13	1.42	0	0	0	27	1.03	2.44	1.81	1.77	0.44	0.08	4.15	0	0	0
Total Selenium	0.001	mg/L	18	0.00002	0.00015	0.00007	0.00006	0.00003	0.00001	1.93	2	0	0	27	0.00002	0.00019	0.00008	0.00008	0.00003	0.00001	2.48	2	0	0
Total Silicon	-	mg/L	18	2.40	11.20	7.85	8.05	2.73	0.64	2.87	0	0	0	27	2.62	6.00	4.70	4.90	0.75	0.15	6.22	0	0	0

Note:

1) Canadian water quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2007
a) Ammonia (NH3) guideline based on ph=8 and temp=20
b) Aluminum (AL-T)= 0.005 mg/L at pH < 6.5: 0.1 mg/L at pH ≥ 6.5
c) Cadmium (Cd) mg/L: 10^(0.86*(log(hardness))-3.2)/1000
d) Copper (Cu) mg/L: (e^0.8545[ln(hardness)]-1.465)*0.2/1000; minimum is 0.002mg/L regardless of water hardness
e) Lead (Pb) mg/L: (e^1.273[ln(hardness)]-4.705)/1000; minimum is 0.001mg/L regardless of water hardness
f) Nickel (Ni) mg/L: (e^0.76[(ln(hardness)]+1.06)/1000; minimum is 0.025mg/L regardless of water hardness
Highlighted cells indicate updates from Project Proposal

"n"	Count
"min"	Minimum Value
"max"	Maximum Value
"sd"	Standard Deviation
"se"	Standard Error
"cov"	Covariance
"<DL"	# of Non-detectable Values
">GL"	# of Exceedances of CCME Guic
"%>GL"	% of Parameters that Exceed CCME Guidelin
"-"	No Data Available

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

Appendix B5. Surface Water Quality Statistics: All sites all parameters, Casino Project, 2008-2012

Parameters	CCME[1] Guideline	unit	W7											W3									
			n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL	n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL
Total Silver	0.0001	mg/L	18	0.000003	0.000026	0.000006	0.000003	0.000006	0.000001	0.92	12	0	0	27	0.000003	0.000014	0.000003	0.000003	0.000003	0.000001	1.17	24	0	0
Total Sodium	-	mg/L	18	0.92	5.27	3.52	3.71	1.32	0.31	2.67	0	0	0	27	1.40	5.90	3.93	3.98	1.23	0.24	3.20	0	0	0
Total Strontium	-	mg/L	18	0.031	0.141	0.085	0.089	0.027	0.006	3.11	0	0	0	27	0.071	0.345	0.209	0.204	0.072	0.014	2.91	0	0	0
Total Sulphur	-	mg/L	4	5.00	21.00	15.25	17.50	7.04	3.52	2.17	1	0	0	6	5.00	40.00	26.50	30.50	13.40	5.47	1.98	1	0	0
Total Thallium	0.0008	mg/L	18	0.0000010	0.0000110	0.0000035	0.0000030	0.0000027	0.0000006	1.27	3	0	0	27	0.0000010	0.0000080	0.0000026	0.0000020	0.0000019	0.0000004	1.34	11	0	0
Total Tin	-	mg/L	18	0.000005	0.000040	0.000008	0.000005	0.000008	0.000002	0.91	15	0	0	27	0.000005	0.000100	0.000014	0.000005	0.000026	0.000005	0.53	24	0	0
Total Titanium	-	mg/L	18	0.00025	0.01620	0.00348	0.00115	0.00498	0.00117	0.70	5	0	0	27	0.00025	0.01280	0.00190	0.00050	0.00315	0.00061	0.60	13	0	0
Total Uranium	0.015	mg/L	18	0.00004	0.00038	0.00013	0.00008	0.00010	0.00002	1.28	0	0	0	27	0.00339	0.03510	0.01226	0.00992	0.00801	0.00154	1.53	0	0	0
Total Vanadium	-	mg/L	18	0.00010	0.00120	0.00041	0.00025	0.00035	0.00008	1.16	4	0	0	27	0.00010	0.00085	0.00023	0.00010	0.00024	0.00005	0.96	18	0	0
Total Zinc	0.03	mg/L	18	0.00610	0.02800	0.01561	0.01410	0.00621	0.00146	2.51	0	0	0	27	0.00050	0.01330	0.00202	0.00110	0.00272	0.00052	0.74	0	0	0
Total Zirconium	-	mg/L	18	0.00005	0.00050	0.00015	0.00005	0.00014	0.00003	1.06	10	0	0	27	0.00005	0.00040	0.00017	0.00010	0.00011	0.00002	1.57	5	0	0
Dissolved Aluminum	0.1	mg/L	18	0.0092	0.3910	0.0899	0.0329	0.1163	0.0274	0.77	0	4	22	26	0.0056	0.2330	0.0377	0.0140	0.0540	0.0106	0.70	0	3	12
Dissolved Antimony	-	mg/L	18	0.00004	0.00009	0.00006	0.00006	0.00001	0.000003	4.60	0	0	0	26	0.00018	0.00049	0.00032	0.00031	0.00009	0.000017	3.62	0	0	0
Dissolved Arsenic	-	mg/L	18	0.00012	0.00064	0.00024	0.00021	0.00012	0.000028	2.03	0	0	0	26	0.00033	0.00083	0.00059	0.00058	0.00015	0.000029	3.97	0	0	0
Dissolved Barium	-	mg/L	18	0.028	0.061	0.046	0.047	0.009	0.002	4.93	0	0	0	26	0.031	0.090	0.056	0.054	0.015	0.003	3.78	0	0	0
Dissolved Beryllium	-	mg/L	18	0.000005	0.000050	0.000015	0.000008	0.000014	0.000003	1.09	9	0	0	26	0.000005	0.000020	0.000007	0.000005	0.000005	0.000001	1.38	22	0	0
Dissolved Bismuth	-	mg/L	18	0.0000025	0.0000150	0.0000032	0.0000025	0.0000029	0.0000007	1.08	17	0	0	26	0.0000025	0.0000025	0.0000025	0.0000025	0	-	-	26	0	0
Dissolved Boron	-	mg/L	18	0.025	0.025	0.025	0.025	0	-	-	18	0	0	26	0.025	0.025	0.025	0.025	0	-	-	26	0	0
Dissolved Cadmium	-	mg/L	18	0.000084	0.000431	0.000195	0.000160	0.000093	0.000022	2.09	0	0	0	26	0.000008	0.000066	0.000022	0.000018	0.000014	0.000003	1.61	0	0	0
Dissolved Calcium	-	mg/L	18	4.49	19.10	12.63	12.50	3.82	0.90	3.31	0	0	0	26	11.50	50.90	34.05	32.95	12.02	2.36	2.83	0	0	0
Dissolved Chromium	-	mg/L	18	0.00005	0.00030	0.00016	0.00020	0.00009	0.00002	1.78	6	0	0	26	0.00005	0.00030	0.00014	0.00015	0.00008	0.00001	1.87	7	0	0
Dissolved Cobalt	-	mg/L	18	0.000018	0.000554	0.000121	0.000061	0.000149	0.000035	0.81	0	0	0	26	0.000017	0.000255	0.000054	0.000043	0.000047	0.000009	1.16	0	0	0
Dissolved Copper	-	mg/L	18	0.0009	0.0079	0.0032	0.0022	0.0022	0.0005	1.43	0	0	0	26	0.0012	0.0072	0.0028	0.0022	0.0017	0.0003	1.65	0	0	0
Dissolved Iron	-	mg/L	18	0.005	0.312	0.068	0.017	0.098	0.023	0.69	0	0	0	26	0.003	0.227	0.037	0.016	0.052	0.010	0.71	0	0	0
Dissolved Lead	-	mg/L	18	0.000007	0.000330	0.000049	0.000017	0.000079	0.000019	0.62	0	0	0	26	0.000003	0.000339	0.000043	0.000016	0.000071	0.000014	0.61	2	0	0
Dissolved Lithium	-	mg/L	18	0.00025	0.00120	0.00069	0.00070	0.00027	0.00006	2.55	3	0	0	26	0.00025	0.00070	0.00044	0.00050	0.00018	0.00004	2.46	11	0	0
Dissolved Magnesium	-	mg/L	18	0.87	3.74	2.62	2.69	0.77	0.18	3.41	0	0	0	26	4.14	17.50	11.19	10.75	3.71	0.73	3.01	0	0	0
Dissolved Manganese	-	mg/L	18	0.0005	0.0672	0.0121	0.0035	0.0193	0.0045	0.63	0	0	0	26	0.0002	0.0189	0.0046	0.0030	0.0052	0.0010	0.90	0	0	0
Dissolved Mercury	-	mg/L	14	0.0000050	0.0000100	0.0000054	0.0000050	0.0000013	0.0000004	4.01	13	0	0	22	0.0000050	0.0000050	0.0000050	0.0000050	0	-	-	22	0	0
Dissolved Molybdenum	-	mg/L	18	0.00003	0.00078	0.00029	0.00026	0.00016	0.00004	1.78	1	0	0	26	0.00037	0.00143	0.00088	0.00087	0.00026	0.00005	3.34	0	0	0
Dissolved Nickel	-	mg/L	18	0.00059	0.00193	0.00101	0.00094	0.00040	0.00009	2.54	0	0	0	26	0.00044	0.00166	0.00079	0.00067	0.00035	0.00007	2.28	0	0	0
Dissolved Phosphorus	-	mg/L	14	0.0010	0.0180	0.0053	0.0025	0.0060	0.0016	0.88	4	0	0	22	0.0010	0.0130	0.0040	0.0030	0.0034	0.0007	1.18	7	0	0
Dissolved Potassium	-	mg/L	18	0.40	2.57	0.77	0.56	0.54	0.13	1.43	0	0	0	26	0.93	2.51	1.83	1.77	0.45	0.09	4.02	0	0	0
Dissolved Selenium	-	mg/L	18	0.00002	0.00015	0.00007	0.00006	0.00003	0.00001	2.16	1	0	0	26	0.00004	0.00019	0.00009	0.00008	0.00003	0.00001	2.98	0	0	0
Dissolved Silicon	-	mg/L	18	2.30	11.90	7.66	8.05	2.63	0.62	2.91	0	0	0	26	2.40	5.40	4.63	4.90	0.79	0.15	5.89	0	0	0
Dissolved Silver	-	mg/L	18	0.000003	0.000022	0.000004	0.000003	0.000005	0.000001	0.86	15	0	0	26	0.000003	0.000009	0.000003	0.000003	0.000002	0.000000	1.90	24	0	0
Dissolved Sodium	-	mg/L	18	0.99	5.03	3.59	3.94	1.29	0.30	2.78	0	0	0	26	1.50	5.81	3.90	4.10	1.16	0.23	3.35	0	0	0
Dissolved Strontium	-	mg/L	18	0.030	0.138	0.085	0.087	0.027	0.006	3.11	0	0	0	26	0.071	0.345	0.210	0.201	0.073	0.014	2.90	0	0	0
Dissolved Sulphur	-	mg/L	4	5.00	20.00	15.75	19.00	7.23	3.61	2.18	1	0	0	6	5.00	40.00	26.33	31.00	13.23	5.40	1.99	1	0	0
Dissolved Thallium	-	mg/L	18	0.0000010	0.0000070	0.0000023	0.0000020	0.0000017	0.0000004	1.33	7	0	0	26	0.0000010	0.0000040	0.0000020	0.0000015	0.0000011	0.0000002	1.73	13	0	0
Dissolved Tin	-	mg/L	18	0.000005	0.000090	0.000010	0.000005	0.000020	0.000005	0.50	16	0	0	26	0.000005	0.000100	0.000016	0.000005	0.000028	0.000005	0.59	22	0	0
Dissolved Titanium	-	mg/L	18	0.00025	0.00300	0.00061	0.00025	0.00077	0.00018	0.80	13	0	0	26	0.00025	0.00220	0.00050	0.00025	0.00051	0.00010	0.98	19	0	0
Dissolved Uranium	-	mg/L	18	0.00004	0.00029	0.00010	0.00007	0.00007	0.00002	1.41	0	0	0	26	0.00317	0.03560	0.01251	0.00977	0.00811	0.00159	1.54	0	0	0
Dissolved Vanadium	-	mg/L	18	0.00010	0.00050	0.00022	0.00020	0.00012	0.00003	1.74	8	0	0	26	0.00010	0.00040	0.00017	0.00010	0.00011	0.00002	1.52	18	0	0
Dissolved Zinc	-	mg/L	18	0.00810	0.02530	0.01461	0.01330	0.00522	0.00123	2.80	0	0	0	26	0.00040	0.00980	0.00173	0.00090	0.00233	0.00046	0.74	0	0	0
Dissolved Zirconium	-	mg/L	18	0.00005	0.00030	0.00011	0.00005	0.00008	0.00002	1.35	10	0	0	26	0.00005	0.00030	0.00015	0.00010	0.00009	0.00002	1.70	7	0	0

Note:

1) Canadian water quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2007
a) Ammonia (NH3) guideline based on ph=8 and temp=20
b) Aluminum (AL-T)= 0.005 mg/L at pH < 6.5: 0.1 mg/L at pH ≥ 6.5
c) Cadmium (Cd) mg/L: 10^(0.86*(log(hardness))-3.2)/1000
d) Copper (Cu) mg/L: (e^0.8545[ln(hardness)]-1.465)*0.2/1000; minimum is 0.002mg/L regardless of water hardness
e) Lead (Pb) mg/L: (e^1.273[ln(hardness)]-4.705)/1000; minimum is 0.001mg/L regardless of water hardness
f) Nickel (Ni) mg/L: (e^0.76[(ln(hardness)]+1.06)/1000; minimum is 0.025mg/L regardless of water hardness

"n"	Count
"min"	Minimum Value
"max"	Maximum Value
"sd"	Standard Deviation
"se"	Standard Error
"cov"	Covariance
"<DL"	# of Non-detectable Values
">GL"	# of Exceedances of CCME Guic
"%>GL"	% of Parameters that Exceed CCME Guidelin
"-"	No Data Available

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

Appendix B5. Surface Water Quality Statistics: All sites all parameters, Casino Project, 2008-2012

Parameters	CCME[1] Guideline	unit	W14										W2									
			n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL	n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL
pH	6.5 - 9.0	pH unit	22	7.00	8.20	7.85	7.91	0.29	0.06	27.23	0	0	0	21	7.10	8.10	7.82	7.90	0.23	0.05	33.40	0	0	0
Conductivity	-	µS/cm	22	49	585	290	283	141	30	2.06	0	0	0	21	78	445	285	287	105	23	2.72	0	0	0
Total Hardness CaCO3	-	mg/L	22	28	291	144	141	72	15	2.00	0	0	0	21	41	211	139	142	51	11	2.70	0	0	0
Dissolved Hardness CaCO3	-	mg/L	4	94	292	199	206	82	41	2.44	0	0	0	4	104	201	169	185	44	22	3.80	0	0	0
Ion Balance	-	no unit	3	0.98	1.10	1.03	1.00	0.06	0.04	15.97	0	0	0	3	1.00	1.10	1.03	1.00	0.06	0.03	17.90	0	0	0
Total Dissolved Solids	-	mg/L	22	46	370	198	200	81	17	2.44	0	0	0	21	78	320	196	200	64	14	3.06	0	0	0
Total Suspended Solids	-	mg/L	22	0.5	34.0	6.0	2.0	8.6	1.8	0.70	6	0	0	21	0.5	25.0	5.3	2.0	7.7	1.7	0.69	9	0	0
Turbidity	-	NTU	22	0.1	2.8	0.6	0.4	0.7	0.1	0.93	0	0	0	21	0.1	2.5	0.6	0.3	0.7	0.1	0.85	1	0	0
Ammonia as N	0.499[a]	mg/L	22	0.003	0.050	0.022	0.015	0.019	0.004	1.15	6	0	0	21	0.003	0.081	0.019	0.010	0.021	0.005	0.92	7	0	0
Alkalinity, Total (as CaCO3)	-	mg/L	22	10.0	160.0	88.09	91.5	39.74	8.47	2.22	0	0	0	21	15.0	120.0	79.81	82.0	29.05	6.34	2.75	0	0	0
Acidity (pH 4.5) as CaCO3	-	mg/L	4	0.25	0.25	0.25	0.25	0	-	-	4	0	0	4	0.25	0.25	0.25	0.25	0	-	-	4	0	0
Acidity (pH8.3) as CaCO3	-	mg/L	11	0.25	12.00	2.61	1.60	3.35	1.01	0.78	3	0	0	12	0.25	4.00	1.63	1.35	1.21	0.35	1.34	3	0	0
Bromide (Br)	-	mg/L	18	0.05	0.20	0.19	0.20	0.04	0.01	5.42	18	0	0	18	0.05	0.20	0.19	0.20	0.04	0.01	5.42	18	0	0
Chloride (Cl)	120	mg/L	22	0.25	1.70	0.79	0.70	0.45	0.10	1.76	6	0	0	21	0.25	1.40	0.59	0.60	0.35	0.08	1.69	8	0	0
Fluoride (F)	0.12	mg/L	18	0.040	0.150	0.094	0.100	0.029	0.007	3.22	0	2	11	18	0.050	0.130	0.096	0.100	0.023	0.005	4.17	0	1	6
Sulphate (SO4)	-	mg/L	22	0.25	130.00	60.59	53.50	36.94	7.88	1.64	1	0	0	21	8.80	110.00	62.61	60.00	28.09	6.13	2.23	0	0	0
Total Nitrogen (N)	-	mg/L	4	0.41	1510.00	377.89	0.58	754.74	377.37	0.50	0	0	0	4	0.34	0.60	0.45	0.44	0.11	0.06	3.96	0	0	0
Nitrate (as N)	13	mg/L	22	0.001	0.437	0.233	0.237	0.145	0.031	1.61	1	0	0	21	0.043	0.407	0.215	0.197	0.115	0.025	1.87	0	0	0
Nitrate plus Nitrite (N)	-	mg/L	4	0.001	0.390	0.250	0.305	0.171	0.085	1.46	1	0	0	4	0.125	0.402	0.300	0.336	0.121	0.060	2.48	0	0	0
Nitrite (as N)	0.06	mg/L	22	0.001	0.010	0.002	0.001	0.003	0.001	0.87	16	0	0	21	0.001	0.012	0.003	0.001	0.003	0.001	0.89	14	0	0
Total Kjeldahl Nitrogen	-	mg/L	21	0.05	0.59	0.30	0.28	0.1513	0.0330	2.01	0	0	0	21	0.06	0.99	0.28	0.21000	0.2234	0.0487	1.23	0	0	0
Ortho Phosphate as P	-	mg/L	22	0.0005	0.0260	0.0025	0.0010	0.0053	0.0011	0.46	6	0	0	21	0.0005	0.0370	0.0032	0.0020	0.0078	0.0017	0.41	4	0	0
Cyanide, Total	0.005	mg/L	22	0.00025	0.00180	0.00091	0.00080	0.00048	0.00010	1.91	4	0	0	21	0.00025	0.00150	0.00070	0.00070	0.00043	0.00009	1.61	8	0	0
Cyanide, Weak Acid Diss	-	mg/L	22	0.00025	0.00170	0.00080	0.00085	0.00042	0.00009	1.91	6	0	0	21	0.00025	0.00140	0.00065	0.00070	0.00040	0.00009	1.62	9	0	0
Dissolved Organic Carbon	-	mg/L	10	5.20	29.20	12.39	10.70	6.40	2.02	1.94	0	0	0	9	3.70	21.20	8.86	8.00	5.16	1.72	1.71	0	0	0
Total Organic Carbon	-	mg/L	18	5.20	28.80	12.74	11.45	5.50	1.30	2.32	0	0	0	17	3.40	21.50	8.58	7.30	4.50	1.09	1.90	0	0	0
Total Aluminum	0.1[b]	mg/L	22	0.0131	0.5420	0.1448	0.0601	0.1688	0.0360	0.86	0	8	36	21	0.0059	0.4600	0.1018	0.0373	0.1259	0.0275	0.81	0	7	33
Total Antimony	-	mg/L	22	0.000120	0.000330	0.000221	0.000230	0.000064	0.000014	3.46	0	0	0	21	0.000180	0.000430	0.000289	0.000270	0.000073	0.000016	3.95	1	0	0
Total Arsenic	0.005	mg/L	22	0.000440	0.001030	0.000620	0.000565	0.000174	0.000037	3.56	0	0	0	21	0.000410	0.001100	0.000661	0.000670	0.000213	0.000046	3.11	0	0	0
Total Barium	-	mg/L	22	0.06	0.12	0.08	0.07410	0.0188	0.0040	4.16	0	0	0	21	0.05	0.08	0.06	0.06280	0.0127	0.0028	5.08	0	0	0
Total Beryllium	-	mg/L	22	0.000005	0.000040	0.000014	0.000010	0.000011	0.000002	1.27	7	0	0	21	0.000005	0.000050	0.000013	0.000005	0.000013	0.000003	1.03	14	0	0
Total Bismuth	-	mg/L	22	0.0000025	0.0000200	0.0000041	0.0000025	0.0000049	0.0000010	0.85	19	0	0	21	0.0000025	0.0005000	0.0000275	0.0000025	0.0001083	0.0000236	0.25	18	0	0
Total Boron	1.5	mg/L	22	0.03	0.03	0.03	0.02500	0	-	-	22	0	0	21	0.03	0.15	0.03	0.02500	0.0273	0.0060	1.13	21	0	0
Total Cadmium	0.000032 [c]	mg/L	22	0.000003	0.000031	0.000013	0.000012	0.000010	0.000002	1.30	6	4	18	21	0.000008	0.000069	0.000022	0.000021	0.000014	0.000003	1.59	1	2	10
Total Calcium	-	mg/L	22	7.03	68.10	34.58	33.65	16.96	3.62	2.04	0	0	0	21	10.30	53.60	34.83	35.70	12.96	2.83	2.69	0	0	0
Total Chromium	0.001	mg/L	22	0.00005	0.00070	0.00030	0.00030	0.00017	0.00004	1.80	1	0	0	21	0.00005	0.00070	0.00025	0.00020	0.00016	0.00004	1.55	3	0	0
Total Cobalt	-	mg/L	22	0.000024	0.000418	0.000111	0.000059	0.000105	0.000022	1.06	0	0	0	21	0.000020	0.000492	0.000120	0.000081	0.000117	0.000025	1.03	1	0	0
Total Copper	0.0023[d]	mg/L	22	0.0008	0.0042	0.0018	0.0016	0.0008	0.0002	2.38	0	5	23	21	0.0013	0.0060	0.0025	0.0024	0.0012	0.0003	2.06	0	8	38
Total Iron	0.3	mg/L	22	0.008	0.567	0.143	0.045	0.167	0.036	0.85	0	5	23	21	0.004	0.549	0.116	0.042	0.143	0.031	0.81	0	2	10
Total Lead	0.003[e]	mg/L	22	0.000007	0.001500	0.000145	0.000024	0.000318	0.000068	0.45	0	0	0	21	0.000007	0.000443	0.000124	0.000066	0.000131	0.000029	0.94	0	0	0
Total Lithium	-	mg/L	22	0.00025	0.00250	0.00094	0.00090	0.00044	0.00009	2.14	1	0	0	21	0.00025	0.00250	0.00082	0.00070	0.00051	0.00011	1.60	6	0	0
Total Magnesium	-	mg/L	22	2.61	29.50	14.12	13.80	7.32	1.56	1.93	0	0	0	21	3.76	19.60	12.65	12.80	4.66	1.02	2.72	0	0	0
Total Manganese	-	mg/L	22	0.0004	0.0431	0.0108	0.0054	0.0127	0.0027	0.85	0	0	0	21	0.0008	0.0369	0.0102	0.0050	0.0103	0.0022	1.00	0	0	0
Total Mercury	0.000026	mg/L	19	0.0000050	0.0000100	0.0000055	0.0000050	0.0000016	0.0000004	3.51	17	0	0	17	0.0000050	0.0000250	0.0000065	0.0000050	0.0000049	0.0000012	1.31	16	1	6
Total Molybdenum	0.073	mg/L	22	0.00009	0.00127	0.00051	0.00054	0.00026	0.00005	1.97	0	0	0	21	0.00026	0.00152	0.00077	0.00071	0.00034	0.00007	2.27	1	0	0
Total Nickel	0.0033[f]	mg/L	22	0.00045	0.00107	0.00066	0.00056	0.00021	0.00004	3.20	0	0	0	21	0.00046	0.00270	0.00087	0.00067	0.00052	0.00011	1.69	0	0	0
Total Phosphorus	-	mg/L	19	0.0010	0.0360	0.0111	0.0080	0.0098	0.0022	1.13	1	0	0	18	0.0010	0.0390	0.0098	0.0050	0.0097	0.0023	1.02	3	0	0
Total Potassium	-	mg/L	22	0.80	2.82	1.80	1.73	0.63	0.14	2.83	0	0	0	21	0.94	2.56	1.88	1.90	0.48	0.11	3.89	0	0	0
Total Selenium	0.001	mg/L	22	0.00002	0.00045	0.00010	0.00008	0.00008	0.00002	1.18	1	0	0	21	0.00002	0.00030	0.00010	0.00010	0.00006	0.00001	1.77	1	0	0
Total Silicon	-	mg/L	22	1.60	5.40	4.04	4.20	0.97	0.21	4.16	0	0	0	21	2.40	5.70	4.49	4.60	0.77	0.17	5.83	0	0	0

Note:

1) Canadian water quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2007
a) Ammonia (NH3) guideline based on ph=8 and temp=20
b) Aluminum (AL-T)= 0.005 mg/L at pH < 6.5: 0.1 mg/L at pH ≥ 6.5
c) Cadmium (Cd) mg/L: 10^(0.86*(log(hardness))-3.2)/1000
d) Copper (Cu) mg/L: (e^0.8545[ln(hardness)]-1.465)*0.2/1000; minimum is 0.002mg/L regardless of water hardness
e) Lead (Pb) mg/L: (e^1.273[ln(hardness)]-4.705)/1000; minimum is 0.001mg/L regardless of water hardness
f) Nickel (Ni) mg/L: (e^0.76[(ln(hardness)]+1.06)/1000; minimum is 0.025mg/L regardless of water hardness
Highlighted cells indicate updates from Project Proposal

"n"	Count
"min"	Minimum Value
"max"	Maximum Value
"sd"	Standard Deviation
"se"	Standard Error
"cov"	Covariance
"<DL"	# of Non-detectable Values
">GL"	# of Exceedances of CCME Guic
"%>GL"	% of Parameters that Exceed CCME Guidelin
"-"	No Data Available

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

Appendix B5. Surface Water Quality Statistics: All sites all parameters, Casino Project, 2008-2012

Parameters	CCME[1] Guideline	unit	W14											W2										
			n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL	n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL
Total Silver	0.0001	mg/L	22	0.000003	0.000011	0.000003	0.000003	0.000002	0.000000	1.58	20	0	0	21	0.000003	0.000015	0.000004	0.000003	0.000004	0.000001	1.08	20	0	0
Total Sodium	-	mg/L	22	0.87	9.44	4.39	4.49	2.17	0.46	2.02	0	0	0	21	1.30	6.67	4.24	4.45	1.48	0.32	2.86	0	0	0
Total Strontium	-	mg/L	22	0.055	0.531	0.277	0.281	0.134	0.029	2.06	0	0	0	21	0.067	0.340	0.235	0.244	0.086	0.019	2.73	0	0	0
Total Sulphur	-	mg/L	4	12.00	57.00	33.75	33.00	18.68	9.34	1.81	0	0	0	4	16.00	38.00	29.50	32.00	9.98	4.99	2.95	0	0	0
Total Thallium	0.0008	mg/L	22	0.0000010	0.0000070	0.0000032	0.0000030	0.0000019	0.0000004	1.64	5	0	0	21	0.0000010	0.0000250	0.0000040	0.0000030	0.0000052	0.0000011	0.76	9	0	0
Total Tin	-	mg/L	22	0.000005	0.000060	0.000010	0.000005	0.000016	0.000003	0.62	20	0	0	21	0.000005	0.002500	0.000130	0.000005	0.000543	0.000119	0.24	19	0	0
Total Titanium	-	mg/L	22	0.00025	0.01610	0.00366	0.00140	0.00443	0.00095	0.83	3	0	0	21	0.00025	0.01510	0.00318	0.00120	0.00421	0.00092	0.76	7	0	0
Total Uranium	0.015	mg/L	22	0.00125	0.09710	0.01278	0.00842	0.01992	0.00425	0.64	0	0	0	21	0.00290	0.04160	0.01495	0.01060	0.01180	0.00257	1.27	0	0	0
Total Vanadium	-	mg/L	22	0.00010	0.00140	0.00051	0.00045	0.00040	0.00009	1.28	5	0	0	21	0.00010	0.00250	0.00049	0.00030	0.00056	0.00012	0.88	9	0	0
Total Zinc	0.03	mg/L	22	0.00020	0.00410	0.00132	0.00095	0.00111	0.00024	1.19	0	0	0	21	0.00050	0.00600	0.00159	0.00130	0.00140	0.00031	1.13	0	0	0
Total Zirconium	-	mg/L	22	0.00010	0.00070	0.00036	0.00040	0.00014	0.00003	2.50	0	0	0	21	0.00005	0.00050	0.00022	0.00020	0.00013	0.00003	1.74	5	0	0
Dissolved Aluminum	0.1	mg/L	22	0.0085	0.3680	0.1020	0.0449	0.1170	0.0250	0.87	0	7	32	21	0.0056	0.2720	0.0613	0.0334	0.0792	0.0173	0.77	0	4	19
Dissolved Antimony	-	mg/L	22	0.00010	0.00032	0.00022	0.00023	0.00007	0.000014	3.33	0	0	0	21	0.00016	0.00042	0.00029	0.00028	0.00007	0.000016	3.91	0	0	0
Dissolved Arsenic	-	mg/L	22	0.00037	0.00078	0.00054	0.00053	0.00008	0.000018	6.42	0	0	0	21	0.00036	0.00076	0.00057	0.00061	0.00011	0.000024	5.20	0	0	0
Dissolved Barium	-	mg/L	22	0.043	0.118	0.075	0.071	0.021	0.004	3.60	0	0	0	21	0.036	0.081	0.062	0.060	0.014	0.003	4.43	0	0	0
Dissolved Beryllium	-	mg/L	22	0.000005	0.000030	0.000011	0.000010	0.000008	0.000002	1.37	10	0	0	21	0.000005	0.000020	0.000008	0.000005	0.000005	0.000001	1.64	14	0	0
Dissolved Bismuth	-	mg/L	22	0.0000025	0.0000060	0.0000027	0.0000025	0.0000007	0.0000002	3.56	21	0	0	21	0.0000025	0.0000025	0.0000025	0.0000025	0	-	-	21	0	0
Dissolved Boron	-	mg/L	22	0.025	0.025	0.025	0.025	0	-	-	22	0	0	21	0.025	0.025	0.025	0.025	0	-	-	21	0	0
Dissolved Cadmium	-	mg/L	22	0.000003	0.000028	0.000012	0.000010	0.000007	0.000002	1.55	4	0	0	21	0.000005	0.000049	0.000019	0.000015	0.000010	0.000002	1.83	0	0	0
Dissolved Calcium	-	mg/L	22	6.83	68.90	33.86	33.30	16.66	3.55	2.03	0	0	0	21	10.30	52.00	34.35	33.70	12.86	2.81	2.67	0	0	0
Dissolved Chromium	-	mg/L	22	0.00005	0.00050	0.00025	0.00020	0.00012	0.00003	2.03	1	0	0	21	0.00005	0.00030	0.00017	0.00020	0.00009	0.00002	1.97	3	0	0
Dissolved Cobalt	-	mg/L	22	0.000022	0.000225	0.000079	0.000053	0.000058	0.000012	1.35	0	0	0	21	0.000017	0.000241	0.000064	0.000051	0.000052	0.000011	1.23	0	0	0
Dissolved Copper	-	mg/L	22	0.0008	0.0032	0.0017	0.0016	0.0006	0.0001	2.91	0	0	0	21	0.0012	0.0053	0.0024	0.0022	0.0011	0.0002	2.09	0	0	0
Dissolved Iron	-	mg/L	22	0.004	0.284	0.083	0.035	0.092	0.020	0.89	0	0	0	21	0.003	0.236	0.054	0.025	0.067	0.015	0.81	0	0	0
Dissolved Lead	-	mg/L	22	0.000003	0.000786	0.000072	0.000019	0.000166	0.000035	0.43	2	0	0	21	0.000003	0.000577	0.000078	0.000024	0.000146	0.000032	0.53	2	0	0
Dissolved Lithium	-	mg/L	22	0.00025	0.00240	0.00086	0.00080	0.00046	0.00010	1.89	3	0	0	21	0.00025	0.00120	0.00068	0.00070	0.00026	0.00006	2.68	3	0	0
Dissolved Magnesium	-	mg/L	22	2.43	29.20	13.97	13.55	6.95	1.48	2.01	0	0	0	21	3.74	18.60	12.35	12.60	4.49	0.98	2.75	0	0	0
Dissolved Manganese	-	mg/L	22	0.0001	0.0320	0.0075	0.0032	0.0093	0.0020	0.81	0	0	0	21	0.0008	0.0186	0.0060	0.0030	0.0063	0.0014	0.96	0	0	0
Dissolved Mercury	-	mg/L	18	0.0000050	0.0000100	0.0000056	0.0000050	0.0000016	0.0000004	3.44	16	0	0	17	0.0000050	0.0000050	0.0000050	0.0000050	0	-	-	17	0	0
Dissolved Molybdenum	-	mg/L	22	0.00015	0.00138	0.00053	0.00053	0.00026	0.00006	1.99	0	0	0	21	0.00028	0.00145	0.00081	0.00079	0.00031	0.00007	2.58	0	0	0
Dissolved Nickel	-	mg/L	22	0.00040	0.00223	0.00068	0.00055	0.00039	0.00008	1.73	0	0	0	21	0.00047	0.00129	0.00070	0.00063	0.00022	0.00005	3.12	0	0	0
Dissolved Phosphorus	-	mg/L	18	0.0010	0.0150	0.0058	0.0035	0.0042	0.0010	1.39	1	0	0	17	0.0010	0.0130	0.0041	0.0030	0.0036	0.0009	1.15	4	0	0
Dissolved Potassium	-	mg/L	22	0.72	2.97	1.80	1.74	0.64	0.14	2.83	0	0	0	21	0.85	2.56	1.85	1.91	0.49	0.11	3.76	0	0	0
Dissolved Selenium	-	mg/L	22	0.00002	0.00043	0.00010	0.00009	0.00008	0.00002	1.33	1	0	0	21	0.00002	0.00020	0.00010	0.00009	0.00004	0.00001	2.64	1	0	0
Dissolved Silicon	-	mg/L	22	1.30	5.30	4.00	4.25	1.01	0.22	3.96	0	0	0	21	2.10	5.78	4.44	4.60	0.86	0.19	5.14	0	0	0
Dissolved Silver	-	mg/L	22	0.000003	0.000008	0.000003	0.000003	0.000001	0.000000	2.35	21	0	0	21	0.000003	0.000008	0.000003	0.000003	0.000001	0.000000	2.11	19	0	0
Dissolved Sodium	-	mg/L	22	0.96	9.41	4.37	4.41	2.09	0.44	2.10	0	0	0	21	1.40	6.08	4.13	4.65	1.34	0.29	3.09	0	0	0
Dissolved Strontium	-	mg/L	22	0.053	0.522	0.272	0.265	0.131	0.028	2.07	0	0	0	21	0.069	0.341	0.233	0.236	0.085	0.018	2.76	0	0	0
Dissolved Sulphur	-	mg/L	4	13.00	55.00	34.25	34.50	17.19	8.60	1.99	0	0	0	4	15.00	37.00	30.00	34.00	10.13	5.07	2.96	0	0	0
Dissolved Thallium	-	mg/L	22	0.0000010	0.0000060	0.0000026	0.0000030	0.0000015	0.0000003	1.73	8	0	0	21	0.0000010	0.0000040	0.0000020	0.0000020	0.0000011	0.0000002	1.83	10	0	0
Dissolved Tin	-	mg/L	22	0.000005	0.000100	0.000011	0.000005	0.000020	0.000004	0.52	19	0	0	21	0.000005	0.000060	0.000008	0.000005	0.000012	0.000003	0.65	19	0	0
Dissolved Titanium	-	mg/L	22	0.00025	0.00410	0.00117	0.00060	0.00131	0.00028	0.89	10	0	0	21	0.00025	0.00260	0.00074	0.00025	0.00079	0.00017	0.94	13	0	0
Dissolved Uranium	-	mg/L	22	0.00109	0.09540	0.01257	0.00806	0.01948	0.00415	0.65	0	0	0	21	0.00275	0.04200	0.01492	0.01040	0.01175	0.00256	1.27	0	0	0
Dissolved Vanadium	-	mg/L	22	0.00010	0.00080	0.00040	0.00040	0.00022	0.00005	1.77	4	0	0	21	0.00010	0.00060	0.00023	0.00020	0.00015	0.00003	1.53	9	0	0
Dissolved Zinc	-	mg/L	22	0.00020	0.00830	0.00178	0.00070	0.00218	0.00047	0.82	0	0	0	21	0.00040	0.00810	0.00156	0.00080	0.00192	0.00042	0.81	0	0	0
Dissolved Zirconium	-	mg/L	22	0.00010	0.00070	0.00034	0.00030	0.00014	0.00003	2.43	0	0	0	21	0.00005	0.00040	0.00021	0.00020	0.00011	0.00002	1.87	3	0	0

Note:

1) Canadian water quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2007
a) Ammonia (NH3) guideline based on ph=8 and temp=20
b) Aluminum (AL-T)= 0.005 mg/L at pH < 6.5: 0.1 mg/L at pH ≥ 6.5
c) Cadmium (Cd) mg/L: 10^(0.86*(log(hardness))-3.2)/1000
d) Copper (Cu) mg/L: (e^0.8545[ln(hardness)]-1.465)*0.2/1000; minimum is 0.002mg/L regardless of water hardness
e) Lead (Pb) mg/L: (e^1.273[ln(hardness)]-4.705)/1000; minimum is 0.001mg/L regardless of water hardness
f) Nickel (Ni) mg/L: (e^0.76[(ln(hardness)]+1.06)/1000; minimum is 0.025mg/L regardless of water hardness

"n"	Count
"min"	Minimum Value
"max"	Maximum Value
"sd"	Standard Deviation
"se"	Standard Error
"cov"	Covariance
"<DL"	# of Non-detectable Values
">GL"	# of Exceedances of CCME Guic
"%>GL"	% of Parameters that Exceed CCME Guidelin
"-"	No Data Available

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

Appendix B5. Surface Water Quality Statistics: All sites all parameters, Casino Project, 2008-2012

Parameters	CCME[1] Guideline	unit	W1										W17									
			n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL	n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL
pH	6.5 - 9.0	pH unit	21	7.20	8.20	7.84	7.90	0.25	0.05	31.14	0	0	0	9	7.40	8.06	7.81	7.90	0.21	0.07	36.57	0	0	0
Conductivity	-	µS/cm	21	92	492	314	312	113	25	2.77	0	0	0	9	96	350	220	193	92	31	2.38	0	0	0
Total Hardness CaCO3	-	mg/L	21	50	248	152	149	57	12	2.66	0	0	0	9	47	159	103	97	40	13	2.59	0	0	0
Dissolved Hardness CaCO3	-	mg/L	4	113	242	188	199	55	28	3.41	0	0	0	5	46	167	115	129	47	21	2.44	0	0	0
Ion Balance	-	no unit	3	0.96	1.00	0.99	1.00	0.02	0.01	42.72	0	0	0	3	0.88	1.00	0.96	0.99	0.07	0.04	14.37	0	0	0
Total Dissolved Solids	-	mg/L	21	92	350	213	220	70	15	3.06	0	0	0	9	94	210	145	150	44	15	3.27	0	0	0
Total Suspended Solids	-	mg/L	21	0.5	190.0	11.1	2.0	41.1	9.0	0.27	8	0	0	9	0.5	37.7	7.2	4.0	11.8	3.9	0.61	3	0	0
Turbidity	-	NTU	21	0.1	3.6	0.6	0.3	0.8	0.2	0.72	0	0	0	9	0.2	5.2	1.0	0.5	1.6	0.5	0.61	0	0	0
Ammonia as N	0.499[a]	mg/L	20	0.003	0.070	0.016	0.008	0.018	0.004	0.88	8	0	0	9	0.003	0.059	0.018	0.010	0.019	0.006	0.98	3	0	0
Alkalinity, Total (as CaCO3)	-	mg/L	21	21.0	120.0	83.38	84.0	27.03	5.90	3.08	0	0	0	9	30.0	110.0	73.22	68.0	28.91	9.64	2.53	0	0	0
Acidity (pH 4.5) as CaCO3	-	mg/L	4	0.25	0.25	0.25	0.25	0	-	-	4	0	0	5	0.25	0.25	0.25	0.25	0	-	-	5	0	0
Acidity (pH8.3) as CaCO3	-	mg/L	12	0.25	5.30	2.02	1.40	1.81	0.52	1.12	3	0	0	6	0.25	5.50	1.73	1.19	1.96	0.80	0.88	2	0	0
Bromide (Br)	-	mg/L	17	0.20	0.20	0.20	0.20	0	-	-	17	0	0	6	0.01	0.20	0.14	0.20	0.10	0.04	1.34	6	0	0
Chloride (Cl)	120	mg/L	21	0.25	7.40	1.30	0.80	1.81	0.39	0.72	7	0	0	9	0.25	1.30	0.94	1.10	0.37	0.12	2.57	1	0	0
Fluoride (F)	0.12	mg/L	17	0.070	0.120	0.101	0.100	0.014	0.003	7.42	0	0	0	6	0.047	0.080	0.067	0.069	0.013	0.005	5.34	0	0	0
Sulphate (SO4)	-	mg/L	21	17.00	140.00	72.29	68.00	33.79	7.37	2.14	0	0	0	9	1.60	66.00	33.56	30.00	21.70	7.23	1.55	0	0	0
Total Nitrogen (N)	-	mg/L	4	0.38	0.61	0.51	0.52	0.10	0.05	4.98	0	0	0	5	0.36	0.74	0.54	0.54	0.17	0.08	3.17	0	0	0
Nitrate (as N)	13	mg/L	21	0.050	0.470	0.229	0.202	0.128	0.028	1.79	0	0	0	8	0.052	0.282	0.153	0.152	0.075	0.026	2.05	0	0	0
Nitrate plus Nitrite (N)	-	mg/L	4	0.201	0.470	0.340	0.344	0.110	0.055	3.08	0	0	0	4	0.099	0.282	0.183	0.176	0.077	0.039	2.38	0	0	0
Nitrite (as N)	0.06	mg/L	21	0.001	0.010	0.002	0.001	0.003	0.001	0.89	15	0	0	9	0.001	0.010	0.002	0.001	0.003	0.001	0.81	6	0	0
Total Kjeldahl Nitrogen	-	mg/L	20	0.05	0.50	0.24	0.23500	0.1124	0.0251	2.09	0	0	0	9	0.13	0.60	0.27	0.23000	0.1547	0.0516	1.73	0	0	0
Ortho Phosphate as P	-	mg/L	21	0.0005	0.0140	0.0020	0.0010	0.0028	0.0006	0.69	5	0	0	9	0.0005	0.0030	0.0012	0.0010	0.0009	0.0003	1.35	4	0	0
Cyanide, Total	0.005	mg/L	21	0.00025	0.00160	0.00060	0.00060	0.00041	0.00009	1.47	10	0	0	9	0.00025	0.00130	0.00074	0.00070	0.00043	0.00014	1.72	3	0	0
Cyanide, Weak Acid Diss	-	mg/L	21	0.00025	0.00140	0.00058	0.00050	0.00038	0.00008	1.53	10	0	0	9	0.00025	0.00140	0.00067	0.00060	0.00035	0.00012	1.89	2	0	0
Dissolved Organic Carbon	-	mg/L	10	0.25	11.30	7.41	7.45	3.09	0.98	2.40	1	0	0	5	4.22	16.80	9.66	9.20	4.79	2.14	2.02	0	0	0
Total Organic Carbon	-	mg/L	17	5.20	20.00	9.09	7.70	4.00	0.97	2.27	0	0	0	6	4.42	19.70	9.85	8.35	5.36	2.19	1.84	0	0	0
Total Aluminum	0.1[b]	mg/L	21	0.0089	0.7230	0.0875	0.0222	0.1600	0.0349	0.55	0	3	14	9	0.0166	0.4580	0.1187	0.0600	0.1447	0.0482	0.82	0	4	44
Total Antimony	-	mg/L	21	0.000180	0.000360	0.000272	0.000280	0.000054	0.000012	5.03	0	0	0	9	0.000130	0.000270	0.000216	0.000230	0.000053	0.000018	4.09	0	0	0
Total Arsenic	0.005	mg/L	21	0.000370	0.001620	0.000589	0.000500	0.000263	0.000057	2.24	0	0	0	9	0.000440	0.001100	0.000668	0.000620	0.000215	0.000072	3.10	0	0	0
Total Barium	-	mg/L	21	0.04	0.11	0.07	0.06060	0.0178	0.0039	3.71	0	0	0	9	0.05	0.12	0.08	0.06950	0.0217	0.0072	3.48	0	0	0
Total Beryllium	-	mg/L	21	0.000005	0.000060	0.000010	0.000005	0.000012	0.000003	0.78	14	0	0	9	0.000005	0.000034	0.000012	0.000005	0.000010	0.000003	1.17	5	0	0
Total Bismuth	-	mg/L	21	0.0000025	0.0000090	0.0000028	0.0000025	0.0000014	0.0000003	1.98	20	0	0	9	0.0000025	0.0000025	0.0000025	0.0000025	0	-	-	9	0	0
Total Boron	1.5	mg/L	21	0.03	0.03	0.03	0.03	0	-	-	21	0	0	9	0.03	0.03	0.03	0.03	0	-	-	9	0	0
Total Cadmium	0.000032 [c]	mg/L	21	0.000009	0.000080	0.000019	0.000015	0.000015	0.000003	1.29	0	1	5	9	0.000013	0.000087	0.000027	0.000021	0.000023	0.000008	1.19	0	2	22
Total Calcium	-	mg/L	21	12.40	62.50	38.08	37.30	14.44	3.15	2.64	0	0	0	9	11.80	37.70	25.18	24.50	9.21	3.07	2.73	0	0	0
Total Chromium	0.001	mg/L	21	0.00005	0.00110	0.00022	0.00020	0.00022	0.00005	1.00	3	1	5	9	0.00005	0.00051	0.00022	0.00030	0.00016	0.00005	1.43	2	0	0
Total Cobalt	-	mg/L	21	0.000026	0.000848	0.000105	0.000051	0.000176	0.000038	0.60	0	0	0	9	0.000023	0.000342	0.000100	0.000062	0.000099	0.000033	1.01	0	0	0
Total Copper	0.0023[d]	mg/L	21	0.0013	0.0066	0.0023	0.0019	0.0012	0.0003	1.96	0	6	29	9	0.0009	0.0027	0.0016	0.0018	0.0006	0.0002	2.87	0	1	11
Total Iron	0.3	mg/L	21	0.006	1.000	0.102	0.031	0.216	0.047	0.47	0	1	5	9	0.014	0.589	0.144	0.058	0.183	0.061	0.79	0	1	11
Total Lead	0.003[e]	mg/L	21	0.000005	0.000866	0.000085	0.000033	0.000184	0.000040	0.46	0	0	0	9	0.000017	0.000401	0.000130	0.000094	0.000121	0.000040	1.07	0	0	0
Total Lithium	-	mg/L	21	0.00025	0.00090	0.00069	0.00070	0.00015	0.00003	4.44	1	0	0	9	0.00050	0.00110	0.00078	0.00080	0.00017	0.00006	4.57	0	0	0
Total Magnesium	-	mg/L	21	4.54	22.30	13.83	13.30	5.16	1.13	2.68	0	0	0	9	4.18	15.70	9.78	8.77	4.12	1.37	2.37	0	0	0
Total Manganese	-	mg/L	21	0.0001	0.0689	0.0071	0.0021	0.0152	0.0033	0.47	0	0	0	9	0.0016	0.0410	0.0106	0.0069	0.0121	0.0040	0.88	0	0	0
Total Mercury	0.000026	mg/L	18	0.0000050	0.0000100	0.0000056	0.0000050	0.0000016	0.0000004	3.44	16	0	0	7	0.0000050	0.0000050	0.0000050	0.0000050	0	-	-	7	0	0
Total Molybdenum	0.073	mg/L	21	0.00030	0.00110	0.00077	0.00078	0.00023	0.00005	3.40	0	0	0	9	0.00020	0.00049	0.00036	0.00039	0.00010	0.00003	3.71	0	0	0
Total Nickel	0.0033[f]	mg/L	21	0.00044	0.00227	0.00074	0.00063	0.00039	0.00008	1.91	0	0	0	9	0.00039	0.00154	0.00074	0.00067	0.00036	0.00012	2.04	0	0	0
Total Phosphorus	-	mg/L	18	0.0010	0.0840	0.0093	0.0040	0.0191	0.0045	0.49	2	0	0	7	0.0030	0.0326	0.0102	0.0050	0.0106	0.0040	0.96	0	0	0
Total Potassium	-	mg/L	21	1.12	2.90	1.96	1.97	0.47	0.10	4.16	0	0	0	9	0.95	1.73	1.23	1.16	0.26	0.09	4.76	0	0	0
Total Selenium	0.001	mg/L	21	0.00002	0.00017	0.00011	0.00011	0.00003	0.00001	3.20	1	0	0	9	0.00002	0.00011	0.00007	0.00007	0.00003	0.00001	2.41	1	0	0
Total Silicon	-	mg/L	21	2.60	5.60	4.49	4.50	0.67	0.15	6.71	0	0	0	9	2.30	4.60	3.83	4.00	0.85	0.28	4.49	0	0	0

Note:

1) Canadian water quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2007
a) Ammonia (NH3) guideline based on ph=8 and temp=20
b) Aluminum (AL-T)= 0.005 mg/L at pH < 6.5: 0.1 mg/L at pH ≥ 6.5
c) Cadmium (Cd) mg/L: 10^(0.86*(log(hardness))-3.2)/1000
d) Copper (Cu) mg/L: (e^0.8545[ln(hardness)]-1.465)*0.2/1000; minimum is 0.002mg/L regardless of water hardness
e) Lead (Pb) mg/L: (e^1.273[ln(hardness)]-4.705)/1000; minimum is 0.001mg/L regardless of water hardness
f) Nickel (Ni) mg/L: (e^0.76[(ln(hardness)]+1.06)/1000; minimum is 0.025mg/L regardless of water hardness
Highlighted cells indicate updates from Project Proposal

"n"	Count
"min"	Minimum Value
"max"	Maximum Value
"sd"	Standard Deviation
"se"	Standard Error
"cov"	Covariance
"<DL"	# of Non-detectable Values
">GL"	# of Exceedances of CCME Guic
"%>GL"	% of Parameters that Exceed CCME Guidelin
"-"	No Data Available

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

Appendix B5. Surface Water Quality Statistics: All sites all parameters, Casino Project, 2008-2012

Parameters	CCME[1] Guideline	unit	W1											W17									
			n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL	n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL
Total Silver	0.0001	mg/L	21	0.000003	0.000010	0.000003	0.000003	0.000002	0.000000	1.75	20	0	0	9	0.000003	0.000012	0.000005	0.000003	0.000003	0.000001	1.31	6	0	0
Total Sodium	-	mg/L	21	1.39	6.09	4.17	4.39	1.30	0.28	3.20	0	0	0	9	1.54	5.05	3.48	3.87	1.24	0.41	2.80	0	0	0
Total Strontium	-	mg/L	21	0.081	0.381	0.239	0.236	0.085	0.019	2.82	0	0	0	9	0.083	0.265	0.171	0.163	0.063	0.021	2.72	0	0	0
Total Sulphur	-	mg/L	4	19.00	50.00	35.75	37.00	13.15	6.57	2.72	0	0	0	5	5.00	23.00	15.00	16.00	7.52	3.36	2.00	1	0	0
Total Thallium	0.0008	mg/L	21	0.0000010	0.0000110	0.0000027	0.0000030	0.0000023	0.0000005	1.20	8	0	0	9	0.0000010	0.0000052	0.0000028	0.0000030	0.0000014	0.0000005	1.95	2	0	0
Total Tin	-	mg/L	21	0.000005	0.000090	0.000009	0.000005	0.000019	0.000004	0.50	19	0	0	9	0.000005	0.000100	0.000034	0.000005	0.000043	0.000014	0.79	7	0	0
Total Titanium	-	mg/L	21	0.00025	0.02540	0.00247	0.00080	0.00550	0.00120	0.45	7	0	0	9	0.00025	0.01630	0.00386	0.00110	0.00529	0.00176	0.73	3	0	0
Total Uranium	0.015	mg/L	21	0.00350	0.03280	0.01385	0.01090	0.00943	0.00206	1.47	0	0	0	9	0.00126	0.00554	0.00248	0.00198	0.00141	0.00047	1.76	0	0	0
Total Vanadium	-	mg/L	21	0.00010	0.00200	0.00032	0.00020	0.00041	0.00009	0.77	9	0	0	9	0.00020	0.00169	0.00053	0.00030	0.00047	0.00016	1.12	0	0	0
Total Zinc	0.03	mg/L	21	0.00030	0.00620	0.00109	0.00080	0.00124	0.00027	0.87	0	0	0	9	0.00040	0.00523	0.00174	0.00140	0.00147	0.00049	1.18	0	0	0
Total Zirconium	-	mg/L	21	0.00010	0.00050	0.00022	0.00020	0.00011	0.00002	2.03	0	0	0	9	0.00010	0.00039	0.00022	0.00020	0.00011	0.00004	2.06	0	0	0
Dissolved Aluminum	0.1	mg/L	21	0.0078	0.2890	0.0574	0.0202	0.0739	0.0161	0.78	0	4	19	9	0.0113	0.1850	0.0638	0.0488	0.0651	0.0217	0.98	0	2	22
Dissolved Antimony	-	mg/L	21	0.00018	0.00039	0.00027	0.00027	0.00006	0.000013	4.50	0	0	0	9	0.00012	0.00027	0.00021	0.00024	0.00006	0.000019	3.77	0	0	0
Dissolved Arsenic	-	mg/L	21	0.00032	0.00076	0.00053	0.00052	0.00012	0.000026	4.49	0	0	0	9	0.00045	0.00069	0.00057	0.00056	0.00008	0.000025	7.45	0	0	0
Dissolved Barium	-	mg/L	21	0.037	0.106	0.064	0.059	0.019	0.004	3.35	0	0	0	9	0.043	0.121	0.073	0.063	0.025	0.008	2.88	0	0	0
Dissolved Beryllium	-	mg/L	21	0.000005	0.000020	0.000007	0.000005	0.000005	0.000001	1.59	15	0	0	9	0.000005	0.000020	0.000008	0.000005	0.000006	0.000002	1.38	7	0	0
Dissolved Bismuth	-	mg/L	21	0.0000025	0.0000050	0.0000026	0.0000025	0.0000005	0.0000001	4.80	20	0	0	9	0.0000025	0.0000084	0.0000032	0.0000025	0.0000020	0.0000007	1.60	8	0	0
Dissolved Boron	-	mg/L	21	0.025	0.025	0.025	0.025	0	-	-	21	0	0	9	0.025	0.025	0.025	0.025	0	-	-	9	0	0
Dissolved Cadmium	-	mg/L	21	0.000003	0.000049	0.000016	0.000014	0.000013	0.000003	1.29	4	0	0	9	0.000003	0.000029	0.000016	0.000018	0.000008	0.000003	1.91	1	0	0
Dissolved Calcium	-	mg/L	21	12.30	63.50	37.64	35.00	14.35	3.13	2.62	0	0	0	9	11.70	38.90	25.18	22.90	9.31	3.10	2.70	0	0	0
Dissolved Chromium	-	mg/L	21	0.00005	0.00040	0.00018	0.00020	0.00010	0.00002	1.73	5	0	0	9	0.00005	0.00030	0.00016	0.00020	0.00010	0.00003	1.58	3	0	0
Dissolved Cobalt	-	mg/L	21	0.000023	0.000204	0.000062	0.000045	0.000048	0.000011	1.29	0	0	0	9	0.000026	0.000086	0.000048	0.000041	0.000023	0.000008	2.13	0	0	0
Dissolved Copper	-	mg/L	21	0.0012	0.0051	0.0023	0.0019	0.0010	0.0002	2.35	0	0	0	9	0.0009	0.0025	0.0015	0.0015	0.0005	0.0002	2.86	0	0	0
Dissolved Iron	-	mg/L	21	0.004	0.236	0.052	0.021	0.066	0.014	0.79	0	0	0	9	0.011	0.157	0.059	0.050	0.054	0.018	1.09	0	0	0
Dissolved Lead	-	mg/L	21	0.000003	0.000564	0.000072	0.000014	0.000136	0.000030	0.53	7	0	0	9	0.000005	0.002260	0.000284	0.000031	0.000742	0.000247	0.38	0	0	0
Dissolved Lithium	-	mg/L	21	0.00025	0.00090	0.00066	0.00070	0.00019	0.00004	3.50	2	0	0	9	0.00025	0.00110	0.00070	0.00070	0.00025	0.00008	2.79	1	0	0
Dissolved Magnesium	-	mg/L	21	4.44	22.50	13.79	13.20	5.05	1.10	2.73	0	0	0	9	4.12	16.90	9.82	8.31	4.28	1.43	2.29	0	0	0
Dissolved Manganese	-	mg/L	21	0.0001	0.0184	0.0037	0.0013	0.0053	0.0012	0.71	0	0	0	9	0.0003	0.0073	0.0037	0.0033	0.0023	0.0008	1.59	0	0	0
Dissolved Mercury	-	mg/L	17	0.0000050	0.0000100	0.0000053	0.0000050	0.0000012	0.0000003	4.37	16	0	0	6	0.0000050	0.0000050	0.0000050	0.0000050	0	-	-	6	0	0
Dissolved Molybdenum	-	mg/L	21	0.00033	0.00106	0.00077	0.00082	0.00021	0.00005	3.62	0	0	0	9	0.00021	0.00055	0.00038	0.00040	0.00010	0.00003	3.65	0	0	0
Dissolved Nickel	-	mg/L	21	0.00047	0.00135	0.00073	0.00063	0.00026	0.00006	2.84	0	0	0	9	0.00030	0.00084	0.00056	0.00053	0.00017	0.00006	3.35	0	0	0
Dissolved Phosphorus	-	mg/L	17	0.0010	0.0130	0.0042	0.0030	0.0036	0.0009	1.16	6	0	0	6	0.0020	0.0110	0.0058	0.0040	0.0040	0.0016	1.45	0	0	0
Dissolved Potassium	-	mg/L	21	1.24	2.89	1.97	1.93	0.45	0.10	4.33	0	0	0	9	0.91	1.84	1.24	1.07	0.30	0.10	4.19	0	0	0
Dissolved Selenium	-	mg/L	21	0.00006	0.00016	0.00011	0.00011	0.00003	0.00001	3.61	0	0	0	9	0.00002	0.00011	0.00007	0.00008	0.00003	0.00001	2.49	1	0	0
Dissolved Silicon	-	mg/L	21	2.20	5.73	4.54	4.60	0.82	0.18	5.56	0	0	0	9	2.16	4.50	3.72	4.10	0.91	0.30	4.11	0	0	0
Dissolved Silver	-	mg/L	21	0.000003	0.000003	0.000003	0.000003	0	-	-	21	0	0	9	0.000003	0.000006	0.000003	0.000003	0.000001	0.000000	2.48	8	0	0
Dissolved Sodium	-	mg/L	21	1.50	5.95	4.10	4.20	1.18	0.26	3.47	0	0	0	9	1.55	5.31	3.50	3.71	1.22	0.41	2.87	0	0	0
Dissolved Strontium	-	mg/L	21	0.079	0.377	0.237	0.227	0.086	0.019	2.76	0	0	0	9	0.081	0.264	0.170	0.157	0.064	0.021	2.68	0	0	0
Dissolved Sulphur	-	mg/L	4	18.00	47.00	34.75	37.00	12.23	6.12	2.84	0	0	0	5	5.00	23.00	14.40	17.00	8.88	3.97	1.62	2	0	0
Dissolved Thallium	-	mg/L	21	0.0000010	0.0000050	0.0000024	0.0000020	0.0000014	0.0000003	1.74	8	0	0	9	0.0000010	0.0000040	0.0000018	0.0000010	0.0000011	0.0000004	1.63	5	0	0
Dissolved Tin	-	mg/L	21	0.000005	0.000080	0.000011	0.000005	0.000017	0.000004	0.63	17	0	0	9	0.000005	0.000100	0.000034	0.000005	0.000045	0.000015	0.77	8	0	0
Dissolved Titanium	-	mg/L	21	0.00025	0.00410	0.00085	0.00025	0.00110	0.00024	0.77	14	0	0	9	0.00025	0.00191	0.00076	0.00025	0.00067	0.00022	1.13	5	0	0
Dissolved Uranium	-	mg/L	21	0.00304	0.03340	0.01386	0.01100	0.00950	0.00207	1.46	0	0	0	9	0.00110	0.00561	0.00246	0.00201	0.00147	0.00049	1.68	0	0	0
Dissolved Vanadium	-	mg/L	21	0.00010	0.00060	0.00023	0.00020	0.00016	0.00004	1.39	10	0	0	9	0.00010	0.00080	0.00035	0.00030	0.00020	0.00007	1.71	1	0	0
Dissolved Zinc	-	mg/L	21	0.00020	0.00690	0.00160	0.00080	0.00187	0.00041	0.86	0	0	0	9	0.00040	0.00860	0.00236	0.00140	0.00277	0.00092	0.85	0	0	0
Dissolved Zirconium	-	mg/L	21	0.00010	0.00040	0.00021	0.00020	0.00009	0.00002	2.36	0	0	0	9	0.00010	0.00030	0.00019	0.00020	0.00008	0.00003	2.42	0	0	0

Note:

1) Canadian water quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2007
a) Ammonia (NH3) guideline based on ph=8 and temp=20
b) Aluminum (AL-T)= 0.005 mg/L at pH < 6.5: 0.1 mg/L at pH ≥ 6.5
c) Cadmium (Cd) mg/L: 10^(0.86*(log(hardness))-3.2)/1000
d) Copper (Cu) mg/L: (e^0.8545[ln(hardness)]-1.465)*0.2/1000; minimum is 0.002mg/L regardless of water hardness
e) Lead (Pb) mg/L: (e^1.273[ln(hardness)]-4.705)/1000; minimum is 0.001mg/L regardless of water hardness
f) Nickel (Ni) mg/L: (e^0.76[(ln(hardness)]+1.06)/1000; minimum is 0.025mg/L regardless of water hardness

"n"	Count
"min"	Minimum Value
"max"	Maximum Value
"sd"	Standard Deviation
"se"	Standard Error
"cov"	Covariance
"<DL"	# of Non-detectable Values
">GL"	# of Exceedances of CCME Guic
"%>GL"	% of Parameters that Exceed CCME Guidelin
"-"	No Data Available

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

Appendix B5. Surface Water Quality Statistics: All sites all parameters, Casino Project, 2008-2012

Parameters	CCME[1] Guideline	unit	W6B										W6A									
			n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL	n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL
pH	6.5 - 9.0	pH unit	25	7.70	8.20	7.97	8.00	0.14	0.03	56.05	0	0	0	23	7.60	8.20	7.95	8.00	0.15	0.03	53.24	0	0	0
Conductivity	-	µS/cm	25	170	243	205	204	17	3	12.16	0	0	0	23	150	257	187	180	29	6	6.39	0	0	0
Total Hardness CaCO3	-	mg/L	24	82	117	102	104	7	2	13.58	0	0	0	22	74	115	90	88	13	3	7.17	0	0	0
Dissolved Hardness CaCO3	-	mg/L	5	99	105	102	103	2	1	44.82	0	0	0	3	77	105	89	86	14	8	6.27	0	0	0
Ion Balance	-	no unit	3	0.88	1.00	0.94	0.93	0.06	0.03	15.54	0	0	0	2	0.91	1.00	0.96	0.96	0.06	0.05	15.01	0	0	0
Total Dissolved Solids	-	mg/L	25	80	180	129	130	25	5	5.15	0	0	0	23	68	150	114	110	22	5	5.18	0	0	0
Total Suspended Solids	-	mg/L	24	0.5	190.0	25.1	11.0	39.5	8.1	0.63	5	0	0	22	0.5	140.0	22.5	10.0	30.7	6.6	0.73	3	0	0
Turbidity	-	NTU	25	0.2	47.4	9.6	5.1	11.2	2.2	0.85	0	0	0	23	0.1	35.1	7.5	2.7	10.2	2.1	0.74	0	0	0
Ammonia as N	0.499[a]	mg/L	24	0.003	0.060	0.017	0.007	0.018	0.004	0.95	12	0	0	22	0.003	0.051	0.012	0.005	0.012	0.003	1.04	12	0	0
Alkalinity, Total (as CaCO3)	-	mg/L	25	61.0	93.9	79.35	79.9	7.74	1.55	10.25	0	0	0	23	61.0	96.0	74.78	73.0	9.92	2.07	7.54	0	0	0
Acidity (pH 4.5) as CaCO3	-	mg/L	6	0.25	0.25	0.25	0.25	0	-	-	6	0	0	4	0.25	0.25	0.25	0.25	0	-	-	4	0	0
Acidity (pH8.3) as CaCO3	-	mg/L	14	0.25	3.70	1.05	0.80	0.95	0.25	1.11	4	0	0	12	0.25	5.00	1.05	0.85	1.32	0.38	0.80	5	0	0
Bromide (Br)	-	mg/L	21	0.01	0.20	0.17	0.20	0.07	0.01	2.68	21	0	0	18	0.05	0.20	0.19	0.20	0.04	0.01	5.42	18	0	0
Chloride (Cl)	120	mg/L	25	0.25	1.30	0.43	0.25	0.31	0.06	1.37	17	0	0	23	0.25	2.20	0.51	0.25	0.46	0.09	1.12	14	0	0
Fluoride (F)	0.12	mg/L	21	0.080	0.140	0.111	0.110	0.014	0.003	7.82	0	3	14	19	0.090	0.130	0.107	0.110	0.011	0.002	10.11	0	1	5
Sulphate (SO4)	-	mg/L	25	19.00	33.00	25.98	25.00	4.31	0.86	6.03	0	0	0	23	12.00	34.00	21.13	21.00	6.23	1.30	3.39	0	0	0
Total Nitrogen (N)	-	mg/L	6	0.12	0.27	0.18	0.16	0.07	0.03	2.76	0	0	0	4	0.10	0.24	0.16	0.15	0.07	0.03	2.39	0	0	0
Nitrate (as N)	13	mg/L	25	0.001	0.117	0.033	0.019	0.033	0.007	1.00	2	0	0	23	0.001	0.168	0.034	0.015	0.044	0.009	0.77	2	0	0
Nitrate plus Nitrite (N)	-	mg/L	6	0.005	0.117	0.049	0.036	0.045	0.018	1.08	0	0	0	4	0.001	0.168	0.053	0.022	0.078	0.039	0.68	1	0	0
Nitrite (as N)	0.06	mg/L	25	0.001	0.008	0.002	0.001	0.002	0.000	1.11	18	0	0	23	0.001	0.019	0.002	0.001	0.004	0.001	0.57	18	0	0
Total Kjeldahl Nitrogen	-	mg/L	25	0.01	0.25	0.11	0.09000	0.0620	0.0124	1.77	1	0	0	23	0.01	0.24	0.12	0.11000	0.0669	0.0139	1.76	1	0	0
Ortho Phosphate as P	-	mg/L	25	0.0005	0.0450	0.0031	0.0010	0.0088	0.0018	0.36	7	0	0	23	0.0005	0.0460	0.0035	0.0010	0.0093	0.0019	0.37	5	0	0
Cyanide, Total	0.005	mg/L	24	0.00025	0.00070	0.00028	0.00025	0.00011	0.00002	2.49	22	0	0	22	0.00025	0.00110	0.00031	0.00025	0.00021	0.00005	1.49	20	0	0
Cyanide, Weak Acid Diss	-	mg/L	24	0.00025	0.00025	0.00025	0.00025	0	-	-	24	0	0	22	0.00025	0.00110	0.00029	0.00025	0.00018	0.00004	1.59	21	0	0
Dissolved Organic Carbon	-	mg/L	12	0.90	9.26	3.41	2.65	2.36	0.68	1.44	0	0	0	10	0.50	7.20	2.80	2.45	1.92	0.61	1.46	0	0	0
Total Organic Carbon	-	mg/L	20	1.60	10.00	3.50	2.85	2.16	0.48	1.62	0	0	0	18	0.80	7.70	2.69	2.45	1.53	0.36	1.76	0	0	0
Total Aluminum	0.1[b]	mg/L	24	0.0024	0.6780	0.1814	0.1220	0.1809	0.0369	1.00	0	14	58	22	0.0022	0.6360	0.1477	0.0911	0.1621	0.0346	0.91	0	10	45
Total Antimony	-	mg/L	24	0.0000700	0.0002500	0.0001367	0.0001250	0.0000465	0.0000095	2.94	1	0	0	22	0.0000700	0.0001700	0.0001082	0.0001000	0.0000226	0.0000048	4.79	0	0	0
Total Arsenic	0.005	mg/L	24	0.0002200	0.0021200	0.0006687	0.0005350	0.0004188	0.0000855	1.60	0	0	0	22	0.0001400	0.0017700	0.0005841	0.0005050	0.0003428	0.0000731	1.70	0	0	0
Total Barium	-	mg/L	24	0.05	0.15	0.06	0.05700	0.0223	0.0045	2.80	0	0	0	22	0.03	0.11	0.05	0.04600	0.0173	0.0037	2.98	0	0	0
Total Beryllium	-	mg/L	24	0.000005	0.000100	0.000020	0.000010	0.000022	0.000004	0.91	11	0	0	22	0.000005	0.000080	0.000013	0.000005	0.000017	0.000004	0.78	13	0	0
Total Bismuth	-	mg/L	24	0.0000025	0.0005000	0.0000256	0.0000025	0.0001011	0.0000206	0.25	16	0	0	22	0.0000025	0.0000160	0.0000044	0.0000025	0.0000037	0.0000008	1.18	16	0	0
Total Boron	1.5	mg/L	24	0.03	0.03	0.03	0.03	0	-	-	24	0	0	22	0.03	0.03	0.03	0.03	0	-	-	22	0	0
Total Cadmium	0.000032 [c]	mg/L	24	0.000014	0.000621	0.000111	0.000067	0.000133	0.000027	0.83	0	17	71	22	0.000008	0.000369	0.000064	0.000039	0.000081	0.000017	0.78	0	14	64
Total Calcium	-	mg/L	24	22.20	33.40	27.76	28.05	2.17	0.44	12.79	0	0	0	22	20.20	32.10	24.95	24.30	3.56	0.76	7.02	0	0	0
Total Chromium	0.001	mg/L	24	0.00005	0.00110	0.00033	0.00025	0.00028	0.00006	1.15	7	1	4	22	0.00005	0.00110	0.00029	0.00020	0.00026	0.00006	1.11	1	1	5
Total Cobalt	-	mg/L	24	0.000014	0.001930	0.000298	0.000172	0.000405	0.000083	0.74	1	0	0	22	0.000003	0.001160	0.000202	0.000110	0.000266	0.000057	0.76	1	0	0
Total Copper	0.0023[d]	mg/L	24	0.0004	0.0081	0.0018	0.0011	0.0017	0.0004	1.02	0	5	21	22	0.0003	0.0060	0.0014	0.0012	0.0013	0.0003	1.13	0	4	18
Total Iron	0.3	mg/L	24	0.019	2.170	0.399	0.190	0.497	0.102	0.80	0	10	42	22	0.002	1.560	0.300	0.161	0.366	0.078	0.82	0	8	36
Total Lead	0.003[e]	mg/L	24	0.000009	0.002900	0.000409	0.000162	0.000611	0.000125	0.67	1	0	0	22	0.000003	0.001830	0.000301	0.000135	0.000411	0.000088	0.73	1	0	0
Total Lithium	-	mg/L	24	0.00110	0.00262	0.00198	0.00195	0.00043	0.00009	4.57	1	0	0	22	0.00100	0.00210	0.00149	0.00140	0.00033	0.00007	4.57	0	0	0
Total Magnesium	-	mg/L	24	6.37	9.01	7.88	7.93	0.68	0.14	11.66	0	0	0	22	5.24	8.73	6.77	6.53	0.98	0.21	6.88	0	0	0
Total Manganese	-	mg/L	24	0.0048	0.1970	0.0395	0.0263	0.0423	0.0086	0.93	0	0	0	22	0.0003	0.1320	0.0223	0.0147	0.0286	0.0061	0.78	0	0	0
Total Mercury	0.000026	mg/L	22	0.0000050	0.0000200	0.0000057	0.0000050	0.0000032	0.0000007	1.78	21	0	0	20	0.0000050	0.0000100	0.0000053	0.0000050	0.0000011	0.0000003	4.70	19	0	0
Total Molybdenum	0.073	mg/L	24	0.00059	0.00126	0.00103	0.00102	0.00018	0.00004	5.70	0	0	0	22	0.00068	0.00128	0.00102	0.00101	0.00015	0.00003	6.61	0	0	0
Total Nickel	0.0033[f]	mg/L	24	0.00042	0.01010	0.00253	0.00214	0.00229	0.00047	1.10	0	0	0	22	0.00028	0.00662	0.00164	0.00124	0.00145	0.00031	1.13	0	0	0
Total Phosphorus	-	mg/L	22	0.0010	0.2680	0.0360	0.0170	0.0574	0.0122	0.63	3	0	0	20	0.0010	0.1970	0.0279	0.0130	0.0441	0.0099	0.63	4	0	0
Total Potassium	-	mg/L	24	0.70	1.17	0.84	0.80	0.13	0.03	6.19	0	0	0	22	0.69	1.07	0.80	0.76	0.11	0.02	7.17	0	0	0
Total Selenium	0.001	mg/L	24	0.00030	0.00069	0.00047	0.00047	0.00010	0.00002	4.68	0	0	0	22	0.00023	0.00068	0.00034	0.00031	0.00011	0.00002	2.93	0	0	0
Total Silicon	-	mg/L	24	2.30	4.00	3.15	3.15	0.41	0.08	7.76	0	0	0	22	2.50	3.60	3.07	3.10	0.34	0.07	9.02	0	0	0

Note:

1) Canadian water quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2007
a) Ammonia (NH3) guideline based on ph=8 and temp=20
b) Aluminum (AL-T)= 0.005 mg/L at pH < 6.5: 0.1 mg/L at pH ≥ 6.5
c) Cadmium (Cd) mg/L: 10^(0.86*(log(hardness))-3.2)/1000
d) Copper (Cu) mg/L: (e^0.8545[ln(hardness)]-1.465)*0.2/1000; minimum is 0.002mg/L regardless of water hardness
e) Lead (Pb) mg/L: (e^1.273[ln(hardness)]-4.705)/1000; minimum is 0.001mg/L regardless of water hardness
f) Nickel (Ni) mg/L: (e^0.76[(ln(hardness)]+1.06)/1000; minimum is 0.025mg/L regardless of water hardness
Highlighted cells indicate updates from Project Proposal

"n"	Count
"min"	Minimum Value
"max"	Maximum Value
"sd"	Standard Deviation
"se"	Standard Error
"cov"	Covariance
"<DL"	# of Non-detectable Values
">GL"	# of Exceedances of CCME Guic
"%>GL"	% of Parameters that Exceed CCME Guidelin
"-"	No Data Available

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

Appendix B5. Surface Water Quality Statistics: All sites all parameters, Casino Project, 2008-2012

Parameters	CCME[1] Guideline	unit	W6B											W6A										
			n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL	n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL
Total Silver	0.0001	mg/L	24	0.000003	0.000022	0.000005	0.000003	0.000005	0.000001	1.10	16	0	0	22	0.000003	0.000011	0.000004	0.000003	0.000002	0.000001	1.46	18	0	0
Total Sodium	-	mg/L	24	1.43	2.21	1.82	1.84	0.21	0.04	8.63	0	0	0	22	1.54	2.23	1.84	1.81	0.21	0.04	8.71	0	0	0
Total Strontium	-	mg/L	24	0.104	0.147	0.126	0.128	0.010	0.002	12.79	0	0	0	22	0.089	0.135	0.113	0.111	0.014	0.003	7.94	0	0	0
Total Sulphur	-	mg/L	5	5.00	11.00	9.60	11.00	2.61	1.17	3.68	1	0	0	3	5.00	10.00	6.67	5.00	2.89	1.67	2.31	2	0	0
Total Thallium	0.0008	mg/L	24	0.0000010	0.0000250	0.0000066	0.0000045	0.0000061	0.0000012	1.07	6	0	0	22	0.0000010	0.0000160	0.0000042	0.0000035	0.0000034	0.0000007	1.25	4	0	0
Total Tin	-	mg/L	24	0.000005	0.002500	0.000125	0.000005	0.000507	0.000104	0.25	20	0	0	22	0.000005	0.000050	0.000007	0.000005	0.000010	0.000002	0.76	20	0	0
Total Titanium	-	mg/L	24	0.00025	0.01710	0.00450	0.00265	0.00451	0.00092	1.00	6	0	0	22	0.00025	0.01720	0.00403	0.00215	0.00455	0.00097	0.88	4	0	0
Total Uranium	0.015	mg/L	24	0.00086	0.00144	0.00104	0.00098	0.00016	0.00003	6.55	0	0	0	22	0.00085	0.00161	0.00105	0.00098	0.00023	0.00005	4.68	0	0	0
Total Vanadium	-	mg/L	24	0.00010	0.00320	0.00086	0.00045	0.00087	0.00018	0.99	6	0	0	22	0.00010	0.00280	0.00063	0.00035	0.00068	0.00014	0.94	6	0	0
Total Zinc	0.03	mg/L	24	0.00110	0.04360	0.00820	0.00560	0.00930	0.00190	0.88	1	1	4	22	0.00080	0.02480	0.00484	0.00285	0.00559	0.00119	0.87	0	0	0
Total Zirconium	-	mg/L	24	0.00005	0.00050	0.00014	0.00010	0.00014	0.00003	0.99	12	0	0	22	0.00005	0.00060	0.00012	0.00005	0.00014	0.00003	0.88	13	0	0
Dissolved Aluminum	0.1	mg/L	24	0.0014	0.0809	0.0228	0.0217	0.0193	0.0039	1.18	0	0	0	22	0.0015	0.0642	0.0182	0.0170	0.0150	0.0032	1.21	0	0	0
Dissolved Antimony	-	mg/L	24	0.00008	0.00017	0.00012	0.00012	0.00002	0.000005	5.14	0	0	0	22	0.00007	0.00013	0.00010	0.00010	0.00001	0.000003	6.85	0	0	0
Dissolved Arsenic	-	mg/L	24	0.00018	0.00059	0.00042	0.00042	0.00010	0.000020	4.30	0	0	0	22	0.00012	0.00053	0.00039	0.00042	0.00011	0.000023	3.71	0	0	0
Dissolved Barium	-	mg/L	24	0.039	0.061	0.047	0.046	0.005	0.001	8.59	0	0	0	22	0.035	0.073	0.042	0.039	0.010	0.002	4.22	0	0	0
Dissolved Beryllium	-	mg/L	24	0.000005	0.000010	0.000005	0.000005	0.000001	0.000000	5.10	23	0	0	22	0.000005	0.000010	0.000005	0.000005	0.000001	0.000000	4.90	21	0	0
Dissolved Bismuth	-	mg/L	24	0.0000025	0.0000025	0.0000025	0.0000025	0	-	-	24	0	0	22	0.0000025	0.0000060	0.0000027	0.0000025	0.0000007	0.0000002	3.56	21	0	0
Dissolved Boron	-	mg/L	24	0.025	0.025	0.025	0.025	0	-	-	24	0	0	22	0.025	0.025	0.025	0.025	0	-	-	22	0	0
Dissolved Cadmium	-	mg/L	24	0.000011	0.000094	0.000033	0.000025	0.000022	0.000005	1.51	0	0	0	22	0.000005	0.000064	0.000023	0.000019	0.000016	0.000003	1.44	0	0	0
Dissolved Calcium	-	mg/L	24	24.70	32.30	27.17	27.00	1.82	0.37	14.97	0	0	0	22	20.10	32.80	24.40	23.80	3.46	0.74	7.06	0	0	0
Dissolved Chromium	-	mg/L	24	0.00005	0.00020	0.00008	0.00005	0.00005	0.00001	1.51	17	0	0	22	0.00005	0.00020	0.00009	0.00005	0.00005	0.00001	1.67	12	0	0
Dissolved Cobalt	-	mg/L	24	0.000007	0.000098	0.000028	0.000022	0.000023	0.000005	1.22	0	0	0	22	0.000003	0.000073	0.000021	0.000015	0.000020	0.000004	1.07	1	0	0
Dissolved Copper	-	mg/L	24	0.0003	0.0026	0.0010	0.0008	0.0006	0.0001	1.69	0	0	0	22	0.0003	0.0021	0.0008	0.0007	0.0005	0.0001	1.70	0	0	0
Dissolved Iron	-	mg/L	24	0.004	0.170	0.036	0.024	0.040	0.008	0.90	0	0	0	22	0.001	0.128	0.026	0.018	0.032	0.007	0.81	1	0	0
Dissolved Lead	-	mg/L	24	0.000003	0.000137	0.000038	0.000040	0.000031	0.000006	1.24	3	0	0	22	0.000003	0.000199	0.000047	0.000024	0.000055	0.000012	0.86	4	0	0
Dissolved Lithium	-	mg/L	24	0.00130	0.00232	0.00177	0.00180	0.00026	0.00005	6.82	0	0	0	22	0.00100	0.00180	0.00135	0.00125	0.00025	0.00005	5.46	0	0	0
Dissolved Magnesium	-	mg/L	24	6.69	8.55	7.78	7.92	0.54	0.11	14.51	0	0	0	22	5.16	8.53	6.64	6.43	0.95	0.20	6.98	0	0	0
Dissolved Manganese	-	mg/L	24	0.0010	0.0853	0.0103	0.0034	0.0183	0.0037	0.56	0	0	0	22	0.0003	0.0117	0.0034	0.0023	0.0034	0.0007	1.00	0	0	0
Dissolved Mercury	-	mg/L	21	0.0000050	0.0000050	0.0000050	0.0000050	0	-	-	21	0	0	19	0.0000050	0.0000050	0.0000050	0.0000050	0	-	-	19	0	0
Dissolved Molybdenum	-	mg/L	24	0.00088	0.00129	0.00111	0.00109	0.00013	0.00003	8.66	0	0	0	22	0.00090	0.00129	0.00108	0.00106	0.00011	0.00002	9.94	0	0	0
Dissolved Nickel	-	mg/L	24	0.00039	0.00386	0.00143	0.00121	0.00090	0.00018	1.58	0	0	0	22	0.00027	0.00252	0.00095	0.00079	0.00062	0.00013	1.53	0	0	0
Dissolved Phosphorus	-	mg/L	21	0.0010	0.0100	0.0027	0.0010	0.0028	0.0006	0.98	12	0	0	19	0.0010	0.0080	0.0023	0.0010	0.0023	0.0005	0.99	13	0	0
Dissolved Potassium	-	mg/L	24	0.64	1.11	0.81	0.78	0.12	0.02	6.63	0	0	0	22	0.67	1.06	0.79	0.76	0.11	0.02	7.42	0	0	0
Dissolved Selenium	-	mg/L	24	0.00035	0.00062	0.00047	0.00048	0.00008	0.00002	5.63	0	0	0	22	0.00023	0.00066	0.00034	0.00032	0.00011	0.00002	3.12	0	0	0
Dissolved Silicon	-	mg/L	24	1.95	3.60	2.89	2.98	0.32	0.07	9.04	0	0	0	22	2.30	3.50	2.89	2.80	0.29	0.06	9.79	0	0	0
Dissolved Silver	-	mg/L	24	0.000003	0.000003	0.000003	0.000003	0	-	-	24	0	0	22	0.000003	0.000003	0.000003	0.000003	0	-	-	22	0	0
Dissolved Sodium	-	mg/L	24	1.51	3.50	1.90	1.82	0.38	0.08	5.06	0	0	0	22	1.55	2.11	1.83	1.84	0.17	0.04	10.44	0	0	0
Dissolved Strontium	-	mg/L	24	0.109	0.145	0.125	0.126	0.010	0.002	12.96	0	0	0	22	0.087	0.136	0.112	0.112	0.014	0.003	7.80	0	0	0
Dissolved Sulphur	-	mg/L	5	5.00	13.00	8.60	10.00	3.51	1.57	2.45	2	0	0	3	5.00	12.00	7.33	5.00	4.04	2.33	1.81	2	0	0
Dissolved Thallium	-	mg/L	23	0.0000010	0.0000054	0.0000025	0.0000030	0.0000014	0.0000003	1.73	9	0	0	22	0.0000010	0.0000050	0.0000020	0.0000020	0.0000011	0.0000002	1.87	9	0	0
Dissolved Tin	-	mg/L	24	0.000005	0.000100	0.000015	0.000005	0.000028	0.000006	0.54	23	0	0	22	0.000005	0.000080	0.000009	0.000005	0.000016	0.000003	0.54	20	0	0
Dissolved Titanium	-	mg/L	24	0.00025	0.00350	0.00055	0.00025	0.00079	0.00016	0.69	20	0	0	22	0.00025	0.00210	0.00043	0.00025	0.00043	0.00009	1.00	17	0	0
Dissolved Uranium	-	mg/L	24	0.00075	0.00152	0.00103	0.00096	0.00019	0.00004	5.42	0	0	0	22	0.00080	0.00162	0.00104	0.00096	0.00023	0.00005	4.54	0	0	0
Dissolved Vanadium	-	mg/L	24	0.00010	0.00050	0.00019	0.00010	0.00012	0.00002	1.63	13	0	0	22	0.00010	0.00060	0.00020	0.00020	0.00013	0.00003	1.59	10	0	0
Dissolved Zinc	-	mg/L	24	0.00030	0.00900	0.00231	0.00175	0.00200	0.00041	1.15	0	0	0	22	0.00030	0.00690	0.00168	0.00110	0.00171	0.00036	0.98	0	0	0
Dissolved Zirconium	-	mg/L	24	0.00005	0.00020	0.00006	0.00005	0.00003	0.00001	1.83	22	0	0	22	0.00005	0.00020	0.00006	0.00005	0.00003	0.00001	1.79	19	0	0

Note:

1) Canadian water quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2007
a) Ammonia (NH3) guideline based on ph=8 and temp=20
b) Aluminum (AL-T)= 0.005 mg/L at pH < 6.5: 0.1 mg/L at pH ≥ 6.5
c) Cadmium (Cd) mg/L: 10^(0.86*(log(hardness))-3.2)/1000
d) Copper (Cu) mg/L: (e^0.8545[ln(hardness)]-1.465)*0.2/1000; minimum is 0.002mg/L regardless of water hardness
e) Lead (Pb) mg/L: (e^1.273[ln(hardness)]-4.705)/1000; minimum is 0.001mg/L regardless of water hardness
f) Nickel (Ni) mg/L: (e^0.76[(ln(hardness)]+1.06)/1000; minimum is 0.025mg/L regardless of water hardness

"n"	Count
"min"	Minimum Value
"max"	Maximum Value
"sd"	Standard Deviation
"se"	Standard Error
"cov"	Covariance
"<DL"	# of Non-detectable Values
">GL"	# of Exceedances of CCME Gui
"%>GL"	% of Parameters that Exceed CCME Guidelin
"-"	No Data Available

Appendix B5. Surface Water Quality Statistics: All sites all parameters, Casino Project, 2008-2012

Parameters	CCME[1] Guideline	unit	W15											W23									
			n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL	n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL
pH	6.5 - 9.0	pH unit	21	7.70	8.10	7.94	7.99	0.11	0.02	70.18	0	0	0	2	7.83	7.96	7.90	7.90	0.09	0.07	85.89	0	0	0
Conductivity	-	µS/cm	21	150	224	196	203	23	5	8.47	0	0	0	2	214	390	302	302	124	88	2.43	0	0	0
Total Hardness CaCO3	-	mg/L	21	79	113	97	100	10	2	10.22	0	0	0	2	104	187	146	146	59	42	2.48	0	0	0
Dissolved Hardness CaCO3	-	mg/L	3	99	102	101	101	2	1	65.90	0	0	0	2	102	196	149	149	66	47	2.24	0	0	0
Moisture	-	%	1	41	41	41	41	0	-	-	0	0	0	-	-	-	-	-	-	-	-	-	-	-
Ion Balance	-	no unit	2	0.93	0.96	0.95	0.95	0.02	0.01	44.55	0	0	0	2	0.99	1.00	1.00	1.00	0.01	0.01	140.71	0	0	0
Total Dissolved Solids	-	mg/L	21	92	150	118	120	17	4	7.14	0	0	0	2	150	240	195	195	64	45	3.06	0	0	0
Total Suspended Solids	-	mg/L	21	0.5	200.0	23.9	8.0	43.7	9.5	0.55	5	0	0	2	0.5	2.0	1.3	1.3	1.1	0.8	1.18	1	0	0
Turbidity	-	NTU	21	0.1	39.7	7.2	3.9	9.5	2.1	0.76	0	0	0	2	0.1	0.3	0.2	0.2	0.1	0.1	1.41	0	0	0
Ammonia as N	0.499[a]	mg/L	21	0.003	0.047	0.015	0.011	0.013	0.003	1.18	9	0	0	2	0.025	0.085	0.055	0.055	0.042	0.030	1.30	0	0	0
Alkalinity, Total (as CaCO3)	-	mg/L	21	63.0	92.0	77.24	77.0	9.23	2.01	8.37	0	0	0	2	64.0	100.0	82.0	82.0	25.46	18.00	3.22	0	0	0
Acidity (pH 4.5) as CaCO3	-	mg/L	3	0.25	0.25	0.25	0.25	0	-	-	3	0	0	2	0.25	0.25	0.25	0.25	0	-	-	2	0	0
Acidity (pH8.3) as CaCO3	-	mg/L	12	0.25	2.60	0.84	0.55	0.77	0.22	1.08	5	0	0	2	0.25	1.90	1.08	1.08	1.17	0.83	0.92	1	0	0
Bromide (Br)	-	mg/L	18	0.20	0.20	0.20	0.20	0	-	-	18	0	0	2	0.20	0.20	0.20	0.20	0	-	-	2	0	0
Chloride (Cl)	120	mg/L	21	0.25	1.60	0.48	0.25	0.37	0.08	1.32	13	0	0	2	0.80	1.40	1.10	1.10	0.42	0.30	2.59	0	0	0
Fluoride (F)	0.12	mg/L	18	0.090	0.130	0.111	0.110	0.011	0.003	10.30	0	2	11	2	0.070	0.070	0.070	0.070	0	-	-	0	0	0
Sulphate (SO4)	-	mg/L	21	13.00	32.00	23.14	23.00	5.11	1.12	4.53	0	0	0	2	43.00	94.00	68.50	68.50	36.06	25.50	1.90	0	0	0
Total Nitrogen (N)	-	mg/L	3	0.11	0.35	0.24	0.25	0.12	0.07	1.96	0	0	0	2	0.54	0.76	0.65	0.65	0.16	0.11	4.18	0	0	0
Nitrate (as N)	13	mg/L	21	0.001	0.099	0.034	0.016	0.036	0.008	0.95	3	0	0	2	0.313	0.443	0.378	0.378	0.092	0.065	4.11	0	0	0
Nitrate plus Nitrite (N)	-	mg/L	3	0.001	0.071	0.027	0.009	0.038	0.022	0.70	1	0	0	2	0.313	0.443	0.378	0.378	0.092	0.065	4.11	0	0	0
Nitrite (as N)	0.06	mg/L	21	0.001	0.009	0.002	0.001	0.002	0.000	1.06	14	0	0	2	0.001	0.001	0.001	0.001	0	-	-	2	0	0
Total Kjeldahl Nitrogen	-	mg/L	21	0.01	0.42	0.13	0.10000	0.1017	0.0222	1.26	1	0	0	2	0.23	0.31	0.27	0.27000	0.0566	0.0400	4.77	0	0	0
Ortho Phosphate as P	-	mg/L	21	0.0005	0.0090	0.0019	0.0010	0.0020	0.0004	0.93	5	0	0	2	0.0020	0.0060	0.0040	0.0040	0.0028	0.0020	1.41	0	0	0
Cyanide, Total	0.005	mg/L	21	0.00025	0.00150	0.00033	0.00025	0.00029	0.00006	1.16	19	0	0	2	0.00025	0.00140	0.00083	0.00083	0.00081	0.00058	1.01	1	0	0
Cyanide, Weak Acid Diss	-	mg/L	21	0.00025	0.00025	0.00025	0.00025	0	-	-	21	0	0	2	0.00025	0.00160	0.00093	0.00093	0.00095	0.00068	0.97	1	0	0
Dissolved Organic Carbon	-	mg/L	10	0.90	6.20	2.58	2.25	1.74	0.55	1.48	0	0	0	2	11.20	13.70	12.45	12.45	1.77	1.25	7.04	0	0	0
Total Organic Carbon	-	mg/L	18	0.70	6.90	2.74	2.40	1.63	0.38	1.68	0	0	0	2	10.20	14.00	12.10	12.10	2.69	1.90	4.50	0	0	0
Total Aluminum	0.1[b]	mg/L	21	0.0015	0.7080	0.1536	0.0847	0.1944	0.0424	0.79	0	9	43	2	0.0380	0.1590	0.0985	0.0985	0.0856	0.0605	1.15	0	1	50
Total Antimony	-	mg/L	21	0.000090	0.000230	0.000123	0.000110	0.000035	0.000008	3.50	0	0	0	2	0.00034	0.00046	0.00040	0.00040	0.00008	0.00006	4.71	0	0	0
Total Arsenic	0.005	mg/L	21	0.000140	0.002040	0.000583	0.000490	0.000437	0.000095	1.33	0	0	0	2	0.00070	0.00094	0.00082	0.00082	0.00017	0.00012	4.83	0	0	0
Total Barium	-	mg/L	21	0.039	0.139	0.061	0.056	0.022	0.005	2.74	0	0	0	2	0.046	0.066	0.056	0.056	0.014	0.010	4.11	0	0	0
Total Beryllium	-	mg/L	21	0.000005	0.000100	0.000016	0.000005	0.000022	0.000005	0.71	13	0	0	2	0.000005	0.000020	0.000013	0.000013	0.000011	0.000008	1.18	1	0	0
Total Bismuth	-	mg/L	21	0.0000025	0.0000150	0.0000040	0.0000025	0.0000035	0.0000008	1.14	17	0	0	2	0.0000025	0.0000025	0.0000025	0.0000025	0	-	-	2	0	0
Total Boron	1.5	mg/L	21	0.03	0.03	0.03	0.03	0	-	-	21	0	0	2	0.03	0.03	0.03	0.03	0	-	-	2	0	0
Total Cadmium	0.000032 [c]	mg/L	21	0.000003	0.000591	0.000082	0.000036	0.000136	0.000030	0.60	1	11	52	2	0.000009	0.000018	0.000014	0.000014	0.000006	0.000005	2.12	0	0	0
Total Calcium	-	mg/L	21	22.00	31.50	26.82	27.60	2.51	0.55	10.69	0	0	0	2	26.80	47.60	37.20	37.20	14.71	10.40	2.53	0	0	0
Total Chromium	0.001	mg/L	21	0.00005	0.00120	0.00030	0.00020	0.00031	0.00007	0.95	7	1	5	2	0.00010	0.00040	0.00025	0.00025	0.00021	0.00015	1.18	0	0	0
Total Cobalt	-	mg/L	21	0.000003	0.001400	0.000221	0.000091	0.000336	0.000073	0.66	1	0	0	2	0.000042	0.000103	0.000073	0.000073	0.000043	0.000031	1.68	0	0	0
Total Copper	0.0023[d]	mg/L	21	0.0002	0.0072	0.0015	0.0009	0.0016	0.0004	0.89	0	2	10	2	0.0015	0.0020	0.0017	0.0017	0.0004	0.0003	4.24	0	0	0
Total Iron	0.3	mg/L	21	0.001	1.950	0.313	0.132	0.477	0.104	0.66	0	6	29	2	0.024	0.145	0.085	0.085	0.086	0.061	0.99	0	0	0
Total Lead	0.003[e]	mg/L	21	0.000005	0.002490	0.000326	0.000118	0.000563	0.000123	0.58	0	0	0	2	0.000008	0.000041	0.000025	0.000025	0.000023	0.000017	1.05	0	0	0
Total Lithium	-	mg/L	21	0.00120	0.00260	0.00170	0.00160	0.00046	0.00010	3.67	0	0	0	2	0.00060	0.00070	0.00065	0.00065	0.00007	0.00005	9.19	0	0	0
Total Magnesium	-	mg/L	21	5.80	9.04	7.41	7.65	0.90	0.20	8.25	0	0	0	2	8.99	16.60	12.80	12.80	5.38	3.81	2.38	0	0	0
Total Manganese	-	mg/L	21	0.0001	0.1730	0.0244	0.0109	0.0400	0.0087	0.61	0	0	0	2	0.0035	0.0074	0.0054	0.0054	0.0027	0.0019	1.97	0	0	0
Total Mercury	0.000026	mg/L	19	0.0000050	0.0000100	0.0000053	0.0000050	0.0000011	0.0000003	4.59	18	0	0	1	0.0000050	0.0000050	0.0000050	0.0000050	0	-	-	1	0	0
Total Molybdenum	0.073	mg/L	21	0.00066	0.00130	0.00099	0.00099	0.00019	0.00004	5.20	0	0	0	2	0.00036	0.00041	0.00039	0.00039	0.00004	0.00003	10.89	0	0	0
Total Nickel	0.0033[f]	mg/L	21	0.00019	0.00925	0.00187	0.00113	0.00218	0.00047	0.86	0	0	0	2	0.00059	0.00078	0.00069	0.00069	0.00013	0.00010	5.10	0	0	0
Total Phosphorus	-	mg/L	19	0.0010	0.2340	0.0305	0.0110	0.0542	0.0124	0.56	5	0	0	1	0.0050	0.0050	0.0050	0.0050	0	-	-	0	0	0
Total Potassium	-	mg/L	21	0.71	1.11	0.80	0.76	0.11	0.02	7.45	0	0	0	2	1.43	1.91	1.67	1.67	0.34	0.24	4.92	0	0	0
Total Selenium	0.001	mg/L	21	0.00026	0.00057	0.00042	0.00038	0.00010	0.00002	4.16	0	0	0	2	0.00012	0.00016	0.00014	0.00014	0.00003	0.00002	4.95	0	0	0

Note:

1) Canadian water quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2007
a) Ammonia (NH3) guideline based on ph=8 and temp=20
b) Aluminum (AL-T)= 0.005 mg/L at pH < 6.5: 0.1 mg/L at pH ≥ 6.5
c) Cadmium (Cd) mg/L: 10^(0.86*(log(hardness))-3.2)/1000
d) Copper (Cu) mg/L: (e^0.8545[ln(hardness)]-1.465)*0.2/1000; minimum is 0.002mg/L regardless of water hardness
e) Lead (Pb) mg/L: (e^1.273[ln(hardness)]-4.705)/1000; minimum is 0.001mg/L regardless of water hardness
f) Nickel (Ni) mg/L: (e^0.76[(ln(hardness)]+1.06)/1000; minimum is 0.025mg/L regardless of water hardness
Highlighted cells indicate updates from Project Proposal

"n"	Count
"min"	Minimum Value
"max"	Maximum Value
"sd"	Standard Deviation
"se"	Standard Error
"cov"	Covariance
"<DL"	# of Non-detectable Values
">GL"	# of Exceedances of CCME Guic
"%>GL"	% of Parameters that Exceed CCME Guidelin
"-"	No Data Available

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

Appendix B5. Surface Water Quality Statistics: All sites all parameters, Casino Project, 2008-2012

Parameters	CCME[1] Guideline	unit	W15											W23										
			n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL	n	min	max	mean	median	sd	se	cov	<DL	>GL	%>GL
Total Silicon	-	mg/L	21	2.60	3.60	3.12	3.00	0.30	0.06	10.54	0	0	0	2	4.10	4.20	4.15	4.15	0.07	0.05	58.69	0	0	0
Total Silver	0.0001	mg/L	21	0.000003	0.000012	0.000004	0.000003	0.000003	0.000001	1.30	16	0	0	2	0.000003	0.000003	0.000003	0.000003	0	-	-	2	0	0
Total Sodium	-	mg/L	21	1.50	2.23	1.80	1.82	0.19	0.04	9.48	0	0	0	2	2.53	3.86	3.20	3.20	0.94	0.67	3.40	0	0	0
Total Strontium	-	mg/L	21	0.091	0.136	0.119	0.123	0.013	0.003	9.41	0	0	0	2	0.182	0.342	0.262	0.262	0.113	0.080	2.32	0	0	0
Total Sulphur	-	mg/L	3	5.00	12.00	9.00	10.00	3.61	2.08	2.50	1	0	0	2	14.00	32.00	23.00	23.00	12.73	9.00	1.81	0	0	0
Total Thallium	0.0008	mg/L	21	0.0000010	0.0000200	0.0000045	0.0000040	0.0000043	0.0000009	1.05	6	0	0	2	0.0000030	0.0000050	0.0000040	0.0000040	0.0000014	0.0000010	2.83	0	0	0
Total Tin	-	mg/L	21	0.000005	0.000070	0.000008	0.000005	0.000014	0.000003	0.59	19	0	0	2	0.000005	0.000070	0.000038	0.000038	0.000046	0.000033	0.82	1	0	0
Total Titanium	-	mg/L	21	0.00025	0.01610	0.00406	0.00300	0.00446	0.00097	0.91	6	0	0	2	0.00060	0.00320	0.00190	0.00190	0.00184	0.00130	1.03	0	0	0
Total Uranium	0.015	mg/L	21	0.00086	0.00153	0.00106	0.00101	0.00018	0.00004	5.84	0	0	0	2	0.00693	0.01410	0.01052	0.01052	0.00507	0.00359	2.07	0	0	0
Total Vanadium	-	mg/L	21	0.00010	0.00320	0.00064	0.00040	0.00078	0.00017	0.82	7	0	0	2	0.00030	0.00080	0.00055	0.00055	0.00035	0.00025	1.56	0	0	0
Total Zinc	0.03	mg/L	21	0.00080	0.03810	0.00618	0.00280	0.00921	0.00201	0.67	0	1	5	2	0.00040	0.00070	0.00055	0.00055	0.00021	0.00015	2.59	0	0	0
Total Zirconium	-	mg/L	21	0.00005	0.00070	0.00011	0.00005	0.00015	0.00003	0.72	13	0	0	2	0.00020	0.00040	0.00030	0.00030	0.00014	0.00010	2.12	0	0	0
Dissolved Aluminum	0.1	mg/L	21	0.0010	0.0693	0.0199	0.0150	0.0187	0.0041	1.06	0	0	0	2	0.0356	0.1070	0.0713	0.0713	0.0505	0.0357	1.41	0	1	50
Dissolved Antimony	-	mg/L	21	0.00009	0.00016	0.00011	0.00010	0.00002	0.000004	5.68	0	0	0	2	0.00035	0.00044	0.00040	0.00040	0.00006	0.000045	6.21	0	0	0
Dissolved Arsenic	-	mg/L	21	0.00013	0.00055	0.00036	0.00042	0.00013	0.000029	2.77	0	0	0	2	0.00071	0.00076	0.00074	0.00074	0.00004	0.000025	20.79	0	0	0
Dissolved Barium	-	mg/L	21	0.0366	0.0723	0.0489	0.0445	0.0129	0.0028	3.80	0	0	0	2	0.0420	0.0701	0.0561	0.0561	0.0199	0.0141	2.82	0	0	0
Dissolved Beryllium	-	mg/L	21	0.000005	0.000010	0.000005	0.000005	0.000002	0.000000	3.64	19	0	0	2	0.000005	0.000020	0.000013	0.000013	0.000011	0.000008	1.18	1	0	0
Dissolved Bismuth	-	mg/L	21	0.0000025	0.0000025	0.0000025	0.0000025	0	-	-	21	0	0	2	0.0000025	0.0000025	0.0000025	0.0000025	0	-	-	2	0	0
Dissolved Boron	-	mg/L	21	0.025	0.025	0.025	0.025	0	-	-	21	0	0	2	0.025	0.025	0.025	0.025	0	-	-	2	0	0
Dissolved Cadmium	-	mg/L	21	0.000003	0.000095	0.000025	0.000021	0.000022	0.000005	1.15	1	0	0	2	0.000003	0.000011	0.000007	0.000007	0.000006	0.000004	1.12	1	0	0
Dissolved Calcium	-	mg/L	21	18.50	30.00	25.82	26.00	3.07	0.67	8.41	0	0	0	2	26.60	49.30	37.95	37.95	16.05	11.35	2.36	0	0	0
Dissolved Chromium	-	mg/L	21	0.00005	0.00020	0.00009	0.00005	0.00005	0.00001	1.62	12	0	0	2	0.00020	0.00040	0.00030	0.00030	0.00014	0.00010	2.12	0	0	0
Dissolved Cobalt	-	mg/L	21	0.000003	0.000083	0.000020	0.000013	0.000021	0.000005	0.94	3	0	0	2	0.000050	0.000071	0.000061	0.000061	0.000015	0.000011	4.07	0	0	0
Dissolved Copper	-	mg/L	21	0.0003	0.0026	0.0008	0.0007	0.0006	0.0001	1.38	0	0	0	2	0.0016	0.0018	0.0017	0.0017	0.0002	0.0001	8.27	0	0	0
Dissolved Iron	-	mg/L	21	0.001	0.159	0.027	0.013	0.040	0.009	0.68	1	0	0	2	0.021	0.076	0.049	0.049	0.039	0.028	1.25	0	0	0
Dissolved Lead	-	mg/L	21	0.000003	0.000125	0.000042	0.000030	0.000035	0.000008	1.19	2	0	0	2	0.000005	0.000027	0.000016	0.000016	0.000016	0.000011	1.03	0	0	0
Dissolved Lithium	-	mg/L	21	0.00110	0.00210	0.00152	0.00150	0.00031	0.00007	4.86	0	0	0	2	0.00050	0.00060	0.00055	0.00055	0.00007	0.00005	7.78	0	0	0
Dissolved Magnesium	-	mg/L	21	5.54	8.52	7.22	7.52	0.87	0.19	8.26	0	0	0	2	8.74	17.60	13.17	13.17	6.26	4.43	2.10	0	0	0
Dissolved Manganese	-	mg/L	21	0.0001	0.0131	0.0025	0.0016	0.0035	0.0008	0.72	0	0	0	2	0.0010	0.0034	0.0022	0.0022	0.0017	0.0012	1.32	0	0	0
Dissolved Mercury	-	mg/L	18	0.0000050	0.0000050	0.0000050	0.0000050	0	-	-	18	0	0	-	-	-	-	-	-	-	-	-	-	-
Dissolved Molybdenum	-	mg/L	21	0.00078	0.00132	0.00105	0.00104	0.00017	0.00004	6.18	0	0	0	2	0.00042	0.00045	0.00044	0.00044	0.00002	0.00002	20.51	0	0	0
Dissolved Nickel	-	mg/L	21	0.00016	0.00378	0.00105	0.00086	0.00091	0.00020	1.16	0	0	0	2	0.00064	0.00065	0.00065	0.00065	0.00001	0.00000	91.22	0	0	0
Dissolved Phosphorus	-	mg/L	18	0.0010	0.0090	0.0022	0.0010	0.0026	0.0006	0.86	13	0	0	-	-	-	-	-	-	-	-	-	-	-
Dissolved Potassium	-	mg/L	21	0.69	1.07	0.78	0.76	0.09	0.02	8.95	0	0	0	2	1.35	2.10	1.73	1.73	0.53	0.38	3.25	0	0	0
Dissolved Selenium	-	mg/L	21	0.00025	0.00057	0.00041	0.00039	0.00010	0.00002	4.07	0	0	0	2	0.00011	0.00018	0.00015	0.00015	0.00005	0.00004	2.93	0	0	0
Dissolved Silicon	-	mg/L	21	1.84	3.80	2.79	2.80	0.41	0.09	6.77	0	0	0	2	4.10	4.40	4.25	4.25	0.21	0.15	20.03	0	0	0
Dissolved Silver	-	mg/L	21	0.000003	0.000003	0.000003	0.000003	0	-	-	21	0	0	2	0.000003	0.000003	0.000003	0.000003	0	-	-	2	0	0
Dissolved Sodium	-	mg/L	21	1.55	3.10	1.83	1.79	0.32	0.07	5.82	0	0	0	2	2.55	4.10	3.33	3.33	1.10	0.78	3.03	0	0	0
Dissolved Strontium	-	mg/L	21	0.091	0.132	0.117	0.121	0.013	0.003	9.26	0	0	0	2	0.174	0.349	0.262	0.262	0.124	0.088	2.11	0	0	0
Dissolved Sulphur	-	mg/L	3	5.00	12.00	9.00	10.00	3.61	2.08	2.50	1	0	0	2	14.00	36.00	25.00	25.00	15.56	11.00	1.61	0	0	0
Dissolved Thallium	-	mg/L	21	0.0000010	0.0000050	0.0000023	0.0000020	0.0000013	0.0000003	1.77	8	0	0	2	0.0000020	0.0000040	0.0000030	0.0000030	0.0000014	0.0000010	2.12	0	0	0
Dissolved Tin	-	mg/L	21	0.000005	0.000080	0.000009	0.000005	0.000016	0.000004	0.54	19	0	0	2	0.000005	0.000060	0.000033	0.000033	0.000039	0.000028	0.84	1	0	0
Dissolved Titanium	-	mg/L	21	0.00025	0.00220	0.00050	0.00025	0.00051	0.00011	1.00	14	0	0	2	0.00025	0.00110	0.00068	0.00068	0.00060	0.00043	1.12	1	0	0
Dissolved Uranium	-	mg/L	21	0.00080	0.00154	0.00102	0.00099	0.00018	0.00004	5.82	0	0	0	2	0.00682	0.01410	0.01046	0.01046	0.00515	0.00364	2.03	0	0	0
Dissolved Vanadium	-	mg/L	21	0.00010	0.00060	0.00020	0.00010	0.00013	0.00003	1.52	11	0	0	2	0.00030	0.00080	0.00055	0.00055	0.00035	0.00025	1.56	0	0	0
Dissolved Zinc	-	mg/L	21	0.00030	0.00840	0.00193	0.00110	0.00213	0.00046	0.91	0	0	0	2	0.00030	0.00030	0.00030	0.00030	0	-	-	0	0	0
Dissolved Zirconium	-	mg/L	21	0.00005	0.00020	0.00006	0.00005	0.00003	0.00001	1.75	20	0	0	2	0.00030	0.00040	0.00035	0.00035	0.00007	0.00005	4.95	0	0	0

Note:

1) Canadian water quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2007
a) Ammonia (NH3) guideline based on ph=8 and temp=20
b) Aluminum (AL-T)= 0.005 mg/L at pH < 6.5: 0.1 mg/L at pH ≥ 6.5
c) Cadmium (Cd) mg/L: 10^(0.86*(log(hardness))-3.2)/1000
d) Copper (Cu) mg/L: (e^0.8545[ln(hardness)]-1.465)*0.2/1000; minimum is 0.002mg/L regardless of water hardness
e) Lead (Pb) mg/L: (e^1.273[ln(hardness)]-4.705)/1000; minimum is 0.001mg/L regardless of water hardness
f) Nickel (Ni) mg/L: (e^0.76[(ln(hardness)]+1.06)/1000; minimum is 0.025mg/L regardless of water hardness

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"%>GL"	% of Parameters that Exceed CCME Guidelin
"-"	No Data Available

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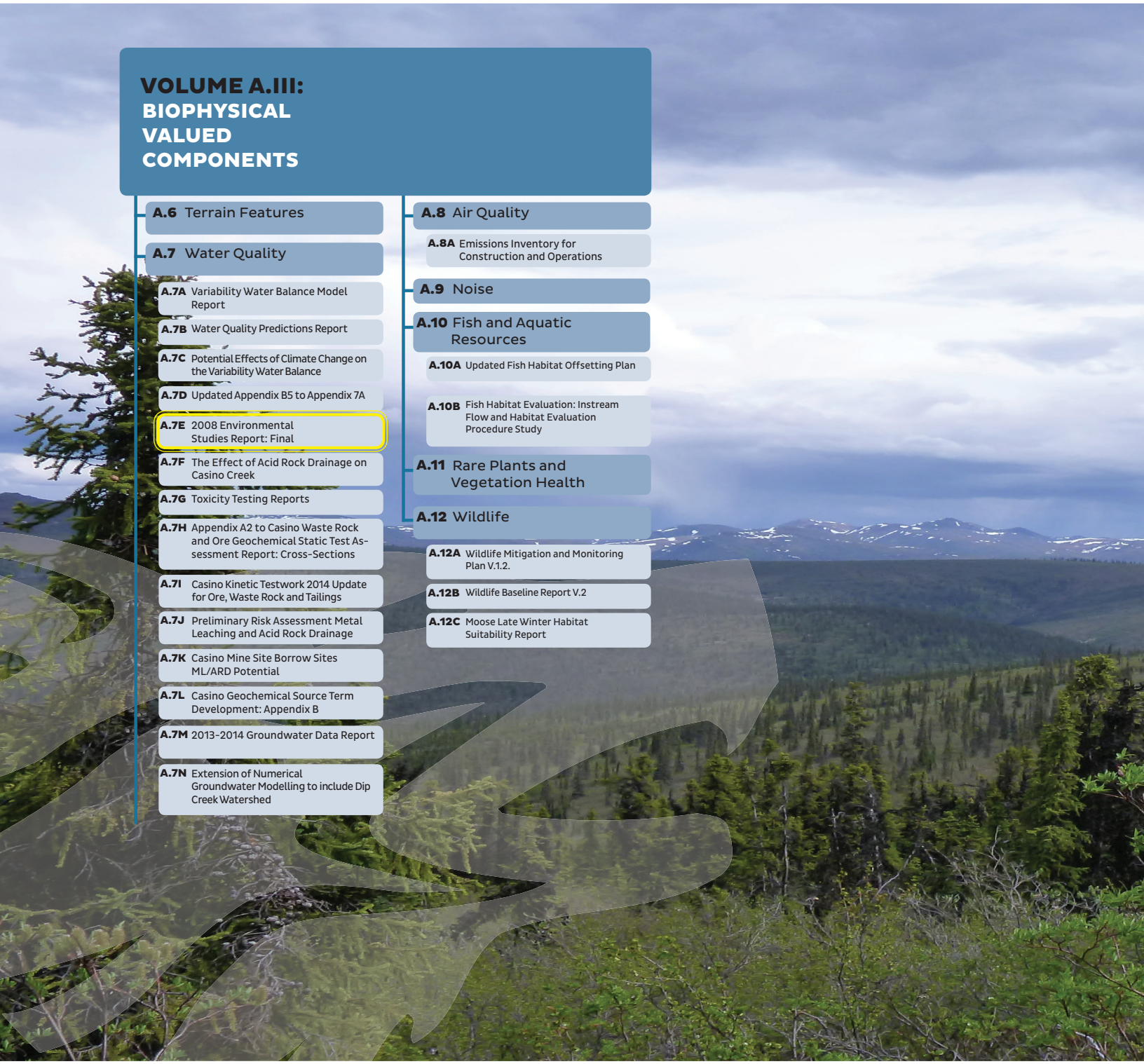
APPENDIX A.7E: 2009 Environmental Studies Report: Final



PALMER ENVIRONMENTAL CONSULTING GROUP INC.

470 Granville Street, Suite 630, Vancouver, BC V6C 1V5 t 604-629-9075

Memorandum

Date: September 3, 2014

Project: Casino Aquatics EA

To: Mary Mioska, Casino Mining Corporation

From: Rick Palmer, PECG

cc

Subject: Casino Project: 2008 Environmental Studies Report

This memo notes that while the Casino Project 2008: Environmental Studies Report submitted by AECOM Canada Ltd. in March 2009 indicates it is “draft for discussion”, the information contained within the report was considered to be final as of 2009.

Sincerely,

R. Palmer

Rick Palmer, M.Sc., R.P.Bio.
Casino Project Aquatics Discipline Lead

AECOM

Report

Western Copper Corporation

Casino Project: 2008 Environmental Studies Report

draft for discussion



Western Copper Corporation

Casino Project: 2008 Environmental Studies Report

draft for discussion

Prepared by:

AECOM Canada Ltd.
275 – 3001 Wayburne Drive, Burnaby, BC, Canada V5G 4W3
T 604.438.5311 F 604.438.5587 www.aecom.com

Project Number:

80049 107402

Date:

March 2009

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March 25, 2009 Project Number: 80049 107402

Paul West-Sells
Executive Vice President, Corporate Development
Western Copper Corporation
2050-1111 West Georgia Street
Vancouver, BC V6E 4M3

draft for discussion

Dear Dr. West-Sells:

Re: Casino Project: 2008 Environmental Studies Report

AECOM is pleased to submit the attached report describing the studies conducted in 2008 on the atmospheric, aquatic and terrestrial environments of the Casino Project area. If there are any questions or comments on this report, then please contact the undersigned. Thank you for the opportunity to work with you on this project.

Sincerely,
AECOM Canada Ltd.

Rick Palmer, B.Sc., R.P.Bio.
Senior Aquatic Biologist
Rick.Palmer@aecom.com

RP:gc

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	AECOM		

Revision Log

Revision #	Revised By	Date	Issue / Revision Description

Executive Summary

This report describes the studies conducted in 2008 on the atmospheric, aquatic and terrestrial environments of the Casino Project area. The Casino Project is a proposed porphyry copper-gold-molybdenum mine located at latitude 62° 44'N and longitude 138° 50'W in west-central Yukon, 300 km northwest of the territorial capital of Whitehorse.

On October 3, 2008, the Casino meteorological station was installed on Patton Hill at an elevation of 1,203 m above sea level. The station consists of a 10 m-high, free-standing tower equipped with instrumentation, datalogger, and logger enclosure. It records wind speed and direction, rainfall, air temperature, barometric pressure, relative humidity and snow depth and stores the records in a datalogger powered by a battery charged with a solar panel. The datalogger is equipped with a satellite modem for remotely accessing the data.

Surveys of the aquatic environment were made on May 9, May 20-24, July 7-11, September 9-13 and October 9-11. The objectives were to measure stream flows, to sample water quality, stream sediment quality, periphyton communities, benthic invertebrate communities and fish communities, and to describe fish habitat.

In May 2008, dataloggers were installed at six hydrometric stations to measure water surface elevation (from which stream flows were calculated) and water temperature. A seventh station was added in October. Those data were downloaded on subsequent trips in July, September and October. Stations were winterized in October. In general, manual measurements of discharge and stage were conducted at medium to high flows. Analysis showed fair to strong correlations of discharge and stage. Reconstruction of the hydrographs showed two large peaks of discharge at all stations that were assumed to be initiated by a regional precipitation event. Historic discharge data for 1993 and 1994 were compared to the 2008 flow data at three sites.

A total of 19 sites were chosen for water quality sampling. Water samples were collected from each site in May, July and September and analyzed for the full suite of physical parameters, anions, nutrients and total and dissolved metals. Exceedances of the Canadian Council of Ministers of the Environment (CCME) guidelines for protection of freshwater aquatic life were observed for nine parameters. The number of exceedances was highest for cadmium, copper and aluminum and least for cyanide. Exceedances were most numerous in May, similar between July and September and least numerous in October, indicating a seasonal trend most likely directly related to hydrological factors such as snow melt and stream flow.

Principal components analysis was used to identify the major spatial and temporal trends in water quality. The first component, WQ1, was positively correlated with 16 dissolved and total metals and negatively correlated with total and dissolved molybdenum, and was the geochemical signal of drainage from the adit of the lower camp into the upper reach of Casino Creek.

The second component, WQ2, was positively correlated with ten dissolved and total metals, sulphate, nitrite and ammonia and negatively correlated with pH, alkalinity, barium and nitrate. This “iron-pH” component

reflects the geochemical signature of the surficial geology of Proctor Gulch, the upper Casino Creek and Britannia Creek.

The third component, WQ3, was positively correlated with hardness, conductivity, Total Dissolved Solids (TDS), and 13 total and dissolved metals. These parameters typically reflect the influence of groundwater flows.

The fourth component, WQ4, was positively correlated with 12 dissolved and total metals, Total Suspended Solids (TSS) and Total Kjeldahl Nitrogen (TKN) and negatively correlated with dissolved and total silicon. The scores for this "vanadium-silicon" component were lowest for sites in Casino Creek and in upper Britannia Creek, and highest for sites in Dip Creek, Britannia Creek, Sunshine Creek and the Yukon River. Therefore, WQ4 represents a geochemical signal found at all sites except those in Casino Creek and upper Britannia Creek.

The fifth component, WQ5, was positively correlated with dissolved and total selenium and nickel and turbidity. The scores for this "selenium-nickel-turbidity" component were highest for sites in the Yukon River, hence WQ5 represents a geochemical signal associated with the Yukon River.

Sediment samples were collected from a sub-set of 12 stream sites in September and pH and total metal concentrations were measured. Exceedances of CCME sediment guidelines were identified for five total metals: arsenic, cadmium, copper, lead and zinc. All of those metals except arsenic were also observed to exceed CCME water quality guidelines at some stations on some dates. A PCA of sediment quality variables extracted three components that accounted for 87.7% of the explained variance. SQ1 was highly positively correlated with manganese, cadmium, cobalt, zinc, lead and antimony; SQ2 was highly positively correlated with vanadium, titanium, aluminum, tin, phosphorus, sodium and barium; and SQ3 was highly positively correlated with bismuth, silver and arsenic and highly negatively correlated with pH.

Five samples each of periphyton and benthic invertebrate communities were collected from seven stream sites in September. There were highly significant differences in mean periphyton density among sites with sites P8, P7 and P4 in Casino Creek having significantly higher mean density than other sites. There were no significant differences among sites in the Shannon-Weiner diversity index, but there were highly significant differences among sites in species richness because of higher richness for sites P8, P7 and P4 than for other sites.

Over 95% of the benthic organisms at each site belonged to eight taxa: the insect Orders of Diptera, Plecoptera, Ephemeroptera, Trichoptera, Prostigmata and Collembola plus the worms of Class Oligochaeta and Phylum Nematoda. There were statistically significant differences in mean density and diversity among sites.

Fish communities at 12 stream sites were sampled in July and September with minnow traps, electrofishers and angling. In addition, an aerial survey of Britannia and Canadian creeks was conducted on September 11 to search for Pacific salmon spawners (none were observed).

A total of 40 fish from two species – Arctic grayling (*Thymallus arcticus*) and slimy sculpin (*Cottus cognatus*) – were captured. Apart from one Arctic grayling caught by angling, all were captured by electrofishing. Only Arctic grayling were found in the Britannia Creek Watershed, but both Arctic grayling and slimy sculpin were found in Casino Creek and Dip Creek watersheds. Slimy sculpin made up the majority of the catch (81 to 86%) in those two watersheds, respectively.

Arctic grayling were absent from the study area in September, most likely due to late-summer outmigration in search of overwintering habitat. In contrast, the mean catch-per-unit-effort (CPUE) of slimy sculpin for Casino and Dip Creeks was not significantly different between July and September, indicating that slimy sculpin either did not outmigrate from Casino Creek until after mid-September.

Arctic grayling ranged in length from 173 to 300 mm and in age from two to siz years, indicating the presence of juvenile and adults but not young-of-the-year. Slimy sculpin ranged in length from 29 to 294 mm, indicating the presence of juveniles and adults.

Nine slimy sculpin were collected from Casino and Dip creeks in July and September and subjected to whole-body tissue metals analysis.

Reconnaissance surveys of the terrestrial environment were conducted on July 7-11 and September 8-11, 2008. The objectives were to provide sufficient preliminary information on soils and vegetation to plan a future air photograph interpretation study of vegetation communities, and to document wildlife presence and use of the various plant communities and habitats.

Aerial surveys of vegetation communities and wildlife were conducted in a helicopter that flew slowly at low altitudes. Aerial surveys were followed by ground surveys conducted on foot or with all terrain vehicles. Soil pits were dug, samples of vegetation were collected and animal sighting and signs (claw marks, paw prints, antlers, scat, etc.) were photographed and their GPS co-ordinates recorded.

The surveys showed that the study area is characterized by smooth, rolling topography with moderate to deeply incised valleys. Wildlife habitat consists of a variety of plant communities ranging from sparsely vegetated bare rock, large expanses of heath tundra, wet sedge meadows with tall riparian shrubland and treed slopes dominated by spruce, aspen, birch and willows. Open stands of black spruce and white spruce occur in valleys and lower slopes, with black spruce on wetter sites and white spruce on better drained sites. Willow, shrub birch, Labrador tea, mosses and lichens are principal understory species.

Fifteen species of mammals and ten species of birds were observed or heard during the surveys. Moose were observed along the Yukon River and along Casino and Dip creeks. The area being considered for the proposed Casino Project appears to be a preferred moose wintering area. Caribou were seen and caribou sign (e.g., pellets, shed antlers, trails, etc.) was found on ridge tops. Numerous wolf tracks and scats were observed along Dip Creek, suggesting the presence of a den site. Grizzly bears and black bears were observed and well-developed small mammal trails were observed in some spruce habitat.

Potential summer and winter range, lambing areas and escape terrain for sheep are limited within the survey area. No thinhorn sheep were observed along the Yukon River bank directly across from Britannia Creek.

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- Project Management:
  - Rick Palmer, B.Sc., Senior Aquatic Biologist
- Hydrology:
  - Chad Davey, B.A., M.Sc., Environmental Scientist
  - Rolf Aslund, P.Eng., Senior Water Resources Engineer
- Surface Water Quality and Sediment Quality:
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  - May Quach, M.Env.Sci., CEPIT, Aquatic Ecologist
- Fish and Fish Habitat:
  - Jennifer Sarchuk, B.Sc., Biologist
  - Genevieve Martin, B.Sc., Environmental Biologist
  - Eric Cleveland, Fish. Wild. Tech., Environmental Technician
- Soils and Vegetation:
  - Sean Bennett, B.Sc., R.P.F., Terrestrial Ecologist
  - Kevin Lloyd, M.Sc., Senior Ecologist
- Wildlife and Wildlife Habitat:
  - Paul Fraser, B.Sc., P.Bio., Senior Wildlife Biologist
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Climate and air quality was the responsibility of the following RWDI staff: Geoff Doerksen, M.Sc., Project Manager, and Kathy Preston.

Acronyms and Abbreviations

ANOVA	Analysis of variance
asl	above sea level
BC MELP	British Columbia Ministry of Environment, Lands and Parks
BC MOE	British Columbia Ministry of Environment
BC MOF	British Columbia Ministry of Forests
BC MWLAP	British Columbia Ministry of Water, Land and Air Protection
CABIN	Canadian Aquatic Biomonitoring Network
CCME	Canadian Council of Ministers of the Environment
CEAA	Canadian Environmental Assessment Agency
CO	Confined
CPUE	Catch-per-Unit-Effort
DFO	Fisheries and Oceans Canada
DOC	Dissolved Organic Carbon
EEM	Environmental Effects Monitoring
EN	Entrenched
EPT	Ephemeroptera-Plecoptera-Trichoptera
FC	Frequently confined
FES	Fraser Environmental Services Ltd.
FISS	Fisheries Information Summary System
GIF	Ground inspection plots
GPS	Global Positioning System
H’	Shannon-Weiner diversity index
HKP	Hallam Knight Piésold Ltd.
ICP	Inductively Coupled Argon Plasma Spectroscopy
ISQG	Interim Sediment Quality Guideline
K	Growth coefficient (von Bertalanffy parameter)
kPa	kilo Pascals
L_∞	Asymptotic length (von Bertalanffy parameter)
LSA	Local Study Area
LWD	Large Woody Debris
MMER	Metal Mining Effluent Regulations
µS	micro-Siemens
NA	Not applicable
NAN	Not a Number
NS	Not sampled
NTU	Nephelometric unit
NWRI	National Water Research Institute
OC	Occasionally confined
P	Probability of making a Type I error
PCA	Principal Component Analysis

Acronyms and Abbreviations (cont'd)

PEL	Probable Effects Level
PQL	Practical Quantitation Limit
QA/QC	Quality Assurance/Quality Control
r^2	coefficient of determination
RDL	Reported Detection Limit
RPD	Relative Percent Difference
RSA	Regional Study Area
S	Taxonomic richness
SE	Standard error
t_0	age at which length is zero (von Bertalanffy parameter)
TDS	Total Dissolved Solids
TEM	Terrestrial Ecosystem Mapping
TIA	Tailings Impoundment Area
TKN	Total Kjeldahl Nitrogen
TOC	Total Organic Carbon
TSS	Total Suspended Solids
UC	Unconfined
U.S. EPA	United States Environmental Protection Agency

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1. Introduction

1.1 Overview

This report describes the studies conducted in 2008 on the atmospheric, aquatic and terrestrial environments of the Casino Project area. Studies on hydrogeology (AECOM in preparation) and geochemistry (Lorax 2009) are reported separately. The purpose of these studies was to characterize the pre-development environment in support of the permitting process for the Casino Project.

The Casino Project is a proposed porphyry copper-gold-molybdenum mine located at latitude 62°44'N and longitude 138°50'W in west-central Yukon, 300 km northwest of the territorial capital of Whitehorse. Figure 1 shows the location of the Casino Project, surrounded by the aquatic Regional Study Area (RSA), in relation to the Yukon River – to which all of the streams in the Casino Project area eventually discharge.

In August 2008, a pre-feasibility study of the Casino Project was completed (M3 Engineering 2008). It envisioned a conventional truck-shovel, open pit mine. Waste rock will be stored in three waste rock dumps located south and east of the open pit (Figure 2). Tailings, process water, treated sewage effluent, leachate from the waste rock dumps and surface runoff from the mine site will be stored in a Tailings Impoundment Area (TIA) located in the headwaters of Casino Creek south of the waste rock dumps. The TIA is intended to be a zero discharge operation, hence makeup water will be pumped to the TIA through a pipeline from a site on the Yukon River approximately 17 km to the north. A 187 km-long unpaved access road (see Figures 6a and 6b) will be built from the Alaskan Highway at a point about 48 km northwest of Burwash Landing out to the mine site. It will be used to bring in equipment, supplies and fuel and to truck out metal concentrate.

1.2 Project History

The first known recording of a lode mineral claim in the area was in 1917. Discovery of silverlead veins in the 1930's led to further exploration that eventually led to the discovery in 1969 of the large copper and molybdenum porphyry deposit on Patton Hill. Over the next 23 years, various parties including Brameda Resources, Quintana Minerals, Teck Corporation and Archer, Cathro and Associates Ltd. acquired the property and did more drilling. In 1992, Pacific Sentinel Gold Corp. acquired the property and ran a major drilling program from 1992 to 1995. In addition, they performed a considerable amount of metallurgical, geotechnical and environmental work and completed a scoping study in 1995. Soon thereafter, First Trimark Resources and CRS Copper Resources obtained the property. In 2004, the two firms combined to form Lumina Copper Corporation and in November 2006 Western Copper Corporation acquired Lumina Copper Corporation and the Casino property.



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NTDB base data, Natural Resources Canada (1:50,000)
All other data, AECOM, 2009

N
W
E
S
0 5 10
Kilometers

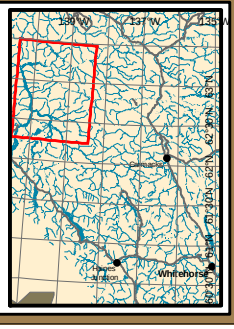
UTM Zone 7N, NAD 83
1:600,000

Legend

- Aquatic Regional Study Area
- Access Road
- Watercourse
- Waterbody

Topography

- Contour (Index 1000 ft)



Western Copper Corporation

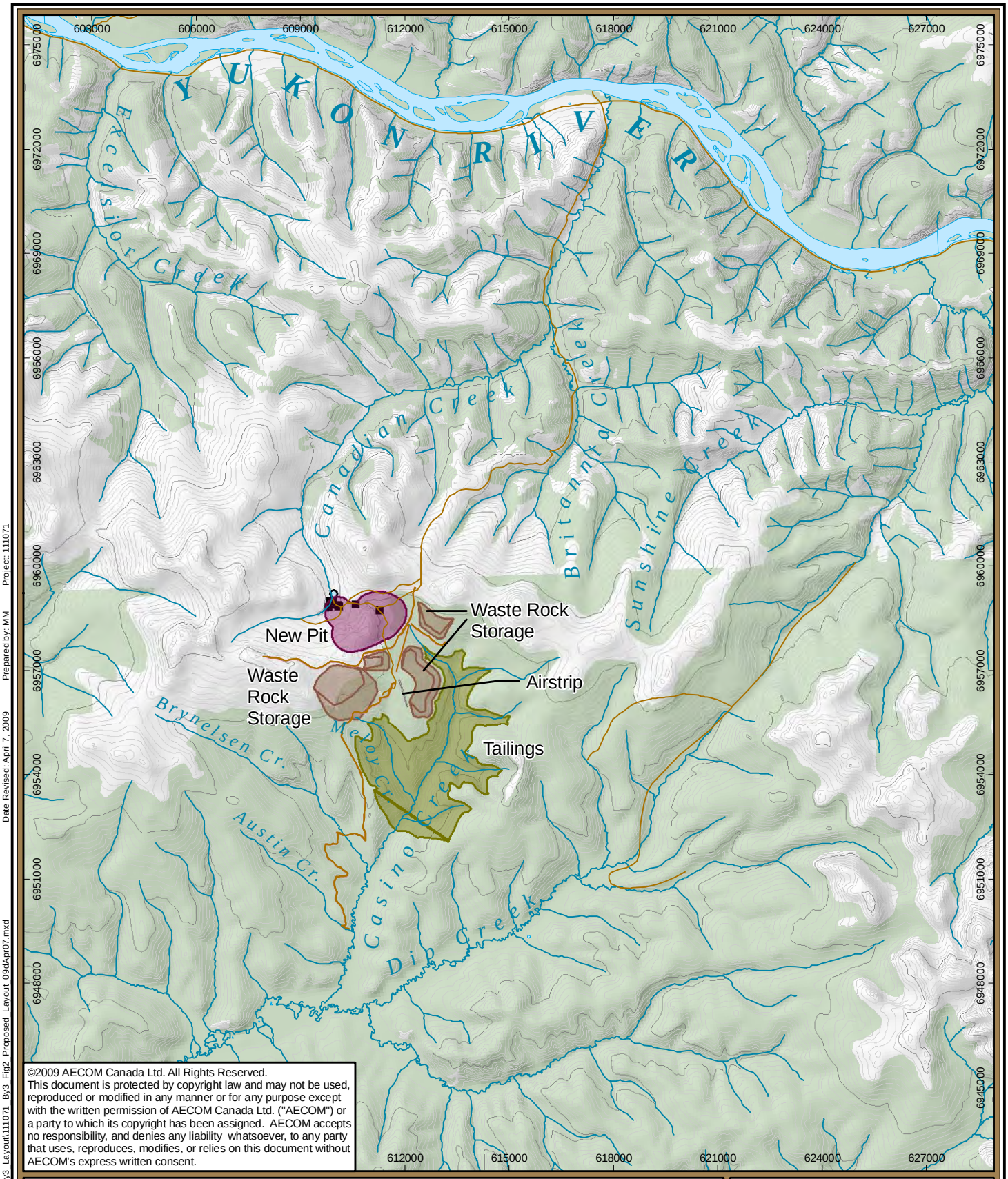
Aquatic Regional Study Area in Relation to the Yukon River

March 2009

AECOM

Figure 1

Map Document: E:\GIS\GIS_proj\Y2009\107402_Casino\By1_Aquatics\107402_By1_Fig1_RSA_and_Yukon_09cMar04.mxd Prepared by: MM Project: 107402



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NTDB base data, Natural Resources Canada (1:50,000)
All other data, AECOM, 2008

N
W E
S

0 1 2 3
Kilometers

UTM Zone 7N, NAD 83
1:150,000

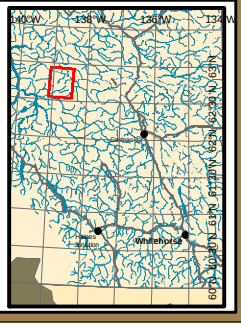
Legend

- Access Road
- Watercourse
- Waterbody

Topography

- Contour (Index 1000 ft)
- Contour (Interm. 100 ft)

overview map



Western Copper Corporation

Proposed Casino Mine Site Layout

April 2009

AECOM

Figure 2

File Location: E:\GIS\GIS_proj\Y2009\111071_CasinoIBy3_Layout\111071_By3_Fig2_Proposed_Layout_09dApr07.mxd Date Revised: April 7, 2009 Prepared by: MM Project: 111071

1.3 Historical Sources of Environmental Data

In 1997, Hallam Knight Piésold Ltd. (HKP) completed a data report for Pacific Sentinel Gold Corp. summarizing the results of environmental baseline studies conducted from 1993 to 1995 (Hallam Knight Piésold 1997). The report provided data on meteorology, hydrology, surface water quality, groundwater quality, stream sediment quality, periphyton, benthic invertebrates, fish, soils, terrestrial vegetation and wildlife. Some of that data was compared to that collected in 2008 in this report.

Apart from Hallam Knight Piésold (1997), there are limited data available on the aquatic environment of the Casino area. Fisheries and Oceans Canada (DFO) has conducted surveys of fish and fish habitat in watersheds in the area, including the reaches of the Yukon River adjacent to the Casino property and the lower reaches of Dip Creek and the Klotassin, Donjek and White rivers. These were conducted for the purposes of managing Pacific salmon fisheries in the Yukon River, and for classifying fish habitat in support of the Yukon Placer Authorization (Government of Canada 2000). The results of these surveys are reported in DFO's Fisheries Information Summary System (FISS) (Appendix B10). The sources of the information listed in the FISS reports are Hallam Knight Piésold (1997) and memoranda, letters, personal communications and other relevant information held in the files of DFO's Whitehorse office.

Fish and Wildlife Branch of Yukon Department of Environment has conducted surveys of wildlife in the Casino study area and along its proposed access routes. Some of that data has been published, e.g., Farnell *et al.* (1991), but most of the baseline information on the relative abundance, seasonal distribution, movement and habitat use of wildlife in the Project area has yet to be collated and published. Some Traditional Knowledge of the Project area is available. For example, the current management plan for the Klaza Caribou Herd was derived in part from Traditional Knowledge of behaviour and habitat use provided by the Little Salmon/Carmacks First Nation (Yukon Environment 2004).

1.4 Study Areas

1.4.1 General

Two types of study area were defined for each of the three environmental components: a Local Study Area (LSA) and a Regional Study Area (RSA). The Canadian Environmental Assessment Agency (CEAA) defines a LSA as:

> "The area within which local effects are assessed (i.e., within close proximity to the action where direct effects are anticipated)" (CEAA 2008)

The boundaries of LSAs are defined by topographic features such as watershed boundaries (for aquatics) and slope breaks (for vegetation and wildlife). The LSA is of a size that lends itself to sampling and mapping at high intensity. CEAA (2008) defines a RSA as:

> "The area within which cumulative effects are assessed (i.e., extending a distance from the project footprint in which both direct and indirect effects are anticipated to occur)."

In practice, the RSA encompasses the LSA plus a larger surrounding area that is of sufficient size to evaluate the potential severity of Project-specific effects in combination with other past, present and reasonably foreseeable effects. The RSA may also include reference sampling sites that will be used as controls to assess Project-related effects on the LSA during the operational and post-closure phases of the Project. The RSA is defined by ecological boundaries and it is of a size that lends itself to sampling and mapping at lower intensities than an LSA.

1.4.2 Atmospheric Environment

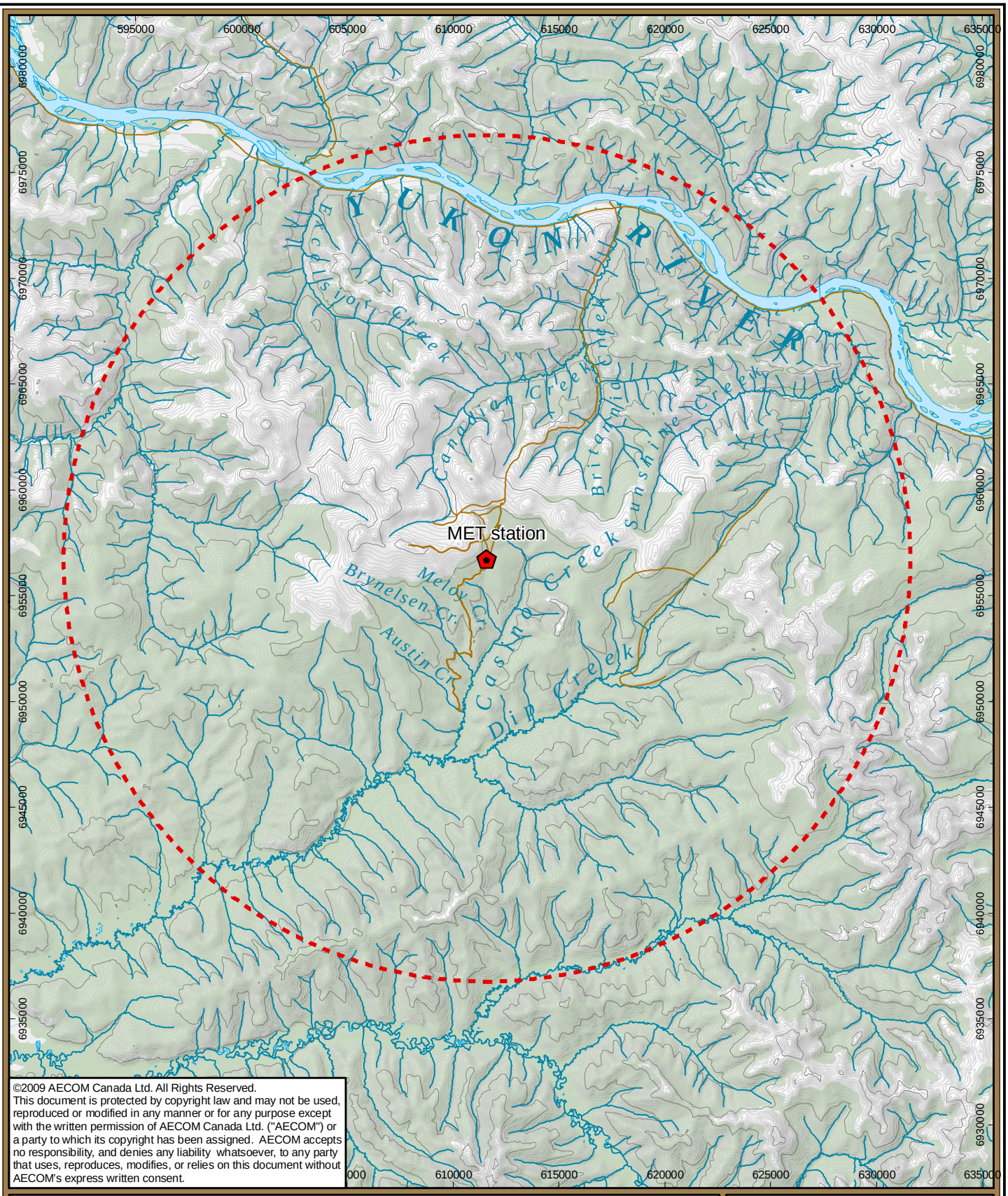
The atmospheric LSA was based on the assumption that the atmospheric conditions measured at the meteorological station at the mine site are representative of conditions up to 20 km away (Geoff Doerksen, RWDI, personal communication) (Figure 3). The atmospheric RSA has not yet been defined.

1.4.3 Aquatic Environment

The LSA for the aquatic environment was defined by the boundaries of the two watersheds surrounding the Casino deposit: the Britannia Creek Watershed to the north and the Casino Creek Watershed to the south (Figure 4). Most of the proposed mine infrastructure will be in the Casino Creek Watershed, but some (e.g., the northern corner of the open pit) will be in the Britannia Creek Watershed. The northern part of the LSA is drained by Britannia Creek and one of its tributaries, Canadian Creek. Britannia Creek flows into the Yukon River. The northern edge of the LSA includes a 2 km-long reach of the Yukon River. The southern part of the property is drained by Casino Creek which flows south to Dip Creek and thence to the Yukon River via the Klotassin, Donjek and White rivers. The southern edge of the LSA includes a 2 km-long reach of Dip Creek.

The aquatics RSA was defined as the LSA plus four adjacent areas:

- ***Dip Creek Watershed***. The headwaters of Dip Creek are not expected to be affected by Project activities, but the reaches of Dip Creek downstream of the confluence of Dip and Casino creeks will be affected by reduction in flows from Casino Creek caused by the impoundment of its headwaters. The effects of those flow reductions will decrease with downstream distance from the confluence of Dip and Casino creeks. One water quality site (W16) was placed approximately 11 km downstream of the confluence to monitor far-field effects.
- **Sunshine Creek Watershed**. This watershed, located to the east of the Britannia Creek Watershed, is not expected to be affected by Project activities. For that reason a reference water quality station – site W17 – was located on Sunshine Creek upstream of its confluence with the Yukon River.
- ***Excelsior Creek Watershed***. This watershed, located to the west of Britannia Creek Watershed, is also not expected to be affected by Project activities. It was originally intended to be the site of a reference water quality site, but that site (W17) was eventually moved to Sunshine Creek for logistical reasons. This watershed may serve as a location for a reference site in the future.



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NTDB base data, Natural Resources Canada (1:50,000). All other data, AECOM, 2008

N
W
E
S

0 2.5 5
Kilometers

UTM Zone 7N, NAD 83
1:250,000

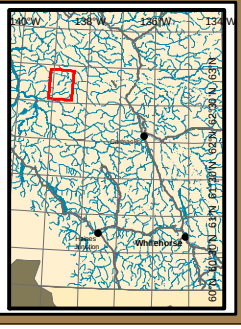
Legend

- MET station
- Atmospheric Local Study Area
- Access Road
- Watercourse
- Waterbody

Topography

- Contour (Index 1000 ft)
- Contour (Interm. 100 ft)

overview map



Western Copper Corporation

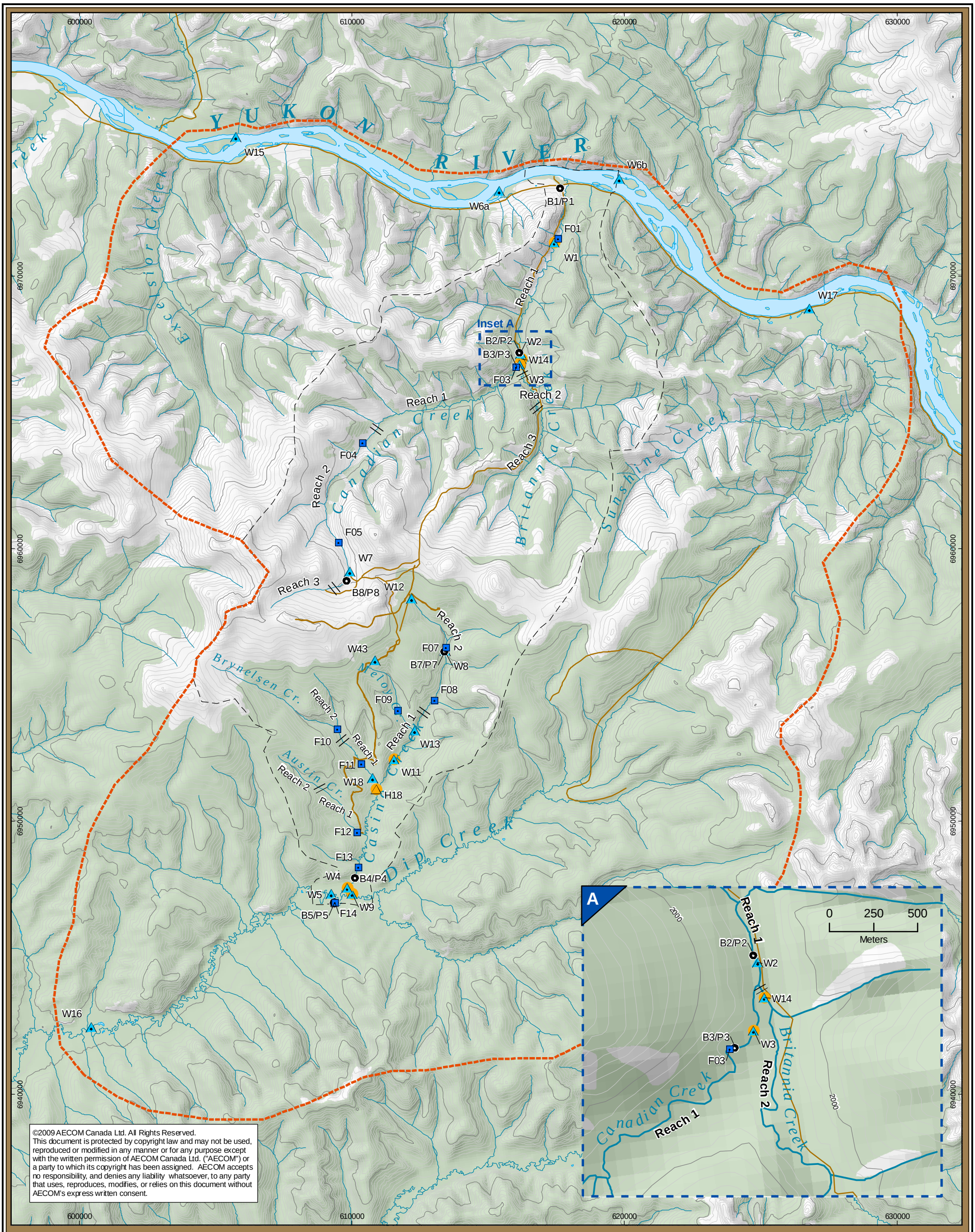
Atmospheric Local Study Area

April 2009

AECOM

Figure 3

File Location: E:\GIS\GIS_proj\Y2009\111071_Casino\By4_Atmospheric\111071_By4_Fig3_Atmospheric_LSA_09cApr07.mxd Date Revised: April 7, 2009 Prepared by: MM Project: 111071



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Map Sources/Notes:
NTDB Basedata NRCAN (1:50 000)
Fish, hydrology and water quality sites, AECOM, 2008.
All other data, AECOM, 2008.

N W E S

0 1 2 3
Kilometres

UTM Zone 7N, NAD 83

1:130,000

Legend

Sampling Features

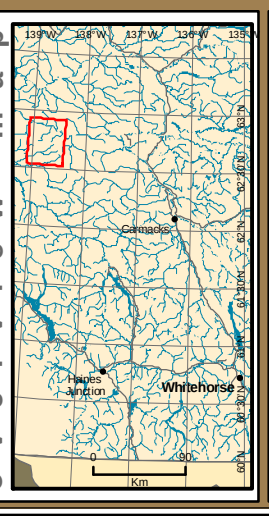
- Benthic Macroinvertebrate and Periphyton Sample Site
- Fish Sample Site
- Water Quality Site
- Hydrology Logger Location
- Water Quality Site and Hydrology Logger Location
- Reach Breaks

- Local Study Area
- Regional Study Area
- Access Road
- Watercourse
- Waterbody

Topography

- Contour (Index 1000 ft)
- Contour (Interm. 100 ft)

overview map



Western Copper Corporation

Casino

Aquatic Regional Study Area with Sampling Sites

June 2009

AECOM

Figure 4

File Location: E:\GIS\GIS_proj\Y2009\111071_Casino\By1_Aquatics\111071_By1_Fig4_WQ_Hyd_Fish_RLSA_09fJune08.mxd Date Revised: June 8, 2009 Prepared by: MM Project: 111071

- ***Yukon River***. This river will be the receiving environment for flows from Britannia Creek. Therefore, water quality sampling stations were placed upstream (W6b – a reference site) and downstream (W6a and W15) of the confluence of Britannia Creek and the Yukon River.

1.4.4 Terrestrial Environment

The terrestrial LSA was defined by the boundaries of the Casino Creek, Britannia Creek and Dip Creek watersheds (Figure 5). It is larger than the aquatics LSA but smaller than the aquatics RSA. The terrestrial RSA has not yet been defined. Figures 6a and 6b show the terrestrial LSA in relation to the proposed road route and the Wildlife Key Areas that have been identified by the Fish and Wildlife Branch of the Yukon Department of Environment.

1.5 Study Objectives

The overall objective of the 2008 environmental studies was to characterize the pre-development atmospheric, aquatic and terrestrial environments of the Casino Project area. The sampling strategy was to use, as much as was possible, the same sampling sites or areas that were monitored by Hallam Knight Piésold Ltd. from 1993 to 1995. This will develop further a multi-year database that will allow assessment of natural inter-annual variability.

The specific objective for the atmospheric studies was to install an automated meteorological station on Patton Hill that was capable of being remotely downloaded and that will record meteorological data continuously from the date of installation to the present. These measurements will provide the necessary observations for air quality modelling.

The specific objectives for the aquatic studies were the following:

- Install hydrometric stations on streams in the LSA that will continuously record stream flows and water temperatures.
- Develop stage-discharge curves for each hydrometric station from manual measurements of stream flow and staff gauge height collected over the open-water season.
- Sample stream water quality at sites in the LSA and RSA throughout the open-water season.
- Sample stream sediment quality at sites in the LSA once in 2008.
- Measure the density and taxonomic composition of the mid-summer periphyton communities in the LSA. Periphyton is the term given to the algal community that grows attached to stream substrates. It is the principal source of primary production for stream ecosystems and, because it is fixed to the substrate, it is useful for assessing mine effects on the aquatic environment.
- Measure the density and taxonomic composition of the stream benthic invertebrate communities in the LSA. Benthic invertebrates are a major source of prey for fish and, because they are attached to the substrate, are useful for assessing mine effects on the aquatic environment. Benthic invertebrates are a required component of the Environmental Effects Monitoring (EEM) guidelines of the Metal Mining Effluent Regulations (MMER) (Environment Canada 2002).

Site O1
- BC (x2)
- BS (x2)
- MD
- Veg Plot: 14 and 15

Site O2
- MD(x3)
- BS(x5)

Site O3
- BS(x3)
- BC(x2)
- RS
- H
- MD
- Veg Plot: 108, 109, and 110

Site O4
- MD(x8)
- GD

Site O5
- MD(x3)
- GD
- PC
- RS(x2)
- Veg Plot: 113

Site O6
- MD(x12)
- BS(x4)
- FS
- Bear ant Log
- SG
- RS(x3)
- M
- MA
- WS

Site O7
- GB
- BS(x3)
- CD(x5)
- MD

Site O8
- CD(x2)
- MD
- BS(x2)
- Veg Plot: 118 and 119

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Map Sources/Notes:
NTDB Basedata NRCAN
Water Monitoring Locations, Gartner Lee Limited

N W E S

0 1 2 3 4 5
Kilometres

UTM Zone 7N, NAD 83

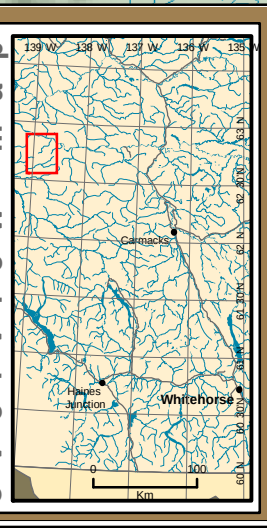
Scale 1:110,000
(when viewed in 11x17)

File Name: 111071_Wildlife_Vegetation_Observations_rh_6Mar09.mxd
Reviewed By:
Prepared By: RH
Date Issued: March 2009
Project Number: 111071-1.1.3

Legend
- Vegetation Plot

Wildlife
- BB - Black Bear
- BC - Bear Claw Marks
- BS - Bear Scat
- BV - Beaver
- CA - Caribou Antlers
- CB - Caribou
- CD - Caribou Droppings
- GB - Grizzly Bear
- GS - Ground Squirrel
- LX - Lynx
- M - Moose
- MA - Moose Antlers
- MD - Moose Droppings
- NBLB - N. Bog Lemming Burrow
- NH - Northern Harrier
- OW - N. Hawk Owl
- RP - Raptor Pellet
- RS - Red Squirrel
- W - Wolf
- WS - Wolf Scat

overview map



Western Copper Corporation

Casino

Terrestrial LSA with Wildlife Observations and Vegetation Plots

March 2009

AECOM

Figure 5

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DAWSON PLATEAU

NISLING RANGE

RIVER

Pyroxene Mountain
Selwyn Dome
Volcano Mountain
Fort Selkirk
Pelly Crossing
Granite Canyon
Diamain Lake
Ptarmigan Mountain
Tatlmain Lake
Mount Cockfield
Mount Pitts
Apex Mtn
Prospector Mountain
Granite Mountain
Mt Nansen
Carmacks
Minto
Tincup Lake
Wellesley Lake
Little Salmon

175 km A
175 km B
150 km B
150 km A
125 km A
125 km B
100 km
75 km
50 km
25 km
0 km

HAYES CREEK OPTION
BIG CREEK OPTION

LHUTSAW WETLAND HABITAT PROTECTION AREA
TA'TLA MUN SPECIAL MANAGEMENT AREA
NORDENSKIOLD HABITAT PROTECTION AREA
KLONDIKE HIGHWAY
Tatchun Creek
Nisling River
Klaza River
Rowlinson Ck
Macintosh Creek
Stevens Creek
Hootalinqua River
Big Salmon River

LEGEND

Big Creek and Hayes Creek Buffer (metres)

250 500 750

L.S.A.
Mineral Claims

- Thinhorn Sheep (spring lambing)
- Thinhorn Sheep (early winter rut)
- Thinhorn Sheep (winter range)
- Thinhorn Sheep (migration corridor)
- Unspecified Raptor (summer nesting)
- Rough-legged Hawk (summer nesting)
- Merlin (summer nesting)
- Peregrine Falcon (summer nesting)
- Bald Eagle (summer nesting)
- Osprey (summer nesting)
- Gyrfalcon (summer nesting)
- Golden Eagle (summer nesting)
- Waterfowl (various seasons & functions)
- Sharp-tailed Grouse (all seasons & functions)

Elevation

0 - 1000	5001 - 6000
1001 - 2000	6001 - 7000
2001 - 3000	7001 - 8000
3001 - 4000	8001 - 9000
4001 - 5000	



NTDB Basedata NRCAN

Km
0 5 10 15 20
1:600,000 UTM Zone 17N, NAD 83

N W E S

Western Copper Corporation

Terrestrial LSA
Access Road and Areas of Interest for Sheep and Raptors

February 2009 - Project 111071 (1.1.3)

AECOM

Figure 6a

Map Document: (J:\Templates\11x17-Landscape_AECOM.mxd)
10/27/2008 - 10:01:33 AM

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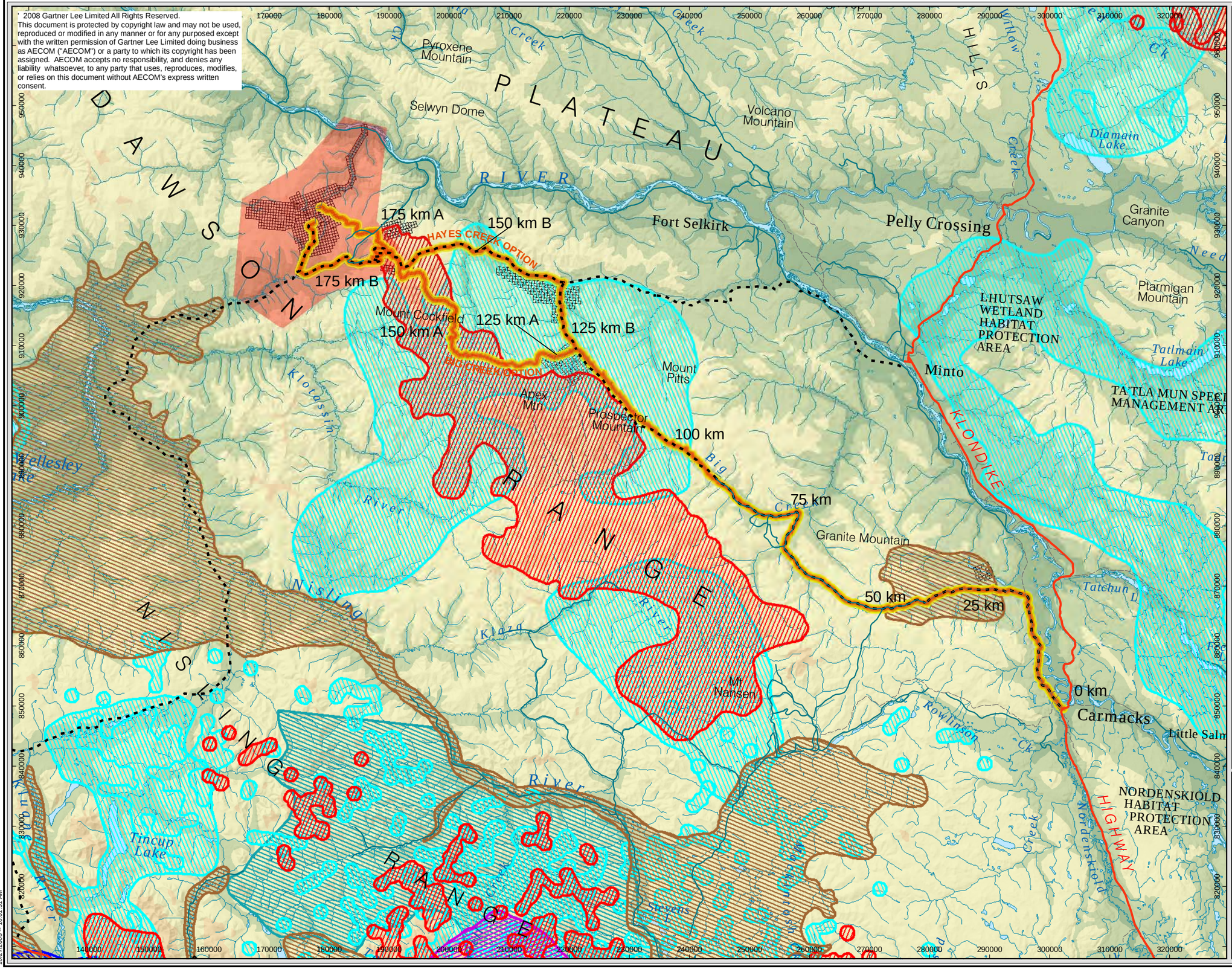


LEGEND

Big Creek and Hayes Creek Buffer (metres)

250 500 750

L.S.A.

Mineral Claims

- Woodland Caribou (fall rut - lsurvey data)
- Woodland Caribou (fall rut - local knowledge)
- Woodland Caribou (winter range - survey data)
- Woodland Caribou (winter range - local knowledge)
- Woodland Caribou (migration corridor)
- Moose (late winter range)
- Moose (all seasons & functions)

Elevation

- 0 - 1000
- 1001 - 2000
- 2001 - 3000
- 3001 - 4000
- 4001 - 5000
- 5001 - 6000
- 6001 - 7000
- 7001 - 8000
- 8001 - 9000



NTDB Basedata NRCAN
Km
0 5 10 15 20
1:600,000 UTM Zone 17N, NAD 83

N W E S

Western Copper Corporation

Terrestrial LSA Access Road and Areas of Interest for Moose and Cariboo

February 2009 - Project 111071 (1.1.3)

AECOM

Figure 6b

Map Document: (J:\Templates\11x17-Landscape_AECOM.mxd)
10/27/2008 - 10:01:31 AM

- Identify the fish species present in the LSA, describe their spatial distributions and measure their relative abundance and biological characteristics. Fish are the principal predators of stream communities and are a required component of the EEM guidelines of the MMER.
- Measure the whole-body tissue metal concentrations of slimy sculpin (*Cottus cognatus*) from each of the two watersheds in the LSA. Slimy sculpin were chosen because they are a resident species, hence their tissue metal concentrations will reflect local background metal concentrations in water. Tissue metal concentrations are a required component of the EEM guidelines of the MMER.
- Measure the key physical characteristics of stream fish habitat in the LSA.

The specific objectives of the terrestrial ecosystem studies were to collect sufficient preliminary information on soils and vegetation to plan a future air photograph interpretation study of the vegetation communities of the terrestrial LSA and RSA, and to document wildlife presence and use of the various plant communities and habitats.

2. Methods

2.1 Atmospheric Environment

2.1.1 Location and Setup of Meteorological Station

The geomorphology of the Casino Project area – a ridge from which watersheds descend to the north and south – meant that the atmospheric characteristics of the study area could be adequately monitored with a single meteorological station installed near the top of the ridge. The Casino meteorological station was installed on Patton Hill on October 3, 2008, and has been recording data continuously since that day. The station is located at 62°43'27.837"N and 138°49'0.562"W (UTM co-ordinates of 611,609E and 6,956,775N) at an elevation of 1,203 m above sea level (asl) (Figure 3). Appendix A1 shows the letter report from RWDI Air Inc. that describes the station and its installation.

The station consists of a 10 m-high, free-standing tower equipped with instrumentation, datalogger, and logger enclosure (Photo 1). The station is sited in a transition zone between tree line and alpine with an unobstructed fetch of at least 100 m in all directions. The site is sparsely covered in low brush and trees that are approximately 10 m tall. The station has instrumentation capable of measuring wind speed and direction, rainfall, air temperature, barometric pressure, relative humidity and snow depth. Observations are recorded and stored by a datalogger, which is powered by a battery charged with a solar panel at the station. The datalogger is equipped with a satellite modem for remotely accessing the data.

2.1.2 Quality Assurance/Quality Control (QA/QC)

Because the meteorological station was installed late in 2008, too few data have been collected from that station to be presented and analyzed in this report. However, the data that are being collected will be processed according to the following QA/QC protocols.

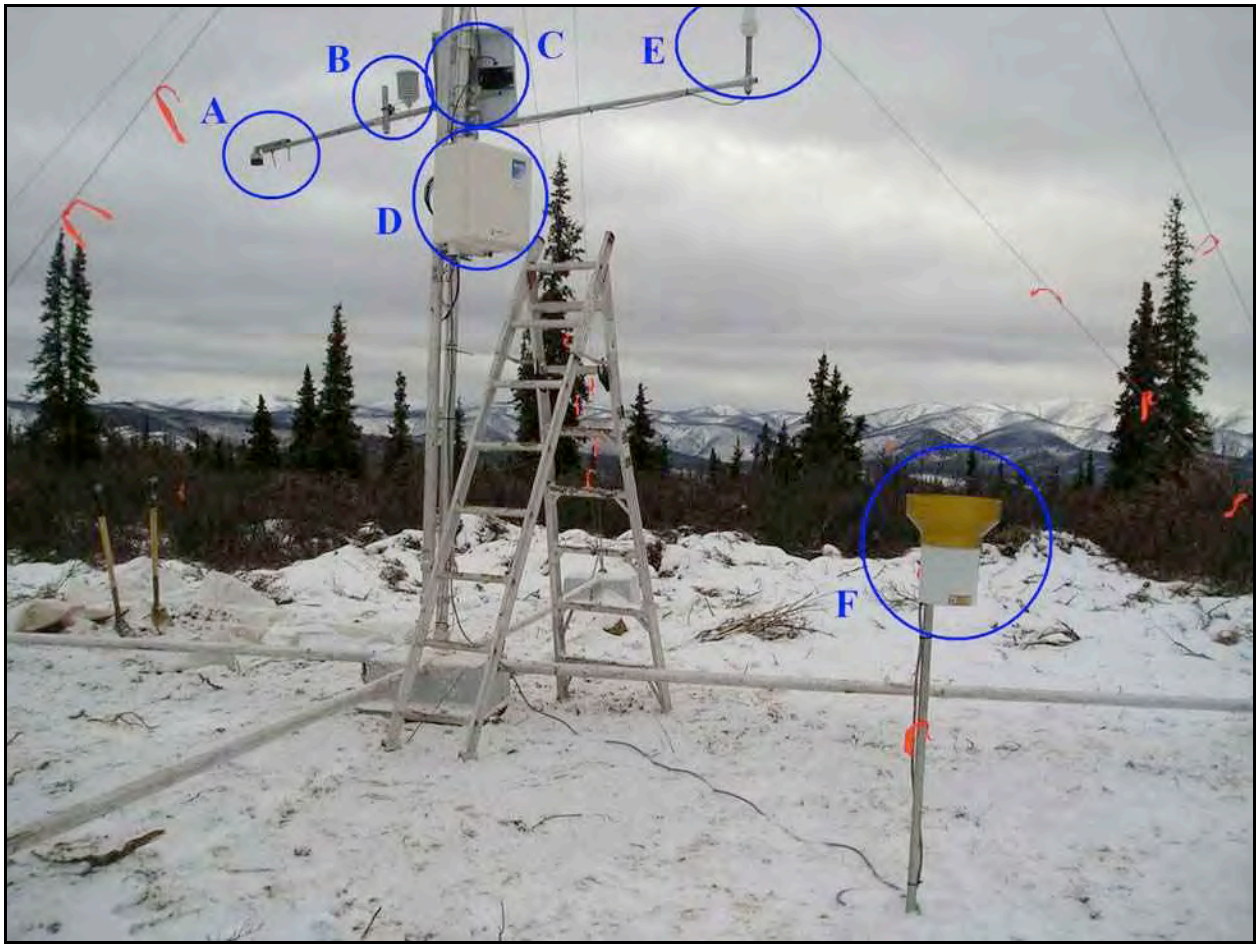


Photo 1. Casino meteorological monitoring station equipped with (A) sonic ranger, (B) relative humidity and temperature probe, (C) solar panel, (D) datalogger enclosure, (E) satellite antenna and (F) rain gauge

Three types of missing data are typically found in the datalogger of the meteorological station. The first is a missing timestamp or record for a particular averaging period. This occurs when the time series skips over a record or series of records entirely. Timestamps of missing periods are manually added to the final dataset. Values for each parameter are given a “Not a Number” (NAN) value for these periods. If missing periods persist or occur regularly, then appropriate action (e.g., send a field technician to the station) will be taken to investigate and resolve the issue.

The second type of missing data is a value for one or more parameters reported as NAN. This flag is typically given to invalid or erroneous data and is excluded in any analysis of data. If one or more parameters persistently shows NAN, then appropriate action (e.g., send a field technician to the station) will be taken to investigate and resolve the issue.

The third type of missing data is a value for one or more parameters that is reported as “0”. This may or may not be an erroneous value, depending on the parameter in question. It is not acceptable under any circumstances for barometric pressure, relative humidity and battery voltage. Values that are reported as zero for those variables will be replaced with NAN and are noted and documented in the final dataset.

Data are checked to see if they are within acceptable upper and lower limits by examining the range of values for each parameter. These limits does not reflect the instrument’s operational range, but they give the physical bounds in which the measurement makes sense. Any values outside the following limits will be considered to be erroneous and will be replaced with NAN:

- Wind speed (0 to 110 km/h);
- Wind direction (0 to 360°);
- Standard deviation of wind direction (0 to 100°);
- Air temperature (-50°C to 35°C);
- Barometric pressure (90 to 110 kPa);
- Relative humidity (0.1% to 100%);
- Rainfall (daily) (0 to 60 mm); and
- Battery voltage (10 to 15 Volts).

2.2 Aquatic Environment

2.2.1 Dates and Locations of Sampling and Surveying

2.2.1.1 General

The study design for the 2008 aquatics work was similar to the sampling design used in the 1993-1995 study by Hallam Knight Piésold. With a few exceptions, the same sampling locations were used and similar sampling techniques were employed. Five sampling trips were made from May to October (Table 1). For each trip, a fixed-wing aircraft was chartered from Alkan Air to fly from Whitehorse to the Casino property. While on the property, aquatic scientists travelled to sampling sites by helicopter (chartered from Capitol Helicopters), by all-terrain vehicles or by foot, depending on weather and trail conditions.

Table 1. Sampling Trips, Aquatic Environment, Casino Project, 2008

Date	Reconnaissance	Hydrology	Water Quality	Sediment Quality	Periphyton and Benthos	Fish and Fish Habitat
May 9	X	-	-	-	-	-
May 20-24	-	X	X	-	-	-
Jul 7-11	-	X	X	-	-	X
Sep 9-13	-	X	X	X	X	X
Oct 9-11	-	X	X	-	-	-

Dashes indicate no data were collected.

2.2.1.2 Hydrology

A total of seven hydrometric stations were installed in 2008. From May 21 to 23, dataloggers (Model 3001 Levelogger Gold, Solinst Corporation) were installed at six hydrometric stations: W1, W3, W4, W9, W11 and W14 (Table 2). This instrument uses a pressure transducer to measure water surface elevation and a thermometer to measure water temperature every hour. Pressure and temperature data were stored in the datalogger and were downloaded on subsequent trips in July, September and October. A barologger was installed at the airstrip to collect barometric air pressure (for barometric compensation for the hydrometric station loggers) and air temperature. On October 9, a seventh hydrometric station was added (H18) on Casino Creek.

Table 2. Summary of Hydrometric Stations and Datalogger Installation Dates, Casino Project, 2008

Watershed	Creek	Site	GPS Co-ordinates*			Dates	
			Easting	Northing		Installation	Winterization
Airstrip	-	-	612,244	6,957,050		May 22	-
Britannia Creek	Britannia	W1	617,439	6,971,241		May 22	Oct 10
	Canadian	W3**	616,141	6,966,789		May 23	Oct 11
	Britannia	W14	616,205	6,966,952		May 23	Oct 10
Casino Creek	Casino	W11	611,557	6,952,289		May 22	Oct 9
	Casino	H18	610,860	6,951,451		Oct 9	Oct 9
	Casino	W4	609,833	6,947,575		May 22	Oct 10
Dip Creek	Dip	W9**	610,018	6,947,352		May 22	Oct 10

**UTM Zone 7N, NAD 83.*

***reference site.*

Dashes indicate no data were available.

During the May field visit, the dataloggers were surveyed using a standard survey rod and level. The water level, the streambed, and the height of the datalogger in the water were determined at each logger station in relation to benchmarks (i.e., large spikes) installed on the creek bank. This allowed for water level measurements to be calculated relative to a fixed land-based benchmark.

Three of the six hydrometric stations were located in the Britannia Creek Watershed:

- W1 on the lower reaches of Britannia Creek;
- W3 on Canadian Creek upstream of the confluence of Canadian and Britannia creeks; and
- W14 on Britannia Creek upstream of its confluence with Canadian Creek.

Two stations were located in the Casino Creek Watershed:

- W11 installed in the upper reach of Casino Creek outside of the southern edge of the proposed TIA; and
- W4 installed on Casino Creek upstream of its confluence with Dip Creek.

One station was located in the Dip Creek Watershed – W9 on Dip Creek upstream of its confluence with Casino Creek.

On October 9, a seventh hydrometric station, H18, was installed in Casino Creek downstream of its confluence with Brynelsen Creek. This station was added to quantify the contribution of flow from Brynelsen Creek.

Two of the seven stations – W3 and W9 – are reference stations, which means they will not be affected by Project activities.

From October 9 to 11, the six dataloggers were winterized by covering each instrument in a latex balloon filled with glycol to prevent damage to the sensors when the surrounding water freezes during winter. Each datalogger was then installed inside a heavy duty, 10 cm-diameters plastic pipe that was partially buried in the stream substrate. Holes were drilled in the pipe to provide hydraulic connection between the stream and the datalogger. Pipes were secured to the stream bank with steel rods anchored by 2 m-long pieces of rebar. All dataloggers were attached with direct read cables for efficient data downloading.

Instantaneous stream flows were also measured manually at additional sites (e.g., W7, W8, W12, W13, W16 and W16 in May). Those sites are summarized in Section 2.2.1.3.

2.2.1.3 Water Quality

A total of 19 sites were chosen for water quality sampling of which six were the hydrometric stations installed in May 2008 (Table 3). Five sites were in the Britannia Creek Watershed:

- hydrometric stations W1, W3 and W14;
- W2 on Britannia Creek just downstream of the confluence of Canadian and Britannia creeks; and
- W7 located on upper Canadian Creek.

Table 3. Summary of Water Quality Sampling Sites, Casino Project, 2008

Watershed	Creek/River	Site	GPS Co-ordinates	
			Easting	Northing
Britannia Creek	Britannia	W2	616,158	6,967,156
	Canadian	W7	609,913	6,959,158
Casino Creek	Casino	W12	612,163	6,958,175
	Casino	W8	613,398	6,956,258
	Meloy	W43	610,823	6,955,906
	Meloy	W13	612,275	6,953,326
	Brynelsen	W18	610,893	6,951,180
Dip Creek	Dip	W9*	610,018	6,947,352
	Dip	W5	609,219	6,947,348
	Dip	W16	600,423	6,942,454
Sunshine Creek	Sunshine	W17*	626,775	6,968,802
Yukon River	Yukon	W6a	615,375	6,973,129
	Yukon	W6b*	619,781	6,973,576
	Yukon	W15	605,721	6,975,108

Dashes indicate no data were available.

Water quality sampling was also conducted at the six hydrometric stations listed in Table 2.

**reference site.*

Five sites were in the Casino Creek Watershed:

- hydrometric stations W11 and W4;
- W12 in Proctor Gulch, the uppermost reach of Casino Creek;
- W8 in the upper reach of Casino Creek upstream of the confluence of Meloy Creek;
- W43 on the adit discharge pipe of the lower camp (which discharges into upper Meloy Creek);
- W13 on Meloy Creek upstream of its confluence with Casino Creek; and
- W18 on Brynelsen Creek upstream of its confluence with Casino Creek.

Three sites were in the Dip Creek Watershed:

- hydrometric station W9;
- W5 on Dip Creek downstream of its confluence with Casino Creek; and
- W16 on Dip Creek 11 km west of site W5 – a far-field site.

One site – W17 – was on Sunshine Creek upstream of its confluence with the Yukon River.

Three sites were located on the Yukon River:

- W6a downstream from the outflow of Britannia Creek;
- W6b upstream of the outflow of Britannia Creek; and
- W15 upstream of the outflow of Excelsior Creek.

Of these 19 sites, three – W9, W17 and W6b – are reference sites, 15 sites are potentially affected by future mine activities, and one – W43 – has already been disturbed.

2.2.1.4 Sediment Quality

A total of 12 stream sites were sampled for sediment quality between September 9 and 10:

- five sites in the Britannia Creek Watershed (W1, W2, W3, W7 and W14);
- five sites in the Casino Creek Watershed (W4, W11, W12, W8 and W13); and
- two sites in the Dip Creek Watershed (W9 and W5).

Only W9 is a reference site. The co-ordinates of the sites are shown in Tables 2 and 3.

2.2.1.5 Periphyton and Benthic Invertebrates

Periphyton and benthic invertebrates were sampled from September 10 to 13. The two communities were sampled at that date because they were expected to have reached their maximum density and diversity after a summer of growth. Four sites were sampled in the Britannia Creek Watershed (Figure 4 and Table 4):

- B1/P1 (where “B” refers to benthos and “P” to periphyton) in lower Britannia Creek upstream of its confluence with the Yukon River;

- B2/P2 in Britannia Creek downstream of the confluence of Canadian and Britannia creeks;
- B3/P3 in Canadian Creek upstream of the confluence of Canadian and Britannia creeks; and
- B8/P8 at the head of Canadian Creek in an area that is proposed to become part of the open pit of the Casino Mine.

Table 4. Summary of Benthos and Periphyton Sampling Sites and Dates, Casino Project, 2008

Watershed	Creek	Site	GPS Co-ordinates		Date
			Easting	Northing	
Britannia Creek	Britannia	B1/P1	617,661	6,973,246	Sep 11
	Britannia	B2/P2	616,163	6,967,197	Sep 10
	Canadian	B3/P3	616,043	6,966,702	Sep 10
	Canadian	B8/P8	609,807	6,958,838	Sep 12
Casino Creek	Casino	B7/P7	613,396	6,956,247	Sep 10
	Casino	B4/P4	610,115	6,947,946	Sep 10
Dip Creek	Dip	B5/P5	609.363	6,947,024	Sep 10

Two sites were sampled in the Casino Creek Watershed – site B4/P4 located upstream of the confluence of Dip and Casino creeks, and site B7/P7 located at the head of Casino Creek in an area that is proposed to be covered by the Casino TIA.

One site were sampled in the Dip Creek Watershed – B5/P5 on Dip Creek, downstream of the confluence of Casino and Dip creeks.

None of these seven sites are reference sites – all are potentially affected by future mine activities.

2.2.1.6 Fish Communities

Fish communities were sampled from July 8 to 11 and from September 10 to 13. Sampling in late May was planned but was cancelled after reconnaissance on May 9 showed that most streams were too turbid to allow visual counts of Arctic grayling spawners or to allow electrofishing.

Four sites were sampled for fish in the Britannia Creek Watershed (Figure 4 and Tables 5 and 6):

- F01 (where “F” refers to fish) on lower Britannia Creek upstream of site B1/P1;
- F03 on lower Britannia Creek below the confluence of Canadian and Britannia creeks;
- F04 on Canadian creek approximately mid-way between sites F03 and F05; and
- F05 on upper Canadian Creek.

Sites F02 and F06 were Hallam Knight Piésold sites that were not sampled in 2008.

Seven sites were sampled for fish in the Casino Creek Watershed:

- F07 on upper Casino Creek downstream of the confluence of an unnamed tributary;
- F08 on upper Casino Creek approximately 2 km downstream of site F07 at the confluence of another unnamed tributary;
- F09 on Meloy Creek, a tributary of Casino Creek;
- F10 and F11 on Brynelsen Creek, another tributary to Casino Creek;
- F12 on Austin Creek upstream of its confluence with Casino Creek; and
- F13 on lower Casino Creek upstream of its confluence with Dip Creek.

One fish sampling site was located in the Dip Creek Watershed – site F14 on Dip Creek downstream of its confluence with Casino Creek.

There were no reference sites for fish in 2008 – all sites may potentially be affected by future mine activities. In particular, sites F07, F08 and F09 are located in an area of Casino Creek that is proposed to be covered by the TIA.

Table 5. Summary of Fish and Fish Habitat Sampling Sites and Dates, Casino Project, 2008

Watershed	Creek	Site	Electrofishing	Minnow Trapping	Angling	Fish Habitat Assessment
Britannia Creek	Britannia	F01	Jul 10	Jul 11	-	-
	Canadian	F03	Jul 8	-	-	Jul 8
	Canadian	F04	Jul 8	-	-	Jul 8
	Canadian	F05	Jul 9	Jul 11	-	-
Casino Creek	Casino	F07	Jul 9	Jul 11	-	Jul 9
	Casino	F08	Jul 9, Sep 12	Jul 11, Sep 12	Jul 11	Jul 9
	Meloy	F09	Jul 9	Jul 11	-	-
	Brynelsen	F10	Jul 9	-	-	-
	Brynelsen	F11	Jul 10, Sep 12	Sep 12	-	-
	Austin	F12	Jul 10	-	-	-
	Casino	F13	Jul 10	-	-	-
Dip Creek	Dip	F14	Sep 12	Jul 11, Sep 12	Jul 11	-

Dashes indicate no sampling at that site and date.

Stations F02 and F06 were not sampled in 2008.

Table 6. Co-ordinates of Electrofishing Upstream and Downstream, Minnow Trapping and Angling, Casino Project, 2008

Method	Site	GPS Co-ordinates	
		Easting	Northing
Electrofishing	F03-us	615,977	6,966,612
	F03-ds	616,015	6,966,696
	F04-us	610,252	6,963,764
	F04-ds	610,392	6,963,879
	F07-us	613,466	6,956,473
	F07-ds	613,449	6,956,383
	F08-us	613,044	6,954,528
	F08-ds	613,032	6,954,443
	F09-us	611,670	6,954,231
	F09-ds	611,689	6,954,068
	F10-us	609,353	6,953,502
	F10-ds	609,456	6,953,369
	F05-us	609,631	6,960,021
	F05-ds	609,518	6,960,215
	F11-us	610,122	6,952,279
	F11-ds	610,346	6,952,105
	F12-us	610,087	6,949,723
	F12-ds	610,190	6,949,589
	F13-us	610,260	6,948,372
	F13-ds	610,245	6,948,318
	F14-ds	609,367	6,947,025
	F01-us	617,439	6,971,280
	F01-ds	617,561	6,971,369
Minnow Trapping	F14	609,480	6,950,644
	F09	611,689	6,954,068
	F08	613,044	6,954,528
	F07	613,449	6,956,383
	F05	609,631	6,960,021
	F01	617,561	6,971,369
Angling	F14	609,480	6,947,025
	F08	613,044	6,954,528

us = upstream and ds = downstream.

In addition to direct sampling of fish communities, an aerial survey of Britannia and Canadian creeks was conducted on September 11 to search for Pacific salmon spawners. The survey was followed by foot surveys of selected stream reaches to ground-truth the aerial observations.

2.2.1.7 Fish Habitat

In July, sections of stream 75 to 200 m length centred over fish sampling sites were surveyed (Table 5): two in Britannia Creek Watershed (F07 and F08) and two in Casino Creek Watershed (F03 and F04).

In September, the focus shifted to surveying representative sections of stream reaches. The reaches and reach breaks were similar to those used by Hallam Knight Piésold (1997) (Figure 4). Table 7 shows the reach numbers for each stream and the GPS co-ordinates of the centre of the representative section that was surveyed.

Table 7. Locations of Fish Habitat Surveys, September 11-12, 2008

Site	Reach	Co-ordinates		Date
		Easting	Northing	
Lower Reach of Britannia Creek	1	617,126	6,970,199	11-Sep
Upper Reach of Britannia Creek	2	616,279	6,966,540	11-Sep
Lover Reach of Canadian Creek	1	615,314	6,966,030	11-Sep
Placer Mine on Canadian Creek	2	614,725	6,965,616	11-Sep
Cascade pools on Canadian Creek	2	609,160	6,960,684	11-Sep
Near Tank Farm on Canadian Creek	4	609,776	6,958,820	11-Sep
Upper Reach of Canadian Creek	3	609,622	6,958,679	11-Sep
At site F14 on Dip Creek	1	609,367	6,947,025	12-Sep
Meloy Creek	1	611,661	6,954,143	12-Sep
Upper Reach of Casino Creek	2	613,087	6,954,573	12-Sep
Lower Reach of Casino Creek	1	610,515	6,950,136	12-Sep
Lower Reach of Brynelsen Creek	1	610,209	6,952,288	12-Sep
Upper Reach of Brynelsen Creek	2	609,448	6,953,393	12-Sep
Lower Reach of Austin Creek	1	610,157	6,949,620	12-Sep
Upper Reach of Austin Creek	2	608,816	6,951,236	12-Sep

2.2.2 Sample Collection

2.2.2.1 Hydrology

In accordance with conventional stream gauging protocols for propeller-type meters, all hydrometric stations were established in straight channels, free from obstructions. Each site was selected to ensure representative hydraulic conditions.

Manual stream velocities were measured with a Marsh-McBirney Flo-mate 2000. The stream discharge (Q, m^3/s) was calculated following the United States Geological Survey mid-section method. The width of the stream was 'discretized' into 'panels', the number of which depending on the total width of the stream and the variation in stream velocity across the section. A stream velocity measurement was taken in the middle of each panel. In most instances, the number of panels was such that only between 5% and 10% of the flow passes though each panel. Stream velocity measurements were collected at 60% of the total depth at each measurement point in the cross-section. At points with depths greater than 50 cm, two velocity measurements were taken: one at 20% of the total depth; and, the other at 80% of the total depth. Flow was calculated at both points and the average of the two flows were used as the contribution of flow from that panel. Flows were summed over all the panels to obtain the total stream flow on that date.

Water stage (h, cm) was measured in two ways: measuring the height of the water at the logger installation, and measuring the depth of water at the thalweg – the deepest, fastest section of water in the cross-section.

2.2.2.2 Water Quality

All surface water samples were grab samples, collected in mid-stream approximately 20 cm under the surface with the bottle mouths facing upstream. Water quality samples were collected for general chemical parameters in pre-cleaned 500 mL plastic bottles supplied by the analytical laboratory. Samples for total metals were collected in 250 mL acid-washed plastic bottles supplied by the laboratory and preserved in the

field with laboratory-supplied nitric acid. Samples for dissolved metals were vacuum filtered in the field through 0.45-micron disposable filterware and preserved with laboratory-supplied nitric acid immediately after filtration. Samples for nutrients – ammonia, total Kjeldhal nitrogen (TKN) and dissolved orthophosphate – were collected in 250 mL bottles and preserved in the field with laboratory-supplied sulphuric acid. Total cyanide was collected in 1 L bottles containing laboratory-supplied sodium hydroxide as a preservative. Total Organic Carbon (TOC) was collected in 125 mL glass-amber bottles and preserved with laboratory-supplied hydrochloric acid. Dissolved Organic Carbon (TOC) was collected in 125 mL glass-amber bottles and preserved with laboratory-supplied hydrochloric acid immediately after filtration.

All samples were kept cold and were not allowed to freeze. They were shipped via air cargo from Whitehorse to Maxxam Analytics in Vancouver, BC. Maxxam Analytics is accredited by the Canadian Association for Environmental Analytical Laboratories. Chain of Custody forms accompanied all samples. Table 8 shows the water quality variables that were measured and their Reported Detection Limits (RDL).

Table 8. Water Quality Parameters and Detection Limits

Parameter	Units	RDL	Parameter	Units	RDL
Physical			Cadmium	mg/L	0.000005
Conductivity	µS/cm	1	Calcium	mg/L	0.05
pH	pH units	0.1	Chromium	mg/L	0.0001
Hardness	mg/L $CaCO_3$	0.5	Cobalt	mg/L	0.000005
Total Dissolved Solids (TDS)	mg/L	1	Copper	mg/L	0.00005
Total Suspended Solids (TSS)	mg/L	1	Iron	mg/L	0.001
Turbidity	NTU	0.1	Lead	mg/L	0.000005
Anions			Lithium	mg/L	0.0005
Alkalinity	mg/L $CaCO_3$	0.5	Magnesium	mg/L	0.05
Chloride	mg/L	0.5	Manganese	mg/L	0.00005
Sulphate	mg/L	0.5	Mercury	mg/L	0.00001
Cyanide (Total)	mg/L	0.0005	Molybdenum	mg/L	0.00005
Cyanide (Weak Acid Dissociable)	mg/L	0.0005	Nickel	mg/L	0.00002
Nutrients			Phosphorus	mg/L	0.002
Ammonia (as N)	mg/L	0.005	Potassium	mg/L	0.05
Nitrate (as N)	mg/L	0.005	Selenium	mg/L	0.00004
Nitrite (as N)	mg/L	0.002	Silicon	mg/L	0.1
Total Kjeldahl Nitrogen	mg/L	0.02	Silver	mg/L	0.000005
Ortho-phosphate (as P)	mg/L	0.001	Sodium	mg/L	0.05
Total and Dissolved Metals			Strontium	mg/L	0.00005
Aluminum	mg/L	0.0002	Thallium	mg/L	0.000002
Antimony	mg/L	0.00002	Tin	mg/L	0.00001
Arsenic	mg/L	0.00002	Titanium	mg/L	0.0005
Barium	mg/L	0.00002	Uranium	mg/L	0.000002
Beryllium	mg/L	0.00001	Vanadium	mg/L	0.0002
Bismuth	mg/L	0.000005	Zinc	mg/L	0.0001
Boron	mg/L	0.005	Zirconium	mg/L	0.0001

RDL = Reported Detection Limit from Maxxam Analytics.

µS = micro-Siemens, and NTU = nephelometric units.

Field measurements of pH, temperature and specific electrical conductivity were made at each site using a YSI Pro pH/conductivity/temperature meter.

2.2.2.3 Sediment Quality

One sample of stream bottom sediment was collected in September 2008 from each of the 12 sites listed in Section 2.2.1.4. The sediment was collected using established protocols from depositional areas of the stream. Where possible, sediment samples were collected by using the jar provided by the analytical lab as a scoop. Appropriate measures were taken to reduce potential for sample contamination. For example, field staff wore disposable nitrile gloves when sampling. All samples were kept cold at all times between sample collection and delivery to the laboratory. Chain of Custody forms accompanied all samples. Table 9 shows the sediment quality variables that were measured and their detection limits.

Table 9. Sediment Quality Parameters and Detection Limits

Parameter	Units	RDL	Parameter	Units	RDL
Physical					
Percent moisture	%	0.3	Manganese	mg/kg	0.2
pH	pH units	0.01	Mercury	mg/kg	0.05
Total Metals			Molybdenum	mg/kg	0.1
Aluminum	mg/kg	100	Nickel	mg/kg	0.8
Antimony	mg/kg	0.1	Phosphorus	mg/kg	10
Arsenic	mg/kg	0.2	Potassium	mg/kg	100
Barium	mg/kg	0.1	Selenium	mg/kg	0.5
Beryllium	mg/kg	0.1	Silver	mg/kg	0.05
Bismuth	mg/kg	0.1	Sodium	mg/kg	100
Cadmium	mg/kg	0.05	Strontium	mg/kg	0.1
Calcium	mg/kg	100	Thallium	mg/kg	0.05
Chromium	mg/kg	1	Tin	mg/kg	0.1
Cobalt	mg/kg	0.3	Titanium	mg/kg	1
Copper	mg/kg	0.5	Vanadium	mg/kg	2
Iron	mg/kg	100	Zinc	mg/kg	1
Lead	mg/kg	0.1	Zirconium	mg/kg	0.5
Magnesium	mg/kg	100			

RDL = Reported Detection Limit from Maxxam Analytics.

All units are mg/kg dry weight unless otherwise noted.

2.2.2.4 Periphyton

Five samples of periphyton were collected from each of the seven sampling sites from September 10 to 11, for a total of 35 samples. Each sample was collected from one rock selected from the stream bed. Each rock was scraped with a scalpel and the scrapings were washed into a sterile 500 mL plastic bottle jar with a squeeze bottle containing stream water. Each sample was preserved by adding Lugol's iodine solution.

All samples were stored in coolers and kept cool until they could be shipped to Fraser Environmental Services Ltd. (FES) of Surrey, BC, for analysis of taxonomic composition. Chain of Custody forms accompanied all samples.

Periphyton density (cells/cm^2) was calculated for each sample by dividing the total number of cells estimated for a sample by the surface area that was scraped for each sample. Sub-sampling was required to estimate numbers of cells (FES 1994). Sample surface area was estimated by tracing the outlines of each rock on a sheet of wax paper. Back in the office, the wax paper outlines were scanned to JPG file format at high resolution. The images were then rasterized and imported into AutoCAD where new vector boundaries were created based on the outside edge of the wax paper for each sample. This process ensured minimal margin of error and allowed for quick calculation once the scans were complete.

2.2.2.5 Benthic Invertebrates

Five samples of benthic invertebrates were collected from each of the seven sampling sites from September 10 to 11, for a total of 35 samples. Samples of benthic invertebrates were taken from areas of riffle habitat with similar stream depths and velocities. The Surber sampler has a surface area of 0.093 m^2 and mesh size of 250 µm. It was placed facing into the stream current with the hinged frame resting on the streambed. Substrate within the area defined by the frame was disturbed by hand for approximately 5 minutes to dislodge benthic organisms, which were swept into the net by the stream current. The organisms caught in the net were then washed into a sample bottle and preserved with 85% ethanol. This was repeated four more times at nearby areas to obtain five replicate samples at each site.

Samples of benthos were shipped to Cordillera Consulting in Summerland, BC, for taxonomic identification to the lowest practical taxonomic level, which was to the Order level for most aquatic insects, to the Class level for oligochaetes and to the Phylum level for nematodes. Chain of Custody forms accompanied all samples. All organisms in each sample were counted and identified – no sub-sampling was required.

Total density of benthic invertebrates collected by a Surber sampler was calculated by dividing the total number of organisms counted from a sample by the sampling area of the Surber sampler.

2.2.2.6 Fish Community

Three gears were used to sample fish: minnow traps, backpack electrofishers and angling. Three minnow traps were installed at each of five sites in July and two traps were installed at each of three sites in September for a total of 21 minnow trap installations. Minnow traps are made of galvanized steal wire and are conical in shape with a length of 42 cm, a width of 23 cm and a mesh size of 0.6 cm. Minnow traps were placed at each site in deep pools or among large woody debris or in slow-moving eddies. They were anchored to large woody debris or rocks and rocks were placed within the traps to weight them down. They were marked with red or yellow fluorescent flagging tape. Each trap was baited with canned salmon placed in a small perforated bag. Traps were soaked for 24 hours.

A mixture of one-pass and three-pass electrofishing was conducted. Three-pass electrofishing was conducted wherever flows were low enough that blocking nets could be installed in streams, but flows were

high enough at many sites to wash blocking nets out. For those sites, only one-pass electrofishing with no blocking nets were used.

For three-pass electrofishing, blocking nets were installed at the upstream and downstream ends of a stream section 75 m in length. Then, a two-person crew walked the stream section in an upstream direction repeatedly sweeping the stream from bank to bank with the wand of the electrofishing unit. Fish that were temporarily stunned by the electric field were scooped up with a dipnet and stored in a water-filled live bucket. After a pass was complete, the crew processed the captured fish on the stream bank. After waiting one half hour, another pass was conducted. After three passes, the blocking nets were removed and all processed fish were released live back into the stream except for those sculpin that were retained for tissue metals analysis.

Between passes, captured fish were identified to species and counted. Then, fork length was measured to the nearest 1 mm with a measuring board (total length was measured for slimy sculpin), and wet weight was measured to the nearest 0.1 g with a balance. Scales were collected from Arctic grayling for age analysis. The collection site was always on the side of the fish mid-way between the lateral line and the dorsal fin. Arctic grayling scales were sent to North Shore Environmental Services Ltd. In Thunder Bay, ON, where the scales were mounted on micro-fiches and the annuli were counted. A Chain of Custody form accompanied the samples.

Angling was conducted at two sites in July using standard angling gear. Angling effort (i.e., time spent angling) was not recorded. Fish were not processed for biological characteristics and no aging structures were collected.

2.2.2.7 Fish Tissue Metals Concentrations

A sub-set of slimy sculpin captured by electrofishing in July and September were collected for analysis of whole-body tissue metals concentrations. Each fish was placed in a labelled plastic bag and frozen immediately. The samples were sent to CANTEST analytical laboratories in Vancouver, BC. Chain of Custody forms accompanied all samples. At CANTEST, samples were digested using a nitric acid-hydrogen peroxide procedure based on U.S. EPA method 200.3. The concentrations of 32 metals were measured using Inductively Coupled Argon Plasma Spectroscopy (ICP) or ICP Mass Spectroscopy (Table 10). The concentrations of mercury were measured using Cold Vapour Atomic Absorption Spectrophotometry or Cold Vapour Atomic Fluorescence Spectrophotometry.

Table 10. Fish Tissue Metals and Detection Limits

Metal	RDL	Metal	RDL
Aluminum	0.5	Nickel	0.1
Antimony	0.1	Phosphorus	0.5
Arsenic	0.1	Potassium	1
Barium	0.1	Selenium	0.2
Beryllium	0.02	Silicon	10
Boron	2	Silver	0.01
Cadmium	0.02	Sodium	1
Calcium	1	Strontium	0.05
Chromium	0.1	Tellurium	0.1
Cobalt	0.1	Thallium	0.02
Copper	0.1	Tin	0.1
Iron	5	Titanium	0.3
Lead	0.1	Uranium	0.04
Magnesium	0.5	Vanadium	0.5
Manganese	0.1	Zinc	0.5
Mercury	0.01	Zirconium	3
Molybdenum	0.1		

All units are µg/g wet weight.

RDL = Reported Detection Limit.

2.2.2.8 Fish Habitat

Fish habitat was characterized following a modified version of the methods described in the *Fish Habitat Assessment Procedures* guide for the British Columbia government (Johnston and Slaney 1994). Stream length and stream width (i.e., wetted and bankfull width) was measured with surveyor's measuring tape. Gradient was measured with a clinometer. Stream depth was measured with a meter stick. Stream stage was assessed as low, medium or high visually by comparison between stream surface height and bankfull height. Habitat was visually assessed into the following five types:

- ***Pools*** have zero gradient, slow-moving water and a concave bottom;
- ***Runs*** (also called glides) are sections of non-turbulent, fast-flowing water;
- ***Riffles*** are areas of turbulent, fast-flowing water with gravel or cobble substrates and with obvious surface turbulence;
- ***Cascades*** are steep, stepped "riffles" of bedrock or emergent cobble or boulders in channels with gradients greater than about 4%;
- ***Other*** includes wetland complexes that lack an identifiable primary channel, sloughs, lakes, areas of sub-surface flow or areas where the channel cannot be observed (e.g., under large log jams).

Stream substrate was assessed visually into the following classes:

- fines (or silt);
- small gravel (2-16 mm particle diameter);
- large gravel (16-54 mm);
- small cobble (64-128 mm);
- large cobble (128-256 mm);

- boulder (>256 mm) or
- bedrock.

The percent of the stream surface that provided fish with cover was described using the following classes:

- deep pool;
- large woody debris (LWD);
- boulder;
- cutbank;
- instream vegetation; and
- overhanging vegetation.

The percentage of the overhead forest canopy that was closed was estimated visually.

The percentages of a stream section that belonged to each habitat type had to add to 100%, as did the percentages of the substrate of a stream section that belonged to each size class and the percent of the canopy that was closed. However, the percentages of cover provided by the various classes did not have to add up to 100%.

Stream confinement was assessed as:

- unconfined (UC) – the stream bank is not touching the valley wall;
- occasionally confined (OC) – the stream bank is occasionally confined by the valley wall or terraces;
- frequently confined (FC) – the stream bank is frequently confined by the valley wall or terraces;
- confined (CO) – the stream bank is in continuous or repeated contact at the outside of meander bends;
- entrenched (EN) – the stream bank is in continuous contact with the valley walls or terraces due to downcutting; and
- not applicable (NA) – no valley walls exist (e.g., alluvial fans).

The stream section was classified as braided or non-braided and the percent of the stream surface area made up of gravel bars was recorded.

Finally, a suite of water quality variables were measured with field instruments (e.g., YSI model 556): pH, water temperature, TDS, conductivity and dissolved oxygen concentration.

2.2.3 QA/QC

2.2.3.1 Water Quality

All field equipment were maintained in good working condition and measuring instruments were calibrated frequently. For example, the pH meter was calibrated prior to each field trip using prepared solutions with pHs of 4 and 7, and the conductivity meter was checked prior to each field trip using the standard 1,413 µS/cm conductivity solution.

Water quality samples were collected by a qualified aquatic biologist and were carried out by the same individual at each sampling site to insure consistency. All water samples were collected using industry standard sampling protocols. Appropriate measures were taken to reduce potential for sample contamination. Field staff wore disposable nitrile gloves when sampling and used bottles and preservative supplied by the analytical laboratory. All samples were collected with the mouth of the sampling bottle facing upstream. Care was taken to ensure that no upstream disturbances occurred as the result of walking within the creek bed prior to sampling.

Ten percent of the number of water quality samples were replicated, hence a total of five replicate samples were collected: two in May, two in July and one in September. Replicate sample locations were chosen randomly. Appendix B6 shows the results of analysis of replicate samples. Relative Percent Difference (RPD) was used to assess analytical variability. RPD was defined as:

$$\%RPD = \frac{2(X_1 - X_2)}{(X_1 + X_2)} * 100$$

where X_1 = the concentration of a parameter in the first sample and X_2 = the concentration of the same parameter in the second sample (i.e., the replicate). An RPD less than 25% is considered an acceptable difference, and an RPD greater than 25% warrants further examination to ensure that the result was not due to sampling error or analytical error. RPD is only relevant when both values are greater than the Practical Quantitation Limit (PQL), which was defined for this project as three times the detection limit. The PQL is considered the lowest concentration that can be accurately measured, as opposed to just detected.

As shown in Appendix B6 and Table 11, between one and seven of the 89 parameters that were measured from each sample had RPDs greater than 25% and met PQL restrictions. This was equivalent to between 1% and 8% of all parameters, which is considered to be an acceptable level of variability.

Table 11. RPD Analysis of Replicate Water Quality Samples, Casino Project, 2008

Month	Replicate	Number of Parameters with RPD>25%	Percent of Parameters with RPD>25%
May	1	7	8
May	2	3	3
July	3	1	1
July	4	3	3
September	5	2	2

A total of 89 parameters were measured from each sample.

The sites, dates and parameters for which RPD was greater than 25% were as follows:

- W1, May, turbidity, sulphate, total iron, total lead, total phosphorus, total titanium and total vanadium;
- W5, May, TSS, turbidity and dissolved thorium;

- W1, July, chloride;
- W43, July, TKN, dissolved aluminum and dissolved silver; and
- W43, September, TKN and dissolved nickel.

Sites W1, W5 and W43 should be targeted in future QA/QC monitoring to investigate further these results.

The results of the field and travel blanks are shown in Appendices B2 to B5. All values were below detection limits, indicating no contamination of samples.

Maxxam Analytics, which conducted the analyses of water and sediment samples, is a certified member of the Canadian Association of Environmental Analytical Laboratories. Maxxam split several samples into duplicates and analyzed each one separately to provide a measure of their laboratories analytical precision. Duplicates were chosen randomly by Maxxam. The results, which are not reported here, met Maxxam's standards for QA/QC.

2.2.3.2 Sediment Quality

Sediment quality samples were collected by a qualified aquatic biologist and were carried out by the same individual at each sampling site to insure consistency. All sediment samples were collected using industry standard sampling protocols. Appropriate measures were taken to reduce potential for sample contamination. Field staff wore disposable nitrile gloves when sampling and used sample bottles supplied by the analytical laboratory.

No replicate sediment quality samples were collected.

2.2.3.3 Periphyton and Benthos

Periphyton and benthic invertebrates samples were collected by a qualified aquatic biologist and were carried out by the same individual at each sampling site to insure consistency.

Fraser Environmental Services Ltd. (FES) has over ten years experience in analysis of periphyton from streams and rivers of western Canada. FES has the following standard QA/QC procedures (FES 1994):

- all microscopes are calibrated on a regular basis;
- consistent sample concentration and sub-sampling techniques are employed for identifications;
- taxonomic identifications are verified by comparison with reference collections, including an in-house reference collection;
- difficult, typical or dominant specimens are sent to external experts for confirmation. Part of this process includes compiling a list of experts for different groups of organisms. Verified specimens are incorporated into FES' reference collection; and
- all FES personnel actively participate in a taxonomists' working group.

Cordillera Consulting has over ten years experience in taxonomic analysis of benthic invertebrates from streams, rivers and lakes of western Canada. The following QA/QC procedures are followed by Cordillera Consulting (http://www.cordilleraconsulting.com):

- sorting efficiency – 10% of the whole sample number was resorted with an expectation of >90% efficiency in the sorting process.
- taxonomic efficiency – 10% of the identified sample vials were sent to another taxonomist. The two results were compared with simple statistics and the taxonomists discussed how best to correct their differences and make appropriate changes to the results.
- taxonomic precision – an externally verified reference collection is maintained by Cordillera Consulting. Any new specimens are sent away to experts of that taxon and the collection is reviewed every five years.

2.2.3.4 Fish and Fish Habitat

All fish and fish habitat field data were recorded on paper field notes and then transferred to electronic spreadsheets in the office. The spreadsheets were compared with the field notes to identify and correct transcription errors. A variety of other measures were taken to further ensure the validity of the data. For example, fish weights were plotted on fish lengths for each species separately to identify outliers that may have been due to errors in recording or transcription. Outliers were then corrected, if possible, or excluded from the analyzed dataset.

Blanks and duplicates were run by CANTEST for each of the two batches of slimy sculpin tissue that were analyzed for metals concentration. Appendix B15 shows those data. In both cases the blanks were below detection limits, indicating no contamination of equipment. RPDs were calculated for each metal from the duplicate samples. In all cases, the RPDs were below the 20% limit specified by the *British Columbia Environmental Laboratory Manual for the Analysis of Water, Wastewater, Sediment, Biological Material and Discrete Ambient Air Samples* (BC MOE 2007).

2.2.4 Data Analysis

2.2.4.1 Hydrology

In order to reconstruct a discharge hydrograph for each hydrometric station, a relationship between manual measurements of discharge and water stage (referred herein as a rating curve) was developed. A power function is used to predict discharge from water stage:

$$Q = a(h - z)^b$$

where Q is discharge (m^3/s), h is stage (m), z is gauge height at “zero flow” (m), and a and b are constants. An estimate of z was obtained by plotting log(Q) versus log (h) – z was the y-intercept when log(Q) = 0. Then, the power function was converted to a linear regression equation by taking logarithms:

$$\log(Q) = \log a + b \log(h - z)$$

and regression analysis was used to estimate values for a and b for each hydrometric site.

To reconstruct a hydrograph at each site, the continuous stage readings recorded by the datalogger were converted to hourly flows using the fitted stage-discharge relationship for each site. Daily mean discharges were calculated from the hourly discharges.

2.2.4.2 Water Quality

The minimum, median and maximum concentrations of selected water quality parameters were calculated for each site sampled in 2008. The median, rather than the arithmetic mean, was assumed to be the best estimate of the central tendency of the data because many water quality variables tend not to be normally distributed. To calculate statistics, all data for each site were pooled over the May-October sampling period and values below detection limits were replaced with one-half the detection limit.

Concentrations of water quality parameters were compared to guidelines for the protection of freshwater aquatic life issued by the Canadian Council of the Ministers of the Environment (CCME) (CCME 2008), and exceedances of the guidelines were identified.

Principal components analysis (PCA) of water quality was used to reduce the redundancy within the dataset and identify underlying trends. The first step in PCA of water quality was to remove all variables for which 90% of the records were below detection limits. For the remaining variables, all values below detection limits were replaced with one-half the detection limit. Concentrations of total and dissolved metals were transformed with natural logarithms to normalize the frequency distributions. The varimax option was used to rotate components in order to maximize the contrast between components and improve comprehension of the results.

2.2.4.3 Sediment Quality

The minimum, median and maximum concentrations of each sediment quality parameter were not calculated because only one sample was taken for each site sampled in September 2008.

The 2008 sediment quality data was compared to the CCME (2008) sediment guidelines for the protection of freshwater aquatic life. There are two classes of guidelines: the Probable Effects Level (PEL), which defines the level above which adverse effects are expected to occur frequently; and the Interim Sediment Quality Guideline (ISQG), which is lower than the PEL and which defines the concentration below which minimal effects on the aquatic environment are expected.

PCA of sediment quality was calculated in the same way as PCA of water quality. All metals for which 90% of the records were below detection limits were removed. For the remaining metals, all values below detection limits were replaced with one-half the detection limit. Metal concentrations were transformed with natural logarithms to normalize the frequency distributions, and the varimax option was used to rotate components.

2.2.4.4 Periphyton and Benthos

One-way Analysis of Variance (ANOVA) was used to compare mean densities of periphyton and of benthic invertebrates between sites. ANOVA assesses the statistical significance of differences using F-ratios. Significance was assessed as none ($P>0.05$), low ($0.01<P<0.05$), medium ($0.001<P<0.01$) and high ($P<0.001$), where P is the probability of making a Type I error (i.e., rejecting a true null hypothesis). Densities were ln-transformed to normalize the frequency distributions and to satisfy the assumption of equal variances – two prerequisites of parametric statistics.

The taxonomic composition of periphyton and benthos communities were assessed using tabular means after pooling replicates for each site.

Two indices of taxonomic diversity were calculated for each sample of periphyton and three indices were calculated for each sample of benthic invertebrates using the protocols recommended by the Canadian Aquatic Biomonitoring Network (CABIN), which is supported by the National Water Research Institute (NWRI) of Environment Canada (NWRI 2008):

- taxonomic richness (S), calculated as the total number of families in a sample, regardless of their relative abundances;
- EPT abundance (EPT), defined as the total number of mayflies (Ephemeroptera), stoneflies (Plecoptera) and caddisflies (Trichoptera) in a sample. These three orders of aquatic insects are typically most sensitive to habitat disturbance. EPT was not calculated for periphyton; and
- Shannon-Weiner diversity index (H'), calculated as $-\Sigma(p_i \ln(p_i))$, where $p_i = n_i/N$, n_i = the total number of individuals in the ith species, N = the total number of organisms in the sample, and H' was calculated by summing over all species (i.e., over S).

For the purposes of calculating S and H', those taxa that could not be identified to the family or species level (e.g., unidentified flagella for periphyton and Phylum Nematoda for benthos) were treated as if they were a family or a species. The periphyton data reported by Fraser Environmental Services included less than signs (<) for some species or genus, indicating that the species or genus were present in the sample but not in sufficient numbers to allow density to be calculated. Those data were used to calculate periphyton richness, but they were not used to calculate densities and Shannon-Wiener diversity indices.

2.2.4.5 Fish and Fish Habitat

The standard error (SE) was the index of dispersion for all arithmetic means shown in this report, and n was the sample size.

Total catch-per-unit-effort (CPUE) of minnow traps was not calculated because the traps caught no fish. Electrofishing CPUE was defined as the number of fish captured per 100 seconds of electrofishing effort. Angling CPUE was not calculated because fishing effort (i.e., angling time) was not recorded.

One-way ANOVA was used to compare mean fish CPUE between seasons and sites and mean fish length and weight between watersheds.

Weight-length regressions for fish were calculated as ln(W) = a + bln(L), where W = weight (g) and L = fork length (mm), a = the intercept of the regression and b = the slope of the regression. Both weight and length were ln-transformed to normalize their frequency distributions and produce homogenous variances. The coefficient of determination (i.e., r^2) for all regressions were adjusted for the number of degrees of freedom.

The length-age relationship for Arctic grayling was estimated by fitting a von Bertalanffy growth model with non-linear regression. The model is $L = L_\infty(1 – \exp(-K(t – t_0)))$ where L = length (mm), t = age (year), L_∞ = length (mm) at infinite age (also known as asymptotic length), K = growth coefficient ($year^{-1}$) and t_0 = the age (year) at which L = 0 mm. The advantage to using a von Bertalanffy model is that it predicts non-zero lengths for 0-age fish.

Analysis of slimy sculpin tissue metal concentrations was similar to that of water quality and sediment quality: remove all metals for which 90% of the records were below detection limits, replace all values below detection limits with one-half the detection limit, and use PCA to identify underlying trends. Metal concentrations were transformed with natural logarithms to normalize the frequency distributions, and the varimax option was used to rotate components.

2.3 Terrestrial Environment

Two terrestrial reconnaissance surveys were conducted in 2008: one from July 7 to 11 and a second from September 8 to 11. Aerial surveys of the terrestrial LSA were conducted in a helicopter at low altitudes (mean height of 150 m above ground level) and low speeds (40 to 55 knots). Two observers scanned the ground with binoculars and recorded observations on vegetation communities and wildlife in field notes and on a map of the LSA. Photographs of vegetation communities were taken.

Aerial surveys were followed by ground-based surveys conducted by foot or with ATVs. A total of 33 sites – 17 in July and 16 in September – were surveyed (Figure 5). At each site, wildlife habitat was classified (e.g., aspen forest, riparian, alpine subalpine, etc.), surficial geology was classified (e.g., collivial, fluvial, bedrock, etc.), and general features of the habitat were described (e.g., slope, aspect, drainage, etc.). Soil pits were dug to a minimum 40 cm (where possible) or to the C layer. Samples of vegetation were collected and animal sighting and signs (claw marks, paw prints, antlers, scat, etc.) were photographed and their GPS co-ordinates recorded with a Garmin 76 handheld GPS with accuracy of between 5 and 10 m.

The vegetation sampling strategy was guided by the *Standards for Terrestrial Ecosystem Mapping (TEM) in British Columbia* (RIC 1998). This system provides an established and uniform means of describing vegetation, soils and terrain characteristics based on air photo interpretation and field data collection programs. Sampling of vegetation used a combination of ground inspection plots (GIF) and visual checks, using Ecosystem Field Forms adapted from methodology outlined in the *Field Manual for Describing Terrestrial Ecosystems* (BC MELP and MOF 1998). Ground inspections used FS212 (adapted) field forms to record site, soil and vegetation information. Notes describing the plot, in context and variability within the polygon, were recorded. Photographs were taken at each plot.

Visual checks involved recording brief point or area characteristics made from the air (helicopter) or ground, and were used to note the basic ecosystem unit, vegetation, and other key features. The primary function of visual plots was to aid in the delineation of polygon and to confirm the placement of polygon boundaries during the photo interpretation and mapping phases proposed for 2009.

Vegetation nomenclature followed that of the *Flora of the Yukon Territory* Second Edition (Cody 2000). A detailed rare plant survey of the Project area was not within the scope of this assessment. Instead, attempts were made to identify potentially rare, sensitive and/or endangered vegetation or vegetation communities within the study area. In general, alpine/sub-alpine and riparian communities across the LSA were expected to possess the greatest potential of harbouring rare plants or sensitive plant communities because they are sensitive to disturbance and may take above mean lengths of time to recover from disturbance. Riparian areas also provide high wildlife habitat value.

The terrestrial data collected in 2008 were reconnaissance-level only and hence were not subjected to extensive analysis. They primary purpose was to provide sufficient data to effectively plan more comprehensive surveys in the future.

3. Results and Discussion

3.1 Atmospheric Environment

There were too few meteorological data to be analyzed in this report because the Casino meteorological station has only been operating since October 3, 2008. Air temperatures recorded by the barologger at the Casino airstrip are shown in Section 3.2.1.2 below.

3.2 Aquatic Environment

3.2.1 Hydrology

3.2.1.1 Stage-Discharge Rating Curves

Appendix B1 shows the stage-discharge data for the six hydrometric stations. Table 12 summarizes the manual discharge measurements and shows the estimates of the gauge height at zero flow (z) for each of the hydrometric stations.

Table 12. Summary of Manual Discharges and 'z' for Hydrometric Stations

Creek	Site	May (m^3/s)	July (m^3/s)	September (m^3/s)	October (m^3/s)	Gauge at Zero Flow (z, m)
Britannia	W1	2.539	0.840	2.136	0.403	0.06
Canadian	W3	1.621	0.332	1.568	0.375	0.26
Casino	W4	1.499	0.495	2.118	0.809	0.18
Dip	W9	3.988	3.613	3.252	1.105	0.29
Casino	W11	0.865	0.136	0.707	0.401	0.06
Britannia	W14	0.864	0.290	0.398	0.145	0.03

Figures 7 through 12 show the stage-discharge rating curves for sites W1, W3, W4, W9, W11 and W14 respectively. The regression statistics shown in each figure – sample size (n), coefficient of determination (r^2) and the probability that the slope is equal to zero (P) – are the results of the log-linear regression analysis. In each case, the regression provided an apparently fair to strong fit to the data. However, two of the regressions – those for W9 and W11 – were not significant (P>0.05) due to the small sample size.

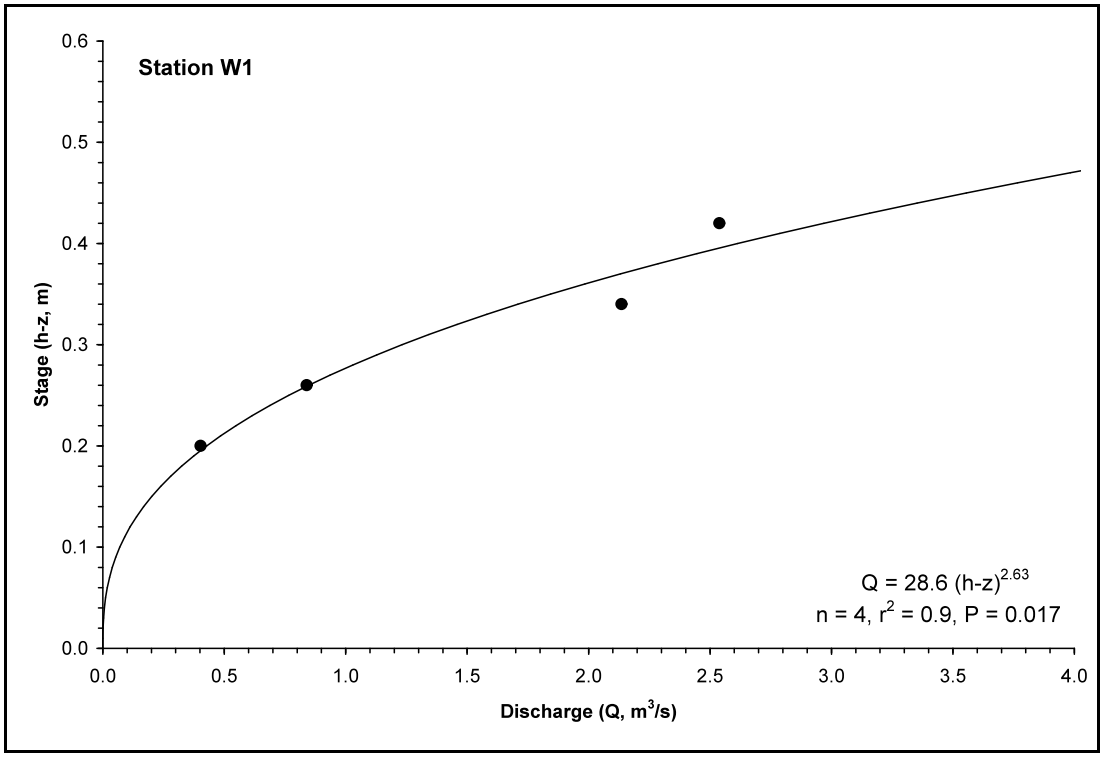


Figure 7. Stage-Discharge Rating Curve for Site W1, Britannia Creek, Casino Project, 2008

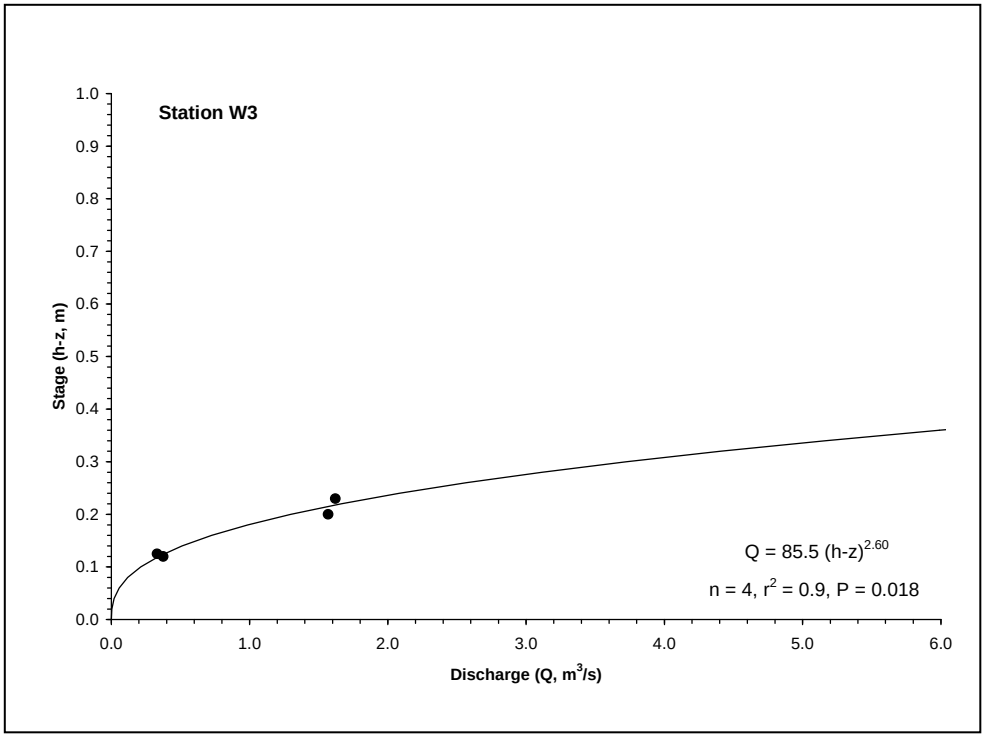


Figure 8. Stage-Discharge Rating Curve for Site W3, Canadian Creek, Casino Project, 2008

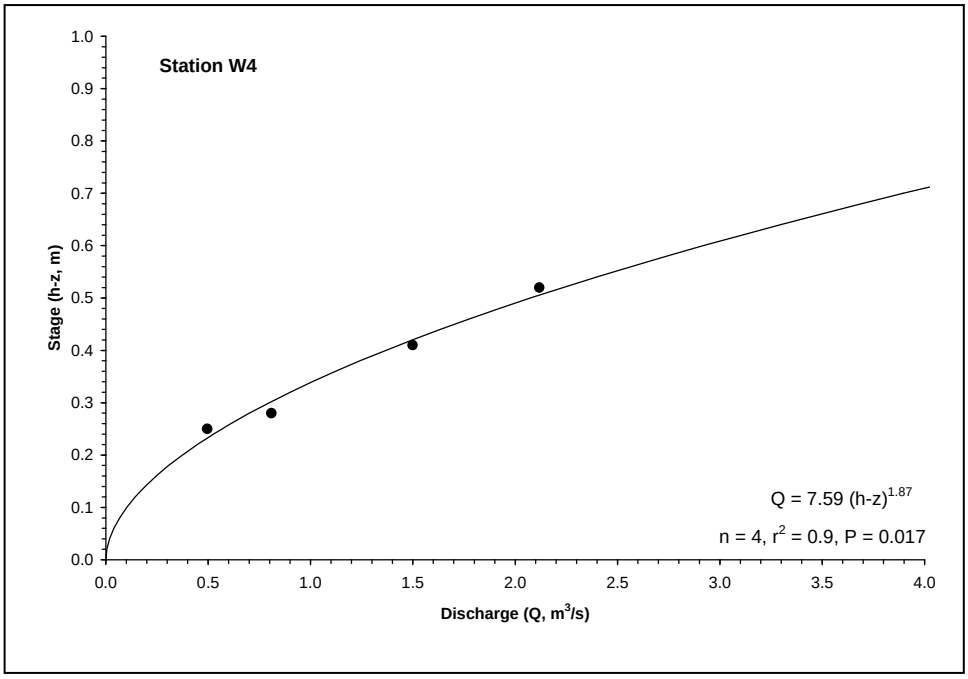


Figure 9. Stage-Discharge Rating Curve for Site W4, Casino Creek, Casino Project, 2008

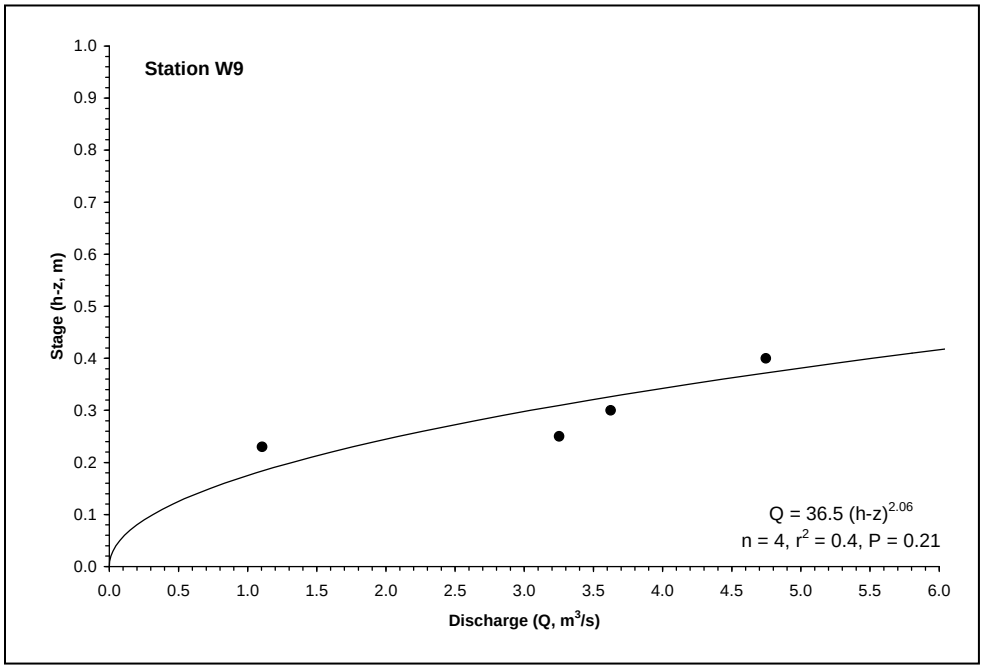


Figure 10. Stage-Discharge Rating Curve for Site W9, Dip Creek, Casino Project, 2008

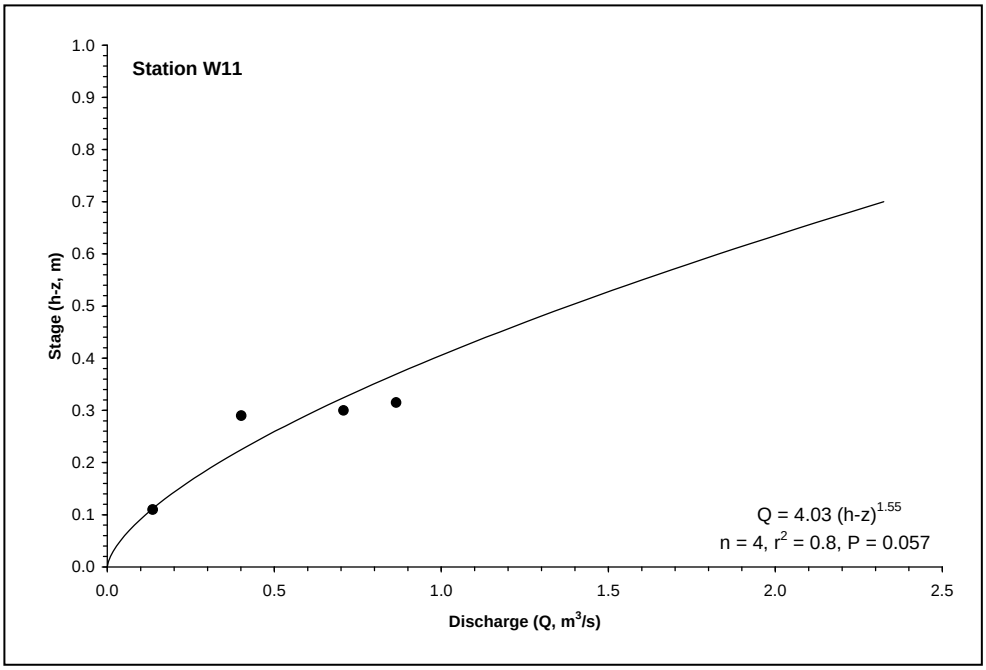


Figure 11. Stage-Discharge Rating Curve for Site W11, Casino Creek, Casino Project, 2008

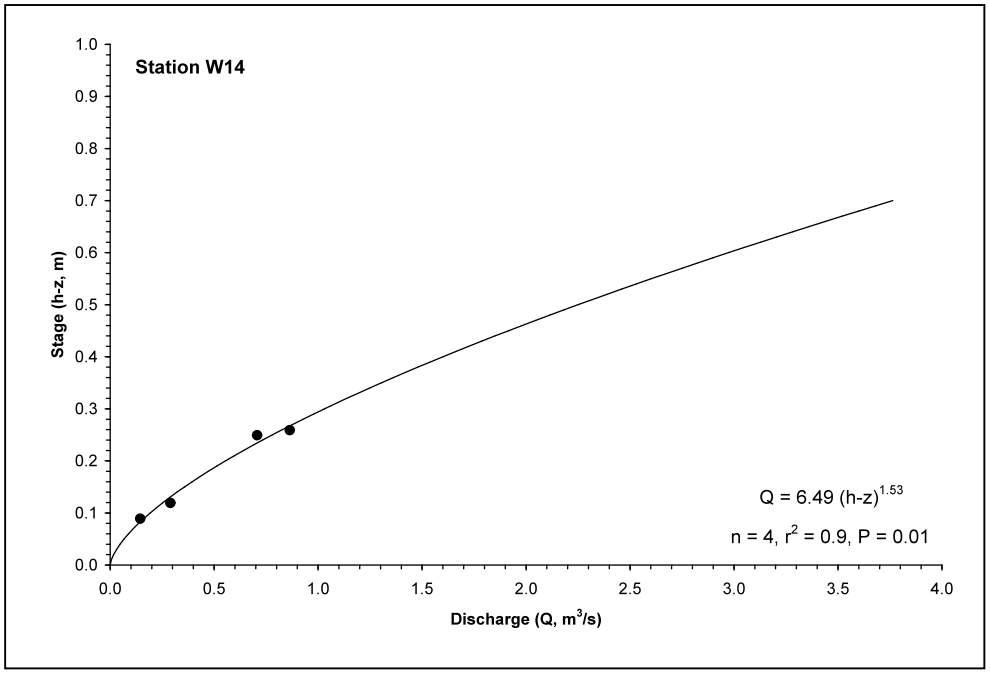


Figure 12. Stage-Discharge Rating Curve for Site W14, Britannia Creek, Casino Project, 2008

In general, the manual measurements during each field visit were conducted during medium to high flow events. Consequently, the reconstruction of discharge at lower flows is less reliable. Future field visits should attempt to capture, if possible, lower flows in efforts to produce more representative stage-discharge rating curves.

3.2.1.2 Hydrographs

Figures 13 to 18 show the hydrographs for stations W1, W3, W4, W9, W11 and W14, respectively. Discharge is shown as a solid blue line, water temperature as the dashed green line and air temperature as the dotted orange line. Due to a logger malfunction at station W4 (Figure 15), data was not collected between May 22 and July 9, 2008.

In the absence of meteorological data, it is difficult to ascertain the source (snow melt, precipitation, permafrost melting, etc.) of specific peaks in discharge for each station. However, The following observations can be made with a moderate degree of confidence, based on the temporal patterns of stream temperature and air temperature, in conjunction with the temporal pattern of specific discharge peaks:

Figure 13. Hydrograph for Station W1, Britannia Creek, Casino Project, 2008

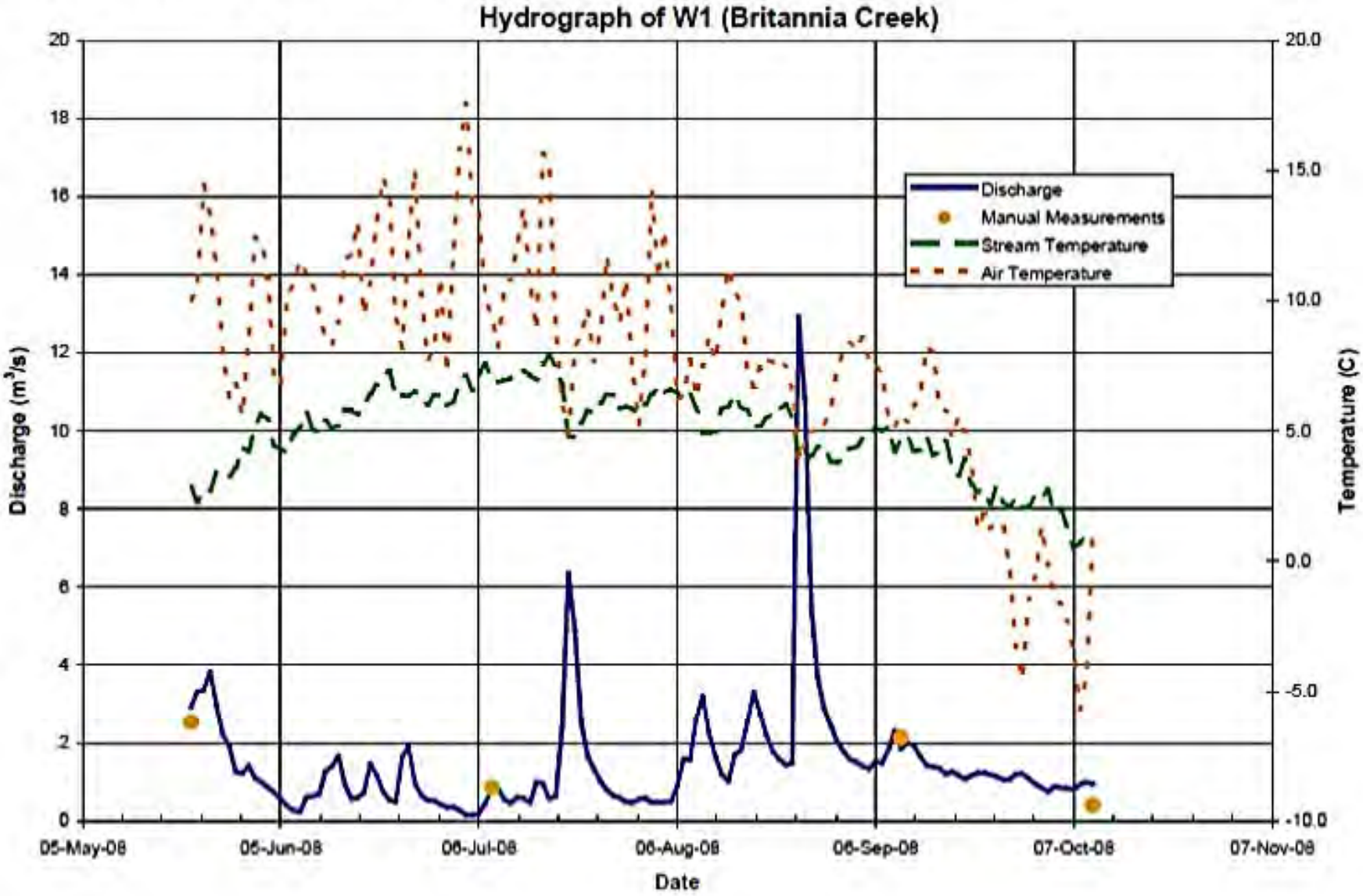


Figure 14. Hydrograph for Station W3, Canadian Creek, Casino Project, 2008

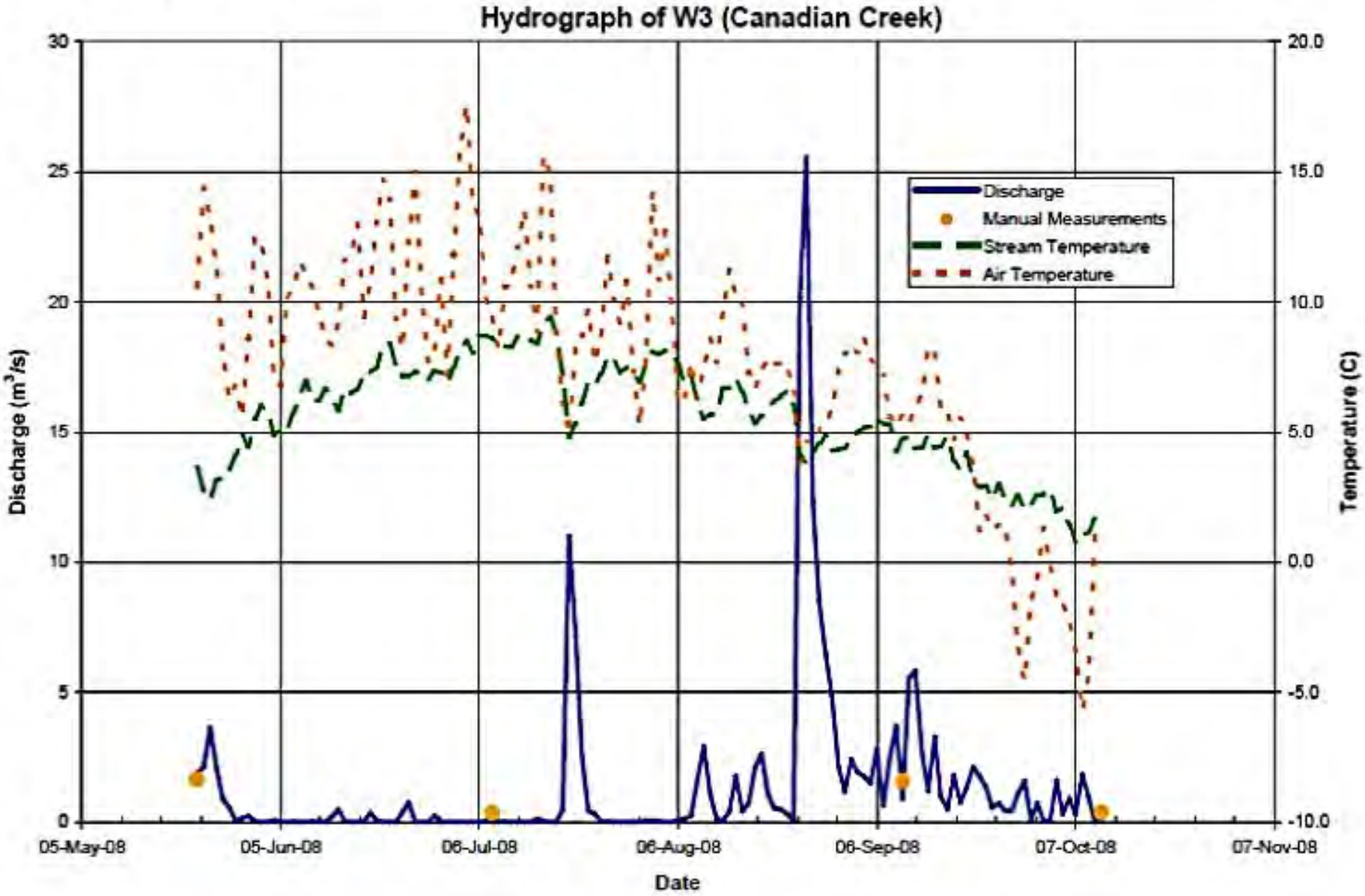


Figure 15. Hydrograph for Station W4, Britannia Creek, Casino Project, 2008

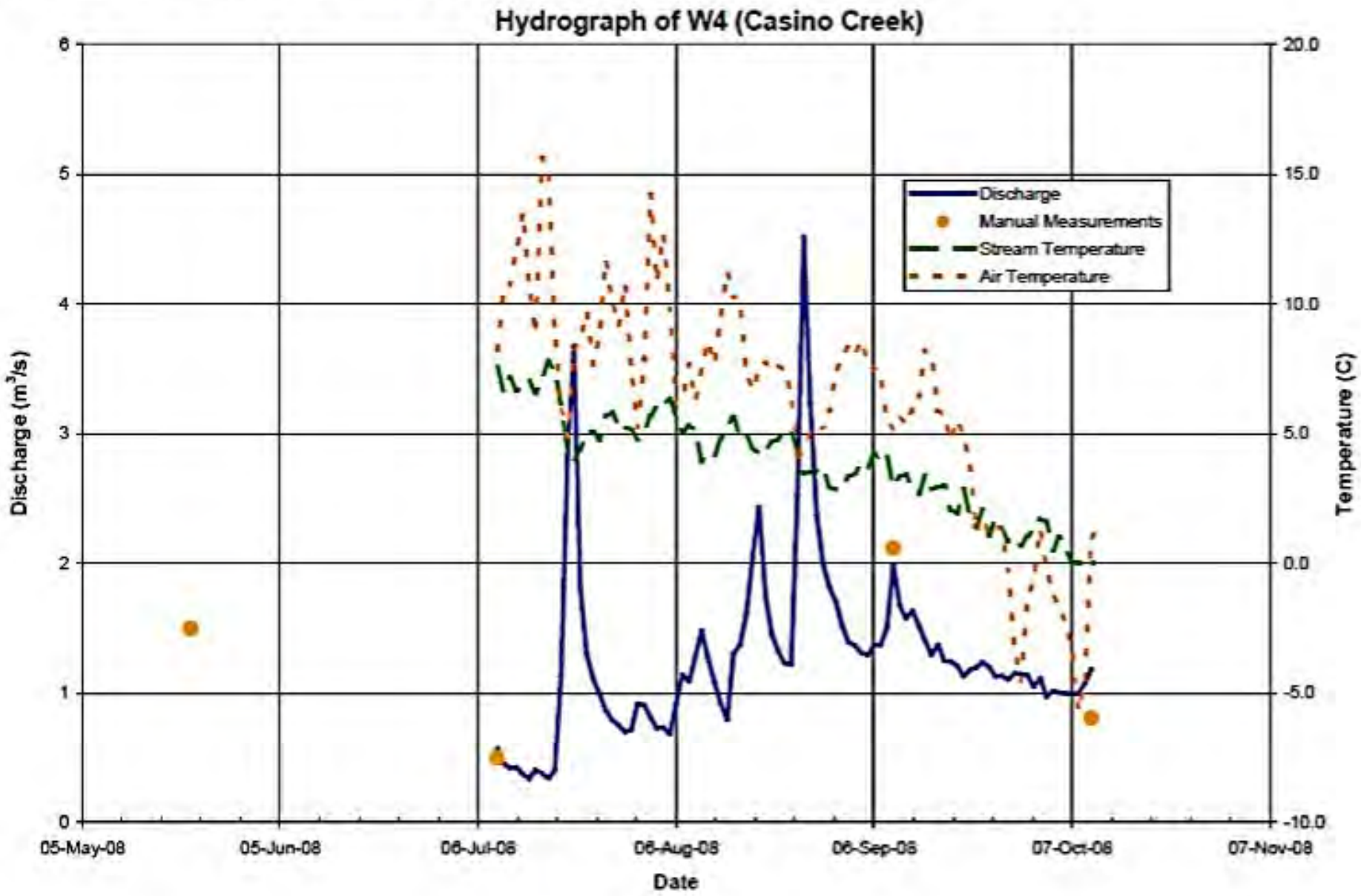


Figure 16. Hydrograph for Station W9, Deep Creek, Casino Project, 2008

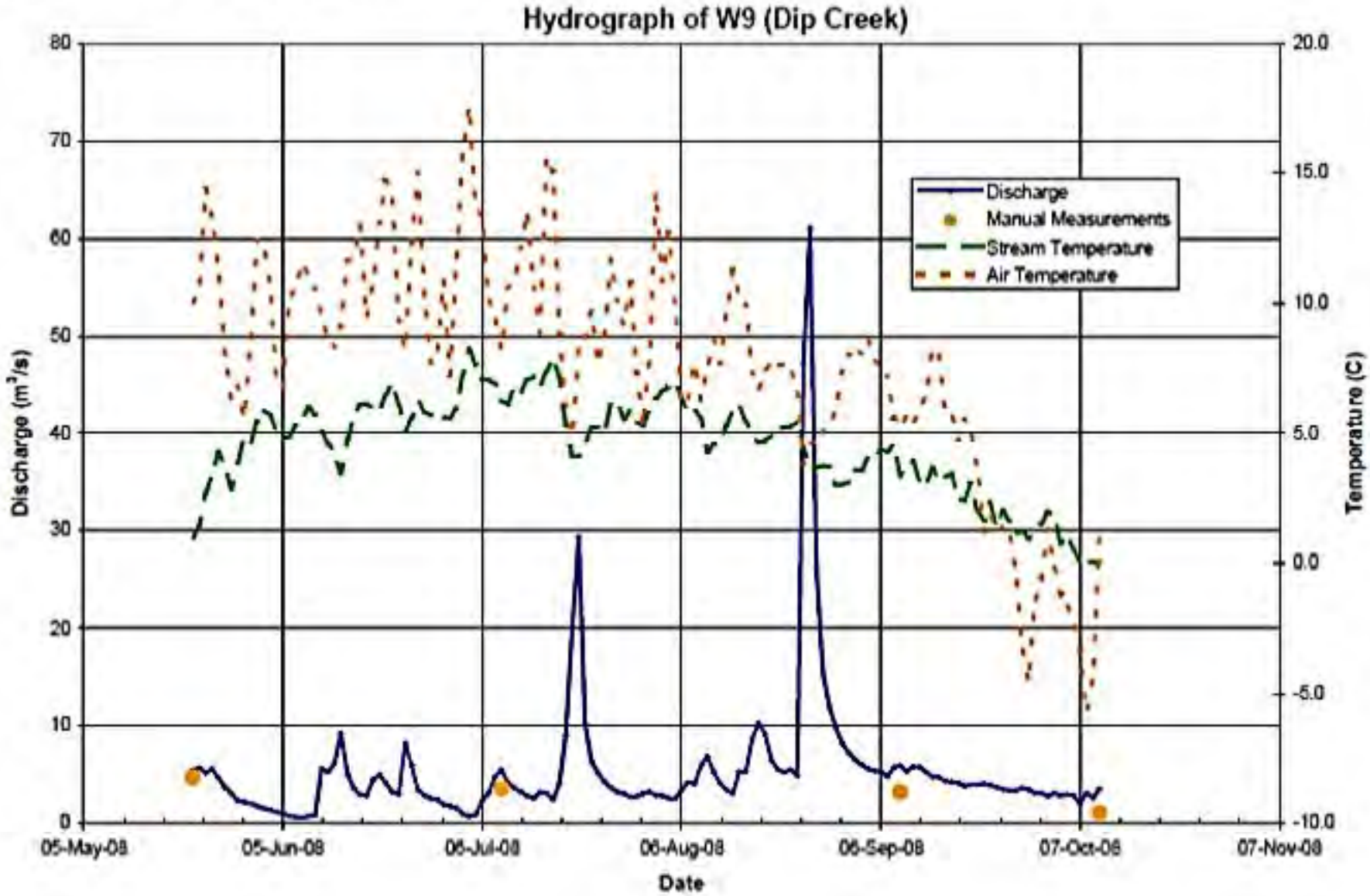


Figure 17. Hydrograph for Station W11, Casino Creek, Casino Project, 2008

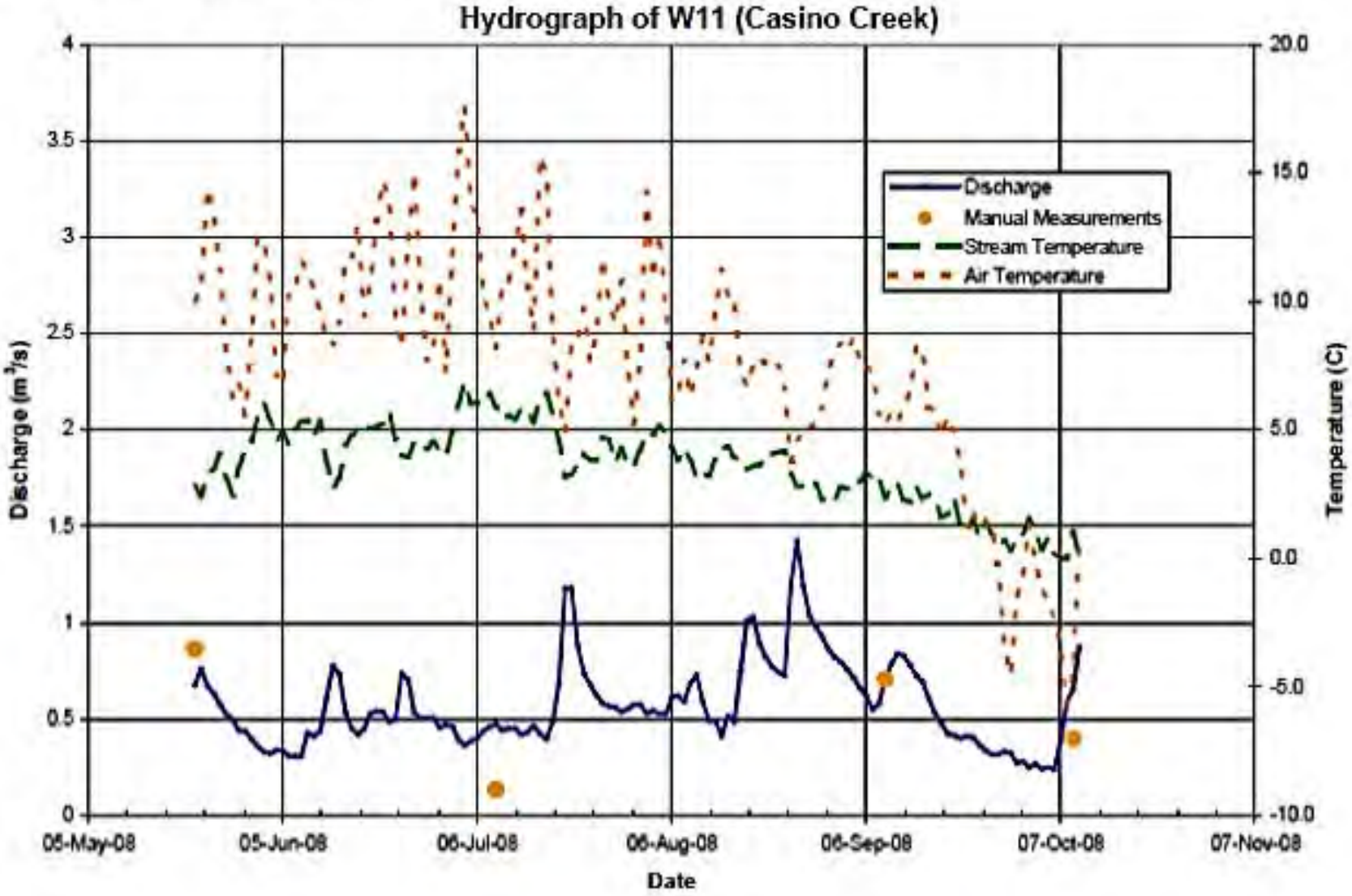
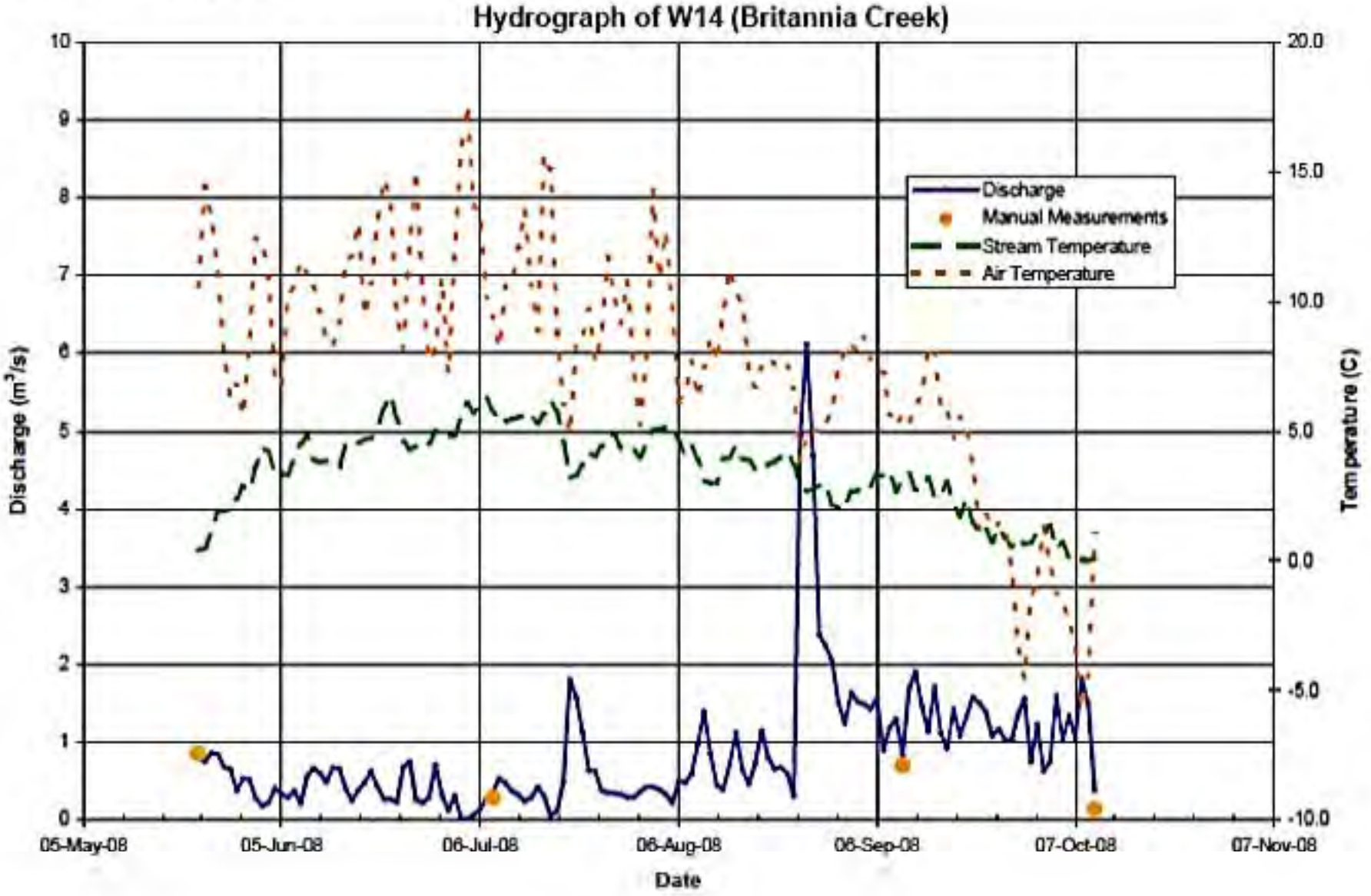


Figure 18. Hydrograph for Station W14, Britannia Creek, Casino Project, 2008



- The peak discharge of freshet, and associated 'falling limb', was only captured at sites along Britannia and Canadian creek (W1 and W3 - Figures 13 and 14).
- A large, regional precipitation event appeared to have occurred, as was evident from a decrease in stream and air temperatures, around July 20, causing a large peak in discharge on July 20 and 21 at all stations.
- A very large, regional precipitation event appeared to have occurred, as was evident from a decrease in stream and air temperatures, around August 25, causing the largest peak in discharge on August 26 for all stations. This peak discharge was large enough to overflow stream banks, as was noted by the presence of overflow channels, newly deposited silt on floodplains and newly deposited debris on floodplain during the September field visit.
- The fluctuating pattern of discharge along Casino Creek (sites W4 and W11 – Figures 15 and 17) and Dip Creek (site W9 – Figure 16) are similar, although unique when comparing these creeks to Canadian Creek (site W3 – Figure 14) and Britannia Creek (sites W1 and W14 – Figures 13 and 18).
- Britannia and Canadian creeks appear to be more "flashy" than Casino and Dip creeks. That is, they appear more responsive to assumed smaller scale precipitation events. However, meteorological data are needed to confirm this conclusion because it is possible that fluctuations in air temperature could be causing melt of permafrost, creating a similar pattern in discharge peaks.
- On several occasions it appears that there no stream flow in Canadian Creek (site W3 – Figure 14), although it is assumed that there was discharge during these times. Additional low flow manual measurements are needed to improve the rating curve at this station.

3.2.1.3 Historic Flow Data

Figures 19 to 21 show the historic flow data calculated from the HKP data that were collected in 1993 and 1994 for hydrometric sites W1, W3 and W4, respectively. When compared to the flow data that was collected in 2008, the following observations can be made:

- peak flow events at site W1 for the HKP data (Figure 19) are similar in magnitude and character (i.e., flashy response) to the peaks observed in 2008 (Figure 13);
- peak flow events at site W3 for the HKP data (Figure 20) are much lower than peak flows observed in 2008 (Figure 14). Both sets of flow data appear to have a flashy response to precipitation events; and
- peak flow events at site W4 for the HKP data (Figure 21) are similar in magnitude and characteristics to the peaks observed in 2008 (Figure 15).

It is important to note that a detailed comparative analyses between the HKP and AECOM flow data are limited due to the relatively small sample size of the manual measurements used to construct the rating curves for the 2008.

3.2.2 Water Quality

3.2.2.1 Statistical Summary

Appendices B2 to B5 show the surface water quality data for the months of May, July, September and October 2008, and Tables 13 and 14 show the minimum, median and maximum values for selected water quality parameters for sites in Casino Creek and Britannia Creek, respectively.

Figure 19. Hydrograph for Station W1, Britannia Creek, Casino Project, 1993-1994

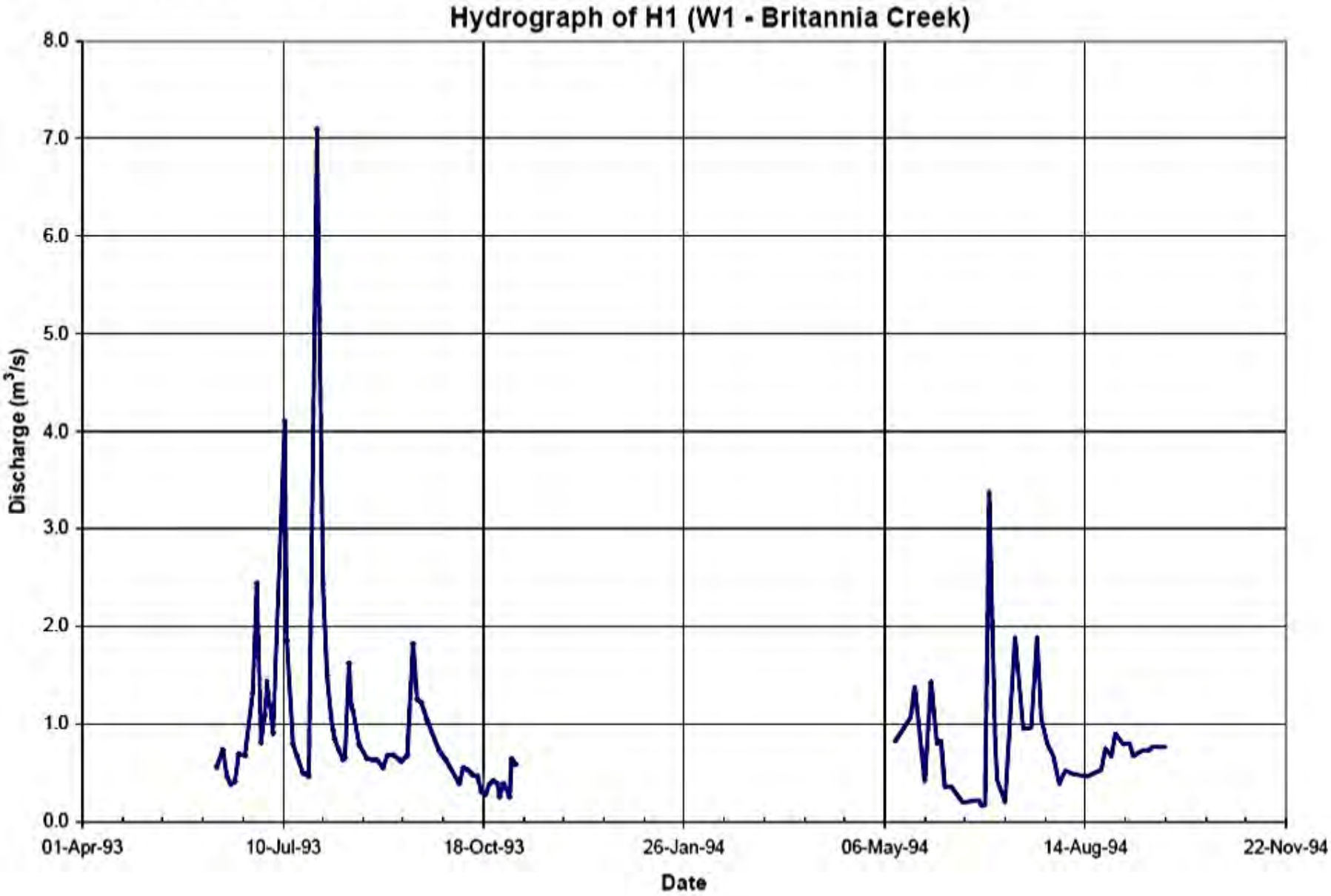


Figure 20. Hydrograph for Station W3, Canadian Creek, Casino Project, 1993-1994

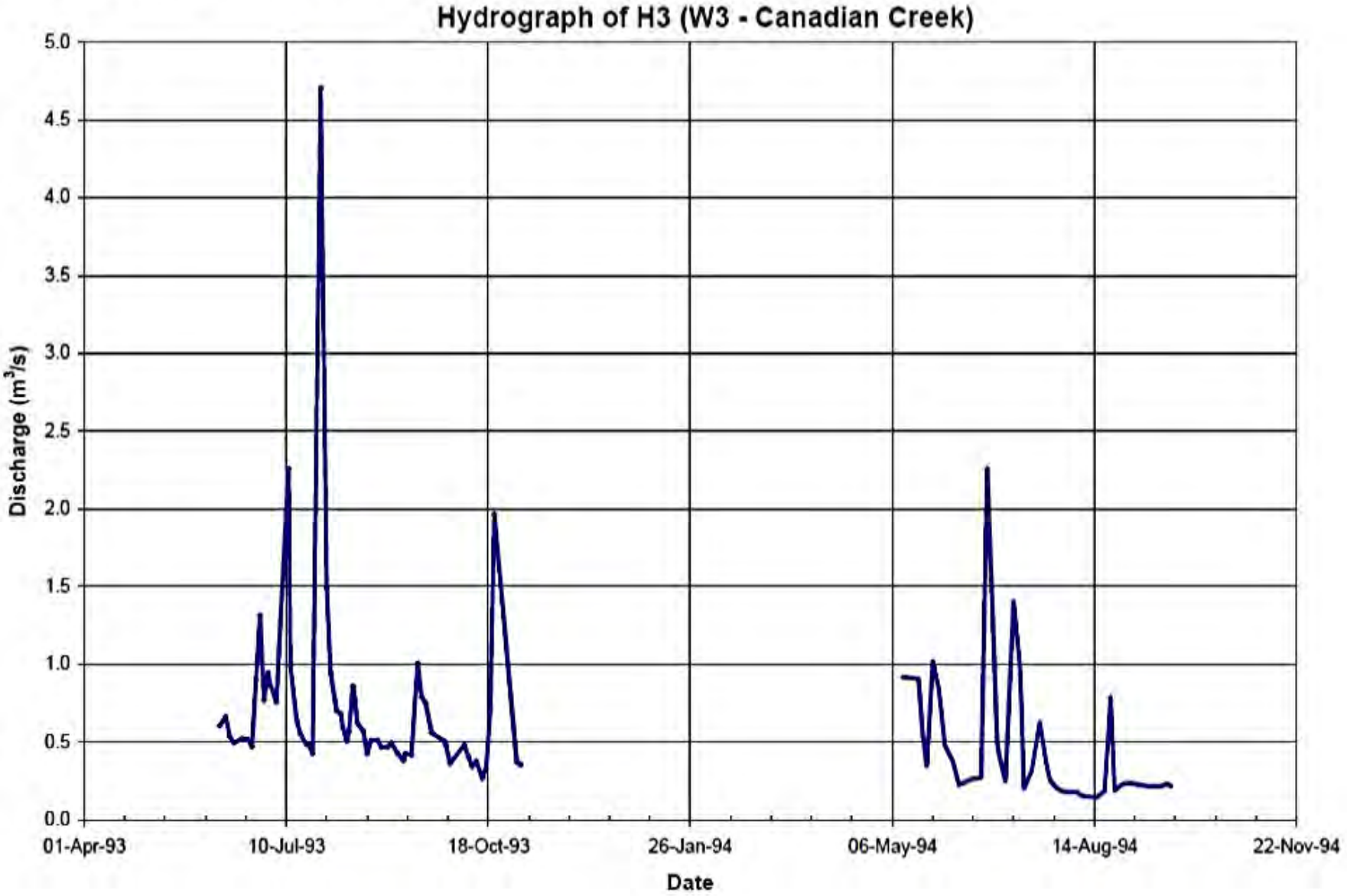


Figure 21. Hydrograph for Station W3, Canadian Creek, Casino Project, 1993-1994

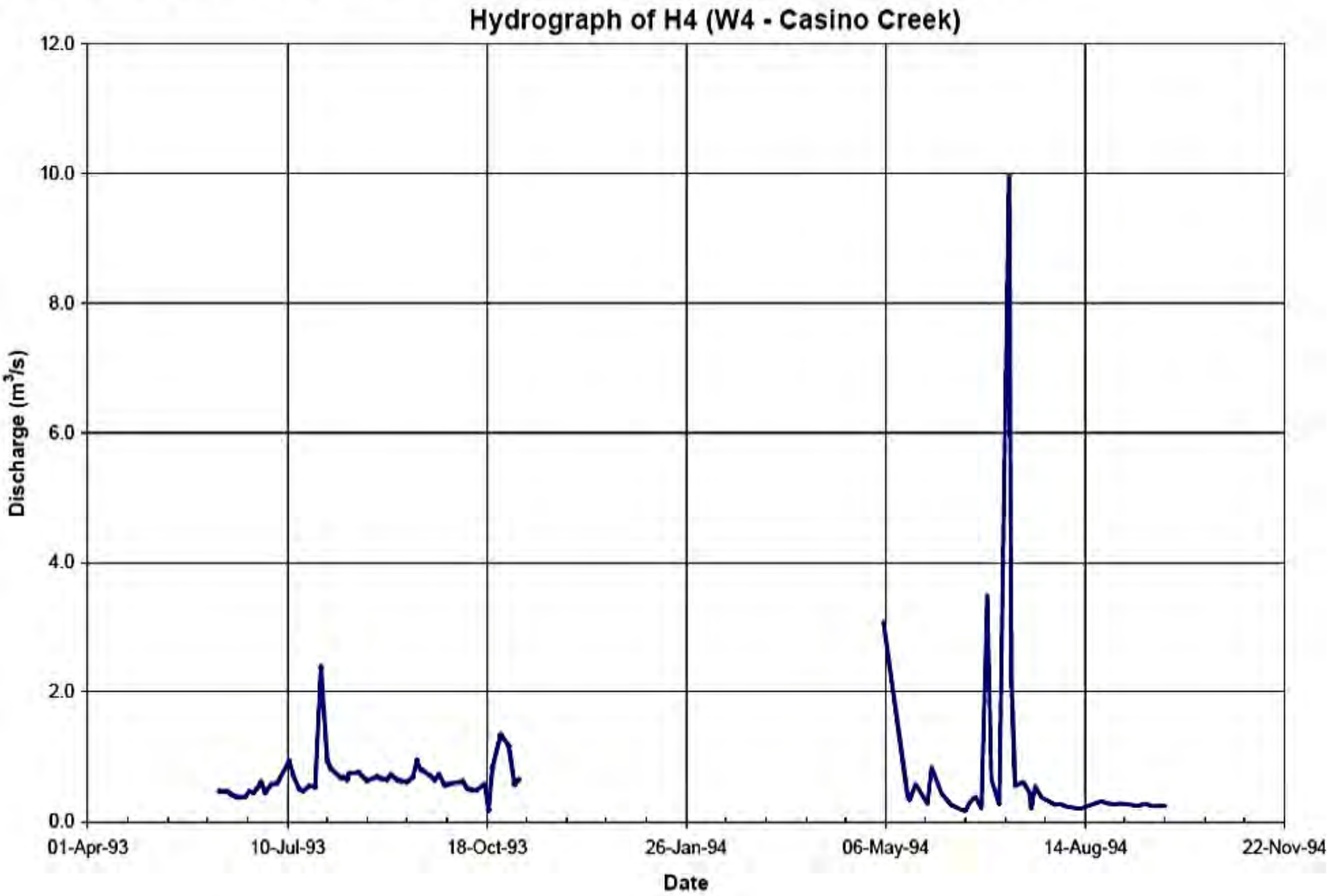


Table 13. Water Quality Summary Statlstics, Casino Creek Watershed, 2008

Station		Hardness (mg/L $CaCO_3$)	Conductivity (µS/cm)	pH	Total Suspended Solids	Total Alkalinity (as mg/L $CaCO_3$)	Sulfate	Total Cyanide	Total Aluminum	Total Arsenic	Total Cadmium	Total Chromium	Total Copper	Total Iron	Total Lead	Total Molybdenum	Total Nickel	Total Selenium	Total Zinc
Water Quality Guidelines	**CCME [a]**	**-**	**-**	**6.5-9.0**	**-**	**-**	**-**	**0.005**	**0.005-0.1**	**0.005**	**0.000017**	**0.001**	**0.002-0.004 [c]**	**0.3**	**0.001-0.007 [d]**	**0.073**	**0.025-0.15**	**0.001**	**0.03**
W43 - Adit Discharge																			
Min		94.4	220	7.5	<1	67	39	<0.0005	0.0024	0.00049	*0.0425*	<0.0001	*0.0608*	0.025	*0.00587*	<0.00005	0.00049	<0.00004	*2.35*
Median		107.55	230	7.5	0.5	75	46.5	<0.0005	0.0088	0.000755	*0.0513*	<0.0001	*0.0717*	0.055	*0.0149*	<0.00005	0.000525	<0.00004	*2.85*
Max		141	300	7.6	4	90	54	<0.0005	0.0235	0.00152	*0.068*	<0.0001	*0.078*	0.112	*0.0181*	<0.00005	0.00057	<0.00004	*3.62*
n		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
W12 - Proctor Gulch																			
Min		75.8	270	*3.2*	2	<0.5	93	<0.0005	*2.43*	0.00027	*0.000799*	0.0003	*0.219*	*6.62*	0.000661	<0.00005	0.00263	0.00008	*0.0575*
Median		285	870	*3.4*	7	<0.5	345	0.00025	*8.33*	0.000275	*0.0021*	0.00055	*0.785*	*20.2*	0.001061	0.000135	0.0054	0.000195	*0.158*
Max		411	1200	*3.9*	14	<0.5	550	0.0101	*12.2*	0.00031	*0.00317*	0.0006	*1.13*	*32.5*	*0.00203*	0.00021	0.00782	0.00025	*0.237*
n		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
W8 - Upper Casino Creek																			
Min		42.3	91	6.9	5	8.8	25	<0.0005	*0.533*	0.00026	*0.000181*	0.0001	*0.0554*	*0.654*	0.000225	0.00014	0.0008	0.00004	0.0128
Median		91.7	210	7.7	13	35	62	0.0006	*0.534*	0.00052	*0.000253*	0.0003	*0.0581*	*0.873*	0.000547	0.00023	0.00113	0.00005	0.0192
Max		125	280	7.8	14	42	90	0.0008	*0.592*	0.00055	*0.00026*	0.0004	*0.0615*	*1.03*	0.00137	0.00025	0.00126	0.00006	0.0214
n		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
W13 - Mouth of Meloy Creek																			
Min		59.1	110	7.5	<1	40	0.6	<0.0005	0.0162	0.00089	*0.000026*	0.0001	0.00054	0.024	0.000218	0.00034	0.00023	<0.00004	0.0014
Median		93.9	200	8.1	3	82	18	0.0007	0.0452	0.00135	*0.000041*	0.0002	0.00098	0.06	0.000662	0.00053	0.0003	0.00004	0.0025
Max		164	330	8.2	5	130	47	0.0009	*0.153*	0.0018	*0.000092*	0.0003	*0.00294*	0.162	*0.00314*	0.00083	0.00084	0.00005	0.0063
n		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
W11 - Casino Creek at proposed tailings impundment																			
Min		56.1	110	7.3	<1	25	21	<0.0005	0.0475	0.00054	*0.000043*	<0.0001	*0.00787*	0.071	0.000041	0.00035	0.0003	<0.00004	0.0018
Median		109.2	240	8.0	2	69.5	46.5	0.000525	*0.142*	0.0006	*0.0000735*	0.000125	*0.0162*	0.236	0.0001325	0.000625	0.000505	0.000075	0.0048
Max		146	300	8.1	4	83	67	0.0009	*0.308*	0.00065	*0.000093*	0.0003	*0.0328*	*0.344*	0.000893	0.00095	0.00092	0.00013	0.0072
n		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
W18 - Brynelsen Creek																			
min/max		70.3	160.0	8.0	1	60	25	0.0005	0.0325	0.00034	0.000008	<0.0001	0.00079	0.025	0.000018	0.00123	0.00019	<0.00004	0.0005
n		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
W4 - Mouth of Casino Creek																			
Min		47.7	92	7.3	1	25	8.8	<0.0005	0.0446	0.00038	0.000013	<0.0001	*0.00371*	0.076	0.000028	0.0005	0.00027	<0.00004	0.0005
Median		94	195	8.0	7	67	32.5	0.0006	*0.122*	0.00046	*0.000031*	0.00025	*0.00697*	0.1835	0.000144	0.000985	0.00045	0.00005	0.00205
Max		111	240	8.0	20	80	42	0.001	*0.368*	0.0007	*0.000066*	0.0004	*0.0164*	*0.414*	0.000847	0.0012	0.00095	0.00006	0.0048
n		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
W9 - Dip Creek upstream of Casino Creek Confluence																			
Min		37.4	65	7.2	3	22	<0.5	0.0009	0.0354	0.00028	<0.000005	0.0001	0.00091	0.072	0.000073	0.00031	0.00032	<0.00004	0.0007
Median		57.15	115	7.9	21	48.5	8.7	0.00095	*0.2525*	0.000525	0.000016	0.0005	0.001885	*0.4075*	0.000457	0.000545	0.000725	0.00003	0.00205
Max		79.7	170	8.0	76	74	15	0.001	*0.583*	0.00086	*0.000057*	0.0007	*0.00333*	*0.931*	*0.00213*	0.0007	0.00146	0.00006	0.0049
n		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
W5 - Dip Creek downstream of Casino Creek Confluence																			
Min		41.4	74	7.3	2	24	<0.5	<0.0005	0.0307	0.00034	0.000015	<0.0001	*0.00226*	0.058	0.000065	0.0004	0.00031	<0.00004	0.001
Median		62.85	130	7.85	21	51.5	13.5	0.0008	*0.313*	0.0006	*0.000028*	0.0005	*0.00341*	*0.504*	0.000664	0.000605	0.0008	0.000035	0.00275
Max		88.2	190	8.0	58	75	25	0.001	*0.489*	0.00077	*0.000054*	0.0006	*0.00669*	*0.724*	*0.00152*	0.00082	0.0011	0.00006	0.0042
n		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
W16 - Dip Creek Far Field Site																			
Min		68.1	140	7.6	13	45	18	<0.0005	*0.203*	0.00063	*0.000018*	0.0005	*0.00296*	*0.384*	0.000222	0.00055	0.00087	<0.00004	0.0015
Median		68.9	140	7.8	18	49	18	0.001	*0.256*	0.00063	*0.000021*	0.0006	*0.00362*	*0.524*	0.000334	0.00057	0.00129	0.00005	0.0029
Max		69	150	7.9	74	56	24	0.0012	*0.413*	0.00123	*0.000048*	0.0007	*0.00529*	*1.09*	0.00104	0.00067	0.00136	0.00008	0.0036
n		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

Foot Notes:

All units mg/L unless otherwise noted

a) Canadian water quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2007

b) 0.005mg/L at pH < 6.5, [Ca2+] < 4 mg/L, DOC < 2 mg/L: 0.1 mg/L at pH ≥ 6.5, [Ca2+] ≥ 4 mg/L, DOC ≥ 2 mg/L

c) 0.002 mg/L at [CaCO3] = 0 - 120 mg/L; 0.003 mg/L at [CaCO3] =120 - 180 mg/L; 0.004 mg/L at [CaCO3] >180mg/L

d) 0.001 mg/L at [CaCO3] = 0 - 60 mg/L; 0.002 mg/L at [CaCO3] =60 - 120 mg/L; 0.004 mg/L at [CaCO3] =120 -180mg/L; 0.007 mg/L at [CaCO3] > 180mg/L

e) 0.025 mg/L at [CaCO3] = 0 - 60 mg/L; 0.065 mg/L at [CaCO3] =60 - 120 mg/L; 0.110 mg/L at [CaCO3] =120 -180mg/L; 0.150 mg/L at [CaCO3] > 180mg/L

Italic results exceed CCME Aquatic Life Guidelines

Table 14. Water Quality Summary Statistics, Britannia Creek Watershed, 2008

Station		Hardness (mg/L $CaCO_3$)	Conductivity (uS/cm)	pH	Total Suspended Solids	Total Alkalinity (as mg/L $CaCO_3$)	Sulfate	Total Cyanide	Total Aluminum	Total Arsenic	Total Cadmium	Total Chromium	Total Copper	Total Iron	Total Lead	Total Molybdenum	Total Nickel	Total Selenium	Total Zinc
Water Quality Guidelines	**CCME [a]**	**-**	**-**	**6.5-9.0**	**-**	**-**	**-**	**0.005**	**0.005-0.1[b]**	**0.005**	**0.000017**	**0.001**	**0.002-0.004[c]**	**0.3**	**0.001-0.007**	**0.073**	**0.025-0.15[d]**	**0.001**	**0.03**
W7 - Upper Brittania Creek																			
Min		15.1	34.0	*5.5*	1.0	0.6	39.0	0.0006	0.0253	0.00016	*0.000087*	0.0001	0.00139	0.019	0.000031	0.0002	0.00063	0.00005	0.0061
Median		39.5	115	7.0	1.0	5.85	43.0	0.0008	0.0754	0.00026	*0.000187*	0.0002	*0.00275*	0.064	0.000117	0.00026	0.00084	0.00006	0.0136
Max		44.7	130	7.1	34.0	7.3	47.0	0.0010	*0.479*	0.00065	*0.000261*	0.0004	*0.0107*	*0.574*	0.000513	0.00033	0.00169	0.00006	0.0195
n		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
W3 - Canadia Creek upstream of Brittania Creek Confluence																			
Min		45.8	89.0	7.4	1.0	22.0	15.0	0.0007	0.0159	0.00057	0.000014	0.0002	*0.00217*	0.016	0.00001	0.00037	0.00066	0.00006	0.0005
Median		101	220	7.9	3.0	57.5	45.0	0.00085	*0.126*	0.000915	*0.0000425*	0.0005	*0.00390*	0.125	0.00023	0.000755	0.00097	0.00006	0.0040
Max		121	260	8	18.0	72	57.0	0.001	*0.415*	0.0012	*0.000084*	0.0008	*0.0081*	*0.540*	0.00147	0.00093	0.00211	0.00007	0.0133
n		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
W14 - Britannia Creek upstream of Canadian Creek Confluence																			
Min		28.3	49	7	2.0	10.0	30.0	0.0007	0.0494	0.0005	0.000007	0.0002	0.00158	0.037	0.000072	0.00009	0.0005	0.00006	0.0006
Median		115	245	7.9	7.0	75.0	52.0	0.00125	*0.203*	0.00078	*0.000020*	0.0004	*0.00211*	0.264	0.00019	0.000505	0.00073	0.00007	0.0016
Max		158	320	8.1	34	100	91.0	0.0017	*0.542*	0.00103	*0.000031*	0.0007	*0.00423*	*0.567*	0.0015	0.000550	0.00105	0.00008	0.0033
n		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
W2 - Britannia Creek downstream of Canadian Creek Confluence																			
Min		41.1	78.0	7.1	3.0	15.0	8.8	0.0006	*0.105*	0.00082	*0.000021*	0.0003	0.00277	0.107	0.000321	0.00026	0.00087	<0.00004	0.0016
Median		83.0	180	7.9	20	50.0	38.0	0.0012	*0.236*	0.00099	*0.000023*	0.0004	*0.00339*	*0.344*	0.000393	0.00057	0.00090	0.00005	0.0016
Max		138	290	8	25	83	60.0	0.0012	*0.46*	0.0011	*0.000069*	0.0007	*0.00603*	*0.549*	0.000443	0.00071	0.00164	0.00008	0.0049
n		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
W1 - Lower Britannia Creek																			
Min		49.6	92	7.2	<1	21.0	17.0	0.0008	0.0222	0.0005	0.000011	<0.0001	0.00194	0.017	0.00003	0.0003	0.0006	<0.00004	0.0003
Median		114	240	8.0	3.5	68.0	43.0	0.001	0.0852	0.000635	0.000015	0.0003	*0.00261*	0.095	0.000062	0.00068	0.00077	0.00008	0.0008
Max		143	300	8.1	190	82.0	63.0	0.0013	*0.723*	0.00162	*0.00008*	*0.0011*	*0.00663*	*1.00*	0.000866	0.00077	0.00227	0.00011	0.0062
n		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
W6b - Yukon River upstream of Britannia Creek																			
Min		98.1	170	7.8	14	61.0	19.0	<0.0005	*0.124*	0.00059	*0.000077*	0.0002	0.00139	0.193	0.000224	0.00059	0.0021	0.00042	0.0061
Median		106	205	8.1	23.5	76.0	28.5	<0.0005	*0.226*	0.00068	*0.000089*	0.0004	0.00168	*0.408*	0.000318	0.00095	0.0027	0.0005	0.0078
Max		109	220	8.1	190	81.0	33.0	<0.0005	*0.678*	0.00212	*0.000621*	*0.0011*	*0.00808*	*2.17*	0.0029	0.0010	0.0101	0.00068	*0.0436*
n		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
W6a - Yukon River downstream of Britannia Creek																			
Min		76.1	150	7.8	12	61.0	13.0	<0.0005	0.0954	0.00051	*0.000032*	0.0002	0.00114	0.152	0.000169	0.00068	0.00117	0.00023	0.0028
Median		84.1	180	8.1	20	68.0	18.5	0.00025	*0.1715*	0.000595	*0.000051*	0.00035	0.00139	0.2845	0.000535	0.00095	0.00152	0.00030	0.0052
Max		93.4	180	8.1	140	73.0	25.0	0.0008	*0.636*	0.00177	*0.000369*	*0.0011*	*0.00595*	*1.56*	0.00183	0.00101	0.00662	0.00033	0.0248
n		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
W15 - Yukon River far field site																			
Min		84.6	160	7.8	32	63.0	17.0	<0.0005	*0.137*	0.00064	*0.000056*	0.0002	0.00143	0.225	0.00027	0.00066	0.00192	0.00034	0.0045
Median		103	180	7.9	32	64.0	24.0	<0.0005	*0.276*	0.00073	*0.000088*	0.0006	0.00176	*0.487*	0.00037	0.00088	0.00219	0.00046	0.0065
Max		107	220	8.1	200	80.0	31.0	<0.0005	*0.708*	0.00204	*0.000591*	*0.0012*	*0.00724*	*1.95*	*0.00249*	0.00102	0.00925	0.00053	*0.0381*
n		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
W17- Sunshine Creek																			
Min		49.9	96.0	7.4	1	30.0	1.6	0.001	0.06	0.00062	*0.000018*	0.0003	0.00175	0.058	0.000094	0.00021	0.00057	0.00004	0.0012
Median		83.9	180	7.9	6	63.0	26.0	0.0011	*0.136*	0.00064	*0.000021*	0.0003	0.00194	0.191	0.00014	0.0004	0.00071	0.00006	0.0014
Max		97.4	190	7.9	7	68.0	27.0	0.0013	*0.214*	0.00092	*0.000022*	0.0003	0.00199	0.196	0.000145	0.00041	0.00083	0.00007	0.0014
n		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

Foot Notes:
All units mg/L unless otherwise noted
a) Canadian water quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2007
b) 0.005mg/L at pH < 6.5, [Ca2+] < 4 mg/L, DOC < 2 mg/L: 0.1 mg/L at pH ≥ 6.5, [Ca2+] ≥ 4 mg/L, DOC ≥ 2 mg/L
c) 0.002 mg/L at [CaCO3] = 0 - 120 mg/L; 0.003 mg/L at [CaCO3] =120 - 180 mg/L; 0.004 mg/L at [CaCO3] >180mg/L
d) 0.001 mg/L at [CaCO3] = 0 - 60 mg/L; 0.002 mg/L at [CaCO3] =60 - 120 mg/L; 0.004 mg/L at [CaCO3] =120 -180mg/L; 0.007 mg/L at [CaCO3] > 180mg/L
e) 0.025 mg/L at [CaCO3] = 0 - 60 mg/L; 0.065 mg/L at [CaCO3] =60 - 120 mg/L; 0.110 mg/L at [CaCO3] =120 -180mg/L; 0.150 mg/L at [CaCO3] > 180mg/L
Italic results exceed CCME Aquatic Life Guidelines

3.2.2.2 Exceedances of Water Quality Guidelines

Table 15 shows that CCME guidelines for protection of freshwater aquatic life were exceeded for pH, total cyanide (CN) and eight total metals: aluminum (Al), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), lead (Pb), silver (Ag) and zinc (Zn). Exceedances of at least one parameter were found at all sites except W18, but that station was only sampled in October. The number of exceedances was highest for cadmium, copper and aluminum and least for cyanide (Figure 22). Exceedances of cadmium, copper and aluminum often occurred together at the same stations. Exceedances were most numerous in May (n = 84), similar between July (n = 46) and September (n = 50), and least numerous in October (n = 24), indicating a seasonal trend related to hydrological factors such as snow melt and stream flow.

Table 15. Water Quality Parameters Exceeding CCME Guidelines, Casino Project, 2008

Site	May	July	September	October
W7	pH, Al, Cd, Cu, Fe	Cd, Cu	Al, Cd, Cu	Cd
W3	Al, Cd, Cu, Fe	-	Al, Cd, Cu	Cu
W14	Al, Cd, Cu, Fe	Al	Al, Cd, Cu, Fe	-
W2	Al, Cd, Cu, Fe	Al, Cd, Fe	Al, Cd, Cu	NS
W1	Al, Cd, Cr, Cu, Fe	-	Cu	-
W6b	Al, Cd, Cr, Cu, Fe, Pb, Zn	Al, Cd, Fe	Al, Cd	Al, Cd, Fe
W6a	Al, Cd, Cr, Cu, Fe	Al, Cd, Fe	Cd	Al, Cd
W15	Al, Cd, Cr, Cu, Fe, Pb, Zn	Al, Cd, Fe	Al, Cd	NS
W17	Al, Cd	Al, Cd	Cd	NS
W43	Cd, Cu, Pb, Zn	Cd, Cu, Pb, Zn	Cd, Cu, Pb, Ag, Zn	Cd, Cu, Pb, Ag, Zn
W12	pH, Al, Cd, Cu, Pb, Fe, Zn	pH, Al, Cd, Cu, Fe, Zn	pH, Al, Cd, Cu, Fe, Zn	pH, CN, Al, Cd, Cu, Fe, Zn
W8	Al, Cd, Cu, Fe	Al, Cd, Cu, Fe	Al, Cd, Cu, Fe	NS
W13	Al, Cd, Cu, Pb	Cd	Cd	NS
W11	Al, Cd, Cu, Fe	Cd, Cu	Al, Cd, Cu	Cd, Cu
W18	NS	NS	NS	-
W4	Al, Cd, Cu, Fe	Cu	Al, Cd, Cu	Cd, Cu
W9	Al, Cd, Cu, Fe, Pb	Al, Cu, Fe	Al	-
W5	Al, Cd, Cu, Fe, Pb	Al, Cd, Cu, Fe	Al, Cd, Cu, Fe	Cu
W16	Al, Cd, Cu, Fe	Al, Cd, Cu, Fe	Al, Cd, Cu, Fe	NS

Dashes indicate no parameters exceeded CCME guidelines. NS = Not sampled.

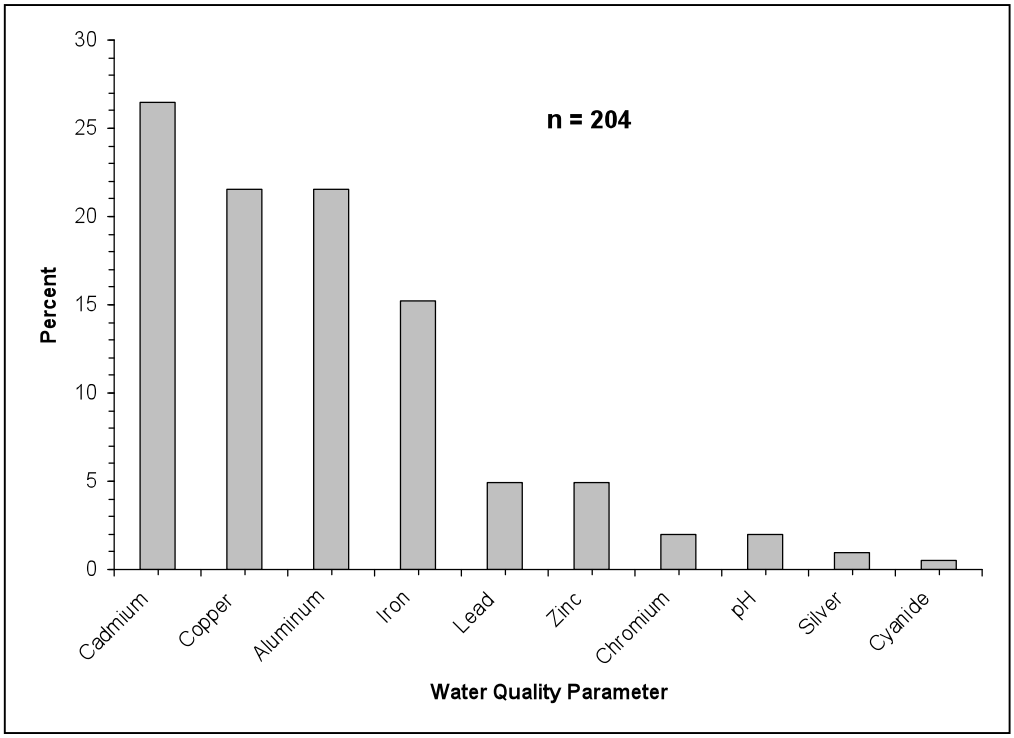


Figure 22. Water Quality Exceedances of CCME Guidelines, Casino Project, 2008

3.2.2.3 Principal Component Analysis

Data

Field measurements of pH and conductivity were excluded from the dataset because the laboratory measurements of pH and conductivity were assumed to be more accurate. Acidity and TOC were excluded because they were measured in less than 10% of the records. Six variables were excluded (total boron, total tin, dissolved bismuth, dissolved boron, dissolved mercury and dissolved tin) because 90% or more of the records were below detection limits. For the remaining 79 variables, a total of 822 records (or 14% of the dataset) were replaced: 732 records of metal concentrations below detection limits were replaced by one-half the detection limit, 60 absent records of DOC for May, July and September were replaced by the mean for October and 30 absent records of dissolved metals for station W3 on September 10 were replaced with the geometric means of dissolved metals that were calculated from records for May, July and October. All metals were ln-transformed to normalize their distributions.

Components and Their Correlations

Eleven components were extracted from the data matrix, but the first five components accounted for 70.5% of the explained variance and a scree plot (not shown here) indicated that the remaining six factors were of little significance (Table 16).

Table 16. Correlations of Water Quality Parameters with Principal Components

Parameter	WQ1	WQ2	WQ3	WQ4	WQ5
Percent explained variance	19.2	16.6	15.4	11.9	7.4
Cumulative explained variance	19.2	35.8	51.2	63.1	70.5
Total Cadmium	0.95	-0.03	0.03	-0.15	0.16
Total Zinc	0.95	0.00	-0.01	-0.12	0.15
Dissolved Cadmium	0.94	-0.04	0.02	-0.27	0.05
Dissolved Zinc	0.93	-0.03	0.01	-0.10	0.00
Total Silver	0.91	0.01	-0.06	0.05	0.05
Dissolved Silver	0.87	0.16	0.17	-0.16	-0.11
Dissolved Lead	0.86	0.07	0.03	0.06	-0.10
Total Lead	0.84	0.01	-0.07	0.37	0.05
Dissolved Manganese	0.83	0.33	0.12	-0.02	-0.17
Total Thallium	0.79	0.36	0.18	0.20	0.28
Total Manganese	0.78	0.32	0.11	0.21	0.14
Dissolved Copper	0.76	0.50	0.20	-0.21	-0.13
Dissolved Thallium	0.74	0.24	0.38	-0.18	0.21
Total Copper	0.74	0.51	0.23	-0.15	-0.02
Total Antimony	0.69	-0.52	0.37	-0.02	-0.12
Dissolved Antimony	0.65	-0.53	0.36	-0.04	-0.15
Total Molybdenum	-0.91	-0.09	0.09	0.13	0.19
Dissolved Molybdenum	-0.90	-0.08	0.02	0.19	0.22
Dissolved Iron	0.09	0.93	0.06	0.26	0.04
Dissolved Aluminum	-0.09	0.91	0.00	0.23	0.08
Dissolved Beryllium	0.24	0.85	-0.02	0.17	0.02
Total Aluminum	-0.09	0.81	-0.01	0.36	0.28
Total Beryllium	0.16	0.78	-0.01	0.38	0.33
Total Iron	0.16	0.75	0.07	0.38	0.31
Dissolved Cobalt	0.55	0.75	0.15	-0.08	-0.08
Total Cobalt	0.45	0.71	0.12	0.19	0.30
Dissolved Chromium	-0.11	0.64	-0.03	0.59	-0.01
Sulfate	0.22	0.57	0.56	-0.25	0.18
Nitrite	0.02	0.45	-0.17	0.08	-0.06
Ammonia	0.08	0.43	0.24	-0.10	0.32
Total Mercury	0.15	0.39	-0.27	0.09	-0.10
pH	-0.40	-0.78	-0.08	0.15	-0.11
Alkalinity	-0.18	-0.75	0.51	-0.04	0.02
Dissolved Barium	-0.13	-0.67	0.12	0.00	-0.22
Total Barium	-0.10	-0.63	-0.01	0.36	0.13
Nitrate	0.20	-0.46	0.43	-0.15	-0.51
Total Magnesium	-0.01	-0.11	0.95	-0.08	0.16
Dissolved Calcium	0.14	0.04	0.88	-0.28	0.23
Total Calcium	0.13	0.03	0.88	-0.28	0.24
Total Strontium	0.18	-0.27	0.85	-0.21	-0.09
Dissolved Strontium	0.20	-0.26	0.85	-0.22	-0.12
Hardness	0.15	0.30	0.82	-0.23	0.24
Total Uranium	-0.18	0.14	0.81	0.13	-0.36
Dissolved Uranium	-0.21	0.07	0.73	0.12	-0.39
Total Potassium	0.30	-0.01	0.72	0.04	0.06
Dissolved Potassium	0.31	0.02	0.71	0.03	0.04
Conductivity	0.20	0.45	0.71	-0.27	0.20
Total Sodium	-0.06	-0.07	0.68	-0.36	-0.24
Dissolved Magnesium	-0.05	-0.20	0.64	-0.03	0.05
TDS	0.16	0.42	0.64	-0.24	0.22
Dissolved Lithium	0.35	0.04	0.41	-0.03	0.22
Total Lithium	0.30	0.02	0.37	0.00	0.26

Parameter	WQ1	WQ2	WQ3	WQ4	WQ5
Total Vanadium	-0.24	0.07	-0.34	0.83	0.20
Total Titanium	-0.30	0.15	-0.34	0.79	0.14
Total Chromium	-0.16	0.45	-0.10	0.78	0.28
Total Phosphorus	-0.01	0.20	-0.33	0.76	0.37
Total Zirconium	-0.30	0.27	-0.17	0.74	-0.20
Total Arsenic	0.15	-0.35	0.10	0.72	0.16
Dissolved Vanadium	-0.20	0.14	-0.19	0.66	-0.07
Dissolved Titanium	0.03	0.46	-0.32	0.65	-0.03
Dissolved Phosphorous	0.09	0.50	-0.37	0.62	-0.03
Dissolved Zirconium	-0.27	0.41	-0.01	0.62	-0.36
TSS	0.06	0.02	-0.14	0.60	0.45
Dissolved Arsenic	-0.19	-0.29	0.24	0.47	-0.03
TKN	-0.15	0.41	-0.26	0.43	-0.18
Dissolved Silicon	0.12	0.00	0.36	-0.46	-0.21
Total Silicon	0.11	-0.01	0.38	-0.49	-0.17
Total Selenium	-0.21	0.09	0.20	0.00	0.87
Dissolved Selenium	-0.27	0.12	0.17	0.11	0.86
Total Nickel	0.18	0.48	-0.02	0.37	0.74
Turbidity	0.13	0.19	0.02	0.29	0.67
Dissolved Nickel	0.25	0.49	-0.08	0.24	0.64
Total Cyanide	-0.04	0.20	0.18	0.09	-0.05
Cyanide WAD	0.03	0.26	0.06	0.16	-0.06
Dissolved Sodium	0.02	0.11	0.53	-0.21	-0.05
Ortho-Phosphorus	0.06	-0.22	0.02	-0.27	0.28
Chloride	0.03	-0.10	0.15	0.04	-0.07
Total Bismuth	0.13	0.22	-0.43	0.41	0.22
DOC	-0.24	-0.01	0.18	0.11	-0.12

The first component, WQ1, was positively correlated with 16 dissolved and total metals, including cadmium, zinc, silver, lead, manganese, thallium, copper and antimony, and negatively correlated with total and dissolved molybdenum. This was called the “heavy metals” component because it reflects the magnitudes of the concentrations of heavy metals. The first component extracted from a water quality data set is almost always a “size” or “magnitude” component.

The second component, WQ2, was positively correlated with ten dissolved and total metals, including iron, aluminum, beryllium, cobalt, chromium and mercury, one anion – sulphate – and two nutrients – nitrite and ammonia – and negatively correlated with pH, alkalinity, barium and nitrate. This was called the “iron-pH” component because it reflects a pH- and alkalinity-related difference in metal concentrations among sites and dates.

The third component, WQ3, was positively correlated with hardness, conductivity, TDS, and 13 total and dissolved metals, including magnesium, calcium, strontium, uranium, potassium, sodium and lithium. The metals are all those associated with TDS, which typically reflects the influence of groundwater flows. Therefore, WQ3 was called the “TDS” component.

The fourth component, WQ4, was positively correlated with 12 dissolved and total metals, including vanadium, titanium chromium, phosphorus, zirconium and arsenic, TSS and TKN and negatively correlated with dissolved and total silicon. It was called the “vanadium-silicon” component.

The fifth component, WQ5, was positively correlated with dissolved and total selenium and nickel and turbidity. It was called the "selenium-nickel-turbidity" component.

Seven parameters – total cyanide, cyanide WAD, dissolved sodium, ortho-phosphorus, chloride, total bismuth and DOC – were not significantly correlated with any of the first six components.

Spatial and Temporal Variation in WQ1 Scores

The highest mean WQ1 score was observed at site W43, the discharge pipe of the adit of the lower camp, which discharges into upper Meloy Creek of the Casino Creek Watershed (Figure 23). The second highest mean WQ1 score was observed for site W12 in Proctor Gulch, the uppermost reach of Casino Creek, and the third highest mean score was at site W8 in the upper reach of Casino Creek upstream of the confluence of Meloy Creek. The lowest mean WQ1 score was for site W18 in Brynelsen Creek. Mean WQ1 scores for the other 15 sites fell within a narrow range. These findings indicate that WQ1 represents the geochemical signal of drainage from the adit of the lower camp, and that adit drainage flows downstream through all of the water quality sampling sites of Casino Creek except for Brynelsen Creek.

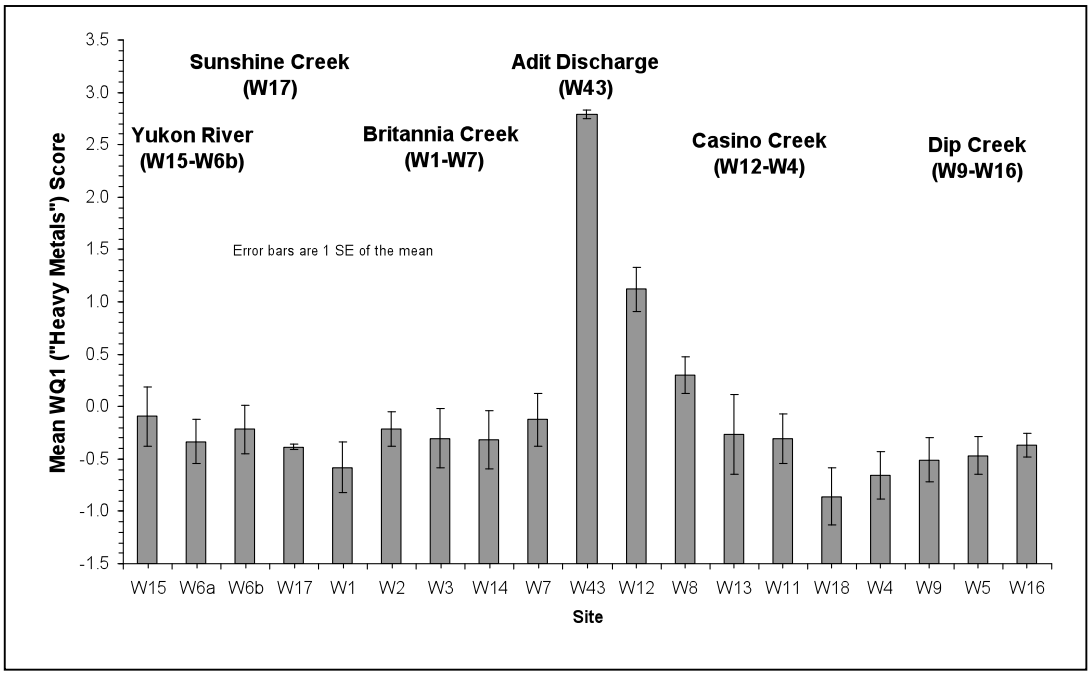


Figure 23. Plot of Mean WQ1 Scores on Sampling Site, Casino Project, 2008

WQ1 scores were highest in May and decreased continuously over the open-water season at all three Yukon River sites (Figure 24). The WQ1 scores for site W17 in Sunshine Creek did not show a seasonal trend. WQ1 scores for the five sites in the Britannia Creek Watershed showed a strong seasonal trend with the highest scores in May and September and the lowest in July and October (Figure 25). WQ1 scores in the Casino Creek Watershed showed the downstream gradient. WQ1 scores for site W43 did not show a seasonal trend, but WQ1 scores for the other five sites showed a bimodal seasonal pattern similar to that

observed in the Britannia Creek Watershed (Figure 26). WQ1 scores for the three sites along Dip Creek showed a strong decreasing seasonal trend with less of a bimodal pattern. (Figure 27). The seasonal trends, particularly the bimodal pattern observed in Britannia and Casino creeks, indicate that WQ1 scores vary directly with stream flow.

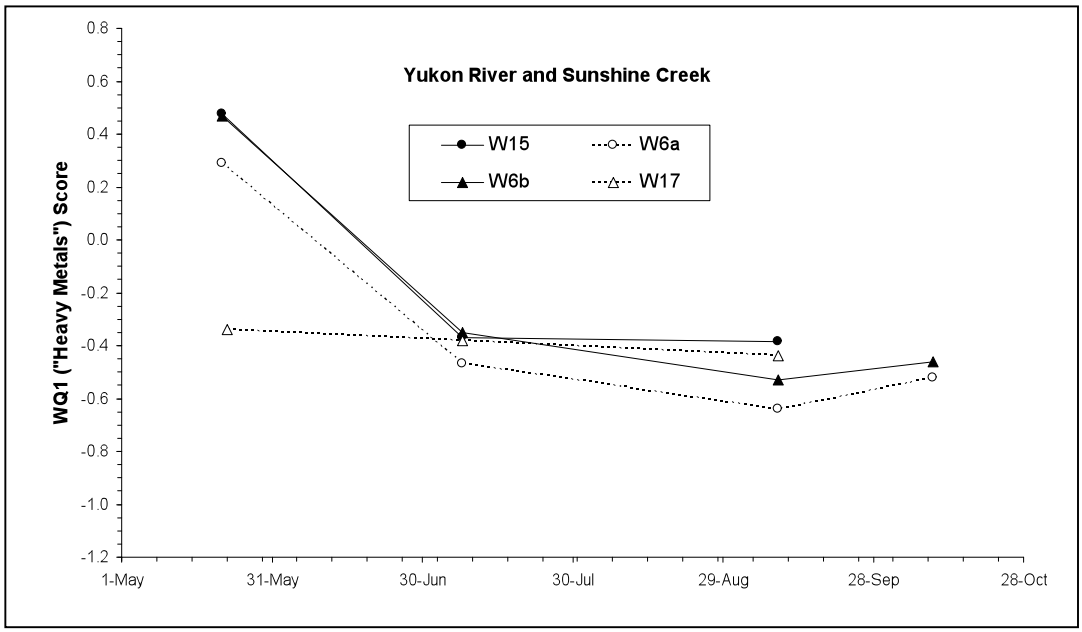
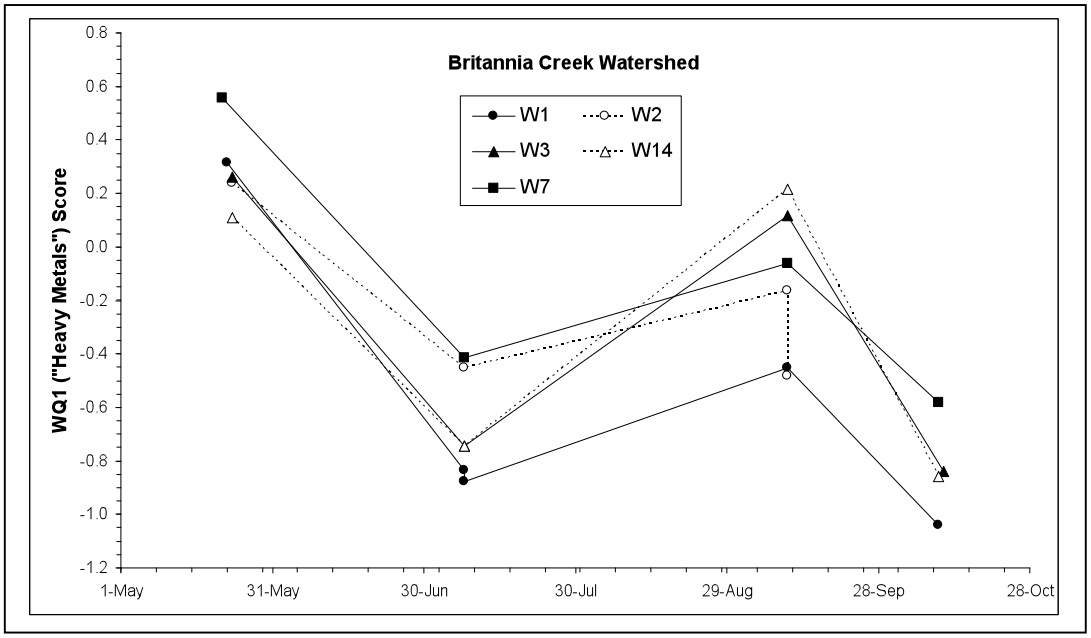


Figure 24. Plot of WQ1 Scores on Sampling Date, Yukon River and Sunshine Creek, Casino Project, 2008



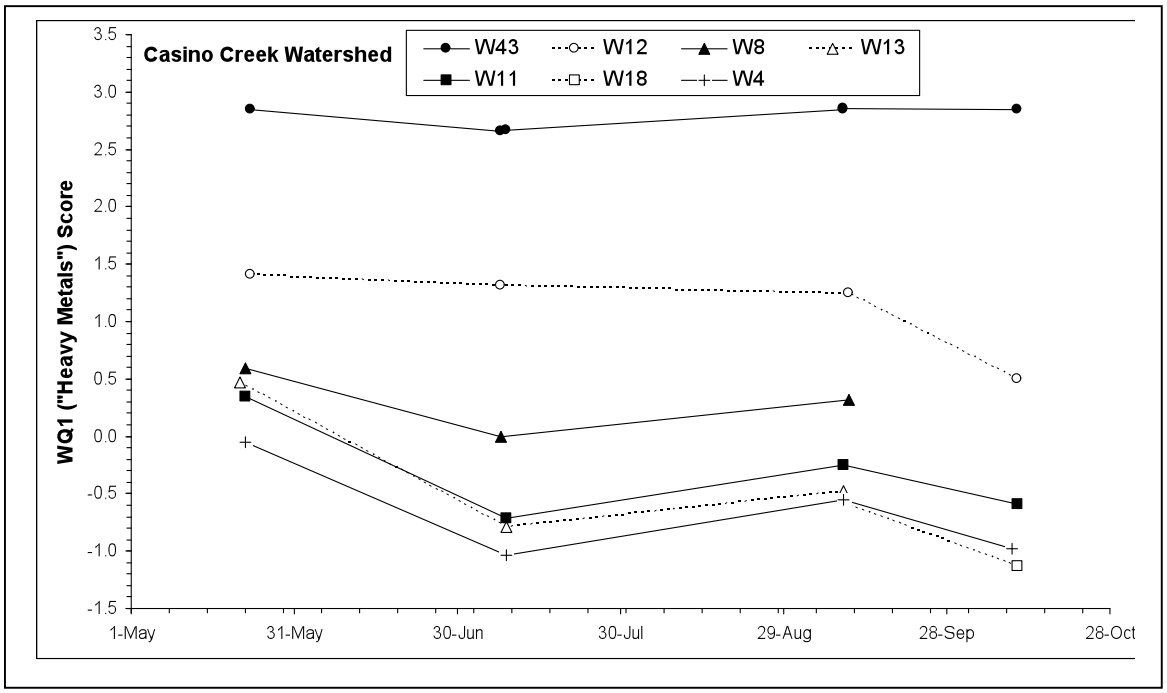
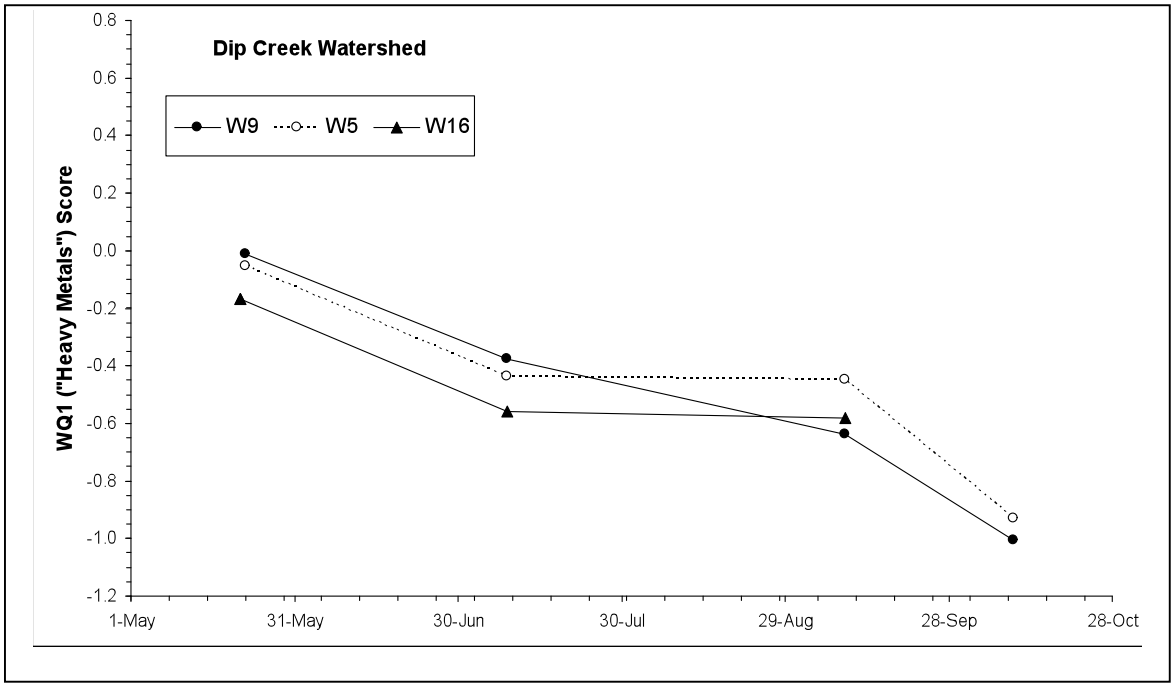


Figure 25. Plot of WQ1 Scores on Sampling Date, Britannia Creek Watershed, Casino Project, 2008

Figure 26. Plot of WQ1 Scores on Sampling Date, Casino Creek Watershed, Casino



Project, 2008

Figure 27. Plot of WQ1 Scores on Sampling Date, Dip Creek Watershed, Casino Project, 2008

In summary, these findings indicate that WQ1 represents the geochemical signal of drainage from the adit of the lower camp, and that adit drainage flows downstream through all of the water quality sampling sites of Casino Creek except for Brynelsen Creek. However, since WQ1 shows spatial and seasonal variation at sites in Dip Creek, Britannia Creek and the Yukon River, it also reflects a geochemical signature found elsewhere in the study area, albeit at lower concentrations than at the adit drainage site.

Spatial and Temporal Variation in WQ2 Scores

The highest mean WQ2 score was observed for site W12 at the head of Casino Creek and the lowest mean WQ2 score was observed at site W43, the adit discharge pipe (Figure 28). Upstream-downstream gradients in mean WQ2 score were observed for the Britannia Creek Watershed and for the upper mainstem of the Dip Creek Watershed (i.e., sites W12, W8 and W13). Mean WQ2 scores were uniformly low for the three sites in the Yukon River. The mean WQ2 score for site W17 in Sunshine Creek was between the values for the Yukon River sites and site W1 in Britannia Creek. Mean WQ2 scores for the three sites in Dip Creek were similar to those at the head of Britannia Creek (i.e., site W7). Therefore, WQ2 reflects the geochemical signature of the surficial geology of Proctor Gulch, the upper Casino Creek and Britannia Creek.

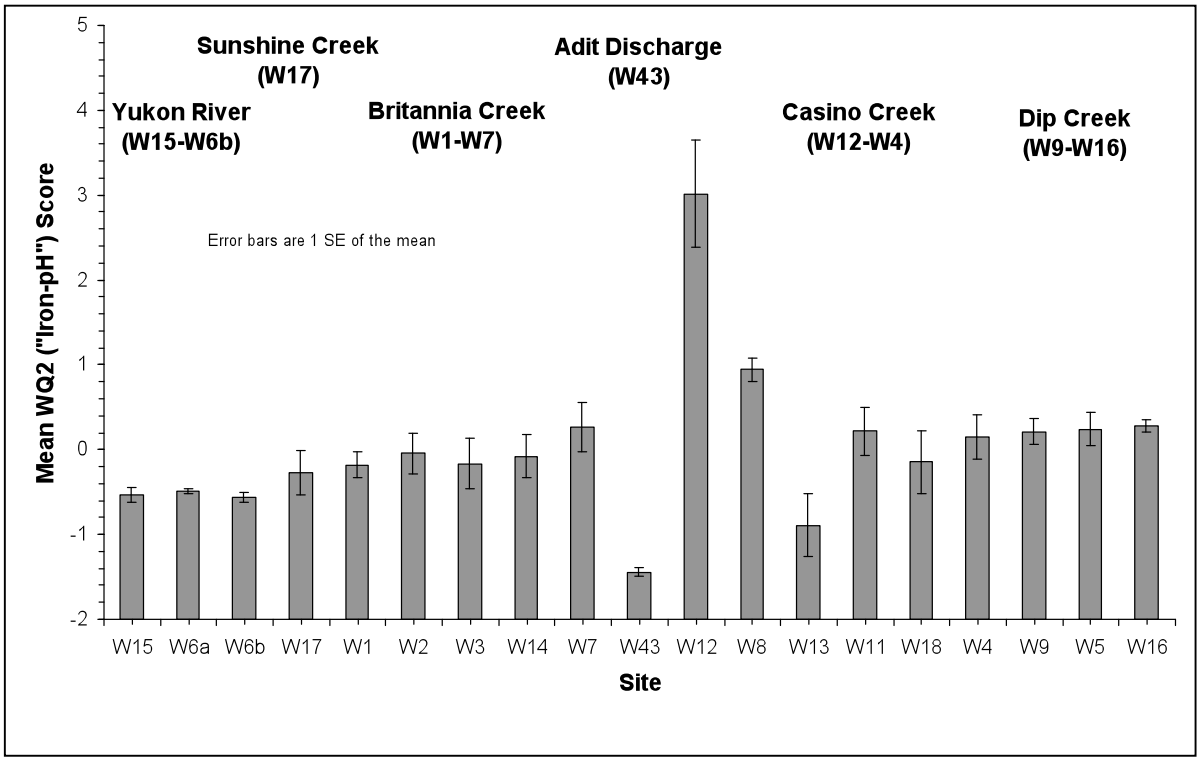


Figure 28. Plot of Mean WQ2 Scores on Sampling Site, Casino Project, 2008

With the exception of sites in the Britannia Creek Watershed, site W17 of Sunshine Creek and site W12 in upper Casino Creek, there was less seasonal variation in WQ2 scores than in WQ1 scores (Figures 29 to 32). As with WQ1, seasonal variation indicates that WQ2 scores vary directly with stream flow.

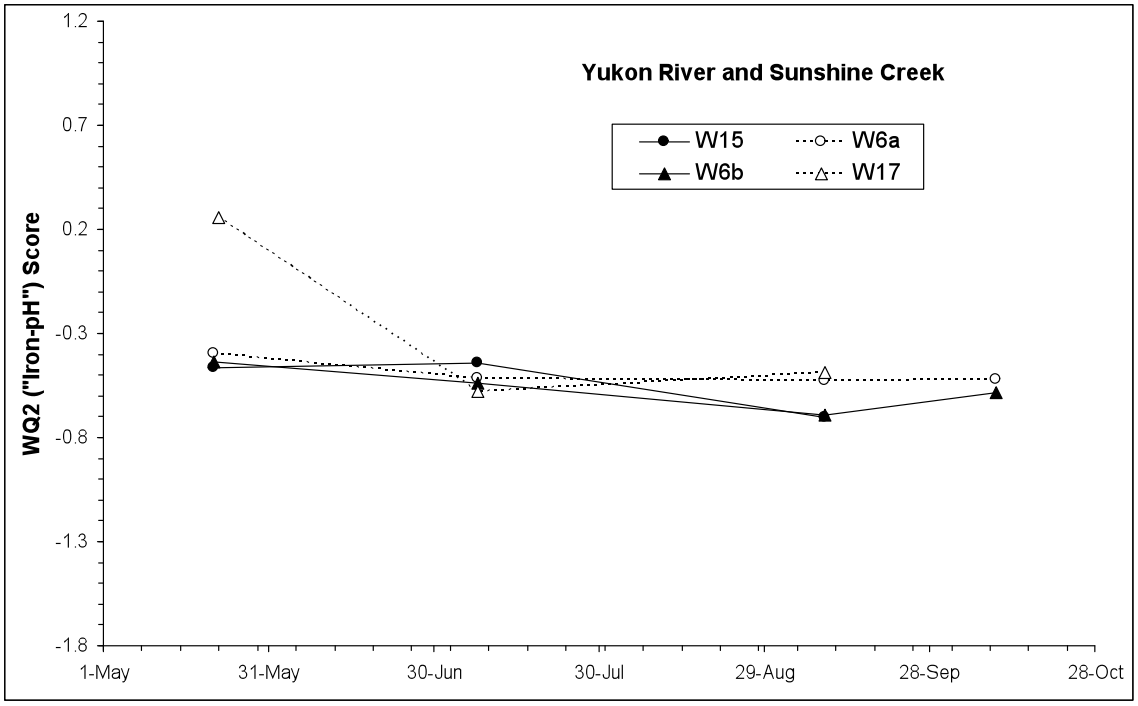


Figure 29. Plot of WQ2 Scores on Sampling Date, Yukon River and Sunshine Creek, Casino Project, 2008

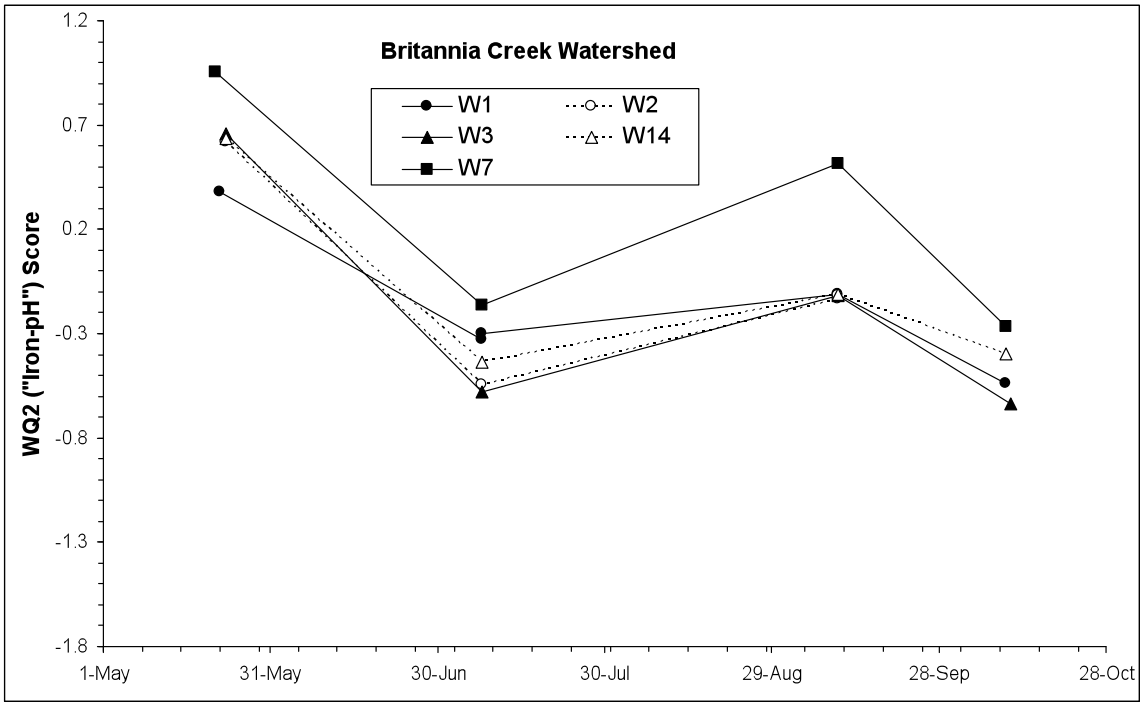


Figure 30. Plot of WQ2 Scores on Sampling Date, Britannia Creek Watershed, Casino Project, 2008

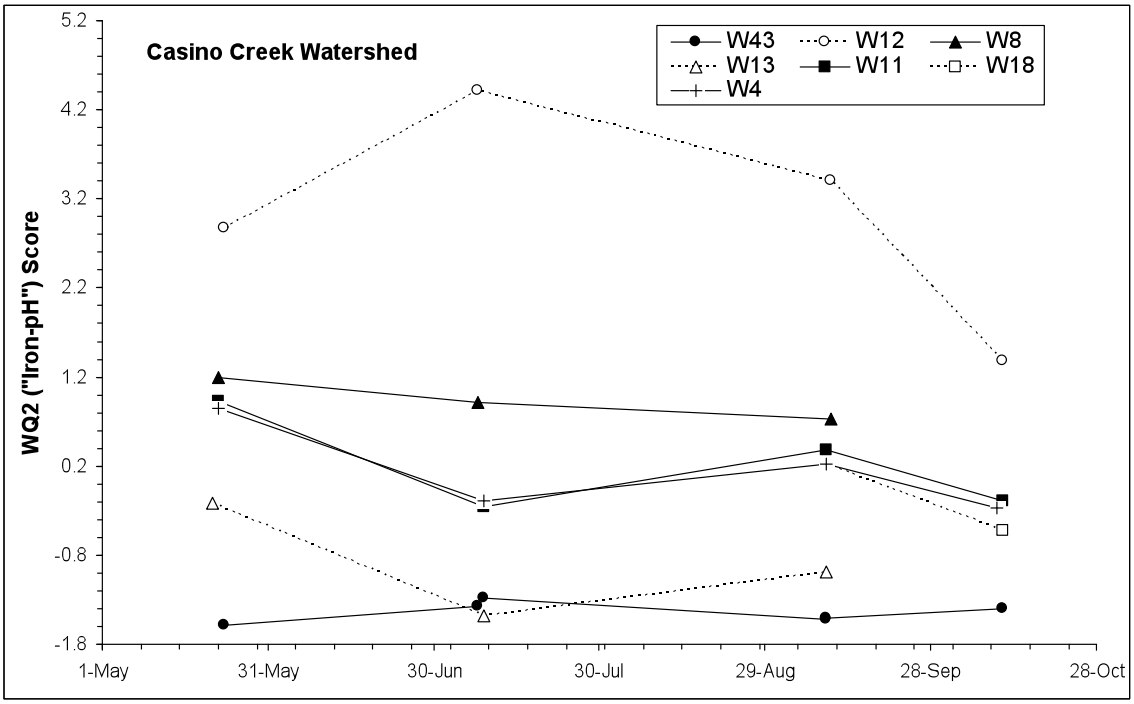


Figure 31. Plot of WQ2 Scores on Sampling Date, Casino Creek Watershed, Casino Project, 2008

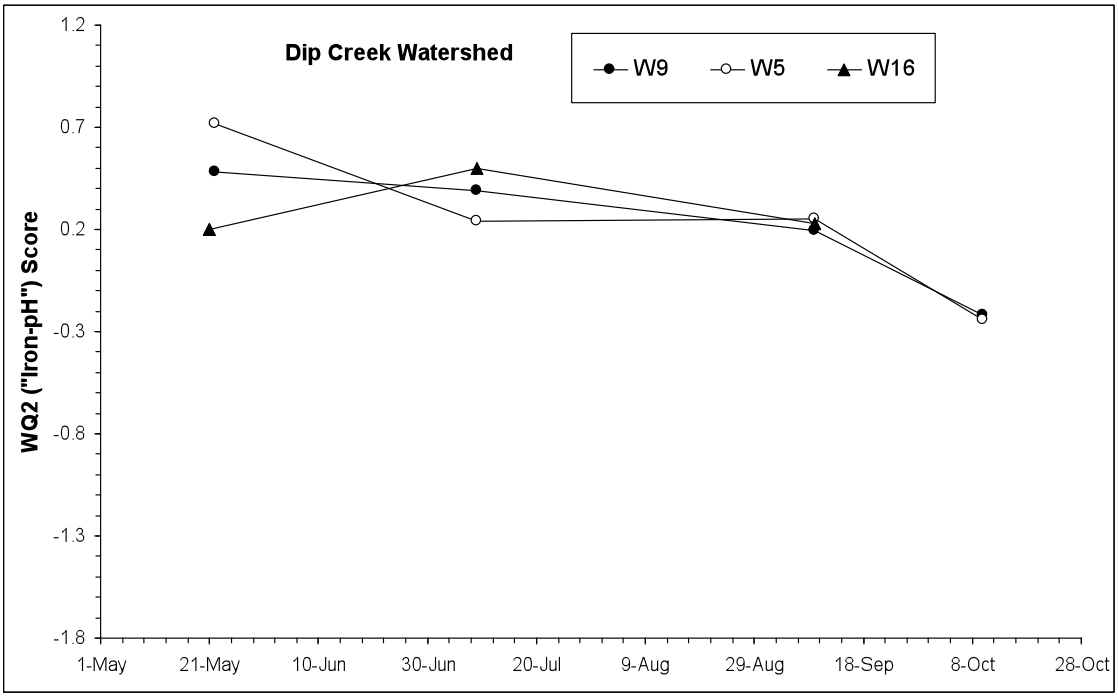


Figure 32. Plot of WQ2 Scores on Sampling Date, Dip Creek Watershed, Casino Project, 2008

In summary, these findings indicate that WQ2 reflects the geochemical signature of the surficial geology of Proctor Gulch, the upper Casino Creek and Britannia Creek. Seasonal trends in WQ2 reflect stream flows.

Spatial Variation in WQ3 Scores

Mean WQ3 scores were lowest for site W7, the uppermost site in Britannia Creek, and highest for site W12 in Proctor Gulch (Figure 33). Since WQ3 is assumed to reflects the influence of groundwater, then site W7 is much less influenced by groundwater than all other sites.

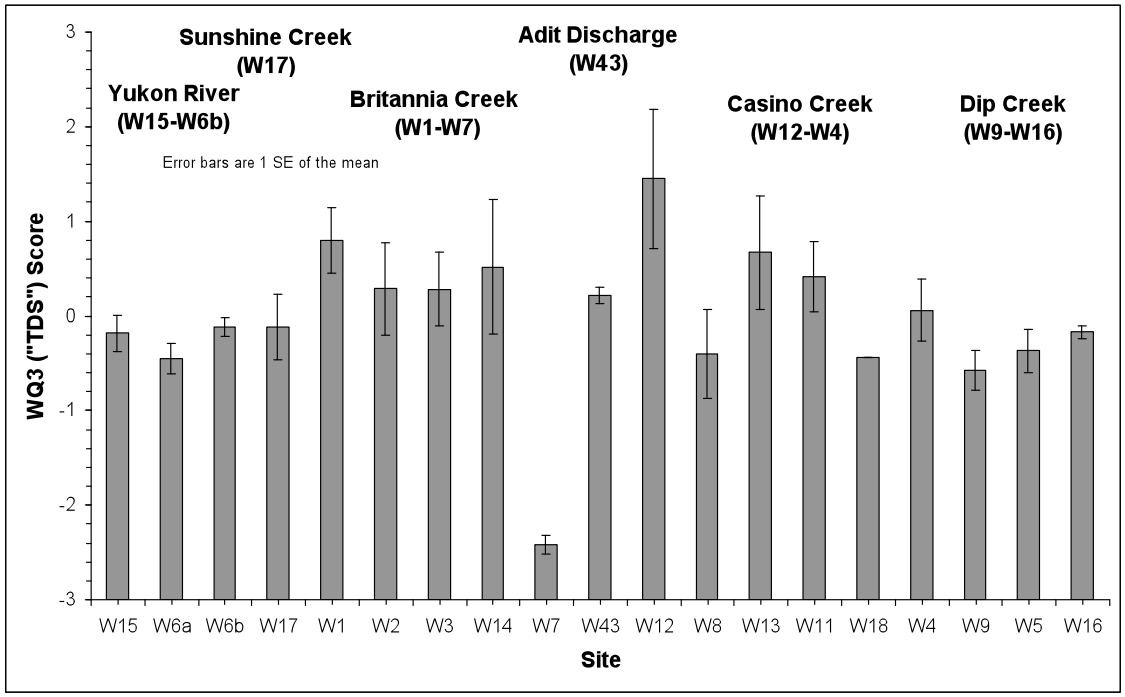


Figure 33. Plot of Mean WQ3 Scores on Sampling Site, Casino Project, 2008

Spatial Variation in WQ4 Scores

Mean WQ4 scores were lowest for sites in Casino Creek and in upper Britannia Creek, and highest for sites in Dip Creek, Britannia Creek, Sunshine Creek and the Yukon River (Figure 34). Therefore, WQ4 represents a geochemical signal found at all sites except those in Casino Creek and upper Britannia Creek.

Spatial Variation in WQ5 Scores

Mean WQ5 scores were highest for sites in the Yukon River (Figure 35). Hence, WQ5 represents a geochemical signal associated with the Yukon River.

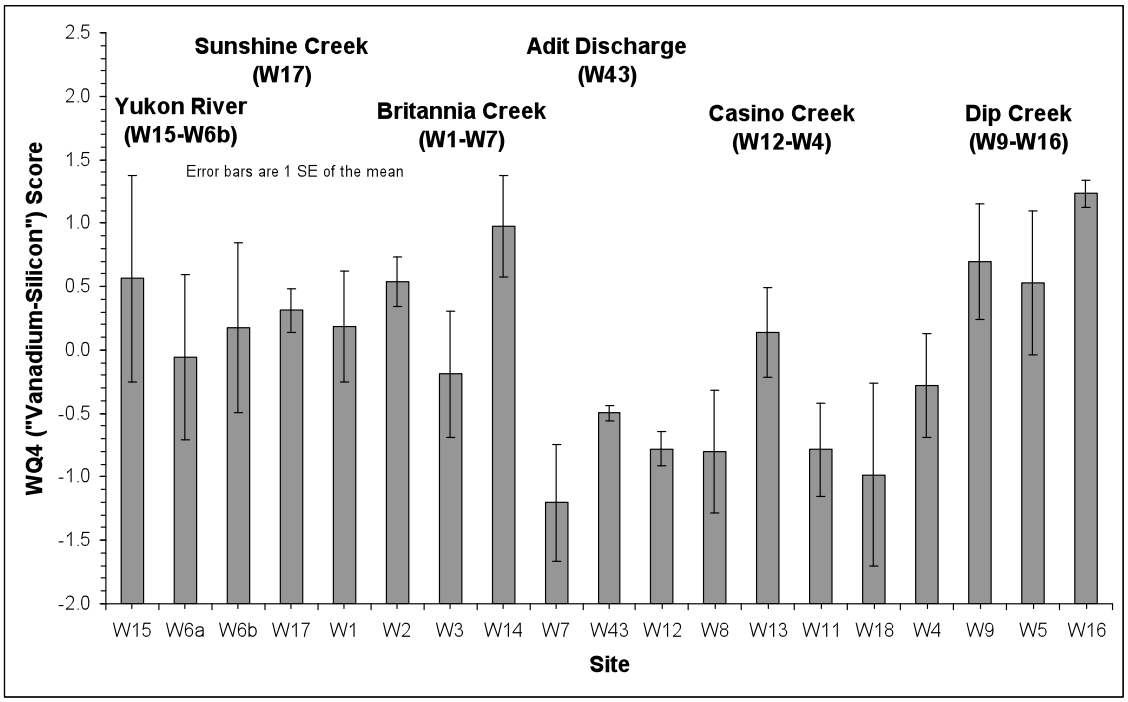


Figure 34. Plot of Mean WQ4 Scores on Sampling Site, Casino Project, 2008

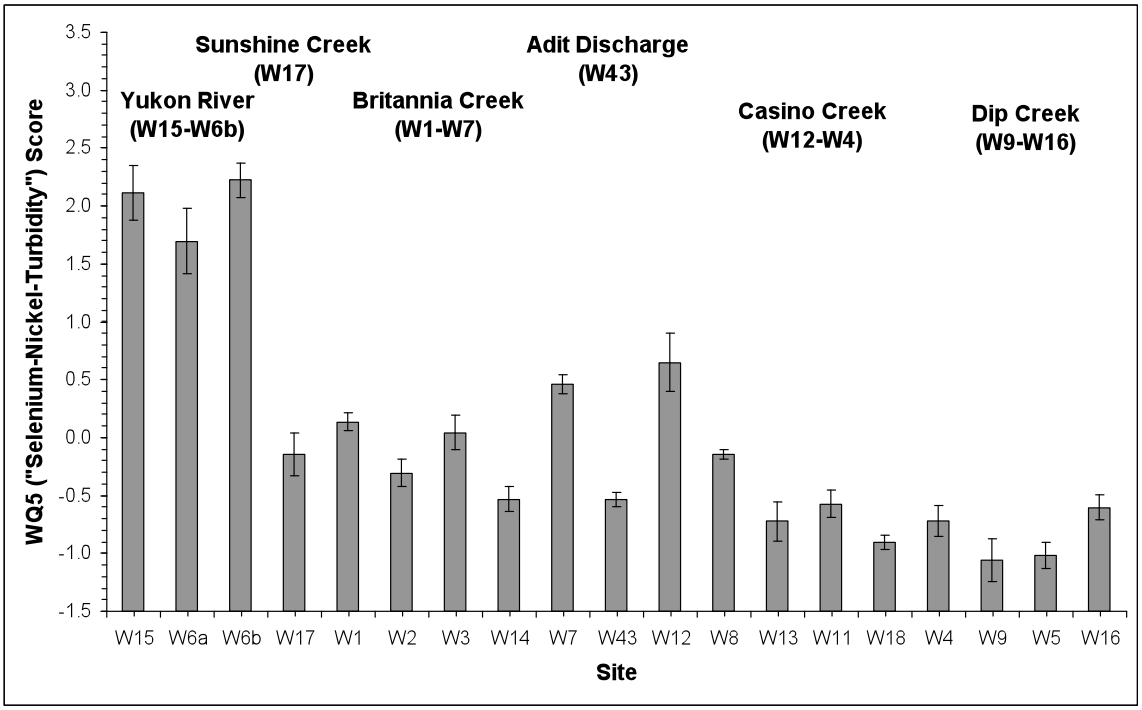


Figure 35. Plot of Mean WQ5 Scores on Sampling Site, Casino Project, 2008

3.2.3 Sediment Quality

3.2.3.1 Exceedances of Sediment Quality Guidelines

Appendix B7 shows the sediment quality data. Table 17 shows that exceedances of CCME sediment guidelines were observed for five total metals: arsenic (As), cadmium (Cd), copper (Cu), lead (Pb) and zinc (Zn). All of those metals except arsenic were also observed to exceed CCME water quality guidelines at some stations on some dates.

Table 17. Sediment Quality Parameters Exceeding CCME Guidelines, Casino Project, 2008

Site	Interim Freshwater Sediment Quality Guideline (ISQG)	ISQG and Probable Effects Level (PEL)
W7	As, Cd, Cu	-
W3	-	As
W14	As	-
W2	-	As
W1	As	-
W12	Pb, Zn	As, Cu
W8	Cd, Pb, Zn	As, Cu
W13	Cd, Zn	As, Pb
W11	Cd, Cu, Zn	As, Pb
W4	As	-
W9	As	-
W5	As	-

Dashes indicate sample did not exceed CCME Guidelines.

3.2.3.2 Principal Component Analysis

Mercury and selenium were removed from PCA because all values of those two metals were below detection limits. Of the remaining metals, a total of 10 concentrations below detection limits (or 3% of the total number of values) were replaced with one-half the detection limit. Then, pH and ln-transformed metal concentrations were entered into PCA. The first run extracted six components of which only the first three explained significant amounts of explained variance. Twelve metals (beryllium, calcium, chromium, copper, iron, magnesium, molybdenum, nickel, potassium, strontium, thallium and zirconium) were not highly correlated with those six components, hence they were removed and PCA was run a second time.

Three components were extracted that accounted for 87.7% of the explained variance: 48.1% for SQ1, 28.2% for SQ2 and 11.4% for SQ3. Table 18 shows that SQ1 was positively correlated with manganese, cadmium, cobalt, zinc, lead and antimony; SQ2 was positively correlated with vanadium, titanium, aluminum, tin, phosphorus, sodium and barium; and SQ3 was positively correlated with bismuth, silver and arsenic and negatively correlated with pH.

Table 18. Correlations of Sediment Quality Variables with Principal Components

Variable	SQ1	SQ2	SQ3
Manganese	0.941	0.279	-0.030
Cadmium	0.927	0.007	0.217
Cobalt	0.833	0.064	0.062
Zinc	0.806	0.321	0.467
Lead	0.798	0.255	0.499
Antimony	0.656	-0.079	0.629
Vanadium	0.185	0.952	0.082
Titanium	0.240	0.919	-0.110
Aluminum	0.289	0.905	0.220
Tin	0.269	0.869	0.268
Phosphorous	-0.177	0.862	0.031
Sodium	-0.369	0.796	-0.425
Barium	0.517	0.721	0.229
Bismuth	0.264	0.039	0.789
Silver	0.472	0.206	0.758
Arsenic	0.476	-0.372	0.706
pH	0.242	-0.238	-0.888

A plot of SQ1 scores on sampling site (Figure 36) showed that the highest scores were at three adjacent sites in Casino Creek (W8, W11 and W13). A plot of SQ2 scores on sampling site (Figure 37) showed a general decreasing north-south trend with the lowest scores in reach 1 of Britannia Creek and the highest scores at two sites in Dip Creek and at site W4 in lower Casino Creek. A plot of SQ3 scores on sampling site (Figure 38) showed the highest score at site W12 in the headwaters of Casino Creek.

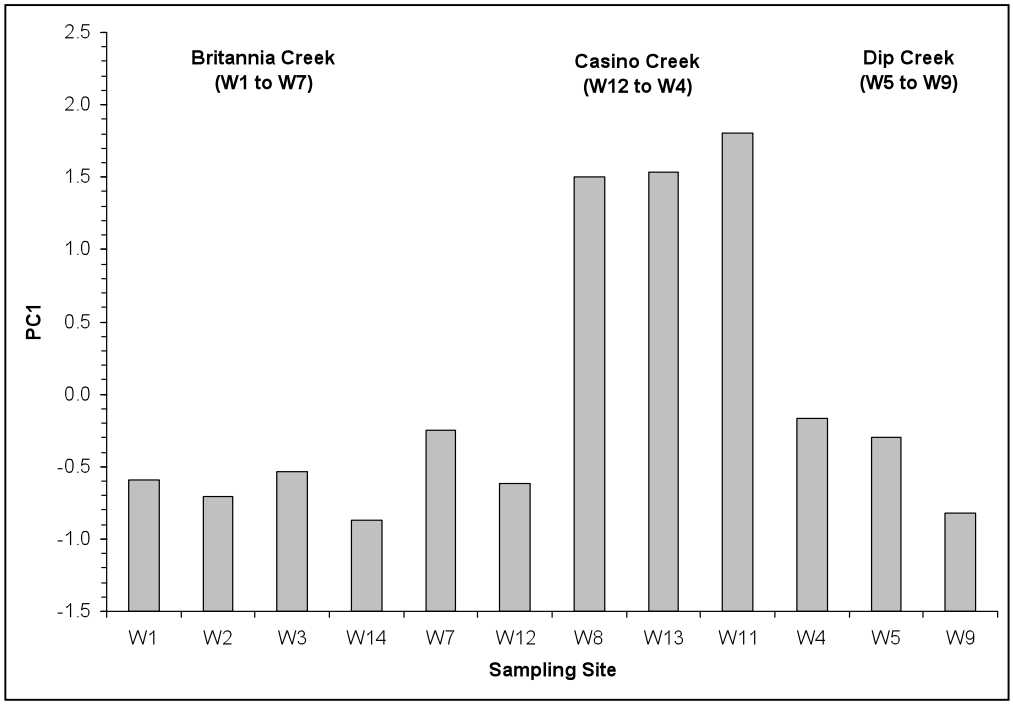


Figure 36. Plot of SQ1 Scores on Sampling Site

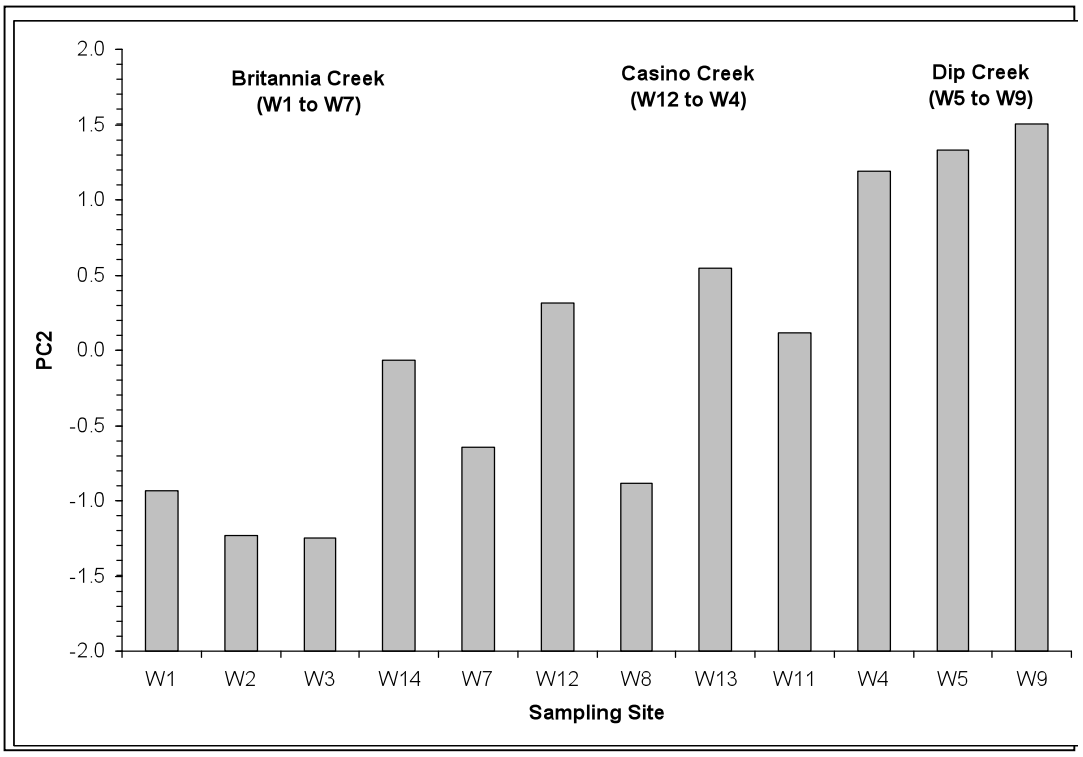


Figure 37. Plot of SQ2 Scores on Sampling Site

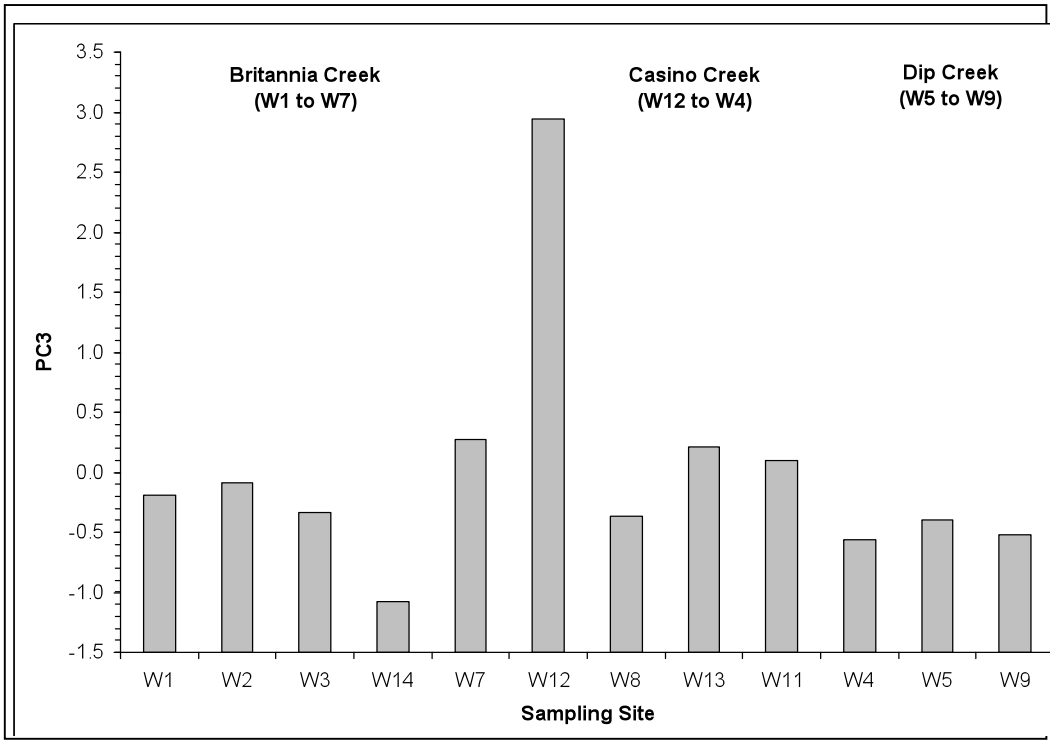


Figure 38. Plot of SQ3 Scores on Sampling Site

3.2.4 Periphyton

Appendix B8 shows the densities (cells/cm^2) by taxa for each of the 35 samples of periphyton collected from the seven sampling sites in September 2008.

Figure 39 shows the mean densities of periphyton for each site. One-way ANOVA of the ln-transformed densities showed there were highly significant differences in mean density among sites ($F_{6,28}$ = 14.34, P<0.001). Post-hoc comparisons of means using the Bonferroni test showed that mean density at sites P8, P7 and P4 were significantly (P<0.05) higher than at other sites.

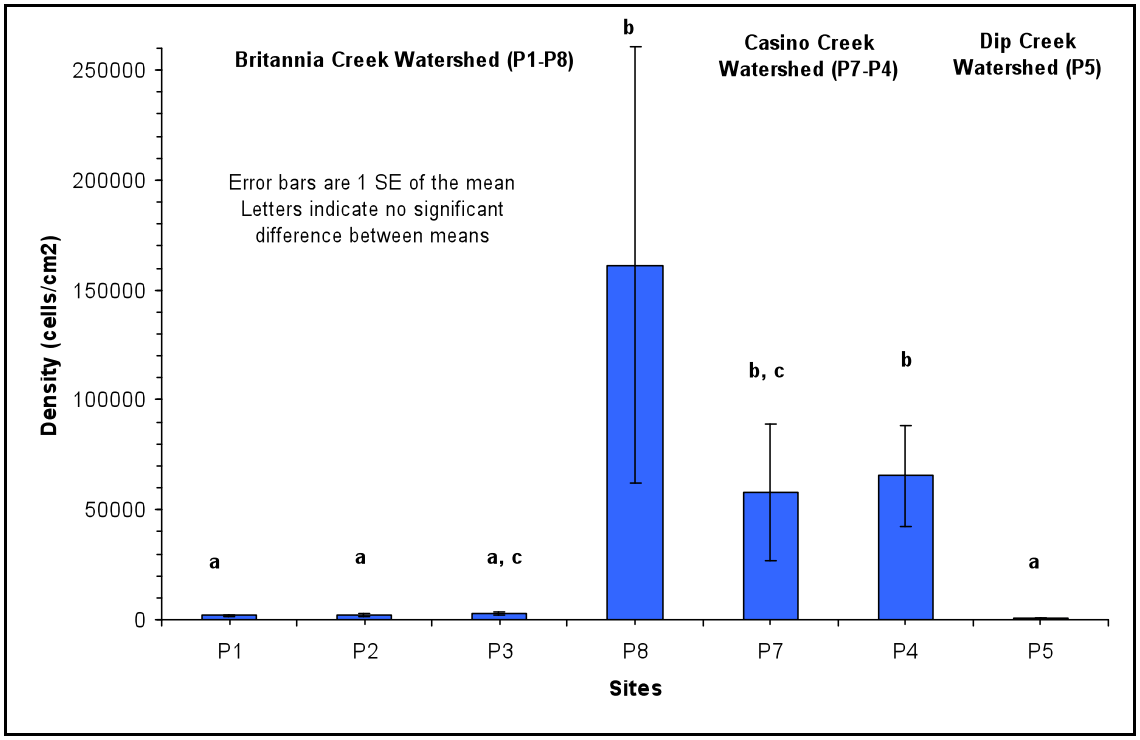


Figure 39. Mean Density of Periphyton by Site, Casino Project, 2008

Table 19 shows the percentage composition of the periphyton community at each sampling site. Britannia Creek sites P1, P2, and P3 were dominated by *Diatoma elongatum* and yellow-brown algae, *Chromulina sp.*, whereas site P8 was dominated by yellow-brown algae, *Homoeothrix varians*, and blue-green algae. Casino Creek site P4 was dominated by two blue-green algae, *Oscillatoria cf. agardhii* and *Homoeothrix varians*, whereas site P7 within the Casino Creek watershed was solely dominated by *Homoeothrix varians*. Dip Creek watershed site,P5 was dominated by blue-green algae, *Chromulina sp.*, followed by *Ceratuneis arcus*.

Table 19. Percentage Composition of Periphyton Communities, Casino Project, 2008

Taxon	Percentage of Number of Cells/cm^2						
	P1	P2	P3	P8	P7	P4	P5
Achnanthes lanceolata	0.00	0.00	0.00	0.04	0.04	0.00	0.00
Achnanthes minutissima	3.22	0.73	0.87	0.01	2.15	1.04	2.26
Achnanthes spp.	0.96	0.76	1.38	0.05	2.62	0.87	2.73
Caloneis spp.	0.00	0.00	0.00	0.00	0.06	0.00	0.00
Ceratoneis arcus	3.13	1.51	2.58	3.15	0.66	3.02	16.70
Cocconeis placentula	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Cymbella cf. cestaii	0.00	0.01	0.01	0.00	0.00	0.00	0.00
Cymbella cistula	0.00	0.00	0.04	0.00	0.00	0.01	0.00
Cymbella minuta	0.52	0.30	0.22	0.00	0.18	0.33	1.08
Cymbella sinuata	0.13	0.52	0.43	0.00	0.11	0.05	1.25
Diatoma elongatum	21.91	37.06	32.69	0.00	0.00	3.16	2.73
Diatoma mesodon	0.01	0.00	0.00	8.82	0.10	0.00	0.00
Didymosphenia geminata	0.00	0.00	0.00	0.00	0.00	0.04	0.00
Eunotia spp.	0.00	0.00	0.00	0.01	0.02	0.00	0.00
Fragilaria capucina	0.00	0.00	0.00	0.00	0.02	0.01	0.37
Fragilaria vaucheriae	5.32	0.73	0.63	0.49	2.24	3.31	5.48
Fragilaria spp.	3.10	1.38	1.23	2.23	0.18	1.43	2.13
Gomphonema acuminatum / parvulum	3.03	0.73	0.35	0.02	0.33	2.56	3.23
Gomphonema spp.	0.09	0.56	0.53	0.04	0.22	3.00	1.95
Meridion circulare	6.37	0.33	0.10	0.49	0.21	0.17	2.61
Navicula radiosa	0.00	0.03	0.04	0.00	0.00	0.00	0.00
Navicula spp.	0.13	0.07	0.09	0.00	0.00	0.03	2.33
Nitzschia spp.	1.83	0.31	0.32	0.01	0.37	0.47	6.13
Pinnularia spp.	0.01	0.08	0.12	0.03	0.23	0.04	0.14
Synedra ulna	0.01	0.34	0.68	0.00	0.00	0.02	0.00
Synedra spp.	1.06	0.41	0.19	0.13	0.06	1.73	2.16
Tabellaria fenestrata	0.00	0.00	0.00	0.02	0.00	0.00	0.00
Tabellaria flocculosa	0.00	0.00	0.00	0.03	0.00	0.00	0.00
UID girdle view	0.00	0.00	0.50	0.00	0.01	0.03	0.14
Chlorophyta							
Stigeoclonium sp.	0.00	0.00	0.00	0.01	0.00	0.00	0.00
UID Chaetophorales	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Hormidium sp.?	0.00	0.00	0.11	0.00	0.00	0.00	0.00
Microspora sp.	0.00	0.00	0.00	0.04	0.00	0.00	0.00
UID Chlorophyta colonial	0.79	0.00	0.00	0.00	0.00	0.00	0.00
UID Chlorophyta filamentous	0.00	0.00	0.79	0.00	0.00	0.00	0.00
UID Chlorophyta unicellular	0.20	0.00	0.09	0.04	0.00	0.00	0.00
Chrysophyta							
Chromulina sp.	38.05	44.68	25.91	22.72	0.06	0.75	34.43
Tribonema spp.	0.00	0.00	0.00	0.05	0.00	0.00	0.00
UID Chrysophyte colonial	2.68	1.92	3.18	0.02	0.00	0.00	0.00
UID Chrysophyte cyst	0.00	0.21	0.00	0.01	0.12	0.01	0.05
UID Chrysophyte flagellate	0.00	0.00	0.01	0.02	0.00	0.00	0.25
UID Chrysophyte unicellular	0.37	0.00	0.00	2.79	0.00	0.00	0.00
Cyanophyta							
Chamaesiphon spp.	0.00	0.00	0.00	11.87	13.38	8.95	0.00
Clastidium setigerum	0.00	0.00	0.00	0.78	8.04	0.03	0.00
UID Chrooccocales	0.00	2.21	3.35	4.95	3.58	4.47	0.00
Nostoc sp. / Anabaena sp.	0.00	0.00	0.00	0.00	0.00	0.16	0.00
Nostoc sp.	0.00	0.00	0.00	0.00	0.14	0.00	0.00
Tolypothrix sp.	0.00	0.00	1.42	0.00	0.00	0.00	0.00
Lyngbya spp.	0.00	0.00	0.32	0.00	0.11	0.00	0.00
Homoeothrix varians	0.00	0.00	0.00	35.00	58.71	25.14	3.47
Microcoleus sp.	0.00	0.00	0.00	0.04	0.00	0.00	0.00

Taxon	Percentage of Number of Cells/cm^2						
	P1	P2	P3	P8	P7	P4	P5
Oscillatoria cf. agardhii	0.00	0.00	15.04	3.77	0.00	27.44	0.00
Oscillatoria spp.	0.00	0.00	0.00	0.08	0.00	0.00	0.00
Pseudoanabaena spp.	0.00	0.26	0.00	0.08	1.23	0.16	0.19
UID Oscillatoriales	0.00	0.00	1.18	0.16	1.54	1.18	0.75
Rhodophyta							
Audouinella sp.	0.00	0.00	0.00	0.04	0.00	1.77	0.00
Batrachospermum sp.	0.00	0.00	0.00	0.00	0.00	4.32	0.00
UID flagellate	0.14	0.00	0.00	0.03	0.00	3.42	0.00
UID colonial	0.00	0.00	0.00	0.00	0.00	0.01	0.61
UID filamentous	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UID unicellular	6.92	4.85	5.57	1.90	3.26	0.88	6.84

**UID = unidentified.*

Figures 40 and 41 show the mean taxonomic richness and Shannon-Wiener diversity index by site. There were no significant differences among sites in diversity ($F_{6,28}$ = 1.94, P = 0.11), but there were highly significant differences among sites in richness ($F_{6,28}$ = 17.70, P < 0.001). Post-hoc tests using Bonferroni test for richness showed that the main cause for variation is the higher richness for sites P8, P7 and P4 compared to most of the other sites.

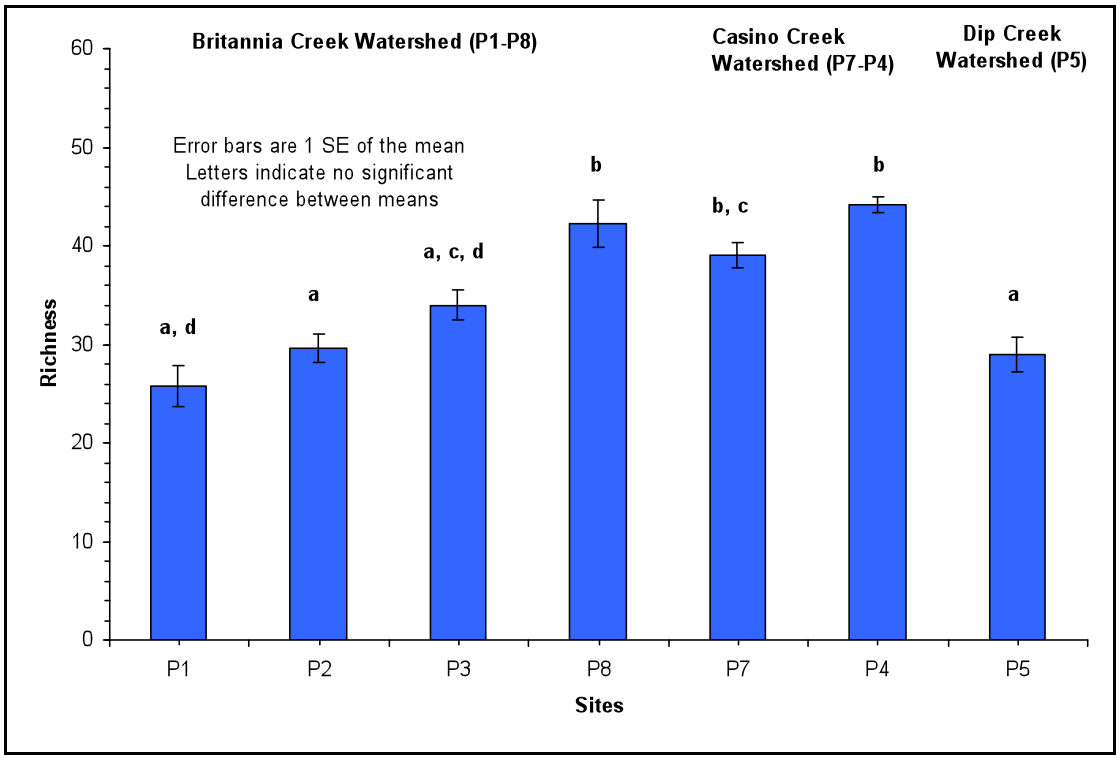


Figure 40. Mean Taxonomic Richness of Periphyton Communities, Casino Project, 2008

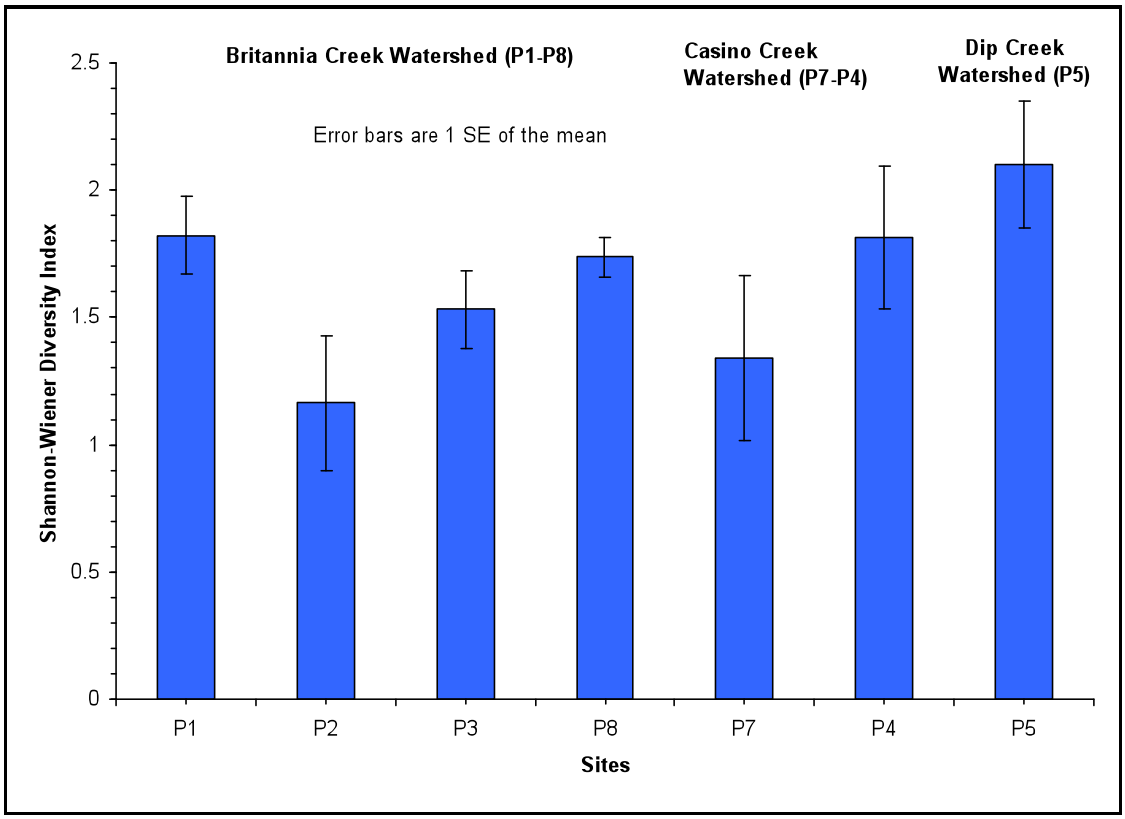


Figure 41. Mean Shannon-Wiener Diversity Index of Periphyton Communities, Casino Project, 2008

3.2.5 Benthic Invertebrates

Appendix B9 shows the number of organisms counted and identified to taxa in each of the 35 samples of benthos collected from the seven sampling sites in September 2008.

Figure 42 shows the mean densities of benthic invertebrates for each site. One-way ANOVA of the ln-transformed densities showed there were highly significant differences in mean density among sites ($F_{5,28}$ = 16.64, P<0.001). Post-hoc comparisons of means using the Bonferroni test showed that mean density at site B8 was significantly higher than the densities at all other sites except for B2 and that mean densities at sites B7 and B4 were significantly lower than mean densities at sites B2 and B3.

Table 20 shows the percentage composition of the benthic invertebrate community at each sampling site. Dipterans dominated the communities at all sites. Over 95% of the organisms at each site belonged to eight taxa: the insect Orders of Diptera, Plecoptera, Ephemeroptera, Trichoptera, Prostigmata and Collembola plus the worms of Class Oligochaeta and Phylum Nematoda.

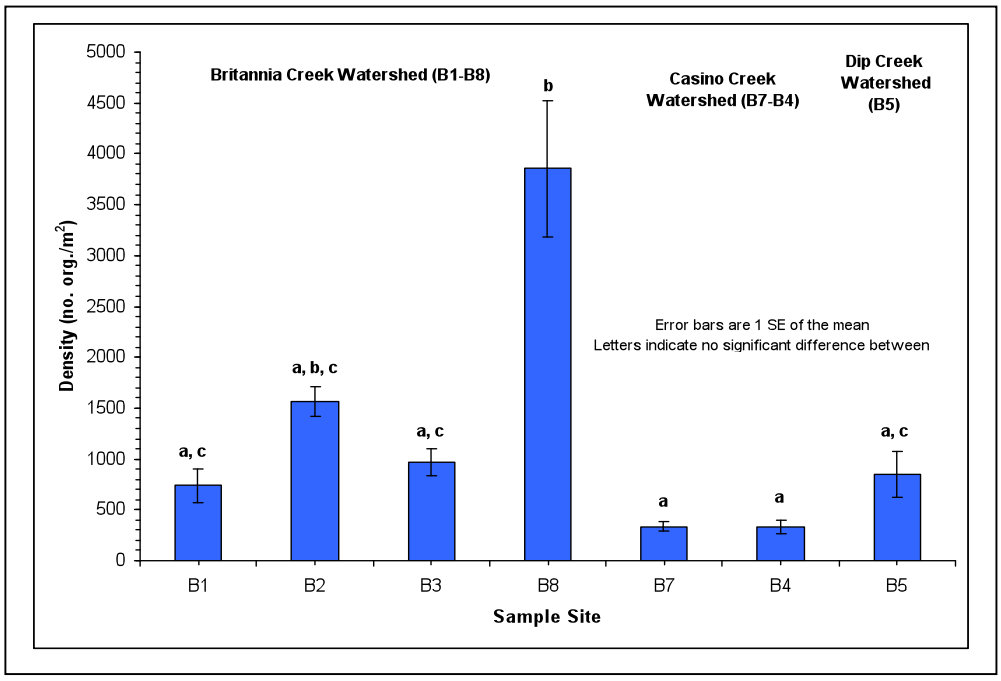


Figure 42. Mean Density of Benthic Invertebrates by Site, Casino Project, 2008

Table 20. Percentage Composition of Benthic Invertebrate Communities, Casino Project, 2008

Taxon	Percent of Total Number of Organisms						
	B1	B2	B3	B4	B5	B7	B8
Order Diptera	43.8	47.7	49.9	31.8	32.8	36.8	31.5
Order Plecoptera	20.4	22.5	7.8	13.2	12.7	29.0	21.7
Order Ephemeroptera	15.4	25.2	31.2	13.2	32.8	1.9	17.3
Class Oligochaeta	9.2	0.3	1.3	17.9	2.8	2.6	25.8
Order Trichoptera	4.4	0.4	1.8	9.9	3.3	0.0	0.2
Order Prostigmata	2.4	1.9	2.2	9.3	9.2	5.8	0.6
Phylum Nematoda	2.1	0.0	0.2	1.3	1.0	5.2	0.4
Order Collembola	1.2	0.8	2.9	0.7	0.8	18.1	2.2
Order Copepoda	0.9	0.3	0.7	2.0	2.3	0.0	0.1
Order Ostracoda	0.3	0.3	0.7	0.0	1.3	0.0	0.3
Order Coleoptera	0.0	0.0	0.2	0.0	0.5	0.0	0.0
Order Lepidoptera	0.0	0.3	0.2	0.7	0.3	0.6	0.0
Order Cladocera	0.0	0.1	0.7	0.0	0.3	0.0	0.0
Order Bivalvia	0.0	0.0	0.2	0.0	0.0	0.0	0.0
Order Gastropoda	0.0	0.1	0.0	0.0	0.0	0.0	0.0

Figures 43 to 45 show the mean taxonomic richness, total EPT abundance and Shannon's index of diversity, respectively, by site. There were highly significant differences among sites in richness ($F_{6,28}$ = 4.79, P<0.001), total EPT ($F_{6,28}$ = 17.07, P<0.001) and in Shannon-Wiener diversity index ($F_{6,28}$ = 7.18, P<0.001). Post-hoc tests using the Bonferroni test showed that the main cause for variation in richness was low richness at site B7 compared to high richness at sites B2 and B5. Post-hoc tests using the Bonferroni test showed that the main cause for variation in total EPT was high total EPT at site B8 compared to low total EPT at all the other sites. Also, site B2 had

significantly higher total EPT than sites B7 and B4. Post-hoc tests using the Bonferroni test showed that the main cause for variation in Shannon-Wiener diversity index was higher diversity for sites B4, B5 and B1 than for sites B2, B3, B8, and B7. Also, diversity was significantly higher for site B4 compared to sites B8 and B7.

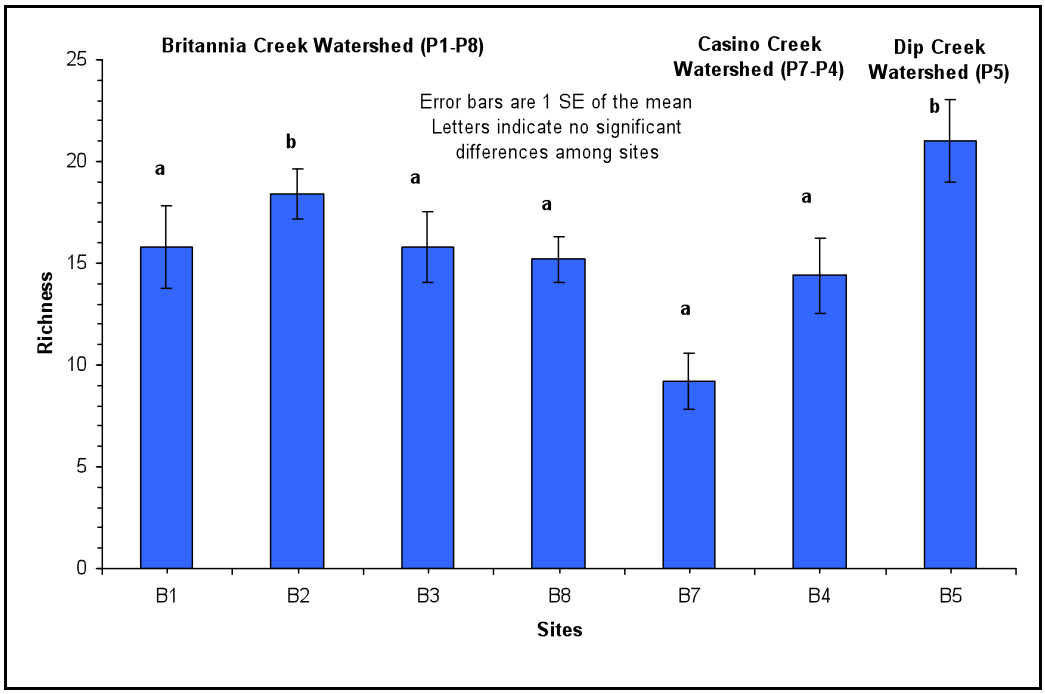


Figure 43. Mean Taxonomic Richness of Benthic Invertebrate Communities, Casino Project, 2008

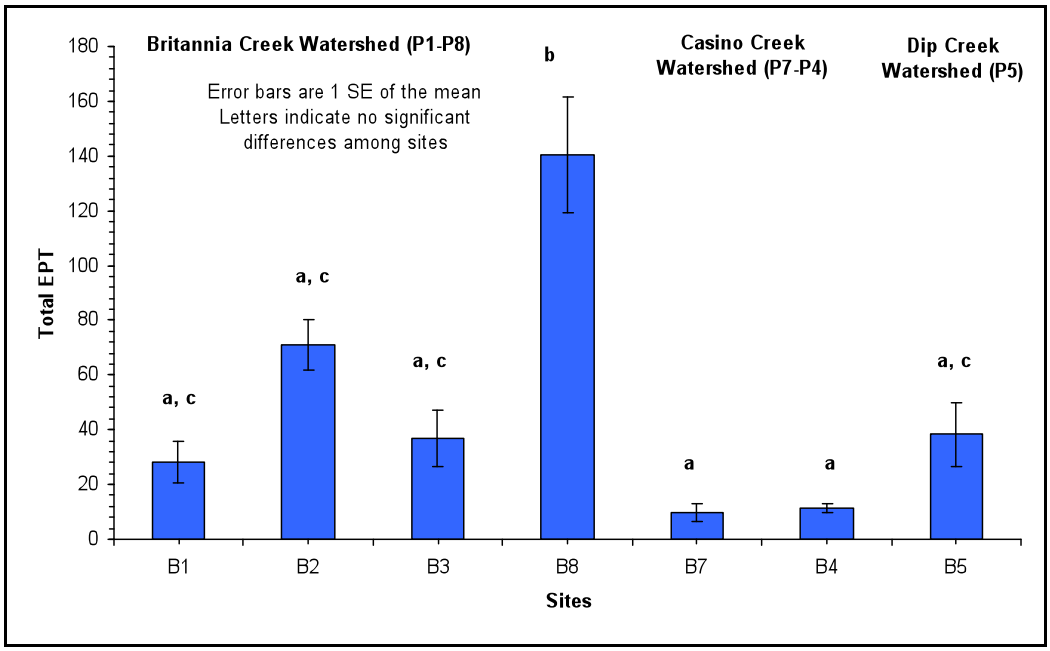


Figure 44. Mean Total EPT of Benthic Invertebrate Communities, Casino Project, 2008

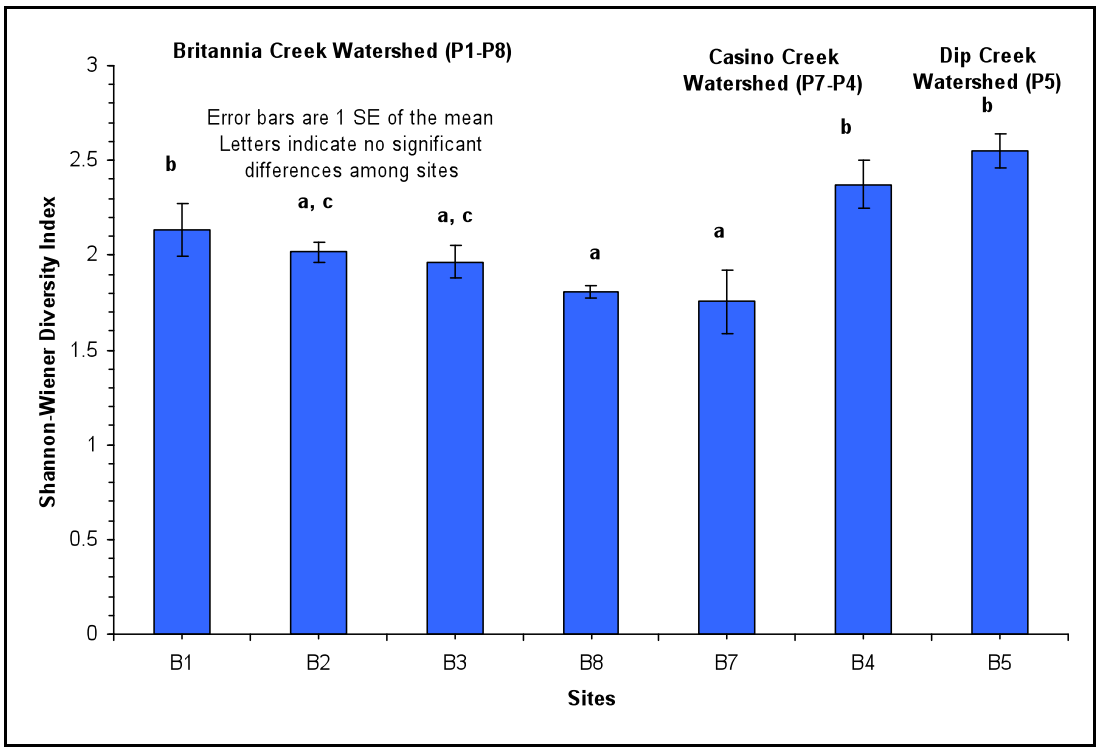


Figure 45. Mean Shannon-Weiner Index of Diversity of Benthic Invertebrate Communities, Casino Project, 2008

3.2.6 Fish Community

3.2.6.1 Catch, Effort and CPUE

Appendices B11, B12 and B13 show the fish catch, effort and CPUE for minnow traps, electrofishing and angling, respectively. A total of 40 fish from two species – Arctic grayling (*Thymallus arcticus*) and slimy sculpin – were captured from the Casino Project LSA in July and September 2008 (Table 21). Apart from one Arctic grayling caught by angling, all were captured by electrofishing.

Only Arctic grayling were found in the Britannia Creek Watershed, but both Arctic grayling and slimy sculpin were found in Casino Creek and Dip Creek watersheds. Slimy sculpin made up the majority of the catch (81 to 86%) in those two watersheds, respectively.

A total of 15 sites were electrofished – 12 in July and three in September. Three sites were electrofished twice. Of those 15 surveys, four were three-pass and 11 were single pass, for a total of 23 separate passes.

Stream sections ranged in length from 75 to 220 m with a mean of 140 m (n = 12, SE = 18). Voltage for each of the passes ranged from 300 to 750 V with a mean of 556 V (n = 23, SE = 23) and effort ranged from 340 to 1,591 sec with a mean of 669 sec (n = 23, SE = 70).

Table 21. Fish Catch, Casino Project, 2008

Gear	Arctic grayling	Slimy sculpin	Total
Britannia Creek Watershed			
Minnow Trap	0	0	0
Electrofishing	7	0	7
Angling	0	0	0
subtotal	7	0	7
Casino Creek Watershed			
Minnow Trap	0	0	0
Electrofishing	6	20	26
Angling	0	0	0
subtotal	5	21	26
Dip Creek Watershed			
Minnow Trap	0	0	0
Electrofishing	0	6	6
Angling	1	0	1
subtotal	1	6	7
Combined			
Minnow Trap	0	0	0
Electrofishing	12	27	39
Angling	1	0	1
Total	13	27	40

Of the four three-pass surveys, one caught no fish (F07 on July 9) and two (F03 on July 8 and F08 on July 9) did not show decreases in catch of Arctic grayling with successive passes. The fourth survey (F13 on July 10) did not show a decrease in catch of Arctic grayling with successive passes, but it did show clear decreases for slimy sculpin. Such decreases are required to estimate total fish number using the three-pass method (e.g., Peterson *et al*. 2004). The low number of three-pass surveys and the general lack of decreasing catch per pass meant that total fish number was not estimated using the three-pass algorithm. Instead, the CPUE of each survey was used as an index of population abundance.

A plot of CPUE on fish sampling site along a north-south trend line (Figure 46) shows that mean CPUE of Arctic grayling in the streams of the LSA was higher in July (mean = 0.10, SE = 0.04, n = 13) than in September (mean = 0.00 fish/100 sec, SE = 0.00, n = 3). This was due to outmigration of Arctic grayling in late summer in search of overwintering habitat. Arctic grayling from the Britannia Creek Watershed migrated to the Yukon River and those from Casino Creek Watershed moved downstream into Dip Creek.

Figure 47 shows that slimy sculpin were absent from the Britannia Creek Watershed in July and September 2008. Unlike Arctic grayling, the mean CPUE of slimy sculpin for Casino and Dip Creeks in September (mean = 0.24, SE = 0.21, n = 3) was not significantly different ($F_{1,8}$ = 0.091, P = 0.08) than the mean for July (mean = 0.16, SE = 0.16, n = 7), indicating that slimy sculpin did not outmigrate from Casino Creek until later in the year.

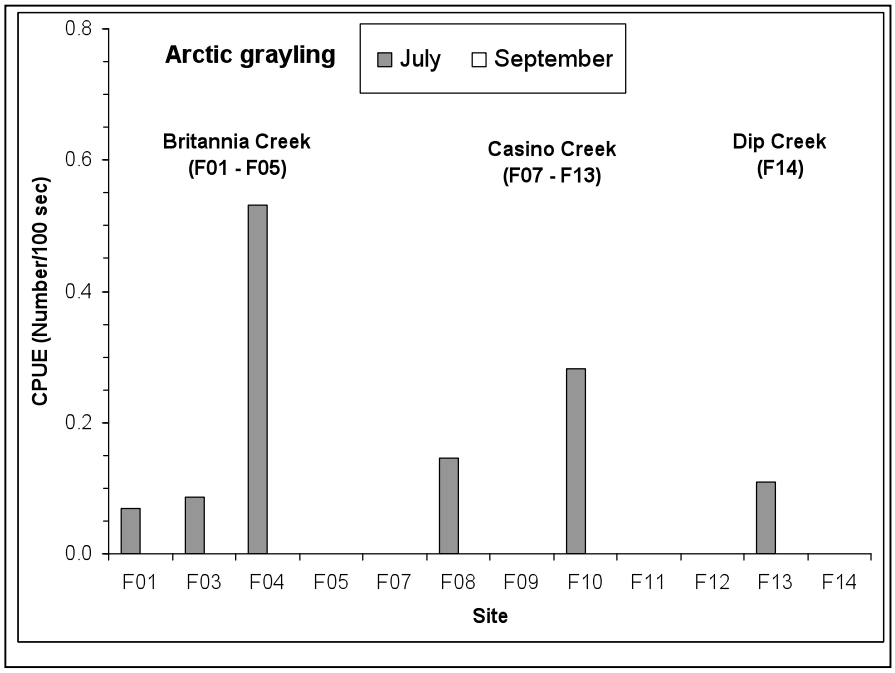


Figure 46. Electrofishing CPUE, Arctic Grayling, Casino Project, 2008

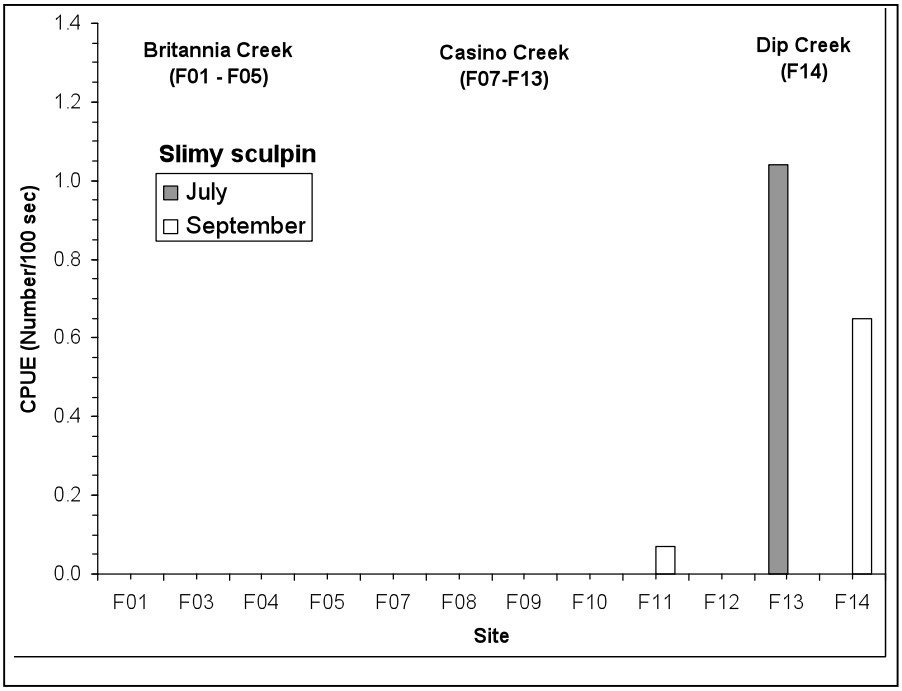


Figure 47. Electrofishing CPUE, Slimy Sculpin, Casino Project, 2008

Although the maximum CPUE of sculpin in Casino and Dip creeks for the combined July and September surveys was higher than the maximum for Arctic grayling in the LSA, the variance of both sets of CPUE was sufficiently high that the mean CPUE of slimy sculpin of Casino and Dip Creeks for the combined July and

September surveys (mean = 0.18, SE = 0.12, n = 10) was not significantly different ($F_{1,20}$ = 0.042, P = 0.52) from the mean CPUE of Arctic grayling in July.

These results were similar to those reported for 1993 and 1994 by Hallam Knight Piésold (1997), but with some important differences. As in 2008, Arctic grayling were observed throughout the Britannia Creek Watershed (Table 22). However, Arctic grayling fry were only observed in lower Britannia Creek near the confluence with the Yukon River in August 1993, indicating that this area provides spawning and rearing habitat for Arctic grayling, but not on a consistent basis.

Table 22. Fish Species in the Aquatics Local Study Area, Casino Project, 1993 to 2008

Species	Life Stage	Britannia Creek Watershed				Casino Creek Watershed		
		1993	1994	2008		1993	1994	2008
Arctic grayling	juveniles/adults fry	Jun, Aug. Sep Aug	Jun, Aug -	Jul -		Jun, Aug, Sep -	Jun, Aug, Sep Aug	Jul
Slimy sculpin	Juveniles/adults	Aug	Aug	-		Jun, Auig, Sep	Jun, Aug, Sep	Jul, Sep
Chinook salmon	juveniles fry	Aug June	- -	- -		- -	- -	- -
Round whitefish	juveniles	Aug	-	-		-	-	-
Burbot	juvenile	Sep	-	-		-	-	-

Unlike 2008, slimy sculpin were observed in the lower reach of Britannia Creek in 1993 and 1994, as were several round whitefish (*Prosopium cylindraceum*), one juvenile burbot (*Lota lota*) and several juvenile chinook salmon (*Oncorhynchus tshawytscha*). Therefore, lower Britannia Creek appears to provide temporary rearing habitat for juvenile fish from the Yukon River fish community. It is not clear why slimy sculpin do not move further upstream in the Britannia Creek Watershed, as they do in the Casino Creek Watershed. The presence of chinook salmon fry in lower Britannia Creek in June 1993 suggests the presence of some chinook salmon rearing habitat in lower Britannia Creek, but the absence of spawners in 1993, 1994 and 2008 indicates little spawning potential.

As in 2008, only slimy sculpin and Arctic grayling were observed in Casino Creek Watershed in 1993 and 1994, but Arctic grayling were found in September 1993 – later than in 2008 – indicating that the time of outmigration varies among years. No Arctic grayling fry were observed in the Casino Creek Watershed in any year, indicating that it offers poor rearing habitat for that species.

3.2.6.2 Size, Age and Growth

Appendix B14 shows lengths, weights and ages for fish captured in the Casino LSA in 2008. There were no significant differences in mean length ($F_{1,10}$ = 1.59, P = 0.24), weight ($F_{1,8}$ = 3.74, P = 0.09) or age ($F_{1,8}$ = 3.6, P = 0.09) of Arctic grayling between Britannia Creek and Casino Creek watersheds, which would be expected based on their geographic proximity. Hence, those data were pooled to calculate mean length, weight and age (Table 23). Since all slimy sculpin were captured from Casino and Dip creeks, which are directly connected, all those data were also pooled to calculate mean length and weight.

Table 23. Mean Size and Age of Fish, Casino Project, 2008

	Arctic Grayling				Slimy Sculpin	
Statistic	Length (mm)	Weight (g)	Age (year)		Length (mm)	Weight (g)
Mean	257	194.2	5		72	4.8
SE	14	25.0	1		9	8.8
n	13	11	11		26	26
minimum	173	44.5	2		29	0.5
maximum	300	260.0	6		129	19.3

SE = standard error and n = sample number.

The length frequency distribution for Arctic grayling shows two modes: one at a length range of 150-199 mm that are assumed to represent juveniles and a second mode at 250-299 mm that are assumed to represent adults (Figure 49). The length frequency distribution for slimy sculpin showed only one mode one at a length range of 50-99 mm that is assumed to represent a mixture of juveniles and adults.

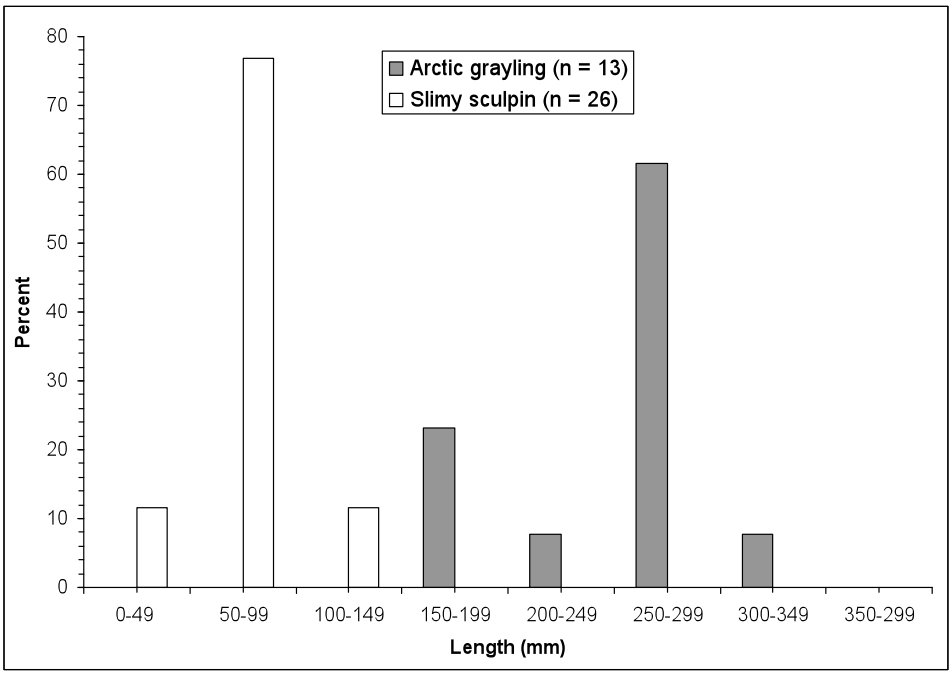


Figure 48. Length Frequencies of Arctic Grayling and Slimy Sculpin, Casino Project, 2008

Linear regressions of weight on length were highly significant for both species and explained between 96 and 97% of the variance in ln(weight) (Figure 50). The slopes of the regressions were both close to the value of 3.0 that is commonly assumed for fish.

The age frequency distribution for Arctic grayling shows two modes: one for fish aged two to three years (juveniles) and a second for fish aged five to six years (adults) (Figure 51). A plot of mean length on age showed that growth rate slows over age and hence mean length begins to approach an asymptote by age five or six years (Figure 52).

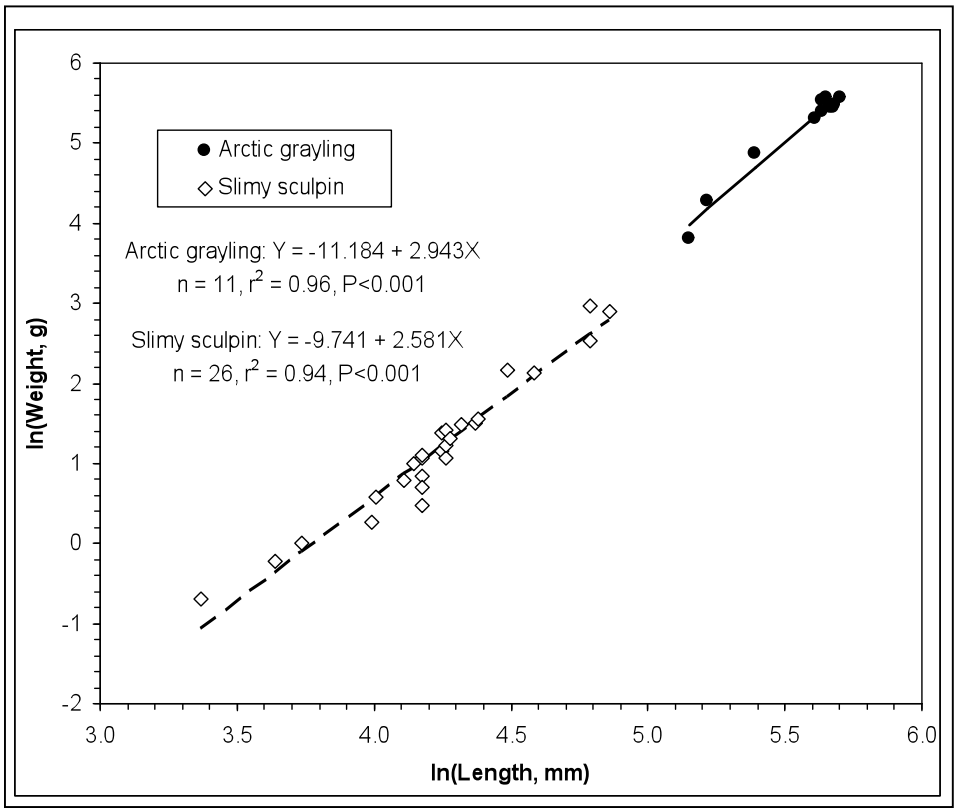


Figure 49. Weight-length Regressions for Arctic Grayling and Slimy Sculpin, Casino Project, 2008

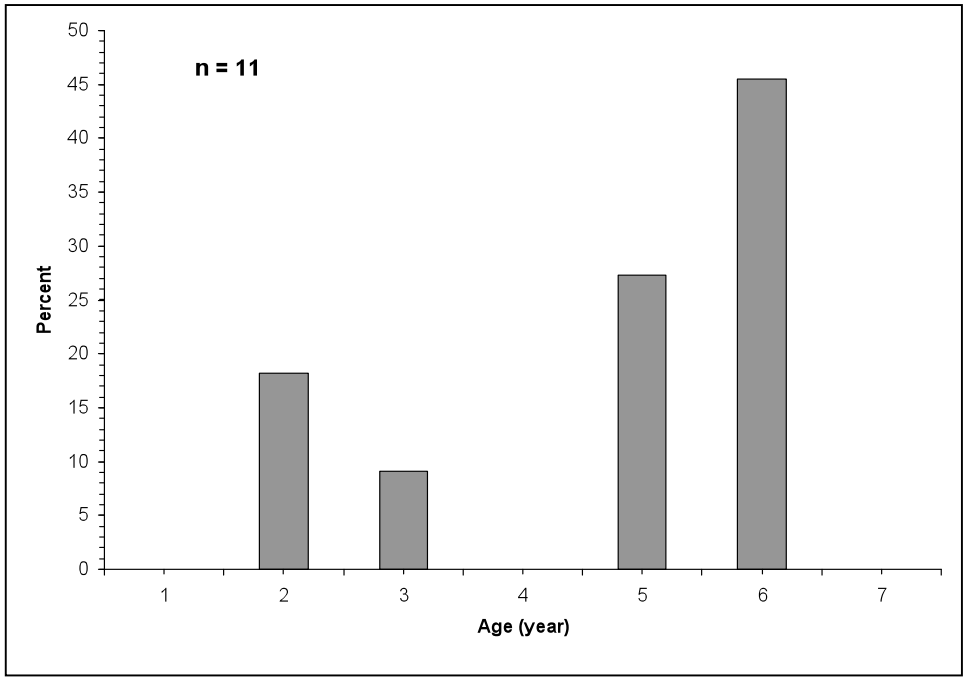


Figure 50. Age Frequency Distribution, Arctic Grayling, Casino Project, 2008

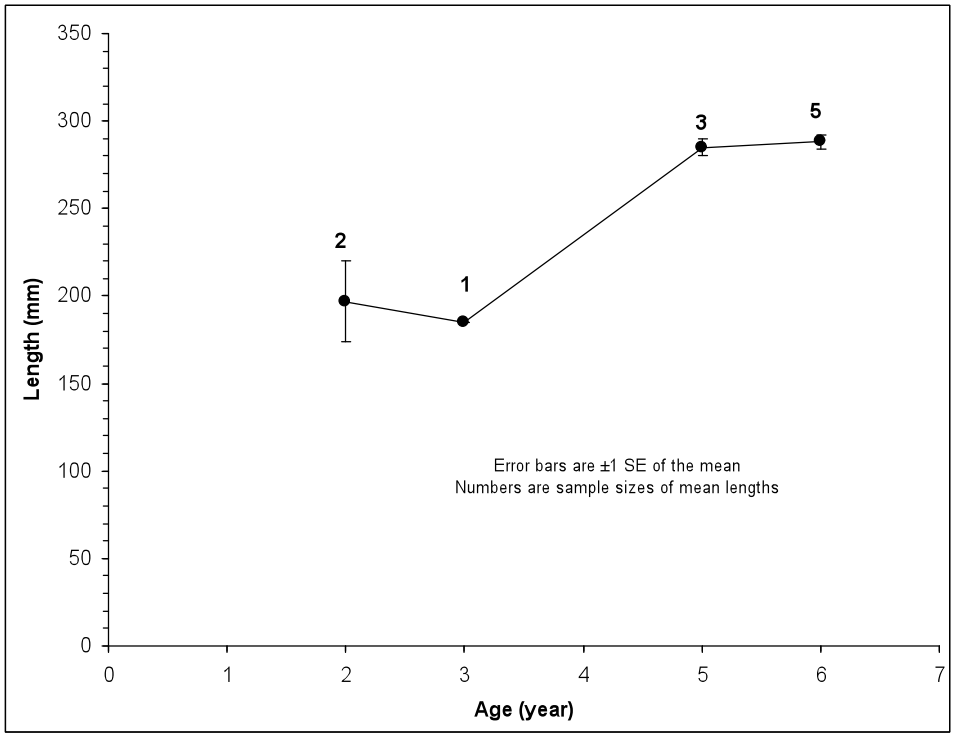


Figure 51. Length-Age Plot, Arctic Grayling, Casino Project, 2008

Too few Arctic grayling were captured in 2008 to permit growth modelling even if data were pooled from both Britannia and Casino watersheds. Therefore, length and age data reported by Hallam Knight Piésold (1997) for 1993 and 1994 were pooled with the 2008 data and von Bertalanffy growth curves were fit to data for Britannia and Casino watersheds separately (Figures 53 and 54). Both models explained 98% or more of the variance in length. There were sufficient data for the Britannia Watershed, particularly length-age data for the critical ages of zero and one years, to provide a good fit to length-at-age data. There were insufficient data for Casino Watershed as is shown by the predicted length at age zero years of 111 mm – twice the value predicted for Britannia Watershed and biologically unrealistic.

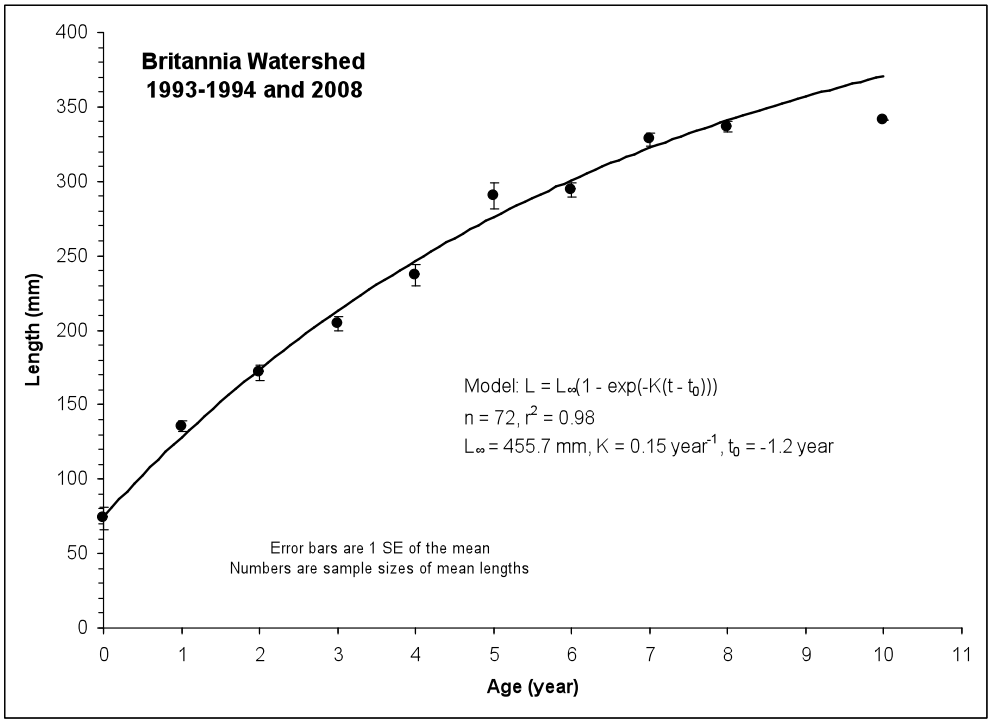


Figure 52. Length-Age Relationship, Arctic Grayling, Britannia Watershed, 1993-1994 and 2008

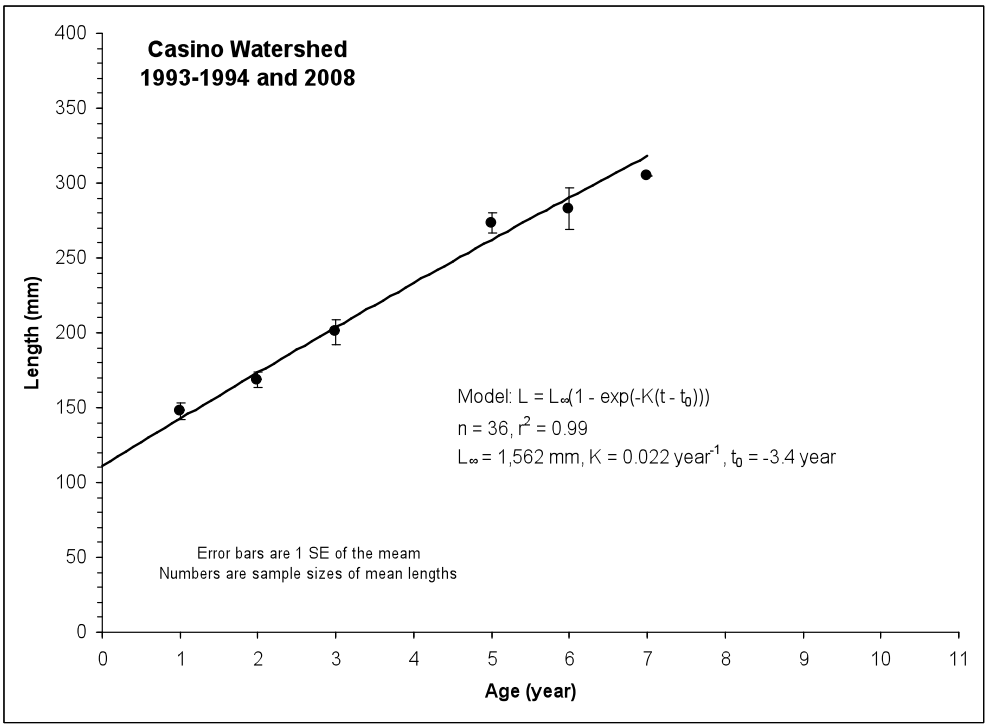


Figure 53. Length-Age Relationship, Arctic Grayling, Casino Watershed, 1993-1994 and 2008

3.2.6.3 Tissue Metals Concentrations

Appendix B15 shows the concentrations of metals measured in nine whole-body samples of slimy sculpin collected from Casino and Dip creeks in July and September 2008. Of the 33 metals, eight (antimony, beryllium, boron, molybdenum, tellurium, thallium, tin and zirconium) were excluded from analysis because all nine values were below detection limits. For the remaining 25 metals, all values below detection limits were replaced by one-half the detection limit to allow statistical analysis. This resulted in replacing 20% of the concentrations (i.e., 44 of 225). Table 24 shows the mean concentrations of metals, sorted in ascending order of mean concentration.

Table 24. Mean Whole-Body Metal Concentrations, Slimy Sculpin, Casino Project, 2008

Metal	Concentration (µg/g wet weight)			
	mean	SE	min	max
Silver	0.006	0.001	0.005	0.010
Mercury	0.040	0.008	0.020	0.090
Cadmium	0.07	0.02	0.00	0.24
Lead	0.08	0.03	0.05	0.30
Nickel	0.08	0.03	0.05	0.30
Chromium	0.09	0.03	0.05	0.30
Cobalt	0.09	0.03	0.05	0.30
Uranium	0.10	0.03	0.02	0.29
Arsenic	0.1	0.02	0.1	0.3
Vanadium	0.48	0.14	0.25	1.50
Selenium	0.7	0.1	0.4	1.1
Copper	1.2	0.1	0.9	2.1
Barium	4.3	0.9	1.2	9.8
Titanium	7.9	2.3	3.7	24.6
Manganese	10.6	2.3	3.1	25.4
Strontium	20.91	4.33	4.89	52.40
Zinc	27.5	3.9	19.2	57.4
Silicon	43	5	22	66
Aluminum	56.8	29.9	9.8	294.0
Iron	143	70	49	693
Magnesium	459	58	295	900
Sodium	1,526	232	1,090	3,360
Potassium	3,447	325	2,510	5,860
Phosphorus	9540	1758	4590	22900
Calcium	13,222	3,196	3,760	37,400

SE = standard error, min = minimum and max = maximum.

N = 9 for all metals.

None of the sculpin had mercury concentrations that exceeded the 0.5 µg/g guideline established by Health Canada (http://www.hc-sc.gc.ca/ahc-asc/media/advisories-avis/_2002/2002_41-eng.php).

PCA extracted two components from the dataset of ln-transformed metals. Four metals – mercury, cadmium, silicon and selenium – were not correlated with either component. Therefore, PCA was run a second time after removing those four metals. The first component, PC1, accounted for 60.8% of the explained variance and the second component, PC2, accounted for another 27.4% for a total of 88.2% of the explained

variance. Table 25 shows the correlations of the metals with each component. PC1 was highly correlated with ten metals including those often associated with metal deposits such as iron, lead and nickel. PC2 was highly correlated with 11 metals many of which are essential biological structural elements such as phosphorus, sodium and calcium and which are present in relatively high concentrations in whole-body tissue samples.

Table 25. Correlations of Principal Components with Slimy Sculpin Tissue Metal Concentrations

Metal	PC1	PC2
iron	0.99	0.13
lead	0.98	0.12
nickel	0.98	0.12
arsenic	0.94	0.30
aluminum	0.94	-0.03
chromium	0.94	-0.07
cobalt	0.93	0.10
titanium	0.91	0.39
vanadium	0.90	0.34
manganese	0.74	0.48
phosphorus	0.09	0.98
sodium	0.11	0.96
calcium	0.10	0.96
magnesium	0.34	0.93
zinc	0.32	0.91
silver	0.14	0.88
strontium	0.08	0.88
potassium	-0.13	0.83
copper	0.13	0.81
barium	0.57	0.74
uranium	0.50	0.68

A plot of PC2 scores on PC1 scores for the nine sculpin showed that seven of the nine fish clustered together in a region with relatively low scores, and that fish from all three sampling sites were present in that cluster (Figure 55). Two fish were outliers; one from site F13 had a relatively high PC2 score and one from site F14 had relatively a high PC1 score.

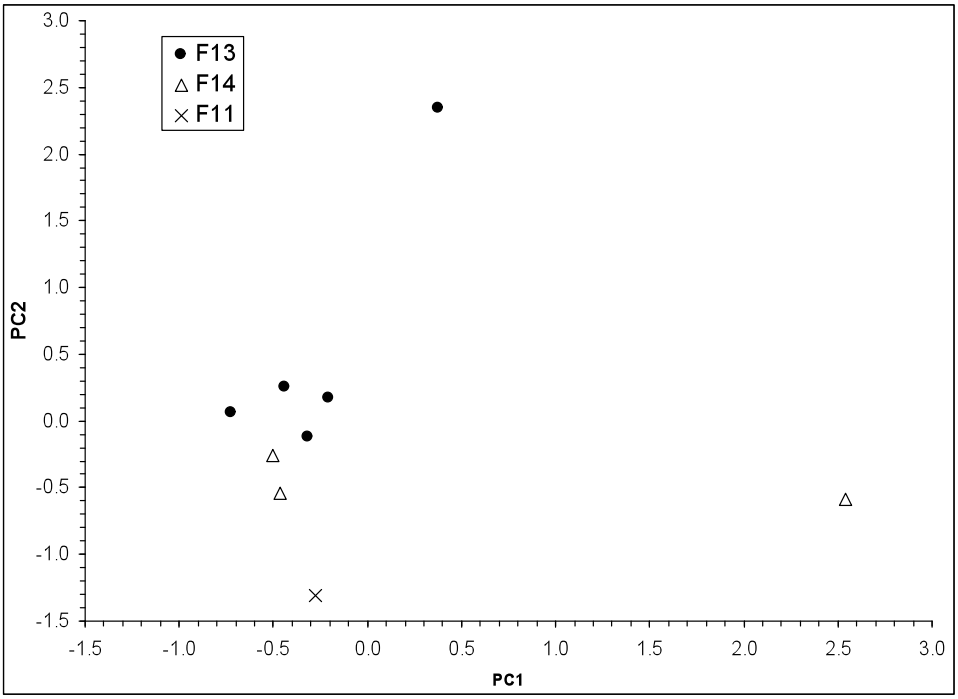


Figure 54. Plot of PC2 Scores on PC1 Scores for Slimy Sculpin Tissue Metal Samples

3.2.6.4 Salmon Spawning Survey

No Pacific salmon spawners were observed during the aerial survey of September 11, but good spawning habitat was observed in 50% of reach 2 of Britannia Creek and approximately 40 m^2 of spawning habitat was observed in Canadian Creek upstream from the confluence with Britannia Creek.

3.2.7 Fish Habitat

3.2.7.1 General

Appendices B16 and B17 show the stream habitat records for the July and September surveys, respectively.

3.2.7.2 Britannia Creek Watershed

The lower reach of Britannia Creek was surveyed on September 11 (Photo 2). At that time the stream stage was classified as high. Habitat consisted of 50% riffles, 30% runs and 20% pools. Gradient was close to 0%. Wetted depth ranged from 0.20 to 0.35 m with a mean of 0.28 m. The substrate was composed of 20% fines, 20% small gravel, 50% small cobble and 10% large cobble. Only 10% of the stream area provided cover and 80% of that area was provided by LWD and 20% by deep pools. Approximately 20% of the stream area consisted of gravel bars. The stream was classified as occasionally confined. This reach was classified as salmonid rearing habitat class II by DFO under the Yukon Placer Authorization (Government of Canada 2000).



Photo 2. Lower Reach of Britannia Creek Looking Upstream, September 11, 2008

The upper reach of Britannia Creek (i.e., reach 2) was also surveyed on September 11 (Photo 3). Habitat consisted of 70% riffle, 20% run and 10% pools. At that time its stage was high, hence its mean wetted width (4.1 m) was the same as its bankfull width. Wetted depth ranged from 0.16 m to 0.42 m with a mean of 0.29 m. Gradient was 1%. The substrate consisted of 30% small gravel, 30% large gravel, 20% large cobble and 10% boulder. Only 10% of the stream area provided cover of which 70% was provided by LWD, 20% by cutbank and 10% by overstream vegetation. The stream was unconfined and contained 10% gravel bars. The crown closure was 20%.

The lower reach of Canadian Creek, upstream of the confluence with Britannia Creek, was surveyed on July 8 (at fish site F03) and on September 11. In early July, the stream stage was low, hence mean wetted width (5.0 m) was lower than mean bankfull width (8.3 m) (Photo 4). Habitat consisted of 90% riffles and 10% pools. Gradient was 3%. The substrate consisted of 10% fines, 15% small gravel, 35% small cobble, 30% large cobble and 10% boulder. Forty five percent of the stream area provided cover of which 40% was provided by LWD, 40% by overhanging vegetation, 15% by cutbanks and 5% by boulders. The stream was unconfined and contained no gravel bars or braids. The crown closure was 7%.



Photo 3. Upper Reach of Britannia Creek Looking Upstream, September 11, 2008



Photo 4. Canadian Creek Above the Confluence with Britannia Creek (Site F03) Looking Upstream, July 8, 2008

In September, habitat consisted of 40% riffle, 40% run and 20% pools. Although the stream stage of the lower reach of Canadian Creek was high, the mean wetted width (4.8 m) was only 61% of the bankfull width (7.9 m) (Photo 5). Wetted depth ranged from 0.26 to 1.00 m with a mean of 0.63 m. Gradient was close to 0%. The substrate consisted of 10% fines, 10% small gravel, 10% large gravel, 20% small cobble and 50% large cobble. Only 10% of the stream area provided cover of which 80% was provided by LWD and 20% by deep pools. The stream was unconfined and contained no gravel bars. The crown closure was 10%.



Photo 5. Lower Reach of Canadian Creek Looking Upstream, September 11, 2008

Reach 2 of Canadian Creek (the cascade pools) was surveyed on July 8 and September 11. In July, the stream stage was low, hence the mean wetted width (5.2 m) was lower than the mean bankfull width (6.5 m) (Photo 6). Habitat consisted of 100% cascade pools. Gradient was 4%. The substrate consisted of 5% fines, 20% large gravel, 15% small cobble, 10% large cobble and 50% boulders. Fifty percent of the stream area provided cover of which 80% was provided by boulders, 10% by LWD and 10% by overhanging vegetation. The stream was unconfined and contained no gravel bars, but it was braided. The crown closure was 17%.

In September, habitat consisted of 100% cascade pools and gradient was 15%. The stream stage of the lower reach of Canadian Creek was high, hence its mean wetted width (8.0 m) was the same as its bankfull width (Photo 7). Wetted depth was 0.43 m. The substrate consisted of 90% boulder, 5% small gravel and 5% fines. Fifty percent of the stream area provided cover of which 100% was provided by boulders. The stream was frequently confined and contained no gravel bars. The crown closure was 0%.



Photo 6. Lower Reach of Canadian Creek (F04) Looking Downstream, July 8, 2008



Photo 7. Reach 2 of Canadian Creek (Cascade Pools) Looking Upstream, September 11, 2008

The upper reach (reach 3) of Canadian Creek was surveyed on September 11 (Photo 8). Habitat consisted of 80% riffles, 10% runs and 10% pools. The stream stage was high, hence its mean wetted width (3.0 m) was the same as its bankfull width. Wetted depth ranged from 0.16 to 0.36 m with a mean of 0.26 m. Gradient was 3%. The substrate consisted of 60% large cobble, 20% boulder, 15% small cobble and 5% fines. Twenty percent of the stream area provided cover of which 100% was provided by boulders. The stream was unconfined and contained no gravel bars. The crown closure was 0%.



Photo 8. Upper Reach (number 3) of Canadian Creek Looking Upstream, September 11, 2008

3.2.7.3 Casino Creek Watershed

The upper reach (reach 2) of Casino Creek was surveyed on September 12 (Photo 9). Habitat consisted of 50% pools, 40% riffles and 10% runs. The stream stage was high, hence its mean wetted width (5.4 m) was the same as its bankfull width. Wetted depth ranged from 0.08 to 0.40 m with a mean of 0.27 m. Gradient was 3%. The substrate consisted of 40% boulders, 20% large cobble, 20% small cobble, 10% large gravel and 10% fines. Thirty percent of the stream area provided cover of which 80% was provided by boulders and 20% by overstream vegetation. The stream was unconfined and contained no gravel bars. The crown closure was 0%.

The lower reach (reach 1) of Casino Creek was surveyed on September 12 (Photo 10). Habitat consisted of 40% runs, 30% riffles and 30% pools. The stream stage was high, hence its mean wetted width (5.7 m) was the same as its bankfull width. Wetted depth ranged from 0.27 to 1.50 m with a mean of 0.71 m. Gradient was 2%. The substrate consisted of 40% large cobble, 30% fines, 20% small cobble, 5% large gravel and 5% small gravel. Thirty percent of the stream area provided cover of which 70% was provided by deep pools and 30% by LWD. The stream was unconfined and contained no gravel bars. The crown closure was 20%.



Photo 9. Upper Reach (number 2) of Casino Creek Looking Upstream, September 12, 2008



Photo 10. Lower Reach (number 1) of Casino Creek Looking Downstream, September 12, 2008

Reach 1 of Meloy Creek, the most upstream named tributary of Casino Creek, was surveyed on September 12 (Photo 11). Habitat consisted of 50% runs, 30% riffles and 20% pools. The stream stage was high, hence its mean wetted width (1.1 m) was the same as its bankfull width. Wetted depth ranged from 0.21 to 0.40 m with a mean of 0.30 m. Gradient was 2.5%. The substrate consisted of 80% fines, 10% boulders, 5% small cobble and 5% small gravel. Seventy percent of the stream area provided cover of which 80% was provided by overstream vegetation and 20% by deep pools. The stream was unconfined and contained no gravel bars. The crown closure was 10%.



Photo 11. Reach 1 of Meloy Creek Looking Upstream, September 12, 2008

The upper reach (Reach 2) of Brynelsen Creek was surveyed on September 12 (Photo 12). Habitat consisted of 70% riffles and 30% pools. The stream stage was high, hence its mean wetted width (4.1 m) was the same as its bankfull width. Wetted depth ranged from 0.35 to 0.40 m with a mean of 0.38 m. Gradient was 2.5%. The substrate consisted of 70% boulders, 20% large cobble and 10% small cobble. Twenty percent of the stream area provided cover of which 80% was provided by boulders and 20% by LWD. The stream was unconfined and contained no gravel bars. The crown closure was 10%.

The lower reach (Reach 1) of Brynelsen Creek was surveyed on September 12 (Photo 13). Habitat consisted of 60% riffles, 20% runs and 20% pools. The stream stage was high, hence its mean wetted width (5.4 m) was the same as its bankfull width. Wetted depth ranged from 0.12 to 0.49 m with a mean of 0.29 m. Gradient was 2%. The substrate consisted of 30% fines, 20% large gravel, 20% small cobble, 20% large cobble and 10% boulders. Ten percent of the stream area provided cover of which 90% was provided by boulders and 10% by overstream vegetation. The stream was unconfined and braided and contained no gravel bars. The crown closure was 10%.



Photo 12. Upper Reach of Brynelsen Creek Looking Upstream, September 12, 2008



Photo 13. Lower Reach of Brynelsen Creek Looking Upstream, September 12, 2008

The upper reach (Reach 2) of Austin Creek was surveyed on September 12 (Photo 14). Habitat consisted of 70% pools, 20% runs and 10% riffles. The stream stage was high, mean wetted width was 1.1 m and mean bankfull width was 0.9 m. Wetted depth ranged from 0.29 to 0.56 m with a mean of 0.43 m. Gradient was not measured. The substrate consisted of 90% fines and 10% boulders. Ninety percent of the stream area provided cover of which 90% was provided by overstream vegetation and 10% by deep pools. The stream was unconfined and braided contained no gravel bars. Crown closure was 0%.



Photo 14. Upper Reach of Austin Creek Looking Upstream, September 12, 2008

The lower reach (Reach 1) of Austin Creek was surveyed on September 12 (Photo 15). Habitat consisted of 70% pools and 30% runs. The stream stage was high, hence the mean wetted width (1.8 m) was the same as mean bankfull width. Wetted depth ranged from 0.39 to 0.54 m with a mean of 0.47 m. Gradient was close to 0%. The substrate consisted of 100% fines. One hundred percent of the stream area provided cover of which all was provided by overstream vegetation. The stream was unconfined and braided contained no gravel bars. Crown closure was 0%.

3.2.7.4 Dip Creek

The reach of Dip Creek that encloses site F14 was surveyed on September 12 (Photo 16). Habitat consisted of 40% riffles, 30% runs and 30% pools. The stream stage was high, hence its mean wetted width (10.5 m) was the same as its bankfull width. Wetted depth was 1.25 m. Gradient was close to 0%. The substrate consisted of 50% fines, 30% small cobble, 10% large cobble and 10% small gravel. Twenty five percent of the stream area provided cover of which 50% was provided by LWD and 50% was provided by deep pools. The stream was unconfined and braided contained no gravel bars. The crown closure was 10%.


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Photo 15. Lower Reach of Austin Creek Looking Upstream, September 12, 2008



Photo 16. Reach of Dip Creek Enclosing Site F14 Looking Downstream, September 12, 2008

3.3 Terrestrial Environment

3.3.1 Soils and Vegetation

Surveys of the Casino LSA in July and September showed that it is characterized by smooth, rolling topography with moderate to deeply incised valleys.

Wildlife habitat consists of a variety of plant communities ranging from sparsely vegetated bare rock, large expanses of heath tundra, wet sedge meadows with tall riparian shrubland and treed slopes dominated by spruce, aspen, birch and willows. Open stands of black spruce and white spruce occur in valleys and lower slopes, with black spruce on wetter sites and white spruce on better drained sites. Willow, shrub birch, Labrador tea, mosses and lichens are principal understory species.

During the July and September surveys, a total of 33 soil pits were dug and plants were sampled and described for the various cover types: spruce, spruce/aspen, spruce/birch, shrub birch/willow, heath tundra, wet sedge meadow, and burns. Appendices C1 and C2 show the data for each of the sampling sites, and Photos 17 to 22 show representative examples of wildlife habitat.



Photo 17. Alpine Habitat, Casino Project, 2008



Photo 18. Felsenmeer Habitat (Exposed Broken Rock), Casino Project, 2008



Photo 19. Aspen Forest Habitat, Casino Project, 2008



Photo 20. Floodplain Habitat, Casino Project, 2008



Photo 21. Island Habitat, Yukon River, Casino Project, 2008



Photo 22. Mixedwood Forest Habitat, Casino Project, 2008

3.3.2 Wildlife Observations

3.3.2.1 General

Appendix C3 shows the observations of wildlife made in July and September of 2008, as well as observations made by other field crews in May and August. Table 26 lists the common names and scientific names of observed wildlife.

Table 26. Common and Scientific Names of Wildlife Observed at the Casino Project Area, 2008

Common Name	Scientific Name	Common Name	Scientific Name
Mammals		**Birds**	
Moose	*Alces alces*	American robin	*Turdus migratorius*
Black bear	*Ursus americanus*	Northern hawk owl	*Surnia ulula*
Grizzly bear	*Ursus arctos horribilis*	Northern harrier	*Circus cyaneus hudsonius*
Beaver	*Castor canadensis*	Spruce grouse	*Dendragapus canadensis*
Wolf	*Canis lupus*	Gray jay	*Perisoreus canadensis*
Caribou	*Rangifer tarandus*	Northern flicker	*Colaptes auratus*
Lynx	*Felis lynx*	Tundra swans	*Cygnus columbianus*
Snowshoe hare	*Lepus americanus*	Ptarmigan	*Lagopus muta*
Porcupine	*Erithizon dorsatum*	Great horned owl	*Bubo virginianus*
Arctic ground squirrel	*Spermophilus parryii*	Golden eagle	*Aquila chrysaetos*
Northern bog lemming	*Synaptomys borealis*		
Vole	*Microtus spp.*		
American red squirrel	*Tamiasciurus hudsonicus*		
Red fox	*Vulpes vulpes*		

Least chipmunk	*Eutamias minimus*		

3.3.2.2 July 7 to 11 Survey

Moose were observed along the Yukon River and along Casino and Dip creeks. The area being considered for the proposed Casino Project appears to be a preferred moose wintering area. No caribou were seen in the LSA, however caribou sign (e.g., pellets, shed antlers, trails, etc.) were found on ridge tops. Several small groups of caribou were observed south of the LSA during the flight from Whitehorse. Terrestrial lichens occur primarily on north-facing slopes and provide an abundant food source for caribou.

Numerous wolf tracks and scats were observed along Dip Creek, suggesting the presence of a den site close by, but it could not be located. Three individual grizzly bears (two blonde and one chocolate brown) and one black bear were observed during the July survey. Bear scats were also observed in the major creek drainages (Canadian, Britannia, Austin, Dip), and on the trails between the airstrip and the lower camp, and the airstrip and tank farm. Bear use appeared to be concentrated at this time of year in areas with buffaloberries, bearberries, and *Hedysarum*.

Small mammals observed in the LSA included snowshoe hare, red squirrel and voles. Well-developed small mammal trails were observed in some spruce habitat.

The rock outcrops on Patton Hill, and various treed habitat types were surveyed by helicopter and on foot for raptors but none were observed or heard. However, waterfowl, upland birds (e.g., ptarmigan) and various songbirds were seen or heard.

3.3.2.3 September 8 to 11 Survey

Wolves were heard howling along Dip Creek, and observed by Casino camp construction personnel on Britannia Creek. Lynx were also seen at the lower camp and on Britannia Creek.

Black and grizzly bears were observed by Casino camp construction personnel on six separate occasions in August and September. Grizzly bear observations included a sow with two, 2-year-old cubs, and a lone, chocolate-brown grizzly bear. Black bear observations included three lone bears, and one sow with two yearling cubs. Bear scats were also observed in the major drainages (Canadian, Britannia, Austin and Dip creeks), and on the trails between the airstrip and the lower camp, and the airstrip and tank farm. Bear use appeared to be concentrated at this time of year in areas with buffaloberries, cranberries, and blueberries.

Moose were observed along the Yukon River, Britannia, Casino and Dip creeks. Caribou were seen in the LSA by Casino camp construction personnel on five separate occasions, and caribou sign (e.g., pellets, shed antlers, trails) were found on ridge tops. One small group of caribou were observed along the proposed road route east of the Casino mine site.

Potential summer and winter range, lambing areas and escape terrain for sheep are limited within the survey area. No thinhorn sheep were observed along the Yukon River bank directly across from Britannia Creek during a survey conducted on September 9.

Small mammals observed in the LSA included snowshoe hare, red squirrel, bog lemmings, Arctic ground squirrel and voles.

The rock outcrops on Patton Hill, and various treed habitat types were surveyed by helicopter and on foot for raptors. Raptors observed or heard included great horned owl, northern harrier, northern hawk owl, and golden eagle. Other birds including tundra swans, ptarmigan, grouse and various songbirds were seen or heard.

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Appendix A

Atmospheric Environment

A1. Casino Mine – Methodology Report for Installation of Meteorological Station

November 26, 2008

AECOM
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Canada

RWDI AIR Project: W08-1104

RWDI
CONSULTING ENGINEERS & SCIENTISTS

RWDI AIR Inc.
999 West Broadway
Suite 830
Vancouver, BC
Canada V5Z 1K5

A member of the RWDI Group of Companies

Attention: **Rick Palmer**

Subject: **Casino Mine – Methodology Report for Installation of Meteorological Station**

RWDI AIR Inc. (RWDI) was retained by Gartner Lee Limited to install a meteorological monitoring station at the Casino Mine. This report provides a discussion on the status of this project and a description of the station.

On September 30, 2008, Geoff Doerksen and Jackson Mak from RWDI arrived at Casino Mine to install the meteorological station. Installation of the meteorological tower was started that afternoon and the tower was erected by the following morning. By the evening of October 1, 2008, all the instruments were mounted on the tower. While configuring the equipment the morning of October 2, 2008, a connection with the data logger could not be established remotely by either the RWDI Vancouver office or by the equipment supplier. It was suspected that the Iridium modem or the antenna was not functioning properly. The satellite modem system was therefore returned to Vancouver for further testing. The removal of the satellite modem system from the station did not affect the meteorological observations as they continued to be collected and stored on the data logger. Data recorded at the station are valid from October 3, 2008 at midnight to present.

Mr. Doerksen and Mr. Mak were scheduled to leave Casino Mine on Thursday afternoon. However, due to poor visibility, the Alkan Air plane was unable to land at the mine site and Mr. Doerksen and Mr. Mak were forced to spend an extra night at camp. The following day they were picked up by a helicopter late in the morning and spent the remainder of the day travelling back to Vancouver.

Upon returning to Vancouver, the satellite modem system was further tested with support provided by the equipment supplier. While there were no apparent problems with the system it was thought that a lose connection with the antenna cable may have been the cause of the problem. The antenna cable was properly secured and a remote connection was established while testing the equipment in Vancouver. The equipment was subsequently shipped back to Casino Mine on October 22, 2008. The satellite modem system was re-installed at the site by Scott Casselmen, the camp manager of Casino Mine. After installation a remote connection with the station was attempted; however it was unsuccessful.

In discussions with the equipment supplier it was determined that the only way to resolve the problem with the satellite modem system was for a technician to travel to the site and replace the non-working equipment. On November 7, 2008 Mark Milner from RWDI travelled to Casino Mine and replaced several components of the satellite modem system including the modem, antenna and data kit. Subsequent tests on the system were successful and a remote connection with the station was established. The station including the satellite modem system is now currently functioning properly and a remote connection with the station is now possible. Data was successfully downloaded remotely on November 7, 14, and 21, 2008.

STATION DESCRIPTION

The meteorological station consists of a 10-m free-standing tower equipped with instrumentation, data logger, and logger enclosure. As shown in Figure 1, the tower is secured by two sets of guy wires attached to the base of the tower. One set of guy wires is attached at the top of the mast while the other set is attached midway up the mast. The guy wires may be a potential hazard; therefore they are flagged with orange flagging tape. The tower base is constructed from five fibreglass pods arranged in a square formation with one pod located at the centre. The four outer pods are connected to the centre pod by aluminum pipes for support. The fibreglass pods are filled with soil to give the base of the tower weight and ensure that the tower is properly secured. The design of the tower has been approved by an engineer.



Figure 1: Meteorological Tower at Casino Mine

The meteorological station is located approximately 300 km northwest of Whitehorse. The station is sited in a transition zone between tree line and alpine with an unobstructed fetch of at least 100 m in all directions. The site is sparsely covered in low brush and trees that are approximately 10 m tall. Figure 2 shows the location of the monitoring station. The map coordinates of the station are summarized in Table 1.



Figure 2: Location of Casino Meteorological Station South of the Yukon River

Table 1: Location of Casino Meteorological Station

Latitude	62º 43’ 27.837” North
Longitude	138º 49’ 0.562” East
Easting (m)	611,609
Northing (m)	6,956,775
UTM Grid Reference	Zone 7
Datum	NAD83
Elevation (m)	1,203

The meteorological station has instrumentation capable of measuring wind speed and direction, rainfall, air temperature, barometric pressure, relative humidity and snow depth. These measurements will provide the necessary observations to calculate atmospheric stability class needed as input for air quality modelling. Observations are recorded and stored by a data logger, which is powered by a battery charged with a solar panel at the station. The data logger is equipped with a satellite modem for remotely accessing the data. The specific model numbers of the equipment are summarized in Table 2.

Table 2: Casino Station Equipment

Equipment	**Model Number**
Datalogger with 4M RAM Memory	CR800-XT
Solar Panel 20 Watt 12 Volt	MSX20R
Iridium Satellite Remote Modem	A3LA-MPT
Iridium Modem Accessory Antenna 1616-1626 MHz	SAF5350A
Iridium Modem Accessory Remote Power & Data Kit	SYN-DC-936R
Relay Kit Crydom 7 Amp c/w Wires	C1701
Enclosure Fiberglass 16” x 18”	ENC 16/18
Sonic Ranger 50 KHz Module	SR50A
Relative Humidity & Air Temperature Probe	HC-S3-XT
RM Young Wind Monitor	05103-10-L
RM Young Barometric Pressure Sensor	61205V
Texas Electronics Tipping Bucket Metric Rain Gauge	TE525M

As shown in Figure 3, the snow depth instrument (Sonic Ranger) is mounted on a cross arm three metres above ground from the main mast. The relative humidity and air temperature probe is housed in a radiation shield mounted on the same cross arm as the Sonic Ranger. The anemometer is mounted at the top of the 10 m tower. The rain gauge has been installed approximately two metres from the tower on a separate post that is approximately one metre above ground.

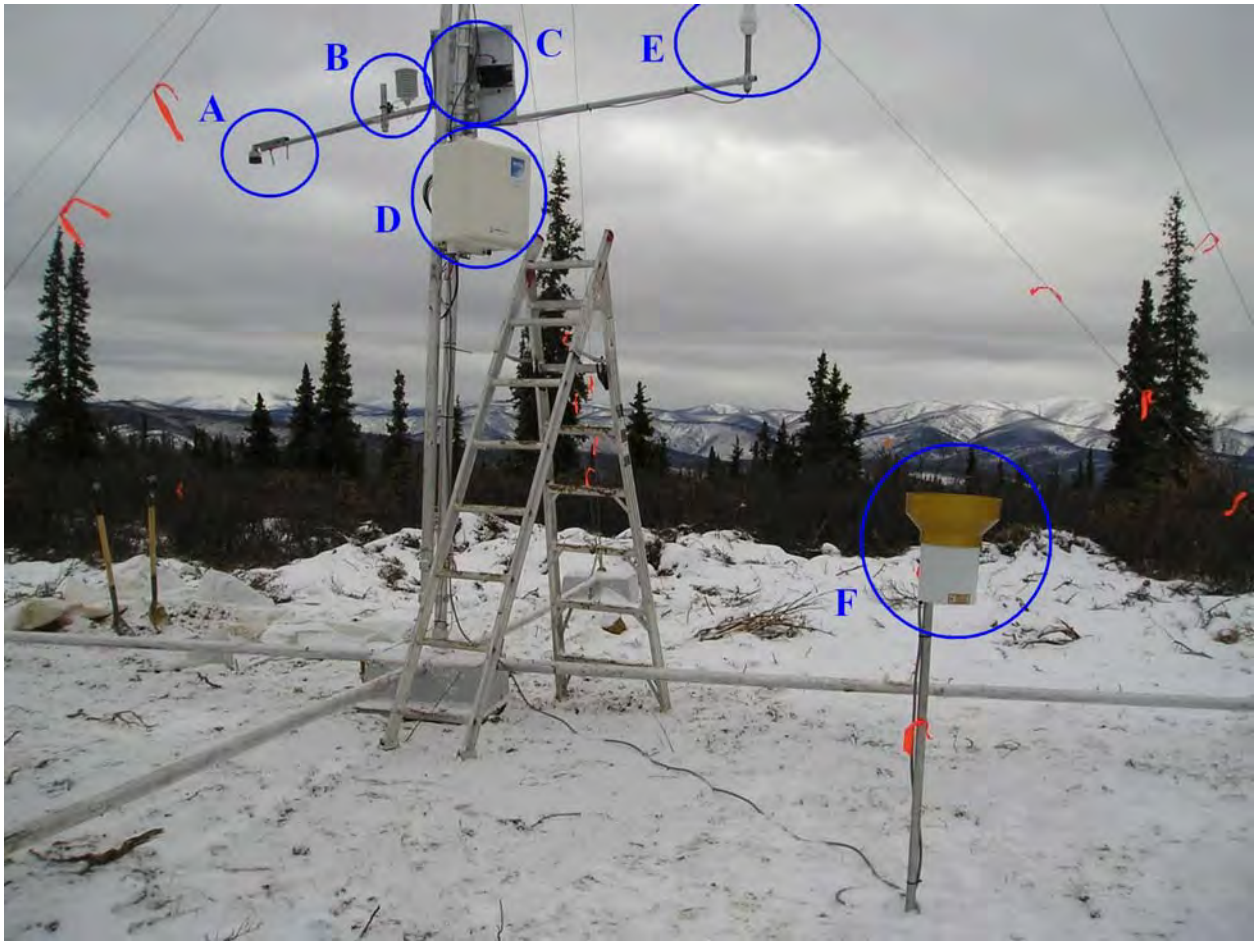

Figure 3: Casino Meteorological Monitoring Station Equipped with A) Sonic Ranger, B) Relative Humidity and Temperature Probe, C) Solar Panel, D) Data Logger Enclosure, E) Satellite Antenna and F) Rain Gauge

The barometric pressure sensor is housed in the data logger enclosure at a height of 2.8 m above ground. The pressure sensor is vented to the outside of the logger enclosure by way of a poly tube attached to a small port on the enclosure. By convention, barometric pressure observations are corrected to report sea-level pressure. The following equation is used to determine the pressure correction factor:

P = 1013.25 [1 – (1 – Elevation/44307.69231) ^5.253283]

where P is the correction factor (in hPa) and elevation is given in metres above sea level.

The solar panel is mounted about three metres above ground facing due south on the main mast. The solar panel is tilted at an angle of 78º relative to ground to receive maximum insolation and prevent the collection of snow. This angle is calculated based on manufacturer's specifications. The data logger enclosure, which houses the data logger, Iridium modem and pressure sensor, has been mounted at a height of 2.8 m above ground. The satellite modem antenna is mounted on a second cross arm extending from the main mast located approximately three metres above ground. A summary of instrumentation measurement heights is provided in Table 3.

Table 3: Measurement Height

Measurement	Height Above Ground (m)
Snow Depth	3
Relative Humidity and Air Temperature	3
Barometric Pressure	2.8
Rainfall	1
Wind Speed and Direction	10

We trust that this report meets your information requirements. If you have any questions or require further information, please contact the undersigned at (604) 730-5688 ext. 3227.

Sincerely,
RWDI AIR Inc.



Geoff Doerksen, M.Sc.
Project Manager

AECOM

Appendix B

Aquatic Environment

B1. Stream Stage-Discharge Data, Casino Project, 2008

Appendix B1. Stream Stage-Discharge Data, Casino Project, 2008

Station	Date	Stage (m)	Discharge (m^3/s)
W1	22-May-08	0.48	2.54
	8-Jul-08	0.32	0.84
	10-Sep-08	0.40	2.14
	10-Oct-08	0.26	0.40
W3	23-May-08	0.49	1.62
	8-Jul-08	0.39	0.33
	10-Sep-08	0.46	1.57
	11-Oct-08	0.38	0.38
W4	22-May-08	0.59	1.50
	9-Jul-08	0.43	0.50
	9-Sep-08	0.70	2.12
	10-Oct-08	0.46	0.81
W9	22-May-08	0.69	4.75
	9-Jul-08	0.59	3.63
	9-Sep-08	0.54	3.25
	10-Oct-08	0.52	1.11
W11	22-May-08	0.38	0.87
	9-Jul-08	0.17	0.14
	9-Sep-08	0.36	0.71
	9-Oct-08	0.35	0.40
W14	23-May-08	0.29	0.86
	8-Jul-08	0.15	0.29
	10-Sep-08	0.28	0.71
	10-Oct-08	0.12	0.15

B2. Surface Water Quality Data, Casino Project, May 2008

Appendix B2. Surface Water Quality Data, Casino Project, May 2008

AECOM

Station	Detection Limits	Water Quality Guidelines	W7 - Upper Canadian Creek	W3 - Canadian Creek us of Confluence with Britannia Creek	W14 - Mouth of Britannia Creek	W2 - Canadian Creek Downstream of Confluence with Britannia Creek	W1 - Mouth of Canadian Creek	W6b - Yukon River Upstream of Canadian Creek	W6a - Yukon River Sownstream of Canadian Creek	W15 - Yukon River Dar Field Site	W17 - Sunshine Creek	W43 - Adit Discharge Pipe at Lower Camp
Date		**CCME [a]**	**21-May-08**	**23-May-08**	**23-May-08**	**23-May-08**	**22-May-08**	**21-May-08**	**21-May-08**	**21-May-08**	**22-May-08**	**23-May-08**
Physical Tests												
Temperature C	-		0.1	2	0.1	1.8	3.4	7.9	7.1	9.4	0.7	4.1
Conductivity (Field) µS/cm	-		30.7	82	35	72	65.8	163	147	164	87.9	274
pH (Field)	-		*6.2*	7.4	7.1	7.4	7.5	7.9	8.1	8.1	7.9	6.8
Hardness $CaCO_3$	0.5		15.1	45.8	28.3	41.1	49.6	105	93.4	103	49.9	141
Conductivity µS/cm	1		34.0	89	49	78	92	170.0	180.0	180.0	96	300
pH	-	6.5-9.0	*5.5*	7.4	7.0	7.1	7.2	7.8	7.8	7.8	7.4	7.5
Total Suspended Solids	1		34	18	34	25	190	190	140	200	6	<1
Total Dissolved Solids	1		32	88	46	78	92	130	150	150	94	210
Turbidity NTU	0.1		3.4	2.5	1.5	1.7	3.6	21.4	35.1	19.1	0.7	0.4
Dissolved Anions & Nutrients												
Ammonia as N	0.005		<0.005	0.031	0.01	0.006	0.011	<0.005	0.017	0.012	<0.005	<0.005
Alkalinity, Total (as $CaCO_3$)	0.5		0.6	22.0	10.0	15.0	21.0	61.0	61.0	63.0	30.0	90.0
Chloride (Cl)	0.5		1.10	1.20	1.40	1.20	1.20	0.90	1.00	0.90	1.30	0.50
Sulfate (SO_4)	0.5		<0.5	15.0	<0.5	8.8	17.0	19.0	25.0	24.0	1.6	54.0
Nitrate (as N)	0.002	13	<0.002	0.05	0.046	0.043	0.05	0.019	0.017	0.016	0.052	0.128
Nitrite (as N)	0.002	0.06	0.004	0.004	0.005	0.005	0.003	0.002	0.002	0.002	0.004	0.002
Total Kjeldahl Nitrogen	0.02		0.52	0.4	0.54	0.54	0.41	0.190	0.210	0.220	0.44	<0.02
Ortho Phosphate as P	0.001		0.001	<0.001	<0.001	0.002	<0.001	0.001	0.002	0.002	<0.001	0.006
Cyanide, Weak Acid Diss	0.0005		0.0008	0.0009	0.001	0.0009	0.001	<0.0005	<0.0005	<0.0005	0.0008	<0.0005
Total Cyanide	0.0005	0.005	0.001	0.001	0.0015	0.0012	0.0013	<0.0005	<0.0005	<0.0005	0.001	<0.0005
Total Metals												
Aluminum	0.0002	0.005-0.1[b]	*0.479*	*0.415*	*0.542*	*0.46*	*0.723*	*0.678*	*0.636*	*0.708*	*0.214*	0.0024
Antimony	0.00002		0.00007	0.0002	0.00012	0.00018	0.00019	0.00021	0.00017	0.00023	0.00013	0.00323
Arsenic	0.00002	0.005	0.00065	0.0012	0.0009	0.0011	0.00162	0.00212	0.00177	0.00204	0.00064	0.00152
Barium	0.00002		0.0385	0.0381	0.0559	0.0455	0.059	0.148	0.112	0.139	0.0458	0.0465
Beryllium	0.00001		0.00005	0.00004	0.00004	0.00004	0.00006	0.0001	0.00008	0.0001	0.00002	<0.00001
Bismuth	0.000005		0.000021	0.00001	<0.000005	0.000008	0.000009	0.000013	0.000016	0.000015	<0.000005	<0.000005
Boron	0.05		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cadmium	0.000005	0.000017	*0.000261*	*0.000084*	*0.000028*	*0.000069*	*0.00008*	*0.000621*	*0.000369*	*0.000591*	*0.000022*	*0.068*
Calcium	0.05		4.49	11.4	7.03	10.3	12.4	28	25.3	27.6	12.5	38.9
Chromium	0.0001	0.001	0.0004	0.0008	0.0005	0.0007	*0.0011*	*0.0011*	*0.0011*	*0.0012*	0.0003	<0.0001
Cobalt	0.000005		0.00064	0.000545	0.000418	0.000492	0.000848	0.00193	0.00116	0.0014	0.000105	0.000247
Copper	0.00005	0.002-0.004[c]	*0.0107*	*0.0081*	*0.00245*	*0.00603*	*0.00663*	*0.00808*	*0.00595*	*0.00724*	0.00199	*0.078*
Iron	0.001	0.3	*0.574*	*0.54*	*0.567*	*0.549*	*1.00*	*2.17*	*1.56*	*1.95*	0.191	0.112
Lead	0.000005	0.001-0.007[d]	0.000513	0.000432	0.000305	0.000443	0.000866	*0.0029*	0.00183	*0.00249*	0.000094	*0.0178*
Lithium	0.0005		<0.0005	<0.0005	<0.0005	<0.0005	0.0007	0.0026	0.002	0.0026	0.0005	0.003
Magnesium	0.05		0.93	4.18	2.61	3.76	4.54	8.47	7.36	8.32	4.5	10.7
Manganese	0.00005		0.0721	0.0329	0.0418	0.0369	0.0689	0.197	0.132	0.173	0.0125	0.351
Mercury	0.00001	0.000026	<0.00001	0.00001	0.00001	0.00001	0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum	0.00005	0.073	0.00025	0.00037	0.00009	0.00026	0.0003	0.00059	0.00068	0.00066	0.00021	<0.00005
Nickel	0.00002	0.025-0.15[e]	0.00169	0.00211	0.00105	0.00164	0.00227	0.0101	0.00662	0.00925	0.00083	0.00057
Phosphorous	0.002		0.042	0.03	0.036	0.039	0.084	0.268	0.197	0.234	0.014	0.002
Potassium	0.05		1.12	1.2	1.02	1.15	1.3	1.1	1.07	1.11	1.01	1.62
Selenium	0.00004	0.001	0.00005	0.00006	<0.00004	0.00005	<0.00004	0.00042	0.00031	0.00046	0.00004	<0.00004
Silicon	0.1		2.5	2.8	1.6	2.4	2.6	3.2	3.5	3.6	2.3	5.9
Silver	0.000005	0.0001	0.000013	0.000013	0.000006	0.000012	0.00001	0.000005	0.000011	0.000012	0.000006	0.000063
Sodium	0.05		0.92	1.47	0.87	1.3	1.39	1.67	1.87	1.69	1.72	3.75
Strontium	0.00005		0.0309	0.071	0.0546	0.0674	0.0809	0.129	0.123	0.128	0.0888	0.342
Thallium	0.000002	0.0008	0.000008	0.000008	0.000006	0.000008	0.000011	0.00002	0.000016	0.00002	0.000003	0.000027
Tin	0.00001		0.00001	<0.00001	<0.00001	0.00003	<0.00001	0.00003	<0.00001	<0.00001	<0.00001	<0.00001
Titanium	0.0005		0.0103	0.0128	0.0161	0.0134	0.0254	0.0134	0.0172	0.0161	0.0037	<0.0005
Uranium	0.000002		0.000305	0.00339	0.00125	0.0029	0.00361	0.000975	0.001	0.00105	0.00139	0.00219
Vanadium	0.0002		0.0009	0.0008	0.0014	0.001	0.002	0.0032	0.0028	0.0032	0.0004	<0.0002
Zinc	0.0001	0.03	0.0145	0.0073	0.0026	0.0049	0.0062	*0.0436*	0.0248	*0.0381*	0.0014	*3.62*
Zirconium	0.0001		0.0003	0.0004	0.0004	0.0004	0.0005	0.0003	0.0006	0.0007	0.0003	<0.0001

Appendix B2. Surface Water Quality Data, Casino Project, May 2008

AECOM

Station	Detection Limits	Water Quality Guidelines	W7 - Upper Canadian Creek	W3 - Canadian Creek us of Confluence with Britannia Creek	W14 - Mouth of Britannia Creek	W2 - Canadian Creek Downstream of Confluence with Britannia Creek	W1 - Mouth of Canadian Creek	W6b - Yukon River Upstream of Canadian Creek	W6a - Yukon River Sownstream of Canadian Creek	W15 - Yukon River Dar Field Site	W17 - Sunshine Creek	W43 - Adit Discharge Pipe at Lower Camp
Date		**CCME [a]**	**21-May-08**	**23-May-08**	**23-May-08**	**23-May-08**	**22-May-08**	**21-May-08**	**21-May-08**	**21-May-08**	**22-May-08**	**23-May-08**
Dissolved Metals												
Aluminum	0.0002		0.337	0.233	0.36	0.272	0.289	0.0809	0.0642	0.0693	0.185	0.0023
Antimony	0.00002		0.00005	0.00018	0.0001	0.00016	0.00018	0.00017	0.00013	0.00016	0.00013	0.0033
Arsenic	0.00002		0.00038	0.00073	0.00054	0.00065	0.0007	0.00055	0.00053	0.00055	0.00055	0.0003
Barium	0.00002		0.0281	0.0313	0.0429	0.036	0.0368	0.0471	0.0406	0.0434	0.0434	0.048
Beryllium	0.00001		0.00005	0.00002	0.00003	0.00002	0.00002	0.00001	0.00001	0.00001	0.00002	<0.00001
Bismuth	0.000005		<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005
Boron	0.05		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cadmium	0.000005		0.000229	0.000066	0.000018	0.000049	0.000039	0.000094	0.000064	0.000095	0.000018	0.0705
Calcium	0.05		4.49	11.5	6.83	10.3	12.3	25.5	24.1	25.6	12.9	40.4
Chromium	0.0001		0.0002	0.0003	0.0004	0.0003	0.0004	0.0002	0.0002	0.0002	0.0003	<0.0001
Cobalt	0.000005		0.00041	0.000255	0.000225	0.000241	0.000204	0.000098	0.000073	0.000083	0.000084	0.000245
Copper	0.00005		0.00756	0.00724	0.00191	0.00527	0.00508	0.00255	0.00214	0.00261	0.00198	0.07
Iron	0.001		0.312	0.227	0.278	0.236	0.236	0.17	0.128	0.159	0.14	0.015
Lead	0.000005		0.000079	0.000083	0.000084	0.000054	0.000064	0.000137	0.000091	0.000125	0.000028	0.00415
Lithium	0.0005		<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.002	0.0015	0.002	0.0005	0.0032
Magnesium	0.05		0.87	4.14	2.43	3.74	4.44	7.7	6.95	7.69	4.73	11
Manganese	0.00005		0.0548	0.0147	0.023	0.0186	0.016	0.0247	0.0117	0.0131	0.00379	0.361
Mercury	0.00001		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum	0.00005		0.00078	0.00037	0.00015	0.00028	0.00033	0.00088	0.00101	0.00086	0.00027	<0.00005
Nickel	0.00002		0.00148	0.00161	0.0008	0.00129	0.00135	0.00386	0.00252	0.00378	0.0007	0.00061
Phosphorous	0.002		0.018	0.013	0.014	0.013	0.013	0.01	0.008	0.009	0.011	<0.002
Potassium	0.05		1.14	1.19	1.01	1.15	1.25	1.06	1.03	1.07	1.05	1.68
Selenium	0.00004		0.00006	0.00005	<0.00004	<0.00004	0.00006	0.00048	0.00033	0.00048	0.00004	<0.00004
Silicon	0.1		2.4	2.4	1.3	2.1	2.2	2.9	3	2.9	2.2	5.7
Silver	0.000005		0.000006	0.000007	<0.000005	0.000006	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	0.000022
Sodium	0.05		0.99	1.55	0.96	1.4	1.5	1.79	1.98	1.78	1.95	3.95
Strontium	0.00005		0.0301	0.0714	0.0528	0.0685	0.0786	0.117	0.114	0.115	0.0903	0.362
Thallium	0.000002		0.000005	<0.000002	<0.000002	<0.000002	0.000005	0.000005	0.000005	0.000005	<0.000002	0.000025
Tin	0.00001		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Titanium	0.0005		0.002	0.0022	0.0039	0.0026	0.0029	0.0022	0.0021	0.0022	0.0017	<0.0005
Uranium	0.000002		0.000225	0.00317	0.00109	0.00275	0.00304	0.00075	0.000842	0.000799	0.00136	0.00217
Vanadium	0.0002		0.0003	0.0003	0.0005	0.0004	0.0003	0.0003	0.0003	0.0003	0.0003	<0.0002
Zinc	0.0001		0.0164	0.0098	0.0083	0.0081	0.0069	0.009	0.0069	0.0084	0.0086	3.73
Zirconium	0.0001		0.0002	0.0003	0.0003	0.0003	0.0004	0.0002	0.0002	0.0002	0.0003	<0.0001

Notes:

All units mg/l unless otherwise noted.

a) Canadian water quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2007.

b) 0.005 mg/L at pH <6.5, [Ca2+] <4 mg/L, DOC <2 mg/L: 0.1 mg/L at pH ≥6.5, [Ca2+] ≥4 mg/L, DOC ≥2 mg/L.

c) 0.002 mg/L at [CaCO3] = 0 - 120 mg/L; 0.003 mg/L at [CaCO3] = 120 - 180 mg/L; 0.004 mg/L at [CaCO3] >180 mg/L.

d) 0.001 mg/L at [CaCO3] = 0 - 60 mg/L; 0.002 mg/L at [CaCO3] = 60 - 120 mg/L; 0.004 mg/L at [CaCO3] =120 -180 mg/L; 0.007 mg/L at [CaCO3] >180 mg/L.

e) 0.025 mg/L at [CaCO3] = 0 - 60 mg/L; 0.065 mg/L at [CaCO3] = 60 - 120 mg/L; 0.110 mg/L at [CaCO3] =120 - 180 mg/L; 0.150 mg/L at [CaCO3] >180 mg/L.

Italic *Results exceed CCME Aquatic Life uidelines.*

Appendix B2. Surface Water Quality Data, Casino Project, May 2008

AECOM

Station	Detection Limits	Water Quality Guidelines	W12 - Proctor Gulch before Confluence with Casino Creek	W8 - Upper Casino Creek	W13 - Meloy Creek	W11 - Casino Creek (proposed dam outflow)	W4 - Mouth of Casino Creek	W9 - Dip Creek us of Confluence with Casino Creek	W5 - Dip Creek ds Casino Confluence	W16 - Dip Creek Far Field	W41 - Field Blank	Maxxam Travel Blank
Date		CCME [a]	23-May-08	22-May-08	21-May-08	22-May-08	22-May-08	22-May-08	22-May-08	21-May-08		
Physical Tests												
Temperature C	-		4.2	2.5	0	2.6	1.6	0.2	1.1	0	-	-
Conductivity (Field) µS/cm	-		203	84	102	101.2	85	60	58.2	127	-	-
pH (Field)	-		*4.0*	7.3	7.8	7.5	7.5	7.2	7.4	7.6	-	-
Hardness $CaCO_3$	0.5		75.8	42.3	59.1	56.1	47.7	37.4	41.4	69	<0.5	<0.5
Conductivity µS/cm	1		*270*	91	110	110	92.0	65	74.0	140.0	1	1
pH	-	6.5-9.0	3.9	6.9	7.5	7.3	7.3	7.2	7.3	7.6	4.5	4.5
Total Suspended Solids	1		14	13	5	4	20	76	58	74	<1	<1
Total Dissolved Solids	1		190	90	110	110	92	64	74	120	6	2
Turbidity NTU	0.1		11.5	1	0.6	0.7	0.8	6.1	4.2	2	0.2	<0.1
Dissolved Anions & Nutrients												
Ammonia as N	0.005		0.012	0.028	<0.005	<0.005	0.044	<0.005	<0.005	<0.005	0.071	<0.005
Alkalinity, Total (as $CaCO_3$)	0.5		<0.5	8.8	40.0	25.0	25.0	22.0	24.0	45.0	<0.5	<0.5
Chloride (Cl)	0.5		0.70	1.20	1.10	1.10	1.30	1.00	1.20	1.10	0.9	1.3
Sulfate (SO_4)	0.5		93.0	25.0	0.6	21.0	8.8	<0.5	<0.5	18.0	3.5	0.9
Nitrate (as N)	0.002	13	0.023	0.011	0.086	0.031	0.038	0.026	0.024	0.026	<0.002	<0.002
Nitrite (as N)	0.002	0.06	0.003	0.004	0.003	0.003	0.004	0.003	0.004	0.003	<0.002	0.002
Total Kjeldahl Nitrogen	0.02		0.4	0.330	0.300	0.45	0.480	0.430	0.420	0.270	<0.02	<0.02
Ortho Phosphate as P	0.001		<0.001	0.002	0.002	<0.001	<0.001	0.002	<0.001	0.002	<0.001	<0.001
Cyanide, Weak Acid Diss	0.0005		<0.0005	0.0007	0.0007	0.0009	0.0008	0.0007	0.0007	<0.0005	<0.0005	<0.0005
Total Cyanide	0.0005	0.005	<0.0005	0.0008	0.0009	0.0009	0.0007	0.0009	0.0008	<0.0005	<0.0005	<0.0005
Total Metals												
Aluminum	0.0002	0.005-0.1 [b]	*2.43*	*0.533*	*0.153*	*0.308*	*0.368*	*0.583*	*0.489*	*0.413*	<0.0002	<0.0002
Antimony	0.00002		0.00009	0.00009	0.00021	0.00012	0.00011	0.00008	0.00009	0.0001	<0.00002	<0.00002
Arsenic	0.00002	0.005	0.00027	0.00052	0.00135	0.00065	0.0007	0.00086	0.00077	0.00123	<0.00002	<0.00002
Barium	0.00002		0.0439	0.0385	0.0517	0.0388	0.0392	0.0526	0.0467	0.0618	<0.00002	0.00006
Beryllium	0.00001		0.00015	0.00004	0.00002	0.00003	0.00003	0.00006	0.00005	0.00004	<0.00001	<0.00001
Bismuth	0.000005		0.000014	0.000007	0.000007	<0.000005	0.000005	0.000012	0.000006	0.000006	<0.000005	<0.000005
Boron	0.05		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cadmium	0.000005	0.000017	*0.000799*	*0.000181*	*0.000092*	*0.000093*	*0.000066*	*0.000057*	*0.000054*	*0.000048*	<0.000005	<0.000005
Calcium	0.05		22.2	12.6	16.2	15.6	13	9.75	10.9	17.3	<0.05	<0.05
Chromium	0.0001	0.001	0.0003	0.0003	0.0003	0.0003	0.0004	0.0007	0.0006	0.0007	<0.0001	<0.0001
Cobalt	0.000005		0.00864	0.00113	0.000081	0.000346	0.000331	0.00052	0.00041	0.000575	<0.000005	<0.000005
Copper	0.00005	0.002-0.004 [c]	*0.219*	*0.0581*	*0.00294*	*0.0328*	*0.0164*	*0.00333*	*0.00669*	*0.00529*	0.00009	0.00007
Iron	0.001	0.3	*6.62*	*0.654*	0.162	*0.344*	*0.414*	*0.931*	*0.724*	*1.09*	<0.001	0.003
Lead	0.000005	0.001-0.007 [d]	*0.00203*	0.000547	*0.00314*	0.000893	0.000847	*0.00213*	*0.00152*	0.00104	0.000014	0.000074
Lithium	0.0005		0.0012	<0.0005	0.0007	0.0007	0.0006	0.0018	0.0014	0.0014	<0.0005	<0.0005
Magnesium	0.05		4.98	2.65	4.51	4.19	3.73	3.17	3.42	6.28	<0.05	<0.05
Manganese	0.00005		0.325	0.0557	0.0511	0.029	0.0305	0.107	0.0785	0.133	<0.00005	0.00008
Mercury	0.00001	0.000026	0.00002	<0.00001	<0.00001	0.00001	0.00001	<0.00001	0.00001	<0.00001	<0.00001	<0.00001
Molybdenum	0.00005	0.073	<0.00005	0.00014	0.00034	0.00035	0.0005	0.00031	0.0004	0.00057	<0.00005	<0.00005
Nickel	0.00002	0.025-0.15 [e]	0.00263	0.00113	0.00084	0.00092	0.00095	0.00146	0.0011	0.00129	<0.00002	<0.00002
Phosphorous	0.002		0.02	0.018	0.015	0.015	0.025	0.073	0.052	0.052	<0.002	<0.002
Potassium	0.05		1.18	0.76	0.98	0.83	0.81	0.65	0.71	0.85	<0.05	<0.05
Selenium	0.00004	0.001	0.00008	0.00005	0.00004	<0.00004	0.00005	0.00004	0.00005	0.00005	<0.00004	<0.00004
Silicon	0.1		2.8	3	3.1	3.2	3.1	2.9	3	3.6	<0.1	<0.1
Silver	0.000005	0.0001	0.000026	0.000022	0.000018	0.000016	0.000011	0.000007	0.00001	0.000007	<0.000005	<0.000005
Sodium	0.05		1.52	1.43	1.84	1.66	1.74	1.5	1.61	2.78	<0.05	<0.05
Strontium	0.00005		0.0675	0.0852	0.103	0.1	0.0803	0.0787	0.0806	0.121	<0.00005	<0.00005
Thallium	0.000002	0.0008	0.000023	0.000008	0.000003	0.000006	0.000006	0.000008	0.000007	0.000006	<0.000002	<0.000002
Tin	0.00001		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Titanium	0.0005		0.0029	0.0049	0.0027	0.0034	0.0059	0.0196	0.0138	0.0169	<0.0005	<0.0005
Uranium	0.000002		0.00276	0.0012	0.00412	0.00278	0.00222	0.0034	0.003	0.00351	0.000005	0.000007
Vanadium	0.0002		<0.0002	0.0003	0.0004	0.0004	0.0009	0.0023	0.0017	0.0025	<0.0002	<0.0002
Zinc	0.0001	0.03	*0.0575*	0.0128	0.0063	0.0072	0.0048	0.0049	0.0042	0.0036	<0.0001	0.0011
Zirconium	0.0001		0.0003	0.0003	0.0003	0.0003	0.0004	0.0005	0.0004	0.0004	<0.0001	<0.0001

Appendix B2. Surface Water Quality Data, Casino Project, May 2008

AECOM

Station	Detection Limits	Water Quality Guidelines	W12 - Proctor Gulch before Confluence with Casino Creek	W8 - Upper Casino Creek	W13 - Meloy Creek	W11 - Casino Creek (proposed dam outflow)	W4 - Mouth of Casino Creek	W9 - Dip Creek us of Confluence with Casino Creek	W5 - Dip Creek ds Casino Confluence	W16 - Dip Creek Far Field	W41 - Field Blank	Maxxam Travel Blank
Date		CCME [a]	23-May-08	22-May-08	21-May-08	22-May-08	22-May-08	22-May-08	22-May-08	21-May-08		
Dissolved Metals												
Aluminum	0.0002		2.44	0.434	0.139	0.268	0.247	0.182	0.197	0.0701	0.0017	<0.0002
Antimony	0.00002		0.00008	0.00008	0.00022	0.00012	0.0001	0.00006	0.00007	0.00009	<0.00002	<0.00002
Arsenic	0.00002		0.00023	0.00035	0.0012	0.00051	0.00047	0.00034	0.00037	0.00053	<0.00002	<0.00002
Barium	0.00002		0.0436	0.0332	0.0476	0.0343	0.0322	0.0293	0.0314	0.0415	<0.00002	<0.00002
Beryllium	0.00001		0.00015	0.00003	0.00002	0.00003	0.00002	0.00002	0.00002	0.00001	<0.00001	<0.00001
Bismuth	0.000005		0.00001	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005
Boron	0.05		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cadmium	0.000005		0.000805	0.000156	0.000049	0.000074	0.000031	0.000011	0.000016	0.000011	<0.000005	<0.000005
Calcium	0.05		22.2	13.1	16.6	15.5	13.3	9.29	10.6	17	<0.05	<0.05
Chromium	0.0001		0.0004	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002	<0.0001	<0.0001
Cobalt	0.000005		0.00855	0.000914	0.000053	0.000234	0.000104	0.000082	0.000086	0.000125	<0.000005	<0.000005
Copper	0.00005		0.215	0.0493	0.00263	0.0292	0.0146	0.00192	0.00523	0.00314	<0.00005	0.00007
Iron	0.001		6	0.419	0.108	0.237	0.201	0.207	0.197	0.24	<0.001	0.001
Lead	0.000005		0.0019	0.000216	0.00164	0.000407	0.000161	0.000172	0.000157	0.000065	<0.000005	0.000058
Lithium	0.0005		0.0012	0.0005	0.0007	0.0007	0.0006	0.0014	0.0012	0.0012	<0.0005	<0.0005
Magnesium	0.05		5	2.73	4.56	4.21	3.89	3.1	3.38	6.16	<0.05	<0.05
Manganese	0.00005		0.327	0.0446	0.019	0.0158	0.00578	0.0122	0.0106	0.0504	<0.00005	<0.00005
Mercury	0.00001		<0.00001	<0.00001	<0.00001	0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum	0.00005		<0.00005	0.00018	0.00034	0.00031	0.00056	0.00037	0.00044	0.00067	<0.00005	<0.00005
Nickel	0.00002		0.00261	0.00101	0.00075	0.00081	0.00079	0.00069	0.00069	0.00063	<0.00002	<0.00002
Phosphorous	0.002		0.016	0.011	0.01	0.01	0.012	0.012	0.013	0.007	<0.002	<0.002
Potassium	0.05		1.18	0.78	1.01	0.82	0.85	0.62	0.69	0.84	<0.05	<0.05
Selenium	0.00004		0.00007	0.00006	0.00005	0.00007	0.00005	0.00004	0.00004	0.00007	<0.00004	<0.00004
Silicon	0.1		2.6	3	3.1	3	3	2.4	2.6	3.3	<0.1	<0.1
Silver	0.000005		0.000019	0.00001	0.000011	0.000011	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005
Sodium	0.05		1.6	1.53	1.85	1.7	1.9	1.63	1.73	2.85	0.07	<0.05
Strontium	0.00005		0.0696	0.086	0.103	0.099	0.0803	0.0757	0.0803	0.119	<0.00005	<0.00005
Thallium	0.000002		0.000022	0.000006	0.000003	0.000005	<0.000002	<0.000002	<0.000002	<0.000002	<0.000002	<0.000002
Tin	0.00001		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	0.00001	<0.00001	<0.00001	<0.00001
Titanium	0.0005		0.0025	0.0014	0.0014	0.0017	0.0021	0.0023	0.0021	0.0012	<0.0005	<0.0005
Uranium	0.000002		0.00269	0.00101	0.00398	0.00263	0.00201	0.00222	0.00223	0.00279	<0.000002	0.000003
Vanadium	0.0002		<0.0002	<0.0002	0.0002	<0.0002	0.0003	0.0004	0.0004	0.0005	<0.0002	<0.0002
Zinc	0.0001		0.0731	0.016	0.0084	0.0098	0.0069	0.0059	0.0053	0.0064	0.0056	0.0008
Zirconium	0.0001		0.0003	0.0003	0.0002	0.0003	0.0003	0.0003	0.0003	0.0002	<0.0001	<0.0001

Notes:

All units mg/l unless otherwise noted.

a) Canadian water quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2007.

b) 0.005 mg/L at pH <6.5, [Ca2+] <4 mg/L, DOC <2 mg/L: 0.1 mg/L at pH ≥6.5, [Ca2+] ≥4 mg/L, DOC ≥2 mg/L.

c) 0.002 mg/L at [CaCO3] = 0 - 120 mg/L; 0.003 mg/L at [CaCO3] = 120 - 180 mg/L; 0.004 mg/L at [CaCO3] >180 mg/L.

d) 0.001 mg/L at [CaCO3] = 0 - 60 mg/L; 0.002 mg/L at [CaCO3] = 60 - 120 mg/L; 0.004 mg/L at [CaCO3] =120 -180 mg/L; 0.007 mg/L at [CaCO3] >180 mg/L.

e) 0.025 mg/L at [CaCO3] = 0 - 60 mg/L; 0.065 mg/L at [CaCO3] = 60 - 120 mg/L, 0.110 mg/L at [CaCO3] =120 - 180 mg/L; 0.150 mg/L at [CaCO3] >180 mg/L.

Italic *Results exceed CCME Aquatic Life u*

B3. Surface Water Quality Data, Casino Project, July 2008

Appendix B3. Surface Water Quality Data, Casino Project, July 2008

AECOM

Station	Detection Limits	Water Quality Guidelines	W7 - Upper Canadian Creek	W3 - Canadian Creek us of Confluence with Britannia Creek	W14 -Mouth of Britannia Creek	W2 - Canadian Creek Downstream of Confluence with Britannia Creek	W1 - Mouth of Canadian Creek	W1 - Replicate taken as W101	W6b - Yukon River Upstream of Canadian Creek	W6a - Yukon River Downstream of Canadian Creek	W15 - Yukon River Far Field Site	W17 - Sunshine Creek	W43 - Adit Discharge Pipe at Lower Camp
Date		CCME [a]	8-Jul-08	8-Jul-08	8-Jul-08	8-Jul-08	8-Jul-08	8-Jul-08	8-Jul-08	8-Jul-08	8-Jul-08	8-Jul-08	8-Jul-08
Physical Tests													
Temperature C	-		7.9	8.2	5	6.5	7.4	7.4	14.5	13.9	14.2	5.3	3.6
Conductivity (Field) µS/cm	-		107	263	318	287	280	280	187	149	162	185	242
pH (Field)	-		7.1	7.7	7.7	7.5	7.9	7.9	8.2	8.0	8.1	7.7	6.7
Hardness $CaCO_3$	0.5		38.0	121	158	138	143	144	98.1	76.1	84.6	97.4	116
Conductivity µS/cm	1		110	260	320	290	280	280	190	150	160	190	240
pH	-	6.5-9.0	7.1	8.0	8.0	8.0	8.1	8.1	8.1	8.1	7.9	7.9	7.5
Total Suspended Solids	1		<1	1	7	20	4	4	33	28	32	7	<1
Total Dissolved Solids	1		98	180	220	210	200	200	110	110	100	150	170
Turbidity NTU	0.1		0.3	0.4	0.4	0.3	0.5	0.3	6.9	4.2	8.4	0.6	0.2
Dissolved Anions & Nutrients													
Ammonia as N	0.005		0.013	<0.005	0.006	<0.005	0.013	0.015	0.008	0.008	0.032	0.032	0.016
Alkalinity, Total (as $CaCO_3$)	0.5		6.9	70	100	83	81	82	71	64	64	68	83
Acidity (pH 8.3) as $CaCO_3$	0.5		-	-	-	-	-	-	-	-	-	-	-
Chloride (Cl)	0.5		<0.5	0.7	1.0	0.8	2.5	5.3	0.6	0.6	0.6	1.1	0.8
Sulfate (SO_4)	0.5		39	57	91	60	63	59	25	13	17	27	44
Nitrate (as N)	0.002	13	<0.002	0.096	0.207	0.135	0.169	0.164	0.019	0.024	0.026	0.148	0.214
Nitrite (as N)	0.002	0.06	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Total Kjeldahl Nitrogen	0.02		0.11	0.32	0.22	0.29	0.24	0.19	0.13	0.11	0.10	0.23	0.07
Ortho Phosphate as P	0.001		<0.001	<0.001	<0.001	0.001	0.001	<0.001	<0.001	0.003	<0.001	0.002	<0.001
Cyanide, Weak Acid Diss	0.0005		<0.0005	<0.0005	0.0007	<0.0005	0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0007	<0.0005
Total Cyanide	0.0005	0.005	<0.0005	0.0007	0.0007	0.0006	0.0008	0.0008	<0.0005	<0.0005	<0.0005	0.0011	<0.0005
Total Metals													
Aluminum	0.0002	0.005-0.1 [b]	0.0388	0.0321	*0.134*	*0.236*	0.0821	0.0752	*0.244*	*0.236*	*0.276*	*0.136*	0.0036
Antimony	0.00002		0.00008	0.00044	0.00022	0.00034	0.00028	0.00027	0.00013	0.00009	0.00011	0.00026	0.00342
Arsenic	0.00002	0.005	0.00026	0.00072	0.00066	0.00099	0.00057	0.00059	0.00076	0.00065	0.00073	0.00092	0.00049
Barium	0.00002		0.0406	0.0570	0.0839	0.0744	0.0627	0.0598	0.0585	0.0441	0.0514	0.0695	0.0517
Beryllium	0.00001		<0.00001	<0.00001	0.00001	0.00002	0.00001	0.00001	0.00002	0.00001	0.00003	0.00002	<0.00001
Bismuth	0.000005		<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	0.000011	0.000006	0.000008	<0.000005	<0.000005
Boron	0.05		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cadmium	0.000005	0.000017	*0.000087*	0.000017	0.000011	*0.000021*	0.000014	0.000011	*0.000077*	*0.000032*	*0.000056*	*0.000021*	*0.0553*
Calcium	0.05		11.5	31.1	37.7	34.3	35.8	36.1	26.8	21.2	23.5	24.5	32.3
Chromium	0.0001	0.001	0.0001	0.0002	0.0003	0.0004	0.0003	0.0003	0.0005	0.0005	0.0006	0.0003	<0.0001
Cobalt	0.000005		0.000032	0.000050	0.000114	0.000254	0.000099	0.000088	0.000307	0.000298	0.000343	0.000133	0.000164
Copper	0.00005	0.002-0.004 [c]	*0.00267*	0.00258	0.00177	0.00277	0.00243	0.00240	0.00176	0.00156	0.00176	0.00194	*0.0608*
Iron	0.001	0.3	0.028	0.042	0.157	*0.344*	0.104	0.099	*0.448*	*0.400*	*0.487*	0.196	0.025
Lead	0.000005	0.001-0.007 [d]	0.000079	0.000032	0.000083	0.000321	0.000059	0.000051	0.000382	0.000794	0.000366	0.000140	*0.00587*
Lithium	0.0005		0.0006	0.0005	0.0010	0.0009	0.0009	0.0009	0.0020	0.0013	0.0016	0.0008	0.0024
Magnesium	0.05		2.25	10.4	15.4	12.7	13.0	13.0	7.56	5.61	6.27	8.77	8.58
Manganese	0.00005		0.00079	0.00355	0.00747	0.0188	0.00454	0.00465	0.0289	0.0236	0.0285	0.0137	0.266
Mercury	0.00001	0.000026	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum	0.00005	0.073	0.00033	0.00093	0.00053	0.00071	0.00077	0.00075	0.00094	0.00089	0.00088	0.00040	<0.00005
Nickel	0.00002	0.025-0.15 [e]	0.00067	0.00072	0.00062	0.00090	0.00077	0.00082	0.00210	0.00143	0.00192	0.00071	0.00050
Phosphorous	0.002		0.004	<0.002	0.009	0.022	0.005	0.005	0.034	0.032	0.038	0.009	0.002
Potassium	0.05		0.56	1.88	1.94	1.93	2.08	2.08	0.77	0.75	0.76	1.16	1.43
Selenium	0.00004	0.001	0.00006	0.00007	0.00008	0.00008	0.00011	0.00011	0.00047	0.00023	0.00034	0.00007	<0.00004
Silicon	0.1		7.6	4.8	4.0	4.6	4.5	4.8	3.4	3.3	3.4	4.0	5.8
Silver	0.000005	0.0001	0.000006	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	0.000009	0.000008	0.000012	0.000008	0.000090
Sodium	0.05		3.49	4.25	4.99	4.64	4.39	4.40	1.66	1.61	1.62	3.87	3.52
Strontium	0.00005		0.0811	0.204	0.316	0.251	0.236	0.234	0.113	0.0908	0.100	0.163	0.280
Thallium	0.000002	0.0008	0.000002	0.000003	0.000006	0.000006	0.000004	0.000003	0.000007	0.000006	0.000008	0.000004	0.000023
Tin	0.00001		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Titanium	0.0005		0.0008	0.0014	0.0071	0.0151	0.0031	0.0027	0.0095	0.0102	0.0106	0.0063	<0.0005
Uranium	0.000002		0.000073	0.00708	0.0103	0.00976	0.00928	0.00907	0.000946	0.000860	0.000884	0.00188	0.00149
Vanadium	0.0002		0.0002	<0.0002	0.0006	0.0011	0.0004	0.0004	0.0010	0.0009	0.0011	0.0007	<0.0002
Zinc	0.0001	0.03	0.0061	0.0005	0.0006	0.0016	0.0008	0.0008	0.0061	0.0029	0.0045	0.0012	*3.06*
Zirconium	0.0001		<0.0001	0.0001	0.0003	0.0003	0.0002	0.0002	0.0001	0.0001	0.0001	0.0002	<0.0001

Appendix B3. Surface Water Quality Data, Casino Project, July 2008

AECOM

Station	Detection Limits	Water Quality Guidelines	W7 - Upper Canadian Creek	W3 - Canadian Creek us of Confluence with Britannia Creek	W14 -Mouth of Britannia Creek	W2 - Canadian Creek Downstream of Confluence with Britannia Creek	W1 - Mouth of Canadian Creek	W1 - Replicate taken as W101	W6b - Yukon River Upstream of Canadian Creek	W6a - Yukon River Downstream of Canadian Creek	W15 - Yukon River Far Field Site	W17 - Sunshine Creek	W43 - Adit Discharge Pipe at Lower Camp
Date		CCME [a]	8-Jul-08	8-Jul-08	8-Jul-08	8-Jul-08	8-Jul-08	8-Jul-08	8-Jul-08	8-Jul-08	8-Jul-08	8-Jul-08	8-Jul-08
Dissolved Metals													
Aluminum	0.0002		0.0336	0.0197	0.0493	0.0334	0.0438	0.0429	0.0346	0.0268	0.0334	0.0546	0.0056
Antimony	0.00002		0.00008	0.00044	0.00024	0.00036	0.00027	0.00030	0.00012	0.00008	0.00010	0.00025	0.00335
Arsenic	0.00002		0.00024	0.00070	0.00055	0.00062	0.00056	0.00054	0.00045	0.00044	0.00045	0.00069	0.00028
Barium	0.00002		0.0400	0.0554	0.0789	0.0669	0.0591	0.0608	0.0426	0.0345	0.0371	0.0627	0.0495
Beryllium	0.00001		<0.00001	<0.00001	0.00001	<0.00001	0.00001	0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Bismuth	0.000005		<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005
Boron	0.05		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Calcium	0.05		11.1	31.3	37.6	33.7	33.3	33.5	24.8	20.1	21.4	22.3	30.1
Cadmium	0.000005		0.000084	0.000014	0.000006	0.000013	0.000008	0.000008	0.000023	0.000015	0.000023	0.000013	0.0515
Chromium	0.0001		0.0002	0.0002	0.0003	0.0002	0.0003	0.0002	0.0002	0.0002	0.0002	0.0003	<0.0001
Cobalt	0.000005		0.000031	0.000035	0.000047	0.000051	0.000051	0.000042	0.000021	0.000016	0.000020	0.000044	0.000157
Copper	0.00005		0.00272	0.00261	0.00166	0.00219	0.00205	0.00211	0.00089	0.00082	0.00082	0.00153	0.0510
Iron	0.001		0.016	0.015	0.035	0.025	0.044	0.045	0.029	0.027	0.029	0.053	0.007
Lead	0.000005		0.000011	0.000008	0.000011	0.000065	<0.000005	<0.000005	0.000029	0.000021	0.000022	0.000016	0.00205
Lithium	0.0005		0.0007	0.0005	0.0010	0.0008	0.0008	0.0008	0.0017	0.0010	0.0013	0.0008	0.0024
Magnesium	0.05		2.30	10.7	16.0	12.9	12.1	12.4	7.19	5.33	5.89	8.31	8.13
Manganese	0.00005		0.00052	0.00255	0.00178	0.00287	0.00131	0.00128	0.00226	0.00182	0.00186	0.00325	0.252
Mercury	0.00001		<0.00001	<0.00001	<0.00001	<0.00001	0.00001	0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum	0.00005		0.00033	0.00094	0.00057	0.00083	0.00073	0.00078	0.00100	0.00095	0.00097	0.00040	<0.00005
Nickel	0.00002		0.00065	0.00077	0.00059	0.00064	0.00075	0.00068	0.00103	0.00067	0.00077	0.00064	0.00045
Phosphorous	0.002		0.002	<0.002	0.003	0.002	<0.002	<0.002	0.002	<0.002	<0.002	0.003	<0.002
Potassium	0.05		0.56	1.91	1.95	1.92	1.94	1.95	0.70	0.69	0.69	1.07	1.33
Selenium	0.00004		0.00005	0.00007	0.00009	0.00008	0.00012	0.00010	0.00048	0.00024	0.00034	0.00008	<0.00004
Silicon	0.1		7.5	5.0	4.5	4.6	3.8	4.1	3.2	3.2	3.2	4.1	6.0
Silver	0.000005		<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	0.000026
Sodium	0.05		3.69	4.42	5.30	4.84	4.20	4.20	1.66	1.63	1.63	3.71	3.44
Strontium	0.00005		0.0790	0.203	0.306	0.250	0.214	0.217	0.109	0.0866	0.0925	0.157	0.265
Thallium	0.000002		0.000002	0.000003	0.000003	0.000003	0.000004	0.000004	0.000004	0.000003	0.000003	0.000002	0.000022
Tin	0.00001		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Titanium	0.0005		<0.0005	<0.0005	0.0007	<0.0005	0.0006	<0.0005	<0.0005	0.0006	0.0006	<0.0005	<0.0005
Uranium	0.000002		0.00009	0.00685	0.00971	0.00923	0.00864	0.00890	0.000863	0.000802	0.000800	0.00172	0.00128
Vanadium	0.0002		0.0002	<0.0002	0.0004	0.0002	0.0003	0.0003	0.0002	<0.0002	0.0002	0.0003	<0.0002
Zinc	0.0001		0.0107	0.0055	0.0058	0.0061	0.0045	0.0042	0.0062	0.0046	0.0065	0.005	2.84
Zirconium	0.0001		0.0001	0.0002	0.0003	0.0002	0.0002	0.0002	<0.0001	<0.0001	<0.0001	0.0002	<0.0001

Notes:

All units mg/l unless otherwise noted.

a) Canadian water quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2007.

b) 0.005 mg/L at pH <6.5, [Ca2+] <4 mg/L, DOC <2 mg/L: 0.1 mg/L at pH ≥6.5, [Ca2+] ≥4 mg/L, DOC ≥2 mg/L.

c) 0.002 mg/L at [CaCO3] = 0 - 120 mg/L; 0.003 mg/L at [CaCO3] = 120 - 180 mg/L; 0.004 mg/L at [CaCO3] >180 mg/L.

d) 0.001 mg/L at [CaCO3] = 0 - 60 mg/L; 0.002 mg/L at [CaCO3] = 60 - 120 mg/L; 0.004 mg/L at [CaCO3] =120 -180 mg/L; 0.007 mg/L at [CaCO3] >180 mg/L.

e) 0.025 mg/L at [CaCO3] = 0 - 60 mg/L; 0.065 mg/L at [CaCO3] = 60 - 120 mg/L; 0.110 mg/L at [CaCO3] =120 - 180 mg/L; 0.150 mg/L at [CaCO3] >180 mg/L.

Italic *Results exceed CCME Aquatic Life guidelines.*

Appendix B3. Surface Water Quality Data, Casino Project, July 2008

AECOM

Station	Detection Limits	Water Quality Guidelines	W43 - Replicate taken as W102	W12 - Proctor Gulch before Confluence with Casino Creek	W8 - Upper Casino Creek	W13 - Meloy Creek	W11 - Casino Creek (proposed dam outflow)	W4 - Mouth of Casino Creek	W9 - Dip Creek us of Confluence with Casino Creek	W5 - Dip Creek ds Casino Confluence	W16 - Dip Creek Far Field	Field Blank (W40)	Maxxam Travel Blank
Date		CCME [a]	9-Jul-08	8-Jul-08	8-Jul-08	9-Jul-08	9-Jul-08	9-Jul-08	9-Jul-08	9-Jul-08	9-Jul-08	9-Jul-08	5-Jul-08
Physical Tests													
Temperature C	-		3.6	7	3.1	3	7.5	6.4	5.7	6.1	6.9	-	-
Conductivity (Field) µS/cm	-		242	1034	281	324	298	232	103	119	141	-	-
pH (Field)	-		6.7	*3.3*	7.4	7.8	7.8	7.7	7.5	7.6	7.5	-	-
Hardness $CaCO_3$	0.5		117	411	125	164	146	111	51.6	58.5	68.1	<0.5	<0.5
Conductivity µS/cm	1		240	1200	280	330	300	230	100	120	140	<1	<1
pH	-	6.5-9.0	7.3	*3.2*	7.8	8.2	8.1	8.0	7.8	7.8	7.8	5.2	5.8
Total Suspended Solids	1		<1	3	5	<1	<1	1	25	17	13	<1	<1
Total Dissolved Solids	1		160	790	200	210	200	150	94	110	120	2	<1
Turbidity NTU	0.1		0.3	2.5	5.1	0.1	0.4	0.2	1.3	1.1	0.9	0.1	<0.1
Dissolved Anions & Nutrients													
Ammonia as N	0.005		<0.005	0.050	0.008	0.005	0.014	<0.005	<0.005	<0.005	<0.005	0.009	0.014
Alkalinity, Total (as $CaCO_3$)	0.5		80	<0.5	42	130	83	79	43	48	49	<0.5	<0.5
Acidity (pH 8.3) as $CaCO_3$	0.5		-	153	-	-	-	-	-	-	-	-	-
Chloride (Cl)	0.5		0.9	0.7	0.7	0.8	0.7	0.9	1.1	1.0	0.9	0.7	<0.5
Sulfate (SO_4)	0.5		45	550	90	47	67	42	7.5	12	24	1.8	1.3
Nitrate (as N)	0.002	13	0.216	0.030	0.073	0.249	0.107	0.087	0.068	0.066	0.035	0.012	<0.002
Nitrite (as N)	0.002	0.06	<0.002	0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.002	<0.002	<0.002
Total Kjeldahl Nitrogen	0.02		0.10	0.18	0.15	0.15	0.21	0.16	0.26	0.27	0.39	0.05	0.04
Ortho Phosphate as P	0.001		<0.001	0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001
Cyanide, Weak Acid Diss	0.0005		<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0005	0.0005	<0.0005	<0.0005
Total Cyanide	0.0005	0.005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0010	0.0008	0.0012	<0.0005	<0.0005
Total Metals													
Aluminum	0.0002	0.005-0.1[b]	0.0030	*12.2*	*0.534*	0.0162	0.0475	0.0446	*0.348*	*0.272*	*0.256*	0.0013	0.0012
Antimony	0.00002		0.00342	0.00013	0.00010	0.00027	0.00015	0.00014	0.00009	0.00011	0.00010	<0.00002	<0.00002
Arsenic	0.00002	0.005	0.00048	0.00031	0.00026	0.00180	0.00060	0.00042	0.00059	0.00054	0.00063	<0.00002	<0.00002
Barium	0.00002		0.0496	0.0102	0.0540	0.0904	0.0643	0.0550	0.0446	0.0455	0.0439	0.00057	<0.00002
Beryllium	0.00001		<0.00001	0.00059	0.00003	<0.00001	<0.00001	<0.00001	0.00003	0.00002	0.00002	<0.00001	<0.00001
Bismuth	0.000005		<0.000005	<0.000005	0.000005	<0.000005	<0.000005	<0.000005	0.000005	0.000006	0.000006	<0.000005	<0.000005
Boron	0.05		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cadmium	0.000005	0.000017	*0.0550*	*0.00317*	*0.000253*	*0.000026*	*0.000043*	0.000013	*0.000017*	*0.000021*	*0.000018*	0.000006	<0.000005
Calcium	0.05		32.7	124	37.4	43.6	39.5	29.6	13.4	15.1	16.4	0.07	<0.05
Chromium	0.0001	0.001	<0.0001	0.0006	0.0001	0.0001	<0.0001	0.0002	0.0006	0.0005	0.0006	<0.0001	<0.0001
Cobalt	0.000005		0.000161	0.0510	0.00222	0.000018	0.000048	0.000045	0.000265	0.000228	0.000268	<0.000005	<0.000005
Copper	0.00005	0.002-0.004[c]	*0.0604*	*1.13*	*0.0554*	0.00054	*0.00787*	*0.00371*	*0.00214*	*0.00228*	*0.00296*	0.00006	<0.00005
Iron	0.001	0.3	0.023	*32.5*	*1.03*	0.024	0.071	0.076	*0.556*	*0.441*	*0.524*	<0.001	0.003
Lead	0.000005	0.001-0.007[d]	*0.00567*	0.00116	0.000225	0.000218	0.000041	0.000028	0.000609	0.000596	0.000222	0.000008	0.000042
Lithium	0.0005		0.0025	0.0065	0.0010	0.0020	0.0013	0.0010	0.0022	0.0020	0.0013	<0.0005	<0.0005
Magnesium	0.05		8.66	25.0	7.68	13.3	11.5	9.11	4.40	5.04	6.57	<0.05	<0.05
Manganese	0.00005		0.268	1.39	0.0676	0.00448	0.0145	0.00498	0.0347	0.0287	0.0294	0.00015	<0.00005
Mercury	0.00001	0.000026	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum	0.00005	0.073	<0.00005	0.00012	0.00023	0.00083	0.00095	0.00120	0.00050	0.00060	0.00055	<0.00005	<0.00005
Nickel	0.00002	0.025-0.15[e]	0.00042	0.00782	0.00080	0.00023	0.00030	0.00035	0.00085	0.00077	0.00136	<0.00002	<0.00002
Phosphorous	0.002		0.002	0.004	<0.002	0.003	0.003	0.003	0.021	0.018	0.015	0.043	<0.002
Potassium	0.05		1.41	2.19	0.86	1.22	0.99	1.02	0.52	0.57	0.60	<0.05	<0.05
Selenium	0.00004	0.001	<0.00004	0.00025	0.00006	0.00005	0.00010	0.00006	0.00006	0.00006	0.00008	<0.00004	<0.00004
Silicon	0.1		6.1	9.2	5.6	5.1	4.8	4.9	4.2	4.3	4.2	<0.1	<0.1
Silver	0.000005	0.0001	0.000088	0.000026	<0.000005	<0.000005	<0.000005	<0.000005	0.000007	0.000007	<0.000005	<0.000005	<0.000005
Sodium	0.05		3.52	7.57	3.86	5.17	4.15	4.13	2.41	2.60	2.72	<0.05	<0.05
Strontium	0.00005		0.281	0.317	0.250	0.269	0.248	0.177	0.110	0.118	0.111	0.00094	<0.00005
Thallium	0.000002	0.0008	0.000023	0.000094	0.000006	<0.000002	0.000003	0.000002	0.000006	0.000006	0.000004	<0.000002	<0.000002
Tin	0.00001		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Titanium	0.0005		<0.0005	0.0005	<0.0005	0.0005	0.0006	0.0014	0.0159	0.0118	0.0093	<0.0005	<0.0005
Uranium	0.000002		0.00154	0.0145	0.00217	0.0180	0.00961	0.00558	0.00250	0.00272	0.00178	0.000004	<0.000002
Vanadium	0.0002		<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0004	0.0013	0.0011	0.0013	<0.0002	<0.0002
Zinc	0.0001	0.03	*2.99*	*0.237*	0.0192	0.0014	0.0018	0.0005	0.0022	0.0020	0.0015	0.0022	0.0008
Zirconium	0.0001		<0.0001	<0.0001	<0.0001	<0.0001	0.0001	0.0002	0.0004	0.0003	0.0005	<0.0001	<0.0001

Appendix B3. Surface Water Quality Data, Casino Project, July 2008

AECOM

Station	Detection Limits	Water Quality Guidelines	W43 - Replicate taken as W102	W12 - Proctor Gulch before Confluence with Casino Creek	W8 - Upper Casino Creek	W13 - Meloy Creek	W11 - Casino Creek (proposed dam outflow)	W4 - Mouth of Casino Creek	W9 - Dip Creek us of Confluence with Casino Creek	W5 - Dip Creek ds Casino Confluence	W16 - Dip Creek Far Field	Field Blank (W40)	Maxxam Travel Blank
Date		CCME [a]	9-Jul-08	8-Jul-08	8-Jul-08	9-Jul-08	9-Jul-08	9-Jul-08	9-Jul-08	9-Jul-08	9-Jul-08	9-Jul-08	5-Jul-08
Dissolved Metals													
Aluminum	0.0002		0.0254	12.2	0.0569	0.0110	0.0307	0.0329	0.0927	0.0845	0.101	0.0031	0.0024
Antimony	0.00002		0.00329	0.00013	0.00009	0.00023	0.00015	0.00014	0.00008	0.00009	0.00009	<0.00002	<0.00002
Arsenic	0.00002		0.00029	0.00031	0.00018	0.00178	0.00056	0.00040	0.00033	0.00034	0.00050	<0.00002	<0.00002
Barium	0.00002		0.0496	0.0103	0.0525	0.0884	0.0619	0.0555	0.0350	0.0385	0.0392	<0.00002	0.00006
Beryllium	0.00001		<0.00001	0.00059	<0.00001	<0.00001	<0.00001	<0.00001	0.00002	0.00001	0.00001	<0.00001	<0.00001
Bismuth	0.000005		<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005
Boron	0.05		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Calcium	0.05		30.9	122	38.1	41.6	38.6	29.2	12.9	14.7	16.3	<0.05	<0.05
Cadmium	0.000005		0.0531	0.00323	0.000220	0.000023	0.000043	0.000014	0.000011	0.000007	0.000011	0.000008	<0.000005
Chromium	0.0001		<0.0001	0.0008	0.0001	<0.0001	0.0001	0.0002	0.0003	0.0003	0.0004	<0.0001	<0.0001
Cobalt	0.000005		0.000161	0.0509	0.00218	0.000010	0.000040	0.000031	0.000052	0.000051	0.000133	<0.000005	<0.000005
Copper	0.00005		0.0534	1.12	0.0313	0.00056	0.00713	0.00356	0.00159	0.00179	0.00249	0.00010	<0.00005
Iron	0.001		0.007	35.1	0.423	0.011	0.045	0.043	0.114	0.105	0.238	<0.001	0.002
Lead	0.000005		0.00218	0.00113	0.000099	0.000029	0.000015	0.000009	0.000062	0.000052	0.000025	<0.000005	0.000043
Lithium	0.0005		0.0024	0.0064	0.0009	0.0020	0.0013	0.0011	0.0019	0.0018	0.0012	<0.0005	<0.0005
Magnesium	0.05		8.33	25.4	7.98	13.1	11.6	9.31	4.35	4.93	6.77	<0.05	<0.05
Manganese	0.00005		0.258	1.39	0.0683	0.00248	0.0136	0.00386	0.00674	0.00681	0.0174	<0.00005	<0.00005
Mercury	0.00001		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum	0.00005		<0.00005	0.00012	0.00024	0.00085	0.00093	0.00127	0.00052	0.00061	0.00056	<0.00005	<0.00005
Nickel	0.00002		0.00053	0.00789	0.00079	0.00022	0.00029	0.00034	0.00057	0.00058	0.00116	0.00002	<0.00002
Phosphorous	0.002		<0.002	0.003	<0.002	<0.002	<0.002	0.002	0.005	0.004	0.005	<0.002	<0.002
Potassium	0.05		1.36	2.17	0.88	1.20	0.98	1.03	0.50	0.55	0.60	<0.05	<0.05
Selenium	0.00004		<0.00004	0.00029	0.00005	0.00006	0.00011	0.00007	0.00006	0.00006	0.00008	<0.00004	<0.00004
Silicon	0.1		5.9	10.6	5.8	5.4	5.2	5.3	4.2	4.3	4.3	<0.1	<0.1
Silver	0.000005		0.000035	0.000021	<0.000005	<0.000005	0.000006	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005
Sodium	0.05		3.45	7.78	4.03	5.22	4.15	4.35	2.48	2.70	2.84	0.07	<0.05
Strontium	0.00005		0.271	0.307	0.246	0.269	0.246	0.182	0.105	0.116	0.111	<0.00005	0.00008
Thallium	0.000002		0.000025	0.000095	0.000006	<0.000002	0.000003	0.000002	0.000003	0.000002	0.000002	<0.000002	<0.000002
Tin	0.00001		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Titanium	0.0005		<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0012	0.0013	0.0017	<0.0005	<0.0005
Uranium	0.000002		0.00134	0.0145	0.00135	0.0177	0.00898	0.00570	0.00194	0.00238	0.00162	0.000006	0.000004
Vanadium	0.0002		<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0003	0.0004	0.0004	0.0006	<0.0002	<0.0002
Zinc	0.0001		2.93	0.241	0.0182	0.0066	0.0051	0.0052	0.0054	0.0047	0.0039	0.0042	0.0007
Zirconium	0.0001		<0.0001	0.0001	<0.0001	<0.0001	0.0001	0.0002	0.0003	0.0003	0.0004	<0.0001	<0.0001

Notes:

All units mg/l unless otherwise noted.

a) Canadian water quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2007.

b) 0.005 mg/L at pH <6.5, [Ca2+] <4 mg/L, DOC <2 mg/L: 0.1 mg/L at pH ≥6.5, [Ca2+] ≥4 mg/L, DOC ≥2 mg/L.

c) 0.002 mg/L at [CaCO3] = 0 - 120 mg/L; 0.003 mg/L at [CaCO3] = 120 - 180 mg/L; 0.004 mg/L at [CaCO3] >180 mg/L.

d) 0.001 mg/L at [CaCO3] = 0 - 60 mg/L; 0.002 mg/L at [CaCO3] = 60 - 120 mg/L; 0.004 mg/L at [CaCO3] =120 -180 mg/L; 0.007 mg/L at [CaCO3] >180 mg/L.

e) 0.025 mg/L at [CaCO3] = 0 - 60 mg/L; 0.065 mg/L at [CaCO3] = 60 - 120 mg 0.110 mg/L at [CaCO3] =120 - 180 mg/L; 0.150 mg/L at [CaCO3] >180 mg/L.

Italic *Results exceed CCME Aquatic Life*

B4. Surface Water Quality Data, Casino Project, September 2008

Appendix B4. Surface Water Quality Data, Casino Project, September 2008

AECOM

Station	Detection Limits	Water Quality Guidelines	W7 - Upper Canadian Creek	W3 - Canadian Creek us of Confluence with Britannia Creek	W14 - Mouth of Britannia Creek	W2 - Canadian Creek Downstream of Confluence with Britannia Creek	W2 - Replicate	W1 - Mouth of Canadian Creek	W6b - Yukon River Upstream of Canadian Creek	W6a - Yukon River Downstream of Canadian Creek	W15 - Yukon River Far Field Site	W17 - Sunshine Creek	W43 - Adit Discharge Pipe at Lower Camp
Date		**CCME [a]**	**10-Sep-08**	**10-Sep-08**	**10-Sep-08**	**10-Sep-08**	**10-Sep-08**	**10-Sep-08**	**9-Sep-08**	**9-Sep-08**	**9-Sep-08**	**9-Sep-08**	**9-Sep-08**
Physical Tests													
Temperature C	-		2.7	4.5	3	4.1	4.1	4.6	9.6	10.0	9.9	4.1	4.2
Conductivity (Field) µS/cm	-		117	175	188	179	179	201	220	174	216	179	347
pH (Field)	-		6.8	7.7	8.0	7.6	7.6	7.8	8.2	8.1	8.1	7.5	7.4
Hardness $CaCO_3$	0.5		41.0	83.7	90.0	83.0	81.7	89.7	107	83.9	107	83.9	94.4
Conductivity µS/cm	1		120	180	190	180	180	200	220	180	220	180	220
pH	-	6.5-9.0	6.8	7.8	7.8	7.9	7.9	7.9	8.1	8.1	8.1	7.9	7.5
Total Suspended Solids	1		1	3	2	3	3	3	14	12	32	1	<1
Total Dissolved Solids	1		100	74	150	120	120	140	180	140	140	96	120
Turbidity NTU	0.1		0.3	0.7	0.4	0.6	0.5	0.7	8.2	3.7	4.9	0.2	0.8
Dissolved Anions & Nutrients													
Ammonia as N	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	0.03	0.04	<0.01	<0.01	<0.01	<0.01
Alkalinity, Total (as $CaCO_3$)	0.5		4.8	45	59	50	50	55	81	72	80	63	67
Acidity (pH 8.3) as $CaCO_3$	0.5		-	-	-	-	-	-	-	-	-	-	13.2
Chloride (Cl)	0.5		<0.5	0.6	0.7	0.6	<0.5	0.8	0.6	0.5	<0.5	0.6	<0.5
Sulfate (SO_4)	0.5		43	40	30	38	40	44	32	18	31	26	39
Nitrate (as N)	0.002	13	<0.002	0.173	0.255	0.197	0.197	0.202	0.014	0.015	0.011	0.206	0.443
Nitrite (as N)	0.002	0.06	<0.002	0.003	0.002	0.003	0.003	0.002	0.003	0.002	0.004	0.002	<0.002
Total Kjeldahl Nitrogen	0.02		0.12	0.21	0.26	0.21	0.25	0.23	0.09	0.11	0.08	0.20	0.04
Ortho Phosphate as P	0.001		0.002	<0.001	<0.001	<0.001	0.001	0.001	0.006	0.003	0.006	<0.001	0.002
Cyanide, Weak Acid Diss	0.0005		<0.0005	0.0007	0.0008	0.0007	0.0006	0.0008	<0.0005	<0.0005	<0.0005	0.0006	<0.0005
Total Cyanide	0.0005	0.005	0.0006	0.0010	0.0017	0.0012	0.0012	0.0012	<0.0005	0.0008	<0.0005	0.0013	<0.0005
Total Metals													
Aluminum	0.0002	0.005-0.1 [b]	*0.112*	*0.219*	*0.271*	*0.105*	0.0866	0.0883	*0.124*	0.0954	*0.137*	0.0600	0.0235
Antimony	0.00002		0.00007	0.00045	0.00033	0.00039	0.00038	0.00034	0.00013	0.00010	0.00015	0.00027	0.00264
Arsenic	0.00002	0.005	0.00026	0.00111	0.00103	0.00082	0.00076	0.00070	0.00060	0.00054	0.00064	0.00062	0.00079
Barium	0.00002		0.0471	0.0438	0.0699	0.0450	0.0431	0.0449	0.0561	0.0421	0.0597	0.0588	0.0658
Beryllium	0.00001		0.00002	0.00003	0.00002	0.00001	0.00001	0.00001	0.00001	0.00001	0.00002	<0.00001	<0.00001
Bismuth	0.000005		0.000040	0.000013	0.000018	0.000005	<0.000005	<0.000005	<0.000005	0.000012	<0.000005	<0.000005	<0.000005
Boron	0.05		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cadmium	0.000005	0.000017	*0.000238*	*0.000068*	*0.000031*	*0.000023*	*0.000019*	0.000015	*0.000080*	*0.000041*	*0.000088*	*0.000018*	*0.0425*
Calcium	0.05		12.2	22.0	21.8	20.9	20.6	22.7	28.8	23.2	28.7	20.8	26.2
Chromium	0.0001	0.001	0.0002	0.0005	0.0007	0.0003	0.0003	0.0003	0.0002	0.0002	0.0002	0.0003	<0.0001
Cobalt	0.000005		0.000144	0.000352	0.000219	0.000108	0.000083	0.000079	0.000181	0.000125	0.000199	0.000062	0.000320
Copper	0.00005	0.002-0.004 [c]	*0.00282*	*0.00521*	*0.00423*	*0.00339*	*0.00303*	*0.00279*	0.00139	0.00114	0.00143	0.00175	*0.0748*
Iron	0.001	0.3	0.100	0.208	*0.370*	0.107	0.084	0.085	0.193	0.152	0.225	0.058	0.047
Lead	0.000005	0.001-0.007 [d]	0.000154	0.00147	0.00150	0.000393	0.000059	0.000064	0.000253	0.000169	0.000270	0.000145	*0.0120*
Lithium	0.0005		0.0007	<0.0005	0.0007	<0.0005	<0.0005	0.0006	0.0022	0.0014	0.0022	0.0008	0.0020
Magnesium	0.05		2.56	6.95	8.63	7.48	7.37	8.04	8.52	6.29	8.50	7.76	7.02
Manganese	0.00005		0.0105	0.0342	0.0138	0.00687	0.00494	0.00404	0.0236	0.0156	0.0243	0.00435	0.524
Mercury	0.00001	0.000026	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum	0.00005	0.073	0.00020	0.00063	0.00048	0.00057	0.00055	0.00059	0.00100	0.00101	0.00102	0.00041	<0.00005
Nickel	0.00002	0.025-0.15 [e]	0.00100	0.00122	0.00083	0.00087	0.00080	0.00076	0.00221	0.00117	0.00219	0.00057	0.00049
Phosphorous	0.002		0.006	0.012	0.017	0.006	0.006	0.005	0.021	0.015	0.021	0.005	0.003
Potassium	0.05		0.41	1.29	1.26	1.20	1.16	1.33	0.72	0.71	0.73	1.01	1.35
Selenium	0.00004	0.001	<0.00004	<0.00004	0.00006	<0.00004	0.00004	0.00006	0.00053	0.00028	0.00053	0.00006	<0.00004
Silicon	0.1		6.9	4.6	4.2	4.6	4.5	4.9	3.0	3.1	3.5	4.4	5.8
Silver	0.000005	0.0001	<0.000005	0.000005	0.000011	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	0.000007	<0.000005	*0.000105*
Sodium	0.05		3.38	3.20	3.00	2.77	2.75	2.77	1.86	1.85	1.91	3.03	3.09
Strontium	0.00005		0.0793	0.127	0.171	0.140	0.136	0.148	0.129	0.105	0.131	0.139	0.220
Thallium	0.000002	0.0008	0.000004	0.000005	0.000007	0.000004	0.000004	0.000004	0.000004	0.000004	0.000005	0.000003	0.000025
Tin	0.00001		<0.00001	<0.00001	0.00006	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	0.00001	<0.00001
Titanium	0.0005		0.0015	0.0050	0.0093	0.0025	0.0021	0.0016	0.0023	0.0024	0.0024	0.0011	<0.0005
Uranium	0.000002		0.000095	0.00434	0.00349	0.00466	0.00465	0.00464	0.000929	0.000916	0.00104	0.00126	0.00126
Vanadium	0.0002		0.0002	0.0006	0.0010	0.0003	0.0002	0.0003	0.0004	0.0004	0.0004	0.0003	<0.0002
Zinc	0.0001	0.03	0.0195	0.0133	0.0033	0.0016	0.0011	0.0008	0.0062	0.0028	0.0065	0.0014	*2.35*
Zirconium	0.0001		0.0002	0.0004	0.0007	0.0004	0.0004	0.0003	0.0001	<0.0001	0.0001	0.0003	<0.0001

Station	Detection Limits	Water Quality Guidelines	W7 - Upper Canadian Creek	W3 - Canadian Creek us of Confluence with Britannia Creek	W14 - Mouth of Britannia Creek	W2 - Canadian Creek Downstream of Confluence with Britannia Creek	W2 - Replicate	W1 - Mouth of Canadian Creek	W6b - Yukon River Upstream of Canadian Creek	W6a - Yukon River Downstream of Canadian Creek	W15 - Yukon River Far Field Site	W17 - Sunshine Creek	W43 - Adit Discharge Pipe at Lower Camp
Date		**CCME [a]**	**10-Sep-08**	**10-Sep-08**	**10-Sep-08**	**10-Sep-08**	**10-Sep-08**	**10-Sep-08**	**9-Sep-08**	**9-Sep-08**	**9-Sep-08**	**9-Sep-08**	**9-Sep-08**
Dissolved Metals													
Aluminum	0.0002		0.0793	-	0.178	0.0782	0.0707	0.0752	0.0234	0.0194	0.0244	0.0672	0.0014
Antimony	0.00002		0.00006	-	0.00032	0.00038	0.00039	0.00036	0.00013	0.00010	0.00013	0.00027	0.00257
Arsenic	0.00002		0.00020	-	0.00078	0.00076	0.00074	0.00074	0.00044	0.00044	0.00045	0.00062	0.00047
Barium	0.00002		0.0456	-	0.0637	0.0442	0.0445	0.0454	0.0469	0.0378	0.0459	0.0594	0.0631
Beryllium	0.00001		0.00002	-	0.00002	0.00001	0.00001	0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Bismuth	0.000005		<0.000005	-	0.000006	<0.000005	<0.000005	0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005
Boron	0.05		<0.05	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cadmium	0.000005		0.000224	-	0.000021	0.000019	0.000020	0.000017	0.000033	0.000017	0.000035	0.000018	0.0414
Calcium	0.05		12.5	-	22.1	21.3	21.3	23.8	28.7	23.7	29.1	21.5	26.8
Chromium	0.0001		0.0002	-	0.0005	0.0003	0.0003	0.0003	<0.0001	0.0001	0.0001	0.0002	<0.0001
Cobalt	0.000005		0.000112	-	0.000140	0.000075	0.000070	0.000075	0.000024	0.000023	0.000025	0.000055	0.000316
Copper	0.00005		0.00270	-	0.00317	0.00331	0.00321	0.00315	0.00098	0.00133	0.00102	0.00245	0.0709
Iron	0.001		0.047	-	0.174	0.077	0.059	0.092	0.024	0.024	0.025	0.066	0.010
Lead	0.000005		0.000022	-	0.000786	0.000577	0.000099	0.000262	0.000031	0.000045	0.000106	0.000103	0.00666
Lithium	0.0005		0.0007	-	0.0007	0.0005	0.0005	0.0006	0.0021	0.0013	0.0021	0.0008	0.0020
Magnesium	0.05		2.57	-	8.52	7.49	7.49	8.44	8.32	6.31	8.37	7.75	7.03
Manganese	0.00005		0.00729	-	0.00834	0.00411	0.00423	0.00308	0.00395	0.00260	0.00195	0.00333	0.537
Mercury	0.00001		<0.00001	-	0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum	0.00005		0.00019	-	0.00043	0.00057	0.00057	0.00062	0.00105	0.00105	0.00107	0.00040	<0.00005
Nickel	0.00002		0.00105	-	0.00077	0.00084	0.00084	0.00083	0.00154	0.00094	0.00157	0.00069	0.00047
Phosphorous	0.002		0.003	-	0.010	0.004	0.003	0.005	0.002	0.002	0.003	0.004	0.002
Potassium	0.05		0.42	-	1.27	1.21	1.20	1.41	0.71	0.73	0.72	1.04	1.39
Selenium	0.00004		0.00007	-	0.00008	0.00008	0.00008	0.00007	0.00057	0.00029	0.00056	0.00008	<0.00004
Silicon	0.1		7.9	-	4.6	5.0	5.0	4.7	3.3	3.1	3.2	4.2	5.6
Silver	0.000005		<0.000005	-	0.000008	0.000008	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	0.000023
Sodium	0.05		3.42	-	2.95	2.81	2.82	2.93	1.83	1.86	1.84	3.05	2.99
Strontium	0.00005		0.0801	-	0.174	0.143	0.142	0.151	0.133	0.110	0.131	0.141	0.226
Thallium	0.000002		0.000002	-	0.000006	0.000004	0.000003	0.000004	0.000003	0.000002	0.000003	0.000002	0.000025
Tin	0.00001		<0.00001	-	0.00002	0.00001	<0.00001	0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Titanium	0.0005		0.0006	-	0.0041	0.0016	0.0010	0.0024	<0.0005	0.0009	0.0007	0.0009	<0.0005
Uranium	0.000002		0.000078	-	0.00359	0.00480	0.00486	0.00477	0.000941	0.000926	0.00102	0.00131	0.00126
Vanadium	0.0002		<0.0002	-	0.0005	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Zinc	0.0001		0.0195	-	0.0029	0.0016	0.0013	0.0012	0.0018	0.0016	0.0023	0.0023	2.28
Zirconium	0.0001		0.0001	-	0.0007	0.0004	0.0004	0.0003	<0.0001	<0.0001	<0.0001	0.0003	<0.0001

Notes:

All units mg/l unless otherwise noted.

a) Canadian water quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2007.

b) 0.005 mg/L at pH <6.5, [Ca2+] <4 mg/L, DOC <2 mg/L: 0.1 mg/L at pH ≥6.5, [Ca2+] ≥4 mg/L, DOC ≥2 mg/L.

c) 0.002 mg/L at [CaCO3] = 0 - 120 mg/L; 0.003 mg/L at [CaCO3] = 120 - 180 mg/L; 0.004 mg/L at [CaCO3] >180 mg/L.

d) 0.001 mg/L at [CaCO3] = 0 - 60 mg/L; 0.002 mg/L at [CaCO3] = 60 - 120 mg/L; 0.004 mg/L at [CaCO3] =120 -180 mg/L; 0.007 mg/L at [CaCO3] >180 mg/L.

e) 0.025 mg/L at [CaCO3] = 0 - 60 mg/L; 0.065 mg/L at [CaCO3] = 60 - 120 mg/L; 0.110 mg/L at [CaCO3] =120 - 180 mg/L; 0.150 mg/L at [CaCO3] >180 mg/L.

Italic *Results exceed CCME Aquatic Life uidelines.*

Appendix B4. Surface Water Quality Data, Casino Project, September 2008

AECOM

Station	Detection Limits	Water Quality Guidelines	W43 - Replicate taken as W43B	W12 - Proctor Gulch before Confluence with Casino Creek	W8 - Upper Casino Creek	W13 - Meloy Creek	W11 - Casino Creek (proposed dam outflow)	H18 - Casino Creek (downstream of Brynelsen Creek)	W4 - Mouth of Casino Creek	W9 - Dip Creek us of Confluence with Casino Creek	W5 - Dip Creek ds Casino Confluence	W16 - Dip Creek far field	Maxxam Travel Blank
Date		**CCME [a]**	**9-Sep-08**	**10-Sep-08**	**10-Sep-08**	**9-Sep-08**	**9-Sep-08**	**9-Sep-08**	**9-Sep-08**	**9-Sep-08**	**9-Sep-08**	**9-Sep-08**	**9-Sep-08**
Physical Tests													
Temperature C	-		4.2	0.7	3.5	1.9	2.5	3.1	2.3	2.5	-	3.9	-
Conductivity (Field) µS/cm	-		347	690	211	195	207	113	162	129	-	119	-
pH (Field)	-		7.4	3.5	7.7	7.5	7.7	7.6	7.8	7.6	-	7.6	-
Hardness $CaCO_3$	0.5		94.9	235	91.7	93.9	93.4	64.5	78.0	62.7	67.2	68.9	<0.5
Conductivity µS/cm	1		220	740	210	200	210	140	160	130	140	150	1
pH	-	6.5-9.0	7.7	*3.4*	7.7	8.1	7.9	7.8	7.9	7.9	7.9	7.9	6.2
Total Suspended Solids	1		<1	11	14	3	3	2	12	17	25	18	<1
Total Dissolved Solids	1		130	470	150	94	100	70	92	56	76	92	<1
Turbidity NTU	0.1		0.9	18.0	3.4	0.3	1.1	0.5	1.6	4.0	1.7	2.8	<0.1
Dissolved Anions & Nutrients													
Ammonia as N	0.01		<0.01	0.03	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	0.01	0.02	0.01
Alkalinity, Total (as $CaCO_3$)	0.5		67	<0.5	35	82	59	45	55	54	55	56	<0.5
Acidity (pH 8.3) as $CaCO_3$	0.5		9.0	82.1	-	-	-	-	-	-	-	-	-
Chloride (Cl)	0.5		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	0.6	<0.5
Sulfate (SO_4)	0.5		39	240	62	18	43	21	25	9.9	15	18	0.5
Nitrate (as N)	0.002	13	0.454	0.081	0.123	0.361	0.189	0.197	0.169	0.130	0.143	0.109	0.004
Nitrite (as N)	0.002	0.06	<0.002	0.003	0.002	<0.002	0.002	0.002	0.002	0.003	0.002	0.002	<0.002
Total Kjeldahl Nitrogen	0.02		0.02	0.13	0.11	0.14	0.15	0.15	0.17	0.15	0.22	0.19	<0.02
Ortho Phosphate as P	0.001		0.002	0.002	0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.001	0.002	<0.001
Cyanide, Weak Acid Diss	0.0005		<0.0005	<0.0005	<0.0005	<0.0005	0.0005	0.0008	0.0005	<0.0005	<0.0005	0.0007	<0.0005
Total Cyanide	0.0005	0.005	<0.0005	<0.0005	0.0006	0.0007	0.0008	0.0013	0.0010	0.0010	0.0010	0.0010	<0.0005
Total Metals													
Aluminum	0.0002	0.005-0.1 [b]	0.0224	*6.35*	*0.592*	0.0452	*0.195*	*0.157*	*0.192*	*0.157*	*0.354*	*0.203*	0.0008
Antimony	0.00002		0.00263	0.00015	0.00014	0.00024	0.00015	0.00013	0.00013	0.00008	0.00010	0.00010	<0.00002
Arsenic	0.00002	0.005	0.00077	0.00028	0.00055	0.00089	0.00060	0.00043	0.00050	0.00046	0.00066	0.00063	<0.00002
Barium	0.00002		0.0649	0.0285	0.0524	0.0718	0.0493	0.0379	0.0447	0.0457	0.0539	0.0466	<0.00002
Beryllium	0.00001		<0.00001	0.00037	0.00005	<0.00001	0.00002	0.00001	0.00002	0.00002	0.00003	0.00002	<0.00001
Bismuth	0.000005		<0.000005	0.000005	0.000009	<0.000005	<0.000005	<0.000005	<0.000005	0.000007	0.000008	<0.000005	0.000021
Boron	0.05		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cadmium	0.000005	0.000017	*0.0427*	*0.00176*	*0.000260*	*0.000041*	*0.000083*	*0.000032*	*0.000034*	0.000015	*0.000035*	*0.000021*	<0.000005
Calcium	0.05		26.3	71.3	27.7	26.1	26.1	17.9	21.0	16.5	17.7	17.7	<0.05
Chromium	0.0001	0.001	<0.0001	0.0005	0.0004	0.0002	0.0002	0.0003	0.0003	0.0004	0.0005	0.0005	<0.0001
Cobalt	0.000005		0.000313	0.0249	0.00235	0.000031	0.000511	0.000180	0.000233	0.000158	0.000393	0.000228	<0.000005
Copper	0.00005	0.002-0.004 [c]	*0.0743*	*0.650*	*0.0615*	0.00098	*0.0206*	*0.00746*	*0.00866*	0.00163	*0.00454*	*0.00362*	<0.00005
Iron	0.001	0.3	0.048	*14.2*	*0.873*	0.060	0.274	0.156	0.273	0.259	*0.567*	*0.384*	<0.001
Lead	0.000005	0.001-0.007 [d]	*0.0120*	0.000962	0.00137	0.000662	0.000165	0.000090	0.000214	0.000305	0.000732	0.000334	0.000009
Lithium	0.0005		0.0020	0.0042	0.0010	0.0010	0.0009	0.0007	0.0009	0.0020	0.0018	0.0013	<0.0005
Magnesium	0.05		7.07	13.9	5.47	7.00	6.86	4.82	6.19	5.25	5.56	5.99	<0.05
Manganese	0.00005		0.526	0.741	0.0717	0.00758	0.0275	0.0103	0.0166	0.0200	0.0419	0.0297	<0.00005
Mercury	0.00001	0.000026	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum	0.00005	0.073	<0.00005	0.00015	0.00025	0.00053	0.00054	0.00072	0.00085	0.00059	0.00061	0.00067	<0.00005
Nickel	0.00002	0.025-0.15 [e]	0.00043	0.00438	0.00126	0.00030	0.00065	0.00045	0.00055	0.00060	0.00083	0.00087	<0.00002
Phosphorous	0.002		0.003	0.007	0.031	0.004	0.004	0.005	0.011	0.014	0.049	0.018	<0.002
Potassium	0.05		1.35	1.49	0.88	0.95	0.74	0.74	0.81	0.57	0.64	0.69	<0.05
Selenium	0.00004	0.001	<0.00004	0.00015	0.00004	<0.00004	0.00005	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004
Silicon	0.1		6.2	8.1	5.8	5.0	4.9	5.1	5.2	4.5	4.7	4.7	<0.1
Silver	0.000005	0.0001	*0.000116*	0.000016	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005
Sodium	0.05		3.07	4.51	3.10	3.11	2.89	2.66	3.08	2.74	2.79	2.89	<0.05
Strontium	0.00005		0.220	0.195	0.180	0.161	0.162	0.101	0.125	0.127	0.125	0.118	<0.00005
Thallium	0.000002	0.0008	0.000026	0.000057	0.000010	0.000002	0.000004	0.000004	0.000004	0.000003	0.000007	0.000003	<0.000002
Tin	0.00001		<0.00001	<0.00001	0.00003	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Titanium	0.0005		<0.0005	<0.0005	0.0058	0.0011	0.0013	0.0018	0.0051	0.0067	0.0196	0.0070	<0.0005
Uranium	0.000002		0.00126	0.00838	0.00164	0.00637	0.00400	0.00229	0.00294	0.00323	0.00338	0.00254	<0.000002
Vanadium	0.0002		<0.0002	<0.0002	0.0004	<0.0002	0.0002	0.0004	0.0008	0.0009	0.0017	0.0012	<0.0002
Zinc	0.0001	0.03	*2.38*	*0.127*	0.0214	0.0025	0.0056	0.0022	0.0024	0.0019	0.0035	0.0029	<0.0001
Zirconium	0.0001		<0.0001	0.0002	0.0002	0.0001	0.0002	0.0003	0.0004	0.0004	0.0004	0.0005	<0.0001

Station	Detection Limits	Water Quality Guidelines	W43 - Replicate taken as W43B	W12 - Proctor Gulch before Confluence with Casino Creek	W8 - Upper Casino Creek	W13 - Meloy Creek	W11 - Casino Creek (proposed dam outflow)	H18 - Casino Creek (downstream of Brynelsen Creek)	W4 - Mouth of Casino Creek	W9 - Dip Creek us of Confluence with Casino Creek	W5 - Dip Creek ds Casino Confluence	W16 - Dip Creek far field	Maxxam Travel Blank
Date		**CCME [a]**	**9-Sep-08**	**10-Sep-08**	**10-Sep-08**	**9-Sep-08**	**9-Sep-08**	**9-Sep-08**	**9-Sep-08**	**9-Sep-08**	**9-Sep-08**	**9-Sep-08**	**9-Sep-08**
Dissolved Metals													
Aluminum	0.0002		0.0014	6.40	0.0604	0.0228	0.0574	0.104	0.0771	0.0588	0.0673	0.0597	0.0007
Antimony	0.00002		0.00252	0.00014	0.00011	0.00024	0.00016	0.00013	0.00013	0.00008	0.00010	0.00009	<0.00002
Arsenic	0.00002		0.00046	0.00030	0.00022	0.00083	0.00049	0.00037	0.00038	0.00033	0.00037	0.00045	<0.00002
Barium	0.00002		0.0620	0.0291	0.0467	0.0704	0.0500	0.0372	0.0407	0.0406	0.0410	0.0420	<0.00002
Beryllium	0.00001		<0.00001	0.00037	0.00001	<0.00001	0.00001	<0.00001	<0.00001	<0.00001	0.00001	0.00001	<0.00001
Bismuth	0.000005		<0.000005	0.000008	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	0.000007
Boron	0.05		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cadmium	0.000005		0.0418	0.00179	0.000190	0.000033	0.000071	0.000025	0.000021	0.000007	0.000012	0.000008	<0.000005
Calcium	0.05		26.7	74.0	27.6	26.0	26.7	16.9	20.2	16.2	17.6	18.2	<0.05
Chromium	0.0001		<0.0001	0.0005	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0003	<0.0001
Cobalt	0.000005		0.000312	0.0262	0.00227	0.000020	0.000464	0.000131	0.000125	0.000063	0.000090	0.000091	<0.000005
Copper	0.00005		0.0703	0.681	0.0323	0.00098	0.0164	0.00544	0.00706	0.00130	0.00323	0.00277	<0.00005
Iron	0.001		0.010	15.1	0.264	0.021	0.136	0.083	0.092	0.097	0.105	0.141	0.001
Lead	0.000005		0.00680	0.00124	0.000105	0.000080	0.000117	0.000029	0.000043	0.000073	0.000042	0.000054	0.000017
Lithium	0.0005		0.0020	0.0043	0.0010	0.0009	0.0009	0.0006	0.0008	0.0019	0.0015	0.0013	<0.0005
Magnesium	0.05		7.00	14.3	5.54	6.81	6.86	4.50	5.84	5.10	5.37	6.11	<0.05
Manganese	0.00005		0.543	0.757	0.0624	0.00359	0.0260	0.00712	0.00787	0.00899	0.0123	0.0140	0.00006
Mercury	0.00001		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum	0.00005		<0.00005	0.00014	0.00020	0.00052	0.00055	0.00076	0.00091	0.00064	0.00072	0.00076	<0.00005
Nickel	0.00002		0.00064	0.00467	0.00095	0.00029	0.00056	0.00045	0.00044	0.00070	0.00044	0.00064	<0.00002
Phosphorous	0.002		0.002	0.005	0.002	<0.002	0.003	0.003	0.003	0.005	0.005	0.005	<0.002
Potassium	0.05		1.38	1.53	0.77	0.94	0.77	0.75	0.78	0.56	0.63	0.71	<0.05
Selenium	0.00004		<0.00004	0.00018	0.00007	<0.00004	0.00008	0.00004	0.00004	0.00004	0.00005	0.00006	<0.00004
Silicon	0.1		5.8	8.9	6.3	4.7	5.4	4.8	4.9	4.8	4.9	4.8	<0.1
Silver	0.000005		0.000022	0.000022	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005
Sodium	0.05		2.96	4.64	3.07	3.02	2.91	2.51	2.91	2.68	2.75	2.96	<0.05
Strontium	0.00005		0.224	0.202	0.178	0.162	0.168	0.0970	0.124	0.125	0.124	0.124	<0.00005
Thallium	0.000002		0.000025	0.000060	0.000007	<0.000002	0.000004	0.000003	0.000003	<0.000002	<0.000002	<0.000002	<0.000002
Tin	0.00001		<0.00001	0.00002	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Titanium	0.0005		<0.0005	0.0023	0.0010	<0.0005	0.0007	0.0011	0.0010	0.0014	0.0022	0.0011	<0.0005
Uranium	0.000002		0.00125	0.00871	0.00108	0.00634	0.00405	0.00213	0.00281	0.00308	0.00293	0.00253	<0.000002
Vanadium	0.0002		<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0003	0.0003	0.0004	<0.0002
Zinc	0.0001		2.28	0.133	0.0125	0.0021	0.0057	0.0017	0.0020	0.0038	0.0010	0.0012	<0.0001
Zirconium	0.0001		<0.0001	0.0002	0.0001	0.0001	0.0002	0.0003	0.0003	0.0003	0.0003	0.0004	<0.0001

Notes:

All units mg/l unless otherwise noted.

a) Canadian water quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2007.

b) 0.005 mg/L at pH <6.5, [Ca2+] <4 mg/L, DOC <2 mg/L: 0.1 mg/L at pH ≥6.5, [Ca2+] ≥4 mg/L, DOC ≥2 mg/L.

c) 0.002 mg/L at [CaCO3] = 0 - 120 mg/L; 0.003 mg/L at [CaCO3] = 120 - 180 mg/L; 0.004 mg/L at [CaCO3] >180 mg/L.

d) 0.001 mg/L at [CaCO3] = 0 - 60 mg/L; 0.002 mg/L at [CaCO3] = 60 - 120 mg/L; 0.004 mg/L at [CaCO3] =120 -180 mg/L; 0.007 mg/L at [CaCO3] >180 mg/L.

e) 0.025 mg/L at [CaCO3] = 0 - 60 mg/L; 0.065 mg/L at [CaCO3] = 60 - 120 mg/L; 0.110 mg/L at [CaCO3] =120 - 180 mg/L; 0.150 mg/L at [CaCO3] >180 mg/L.

Italic *Results exceed CCME Aquatic Life u*

B5. Surface Water Quality Data, Casino Project, October 2008

Appendix B5. Surface Water Quality Data, Casino Project, October 2008

AECOM

Station	Detection Limits	Water Quality Guidelines	W7 - Upper Canadian Creek	W3 - Canadian Creek us of Confluence with Britannia Creek	W14 - Mouth of Britannia Creek	W1 - Mouth of Canadian Creek	W6b - Yukon River Upstream of Canadian Creek	W6a - Yukon River Downstream of Canadian Creek	W43 - Adit Discharge Pipe at Lower Camp	W12 - Proctor Gulch before Confluence with Casino Creek
Date		CCME [a]	10-Oct-08	11-Oct-08	10-Oct-08	10-Oct-08	10-Oct-08	10-Oct-08	11-Oct-08	11-Oct-08
Physical Tests										
Temperature C	-		0.0	1.8	0.3	1.9	4.3	3.6	1.5	0.4
Conductivity (Field) µS/cm	-		136	265	294	298	183	225	228	1026
pH (Field)	-		6.9	8.0	7.6	7.8	8.0	8.0	6.8	*3.5*
Hardness $CaCO_3$	0.5		44.7	119	139	138	109	84.2	99.1	335
Conductivity µS/cm	1		130	260	300	300	220	180	220	1000
pH	-	6.5-9.0	7.1	8.0	8.1	8.1	8.1	8.1	7.6	*3.3*
Total Suspended Solids	1		1	<1	<1	<1	14	12	4	2
Total Dissolved Solids	1		110	210	230	240	180	130	170	1000
Turbidity NTU	0.1		0.3	0.2	0.3	0.2	11.0	3.6	0.9	10.0
Dissolved Anions & Nutrients										
Ammonia as N	0.01		<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	0.05
Alkalinity, Total (as $CaCO_3$)	0.5		7.3	72	91	82	81	73	67	<0.5
Acidity (pH 8.3) as $CaCO_3$	0.5		-	-	-	-	-	-	13.7	131
Chloride (Cl)	0.5		0.6	1.2	1.5	1.5	0.8	0.8	5.0	1.0
Sulfate (SO_4)	0.5		47	50	52	42	33	19	49	450
Nitrate (as N)	0.002	13	0.004	0.236	0.304	0.249	0.015	0.014	0.296	0.032
Nitrite (as N)	0.002	0.06	<0.002	0.002	0.002	0.004	<0.002	0.002	0.002	0.005
Total Kjeldahl Nitrogen	0.02		0.11	0.20	0.28	0.39	0.09	0.09	0.07	0.16
Ortho Phosphate as P	0.001		0.002	0.003	0.002	0.002	0.002	0.002	0.002	0.003
Cyanide, Weak Acid Diss	0.0005		<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0038
Total Cyanide	0.0005	0.005	<0.0005	0.0007	0.0010	0.0008	<0.0005	<0.0005	<0.0005	*0.0101*
Total Organic Carbon	0.5		2.8	8.0	11.5	8.6	3.9	3.6	1.4	3.0
Total Metals										
Aluminum	0.0002	0.005-0.1[b]	0.0253	0.0159	0.0494	0.0222	*0.208*	*0.107*	0.0139	*10.3*
Antimony	0.00002		0.00005	0.00035	0.00023	0.00027	0.00013	0.00010	0.00272	0.00016
Arsenic	0.00002	0.005	0.00016	0.00057	0.00050	0.00050	0.00059	0.00051	0.00072	0.00027
Barium	0.00002		0.0472	0.0528	0.0782	0.0597	0.0579	0.0427	0.0652	0.0108
Beryllium	0.00001		0.00001	<0.00001	0.00001	<0.00001	0.00002	0.00001	<0.00001	0.00053
Bismuth	0.000005		<0.000005	<0.000005	<0.000005	<0.000005	0.000005	<0.000005	0.000010	<0.000005
Boron	0.05		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cadmium	0.000005	0.000017	*0.000135*	0.000014	0.000007	0.000011	*0.000097*	*0.000061*	*0.0473*	*0.00244*
Calcium	0.05		13.2	30.4	32.7	34.2	28.7	23.0	27.3	99.1
Chromium	0.0001	0.001	<0.0001	<0.0001		<0.0001	0.0003	0.0002	<0.0001	0.0006
Cobalt	0.000005		0.000033	0.000044	0.000050	0.000042	0.000219	0.000138	0.000366	0.0409
Copper	0.00005	0.002-0.004[c]	0.00139	*0.00217*	0.00158	0.00194	0.00159	0.00121	*0.0686*	*0.92*
Iron	0.001	0.3	0.019	0.016	0.037	0.017	*0.368*	0.169	0.063	*26.2*
Lead	0.000005	0.001-0.007[d]	0.000031	0.000010	0.000072	0.000030	0.000224	0.000275	*0.0181*	0.000661
Lithium	0.0005		0.0007	<0.0005	0.0009	0.0007	0.0023	0.0015	0.0022	0.0059
Magnesium	0.05		2.83	10.5	14.0	12.7	9.01	6.52	7.51	21.2
Manganese	0.00005		0.00127	0.00675	0.00294	0.00171	0.0220	0.0152	0.472	1.04
Mercury	0.00001	0.000026	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum	0.00005	0.073	0.00027	0.00088	0.00055	0.00077	0.00096	0.00100	<0.00005	0.00021
Nickel	0.00002	0.025-0.15[e]	0.00063	0.00066	0.00050	0.00060	0.00314	0.00160	0.00055	0.00642
Phosphorous	0.002		<0.002	<0.002	0.004	<0.002	0.017	0.015	0.003	0.004
Potassium	0.05		0.47	1.63	1.65	1.81	0.70	0.70	1.27	1.80
Selenium	0.00004	0.001	0.00006	0.00006	0.00007	0.00010	0.00068	0.00033	<0.00004	0.00024
Silicon	0.1		9.9	5.3	4.6	5.1	3.8	3.1	4.6	6.8
Silver	0.000005	0.0001	<0.000005	<0.000005	<0.000005	<0.000005	0.000007	<0.000005	*0.000146*	0.000021
Sodium	0.05		4.40	3.89	4.44	4.12	1.91	1.92	3.38	6.26
Strontium	0.00005		0.0908	0.198	0.286	0.223	0.135	0.107	0.245	0.287
Thallium	0.000002	0.0008	0.000002	0.000002	0.000003	0.000003	0.000005	0.000003	0.000027	0.000082
Tin	0.00001		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Titanium	0.0005		<0.0005	<0.0005	0.0010	0.0006	0.0045	0.0022	<0.0005	<0.0005
Uranium	0.000002		0.000043	0.0101	0.00833	0.0102	0.00102	0.000968	0.00128	0.0125
Vanadium	0.0002		0.0002	<0.0002	0.0002	<0.0002	0.0006	0.0003	<0.0002	<0.0002
Zinc	0.0001	0.03	0.0126	0.0006	0.0006	0.0003	0.0093	0.0074	*2.64*	*0.189*
Zirconium	0.0001		<0.0001	0.0002	0.0004	0.0002	0.0001	<0.0001	<0.0001	<0.0001

Appendix B5. Surface Water Quality Data, Casino Project, October 2008

Station	Detection Limits	Water Quality Guidelines	W7 - Upper Canadian Creek	W3 - Canadian Creek us of Confluence with Britannia Creek	W14 - Mouth of Britannia Creek	W1 - Mouth of Canadian Creek	W6b - Yukon River Upstream of Canadian Creek	W6a - Yukon River Downstream of Canadian Creek	W43 - Adit Discharge Pipe at Lower Camp	W12 - Proctor Gulch before Confluence with Casino Creek
Date		**CCME [a]**	**10-Oct-08**	**11-Oct-08**	**10-Oct-08**	**10-Oct-08**	**10-Oct-08**	**10-Oct-08**	**11-Oct-08**	**11-Oct-08**
Dissolved Metals										
Aluminum	0.0002	0.005-0.1[b]	0.0176	0.0142	0.0404	0.0179	0.0241	0.0224	0.0013	2.58
Antimony	0.00002		0.00005	0.00034	0.00023	0.00024	0.00012	0.00009	0.00243	<0.0001
Arsenic	0.00002	0.005	0.00012	0.00053	0.00045	0.00045	0.00036	0.00036	0.00029	0.0001
Barium	0.00002		0.0427	0.0505	0.0732	0.0525	0.0433	0.0361	0.0590	0.0089
Beryllium	0.00001		<0.00001	<0.00001	0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00005
Bismuth	0.000005		<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.00003
Boron	0.05		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.3
Cadmium	0.000005	0.000017	0.000120	0.000019	<0.000005	0.000010	0.000038	0.000037	0.0438	0.00005
Calcium	0.05		12.5	29.0	30.0	32.6	26.8	22.5	25.4	83.7
Chromium	0.0001	0.001	<0.0001	<0.0001	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0005
Cobalt	0.000005		0.000024	0.000042	0.000044	0.000042	0.000025	0.000027	0.000332	0.00063
Copper	0.00005	0.002-0.004[c]	0.00131	0.00212	0.00149	0.00189	0.00099	0.00084	0.0623	0.0162
Iron	0.001	0.3	0.007	0.015	0.031	0.014	0.028	0.025	0.011	0.355
Lead	0.000005	0.001-0.007[d]	0.000010	0.000065	0.000086	0.000014	0.000065	0.000185	0.00626	0.00005
Lithium	0.0005		0.0006	<0.0005	0.0008	0.0007	0.0021	0.0014	0.0021	0.006
Magnesium	0.05		2.72	10.1	13.0	12.4	8.36	6.38	6.93	0.34
Manganese	0.00005		0.00074	0.00663	0.00220	0.00137	0.00238	0.00427	0.430	0.0154
Mercury	0.00001	0.000026	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00005
Molybdenum	0.00005	0.073	0.00025	0.00084	0.00051	0.00070	0.00096	0.00098	<0.00005	<0.0003
Nickel	0.00002	0.025-0.15[e]	0.00062	0.00064	0.00046	0.00056	0.00216	0.00111	0.00048	0.0002
Phosphorous	0.002		<0.002	<0.002	0.003	<0.002	<0.002	0.003	<0.002	<0.01
Potassium	0.05		0.44	1.54	1.53	1.72	0.64	0.67	1.18	2.28
Selenium	0.00004	0.001	0.00005	0.00007	0.00008	0.00011	0.00062	0.00031	<0.00004	<0.0002
Silicon	0.1		8.8	4.9	4.3	5.0	3.0	2.8	5.2	4.0
Silver	0.000005	0.0001	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	0.000023	<0.00003
Sodium	0.05		4.13	3.68	4.11	3.93	1.77	1.85	3.05	1430
Strontium	0.00005		0.0852	0.189	0.258	0.195	0.125	0.105	0.226	0.281
Thallium	0.000002	0.0008	<0.000002	<0.000002	0.000003	0.000002	0.000003	0.000002	0.000024	0.00007
Tin	0.00001		<0.00001	0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00005
Titanium	0.0005		<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.003
Uranium	0.000002		0.000039	0.00954	0.00767	0.00915	0.000906	0.000942	0.00116	0.00033
Vanadium	0.0002		0.0003	<0.0002	0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.001
Zinc	0.0001	0.03	0.0114	0.0009	0.0007	0.0004	0.0023	0.0051	2.47	0.0034
Zirconium	0.0001		<0.0001	0.0001	0.0004	0.0002	<0.0001	<0.0001	<0.0001	<0.0005

Notes:

All units mg/l unless otherwise noted.

a) Canadian water quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2007.

b) 0.005 mg/L at pH <6.5, [Ca2+] <4 mg/L, DOC <2 mg/L: 0.1 mg/L at pH ≥6.5, [Ca2+] ≥4 mg/L, DOC ≥2 mg/L.

c) 0.002 mg/L at [CaCO3] = 0 - 120 mg/L; 0.003 mg/L at [CaCO3] = 120 - 180 mg/L; 0.004 mg/L at [CaCO3] >180 mg/L.

d) 0.001 mg/L at [CaCO3] = 0 - 60 mg/L; 0.002 mg/L at [CaCO3] = 60 - 120 mg/L; 0.004 mg/L at [CaCO3] =120 -180 mg/L; 0.007 mg/L at [CaCO3] >180 mg/L.

e) 0.025 mg/L at [CaCO3] = 0 - 60 mg/L; 0.065 mg/L at [CaCO3] = 60 - 120 mg/L; 0.110 mg/L at [CaCO3] =120 - 180 mg/L; 0.150 mg/L at [CaCO3] >180 mg/L.

Italic *Results exceed CCME Aquatic Life uidelines.*

Appendix B5. Surface Water Quality Data, Casino Project, October 2008

Station	Detection Limits	Water Quality Guidelines	W11 - Casino Creek (proposed dam outflow)	W18 - Brynelsen Creek	W4 - Mouth of Casino Creek	W9 - Dip Creek us of Confluence with Casino Creek	W5 - Dip Creek ds Casino Confluence
Date		CCME [a]	11-Oct-08	11-Oct-08	10-Oct-08	10-Oct-08	10-Oct-08
Physical Tests							
Temperature C	-		0.0	0.0	0.0	0.1	0.4
Conductivity (Field) µS/cm	-		278	165	240	172	198
pH (Field)	-		6.9	7.6	7.7	7.5	7.6
Hardness $CaCO_3$	0.5		125	70.3	110	79.7	88.2
Conductivity µS/cm	1		270	160	240	170	190
pH	-	6.5-9.0	8.1	8.0	8.0	8.0	8.0
Total Suspended Solids	1		1	1	2	3	2
Total Dissolved Solids	1		220	110	190	130	150
Turbidity NTU	0.1		1.0	0.3	0.7	0.4	0.5
Dissolved Anions & Nutrients							
Ammonia as N	0.01		<0.01	<0.01	<0.01	<0.01	<0.01
Alkalinity, Total (as $CaCO_3$)	0.5		80	60	80	74	75
Acidity (pH 8.3) as $CaCO_3$	0.5		-	-			
Chloride (Cl)	0.5		0.6	0.6	1.0	1.4	2.5
Sulfate (SO_4)	0.5		50	25	40	15	25
Nitrate (as N)	0.002	13	0.245	0.236	0.203	0.191	0.189
Nitrite (as N)	0.002	0.06	0.003	0.003	0.003	0.003	<0.002
Total Kjeldahl Nitrogen	0.02		0.13	0.10	0.08	0.13	0.12
Ortho Phosphate as P	0.001		0.002	0.003	0.002	0.005	0.002
Cyanide, Weak Acid Diss	0.0005		<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Total Cyanide	0.0005	0.005	<0.0005	0.0005	0.0005	0.0009	<0.0005
Total Organic Carbon	0.5		2.9	4.7	5.1	6.6	5.8
Total Metals							
Aluminum	0.0002	0.005-0.1 [b]	0.0889	0.0325	0.0519	0.0354	0.0307
Antimony	0.00002		0.00015	0.00014	0.00013	0.00009	0.00010
Arsenic	0.00002	0.005	0.00054	0.00034	0.00038	0.00028	0.00034
Barium	0.00002		0.0623	0.0404	0.0550	0.0515	0.0498
Beryllium	0.00001		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Bismuth	0.000005		<0.000005	<0.000005	<0.000005	0.000011	<0.000005
Boron	0.05		<0.05	<0.05	<0.05	<0.05	<0.05
Cadmium	0.000005	0.000017	*0.000064*	0.000008	*0.000028*	<0.000005	0.000015
Calcium	0.05		34.0	19.0	29.2	20.6	22.9
Chromium	0.0001	0.001	<0.0001	<0.0001	<0.0001	0.0001	<0.0001
Cobalt	0.000005		0.000245	0.000027	0.000074	0.000050	0.000047
Copper	0.00005	0.002-0.004 [c]	*0.0118*	0.00079	*0.00528*	0.00091	*0.00226*
Iron	0.001	0.3	0.198	0.025	0.094	0.072	0.058
Lead	0.000005	0.001-0.007 [d]	0.000100	0.000018	0.000074	0.000073	0.000065
Lithium	0.0005		0.0012	0.0006	0.0011	0.0023	0.0018
Magnesium	0.05		9.84	5.53	8.95	6.87	7.52
Manganese	0.00005		0.0264	0.00263	0.00964	0.0127	0.0104
Mercury	0.00001	0.000026	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum	0.00005	0.073	0.00071	0.00123	0.00112	0.00070	0.00082
Nickel	0.00002	0.025-0.15 [e]	0.00036	0.00019	0.00027	0.00032	0.00031
Phosphorous	0.002		<0.002	<0.002	0.003	0.005	0.002
Potassium	0.05		0.87	0.89	0.94	0.64	0.74
Selenium	0.00004	0.001	0.00013	<0.00004	0.00005	<0.00004	<0.00004
Silicon	0.1		6.5	5.6	5.6	5.2	5.4
Silver	0.000005	0.0001	<0.000005	<0.000005	<0.000005	<0.000005	0.000007
Sodium	0.05		3.76	3.30	4.20	3.64	3.81
Strontium	0.00005		0.220	0.104	0.180	0.169	0.165
Thallium	0.000002	0.0008	0.000003	0.000002	<0.000002	0.000003	<0.000002
Tin	0.00001		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Titanium	0.0005		<0.0005	0.0006	0.0009	0.0015	0.0006
Uranium	0.000002		0.00820	0.00300	0.00627	0.00583	0.00558
Vanadium	0.0002		<0.0002	<0.0002	<0.0002	0.0003	0.0002
Zinc	0.0001	0.03	0.0040	0.0005	0.0017	0.0007	0.0010
Zirconium	0.0001		<0.0001	0.0001	0.0001	0.0002	0.0002

Appendix B5. Surface Water Quality Data, Casino Project, October 2008

Station	Detection Limits	Water Quality Guidelines	W11 - Casino Creek (proposed dam outflow)	W18 - Brynelsen Creek	W4 - Mouth of Casino Creek	W9 - Dip Creek us of Confluence with Casino Creek	W5 - Dip Creek ds Casino Confluence
Date		CCME [a]	11-Oct-08	11-Oct-08	10-Oct-08	10-Oct-08	10-Oct-08
Dissolved Metals							
Aluminum	0.0002	0.005-0.1[b]	0.0207	0.0250	0.0210	0.0219	0.0187
Antimony	0.00002		0.00013	0.00013	0.00012	0.00007	0.00009
Arsenic	0.00002	0.005	0.00042	0.00030	0.00032	0.00026	0.00028
Barium	0.00002		0.0584	0.0386	0.0528	0.0478	0.0489
Beryllium	0.00001		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Bismuth	0.000005		<0.000005	<0.000005	<0.000005	<0.000005	<0.000005
Boron	0.05		<0.05	<0.05	<0.05	<0.05	<0.05
Cadmium	0.000005	0.000017	0.000052	0.000006	0.000018	<0.000005	0.000010
Calcium	0.05		32.5	18.6	27.4	19.5	21.7
Chromium	0.0001	0.001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cobalt	0.000005		0.000229	0.000020	0.000058	0.000055	0.000039
Copper	0.00005	0.002-0.004[c]	0.00704	0.00077	0.00363	0.00086	0.00182
Iron	0.001	0.3	0.036	0.014	0.030	0.042	0.035
Lead	0.000005	0.001-0.007[d]	0.000025	0.000022	0.000020	0.000040	0.000010
Lithium	0.0005		0.0011	<0.0005	0.0010	0.0023	0.0018
Magnesium	0.05		9.42	5.40	8.41	6.64	7.09
Manganese	0.00005		0.0242	0.00184	0.00684	0.0104	0.00963
Mercury	0.00001	0.000026	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum	0.00005	0.073	0.00065	0.00115	0.00105	0.00070	0.00078
Nickel	0.00002	0.025-0.15[e]	0.00033	0.00018	0.00024	0.00028	0.00028
Phosphorous	0.002		<0.002	<0.002	<0.002	0.003	<0.002
Potassium	0.05		0.84	0.88	0.88	0.62	0.71
Selenium	0.00004	0.001	0.00009	<0.00004	0.00004	<0.00004	<0.00004
Silicon	0.1		5.2	4.8	5.1	4.5	5.1
Silver	0.000005	0.0001	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005
Sodium	0.05		3.55	3.21	3.82	3.41	3.50
Strontium	0.00005		0.212	0.0996	0.176	0.160	0.169
Thallium	0.000002	0.0008	0.000003	0.000003	<0.000002	<0.000002	0.000002
Tin	0.00001		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Titanium	0.0005		<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Uranium	0.000002		0.00762	0.00287	0.00590	0.00543	0.00539
Vanadium	0.0002		<0.0002	0.0002	<0.0002	0.0002	<0.0002
Zinc	0.0001	0.03	0.0031	0.0005	0.0012	0.0005	0.0007
Zirconium	0.0001		<0.0001	0.0001	0.0001	0.0002	0.0001

Notes:

All units mg/l unless otherwise noted.

a) Canadian water quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2007.

b) 0.005 mg/L at pH <6.5, [Ca2+] <4 mg/L, DOC <2 mg/L: 0.1 mg/L at pH ≥6.5, [Ca2+] ≥4 mg/L, DOC ≥2 mg/L.

c) 0.002 mg/L at [CaCO3] = 0 - 120 mg/L; 0.003 mg/L at [CaCO3] = 120 - 180 mg/L; 0.004 mg/L at [CaCO3] >180 mg/L.

d) 0.001 mg/L at [CaCO3] = 0 - 60 mg/L; 0.002 mg/L at [CaCO3] = 60 - 120 mg/L; 0.004 mg/L at [CaCO3] =120 -180 mg/L; 0.007 mg/L at [CaCO3] >180 mg/L.

e) 0.025 mg/L at [CaCO3] = 0 - 60 mg/L; 0.065 mg/L at [CaCO3] = 60 - 120 mg/L 0.110 mg/L at [CaCO3] =120 - 180 mg/L; 0.150 mg/L at [CaCO3] >180 mg/L.

Italic *Results exceed CCME Aquatic Life u*

B6. Surface Water Quality Replicate Data, Casino Project, 2008

Appendix B6. Surface Water Quality Replicate Data, Casino Project, May 2008

Station	W1	W1-R (W42)	RPD	Station	W1	W1-R (W42)	RPD
Date	5/22/2008	5/22/2008	%	Date	5/22/2008	5/22/2008	%
Physical Tests				**Dissolved Anions & Nutrients**			
Conductivity (us/cm)	92	92	0%	Alkalinity-Total	21	21	0%
Dissolved Hardness	48.9	48.6	1%	Alkalinity (PP as CaCO3)	<0.5	<0.5	n/c
pH	7.2	7.2	0%	Ammonia Nitrogen	0.011	0.009	20%
Total Suspended Solids	190	150	24%	Bicarbonate (HCO3)	26	25	4%
Total Dissolved Solids	92	92	0%	Carbonate (CO3)	<0.5	<0.5	n/c
Tubidity (NTU)	3.6	2.4	**40%**	Chloride Cl	1.2	1.2	0%
Cyanide + Thiocyanate	0.0013	0.0012	8%	Hydroxide (OH)	<0.5	<0.5	n/c
Total Hardness	49.6	48.9	1%	Nitrate Nitrogen	0.05	0.048	4%
Weak Acid Dissoc. Cyanide	0.001	0.0009	11%	Nitrite Nitrogen	0.003	0.003	0%
				Nitrate plus Nitrite	0.053	0.051	4%
				Ortho Phosphate as P	<0.001	<0.001	n/c
				Sulphate	17	13	**27%**
				Total Kjeldahl Nitrogen	0.41	0.32	25%
				Total Nitrogen	0.46	0.37	22%
Total Metals				**Dissolved Metals**			
Aluminum	0.723	0.579	22%	Aluminum	0.289	0.29	0%
Antimony	0.00019	0.00018	5%	Antimony	0.00018	0.00017	6%
Arsenic	0.00162	0.00134	19%	Arsenic	0.0007	0.0007	0%
Barium	0.059	0.0552	7%	Barium	0.0368	0.0365	1%
Beryllium	0.00006	0.00005	18%	Beryllium	0.00002	0.00003	**40%**
Bismuth	0.000009	0.000015	**50%**	Bismuth	<0.000005	<0.000005	n/c
Boron	<0.05	<0.05	n/c	Boron	<0.05	<0.05	n/c
Cadmium	0.00008	0.000084	5%	Cadmium	0.000039	0.000037	5%
Calcium	12.4	12.3	1%	Calcium	12.3	12.2	1%
Chromium	0.0011	0.0009	20%	Chromium	0.0004	0.0004	0%
Cobalt	0.000848	0.00066	25%	Cobalt	0.000204	0.000208	2%
Copper	0.00663	0.00634	4%	Copper	0.00508	0.00508	0%
Iron	1.00	0.709	**34%**	Iron	0.236	0.24	2%
Lead	0.000866	0.000625	**32%**	Lead	0.000064	0.000061	5%
Lithium	0.0007	0.0006	15%	Lithium	<0.0005	<0.0005	n/c
Magnesium	4.54	4.41	3%	Magnesium	4.44	4.39	1%
Manganese	0.0689	0.0612	12%	Manganese	0.016	0.0161	1%
Mercury	0.00001	0.00001	0%	Mercury	<0.00001	<0.00001	n/c
Molybdenum	0.0003	0.0003	0%	Molybdenum	0.00033	0.0003	10%
Nickel	0.00227	0.00208	9%	Nickel	0.00135	0.00134	1%
Phosphorus	0.084	0.062	**30%**	Phosphorus	0.013	0.014	7%
Potassium	1.3	1.27	2%	Potassium	1.25	1.24	1%
Selenium	<0.00004	<0.00004	n/c	Selenium	0.00006	0.00006	0%
Silicon	2.6	2.4	8%	Silicon	2.2	2.2	0%
Silver	0.00001	0.000008	22%	Silver	<0.000005	0.000005	n/c
Sodium	1.39	1.38	1%	Sodium	1.5	1.5	0%
Strontium	0.0809	0.0798	1%	Strontium	0.0786	0.0792	1%
Sulfur	6	6	0%	Sulfur	7	6	15%
Tellurium	<0.00002	<0.00002	n/c	Tellurium	<0.00002	<0.00002	n/c
Thallium	0.000011	0.000011	0%	Thallium	0.000005	0.000005	0%
Thorium	0.000275	0.000251	9%	Thorium	0.000227	0.000231	2%
Tin	<0.00001	<0.00001	n/c	Tin	<0.00001	<0.00001	n/c
Titanium	0.0254	0.0165	**42%**	Titanium	0.0029	0.0031	7%
Tungsten	0.00002	0.00002	0%	Tungsten	<0.00001	<0.00001	n/c
Uranium	0.00361	0.00343	5%	Uranium	0.00304	0.00302	1%
Vanadium	0.002	0.0015	**29%**	Vanadium	0.0003	0.0003	0%
Zinc	0.0062	0.0051	19%	Zinc	0.0069	0.0072	4%
Zirconium	0.0005	0.0005	0%	Zirconium	0.0004	0.0003	**29%**

Bold	*Exceedes Data Quality objective of 25%.*
Bold	*Exceedes Data Quality objective of 25%, but does not meet Pratical Quantitation Limit.*
RPD	*Relative Percent Difference.*
"-"	*Not Analyzed.*
"n/c"	*Not able to be calculated, because one or both values not precisely known, or within 3x the DL.*
"<"	*Less than detection limit.*

Appendix B6. Surface Water Quality Replicate Data, Casino Project, May 2008 (cont'd)

Station	W5	W5-R (W40)	RPD	Station	W5	W5-R (W40)	RPD
Date	5/22/2008	5/22/2008	%	Date	5/22/2008	5/22/2008	%
Physical Tests				**Dissolved Anions & Nutrients**			
Conductivity (us/cm)	74	74	0%	Alkalinity-Total	24	24	0%
Dissolved Hardness	40.3	39.8	1%	Alkalinity (PP as CaCO3)	<0.5	<0.5	n/c
pH	7.3	7.3	0%	Ammonia Nitrogen	<0.005	0.022	n/c
Total Suspended Solids	58	24	**83%**	Bicarbonate	29	30	3%
Total Dissolved Solids	74	76	3%	Carbonate	<0.5	<0.5	n/c
Tubidity (NTU)	4.2	2.5	**51%**	Chloride	1.2	1.2	0%
Cyanide + Thiocyanate	0.0008	0.0008	0%	Hydroxide	<0.5	<0.5	n/c
Total Hardness	41.4	40.4	2%	Nitrate Nitrogen	0.024	0.026	8%
Weak Acid Dissoc. Cyanide	0.0007	0.0008	13%	Nitrite Nitrogen	0.004	0.003	**29%**
				Nitrate plus Nitrite	0.028	0.029	4%
				Ortho Phosphate as P	<0.001	<0.001	n/c
				Sulphate	<0.5	<0.5	n/c
				Total Kjeldahl Nitrogen	0.42	0.46	9%
				Total Nitrogen	0.45	0.49	9%
Total Metals				**Dissolved Metals**			
Aluminum	0.489	0.476	3%	Aluminum	0.197	0.201	2%
Antimony	0.00009	0.00008	12%	Antimony	0.00007	0.00007	0%
Arsenic	0.00077	0.00077	0%	Arsenic	0.00037	0.00036	3%
Barium	0.0467	0.0455	3%	Barium	0.0314	0.0295	6%
Beryllium	0.00005	0.00005	0%	Beryllium	0.00002	0.00002	0%
Bismuth	0.000006	0.000008	n/c	Bismuth	<0.000005	<0.000005	n/c
Boron	<0.05	<0.05	n/c	Boron	<0.05	<0.05	n/c
Cadmium	0.000054	0.000047	14%	Cadmium	0.000016	0.000024	n/c
Calcium	10.9	10.7	2%	Calcium	10.6	10.6	0%
Chromium	0.0006	0.0005	18%	Chromium	0.0003	0.0003	0%
Cobalt	0.00041	0.000402	2%	Cobalt	0.000086	0.000084	2%
Copper	0.00669	0.00653	2%	Copper	0.00523	0.00483	8%
Iron	0.724	0.714	1%	Iron	0.197	0.2	2%
Lead	0.00152	0.00146	4%	Lead	0.000157	0.000153	3%
Lithium	0.0014	0.0014	0%	Lithium	0.0012	0.0012	0%
Magnesium	3.42	3.32	3%	Magnesium	3.38	3.26	4%
Manganese	0.0785	0.0741	6%	Manganese	0.0106	0.0103	3%
Mercury	0.00001	0.00001	0%	Mercury	<0.00001	0.00001	n/c
Molybdenum	0.0004	0.00037	8%	Molybdenum	0.00044	0.00039	12%
Nickel	0.0011	0.00103	7%	Nickel	0.00069	0.00064	8%
Phosphorus	0.052	0.047	10%	Phosphorus	0.013	0.011	17%
Potassium	0.71	0.69	3%	Potassium	0.69	0.69	0%
Selenium	0.00005	0.00005	0%	Selenium	0.00004	0.00006	n/c
Silicon	3	2.8	7%	Silicon	2.6	2.7	4%
Silver	0.00001	0.000011	10%	Silver	<0.000005	<0.000005	n/c
Sodium	1.61	1.57	3%	Sodium	1.73	1.61	7%
Strontium	0.0806	0.08	1%	Strontium	0.0803	0.0768	4%
Sulfur	<3	<3	n/c	Sulfur	<3	<3	n/c
Tellurium	<0.00002	<0.00002	n/c	Tellurium	<0.00002	<0.00002	n/c
Thallium	0.000007	0.000007	0%	Thallium	<0.000002	0.000003	n/c
Thorium	0.000192	0.000214	11%	Thorium	0.000157	0.000114	**32%**
Tin	<0.00001	<0.00001	n/c	Tin	0.00001	<0.00001	n/c
Titanium	0.0138	0.0152	10%	Titanium	0.0021	0.0021	0%
Tungsten	0.00003	0.00003	0%	Tungsten	<0.00001	0.00002	n/c
Uranium	0.003	0.00296	1%	Uranium	0.00223	0.00212	5%
Vanadium	0.0017	0.0017	0%	Vanadium	0.0004	0.0003	**29%**
Zinc	0.0042	0.0036	15%	Zinc	0.0053	0.0049	8%
Zirconium	0.0004	0.0005	22%	Zirconium	0.0003	0.0002	**40%**

Bold	*Exceedes Data Quality objective of 25%.*
Bold	*Exceedes Data Quality objective of 25%, but does not meet Pratical Quantitation Limit.*
RPD	*Relative Percent Difference.*
"-"	*Not Analyzed.*
"n/c"	*Not able to be calculated, because one or both values not precisely known, or within 3x the DL.*
"<"	*Less than detection limit.*

Appendix B6. Surface Water Quality Replicate Data, Casino Project, July 2008

Station	W1	W1-R (W101)	RPD	Station	W1	W1-R (W101)	RPD
Date	7/8/2008	7/8/2008	%	Date	7/8/2008	7/8/2008	%
Physical Tests				**Dissolved Anions & Nutrients**			
Conductivity (us/cm)	280	280	0%	Alkalinity-Total	81	82	1%
Dissolved Hardness	133	135	1%	Alkalinity (PP as CaCO3)	<0.5	<0.5	n/c
pH	8.1	8.1	0%	Ammonia Nitrogen	0.013	0.015	14%
Total Suspended Solids	4	4	0%	Bicarbonate (HCO3)	99	100	1%
Total Dissolved Solids	200	200	0%	Carbonate (CO3)	<0.5	<0.5	n/c
Tubidity (NTU)	0.5	0.3	**50%**	Chloride Cl	2.5	5.3	**72%**
Cyanide + Thiocyanate	0.0008	0.0008	0%	Hydroxide (OH)	<0.5	<0.5	n/c
Total Hardness	143	144	1%	Nitrate Nitrogen	0.169	0.164	3%
Weak Acid Dissoc. Cyanide	0.0005	<0.0005	n/c	Nitrite Nitrogen	<0.002	<0.002	n/c
				Nitrate plus Nitrite	0.169	0.164	3%
				Ortho Phosphate as P	0.001	<0.001	n/c
				Sulphate	63	59	7%
				Total Kjeldahl Nitrogen	0.24	0.19	23%
				Total Nitrogen	0.41	0.35	16%
Total Metals				**Dissolved Metals**			
Aluminum	0.0821	0.0752	9%	Aluminum	0.0438	0.0429	2%
Antimony	0.00028	0.00027	4%	Antimony	0.00027	.00030	11%
Arsenic	0.00057	0.00059	3%	Arsenic	0.00056	0.00054	4%
Barium	0.0627	0.0598	5%	Barium	0.0591	0.0608	3%
Beryllium	0.00001	0.00001	0%	Beryllium	0.00001	0.00001	0%
Bismuth	<0.000005	<0.000005	n/c	Bismuth	<0.000005	<0.000005	n/c
Boron	<0.05	<0.05	n/c	Boron	<0.05	<0.05	n/c
Cadmium	0.000014	0.000011	24%	Cadmium	0.000008	0.000008	0%
Calcium	35.8	36.1	1%	Calcium	33.3	33.5	1%
Chromium	0.0003	0.0003	0%	Chromium	0.0003	0.0002	**40%**
Cobalt	0.000099	0.000088	12%	Cobalt	0.000051	0.000042	19%
Copper	0.00243	0.00240	1%	Copper	0.00205	0.00211	3%
Iron	0.104	0.099	5%	Iron	0.044	0.045	2%
Lead	0.000059	0.000051	15%	Lead	<0.000005	<0.000005	n/c
Lithium	0.0009	0.0009	0%	Lithium	0.0008	0.0008	0%
Magnesium	13.0	13.0	0%	Magnesium	12.1	12.4	2%
Manganese	0.00454	0.00465	2%	Manganese	0.00131	0.00128	2%
Mercury	<0.00001	<0.00001	n/c	Mercury	0.00001	0.00001	0%
Molybdenum	0.00077	0.00075	3%	Molybdenum	0.00073	0.00078	7%
Nickel	0.00077	0.00082	6%	Nickel	0.00075	0.00068	10%
Phosphorus	0.005	0.005	0%	Phosphorus	<0.002	<0.002	n/c
Potassium	2.08	2.08	0%	Potassium	1.94	1.95	1%
Selenium	0.00011	0.00011	0%	Selenium	0.00012	.00010	18%
Silicon	4.5	4.8	6%	Silicon	3.8	4.1	8%
Silver	<0.000005	<0.000005	n/c	Silver	<0.000005	<0.000005	n/c
Sodium	4.39	4.40	0%	Sodium	4.20	4.20	0%
Strontium	0.236	0.234	1%	Strontium	0.214	0.217	1%
Sulfur	23	22	4%	Sulfur	21	21	0%
Thallium	0.000004	0.000003	**29%**	Thallium	0.000004	0.000004	0%
Tin	<0.00001	<0.00001	n/c	Tin	<0.00001	<0.00001	n/c
Titanium	0.0031	0.0027	14%	Titanium	0.0006	<0.0005	n/c
Uranium	0.00928	0.00907	2%	Uranium	0.00864	.00890	3%
Vanadium	0.0004	0.0004	0%	Vanadium	0.0003	0.0003	0%
Zinc	0.0008	0.0008	0%	Zinc	0.0045	0.0042	7%
Zirconium	0.0002	0.0002	0%	Zirconium	0.0002	0.0002	0%

Bold	*Exceedes Data Quality objective of 25%.*
Bold	*Exceedes Data Quality objective of 25%, but does not meet Pratical Quantitation Limit.*
RPD	*Relative Percent Difference.*
"-"	*Not Analyzed.*
"n/c"	*Not able to be calculated, because one or both values not precisely known, or within 3x the DL.*
"<"	*Less than detection limit.*

Appendix B6. Surface Water Quality Replicate Data, Casino Project, July 2008 (cont'd)

Station	W43	W43-R (W102)	RPD	Station	W43	W43-R (W102)	RPD
Date	7/8/2008	7/8/2008	%	Date	7/8/2008	7/8/2008	%
Physical Tests				**Dissolved Anions & Nutrients**			
Conductivity (us/cm)	240	240	0%	Alkalinity-Total	83	80	4%
Dissolved Hardness	109	112	3%	Alkalinity (PP as CaCO3)	<0.5	<0.5	n/c
pH	7.5	7.3	3%	Ammonia Nitrogen	0.016	<0.005	n/c
Total Suspended Solids	<1	<1	n/c	Bicarbonate (HCO3)	100	98	2%
Total Dissolved Solids	170	160	6%	Carbonate (CO3)	<0.5	<0.5	n/c
Tubidity (NTU)	0.2	0.3	**40%**	Chloride Cl	0.8	0.9	12%
Cyanide + Thiocyanate	<0.0005	<0.0005	n/c	Hydroxide (OH)	<0.5	<0.5	n/c
Total Hardness	116	117	1%	Nitrate Nitrogen	0.214	0.216	1%
Weak Acid Dissoc. Cyanide	<0.0005	<0.0005	n/c	Nitrite Nitrogen	<0.002	<0.002	n/c
				Nitrate plus Nitrite	0.214	0.216	1%
				Ortho Phosphate as P	<0.001	<0.001	n/c
				Sulphate	44	45	2%
				Total Kjeldahl Nitrogen	0.07	0.10	**35%**
				Total Nitrogen	0.28	0.31	10%
Total Metals				**Dissolved Metals**			
Aluminum	0.0036	0.0030	18%	Aluminum	0.0056	0.0254	**128%**
Antimony	0.00342	0.00342	0%	Antimony	0.00335	0.00329	2%
Arsenic	0.00049	0.00048	2%	Arsenic	0.00028	0.00029	4%
Barium	0.0517	0.0496	4%	Barium	0.0495	0.0496	0%
Beryllium	<0.00001	<0.00001	n/c	Beryllium	<0.00001	<0.00001	n/c
Bismuth	<0.000005	<0.000005	n/c	Bismuth	<0.000005	<0.000005	n/c
Boron	<0.05	<0.05	n/c	Boron	<0.05	<0.05	n/c
Cadmium	0.0553	0.0550	1%	Cadmium	0.0515	0.0531	3%
Calcium	32.3	32.7	1%	Calcium	30.1	30.9	3%
Chromium	<0.0001	<0.0001	n/c	Chromium	<0.0001	<0.0001	n/c
Cobalt	0.000164	0.000161	2%	Cobalt	0.000157	0.000161	3%
Copper	0.0608	0.0604	1%	Copper	0.0510	0.0534	5%
Iron	0.025	0.023	8%	Iron	0.007	0.007	0%
Lead	0.00587	0.00567	3%	Lead	0.00205	0.00218	6%
Lithium	0.0024	0.0025	4%	Lithium	0.0024	0.0024	0%
Magnesium	8.58	8.66	1%	Magnesium	8.13	8.33	2%
Manganese	0.266	0.268	1%	Manganese	0.252	0.258	2%
Mercury	<0.00001	<0.00001	n/c	Mercury	<0.00001	<0.00001	n/c
Molybdenum	<0.00005	<0.00005	n/c	Molybdenum	<0.00005	<0.00005	n/c
Nickel	.00050	0.00042	17%	Nickel	0.00045	0.00053	16%
Phosphorus	0.002	0.002	0%	Phosphorus	<0.002	<0.002	n/c
Potassium	1.43	1.41	1%	Potassium	1.33	1.36	2%
Selenium	<0.00004	<0.00004	n/c	Selenium	<0.00004	<0.00004	n/c
Silicon	5.8	6.1	5%	Silicon	6.0	5.9	2%
Silver	0.000090	0.000088	2%	Silver	0.000026	0.000035	**30%**
Sodium	3.52	3.52	0%	Sodium	3.44	3.45	0%
Strontium	0.280	0.281	0%	Strontium	0.265	0.271	2%
Sulfur	14	15	7%	Sulfur	15	16	6%
Thallium	0.000023	0.000023	0%	Thallium	0.000022	0.000025	13%
Tin	<0.00001	<0.00001	n/c	Tin	<0.00001	<0.00001	n/c
Titanium	<0.0005	<0.0005	n/c	Titanium	<0.0005	<0.0005	n/c
Uranium	0.00149	0.00154	3%	Uranium	0.00128	0.00134	5%
Vanadium	<0.0002	<0.0002	n/c	Vanadium	<0.0002	<0.0002	n/c
Zinc	3.06	2.99	2%	Zinc	2.84	2.93	3%
Zirconium	<0.0001	<0.0001	n/c	Zirconium	<0.0001	<0.0001	n/c

Bold	*Exceedes Data Quality objective of 25%.*
Bold	*Exceedes Data Quality objective of 25%, but does not meet Pratical Quantitation Limit.*
RPD	*Relative Percent Difference.*
"-"	*Not Analyzed.*
"n/c"	*Not able to be calculated, because one or both values not precisely known, or within 3x the DL.*
"<"	*Less than detection limit.*

Appendix B6. Surface Water Quality Replicate Data, Casino Project, September 2008

Station	W43	W43-R (W43-B)	RPD	Station	W43	W43-R (W43-B)	RPD
Date	9/9/2008	9/9/2008	%	Date	9/9/2008	9/9/2008	%
Physical Tests				**Dissolved Anions & Nutrients**			
Conductivity (us/cm)	220	220	0%	Alkalinity-Total	67	67	0%
Dissolved Hardness	95.8	95.4	0%	Ammonia Nitrogen	<0.01	<0.01	n/c
pH	7.5	7.7	3%	Chloride Cl	<0.5	<0.5	n/c
Total Suspended Solids	<1	<1	n/c	Nitrate Nitrogen	0.443	0.454	2%
Total Dissolved Solids	120	130	8%	Nitrite Nitrogen	<0.002	<0.002	n/c
Tubidity (NTU)	0.8	0.9	12%	Nitrate plus Nitrite	0.443	0.454	2%
Cyanide + Thiocyanate	<0.0005	<0.0005	n/c	Ortho Phosphate as P	0.002	0.002	0%
Total Hardness	94.4	94.9	1%	Sulphate	39	39	0%
Weak Acid Dissoc. Cyanide	<0.0005	<0.0005	n/c	Total Kjeldahl Nitrogen	0.04	0.02	**67%**
				Total Nitrogen	0.48	0.47	2%
Total Metals				**Dissolved Metals**			
Aluminum	0.0235	0.0224	5%	Aluminum	0.0014	0.0014	0%
Antimony	0.00264	0.00263	0%	Antimony	0.00257	0.00252	2%
Arsenic	0.00079	0.00077	3%	Arsenic	0.00047	0.00046	2%
Barium	0.0658	0.0649	1%	Barium	0.0631	0.0620	2%
Beryllium	<0.00001	<0.00001	n/c	Beryllium	<0.00001	<0.00001	n/c
Bismuth	<0.000005	<0.000005	n/c	Bismuth	<0.000005	<0.000005	n/c
Boron	<0.05	<0.05	n/c	Boron	<0.05	<0.05	n/c
Cadmium	0.0425	0.0427	0%	Cadmium	0.0414	0.0418	1%
Calcium	26.2	26.3	0%	Calcium	26.8	26.7	0%
Chromium	<0.0001	<0.0001	n/c	Chromium	<0.0001	<0.0001	n/c
Cobalt	0.000320	0.000313	2%	Cobalt	0.000316	0.000312	1%
Copper	0.0748	0.0743	1%	Copper	0.0709	0.0703	1%
Iron	0.047	0.048	2%	Iron	0.010	0.010	0%
Lead	0.0120	0.0120	0%	Lead	0.00666	0.00680	2%
Lithium	0.0020	0.0020	0%	Lithium	0.0020	0.0020	0%
Magnesium	7.02	7.07	1%	Magnesium	7.03	7.00	0%
Manganese	0.524	0.526	0%	Manganese	0.537	0.543	1%
Mercury	<0.00001	<0.00001	n/c	Mercury	<0.00001	<0.00001	n/c
Molybdenum	<0.00005	<0.00005	n/c	Molybdenum	<0.00005	<0.00005	n/c
Nickel	0.00049	0.00043	13%	Nickel	0.00047	0.00064	**31%**
Phosphorus	0.003	0.003	0%	Phosphorus	0.002	0.002	0%
Potassium	1.35	1.35	0%	Potassium	1.39	1.38	1%
Selenium	<0.00004	<0.00004	n/c	Selenium	<0.00004	<0.00004	n/c
Silicon	5.8	6.2	7%	Silicon	5.6	5.8	4%
Silver	0.000105	0.000116	10%	Silver	0.000023	0.000022	4%
Sodium	3.09	3.07	1%	Sodium	2.99	2.96	1%
Strontium	0.220	0.220	0%	Strontium	0.226	0.224	1%
Sulfur	14	14	0%	Sulfur	14	13	7%
Thallium	0.000025	0.000026	4%	Thallium	0.000025	0.000025	0%
Tin	<0.00001	<0.00001	n/c	Tin	<0.00001	<0.00001	n/c
Titanium	<0.0005	<0.0005	n/c	Titanium	<0.0005	<0.0005	n/c
Uranium	0.00126	0.00126	0%	Uranium	0.00126	0.00125	1%
Vanadium	<0.0002	<0.0002	n/c	Vanadium	<0.0002	<0.0002	n/c
Zinc	2.35	2.38	1%	Zinc	2.28	2.28	0%
Zirconium	<0.0001	<0.0001	n/c	Zirconium	<0.0001	<0.0001	n/c

Bold	*Exceedes Data Quality objective of 25%*
Bold	*Exceedes Data Quality objective of 25%, but does not meet Pratical Quantitation Limit*
RPD	*Relative Percent Difference*
"-"	*Not Analyzed*
"n/c"	*Not able to be calculated, because one or both values not precisely known, or within 3x the DL*
"<"	*Less than detection limit*

B7. Sediment Quality Data, Casino Project, September 2008

Appendix B7. Sediment Quality Data, Casino Project, September 2008

Station	Detection Limits	CCME Sediement Quality Guidelines for the Protection of Aquatic Life[a]		W7 - Upper Canadian Creek	W3 - Canadian Creek us of Confluence with Britannia Creek	W14 - Mouth of Britannia Creek	W2 - Canadian Creek Downstream of Confluence with Britannia Creek	W1 - Mouth of Canadian Creek	W12 - Proctor Gulch before Confluence with Casino Creek	W8 - Upper Casino Creek	W13 - Meloy Creek	W11 - Casino Creek (proposed dam outflow)	W4 - Mouth of Casino Creek	W9 - Dip Creek us of Confluence with Casino Creek	W5 - Dip Creek ds Casino Confluence
Date		**ISQG[b]**	**PEL[c]**	**10-Sep-08**	**10-Sep-08**	**10-Sep-08**	**10-Sep-08**	**10-Sep-08**	**10-Sep-08**	**10-Sep-08**	**9-Sep-08**	**9-Sep-08**	**9-Sep-08**	**9-Sep-08**	**9-Sep-08**
Physical Tests															
Moisture %	0.3			20	20	23	21	23	35	23	25	29	37	30	31
pH	0.01			6.45	7.27	7.37	7.38	7.45	3.28	7.16	7.41	7.29	6.66	6.92	6.59
Total Metals															
Aluminum	100			6810	6160	6690	5940	6900	11100	8010	10800	11200	11800	12000	13200
Antimony	0.1			0.8	1.0	0.8	0.9	0.9	2.4	1.2	2.3	2.6	0.8	0.6	0.7
Arsenic	0.2	5.9	17	*13.1*	***18.5***	*12.2*	***18.4***	*15.5*	***46.0***	***24.5***	***25.8***	***27.5***	*13.0*	*6.4*	*10.0*
Barium	0.1			144	98.9	159	96.8	96.7	188	140	272	217	156	169	206
Beryllium	0.1			0.2	0.2	0.1	0.2	0.2	0.3	0.4	0.4	0.4	0.2	0.4	0.4
Bismuth	0.1			0.5	0.1	<0.1	0.2	0.1	0.9	0.3	0.2	0.3	0.1	0.2	0.2
Cadmium	0.05	0.6	3.5	*0.68*	0.21	0.08	0.19	0.15	0.35	*1.80*	*1.55*	*1.78*	0.35	0.19	0.26
Calcium	100			1200	1860	2250	1850	2300	1170	2030	3780	3920	3590	5440	5090
Chromium	1	37.3	90	6	15	9	12	17	13	5	12	9	14	18	15
Cobalt	0.3			8.3	7.3	6.6	6.9	8.0	10.1	29.1	10.4	23.2	11.1	8.5	10.5
Copper	0.5	35.7	197	*57.0*	18.0	6.4	15.8	20.3	***223***	***292***	15.0	*191*	33.4	12.6	19.8
Iron	100			16500	13900	16700	13800	16000	83500	36600	27300	34900	29100	25700	27500
Lead	0.1	35	91.3	11.4	10.5	4.4	7.8	9.6	*73.9*	*42.9*	***192***	***111***	24.9	11.8	14.3
Magnesium	100			3560	4840	3890	4800	4890	3460	2880	4970	4440	6040	5370	5590
Manganese	0.2			450	343	355	354	336	407	1200	1400	1390	500	514	709
Mercury	0.05	0.17	0.486	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Molybdenum	0.1			5.5	2.5	0.4	2.7	2.4	5.0	2.9	1.2	2.4	1.5	1.1	1.1
Nickel	0.8			5.1	13.8	6.0	13.3	13.0	7.5	6.4	9.4	9.9	8.2	12.2	12.5
Phosphorous	10			337	374	431	428	405	577	434	498	444	584	965	703
Potassium	100			1310	1360	1280	1190	1480	880	665	2120	1300	2170	1080	1480
Selenium	0.5			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Silver	0.05			0.12	0.05	<0.05	0.06	0.18	0.62	0.12	0.38	0.29	0.08	0.10	0.11
Sodium	100			<100	<100	107	<100	<100	<100	<100	<100	<100	176	197	156
Strontium	0.1			9.7	11.6	14.6	12.4	13.5	9.2	14.8	25.4	28.1	17.6	33.2	36.3
Thallium	0.05			0.17	0.12	0.12	0.12	0.12	0.17	0.13	0.32	0.22	0.25	0.15	0.22
Tin	0.1			0.3	0.2	0.3	0.2	0.2	0.5	0.2	0.7	0.5	0.5	0.5	0.5
Titanium	1			443	292	568	254	365	471	342	859	722	974	748	888
Vanadium	2			30	23	36	23	27	46	31	50	45	70	54	53
Zinc	1	123	315	65	40	34	41	43	*169*	*180*	*226*	*192*	94	64	76
Zirconium	0.5			1.1	0.7	0.6	0.7	0.8	0.8	0.9	1.0	0.9	0.9	1.3	1.5

Notes:

All units mg/kg dry weight unless otherwise noted.

a) Canadian Sediment quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2008.

b) ISQG: Interim Freshwater Sediment Quality Guidelines.

c) PEL: Probable Effects Levels.

Italic	*Results exceed ISQG.*
Italic	*Results exceed ISQG & PEL.*

B8. Periphyton Taxonomy, Casino Project, September 2008

Appendix B8. Periphyton Taxonomy, Casino Project, September 2009

FES Sample Number			080476	080477	080478	080479	080480	080481	080482	080483	080484	080485	0804
Sample Site			P1-1	P1-2	P1-3	P1-4	P1-5	P2-1	P2-2	P2-3	P2-4	P2-5	P3-
Sampling Date			11-Sep-08	11-Sep-08	11-Sep-08	11-Sep-08	11-Sep-08	10-Sep-08	10-Sep-08	10-Sep-08	10-Sep-08	10-Sep-08	10-Sep
Area Sampled (cm^2)			214.58	199.16	220.90	322.84	240.39	102.71	243.87	217.29	246.39	313.23	214.8
Phylum	**Order**	**Genera and Species**											
		Cyclotella sp.											
		Melosira sp.											
	Pennales	*Achnanthes flexella*						<3.1	<1.0	<1.5			<1.2
		Achnanthes lanceolata											
		Achnanthes minutissima	12.8	33.6	<1.3	33.6	53.6	37.2	12.0	9.0	6.4	4.2	1.2
		Achnanthes spp.	9.6	2.8	7.8	16.8	26.8	6.2	8.0	12.0	16.0	4.2	4.8
		Amphipleura pellucida					<1.7						
		Amphora spp.											
		Caloneis spp.		<1.4									
		Caloneis sp.?											
		Ceratoneis arcus	120.0	14.0	15.6	15.4	78.2	117.8	6.0	9.0	38.4	14.0	26.4
		Cocconeis placentula								<1.5	<1.6		
		Cymbella cf. cestaii	<1.6					3.1	<1.0			<0.7	<1.2
		Cymbella cistula	<1.6					<3.1		<1.5	<1.6	<0.7	<1.2
		Cymbella minuta	16.0	2.8	<1.3	6.6	20.4	6.2	2.0	3.0	9.6	1.4	
		Cymbella sinuata	<1.6	<1.4	2.6	2.2	<1.7	9.3	1.0	15.0	6.4	0.7	1.2
		Cymbella spp.	<1.6			<1.1		<3.1	<1.0		<1.6	<0.7	
		Denticula sp.	<1.6				<1.7	<3.1	<1.0		<1.6	<0.7	
		Diatoma elongatum	1,108.8	67.2	117.6	268.8	415.4	3,642.6	144.0	471.5	430.5	270.4	211.
		Diatoma mesodon	<1.6	<1.4	<1.3	<1.1	1.7	<3.1		<1.5		<0.7	<1.2
		Diatomella sp.											
		Didymosphenia geminata											
		Diploneis spp.											
		Epithemia spp.											
		Eunotia spp.						<3.1			<1.6		
		Fragilaria capucina	<1.6										
		Fragilaria construens									<1.6		
		Fragilaria crotonensis											
		Fragilaria vaucheriae	216.0	2.8	18.2	117.6	241.2	62.0		9.0	16.0	1.4	2.4
		Fragilaria spp.	9.6	11.2	10.4	33.6	174.2	62.0	4.0	27.0	22.4	7.0	4.8
		Frustulia sp.											
		Gomphonema acuminatum / parvulum	19.2	25.2	7.8	50.4	40.8	99.2	2.0	6.0	9.6	<0.7	<1.2
		Gomphonema spp.	6.4	<1.4	<1.3		6.8	74.4	<1.0	9.0	3.2	<0.7	1.2
		Hanitzschia sp.											
		Meridion circulare	180.0	25.2	28.6	109.2	160.8	3.1	<1.0	9.0	6.4	<0.7	<1.2
		Navicula radiosa					<1.7	<3.1	<1.0	<1.5	1.6		
		Navicula spp.	1.6			6.6	6.8	12.4	<1.0	<1.5	1.6	<0.7	<1.2
		Neidium spp.											
		Nitzschia spp.	36.0	19.6	2.6	8.8	6.8	6.2	1.0	6.0	6.4	2.8	<1.2
		Pinnularia spp.	<1.6	<1.4	<1.3	1.1	<1.7	6.2	<1.0	<1.5	3.2	0.7	<1.2
		Rhopalodia sp.											
		Stauroneis spp.											
		Surirella spp.											
		Synedra ulna	1.6	<1.4		<1.1	<1.7	37.2	<1.0	1.5	9.6	<0.7	4.8
		Synedra spp.	6.4	5.6	9.8	11.0	13.6	12.4	1.0	9.0	6.4	2.8	<1.2
		Tabellaria fenestrata											
		Tabellaria flocculosa	<1.6										
		UID girdle view			<1.3					<1.5	<1.6		9.6
Chlorophyta	Chaetophorales	*Stigeoclonium sp.*											
		UID Chaetophorales											
	Chlorococcales	*Oocystis spp.*	<1.6										

Appendix B8. Periphyton Taxonomy, Casino Project, September 2009

FES Sample Number			080476	080477	080478	080479	080480	080481	080482	080483	080484	080485	0804
Sample Site			P1-1	P1-2	P1-3	P1-4	P1-5	P2-1	P2-2	P2-3	P2-4	P2-5	P3-
Sampling Date			11-Sep-08	11-Sep-08	11-Sep-08	11-Sep-08	11-Sep-08	10-Sep-08	10-Sep-08	10-Sep-08	10-Sep-08	10-Sep-08	10-Sep
Area Sampled (cm^2)			214.58	199.16	220.90	322.84	240.39	102.71	243.87	217.29	246.39	313.23	214.8
	Oedogoniales	*Oedogonium spp.*											
	Ulothricales	*Hormidium sp.?*											<1.2
		Microspora sp.											
		Ulothrix spp.	<1.6			<1.1							
		UID Ulothricales											
	Zygnematales	*Closterium spp.*											
		Cosmarium spp.	<1.6										
		Cylindrocystis spp.											
		Mougeotia spp.											
		Roya sp.											
Chlorophyta		UID Chlorophyta colonial		11.2									
		UID Chlorophyta filamentous										<0.7	16.8
		UID Chlorophyta unicellular		2.8									1.2
Chrysophyta	Chromulinales	*Chromulina sp.*	1,663.2		205.8	1,328.4	930.6	840.6	800.8	207.0	172.2	2,772.0	28.8
		Hudrurus sp.									<1.6	<0.7	
	Tribonematales	*Tribonema spp.*	<1.6										
Chrysophyta		UID Chrysophyte colonial	22.4	11.2	7.8	81.4	80.4			24.0	73.8	20.8	
		UID Chrysophyte cyst			<1.3						12.3	1.4	<1.2
		UID Chrysophyte flagellate											
		UID Chrysophyte unicellular	12.0	2.8	2.6								
Cyanophyta	Chamaesiphonale	*Chamaesiphon spp.*											
		Clastidium setigerum											
	Chroococcales	*Aphanocapsa spp.*											
		UID Chrooccocales						24.3	8.0		110.7	20.8	57.6
	Nostocales	*Anabaena sp. ?*					<1.7						
		Calothrix sp. ?											
		Nostoc sp. / Anabaena sp.										<0.7	
		Nostoc sp.											
		Tolypothrix sp.											13.2
		UID Nostocales				<1.1		<3.1					
	Oscillatoriales	*Lyngbya spp.*							<1.0		<1.6	<0.7	
		Homoeothrix varians										<0.7	
		Microcoleus sp.											
		Oscillatoria cf. agardhii											
		Oscillatoria spp.											
		Phormidium sp.?											
		Pseudoanabaena spp.	<1.6		<1.3	<1.1				<1.5	16.0	<0.7	<1.2
		UID Oscillatoriales	<1.6	<1.4	<1.3		<1.7		<1.0	<1.5	<1.6	<0.7	<1.2
Rhodophyta	Nemalionales	*Audouinella sp.*											
		Batrachospermum sp.											
		UID flagellate	12.0			8.4							
		UID colonial											<1.2
		UID filamentous							<1.0	<1.5			<1.2
		UID unicellular	138.6	44.8	39.2	97.2	51.7	93.4	8.0	11.5	236.5	26.0	38.4

Appendix B8. Periphyton Taxonomy, Casino Project, September 2009

FES Sample Number			080490	080491	080492	080493	080494	080495	080496	080497	080498	080499	080500	080501	080502	080503
Sample Site			P3-5	P4-1	P4-2	P4-3	P4-4	P4-5	P5-1	P5-2	P5-3	P5-4	P5-5	P7-1	P7-2	P7-3
Sampling Date			10-Sep-08	10-Sep-08	10-Sep-08	10-Sep-08	10-Sep-08	10-Sep-08	10-Sep-08	10-Sep-08	10-Sep-08	10-Sep-08	10-Sep-08	10-Sep-08	10-Sep-08	10-Sep-08
Area Sampled (cm^2)			134.26	225.42	238.90	227.48	283.93	128.71	122.45	103.48	142.45	73.16	176.26	155.61	199.81	304.84
Phylum	**Order**	**Genera and Species**														
		Cyclotella sp.														
		Melosira sp.										<1.9				
	Pennales	*Achnanthes flexella*			<2.7		<1.3	<2.6		<1.8						<1.4
		Achnanthes lanceolata		<1.3	2.7		<1.3						<1.3	5.8	<5.8	<1.4
		Achnanthes minutissima	16.0	30.0	208.0	3,393.6	147.0	102.5	13.0	10.8	16.0	3.8	2.6	113.0	267.6	99.0
		Achnanthes spp.	19.2	60.0	187.2	2,181.6	52.5	123.0	10.4	7.2	24.0	11.4	7.8	203.4	490.6	66.0
		Amphipleura pellucida														
		Amphora spp.		<1.3			<1.3	<2.6						<2.9	<5.8	<1.4
		Caloneis spp.				<2.0	2.6				<1.0	<1.9	<1.3		5.8	2.8
		Caloneis sp.?		<1.3												
		Ceratoneis arcus	38.4	180.0	2,723.4	2,908.8	683.4	1,260.8	58.8	126.9	118.4	22.8	41.6	90.4	81.2	36.8
		Cocconeis placentula		1.3	5.4	<2.0	<1.3	<2.6	<1.3			<1.9	<1.3		<5.8	
		Cymbella cf. cestaii	<1.6	<1.3		<2.0	<1.3	<2.6		<1.8						
		Cymbella cistula	<1.6		2.7	8.0	5.2	<2.6			<1.0			<2.9		<1.4
		Cymbella minuta	3.2	13.0	166.4	666.6	63.0	164.0	10.4	1.8	8.0	<1.9	<1.3	23.2	23.2	8.4
		Cymbella sinuata	22.4	5.2	41.6	31.6	2.6		7.8	10.8	4.0			11.6	34.8	<1.4
		Cymbella spp.	<1.6	<1.3		<2.0		<2.6	<1.3		<1.0			<2.9	<5.8	<1.4
		Denticula sp.														
		Diatoma elongatum	1,047.2	90.0	1,201.5	8,847.6	442.2	1,260.8	10.4	14.4	12.0	11.4	5.2			
		Diatoma mesodon		<1.3	<2.7	2.0	2.6	<2.6		<1.8		<1.9	<1.3	2.9	<5.8	
		Diatomella sp.												<2.9		
		Didymosphenia geminata			<2.7	<2.0	31.2	109.2	<1.3					<2.9		
		Diploneis spp.		<1.3	<2.7		<1.3	<2.6	<1.3							
		Epithemia spp.														
		Eunotia spp.		<1.3	<2.7					<1.8			<1.3	<2.9		<1.4
		Fragilaria capucina		<1.3	10.8	12.0	<1.3	31.2		5.4	4.0	<1.9	<1.3	<2.9	<5.8	4.2
		Fragilaria construens		<1.3										5.8		<1.4
		Fragilaria crotonensis					<1.3									
		Fragilaria vaucheriae	19.2	190.0	2,242.8	3,030.0	884.4	2,364.0	15.6	25.2	32.0	30.4	7.8	316.4	401.4	77.0
		Fragilaria spp.	19.2	130.0	801.0	848.4	361.8	472.4	2.6	14.4	8.0	11.4	7.8	22.6	11.6	8.4
		Frustulia sp.			<2.7			<2.6								
		Gomphonema acuminatum / parvulum	6.4	13.0	270.4	11,756.4	21.0	41.0	7.8	14.4	12.0	22.8	3.9	67.8	58.0	11.2
		Gomphonema spp.	22.4	10.4	145.6	13,938.0	63.0	61.5	5.2	7.2	36.0	3.8	2.6	11.6	23.2	8.4
		Hanitzschia sp.														<1.4
		Meridion circulare	<1.6	7.8	75.6	158.0	49.4	246.0	15.6	10.8	10.0	7.6	3.9	29.0	46.4	5.6
		Navicula radiosa	<1.6	<1.3	<2.7	2.0	1.3	2.6	<1.3	<1.8	<1.0	<1.9				
		Navicula spp.		2.6	<2.7	<2.0	13.0	10.4		21.6	20.0	11.4		<2.9	<5.8	
		Neidium spp.		<1.3										<2.9	<5.8	
		Nitzschia spp.	9.6	50.0	83.2	363.6	105.0	184.5	18.2	25.2	96.0	15.4	5.2	17.4	58.0	22.4
		Pinnularia spp.	1.6	5.2	5.4	<2.0	13.0	15.6	<1.3	1.8	2.0	<1.9	<1.3	11.6	46.4	8.4
		Rhopalodia sp.						<2.6								
		Stauroneis spp.	<1.6	<1.3	<2.7	<2.0	<1.3	<2.6			<1.0					<1.4
		Surirella spp.			<2.7	<2.0	<1.3				<1.0					
		Synedra ulna	19.2	1.3	27.0	<2.0	2.6	10.4		<1.8	<1.0	<1.9	<1.3			
		Synedra spp.	3.2	50.0	640.8	3,999.6	361.8	1,182.0	7.8	3.6	16.0	11.4	7.8	5.8	11.6	1.4
		Tabellaria fenestrata	<1.6		2.7	<2.0		5.2						<2.9		
		Tabellaria flocculosa		<1.3	2.7	<2.0	<1.3	<2.6			<1.0			<2.9	<5.8	<1.4
		UID girdle view		2.6		63.2	2.6			<1.8	6.0	<1.9		5.8	<5.8	2.8
Chlorophyta	Chaetophorales	*Stigeoclonium sp.*														
		UID Chaetophorales													<5.8	
	Chlorococcales	*Oocystis spp.*														

Appendix B8. Periphyton Taxonomy, Casino Project, September 2009

FES Sample Number			080490	080491	080492	080493	080494	080495	080496	080497	080498	080499	080500	080501	080502	080503
Sample Site			P3-5	P4-1	P4-2	P4-3	P4-4	P4-5	P5-1	P5-2	P5-3	P5-4	P5-5	P7-1	P7-2	P7-3
Sampling Date			10-Sep-08	10-Sep-08	10-Sep-08	10-Sep-08	10-Sep-08	10-Sep-08	10-Sep-08	10-Sep-08	10-Sep-08	10-Sep-08	10-Sep-08	10-Sep-08	10-Sep-08	10-Sep-08
Area Sampled (cm^2)			134.26	225.42	238.90	227.48	283.93	128.71	122.45	103.48	142.45	73.16	176.26	155.61	199.81	304.84
	Oedogoniales	*Oedogonium spp.*									<1.0					<1.4
	Ulothricales	*Hormidium sp.?*	<1.6													
		Microspora sp.														
		Ulothrix spp.				<2.0	<1.3									
		UID Ulothricales														
	Zygnematales	*Closterium spp.*				<2.0		<2.6		<1.8						
		Cosmarium spp.	<1.6		<2.7							<1.9	<1.3			
		Cylindrocystis spp.												<2.9		<1.4
		Mougeotia spp.								<1.8				<2.9		
		Roya sp.														
Chlorophyta		UID Chlorophyta colonial														
		UID Chlorophyta filamentous					<1.3					<1.9				
		UID Chlorophyta unicellular	3.2	<1.3										<2.9		
Chrysophyta	Chromulinales	*Chromulina sp.*	618.8	80.0	41.6	909.0	160.8	41.0	39.2	56.4	333.0	88.8	453.2	45.2		2.8
		Hudrurus sp.														
	Tribonematales	*Tribonema spp.*			<2.7											
Chrysophyta		UID Chrysophyte colonial												<2.9		
		UID Chrysophyte cyst		2.6	<2.7	<2.0		<2.6			2.0			17.4	23.2	5.6
		UID Chrysophyte flagellate								<1.8		3.8				
		UID Chrysophyte unicellular														
Cyanophyta	Chamaesiphonale	*Chamaesiphon spp.*		490.0	665.6	4,908.6	5,185.8	6,146.4						8,246.0	267.6	1,941.2
		Clastidium setigerum				47.4	10.5	61.5						4,774.0	579.8	1,139.4
	Chroococcales	*Aphanocapsa spp.*	<1.6													
		UID Chrooccocales	19.2	770.0	41.6	303.0	402.0	394.0		<1.8		<1.9		607.6	401.4	295.4
	Nostocales	*Anabaena sp. ?*														
		Calothrix sp. ?														
		Nostoc sp. / Anabaena sp.		31.2												<1.4
		Nostoc sp.	<1.6	<1.3		<2.0	<1.3	<2.6							<5.8	<1.4
		Tolypothrix sp.	<1.6													<1.4
		UID Nostocales											<1.3			
	Oscillatoriales	*Lyngbya spp.*												<2.9		25.2
		Homoeothrix varians		660.0	47,739.6	6,120.6	5,668.2	19,069.6			30.0	22.8	39.0	110,583.2	2,988.2	803.0
		Microcoleus sp.														
		Oscillatoria cf. agardhii	<1.6	26.0	48.6	32,239.2	7,477.2	92,038.4						<2.9		
		Oscillatoria spp.														
		Phormidium sp.?								<1.8						
		Pseudoanabaena spp.	<1.6			94.8	168.0		<1.3	<1.8	8.0				174.0	42.0
		UID Oscillatoriales	25.6	220.0	124.8				<1.3	14.4	<1.0	<1.9	<1.3	156.6	356.8	56.0
Rhodophyta	Nemalionales	*Audouinella sp.*		13.0	232.2		1,900.5	512.5								
		Batrachospermum sp.		249.6	11,169.6		33.8									
		UID flagellate		385.0	5,286.6											
		UID colonial				47.4					26.0				<5.8	
		UID filamentous							<1.3							
		UID unicellular	95.2	77.0	400.5	1,212.0	120.6	157.6	39.2	14.1	22.2	29.6	20.6	434.0	515.4	126.6

Appendix B8. Periphyton Taxonomy, Casino Project, September 2009

FES Sample Number			080504	080505	080506	080507	080508	080509	080510
Sample Site			P7-4	P7-5	P8-1	P8-2	P8-3	P8-4	P8-5
Sampling Date			10-Sep-08	10-Sep-08	10-Sep-08	10-Sep-08	10-Sep-08	10-Sep-08	10-Sep-08
Area Sampled (cm^2)			117.23	114.00	168.77	154.97	185.16	192.39	275.81
Phylum	**Order**	**Genera and Species**							
		Cyclotella sp.							
		Melosira sp.	<4.9						
	Pennales	*Achnanthes flexella*	<4.9						
		Achnanthes lanceolata	19.6	50.4	500.5	4.0	15.9	60.4	2.6
		Achnanthes minutissima	414.7	1,490.4	214.5				
		Achnanthes spp.	377.0	1,555.2	357.5	2.0	21.2	90.6	7.8
		Amphipleura pellucida							
		Amphora spp.	<4.9						
		Caloneis spp.	19.6	8.4	18.6		<0.7	3.9	<1.3
		Caloneis sp.?							
		Ceratoneis arcus	127.4	235.2	26,979.4	347.8	1,359.6	5,224.5	135.2
		Cocconeis placentula							
		Cymbella cf. cestaii	<4.9						
		Cymbella cistula	<4.9	<8.4					
		Cymbella minuta	39.2	67.2				<3.9	<1.3
		Cymbella sinuata	<4.9	16.8	9.3	1.0		7.8	<1.3
		Cymbella spp.		<8.4	<9.3		<0.7	<3.9	<1.3
		Denticula sp.							
		Diatoma elongatum							
		Diatoma mesodon	49.0	67.2	99,108.0	400.4	3,296.0	15,441.3	343.2
		Diatomella sp.		<8.4					
		Didymosphenia geminata	<4.9	<8.4					
		Diploneis spp.							
		Epithemia spp.	<4.9						
		Eunotia spp.	9.8	8.4	55.8	4.0	2.8	31.2	2.6
		Fragilaria capucina	<4.9	<8.4	18.6	<1.0	4.2	<3.9	
		Fragilaria construens		<8.4				<3.9	
		Fragilaria crotonensis						<3.9	
		Fragilaria vaucheriae	263.9	1,620.0	2,477.7	74.0	247.2	928.8	31.2
		Fragilaria spp.	37.7	324.0	24,226.4	118.4	576.8	5,688.9	166.4
		Frustulia sp.							
		Gomphonema acuminatum / parvulum	58.8	33.6	286.0	<1.0	5.3	30.2	<1.3
		Gomphonema spp.	58.8	84.0	214.5	4.0	21.2	120.8	
		Hanitzschia sp.				<1.0	<0.7	<3.9	
		Meridion circulare	19.6	67.2	4,404.8	6.0	247.2	906.0	7.8
		Navicula radiosa							
		Navicula spp.							
		Neidium spp.		<8.4			<0.7	<3.9	
		Nitzschia spp.	58.8	33.6	143.0	6.0	<0.7	7.8	5.2
		Pinnularia spp.	29.4	33.6	55.8	12.0	18.2	3.9	10.4
		Rhopalodia sp.							
		Stauroneis spp.							
		Surirella spp.				<1.0			
		Synedra ulna							
		Synedra spp.	9.8	33.6	1,651.8	14.8	21.1	181.2	41.6
		Tabellaria fenestrata	<4.9		223.2	<1.0	8.4	39.0	<1.3
		Tabellaria flocculosa	<4.9		241,8	<1.0	9.8	140.4	5.2
		UID girdle view			9.3	2.0		<3.9	1.3
Chlorophyta	Chaetophorales	*Stigeoclonium sp.*			55.8		4.2	46.8	
		UID Chaetophorales			<9.3	10.0			
	Chlorococcales	*Oocystis spp.*			<9.3				

Appendix B8. Periphyton Taxonomy, Casino Project, September 2009

FES Sample Number			080504	080505	080506	080507	080508	080509	080510
Sample Site			P7-4	P7-5	P8-1	P8-2	P8-3	P8-4	P8-5
Sampling Date			10-Sep-08	10-Sep-08	10-Sep-08	10-Sep-08	10-Sep-08	10-Sep-08	10-Sep-08
Area Sampled (cm^2)			117.23	114.00	168.77	154.97	185.16	192.39	275.81
	Oedogoniales	*Oedogonium spp.*							
	Ulothricales	*Hormidium sp.?*							
		Microspora sp.		<8.4	130.2	<1.0	21.0	109.2	
		Ulothrix spp.							
		UID Ulothricales	<4.9				<0.7		
	Zygnematales	*Closterium spp.*			<9.3		<0.7	3.9	
		Cosmarium spp.			9.3		<0.7		
		Cylindrocystis spp.			55.8		2.8	15.6	
		Mougeotia spp.					<0.7	<3.9	<1.3
		Roya sp.			<9.3		<0.7		
Chlorophyta		UID Chlorophyta colonial							
		UID Chlorophyta filamentous			<9.3				<1.3
		UID Chlorophyta unicellular		<8.4	214.5	4.0	10.6	60.4	20.8
Chrysophyta	Chromulinales	*Chromulina sp.*	19.6	50.4	56,711.8	11,554.4	8,981.6	13,235.4	2,406.0
		Hudrurus sp.							
	Tribonematales	*Tribonema spp.*			930.0	<1.0	2.8	148.2	
Chrysophyta		UID Chrysophyte colonial			<9.3	8.0			31.2
		UID Chrysophyte cyst	9.8	33.6	143.0		5.3	30.2	2.6
		UID Chrysophyte flagellate					10.6	60.4	
		UID Chrysophyte unicellular			14,866.2	514.8	1,112.4	5,572.8	401.0
Cyanophyta	Chamaesiphonale	*Chamaesiphon spp.*	1,583.4	2,916.0	22,574.6	1,258.4	1,277.2	24,845.4	13,643.0
		Clastidium setigerum	263.9	2,656.8	825.9	143.0			1,443.6
	Chroococcales	*Aphanocapsa spp.*							
		UID Chrooccocales	453.3	1,993.6	12,113.2	1,172.6	618.0	5,108.4	5,373.4
	Nostocales	*Anabaena sp. ?*							
		Calothrix sp. ?							
		Nostoc sp. / Anabaena sp.			<9.3	<1.0	<0.7		
		Nostoc sp.	78.8			<1.0	<0.7	<3.9	
		Tolypothrix sp.	<4.9	<8.4					
		UID Nostocales							
	Oscillatoriales	*Lyngbya spp.*	<4.9	<8.4					
		Homoeothrix varians	6,371.3	125,596.8	256,579.6	5,548.4	3,357.8	87,075.0	17,563.8
		Microcoleus sp.				40.0			
		Oscillatoria cf. agardhii			3,360.5	1,235.8	114.8	5,828.6	4,090.2
		Oscillatoria spp.					65.8	234.0	<1.3
		Phormidium sp.?							
		Pseudoanabaena spp.	274.4	470.4	1,358.5		16.8	156.0	
		UID Oscillatoriales	117.6	252.0	2,073.5		95.4	<3.9	
Rhodophyta	Nemalionales	*Audouinella sp.*			<9.3			<3.9	83.2
		Batrachospermum sp.							
		UID flagellate			275.3	7.4			20.8
		UID colonial							
		UID filamentous				<1.0	<0.7		
		UID unicellular	580.4	996.8	9,360.2	143.0	1,359.6	1,625.4	120.3

B9. Benthic Invertebrate Taxonomy, Casino Project, September 2008

Appendix B9. Benthic Invertebrate Taxonomy, Casino Project, September 2008

	Sample ID:	B1-1	B1-2	B1-3	B1-4	B1-5	B2-1	B2-2	B2-3	B2-4	B2-5	B3-1	B3-2	B3-3	B3-4	B3-5	B4-1	B4-2	B4-3	B4-4	B4-5	B5-1	B5-2	B5-3
	CC#:	080450	080451	080452	080453	080454	080455	080456	080457	080458	080459	080460	080461	080462	080463	080464	080465	080466	080467	080468	080469	080470	080471	080472
Order: Ephemeroptera	adult			1		4	3	3	1	1	1				1		1	1						
Order: Ephemeroptera	nymph (dam./juv.)	1				1			1															
Family: Ameletidae																								
Ameletus sp.	nymph	1	1	1		6	2		1	2	2	4	2	1	1					1	1	4		1
Family: Baetidae	nymph (dam./juv.)					1	3	4		8		3	1		1			1						
Baetis sp.	nymph	4	1	2		2		3	12	4	18	14	1	7		8						6		3
Baetis bicaudatus	nymph	2		2	1		1	2	3	5	5			2		2				1	1	7		2
Baetis tricaudatus	nymph					1																		
Acentrella sp.	nymph			1		1																		
Family: Heptageniidae	nymph		1	2	1	2	7	4	25	8	12	17	2	7	5	8	1	2		3	2	13	1	
Cinygmula sp.	nymph	3				1		1		1						1		3				8	4	4
Epeorus sp.	nymph						1		3		2	6		1		1	1			1		13	3	5
Family: Ephemerellidae	nymph		1			1	1		3	1	1	1										2		1
Serratella sp.	nymph			1		1																		
Ephemerella sp.	nymph															1								
Drunella sp.	nymph																							1
Drunella doddsi	nymph	2		4		2	3	3	10	8	11	12	6	14	4	5			1	1		5	1	1
Drunella coloradensis	nymph			1						1				1		1								
Order: Plecoptera	adult									2														
Order: Plecoptera	nymph (dam./juv.)	1	1				7	1	2	8	3	3								1		2		
Family: Chloroperlidae	nympg (dam./juv.)					1			1								2							
Suwallia sp.	nymph		1	2		1	1		4	3	6				1	1			1	6	2	8	1	2
Family: Perlodidae	nymph (dam./juv.)	17	5	4	3	9	2	1	2	4				4		3		1				5	2	6
Skwala sp.	nymph			1															1					
Isoperla sp.	nymph										3													
Megarcys sp.	nymph																							
Family: Nemouridae	nymph (dam./juv.)																							
Podmosta sp.	nymph						1	28	11	6	13													
Ostrocerca sp.	nymph										1													
Zapada oregonensis/haysi	nymph							1				1					1					2		
Family: Taeniopterygidae																								
Taenionema sp.	nymph			1				1		2		1												
Family: Capniidae	nymph (dam./juv.)	4	3	6	1	8	3	19	6	15	5	7	1	5	3	5	2	1	1	1		2		1
Capnia sp.	nymph																							
Order: Trichoptera	larvae (dam./juv.)					2																		
Family: Apataniidae																								
Apatania sp.	larvae																				1			
Family: Glossosomatidae																								
Glossosoma sp.	larvae			1				1						1										
Family: Limnephilidae	larvae (dam./juv.)	6	1	1				1							1			1	3	2		4		
Ecclisomyia sp.	larvae			1		3					1	1		5			3	2	1		1		2	
Hydratophylax/Pycnopsyche sp.	larvae																					1		
Family: Rhyacophilidae																								
Rhyacophila sp.	larvae																	1						
Order: Diptera UID	larvae	1	1	1	1	3		3	2		2		9	4	2	3	2	2		4	3	4	3	3
Order: Diptera UID	pupae	3	2			3	1		3															
Family: Muscidae	larvae (juv./dam.)									1												1		
Family: Ceratopogonidae																								
Bezzia/Metachela sp.	larvae																							
Family: Tipulidae	larvae (juv./dam.)			1					1			1												1
Tipula sp.	larvae	1	2					1											1				1	
Limonia sp.	larvae		1																					
Dicranota sp.	larvae							1												1		1		
Family: Psychodidae UID	larvae													2										
Pericoma sp.	larvae	1		2		1												1	2		1		1	2
Family: Empididae	larvae (juv.)	1																				1		
Chelifera/Metachela sp.	larvae	1	1				1	1						1			4	2		1			3	1
Clinocera sp.	larvae																							
Family: Simuliidae	pupae					2	2	3		1		1	1	2	2							1	1	
Simulium sp.	larvae																							

Appendix B9. Benthic Invertebrate Taxonomy, Casino Project, September 2008

	Sample ID:	B1-1	B1-2	B1-3	B1-4	B1-5	B2-1	B2-2	B2-3	B2-4	B2-5	B3-1	B3-2	B3-3	B3-4	B3-5	B4-1	B4-2	B4-3	B4-4	B4-5	B5-1	B5-2	B5-3
	CC#:	080450	080451	080452	080453	080454	080455	080456	080457	080458	080459	080460	080461	080462	080463	080464	080465	080466	080467	080468	080469	080470	080471	080472
Prosimulium sp.	larvae						2	3	1	3	1	2		3						1				1
Family: Chironomidae	larvae																							
Family: Chironomidae	pupae		2	3		4	5	2		1			6	13	12	5	2	4					2	2
Subfamily : Orthocladiinae	larvae											1	1											
Cricotopus/Orthocladius sp.	larvae	2	1				1		2		2			4	2							3		4
Eukiefferiella sp.	larvae			8	2	5	11	4		11	7			6	6		3					11	2	2
Hydrobaenus sp.	larvae																							
Parasmittia sp.	larvae											3												
Metriocnemus sp.	larvae																							
Tvetenia sp.	larvae			2	1	2	2	6	3	5	4				2									
Subfamily : Diamesinae	larvae																							
Diamesa sp.	larvae	14	5	40	4	7	25	65	36	53	46	32	21	11	10	24	4	4			2	15	3	
Pseudodiamesa sp.	larvae					1				1								1						
Pagastia sp.	larvae	2	2	8		4	4	3	8	3	1	5	2	15	4	4				3		6	3	
Potthastia sp.	larvae																							
Subfamily : Chironominae	larvae																							
Tribelos sp.	larvae												1											
Subfamily : Tanypodinae	larvae													1										
Subfamily : Podonominae	larvae																							
Trichotanypus sp.	larvae																						1	
Order: Coleoptera																								
Family: Dytiscidae	larvae (juv./dam.)															1								1
Family: Curculionidae	adult																					1		
Order: Lepidoptera	larvae								1		1		1					1						
Order: Collembola	larvae	3	1				2	1	1	2		3	4	3	3					1		1		1
Class: Crustacea																								
Order: Ostracoda			1				1		1			1	1		1							2	1	1
Order: Copepoda				3						2			2	1			1	1		1		5		2
Order: Cladocera								1					2		1							1		
Order: Bivalvia													1											
Order: Gastropoda																								
Family: Hydrobiidae								1																
Phylum: Annelida																								
Class: Oligochaeta				3					1			1		1	1			7					1	1
Family: Lumbriculidae			20		2	6		1					3				13	2		3	2	9		
Phylum: Nematoda			1	3		3							1				1	1				3		
Order: Prostigmata UID	adult																1					1	1	2
Order: Prostigmata	deutonymph		1												1		1							
Family: Hydrozetidae	adult	1		2	1	2	3	2	3			1	2	2			1	1	1	2	1	5	1	3
Family: Aturidae																								
Aturus	adult																					2		
Family: Hygrobatidae																								
Hygrobates	adult																2	1		1		4	1	1
Family: Limnesiidae																								
Limnesia	adult																							
Family: Sperchontidae																								
Sperchon	adult									1													1	
Family: Lebertiidae																								
Lebertia	adult							1				1		1	1						1			1
Family: Feltridae																								
Feltria	adult			1					2	2		1									1			1
TOTAL NUMBER		**71**	**56**	**108**	**17**	**86**	**92**	**169**	**149**	**164**	**147**	**123**	**71**	**118**	**64**	**73**	**45**	**40**	**12**	**35**	**19**	**159**	**40**	**57**
DENSITY (no. org./m^2)		**763**	**602**	**1,161**	**183**	**925**	**989**	**1,817**	**1,602**	**1,763**	**1,581**	**1,323**	**763**	**1,269**	**688**	**785**	**484**	**430**	**129**	**376**	**204**	**1,710**	**430**	**613**

Notes:

juv. = juvenile, dam. = damaged

Appendix B9. Benthic Invertebrate T

	Sample ID:	B5-4	B5-5	B7-1	B7-2	B7-3	B7-4	B7-5	B8-1	B8-2	B8-3	B8-4	B8-5
	CC#:	080473	080474	080475	080476	080477	080478	080479	080480	080481	080482	080483	080484
Order: Ephemeroptera	adult								1				
Order: Ephemeroptera	nymph (dam./juv.)	2	1										
Family: Ameletidae													
Ameletus sp.	nymph								3	2	1	2	3
Family: Baetidae	nymph (dam./juv.)		1										
Baetis sp.	nymph	2	3										
Baetis bicaudatus	nymph	1	8									2	
Baetis tricaudatus	nymph												
Acentrella sp.	nymph	2											
Family: Heptageniidae	nymph	2	4		1		1	1	106	21	85	46	29
Cinygmula sp.	nymph	1	3						4	1	2	1	2
Epeorus sp.	nymph	6	5										
Family: Ephemerellidae	nymph	1	1										
Serratella sp.	nymph												
Ephemerella sp.	nymph												
Drunella sp.	nymph												
Drunella doddsi	nymph		1										
Drunella coloradensis	nymph												
Order: Plecoptera	adult												
Order: Plecoptera	nymph (dam./juv.)	1	1	1				7	9	5	11	9	3
Family: Chloroperlidae	nympg (dam./juv.)			3			3	7					
Suwallia sp.	nymph	3	3	2		1		1					
Family: Perlodidae	nymph (dam./juv.)	3	3	6	4	1	3	1					
Skwala sp.	nymph							1	1			1	2
Isoperla sp.	nymph												
Megarcys sp.	nymph										5	2	
Family: Nemouridae	nymph (dam./juv.)							1	4	6	19	8	7
Podmosta sp.	nymph								9	15	13	20	15
Ostrocerca sp.	nymph										4	3	
Zapada oregonensis/haysi	nymph	2											
Family: Taeniopterygidae													
Taenionema sp.	nymph												
Family: Capniidae	nymph (dam./juv.)	1	2			1		2	48	37	53	36	42
Capnia sp.	nymph											1	
Order: Trichoptera	larvae (dam./juv.)												
Family: Apataniidae													
Apatania sp.	larvae												
Family: Glossosomatidae													
Glossosoma sp.	larvae												
Family: Limnephilidae	larvae (dam./juv.)	2											
Ecclisomyia sp.	larvae		4									2	1
Hydratophylax/Pycnopsyche sp.	larvae												
Family: Rhyacophilidae													
Rhyacophila sp.	larvae												
Order: Diptera UID	larvae	6	5	1				2			1		
Order: Diptera UID	pupae	1											
Family: Muscidae	larvae (juv./dam.)												
Family: Ceratopogonidae													
Bezzia/Metachela sp.	larvae				2		2						
Family: Tipulidae	larvae (juv./dam.)												
Tipula sp.	larvae								3			1	2
Limonia sp.	larvae												
Dicranota sp.	larvae								1			1	
Family: Psychodidae UID	larvae												
Pericoma sp.	larvae	1											
Family: Empididae	larvae (juv.)									1			
Chelifera/Metachela sp.	larvae										1	2	3
Clinocera sp.	larvae	1							2	1	1	5	1
Family: Simuliidae	pupae	1			1				1	1	1	3	
Simulium sp.	larvae										1		

Appendix B9. Benthic Invertebrate T

	Sample ID:	B5-4	B5-5	B7-1	B7-2	B7-3	B7-4	B7-5	B8-1	B8-2	B8-3	B8-4	B8-5
	CC#:	080473	080474	080475	080476	080477	080478	080479	080480	080481	080482	080483	080484
Prosimulium sp.	larvae	1	1					1	1		3	1	1
Family: Chironomidae	larvae												
Family: Chironomidae	pupae		3			1				3	12	11	5
Subfamily : Orthocladiinae	larvae												
Cricotopus/Orthocladius sp.	larvae	5	5						27	2			
Eukiefferiella sp.	larvae	3							16	12	87	23	45
Hydrobaenus sp.	larvae								1				
Parasmittia sp.	larvae												
Metriocnemus sp.	larvae	1											
Tvetenia sp.	larvae												
Subfamily : Diamesinae	larvae												
Diamesa sp.	larvae			16	10	2	6	13	17		125	66	67
Pseudodiamesa sp.	larvae												
Pagastia sp.	larvae	9	6						6				
Potthastia sp.	larvae		1										
Subfamily : Chironominae	larvae												
Tribelos sp.	larvae												
Subfamily : Tanypodinae	larvae												
Subfamily : Podonominae	larvae												
Trichotanypus sp.	larvae								1				
Order: Coleoptera													
Family: Dytiscidae	larvae (juv./dam.)												
Family: Curculionidae	adult												
Order: Lepidoptera	larvae	1						1					
Order: Collembola	larvae	1		2	3	10	11	2	4	4	23	3	5
Class: Crustacea													
Order: Ostracoda		1							2	2	1		
Order: Copepoda		1	1									1	
Order: Cladocera													
Order: Bivalvia													
Order: Gastropoda													
Family: Hydrobiidae													
Phylum: Annelida													
Class: Oligochaeta					1								
Family: Lumbriculidae							2	1	139	34	60	151	78
Phylum: Nematoda			1				6	2	3		1	1	2
Order: Prostigmata UID	adult			1									
Order: Prostigmata	deutonymph				1								
Family: Hydrozetidae	adult	3	3		3	1	1	1	1		2	2	1
Family: Aturidae													
Aturus	adult												
Family: Hygrobatidae													
Hygrobates	adult	4	1										
Family: Limnesiidae													
Limnesia	adult								1				
Family: Sperchontidae													
Sperchon	adult												
Family: Lebertiidae													
Lebertia	adult	1											
Family: Feltridae													
Feltria	adult				1						4		
TOTAL NUMBER		**70**	**67**	**32**	**27**	**17**	**35**	**44**	**410**	**147**	**516**	**404**	**314**
DENSITY (no. org./m^2)		**753**	**720**	**344**	**290**	**183**	**376**	**473**	**4,409**	**1,581**	**5,548**	**4,344**	**3,376**

Notes:

juv. = juvenile, dam. = damaged

B10. FISS Reports for Watersheds of the Aquatic Regional Study Area of the Casino Project

FISS Search Results

Fisheries and Oceans Canada

Pêches et Océans Canada

REFERENCE INFORMATION			
Waterbody Names			
Gazetteer Name:	BRITANNIA CREEK	Alias1:	
		Alias2:	
Waterbody Codes			
Watershed code:	800787800000000000000000000000000000		
SISS/RAB code:	603769000000000000	Lake Seq. No.:	0
Confluence Information			
Map No:		Confluence ID:	
	Zone:	7	
Easting:	6179	Northing:	69735
Comments			
FLOWS NE AND N INTO YUKON R., YUKON TERRITORY. DRAINAGE BASIN AREA =115KM SQUARE.			

STREAM INFORMATION				
MapNo	**ID**	**Station**	**Reference**	**Mean Annual Runoff**

PROVINCIAL FISHERIES MANAGEMENT OBJECTIVES		
Habitat Type	Mgmt Obj.1	Mgmt Obj.2

ENHANCEMENT AND MANAGEMENT ACTIVITIES								
MapNo	**ID**	**Type**	**Activity**	**Project**	**Start**	**Finish**	**Species**	**Reference**

		W	M				SA			800001
			THE LOWER SECTION OF THIS CREEK IS CLASSIFIED AS TYPE II - SALMONID REARING STREAM, BY THE YUKON PLACER AUTHORIZATION. THE REST OF THE WATERSHED IS CLASSIFIED AS TYPE IV							
115J15	5	U	MA			93	SA			800001
			YPA TYPE II							
115J15	6	U	MA			93				800001
115J15	5	D	YPA TYPE IV							
115J15	17	P	MSB		94	94				110121
			TEMPERATURE AND TDS DATA. NO FISH CAPTURED. NOTICEABLY NAIVE ARTIC GRAYLING AND ROUND WHITEFISH OBSERVED							
115J15	18	P	MSB		94	94				110121
			TEMPERATURE AND TDS DATA. NO FISH CAPTURED. ARCTIC GRAYLING OBSERVED DOWNSTREAM OF STATION							
		W	MSS		93	93	GR	WF	CH	110121
			FISH SCALE AGING RESULTS FOR THE CASINO PROJECT - FISHERIES ASSESSMENT PART 1. JUNE 1993							
		W	MSS							80092
			CASINO PROJECT ENVIRONMENTAL MONITORING PROGRAM - ELECTROFISHING AND MINNOW TRAPS. JUNE, AUGUST, AND SEPTEMBER 1993							830006
		W	MSB		00	00	CH			110121
			AERIAL SURVEY-1 ADULT CHINOOK CARCASS FOUND (AUGUST-2000)							
		W	MSS		00	00	CH			110121
			MINNOW TRAPPING- JUVENILE CHINOOK CAPTURED (JULY 2000							
		W	MSS		93	93	GR	CH	WF	110121
			CASINO PROJECT SAMPLING DATA-AGE/ SPECIES							

RESOURCE USE INFORMATION

MapNo	ID	Type	Code	Catch Mean	High	Low	Effort Mean	High	Low	Reference

FISHERIES POTENTIAL AND CONSTRAINTS

MapNo	ID	Type	Activity	P	L	Species	Reference
		W	WC	G			110121
			PHOTOGRAPH SHOWING WATER COLOUR AND TURBIDITY RESULTS OF MINING				
115J15	2004	P	W	G			80092
			CASINO PROJECT ENVIRONMENTAL MONITORING PROGRAM INITIATED SAMPLING HERE IN JUNE 1993				
115J15	19	P	W	G			80092
			CASINO PROJECT ENVIRONMENTAL MONITORING PROGRAM INITATED SAMPLING HERE IN JUNE 1993				
		W	W	G			830006
			AERIAL PHOTGRAPHS OF CREEK				
115J15	25	U	WDP	C		SA	110121
			AUGUST 2000. A PLACER OPERATION ON CANADIAN CREEK WAS DISCHARGING UNSETTLED, TURBID EFFLUENT INTO BRITTANIA CREEK, DETRIMENTAL TO HATCHED SALMON FRY.				
		W	HS	P		CH	110121
			AUGUST 17, 2000. SINGLE DEAD SALMON CARCASS OBSERVED AT CREEK OUTLET. NUMEROUS JUVENILE CHINOOK WERE CAPTURED IN JULY 2000 MINNOW TRAPS. ADULT CHINOOK SALMON ARE UTILIZING THE CREEK AS A SPAWNING AREA.				

OBSTRUCTIONS

MapNo	ID	Type	OBS	Height	Length	Species Blocked	Reference

LAND USE

MapNo	ID	Type	Land Use	Start Date	Reference
		W	MI		11057
			UPPER WATERSHED EXTENSIVELY PLACER MINED. EXTENSIVE QUARTZ MINING EXPLORATION IN THE UPPER WATERSHED		
		W	PM		110121
			PHOTOGRAPH SHOWING RESLTS OF MINING		
		W	RD		830006
			1994 - ACCESS ROAD TO CASINO MINE SITE RUNS ALONG BRITANNIA CREEK FROM THE YUKON RIVER		

VALUE COMMENTS

MapNo	ID	Type	Value Code	Reference

SENSITIVITY COMMENTS

MapNo	ID	Type	Sensitivity Code	Reference

SPECIES / STOCK IDENTIFICATION

Species	Char	Stock	Stock Type	Mgmt Class
CH				
GR				
RW				
SA				

FISH DISTRIBUTION

MapNo	ID	Species	Type	Activity	Reference
		CH	W	REA	110121
				FRY REARING IN THIS STREAM	
		GR	W	OBL	110121
				PRESENCE NOTED	
115J15	18	RW	P	OBL	110121
				FISH NOTICEABLY NAIVE; ALLOWED APPROACH TO WITHIN 2 - 0.5 M. THIS IS NOT NORMAL	
115J15	5	SA	U	REA	800001
115J15	17	GR	P	OBL	110121
				LARGE CONGREGATION OF GRAYLING OBSERVED. FISH NOTICEABLY NAIVE; ALLOWED APPROACH TO WITHIN 2 - .5 M	
115J15	20	GR	P	OBL	830006
				PRELIMINARY ASSESSMENT OF FISHERIES - ELECTROFISHING DATA: LENGTH, WEIGHT AND AGE OF CAPTURED FISH (CASINO MINE PROJECT)	
115J15	21	GR	P	OBL	830006
				PRELIMINARY ASSESSMENT OF FISHEREIES - ELECTROFISHING DATA: LENGTH, WEIGHT AND AGE OF CAPTURED FISH (CASINO MINE PROJECT)	
115J15	2004	CH	P	OBL	110121
				1 ADULT CHINOOK CARCASS OBSERVED (AUGUST 2000)	
		CH	W	OBL	110121
				NUMEROUS JUVENILE CHINOOK SALMON CAPTURED (JULY 2000)	

FISS Search Results

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REFERENCE INFORMATION			
Waterbody Names			
Gazetteer Name:	CANADIAN CREEK	Alias1:	
		Alias2:	
Waterbody Codes			
Watershed code:	800787850000000000000000000000000000		
SISS/RAB code:		Lake Seq. No.:	0
Confluence Information			
Map No:		Confluence ID:	
	Zone:		
Easting:		Northing:	
Comments			
TRIBUTARY TO BRITTANICA			

STREAM INFORMATION				
MapNo	**ID**	**Station**	**Reference**	**Mean Annual Runoff**

PROVINCIAL FISHERIES MANAGEMENT OBJECTIVES		
Habitat Type	Mgmt Obj.1	Mgmt Obj.2

ENHANCEMENT AND MANAGEMENT ACTIVITIES								
MapNo	**ID**	**Type**	**Activity**	**Project**	**Start**	**Finish**	**Species**	**Reference**

W	MA		93			800001
	YPA TYPE IV					
W	MSS	93	93	GR		110121
	FISH SCALE AGING RESULTS FOR THE CASINO PROJECT - FISHERIES ASSESSMENT PART 1. JUNE 1993					
W	MSS	93	93			80092
	CASINO PROJECT ENVIRONMENTAL MONITORING PROGRAM - ELECTROFISHING AND MINNOW TRAPS: JUNE, AUG. AND SEPT. 1993					830006

RESOURCE USE INFORMATION

MapNo	ID	Type	Code	Catch Mean	High	Low	Effort Mean	High	Low	Reference

FISHERIES POTENTIAL AND CONSTRAINTS

MapNo	ID	Type	Activity	P	L	Species	Reference
115J15	13	P	W	G			80092
			CASINO PROJECT ENVIRONMENTAL MONITORING PROGRAM INITIATED WATER SAMPLING HERE IN JUNE 1993				
115J15	14	P	W	G			80092
			CASINO PROJECT ENVIRONMENTAL MONITORING PROGRAM INITIATED WATER SAMPLING HERE IN JUNE 1993				
		W	H	G			830006
			AERIAL PHOTOGRAPHS OF CREEK				

OBSTRUCTIONS

MapNo	ID	Type	OBS	Height	Length	Species Blocked	Reference

LAND USE

MapNo	ID	Type	Land Use	Start Date	Reference
		W	MI		830006
			1993 - HEADWATERS IN CASINO MINE EXPLORATION SITE		

VALUE COMMENTS

MapNo	ID	Type	Value Code	Reference

SENSITIVITY COMMENTS

MapNo	ID	Type	Sensitivity Code	Reference

SPECIES / STOCK IDENTIFICATION

Species	Char	Stock	Stock Type	Mgmt Class
GR				

FISH DISTRIBUTION

MapNo	ID	Species	Type	Activity	Reference
115J15	13	GR	P	OBL	830006
				PRELIMINARY ASSESSMENT OF FISHERIES - CASINO MINE PROJECT. ELCTROFISHING DATA: LENGTH, AGE, EFFORT	

Return to the search screen.

FISS Search Results

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REFERENCE INFORMATION			
Waterbody Names			
Gazetteer Name:	CASINO CREEK	Alias1:	
		Alias2:	
Waterbody Codes			
Watershed code:	843102510971100000000000000000000000		
SISS/RAB code:		Lake Seq. No.:	0
Confluence Information			
Map No:		Confluence ID:	
	Zone:		
Easting:		Northing:	
Comments			
TRIBUTARY OF DIP CREEK WHICH DRAINS INTO KLOTTASIN, THEN DONJEK R. AND INTO WHITE RIVER			

STREAM INFORMATION				
MapNo	**ID**	**Station**	**Reference**	**Mean Annual Runoff**

PROVINCIAL FISHERIES MANAGEMENT OBJECTIVES		
Habitat Type	Mgmt Obj.1	Mgmt Obj.2

ENHANCEMENT AND MANAGEMENT ACTIVITIES								
MapNo	**ID**	**Type**	**Activity**	**Project**	**Start**	**Finish**	**Species**	**Reference**

115J10	6	P	MSS	93	93	GR	CCG	13085
			HABITAT CHARACTERISTICS; ELECTROFISHING; CALCULATED WATER FLOW; METAL ANALYSIS SAMPLES (GR). JUNE					
115J10	7	P	MSS	93	93	GR		13085
			HABITAT; ELECTROFISHING; STOP NETS; CALCULATED WATER FLOW. AGING, METAL ANALYSIS SAMPLES. JUNE					
115J10	9	P	MSS	93	93	NF		13085
			HABITAT; ELECTROFISHING. JUNE.					
115J10	6	P	MSS	93	93	GR	CCG	13086
			STOPNETS, ELECTROSHOCKING; MINNOW TRAPS (3). AUGUST.					
115J10	7	P	MSS	93	93	GR	CCG	13086
			STOPNETS; ELECTROSHOCKING; MINNOW TRAPS (3). AUGUST.					
115J10	8	P	MSS	93	93	NF		13086
			ELECTROSHOCKING; MINNOW TRAPS (3). AUGUST.					
115J16	6	P	MSS	93	93	GR	CCG	13087
			STOPNETS, ELECTROSHOCKING; MINNOW TRAPS (3); PHYSICAL CHARACTERISTICS. SEPTEMBER.					
115J10	8	P	MSS	93	93	NF		13087
			ELECTROFISHING; MINNOW TRAPS (3) PHYSICAL CHARACTGERISTICS. SEPTEMBER.					
115J10	7	P	MS	93	93	GR	CCG	13087
			STOPNETS, ELECTROSHOCKING; MINNOW TRAPS (3) PHYSICAL CHARACTERISTICS. SEPTEMBER.					
		W	MSS	93	93	GR		110121
			FISH SCALE AGING RESULTS FOR THE CASINO PROJECT - FISHERIES ASSESSMENT PART I. JUNE 1993.					
		W	MSS	93	93			80092
			CASINO PROJECT ENVIRONMENTAL MONITORING PROGRAM - ELECTROFISHING AND MINNOW TRAPS.					830006

JUNE, AUGUST AND SEPTEMBER 1993.

RESOURCE USE INFORMATION										
MapNo	**ID**	**Type**	**Code**	**Catch Mean**	**High**	**Low**	**Effort Mean**	**High**	**Low**	**Reference**

FISHERIES POTENTIAL AND CONSTRAINTS							
MapNo	**ID**	**Type**	**Activity**	**P**	**L**	**Species**	**Reference**
115J10	6	P	W	G			80092
			CASINO PROJECT ENVIRONMENTAL MONITORING PROGRAM WATER QUALITY SAMPLING INITIATED HERE JUNE 1993.				
115J10	14	P	W	G			80092
			CASINO PROJECT ENVIRONMENTAL MONITORING PROGRAM WATER QUALITY SAMPLING INITIATED HERE JUNE 1993.				
		W	H	G			830006
			AERIAL PHOTOGRAPHS OF CREEK				

OBSTRUCTIONS							
MapNo	**ID**	**Type**	**OBS**	**Height**	**Length**	**Species Blocked**	**Reference**

LAND USE					
MapNo	**ID**	**Type**	**Land Use**	**Start Date**	**Reference**
		W	MI	1993-01-01 00:00:00.0	830006
			HEADWATERS IN CASINO MINE EXPLORATION SITE.		

VALUE COMMENTS

MapNo	ID	Type	Value Code	Reference

SENSITIVITY COMMENTS

MapNo	ID	Type	Sensitivity Code	Reference

SPECIES / STOCK IDENTIFICATION

Species	Char	Stock	Stock Type	Mgmt Class
GR				
GR	RS			
CCG	RS			

FISH DISTRIBUTION

MapNo	ID	Species	Type	Activity	Reference
115J10	6	CCG	P	OBL	13085
					13086
115J10	7	CCG	P	OBL	13087
115J10	6	GR	P	OBL	830006
				PRELIMINARY ASSESSMENT OF FISHERIES - CASINO MINE PROJECT - ELECTROFISHING DATA: EFFORT, LENGTH, AGE, WEIGHT.	
115J10	7	GR	P	OBL	830006
				PRELIMINARY ASSESSMENT OF FISHERIES - CASINO MINE PROJECT. ELECTROFISHING DATA: EFFORT, LENGTH, AGE, WEIGHT.	
115J10	6	GR	P	OBL	13085
				METAL ANALYSIS SAMPLES TAKEN; SOME GR SHOWED EVIDENCE OF GILL LICE.	

115J10	7	GR	P	OBL	13085
				METAL ANALYSIS SAMPLES; AGING.	
115J10	6	GR	P	OBL	13086
				LENGTH/WEIGHT MEASUREMENTS; SCALES TAKEN FOR AGING; EVIDENCE OF GILL LICE.	13087
115J10	7	GR	P	OBL	13086
				LENGTH/WEIGHT MEASUREMENTS; SCALES TAKEN FOR AGING.	13087

Return to the search screen.

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REFERENCE INFORMATION			
Waterbody Names			
Gazetteer Name:	DIP CREEK	Alias1:	
		Alias2:	
Waterbody Codes			
Watershed code:	843102510900000000000000000000000000		
SISS/RAB code:		Lake Seq. No.:	0
Confluence Information			
Map No:		Confluence ID:	
	Zone:		
Easting:		Northing:	
Comments			
TRIBUTARY TO KLOTASSIN R.			

STREAM INFORMATION				
MapNo	**ID**	**Station**	**Reference**	**Mean Annual Runoff**
115J11	1		DFO0011	

PROVINCIAL FISHERIES MANAGEMENT OBJECTIVES				
Habitat Type	AR	Mgmt Obj.1	PR	Mgmt Obj.2

ENHANCEMENT AND MANAGEMENT ACTIVITIES

MapNo	ID	Type	Activity	Project	Start	Finish	Species			Reference
		W	MS		94	94				110121
			HELICOPTER SURVEY - HABITAT. SET UP STATIONS.							
115J11	1	P	MSS		94	94	CH	CCG	BB	110121
115J11	2	P	MSS		94	94	CCG			110121
115J10	1	P	MSS		94	94	CCG			110121
115J10	5	P	MSS		93	93	CCG			13085
			HABITAT CHARACTERISTICS; ELECTROFISHING. JUNE.							
115J10	5	P	MSS		93	93	CCG	GR		13086
			ELECTROFISHING, MINNOW TRAPS. AUGUST.							
115J10	5	P	MSS		93	93	CCG			13087
			ELECTROSHOCKING; MINNOW TRAPS (3). SEPTEMBER.							
115J10	17	P	MSS		93	93				80092
			CASINO PROJECT ENVIRONMENTAL MONITORING PROGRAM - ELECTROFISHING AND MINNOW TRAPS: JUNE, AUGUST AND SEPTEMBER, 1993.							830006
115J10	18	P	MSB		93	93				830006
			CASINO PROJECT ENVIRONMENTAL MONITORING PROGRAM - JUNE, AUGUST AND SEPTEMBER 1993. WATER QUALITY AND HYDROLOGY STATION.							80092
115J10	19	P	MSS		93	93				830006
			CASINO PROJECT ENVIRONMENTAL MONITORING PROGRAM - JUNE AUGUST AND SEPTEMBER 1993. WATER QUALITY STATION.							80092
		W	MS	YRP	98	98	CH			DFO0011
			IDENTIFY AREAS UTILIZED BY CHINOOK, PILOT SURVEY FOR FUTURE ENHANCEMENT AND RESTORATION							
115J11	3	P	MSS	YRP	98	98	CH			DFO0011
			2 MINNOW TRAPS SET							

RESOURCE USE INFORMATION

MapNo	ID	Type	Code	Catch Mean	High	Low	Effort Mean	High	Low	Reference

FISHERIES POTENTIAL AND CONSTRAINTS

MapNo	ID	Type	Activity	P	L	Species	Reference
115J10	18	P	W	G			80092
			CASINO PROJECT ENVIRONMENTAL MONITORING PROGRAM WATE QUALITY SAMPLING INITIATED HERE JUNE 1993.				
115J10	19	P	W	G			80092
			CASINO PROJECT ENVIRONMENTAL MONITORING PROGRAM WATER QUALITY SAMPLING INITIATED HERE JUNE 1993.				
		W	NS	G			830006
			AERIAL PHOTOGRAPHY OF CREEK.				
		W	FAN	G		CH	DFO0011
			DIFFICULT TO REACH BY BOAT OR HELICOPTER				
		W	EHS	P	M	CH	DFO0011
			ALTHOUGH RESULTS OF TRAPPING INDICATED FEW JUVINILE CHINOOK, SCHOOLS WERE SEEN IN AREA BUT RELUCTANT TO ENTER TRAPS				

OBSTRUCTIONS

MapNo	ID	Type	OBS	Height	Length	Species Blocked	Reference

LAND USE

MapNo	ID	Type	Land Use	Start Date	Reference

115J11	0001	P	PM	800001
			STREAM CLASSIFICATION.	

VALUE COMMENTS

MapNo	ID	Type	Value Code	Reference

SENSITIVITY COMMENTS

MapNo	ID	Type	Sensitivity Code	Reference
115J11	0002	P	HAB	110121
			CH REARING.	

SPECIES / STOCK IDENTIFICATION

Species	Char	Stock	Stock Type	Mgmt Class
CH	AN			
GR				
BB	RS			
GR	RS			
CCG	RS			
RW				WI
BB				WI

FISH DISTRIBUTION

MapNo	ID	Species	Type	Activity	Reference
115J11	1	BB	P	OBL	110121
115J11	2	BB	P	OBL	110121

115J11	1	CCG	P	OBL	110121
115J10	5	CCG	P	OBL	13085
					13086
115J10	5	CCG	P	OBL	13087
115J11	2	CH	P	REA	110121
		CH	W	REA	110121
				NO CHINOOK SPAWNING IN 1993.	
115J10	17	GR	P	OBL	830006
				PRELIMINARY ASSESSMENT OF FISHERIES - CASINO MINE PROJECT, ELECTROFISHING DATA: LENGTH, WEIGHT, AGE, EFFORT.	
115J10	5	GR	P	OBL	13086
				WEIGHT, LENGTH MEASUREMENTS; SCALES TAKEN FOR AGING.	
115J11	3	CH	P	OBL	DFO0011
				2 MINNOW TRAPS SET (JULY 9, 1998) 1 JUVINILE CHINOOK CAUGHT	
115J11	3	RW	P	OBL	DFO0011
				2 MINNOW TRAPS SET (JULY 9, 1998) 24 FISH CAUGHT	
115J11	3	BB	P	OBL	DFO0011
				2 MINNOW TRAPS SET (JULY 9, 1998) 1 FISH CAUGHT	
115J11	6	CH	P	OBL	110121
				1 ADULT CHINOOK OBSERVED AND SAMPLED	
		CH	W	OBL	110121
				A PAIR OF ADULT CHINOOK OBSERVED	

FISS Search Results

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REFERENCE INFORMATION			
Waterbody Names			
Gazetteer Name:	EXCELSIOR CREEK	Alias1:	
		Alias2:	
Waterbody Codes			
Watershed code:	800782700000000000000000000000000000		
SISS/RAB code:	603619000000000000000	Lake Seq. No.:	0
Confluence Information			
Map No:		Confluence ID:	
	Zone:	7	
Easting:	6040	Northing:	69742
Comments			
FLOWS NE INTO YUKON R., YUKON TERRITORY			

STREAM INFORMATION				
MapNo	**ID**	**Station**	**Reference**	**Mean Annual Runoff**

PROVINCIAL FISHERIES MANAGEMENT OBJECTIVES		
Habitat Type	Mgmt Obj.1	Mgmt Obj.2

ENHANCEMENT AND MANAGEMENT ACTIVITIES								
MapNo	**ID**	**Type**	**Activity**	**Project**	**Start**	**Finish**	**Species**	**Reference**

	W	M				SA		800001
		THE LOWER END OF THIS CREEK IS CLASSIFIED AS TYPE II - SALMONID REARING STREAM, BY THE YUKON PLACER AUTHORIZATION						
115J15	2	U	MA		93	SA		800001
		YPA TYPE II						

RESOURCE USE INFORMATION

MapNo	ID	Type	Code	Catch Mean	High	Low	Effort Mean	High	Low	Reference

FISHERIES POTENTIAL AND CONSTRAINTS

MapNo	ID	Type	Activity	P	L	Species	Reference

OBSTRUCTIONS

MapNo	ID	Type	OBS	Height	Length	Species Blocked	Reference

LAND USE

MapNo	ID	Type	Land Use	Start Date	Reference

VALUE COMMENTS

MapNo	ID	Type	Value Code	Reference

SENSITIVITY COMMENTS

MapNo	ID	Type	Sensitivity Code	Reference

SPECIES / STOCK IDENTIFICATION				
Species	**Char**	**Stock**	**Stock Type**	**Mgmt Class**
CH				
SA				

FISH DISTRIBUTION					
MapNo	**ID**	**Species**	**Type**	**Activity**	**Reference**
		CH	W	UNC	11057
				SUSPECTED REARING IN THIS STREAM	
115J15	2	SA	U	REA	800001

Return to the search screen.

B11. Minnow Trapping Catch, Effort and CPUE, Casino Project, 2008

Appendix B11. Minnow Trapping Catch, Effort and CPUE, Casino Project, 2008

			Catch			CPUE (number/trap-day)		
Date	Site	Trap	ARGR	SLSC	Total	ARGR	SLSC	Total
11-Jul	F07	A	0	0	0	0	0	0
11-Jul	F07	B	0	0	0	0	0	0
11-Jul	F07	C	0	0	0	0	0	0
11-Jul	F09	A	0	0	0	0	0	0
11-Jul	F09	B	0	0	0	0	0	0
11-Jul	F09	C	0	0	0	0	0	0
11-Jul	F05	A	0	0	0	0	0	0
11-Jul	F05	B	0	0	0	0	0	0
11-Jul	F05	C	0	0	0	0	0	0
11-Jul	F01	A	0	0	0	0	0	0
11-Jul	F01	B	0	0	0	0	0	0
11-Jul	F01	C	0	0	0	0	0	0
11-Jul	F14	A	0	0	0	0	0	0
11-Jul	F14	B	0	0	0	0	0	0
11-Jul	F14	C	0	0	0	0	0	0
12-Sep	F14	A	0	0	0	0	0	0
12-Sep	F14	B	0	0	0	0	0	0
12-Sep	F11	A	0	0	0	0	0	0
12-Sep	F11	B	0	0	0	0	0	0
12-Sep	F08	A	0	0	0	0	0	0
12-Sep	F08	B	0	0	0	0	0	0

Note:

ARGR = Arctic grayling, SLSC = slimy sculpin and CPUE = catch-per-unit-effort.

All traps were soaked for one day.

B12. Electrofishing Effort, Catch and CPUE, Casino Project, 2008

Appendix B12. Electrofishing Effort, Catch and CPUE, Casino Project, 2008

Date	Site	Section Length (m)	Pass	Voltage	Effort (sec)	Catch ARGR	Catch SLSC	Catch Total	CPUE (number/100 sec) ARGR	CPUE (number/100 sec) SLSC	CPUE (number/100 sec) Total	Comments
8-Jul	F03	75	1	600	1,190	1	0	1	0.08	0.00	0.08	-
8-Jul	F03	75	2	750	834	0	0	0	0.00	0.00	0.00	Saw 1 ARGR (~150 mm long)
8-Jul	F03	38	3	750	269	1	0	1	0.37	0.00	0.37	Only half of section electrofished.
	sum				2,293	2	0	2	0.09	0.00	0.09	
8-Jul	F04	200	1	600	754	4	0	4	0.53	0.00	0.53	-
9-Jul	F07	75	1	600	476	0	0	0	0.00	0.00	0.00	-
9-Jul	F07	75	2	600	437	0	0	0	0.00	0.00	0.00	-
9-Jul	F07	75	3	600	420	0	0	0	0.00	0.00	0.00	-
	sum				1,333	0	0	0	0.00	0.00	0.00	
9-Jul	F08	75	1	550	447	1	0	1	0.22	0.00	0.22	-
9-Jul	F08	75	2	550	512	0	0	0	0.00	0.00	0.00	-
9-Jul	F08	75	3	550	419	1	0	1	0.24	0.00	0.24	-
	sum				1,378	2	0	2	0.15	0.00	0.15	
9-Jul	F09	168	1	550	340	0	0	0	0.00	0.00	0.00	-
9-Jul	F10	168	1	530	709	2	0	2	0.28	0.00	0.28	Saw 3 ARGR (~300 mm long)
9-Jul	F05	226	1	550	577	0	0	0	0.00	0.00	0.00	-
10-Jul	F11	220	1	550	1,591	0	0	0	0.00	0.00	0.00	-
10-Jul	F12	200	1	500	353	0	0	0	0.00	0.00	0.00	Section length was approximate.
10-Jul	F13	75	1	600	787	0	11	11	0.00	1.40	1.40	-
10-Jul	F13	75	2	600	600	0	8	8	0.00	1.33	1.33	-
10-Jul	F13	75	3	600	438	1	1	2	0.23	0.23	0.46	-
		sum			1,825	1	20	21	0.05	1.10	1.15	
10-Jul	F01	100	1	650	707	1	0	1	0.14	0.00	0.14	-
11-Jul	F01	100	1	550	707	0	0	0	0.00	0.00	0.00	-
12-Sep	F14		1	300	922	0	6	6	0.00	0.65	0.65	-
12-Sep	F11		1	360	1,377	0	1	1	0.00	0.07	0.07	One SLSC seen, but it escaped.
12-Sep	F08		1	300	523	0	0	0	0.00	0.00	0.00	-

Note:

ARGR = Arctic grayling, SLSC = slimy sculpin and CPUE = catch-per-unit-effort.

Dashes indiacte no data were available or no comments.

B13. Angling Catch, Casino Project, 2008

Appendix B13. Angling Catch, Casino Project, 2008

Date	Site	Catch ARGR	Catch SLSC	Total	Comments
10-Jul	F08	0	0	0	Observed 1 ARGR (~150 mm)
10-Jul	F14	1	0	1	Fish was not measured (~200 mm)

Note:

ARGR = Arctic grayling, SLSC = slimy sculpin.

B14. Fish Biological Characteristics, Casino Project, 2008

Appendix B14. Fish Biological Characteristics, Casino Project, 2008

Date	Watershed	Site	Gear	Fish ID	Species	Length (mm)	Weight (g)	Scales?	Age (year)	Tissue?	Comments
8-Jul	Britannia	F03	EF	1	ARGR	280	200+	No	-	No	Too heavy for balance.
8-Jul	Britannia	F03	EF	2	ARGR	190	200+	No	-	No	Too heavy for balance.
8-Jul	Britannia	F04	EF	3	ARGR	280	220.0	Yes	5	No	-
8-Jul	Britannia	F04	EF	4	ARGR	285	260.0	Yes	6	No	-
8-Jul	Britannia	F04	EF	5	ARGR	290	230.0	Yes	6	No	-
8-Jul	Britannia	F04	EF	6	ARGR	280	250.0	Yes	5	No	-
9-Jul	Casino	F08	EF	7	ARGR	185	71.6	Yes	3	No	-
9-Jul	Casino	F08	EF	8	ARGR	173	44.5	Yes	2	No	-
9-Jul	Casino	F10	EF	9	ARGR	293	230.0	Yes	6	No	-
9-Jul	Casino	F10	EF	10	ARGR	300	260.0	Yes	6	No	-
10-Jul	Casino	F13	EF	11	SLSC	120	19.3	No	-	No	-
10-Jul	Casino	F13	EF	12	SLSC	72	3.7	No	-	No	-
10-Jul	Casino	F13	EF	13	SLSC	70	3.2	No	-	No	-
10-Jul	Casino	F13	EF	14	SLSC	71	2.9	No	-	No	-
10-Jul	Casino	F13	EF	15	SLSC	71	4.1	No	-	No	-
10-Jul	Casino	F13	EF	16	SLSC	61	2.2	No	-	No	-
10-Jul	Casino	F13	EF	17	SLSC	120	12.5	No	-	Yes	-
10-Jul	Casino	F13	EF	18	SLSC	98	8.4	No	-	Yes	-
10-Jul	Casino	F13	EF	19	SLSC	71	3.4	No	-	Yes	-
10-Jul	Casino	F13	EF	20	SLSC	65	2.3	No	-	Yes	-
10-Jul	Casino	F13	EF	21	SLSC	65	2.9	No	-	Yes	-
10-Jul	Casino	F13	EF	22	ARGR	294	240.0	Yes	-	No	-
10-Jul	Casino	F13	EF	23	SLSC	129	18.1	No	-	No	-
10-Jul	Casino	F13	EF	24	SLSC	55	1.8	No	-	No	-
10-Jul	Casino	F13	EF	25	SLSC	79	4.5	No	-	No	-
10-Jul	Casino	F13	EF	26	SLSC	65	1.6	No	-	No	-
10-Jul	Casino	F13	EF	27	SLSC	75	4.4	No	-	No	-
10-Jul	Casino	F13	EF	28	SLSC	54	1.3	No	-	No	-
10-Jul	Casino	F13	EF	29	SLSC	65	2.0	No	-	No	-
10-Jul	Casino	F13	EF	30	SLSC	65	3.0	No	-	No	-
10-Jul	Casino	F13	EF	31	ARGR	220	130.0	Yes	2	No	-
10-Jul	Britannia	F01	EF	32	ARGR	274	200.0	Yes	6	No	-
10-Jul	Dip	F14	AN	33	ARGR	~200	-	No	-	No	-
12-Sep	Dip	F14	EF	34	SLSC	70	4.0	No	-	Yes	-
12-Sep	Dip	F14	EF	35	SLSC	80	4.7	No	-	Yes	-
12-Sep	Dip	F14	EF	36	SLSC	63	2.7	No	-	Yes	-
12-Sep	Dip	F14	EF	37	SLSC	42	1.0	No	-	No	-
12-Sep	Dip	F14	EF	38	SLSC	29	0.5	No	-	No	-
12-Sep	Dip	F14	EF	39	SLSC	38	0.8	No	-	No	-
12-Sep	Casino	F11	EF	40	SLSC	89	8.7	No	-	Yes	-

Notes:

EF = electrofishing, AN = angling, ARGR = Arctic grayling and SLSC = slimy sculpin.

B15. Fish Tissue Metal Concentrations, Casino Project, 2008

Analysis Report

REPORT ON: Amended Report - Analysis of Tissue Samples

REPORTED TO: Gartner Lee Limited
490-6400 Roberts St
Burnaby, BC
V5G 4C9

Att'n: Genevieve Martin

CHAIN OF CUSTODY: 188716
PROJECT NAME: Casino
PROJECT NUMBER: 80049

NUMBER OF SAMPLES: 5

REPORT DATE: December 11, 2008

DATE SUBMITTED: July 15, 2008

GROUP NUMBER: 90716049

SAMPLE TYPE: Tissue

NOTE: Results contained in this report refer only to the testing of samples as submitted. Other information is available on request.

TEST METHODS:

Mercury in Tissue - samples were digested using a nitric acid-hydrogen peroxide digestion procedure based on EPA Method 200.3. Analysis was performed using Cold Vapour Atomic Absorption Spectrophotometry or Cold Vapour Atomic Fluorescence Spectrophotometry.

Metals in Tissue - samples were digested using a nitric acid-hydrogen peroxide digestion procedure based on EPA Method 200.3. Analysis was performed using Inductively Coupled Argon Plasma Spectroscopy (ICP), or ICP Mass Spectrometry (ICP/MS).

COMMENTS:

Amended Report - This report supercedes final hard copy sent on August 6, 2008 via mail. The tissue results are based on a wet weight basis - not dry weight as indicated in the footnotes of the report. cjw December 11, 2008

TEST RESULTS:

(See following pages)

CANTEST LTD.

Anna Becalska, PhD
Coordinator, Trace Metals

4606 Canada Way, Burnaby, BC V5G 1K5
Tel: 604 734 7276 Fax: 604 731 2386

REPORTED TO: Gartner Lee Limited

REPORT DATE: December 11, 2008

GROUP NUMBER: 90716049

CANTEST

Metals Analysis in Tissue

CLIENT SAMPLE IDENTIFICATION:		F13 CCG-7	F13 CCG-8	F13 CCG-9	F13 CCG-10	
DATE SAMPLED:		Jul 10/08	Jul 10/08	Jul 10/08	Jul 10/08	DETECTION LIMIT
CANTEST ID:		807160139	807160141	807160142	807160145	
Aluminum	Al	43.7	23.3	23	9.8	0.5
Antimony	Sb	<	<	<	<	0.1
Arsenic	As	0.2	0.1	0.1	0.1	0.1
Barium	Ba	9.8	3.9	3.1	3.1	0.1
Beryllium	Be	<	<	<	<	0.02
Boron	B	<	<	<	<	2
Cadmium	Cd	0.24	0.07	0.06	0.04	0.02
Calcium	Ca	37400	15100	11300	12800	1
Chromium	Cr	0.1	<	<	<	0.1
Cobalt	Co	0.1	<	0.1	<	0.1
Copper	Cu	2.1	1.1	1.1	1.1	0.1
Iron	Fe	161	70	63	49	5
Lead	Pb	0.1	<	<	<	0.1
Magnesium	Mg	900	450	427	437	0.5
Manganese	Mn	17.9	8.1	10.3	5.8	0.1
Mercury	Hg	0.09	0.07	0.03	0.02	0.01
Molybdenum	Mo	<	<	<	<	0.1
Nickel	Ni	0.1	<	<	<	0.1
Phosphorus	P	22900	10300	8500	9470	0.5
Potassium	K	5860	3060	3190	3710	1
Selenium	Se	0.9	0.4	0.7	0.7	0.2
Silicon	Si	66	22	35	31	10
Silver	Ag	0.01	<	<	<	0.01
Sodium	Na	3360	1450	1420	1300	1
Strontium	Sr	52.4	23	16.8	24.1	0.05
Tellurium	Te	<	<	<	<	0.1
Thallium	Tl	<	<	<	<	0.02
Tin	Sn	<	<	<	<	0.1
Titanium	Ti	13.1	5.6	4.9	4.9	0.3
Uranium	U	0.29	0.11	0.05	<	0.04
Vanadium	V	0.8	<	<	<	0.5
Zinc	Zn	57.4	30.2	21.7	22.4	0.5
Zirconium	Zr	<	<	<	<	3

Results expressed as micrograms per gram, dry basis (µg/g)
< = Less than detection limit

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REPORTED TO: Gartner Lee Limited

REPORT DATE: December 11, 2008

GROUP NUMBER: 90716049

CANTEST

Metals Analysis in Tissue

CLIENT SAMPLE IDENTIFICATION:		F13 CCG-11	
DATE SAMPLED:		Jul 10/08	DETECTION LIMIT
CANTEST ID:		807160146	
Aluminum	Al	46.1	0.5
Antimony	Sb	<	0.1
Arsenic	As	0.1	0.1
Barium	Ba	3.9	0.1
Beryllium	Be	<	0.02
Boron	B	<	2
Cadmium	Cd	0.1	0.02
Calcium	Ca	10700	1
Chromium	Cr	<	0.1
Cobalt	Co	<	0.1
Copper	Cu	1.9	0.1
Iron	Fe	81	5
Lead	Pb	<	0.1
Magnesium	Mg	412	0.5
Manganese	Mn	7.8	0.1
Mercury	Hg	0.02	0.01
Molybdenum	Mo	<	0.1
Nickel	Ni	<	0.1
Phosphorus	P	8380	0.5
Potassium	K	3380	1
Selenium	Se	0.7	0.2
Silicon	Si	45	10
Silver	Ag	<	0.01
Sodium	Na	1350	1
Strontium	Sr	15.1	0.05
Tellurium	Te	<	0.1
Thallium	Tl	<	0.02
Tin	Sn	<	0.1
Titanium	Ti	6.2	0.3
Uranium	U	0.2	0.04
Vanadium	V	0.5	0.5
Zinc	Zn	25.8	0.5
Zirconium	Zr	<	3

Results expressed as micrograms per gram, dry basis (µg/g)
< = Less than detection limit

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Tel: 604 734 7276 Fax: 604 731 2386

REPORTED TO: Gartner Lee Limited

REPORT DATE: December 11, 2008

GROUP NUMBER: 90716049

CANTEST

Batch Quality Control for Dissolved Metals Analysis in Tissue (QC# 111086)

Parameter		Blank (ug/g)	Blank Limits	Duplicate (R.P.D.) 807160241	Duplicate Limits	Duplicate (R.P.D.) 807170051	Duplicate Limits
Aluminum	Al	< 0.5	0.2	-	-	-	-
Antimony	Sb	< 0.1	0.001	-	-	-	-
Arsenic	As	< 0.1	0.002	NC	20	-	-
Barium	Ba	< 0.1	0.001	-	-	-	-
Beryllium	Be	< 0.02	0.001	-	-	-	-
Boron	B	< 2	0.02	-	-	-	-
Cadmium	Cd	< 0.02	0.0004	NC	20	5.1	20
Calcium	Ca	< 1	0.3	6.1	20	-	-
Chromium	Cr	< 0.1	0.001	-	-	-	-
Cobalt	Co	< 0.1	0.001	-	-	-	-
Copper	Cu	< 0.1	0.001	PASS	20	-	-
Iron	Fe	< 5	0.05	NC	20	-	-
Lead	Pb	< 0.1	0.002	NC	20	NC	20
Magnesium	Mg	< 0.5	0.2	PASS	20	-	-
Manganese	Mn	< 0.1	0.01	NC	20	-	-
Molybdenum	Mo	< 0.1	0.002	-	-	-	-
Nickel	Ni	< 0.1	0.003	-	-	-	-
Phosphorus	P	< 0.5	0.1	2.6	20	-	-
Potassium	K	< 1	0.3	0	20	-	-
Selenium	Se	< 0.2	0.004	-	-	-	-
Silver	Ag	< 0.01	0.001	-	-	-	-
Sodium	Na	< 1	0.5	2.3	20	-	-
Strontium	Sr	< 0.05	0.002	-	-	-	-
Tellurium	Te	< 0.1	0.002	-	-	-	-
Thallium	Tl	< 0.02	0.002	-	-	-	-
Tin	Sn	< 0.1	0.01	-	-	-	-
Titanium	Ti	< 0.3	0.01	-	-	-	-
Uranium	U	< 0.04	0.002	-	-	-	-
Vanadium	V	< 0.5	0.002	-	-	-	-
Zinc	Zn	< 0.5	0.04	NC	20	-	-
Zirconium	Zr	< 3	0.04	-	-	-	-

ug/g = micrograms per gram, dry basis
R.P.D. = Relative Percent Difference
PASS = Duplicate sample results were in the range of one to five times the detection limit. R.P.D. calculation is not applicable in this range. Acceptance criteria is a maximum difference between the duplicates equivalent to the value of the detection limit.
NC = Not Calculated. Duplicate sample results were less than the detection limit. Relative Percent Difference calculation is not defined for analyte levels of less than detection limit.

4606 Canada Way, Burnaby, BC V5G 1K5
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Batch Quality Control for Dissolved Metals Analysis in Tissue (QC# 111086)

Parameter		Duplicate (R.P.D.) 807170062	Duplicate Limits	NRC TORT-2, "Lobster Tissue" (% Recovery)	NRC TORT-2, "Lobster Tissue" Limits
Arsenic	As	-	-	87	66 - 113
Cadmium	Cd	0	20	88	63 - 118
Chromium	Cr	-	-	65	60 - 120
Cobalt	Co	-	-	78	60 - 120
Copper	Cu	-	-	87	60 - 120
Iron	Fe	-	-	90	60 - 120
Lead	Pb	NC	20	86	39 - 150
Manganese	Mn	-	-	87	60 - 120
Mercury	Hg	-	-	93	78 - 122
Molybdenum	Mo	-	-	95	60 - 120
Nickel	Ni	-	-	80	50 - 122
Selenium	Se	-	-	89	67 - 118
Strontium	Sr	-	-	93	60 - 120
Vanadium	V	-	-	116	60 - 120
Zinc	Zn	-	-	83	53 - 125

ug/g = micrograms per gram, dry basis
R.P.D. = Relative Percent Difference
NC = Not Calculated. Duplicate sample results were less than the detection limit. Relative Percent Difference calculation is not defined for analyte levels of less than detection limit.

4606 Canada Way, Burnaby, BC V5G 1K5
Tel: 604 734 7276 Fax: 604 731 2386

Instrument Quality Control for the Mercury Monitor (QC# 216250)

QC Type: Calibration Verification

Parameter	% Recovery	Limits
Mercury Hg	93	90 - 110

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Tel: 604 734 7276 Fax: 604 731 2386

Batch Quality Control Frequency Summary

Metals Plant Tissue Digestion (Batch# 111086)

QC Type	No. Samples
NRC TORT-2, "Lobster Tissue"	1
Blank	2
Duplicate	3
Batch Size	21

4606 Canada Way, Burnaby, BC V5G 1K5
Tel: 604 734 7276 Fax: 604 731 2386

Analysis Report

REPORT ON: Amended Report - Analysis of Tissue Samples

REPORTED TO: Gartner Lee Limited
490-6400 Roberts St
Burnaby, BC
V5G 4C9

Att'n: Genevieve Martin

CHAIN OF CUSTODY: 2106142
PROJECT NAME: Casino
PROJECT NUMBER: 80049

NUMBER OF SAMPLES: 4

REPORT DATE: December 11, 2008

DATE SUBMITTED: September 16, 2008

GROUP NUMBER: 90917022

SAMPLE TYPE: Tissue

NOTE: Results contained in this report refer only to the testing of samples as submitted. Other information is available on request.

TEST METHODS:

Mercury in Tissue - samples were digested using a nitric acid-hydrogen peroxide digestion procedure based on EPA Method 200.3. Analysis was performed using Cold Vapour Atomic Absorption Spectrophotometry or Cold Vapour Atomic Fluorescence Spectrophotometry.

Metals in Tissue - samples were digested using a nitric acid-hydrogen peroxide digestion procedure based on EPA Method 200.3. Analysis was performed using Inductively Coupled Argon Plasma Spectroscopy (ICP), or ICP Mass Spectrometry (ICP/MS).

COMMENTS:

Amended Report - This report supercedes final hard copy sent on October 15, 2008 via mail. The tissue results are based on a wet weight basis - not dry weight as indicated in the footnotes of the report. cjw December 11, 2008

TEST RESULTS:

(See following pages)

CANTEST LTD.

per Anna Becalska, PhD
Coordinator, Trace Metals

4606 Canada Way, Burnaby, BC V5G 1K5
Tel: 604 734 7276 Fax: 604 731 2386

REPORTED TO: Gartner Lee Limited

REPORT DATE: December 11, 2008

GROUP NUMBER: 90917022

CANTEST

Metals Analysis in Tissue

CLIENT SAMPLE IDENTIFICATION:		F14-1	F14-2	F14-3	F11-1	
DATE SAMPLED:		Sep 12/08	Sep 12/08	Sep 12/08	Sep 12/08	DETECTION LIMIT
CANTEST ID:		809170067	809170068	809170069	809170070	
Aluminum	Al	19.5	294	16.2	35.6	0.5
Antimony	Sb	<	<	<	<	0.1
Arsenic	As	0.1	0.3	0.1	0.1	0.1
Barium	Ba	3.2	7.3	3.1	1.2	0.1
Beryllium	Be	<	<	<	<	0.02
Boron	B	<	<	<	<	2
Cadmium	Cd	0.03	0.04	<	0.03	0.02
Calcium	Ca	9630	10100	8210	3760	1
Chromium	Cr	<	0.3	<	0.1	0.1
Cobalt	Co	<	0.3	<	<	0.1
Copper	Cu	1	1.1	0.9	0.9	0.1
Iron	Fe	51	693	51	71	5
Lead	Pb	<	0.3	<	<	0.1
Magnesium	Mg	363	486	360	295	0.5
Manganese	Mn	8.2	25.4	8.8	3.1	0.1
Mercury	Hg	0.032	0.038	0.034	0.027	0.01
Molybdenum	Mo	<	<	<	<	0.1
Nickel	Ni	<	0.3	<	<	0.1
Phosphorus	P	7450	7660	6610	4590	0.5
Potassium	K	3320	2670	2510	3320	1
Selenium	Se	0.8	0.7	0.7	1.1	0.2
Silicon	Si	41	64	49	38	10
Silver	Ag	<	<	<	<	0.01
Sodium	Na	1250	1260	1250	1090	1
Strontium	Sr	17.4	17	17.5	4.89	0.05
Tellurium	Te	<	<	<	<	0.1
Thallium	Tl	<	<	<	<	0.02
Tin	Sn	<	<	<	<	0.1
Titanium	Ti	4.2	24.6	3.9	3.7	0.3
Uranium	U	0.05	0.13	<	<	0.04
Vanadium	V	<	1.5	<	<	0.5
Zinc	Zn	21.6	28	21.2	19.2	0.5
Zirconium	Zr	<	<	<	<	3

Results expressed as micrograms per gram, dry basis (µg/g)
< = Less than detection limit

4606 Canada Way, Burnaby, BC V5G 1K5
Tel: 604 734 7276 Fax: 604 731 2386

REPORTED TO: Gartner Lee Limited

REPORT DATE: December 11, 2008

GROUP NUMBER: 90917022

CANTEST

Batch Quality Control for Dissolved Metals Analysis in Tissue (QC# 113690)

Parameter		Blank (ug/g)	Blank Limits	Duplicate (R.P.D.) 809170495	Duplicate Limits	Duplicate (R.P.D.) 809170515	Duplicate Limits
Aluminum	Al	< 0.5	0.2	8.6	20	4.2	20
Antimony	Sb	< 0.1	0.001	NC	20	NC	20
Arsenic	As	< 0.1	0.002	NC	20	PASS	20
Barium	Ba	< 0.1	0.001	0.2	20	2.1	20
Beryllium	Be	< 0.02	0.001	NC	20	NC	20
Boron	B	< 2	0.02	PASS	20	5.7	20
Cadmium	Cd	< 0.02	0.0004	PASS	20	PASS	20
Calcium	Ca	< 1	0.3	2.3	20	3.5	20
Chromium	Cr	< 0.1	0.001	0	20	11.8	20
Cobalt	Co	< 0.1	0.001	PASS	20	PASS	20
Copper	Cu	< 0.1	0.001	6.7	20	2.2	20
Iron	Fe	< 5	0.05	5.6	20	5	20
Lead	Pb	< 0.1	0.002	NC	20	PASS	20
Magnesium	Mg	< 0.5	0.2	5.6	20	2.1	20
Manganese	Mn	< 0.1	0.01	8.5	20	1	20
Molybdenum	Mo	< 0.1	0.002	0	20	0	20
Nickel	Ni	< 0.1	0.003	3.3	20	0	20
Phosphorus	P	< 0.5	0.1	3.5	20	0.5	20
Potassium	K	< 1	0.3	2.2	20	0.9	20
Selenium	Se	< 0.2	0.004	NC	20	PASS	20
Silver	Ag	< 0.01	0.001	NC	20	NC	20
Sodium	Na	< 1	0.5	11.8	20	8.7	20
Strontium	Sr	< 0.05	0.002	2.6	20	6.4	20
Tellurium	Te	< 0.1	0.002	NC	20	NC	20
Thallium	Tl	< 0.02	0.002	PASS	20	NC	20
Tin	Sn	< 0.1	0.01	NC	20	NC	20
Titanium	Ti	< 0.3	0.01	6.1	20	0	20
Uranium	U	< 0.04	0.002	NC	20	NC	20
Vanadium	V	< 0.5	0.002	NC	20	NC	20
Zinc	Zn	< 0.5	0.04	3.6	20	4.3	20
Zirconium	Zr	< 3	0.04	NC	20	NC	20

ug/g = micrograms per gram, dry basis
R.P.D. = Relative Percent Difference
PASS = Duplicate sample results were in the range of one to five times the detection limit. R.P.D. calculation is not applicable in this range. Acceptance criteria is a maximum difference between the duplicates equivalent to the value of the detection limit.
NC = Not Calculated. Duplicate sample results were less than the detection limit. Relative Percent Difference calculation is not defined for analyte levels of less than detection limit.

4606 Canada Way, Burnaby, BC V5G 1K5
Tel: 604 734 7276 Fax: 604 731 2386

REPORTED TO: Gartner Lee Limited

REPORT DATE: December 11, 2008

GROUP NUMBER: 90917022

CANTEST

Batch Quality Control for Dissolved Metals Analysis in Tissue (QC# 113690)

Parameter		Duplicate (R.P.D.) 809180212	Duplicate Limits	NIST1573a Tomato Leaves (% Recovery)	NIST1573a Tomato Leaves Limits	NRC TORT-2, "Lobster Tissue" (% Recovery)	NRC TORT-2, "Lobster Tissue" Limits
Aluminum	Al	-	-	32	7 - 91	-	-
Arsenic	As	-	-	195	80 - 283	88	66 - 113
Boron	B	-	-	96	62 - 142	-	-
Cadmium	Cd	-	-	79	30 - 124	89	63 - 118
Calcium	Ca	3.4	20	97	60 - 120	-	-
Chromium	Cr	-	-	50	28 - 97	75	60 - 120
Cobalt	Co	-	-	97	50 - 150	95	60 - 120
Copper	Cu	5.3	20	85	59 - 125	89	60 - 120
Iron	Fe	0.3	20	87	52 - 167	87	60 - 120
Lead	Pb	-	-	-	-	87	39 - 150
Magnesium	Mg	6	20	-	-	-	-
Manganese	Mn	6.2	20	101	62 - 131	88	60 - 120
Mercury	Hg	-	-	(*)	88.24 - 111.8	119	78 - 122
Molybdenum	Mo	-	-	-	-	94	60 - 120
Nickel	Ni	-	-	63	28 - 143	80	50 - 122
Phosphorus	P	9.6	20	110	60 - 120	-	-
Potassium	K	2.8	20	105	60 - 120	-	-
Selenium	Se	-	-	-	-	89	67 - 118
Sodium	Na	6.5	20	84	60 - 120	-	-
Strontium	Sr	-	-	-	-	86	60 - 120
Vanadium	V	-	-	62	50 - 150	100	60 - 120
Zinc	Zn	4.7	20	87	49 - 109	92	53 - 125

ug/g = micrograms per gram, dry basis
R.P.D. = Relative Percent Difference
(*) = Quality Control results exceeded internally set limits; after review by Quality Assurance Unit, non-conformance overridden and batch sample analysis results released for reporting

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Instrument Quality Control for the Mercury Monitor (QC# 221756)

QC Type: Calibration Verification

Parameter	% Recovery	Limits
Mercury Hg	96	90 - 110

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Batch Quality Control Frequency Summary

Metals Plant Tissue Digestion (Batch# 113690)

QC Type	No. Samples
NIST1573a Tomato Leaves	1
NRC TORT-2, "Lobster Tissue"	1
Blank	2
Duplicate	3
Batch Size	25

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B16. Fish Habitat Data, Casino Project, July 2008

Appendix B16. Fish Habitat Data, Casino Project, July 2008

Site	Date	Distance Surveyed (m)	Stream Characteristics				Habitat Type (%)					Side Channel (%)	Bed Material (%)						
													Fines	Gravels		Larges			Bedrock
			Stage (H/M/L)	Gradient (%)	Wet Width (m)	Channel Width (m)	Pool	Run	Riffle	Cascade	Other			Small (2-16 mm)	Large (16-64 mm)	Small Cobble (64-128 mm)	Large Cobbles (128-256 mm)	Boulder (>256 mm)	
F08	9-Jul	75	Low	3.0	2.9	3.3	40	0	0	60	0	0	10	30	0	0	40	20	0
					4.5	5.8													
					2.2	5.6													
F07	9-Jul	75	Low	9.0	3.4	4.7	Cascade Pool					0	20	10	0	5	15	50	0
					4.4	6.2													
					5.4	8.1													
F03	8-Jul	75	Low	3.0	4.7	6.2	10	0	90	0	0	0	10	15	0	35	30	10	0
					7.0	7.0													
					4.5	9.5													
					3.7	10.3													
F04	8-Jul	200	Low	4.0	5.6	5.6	Cascade Pool					0-10	5	0	20	15	10	50	0
					5.0	8.8													
					5.0	5.1													

Appendix B16. Fish Habitat Data, Casino Project, July 2008

Site	Date	Distance Surveyed (m)	Cover Type (%)							Crown Closure (%)	Banks (F, G, L, R)	Confinement (EN, CO, FC, OC, UC, N/A)	Braided (Y or N)	pH	Water Temp (°C)	TDS (g/L)	Conductivity (25°C) (µs/cm)	DO (%)	DO (mg/L)	Comments
			Total Overall	Deep Pool	LOD	Boulder	Cutbank	Instream Veg	Overstream Veg											
F08	9-Jul	75	30	20	0	70	5	0	5	5	F, L	UC	N	7.39	5.93	0.173	264	86.8	10.81	Casino Creek, Cascade Pool habitat
F07	9-Jul	75	30	3	0	85	2	0	10	5	F, L	UC	N	6.9	3.4	0.181	278	92.9	12.36	Upper Reach of Casino Creek, Cascade Pool habitat
F03	8-Jul	75	45	0	40	5	15	0	40	7	F, L	UC	N	7.45	9	0.167	256	95.5	11.0	Upstream of Britannia Creek
F04	8-Jul	200	50	0	10	80	0	0	10	17	F, L	UC	Y	6.53	6.34	0.075	111	93.4	11.45	Upstream of F03, Cascade Pool habitat

B17. Fish Habitat Data, Casino Project, September 2008

Appendix B17. Fish Habitat Data, Casino Project, September 2008

Site ID	Date	Reach	Co-ordinates		Stream Characteristics					Habitat Type (%)				Side Channel %	Bed Material (%)							Co		
																Gravels		Larges						
			Easting	Northing	Stage (H/M/L)	Gradient (%)	Wet Width (m)	Channel Width (m)	Depth (m)	Pool	Run	Riffle	Other		Fines	Small (2-16 mm)	Large (16-64 mm)	Small Cobble (64-128 mm)	Large Cobbles (128-256 mm)	Boulder (>256 mm)	Bedrock	Total Overall	Deep Pool	LOD
Lower Reach of Britannia Creek	11-Sep	1	617,126	6,970,199	High	0.0	-	-	0.35	20	30	50	0	(only 1)	20	20	0	50	10	0	0	10	20	80
									0.20															
Upper Reach of Britannia Creek	11-Sep	2	616,279	6,966,540	High	1.0	4.2	4.2	0.21	10	20	70	0		0	30	30	0	20	20	0	10	0	70
							3.9	3.9	0.42															
									0.16															
									0.42															
									0.23															
Lower Reach of Canadian Creek	11-Sep	1	615,314	6,966,030	High	0.0	4.8	7.9	1.00	20	40	40	0		10	10	10	20	50	0	0	10	20	80
									0.26															
Cascade pools on Canadian Creek	11-Sep	2	609,160	690,684	High	15.0	8.0	8.0	0.43						5	0	5	0	0	90	0	50	0	0
Upper Reach of Canadian Creek	11-Sep	3	609,622	6,958,679	High	3.0	4.0	4.0	0.36	10	10	80	0		5	0	0	15	60	20	0	20	0	0
							1.95	1.95	0.16															
At site F14 on Dip Creek	12-Sep	1	609,367	6,947,025	High	0.0	11.0	11.0	1.25	30	30	40	0		50	10	0	30	10	0	0	25	50	50
							10.0	10.0																
Meloy Creek	12-Sep	1	611,661	6,954,143	High	2 to 3	1.8	1.8	0.40	20	50	30	0		80	5	0	5	0	10	0	70	20	0
							1.1	1.1	0.21															
							0.5	0.5																
Upper Reach of Casino Creek	12-Sep	2	613,087	6,954,573	High	3.0	6.1	6.1	0.34	50	10	40	0		10	0	10	20	20	40	0	30	0	0
							4.7	4.7	0.08															
									0.40															
Lower Reach of Casino Creek	12-Sep	1	610,515	6,950,136	High	2.0	5.8	5.8	1.50	30	40	30	0		30	5	5	20	40	0	0	30	70	30
							5.6	5.6	0.40															
									0.27															
									0.65															
Lower Reach of Brynelson Creek	12-Sep	1	610,209	6,952,288	High	2.0	6.1	6.1	0.12	20	20	60	0		30	0	20	20	20	10	0	10	0	0
							4.7	4.7	0.26															
									0.49															
									0.30															
Upper Reach of Brynelson Creek	12-Sep	2	609,448	6,953,393	High	2 to 3	4.1	4.1	0.40	30		70	0		0	0	0	10	20	70	0	20	0	20
									0.35															
									0.40															
Lower Reach of Austin Creek	12-Sep	1	610,157	6,949,620	High	0.0	1.9	1.9	0.54	70	30		0		100	0	0	0	0	0	0	100	0	0
							1.6	1.6	0.39															
Upper Reach of Austin Creek	12-Sep	2	608,816	6,951,236	High		1.08	1.08	0.56	70	20	10	0		90	0	0	0	0	10	0	90	10	0
								0.80	0.29															

Appendix B17. Fish Habitat Data, Casino Project, September 2008

Site ID	Cover Type (%)				Crown Closure (%)	Bars (%)	Confinement (EN, CO, FC, OC, UC, N/A)	Braided (Y or N)	YSI 556						Hanna Combo Pen		
	Boulder	Cutbank	Instream Veg	Overstream Veg					pH	Water Temperature (°C)	TDS (g/L)	Conductivity (25°C) (µs/cm)	DO %	DO (mg/L)	Water Temperature (°C)	Conductivity (25°C) (µs/cm)	pH
Lower Reach of Britannia Creek	0	0	0	0	10	20	OC	N	7.16	5.42	0.126	195	95.5	12.04	5.9	-	8.04
Upper Reach of Britannia Creek	0	20	0	10	20	10	UC		9.73	3.08	0.117	175	96	12.9	3	150	7.96
Lower Reach of Canadian Creek	0	0	0	0	10	0	UC	N	7.01	5.65	0.102	161	88.1	11.06	-	-	-
Cascade pools on Canadian Creek	100	0	0	0	0	0	FC	N	6.92	4.01	0.073	108	84.5	11.08	-	-	-
Upper Reach of Canadian Creek	100	0	0	0	0	0	UC	N	6.82	3.17	0.075	118	79.2	10.6	-	-	-
At site F14 on Dip Creek	0	0	0	0	10	0	UC	Y	6.91	2	0.1	152	85.2	11.79	-	-	-
Meloy Creek	0	0	0	80	10	0	UC	N	6.69	1.99	0.128	188	85	11.75	-	-	-
Upper Reach of Casino Creek	80	0	0	20	0	0	UC	N	7	3.39	0.133	202	87.7	11.66	-	-	-
Lower Reach of Casino Creek	0	0	0	0	20	0	UC	N	7	4.64	0.19	180	84.9	10.97	-	-	-
Lower Reach of Brynelson Creek	90	0	0	10	10	0	UC	Y	6.92	2.56	0.077		93.1	12.69	2.9	92	7.96
Upper Reach of Brynelson Creek	80	0	0	0	10	0	UC	N	6.78	3.01	0.067	105	90.1	12.12	-	-	-
Lower Reach of Austin Creek	0	0	0	100	0	0	UC	Y	7	2.85	0.135	208	87.2	11.75	-	-	-
Upper Reach of Austin Creek	0	0	0	90	0	0	UC	Y	5.82	1.94	0.068	110	90.1	12.43	-	-	-

Appendix C

Terrestrial Environment

C1. Ecosystem Classification Data, Casino Project, July 2008

Appendix C1. Ecosystem Classification Data, Casino Project, July 2008.

Number of Ecosite Sampling Points				**13**				
Site Observations								
Plot ID	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Plot Type	Ground	Ground	Ground	Ground	Ground	Ground	Ground	Ground
Assessment Date	7/8/2008	7/8/2008	7/8/2008	7/8/2008	7/8/2008	7/9/2008	7/9/2008	7/9/2008
Location (UTM Co-ordinates)	7V 0615740 E 6966668 N	7V 0615899 E 6966475 N	7V 0608513 E 6957166 N	7V 0606672 E 6946763 N	7V 0610514 E 6963530 N	7V 0610965 E 6941982 N	7V 0610685 E 6940964 N	7V 0610206 E 6941620 N
Ecological Region								
Habitat Description	Aspen Forest	Riparian	Low Shrub	Dry Shrub	Tussock Sedge	Subalpine	Alpine	Subalpine
Parent Material	Collivial	Fluvial	Bedrock	Collivial	Organic	Collivial	Collivial	Collivial
Site Position (Macro)	Inclined	Flood Plain	Ridged	Inclined	Inclined	Inclined	Ridged	Inclined
Site Position (Meso)	Mid Slope	Level	Crest	Upper Slope	Lower Slope	Upper Slope	Crest	Mid Slope
Slope (%)	55	2	3	58	50	56	2	50
Aspect (degree)	153	40	335	195	10	272	360	70
Drainage	Well Drained (3)	Imperfectly Drained (5)	Poorly Drained (6)	Rapidly (2)	Poorly Drained (6)	Moderately Well Drained (4)	Moderately Well Drained (4)	Poorly Drained (6)
Site Photos								
Vegetation								
Main Canopy Descriptor	-	A16Sb10	-	-	-	A05Bw8Sb2	-	-
Sub Canopy Descriptor	D4Aw10	-	-	-	-	-	-	-
Structural Stage	Pole/Sapling	Mature Forest	Low Shrub	Dwarf Shrub	Dwarf-shrub Dominated	Tall Shrub/Woodland	Bryoid	Tall Shrub/Woodland
Dominant Shrub Species (% cover)	*Rosa acicularis (15)*	*Alnus incana (20)*	*Betula glandulosa (45)*	*Arctostaphylos uva-ursi (15)*	*Ledum decumbens (35)*	*Betula grandulosa (50)*	*Betula grandulosa (15)*	*Ledum decumbens (35)*
Sub-dominant Shrub Species (% cover)	*Shepherdia canadensis (5)*	*Vaccinium vitis-idaea (15)*	*Salix glauca. (25)*	*Rosa acicularis (5)*	*Andromeda polifolia (15) and Betula glandulosa (15)*	*Salix glauca (20)*	*Arctostaphylos alpina (10)*	*Oxycoccus microcarpus (15)*
Dominant Herb/Forb Species (% cover)	*Epilobium angustifolium (4)*	*Equisetum arvense (4)*	*Petasites spp. (3)*	*Artemisia frigida (15)*	*Equisetum sylvaticum (6)*	*Mertensia paniculata (3)*	*Dryas spp. (45)*	*Polygonum vivparum (2) and Petasites spp. (2)*
Sub-dominant Herb/Forb Species (% cover)	*Galium boreale (2) and Achillea millefolium (2)*	*Equisetum scirpoides (2)*	*Jacobs Ladder (2)*	*Fragaria virginiana (6) and Solidago simplex (6)*	*Polygonum vivparum (5) and Lycopodium annotinum (5)*	*Epilobium angustifolium (2) and Saxifraga bronchialis (2)*	*Saxifraga bronchialis (4)*	-
Dominant Graminoid Species (% cover)	-	-	*Carex spp. (20)*	*Poa spp. (8)*	-		-	*Carex spp. (15)*
Sub-dominant Graminoid Species (% cover)	-	-	-	-	-	-	-	-
Dominant Mosses, Liverwort, Lichen Species (% cover)	-	*Hylocomium splendens (20)*	*Hylocomium splendens (45)*	-	*Sphagnum spp. (65)*	*Hylocomium splendens (20)*	*Cladina spp (8)*	*Pleurozium schreberi (65)*
Sub-dominant Mosses, Liverwort, Lichen Species (% cover)	-	-	*Sphagnum spp. (15)*	-	-	*Cladina spp (5) and Polytrichum spp (5)*	-	*Sphagnum spp. (15)*
Moisture Regime	Submesic (4)	Subhygric (6)	Hygric (7)	Submesic (4)	Subhydric (8)	Mesic (5)	Mesic (5)	Subhygric (6)
Nutrient Regime	Medium (C)	Medium (C)	Poor (B)	Medium (C)	Poor (B)	Poor (B)	Poor (B)	Poor (B)
Ecosite Classification								
Soils Characteristics								
Organic Layer								
Organic Thickness (cm)	-	10 (buried organic within profile)	-	-	0-31	-	-	30
LFH Thickness (cm)	1	2	5	0	-	2	3	-
Humus Form	Moder	Raw Moder	Mor	-	-	Mor	Mor	-
Mineral Soil (Topsoil)								
Topsoil Thickness (cm)	0-7	-	0-9	0-11	-	0-4	0-3	-
Topsoil Texture	L	-	L	L	-	L	L	-
Topsoil Color	10YR 4/4	-	7.5 YR 3/4	10YR 2/2	-	10YR 3/2	10YR 3/2	-
Coarse Fragment Class	Gravel	-	-	-	-	Cobble / Sand	-	-
Coarse Fragment (%)	<15	0	0	-	-	< 15	-	-

Appendix C1. Ecosystem Classification Data, Casino Project, July 2008.

Number of Ecosite Sampling Points				**13**				
Site Observations								
Plot ID	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Mineral Soil (Subsoil)								
Subsoil Thickness (cm)	7-45	10-50	9-60	11-29 / 29-55	-	4-35	3-35	-
Subsoil Texture	LS	cS	fSCL	grL / grL	-	L	L	-
Subsoil Color	10YR 4/4	10YR 4/4	Gley 1 4/10Y	10YR 4/4 / 10YR 4/3	-	10YR 3/6	10YR 4/3	-
Coarse Fragment Class	Gravel / Cobble	-	-	Gravel	-	Cobble / Sand	Sand	-
Coarse Fragment (%)	<30	0	0	<50	-	< 80	< 50	-
Presence of/Depth to (cm):								
Carbonates	-	-	-	-	-	-	-	-
Mottles/ Gleying	-	15	10	-	-	-	-	-
Water Table	-	-	-	-	-	-	-	30
Bedrock	-	-	-	-	-	-	35	-
Root Restriction	-	-	-	-	31	-	-	30
Effective Rooting Depth	40	15	15	35	30	20	6	-
Effective Texture	7	10	-	11	-	20	20	-
Pit Depth	45	55	60	55	30	35	35	30
Permafrost Depth	-	-	-	-	30	-	-	30
Seepage	N	N	Y	N	Y	N	N	Y
Soil Classification								
Comments								
	Immature Trembling aspen stand with ~ 3 m height. Scattered standing aspen remnants throughout stand. Aspen trees have silver coloring from unknown insect infestation. Soils shallow with coarse frags and bare soil prevelant across site.	Buried organic horizons to 10 cm with mottles present. Alder, willow and birch dominate understory shurb layer.	Plot located at crest of long slope near area of exposed bedrock with willow, dwarf birch and mossess dominating site.	Plot located on steep graminoid/forb dominated sideslope immediately above Dip Creek.	Plot located on north facing, poorly drained, wet tundra slope.	Plot within shrubby slope transitiong into open alpine located at upper slope position.	Plot located at saddle of alpine area with large amounts of exposed bedrock.	Plot located on open tundra slope with scattered dwarf birch and willow with the site dominated by ericarious shrubs and feathermoss.

Appendix C1. Ecosystem Classification Data, Casino Project, July 2008.

Number of Ecosite Sampling Points									
Site Observations									
Plot ID	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
Plot Type	Ground	Ground	Ground	Ground	Ground	Ground	Visual	Ground	Ground
Assessment Date	7/9/2008	7/9/2008	7/9/2008	7/10/2008	7/10/2008	7/10/2008	7/10/2008	7/10/2008	7/10/2008
Location (UTM Co-ordinates)	7V 0609812 E 6948824 N	7V 0609654 E 6949236 N	7V 614952 E 6966217 N	7V 0619197 E 6963646 N	7V 0618722 E 6963601 N	7V 0601196 E 6943376 N	7V 0601355 E 6943360 N	7V 0602780 E 6942145 N	7V 0602740 E 6942316 N
Ecological Region									
Habitat Description	Aspen Forest	Spruce/Birch Forest	Disturbance	Subalpine	Aspen Forest	Aspen Forest	Dry Shrub	Tussock Sedge	Treed Bog (sloped)
Parent Material	Morainal	Morainal	Morainal	Collivial	Morainal	Morainal	Collivial	Organic	Organic
Site Position (Macro)	Inclined	Inclined	Inclined	Inclined	Inclined	Inclined	Inclined	Inclined	Level
Site Position (Meso)	Mid Slope	Upper Slope	Mid Slope	Upper Slope	Upper Slope	Upper Slope	Upper Slope	Lower Slope	Level
Slope (%)	34	18	40	60	48	28	44	18	1
Aspect (degree)	196	40	105	340	215	225	180	10	10
Drainage	Well Drained (3)	Imperfectly Drained (5)	Moderately Well Drained (4)	Imperfectly Drained (5)	Well Drained (3)	Well Drained (3)	Rapidly Drained (2)	Imperfectly Drained (5)	Poorly Drained (6)
Site Photos									
Vegetation									
Main Canopy Descriptor	D12Aw9Sw1	B09Bw6Sb4	A10Aw7Sw2Bw1	-	C8Aw8Bw1Sw1	C9Aw9Sw1	-	C6Sb10	-
Sub Canopy Descriptor	-	A05Sb8Bw2	-	-	B4Aw10	B5Aw10	-	-	-
Structural Stage	Mature Forest	Mature Forest	Old Forest	Tall Shrub/Woodland	Mature Forest	Young Forest	Dwarf-shrub Dominated	Shrub/Woodland	Shrub/Woodland
Dominant Shrub Species (% cover)	*Vaccinium vitis-idaea (15)*	*Ledum decumbens (50)*	*Shepherdia canadensis (15) and Linnaea borealis (15)*	*Ledum decumbens (60)*	*Shepherdia canadensis (20)*	*Vaccinium vitis-idaea (45)*	*Arctostaphylos uva-ursi (65)*	*Ledum decumbens (20)*	*Ledum decumbens (35)*
Sub-dominant Shrub Species (% cover)	*Linnaea borealis (10)*	*Vaccinium vitis-idaea (30)*	*Viburnum edule (8)*	*Betula grandulosa (30)*	*Arctostaphylos uva-ursi (12)*	*Arctostaphylos uva-ursi (30)*	*Populus tremuloides (6)*	*Salix spp. (6)*	*Betula grandulosa (30)*
Dominant Herb/Forb Species (% cover)	*Epilobium angustifolium (5)*	*Lycopodium complanatum (3)*	*Epilobium angustifolium (6)*	*Epilobium latifolium (1) and Rumex arcticus (1)*	*Mertensia paniculata (4)*	*Pyrola asarifolia (2); Mertensia paniculata (2) and Delphinium glaucum (2)*	*Fragaria virginiana (5)*	*Petasites frigidus (3)*	*Rubus chamaemorus (8)*
Sub-dominant Herb/Forb Species (% cover)	*Mertensia paniculata (2); Pyrola asarifolia (2); Zigadenus elegans (2) and Delphinium glaucum (2)*		*Mertensia paniculata (4)*	-	*Epilobium angustifolium (3)*	*Anemone multifida (1)*	*Zygadenus elegans (4) and Vicia americana (4)*	*Equisetum arvense (2) and Equisetum pratense (2)*	-
Dominant Graminoid Species (% cover)	-	-	*Festuca altaica (10)*	*Poa artica (1)*	*Poa artica (6)*	*Poa spp. (6)*		-	*Eriophorum vaginatum (25)*
Sub-dominant Graminoid Species (% cover)	-	-	-	-	-	-	-	-	-
Dominant Mosses, Liverwort, Lichen Species (% cover)	-	*Hylocomium splendens (75)*	-	*Pleurozium schreberi (45)*	-	-	-	*Hylocomium splendens (45)*	*Sphagnum spp. (50)*
Sub-dominant Mosses, Liverwort, Lichen Species (% cover)	-	*Pleurozium schreberi (15)*	-	*Hylocomium splendens (35)*	-	-	-	*Pleurozium schreberi (25) and Cladina spp. (20)*	-
Moisture Regime	Mesic (5)	Subhydric (6)	Mesic (5)	Subhydric (6)	Mesic (5)	Submesic (4)	Submesic (4)	Subhygric (6)	Hygric (7)
Nutrient Regime	Medium (C)	Poor (B)	Medium (C)	Poor (B)	Medium (C)	Medium (C)	Medium (C)	Poor (B)	Poor (B)
Ecosite Classification									
Soils Characteristics									
Organic Layer									
Organic Thickness (cm)	-	-	-	-	-	-		15	18
LFH Thickness (cm)	4	3	-	16	4	2		-	-
Humus Form	Mor	Mor	-	Mor	Moder	Moder		Peaty Mor	-
Mineral Soil (Topsoil)									
Topsoil Thickness (cm)	0-11	0-6	0-11	0-25	0-9	0-13		0-18	-
Topsoil Texture	L	L	L	L	L	L		L	-
Topsoil Color	10YR 4/4	10YR 4/2	10YR 3/3	10YR 3/3	7.5YR 3/3	7.5YR 3/3		5Y 3/2	-
Coarse Fragment Class	-	Gravel	Gravel	Gravel/Cobble/Sand	Gravel/Cobble	Small Gravel		-	-
Coarse Fragment (%)	-	< 30	< 5	< 80	< 50	< 50		0	-

Appendix C1. Ecosystem Classification Data, Casino Project, July 2008.

Number of Ecosite Sampling Points									
Site Observations									
Plot ID	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
Mineral Soil (Subsoil)									
Subsoil Thickness (cm)	11-42	6-45	11-45	-	9-43	13-50		18-27	-
Subsoil Texture	L-CL	L-CL	L	-	SL	L		SiCL	-
Subsoil Color	10YR 4/4	10YR 4/4	10YR 4/3	-	10YR 4/3	7.5YR 3/4		5Y 3/2	-
Coarse Fragment Class	Gravel	Gravel	Gravel	-	Cobble	Small Gravel		-	-
Coarse Fragment (%)	< 30	<30	<5	-	< 30	< 50		0	-
Presence of/Depth to (cm):									
Carbonates	-	-	-	-	-	-		-	-
Mottles/ Gleying	-	-	-	-	-	-		At Surface	-
Water Table	-	-	-	-	-	-		-	-
Bedrock	-	-	-	At surface	-	-		-	-
Root Restriction	-	-	-	-	-	-		27	18
Effective Rooting Depth	28	18	20	-	22	30		5	-
Effective Texture	11	6	11	-	9	13		20	-
Pit Depth	42	45	45	25	43	50		27	18
Permafrost Depth	-	-	-	-	-	-		18	18
Seepage	N	N	N	N	N	N		Y	Y
Soil Classification									
Comments									
	Dry south facing, immature aspen stand dominated by short shrubs.	Plot characteristic of similar topographic positions throughout local study area.	Numerous dead standing snags, remnants of previous burn with large amounts of blowdown across hillside.	Plot located near top of Black spruce/ dwarf birch/lab tea scrub slope. Open tundra slope to west. Coluvium or fractured bedrock immediately below moss layer with very little soil present.	Immature aspen stand on Southwest facing slope. Some birch and spruce scattered throughout.	Characteristic aspen stand on south or southwest facing well drained slope.	Open, dry south facing slope with vegetation primarily ground shrubs (bearberry).	Black spruce stand on North facing slope, characterized as a Sb treed bog on a slope. Surfacewater moving downslope over surface of permafrost.	Open shrubby bog with cottongrass and sphagnum hummocks throughtout caused by surface water held up from permafrost.

C2. Ecosystem Classification Data, Casino Project, September 2008

Appendix C2. Ecosystem Classification Data, Casino Project, September 2008

Site Observations					
Plot ID	**18**	**19**	**20**	**21**	**22**
Plot Type	Ground	Visual	Visual	Ground	Visual
Assessment Date	9/9/2008	9/9/2008	9/10/2008	9/10/2008	9/10/2008
Location (UTM Co-ordinates)	7V 0605681 E 6958060 N	7V 0604883 E 6960270 N		7V 0599985 E 6943470 N	7V 0600113 E 6943246 N
Ecological Region					
Habitat Description	Alpine	Felsenmeer		Aspen Forest	Treed Bog (sloped)
Parent Material	Collivial	Bedrock	Colluvial	Colluvial	Organic
Site Position (Macro)	Ridged	Ridged	Inclined	Inclined	Inclined
Site Position (Meso)	Crest	Upper Slope	Upper Slope	Mid Slope	Lower Slope
Slope (%)	-	12	20	30	-
Aspect (degree)	-	360	345	162	-
Drainage	Rapidly Drained (2)	Well Drained (3)	Poorly Drained (7)	Well Drained (3)	Poorly Drained (7)
Site Photos					
Vegetation					
Main Canopy Descriptor	-	-	-	-	-
Sub Canopy Descriptor	-	-	-	-	-
Structural Stage	Sparse/Bryoid	Sparse/Bryoid	Low Shrub	Mature Forest	Tall Shrub/Woodland
Dominant Shrub Species (% cover)	*Drya spp. (50)*	*Betula glandulosa*	*Ledum decumbens*	*Vaccinium vitis-idaea (35)*	
Sub-dominant Shrub Species (% cover)	*Vaccinium vitis-idaea (3)*	*Cassiope tetragona, Empetrum nigrum & Vaccinium membranaceum*	*Vaccinium vitis-idaea, Empetrum nigrum & Vaccinium membranaceum*	*Arctostaphylos uva-ursi (25)*	
Dominant Herb/Forb Species (% cover)	-	*Dryas spp.*	*Polygonum bistora*	*Galium boreale (2)*	
Sub-dominant Herb/Forb Species (% cover)	-	-	-	*Epilobium angustifolium (1)*	
Dominant Graminoid Species (% cover)	*Hierochloe alpina (10)*	-	*Luzula parviflora*	*Calamagrostis purpurascens (5)*	
Sub-dominant Graminoid Species (% cover)	*Luzula spp. (3)*	-	-	-	
Dominant Mosses, Liverwort, Lichen Species (% cover)	*Polytrichum juniperinum (3)*	-	*Hylocomium splendens*	*Cladina rangifernia (2)*	
Sub-dominant Mosses, Liverwort, Lichen Species (% cover)	-	-	-	*Lycopodium complanatum*	
Moisture Regime	Subxeric (3)	Subhygric (6)	Hygric (7)	Submesic (4)	
Nutrient Regime	Poor (B)	Poor (B)	Poor (B)	Poor (B)	

Appendix C2. Ecosystem Classification Data, Casino Project, September 2008

Site Observations					
Plot ID	**18**	**19**	**20**	**21**	**22**
Ecosite Classification					
Soils Characteristics					
Organic Layer					
Organic Thickness (cm)	2	-	20	-	-
LFH Thickness (cm)	-	-	-	7	-
Humus Form	Peaty Mor	-	Peaty Mor	Mor	-
Mineral Soil (Topsoil)					
Topsoil Thickness (cm)	0-3	-	0-23	0-8	-
Topsoil Texture	L	-	SCL	L	-
Topsoil Color	10YR 2/1	-		10YR 3/4	-
Coarse Fragment Class	-	-	-	-	-
Coarse Fragment (%)	-	-	-	-	-
Mineral Soil (Subsoil)					
Subsoil Thickness (cm)	3-29 / 29-42	-	-	8-40	-
Subsoil Texture	CL / CL	-	-	SL	-
Subsoil Color	2.5Y 4/4 / 2.5Y 4/3	-	-	2.5Y4/3	-
Coarse Fragment Class		-	-	-	-
Coarse Fragment (%)		-	-	-	-
Presence of/Depth to (cm):					
Carbonates	-	-	-	-	-
Mottles/ Gleying	-	-	-	-	-
Water Table	-	-	-	-	-
Bedrock	-	-	-	-	-
Root Restriction	-	-	-	-	-
Effective Rooting Depth	-	-	-	-	-
Effective Texture	-	-	-	-	-
Pit Depth	42	-	23	40	-
Permafrost Depth	-	-	-	-	-
Seepage	-	-	-	-	-
Soil Classification	-	-	-	-	-
Comments					
	Vegetation hardened of and done for the season. Crest and upper slope position easily typed the same.	Rocky Scree slope grades into birch shrub.	Surface and subsurface drainage channels into shallow gully with a high water table.	Aspen stand on dry, south facing slope, charactistic of these types observed thoughout study area.	South of site #108 where slope decrease and drainage is poor. Black spruce treed bog.

Appendix C2. Ecosystem Classification Data, Casino Project, September 2008

Site Observations						
Plot ID	**23**	**24**	**25**	**26**	**27**	**28**
Plot Type	Ground	Ground	Ground	Ground	Ground	Ground
Assessment Date	9/10/2008	9/10/2008	9/10/2008	9/10/2008	9/10/2008	9/10/2008
Location (UTM Co-ordinates)	7V 0600185 E 6942998 N	7V 620660 E 6951944 N	7V 620653 E 6951802 N	7V 608536 E 6946051 N	7V 611658 E 6973460 N	7V 613793 E 6973079 N
Ecological Region						
Habitat Description	Shrubby Bog (sloped)	Disturbance	Spruce Forest	Spruce/Birch Forest	Birch Forest	Birch Forest
Parent Material	Organic	Colluvial	Colluvial	Morainal	Alluvial	Alluvial
Site Position (Macro)	Level	Inclined	Inclined	Inclined	Floodplain	Floodplain
Site Position (Meso)	Level	Upper Slope	Mid Slope	Lower Slope	Level	Level
Slope (%)	-	22	42	24	-	-
Aspect (degree)	-	208	200	270	-	-
Drainage	Poorly Drained (7)	Moderately Well Drained (4)	Moderately Well Drained (4)	Well Drained (3)	Imperfectly Drained (6)	Imperfectly Drained (6)
Site Photos						
Vegetation						
Main Canopy Descriptor	-	-	-	-	-	-
Sub Canopy Descriptor	-	-	-	-	-	-
Structural Stage	Shrub/Woodland	Old Forest	Old Forest	Mature Forest	Mature Forest	Mature Forest
Dominant Shrub Species (% cover)	*Betula glandulosa (35)*	*Vaccinium vitis-idaea (45)*	*Vaccinium vitis-idaea (15)*	*Vaccinium vitis-idaea (15) and Ledum decumbens (15)*	*Rosa acicularis (20)*	*Rosa acicularis (35)*
Sub-dominant Shrub Species (% cover)	*Salix planifolia (20)*	*Ledum decumbens (30)*	*Empetrum nigrum (4)*	*Arctostaphylos uva-ursi (10)*	*Cornus stolonifera (15), Alnus tenuifolia (15)*	*Rubus idaeus (30)*
Dominant Herb/Forb Species (% cover)	*Rubus chamaemorus (3)*	-		*Mertensia paniculata (1)*	*Epilobium angustifolium (4)*	*Equisetum arvense (20)*
Sub-dominant Herb/Forb Species (% cover)	*Pedasites spp. (2)*	-	-	-	*Mertensia paniculata (3), Delphinium glancum (3)*	-
Dominant Graminoid Species (% cover)	*Eriophorum spp. (40)*	-	-		*Calamagrostis canadensis (5)*	*Calamagrostis canadensis (20)*
Sub-dominant Graminoid Species (% cover)	-	-	-	-	-	-
Dominant Mosses, Liverwort, Lichen Species (% cover)	*Sphagnum spp.*	*Hylocomium splendens (25)*	*Hylocomium splendens (85)*	*Hylocomium splendens (20)*	-	-
Sub-dominant Mosses, Liverwort, Lichen Species (% cover)	-	*Polytrichum juniperinum (2)*	-	*Pleurozium schreberi (5)*	-	-
Moisture Regime	Subhygric (6)	Mesic (5)	Mesic (5)	Submesic (4)	Subhygric (6)	Subhygric (6)
Nutrient Regime	Poor (B)	Poor (B)	Poor (B)	Poor (B)	Rich (D)	Rich (D)

Appendix C2. Ecosystem Classification Data, Casino Project, September 2008

Site Observations						
Plot ID	**23**	**24**	**25**	**26**	**27**	**28**
Ecosite Classification						
Soils Characteristics						
Organic Layer						
Organic Thickness (cm)	35	-	-	-	-	-
LFH Thickness (cm)	-	5	13	2	10	12
Humus Form		Mor	Mor	Mor	Moder	Mor
Mineral Soil (Topsoil)						
Topsoil Thickness (cm)	-	0-5	0-12	0-5	-	0-6
Topsoil Texture	-	L	L	L	-	fS
Topsoil Color	-	10YR 3/3	10YR 3/3	10YR 4/3	-	10YR 3/1
Coarse Fragment Class	-	-	-	-	-	-
Coarse Fragment (%)	-	-	-	-	-	-
Mineral Soil (Subsoil)						
Subsoil Thickness (cm)	35	5-43	12+	5-35 / 35-54	0-45	6-36
Subsoil Texture	-	gSL	gSL	L / N/A	S	fS
Subsoil Color	-	2.5Y 4/3	2.5Y4/3	10YR 4/3 / 7.5Y 3/4	5Y 3/2	2.5Y 3/1
Coarse Fragment Class	-	-	-	-	-	-
Coarse Fragment (%)	-	-	-	-	-	-
Presence of/Depth to (cm):						
Carbonates	-	-	-	-	-	-
Mottles/ Gleying	-	-	-	-	-	-
Water Table	-	-	-	-	-	-
Bedrock	-	-	-	-	-	-
Root Restriction	-	-	-	-	-	-
Effective Rooting Depth	-	-	-	-	-	-
Effective Texture	-	-	-	-	-	-
Pit Depth	35	43	12+	54	45	46
Permafrost Depth	35	-	-	-	-	-
Seepage	-	-	-	-	-	-
Soil Classification	-	-	-	-	-	-
Comments						
	Shrub layer generally <1 m. Extremely Hummocky ground with tussock sedge.	Site in proximity to historic placer mining activity, east of lod air strip. Area appears to be in historicly burned in early 90's.	Thick mor humus form with evidence of historic burn as seen thru charcoal within profile. Very gravelly Bm horizon.	C horizon contains high % gravel with mica flakes and limited soil present. High % of lichen cover observed on site. Site was a black spruce dominated stand on a northwest facing slope	Poorly developed soil horizons as a result of depostional characteristics and periodic flooding events. Island in middle of Yukon river, site is unlike any other within LSA, Poplar stand with rich shrub layer.	Large healthy stand of high quality white birch. Buried log at 36 cm with former Ah horizon below within the soil profile.

Appendix C2. Ecosystem Classification Data, Casino Project, September 2008

Site Observations					
Plot ID	**29**	**30**	**31**	**32**	**33**
Plot Type	Visual	Ground	Visual	Ground	Visual
Assessment Date	9/10/2008	9/10/2008	9/10/2008	9/10/2008	9/10/2008
Location (UTM Co-ordinates)	7V 613919 E 6973035 N	7V 635414 E 6957579 N	7V 634959 E 6957682 N	7V 611733 E 6959586 N	7V 611879 E 6959889 N
Ecological Region					
Habitat Description	Spruce (Sw) Forest	Spruce (Sw) Forest	Treed Bog (sloped)	Subalpine	Felsenmeer
Parent Material	Alluvial	Colluvial	organic/Colluvial	Collivial	Bedrock
Site Position (Macro)	Floodplain	Inclined	Inclined	Inclined	Ridged
Site Position (Meso)	Level	Upper Slope	Upper Slope	Mid Slope	Upper Slope
Slope (%)	-	23	-	22	-
Aspect (degree)	-	219	-	180	-
Drainage	Imperfectly Drained (6)	Imperfectly Drained (6)	Imperfectly Drained (6)	Poorly Drained (7)	Moderately Well Drained (4)
Site Photos					
Vegetation					
Main Canopy Descriptor	B30Sw10				
Sub Canopy Descriptor	B24Bw10				
Structural Stage	Mature Forest	Mature Forest	Young Forest	Tall Shrub/Woodland	Low Shrub
Dominant Shrub Species (% cover)		*Betula glandulosa (10), Empetrum nigrum (10)*		*Vaccinium uliginosum (40)*	*Betula glandulosa, Empetrum nigrum, Vaccinium vitis-idaea, Salix glauca*
Sub-dominant Shrub Species (% cover)		*Ledum decumbens (6)*		*Ledum decumbens (30)*	
Dominant Herb/Forb Species (% cover)		*Mertensia paniculata (2), Lupinus arcticus (2)*		-	*Lupinus arcticus, Cystopteris fragilis*
Sub-dominant Herb/Forb Species (% cover)		-		-	
Dominant Graminoid Species (% cover)		*Calamagrostis canadensis (15)*		-	
Sub-dominant Graminoid Species (% cover)		-		-	
Dominant Mosses, Liverwort, Lichen Species (% cover)		*Hylocomium splendens (65)*		*Hylocomium splendens (40)*	*Flavocetraria cucullata, Cladina mitis, Cladina stellaris, Tomenthypnum nitens*
Sub-dominant Mosses, Liverwort, Lichen Species (% cover)		-		*Pleurozium schreberi (25)*	
Moisture Regime		Subhygric (6)		Subhygric (6)	
Nutrient Regime		Rich (D)		Rich (D)	

Appendix C2. Ecosystem Classification Data, Casino Project, September 2008

Site Observations					
Plot ID	**29**	**30**	**31**	**32**	**33**
Ecosite Classification					
Soils Characteristics					
Organic Layer					
Organic Thickness (cm)	-	-	-	18	-
LFH Thickness (cm)	-	8	-	-	-
Humus Form	-	Mor	-	-	-
Mineral Soil (Topsoil)					
Topsoil Thickness (cm)	-	-	-	-	-
Topsoil Texture	-	-	-	-	-
Topsoil Color	-	-	-	-	-
Coarse Fragment Class	-	-	-	-	-
Coarse Fragment (%)	-	-	-	-	-
Mineral Soil (Subsoil)					
Subsoil Thickness (cm)	-	0-22	-	18-42 / 42+	-
Subsoil Texture	-	SiC	-	CL / CL	-
Subsoil Color	-	2.5Y 3/1	-	10YR 4/3 / 2.5Y 4/4	-
Coarse Fragment Class	-	-	-	-	-
Coarse Fragment (%)	-	-	-	-	-
Presence of/Depth to (cm):					
Carbonates	-	-	-	-	-
Mottles/ Gleying	-	-	-	-	-
Water Table	-	-	-	-	-
Bedrock	-	-	-	-	-
Root Restriction	-	-	-	-	-
Effective Rooting Depth	-	-	-	-	-
Effective Texture	-	-	-	-	-
Pit Depth		22		42+	
Permafrost Depth	-	-	-	-	-
Seepage	-	-	-	-	-
Soil Classification	-	-	-	-	-
Comments					
	East of pure Bw stand wich grades into mixedwood type. Very large white spruce stems (~30 m height and Diam 57.8 cm). Ground Vegetation and soils similar to that of site 115.	Very shallow soils. High % coarse fragments.	Scrubby black spruce treed bog with large patches of birch.	Rocky/Bouldery scree slope grades into birch and willow shrub slope on south facing site. Shallow soils with poor drainage. Seepage present within soil profile.	Shrubby scree slope.

C3. Wildlife Survey Data, Casino Project, 2008

Appendix C3. Wildlife Survey Data, Casino Project, 2008

Date	Time	Waypoint	Easting	Northing	Elevation (m)	Species	Comments
21-May	11:51	-	619,781	6,973,576	470	black bear	observed at W6b water quality site
7-Jul	11:50	466	610,594	6,959,232	1,334	grizzly bear	large blonde-coloured grizzly bear by tank farm
7-Jul	19:44	467	617,430	6,973,771	473	moose	moose on Yukon River
8-Jul	12:30	468	615,643	6,968,170	846	grizzly bear	blonde-coloured grizzly bear on Britannia Creek
8-Jul	12:36	469	614,545	6,972,795	452	moose	cow moose and calf on island in Yukon River; photos 1406-1408
8-Jul	16:20	470	609,718	6,959,554	1,388	wolf scat	wolf scat at Dip Creek; photos 1468-1470
8-Jul	16:25	471	607,837	6,957,167	1,560	beaver sign	beaver-chewed aspen trees on north side of Dip Creek; photo 1471
8-Jul	17:33	472	606,489	6,946,636	635	wolf scat	wolf scat at Dip Creek; photos 1488-1489
8-Jul	17:38	473	606,500	6,946,604	627	bear scat	bear scat at Dip Creek; photos 1490-1491
8-Jul	17:43	474	606,626	6,946,499	640	moose	bull moose; moose skull with antlers on Dip Creek; photos 1492-1493
9-Jul	13:01	476	611,243	6,941,817	1,320	caribou droppings	caribou pellets on N-facing ridge south of Dip Creek
9-Jul	14:49	477	610,603	6,940,867	1,323	moose and bear droppings	moose pellets and bear scat on N-facing ridges south of Dip Creek
9-Jul	16:15	478	610,600	6,941,472	1,169	moose antlers	bull moose antlers on south side of Dip Creek
9-Jul	16:44	480	609,430	6,949,158	856	bear claw marks	bear claw marks on aspen; photo 1526
9-Jul	16:47	481	609,402	6,949,172	849	moose droppings	moose pellets
9-Jul	16:56	482	609,345	6,949,154	840	bear scat	bear scat; photos 1527-1528
9-Jul	17:06	483	609,205	6,949,213	846	bear claw marks	bear claw marks on aspen; photo 1529
9-Jul	17:18	484	609,147	6,949,267	842	bear scat	grouse droppings; bear scat (photos 1532-1533) and grizzly bear tracks
9-Jul	18:46	486	615,047	6,965,946	563	bear scat	bear scat on Canadian Creek; photo 1544
10-Jul	10:27	488	618,816	6,963,724	1,126	caribou antlers	bull caribou antler in Britannia Creek area; photos 1552-1553
10-Jul	10:40	489	618,743	6,963,643	1,136	moose droppings	moose pellets on SW-facing slope
10-Jul	11:37	490	601,265	6,943,372	754	moose droppings	moose pellets on S-facing slopes on north side of Dip Creek
10-Jul	11:48	491	601,312	6,943,431	769	moose and bear droppings	moose pellets and bear scat on S-facing ridge north of Dip Creek
10-Jul	11:59	492	601,347	6,943,433	765	bear scat	bear scat on S-facing slopes on N side of Dip Creek; photo 1572-1573
10-Jul	12:00	493	601,342	6,943,439	768	bear scat	bear scat on S-facing slopes on N side of Dip Creek; photo 1575-1576
10-Jul	12:06	494	601,391	6,943,445	775	moose droppings	moose pellets on S-facing slopes on north side of Dip Creek
10-Jul	12:18	495	601,270	6,943,365	749	bear scat	bear scat on S-facing slopes on north side of Dip Creek; photos 1577-1578
10-Jul	12:19	496	601,267	6,943,365	752	bear scat	bear scat on S-facing slopes on north side of Dip Creek; photos 1579-1580
10-Jul	13:20	497	600,685	6,942,727	649	moose	1st cow moose in oxbow lake south on Dip Creek
10-Jul	13:21	498	600,491	6,942,371	649	moose	2nd cow moose in oxbow lake south on Dip Creek
10-Jul	13:25	499	613,943	6,961,605	1,280	grizzly bear	chocolate-coloured grizzly bear observed feeding
10-Jul	17:26	500	611,829	6,956,759	-	bear scat	bear scat on trail to tank farm
10-Jul	17:29	501	611,251	6,958,739	1,196	bear scat	bear scat on trail to tank farm; photo 1601
10-Jul	17:31	502	610,539	6,958,945	1,268	bear scat	bear scat on trail to tank farm
10-Jul	17:32	503	610,513	6,958,945	1,270	bear scat	bear scat on trail to tank farm
10-Jul	18:11	504	611,549	6,956,498	1,172	bear scat	bear scat on trail to tank farm
11-Jul	-	-	616,372	6,966,651	-	black bear	observed by Scott Casselman on Canadian Creek
15-Aug	-	-			-	bull caribou	old shop at tank farm
16-Aug	-	-	616,058	6,968,432	-	black bear	barge landing
17-Aug	-	-	611,407	6,956,335	-	lynx	300 m from camp
18-Aug	-	-	616,098	6,964,795	-	bull moose	airstrip
20-Aug	-	-	611,202	6,960,600	-	bull caribou	on ore deposit
22-Aug	-	-			-	bull and cow caribou	N of ore deposit
24-Aug	-	-			-	1 bull and 8 cow caribou	between ore deposit and old shop
25-Aug	-	-	613,873	6,962,494	-	wolf	uphill from Britannia Creek
26-Aug	-	-	611,538	6,958,378	-	sow grizzly with 2 2-yr-old cubs	bottom of ore deposit
29-Aug	-	-	617,271	6,971,511	-	black bear	Britannia Creek
30-Aug	-	-	616,631	6,965,040	-	wolf	Britannia Creek
30-Aug	-	-			-	cow moose and 2-yr-old bull	down from Britannia Creek
31-Aug	-	-	610,575	6,959,760	-	2 bull caribou	north ridge of ore deposit
1-Sep	-	-	616,243	6,967,437	-	cow moose and calf	barge landing

Appendix C3. Wildlife Survey Data, Casino Project, 2008

Date	Time	Waypoint	Easting	Northing	Elevation (m)	Species	Comments
1-Sep	-	-	615,975	6,964,431	-	lynx	Britannia Creek
2-Sep	-	-	611,615	6,960,546	-	chocolate brown grizzly	N side of pass to Yukon River
3-Sep	-	-	615,992	6,963,950	-	black bear	Canadian Creek
5-Sep	-	-	609,993	6,955,887	-	black bear with 2 yrlg cubs	top of road to old camp
5-Sep	-	-			-	snowshoe hares	road from old camp to airstrip
7-Sep	-	-			-	robin and porcupine	on road
7-Sep	-	-			-	bull and cow caribou	turn on road to Placer camp
7-Sep	-	-	612,351	6,960,616	-	northern hawk owl	terrible two's
9-Sep	-	2	605,549	6,958,043	-	raptor pellet	photo 2132 and 2133
9-Sep	-	4	605,484	6,958,070	-	arctic gr. squirrel burrow	photo 2135
9-Sep	-	5	605,908	6,957,508	-	bear dig at gr. squirrel burrow	-
9-Sep	-	6	605,929	6,957,478	-	arctic gr. squirrel burrow	photos 2138 and 2139
9-Sep	-	7	605,945	6,957,408	-	northern bog lemming burrows	photo 2140
9-Sep	-	8	605,943	6,957,303	-	large gr. squirrel site	photos 2141 and 2142
9-Sep	-	9	605,783	6,956,666	-	moose droppings	-
9-Sep	-	10	601,338	6,951,194	-	northern harrier	foraging at site 3: open, wet dwarf birch meadow; photo 2146
9-Sep	-	11	602,957	6,947,115	-	moose droppings	site 4: birch/alder/lab tea habitat
9-Sep	-	12	602,983	6,947,152	-	moose droppings	site 4: birch/alder/lab tea habitat
9-Sep	-	13	603,035	6,947,209	-	moose droppings	site 4: birch/alder/lab tea habitat
9-Sep	-	14	603,026	6,947,255	-	moose droppings	site 4: birch/alder/lab tea habitat
9-Sep	-	15	603,005	6,947,355	-	moose droppings	site 4: birch/alder/lab tea habitat
9-Sep	-	16	603,057	6,947,386	-	moose droppings	site 4: birch/alder/lab tea habitat
9-Sep	-	17	602,943	6,947,575	-	moose droppings	site 5: bl. Spruce/sphagnum moss/lab tea/ willow stand
9-Sep	-	18	602,974	6,947,629	-	moose droppings	site 5: bl. Spruce/sphagnum moss/lab tea/ willow stand
9-Sep	-	19	602,916	6,947,834	-	spruce grouse droppings	site 5: bl. Spruce/sphagnum moss/lab tea/ willow stand
9-Sep	-	21			-	gray jay	at Casino camp
10-Sep	-	22	599,973	6,943,490	-	bear scat	s-facing aspen/wh. spruce/bearberry/buffaloberry habitat
10-Sep	-	23			-	northern flicker	s-facing aspen/wh. spruce/bearberry/buffaloberry habitat
10-Sep	-	24	599,976	6,943,553	-	bear scat	s-facing aspen/wh. spruce/bearberry/buffaloberry habitat
10-Sep	-	25	599,969	6,943,506	-	bear scat	s-facing aspen/wh. spruce/bearberry/buffaloberry habitat
10-Sep	-	26	599,913	6,943,440	-	bear claw marks on aspen	s-facing aspen/wh. spruce/bearberry/buffaloberry habitat; photo 2180
10-Sep	-	27	599,893	6,943,498	-	bear claw marks on aspen	s-facing aspen/wh. spruce/bearberry/buffaloberry habitat
10-Sep	-	28	599,918	6,943,380	-	red squirrel midden, hare and grouse pellets	bl. spr/willow/lab tea habitat
10-Sep	-	29	600,028	6,943,296	-	moose droppings	bl. spr/willow/lab tea habitat
10-Sep	-	30			-	tundra swans on oxbow lake	same oxbow as wypt 497 moose
10-Sep	-	31	620,421	6,951,948	-	moose droppings	Rude Creek airstrip; aspen/spr habitat; photos 2191 and 2192
10-Sep	-	32	620,197	6,951,895	-	moose droppings	Rude Creek airstrip; aspen/spr habitat; photos 2191 and 2192
10-Sep	-	33	620,198	6,951,819	-	moose droppings	Rude Creek airstrip; aspen/spr habitat; photos 2191 and 2192
10-Sep	-	34	620,207	6,951,834	-	bear scat	Rude Creek airstrip; aspen/spr habitat; photos 2191 and 2192
10-Sep	-	35	620,207	6,951,822	-	bear scat	Rude Creek airstrip; aspen/spr habitat; photos 2191 and 2192
10-Sep	-	36	620,352	6,951,932	-	fox scat	Rude Creek airstrip; aspen/spr habitat; photos 2191 and 2192
10-Sep	-	37	620,670	6,952,004	-	bear ant log	bl. spr/willow/lab tea habitat
10-Sep	-	38	620,653	6,951,979	-	moose droppings	bl. spr/willow/lab tea habitat
10-Sep	-	39	620,614	6,951,984	-	moose droppings	bl. spr/willow/lab tea habitat
10-Sep	-	40	620,666	6,951,804	-	spruce grouse	bl. spr/willow/lab tea habitat
10-Sep	-	41	620,655	6,941,809	-	spruce grouse	site 3: bl. spr/sphagnum moss/bog cranberry habitat; photos 2205 and 2206
10-Sep	-	42	620,633	6,951,755	-	red squirrel midden	site 3: bl. spr/sphagnum moss/bog cranberry habitat; photos 2207
10-Sep	-	43	620,679	6,951,765	-	red squirrel midden	site 3: bl. spr/sphagnum moss/bog cranberry habitat
10-Sep	-	44	620,645	6,951,693	-	red squirrel midden; moose pellets	site 3: bl. spr/sphagnum moss/bog cranberry habitat
10-Sep	-	45	620,632	6,951,572	-	moose droppings	trail to Placer camp
10-Sep	-	46	620,600	6,951,584	-	moose droppings	trail to Placer camp

Appendix C3. Wildlife Survey Data, Casino Project, 2008

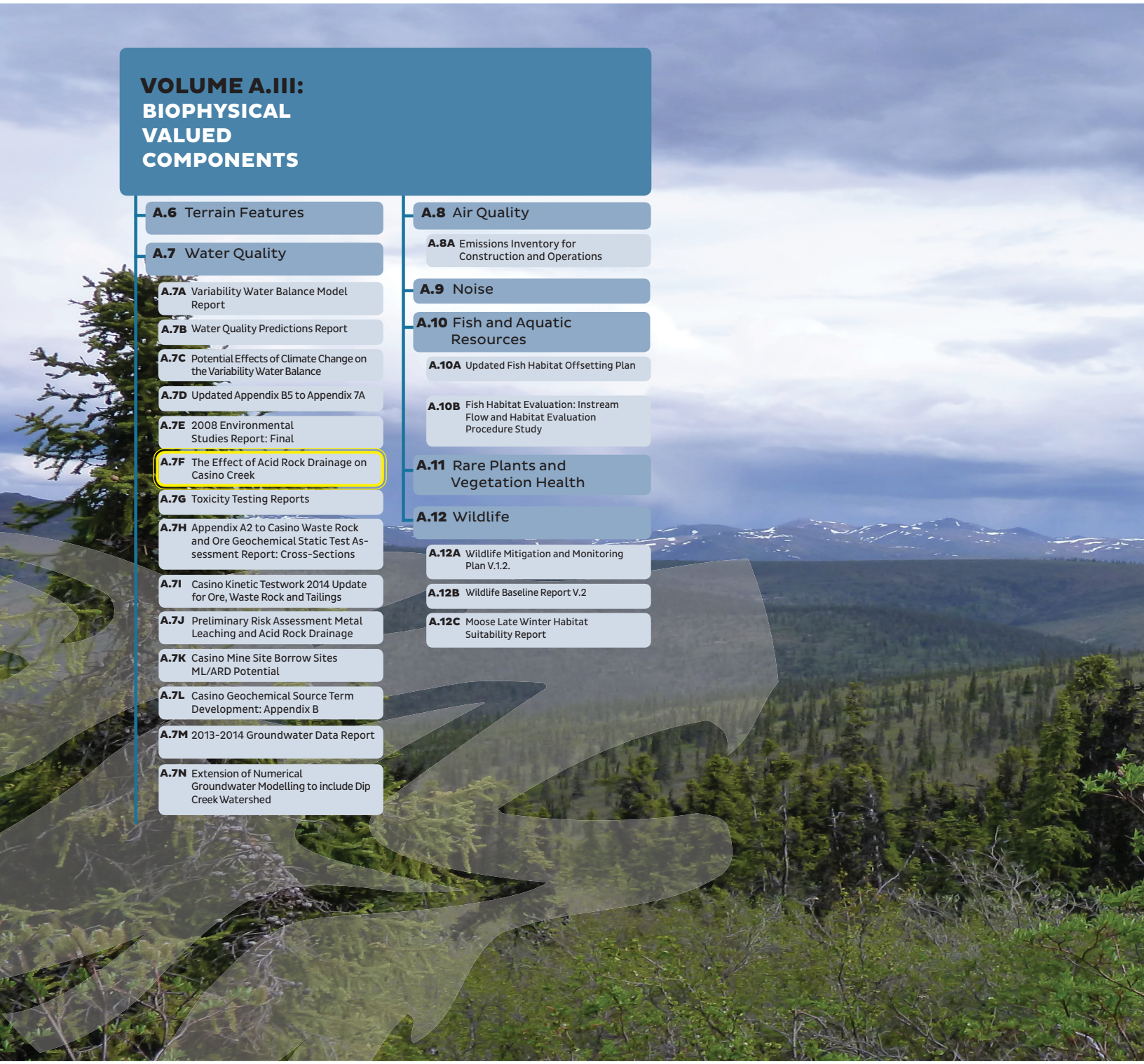
Date	Time	Waypoint	Easting	Northing	Elevation (m)	Species	Comments
10-Sep	-	47	620,563	6,951,603	-	moose droppings	trail to Placer camp
10-Sep	-	48	620,531	6,951,566	-	moose antler	trail to Placer camp
10-Sep	-	49	620,501	6,951,569	-	moose droppings	trail to Placer camp
10-Sep	-	50	620,617	6,951,610	-	moose droppings	trail to Placer camp
10-Sep	-	51	620,729	6,951,611	-	wolf scat	trail to Placer camp
10-Sep	-	52	620,788	6,951,631	-	bear scat	trail to Placer camp
10-Sep	-	53	620,813	6,951,652	-	bear scat	trail to Placer camp
10-Sep	-	54	620,788	6,951,635	-	moose droppings	trail to Placer camp
10-Sep	-	55	620,871	6,951,669	-	moose droppings	trail to Placer camp
10-Sep	-	56	608,648	6,945,807	-	moose droppings	bl. spr/sphagnum moss/lab tea habitat
10-Sep	-	57	608,637	6,945,816	-	moose droppings	bl. spr/sphagnum moss/lab tea habitat
10-Sep	-	58	608,536	6,946,054	-	spruce grouse pellets	site 4: bl. spr/bog cranberry/lab tea habitat
10-Sep	-	59	608,530	6,946,045	-	porcupine chewings	site 4: bl. spr/bog cranberry/lab tea habitat
10-Sep	-	60	608,516	6,946,081	-	red squirrel midden	site 4: bl. spr/bog cranberry/lab tea habitat
10-Sep	-	61	608,503	6,946,116	-	red squirrel midden	site 4: bl. spr/bog cranberry/lab tea habitat
10-Sep	-	62	608,468	6,946,117	-	moose droppings	site 4: bl. spr/bog cranberry/lab tea habitat
10-Sep	-	63	611,661	6,973,470	-	bear scat	site 5: poplar/rose/Viburnum habitat on island in Yukon River
10-Sep	-	64	611,574	6,973,561	-	beaver sign	site 5: poplar/rose/Viburnum habitat on island in Yukon River
10-Sep	-	65	611,563	6,973,571	-	moose droppings	site 5: poplar/rose/Viburnum habitat on island in Yukon River
10-Sep	-	66	-	-	-	caribou pellets	site 5: poplar/rose/Viburnum habitat on island in Yukon River
10-Sep	-	67	611,453	6,973,646	-	beaver sign	site 5: poplar/rose/Viburnum habitat on island in Yukon River
10-Sep	-	68	613,775	6,972,974	-	bear scat	site 6: birch/rose/Equisetum/Viburnum habitat on island in Yukon River; photo 2224
10-Sep	-	69	613,762	6,972,998	-	bear scat	site 6: birch/rose/Equisetum/Viburnum habitat on island in Yukon River; photo 2228
10-Sep	-	70	613,749	6,973,104	-	moose droppings	site 6: birch/rose/Equisetum/Viburnum habitat on island in Yukon River
10-Sep	-	71	613,797	6,973,120	-	moose antler	site 6: birch/rose/Equisetum/Viburnum habitat on island in Yukon River
10-Sep	-	72	613,752	6,973,016	-	2 bear scats	site 6: birch/rose/Equisetum/Viburnum habitat on island in Yukon River; photo 2230
11-Sep	-	73			-	chipmunk	barge landing
11-Sep	-	74	635,391	6,957,527	-	northen bog lemming burrows	site 1: bl. spr/willow/bog cranberry/lab tea habitat
11-Sep	-	75	635,320	6,957,581	-	spr. grouse pellets	site 1: bl. spr/willow/bog cranberry/lab tea habitat
11-Sep	-	76	635,312	6,957,606	-	caribou pellets	site 1: bl. spr/willow/bog cranberry/lab tea habitat
11-Sep	-	77	635,314	6,957,666	-	caribou pellets	site 1: bl. spr/willow/bog cranberry/lab tea habitat
11-Sep	-	78	635,328	6,957,650	-	bear scat	site 1: bl. spr/willow/bog cranberry/lab tea habitat
11-Sep	-	79			-	caribou	near wypt 51 in alpine tundra habitat; photos
11-Sep	-	80	611,848	6,959,863	-	caribou pellets	site 2: dwarf birch/willow/moss/lichen habitat
11-Sep	-	81	611,739	6,959,552	-	moose droppings	site 2: dwarf birch/willow/moss/lichen habitat
11-Sep	-	82	611,747	6,959,541	-	bear scat	site 2: dwarf birch/willow/moss/lichen habitat
11-Sep	-	83	611,799	6,959,416	-	caribou pellets; bear scat	near tank farm
11-Sep	-	84	610,189	6,958,862	-	caribou pellets	near tank farm
11-Sep	-	85	610,115	6,958,851	-	bear scat	near tank farm
11-Sep	-	86	610,102	6,958,855	-	caribou pellets	near tank farm
11-Sep	-	87	610,091	6,958,858	-	moose droppings	near tank farm
11-Sep	-	88	610,032	6,958,883	-	caribou pellets	near tank farm
11-Sep	-	89	609,927	6,958,989	-	caribou pellets	near tank farm
11-Sep	-	90	609,963	6,958,929	-	caribou pellets	near tank farm
11-Sep	-	91	609,440	6,947,118	-	bull moose	jctn Dip and Casino Ck
11-Sep	-	92	609,872	6,947,252	-	bear scat	jctn Dip and Casino Ck

Notes:

Dashes indicate no data were available.



APPENDIX A.7F: The Effect of Acid Rock Drainage on Casino Creek



PACIFIC SENTINEL GOLD CORPORATION
CASINO PROJECT

THE EFFECT OF NATURAL ACID ROCK DRAINAGE ON CASINO CREEK

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PACIFIC SENTINEL GOLD CORPORATION
CASINO PROJECT

THE EFFECT OF NATURAL ACID ROCK DRAINAGE ON CASINO CREEK

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Appendix A Soil Samples

Appendix B Water Quality

1.0 SUMMARY

Proctor Gulch is a small alpine stream in the vicinity of the Casino Property in the southwest Yukon Territory. This creek intermittently flows underground and consequently passes through a fault zone. The gougy material within the fault zone contains iron sulphides which are oxidized by the water to form sulphuric acid. The water which re-emerges to the surface is highly acidic and loaded with metals.

Proctor Gulch confluences with Casino Creek, a larger alpine stream. Above the confluence of these two streams, Casino Creek has a near neutral pH and relatively low metal content. This study is designed to investigate the aerial extent and the nature of effects Proctor Gulch has on the aquatic and riparian environs of Casino Creek.

Six sampling sites were located along the Casino Creek watershed. The upper Casino Creek site above the outfall of Proctor Gulch site served as a control on the downstream portion of Casino Creek. The composition of the natural pollutant was established by a sample station on Proctor Gulch. Four sample sites between Proctor Gulch and the outfall of Casino Creek were used to delineate the aerial extent of the effects of Proctor Gulch.

Samples of water, stream sediment, algae and benthos were collected at all sites during 1993 and 1994. In 1992, soil samples were collected at regular intervals along the upper reaches of Casino Creek and Proctor Gulch. Species lists were compiled from vegetation plots on Upper Casino Creek, Proctor Gulch and three sites below Proctor Gulch. One of these plots were done in 1993 and the others in 1994.

Water quality appears heavily influenced by Proctor Gulch. Casino Creek shows loadings of copper and iron up to 7 km downstream of the Proctor Gulch confluence. The creek is strongly acidic 500 m below the outfall of Proctor Gulch. Algae and benthic invertebrates in Casino Creek may be influenced by Proctor Gulch. The variation in diversity and abundance between sampling sites may be the result of the natural acid rock drainage flowing into Casino Creek. Differences in habitat are likely to influence algae and benthos. Species composition in Proctor Gulch is much different than all sampling sites on Casino Creek. Both algae and benthos are dominated by one species. This is likely due to the constant and specific nature of the habitat.

Soil samples seem to indicate leaching of metals. Some soil metals appear less concentrated in Proctor Gulch than in Casino Creek. Due to a rapid rise in pH, metals may be deposited at the outfall of Proctor Gulch. Soil chemistry, as influenced by natural acid rock drainage, is likely to affect vegetation. Species composition is visibly different between Upper Casino Creek and Proctor Gulch. This may be due to the influence of Proctor Gulch. Factors such as gradient, elevation and aspect probably play an important role in determining species composition along Casino Creek.

2.0 INTRODUCTION

Casino Creek, which is located about 300 km north north-west of Whitehorse, Yukon Territory, originates on the south flanks of Patton Hill at elevation 1200 m and flows in a south westerly direction over a total length of 13 km where it eventually discharges to Dip Creek at elevation 700 m for a total fall of approximately 500 m. Dip Creek discharges to the Yukon River drainage via the White River and ultimately flows to the Bering Sea.

Casino Creek has a drainage area of approximately 83 km^2. Peak flows occur during summer when annual precipitation is at a maximum. Flows measured during the summer of 1993 were found to be 0.537 m^3/s. Low flows are expected to occur in mid-winter. A low flow of 0.397 m^3/s was measured in the late fall of 1993 before the onset of cold weather.

In the upper reach of Casino Creek, very near its origin, is a small tributary called Proctor Gulch which originates as groundwater recharge in the alpine areas of Patton Hill. It has an overall length of about 1.5 km and total drop of 300 m before discharging to Casino Creek.

Flows in Proctor Gulch, which are estimated to contribute about 0.006 m^3/s to the flows in Casino Creek, intermittently disappears underground. During one such occurrence, the water flowed through a geologic formation called the Casino Fault. The water re-emerging at the surface, some 25 m beyond its entry to the ground, underwent marked chemical changes. Somewhere in this 25 m interval, the pH of Proctor Gulch drops from around 6.4 to 3.5 and increases in metal content.

It is postulated that the drop in pH and increase in metal content is likely a result of its contact with oxidizable iron sulphides (pyrites) within the gougy material comprising the fault zone (Tom Becker, per. comm.). These sulphides, when in contact with water and oxygen or oxygenated water, oxidize to form sulphuric acid, which in turn solubilizes trace metals in the surrounding rocks and soils. As a result, the water in Proctor Gulch, re-emerges from the fault zone carrying the products of pyrite oxidation and is acidic and laden with metals.

As it travels the remaining 670 m to Casino Creek, the pH continues to decline. pH values as low as 3.02 have been measured near the mouth of Proctor Gulch immediately upstream of its confluence with Casino Creek.

There are three possible causes for this declining gradient in pH:

- exposure to atmospheric oxygen
- residual biological activity
- evaporation

As Proctor Gulch re-emerges from the fault zone, it is exposed to turbulence and mixed with atmospheric oxygen, in which case dissolved oxygen levels in the water would be expected to increase. This creates an increase in the oxidation of ferrous iron which then reacts with water to form ferric hydroxide and hydrogen ions. The result would be a decrease in pH.

The presence of *Thiobacillus ferrooxidans* a bacteria associated with pyrite oxidation may also cause a decrease in pH. The rate at which this bacteria can oxidize ferrous ions is dependent on temperature (Knapp, 1987). A profile of Proctor Gulch does show temperature increase with distance downstream as it approaches Casino Creek. If the pH is dependant on these bacteria, the increasing temperature may lead to the observed pH decrease.

The third possibility is evaporation of creek water leading to the concentration of H^+ ions.

Whatever the causes for the state of Proctor Gulch, the end result is a naturally occurring point source of metal and acid pollution for Casino Creek. Due to its location (near the origin of the creek) this point source has the potential to affect nearly the entire length of the Casino Creek and the waterways beyond.

The purpose of this investigation is two fold:

- delineate the downstream aerial extent of effects of Proctor Gulch on Casino Creek, and
- characterize the nature of the effects on aquatic and riparian environs including water quality, stream sediments, periphytic algae, benthos, soils and vegetation,.

3.0 WATER QUALITY

3.1 Methods

In order to determine the effects of acid rock drainage on Casino Creek, water quality samples were collected from the six sampling locations by J. Himmelright (CC1, CC2, CC3, CC4) and Casino Property personnel (W4, W8). Site CC3 represents Upper Casino Creek, just above the outfall of Proctor Gulch. Data collected from this site were used as a control or an indication of the water quality before being influenced by the acidic stream. Water quality samples from Proctor Gulch were also analyzed (CC4). This allowed interpretation as to which parameters within Casino Creek were being strongly influenced by the gulch. Four separate sampling sites, spread over the remaining length of Casino Creek (W8, CC2, CC1, W4), indicated the influence of Proctor Gulch with distance downstream.

Each sample set consists of five bottles: general analysis (1000 ml), cyanide (1000 ml), mercury (500 ml), dissolved metals (250 ml) and total metals (250 ml). The dissolved metals samples are filtered at the time of collection using disposable 60 cc syringes and 45 μ (micron) millipore filters. Samples are sent to Analytical Services Laboratories Ltd. of Vancouver for analyses. An complete list of the test parameters and their detection limits are presented in Table 1. Water quality samples were collected during July and August of 1994.

3.2 Results

The results of water quality sampling are presented in Table 9. Table 10 contains guidelines set by both CCME and MMLER. These guidelines provide standards for drinking water, liquid mine effluent and safety of aquatic life. Those water quality parameters exceeding CCME (Canadian Council of Ministers of the Environment) guidelines for aquatic life included pH, total cyanide, total aluminium, total cadmium, total copper, total iron, and total zinc. Drinking water guidelines for total dissolved solids, pH, sulphate, total copper, total iron and total manganese were exceeded. At a few locations, pH and total copper parameters exceeded MMLER (Metal Mining Liquid Effluent Regulations) guidelines for mine effluent.

At all sampling sites, at least one parameter exceeded the guidelines for aquatic life. With a pH of 3.5 - 3.02, Proctor Gulch exceeds CCME guidelines for aquatic life. Water is still too acidic at W8 (pH = 4.25) to be considered safe for aquatic organisms. The amounts of total cyanide found at CC2 (0.007 mg/l), CC1 (0.009 mg/l) and W4 (0.006 mg/l) were in exceedence of the CCME limit (0.005 mg/l). CCME recommends a maximum of 0.1 mg/l aluminium. CC3 (0.305 mg/l), CC4 (12.7 mg/l), W8 (4.31 mg/l), CC2 (0.618 mg/l) and CC1 (0.748 mg/l) are all above this concentration. Cadmium values exceed guideline limits (0.0002 mg/l) only in Proctor Gulch where total cadmium was sampled at 0.0033 mg/l. Although it may appear that CC3 and W8 also exceeded this value, high water hardness at these sites will mitigate the toxicity of

cadmium. Copper is one of the most abundant metals found in this watershed. Concentrations of copper in Casino Creek are shown in Table 9. All values are above the CCME guideline of 0.002 mg/l. Iron concentrations is also above these guidelines in all cases except W4 (refer to Table 9 and Table 10). With a zinc concentration of 0.034 mg/l, Upper Casino Creek is above the CCME guideline of 0.03 mg/l. The same is true of CC4 (0.293 mg/l) and W8 (0.115 mg/l).

Upper Casino Creek Gulch exceeds drinking water guidelines for total manganese (0.187 mg/l) and total iron (0.827 mg/l). Water from Proctor Gulch is not fit for human consumption. A comparison of values presented in Table 9 and Table 10 shows many examples of guideline exceedence.

Water quality at W8 is somewhat better than at Proctor Gulch. The only concentrations of concern are total iron (7.58 mg/l) and total manganese (0.571 mg/l). The pH at this site was 4.25, which is below CCME guidelines. Farther down Casino Creek, at CC2, the iron content (0.692 mg/l) is still above the guideline. At CC1, total manganese (.054 mg/l) is above suggested concentration. With a value of 0.718 mg/l , iron is considered a problem at this point in the creek. At W4, near the Casino/Dip Creek confluence, all measured water quality parameters are safe for drinking.

Water quality at two sample sites exceeded even the MMLER regulations for mine effluent. Proctor Gulch pH and copper values (3.02, 1.39 mg/l) are beyond those acceptable for mine effluent (6.0 and 0.3 mg/l respectively). Site W8, just downstream of the Proctor Gulch outfall, has the same problem. Copper is measured as 0.465 mg/l and the pH is 4.25.

3.3 Discussion

Water quality in Casino Creek above the outfall of Proctor Gulch is less than good. Copper, iron, aluminium, zinc and manganese are all found in relatively high concentrations. Although pH values are neutral (7.22 in collected sample), this creek is high in metals. This may be a function of the creek's underlying lithology. The acid rock drainage flowing from Proctor Gulch is toxic; high levels of metals and hydrogen ions make it unsafe for drinking or most aquatic life.

As Proctor Gulch empties into Casino Creek, it increases metals concentrations already present in the creek and decreases pH. The result is water that is too poor to drink or support most aquatic life. In the area immediately downstream of the outfall water quality exceeds guidelines for mine effluent.

At least 500 m of Casino Creek are heavily influenced by Proctor Gulch. The water this far downstream shows large increases in those metals found in the gulch. The influence of Proctor Gulch at CC2, 5 km below the confluence, seems to be diluted. Metals concentrations

approximate values found in Upper Casino Creek. If the metals in Upper Casino Creek are the result of its underlying lithology, a dilution ratio of 1:16 between Upper Casino and Casino Creek at CC2 should have reduced those concentrations. Poor water quality at this point in the creek may be due to Proctor Gulch. Cyanide concentrations at CC2 (and all other sample sites downstream) exceed those recommended for aquatic life.

Farther downstream, at CC1, metals concentrations are not much different than CC2. Since the dilution ratio between CC2 and CC1 is 1:1.5 there is less chance for dilution between these two points which may explain the stabilized values. At the outfall of Casino Creek, water quality seems good. Due to the influx of Bryanelsen Creek, dilution between here and Proctor Gulch is 89:1; concentrations resulting from the gulch would likely not be detected.

Although Casino Creek at W4 is "clean" , this does not mean that the problem of metals contamination has been solved. It is unlikely that concentrations originating in Proctor Gulch have simply been diluted to safe levels. A gradual decrease in the dissolved metals concentration (see graphs in Appendix B) seems to indicate partitioning processes within the Casino Creek. Increases in sediment metal levels at more downstream sites (Table 11) also indicate transitions in the phase of Casino Creek metals. Since partitioning may affect bioavailability and hence the toxicity of these metals, it may be important to realize both proportions and total amounts of partitioned states. Chapman *et al.* (1983) have shown concretion to be an important process for metal removal in streams polluted by acid mine drainage. Precipitation may also help to remove metals from solution (Boult *et al.* 1994). Those portions adsorbed to suspended material and remaining in solution will also play a role in the overall toxicity of the aquatic environment.

Also contributing to overall toxicity is temporal variation in concentrations. Daily "pulses" of copper at near lethal concentrations have been shown to affect survival of rainbow trout and *Daphnia pulex*, even though average concentrations were below the "no effect" limit (U.S. EPA, 1985). The water quality presented in this report represents summer low flows. Higher discharges may resuspend sediments (Boult *et al.* 1994) which would carry metals farther downstream.

4.0 ALGAE & BENTHOS

4.1 Methods

Periphyton samples were collected in concurrence with the benthic sampling at all sampling stations. Samples were normalized by sampling areas with similar depth and velocity. Algae samples were removed from representative natural substrate (cobbles) at each site using a Stockner toothbrush sampler. In 1993, twelve replicate samples were taken at W4 and W8. Six samples were preserved with Lugol's iodine solution and sent to Munro Environmental Consulting, Vancouver, for identification of dominant and subordinate species. Six samples were filtered through a 0.45 μ cellulose acetate filter, buffered with MgCO3 and sent to ASL Laboratories for chlorophyll "a" (ug/cm^2) analysis. Susan Blundell (Hallam Knight Piesold, Project Biologist) collected all samples completed in 1993. Six samples were collected from CC1, CC2, CC3 and CC4 in 1994. These samples were preserved with formalin/Rose Bengal solution and also sent to Munro Environmental Consulting for similar analysis as 1993 samples. In 1994, productivity was measured by analysis of chlorophyll "a" content in 1 litre of water. These samples were filtered through a 0.45 μ cellulose acetate filter, frozen and sent to ASL Laboratories for chlorophyll "a" analysis. J. Himmelright collected all 1994 samples.

Aquatic macroinvertebrate samples for W4 and W8 were collected in late August 1993. Three replicate samples were taken at each site. These samples were taken using a modified Hess sampler (measuring 17" high, 14" in diameter, and having a 250 μ mesh) to a depth of 10 cm. A Surber (0.25 m^2 ,250 μ mesh) sampler was used to collect samples of benthic invertebrates at CC1, CC2, CC3 and CC4. These samples were collected in early August of 1994. Samples were standardized by sampling in riffle areas with similar depth, velocity and substrate types. Samples were stained and preserved with a buffered formalin/Rose Bengal solution and sent to Dr. Charles Low, Victoria, for taxonomic analysis and enumeration. Indices for community dominance, diversity, equatability and richness were applied to the results of these samples.

4.2 Results

Periphyton samples at CC3 (Table 12) contained very little sediment, either fine grit or soft detritus with a small amount of algae mixed in. A colonial chrysophyte, identified as *Hydrurus foetidus*, made up 90 to 100% of the algae. This is a common species in cool streams. Chlorophyll "a" samples from this site showed $<$ 0.04 *u*g/l).

Six benthic samples from this same site collected 151 individuals representing 26 taxa (Table 13). Five percent of collected specimens are considered sensitive, 66% are facultative and 29% are classed as tolerant. The Shannon - Weiner Diversity Index produced a value of 3.27 for this site. The equitability index, which measures the evenness with which individuals are distributed among

sampled taxa, was calculated at 0.69. Richness, a relationship between sample size and number of taxa sampled, was measured at 4.98. Relative abundance of sampled taxa, as measured by the Dominance index, showed a value of 0.17 (maximum value of 1.0 when only one taxa is sampled). A more complete explanation of these indices can be found in Hallam Knight Piésold (1993).

Proctor Gulch, as represented by sample site CC4 (Table 14), showed the highest abundance of algae for all sites sampled. The predominant species in most samples (60 - 100%) was *Microthamnion*, a filamentous green algae. Other species present included *Hydrurus foetidus* (15 - 80% in four samples) and the diatom *Eunotia* (10 - 65% in three samples). Chlorophyll "a" samples produced an average value of 0.05 *u*g/l, indicating that this site has the highest productivity of all sample sites.

Of the 1,182 invertebrates collected from Proctor Gulch, 99.8% are facultative (Table 15), and 0.2% of individuals are tolerant. There are no sensitive species in any of the samples. With only 16 taxa sampled, diversity is low (0.51). Ninety-four percent of all sampled individuals belong to one taxa, producing a very high dominance index value (0.89). Equitability and richness indices were low (0.1 and 1.98 respectively).

Site W8 samples contained small amounts of sediment composed mainly of soft detritus and bacteria. No algae were present in any of the samples. Chlorophyll "a" values were low with an average of 0.024 $u g/cm^2$.

Only 28 individuals representing 12 taxa were collected at W8 (Table 16). Eighty-two percent are facultative. Tolerant taxa make up the remaining 18% Due to the low number of taxa sampled and low diversity value (0.016), the equitability index is also low (0.004). Dominance is low (0.14), indicating fairly equatable numbers of individuals for each taxon sampled. The low numbers of taxa and individuals contribute to a richness measurement of 3.3.

Periphyton samples taken at CC2 (Table 17) contained very little algae. *Achnanthes sp.* and *Synedra rumpens* are the two species of diatoms which comprised 25 - 100% of the samples. *Phormidium sp.*, a filamentous blue-green, made up 75% of two samples. Chlorophyll "a" samples indicate low productivity, averaging < 0.05 *u*g/l.

Six samples of benthic invertebrates contained 362 individuals from 25 different taxa (Table 18). Tolerance classification returned the following results: 33% sensitive, 51% facultative, and 16% tolerant. Diversity, richness and equitability were relatively high (3.27, 4.07 and 0.70 respectively). The dominance index was low (0.15).

Stockner samples from CC1 also contained very little algae (Table 19). Diatoms, dominated by *Achnanthes sp.*, *Synedra rumpens* and *Diatoma anceps*, comprised 90 - 100% of the samples.

Small amounts of green or blue-green algae were also present. Chlorophyll "a" samples showed < 0.043 ug/l, indicating low productivity.

In six Surber samples collected at CC1 there were 871 invertebrates from 35 taxa (Table 20). Eighty-two percent of the taxa were facultative, 12% tolerant and 6% sensitive. The richness index for these samples is 5.02. Diversity and equatability were calculated to be 3.03 and 0.6 respectively. The dominance value was 0.25.

Samples of algae collected at W4 were comprised of 93 - 98% diatoms (Table 21). Small amounts of blue-green and red algae were also present. Chlorophyll "a" was sampled at 0.131 ug/cm^2 for this site.

A total of 1292 benthic invertebrates were collected from this site (Table 22). Fifty-four different taxa were present. Thirty-five percent of the individuals were sensitive, 46% facultative and 19% tolerant. Diversity, equatability, and richness are all high (4.34, 0.75 and 7.4 respectively). The index for dominance gave a low result of 0.078.

4.3 Discussion

Above the outfall of Proctor Gulch, the aquatic fauna of Casino Creek appear quite healthy. This section of the waterway supports at least one species of alga and 26 species of benthic invertebrates. The alga found here (*Hydrurus foetidus*) is typical of cool streams. Of the 26 taxa of invertebrates found here, seven are considered sensitive. The diversity index used in analysis ranks this site third out of the six sample sites. An equitability value of 0.69 indicates an even distribution of individuals/taxa. The low productivity of this location is probably a function of its high altitude (1100 m) and low flow (0.0107 m^3/s).

Proctor Gulch is a very simple, yet interesting, system. Dominated by one type of algae and one species of invertebrate, this creek has a higher productivity than others of comparable size and location (Upper Casino Creek for example). This is likely due to the extreme, stable environment provided by the creek waters. Such an environment will prevent colonization by most life forms, leaving those who can tolerate it to thrive in the absence of competition. In Proctor Gulch, the predominant algae is *Microthamnion*, a type of filamentous green. This green algae belongs to the same family (Chaetophoraceae) as *Stigeoclonium*; an alga that can tolerate high levels of metal (McLean, 1974). As for the invertebrates, 94% of all sampled individuals were of the genus *Eukiefferiella*. This genus belongs to the sub-family Orthocladiinae, a type of grazing chironomid. Many chironomids living in acidic streams and lakes (Hermann, 1990; Wickham *et al.* 1986). With the ample supply of forage provided by the algae in this stream, large numbers thrive in Proctor Gulch.

The presence of algae within Proctor Gulch does raise some possibilities. Ramelow *et al.* (1986) found periphyton to contain higher concentrations of metals than the surrounding sediments. This would indicate that periphyton, such as *Microthamnion*, may provide a sink for metals resulting from ARD. They could also be used as indicator species for potential acid mine drainage.

Site W8 contains no algae. This may be due to adverse, variable conditions such as pH which varies from 3.86 to 4.62. The lack of forage and fluctuating pH may contribute to the lack of invertebrates here. Some invertebrate species have been shown to increase drift intensity when faced with a drop in pH (Radum & Fjellhiem, 1987).

Data collected at site CC2 (in comparison to Upper Casino Creek CC3) seems to indicate recovery of the aquatic fauna. Primary production, as indicated by chlorophyll "a" samples, is higher here than at CC3. Though they are not the same species as in Upper Casino Creek, there are algae growing here. Invertebrate populations appear to have also recovered. Index values calculated for this community approximate those for CC3 samples. There does appear to be a higher density of organisms at this lower site (362 individuals collected versus 151 for CC3).

There is some change at CC1, approximately 2 km downstream of CC2. Chlorophyll "a" samples indicate a slight reduction in primary productivity. Many of the same species of algae are found at CC1 and CC2 although in different amounts. A comparison of index calculations for benthic organisms do show slight variation. This is probably due to two factors; dominance of one taxa (*Synorthocladius sp.*) and the larger number of taxa found at the more downstream site. Density has also increased from CC2 to CC1, with 871 organisms collected (more than twice that sampled at CC2). As compared to CC3, this is a 580% increase in density. This is probably due to a 375 m drop in elevation between these two sampling points.

At the most downstream site (W4), primary production is much higher than immediately below the outfall of Proctor Gulch. Comparisons to other locations within the stream are difficult due to differences in sampling techniques. Algae here at W4 seem a little more abundant as compared to more upstream sites. There are large differences in the benthic communities between this station and upstream locations. There is a much higher density and a significant increase in the number of taxa found. Index calculations show increases in diversity, equatability, and richness of the benthic community this far downstream. This may be due to the influx of Bryanelsen Creek which confluences with Casino Creek between sites CC1 and W4. At this confluence, Bryanelsen is almost as large as Casino and nearly doubles the flow. The marked decrease of metal in stream sediments at W4 (Table 10) may also contribute to the success of the benthic community.

5.0 SOILS & VEGETATION

5.1 Methods

In order to investigate the possible effects of Proctor Gulch on the soils of Casino Creek, soil sample data (collected in 1992 by Archer Cathro and Assoc. Ltd) are pooled into one of three categories:

Proctor Gulch
Upper Casino Creek (above Proctor Gulch confluence)
Lower Casino Creek (below Proctor Gulch confluence)

For each data set, an average, standard deviation, maximum and minimum are reported (Tables 1-3).

It is difficult to draw direct conclusions as each data pool represents a different sampling density. However, trends can be recognized and possible causes and effects suggested.

Vegetation and soils are intimately linked and so are analyzed together. In the analysis of soil data, particular attention is paid to those elements which are important to plant life. A list of plant species was compiled for each soil region. Data for these lists were collected by visual inspection of a selected site within each area. There were 5 vegetation sites, three of which were in Lower Casino Creek:

CC1 (7 km downstream of Casino Creek-Proctor Gulch confluence)
CC2 (5 km downstream of Casino Creek-Proctor Gulch confluence)
Site #7 (represents Casino Creek-Proctor Gulch confluence, completed in 1993 by S. Blundell, HKP).

These sites are spread between the Proctor Gulch outfall and the confluence of Casino Creek with Dip Creek.

5.2 Results

Proctor Gulch:

At the site selected for vegetation description of Proctor Gulch, 13 plant species were identified (Table 1). Most of the plants were indicators of a poorly drained, acidic site. Only one species , birch - leaved spirea, has a broad ecological tolerance (inhabiting moist and dry sites).

The results of soil sampling are presented in Table 2. These results represent 26 samples covering 1.4 km of creek length.

Upper Casino Creek:

Seventeen plant species were identified at Upper Casino Creek (Table 3). Again , most of the plants were indicators of a wet, acidic environment. A few species (bog blueberry, prickly rose, cinquefoil and fireweed) point to a rocky or gravel substrate.

Soil sample results are presented in Table 4. These results were drawn from 17 samples covering 1.8 km of creek length.

Lower Casino Creek:

At the vegetation site immediately below the Proctor Gulch/Casino Creek confluence (Table 5) 22 species of plants were identified. Again, most species are indicators of a poorly drained site. (MacKinnon et. al., 1992).

At site CC2, 5 km downstream of Proctor Gulch, 13 species of plants were identified (Table 6). Indications are of a sub-alpine, poorly drained site. This site appears to have more willow (*Salix sp.*) than previous sites both in terms of species present and total cover.

Vegetation plot CC1 (Table 7) contained fourteen species, all indicating a wet site. Stunted black spruce (*Picea mariana*) indicate permafrost. This site is 7 km downstream of Proctor Gulch.

Soil sample results are shown on Table 8. These numbers were calculated from the results of 69 samples taken between Proctor Gulch and Meloy Creek, totalling 5.6 km of creek length.

5.3 Discussion

The three nutrients required in large amounts by plants are phosphorous, nitrogen and potassium. Since soils collected on the Casino property were not analyzed for nitrogen, no information as to its abundance and distribution is available. Potassium values are relatively constant. Phosphorous values peak in a gossan in Proctor Gulch; values elsewhere are low and constant (refer to graphs in Appendix A).

Those nutrients required in trace amounts (micronutrients) are more dynamic in their distribution, possibly a consequence of leaching from Proctor Gulch. A good example is aluminium. Within the gulch itself, aluminium in soil is low ($1.76 \pm 0.62\%$). In Upper Casino Creek, values are somewhat higher ($2.53 \pm 0.70\%$). Aluminium peaks immediately downstream of Proctor Gulch

and then returns to lower values farther down the creek (see graphs in Appendix A). This pattern could be due to the leaching of aluminium from the soils of Proctor Gulch followed by deposition as the pH climbs back to near neutral levels in Casino Creek. If this is the case, water quality data should show high levels of aluminium within Proctor Gulch itself which decrease with distance from the confluence of the two creeks. This trend is seen in the water quality data (see graphs in Appendix B).

The same pattern occurs with cobalt and magnesium. Concentrations are high in samples taken near the bottom of Proctor Gulch but drop rapidly downstream.

Copper and molybdenum show a different pattern. Relatively high values appear in Upper Casino Creek and the gossan zone of Proctor Gulch (likely associated with the lithology), dropping to lower, more constant values in Lower Casino Creek (refer to graphs in Appendix A). Proctor Gulch does not appear to be significantly affecting the soil distribution of these elements.

Calcium values are variable along Casino Creek (graph, Appendix A). In general, there seems to be a steady increase from high to low elevation. Proctor Gulch itself has low calcium levels (probably a result of years of leaching) but it is difficult to say whether or not soil calcium is affected downstream of the confluence. There is no "deposition peak" as with cobalt or magnesium; calcium levels appear to rise continuously from the source to the outfall of Casino Creek. Although soil calcium is definitely being affected within Proctor Gulch, outside the gulch it appears more uninfluenced.

Soil zinc levels seem strongly influenced by the acid drainage coming out of Proctor Gulch. A sharp increase in zinc levels immediately downstream of Proctor Gulch indicates deposition, likely triggered by the rise in pH. If this zinc loading is the result of leaching by acidic water, water quality data should show high concentrations of zinc in Proctor Gulch which decrease downstream. The graph in Appendix B shows this trend.

Manganese, iron, and sodium distributions do not appear to be affected by Proctor Gulch. A Gossan zone within the gulch is high in iron and low in sodium. Otherwise, sampled areas contain relatively constant amounts of these two elements. Manganese is low in Proctor Gulch (refer to graphs in Appendix A). However Proctor Gulch values are relatively constant. The apparent lack of a deposition peak for these three elements may to due to a more gradual deposition rate or higher solubility. Random variation in soil sample values may then mask any noticeable effect.

There were no soil data for nitrogen, silicon, sulphur, boron and chlorine, therefore, the distribution of these elements cannot be discussed adequately. Also not available was soil texture data. Since soil texture may be as important as soil chemistry in determining plant distribution, it is impossible to conclude that differences in vegetation are solely the result of the acid rock drainage from Proctor Gulch.

The acidic stream is likely to affect plant life in some way. Species composition is visibly different between Upper Casino Creek (Table 3) and Proctor Gulch (Table 1). In Proctor Gulch, there is an increase in the abundance of Wild Rhubarb (*Polygonum alaskanum*) and Scrub Birch (*Betula glandulosa*). The amount of willow (*Salix* sp.) is noticeably less. Since the two sample sites are less than 100 m apart, variability in environmental parameters such as elevation and gradient is minimal. The acid rock drainage is suspected to affect soil chemistry. Soil texture, combined with a slight variation in aspect, may also contribute to the difference in vegetation.

It cannot be definitely concluded that Proctor Gulch is affecting plant nutrient distribution. All soil data does show randomness. Trends, interpreted here as the effect of Proctor Gulch, may actually be random. There is also the question of sample collection. There is no way of knowing whether or not soil was collected from stream sediments, creek banks or some distance from the creek. Obviously, samples at a distance from the creek are less likely to be influenced by the creek itself.

The apparent increase in diversity between Upper Casino (CC3) and the first Lower Casino site (Site 7) is a function of sampling technique. Vegetation surveys in 1993 (Site 7) were much more detailed than in 1994. Soil chemistry at Site 7 may be affected by Proctor Gulch; this site is near the deposition zone created by the acid stream. There is a minor variation in elevation (25 m from CC3 to Site 7) but gradient and aspect are relatively constant. Variation in vegetation is not so visibly obvious as in the comparison of CC4 and CC3.

It is more difficult to compare the Lower Casino vegetation sample sites. The large distances between these three sites (7 km between all three) and a 450 m drop in elevation probably have greater effect on the vegetation than acid drainage from Proctor Gulch. There is little visible difference between these sites.

In conclusion, the acidic waters of Proctor Gulch may be affecting vegetation along the gulch itself. Visibly different plant distribution, combined with soil chemistry data, provide some evidence for this. It is more difficult to conclude that acid rock drainage is affecting the plants along Casino Creek. The deposition of nutrients immediately downstream of the confluence may be having some effect on plant life. In addition, metal loadings to soils may influence soil invertebrate survival which would in turn affect vegetation. Other factors such as elevation, gradient and aspect are probably more important in determining the characteristics of the vegetation near Casino Creek.

6.0 CONCLUSION

Proctor Gulch appears to affect Casino Creek in several different ways. It is possible that soils and vegetation may be influenced by the acidic stream. A comparison of plant life on Upper Casino Creek and Proctor Gulch would seem to indicate that this is the case. For the more downstream sites, it is difficult to interpret differences in vegetation being due to acid rock drainage. Elevation, gradient and aspect are probably more important influences on the distribution of vegetation along Casino Creek. The influence of Proctor Gulch on the water quality of Casino is much more obvious. As far as 7 km downstream of the outfall, loadings of copper and iron, which may be due to Proctor Gulch, can still be found. Metal loadings to sediments are probably also due the metal-rich waters of Proctor Gulch. The influx of Bryanelsen Creek is probably the dilution factor responsible for reducing these concentrations to the "safe" levels found at the mouth of Casino Creek. Aquatic fauna also appear influenced by Proctor Gulch although the effects are not as easily defined as those for water. The sharp increase in abundance and diversity found at the outfall of Casino Creek (as compared to CC1, 6 km upstream) is likely due in part to the extra aquatic habitat provided by Bryanelsen Creek. By further diluting Casino Creek, Bryanelsen also serves to change water and sediment quality. Significant effects on algae and invertebrates cannot be demonstrated. For the upstream sites, the results are ambiguous. Diversity returns to pre-acid values; abundance does increase with a decrease in elevation, with the exception of the sample site immediately downstream of Proctor Gulch. The lack of benthos and algae here may be due to acid rock drainage. However, this cannot be concluded without further investigation.

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TABLES

TABLE 1
CASINO PROJECT
PROCTOR GULCH VEGETATION, SITE CC4

TREES		
Black spruce	(*Picea mariana*)	
SHRUBS		
Scrub birch	(*Betula glandulosa*)	- 2 species - Predominant
Labrador tea	(*Ledum greonlandicum*)	
Willow	(*Salix sp.*)	
Lingonberry	(*Vaccinium vitis-idaea*)	
Birch-leaved spirea	(*Spiraea betulifolia*)	
Crowberry	(*Empetrum nigrum*)	- Common (ground cover)
HERBS		
Wild rhubarb	(*Polygonum alaskanum*)	- Predominant
Moss	Unspecified	- 2 species - Predominant (ground cover)
Grass	Unspecified	- Common (groundcover)
Staghorn lichen	(*Lobaria pulmonaria*)	

TABLE 2

CASINO PROJECT

PROCTOR GULCH SOIL SAMPLES

Sample number	Al (%)	Ca (%)	Cd (ppm)	Co (ppm)	Cu (ppm)	Fe (%)	K (%)	Mg (%)	Mn (ppm)	Mo (ppm)	Na (%)	Zn (ppm)
4724	1.91	0.18	0	15	66	3.98	0.16	0.4	840	6	0.01	54
4723	2.25	0.2	0	7	71	4.41	0.17	0.44	360	4	0.01	56
4722	2.37	0.25	0	6	53	2.69	0.11	0.47	180	1	0.03	60
4721	2.33	0.38	0	8	48	3.76	0.09	0.61	205	1	0.01	76
4720	1.61	0.3	0	6	88	3.83	0.13	0.3	380	4	0.01	74
4719	1.53	0.37	0	5	97	5.47	0.13	0.4	195	3	0.01	78
4725	2.51	0.17	0	3	752	6.33	0.08	0.36	115	21	0	44
4726	1.2	0.1	0	3	229	14.44	0.13	0.24	125	41	0	36
4727	0.77	0.07	0	1	633	15	0.13	0.14	70	6	0	22
4728	1.6	0.12	0	7	522	15	0.18	0.36	330	3	0.01	66
4729	0.77	0.09	0	2	887	15	0.1	0.12	155	6	0	30
4730	1.76	0.12	0	6	498	15	0.08	0.33	210	0	0	74
4731	1.9	0.18	0	8	259	12.12	0.09	0.54	305	0	0.01	80
4732	2.83	0.28	0	14	144	4.8	0.1	0.73	1005	0	0.01	168
4733	2.47	0.32	0	12	230	5.01	0.18	0.61	885	0	0.01	258
4734	2.03	0.28	1.5	17	301	5.68	0.22	0.5	1425	2	0.01	496
4735	1.87	0.26	0.5	15	328	5.48	0.28	0.45	1070	2	0.01	480
4736	2.39	0.18	0	10	307	10.24	0.25	0.64	505	1	0.01	270
4737	2.17	0.35	0	13	180	5.08	0.16	0.62	825	4	0.01	298
4738	0.98	0.12	0	3	592	15	0.08	0.23	110	6	0	46
4739	2.56	0.4	0	22	114	4.7	0.1	0.65	880	1	0.01	272
4759	1.6	0.36	0	9	101	3.83	0.14	0.51	310	31	0.01	58
4760	0.39	0.09	1.5	1	87	15	0.13	0.09	50	16	0	4
4761	1.44	0.32	0	15	104	3.67	0.25	0.25	680	37	0.01	60
4762	1.45	0.17	0	5	123	3.98	0.35	0.25	290	69	0.01	44
4763	1.03	0.11	0	6	42	4.16	0.27	0.22	175	16	0.01	36
Average	1.7584615	0.2219231	0.1346154	8.4230769	263.69231	7.8330769	0.1573077	0.4023077	449.23077	10.807692	0.0080769	124.61538
Standard deviation	0.623197	0.1030317	0.4056735	5.3577627	234.0422	4.7064406	0.0707954	0.176315	367.71041	16.302476	0.0062137	133.489
Maximum	2.83	0.4	1.5	22	887	15	0.35	0.73	1425	69	0.03	496
Minimum	0.39	0.07	0	1	42	2.69	0.08	0.09	50	0	0	4
Sample size	26	26	26	26	26	26	26	26	26	26	26	26

TABLE 3
CASINO PROJECT
UPPER CASINO CREEK VEGETATION, SITE CC3

TREES		
Black spruce	(*Picea mariana*)	
SHRUBS		
Willow	(*Salix sp.*)	- 2 species - Predominant
Cinquefoil	(*Potentilla sp.*)	- Predominant
Scrub birch	(*Betula glandulosa*)	- Common
Crowberry	(*Empetrum nigrum*)	- Predominant (ground cover)
Willow	(*Salix sp.*)	- 1 species - Common (ground cover)
Blueberry	(*Vaccinium sp.*)	
Prickly rose	(*Rosa acicularis*)	
Labrador tea	(*Ledum sp.*)	- 2 species
HERBS		
Fireweed	(*Epilobium angustifolium*)	
Bearberry	(*Arctostyphlos rubru*)	
Tall bluebell	(*Martinsia pinaculata*)	
Scouring grass	(*Equisetum sp.*)	
Wild rhubarb	(*Polygonum alaskanum*)	- Trace
Moss	Unspecified	- 1 species

TABLE 4
CASINO PROJECT
UPPER CASINO CREEK SOIL SAMPLES

Sample number	Al (%)	Ca (%)	Co (ppm)	Cu (ppm)	Fe (%)	K (%)	Mg (%)	Mn (ppm)	Mo (ppm)	Na (%)	P (ppm)	Zn (ppm)
4707	2.4	0.37	3	79	1.9	0.05	0.45	105	0	0.01	470	38
4708	2.66	0.47	5	144	2.38	0.09	0.72	150	10	0.02	560	66
4709	2.33	0.46	9	581	3.42	0.13	0.75	260	94	0.01	940	80
4710	2.18	0.31	11	1315	4.11	0.29	0.71	370	238	0.01	790	106
4711	2.6	0.33	13	364	3.97	0.08	0.61	920	77	0.01	880	68
4712	2.04	0.47	10	77	3.25	0.08	0.62	680	1	0.01	820	70
4713	2.15	0.44	11	511	3.64	0.13	0.62	655	68	0.01	870	74
4714	2.36	0.25	8	645	4.57	0.16	0.53	320	75	0.01	960	58
4715	2.5	0.29	7	408	3.27	0.07	0.56	170	24	0.01	760	60
4716	2.09	0.3	10	762	4.59	0.17	0.54	435	81	0.01	1010	62
4717	2.19	0.43	10	464	4.16	0.18	0.58	410	50	0.02	950	66
4718	2.78	0.49	9	175	3.42	0.08	0.62	440	16	0.01	720	74
4740	2.08	0.37	12	543	4.04	0.14	0.55	440	46	0.01	850	66
4741	2.53	0.58	11	221	4.79	0.11	0.7	450	7	0.01	750	98
4742	2.72	0.83	40	616	3.98	0.07	0.6	3200	9	0.01	830	188
4743	2.38	0.56	28	790	4.78	0.12	0.59	765	37	0.01	850	104
4744	5.17	0.61	22	829	8.89	0.11	0.56	4500	4	0.01	740	188
Average	2.53882	0.44471	12.8824	501.412	4.06824	0.12118	0.60647	839.412	49.2353	0.01118	808.824	86.2353
Standard deviation	0.69522	0.14068	8.85094	312.75	1.42893	0.05582	0.07545	1141.49	56.3983	0.00322	134.771	40.6702
Maximum	5.17	0.83	40	1315	8.89	0.29	0.75	4500	238	0.02	1010	188
Minimum	2.04	0.25	3	77	1.9	0.05	0.45	105	0	0.01	470	38
Sample size	17	17	17	17	17	17	17	17	17	17	17	17

TABLE 5
CASINO PROJECT
LOWER CASINO CREEK VEGETATION, SITE #7

Gradient: 15°

Altitude: 914 m (3000 ft)

Observations:

Transect situated below Casino Creek/Proctor Gulch confluence. Proctor Gulch has a low pH, ranging from 3.2 to 4.5, sediments are orange indicating a high iron (and other metals) content. Most of the Black spruce trees were stunted (may be due to permafrost).

Species present:

Black spruce (*Picea mariana*)
Scrub birch
Sweet coltsfoot
Labrador tea (*Ledum groenlandicum*)
Northern Labrador Tea (*Ledum palustre*)
Tall Lungwort (*Mertensia paniculata*)
Bog blueberry (*Vaccinium uliginosum*)
Sphagnum moss
Rock worm lichen
Tufted wheat grass
Many bladed, short, bending grass
triangular stem with three inflourescenses (Sedge sp.)
Labrador lousewort (*Pedicularis labradorica*)
Mountain heliotrope (*Valeriana capitata*)
Pink mountain-heather (*Phyllodoce empetriformis*)
moonshine lichen
waxpaper lichen
old man's beard
Reindeer lichen
Freckled lichen (*Peltigera aphthosa*)
Pixie cup lichen
Cloudberry

Most common:

Scrub birch 20%
Black spruce 10%
Labrador tea 15%
Northern Labrador Tea 5%
Vaccinium sp. 7%
Sphagnum moss 35%
Mertensia 5%
Bent grass 5%
Pink mountain-heather 5%
Reindeer lichen 5%
Cloudberry 3%

TABLE 6
CASINO PROJECT
LOWER CASINO CREEK VEGETATION, SITE CC2

TREES		
Black spruce	(*Picea mariana*)	
SHRUBS		
Willow	(*Salix sp.*)	- 3 species - Predominant
Cinquefoil	(*Potentilla sp.*)	
Blueberry	(*Vaccinium sp.*)	
Mountain alder	(*Alnus incana*)	
HERBS		
Northern Grass-of-Parnassus	(*Parnassia palustris*)	
Fireweed	(*Epilobium angustifolium*)	
Milk-vetch	(*Astragalus sp.*)	
Tall bluebell	(*Mertensia pinaculata*)	
Northern scouring-rush	(*Equisetum variegatum*)	
Grass	Unspecified	

TABLE 7
CASINO PROJECT
LOWER CASINO CREEK VEGETATION, SITE CC1

TREES		
Black spruce	(*Picea mariana*)	- Krummholtz formation
SHRUBS		
Willow	(*Salix sp.*)	- 3 species - Predominant
Scrub birch	(*Betula glandulosa*)	
Labrador tea	(*Ledum sp.*)	- 2 species
Bog blueberry	(*Vaccinium uliginosum*)	- Common
Cinquefoil	(*Potentilla sp.*)	
HERBS		
Mitrewort	(*Mitella sp.*)	
Wheatgrass	(*Agropyron sp.*)	
Milk-vetch	(*Astragalus sp.*)	
Horsetail	(*Equisetum sp.*)	
Russet sedge	(*Carex saxatilis*)	

TABLE 8
LOWER CASINO CREEK SOIL SAMPLES

Sample number	Al (%)	Ca (%)	Co (ppm)	Cu (ppm)	Fe (%)	K (%)	Mg (%)	Mn (ppm)	Mo (ppm)	Na (%)	P (ppm)	Zn (ppm)
4600	2.2	0.87	12	80	3.61	0.13	0.67	430	2	0.02	900	168
4601	2.11	0.82	10	84	3.59	0.08	0.65	390	1	0.02	770	118
4602	2.01	1.22	6	37	2.11	0.1	0.66	240	0	0.03	580	82
4603	2.24	1.17	14	55	3.96	0.18	0.79	1005	0	0.02	680	122
4604	1.84	0.77	14	111	2.74	0.08	0.57	440	0	0.01	710	138
4605	2.49	1.13	15	134	3.54	0.11	0.69	860	1	0.02	860	242
4606	1.86	2.54	12	166	2.64	0.08	0.57	845	0	0.02	880	186
4607	1.86	0.65	23	233	5.44	0.15	0.63	960	2	0.01	720	204
4608	2.44	0.86	27	373	4.93	0.17	0.7	1020	5	0.02	850	232
4609	2.36	1.16	12	55	3.29	0.2	0.72	1065	1	0.02	790	290
4707	2.4	0.37	3	79	1.9	0.05	0.45	105	0	0.01	470	38
4708	2.66	0.47	5	144	2.38	0.09	0.72	150	10	0.02	560	66
4709	2.33	0.46	9	581	3.42	0.13	0.75	260	94	0.01	940	80
4745	3.06	0.85	13	415	5.03	0.11	0.67	495	3	0.01	830	184
4746	2.77	1.05	11	277	3.93	0.13	0.69	445	4	0.01	810	318
4747	3	1.17	21	927	4.75	0.11	0.58	645	6	0.01	920	350
4748	3.6	1.14	30	893	4.66	0.13	0.68	880	4	0.01	940	444
4749	2.72	1.04	13	150	4.48	0.14	0.69	905	1	0.01	760	904
4750	2.54	0.97	17	298	4.06	0.09	0.57	825	3	0.01	840	276
4751	2.39	0.59	11	77	4.02	0.12	0.73	875	0	0.02	840	264
4752	3.1	0.59	18	560	4.54	0.08	0.66	765	1	0.01	530	420
4753	2.66	0.92	10	40	3.37	0.13	0.75	810	0	0.01	730	226
4754	2.39	0.79	12	42	3.52	0.12	0.81	590	0	0.02	880	176
4755	2.57	0.52	7	18	2.88	0.1	0.74	275	0	0.01	650	170
4756	2.53	0.54	17	412	4.45	0.13	0.63	830	17	0.01	830	210
4757	2.06	0.59	13	32	3.22	0.08	0.67	385	3	0.01	900	100
4758	2.38	1.13	12	184	3.82	0.09	0.58	425	3	0.01	970	154
4759	1.6	0.36	9	101	3.83	0.14	0.51	310	31	0.01	730	58
4760	0.39	0.09	1	87	15	0.13	0.09	50	16	0	390	4
4761	1.44	0.32	15	104	3.67	0.25	0.25	680	37	0.01	1090	60
4762	1.45	0.17	5	123	3.98	0.35	0.25	290	69	0.01	1040	44
4763	1.03	0.11	6	42	4.16	0.27	0.22	175	16	0.01	500	36
4764	2.41	0.69	17	291	4.41	0.14	0.6	1810	8	0.01	1100	226
4765	2.18	1.13	17	278	5.3	0.1	0.58	760	7	0.01	980	228
4766	2.05	0.79	10	75	3.53	0.11	0.67	590	3	0.01	790	204
4767	2.28	0.53	17	323	4.88	0.11	0.67	815	11	0.01	800	244
4768	2.88	0.68	9	39	4.17	0.1	0.66	470	3	0.01	290	128
4769	2.42	0.72	14	266	4.35	0.11	0.61	660	6	0.01	750	196
4770	2.17	0.64	7	23	3.55	0.1	0.5	365	2	0.01	320	102
4771	2.08	0.94	19	293	6.3	0.12	0.58	830	7	0.01	880	204
4772	1.82	0.77	10	99	3.49	0.09	0.57	495	2	0.01	840	130
4773	2.77	0.96	26	117	4.42	0.1	0.46	2115	4	0.01	1160	154
4774	2.31	0.77	13	154	4.33	0.12	0.59	655	7	0.01	760	166
4775	2.38	0.47	7	35	3.47	0.11	0.47	415	2	0.01	370	106
4776	2.56	0.77	11	71	4.07	0.12	0.67	500	4	0.01	960	162
4777	2.23	0.58	8	36	2.91	0.13	0.57	525	2	0.01	580	114
4778	1.81	0.59	10	35	3	0.09	0.53	485	1	0.01	490	108
4779	1.79	0.51	8	21	3.54	0.14	0.5	675	4	0.01	360	100
4780	2.05	0.37	9	54	2.94	0.16	0.48	565	3	0.01	490	150
4781	1.91	1.5	17	259	4.36	0.06	0.51	790	4	0.01	510	250
4782	2.13	0.95	8	28	2.42	0.11	0.71	385	0	0.02	870	126
4783	1.93	0.49	15	10	4.47	0.25	0.6	1605	4	0.01	630	286
4784	2.49	0.98	26	256	4.33	0.12	0.65	1450	5	0.01	1010	276
4785	2.58	0.84	12	25	3.85	0.15	0.79	600	3	0.01	820	104
4786	2.58	1.01	23	80	6.14	0.38	1.11	1935	4	0.01	1000	214
4787	2.88	0.7	29	24	4.7	0.25	0.88	3380	1	0.02	1500	90
4788	2.66	0.59	12	21	3.46	0.14	0.78	540	3	0.02	1060	76
4789	2.11	1.23	10	76	3.43	0.19	0.7	475	2	0.01	940	146
4790	2.3	1.09	22	306	4.99	0.15	0.66	990	6	0.02	930	272
4791	2.53	0.98	14	91	3.88	0.11	0.72	830	2	0.02	920	206
4792	2.42	0.71	22	182	6.54	0.31	0.9	1085	4	0.02	950	214
4793	1.99	0.85	10	67	3.31	0.11	0.64	440	3	0.02	920	132
4794	2.16	1.06	22	245	4.82	0.2	0.73	1260	6	0.01	860	218
4795	2.42	0.73	12	24	3.44	0.1	0.79	750	1	0.02	880	92
4796	0.52	0.22	8	17	2.07	0.1	0.15	320	2	0	510	76
4797	2.19	1.37	13	32	3.3	0.15	0.68	615	3	0.02	670	86
4798	1.9	1.42	10	32	2.85	0.08	0.63	560	0	0.02	910	96
4799	2.17	1.15	12	34	3.29	0.08	0.64	475	0	0.03	730	84
4800	2.45	0.88	12	24	3.34	0.28	0.89	400	1	0.03	820	94
Average	2.24623	0.8129	13.3913	158.797	4.03725	0.13797	0.62623	725.217	6.66667	0.01348	786.232	177.159
Standard deviation	0.51531	0.37446	6.1201	183.703	1.62249	0.0652	0.16543	514.752	14.534	0.0061	216.709	124.592
Maximum	3.6	2.54	30	927	15	0.38	1.11	3380	94	0.03	1500	904
Minimum	0.39	0.09	1	10	1.9	0.05	0.09	50	0	0	290	4
Sample size	69	69	69	69	69	69	69	69	69	69	69	69

TABLE 9
CASINO PROJECT
SURFACE WATER QUALITY

Physical Tests	CC3	CC4	W8	CC2	CC1	W4
Conductivity umhos/cm	338	1080	536	241	230	241
Total Dissolved Solids	253	863	393	166	155	163
Hardness CaCO3	152	377	215	110	109	107
pH	7.22	3.02	4.25	7.86	7.96	7.68
Total Suspended Solids	5	5	13	14	23	<1.0
Turbidity NTU	2.2	15	13.8	6.5	13.3	0.51
Dissolved Anions						
Alkallnity - Total CaCO3	20.2	<1.0	<1.0	55.7	61	77.7
Chloride Cl	0.5	0.5	0.5	0.8	0.7	0.5
Fluoride F	0.13	0.28	0.22	0.07	0.06	0.08
Sulphate SO4	133	527	252	59.4	48.9	52
Nutrients						
Ammonia Nitrogen N	0.225	0.037	0.023	<0.005	<0.005	<0.005
Nitrate Nitrogen N	0.082	0.05	0.037	0.13	0.122	0.083
Nitrite Nitrogen N	0.001	<0.001	0.001	0.002	0.003	0.002
ortho-Phosphate P	0.001	0.003	<0.001	0.008	0.004	0.001
Total Dissolved Phosphate P	0.004	0.003	0.003	0.008	0.008	0.003
Total Phosphorus P	0.006	0.005	0.003	0.015	0.031	0.003
Cyanides						
Total Cyanide CN	<0.001	0.002	<0.001	0.007	0.009	0.006
Total Metals						
Aluminum T-Al	0.305	12.7	4.31	0.618	0.748	0.031
Antimony T-Sb	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Arsenic T-As	0.0003	0.0004	0.0001	0.0017	0.0024	0.0003
Barium T-Ba	0.038	0.021	0.029	0.061	0.069	0.064
Beryllium T-Be	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Bismuth T-Bi	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Boron T-B	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Cadmium T-Cd	0.0003	0.0033	0.0016	<0.0002	<0.0002	<0.0002
Calcium T-Ca	48.8	112	66.1	30.9	29.6	28.7
Chromium T-Cr	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt T-Co	0.004	0.063	0.031	0.001	0.001	<0.001
Copper T-Cu	0.067	1.39	0.465	0.038	0.023	0.005
Iron T-Fe	0.827	28.6	7.58	0.692	0.718	0.034
Lead T-Pb	<0.001	0.001	<0.001	0.001	<0.001	<0.001
Magnesium T-Mg	7.24	23.6	12.7	8.2	8.42	9.14
Manganese T-Mn	0.187	1.28	0.571	0.04	0.054	0.006
Mercury T-Hg	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum T-Mo	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel T-Ni	0.001	0.01	0.004	0.001	<0.001	<0.001
Selenium T-Se	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Silicon T-Si	10	9.81	8.97	4.99	4.81	4.64
Silver T-Ag	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Strontium T-Sr	0.243	0.263	0.232	0.2	0.189	0.178
Uranium T-U	0.00014	0.006	0.00335	0.0024	0.0027	0.00501
Vanadium T-V	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Zinc T-Zn	0.034	0.293	0.115	0.014	0.01	<0.005
Dissolved Metals						
Aluminum D-Al	0.091	12.6	3.91	0.111	0.096	0.024
Antimony D-Sb	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Arsenic D-As	0.0001	<0.0001	<0.0001	0.0011	0.001	0.0003
Barium D-Ba	0.038	0.021	0.029	0.059	0.064	0.064
Beryllium D-Be	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Bismuth D-Bi	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Boron D-B	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Cadmium D-Cd	<0.0002	<0.0002	0.0016	<0.0002	<0.0002	<0.0002
Calcium D-Ca	48.8	112	65.3	30.6	29.6	28.3
Chromium D-Cr	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt D-Co	<0.001	<0.001	0.031	<0.001	<0.001	<0.001
Copper D-Cu	0.056	1.39	0.452	0.023	0.021	0.005
Iron D-Fe	0.534	28.2	4.56	0.279	0.224	0.03
Lead D-Pb	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Magnesium D-Mg	7.24	23.5	12.5	8.2	8.42	8.94
Manganese D-Mn	0.187	1.28	0.562	0.032	0.036	0.006
Molybdenum D-Mo	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel D-Ni	0.001	0.01	0.004	<0.001	<0.001	<0.001
Potassium D-K	1.23	2.16	1.44	0.75	0.8	1.09
Selenium D-Se	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Silicon D-Si	9.97	9.79	8.78	4.99	4.81	4.55
Silver D-Ag	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Sodium D-Na	6.49	8.63	6.44	3.21	3.21	4.03
Strontium D-Sr	0.243	0.262	0.23	0.2	0.189	0.175
Uranium D-U	0.00011	0.0058	0.00288	0.0021	0.0023	0.0046
Vanadium D-V	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Zinc D-Zn	0.031	0.292	0.115	0.008	0.006	<0.005

PACIFIC SENTINEL GOLD CORPORATION
CASINO PROJECT

TABLE 10
FEDERAL AND PROVINCIAL WATER QUALITY GUIDELINES

PARAMETER	EFFLUENT		DRINKING WATER		AQUATIC LIFE	
	FEDERAL MMLER	PROV. Pollution Control	FEDERAL CCME	PROV. 1991	FEDERAL CCME	PROV. 1991
pH	6.0	6.5-8.5	6.5-8.5	6.5-8.5	6.5-9.0	6.5-9.0
Nitrate + Nitrite		10.0	10.0	10.0		40
Ammonia (NH_3)		1.0			1.37	1.86**
Total Phosphorous		2.0		0.01		
Total Suspended Solids	25*	25	10[1]			
Total Dissolved Solids		2500	500			
Hardness ($CaCO_3$)				80-100		
Sulphate (SO_4)			500	500		100
Chloride (Cl)			250	250		
Fluoride (F)		2.5	1.5	1.0		0.2
Cyanide (CN)		0.1	0.2	0.2	0.005	0.005
Metals						
Total Aluminum (Al)		0.5			0.1	
Diss. Aluminum (Al)				0.2		0.05
Total Antimony (Sb)		0.25		0.05		0.05
Total Arsenic (As)	0.5		0.05	0.05	0.05	0.05
Diss. Arsenic (As)		0.10				
Total Barium (Ba)			5.0	5.0		5.0
Total Beryllium(Be)						0.011
Total Cadmium (Cd)		0.01	0.005	0.005	0.0002	0.0002
Total Chromium (Cr)		0.05	0.05	0.05	0.002	0.002
Total Cobalt (Co)		0.5				0.05
Total Copper (Cu)	0.3	0.05	1.0	0.5	0.002	0.002
Total Iron (Fe)		0.3	0.3	0.3	0.3	0.3
Total Lead (Pb)	0.2	0.05	0.05	0.05	0.001	0.003
Diss. Magnesium (Mg)				100		
Total Manganese (Mn)		0.1	0.05	0.05		0.1
Total Mercury (Hg)		Nil	0.001	0.001	0.0001	0.00002
Total Molybdenum (Mo)		0.5		0.25		1
Total Nickel (Ni)	0.5	0.2		0.2	0.025	0.025
Radium 226 (pCi/L)	10	10	1Bq/L			
Total Selenium (Se)		0.05	0.01	0.01	0.001	0.001
Total Silver (Ag)		0.05	0.05		0.0001	0.0001
Diss. Sodium (Na)				20		
Total Uranium (U)			0.02	0.1		0.3
Total Vanadium (V)				0.1		
Total Zinc (Zn)	0.5	0.2	5	5	0.03	0.03

Criteria recorded in mg/L except when stated otherwise.
*Not applicable to approved direct discharge of tailings solids.
**Criteria level for 10°C and pH 7.7.
[1]10 mg/L above background for background $\leq$100 mg/L, increase of 10% over background >100mg/L.

Pacific Sentinel Gold Corporation
Casino Project

Table 11
Stream Sediment Analysis[+]

ANALYSIS	W4	CC1	CC2	W8 (Casino Creek d/stream of Proctor Gulch)	CC3 (Casino Creek u/stream of Proctor Gulch)	CC4 (Proctor Gulch)
Physical Tests:						
Loss On Ignition %	0.87	0.09	1.90	3.28	2.90	14.50
Moisture %	21.50	9.94	15.20	28.30	29.70	42.10
Total Metals: [*]						
Arsenic	11.50	21.30	28.70	40.90	20.00	48.60
Copper	35.90	140.50	280.80	655.00	1670.00	396.00
Lead	23.10	133.50	42.20	59.00	17.00	50.80
Mercury	0.02	0.01	0.01	0.03	0.02	0.05
Molybdenum	<4.0	<4.0	<4.0	21.10	37.70	<12.0
Silver	<2.0	<2.0	<2.0	<2.0	<2.0	<6.0
Zinc	81.50	199.00	200.00	184.00	77.20	77.50

[+] Values expressed are means
[*] Results are expressed as milligram per dry kilogram

TABLE 12
CASINO PROJECT
PERIPHYTON SITE CC3 (July, 1994)

	REPLICATES					
	3-1	3-2	3-3	3-4	3-5	3-6
Bluegreen Algae (Cyanophyceae)						
Chamaesiphon sp.						
Phormidium sp.						
Green Algae (Chlorophyceae)						
Ulothrix tenuissima						
cf. Microthamnion						
Chrysophyte Algae (Chrysophyceae)						
colonial (*Hydrurus foetidus*?)	>99%	100%	100%	90%	>99%	100%
Unidentified						
cyst						
Diatoms (Bacillariophyceae)						
Achnanthes spp.	+				+	
Caloneis sp.	+					
Cymbella spp.						
Cymbella mexicana						
Diatoma anceps						
Eunotia sp.						
Fragilaria cf. *capucina*						
Fragilaria construens						
Gomphonema spp.						
Hannaea arcus						
Meridion circulare						
Navicula spp.			+			
Pinnularia sp.				+		
Synedra acus						
Synedra rumpens					+	
% DIATOMS	<1%	0%	0%	10%	<1%	0%

Key to Abundance:

+++	Dominant
++	Common
+	Present

# of Bluegreens	0	0	0	0	0	0
# of Greens	0	0	0	0	0	0
# of Chrysophytes	1	1	1	1	1	1
# of unidentified	0	0	0	0	0	0
# of Diatoms	2	0	0	2	2	0
Total Species	2	1	1	3	3	1

TABLE 13
CASINO PROJECT
BENTHIC MACROINVERTEBRATES
CC3 – Upper Casino Creek

Organisms/Station	1	2	3	4	5	6	total	mean	N/m2	Dominance	Diversity	Pi	Pi^2	Pi^3	log N/m^2
Sensitive Organisms															
EPHEMEROPTERA							0	0.000	0.000	0	0	0	0	0	0
Ephemeroptera Unid J					1		1	0.167	3.597	0.00004386	0.04793645	0.00662252	0.00004386	2.904E-07	0.5559552
Baetis sp				2			2	0.333	7.194	0.00017543	0.08262787	0.01324503	0.00017543	2.324E-06	0.8569852
Cinygmula sp							0	0.000	0.000	0	0	0	0	0	0
Ephemerella doddsi							0	0.000	0.000	0	0	0	0	0	0
Ephemerella grandis							0	0.000	0.000	0	0	0	0	0	0
Ephemerella infrequens							0	0.000	0.000	0	0	0	0	0	0
Ephemerella sp.							0	0.000	0.000	0	0	0	0	0	0
Paraleptophlebia sp							0	0.000	0.000	0	0	0	0	0	0
Rhithrogena sp		1					1	0.167	3.597	0.00004386	0.04793645	0.00662252	0.00004386	2.904E-07	0.5559552
							0	0.000	0.000	0	0	0	0	0	0
PLECOPTERA, unid J/D					1		1	0.167	3.597	0.00004386	0.04793645	0.00662252	0.00004386	2.904E-07	0.5559552
Capnia sp.							0	0.000	0.000	0	0	0	0	0	0
Cultus sp.							0	0.000	0.000	0	0	0	0	0	0
Podmosta sp.							0	0.000	0.000	0	0	0	0	0	0
Skwala (curvata)							0	0.000	0.000	0	0	0	0	0	0
Sweltsa sp.group	1	1					2	0.333	7.194	0.00017543	0.08262787	0.01324503	0.00017543	2.324E-06	0.8569852
Utaperla sp.							0	0.000	0.000	0	0	0	0	0	0
Visoka cataractae							0	0.000	0.000	0	0	0	0	0	0
Zapada sp.							0	0.000	0.000	0	0	0	0	0	0
							0	0.000	0.000	0	0	0	0	0	0
TRICHOPTERA, unid J/D							0	0.000	0.000	0	0	0	0	0	0
Apatania sp.							0	0.000	0.000	0	0	0	0	0	0
Clostoeca sp.							0	0.000	0.000	0	0	0	0	0	0
Ecclisomyia sp.							0	0.000	0.000	0	0	0	0	0	0
Glossoma sp.							0	0.000	0.000	0	0	0	0	0	0
							0	0.000	0.000	0	0	0	0	0	0
							0	0.000	0.000	0	0	0	0	0	0
Facultative Organisms							0	0.000	0.000	0	0	0	0	0	0
							0	0.000	0.000	0	0	0	0	0	0
DIPTERA unid Adult							0	0.000	0.000	0	0	0	0	0	0
Chironomidae, unid Juv/			1	3			4	0.667	14.388	0.00070172	0.13876568	0.02649007	0.00070172	0.00001859	1.1580152
Chironomidae pupae			1		1		2	0.333	7.194	0.00017543	0.08262787	0.01324503	0.00017543	2.324E-06	0.8569852
Chironomidae adult	11	7	2		12	6	38	6.333	136.691	0.06333056	0.50091478	0.25165563	0.06333056	0.01593749	2.1357388
S.F. Chironominae							0	0.000	0.000	0	0	0	0	0	0
Micropsectra sp.							0	0.000	0.000	0	0	0	0	0	0
Diamesa sp	4	10	9	2	3	1	29	4.833	104.317	0.03688435	0.45716746	0.19205298	0.03688435	0.00708375	2.0183532
Boreoheptagya sp.							0	0.000	0.000	0	0	0	0	0	0
Monodiamesa sp.							0	0.000	0.000	0	0	0	0	0	0
Pseudokeifferiella sp.							0	0.000	0.000	0	0	0	0	0	0
S.F. Orthocladiinae							0	0.000	0.000	0	0	0	0	0	0
Brillia sp.							0	0.000	0.000	0	0	0	0	0	0
Cardiocladius sp							0	0.000	0.000	0	0	0	0	0	0
Corynoneura sp.							0	0.000	0.000	0	0	0	0	0	0
Cricotopus sp	1				1		2	0.333	7.194	0.00017543	0.08262787	0.01324503	0.00017543	2.324E-06	0.8569852

Eukiefferiella sp							0	0.000	0.000	0	0	0	0	0	0
Eurylhapsis sp	1						1	0.167	3.597	0.00004386	0.04793645	0.00662252	0.00004386	2.904E-07	0.5559552
Heleniella sp	1					1	2	0.333	7.194	0.00017543	0.08262787	0.01324503	0.00017543	2.324E-06	0.8569852
Psectrocladius? sp.							0	0.000	0.000	0	0	0	0	0	0
Krenosmittia sp.							0	0.000	0.000	0	0	0	0	0	0
Rheocricotopus sp.							0	0.000	0.000	0	0	0	0	0	0
Synorthocladius sp	3		2				5	0.833	17.986	0.00109644	0.16279724	0.03311258	0.00109644	0.00003631	1.25492521
Trichotanypus sp							0	0.000	0.000	0	0	0	0	0	0
Ceratopogonidae							0	0.000	0.000	0	0	0	0	0	0
Palpomyia sp	1						1	0.167	3.597	0.00004386	0.04793645	0.00662252	0.00004386	2.904E-07	0.5559552
Culicidae A	1	1				1	3	0.500	10.791	0.00039472	0.11232004	0.01986755	0.00039472	7.842E-06	1.03307646
Empididae							0	0.000	0.000	0	0	0	0	0	0
Chelifera sp							0	0.000	0.000	0	0	0	0	0	0
Clinocera sp.							0	0.000	0.000	0	0	0	0	0	0
Weidemannia sp.							0	0.000	0.000	0	0	0	0	0	0
Muscidae, unid J/D							0	0.000	0.000	0	0	0	0	0	0
Psychodidae							0	0.000	0.000	0	0	0	0	0	0
Pericoma sp.							0	0.000	0.000	0	0	0	0	0	0
Sciomyzidae ?L							0	0.000	0.000	0	0	0	0	0	0
Syrphidae unid L	1						1	0.167	3.597	0.00004386	0.04793645	0.00662252	0.00004386	2.904E-07	0.5559552
Prosimulium sp L							0	0.000	0.000	0	0	0	0	0	0
Cryptolabis sp							0	0.000	0.000	0	0	0	0	0	0
Antocha spl							0	0.000	0.000	0	0	0	0	0	0
Dicranota sp.							0	0.000	0.000	0	0	0	0	0	0
Hexatoma sp.			1				1	0.167	3.597	0.00004386	0.04793645	0.00662252	0.00004386	2.904E-07	0.5559552
Ormosia sp						1	1	0.167	3.597	0.00004386	0.04793645	0.00662252	0.00004386	2.904E-07	0.5559552
							0	0.000	0.000	0	0	0	0	0	0
HOMOPTERA							0	0.000	0.000	0	0	0	0	0	0
Aphididae							0	0.000	0.000	0	0	0	0	0	0
							0	0.000	0.000	0	0	0	0	0	0
Hymenoptera unid A							0	0.000	0.000	0	0	0	0	0	0
Formicidae							0	0.000	0.000	0	0	0	0	0	0
							0	0.000	0.000	0	0	0	0	0	0
Lepidoptera unid L							0	0.000	0.000	0	0	0	0	0	0
							0	0.000	0.000	0	0	0	0	0	0
Collembola Unid J/D							0	0.000	0.000	0	0	0	0	0	0
Bourletiella spinata					1		1	0.167	3.597	0.00004386	0.04793645	0.00662252	0.00004386	2.904E-07	0.5559552
Hypogastrura sp							0	0.000	0.000	0	0	0	0	0	0
Isotomurus sp	1						1	0.167	3.597	0.00004386	0.04793645	0.00662252	0.00004386	2.904E-07	0.5559552
Isotoma sp	3		1	1			5	0.833	17.986	0.00109644	0.16279724	0.03311258	0.00109644	0.00003631	1.25492521
							0	0.000	0.000	0	0	0	0	0	0
							0	0.000	0.000	0	0	0	0	0	0
Hydracarina unid J							0	0.000	0.000	0	0	0	0	0	0
Unioncola sp							0	0.000	0.000	0	0	0	0	0	0
Oribatei							0	0.000	0.000	0	0	0	0	0	0
Sperchon sp.							0	0.000	0.000	0	0	0	0	0	0
Torrenticola sp.							0	0.000	0.000	0	0	0	0	0	0
Wandesia sp.							0	0.000	0.000	0	0	0	0	0	0
Oribatei							0	0.000	0.000	0	0	0	0	0	0
							0	0.000	0.000	0	0	0	0	0	0
COPEPODA							0	0.000	0.000	0	0	0	0	0	0
Cyclopoida							0	0.000	0.000	0	0	0	0	0	0
Harpacticoida				1			1	0.167	3.597	0.00004386	0.04793645	0.00662252	0.00004386	2.904E-07	0.5559552

							0	0.000	0.000	0	0	0	0	0	0
OSTRACODA							0	0.000	0.000	0	0	0	0	0	0
							0	0.000	0.000	0	0	0	0	0	0
OLIGOCHAETA, Naididae							0	0.000	0.000	0	0	0	0	0	0
Nais sp							0	0.000	0.000	0	0	0	0	0	0
							0	0.000	0.000	0	0	0	0	0	0
GASTROPODA							0	0.000	0.000	0	0	0	0	0	0
Valvata sincera							0	0.000	0.000	0	0	0	0	0	0
							0	0.000	0.000	0	0	0	0	0	0
BIVALVIA							0	0.000	0.000	0	0	0	0	0	0
Sphaerium sp							0	0.000	0.000	0	0	0	0	0	0
							0	0.000	0.000	0	0	0	0	0	0
NEMATODA		1					1	0.167	3.597	0.00004386	0.04793645	0.00662252	0.00004386	2.904E-07	0.5559552
							0	0.000	0.000	0	0	0	0	0	0
Turbellaria unid			1				1	0.167	3.597	0.00004386	0.04793645	0.00662252	0.00004386	2.904E-07	0.5559552
							0	0.000	0.000	0	0	0	0	0	0
Tolerant Organisms							0	0.000	0.000	0	0	0	0	0	0
							0	0.000	0.000	0	0	0	0	0	0
Enchytraeidae							0	0.000	0.000	0	0	0	0	0	0
Lumbriculidae	10	2	2	20	2	2	38	6.333	136.691	0.06333056	0.50091478	0.25165563	0.06333056	0.01593749	2.1357388
Kincaidiana hexatheca	1		1	1	3		6	1.000	21.583	0.00157888	0.18490498	0.0397351	0.00157888	0.00006274	1.33410645
Tubificidae							0	0.000	0.000	0	0	0	0	0	0
TOTALS							151	25.1666667	543.165468	0.16986097	3.25689549	1	0.16986097	0.0391359	23.837223
	sensitive=						7	4.63576159		Equitab.	Richness				
	facultat=						100	66.2251656		0.69289168	4.98277968	s=	26		
	tolerant=						44	29.1390728			TU=	0.83567329			
								---------		variance=		0.04113262			
								100							

TABLE 14
CASINO PROJECT
PERIPHYTON SITE CC4 (July, 1994)

	REPLICATES					
	4-1	4-2	4-3	4-4	4-5	4-6
Bluegreen Algae (Cyanophyceae)						
Chamaesiphon sp.						
Phormidium sp.						
Green Algae (Chlorophyceae)						
Ulothrix tenuissima						
cf. *Microthamnion*	100%	75%	10%	99%	5%	60%
Chrysophyte Algae (Chrysophyceae)						
colonial (*Hydrurus foetidus*?)	20%	15%		80%	25%	
Unidentified						
cyst		5%	10%	1%	5%	5%
Diatoms (Bacillariophyceae)						
Achnanthes spp.						
Caloneis sp.						
Cymbella spp.						
Cymbella mexicana						
Diatoma anceps						
Eunotia sp.			+++		++	++
Fragilaria cf. *capucina*						
Fragilaria construens						
Gomphonema spp.						
Hannaea arcus						
Meridion circulare						
Navicula spp.						
Pinnularia sp.						
Synedra acus						
Synedra rumpens						
% DIATOMS	<1%	0%	0%	10%	<1%	0%

Key to Abundance:

+++	Dominant
++	Common
+	Present

# of Bluegreens	0	0	0	0	0	0
# of Greens	1	1	1	1	1	1
# of Chrysophytes	0	1	1	0	1	1
# of unidentified	0	1	1	1	1	1
# of Diatoms	0	0	1	0	1	1
Total Species	1	3	4	2	4	4

TABLE 15
CASINO PROJECT
BENTHIC MACROINVERTEBRATES
CC4 – Proctor Gulch

Organisms/Station	1	2	3	4	5	6	total	mean	N/m2	Dominance	Diversity	Pi	Pi^2	Pi^3	log N/m^2
Sensitive Organisms															
EPHEMEROPTERA							0	0.000	0.000	0	0	0	0	0	0
Ephemeroptera Unid J							0	0.000	0.000	0	0	0	0	0	0
Baetis sp							0	0.000	0.000	0	0	0	0	0	0
Cinygmula sp							0	0.000	0.000	0	0	0	0	0	0
Ephemerella doddsi							0	0.000	0.000	0	0	0	0	0	0
Ephemerella grandis							0	0.000	0.000	0	0	0	0	0	0
Ephemerella infrequens							0	0.000	0.000	0	0	0	0	0	0
Ephemerella sp.							0	0.000	0.000	0	0	0	0	0	0
Paraleptophlebia sp							0	0.000	0.000	0	0	0	0	0	0
Rhithrogena sp							0	0.000	0.000	0	0	0	0	0	0
							0	0.000	0.000	0	0	0	0	0	0
PLECOPTERA, unid J/D							0	0.000	0.000	0	0	0	0	0	0
Capnia sp.							0	0.000	0.000	0	0	0	0	0	0
Cultus sp.							0	0.000	0.000	0	0	0	0	0	0
Podmosta sp.							0	0.000	0.000	0	0	0	0	0	0
Skwala (curvata)							0	0.000	0.000	0	0	0	0	0	0
Sweltsa sp. group							0	0.000	0.000	0	0	0	0	0	0
Utaperla sp.							0	0.000	0.000	0	0	0	0	0	0
Visoka cataractae							0	0.000	0.000	0	0	0	0	0	0
Zapada sp.							0	0.000	0.000	0	0	0	0	0	0
							0	0.000	0.000	0	0	0	0	0	0
TRICHOPTERA, unid J/D							0	0.000	0.000	0	0	0	0	0	0
Apatania sp.							0	0.000	0.000	0	0	0	0	0	0
Clostoca sp.							0	0.000	0.000	0	0	0	0	0	0
Ecclisomyia sp.							0	0.000	0.000	0	0	0	0	0	0
Glossoma sp.							0	0.000	0.000	0	0	0	0	0	0
							0	0.000	0.000	0	0	0	0	0	0

							0	0.000	0.000	0	0	0	0	0	0
Facultative Organisms							0	0.000	0.000	0	0	0	0	0	0
							0	0.000	0.000	0	0	0	0	0	0
DIPTERA unid Adult							0	0.000	0.000	0	0	0	0	0	0
Chironomidae, unid Juv/	1	2			2		5	0.833	17.986	0.00001777	0.0332629	0.00421585	0.00001777	7.493E-08	1.25492521
Chironomidae pupae		9	1	1	1	9	21	3.500	75.540	0.00031352	0.10304468	0.01770658	0.00031352	5.551E-06	1.8781745
Chironomidae adult	1		4	1	4	1	11	1.833	39.568	0.00008602	0.0626218	0.00927487	0.00008602	7.979E-07	1.59734789
S.F. Chironominae							0	0.000	0.000	0	0	0	0	0	0
Micropsectra sp.							0	0.000	0.000	0	0	0	0	0	0
Diamesa sp		1			1		2	0.333	7.194	2.844E-06	0.01553438	0.00168634	2.844E-06	4.796E-09	0.8569852
Boreoheptagya sp.							0	0.000	0.000	0	0	0	0	0	0
Monodiamesa sp.							0	0.000	0.000	0	0	0	0	0	0
Pseudokeifferiella sp.							0	0.000	0.000	0	0	0	0	0	0
S.F. Orthocladiinae							0	0.000	0.000	0	0	0	0	0	0
Brillia sp.							0	0.000	0.000	0	0	0	0	0	0
Cardiocladius sp							0	0.000	0.000	0	0	0	0	0	0
Corynoneura sp.							0	0.000	0.000	0	0	0	0	0	0
Cricotopus sp		1					1	0.167	3.597	7.109E-07	0.00861036	0.00084317	7.109E-07	5.994E-10	0.5559552
Eukiefferiella sp	9	236	16	32	79	744	1116	186.000	4014.388	0.88543974	0.0825868	0.94097808	0.88543974	0.83317939	3.6036194
Euryhapsis sp							0	0.000	0.000	0	0	0	0	0	0
Heleniella sp							0	0.000	0.000	0	0	0	0	0	0
Psectrocladius? sp.							0	0.000	0.000	0	0	0	0	0	0
Krenosmittia sp.							0	0.000	0.000	0	0	0	0	0	0
Rheocricotopus sp.							0	0.000	0.000	0	0	0	0	0	0
Synorthocladius sp							0	0.000	0.000	0	0	0	0	0	0
Trichotanypus sp							0	0.000	0.000	0	0	0	0	0	0
Ceratopogonidae							0	0.000	0.000	0	0	0	0	0	0
Palpomyia sp							0	0.000	0.000	0	0	0	0	0	0
Culicidae A							0	0.000	0.000	0	0	0	0	0	0
Empididae							0	0.000	0.000	0	0	0	0	0	0
Chelifera sp							0	0.000	0.000	0	0	0	0	0	0
Clinocera sp.							0	0.000	0.000	0	0	0	0	0	0
Weidemannia sp.							0	0.000	0.000	0	0	0	0	0	0
Lispe sp						1	1	0.167	3.597	7.109E-07	0.00861036	0.00084317	7.109E-07	5.994E-10	0.5559552
Psychodidae							0	0.000	0.000	0	0	0	0	0	0
Pericoma sp.							0	0.000	0.000	0	0	0	0	0	0
Sciomyzidae ? L							0	0.000	0.000	0	0	0	0	0	0
Syrphidae unid L							0	0.000	0.000	0	0	0	0	0	0
Prosimulium sp L							0	0.000	0.000	0	0	0	0	0	0
Cryptolabis sp							0	0.000	0.000	0	0	0	0	0	0
Antocha spl							0	0.000	0.000	0	0	0	0	0	0
Dicranota sp.							0	0.000	0.000	0	0	0	0	0	0
Hexatoma sp.							0	0.000	0.000	0	0	0	0	0	0
Ormosia sp							0	0.000	0.000	0	0	0	0	0	0
							0	0.000	0.000	0	0	0	0	0	0

HOMOPTERA						0	0.000	0.000	0	0	0	0	0	0
Aphididae						0	0.000	0.000	0	0	0	0	0	0
						0	0.000	0.000	0	0	0	0	0	0
Hymenoptera unid A						0	0.000	0.000	0	0	0	0	0	0
Formicidae						0	0.000	0.000	0	0	0	0	0	0
						0	0.000	0.000	0	0	0	0	0	0
Lepidoptera unid L						0	0.000	0.000	0	0	0	0	0	0
						0	0.000	0.000	0	0	0	0	0	0
Collembola Unid J/D					3		3	0.500	10.791	6.398E-06	0.0218219	0.00252951	6.398E-06	1.618E-08	1.03307646
Bourletiella spinata	1			1		1	3	0.500	10.791	6.398E-06	0.0218219	0.00252951	6.398E-06	1.618E-08	1.03307646
Hypogastrura sp		1				2	3	0.500	10.791	6.398E-06	0.0218219	0.00252951	6.398E-06	1.618E-08	1.03307646
Isotomurus sp		2	1		7		10	1.667	35.971	0.00007109	0.0580941	0.0084317	0.00007109	5.994E-07	1.5559552
Isotoma sp					1		1	0.167	3.597	7.109E-07	0.00861036	0.00084317	7.109E-07	5.994E-10	0.5559552
							0	0.000	0.000	0	0	0	0	0	0
							0	0.000	0.000	0	0	0	0	0	0
Hydracarina unid J	1	2				2	5	0.833	17.986	0.00001777	0.0332629	0.00421585	0.00001777	7.493E-08	1.25492521
Unioncola sp							0	0.000	0.000	0	0	0	0	0	0
Oribatei							0	0.000	0.000	0	0	0	0	0	0
Sperchon sp.							0	0.000	0.000	0	0	0	0	0	0
Torrenticola sp.							0	0.000	0.000	0	0	0	0	0	0
Wandesia sp.							0	0.000	0.000	0	0	0	0	0	0
Oribatei							0	0.000	0.000	0	0	0	0	0	0
							0	0.000	0.000	0	0	0	0	0	0
COPEPODA							0	0.000	0.000	0	0	0	0	0	0
Cyclopoida							0	0.000	0.000	0	0	0	0	0	0
Harpacticoida							0	0.000	0.000	0	0	0	0	0	0
							0	0.000	0.000	0	0	0	0	0	0
OSTRACODA							0	0.000	0.000	0	0	0	0	0	0
							0	0.000	0.000	0	0	0	0	0	0
OLIGOCHAETA, Naididae							0	0.000	0.000	0	0	0	0	0	0
Nais sp							0	0.000	0.000	0	0	0	0	0	0
							0	0.000	0.000	0	0	0	0	0	0
GASTROPODA							0	0.000	0.000	0	0	0	0	0	0
Valvata sincera							0	0.000	0.000	0	0	0	0	0	0
							0	0.000	0.000	0	0	0	0	0	0
BIVALVIA							0	0.000	0.000	0	0	0	0	0	0
Sphaerium sp							0	0.000	0.000	0	0	0	0	0	0
							0	0.000	0.000	0	0	0	0	0	0
NEMATODA		1	1				2	0.333	7.194	2.844E-06	0.01553438	0.00168634	2.844E-06	4.796E-09	0.8569852
							0	0.000	0.000	0	0	0	0	0	0
Turbellaria unid							0	0.000	0.000	0	0	0	0	0	0
							0	0.000	0.000	0	0	0	0	0	0
Tolerant Organisms							0	0.000	0.000	0	0	0	0	0	0
							0	0.000	0.000	0	0	0	0	0	0
Enchytraeidae							0	0.000	0.000	0	0	0	0	0	0
Lumbriculidae		2					2	0.333	7.194	2.844E-06	0.01553438	0.00168634	2.844E-06	4.796E-09	0.8569852
Kincaidiana hexatheca							0	0.000	0.000	0	0	0	0	0	0
Tubificidae							0	0.000	0.000	0	0	0	0	0	0
TOTALS							1186	197.666667	4266.18705	0.88597579	0.51077949	1	0.88597579	0.83318655	18.482998
	sensitive=						0	0		Equitab.	Richness				
	facultat=						1184	99.8313659		0.13073811	1.97786443	s=	15		
	tolerant=						2	0.16863406		TU=	0.11412043				
										variance=	0.19293381				
								100							

CASINO PROJECT
TABLE 16
BENTHIC MACROINVERTEBRATES, SITE W8

Organisms/Station	1	2	3	total	mean	N/m2	Dominance	Diversity	Pi	Pi ^ 2	Pi ^ 3	log N/m ^ 2
EPHEMEROPTERA				0	0.000	0.000	0	0	0	0	0	0
Ameletus sp				0	0.000	0.000	0	0	0	0	0	0
Baetis sp				0	0.000	0.000	0	0	0	0	0	0
Cinygmula sp				0	0.000	0.000	0	0	0	0	0	0
Ephemerella doddsi				0	0.000	0.000	0	0	0	0	0	0
Ephemerella grandis				0	0.000	0.000	0	0	0	0	0	0
Ephemerella infrequens				0	0.000	0.000	0	0	0	0	0	0
Ephemerella sp.				0	0.000	0.000	0	0	0	0	0	0
Epeorus albertae				0	0.000	0.000	0	0	0	0	0	0
Epeorus deceptivus				0	0.000	0.000	0	0	0	0	0	0
				0	0.000	0.000	0	0	0	0	0	0
PLECOPTERA, unid J/D				0	0.000	0.000	0	0	0	0	0	0
Capnia sp.				0	0.000	0.000	0	0	0	0	0	0
Cultus sp.				0	0.000	0.000	0	0	0	0	0	0
Podmosta sp.				0	0.000	0.000	0	0	0	0	0	0
Skwala (curvata)				0	0.000	0.000	0	0	0	0	0	0
Sweltsa sp. group				0	0.000	0.000	0	0	0	0	0	0
Utaperla sp.				0	0.000	0.000	0	0	0	0	0	0
Visoka cataractae				0	0.000	0.000	0	0	0	0	0	0
Zapada sp.				0	0.000	0.000	0	0	0	0	0	0
				0	0.000	0.000	0	0	0	0	0	0
TRICHOPTERA, unid J/D				0	0.000	0.000	0	0	0	0	0	0
Apatania sp.				0	0.000	0.000	0	0	0	0	0	0
Clostoeca sp.				0	0.000	0.000	0	0	0	0	0	0
Ecclisomyia sp.				0	0.000	0.000	0	0	0	0	0	0
Glossoma sp.				0	0.000	0.000	0	0	0	0	0	0
				0	0.000	0.000	0	0	0	0	0	0
Facultative Organisms				0	0.000	0.000	0	0	0	0	0	0
				0	0.000	0.000	0	0	0	0	0	0
				0	0.000	0.000	0	0	0	0	0	0
DIPTERA unid Adult				0	0.000	0.000	0	0	0	0	0	0
Chironomidae, unid Juv/			1	1	0.333	3.597	0.00127551	0.00014172	0.0357143	0.0012755	0.0000456	0.555955204
Chironomidae pupae				0	0.000	0.000	0	0	0	0	0	0
Chironomidae adult	3		2	5	1.667	17.986	0.031887755	0.00354308	0.1785714	0.0318878	0.0056942	1.254925208
S.F. Chironominae				0	0.000	0.000	0	0	0	0	0	0
Micropsectra sp.				0	0.000	0.000	0	0	0	0	0	0
S.F. Diamesinae				0	0.000	0.000	0	0	0	0	0	0
Boreoheptagya sp.				0	0.000	0.000	0	0	0	0	0	0
Monodiamesa sp.				0	0.000	0.000	0	0	0	0	0	0
Pseudokeifferiella sp.				0	0.000	0.000	0	0	0	0	0	0
S.F. Orthocladiinae				0	0.000	0.000	0	0	0	0	0	0
Brillia sp.				0	0.000	0.000	0	0	0	0	0	0
Cardiocladius sp.				0	0.000	0.000	0	0	0	0	0	0
Corynoneura sp.				0	0.000	0.000	0	0	0	0	0	0
Cricotopus sp.				0	0.000	0.000	0	0	0	0	0	0
Eukiefferiella sp.				0	0.000	0.000	0	0	0	0	0	0
Euryhapsis sp.	1			1	0.333	3.597	0.00127551	0.00014172	0.0357143	0.0012755	0.0000456	0.555955204
Heleniella sp.				0	0.000	0.000	0	0	0	0	0	0
Psectrocladius? sp.				0	0.000	0.000	0	0	0	0	0	0
Krenosmittia sp.				0	0.000	0.000	0	0	0	0	0	0
Rheocricotopus sp.	4		3	7	2.333	25.180	0.0625	0.00694444	0.25	0.0625	0.015625	1.401053244
Synorthocladius sp.				0	0.000	0.000	0	0	0	0	0	0
Thienemanniella sp.				0	0.000	0.000	0	0	0	0	0	0
Ceratopogonidae				0	0.000	0.000	0	0	0	0	0	0
Culicoides sp.				0	0.000	0.000	0	0	0	0	0	0
Culicidae A				0	0.000	0.000	0	0	0	0	0	0
Empididae				0	0.000	0.000	0	0	0	0	0	0
Chelifera sp.				0	0.000	0.000	0	0	0	0	0	0

Clinocera sp.				0	0.000	0.000	0	0	0	0	0	0
Weidemannia sp.				0	0.000	0.000	0	0	0	0	0	0
Muscidae, unid J/D				0	0.000	0.000	0	0	0	0	0	0
Psychodidae				0	0.000	0.000	0	0	0	0	0	0
Pericoma sp.				0	0.000	0.000	0	0	0	0	0	0
Sciomyzidae ? L				0	0.000	0.000	0	0	0	0	0	0
Simulidae				0	0.000	0.000	0	0	0	0	0	0
Prosimulium sp.				0	0.000	0.000	0	0	0	0	0	0
Tipulidae unid J/D				0	0.000	0.000	0	0	0	0	0	0
Antocha spl				0	0.000	0.000	0	0	0	0	0	0
Dicranota sp.				0	0.000	0.000	0	0	0	0	0	0
Hexatoma sp.				0	0.000	0.000	0	0	0	0	0	0
Tipula sp.				0	0.000	0.000	0	0	0	0	0	0
				0	0.000	0.000	0	0	0	0	0	0
HOMOPTERA		1	2	3	1.000	10.791	0.011479592	0.00127551	0.1071429	0.0114796	0.00123	1.033076459
Aphididae				0	0.000	0.000	0	0	0	0	0	0
				0	0.000	0.000	0	0	0	0	0	0
Hymenoptera unid A				0	0.000	0.000	0	0	0	0	0	0
Formicidae	1			1	0.333	3.597	0.00127551	0.00014172	0.0357143	0.0012755	0.0000456	0.555955204
				0	0.000	0.000	0	0	0	0	0	0
Lepidoptera unid L				0	0.000	0.000	0	0	0	0	0	0
				0	0.000	0.000	0	0	0	0	0	0
Collembola				0	0.000	0.000	0	0	0	0	0	0
Bourletiella spinata				0	0.000	0.000	0	0	0	0	0	0
Hypogastrura sp.				0	0.000	0.000	0	0	0	0	0	0
Isotoma sp.	1	1		2	0.667	7.194	0.005102041	0.00056689	0.0714286	0.005102	0.0003644	0.8569852
				0	0.000	0.000	0	0	0	0	0	0
Arachnida	1			1	0.333	3.597	0.00127551	0.00014172	0.0357143	0.0012755	0.0000456	0.555955204
				0	0.000	0.000	0	0	0	0	0	0
Hydracarina unid J		1		1	0.333	3.597	0.00127551	0.00014172	0.0357143	0.0012755	0.0000456	0.555955204
Kerendowskia sp.				0	0.000	0.000	0	0	0	0	0	0
Lebertia sp.				0	0.000	0.000	0	0	0	0	0	0
Sperchon sp.				0	0.000	0.000	0	0	0	0	0	0
Torrenticola sp.				0	0.000	0.000	0	0	0	0	0	0
Wandesia sp.				0	0.000	0.000	0	0	0	0	0	0
Oribatei				0	0.000	0.000	0	0	0	0	0	0
				0	0.000	0.000	0	0	0	0	0	0
COPEPODA				0	0.000	0.000	0	0	0	0	0	0
Cyclopoida				0	0.000	0.000	0	0	0	0	0	0
Harpacticoida				0	0.000	0.000	0	0	0	0	0	0
				0	0.000	0.000	0	0	0	0	0	0
OSTRACODA				0	0.000	0.000	0	0	0	0	0	0
				0	0.000	0.000	0	0	0	0	0	0
OLIGOCHAETA, Naididae				0	0.000	0.000	0	0	0	0	0	0
Nais (communis)				0	0.000	0.000	0	0	0	0	0	0
				0	0.000	0.000	0	0	0	0	0	0
GASTROPODA				0	0.000	0.000	0	0	0	0	0	0
Limacidae				0	0.000	0.000	0	0	0	0	0	0
				0	0.000	0.000	0	0	0	0	0	0
NEMATODA		1		1	0.333	3.597	0.00127551	0.00014172	0.0357143	0.0012755	0.0000456	0.555955204
				0	0.000	0.000	0	0	0	0	0	0
Turbellaria				0	0.000	0.000	0	0	0	0	0	0
				0	0.000	0.000	0	0	0	0	0	0
Tolerant Organisms				0	0.000	0.000	0	0	0	0	0	0
				0	0.000	0.000	0	0	0	0	0	0
Enchytraeidae				0	0.000	0.000	0	0	0	0	0	0
Lumbriculidae	2	1	1	4	1.333	14.388	0.020408163	0.00226757	0.1428571	0.0204082	0.0029155	1.158015195
Kincaidiana hexatheca	1			1	0.333	3.597	0.00127551	0.00014172	0.0357143	0.0012755	0.0000456	0.555955204
Tubificidae				0	0.000	0.000	0	0	0	0	0	0
				28	9.3333	100.71942	0.140306122	0.01558957	1	0.1403061	0.026148	9.595741735
		sensitive=		0	0		Equitab.	Richness				
		facultat=		23	82.143		0.0043486	3.30111791	s=	12		
		tolerant=		5	17.857		TU=	0.89153439				
	0	0	0		-------		variance=	0.0258486				
	37	37	37		100							
	0	0	0									
	14.388	0	10.791									
	14.388	0	10.791									

TABLE 17
CASINO PROJECT
PERIPHYTON SITE CC2 (July, 1994)

	REPLICATES					
	2-1	2-2	2-3	2-4	2-5	2-6
Bluegreen Algae (Cyanophyceae)						
Chamaesiphon sp.	+		+			
Phormidium sp.	75%		75%			
Green Algae (Chlorophyceae)						
Ulothrix tenuissima						
cf. *Microthamnion*						
unidentified filament				+		
Chrysophyte Algae (Chrysophyceae)						
colonial (*Hydrurus foetidus*?)						
Unidentified						
cyst						
Diatoms (Bacillariophyceae)						
Achnanthes spp.	++	++	++	++	++	
Caloneis sp.						
Cymbella spp.				+	+	
Cymbella mexicana						
Diatoma anceps		+				
Eunotia sp.						
Fragilaria cf. *capucina*						
Fragilaria construens			+			
Gomphonema spp.			+		+	
Hannaea arcus			+			
Meridion circulare	+		+		+	
Navicula spp.	+	+				+
Pinnularia sp.						
Synedra acus						
Synedra rumpens	++	++	++	++	++	+
% DIATOMS	25%	100%	25%	100%	100%	na

Key to Abundance:

+++	Dominant
++	Common
+	Present
na	not applicable, too few cells seen

# of Bluegreens	2	0	2	0	0	0
# of Greens	0	0	0	0	0	1
# of Chrysophytes	0	0	0	0	0	0
# of unidentified	0	0	0	0	0	0
# of Diatoms	4	4	5	4	5	2
Total Species	6	4	7	4	5	3

TABLE 18
CASINO PROJECT
BENTHIC MACROINVERTEBRATES
CC2 – Casino Creek

Organisms/Station	1	2	3	4	5	6	total	mean	N/m2	Dominance	Diversity	Pi	Pi^2	Pi^3	log N/m^2
Sensitive Organisms															
EPHEMEROPTERA							0	0.000	0.000	0	0	0	0	0	0
Ephemeroptera Unid J	1						1	0.167	3.597	7.6E-06	0.02348	0.002762	7.6E-06	2.1E-08	0.555955
Baetis sp	15	12	19	12	3	43	104	17.333	374.101	0.082537	0.516956	0.287293	0.082537	0.023712	2.572989
Cinygmula sp							0	0.000	0.000	0	0	0	0	0	0
Ephemerella doddsi							0	0.000	0.000	0	0	0	0	0	0
Ephemerella grandis							0	0.000	0.000	0	0	0	0	0	0
Ephemerella infrequens							0	0.000	0.000	0	0	0	0	0	0
Ephemerella sp.							0	0.000	0.000	0	0	0	0	0	0
Paraleptophlebia sp							0	0.000	0.000	0	0	0	0	0	0
Rhithrogena sp							0	0.000	0.000	0	0	0	0	0	0
PLECOPTERA, unid J/D							0	0.000	0.000	0	0	0	0	0	0
Capnia sp.			3			2	5	0.833	17.986	0.000191	0.08533	0.013812	0.000191	2.6E-06	1.254925
Cultus sp.							0	0.000	0.000	0	0	0	0	0	0
Podmosta sp.						4	4	0.667	14.388	0.000122	0.071821	0.01105	0.000122	1.3E-06	1.158015
Skwala (curvata)							0	0.000	0.000	0	0	0	0	0	0
Sweltsa sp.group	1	1	2			1	5	0.833	17.986	0.000191	0.08533	0.013812	0.000191	2.6E-06	1.254925
Utaperla sp.							0	0.000	0.000	0	0	0	0	0	0
Visoka cataractae							0	0.000	0.000	0	0	0	0	0	0
Zapada sp.							0	0.000	0.000	0	0	0	0	0	0
TRICHOPTERA, unid J/D						1	1	0.167	3.597	7.6E-06	0.02348	0.002762	7.6E-06	2.1E-08	0.555955
Apatania sp.							0	0.000	0.000	0	0	0	0	0	0
Closteca sp.							0	0.000	0.000	0	0	0	0	0	0
Ecclisomyia sp.							0	0.000	0.000	0	0	0	0	0	0
Glossoma sp.							0	0.000	0.000	0	0	0	0	0	0
Facultative Organisms							0	0.000	0.000	0	0	0	0	0	0
							0	0.000	0.000	0	0	0	0	0	0
DIPTERA unid Adult							0	0.000	0.000	0	0	0	0	0	0
Chironomidae, unid Juv/							0	0.000	0.000	0	0	0	0	0	0
Chironomidae pupae		1	3	3		2	9	1.500	32.374	0.000618	0.132512	0.024862	0.000618	0.000015	1.510198
Chironomidae adult	1						1	0.167	3.597	7.6E-06	0.02348	0.002762	7.6E-06	2.1E-08	0.555955
S.F. Chironominae							0	0.000	0.000	0	0	0	0	0	0
Micropsectra sp.							0	0.000	0.000	0	0	0	0	0	0
Diamesa sp	6	11	24	4		17	62	10.333	223.022	0.029334	0.435995	0.171271	0.029334	0.005024	2.348347
Boreoheptagya sp.							0	0.000	0.000	0	0	0	0	0	0
Monodiamesa sp.							0	0.000	0.000	0	0	0	0	0	0
Pseudokeifferiella sp.							0	0.000	0.000	0	0	0	0	0	0
S.F. Orthocladiinae							0	0.000	0.000	0	0	0	0	0	0
Brillia sp.							0	0.000	0.000	0	0	0	0	0	0
Cardiocladius sp		1	1			6	8	1.333	28.777	0.000488	0.121544	0.022099	0.000488	0.000011	1.459045
Corynoneura sp.							0	0.000	0.000	0	0	0	0	0	0
Cricotopus sp		5	1			1	7	1.167	25.180	0.000374	0.110076	0.019337	0.000374	7.2E-06	1.401053
Eukiefferiella sp		3	5	2		3	13	2.167	46.763	0.00129	0.172354	0.035912	0.00129	0.000046	1.669899
Eurylhapsis sp		4	3	1	2		10	1.667	35.971	0.000763	0.143036	0.027624	0.000763	0.000021	1.555955
Heleniella sp		1	2				3	0.500	10.791	0.000069	0.057306	0.008287	0.000069	5.7E-07	1.033076

Psectrocladius? sp.					0	0.000	0.000	0	0	0	0	0	0
Krenosmittia sp.					0	0.000	0.000	0	0	0	0	0	0
Rheocricotopus sp.					0	0.000	0.000	0	0	0	0	0	0
Synorthocladius sp		7	10	7	12	36	6.000	129.496	0.00989	0.331152	0.099448	0.00989	0.000984	2.112258
Trichotanypus sp						0	0.000	0.000	0	0	0	0	0	0
Ceratopogonidae						0	0.000	0.000	0	0	0	0	0	0
Palpomyia sp					4	4	0.667	14.388	0.000122	0.071821	0.01105	0.000122	1.3E-06	1.158015
Culicidae A						0	0.000	0.000	0	0	0	0	0	0
Empididae						0	0.000	0.000	0	0	0	0	0	0
Chelifera sp						0	0.000	0.000	0	0	0	0	0	0
Clinocera sp.						0	0.000	0.000	0	0	0	0	0	0
Weidemannia sp.	1					1	0.167	3.597	7.6E-06	0.02348	0.002762	7.6E-06	2.1E-08	0.555955
Muscidae, unid J/D						0	0.000	0.000	0	0	0	0	0	0
Psychodidae						0	0.000	0.000	0	0	0	0	0	0
Pericoma sp.						0	0.000	0.000	0	0	0	0	0	0
Sciomyzidae ? L						0	0.000	0.000	0	0	0	0	0	0
Syrphidae unid L			1			1	0.167	3.597	7.6E-06	0.02348	0.002762	7.6E-06	2.1E-08	0.555955
Prosimulium sp L						0	0.000	0.000	0	0	0	0	0	0
Cryptolabis sp						0	0.000	0.000	0	0	0	0	0	0
Antocha spl						0	0.000	0.000	0	0	0	0	0	0
Dicranota sp.						0	0.000	0.000	0	0	0	0	0	0
Hexatoma sp.						0	0.000	0.000	0	0	0	0	0	0
Tipula sp.						0	0.000	0.000	0	0	0	0	0	0
HOMOPTERA						0	0.000	0.000	0	0	0	0	0	0
Aphididae						0	0.000	0.000	0	0	0	0	0	0
Hymenoptera unid A						0	0.000	0.000	0	0	0	0	0	0
Formicidae						0	0.000	0.000	0	0	0	0	0	0
Lepidoptera unid L						0	0.000	0.000	0	0	0	0	0	0
Collembola Unid J/D			1	1		2	0.333	7.194	0.000031	0.041436	0.005525	0.000031	1.7E-07	0.856985
Bourletiella spinata						0	0.000	0.000	0	0	0	0	0	0
Hypogastrura sp						0	0.000	0.000	0	0	0	0	0	0
Isotomurus sp						0	0.000	0.000	0	0	0	0	0	0
Arachnida						0	0.000	0.000	0	0	0	0	0	0
Hydracarina unid J						0	0.000	0.000	0	0	0	0	0	0
Unioncola sp	1					1	0.167	3.597	7.6E-06	0.02348	0.002762	7.6E-06	2.1E-08	0.555955
Oribatei				1		1	0.167	3.597	7.6E-06	0.02348	0.002762	7.6E-06	2.1E-08	0.555955
Sperchon sp.						0	0.000	0.000	0	0	0	0	0	0
Torrenticola sp.						0	0.000	0.000	0	0	0	0	0	0
Wandesia sp.						0	0.000	0.000	0	0	0	0	0	0
Oribatei						0	0.000	0.000	0	0	0	0	0	0
COPEPODA						0	0.000	0.000	0	0	0	0	0	0
Cyclopoida						0	0.000	0.000	0	0	0	0	0	0
Harpacticoida				1		1	0.167	3.597	7.6E-06	0.02348	0.002762	7.6E-06	2.1E-08	0.555955

OSTRACODA							0	0.000	0.000	0	0	0	0	0	0
OLIGOCHAETA, Naididae							0	0.000	0.000	0	0	0	0	0	0
Nais sp							0	0.000	0.000	0	0	0	0	0	0
GASTROPODA							0	0.000	0.000	0	0	0	0	0	0
Valvata sincera							0	0.000	0.000	0	0	0	0	0	0
BIVALVIA							0	0.000	0.000	0	0	0	0	0	0
Sphaerium sp							0	0.000	0.000	0	0	0	0	0	0
NEMATODA	1	6	13	2		3	25	4.167	89.928	0.004769	0.266298	0.069061	0.004769	0.000329	1.953895
Turbellaria unid		1					1	0.167	3.597	7.6E-06	0.02348	0.002762	7.6E-06	2.1E-08	0.555955
Tolerant Organisms							0	0.000	0.000	0	0	0	0	0	0
Enchytraeidae							0	0.000	0.000	0	0	0	0	0	0
Lumbriculidae	5	7	10	15	1	18	56	9.333	201.439	0.023931	0.416518	0.154696	0.023931	0.003702	2.304143
Kincaidiana hexatheca							0	0.000	0.000	0	0	0	0	0	0
Tubificidae							0	0.000	0.000	0	0	0	0	0	0
TOTALS							362	60.33333	1302.158	0.154788	3.270809	1	0.154788	0.033861	30.60732
	sensitive=						120	33.14917		Equitab.	Richness				
	facultat=						186	51.38122		0.70433	4.073566	s=	25		
	tolerant=						56	15.46961		TU=	0.847554				
								-------.		variance=	0.039607				
								100							

TABLE 19
CASINO PROJECT
PERIPHYTON SITE CC1 (July, 1994)

	REPLICATES					
	1-1	1-2	1-3	1-4	1-5	1-6
Bluegreen Algae (Cyanophyceae)						
Chamaesiphon sp.				+		
Phormidium sp.				10%	1%	
Green Algae (Chlorophyceae)						
Ulothrix tenuissima		5%			+	
cf. *Microthamnion*						
unidentified filament						
Chrysophyte Algae (Chrysophyceae)						
colonial (*Hydrurus foetidus*?)						
Unidentified						
cyst						
Diatoms (Bacillariophyceae)						
Achnanthes spp.	++	++	++	++	++	++
Caloneis sp.						
Cymbella spp.	+	+	+	+		+
Cymbella mexicana		+				
Diatoma anceps	++	++	+++	++	+	++
Eunotia sp.	+					+
Fragilaria cf. *capucina*	+		+	+		
Fragilaria construens						
Gomphonema spp.	+				+	
Hannaea arcus	+	+	+			
Meridion circulare	+			+		+
Navicula spp.	+	+	+	+	+	+
Pinnularia sp.		+	+	+	+	+
Synedra acus		+				
Synedra rumpens	++	++	++	++	++	++
% DIATOMS	100%	100%	95%	90%	99%	>99%

Key to Abundance:

+++	Dominant
++	Common
+	Present

# of Bluegreens	0	0	0	2	1	0
# of Greens	0	0	1	0	0	1
# of Chrysophytes	0	0	0	0	0	0
# of unidentified	0	0	0	0	0	0
# of Diatoms	10	8	9	8	6	8
Total Species	10	8	10	10	7	9

TABLE 20
CASINO PROJECT
BENTHIC MACROINVERTEBRATES
CC1 – Casino Creek

Organisms/Station	1	2	3	4	5	6	total	mean	N/m2	Dominance	Diversity	Pi	Pi^2	Pi^3	log N/m^2
Sensitive Organisms															
EPHEMEROPTERA							0	0.000	0.000	0	0	0	0	0	0
Ameletus sp							0	0.000	0.000	0	0	0	0	0	0
Baetis sp	2		10	2	16		30	5.000	107.914	0.0011863	0.1673813	0.0344432	0.0011863	0.0000409	2.0330765
Cinygmula sp							0	0.000	0.000	0	0	0	0	0	0
Ephemerella doddsi							0	0.000	0.000	0	0	0	0	0	0
Ephemerella grandis							0	0.000	0.000	0	0	0	0	0	0
Ephemerella infrequens							0	0.000	0.000	0	0	0	0	0	0
Ephemerella sp.							0	0.000	0.000	0	0	0	0	0	0
Paraleptophlebia sp			1				1	0.167	3.597	1.32E-06	0.011213	0.0011481	1.32E-06	1.51E-09	0.5559552
Rhithrogena sp							0	0.000	0.000	0	0	0	0	0	0
PLECOPTERA, unid J/D							0	0.000	0.000	0	0	0	0	0	0
Capnia sp.	1		5	1	1	1	9	1.500	32.374	0.0001068	0.0681624	0.010333	0.0001068	1.10E-06	1.5101977
Cultus sp.							0	0.000	0.000	0	0	0	0	0	0
Podmosta sp.			3	1	3	1	8	1.333	28.777	0.0000844	0.0621495	0.0091848	0.0000844	7.75E-07	1.4590452
Skwala (curvata)							0	0.000	0.000	0	0	0	0	0	0
Sweltsa sp. group				1			1	0.167	3.597	1.32E-06	0.011213	0.0011481	1.32E-06	1.51E-09	0.5559552
Utaperla sp.							0	0.000	0.000	0	0	0	0	0	0
Visoka cataractae							0	0.000	0.000	0	0	0	0	0	0
Zapada sp.							0	0.000	0.000	0	0	0	0	0	0
TRICHOPTERA, unid J/D							0	0.000	0.000	0	0	0	0	0	0
Apatania sp.							0	0.000	0.000	0	0	0	0	0	0
Closoteca sp.							0	0.000	0.000	0	0	0	0	0	0
Ecclisomyia sp.							0	0.000	0.000	0	0	0	0	0	0
Glossoma sp.							0	0.000	0.000	0	0	0	0	0	0

Facultative Organisms															
DIPTERA unid Adult							0	0.000	0.000	0	0	0	0	0	0
Chironomidae, unid Juv/	1	1	5	4	4	2	17	2.833	61.151	0.0003809	0.1108428	0.0195178	0.0003809	7.44E−06	1.7864041
Chironomidae pupae	2	5	8	4	6	2	27	4.500	97.122	0.0009609	0.1553551	0.0309989	0.0009609	0.0000298	1.987319
Chironomidae adult				1			1	0.167	3.597	1.32E−06	0.011213	0.0011481	1.32E−06	1.51E−09	0.5559552
S.F. Chironominae							0	0.000	0.000	0	0	0	0	0	0
Micropsectra sp.							0	0.000	0.000	0	0	0	0	0	0
Diamesa sp	2		29	5	9	5	50	8.333	179.856	0.0032954	0.2366632	0.0574053	0.0032954	0.0001892	2.2549252
Boreoheptagya sp.							0	0.000	0.000	0	0	0	0	0	0
Monodiamesa sp.							0	0.000	0.000	0	0	0	0	0	0
Pseudokeifferiella sp.							0	0.000	0.000	0	0	0	0	0	0
S.F. Orthocladiinae							0	0.000	0.000	0	0	0	0	0	0
Brillia sp.							0	0.000	0.000	0	0	0	0	0	0
Cardiocladius sp	1	1	1	4	5	1	13	2.167	46.763	0.0002228	0.0905386	0.0149254	0.0002228	3.32E−06	1.6698986
Corynoneura sp.							0	0.000	0.000	0	0	0	0	0	0
Cricotopus sp	7	7	18	8	21	11	72	12.000	258.993	0.0068333	0.2973082	0.0826636	0.0068333	0.0005649	2.4132877
Eukiefferiella sp	2	2	8	1	3	3	19	3.167	68.345	0.0004759	0.1203828	0.021814	0.0004759	0.0000104	1.8347088
Euryhapsis sp	6	2	8	5	6	4	31	5.167	111.511	0.0012667	0.171277	0.0355913	0.0012667	0.0000451	2.0473169
Heleniella sp		1	1	1	2		5	0.833	17.986	0.000033	0.0427359	0.0057405			
Psectrocladius? sp.							0	0.000	0.000	0	0	0	0	0	0
Krenosmittia sp.							0	0.000	0.000	0	0	0	0	0	0
Rheocricotopus sp.							0	0.000	0.000	0	0	0	0	0	0
Synorthocladius sp	6	29	140	57	138	40	410	68.333	1474.820	0.2215804	0.5116992	0.4707233	0.2215804	0.1043031	3.1687391
Trichotanypus sp				1	1	2	4	0.667	14.388	0.0000211	0.0356672	0.0045924	0.0000211	9.69E−08	1.1580152
Ceratopogonidae							0	0.000	0.000	0	0	0			
Culicoides sp.							0	0.000	0.000	0	0	0	0	0	0
Culicidae A							0	0.000	0.000	0	0	0	0	0	0
Empididae							0	0.000	0.000	0	0	0	0	0	0
Chelifera sp	1		1	1	1	1	5	0.833	17.986	0.000033	0.0427359	0.0057405	0.000033	1.89E−07	1.2549252
Clinocera sp.							0	0.000	0.000	0	0	0	0	0	0
Weidemannia sp.							0	0.000	0.000	0	0	0	0	0	0
Muscidae, unid J/D							0	0.000	0.000	0	0	0	0	0	0

Psychodidae						0	0.000	0.000	0	0	0	0	0	0
Pericoma sp.						0	0.000	0.000	0	0	0	0	0	0
Sciomyzidae ? L						0	0.000	0.000	0	0	0	0	0	0
Simulium sp L	1		2			3	0.500	10.791	0.0000119	0.0281799	0.0034443	0.0000119	4.09E−08	1.0330765
Prosimulium sp L				1		1	0.167	3.597	1.32E−06	0.011213	0.0011481	1.32E−06	1.51E−09	0.5559552
Cryptolabis sp	1				1	2	0.333	7.194	5.27E−06	0.0201298	0.0022962	5.27E−06	1.21E−08	0.8569852
Antocha spl						0	0.000	0.000	0	0	0	0	0	0
Dicranota sp.						0	0.000	0.000	0	0	0	0	0	0
Hexatoma sp.						0	0.000	0.000	0	0	0	0	0	0
Tipula sp.						0	0.000	0.000	0	0	0	0	0	0
HOMOPTERA						0	0.000	0.000	0	0	0	0	0	0
Aphididae						0	0.000	0.000	0	0	0	0	0	0
Hymenoptera unid A						0	0.000	0.000	0	0	0	0	0	0
Formicidae						0	0.000	0.000	0	0	0	0	0	0
Lepidoptera unid L						0	0.000	0.000	0	0	0	0	0	0
Collembola Unid J/D				1	1	2	0.333	7.194	5.27E−06	0.0201298	0.0022962	5.27E−06	1.21E−08	0.8569852
Bourletiella spinata				2		2	0.333	7.194	5.27E−06	0.0201298	0.0022962	5.27E−06	1.21E−08	0.8569852
Hypogastrura sp				1	1	2	0.333	7.194	5.27E−06	0.0201298	0.0022962	5.27E−06	1.21E−08	0.8569852
Isotomurus sp	1					1	0.167	3.597	1.32E−06	0.011213	0.0011481	1.32E−06	1.51E−09	0.5559552
Arachnida						0	0.000	0.000	0	0	0	0	0	0
Hydracarina unid J					1	1	0.167	3.597	1.32E−06	0.011213	0.0011481	1.32E−06	1.51E−09	0.5559552
Kerendowskia sp.						0	0.000	0.000	0	0	0	0	0	0
Lebertia sp.						0	0.000	0.000	0	0	0	0	0	0
Sperchon sp.						0	0.000	0.000	0	0	0	0	0	0
Torrenticola sp.						0	0.000	0.000	0	0	0	0	0	0
Wandesia sp.						0	0.000	0.000	0	0	0	0	0	0
Oribatei						0	0.000	0.000	0	0	0	0	0	0

COPEPODA							0	0.000	0.000	0	0	0	0	0	0
Cyclopoida		1			1	1	3	0.500	10.791	0.0000119	0.0281799	0.0034443	0.0000119	4.09E−08	1.0330765
Harpacticoida					1		1	0.167	3.597	1.32E−06	0.011213	0.0011481	1.32E−06	1.51E−09	0.5559552
OSTRACODA			2				2	0.333	7.194	5.27E−06	0.0201298	0.0022962	5.27E−06	1.21E−08	0.8569852
OLIGOCHAETA, Naididae							0	0.000	0.000	0	0	0	0	0	0
Nais sp			1	1	1		3	0.500	10.791	0.0000119	0.0281799	0.0034443	0.0000119	4.09E−08	1.0330765
GASTROPODA							0	0.000	0.000	0	0	0	0	0	0
Valvata sincera					1		1	0.167	3.597	1.32E−06	0.011213	0.0011481	1.32E−06	1.51E−09	0.5559552
BIVALVIA								0.000		0	0	0	0	0	0
Sphaerium sp	1						1	0.167	3.597	1.32E−06	0.011213	0.0011481	1.32E−06	1.51E−09	0.5559552
NEMATODA	6	2	12	7	4	6	37	6.167	133.094	0.0018045	0.1935841	0.0424799	0.0018045	0.0000767	2.1241569
Turbellaria unid	1				2		3	0.500	10.791	0.0000119	0.0281799	0.0034443	0.0000119	4.09E−08	1.0330765
Tolerant Organisms								0.000		0	0	0	0	0	0
Enchytraeidae			1		1		2	0.333	7.194	5.27E−06	0.0201298	0.0022962	5.27E−06	1.21E−08	0.8569852
Lumbriculidae	8	3	31	14	35	5	96	16.000	345.324	0.012148	0.3506663	0.1102181	0.012148	0.0013389	2.5382264
Kincaidiana hexatheca							0	0.000	0.000	0	0	0	0	0	0
Tubificidae	1		2	1	1		5	0.833	17.986	0.000033	0.0427359	0.0057405	0.000033	1.89E−07	1.2549252
TOTALS							871	145.2	3133.1	0.2505572	3.0343013	1	0.2505243	0.1066122	44.772982
		sensitive=					49	5.626		Equitab.	Richness				
		facultat=					719	82.55		0.5915644	5.0224222	s=	35		
		tolerant=					103	11.83		TU=	0.7503372				
								-----		variance=	0.175399				
								100							

TABLE 21
CASINO PROJECT
PERIPHYTON SITE W4

	REPLICATES					
	1-1	1-2	1-3	1-4	1-5	1-6
Bluegreen Algae (Cyanophyceae)						
Anabaena sp.					+	
Lyngbya diguetti	+		+	+	+	+
Rivularia sp.						+
Chamaesiphon sp.	+					
Phormidium sp.	+	+	+			
Green Algae (Chlorophyceae)						
Ulothrix tenerrima	+	+	+	+		
Closterium sp.	+					
Mougeotia sp.			+			
Stigeoclonium sp.			+			
Cryptophyceae						
Cryptomonas sp.				+		
Red Algae (Rhodophyceae)						
Andouinella violacea		+	+	+	+	+
Batrachospermum		+				
Diatoms (Bacillariophyceae)						
Achnanthes spp.	+		+		+	
Achnanthes minutissima	+	+	+	++	+	++
Cymbella spp.	+	+		+		+
Cymbella cistula						+
Cymbella minuta	+	+	+		+	
Cymbella sinuata	+					
Cymbella tumida				+		+
Diatoma hiemale						+
Diatoma tenue	+++	+++	+++	+++	+++	+++
Didymosphenia geminata	+					
Fragilaria cf. *capucina*				+		
Fragilaria construens	+					
Gomphonema spp.				+	+	
Gomphonema angustatum	+	+	+	+	+	+
Gomphonema brebissonii					+	
Hannaea arcus	++	+	+	+	+	+
Meridion circulare	+	+	+	+	+	
Navicula spp.	+	+		+	+	+

TABLE 21 (continued)
CASINO PROJECT
PERIPHYTON SITE W4 contd.

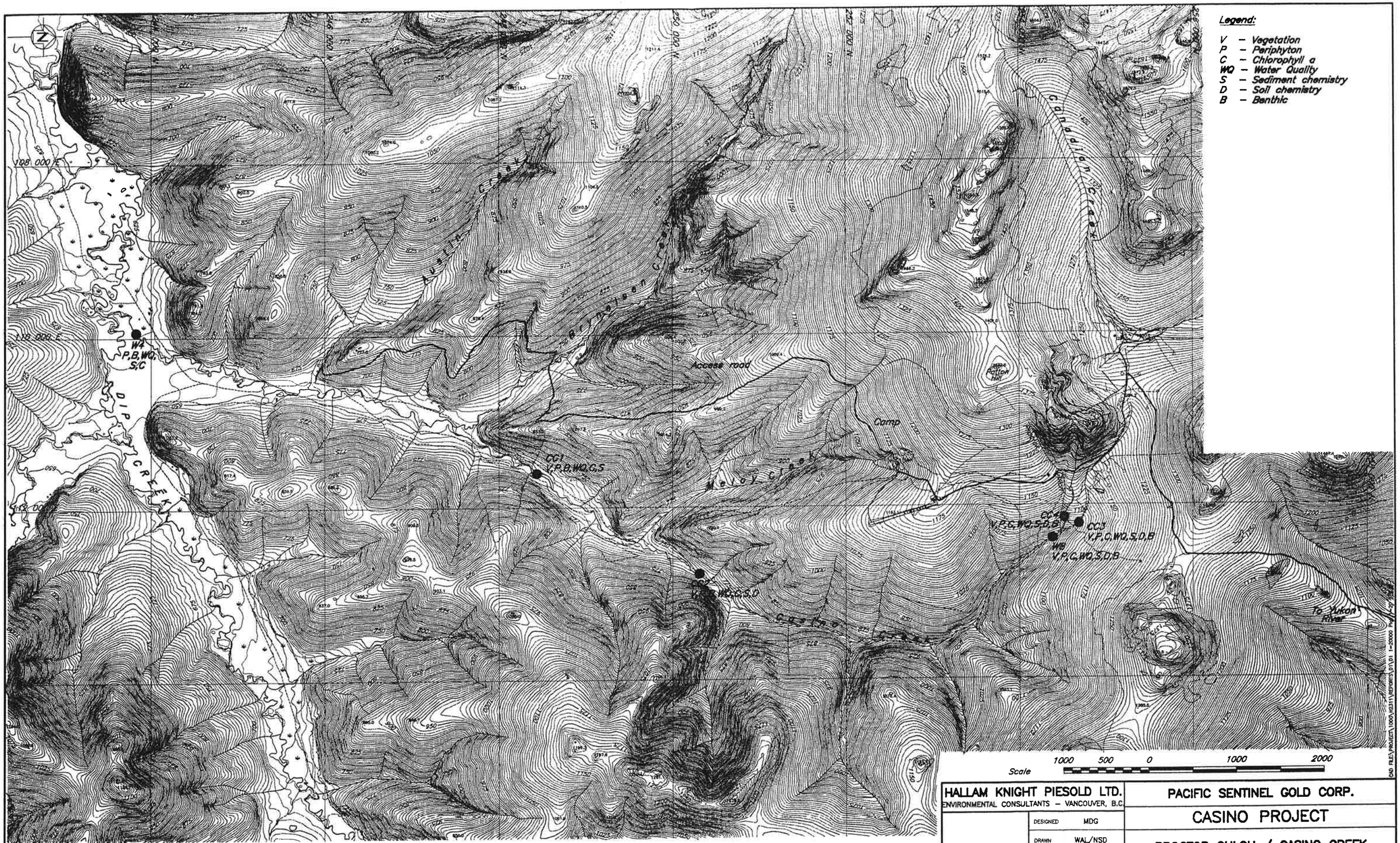
	REPLICATES					
	1-1	1-2	1-3	1-4	1-5	1-6
Diatoms (Bacillariophyceae)						
Navicula lancleota	+			+		+
Nitzschia sp.	++	++	++	+	+	+
Pinnularia sp.	+	+				
Synedra sp.	+++	+++	+++	++	+++	+++
Synedra rumpens	++	++	++	++	++	++
Synedra ulna	+	+	+			+
Key to Abundance:						
+++ Dominant						
++ Common						
+ Present						
# of Bluegreens	3	1	2	1	2	2
# of Greens	2	1	3	1	0	0
# of Cryptophyceae	0	0	0	1	0	0
# of Reds	0	2	1	1	1	1
# of Diatoms	18	13	11	14	13	15
Total Species	23	17	17	18	16	18

PACIFIC SENTINEL GOLD CORPORATION
CASINO PROJECT
TABLE 22
BENTHIC MACROINVERTEBRATES, SITE W4

Organisms/Station	1	2	3	total	mean	N/m2	Dominance	Diversity	Pi	Pi ^ 2	Pi ^ 3	log N/m ^ 2
EPHEMEROPTERA				0	0.000	0.000	0	0	0	0	0	0
Ameletus sp		1	1	2	0.667	7.194	2.3963E-06	0.014451068	0.001547988	2.3963E-06	3.7094E-09	0.8569852
Baetis sp	5	1	5	11	3.667	39.568	0.000072487	0.058541443	0.008513932	0.000072487	6.1715E-07	1.597347889
Cinygmula sp	10	10	13	33	11.000	118.705	0.000652383	0.135141541	0.025541796	0.000652383	0.000016663	2.074469144
Ephemerella doddsi	5	1	10	16	5.333	57.554	0.000153361	0.078456844	0.012383901	0.000153361	1.8992E-06	1.760075187
Ephemerella grandis				0	0.000	0.000	0	0	0	0	0	0
Ephemerella infrequens				0	0.000	0.000	0	0	0	0	0	0
Ephemerella sp.		3	1	4	1.333	14.388	9.5851E-06	0.025806161	0.003095975	9.5851E-06	2.9675E-08	1.158015195
Epeorus albertae			1	1	0.333	3.597	5.9907E-07	0.007999528	0.000773994	5.9907E-07	4.6367E-10	0.555955204
Epeorus deceptivus		1		1	0.333	3.597	5.9907E-07	0.007999528	0.000773994	5.9907E-07	4.6367E-10	0.555955204
				0	0.000	0.000	0	0	0	0	0	0
PLECOPTERA, unid J/D	34	72	102	208	69.333	748.201	0.025918009	0.424202567	0.160990712	0.025918009	0.004172559	2.874018539
Capnia sp.	12	21	30	63	21.000	226.619	0.002377695	0.212508475	0.04876161	0.002377695	0.00011594	2.355295754
Cultus sp.				0	0.000	0.000	0	0	0	0	0	0
Podmosta sp.	5	6	4	15	5.000	53.957	0.00013479	0.074634283	0.011609907	0.00013479	1.5649E-06	1.732046463
Skwala (curvata)		2	1	3	1.000	10.791	5.3916E-06	0.02031833	0.002321981	5.3916E-06	1.2519E-08	1.033076459
Sweltsa sp. group	8	5	3	16	5.333	57.554	0.000153361	0.078456844	0.012383901	0.000153361	1.8992E-06	1.760075187
Utaperla sp.				0	0.000	0.000	0	0	0	0	0	0
Visoka cataractae				0	0.000	0.000	0	0	0	0	0	0
Zapada sp.	6	7	22	35	11.667	125.899	0.000733856	0.141032315	0.027089783			
							0	0	0			
TRICHOPTERA, unid J/D	2	1	5	8	2.667	28.777	0.00003834	0.045420372	0.00619195	0.00003834	2.3740E-07	1.459045191
Apatania sp.	2	1	5	8	2.667	28.777	0.00003834	0.045420372	0.00619195	0.00003834	2.3740E-07	1.459045191
Clostoteca sp.	2		2	4	1.333	14.388	9.5851E-06	0.025806161	0.003095975	9.5851E-06	2.9675E-08	1.158015195
Ecclisomyia sp.	2	1	3	6	2.000	21.583	0.000021566	0.035992698	0.004643963	0.000021566	1.0015E-07	1.334106454
Glossoma sp.	7	7	2	16	5.333	57.554	0.000153361	0.078456844	0.012383901	0.000153361	1.8992E-06	1.760075187
				0	0.000	0.000	0	0	0	0	0	0
Facultative Organisms							0	0	0			
							0	0	0			
				0	0.000	0.000	0	0	0	0	0	0
DIPTERA unid Adult			1	1	0.333	3.597	5.9907E-07	0.007999528	0.000773994	5.9907E-07	4.6367E-10	0.555955204
Chironomidae, unid Juv	4	21	19	44	14.667	158.273	0.001159793	0.166054318	0.034055728	0.001159793	0.000039498	2.199407881
Chironomidae pupae	11	10	13	34	11.333	122.302	0.000692521	0.138103352	0.026315789	0.000692521	0.000018224	2.087434121
Chironomidae adult	2	3	7	12	4.000	43.165	0.000086266	0.062697471	0.009287926	0.000086266	8.0123E-07	1.635513645
S.F. Chironominae				0	0.000	0.000	0	0	0	0	0	0
Micropsectra sp.		1	2	3	1.000	10.791	5.3916E-06	0.02031833	0.002321981	5.3916E-06	1.2519E-08	1.033076459
S.F. Diamesinae				0	0.000	0.000	0	0	0	0	0	0
Boreoheptagya sp.				0	0.000	0.000	0	0	0	0	0	0
Monodiamesa sp.				0	0.000	0.000	0	0	0	0	0	0
Pseudokeifferiella sp.			6	6	2.000	21.583	0.000021566	0.035992698	0.004643963	0.000021566	1.0015E-07	1.334106454
S.F. Orthocladiinae				0	0.000	0.000	0	0	0	0	0	0
Brillia sp.				0	0.000	0.000	0	0	0	0	0	0
Cardiocladius sp.	21	29	68	118	39.333	424.460	0.008341401	0.315343785	0.091331269	0.008341401	0.000761831	2.627837211
Corynoneura sp.				0	0.000	0.000	0	0	0	0	0	0
Cricotopus sp.	45	45	66	156	52.000	561.151	0.01457888	0.368264811	0.120743034	0.01457888	0.001760298	2.749079802
Eukiefferiella sp.	5	11	13	29	9.667	104.317	0.000503815	0.122944943	0.02244582	0.000503815	0.000011309	2.018353202
Eurythapsis sp.				0	0.000	0.000	0	0	0	0	0	0
Heleniella sp.	2	1		3	1.000	10.791	5.3916E-06	0.02031833	0.002321981			
Psectrocladius? sp.				0	0.000	0.000	0	0	0	0	0	0
Krenosmittia sp.				0	0.000	0.000	0	0	0	0	0	0
Rheocricotopus sp.			1	1	0.333	3.597	5.9907E-07	0.007999528	0.000773994	5.9907E-07	4.6367E-10	0.555955204
Synorthocladius sp.	9	5	15	29	9.667	104.317	0.000503815	0.122944943	0.02244582	0.000503815	0.000011309	2.018353202
Thienemanniella sp.				0	0.000	0.000	0	0	0	0	0	0
Ceratopogonidae				0	0.000	0.000	0	0	0	0	0	
Culicoides sp.		1		1	0.333	3.597	5.9907E-07	0.007999528	0.000773994	5.9907E-07	4.6367E-10	44.29829783
Culicidae A				0	0.000	0.000	0	0	0	0	0	88.59659567
Empididae				0	0.000	0.000	0	0	0	0	0	176.3362061
Chelifera sp.	17	24	5	46	15.333	165.468	0.001267625	0.171318963	0.035603715	0.001267625	0.000045132	351.0750644
Clinocera sp.				0	0.000	0.000	0	0	0	0	0	700.0756596
Weidemannia sp.	1			1	0.333	3.597	5.9907E-07	0.007999528	0.000773994	5.9907E-07	4.6367E-10	1398.391244

Muscidae, unid J/D				0	0.000	0.000	0	0	0	0	0	2796.782488
Psychodidae				0	0.000	0.000	0	0	0	0	0	5593.564976
Pericoma sp.			6	6	2.000	21.583	0.000021566	0.035992698	0.004643963	0.000021566	1.0015E-07	11185.97194
Sciomyzidae ? L				0	0.000	0.000	0	0	0	0	0	22371.38792
Simulidae				0	0.000	0.000	0	0	0	0	0	44742.21988
Prosimulium sp.			1	1	0.333	3.597	5.9907E-07	0.007999528	0.000773994	5.9907E-07	4.6367E-10	89484.43977
Tipulidae unid J/D	1		2	3	1.000	10.791	5.3916E-06	0.02031833	0.002321981	5.3916E-06	1.2519E-08	178966.0055
Antocha spl				0	0.000	0.000	0	0	0	0	0	357929.6557
Dicranota sp.				0	0.000	0.000	0	0	0	0	0	715859.3115
Hexatoma sp.				0	0.000	0.000	0	0	0	0	0	1431716.891
Tipula sp.		5	3	8	2.667	28.777	0.00003834	0.045420372	0.00619195	0.00003834	2.3740E-07	2863432.749
					0.000	0.000	0	0	0	0	0	5726863.737
HOMOPTERA				0	0.000	0.000	0	0	0	0	0	11453727.47
Aphididae	1	1	2	4	1.333	14.388	9.5851E-06	0.025806161	0.003095975	9.5851E-06	2.9675E-08	22907454.95
				0	0.000	0.000	0	0	0	0	0	45814909.9
Hymenoptera unid A		2		2	0.667	7.194	2.3963E-06	0.014451068	0.001547988	2.3963E-06	3.7094E-09	9162981.8
Formicidae				0	0.000	0.000	0	0	0	0	0	183259638.1
				0	0.000	0.000	0	0	0	0	0	366519274.8
Lepidoptera unid L				0	0.000	0.000	0	0	0	0	0	733038548.5
				0	0.000	0.000	0	0	0	0	0	1466077096
Collembola				0	0.000	0.000	0	0	0	0	0	2932154189
Bourletiella spinata				0	0.000	0.000	0	0	0	0	0	5864308379
Hypogastrura sp.			5	5	1.667	17.986	0.000014977	0.03101185	0.003869969	0.000014977	5.7959E-08	11728616758
Isotoma sp.	1		3	4	1.333	14.388	9.5851E-06	0.025806161	0.003095975	9.5851E-06	2.9675E-08	23457233516
				0	0.000	0.000	0	0	0	0	0	46914467031
Arachnida				0	0.000	0.000	0	0	0	0	0	93828934062
				0	0.000	0.000	0	0	0	0	0	1.8766E+11
Hydracarina unid J	6	6	6	18	6.000	64.748	0.000194098	0.085896574	0.013931889	0.000194098	2.7041E-06	3.7532E+11
Kerendowskia sp.				0	0.000	0.000	0	0	0	0	0	7.5063E+11
Lebertia sp.		1		1	0.333	3.597	5.9907E-07	0.007999528	0.000773994	5.9907E-07	4.6367E-10	1.5013E+12
Sperchon sp.	1		1	2	0.667	7.194	2.3963E-06	0.014451068	0.001547988	2.3963E-06	3.7094E-09	3.0025E+12
Torrenticola sp.	1		2	3	1.000	10.791	5.3916E-06	0.02031833	0.002321981	5.3916E-06	1.2519E-08	6.0051E+12
Wandesia sp.				0	0.000	0.000	0	0	0	0	0	1.2010E+13
Oribatei				0	0.000	0.000	0	0	0	0	0	2.4020E+13
				0	0.000	0.000	0	0	0	0	0	4.8040E+13
COPEPODA				0	0.000	0.000	0	0	0	0	0	9.6081E+13
Cyclopoida			4	4	1.333	14.388	9.5851E-06	0.025806161	0.003095975	9.5851E-06	2.9675E-08	1.9216E+14
Harpacticoida	3	2	3	8	2.667	28.777	0.00003834	0.045420372	0.00619195	0.00003834	2.3740E-07	3.8432E+14
				0	0.000	0.000	0	0	0	0	0	7.6865E+14
OSTRACODA	7	2	5	14	4.667	50.360	0.000117417	0.070737224	0.010835913	0.000117417	1.2723E-06	1.5373E+15
				0	0.000	0.000	0	0	0	0	0	3.0746E+15
OLIGOCHAETA, Naididae				0	0.000	0.000	0	0	0	0	0	6.1492E+15
Nais (communis)	1			1	0.333	3.597	5.9907E-07	0.007999528	0.000773994	5.9907E-07	4.6367E-10	1.2298E+16
				0	0.000	0.000	0	0	0	0	0	2.4597E+16
GASTROPODA				0	0.000	0.000	0	0	0	0	0	4.9193E+16
Limacidae				0	0.000	0.000	0	0	0	0	0	9.8387E+16
				0	0.000	0.000	0	0	0	0	0	1.9677E+17
NEMATODA	3	12	13	28	9.333	100.719	0.000469668	0.119802622	0.021671827	0.000469668	0.000010179	3.9355E+17
				0	0.000	0.000	0	0	0	0	0	7.8709E+17
Turbellaria		1		1	0.333	3.597	5.9907E-07	0.007999528	0.000773994	5.9907E-07	4.6367E-10	1.5742E+18
				0	0.000	0.000	0	0	0	0	0	3.1484E+18
Tolerant Organisms				0	0.000	0.000	0	0	0	0	0	6.2968E+18
				0	0.000	0.000	0	0	0	0	0	1.2594E+19
Enchytraeidae	29	30	27	86	28.667	309.353	0.004430695	0.260204947	0.066563467	0.004430695	0.000294922	2.5187E+19
Lumbriculidae	51	57	49	157	52.333	564.748	0.014766388	0.369505274	0.121517028	0.014766388	0.001794368	5.0374E+19
Kincaidiana hexatheca				0	0.000	0.000	0	0	0	0	0	1.0075E+20
Tubificidae	1	1		2	0.667	7.194	2.3963E-06	0.014451068	0.001547988	2.3963E-06	3.7094E-09	2.0150E+20
				1292	430.66667	4647.482	0.07778518	4.344343828	1	0.077045932	0.009066414	4.0299E+20
		sensitive=		450	34.829721		Equitab.	Richness				
		facultat=		597	46.20743		0.754896416	7.398156677	s=	54		
		tolerant=		245	18.962848		TU=	0.923668982				
	0	3.5971	0		---------		variance=	0.012521353				
	34	36	37		100							

FIGURES



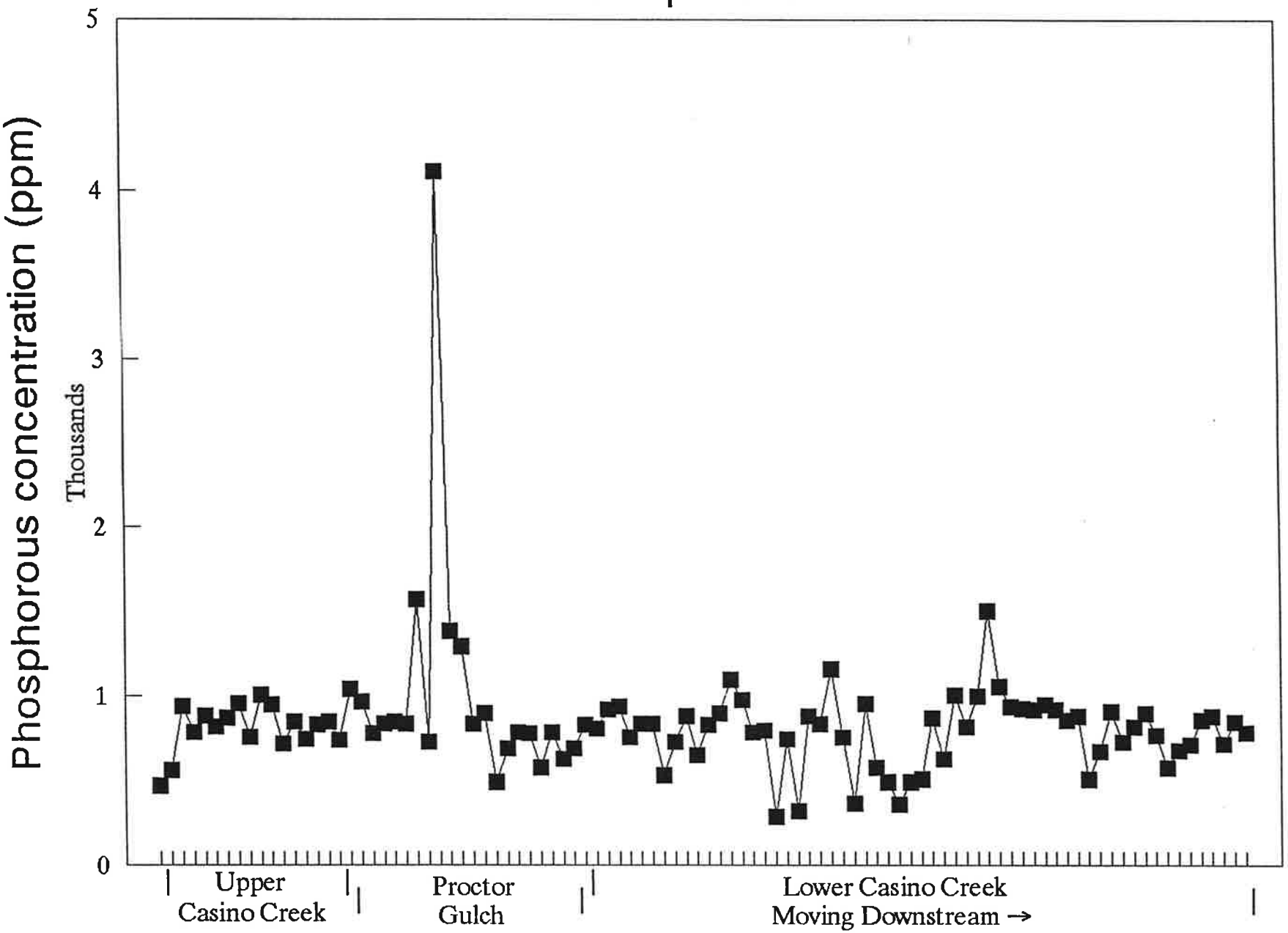
HALLAM KNIGHT PIESOLD LTD. ENVIRONMENTAL CONSULTANTS – VANCOUVER, B.C.	PACIFIC SENTINEL GOLD CORP.
DESIGNED MDG DRAWN WAL/NSD CHECKED APPROVED	CASINO PROJECT PROCTOR GULCH / CASINO CREEK SAMPLING SITES FIGURE 1
DATE AUG. 22, 1994	SCALE AS SHOWN
DRG. NO. H2311	REV. –

DRG. NO.	DESCRIPTION	REV.	DATE	DESCRIPTION	APPROVED	REV.	DATE	DESCRIPTION	APPROVED
REFERENCE DRAWINGS		REVISIONS				REVISIONS			

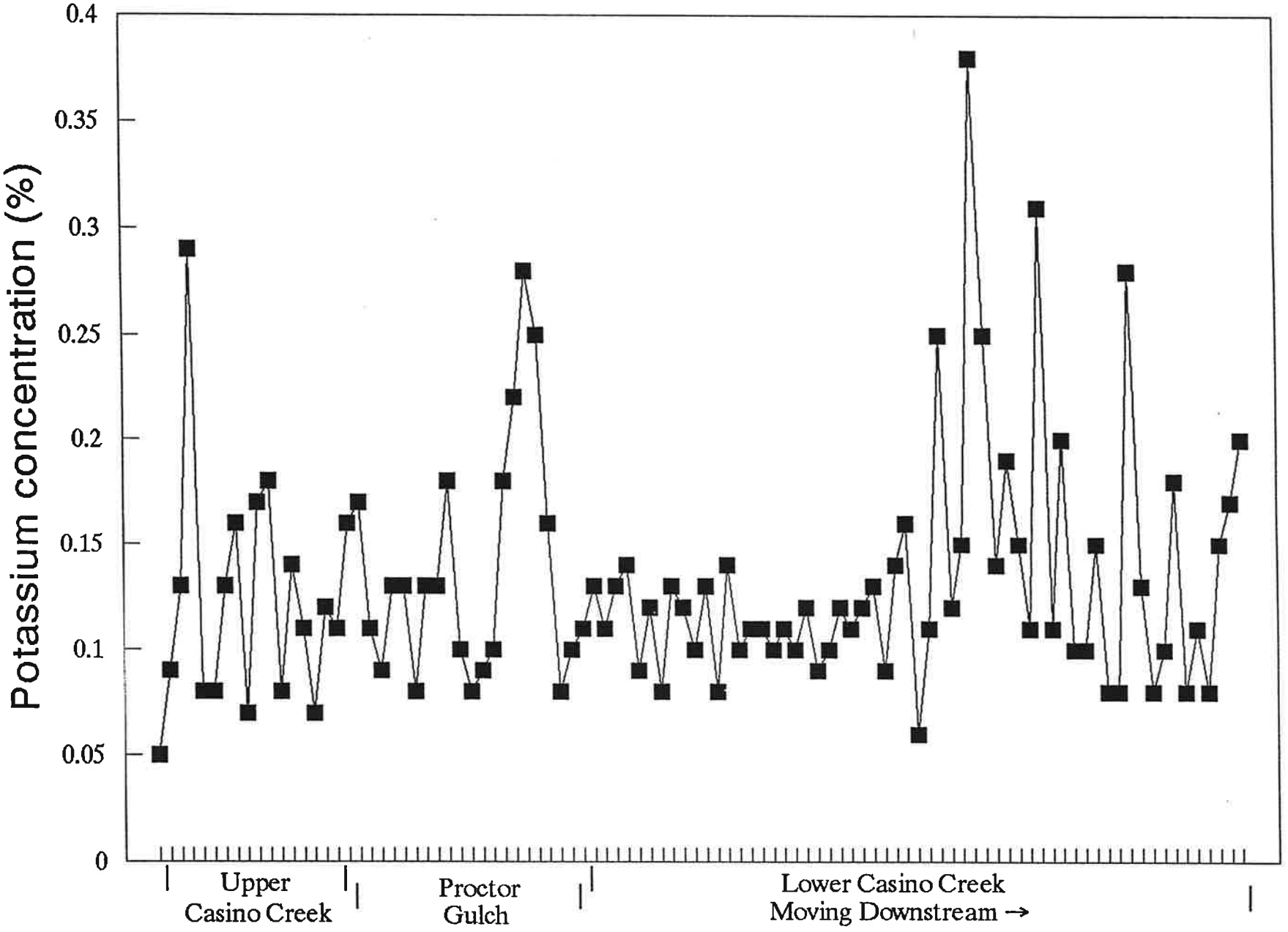
APPENDIX A

SOIL SAMPLES

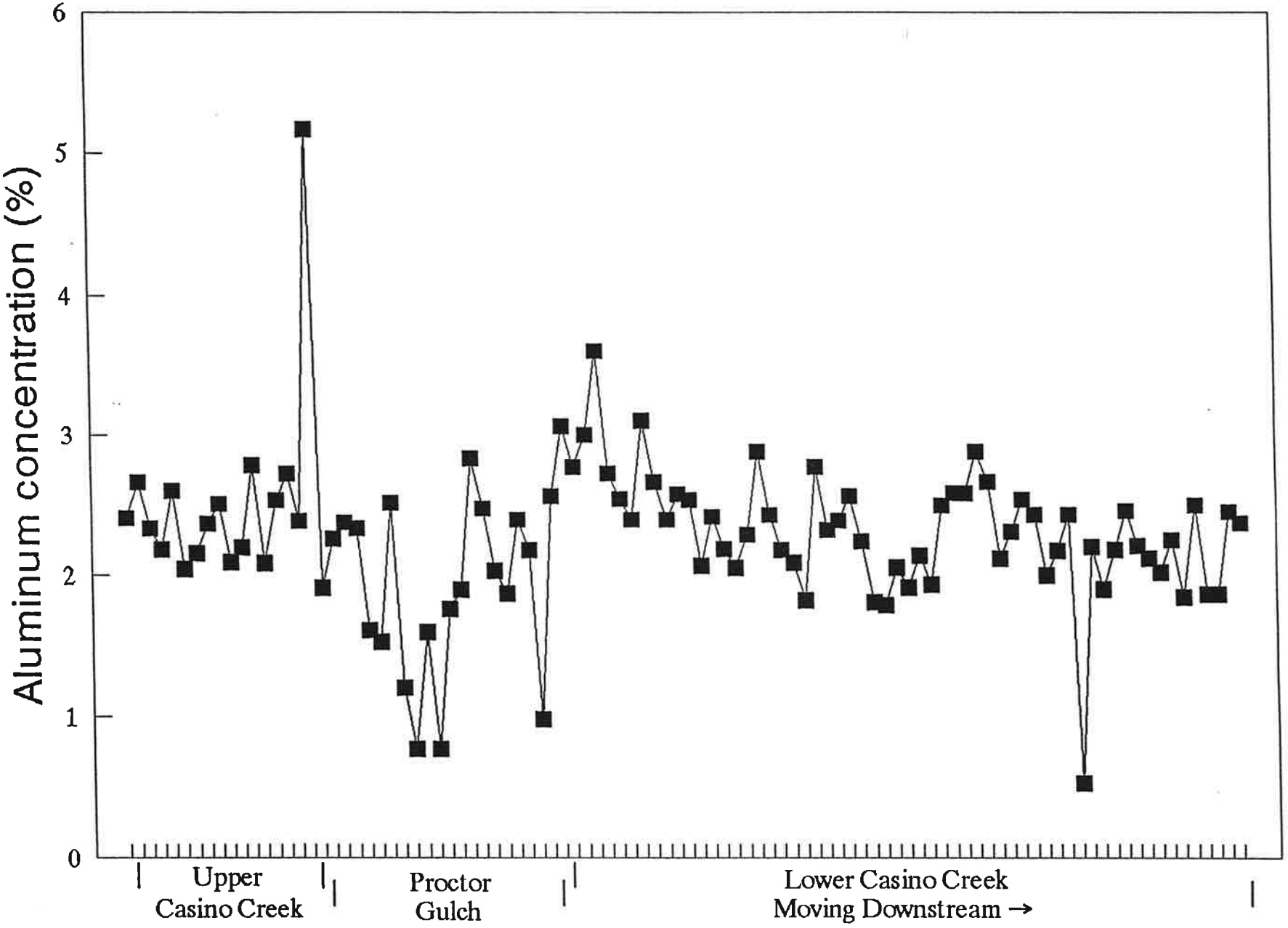
Soil Sample Results
Phosphorous



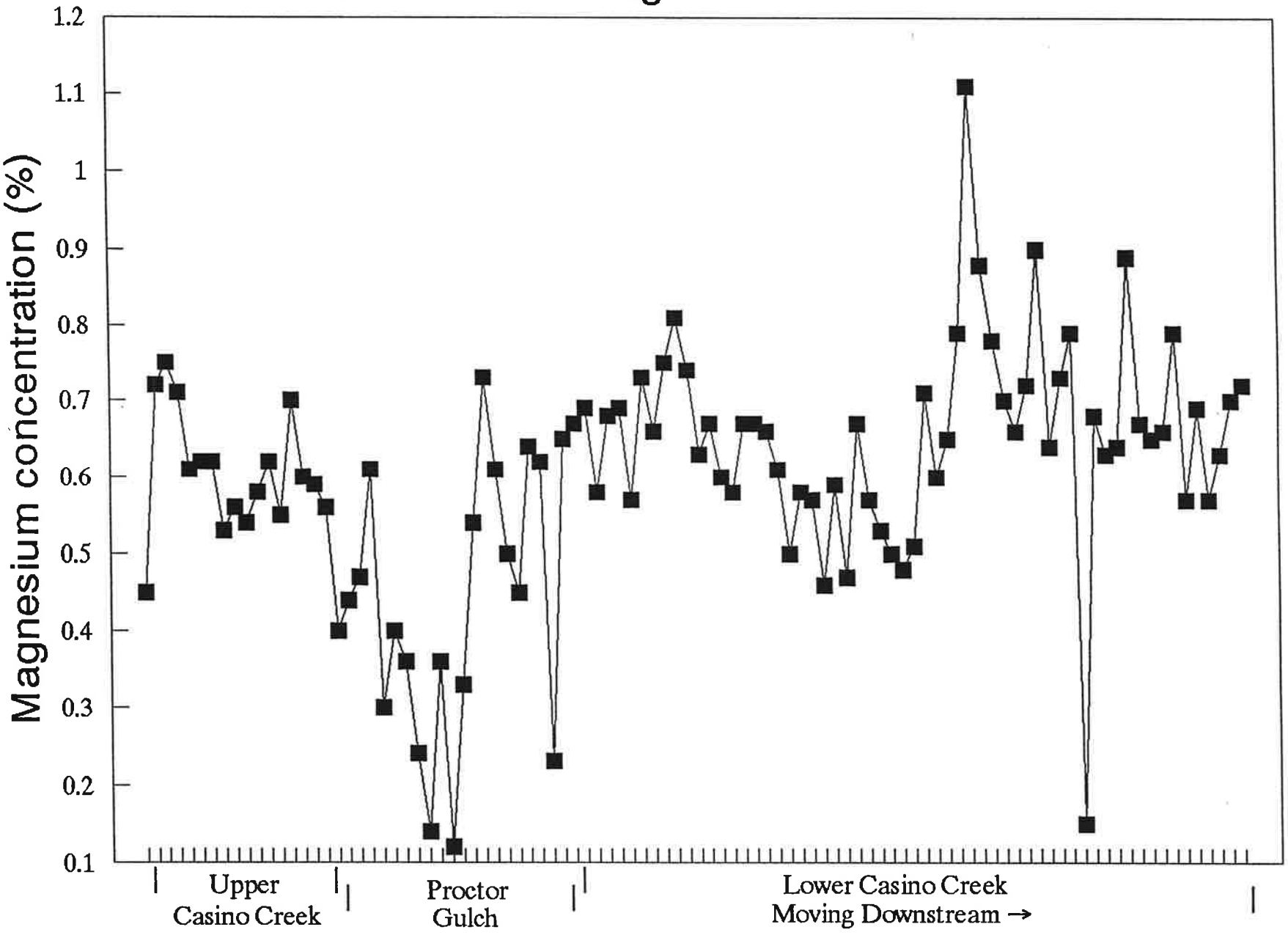
Soil Sample Results
Potassium



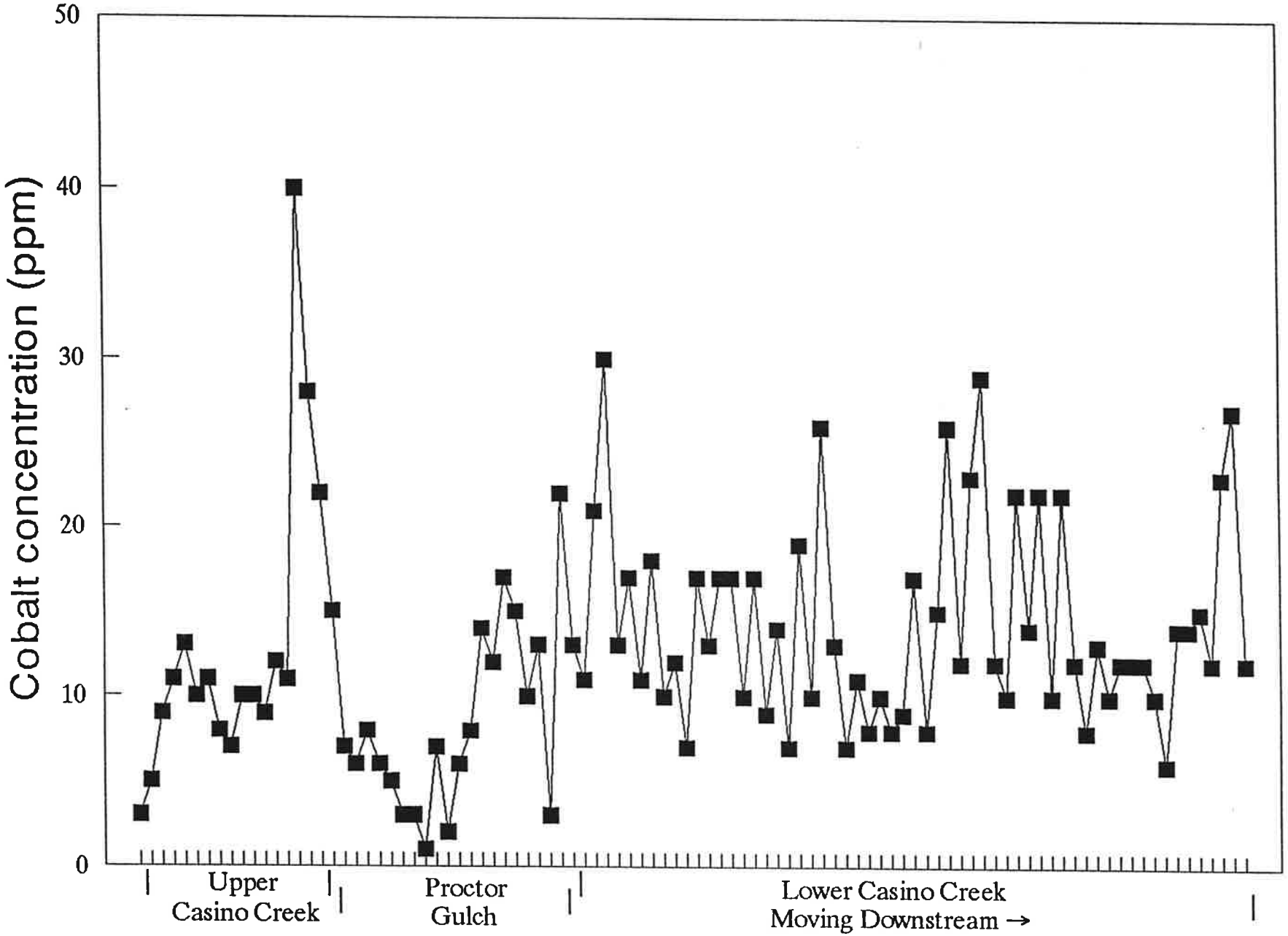
Soil Sample Results
Aluminum



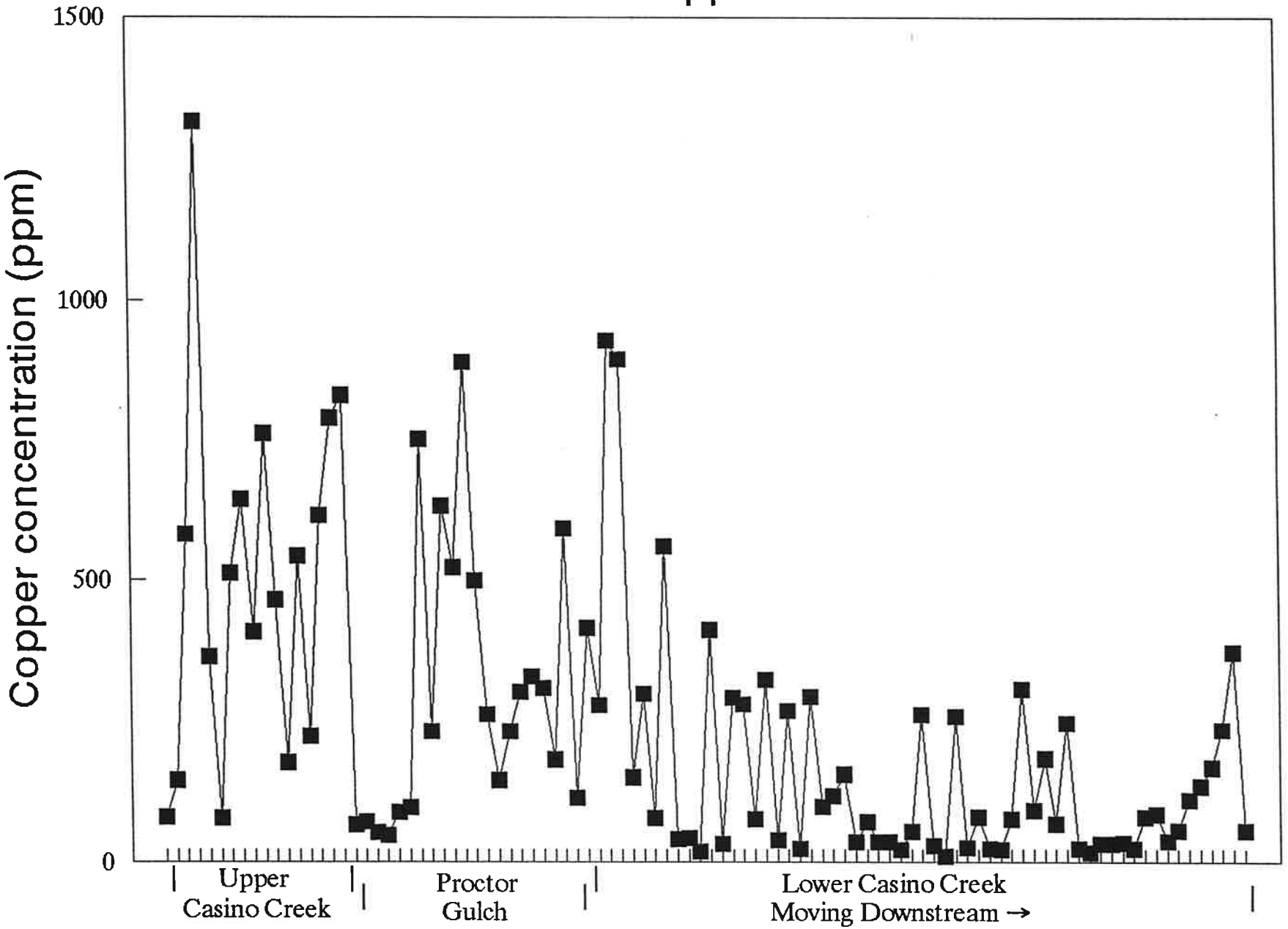
Soil Sample Results
Magnesium



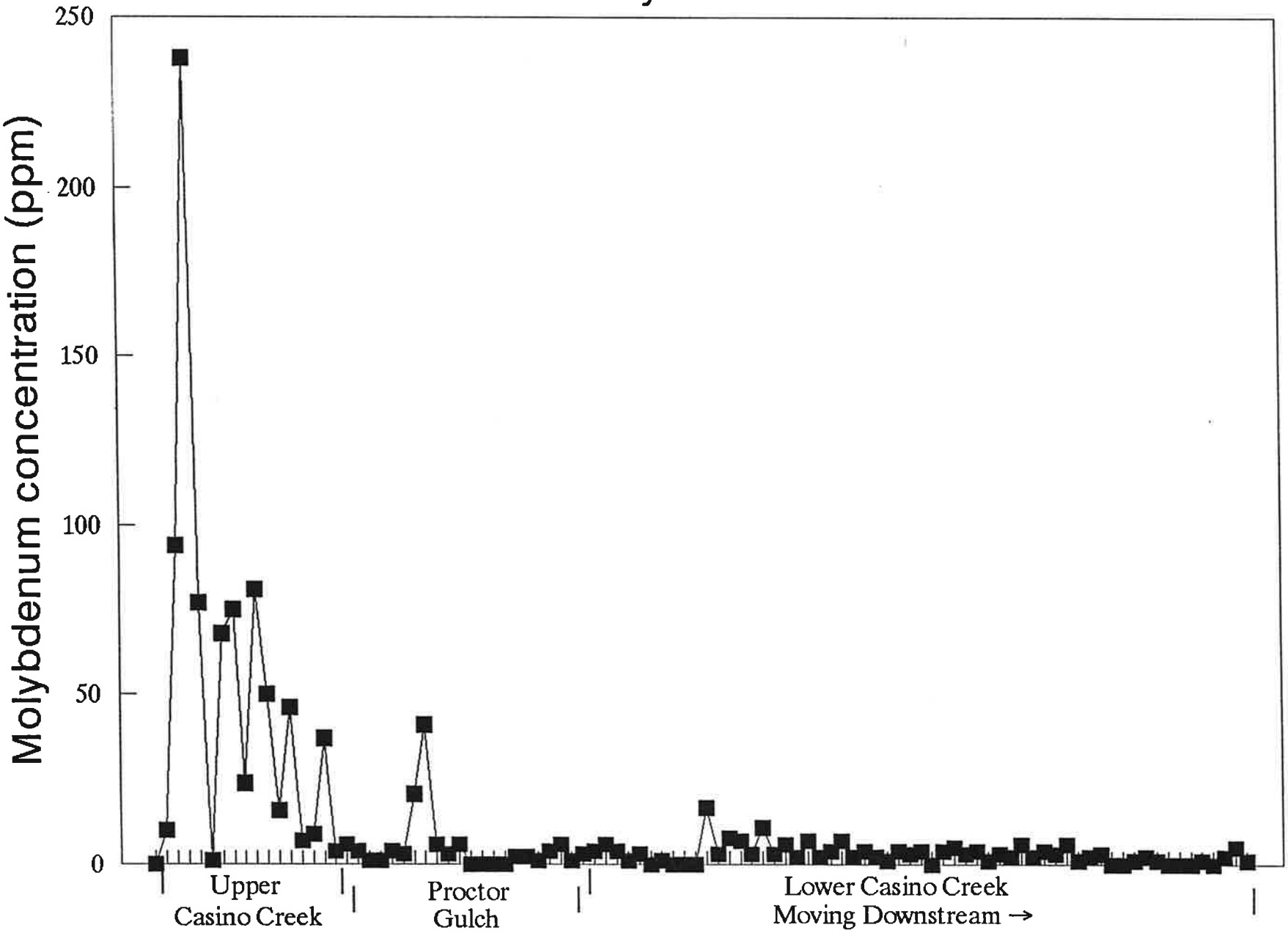
Soil Sample Results
Cobalt



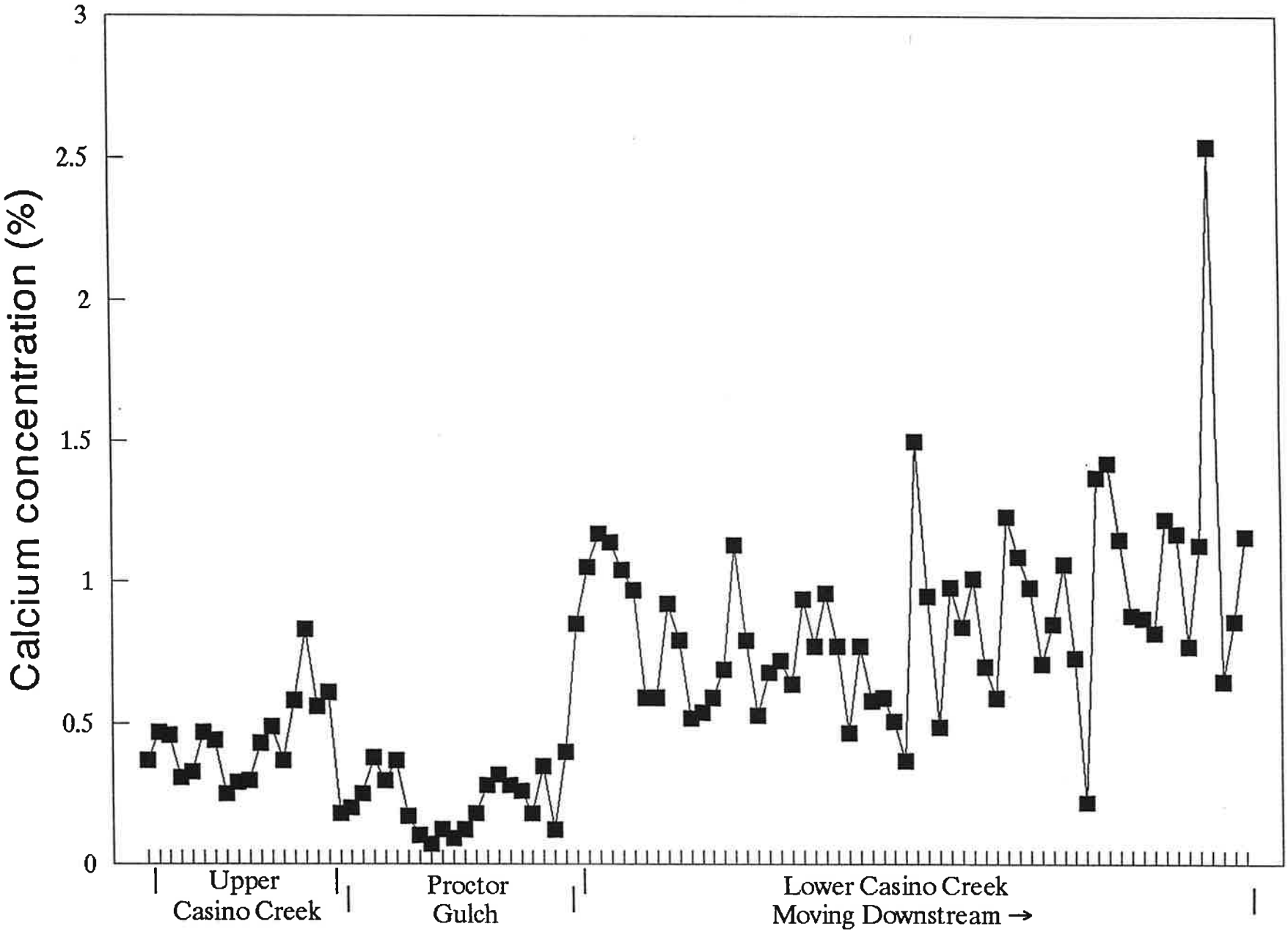
Soil Sample Results
Copper



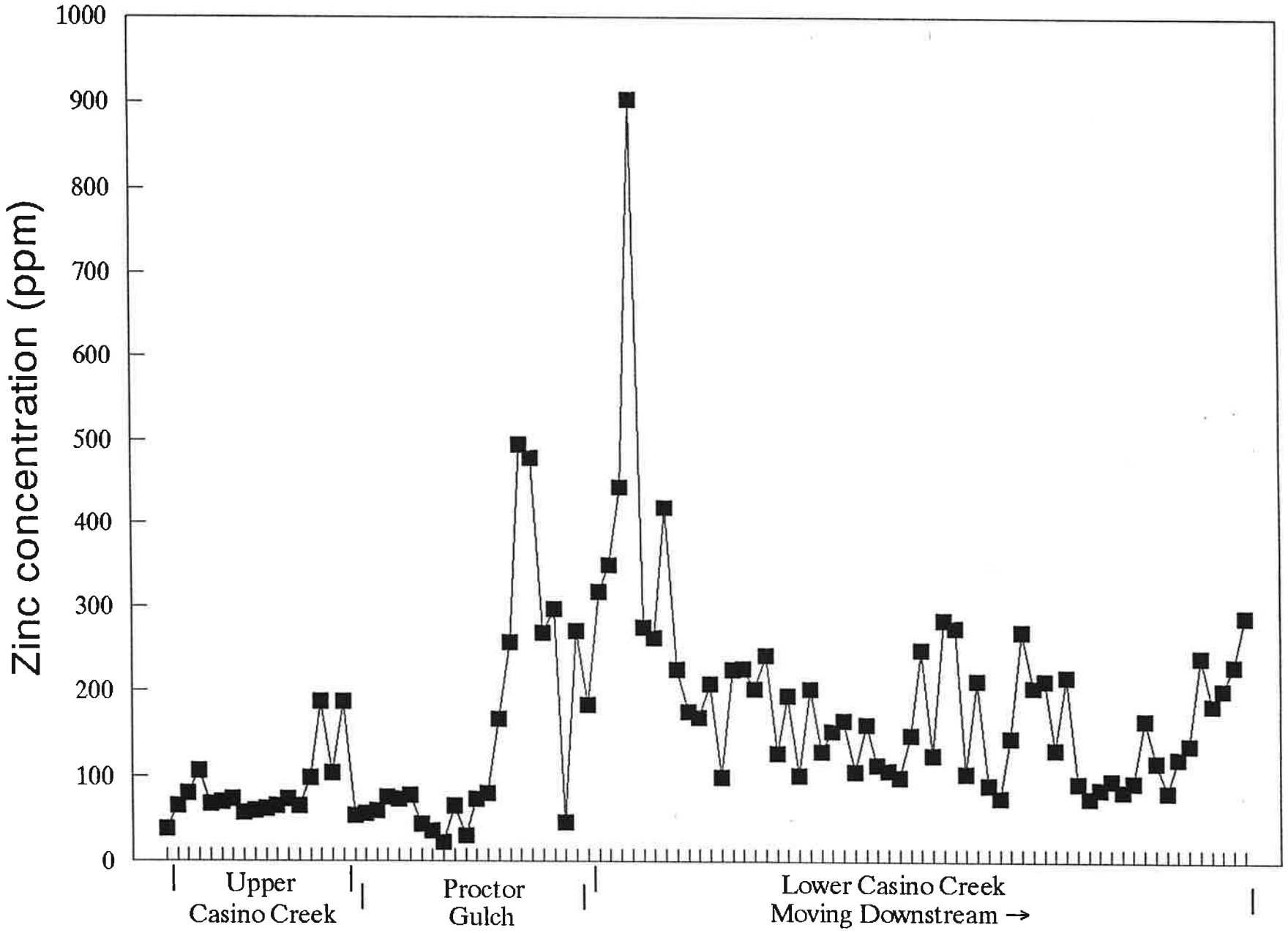
Soil Sample Results
Molybdenum



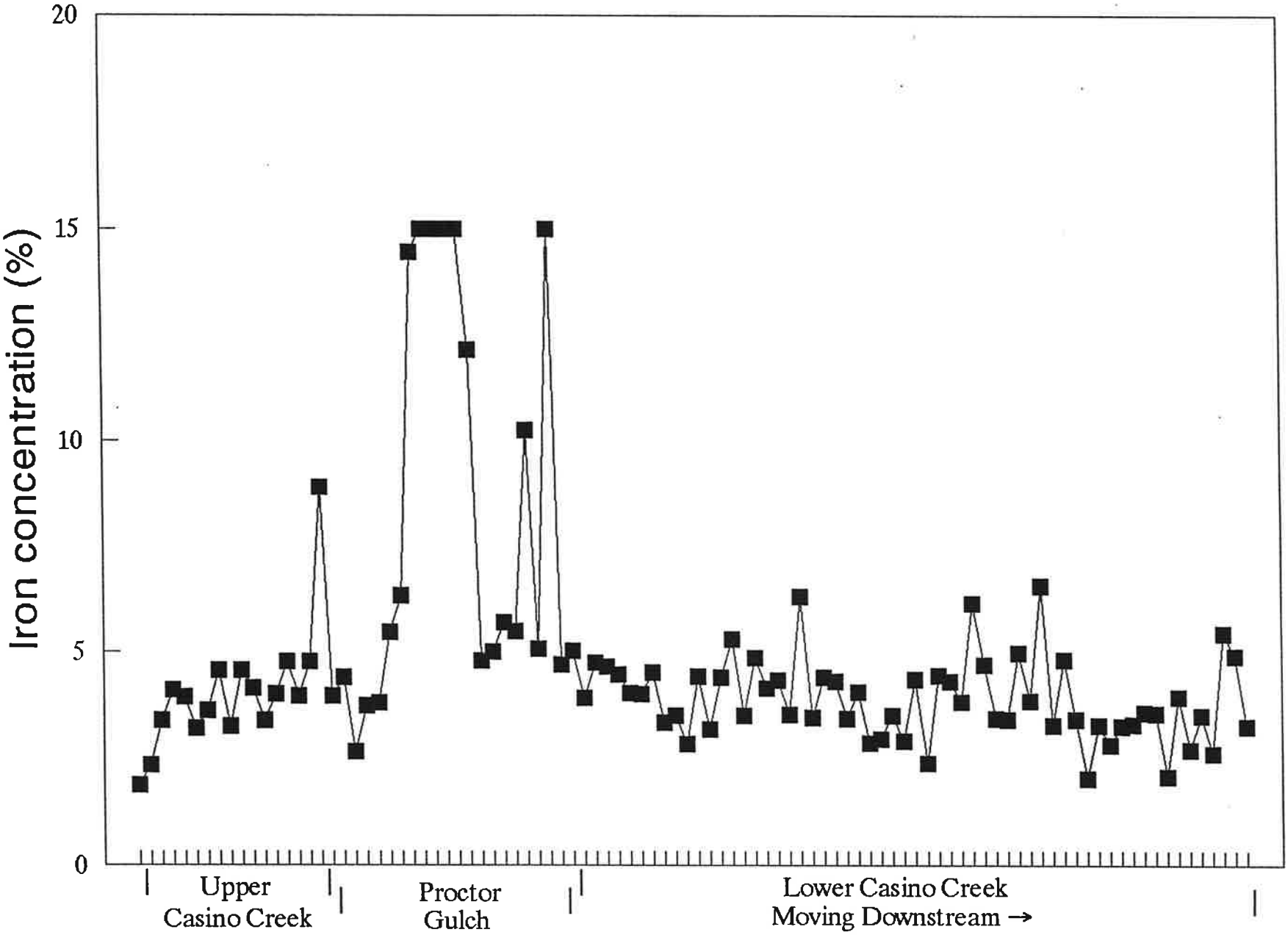
Soil Sample Results
Calcium



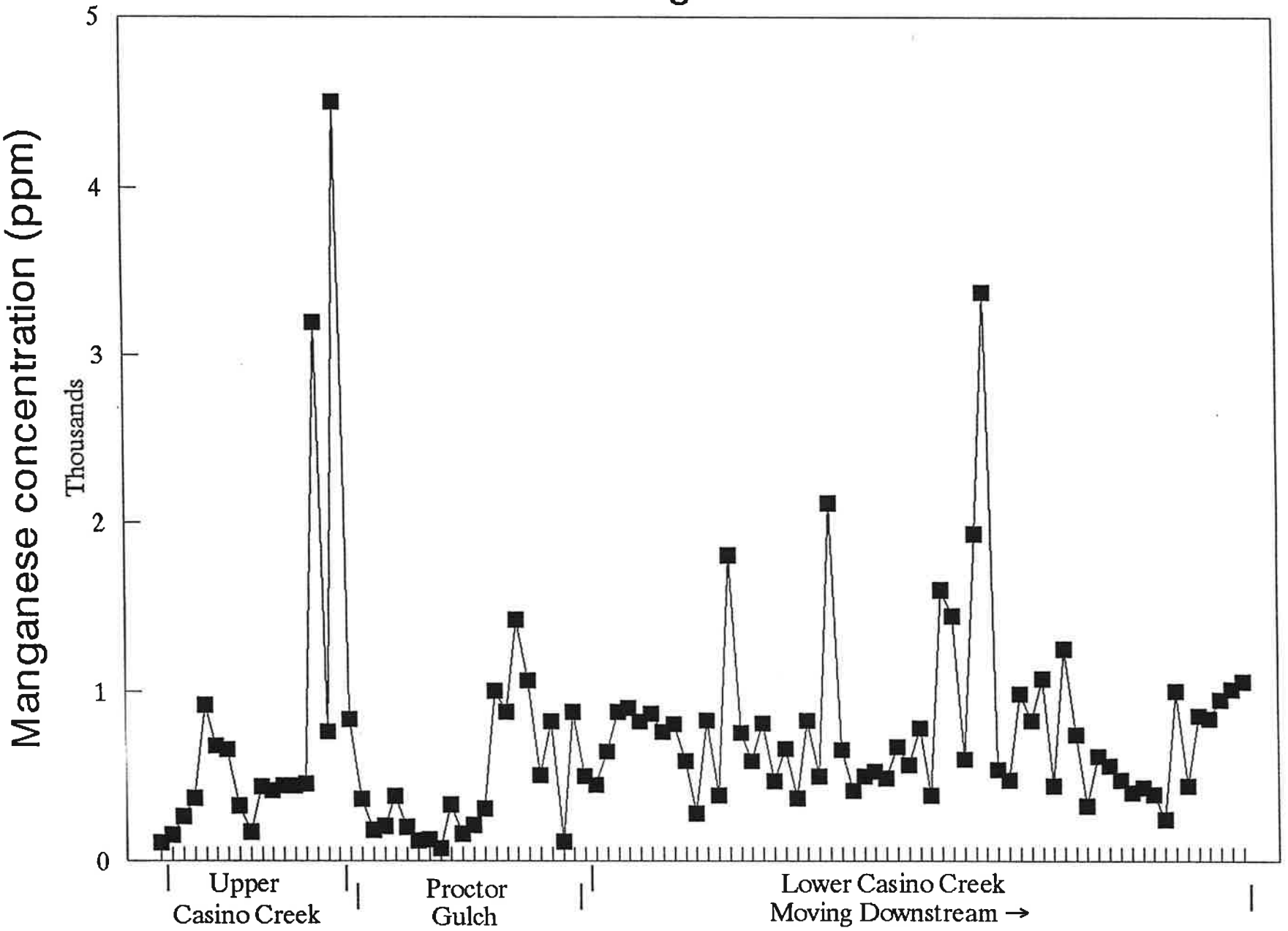
Soil Sample Results
Zinc



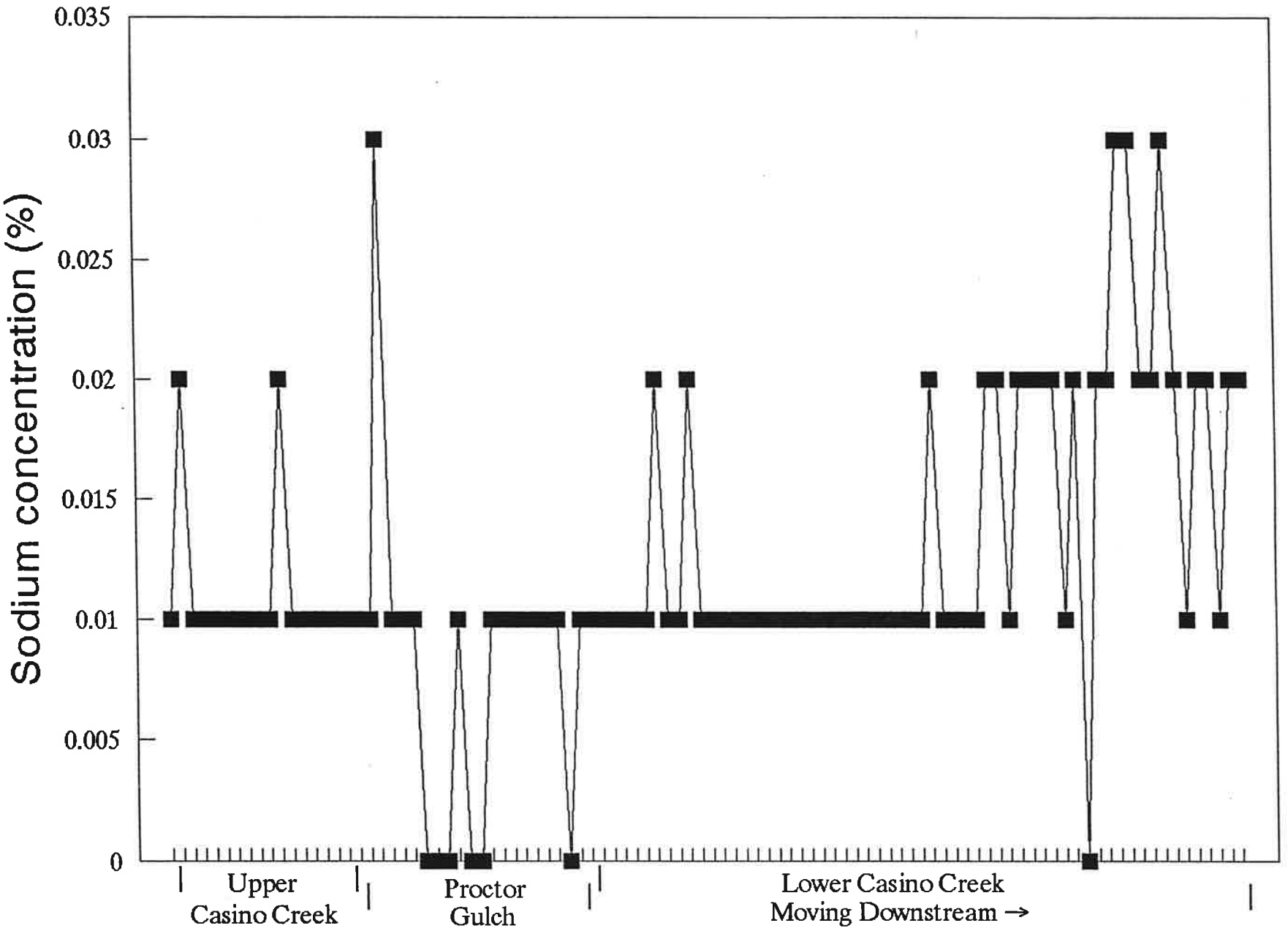
Soil Sample Results
Iron



Soil Sample Results
Manganese

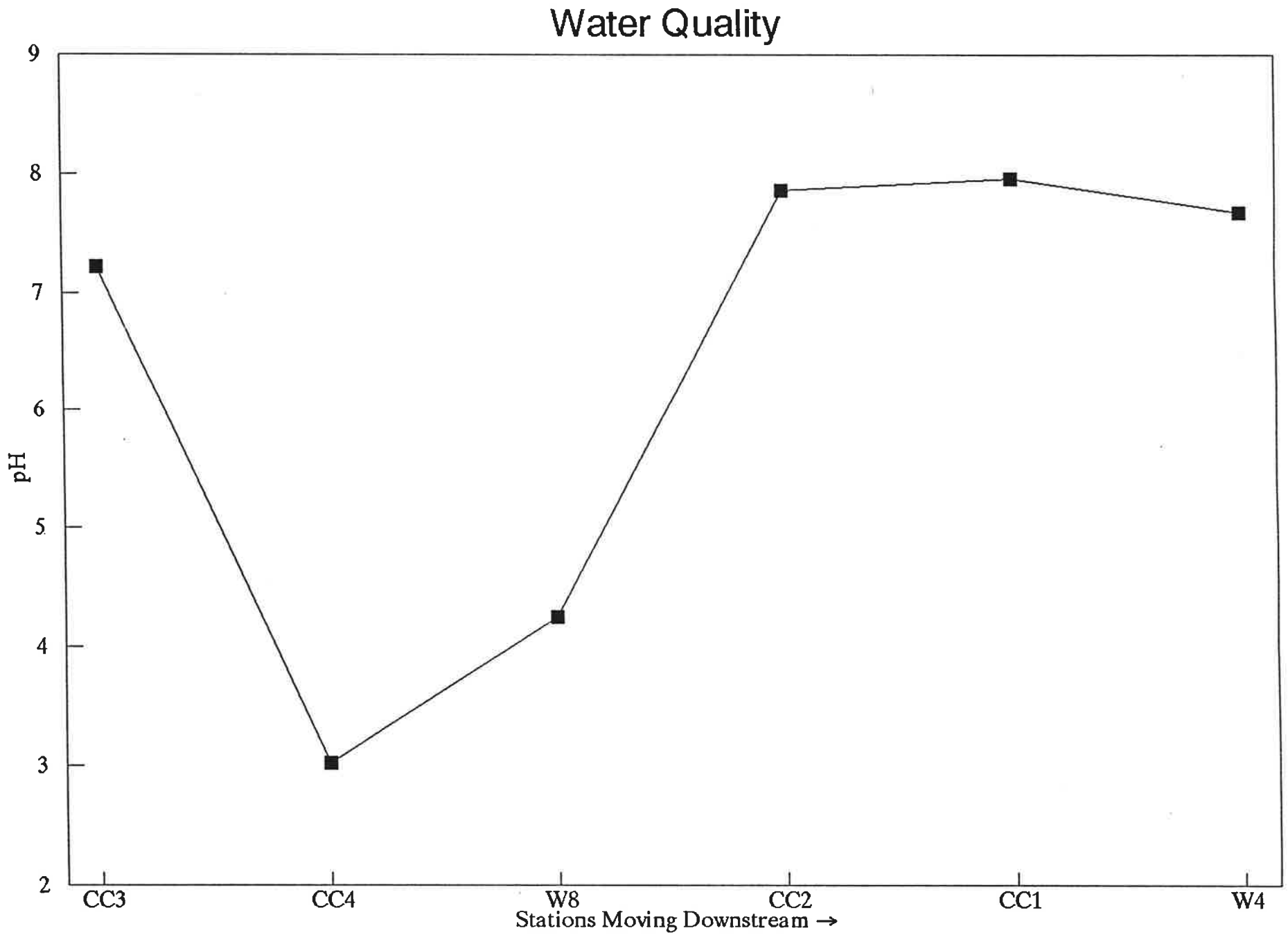


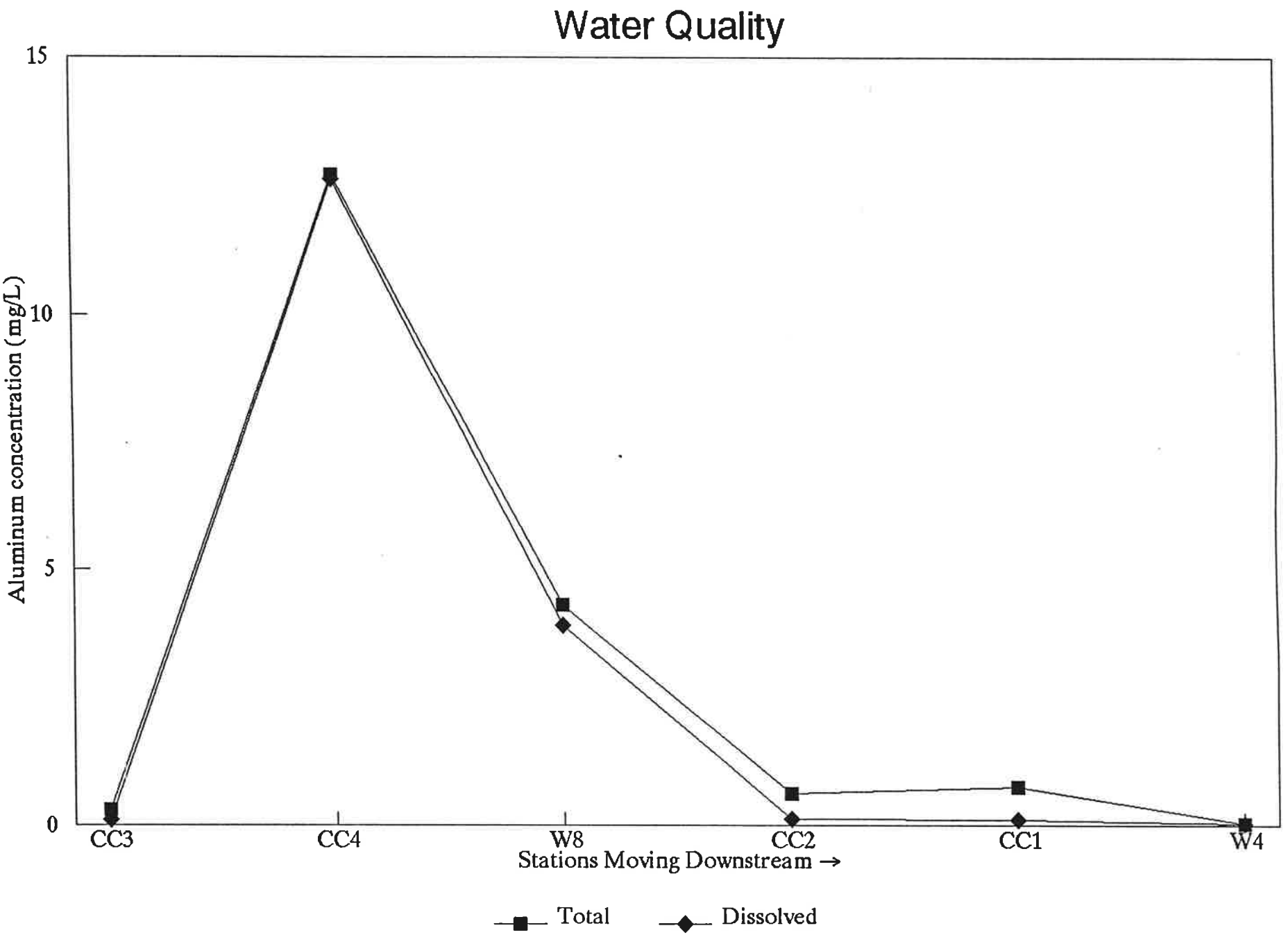
Soil Sample Results
Sodium

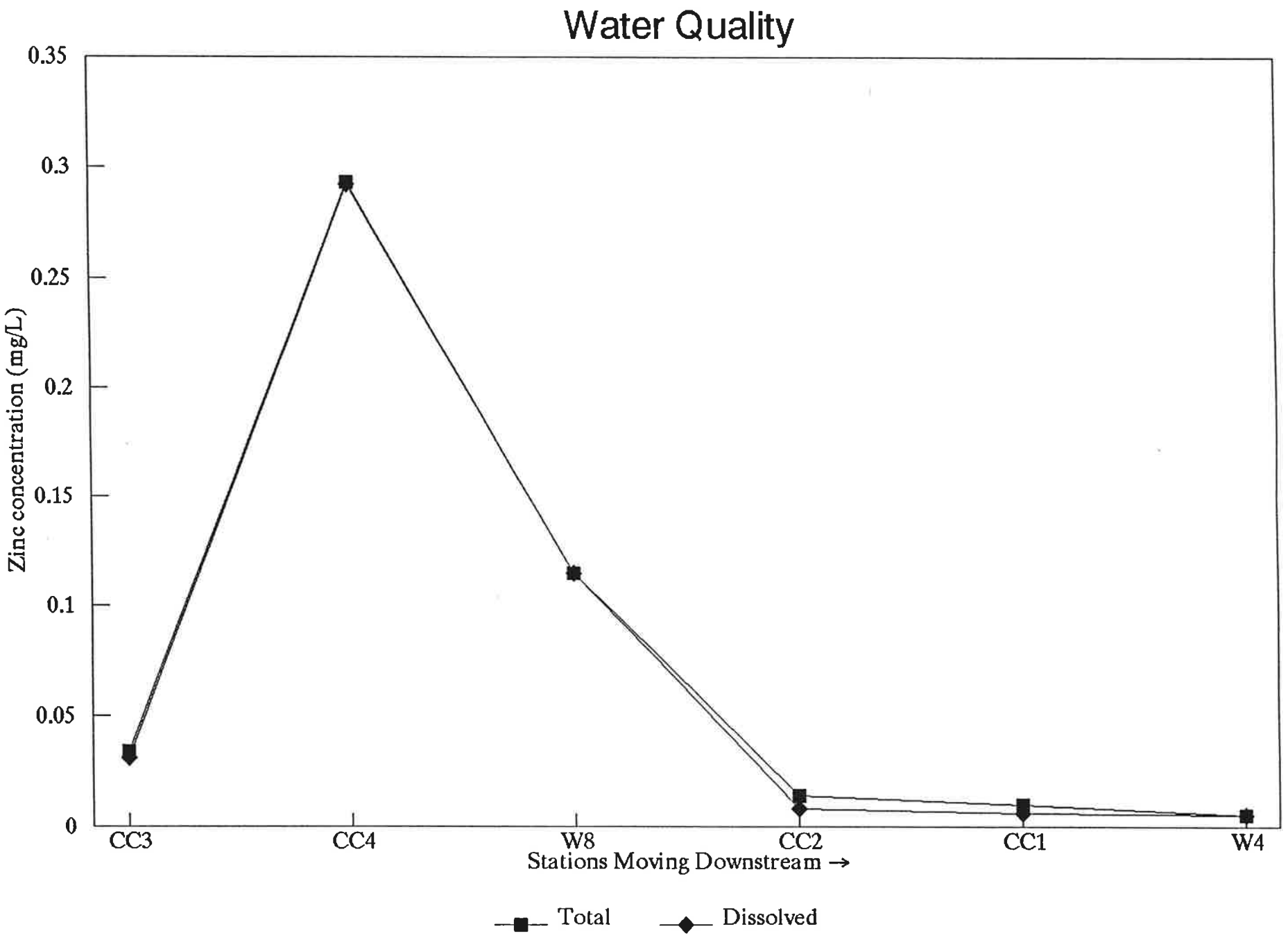


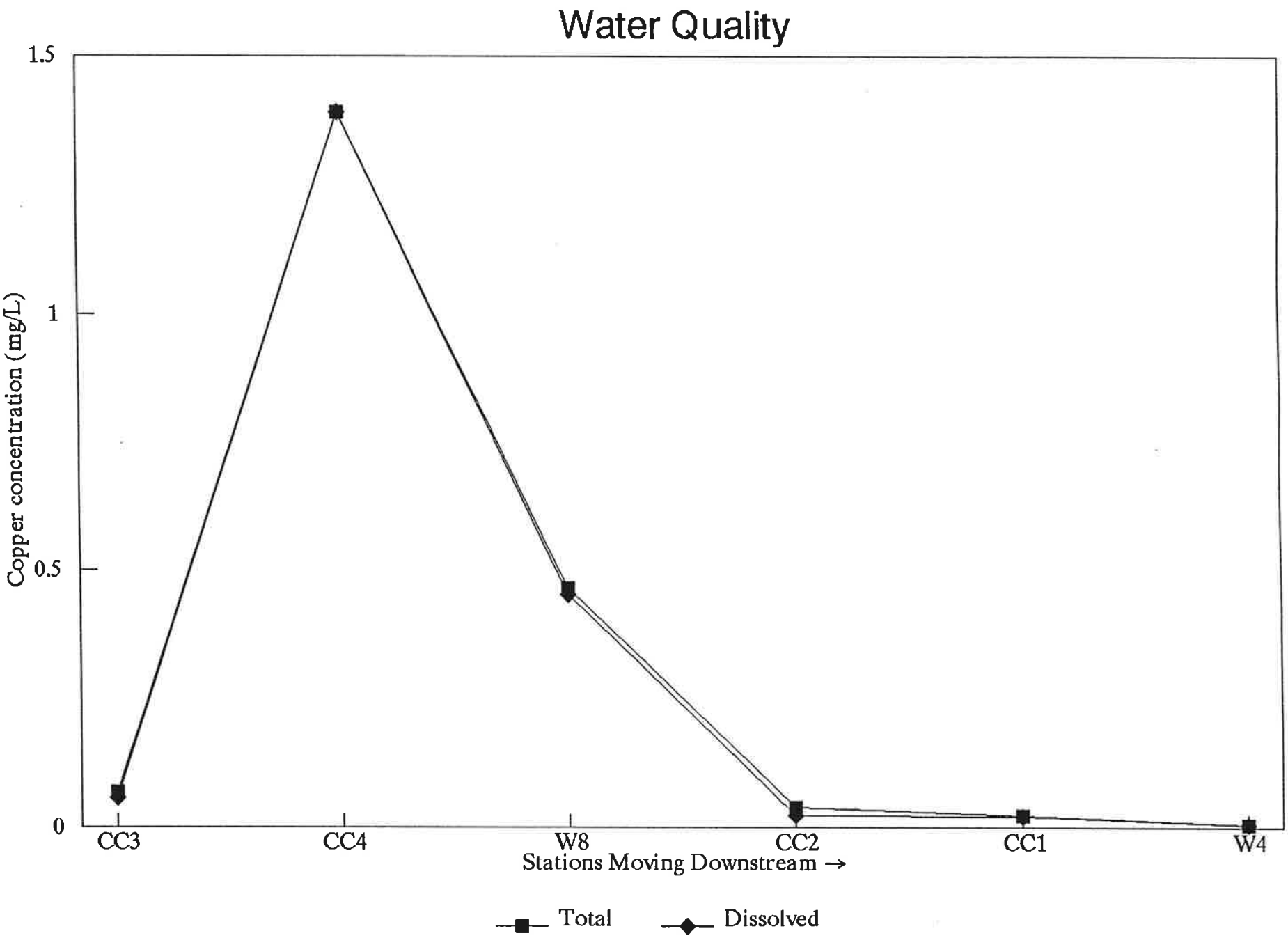
APPENDIX B

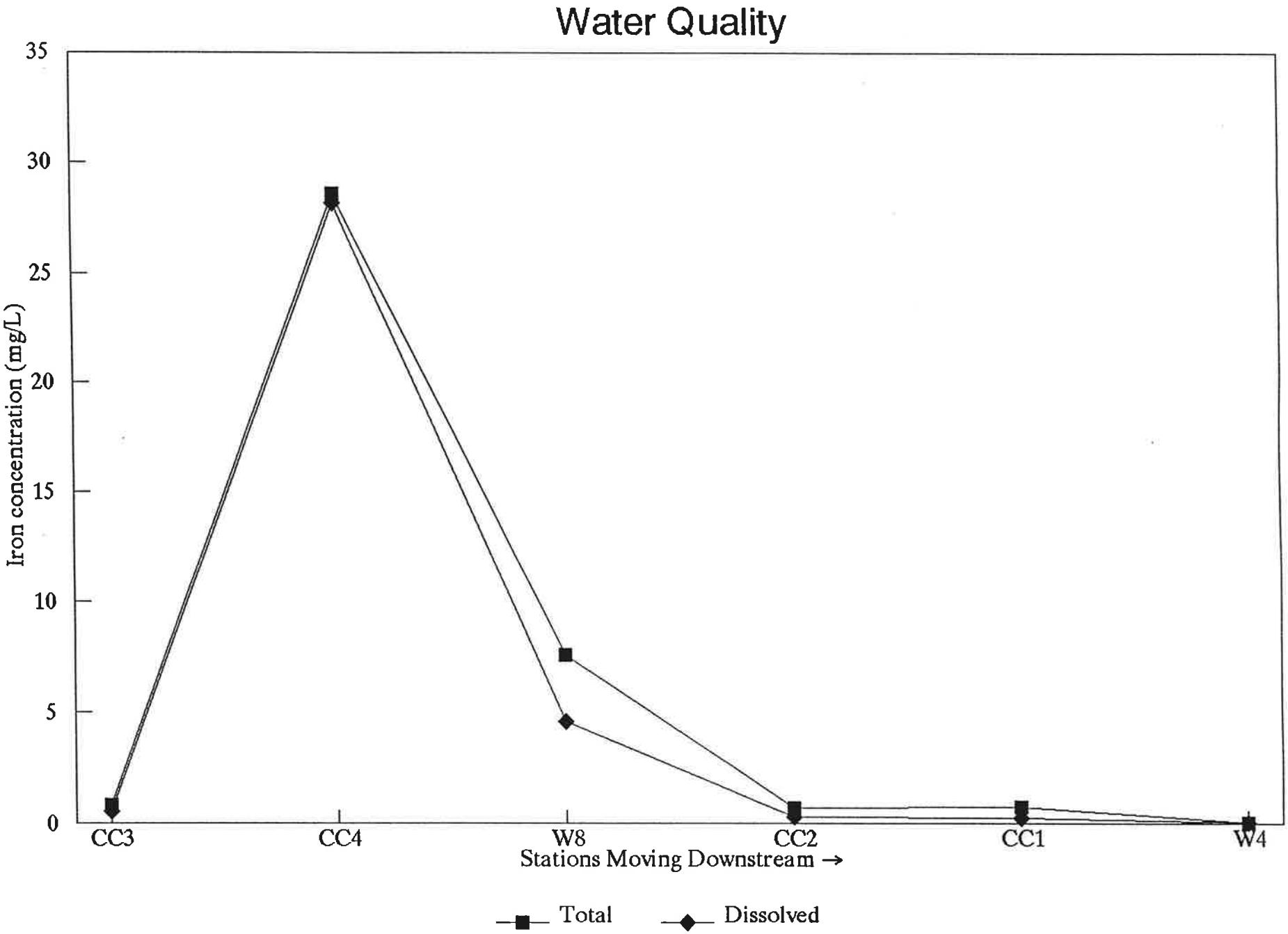
WATER QUALITY


Water Quality
9
8
7
6
5
4
3
2
pH
CC3
CC4
W8
CC2
CC1
W4
Stations Moving Downstream →

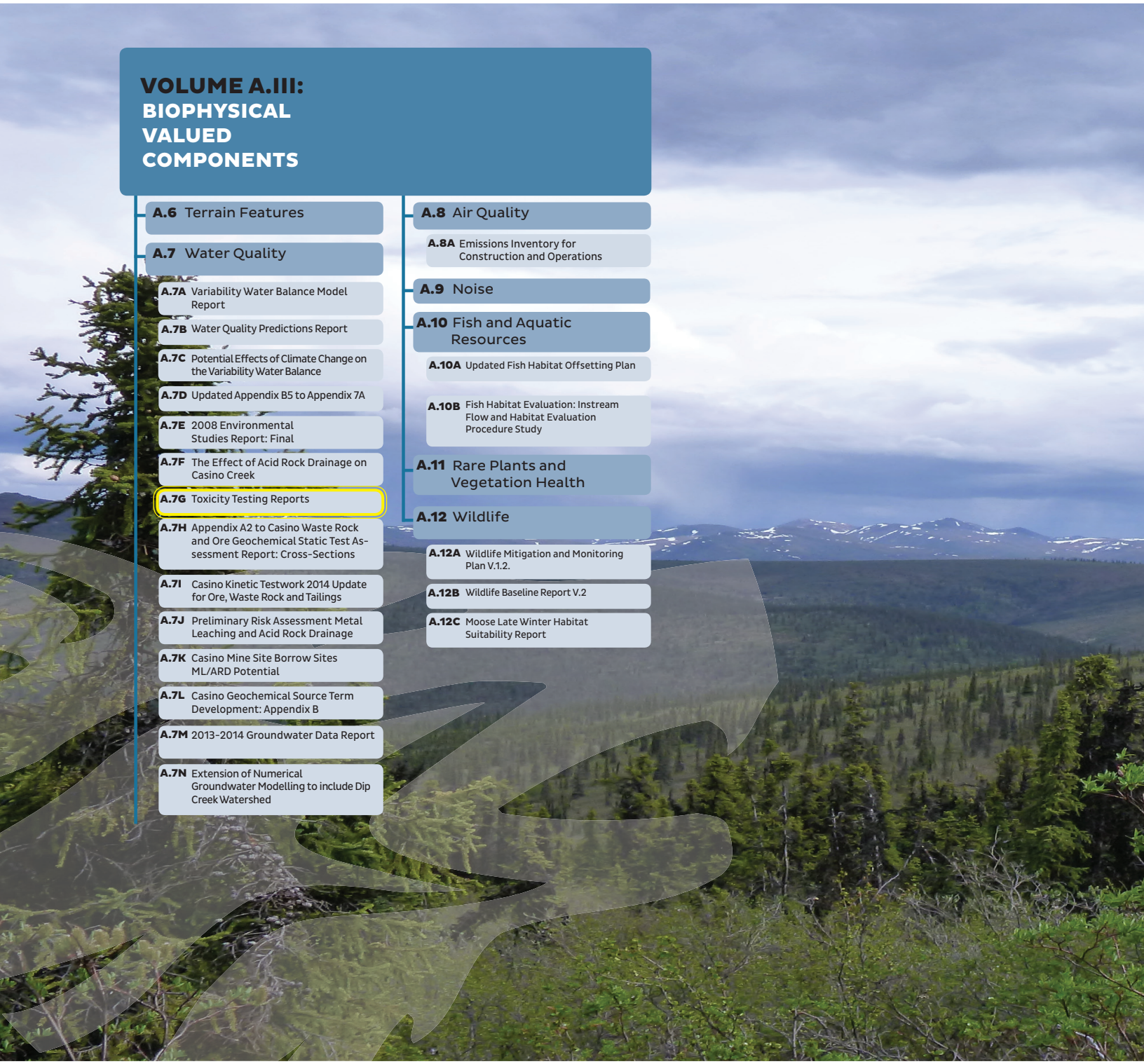

Water Quality
15
10
5
0
Aluminum concentration (mg/L)
CC3
CC4
W8
CC2
CC1
W4
Stations Moving Downstream →
Total
Dissolved


Water Quality
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Zinc concentration (mg/L)
CC3
CC4
W8
CC2
CC1
W4
Stations Moving Downstream →
Total
Dissolved


Water Quality
1.5
1
0.5
0
Copper concentration (mg/L)
CC3
CC4
W8
CC2
CC1
W4
Stations Moving Downstream →
Total
Dissolved


Water Quality
35
30
25
20
15
10
5
0
Iron concentration (mg/L)
CC3
CC4
W8
CC2
CC1
W4
Stations Moving Downstream →
Total
Dissolved

APPENDIX A.7G: Toxicity Testing Reports



Nautilus Environmental

Freshwater sediment toxicity testing on sample identified as W18

Sample collected July 30, 2014

Final Report

Report date:
December 3, 2014

Submitted to:

Palmer Environmental Consulting Group
Vancouver, BC

8664 Commerce Court
Burnaby, BC
V5A 4N7

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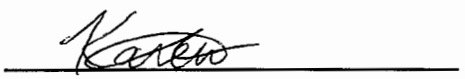
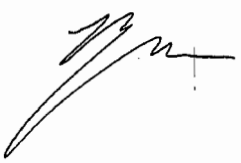


Karen Lee, B.Sc.
Testing Manager



James Elphick, R.P.Bio.
Senior Reviewer

This report has been prepared by Nautilus Environmental Company Inc. based on data and/or samples provided by our client and the results of this study are for their sole benefit. Any reliance on the data by a third party is at the sole and exclusive risk of that party. The results presented here relate only to the samples tested.

1.0 INTRODUCTION

Nautilus Environmental conducted freshwater sediment toxicity tests for Palmer Environmental Consulting Group on a sample identified as W18. The sample was collected on July 28, 2014 and delivered to the laboratory in Burnaby, BC on July 30, 2014. The sample was transported in two 4-L plastic pails and was received at a temperature of 7.5°C. The sample was stored in the dark at 4 ± 2°C prior to testing.

A 28-d *Hyalella azteca* and a 10-d *Chironomus dilutus* survival and growth test was conducted on the sample. This report describes the results of these toxicity tests. Copies of laboratory data sheets and printouts of statistical analyses for the tests are provided in Appendices A and B. The chain-of-custody form is provided in Appendix C.

2.0 METHODS

Methods for the toxicity tests are summarized in Tables 1 and 2. Testing of the survival and growth of *H. azteca* followed procedures described in USEPA (2000) including modifications that have recently been proposed by the *Hyalella azteca* Advisory Group, which is coordinated by Chris Ingersoll of USGS. Testing of survival and growth of *C. dilutus* was performed according to procedures described by Environment Canada (1997).

Statistical analyses were performed using CETIS (Tidepool Scientific Software, 2013). Ammonia levels were monitored at the start and end of the test. The ammonia concentrations in the overlying water of the samples and control were measured by ALS Environmental, Burnaby and are provided in Appendices A and B.

Table 1. Summary of test conditions: *Hyalella azteca* survival and growth test.

Test organism	*Hyalella azteca*
Test organism source	Aquatic BioSystems, Fort Collins, CO
Test organism age	7 – 8 days old
Test type	Static-renewal
Test duration	28 days
Test vessel	375 mL glass container
Test volume	100 mL sediment; 175 mL overlying water
Test replicates	5 laboratory replicates per sample
Number of organisms	10 per replicate
Control water	Moderately-hard synthetic water prepared by addition of salts to dechlorinated municipal water. Containing ~28 mg/L Cl and supplemented with 0.02 mg/L Br.
Test solution renewal	Overlying water replaced twice per day
Test temperature	23 ± 1°C
Feeding	1 mL of YCT daily to each container. Tetramin daily, with amounts increasing weekly: Week 1: 0.5 mg, Week 2: 0.75 mg, Week 3: 1 mg, Week 4: 1.5 mg in each test container.
Light intensity	500 to 1000 lux at water surface
Photoperiod	16 hours light/8 hours dark
Aeration	Gentle aeration throughout test
Test protocol	Modified from USEPA (2000)
Statistical software	CETIS (2013)
Test endpoint	Survival and dry weight
Test acceptability criteria for controls	Mean control survival of ≥80% survival
Reference toxicant	Sodium chloride

Table 2. Summary of test conditions: *Chironomus dilutus* survival and growth test.

Test organism	*Chironomus dilutus*
Test organism source	Aquatic BioSystems, Fort Collins, CO
Test organism age	3rd Instar
Test type	Static
Test duration	10 days
Test vessel	375-mL glass containers
Test volume	100 mL sediment; 175 mL overlying water
Test replicates	5 laboratory replicates per treatment
No. of organisms	10 per replicate
Control water	Moderately-hard synthetic water prepared by addition of salts to dechlorinated municipal water
Test solution renewal	None
Test temperature	23 ± 1°C
Feeding	6.0 mg Tetramin in 1.5 mL suspension per replicate daily
Light intensity	500 – 1000 lux at water surface
Photoperiod	16 hours light/8 hours dark
Aeration	Gentle aeration thoughout test
Test protocol	Environment Canada (1997), EPS 1/RM/32
Statistical software	CETIS (2013)
Test endpoint	Survival and dry weight
Test acceptability criteria for controls	Mean control survival ≥70% survival and ≥0.6 mg/worm dry weight
Reference toxicant	Potassium chloride

3.0 RESULTS

There were no effects on survival or dry weight of either *H. azteca* or *C. dilutus* (Tables 3 and 4). Measured ammonia concentrations in the overlying water are summarized in Tables 5 and 6.

Table 3. Results: *Hyalella azteca* survival and growth test.

Sample ID	Mean ± SD	
	Survival (%)	Dry Weight (mg)
Control Sediment	94.0 ± 5.5	0.43 ± 0.11
W18	92.0 ± 8.4	0.37 ± 0.19

SD = Standard Deviation.

Table 4. Results: *Chironomus dilutus* survival and growth test.

Sample ID	Mean ± SD	
	Survival (%)	Dry Weight (mg)
Control Sediment	92.0 ± 13.0	2.04 ± 0.26
W18	88.0 ± 11.0	2.04 ± 0.16

SD = Standard Deviation.

Table 5. Ammonia concentrations in the 28-d *H. azteca* sediment toxicity test.

Sample ID	Ammonia (mg/L N)	
	Day 0	Day 28
Control Sediment	<0.005	0.202
W18	<0.005	0.0557

Table 6. Ammonia concentrations in the 10-d *C. dilutus* sediment toxicity test.

Sample ID	Total Ammonia (mg/L N)	
	Day 0	Day 10
Control Sediment	0.0150	3.00
W18	<0.005	1.30

4.0 QA/QC

The health histories of the test organisms used in the exposures were acceptable and met the requirements of the test protocols. The tests met control acceptability criteria and water quality parameters remained within ranges specified in the protocols throughout the tests. Uncertainty associated with these tests is best described by the standard deviation around the mean.

Results of the reference toxicant tests conducted during the testing program are summarized in Table 7. The results of the tests fell within the acceptable range for organism performance of mean and two standard deviation based on previous results obtained by the laboratory with these tests. Thus, the sensitivity of the organisms used in the tests was considered to be appropriate.

Table 7. Reference toxicant results.

Test Species	Endpoint	Historical Mean (2 SD Range)	CV (%)	Test Date
H. azteca	Survival (LC50): 5.3 g/L NaCl	4.4 (3.0 – 6.7)	22	September 5, 2014
C. dilutus	Survival (LC50): 4.0 g/L KCl	6.0 (3.9 – 9.2)	24	August 15, 2014

SD = Standard Deviation, LC = Lethal Concentration, CV = Coefficient of Variation.

5.0 REFERENCES

Environment Canada. 1997. Biological test method: test for survival and growth in sediment using the larvae of freshwater midges *(Chironomus tentans* and *Chrironomus riparius)*. EPS 1/RM/32. December 1997. Method Development and Application Section, Environmental Technology Centre, Ottawa, ON.

Tidepool Scientific Software. 2013. CETIS comprehensive environmental toxicity information system, version 1.8.7.16 Tidepool Scientific Software, McKinleyville, CA. 222 pp.

USEPA. 2000. Methods for measuring the toxicity and bioaccumulation of sediment-associated contaminants with freshwater invertebrates. EPA 600/R-99/064. March 2000.

APPENDIX A – *Hyalella azteca* Toxicity Test Data

Hyalella azteca Sediment Test Summary Sheet

Client: PECG
Work Order No.: 14488

Start Date: 05-Sep-14
Set up by: KJL

Sample Information:

Sample ID: W18
Sample Date: 28-Jul-14
Date Received: 30-Jul-14
Sample Volume: 2x 4L

Test Organism Information:

Species: *Hyalella azteca*
Supplier: Aquatic Biosystems, CO
Date received: 03-Sep-14
Age or size (Day 0): 7-8 days

NaCl Reference Toxicant Results:

Reference Toxicant ID: HA70
Stock Solution ID: n/a
Date Initiated: 05-Sep-14

96-h LC50 (95% CL): 5.3 (4.6 - 6.0)

96-h LC50 Reference Toxicant Mean and Range: 4.4 (3.0 - 6.7) CV (%): 22

Test Results:

Sample ID	Survival ± SD (%)	Average Dry Wt. ± SD (mg)
Control Sediment	94.0 ± 5.5	0.43 ± 0.11
W18	92.0 ± 8.4	0.37 ± 0.19
	±	±
	±	±
	±	±
	±	±
	±	±
	±	±

Reviewed by: JOL

Date reviewed: Nov. 5/14

Chronic *H. azteca* Sediment Toxicity Test Data Sheet

Freshwater Sediment Water Quality

Client: PECG
Work Order No.: 14488

Start Date: 05-Sep-14
Termination Date: 03-Oct-14
Test Organism: *Hyalella azteca*

Temperature (°C)

Sample ID	Day														
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Control Sediment	22.5	22.0	22.0	22.5	22.0	22.5	22.5	22.0	22.0	22.0	22.5	22.0	22.0	22.5	22.0
W18	22.5	22.0	22.0	22.5	22.0	22.5	22.5	22.0	22.0	22.0	22.5	22.0	22.0	22.5	22.0
Technician Initials	KJL	"	"	KJL IEC	KJL SSD	SSD LD	KJL LD	KJL LD	JBF	KJL	KJL SSD	KJL EC	LD	LD	LD

Sample ID	Day														
	15	16	17	18	19	20	21	22	23	24	25	26	27	28	
Control Sediment	22.5	22.5	22.0	22.0	22.0	22.0	22.5	22.0	22.0	23.0	22.5	23.0	23.0	23.0	
W18	22.5	22.5	22.0	22.0	22.0	22.0	22.5	22.0	22.0	23.0	22.5	23.0	23.0	23.0	
Technician Initials	KJL KJL	"	LD	LD	LD	LD/SSD	LD/EC	JBF	KJL	LD/EC	LD	LD	LD	LD	

Conductivity (µS)

Sample ID	Day														
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Control Sediment	398	424	425	423	417	418	442	419	422	428	427	423	417	411	414
W18	385	392	401	411	413	419	422	420	422	429	422	421	413	406	407
Technician Initials	KJL	"	"	KJL IEC	KJL SSD	SSD LD	KJL LD	KJL LD	JBF	KJL	KJL	KJL EC	LD	LD	LD

Sample ID	Day														
	15	16	17	18	19	20	21	22	23	24	25	26	27	28	
Control Sediment	410	411	414	408	408	409	409	413	414	415	411	406	405	410	
W18	407	406	408	407	407	403	408	410	407	415	411	408	406	411	
Technician Initials	KJL KJL	"	LD	LD	LD	LD/SSD	LD/EC	JBF	KJL	LD/EC	LD	LD	LD	LD	

Comments:

Reviewed by: JBF

Date Reviewed: Oct. 22/14

H. azteca Sediment Toxicity Test Data Sheet

Freshwater Sediment 14-d Survival and Weight

Client: PECG

Work Order No: 14488

Sample ID: W18

Start Date: ~~15-Aug-14~~ Sept 5/14

Termination Date: ~~29-Aug-14~~ ~~Sept 12, 2014~~ oct 3/14

Test Organism: *Hyalella azteca*

Sample ID	PECG Pan No. purple	Rep	No. alive	No. dead	No. missing	Initials	Pan weight (mg)	Pan + organism (mg)	No. weighed	Initials
Sediment Control	1	A	10	0	0	KJL	1044.81	1049.60	10	KJL
	2	B	9	0	1	↓	1029.07	1031.19	9	↓
	3	C	9	0	1	↓	1028.~~69~~76	1032.62	9	↓
	4	D	9	0	1	↓	1049.73	1054.44	9	↓
	5	E	10	0	0	↓	1048.21	1052.93	10	↓
W18	6	A	8	0	2①	JW	10~~29~~30.00	1031.58	8	↓
	7	B	10	0	0	JW	1044.38	1049.16	10	↓
	8	C	10	0	0	BTC	1045.24	104~~8~~9.12	10	↓
	9	D	9	0	1	JW	1051.17	1052.70	9	↓
	10	E	9	0	1	KJL	1020.92	1026.43	9	↓
		A								
		B								
		C								
		D								
		E								
		A								
		B								
		C								
		D								
		E								

Comments: ① checked by KJL

Reweighed pan: 5 - 1052.89

Reviewed by: JGL

Date Reviewed: Oct-22/14

Client: PECG

W.O.#: 14488, 14594

Hardness and Alkalinity Datasheet

		Alkalinity					Hardness			
	Sample ID	Sample Date	Sample Volume (mL)	(mL) 0.02N HCL/H_2SO_4 used to pH 4.5	(mL) of 0.02N HCL/H_2SO_4 used to pH 4.2	Total Alkalinity ($mg/LCaCO_3$)	Sample Volume (mL)	Volume of 0.01M EDTA Used (mL)	Total Hardness ($mg/L\ CaCO_3$)	Technician
Chiron	Control (Day 0)	Aug 15/14	50	2.9	3.0	56	50	5.0	100	LD
	W18 (Day 0)	↓	50	3.0	3.1	58	50	5.6	112	LD
	Control (Day 10)	Aug 25/14	50	3.0	3.1	58	50	5.2	104	SSD/LD
	W18 (Day 10)	↓	50	~~3.0~~ 3.1	3.2	60	50	5.6	112	SSD/LD
Hyal	Control (Day 0)	Sept 5/14	50	3.0	3.1	58	50	6.5	130	SSD/LD
	W18 (Day 0)	↓	50	3.2	3.3	~~64~~ 62 LD	50	6.6	132	SSD/LD
	Control (Day 28)	Oct 3/14	50	2.6	2.7	50	50	6.4	128	SSD
	W18 (Day 28)	↓	50	2.5	2.6	48	50	6.2	124	SSD

Notes:

Reviewed by: JCh

Date Reviewed: Nov. 5/14

CETIS Summary Report

Report Date:	07 Oct-14 10:54 (p 1 of 1)
Test Code:	14488 | 14-7400-5097

Hyalella 28-d Survival and Growth Sediment Test — **Nautilus Environmental**

Batch ID:	19-7004-5768	**Test Type:**	Survival-Growth	**Analyst:**	Karen Lee
Start Date:	05 Sep-14	**Protocol:**	EPA/600/R-99/064 (2000)	**Diluent:**	Mod-Hard Synthetic Water
Ending Date:	03 Oct-14	**Species:**	Hyalella azteca	**Brine:**	
Duration:	28d 0h	**Source:**	Aquatic Biosystems, CO	**Age:**	7-8d

Sample Code	Sample ID	Sample Date	Receive Date	Sample Age	Client Name	Project
Control Sedimen	03-5726-6794	05 Sep-14	05 Sep-14	NA	PECG	
W18	04-1548-9802	28 Jul-14 14:00	30 Jul-14 14:40	38d 10h (7.5 °		

Sample Code	Material Type	Sample Source	Station Location	Latitude	Longitude
Control Sedimen	Sediment Sample	PECG	Control Sediment		
W18	Sediment Sample	PECG	W18		

Test Acceptability

Analysis ID	Endpoint	Attribute	Test Stat	TAC Limits	Overlap	Decision
12-8663-0645	Survival Rate	Control Resp	0.94	0.8 - NL	Yes	Passes Acceptability Criteria

Survival Rate Summary

Sample Code	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
Control Sedimen	5	0.94	0.872	1	0.9	1	0.02449	0.05477	5.83%	0.0%
W18	5	0.92	0.8161	1	0.8	1	0.03742	0.08367	9.09%	2.13%

Survival Rate Detail

Sample Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Control Sedimen	1	0.9	0.9	0.9	1
W18	0.8	1	1	0.9	0.9

Survival Rate Binomials

Sample Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Control Sedimen	10/10	9/10	9/10	9/10	10/10
W18	8/10	10/10	10/10	9/10	9/10

CETIS Analytical Report

Hyalella 28-d Survival and Growth Sediment Test — **Nautilus Environmental**

Analysis ID:	12-8663-0645	**Endpoint:**	Survival Rate	**CETIS Version:**	CETISv1.8.7
Analyzed:	07 Oct-14 10:54	**Analysis:**	Parametric-Two Sample	**Official Results:**	Yes
Batch ID:	19-7004-5768	**Test Type:**	Survival-Growth	**Analyst:**	Karen Lee
Start Date:	05 Sep-14	**Protocol:**	EPA/600/R-99/064 (2000)	**Diluent:**	Mod-Hard Synthetic Water
Ending Date:	03 Oct-14	**Species:**	Hyalella azteca	**Brine:**	
Duration:	28d 0h	**Source:**	Aquatic Biosystems, CO	**Age:**	7-8d

Sample Code	Sample ID	Sample Date	Receive Date	Sample Age	Client Name	Project
Control Sedimen	03-5726-6794	05 Sep-14	05 Sep-14	NA	PECG	
W18	04-1548-9802	28 Jul-14 14:00	30 Jul-14 14:40	38d 10h (7.5 °		

Sample Code	Material Type	Sample Source	Station Location	Latitude	Longitude
Control Sedimen	Sediment Sample	PECG	Control Sediment		
W18	Sediment Sample	PECG	W18		

Data Transform	Zeta	Alt Hyp	Trials	Seed	PMSD	Test Result
Angular (Corrected)	NA	C > T	NA	NA	8.77%	

Equal Variance t Two-Sample Test

Sample Code	vs	Sample Code	Test Stat	Critical	MSD	DF	P-Value	P-Type	Decision(α:5%)
Control Sedimen		W18	0.4047	1.86	0.130	8	0.3482	CDF	Non-Significant Effect

Test Acceptability Criteria

Attribute	Test Stat	TAC Limits	Overlap	Decision
Control Resp	0.94	0.8 - NL	Yes	Passes Acceptability Criteria

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	0.002013477	0.002013477	1	0.1638	0.6963	Non-Significant Effect
Error	0.09835023	0.01229378	8			
Total	0.1003637		9			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Variance Ratio F	2.086	23.15	0.4940	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.8717	0.7411	0.1046	Normal Distribution

Survival Rate Summary

Sample Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
Control Sedimen	5	0.94	0.872	1	0.9	0.9	1	0.02449	5.83%	0.0%
W18	5	0.92	0.8161	1	0.9	0.8	1	0.03742	9.09%	2.13%

Angular (Corrected) Transformed Summary

Sample Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
Control Sedimen	5	1.314	1.203	1.425	1.249	1.249	1.412	0.03992	6.79%	0.0%
W18	5	1.286	1.126	1.446	1.249	1.107	1.412	0.05765	10.03%	2.16%

Survival Rate Detail

Sample Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Control Sedimen	1	0.9	0.9	0.9	1
W18	0.8	1	1	0.9	0.9

Angular (Corrected) Transformed Detail

Sample Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Control Sedimen	1.412	1.249	1.249	1.249	1.412
W18	1.107	1.412	1.412	1.249	1.249

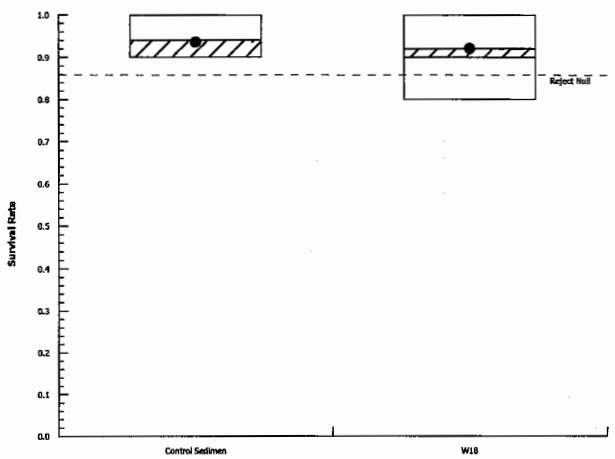
Hyalella 28-d Survival and Growth Sediment Test — **Nautilus Environmental**

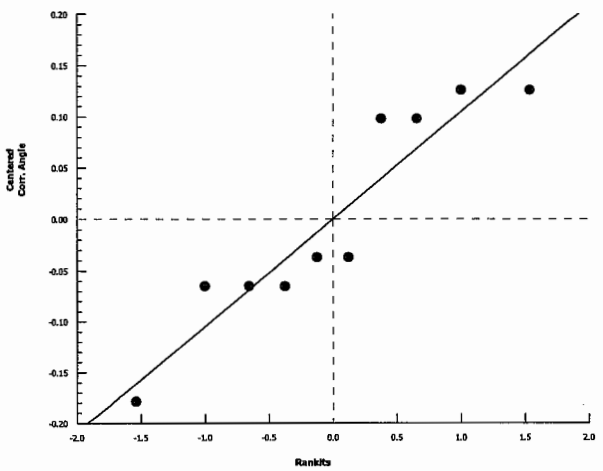
Analysis ID:	12-8663-0645	**Endpoint:**	Survival Rate	**CETIS Version:**	CETISv1.8.7
Analyzed:	07 Oct-14 10:54	**Analysis:**	Parametric-Two Sample	**Official Results:**	Yes

Survival Rate Binomials

Sample Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Control Sedimen	10/10	9/10	9/10	9/10	10/10
W18	8/10	10/10	10/10	9/10	9/10

Graphics





CETIS Summary Report

Hyalella 28-d Survival and Growth Sediment Test — **Nautilus Environmental**

Batch ID:	19-7004-5768	**Test Type:**	Survival-Growth	**Analyst:**	Karen Lee
Start Date:	05 Sep-14	**Protocol:**	EPA/600/R-99/064 (2000)	**Diluent:**	Mod-Hard Synthetic Water
Ending Date:	03 Oct-14	**Species:**	Hyalella azteca	**Brine:**	
Duration:	28d 0h	**Source:**	Aquatic Biosystems, CO	**Age:**	7-8d

Sample Code	Sample ID	Sample Date	Receive Date	Sample Age	Client Name	Project
Control Sedimen	03-5726-6794	05 Sep-14	05 Sep-14	NA	PECG	
W18	04-1548-9802	28 Jul-14 14:00	30 Jul-14 14:40	38d 10h (7.5 °		

Sample Code	Material Type	Sample Source	Station Location	Latitude	Longitude
Control Sedimen	Sediment Sample	PECG	Control Sediment		
W18	Sediment Sample	PECG	W18		

Mean Dry Weight-mg Summary

Sample Code	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
Control Sedimen	5	0.4278	0.288	0.5675	0.2356	0.5233	0.05033	0.1125	26.31%	0.0%
W18	5	0.3691	0.1365	0.6018	0.17	0.6122	0.08379	0.1874	50.76%	13.7%

Mean Dry Weight-mg Detail

Sample Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Control Sedimen	0.479	0.2356	0.4289	0.5233	0.472
W18	0.1975	0.478	0.388	0.17	0.6122

Hyalella 28-d Survival and Growth Sediment Test — **Nautilus Environmental**

Analysis ID:	18-6903-0538	**Endpoint:**	Mean Dry Weight-mg	**CETIS Version:**	CETISv1.8.7
Analyzed:	07 Oct-14 12:34	**Analysis:**	Parametric-Two Sample	**Official Results:**	Yes
Batch ID:	19-7004-5768	**Test Type:**	Survival-Growth	**Analyst:**	Karen Lee
Start Date:	05 Sep-14	**Protocol:**	EPA/600/R-99/064 (2000)	**Diluent:**	Mod-Hard Synthetic Water
Ending Date:	03 Oct-14	**Species:**	Hyalella azteca	**Brine:**	
Duration:	28d 0h	**Source:**	Aquatic Biosystems, CO	**Age:**	7-8d

Sample Code	Sample ID	Sample Date	Receive Date	Sample Age	Client Name	Project
Control Sedimen	03-5726-6794	05 Sep-14	05 Sep-14	NA	PECG	
W18	04-1548-9802	28 Jul-14 14:00	30 Jul-14 14:40	38d 10h (7.5 °		

Sample Code	Material Type	Sample Source	Station Location	Latitude	Longitude
Control Sedimen	Sediment Sample	PECG	Control Sediment		
W18	Sediment Sample	PECG	W18		

Data Transform	Zeta	Alt Hyp	Trials	Seed	PMSD	Test Result
Untransformed	NA	C > T	NA	NA	42.5%	

Equal Variance t Two-Sample Test

Sample Code	vs	Sample Code	Test Stat	Critical	MSD	DF	P-Value	P-Type	Decision(α:5%)
Control Sedimen		W18	0.5996	1.86	0.182	8	0.2827	CDF	Non-Significant Effect

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	0.008588097	0.008588097	1	0.3596	0.5653	Non-Significant Effect
Error	0.1910828	0.02388535	8			
Total	0.1996709		9			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Variance Ratio F	2.772	23.15	0.3472	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.9109	0.7411	0.2874	Normal Distribution

Mean Dry Weight-mg Summary

Sample Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
Control Sedimen	5	0.4278	0.288	0.5675	0.472	0.2356	0.5233	0.05033	26.31%	0.0%
W18	5	0.3691	0.1365	0.6018	0.388	0.17	0.6122	0.08379	50.76%	13.7%

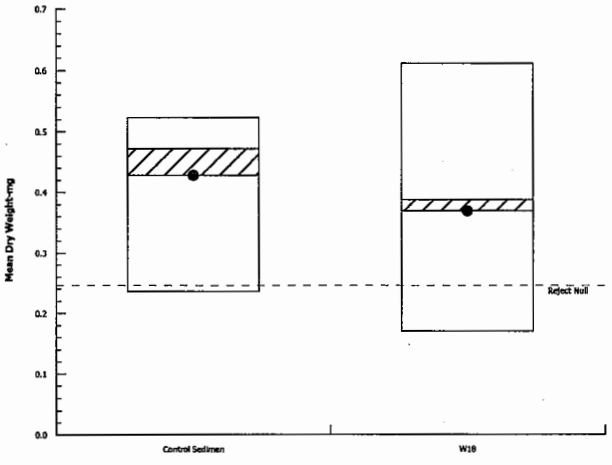
Mean Dry Weight-mg Detail

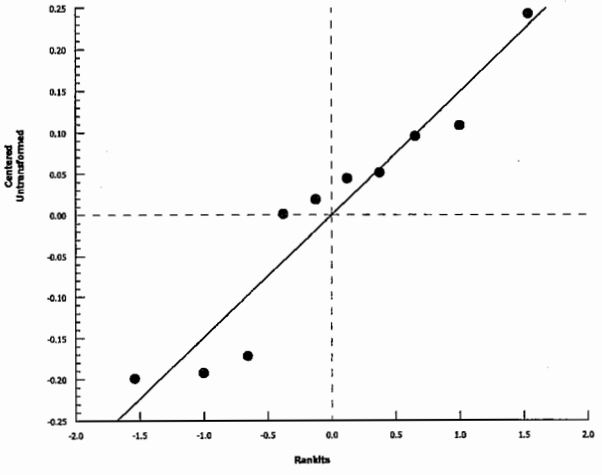
Sample Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Control Sedimen	0.479	0.2356	0.4289	0.5233	0.472
W18	0.1975	0.478	0.388	0.17	0.6122

Hyalella 28-d Survival and Growth Sediment Test — **Nautilus Environmental**

Analysis ID:	18-6903-0538	**Endpoint:**	Mean Dry Weight-mg	**CETIS Version:**	CETISv1.8.7
Analyzed:	07 Oct-14 12:34	**Analysis:**	Parametric-Two Sample	**Official Results:**	Yes

Graphics





APPENDIX B – *Chironomus dilutus* Toxicity Test Data

Chironomus dilutus Sediment Test Summary Sheet

Client: PECG
Work Order No.: 14594

Start Date: 15-Aug-14
Set up by: KJL/JW

Sample Information:

Sample ID: W18
Sample Date: 28-Jul-14
Date Received: 30-Jul-14
Sample Volume: 2x 4L

Test Organism Information:

Species: *C. dilutus*
Supplier: Aquatic Biosystems, CO
Date received: 14-Aug-14
Age or size (Day 0): 3rd instar

KCl Reference Toxicant Results:

Reference Toxicant ID: CT32
Stock Solution ID: n/a
Date Initiated: 15-Aug-14

96-h LC50 (95% CL): 4.0 (3.1 - 5.4)

96-h LC50 Reference Toxicant Mean and Range: 6.0 (3.9 - 9.2) CV (%): 24

Test Results:

Sample ID	Survival ± SD (%)	Average Dry Wt. ± SD (mg)
Control Sediment	92.0 ± 13.0	2.04 ± 0.26
W18	88.0 ± 11.0	2.04 ± 0.16
	±	±
	±	±
	±	±
	±	±
	±	±
	±	±

Reviewed by: JGL

Date reviewed: Sep. 22/14

10-d Chironomid Sediment Toxicity Test Data Sheet

Freshwater Sediment 10-d Water Quality

Client: PECG
W.O #: 14594

Start Date: 15-Aug-14
Termination Date: 25-Aug-14
Test Organism: *Chironomus dilutus*

Temperature (°C)

Sample ID	Day										
	0	1	2	3	4	5	6	7	8	9	10
Control Sediment	22.0	22.5	22.5	22.0	22.5	22.0	22.0	22.0	22.5	22.5	22.0
W18	22.0	22.5	22.5	22.5	22.5	22.0	22.0	22.0	22.5	22.5	22.0
Technician Initials	JW	〃	〃	JW/KJL	JW	JW	KLP	BTL	〃	〃	JW/MML

Conductivity (µS)

Sample ID	Day										
	0	1	2	3	4	5	6	7	8	9	10
Control Sediment	353	360	357	379	387	394	400	402	403	420	433
W18	346	351	360	370	374	379	387	439	402	412	414
Technician Initials	JW	〃	〃	JW/KJL	JW	JW	KLP	BTL	〃	〃	JW/MML

Dissolved oxygen (mg/L)

Sample ID	Day										
	0	1	2	3	4	5	6	7	8	9	10
Control Sediment	8.0	7.9	8.0	7.8	8.3	8.2	7.5	7.8	7.9	7.7	7.8
W18	8.1	8.0	8.1	7.8	8.4	8.3	7.4	7.8	8.0	7.8	7.8
Technician Initials	JW	〃	〃	JW/KJL	JW	JW	KLP	BTL	〃	〃	JW/MML

pH

Sample ID	Day										
	0	1	2	3	4	5	6	7	8	9	10
Control Sediment	8.0	8.1	8.1	8.1	8.0	8.1	8.0	8.1	8.0	8.1	8.2
W18	8.0	8.1	8.1	8.0	8.0	8.0	7.9	8.0	8.0	8.1	8.1
Technician Initials	KJL	〃	〃	JW/KJL	JW	JW	KLP	BTL	〃	〃	JW/MML

Comments:

Reviewed by: JCL

Date Reviewed: Sep. 22/14

10-d Chironomid Sediment Toxicity Test Data Sheet

Freshwater Sediment 10-d Survival and Weight

Client: PECG
W.O. #: 14594
Sample ID: W18

Start Date: 15-Aug-14
Termination Date: 25-Aug-14
Test Organism: *Chironomus dilutus*

Sample ID	CAS Pan No. Orange	Rep	No. alive	No. dead	No. missing	Initials	Pan weight (mg)	Pan + organism (mg)	No. weighed	Initials
Control Sediment	1	A	② 7 ①	0	3	JW	1046.02	1060.98	6	KJL
	2	B	10 ①	0	0		1044.09	1062.41	9	
	3	C	10 ①	0	0		1020.27	1037.35	9	
	4	D	10 ①	0	0		1015.76	1032.34	9	
	5	E	9	0	0		1022.81	1038.21	8 ③	
W18	6	A	9	0	1	JW	1048.09	1065.85	9	
	7	B	7 ②	1	2		1051.91	1067.02	7	
	8	C	9 ①	0	1		1050.854	1067.74	8	
	9	D	10	0	0		1034.51	1052.43	10	
	10	E	9 ①	0	1		1032.74	1050.18	8	
		A								
		B								
		C								
		D								
		E								
		A								
		B								
		C								
		D								
		E								

Comments: ① 1 purge ② Checked by KJL ③ 1 organism lost in transfer
Reweighed pan 2 - 1062.34

Reviewed by: JCh

Date Reviewed: Sep. 22/14

CETIS Summary Report

Chironomus 10-d Survival and Growth Sediment Test — **Nautilus Environmental**

Batch ID:	11-9763-4108	**Test Type:**	Growth-Survival (10d)	**Analyst:**	Karen Lee
Start Date:	15 Aug-14	**Protocol:**	EC/EPS 1/RM/32	**Diluent:**	Mod-Hard Synthetic Water
Ending Date:	25 Aug-14	**Species:**	Chironomus tentans	**Brine:**	
Duration:	10d 0h	**Source:**	Aquatic Biosystems, CO	**Age:**	3rd Instar

Sample Code	Sample ID	Sample Date	Receive Date	Sample Age	Client Name	Project
Control Sedimen	10-4453-5180	15 Aug-14	25 Aug-14	NA	PECG	
W18	04-1548-9802	28 Jul-14 14:00	30 Jul-14 14:40	17d 10h (7.5 °		

Sample Code	Material Type	Sample Source	Station Location	Latitude	Longitude
Control Sedimen	Sediment Sample	PECG	Control Sediment		
W18	Sediment Sample	PECG	W18		

10d Survival Rate Summary

Sample Code	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
Control Sedimen	5	0.92	0.7581	1	0.7	1	0.05831	0.1304	14.17%	0.0%
W18	5	0.88	0.744	1	0.7	1	0.04899	0.1095	12.45%	4.35%

10d Survival Rate Detail

Sample Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Control Sedimen	0.7	1	1	1	0.9
W18	0.9	0.7	0.9	1	0.9

10d Survival Rate Binomials

Sample Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Control Sedimen	7/10	10/10	10/10	10/10	9/10
W18	9/10	7/10	9/10	10/10	9/10

CETIS Analytical Report

Test Code: 14594 | 02-7440-5359

Chironomus 10-d Survival and Growth Sediment Test — **Nautilus Environmental**

Analysis ID:	18-1086-6521	**Endpoint:**	10d Survival Rate	**CETIS Version:**	CETISv1.8.7
Analyzed:	28 Aug-14 15:01	**Analysis:**	Parametric-Two Sample	**Official Results:**	Yes
Batch ID:	11-9763-4108	**Test Type:**	Growth-Survival (10d)	**Analyst:**	Karen Lee
Start Date:	15 Aug-14	**Protocol:**	EC/EPS 1/RM/32	**Diluent:**	Mod-Hard Synthetic Water
Ending Date:	25 Aug-14	**Species:**	Chironomus tentans	**Brine:**	
Duration:	10d 0h	**Source:**	Aquatic Biosystems, CO	**Age:**	3rd Instar

Sample Code	Sample ID	Sample Date	Receive Date	Sample Age	Client Name	Project
Control Sedimen	10-4453-5180	15 Aug-14	25 Aug-14	NA	PECG	
W18	04-1548-9802	28 Jul-14 14:00	30 Jul-14 14:40	17d 10h (7.5 °		

Sample Code	Material Type	Sample Source	Station Location	Latitude	Longitude
Control Sedimen	Sediment Sample	PECG	Control Sediment		
W18	Sediment Sample	PECG	W18		

Data Transform	Zeta	Alt Hyp	Trials	Seed	PMSD	Test Result
Angular (Corrected)	NA	C > T	NA	NA	13.9%	

Equal Variance t Two-Sample Test

Sample Code	vs	Sample Code	Test Stat	Critical	MSD	DF	P-Value	P-Type	Decision(α:5%)
Control Sedimen		W18	0.6122	1.86	0.198	8	0.2787	CDF	Non-Significant Effect

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	0.01062373	0.01062373	1	0.3748	0.5574	Non-Significant Effect
Error	0.2267749	0.02834686	8			
Total	0.2373986		9			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Variance Ratio F	1.485	23.15	0.7110	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.8646	0.7411	0.0864	Normal Distribution

10d Survival Rate Summary

Sample Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
Control Sedimen	5	0.92	0.7581	1	1	0.7	1	0.05831	14.17%	0.0%
W18	5	0.88	0.744	1	0.9	0.7	1	0.04899	12.45%	4.35%

Angular (Corrected) Transformed Summary

Sample Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
Control Sedimen	5	1.295	1.067	1.524	1.412	0.9912	1.412	0.08231	14.21%	0.0%
W18	5	1.23	1.043	1.418	1.249	0.9912	1.412	0.06755	12.28%	5.03%

10d Survival Rate Detail

Sample Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Control Sedimen	0.7	1	1	1	0.9
W18	0.9	0.7	0.9	1	0.9

Angular (Corrected) Transformed Detail

Sample Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Control Sedimen	0.9912	1.412	1.412	1.412	1.249
W18	1.249	0.9912	1.249	1.412	1.249

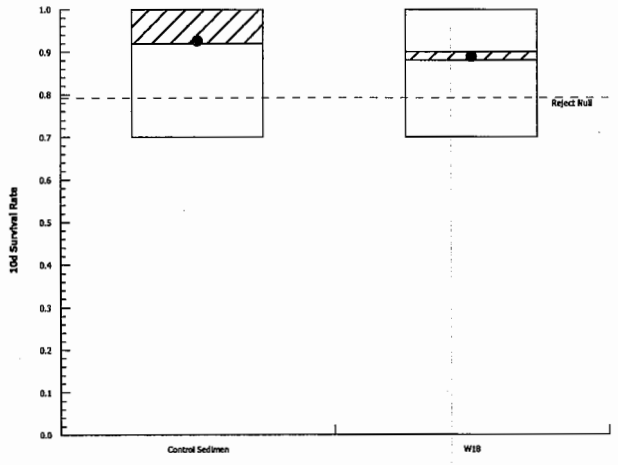
10d Survival Rate Binomials

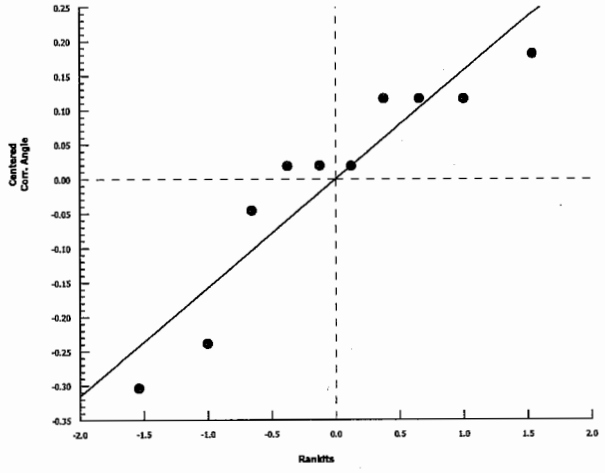
Sample Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Control Sedimen	7/10	10/10	10/10	10/10	9/10
W18	9/10	7/10	9/10	10/10	9/10

Chironomus 10-d Survival and Growth Sediment Test — **Nautilus Environmental**

Analysis ID:	18-1086-6521	**Endpoint:**	10d Survival Rate	**CETIS Version:**	CETISv1.8.7
Analyzed:	28 Aug-14 15:01	**Analysis:**	Parametric-Two Sample	**Official Results:**	Yes

Graphics





CETIS Summary Report

Test Code: 14594 | 02-7440-5359

Chironomus 10-d Survival and Growth Sediment Test — **Nautilus Environmental**

Batch ID:	11-9763-4108	**Test Type:**	Growth-Survival (10d)	**Analyst:**	Karen Lee
Start Date:	15 Aug-14	**Protocol:**	EC/EPS 1/RM/32	**Diluent:**	Mod-Hard Synthetic Water
Ending Date:	25 Aug-14	**Species:**	Chironomus tentans	**Brine:**	
Duration:	10d 0h	**Source:**	Aquatic Biosystems, CO	**Age:**	3rd instar

Sample Code	Sample ID	Sample Date	Receive Date	Sample Age	Client Name	Project
Control Sedimen	10-4453-5180	15 Aug-14	25 Aug-14	NA	PECG	
W18	04-1548-9802	28 Jul-14 14:00	30 Jul-14 14:40	17d 10h (7.5 °		

Sample Code	Material Type	Sample Source	Station Location	Latitude	Longitude
Control Sedimen	Sediment Sample	PECG	Control Sediment		
W18	Sediment Sample	PECG	W18		

Mean Dry Weight-mg Summary

Sample Code	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
Control Sedimen	5	2.039	1.711	2.366	1.842	2.493	0.1179	0.2637	12.93%	0.0%
W18	5	2.043	1.842	2.244	1.792	2.18	0.07239	0.1619	7.92%	-0.22%

Mean Dry Weight-mg Detail

Sample Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Control Sedimen	2.493	2.036	1.898	1.842	1.925
W18	1.973	2.159	2.113	1.792	2.18

Chironomus 10-d Survival and Growth Sediment Test — **Nautilus Environmental**

Analysis ID:	08-9658-2200	**Endpoint:**	Mean Dry Weight-mg	**CETIS Version:**	CETISv1.8.7
Analyzed:	28 Aug-14 15:01	**Analysis:**	Parametric-Two Sample	**Official Results:**	Yes
Batch ID:	11-9763-4108	**Test Type:**	Growth-Survival (10d)	**Analyst:**	Karen Lee
Start Date:	15 Aug-14	**Protocol:**	EC/EPS 1/RM/32	**Diluent:**	Mod-Hard Synthetic Water
Ending Date:	25 Aug-14	**Species:**	Chironomus tentans	**Brine:**	
Duration:	10d 0h	**Source:**	Aquatic Biosystems, CO	**Age:**	3rd instar

Sample Code	Sample ID	Sample Date	Receive Date	Sample Age	Client Name	Project
Control Sedimen	10-4453-5180	15 Aug-14	25 Aug-14	NA	PECG	
W18	04-1548-9802	28 Jul-14 14:00	30 Jul-14 14:40	17d 10h (7.5 °		

Sample Code	Material Type	Sample Source	Station Location	Latitude	Longitude
Control Sedimen	Sediment Sample	PECG	Control Sediment		
W18	Sediment Sample	PECG	W18		

Data Transform	Zeta	Alt Hyp	Trials	Seed	PMSD	Test Result
Untransformed	NA	C > T	NA	NA	12.6%	

Equal Variance t Two-Sample Test

Sample Code	vs	Sample Code	Test Stat	Critical	MSD	DF	P-Value	P-Type	Decision(α:5%)
Control Sedimen		W18	-0.03259	1.86	0.257	8	0.5126	CDF	Non-Significant Effect

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	5.082009E-05	5.082009E-05	1	0.001062	0.9748	Non-Significant Effect
Error	0.3828999	0.04786249	8			
Total	0.3829507		9			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Variance Ratio F	2.653	23.15	0.3675	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.9236	0.7411	0.3875	Normal Distribution

Mean Dry Weight-mg Summary

Sample Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
Control Sedimen	5	2.039	1.711	2.366	1.925	1.842	2.493	0.1179	12.93%	0.0%
W18	5	2.043	1.842	2.244	2.113	1.792	2.18	0.07239	7.92%	-0.22%

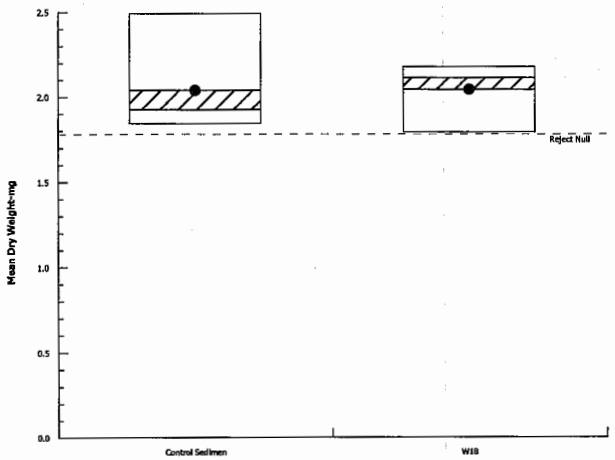
Mean Dry Weight-mg Detail

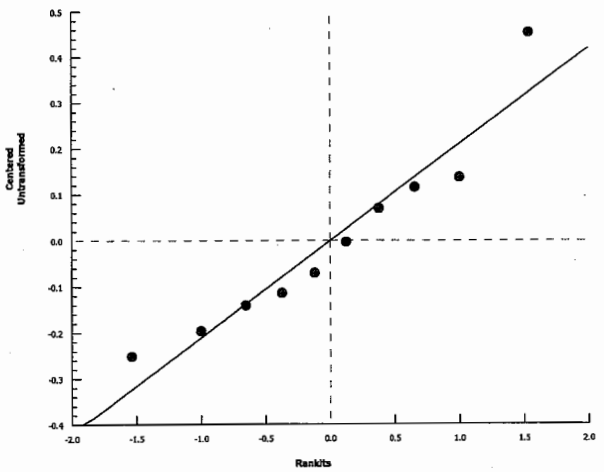
Sample Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Control Sedimen	2.493	2.036	1.898	1.842	1.925
W18	1.973	2.159	2.113	1.792	2.18

Chironomus 10-d Survival and Growth Sediment Test — **Nautilus Environmental**

Analysis ID:	08-9658-2200	**Endpoint:**	Mean Dry Weight-mg	**CETIS Version:**	CETISv1.8.7
Analyzed:	28 Aug-14 15:01	**Analysis:**	Parametric-Two Sample	**Official Results:**	Yes

Graphics





Sediment Description Data Sheet

Client: PECG
Work Order No.: 14488

Date: August 14, 204
Test Organism: *Hyalella azteca* /*C. dilutus*

Sample ID	Grain Size	Colour	Odour	Debris	Other	Initials
Sediment Control	Sand	grey	none	—	—	KJL
W18	sand	brown	none	small rocks, wood chips	n/a	JN

Reviewed by: JCL

Date Reviewed: Sep. 22/14

Client : PECG
W.O.: 14488

Table of PKa values

Temperature (°C)	TDS (mg/L)			Salinity (g/kg)		
	0	*250*	*2000*	*10*	*20*	*30*
12	9.662	9.699	9.754	9.788	9.819	9.837
15	9.564	9.601	9.655	9.688	9.719	9.737
18	9.465	9.502	9.557	9.588	9.619	9.636
20	9.401	**9.438**	9.492	9.523	9.554	9.571
22		**9.391**				
23	9.307	**9.344**	9.398	9.426	9.459	9.476
24		**9.314**				
25	9.246	9.283	9.337	9.366	9.397	9.414

In-house measured Ammonia

Date	Sample ID	Temperature (C)	pH	Total Ammonia Kit Reading (mg/L)	Dilution Factor	Total Ammonia (as N) (mg/L)	pKa	Unionized Ammonia (mg/L)
5-Sep-14	W18	22.5	8.1	0.06	1	0.06	9.391	**0.002921**
8-Sep-14	W18	22.5	8.0	0.60	1	0.60	9.391	**0.023434**
10-Sep-14	W18	22.5	7.7	0.82	1	0.82	9.391	**0.016370**
12-Sep-14	W18	22.0	7.9	0.76	1	0.76	9.391	**0.023769**
15-Sep-14	W18	22.5	7.9	0.38	1	0.38	9.391	**0.011885**
17-Sep-14	W18	22.0	7.7	0.24	1	0.24	9.391	**0.004791**
19-Sep-14	W18	22.0	7.1	0.13	1	0.13	9.391	**0.000662**
22-Sep-14	W18	22.0	7.9	0.21	1	0.21	9.391	**0.006568**
24-Sep-14	W18	22.0	7.7	0.10	1	0.10	9.391	**0.001996**
26-Sep-14	W18	22.5	7.7	0.05	1	0.05	9.391	**0.000998**
29-Sep-14	W18	23.0	7.7	0.01	1	0.01	9.344	**0.000221949**
1-Oct-14	W18	23.0	7.8	0	1	0.00	9.344	**0**

JGe
Nov. 18/14

Nautilus Environmental
Sediment Toxicity Test - Water Quality Data For Ammonia

Client : PECG **Species :** *H. azteca*

Work Order No: 14488 **Sample Type:** Ammonia

Date Measured: See below

Date	Sample ID	Temperature (°C)	pH	Total Ammonia (mg/L)	Unionized Ammonia (mg/L) N	Tech Init
Sep-05	W18	22.5	8.1	0.06	0.003	KJL
Sep-08	W18	22.5	8.0	0.60	0.023	JW
Sep-10	W18	22.5	7.7	0.82	0.016	KJL
Sep-12	W18	22.0	7.9	0.76	0.023 KJL	KJL
Sep-15	W18	22.5	7.9	0.38	0.012	KJL
Sep-17	W18	22.0	7.7	0.24	0.005	LD
Sep-19	W18	22.0	7.1	0.13	0.001	LD
Sep-22	W18	22.0	7.9	0.21	0.007	LD
Sep-24	W18	22.0	7.7	0.10	0.002	KJL
Sep-26	W18	22.5	7.7	0.05	0.001	JAB
Sep-29	W18	23.0	7.7	0.01	0.0002	KJL
Oct-01	W18	23.0	7.8	0.00	0.0	LD

Comments:

Reviewed by: JCh **Date Reviewed:** Nov 18/14

APPENDIX C - Chain of Custody Form

Nautilus Environmental

BRITISH COLUMBIA
8664 Commerce Court
Burnaby British Columbia Canada V5A 4N7
Phone 604.420.8773
Fax 604.357.1361

WO # 14,488

Chain of Custody

0951

Date July 29, 2014 Page 1 of 1

Sample Collection by: PECG. - Palmer Environmental Consulting Group

Report to:
Company PECG
Address 470 Granville St Suite 630
City Vancouver Prov. BC PC V6C 2V5
Contact May Quach
Phone No. 604 629-9075

Invoice to:
Company Same as previous
Address
City Prov. PC
Contact
Phone No.

SAMPLE ID	DATE	TIME	MATRIX	CONTAINER TYPE	NUMBER OF CONTAINERS	COMMENTS	Metals	Total Organic Carbon	pH	Temperature	Toxicity	HyalHela 28-d	Chironomus 10-d					RECEIPT TEMPERATURE (°C)
W18 (1/2)	07/28/14	14:00	Sediment	4L	1	toxicity tests as discussed with M. Quach.					✓	WO 14487	WO 14594					7.5
W18 (2/2)	07/28/14	14:00	Sediment	4L	1	extra if needed.												7.5

PROJECT INFORMATION
CLIENT Casino Mining Corp.
P.O. NO.
SHIPPED VIA:

SAMPLE RECEIPT
TOTAL NO. OF CONTAINERS 2
REC'D GOOD CONDITION Y
Y

SPECIAL INSTRUCTIONS/COMMENTS:

RELINQUISHED BY (CLIENT)
(Signature) (Time)
(Printed Name) (Date)
(Company)

RELINQUISHED BY (COURIER)
(Signature) (Time)
(Printed Name) (Date)
(Company)

RECEIVED BY (COURIER)
(Signature) (Time)
(Printed Name) (Date)
(Company)

RECEIVED BY (LABORATORY)
NAUTILUS
(Signature) (Time)
(Printed Name) (Date)
NAIRYAMAMOTO
July 30/14 @ 14:40.

Additional costs may be required for sample disposal or storage. Net 30 unless otherwise contracted.

DISTRIBUTION: WHITE - Nautilus Environmental, COLOR - Originator

Nautilus Environmental

Freshwater toxicity testing on a mixture of constituents added into sample identified as W18-1

Final Report

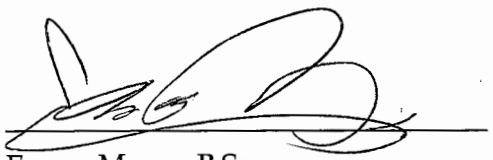
Report date:
December 3, 2014

Submitted to:

Palmer Environmental Consulting Group
Vancouver, BC

Burnaby Laboratory
8664 Commerce Court
Burnaby, BC
V5A 4N7

SIGNATURE PAGE



Emma Marus, B.Sc.
Laboratory Biologist

James Elphick, R.P.Bio.
Senior Reviewer

This report has been prepared by Nautilus Environmental Company Inc. based on data and/or samples provided by our client and the results of this study are for their sole benefit. Any reliance on the data by a third party is at the sole and exclusive risk of that party. The results presented here relate only to the samples tested.

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1.0 INTRODUCTION

Nautilus Environmental conducted sub-lethal toxicity tests for Palmer Environmental Consulting Group (Palmer) on a sample identified as W18-1 supplemented with a number of constituents of interest to achieve two mixtures (Mixture 1 and Mixture 2) specified by Palmer. The sample was collected on September 30, 2014 and delivered to the laboratory in Burnaby, BC on October 2, 2014. The sample was transported in two 20-L plastic containers and was received at a temperature of approximately 3.0°C. The sample was stored in the dark at 4 ± 2°C prior to testing. The following sub-lethal toxicity tests were conducted on the sample:

- *Ceriodaphnia dubia* survival and reproduction
- 72-h algal (*Pseudokirchneriella subcapitata*) growth inhibition

This report describes the results of these toxicity tests. Copies of laboratory data sheets and printouts of statistical analyses for each test are provided in Appendices A and B. Analytical results are provided in Appendix C and the chain-of-custody form is provided in Appendix D.

2.0 METHODS

Mixture 2, referred to here as the 100% test concentration, was prepared using W18-1 as the base water supplemented with $CaSO_4*2H_20$, KCl, $MgCl_2*6H_20$, $MgSO_4*7H_20$, Na_2SO4 and NaF along with metal stock solutions of $CdCl_2$, $CuCl_2$, $Na_2SeO_4*10H_20$, $Na_2MoO_4*2H_20$ and $MnCl_2*4H_20$ to achieve targeted ion concentrations. Mixture 1 was prepared by diluting Mixture 2 to 77% using unspiked W18-1 site water for dilution. Additional dilutions were also tested.

Methods for the toxicity tests are summarized in Tables 1 and 2. Testing was conducted according to procedures described by Environment Canada (2007a and 2007b). Statistical analyses for all tests were performed using CETIS (Tidepool Scientific Software, 2013).

Table 1. Summary of test conditions: *Ceriodaphnia dubia* survival and reproduction test.

Test organism	*Ceriodaphnia dubia*
Test organism source	In-house culture
Test organism age	<24 h old neonates produced within 12 h
Test type	Static-renewal
Test duration	7 ± 1 day
Test vessel	20 mL test tube
Test volume	15 mL
Test replicates	10 test replicates per treatment
No. of organisms	1 per replicate
Control water	20% Perrier water
Test solution renewal	Daily
Test temperature	25 ± 1°C
Feeding	*Pseudokirchneriella subcapitata* and YCT
Light intensity	100 to 600 lux at water surface
Photoperiod	16 hours light/8 hours dark
Aeration	None
Test protocol	Environment Canada (2007a), EPS 1/RM/21
Statistical software	CETIS (Tidepool Scientific Software 2013)
Test endpoint	Survival and reproduction
Test acceptability criteria for controls	≥80% survival; ≥15 young per surviving control producing three broods; ≥60% of controls producing three or more broods
Reference toxicant	Sodium chloride

Table 2. Summary of test conditions: *Pseudokirchneriella subcapitata* growth inhibition test.

Test organism	*Pseudokirchneriella subcapitata* (Strain CPCC #37)
Test organism source	In-house culture, obtained from Canadian Phycological Culture Center, and originally isolated from Nivelta River, Norway.
Test organism age	4 to 7 day old culture in logarithmic growth phase
Test type	Static
Test duration	72 hours
Test vessel	Microplate
Test volume	220 µL
Test replicates	4 test replicates per treatment; 8 replicates for control
No. of organisms	10, 000 cells/mL
Control water	Deionized water with nutrients added
Test solution renewal	None
Test temperature	24 ± 2°C
Feeding	None
Light intensity	3600 to 4400 lux
Photoperiod	24 hours light
Aeration	None
Test protocol	Environment Canada (2007b), EPS 1/RM/25
Statistical software	CETIS (Tidepool Scientific 2013)
Test endpoint	Algal cell growth inhibition
Test acceptability criteria for controls	> 16-fold increase in number of algal cells; CV ≤ 20%; no trend when analyzed using Mann-Kendall test
Reference toxicant	Zinc

3.0 RESULTS

Targeted and measured values of constituents in Mixture 1 (77% sample) and Mixture 2 (100% sample) are provided in Table 3. Iron, silicon and bicarbonate were not added to the W18-1 water, since the concentration that was already present in this water already exceeded the target concentrations for Mixtures 1 and 2. Uranium was not added because this constituent was not available since protocols were not in place in the laboratory for safe handling of this material. Other than these materials, the measured concentrations were in good agreement with the target concentrations

Table 3. Targeted and measured values of constituents in the mixtures.

Constituent	W18-1	Mixture 1 (77%)		Mixture 2 (100%	
		Targeted (mg/L)	Measured (mg/L)	Targeted (mg/L)	Measured (mg/L)
Hardness	70.1	495	512	642	659
SO_4	20.8	441	441	573	581
HCO_3 [1]	75.8	54.5	82.6	70.8	84.1
Cl	5.5	13.7	15.8	17.8	18.8
F	0.03	0.78	0.68	1.02	0.87
Cd	<0.00005	0.00050	0.00055	0.00065	0.00066
Ca	19.0	182	186	236	242
Cu	0.0012	0.0174	0.0167	0.0226	0.0199
Fe [1]	0.055	0.0057	0.067	0.0074	0.0970
Mg	5.5	10.0	11.4	13.0	13.1
Mn	0.004	0.702	0.691	0.912	0.883
Mo	0.001	0.100	0.113	0.130	0.146
K	<2	1.8	2.0	2.3	2.3
Se	<0.0010	0.0030	0.0035	0.0040	0.0046
Si [1]	5.4	3.55	5.67	4.62	5.62
Na	3.2	15.6	16.7	20.2	20.4
U [2]	0.0027	0.0210	0.00280	0.0273	0.00283

[1] Measured value exceeded target value because this constituent already contained the measured amount upon receipt.
[2] Uranium was not added to the mixture.

Results of the toxicity tests conducted on the Mixture prepared in sample W18-1 are summarized in Tables 4 and 5. No adverse effects were observed on *C. dubia* survival or reproduction; the LC50, IC25 and IC50 were each >100%. In the 72-h *P. subcapitata* toxicity test, a reduction in cell yield was observed relative to the unspiked W18-1 sample, resulting in an IC25 of 74.9% sample. However, cell yield was greater than in the laboratory water control in all test concentrations. Thus, there was no adverse effect in the test concentrations relative to the laboratory control performance.

Table 4. Results: *Ceriodaphnia dubia* survival and reproduction test.

Concentration (% v/v)	**Survival (%)**	**Reproduction (mean ± SD)**
Lab Control	100	24.5 ± 2.3
W18-1 Unspiked Site Control*	100	28.6 ± 3.5
20	100	29.2 ± 2.3
25	100	28.3 ± 1.9
35	100	28.1 ± 3.1
45	100	27.9 ± 2.3
60	90	23.7 ± 7.8
77	90	23.1 ± 8.4
100	100	24.9 ± 2.0
Test endpoint (% v/v)		
LC50	>100	--
IC25	--	>100
IC50	--	>100

SD = Standard Deviation, LC = Lethal Concentration, IC = Inhibition Concentration.
*Site control used for statistical analysis.

Table 5. Results: *Pseudokirchneriella subcapitata* growth inhibition test.

Concentration (% v/v)	Cell Yield (x 10^4 cells/mL) (Mean ± SD)	
Lab Control	55.4 ± 4.0	
W18-1 Unspiked Site	171.6 ± 10.8	
Control*	155.0 ± 14.5	
20	164.5 ± 9.3	
25	131.5 ± 11.7	
35	152.8 ± 13.8	
45	143.8 ± 17.5	
60	127.0 ± 11.5	
77	89.8 ± 15.8	
100		
Test endpoint (% v/v)	**Relative to W18-1**	**Relative to Lab Control**
IC25 (95% CL)	74.9 (57.1 – 85.2)	>100
IC50	>100	>100

SD = Standard Deviation, IC = Inhibition Concentration, CL = Confidence limits.

4.0 QA/QC

The health history of the test organisms used in the exposures was acceptable and met the requirements of the Environment Canada test protocols. The tests met all control acceptability criteria and water quality parameters remained within ranges specified in the protocols throughout the tests. There were no deviations from the test methodologies. Uncertainty associated with these tests is best described by the standard deviation around the mean and/or the confidence limits around the point estimates.

Results of the reference toxicant tests conducted during the testing program are summarized in Table 6. Results for these tests fell within the range for organism performance of mean and two standard deviation range, based on historical results obtained by the laboratory with these tests. Thus, the sensitivity of the organisms used in these tests was appropriate

Table 6. Reference toxicant test results.

Test Species	Endpoint	Historical Mean (2 SD Range)	CV (%)	Test Date
C. dubia	Survival (LC50): 2.1 g/L NaCl	1.9 (1.4 – 2.5)	16	October 22, 2014
	Reproduction (IC50): 1.8 g/L NaCl	1.4 (1.0 – 2.0)	18	
P. subcapitata	Growth (IC50): 24.2 µg/L Zn	25.4 (14.8 – 43.4)	31	October 3, 2014

SD = Standard Deviation, CV = Coefficient of Variation, LC = Lethal Concentration, IC = Inhibition Concentration.

5.0 REFERENCES

Environment Canada. 2007a. Biological test method: test of reproduction and survival using the cladoceran *Ceriodaphnia dubia*. EPS 1/RM/21, Second Edition, February 2007. Environment Canada, Method Development and Application Section, Environmental Science and Technology Centre, Science and Technology Branch, Ottawa, ON.

Environment Canada. 2007b. Biological test method: growth inhibition test using the freshwater alga. EPS 1/RM/25. Second Edition, March 2007. Environment Canada, Method Development and Application Section, Environmental Science and Technology Centre, Science and Technology Branch, Ottawa, ON.

Tidepool Scientific Software. 2013. CETIS comprehensive environmental toxicity information system, version 1.8.7.16 Tidepool Scientific Software, McKinleyville, CA. 222 pp.

APPENDIX A – *Ceriodaphnia dubia* Toxicity Test Data

Ceriodaphnia dubia Summary Sheet

Client: Palmer Environmental
Work Order No.: 14702-1 emn

Start Date/Time: Oct 10/14 @ 1200h 8 em
Set up by: EMN

Sample Information:

Sample ID: CW18-1
Sample Date: Sept-30/14
Date Received: ~~Oct 2/14~~ emn Oct 2/14
Sample Volume: 20 L

Test Validity Criteria:

1) Mean survival of first generation controls is ≥80 %
2) At least 60% of controls have produced three broods within 8 days
3) An average of ≥15 live young produced per surviving female in the control solutions during the first three broods.
4) Invalid if ephippia observed in any control solution at any time.

WQ Ranges:

T (°C) = 25 ± 1; DO (mg/L) = 3.3 to 8.4 ; pH = 6.0 to 8.5

Test Organism Information:

Broodstock No.: 092614B
Age of young (Day 0): <24-h (within 12-h)
Avg No. young in first 3 broods of previous 7 d: 32
Mortality (%) in previous 7 d: 10
Individual female # used ≥8 young on test day: 23~~4~~, 25, 27, 29, 30

NaCl Reference Toxicant Results:

Reference Toxicant ID: Cd119
Stock Solution ID: 14Na07
Date Initiated: Oct 22/14

7-d LC50 (95% CL): 2.1 (2.0 – 2.2) g/L NaCl
7-d IC50 (95% CL): 1.8 (1.5 – 2.0) g/L NaCl

7-d LC50 Reference Toxicant Mean and Historical Range: 1.9 (1.4–2.5) g/L NaCl CV (%): 16
7-d IC50 Reference Toxicant Mean and Historical Range: 1.4 (1.0–2.0) g/L NaCl CV (%): 18

Test Results:

	Survival	Reproduction
LC50 % (v/v) (95% CL)	>100	
IC25 % (v/v) (95% CL)		>100
IC50 % (v/v) (95% CL)		>100

Reviewed by: JGL
Date reviewed: Nov. 26/14

Chronic Freshwater Toxicity Test
Initial and Final Water Quality Measurements

Client: Palmer Environmental
Sample ID: W18-1 spiked (Casina)
Work Order #: 14701

Start Date & Time: Oct 8/14 @ 1200
Stop Date & Time: Oct 14/14 @ 1300
Test Species: *Ceriodaphnia dubia*

(lab H_2O) Concentration 20% perner Ctrl	Days 0	1		2		3		4		5		final 6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	25.0	24.0	24.0		
DO (mg/L)	8.03	7.4	8.0	6.2	7.7	7.7	8.0	7.6	8.0	7.5	8.1	7.0		
pH	7.8 EC	7.5	7.8	7.4	7.8	7.6	7.8	7.7	8.0	7.6	7.9	7.5		
Cond. (µS/cm)	221	211		215		211		214		215		221		
Initials	EC	EC/KJL		EC		JW		YML		EMM		EC		

(dilution H_2O) Concentration W18 unspiked Ctrl	Days 0	1		2		3		4		5		final 6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	25.0	24.0	24.0		
DO (mg/L)	8.3	7.7	8.2	7.7	7.7	7.6	8.1	7.5	8.0	7.7	7.8	7.1		
pH	7.4	7.4	7.5	7.5	7.4	7.5	7.5	7.5	7.6	7.8	7.5	7.5		
Cond. (µS/cm)	160	159.5		156		160		159		160		158 EC		
Initials	EC	EC/KJL		EC		JW		YML		EMM		EC		

(spiked) Concentration 20% (v/v) W18-1	Days 0	1		2		3		4		5		final 6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	25.0	24.0	24.0		
DO (mg/L)	8.3	7.4	8.2	7.1	7.7	7.6	8.1	7.5	8.1	7.8	7.8	7.2		
pH	7.4	7.3	7.5	7.3	7.5	7.5	7.4	7.5	7.5	7.6	7.5	7.5		
Cond. (µS/cm)	417	424		408		408		415		410		400		
Initials	EC	EC/KJL		EC		JW		YML		EMM		EC		

(spiked) Concentration 25% (v/v) W18-1	Days 0	1		2		3		4		5		final 6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	25.0	24.0	24.0		
DO (mg/L)	8.3	7.3	8.2	7.2	7.7	7.7	8.1	7.5	8.0	7.7	7.8	7.2		
pH	7.4	7.4	7.5	7.4	7.5	7.6	7.5	7.4	7.5	7.6	7.5	7.5		
Cond. (µS/cm)	468	EC ~~558~~ 463		460		460		461		462		448		
Initials	EC	EC/KJL		EC		JW		YML		EMM		EC		

W18-1 dilution water

	Control	100% (v/v)		
Hardness*	100	80		
Alkalinity*	76	50		

* mg/L as CaCO3

Analysts: EMM, EC, YYC, JW, AWD, KJL
Reviewed by: JGL
Date reviewed: Nov-26/14

WQ Ranges: T (°C) = 25 ± 1; DO (mg/L) = 3.3 to 8.4 (mg/L) ; pH = 6 to 8.5

Sample Description: W18-1 spiked - yellow, clear; ppt present w/ metal mixture

Comments: **Broodboard Used:** 092614B

Chronic Freshwater Toxicity Test
Initial and Final Water Quality Measurements

Client: Palmer Environmental
Sample ID: WI8-1 spiked (Casino)
Work Order #: 14781

Start Date & Time: Oct 8/14 @ 1200
Stop Date & Time: Oct 14/14 @ 1300
Test Species: *Ceriodaphnia dubia*

(Spiked) Concentration 35%(v/v) WI8-1

	Days														
	0	1		2		3		4		5		final 6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	25.0	24.0	24.0		
DO (mg/L)	8.3	7.3	8.1	7.5	7.7	7.6	8.1	7.4	8.1	7.8	7.8	6.8		
pH	7.4	7.4	7.4	7.5	7.5	7.5	7.5	7.6	7.5	7.6	7.5	7.4		
Cond. (µS/cm)	561	558		553		551		545		550		558		
Initials	EC	EC/KJL		GC		JW		YML		EMM		EC		

(Spiked) Concentration 45%(v/v) WI8-1

	Days														
	0	1		2		3		4		5		final 6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	25.0	24.0	24.0		
DO (mg/L)	8.3	7.3	8.0	7.1	7.7	7.6	8.1	7.4	8.1	7.8	7.7	6.9		
pH	7.4	7.4	7.5	7.2	7.5	7.6	7.5	7.6	7.5	7.6	7.5	7.5		
Cond. (µS/cm)	671	659		660		663		662		661		661		
Initials	EC	EC/KJL		EC		JW		YML		EMM		EC		

(Spiked) Concentration 60%(v/v) WI8-1

	Days														
	0	1		2		3		4		5		final 6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	25.0	24.0	24.0		
DO (mg/L)	8.3	7.4	7.9	7.3	7.7	7.6	8.1	7.4	8.0	7.7	7.7	7.1		
pH	7.4	7.4	7.5	7.4	7.4	7.5	7.4	7.6	7.4	7.6	7.4	7.5		
Cond. (µS/cm)	805	803		796 760 EC		799		807		801		801		
Initials	EC	EC/KJL		EC		JW		YML		EMM		EC		

(Spiked) Concentration 77%(v/v) WI8-1

	Days														
	0	1		2		3		4		5		final 6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	25.0	24.0	24.0		
DO (mg/L)	8.3	7.3	7.9	7.3	7.7	7.6	8.1	7.3	8.1	7.6	7.6	7.1		
pH	7.4	7.34	7.5	7.4	7.5	7.5	7.5	7.6	7.4	7.5	7.4	7.5		
Cond. (µS/cm)	948	958		953		946		947		947		932		
Initials	EC	EC/KJL		EC		JW		YML		EMM		EC		

refer to page 1

	Control			
Hardness*				
Alkalinity*				

Analysts: EMM, EC, AWD, KJL, JW, YML
Reviewed by: JRL
Date reviewed: Nov-26/14

* mg/L as CaCO3
WQ Ranges: T (°C) = 25 ± 1; DO (mg/L) = 3.3 to 8.4 (mg/L) ; pH = 6 to 8.5
Sample Description:

Comments: **Broodboard Used:**

Chronic Freshwater Toxicity Test
Initial and Final Water Quality Measurements

Client: Palmer Environmental
Sample ID: W18-1 spiked (Casino)
Work Order #: 14701

Start Date & Time: Oct 8/14 @1200
Stop Date & Time: Oct 14/14 @1300
Test Species: *Ceriodaphnia dubia*

(spiked) Concentration 100% (v/v) W18	Days 0	1		2		3		4		5		final 6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	25.0	24.0	24.1		
DO (mg/L)	8.3	7.3	7.9	7.3	7.4	7.5	8.1	7.3	7.9	7.7	7.8	7.1		
pH	7.4	7.4	7.4	7.4	7.4	7.5	7.4	7.6	7.3	7.6	7.3	7.5		
Cond. (µS/cm)	1175	1178		1167		1171		1176		1163		1146		
Initials	EC	EC/KV		EC		JW		YML		EMM		EC		

Concentration	Days 0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)														
DO (mg/L)														
pH														
Cond. (µS/cm)														
Initials														

Concentration	Days 0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)														
DO (mg/L)														
pH														
Cond. (µS/cm)														
Initials														

Concentration	Days 0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)														
DO (mg/L)														
pH														
Cond. (µS/cm)														
Initials														

refer to page 1

	Control			
Hardness*				
Alkalinity*				

* mg/L as CaCO3

Analysts: EMM, AWD, KTL, JW, YML, EC
Reviewed by: JGW
Date reviewed: Nov. 26/14

WQ Ranges: T (°C) = 25 ± 1; DO (mg/L) = 3.3 to 8.4 (mg/L) ; pH = 6 to 8.5

Sample Description:

Comments: **Broodboard Used:**

Chronic Freshwater Toxicity Test
C. dubia Reproduction Data

Client: Palmer Environmental
Sample ID: W18 spiked (casino)
Work Order: 14701

Start Date & Time: Oct 8/14 @ 1200h
Stop Date & Time: Oct 14/14 @ 1300h
Set up by: Emm

Days	Concentration: 20% perrier Ctrl										
	A	B	C	D	E	F	G	H	I	J	Init
1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	KJ
2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	EL
3	4	4	5	5	6	4	4	6	4	5	JW
4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	YM
5	8	11	8	11	10	11	10	9	9	10	Emm
6	9	10	11	10	11	10	12	10	X	11	EL
7											
8											
Total	21	25	24	26	27	25	26	25	20	26	EL

Days	Concentration: W18 unspiked Ctrl										
	A	B	C	D	E	F	G	H	I	J	Init
1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	KJ
2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	EL
3	5	5	5	5	6	5	6	6	6	5	JW
4	✓	✓		✓	✓	✓	✓	✓	✓	✓	YM
5	11	9	8	11	13	12	14	12	11	10	Emm
6	15	11	12	14	14	14	12	12	9	8	EL
7											
8											
Total	31	25	25	30	33	31	32	30	26	23	EL

Days	Concentration: 20% (v/v) W18-1										
	A	B	C	D	E	F	G	H	I	J	Init
1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	KJ
2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	EL
3	6	6	6	5	5	6	4	6	6	6	JW
4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	YM
5	11	12	11	13	12	11	13	12	11	12	Emm
6	13	11	11	14	16	11	13	12	9	8	EL
7											
8											
Total	30	29	28	32	33	28	30	30	26	26	EL

Days	Concentration: 25% (v/v) W18-1										
	A	B	C	D	E	F	G	H	I	J	Init
1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	KJ
2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	EL
3	4	4	5	4	6	6	4	4	4	4	JW
4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	YM
5	12	10	11	12	12	13	12	10	11	14	Emm
6	12	12	12	12	13	13	10	14	14	9	EL
7											
8											
Total	28	26	28	28	31	32	26	28	29	27	EL

Days	Concentration: 35% (v/v) W18-1										
	A	B	C	D	E	F	G	H	I	J	Init
1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	KJ
2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	EL
3	6	4	6	6	6	6	3	6	6	4	JW
4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	YM
5	10	12	12	10	10	12	9	12	15	12	Emm
6	12	14	10	6	12	13	13	14	10	10	EL
7											
8											
Total	28	30	28	22	28	31	25	32	31	26	EL

Days	Concentration: 45% (v/v) W18-1										
	A	B	C	D	E	F	G	H	I	J	Init
1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	KJ
2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	EL
3	4	4	5	5	4	3	5	5	4	4	JW
4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	YM
5	12	14	13	11	13	13	8	12	14	10	Emm
6	13	10	12	9	14	8	13	12	12	13	EL
7											
8											
Total	29	28	30	25	31	24	26	29	30	27	EL

Days	Concentration: 60% (v/v) W18-1										
	A	B	C	D	E	F	G	H	I	J	Init
1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	KJ
2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	EL
3	5	4	5	5	4	5	4	5	4	✓	JW
4	✓	✓	✓	✓	✓	✓	✓	✓	✓	6	YM
5	10	X	10	8	9	12	11	11	8	✓	Emm
6	13	|	11	14	15	11	10	13	14	10	EL
7											
8											
Total	28	4X	26	27	28	28	25	29	26	16	EL

Days	Concentration: 77% (v/v) W18-1										
	A	B	C	D	E	F	G	H	I	J	Init
1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	KJ
2	✓	✓	✓	✓	✓	X	✓	✓	✓	✓	EL
3	5	4	4	4	4	|	4	5	4	4	JW
4	✓	✓	✓	✓	✓	|	✓	✓	✓	✓	YM
5	10	6	9	8	9	|	11	12	11	9	Emm
6	12	14	12	12	11	|	14	13	10	10	EL
7						↓					
8						0X					
Total	27	24	25	24	24		29	30	28	23	EL

Days	Concentration: 100% (v/v) W18-1										
	A	B	C	D	E	F	G	H	I	J	Init
1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	KJ
2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	EL
3	4	4	4	4	4	4	4	3	4	5	JW
4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	YM
5	13	11	10	10	9	10	11	10	8	12	Emm
6	11	11	10	10	13	8	10	12	10	10	EL
7											
8											
Total	28	26	24	24	26	22	25	25	22	27	EL

Notes: X = mortality.

Sample Description: W18+ yellow, clear; ppt present

Comments: Total # Young only based on the first 3 Broods. Fourth and subsequent broods not included in total count.

Reviewed by: JW

Date reviewed: Nov. 26/14

Ceriodaphnia 7-d Survival and Reproduction Test

Nautilus Environmental

Analysis ID:	00-3286-8768	**Endpoint:**	6d Survival Rate	**CETIS Version:**	CETISv1.8.7
Analyzed:	24 Nov-14 11:38	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes
Batch ID:	19-4145-7141	**Test Type:**	Reproduction-Survival (7d)	**Analyst:**	Emma Marus
Start Date:	08 Oct-14 12:00	**Protocol:**	EPA/821/R-02-013 (2002)	**Diluent:**	Site Water
Ending Date:	14 Oct-14 13:00	**Species:**	Ceriodaphnia dubia	**Brine:**	
Duration:	6d 1h	**Source:**	In-House Culture	**Age:**	<24h
Sample ID:	20-9728-7274	**Code:**	7D02106A	**Client:**	Palmer Environmental Consulting Gro
Sample Date:	30 Sep-14 01:00	**Material:**	Water Sample	**Project:**	Casino
Receive Date:	02 Oct-14 10:25	**Source:**	Palmer Environmental Consulting Group		
Sample Age:	8d 11h (2.8 °C)	**Station:**	W18-1		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	2081312	200	Yes	Two-Point Interpolation

Point Estimates

Level	%	95% LCL	95% UCL	TU	95% LCL	95% UCL
EC5	55.84	49.06	N/A	1.791	NA	2.038
EC10	>100	N/A	N/A	<1	NA	NA
EC15	>100	N/A	N/A	<1	NA	NA
EC20	>100	N/A	N/A	<1	NA	NA
EC25	>100	N/A	N/A	<1	NA	NA
EC40	>100	N/A	N/A	<1	NA	NA
EC50	>100	N/A	N/A	<1	NA	NA

6d Survival Rate Summary

			Calculated Variate(A/B)								
C-%	Control Type	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect	A	B
0	Negative Control	10	1	1	1	0	0	0.0%	0.0%	10	10
20		10	1	1	1	0	0	0.0%	0.0%	10	10
25		10	1	1	1	0	0	0.0%	0.0%	10	10
35		10	1	1	1	0	0	0.0%	0.0%	10	10
45		10	1	1	1	0	0	0.0%	0.0%	10	10
60		10	0.9	0	1	0.1	0.3162	35.14%	10.0%	9	10
77		10	0.9	0	1	0.1	0.3162	35.14%	10.0%	9	10
100		10	1	1	1	0	0	0.0%	0.0%	10	10

6d Survival Rate Detail

C-%	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	Negative Control	1	1	1	1	1	1	1	1	1	1
20		1	1	1	1	1	1	1	1	1	1
25		1	1	1	1	1	1	1	1	1	1
35		1	1	1	1	1	1	1	1	1	1
45		1	1	1	1	1	1	1	1	1	1
60		1	0	1	1	1	1	1	1	1	1
77		1	1	1	1	1	0	1	1	1	1
100		1	1	1	1	1	1	1	1	1	1

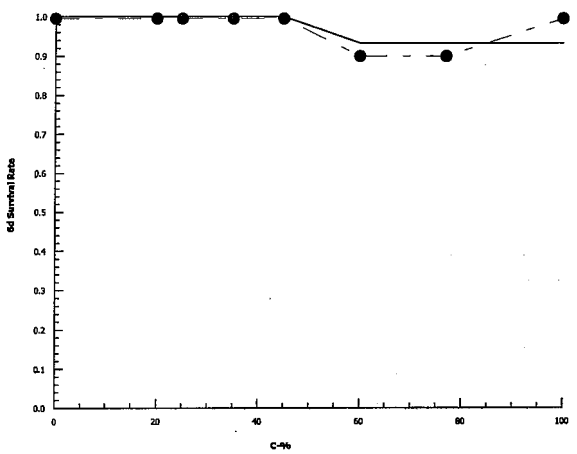
Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID: 00-3286-8768 **Endpoint:** 6d Survival Rate **CETIS Version:** CETISv1.8.7
Analyzed: 24 Nov-14 11:38 **Analysis:** Linear Interpolation (ICPIN) **Official Results:** Yes

6d Survival Rate Binomials

C-%	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	Lab Water	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
0	Negative Control	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
20		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
25		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
35		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
45		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
60		1/1	0/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
77		1/1	1/1	1/1	1/1	1/1	0/1	1/1	1/1	1/1	1/1
100		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1

Graphics



CETIS Analytical Report

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	02-1636-1945	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv1.8.7
Analyzed:	24 Nov-14 11:41	**Analysis:**	Nonlinear Regression	**Official Results:**	Yes
Batch ID:	19-4145-7141	**Test Type:**	Reproduction-Survival (7d)	**Analyst:**	Emma Marus
Start Date:	08 Oct-14 12:00	**Protocol:**	EPA/821/R-02-013 (2002)	**Diluent:**	Site Water
Ending Date:	14 Oct-14 13:00	**Species:**	Ceriodaphnia dubia	**Brine:**	
Duration:	6d 1h	**Source:**	In-House Culture	**Age:**	<24h
Sample ID:	20-9728-7274	**Code:**	7D02106A	**Client:**	Palmer Environmental Consulting Gro
Sample Date:	30 Sep-14 01:00	**Material:**	Water Sample	**Project:**	Casino
Receive Date:	02 Oct-14 10:25	**Source:**	Palmer Environmental Consulting Group		
Sample Age:	8d 11h (2.8 °C)	**Station:**	W18-1		

Non-Linear Regression Options

Model Function	X Transform	Y Transform	Weighting Function	PTBS Function
2P Exponential EV [Y=A*exp(log(0.5)*X/D)]	None	None	Normal [W=1]	Off [Y*=Y]

Regression Summary

Iters	Log LL	AICc	BIC	Adj R2	Optimize	F Stat	Critical	P-Value	Decision(α:5%)
3	-162	328.2	332.8	0.1303	Yes	1.017	2.227	0.4211	Non-Significant Lack of Fit

Point Estimates

Level	%	95% LCL	95% UCL	TU	95% LCL	95% UCL
IC5	22.08	3.032	42.01	4.529	2.38	32.98
IC10	45.36	29.11	62.25	2.205	1.606	3.436
IC15	69.96	47.63	93.52	1.429	1.069	2.1
IC20	96.06	62.76	132.2	1.041	0.7567	1.593
IC25	123.8	77.67	175.6	0.8074	0.5696	1.287 JGu
IC40	219.9	129.6	334.4	0.4547	0.2991	0.7718
IC50	298.4	174.5	473.1	0.3351	0.2114	0.5732

> 100 % (v/v)

Test Acceptability Criteria

Attribute	Test Stat	TAC Limits	Overlap	Decision
Control Resp	28.6	15 - NL	Yes	Passes Acceptability Criteria

Regression Parameters

Parameter	Estimate	Std Error	95% LCL	95% UCL	t Stat	P-Value	Decision(α:5%)
A	29.61	0.9845	27.68	31.54	30.08	<0.0001	Significant Parameter
D	298.4	84.41	132.9	463.9	3.535	0.0007	Significant Parameter

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Model	278.0882	278.0882	1	12.84	0.0006	Significant
Lack of Fit	132.0618	22.0103	6	1.017	0.4211	Non-Significant
Pure Error	1557.8	21.63611	72			
Residual	1689.862	21.6649	78			

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Variances	Mod Levene Equality of Variance	0.871	2.14	0.5337	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.678	0.9691	<0.0001	Non-normal Distribution
	Anderson-Darling A2 Normality	5.836	2.492	<0.0001	Non-normal Distribution

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID: 02-1636-1945 **Endpoint:** Reproduction **CETIS Version:** CETISv1.8.7
Analyzed: 24 Nov-14 11:41 **Analysis:** Nonlinear Regression **Official Results:** Yes

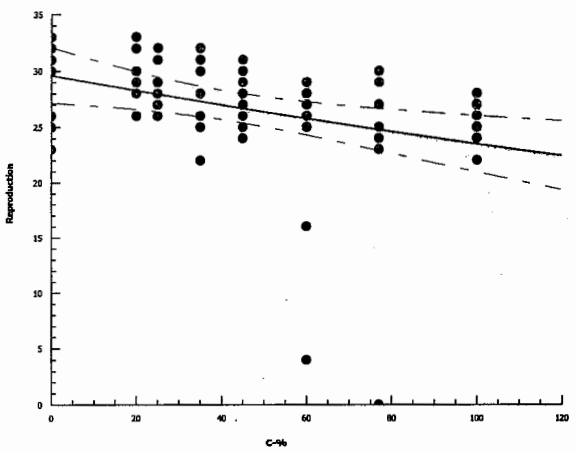
Reproduction Summary

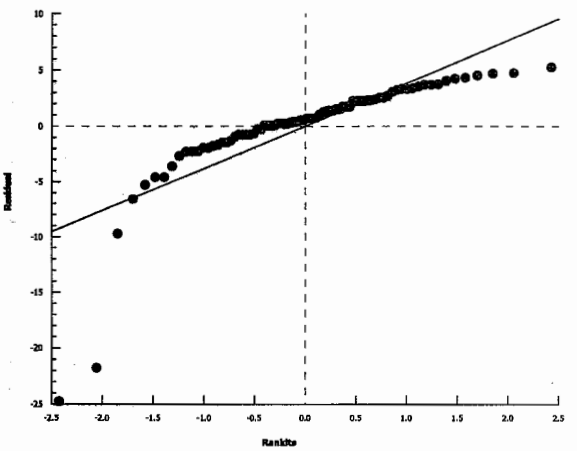
			Calculated Variate						
C-%	Control Type	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Negative Control	10	28.6	23	33	1.108	3.502	12.25%	0.0%
20		10	29.2	26	33	0.7272	2.3	7.88%	-2.1%
25		10	28.3	26	32	0.6155	1.947	6.88%	1.05%
35		10	28.1	22	32	0.9826	3.107	11.06%	1.75%
45		10	27.9	24	31	0.7371	2.331	8.36%	2.45%
60		10	23.7	4	29	2.481	7.846	33.11%	17.13%
77		10	23.1	0	30	2.669	8.439	36.53%	19.23%
100		10	24.9	22	28	0.6227	1.969	7.91%	12.94%

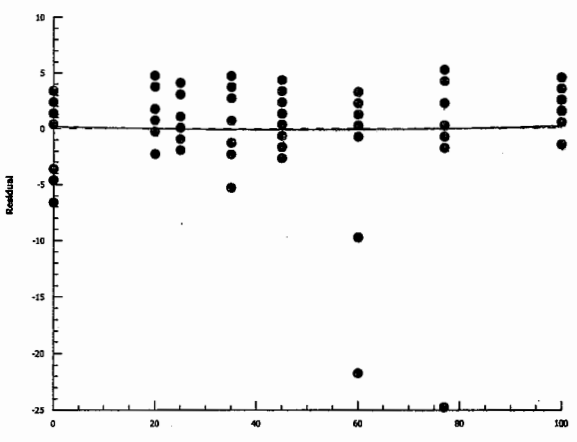
Reproduction Detail

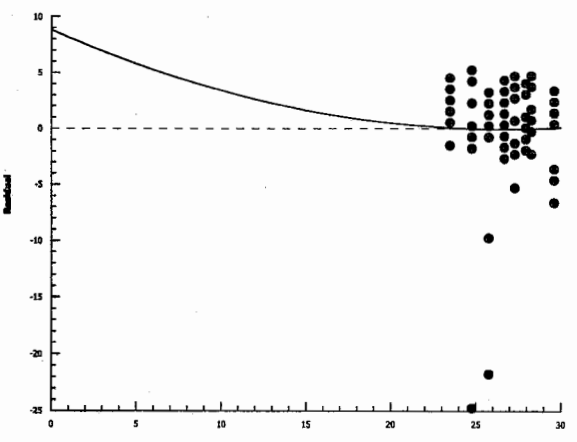
C-%	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	Negative Control	31	25	25	30	33	31	32	30	26	23
20		30	29	28	32	33	28	30	30	26	26
25		28	26	28	28	31	32	26	28	29	27
35		28	30	28	22	28	31	25	32	31	26
45		29	28	30	25	31	24	26	29	30	27
60		28	4	26	27	28	28	25	29	26	16
77		27	24	25	24	24	0	29	30	25	23
100		28	26	24	24	26	22	25	25	22	27

Graphics 2P Exponential EV [Y=A*exp(log(0.5)*X/D)]









CETIS Analytical Report

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	03-4340-5062	**Endpoint:**	6d Survival Rate	**CETIS Version:**	CETISv1.8.7
Analyzed:	24 Nov-14 11:42	**Analysis:**	Single 2x2 Contingency Table	**Official Results:**	Yes
Batch ID:	19-4145-7141	**Test Type:**	Reproduction-Survival (7d)	**Analyst:**	Emma Marus
Start Date:	08 Oct-14 12:00	**Protocol:**	EPA/821/R-02-013 (2002)	**Diluent:**	Site Water
Ending Date:	14 Oct-14 13:00	**Species:**	Ceriodaphnia dubia	**Brine:**	
Duration:	6d 1h	**Source:**	In-House Culture	**Age:**	<24h
Sample ID:	20-9728-7274	**Code:**	7D02106A	**Client:**	Palmer Environmental Consulting Gro
Sample Date:	30 Sep-14 01:00	**Material:**	Water Sample	**Project:**	Casino
Receive Date:	02 Oct-14 10:25	**Source:**	Palmer Environmental Consulting Group		
Sample Age:	8d 11h (2.8 °C)	**Station:**	W18-1		

Data Transform	Zeta	Alt Hyp	Trials	Seed	Test Result
Untransformed		C < T	NA	NA	Passes 6d survival rate

Fisher Exact Test

Control	vs	Control	Test Stat	P-Value	P-Type	Decision(α:5%)
Negative Control		Lab Water	1	1.0000	Exact	Non-Significant Effect

Data Summary

C-%	Control Type	NR	R	NR + R	Prop NR	Prop R	%Effect
0	Lab Water	10	0	10	1	0	0.0%
0	Negative Contr	10	0	10	1	0	0.0%

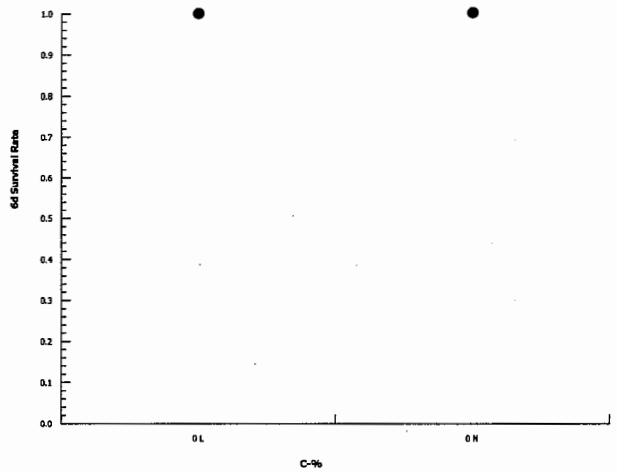
6d Survival Rate Detail

C-%	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	Lab Water	1	1	1	1	1	1	1	1	1	1
0	Negative Control	1	1	1	1	1	1	1	1	1	1

6d Survival Rate Binomials

C-%	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0 ①	Lab Water	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
0	Negative Control	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1

Graphics



① lab water = 20% perner lab control water
- negative control = dilution, unspiked W18-1 water

Ceriodaphnia 7-d Survival and Reproduction Test

Nautilus Environmental

Analysis ID:	07-6719-9584	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv1.8.7
Analyzed:	24 Nov-14 11:42	**Analysis:**	Parametric-Two Sample	**Official Results:**	Yes
Batch ID:	19-4145-7141	**Test Type:**	Reproduction-Survival (7d)	**Analyst:**	Emma Marus
Start Date:	08 Oct-14 12:00	**Protocol:**	EPA/821/R-02-013 (2002)	**Diluent:**	Site Water
Ending Date:	14 Oct-14 13:00	**Species:**	Ceriodaphnia dubia	**Brine:**	
Duration:	6d 1h	**Source:**	In-House Culture	**Age:**	<24h
Sample ID:	20-9728-7274	**Code:**	7D02106A	**Client:**	Palmer Environmental Consulting Gro
Sample Date:	30 Sep-14 01:00	**Material:**	Water Sample	**Project:**	Casino
Receive Date:	02 Oct-14 10:25	**Source:**	Palmer Environmental Consulting Group		
Sample Age:	8d 11h (2.8 °C)	**Station:**	W18-1		

Data Transform	Zeta	Alt Hyp	Trials	Seed	PMSD	Test Result
Untransformed	NA	C < T	NA	NA	8.01%	Passes reproduction

Equal Variance t Two-Sample Test

Control	vs	Control	Test Stat	Critical	MSD	DF	P-Value	P-Type	Decision(α:5%)
Negative Control		Lab Water	-3.105	1.734	2.29	18	0.9969	CDF	Non-Significant Effect

Test Acceptability Criteria

Attribute	Test Stat	TAC Limits	Overlap	Decision
Control Resp	28.6	15 - NL	Yes	Passes Acceptability Criteria
Control Resp	24.5	15 - NL	Yes	Passes Acceptability Criteria
PMSD	0.08006	0.13 - 0.47	Yes	Below Acceptability Criteria

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	84.05	84.05	1	9.642	0.0061	Significant Effect
Error	156.9	8.716666	18			
Total	240.95		19			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Variance Ratio F	2.374	6.541	0.2138	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.9105	0.866	0.0652	Normal Distribution

Reproduction Summary

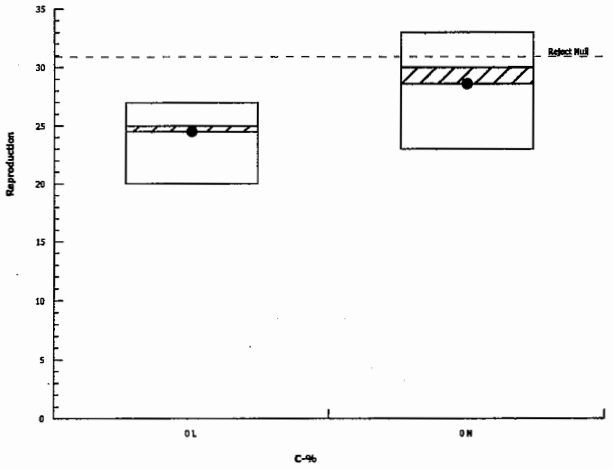
C-%	Control Type	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	Lab Water	10	24.5	22.87	26.13	25	20	27	0.7188	9.28%	0.0%
0	Negative Control	10	28.6	26.09	31.11	30	23	33	1.108	12.25%	-16.73%

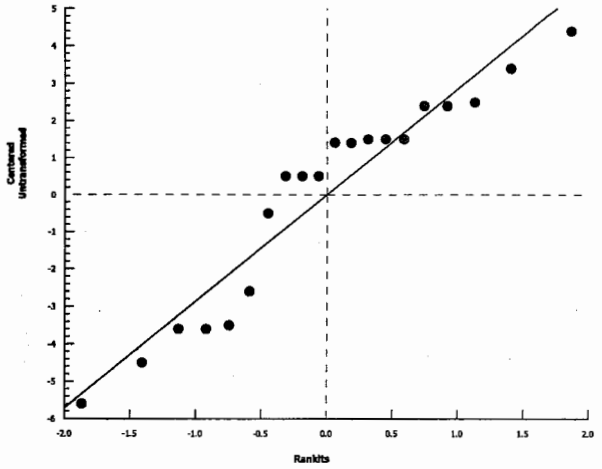
Reproduction Detail

C-%	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	Lab Water	21	25	24	26	27	25	26	25	20	26
0	Negative Control	31	25	25	30	33	31	32	30	26	23

Analysis ID:	07-6719-9584	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv1.8.7
Analyzed:	24 Nov-14 11:42	**Analysis:**	Parametric-Two Sample	**Official Results:**	Yes

Graphics





Client: Palmer Environmental

W.O.#: 14701

Hardness and Alkalinity Datasheet

	Alkalinity						Hardness			
Sample ID	Sample Date	Sample Volume (mL)	(mL) 0.02N HCL/H_2SO_4 used to pH 4.5	(mL) of 0.02N HCL/H_2SO_4 used to pH 4.2	Total Alkalinity ($mg/LCaCO_3$)		Sample Volume (mL)	Volume of 0.01M EDTA Used (mL)	Total Hardness ($mg/L\ CaCO_3$)	Technician
W18-1	Oct 18, 14	50	2.6	2.7	50		50	4.0	80	EC
20% Remedial	Oct 18/14	50	4.0	4.2	76		50	5.0	100	SMM

Notes:

Reviewed by: JGu

Date Reviewed: Nov. 26/14

APPENDIX B - ***Pseudokirchneriella subcapitata*** **Toxicity Test Data**

Pseudokirchneriella subcapitata Summary Sheet

Client: Palmer Environmental
Work Order No.: 14702

Start Date: Oct 16/14
Set up by: EMM

Sample Information:

Sample ID: W18-1
Sample Date: Sept 30/14
Date Received: ~~Oct 21/14~~ em Oct 2/14
Sample Volume: ~~2 x 1~~ 20 L x 1
em

Test Organism Information:

Culture Date: Oct 3/14
Age of culture (Day 0): 7d

Zinc Reference Toxicant Results:

Reference Toxicant ID: SC119
Stock Solution ID: 147-h01
Date Initiated: Oct 3/14

72-h IC50 (95% CL): 24.2 (20.5 – 28.2) µg/L Zn

72-h IC50 Reference Toxicant Mean and Range: 25.4 (14.8 – 43.4) µg/L Zn CV (%): 31

Test Results:

	Algal Growth
IC25 %(v/v) (95% CL)	74.9 (57.1 – 85.2)
IC50 %(v/v) (95% CL)	7100

Reviewed by: JGL

Date reviewed: Nov. 26/14

72-h Algal Growth Inhibition Toxicity Test
Water Quality Measurements

Client : Casino **Setup by:** EMM

Sample ID: WI8Ispiked **Test Date/Time:** OCT 10/14 @ 1700

Work Order No.: 14702 **Test Species:** *Pseudokirchneriella subcapitata*

Culture Date: OCT 3/14 **Age of Culture:** 7d **Culture Health:** Good

Culture Count: 1 432 2 500 **Average:** 466 **Culture Cell Density (c1):** 466x10⁴ cells/mL

v1 = 220,000 cells/ml x 100 ml / (c1) 466x10⁴ cells/ml = 4.8mL

Time Zero Counts: 1 20 2 25 **Average:** 22.5

No. of Cells/mL: 22.5x10⁴ **Initial Density:** # cells/mL ÷ 220 µL x 10 µL = 10227cells/mL

Concentration %(v/v)	Water Quality Measurements					Microplates rotated 2X per day?			
	pH	Temp (°C)							
	0 h	0 h	24 h	48 h	72 h	0 h	24 h	48 h	72 h
Control Lab	6.8	24.0	25.5	25.0	25.0	✓	✓	✓	✓
WI8 control (unspiked)	7.2	24.0				✓	✓	✓	✓
20% spiked	7.3	24.0				✓	✓	✓	✓
25% spiked	7.2	24.0				✓	✓	✓	✓
35% spiked	7.2	24.0				✓	✓	✓	✓
45% spiked	7.0	24.0				✓	✓	✓	✓
60% spiked	7.3	24.0				✓	✓	✓	✓
77% spiked	7.3	24.0				✓	✓	✓	✓
100% spiked	7.4	24.0	✓	✓	✓	✓	✓	✓	✓
Initials	EMM	EMM	~	~	EMM	EMM	~	~	EMM

Initial control pH: Well 1: 6.8 Well 2: 6.8

Final control pH: Well 1: 7.0 Well 2: 7.0

Light intensity (lux): 3900 **Date measured:** OCT 10/14

Sample Description: WI8-1 spiked, and diluted w/ unspike site WI8 water with metal mixture

Comments:

Reviewed: JGL **Date reviewed:** NOV-26/14

Pseudokirchneriella subcapitata Toxicity Test Data Sheet
72-h Algal Cell Counts

Client: casino
Work Order #: 14702
Sample ID: WL8-1 spiked
%(v/v)

Start Date/Time: OCT 13/14 @ 1730h
Termination Date: OCT 13/14 @ 1730h
Test set up by: EMM

Concentration	Rep	Count 1	Count 2	Count 3	Count 4	Comments	Initials
Control lab (CO.FW/ nutrients)	A	60					EMM
	B	57					
	C	59					
	D	61					
	E	52					
	F	60					
	G	53					
	H	54					
WL8-1 control (site-unspiked) diluted water	A	164					
	B	192					
	C	159					
	D	164					
	E (A)	180					
	F (B)	173					
	G (C)	179					
	H (D)	170					
20% spiked WL8-1	A	162					
	B	173					
	C	149					
	D	140					
25% spiked WL8-1	A	158					
	B	169					
	C	177					
	D	158					
35% spiked WL8-1	A	129					
	B	118					
	C	138					
	D	145					
45% spiked WL8-1	A	156					
	B	147					
	C	140					
	D	172					
60% spiked WL8-1	A	145					
	B	159					
	C	120					
	D	155					

Comments:

Reviewed by: [illegible] Date Reviewed: Nov. 26/14

Pseudokirchneriella subcapitata Toxicity Test Data Sheet
72-h Algal Cell Counts

Client: Casino
Start Date/Time: OCT10/14 @ 1700h
Work Order #: W18 spiked
Termination Date: OCT13/14 @ 1700h
Sample ID: 14702
Test set up by: EMM

%(v/v)

Concentration	Rep	Count 1	Count 2	Count 3	Count 4	Comments	Initials
Control	A						E
	B						
	C						
	D						
	E						
	F						
	G						
	H						
77% spiked W18-1	A	113					EMM
	B	141					
	C	130					
	D	128					
100% spiked W18-1	A	88					
	B	95					
	C	109					
	D	69	74				
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						

Comments:

Reviewed by: JOL
Date Reviewed: Nov. 26/14

Pseudokirchneriella subcapitata Algal Counts

Client: Palmer Environmental
WO#: 14702
Sample ID: W18-1 spiked
(diluted with unspiked W18-1)

Start Date/Time: 10-Oct-14 @ 1700h
Termination Date: 13-Oct-14 @ 1700h
Initial Cell Density: 10227 cell/mL

225000
0.22
0.01
10227.27

Concentrat % v/v	Rep	Count 1 (x 10^4)	Count 2 (x 10^4)	Count 3 (x 10^4)	Count 4 (x 10^4)	Mean (x 10^4)	Cell Yield (x 10^4) cell/mL		
Lab Control	A	60				60	59.0	mean	55.4
	B	52				52	51.0	SD	3.961872
	C	59				59	58.0	CV	7.157559
	D	61				61	60.0		
	E	52				52	51.0		
	F	60				60	59.0		
	G	53				53	52.0		
	H	54				54	53.0		
Site Control (unspiked W18-1)	A	164				164	163.0	mean	171.6
	B	192				192	191.0	SD	10.7695
	C	159				159	158.0	CV	6.27585
	D	164				164	163.0		
	E	180				180	179.0		
	F	173				173	172.0		
	G	179				179	178.0		
	H	170				170	169.0		
20	A	162				162	161.0		
	B	173				173	172.0		
	C	149				149	148.0		
	D	140				140	139.0		
25	A	158				158	157.0		
	B	169				169	168.0		
	C	177				177	176.0		
	D	158				158	157.0		
35	A	129				129	128.0		
	B	118				118	117.0		
	C	138				138	137.0		
	D	145				145	144.0		
45	A	156				156	155.0		
	B	147				147	146.0		
	C	140				140	139.0		
	D	172				172	171.0		
60	A	145				145	144.0		
	B	159				159	158.0		
	C	120				120	119.0		
	D	155				155	154.0		
77	A	113				113	112.0		
	B	141				141	140.0		
	C	130				130	129.0		
	D	128				128	127.0		
100	A	88				88	87.0		
	B	95				95	94.0		
	C	109				109	108.0		
	D	69	74			71.5	70.5		

Nov-26/14

CETIS Analytical Report

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	02-6882-3382	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	24 Nov-14 11:16	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes
Batch ID:	15-3528-0311	**Test Type:**	Cell Growth	**Analyst:**	Emma Marus
Start Date:	10 Oct-14 17:00	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Site Water
Ending Date:	13 Oct-14 17:00	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	7d
Sample ID:	20-9728-7274	**Code:**	7D02106A	**Client:**	Palmer Environmental Consulting Gro
Sample Date:	30 Sep-14 01:00	**Material:**	Water Sample	**Project:**	Casino
Receive Date:	02 Oct-14 10:25	**Source:**	Palmer Environmental Consulting Group		
Sample Age:	10d 16h (2.8 °C)	**Station:**	W18-1		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	1867945	200	Yes	Two-Point Interpolation

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Control Trend	Mann-Kendall Trend			0.9049	Non-significant Trend in Controls

Point Estimates

Level	%	95% LCL	95% UCL	TU	95% LCL	95% UCL
IC5	8.026	N/A	40.18	12.46	2.489	NA
IC10	27.76	5.672	36.52	3.603	2.738	17.63
IC15	32.86	27.64	82.76	3.043	1.208	3.618
IC20	65.36	15.72	84.06	1.53	1.19	6.36
IC25	74.92	57.12	85.25	1.335	1.173	1.751
IC40	91.15	82.3	103.6	1.097	0.9655	1.215
IC50	>100	N/A	N/A	<1	NA	NA

Cell Yield Summary

			Calculated Variate						
C-%	Control Type	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Negative Control	8	171.6	158	191	3.808	10.77	6.28%	0.0%
20		4	155	139	172	7.246	14.49	9.35%	9.69%
25		4	164.5	157	176	4.628	9.256	5.63%	4.15%
35		4	131.5	117	144	5.838	11.68	8.88%	23.38%
45		4	152.8	139	171	6.909	13.82	9.05%	11.0%
60		4	143.8	119	158	8.76	17.52	12.19%	16.24%
77		4	127	112	140	5.759	11.52	9.07%	26.0%
100		4	89.75	70	108	7.899	15.8	17.6%	47.71%

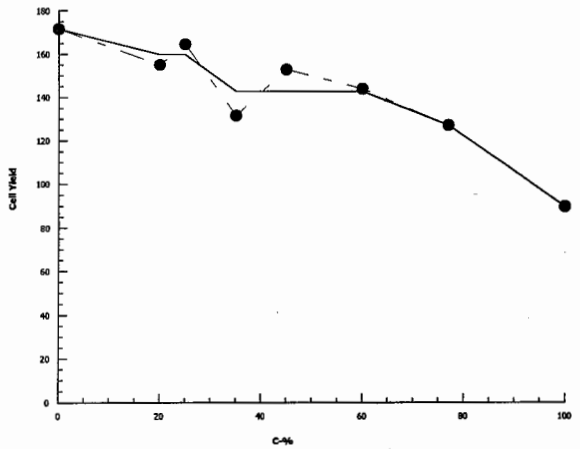
Cell Yield Detail

C-%	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	Negative Control	163	191	158	163	179	172	178	169
20		161	172	148	139				
25		157	168	176	157				
35		128	117	137	144				
45		155	146	139	171				
60		144	158	119	154				
77		112	140	129	127				
100		87	94	108	70				

EC Alga Growth Inhibition Test **Nautilus Environmental**

Analysis ID:	02-6882-3382	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	24 Nov-14 11:16	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Graphics



CETIS Analytical Report

EC Alga Growth Inhibition Test

Nautilus Environmental

Analysis ID:	12-1115-3751	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	24 Nov-14 11:18	**Analysis:**	Parametric-Two Sample	**Official Results:**	Yes
Batch ID:	15-3528-0311	**Test Type:**	Cell Growth	**Analyst:**	Emma Marus
Start Date:	10 Oct-14 17:00	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Site Water
Ending Date:	13 Oct-14 17:00	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	7d
Sample ID:	20-9728-7274	**Code:**	7D02106A	**Client:**	Palmer Environmental Consulting Gro
Sample Date:	30 Sep-14 01:00	**Material:**	Water Sample	**Project:**	Casino
Receive Date:	02 Oct-14 10:25	**Source:**	Palmer Environmental Consulting Group		
Sample Age:	10d 16h (2.8 °C)	**Station:**	W18-1		

Data Transform	Zeta	Alt Hyp	Trials	Seed	PMSD	Test Result
Untransformed	NA	C < T	NA	NA	4.16%	Passes cell yield

Equal Variance t Two-Sample Test

Control	vs	Control	Test Stat	Critical	MSD	DF	P-Value	P-Type	Decision(α:5%)
Negative Control		Lab Water	-28.65	1.761	7.146	14	1.0000	CDF	Non-Significant Effect

Auxiliary Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:5%)
Control Trend	Mann-Kendall Trend			0.9049	Non-significant Trend in Controls

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	54056.25	54056.25	1	821	<0.0001	Significant Effect
Error	921.75	65.83929	14			
Total	54978		15			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Variance Ratio F	7.389	8.885	0.0171	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.9571	0.8408	0.6092	Normal Distribution

Cell Yield Summary

C-%	Control Type	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	Lab Water	8	55.38	52.06	58.69	55.5	51	60	1.401	7.16%	0.0%
0	Negative Control	8	171.6	162.6	180.6	170.5	158	191	3.808	6.28%	-209.9%

Cell Yield Detail

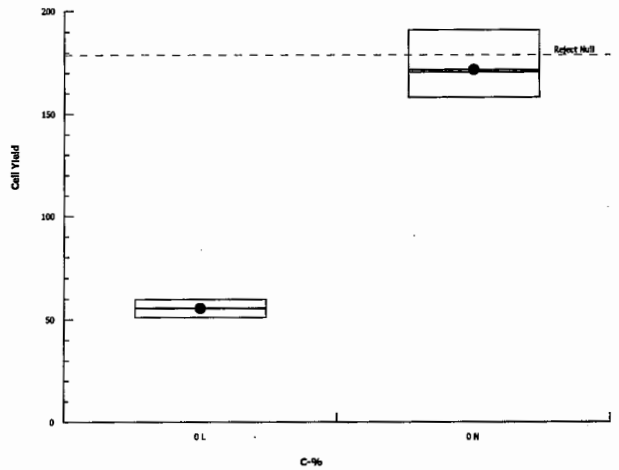
C-%	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	Lab Water	59	51	58	60	51	59	52	53
0 ①	Negative Control	163	191	158	163	179	172	178	169

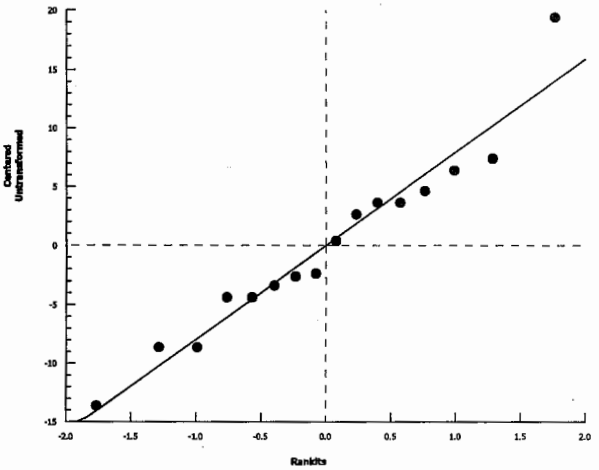
① lab water = 20% perner lab control water
negative control = dilution, unspiked W18-1 water

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	12-1115-3751	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	24 Nov-14 11:18	**Analysis:**	Parametric-Two Sample	**Official Results:**	Yes

Graphics





APPENDIX C – Analytical Results

NAUTILUS ENVIRONMENTAL
ATTN: Emma Marcus
8664 Commerce Court
Imperial Square Lake City
Burnaby BC V5A 4N7

Date Received: 30-OCT-14
Report Date: 04-NOV-14 14:22 (MT)
Version: FINAL

Client Phone: 604-420-8773

Certificate of Analysis

Lab Work Order #: L1540861

Project P.O. #: NOT SUBMITTED
Job Reference:
C of C Numbers: 1
Legal Site Desc:



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ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1540861-1 Water 08-OCT-14 REGULAR CTRL	L1540861-2 Water 08-OCT-14 W18 CONTROL	L1540861-3 Water 08-OCT-14 20% W18 SPIKED	L1540861-4 Water 08-OCT-14 25% W18 SPIKED	L1540861-5 Water 08-OCT-14 35% W18 SPIKED
Sample ID / Description / Sampled Date / Sampled Time / Client ID						
WATER						
Physical Tests	Hardness (as CaCO3) (mg/L)	102	70.1	198	214	273
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)	96.3	62.1	65.7	67.2	66.7
	Chloride (Cl) (mg/L)	5.46	<0.50	3.84	4.72	6.23
	Fluoride (F) (mg/L)	0.026	0.036	0.225	0.275	0.355
	Sulfate (SO4) (mg/L)	7.95	20.8	137	162	209
Total Metals	Aluminum (Al)-Total (mg/L)	0.0062	0.0727	0.0866	0.0962	0.0951
	Antimony (Sb)-Total (mg/L)	<0.00010	0.00014	0.00014	0.00014	0.00015
	Arsenic (As)-Total (mg/L)	<0.00010	0.00037	0.00039	0.00038	0.00042
	Barium (Ba)-Total (mg/L)	0.00622	0.0406	0.0416	0.0408	0.0423
	Beryllium (Be)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Bismuth (Bi)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Boron (B)-Total (mg/L)	0.012	<0.010	<0.010	<0.010	<0.010
	Cadmium (Cd)-Total (mg/L)	<0.000050	<0.000050	0.000151	0.000154	0.000228
	Calcium (Ca)-Total (mg/L)	39.2	19.0	67.4	73.9	95.9
	Chromium (Cr)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Cobalt (Co)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Copper (Cu)-Total (mg/L)	0.00056	0.00118	0.00551	0.00632	0.00828
	Iron (Fe)-Total (mg/L)	<0.030	0.055	0.046	0.054	0.046
	Lead (Pb)-Total (mg/L)	<0.000050	<0.000050	0.000061	0.000077	0.000079
	Lithium (Li)-Total (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
	Magnesium (Mg)-Total (mg/L)	1.04	5.48	7.18	7.21	8.14
	Manganese (Mn)-Total (mg/L)	0.000127	0.00390	0.185	0.221	0.302
	Molybdenum (Mo)-Total (mg/L)	0.000223	0.00129	0.0272	0.0348	0.0490
	Nickel (Ni)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Phosphorus (P)-Total (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Total (mg/L)	<2.0	<2.0	<2.0	<2.0	<2.0
	Selenium (Se)-Total (mg/L)	0.0047	<0.0010	<0.0010	0.0011	0.0015
	Silicon (Si)-Total (mg/L)	1.13	5.42	5.64	5.42	5.59
	Silver (Ag)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Total (mg/L)	2.5	3.2	6.9	7.4	9.1
	Strontium (Sr)-Total (mg/L)	0.161	0.107	0.121	0.130	0.148
	Thallium (Tl)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Tin (Sn)-Total (mg/L)	0.00028	<0.00010	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Total (mg/L)	<0.010	<0.010	0.011	0.012	0.014
	Uranium (U)-Total (mg/L)	0.000791	0.00272	0.00265	0.00269	0.00282
	Vanadium (V)-Total (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Zinc (Zn)-Total (mg/L)	<0.0030	0.0044	0.0044	0.0048	0.0043

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1540861-6 Water 08-OCT-14 45% W18 SPIKED	L1540861-7 Water 08-OCT-14 60% W18 SPIKED	L1540861-8 Water 08-OCT-14 77% W18 SPIKED	L1540861-9 Water 08-OCT-14 100% W18 SPIKED	
WATER						
Physical Tests	Hardness (as CaCO3) (mg/L)	333	413	511	659	
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)	64.5	67.5	67.7	68.9	
	Chloride (Cl) (mg/L)	8.22	13.7	15.8	18.8	
	Fluoride (F) (mg/L)	0.461	0.55	0.68	0.87	
	Sulfate (SO4) (mg/L)	266	356	441	581	
Total Metals	Aluminum (Al)-Total (mg/L)	0.0967	0.111	0.151	0.118	
	Antimony (Sb)-Total (mg/L)	0.00015	0.00015	0.00015	0.00015	
	Arsenic (As)-Total (mg/L)	0.00041	0.00043	0.00044	0.00046	
	Barium (Ba)-Total (mg/L)	0.0419	0.0402	0.0416	0.0425	
	Beryllium (Be)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	
	Bismuth (Bi)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	
	Boron (B)-Total (mg/L)	<0.010	<0.010	<0.010	<0.010	
	Cadmium (Cd)-Total (mg/L)	0.000319	0.000383	0.000553	0.000659	
	Calcium (Ca)-Total (mg/L)	118	149	186	242	
	Chromium (Cr)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	
	Cobalt (Co)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	
	Copper (Cu)-Total (mg/L)	0.0104	0.0139	0.0167	0.0199	
	Iron (Fe)-Total (mg/L)	0.046	0.045	0.067	0.097	
	Lead (Pb)-Total (mg/L)	0.000077	0.000103	0.000188	0.000147	
	Lithium (Li)-Total (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	
	Magnesium (Mg)-Total (mg/L)	9.02	9.91	11.4	13.1	
	Manganese (Mn)-Total (mg/L)	0.401	0.527	0.691	0.883	
	Molybdenum (Mo)-Total (mg/L)	0.0640	0.0857	0.113	0.146	
	Nickel (Ni)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	
	Phosphorus (P)-Total (mg/L)	<0.30	<0.30	<0.30	<0.30	
	Potassium (K)-Total (mg/L)	<2.0	<2.0	2.0	2.3	
	Selenium (Se)-Total (mg/L)	0.0020	0.0026	0.0035	0.0046	
	Silicon (Si)-Total (mg/L)	5.56	5.45	5.67	5.62	
	Silver (Ag)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	
	Sodium (Na)-Total (mg/L)	11.1	13.4	16.7	20.4	
	Strontium (Sr)-Total (mg/L)	0.157	0.169	0.191	0.220	
	Thallium (Tl)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	
	Tin (Sn)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	
	Titanium (Ti)-Total (mg/L)	0.015	0.018	0.021	0.024	
	Uranium (U)-Total (mg/L)	0.00276	0.00272	0.00280	0.00283	
	Vanadium (V)-Total (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	
	Zinc (Zn)-Total (mg/L)	0.0041	0.0043	0.0051	0.0048	

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-COL-VA	Water	Alkalinity by Colourimetric (Automated)	EPA 310.2
This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.			
ANIONS-CL-IC-VA	Water	Chloride by Ion Chromatography	APHA 4110 B.
This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".			
ANIONS-F-IC-VA	Water	Fluoride by Ion Chromatography	APHA 4110 B.
This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".			
ANIONS-SO4-IC-VA	Water	Sulfate by Ion Chromatography	APHA 4110 B.
This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".			
HARDNESS-CALC-VA	Water	Hardness	APHA 2340B
Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.			
MET-TOT-ICP-VA	Water	Total Metals in Water by ICPOES	EPA SW-846 3005A/6010B
This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).			
MET-TOT-LOW-MS-VA	Water	Total Metals in Water by ICPMS(Low)	EPA SW-846 3005A/6020A
This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - mass spectrometry (EPA Method 6020A).			

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

1

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Nautilus Environmental

BRITISH COLUMBIA
8664 Commerce Court
Burnaby British Columbia Canada
Phone 604.420.8773
Fax 604.357.1361

L1540861-COFC

Chain of Custody

1200

Date Oct 30/14 Page 1 of 1

Sample Collection by: _____

Report to:
Company Nautilus Environmental
Address (1)
City _____ Prov. _____ PC _____
Contact emma@nautilusenvironmental.com
Phone No. _____

Invoice to:
Company same as report to
Address _____
City _____ Prov. _____ PC _____
Contact _____
Phone No. +lisa@nautilusenvironmental.com

SAMPLE ID	DATE	TIME	MATRIX	CONTAINER TYPE	NUMBER OF CONTAINERS	COMMENTS	ANALYSIS REQUIRED: low level metals	sulphate	chloride	fluoride	alkalinity	RECEIPT TEMPERATURE (°C)
regular ctrl	oct8/14	~	water	125mL plastic	1	Day 0 - ceiling	X	X	X	X	X	
WB control												
20% WB spiked												
25% WB spiked												
35% WB spiked												
45% WB spiked												
60% WB spiked												
77% WB spiked												
100% WB spiked												

PROJECT INFORMATION	SAMPLE RECEIPT
CLIENT	TOTAL NO. OF CONTAINERS
P.O. NO.	REC'D GOOD CONDITION
SHIPPED VIA:	

SPECIAL INSTRUCTIONS/COMMENTS:

please RUSH analysis

RELINQUISHED BY (CLIENT)	RELINQUISHED BY (COURIER)
(Signature) (Time)	(Signature) (Time)
(Printed Name) EMMA MANS (Date)	(Printed Name) (Date)
(Company) (1)	(Company)
RECEIVED BY (COURIER)	**RECEIVED BY (LABORATORY)** Slater
(Signature) (Time)	(Signature) 19:05 (Time)
(Printed Name) (Date)	(Printed Name) Oct. 30 (Date)
(Company)	12°C

Additional costs may be required for sample disposal or storage. Net 30 unless otherwise contracted.

DISTRIBUTION: WHITE - Nautilus Environmental, COLOR - Originator

APPENDIX D Chain–of-Custody Form

Nautilus Environmental

BRITISH COLUMBIA
8664 Commerce Court
Burnaby British Columbia Canada V5A 4N7
Phone 604.420.8773
Fax 604.357.1361

Chain of Custody
1183

Date _____ Page _____ of _____

Sample Collection by: May Quach

Report to:
Company: Palmer Environmental Consulting Group
Address:
City: Prov. PC
Contact: May Quach
Phone No.: 604 837 1858

Invoice to:
Company: Same as Report to
Address:
City: Prov. PC
Contact:
Phone No.:

SAMPLE ID	DATE	TIME	MATRIX	CONTAINER TYPE	NUMBER OF CONTAINERS	COMMENTS	7-d C.dubia	72-h P.subcapitata	RECEIPT TEMPERATURE (°C)
② W18-1	Sept 30/14	1300	Water	20L	~~21~~ ①	Hold for testing until chem is done	X	X	2.8
② W18-2	↓	↓	↓	↓	↓	↓	X	X	3.0
(W18-1 and W18-2 are same sample as ~~identified~~ confirmed by client; project manager)									
							WO#14701	WO#14702	

PROJECT INFORMATION	SAMPLE RECEIPT	
CLIENT	TOTAL NO. OF CONTAINERS	2
P.O. NO.	REC'D GOOD CONDITION	No ①
SHIPPED VIA:		

SPECIAL INSTRUCTIONS/COMMENTS:
① Carboy for W18-1 leaking, W18-2 O.K. transferred to 20-L pail
② W18-1 and W18-2 are same sample as confirmed by client.

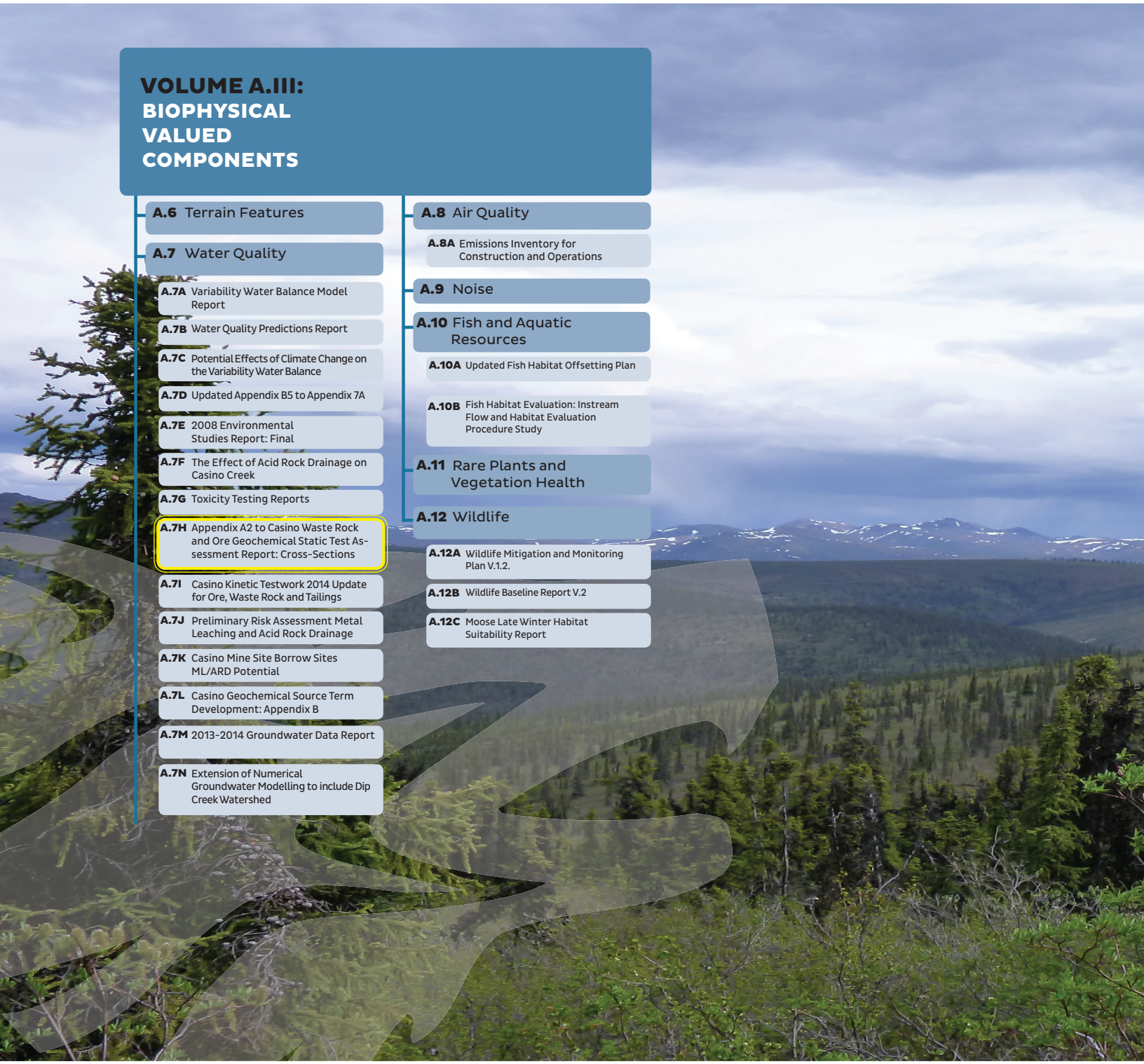
RELINQUISHED BY (CLIENT)		RELINQUISHED BY (COURIER)	
(Signature)	(Time)	(Signature)	(Time)
(Printed Name)	(Date)	(Printed Name)	(Date)
(Company)		(Company)	

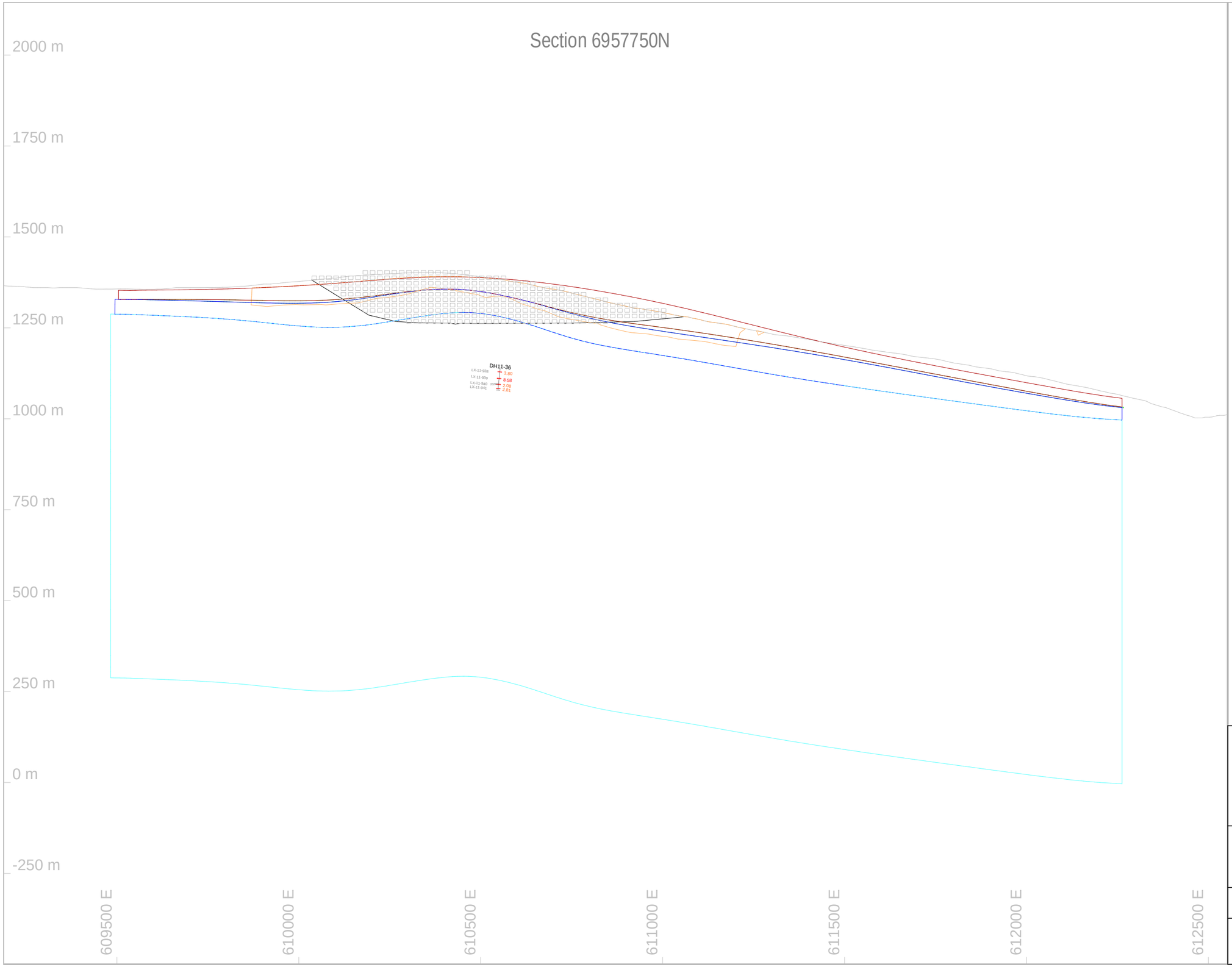
RECEIVED BY (COURIER)		RECEIVED BY (LABORATORY)	
(Signature)	(Time)	(Signature) Krysta Pearcy	(Time) 1025
(Printed Name)	(Date)	(Printed Name) Krysta Pearcy	(Date) Oct 2/14
(Company)			

Additional costs may be required for sample disposal or storage. Net 30 unless otherwise contracted.

DISTRIBUTION: WHITE - Nautilus Environmental, COLOR - Originator

APPENDIX A.7H: Appendix A2 to Casino Waste Rock and Ore Geochemical Static Test Assessment Report: Cross Sections





Mineralized Zone
- CAP
- SOX
- SUS
- HYP

Alteration
- POT
- PRO
- ARG

Rinse pH (bar on left)
- < 5.0
- 5.0 - 6.4
- 6.4 - 7.0
- > 7.0

CANP/AP (centre bar)
- < 1.0
- 1.0 - 2.0
- > 2.0

Total S% (text on right)
- 0.0 - 0.1
- 0.1 - 0.5
- 0.5 - 1.0
- 1.0 - 5.0
- 5.0 - 10.0
- 10.0 - 100

PFS Material Routing (blocks)
- Overburden
- Leach Cap Gold Ore
- Leach Cap Potential Ore
- Sox Stockpile Ore
- Low Grade Stockpile
- Direct Feed Ore
- Waste

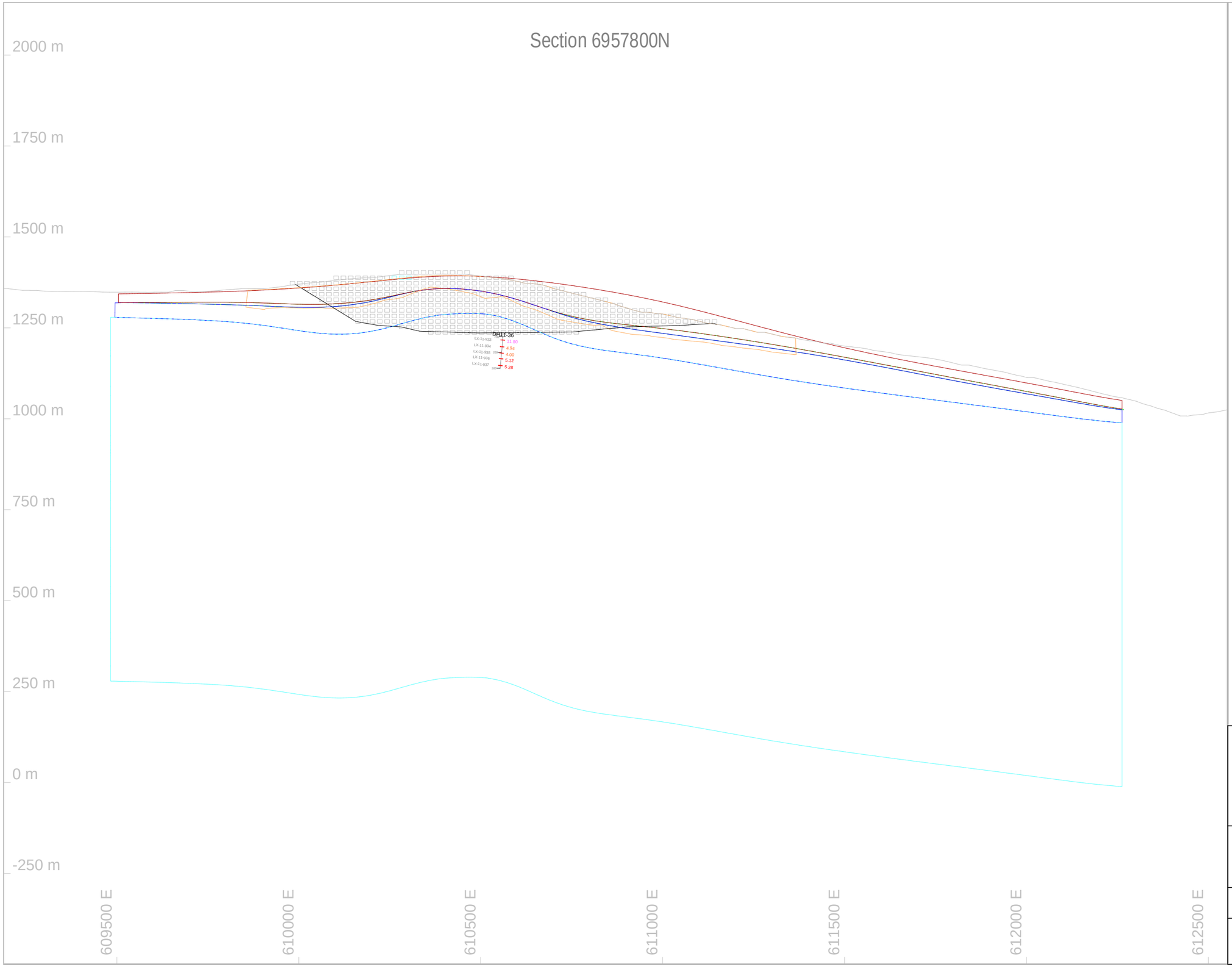
Casino Project

Lorax Environmental Services:
ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 21, 2014



Mineralized Zone
- CAP
- SOX
- SUS
- HYP

Alteration
- POT
- PRO
- ARG

Rinse pH (bar on left)
- < 5.0
- 5.0 - 6.4
- 6.4 - 7.0
- > 7.0

CANP/AP (centre bar)
- < 1.0
- 1.0 - 2.0
- > 2.0

Total S% (text on right)
- 0.0 - 0.1
- 0.1 - 0.5
- 0.5 - 1.0
- 1.0 - 5.0
- 5.0 - 10.0
- 10.0 - 100

PFS Material Routing (blocks)
- Overburden
- Leach Cap Gold Ore
- Leach Cap Potential Ore
- Sox Stockpile Ore
- Low Grade Stockpile
- Direct Feed Ore
- Waste

Casino Project

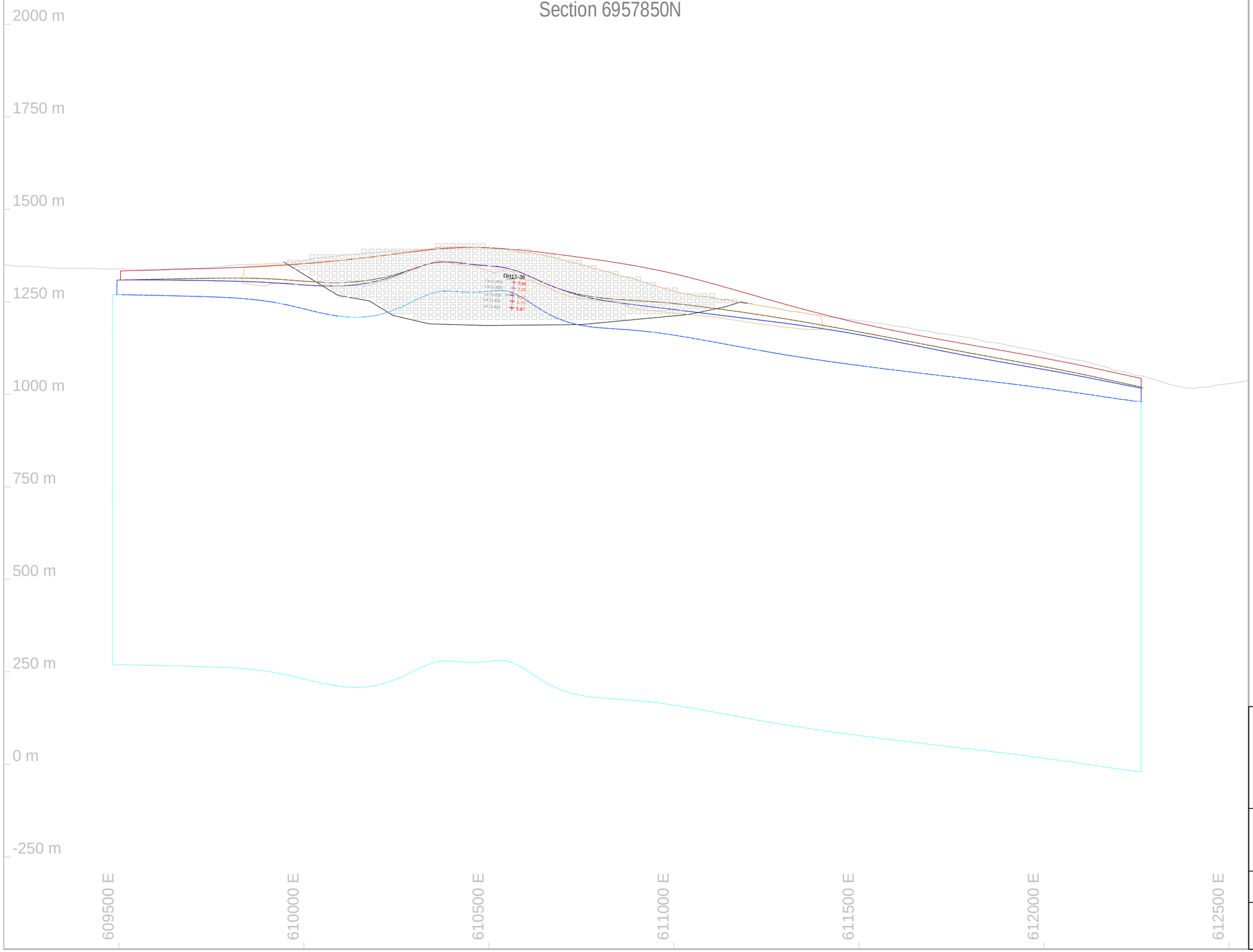
Lorax Environmental Services:
ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 21, 2014

Section 6957850N



Mineralized Zone

CAP	
SOX	
SUS	
HYP	

Alteration

POT	
PRO	
ARG	

Rinse pH (bar on left)

< 5.0	
5.0 - 6.4	
6.4 - 7.0	
> 7.0	

CANP/AP (centre bar)

< 1.0	
1.0 - 2.0	
> 2.0	

Total S% (text on right)

0.0 - 0.1	
0.1 - 0.5	
0.5 - 1.0	
1.0 - 5.0	
5.0 - 10.0	
10.0 - 100	

PFS Material Routing (blocks)

Overburden	
Leach Cap Gold Ore	
Leach Cap Potential Ore	
Sox Stockpile Ore	
Low Grade Stockpile	
Direct Feed Ore	
Waste	

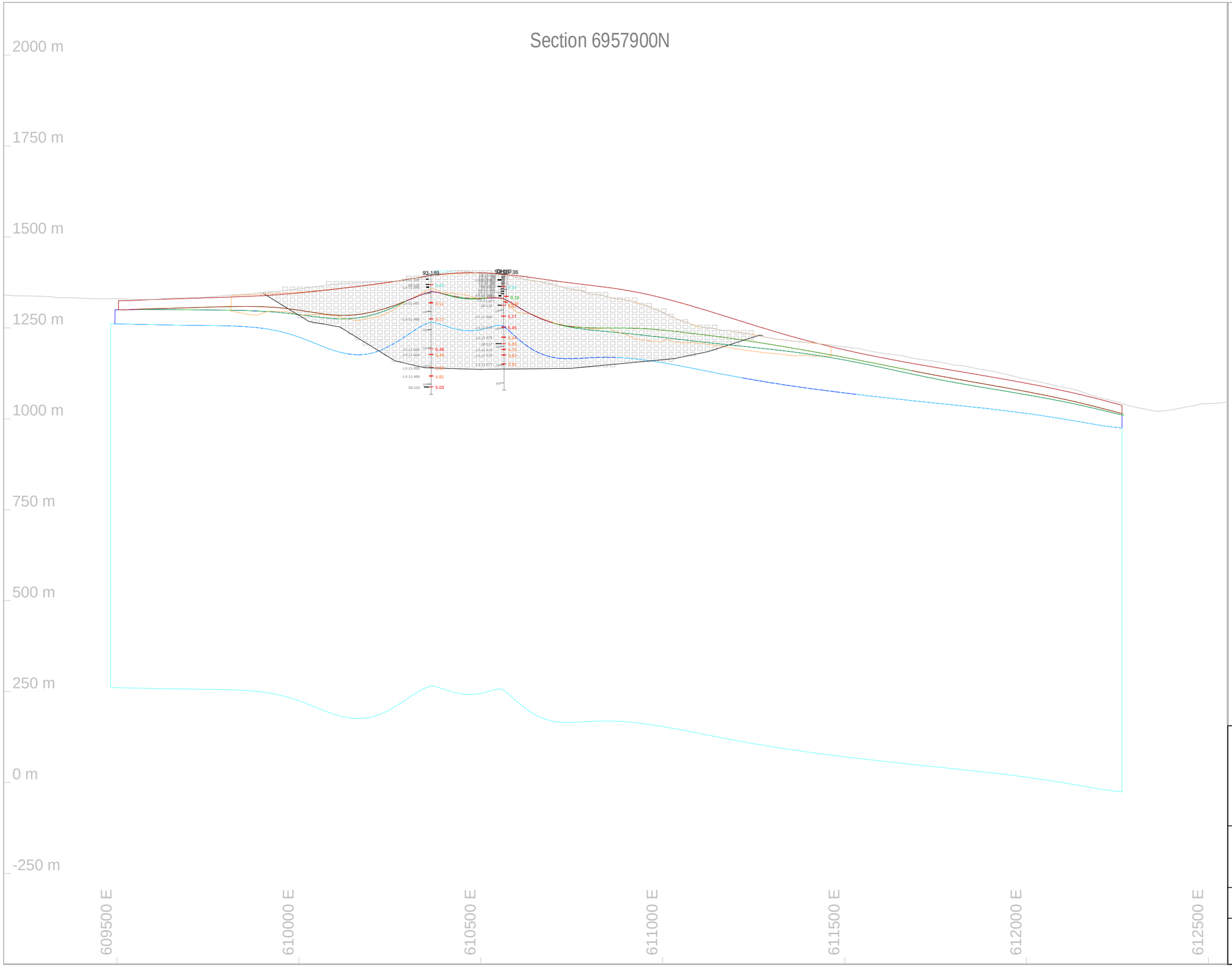
Casino Project

Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 21, 2014



Mineralized Zone
- CAP
- SOX
- SUS
- HYP

Alteration
- POT
- PRO
- ARG

Rinse pH (bar on left)
- < 5.0
- 5.0 - 6.4
- 6.4 - 7.0
- > 7.0

CANP/AP (centre bar)
- < 1.0
- 1.0 - 2.0
- > 2.0

Total S% (text on right)
- 0.0 - 0.1
- 0.1 - 0.5
- 0.5 - 1.0
- 1.0 - 5.0
- 5.0 - 10.0
- 10.0 - 100

PFS Material Routing (blocks)
- Overburden
- Leach Cap Gold Ore
- Leach Cap Potential Ore
- Sox Stockpile Ore
- Low Grade Stockpile
- Direct Feed Ore
- Waste

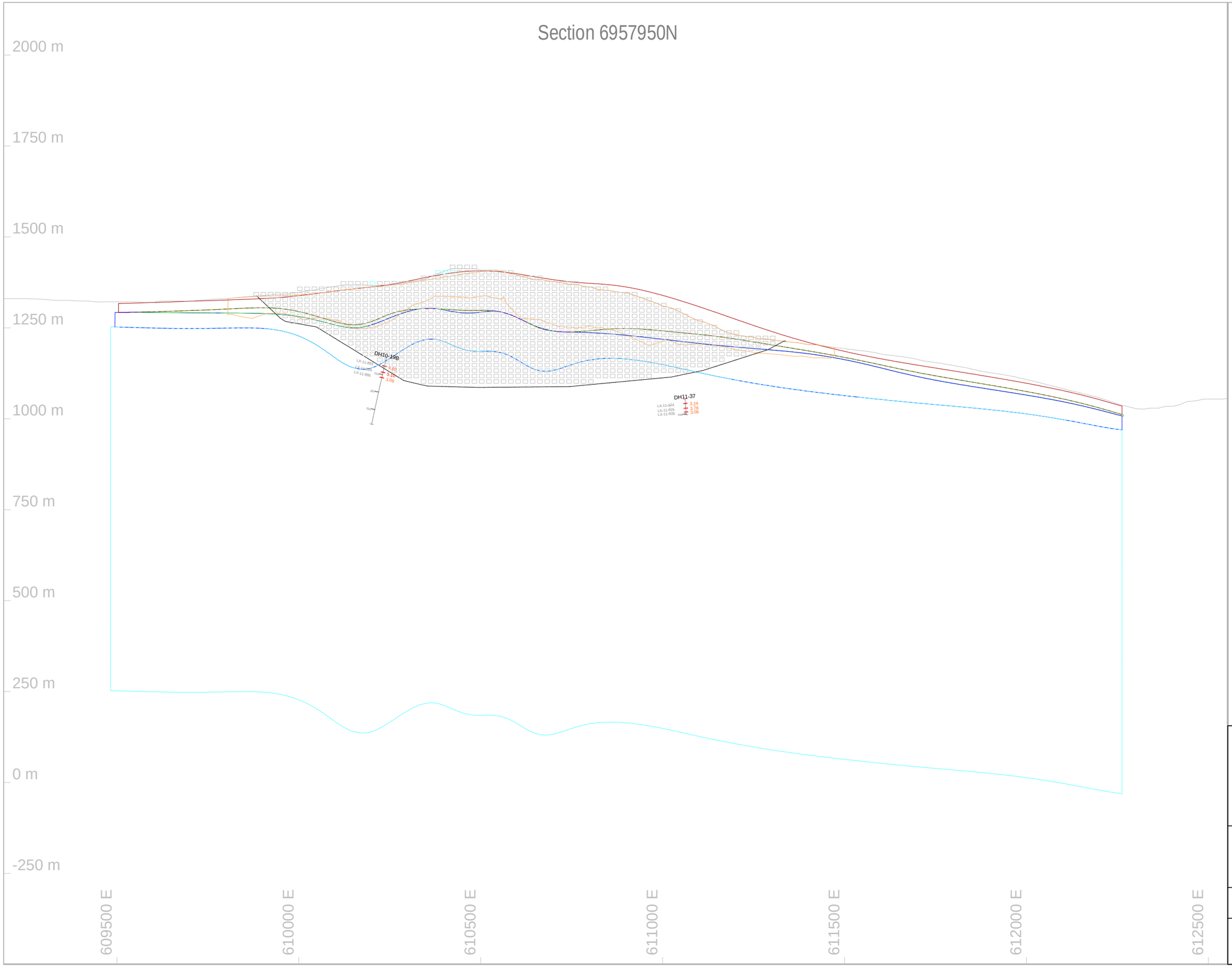
Casino Project

Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 21, 2014



Mineralized Zone

CAP	
SOX	
SUS	
HYP	

Alteration

POT	
PRO	
ARG	

Rinse pH (bar on left)

< 5.0	
5.0 - 6.4	
6.4 - 7.0	
> 7.0	

CANP/AP (centre bar)

< 1.0	
1.0 - 2.0	
> 2.0	

Total S% (text on right)

0.0 - 0.1	
0.1 - 0.5	
0.5 - 1.0	
1.0 - 5.0	
5.0 - 10.0	
10.0 - 100	

PFS Material Routing (blocks)

Overburden	
Leach Cap Gold Ore	
Leach Cap Potential Ore	
Sox Stockpile Ore	
Low Grade Stockpile	
Direct Feed Ore	
Waste	

Casino Project

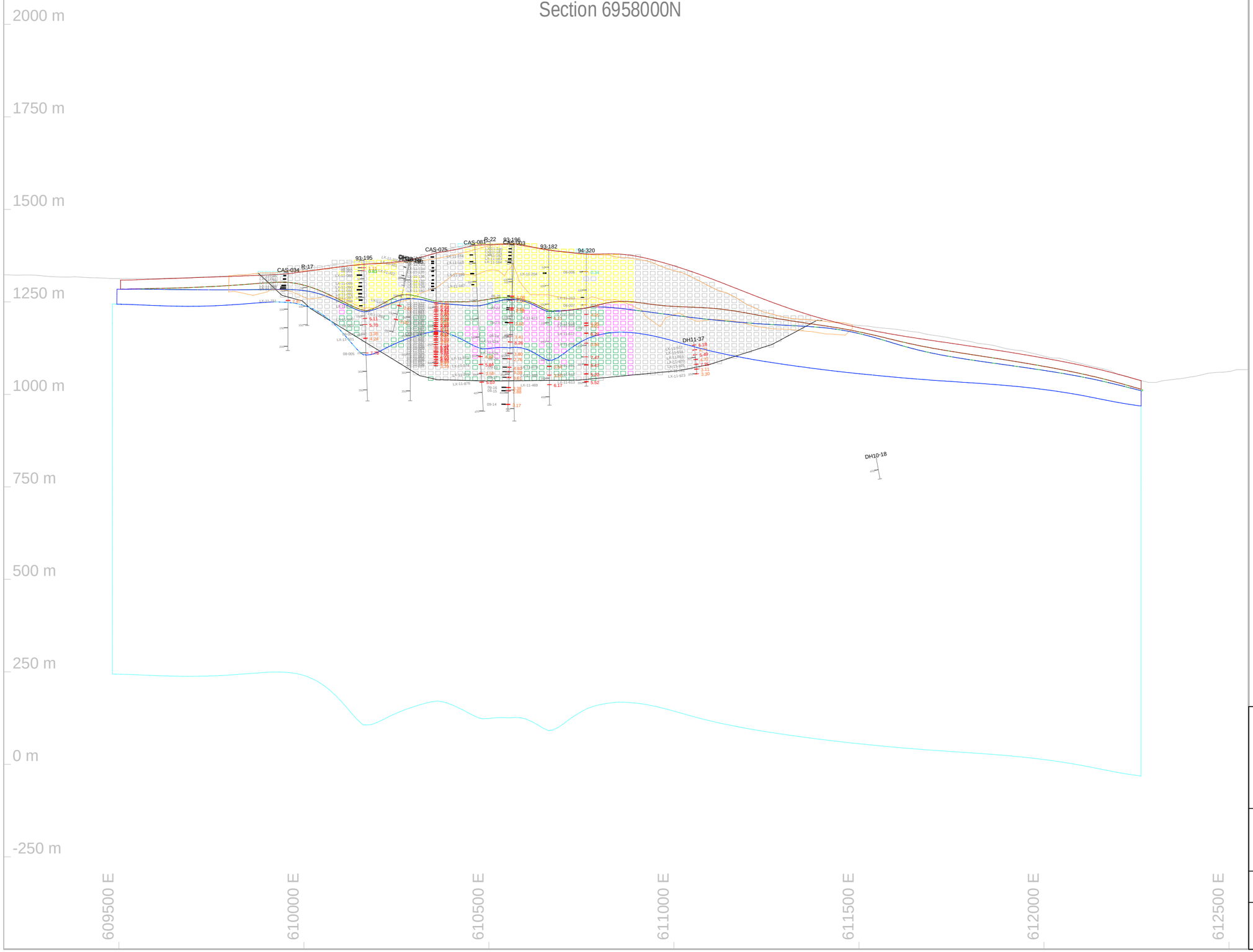
Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 21, 2014

Section 6958000N



Mineralized Zone

CAP	
SOX	
SUS	
HYP	

Alteration

POT	
PRO	
ARG	

Rinse pH (bar on left)

< 5.0	
5.0 - 6.4	
6.4 - 7.0	
> 7.0	

CANP/AP (centre bar)

< 1.0	
1.0 - 2.0	
> 2.0	

Total S% (text on right)

0.0 - 0.1	
0.1 - 0.5	
0.5 - 1.0	
1.0 - 5.0	
5.0 - 10.0	
10.0 - 100	

PFS Material Routing (blocks)

Overburden	
Leach Cap Gold Ore	
Leach Cap Potential Ore	
Sox Stockpile Ore	
Low Grade Stockpile	
Direct Feed Ore	
Waste	

Casino Project

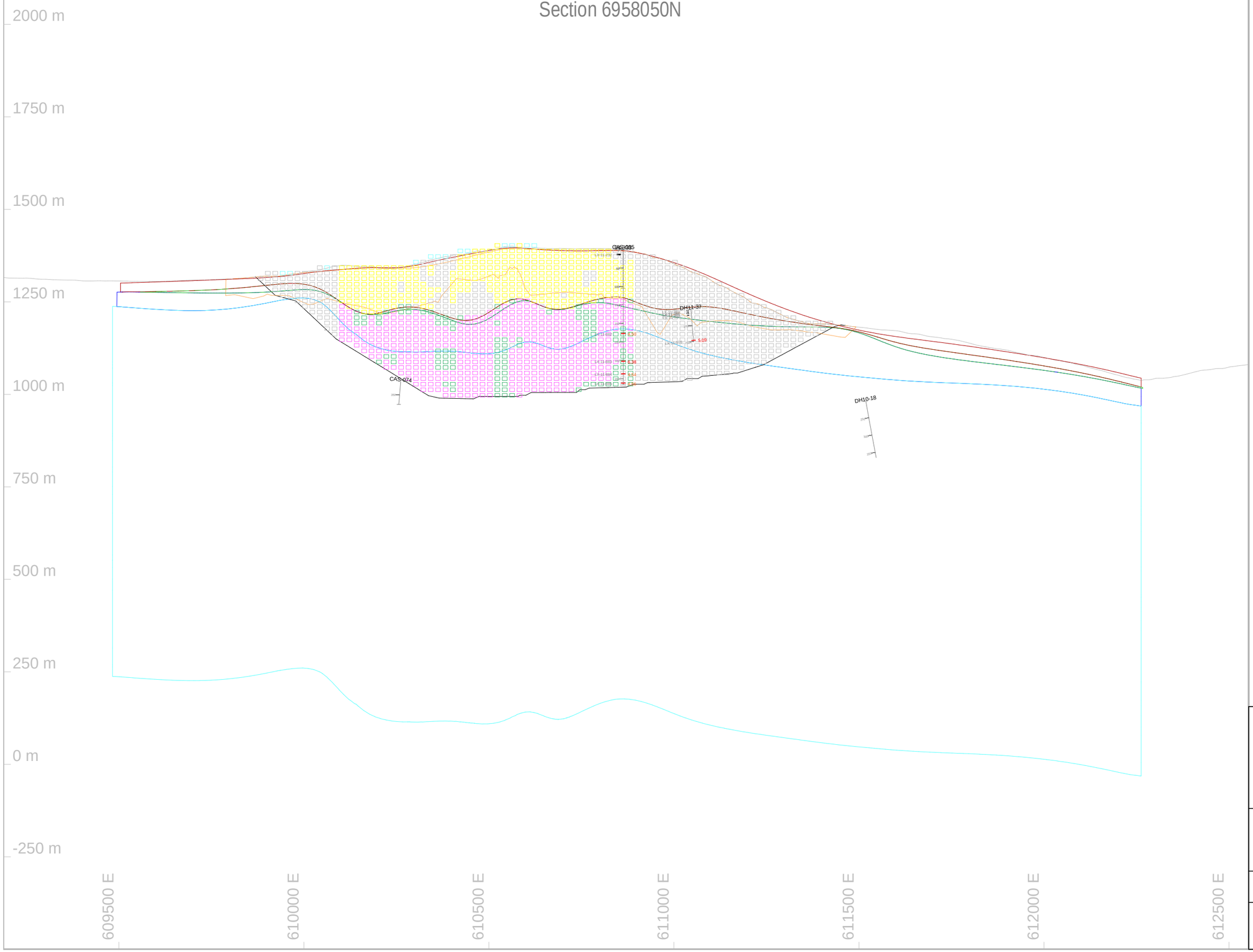
Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 21, 2014

Section 6958050N



Mineralized Zone

CAP
SOX
SUS
HYP

Alteration

POT
PRO
ARG

Rinse pH (bar on left)

< 5.0
5.0 - 6.4
6.4 - 7.0
> 7.0

CANP/AP (centre bar)

< 1.0
1.0 - 2.0
> 2.0

Total S% (text on right)

0.0 - 0.1
0.1 - 0.5
0.5 - 1.0
1.0 - 5.0
5.0 - 10.0
10.0 - 100

PFS Material Routing (blocks)

Overburden
Leach Cap Gold Ore
Leach Cap Potential Ore
Sox Stockpile Ore
Low Grade Stockpile
Direct Feed Ore
Waste

Casino Project

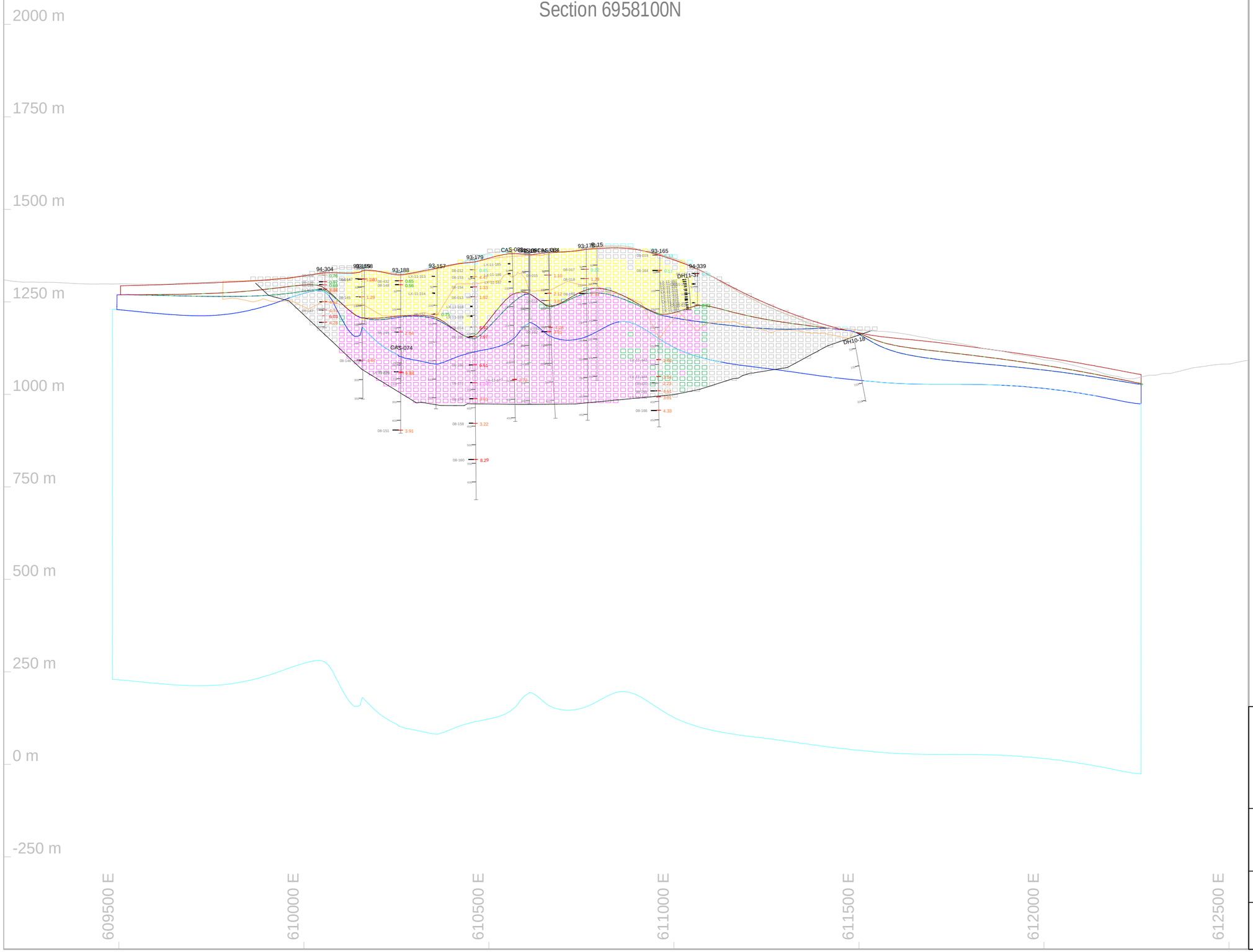
Lorax Environmental Services:
ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 21, 2014

Section 6958100N



Mineralized Zone

CAP	
SOX	
SUS	
HYP	

Alteration

POT	
PRO	
ARG	

Rinse pH (bar on left)

< 5.0	
5.0 - 6.4	
6.4 - 7.0	
> 7.0	

CANP/AP (centre bar)

< 1.0	
1.0 - 2.0	
> 2.0	

Total S% (text on right)

0.0 - 0.1	
0.1 - 0.5	
0.5 - 1.0	
1.0 - 5.0	
5.0 - 10.0	
10.0 - 100	

PFS Material Routing (blocks)

Overburden	
Leach Cap Gold Ore	
Leach Cap Potential Ore	
Sox Stockpile Ore	
Low Grade Stockpile	
Direct Feed Ore	
Waste	

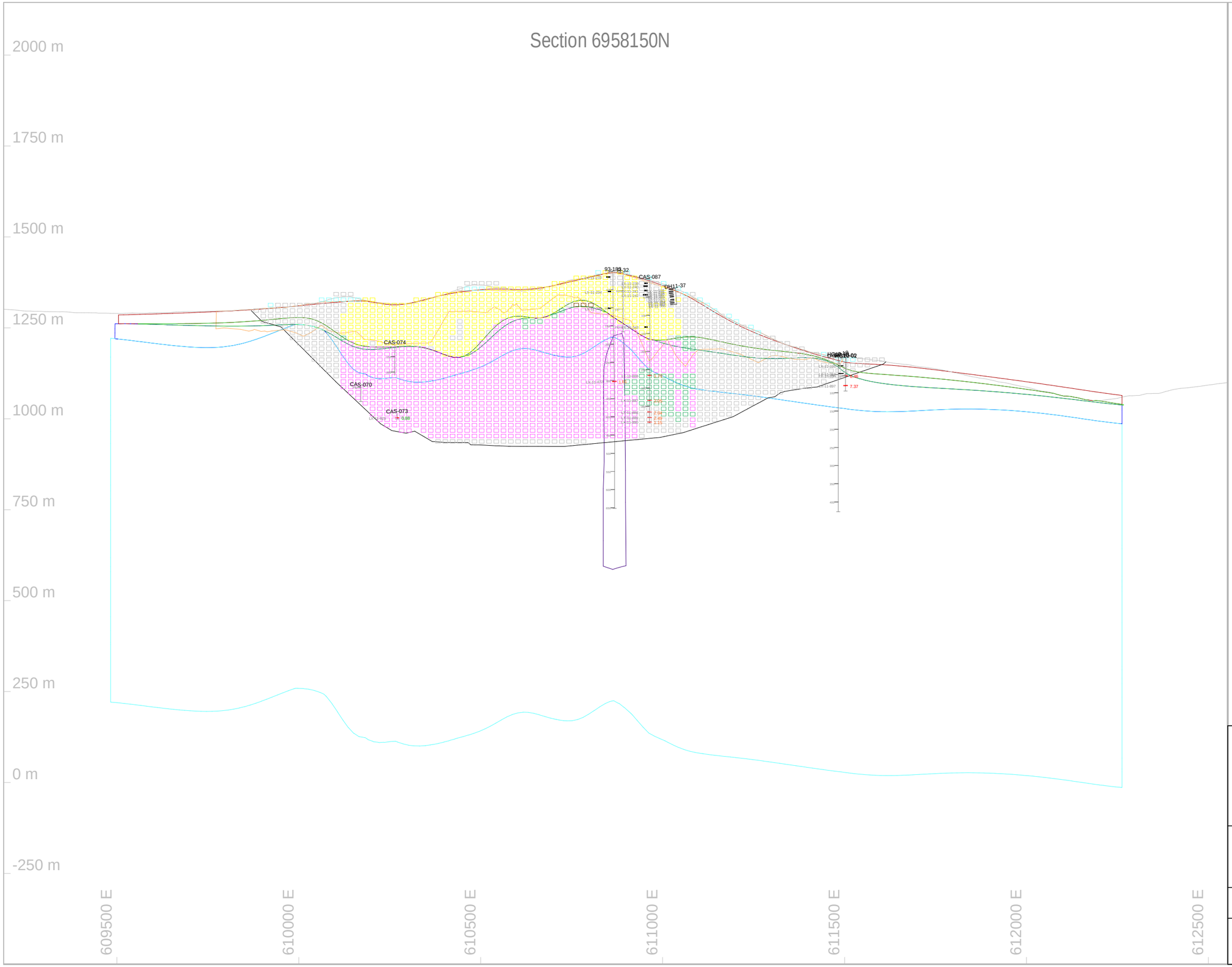
Casino Project

Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 21, 2014



Mineralized Zone

CAP	
SOX	
SUS	
HYP	

Alteration

POT	
PRO	
ARG	

Rinse pH (bar on left)

< 5.0	
5.0 - 6.4	
6.4 - 7.0	
> 7.0	

CANP/AP (centre bar)

< 1.0	
1.0 - 2.0	
> 2.0	

Total S% (text on right)

0.0 - 0.1	
0.1 - 0.5	
0.5 - 1.0	
1.0 - 5.0	
5.0 - 10.0	
10.0 - 100	

PFS Material Routing (blocks)

Overburden	
Leach Cap Gold Ore	
Leach Cap Potential Ore	
Sox Stockpile Ore	
Low Grade Stockpile	
Direct Feed Ore	
Waste	

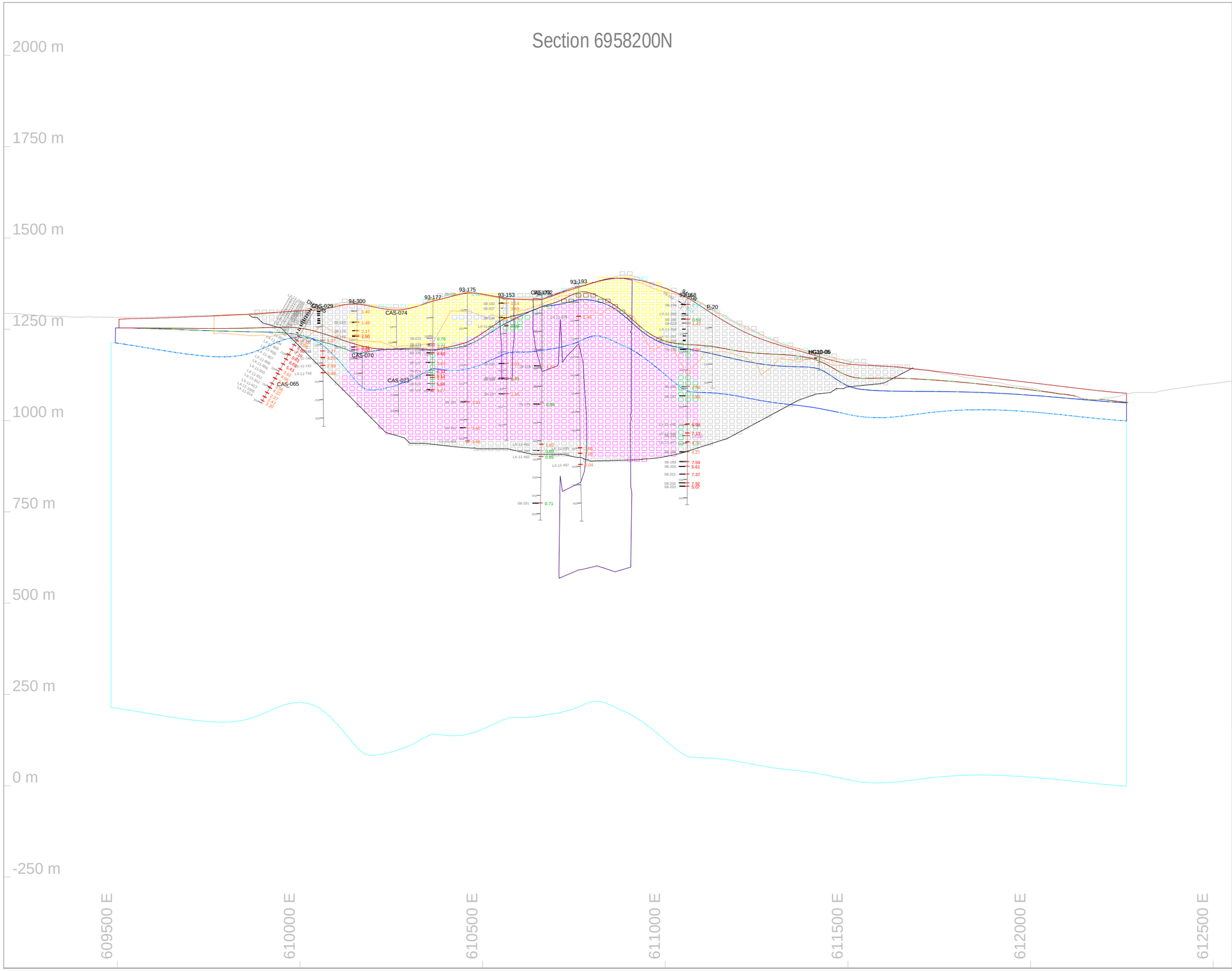
Casino Project

Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 21, 2014



Mineralized Zone

CAP	
SOX	
SUS	
HYP	

Alteration

POT	
PRO	
ARG	

Rinse pH (bar on left)

< 5.0	
5.0 - 6.4	
6.4 - 7.0	
> 7.0	

CANP/AP (centre bar)

< 1.0	
1.0 - 2.0	
> 2.0	

Total S% (text on right)

0.0 - 0.1	
0.1 - 0.5	
0.5 - 1.0	
1.0 - 5.0	
5.0 - 10.0	
10.0 - 100	

PFS Material Routing (blocks)

Overburden	
Leach Cap Gold Ore	
Leach Cap Potential Ore	
Sox Stockpile Ore	
Low Grade Stockpile	
Direct Feed Ore	
Waste	

Casino Project

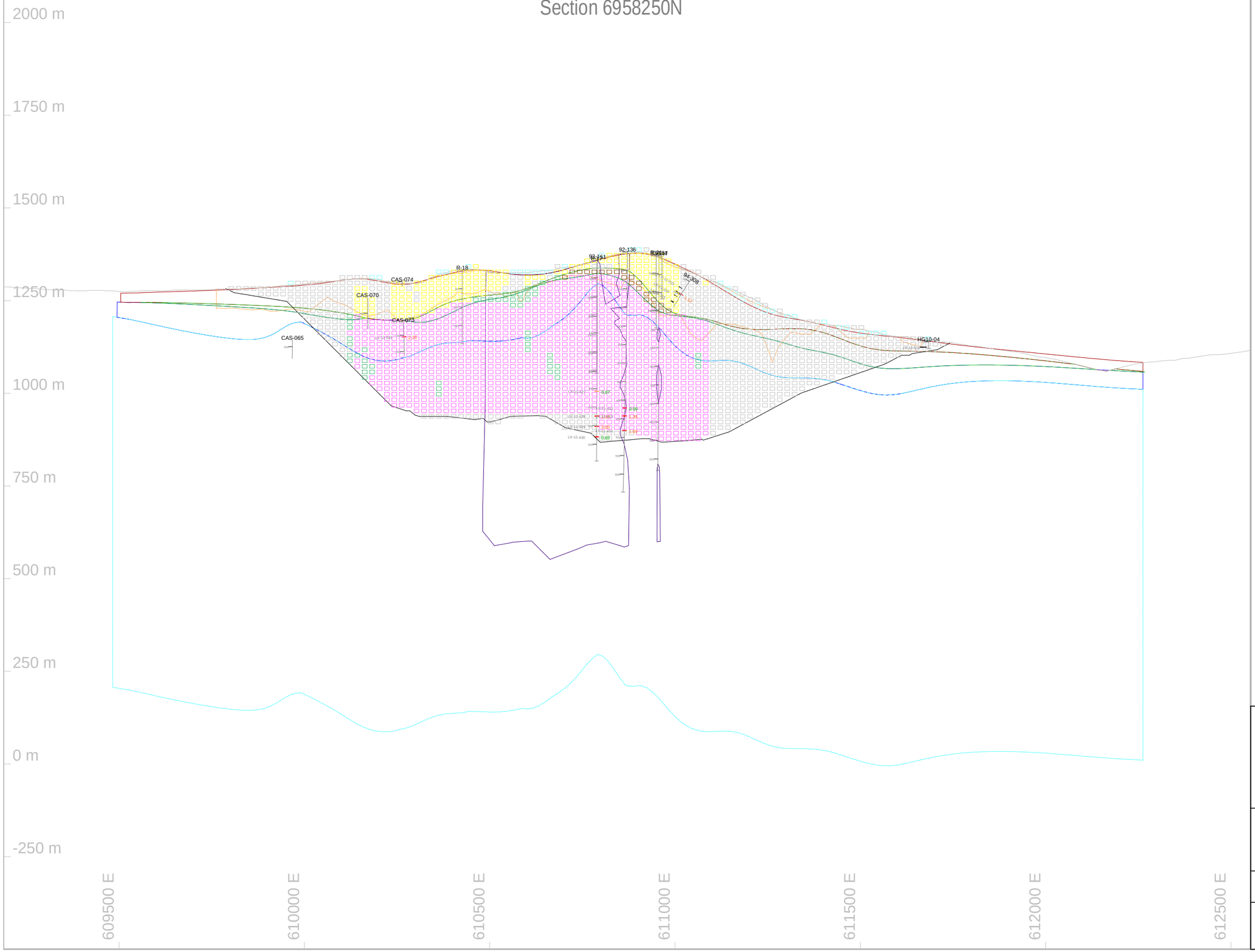
Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 21, 2014

Section 6958250N



Mineralized Zone

CAP
SOX
SUS
HYP

Alteration

POT
PRO
ARG

Rinse pH (bar on left)

< 5.0
5.0 - 6.4
6.4 - 7.0
> 7.0

CANP/AP (centre bar)

< 1.0
1.0 - 2.0
> 2.0

Total S% (text on right)

0.0 - 0.1
0.1 - 0.5
0.5 - 1.0
1.0 - 5.0
5.0 - 10.0
10.0 - 100

PFS Material Routing (blocks)

Overburden
Leach Cap Gold Ore
Leach Cap Potential Ore
Sox Stockpile Ore
Low Grade Stockpile
Direct Feed Ore
Waste

Casino Project

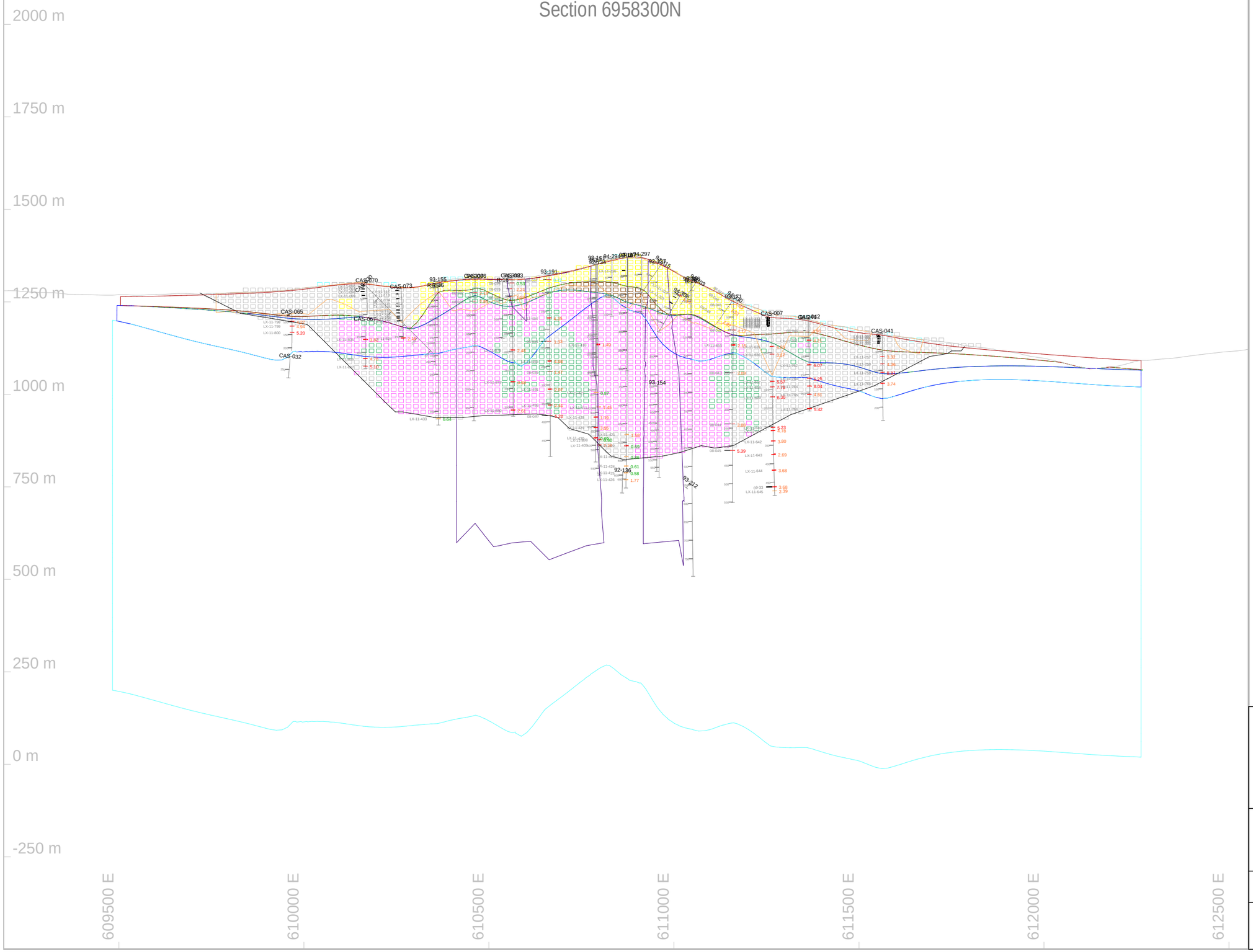
Lorax Environmental Services:
ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 21, 2014

Section 6958300N



Mineralized Zone

CAP	
SOX	
SUS	
HYP	

Alteration

POT	
PRO	
ARG	

Rinse pH (bar on left)

< 5.0	
5.0 - 6.4	
6.4 - 7.0	
> 7.0	

CANP/AP (centre bar)

< 1.0	
1.0 - 2.0	
> 2.0	

Total S% (text on right)

0.0 - 0.1	
0.1 - 0.5	
0.5 - 1.0	
1.0 - 5.0	
5.0 - 10.0	
10.0 - 100	

PFS Material Routing (blocks)

Overburden	
Leach Cap Gold Ore	
Leach Cap Potential Ore	
Sox Stockpile Ore	
Low Grade Stockpile	
Direct Feed Ore	
Waste	

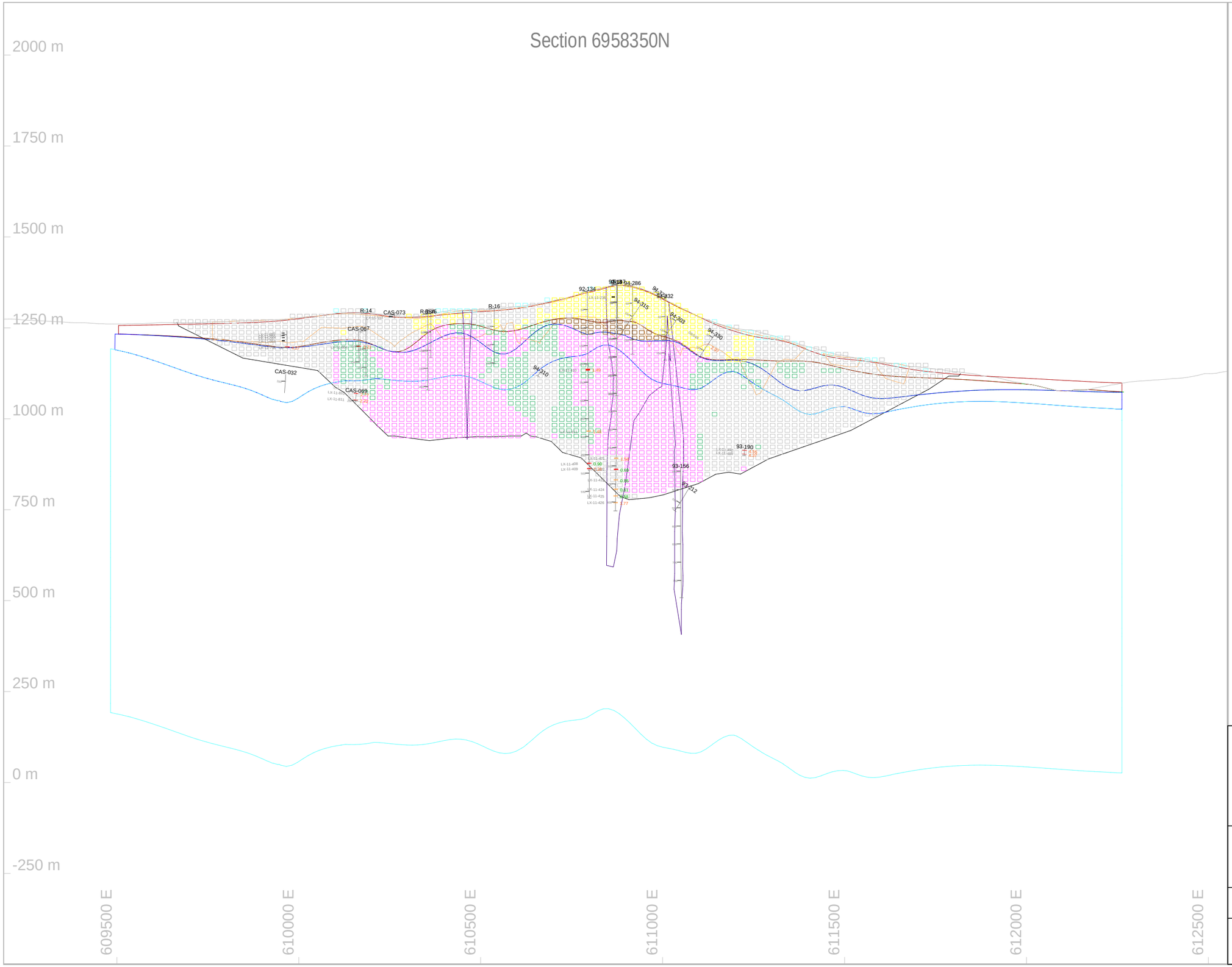
Casino Project

Lorax Environmental Services:
ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 21, 2014



Mineralized Zone

CAP	
SOX	
SUS	
HYP	

Alteration

POT	
PRO	
ARG	

Rinse pH (bar on left)

< 5.0	
5.0 - 6.4	
6.4 - 7.0	
> 7.0	

CANP/AP (centre bar)

< 1.0	
1.0 - 2.0	
> 2.0	

Total S% (text on right)

0.0 - 0.1	
0.1 - 0.5	
0.5 - 1.0	
1.0 - 5.0	
5.0 - 10.0	
10.0 - 100	

PFS Material Routing (blocks)

Overburden	
Leach Cap Gold Ore	
Leach Cap Potential Ore	
Sox Stockpile Ore	
Low Grade Stockpile	
Direct Feed Ore	
Waste	

Casino Project

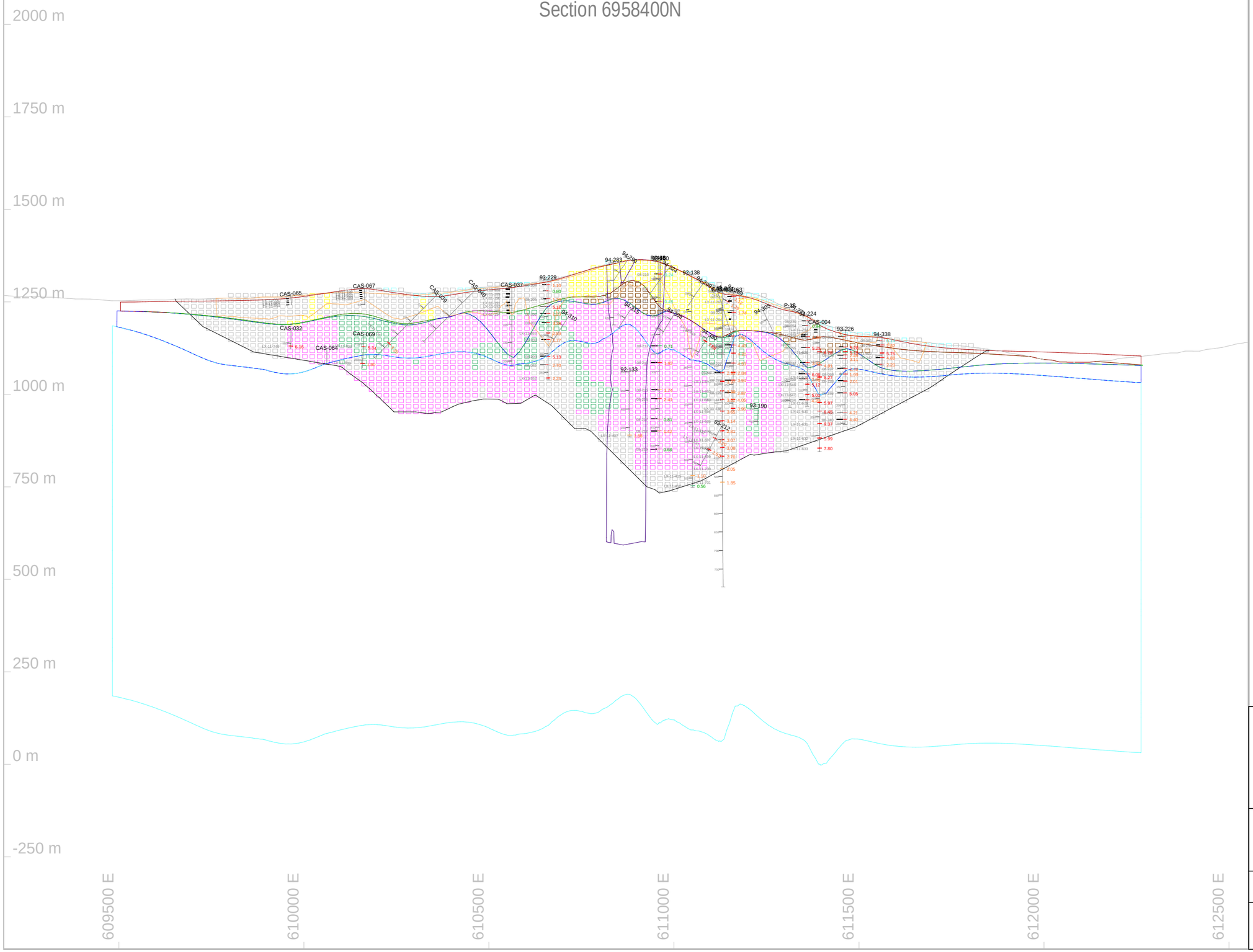
Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 21, 2014

Section 6958400N



Mineralized Zone

CAP	
SOX	
SUS	
HYP	

Alteration

POT	
PRO	
ARG	

Rinse pH (bar on left)

< 5.0	
5.0 - 6.4	
6.4 - 7.0	
> 7.0	

CANP/AP (centre bar)

< 1.0	
1.0 - 2.0	
> 2.0	

Total S% (text on right)

0.0 - 0.1	
0.1 - 0.5	
0.5 - 1.0	
1.0 - 5.0	
5.0 - 10.0	
10.0 - 100	

PFS Material Routing (blocks)

Overburden	
Leach Cap Gold Ore	
Leach Cap Potential Ore	
Sox Stockpile Ore	
Low Grade Stockpile	
Direct Feed Ore	
Waste	

Casino Project

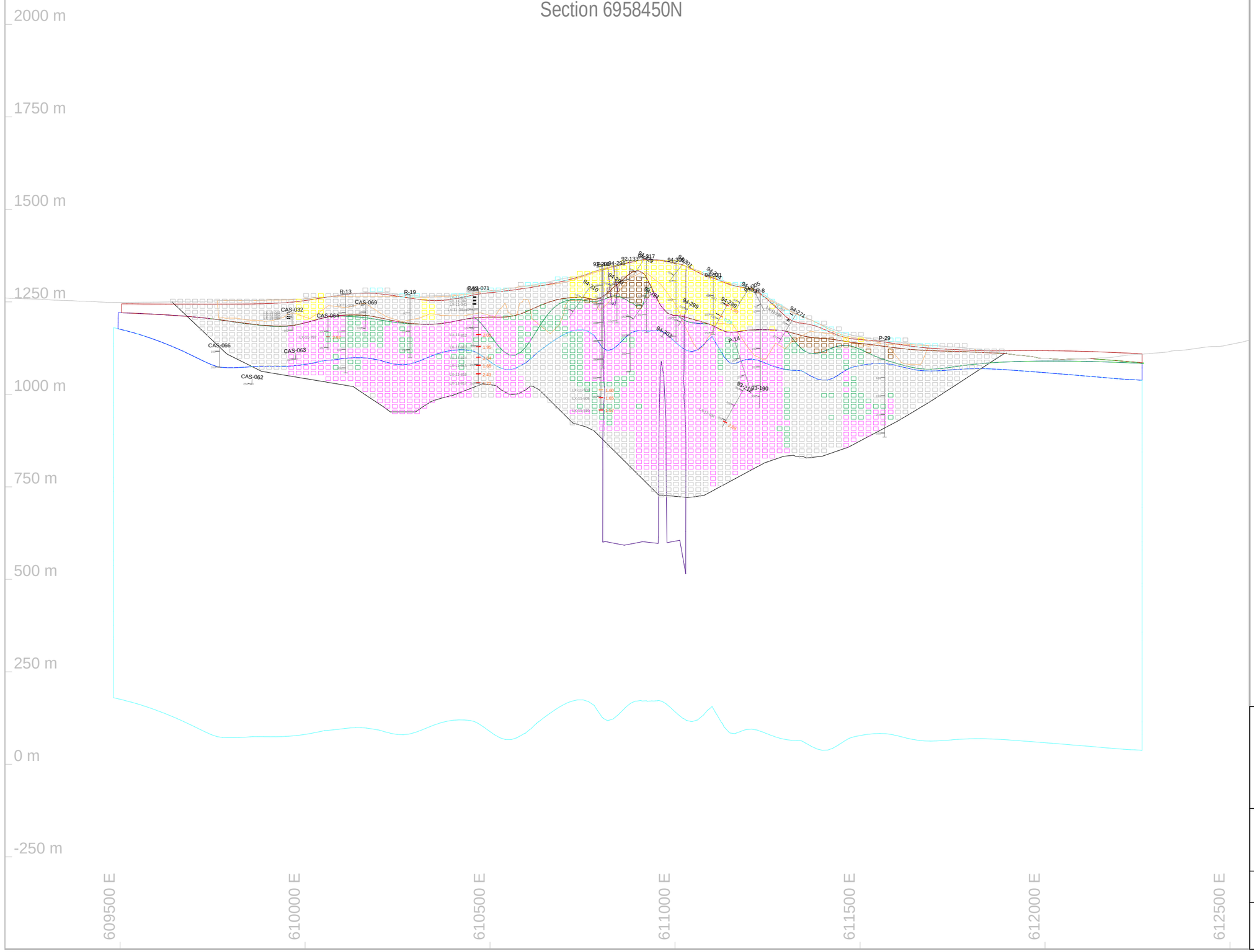
Lorax Environmental Services:
ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 21, 2014

Section 6958450N



Mineralized Zone

CAP	
SOX	
SUS	
HYP	

Alteration

POT	
PRO	
ARG	

Rinse pH (bar on left)

< 5.0	
5.0 - 6.4	
6.4 - 7.0	
> 7.0	

CANP/AP (centre bar)

< 1.0	
1.0 - 2.0	
> 2.0	

Total S% (text on right)

0.0 - 0.1	
0.1 - 0.5	
0.5 - 1.0	
1.0 - 5.0	
5.0 - 10.0	
10.0 - 100	

PFS Material Routing (blocks)

Overburden	
Leach Cap Gold Ore	
Leach Cap Potential Ore	
Sox Stockpile Ore	
Low Grade Stockpile	
Direct Feed Ore	
Waste	

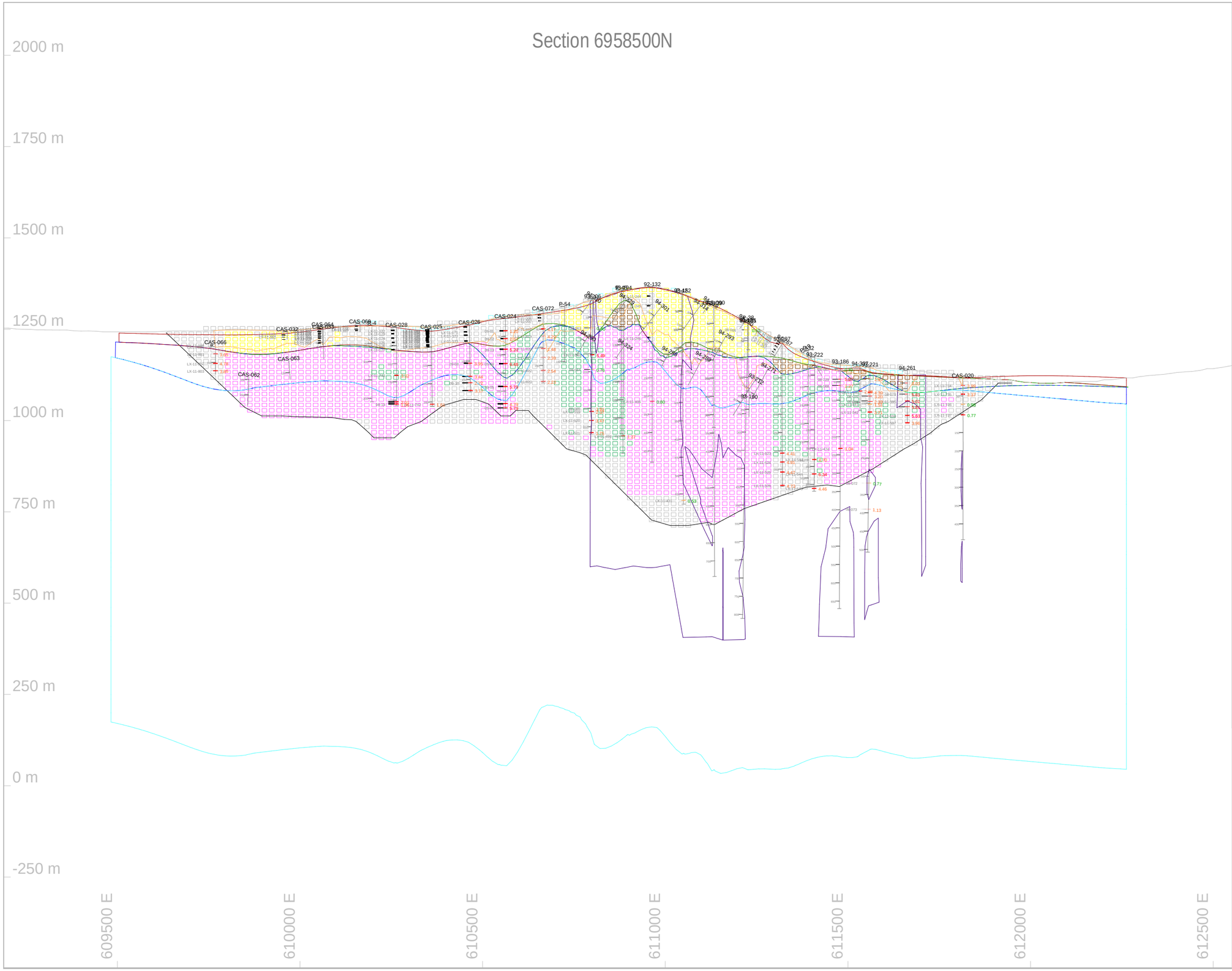
Casino Project

Lorax Environmental Services:
ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 21, 2014



Mineralized Zone

CAP	
SOX	
SUS	
HYP	

Alteration

POT	
PRO	
ARG	

Rinse pH (bar on left)

< 5.0	
5.0 - 6.4	
6.4 - 7.0	
> 7.0	

CANP/AP (centre bar)

< 1.0	
1.0 - 2.0	
> 2.0	

Total S% (text on right)

0.0 - 0.1	
0.1 - 0.5	
0.5 - 1.0	
1.0 - 5.0	
5.0 - 10.0	
10.0 - 100	

PFS Material Routing (blocks)

Overburden	
Leach Cap Gold Ore	
Leach Cap Potential Ore	
Sox Stockpile Ore	
Low Grade Stockpile	
Direct Feed Ore	
Waste	

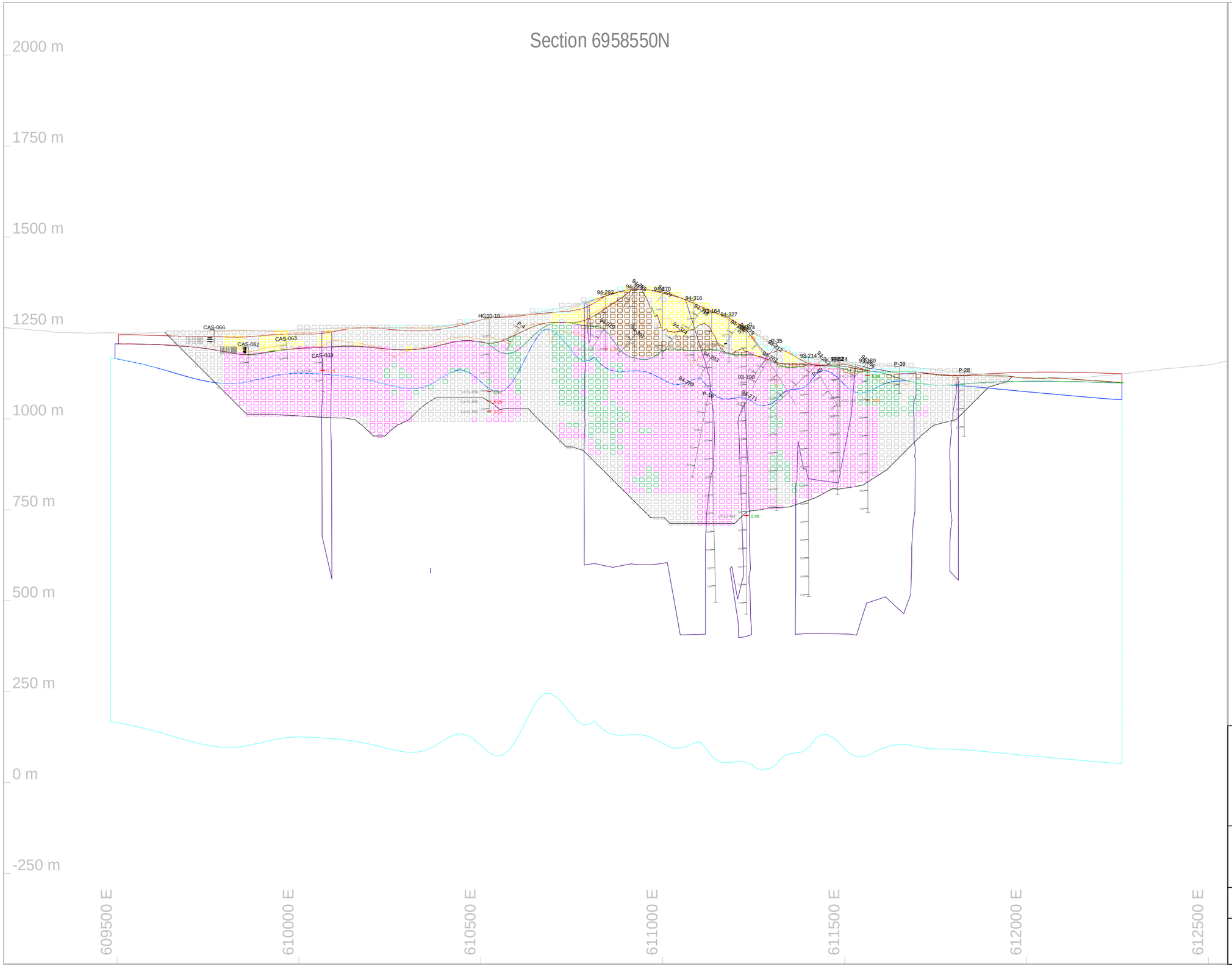
Casino Project

Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 21, 2014



Mineralized Zone

CAP	
SOX	
SUS	
HYP	

Alteration

POT	
PRO	
ARG	

Rinse pH (bar on left)

< 5.0	
5.0 - 6.4	
6.4 - 7.0	
> 7.0	

CANP/AP (centre bar)

< 1.0	
1.0 - 2.0	
> 2.0	

Total S% (text on right)

0.0 - 0.1	
0.1 - 0.5	
0.5 - 1.0	
1.0 - 5.0	
5.0 - 10.0	
10.0 - 100	

PFS Material Routing (blocks)

Overburden	
Leach Cap Gold Ore	
Leach Cap Potential Ore	
Sox Stockpile Ore	
Low Grade Stockpile	
Direct Feed Ore	
Waste	

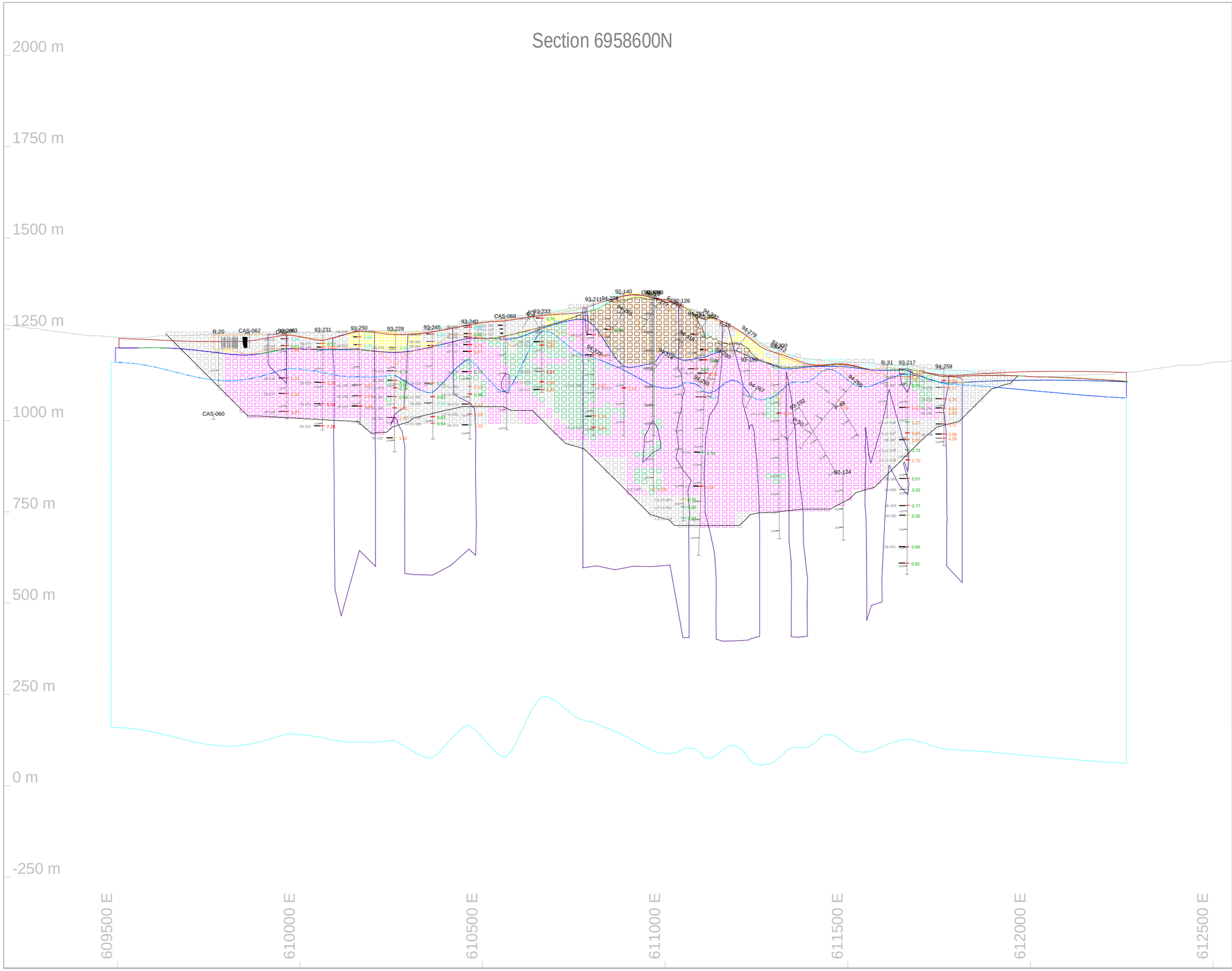
Casino Project

Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 21, 2014


Section 6958600N
2000 m
1750 m
1500 m
1250 m
1000 m
750 m
500 m
250 m
0 m
-250 m
609500 E
610000 E
610500 E
611000 E
611500 E
612000 E
612500 E
R-20
CAS-062
CAS-063
93-231
93-250
93-228
93-245
93-240
CAS-068
93-233
92-140
93-211
94-278
93-126
R-16
94-279
93-190
R-31
93-217
94-259
CAS-060
92-124
92-102
92-120
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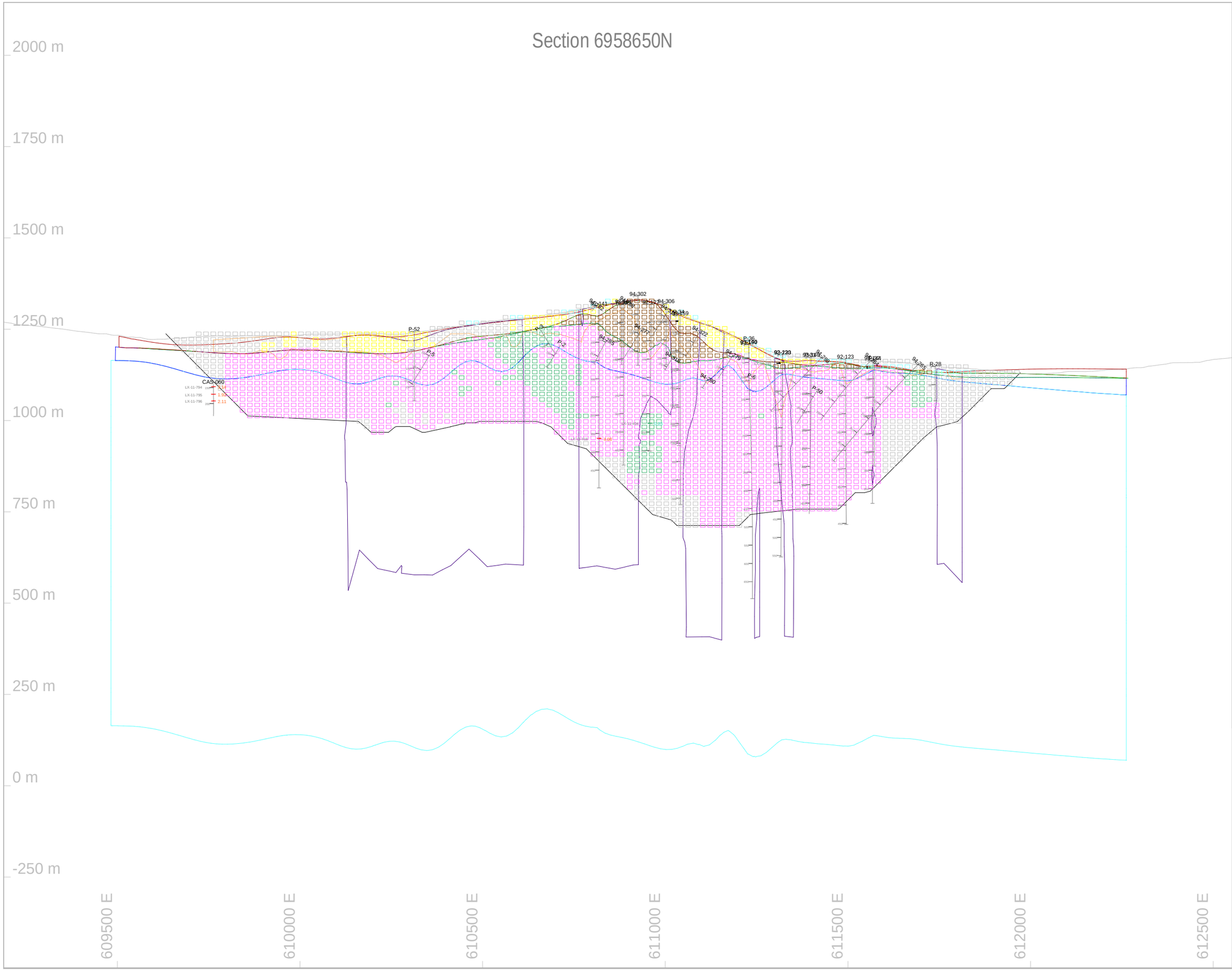
94-319



Mineralized Zone

CAP
SOX
SUS
HYP

Alteration

POT
PRO
ARG

Rinse pH (bar on left)

< 5.0
5.0 - 6.4
6.4 - 7.0
> 7.0

CANP/AP (centre bar)

< 1.0
1.0 - 2.0
> 2.0

Total S% (text on right)

0.0 - 0.1
0.1 - 0.5
0.5 - 1.0
1.0 - 5.0
5.0 - 10.0
10.0 - 100

PFS Material Routing (blocks)

Overburden
Leach Cap Gold Ore
Leach Cap Potential Ore
Sox Stockpile Ore
Low Grade Stockpile
Direct Feed Ore
Waste

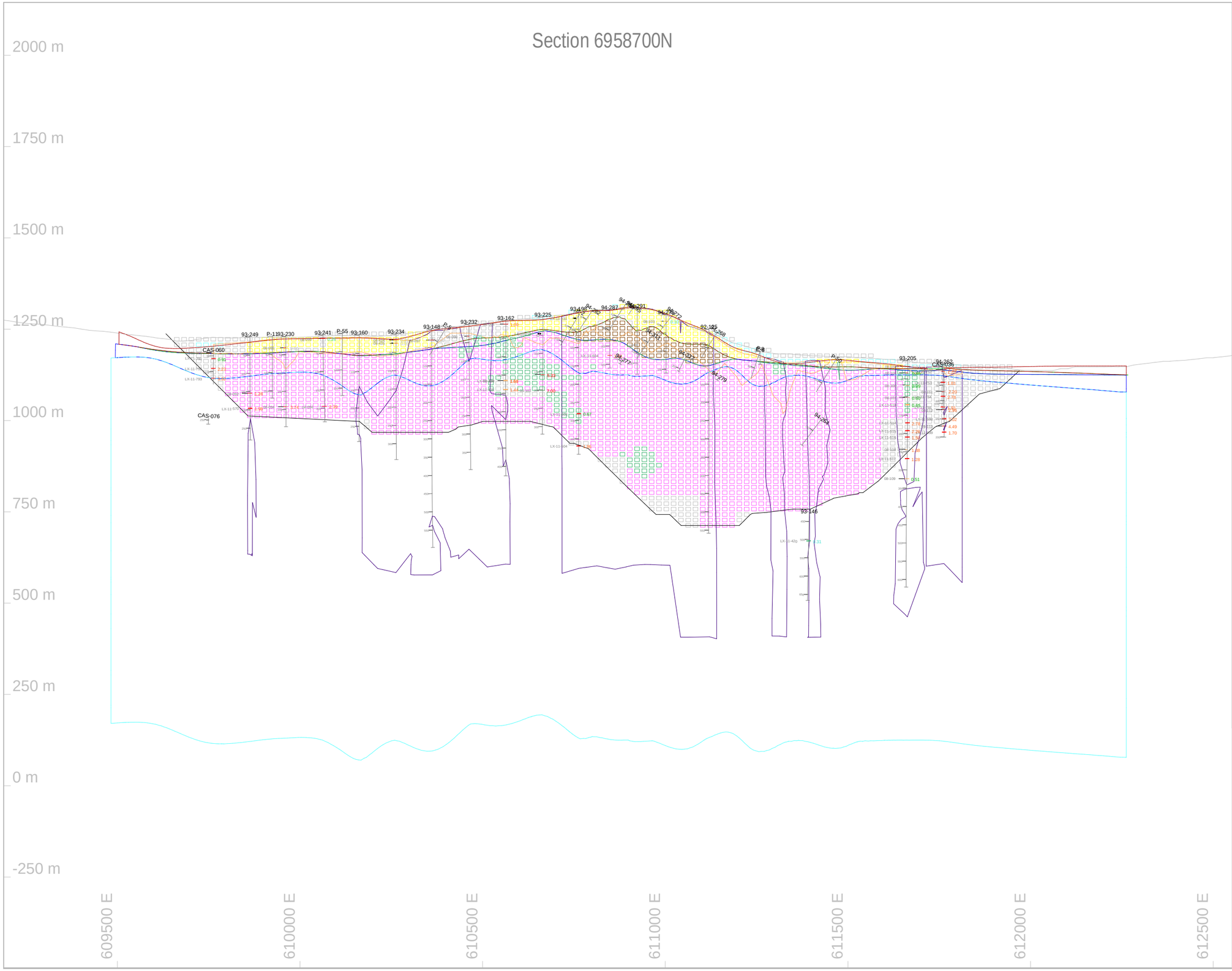
Casino Project

Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 21, 2014


Section 6958700N
2000 m
1750 m
1500 m
1250 m
1000 m
750 m
500 m
250 m
0 m
-250 m
609500 E
610000 E
610500 E
611000 E
611500 E
612000 E
612500 E
CAS-060
CAS-076
CAS-036
93-249
P-119
93-230
93-241
P-55
93-160
93-234
93-148
93-232
93-162
93-225
93-205
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92-125
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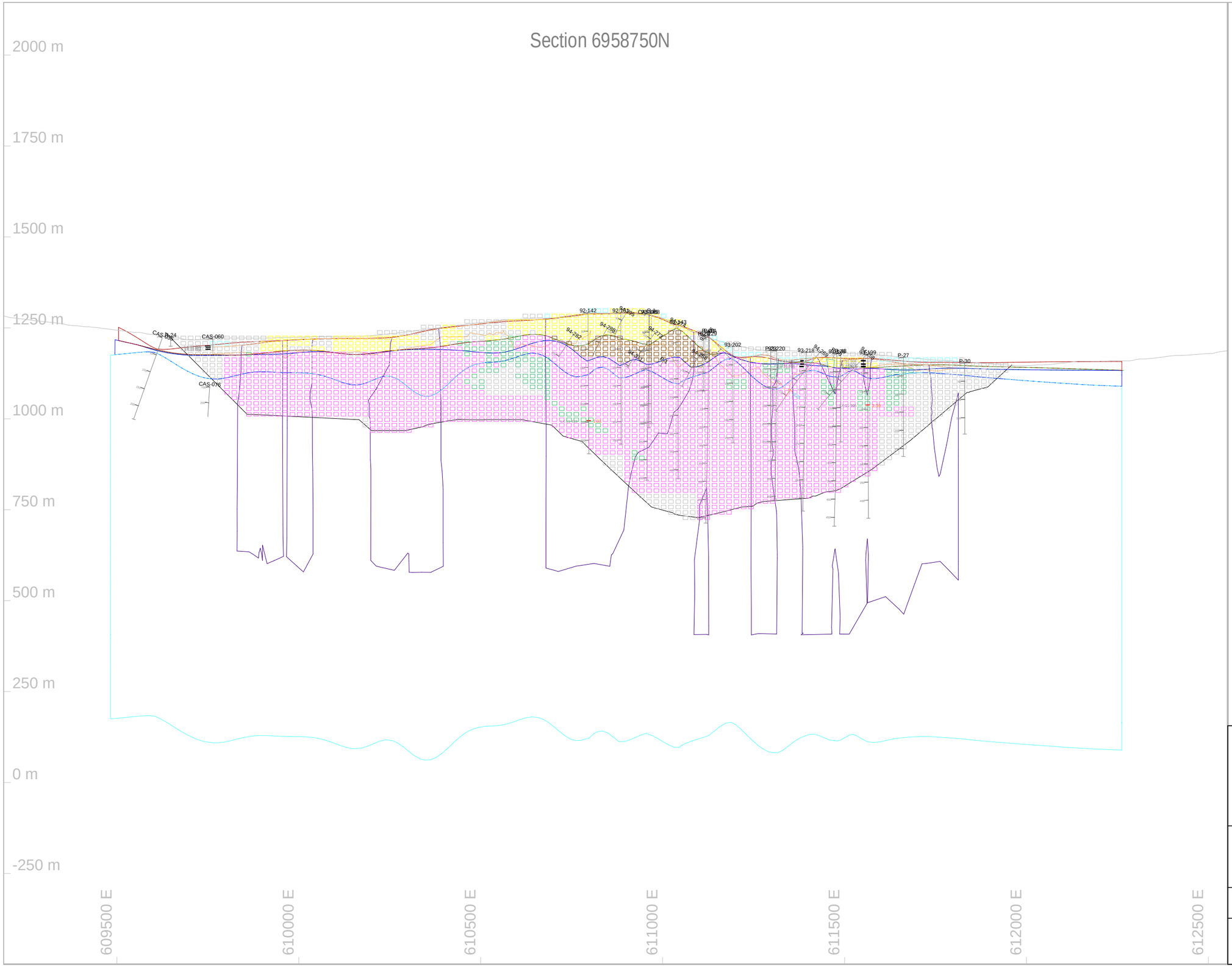


Mineralized Zone

CAP	
SOX	
SUS	
HYP	

Alteration

POT	
PRO	
ARG	

Rinse pH (bar on left)

< 5.0	
5.0 - 6.4	
6.4 - 7.0	
> 7.0	

CANP/AP (centre bar)

< 1.0	
1.0 - 2.0	
> 2.0	

Total S% (text on right)

0.0 - 0.1	
0.1 - 0.5	
0.5 - 1.0	
1.0 - 5.0	
5.0 - 10.0	
10.0 - 100	

PFS Material Routing (blocks)

Overburden	
Leach Cap Gold Ore	
Leach Cap Potential Ore	
Sox Stockpile Ore	
Low Grade Stockpile	
Direct Feed Ore	
Waste	

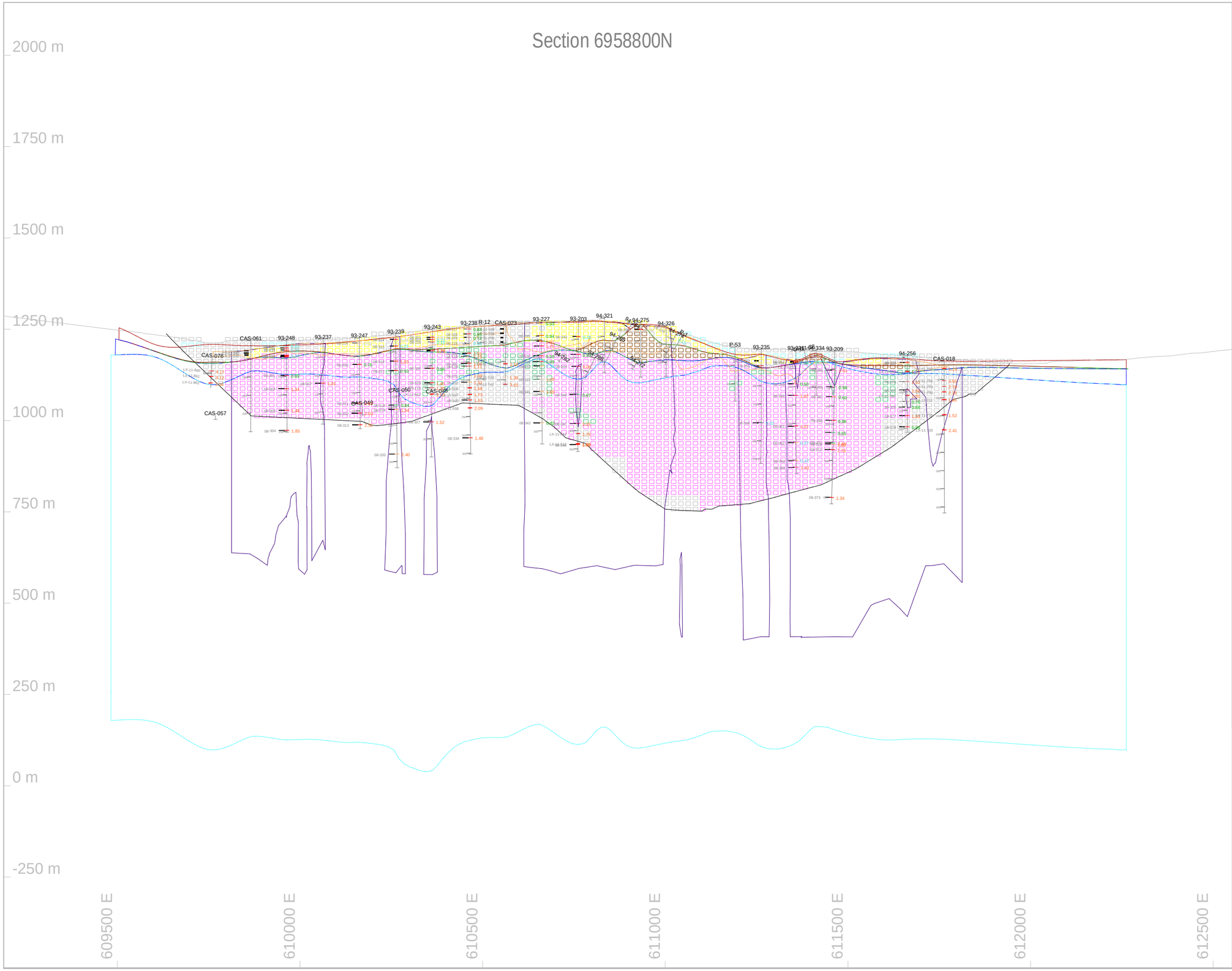
Casino Project

Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 21, 2014



Mineralized Zone

CAP	
SOX	
SUS	
HYP	

Alteration

POT	
PRO	
ARG	

Rinse pH (bar on left)

< 5.0	
5.0 - 6.4	
6.4 - 7.0	
> 7.0	

CANP/AP (centre bar)

< 1.0	
1.0 - 2.0	
> 2.0	

Total S% (text on right)

0.0 - 0.1	
0.1 - 0.5	
0.5 - 1.0	
1.0 - 5.0	
5.0 - 10.0	
10.0 - 100	

PFS Material Routing (blocks)

Overburden	
Leach Cap Gold Ore	
Leach Cap Potential Ore	
Sox Stockpile Ore	
Low Grade Stockpile	
Direct Feed Ore	
Waste	

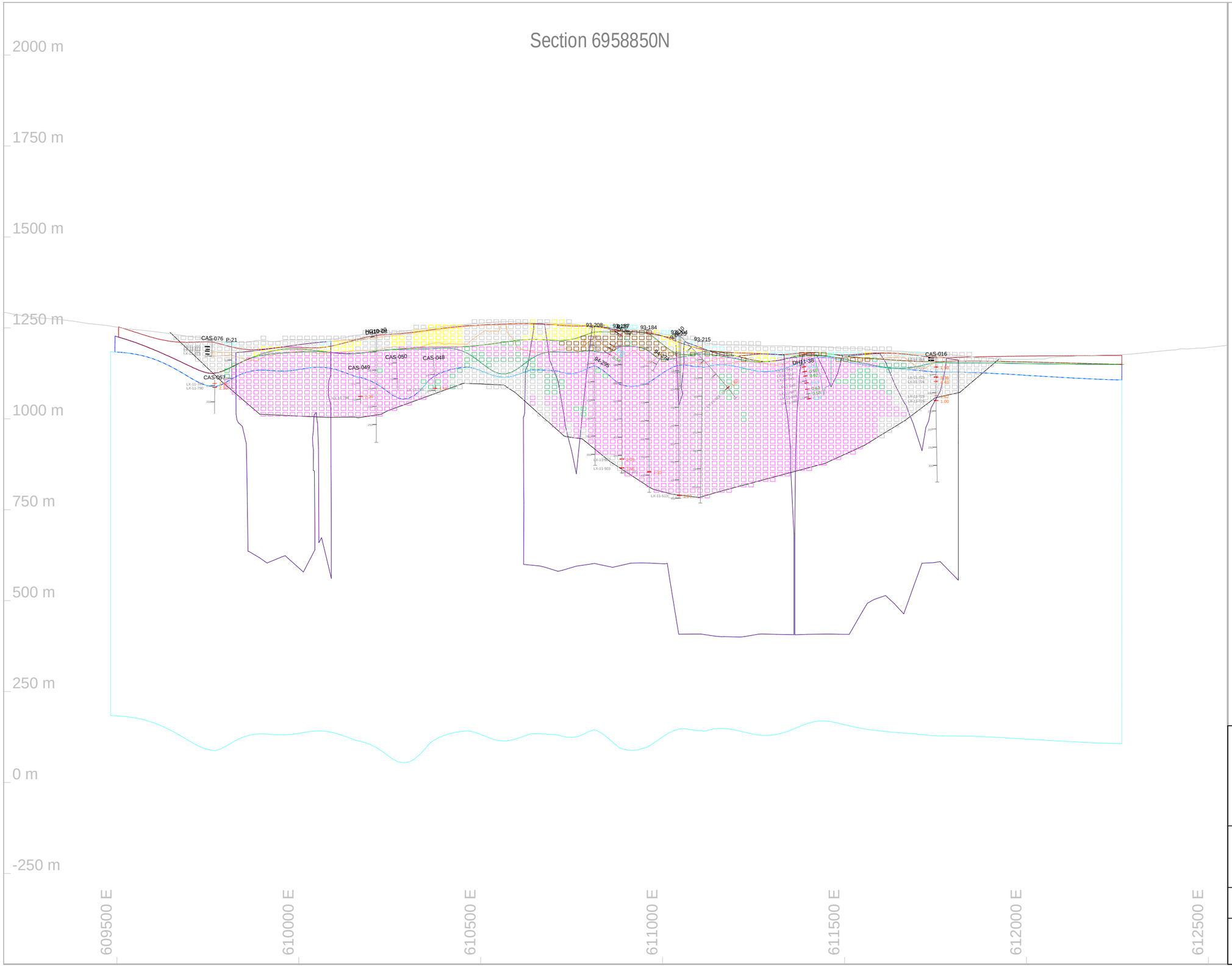
Casino Project

Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 21, 2014



Mineralized Zone

CAP	
SOX	
SUS	
HYP	

Alteration

POT	
PRO	
ARG	

Rinse pH (bar on left)

< 5.0	
5.0 - 6.4	
6.4 - 7.0	
> 7.0	

CANP/AP (centre bar)

< 1.0	
1.0 - 2.0	
> 2.0	

Total S% (text on right)

0.0 - 0.1	
0.1 - 0.5	
0.5 - 1.0	
1.0 - 5.0	
5.0 - 10.0	
10.0 - 100	

PFS Material Routing (blocks)

Overburden	
Leach Cap Gold Ore	
Leach Cap Potential Ore	
Sox Stockpile Ore	
Low Grade Stockpile	
Direct Feed Ore	
Waste	

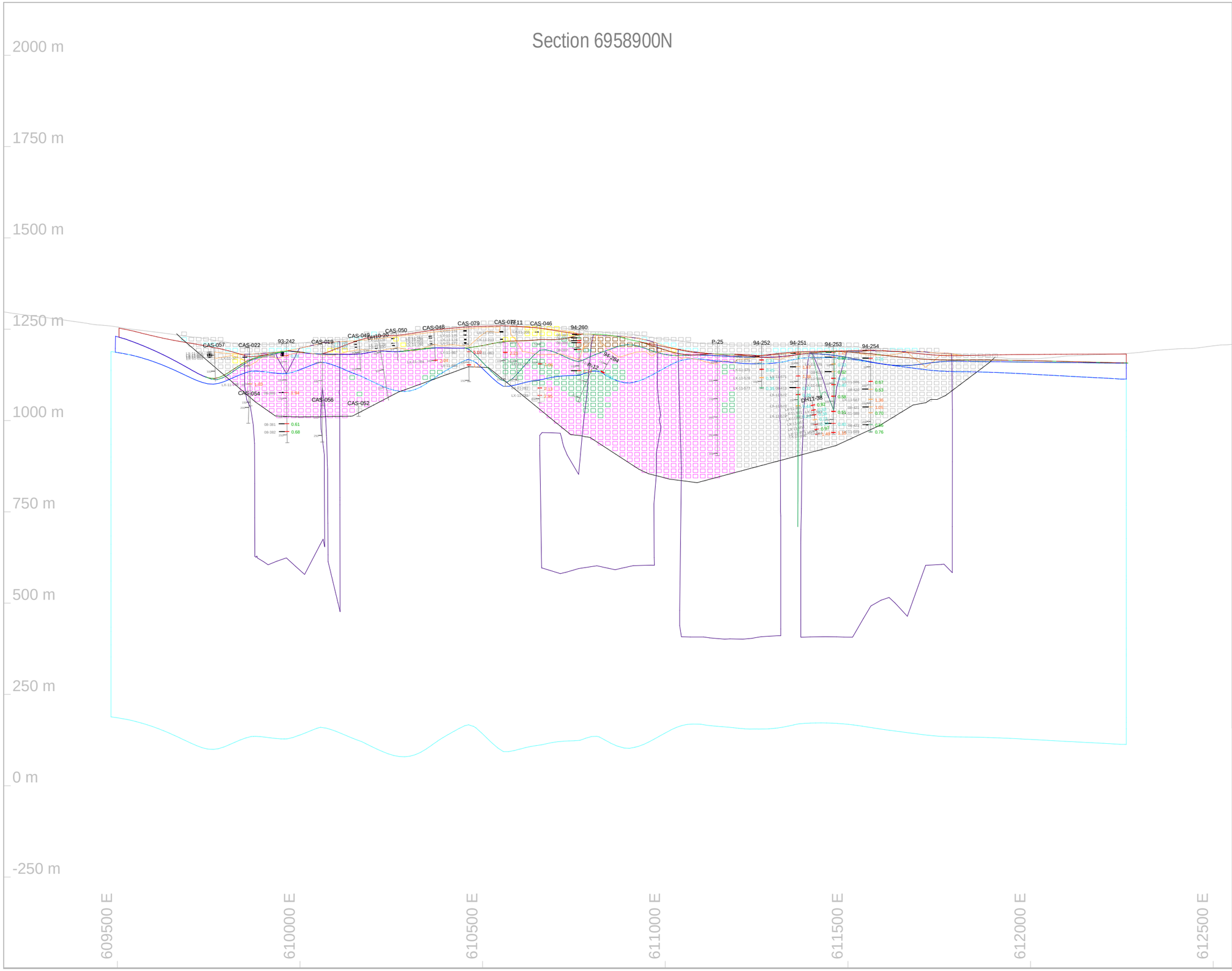
Casino Project

Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 21, 2014



Mineralized Zone

CAP	
SOX	
SUS	
HYP	

Alteration

POT	
PRO	
ARG	

Rinse pH (bar on left)

< 5.0	
5.0 - 6.4	
6.4 - 7.0	
> 7.0	

CANP/AP (centre bar)

< 1.0	
1.0 - 2.0	
> 2.0	

Total S% (text on right)

0.0 - 0.1	
0.1 - 0.5	
0.5 - 1.0	
1.0 - 5.0	
5.0 - 10.0	
10.0 - 100	

PFS Material Routing (blocks)

Overburden	
Leach Cap Gold Ore	
Leach Cap Potential Ore	
Sox Stockpile Ore	
Low Grade Stockpile	
Direct Feed Ore	
Waste	

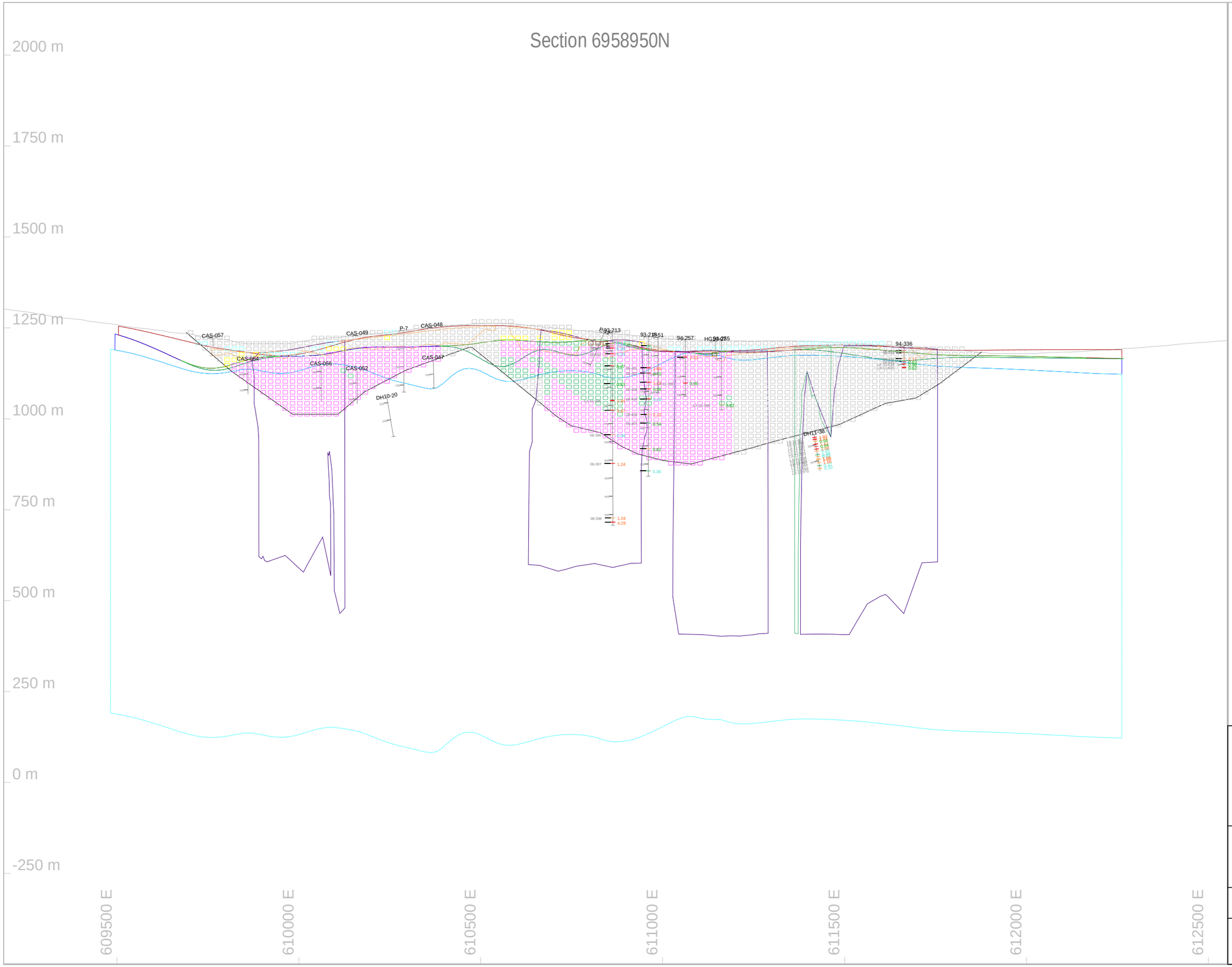
Casino Project

Lorax Environmental Services:
ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 21, 2014



Mineralized Zone

CAP	
SOX	
SUS	
HYP	

Alteration

POT	
PRO	
ARG	

Rinse pH (bar on left)

< 5.0	
5.0 - 6.4	
6.4 - 7.0	
> 7.0	

CANP/AP (centre bar)

< 1.0	
1.0 - 2.0	
> 2.0	

Total S% (text on right)

0.0 - 0.1	
0.1 - 0.5	
0.5 - 1.0	
1.0 - 5.0	
5.0 - 10.0	
10.0 - 100	

PFS Material Routing (blocks)

Overburden	
Leach Cap Gold Ore	
Leach Cap Potential Ore	
Sox Stockpile Ore	
Low Grade Stockpile	
Direct Feed Ore	
Waste	

Casino Project

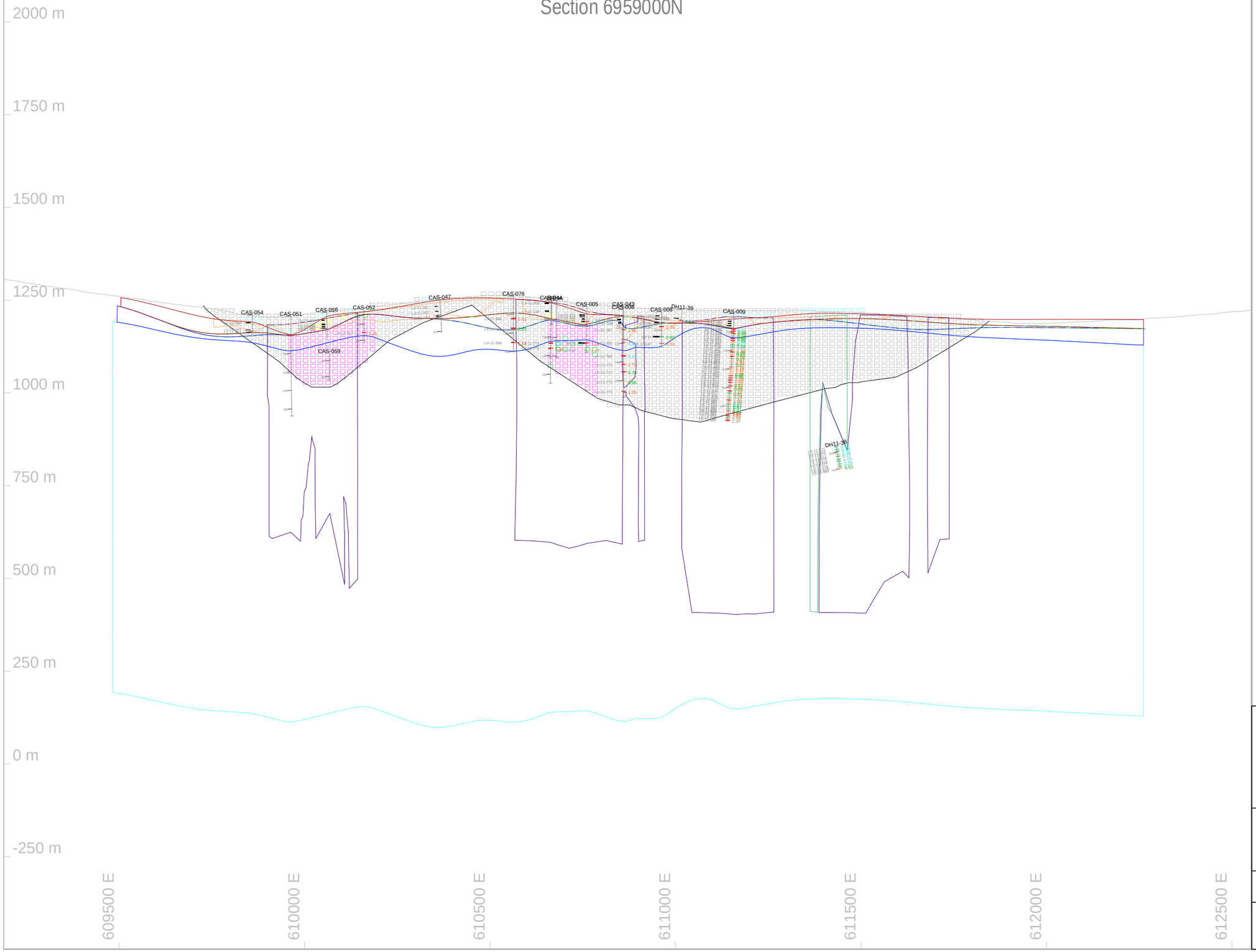
Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 21, 2014

Section 6959000N



Mineralized Zone

CAP	
SOX	
SUS	
HYP	

Alteration

POT	
PRO	
ARG	

Rinse pH (bar on left)

< 5.0	
5.0 - 6.4	
6.4 - 7.0	
> 7.0	

CANP/AP (centre bar)

< 1.0	
1.0 - 2.0	
> 2.0	

Total S% (text on right)

0.0 - 0.1	
0.1 - 0.5	
0.5 - 1.0	
1.0 - 5.0	
5.0 - 10.0	
10.0 - 100	

PFS Material Routing (blocks)

Overburden	
Leach Cap Gold Ore	
Leach Cap Potential Ore	
Sox Stockpile Ore	
Low Grade Stockpile	
Direct Feed Ore	
Waste	

Casino Project

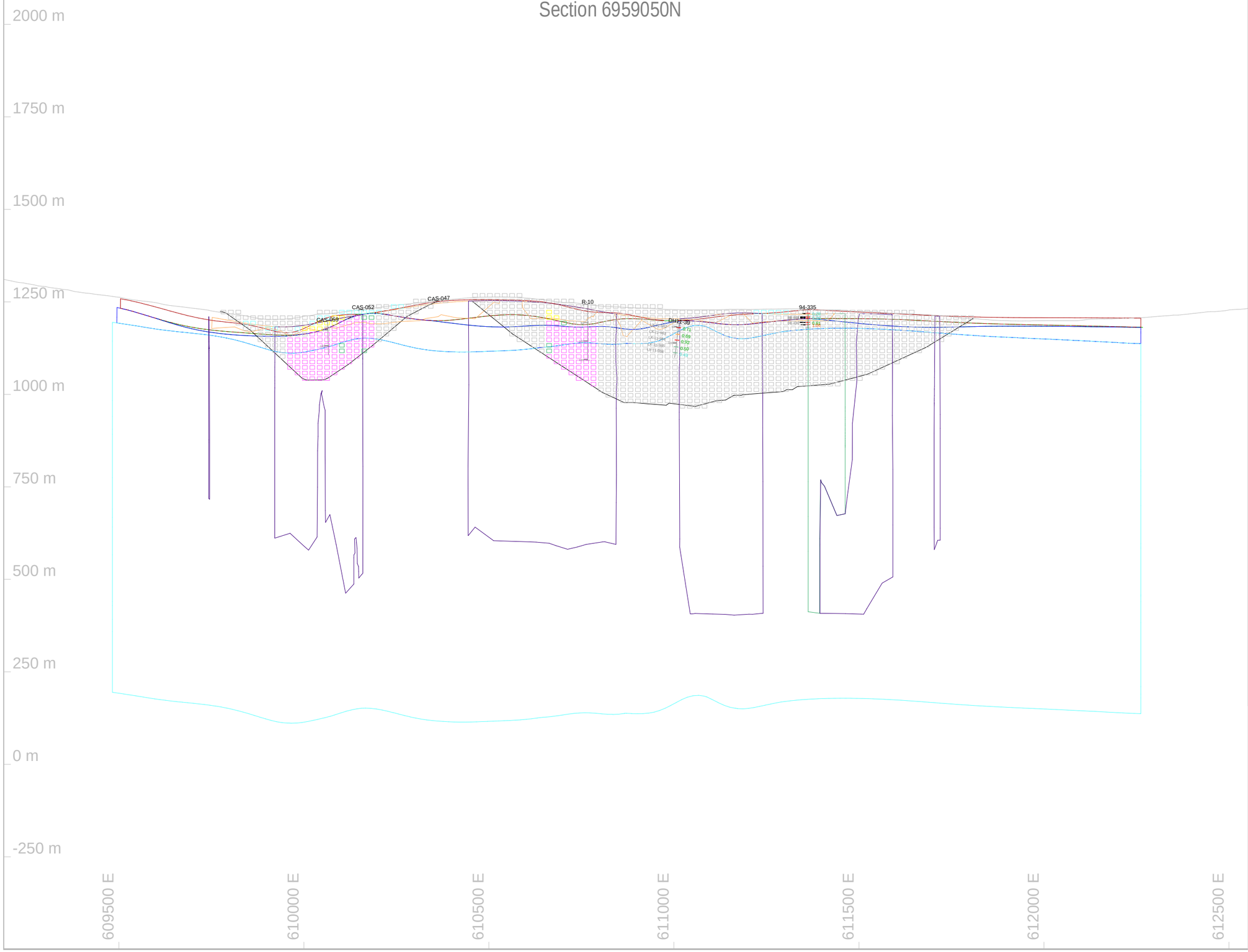
Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 21, 2014

Section 6959050N



Mineralized Zone

CAP	
SOX	
SUS	
HYP	

Alteration

POT	
PRO	
ARG	

Rinse pH (bar on left)

< 5.0	
5.0 - 6.4	
6.4 - 7.0	
> 7.0	

CANP/AP (centre bar)

< 1.0	
1.0 - 2.0	
> 2.0	

Total S% (text on right)

0.0 - 0.1	
0.1 - 0.5	
0.5 - 1.0	
1.0 - 5.0	
5.0 - 10.0	
10.0 - 100	

PFS Material Routing (blocks)

Overburden	
Leach Cap Gold Ore	
Leach Cap Potential Ore	
Sox Stockpile Ore	
Low Grade Stockpile	
Direct Feed Ore	
Waste	

Casino Project

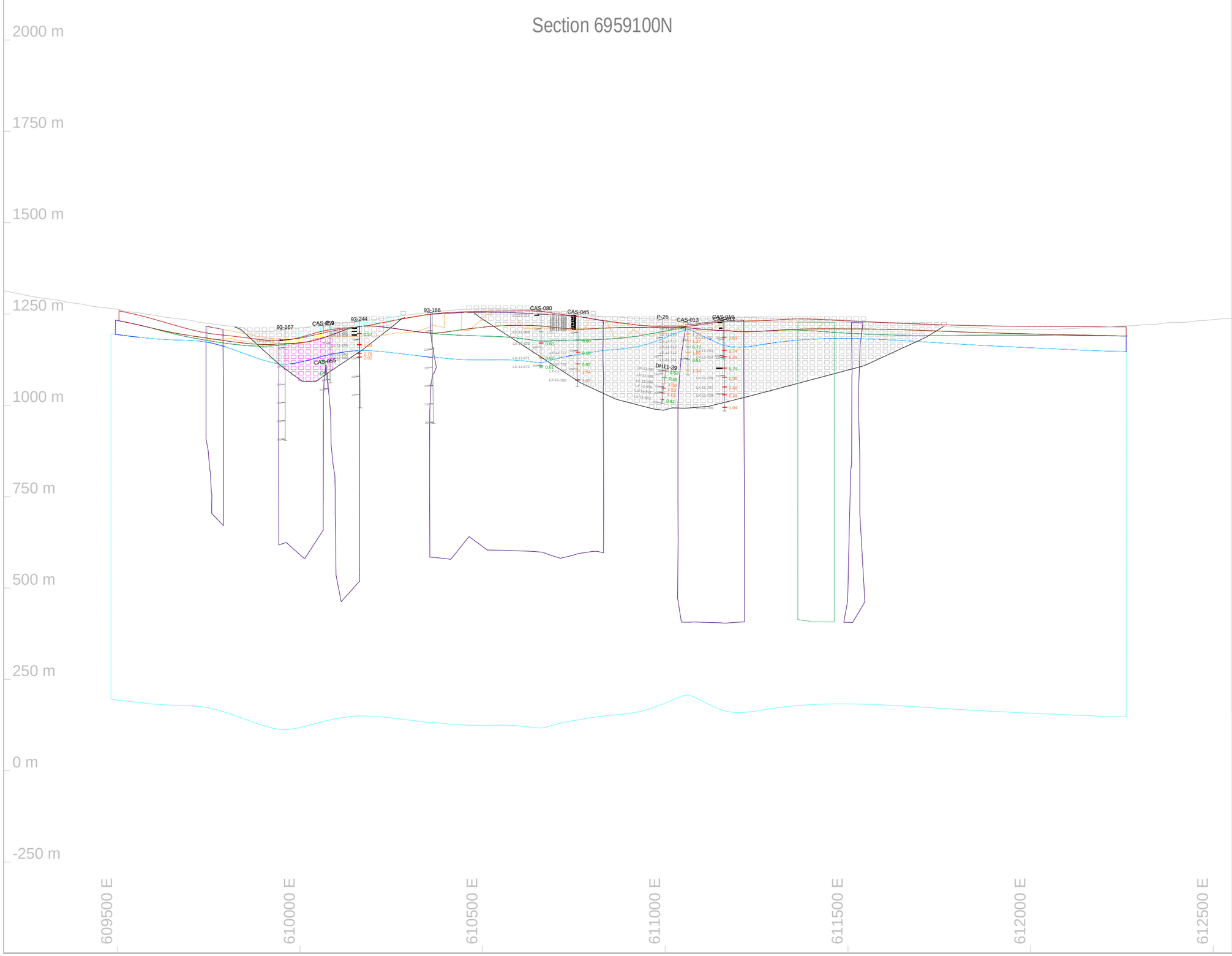
Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 21, 2014

Section 6959100N



Mineralized Zone

CAP	
SOX	
SUS	
HYP	

Alteration

POT	
PRO	
ARG	

Rinse pH (bar on left)

< 5.0	
5.0 - 6.4	
6.4 - 7.0	
> 7.0	

CANP/AP (centre bar)

< 1.0	
1.0 - 2.0	
> 2.0	

Total S% (text on right)

0.0 - 0.1	
0.1 - 0.5	
0.5 - 1.0	
1.0 - 5.0	
5.0 - 10.0	
10.0 - 100	

PFS Material Routing (blocks)

Overburden	
Leach Cap Gold Ore	
Leach Cap Potential Ore	
Sox Stockpile Ore	
Low Grade Stockpile	
Direct Feed Ore	
Waste	

Casino Project

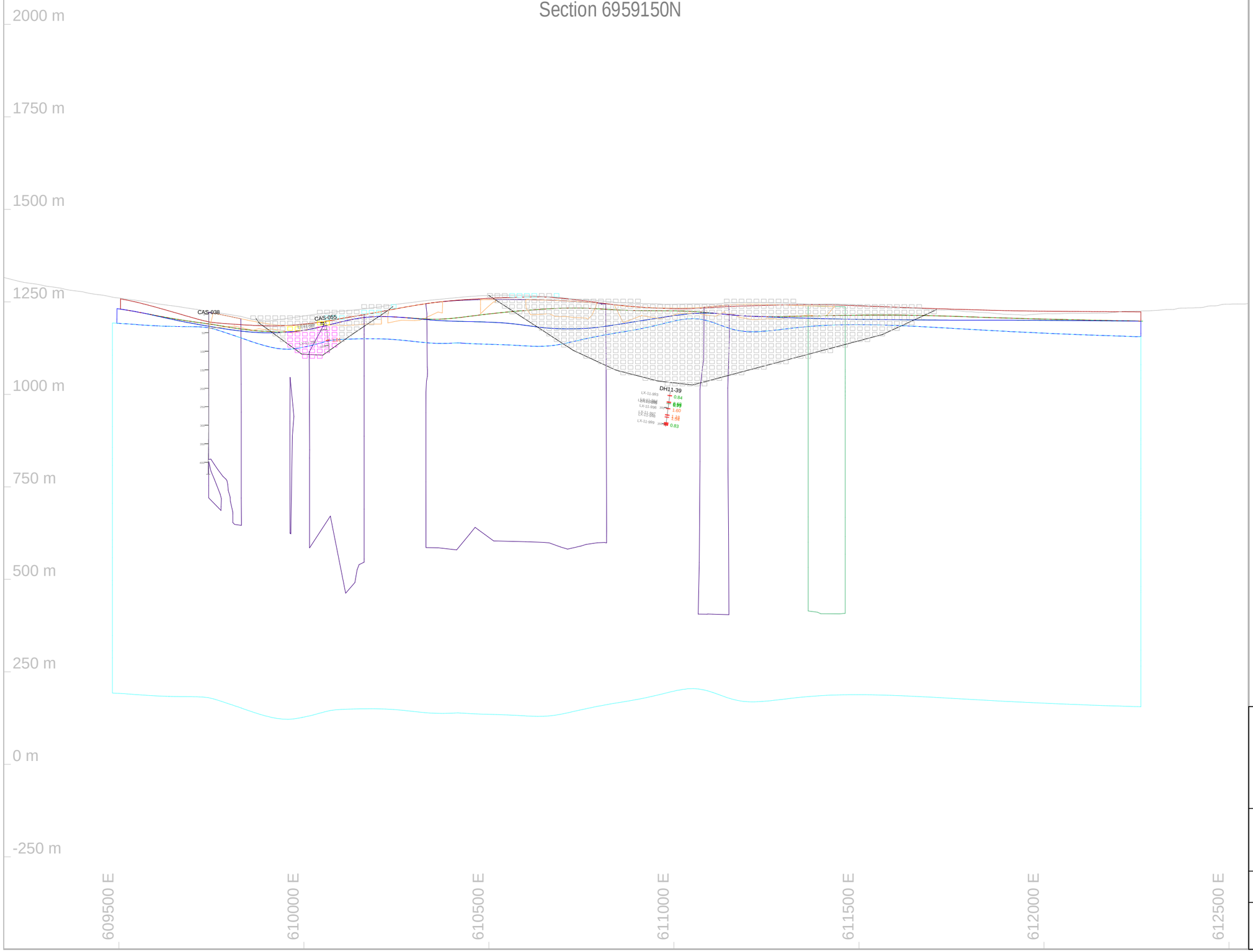
Lorax Environmental Services:
ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 21, 2014

Section 6959150N



Mineralized Zone

- CAP
- SOX
- SUS
- HYP

Alteration

- POT
- PRO
- ARG

Rinse pH (bar on left)

- < 5.0
- 5.0 - 6.4
- 6.4 - 7.0
- > 7.0

CANP/AP (centre bar)

- < 1.0
- 1.0 - 2.0
- > 2.0

Total S% (text on right)

- 0.0 - 0.1
- 0.1 - 0.5
- 0.5 - 1.0
- 1.0 - 5.0
- 5.0 - 10.0
- 10.0 - 100

PFS Material Routing (blocks)

- Overburden
- Leach Cap Gold Ore
- Leach Cap Potential Ore
- Sox Stockpile Ore
- Low Grade Stockpile
- Direct Feed Ore
- Waste

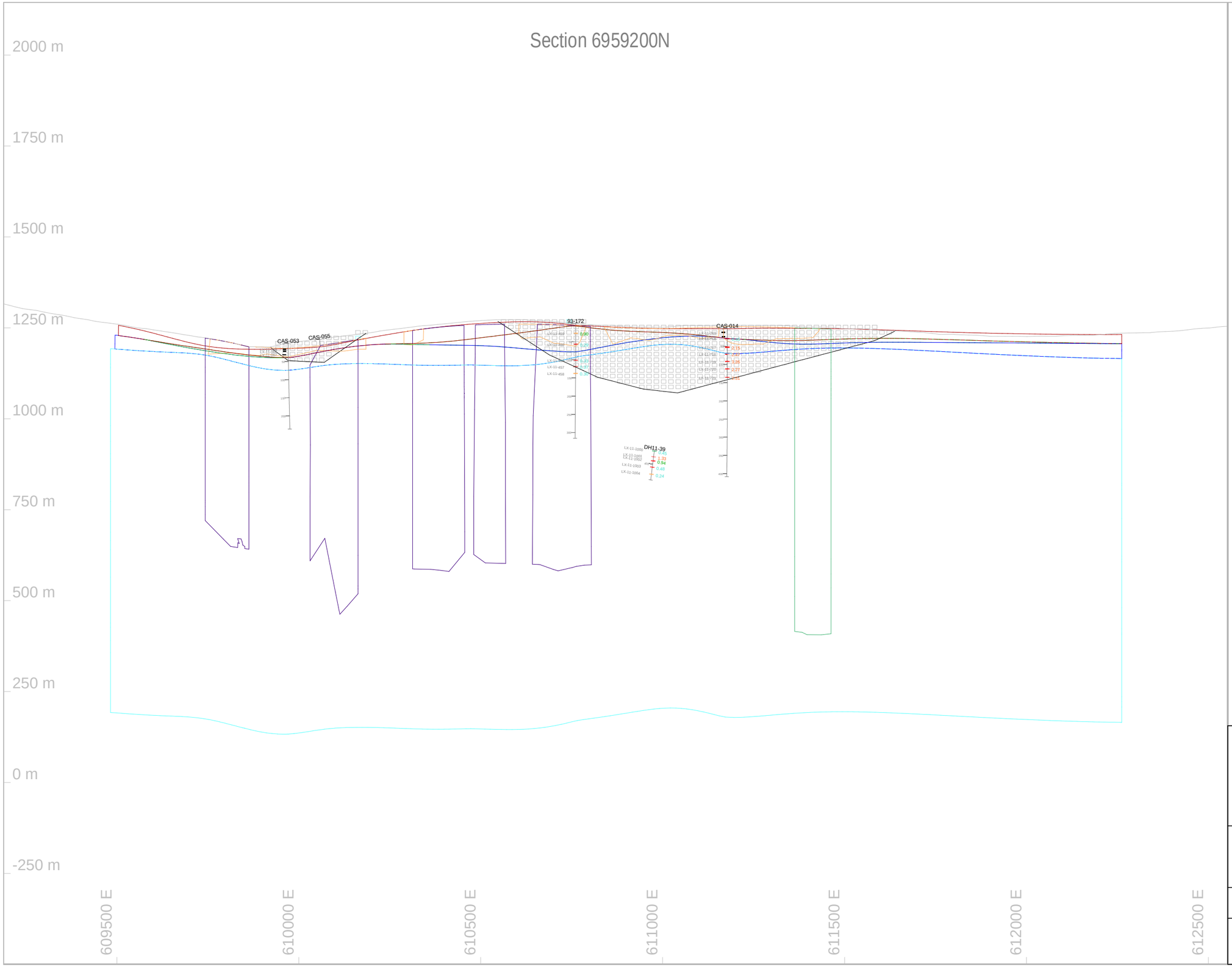
Casino Project

Lorax Environmental Services:
ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 21, 2014



Mineralized Zone

CAP	
SOX	
SUS	
HYP	

Alteration

POT	
PRO	
ARG	

Rinse pH (bar on left)

< 5.0	
5.0 - 6.4	
6.4 - 7.0	
> 7.0	

CANP/AP (centre bar)

< 1.0	
1.0 - 2.0	
> 2.0	

Total S% (text on right)

0.0 - 0.1	
0.1 - 0.5	
0.5 - 1.0	
1.0 - 5.0	
5.0 - 10.0	
10.0 - 100	

PFS Material Routing (blocks)

Overburden	
Leach Cap Gold Ore	
Leach Cap Potential Ore	
Sox Stockpile Ore	
Low Grade Stockpile	
Direct Feed Ore	
Waste	

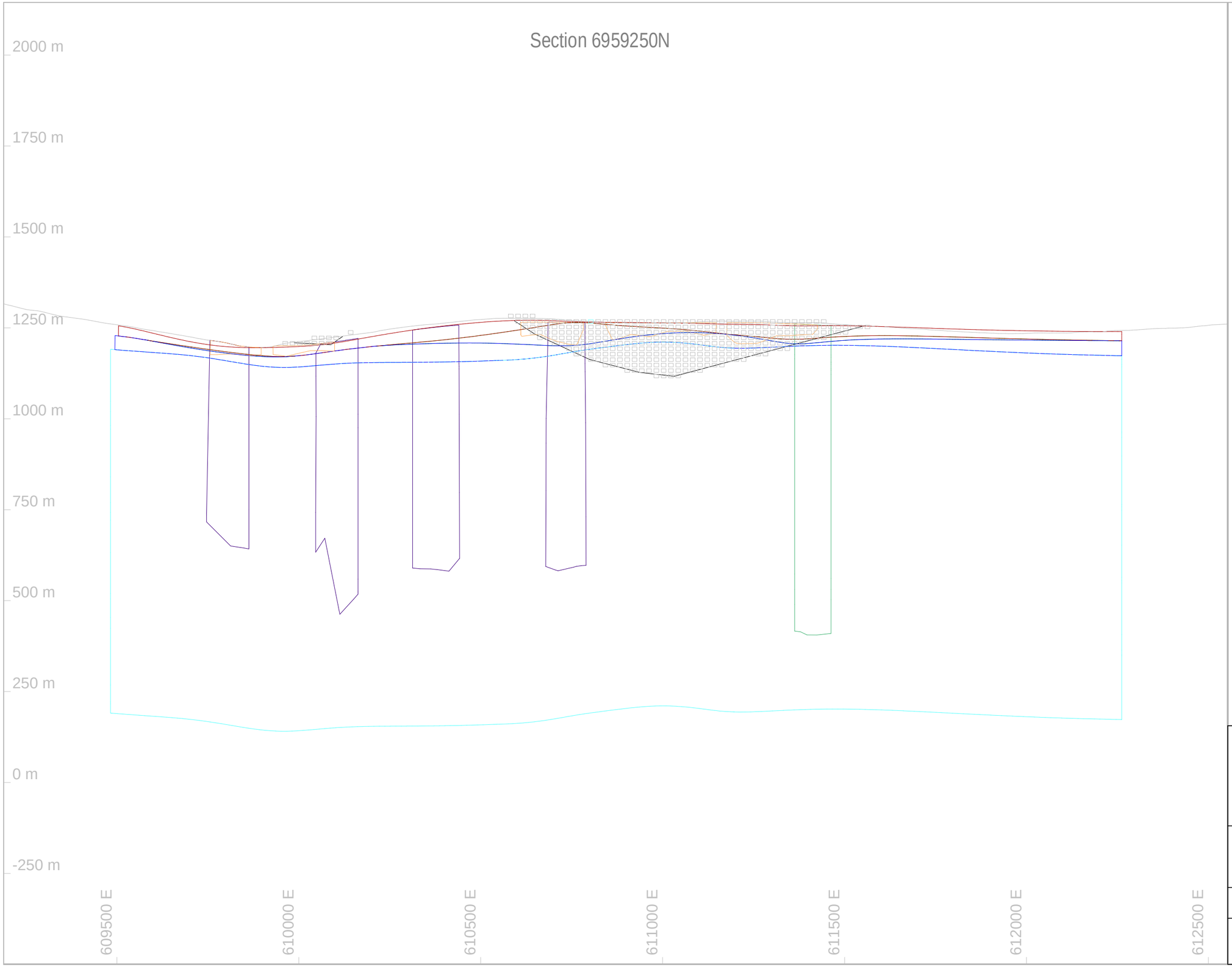
Casino Project

Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 21, 2014



Mineralized Zone

CAP	
SOX	
SUS	
HYP	

Alteration

POT	
PRO	
ARG	

Rinse pH (bar on left)

< 5.0	
5.0 - 6.4	
6.4 - 7.0	
> 7.0	

CANP/AP (centre bar)

< 1.0	
1.0 - 2.0	
> 2.0	

Total S% (text on right)

0.0 - 0.1	
0.1 - 0.5	
0.5 - 1.0	
1.0 - 5.0	
5.0 - 10.0	
10.0 - 100	

PFS Material Routing (blocks)

Overburden	
Leach Cap Gold Ore	
Leach Cap Potential Ore	
Sox Stockpile Ore	
Low Grade Stockpile	
Direct Feed Ore	
Waste	

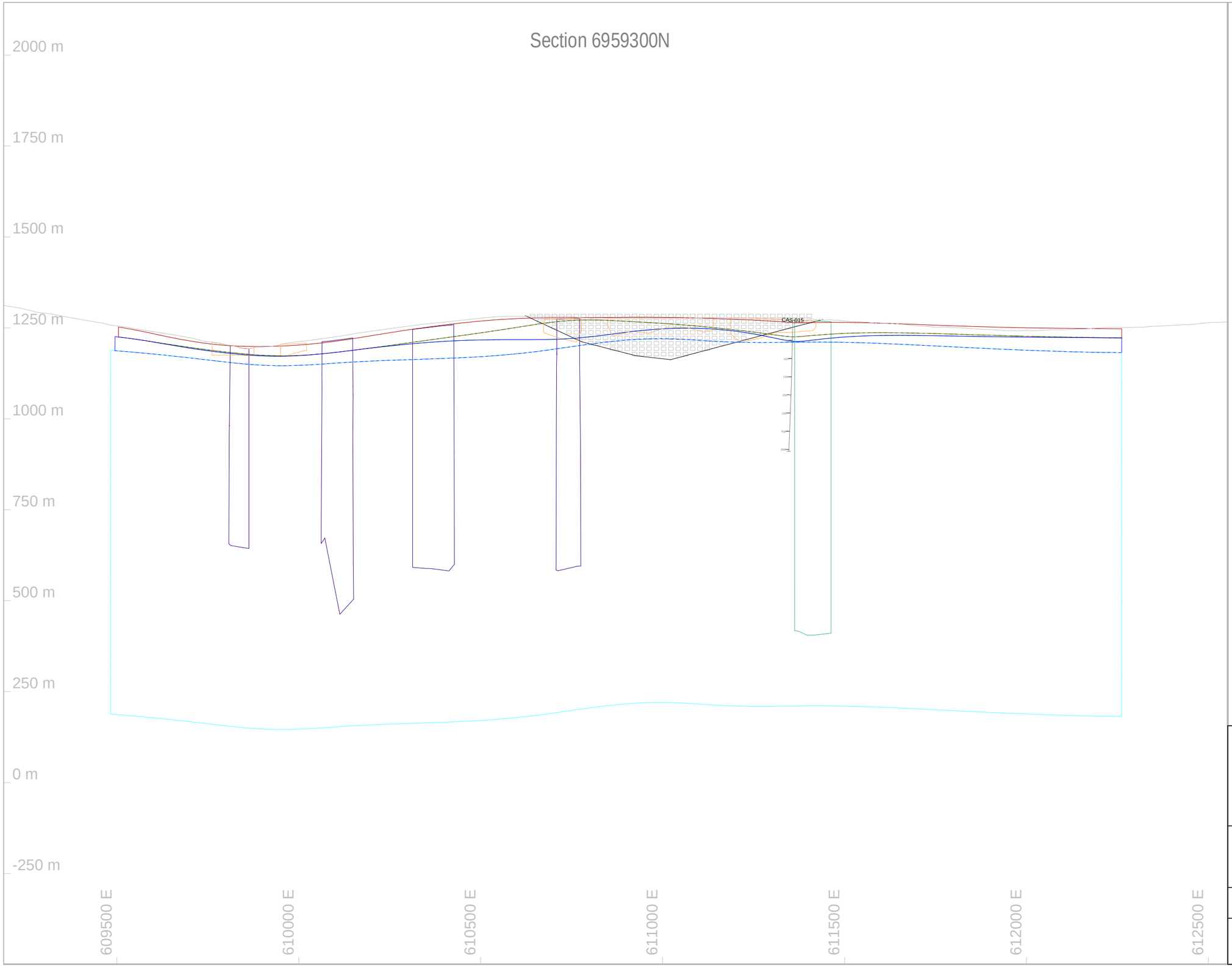
Casino Project

Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 21, 2014



Mineralized Zone

CAP	
SOX	
SUS	
HYP	

Alteration

POT	
PRO	
ARG	

Rinse pH (bar on left)

< 5.0	
5.0 - 6.4	
6.4 - 7.0	
> 7.0	

CANP/AP (centre bar)

< 1.0	
1.0 - 2.0	
> 2.0	

Total S% (text on right)

0.0 - 0.1	
0.1 - 0.5	
0.5 - 1.0	
1.0 - 5.0	
5.0 - 10.0	
10.0 - 100	

PFS Material Routing (blocks)

Overburden	
Leach Cap Gold Ore	
Leach Cap Potential Ore	
Sox Stockpile Ore	
Low Grade Stockpile	
Direct Feed Ore	
Waste	

Casino Project

Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 21, 2014

Section 6959350N

2000 m
1750 m
1500 m
1250 m
1000 m
750 m
500 m
250 m
0 m
-250 m

609500 E
610000 E
610500 E
611000 E
611500 E
612000 E
612500 E

Mineralized Zone

CAP	
SOX	
SUS	
HYP	

Alteration

POT	
PRO	
ARG	

Rinse pH (bar on left)

< 5.0	
5.0 - 6.4	
6.4 - 7.0	
> 7.0	

CANP/AP (centre bar)

< 1.0	
1.0 - 2.0	
> 2.0	

Total S% (text on right)

0.0 - 0.1	
0.1 - 0.5	
0.5 - 1.0	
1.0 - 5.0	
5.0 - 10.0	
10.0 - 100	

PFS Material Routing (blocks)

Overburden	
Leach Cap Gold Ore	
Leach Cap Potential Ore	
Sox Stockpile Ore	
Low Grade Stockpile	
Direct Feed Ore	
Waste	

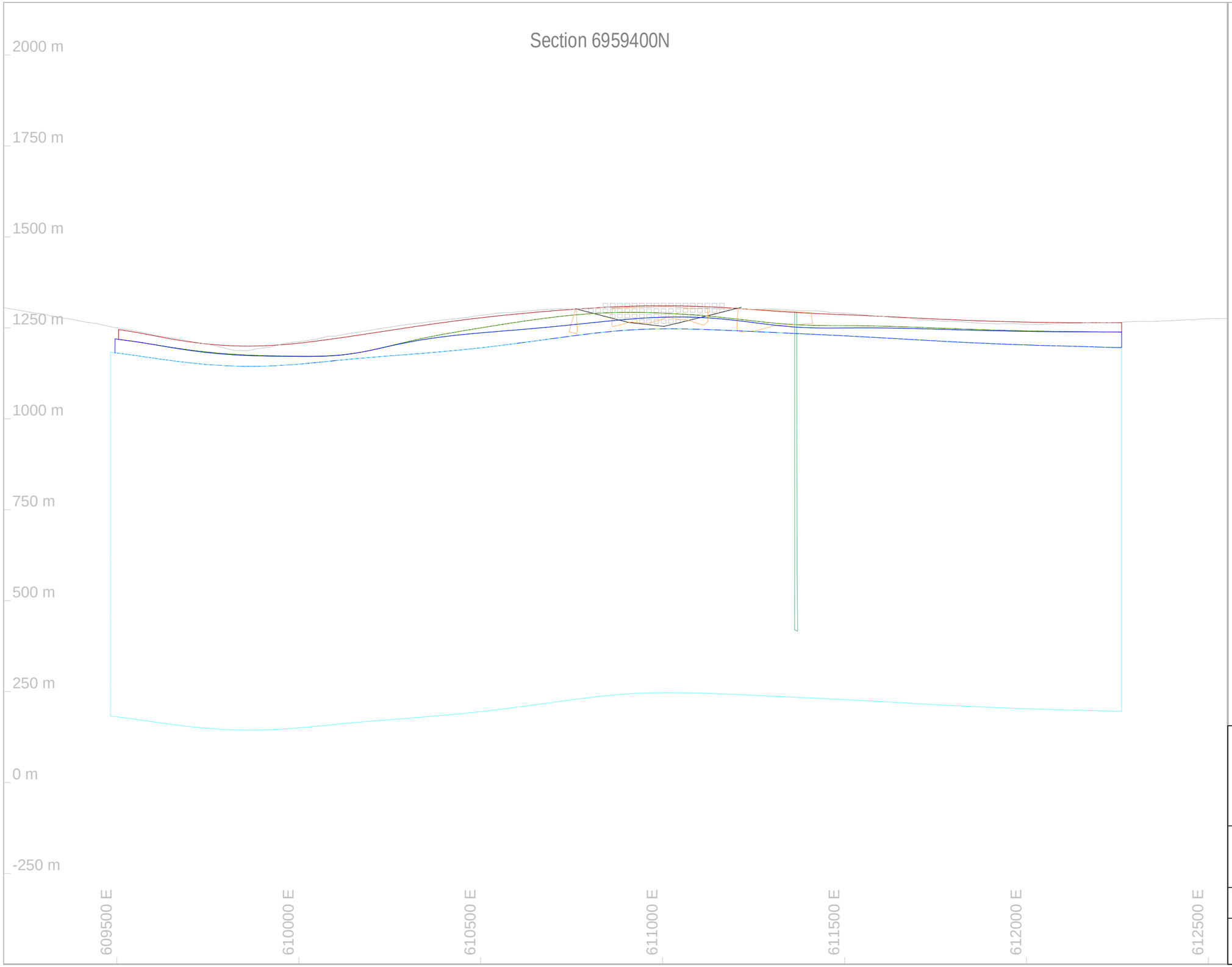
Casino Project

Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 21, 2014



Mineralized Zone

CAP
SOX
SUS
HYP

Alteration

POT
PRO
ARG

Rinse pH (bar on left)

< 5.0
5.0 - 6.4
6.4 - 7.0
> 7.0

CANP/AP (centre bar)

< 1.0
1.0 - 2.0
> 2.0

Total S% (text on right)

0.0 - 0.1
0.1 - 0.5
0.5 - 1.0
1.0 - 5.0
5.0 - 10.0
10.0 - 100

PFS Material Routing (blocks)

Overburden
Leach Cap Gold Ore
Leach Cap Potential Ore
Sox Stockpile Ore
Low Grade Stockpile
Direct Feed Ore
Waste

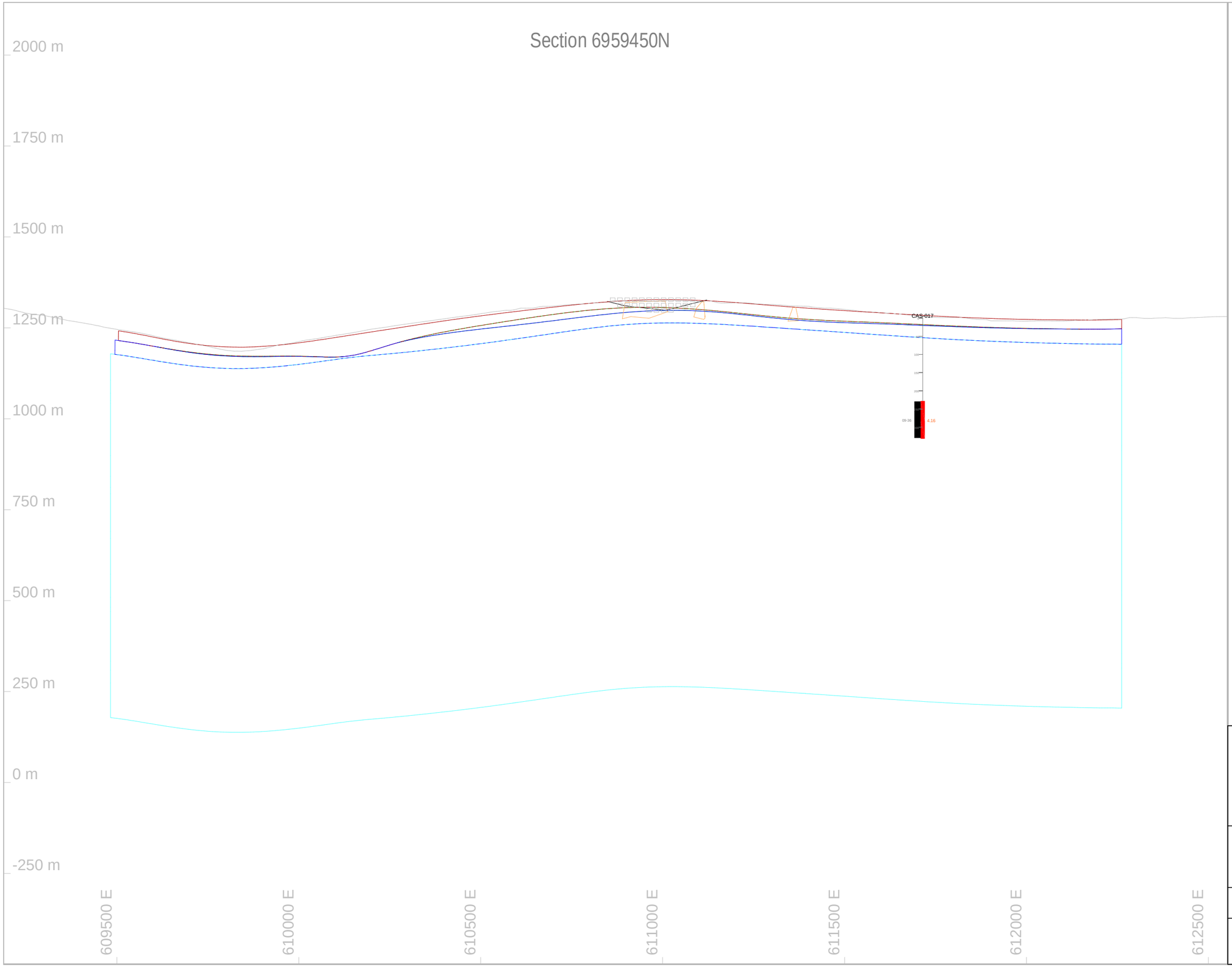
Casino Project

Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 21, 2014



Mineralized Zone

CAP	
SOX	
SUS	
HYP	

Alteration

POT	
PRO	
ARG	

Rinse pH (bar on left)

< 5.0	
5.0 - 6.4	
6.4 - 7.0	
> 7.0	

CANP/AP (centre bar)

< 1.0	
1.0 - 2.0	
> 2.0	

Total S% (text on right)

0.0 - 0.1	
0.1 - 0.5	
0.5 - 1.0	
1.0 - 5.0	
5.0 - 10.0	
10.0 - 100	

PFS Material Routing (blocks)

Overburden	
Leach Cap Gold Ore	
Leach Cap Potential Ore	
Sox Stockpile Ore	
Low Grade Stockpile	
Direct Feed Ore	
Waste	

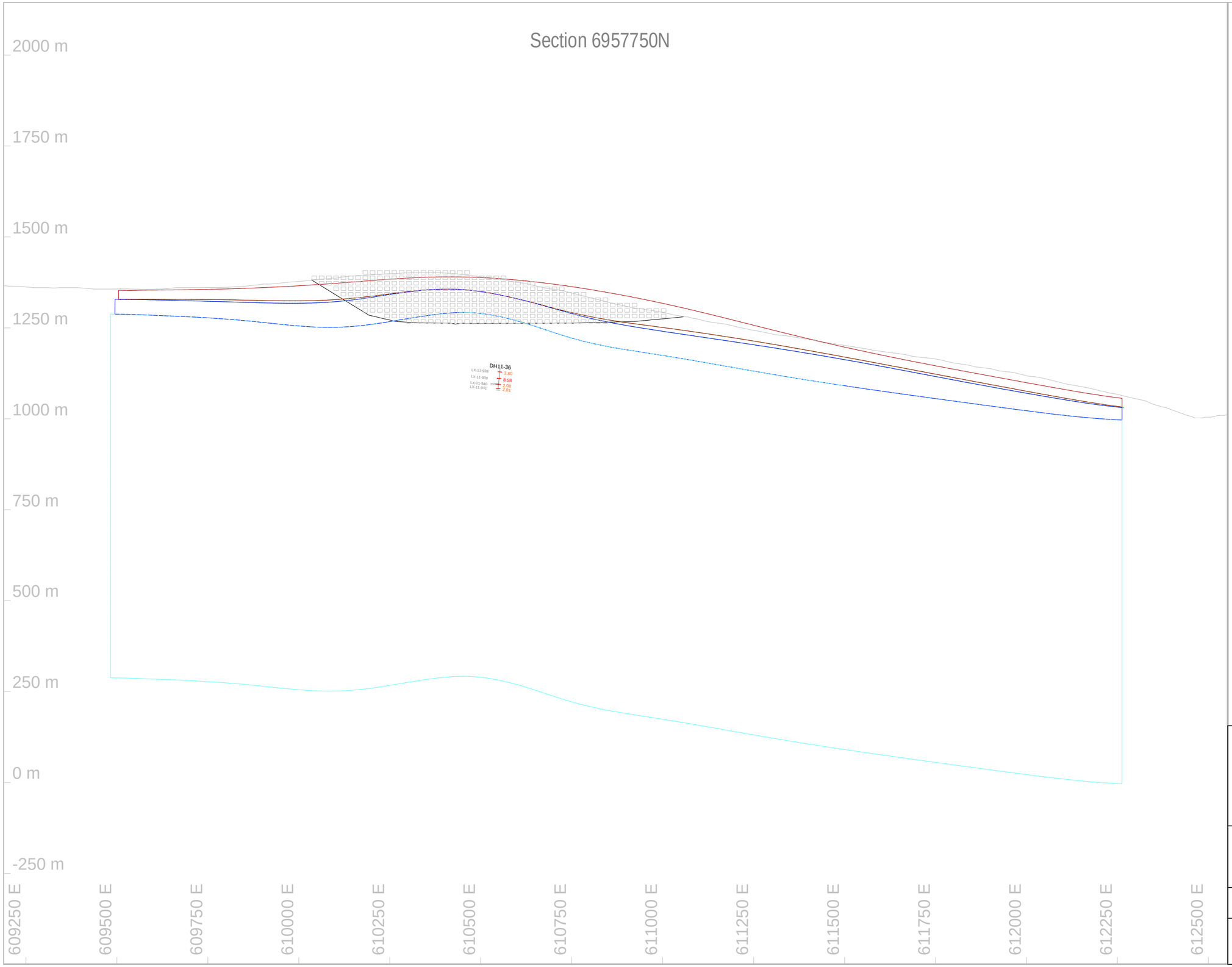
Casino Project

Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 21, 2014



Mineralized Zone

CAP	
SOX	
SUS	
HYP	

Lithology

IX	
MX	
PP	

Rinse pH (bar on left)

< 5.0	
5.0 - 6.4	
6.4 - 7.0	
> 7.0	

CANP/AP (centre bar)

< 1.0	
1.0 - 2.0	
> 2.0	

Total S% (text on right)

0.0 - 0.1	
0.1 - 0.5	
0.5 - 1.0	
1.0 - 5.0	
5.0 - 10.0	
10.0 - 100	

PFS Material Routing (blocks)

Overburden	
Leach Cap Gold Ore	
Leach Cap Potential Ore	
Sox Stockpile Ore	
Low Grade Stockpile	
Direct Feed Ore	
Waste	

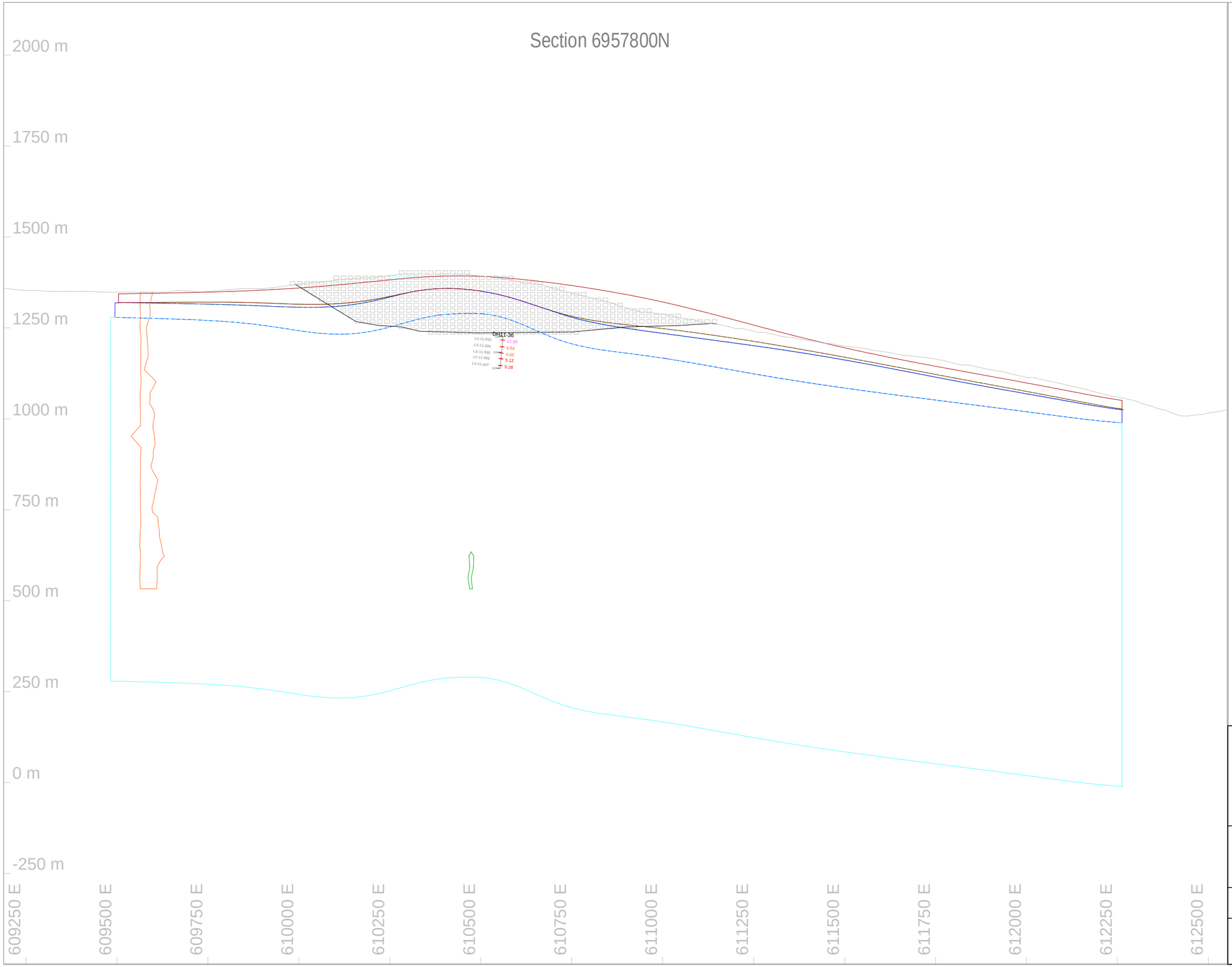
Casino Project

Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 8, 2014



Mineralized Zone
- CAP
- SOX
- SUS
- HYP

Lithology
- IX
- MX
- PP

Rinse pH (bar on left)
- < 5.0
- 5.0 - 6.4
- 6.4 - 7.0
- > 7.0

CANP/AP (centre bar)
- < 1.0
- 1.0 - 2.0
- > 2.0

Total S% (text on right)
- 0.0 - 0.1
- 0.1 - 0.5
- 0.5 - 1.0
- 1.0 - 5.0
- 5.0 - 10.0
- 10.0 - 100

PFS Material Routing (blocks)
- Overburden
- Leach Cap Gold Ore
- Leach Cap Potential Ore
- Sox Stockpile Ore
- Low Grade Stockpile
- Direct Feed Ore
- Waste

Casino Project

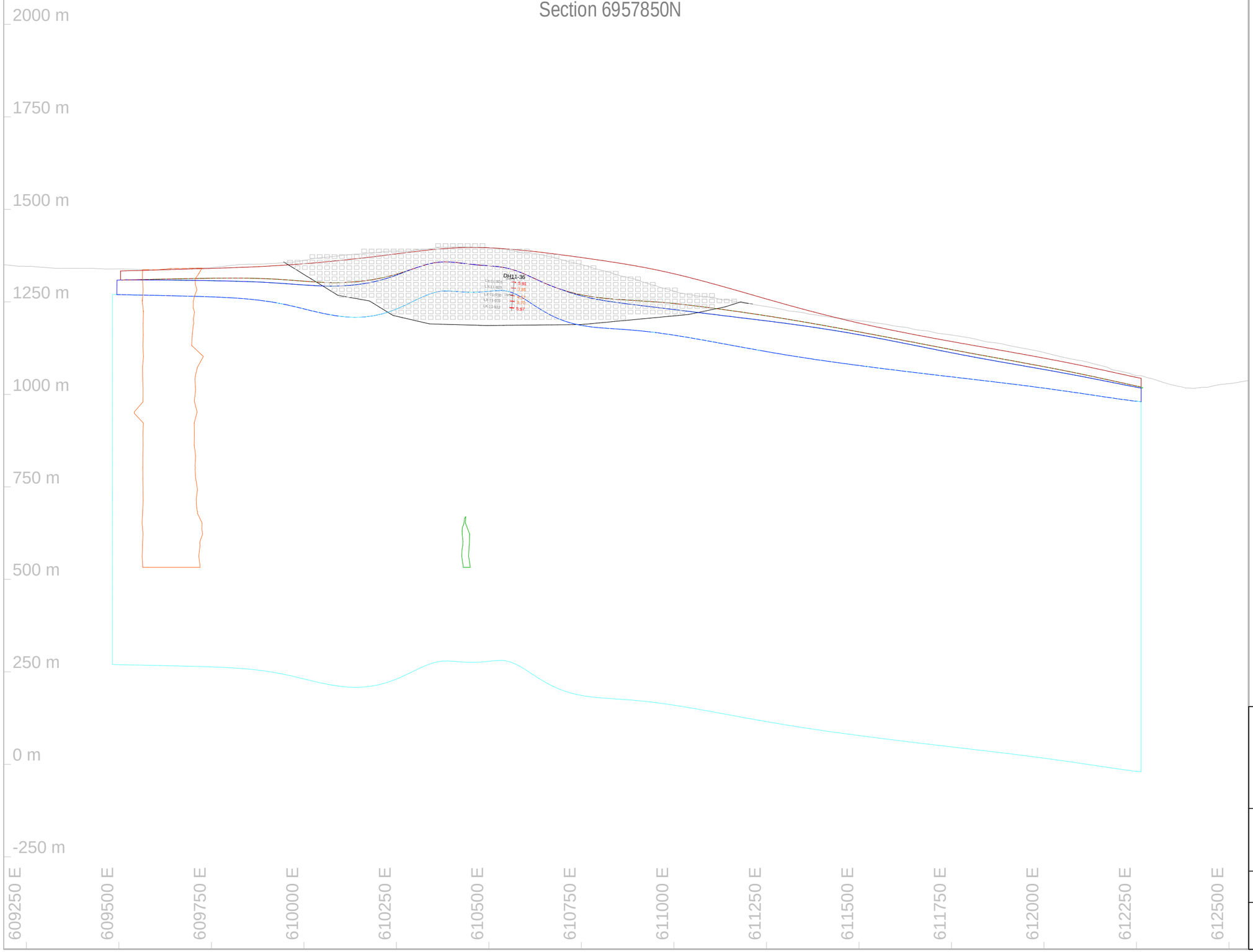
Lorax Environmental Services:
ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 8, 2014

Section 6957850N



Mineralized Zone

CAP
SOX
SUS
HYP

Lithology

IX
MX
PP

Rinse pH (bar on left)

< 5.0
5.0 - 6.4
6.4 - 7.0
> 7.0

CANP/AP (centre bar)

< 1.0
1.0 - 2.0
> 2.0

Total S% (text on right)

0.0 - 0.1
0.1 - 0.5
0.5 - 1.0
1.0 - 5.0
5.0 - 10.0
10.0 - 100

PFS Material Routing (blocks)

Overburden
Leach Cap Gold Ore
Leach Cap Potential Ore
Sox Stockpile Ore
Low Grade Stockpile
Direct Feed Ore
Waste

Casino Project

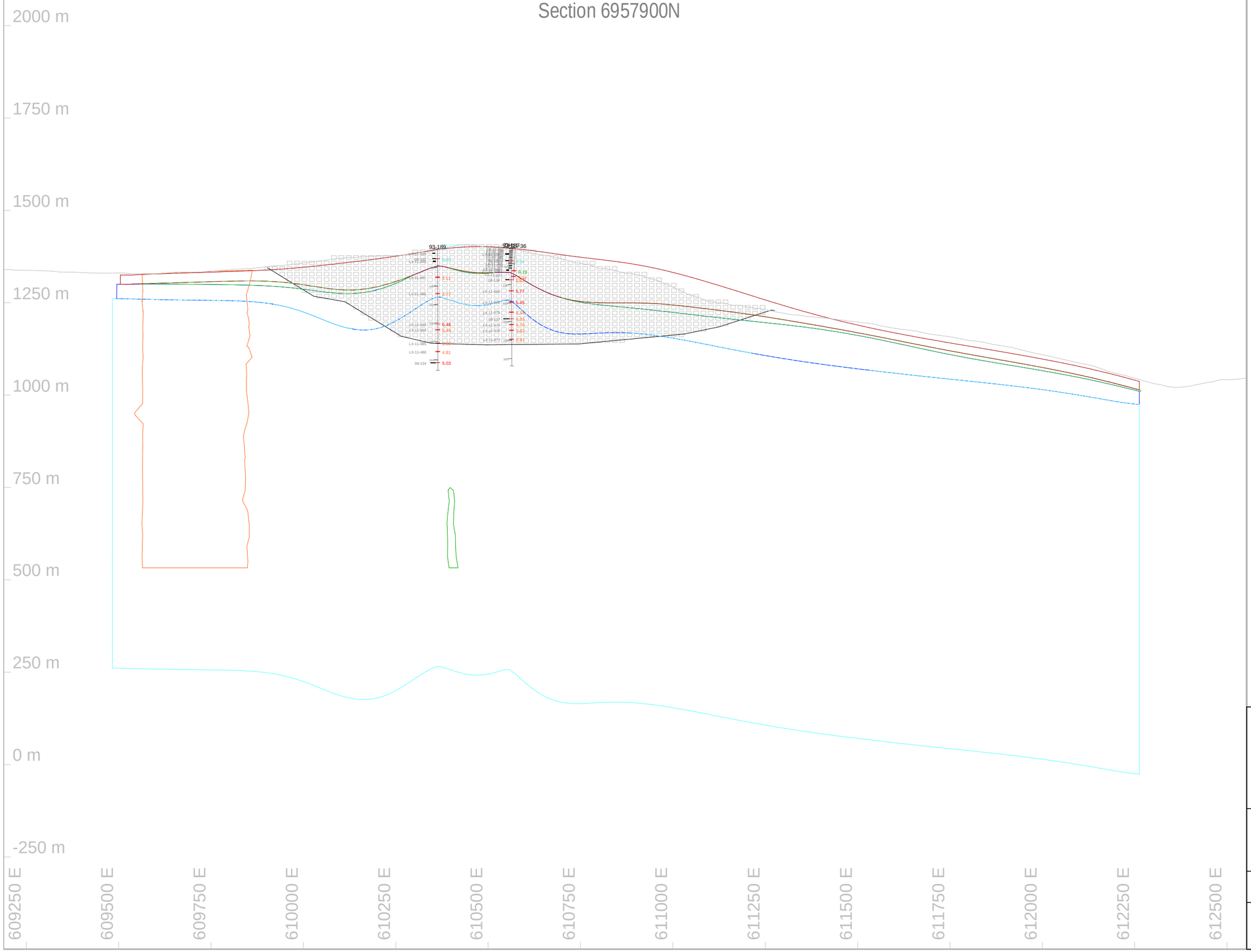
Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 8, 2014

Section 6957900N



Mineralized Zone

CAP
SOX
SUS
HYP

Lithology

IX
MX
PP

Rinse pH (bar on left)

< 5.0
5.0 - 6.4
6.4 - 7.0
> 7.0

CANP/AP (centre bar)

< 1.0
1.0 - 2.0
> 2.0

Total S% (text on right)

0.0 - 0.1
0.1 - 0.5
0.5 - 1.0
1.0 - 5.0
5.0 - 10.0
10.0 - 100

PFS Material Routing (blocks)

Overburden
Leach Cap Gold Ore
Leach Cap Potential Ore
Sox Stockpile Ore
Low Grade Stockpile
Direct Feed Ore
Waste

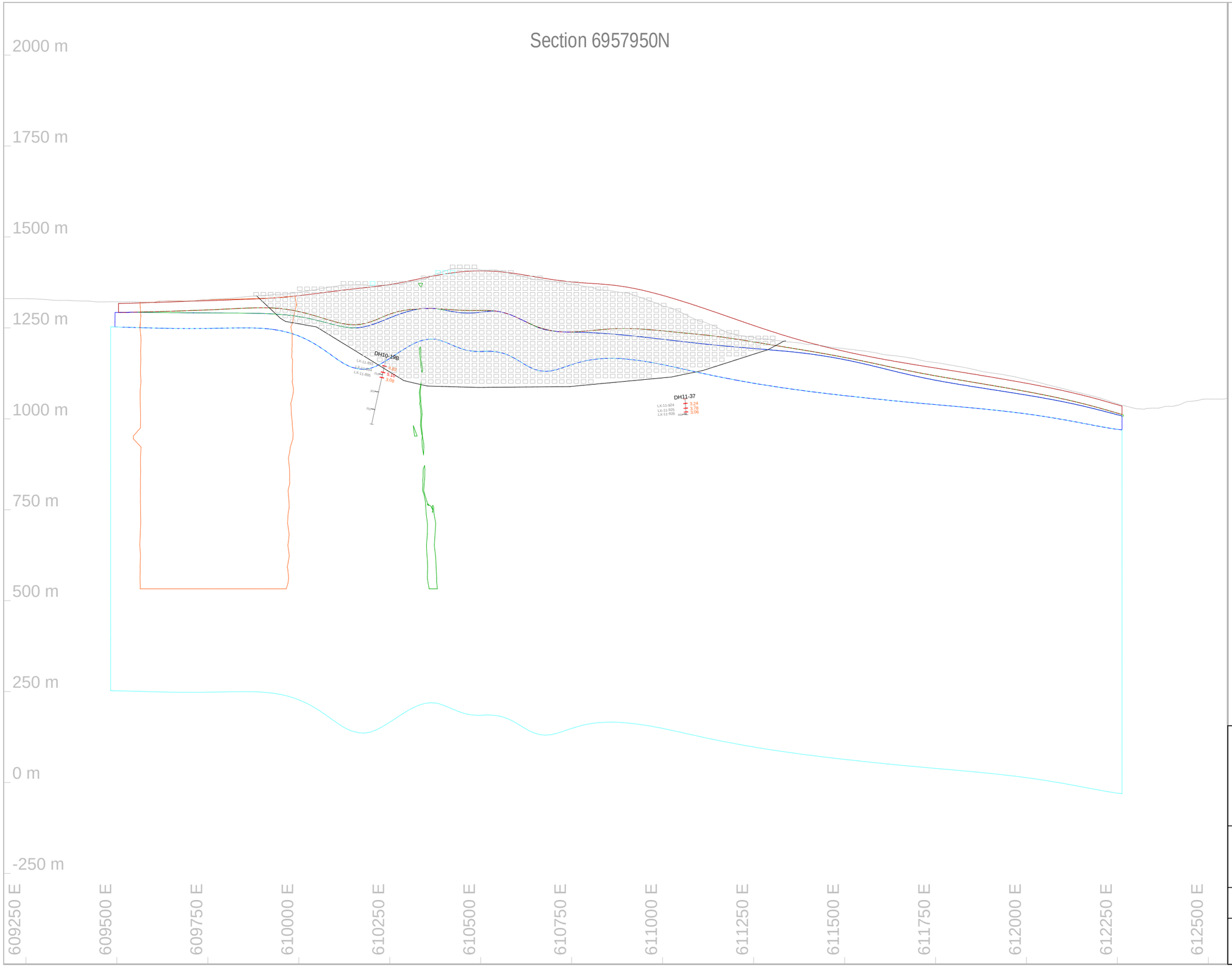
Casino Project

Lorax Environmental Services:
ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 8, 2014



Mineralized Zone

CAP
SOX
SUS
HYP

Lithology

IX
MX
PP

Rinse pH (bar on left)

< 5.0
5.0 - 6.4
6.4 - 7.0
> 7.0

CANP/AP (centre bar)

< 1.0
1.0 - 2.0
> 2.0

Total S% (text on right)

0.0 - 0.1
0.1 - 0.5
0.5 - 1.0
1.0 - 5.0
5.0 - 10.0
10.0 - 100

PFS Material Routing (blocks)

Overburden
Leach Cap Gold Ore
Leach Cap Potential Ore
Sox Stockpile Ore
Low Grade Stockpile
Direct Feed Ore
Waste

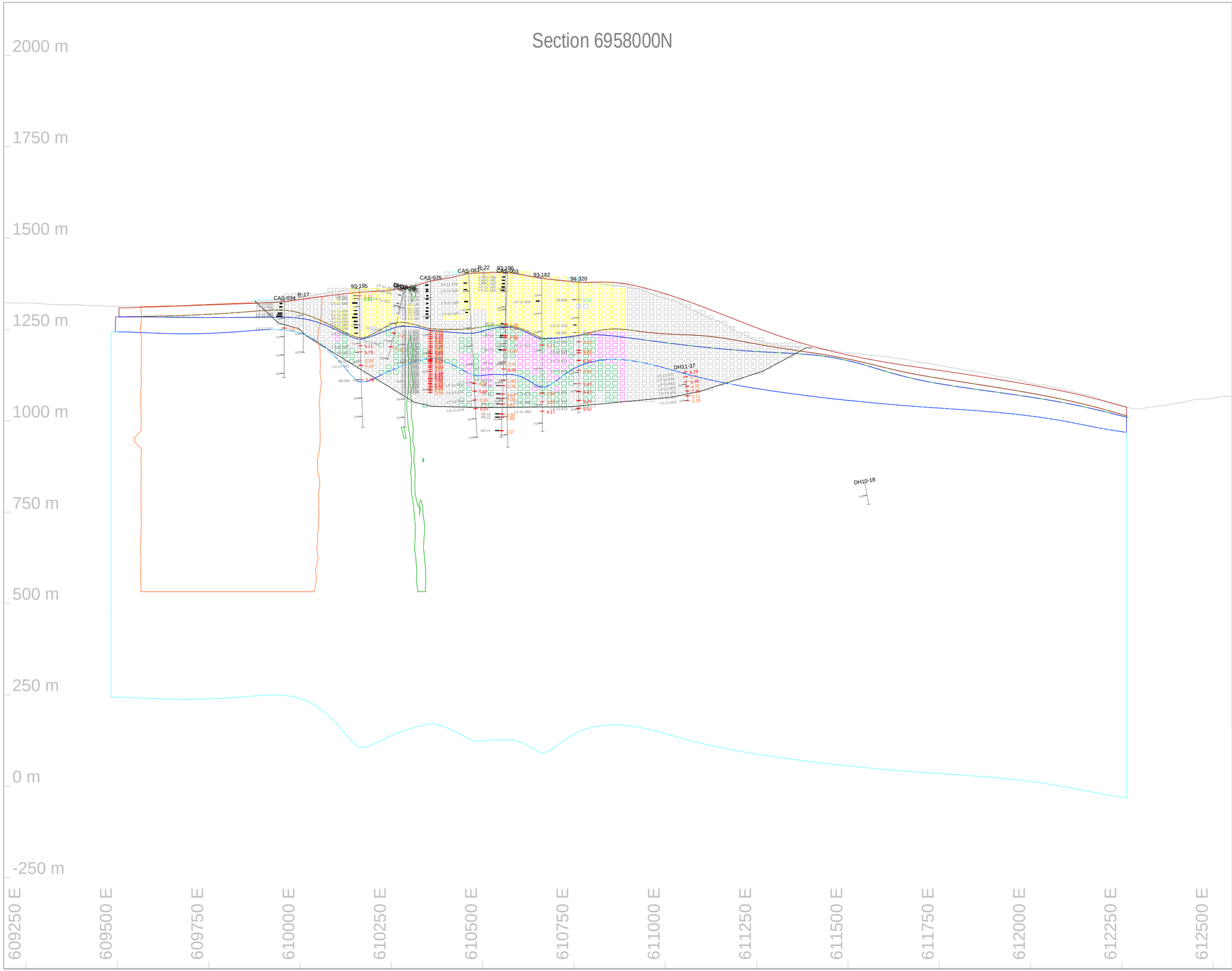
Casino Project

Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 8, 2014



Mineralized Zone

CAP
SOX
SUS
HYP

Lithology

IX
MX
PP

Rinse pH (bar on left)

< 5.0
5.0 - 6.4
6.4 - 7.0
> 7.0

CANP/AP (centre bar)

< 1.0
1.0 - 2.0
> 2.0

Total S% (text on right)

0.0 - 0.1
0.1 - 0.5
0.5 - 1.0
1.0 - 5.0
5.0 - 10.0
10.0 - 100

PFS Material Routing (blocks)

Overburden
Leach Cap Gold Ore
Leach Cap Potential Ore
Sox Stockpile Ore
Low Grade Stockpile
Direct Feed Ore
Waste

Casino Project

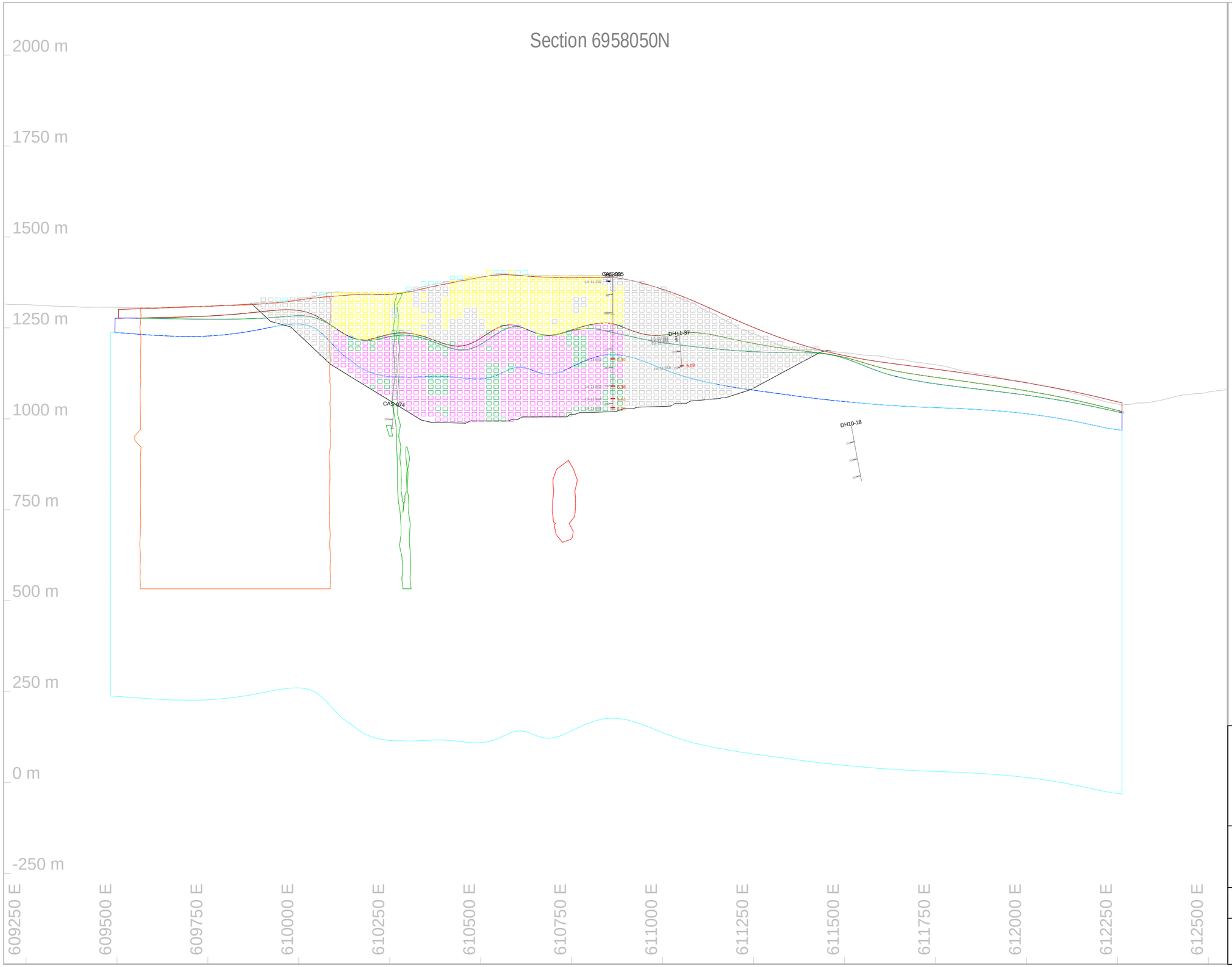
Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 8, 2014

Section 6958050N



Mineralized Zone

CAP
SOX
SUS
HYP

Lithology

IX
MX
PP

Rinse pH (bar on left)

< 5.0
5.0 - 6.4
6.4 - 7.0
> 7.0

CANP/AP (centre bar)

< 1.0
1.0 - 2.0
> 2.0

Total S% (text on right)

0.0 - 0.1
0.1 - 0.5
0.5 - 1.0
1.0 - 5.0
5.0 - 10.0
10.0 - 100

PFS Material Routing (blocks)

Overburden
Leach Cap Gold Ore
Leach Cap Potential Ore
Sox Stockpile Ore
Low Grade Stockpile
Direct Feed Ore
Waste

Casino Project

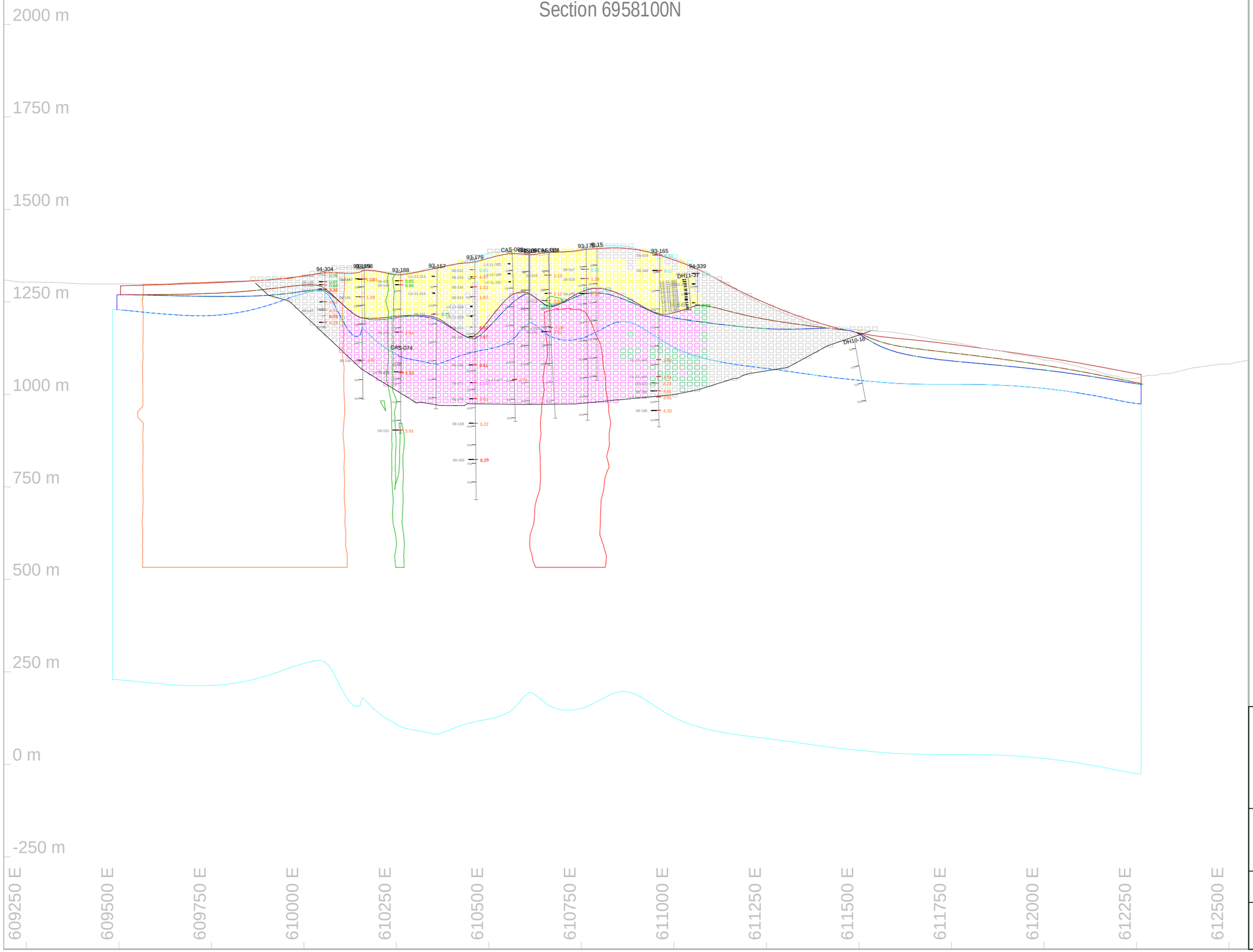
Lorax Environmental Services:
ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 8, 2014

Section 6958100N



Mineralized Zone

CAP
SOX
SUS
HYP

Lithology

IX
MX
PP

Rinse pH (bar on left)

< 5.0
5.0 - 6.4
6.4 - 7.0
> 7.0

CANP/AP (centre bar)

< 1.0
1.0 - 2.0
> 2.0

Total S% (text on right)

0.0 - 0.1
0.1 - 0.5
0.5 - 1.0
1.0 - 5.0
5.0 - 10.0
10.0 - 100

PFS Material Routing (blocks)

Overburden
Leach Cap Gold Ore
Leach Cap Potential Ore
Sox Stockpile Ore
Low Grade Stockpile
Direct Feed Ore
Waste

Casino Project

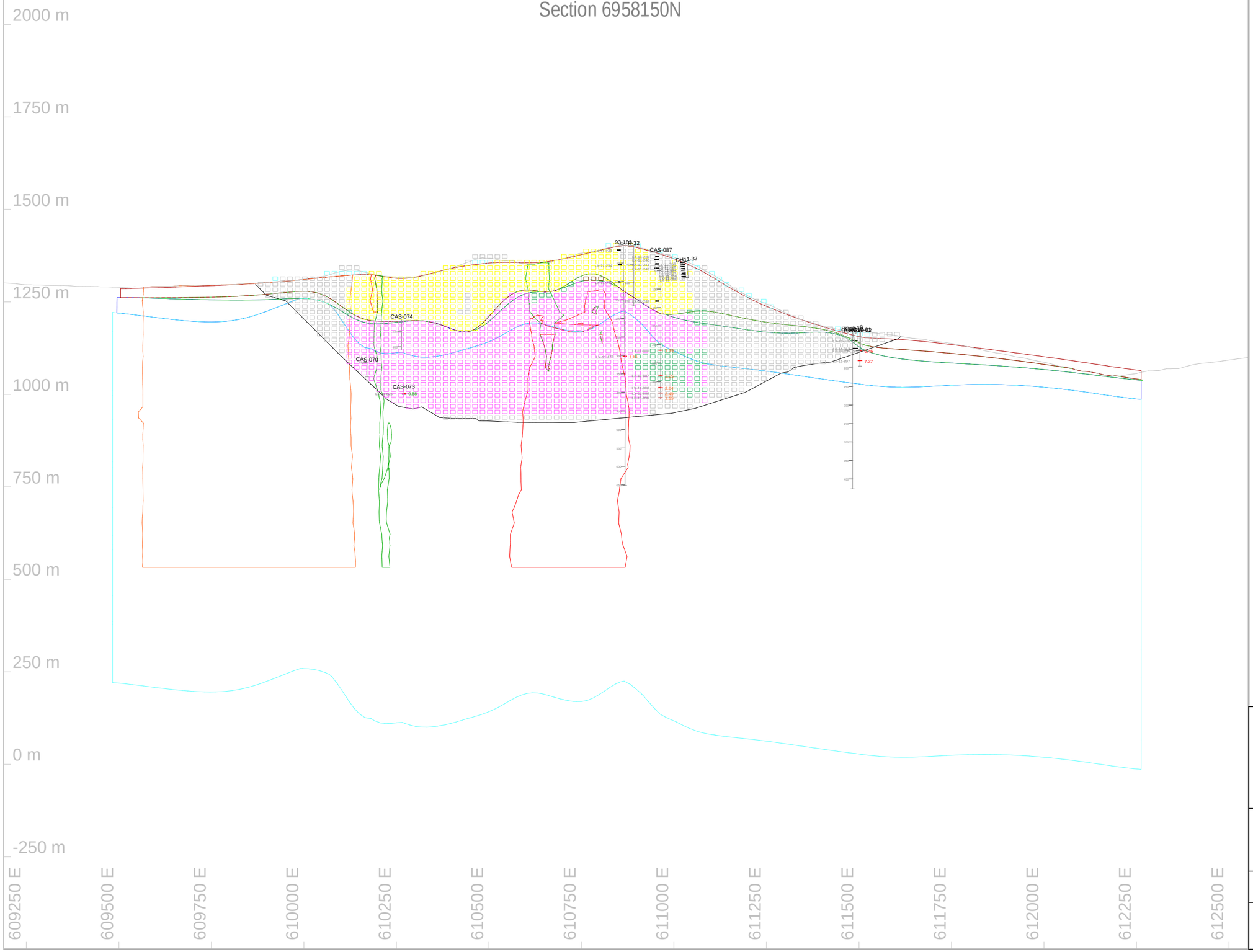
Lorax Environmental Services:
ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 8, 2014

Section 6958150N



Mineralized Zone

CAP
SOX
SUS
HYP

Lithology

IX
MX
PP

Rinse pH (bar on left)

< 5.0
5.0 - 6.4
6.4 - 7.0
> 7.0

CANP/AP (centre bar)

< 1.0
1.0 - 2.0
> 2.0

Total S% (text on right)

0.0 - 0.1
0.1 - 0.5
0.5 - 1.0
1.0 - 5.0
5.0 - 10.0
10.0 - 100

PFS Material Routing (blocks)

Overburden
Leach Cap Gold Ore
Leach Cap Potential Ore
Sox Stockpile Ore
Low Grade Stockpile
Direct Feed Ore
Waste

Casino Project

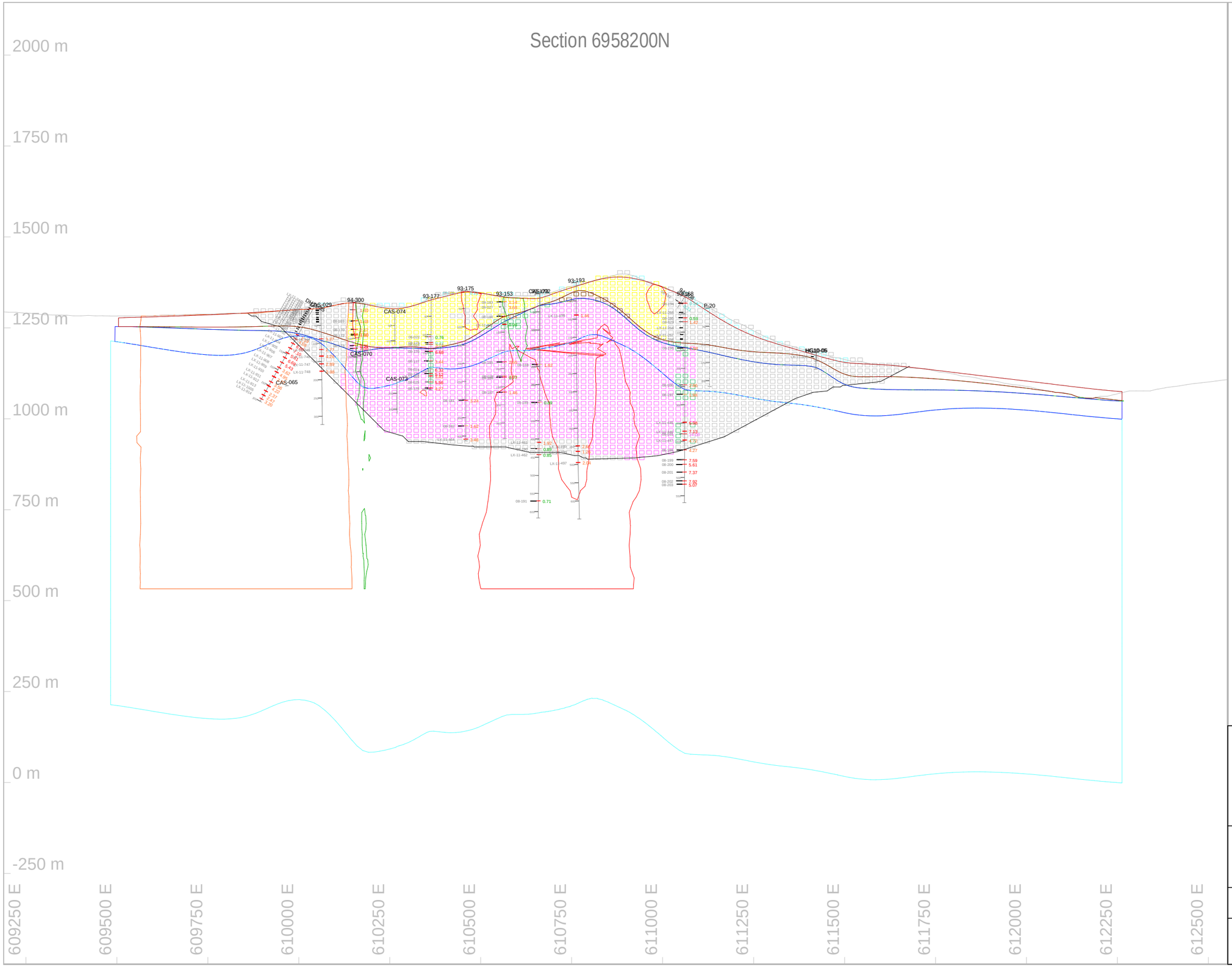
Lorax Environmental Services:
ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 8, 2014

Section 6958200N



Mineralized Zone

CAP
SOX
SUS
HYP

Lithology

IX
MX
PP

Rinse pH (bar on left)

< 5.0
5.0 - 6.4
6.4 - 7.0
> 7.0

CANP/AP (centre bar)

< 1.0
1.0 - 2.0
> 2.0

Total S% (text on right)

0.0 - 0.1
0.1 - 0.5
0.5 - 1.0
1.0 - 5.0
5.0 - 10.0
10.0 - 100

PFS Material Routing (blocks)

Overburden
Leach Cap Gold Ore
Leach Cap Potential Ore
Sox Stockpile Ore
Low Grade Stockpile
Direct Feed Ore
Waste

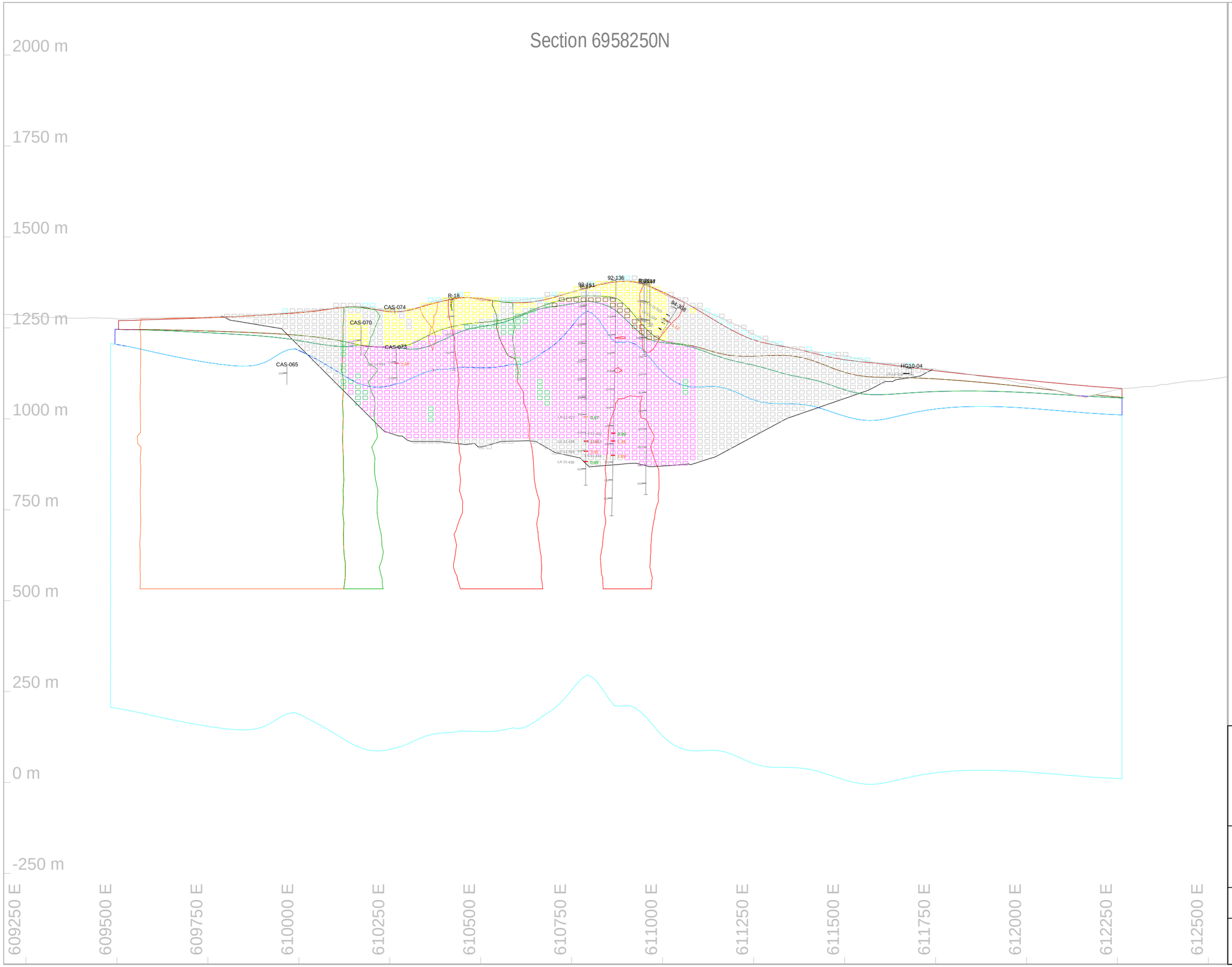
Casino Project

Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 8, 2014



Mineralized Zone

CAP
SOX
SUS
HYP

Lithology

IX
MX
PP

Rinse pH (bar on left)

< 5.0
5.0 - 6.4
6.4 - 7.0
> 7.0

CANP/AP (centre bar)

< 1.0
1.0 - 2.0
> 2.0

Total S% (text on right)

0.0 - 0.1
0.1 - 0.5
0.5 - 1.0
1.0 - 5.0
5.0 - 10.0
10.0 - 100

PFS Material Routing (blocks)

Overburden
Leach Cap Gold Ore
Leach Cap Potential Ore
Sox Stockpile Ore
Low Grade Stockpile
Direct Feed Ore
Waste

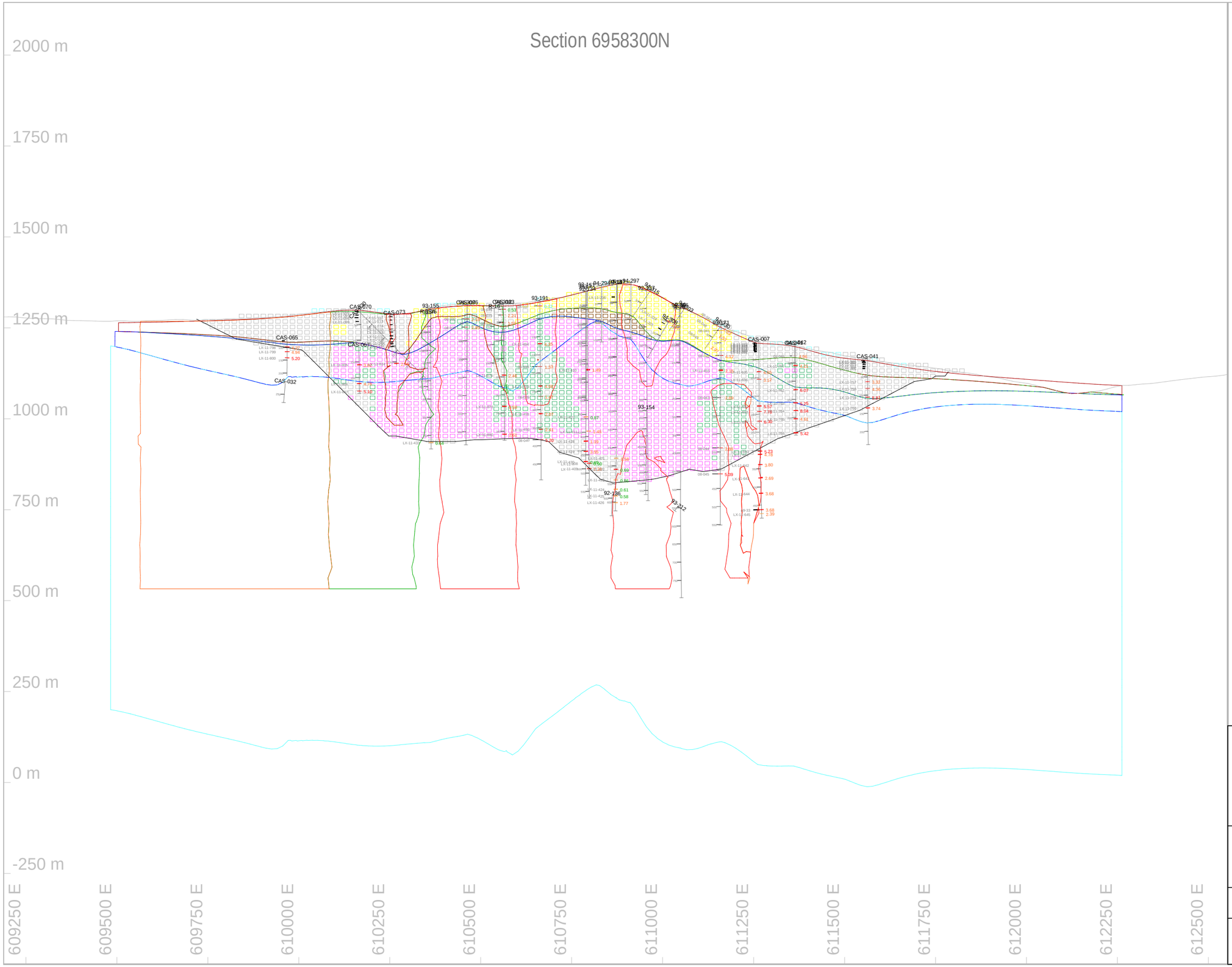
Casino Project

Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 8, 2014



Mineralized Zone

CAP
SOX
SUS
HYP

Lithology

IX
MX
PP

Rinse pH (bar on left)

< 5.0
5.0 - 6.4
6.4 - 7.0
> 7.0

CANP/AP (centre bar)

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1.0 - 2.0
> 2.0

Total S% (text on right)

0.0 - 0.1
0.1 - 0.5
0.5 - 1.0
1.0 - 5.0
5.0 - 10.0
10.0 - 100

PFS Material Routing (blocks)

Overburden
Leach Cap Gold Ore
Leach Cap Potential Ore
Sox Stockpile Ore
Low Grade Stockpile
Direct Feed Ore
Waste

Casino Project

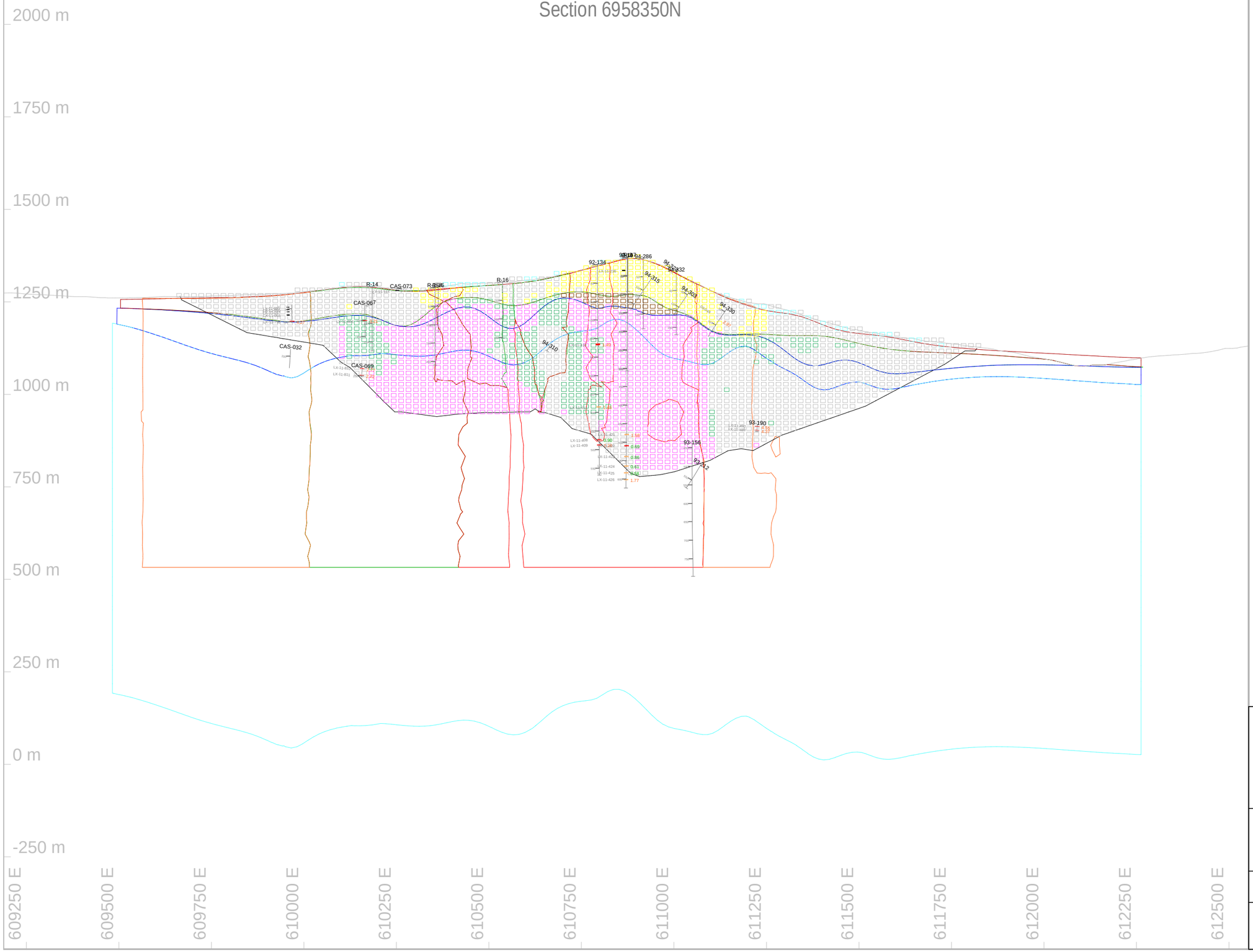
Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 8, 2014

Section 6958350N



Mineralized Zone

CAP
SOX
SUS
HYP

Lithology

IX
MX
PP

Rinse pH (bar on left)

< 5.0
5.0 - 6.4
6.4 - 7.0
> 7.0

CANP/AP (centre bar)

< 1.0
1.0 - 2.0
> 2.0

Total S% (text on right)

0.0 - 0.1
0.1 - 0.5
0.5 - 1.0
1.0 - 5.0
5.0 - 10.0
10.0 - 100

PFS Material Routing (blocks)

Overburden
Leach Cap Gold Ore
Leach Cap Potential Ore
Sox Stockpile Ore
Low Grade Stockpile
Direct Feed Ore
Waste

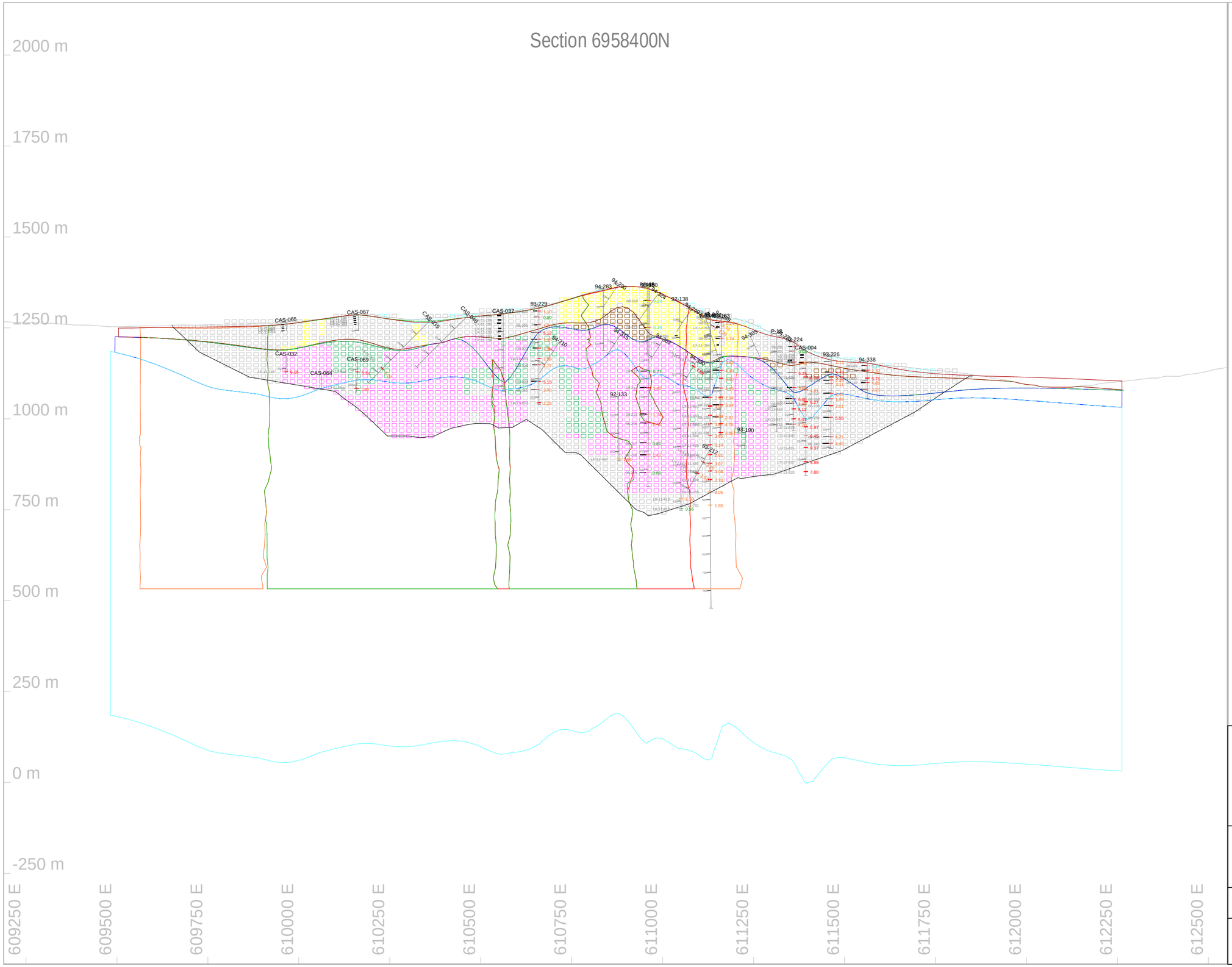
Casino Project

Lorax Environmental Services:
ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 8, 2014



Mineralized Zone

CAP	
SOX	
SUS	
HYP	

Lithology

IX	
MX	
PP	

Rinse pH (bar on left)

< 5.0	
5.0 - 6.4	
6.4 - 7.0	
> 7.0	

CANP/AP (centre bar)

< 1.0	
1.0 - 2.0	
> 2.0	

Total S% (text on right)

0.0 - 0.1	
0.1 - 0.5	
0.5 - 1.0	
1.0 - 5.0	
5.0 - 10.0	
10.0 - 100	

PFS Material Routing (blocks)

Overburden	
Leach Cap Gold Ore	
Leach Cap Potential Ore	
Sox Stockpile Ore	
Low Grade Stockpile	
Direct Feed Ore	
Waste	

Casino Project

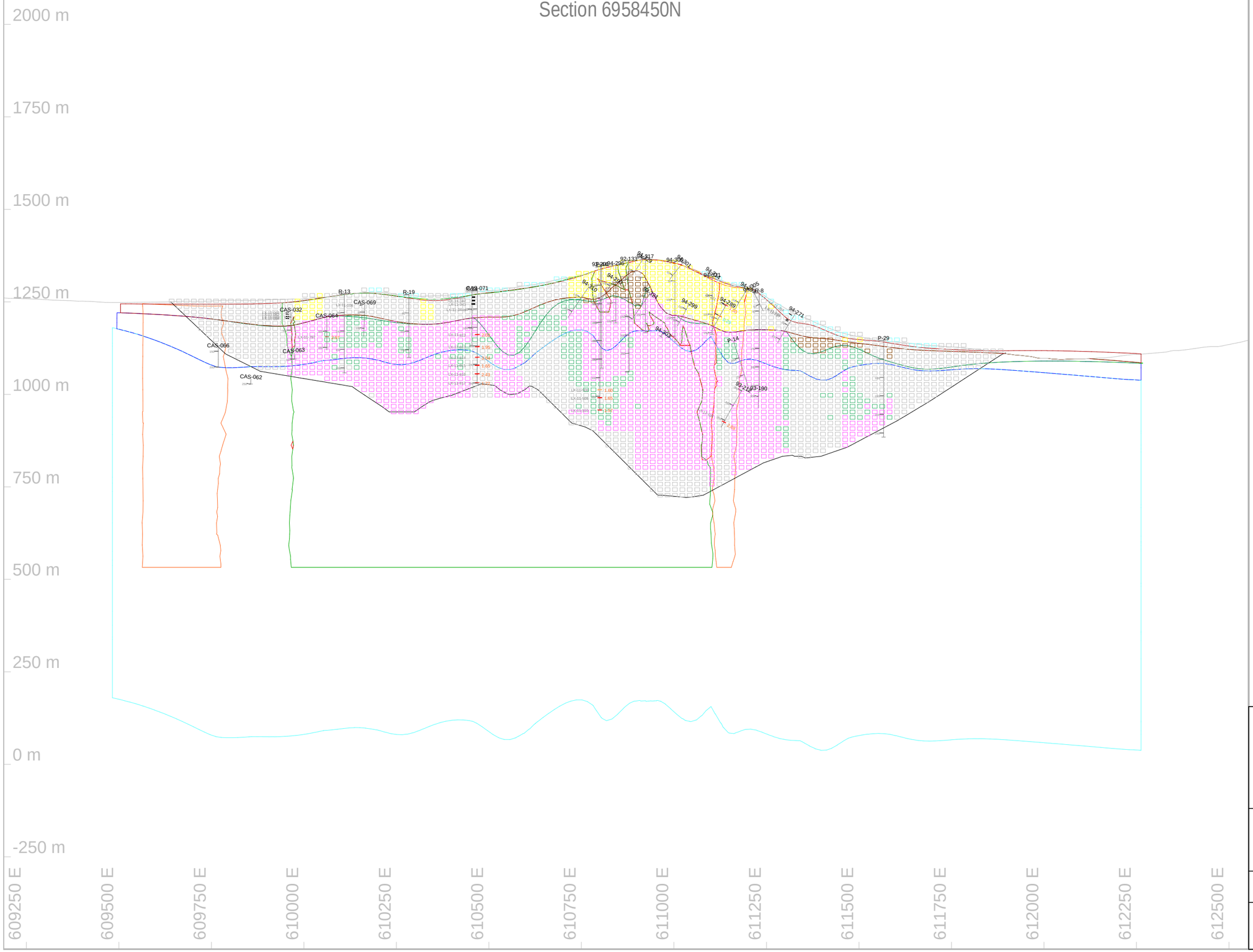
Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 8, 2014

Section 6958450N



Mineralized Zone

CAP
SOX
SUS
HYP

Lithology

IX
MX
PP

Rinse pH (bar on left)

< 5.0
5.0 - 6.4
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0.1 - 0.5
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10.0 - 100

PFS Material Routing (blocks)

Overburden
Leach Cap Gold Ore
Leach Cap Potential Ore
Sox Stockpile Ore
Low Grade Stockpile
Direct Feed Ore
Waste

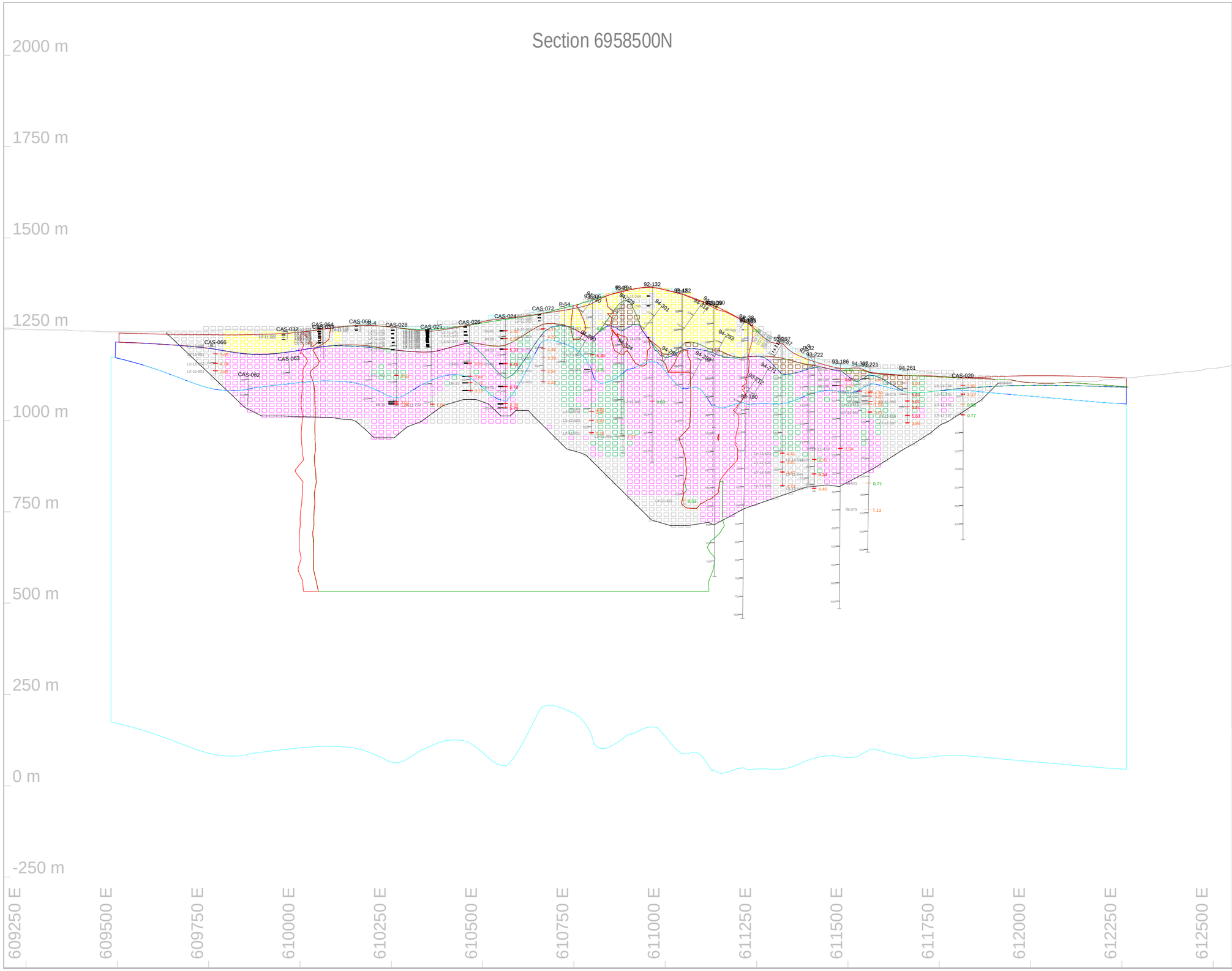
Casino Project

Lorax Environmental Services:
ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 8, 2014



Mineralized Zone

CAP
SOX
SUS
HYP

Lithology

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MX
PP

Rinse pH (bar on left)

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5.0 - 6.4
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0.1 - 0.5
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1.0 - 5.0
5.0 - 10.0
10.0 - 100

PFS Material Routing (blocks)

Overburden
Leach Cap Gold Ore
Leach Cap Potential Ore
Sox Stockpile Ore
Low Grade Stockpile
Direct Feed Ore
Waste

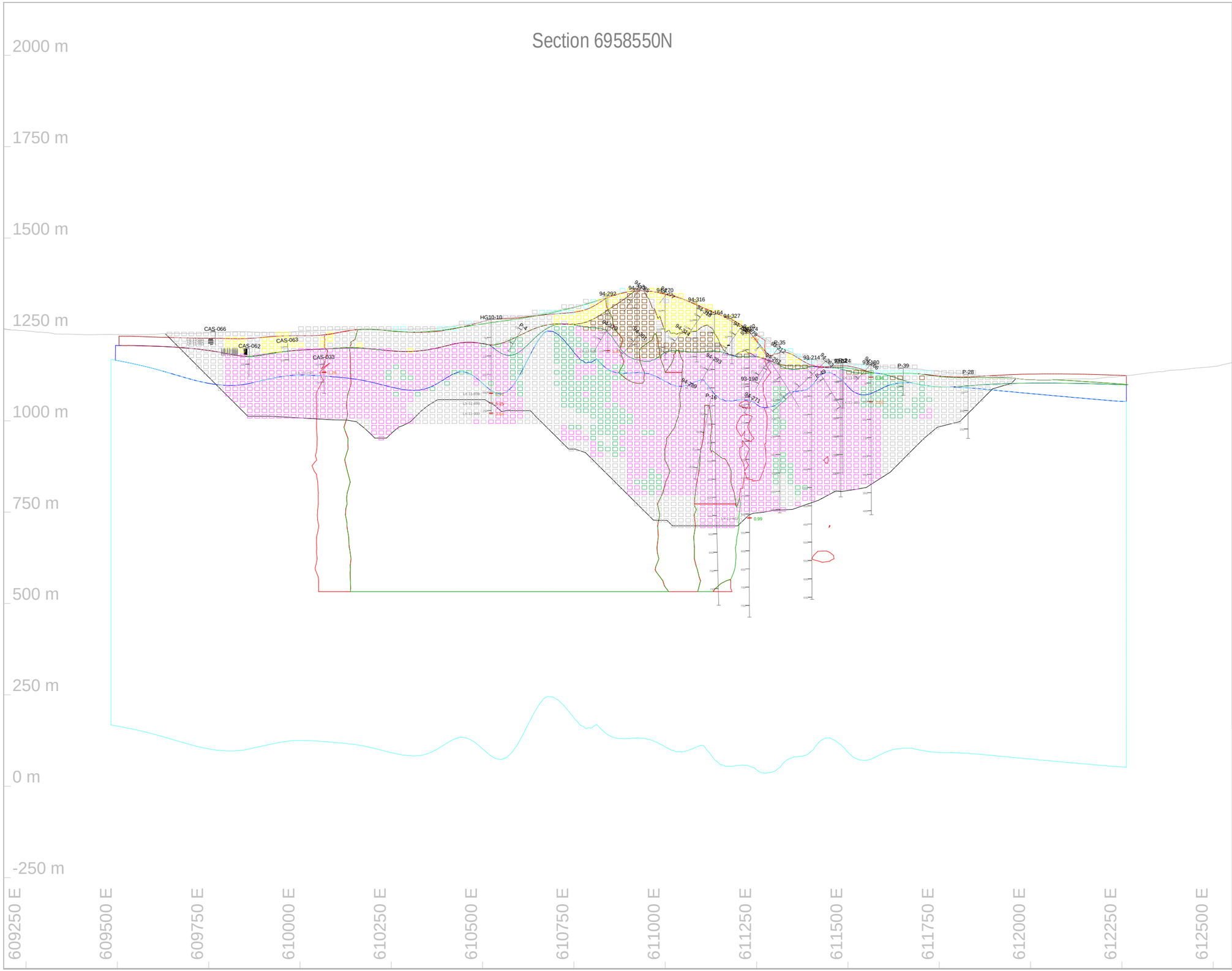
Casino Project

Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 8, 2014



Mineralized Zone

CAP
SOX
SUS
HYP

Lithology

IX
MX
PP

Rinse pH (bar on left)

< 5.0
5.0 - 6.4
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0.5 - 1.0
1.0 - 5.0
5.0 - 10.0
10.0 - 100

PFS Material Routing (blocks)

Overburden
Leach Cap Gold Ore
Leach Cap Potential Ore
Sox Stockpile Ore
Low Grade Stockpile
Direct Feed Ore
Waste

Casino Project

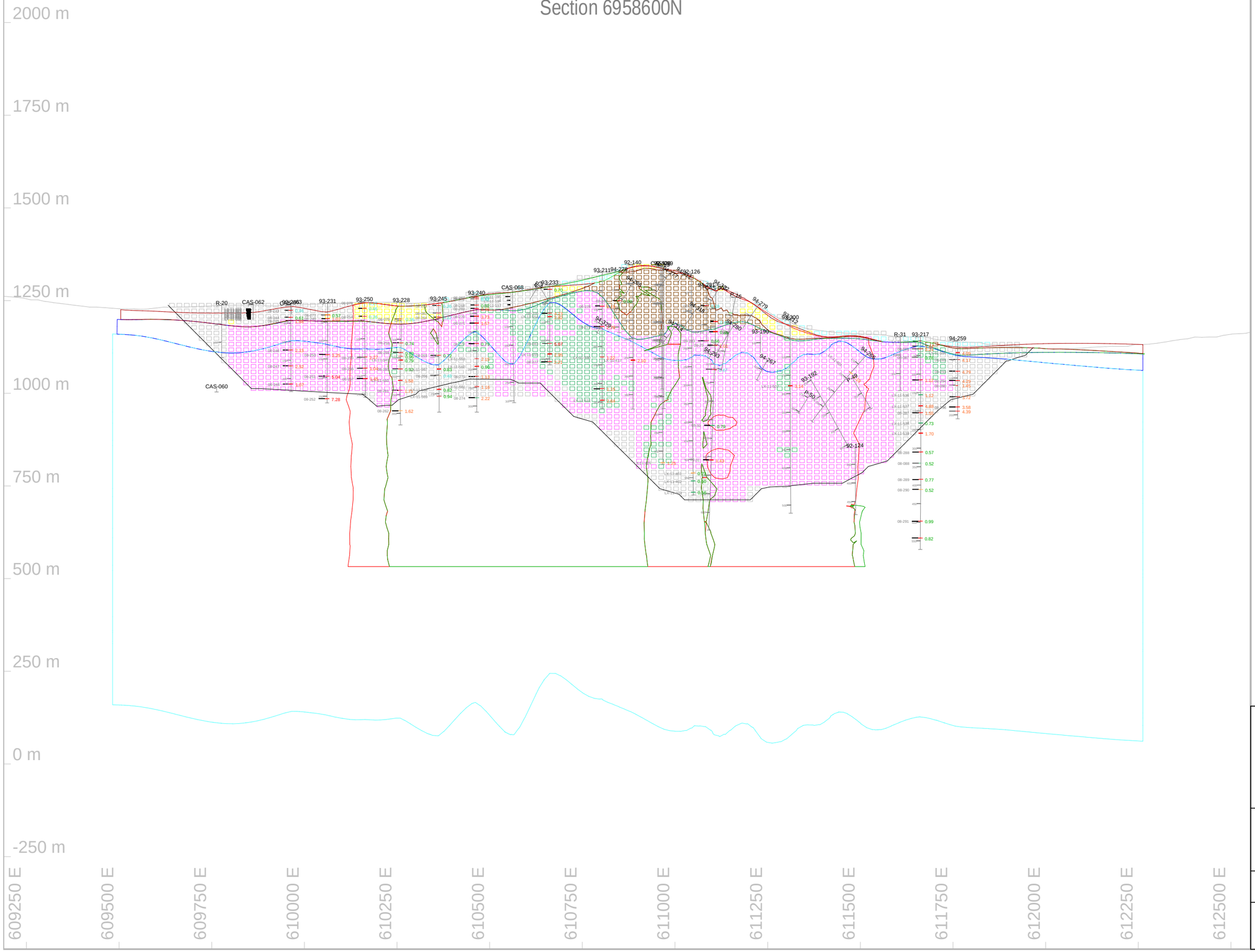
Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 8, 2014

Section 6958600N



Mineralized Zone

CAP	
SOX	
SUS	
HYP	

Lithology

IX	
MX	
PP	

Rinse pH (bar on left)

< 5.0	
5.0 - 6.4	
6.4 - 7.0	
> 7.0	

CANP/AP (centre bar)

< 1.0	
1.0 - 2.0	
> 2.0	

Total S% (text on right)

0.0 - 0.1	
0.1 - 0.5	
0.5 - 1.0	
1.0 - 5.0	
5.0 - 10.0	
10.0 - 100	

PFS Material Routing (blocks)

Overburden	
Leach Cap Gold Ore	
Leach Cap Potential Ore	
Sox Stockpile Ore	
Low Grade Stockpile	
Direct Feed Ore	
Waste	

Casino Project

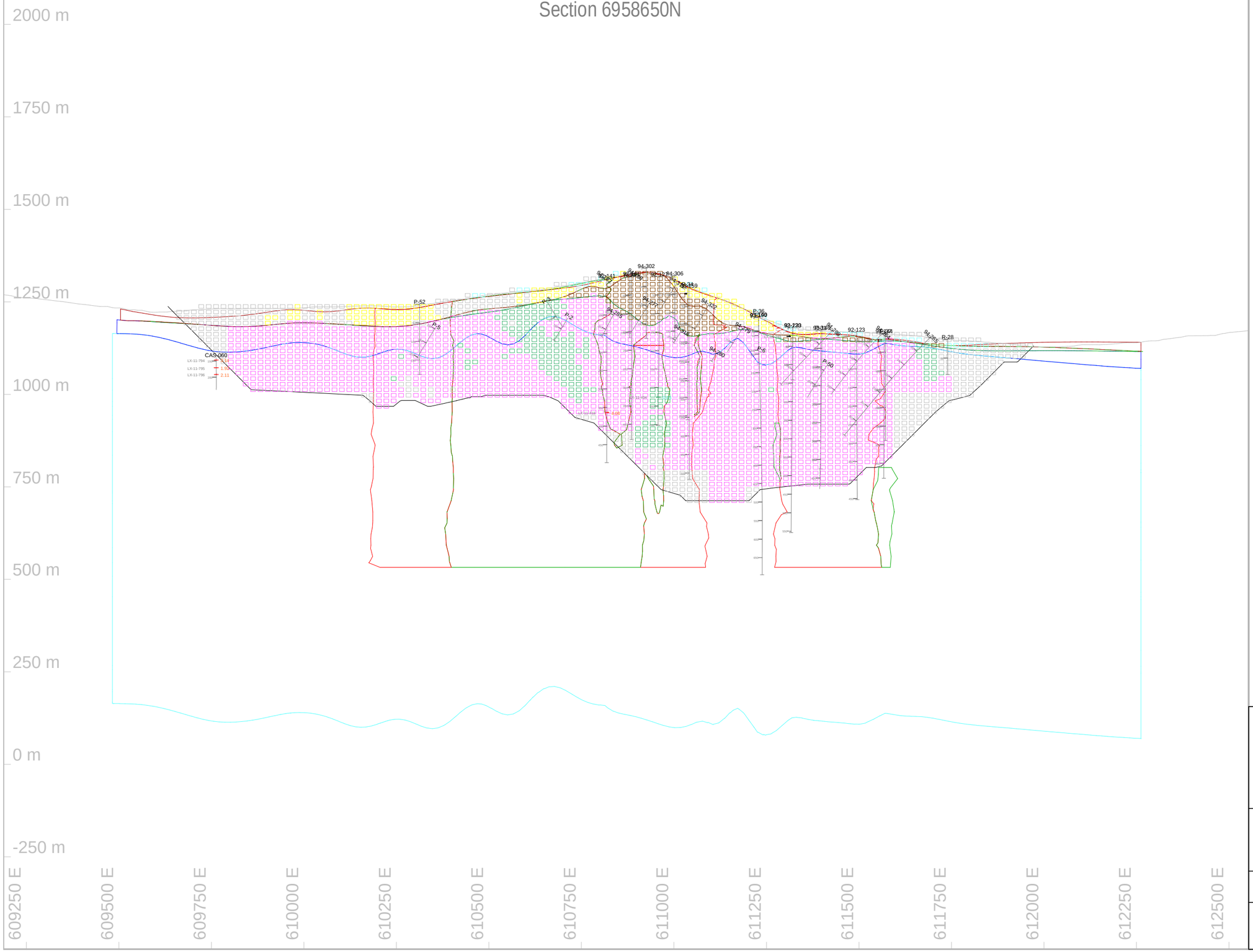
Lorax Environmental Services:
ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 8, 2014

Section 6958650N



Mineralized Zone

CAP
SOX
SUS
HYP

Lithology

IX
MX
PP

Rinse pH (bar on left)

< 5.0
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1.0 - 5.0
5.0 - 10.0
10.0 - 100

PFS Material Routing (blocks)

Overburden
Leach Cap Gold Ore
Leach Cap Potential Ore
Sox Stockpile Ore
Low Grade Stockpile
Direct Feed Ore
Waste

Casino Project

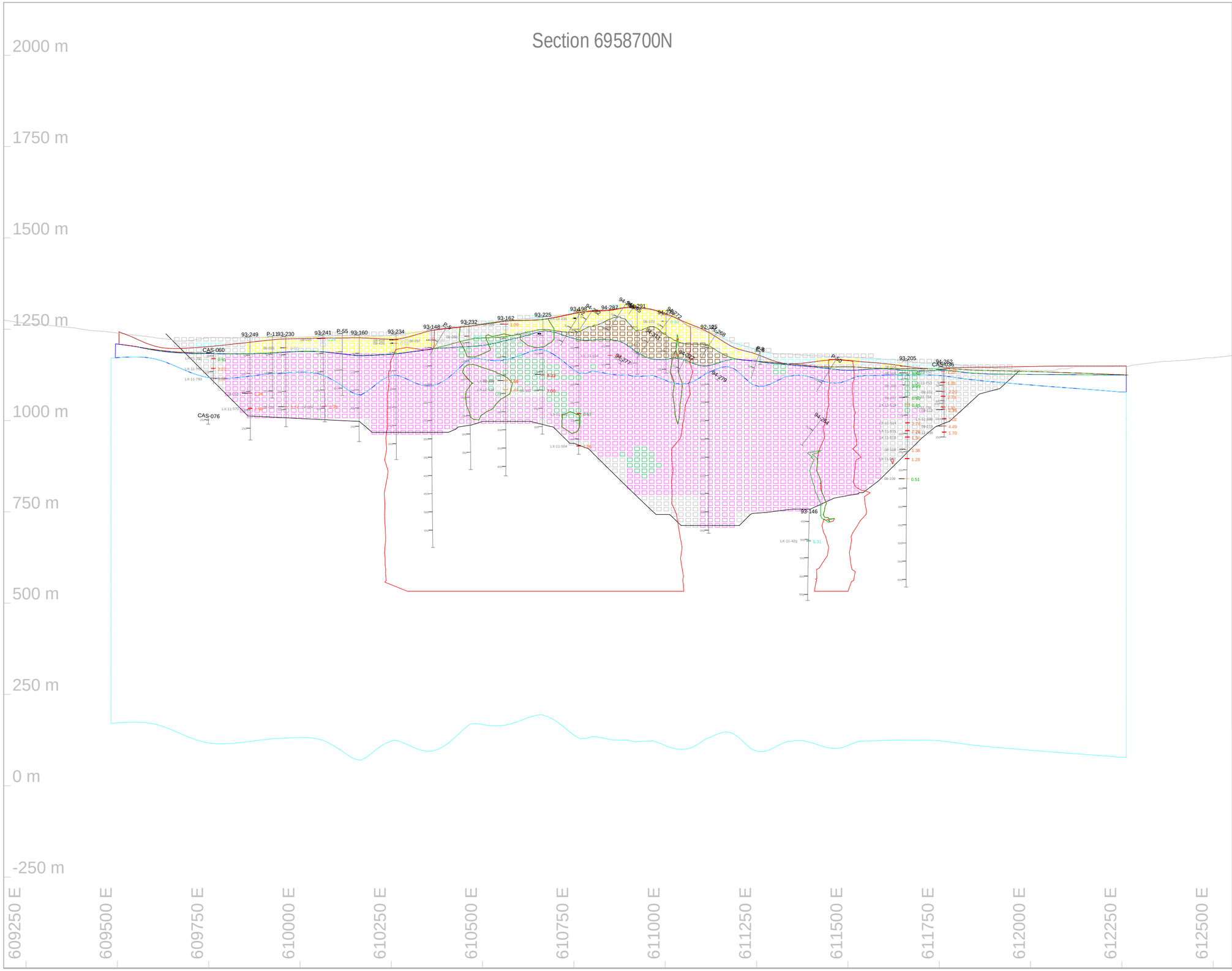
Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 8, 2014

Section 6958700N



Mineralized Zone

CAP
SOX
SUS
HYP

Lithology

IX
MX
PP

Rinse pH (bar on left)

< 5.0
5.0 - 6.4
6.4 - 7.0
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CANP/AP (centre bar)

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1.0 - 5.0
5.0 - 10.0
10.0 - 100

PFS Material Routing (blocks)

Overburden
Leach Cap Gold Ore
Leach Cap Potential Ore
Sox Stockpile Ore
Low Grade Stockpile
Direct Feed Ore
Waste

Casino Project

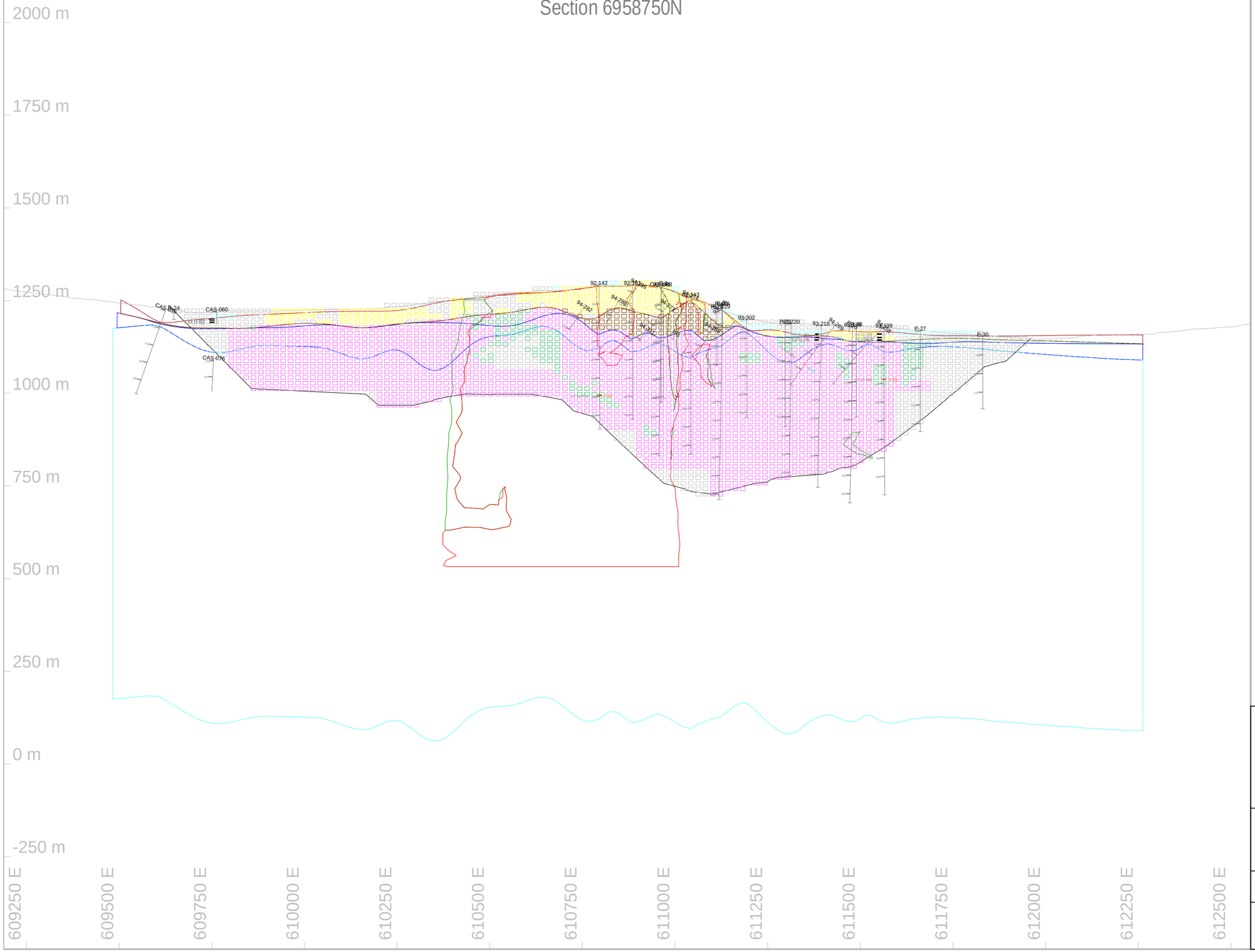
Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 8, 2014

Section 6958750N



Mineralized Zone

CAP
SOX
SUS
HYP

Lithology

IX
MX
PP

Rinse pH (bar on left)

< 5.0
5.0 - 6.4
6.4 - 7.0
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CANP/AP (centre bar)

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Total S% (text on right)

0.0 - 0.1
0.1 - 0.5
0.5 - 1.0
1.0 - 5.0
5.0 - 10.0
10.0 - 100

PFS Material Routing (blocks)

Overburden
Leach Cap Gold Ore
Leach Cap Potential Ore
Sox Stockpile Ore
Low Grade Stockpile
Direct Feed Ore
Waste

Casino Project

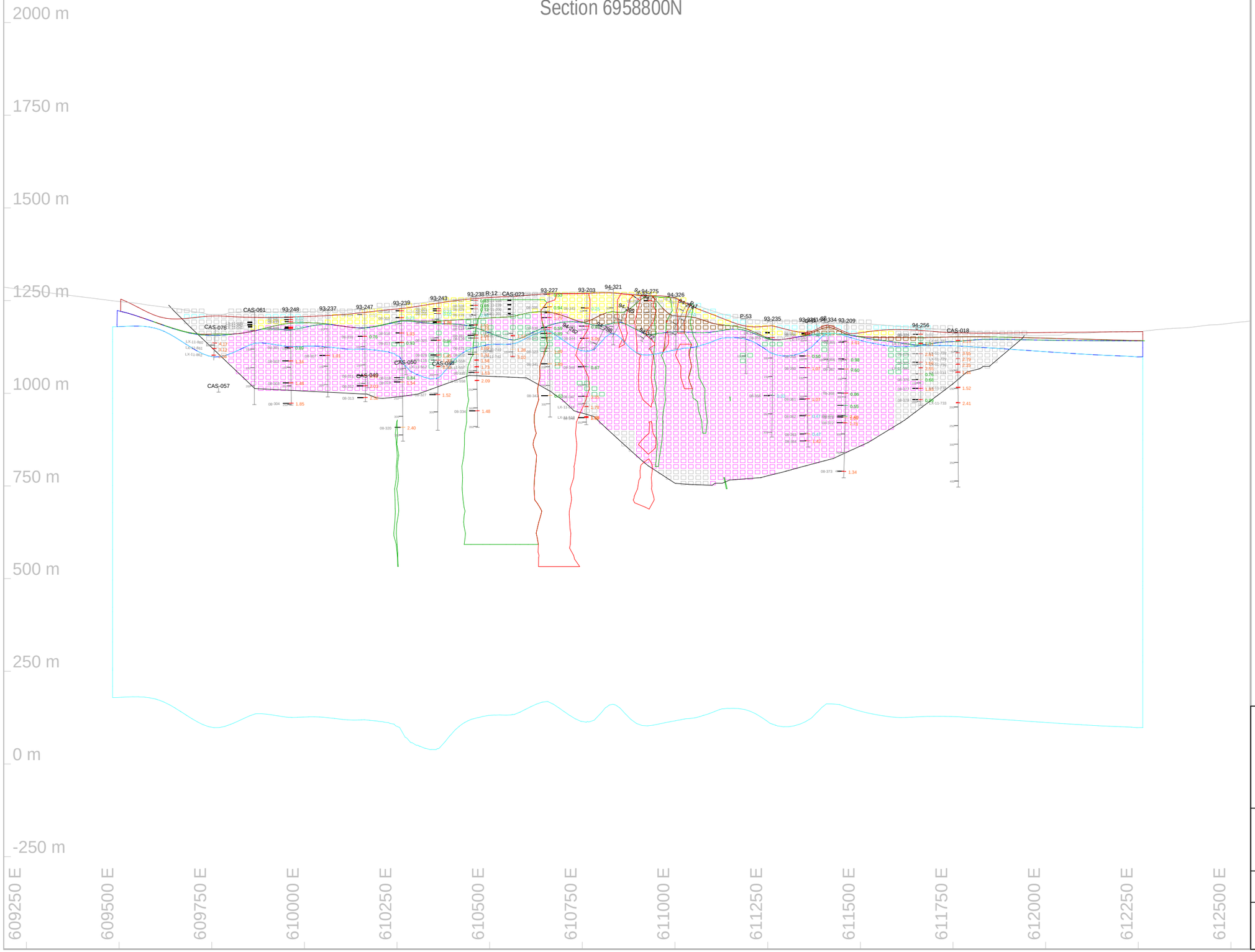
Lorax Environmental Services:
ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 8, 2014

Section 6958800N



Mineralized Zone

CAP	
SOX	
SUS	
HYP	

Lithology

IX	
MX	
PP	

Rinse pH (bar on left)

< 5.0	
5.0 - 6.4	
6.4 - 7.0	
> 7.0	

CANP/AP (centre bar)

< 1.0	
1.0 - 2.0	
> 2.0	

Total S% (text on right)

0.0 - 0.1	
0.1 - 0.5	
0.5 - 1.0	
1.0 - 5.0	
5.0 - 10.0	
10.0 - 100	

PFS Material Routing (blocks)

Overburden	
Leach Cap Gold Ore	
Leach Cap Potential Ore	
Sox Stockpile Ore	
Low Grade Stockpile	
Direct Feed Ore	
Waste	

Casino Project

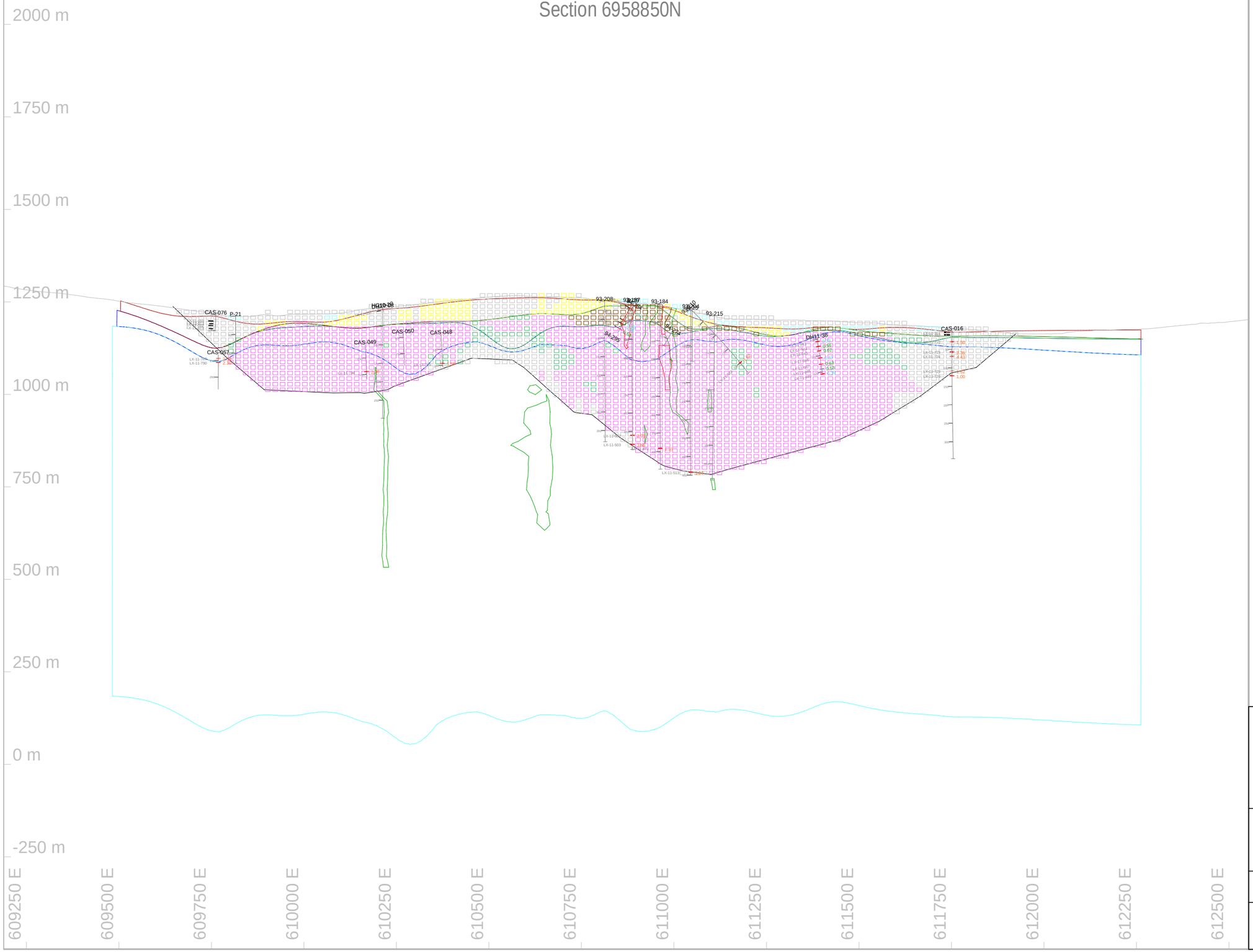
Lorax Environmental Services:
ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 8, 2014

Section 6958850N



Mineralized Zone

CAP
SOX
SUS
HYP

Lithology

IX
MX
PP

Rinse pH (bar on left)

< 5.0
5.0 - 6.4
6.4 - 7.0
> 7.0

CANP/AP (centre bar)

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1.0 - 2.0
> 2.0

Total S% (text on right)

0.0 - 0.1
0.1 - 0.5
0.5 - 1.0
1.0 - 5.0
5.0 - 10.0
10.0 - 100

PFS Material Routing (blocks)

Overburden
Leach Cap Gold Ore
Leach Cap Potential Ore
Sox Stockpile Ore
Low Grade Stockpile
Direct Feed Ore
Waste

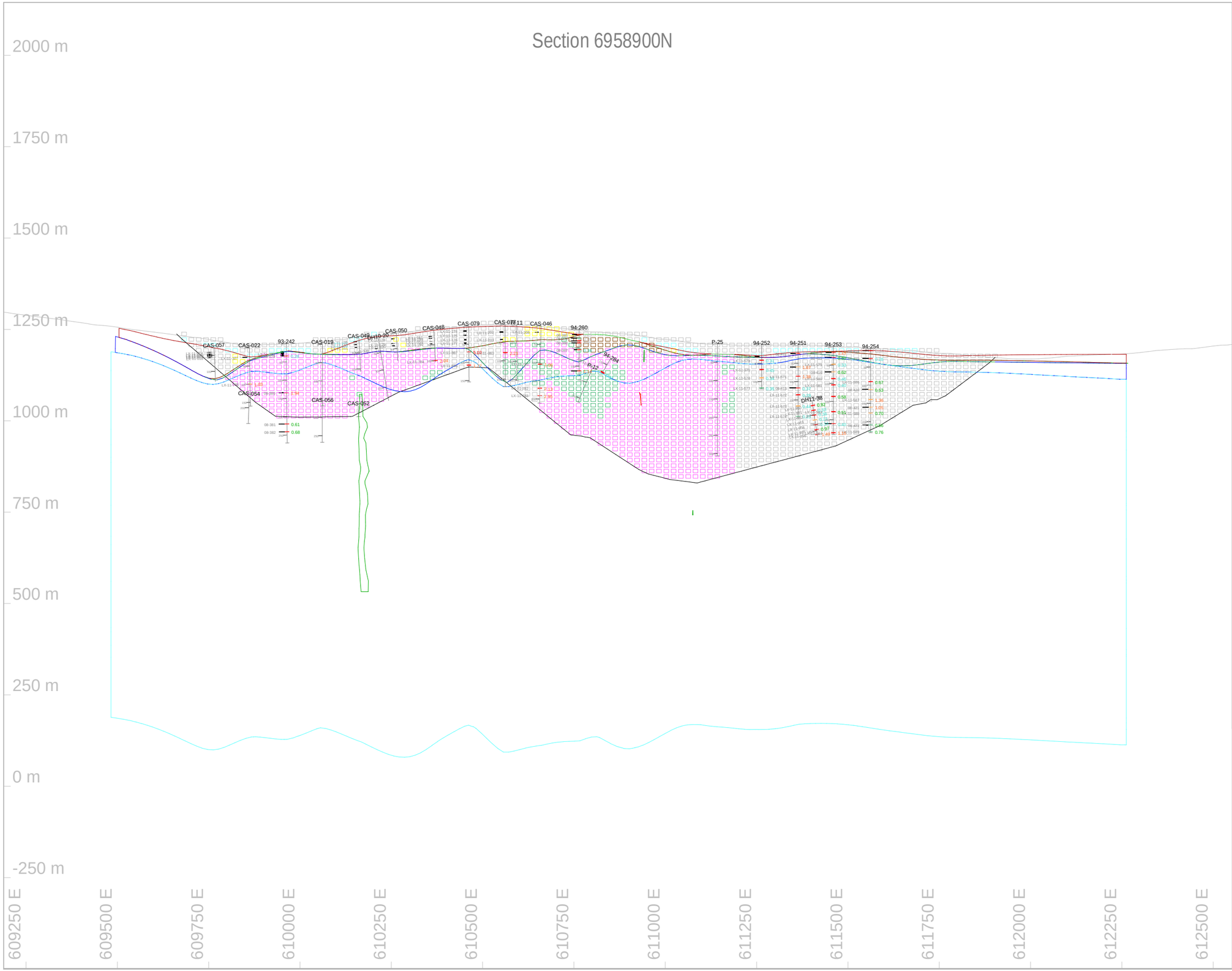
Casino Project

Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 8, 2014



Mineralized Zone

CAP
SOX
SUS
HYP

Lithology

IX
MX
PP

Rinse pH (bar on left)

< 5.0
5.0 - 6.4
6.4 - 7.0
> 7.0

CANP/AP (centre bar)

< 1.0
1.0 - 2.0
> 2.0

Total S% (text on right)

0.0 - 0.1
0.1 - 0.5
0.5 - 1.0
1.0 - 5.0
5.0 - 10.0
10.0 - 100

PFS Material Routing (blocks)

Overburden
Leach Cap Gold Ore
Leach Cap Potential Ore
Sox Stockpile Ore
Low Grade Stockpile
Direct Feed Ore
Waste

Casino Project

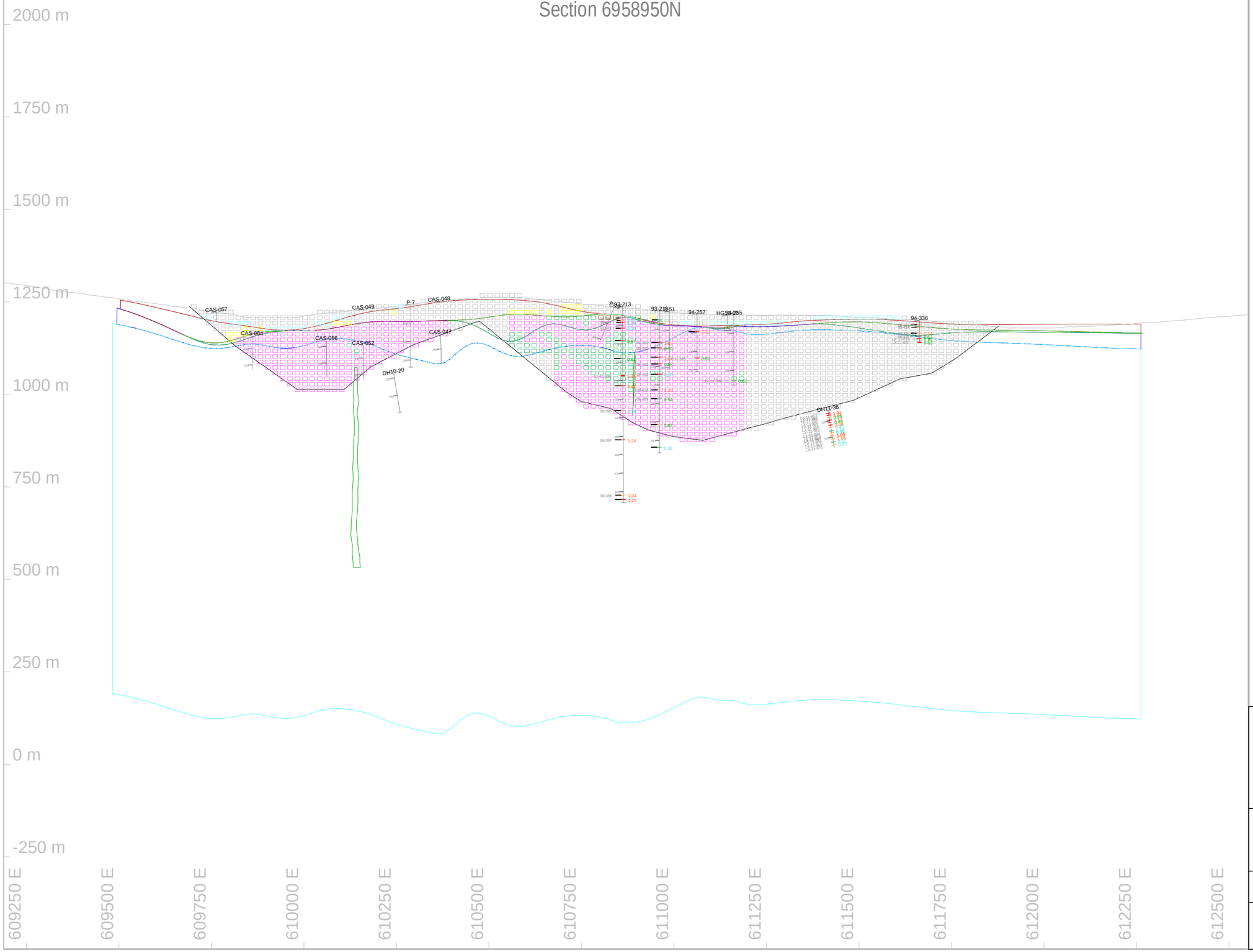
Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 8, 2014

Section 6958950N



Mineralized Zone

CAP
SOX
SUS
HYP

Lithology

IX
MX
PP

Rinse pH (bar on left)

< 5.0
5.0 - 6.4
6.4 - 7.0
> 7.0

CANP/AP (centre bar)

< 1.0
1.0 - 2.0
> 2.0

Total S% (text on right)

0.0 - 0.1
0.1 - 0.5
0.5 - 1.0
1.0 - 5.0
5.0 - 10.0
10.0 - 100

PFS Material Routing (blocks)

Overburden
Leach Cap Gold Ore
Leach Cap Potential Ore
Sox Stockpile Ore
Low Grade Stockpile
Direct Feed Ore
Waste

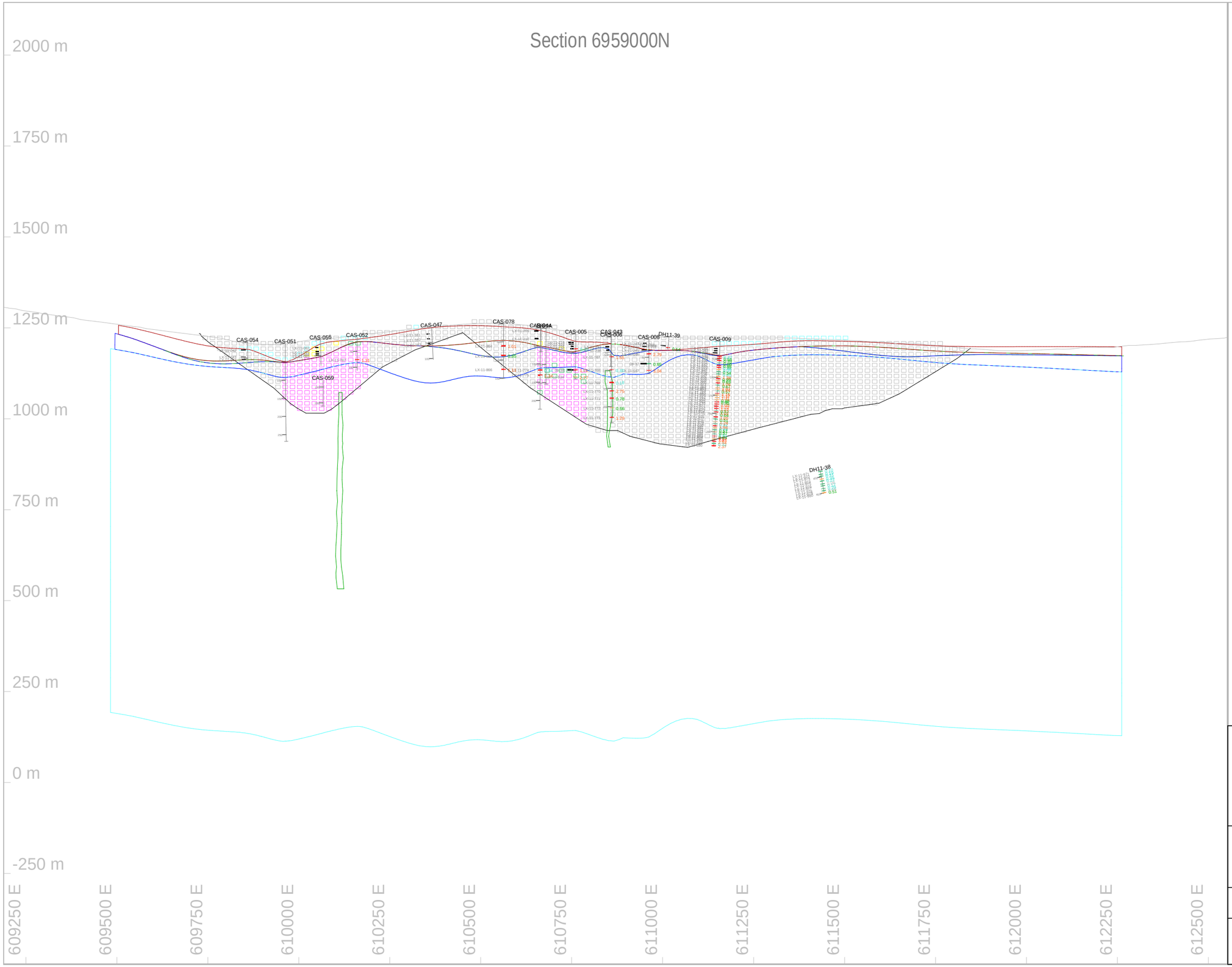
Casino Project

Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 8, 2014



Mineralized Zone

CAP	
SOX	
SUS	
HYP	

Lithology

IX	
MX	
PP	

Rinse pH (bar on left)

< 5.0	
5.0 - 6.4	
6.4 - 7.0	
> 7.0	

CANP/AP (centre bar)

< 1.0	
1.0 - 2.0	
> 2.0	

Total S% (text on right)

0.0 - 0.1	
0.1 - 0.5	
0.5 - 1.0	
1.0 - 5.0	
5.0 - 10.0	
10.0 - 100	

PFS Material Routing (blocks)

Overburden	
Leach Cap Gold Ore	
Leach Cap Potential Ore	
Sox Stockpile Ore	
Low Grade Stockpile	
Direct Feed Ore	
Waste	

Casino Project

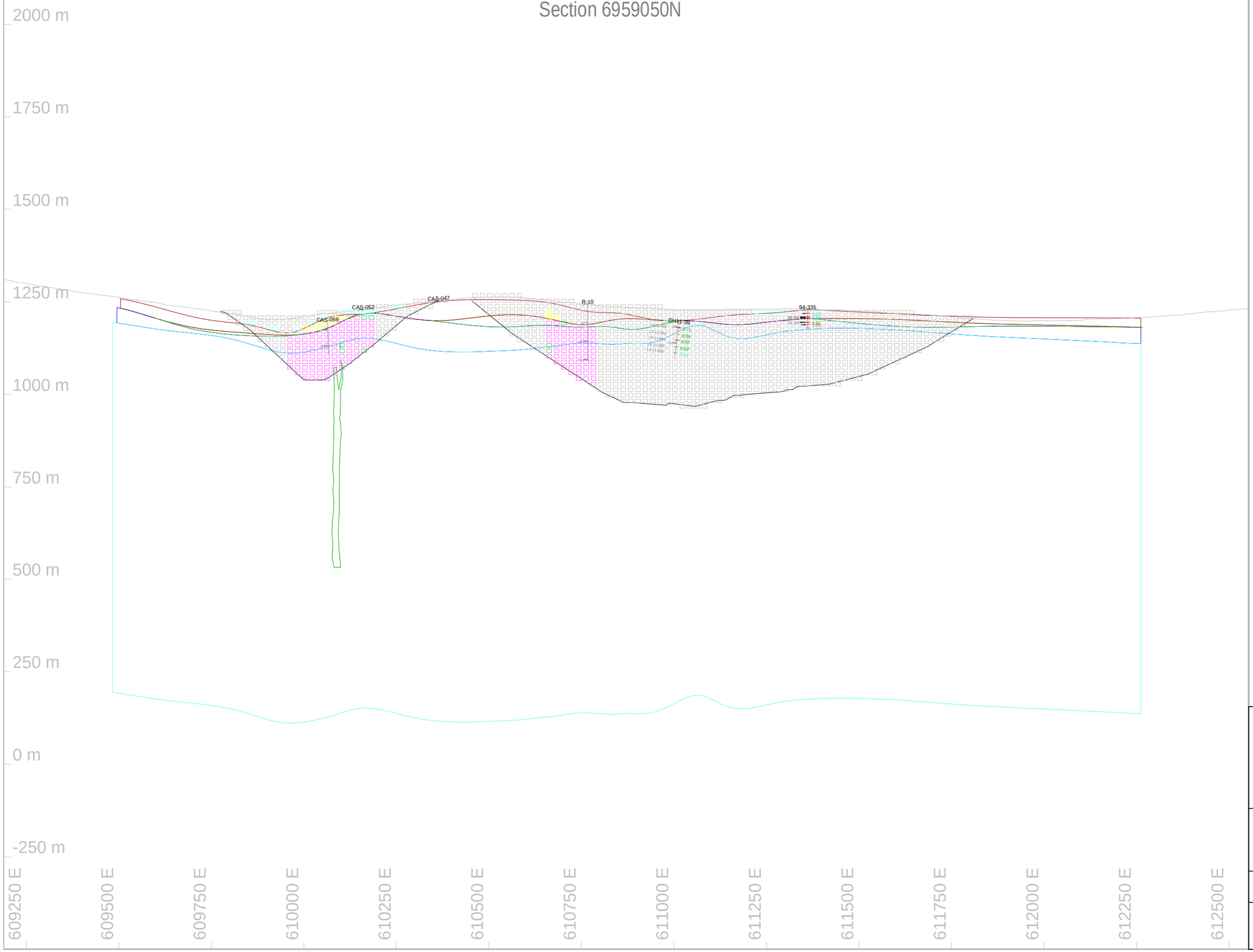
Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 8, 2014

Section 6959050N



Mineralized Zone

CAP
SOX
SUS
HYP

Lithology

IX
MX
PP

Rinse pH (bar on left)

< 5.0
5.0 - 6.4
6.4 - 7.0
> 7.0

CANP/AP (centre bar)

< 1.0
1.0 - 2.0
> 2.0

Total S% (text on right)

0.0 - 0.1
0.1 - 0.5
0.5 - 1.0
1.0 - 5.0
5.0 - 10.0
10.0 - 100

PFS Material Routing (blocks)

Overburden
Leach Cap Gold Ore
Leach Cap Potential Ore
Sox Stockpile Ore
Low Grade Stockpile
Direct Feed Ore
Waste

Casino Project

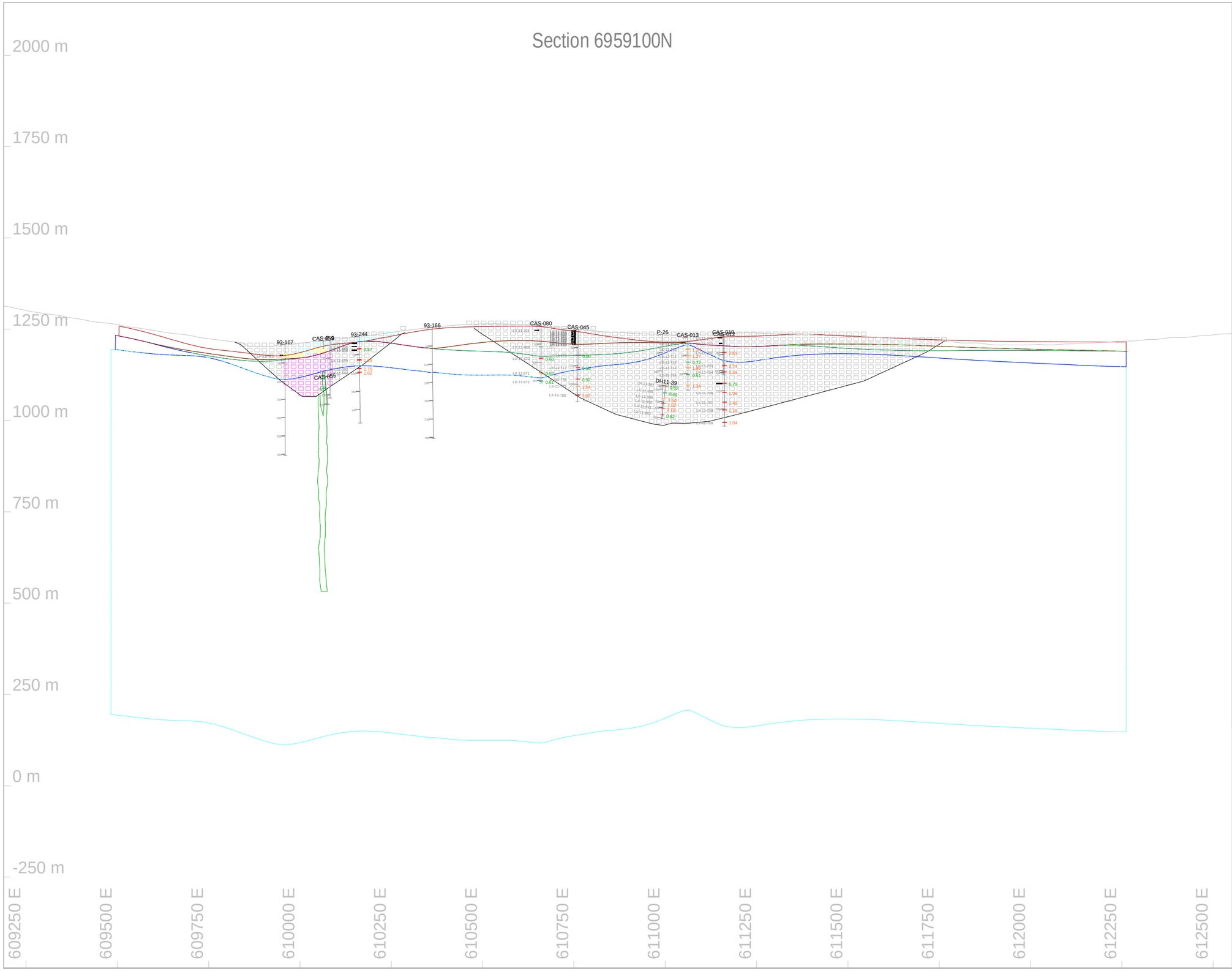
Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 8, 2014

Section 6959100N



Mineralized Zone

CAP
SOX
SUS
HYP

Lithology

IX
MX
PP

Rinse pH (bar on left)

< 5.0
5.0 - 6.4
6.4 - 7.0
> 7.0

CANP/AP (centre bar)

< 1.0
1.0 - 2.0
> 2.0

Total S% (text on right)

0.0 - 0.1
0.1 - 0.5
0.5 - 1.0
1.0 - 5.0
5.0 - 10.0
10.0 - 100

PFS Material Routing (blocks)

Overburden
Leach Cap Gold Ore
Leach Cap Potential Ore
Sox Stockpile Ore
Low Grade Stockpile
Direct Feed Ore
Waste

Casino Project

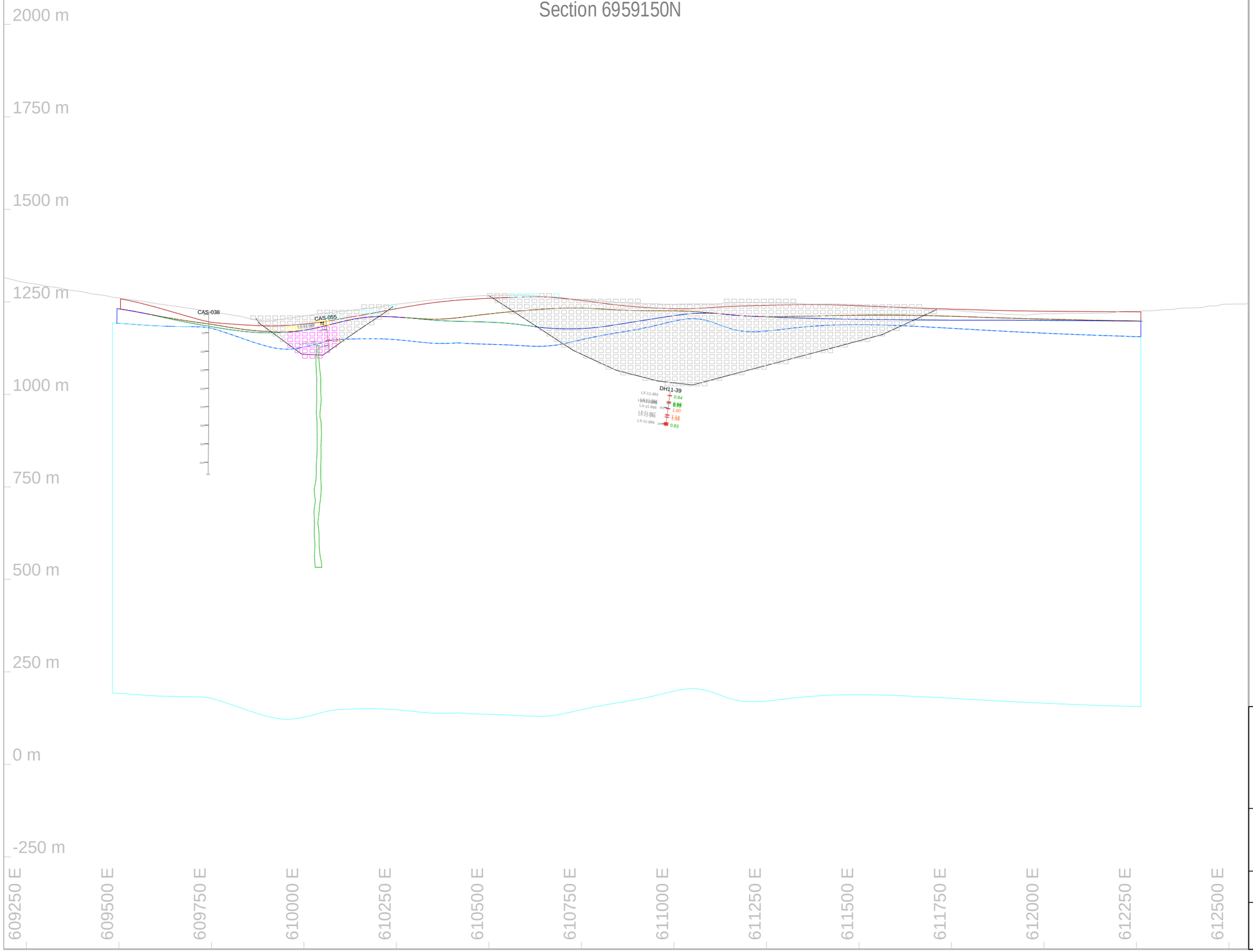
Lorax Environmental Services:
ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 8, 2014

Section 6959150N



Mineralized Zone

CAP
SOX
SUS
HYP

Lithology

IX
MX
PP

Rinse pH (bar on left)

< 5.0
5.0 - 6.4
6.4 - 7.0
> 7.0

CANP/AP (centre bar)

< 1.0
1.0 - 2.0
> 2.0

Total S% (text on right)

0.0 - 0.1
0.1 - 0.5
0.5 - 1.0
1.0 - 5.0
5.0 - 10.0
10.0 - 100

PFS Material Routing (blocks)

Overburden
Leach Cap Gold Ore
Leach Cap Potential Ore
Sox Stockpile Ore
Low Grade Stockpile
Direct Feed Ore
Waste

Casino Project

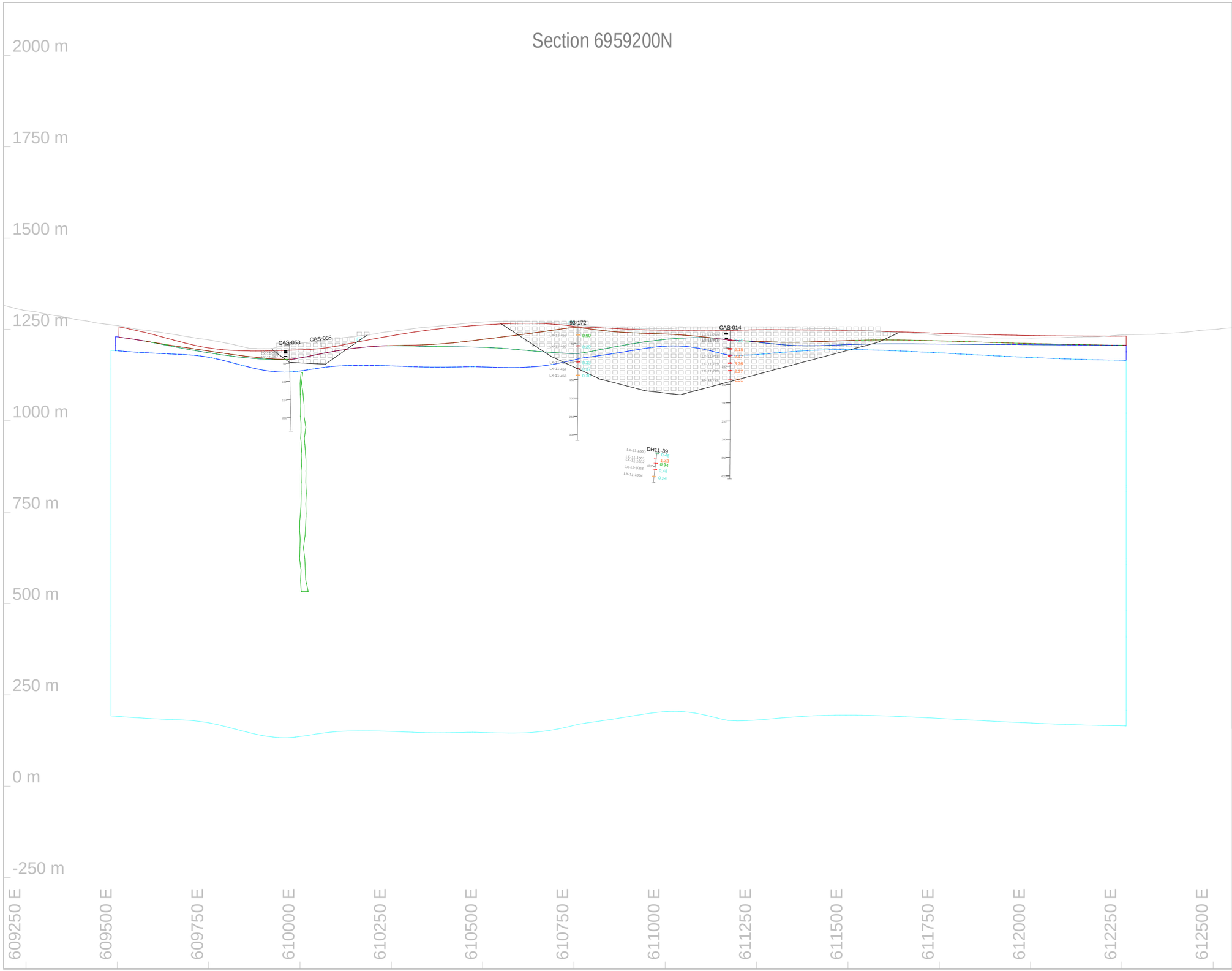
Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 8, 2014

Section 6959200N



Mineralized Zone

CAP	
SOX	
SUS	
HYP	

Lithology

IX	
MX	
PP	

Rinse pH (bar on left)

< 5.0	
5.0 - 6.4	
6.4 - 7.0	
> 7.0	

CANP/AP (centre bar)

< 1.0	
1.0 - 2.0	
> 2.0	

Total S% (text on right)

0.0 - 0.1	
0.1 - 0.5	
0.5 - 1.0	
1.0 - 5.0	
5.0 - 10.0	
10.0 - 100	

PFS Material Routing (blocks)

Overburden	
Leach Cap Gold Ore	
Leach Cap Potential Ore	
Sox Stockpile Ore	
Low Grade Stockpile	
Direct Feed Ore	
Waste	

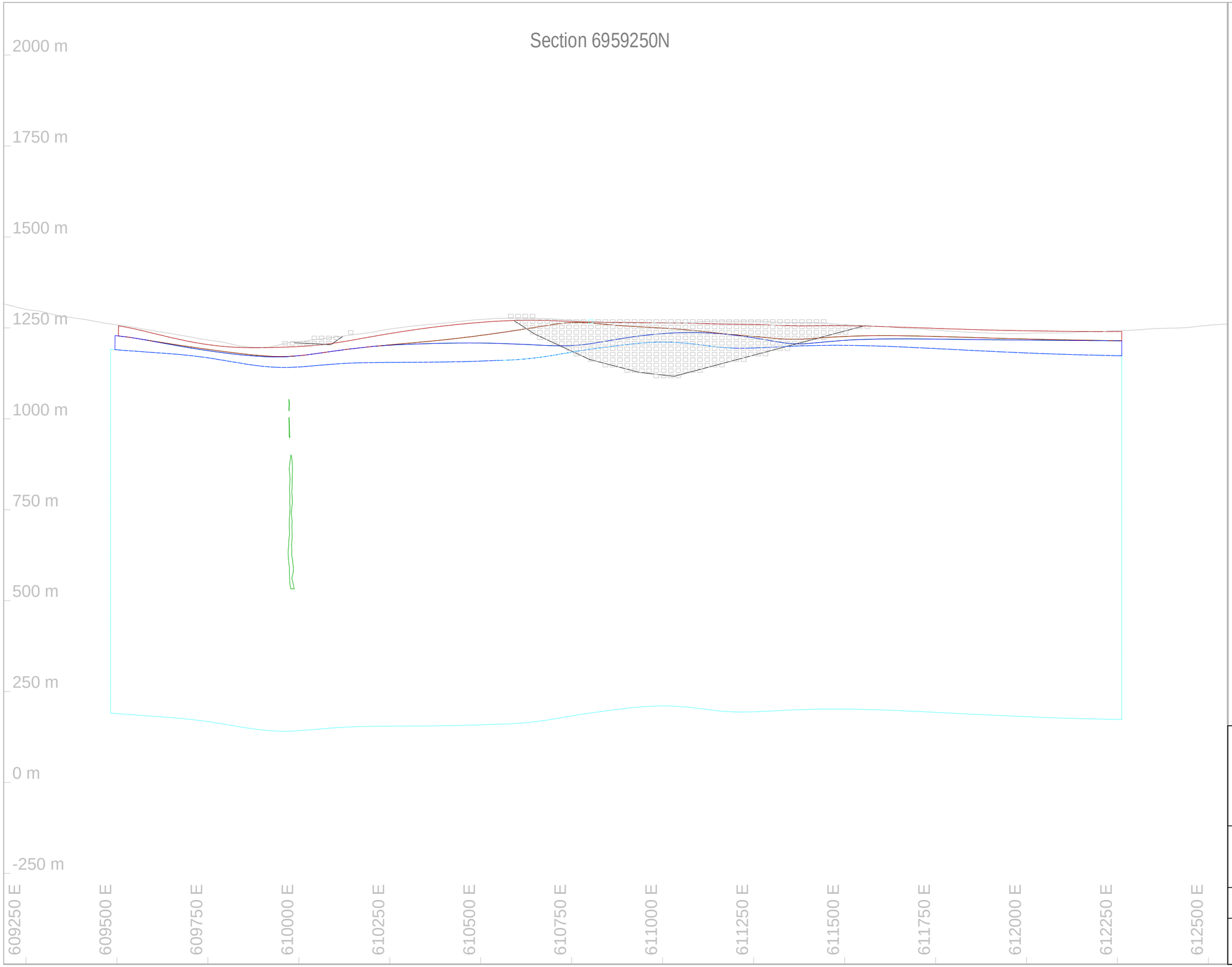
Casino Project

Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 8, 2014



Mineralized Zone

CAP	
SOX	
SUS	
HYP	

Lithology

IX	
MX	
PP	

Rinse pH (bar on left)

< 5.0	
5.0 - 6.4	
6.4 - 7.0	
> 7.0	

CANP/AP (centre bar)

< 1.0	
1.0 - 2.0	
> 2.0	

Total S% (text on right)

0.0 - 0.1	
0.1 - 0.5	
0.5 - 1.0	
1.0 - 5.0	
5.0 - 10.0	
10.0 - 100	

PFS Material Routing (blocks)

Overburden	
Leach Cap Gold Ore	
Leach Cap Potential Ore	
Sox Stockpile Ore	
Low Grade Stockpile	
Direct Feed Ore	
Waste	

Casino Project

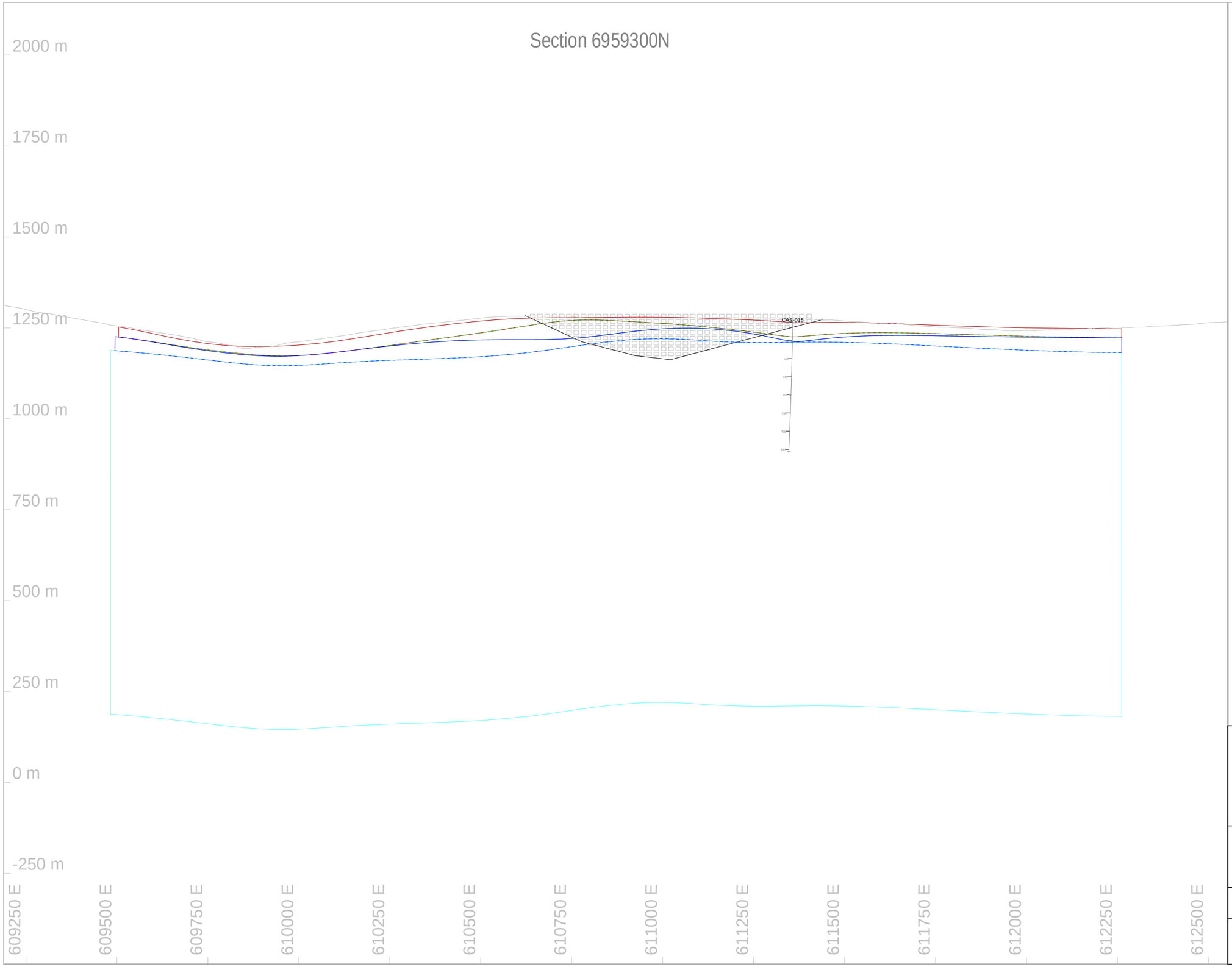
Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 8, 2014

Section 6959300N



Mineralized Zone

CAP
SOX
SUS
HYP

Lithology

IX
MX
PP

Rinse pH (bar on left)

< 5.0
5.0 - 6.4
6.4 - 7.0
> 7.0

CANP/AP (centre bar)

< 1.0
1.0 - 2.0
> 2.0

Total S% (text on right)

0.0 - 0.1
0.1 - 0.5
0.5 - 1.0
1.0 - 5.0
5.0 - 10.0
10.0 - 100

PFS Material Routing (blocks)

Overburden
Leach Cap Gold Ore
Leach Cap Potential Ore
Sox Stockpile Ore
Low Grade Stockpile
Direct Feed Ore
Waste

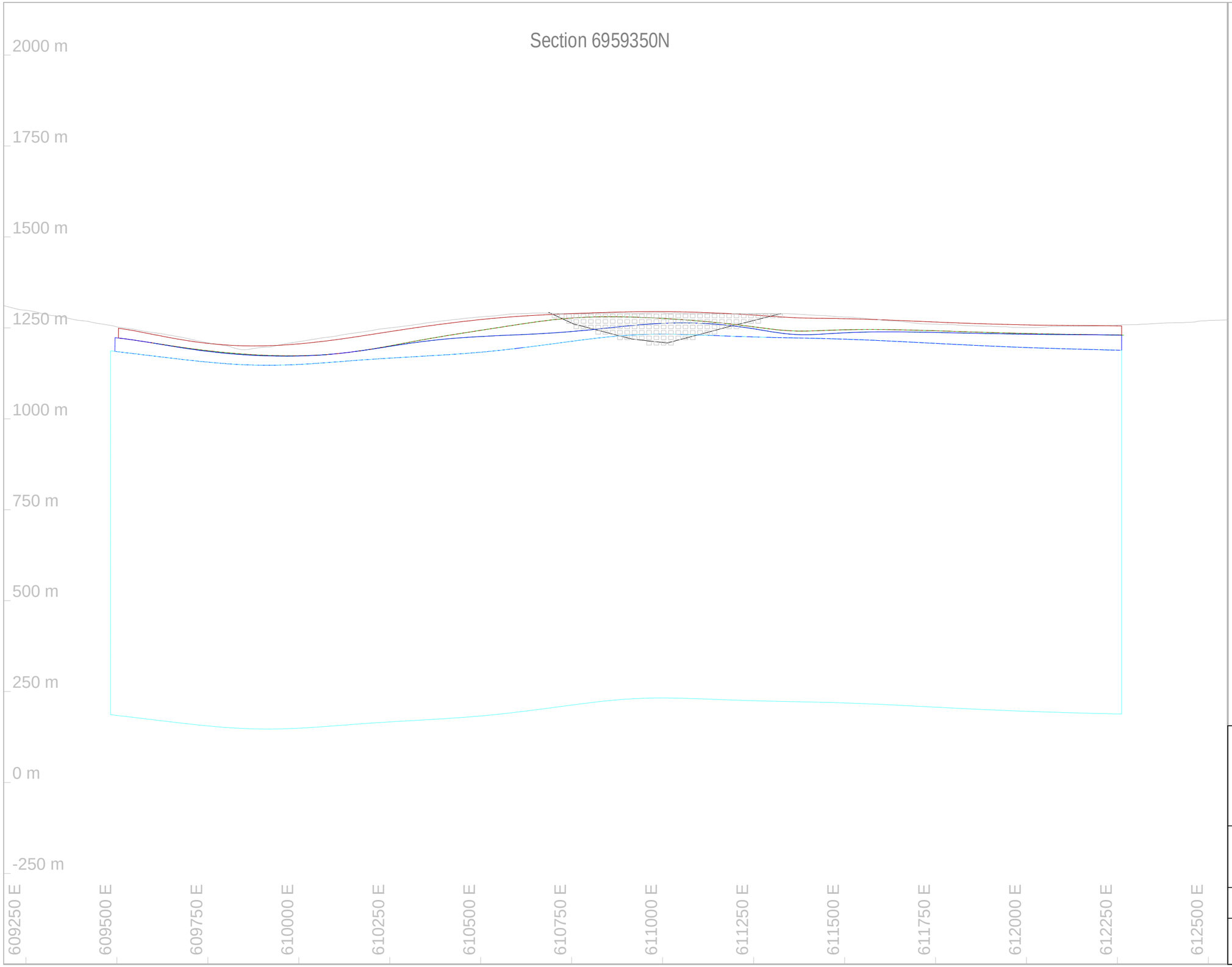
Casino Project

Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 8, 2014



Mineralized Zone

CAP	
SOX	
SUS	
HYP	

Lithology

IX	
MX	
PP	

Rinse pH (bar on left)

< 5.0	
5.0 - 6.4	
6.4 - 7.0	
> 7.0	

CANP/AP (centre bar)

< 1.0	
1.0 - 2.0	
> 2.0	

Total S% (text on right)

0.0 - 0.1	
0.1 - 0.5	
0.5 - 1.0	
1.0 - 5.0	
5.0 - 10.0	
10.0 - 100	

PFS Material Routing (blocks)

Overburden	
Leach Cap Gold Ore	
Leach Cap Potential Ore	
Sox Stockpile Ore	
Low Grade Stockpile	
Direct Feed Ore	
Waste	

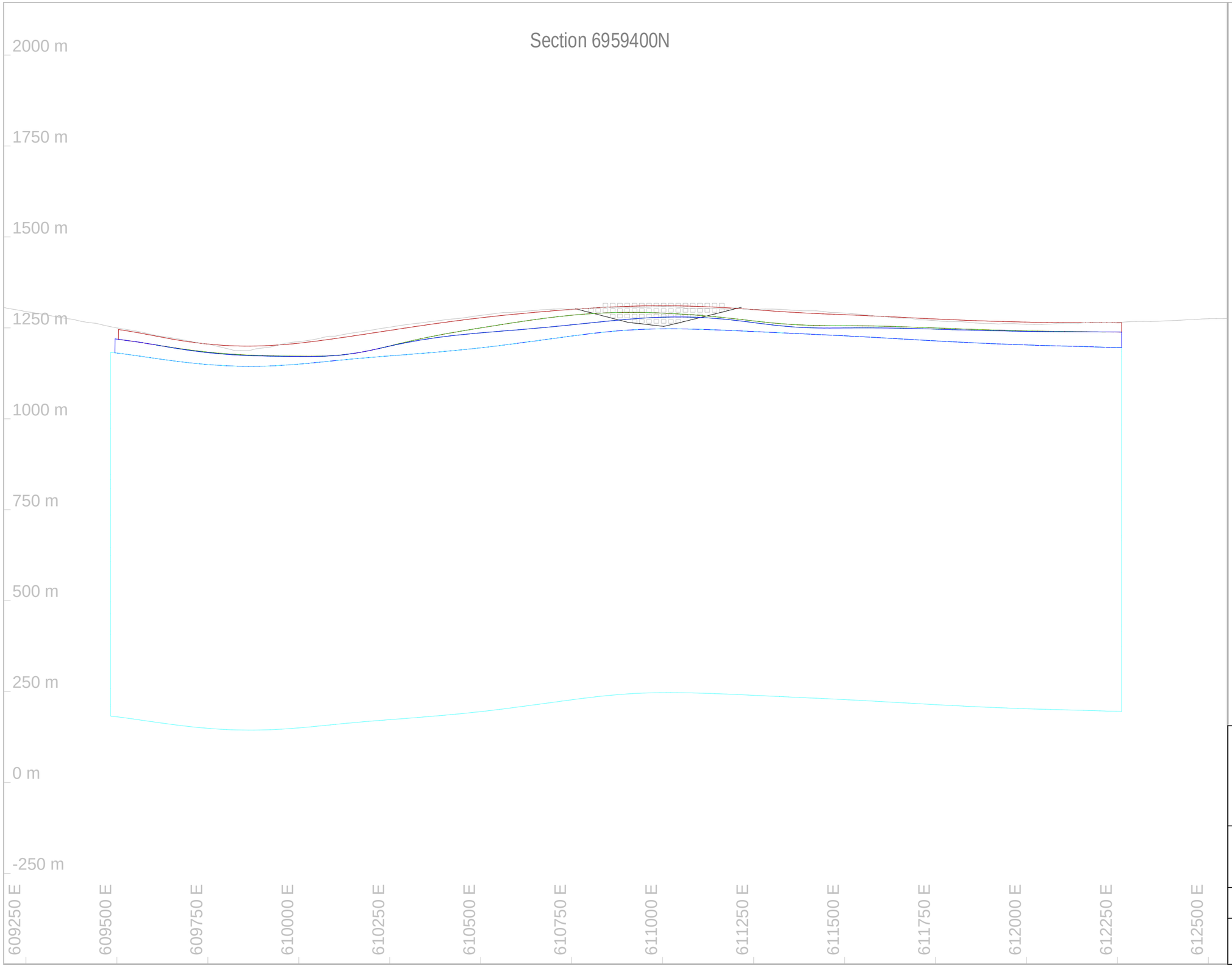
Casino Project

Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 8, 2014



Mineralized Zone

CAP	
SOX	
SUS	
HYP	

Lithology

IX	
MX	
PP	

Rinse pH (bar on left)

< 5.0	
5.0 - 6.4	
6.4 - 7.0	
> 7.0	

CANP/AP (centre bar)

< 1.0	
1.0 - 2.0	
> 2.0	

Total S% (text on right)

0.0 - 0.1	
0.1 - 0.5	
0.5 - 1.0	
1.0 - 5.0	
5.0 - 10.0	
10.0 - 100	

PFS Material Routing (blocks)

Overburden	
Leach Cap Gold Ore	
Leach Cap Potential Ore	
Sox Stockpile Ore	
Low Grade Stockpile	
Direct Feed Ore	
Waste	

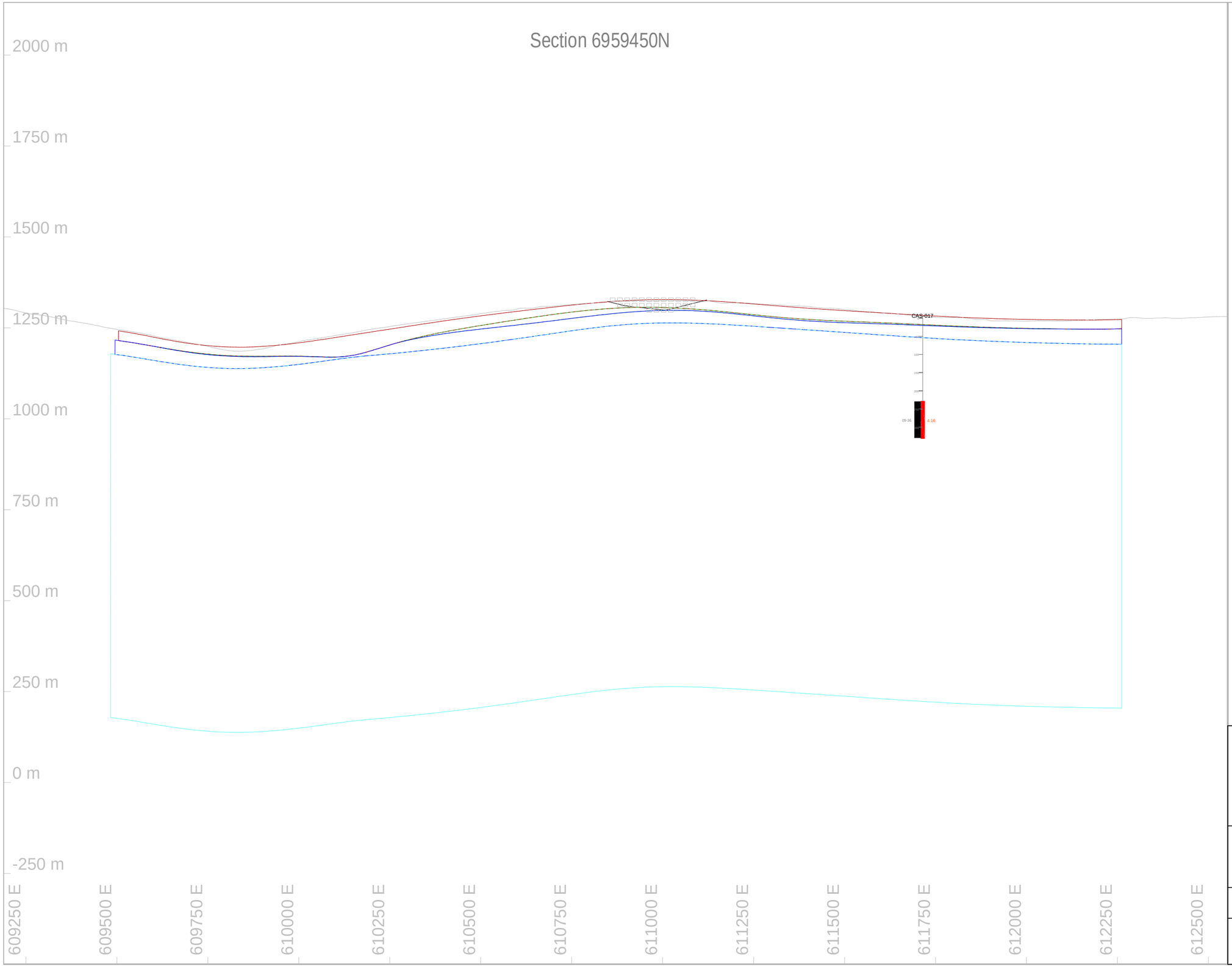
Casino Project

Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 8, 2014



Mineralized Zone

CAP	
SOX	
SUS	
HYP	

Lithology

IX	
MX	
PP	

Rinse pH (bar on left)

< 5.0	
5.0 - 6.4	
6.4 - 7.0	
> 7.0	

CANP/AP (centre bar)

< 1.0	
1.0 - 2.0	
> 2.0	

Total S% (text on right)

0.0 - 0.1	
0.1 - 0.5	
0.5 - 1.0	
1.0 - 5.0	
5.0 - 10.0	
10.0 - 100	

PFS Material Routing (blocks)

Overburden	
Leach Cap Gold Ore	
Leach Cap Potential Ore	
Sox Stockpile Ore	
Low Grade Stockpile	
Direct Feed Ore	
Waste	

Casino Project

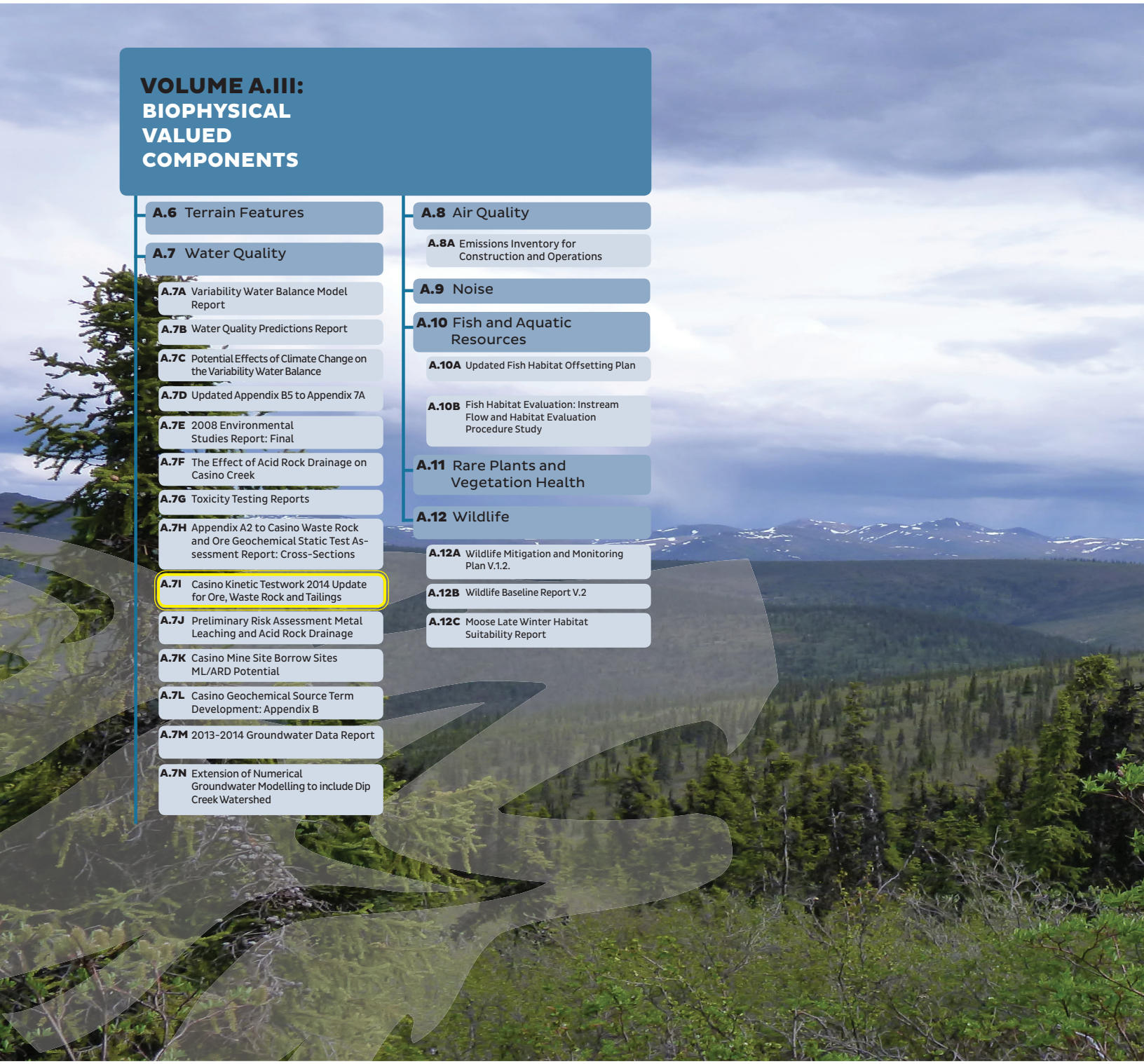
Lorax Environmental Services: ARD Sampling Program

Vertical E-W Cross Sections
Viewing North

Coordinate System: UTM, Zone 7N

Drawn By: H. Brown
Date: May 8, 2014

APPENDIX A.7I: Casino Kinetic Testwork 2014 Update for Ore, Waste Rock and Tailings



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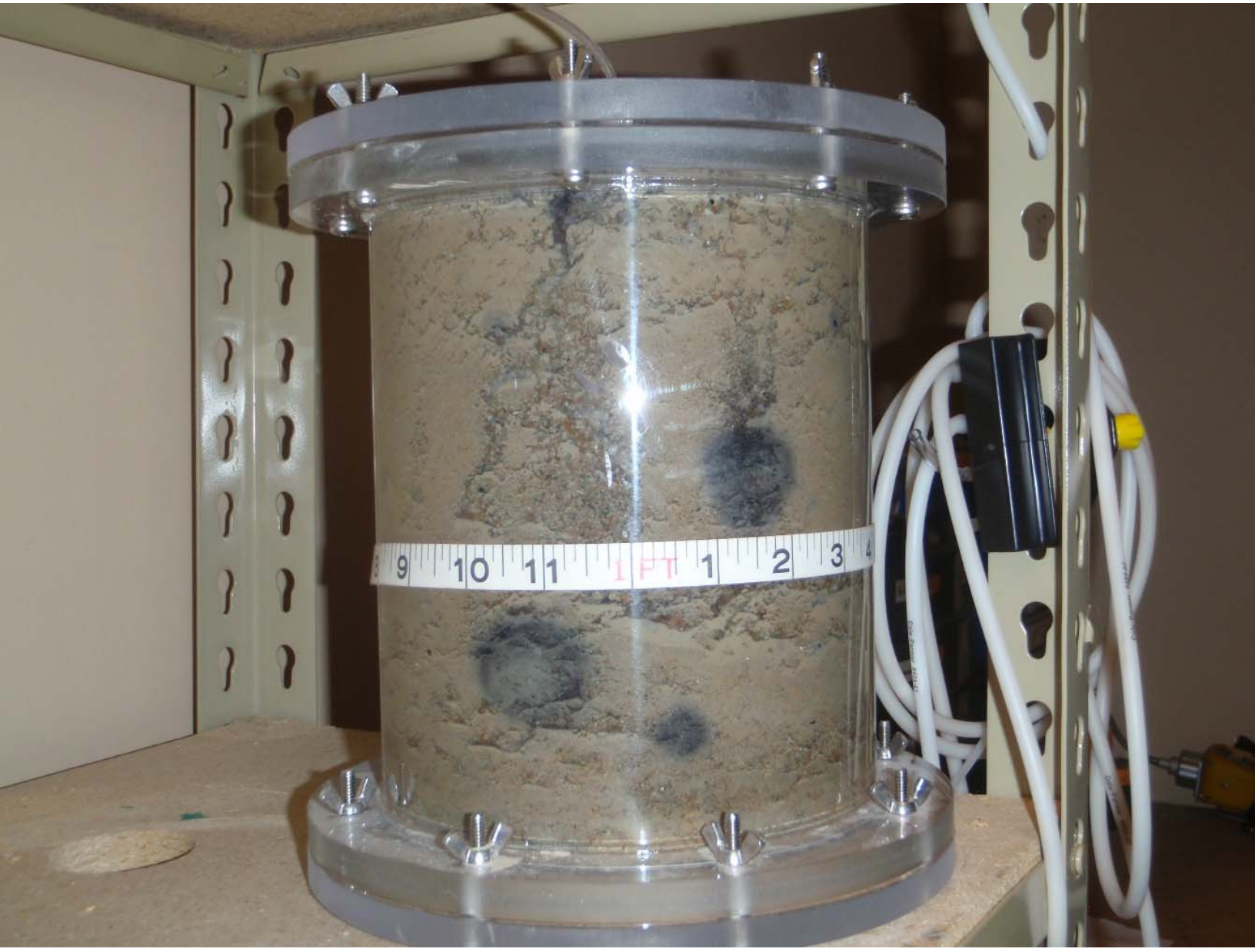
Casino Kinetic Testwork 2014 Update for Ore, Waste Rock and Tailings



Project No. J862-6
15 December 2014

LORAX ENVIRONMENTAL
2289 Burrard Street
Vancouver, BC, V6J 3H9
Canada
1-604-688-7173

Executive Summary

CASINO

Executive Summary

The Casino kinetic test program evaluates the metal leaching and acid rock drainage (ML/ARD) potential of waste rock, tailings and ore samples in support of the geochemical assessment for the Casino Project. A total of 53 kinetic tests have been undertaken for the Casino Project, which includes saturated columns, unsaturated columns, humidity cells and field weathering bins. Additional data has continued to be collected for a number of kinetic tests discussed in the 2013 Kinetic Test Update report and/or the 2013 Casino Source Term Development report. This report presents the results for the laboratory kinetic tests up to September 2014. The most relevant findings are summarized here.

Final Stabilized Metal Leaching Rates

- 95th percentile concentrations in saturated column tests were used to estimate the source term for the saturated impoundment. Concentrations produced by column experiments have generally decreased with time.
- Geochemical loading rates measured in neutral and acidic pH waste rock humidity cells were used to predict pit wall and unsaturated waste rock source terms. The latest available data (Cycles 49-65) were applied at the time of source term development. Since this time, final geochemical loading rates have decreased by on average 20% (Cycles 69-79).
- Geochemical loading rates measured in tailings humidity cells and unsaturated columns were used to estimate loading rates for the tailings embankment and beach. Closure source terms were predicted using HYP tailings kinetic tests Col6 and T7. Now, an additional 50 cycles of data is available. Overall, the geochemical loading rates have decreased by an average of 14% and 29% in Col 6 and T7, respectively. Specifically, sulphate loading rates have decreased 40% and 75% in these kinetic tests. Conversely, there are several elements which have shown increased loading rates. The most significant of these increases is Cu in Col 6, which increased by 51% and Mo in T7 which increased by 107%.

Temperature Effects

Kinetic oxidation rates are temperature sensitive so temperature effects must be considered when relating laboratory loading rates to field conditions. At the time of source term development, data was available from one kinetic test (T1) which had been moved from a room temperature environment to a 4°C environment after rates had stabilized. Since the time of initial source term calculations, a number of other kinetic tests were moved from

room temperature to 4°C environment to provide further information regarding temperature affects. The updated kinetic test data generally shows that the assumptions related to site temperature effects on metal leaching rates that were applied during the source term development are of sound basis. That is, acidic metal leaching rates are more sensitive to temperature then that of neutral metal leaching rates and oxide CAP is generally not as sensitive to temperature affects as sulphidic SUP or HYP rock types.

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CASINO

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1. Introduction

CASINO

1. Introduction

1.1 Introduction

A series of laboratory and field based kinetic tests have been conducted to evaluate the acid rock drainage and metal leaching potential (ML/ARD) for waste rock, tailings and ore that will be produced during mine operations at Casino Mining Corporation's (CMC) Casino Project in the Yukon. The primary objective of this report is to provide an update of the ongoing kinetic test program presented in Lorax 2013c in order to determine if the Casino source term predictions (Lorax, 2013b) require revising. This report presents an update of the static and kinetic test results of kinetic tests completed, and ongoing, since March 2013. It also provides an evaluation of the effect of temperature on leachate quality for those tests that were moved from 22 ºC to 4 ºC storage.

1.2 Geology

The Casino deposit is a large gold-copper-molybdenum (Au-Cu-Mo) porphyry deposit that occurs in the Yukon Crystalline Terrane. A more detailed description of the site geology and can be found in Lorax (2013a,b,c).

The mineralization zones identified in the core of the Casino deposit include:

- Leached oxide cap zone (CAP);
- Supergene (SUP) Zone (Supergene Oxide (SOX) + Supergene Sulphide (SUS)); and
- Hypogene Zone (HYP).

1.3 Test Program Overview

A total of 53 kinetic tests have been undertaken for the Casino Project, including:

- Waste rock: 11 saturated columns, 5 unsaturated columns, 10 humidity cells, and 8 field bins;
- Tailings: 6 saturated columns, 4 unsaturated columns (including 2 composed of CAP heap leach residue), and 7 humidity cells; and
- Ore: 2 humidity cells.

This report provides an update for the 15 kinetic tests that are ongoing or have additional data since March, 2013:

- Waste rock: 4 saturated columns, 2 unsaturated columns, 10 humidity cells; and,
- Tailings: 2 saturated columns, 1 unsaturated, and 2 humidity cells.

The description and details for the Casino Project kinetic testing are summarized in Table 1-1 and Table 1-2. Additional information can be found in Lorax documents (2008, 2010, 2013a,b,c).

Table 1-1:
Summary of waste rock kinetic tests for the Casino Project.

Kinetic Test Type	Sample ID	Sample Selection Rational	Sample Description		Test Details		
			Mineralization Zone	Lithology	Mass (kg)	Start Date	End Date*
Saturated Waste Rock Columns	Sat Col 2	Moderate S CAP (duplicate of Col 2A)	95% CAP, 5% SUP	85% WR, 5% IX, 5% MX, 5% PP	5	24-Feb-10	11-Jan-13
	Sat Col 3	Moderate S HYP	HYP	70% WR, 20% PP,10% MX	5	24-Feb-10	11-Jan-13
	Sat Col 4	High S HYP	HYP	70% WR, 20% PP, 10% MX	5	24-Feb-10	11-Jan-13
	Sat Col 5	High S SUP	90% SUP, 5%CAP, 5%HYP	95% WR, 5% MX	5	24-Feb-10	11-Jan-13
	Sat Col 6	Acidic SUP	50%SUP, 50%CAP	WR	5	24-Feb-10	11-Jan-13
	Sat Col 7	Moderate S HYP (Duplicate of Sat Col3)	HYP	70% WR, 20% PP,10% MX	10	24-Feb-10	11-Jan-13
	Sat Col 9	Layered CAP and HYP (only upper port sampled)	89% HYP, 11% SUP	89% WR, 11% PP	5	1-Apr-10	25-May-12
			CAP	78% WR, 11% PP, 11% MX	5		
	Sat Col 12	Layered acidic SUP and HYP (upper and lower ports sampled)	25% HYP	60% WR, 20% MX, 20% IX	3	12-Jul-12	13-Feb-14
			75% acidic SUP	88% WR, 12% IX	9.1		
	Sat Col 13	Layered neutral SUP and HYP (upper and lower ports sampled)	25% HYP	60% WR, 20% MX, 20% IX	3.3	17-Jul-12	on-going
			75% neutral SUP	57% PP, 43% WR	9.8		
	Sat Col 14	Layered acidic SUP and HYP (upper and lower ports sampled)	50% HYP	60% WR, 20% MX, 20% IX	5.6	12-Jul-12	13-Feb-14
			50% acidic SUP	88% WR, 12% IX	5.6		
	Sat Col 15	Neutral SUP	neutral SUP	57% PP, 43% WR	7.9	17-Jul-12	13-Feb-14
Unsaturated Waste Rock Columns	Col 1	Low S CAP (duplicate of FB2)	CAP	WR	5	27-Jan-10	26-Feb-14
	Col 2A	5 kg Moderate S CAP (duplicate of Sat Col 2 & Col 2B)	95% CAP, 5% SUP	85% WR, 5% IX,5% MX, 5% PP	5	27-Jan-10	on-going
	Col 2B	10 kg Moderate S CAP (duplicate of Sat Col 2 and Col 2b)	95% CAP, 5% SUP	85% WR, 5% IX, 5% MX, 5% PP	10	27-Jan-10	5-Dec-12
	Col 3	High S CAP	80% CAP, 20% SUP	70% WR, 20% PP, 10% MX	5	27-Jan-10	5-Dec-12
	Col 4a	Neutral CAP (pH > 6)	81% CAP, 13% SUP, 6.3% OVB	81%WR, 19% PP	5	1-Apr-10	5-Dec-12

Kinetic Test Type	Sample ID	Sample Selection Rational	Sample Description		Test Details		
			Mineralization Zone	Lithology	Mass (kg)	Start Date	End Date*
Waste Rock Humidity Cells	HC3	Neutral pH, high S (sample: 08-276)	HYP	PP	1	29-Nov-12	25-Feb-14
	HC4	Neutral pH, high S (sample 08-294)	HYP	WR	1	29-Nov-12	25-Feb-14
	HC5	Neutral pH, moderate S (sample 08-277)	HYP	PP	1	29-Nov-12	25-Feb-14
	HC6	Neutral pH, moderate S (sample 08-028)	HYP	WR	1	29-Nov-12	25-Feb-14
	HC7	Neutral pH, moderate S (50% of 08-043 & 08-225)	HYP	50% IX, 50% MX	1	29-Nov-12	25-Feb-14
	HC8	Acidic paste pH (sample 08-143)	HYP	MX	1	29-Nov-12	on-going
	HC9	Carbonate depleted (sample 08-260)	HYP	PP	1	29-Nov-12	on-going
	HC10	Acidic paste pH (50% of 08-059 / 08-178)	HYP	WR	1	29-Nov-12	on-going
	HC11	Neutral SUP (sample 08-068)	SUS	WR	1	29-Nov-12	25-Feb-14
	HC12	Acidic SUP (sample 08-058)	SUS	WR	1	29-Nov-12	on-going
Waste Rock Field Bins	FB1	pH>6 Moderate S CAP	CAP	WR	166	1-Sep-08	on-going
	FB2	pH > 6 Low S CAP	CAP	WR	151	1-Sep-08	on-going
	FB3	pH<6 Low S CAP	CAP	WR	155	1-Sep-08	on-going
	FB4	pH<6 High S CAP	CAP	52% PP, 48% MX	150	1-Sep-08	on-going
	FB5	Neutral SUP	56% SUP, 44% CAP	WR	169	1-Sep-08	on-going
	FB6	Moderate S HYP	92% HYP, 8% SUP	WR	172	1-Sep-08	on-going
	FB7	High S HYP	HYP	WR	132	1-Sep-08	on-going

* Only samples that are either ongoing or have end dates after March-2013 are reported herein (shaded grey).

Table 1-2:
Summary of tailings and ore kinetic tests for the Casino Project.

Kinetic Test Type	Sample ID	Sample Selection Rational	Sample Description			Test Details		
			Material Type	Mineralization Zone	Lithology	Mass (kg)	Start Date	End Date*
Ore Kinetic Tests								
Humidity Cells	HC1	HYP Ore	2009-Ore	100% HYP	75% WR, 25% IX	5	3-Dec-09	1-Sep-10
	HC2	SUP Ore	2009-Ore	81.7% SUP, 18.3% HYP	60% WR, 40% IX	5	3-Dec-09	1-Sep-10
Tailings Kinetic Tests								
Saturated Columns	Sat Col 1	Rougher whole tailings	2009-Bench	50% HYP, 50% SUP	66% PP, 34% IX	4.5	24-Feb-10	11-Jan-13
	Sat Col 8	Rougher whole tailings	2009-Bench	83% HYP, 17% SUP	55% PP, 45% IX	4.5	24-Feb-10	11-Jan-13
	Sat Col 10	Pyrite rougher whole tailings	2010-Bench	85% SUP, 15% HYP	64% WR, 18% PP, 16% MX, 2% IX	5	20-Jul-11	6-Jun-13
	Sat Col 11	Pyrite concentrate with 21% slimes	2010-Bench	85% SUP, 15% HYP	64% WR, 18% PP, 16% MX, 2% IX	5	28-Jul-11	6-Jun-13
	Sat Col 16	Pyrite rougher whole tailings	2012-Pilot Plant	100% HYP	87% IXWR, 13% IXPP	5.4	1-Mar-13	12-Feb-14
	Sat Col 17	Pyrite concentrate	2012-Pilot Plant	100% HYP	87% IXWR, 13% IXPP	6.6	1-Mar-13	12-Feb-14
Unsaturated Columns	Col 5	Pyrite rougher tailings sands (duplicate of T6)	2010-Bench	85% SUP, 15% HYP	64% WR, 18% PP, 16% MX, 2% IX	4.96	4-May-11	5-Dec-12
	Col 6	Pyrite rougher tailings sands	2012-Pilot Plant	100% HYP	87% IXWR, 13% IXPP	1	3-May-11	on-going
	Col 7	Heap leach residue (sample CL-01 L)	Column leach residue	100% CAP	Mixed	10	20-Mar-13	on-going
	Col 8	Heap leach residue (sample CL-01 L)	Column leach residue	100% CAP	Mixed	25	20-Mar-13	19-Jun-13
Humidity Cells	T1	Rougher whole tailings	2008-Pilot Plant	71% SUP, 22% HYP, 7% CAP	52% IX, 43% WR, 5% PP	5	1-May-08	1-May-10
	T2	Rougher whole tailings	2008-Pilot Plant			5	1-May-08	1-May-10
	T3	Rougher whole tailings	2008-Pilot Plant			5	1-May-08	12-Feb-09
	T4	Rougher whole tailings	2009-Bench	60% HYP, 40% SUP	59% IX, 22% PP, 20% WR	1	15-Dec-09	on-going
	T5	Pyrite rougher whole tailings	2010-Bench	85% SUP, 15% HYP	64% WR, 18% PP, 16% MX, 2% IX	0.9	3-May-11	4-Dec-12
	T6	Pyrite rougher tailings sands	2010-Bench	85% SUP, 15% HYP	64% WR, 18% PP, 16% MX, 2% IX	1	3-May-11	4-Dec-12
	T7	Pyrite rougher whole tailings	2012-Pilot Plant	100% HYP	87% IXWR, 13% IXPP	1	5-Mar-13	on-going

Notes: Only samples that are either ongoing or have end dates after March-2013 are reported herein with the exception of unsaturated columns Col 7 and Col 8. The data for those two columns will be provided in a separate report addressing the heap leach pile. The kinetic tests reported on in this report are shaded grey.

1.4 Errata

During preparation of this report, reviews of previous reports found that, in some cases, the units for Hg concentrations and loadings were presented erroneously.

The report Casino_Kinetic Testwork_Update_Final_updated 18th December, 2013 was reviewed in detail with the following findings:

- The units for Hg were presented as µg/x or mg/x in the report. However, the values are consistent with the units given in each table with the exception of Table 4-41. In that table, the Hg units are listed as ug/L. However, in some columns of the table, Hg is reported as <0.01 (µg/L), but in other columns it is reported as <0.00001. The values <0.00001 are actually in units of mg/L.
- The Hg loading values listed in tables of Appendix E: Unsaturated Kinetic Test Results, represent µg/kg not mg/kg.
- The Hg loading values given in the figures in Appendix E represent µg/kg, not mg/kg.

The source term calculations were checked and it was found that the conversion from µg/L to mg/kg was done correctly. The loading values for Hg presented in the report, Casino Geochemical Source Term Development_FINAL, are correct. Therefore, the error is a presentation error and does not affect the source term values. The units for Hg loading rates have been corrected to mg/kg for the tables presented in this report.

2. Saturated Column Results

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2. Saturated Column Results

Saturated kinetic tests with new data since the 2013 kinetic test report and/or the 2013 Source Term Development report (Lorax 2013b,c) are listed in Table 2-1.

Table 2-1:
Saturated tests with new data since the 2013 kinetic test report

Kinetic Test ID	Mineralization Zone	Details / Notes	Start Date	End Date
Waste Rock				
Sat Col 12	25% HYP 75% acidic SUP	Layered acidic SUP and HYP (upper and lower ports sampled)	12-Jul-12	13-Feb-14
Sat Col 13	25% HYP 75% neutral SUP	Layered neutral SUP and HYP (upper and lower ports sampled)	17-Jul-12	Ongoing
Sat Col 14	50% HYP 50% acidic SUP	Layered acidic SUP and HYP (upper and lower ports sampled)	12-Jul-12	13-Feb-14
Sat Col 15	SUP	Neutral SUP	17-Jul-12	13-Feb-14
Tailings				
Sat Col 10	85% SUP, 15% HYP	Pyrite rougher whole tailings	20-Jul-11	6-Jun-13
Sat Col 11	85% SUP, 15% HYP	Pyrite concentrate with 21% slimes	28-Jul-11	6-Jun-13
Sat Col 16	100% HYP (87% IXWR, 13% IXPP)	Pyrite rougher whole tailings	01-Mar-13	12-Feb-14
Sat Col 17	100% HYP (87% IXWR, 13% IXPP)	Pyrite concentrate	01-Mar-13	12-Feb-14

The composition of the saturated column leachate is controlled by the flushing of water soluble oxidation products and reductive dissolution of reducible phases (*i.e.*, Fe and Mn oxides). Peak concentrations are generally observed during the first pore volume that is flushed through the columns, although concentrations of some parameters have been observed to increase or remain constant with time. In the saturated TMF, flushing of one pore volume will take in excess of 100 years. During this time, waste rock and tailings will impart a concentration on drainage water which is best represented by the peak concentrations observed in the saturated columns. The 95th percentile concentrations in saturated column data was used for the source term development (Lorax 2013b). The 95th percentile was calculated from the current data set and compared against the values used in the source term development to assess if there has been a significant difference in concentrations since the source term development. Column leachate trends for selected analytes over time are shown in Appendix A (Figures A-1 and A-2). The comparison is provided in Table B-1 (Appendix B) and the complete dataset is provided in Appendix C.

Analytes that were consistently below detection for a test column (*e.g.*, NO_3, NO_2, Be, Bi, Cr, Hg, P, Ag, Sn, Ti, Zr) in the data set were excluded from the assessment. Table 2-2 provides the summary statics from the comparison; negative values indicate that, overall, the current 95th percentile values are less than the values used in the source term development. Therefore, the source term values are considered conservative. The statistics are based on the complete analysis suite (the average of the relative differences of all analytes above detection) except for pH because a lower pH used in the source term development is considered conservative. In all cases, the pH has increased with time, typically by 5 to 10%, with the exception of the lower port of Sat Col 14, which has increased by 39%, going from a pH of 3.35 to a pH of 5.88 (Table 2-2). This increase in pH is accompanied by an increase in alkalinity values. That is, the largest increase in the 95th percentiles, 141% (Table 2-2), is from the alkalinity values. The 95th percentile for sulphate concentrations decreased in all the saturated columns by a maximum of 31% (Table B-1). The overall relative differences are negative, meaning the current 95th percentile values are typically less than the values used in the source term development.

Two saturated tailings columns (Sat Col 16 and Sat Col 17) were initiated in early 2013, and results were not available by the cut-off date for reporting in the 2013 Casino Kinetic test Update (Lorax, 2013c). Results for these columns are included alongside other saturated tailings columns in Figures A-3 and Figure A-4. These saturated columns contain pyrite rougher tailings (Sat Col 16) and pyrite concentrate (Sat Col 17) from the 2012 pilot plant. These tailings samples were produced exclusively from HYP ore. Most of the existing saturated tailings columns were composed of a mixture of SUP and HYP. The pH of these two columns is similar to the 83% Hyp (Sat Col 8) and 85% Sup (Sat Col 10 and 11) columns, as is alkalinity and dissolved Fe. The sulphate concentrations from both columns are still trending downward and are now <1.0 mg/L for Sat Col 16 and 10 mg/L for Sat Col 17 (similar to Sat Col 8 and Sat Col 10 stabilized values). The rapid depletion of sulphate in column drainage is presumably related to production of H_2S, which was detected in concentrations as high as 0.76 mg/L and 0.089 mg/L in Sat Col 16 and Sat Col 17, respectively. The dissolved metals concentrations eluting from these two columns are frequently below detection (*e.g.*, Cd, Cu, Pb, Se and Zn). The As and Mo concentrations are very similar to Sat Col 1 (60% HYP). Therefore, when HYP ore is the primary mill feed, the tailings are expected to have similar, or slightly lower, metal leaching potential than when mixed mill feeds are running. It is unclear why these samples provided more favorable conditions for SO_4 reduction and H_2S production. This may be related to the relatively high dissolved organic carbon content (DOC), with concentrations ranging from 45 mg/L to 125 mg/L in Sat Col 16 and Sat Col 17, while DOC remained below 10 mg/L in other tailings columns (Sat Col 1, 8, 10 and 11).

Table 2-2:
Summary statistics for saturated columns showing relative difference between the 95th percentile used in the source term development and the current 95th percentile.

	pH	Cu	SO_4	All analyses combined			
	s.u.	mg/L	mg/L	Median	Mean	Min	Max
Sat Col 10							
Current	8.14	0.033	113				
Relative difference	8%	-2%	-1%	-1%	-3%	-17%	1%
Sat Col 11							
Current	8.07	0.001	369				
Relative difference	9%	-5%	12%	-2%	-2%	-14%	12%
Sat Col 12 upper port							
Current	7.04	4.213	2028				
Relative difference	10%	-63%	-12%	-11%	-18%	-63%	-1%
Sat Col 12 lower port							
Current	4.16	222	3278				
Relative difference	15%	-41%	-31%	-29%	-20%	-49%	141%
Sat Col 13 upper port							
Current	7.65	0.002	1080				
Relative difference	10%	-60%	-20%	-14%	-18%	-105%	95%
Sat Col 13 lower port							
Current	7.67	0.034	1356				
Relative difference	10%	-64%	-9%	-11%	-21%	-101%	78%
Sat Col 14 upper port							
Current	7.18	0.870	2166				
Relative difference	9%	-72%	-8%	-9%	-17%	-75%	1%
Sat Col 14 lower port							
Current	5.88	398	4760				
Relative difference	39%	-21%	-21%	-19%	-13%	-117%	141%
Sat Col 15							
Current	7.40	0.026	759				
Relative difference	6%	-80%	-25%	-14%	-14%	-94%	94%
Sat Col 16							
Current	8.66	<0.0001	615				
Relative difference	5%	NS	-2%	-2%	9%	-28%	126%
Sat Col 17							
Current	8.20	0.0004	1376				
Relative difference	9%	62%	-4%	-3%	7%	-94%	116%

Notes: Negative values indicate that the current 95th percentile value is less than the 95th percentile used for the source term development.
"NS" means difference is Not Significant because both medians are less than 5 x's the reporting limit.

3. Unsaturated Kinetic Test Update

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3. Unsaturated Kinetic Test Update

3.1 Waste Rock

Unsaturated waste rock kinetic tests with new data since the 2013 Kinetic Test Report Update and/or the 2013 Source Term Development Report are listed in Table 3-1.

Table 3-1:
Unsaturated waste rock kinetic tests with new data since the 2013 kinetic test report.

	Kinetic Test ID	Sample Description		Details of Test		
		Lithology	Details / Notes	Start Date	Terminated	Temperature change to 4ºC
CAP	Col 1	WR	Low S, duplicate of FB2	27-Jan-10	26-Feb-14	No change
	Col 2A	85% WR, 5%IX, 5%MX, 5%PP	Moderate S	27-Jan-10	on-going	No change
HYP	HC3	PP	Neutral pH, high S	29-Nov-12	25-Feb-14	4-Jun-13 Cycle 79
	HC4	WR	Neutral pH, high S	29-Nov-12	25-Feb-14	
	HC5	PP	Neutral pH, moderate S	29-Nov-12	25-Feb-14	
	HC6	WR	Neutral pH, moderate S	29-Nov-12	25-Feb-14	
	HC7	50% IX, 50% MX	Neutral pH, moderate S	29-Nov-12	25-Feb-14	
	HC8	MX	Acidic paste pH	29-Nov-12	on-going	4-Mar-14 Cycle 118
	HC9	PP	Carbonate depleted	29-Nov-12	on-going	No change
	HC10	WR	Acidic paste pH	29-Nov-12	on-going	4-Mar-14 Cycle 118
SUP	HC11	WR	Neutral SUP	29-Nov-12	25-Feb-14	4-Jun-13 Cycle 79
	HC12	WR	Acidic SUP	29-Nov-12	on-going	4-Mar-14 Cycle 118

Notes: The CAP unsaturated columns were trickle leached and the SUP and HYP humidity cells were flood leached; temperature for each test maintained between 22°C and 24°C unless otherwise specified; sampling was/is conducted weekly without sample preparation prior to flushing. No initial flushing was conducted.

Column leachate trends for selected analytes over time are shown in Appendix A (Figures A-5 to A-8). Table 3-2 provides the summary statics from the comparison; negative values indicate that the stabilized final values are less than the values that were used in the source term development. The percent difference calculation is not an appropriate comparison when both values are near detection limits considering analytical precision. The BC Field Manual (MOE, 2013) states that relative percent difference is not a meaningful comparison

if both values are less than 5 times the detection limit. Therefore, if both the values used in the source term development and the current values are less than 5 times the analytical reporting limit (Table B-1) the relative difference is deemed Not Significant. The comparison is provided in Table B-2 (Appendix B) and the complete dataset is provided in Appendix C.

Table 3-2:
Summary statistics for the relative difference between values used in the source term development and the final, stablized leaching rates: Unsaturated waste rock.

	pH	Cu	SO_4	All analyses combined			
	s.u.	mg/kg/wk	mg/kg/wk	Median	Mean	Min	Max
Col 1							
22°C Median	4.97	0.05	1.50				
Relative Difference	-4%	-10%	-45%	-13%	-37%	-508%	10%
Col 2a							
22°C Median	5.66	0.0019	23.53				
Relative Difference	-4%	-68%	-19%	-19%	-15%	-87%	35%
HC3							
22°C Median	7.57	0.0005	6.59				
Relative Difference	2%	NS	-18%	-13%	-16%	-79%	32%
HC4							
22°C Median	7.56	0.0004	11.50				
Relative Difference	1%	NS	8%	7%	-10%	-116%	30%
HC5							
22°C Median	7.58	0.0002	6.30				
Relative Difference	0%	NS	4%	-13%	-18%	-91%	33%
HC6							
22°C Median	7.51	0.0007	2.67				
Relative Difference	1%	NS	NS	-19%	-21%	-81%	30%
H7							
22°C Median	7.40	0.0011	10.44				
Relative Difference	1%	-5%	-12%	-12%	-15%	-71%	37%
HC8							
22°C Median	2.91	0.40	80.84				
Relative Difference	-10%	-84%	38%	16%	10%	-111%	108%
HC10							
22°C Median	3.24	1.19	56.25				
Relative Difference	2%	-29%	-20%	-26%	-30%	-121%	7%
HC11							
22°C Median	6.82	0.0009	4.40				
Relative Difference	-3%	-60%	NS	-19%	-19%	-95%	46%
HC12							
22°C Median	3.41	0.36	18.70				
Relative Difference	-8%	-96%	-20%	-32%	-32%	-98%	64%

Notes: The 22°C median represents the median of the last five complete analysis sets at a temperature of 22°C. The relative difference represents the difference between the median values used in the source term and the median from the last 5 complete analyses at a temperature of 22 °C (pH values excluded). "NS" means difference is Not Significant because both medians are less than 5 x's the reporting limit. Negative values mean the current median is less than the median used in the source predictions.

The pH did not change by more than 20% and in most tests remained relatively constant (Table 3-2). The final copper and sulphate loading rates either decreased or did not change significantly between values currently observed and those used in source term development. Updating source terms with currently observed values would reflect the general decline in stabilized loading rates, resulting in generally lower geochemical loading rates used in source terms.

3.2 Tailings

Unsaturated tailings kinetic tests with new data since the 2013 Kinetic Test Report Update and/or the 2013 Source Term Development Report are listed in Table 3-3.

Table 3-3:
Unsaturated tailings kinetic tests with new data since the 2013 kinetic test report.

Kinetic Test ID	Mineralization Zone	Operational Procedure						
		Start Date	Terminated	Temperature change to 4ºC	Mass (kg)	Flushing Rate/ Weekly Input (mL)	Leach Procedure	Sample Prep for Flushings
Whole Tailings								
T4	60% HYP, 40% SUP	15-Dec-09	on-going	4-Mar-14 Cycle 220	1	500	Flood	Stirred
Depyritized Pyrite Rougher Whole Tailings								
T7	HYP	5-Mar-13	on-going	No change	1	500	Flood	Stirred
Depyritized Pyrite Rougher Tailings Sands (>75 µm)								
Col 6	HYP	19-Dec-12	on-going	No change	5.0	300	Trickle	None

Notes: Temperature for each test is maintained between 22°C and 24°C unless otherwise specified.

Column leachate trends for selected analytes over time are shown in Appendix A (Figures A-9 and A-10). Table 3-4 provides the summary statistics from the comparison; negative values indicate that the current stabilized final values are less than the values that were used in the source term development. If both the values used in the source term development and the current values were less than 5 times the analytical reporting limit the relative difference was deemed Not Significant. The comparison is provided in Table B-3 (Appendix B) and the complete dataset is provided in Appendix C.

The pH remained relatively constant (Table 3-4). The final loading rates have declined for most parameters compared to what was used in source term development as shown in the 'all analyses combined' results in Table 3-4. One significant result is that Cu leaching rates for Cu have increased in Col 6. Other loading rates which increased in this kinetic test were of Cd, Co, Mn, Mg and Ni. The cause of these increases is unclear, as pH and alkalinity have remained stable and most other parameters (*e.g.*, sulphate) have declined over this time period.

Table 3-4:
Summary statistics for the relative difference between values used in the source term development and the final, stabilized leaching rates: Unsaturated tailings.

	pH	Cu	SO_4	All analyses combined			
	s.u.	mg/kg/wk	mg/kg/wk	Median	Mean	Min	Max
Col 6							
22°C Median	7.95	0.0005	1.04				
Relative Difference	2%	51%	-40%	-7%	-14%	-107%	51%
T4							
22°C Median	7.72	0.0003	25.20				
Relative Difference	2%	NS	11%	-17%	-14%	-36%	11%
T7							
22°C Median	7.91	0.0003	3.92				
Relative Difference	3%	NS	-75%	-36%	-29%	-101%	107%

Notes: The 22°C median represents the median of the last five complete analysis sets at a temperature of 22 °C. The relative difference represents the difference between the values used for the source term development and the median from the last 5 complete analyses at a temperature of 22 °C (pH values excluded). Negative values mean the current median is less than the median used in the source predictions

4. Temperature Dependence

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4. Temperature Dependence

The oxidation rate of Casino mine waste is influenced by temperature. Laboratory tests are typically conducted at room temperature (~22°C) while the average ambient temperature at the Casino mine site is near 1°C. Therefore, the rate of sulphide oxidation observed in kinetic test work likely overestimates field conditions. To assess and address the influence of temperature on oxidation rates, 12 humidity cells were moved from room temperature to a cold room maintained at 4°C. The cycle at which the temperature was changed is marked for all applicable test cells in their respective Figures (Appendix A).

4.1 Acid Generation

Briefly, it has been found that the kinetic rate of pyrite oxidation can generally be described by an Arrhenius relationship:

$$k = Ae^{-Ea/RT}$$

where k is the reaction rate, A is the pre-exponential factor, Ea is the activation energy, R is the noble gas constant, and T is the temperature in Kelvin. The pre-exponential factor is a constant, with a value of 9.28×10^{-14} mole m^{-2} s^{-1}. The Ea of a reaction can be derived from the slope of the Arrhenius relationship (1000/T versus log k) and estimates of sulphide oxidation activation energies based on the results from each of the humidity cells (Table 4-1).

The activation energy can be somewhat variable due to chemical differences in pyrite composition. The range of Ea values reported in the literature is 39 KJ mol^{-1} to 88.0 KJ mol^{-1} (Lowson, 1982). Activation energy values calculated for the 12 kinetic tests ranged from 4 to 69 KJ mol^{-1} with a mean of 43 KJ mol^{-1}. This average value is consistent with the Ea observed in T1 of 44 KJ mol^{-1} which was applied to source term calculations. The temperature sensitivity of sulphide oxidation assuming an activation energy of 44 KJ mol^{-1} is plotted in Figure 4-1.

Three tests (Col 2A, HC6 and HC10) have notably lower activation energy estimates. From the data plots (Figures A-5 and A-7), it appears HC10 and possibly HC6 may not have reached steady-state sulphate leaching rates before the temperature was decreased. The unsaturated column Col2A contains oxide CAP waste rock which only contains trace quantities of pyrite, with jarosite being the primary host of sulphur. Sulphate release from this material is poorly described by sulphide oxidation kinetics.

Table 4-1:
pH, sulphate and activation energy of sulphide oxidation in Casino unsaturated humidity cells.

		21°C		4°C		Ea
ID	**Mineralization**	**pH**	**SO_4**	**pH**	**SO_4**	**KJ mol^{-1}**
Col 2A	CAP	5.66	0.41	6.39	0.25	21
HC3	HYP	7.57	6.59	7.69	1.90	50
HC4	HYP	7.56	11.50	7.73	1.90	72
HC5	HYP	7.58	6.30	7.52	1.65	53
HC6	HYP	7.51	2.67	7.53	1.46	24
HC7	HYP	7.40	10.44	7.46	2.88	51
HC8	HYP	2.91	80.84	3.37	18.53	59
HC10	HYP	3.74	7.52	3.74	6.72	4
HC11	SUP	6.82	4.40	7.14	1.94	33
HC12	SUP	3.41	18.70	3.69	6.90	40
T1	71% SUP, 22% HYP, 7% CAP	7.76	18.86	7.71	6.28	44
T4	60% HYP, 40% SUP	7.72	25.20	7.66	4.60	68
					Mean	**43**

Notes: Sulphate loadings in mg/kg/week; T1 values from Lorax (2013c).

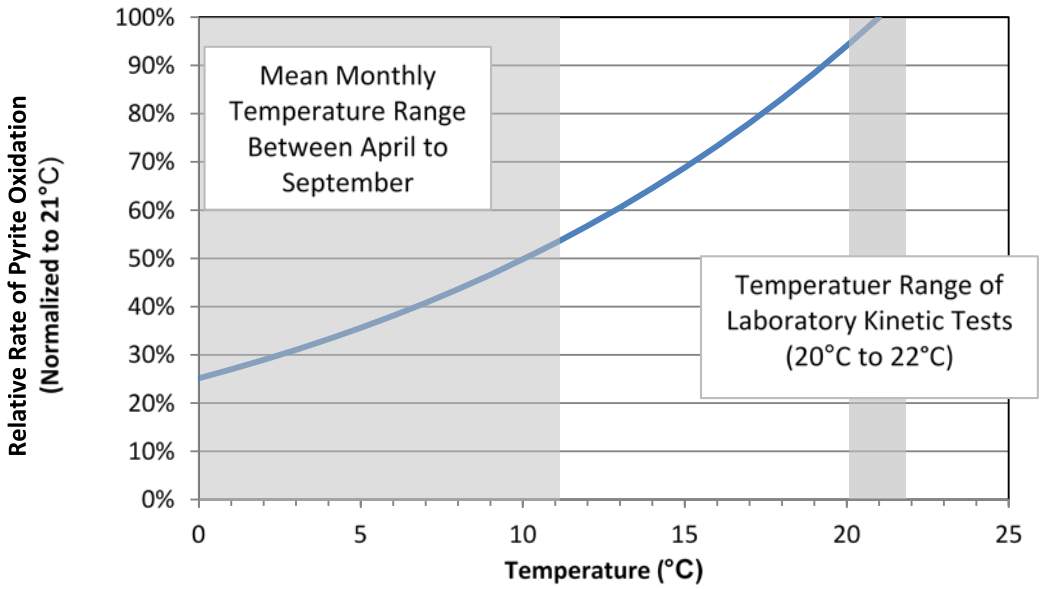

Figure 4-1: Influence of temperature on pyrite oxidation rate in Casino tailings normalized to activation energy of 44 KJ mol^{-1}.

4.2 Metal Leaching Rate

The effect of temperature on metal release rates was evaluated by considering the ratio of the median loading rate from the last 5 complete analyses at 4°C to the median loading rate from the last 5 complete analyses at 22°C.

The leaching rate of most metals decreased when the humidity cells were moved from 22°C to 4°C as indicated by the geometric means of the ratios (4°C/22°C) of the datasets being <1 (Appendix B). The difference in metal leaching rates between 4°C and 22°C is presented in Table 4-2 to Table 4-5. These tables group temperature effects by weathering state (acidic vs. neutral) and material type (tailings, waste rock, oxide cap). These tables also compare the difference in metal leaching rate between 22°C to 4°C observed in recent test work with scaling factors based on results from humidity cell T1 used in source term predictions. In general, test results show that metal leaching rates in acidic waste rock are much more temperature sensitive than in neutral pH waste rock and tailings, and oxide CAP is generally not as temperature sensitive as sulphidic HYP or SUP. For most elements, the temperature scaling factors applied to source terms generally fall within the range observed in the updated kinetic test work.

Table 4-2:
Comparison of temperature scaling factor (rate at 4°C/ rate at 22°C) applied to neutral pH waste rock with recent results from neutral pH waste rock humidity cells.

Element	Scaling Factor Applied to Source Term	HC3	HC4	HC5	HC6	H7	HC11
Sulphate	0.33	0.29	0.17	0.31	0.54	0.28	NS
Al	0.39	0.38	0.41	0.28	0.28	0.42	0.47
Sb	0.58	NS	NS	NS	NS	NS	NS
As	0.65	NS	NS	NS	NS	0.46	NS
Ba	0.84	0.99	1.03	0.92	0.87	1.17	1.39
Cd	0.82	NS	NS	NS	NS	NS	NS
Ca	0.74	0.63	0.62	0.84	0.98	0.57	0.89
Co	1.18	0.98	0.89	0.96	0.85	0.77	0.97
Cu	1.06	0.58	0.76	1.05	0.41	0.79	0.88
Mg	0.76	0.52	0.55	0.65	0.85	0.48	0.79
Mn	1.00	1.32	1.16	1.40	1.07	1.02	1.98
Mo	0.41	0.22	0.15	0.23	0.27	0.29	0.08
Ni	1.04	NS	NS	NS	NS	NS	NS
K	0.51	0.42	0.41	0.42	0.53	0.42	0.54
Se	0.35	NS	NS	NS	NS	0.35	NS
Si	0.63	0.42	0.49	0.56	0.54	0.54	0.53
Na	0.47	0.22	0.20	0.28	0.22	0.22	0.41
Sr	0.75	0.65	0.56	0.71	0.93	0.72	0.82
U	0.28	0.81	0.79	0.78	1.50	1.10	1.07
Zn	0.95	NS	NS	NS	1.10	1.10	NS

Note: Scaling factors applied to source term which are 20% greater than max observed in recent humidity cell test work highlighted blue, while scaling factors which are 20% below the min observed in recent humidity cell test work are highlighted red. "NS" means difference is Not Significant because both medians are less than 5 x's the reporting limit. Negative values mean the current median is less than the median used in the source predictions.

Table 4-3:
Comparison of temperature scaling factor (rate at 4°C/ rate at 22°C) applied to acidic pH waste rock with recent results from acidic pH waste rock humidity cells.

Element	Scaling Factor Applied to Source Term	HC8	HC10	HC12
Sulphate	0.33	0.23	0.12	0.37
Al	0.33	0.09	0.06	0.25
Sb	0.33	NS	NS	NS
As	0.33	0.09	NS	NS
Ba	0.33	0.61	1.31	1.58
Cd	0.33	0.15	0.14	0.23
Ca	0.33	0.19	0.22	0.18
Co	0.33	0.24	0.14	0.30
Cu	0.33	0.23	0.17	0.29
Mg	0.33	0.07	0.09	0.10
Mn	0.33	0.20	0.12	0.38
Mo	0.33	0.21	0.53	NS
Ni	0.33	0.23	0.11	NS
K	0.33	0.32	0.42	0.27
Se	0.33	0.21	0.21	0.33
Si	0.33	0.17	0.36	0.38
Na	0.33	NS	NS	NS
Sr	0.33	0.23	0.55	0.39
U	0.33	0.09	0.09	0.21
Zn	0.33	0.23	0.14	0.28

Note: Scaling factors applied to source term which are 20% greater than max observed in recent humidity cell test work highlighted blue, while scaling factors which are 20% below the min observed in recent humidity cell test work are highlighted red. "NS" means difference is Not Significant because both medians are less than 5 x's the reporting limit.

Table 4-4:
Comparison of temperature scaling factor (rate at 4°C/ rate at 22°C) applied to tailings with recent results from tailings humidity cells.

Element	Scaling Factor Applied to Source Term	T4
Sulphate	0.33	0.18
Al	0.39	0.76
Sb	0.58	NS
As	0.65	NS
Ba	0.84	1.13
Cd	0.82	NS
Ca	0.74	0.48
Co	1.18	0.63
Cu	1.06	NS
Mg	0.76	0.48
Mn	1.00	1.21
Mo	0.41	0.24
Ni	1.04	NS
K	0.51	0.53
Se	0.35	NS
Si	0.63	0.55
Na	0.47	NS
Sr	0.75	0.55
U	0.28	0.24
Zn	0.95	NS

Note: Scaling factors applied to source term which are 20% greater than max observed in recent humidity cell test work highlighted blue, while scaling factors which are 20% below the min observed in recent humidity cell test work are highlighted red. "NS" means difference is Not Significant because both medians are less than 5 x's the reporting limit.

Table 4-5:
Comparison of temperature scaling factor (rate at 4°C/ rate at 22°C) applied to oxide CAP with recent results from oxide CAP unsaturated column.

Element	Scaling Factor Applied to Source Term	Col 2a
Sulphate	1.0	0.6
Al	1.0	0.4
Sb	1.0	NS
As	1.0	NS
Ba	1.0	0.6
Cd	1.0	0.5
Ca	1.0	0.6
Co	1.0	0.6
Cu	1.0	0.5
Mg	1.0	0.6
Mn	1.0	0.6
Mo	1.0	1.0
Ni	1.0	NS
K	1.0	0.4
Se	1.0	NS
Si	1.0	0.4
Na	1.0	0.5
Sr	1.0	0.7
U	1.0	0.4
Zn	1.0	0.6

Note: Scaling factors applied to source term which are 20% greater than max observed in recent column test work highlighted blue, while scaling factors which are 20% below the min observed in recent column test work are highlighted red. "NS" means difference is Not Significant because both medians are less than 5 x's the reporting limit.

5. Static Testing of Kinetic Test Material

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5. Static Testing of Kinetic Test Material

The static testing results from pre- and post-kinetic testing for tests that have been terminated since the 2013 reports (Lorax 2013b,c) are provided in Appendix D.

The paste pH in the lower layers of saturated columns 12 and 14 (acidic SUP) increased from 4.0 to 4.3 and from 4.0 to 5.1, respectively. The neutral upper layers of those columns (HYP) decreased by no more than 0.6 pH units from the original paste pH of 8.2. The paste pH in Sat Col 15 (neutral SUP) remained essentially the same, with a pre-test value of 7.7 and a post-test value of 7.8. The paste pH in the neutral humidity cells dropped in all cells by ~1 pH unit (*e.g.*, from a paste pH of 8.4 to 7.7).

Total inorganic carbon concentrations generally remain the same or are slightly lower post-test in both the saturated and unsaturated tests. Likewise, post-test non-sulphate sulphide is slightly lower or remains the same (within error) as pre-kinetic test values in the saturated and unsaturated tests. The NPR values for Sat Col 6 drop slightly post-kinetic testing, but remain above an NPR value of 2.0. The NPR for all remaining tests remained essentially the same.

Metals concentrations generally are similar pre and post kinetic testing, within the natural heterogeneity that may be expected for this material.

6. Summary

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6. Summary

Kinetic test data that have been acquired since the previous reporting cut-off date, March 2013, (Lorax, 2013b,c) has been compiled in this report and the kinetic test leaching trends have been evaluated to determine if recalculating the source terms is required. The most relevant findings are summarized here.

Final Stabilized Metal Leaching Rates

- 95th percentile concentrations in saturated column tests were used to estimate the source term for the saturated impoundment. Concentrations produced by column experiments have generally decreased with time. As such, re-calculating 95th percentile values with the updated data results in lower concentrations.
- Geochemical loading rates measured in neutral and acidic pH waste rock humidity cells were used to predict pit wall and unsaturated waste rock source terms. The latest available data (Cycles 49-65) were applied at the time of source term development. Since this time, geochemical loading rates have decreased by on average 20% between Cycles 69-79.
- Geochemical loading rates measured in tailings humidity cells and unsaturated columns were used to estimate loading rates for the tailings embankment and beach. Closure source terms were predicted using HYP tailings kinetic tests Col6 and T7. At the time of source term development the kinetic tests had not been running for very long, and the last two cycles available for Col6 and T7 were applied to the source term (cycles 28-30 and cycles 15-17, respectively). Now, an additional 50 cycles of data is available. A comparison of loading rates used in source term development with recent loading rates shows that the geochemical loading rates have generally decreased by an average of 14% and 29% in Col 6 and T7, respectively. Specifically, sulphate loading rates have decreased 40% and 75% in these kinetic tests. However, there are several notable elements which have shown increased loading rates in recent data compared to that which was used in source term development. The most significant of these increases are Cu in Col 6, which increased by 51% and Mo in T7 which increased by 107%.

Temperature Effects

Kinetic oxidation rates are temperature sensitive so temperature effects must be considered when relating laboratory loading rates to field conditions. At the time of source term development, data was available from one kinetic test (T1) which had been moved from a

room temperature environment to a 4°C environment after rates had stabilized. The temperature effects on metal leaching rates observed in this humidity cell, along with supporting data from literature sources, was used to scale acid generation and metal leaching rates. Since the time of initial source term calculations, a number of other kinetic tests were moved from room temperature to 4°C environment to provide further information regarding temperature affects. The assumptions applied to source term development (which this additional test work was initiated to support) include:

- Under neutral conditions, mineral solubility will effect metal loading metal loading rates. Neutral SUP and HYP loading rates are scaled based on observed variation from stabilized rates at laboratory and site temperatures.
- Under acidic conditions, the influence of oxide mineral solubility and metal adsorption will be less significant than under neutral pH. Acidic SUP and HYP loading rates are scaled based on a site-specific Arrhenius relationship.
- Metal leaching from CAP material is driven by oxide dissolution which is expected to not be as sensitive to temperature affects as sulphide oxidation. Therefore, oxide CAP leaching rates were not adjusted to account for temperature affects.

The updated kinetic test data generally shows that these assumptions are of sound basis. That is, acidic metal leaching rates are more sensitive to temperature then that of neutral metal leaching rates and oxide CAP is generally not as sensitive to temperature affects as sulphidic SUP or HYP rock types.

7. Closure

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7. Closure

This report was prepared and reviewed by the undersigned.

Sincerely,

LORAX ENVIRONMENTAL SERVICES LTD.

Original signed by:

Diana Loomer, M.Sc.
Senior Hydrogeochemist

Original signed by:

John Dockrey, M.Sc.
Environmental Geochemist

Reviewed by:

Original signed by:

Bruce Mattson, M.Sc., P.Geo.
Principal

References

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Lorax Environmental Services Ltd. (2008). Casino Phase I Geochemical Assessment Report. Prepared for Western Copper Corporation, November 2008.

Lorax Environmental Services Ltd. (2010). Casino Phase II Geochemical Assessment Report. Prepared for Western Copper Corporation, January 2010.

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Lorax Environmental Services Ltd. (2013b). Casino Geochemical Source Term Development; Prepared for Casino Mining Corporation, 4 December 2013.

Lorax Environmental Services Ltd. (2013c). Casino Kinetic Testwork Update for Ore, Waste Rock and Tailings; Prepared for Casino Mining Corporation, 11 December 2013.

Lowson, R.T. (1982). Aqueous oxidation of pyrite by molecular oxygen, Chem. Rev. 82, 461-497.

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Appendices

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Appendix A: Leachate Chemistry Time-Series Plots

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Appendix A: Leachate Chemistry Time-Series Plots

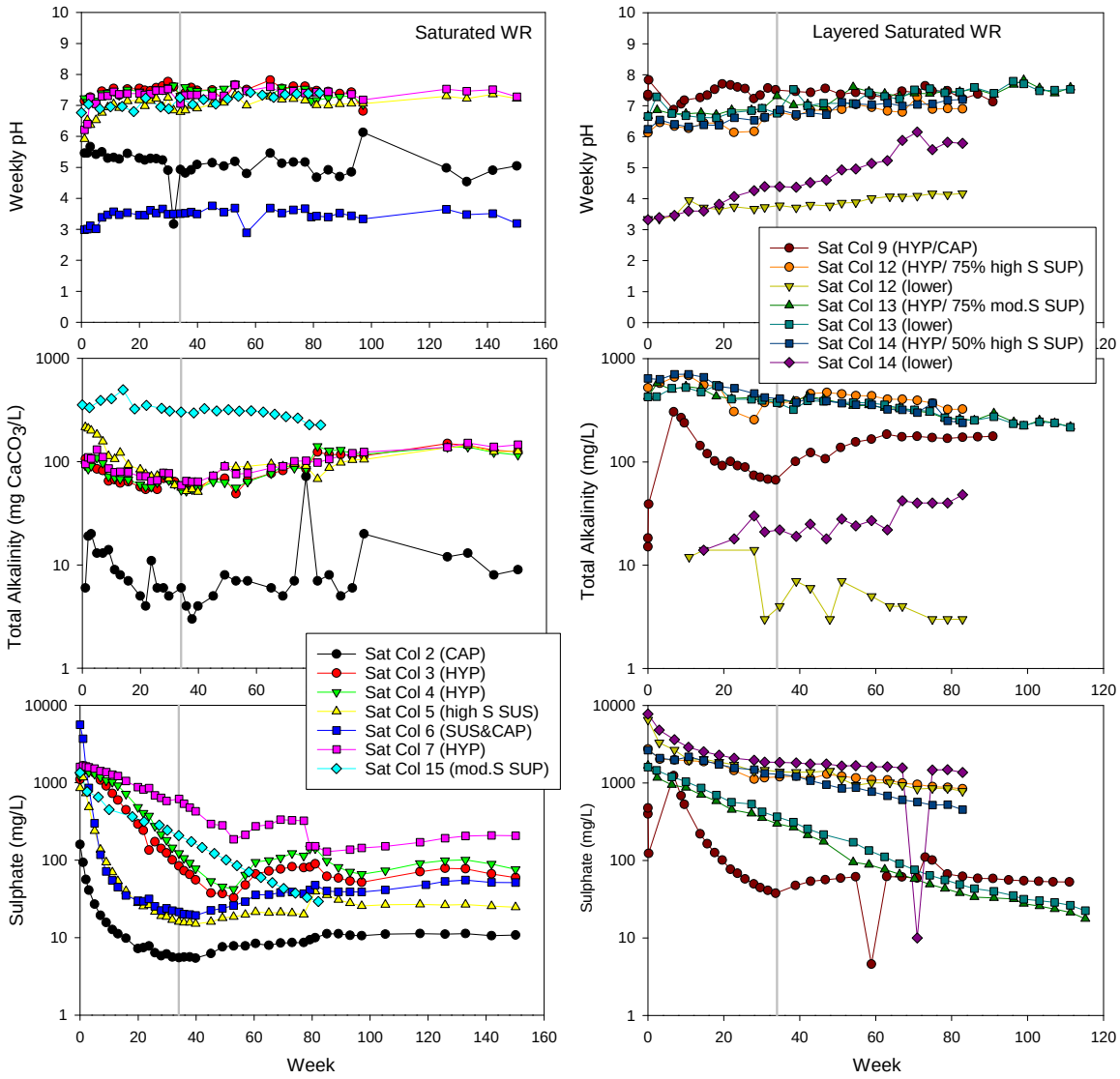

Figure A-1: Saturated waste rock column effluent pH and total alkalinity and sulphate concentrations. Note that only partial results were reported for Sat Col 12, 13, 14 and 15 in the previous kinetic test report. The grey line indicates the last cycle used in the source term development for these columns. There is no new data for Sat Cols 2-7 and Sat Col 9, but previous results are provided here for comparison.

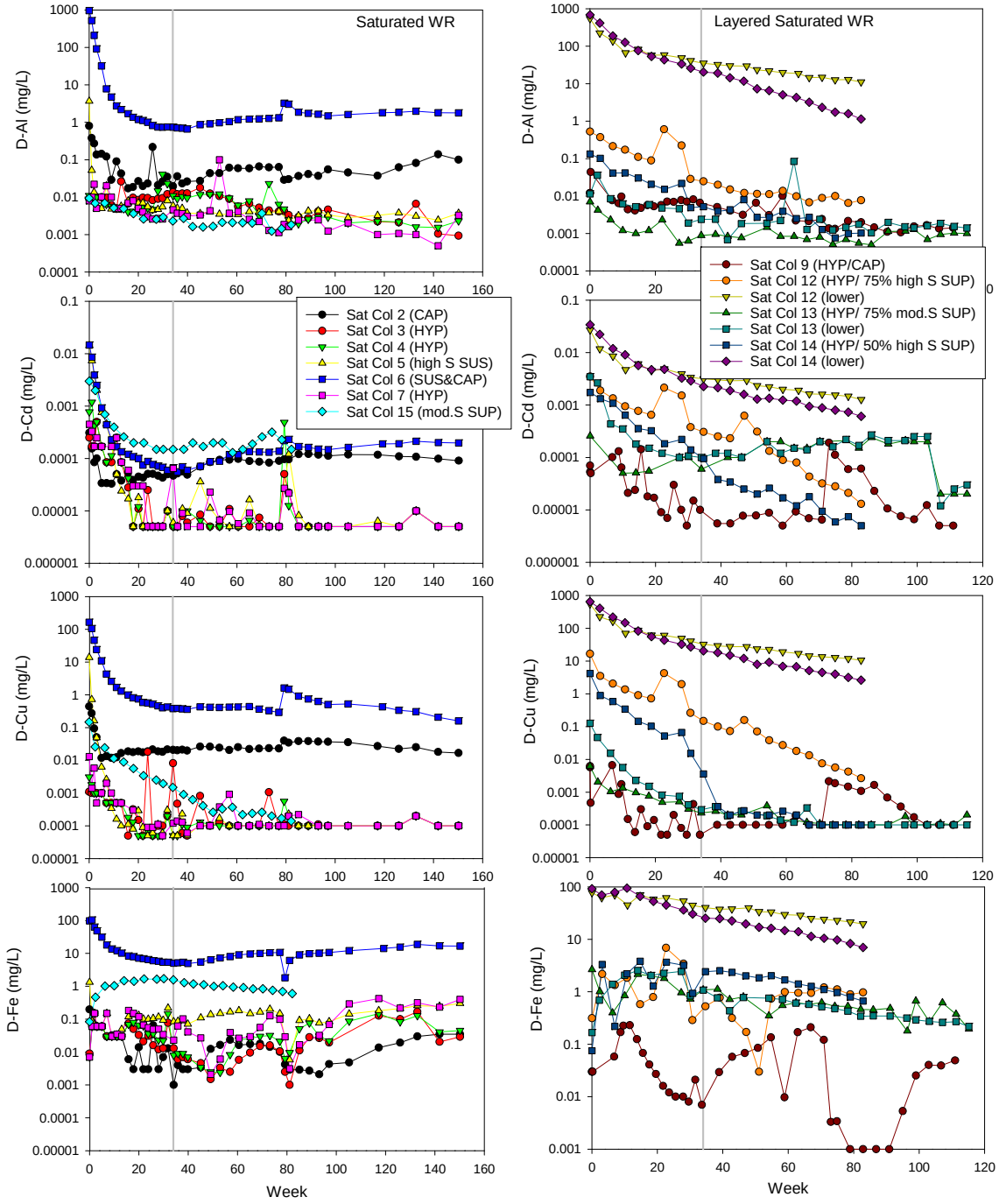

Figure A-2: Saturated waste rock column effluent concentrations for dissolved metals that may be of concern. Note that only partial results were reported for Sat Col 12, 13, 14 and 15 in the previous kinetic test report. The grey line indicates the last cycle used in the source term development for these columns. There is no new data for Sat Cols 2-7 and Sat Col 9, but previous results are provided here for comparison.

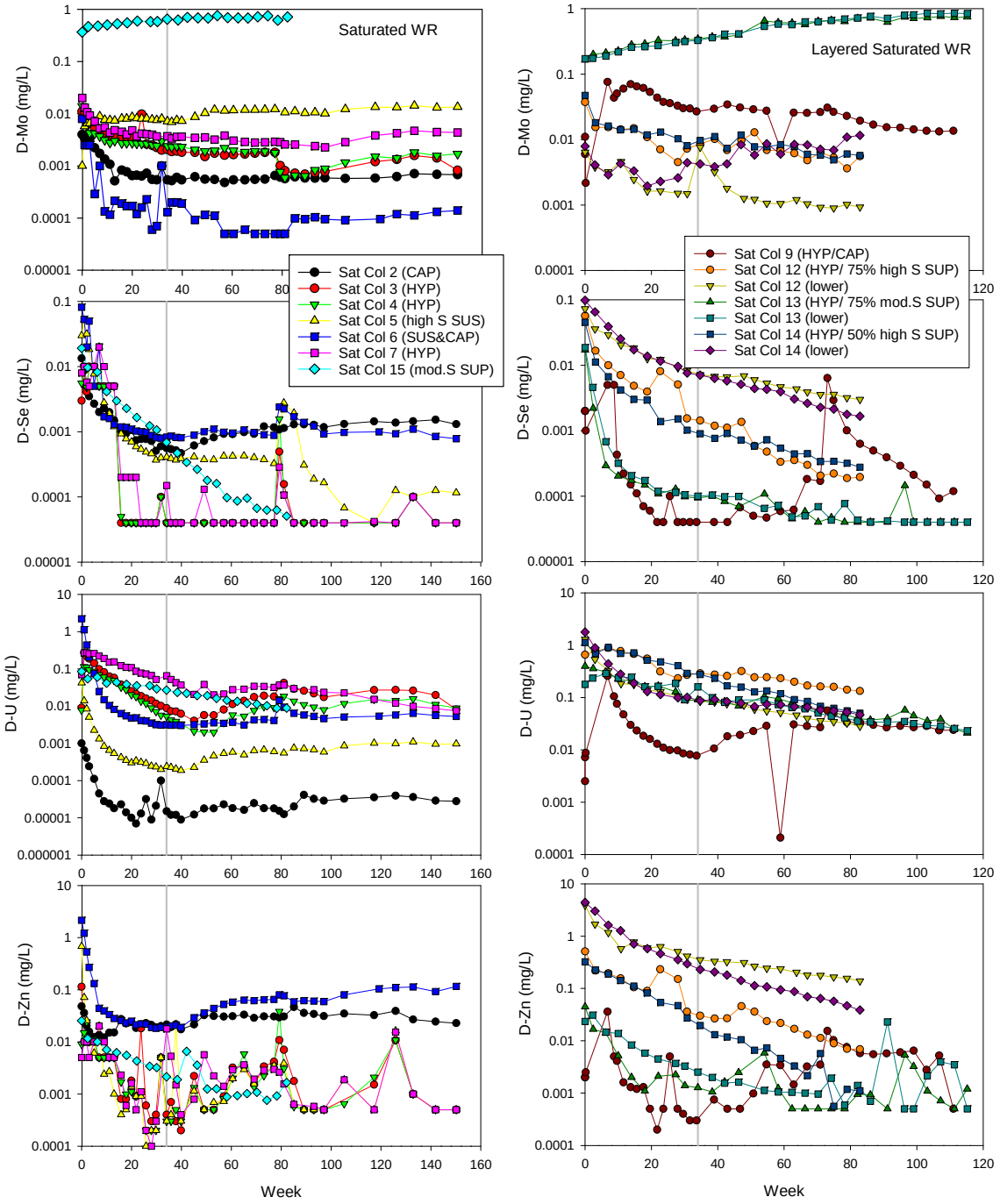

Figure A-2 cont.: Saturated waste rock column effluent concentrations for dissolved metals that may be of concern. Note that only partial results were reported for Sat Col 12, 13, 14 and 15 in the previous kinetic test report. The grey line indicates the last cycle used in the source term development for these columns. There is no new data for Sat Cols 2-7 and Sat Col 9, but previous results are provided here for comparison.

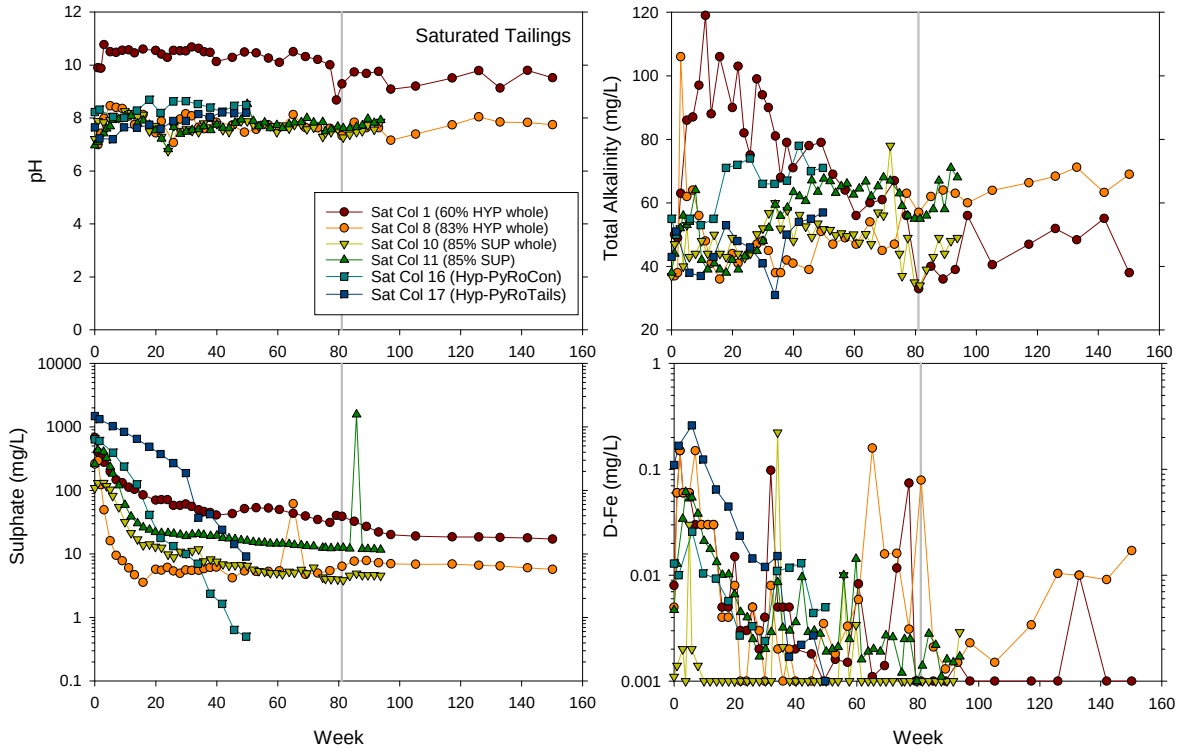

Figure A-3: Saturated tailings column effluent pH and total alkalinity, sulphate concentrations and dissolved iron. Note that only partial results were reported for Sat Col 10 and 11 in the previous kinetic test report. The grey line indicates the last cycle used in the source term development for Sat Col 10 & Sat Col 11. There is no new data for Sat Col 1 and Sat Col 8, but previous results are provided here for comparison. Note that data from Col 16 and 17 was not presented in the previous kinetic test report.

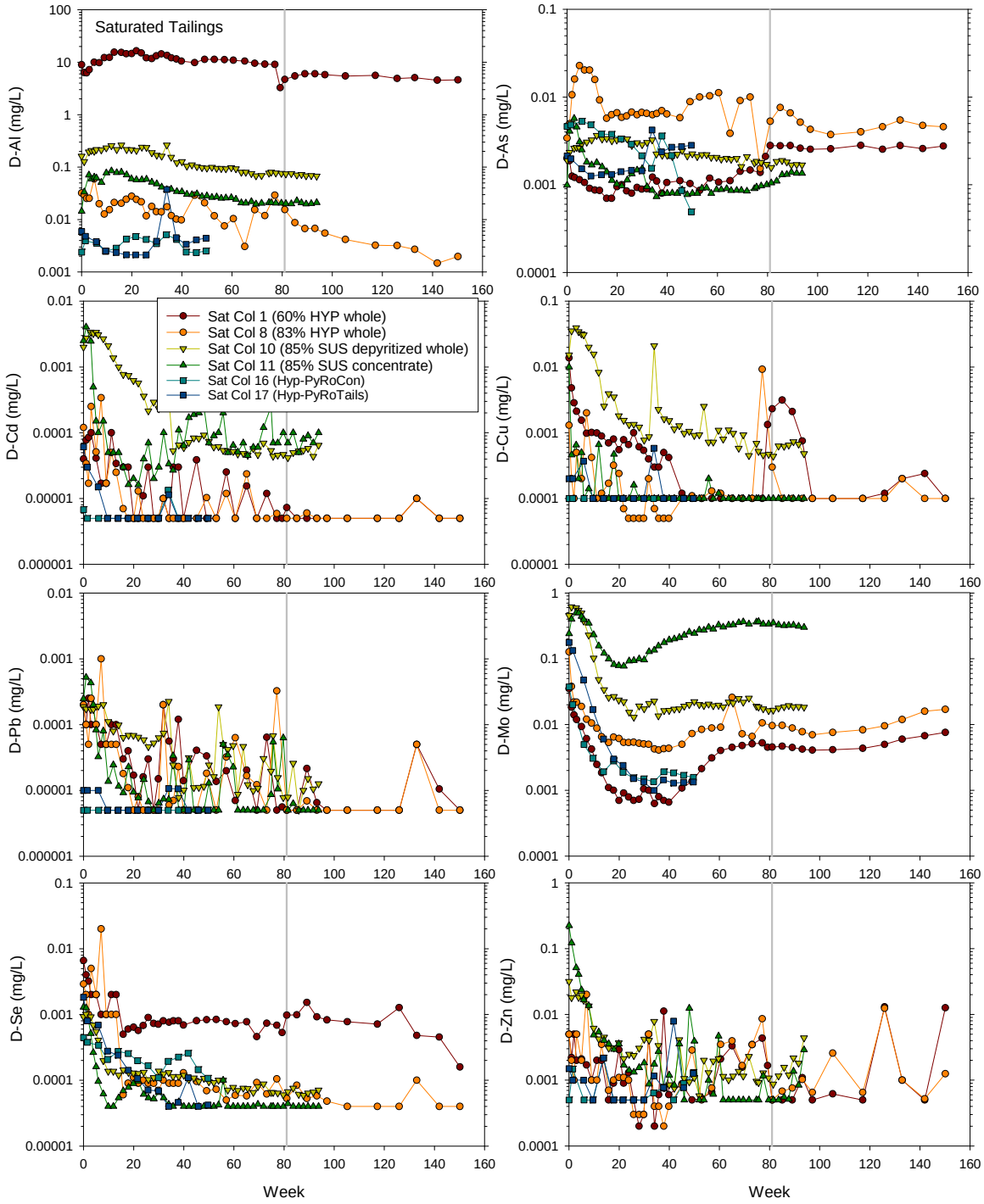

Figure A-4: Saturated tailings column effluent concentrations for dissolved metals that may be of concern Note that only partial results were reported for Sat Col 10 and 11 in the previous kinetic test report. The grey line indicates the last cycle used in the source term development for Sat Col 10 & Sat Col 11. There is no new data for Sat Col 1 and Sat Col 8, but previous results are provided here for comparison. Note that data from Col 16 and 17 was not presented in the previous kinetic test report.

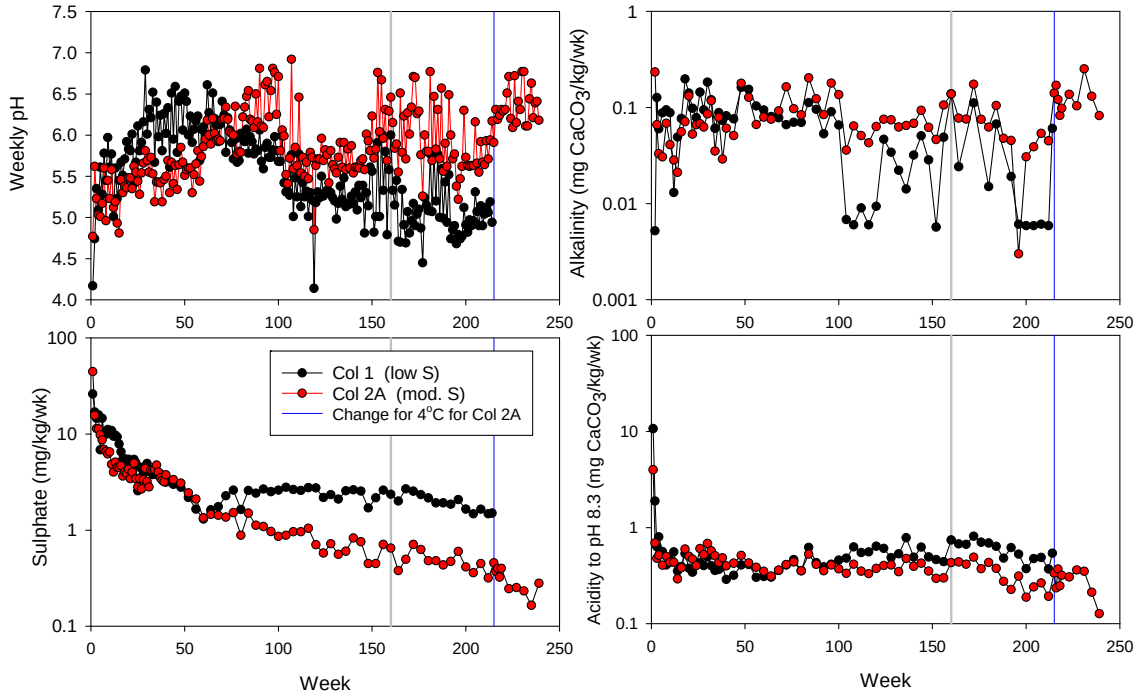

Figure A-5: Weekly pH and loading rates for total alkalinity, acidity and sulphate from unsaturated CAP waste rock columns. The grey line indicates the last cycle used in the source term development.

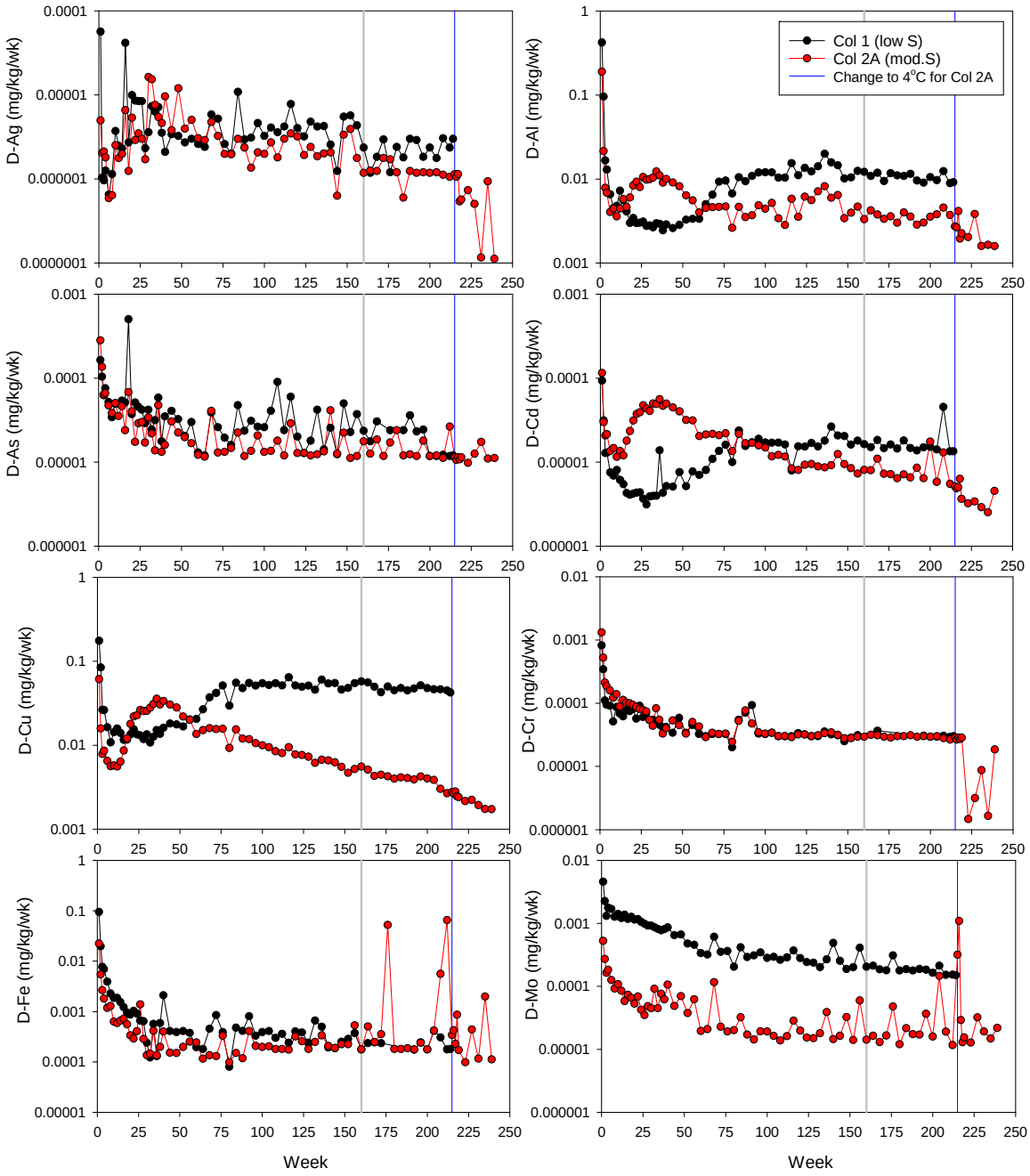

Figure A-6: Loading rates for dissolved metals that may be of concern from unsaturated CAP waste rock column tests. The grey line indicates the last cycle used in the source term development.

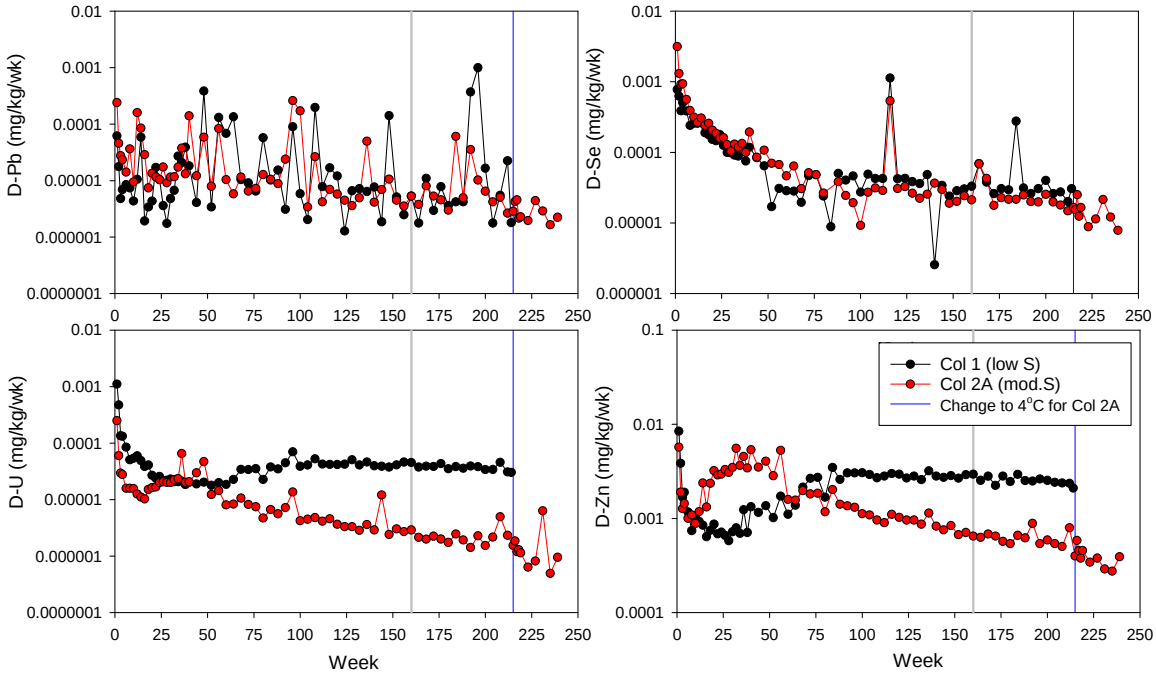

Figure A-6 cont.: Loading rates for dissolved metals that may be of concern from unsaturated CAP waste rock column tests. The grey line indicates the last cycle used in the source term development.

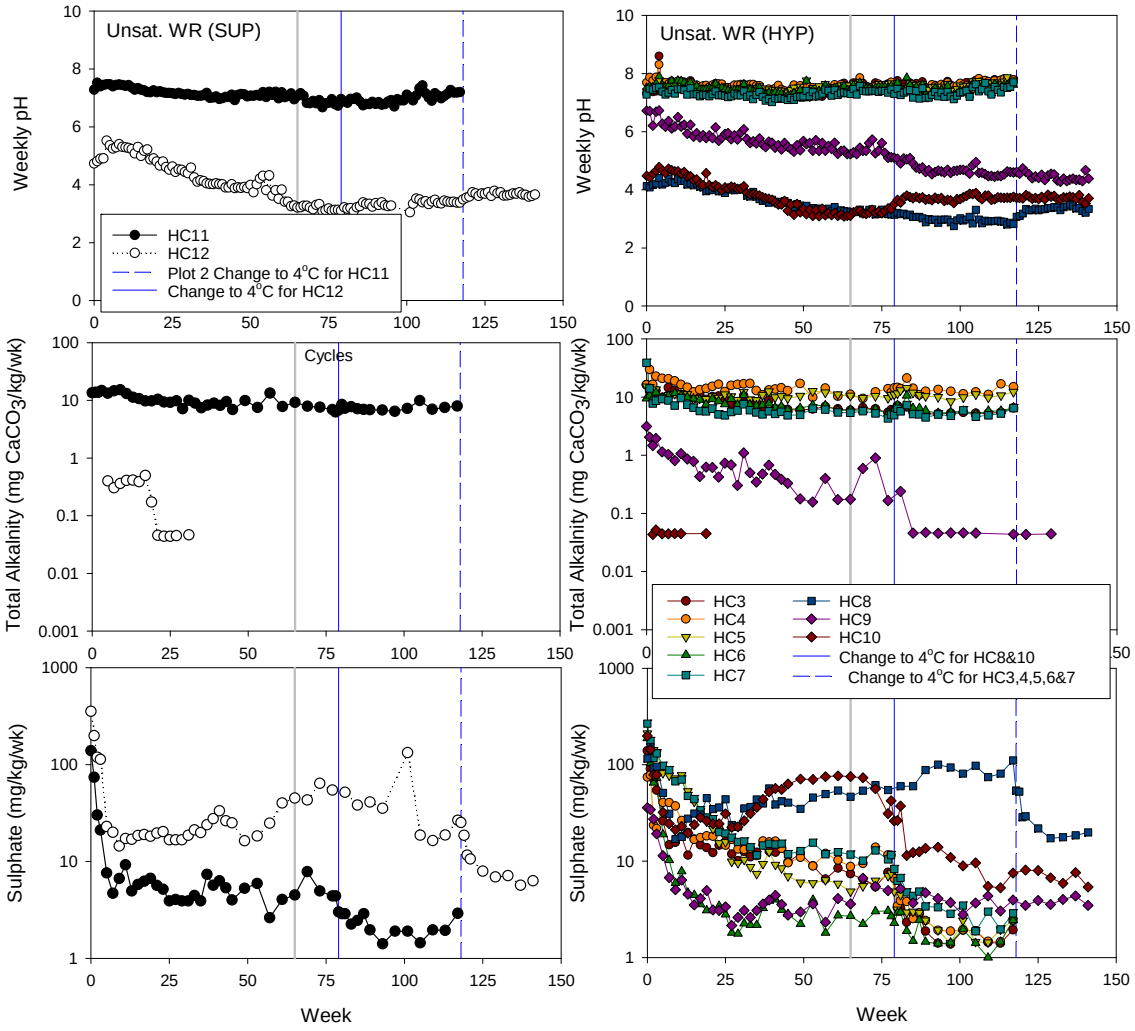

Figure A-7: Weekly pH and loading rates for total alkalinity and sulphate from unsaturated SUP and HYP waste rock humidity cells. The grey line indicates the last cycle used in the source term development.

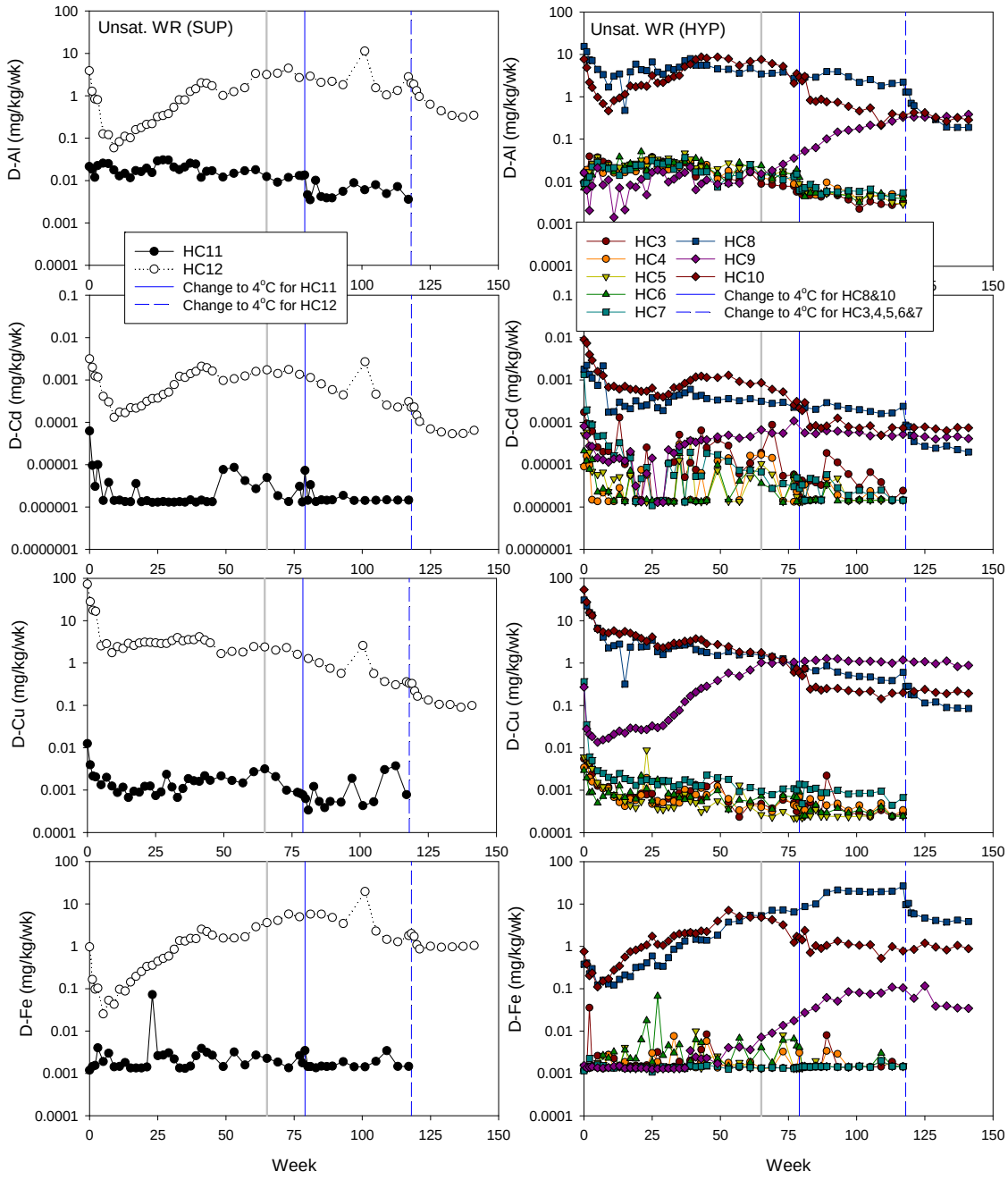

Figure A-8: Loading rates for dissolved metals that may be of concern from unsaturated SUP and HYP waste rock humidity cells. The grey line indicates the last cycle used in the source term development.

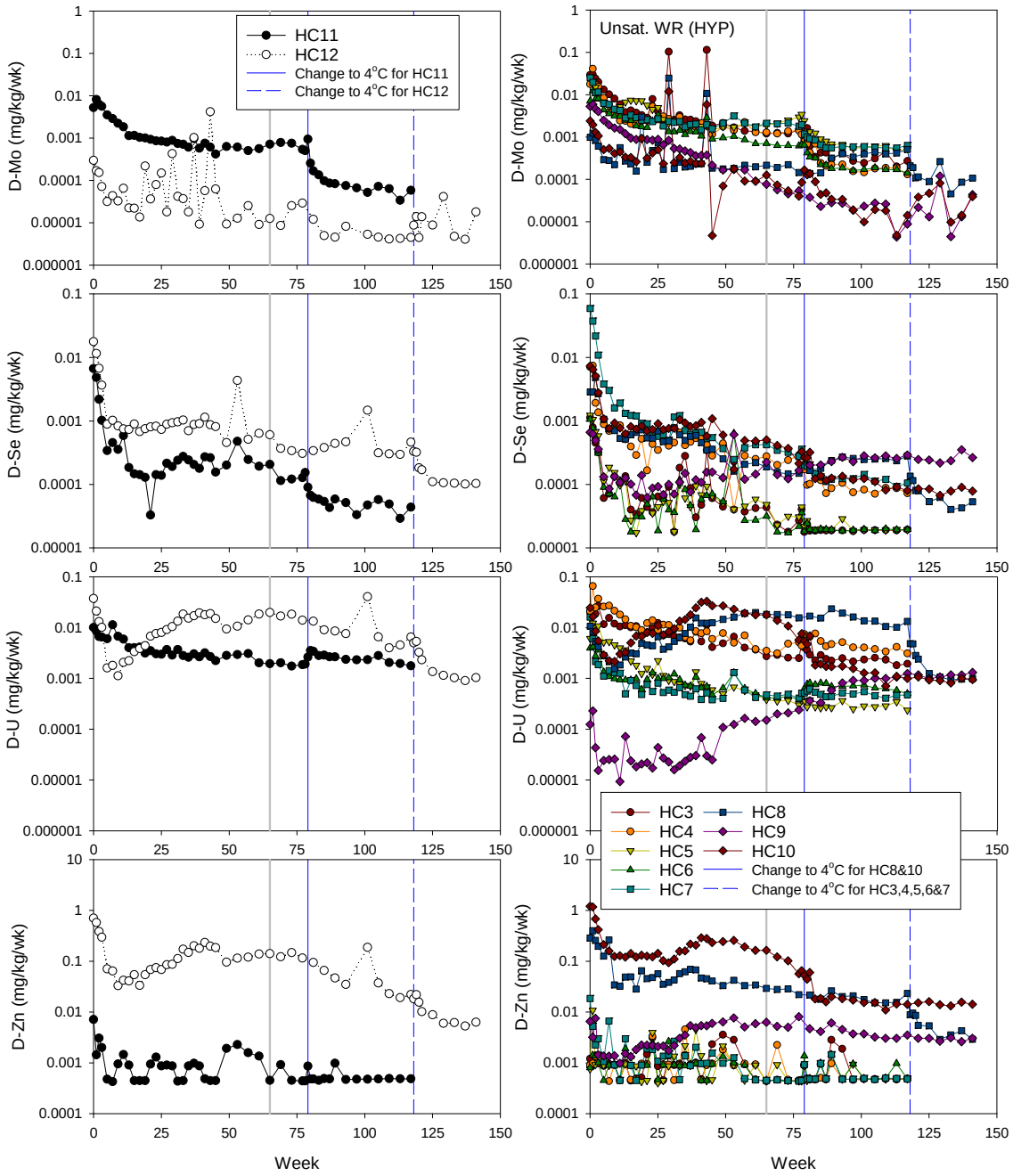

Figure A-8 (cont.): Loading rates for dissolved metals that may be of concern from unsaturated SUP and HYP waste rock humidity cells. The grey line indicates the last cycle used in the source term development.

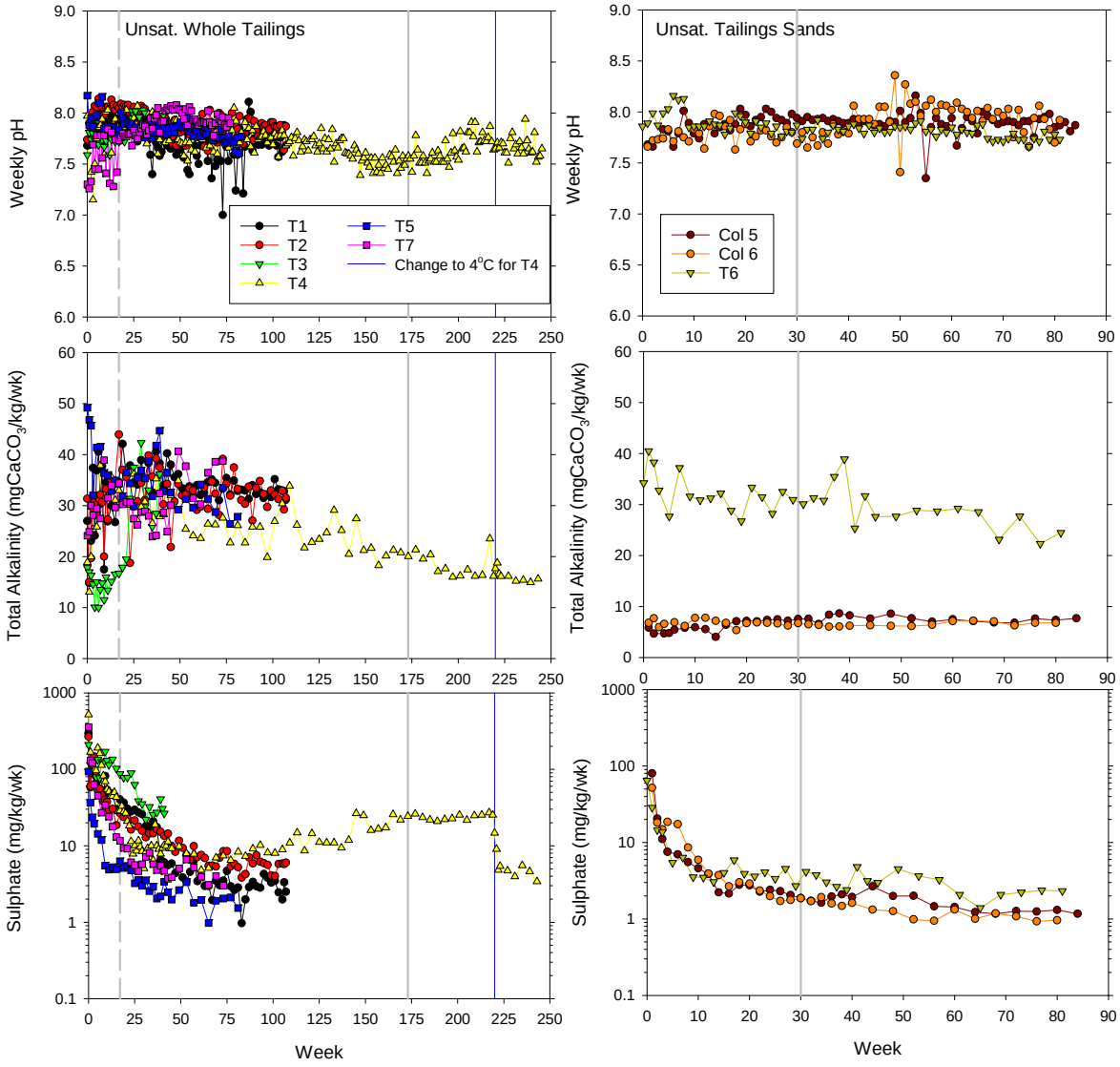

Figure A-9: pH, total alkalinity (as $CaCO_3$) and sulphate in leachate from whole tailings and tailings sands kinetic tests. The grey lines indicate the last cycle used in the 2013 source term development (solid grey: T4 and Col 6) and (dashed grey: T7). There is no new data for T1, T2, T3, T5 and T6 and for Col 5, but previous results are provided here for comparison. Note, the 90th percentiles of all available cycles were used for T5 and Col 5 source term development.

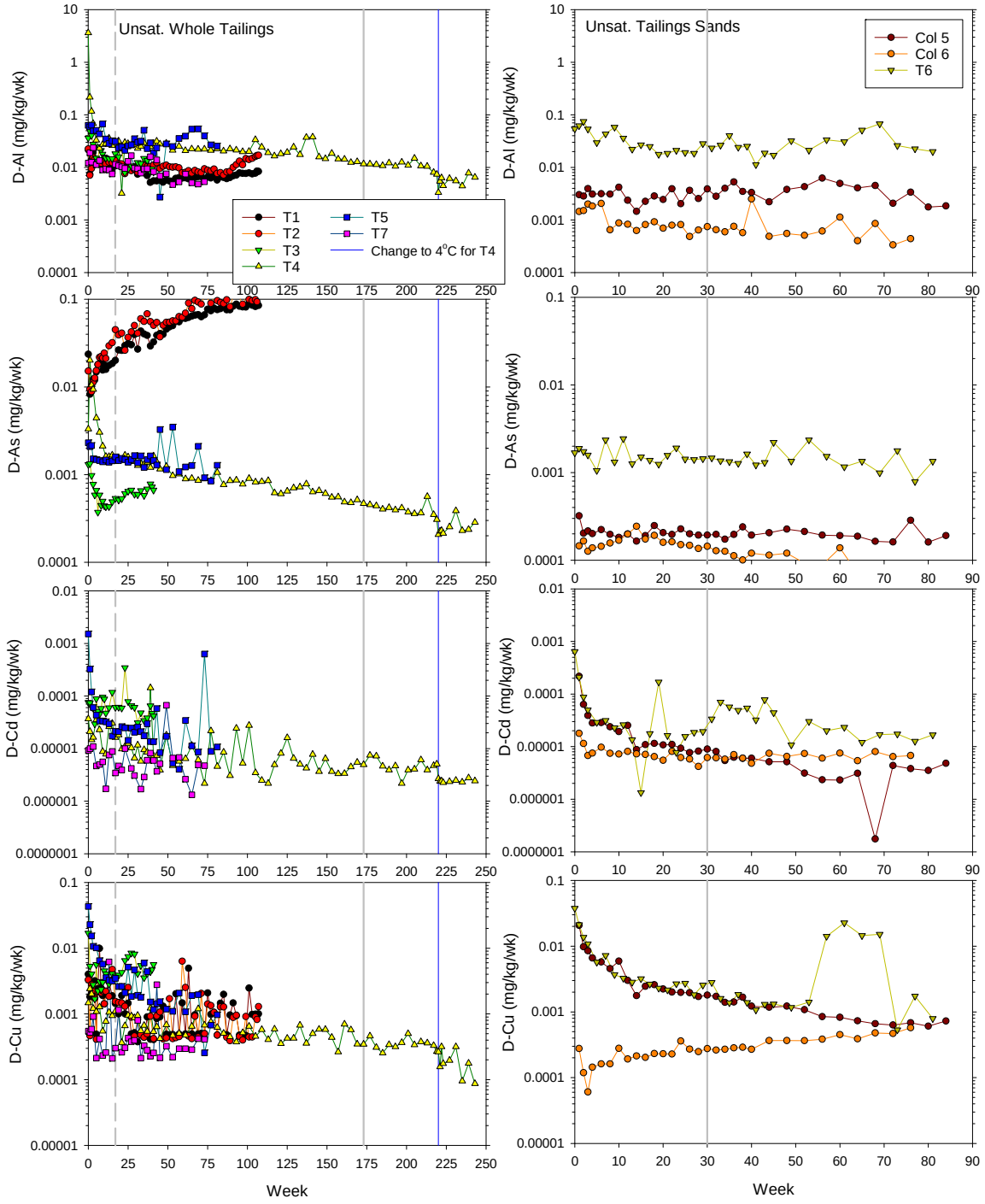

Figure A-10: Loading rates for dissolved metals that may be of concern from unsaturated whole tailings and tailings sands kinetic tests. The grey lines indicate the last cycle used in the 2013 source term development (solid grey: T4 and Col 6) and (dashed grey: T7). There is no new data for T1, T2, T3, T5 and T6 and for Col 5, but previous results are provided here for comparison. Note the 90th percentiles of all available cycles were used for T5 and Col 5 source term development.

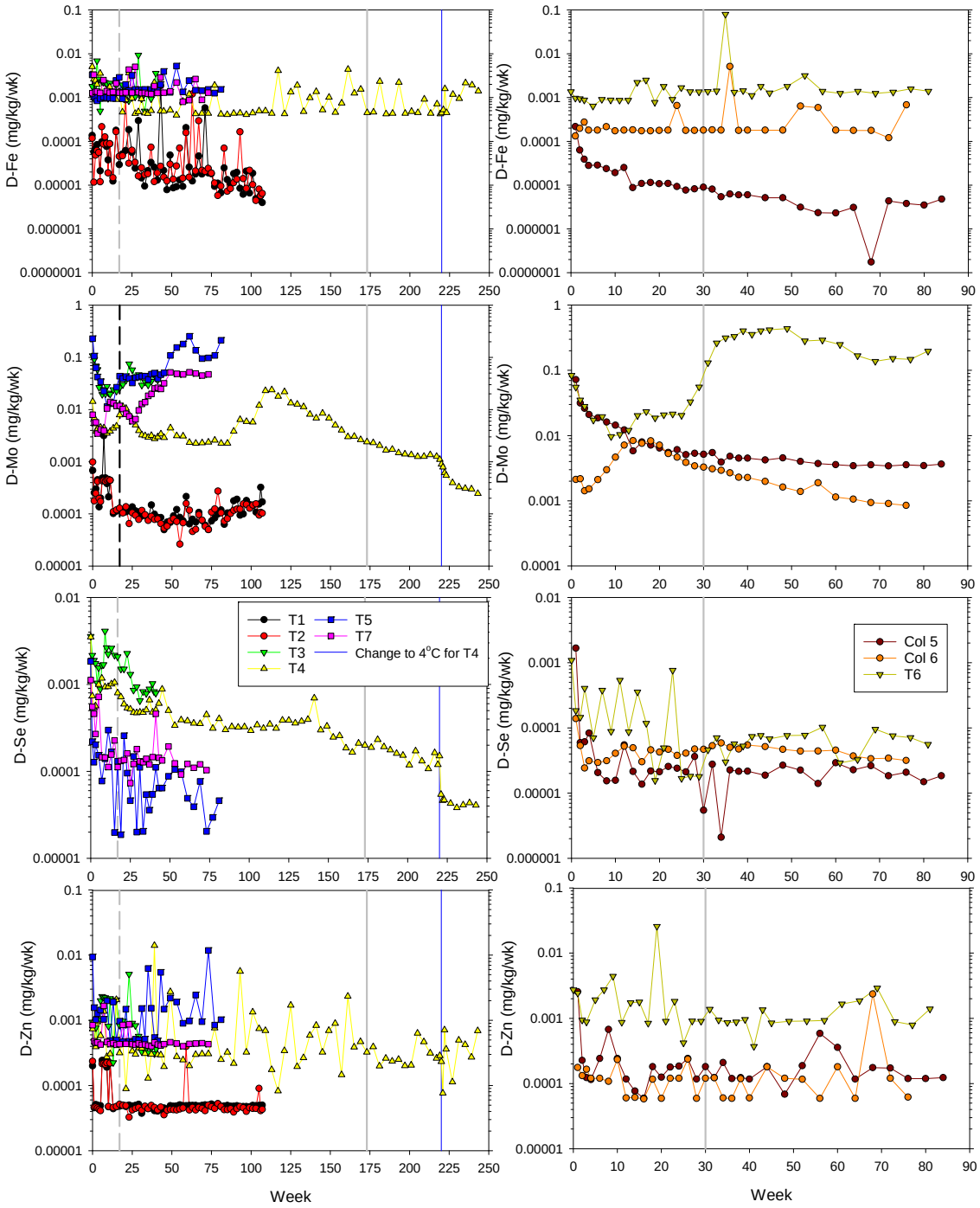

Figure A-10 (cont.): Loading rates for dissolved metals that may be of concern from unsaturated whole tailings and tailings sands kinetic tests. The grey lines indicate the last cycle used in the 2013 source term development (solid grey: T4 and Col 6) and (dashed grey: T7). There is no new data for T1, T2, T3, T5 and T6 and for Col 5, but previous results are provided here for comparison. Note the 90th percentiles of all available cycles were used for T5 and Col 5 source term development.

Appendix B: Kinetic Test Comparison Tables

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Appendix B: Kinetic Test Comparison Tables

Table B-1:
SGS Target Reporting Limit for Laboratory Kinetic Testing

Parameter	Units	Reporting Limit	Parameter	Units	Reporting Limit
pH		0.01	Fe	mg/L	0.003
Cond.	umhos/cm	1	Pb	mg/L	0.00002
Acidity to pH 4.5	mg$CaCO_3$/L	0.5	Li	mg/L	0.001
Acidity to pH 8.3	mg$CaCO_3$/L	0.5	Mg	mg/L	0.001
Alkalinity	mg$CaCO_3$/L	0.5	Mn	mg/L	0.0002
Sulphate	mg/L	2	Hg	ug/L	0.01
Cl	mg/L	0.2	Mo	mg/L	0.00001
F	mg/L	0.3	Ni	mg/L	0.0001
Br	mg/L	0.06	P	mg/L	0.009
Total CN	mg/L	0.01	K	mg/L	0.006
WAD CN	mg/L	0.01	Se	mg/L	0.00004
Hardness	mg/L	0.05	Si	mg/L	0.01
Al	mg/L	0.0002	Ag	mg/L	0.00001
Sb	mg/L	0.0002	Na	mg/L	0.01
As	mg/L	0.0002	Sr	mg/L	0.0001
Ba	mg/L	0.00001	S	mg/L	0.03
Be	mg/L	0.00002	Tl	mg/L	0.00002
Bi	mg/L	0.00001	Sn	mg/L	0.00001
B	mg/L	0.0002	Ti	mg/L	0.0001
Cd	mg/L	0.000003	U	mg/L	0.000001
Ca	mg/L	0.02	V	mg/L	0.00003
Cr	mg/L	0.0005	Zn	mg/L	0.001
Co	mg/L	0.000002	Zr	mg/L	0.00001
Cu	mg/L	0.0005			

Comparision of the 95th percentile concentration values used in the 2013 source term development and current 95% percentile concentrations

	pH	Cond-L	T-Alk	SO4	D-Cl	D-F	D-Br	NH3	NO2-N	NO3-N	DOC	D-Sulphide	D-Al	D-Sb	D-As	D-Ba	D-Be	D-Bi	D-B	D-Cd	D-Ca	D-Cr	D-Co
MMM	-		-	-	-	-	-	-	-	-	-	-	-	-	*5.0E-1*	-	-	-	-	-	-	-	-
MCS	-		-	-	-	-	-	-	-	-	-	-	-	-	***7.5E-1***	-	-	-	-	-	-	-	-
MGS	-		-	-	-	-	-	-	-	-	-	-	-	-	***1.0E+0***	-	-	-	-	-	-	-	-
Sat Col 10																							
Used in Source Term	7.27	3.8E+02	58	116	1.8E+01	2.8E-2	9.0E-1	9.2E-3	5.2E-3	1.0E-3	4.7E+0	1.0E-2	2.5E-1	1.6E-3	3.4E-3	1.9E-1	1.3E-5	3.1E-5	4.6E-2	3.2E-3	5.0E+1	5.0E-5	1.3E-3
Current	8.14	3.9E+02	56	113	1.5E+01	2.8E-2	7.5E-1	7.3E-3	1.0E-3	5.1E-3	4.6E+0	1.0E-2	2.5E-1	1.6E-3	3.3E-3	1.9E-1	1.2E-5	2.2E-5	4.6E-2	3.2E-3	4.9E+1	1.0E-4	1.2E-3
Relative difference	8%	1%	-2%	-1%	-10%	0%	-13%	-16%	NS	NS	-1%	NS	-1%	0%	0%	0%	NS	NS	0%	-1%	-1%	NS	-2%
Sat Col 11																							
Used in Source Term	7.12	9.1E+02	67	313	6.5E+01	1.9E-1	5.0E-1	1.9E-2	5.0E-2	1.0E-2	5.0E+0	1.0E-2	7.8E-2	4.1E-3	3.9E-3	1.4E-1	1.0E-5	5.0E-6	8.4E-2	2.2E-3	1.4E+2	5.0E-5	2.5E-3
Current	8.07	9.5E+02	68	369	6.3E+01	2.0E-1	5.0E-1	1.8E-2	1.0E-2	7.7E-2	4.9E+0	1.0E-2	7.8E-2	4.1E-3	3.6E-3	1.5E-1	1.0E-5	5.0E-6	8.2E-2	2.5E-3	1.3E+2	1.0E-4	2.5E-3
Relative difference	9%	3%	1%	12%	-2%	4%	NS	-2%	NS	NS	-2%	NS	0%	-1%	-6%	7%	NS	NS	-2%	9%	-3%	NS	-2%
Sat Col 12 upper port																							
Used in Source Term	6.13	4.2E+03	675	2421	3.6E+01	3.1E+0	1.0E+0	1.6E+0	1.2E-1	2.1E-2	5.9E+1	1.0E-2	5.7E-1	5.1E-3	7.1E-3	2.4E-2	1.3E-3	6.4E-5	5.4E-2	2.9E-3	7.9E+2	5.0E-4	2.9E-1
Current	7.04	3.7E+03	659	2028	2.6E+01	3.0E+0	1.0E+0	1.5E+0	2.1E-2	1.0E-1	3.0E+1	1.0E-2	5.2E-1	4.7E-3	6.2E-3	2.1E-2	1.3E-3	5.4E-5	5.1E-2	2.1E-3	7.2E+2	5.0E-4	2.2E-1
Relative difference	10%	-8%	-2%	-12%	-23%	-2%	NS	-3%	NS	NS	-45%	NS	-7%	-6%	-10%	-8%	-1%	NS	-4%	-21%	-6%	NS	-18%
Sat Col 12 lower port																							
Used in Source Term	3.34	5.3E+03	0	5081	2.9E+1	3.2E+1	1.8E+0	6.3E+0	4.1E-1	4.6E-2	5.2E+1	1.0E-2	4.0E+2	6.6E-3	1.7E-2	1.1E-2	3.6E-2	9.0E-4	4.6E-1	2.0E-2	4.2E+2	5.0E-2	1.8E+0
Current	4.16	3.9E+03	14	3278	1.7E+1	1.8E+1	2.4E+0	4.2E+0	5.0E-2	1.7E-1	3.5E+1	1.0E-2	2.2E+2	5.4E-3	1.6E-2	1.2E-2	2.2E-2	1.0E-4	4.0E-1	1.2E-2	4.2E+2	2.4E-2	1.0E+0
Relative difference	15%	-22%	141%	-31%	NS	-41%	NS	-29%	NS	NS	-28%	NS	-41%	-14%	-5%	3%	-34%	NS	-10%	-38%	0%	-49%	-37%
Sat Col 13 upper port																							
Used in Source Term	6.69	3.1E+03	559	1445	6.3E+1	1.7E+0	1.0E+0	9.9E-1	1.0E-1	2.0E-2	5.5E+1	1.0E-2	5.7E-3	3.4E-3	1.3E-2	2.9E-2	7.6E-5	6.9E-5	9.7E-2	1.9E-4	4.7E+2	2.0E-4	1.5E-2
Current	7.65	2.6E+03	530	1080	4.4E+1	2.6E+0	1.0E+0	9.5E-1	2.0E-2	1.0E-1	3.6E+1	1.0E-2	3.4E-3	8.9E-4	1.2E-2	1.5E-1	6.7E-5	1.0E-5	9.0E-2	2.5E-4	3.7E+2	2.0E-4	9.5E-3
Relative difference	10%	-13%	-4%	-20%	-25%	30%	NS	-4%	NS	NS	-28%	0%	-35%	-83%	-9%	95%	-9%	NS	-5%	NS	-18%	NS	-31%
Sat Col 13 lower port																							
Used in Source Term	6.61	3.2E+03	539	1537	6.4E+1	1.7E+0	1.0E+0	1.7E+0	1.0E-1	3.2E-2	5.4E+1	1.0E-2	2.5E-2	1.3E-3	5.5E-3	2.5E-2	3.2E-4	1.8E-4	1.8E-1	3.1E-3	4.2E+2	1.5E-3	2.9E-2
Current	7.67	2.9E+03	522	1356	4.9E+1	2.7E+0	1.0E+0	1.6E+0	3.0E-2	1.0E-1	4.5E+1	1.0E-2	2.6E-2	8.1E-4	5.2E-3	8.6E-2	8.3E-5	6.9E-5	9.9E-2	1.8E-3	4.1E+2	5.0E-4	2.3E-2
Relative difference	10%	-5%	-2%	-9%	-19%	33%	NS	-1%	-77%	NS	-13%	NS	3%	-35%	-3%	78%	-83%	NS	-42%	NS	-1%	NS	-17%
Sat Col 14 upper port																							
Used in Source Term	6.28	4.3E+03	705	2434	4.4E+1	2.1E+0	1.0E+0	1.2E+0	1.0E-1	3.2E-2	6.8E+1	1.0E-2	1.2E-1	5.3E-3	1.2E-2	2.5E-2	6.7E-4	1.1E-4	5.1E-2	1.6E-3	8.1E+2	7.3E-4	1.8E-1
Current	7.18	3.8E+03	702	2166	3.7E+1	2.1E+0	1.0E+0	1.2E+0	2.2E-2	1.0E-1	3.2E+1	1.0E-2	9.8E-2	2.7E-3	1.1E-2	2.4E-2	6.5E-4	9.3E-5	4.7E-2	1.3E-3	7.1E+2	5.0E-4	1.7E-1
Relative difference	9%	-8%	0%	-8%	-13%	1%	NS	0%	NS	NS	-50%	NS	-13%	-46%	-5%	-5%	NS	NS	-6%	-12%	-10%	NS	-4%
Sat Col 14 lower port																							
Used in Source Term	3.35	6.1E+03	0	6443	4.0E+1	4.3E+1	2.5E+0	6.9E+0	5.1E-1	5.0E-2	7.1E+1	1.0E-2	5.7E+2	7.8E-3	1.8E-2	1.1E-2	5.2E-2	1.0E-3	3.9E-1	2.9E-2	4.8E+2	7.1E-2	2.5E+0
Current	5.88	4.3E+03	42	4760	3.1E+1	2.9E+1	2.5E+0	5.3E+0	4.9E-2	3.5E-1	5.6E+1	1.0E-2	4.0E+2	5.9E-3	1.8E-2	9.3E-3	3.4E-2	2.9E-4	2.4E-1	2.2E-2	5.0E+2	4.9E-2	2.0E+0
Relative difference	39%	-24%	141%	-21%	-19%	-28%	NS	-19%	-117%	106%	-17%	NS	-23%	-19%	-2%	-12%	-31%	-78%	-33%	-20%	3%	-26%	-15%
Sat Col 15																							
Used in Source Term	6.78	2.5E+03	457	1087	5.7E+1	2.2E+0	1.0E+0	1.6E+0	1.0E-1	2.0E-2	4.7E+1	1.0E-2	8.3E-3	6.0E-4	4.9E-3	3.2E-2	5.8E-5	1.0E-5	1.2E-1	1.3E-3	3.1E+2	2.3E-4	1.8E-2
Current	7.40	2.0E+03	406	759	3.6E+1	2.3E+0	1.0E+0	1.5E+0	2.0E-2	1.0E-1	3.0E+1	1.0E-2	6.9E-3	5.8E-4	4.8E-3	8.3E-2	4.9E-5	5.2E-6	1.1E-1	1.9E-3	2.4E+2	1.6E-4	8.7E-3
Relative difference	6%	-18%	-8%	-25%	-31%	4%	NS	-4%	-94%	94%	-31%	NS	-13%	-3%	0%	63%	-13%	NS	-9%	NS	-19%	-26%	-49%
Sat Col 16																							
Used in Source Term	8.01	1.3E+03	55	633	2.1E+1	6.6E-1	5.0E-1	1.4E-1	5.0E-2	3.4E-2	1.2E+2	6.7E-1	3.9E-3	9.3E-4	5.2E-3	2.6E-2	1.0E-5	5.0E-6	2.3E-2	6.5E-6	2.3E+2	5.0E-5	7.8E-6
Current	8.66	1.3E+03	75	615	2.0E+1	1.1E+0	5.0E-1	1.2E-1	3.3E-2	5.0E-2	1.1E+2	6.1E-1	4.9E-3	6.6E-4	5.0E-3	4.6E-1	1.0E-5	5.0E-6	2.5E-2	9.1E-6	2.2E+2	1.0E-4	6.9E-6
Relative difference	5%	-1%	22%	-2%	-2%	36%	NS	-9%	-28%	27%	-5%	-7%	17%	-24%	-3%	126%	NS	NS	6%	23%	-4%	NS	-9%
Sat Col 17																							
Used in Source Term	7.20	2.4E+03	50	1456	3.8E+1	9.2E-1	1.0E+0	8.9E-1	1.0E-1	2.0E-2	4.4E+1	8.3E-2	5.7E-3	1.9E-3	2.1E-3	2.1E-2	2.0E-5	5.4E-5	2.8E-2	5.6E-5	5.3E+2	5.0E-5	2.6E-5
Current	8.20	2.3E+03	56	1376	3.6E+1	1.5E+0	1.0E+0	8.6E-1	2.0E-2	1.0E-1	4.1E+1	6.1E-2	1.7E-2	1.8E-3	3.3E-3	2.2E-1	2.0E-5	2.8E-5	2.8E-2	4.1E-5	4.8E+2	2.0E-4	2.4E-5
Relative difference	9%	-4%	8%	-4%	-3%	36%	NS	-2%	-94%	94%	-4%	-21%	70%	-2%	31%	116%	NS	-45%	0%	-23%	-7%	NS	-6%

Notes: Units in mg/L; Allalinity as mg $CaCO_3$/L; Blue text indicates analytes that were below detection; NS means "Not Significant"; highlighted texts indicates concentrations that have increased since the source term was developed.
Values which exceed CCME aquatic life guidelines shaded in blue, values exceeding Metal Mining Effluent Regulations: MMM guidelines in italic, values exceeding MCS are in bold text, values exceeding MGS are highlighted in yellow.

Comparision of the 95th percentile concentration values used in the 2013 source term development and current 95% percentile concentrations

	pH	D-Cu	D-Fe	D-Pb	D-Li	D-Mg	D-Mn	D-Hg	D-Mo	D-Ni	D-P	D-K	D-Se	D-Si	D-Ag	D-Na	D-Sr	D-Tl	D-Sn	D-Ti	D-U	D-V	D-Zn	D-Zr
MMM	-	*3.0E-1*		*2.0E-1*		-	-	-	-	*5.0E-1*			-	-	-	-	-	-	-	-	-		*5.0E-1*	
MCS	-	***4.5E-1***		***3.0E-1***		-	-	-	-	***7.5E-1***			-	-	-	-	-	-	-	-	-		***7.5E-1***	
MGS	-	***6.0E-1***		***4.0E-1***		-	-	-	-	***1.0E+0***			-	-	-	-	-	-	-	-	-		***1.0E+0***	
Sat Col 10																								
Used in Source Term	7.27	3.4E-2	9.0E-3	1.9E-4	5.0E-4	1.3E+0	2.1E-2	1.0E-5	5.4E-1	4.9E-4	3.0E-1	1.8E+1	8.9E-4	1.0E+0	2.6E-6	1.0E+1	2.1E-1	4.9E-5	5.0E-5	7.7E-4	4.8E-3	1.9E-3	1.9E-2	1.0E-04
Current	8.14	3.3E-2	7.0E-3	1.9E-4	5.0E-4	1.3E+0	2.0E-2	2.0E-5	5.2E-1	4.6E-4	3.0E-1	1.8E+1	8.2E-4	9.9E-1	5.6E-6	9.9E+0	2.0E-1	4.7E-5	4.1E-5	7.4E-4	4.8E-3	1.9E-3	1.9E-2	1.0E-04
Relative difference	8%	-2%	-17%	0%	NS	0%	-3%	NS	-2%	-4%	NS	-1%	-6%	0%	NS	0%	-2%	-2%	-13%	-3%	0%	0%	-2%	NS
Sat Col 11																								
Used in Source Term	7.12	6.3E-4	5.1E-2	2.4E-4	5.0E-4	8.8E+0	6.3E-2	1.0E-5	4.3E-1	3.2E-3	3.0E-1	1.9E+1	4.8E-4	2.7E+0	1.1E-5	1.7E+1	5.2E-1	9.9E-6	1.0E-5	5.0E-4	4.2E-3	8.1E-4	5.0E-2	1.0E-04
Current	8.07	5.8E-4	4.6E-2	2.3E-4	5.0E-4	8.6E+0	5.8E-2	2.0E-5	4.2E-1	3.0E-3	3.0E-1	1.8E+1	4.0E-4	2.6E+0	1.1E-5	1.7E+1	4.9E-1	9.6E-6	1.0E-5	5.0E-4	3.5E-3	7.9E-4	4.6E-2	1.0E-04
Relative difference	9%	-5%	-7%	-4%	NS	-2%	-6%	NS	-2%	-4%	NS	-2%	-12%	-1%	NS	-1%	-4%	-2%	NS	NS	-14%	NS	-5%	NS
Sat Col 12 upper port																								
Used in Source Term	6.13	*1.1E+1*	5.3E+0	7.2E-4	4.0E-2	1.8E+2	3.5E+0	7.2E-5	2.7E-2	7.4E-2	1.5E+0	4.7E+1	3.9E-2	1.1E+1	2.9E-5	1.1E+2	4.8E+0	2.2E-4	9.8E-5	2.5E-3	8.3E-1	2.5E-4	3.8E-1	1.0E-03
Current	7.04	*4.2E+0*	3.4E+0	3.6E-4	2.6E-2	1.6E+2	3.4E+0	1.0E-5	1.5E-2	4.5E-2	1.5E+0	4.1E+1	1.6E-2	1.1E+1	2.5E-5	8.4E+1	4.1E+0	1.9E-4	5.0E-5	2.5E-3	7.7E-1	2.5E-4	2.3E-1	8.3E-04
Relative difference	10%	-63%	-32%	-47%	-31%	-8%	-2%	NS	-40%	-33%	NS	-10%	-58%	-1%	NS	-16%	-11%	-13%	NS	NS	-6%	NS	-35%	-14%
Sat Col 12 lower port																								
Used in Source Term	3.34	*4.1E+2*	7.5E+1	8.2E-4	1.2E-1	2.1E+2	8.7E+0	2.4E-5	7.1E-3	4.8E-1	1.9E+1	2.1E+1	5.6E-2	2.6E+1	3.9E-4	1.0E+2	6.3E-1	9.2E-4	6.9E-4	3.2E-2	9.6E-1	5.1E-3	*2.9E+0*	6.4E-03
Current	4.16	*2.2E+2*	7.1E+1	4.8E-4	7.2E-2	1.4E+2	5.6E+0	2.0E-5	6.3E-3	2.7E-1	3.0E+0	1.7E+1	3.6E-2	2.5E+1	2.4E-4	6.3E+1	4.5E-1	7.2E-4	2.0E-4	1.0E-2	5.2E-1	5.1E-3	*1.7E+0*	2.0E-03
Relative difference	15%	-41%	-4%	NS	-32%	-29%	-30%	NS	-8%	-40%	NS	-15%	-32%	-5%	NS	-34%	-23%	-17%	NS	NS	-41%	0%	-38%	NS
Sat Col 13 upper port																								
Used in Source Term	6.69	4.3E-3	2.4E+0	2.6E-3	1.6E-2	8.5E+1	2.6E+0	5.0E-6	3.4E-1	2.2E-2	1.1E+0	4.1E+1	1.0E-2	1.4E+1	2.7E-5	2.0E+2	3.0E+0	3.0E-5	5.5E-5	1.8E-3	3.8E-1	6.4E-4	3.2E-2	9.2E-04
Current	7.65	1.8E-3	2.1E+0	6.3E-4	1.4E-2	6.9E+1	2.0E+0	1.0E-5	7.5E-1	1.5E-2	6.0E-1	3.8E+1	1.5E-3	1.4E+1	1.0E-5	1.7E+2	2.5E+0	6.2E-6	7.3E-5	1.0E-3	3.4E-1	3.1E-4	1.6E-2	4.0E-04
Relative difference	10%	-60%	-10%	-86%	-9%	-14%	-16%	NS	53%	-23%	NS	-7%	-105%	-2%	NS	-12%	-14%	NS	19%	-41%	-8%	-49%	-49%	-55%
Sat Col 13 lower port																								
Used in Source Term	6.61	9.0E-2	2.5E+0	1.7E-3	1.8E-2	8.7E+1	6.0E+0	5.0E-6	3.2E-1	2.0E-2	8.9E+0	3.7E+1	1.2E-2	1.5E+1	1.5E-4	2.3E+2	2.0E+0	1.5E-4	3.0E-4	1.5E-2	2.7E-1	1.5E-3	2.8E-2	3.0E-03
Current	7.67	3.4E-2	2.4E+0	1.2E-3	8.9E-3	8.4E+1	5.1E+0	1.0E-5	8.5E-1	1.7E-2	1.2E+0	3.5E+1	3.0E-3	1.4E+1	2.5E-5	2.1E+2	1.9E+0	1.1E-4	5.0E-5	2.5E-3	2.4E-1	2.5E-4	2.3E-2	5.0E-04
Relative difference	10%	-64%	-4%	-26%	-47%	-2%	-11%	NS	64%	-13%	NS	-2%	-86%	-3%	NS	-8%	-4%	-20%	NS	-101%	-8%	-101%	-12%	-101%
Sat Col 14 upper port																								
Used in Source Term	6.28	*2.7E+0*	3.8E+0	9.1E-4	3.7E-2	1.8E+2	2.9E+0	7.5E-5	3.4E-2	6.9E-2	1.5E+0	5.2E+1	3.0E-2	1.3E+1	4.4E-5	1.1E+2	5.2E+0	1.6E-4	2.4E-4	2.5E-3	1.0E+0	6.3E-4	2.8E-1	3.3E-03
Current	7.18	*8.7E-1*	3.7E+0	2.8E-4	3.0E-2	1.7E+2	2.7E+0	1.0E-5	1.8E-2	6.1E-2	1.5E+0	4.6E+1	1.1E-2	1.3E+1	3.7E-5	9.2E+1	4.3E+0	1.2E-4	2.3E-4	2.5E-3	8.9E-1	5.7E-4	2.2E-1	2.2E-03
Relative difference	9%	-72%	-2%	-75%	-16%	-5%	-3%	NS	-44%	-9%	NS	-9%	-66%	0%	NS	-13%	-13%	-22%	-3%	0%	-10%	-8%	-16%	-30%
Sat Col 14 lower port																								
Used in Source Term	3.35	*5.4E+2*	9.4E+1	1.0E-3	1.6E-1	3.3E+2	1.4E+1	2.4E-5	6.3E-3	*6.8E-1*	2.3E+1	2.8E+1	8.4E-2	3.1E+1	3.9E-4	1.6E+2	8.4E-1	1.2E-3	9.9E-4	3.9E-2	1.4E+0	9.4E-3	*3.8E+0*	7.7E-03
Current	5.88	*4.0E+2*	9.2E+1	6.4E-4	1.1E-1	3.0E+2	1.2E+1	2.0E-5	1.1E-2	*5.3E-1*	1.5E+1	2.6E+1	6.4E-2	3.0E+1	2.5E-4	1.4E+2	8.5E-1	9.2E-4	5.0E-4	2.4E-2	8.6E-1	7.9E-3	*2.9E+0*	4.9E-03
Relative difference	39%	-21%	-2%	-34%	-26%	-6%	-10%	NS	37%	-18%	NS	-6%	-19%	-2%	-31%	-6%	1%	-17%	-47%	NS	-32%	-12%	-18%	NS
Sat Col 15																								
Used in Source Term	6.78	9.3E-2	1.7E+0	1.3E-4	8.5E-3	5.2E+1	4.3E+0	5.0E-6	6.3E-1	6.9E-3	4.7E-1	3.1E+1	1.5E-2	1.6E+1	3.9E-6	2.2E+2	1.1E+0	1.4E-4	9.4E-5	8.6E-4	7.4E-2	1.8E-4	1.9E-2	2.4E-04
Current	7.40	2.6E-2	1.7E+0	1.2E-4	6.8E-3	4.0E+1	3.1E+0	1.0E-5	7.5E-1	4.6E-3	3.0E-1	2.9E+1	9.6E-3	1.4E+1	5.0E-6	1.6E+2	8.9E-1	1.2E-4	9.2E-5	6.9E-4	6.0E-2	1.7E-4	1.2E-2	1.6E-04
Relative difference	6%	-80%	-1%	-9%	-16%	-18%	-22%	NS	13%	-28%	NS	-7%	-30%	-6%	NS	-21%	-12%	-11%	-2%	-16%	-15%	-3%	-35%	-27%
Sat Col 16																								
Used in Source Term	8.01	1.0E-4	2.4E-2	2.5E-6	9.2E-4	3.5E+0	2.9E-2	5.0E-6	3.5E-2	1.8E-4	1.3E+0	4.8E+1	4.3E-4	3.3E+0	2.5E-6	3.0E+1	1.1E+0	1.0E-6	2.5E-5	5.0E-4	1.3E-4	5.0E-5	1.3E-3	1.0E-04
Current	8.66	1.0E-4	1.7E-2	5.0E-6	1.0E-3	3.2E+0	2.8E-2	1.0E-5	2.6E-2	1.8E-4	1.3E+0	4.5E+1	4.0E-4	4.1E+0	5.0E-6	3.0E+1	1.1E+0	5.3E-6	2.3E-5	5.0E-4	4.0E-4	5.1E-5	1.7E-3	1.0E-04
Relative difference	5%	NS	-22%	NS	8%	-6%	-4%	NS	-20%	-1%	0%	-4%	-6%	14%	NS	0%	-2%	97%	-7%	NS	71%	2%	18%	NS
Sat Col 17																								
Used in Source Term	7.20	1.7E-4	2.5E-1	5.0E-6	1.5E-3	9.2E+0	8.0E-2	5.0E-6	1.7E-1	1.1E-3	2.0E+0	7.3E+1	1.7E-3	2.5E+0	1.7E-5	4.9E+1	2.2E+0	9.6E-5	1.1E-4	1.0E-3	6.2E-5	1.0E-4	1.4E-3	2.0E-04
Current	8.20	4.4E-4	2.0E-1	1.1E-5	1.4E-3	8.5E+0	7.9E-2	1.0E-5	1.5E-1	1.0E-3	1.9E+0	7.0E+1	1.2E-3	3.3E+0	2.0E-5	4.7E+1	2.0E+0	4.3E-5	8.4E-5	1.0E-3	2.0E-4	1.0E-4	4.2E-3	2.0E-04
Relative difference	9%	62%	-15%	51%	-3%	-6%	-2%	NS	-10%	-2%	-5%	-3%	-26%	20%	11%	-4%	-4%	-54%	-21%	NS	74%	NS	69%	NS

Unsaturated waste rock kinetic test statistics summary

	Cycle	pH	Cond.	Acidity	Acidity	Alk.	SO4	Cl	F	Br	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu	Fe	Pb
HC3																									
Temperature change to 4°C on 4-Jun-13, cycle 79																									
Median used in Source Term	49 - 65	7.4E+0	7.0E+1	0.0E+0	1.3E+0	6.3E+0	8.5E+0	9.3E-2	2.8E-2	1.4E-1	1.3E+1	1.2E-2	9.3E-5	1.3E-4	1.6E-3	9.3E-6	4.7E-6	4.7E-4	1.9E-5	3.5E+0	2.3E-4	6.3E-5	4.8E-4	1.4E-3	1.3E-5
22°C Median	69 - 79	7.6E+0	6.1E+1	0.0E+0	1.9E+0	6.1E+0	6.6E+0	9.0E-2	2.7E-2	1.4E-1	1.1E+1	7.7E-3	9.0E-5	9.0E-5	1.3E-3	9.0E-6	4.5E-6	7.4E-4	5.4E-6	2.9E+0	2.3E-4	2.5E-5	5.0E-4	1.4E-3	9.0E-6
Relative Difference		2%	-10%	NS	26%	-2%	-18%	NS	NS	NS	-10%	-28%	NS	NS	-13%	NS	NS	32%	-79%	-14%	NS	-62%	NS	NS	NS
HC4																									
Temperature change to 4°C on 4-Jun-13, cycle 79																									
Median used in Source Term	49 - 65	7.5E+0	9.0E+1	0.0E+0	1.2E+0	1.1E+1	1.0E+1	9.1E-2	2.8E-2	1.4E-1	1.8E+1	1.6E-2	6.2E-4	2.6E-4	4.9E-3	9.1E-6	4.6E-6	7.1E-4	1.4E-5	6.3E+0	2.3E-4	3.9E-5	4.7E-4	1.4E-3	1.3E-5
22°C Median	69 - 79	7.6E+0	9.2E+1	0.0E+0	1.9E+0	1.2E+1	1.2E+1	9.0E-2	2.7E-2	1.4E-1	2.1E+1	1.1E-2	7.4E-4	1.8E-4	5.4E-3	9.0E-6	4.5E-6	1.0E-3	1.4E-6	7.1E+0	2.3E-4	9.8E-6	4.5E-4	1.4E-3	9.2E-6
Relative Difference		1%	2%	NS	30%	7%	8%	NS	NS	NS	9%	-26%	13%	NS	7%	NS	NS	25%	-116%	8%		-84%	NS	NS	NS
HC5																									
Temperature change to 4°C on 4-Jun-13, cycle 79																									
Median used in Source Term	49 - 65	7.5E+0	7.3E+1	0.0E+0	1.1E+0	1.1E+1	5.9E+0	9.0E-2	9.1E-2	1.4E-1	1.6E+1	2.1E-2	9.0E-5	9.1E-5	2.4E-3	9.0E-6	4.5E-6	6.3E-4	5.0E-6	4.7E+0	2.3E-4	3.0E-5	4.1E-4	1.4E-3	1.7E-5
22°C Median	69 - 79	7.6E+0	6.7E+1	0.0E+0	1.8E+0	1.0E+1	6.3E+0	8.8E-2	6.8E-2	1.3E-1	1.4E+1	1.4E-2	8.8E-5	8.8E-5	2.2E-3	8.8E-6	4.4E-6	7.5E-4	1.8E-6	3.9E+0	2.2E-4	1.3E-5	2.3E-4	1.3E-3	8.8E-6
Relative Difference		0%	-5%	NS	33%	-5%	4%	NS	NS	NS	-11%	-27%	NS	NS	-8%	NS	NS	12%	NS	-14%	NS	-57%	NS	NS	NS
HC6																									
Temperature change to 4°C on 4-Jun-13, cycle 79																									
Median used in Source Term	49 - 65	7.4E+0	3.9E+1	0.0E+0	1.2E+0	6.5E+0	2.7E+0	9.0E-2	2.7E-2	1.4E-1	8.4E+0	2.1E-2	9.1E-5	1.8E-4	2.5E-3	9.0E-6	4.5E-6	4.1E-4	4.1E-6	3.0E+0	2.3E-4	2.6E-5	5.9E-4	2.2E-3	1.3E-5
22°C Median	69 - 79	7.5E+0	3.5E+1	0.0E+0	1.8E+0	6.0E+0	2.7E+0	8.9E-2	2.7E-2	1.3E-1	6.6E+0	1.5E-2	8.9E-5	1.4E-4	1.9E-3	8.9E-6	4.5E-6	5.7E-4	2.7E-6	2.3E+0	2.2E-4	1.0E-5	7.0E-4	4.5E-3	1.3E-5
Relative Difference		1%	-8%	NS	30%	-6%	NS	NS	NS	NS	-16%	-24%	NS	NS	-18%	NS	NS	23%	NS	-17%	NS	-60%	NS	NS	NS
H7																									
Temperature change to 4°C on 4-Jun-13, cycle 79																									
Median used in Source Term	49 - 65	7.3E+0	8.1E+1	0.0E+0	1.4E+0	5.5E+0	1.2E+1	9.2E-2	3.8E-2	1.4E-1	1.7E+1	1.4E-2	3.7E-4	9.3E-4	8.8E-3	9.2E-6	4.6E-6	3.9E-4	7.4E-6	6.3E+0	2.3E-4	7.4E-5	1.2E-3	1.4E-3	1.3E-5
22°C Median	69 - 79	7.4E+0	7.6E+1	0.0E+0	1.8E+0	5.0E+0	1.0E+1	8.9E-2	2.7E-2	1.3E-1	1.4E+1	1.3E-2	3.6E-4	8.3E-4	6.0E-3	8.9E-6	4.5E-6	6.7E-4	3.0E-6	5.1E+0	2.2E-4	4.0E-5	1.1E-3	1.3E-3	9.2E-6
Relative Difference		1%	-5%	NS	21%	-6%	-12%	NS	NS	NS	-14%	-3%	NS	-8%	-27%	NS	NS	37%	-59%	-15%	NS	-41%	-5%	NS	NS
HC8																									
Temperature change to 4°C on 4-Jun-13, cycle 79																									
Median used in Source Term	49 - 65	3.3E+0	3.2E+2	2.3E+1	4.2E+1	0.0E+0	4.6E+1	4.6E-1	2.8E-2	1.4E-1	5.0E-1	4.5E+0	1.4E-4	1.4E-4	1.5E-3	2.8E-4	4.6E-6	3.7E-4	3.4E-4	1.8E-1	1.1E-3	3.5E-3	1.6E+0	4.0E+0	1.2E-4
22°C Median	105 - 118	2.9E+0	7.3E+2	6.1E+1	8.5E+1	0.0E+0	8.1E+1	4.4E-1	2.8E-2	1.4E-1	1.2E+0	2.1E+0	9.3E-5	1.0E-3	1.0E-3	1.2E-4	4.7E-6	4.8E-4	1.7E-4	4.1E-1	1.5E-3	6.1E-3	4.0E-1	2.0E+1	1.4E-5
Relative Difference		-10%	56%	64%	49%		38%	-4%	1%	NS	58%	-52%	-28%	108%	-27%	NS	NS	18%	-47%	57%	NS	38%	-84%	94%	-111%
HC9																									
Not used in the original source term calculations due to intermediate pH at time of reporting																									
Median at time of Source Term	27 - 65	5.6E+0		0.0E+0	2.3E+0	3.9E-1	3.1E+0	9.0E-2	2.7E-2	1.4E-1	2.6E+0	1.1E-2	9.0E-5	9.3E-5	3.7E-3	9.0E-6	4.5E-6	7.4E-4	3.7E-5	8.8E-1	2.3E-4	1.8E-3	2.1E-1	2.2E-3	1.4E-5
22°C Median	125 - 143	4.4E+0		0.0E+0	6.0E+0	0.0E+0	3.9E+0	8.7E-2	2.6E-2	1.3E-1	9.6E-1	3.3E-1	8.7E-5	8.7E-5	8.1E-3	8.9E-5	3.0E-6	8.9E-4	4.5E-5	3.0E-1	1.3E-5	1.9E-3	9.7E-1	3.9E-2	1.3E-5
Relative Difference		-17%		NS	64%	-141%	NS	NS	NS	NS	-66%	132%	NS	NS	53%	NS	NS	13%	14%	-69%	NS	3%	92%	126%	NS
HC10																									
Temperature change to 4°C on 4-Jun-13, cycle 79																									
Median used in Source Term	49 - 65	3.2E+0	4.8E+2	3.7E+1	6.6E+1	0.0E+0	7.5E+1	4.5E-1	1.7E-1	1.4E-1	3.4E+0	7.6E+0	1.8E-4	8.2E-4	2.3E-3	4.2E-4	4.5E-6	4.5E-4	9.2E-4	4.6E-1	2.3E-3	2.0E-2	1.8E+0	4.9E+0	1.2E-4
22°C Median	65 - 78	3.2E+0	4.1E+2	3.3E+1	5.3E+1	#N/A	5.6E+1	4.5E-1	1.8E-1	1.4E-1	2.4E+0	5.2E+0	1.4E-4	5.0E-4	2.5E-3	2.9E-4	4.5E-6	5.0E-4	5.2E-4	3.2E-1	1.2E-3	1.4E-2	1.2E+0	3.2E+0	8.7E-5
Relative Difference		2%	-11%	-8%	-16%	NS	-20%	0%	NS	NS	-26%	-26%	NS	-35%	5%	NS	NS	7%	-39%	-26%	NS	-27%	-29%	-29%	-20%
HC11																									
Temperature change to 4°C on 4-Jun-13, cycle 79																									
Median used in Source Term	49 - 65	7.1E+0	6.0E+1	0.0E+0	1.8E+0	9.2E+0	4.5E+0	9.1E-2	8.6E-2	1.4E-1	1.3E+1	1.5E-2	7.7E-4	4.1E-4	9.4E-3	9.1E-6	4.6E-6	4.1E-4	5.0E-6	4.4E+0	2.3E-4	1.2E-4	2.2E-3	2.3E-3	1.4E-5
22°C Median	69 - 79	6.8E+0	5.5E+1	0.0E+0	2.0E+0	6.9E+0	4.4E+0	8.8E-2	4.4E-2	1.3E-1	9.6E+0	1.3E-2	6.8E-4	3.5E-4	1.0E-2	8.8E-6	4.4E-6	5.7E-4	1.8E-6	3.4E+0	2.3E-4	2.9E-5	8.8E-4	1.8E-3	1.3E-5
Relative Difference		-3%	-7%	NS	9%	-20%	NS	NS	NS	NS	-19%	-9%	-10%	NS	5%	NS	NS	23%	NS	-18%	NS	-86%	-60%	NS	NS
HC12																									
Temperature change to 4°C on 4-Mar-14, cycle 118																									
Median used in Source Term	49 - 65	3.8E+0		9.3E+0	2.5E+1	0.0E+0	2.5E+1	9.3E-2	9.8E-2	1.3E-1	2.0E+0	1.5E+0	8.5E-5	1.4E-4	3.6E-4	1.7E-4	4.3E-6	2.7E-4	1.2E-3	6.6E-1	2.3E-4	3.7E-3	1.9E+0	1.7E+0	5.0E-5
22°C Median	105 - 118	3.4E+0		1.1E+1	2.4E+1	0.0E+0	1.9E+1	9.0E-2	7.7E-2	1.3E-1	1.2E+0	1.5E+0	8.7E-5	8.7E-5	2.8E-4	1.0E-4	4.4E-6	7.2E-4	2.5E-4	4.2E-1	6.2E-4	3.4E-3	3.6E-1	1.8E+0	1.7E-5
Relative Difference		-8%		9%	-4%	NS	-20%	NS	NS	NS	-35%	0%	NS	NS	-17%	-32%	NS	64%	-93%	-31%	NS	-6%	-96%	5%	-69%
Col 1																									
Median used in Source Term	114 - 160	5.3E+0	1.1E+2	0.0E+0	5.5E-1	3.0E-2	2.5E+0	1.2E-2	4.8E-3	1.8E-2	1.5E+0	1.3E-2	1.2E-5	2.3E-5	3.0E-3	1.1E-5	6.1E-7	5.1E-4	1.7E-5	4.4E-1	3.1E-5	5.1E-4	5.3E-2	2.7E-4	6.5E-6
22°C Median	125 - 143	5.0E+0	8.9E+1	0.0E+0	4.8E-1	5.9E-3	1.5E+0	1.2E-2	3.6E-3	1.8E-2	1.3E+0	9.7E-3	1.2E-5	1.2E-5	3.2E-3	1.0E-5	5.9E-7	5.9E-4	1.4E-5	3.9E-1	3.0E-5	4.5E-4	4.6E-2	1.8E-4	5.5E-6
Relative Difference		-4%	-15%	NS	-10%	NS	-45%	NS	NS	NS	-10%	-24%	NS	NS	6%	NS	NS	9%	-12%	-10%	NS	-9%	-10%	NS	-13%
Col 2a																									
Temperature change to 4°C on 5-Mar-14, cycle 215																									
Median used in Source Term	144 - 160	6.0E+0	3.1E+1	0.0E+0	3.5E-1	9.3E-2	6.5E-1	1.2E-2	4.1E-3	1.8E-2	4.0E-1	4.0E-3	3.0E-5	1.3E-5	5.8E-3	2.4E-6	5.9E-7	4.4E-4	8.5E-6	1.2E-1	3.0E-5	1.7E-4	5.5E-3	2.2E-4	5.3E-6
22°C Median	196 - 214	5.7E+0	2.4E+1	0.0E+0	2.4E-1	3.9E-2	4.1E-1	1.2E-2	3.5E-3	1.8E-2	2.9E-1	3.7E-3	3.0E-5	1.2E-5	6.8E-3	1.8E-6	5.9E-7	7.3E-4	6.4E-6	9.1E-2	3.0E-5	1.2E-4	3.8E-3	4.2E-4	5.0E-6
Relative Difference		-4%	-19%	NS	-27%	NS	-31%	NS	NS	NS	-21%	-4%	NS	NS	12%	NS	NS	35%	-19%	-21%	NS	-22%	-25%	NS	-4%

Notes:
1. Units in mg/kg; Alk. = Alkalinity as $CaCC_3$.
2. Values in Blue represent elements that were consistently below detection.
3. "NS" means difference is Not Significant because both medians are less than 5 x's the reporting limit

Unsaturated waste rock kinetic test statistics summary

	Cycle	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Median	Mean	Min	Max
HC3																										
Temperature change to 4°C on 4-Jun-13, cycle																										
Median used in Source Term	49 - 65	4.7E-4	9.6E-1	8.6E-3	4.7E-6	1.4E-3	4.7E-5	5.2E-3	2.0E-1	4.4E-5	1.6E-1	4.7E-6	5.2E-2	8.3E-3	2.8E+0	9.3E-6	1.2E-4	8.9E-5	4.0E-3	8.5E-5	9.3E-4	4.7E-06				
22°C Median	69 - 79	4.5E-4	9.5E-1	6.5E-3	4.5E-6	1.2E-3	1.4E-4	4.1E-3	1.8E-1	2.3E-5	1.4E-1	4.5E-6	4.5E-2	6.6E-3	2.5E+0	9.0E-6	6.5E-5	4.5E-5	2.9E-3	2.7E-5	4.5E-4	4.5E-06				
Relative Difference		NS	-1%	-20%	NS	-8%	NS	NS	-7%	NS	-12%	NS	-11%	-16%	-10%	NS	-41%	NS	-24%	NS	NS	NS	-13%	-16%	-79%	32%
HC4																										
Temperature change to 4°C on 4-Jun-13, cycle																										
Median used in Source Term	49 - 65	4.6E-4	6.4E-1	8.6E-4	4.6E-6	1.4E-3	8.8E-5	4.3E-3	5.5E-1	2.8E-4	2.2E-1	4.6E-6	4.5E-2	7.6E-2	3.7E+0	9.1E-6	1.1E-4	8.9E-5	5.0E-3	1.7E-4	9.3E-4	4.6E-06				
22°C Median	69 - 79	4.5E-4	7.5E-1	7.2E-4	4.5E-6	1.2E-3	4.7E-5	4.1E-3	5.9E-1	2.4E-4	2.6E-1	4.5E-6	5.0E-2	8.6E-2	3.5E+0	9.0E-6	3.7E-5	4.5E-5	4.8E-3	9.3E-5	4.7E-4	4.5E-06				
Relative Difference		NS	11%	-13%	NS	-13%	NS	NS	5%	-10%	10%	NS	8%	8%	-3%	NS	-71%	NS	-3%	-42%	NS	NS	7%	-10%	-116%	30%
HC5																										
Temperature change to 4°C on 4-Jun-13, cycle																										
Median used in Source Term	49 - 65	4.5E-4	9.3E-1	2.7E-3	4.5E-6	1.8E-3	8.6E-5	4.1E-3	4.0E-1	4.8E-5	1.4E-1	4.5E-6	1.0E-1	1.1E-1	2.5E+0	9.0E-6	9.5E-5	9.0E-5	4.9E-4	8.2E-5	9.0E-4	4.5E-06				
22°C Median	69 - 79	4.4E-4	1.1E+0	1.6E-3	4.4E-6	2.5E-3	4.5E-5	4.1E-3	3.0E-1	3.1E-5	1.1E-1	4.4E-6	6.8E-2	9.0E-2	2.1E+0	8.8E-6	2.6E-5	4.4E-5	3.6E-4	1.8E-5	4.5E-4	4.4E-06				
Relative Difference		NS	9%	-36%	NS	24%	NS	NS	-20%	NS	-13%	NS	-31%	-16%	-12%	NS	-80%	NS	-22%	-91%	NS	NS	-13%	-18%	-91%	33%
HC6																										
Temperature change to 4°C on 4-Jun-13, cycle																										
Median used in Source Term	49 - 65	4.5E-4	2.4E-1	1.2E-3	4.5E-6	8.6E-4	4.6E-5	4.5E-3	4.9E-1	3.2E-5	2.6E-1	4.5E-6	3.0E-2	6.7E-3	1.0E+0	9.0E-6	6.4E-5	1.8E-4	6.3E-4	9.9E-5	9.0E-4	5.0E-06				
22°C Median	69 - 79	4.5E-4	1.8E-1	9.3E-4	4.5E-6	6.3E-4	4.5E-5	4.0E-3	3.5E-1	1.8E-5	2.0E-1	4.5E-6	2.2E-2	5.1E-3	7.8E-1	8.9E-6	1.7E-5	1.7E-4	4.2E-4	4.7E-5	4.5E-4	8.6E-06				
Relative Difference		NS	-22%	-18%	NS	-22%	NS	NS	-23%	NS	-19%	NS	-20%	-19%	-18%	NS	-81%	NS	-29%	-50%	NS	NS	-19%	-21%	-81%	30%
H7																										
Temperature change to 4°C on 4-Jun-13, cycle																										
Median used in Source Term	49 - 65	4.6E-4	3.3E-1	9.1E-3	4.6E-6	2.1E-3	4.9E-5	2.1E-2	2.4E-1	3.8E-4	1.2E-1	4.6E-6	3.8E-2	6.1E-2	4.2E+0	9.2E-6	5.4E-5	9.2E-5	4.7E-4	8.0E-5	4.9E-4	4.6E-06				
22°C Median	69 - 79	4.5E-4	2.9E-1	5.9E-3	4.5E-6	2.0E-3	4.5E-5	1.7E-2	2.1E-1	3.2E-4	9.8E-2	4.5E-6	2.2E-2	5.9E-2	3.4E+0	8.9E-6	2.2E-5	4.5E-5	4.9E-4	2.7E-5	4.5E-4	4.6E-06				
Relative Difference		NS	-10%	-31%	NS	-6%	NS	NS	-10%	-12%	-13%	NS	-37%	-2%	-15%	NS	NS	NS	2%	-71%	NS	NS	-12%	-15%	-71%	37%
HC8																										
Temperature change to 4°C on 4-Jun-13, cycle																										
Median used in Source Term	49 - 65	4.6E-4	1.7E-2	7.2E-3	4.6E-6	2.0E-4	3.9E-3	1.3E-2	1.7E-1	2.1E-4	7.0E-1	2.5E-5	2.6E-2	4.7E-3	1.5E+1	9.2E-6	6.9E-5	4.6E-5	1.8E-2	5.7E-4	3.3E-2	4.6E-06				
22°C Median	105 - 118	4.7E-4	3.7E-2	2.6E-2	4.7E-6	4.2E-4	6.4E-3	1.8E-1	8.8E-2	2.5E-4	4.5E-1	8.7E-5	2.2E-2	2.9E-3	2.8E+1	9.3E-6	3.0E-5	2.4E-4	1.0E-2	7.7E-4	1.5E-2	8.6E-06				
Relative Difference		NS	52%	80%	NS	50%	34%	NS	-45%	14%	-31%	79%	-13%	-33%	42%	1%	-54%	96%	-38%	21%	-52%	43%	16%	10%	-111%	108%
HC9																										
Not used in the original source term calculation																										
Median at time of Source Term	27 - 65	4.5E-4	9.5E-2	9.5E-3	4.5E-6	3.7E-4	4.0E-4	4.1E-3	3.9E-1	1.2E-4	5.6E-1	4.5E-6	1.3E-1	6.5E-3	1.2E+0	9.0E-6	7.4E-5	4.6E-5	3.0E-5	1.1E-4	5.3E-3	4.5E-06				
22°C Median	125 - 143	3.5E-4	4.5E-2	3.4E-3	4.5E-6	1.3E-5	9.1E-4	1.6E-2	2.2E-1	2.4E-4	6.3E-1	1.8E-6	1.1E-1	5.1E-3	1.9E+0	4.5E-6	5.7E-5	2.7E-5	1.2E-3	4.4E-6	3.0E-3	8.7E-04				
Relative Difference		NS	-51%	-67%	NS	-132%	56%	NS	-39%	48%	9%	-61%	-13%	-16%	33%	-48%	-18%	NS	134%	-131%	-39%	140%	-5%	1%	-141%	140%
HC10																										
Temperature change to 4°C on 4-Jun-13, cycle																										
Median used in Source Term	49 - 65	1.4E-3	5.5E-1	8.0E-2	4.5E-6	9.1E-5	1.1E-2	2.0E-2	8.3E-2	4.9E-4	8.6E-1	1.4E-5	2.7E-2	3.8E-3	2.4E+1	2.3E-5	7.8E-5	8.7E-5	1.9E-2	1.6E-4	1.9E-1	6.3E-05				
22°C Median	65 - 78	9.2E-4	4.1E-1	2.7E-2	4.5E-6	7.4E-5	7.2E-3	4.1E-3	6.8E-2	3.7E-4	6.1E-1	1.4E-5	2.3E-2	3.0E-3	1.6E+1	1.8E-5	1.4E-5	4.5E-5	1.1E-2	1.2E-4	1.0E-1	4.8E-06				
Relative Difference		NS	-21%	-71%	NS	-15%	-27%	NS	-14%	-20%	-23%	NS	-14%	-18%	-28%	NS	-99%	NS	-40%	-24%	-43%	-121%	-26%	-30%	-121%	7%
HC11																										
Temperature change to 4°C on 4-Jun-13, cycle																										
Median used in Source Term	49 - 65	4.6E-4	3.9E-1	7.2E-4	4.6E-6	6.1E-4	9.6E-5	4.3E-3	4.6E-1	2.1E-4	2.8E-1	4.6E-6	4.7E-2	1.9E-2	1.8E+0	9.1E-6	6.8E-5	1.4E-4	2.8E-3	1.3E-4	1.6E-3	4.6E-06				
22°C Median	69 - 79	4.4E-4	2.9E-1	4.4E-4	4.4E-6	7.5E-4	4.5E-5	4.0E-3	3.9E-1	1.2E-4	2.8E-1	4.5E-6	3.4E-2	1.6E-2	1.4E+0	8.8E-6	1.3E-5	2.6E-4	1.9E-3	7.8E-5	4.5E-4	4.4E-06				
Relative Difference		NS	-20%	-34%	NS	15%	NS	NS	-12%	-37%	0%	NS	-22%	-15%	-19%	NS	-95%	46%	-27%	-37%	NS	NS	-19%	-19%	-95%	46%
HC12																										
Temperature change to 4°C on 4-Mar-14, cycle																										
Median used in Source Term	49 - 65	8.4E-4	8.9E-2	7.2E-3	4.3E-6	1.3E-5	1.3E-3	5.5E-3	5.2E-2	6.0E-4	3.4E-1	8.4E-6	1.9E-2	3.8E-3	7.3E+0	8.5E-6	6.8E-5	4.3E-5	1.4E-2	4.7E-5	1.2E-1	4.3E-06				
22°C Median	105 - 118	8.2E-4	3.4E-2	3.5E-3	4.4E-6	4.5E-6	5.5E-4	4.1E-3	8.2E-2	3.1E-4	2.3E-1	4.4E-6	1.6E-2	2.5E-3	8.2E+0	8.7E-6	3.6E-5	4.4E-5	5.0E-3	1.6E-5	2.2E-2	4.4E-06				
Relative Difference		NS	-63%	-48%	NS	NS	-59%	NS	31%	-45%	-27%	NS	NS	-30%	9%	NS	-44%	NS	-67%	NS	-98%	NS	-32%	-32%	-98%	64%
Col 1																										
Median used in Source Term	114 - 160	1.9E-4	1.0E-1	1.2E-2	6.2E-7	2.5E-4	2.2E-4	5.5E-4	2.7E-1	3.5E-5	8.5E-1	4.2E-6	4.5E-2	3.9E-3	7.9E-1	9.5E-6	2.3E-5	1.6E-5	4.2E-5	2.4E-5	2.8E-3	6.1E-07				
22°C Median	125 - 143	1.8E-4	9.0E-2	1.0E-2	5.9E-7	1.5E-4	1.9E-4	5.5E-4	1.8E-1	2.7E-5	7.4E-1	2.4E-6	5.2E-2	3.4E-3	6.2E-1	7.1E-6	1.0E-5	1.2E-5	3.4E-5	3.0E-6	2.4E-3	5.9E-07				
Relative Difference		NS	-12%	-13%	NS	-44%	-11%	NS	-38%	-20%	-10%	-56%	10%	-11%	-20%	-24%	-88%	NS	-17%	-508%	-14%	NS	-13%	-37%	-508%	10%
Col 2a																										
Temperature change to 4°C on 5-Mar-14, cycle																										
Median used in Source Term	144 - 160	5.9E-5	2.2E-2	2.9E-3	5.9E-7	1.6E-5	3.0E-5	5.3E-4	7.3E-2	2.1E-5	6.7E-1	1.8E-6	6.8E-2	1.5E-3	2.1E-1	1.2E-6	3.6E-5	1.2E-5	2.9E-6	1.7E-5	7.1E-4	4.1E-06				
22°C Median	196 - 214	5.9E-5	1.6E-2	2.0E-3	5.9E-7	1.9E-5	2.8E-5	5.3E-4	5.2E-2	2.0E-5	6.3E-1	1.2E-6	6.0E-2	1.1E-3	1.7E-1	1.2E-6	4.2E-5	5.9E-6	2.3E-6	3.9E-6	5.4E-4	1.1E-04				
Relative Difference		NS	-23%	-27%	NS	11%	-4%	NS	-23%	-5%	-5%	NS	-9%	-21%	-15%	NS	10%	NS	-17%	-87%	-19%	NS	-19%	-15%	-87%	35%

Unsaturated tailings kinetic test statistics summary

	Cycle	pH	Cond.	Acidity	Alkalinity	Sulphate	Cl	F	Br	Hardness	Al	Sb	As	Ba	Be	Bi
			umhos/cm													
Col 6																
Mean used in source term	28 - 30	7.8E+00	2.6E+02	5.6E-01	6.5E+00	1.8E+00	4.2E-02	2.4E-02	1.8E-02	7.5E+00	6.9E-04	9.1E-04	1.4E-04	4.6E-03	1.2E-06	6.0E-07
22°C Median	60 - 80	8.0E+00	2.4E+02	3.7E-01	6.9E+00	1.0E+00	2.4E-02	1.3E-02	1.8E-02	7.6E+00	4.4E-04	5.3E-04	6.8E-05	5.7E-03	1.2E-06	5.9E-07
Relative Difference		2%	-6%	-30%	5%	-40%	NS	NS	1%	1%	-30%	-35%	-52%	16%	NS	NS
T4																
Median used in source term	149 - 173	7.52	1.7E+02	2.7E+00	2.1E+01	2.2E+01	5.0E-02	5.0E-02		3.9E+01	1.4E-02	2.6E-04	5.1E-04	3.9E-02	4.5E-06	2.3E-06
22°C Median	209 - 220	7.72	2.2E+02	1.7E+00	1.6E+01	2.5E+01	5.0E-02	5.0E-02		4.3E+01	8.0E-03	1.6E-04	3.5E-04	2.8E-02	4.4E-06	2.2E-06
Relative Difference		2%	20%	-36%	-17%	11%	NS	NS		NS	NS	NS	NS	NS	NS	NS
4°C Median	227 - 243	7.66	8.6E+01	2.4E+00	1.5E+01	4.6E+00	3.9E-02	3.9E-02		2.1E+01	6.1E-03	9.0E-05	2.5E-04	3.2E-02	4.7E-06	2.4E-06
4°C/22°C Current		1.0	0.4	1.4	0.9	0.2	NS	NS		0.5	0.8	NS	NS	1.1	NS	NS
T7																
Mean used in source term	15 - 17	7.63	1.9E+02	3.7E+00	3.2E+01	1.2E+01	2.1E-01	1.8E-01	1.3E-01	3.6E+01	9.5E-03	1.4E-03	#N/A	3.0E-02	8.5E-06	4.3E-06
22°C Median	57 - 77	7.91	1.7E+02	1.9E+00	3.6E+01	3.9E+00	2.2E-01	8.0E-02	1.3E-01	3.7E+01	5.3E-03	5.2E-04	NA	6.6E-02	3.1E-06	3.1E-06
Relative Difference		3%	-8%	-47%	9%	-75%	NS	NS	NS	1%	-37%	-65%	NA	62%	NS	NS

Unsaturated tailings kinetic test statistics summary

	Cycle	B	Cd	Ca	Cr	Co	Cu	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se
Col 6																		
Mean used in source term	28 - 30	6.2E-04	5.2E-06	2.5E+00	3.0E-05	1.3E-05	2.6E-04	1.8E-04	7.1E-06	6.0E-05	2.7E-01	3.1E-03	6.0E-07	3.3E-03	3.0E-05	3.2E-03	4.9E-01	4.7E-05
22°C Median	60 - 80	4.9E-04	6.8E-06	2.5E+00	3.0E-05	2.3E-05	4.7E-04	1.8E-04	1.8E-06	6.0E-05	3.0E-01	4.1E-03	6.0E-07	9.4E-04	4.1E-05	2.1E-03	1.9E-01	3.4E-05
Relative Difference		-16%	20%	0%	NS	46%	51%	NS	-107%	NS	7%	20%	NS	-67%	33%	NS	-53%	-23%
T4																		
Median used in source term	149 - 173	2.3E-02	4.5E-06	8.8E+00	4.5E-05	8.7E-06	4.4E-04	1.0E-03	5.5E-06	2.3E-04	3.8E+00	1.8E-03	4.5E-06	3.0E-03	3.8E-05	2.0E-02	3.1E-01	2.1E-04
22°C Median	209 - 220	2.2E-02	4.8E-06	9.7E+00	4.4E-05	1.1E-05	3.3E-04	4.5E-04	4.8E-06	2.2E-04	4.6E+00	4.1E-03	4.4E-06	1.3E-03	2.7E-05	1.4E-02	3.3E-01	1.3E-04
Relative Difference		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
4°C Median	227 - 243	2.3E-02	2.4E-06	4.7E+00	4.7E-05	6.9E-06	1.8E-04	1.4E-03	4.2E-06	2.4E-04	2.2E+00	5.0E-03	4.7E-06	3.1E-04	3.5E-05	1.7E-02	1.7E-01	4.1E-05
4°C/22°C Current		1.1	NS	0.5	NS	0.6	NS	NS	NS	NS	0.5	1.2	NS	0.2	NS	NS	0.5	NS
T7																		
Mean used in source term	15 - 17	3.7E-03	6.1E-06	1.2E+01	2.1E-04	3.7E-05	2.6E-04	1.7E-03	8.5E-06	4.3E-04	1.4E+00	3.5E-03	4.3E-06	1.2E-02	1.1E-04	6.8E-03	2.9E+00	1.7E-04
22°C Median	57 - 77	2.2E-03	4.7E-06	1.2E+01	3.0E-05	3.1E-05	3.0E-04	8.9E-04	8.7E-06	3.2E-04	1.8E+00	3.9E-04	4.4E-06	4.7E-02	1.2E-04	4.0E-03	8.1E-01	1.1E-04
Relative Difference		-35%	NS	-3%	NS	-13%	NS	NS	NS	NS	18%	-96%	NS	107%	NS	NS	-67%	-36%

Unsaturated tailings kinetic test statistics summary

	Cycle	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Median	Mean	Min	Max
Col 6																	
Mean used in source term	28 - 30	1.7E-01	6.0E-07	2.3E-02	2.1E-02	6.3E-01	1.5E-06	6.0E-04	6.0E-06	1.3E-03	2.8E-05	9.0E-05	9.0E-07				
22°C Median	60 - 80	1.6E-01	5.9E-07	1.5E-02	2.1E-02	4.3E-01	1.2E-06	2.2E-04	6.6E-06	1.2E-03	2.7E-05	1.2E-04	6.0E-07				
Relative Difference		-7%	NS	-28%	0%	-25%	NS	-57%	NS	-6%	-2%	NS	NS	-7%	-14%	-107%	51%
T4																	
Median used in source term	149 - 173	6.8E-01	2.3E-06	2.8E-02	9.6E-03	7.2E+00	3.6E-06	1.6E-03	2.3E-04	8.3E-04	1.9E-04	4.7E-04	4.5E-05				
22°C Median	209 - 220	6.5E-01	2.2E-06	3.9E-02	7.3E-03	9.9E+00	2.6E-06	1.8E-03	2.2E-04	6.1E-04	1.6E-04	2.9E-04	4.4E-05				
Relative Difference		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	-17%	-14%	-36%	11%
4°C Median	227 - 243	3.6E-01	2.4E-06	2.4E-02	4.0E-03	2.0E+00	1.9E-06	2.1E-03	2.4E-04	1.5E-04	1.1E-04	4.2E-04	4.7E-05				
4°C/22°C Current		0.6	NS	NS	0.6	0.2	NS	1.2	NS	0.2	0.7	NS	NS	0.6	0.7	0.2	1.4
T7																	
Mean used in source term	15 - 17	2.1E+00	4.3E-06	1.4E-01	7.6E-02	4.2E+00	8.5E-06	1.5E-02	6.4E-05	4.1E-03	9.4E-05	4.3E-04	4.3E-06				
22°C Median	57 - 77	5.7E-01	1.3E-06	7.0E-02	5.6E-02	1.6E+00	3.9E-06	5.1E-04	3.0E-05	2.7E-03	6.4E-05	4.4E-04	8.7E-04				
Relative Difference		-69%	NS	-46%	-20%	-55%	NS	-101%	NS	-27%	-35%	NS	NS	-36%	-29%	-101%	107%

Unsaturated waste rock kinetic test temperature sensitivity assessment

	Cycle	pH	Cond.	Acidity	Alk.	SO4	Cl	F	Br	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca
Col 2A																		
Temperature change to 4°C on 5-Mar-14, cycle 215																		
22°C Median	196 - 214	5.66	23.53	0.24	0.04	0.41	1.2E-02	3.5E-03	1.8E-02	3.7E-03	3.0E-05	1.2E-05	6.8E-03	1.8E-06	5.9E-07	7.3E-04	6.4E-06	9.1E-02
4°C Median	223 - 239	6.39	1.2E+01	3.1E-01	1.3E-01	0.25	1.1E-02	3.5E-03	1.7E-02	1.6E-03	1.5E-05	1.1E-05	4.3E-03	4.1E-07	3.9E-07	1.8E-04	3.2E-06	5.5E-02
4°C/22°C		1.1	0.5	1.3	NS	0.6	NS	NS	NS	0.4	NS	NS	0.6	NS	NS	0.2	0.5	0.6
HC3																		
Temperature change to 4°C on 4-Jun-13, cycle 79																		
22°C Median	69-79	7.57	60.66	1.88	6.08	6.59	9.0E-02	2.7E-02	1.4E-01	7.7E-03	9.0E-05	9.0E-05	1.3E-03	9.0E-06	4.5E-06	7.4E-04	5.4E-06	2.9E+00
4°C Median	101-117	7.69	28.91	0.84	5.47	1.90	9.6E-02	2.9E-02	1.4E-01	2.9E-03	9.6E-05	9.6E-05	1.3E-03	9.6E-06	4.8E-06	6.2E-04	2.9E-06	1.8E+00
4°C/22°C		1.0	0.5	0.4	0.9	0.3	NS	NS	NS	0.4	NS	NS	1.0	NS	NS	0.8	NS	0.6
HC4																		
Temperature change to 4°C on 4-Jun-13, cycle 79																		
22°C Median	69-79	7.56	92.14	1.90	12.31	11.50	9.0E-02	2.7E-02	1.4E-01	1.1E-02	7.4E-04	1.8E-04	5.4E-03	9.0E-06	4.5E-06	1.0E-03	1.4E-06	7.1E+00
4°C Median	101-117	7.73	56.68	0.84	12.25	1.90	9.7E-02	2.9E-02	1.5E-01	4.6E-03	3.3E-04	9.7E-05	5.6E-03	9.7E-06	4.9E-06	7.3E-04	1.5E-06	4.4E+00
4°C/22°C		1.0	0.6	0.4	1.0	0.2	NS	NS	NS	0.4	NS	NS	1.0	NS	NS	0.7	NS	0.6
HC5																		
Temperature change to 4°C on 4-Jun-13, cycle 79																		
22°C Median	69-79	7.58	67.40	1.80	10.44	6.30	8.8E-02	6.8E-02	1.3E-01	1.4E-02	8.8E-05	8.8E-05	2.2E-03	8.8E-06	4.4E-06	7.5E-04	1.8E-06	3.9E+00
4°C Median	101-117	7.67	47.25	0.82	10.76	1.96	9.7E-02	2.9E-02	1.5E-01	4.0E-03	9.7E-05	9.7E-05	2.0E-03	9.7E-06	4.9E-06	6.8E-04	1.5E-06	3.2E+00
4°C/22°C		1.0	0.70	0.45	1.03	0.31	NS	NS	NS	0.3	NS	NS	0.9	NS	NS	0.9	NS	0.8
HC6																		
Temperature change to 4°C on 4-Jun-13, cycle 79																		
22°C Median	69-79	7.51	34.56	1.82	5.96	2.67	8.9E-02	2.7E-02	1.3E-01	1.5E-02	8.9E-05	1.4E-04	1.9E-03	8.9E-06	4.5E-06	5.7E-04	2.7E-06	2.3E+00
4°C Median	101-117	7.53	24.83	0.82	5.80	1.46	9.7E-02	2.9E-02	1.5E-01	4.2E-03	9.7E-05	9.7E-05	1.7E-03	9.7E-06	4.9E-06	6.9E-04	1.5E-06	2.3E+00
4°C/22°C		1.0	0.72	0.45	0.97	0.54	NS	NS	NS	0.3	NS	NS	0.9	NS	NS	1.2	NS	1.0
H7																		
Temperature change to 4°C on 4-Jun-13, cycle 79																		
22°C Median	69-79	7.40	75.89	1.84	5.01	10.44	8.9E-02	2.7E-02	1.3E-01	1.3E-02	3.6E-04	8.3E-04	6.0E-03	8.9E-06	4.5E-06	6.7E-04	3.0E-06	5.1E+00
4°C Median	101-117	7.46	34.68	0.89	5.21	2.88	9.8E-02	2.9E-02	1.5E-01	5.4E-03	1.4E-04	3.8E-04	7.1E-03	9.8E-06	4.9E-06	6.4E-04	1.9E-06	2.9E+00
4°C/22°C		1.0	0.46	0.48	1.04	0.28	NS	NS	NS	0.4	NS	0.5	1.2	NS	NS	1.0	NS	0.6
HC8																		
Temperature change to 4°C on 4-Jun-13, cycle 79																		
22°C Median	105-118	2.91			NA	80.84	4.4E-01	2.8E-02	1.4E-01	2.1E+00	9.3E-05	1.0E-03	1.0E-03	1.2E-04	4.7E-06	4.8E-04	1.7E-04	4.1E-01
4°C Median	119-121	3.18			NA	80.84	4.4E-01	2.8E-02	1.4E-01	2.1E+00	9.3E-05	1.0E-03	1.0E-03	1.2E-04	4.7E-06	4.8E-04	1.7E-04	4.1E-01
4°C/22°C		1.16	NS	NS	NA	0.23	NS	NS	NS	0.09	NS	0.09	0.61	0.09	NS	2.05	0.15	0.19
HC10																		
Temperature change to 4°C on 4-Jun-13, cycle 79																		
22°C Median	65-78	3.24	413.74	53.03	NA	56.25	4.5E-01	1.8E-01	1.4E-01	5.2E+00	1.4E-04	5.0E-04	2.5E-03	2.9E-04	4.5E-06	5.0E-04	5.2E-04	3.2E-01
4°C Median	125-143	3.74		10.42	NA	6.72	9.6E-02	2.9E-02	1.4E-01	3.2E-01	1.9E-04	1.4E-04	3.2E-03	2.1E-05	3.4E-06	7.1E-04	7.4E-05	7.1E-02
4°C/22°C		1.15		0.20	NA	0.12	NS	NS	NS	0.06	NS	NS	1.31	NS	NS	1.44	0.14	0.22
HC11																		
Temperature change to 4°C on 4-Jun-13, cycle 79																		
22°C Median	69-79	6.82	54.64	2.02	6.95	4.40	8.8E-02	4.4E-02	1.3E-01	1.3E-02	6.8E-04	3.5E-04	1.0E-02	8.8E-06	4.4E-06	5.7E-04	1.8E-06	3.4E+00
4°C Median	101-117	7.14	36.41	1.07	7.56	1.94	9.7E-02	2.9E-02	1.5E-01	6.0E-03	3.3E-04	9.7E-05	1.4E-02	9.7E-06	4.9E-06	5.3E-04	1.5E-06	3.0E+00
4°C/22°C		1.0	0.67	0.53	1.09	NS	NS	NS	NS	0.5	NS	NS	1.4	NS	NS	0.9	NS	0.9
HC12																		
Temperature change to 4°C on 4-Mar-14, cycle 118																		
22°C Median	105 -118	3.41	NA		NA	18.70	9.0E-02	7.7E-02	1.3E-01	1.5E+00	8.7E-05	8.7E-05	2.8E-04	1.0E-04	4.4E-06	7.2E-04	2.5E-04	4.2E-01
4°C Median	125-143	3.69	NA		NA	6.90	9.0E-02	2.7E-02	1.4E-01	3.5E-01	9.0E-05	9.0E-05	4.5E-04	1.9E-05	3.2E-06	6.8E-04	5.9E-05	7.7E-02
4°C/22°C		1.0	NA	NS	NS	0.37	NS	NS	NS	0.3	NS	NS	1.6	0.2	NS	0.9	0.2	0.2

Notes:
Units in mg/kg; Alk. = Alkalinity as $CaCC_3$.
2. Values in Blue represent elements that were consistently below detection.
3. "NS" means difference is Not Significant because both medians are less than 5 x's the reporting limit; gray shading + italic text indicates analyte concentrations that are within 5 x's the reporting limit.
4. Highlighted cells indicate an increase in dissolved metal/metaloid production rate at 4°C.

Unsaturated waste rock kinetic test temperature sensitivity assessment

	Cycle	Cr	Co	Cu	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na
Col 2A																		
Temperature change to 4°C on 5-M																		
22°C Median	196 - 214	3.0E-05	1.2E-04	3.8E-03	4.2E-04	5.0E-06	5.9E-05	1.6E-02	2.0E-03	5.9E-07	1.9E-05	2.8E-05	5.3E-04	5.2E-02	2.0E-05	6.3E-01	1.2E-06	6.0E-02
4°C Median	223 - 239	3.2E-06	6.7E-05	1.9E-03	1.2E-04	2.2E-06	1.3E-05	8.9E-03	1.1E-03	5.6E-07	1.9E-05	1.5E-05	5.6E-04	2.1E-02	1.1E-05	2.4E-01	5.0E-07	2.7E-02
4°C/22°C		NS	0.6	0.5	NS	NS	NS	0.6	0.6	NS	1.0	NS	NS	0.4	NS	0.4	NS	0.5
HC3																		
Temperature change to 4°C on 4-Ju																		
22°C Median	69-79	2.3E-04	2.5E-05	5.0E-04	1.4E-03	9.0E-06	4.5E-04	9.5E-01	6.5E-03	4.5E-06	1.2E-03	1.4E-04	4.1E-03	1.8E-01	2.3E-05	1.4E-01	4.5E-06	4.5E-02
4°C Median	101-117	2.4E-04	2.4E-05	2.9E-04	1.4E-03	9.6E-06	4.8E-04	5.0E-01	8.6E-03	4.8E-06	2.7E-04	4.8E-05	4.3E-03	7.5E-02	1.9E-05	5.7E-02	4.8E-06	9.6E-03
4°C/22°C		NS	1.0	0.6	NS	NS	NS	0.5	1.3	NS	0.2	NS	NS	0.4	NS	0.4	NS	0.2
HC4																		
Temperature change to 4°C on 4-Ju																		
22°C Median	69-79	2.3E-04	9.8E-06	4.5E-04	1.4E-03	9.2E-06	4.5E-04	7.5E-01	7.2E-04	4.5E-06	1.2E-03	4.7E-05	4.1E-03	5.9E-01	2.4E-04	2.6E-01	4.5E-06	5.0E-02
4°C Median	101-117	2.4E-04	8.7E-06	3.4E-04	1.5E-03	9.7E-06	4.9E-04	4.1E-01	8.3E-04	4.9E-06	1.8E-04	4.9E-05	4.4E-03	2.4E-01	8.2E-05	1.3E-01	4.9E-06	9.7E-03
4°C/22°C		NS	0.9	0.8	NS	NS	NS	0.6	1.2	NS	0.1	NS	NS	0.4	NS	0.5	NS	0.2
HC5																		
Temperature change to 4°C on 4-Ju																		
22°C Median	69-79	2.2E-04	1.3E-05	2.3E-04	1.3E-03	8.8E-06	4.4E-04	1.1E+00	1.6E-03	4.4E-06	2.5E-03	4.5E-05	4.1E-03	3.0E-01	3.1E-05	1.1E-01	4.4E-06	6.8E-02
4°C Median	101-117	2.4E-04	1.2E-05	2.4E-04	1.5E-03	9.7E-06	4.9E-04	6.8E-01	2.3E-03	4.9E-06	5.8E-04	4.9E-05	4.4E-03	1.3E-01	1.9E-05	6.4E-02	4.9E-06	1.9E-02
4°C/22°C		NS	1.0	1.1	NS	NS	NS	0.6	1.4	NS	0.2	NS	NS	0.4	NS	0.6	NS	0.3
HC6																		
Temperature change to 4°C on 4-Ju																		
22°C Median	69-79	2.2E-04	1.0E-05	7.0E-04	4.5E-03	1.3E-05	4.5E-04	1.8E-01	9.3E-04	4.5E-06	6.3E-04	4.5E-05	4.0E-03	3.5E-01	1.8E-05	2.0E-01	4.5E-06	2.2E-02
4°C Median	101-117	2.4E-04	8.8E-06	2.8E-04	1.5E-03	9.7E-06	4.9E-04	1.5E-01	1.0E-03	4.9E-06	1.7E-04	4.9E-05	4.4E-03	1.9E-01	1.9E-05	1.1E-01	4.9E-06	5.0E-03
4°C/22°C			0.9	0.4	NS	NS	NS	0.8	1.1	NS	0.3	NS	NS	0.5	NS	0.5	NS	0.2
H7																		
Temperature change to 4°C on 4-Ju																		
22°C Median	69-79	2.2E-04	4.0E-05	1.1E-03	1.3E-03	9.2E-06	4.5E-04	2.9E-01	5.9E-03	4.5E-06	2.0E-03	4.5E-05	1.7E-02	2.1E-01	3.2E-04	9.8E-02	4.5E-06	2.2E-02
4°C Median	101-117	2.5E-04	3.1E-05	8.4E-04	1.5E-03	9.8E-06	4.9E-04	1.4E-01	6.0E-03	5.0E-06	5.7E-04	4.9E-05	7.5E-03	8.8E-02	1.1E-04	5.3E-02	4.9E-06	4.9E-03
4°C/22°C			0.8	0.8	NS	NS	NS	0.5	1.0	NS	0.3	NS	NS	0.4	0.4	0.5	NS	0.2
HC8																		
Temperature change to 4°C on 4-Ju																		
22°C Median	105-118	1.5E-03	6.1E-03	4.0E-01	2.0E+01	1.4E-05	4.7E-04	3.7E-02	2.6E-02	4.7E-06	4.2E-04	6.4E-03	1.8E-01	8.8E-02	2.5E-04	4.5E-01	8.7E-05	2.2E-02
4°C Median	119-121	1.5E-03	6.1E-03	4.0E-01	2.0E+01	1.4E-05	4.7E-04	3.7E-02	2.6E-02	4.7E-06	4.2E-04	6.4E-03	1.8E-01	8.8E-02	2.5E-04	4.5E-01	8.7E-05	2.2E-02
4°C/22°C		0.08	0.24	0.23	0.21	NS	NS	0.07	0.20	NS	0.21	0.23	0.05	0.32	0.21	0.17	0.05	NS
HC10																		
Temperature change to 4°C on 4-Ju																		
22°C Median	65-78	1.2E-03	1.4E-02	1.2E+00	3.2E+00	8.7E-05	9.2E-04	4.1E-01	2.7E-02	4.5E-06	7.4E-05	7.2E-03	4.1E-03	6.8E-02	3.7E-04	6.1E-01	1.4E-05	2.3E-02
4°C Median	125-143	9.3E-05	1.9E-03	2.0E-01	9.6E-01	2.0E-05	9.0E-05	3.5E-02	3.3E-03	4.8E-06	3.9E-05	7.7E-04	4.4E-03	2.9E-02	7.8E-05	2.2E-01	3.9E-06	1.5E-02
4°C/22°C		NS	0.14	0.17	0.30	0.22	NS	0.09	0.12	NS	0.53	0.11	NS	0.42	0.21	0.36	NS	NS
HC11																		
Temperature change to 4°C on 4-Ju																		
22°C Median	69-79	2.3E-04	2.9E-05	8.8E-04	1.8E-03	1.3E-05	4.4E-04	2.9E-01	4.4E-04	4.4E-06	7.5E-04	4.5E-05	4.0E-03	3.9E-01	1.2E-04	2.8E-01	4.5E-06	3.4E-02
4°C Median	101-117	2.4E-04	2.8E-05	7.8E-04	1.5E-03	9.7E-06	4.9E-04	2.3E-01	8.7E-04	4.9E-06	5.8E-05	4.9E-05	4.4E-03	2.1E-01	4.8E-05	1.5E-01	4.9E-06	1.4E-02
4°C/22°C		1.0	1.0	0.9	NS	NS	NS	0.8	2.0	NS	0.1	NS	NS	0.5	NS	0.5	NS	0.4
HC12																		
Temperature change to 4°C on 4-M																		
22°C Median	105 -118	6.2E-04	3.4E-03	3.6E-01	1.8E+00	1.7E-05	8.2E-04	3.4E-02	3.5E-03	4.4E-06	4.5E-06	5.5E-04	4.1E-03	8.2E-02	3.1E-04	2.3E-01	4.4E-06	1.6E-02
4°C Median	125-143	1.2E-04	1.0E-03	1.0E-01	9.9E-01	3.5E-05	7.8E-05	3.3E-03	1.3E-03	4.5E-06	8.8E-06	1.4E-04	4.1E-03	2.2E-02	1.0E-04	8.8E-02	1.6E-06	9.5E-03
4°C/22°C		NS	0.3	0.3	0.6	NS	NS	0.1	0.4	NS	NS	NS	NS	0.3	0.3	0.4	NS	NS

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Unsaturated waste rock kinetic test temperature sensitively assessment

	Cycle	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	median	geometric mean	arithmatic mean	min	max
Col 2A															
Temperature change to 4°C on 5-M															
22°C Median	196 - 214	1.1E-03	1.7E-01	1.2E-06	4.2E-05	5.9E-06	2.3E-06	3.9E-06	5.4E-04	1.1E-04					
4°C Median	223 - 239	7.4E-04	8.2E-02	2.9E-07	3.0E-05	7.8E-06	8.2E-07	1.5E-06	3.4E-04	1.1E-04					
4°C/22°C		0.7	0.5	NS	0.7	NS	0.4	NS	0.6	NS	0.6	0.6	0.6	0.2	1.3
HC3															
Temperature change to 4°C on 4-Ju															
22°C Median	69-79	6.6E-03	2.5E+00	9.0E-06	6.5E-05	4.5E-05	2.9E-03	2.7E-05	4.5E-04	4.5E-06					
4°C Median	101-117	4.3E-03	5.8E-01	9.6E-06	9.1E-05	4.8E-05	2.3E-03	1.5E-05	4.8E-04	4.8E-06					
4°C/22°C		0.7	0.2	NS	1.4	NS	0.8	NS	NS	NS	0.6	0.6	0.7	0.2	1.4
HC4															
Temperature change to 4°C on 4-Ju															
22°C Median	69-79	8.6E-02	3.5E+00	9.0E-06	3.7E-05	4.5E-05	4.8E-03	9.3E-05	4.7E-04	4.5E-06					
4°C Median	101-117	4.8E-02	6.5E-01	9.7E-06	3.8E-04	4.9E-05	3.8E-03	3.4E-05	4.9E-04	4.9E-06					
4°C/22°C		0.6	0.2	NS	NS	NS	0.8	NS	NS	NS	0.6	0.5	0.6	0.1	1.2
HC5															
Temperature change to 4°C on 4-Ju															
22°C Median	69-79	9.0E-02	2.1E+00	8.8E-06	2.6E-05	4.4E-05	3.6E-04	1.8E-05	4.5E-04	4.4E-06					
4°C Median	101-117	6.4E-02	6.1E-01	9.7E-06	6.7E-05	4.9E-05	2.9E-04	1.5E-05	4.9E-04	4.9E-06					
4°C/22°C		0.7	0.3	NS	2.5	NS	0.8	NS	NS	NS	0.7	0.6	0.8	0.2	2.5
HC6															
Temperature change to 4°C on 4-Ju															
22°C Median	69-79	5.1E-03	7.8E-01	8.9E-06	1.7E-05	1.7E-04	4.2E-04	4.7E-05	4.5E-04	8.6E-06					
4°C Median	101-117	4.7E-03	2.9E-01	9.7E-06	7.5E-05	4.9E-05	6.3E-04	1.5E-05	4.9E-04	4.9E-06					
4°C/22°C		0.9	0.4	NS	4.3	NS	1.5	NS	1.1	NS	0.9	0.7	0.9	0.2	4.3
H7															
Temperature change to 4°C on 4-Ju															
22°C Median	69-79	5.9E-02	3.4E+00	8.9E-06	2.2E-05	4.5E-05	4.9E-04	2.7E-05	4.5E-04	4.6E-06					
4°C Median	101-117	4.2E-02	9.6E-01	9.8E-06	4.6E-04	4.9E-05	4.6E-04	1.5E-05	4.9E-04	4.9E-06					
4°C/22°C		0.7	0.3	NS	21.0	NS	1.1	NS	1.1	NS	0.6	0.7	1.5	0.2	21.0
HC8															
Temperature change to 4°C on 4-Ju															
22°C Median	105-118	2.9E-03	2.8E+01	9.3E-06	3.0E-05	2.4E-04	1.0E-02	7.7E-04	1.5E-02	8.6E-06					
4°C Median	119-121	2.9E-03	2.8E+01	9.3E-06	3.0E-05	2.4E-04	1.0E-02	7.7E-04	1.5E-02	8.6E-06					
4°C/22°C		0.23	0.24	NS	2.50	0.10	0.09	0.02	0.23	NS	0.21	0.19	0.36	0.02	2.50
HC10															
Temperature change to 4°C on 4-Ju															
22°C Median	65-78	3.0E-03	1.6E+01	1.8E-05	1.4E-05	4.5E-05	1.1E-02	1.2E-04	1.0E-01	1.8E-05					
4°C Median	125-143	1.6E-03	2.9E+00	6.2E-06	3.6E-04	2.4E-05	9.3E-04	1.9E-05	1.4E-02	9.6E-04					
4°C/22°C		0.55	0.18	NS	NS	NS	0.09	NS	0.14	NS	0.2	0.2	0.4	0.1	1.4
HC11															
Temperature change to 4°C on 4-Ju															
22°C Median	69-79	1.6E-02	1.4E+00	8.8E-06	1.3E-05	2.6E-04	1.9E-03	7.8E-05	4.5E-04	4.4E-06					
4°C Median	101-117	1.3E-02	5.2E-01	9.7E-06	1.0E-03	4.9E-05	2.0E-03	1.9E-05	4.9E-04	4.9E-06					
4°C/22°C		0.8	0.4	NS	78.6	1.1	1.1	0.2	NS	NS	0.9	0.8	4.2	0.1	78.6
HC12															
Temperature change to 4°C on 4-M															
22°C Median	105 -118	2.5E-03	8.2E+00	8.7E-06	3.6E-05	4.4E-05	5.0E-03	1.6E-05	2.2E-02	4.4E-06					
4°C Median	125-143	9.7E-04	3.0E+00	2.3E-06	4.3E-04	2.3E-05	1.0E-03	4.6E-06	6.2E-03	9.0E-04	median	geometric mean	arithmatic mean	min	max
4°C/22°C		0.4	0.4	NS	12.0	NS	0.2	NS	0.3	NS	0.3	0.4	1.0	0.1	12.0

Appendix C: Kinetic Test Data Tables

CASiNO

Saturated column kentic test results

ID	Date	cycle	Flow Between Events	pH	Cond-L	T-Alk	SO4	D-Cl	D-F	D-Br	NH3	NO2-N	NO3-N	DOC	D-Sulphide	D-Al	D-Sb	D-As	D-Ba	D-Be	D-Bi	D-B	D-Cd	D-Ca
			mL	pH	uS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Sat Col 10	19/Aug/11	0	110	7.21	3.8E+02	3.7E+01	1.1E+02	1.9E+01	2.1E-02	5.0E-02	<0.13	1.0E-03	5.0E-03	4.7E+00	5.0E-03	1.6E-01	1.2E-03	1.9E-03	3.9E-02	1.0E-05	5.0E-06	4.1E-02	2.0E-03	5.0E+01
Sat Col 10	26/Aug/11	1	775	7.89	4.7E+02	4.7E+01	1.3E+02	2.5E+01	2.1E-02	2.6E+00	5.0E-02	1.0E-03	5.0E-03	4.5E+00	5.0E-03	1.3E-01	1.3E-03	2.3E-03	4.5E-02	1.0E-05	5.0E-06	4.6E-02	2.8E-03	6.2E+01
Sat Col 10	8/Sep/11	3	1431	7.84	4.3E+02	5.2E+01	1.3E+02	1.9E+01	2.1E-02	1.2E+00	5.0E-03	1.0E-03	5.0E-03	5.8E+00	5.0E-03	2.0E-01	1.4E-03	2.6E-03	4.0E-02	1.0E-05	5.0E-06	6.2E-02	3.4E-03	5.8E+01
Sat Col 10	15/Sep/11	4	749	7.63	3.8E+02	4.0E+01	1.2E+02	1.1E+01	2.1E-02	9.8E-01	5.0E-03	1.0E-03	5.0E-03	4.2E+00	5.0E-03	2.1E-01	1.5E-03	2.7E-03	3.6E-02	1.0E-05	5.0E-06	4.6E-02	3.2E-03	4.7E+01
Sat Col 10	23/Sep/11	5	856	7.93	3.4E+02	5.3E+01	1.0E+02	5.9E+00	2.0E-02	4.8E-01	5.0E-03	1.0E-03	5.0E-03		5.0E-03	2.0E-01	1.5E-03	2.6E-03	3.4E-02	1.0E-04	5.0E-04	4.9E-02	3.4E-03	4.5E+01
Sat Col 10	29/Sep/11	6	1037	8.08	2.8E+02	4.3E+01	8.2E+01	3.4E+00	2.3E-02	2.0E-01	5.3E-03	1.0E-03	5.0E-03	2.9E+00	5.0E-03	2.2E-01	1.6E-03	2.9E-03	3.5E-02	1.0E-05	5.0E-06	4.1E-02	3.1E-03	3.3E+01
Sat Col 10	13/Oct/11	8	2447	8.01	2.2E+02	4.4E+01	5.5E+01	1.2E+00	2.4E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	2.1E+00	5.0E-03	2.1E-01	1.6E-03	3.1E-03	4.5E-02	1.0E-05	5.0E-06	4.3E-02	2.7E-03	2.7E+01
Sat Col 10	27/Oct/11	10	2414	8.26	1.6E+02	4.8E+01	3.2E+01	5.0E-01	2.5E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	1.4E+00	5.0E-03	2.3E-01	1.7E-03	3.2E-03	5.8E-02	1.0E-05	5.0E-06	4.1E-02	2.1E-03	2.1E+01
Sat Col 10	10/Nov/11	12	2450	8.19	1.3E+02	4.4E+01	2.1E+01	5.0E-01	3.0E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	1.3E+00	5.0E-03	2.6E-01	1.7E-03	3.7E-03	7.3E-02	1.0E-05	5.0E-06	2.9E-02	1.4E-03	1.7E+01
Sat Col 10	25/Nov/11	14	2617	8.04	1.2E+02	5.0E+01	1.7E+01	5.0E-01	2.8E-02	5.0E-02	5.3E-03	1.0E-03	5.0E-03	9.1E-01	2.0E-03	2.2E-01	1.6E-03	3.3E-03	8.9E-02	1.0E-05	5.0E-06	2.4E-02	1.0E-03	1.6E+01
Sat Col 10	8/Dec/11	16	1298	8.13	1.1E+02	4.4E+01	1.4E+01	5.0E-01	2.8E-02	5.0E-02	5.0E-03	1.0E-03	5.2E-03	7.5E-01	5.0E-03	2.6E-01	1.5E-03	3.4E-03	9.3E-02	1.0E-05	5.0E-06	2.2E-02	7.7E-04	1.5E+01
Sat Col 10	23/Dec/11	18	1441	7.50	1.2E+02	4.3E+01	1.4E+01	5.0E-01	2.5E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	5.6E-01	5.0E-03	2.2E-01	1.5E-03	3.2E-03	9.6E-02	1.0E-05	5.0E-06	2.1E-02	7.4E-04	1.6E+01
Sat Col 10	5/Jan/12	20	1371	7.70	1.2E+02	4.9E+01	1.3E+01	5.0E-01	2.4E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	1.1E+00	5.0E-03	2.2E-01	1.5E-03	3.2E-03	1.1E-01	1.0E-05	5.0E-06	1.9E-02	6.2E-04	1.7E+01
Sat Col 10	19/Jan/12	22	2213				1.3E+01	7.0E-01	2.5E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	1.7E+00	5.0E-03	2.1E-01	1.5E-03	3.4E-03	1.1E-01	1.0E-05	5.0E-06	1.9E-02	5.7E-04	1.7E+01
Sat Col 10	3/Feb/12	24	3167				9.9E+00	5.0E-01	2.9E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	7.9E-01	5.0E-03	2.4E-01	1.3E-03	3.3E-03	1.1E-01	1.0E-05	5.0E-06	1.3E-02	3.6E-04	1.5E+01
Sat Col 10	16/Feb/12	26	2641				8.9E+00	5.0E-01	2.6E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	1.2E+00	5.0E-03	2.4E-01	1.1E-03	2.8E-03	1.1E-01	1.0E-05	5.0E-06	9.7E-03	2.2E-04	1.4E+01
Sat Col 10	2/Mar/12	28	3076				1.1E+01	5.0E-01	2.3E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	6.6E-01	5.0E-03	1.9E-01	1.5E-03	3.0E-03	1.3E-01	1.0E-05	5.0E-06	1.3E-02	2.9E-04	1.7E+01
Sat Col 10	16/Mar/12	30	2740				1.0E+01	5.0E-01	2.3E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	1.3E+00	5.0E-03	1.7E-01	1.4E-03	2.9E-03	1.2E-01	1.0E-05	5.0E-06	1.1E-02	2.3E-04	1.7E+01
Sat Col 10	30/Mar/12	32	427				1.1E+01	5.0E-01	2.2E-02	5.0E-02	9.5E-03	1.0E-03	5.0E-03	8.7E-01	5.0E-03	1.6E-01	1.4E-03	3.0E-03	1.5E-01	1.0E-05	5.0E-06	1.4E-02	3.2E-04	1.8E+01
Sat Col 10	13/Apr/12	34	461				1.2E+01	5.0E-01	2.3E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	1.4E+00	5.0E-03	2.6E-01	1.5E-03	3.3E-03	1.7E-01	1.3E-05	3.6E-05	1.7E-02	3.4E-04	2.0E+01
Sat Col 10	25/Apr/12	36	416				7.7E+00	5.0E-01	2.5E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	1.4E+00	5.0E-03	1.5E-01	8.7E-04	2.2E-03	1.2E-01	1.0E-05	5.0E-06	7.6E-03	5.3E-05	1.5E+01
Sat Col 10	11/May/12	38	487				8.2E+00	5.3E-01	2.3E-02	5.0E-02	7.4E-03	1.0E-03	5.0E-03	7.2E-01	5.0E-03	1.2E-01	9.1E-04	2.2E-03	1.6E-01	1.0E-05	5.0E-06	8.7E-03	<0.000065	1.7E+01
Sat Col 10	25/May/12	40	453				7.6E+00	5.1E-01	2.5E-02	5.0E-02	5.0E-03	1.0E-03	5.9E-03	1.1E+00	5.0E-03	1.3E-01	8.6E-04	2.2E-03	1.4E-01	1.0E-05	5.0E-06	8.5E-03	5.9E-05	1.7E+01
Sat Col 10	8/Jun/12	42	452				6.9E+00	5.4E-01	2.3E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	5.0E-01	5.0E-03	1.0E-01	8.7E-04	2.1E-03	1.5E-01	1.0E-05	5.0E-06	8.9E-03	7.1E-05	1.6E+01
Sat Col 10	22/Jun/12	44	427				6.6E+00	5.5E-01	2.3E-02	5.0E-02	7.2E-03	1.0E-03	5.6E-03	1.4E+00	5.7E-03	1.1E-01	9.0E-04	2.2E-03	1.5E-01	1.0E-05	5.0E-06	7.7E-03	8.4E-05	1.7E+01
Sat Col 10	6/Jul/12	46	452	7.79	1.1E+02	4.9E+01	6.7E+00	6.1E-01	2.4E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	1.5E+00	5.0E-03	1.0E-01	9.5E-04	2.5E-03	1.7E-01	1.0E-05	5.0E-06	9.1E-03	8.2E-05	1.7E+01
Sat Col 10	20/Jul/12	48	442	7.88	1.1E+02	5.4E+01	6.7E+00	6.9E-01	2.2E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	9.9E-01	5.0E-03	9.8E-02	1.0E-03	2.1E-03	1.7E-01	1.0E-05	5.0E-06	8.3E-03	9.2E-05	1.8E+01
Sat Col 10	3/Aug/12	50	402	7.83	1.1E+02	5.2E+01	6.5E+00	6.7E-01	2.5E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	2.6E+00	<0.0080	9.6E-02	9.8E-04	2.3E-03	1.6E-01	1.0E-05	5.0E-06	8.0E-03	7.4E-05	1.6E+01
Sat Col 10	17/Aug/12	52	480	7.75	1.0E+02	5.1E+01	5.7E+00	5.2E-01	2.5E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	6.7E-01	5.0E-03	9.9E-02	8.8E-04	2.1E-03	1.6E-01	1.0E-05	5.0E-06	7.2E-03	6.1E-05	1.5E+01
Sat Col 10	30/Aug/12	54	495	7.69	9.8E+01	5.0E+01	5.4E+00	5.2E-01	2.3E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	8.4E-01	5.0E-03	9.5E-02	8.3E-04	2.2E-03	1.6E-01	1.0E-05	5.0E-06	7.4E-03	6.2E-05	1.5E+01
Sat Col 10	12/Sep/12	56	512	7.79	9.7E+01	5.0E+01	5.3E+00	5.0E-01	2.2E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	9.2E-01	5.0E-03	9.4E-02	9.0E-04	2.2E-03	1.6E-01	1.0E-04	5.0E-04	1.0E-02	5.4E-05	1.7E+01
Sat Col 10	25/Sep/12	57	516	7.70	9.6E+01	5.0E+01	5.0E+00	5.0E-01	2.8E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	2.0E+00	5.0E-03	9.3E-02	8.0E-04	2.1E-03	1.7E-01	1.0E-05	5.0E-06	7.6E-03	5.3E-05	1.5E+01
Sat Col 10	10/Oct/12	60	570	7.47	9.4E+01	5.0E+01	5.0E+00	5.0E-01	2.2E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	8.3E-01	5.0E-03	9.7E-02	7.9E-04	2.1E-03	1.7E-01	1.0E-05	5.0E-06	7.4E-03	5.2E-05	1.5E+01
Sat Col 10	23/Oct/12	61	536	7.72	9.0E+01	4.7E+01	4.8E+00	5.0E-01	2.3E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	7.9E-01	5.0E-03	9.3E-02	7.5E-04	2.0E-03	1.6E-01	1.0E-05	5.0E-06	6.6E-03	4.8E-05	1.4E+01
Sat Col 10	7/Nov/12	64	532	7.61	9.9E+01	5.0E+01	5.3E+00	5.1E-01	2.0E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	9.1E-01	1.0E-02	8.0E-02	8.5E-04	2.0E-03	2.0E-01	1.0E-05	5.0E-06	7.3E-03	4.8E-05	1.6E+01
Sat Col 10	20/Nov/12	65	475	7.74	9.8E+01	4.7E+01	5.1E+00	5.0E-01	2.2E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	9.0E-01	1.0E-02	8.0E-02	7.7E-04	2.0E-03	1.9E-01	1.0E-05	5.0E-06	6.9E-03	4.6E-05	1.6E+01
Sat Col 10	5/Dec/12	68	383	7.76	1.1E+02	5.7E+01	5.6E+00	5.0E-01	2.0E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	9.4E-01	1.0E-02	7.6E-02	8.4E-04	2.0E-03	1.9E-01	1.0E-05	5.0E-06	8.6E-03	5.7E-05	1.8E+01
Sat Col 10	18/Dec/12	70	380	7.58	9.8E+01	5.6E+01	5.0E+00	5.0E-01	2.1E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	9.6E-01	1.0E-02	6.8E-02	8.1E-04	1.6E-03	1.6E-01	1.0E-05	5.0E-06	6.4E-03	4.6E-05	1.5E+01
Sat Col 10	3/Jan/13	72	485	7.64	1.2E+02	7.8E+01	6.1E+00	5.3E-01	2.0E-02	5.0E-02	5.5E-03	1.0E-03	5.0E-03	1.3E+00	1.0E-02	6.9E-02	9.0E-04	2.1E-03	2.0E-01	1.0E-05	5.0E-06	8.8E-03	7.0E-05	1.9E+01
Sat Col 10	24/Jan/13	75	500	7.29	9.2E+01	4.4E+01	4.3E+00	5.0E-01	2.0E-02	5.0E-02	5.9E-03	1.0E-03	5.0E-03	8.5E-01	1.0E-02	7.7E-02	7.2E-04	1.8E-03	1.7E-01	1.0E-05	5.0E-06	6.1E-03	5.4E-05	1.4E+01
Sat Col 10	30/Jan/13	76	355	7.44	8.8E+01	3.7E+01	4.1E+00	5.0E-01	2.0E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	5.4E+00	5.0E-03	8.0E-02	6.6E-04	1.9E-03	1.6E-01	1.0E-05	5.0E-06	6.6E-03	4.4E-05	1.4E+01
Sat Col 10	12/Feb/13	77	500	7.47	8.5E+01	4.9E+01	4.0E+00	5.0E-01	2.0E-02	5.0E-02	6.8E-03	1.0E-03	5.0E-03	5.0E-01	5.0E-03	7.7E-02	6.6E-04	1.8E-03	1.5E-01	1.0E-05	5.0E-06	5.7E-03	4.6E-05	1.3E+01
Sat Col 10	27/Feb/13	80	545	7.58	8.3E+01	3.5E+01	4.0E+00	5.0E-01	2.1E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	1.4E+00	5.0E-03	7.6E-02	6.6E-04	1.7E-03	1.5E-01	1.0E-05	5.0E-06	6.0E-03	4.7E-05	1.3E+01
Sat Col 10	12/Mar/13	81	585	7.27	8.0E+01	3.4E+01	3.9E+00	5.0E-01	2.1E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	8.1E-01	5.0E-03	7.4E-02	6.0E-04	1.6E-03	1.5E-01	1.0E-05	5.0E-06	6.4E-03	4.2E-05	1.3E+01
Sat Col 10	27/Mar/13	84	365	7.38	9.4E+01	3.9E+01	4.6E+00	5.6E-01	2.0E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03		5.0E-03	7.6E-02	7.1E-04	1.8E-03	1.7E-01	1.0E-05	5.0E-06	5.9E-03	5.0E-05	1.4E+01
Sat Col 10	11/Apr/13	86	435	7.47	1.0E+02	4.3E+01	4.9E+00	5.0E-01	2.3E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	9.4E-01	5.0E-03	7.1E-02	8.1E-04	1.9E-03	1.9E-01	1.0E-05	5.0E-06	7.0E-03	5.3E-05	1.5E+01
Sat Col 10	24/Apr/13	88	430	7.51	9.8E+01	4.9E+01	4.7E+00	5.0E-01	2.2E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	7.5E-01	5.0E-03	7.3E-02	7.4E-04	1.8E-03	1.7E-01	1.0E-05	5.0E-06	6.8E-03	5.4E-05	1.6E+01
Sat Col 10	7/May/13	90	440	7.73	9.9E+01	4.4E+01	4.7E+00	5.0E-01	2.1E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	8.4E-01	5.0E-03	6.8E-02	7.2E-04	1.7E-03	1.9E-01	1.0E-05	5.0E-06	7.6E-03	5.8E-05	1.5E+01
Sat Col 10	22/May/13	92	500	7.56	9.6E+01	4.8E+01	4.7E+00	1.0E+00	2.2E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	1.7E+00	5.0E-03	6.9E-02	7.2E-04	1.7E-03	1.9E-01	1.0E-05	5.0E-06	6.7E-03	4.4E-05	1.5E+01
Sat Col 10	6/Jun/13	94	315	7.86	9.8E+01	4.9E+01	4.6E+00	5.0E-01	2.1E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	9.4E-01	5.0E-03	6.7E-02	7.2E-04	1.7E-03	1.9E-01	1.0E-05	5.0E-06	6.4E-03	6.5E-05	1.5E+01

Saturated column kentic test results

ID	Date	cycle	Flow Between Events	pH	Cond-L	T-Alk	SO4	D-Cl	D-F	D-Br	NH3	NO2-N	NO3-N	DOC	D-Sulphide	D-Al	D-Sb	D-As	D-Ba	D-Be	D-Bi	D-B	D-Cd	D-Ca
			mL	pH	uS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Sat Col 11	19/Aug/11	0	103	6.97	8.0E+02	3.8E+01	2.6E+02	6.9E+01	1.0E-01	2.5E-01	2.0E-01	5.0E-03	2.5E-02	4.2E+00	1.1E-02	1.4E-02	1.5E-03	9.9E-04	3.1E-02	1.0E-05	5.0E-06	6.2E-02	2.5E-03	1.2E+02
Sat Col 11	26/Aug/11	1	725	7.10	1.1E+03	4.4E+01	4.3E+02	7.1E+01	2.0E-01	5.0E-01	5.0E-02	1.0E-02	5.0E-02	4.5E+00	5.4E-03	3.4E-02	2.7E-03	4.1E-03	3.5E-02	1.0E-05	5.0E-06	7.8E-02	4.0E-03	1.7E+02
Sat Col 11	8/Sep/11	3	1337	7.42	1.1E+03	5.2E+01	4.1E+02	6.6E+01	2.0E-01	5.0E-01	5.0E-03	1.0E-02	9.9E-02	6.8E+00		7.1E-02	2.9E-03	5.7E-03	2.9E-02	1.0E-05	5.0E-06	1.1E-01	2.5E-03	1.8E+02
Sat Col 11	15/Sep/11	4	735	7.60	9.3E+02	5.6E+01	3.2E+02	6.0E+01	2.0E-01	5.0E-01	5.0E-03	1.0E-02	5.0E-02	6.1E+00		5.9E-02	2.9E-03	4.5E-03	2.7E-02	1.0E-05	5.0E-06	9.7E-02	5.0E-04	1.4E+02
Sat Col 11	23/Sep/11	5	853	7.69	7.2E+02	5.3E+01	2.4E+02	4.3E+01	4.0E-01	1.0E+00	1.3E-02	2.0E-02	1.0E-01	5.1E+00	5.0E-03	6.4E-02	3.9E-03	3.1E-03	2.7E-02	1.0E-04	5.0E-04	8.5E-02	1.5E-04	1.2E+02
Sat Col 11	29/Sep/11	6	804	7.92	6.0E+02	5.4E+01	1.8E+02	3.2E+01	3.1E-02	5.0E-02	1.5E-02	1.0E-03	5.0E-03	4.6E+00	5.0E-03	6.2E-02	4.1E-03	2.5E-03	2.9E-02	1.0E-05	5.0E-06	7.9E-02	1.0E-04	8.6E+01
Sat Col 11	13/Oct/11	8	2440	7.95	4.1E+02	6.4E+01	1.2E+02	1.5E+01	3.4E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	2.9E+00	5.0E-03	5.1E-02	4.8E-03	1.8E-03	2.7E-02	1.0E-05	5.0E-06	7.3E-02	1.5E-04	5.6E+01
Sat Col 11	27/Oct/11	10	2298	8.07	2.3E+02	4.2E+01	5.9E+01	3.3E+00	3.7E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	1.8E+00	5.0E-03	7.7E-02	4.4E-03	1.7E-03	3.6E-02	1.0E-05	5.0E-06	5.3E-02	5.0E-05	3.1E+01
Sat Col 11	10/Nov/11	12	2523	8.07	1.7E+02	3.9E+01	3.9E+01	7.6E-01	3.7E-02	5.0E-02	8.6E-03	1.0E-03	5.0E-03	1.9E+00	5.0E-03	8.5E-02	4.0E-03	1.8E-03	4.7E-02	1.0E-05	5.0E-06	4.2E-02	5.0E-05	2.3E+01
Sat Col 11	25/Nov/11	14	574	7.80	1.4E+02	4.1E+01	3.0E+01	5.0E-01	3.6E-02	5.0E-02	1.7E-02	1.0E-03	5.0E-03	8.6E-01	2.0E-03	7.9E-02	3.6E-03	1.6E-03	5.5E-02	1.0E-05	5.0E-06	3.8E-02	5.0E-05	1.9E+01
Sat Col 11	8/Dec/11	16	1298	7.90	1.3E+02	3.9E+01	2.6E+01	5.0E-01	3.2E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	8.7E-01	5.0E-03	8.0E-02	3.2E-03	1.4E-03	5.5E-02	1.0E-05	5.0E-06	3.7E-02	3.0E-05	1.8E+01
Sat Col 11	23/Dec/11	18	1441	7.74	1.3E+02	3.8E+01	2.4E+01	5.0E-01	3.1E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	9.3E-01	5.0E-03	7.1E-02	3.1E-03	1.1E-03	6.1E-02	1.0E-05	5.0E-06	3.5E-02	1.6E-05	1.7E+01
Sat Col 11	5/Jan/12	20	1371	7.53	1.2E+02	4.2E+01	2.2E+01	5.0E-01	3.0E-02	5.0E-02	5.5E-03	1.0E-03	5.0E-03	1.1E+00	5.0E-03	6.0E-02	2.9E-03	1.0E-03	6.2E-02	1.0E-05	5.0E-06	3.3E-02	2.0E-05	1.9E+01
Sat Col 11	19/Jan/12	22	2454				2.1E+01	5.0E-01	3.0E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	1.6E+00	5.0E-03	5.7E-02	3.0E-03	9.7E-04	6.7E-02	1.0E-05	5.0E-06	3.3E-02	1.6E-05	1.7E+01
Sat Col 11	3/Feb/12	24	3061				2.1E+01	5.0E-01	3.1E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	9.0E-01	5.0E-03	5.7E-02	3.5E-03	1.1E-03	7.1E-02	1.0E-05	5.0E-06	3.4E-02	4.0E-05	1.8E+01
Sat Col 11	16/Feb/12	26	2562				2.1E+01	5.0E-01	2.9E-02	5.0E-02	1.9E-02	1.0E-03	5.8E-03	1.4E+00	5.0E-03	5.9E-02	3.4E-03	1.3E-03	7.3E-02	1.0E-05	5.0E-06	3.1E-02	<0.000070	1.8E+01
Sat Col 11	2/Mar/12	28	2960				2.0E+01	5.0E-01	2.9E-02	5.0E-02	5.4E-03	1.0E-03	5.0E-03	7.6E-01	5.0E-03	5.1E-02	3.5E-03	1.5E-03	7.6E-02	1.0E-05	5.0E-06	3.0E-02	2.0E-05	1.9E+01
Sat Col 11	16/Mar/12	30	2638				1.9E+01	5.0E-01	2.9E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	1.4E+00	5.7E-03	4.8E-02	3.4E-03	1.5E-03	7.4E-02	1.0E-05	5.0E-06	2.7E-02	3.0E-05	1.9E+01
Sat Col 11	30/Mar/12	32	480				2.0E+01	5.0E-01	2.8E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	9.6E-01	5.0E-03	4.2E-02	3.3E-03	9.5E-04	8.9E-02	1.0E-05	5.0E-06	3.3E-02	1.0E-04	2.1E+01
Sat Col 11	13/Apr/12	34	190				2.1E+01	5.0E-01	2.7E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	9.2E-01	5.0E-03	3.7E-02	3.2E-03	8.6E-04	9.1E-02	1.0E-05	5.0E-06	3.7E-02	3.4E-05	2.1E+01
Sat Col 11	25/Apr/12	36	440				2.0E+01	5.0E-01	2.5E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	1.7E+00	5.7E-03	3.8E-02	3.0E-03	7.3E-04	9.6E-02	1.0E-05	5.0E-06	3.8E-02	2.7E-05	2.3E+01
Sat Col 11	11/May/12	38	519				1.9E+01	5.0E-01	2.3E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	1.2E+00	5.0E-03	3.4E-02	2.9E-03	7.9E-04	1.1E-01	1.0E-05	5.0E-06	4.1E-02	1.1E-04	2.3E+01
Sat Col 11	25/May/12	40	481				2.0E+01	5.0E-01	2.5E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	1.4E+00	5.0E-03	3.4E-02	2.7E-03	8.0E-04	1.0E-01	1.0E-05	5.0E-06	4.2E-02	6.4E-05	2.3E+01
Sat Col 11	8/Jun/12	42	500				1.8E+01	5.0E-01	2.4E-02	5.0E-02	6.8E-03	1.0E-03	5.0E-03	8.3E-01	5.0E-03	3.0E-02	2.4E-03	8.1E-04	1.1E-01	1.0E-05	5.0E-06	4.0E-02	1.7E-04	2.2E+01
Sat Col 11	22/Jun/12	44	480				1.8E+01	5.0E-01	2.5E-02	5.0E-02	5.6E-03	1.0E-03	5.0E-03	1.7E+00	5.0E-03	3.0E-02	2.3E-03	8.0E-04	1.1E-01	1.0E-05	5.0E-06	3.6E-02	1.9E-04	2.3E+01
Sat Col 11	6/Jul/12	46	520	7.82	1.6E+02	6.7E+01	1.7E+01	5.0E-01	2.2E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	1.3E+00	5.0E-03	3.1E-02	2.1E-03	8.7E-04	1.2E-01	1.0E-05	5.0E-06	4.2E-02	2.0E-04	2.3E+01
Sat Col 11	20/Jul/12	48	510	7.94	1.5E+02	6.4E+01	1.6E+01	5.2E-01	2.2E-02	5.0E-02	6.2E-03	1.0E-03	5.0E-03	1.3E+00	5.0E-03	2.7E-02	2.1E-03	7.7E-04	1.1E-01	1.0E-05	5.0E-06	3.8E-02	2.5E-04	2.4E+01
Sat Col 11	3/Aug/12	50	505	8.53	1.5E+02	6.8E+01	1.6E+01	5.1E-01	2.1E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	1.6E+00	5.0E-03	2.8E-02	1.9E-03	8.0E-04	1.1E-01	1.0E-05	5.0E-06	3.6E-02	<0.000070	2.2E+01
Sat Col 11	17/Aug/12	52	523	7.89	1.5E+02	6.7E+01	1.5E+01	5.0E-01	2.2E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	8.8E-01	5.0E-03	2.6E-02	1.7E-03	8.0E-04	1.1E-01	1.0E-05	5.0E-06	3.4E-02	<0.000090	2.1E+01
Sat Col 11	30/Aug/12	54	486	7.69	1.5E+02	6.3E+01	1.5E+01	5.0E-01	2.4E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	1.3E+00	5.0E-03	2.7E-02	1.7E-03	9.2E-04	1.1E-01	1.0E-05	5.0E-06	3.5E-02	1.0E-04	2.2E+01
Sat Col 11	12/Sep/12	56	488	7.83	1.5E+02	6.5E+01	1.5E+01	5.0E-01	2.2E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	1.4E+00	5.0E-03	2.6E-02	1.7E-03	9.2E-04	1.2E-01	1.0E-04	5.0E-04	3.5E-02	2.0E-04	2.5E+01
Sat Col 11	25/Sep/12	57	487	7.61	1.5E+02	6.6E+01	1.5E+01	5.0E-01	2.3E-02	5.0E-02	5.3E-03	1.0E-03	5.0E-03	2.5E+00	5.0E-03	2.6E-02	1.5E-03	8.0E-04	1.2E-01	1.0E-05	5.0E-06	3.4E-02	5.0E-05	2.2E+01
Sat Col 11	10/Oct/12	60	515	7.73	1.5E+02	6.3E+01	1.5E+01	5.0E-01	2.1E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	1.3E+00	5.0E-03	2.6E-02	1.5E-03	8.8E-04	1.3E-01	1.0E-05	5.0E-06	3.8E-02	6.4E-05	2.3E+01
Sat Col 11	23/Oct/12	61	487	7.62	1.5E+02	6.5E+01	1.5E+01	5.0E-01	2.2E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	1.2E+00	5.0E-03	2.4E-02	1.3E-03	8.8E-04	1.3E-01	1.0E-05	5.0E-06	3.1E-02	5.1E-05	2.1E+01
Sat Col 11	7/Nov/12	64	487	7.76	1.5E+02	6.7E+01	1.4E+01	5.0E-01	2.0E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	1.3E+00	1.0E-02	2.1E-02	1.3E-03	9.0E-04	1.4E-01	1.0E-05	5.0E-06	3.3E-02	<0.000070	2.1E+01
Sat Col 11	20/Nov/12	65	438	7.83	1.5E+02	6.2E+01	1.4E+01	5.0E-01	2.1E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	1.3E+00	1.0E-02	2.1E-02	1.2E-03	8.6E-04	1.3E-01	1.0E-05	5.0E-06	3.2E-02	4.5E-05	2.2E+01
Sat Col 11	5/Dec/12	68	469	7.84	1.5E+02	6.5E+01	1.4E+01	5.0E-01	2.0E-02	5.0E-02	5.0E-03	1.4E-03	5.0E-03	1.1E+00	1.0E-02	2.2E-02	1.1E-03	8.7E-04	1.3E-01	1.0E-05	5.0E-06	3.5E-02	<0.000060	2.3E+01
Sat Col 11	18/Dec/12	70	405	8.00	1.5E+02	6.8E+01	1.3E+01	5.0E-01	2.0E-02	5.0E-02	9.9E-03	1.0E-03	5.0E-03	1.4E+00	1.0E-02	2.0E-02	1.1E-03	8.6E-04	1.3E-01	1.0E-05	5.0E-06	2.8E-02	<0.000060	2.3E+01
Sat Col 11	3/Jan/13	72	500	7.83	1.5E+02	6.7E+01	1.3E+01	5.0E-01	2.0E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	1.4E+00	1.0E-02	2.1E-02	1.0E-03	8.5E-04	1.3E-01	1.0E-05	5.0E-06	3.1E-02	1.2E-04	2.3E+01
Sat Col 11	24/Jan/13	75	505	7.85	1.5E+02	6.3E+01	1.3E+01	5.0E-01	2.0E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	1.5E+00	1.0E-02	2.1E-02	1.0E-03	9.0E-04	1.4E-01	1.0E-05	5.0E-06	2.8E-02	2.5E-04	2.3E+01
Sat Col 11	30/Jan/13	76	363	7.50	1.5E+02	5.9E+01	1.3E+01	5.0E-01	2.2E-02	5.0E-02	5.1E-03	1.0E-03	5.0E-03	4.1E+00	5.0E-03	2.1E-02	9.9E-04	9.4E-04	1.2E-01	1.0E-05	5.0E-06	3.0E-02	<0.000070	2.4E+01
Sat Col 11	12/Feb/13	77	505	7.57	1.5E+02	5.6E+01	1.2E+01	5.0E-01	2.0E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	7.8E-01	5.0E-03	2.1E-02	1.0E-03	9.7E-04	1.3E-01	1.0E-05	5.0E-06	2.9E-02	<0.000070	2.3E+01
Sat Col 11	27/Feb/13	80	430	7.67	1.5E+02	5.5E+01	1.3E+01	5.0E-01	2.0E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	1.6E+00	5.0E-03	2.1E-02	9.6E-04	1.0E-03	1.3E-01	1.0E-05	5.0E-06	2.9E-02	1.0E-04	2.3E+01
Sat Col 11	12/Mar/13	81	425	7.62	1.5E+02	5.5E+01	1.3E+01	5.0E-01	2.0E-02	5.0E-02	6.8E-03	1.0E-03	5.0E-03	1.2E+00	5.0E-03	2.0E-02	9.0E-04	1.1E-03	1.4E-01	1.0E-05	5.0E-06	2.8E-02	<0.000070	2.2E+01
Sat Col 11	27/Mar/13	84	390	7.61	1.5E+02	5.6E+01	1.2E+01	1.1E+00	2.0E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03		5.0E-03	2.0E-02	8.7E-04	1.1E-03	1.4E-01	1.0E-05	5.0E-06	2.5E-02	1.0E-04	2.2E+01
Sat Col 11	11/Apr/13	86	470	7.66	1.5E+02	5.8E+01	1.6E+03	1.0E+01	1.3E+00	1.0E+00	5.0E-03	2.0E-02	1.0E-01	1.0E+00	5.0E-03	2.3E-02	9.0E-04	1.3E-03	1.5E-01	1.0E-05	5.0E-06	2.7E-02	5.0E-05	2.2E+01
Sat Col 11	24/Apr/13	88	445	7.72	1.5E+02	6.7E+01	1.2E+01	5.0E-01	2.1E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	9.4E-01	5.0E-03	2.1E-02	8.8E-04	1.3E-03	1.4E-01	1.0E-05	5.0E-06	2.8E-02	<0.000080	2.5E+01
Sat Col 11	7/May/13	90	437	7.97	1.5E+02	5.8E+01	1.2E+01	5.0E-01	2.1E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	9.4E-01	5.0E-03	2.0E-02	8.6E-04	1.4E-03	1.6E-01	1.0E-05	5.0E-06	2.8E-02	<0.000090	2.2E+01
Sat Col 11	22/May/13	92	485	7.82	1.5E+02	7.1E+01	1.2E+01	5.0E-01	2.0E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	1.1E+00	5.0E-03	2.0E-02	8.1E-04	1.4E-03	1.6E-01	1.0E-05	5.0E-06	2.6E-02	<0.000070	2.3E+01
Sat Col 11	6/Jun/13	94	535	7.92	1.5E+02	6.8E+01	1.2E+01	5.0E-01	2.0E-02	5.0E-02	5.0E-03	1.0E-03	5.0E-03	9.1E-01	5.0E-03	2.1E-02	7.6E-04	1.4E-03	1.6E-01	1.0E-05	5.0E-06	2.6E-02	1.0E-04	2.2E+01
Sat Col 12 upper port	12/Jul/12	0	250	6.13	4.5E+03	5.2E+02	2.7E+03	4.4E+01	2.5E+00	1.0E+00	9.6E-01	2.0E-02	1.4E-01	8.2E+01	5.0E-03	5.3E-01	5.3E-03	1.7E-03	2.6E-02	6.8E-04	2.5E-05	5.1E-02	3.5E-03	8.5E+02
Sat Col 12 upper port	3/Aug/12	50	150	6.46	3.6E+03	5.8E+02	2.0E+03	2.6E+01	3.0E+00	1.0E+00	1.4E+00	2.1E-02	1.0E-01	3.1E+01	5.0E-03	3.7E-01	4.8E-03	3.5E-03	2.1E-02	1.3E-03	5.6E-05	4.5E-02	1.9E-03	7.2E+02
Sat Col 12 upper port	30/Aug/12	54	180	6.34	3.7E+03	6.6E+02	2.0E+03	2.4E+01	3.0E+00	1.0E+00	1.4E+00	2.0E-02	1.0E-01	2.7E+01	5.0E-03	2.1E-01	3.1E-03	5.9E-03	2.1E-02	1.0E-03	2.5E-05	5.6E-02	1.3E-03	7.1E+02
Sat Col 12 upper port	25/Sep/12	57	200	6.27	3.6E+03	6.9E+02	1.9E+03	1.8E+01	2.9E+00	1.0E+00	1.5E+00	2.0E-02	1.0E-01	1.7E+01	5.0E-03	1.7E-01	2.3E-03	7.8E-03	1.9E-02	7.7E-04	7.0E-05	4.2E-02	9.4E-04	6.6E+02
Sat Col 12 upper port	23/Oct/12	61	200	6.44	3.3E+03	5.6E+02	1.9E+03	1.5E+01	2.6E+00	1.0E+00	1.4E+00	2.0E-02	1.0E-01	2.0E+01	5.7E-03	1.1E-01	1.7E-03	6.2E-03	1.8E-02	6.6E-04	2.5E-05	4.0E-02	7.7E-04	6.8E+02
Sat Col 12 upper port	20/Nov/12	65	200	6.44	3.3E+03	5.4E+02	1.8E+03	1.4E+01	2.4E+00	1.0E+00	1.5E+00	2.0E-02	1.0E-01	1.7E+01	1.0E-02	8.9E-02	1.3E-03	5.7E-03	1.6E-02	5.2E-04	2.5E-05	3.2E-02	6.5E-04	5.5E+02
Sat Col 12 upper port	17/Dec/12	69	570	6.14	2.5E+03	3.1E+02	1.5E+03	1.0E+01	3.0E+00	1.0E+00	1.6E+00	2.0E-02	1.0E-01	1.2E+01	1.0E-02	6.0E-01	1.7E-03	3.2E-03	1.6E-02	1.3E-03	2.5E-05	2.6E-02	2.1E-03	5.0E+02
Sat Col 12 upper port	24/Jan/13	75	1500-2000	6.17	2.1E+03	2.6E+02	1.1E+03	1.0E+01	3.2E+00	1.0E+00	1.2E+00	2.0E-02	1.0E-01	7.4E+00	1.0E-02	2.2E-01	1.1E-03	1.9E-03	2.0E-02	8.1E-04	1.0E-05	1.8E-02	1.5E-03	3.8E+02
Sat Col 12 upper port	12/Feb/13	77	263	6.62	2.3E+03	3.8E+02	1.2E+03	1.0E+01	2.5E+00	1.0E+00	1.1E+00	2.0E-02	1.0E-01	6.1E+00	5.0E-03	2.9E-02	7.8E-04	3.5E-03	1.9E-02	2.3E-04	1.0E-05	2.2E-02	3.8E-04	4.7E+02
Sat Col 12 upper port	12/Mar/13	81	255	6.79	2.4E+03	3.7E+02	1.2E+03	1.0E+01	2.5E+00	1.0E+00	1.1E+00	2.0E-02	1.0E-01	7.7E+00	5.0E-03	2.5E-02	6.9E-04	4.4E-03	1.8E-02	2.1E-04	1.0E-05	2.4E-02	3.1E-04	4.7E+02
Sat Col 12 upper port	11/Apr/13	86	244	6.67	2.3E+03	3.9E+02	1.2E+03	1.0E+01	2.5E+00	1.0E+00	1.2E+00	2.0E-02	1.0E-01	6.0E+00	5.0E-03	2.0E-02	7.1E-04	5.4E-03	1.9E-02	2.0E-04	1.0E-05	2.5E-02	2.5E-04	4.4E+02
Sat Col 12 upper port	7/May/13	90	237	6.86	2.3E+03	4.6E+02	1.1E+03	1.0E+01	2.4E+00	1.0E+00	1.1E+00	2.0E-02	1.0E-01	6.6E+00	5.0E-03	1.5E-02	6.4E-04	4.4E-03	1.9E-02	2.0E-04	1.0E-05	2.5E-02	2.3E-04	4.4E+02
Sat Col 12 upper port	7/Jun/13	94	285	6.85	2.6E+03	4.7E+02	1.3E+03	1.0E+01	2.8E+00	1.0E+00	1.0E+00	2.0E-02	1.0E-01	9.5E+00	5.0E-03	1.2E-02	2.6E-03	3.5E-03	2.1E-02	1.8E-04	1.0E-05	2.4E-02	6.2E-04	5.2E+02
Sat Col 12 upper port	4/Jul/13	98	245	6.88	2.4E+03	4.6E+02	1.2E+03	1.0E+01	1.9E+00	1.0E+00	1.1E+00	2.0E-02	1.0E-01	6.4E+00	5.0E-03	1.1E-02	6.7E-04	3.5E-03	1.8E-02	1.7E-04	1.0E-05	2.6E-02	3.1E-04	4.6E+02
Sat Col 12 upper port	30/Jul/13	102	250	7.04	2.3E+03	4.4E+02	1.2E+03	1.0E+01	2.1E+00	1.0E+00	1.1E+00	2.0E-02	1.0E-01	6.2E+00	5.0E-03	1.1E-02	5.2E-04	5.0E-03	1.8E-02	1.5E-04	1.0E-05	2.4E-02	1.3E-04	4.8E+02
Sat Col 12 upper port	28/Aug/13	106	260	6.95	2.2E+03	4.4E+02	1.1E+03	1.0E+01	2.2E+00	1.0E+00	1.2E+00	2.0E-02	1.0E-01	6.2E+00	5.0E-03	1.4E-02	4.7E-04	5.1E-03	2.1E-02	1.8E-04	1.0E-05	2.7E-02	8.9E-05	4.6E+02
Sat Col 12 upper port	26/Sep/13	110	244	6.83	2.2E+03	4.1E+02	1.1E+03	1.0E+01	1.7E+00	1.0E+00	1.1E+00	2.0E-02	1.0E-01	5.9E+00	5.0E-03	9.9E-03	4.3E-04	4.5E-03	1.7E-02	1.7E-04	2.0E-05	2.5E-02	8.0E-05	4.1E+02
Sat Col 12 upper port	24/Oct/13	114	240	6.79	2.1E+03	4.0E+02	1.0E+03	1.0E+01	1.9E+00	1.0E+00	1.1E+00	2.0E-02	1.0E-01	5.1E+00	5.0E-03	6.8E-03	3.1E-04	4.5E-03	1.9E-02	1.4E-04	1.0E-05	2.3E-02	4.3E-05	3.9E+02
Sat Col 12 upper port	20/Nov/13	118	238	7.28	2.0E+03	3.9E+02	9.6E+02	1.0E+01	1.7E+00	1.0E+00	9.8E-01	2.0E-02	1.0E-01	5.2E+00	5.0E-03	8.9E-03	2.4E-04	4.3E-03	1.9E-02	1.4E-04	1.0E-05	2.4E-02	3.2E-05	3.9E+02
Sat Col 12 upper port	18/Dec/13	122	477	6.89	2.0E+03	3.7E+02	8.9E+02	1.0E+01	1.7E+00	1.0E+00	1.0E+00	2.1E-02	1.0E-01	4.3E+00	2.0E-03	1.0E-02	2.4E-04	4.0E-03	1.8E-02	1.4E-04	1.9E-05	2.0E-02	2.8E-05	4.0E+02
Sat Col 12 upper port	15/Jan/14	126	243	6.91	1.9E+03	3.2E+02	8.8E+02	1.0E+01	1.7E+00	1.0E+00	8.6E-01	2.0E-02	1.0E-01	4.2E+00	5.0E-03	6.5E-03	2.1E-04	3.7E-03	1.9E-02	1.2E-04	1.0E-05	2.2E-02	2.1E-05	3.7E+02
Sat Col 12 upper port	12/Feb/14	130	225	6.90	1.8E+03	3.2E+02	8.4E+02	1.0E+01	1.9E+00	1.0E+00	9.7E-01	2.0E-02	1.0E-01	3.6E+00	2.0E-03	7.7E-03	1.7E-04	3.7E-03	1.9E-02	1.1E-04	1.0E-05	2.0E-02	1.3E-05	3.6E+02

Saturated column kentic test results

ID	Date	cycle	Flow Between Events	pH	Cond-L	T-Alk	SO4	D-Cl	D-F	D-Br	NH3	NO2-N	NO3-N	DOC	D-Sulphide	D-Al	D-Sb	D-As	D-Ba	D-Be	D-Bi	D-B	D-Cd	D-Ca
			mL	pH	uS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Sat Col 12 lower port	13/Jul/12	0	210	3.34	6.5E+03	0.0E+00	6.5E+03	3.9E+01	4.4E+01	2.5E+00	8.0E+00	5.0E-02	6.0E-01	6.6E+01	5.0E-03	5.5E+02	7.5E-03	1.6E-02	1.1E-02	4.7E-02	1.6E-03	5.0E-01	2.7E-02	4.2E+02
Sat Col 12 lower port	3/Aug/12	3	250	3.35	3.9E+03	0.0E+00	3.3E+03	1.6E+01	1.8E+01	1.0E+00	4.2E+00	2.0E-02	1.7E-01	3.5E+01	5.0E-03	2.3E+02	4.5E-03	8.0E-03	8.9E-03	2.2E-02	1.0E-04	1.0E-01	1.2E-02	4.2E+02
Sat Col 12 lower port	31/Aug/12	7	225	3.44	3.5E+03	0.0E+00	2.7E+03	1.7E+01	1.2E+01	1.0E+00	3.6E+00	2.0E-02	1.0E-01	3.3E+01	5.0E-03	1.4E+02	3.9E-03	7.2E-03	9.0E-03	1.5E-02	1.0E-04	1.0E-01	8.6E-03	4.0E+02
Sat Col 12 lower port	27/Sep/12	11	950	3.95	3.2E+03	1.2E+01	2.0E+03	1.4E+01	5.1E+00	1.0E+00	2.6E+00	2.0E-02	1.0E-01	2.1E+01	5.0E-03	6.7E+01	5.4E-03	1.8E-02	9.0E-03	7.2E-03	5.0E-05	4.1E-01	4.7E-03	3.9E+02
Sat Col 12 lower port	24/Oct/12	15	225	3.71	2.7E+03	1.4E+01	2.0E+03	1.4E+01	7.1E+00	1.0E+00	2.3E+00	4.0E-02	1.0E-01	3.5E+00	5.0E-03	8.3E+01	3.4E-03	4.7E-03	7.2E-03	9.7E-03	5.0E-05	5.0E-02	6.1E-03	4.2E+02
Sat Col 12 lower port	21/Nov/12	19	2260	3.65	2.6E+03	0.0E+00	1.9E+03	1.0E+01	6.1E+00	1.0E+00	2.4E+00	2.0E-02	1.0E-01	1.6E+01	1.0E-02	5.8E+01	3.0E-03	1.4E-02	7.9E-03	7.0E-03	5.0E-05	5.0E-02	4.5E-03	2.9E+02
Sat Col 12 lower port	19/Dec/12	23	520	3.74	2.4E+03	0.0E+00	1.7E+03	1.0E+01	6.3E+00	1.0E+00	2.4E+00	2.0E-02	1.3E-01	1.6E+01	1.0E-02	5.9E+01	2.7E-03	1.2E-02	9.0E-03	6.7E-03	5.0E-05	5.0E-02	4.9E-03	3.2E+02
Sat Col 12 lower port	25/Jan/13	28	220	3.67	2.1E+03	1.4E+01	1.4E+03	1.0E+01	5.2E+00	1.0E+00	1.7E+00	2.0E-02	1.0E-01	1.0E+01	1.0E-02	4.9E+01	2.3E-03	7.9E-03	1.1E-02	5.6E-03	2.5E-05	2.5E-02	4.0E-03	2.6E+02
Sat Col 12 lower port	13/Feb/13	31	250	3.72	2.2E+03	3.0E+00	1.5E+03	1.0E+01	4.8E+00	1.0E+00	1.6E+00	2.0E-02	1.0E-01	1.0E+01	5.0E-03	4.1E+01	2.4E-03	7.3E-03	8.7E-03	5.1E-03	5.0E-05	5.0E-02	3.4E-03	3.0E+02
Sat Col 12 lower port	13/Mar/13	35	225	3.78	2.1E+03	4.0E+00	1.4E+03	1.0E+01	4.0E+00	1.0E+00	1.6E+00	2.0E-02	1.0E-01	1.9E+00	5.0E-03	3.5E+01	2.4E-03	6.5E-03	8.8E-03	4.4E-03	2.5E-05	2.5E-02	3.2E-03	2.9E+02
Sat Col 12 lower port	12/Apr/13	39	210	3.71	2.1E+03	7.0E+00	1.4E+03	1.4E+01	3.1E+00	1.0E+00	1.6E+00	2.0E-02	1.0E-01	9.4E+00	5.0E-03	3.2E+01	2.6E-03	7.2E-03	9.0E-03	4.4E-03	2.5E-05	2.7E-02	3.0E-03	3.3E+02
Sat Col 12 lower port	8/May/13	43	175	3.80	2.0E+03	6.0E+00	1.4E+03	1.0E+01	3.9E+00	1.0E+00	1.6E+00	2.0E-02	1.0E-01	9.0E+00	5.0E-03	3.0E+01	2.8E-03	6.5E-03	8.8E-03	4.3E-03	2.5E-05	2.8E-02	2.9E-03	3.4E+02
Sat Col 12 lower port	13/Jun/13	48	200	3.77	2.1E+03	3.0E+00	1.4E+03	1.0E+01	3.5E+00	1.0E+00	1.8E+00	2.0E-02	1.0E-01	8.4E+00	5.0E-03	3.0E+01	2.6E-03	7.0E-03	8.7E-03	4.1E-03	2.5E-05	2.7E-02	2.9E-03	3.3E+02
Sat Col 12 lower port	5/Jul/13	51	250	3.86	1.8E+03	7.0E+00	1.1E+03	1.0E+01	2.7E+00	1.0E+00	1.3E+00	2.0E-02	1.0E-01	7.1E+00	5.0E-03	2.4E+01	2.3E-03	5.7E-03	1.1E-02	3.4E-03	2.5E-05	2.5E-02	2.3E-03	2.8E+02
Sat Col 12 lower port	31/Jul/13	55	240	3.88	1.7E+03	0.0E+00	9.4E+02	1.0E+01	2.7E+00	2.5E+00	1.3E+00	5.0E-02	1.0E-01	6.8E+00	5.2E-03	2.2E+01	2.3E-03	5.5E-03	1.2E-02	3.2E-03	1.0E-04	2.7E-02	2.2E-03	2.7E+02
Sat Col 12 lower port	29/Aug/13	59	210	4.01	1.6E+03	5.0E+00	1.0E+03	1.0E+01	2.8E+00	1.0E+00	1.1E+00	2.0E-02	1.0E-01	6.4E+00	5.5E-03	2.0E+01	2.2E-03	4.7E-03	1.2E-02	3.1E-03	1.0E-05	2.4E-02	2.0E-03	2.8E+02
Sat Col 12 lower port	2/Oct/13	64	230	4.07	1.6E+03	4.0E+00	1.0E+03	1.0E+01	2.2E+00	1.0E+00	1.1E+00	2.0E-02	1.0E-01	5.8E+00	2.0E-03	1.9E+01	2.1E-03	4.2E-03	1.0E-02	3.0E-03	1.0E-05	2.5E-02	1.9E-03	2.6E+02
Sat Col 12 lower port	25/Oct/13	67	210	4.06	1.5E+03	4.0E+00	9.4E+02	5.0E+00	2.0E+00	5.0E-01	1.0E+00	1.0E-02	5.0E-02	5.3E+00	2.0E-03	1.5E+01	1.9E-03	3.5E-03	1.1E-02	2.4E-03	1.0E-05	2.1E-02	1.6E-03	2.3E+02
Sat Col 12 lower port	21/Nov/13	71	235	4.09	1.5E+03	0.0E+00	8.4E+02	1.3E+00	1.7E+00	5.0E-02	9.4E-01	1.0E-03	5.0E-03	4.8E+00	5.0E-03	1.5E+01	1.9E-03	3.0E-03	1.0E-02	2.3E-03	1.0E-05	2.3E-02	1.6E-03	2.3E+02
Sat Col 12 lower port	19/Dec/13	75	210	4.16	1.4E+03	3.0E+00	8.5E+02	5.0E+00	2.1E+00	5.0E-01	9.5E-01	1.6E-02	5.0E-02	4.8E+00	5.0E-03	1.3E+01	1.9E-03	3.2E-03	1.0E-02	2.1E-03	1.0E-05	1.9E-02	1.6E-03	2.3E+02
Sat Col 12 lower port	16/Jan/14	79	723	4.13	1.5E+03	3.0E+00	8.5E+02	5.0E+00	1.7E+00	5.0E-01	8.2E-01	1.0E-02	5.0E-02	4.8E+00	2.0E-03	1.3E+01	1.8E-03	2.6E-03	9.8E-03	2.1E-03	1.0E-05	1.9E-02	1.5E-03	2.2E+02
Sat Col 12 lower port	13/Feb/14	83	230	4.17	4.2E+00	3.0E+00	7.8E+02	5.0E+00	1.5E+00	5.0E-01	7.4E-01	1.0E-02	5.0E-02	4.0E+00	2.0E-03	1.1E+01	1.7E-03	2.6E-03	1.1E-02	1.8E-03	1.0E-05	1.6E-02	1.3E-03	2.2E+02
Sat Col 13 upper port	17/Jul/12	0	215	6.67	3.4E+03	4.3E+02	1.7E+03	7.6E+01	1.1E+00	1.0E+00	8.0E-01	2.0E-02	1.0E-01	6.5E+01	5.0E-03	7.0E-03	5.4E-03	1.6E-02	2.5E-02	8.2E-05	1.2E-04	9.9E-02	2.6E-04	5.4E+02
Sat Col 13 upper port	3/Aug/12	2	175	6.86	2.7E+03	5.8E+02	1.2E+03	4.8E+01	1.2E+00	1.0E+00	8.4E-01	2.0E-02	1.0E-01	4.3E+01	5.0E-03	4.2E-03	9.7E-04	9.1E-03	2.4E-02	6.9E-05	1.0E-05	9.4E-02	8.0E-05	3.9E+02
Sat Col 13 upper port	30/Aug/12	6	200	6.74	2.4E+03	5.0E+02	9.5E+02	3.9E+01	1.1E+00	1.0E+00	1.0E+00	2.0E-02	1.0E-01	2.7E+01	5.0E-03	2.3E-03	4.6E-04	8.2E-03	2.4E-02	6.4E-05	1.0E-05	8.4E-02	7.0E-05	3.4E+02
Sat Col 13 upper port	25/Sep/12	10	200	6.74	2.3E+03	5.4E+02	8.7E+02	3.2E+01	1.2E+00	1.0E+00	9.8E-01	2.0E-02	1.0E-01	2.5E+01	5.0E-03	1.2E-03	2.8E-04	6.8E-03	2.1E-02	6.1E-05	1.0E-05	7.1E-02	5.0E-05	3.1E+02
Sat Col 13 upper port	23/Oct/12	14	240	6.77	1.9E+03	5.1E+02	7.1E+02	2.5E+01	1.3E+00	1.0E+00	9.0E-01	2.0E-02	1.0E-01	2.2E+01	5.0E-03	1.0E-03	1.8E-04	6.8E-03	2.2E-02	6.2E-05	1.0E-05	6.8E-02	5.1E-05	2.6E+02
Sat Col 13 upper port	20/Nov/12	18	225	6.71	1.7E+03	4.3E+02	5.9E+02	2.1E+01	1.3E+00	1.0E+00	8.7E-01	2.0E-02	1.0E-01	1.9E+01	1.0E-02	1.2E-03	1.3E-04	6.8E-03	2.1E-02	5.7E-05	1.0E-05	5.7E-02	5.5E-05	2.3E+02
Sat Col 13 upper port	18/Dec/12	22	258	6.86	1.5E+03	4.1E+02	4.5E+02	1.5E+01	1.4E+00	5.0E-01	8.5E-01	1.0E-02	5.0E-02	1.5E+01	1.0E-02	2.3E-03	1.0E-04	5.7E-03	2.5E-02	5.4E-05	1.0E-05	5.0E-02	6.0E-05	2.1E+02
Sat Col 13 upper port	24/Jan/13	27	200	6.86	1.4E+03	4.2E+02	4.0E+02	1.3E+01	1.6E+00	5.0E-01	7.5E-01	1.0E-02	5.0E-02	1.2E+01	1.0E-02	5.5E-04	1.4E-04	3.9E-03	2.3E-02	4.9E-05	5.0E-06	4.4E-02	1.0E-04	1.9E+02
Sat Col 13 upper port	12/Feb/13	30	226	6.89	1.3E+03	4.1E+02	3.5E+02	1.1E+01	1.6E+00	5.0E-01	7.4E-01	1.0E-02	5.0E-02	1.0E+01	5.0E-03	6.3E-04	8.5E-05	4.0E-03	2.8E-02	4.6E-05	5.0E-06	4.4E-02	1.0E-04	1.8E+02
Sat Col 13 upper port	12/Mar/13	34	227	7.31	1.2E+03	3.9E+02	3.0E+02	8.7E+00	1.8E+00	5.0E-01	7.4E-01	1.0E-02	5.0E-02	1.3E+01	5.0E-03	8.9E-04	7.2E-05	5.0E-03	3.0E-02	4.6E-05	5.0E-06	4.4E-02	6.0E-05	1.6E+02
Sat Col 13 upper port	11/Apr/13	38	247	7.02	1.2E+03	3.9E+02	2.7E+02	7.9E+00	1.8E+00	5.0E-01	7.5E-01	1.0E-02	5.0E-02	5.6E+00	5.0E-03	9.5E-04	8.6E-05	5.9E-03	3.3E-02	4.6E-05	5.0E-06	4.5E-02	6.0E-05	1.5E+02
Sat Col 13 upper port	7/May/13	42	221	7.05	1.1E+03	4.3E+02	2.1E+02	6.4E+00	1.8E+00	5.0E-01	7.0E-01	1.0E-02	5.0E-02	8.7E+00	5.0E-03	8.4E-04	7.5E-05	4.8E-03	3.7E-02	4.2E-05	5.0E-06	4.1E-02	1.0E-04	1.3E+02
Sat Col 13 upper port	6/Jun/13	46	265	6.95	9.8E+02	4.1E+02	1.8E+02	6.6E+00	1.8E+00	5.0E-01	6.4E-01	1.0E-02	5.0E-02	7.9E+00	5.7E-03	7.7E-04	6.8E-05	5.6E-03	4.1E-02	4.2E-05	5.0E-06	3.8E-02	1.0E-04	1.1E+02
Sat Col 13 upper port	30/Jul/13	54	1245	7.60	7.5E+02	3.5E+02	9.5E+01	2.8E+00	2.3E+00	2.5E-01	6.3E-01	5.0E-03	2.5E-02	5.1E+00	5.0E-03	1.5E-03	6.4E-04	1.3E-02	8.6E-02	4.4E-05	8.2E-06	3.4E-02	2.0E-04	1.0E+02
Sat Col 13 upper port	28/Aug/13	58	245	7.46	7.5E+02	3.5E+02	8.8E+01	2.7E+00	2.2E+00	5.0E-02	6.5E-01	1.0E-03	5.0E-03	5.4E+00	5.0E-03	8.4E-04	2.2E-04	9.7E-03	7.3E-02	3.7E-05	5.0E-06	3.4E-02	2.0E-04	9.5E+01
Sat Col 13 upper port	26/Sep/13	62	240	7.39	7.2E+02	3.3E+02	7.7E+01	2.9E+00	2.2E+00	2.5E-01	6.0E-01	5.0E-03	2.5E-02	5.5E+00	5.0E-03	8.4E-04	1.3E-04	7.0E-03	6.4E-02	4.5E-05	5.0E-06	2.9E-02	1.5E-04	8.7E+01
Sat Col 13 upper port	24/Oct/13	66	235	7.31	7.0E+02	3.3E+02	6.7E+01	2.8E+00	2.2E+00	2.5E-01	5.9E-01	5.0E-03	2.5E-02	4.8E+00	5.0E-03	6.9E-04	9.2E-05	6.5E-03	7.2E-02	3.4E-05	5.0E-06	2.8E-02	1.5E-04	8.6E+01
Sat Col 13 upper port	20/Nov/13	70	248	7.40	6.6E+02	3.1E+02	5.8E+01	2.1E+00	2.3E+00	5.0E-02	5.2E-01	1.0E-03	5.1E-03	4.7E+00	2.3E-03	8.0E-04	6.9E-05	5.6E-03	7.9E-02	3.0E-05	5.0E-06	2.8E-02	2.0E-04	8.3E+01
Sat Col 13 upper port	18/Dec/13	74	278	7.39	6.3E+02	3.0E+02	4.9E+01	1.9E+00	2.3E+00	5.0E-02	5.4E-01	1.0E-03	5.0E-03	3.9E+00	5.9E-03	5.1E-04	6.4E-05	5.6E-03	7.9E-02	3.5E-05	5.0E-06	2.3E-02	3.0E-04	8.2E+01
Sat Col 13 upper port	15/Jan/14	78	251	7.46	6.0E+02	2.6E+02	4.3E+01	1.7E+00	2.4E+00	5.0E-02	4.5E-01	1.0E-03	5.0E-03	3.9E+00	8.0E-03	6.9E-04	5.6E-05	5.6E-03	9.1E-02	3.3E-05	5.0E-06	2.3E-02	2.1E-04	7.7E+01
Sat Col 13 upper port	12/Feb/14	82	225	7.45	5.6E+02	2.6E+02	3.8E+01	1.4E+00	2.4E+00	5.0E-02	5.2E-01	1.0E-03	5.0E-03	3.5E+00	2.9E-03	5.5E-04	4.6E-05	5.2E-03	9.1E-02	2.8E-05	5.0E-06	2.3E-02	1.5E-04	7.4E+01
Sat Col 13 upper port	11/Mar/14	86	220	7.55	5.4E+02	2.5E+02	3.4E+01	1.3E+00	2.5E+00	5.0E-02	5.1E-01	1.0E-03	5.0E-03	3.2E+00	7.3E-03	5.0E-04	4.3E-05	5.2E-03	9.9E-02	2.9E-05	5.0E-06	2.1E-02	2.4E-04	7.2E+01
Sat Col 13 upper port	16/Apr/14	91	212	7.36	5.6E+02	3.0E+02	3.3E+01	1.6E+00	2.4E+00	5.0E-02	5.0E-01	1.0E-03	5.0E-03	3.5E+00	6.2E-03	1.1E-03	3.7E-05	5.3E-03	1.1E-01	2.9E-05	5.0E-06	2.2E-02	1.8E-04	7.3E+01
Sat Col 13 upper port	22/May/14	96	235	7.68	5.4E+02	2.4E+02	3.2E+01	2.7E+00	2.5E+00	5.0E-02	4.5E-01	5.0E-03	5.9E-03	2.7E+00	5.0E-03	1.2E-03	7.7E-04	4.4E-03	1.4E-01	1.9E-05	5.0E-06	2.1E-02	2.1E-04	7.4E+01
Sat Col 13 upper port	10/Jun/14	99	245	7.83	5.3E+02	2.2E+02	2.8E+01	1.8E+01	2.5E+00	5.0E-02	5.3E-01	1.0E-03	5.0E-03	2.9E+00	5.0E-03	1.3E-03	1.7E-04	6.0E-03	1.3E-01	3.4E-05	5.0E-06	2.0E-02	2.0E-04	6.5E+01
Sat Col 13 upper port	9/Jul/14	103	225	7.57	5.1E+02	2.5E+02	2.6E+01	1.3E+00	2.5E+00	5.0E-02	4.7E-01	1.0E-03	5.0E-03	2.7E+00	5.0E-03	6.9E-04	7.3E-05	4.2E-03	1.4E-01	1.6E-05	5.0E-06	2.0E-02	2.0E-04	6.7E+01
Sat Col 13 upper port	6/Aug/14	107	237	7.40	5.0E+02	2.4E+02	2.4E+01	8.1E+00	2.6E+00	5.0E-02	4.9E-01	1.0E-03	5.0E-03	2.8E+00	5.0E-03	9.4E-04	5.5E-05	5.5E-03	1.5E-01	2.6E-05	5.0E-06	2.2E-02	2.0E-05	6.1E+01
Sat Col 13 upper port	4/Sep/14	111	272	7.59	5.1E+02	2.2E+02	2.1E+01	1.3E+00	2.6E+00	5.0E-02	5.0E-01	1.0E-03	5.0E-03	2.7E+00	5.0E-03	1.0E-03	4.8E-05	5.4E-03	1.5E-01	1.7E-05	5.0E-06	2.0E-02	2.0E-05	6.1E+01
Sat Col 13 upper port	1/Oct/14	115	419				1.8E+01	9.3E-01	2.7E+00	5.0E-02	4.3E-01	1.0E-03	5.0E-03	1.8E+00	5.0E-03	1.0E-03	8.9E-05	3.6E-03	1.4E-01	2.0E-05	1.0E-05	1.8E-02	2.0E-05	5.7E+01

Saturated column kentic test results

ID	Date	cycle	Flow Between Events	pH	Cond-L	T-Alk	SO4	D-Cl	D-F	D-Br	NH3	NO2-N	NO3-N	DOC	D-Sulphide	D-Al	D-Sb	D-As	D-Ba	D-Be	D-Bi	D-B	D-Cd	D-Ca
			mL	pH	uS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Sat Col 13 lower port	18/Jul/12	0	215	6.65	3.3E+03	4.3E+02	1.6E+03	7.2E+01	1.3E+00	1.0E+00	1.7E+00	2.0E-02	1.0E-01	5.8E+01	5.0E-03	1.1E-02	1.6E-03	4.5E-03	2.4E-02	9.1E-05	9.9E-05	1.0E-01	3.5E-03	4.2E+02
Sat Col 13 lower port	3/Aug/12	2	110	7.29	3.0E+03	4.3E+02	1.5E+03	5.4E+01	1.4E+00	1.0E+00	1.7E+00	2.0E-02	1.0E-01	5.0E+01	<0.0067	3.6E-02	1.0E-03	3.2E-03	2.3E-02	5.0E-04	2.5E-04	2.5E-01	2.6E-03	4.2E+02
Sat Col 13 lower port	31/Aug/12	6	250	6.75	2.7E+03	5.2E+02	1.2E+03	4.1E+01	1.2E+00	1.0E+00	1.6E+00	2.0E-02	1.0E-01	3.8E+01	5.0E-03	8.5E-03	5.2E-04	5.2E-03	2.3E-02	7.0E-05	2.5E-05	9.4E-02	4.4E-04	4.0E+02
Sat Col 13 lower port	26/Sep/12	10	250	6.68	2.5E+03	5.3E+02	1.0E+03	3.4E+01	1.2E+00	1.0E+00	1.6E+00	3.0E-02	1.0E-01	3.4E+01	5.0E-03	6.2E-03	3.6E-04	5.6E-03	2.2E-02	7.1E-05	1.3E-05	8.6E-02	3.5E-04	3.4E+02
Sat Col 13 lower port	24/Oct/12	14	250	6.62	2.2E+03	4.8E+02	8.6E+02	2.7E+01	1.3E+00	1.0E+00	1.0E+00	2.9E-02	1.0E-01	5.6E+00	5.0E-03	5.2E-03	2.2E-04	5.3E-03	2.2E-02	6.0E-05	1.0E-05	7.8E-02	1.8E-04	3.0E+02
Sat Col 13 lower port	21/Nov/12	18	350	6.61	1.9E+03	5.5E+02	7.0E+02	2.1E+01	1.2E+00	1.0E+00	1.2E+00	3.3E-02	1.0E-01	2.1E+01	1.0E-02	5.9E-03	1.6E-04	4.7E-03	2.2E-02	6.0E-05	1.0E-05	6.2E-02	1.5E-04	2.5E+02
Sat Col 13 lower port	19/Dec/12	22	250	6.78	1.7E+03	4.1E+02	5.6E+02	1.5E+01	1.2E+00	1.0E+00	1.1E+00	2.6E-02	1.0E-01	1.7E+01	1.0E-02	4.8E-03	9.8E-05	4.2E-03	2.2E-02	4.8E-05	1.0E-05	5.5E-02	1.2E-04	2.0E+02
Sat Col 13 lower port	25/Jan/13	27	210	6.84	1.7E+03	4.0E+02	5.4E+02	1.3E+01	1.3E+00	1.0E+00	1.1E+00	2.0E-02	1.0E-01	1.7E+01	1.0E-02	4.6E-03	9.2E-05	4.0E-03	2.2E-02	4.9E-05	1.0E-05	5.9E-02	1.0E-04	2.1E+02
Sat Col 13 lower port	13/Feb/13	30	230	6.92	1.5E+03	4.0E+02	4.2E+02	1.0E+01	1.6E+00	5.0E-01	9.7E-01	1.0E-02	6.5E-02	1.5E+01	5.0E-03	1.9E-03	6.7E-05	3.4E-03	2.5E-02	3.9E-05	5.0E-06	4.9E-02	1.1E-04	1.9E+02
Sat Col 13 lower port	13/Mar/13	34	225	6.76	1.3E+03	3.8E+02	3.7E+02	8.2E+00	1.8E+00	5.0E-01	1.0E+00	1.0E-02	5.0E-02	2.7E+00	5.0E-03	2.4E-03	7.3E-05	3.5E-03	2.4E-02	3.8E-05	6.6E-06	5.1E-02	1.0E-04	1.6E+02
Sat Col 13 lower port	12/Apr/13	38	210	7.53	1.2E+03	3.2E+02	3.1E+02	1.2E+01	1.5E+00	5.0E-01	9.8E-01	1.0E-02	5.0E-02	1.2E+01	5.0E-03	2.4E-03	6.9E-05	3.8E-03	2.7E-02	4.1E-05	5.0E-06	5.3E-02	1.2E-04	1.6E+02
Sat Col 13 lower port	8/May/13	42	200	7.00	1.1E+03	3.9E+02	2.6E+02	5.3E+00	2.0E+00	5.0E-01	9.5E-01	1.0E-02	5.0E-02	1.0E+01	5.0E-03	6.8E-04	6.2E-05	2.9E-03	3.0E-02	2.8E-05	5.0E-06	4.8E-02	1.2E-04	1.3E+02
Sat Col 13 lower port	7/Jun/13	46	210	7.08	1.1E+03	3.9E+02	2.2E+02	5.0E+00	2.0E+00	5.0E-01	8.1E-01	1.0E-02	5.0E-02	9.5E+00	5.0E-03	1.8E-03	5.9E-05	3.6E-03	3.3E-02	2.9E-05	5.0E-06	4.7E-02	1.0E-04	1.3E+02
Sat Col 13 lower port	31/Jul/13	54	210	7.07	9.3E+02	3.8E+02	1.7E+02	5.0E+00	2.0E+00	5.0E-01	9.5E-01	1.0E-02	5.0E-02	8.5E+00	5.0E-03	1.9E-03	2.1E-04	3.4E-03	3.5E-02	2.7E-05	5.0E-06	4.3E-02	2.0E-04	1.2E+02
Sat Col 13 lower port	29/Aug/13	58	200	7.42	8.6E+02	3.7E+02	1.3E+02	5.0E+00	2.2E+00	5.0E-01	9.2E-01	1.0E-02	5.0E-02	7.4E+00	5.0E-03	2.2E-03	1.5E-04	3.6E-03	4.2E-02	2.5E-05	5.0E-06	4.3E-02	1.2E-04	1.1E+02
Sat Col 13 lower port	27/Sep/13	62	185	7.30	8.0E+02	3.6E+02	1.1E+02	2.5E+00	2.1E+00	2.5E-01	8.0E-01	5.0E-03	2.5E-02	6.7E+00	5.0E-03	8.4E-02	1.0E-04	3.2E-03	4.5E-02	2.6E-05	5.0E-06	3.5E-02	1.5E-04	9.3E+01
Sat Col 13 lower port	25/Oct/13	66	210	7.21	7.6E+02	3.3E+02	9.1E+01	3.6E+00	2.1E+00	2.5E-01	8.2E-01	5.0E-03	2.5E-02	5.9E+00	2.0E-03	1.3E-03	8.7E-05	3.3E-03	4.8E-02	2.6E-05	5.0E-06	3.8E-02	1.4E-04	9.7E+01
Sat Col 13 lower port	21/Nov/13	70	235	7.51	7.0E+02	3.2E+02	7.6E+01	1.4E+00	2.1E+00	5.0E-02	8.0E-01	1.0E-03	5.5E-03	5.3E+00	5.0E-03	2.4E-03	8.1E-05	3.0E-03	4.8E-02	1.7E-05	5.0E-06	3.1E-02	2.0E-04	8.5E+01
Sat Col 13 lower port	19/Dec/13	74	200	7.55	6.5E+02	3.1E+02	6.4E+01	1.2E+00	2.2E+00	5.0E-02	8.0E-01	1.0E-03	5.0E-03	4.8E+00	5.0E-03	1.2E-03	7.5E-05	3.2E-03	5.1E-02	1.9E-05	5.0E-06	3.0E-02	1.6E-04	8.1E+01
Sat Col 13 lower port	16/Jan/14	78	230	7.42	6.3E+02	2.7E+02	5.6E+01	1.1E+00	2.3E+00	5.0E-02	6.8E-01	1.0E-03	5.0E-03	4.5E+00	2.0E-03	1.5E-03	4.9E-05	3.0E-03	5.1E-02	1.6E-05	5.0E-06	2.8E-02	2.2E-04	7.4E+01
Sat Col 13 lower port	13/Feb/14	82	230	7.44	7.4E+00	2.6E+02	4.9E+01	9.2E-01	2.4E+00	5.0E-02	6.8E-01	1.0E-03	5.0E-03	4.3E+00	2.0E-03	1.8E-03	5.2E-05	2.8E-03	5.7E-02	1.9E-05	5.0E-06	2.9E-02	1.7E-04	7.7E+01
Sat Col 13 lower port	12/Mar/14	86	220	7.59	5.7E+02	2.5E+02	4.3E+01	8.4E-01	2.5E+00	5.0E-02	7.0E-01	1.0E-03	5.0E-03	3.7E+00	5.0E-03	1.0E-03	4.9E-05	3.0E-03	6.1E-02	2.3E-05	5.0E-06	2.5E-02	2.7E-04	7.5E+01
Sat Col 13 lower port	17/Apr/14	91	209	7.40	5.7E+02	2.7E+02	4.0E+01	9.7E-01	2.5E+00	5.0E-02	6.7E-01	1.0E-03	5.0E-03	3.6E+00	5.0E-03	2.0E-03	4.2E-05	2.9E-03	6.6E-02	2.0E-05	5.0E-06	2.7E-02	2.1E-04	7.0E+01
Sat Col 13 lower port	22/May/14	96	253	7.79	5.3E+02	2.4E+02	3.5E+01	8.0E-01	2.6E+00	5.0E-02	6.1E-01	1.0E-03	5.0E-03	3.2E+00	5.0E-03	1.5E-03	3.6E-05	2.9E-03	6.9E-02	1.8E-05	5.0E-06	3.1E-02	2.1E-04	6.8E+01
Sat Col 13 lower port	11/Jun/14	99	235	7.71	5.1E+02	2.3E+02	3.2E+01	7.6E-01	2.6E+00	5.0E-02	6.9E-01	1.0E-03	5.0E-03	3.2E+00	5.0E-03	1.4E-03	3.1E-05	2.8E-03	7.4E-02	1.3E-05	5.0E-06	2.4E-02	2.5E-04	6.2E+01
Sat Col 13 lower port	10/Jul/14	103	220	7.48	5.1E+02	2.4E+02	3.0E+01	7.4E-01	2.7E+00	5.0E-02	6.4E-01	1.0E-03	5.0E-03	2.8E+00	5.0E-03	1.6E-03	2.5E-05	2.8E-03	8.1E-02	1.1E-05	5.0E-06	2.5E-02	2.5E-04	6.7E+01
Sat Col 13 lower port	7/Aug/14	107	205	7.50	5.0E+02	2.4E+02	2.9E+01	6.8E-01	2.7E+00	5.0E-02	6.4E-01	1.0E-03	5.0E-03	2.6E+00	5.0E-03	1.9E-03	3.0E-05	2.9E-03	8.6E-02	1.7E-05	5.0E-06	2.3E-02	1.2E-05	6.7E+01
Sat Col 13 lower port	5/Sep/14	111	198	7.53	5.0E+02	2.2E+02	2.6E+01	6.9E-01	2.7E+00	5.0E-02	6.5E-01	1.0E-03	5.0E-03	2.8E+00	5.0E-03	1.5E-03	3.3E-05	2.8E-03	8.8E-02	1.0E-05	5.0E-06	2.4E-02	2.5E-05	6.2E+01
Sat Col 13 lower port	2/Oct/14	115	230				2.2E+01	6.3E-01	2.9E+00	5.0E-02	6.0E-01	1.0E-03	5.0E-03	2.3E+00	5.0E-03	1.4E-03	2.7E-05	2.7E-03	8.6E-02	1.0E-05	5.0E-06	2.2E-02	3.0E-05	5.9E+01
Sat Col 14 upper port	12/Jul/12	0	250	6.24	4.6E+03	6.4E+02	2.7E+03	5.0E+01	1.8E+00	1.0E+00	6.4E-01	2.0E-02	1.0E-01	9.7E+01	5.0E-03	1.3E-01	7.5E-03	3.7E-03	2.8E-02	6.7E-04	3.5E-05	5.4E-02	1.7E-03	8.9E+02
Sat Col 14 upper port	3/Aug/12	3	150	6.54	3.8E+03	6.3E+02	2.1E+03	3.7E+01	2.2E+00	1.0E+00	9.6E-01	2.2E-02	1.0E-01	3.3E+01	5.0E-03	1.0E-01	2.7E-03	1.2E-02	2.2E-02	6.6E-04	9.6E-05	4.2E-02	1.3E-03	6.8E+02
Sat Col 14 upper port	30/Aug/12	7	175	6.40	3.7E+03	7.0E+02	2.0E+03	2.8E+01	1.7E+00	1.0E+00	9.5E-01	2.0E-02	1.0E-01	2.7E+01	5.0E-03	4.1E-02	2.5E-03	6.7E-03	2.0E-02	5.7E-04	2.5E-05	4.7E-02	1.1E-03	7.1E+02
Sat Col 14 upper port	25/Sep/12	11	180	6.32	3.6E+03	7.1E+02	2.2E+03	2.4E+01	2.0E+00	1.0E+00	1.2E+00	2.0E-02	1.0E-01	2.3E+01	5.0E-03	4.2E-02	1.5E-03	9.6E-03	1.9E-02	5.0E-04	1.3E-04	3.9E-02	6.4E-04	6.6E+02
Sat Col 14 upper port	23/Oct/12	15	200	6.38	3.5E+03	6.6E+02	1.9E+03	1.9E+01	1.8E+00	1.0E+00	1.2E+00	2.0E-02	1.0E-01	2.0E+01	5.0E-03	3.0E-02	1.2E-03	1.1E-02	1.8E-02	4.1E-04	2.5E-05	4.0E-02	3.6E-04	7.0E+02
Sat Col 14 upper port	20/Nov/12	19	200	6.37	3.2E+03	5.4E+02	1.7E+03	1.5E+01	1.8E+00	1.0E+00	1.2E+00	4.0E-02	1.0E-01	1.6E+01	1.0E-02	2.1E-02	9.0E-04	7.9E-03	1.7E-02	3.6E-04	5.0E-06	3.3E-02	3.2E-04	6.3E+02
Sat Col 14 upper port	18/Dec/12	23	215	6.61	3.0E+03	5.2E+02	1.6E+03	1.3E+01	1.7E+00	1.0E+00	1.1E+00	2.0E-02	1.0E-01	1.3E+01	1.0E-02	1.5E-02	6.3E-04	8.4E-03	1.7E-02	2.9E-04	2.5E-05	2.7E-02	1.8E-04	6.0E+02
Sat Col 14 upper port	24/Jan/13	28	200	6.53	2.9E+03	4.6E+02	1.5E+03	1.0E+01	2.0E+00	1.0E+00	1.1E+00	2.0E-02	1.0E-01	9.3E+00	1.0E-02	2.2E-02	6.7E-04	7.0E-03	1.6E-02	2.7E-04	2.5E-05	2.6E-02	2.2E-04	5.7E+02
Sat Col 14 upper port	12/Feb/13	31	237	6.63	2.6E+03	4.2E+02	1.3E+03	1.0E+01	2.0E+00	1.0E+00	1.0E+00	2.0E-02	1.0E-01	6.9E+00	5.0E-03	4.9E-03	4.4E-04	4.1E-03	1.9E-02	1.9E-04	1.0E-05	2.3E-02	1.4E-04	5.2E+02
Sat Col 14 upper port	12/Mar/13	35	235	6.87	2.5E+03	4.1E+02	1.3E+03	1.0E+01	2.1E+00	1.0E+00	9.8E-01	2.0E-02	1.0E-01	8.3E+00	5.0E-03	5.2E-03	4.3E-04	5.4E-03	1.8E-02	1.6E-04	1.9E-05	2.2E-02	9.5E-05	4.8E+02
Sat Col 14 upper port	11/Apr/13	39	256	6.72	2.4E+03	3.8E+02	1.2E+03	1.0E+01	2.1E+00	1.0E+00	9.9E-01	2.0E-02	1.0E-01	9.7E+00	5.0E-03	3.9E-03	4.2E-04	5.5E-03	1.9E-02	1.4E-04	1.0E-05	2.4E-02	3.8E-05	4.5E+02
Sat Col 14 upper port	7/May/13	43	224	6.77	2.2E+03	4.2E+02	1.1E+03	1.0E+01	2.2E+00	1.0E+00	9.1E-01	2.0E-02	1.0E-01	5.3E+00	5.0E-03	4.3E-03	3.2E-04	4.8E-03	2.1E-02	1.2E-04	1.0E-05	1.7E-02	3.4E-05	3.6E+02
Sat Col 14 upper port	6/Jun/13	47	280	6.71	2.0E+03	3.9E+02	9.5E+02	1.0E+01	1.8E+00	1.0E+00	7.9E-01	2.0E-02	1.0E-01	4.6E+00	5.0E-03	8.0E-03	3.3E-04	4.4E-03	2.1E-02	1.2E-04	1.0E-05	2.1E-02	2.5E-05	3.7E+02
Sat Col 14 upper port	4/Jul/13	51	240	7.11	1.9E+03	3.7E+02	8.5E+02	1.4E+01	1.7E+00	1.0E+00	7.8E-01	2.0E-02	1.0E-01	4.1E+00	5.0E-03	2.7E-03	2.5E-04	3.5E-03	2.2E-02	8.6E-05	1.0E-05	1.9E-02	2.0E-05	3.4E+02
Sat Col 14 upper port	30/Jul/13	55	245	7.06	1.9E+03	3.6E+02	8.7E+02	1.0E+01	2.1E+00	1.0E+00	7.6E-01	2.0E-02	1.0E-01	3.9E+00	5.0E-03	2.7E-03	2.5E-04	3.9E-03	2.3E-02	1.0E-04	1.0E-05	1.9E-02	2.6E-05	3.7E+02
Sat Col 14 upper port	28/Aug/13	59	240	7.03	1.7E+03	3.6E+02	7.7E+02	5.0E+00	1.9E+00	5.0E-01	7.7E-01	1.0E-02	5.0E-02	3.6E+00	5.0E-03	3.9E-03	2.3E-04	3.6E-03	2.0E-02	8.5E-05	1.0E-05	2.0E-02	1.7E-05	3.3E+02
Sat Col 14 upper port	26/Sep/13	63	291	7.08	1.6E+03	3.2E+02	6.8E+02	5.0E+00	1.7E+00	5.0E-01	7.0E-01	1.0E-02	5.0E-02	3.1E+00	5.0E-03	2.5E-03	2.1E-04	2.9E-03	1.9E-02	7.1E-05	1.0E-05	1.8E-02	1.2E-05	2.9E+02
Sat Col 14 upper port	24/Oct/13	67	260	6.99	1.5E+03	3.2E+02	6.1E+02	2.8E+00	1.7E+00	2.5E-01	6.7E-01	6.6E-03	2.5E-02	2.8E+00	5.0E-03	2.7E-03	1.9E-04	3.0E-03	2.3E-02	6.9E-05	5.0E-06	1.7E-02	1.8E-05	2.9E+02
Sat Col 14 upper port	20/Nov/13	71	273	7.04	1.4E+03	3.0E+02	5.7E+02	5.0E+00	1.6E+00	5.0E-01	5.8E-01	1.0E-02	5.0E-02	2.8E+00	2.0E-03	1.3E-03	1.6E-04	2.4E-03	2.4E-02	5.7E-05	5.0E-06	1.7E-02	9.4E-06	2.5E+02
Sat Col 14 upper port	18/Dec/13	75	290	7.06	1.3E+03	3.7E+02	5.2E+02	5.0E+00	1.6E+00	5.0E-01	5.5E-01	1.0E-02	5.0E-02	2.3E+00	2.0E-03	7.6E-04	1.7E-04	2.3E-03	2.2E-02	5.3E-05	5.0E-06	1.4E-02	5.9E-06	2.3E+02
Sat Col 14 upper port	15/Jan/14	79	270	7.18	1.3E+03	2.5E+02	5.2E+02	5.0E+00	1.7E+00	5.0E-01	4.7E-01	1.0E-02	5.0E-02	2.2E+00	5.0E-03	1.0E-03	1.6E-04	2.5E-03	2.3E-02	4.2E-05	5.0E-06	1.4E-02	7.4E-06	2.3E+02
Sat Col 14 upper port	12/Feb/14	83	230	7.20	1.2E+03	2.4E+02	4.5E+02	5.0E+00	1.7E+00	5.0E-01	5.2E-01	1.0E-02	5.0E-02	2.1E+00	2.0E-03	1.0E-03	1.4E-04	2.3E-03	2.4E-02	3.4E-05	5.0E-06	1.3E-02	5.0E-06	2.2E+02
Sat Col 14 lower port	13/Jul/12	0	225	3.32	7.5E+03	0.0E+00	7.8E+03	4.8E+01	5.4E+01	2.5E+00	8.2E+00	5.0E-02	6.4E-01	8.2E+01	5.0E-03	6.9E+02	9.2E-03	1.9E-02	1.2E-02	6.7E-02	1.6E-03	5.0E-01	3.4E-02	4.9E+02
Sat Col 14 lower port	3/Aug/12	3	140	3.39	2.4E+03	0.0E+00	4.8E+03	3.1E+01	3.0E+01	2.5E+00	5.3E+00	5.0E-02	3.6E-01	5.7E+01	6.7E-03	4.2E+02	6.0E-03	1.2E-02	9.3E-03	3.4E-02	2.5E-04	2.5E-01	2.2E-02	4.4E+02
Sat Col 14 lower port	31/Aug/12	7	210	3.46	4.3E+03	0.0E+00	3.6E+03	2.3E+01	1.9E+01	1.0E+00	3.9E+00	2.0E-02	1.8E-01	3.8E+01	5.0E-03	1.9E+02	4.9E-03	8.2E-03	8.0E-03	2.0E-02	1.0E-04	1.0E-01	1.2E-02	4.4E+02
Sat Col 14 lower port	26/Sep/12	11	200	3.60	3.8E+03	0.0E+00	2.9E+03	1.6E+01	1.4E+01	1.0E+00	3.4E+00	3.3E-02	1.6E-01	2.9E+01	5.7E-03	1.3E+02	4.0E-03	7.2E-03	8.9E-03	1.5E-02	2.9E-04	1.0E-01	9.1E-03	4.0E+02
Sat Col 14 lower port	24/Oct/12	15	225	3.60	3.4E+03	1.4E+01	2.5E+03	2.2E+01	8.5E+00	1.0E+00	2.5E+00	2.4E-02	1.0E-01	4.8E+00	5.0E-03	7.7E+01	3.6E-03	1.8E-02	9.1E-03	8.5E-03	5.0E-05	5.0E-02	5.7E-03	3.6E+02
Sat Col 14 lower port	21/Nov/12	19	600	3.82	3.1E+03	0.0E+00	2.3E+03	1.3E+01	5.5E+00	1.0E+00	2.5E+00	2.3E-02	1.0E-01	1.8E+01	1.0E-02	5.4E+01	3.2E-03	2.3E-03	6.5E-03	6.7E-03	5.0E-05	5.0E-02	4.7E-03	3.8E+02
Sat Col 14 lower port	19/Dec/12	23	210	4.07	2.9E+03	1.8E+01	2.1E+03	1.0E+01	4.2E+00	1.0E+00	2.0E+00	2.1E-02	1.0E-01	1.4E+01	1.0E-02	4.3E+01	3.4E-03	3.2E-03	7.0E-03	4.5E-03	2.5E-05	2.5E-02	4.8E-03	4.1E+02
Sat Col 14 lower port	25/Jan/13	28	210	4.26	2.8E+03	3.0E+01	2.0E+03	1.0E+01	3.6E+00	1.0E+00	1.9E+00	2.0E-02	1.0E-01	1.3E+01	1.0E-02	3.4E+01	3.5E-03	2.4E-03	6.9E-03	4.4E-03	2.5E-05	3.3E-02	3.3E-03	4.7E+02
Sat Col 14 lower port	13/Feb/13	31	230	4.39	2.7E+03	2.1E+01	1.9E+03	1.0E+01	3.3E+00	1.0E+00	1.7E+00	2.0E-02	1.0E-01	1.2E+01	5.0E-03	2.6E+01	3.4E-03	2.1E-03	7.4E-03	3.5E-03	2.5E-05	3.1E-02	2.9E-03	4.7E+02
Sat Col 14 lower port	13/Mar/13	35	225	4.39	2.7E+03	2.2E+01	1.8E+03	1.0E+01	2.8E+00	1.0E+00	1.6E+00	2.0E-02	1.0E-01	2.4E+00	5.0E-03	2.1E+01	3.7E-03	2.0E-03	7.1E-03	3.1E-03	3.5E-05	3.1E-02	2.3E-03	4.7E+02
Sat Col 14 lower port	12/Apr/13	39	200	4.37	2.7E+03	1.9E+01	1.8E+03	2.1E+01	2.0E+00	1.0E+00	1.6E+00	2.0E-02	1.0E-01	1.0E+01	5.0E-03	1.9E+01	3.9E-03	1.5E-03	7.7E-03	3.1E-03	1.0E-05	3.4E-02	2.2E-03	4.8E+02
Sat Col 14 lower port	8/May/13	43	200	4.52	2.5E+03	2.5E+01	1.8E+03	1.0E+01	2.3E+00	1.0E+00	1.4E+00	2.0E-02	1.0E-01	8.9E+00	5.0E-03	1.4E+01	3.9E-03	9.6E-04	7.7E-03	2.4E-03	1.0E-05	3.0E-02	1.9E-03	4.6E+02
Sat Col 14 lower port	7/Jun/13	47	180	4.60	2.6E+03	1.8E+01	1.8E+03	1.0E+01	2.2E+00	1.0E+00	1.2E+00	2.0E-02	1.0E-01	8.4E+00	5.0E-03	1.2E+01	3.7E-03	1.4E-03	7.8E-03	2.1E-03	1.0E-05	3.1E-02	1.6E-03	4.7E+02
Sat Col 14 lower port	5/Jul/13	51	200	4.93	2.5E+03	2.8E+01	1.7E+03	1.0E+01	1.3E+00	1.0E+00	1.2E+00	2.0E-02	1.0E-01	7.5E+00	5.0E-03	7.3E+00	4.0E-03	1.2E-03	7.8E-03	1.7E-03	1.0E-05	2.9E-02	1.3E-03	4.8E+02
Sat Col 14 lower port	31/Jul/13	55	200	4.96	2.5E+03	2.4E+01	1.7E+03	1.0E+01	1.7E+00	2.5E+00	1.2E+00	2.0E-02	1.0E-01	7.4E+00	5.0E-03	6.6E+00	3.6E-03	1.3E-03	7.8E-03	1.4E-03	1.0E-05	2.8E-02	1.4E-03	5.1E+02
Sat Col 14 lower port	29/Aug/13	59	175	5.14	2.4E+03	2.7E+01	1.6E+03	1.0E+01	1.5E+00	1.0E+00	1.1E+00	2.0E-02	1.0E-01	6.8E+00	5.0E-03	5.0E+00	4.0E-03	1.0E-03	8.1E-03	1.2E-03	1.0E-05	2.5E-02	1.2E-03	4.8E+02
Sat Col 14 lower port	27/Sep/13	63	200	5.23	2.5E+03	2.2E+01	1.6E+03	1.0E+01	9.4E-01	1.0E+00	1.1E+00	2.0E-02	1.0E-01	6.3E+00	5.0E-03	4.3E+00	3.6E-03	8.4E-04	7.5E-03	1.2E-03	1.0E-05	2.5E-02	1.2E-03	4.9E+02
Sat Col 14 lower port	25/Oct/13	67	190	5.88	2.4E+03	4.2E+01	1.6E+03	1.0E+01	8.8E-01	1.0E+00	1.0E+00	2.0E-02	1.0E-01	5.7E+00	2.0E-03	3.2E+00	3.5E-03	9.6E-04	7.3E-03	9.9E-04	1.0E-05	2.6E-02	9.4E-04	5.0E+02
Sat Col 14 lower port	21/Nov/13	71	200	6.15	2.3E+03	4.0E+01	1.0E+01	1.0E+01	4.0E-01	1.0E+00	9.8E-01	2.0E-02	1.0E-01	5.4E+00	5.0E-03	2.3E+00	3.4E-03	9.2E-04	6.9E-03	8.1E-04	1.0E-05	2.5E-02	8.9E-04	4.7E+02
Sat Col 14 lower port	19/Dec/13	75	210	5.58	2.2E+03	4.0E+01	1.5E+03	1.0E+01	1.1E+00	1.0E+00	9.7E-01	2.0E-02	1.0E-01	5.0E+00	5.0E-03	1.7E+00	3.5E-03	7.6E-04	7.2E-03	7.6E-04	1.0E-05	2.2E-02	8.0E-04	4.9E+02
Sat Col 14 lower port	16/Jan/14	79	225	5.82	2.3E+03	4.0E+01	1.5E+03	1.0E+01	7.0E-01	1.0E+00	7.9E-01	2.

Saturated column kentic test results

ID	Date	cycle	Flow Between Events	pH	Cond-L	T-Alk	SO4	D-Cl	D-F	D-Br	NH3	NO2-N	NO3-N	DOC	D-Sulphide	D-Al	D-Sb	D-As	D-Ba	D-Be	D-Bi	D-B	D-Cd	D-Ca
			mL	pH	uS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Sat Col 15	17/Jul/12	0	200	6.77	3.0E+03	3.6E+02	1.4E+03	7.3E+01	1.4E+00	1.0E+00	1.7E+00	2.0E-02	1.0E-01	6.0E+01	5.0E-03	9.4E-03	5.9E-04	4.3E-03	2.7E-02	6.6E-05	1.4E-05	1.4E-01	3.0E-03	3.7E+02
Sat Col 15	3/Aug/12	2	150	7.04	2.0E+03	3.3E+02	7.7E+02	3.7E+01	1.7E+00	1.0E+00	1.5E+00	2.0E-02	1.0E-01	3.0E+01	5.0E-03	6.9E-03	6.2E-04	3.6E-03	2.4E-02	4.9E-05	5.0E-06	1.1E-01	2.0E-03	2.4E+02
Sat Col 15	30/Aug/12	6	200	6.89	1.8E+03	3.9E+02	6.5E+02	2.5E+01	1.6E+00	1.0E+00	1.6E+00	2.0E-02	1.0E-01	2.4E+01	5.0E-03	7.0E-03	4.8E-04	4.9E-03	3.1E-02	4.5E-05	5.0E-06	1.0E-01	7.0E-04	2.3E+02
Sat Col 15	25/Sep/12	10	200	6.96	1.4E+03	4.1E+02	4.5E+02	1.4E+01	1.9E+00	5.0E-01	1.2E+00	1.0E-02	5.0E-02	1.9E+01	5.0E-03	5.2E-03	3.5E-04	4.2E-03	2.8E-02	3.4E-05	5.0E-06	8.1E-02	4.0E-04	1.6E+02
Sat Col 15	23/Oct/12	14	225	6.97	1.3E+03	5.0E+02	5.0E+00	5.0E+00	2.0E-01	5.0E-01	1.2E+00	1.0E-02	5.0E-02	1.9E+01	5.0E-03	4.9E-03	3.0E-04	4.4E-03	2.9E-02	3.1E-05	5.0E-06	7.8E-02	2.6E-04	1.5E+02
Sat Col 15	20/Nov/12	18	220	6.80	1.2E+03	3.3E+02	3.6E+02	1.1E+01	2.1E+00	5.0E-01	1.1E+00	1.0E-02	5.0E-02	1.7E+01	1.0E-02	3.6E-03	2.7E-04	4.4E-03	2.8E-02	3.8E-05	5.2E-06	7.3E-02	2.0E-04	1.5E+02
Sat Col 15	18/Dec/12	22	1067	7.24	1.2E+03	3.5E+02	3.1E+02	9.3E+00	1.9E+00	5.0E-01	1.1E+00	1.0E-02	5.0E-02	1.5E+01	1.0E-02	2.6E-03	2.2E-04	4.9E-03	3.0E-02	2.7E-05	5.0E-06	5.9E-02	2.0E-04	1.5E+02
Sat Col 15	24/Jan/13	27	210	6.95	1.1E+03	3.3E+02	2.8E+02	7.7E+00	2.0E+00	5.0E-01	1.0E+00	1.0E-02	5.0E-02	1.3E+01	1.0E-02	2.6E-03	1.9E-04	4.3E-03	3.1E-02	3.5E-05	5.0E-06	6.6E-02	1.5E-04	1.3E+02
Sat Col 15	12/Feb/13	30	250	6.89	1.0E+03	3.1E+02	2.4E+02	6.9E+00	2.1E+00	5.0E-01	9.5E-01	1.0E-02	5.0E-02	1.2E+01	5.0E-03	2.9E-03	1.7E-04	4.4E-03	3.1E-02	3.2E-05	5.0E-06	6.2E-02	1.5E-04	1.2E+02
Sat Col 15	12/Mar/13	34	238	7.25	9.5E+02	3.0E+02	2.1E+02	5.7E+00	2.2E+00	5.0E-01	9.3E-01	1.0E-02	5.0E-02	1.3E+01	5.0E-03	2.3E-03	1.4E-04	4.1E-03	3.3E-02	2.3E-05	5.0E-06	6.1E-02	1.5E-04	1.1E+02
Sat Col 15	11/Apr/13	38	248	7.03	8.8E+02	3.0E+02	1.7E+02	5.0E+00	2.3E+00	5.0E-01	9.3E-01	1.0E-02	5.0E-02	1.3E+01	5.0E-03	2.7E-03	1.4E-04	4.4E-03	3.8E-02	2.3E-05	5.0E-06	5.7E-02	1.5E-04	9.7E+01
Sat Col 15	7/May/13	42	245	7.19	8.3E+02	3.3E+02	1.5E+02	5.0E+00	2.3E+00	5.0E-01	9.0E-01	1.0E-02	5.1E-02	1.0E+01	5.0E-03	1.6E-03	1.2E-04	4.3E-03	4.3E-02	2.2E-05	5.0E-06	5.4E-02	2.0E-04	9.7E+01
Sat Col 15	6/Jun/13	46	265	7.05	7.8E+02	3.1E+02	1.2E+02	3.9E+00	2.2E+00	5.0E-02	8.0E-01	1.0E-03	5.0E-03	8.5E+00	5.0E-03	1.6E-03	1.0E-04	4.1E-03	4.5E-02	2.5E-05	5.0E-06	5.5E-02	1.7E-04	9.3E+01
Sat Col 15	4/Jul/13	50	235	7.21	7.2E+02	3.2E+02	1.0E+02	6.1E+00	2.2E+00	2.5E-01	7.9E-01	5.0E-03	2.5E-02	7.5E+00	5.0E-03	1.7E-03	1.2E-04	3.8E-03	5.5E-02	1.7E-05	5.0E-06	5.0E-02	2.0E-04	8.8E+01
Sat Col 15	30/Jul/13	54	253	7.30	6.9E+02	3.1E+02	8.5E+01	2.8E+00	2.3E+00	5.0E-02	7.7E-01	1.0E-03	5.0E-03	7.1E+00	5.0E-03	2.1E-03	1.2E-04	4.0E-03	5.4E-02	1.9E-05	5.0E-06	5.1E-02	2.0E-04	8.5E+01
Sat Col 15	28/Aug/13	58	255	7.42	6.5E+02	3.1E+02	7.1E+01	2.5E+00	2.3E+00	5.0E-02	7.8E-01	1.0E-03	5.0E-03	7.0E+00	5.0E-03	2.1E-03	8.7E-05	3.5E-03	5.4E-02	1.7E-05	5.0E-06	4.6E-02	1.3E-04	7.9E+01
Sat Col 15	26/Sep/13	62	288	7.34	6.2E+02	3.0E+02	6.0E+01	2.3E+00	2.2E+00	5.0E-02	7.6E-01	1.0E-03	5.0E-03	6.2E+00	5.0E-03	2.1E-03	8.4E-05	3.2E-03	5.5E-02	1.6E-05	5.0E-06	3.9E-02	1.5E-04	7.1E+01
Sat Col 15	24/Oct/13	66	270	7.26	6.0E+02	2.9E+02	5.1E+01	2.0E+00	2.2E+00	5.0E-02	7.7E-01	1.0E-03	5.0E-03	5.6E+00	5.0E-03	2.0E-03	6.5E-05	3.1E-03	6.2E-02	1.5E-05	5.0E-06	3.6E-02	1.9E-04	7.3E+01
Sat Col 15	20/Nov/13	70	279	7.35	5.7E+02	2.7E+02	4.3E+01	1.8E+00	2.2E+00	5.0E-02	6.9E-01	1.0E-03	7.3E-03	5.4E+00	2.0E-03	3.7E-03	6.6E-05	3.1E-03	6.7E-02	1.3E-05	5.0E-06	3.9E-02	2.6E-04	7.0E+01
Sat Col 15	18/Dec/13	74	280	7.37	5.5E+02	2.7E+02	3.8E+01	1.6E+00	2.3E+00	5.0E-02	6.7E-01	1.0E-03	5.7E-03	4.6E+00	2.9E-03	1.2E-03	5.1E-05	3.2E-03	7.2E-02	1.6E-05	5.0E-06	3.3E-02	3.2E-04	7.5E+01
Sat Col 15	15/Jan/14	78	260	7.39	5.3E+02	2.3E+02	3.3E+01	1.4E+00	2.3E+00	5.0E-02	5.9E-01	1.0E-03	5.0E-03	4.3E+00	5.0E-03	1.4E-03	4.4E-05	3.1E-03	8.4E-02	1.2E-05	5.0E-06	2.8E-02	2.3E-04	6.2E+01
Sat Col 15	12/Feb/14	82	220	7.40	5.0E+02	2.3E+02	2.9E+01	1.3E+00	2.3E+00	5.0E-02	6.4E-01	1.0E-03	5.0E-03	3.9E+00	2.0E-03	1.8E-03	4.9E-05	2.9E-03	8.4E-02	1.2E-05	5.0E-06	3.1E-02	1.5E-04	6.6E+01
Sat Col 16	1/Mar/13	0	174	8.23	1.3E+03	5.5E+01	6.4E+02	2.0E+01	6.2E-01	5.0E-01	1.1E-01	2.1E-02	5.0E-02	1.1E+02	1.8E-01	2.4E-03	4.8E-04	4.6E-03	2.5E-02	1.0E-05	5.0E-06	2.2E-02	6.8E-06	2.4E+02
Sat Col 16	12/Mar/13	1	229	8.32	1.3E+03	5.0E+01	6.0E+02	2.0E+01	6.7E-01	5.0E-01	1.4E-01	3.6E-02	5.0E-02	1.3E+02	7.6E-01	3.9E-03	2.0E-04	4.8E-03	2.3E-02	1.0E-05	5.0E-06	2.3E-02	5.0E-06	2.1E+02
Sat Col 16	12/Apr/13	6	232	8.04	9.5E+02	5.5E+01	3.9E+02	2.1E+01	4.8E-01	5.0E-01	2.4E-02	1.0E-02	5.0E-02	1.0E+02	1.8E-01	3.5E-03	2.2E-04	5.3E-03	2.5E-02	1.0E-05	5.0E-06	2.2E-02	5.0E-06	1.4E+02
Sat Col 16	7/May/13	10	224	8.01	6.6E+02	5.3E+01	2.4E+02	1.4E+01	6.3E-01	2.5E-01	2.6E-02	1.0E-02	2.5E-02	8.9E+01	1.6E-01	2.5E-03	1.0E-03	4.8E-03	2.7E-02	1.0E-05	5.0E-06	2.3E-02	5.0E-06	8.0E+01
Sat Col 16	6/Jun/13	14	265	8.28	4.5E+02	5.5E+01	1.3E+02	1.1E+01	7.9E-01	5.0E-02	5.0E-03	1.9E-02	5.0E-03	7.8E+01	2.8E-01	2.8E-03	9.7E-05	3.8E-03	3.5E-02	1.0E-05	5.0E-06	2.3E-02	5.0E-06	4.4E+01
Sat Col 16	4/Jul/13	18	235	8.69	2.7E+02	7.1E+01	4.1E+01	9.5E+00	9.1E-01	5.0E-02	5.0E-03	3.0E-02	5.7E-03	6.7E+01	5.1E-01	4.2E-03	3.7E-05	3.8E-03	7.9E-02	1.0E-05	5.0E-06	2.3E-02	5.0E-06	2.3E+01
Sat Col 16	30/Jul/13	22	245	8.19	2.2E+02	7.2E+01	1.8E+01	7.4E+00	1.0E+00	5.0E-02	5.0E-03	3.2E-02	5.0E-03	6.3E+01	5.3E-01	4.8E-03	6.3E-05	3.3E-03	3.0E-01	1.0E-05	5.0E-06	2.6E-02	5.0E-06	1.6E+01
Sat Col 16	28/Aug/13	26	250	8.63	2.1E+02	7.4E+01	1.3E+01	6.9E+00	1.0E+00	5.0E-02	5.0E-03	1.9E-02	5.0E-03	5.3E+01	3.9E-01	4.2E-03	2.0E-05	2.9E-03	3.6E-01	1.0E-05	5.0E-06	2.5E-02	5.0E-06	1.5E+01
Sat Col 16	26/Sep/13	30	244	8.64	2.0E+02	6.6E+01	1.0E+01	4.7E+00	1.1E+00	5.0E-02	5.0E-03	1.6E-02	5.0E-03	4.3E+01	3.6E-01	3.5E-03	2.3E-05	2.1E-03	3.2E-01	1.0E-05	5.0E-06	2.4E-02	5.0E-06	1.4E+01
Sat Col 16	24/Oct/13	34	240	8.53	1.9E+02	6.6E+01	7.0E+00	5.1E+00	1.0E+00	5.0E-02	5.0E-03	9.7E-03	5.0E-03	3.4E+01	2.7E-01	5.2E-03	6.2E-05	1.5E-03	3.3E-01	1.0E-05	5.0E-06	2.2E-02	1.3E-05	1.3E+01
Sat Col 16	21/Nov/13	38	261	8.40	1.8E+02	6.7E+01	2.4E+00	3.0E+00	1.1E+00	5.0E-02	5.0E-03	5.5E-03	5.0E-03	2.3E+01	1.1E-01	4.2E-03	3.3E-04	3.6E-03	4.0E-01	1.0E-05	5.0E-06	2.3E-02	5.0E-06	1.4E+01
Sat Col 16	18/Dec/13	42	215	8.24	1.8E+02	7.8E+01	1.6E+00	3.8E+00	1.1E+00	5.0E-02	5.0E-03	2.5E-03	5.0E-03	1.8E+01	6.6E-02	2.4E-03	4.1E-04	2.2E-03	4.4E-01	1.0E-05	5.0E-06	2.2E-02	5.0E-06	1.4E+01
Sat Col 16	15/Jan/14	46	267	8.46	1.7E+02	7.0E+01	6.4E-01	4.3E+00	1.1E+00	5.0E-02	5.0E-03	2.7E-03	5.0E-03	1.7E+01	5.0E-03	2.4E-03	2.0E-04	8.6E-04	4.5E-01	1.0E-05	5.0E-06	2.2E-02	5.0E-06	1.3E+01
Sat Col 16	12/Feb/14	50	225	8.49	1.6E+02	7.1E+01	5.0E-01	2.1E+00	1.1E+00	5.0E-02	5.0E-03	2.9E-03	5.0E-03	1.3E+01	9.9E-02	2.5E-03	2.7E-04	4.9E-04	4.7E-01	1.0E-05	5.0E-06	2.4E-02	5.0E-06	1.3E+01
Sat Col 17	1/Mar/13	0	169	7.65	2.5E+03	4.3E+01	1.5E+03	3.8E+01	7.7E-01	1.0E+00	9.0E-01	2.0E-02	1.0E-01	4.5E+01	8.9E-02	5.9E-03	1.8E-03	2.1E-03	2.1E-02	2.0E-05	1.0E-05	2.8E-02	6.1E-05	5.4E+02
Sat Col 17	12/Mar/13	1	219	7.23	2.2E+03	5.1E+01	1.3E+03	3.5E+01	9.3E-01	1.0E+00	8.4E-01	2.0E-02	1.0E-01	4.0E+01	4.6E-02	4.8E-03	1.9E-03	2.0E-03	2.0E-02	2.0E-05	1.0E-05	2.8E-02	3.0E-05	4.5E+02
Sat Col 17	11/Apr/13	6	321	7.20	1.9E+03	3.8E+01	1.0E+03	2.9E+01	8.8E-01	1.0E+00	6.5E-01	2.0E-02	1.0E-01	2.7E+01	1.8E-02	3.8E-03	1.6E-03	1.5E-03	2.0E-02	2.0E-05	6.2E-05	2.8E-02	1.5E-05	3.5E+02
Sat Col 17	7/May/13	10	231	7.65	1.6E+03	3.7E+01	8.4E+02	2.6E+01	7.9E-01	1.0E+00	6.4E-01	2.0E-02	1.0E-01	2.5E+01	1.8E-02	2.5E-03	1.2E-03	1.3E-03	1.9E-02	1.0E-05	5.0E-06	2.7E-02	5.0E-06	2.8E+02
Sat Col 17	6/Jun/13	14	242	7.63	1.3E+03	4.3E+01	6.5E+02	2.2E+01	1.1E+00	5.0E-01	4.9E-01	1.0E-02	5.0E-02	2.2E+01	1.8E-02	2.4E-03	1.1E-03	1.3E-03	1.9E-02	1.0E-05	5.0E-06	2.6E-02	5.0E-06	2.1E+02
Sat Col 17	4/Jul/13	18	235	7.75	1.1E+03	5.3E+01	4.9E+02	2.0E+01	9.6E-01	5.0E-01	3.4E-01	1.0E-02	5.0E-02	1.7E+01	2.1E-02	2.1E-03	8.9E-04	1.3E-03	2.0E-02	1.0E-05	5.0E-06	2.3E-02	5.0E-06	1.5E+02
Sat Col 17	30/Jul/13	22	235	7.59	8.7E+02	4.8E+01	3.7E+02	1.5E+01	9.3E-01	1.0E+00	2.8E-01	2.0E-02	1.0E-01	1.6E+01	2.2E-02	2.1E-03	8.9E-04	1.4E-03	2.1E-02	1.0E-05	5.0E-06	2.6E-02	5.0E-06	1.3E+02
Sat Col 17	28/Aug/13	26	275	7.89	6.9E+02	4.6E+01	2.7E+02	1.2E+01	8.7E-01	2.5E-01	1.8E-01	5.0E-03	2.5E-02	1.4E+01	2.7E-02	2.1E-03	6.1E-04	1.5E-03	2.2E-02	1.0E-05	5.0E-06	2.4E-02	5.0E-06	8.4E+01
Sat Col 17	26/Sep/13	30	254	7.89	5.4E+02	4.1E+01	1.9E+02	1.2E+01	1.1E+00	5.0E-02	5.6E-02	1.0E-03	5.0E-03	1.2E+01	1.5E-02	3.9E-03	4.6E-04	1.4E-03	2.4E-02	1.0E-05	5.0E-06	2.4E-02	5.0E-06	5.4E+01
Sat Col 17	25/Oct/13	34	285	8.15	1.8E+02	3.1E+01	3.7E+01	4.8E+00	5.9E-01	5.0E-02	1.7E-02	6.1E-03	9.4E-03	3.5E+00	8.1E-03	3.7E-02	1.8E-03	4.2E-03	4.0E-02	1.0E-05	5.0E-06	1.2E-02	1.1E-05	1.6E+01
Sat Col 17	20/Nov/13	38	254	8.04	2.3E+02	5.0E+01	4.2E+01	6.9E+00	1.3E+00	5.0E-02	5.0E-03	1.4E-03	5.0E-03	7.0E+00	4.5E-03	4.5E-03	5.3E-04	2.4E-03	5.7E-02	1.0E-05	5.0E-06	2.4E-02	5.0E-06	1.8E+01
Sat Col 17	18/Dec/13	42	240	8.21	2.0E+02	5.4E+01	2.4E+01	6.0E+00	1.5E+00	5.0E-02	5.0E-03	1.0E-03	5.2E-03	5.4E+00	1.2E-02	3.4E-03	5.4E-04	2.7E-03	8.6E-02	1.0E-05	5.0E-06	2.2E-02	5.0E-06	1.4E+01
Sat Col 17	15/Jan/14	46	235	8.18	1.8E+02	5.5E+01	1.4E+01	5.3E+00	1.6E+00	5.0E-02	5.0E-03	1.0E-03	7.5E-03	4.8E+00	5.0E-03	4.1E-03	4.2E-04	2.7E-03	1.9E-01	1.0E-05	5.0E-06	2.2E-02	5.0E-06	1.2E+01
Sat Col 17	12/Feb/14	50	200	8.20	1.6E+02	5.7E+01	9.1E+00	4.0E+00	1.5E+00	5.0E-02	5.0E-03	1.0E-03	5.0E-03	3.8E+00	3.1E-03	4.4E-03	4.4E-04	2.8E-03	2.7E-01	1.0E-05	5.0E-06	2.3E-02	5.0E-06	1.1E+01

Saturated column kentic test results

ID	Date	cycle	D-Cr	D-Co	D-Cu	D-Fe	D-Pb	D-Li	D-Mg	D-Mn	D-Hg	D-Mo	D-Ni	D-P	D-K	D-Se	D-Si	D-Ag	D-Na	D-Sr	D-Tl	D-Sn	D-Ti	D-U	D-V	D-Zn	D-Zr
			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Sat Col 10	19/Aug/11	0	1.0E-04	6.8E-04	1.5E-02	1.1E-03	1.9E-04	6.4E-04	1.3E+00	1.4E-02	2.0E-05	4.5E-01	2.6E-04	3.0E-01	1.8E+01	9.3E-04	9.0E-01	5.0E-06	1.0E+01	2.1E-01	5.8E-05	1.0E-05	5.0E-04	4.4E-03	1.4E-03	3.2E-02	1.0E-04
Sat Col 10	26/Aug/11	1	1.0E-04	1.1E-03	3.5E-02	1.4E-03	1.7E-04	5.0E-04	1.7E+00	2.2E-02	2.5E-05	6.1E-01	4.2E-04	3.0E-01	2.1E+01	1.0E-03	1.1E+00	5.0E-06	1.2E+01	2.6E-01	5.8E-05	1.0E-05	7.8E-04	6.3E-03	1.1E-03	1.8E-02	1.0E-04
Sat Col 10	8/Sep/11	3	1.0E-04	1.4E-03	3.9E-02	2.0E-03	1.7E-04	5.0E-04	1.6E+00	2.1E-02	5.0E-05	5.9E-01	1.4E-04	3.0E-01	2.1E+01	9.2E-04	1.1E+00	5.0E-06	1.2E+01	2.2E-01	5.0E-05	1.0E-05	5.0E-04	5.2E-03	1.4E-03	2.2E-02	1.0E-04
Sat Col 10	15/Sep/11	4	1.0E-04	1.3E-03	3.4E-02	1.0E-03	1.7E-04	5.0E-04	1.3E+00	1.9E-02	2.0E-05	5.5E-01	3.2E-04	3.0E-01	1.7E+01	6.9E-04	9.8E-01	5.0E-06	9.9E+00	1.9E-01	4.3E-05	1.0E-05	5.6E-04	4.8E-03	1.5E-03	1.8E-02	1.0E-04
Sat Col 10	23/Sep/11	5	1.0E-04	1.3E-03	3.2E-02	3.0E-02	1.9E-04	5.0E-04	1.2E+00	1.7E-02		4.9E-01	5.0E-04	3.0E-01	1.6E+01	5.5E-04	1.0E+00	1.0E-05	9.9E+00	1.7E-01	4.4E-05	1.0E-04	1.0E-02	4.7E-03	1.6E-03	2.0E-02	
Sat Col 10	29/Sep/11	6	1.0E-04	1.2E-03	3.1E-02	2.0E-03	1.9E-04	5.0E-04	9.9E-01	1.5E-02	2.0E-05	3.8E-01	2.4E-04	3.0E-01	1.5E+01	4.1E-04	9.4E-01	5.0E-06	7.2E+00	1.4E-01	4.1E-05	5.4E-05	5.0E-04	4.1E-03	1.8E-03	1.6E-02	1.0E-04
Sat Col 10	13/Oct/11	8	1.0E-04	9.5E-04	2.0E-02	1.4E-03	2.0E-04	5.0E-04	7.5E-01	1.1E-02	2.0E-05	2.3E-01	1.8E-04	3.0E-01	1.2E+01	2.0E-04	9.1E-01	5.0E-06	4.8E+00	1.2E-01	3.5E-05	1.7E-05	5.0E-04	3.2E-03	1.8E-03	1.3E-02	1.0E-04
Sat Col 10	27/Oct/11	10	1.0E-04	7.6E-04	1.6E-02	1.0E-03	1.1E-04	5.0E-04	5.9E-01	7.8E-03	1.0E-05	1.0E-01	1.3E-04	3.0E-01	1.1E+01	1.4E-04	8.8E-01	5.0E-06	2.7E+00	1.1E-01	2.8E-05	2.3E-05	5.0E-04	2.3E-03	1.9E-03	6.2E-03	1.0E-04
Sat Col 10	10/Nov/11	12	1.0E-04	5.4E-04	8.3E-03	1.0E-03	8.0E-05	5.0E-04	4.9E-01	4.6E-03	1.0E-05	4.8E-02	5.0E-05	3.0E-01	9.6E+00	1.4E-04	8.2E-01	5.0E-06	1.3E+00	8.8E-02	2.2E-05	1.0E-05	5.0E-04	1.6E-03	2.2E-03	4.2E-03	1.0E-04
Sat Col 10	25/Nov/11	14	1.0E-04	3.8E-04	2.5E-03	1.0E-03	9.9E-05	5.0E-04	4.9E-01	4.2E-03	1.0E-05	3.4E-02	5.0E-05	3.0E-01	8.3E+00	1.2E-04	7.7E-01	5.0E-06	8.5E-01	9.2E-02	2.1E-05	2.6E-05	5.0E-04	1.3E-03	1.9E-03	4.5E-03	1.0E-04
Sat Col 10	8/Dec/11	16	1.0E-04	3.1E-04	3.9E-03	1.0E-03	6.4E-05	5.0E-04	4.7E-01	2.9E-03	1.0E-05	2.6E-02	5.0E-05	3.0E-01	7.8E+00	1.4E-04	7.9E-01	5.0E-06	6.1E-01	8.9E-02	1.9E-05	1.0E-05	5.0E-04	1.1E-03	1.9E-03	3.1E-03	1.0E-04
Sat Col 10	23/Dec/11	18	1.0E-04	3.0E-04	3.5E-03	1.0E-03	6.9E-05	5.0E-04	5.2E-01	3.2E-03	1.0E-05	2.7E-02	5.0E-05	3.0E-01	7.9E+00	1.3E-04	8.4E-01	5.0E-06	6.0E-01	8.6E-02	1.8E-05	1.0E-05	5.0E-04	1.1E-03	1.8E-03	3.1E-03	1.0E-04
Sat Col 10	5/Jan/12	20	1.0E-04	2.4E-04	1.8E-03	1.0E-03	6.8E-05	5.0E-04	5.1E-01	2.6E-03	1.0E-05	2.4E-02	5.0E-05	3.0E-01	7.5E+00	1.3E-04	8.3E-01	5.0E-06	4.5E-01	8.9E-02	1.7E-05	1.0E-05	5.0E-04	1.1E-03	1.7E-03	3.7E-03	1.0E-04
Sat Col 10	19/Jan/12	22	1.0E-04	2.2E-04	1.6E-03	1.0E-03	6.4E-05	5.0E-04	5.2E-01	2.6E-03	1.0E-05	2.2E-02	5.0E-05	3.0E-01	7.1E+00	1.3E-04	8.0E-01	5.0E-06	4.2E-01	9.4E-02	1.5E-05	1.0E-05	5.0E-04	1.3E-03	1.7E-03	2.1E-03	1.0E-04
Sat Col 10	3/Feb/12	24	1.0E-04	1.5E-04	1.3E-03	1.0E-03	5.9E-05	5.0E-04	4.8E-01	1.9E-03	1.0E-05	1.5E-02	5.0E-05	3.0E-01	6.6E+00	1.3E-04	7.5E-01	5.0E-06	2.8E-01	8.5E-02	2.1E-05	1.0E-05	5.0E-04	9.0E-04	1.8E-03	2.5E-03	1.0E-04
Sat Col 10	16/Feb/12	26	1.0E-04	9.6E-05	1.3E-03	1.0E-03	4.6E-05	5.0E-04	4.4E-01	1.6E-03	1.0E-05	1.3E-02	5.0E-05	3.0E-01	5.5E+00	1.0E-04	6.9E-01	5.0E-06	2.1E-01	8.1E-02	1.4E-05	1.0E-05	5.0E-04	8.2E-04	1.7E-03	2.4E-03	1.0E-04
Sat Col 10	2/Mar/12	28	1.0E-04	1.3E-04	1.2E-03	1.0E-03	5.3E-05	5.0E-04	5.7E-01	3.0E-03	1.0E-05	1.9E-02	5.0E-05	3.0E-01	6.3E+00	1.1E-04	7.6E-01	5.0E-06	2.8E-01	9.6E-02	1.6E-05	1.0E-05	5.0E-04	1.2E-03	1.6E-03	3.1E-03	1.0E-04
Sat Col 10	16/Mar/12	30	1.0E-04	1.1E-04	7.7E-04	1.0E-03	6.3E-05	5.0E-04	5.0E-01	1.8E-03	1.0E-05	1.7E-02	5.0E-05	3.0E-01	5.4E+00	1.4E-04	7.8E-01	5.0E-06	3.1E-01	9.5E-02	1.9E-05	1.0E-05	5.0E-04	1.3E-03	1.5E-03	4.2E-03	1.0E-04
Sat Col 10	30/Mar/12	32	1.0E-04	1.2E-04	8.7E-04	1.0E-03	7.4E-05	5.0E-04	6.2E-01	2.0E-03	1.0E-05	2.1E-02	8.1E-05	3.0E-01	6.6E+00	1.3E-04	8.5E-01	5.0E-06	3.3E-01	1.1E-01	1.5E-05	1.0E-05	5.0E-04	1.4E-03	1.5E-03	4.0E-03	1.0E-04
Sat Col 10	13/Apr/12	34	1.3E-04	3.2E-04	2.1E-02	2.2E-01	2.3E-04	5.0E-04	7.2E-01	2.1E-02	1.0E-05	2.3E-02	1.7E-04	3.0E-01	7.2E+00	1.3E-04	9.9E-01	5.0E-06	4.0E-01	1.1E-01	1.8E-05	1.0E-05	6.9E-04	2.0E-03	1.8E-03	7.8E-03	1.0E-04
Sat Col 10	25/Apr/12	36	1.0E-04	4.6E-05	2.3E-03	2.1E-03	2.4E-05	5.0E-04	6.4E-01	2.6E-03		1.4E-02	5.0E-05	3.0E-01	4.6E+00	1.1E-04	7.3E-01	5.3E-06	2.3E-01	8.4E-02	1.9E-05	1.0E-05	5.0E-04	8.7E-04	1.2E-03	3.4E-03	1.0E-04
Sat Col 10	11/May/12	38	1.0E-04	3.3E-05	1.6E-03	1.0E-03	7.8E-06	5.0E-04	7.7E-01	8.0E-03	1.0E-05	1.6E-02	5.0E-05	3.0E-01	4.6E+00	1.1E-04	7.6E-01	5.0E-06	2.5E-01	9.7E-02	1.7E-05	1.0E-05	5.0E-04	8.4E-04	1.2E-03	7.7E-04	1.0E-04
Sat Col 10	25/May/12	40	1.0E-04	2.8E-05	1.5E-03	1.0E-03	1.0E-05	5.0E-04	7.6E-01	8.1E-03	1.0E-05	1.6E-02	5.0E-05	3.0E-01	4.7E+00	1.2E-04	8.1E-01	5.0E-06	2.7E-01	9.2E-02	2.1E-05	1.0E-05	5.0E-04	8.7E-04	1.1E-03	8.5E-04	1.0E-04
Sat Col 10	8/Jun/12	42	1.0E-04	2.8E-05	1.1E-03	1.0E-03	3.1E-05	5.0E-04	7.7E-01	9.2E-03	1.0E-05	1.7E-02	5.0E-05	3.0E-01	4.2E+00	1.0E-04	7.9E-01	5.0E-06	2.6E-01	9.3E-02	1.9E-05	1.0E-05	5.0E-04	8.1E-04	1.1E-03	7.5E-04	1.0E-04
Sat Col 10	22/Jun/12	44	1.0E-04	2.8E-05	1.3E-03	1.0E-03	1.1E-05	5.0E-04	7.7E-01	9.2E-03	1.0E-05	1.7E-02	5.0E-05	3.0E-01	4.4E+00	1.1E-04	8.0E-01	5.0E-06	2.8E-01	9.3E-02	2.2E-05	1.0E-05	5.0E-04	8.0E-04	1.1E-03	4.1E-03	1.0E-04
Sat Col 10	6/Jul/12	46	1.0E-04	2.4E-05	9.8E-04	1.0E-03	1.1E-05	5.0E-04	8.3E-01	1.0E-02	1.0E-05	1.9E-02	5.0E-05	3.0E-01	4.3E+00	9.6E-05	8.5E-01	5.0E-06	3.3E-01	9.6E-02	2.0E-05	1.0E-05	5.0E-04	7.3E-04	1.2E-03	1.1E-03	1.0E-04
Sat Col 10	20/Jul/12	48	1.0E-04	2.9E-05	1.1E-03	1.0E-03	1.2E-05	5.0E-04	8.3E-01	1.1E-02	1.0E-05	2.0E-02	5.0E-05	3.0E-01	4.5E+00	1.1E-04	8.6E-01	5.0E-06	3.4E-01	9.9E-02	2.1E-05	1.0E-05	5.0E-04	8.7E-04	1.1E-03	9.4E-04	1.0E-04
Sat Col 10	3/Aug/12	50	1.0E-04	2.7E-05	9.1E-04	1.0E-03	2.4E-05	5.0E-04	8.3E-01	9.9E-03	1.0E-05	2.2E-02	5.0E-05	3.0E-01	4.3E+00	9.5E-05	8.4E-01	5.0E-06	3.5E-01	1.0E-01	2.2E-05	1.0E-05	5.0E-04	9.3E-04	1.2E-03	1.1E-03	1.0E-04
Sat Col 10	17/Aug/12	52	1.0E-04	1.7E-05	9.3E-04	1.0E-03	1.6E-05	5.0E-04	7.7E-01	9.4E-03	1.0E-05	2.0E-02	7.2E-05	3.0E-01	3.9E+00	9.2E-05	8.2E-01	5.0E-06	3.3E-01	8.9E-02	1.8E-05	1.0E-05	5.0E-04	7.5E-04	1.1E-03	5.8E-04	1.0E-04
Sat Col 10	30/Aug/12	54	1.0E-04	1.8E-05	2.5E-03	1.0E-03	1.9E-04	5.0E-04	7.8E-01	9.3E-03	1.0E-05	1.9E-02	8.5E-05	3.0E-01	3.8E+00	1.0E-04	8.0E-01	5.0E-06	3.2E-01	9.4E-02	1.7E-05	1.0E-05	5.0E-04	6.9E-04	1.1E-03	2.0E-03	1.0E-04
Sat Col 10	12/Sep/12	56	1.0E-04	1.0E-04	7.2E-04	1.0E-02	5.0E-05	5.0E-04	9.0E-01	9.6E-03	1.0E-05	2.0E-02	5.0E-04	7.1E-02	4.2E+00	1.0E-04	7.9E-01	1.0E-05	3.3E-01	8.9E-02	1.9E-05	1.0E-04	1.0E-02	7.0E-04	1.0E-03	1.3E-03	
Sat Col 10	25/Sep/12	57	1.0E-04	2.0E-05	7.2E-04	1.0E-03	4.2E-05	5.0E-04	7.8E-01	9.9E-03	1.0E-05	1.9E-02	6.4E-05	3.0E-01	3.4E+00	7.1E-05	8.1E-01	5.0E-06	3.4E-01	8.6E-02	1.8E-05	1.0E-05	5.0E-04	5.9E-04	1.1E-03	2.0E-03	1.0E-04
Sat Col 10	10/Oct/12	60	1.0E-04	3.2E-05	1.1E-03	3.4E-03	4.8E-05	5.0E-04	7.9E-01	9.6E-03	1.0E-05	2.0E-02	1.1E-04	3.0E-01	3.6E+00	7.8E-05	7.9E-01	5.0E-06	3.3E-01	8.3E-02	1.7E-05	1.0E-05	5.0E-04	6.9E-04	1.1E-03	2.1E-03	1.0E-04
Sat Col 10	23/Oct/12	61	1.0E-04	2.5E-05	8.0E-04	1.0E-03	8.7E-06	5.0E-04	7.7E-01	9.5E-03	1.0E-05	1.9E-02	1.7E-04	3.0E-01	3.2E+00	7.0E-05	7.2E-01	5.0E-06	3.2E-01	8.0E-02	1.6E-05	1.0E-05	5.0E-04	6.3E-04	1.0E-03	1.1E-03	1.0E-04
Sat Col 10	7/Nov/12	64	1.0E-04	2.2E-05	1.1E-03	1.0E-03	4.7E-05	5.0E-04	7.5E-01	1.1E-02	1.0E-05	2.2E-02	9.7E-05	3.0E-01	3.4E+00	7.6E-05	7.7E-01	5.0E-06	3.6E-01	9.4E-02	1.7E-05	1.0E-05	5.0E-04	7.0E-04	1.0E-03	1.0E-03	1.0E-04
Sat Col 10	20/Nov/12	65	1.0E-04	1.7E-05	9.8E-04	1.0E-03	1.2E-05	5.0E-04	8.6E-01	1.0E-02	1.0E-05	2.1E-02	7.3E-05	3.0E-01	3.4E+00	7.5E-05	7.8E-01	5.0E-06	3.8E-01	8.8E-02	1.7E-05	1.0E-05	5.0E-04	6.6E-04	1.0E-03	1.2E-03	1.0E-04
Sat Col 10	5/Dec/12	68	1.0E-04	2.2E-05	5.8E-04	1.0E-03	9.9E-06	5.0E-04	9.4E-01	1.1E-02	1.0E-05	2.5E-02	5.0E-05	3.0E-01	3.4E+00	6.5E-05	8.1E-01	5.0E-06	4.0E-01	1.0E-01	1.6E-05	1.0E-05	5.0E-04	8.2E-04	9.0E-04	1.4E-03	1.0E-04
Sat Col 10	18/Dec/12	70	1.0E-04	2.4E-05	9.3E-04	1.0E-03	1.1E-05	5.0E-04	7.7E-01	9.4E-03	1.0E-05	2.2E-02	5.0E-05	3.0E-01	2.8E+00	8.0E-05	7.5E-01	5.0E-06	3.3E-01	8.8E-02	1.5E-05	1.0E-05	5.0E-04	6.9E-04	8.4E-04	1.2E-03	1.0E-04
Sat Col 10	3/Jan/13	72	1.0E-04	3.7E-05	4.5E-04	1.0E-03	3.1E-05	5.0E-04	9.8E-01	1.3E-02	1.0E-05	2.5E-02	1.6E-03	3.0E-01	3.9E+00	8.8E-05	8.5E-01	5.0E-06	4.6E-01	1.1E-01	1.6E-05	1.0E-05	5.0E-04	9.0E-04	8.8E-04	2.3E-03	1.0E-04
Sat Col 10	24/Jan/13	75	1.0E-04	1.9E-05	6.9E-04	1.0E-03	2.0E-05	5.0E-04	7.7E-01	9.7E-03	1.0E-05	1.9E-02	9.3E-05	3.0E-01	2.7E+00	6.5E-05	7.4E-01	5.0E-06	3.3E-01	8.2E-02	1.3E-05	1.0E-05	5.0E-04	5.8E-04	9.2E-04	9.6E-04	1.0E-04
Sat Col 10	30/Jan/13	76	1.0E-04	2.4E-05	5.2E-04	1.0E-03	6.8E-05	5.0E-04	7.8E-01	9.7E-03	1.0E-05	1.8E-02	5.0E-05	3.0E-01	2.8E+00	6.5E-05	6.9E-01	5.0E-06	3.3E-01	8.5E-02	1.2E-05	1.0E-05	5.0E-04	5.2E-04	8.5E-04	9.2E-04	1.0E-04
Sat Col 10	12/Feb/13	77	1.0E-04	2.0E-05	4.6E-04	1.0E-03	1.6E-05	5.0E-04	7.8E-01	1.0E-02	1.0E-05	1.7E-02	7.6E-05	3.0E-01	2.7E+00	6.4E-05	6.9E-01	5.0E-06	3.3E-01	7.6E-02	1.2E-05	1.0E-05	5.0E-04	5.3E-04	8.3E-04	1.3E-03	1.0E-04
Sat Col 10	27/Feb/13	80	1.0E-04	1.7E-05	4.7E-04	1.0E-03	7.8E-06	5.0E-04	7.5E-01	9.4E-03	1.0E-05	1.6E-02	5.0E-05	3.0E-01	2.6E+00	6.0E-05	6.8E-01	5.0E-06	3.0E-01	7.4E-02	1.1E-05	1.5E-05	5.0E-04	5.0E-04	8.5E-04	1.1E-03	1.0E-04
Sat Col 10	12/Mar/13	81	1.0E-04	5.0E-06	4.4E-04	1.0E-03	7.9E-06	5.0E-04	7.2E-01	8.9E-03	1.0E-05	1.7E-02	5.0E-05	3.0E-01	2.6E+00	6.7E-05	6.6E-01	5.0E-06	3.2E-01	7.9E-02	1.0E-05	1.0E-05	5.0E-04	4.0E-04	7.8E-04	8.7E-04	1.0E-04
Sat Col 10	27/Mar/13	84	1.0E-04	2.1E-05	6.3E-04	1.0E-03	2.6E-05	5.0E-04	8.5E-01	1.1E-02	1.0E-05	1.8E-02	5.0E-05	3.0E-01	2.9E+00	7.6E-05	7.4E-01	5.0E-06	3.5E-01	8.7E-02	1.1E-05	1.0E-05	5.0E-04	5.5E-04	7.9E-04	1.2E-03	1.0E-04
Sat Col 10	11/Apr/13	86	1.0E-04	2.2E-05	6.2E-04	1.0E-03	5.0E-06	5.0E-04	8.7E-01	1.3E-02	1.0E-05	1.9E-02	5.0E-05	3.0E-01	3.6E+00	6.1E-05	8.5E-01	5.0E-06	4.3E-01	9.3E-02	1.1E-05	1.0E-05	5.0E-04	5.5E-04	8.9E-04	1.6E-03	1.0E-04
Sat Col 10	24/Apr/13	88	1.0E-04	2.5E-05	6.5E-04	1.0E-03	1.0E-05	5.0E-04	8.8E-01	1.3E-02	1.0E-05	1.9E-02	5.0E-05	3.0E-01	3.0E+00	5.9E-05	8.0E-01	5.0E-06	3.9E-01	8.8E-02	1.2E-05	1.0E-05	5.0E-04	5.6E-04	9.0E-04	1.2E-03	1.0E-04
Sat Col 10	7/May/13	90	1.0E-04	2.1E-05	7.3E-04	1.0E-03	1.5E-05	5.0E-04	8.9E-01	1.3E-02	1.0E-05	1.9E-02	5.0E-05	3.0E-01	3.0E+00	6.4E-05	8.2E-01	5.0E-06	4.5E-01	8.8E-02	1.2E-05	1.0E-05	5.0E-04	5.7E-04	8.9E-04	2.2E-03	1.0E-04
Sat Col 10	22/May/13	92	1.0E-04	2.9E-05	6.7E-04	1.0E-03	1.1E-05	5.0E-04	9.1E-01	1.3E-02	1.0E-05	1.9E-02	5.0E-05	3.0E-01	3.0E+00	6.6E-05	8.2E-01	5.0E-06	4.1E-01	8.7E-02	1.2E-05	1.0E-05	5.0E-04	5.5E-04	8.6E-04	1.8E-03	1.0E-04
Sat Col 10	6/Jun/13	94	1.0E-04	5.5E-05	4.8E-04	2.9E-03	1.3E-05	5.0E-04	8.3E-01	1.3E-02	1.0E-05	1.8E-02	9.7E-05	3.0E-01	3.0E+00	7.1E-05	8.5E-01	5.9E-06	4.3E-01	8.7E-02	2.0E-05	1.0E-05	5.0E-04	4.8E-04	8.4E-04	4.4E-03	1.0E-04

Saturated column kentic test results

ID	Date	cycle	D-Cr	D-Co	D-Cu	D-Fe	D-Pb	D-Li	D-Mg	D-Mn	D-Hg	D-Mo	D-Ni	D-P	D-K	D-Se	D-Si	D-Ag	D-Na	D-Sr	D-Tl	D-Sn	D-Ti	D-U	D-V	D-Zn	D-Zr
			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Sat Col 11	19/Aug/11	0	1.0E-04	9.8E-04	1.0E-02	4.7E-03	2.5E-04	5.0E-04	8.9E+00	4.4E-02	2.0E-05	2.4E-01	9.9E-04	3.0E-01	1.8E+01	1.3E-03	1.3E+00	2.0E-04	1.3E+01	4.3E-01	2.7E-05	1.0E-05	5.0E-04	5.5E-03	4.4E-04	2.2E-01	1.0E-04
Sat Col 11	26/Aug/11	1	1.0E-04	2.4E-03	4.6E-04	1.3E-02	5.2E-04	5.0E-04	1.1E+01	6.6E-02	2.5E-05	4.0E-01	1.7E-03	3.0E-01	2.1E+01	1.3E-03	2.5E+00	5.0E-06	1.8E+01	6.5E-01	6.3E-06	1.0E-05	5.0E-04	8.6E-03	7.6E-04	1.2E-01	1.0E-04
Sat Col 11	8/Sep/11	3	1.0E-04	4.4E-03	6.5E-04	3.4E-02	4.3E-04	5.0E-04	1.0E+01	7.4E-02	5.0E-05	5.0E-01	3.3E-03	3.0E-01	2.3E+01	5.1E-04	2.9E+00	5.2E-06	2.2E+01	6.2E-01	2.0E-06	1.0E-05	5.0E-04	4.6E-03	8.1E-04	5.1E-02	1.0E-04
Sat Col 11	15/Sep/11	4	1.0E-04	3.6E-03	2.0E-04	6.1E-02	2.0E-04	5.0E-04	8.1E+00	6.6E-02	2.0E-05	5.0E-01	3.5E-03	3.0E-01	1.9E+01	2.6E-04	2.9E+00	5.0E-06	2.0E+01	5.3E-01	2.0E-06	1.0E-05	5.0E-04	2.1E-03	5.0E-04	4.1E-02	1.0E-04
Sat Col 11	23/Sep/11	5	1.0E-04	2.6E-03	5.0E-04	5.3E-02	8.3E-05	5.0E-04	6.4E+00	4.9E-02		4.4E-01	2.7E-03	3.0E-01	1.6E+01	1.6E-04	2.7E+00	1.0E-05	1.7E+01	4.1E-01	1.0E-05	1.0E-04	1.0E-02	7.2E-04	1.0E-03	2.4E-02	
Sat Col 11	29/Sep/11	6	1.0E-04	1.8E-03	1.0E-04	5.4E-02	3.2E-05	5.0E-04	4.7E+00	3.7E-02	2.0E-05	3.9E-01	2.3E-03	3.0E-01	1.5E+01	9.6E-05	2.5E+00	5.0E-06	1.3E+01	3.4E-01	2.0E-06	1.0E-05	5.0E-04	4.1E-04	1.2E-04	1.7E-02	1.0E-04
Sat Col 11	13/Oct/11	8	1.0E-04	8.8E-04	1.4E-04	3.8E-02	8.0E-05	5.0E-04	2.7E+00	1.9E-02	2.0E-05	3.5E-01	2.0E-03	3.0E-01	1.2E+01	6.2E-05	2.2E+00	1.1E-05	9.7E+00	2.4E-01	2.0E-06	1.0E-05	5.0E-04	2.2E-04	8.3E-05	1.4E-02	1.0E-04
Sat Col 11	27/Oct/11	10	1.0E-04	3.5E-04	1.0E-04	2.1E-02	1.4E-05	5.0E-04	1.2E+00	8.7E-03	1.0E-05	2.3E-01	4.7E-04	3.0E-01	8.1E+00	4.0E-05	1.8E+00	5.0E-06	5.3E+00	1.6E-01	2.0E-06	1.0E-05	5.0E-04	1.4E-04	5.2E-05	4.9E-03	1.0E-04
Sat Col 11	10/Nov/11	12	1.0E-04	2.1E-04	6.6E-04	1.8E-02	2.4E-05	5.0E-04	7.8E-01	6.4E-03	1.0E-05	1.6E-01	3.8E-04	3.0E-01	6.7E+00	4.0E-05	1.6E+00	5.0E-06	3.0E+00	1.2E-01	2.0E-06	1.0E-05	5.0E-04	1.1E-04	5.2E-05	5.4E-03	1.0E-04
Sat Col 11	25/Nov/11	14	1.0E-04	1.1E-04	1.0E-04	1.3E-02	1.2E-05	5.0E-04	6.3E-01	5.4E-03	1.0E-05	1.2E-01	9.5E-05	3.0E-01	5.8E+00	5.4E-05	1.4E+00	5.0E-06	2.3E+00	1.1E-01	2.0E-06	1.0E-05	5.0E-04	8.2E-05	5.0E-05	4.0E-03	1.0E-04
Sat Col 11	8/Dec/11	16	1.0E-04	7.9E-05	1.0E-04	1.0E-02	9.2E-06	5.0E-04	5.8E-01	5.0E-03	1.0E-05	9.9E-02	7.1E-05	3.0E-01	5.5E+00	6.9E-05	1.4E+00	5.0E-06	1.9E+00	1.1E-01	2.0E-06	1.0E-05	5.0E-04	6.3E-05	5.0E-05	3.6E-03	1.0E-04
Sat Col 11	23/Dec/11	18	1.0E-04	4.6E-05	4.7E-04	1.0E-02	2.3E-05	5.0E-04	5.7E-01	5.1E-03	1.0E-05	8.2E-02	1.7E-04	3.0E-01	5.2E+00	7.8E-05	1.4E+00	5.0E-06	1.6E+00	9.6E-02	2.0E-06	1.0E-05	5.0E-04	4.6E-05	5.0E-05	2.9E-03	1.0E-04
Sat Col 11	5/Jan/12	20	1.0E-04	4.4E-05	1.0E-04	6.6E-03	9.4E-06	5.0E-04	5.6E-01	5.1E-03	1.0E-05	7.9E-02	6.0E-05	3.0E-01	5.0E+00	8.9E-05	1.4E+00	5.0E-06	1.4E+00	9.7E-02	2.0E-06	1.0E-05	5.0E-04	4.6E-05	5.0E-05	3.6E-03	1.0E-04
Sat Col 11	19/Jan/12	22	1.0E-04	3.6E-05	1.0E-04	4.5E-03	7.7E-06	5.0E-04	5.4E-01	5.3E-03	1.0E-05	7.7E-02	5.0E-05	3.0E-01	4.8E+00	9.7E-05	1.3E+00	5.0E-06	1.3E+00	1.0E-01	2.0E-06	1.0E-05	5.0E-04	4.4E-05	5.0E-05	1.7E-03	1.0E-04
Sat Col 11	3/Feb/12	24	1.0E-04	3.4E-05	1.0E-04	4.0E-03	1.5E-05	5.0E-04	5.5E-01	5.6E-03	1.0E-05	9.3E-02	5.0E-05	3.0E-01	5.4E+00	6.1E-05	1.4E+00	5.0E-06	1.3E+00	1.1E-01	8.7E-06	1.0E-05	5.0E-04	4.3E-05	5.0E-05	1.4E-03	1.0E-04
Sat Col 11	16/Feb/12	26	1.0E-04	2.5E-05	1.6E-04	2.5E-03	6.7E-06	5.0E-04	4.9E-01	5.0E-03	1.0E-05	9.4E-02	6.6E-05	3.0E-01	5.4E+00	5.4E-05	1.5E+00	5.0E-06	1.2E+00	1.1E-01	6.9E-06	1.0E-05	5.0E-04	4.0E-05	5.0E-05	1.3E-03	1.0E-04
Sat Col 11	2/Mar/12	28	1.0E-04	2.4E-05	1.0E-04	1.7E-03	5.0E-06	5.0E-04	5.0E-01	5.2E-03	1.0E-05	9.9E-02	5.7E-05	3.0E-01	5.5E+00	5.2E-05	1.4E+00	5.0E-06	1.2E+00	1.1E-01	3.8E-06	1.0E-05	5.0E-04	3.8E-05	5.0E-05	1.6E-03	1.0E-04
Sat Col 11	16/Mar/12	30	1.0E-04	1.9E-05	1.0E-04	2.0E-03	6.4E-06	5.0E-04	4.4E-01	5.1E-03	1.0E-05	9.6E-02	5.0E-05	3.0E-01	4.9E+00	6.5E-05	1.4E+00	5.0E-06	1.1E+00	1.1E-01	9.0E-06	1.0E-05	5.0E-04	3.3E-05	5.0E-05	1.8E-03	1.0E-04
Sat Col 11	30/Mar/12	32	1.0E-04	2.4E-05	1.0E-04	2.9E-03	7.4E-06	5.0E-04	5.7E-01	6.7E-03	1.0E-05	1.3E-01	5.0E-05	3.0E-01	5.9E+00	5.4E-05	1.6E+00	5.0E-06	1.4E+00	1.3E-01	2.0E-06	1.0E-05	5.0E-04	4.1E-05	5.0E-05	8.7E-04	1.0E-04
Sat Col 11	13/Apr/12	34	1.0E-04	1.8E-05	1.0E-04	8.6E-03	7.3E-06	5.0E-04	6.0E-01	7.6E-03	1.0E-05	1.4E-01	5.0E-05	3.0E-01	6.2E+00	4.3E-05	1.7E+00	5.0E-06	1.5E+00	1.3E-01	2.0E-06	1.0E-05	5.0E-04	4.2E-05	5.0E-05	1.8E-03	1.0E-04
Sat Col 11	25/Apr/12	36	1.0E-04	1.9E-05	1.0E-04	3.2E-03	3.4E-05	5.0E-04	6.3E-01	8.3E-03		1.6E-01	5.0E-05	3.0E-01	6.6E+00	4.0E-05	1.7E+00	1.5E-05	1.6E+00	1.4E-01	2.0E-06	1.0E-05	5.0E-04	4.9E-05	5.0E-05	2.7E-03	1.0E-04
Sat Col 11	11/May/12	38	1.0E-04	1.6E-05	1.0E-04	3.0E-03	5.0E-06	5.0E-04	6.4E-01	8.9E-03	1.0E-05	1.8E-01	5.0E-05	3.0E-01	6.8E+00	4.7E-05	1.7E+00	5.0E-06	1.8E+00	1.5E-01	2.0E-06	1.0E-05	5.0E-04	3.9E-05	5.0E-05	7.3E-04	1.0E-04
Sat Col 11	25/May/12	40	1.0E-04	1.4E-05	1.0E-04	3.6E-03	5.0E-06	5.0E-04	6.6E-01	9.4E-03	1.0E-05	1.9E-01	5.0E-05	3.0E-01	6.9E+00	4.0E-05	1.9E+00	5.0E-06	2.0E+00	1.5E-01	2.0E-06	1.0E-05	5.0E-04	4.6E-05	5.0E-05	1.2E-03	1.0E-04
Sat Col 11	8/Jun/12	42	1.0E-04	1.8E-05	1.0E-04	9.6E-03	2.9E-05	5.0E-04	6.3E-01	9.2E-03	1.0E-05	2.0E-01	1.4E-02	3.0E-01	6.5E+00	4.0E-05	1.8E+00	5.0E-06	1.9E+00	1.4E-01	2.0E-06	1.0E-05	5.0E-04	4.8E-05	5.0E-05	8.4E-04	1.0E-04
Sat Col 11	22/Jun/12	44	1.0E-04	9.2E-06	1.0E-04	2.9E-03	5.0E-06	5.0E-04	6.6E-01	9.5E-03	1.0E-05	2.1E-01	5.0E-05	3.0E-01	6.8E+00	4.0E-05	1.9E+00	5.0E-06	2.0E+00	1.5E-01	2.0E-06	1.0E-05	5.0E-04	4.5E-05	5.0E-05	3.6E-03	1.0E-04
Sat Col 11	6/Jul/12	46	1.0E-04	8.6E-06	1.0E-04	3.0E-03	5.0E-06	5.0E-04	6.6E-01	9.9E-03	1.0E-05	2.3E-01	6.6E-05	3.0E-01	6.5E+00	4.0E-05	2.0E+00	5.0E-06	2.1E+00	1.5E-01	2.0E-06	1.0E-05	5.0E-04	4.2E-05	5.0E-05	5.0E-04	1.0E-04
Sat Col 11	20/Jul/12	48	1.0E-04	9.2E-06	1.0E-04	2.8E-03	5.0E-06	5.0E-04	6.6E-01	9.9E-03	1.0E-05	2.5E-01	5.0E-05	3.0E-01	6.9E+00	4.0E-05	1.9E+00	5.0E-06	2.3E+00	1.6E-01	2.0E-06	1.0E-05	5.0E-04	5.1E-05	5.0E-05	1.2E-02	1.0E-04
Sat Col 11	3/Aug/12	50	1.0E-04	2.7E-05	1.0E-04	1.9E-03	1.3E-05	5.0E-04	6.7E-01	1.0E-02	1.0E-05	2.4E-01	5.0E-05	3.0E-01	6.9E+00	4.0E-05	2.0E+00	5.0E-06	2.3E+00	1.5E-01	2.0E-06	1.0E-05	5.0E-04	4.1E-05	5.0E-05	3.9E-03	1.0E-04
Sat Col 11	17/Aug/12	52	1.0E-04	5.0E-06	1.0E-04	2.0E-03	5.0E-06	5.0E-04	6.5E-01	1.0E-02	1.0E-05	2.7E-01	5.0E-05	3.0E-01	7.0E+00	4.0E-05	2.0E+00	5.0E-06	2.2E+00	1.5E-01	2.0E-06	1.0E-05	5.0E-04	4.7E-05	5.0E-05	5.0E-04	1.0E-04
Sat Col 11	30/Aug/12	54	1.0E-04	5.1E-06	1.0E-04	2.1E-03	5.0E-06	5.0E-04	6.7E-01	1.0E-02	1.0E-05	2.7E-01	7.3E-05	3.0E-01	6.8E+00	4.2E-05	2.0E+00	5.0E-06	2.2E+00	1.6E-01	2.0E-06	1.0E-05	5.0E-04	4.6E-05	5.0E-05	5.0E-04	1.0E-04
Sat Col 11	12/Sep/12	56	1.0E-04	1.0E-04	2.0E-04	1.0E-02	5.0E-05	5.0E-04	7.9E-01	1.0E-02	1.0E-05	3.0E-01	5.0E-04	1.1E-01	8.4E+00	1.0E-04	2.1E+00	1.0E-05	2.2E+00	1.6E-01	1.0E-05	1.0E-04	1.0E-02	4.7E-05	1.0E-03	1.0E-03	
Sat Col 11	25/Sep/12	57	1.0E-04	6.3E-06	1.0E-04	2.5E-03	3.5E-05	5.0E-04	6.9E-01	1.1E-02	1.0E-05	2.8E-01	5.6E-05	3.0E-01	6.6E+00	4.0E-05	2.2E+00	5.0E-06	2.3E+00	1.5E-01	2.0E-06	1.0E-05	5.0E-04	4.2E-05	5.0E-05	6.1E-04	1.0E-04
Sat Col 11	10/Oct/12	60	1.0E-04	4.5E-05	1.2E-04	1.4E-02	2.3E-05	5.0E-04	7.1E-01	1.2E-02	1.0E-05	3.3E-01	1.6E-04	3.0E-01	6.9E+00	4.0E-05	2.1E+00	5.0E-06	2.3E+00	1.6E-01	2.0E-06	1.0E-05	5.0E-04	5.3E-05	5.0E-05	4.7E-03	1.0E-04
Sat Col 11	23/Oct/12	61	1.0E-04	5.5E-06	1.0E-04	1.6E-03	5.0E-06	5.0E-04	7.0E-01	1.1E-02	1.0E-05	3.0E-01	5.0E-05	3.0E-01	7.0E+00	4.0E-05	2.1E+00	5.0E-06	2.2E+00	1.4E-01	2.0E-06	1.0E-05	5.0E-04	5.3E-05	5.0E-05	5.0E-04	1.0E-04
Sat Col 11	7/Nov/12	64	1.0E-04	5.0E-06	1.0E-04	1.9E-03	5.0E-06	5.0E-04	6.1E-01	1.1E-02	1.0E-05	3.2E-01	5.0E-05	3.0E-01	6.5E+00	4.0E-05	2.2E+00	5.0E-06	2.1E+00	1.6E-01	2.0E-06	1.0E-05	5.0E-04	5.3E-05	5.0E-05	5.0E-04	1.0E-04
Sat Col 11	20/Nov/12	65	1.0E-04	5.0E-06	1.0E-04	2.0E-03	5.0E-06	5.0E-04	7.0E-01	1.1E-02	1.0E-05	3.3E-01	5.0E-05	3.0E-01	6.9E+00	4.0E-05	2.2E+00	5.0E-06	2.2E+00	1.5E-01	2.0E-06	1.0E-05	5.0E-04	5.1E-05	5.0E-05	5.0E-04	1.0E-04
Sat Col 11	5/Dec/12	68	1.0E-04	5.0E-06	1.0E-04	1.9E-03	5.0E-06	5.0E-04	7.2E-01	1.1E-02	1.0E-05	3.5E-01	5.0E-05	3.0E-01	6.5E+00	4.0E-05	2.0E+00	5.0E-06	2.1E+00	1.6E-01	2.0E-06	1.0E-05	5.0E-04	6.2E-05	5.0E-05	5.0E-04	1.0E-04
Sat Col 11	18/Dec/12	70	1.0E-04	6.0E-06	1.0E-04	2.7E-03	5.0E-06	5.0E-04	7.0E-01	1.1E-02	1.0E-05	3.6E-01	5.0E-05	3.0E-01	6.1E+00	4.3E-05	2.1E+00	5.0E-06	2.1E+00	1.6E-01	2.0E-06	1.0E-05	5.0E-04	6.5E-05	5.0E-05	5.0E-04	1.0E-04
Sat Col 11	3/Jan/13	72	1.0E-04	5.1E-06	1.0E-04	2.6E-03	5.0E-06	5.0E-04	7.3E-01	1.2E-02	1.0E-05	3.4E-01	5.0E-05	3.0E-01	6.2E+00	4.0E-05	2.0E+00	5.0E-06	2.1E+00	1.6E-01	2.0E-06	1.0E-05	5.0E-04	6.6E-05	5.0E-05	5.0E-04	1.0E-04
Sat Col 11	24/Jan/13	75	1.0E-04	5.0E-06	1.0E-04	1.2E-03	8.6E-06	5.0E-04	7.1E-01	1.2E-02	1.0E-05	3.6E-01	5.0E-05	3.0E-01	6.3E+00	4.0E-05	2.2E+00	5.0E-06	2.0E+00	1.6E-01	2.0E-06	1.0E-05	5.0E-04	6.8E-05	5.0E-05	5.0E-04	1.0E-04
Sat Col 11	30/Jan/13	76	1.0E-04	5.0E-06	1.0E-04	2.5E-03	5.5E-05	5.0E-04	7.4E-01	1.1E-02	1.0E-05	3.7E-01	5.0E-05	3.0E-01	6.3E+00	4.0E-05	2.1E+00	5.0E-06	2.0E+00	1.6E-01	2.0E-06	1.0E-05	5.0E-04	6.4E-05	5.0E-05	5.0E-04	1.0E-04
Sat Col 11	12/Feb/13	77	1.0E-04	5.0E-06	1.0E-04	2.5E-03	1.1E-05	5.0E-04	7.2E-01	1.2E-02	1.0E-05	3.4E-01	7.9E-05	3.0E-01	6.1E+00	4.0E-05	2.1E+00	5.0E-06	2.0E+00	1.6E-01	2.0E-06	1.0E-05	5.0E-04	7.2E-05	5.0E-05	1.2E-03	1.0E-04
Sat Col 11	27/Feb/13	80	1.0E-04	5.0E-06	1.0E-04	1.0E-03	6.3E-05	5.0E-04	7.4E-01	1.2E-02	1.0E-05	3.4E-01	5.0E-05	3.0E-01	6.2E+00	4.0E-05	2.2E+00	5.0E-06	1.9E+00	1.7E-01	3.1E-06	1.0E-05	5.0E-04	7.6E-05	5.0E-05	5.0E-04	1.0E-04
Sat Col 11	12/Mar/13	81	1.0E-04	5.0E-06	1.0E-04	1.4E-03	5.0E-06	5.0E-04	7.2E-01	1.1E-02	1.0E-05	3.5E-01	5.0E-05	3.0E-01	6.1E+00	4.4E-05	2.2E+00	5.0E-06	1.9E+00	1.7E-01	2.0E-06	1.0E-05	5.0E-04	7.0E-05	5.0E-05	5.0E-04	1.0E-04
Sat Col 11	27/Mar/13	84	1.0E-04	5.0E-06	1.0E-04	2.8E-03	6.3E-06	5.0E-04	7.6E-01	1.2E-02	1.0E-05	3.3E-01	5.0E-05	3.0E-01	6.2E+00	4.0E-05	2.1E+00	5.0E-06	1.9E+00	1.6E-01	2.0E-06	1.0E-05	5.0E-04	7.5E-05	5.0E-05	5.0E-04	1.0E-04
Sat Col 11	11/Apr/13	86	1.0E-04	5.0E-06	1.0E-04	2.2E-03	5.0E-06	5.0E-04	7.3E-01	1.3E-02	1.0E-05	3.2E-01	5.0E-05	3.0E-01	6.5E+00	4.0E-05	2.3E+00	5.0E-06	1.8E+00	1.6E-01	2.0E-06	1.0E-05	5.0E-04	6.9E-05	5.0E-05	5.5E-04	1.0E-04
Sat Col 11	24/Apr/13	88	1.0E-04	5.0E-06	1.0E-04	1.1E-03	5.0E-06	5.0E-04	7.3E-01	1.2E-02	1.0E-05	3.2E-01	5.0E-05	3.0E-01	5.9E+00	4.0E-05	2.3E+00	5.0E-06	1.7E+00	1.7E-01	2.0E-06	1.0E-05	5.0E-04	8.7E-05	5.0E-05	5.1E-04	1.0E-04
Sat Col 11	7/May/13	90	1.0E-04	5.0E-06	1.0E-04	1.6E-03	5.0E-06	5.0E-04	7.6E-01	1.3E-02	1.0E-05	3.2E-01	6.6E-05	3.0E-01	5.9E+00	4.0E-05	2.3E+00	5.0E-06	1.9E+00	1.6E-01	2.0E-06	1.0E-05	5.0E-04	8.6E-05	5.0E-05	1.4E-03	1.0E-04
Sat Col 11	22/May/13	92	1.0E-04	5.0E-06	1.0E-04	1.5E-03	5.0E-06	5.0E-04	7.5E-01	1.3E-02	1.0E-05	3.1E-01	5.0E-05	3.0E-01	5.9E+00	4.0E-05	2.3E+00	5.0E-06	1.7E+00	1.7E-01	2.0E-06	1.0E-05	5.0E-04	9.6E-05	5.0E-05	8.4E-04	1.0E-04
Sat Col 11	6/Jun/13	94	1.0E-04	1.9E-05	1.0E-04	1.7E-03	5.0E-06	5.0E-04	7.8E-01	1.4E-02	1.0E-05	3.0E-01	5.0E-05	3.0E-01	6.1E+00	4.0E-05	2.3E+00	5.0E-06	1.7E+00	1.6E-01	2.0E-06	1.0E-05	5.0E-04	9.4E-05	5.0E-05	2.9E-03	1.0E-04
Sat Col 12 upper port	12/Jul/12	0	5.0E-04	3.4E-01	1.7E+01	3.1E-01	2.5E-04	5.2E-02	2.0E+02	3.3E+00	1.2E-04	3.7E-02	9.6E-02	1.5E+00	5.2E+01	5.7E-02	1.1E+01	2.5E-05	1.2E+02	5.4E+00	2.5E-04	5.0E-05	2.5E-03	6.6E-01	2.5E-04	5.1E-01	5.0E-04
Sat Col 12 upper port	3/Aug/12	50	5.0E-04	2.3E-01	3.5E+00	2.2E+00	1.0E-03	2.3E-02	1.5E+02	3.5E+00	1.0E-05	1.5E-02	4.6E-02	1.5E+00	3.9E+01	1.7E-02	1.1E+01	3.3E-05	7.8E+01	3.9E+00	1.9E-04	5.0E-05	2.5E-03	7.6E-01	2.5E-04	2.2E-01	8.2E-04
Sat Col 12 upper port	30/Aug/12	54	5.0E-04	1.9E-01	2.1E+00	1.3E+00	1.4E-04	2.6E-02	1.6E+02	3.4E+00	1.0E-05	1.5E-02	3.4E-02	1.5E+00	4.1E+01	1.0E-02	1.1E+01	2.5E-05	8.5E+01	4.1E+00	1.4E-04	5.0E-05	2.5E-03	8.9E-01	2.5E-04	1.9E-01	8.3E-04
Sat Col 12 upper port	25/Sep/12	57	5.0E-04	1.5E-01	1.4E+00	1.8E+00	2.8E-05	1.9E-02	1.5E+02	3.1E+00	1.0E-05	1.4E-02	2.9E-02	1.5E+00	3.9E+01	7.1E-03	1.0E+01	2.5E-05	6.9E+01	3.6E+00	8.8E-05	1.4E-04	2.5E-03	7.7E-01	2.5E-04	1.6E-01	1.2E-03
Sat Col 12 upper port	23/Oct/12	61	5.0E-04	1.2E-01	9.0E-01	5.8E-01	9.4E-05	2.0E-02	1.4E+02	2.9E+00	1.0E-05	1.5E-02	2.2E-02	1.5E+00	3.9E+01	4.9E-03	9.3E+00	2.5E-05	6.4E+01	3.5E+00	9.4E-05	5.0E-05	2.5E-03	6.8E-01	2.5E-04	1.1E-01	5.2E-04
Sat Col 12 upper port	20/Nov/12	65	5.0E-04	1.0E-01	7.2E-01	7.9E-01	1.7E-04	1.3E-02	1.2E+02	2.7E+00	1.0E-05	1.1E-02	1.9E-02	1.5E+00	3.2E+01	4.0E-03	8.0E+00	2.5E-05	5.1E+01	2.9E+00	6.1E-05	5.0E-05	2.5E-03	5.5E-01	2.5E-04	9.0E-02	5.0E-04
Sat Col 12 upper port	17/Dec/12	69	5.0E-04	2.0E-01	4.3E+00	6.9E+00	3.6E-04	2.0E-02	1.0E+02	3.0E+00	1.0E-05	7.1E-03	2.5E-02	1.5E+00	2.4E+01	8.1E-03	1.0E+01	2.5E-05	3.3E+01	2.1E+00	1.1E-04	5.0E-05	2.5E-03	3.1E-01	2.5E-04	2.3E-01	5.0E-04
Sat Col 12 upper port	24/Jan/13	75	3.1E-04	1.5E-01	2.0E+00	3.4E+00	1.2E-04	1.4E-02	7.3E+01	2.3E+00	1.0E-05	4.5E-03	1.9E-02	6.0E-01	1.8E+01	5.1E-03	7.2E+00	1.0E-05	1.8E+01	1.5E+00	6.9E-05	2.0E-05	1.0E-03	2.3E-01	1.0E-04	1.5E-01	2.0E-04
Sat Col 12 upper port	12/Feb/13	77	2.0E-04	5.0E-02	2.6E-01	2.9E-01	4.1E-05	8.9E-03	7.5E+01	1.8E+00	1.0E-05	7.3E-03	7.5E-03	6.0E-01	2.3E+01	1.5E-03	7.1E+00	1.0E-05	2.2E+01	1.9E+00	3.5E-05	2.0E-05	1.0E-03	2.7E-01	1.0E-04	3.6E-02	2.0E-04
Sat Col 12 upper port	12/Mar/13	81	2.0E-04	4.3E-02	1.5E-01	5.3E-01	5.0E-05	7.4E-03	7.6E+01	1.7E+00	1.0E-05	8.5E-03	6.6E-03	6.0E-01	2.3E+01	1.4E-03	7.5E+00	1.0E-05	2.0E+01	2.0E+00	2.9E-05	2.0E-05	1.0E-03	2.9E-01	1.0E-04	3.0E-02	2.0E-04
Sat Col 12 upper port	11/Apr/13	86	2.0E-04	3.6E-02	1.0E-01	7.7E-01	5.7E-05	7.0E-03	7.2E+01	1.7E+00	1.0E-05	1.0E-02	6.0E-03	6.0E-01	2.4E+01	1.2E-03	8.2E+00	1.0E-05	1.8E+01	1.9E+00	2.0E-05	2.0E-05	1.0E-03	2.7E-01	1.0E-04	2.7E-02	2.0E-04
Sat Col 12 upper port	7/May/13	90	2.0E-04	3.3E-02	7.2E-02	3.2E-01	3.0E-05	6.4E-03	7.0E+01	1.7E+00	1.0E-05	6.9E-03	5.4E-03	6.0E-01	2.2E+01	1.1E-03	8.1E+00	1.0E-05	1.7E+01	1.9E+00	2.0E-05	2.0E-05	1.0E-03	2.6E-01	1.0E-04	2.7E-02	2.0E-04
Sat Col 12 upper port	7/Jun/13	94	2.0E-04	4.5E

Saturated column kentic test results

ID	Date	cycle	D-Cr	D-Co	D-Cu	D-Fe	D-Pb	D-Li	D-Mg	D-Mn	D-Hg	D-Mo	D-Ni	D-P	D-K	D-Se	D-Si	D-Ag	D-Na	D-Sr	D-Tl	D-Sn	D-Ti	D-U	D-V	D-Zn	D-Zr
			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Sat Col 12 lower port	13/Jul/12	0	7.0E-02	2.4E+00	5.5E+02	7.8E+01	1.1E-03	1.5E-01	2.6E+02	1.1E+01	2.8E-05	6.4E-03	6.5E-01	<30	2.5E+01	7.3E-02	2.8E+01	5.0E-04	1.4E+02	3.6E-01	1.1E-03	1.1E-03	5.0E-02	1.3E+00	5.0E-03	3.9E+00	1.0E-02
Sat Col 12 lower port	3/Aug/12	3	2.5E-02	1.1E+00	2.3E+02	6.2E+01	3.4E-04	7.3E-02	1.4E+02	5.7E+00	1.8E-05	3.8E-03	2.7E-01	<6.0	1.7E+01	3.6E-02	2.2E+01	1.0E-04	6.4E+01	4.0E-01	7.3E-04	2.0E-04	1.0E-02	5.3E-01	4.1E-03	1.7E+00	2.0E-03
Sat Col 12 lower port	31/Aug/12	7	1.6E-02	7.6E-01	1.6E+02	7.0E+01	4.9E-04	6.2E-02	1.2E+02	4.7E+00	2.0E-05	3.2E-03	1.9E-01	<6.0	1.5E+01	2.9E-02	2.5E+01	2.5E-04	5.6E+01	4.2E-01	6.2E-04	2.0E-04	1.0E-02	3.2E-01	5.1E-03	1.2E+00	2.0E-03
Sat Col 12 lower port	27/Sep/12	11	8.7E-03	4.1E-01	7.0E+01	4.5E+01	1.2E-04	2.8E-02	1.1E+02	3.7E+00	1.0E-05	4.6E-03	1.0E-01	3.0E-01	1.7E+01	2.1E-02	1.4E+01	5.0E-05	4.7E+01	7.7E-01	4.3E-04	1.0E-04	5.0E-03	1.8E-01	3.2E-03	5.8E-01	1.0E-03
Sat Col 12 lower port	24/Oct/12	15	1.2E-02	5.7E-01	8.6E+01	7.1E+01	7.0E-05	3.7E-02	1.3E+02	4.5E+00	1.0E-05	2.4E-03	1.4E-01	3.0E+00	1.7E+01	1.8E-02	2.2E+01	5.0E-05	5.0E+01	4.6E-01	4.8E-04	1.0E-04	5.0E-03	1.8E-01	5.2E-03	7.7E-01	1.0E-03
Sat Col 12 lower port	21/Nov/12	19	8.1E-03	4.0E-01	6.2E+01	5.9E+01	5.0E-05	3.2E-02	7.9E+01	3.2E+00	1.0E-05	1.6E-03	9.8E-02	3.0E+00	1.2E+01	1.3E-02	1.8E+01	5.0E-05	3.0E+01	3.7E-01	3.6E-04	1.0E-04	5.0E-03	1.4E-01	4.3E-03	5.9E-01	1.0E-03
Sat Col 12 lower port	19/Dec/12	23	8.8E-03	4.0E-01	6.1E+01	6.2E+01	6.4E-05	3.0E-02	7.6E+01	2.8E+00	1.0E-05	1.6E-03	9.8E-02	3.0E+00	1.2E+01	1.2E-02	1.9E+01	5.0E-05	2.6E+01	3.6E-01	3.5E-04	1.0E-04	5.0E-03	1.3E-01	4.2E-03	6.3E-01	1.0E-03
Sat Col 12 lower port	25/Jan/13	28	5.9E-03	3.3E-01	5.0E+01	5.4E+01	2.5E-05	2.5E-02	5.8E+01	2.4E+00	1.0E-05	1.5E-03	8.0E-02	1.5E+00	9.3E+00	9.2E-03	1.6E+01	2.5E-05	1.5E+01	2.8E-01	3.0E-04	5.0E-05	2.5E-03	1.1E-01	3.1E-03	5.1E-01	5.0E-04
Sat Col 12 lower port	13/Feb/13	31	5.1E-03	2.8E-01	4.0E+01	4.4E+01	5.0E-05	2.0E-02	5.7E+01	2.2E+00	1.0E-05	1.5E-03	6.7E-02	3.0E+00	8.4E+00	8.3E-03	1.6E+01	5.0E-05	1.4E+01	3.2E-01	2.8E-04	1.0E-04	5.0E-03	9.3E-02	2.4E-03	4.1E-01	1.0E-03
Sat Col 12 lower port	13/Mar/13	35	4.5E-03	2.5E-01	3.3E+01	4.0E+01	2.5E-05	1.7E-02	5.3E+01	2.2E+00	1.0E-05	7.6E-03	5.9E-02	1.5E+00	8.7E+00	7.2E-03	1.7E+01	2.5E-05	1.3E+01	3.1E-01	2.9E-04	5.0E-05	2.5E-03	8.4E-02	1.8E-03	3.5E-01	5.0E-04
Sat Col 12 lower port	12/Apr/13	39	3.8E-03	2.2E-01	2.9E+01	3.8E+01	2.5E-05	2.0E-02	5.1E+01	2.1E+00	1.0E-05	3.2E-03	5.3E-02	1.5E+00	8.8E+00	6.8E-03	1.8E+01	2.5E-05	1.3E+01	3.3E-01	3.0E-04	5.0E-05	2.5E-03	8.2E-02	1.5E-03	3.3E-01	5.0E-04
Sat Col 12 lower port	8/May/13	43	4.4E-03	2.1E-01	2.8E+01	3.8E+01	2.5E-05	1.9E-02	5.5E+01	2.1E+00	1.0E-05	1.8E-03	5.0E-02	1.5E+00	9.1E+00	6.7E-03	2.0E+01	2.5E-05	1.4E+01	3.3E-01	3.0E-04	5.0E-05	2.5E-03	7.6E-02	1.6E-03	3.2E-01	5.0E-04
Sat Col 12 lower port	13/Jun/13	48	4.4E-03	2.1E-01	2.7E+01	4.0E+01	2.5E-05	1.9E-02	5.2E+01	2.0E+00	1.0E-05	1.3E-03	5.0E-02	1.5E+00	9.1E+00	6.9E-03	2.2E+01	2.5E-05	1.1E+01	3.1E-01	2.8E-04	5.0E-05	2.5E-03	7.1E-02	1.8E-03	3.1E-01	5.0E-04
Sat Col 12 lower port	5/Jul/13	51	3.7E-03	1.7E-01	2.3E+01	3.4E+01	2.5E-05	1.7E-02	4.4E+01	1.6E+00	1.0E-05	1.2E-03	4.2E-02	1.5E+00	8.1E+00	6.0E-03	2.0E+01	2.5E-05	8.8E+00	2.6E-01	2.5E-04	5.0E-05	2.5E-03	5.9E-02	1.3E-03	2.7E-01	5.0E-04
Sat Col 12 lower port	31/Jul/13	55	3.5E-03	1.6E-01	2.3E+01	3.3E+01	2.5E-05	1.6E-02	4.1E+01	1.5E+00	1.0E-05	1.1E-03	3.9E-02	1.5E+00	7.7E+00	5.4E-03	2.0E+01	2.5E-05	7.6E+00	2.4E-01	2.4E-04	5.0E-05	2.5E-03	5.5E-02	1.5E-03	2.4E-01	5.0E-04
Sat Col 12 lower port	29/Aug/13	59	3.3E-03	1.4E-01	1.9E+01	3.0E+01	1.0E-05	1.7E-02	3.9E+01	1.4E+00	1.0E-05	1.1E-03	3.4E-02	6.0E-01	7.2E+00	4.7E-03	2.1E+01	1.0E-05	6.7E+00	2.4E-01	2.2E-04	2.0E-05	1.0E-03	5.2E-02	1.3E-03	2.4E-01	2.0E-04
Sat Col 12 lower port	2/Oct/13	64	2.9E-03	1.3E-01	1.7E+01	2.9E+01	1.0E-05	1.5E-02	3.8E+01	1.3E+00	1.0E-05	1.2E-03	3.2E-02	6.0E-01	7.0E+00	4.4E-03	2.0E+01	1.0E-05	6.0E+00	2.2E-01	2.2E-04	2.0E-05	1.0E-03	4.6E-02	1.1E-03	2.0E-01	2.0E-04
Sat Col 12 lower port	25/Oct/13	67	2.5E-03	1.1E-01	1.4E+01	2.5E+01	1.0E-05	1.2E-02	3.2E+01	1.1E+00	1.0E-05	1.0E-03	2.7E-02	6.0E-01	5.9E+00	3.9E-03	1.7E+01	1.0E-05	4.8E+00	2.0E-01	2.0E-04	2.0E-05	1.0E-03	4.0E-02	8.9E-04	1.8E-01	2.0E-04
Sat Col 12 lower port	21/Nov/13	71	2.2E-03	1.1E-01	1.4E+01	2.4E+01	1.0E-05	1.4E-02	3.1E+01	1.1E+00	1.0E-05	9.2E-04	2.6E-02	6.0E-01	6.0E+00	3.6E-03	1.8E+01	1.0E-05	4.4E+00	1.9E-01	1.8E-04	2.0E-05	1.0E-03	3.6E-02	7.2E-04	1.8E-01	2.0E-04
Sat Col 12 lower port	19/Dec/13	75	2.2E-03	1.0E-01	1.3E+01	2.3E+01	1.0E-05	1.0E-02	3.0E+01	1.0E+00	1.0E-05	9.0E-04	2.5E-02	6.0E-01	5.6E+00	3.6E-03	1.6E+01	1.0E-05	4.2E+00	2.0E-01	1.8E-04	2.0E-05	1.0E-03	3.4E-02	6.8E-04	1.7E-01	2.0E-04
Sat Col 12 lower port	16/Jan/14	79	2.0E-03	9.5E-02	1.2E+01	2.1E+01	1.0E-05	1.2E-02	2.8E+01	9.3E-01	1.0E-05	1.0E-03	2.2E-02	6.0E-01	5.5E+00	3.2E-03	1.7E+01	1.0E-05	3.6E+00	1.8E-01	1.7E-04	2.0E-05	1.0E-03	3.2E-02	6.4E-04	1.6E-01	2.0E-04
Sat Col 12 lower port	13/Feb/14	83	1.8E-03	8.5E-02	1.1E+01	2.0E+01	4.7E-05	9.2E-03	2.6E+01	8.6E-01	1.0E-05	9.3E-04	2.1E-02	6.0E-01	5.1E+00	3.0E-03	1.7E+01	1.0E-05	3.3E+00	1.8E-01	1.6E-04	3.7E-05	1.0E-03	2.8E-02	5.2E-04	1.4E-01	2.0E-04
Sat Col 13 upper port	17/Jul/12	0	5.0E-04	1.9E-02	6.2E-03	2.7E+00	3.9E-03	1.7E-02	9.4E+01	3.0E+00	1.0E-05	1.7E-01	2.6E-02	1.5E+00	4.3E+01	1.7E-02	1.3E+01	4.0E-05	2.2E+02	3.2E+00	4.8E-05	7.3E-05	2.5E-03	3.9E-01	9.0E-04	4.5E-02	1.3E-03
Sat Col 13 upper port	3/Aug/12	2	2.0E-04	1.0E-02	2.0E-03	1.0E+00	9.0E-04	1.5E-02	7.4E+01	2.1E+00	1.0E-05	2.0E-01	1.6E-02	6.0E-01	3.9E+01	2.2E-03	1.1E+01	1.0E-05	1.8E+02	2.8E+00	4.0E-06	2.0E-05	1.0E-03	3.6E-01	3.2E-04	1.7E-02	4.6E-04
Sat Col 13 upper port	30/Aug/12	6	2.0E-04	8.4E-03	1.0E-03	4.0E-01	1.0E-04	1.2E-02	6.3E+01	2.0E+00	1.0E-05	2.1E-01	1.4E-02	6.0E-01	3.5E+01	2.9E-04	1.3E+01	1.0E-05	1.5E+02	2.1E+00	7.7E-06	2.0E-05	1.0E-03	3.1E-01	1.7E-04	1.4E-02	2.1E-04
Sat Col 13 upper port	25/Sep/12	10	2.0E-04	6.5E-03	1.3E-03	8.4E-01	1.8E-05	1.1E-02	5.9E+01	1.8E+00	1.0E-05	2.3E-01	1.3E-02	6.0E-01	3.3E+01	2.0E-04	1.4E+01	1.0E-05	1.2E+02	1.9E+00	4.0E-06	2.0E-05	1.0E-03	2.2E-01	1.2E-04	5.2E-03	2.0E-04
Sat Col 13 upper port	23/Oct/12	14	2.0E-04	4.1E-03	9.6E-04	2.2E+00	5.1E-05	9.6E-03	5.1E+01	1.5E+00	1.0E-05	2.8E-01	1.1E-02	6.0E-01	3.1E+01	1.7E-04	1.3E+01	1.0E-05	1.1E+02	1.6E+00	4.0E-06	3.3E-05	1.0E-03	2.1E-01	2.9E-04	2.0E-03	2.1E-04
Sat Col 13 upper port	20/Nov/12	18	2.0E-04	2.7E-03	7.5E-04	2.0E+00	4.7E-05	8.0E-03	4.3E+01	1.3E+00	1.0E-05	2.9E-01	9.0E-03	6.0E-01	2.9E+01	1.5E-04	1.4E+01	1.0E-05	9.3E+01	1.4E+00	4.0E-06	2.3E-05	1.0E-03	1.6E-01	3.0E-04	1.1E-03	2.8E-04
Sat Col 13 upper port	18/Dec/12	22	2.0E-04	2.2E-03	4.9E-04	1.8E+00	7.9E-05	6.1E-03	3.8E+01	1.2E+00	1.0E-05	3.3E-01	7.6E-03	6.0E-01	2.6E+01	1.1E-04	1.2E+01	1.0E-05	7.8E+01	1.2E+00	4.0E-06	3.0E-05	1.0E-03	1.7E-01	2.5E-04	2.1E-03	3.2E-04
Sat Col 13 upper port	24/Jan/13	27	1.0E-04	1.7E-03	5.1E-04	9.6E-01	3.8E-05	6.2E-03	3.5E+01	9.6E-01	1.0E-05	3.2E-01	7.1E-03	3.0E-01	2.5E+01	1.3E-04	1.2E+01	5.0E-06	6.8E+01	1.2E+00	2.0E-06	3.3E-05	5.0E-04	1.3E-01	1.3E-04	2.3E-03	1.6E-04
Sat Col 13 upper port	12/Feb/13	30	1.0E-04	1.6E-03	3.0E-04	7.3E-01	1.3E-05	6.3E-03	3.2E+01	8.5E-01	1.0E-05	3.3E-01	6.6E-03	3.0E-01	2.4E+01	9.8E-05	1.1E+01	5.0E-06	7.1E+01	1.1E+00	2.0E-06	2.1E-05	5.0E-04	8.7E-02	1.1E-04	1.4E-03	1.0E-04
Sat Col 13 upper port	12/Mar/13	34	1.0E-04	1.4E-03	2.3E-04	1.1E+00	2.9E-05	5.7E-03	2.9E+01	7.6E-01	1.0E-05	3.5E-01	5.8E-03	3.0E-01	2.3E+01	9.4E-05	1.2E+01	5.0E-06	6.1E+01	1.0E+00	2.0E-06	3.4E-05	5.0E-04	9.0E-02	1.6E-04	1.3E-03	1.3E-04
Sat Col 13 upper port	11/Apr/13	38	1.0E-04	1.1E-03	2.6E-04	1.1E+00	1.9E-05	6.6E-03	2.7E+01	6.4E-01	1.0E-05	3.7E-01	5.8E-03	3.0E-01	2.4E+01	1.0E-04	1.2E+01	5.0E-06	5.6E+01	9.6E-01	2.0E-06	4.9E-05	5.0E-04	8.1E-02	2.1E-04	1.1E-03	1.4E-04
Sat Col 13 upper port	7/May/13	42	1.0E-04	7.6E-04	2.0E-04	7.2E-01	7.9E-06	5.4E-03	2.5E+01	5.7E-01	1.0E-05	3.7E-01	4.9E-03	3.0E-01	2.1E+01	8.3E-05	1.2E+01	5.0E-06	5.2E+01	8.8E-01	2.0E-06	1.4E-05	5.0E-04	8.3E-02	9.3E-05	1.6E-03	1.0E-04
Sat Col 13 upper port	6/Jun/13	46	1.0E-04	5.6E-04	2.0E-04	8.0E-01	7.7E-06	4.7E-03	2.4E+01	5.3E-01	1.0E-05	4.0E-01	4.2E-03	3.0E-01	2.1E+01	6.9E-05	1.2E+01	5.0E-06	4.4E+01	7.6E-01	2.0E-06	2.0E-05	5.0E-04	6.9E-02	8.9E-05	2.5E-03	1.0E-04
Sat Col 13 upper port	30/Jul/13	54	1.0E-04	1.0E-03	3.8E-04	3.5E-01	2.2E-04	4.0E-03	1.8E+01	4.2E-01	1.0E-05	6.6E-01	3.8E-03	3.0E-01	1.9E+01	1.1E-04	9.3E+00	5.5E-06	3.0E+01	6.4E-01	2.0E-06	7.3E-05	5.0E-04	1.0E-01	2.4E-04	5.9E-03	1.0E-04
Sat Col 13 upper port	28/Aug/13	58	1.0E-04	5.6E-04	1.4E-04	5.5E-01	9.3E-05	3.9E-03	1.8E+01	3.8E-01	1.0E-05	6.2E-01	3.2E-03	3.0E-01	1.8E+01	6.6E-05	9.9E+00	5.0E-06	2.8E+01	6.4E-01	2.0E-06	9.1E-05	5.0E-04	9.5E-02	2.1E-04	1.2E-03	1.0E-04
Sat Col 13 upper port	26/Sep/13	62	1.0E-04	3.4E-04	1.4E-04	6.2E-01	5.1E-05	3.9E-03	1.5E+01	3.4E-01	1.0E-05	6.1E-01	2.7E-03	3.0E-01	1.6E+01	4.5E-05	9.6E+00	5.0E-06	2.4E+01	6.0E-01	2.0E-06	6.8E-05	5.0E-04	8.0E-02	1.4E-04	5.0E-04	1.0E-04
Sat Col 13 upper port	24/Oct/13	66	1.0E-04	2.7E-04	1.2E-04	5.8E-01	3.8E-05	3.6E-03	1.5E+01	3.1E-01	1.0E-05	5.7E-01	2.4E-03	3.0E-01	1.6E+01	5.8E-05	9.5E+00	5.0E-06	2.3E+01	5.8E-01	2.0E-06	3.2E-05	5.0E-04	6.3E-02	1.5E-04	5.0E-04	1.0E-04
Sat Col 13 upper port	20/Nov/13	70	1.0E-04	2.1E-04	1.1E-04	6.2E-01	3.0E-05	3.8E-03	1.5E+01	3.0E-01	1.0E-05	6.4E-01	1.9E-03	3.0E-01	1.5E+01	4.0E-05	9.4E+00	5.0E-06	2.1E+01	5.8E-01	2.0E-06	4.6E-05	5.0E-04	5.7E-02	1.5E-04	5.0E-04	1.0E-04
Sat Col 13 upper port	18/Dec/13	74	1.0E-04	1.8E-04	1.0E-04	5.3E-01	2.8E-05	3.3E-03	1.5E+01	2.7E-01	1.0E-05	6.7E-01	1.8E-03	3.0E-01	1.4E+01	4.7E-05	8.8E+00	5.0E-06	2.0E+01	5.8E-01	2.0E-06	2.9E-05	5.0E-04	5.0E-02	1.2E-04	5.0E-04	1.9E-04
Sat Col 13 upper port	15/Jan/14	78	1.0E-04	1.5E-04	1.0E-04	5.3E-01	3.3E-05	3.2E-03	1.4E+01	2.8E-01		6.4E-01	1.6E-03	3.0E-01	1.5E+01	4.0E-05	9.2E+00	5.0E-06	1.8E+01	5.3E-01	2.0E-06	2.8E-05	5.2E-04	4.8E-02	9.7E-05	5.0E-04	1.0E-04
Sat Col 13 upper port	12/Feb/14	82	1.0E-04	1.3E-04	1.0E-04	4.6E-01	2.1E-05	2.8E-03	1.3E+01	2.6E-01	1.0E-05	7.2E-01	1.4E-03	3.0E-01	1.4E+01	4.0E-05	9.0E+00	5.0E-06	1.7E+01	5.4E-01	2.0E-06	2.1E-05	5.7E-04	4.0E-02	8.5E-05	9.5E-04	1.0E-04
Sat Col 13 upper port	11/Mar/14	86	1.0E-04	1.0E-04	1.0E-04	4.5E-01	1.0E-05	2.8E-03	1.2E+01	2.4E-01	1.0E-05	7.2E-01	1.2E-03	3.0E-01	1.4E+01	4.0E-05	8.7E+00	5.0E-06	1.5E+01	5.1E-01	2.0E-06	1.0E-05	5.0E-04	3.7E-02	5.0E-05	9.3E-04	1.0E-04
Sat Col 13 upper port	16/Apr/14	91	1.0E-04	8.5E-05	1.0E-04	4.8E-01	1.2E-05	3.2E-03	1.3E+01	2.4E-01	1.0E-05	6.2E-01	1.4E-03	3.0E-01	1.5E+01	4.0E-05	8.9E+00	5.0E-06	1.5E+01	5.5E-01	2.0E-06	2.8E-05	5.0E-04	4.0E-02	8.6E-05	5.0E-04	1.0E-04
Sat Col 13 upper port	22/May/14	96	1.0E-04	4.3E-04	1.8E-04	1.8E-01	5.4E-05	2.7E-03	1.3E+01	2.4E-01	1.0E-05	7.5E-01	1.6E-03	3.0E-01	1.4E+01	1.5E-04	7.9E+00	5.0E-06	1.4E+01	5.4E-01	2.0E-06	3.4E-05	5.0E-04	5.8E-02	1.9E-04	5.3E-03	1.0E-04
Sat Col 13 upper port	10/Jun/14	99	1.0E-04	2.0E-04	1.0E-04	6.7E-01	5.6E-05	2.9E-03	1.2E+01	2.3E-01	1.0E-05	7.1E-01	1.1E-03	3.0E-01	1.4E+01	4.0E-05	8.3E+00	5.0E-06	1.2E+01	5.1E-01	2.5E-06	4.8E-05	5.7E-04	4.5E-02	1.3E-04	3.2E-03	1.0E-04
Sat Col 13 upper port	9/Jul/14	103	1.0E-04	1.0E-04	1.0E-04	2.7E-01	2.5E-05	3.0E-03	1.2E+01	2.2E-01	1.0E-05	7.3E-01	9.4E-04	3.0E-01	1.4E+01	4.0E-05	8.5E+00	5.0E-06	1.2E+01	5.3E-01	2.0E-06	2.2E-05	5.0E-04	3.6E-02	1.3E-04	1.1E-03	1.0E-04
Sat Col 13 upper port	6/Aug/14	107	1.0E-04	7.8E-05	1.1E-04	6.2E-01	2.5E-05	2.8E-03	1.1E+01	2.1E-01	1.0E-05	7.6E-01	8.2E-04	3.0E-01	1.3E+01	4.0E-05	7.9E+00	5.0E-06	1.0E+01	5.4E-01	2.0E-06	3.4E-05	6.7E-04	3.8E-02	1.0E-04	7.1E-04	1.0E-04
Sat Col 13 upper port	4/Sep/14	111	1.0E-04	6.5E-05	1.0E-04	3.7E-01	9.6E-06	2.6E-03	1.2E+01	2.2E-01	1.0E-05	7.3E-01	7.5E-04	3.0E-01	1.3E+01	4.0E-05	8.2E+00	5.0E-06	1.0E+01	5.0E-01	2.0E-06	1.2E-05	5.6E-04	2.5E-02	5.5E-05	5.0E-04	1.0E-04
Sat Col 13 upper port	1/Oct/14	115	2.0E-04	8.1E-05	2.0E-04	2.0E-01	1.3E-05	2.2E-03	9.9E+00	1.9E-01	1.0E-05	7.5E-01	5.4E-04	6.0E-01	1.2E+01	<0.000080	7.6E+00	1.0E-05	7.7E+00	4.3E-01	4.0E-06	2.0E-05	1.0E-03	2.1E-02	1.0E-04	1.2E-03	2.0E-04

Saturated column kentic test results

ID	Date	cycle	D-Cr	D-Co	D-Cu	D-Fe	D-Pb	D-Li	D-Mg	D-Mn	D-Hg	D-Mo	D-Ni	D-P	D-K	D-Se	D-Si	D-Ag	D-Na	D-Sr	D-Tl	D-Sn	D-Ti	D-U	D-V	D-Zn	D-Zr
			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Sat Col 13 lower port	18/Jul/12	0	5.0E-04	3.1E-02	1.3E-01	1.7E-01	1.4E-03	8.8E-03	8.8E+01	6.3E+00	1.0E-05	1.7E-01	1.7E-02	1.5E+00	3.7E+01	1.9E-02	1.2E+01	2.5E-05	2.4E+02	1.7E+00	1.5E-04	5.0E-05	2.5E-03	1.8E-01	2.5E-04	2.3E-02	5.0E-04
Sat Col 13 lower port	3/Aug/12	2	5.0E-03	2.6E-02	4.6E-02	6.9E-01	1.9E-03	2.5E-02	8.6E+01	5.6E+00	1.0E-05	1.7E-01	2.3E-02	<15	3.6E+01	4.6E-03	1.2E+01	2.5E-04	2.2E+02	2.0E+00	1.5E-04	5.0E-04	2.5E-02	2.4E-01	2.5E-03	3.1E-02	5.0E-03
Sat Col 13 lower port	31/Aug/12	6	5.0E-04	1.7E-02	1.5E-02	1.4E+00	8.3E-04	9.0E-03	8.2E+01	4.3E+00	1.0E-05	1.9E-01	1.7E-02	1.5E+00	3.4E+01	6.8E-04	1.3E+01	2.5E-05	1.8E+02	2.0E+00	5.8E-05	5.0E-05	2.5E-03	2.9E-01	2.5E-04	1.5E-02	5.0E-04
Sat Col 13 lower port	26/Sep/12	10	2.0E-04	1.3E-02	5.6E-03	2.1E+00	4.2E-05	8.5E-03	7.0E+01	3.6E+00	1.0E-05	2.2E-01	1.6E-02	6.0E-01	3.4E+01	3.2E-04	1.4E+01	1.0E-05	1.6E+02	1.7E+00	4.0E-06	2.2E-05	1.0E-03	2.4E-01	2.4E-04	1.4E-02	2.5E-04
Sat Col 13 lower port	24/Oct/12	14	2.0E-04	9.7E-03	2.3E-03	2.6E+00	3.2E-04	7.0E-03	6.4E+01	3.4E+00	1.0E-05	2.6E-01	1.4E-02	6.0E-01	3.3E+01	2.1E-04	1.5E+01	1.0E-05	1.4E+02	1.5E+00	4.0E-06	2.0E-05	1.0E-03	2.5E-01	2.2E-04	8.3E-03	2.0E-04
Sat Col 13 lower port	21/Nov/12	18	2.0E-04	7.6E-03	1.5E-03	2.1E+00	1.3E-04	5.5E-03	5.2E+01	2.6E+00	1.0E-05	2.6E-01	1.2E-02	6.0E-01	3.0E+01	1.7E-04	1.3E+01	1.0E-05	1.1E+02	1.2E+00	4.0E-06	2.0E-05	1.0E-03	1.6E-01	1.7E-04	5.8E-03	2.0E-04
Sat Col 13 lower port	19/Dec/12	22	2.0E-04	6.1E-03	8.1E-04	2.3E+00	1.9E-04	4.5E-03	4.4E+01	2.0E+00	1.0E-05	2.7E-01	9.9E-03	6.0E-01	2.4E+01	1.2E-04	1.3E+01	1.0E-05	9.4E+01	1.1E+00	4.0E-06	2.0E-05	1.0E-03	1.6E-01	1.4E-04	4.5E-03	2.0E-04
Sat Col 13 lower port	25/Jan/13	27	2.0E-04	5.6E-03	7.4E-04	2.5E+00	1.9E-04	5.5E-03	4.1E+01	2.0E+00	1.0E-05	3.0E-01	1.0E-02	6.0E-01	2.5E+01	1.1E-04	1.3E+01	1.0E-05	8.8E+01	1.1E+00	4.0E-06	2.0E-05	1.0E-03	1.9E-01	1.8E-04	3.7E-03	2.0E-04
Sat Col 13 lower port	13/Feb/13	30	1.0E-04	4.5E-03	4.1E-04	8.4E-01	3.5E-05	4.2E-03	3.6E+01	1.7E+00	1.0E-05	3.2E-01	8.5E-03	3.0E-01	2.5E+01	1.1E-04	1.2E+01	5.0E-06	8.2E+01	9.7E-01	2.0E-06	1.0E-05	5.0E-04	9.1E-02	6.0E-05	3.3E-03	1.0E-04
Sat Col 13 lower port	13/Mar/13	34	1.0E-04	3.9E-03	2.9E-04	1.1E+00	6.0E-05	3.9E-03	3.3E+01	1.5E+00	1.0E-05	3.3E-01	7.6E-03	3.0E-01	2.2E+01	1.0E-04	1.3E+01	7.7E-06	6.7E+01	9.2E-01	2.3E-06	1.0E-05	5.0E-04	1.6E-01	1.1E-04	2.5E-03	1.0E-04
Sat Col 13 lower port	12/Apr/13	38	1.0E-04	3.1E-03	3.6E-04	7.7E-01	4.9E-05	4.2E-03	2.9E+01	1.2E+00	1.0E-05	3.6E-01	6.8E-03	3.0E-01	2.1E+01	1.0E-04	1.2E+01	5.0E-06	6.0E+01	8.3E-01	2.0E-06	1.0E-05	5.0E-04	1.0E-01	8.2E-05	2.0E-03	1.0E-04
Sat Col 13 lower port	8/May/13	42	1.0E-04	2.7E-03	1.9E-04	4.4E-01	3.5E-05	3.5E-03	2.7E+01	1.1E+00	1.0E-05	4.1E-01	6.2E-03	3.0E-01	2.2E+01	9.8E-05	1.2E+01	5.0E-06	6.1E+01	7.3E-01	2.0E-06	1.0E-05	5.0E-04	8.1E-02	9.2E-05	1.6E-03	1.0E-04
Sat Col 13 lower port	7/Jun/13	46	1.0E-04	2.4E-03	2.6E-04	7.8E-01	7.3E-05	3.3E-03	2.5E+01	1.0E+00	1.0E-05	4.1E-01	5.2E-03	3.0E-01	2.1E+01	9.9E-05	1.2E+01	5.0E-06	5.1E+01	6.7E-01	2.0E-06	1.0E-05	5.0E-04	9.0E-02	7.4E-05	1.6E-03	1.0E-04
Sat Col 13 lower port	31/Jul/13	54	1.0E-04	2.1E-03	1.9E-04	7.6E-01	2.5E-04	3.5E-03	2.3E+01	8.5E-01	1.0E-05	5.4E-01	5.5E-03	3.0E-01	2.1E+01	6.5E-05	1.2E+01	5.0E-06	4.5E+01	6.6E-01	2.0E-06	1.0E-05	5.0E-04	9.0E-02	7.6E-05	1.1E-03	1.0E-04
Sat Col 13 lower port	29/Aug/13	58	1.0E-04	1.9E-03	1.4E-04	7.2E-01	1.7E-04	2.9E-03	2.0E+01	7.7E-01	1.0E-05	5.8E-01	4.5E-03	3.0E-01	1.8E+01	7.2E-05	1.2E+01	5.0E-06	3.9E+01	5.9E-01	2.0E-06	1.0E-05	5.0E-04	7.3E-02	6.6E-05	1.1E-03	1.0E-04
Sat Col 13 lower port	27/Sep/13	62	1.0E-04	1.6E-03	1.2E-04	6.1E-01	1.2E-04	2.2E-03	1.9E+01	6.9E-01	1.0E-05	5.7E-01	4.1E-03	3.0E-01	1.7E+01	4.8E-05	1.1E+01	5.0E-06	3.3E+01	5.3E-01	2.0E-06	1.0E-05	5.0E-04	6.4E-02	5.9E-05	1.0E-03	3.5E-04
Sat Col 13 lower port	25/Oct/13	66	1.0E-04	1.4E-03	3.3E-04	5.8E-01	1.1E-04	3.1E-03	1.8E+01	6.1E-01	1.0E-05	6.3E-01	3.7E-03	3.0E-01	1.7E+01	5.0E-05	1.1E+01	5.0E-06	3.2E+01	5.6E-01	2.0E-06	1.0E-05	5.0E-04	6.1E-02	7.0E-05	1.0E-03	1.0E-04
Sat Col 13 lower port	21/Nov/13	70	1.0E-04	1.2E-03	1.0E-04	5.2E-01	8.3E-05	2.3E-03	1.6E+01	5.5E-01	1.0E-05	6.3E-01	3.1E-03	3.0E-01	1.4E+01	6.9E-05	1.0E+01	5.0E-06	2.5E+01	4.8E-01	4.1E-06	1.0E-05	5.0E-04	5.0E-02	6.1E-05	9.6E-04	1.0E-04
Sat Col 13 lower port	19/Dec/13	74	1.0E-04	1.1E-03	1.0E-04	4.8E-01	6.8E-05	2.0E-03	1.6E+01	5.3E-01	1.0E-05	6.6E-01	2.8E-03	3.0E-01	1.6E+01	4.3E-05	9.9E+00	5.0E-06	2.5E+01	4.7E-01	2.0E-06	1.0E-05	5.0E-04	4.4E-02	5.0E-05	1.9E-03	1.4E-04
Sat Col 13 lower port	16/Jan/14	78	1.0E-04	9.9E-04	1.0E-04	4.3E-01	5.6E-05	2.0E-03	1.4E+01	4.8E-01	1.0E-05	7.0E-01	2.4E-03	3.0E-01	1.5E+01	7.7E-05	9.8E+00	5.0E-06	2.1E+01	4.4E-01	2.0E-06	1.0E-05	5.0E-04	4.1E-02	8.6E-05	5.9E-04	1.0E-04
Sat Col 13 lower port	13/Feb/14	82	1.0E-04	9.0E-04	1.0E-04	3.4E-01	4.9E-05	1.6E-03	1.3E+01	4.2E-01	1.0E-05	7.2E-01	2.2E-03	3.0E-01	1.4E+01	4.3E-05	1.0E+01	5.0E-06	2.0E+01	4.5E-01	2.4E-06	1.0E-05	5.0E-04	3.5E-02	5.0E-05	1.4E-03	1.0E-04
Sat Col 13 lower port	12/Mar/14	86	1.0E-04	8.3E-04	1.0E-04	3.5E-01	3.9E-05	1.7E-03	1.3E+01	4.0E-01	1.0E-05	7.6E-01	2.0E-03	3.0E-01	1.4E+01	4.0E-05	9.9E+00	5.0E-06	1.7E+01	4.2E-01	2.0E-06	1.0E-05	5.0E-04	3.4E-02	5.0E-05	7.0E-04	1.0E-04
Sat Col 13 lower port	17/Apr/14	91	1.0E-04	7.7E-04	1.0E-04	3.5E-01	4.1E-05	1.9E-03	1.3E+01	4.1E-01	1.0E-05	7.1E-01	1.9E-03	3.0E-01	1.4E+01	4.2E-05	9.8E+00	5.7E-06	1.7E+01	4.3E-01	4.5E-06	1.0E-05	5.0E-04	3.4E-02	5.0E-05	2.3E-02	1.0E-04
Sat Col 13 lower port	22/May/14	96	1.0E-04	7.2E-04	1.0E-04	3.2E-01	3.5E-05	1.3E-03	1.3E+01	3.9E-01	1.0E-05	8.0E-01	1.7E-03	3.0E-01	1.4E+01	4.0E-05	1.0E+01	5.0E-06	1.6E+01	4.1E-01	2.0E-06	1.0E-05	5.0E-04	3.5E-02	5.0E-05	5.0E-04	1.0E-04
Sat Col 13 lower port	11/Jun/14	99	1.0E-04	6.9E-04	1.0E-04	2.9E-01	2.8E-05	1.7E-03	1.2E+01	3.5E-01	1.0E-05	8.1E-01	1.5E-03	3.0E-01	1.4E+01	4.0E-05	9.9E+00	5.0E-06	1.3E+01	3.8E-01	2.0E-06	1.0E-05	5.0E-04	3.2E-02	5.0E-05	5.0E-04	1.0E-04
Sat Col 13 lower port	10/Jul/14	103	1.0E-04	6.5E-04	1.0E-04	2.7E-01	2.2E-05	1.7E-03	1.2E+01	3.5E-01	1.0E-05	8.5E-01	1.4E-03	3.0E-01	1.4E+01	4.0E-05	1.0E+01	5.0E-06	1.2E+01	4.0E-01	2.0E-06	1.0E-05	5.0E-04	3.0E-02	5.0E-05	2.1E-03	1.0E-04
Sat Col 13 lower port	7/Aug/14	107	1.0E-04	6.2E-04	1.0E-04	2.6E-01	2.4E-05	1.5E-03	1.2E+01	3.4E-01	1.0E-05	8.4E-01	1.4E-03	3.0E-01	1.4E+01	4.0E-05	9.3E+00	5.0E-06	1.3E+01	4.0E-01	2.0E-06	1.0E-05	8.2E-04	2.8E-02	5.0E-05	4.0E-03	1.0E-04
Sat Col 13 lower port	5/Sep/14	111	1.0E-04	5.8E-04	1.0E-04	2.7E-01	2.3E-05	1.6E-03	1.2E+01	3.4E-01	1.0E-05	8.6E-01	1.2E-03	3.0E-01	1.3E+01	4.0E-05	9.3E+00	5.0E-06	1.2E+01	4.0E-01	2.0E-06	1.0E-05	8.2E-04	2.6E-02	5.0E-05	3.5E-03	1.0E-04
Sat Col 13 lower port	2/Oct/14	115	1.0E-04	5.0E-04	1.0E-04	2.2E-01	2.2E-05	1.4E-03	1.1E+01	3.0E-01	1.0E-05	8.5E-01	1.1E-03	3.0E-01	1.2E+01	4.0E-05	8.7E+00	5.0E-06	1.0E+01	3.7E-01	2.0E-06	1.0E-05	5.0E-04	2.3E-02	5.0E-05	5.0E-04	1.0E-04
Sat Col 14 upper port	12/Jul/12	0	5.0E-04	1.8E-01	4.1E+00	7.5E-02	2.7E-04	4.3E-02	1.9E+02	2.3E+00	1.3E-04	4.7E-02	7.5E-02	1.5E+00	5.7E+01	4.5E-02	1.3E+01	4.8E-05	1.3E+02	5.9E+00	1.9E-04	5.0E-05	2.5E-03	1.1E+00	6.8E-04	3.2E-01	4.2E-03
Sat Col 14 upper port	3/Aug/12	3	9.1E-04	1.7E-01	8.9E-01	3.3E+00	1.4E-03	2.9E-02	1.5E+02	3.0E+00	1.0E-05	1.8E-02	6.2E-02	1.5E+00	4.1E+01	1.1E-02	1.3E+01	3.8E-05	8.0E+01	4.2E+00	1.2E-04	2.4E-04	2.5E-03	7.0E-01	4.9E-04	2.3E-01	2.2E-03
Sat Col 14 upper port	30/Aug/12	7	5.0E-04	1.3E-01	5.8E-01	2.2E-01	1.5E-04	3.0E-02	1.7E+02	2.7E+00	1.0E-05	1.6E-02	4.3E-02	1.5E+00	4.6E+01	6.7E-03	1.2E+01	2.5E-05	9.2E+01	4.3E+00	1.1E-04	5.0E-05	2.5E-03	9.0E-01	5.7E-04	1.9E-01	2.0E-03
Sat Col 14 upper port	25/Sep/12	11	5.0E-04	1.2E-01	3.4E-01	2.2E+00	2.7E-04	2.7E-02	1.4E+02	2.7E+00	1.0E-05	1.4E-02	3.8E-02	1.5E+00	4.1E+01	4.2E-03	1.1E+01	2.5E-05	6.9E+01	3.7E+00	6.2E-05	2.4E-04	2.5E-03	6.9E-01	3.8E-04	1.4E-01	1.5E-03
Sat Col 14 upper port	23/Oct/12	15	5.0E-04	1.1E-01	1.4E-01	3.8E+00	2.8E-04	2.8E-02	1.5E+02	2.8E+00	1.0E-05	1.4E-02	3.0E-02	1.5E+00	4.2E+01	3.0E-03	1.2E+01	2.5E-05	6.9E+01	3.8E+00	3.6E-05	5.6E-05	2.5E-03	7.1E-01	2.9E-04	1.1E-01	1.3E-03
Sat Col 14 upper port	20/Nov/12	19	1.0E-04	9.5E-02	1.0E-01	1.3E+00	7.7E-05	2.5E-02	1.2E+02	2.6E+00	1.0E-05	1.2E-02	2.3E-02	3.0E-01	3.8E+01	2.9E-03	1.2E+01	5.0E-06	5.0E+01	3.1E+00	2.4E-05	1.0E-05	5.0E-04	5.2E-01	1.2E-04	8.2E-02	4.7E-04
Sat Col 14 upper port	18/Dec/12	23	5.0E-04	7.3E-02	5.1E-02	3.7E+00	1.4E-04	1.9E-02	1.2E+02	2.1E+00	1.0E-05	1.3E-02	1.8E-02	1.5E+00	3.3E+01	1.4E-03	1.0E+01	2.5E-05	4.2E+01	3.0E+00	1.0E-05	5.0E-05	2.5E-03	4.8E-01	3.7E-04	5.4E-02	7.6E-04
Sat Col 14 upper port	24/Jan/13	28	5.0E-04	6.9E-02	6.6E-02	3.2E+00	1.5E-04	1.7E-02	1.0E+02	2.1E+00	1.0E-05	1.0E-02	1.5E-02	1.5E+00	2.9E+01	1.5E-03	1.0E+01	2.5E-05	3.4E+01	2.6E+00	1.3E-05	5.0E-05	2.5E-03	4.1E-01	2.5E-04	4.7E-02	5.6E-04
Sat Col 14 upper port	12/Feb/13	31	2.0E-04	4.9E-02	1.5E-02	9.3E-01	1.9E-05	1.5E-02	8.8E+01	1.8E+00	1.0E-05	8.1E-03	1.0E-02	6.0E-01	2.8E+01	1.0E-03	9.2E+00	1.0E-05	2.8E+01	2.2E+00	5.7E-06	2.0E-05	1.0E-03	2.9E-01	1.0E-04	2.7E-02	2.0E-04
Sat Col 14 upper port	12/Mar/13	35	2.0E-04	4.0E-02	3.6E-03	2.4E+00	5.8E-05	1.4E-02	8.1E+01	1.6E+00	1.0E-05	9.7E-03	8.3E-03	6.0E-01	2.5E+01	9.0E-04	8.9E+00	1.0E-05	2.3E+01	2.1E+00	0.000004	2.0E-05	1.0E-03	2.8E-01	1.3E-04	2.0E-02	2.6E-04
Sat Col 14 upper port	11/Apr/13	39	2.0E-04	3.2E-02	3.6E-04	2.5E+00	2.5E-05	1.4E-02	7.3E+01	1.6E+00	1.0E-05	1.1E-02	6.4E-03	6.0E-01	2.6E+01	7.6E-04	9.3E+00	1.0E-05	1.9E+01	1.9E+00	0.000004	2.0E-05	1.0E-03	2.3E-01	1.0E-04	1.3E-02	2.6E-04
Sat Col 14 upper port	7/May/13	43	2.0E-04	2.8E-02	2.0E-04	2.4E+00	3.0E-05	1.2E-02	7.3E+01	1.5E+00	1.0E-05	7.3E-03	5.2E-03	6.0E-01	2.3E+01	9.1E-04	9.6E+00	1.0E-05	1.6E+01	1.5E+00	0.000004	2.0E-05	1.0E-03	1.7E-01	1.0E-04	1.2E-02	2.0E-04
Sat Col 14 upper port	6/Jun/13	47	2.0E-04	2.3E-02	2.7E-04	2.0E+00	2.8E-05	1.0E-02	5.9E+01	1.3E+00	1.0E-05	1.2E-02	4.1E-03	6.0E-01	2.0E+01	7.2E-04	8.8E+00	1.0E-05	1.2E+01	1.4E+00	0.000004	4.4E-05	1.0E-03	1.6E-01	1.1E-04	1.1E-02	2.0E-04
Sat Col 14 upper port	4/Jul/13	51	2.0E-04	1.9E-02	2.0E-04	1.9E+00	2.3E-05	1.1E-02	5.2E+01	1.1E+00	1.0E-05	7.8E-03	3.5E-03	6.0E-01	1.7E+01	5.8E-04	8.6E+00	1.0E-05	9.5E+00	1.4E+00	0.000004	2.0E-05	1.0E-03	1.3E-01	1.0E-04	6.6E-03	2.0E-04
Sat Col 14 upper port	30/Jul/13	55	2.0E-04	2.0E-02	2.0E-04	2.0E+00	1.9E-05	1.1E-02	5.3E+01	1.1E+00	1.0E-05	7.8E-03	3.1E-03	6.0E-01	1.8E+01	7.3E-04	9.5E+00	1.0E-05	9.3E+00	1.4E+00	0.000004	5.9E-05	1.0E-03	1.3E-01	1.0E-04	7.3E-03	2.0E-04
Sat Col 14 upper port	28/Aug/13	59	2.0E-04	1.5E-02	2.6E-04	1.7E+00	2.8E-05	8.7E-03	4.8E+01	1.0E+00	1.0E-05	8.4E-03	2.7E-03	6.0E-01	1.6E+01	5.4E-04	8.9E+00	1.0E-05	8.1E+00	1.2E+00	0.000004	6.3E-05	1.0E-03	1.2E-01	1.4E-04	4.6E-03	2.0E-04
Sat Col 14 upper port	26/Sep/13	63	2.0E-04	1.2E-02	2.0E-04	1.4E+00	1.8E-05	8.7E-03	4.1E+01	9.1E-01	1.0E-05	7.8E-03	2.0E-03	6.0E-01	1.4E+01	4.4E-04	8.6E+00	1.0E-05	6.7E+00	1.0E+00	0.000004	5.2E-05	1.0E-03	9.1E-02	1.0E-04	3.3E-03	2.0E-04
Sat Col 14 upper port	24/Oct/13	67	1.0E-04	9.7E-03	1.0E-04	1.3E+00	1.3E-05	8.2E-03	4.2E+01	8.8E-01	1.0E-05	6.0E-03	1.7E-03	3.0E-01	1.5E+01	4.5E-04	9.6E+00	5.0E-06	6.3E+00	1.0E+00	2.0E-06	2.7E-05	5.0E-04	8.4E-02	5.0E-05	2.2E-03	1.0E-04
Sat Col 14 upper port	20/Nov/13	71	1.0E-04	8.1E-03	1.0E-04	1.1E+00	1.7E-05	7.0E-03	3.5E+01	7.8E-01	1.0E-05	5.8E-03	1.2E-03	3.0E-01	1.2E+01	3.4E-04	7.9E+00	5.0E-06	5.0E+00	8.9E-01	4.3E-06	4.0E-05	5.0E-04	6.8E-02	6.6E-05	5.7E-03	1.0E-04
Sat Col 14 upper port	18/Dec/13	75	1.0E-04	6.5E-03	1.0E-04	9.7E-01	1.4E-05	5.4E-03	3.2E+01	7.4E-01	1.0E-05	4.9E-03	1.1E-03	3.0E-01	1.2E+01	3.4E-04	7.8E+00	5.0E-06	4.2E+00	8.6E-01	2.0E-06	1.7E-05	5.0E-04	6.2E-02	5.3E-05	5.6E-04	1.0E-04
Sat Col 14 upper port	15/Jan/14	79	1.0E-04	5.2E-03	1.0E-04	8.0E-01	3.2E-05	5.4E-03	3.2E+01	6.8E-01	1.0E-05	6.0E-03	8.9E-04	3.0E-01	1.1E+01	3.2E-04	7.5E+00	5.0E-06	3.8E+00	7.8E-01	2.0E-06	1.3E-05	5.0E-04	5.6E-02	5.7E-05	1.2E-03	1.0E-04
Sat Col 14 upper port	12/Feb/14	83	1.0E-04	4.5E-03	1.0E-04	6.7E-01	1.7E-05	4.8E-03	2.8E+01	6.1E-01	1.0E-05	5.7E-03	7.9E-04	3.0E-01	1.0E+01	2.8E-04	7.3E+00	5.0E-06	3.3E+00	7.9E-01	2.0E-06	1.5E-05	5.0E-04	5.0E-02	5.0E-05	1.1E-03	1.0E-04
Sat Col 14 lower port	13/Jul/12	0	8.8E-02	2.9E+00	6.4E+02	9.3E+01	1.4E-03	2.1E-01	3.5E+02	1.5E+01	2.8E-05	7.9E-03	7.9E-01	3.0E+01	2.6E+01	9.8E-02	3.1E+01	5.0E-04	1.7E+02	5.4E-01	1.4E-03	1.4E-03	5.0E-02	1.8E+00	8.0E-03	4.4E+00	1.0E-02
Sat Col 14 lower port	3/Aug/12	3	5.1E-02	2.1E+00	4.1E+02	7.0E+01	2.5E-04	1.2E-01	3.1E+02	1.2E+01	2.0E-05	4.1E-03	5.4E-01	1.5E+01	3.0E+01	6.5E-02	3.0E+01	2.5E-04	1.5E+02	6.6E-01	9.3E-04	5.0E-04	2.5E-02	8.9E-01	6.1E-03	3.0E+00	5.0E-03
Sat Col 14 lower port	31/Aug/12	7	2.2E-02	1.1E+00	2.2E+02	7.9E+01	4.0E-04	7.2E-02	2.0E+02	7.1E+00	1.3E-05	2.9E-03	2.8E-01	6.0E+00	2.1E+01	3.9E-02	2.7E+01	2.4E-04	8.7E+01	7.2E-01	7.2E-04	2.0E-04	1.0E-02	4.4E-01	6.8E-03	1.6E+00	2.0E-03
Sat Col 14 lower port	26/Sep/12	11	1.8E-02	8.2E-01	1.5E+02	9.5E+01	6.5E-04	6.2E-02	1.5E+02	5.3E+00	1.0E-05	4.3E-03	2.1E-01	6.0E+00	1.7E+01	2.6E-02	2.6E+01	1.0E-04	5.5E+01	5.6E-01	5.8E-04	4.1E-04	1.0E-02	2.8E-01	1.1E-02	1.3E+00	2.0E-03
Sat Col 14 lower port	24/Oct/12	15	1.2E-02	4.9E-01	8.3E+01	6.6E+01	5.0E-05	3.9E-02	1.0E+02	3.9E+00	1.0E-05	3.3E-03	1.2E-01	3.0E+00	1.5E+01	1.7E-02	2.2E+01	5.0E-05	4.1E+01	4.9E-01	4.5E-04	1.0E-04	5.0E-03	1.9E-01	4.5E-03	7.1E-01	1.0E-03
Sat Col 14 lower port	21/Nov/12	19	6.9E-03	4.2E-01	5.5E+01	5.3E+01	5.0E-05	2.2E-02	1.1E+02	3.9E+00	1.0E-05	2.0E-03	1.0E-01	3.0E+00	1.6E+01	1.4E-02	1.9E+01	5.0E-05	3.9E+01	6.7E-01	4.0E-04	1.0E-04	5.0E-03	1.3E-01	3.2E-03	5.8E-01	1.0E-03
Sat Col 14 lower port	19/Dec/12	23	5.8E-03	3.5E-01	4.3E+01	4.5E+01	2.5E-05	1.4E-02	1.1E+02	3.4E+00	1.0E-05	2.3E-03	8.5E-02	1.5E+00	1.6E+01	1.2E-02	1.9E+01	2.5E-05	3.5E+01	8.2E-01	3.7E-04	5.0E-05	2.5E-03	1.1E-01	2.2E-03	4.6E-01	5.0E-04
Sat Col 14 lower port	25/Jan/13	28	3.9E-03	2.8E-01	3.3E+01	3.6E+01	2.5E-05	1.5E-02	1.1E+02	3.3E+00	1.0E-05	2.6E-03	6.4E-02	1.5E+00	1.6E+01	9.6E-03	1.9E+01	2.5E-05	2.9E+01	8.5E-01	3.5E-04	9.2E-05	2.5E-03	9.9E-02	1.4E-03	3.6E-01	5.0E-04
Sat Col 14 lower port	13/Feb/13	31	2.7E-03	2.2E-01	2.7E+01	3.0E+01	2.5E-05	1.3E-02	9.5E+01	3.0E+00	1.0E-05	4.4E-03	5.3E-02	1.5E+00	1.5E+01	7.6E-03	1.7E+01	2.5E-05	2.7E+01	8.3E-01	3.0E-04	5.0E-05	2.5E-03	1.0E-01	9.4E-04	3.0E-01	5.0E-04
Sat Col 14 lower port	13/Mar/13	35	3.6E-03	1.8E-01	2.1E+01	2.5E+01	2.8E-05	1.2E-02	8.6E+01	2.6E+00	1.0E-05	4.2E-03	4.3E-02	1.5E+00	1.4E+01	7.1E-03	1.7E+01	2.5E-05	2.3E+01	8.2E-01	2.9E-04	3.4E-04	2.5E-03	8.7E-02	8.1E-04	2.3E-01	5.0E-04
Sat Col 14 lower port	12/Apr/13	39	2.8E-03	1.6E-01	1.8E+01	2.5E+01	1.0E-05	1.2E-02	8.4E+01	2.4E+00

Saturated column kentic test results

ID	Date	cycle	D-Cr	D-Co	D-Cu	D-Fe	D-Pb	D-Li	D-Mg	D-Mn	D-Hg	D-Mo	D-Ni	D-P	D-K	D-Se	D-Si	D-Ag	D-Na	D-Sr	D-Tl	D-Sn	D-Ti	D-U	D-V	D-Zn	D-Zr
			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Sat Col 15	17/Jul/12	0	2.9E-04	2.6E-02	1.5E-01	8.4E-02	5.4E-05	9.9E-03	6.2E+01	5.3E+00	1.0E-05	3.7E-01	8.8E-03	6.0E-01	3.4E+01	1.9E-02	1.3E+01	1.0E-05	2.6E+02	1.2E+00	1.6E-04	2.3E-05	1.0E-03	8.6E-02	1.7E-04	2.5E-02	3.0E-04
Sat Col 15	3/Aug/12	2	1.3E-04	8.8E-03	2.6E-02	4.7E-01	7.6E-05	6.9E-03	3.6E+01	3.0E+00	1.0E-05	4.7E-01	4.7E-03	3.0E-01	2.6E+01	9.7E-03	1.4E+01	5.0E-06	1.6E+02	9.0E-01	1.2E-04	1.0E-05	5.0E-04	5.4E-02	1.7E-04	1.2E-02	1.6E-04
Sat Col 15	30/Aug/12	6	1.6E-04	6.5E-03	2.4E-02	1.0E+00	1.1E-04	4.9E-03	4.1E+01	3.1E+00	1.0E-05	4.8E-01	4.5E-03	3.0E-01	2.9E+01	8.3E-03	1.7E+01	5.0E-06	1.5E+02	7.9E-01	1.0E-04	6.8E-05	5.0E-04	6.0E-02	1.8E-04	1.0E-02	1.6E-04
Sat Col 15	25/Sep/12	10	1.4E-04	3.9E-03	1.1E-02	1.0E+00	1.2E-04	3.4E-03	2.7E+01	2.1E+00	1.0E-05	5.1E-01	3.1E-03	3.0E-01	2.1E+01	4.1E-03	1.4E+01	5.0E-06	1.0E+02	5.8E-01	7.6E-05	6.9E-05	5.0E-04	4.1E-02	1.2E-04	7.1E-03	1.2E-04
Sat Col 15	23/Oct/12	14	1.2E-04	3.2E-03	8.9E-03	1.5E+00	1.5E-04	3.0E-03	2.5E+01	1.8E+00	1.0E-05	5.3E-01	2.9E-03	3.0E-01	2.0E+01	3.0E-03	1.3E+01	5.0E-06	8.2E+01	5.3E-01	5.2E-05	6.0E-05	5.0E-04	4.4E-02	1.2E-04	6.2E-03	1.2E-04
Sat Col 15	20/Nov/12	18	1.0E-04	2.7E-03	5.7E-03	1.4E+00	7.8E-05	2.9E-03	2.5E+01	1.7E+00	1.0E-05	5.5E-01	2.7E-03	3.0E-01	2.1E+01	2.3E-03	1.4E+01	5.0E-06	8.3E+01	5.2E-01	3.5E-05	9.3E-05	6.9E-04	3.9E-02	9.3E-05	5.5E-03	1.1E-04
Sat Col 15	18/Dec/12	22	1.0E-04	2.3E-03	3.4E-03	1.7E+00	5.7E-05	2.6E-03	2.3E+01	1.5E+00	1.0E-05	6.0E-01	2.5E-03	3.0E-01	1.9E+01	1.7E-03	1.4E+01	5.0E-06	7.4E+01	5.0E-01	1.5E-05	9.5E-05	5.0E-04	3.5E-02	9.5E-05	4.3E-03	1.0E-04
Sat Col 15	24/Jan/13	27	1.0E-04	2.3E-03	2.5E-03	1.6E+00	4.4E-05	2.5E-03	2.1E+01	1.4E+00	1.0E-05	5.8E-01	2.4E-03	3.0E-01	1.8E+01	1.2E-03	1.4E+01	5.0E-06	6.7E+01	4.6E-01	9.6E-06	6.5E-05	5.7E-04	3.5E-02	7.3E-05	3.4E-03	1.0E-04
Sat Col 15	12/Feb/13	30	1.0E-04	2.1E-03	2.0E-03	1.7E+00	4.3E-05	2.2E-03	2.0E+01	1.3E+00	1.0E-05	5.9E-01	2.3E-03	3.0E-01	1.8E+01	1.1E-03	1.4E+01	5.0E-06	6.6E+01	4.3E-01	4.1E-06	4.0E-05	5.0E-04	2.9E-02	7.8E-05	3.2E-03	1.0E-04
Sat Col 15	12/Mar/13	34	1.0E-04	1.8E-03	1.5E-03	1.6E+00	2.9E-05	1.8E-03	1.8E+01	1.2E+00	1.0E-05	6.5E-01	2.2E-03	3.0E-01	1.6E+01	6.9E-04	1.4E+01	5.0E-06	5.7E+01	4.1E-01	2.0E-06	4.7E-05	5.0E-04	2.7E-02	6.5E-05	2.1E-03	1.0E-04
Sat Col 15	11/Apr/13	38	1.0E-04	1.6E-03	9.1E-04	1.3E+00	1.9E-05	1.8E-03	1.6E+01	1.1E+00	1.0E-05	6.2E-01	2.0E-03	3.0E-01	1.7E+01	4.7E-04	1.3E+01	5.0E-06	5.1E+01	3.7E-01	2.0E-06	4.2E-05	5.7E-04	2.3E-02	6.2E-05	1.9E-03	1.0E-04
Sat Col 15	7/May/13	42	1.0E-04	1.5E-03	6.3E-04	1.2E+00	2.8E-05	1.8E-03	1.6E+01	9.9E-01	1.0E-05	7.0E-01	2.0E-03	3.0E-01	1.6E+01	3.4E-04	1.3E+01	5.0E-06	5.2E+01	3.8E-01	2.0E-06	3.0E-05	5.0E-04	2.2E-02	7.1E-05	6.6E-03	1.0E-04
Sat Col 15	6/Jun/13	46	1.0E-04	1.4E-03	4.1E-04	1.1E+00	1.8E-05	1.3E-03	1.5E+01	9.4E-01	1.0E-05	6.9E-01	1.8E-03	3.0E-01	1.7E+01	2.7E-04	1.3E+01	5.0E-06	4.2E+01	3.5E-01	2.0E-06	4.6E-05	6.3E-04	1.9E-02	5.4E-05	3.6E-03	1.0E-04
Sat Col 15	4/Jul/13	50	1.0E-04	1.2E-03	2.6E-04	1.0E+00	1.7E-05	5.0E-04	1.3E+01	8.2E-01	1.0E-05	6.8E-01	1.6E-03	3.0E-01	1.5E+01	1.8E-04	1.3E+01	5.0E-06	3.8E+01	3.4E-01	2.0E-06	2.8E-05	5.0E-04	1.9E-02	5.0E-05	1.3E-03	1.0E-04
Sat Col 15	30/Jul/13	54	1.0E-04	1.1E-03	3.3E-04	1.0E+00	1.7E-05	1.3E-03	1.4E+01	7.7E-01	1.0E-05	7.6E-01	1.4E-03	3.0E-01	1.5E+01	1.6E-04	1.3E+01	5.0E-06	3.5E+01	3.3E-01	2.0E-06	6.5E-05	5.7E-04	1.6E-02	5.0E-05	1.3E-03	1.0E-04
Sat Col 15	28/Aug/13	58	1.0E-04	9.2E-04	3.7E-04	9.5E-01	1.6E-05	1.4E-03	1.2E+01	6.9E-01	1.0E-05	6.9E-01	1.2E-03	3.0E-01	1.3E+01	9.8E-05	1.3E+01	5.0E-06	2.9E+01	2.9E-01	2.0E-06	4.1E-05	5.0E-04	1.4E-02	5.0E-05	8.8E-04	1.0E-04
Sat Col 15	26/Sep/13	62	1.0E-04	8.6E-04	2.2E-04	9.1E-01	1.3E-05	1.5E-03	1.1E+01	6.3E-01	1.0E-05	6.9E-01	1.1E-03	3.0E-01	1.2E+01	8.7E-05	1.2E+01	5.0E-06	2.5E+01	2.8E-01	2.0E-06	4.0E-05	5.0E-04	1.3E-02	5.0E-05	9.3E-04	1.0E-04
Sat Col 15	24/Oct/13	66	1.0E-04	7.9E-04	2.4E-04	8.3E-01	1.2E-05	9.3E-04	1.1E+01	6.1E-01	1.0E-05	6.8E-01	1.1E-03	3.0E-01	1.3E+01	9.6E-05	1.2E+01	5.0E-06	2.4E+01	3.0E-01	2.0E-06	2.7E-05	5.2E-04	1.2E-02	5.0E-05	1.0E-03	1.0E-04
Sat Col 15	20/Nov/13	70	1.0E-04	7.5E-04	2.6E-04	8.4E-01	5.5E-05	1.2E-03	1.1E+01	5.9E-01	1.0E-05	7.2E-01	9.7E-04	3.0E-01	1.2E+01	6.7E-05	1.1E+01	5.0E-06	2.1E+01	2.9E-01	2.0E-06	4.3E-05	5.0E-04	1.1E-02	7.9E-05	1.1E-03	1.0E-04
Sat Col 15	18/Dec/13	74	1.0E-04	6.8E-04	2.0E-04	7.6E-01	1.2E-05	1.2E-03	1.1E+01	5.3E-01	1.0E-05	7.5E-01	9.7E-04	3.0E-01	1.2E+01	6.3E-05	1.1E+01	5.0E-06	1.9E+01	3.1E-01	2.0E-06	2.1E-05	5.0E-04	1.0E-02	5.0E-05	7.6E-04	1.0E-04
Sat Col 15	15/Jan/14	78	1.0E-04	6.2E-04	1.7E-04	6.9E-01	1.7E-05	1.0E-03	1.0E+01	5.4E-01	1.0E-05	6.2E-01	8.6E-04	3.0E-01	1.2E+01	6.3E-05	1.2E+01	5.0E-06	1.7E+01	2.5E-01	2.0E-06	1.8E-05	5.0E-04	8.8E-03	5.0E-05	9.2E-04	1.0E-04
Sat Col 15	12/Feb/14	82	1.0E-04	5.5E-04	1.4E-04	6.0E-01	9.1E-06	6.2E-04	9.4E+00	4.9E-01	1.0E-05	7.2E-01	7.8E-04	3.0E-01	1.1E+01	5.1E-05	1.1E+01	5.0E-06	1.6E+01	2.9E-01	2.0E-06	2.2E-05	6.2E-04	8.8E-03	5.0E-05	1.7E-03	1.0E-04
Sat Col 16	1/Mar/13	0	1.0E-04	5.7E-06	1.0E-04	1.3E-02	5.0E-06	5.0E-04	3.6E+00	2.6E-02	1.0E-05	3.7E-02	1.7E-04	1.3E+00	4.9E+01	4.4E-04	2.7E+00	5.0E-06	3.0E+01	1.1E+00	2.0E-06	2.6E-05	5.0E-04	2.9E-05	5.0E-05	5.0E-04	1.0E-04
Sat Col 16	12/Mar/13	1	1.0E-04	8.1E-06	1.0E-04	1.0E-02	5.0E-06	7.2E-04	3.0E+00	1.5E-02	1.0E-05	2.0E-02	1.8E-04	1.3E+00	4.4E+01	3.8E-04	2.8E+00	5.0E-06	3.0E+01	1.1E+00	2.0E-06	2.1E-05	5.0E-04	1.5E-05	5.0E-05	1.5E-03	1.0E-04
Sat Col 16	12/Apr/13	6	1.0E-04	5.8E-06	1.0E-04	2.6E-02	5.0E-06	5.0E-04	2.3E+00	3.0E-02	1.0E-05	5.0E-03	1.3E-04	1.0E+00	3.8E+01	3.4E-04	3.1E+00	5.0E-06	2.7E+01	7.2E-01	2.0E-06	1.0E-05	5.0E-04	1.5E-04	5.0E-05	5.0E-04	1.0E-04
Sat Col 16	7/May/13	10	1.0E-04	5.0E-06	1.0E-04	1.0E-02	5.0E-06	9.6E-04	1.7E+00	2.5E-02	1.0E-05	3.1E-03	6.5E-05	9.3E-01	3.2E+01	2.1E-04	3.4E+00	5.0E-06	2.5E+01	4.9E-01	2.0E-06	1.0E-05	5.0E-04	4.5E-05	5.0E-05	5.0E-04	1.0E-04
Sat Col 16	6/Jun/13	14	1.0E-04	5.0E-06	1.0E-04	9.3E-03	5.0E-06	1.0E-03	1.0E+00	1.4E-02	1.0E-05	1.9E-03	5.0E-05	7.7E-01	2.8E+01	2.8E-04	3.4E+00	5.0E-06	2.0E+01	2.9E-01	2.0E-06	1.0E-05	5.0E-04	1.9E-05	5.0E-05	2.2E-03	1.0E-04
Sat Col 16	4/Jul/13	18	1.0E-04	5.0E-06	1.0E-04	5.7E-03	5.0E-06	5.0E-04	5.2E-01	7.1E-03	1.0E-05	2.8E-03	5.4E-05	6.8E-01	2.0E+01	2.6E-04	3.6E+00	5.0E-06	1.7E+01	1.9E-01	2.0E-06	1.0E-05	5.0E-04	1.9E-05	5.0E-05	5.0E-04	1.0E-04
Sat Col 16	30/Jul/13	22	1.0E-04	5.0E-06	1.0E-04	2.7E-03	5.0E-06	5.0E-04	4.3E-01	6.4E-03	1.0E-05	1.9E-03	6.0E-05	6.8E-01	2.0E+01	2.0E-04	3.8E+00	5.0E-06	1.6E+01	1.7E-01	2.0E-06	1.0E-05	5.0E-04	1.4E-05	5.0E-05	5.0E-04	1.0E-04
Sat Col 16	28/Aug/13	26	1.0E-04	5.0E-06	1.0E-04	3.3E-03	5.0E-06	7.9E-04	4.6E-01	8.5E-03	1.0E-05	1.6E-03	5.0E-05	5.6E-01	1.8E+01	1.7E-04	4.0E+00	5.0E-06	1.4E+01	1.5E-01	2.0E-06	1.0E-05	5.0E-04	2.0E-06	5.0E-05	5.0E-04	1.0E-04
Sat Col 16	26/Sep/13	30	1.0E-04	5.0E-06	1.0E-04	2.4E-03	5.0E-06	1.1E-03	4.3E-01	9.2E-03	1.0E-05	1.5E-03	5.0E-05	3.6E-01	1.7E+01	1.1E-04	3.9E+00	5.0E-06	1.2E+01	1.5E-01	2.7E-06	1.0E-05	5.0E-04	2.0E-05	5.0E-05	5.0E-04	1.0E-04
Sat Col 16	24/Oct/13	34	1.0E-04	6.2E-06	1.0E-04	1.1E-02	5.0E-06	5.9E-04	4.2E-01	9.3E-03	1.0E-05	1.4E-03	5.0E-05	3.0E-01	1.8E+01	1.9E-04	3.9E+00	5.0E-06	1.1E+01	1.4E-01	3.1E-06	1.0E-05	5.0E-04	2.0E-05	5.0E-05	6.4E-04	1.0E-04
Sat Col 16	21/Nov/13	38	1.0E-04	5.0E-06	1.0E-04	1.2E-02	5.0E-06	9.9E-04	4.4E-01	1.3E-02	1.0E-05	1.9E-03	5.0E-05	3.0E-01	1.6E+01	2.3E-04	3.9E+00	5.0E-06	1.0E+01	1.4E-01	9.4E-06	1.0E-05	5.0E-04	5.1E-04	5.4E-05	7.8E-04	1.0E-04
Sat Col 16	18/Dec/13	42	1.0E-04	5.0E-06	1.0E-04	1.3E-02	5.0E-06	9.8E-04	4.9E-01	1.6E-02	1.0E-05	1.8E-03	5.0E-05	3.0E-01	1.7E+01	2.6E-04	3.8E+00	5.0E-06	1.0E+01	1.5E-01	2.0E-06	1.0E-05	5.0E-04	3.4E-04	5.0E-05	5.0E-04	1.0E-04
Sat Col 16	15/Jan/14	46	1.0E-04	5.0E-06	1.0E-04	4.4E-03	5.0E-06	9.0E-04	4.6E-01	1.4E-02	1.0E-05	1.7E-03	5.0E-05	3.0E-01	1.8E+01	1.5E-04	4.1E+00	5.0E-06	9.6E+00	1.4E-01	2.0E-06	1.0E-05	5.0E-04	1.2E-04	5.0E-05	8.9E-04	1.0E-04
Sat Col 16	12/Feb/14	50	1.0E-04	5.0E-06	1.0E-04	5.0E-03	5.0E-06	6.5E-04	4.3E-01	1.3E-02	1.0E-05	1.6E-03	5.0E-05	3.0E-01	1.6E+01	1.1E-04	4.0E+00	5.0E-06	8.9E+00	1.4E-01	2.0E-06	1.0E-05	5.0E-04	2.7E-05	5.0E-05	1.3E-03	1.0E-04
Sat Col 17	1/Mar/13	0	2.0E-04	2.7E-05	2.0E-04	1.1E-01	1.0E-05	1.0E-03	9.4E+00	6.9E-02	1.0E-05	1.8E-01	7.5E-04	2.1E+00	7.4E+01	1.8E-03	1.7E+00	1.0E-05	5.0E+01	2.2E+00	5.4E-06	1.2E-04	1.0E-03	6.7E-05	1.0E-04	1.5E-03	2.0E-04
Sat Col 17	12/Mar/13	1	2.0E-04	2.3E-05	2.0E-04	1.7E-01	1.0E-05	1.0E-03	8.0E+00	7.4E-02	1.0E-05	1.3E-01	1.0E-03	1.8E+00	6.8E+01	8.0E-04	1.8E+00	1.0E-05	4.5E+01	2.0E+00	0.000004	6.3E-05	1.0E-03	3.1E-05	1.0E-04	1.0E-03	2.0E-04
Sat Col 17	11/Apr/13	6	2.0E-04	1.8E-05	3.7E-04	2.6E-01	1.0E-05	1.1E-03	7.4E+00	8.1E-02	1.0E-05	4.8E-02	1.1E-03	1.5E+00	6.2E+01	6.9E-04	2.2E+00	3.9E-05	4.0E+01	1.6E+00	1.1E-04	3.9E-05	1.0E-03	1.4E-05	1.0E-04	1.0E-03	2.0E-04
Sat Col 17	7/May/13	10	1.0E-04	1.0E-05	1.0E-04	1.2E-01	5.0E-06	1.5E-03	6.1E+00	7.7E-02	1.0E-05	1.7E-02	2.4E-04	1.3E+00	6.2E+01	2.8E-04	2.5E+00	5.0E-06	3.9E+01	1.4E+00	2.0E-06	1.0E-05	5.0E-04	1.0E-05	5.0E-05	5.0E-04	1.0E-04
Sat Col 17	6/Jun/13	14	1.0E-04	9.4E-06	1.0E-04	6.5E-02	5.0E-06	1.3E-03	5.1E+00	7.1E-02	1.0E-05	6.0E-03	1.5E-04	1.1E+00	5.4E+01	2.4E-04	2.7E+00	5.0E-06	3.4E+01	1.0E+00	2.0E-06	2.0E-05	5.0E-04	6.6E-06	5.0E-05	2.2E-03	1.0E-04
Sat Col 17	4/Jul/13	18	1.0E-04	7.9E-06	1.0E-04	4.5E-02	5.0E-06	5.0E-04	4.0E+00	5.9E-02	1.0E-05	3.0E-03	1.3E-04	8.2E-01	4.5E+01	1.4E-04	2.9E+00	5.0E-06	2.9E+01	7.7E-01	2.0E-06	1.0E-05	5.0E-04	4.6E-06	5.0E-05	5.0E-04	1.0E-04
Sat Col 17	30/Jul/13	22	1.0E-04	9.7E-06	1.0E-04	2.4E-02	5.0E-06	1.0E-03	3.1E+00	5.0E-02	1.0E-05	2.4E-03	1.5E-04	7.7E-01	4.2E+01	1.1E-04	3.0E+00	7.9E-06	2.6E+01	7.2E-01	3.3E-06	1.4E-05	5.0E-04	4.5E-06	5.0E-05	5.0E-04	1.0E-04
Sat Col 17	28/Aug/13	26	1.0E-04	8.0E-06	1.0E-04	1.4E-02	5.0E-06	1.0E-03	2.3E+00	3.4E-02	1.0E-05	1.5E-03	1.0E-04	6.6E-01	3.3E+01	7.1E-05	3.1E+00	5.0E-06	2.2E+01	4.9E-01	2.0E-06	1.0E-05	5.0E-04	2.7E-06	5.0E-05	5.0E-04	1.0E-04
Sat Col 17	26/Sep/13	30	1.0E-04	7.8E-06	1.0E-04	1.2E-02	5.0E-06	1.1E-03	1.5E+00	2.3E-02	1.0E-05	1.3E-03	5.0E-05	5.8E-01	2.8E+01	6.9E-05	3.1E+00	5.0E-06	2.1E+01	3.6E-01	2.0E-06	1.0E-05	5.0E-04	3.6E-06	5.0E-05	5.0E-04	1.0E-04
Sat Col 17	25/Oct/13	34	1.0E-04	1.5E-05	5.8E-04	1.5E-02	1.1E-05	9.2E-04	4.5E-01	4.7E-03	1.0E-05	9.9E-04	1.0E-04	3.0E-01	1.3E+01	4.0E-05	1.9E+00	5.0E-06	8.1E+00	1.1E-01	2.0E-06	1.0E-05	5.0E-04	4.4E-04	8.1E-05	1.2E-03	1.0E-04
Sat Col 17	20/Nov/13	38	1.0E-04	1.2E-05	1.0E-04	1.7E-03	1.1E-05	8.4E-04	5.6E-01	1.0E-02	1.0E-05	1.4E-03	5.0E-05	3.1E-01	1.7E+01	4.6E-05	3.0E+00	5.0E-06	1.2E+01	1.4E-01	2.0E-06	1.0E-05	5.0E-04	2.7E-05	5.0E-05	7.7E-04	1.0E-04
Sat Col 17	18/Dec/13	42	1.0E-04	5.0E-06	1.0E-04	2.2E-03	5.0E-06	8.0E-04	4.7E-01	8.8E-03	1.0E-05	1.3E-03	5.0E-05	3.0E-01	1.6E+01	1.1E-04	2.9E+00	5.0E-06	1.1E+01	1.3E-01	2.0E-06	1.0E-05	5.0E-04	2.1E-05	5.0E-05	7.9E-03	1.0E-04
Sat Col 17	15/Jan/14	46	1.0E-04	5.0E-06	1.0E-04	2.7E-03	5.0E-06	5.0E-04	4.1E-01	7.5E-03	1.0E-05	1.3E-03	5.0E-05	3.0E-01	1.6E+01	4.0E-05	3.3E+00	5.0E-06	1.1E+01	1.1E-01	2.0E-06	1.0E-05	5.0E-04	2.1E-05	5.0E-05	7.7E-04	1.0E-04
Sat Col 17	12/Feb/14	50	1.0E-04	5.0E-06	1.0E-04	1.0E-03	5.0E-06	5.0E-04	3.7E-01	6.8E-03	1.0E-05	1.3E-03	5.0E-05	3.0E-01	1.5E+01	4.2E-05	3.3E+00	5.0E-06	1.0E+01	1.2E-01	2.0E-06	1.0E-05	5.0E-04	1.1E-05	5.0E-05	1.3E-03	1.0E-04

Col 1
Sample = FB2 +#4 + FB2 -#4 Composite

Date	Cycle	Approxi.	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Cl	F	Br	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Flow Rate	Input	Output		umhos/cm	(pH 4.5)	(pH 8.3)						CaCO3												
		(mL/min)					mgCaCO3/L	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
27-Jan-10	1	0.5	1334	315	4.17	1.5E+03	3.6E+01	1.7E+02	#N/A	4.1E+02	1.9E+02	5.9E-01	1.9E+00	1.2E+02	6.7E+00	2.3E-03	2.6E-03	7.3E-02	1.0E-03	1.0E-05	5.6E-02	1.5E-03	3.3E+01	1.3E-02	2.1E-02	2.8E+00
3-Feb-10	2	0.5	300	260	4.74	8.7E+02	#N/A	3.6E+01	1.0E-01	3.3E+02	4.6E+01	3.7E-01	3.0E-01	4.7E+01	1.8E+00	1.3E-03	2.0E-03	2.3E-02	3.6E-04	1.0E-05	3.2E-02	6.0E-04	1.3E+01	6.6E-03	1.3E-02	1.6E+00
10-Feb-10	3	0.5	300	240	5.35	7.3E+02	#N/A	1.3E+01	2.6E+00	3.0E+02	1.8E+01	1.0E-01	3.0E-01	2.5E+01	3.5E-01	7.0E-04	1.3E-03	2.2E-02	1.5E-04	1.0E-05	2.8E-02	2.7E-04	7.0E+00	2.3E-03	6.0E-03	5.5E-01
17-Feb-10	4	0.5	300	315	5.09	5.6E+02	#N/A	1.3E+01	9.5E-01	2.5E+02	1.0E+01	7.0E-02	3.0E-01	1.8E+01	2.1E-01	6.0E-04	1.2E-03	2.1E-02	1.1E-04	1.0E-05	2.8E-02	2.1E-04	5.2E+00	1.5E-03	4.9E-03	4.2E-01
24-Feb-10	5	0.5	300	150	5.61	5.5E+02				2.3E+02																
3-Mar-10	6	0.5	300	325	5.28	4.9E+02	#N/A	8.6E+00	1.4E+00	2.2E+02	4.2E+00	6.0E-02	3.0E-01	1.1E+01	1.0E-01	5.0E-04	8.0E-04	2.1E-02	7.0E-05	1.0E-05	3.3E-02	1.2E-04	3.1E+00	1.4E-03	2.8E-03	2.5E-01
10-Mar-10	7	0.5	300	295	5.78	4.5E+02				1.7E+02																
17-Mar-10	8	0.5	300	285	5.45	4.4E+02	#N/A	7.2E+00	1.7E+00	1.7E+02	2.9E+00	6.0E-02	3.0E-01	9.8E+00	7.9E-02	4.0E-04	6.0E-04	2.0E-02	7.0E-05	1.0E-05	2.3E-02	1.2E-04	2.8E+00	9.0E-04	2.2E-03	1.9E-01
24-Mar-10	9	0.5	300	285	5.97	4.1E+02				2.0E+02																
31-Mar-10	10	0.5	300	310	5.61	3.6E+02	#N/A	7.5E+00	1.4E+00	1.7E+02	2.1E+00	6.0E-02	3.0E-01	8.9E+00	7.7E-02	3.0E-04	8.0E-04	2.5E-02	7.0E-05	1.0E-05	2.3E-02	1.3E-04	2.6E+00	1.4E-03	2.3E-03	2.3E-01
7-Apr-10	11	0.5	300	295	5.77	3.7E+02				1.8E+02																
14-Apr-10	12	0.5	300	310	5.01	3.4E+02	#N/A	9.0E+00	2.1E-01	1.5E+02	1.4E+00	6.0E-02	3.0E-01	8.2E+00	1.2E-01	4.0E-04	8.0E-04	3.1E-02	8.0E-05	8.0E-05	2.3E-02	9.9E-05	2.4E+00	1.1E-03	2.3E-03	2.6E-01
21-Apr-10	13	0.5	300	335	5.60	3.2E+02				1.5E+02																
28-Apr-10	14	0.5	300	385	5.23	2.7E+02	#N/A	4.6E+00	6.4E-01	1.2E+02	9.0E-01	6.0E-02	3.0E-01	6.6E+00	7.3E-02	2.0E-04	7.0E-04	9.7E-02	5.0E-05	1.0E-05	1.9E-02	7.1E-05	1.9E+00	8.0E-04	1.8E-03	1.8E-01
5-May-10	15	0.5	300	300	5.45	2.9E+02				1.3E+02																
12-May-10	16	0.5	300	320	5.67	2.9E+02	#N/A	6.2E+00	1.2E+00	1.0E+02	9.0E-01	6.0E-02	3.0E-01	6.6E+00	6.4E-02	4.0E-04	8.0E-04	4.8E-02	4.0E-05	1.0E-05	2.2E-02	6.7E-05	1.9E+00	1.2E-03	1.8E-03	1.8E-01
19-May-10	17	0.5	300	300	5.51	2.9E+02				9.1E+01																
26-May-10	18	0.5	300	340	5.71	2.4E+02	#N/A	7.9E+00	2.9E+00	8.1E+01	8.0E-01	6.0E-02	3.0E-01	5.8E+00	4.4E-02	4.0E-04	7.4E-03	5.2E-02	5.0E-05	1.0E-05	2.4E-02	6.0E-05	1.7E+00	1.1E-03	2.1E-03	1.7E-01
2-Jun-10	19	0.5	300	340	5.92	2.4E+02				7.6E+01																
9-Jun-10	20	0.5	300	310	5.83	2.5E+02	#N/A	6.1E+00	2.3E+00	8.8E+01	7.0E-01	6.0E-02	3.0E-01	6.9E+00	5.5E-02	2.0E-04	6.0E-04	5.8E-02	4.0E-05	1.0E-05	2.3E-02	6.8E-05	2.0E+00	1.3E-03	1.9E-03	2.2E-01
16-Jun-10	21	0.5	300	290	5.81	2.5E+02				7.5E+01																
23-Jun-10	22	0.5	300	285	6.01	2.5E+02	#N/A	6.0E+00	1.7E+00	8.6E+01	7.0E-01	6.0E-02	3.0E-01	6.7E+00	5.2E-02	5.0E-04	9.0E-04	3.3E-02	5.0E-05	2.0E-05	2.4E-02	7.6E-05	1.9E+00	1.0E-03	1.9E-03	2.7E-01
30-Jun-10	23	0.5	300	320	5.41	2.2E+02				8.5E+01																
7-Jul-10	24	0.5	300	325	5.67	2.2E+02	#N/A	6.2E+00	1.2E+00	7.7E+01	5.0E-01	6.0E-02	3.0E-01	5.5E+00	4.6E-02	3.0E-04	7.0E-04	3.8E-02	4.0E-05	1.0E-05	1.9E-02	6.7E-05	1.5E+00	1.4E-03	1.8E-03	2.1E-01
14-Jul-10	25	0.5	300	305	6.11	2.1E+02				4.2E+01																
21-Jul-10	26	0.5	300	300	5.81	2.2E+02	#N/A	7.2E+00	2.4E+00	7.5E+01	5.0E-01	6.0E-02	3.0E-01	6.0E+00	5.2E-02	2.0E-04	7.0E-04	3.3E-02	5.0E-05	1.0E-05	2.0E-02	6.1E-05	1.7E+00	1.0E-03	1.9E-03	2.2E-01
28-Jul-10	27	0.5	300	290	5.91	2.1E+02				7.7E+01																
4-Aug-10	28	0.5	300	290	6.16	2.0E+02	#N/A	6.9E+00	1.6E+00	6.6E+01	5.0E-01	6.0E-02	3.0E-01	6.5E+00	4.8E-02	2.0E-04	5.0E-04	3.2E-02	4.0E-05	1.0E-05	5.2E-02	5.4E-05	1.9E+00	1.2E-03	1.8E-03	2.0E-01
11-Aug-10	29	0.5	300	295	6.79	2.0E+02				7.8E+01																
18-Aug-10	30	0.5	300	300	6.01	1.9E+02	#N/A	8.2E+00	3.1E+00	8.2E+01	5.0E-01	6.0E-02	3.0E-01	6.3E+00	4.7E-02	2.0E-04	7.0E-04	3.3E-02	5.0E-05	1.0E-05	2.4E-02	6.5E-05	1.8E+00	9.0E-04	1.9E-03	2.2E-01
25-Aug-10	31	0.5	300	315	6.31	1.7E+02				6.7E+01																
1-Sep-10	32	0.5	300	305	6.21	1.6E+02	#N/A	6.6E+00	2.0E+00	6.6E+01	4.0E-01	6.0E-02	3.0E-01	6.4E+00	4.4E-02	3.0E-04	4.0E-04	3.4E-02	4.0E-05	1.0E-05	1.7E-02	6.5E-05	1.9E+00	9.0E-04	1.7E-03	1.8E-01
8-Sep-10	33	0.5	300	305	6.52	1.8E+02				6.2E+01																
15-Sep-10	34	0.5	300	315	5.67	1.5E+02	#N/A	5.7E+00	9.6E-01	6.5E+01	4.0E-01	6.0E-02	3.0E-01	6.6E+00	4.7E-02	7.0E-04	5.0E-04	3.2E-02	5.0E-05	3.0E-05	1.7E-02	6.3E-05	1.9E+00	8.0E-04	1.8E-03	2.0E-01
22-Sep-10	35	0.5	300	285	6.40	1.3E+02				7.2E+01																
29-Sep-10	36	0.5	300	325	5.98	1.2E+02	#N/A	5.6E+00	1.4E+00	5.7E+01	4.0E-01	6.0E-02	3.0E-01	6.5E+00	4.5E-02	8.4E-03	9.0E-04	3.5E-02	4.0E-05	1.0E-05	1.9E-02	2.1E-04	1.9E+00	7.0E-04	2.7E-03	2.3E-01
6-Oct-10	37	0.5	300	300	6.24	1.6E+02				6.4E+01																
13-Oct-10	38	0.5	300	295	5.81	1.6E+02	#N/A	6.7E+00	1.2E+00	6.0E+01	4.0E-01	6.0E-02	3.0E-01	1.1E+01	4.1E-02	6.0E-04	3.0E-04	3.8E-02	5.0E-05	5.0E-05	2.0E-02	7.3E-05	3.3E+00	7.0E-04	2.0E-03	2.3E-01
20-Oct-10	39	0.5	300	275	6.26	1.5E+02				6.1E+01																
27-Oct-10	40	0.5	300	350	6.02	1.4E+02	#N/A	4.1E+00	1.2E+00	4.5E+01	3.0E-01	6.0E-02	3.0E-01	6.1E+00	4.1E-02	2.0E-04	5.0E-04	3.6E-02	4.0E-05	1.0E-05	1.7E-02	7.4E-05	1.8E+00	6.0E-04	2.2E-03	2.3E-01
3-Nov-10	41	0.5	300	270	6.33	1.5E+02																				
10-Nov-10	42	0.5	300	360	5.61	1.4E+02																				
17-Nov-10	43	0.5	300	355	6.51	1.5E+02																				
24-Nov-10	44	0.5	300	340	5.95	1.2E+02	#N/A	4.7E+00	1.1E+00	4.4E+01	4.0E-01	6.0E-02	3.0E-01	6.5E+00	3.8E-02	2.0E-04	6.0E-04	4.1E-02	5.0E-05	1.0E-05	1.3E-02	7.5E-05	1.9E+00	5.0E-04	2.2E-03	2.7E-01
1-Dec-10	45	0.5	300	320	6.59	1.2E+02																				
8-Dec-10	46	0.5	300	335	5.79	1.1E+02																				
15-Dec-10	47	0.5	300	315	6.41	1.1E+02																				
22-Dec-10	48	0.5	300	325	6.47	1.1E+02	#N/A	6.3E+00	2.5E+00	4.3E+01	3.0E-01	6.0E-02	3.0E-01	8.0E+00	4.4E-02	1.9E-03	5.0E-04	4.4E-02	5.0E-05	1.0E-05	1.6E-02	1.2E-04	2.3E+00	9.0E-04	2.5E-03	2.7E-01
29-Dec-10	49	0.5	300	345	6.06	8.9E+01																				
5-Jan-11	50	0.5	300	325	6.51	8.8E+01																				
12-Jan-11	51	0.5	300	310	6.41	9.7E+01																				
19-Jan-11	52	0.5	300	340	6.00	8.5E+01	#N/A	6.1E+00	2.3E+00	3.2E+01	3.0E-01	6.0E-02	3.0E-01	8.0E+00	4.8E-02	4.0E-04	3.0E-04	5.0E-02	5.0E-05	1.0E-05	1.2E-02	7.6E-05	2.3E+00	5.0E-04	2.3E-03	2.5E-01
26-Jan-11	53	0.5	300	330	6.23	8.4E+01																				
2-Feb-11	54	0.5	300	385	5.91	6.9E+01																				
9-Feb-11	55	0.5	300	360	6.07	7.5E+01																				

Col 1

Sample = FB2 +#4 + FB2 -#4 Composite

Date	Cycle	Approxi.	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Cl	F	Br	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Flow Rate	Input	Output		umhos/cm	(pH 4.5)	(pH 8.3)						CaCO3												
		(mL/min)					mgCaCO3/L	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
16-Feb-11	56	0.5	300	375	6.17	7.3E+01	#N/A	4.1E+00	1.4E+00	2.2E+01	2.0E-01	6.0E-02	3.0E-01	8.3E+00	4.5E-02	2.0E-04	4.0E-04	4.8E-02	6.0E-05	1.0E-05	2.4E-02	1.0E-04	2.4E+00	6.0E-04	2.5E-03	2.7E-01
23-Feb-11	57	0.5	300	430	6.23	8.5E+01																				
2-Mar-11	58	0.5	300	415	5.69	7.9E+01																				
9-Mar-11	59	0.5	300	425	6.07	7.6E+01																				
16-Mar-11	60	0.5	300	325	6.10	7.4E+01	#N/A	4.8E+00	1.5E+00	2.0E+01	2.0E-01	6.0E-02	3.0E-01	9.8E+00	5.2E-02	7.0E-04	2.0E-04	7.3E-02	7.0E-05	1.0E-05	8.3E-03	1.1E-04	2.9E+00	5.0E-04	2.8E-03	3.2E-01
23-Mar-11	61	0.5	300	405	6.01	7.9E+01																				
30-Mar-11	62	0.5	300	385	6.61	7.9E+01																				
6-Apr-11	63	0.5	300	360	6.27	7.7E+01																				
13-Apr-11	64	0.5	300	300	6.01	8.7E+01	#N/A	5.1E+00	1.3E+00	2.7E+01	2.0E-01	6.0E-02	3.0E-01	1.3E+01	8.4E-02	2.0E-04	2.0E-04	8.2E-02	8.0E-05	1.0E-05	1.0E-02	1.3E-04	3.7E+00	5.0E-04	4.2E-03	4.5E-01
20-Apr-11	65	0.5	300	300	6.51	9.2E+01																				
27-Apr-11	66	0.5	300	340	6.20	8.7E+01																				
4-May-11	67	0.5	300	305	6.12	9.4E+01																				
11-May-11	68	0.5	300	325	5.92	9.5E+01	#N/A	5.5E+00	1.2E+00	2.7E+01	2.0E-01	6.0E-02	3.0E-01	1.6E+01	1.0E-01	2.0E-04	6.0E-04	7.7E-02	1.2E-04	1.0E-05	1.1E-02	1.7E-04	4.7E+00	5.0E-04	5.7E-03	5.7E-01
18-May-11	69	0.5	300	300	6.13	1.1E+02																				
25-May-11	70	0.5	300	320	6.41	9.8E+01																				
1-Jun-11	71	0.5	300	295	6.24	1.0E+02																				
8-Jun-11	72	0.5	300	325	5.79	1.1E+02	#N/A	6.3E+00	1.0E+00	3.5E+01	2.0E-01	6.0E-02	3.0E-01	1.9E+01	1.4E-01	3.0E-04	4.0E-04	6.9E-02	1.3E-04	5.0E-05	1.0E-02	2.1E-04	5.4E+00	5.0E-04	6.2E-03	6.4E-01
15-Jun-11	73	0.5	300	305	6.21	1.0E+02																				
22-Jun-11	74	0.5	300	345	6.06	1.0E+02																				
29-Jun-11	75	0.5	300	310	5.91	1.1E+02																				
6-Jul-11	76	0.5	300	325	5.71	1.1E+02	#N/A	7.1E+00	1.1E+00	4.0E+01	2.0E-01	6.0E-02	3.0E-01	2.3E+01	1.5E-01	2.0E-04	3.0E-04	7.2E-02	1.3E-04	1.0E-05	1.1E-02	2.5E-04	6.5E+00	5.0E-04	7.5E-03	7.9E-01
13-Jul-11	77	0.5	300	295	5.95	1.1E+02																				
20-Jul-11	78	0.5	300	335	5.67	1.1E+02																				
27-Jul-11	79	0.5	300	320	5.69	1.1E+02																				
3-Aug-11	80	0.5	300	200	6.02	1.1E+02	#N/A	8.9E+00	1.8E+00	4.1E+01	2.0E-01	7.0E-02	3.0E-01	2.4E+01	1.7E-01	2.0E-04	4.0E-04	6.1E-02	1.4E-04	1.0E-05	1.0E-02	2.5E-04	6.8E+00	5.0E-04	7.6E-03	7.4E-01
10-Aug-11	81	0.5	300	330	5.95	1.1E+02																				
17-Aug-11	82	0.5	300	315	5.92	1.1E+02																				
24-Aug-11	83	0.5	300	300	6.07	1.1E+02																				
31-Aug-11	84	0.5	300	340	5.78	1.1E+02	#N/A	9.1E+00	1.7E+00	3.8E+01	2.0E-01	6.0E-02	3.0E-01	2.3E+01	1.5E-01	3.0E-04	7.0E-04	5.4E-02	1.4E-04	1.0E-05	1.2E-02	3.5E-04	6.5E+00	8.0E-04	8.9E-03	8.1E-01
7-Sep-11	85	0.5	300	335	5.98	1.1E+02																				
14-Sep-11	86	0.5	300	315	5.92	1.1E+02																				
21-Sep-11	87	0.5	300	315	5.77	1.1E+02																				
28-Sep-11	88	0.5	300	295	5.83	1.2E+02	#N/A	7.3E+00	1.6E+00	4.1E+01	3.0E-01	7.0E-01	3.0E-01	2.5E+01	1.6E-01	2.0E-04	4.0E-04	5.1E-02	1.5E-04	1.0E-04	8.4E-03	2.6E-04	7.1E+00	1.2E-03	8.1E-03	8.1E-01
5-Oct-11	89	0.5	300	350	5.81	1.0E+02																				
12-Oct-11	90	0.5	300	300	6.06	1.2E+02																				
19-Oct-11	91	0.5	300	305	5.68	1.2E+02																				
26-Oct-11	92	0.5	300	310	5.59	1.2E+02	#N/A	6.3E+00	8.6E-01	4.3E+01	4.0E-01	9.0E-02	3.0E-01	2.6E+01	1.8E-01	2.0E-04	5.0E-04	5.6E-02	1.6E-04	5.0E-05	1.0E-02	2.8E-04	7.5E+00	1.5E-03	8.2E-03	8.9E-01
2-Nov-11	93	0.5	300	305	5.85	1.2E+02																				
9-Nov-11	94	0.5	300	315	5.90	1.2E+02																				
16-Nov-11	95	0.5	300	310	5.73	1.2E+02																				
23-Nov-11	96	0.5	300	330	5.73	1.2E+02	#N/A	6.3E+00	1.4E+00	3.8E+01	2.0E-01	2.1E-01	3.0E-01	2.4E+01	1.8E-01	8.0E-04	4.0E-04	4.8E-02	1.6E-04	1.0E-05	1.4E-02	2.9E-04	6.9E+00	5.0E-04	7.6E-03	7.7E-01
30-Nov-11	97	0.5	300	330	5.82	1.1E+02																				
7-Dec-11	98	0.5	300	330	5.98	1.2E+02																				
14-Dec-11	99	0.5	300	325	5.81	1.1E+02																				
21-Dec-11	100	0.5	300	325	5.68	1.1E+02	#N/A	7.1E+00	1.0E+00	4.0E+01	2.0E-01	6.0E-02	3.0E-01	2.5E+01	1.9E-01	2.0E-04	4.0E-04	4.9E-02	1.3E-04	1.0E-05	9.6E-03	2.6E-04	7.1E+00	5.0E-04	7.9E-03	8.4E-01
28-Dec-11	101	0.5	300	330	5.68	1.1E+02																				
4-Jan-12	102	0.5	300	295	5.99	1.1E+02																				
11-Jan-12	103	0.5	300	310	5.42	1.2E+02																				
18-Jan-12	104	0.5	300	340	5.31	1.0E+02	#N/A	7.1E+00	1.0E-01	4.1E+01	2.0E-01	7.0E-02	3.0E-01	2.4E+01	1.8E-01	2.0E-04	6.0E-04	4.5E-02	1.6E-04	1.0E-05	7.4E-03	2.5E-04	7.0E+00	5.0E-04	7.4E-03	7.6E-01
25-Jan-12	105	0.5	300	310	5.32	1.0E+02																				
1-Feb-12	106	0.5	300	350	5.27	1.1E+02																				
8-Feb-12	107	0.5	300	305	5.76	1.2E+02																				
15-Feb-12	108	0.5	300	300	5.01	1.2E+02	#N/A	1.0E+01	1.0E-01	4.4E+01	2.0E-01	8.0E-02	3.0E-01	2.7E+01	1.7E-01	6.0E-04	1.5E-03	4.6E-02	1.5E-04	1.0E-05	8.3E-03	2.8E-04	7.8E+00	5.0E-04	8.3E-03	9.1E-01
22-Feb-12	109	0.5	300	305	5.48	1.2E+02																				
29-Feb-12	110	0.5	300	285	5.25	1.1E+02																				
7-Mar-12	111	0.5	300	340	5.77	1.1E+02																				
14-Mar-12	112	0.5	300	300	5.13	1.1E+02	#N/A	9.2E+00	1.5E-01	4.3E+01	2.0E-01	8.0E-02	3.0E-01	2.7E+01	1.7E-01	2.0E-04	4.0E-04	4.8E-02	1.6E-04	1.2E-04	7.2E-03	2.7E-04	7.7E+00	5.0E-04	8.3E-03	8.6E-01
21-Mar-12	113	0.5	300	315	5.42	1.1E+02																				
28-Mar-12	114	0.5	300	300	5.25	1.1E+02																				
4-Apr-12	115	0.5	300	295	5.32	1.2E+02																				

Col 1

Sample = FB2 +#4 + FB2 -#4 Composite

Date	Cycle	Approxi.	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Cl	F	Br	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Flow Rate	Input	Output		umhos/cm	(pH 4.5)	(pH 8.3)						CaCO3												
		(mL/min)					mgCaCO3/L	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
11-Apr-12	116	0.5	300	300	5.01	1.1E+02	#N/A	9.3E+00	1.0E-01	4.6E+01	2.0E-01	8.0E-02	3.0E-01	2.6E+01	2.6E-01	2.0E-04	1.0E-03	4.7E-02	1.5E-04	1.0E-05	9.5E-03	1.3E-04	7.4E+00	5.0E-04	9.7E-03	1.1E+00
18-Apr-12	117	0.5	300	305	5.30	1.1E+02																				
25-Apr-12	118	0.5	300	300	5.21	1.2E+02																				
2-May-12	119	0.5	300	295	4.14	1.3E+02																				
9-May-12	120	0.5	300	335	5.18	1.1E+02	#N/A	9.6E+00	1.4E-01	4.1E+01	2.0E-01	7.0E-02	3.0E-01	2.4E+01	1.7E-01	2.0E-04	3.0E-04	4.3E-02	1.6E-04	1.0E-05	9.3E-03	2.3E-04	7.0E+00	5.0E-04	7.6E-03	7.7E-01
16-May-12	121	0.5	300	350	5.31	1.2E+02																				
23-May-12	122	0.5	300	335	5.24	1.0E+02																				
30-May-12	123	0.5	300	360	5.50	9.9E+01																				
6-Jun-12	124	0.5	300	320	5.26	1.1E+02	#N/A	9.5E+00	7.3E-01	3.4E+01	4.0E-01	7.0E-02	3.0E-01	2.6E+01	2.1E-01	2.0E-04	2.0E-04	5.0E-02	1.9E-04	1.0E-05	1.4E-02	2.4E-04	7.4E+00	5.0E-04	7.6E-03	7.7E-01
13-Jun-12	125	0.5	300	320	5.29	1.1E+02																				
20-Jun-12	126	0.5	300	315	5.33	1.1E+02																				
27-Jun-12	127	0.5	300	305	5.32	1.1E+02																				
4-Jul-12	128	0.5	300	300	5.30	1.1E+02	#N/A	8.1E+00	5.7E-01	3.9E+01	3.0E-01	9.0E-02	3.0E-01	2.5E+01	2.1E-01	2.0E-04	3.0E-04	5.0E-02	1.8E-04	1.0E-05	8.9E-03	2.8E-04	7.2E+00	5.0E-04	8.0E-03	8.5E-01
11-Jul-12	129	0.5	300	300	5.24	1.1E+02																				
18-Jul-12	130	0.5	300	335	5.20	1.0E+02																				
25-Jul-12	131	0.5	300	300	4.98	1.1E+02																				
1-Aug-12	132	0.5	300	300	5.17	1.1E+02	#N/A	8.9E+00	3.7E-01	3.5E+01	2.0E-01	7.0E-02	3.0E-01	2.5E+01	2.4E-01	2.0E-04	7.0E-04	5.8E-02	1.6E-04	1.0E-05	7.9E-03	2.6E-04	7.3E+00	5.0E-04	8.0E-03	7.6E-01
8-Aug-12	133	0.5	300	295	5.38	1.1E+02																				
15-Aug-12	134	0.5	300	325	5.22	1.1E+02																				
22-Aug-12	135	0.5	300	295	5.48	9.7E+01																				
29-Aug-12	136	0.5	300	355	5.13	1.0E+02	#N/A	1.1E+01	2.0E-01	3.6E+01	2.0E-01	8.0E-02	3.0E-01	2.4E+01	2.8E-01	2.0E-04	2.0E-04	5.4E-02	1.6E-04	1.0E-05	6.4E-03	2.5E-04	6.9E+00	5.0E-04	8.1E-03	8.5E-01
5-Sep-12	137	0.5	300	355	5.17	1.4E+02																				
12-Sep-12	138	0.5	300	340	5.16	1.0E+02																				
19-Sep-12	139	0.5	300	335	5.26	1.0E+02																				
26-Sep-12	140	0.5	300	320	5.17	1.0E+02	#N/A	7.7E+00	5.0E-01	4.1E+01	2.0E-01	8.0E-02	3.0E-01	2.4E+01	2.5E-01	2.0E-04	4.0E-04	4.7E-02	6.0E-05	1.0E-05	7.1E-03	4.1E-04	7.0E+00	5.0E-04	8.1E-03	8.5E-01
3-Oct-12	141	0.5	300	355	5.31	1.0E+02																				
10-Oct-12	142	0.5	300	335	5.09	9.5E+01																				
17-Oct-12	143	0.5	300	315	5.39	1.2E+02																				
24-Oct-12	144	0.5	300	310	5.24	1.1E+02	#N/A	1.0E+01	8.2E-01	4.1E+01	2.0E-01	7.0E-02	3.0E-01	2.5E+01	2.4E-01	2.0E-04	2.0E-04	4.7E-02	1.8E-04	1.0E-05	9.1E-03	3.3E-04	7.1E+00	5.0E-04	7.9E-03	8.8E-01
31-Oct-12	145	0.5	300	340	5.39	1.2E+02																				
7-Nov-12	146	0.5	300	360	4.81	8.7E+01																				
14-Nov-12	147	0.5	300	300	5.30	1.1E+02																				
21-Nov-12	148	0.5	300	250	5.14	1.1E+02	#N/A	9.9E+00	5.7E-01	3.4E+01	2.0E-01	1.2E-01	3.0E-01	2.7E+01	2.0E-01	2.0E-04	1.0E-03	5.2E-02	1.9E-04	1.0E-05	6.1E-03	4.1E-04	7.9E+00	5.0E-04	9.2E-03	9.2E-01
28-Nov-12	149	0.5	300	285	5.61	1.3E+02																				
5-Dec-12	150	0.5	300	315	5.56	1.1E+02																				
12-Dec-12	151	0.5	300	275	4.82	1.1E+02																				
19-Dec-12	152	0.5	300	285	5.01	1.0E+02	#N/A	8.2E+00	1.0E-01	3.8E+01	2.0E-01	9.0E-02	3.0E-01	2.5E+01	1.8E-01	2.0E-04	4.0E-04	5.0E-02	1.8E-04	1.0E-05	7.2E-03	2.8E-04	7.3E+00	5.0E-04	8.8E-03	8.4E-01
26-Dec-12	153	0.5	300	305	5.91	1.1E+02																				
2-Jan-13	154	0.5	300	300	5.01	1.0E+02																				
9-Jan-13	155	0.5	300	270	6.01	1.1E+02																				
16-Jan-13	156	0.5	300	310	5.33	1.1E+02	#N/A	7.1E+00	7.9E-01	4.2E+01	2.0E-01	7.0E-02	3.0E-01	2.5E+01	2.0E-01	2.0E-04	6.0E-04	5.1E-02	2.0E-04	1.0E-05	8.3E-03	2.9E-04	7.2E+00	5.0E-04	8.5E-03	8.8E-01
23-Jan-13	157	0.5	300	305	5.80	1.1E+02																				
30-Jan-13	158	0.5	300	290	4.79	1.0E+02																				
6-Feb-13	159	0.5	300	300	5.58	1.1E+02																				
13-Feb-13	160	0.5	300	295	6.00	1.0E+02	#N/A	1.3E+01	2.4E+00	4.0E+01	2.0E-01	8.0E-02	3.0E-01	2.5E+01	2.1E-01	2.0E-04	4.0E-04	4.6E-02	2.1E-04	1.0E-05	8.7E-03	2.8E-04	7.0E+00	5.0E-04	8.8E-03	9.7E-01
20-Feb-13	161	0.5	300	265	5.33	1.1E+02																				
27-Feb-13	162	0.5	300	335	5.15	1.0E+02																				
6-Mar-13	163	0.5	300	290	5.45	1.1E+02																				
13-Mar-13	164	0.5	300	295	4.71	1.0E+02	#N/A	1.1E+01	4.1E-01	3.4E+01	2.0E-01	8.0E-02	3.0E-01	2.6E+01	1.8E-01	2.0E-04	3.0E-04	5.4E-02	1.8E-04	7.0E-05	6.6E-03	2.6E-04	7.4E+00	5.0E-04	8.3E-03	9.4E-01
20-Mar-13	165	0.5	300	270	4.70	1.0E+02																				

Col 1

Sample = FB2 +#4 + FB2 -#4 Composite

Date	Cycle	Approxi.	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Cl	F	Br	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Flow Rate	Input	Output		umhos/cm	(pH 4.5)	(pH 8.3)						CaCO3												
		(mL/min)					mgCaCO3/L	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
27-Mar-13	166	0.5	300	315	5.34	9.7E+01																				
3-Apr-13	167	0.5	300	295	4.91	1.0E+02																				
10-Apr-13	168	0.5	300	305	4.69	1.0E+02	#N/A	1.1E+01	1.0E-01	4.4E+01	2.0E-01	8.0E-02	3.0E-01	2.4E+01	1.9E-01	2.0E-04	5.0E-04	4.6E-02	1.6E-04	1.0E-05	8.6E-03	3.0E-04	6.8E+00	6.0E-04	8.3E-03	8.1E-01
17-Apr-13	169	0.5	300	300	5.07	9.9E+01																				
24-Apr-13	170	0.5	300	295	4.81	1.0E+02																				
1-May-13	171	0.5	300	300	4.96	1.0E+02																				
8-May-13	172	0.5	300	295	5.17	9.7E+01	#N/A	1.4E+01	1.9E+00	4.3E+01	2.0E-01	< 0.06	3.0E-01	2.4E+01	1.6E-01	2.0E-04	2.0E-04	4.6E-02	1.7E-04	1.0E-05	6.5E-03	2.5E-04	7.0E+00	5.0E-04	7.1E-03	7.2E-01
15-May-13	173	0.5	300	300	4.90	8.9E+01																				
22-May-13	174	0.5	300	300	5.04	9.4E+01																				
29-May-13	175	0.5	300	295	5.10	1.0E+02																				
5-Jun-13	176	0.5	300	300	4.87	1.0E+02	#N/A	1.2E+01	1.0E-01	3.9E+01	2.0E-01	7.0E-02	3.0E-01	2.5E+01	2.0E-01	2.0E-04	4.0E-04	5.1E-02	1.6E-04	1.0E-05	9.0E-03	2.7E-04	7.2E+00	5.0E-04	8.5E-03	8.3E-01
12-Jun-13	177	0.5	300	300	4.45	9.5E+01																				
19-Jun-13	178	0.5	300	300	5.24	1.0E+02																				
26-Jun-13	179	0.5	300	290	5.15	1.0E+02																				
3-Jul-13	180	0.5	300	300	5.08	1.0E+02	#N/A	1.2E+01	2.5E-01	3.6E+01	3.0E-01	7.0E-02	3.0E-01	2.4E+01	1.8E-01	2.0E-04	2.0E-04	4.7E-02	1.8E-04	1.0E-05	8.5E-03	2.4E-04	6.8E+00	5.0E-04	7.4E-03	7.5E-01
10-Jul-13	181	0.5	300	295	5.77	9.6E+01																				
17-Jul-13	182	0.5	300	295	5.07	9.9E+01																				
24-Jul-13	183	0.5	300	310	5.79	9.8E+01																				
31-Jul-13	184	0.5	300	300	5.20	1.0E+02	#N/A	1.1E+01	1.1E+00	3.2E+01	2.0E-01	7.0E-02	3.0E-01	2.4E+01	1.8E-01	2.0E-04	4.0E-04	4.7E-02	1.8E-04	1.0E-05	9.2E-03	3.0E-04	7.0E+00	5.0E-04	7.8E-03	8.0E-01
7-Aug-13	185	0.5	300	300	5.77	9.8E+01																				
14-Aug-13	186	0.5	300	295	5.00	1.0E+02																				
21-Aug-13	187	0.5	300	300	5.59	1.0E+02																				
28-Aug-13	188	0.5	300	300	4.99	9.3E+01	#N/A	8.0E+00	1.0E-01	3.2E+01	2.0E-01	< 0.06	3.0E-01	2.3E+01	1.9E-01	2.0E-04	6.0E-04	5.0E-02	2.1E-04	1.0E-05	1.1E-02	2.5E-04	6.8E+00	5.0E-04	7.6E-03	7.5E-01
4-Sep-13	189	0.5	300	300	5.43	9.2E+01																				
11-Sep-13	190	0.5	300	295	4.94	9.2E+01																				
18-Sep-13	191	0.5	300	300	5.52	9.6E+01																				
25-Sep-13	192	0.5	300	290	4.74	9.9E+01	#N/A	1.1E+01	3.3E-01	3.2E+01	2.0E-01	7.0E-02	3.0E-01	2.3E+01	1.7E-01	2.0E-04	4.0E-04	5.5E-02	1.8E-04	1.0E-05	1.2E-02	2.4E-04	6.7E+00	5.0E-04	7.8E-03	8.1E-01
2-Oct-13	193	0.5	300	300	4.85	9.7E+01																				
9-Oct-13	194	0.5	300	300	4.90	9.5E+01																				
16-Oct-13	195	0.5	300	305	4.68	9.4E+01																				
23-Oct-13	196	0.5	300	305	4.79	9.6E+01	#N/A	8.7E+00	1.0E-01	3.4E+01	2.0E-01	7.0E-02	3.0E-01	2.2E+01	1.5E-01	2.0E-04	4.0E-04	5.9E-02	1.9E-04	1.0E-05	1.3E-02	2.5E-04	6.5E+00	5.0E-04	7.8E-03	8.5E-01
30-Oct-13	197	0.5	300	295	4.74	9.6E+01																				
6-Nov-13	198	0.5	300	305	4.77	9.4E+01																				
13-Nov-13	199	0.5	300	305	5.12	9.4E+01																				
20-Nov-13	200	0.5	300	295	4.91	9.5E+01	#N/A	6.3E+00	1.0E-01	2.8E+01	2.0E-01	6.0E-02	3.0E-01	2.3E+01	1.8E-01	2.0E-04	2.0E-04	5.6E-02	1.9E-04	1.0E-05	1.5E-02	2.6E-04	6.6E+00	5.0E-04	1.0E-02	8.1E-01
27-Nov-13	201	0.5	300	305	4.82	9.3E+01																				
4-Dec-13	202	0.5	300	300	4.97	9.1E+01																				
11-Dec-13	203	0.5	300	300	4.90	8.8E+01																				
18-Dec-13	204	0.5	300	295	4.96	8.7E+01	#N/A	8.1E+00	1.0E-01	2.5E+01	2.0E-01	8.0E-02	3.0E-01	2.3E+01	1.6E-01	2.0E-04	2.0E-04	5.5E-02	1.7E-04	1.0E-05	1.6E-02	2.4E-04	6.6E+00	5.0E-04	7.3E-03	7.8E-01
25-Dec-13	205	0.5	300	300	5.31	8.9E+01																				
1-Jan-14	206	0.5	300	295	5.07	8.8E+01																				
8-Jan-14	207	0.5	300	300	4.90	9.2E+01																				
15-Jan-14	208	0.5	300	305	5.14	9.2E+01	#N/A	8.0E+00	1.0E-01	2.7E+01	2.0E-01	6.0E-02	3.0E-01	2.4E+01	2.0E-01	2.0E-04	2.0E-04	5.4E-02	1.9E-04	1.0E-05	9.6E-03	7.4E-04	6.9E+00	5.0E-04	7.7E-03	7.6E-01
22-Jan-14	209	0.5	300	300	4.90	9.4E+01																				
29-Jan-14	210	0.5	300	295	5.04	8.7E+01																				
5-Feb-14	211	0.5	300	300	5.12	8.8E+01																				
12-Feb-14	212	0.5	300	295	5.06	8.4E+01	#N/A	6.3E+00	1.0E-01	2.5E+01	2.0E-01	6.0E-02	3.0E-01	2.2E+01	1.5E-01	2.0E-04	2.0E-04	5.3E-02	1.7E-04	1.0E-05	8.8E-03	2.3E-04	6.2E+00	5.0E-04	7.6E-03	7.6E-01
19-Feb-14	213	0.5	300	295	5.19	8.8E+01																				
26-Feb-14	214	0.5	300	300	4.94	9.4E+01	#N/A	9.0E+00	1.0E+00	2.5E+01	2.0E-01	6.0E-02	3.0E-01	2.2E+01	1.5E-01	2.0E-04	2.0E-04	5.3E-02	1.5E-04	1.0E-05	7.1E-03	2.2E-04	6.4E+00	5.0E-04	6.8E-03	7.0E-01

Col 1
Sample = FB2 +#4 + FB2 -#4 Composite

Date	Cycle No.	Approxi. Flow Rate (mL/min)	Fe mg/L	Pb mg/L	Li mg/L	Mg mg/L	Mn mg/L	Hg ug/L	Mo mg/L	Ni mg/L	P mg/L	K mg/L	Se mg/L	Si mg/L	Ag mg/L	Na mg/L	Sr mg/L	S mg/L	Tl mg/L	Sn mg/L	Ti mg/L	U mg/L	V mg/L	Zn mg/L	Zr mg/L	Major Anions	Major Cations	Diff	Diff (%)
27-Jan-10	1	0.5	1.5E+00	9.8E-04	1.9E-02	8.6E+00	7.5E-01	4.4E-01	7.3E-02	1.1E-02	1.4E-01	1.7E+01	1.2E-02	4.2E+01	9.0E-04	2.5E+02	2.5E-01	1.3E+02	4.0E-04	3.0E-05	3.8E-03	1.8E-02	1.1E-03	1.3E-01	1.0E-03	1.4E+01	1.5E+01	6.5E-01	2.3E-02
3-Feb-10	2	0.5	3.8E-01	3.4E-04	9.0E-03	3.2E+00	3.4E-01	3.8E-01	4.3E-02	5.6E-03	2.0E-02	9.6E+00	1.2E-02	3.5E+01	2.0E-05	1.7E+02	9.6E-02	1.0E+02	3.0E-04	6.0E-04	1.9E-03	9.1E-03	5.3E-04	7.4E-02	4.3E-04	8.1E+00	8.9E+00	8.2E-01	4.8E-02
10-Feb-10	3	0.5	1.6E-01	1.0E-04	6.0E-03	1.7E+00	1.9E-01	1.0E-02	2.7E-02	2.7E-03	3.0E-02	7.6E+00	8.1E-03	2.8E+01	2.0E-05	1.2E+02	5.5E-02	9.7E+01	2.0E-04	2.4E-04	1.8E-03	2.8E-03	2.9E-04	3.5E-02	1.1E-04	6.8E+00	6.1E+00	-7.5E-01	-5.8E-02
17-Feb-10	4	0.5	1.1E-01	1.1E-04	4.0E-03	1.2E+00	1.4E-01	1.0E-02	2.8E-02	2.4E-03	3.0E-02	6.9E+00	8.0E-03	2.7E+01	2.0E-05	1.0E+02	3.9E-02	8.3E+01	2.0E-04	9.0E-05	1.8E-03	2.1E-03	2.1E-04	3.0E-02	9.0E-05	5.5E+00	5.0E+00	-5.4E-01	-5.1E-02
24-Feb-10	5	0.5																											
3-Mar-10	6	0.5	6.0E-02	1.3E-04	3.0E-03	7.4E-01	8.8E-02	1.0E-02	2.6E-02	1.9E-03	2.0E-02	5.1E+00	5.9E-03	2.4E+01	1.0E-05	8.8E+01	2.5E-02	6.7E+01	2.0E-04	7.0E-04	8.0E-04	1.3E-03	1.5E-04	1.8E-02	7.0E-05	4.8E+00	4.2E+00	-5.7E-01	-6.4E-02
10-Mar-10	7	0.5																											
17-Mar-10	8	0.5	4.0E-02	1.3E-04	3.0E-03	6.7E-01	8.0E-02	7.0E-02	2.2E-02	1.1E-03	2.0E-02	4.6E+00	4.2E-03	2.4E+01	2.0E-05	7.5E+01	2.3E-02	6.0E+01	2.0E-04	1.0E-05	8.0E-04	8.9E-04	9.0E-05	1.3E-02	4.0E-05	3.7E+00	3.6E+00	-1.1E-01	-1.4E-02
24-Mar-10	9	0.5																											
31-Mar-10	10	0.5	3.0E-02	7.0E-05	2.0E-03	6.2E-01	7.0E-02	7.0E-02	2.3E-02	1.2E-03	4.0E-02	4.4E+00	4.2E-03	2.1E+01	6.0E-05	9.6E+01	2.1E-02	5.5E+01	2.0E-04	1.6E-04	9.0E-04	8.7E-04	8.0E-05	1.7E-02	5.0E-05	3.7E+00	4.5E+00	8.2E-01	1.0E-01
7-Apr-10	11	0.5																											
14-Apr-10	12	0.5	3.0E-02	1.7E-04	2.0E-03	5.6E-01	6.4E-02	1.0E-02	2.0E-02	1.1E-03	4.0E-02	4.6E+00	4.2E-03	2.1E+01	4.0E-05	5.8E+01	2.0E-02	4.8E+01	2.0E-04	1.7E-04	4.0E-04	9.6E-04	1.3E-04	1.5E-02	6.0E-05	3.2E+00	2.8E+00	-4.0E-01	-6.7E-02
21-Apr-10	13	0.5																											
28-Apr-10	14	0.5	2.0E-02	7.6E-04	1.0E-03	4.5E-01	5.2E-02	3.0E-02	1.8E-02	8.0E-04	3.0E-02	3.2E+00	3.4E-03	1.6E+01	3.0E-05	4.4E+01	1.7E-02	3.5E+01	2.0E-04	1.5E-04	4.0E-04	6.4E-04	7.0E-05	1.1E-02	2.0E-05	2.5E+00	2.2E+00	-3.9E-01	-8.3E-02
5-May-10	15	0.5																											
12-May-10	16	0.5	1.9E-02	3.0E-05	1.0E-03	4.5E-01	5.0E-02	2.0E-02	1.8E-02	1.2E-03	4.1E-02	3.6E+00	3.0E-03	2.0E+01	6.5E-04	4.9E+01	1.6E-02	3.9E+01	2.0E-04	2.2E-04	4.0E-04	6.0E-04	5.0E-05	1.0E-02	6.0E-05	2.2E+00	2.4E+00	2.3E-01	5.0E-02
19-May-10	17	0.5																											
26-May-10	18	0.5	1.4E-02	5.0E-05	2.0E-03	4.0E-01	4.5E-02	3.0E-02	1.9E-02	7.0E-04	4.0E-02	3.1E+00	2.6E-03	1.7E+01	4.0E-05	3.9E+01	1.4E-02	3.2E+01	2.0E-04	3.3E-04	3.0E-04	6.0E-04	7.0E-05	1.1E-02	2.0E-05	1.7E+00	1.9E+00	1.9E-01	5.3E-02
2-Jun-10	19	0.5																											
9-Jun-10	20	0.5	1.4E-02	7.0E-05	1.0E-03	4.5E-01	4.6E-02	1.0E-02	1.8E-02	8.0E-04	1.4E-02	3.2E+00	2.5E-03	1.9E+01	1.6E-04	4.0E+01	1.7E-02	3.3E+01	2.0E-04	5.1E-04	3.0E-04	4.3E-04	1.0E-04	1.4E-02	4.0E-05	1.9E+00	2.0E+00	1.2E-01	3.2E-02
16-Jun-10	21	0.5																											
23-Jun-10	22	0.5	1.8E-02	3.0E-04	2.0E-03	4.5E-01	5.2E-02	1.0E-02	2.1E-02	1.2E-03	2.2E-02	3.8E+00	2.6E-03	2.1E+01	1.5E-04	4.1E+01	1.6E-02	3.4E+01	2.0E-04	1.1E-03	4.0E-04	4.2E-04	7.0E-05	1.2E-02	3.0E-05	1.8E+00	2.0E+00	2.0E-01	5.3E-02
30-Jun-10	23	0.5																											
7-Jul-10	24	0.5	1.4E-02	1.6E-04	2.0E-03	4.2E-01	4.9E-02	1.0E-02	1.6E-02	2.1E-03	3.8E-02	3.6E+00	2.8E-03	1.8E+01	1.3E-04	3.3E+01	1.6E-02	2.9E+01	2.0E-04	5.5E-04	4.0E-04	4.0E-04	4.0E-05	1.1E-02	2.0E-05	1.6E+00	1.7E+00	4.7E-02	1.4E-02
14-Jul-10	25	0.5																											
21-Jul-10	26	0.5	1.1E-02	6.0E-05	1.0E-03	4.3E-01	4.9E-02	1.0E-02	1.6E-02	1.0E-03	3.1E-02	3.8E+00	2.1E-03	2.0E+01	1.4E-04	3.2E+01	1.6E-02	2.7E+01	2.0E-04	1.5E-03	3.0E-04	3.6E-04	4.0E-05	1.1E-02	2.0E-05	1.6E+00	1.6E+00	5.2E-02	1.6E-02
28-Jul-10	27	0.5																											
4-Aug-10	28	0.5	1.1E-02	3.0E-05	2.0E-03	4.4E-01	4.8E-02	2.0E-02	1.6E-02	7.0E-04	2.7E-02	3.4E+00	1.7E-03	1.9E+01	4.0E-05	3.1E+01	1.6E-02	2.5E+01	2.0E-04	1.5E-03	3.0E-04	3.8E-04	1.1E-04	1.0E-02	1.0E-05	1.4E+00	1.6E+00	1.9E-01	6.3E-02
11-Aug-10	29	0.5																											
18-Aug-10	30	0.5	4.0E-03	8.0E-05	2.0E-03	4.2E-01	4.6E-02	1.0E-02	1.5E-02	8.0E-04	1.4E-02	3.6E+00	1.6E-03	2.0E+01	6.0E-05	2.9E+01	1.5E-02	3.4E+01	2.0E-04	1.2E-03	3.0E-04	3.8E-04	1.0E-04	1.2E-02	1.0E-05	1.7E+00	1.5E+00	-2.4E-01	-7.4E-02
25-Aug-10	31	0.5																											
1-Sep-10	32	0.5	2.0E-03	1.1E-04	1.0E-03	4.0E-01	3.8E-02	1.0E-02	1.4E-02	8.0E-04	2.6E-02	3.5E+00	1.5E-03	1.9E+01	1.2E-04	2.2E+01	1.4E-02	2.3E+01	2.0E-04	1.3E-03	4.0E-04	3.4E-04	7.0E-05	1.3E-02	1.0E-05	1.4E+00	1.2E+00	-1.9E-01	-7.4E-02
8-Sep-10	33	0.5																											
15-Sep-10	34	0.5	9.0E-03	4.3E-04	2.0E-03	4.5E-01	5.1E-02	1.0E-02	1.3E-02	7.0E-04	9.0E-03	3.2E+00	1.4E-03	1.8E+01	1.0E-04	2.1E+01	1.6E-02	2.1E+01	2.0E-04	1.3E-03	3.0E-04	3.3E-04	3.0E-05	1.1E-02	3.0E-05	1.4E+00	1.1E+00	-2.3E-01	-9.3E-02
22-Sep-10	35	0.5																											
29-Sep-10	36	0.5	2.0E-03	3.2E-04	2.0E-03	4.5E-01	5.0E-02	2.0E-02	1.2E-02	1.2E-03	3.0E-02	3.6E+00	1.9E-03	2.0E+01	1.1E-04	2.2E+01	1.6E-02	2.4E+01	2.0E-04	2.1E-03	1.2E-03	3.3E-04	4.0E-05	1.9E-02	3.0E-05	1.2E+00	1.2E+00	5.0E-03	2.1E-03
6-Oct-10	37	0.5																											
13-Oct-10	38	0.5	1.0E-02	6.6E-04	1.0E-03	5.6E-01	6.6E-02	1.0E-02	1.4E-02	9.0E-04	3.7E-02	3.8E+00	1.3E-03	2.2E+01	6.0E-05	2.1E+01	1.9E-02	2.1E+01	2.0E-04	1.6E-03	3.8E-03	3.1E-04	6.0E-05	1.2E-02	8.0E-05	1.3E+00	1.2E+00	-6.2E-02	-2.5E-02
20-Oct-10	39	0.5																											
27-Oct-10	40	0.5	3.0E-02	2.6E-04	1.0E-03	4.1E-01	4.8E-02	1.0E-02	1.2E-02	1.4E-03	2.6E-02	3.1E+00	1.7E-03	1.7E+01	3.0E-05	1.7E+01	1.5E-02	1.7E+01	2.0E-04	1.2E-03	4.1E-03	2.9E-04	3.0E-05	1.9E-02	1.0E-05	9.7E-01	9.7E-01	4.8E-03	2.5E-03
3-Nov-10	41	0.5																											
10-Nov-10	42	0.5																											
17-Nov-10	43	0.5																											
24-Nov-10	44	0.5	6.0E-03	6.0E-05	1.0E-03	4.4E-01	5.3E-02	1.0E-02	9.5E-03	7.0E-04	9.0E-03	3.1E+00	1.2E-03	1.6E+01	5.0E-05	1.4E+01	1.7E-02	1.4E+01	2.0E-04	7.8E-04	6.0E-04	2.8E-04	3.0E-05	1.7E-02	1.0E-05	9.5E-01	8.5E-01	-1.0E-01	-5.6E-02
1-Dec-10	45	0.5																											
8-Dec-10	46	0.5																											
15-Dec-10	47	0.5																											
22-Dec-10	48	0.5	6.0E-03	5.9E-03	2.0E-03	5.3E-01	6.1E-02	1.0E-02	1.0E-02	1.0E-03	4.3E-02	3.7E+00	9.9E-04	2.0E+01	5.0E-05	1.2E+01	2.0E-02	1.8E+01	2.0E-04	1.4E-03	5.0E-04	3.1E-04	6.0E-05	2.1E-02	1.0E-05	9.5E-01	8.1E-01	-1.5E-01	-8.3E-02
29-Dec-10	49	0.5																											
5-Jan-11	50	0.5																											
12-Jan-11	51	0.5																											
19-Jan-11	52	0.5	6.0E-03	5.0E-05	2.0E-03	5.4E-01	6.3E-02	1.0E-02	7.0E-03	1.0E-03	2.0E-02	3.3E+00	2.5E-04	1.6E+01	4.0E-05	8.0E+00	2.0E-02	1.1E+01	2.0E-04	6.4E-04	2.0E-04	2.6E-04	5.0E-05	1.5E-02	1.0E-05	7.2E-01	6.1E-01	-1.1E-01	-8.3E-02
26-Jan-11	53	0.5																											
2-Feb-11	54	0.5																											
9-Feb-11	55	0.5																											

Col 1
Sample = FB2 +#4 + FB2 -#4 Composite

Date	Cycle No.	Approxi. Flow Rate	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Major Anions	Major Cations	Diff	Diff (%)
		(mL/min)	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L				
16-Feb-11	56	0.5	5.0E-03	1.8E-03	2.0E-03	5.7E-01	6.4E-02	1.0E-02	6.1E-03	1.0E-03	9.0E-03	3.0E+00	4.1E-04	1.5E+01	4.0E-05	5.8E+00	2.1E-02	8.8E+00	2.0E-04	4.7E-04	2.0E-04	2.7E-04	3.0E-05	2.3E-02	1.0E-05	4.9E-01	5.2E-01	2.9E-02	2.8E-02
23-Feb-11	57	0.5																											
2-Mar-11	58	0.5																											
9-Mar-11	59	0.5																											
16-Mar-11	60	0.5	3.0E-03	1.1E-03	2.0E-03	6.4E-01	7.2E-02	1.0E-02	5.2E-03	1.6E-03	1.9E-02	3.3E+00	4.4E-04	1.5E+01	4.0E-05	3.4E+00	2.4E-02	8.9E+00	2.0E-04	6.6E-04	2.0E-04	2.9E-04	3.0E-05	1.7E-02	1.0E-05	4.5E-01	4.5E-01	-2.5E-03	-2.8E-03
23-Mar-11	61	0.5																											
30-Mar-11	62	0.5																											
6-Apr-11	63	0.5																											
13-Apr-11	64	0.5	3.0E-03	2.3E-03	2.0E-03	8.7E-01	1.0E-01	1.0E-02	5.3E-03	2.0E-03	2.5E-02	4.0E+00	4.7E-04	1.6E+01	4.0E-05	2.8E+00	3.2E-02	9.6E+00	2.0E-04	2.9E-04	1.8E-03	3.8E-04	3.0E-05	2.3E-02	1.0E-05	5.9E-01	5.1E-01	-8.4E-02	-7.6E-02
20-Apr-11	65	0.5																											
27-Apr-11	66	0.5																											
4-May-11	67	0.5																											
11-May-11	68	0.5	7.0E-03	1.6E-04	2.0E-03	1.1E+00	1.3E-01	1.0E-02	9.4E-03	2.1E-03	9.0E-03	4.5E+00	3.0E-04	1.6E+01	9.0E-05	2.2E+00	4.1E-02	1.1E+01	2.0E-04	5.1E-04	4.0E-04	5.3E-04	3.0E-05	3.3E-02	2.0E-05	5.9E-01	5.7E-01	-2.1E-02	-1.8E-02
18-May-11	69	0.5																											
25-May-11	70	0.5																											
1-Jun-11	71	0.5																											
8-Jun-11	72	0.5	1.3E-02	1.4E-04	3.0E-03	1.3E+00	1.5E-01	1.0E-02	5.4E-03	2.8E-03	5.8E-02	4.8E+00	7.2E-04	1.8E+01	8.0E-05	1.8E+00	4.7E-02	1.1E+01	1.9E-04	4.0E-04	3.0E-04	5.2E-04	7.0E-05	4.1E-02	3.0E-05	7.6E-01	6.2E-01	-1.3E-01	-9.6E-02
15-Jun-11	73	0.5																											
22-Jun-11	74	0.5																											
29-Jun-11	75	0.5																											
6-Jul-11	76	0.5	6.0E-03	1.0E-04	3.0E-03	1.6E+00	1.8E-01	1.0E-02	5.6E-03	2.8E-03	9.0E-03	5.3E+00	7.4E-04	1.9E+01	4.0E-05	1.5E+00	5.7E-02	1.3E+01	1.8E-04	2.3E-04	2.0E-04	5.4E-04	3.0E-05	4.2E-02	1.0E-05	8.6E-01	7.0E-01	-1.6E-01	-1.0E-01
13-Jul-11	77	0.5																											
20-Jul-11	78	0.5																											
27-Jul-11	79	0.5																											
3-Aug-11	80	0.5	2.0E-03	1.4E-03	3.0E-03	1.6E+00	1.9E-01	1.0E-02	5.1E-03	3.2E-03	9.0E-03	5.0E+00	6.0E-04	1.5E+01	5.0E-05	1.1E+00	5.9E-02	1.2E+01	1.6E-04	1.8E-04	3.0E-04	5.7E-04	3.0E-05	4.2E-02	1.0E-05	8.9E-01	7.0E-01	-1.9E-01	-1.2E-01
10-Aug-11	81	0.5																											
17-Aug-11	82	0.5																											
24-Aug-11	83	0.5																											
31-Aug-11	84	0.5	7.0E-03	1.5E-04	3.0E-03	1.6E+00	1.8E-01	1.0E-02	6.1E-03	3.5E-03	9.0E-03	5.2E+00	1.3E-04	1.5E+01	1.6E-04	1.1E+00	6.0E-02	1.4E+01	1.9E-04	3.3E-04	5.0E-04	5.6E-04	3.0E-05	5.1E-02	1.0E-05	8.3E-01	6.9E-01	-1.4E-01	-9.2E-02
7-Sep-11	85	0.5																											
14-Sep-11	86	0.5																											
21-Sep-11	87	0.5																											
28-Sep-11	88	0.5	7.0E-03	2.6E-04	3.0E-03	1.7E+00	2.0E-01	1.0E-02	4.9E-03	3.3E-03	9.0E-03	5.0E+00	8.5E-04	1.5E+01	5.0E-05	9.4E-01	6.2E-02	1.3E+01	1.8E-04	3.2E-04	3.0E-04	5.9E-04	3.0E-05	4.4E-02	4.0E-05	9.0E-01	7.1E-01	-1.8E-01	-1.1E-01
5-Oct-11	89	0.5																											
12-Oct-11	90	0.5																											
19-Oct-11	91	0.5																											
26-Oct-11	92	0.5	1.3E-02	5.0E-05	3.0E-03	1.8E+00	2.0E-01	1.0E-02	5.0E-03	3.3E-03	9.0E-03	5.4E+00	6.5E-04	1.4E+01	5.0E-05	8.9E-01	6.6E-02	1.4E+01	1.9E-04	3.5E-04	4.0E-04	7.2E-04	3.0E-05	4.9E-02	1.0E-05	9.2E-01	7.6E-01	-1.7E-01	-9.9E-02
2-Nov-11	93	0.5																											
9-Nov-11	94	0.5																											
16-Nov-11	95	0.5																											
23-Nov-11	96	0.5	5.0E-03	1.4E-03	3.0E-03	1.7E+00	2.0E-01	1.0E-02	5.2E-03	3.2E-03	9.0E-03	4.8E+00	7.0E-04	1.4E+01	7.0E-05	7.7E-01	6.0E-02	1.2E+01	1.9E-04	2.4E-04	5.0E-04	1.1E-03	4.0E-04	4.6E-02	1.0E-05	8.2E-01	6.9E-01	-1.2E-01	-8.2E-02
30-Nov-11	97	0.5																											
7-Dec-11	98	0.5																											
14-Dec-11	99	0.5																											
21-Dec-11	100	0.5	6.0E-03	9.0E-05	3.0E-03	1.7E+00	1.9E-01	1.0E-02	4.3E-03	3.3E-03	9.0E-03	4.8E+00	4.2E-04	1.3E+01	5.0E-05	7.2E-01	6.1E-02	1.3E+01	1.6E-04	5.0E-05	5.0E-04	6.0E-04	3.4E-04	4.7E-02	1.0E-05	8.5E-01	7.0E-01	-1.5E-01	-9.6E-02
28-Dec-11	101	0.5																											
4-Jan-12	102	0.5																											
11-Jan-12	103	0.5																											
18-Jan-12	104	0.5	6.0E-03	3.0E-05	3.0E-03	1.6E+00	2.0E-01	2.0E-02	4.3E-03	2.8E-03	9.0E-03	4.5E+00	7.2E-04	1.3E+01	6.0E-05	6.7E-01	6.0E-02	1.3E+01	1.6E-04	2.2E-04	5.0E-04	6.0E-04	4.1E-04	4.3E-02	1.0E-05	8.5E-01	6.8E-01	-1.7E-01	-1.1E-01
25-Jan-12	105	0.5																											
1-Feb-12	106	0.5																											
8-Feb-12	107	0.5																											
15-Feb-12	108	0.5	5.0E-03	3.3E-03	4.0E-03	1.8E+00	2.2E-01	1.0E-02	4.4E-03	4.9E-03	1.0E-02	5.2E+00	7.1E-04	1.7E+01	6.0E-05	7.4E-01	6.8E-02	1.4E+01	1.8E-04	1.1E-04	9.0E-04	8.8E-04	4.4E-04	4.5E-02	1.0E-05	9.2E-01	7.6E-01	-1.6E-01	-9.3E-02
22-Feb-12	109	0.5																											
29-Feb-12	110	0.5																											
7-Mar-12	111	0.5																											
14-Mar-12	112	0.5	6.0E-03	1.3E-04	3.0E-03	1.8E+00	2.2E-01	1.0E-02	4.8E-03	3.3E-03	1.3E-02	5.1E+00	7.1E-04	1.4E+01	7.0E-05	7.5E-01	6.8E-02	1.4E+01	1.7E-04	3.8E-04	1.0E-04	7.1E-04	3.0E-05	4.7E-02	1.0E-05	9.0E-01	7.6E-01	-1.4E-01	-8.6E-02
21-Mar-12	113	0.5																											
28-Mar-12	114	0.5																											
4-Apr-12	115	0.5																											

Col 1
Sample = FB2 +#4 + FB2 -#4 Composite

Date	Cycle No.	Approxi. Flow Rate (mL/min)	Fe mg/L	Pb mg/L	Li mg/L	Mg mg/L	Mn mg/L	Hg ug/L	Mo mg/L	Ni mg/L	P mg/L	K mg/L	Se mg/L	Si mg/L	Ag mg/L	Na mg/L	Sr mg/L	S mg/L	Tl mg/L	Sn mg/L	Ti mg/L	U mg/L	V mg/L	Zn mg/L	Zr mg/L	Major Anions	Major Cations	Diff	Diff (%)
11-Apr-12	116	0.5	4.0E-03	2.8E-04	4.0E-03	1.8E+00	2.1E-01	2.0E-02	6.2E-03	4.3E-03	9.0E-03	5.0E+00	1.9E-02	1.5E+01	1.3E-04	8.3E-01	6.5E-02	1.4E+01	1.8E-04	3.3E-04	9.0E-04	7.0E-04	2.6E-04	5.0E-02	1.0E-05	9.6E-01	7.5E-01	-2.0E-01	-1.2E-01
18-Apr-12	117	0.5																											
25-Apr-12	118	0.5																											
2-May-12	119	0.5																											
9-May-12	120	0.5	6.0E-03	1.8E-04	3.0E-03	1.6E+00	2.0E-01	1.0E-02	4.2E-03	3.1E-03	9.0E-03	4.3E+00	6.3E-04	1.2E+01	6.0E-05	6.5E-01	6.2E-02	1.2E+01	1.6E-04	4.6E-04	3.0E-04	6.2E-04	3.5E-04	4.4E-02	1.0E-05	8.6E-01	6.7E-01	-1.8E-01	-1.2E-01
16-May-12	121	0.5																											
23-May-12	122	0.5																											
30-May-12	123	0.5																											
6-Jun-12	124	0.5	6.0E-03	2.0E-05	3.0E-03	1.7E+00	2.1E-01	1.0E-02	3.8E-03	3.2E-03	9.0E-03	4.7E+00	6.7E-04	1.4E+01	5.0E-05	7.0E-01	6.6E-02	1.3E+01	1.6E-04	1.1E-04	3.0E-04	6.6E-04	4.2E-04	4.2E-02	1.0E-05	7.2E-01	7.2E-01	1.1E-03	7.5E-04
13-Jun-12	125	0.5																											
20-Jun-12	126	0.5																											
27-Jun-12	127	0.5																											
4-Jul-12	128	0.5	4.0E-03	1.1E-04	3.0E-03	1.6E+00	2.0E-01	1.0E-02	4.0E-03	3.3E-03	9.0E-03	4.7E+00	6.4E-04	1.5E+01	8.0E-05	7.1E-01	6.4E-02	1.3E+01	1.8E-04	6.0E-04	2.0E-04	8.5E-04	3.4E-04	4.7E-02	1.0E-05	8.2E-01	7.1E-01	-1.2E-01	-7.7E-02
11-Jul-12	129	0.5																											
18-Jul-12	130	0.5																											
25-Jul-12	131	0.5																											
1-Aug-12	132	0.5	1.1E-02	1.2E-04	3.0E-03	1.7E+00	2.1E-01	1.0E-02	3.4E-03	3.7E-03	9.0E-03	4.7E+00	6.0E-04	1.7E+01	7.0E-05	7.3E-01	6.6E-02	1.4E+01	1.6E-04	3.1E-04	3.0E-04	6.8E-04	5.2E-04	4.3E-02	1.0E-05	7.4E-01	7.2E-01	-1.6E-02	-1.1E-02
8-Aug-12	133	0.5																											
15-Aug-12	134	0.5																											
22-Aug-12	135	0.5																											
29-Aug-12	136	0.5	7.0E-03	9.0E-05	3.0E-03	1.6E+00	1.9E-01	3.0E-02	3.8E-03	3.3E-03	9.0E-03	4.1E+00	6.8E-04	1.3E+01	6.0E-05	6.7E-01	6.2E-02	1.2E+01	1.5E-04	3.2E-04	2.0E-04	6.5E-04	3.5E-04	4.5E-02	4.0E-05	7.5E-01	6.8E-01	-7.5E-02	-5.2E-02
5-Sep-12	137	0.5																											
12-Sep-12	138	0.5																											
19-Sep-12	139	0.5																											
26-Sep-12	140	0.5	3.0E-03	1.2E-04	3.0E-03	1.7E+00	1.9E-01	1.0E-02	7.6E-03	4.3E-03	9.0E-03	3.8E+00	4.0E-05	1.3E+01	4.0E-05	8.0E-01	6.3E-02	1.2E+01	3.0E-05	5.4E-04	2.0E-04	6.2E-04	5.1E-04	4.4E-02	3.0E-05	8.6E-01	6.9E-01	-1.8E-01	-1.1E-01
3-Oct-12	141	0.5																											
10-Oct-12	142	0.5																											
17-Oct-12	143	0.5																											
24-Oct-12	144	0.5	3.0E-03	3.0E-05	3.0E-03	1.7E+00	2.0E-01	1.0E-02	4.1E-03	4.2E-03	9.0E-03	4.2E+00	5.5E-04	1.5E+01	2.0E-05	7.5E-01	6.2E-02	1.3E+01	1.3E-04	3.7E-04	5.0E-04	6.3E-04	4.9E-04	4.4E-02	1.0E-05	8.7E-01	7.0E-01	-1.7E-01	-1.1E-01
31-Oct-12	145	0.5																											
7-Nov-12	146	0.5																											
14-Nov-12	147	0.5																											
21-Nov-12	148	0.5	5.0E-03	2.8E-03	3.0E-03	1.9E+00	2.2E-01	1.0E-02	3.8E-03	3.9E-03	9.0E-03	4.0E+00	4.8E-04	1.3E+01	1.1E-04	8.2E-01	7.3E-02	1.3E+01	1.5E-04	5.7E-04	8.0E-04	7.5E-04	5.3E-04	5.7E-02	1.0E-05	7.2E-01	7.5E-01	3.2E-02	2.1E-02
28-Nov-12	149	0.5																											
5-Dec-12	150	0.5																											
12-Dec-12	151	0.5																											
19-Dec-12	152	0.5	5.0E-03	9.0E-05	3.0E-03	1.7E+00	2.1E-01	1.0E-02	3.5E-03	3.7E-03	9.0E-03	3.9E+00	5.0E-04	1.1E+01	1.0E-04	7.9E-01	6.5E-02	1.2E+01	1.6E-04	2.7E-04	2.0E-04	7.2E-04	1.2E-04	4.7E-02	1.0E-05	7.9E-01	7.0E-01	-9.6E-02	-6.5E-02
26-Dec-12	153	0.5																											
2-Jan-13	154	0.5																											
9-Jan-13	155	0.5																											
16-Jan-13	156	0.5	6.0E-03	4.0E-05	3.0E-03	1.7E+00	2.0E-01	1.0E-02	6.6E-03	3.6E-03	9.0E-03	3.9E+00	4.9E-04	1.2E+01	7.0E-05	6.6E-01	6.5E-02	1.3E+01	1.5E-04	1.3E-03	2.0E-04	7.4E-04	3.7E-04	4.7E-02	3.6E-04	8.8E-01	6.9E-01	-1.9E-01	-1.2E-01
23-Jan-13	157	0.5																											
30-Jan-13	158	0.5																											
6-Feb-13	159	0.5																											
13-Feb-13	160	0.5	3.0E-03	9.0E-05	3.0E-03	1.7E+00	2.0E-01	1.0E-02	3.5E-03	3.6E-03	9.0E-03	4.0E+00	5.6E-04	1.4E+01	4.0E-05	7.9E-01	6.6E-02	1.2E+01	1.5E-04	1.3E-04	1.0E-04	7.7E-04	1.0E-04	5.0E-02	1.0E-05	8.8E-01	6.9E-01	-1.9E-01	-1.2E-01
20-Feb-13	161	0.5																											
27-Feb-13	162	0.5																											
6-Mar-13	163	0.5																											
13-Mar-13	164	0.5	4.0E-03	3.0E-05	3.0E-03	1.7E+00	2.0E-01	1.0E-02	3.6E-03	3.3E-03	9.0E-03	3.9E+00	1.2E-03	1.3E+01	2.0E-05	7.8E-01	6.5E-02	1.3E+01	1.4E-04	1.3E-04	1.0E-04	6.4E-04	4.0E-05	4.3E-02	1.0E-05	7.2E-01	7.1E-01	-9.3E-03	-6.5E-03
20-Mar-13	165	0.5																											

Col 1
Sample = FB2 +#4 + FB2 -#4 Composite

Date	Cycle No.	Approxi. Flow Rate (mL/min)	Fe mg/L	Pb mg/L	Li mg/L	Mg mg/L	Mn mg/L	Hg ug/L	Mo mg/L	Ni mg/L	P mg/L	K mg/L	Se mg/L	Si mg/L	Ag mg/L	Na mg/L	Sr mg/L	S mg/L	Tl mg/L	Sn mg/L	Ti mg/L	U mg/L	V mg/L	Zn mg/L	Zr mg/L	Major Anions	Major Cations	Diff	Diff (%)
27-Mar-13	166	0.5																											
3-Apr-13	167	0.5																											
10-Apr-13	168	0.5	4.0E-03	1.8E-04	3.0E-03	1.6E+00	1.9E-01	1.0E-02	3.0E-03	3.3E-03	9.0E-03	3.7E+00	6.2E-04	1.4E+01	3.0E-05	8.7E-01	6.3E-02	1.2E+01	1.7E-04	2.8E-04	1.0E-04	6.4E-04	3.0E-05	4.6E-02	1.0E-05	9.2E-01	6.6E-01	-2.5E-01	-1.6E-01
17-Apr-13	169	0.5																											
24-Apr-13	170	0.5																											
1-May-13	171	0.5																											
8-May-13	172	0.5	4.0E-03	5.0E-05	3.0E-03	1.7E+00	2.0E-01	1.0E-02	3.0E-03	2.9E-03	1.9E-02	3.6E+00	4.4E-04	1.2E+01	5.0E-05	7.5E-01	6.5E-02	1.2E+01	1.3E-04	6.0E-05	3.0E-04	6.5E-04	5.0E-05	3.8E-02	1.0E-05	9.3E-01	6.6E-01	-2.7E-01	-1.7E-01
15-May-13	173	0.5																											
22-May-13	174	0.5																											
29-May-13	175	0.5																											
5-Jun-13	176	0.5	3.0E-03	1.3E-04	3.0E-03	1.7E+00	2.0E-01	1.0E-02	5.2E-03	5.5E-03	1.0E-02	3.6E+00	5.1E-04	1.3E+01	2.0E-05	7.7E-01	6.4E-02	1.2E+01	1.4E-04	1.3E-04	1.0E-04	7.2E-04	5.0E-05	4.7E-02	1.0E-05	8.1E-01	6.8E-01	-1.3E-01	-8.8E-02
12-Jun-13	177	0.5																											
19-Jun-13	178	0.5																											
26-Jun-13	179	0.5																											
3-Jul-13	180	0.5	3.0E-03	6.0E-05	3.0E-03	1.6E+00	1.9E-01	1.0E-02	3.0E-03	3.1E-03	9.0E-03	3.5E+00	4.9E-04	1.2E+01	4.0E-05	8.3E-01	6.5E-02	1.2E+01	1.2E-04	1.2E-04	1.0E-04	5.9E-04	5.0E-05	4.1E-02	1.0E-05	7.6E-01	6.6E-01	-9.8E-02	-6.9E-02
10-Jul-13	181	0.5																											
17-Jul-13	182	0.5																											
24-Jul-13	183	0.5																											
31-Jul-13	184	0.5	3.0E-03	7.0E-05	3.0E-03	1.6E+00	1.9E-01	1.0E-02	3.1E-03	3.4E-03	9.0E-03	3.4E+00	4.6E-03	1.3E+01	3.0E-05	7.6E-01	6.5E-02	1.2E+01	1.2E-04	1.9E-04	1.0E-04	6.4E-04	5.0E-05	4.9E-02	1.0E-05	6.9E-01	6.6E-01	-3.0E-02	-2.2E-02
7-Aug-13	185	0.5																											
14-Aug-13	186	0.5																											
21-Aug-13	187	0.5																											
28-Aug-13	188	0.5	3.0E-03	7.0E-05	3.0E-03	1.5E+00	1.9E-01	1.0E-02	3.0E-03	3.1E-03	9.0E-03	3.2E+00	5.2E-04	1.2E+01	5.0E-05	7.6E-01	6.5E-02	1.0E+01	1.1E-04	3.2E-03	1.0E-04	6.0E-04	2.3E-04	4.2E-02	1.0E-05	6.7E-01	6.4E-01	-2.6E-02	-2.0E-02
4-Sep-13	189	0.5																											
11-Sep-13	190	0.5																											
18-Sep-13	191	0.5																											
25-Sep-13	192	0.5	3.0E-03	6.4E-03	3.0E-03	1.6E+00	1.9E-01	1.0E-02	3.3E-03	3.4E-03	1.3E-02	3.3E+00	4.5E-04	1.2E+01	5.0E-05	8.0E-01	6.0E-02	1.1E+01	1.3E-04	1.6E-04	1.0E-04	6.8E-04	5.0E-05	4.3E-02	1.0E-05	6.7E-01	6.4E-01	-3.3E-02	-2.5E-02
2-Oct-13	193	0.5																											
9-Oct-13	194	0.5																											
16-Oct-13	195	0.5																											
23-Oct-13	196	0.5	4.0E-03	1.6E-02	3.0E-03	1.5E+00	1.8E-01	1.0E-02	3.0E-03	3.4E-03	9.0E-03	2.9E+00	5.0E-04	1.2E+01	3.0E-05	7.7E-01	5.8E-02	1.1E+01	1.2E-04	1.6E-04	1.0E-04	6.3E-04	6.0E-05	4.3E-02	1.0E-05	7.1E-01	6.1E-01	-1.0E-01	-7.6E-02
30-Oct-13	197	0.5																											
6-Nov-13	198	0.5																											
13-Nov-13	199	0.5																											
20-Nov-13	200	0.5	3.0E-03	2.8E-04	3.0E-03	1.6E+00	1.8E-01	1.0E-02	2.8E-03	4.8E-03	9.0E-03	3.0E+00	6.8E-04	1.2E+01	4.0E-05	8.1E-01	6.0E-02	1.1E+01	2.9E-04	4.0E-04	2.0E-04	5.8E-04	5.0E-05	4.3E-02	1.0E-05	5.8E-01	6.3E-01	4.7E-02	3.9E-02
27-Nov-13	201	0.5																											
4-Dec-13	202	0.5																											
11-Dec-13	203	0.5																											
18-Dec-13	204	0.5	7.0E-03	3.0E-05	3.0E-03	1.5E+00	1.8E-01	1.0E-02	3.6E-03	2.6E-03	9.0E-03	3.1E+00	4.4E-04	1.3E+01	3.0E-05	9.2E-01	5.8E-02	1.1E+01	1.2E-04	1.8E-04	2.0E-04	5.8E-04	5.0E-05	4.1E-02	1.0E-05	5.2E-01	6.3E-01	1.1E-01	9.6E-02
25-Dec-13	205	0.5																											
1-Jan-14	206	0.5																											
8-Jan-14	207	0.5																											
15-Jan-14	208	0.5	5.0E-03	9.0E-05	3.0E-03	1.6E+00	1.9E-01	1.0E-02	2.5E-03	3.6E-03	9.0E-03	2.9E+00	4.5E-04	1.2E+01	5.0E-05	9.2E-01	6.2E-02	1.2E+01	1.2E-04	1.1E-04	2.0E-04	7.5E-04	8.0E-05	3.9E-02	1.0E-05	5.6E-01	6.4E-01	8.2E-02	6.8E-02
22-Jan-14	209	0.5																											
29-Jan-14	210	0.5																											
5-Feb-14	211	0.5																											
12-Feb-14	212	0.5	3.0E-03	3.8E-04	3.0E-03	1.5E+00	1.7E-01	1.0E-02	2.6E-03	3.2E-03	1.1E-02	2.8E+00	3.4E-04	1.3E+01	4.0E-05	8.3E-01	5.6E-02	1.0E+01	1.0E-04	8.0E-05	3.0E-04	5.2E-04	9.0E-05	4.0E-02	1.0E-05	5.2E-01	5.9E-01	7.2E-02	6.5E-02
19-Feb-14	213	0.5																											
26-Feb-14	214	0.5	3.0E-03	3.0E-05	2.0E-03	1.5E+00	1.7E-01	1.0E-02	2.5E-03	2.8E-03	1.0E-02	2.8E+00	5.1E-04	1.3E+01	5.0E-05	8.7E-01	5.7E-02	1.0E+01	1.0E-04	1.7E-04	1.0E-04	5.1E-04	3.0E-05	3.5E-02	1.0E-05	5.2E-01	6.0E-01	7.8E-02	6.9E-02

Col 1

Sample = FB2 +#4 + FB2 -#4 Composite

Date	Cycle	Approxi.	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Cl	F	Br	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Flow Rate	Input	Output		umhos/cm	(pH 4.5)	(pH 8.3)						CaCO3												
		(mL/min)					mgCaCO3/kg	mgCaCO3/kg	mgCaCO3/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
27-Jan-10	1	0.5	1334	315	4.17	1.5E+03	2.3E+00	1.1E+01	#N/A	2.6E+01	1.2E+01	3.7E-02	1.2E-01	7.5E+00	4.2E-01	1.4E-04	1.6E-04	4.6E-03	6.3E-05	6.3E-07	3.5E-03	9.3E-05	2.1E+00	8.2E-04	1.3E-03	1.8E-01
3-Feb-10	2	0.5	300	260	4.74	8.7E+02	#N/A	1.9E+00	5.2E-03	1.7E+01	2.4E+00	1.9E-02	1.6E-02	2.4E+00	9.6E-02	6.8E-05	1.0E-04	1.2E-03	1.9E-05	5.2E-07	1.7E-03	3.1E-05	6.9E-01	3.4E-04	6.7E-04	8.4E-02
10-Feb-10	3	0.5	300	240	5.35	7.3E+02	#N/A	6.3E-01	1.3E-01	1.5E+01	8.6E-01	4.8E-03	1.4E-02	1.2E+00	1.7E-02	3.4E-05	6.2E-05	1.0E-03	7.2E-06	4.8E-07	1.3E-03	1.3E-05	3.4E-01	1.1E-04	2.9E-04	2.6E-02
17-Feb-10	4	0.5	300	315	5.09	5.6E+02	#N/A	8.0E-01	6.0E-02	1.6E+01	6.3E-01	4.4E-03	1.9E-02	1.1E+00	1.3E-02	3.8E-05	7.6E-05	1.3E-03	6.9E-06	6.3E-07	1.8E-03	1.3E-05	3.3E-01	9.5E-05	3.1E-04	2.6E-02
24-Feb-10	5	0.5	300	150	5.61	5.5E+02				6.8E+00																
3-Mar-10	6	0.5	300	325	5.28	4.9E+02	#N/A	5.6E-01	8.8E-02	1.5E+01	2.7E-01	3.9E-03	2.0E-02	7.1E-01	6.6E-03	3.3E-05	5.2E-05	1.4E-03	4.6E-06	6.5E-07	2.1E-03	7.5E-06	2.0E-01	9.1E-05	1.8E-04	1.6E-02
10-Mar-10	7	0.5	300	295	5.78	4.5E+02				1.0E+01																
17-Mar-10	8	0.5	300	285	5.45	4.4E+02	#N/A	4.1E-01	9.5E-02	9.9E+00	1.7E-01	3.4E-03	1.7E-02	5.6E-01	4.5E-03	2.3E-05	3.4E-05	1.1E-03	4.0E-06	5.7E-07	1.3E-03	6.9E-06	1.6E-01	5.1E-05	1.3E-04	1.1E-02
24-Mar-10	9	0.5	300	285	5.97	4.1E+02				1.1E+01																
31-Mar-10	10	0.5	300	310	5.61	3.6E+02	#N/A	4.6E-01	8.8E-02	1.1E+01	1.3E-01	3.7E-03	1.9E-02	5.5E-01	4.8E-03	1.9E-05	5.0E-05	1.6E-03	4.3E-06	6.2E-07	1.4E-03	8.1E-06	1.6E-01	8.7E-05	1.4E-04	1.4E-02
7-Apr-10	11	0.5	300	295	5.77	3.7E+02				1.1E+01																
14-Apr-10	12	0.5	300	310	5.01	3.4E+02	#N/A	5.6E-01	1.3E-02	9.5E+00	8.7E-02	3.7E-03	1.9E-02	5.1E-01	7.3E-03	2.5E-05	5.0E-05	1.9E-03	5.0E-06	5.0E-06	1.4E-03	6.1E-06	1.5E-01	6.8E-05	1.5E-04	1.6E-02
21-Apr-10	13	0.5	300	335	5.60	3.2E+02				9.7E+00																
28-Apr-10	14	0.5	300	385	5.23	2.7E+02	#N/A	3.5E-01	4.9E-02	9.3E+00	6.9E-02	4.6E-03	2.3E-02	5.1E-01	5.6E-03	1.5E-05	5.4E-05	7.5E-03	3.9E-06	7.7E-07	1.5E-03	5.5E-06	1.5E-01	6.2E-05	1.4E-04	1.4E-02
5-May-10	15	0.5	300	300	5.45	2.9E+02				7.9E+00																
12-May-10	16	0.5	300	320	5.67	2.9E+02	#N/A	3.9E-01	7.7E-02	6.5E+00	5.8E-02	3.8E-03	1.9E-02	4.2E-01	4.1E-03	2.6E-05	5.1E-05	3.0E-03	2.6E-06	6.4E-07	1.4E-03	4.3E-06	1.2E-01	7.7E-05	1.1E-04	1.2E-02
19-May-10	17	0.5	300	300	5.51	2.9E+02				5.5E+00																
26-May-10	18	0.5	300	340	5.71	2.4E+02	#N/A	5.4E-01	2.0E-01	5.5E+00	5.4E-02	4.1E-03	2.0E-02	3.9E-01	3.0E-03	2.7E-05	5.0E-04	3.5E-03	3.4E-06	6.8E-07	1.6E-03	4.1E-06	1.1E-01	7.5E-05	1.4E-04	1.2E-02
2-Jun-10	19	0.5	300	340	5.92	2.4E+02				5.2E+00																
9-Jun-10	20	0.5	300	310	5.83	2.5E+02	#N/A	3.8E-01	1.4E-01	5.5E+00	4.3E-02	3.7E-03	1.9E-02	4.3E-01	3.4E-03	1.2E-05	3.7E-05	3.6E-03	2.5E-06	6.2E-07	1.4E-03	4.2E-06	1.2E-01	8.1E-05	1.2E-04	1.3E-02
16-Jun-10	21	0.5	300	290	5.81	2.5E+02				4.4E+00																
23-Jun-10	22	0.5	300	285	6.01	2.5E+02	#N/A	3.4E-01	9.8E-02	4.9E+00	4.0E-02	3.4E-03	1.7E-02	3.8E-01	3.0E-03	2.9E-05	5.1E-05	1.9E-03	2.9E-06	1.1E-06	1.4E-03	4.3E-06	1.1E-01	5.7E-05	1.1E-04	1.5E-02
30-Jun-10	23	0.5	300	320	5.41	2.2E+02				5.4E+00																
7-Jul-10	24	0.5	300	325	5.67	2.2E+02	#N/A	4.1E-01	7.9E-02	5.0E+00	3.3E-02	3.9E-03	2.0E-02	3.6E-01	3.0E-03	2.0E-05	4.6E-05	2.5E-03	2.6E-06	6.5E-07	1.2E-03	4.4E-06	9.8E-02	9.1E-05	1.2E-04	1.3E-02
14-Jul-10	25	0.5	300	305	6.11	2.1E+02				2.6E+00																
21-Jul-10	26	0.5	300	300	5.81	2.2E+02	#N/A	4.3E-01	1.4E-01	4.5E+00	3.0E-02	3.6E-03	1.8E-02	3.6E-01	3.1E-03	1.2E-05	4.2E-05	2.0E-03	2.4E-06	6.0E-07	1.2E-03	3.7E-06	1.0E-01	6.0E-05	1.1E-04	1.3E-02
28-Jul-10	27	0.5	300	290	5.91	2.1E+02				4.5E+00																
4-Aug-10	28	0.5	300	290	6.16	2.0E+02	#N/A	4.0E-01	9.5E-02	3.8E+00	2.9E-02	3.5E-03	1.7E-02	3.8E-01	2.8E-03	1.2E-05	2.9E-05	1.9E-03	2.3E-06	5.8E-07	3.0E-03	3.1E-06	1.1E-01	7.0E-05	1.1E-04	1.2E-02
11-Aug-10	29	0.5	300	295	6.79	2.0E+02				4.6E+00																
18-Aug-10	30	0.5	300	300	6.01	1.9E+02	#N/A	4.9E-01	1.8E-01	4.9E+00	3.0E-02	3.6E-03	1.8E-02	3.8E-01	2.8E-03	1.2E-05	4.2E-05	2.0E-03	3.0E-06	6.0E-07	1.4E-03	3.9E-06	1.1E-01	5.4E-05	1.1E-04	1.3E-02
25-Aug-10	31	0.5	300	315	6.31	1.7E+02				4.2E+00																
1-Sep-10	32	0.5	300	305	6.21	1.6E+02	#N/A	4.0E-01	1.2E-01	4.0E+00	2.4E-02	3.7E-03	1.8E-02	3.9E-01	2.7E-03	1.8E-05	2.4E-05	2.1E-03	2.4E-06	6.1E-07	1.0E-03	4.0E-06	1.1E-01	5.5E-05	1.0E-04	1.1E-02
8-Sep-10	33	0.5	300	305	6.52	1.8E+02				3.8E+00																
15-Sep-10	34	0.5	300	315	5.67	1.5E+02	#N/A	3.6E-01	6.0E-02	4.1E+00	2.5E-02	3.8E-03	1.9E-02	4.2E-01	3.0E-03	4.4E-05	3.2E-05	2.0E-03	3.2E-06	1.9E-06	1.1E-03	4.0E-06	1.2E-01	5.0E-05	1.2E-04	1.3E-02
22-Sep-10	35	0.5	300	285	6.40	1.3E+02				4.1E+00																
29-Sep-10	36	0.5	300	325	5.98	1.2E+02	#N/A	3.7E-01	8.8E-02	3.7E+00	2.6E-02	3.9E-03	2.0E-02	4.2E-01	2.9E-03	5.5E-04	5.9E-05	2.3E-03	2.6E-06	6.5E-07	1.2E-03	1.4E-05	1.2E-01	4.6E-05	1.8E-04	1.5E-02
6-Oct-10	37	0.5	300	300	6.24	1.6E+02				3.8E+00																
13-Oct-10	38	0.5	300	295	5.81	1.6E+02	#N/A	3.9E-01	7.3E-02	3.5E+00	2.4E-02	3.5E-03	1.8E-02	6.2E-01	2.4E-03	3.5E-05	1.8E-05	2.2E-03	3.0E-06	3.0E-06	1.2E-03	4.3E-06	1.9E-01	4.1E-05	1.2E-04	1.4E-02
20-Oct-10	39	0.5	300	275	6.26	1.5E+02				3.4E+00																
27-Oct-10	40	0.5	300	350	6.02	1.4E+02	#N/A	2.9E-01	8.2E-02	3.2E+00	2.1E-02	4.2E-03	2.1E-02	4.3E-01	2.9E-03	1.4E-05	3.5E-05	2.5E-03	2.8E-06	7.0E-07	1.2E-03	5.2E-06	1.2E-01	4.2E-05	1.5E-04	1.6E-02
3-Nov-10	41	0.5	300	270	6.33	1.5E+02																				
10-Nov-10	42	0.5	300	360	5.61	1.4E+02																				
17-Nov-10	43	0.5	300	355	6.51	1.5E+02																				
24-Nov-10	44	0.5	300	340	5.95	1.2E+02	#N/A	3.2E-01	7.6E-02	3.0E+00	2.7E-02	4.1E-03	2.0E-02	4.4E-01	2.6E-03	1.4E-05	4.1E-05	2.8E-03	3.4E-06	6.8E-07	8.9E-04	5.1E-06	1.3E-01	3.4E-05	1.5E-04	1.8E-02
1-Dec-10	45	0.5	300	320	6.59	1.2E+02																				
8-Dec-10	46	0.5	300	335	5.79	1.1E+02																				
15-Dec-10	47	0.5	300	315	6.41	1.1E+02																				
22-Dec-10	48	0.5	300	325	6.47	1.1E+02	#N/A	4.1E-01	1.6E-01	2.8E+00	2.0E-02	3.9E-03	2.0E-02	5.2E-01	2.8E-03	1.2E-04	3.3E-05	2.9E-03	3.3E-06	6.5E-07	1.0E-03	7.6E-06	1.5E-01	5.9E-05	1.6E-04	1.8E-02
29-Dec-10	49	0.5	300	345	6.06	8.9E+01																				
5-Jan-11	50	0.5	300	325	6.51	8.8E+01																				
12-Jan-11	51	0.5	300	310	6.41	9.7E+01																				
19-Jan-11	52	0.5	300	340	6.00	8.5E+01	#N/A	4.1E-01	1.5E-01	2.2E+00	2.0E-02	4.1E-03	2.0E-02	5.4E-01	3.3E-03	2.7E-05	2.0E-05	3.4E-03	3.4E-06	6.8E-07	8.3E-04	5.2E-06	1.6E-01	3.4E-05	1.6E-04	1.7E-02
26-Jan-11	53	0.5	300	330	6.23	8.4E+01																				
2-Feb-11	54	0.5	300	385	5.91	6.9E+01																				
9-Feb-11	55	0.5	300	360	6.07	7.5E+01																				

Col 1

Sample = FB2 +#4 + FB2 -#4 Composite

Date	Cycle	Approxi.	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Cl	F	Br	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Flow Rate	Input	Output		umhos/cm	(pH 4.5)	(pH 8.3)						CaCO3												
		(mL/min)					mgCaCO3/kg	mgCaCO3/kg	mgCaCO3/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
16-Feb-11	56	0.5	300	375	6.17	7.3E+01	#N/A	3.0E-01	1.0E-01	1.7E+00	1.5E-02	4.5E-03	2.3E-02	6.2E-01	3.4E-03	1.5E-05	3.0E-05	3.6E-03	4.5E-06	7.5E-07	1.8E-03	7.7E-06	1.8E-01	4.5E-05	1.9E-04	2.0E-02
23-Feb-11	57	0.5	300	430	6.23	8.5E+01																				
2-Mar-11	58	0.5	300	415	5.69	7.9E+01																				
9-Mar-11	59	0.5	300	425	6.07	7.6E+01																				
16-Mar-11	60	0.5	300	325	6.10	7.4E+01	#N/A	3.1E-01	9.4E-02	1.3E+00	1.3E-02	3.9E-03	2.0E-02	6.4E-01	3.4E-03	4.6E-05	1.3E-05	4.7E-03	4.6E-06	6.5E-07	5.4E-04	7.0E-06	1.9E-01	3.3E-05	1.8E-04	2.0E-02
23-Mar-11	61	0.5	300	405	6.01	7.9E+01																				
30-Mar-11	62	0.5	300	385	6.61	7.9E+01																				
6-Apr-11	63	0.5	300	360	6.27	7.7E+01																				
13-Apr-11	64	0.5	300	300	6.01	8.7E+01	#N/A	3.0E-01	8.0E-02	1.6E+00	1.2E-02	3.6E-03	1.8E-02	7.7E-01	5.0E-03	1.2E-05	1.2E-05	4.9E-03	4.8E-06	6.0E-07	6.2E-04	8.0E-06	2.2E-01	3.0E-05	2.5E-04	2.7E-02
20-Apr-11	65	0.5	300	300	6.51	9.2E+01																				
27-Apr-11	66	0.5	300	340	6.20	8.7E+01																				
4-May-11	67	0.5	300	305	6.12	9.4E+01																				
11-May-11	68	0.5	300	325	5.92	9.5E+01	#N/A	3.6E-01	7.8E-02	1.8E+00	1.3E-02	3.9E-03	2.0E-02	1.1E+00	6.5E-03	1.3E-05	3.9E-05	5.0E-03	7.8E-06	6.5E-07	6.8E-04	1.1E-05	3.0E-01	3.3E-05	3.7E-04	3.7E-02
18-May-11	69	0.5	300	300	6.13	1.1E+02																				
25-May-11	70	0.5	300	320	6.41	9.8E+01																				
1-Jun-11	71	0.5	300	295	6.24	1.0E+02																				
8-Jun-11	72	0.5	300	325	5.79	1.1E+02	#N/A	4.1E-01	6.6E-02	2.3E+00	1.3E-02	3.9E-03	2.0E-02	1.2E+00	9.3E-03	2.0E-05	2.6E-05	4.5E-03	8.5E-06	3.3E-06	6.5E-04	1.4E-05	3.5E-01	3.3E-05	4.0E-04	4.2E-02
15-Jun-11	73	0.5	300	305	6.21	1.0E+02																				
22-Jun-11	74	0.5	300	345	6.06	1.0E+02																				
29-Jun-11	75	0.5	300	310	5.91	1.1E+02																				
6-Jul-11	76	0.5	300	325	5.71	1.1E+02	#N/A	4.6E-01	7.0E-02	2.6E+00	1.3E-02	3.9E-03	2.0E-02	1.5E+00	9.6E-03	1.3E-05	2.0E-05	4.7E-03	8.5E-06	6.5E-07	7.3E-04	1.6E-05	4.2E-01	3.3E-05	4.9E-04	5.1E-02
13-Jul-11	77	0.5	300	295	5.95	1.1E+02																				
20-Jul-11	78	0.5	300	335	5.67	1.1E+02																				
27-Jul-11	79	0.5	300	320	5.69	1.1E+02																				
3-Aug-11	80	0.5	300	200	6.02	1.1E+02	#N/A	3.6E-01	7.0E-02	1.6E+00	8.0E-03	2.8E-03	1.2E-02	9.4E-01	6.7E-03	8.0E-06	1.6E-05	2.4E-03	5.6E-06	4.0E-07	4.2E-04	1.0E-05	2.7E-01	2.0E-05	3.0E-04	3.0E-02
10-Aug-11	81	0.5	300	330	5.95	1.1E+02																				
17-Aug-11	82	0.5	300	315	5.92	1.1E+02																				
24-Aug-11	83	0.5	300	300	6.07	1.1E+02																				
31-Aug-11	84	0.5	300	340	5.78	1.1E+02	#N/A	6.2E-01	1.1E-01	2.6E+00	1.4E-02	4.1E-03	2.0E-02	1.6E+00	1.0E-02	2.0E-05	4.8E-05	3.7E-03	9.5E-06	6.8E-07	8.3E-04	2.4E-05	4.4E-01	5.4E-05	6.1E-04	5.5E-02
7-Sep-11	85	0.5	300	335	5.98	1.1E+02																				
14-Sep-11	86	0.5	300	315	5.92	1.1E+02																				
21-Sep-11	87	0.5	300	315	5.77	1.1E+02																				
28-Sep-11	88	0.5	300	295	5.83	1.2E+02	#N/A	4.3E-01	9.6E-02	2.4E+00	1.8E-02	4.1E-02	1.8E-02	1.4E+00	9.4E-03	1.2E-05	2.4E-05	3.0E-03	8.9E-06	5.9E-06	5.0E-04	1.6E-05	4.2E-01	7.1E-05	4.8E-04	4.8E-02
5-Oct-11	89	0.5	300	350	5.81	1.0E+02																				
12-Oct-11	90	0.5	300	300	6.06	1.2E+02																				
19-Oct-11	91	0.5	300	305	5.68	1.2E+02																				
26-Oct-11	92	0.5	300	310	5.59	1.2E+02	#N/A	3.9E-01	5.3E-02	2.7E+00	2.5E-02	5.6E-03	1.9E-02	1.6E+00	1.1E-02	1.2E-05	3.1E-05	3.5E-03	9.9E-06	3.1E-06	6.3E-04	1.7E-05	4.6E-01	9.3E-05	5.1E-04	5.5E-02
2-Nov-11	93	0.5	300	305	5.85	1.2E+02																				
9-Nov-11	94	0.5	300	315	5.90	1.2E+02																				
16-Nov-11	95	0.5	300	310	5.73	1.2E+02																				
23-Nov-11	96	0.5	300	330	5.73	1.2E+02	#N/A	4.2E-01	9.0E-02	2.5E+00	1.3E-02	1.4E-02	2.0E-02	1.6E+00	1.2E-02	5.3E-05	2.6E-05	3.2E-03	1.1E-05	6.6E-07	9.4E-04	1.9E-05	4.6E-01	3.3E-05	5.0E-04	5.1E-02
30-Nov-11	97	0.5	300	330	5.82	1.1E+02																				
7-Dec-11	98	0.5	300	330	5.98	1.2E+02																				
14-Dec-11	99	0.5	300	325	5.81	1.1E+02																				
21-Dec-11	100	0.5	300	325	5.68	1.1E+02	#N/A	4.6E-01	6.6E-02	2.6E+00	1.3E-02	3.9E-03	2.0E-02	1.6E+00	1.2E-02	1.3E-05	2.6E-05	3.2E-03	8.5E-06	6.5E-07	6.2E-04	1.7E-05	4.6E-01	3.3E-05	5.1E-04	5.5E-02
28-Dec-11	101	0.5	300	330	5.68	1.1E+02																				
4-Jan-12	102	0.5	300	295	5.99	1.1E+02																				
11-Jan-12	103	0.5	300	310	5.42	1.2E+02																				
18-Jan-12	104	0.5	300	340	5.31	1.0E+02	#N/A	4.8E-01	6.8E-03	2.8E+00	1.4E-02	4.8E-03	2.0E-02	1.7E+00	1.2E-02	1.4E-05	4.1E-05	3.1E-03	1.1E-05	6.8E-07	5.0E-04	1.7E-05	4.8E-01	3.4E-05	5.1E-04	5.2E-02
25-Jan-12	105	0.5	300	310	5.32	1.0E+02																				
1-Feb-12	106	0.5	300	350	5.27	1.1E+02																				
8-Feb-12	107	0.5	300	305	5.76	1.2E+02																				
15-Feb-12	108	0.5	300	300	5.01	1.2E+02	#N/A	6.3E-01	6.0E-03	2.6E+00	1.2E-02	4.8E-03	1.8E-02	1.6E+00	1.0E-02	3.6E-05	9.0E-05	2.7E-03	9.0E-06	6.0E-07	5.0E-04	1.7E-05	4.7E-01	3.0E-05	5.0E-04	5.5E-02
22-Feb-12	109	0.5	300	305	5.48	1.2E+02																				
29-Feb-12	110	0.5	300	285	5.25	1.1E+02																				
7-Mar-12	111	0.5	300	340	5.77	1.1E+02																				

Col 1

Sample = FB2 +#4 + FB2 -#4 Composite

Date	Cycle	Approxi.	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Cl	F	Br	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Flow Rate	Input	Output		umhos/cm	(pH 4.5)	(pH 8.3)						CaCO3												
		(mL/min)					mgCaCO3/kg	mgCaCO3/kg	mgCaCO3/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
14-Mar-12	112	0.5	300	300	5.13	1.1E+02	#N/A	5.5E-01	9.0E-03	2.6E+00	1.2E-02	4.8E-03	1.8E-02	1.6E+00	1.0E-02	1.2E-05	2.4E-05	2.9E-03	9.6E-06	7.2E-06	4.3E-04	1.6E-05	4.6E-01	3.0E-05	5.0E-04	5.1E-02
21-Mar-12	113	0.5	300	315	5.42	1.1E+02																				
28-Mar-12	114	0.5	300	300	5.25	1.1E+02																				
4-Apr-12	115	0.5	300	295	5.32	1.2E+02																				
11-Apr-12	116	0.5	300	300	5.01	1.1E+02	#N/A	5.6E-01	6.0E-03	2.8E+00	1.2E-02	4.8E-03	1.8E-02	1.5E+00	1.5E-02	1.2E-05	6.0E-05	2.8E-03	9.0E-06	6.0E-07	5.7E-04	7.9E-06	4.5E-01	3.0E-05	5.8E-04	6.4E-02
18-Apr-12	117	0.5	300	305	5.30	1.1E+02																				
25-Apr-12	118	0.5	300	300	5.21	1.2E+02																				
2-May-12	119	0.5	300	295	4.14	1.3E+02																				
9-May-12	120	0.5	300	335	5.18	1.1E+02	#N/A	6.4E-01	9.4E-03	2.7E+00	1.3E-02	4.7E-03	2.0E-02	1.6E+00	1.1E-02	1.3E-05	2.0E-05	2.9E-03	1.1E-05	6.7E-07	6.2E-04	1.5E-05	4.7E-01	3.4E-05	5.1E-04	5.1E-02
16-May-12	121	0.5	300	350	5.31	1.2E+02																				
23-May-12	122	0.5	300	335	5.24	1.0E+02																				
30-May-12	123	0.5	300	360	5.50	9.9E+01																				
6-Jun-12	124	0.5	300	320	5.26	1.1E+02	#N/A	6.1E-01	4.7E-02	2.2E+00	2.6E-02	4.5E-03	1.9E-02	1.6E+00	1.4E-02	1.3E-05	1.3E-05	3.2E-03	1.2E-05	6.4E-07	8.9E-04	1.5E-05	4.7E-01	3.2E-05	4.9E-04	5.0E-02
13-Jun-12	125	0.5	300	320	5.29	1.1E+02																				
20-Jun-12	126	0.5	300	315	5.33	1.1E+02																				
27-Jun-12	127	0.5	300	305	5.32	1.1E+02																				
4-Jul-12	128	0.5	300	300	5.30	1.1E+02	#N/A	4.9E-01	3.4E-02	2.3E+00	1.8E-02	5.4E-03	1.8E-02	1.5E+00	1.2E-02	1.2E-05	1.8E-05	3.0E-03	1.1E-05	6.0E-07	5.3E-04	1.7E-05	4.3E-01	3.0E-05	4.8E-04	5.1E-02
11-Jul-12	129	0.5	300	300	5.24	1.1E+02																				
18-Jul-12	130	0.5	300	335	5.20	1.0E+02																				
25-Jul-12	131	0.5	300	300	4.98	1.1E+02																				
1-Aug-12	132	0.5	300	300	5.17	1.1E+02	#N/A	5.3E-01	2.2E-02	2.1E+00	1.2E-02	4.2E-03	1.8E-02	1.5E+00	1.4E-02	1.2E-05	4.2E-05	3.5E-03	9.6E-06	6.0E-07	4.7E-04	1.5E-05	4.4E-01	3.0E-05	4.8E-04	4.6E-02
8-Aug-12	133	0.5	300	295	5.38	1.1E+02																				
15-Aug-12	134	0.5	300	325	5.22	1.1E+02																				
22-Aug-12	135	0.5	300	295	5.48	9.7E+01																				
29-Aug-12	136	0.5	300	355	5.13	1.0E+02	#N/A	7.8E-01	1.4E-02	2.6E+00	1.4E-02	5.7E-03	2.1E-02	1.7E+00	2.0E-02	1.4E-05	1.4E-05	3.8E-03	1.1E-05	7.1E-07	4.5E-04	1.8E-05	4.9E-01	3.6E-05	5.8E-04	6.0E-02
5-Sep-12	137	0.5	300	355	5.17	1.4E+02																				
12-Sep-12	138	0.5	300	340	5.16	1.0E+02																				
19-Sep-12	139	0.5	300	335	5.26	1.0E+02																				
26-Sep-12	140	0.5	300	320	5.17	1.0E+02	#N/A	4.9E-01	3.2E-02	2.6E+00	1.3E-02	5.1E-03	1.9E-02	1.6E+00	1.6E-02	1.3E-05	2.6E-05	3.0E-03	3.8E-06	6.4E-07	4.5E-04	2.6E-05	4.5E-01	3.2E-05	5.2E-04	5.4E-02
3-Oct-12	141	0.5	300	355	5.31	1.0E+02																				
10-Oct-12	142	0.5	300	335	5.09	9.5E+01																				
17-Oct-12	143	0.5	300	315	5.39	1.2E+02																				
24-Oct-12	144	0.5	300	310	5.24	1.1E+02	#N/A	6.3E-01	5.1E-02	2.5E+00	1.2E-02	4.3E-03	1.9E-02	1.5E+00	1.5E-02	1.2E-05	1.2E-05	2.9E-03	1.1E-05	6.2E-07	5.6E-04	2.1E-05	4.4E-01	3.1E-05	4.9E-04	5.5E-02
31-Oct-12	145	0.5	300	340	5.39	1.2E+02																				
7-Nov-12	146	0.5	300	360	4.81	8.7E+01																				
14-Nov-12	147	0.5	300	300	5.30	1.1E+02																				
21-Nov-12	148	0.5	300	250	5.14	1.1E+02	#N/A	5.0E-01	2.9E-02	1.7E+00	1.0E-02	6.0E-03	1.5E-02	1.4E+00	1.0E-02	1.0E-05	5.0E-05	2.6E-03	9.5E-06	5.0E-07	3.1E-04	2.0E-05	4.0E-01	2.5E-05	4.6E-04	4.6E-02
28-Nov-12	149	0.5	300	285	5.61	1.3E+02																				
5-Dec-12	150	0.5	300	315	5.56	1.1E+02																				
12-Dec-12	151	0.5	300	275	4.82	1.1E+02																				
19-Dec-12	152	0.5	300	285	5.01	1.0E+02	#N/A	4.7E-01	5.7E-03	2.2E+00	1.1E-02	5.1E-03	1.7E-02	1.4E+00	1.0E-02	1.1E-05	2.3E-05	2.9E-03	1.0E-05	5.7E-07	4.1E-04	1.6E-05	4.1E-01	2.9E-05	5.0E-04	4.8E-02
26-Dec-12	153	0.5	300	305	5.91	1.1E+02																				
2-Jan-13	154	0.5	300	300	5.01	1.0E+02																				
9-Jan-13	155	0.5	300	270	6.01	1.1E+02																				
16-Jan-13	156	0.5	300	310	5.33	1.1E+02	#N/A	4.4E-01	4.9E-02	2.6E+00	1.2E-02	4.3E-03	1.9E-02	1.6E+00	1.2E-02	1.2E-05	3.7E-05	3.1E-03	1.2E-05	6.2E-07	5.1E-04	1.8E-05	4.5E-01	3.1E-05	5.2E-04	5.5E-02
23-Jan-13	157	0.5	300	305	5.80	1.1E+02																				
30-Jan-13	158	0.5	300	290	4.79	1.0E+02																				
6-Feb-13	159	0.5	300	300	5.58	1.1E+02																				
13-Feb-13	160	0.5	300	295	6.00	1.0E+02	#N/A	7.4E-01	1.4E-01	2.4E+00	1.2E-02	4.7E-03	1.8E-02	1.4E+00	1.2E-02	1.2E-05	2.4E-05	2.7E-03	1.2E-05	5.9E-07	5.1E-04	1.6E-05	4.1E-01	3.0E-05	5.2E-04	5.7E-02
20-Feb-13	161	0.5	300	265	5.33	1.1E+02																				
27-Feb-13	162	0.5	300	335	5.15	1.0E+02																				
6-Mar-13	163	0.5	300	290	5.45	1.1E+02																				
13-Mar-13	164	0.5	300	295	4.71	1.0E+02	#N/A	6.8E-01	2.4E-02	2.0E+00	1.2E-02	4.7E-03	1.8E-02	1.5E+00	1.1E-02	1.2E-05	1.8E-05	3.2E-03	1.1E-05	4.1E-06	3.9E-04	1.5E-05	4.4E-01	3.0E-05	4.9E-04	5.6E-02
20-Mar-13	165	0.5	300	270	4.70	1.0E+02																				
27-Mar-13	166	0.5	300	315	5.34	9.7E+01																				
3-Apr-13	167	0.5	300	295	4.91	1.0E+02																				

Col 1

Sample = FB2 +#4 + FB2 -#4 Composite

Date	Cycle	Approxi.	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Cl	F	Br	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Flow Rate	Input	Output		umhos/cm	(pH 4.5)	(pH 8.3)						CaCO3												
		(mL/min)					mgCaCO3/kg	mgCaCO3/kg	mgCaCO3/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
10-Apr-13	168	0.5	300	305	4.69	1.0E+02	#N/A	6.7E-01	6.1E-03	2.7E+00	1.2E-02	4.9E-03	1.8E-02	1.4E+00	1.2E-02	1.2E-05	3.1E-05	2.8E-03	9.8E-06	6.1E-07	5.2E-04	1.8E-05	4.1E-01	3.7E-05	5.1E-04	5.0E-02
17-Apr-13	169	0.5	300	300	5.07	9.9E+01																				
24-Apr-13	170	0.5	300	295	4.81	1.0E+02																				
1-May-13	171	0.5	300	300	4.96	1.0E+02																				
8-May-13	172	0.5	300	295	5.17	9.7E+01	#N/A	8.1E-01	1.1E-01	2.5E+00	1.2E-02	#VALUE!	1.8E-02	1.4E+00	9.4E-03	1.2E-05	1.2E-05	2.7E-03	1.0E-05	5.9E-07	3.8E-04	1.5E-05	4.1E-01	3.0E-05	4.2E-04	4.3E-02
15-May-13	173	0.5	300	300	4.90	8.9E+01																				
22-May-13	174	0.5	300	300	5.04	9.4E+01																				
29-May-13	175	0.5	300	295	5.10	1.0E+02																				
5-Jun-13	176	0.5	300	300	4.87	1.0E+02	#N/A	7.1E-01	6.0E-03	2.3E+00	1.2E-02	4.2E-03	1.8E-02	1.5E+00	1.2E-02	1.2E-05	2.4E-05	3.1E-03	9.6E-06	6.0E-07	5.4E-04	1.6E-05	4.3E-01	3.0E-05	5.1E-04	5.0E-02
12-Jun-13	177	0.5	300	300	4.45	9.5E+01																				
19-Jun-13	178	0.5	300	300	5.24	1.0E+02																				
26-Jun-13	179	0.5	300	290	5.15	1.0E+02																				
3-Jul-13	180	0.5	300	300	5.08	1.0E+02	#N/A	6.9E-01	1.5E-02	2.2E+00	1.8E-02	4.2E-03	1.8E-02	1.4E+00	1.1E-02	1.2E-05	1.2E-05	2.8E-03	1.1E-05	6.0E-07	5.1E-04	1.5E-05	4.1E-01	3.0E-05	4.4E-04	4.5E-02
10-Jul-13	181	0.5	300	295	5.77	9.6E+01																				
17-Jul-13	182	0.5	300	295	5.07	9.9E+01																				
24-Jul-13	183	0.5	300	310	5.79	9.8E+01																				
31-Jul-13	184	0.5	300	300	5.20	1.0E+02	#N/A	6.4E-01	6.7E-02	1.9E+00	1.2E-02	4.2E-03	1.8E-02	1.4E+00	1.1E-02	1.2E-05	2.4E-05	2.8E-03	1.1E-05	6.0E-07	5.5E-04	1.8E-05	4.2E-01	3.0E-05	4.7E-04	4.8E-02
7-Aug-13	185	0.5	300	300	5.77	9.8E+01																				
14-Aug-13	186	0.5	300	295	5.00	1.0E+02																				
21-Aug-13	187	0.5	300	300	5.59	1.0E+02																				
28-Aug-13	188	0.5	300	300	4.99	9.3E+01	#N/A	4.8E-01	6.0E-03	1.9E+00	1.2E-02	#VALUE!	1.8E-02	1.4E+00	1.2E-02	1.2E-05	3.6E-05	3.0E-03	1.3E-05	6.0E-07	6.8E-04	1.5E-05	4.1E-01	3.0E-05	4.6E-04	4.5E-02
4-Sep-13	189	0.5	300	300	5.43	9.2E+01																				
11-Sep-13	190	0.5	300	295	4.94	9.2E+01																				
18-Sep-13	191	0.5	300	300	5.52	9.6E+01																				
25-Sep-13	192	0.5	300	290	4.74	9.9E+01	#N/A	6.2E-01	1.9E-02	1.9E+00	1.2E-02	4.1E-03	1.7E-02	1.3E+00	9.6E-03	1.2E-05	2.3E-05	3.2E-03	1.0E-05	5.8E-07	7.1E-04	1.4E-05	3.9E-01	2.9E-05	4.5E-04	4.7E-02
2-Oct-13	193	0.5	300	300	4.85	9.7E+01																				
9-Oct-13	194	0.5	300	300	4.90	9.5E+01																				
16-Oct-13	195	0.5	300	305	4.68	9.4E+01																				
23-Oct-13	196	0.5	300	305	4.79	9.6E+01	#N/A	5.3E-01	6.1E-03	2.1E+00	1.2E-02	4.3E-03	1.8E-02	1.4E+00	9.0E-03	1.2E-05	2.4E-05	3.6E-03	1.2E-05	6.1E-07	7.8E-04	1.5E-05	3.9E-01	3.1E-05	4.7E-04	5.2E-02
30-Oct-13	197	0.5	300	295	4.74	9.6E+01																				
6-Nov-13	198	0.5	300	305	4.77	9.4E+01																				
13-Nov-13	199	0.5	300	305	5.12	9.4E+01																				
20-Nov-13	200	0.5	300	295	4.91	9.5E+01	#N/A	3.7E-01	5.9E-03	1.7E+00	1.2E-02	3.5E-03	1.8E-02	1.4E+00	1.1E-02	1.2E-05	1.2E-05	3.3E-03	1.1E-05	5.9E-07	8.9E-04	1.5E-05	3.9E-01	3.0E-05	6.1E-04	4.8E-02
27-Nov-13	201	0.5	300	305	4.82	9.3E+01																				
4-Dec-13	202	0.5	300	300	4.97	9.1E+01																				
11-Dec-13	203	0.5	300	300	4.90	8.8E+01																				
18-Dec-13	204	0.5	300	295	4.96	8.7E+01	#N/A	4.8E-01	5.9E-03	1.5E+00	1.2E-02	4.7E-03	1.8E-02	1.3E+00	9.7E-03	1.2E-05	1.2E-05	3.2E-03	1.0E-05	5.9E-07	9.4E-04	1.4E-05	3.9E-01	3.0E-05	4.3E-04	4.6E-02
25-Dec-13	205	0.5	300	300	5.31	8.9E+01																				
1-Jan-14	206	0.5	300	295	5.07	8.8E+01																				
8-Jan-14	207	0.5	300	300	4.90	9.2E+01																				
15-Jan-14	208	0.5	300	305	5.14	9.2E+01	#N/A	4.9E-01	6.1E-03	1.6E+00	1.2E-02	3.7E-03	1.8E-02	1.4E+00	1.2E-02	1.2E-05	1.2E-05	3.3E-03	1.2E-05	6.1E-07	5.9E-04	4.5E-05	4.2E-01	3.1E-05	4.7E-04	4.6E-02
22-Jan-14	209	0.5	300	300	4.90	9.4E+01																				
29-Jan-14	210	0.5	300	295	5.04	8.7E+01																				
5-Feb-14	211	0.5	300	300	5.12	8.8E+01																				
12-Feb-14	212	0.5	300	295	5.06	8.4E+01	#N/A	3.7E-01	5.9E-03	1.5E+00	1.2E-02	3.5E-03	1.8E-02	1.3E+00	8.9E-03	1.2E-05	1.2E-05	3.1E-03	1.0E-05	5.9E-07	5.2E-04	1.3E-05	3.7E-01	3.0E-05	4.5E-04	4.5E-02
19-Feb-14	213	0.5	300	295	5.19	8.8E+01																				
26-Feb-14	214	0.5	300	300	4.94	9.4E+01	#N/A	5.4E-01	6.1E-02	1.5E+00	1.2E-02	3.6E-03	1.8E-02	1.3E+00	9.1E-03	1.2E-05	1.2E-05	3.2E-03	9.0E-06	6.0E-07	4.3E-04	1.3E-05	3.8E-01	3.0E-05	4.1E-04	4.2E-02

Col 1

Sample = FB2 +#4 + FB2 -#4 Composite

Date	Cycle No.	Approxi. Flow Rate (mL/min)	Fe mg/kg	Pb mg/kg	Li mg/kg	Mg mg/kg	Mn mg/kg	Hg mg/kg	Mo mg/kg	Ni mg/kg	P mg/kg	K mg/kg	Se mg/kg	Si mg/kg	Ag mg/kg	Na mg/kg	Sr mg/kg	S mg/kg	Tl mg/kg	Sn mg/kg	Ti mg/kg	U mg/kg	V mg/kg	Zn mg/kg	Zr mg/kg
27-Jan-10	1	0.5	9.5E-02	6.2E-05	1.2E-03	5.4E-01	4.7E-02	2.8E-05	4.6E-03	6.6E-04	8.8E-03	1.1E+00	7.7E-04	2.6E+00	5.7E-05	1.6E+01	1.5E-02	8.3E+00	2.5E-05	1.9E-06	2.4E-04	1.1E-03	6.9E-05	8.4E-03	6.6E-05
3-Feb-10	2	0.5	2.0E-02	1.8E-05	4.7E-04	1.7E-01	1.8E-02	2.0E-05	2.3E-03	2.9E-04	1.0E-03	5.0E-01	6.2E-04	1.8E+00	1.0E-06	8.9E+00	5.0E-03	5.4E+00	1.6E-05	3.1E-05	9.9E-05	4.7E-04	2.8E-05	3.8E-03	2.2E-05
10-Feb-10	3	0.5	7.7E-03	4.8E-06	2.9E-04	8.1E-02	8.9E-03	4.8E-07	1.3E-03	1.3E-04	1.4E-03	3.7E-01	3.9E-04	1.3E+00	9.6E-07	5.9E+00	2.6E-03	4.7E+00	9.6E-06	1.2E-05	8.6E-05	1.3E-04	1.4E-05	1.7E-03	5.3E-06
17-Feb-10	4	0.5	6.9E-03	6.9E-06	2.5E-04	7.4E-02	8.8E-03	6.3E-07	1.8E-03	1.5E-04	1.9E-03	4.3E-01	5.1E-04	1.7E+00	1.3E-06	6.4E+00	2.5E-03	5.2E+00	1.3E-05	5.7E-06	1.1E-04	1.3E-04	1.3E-05	1.9E-03	5.7E-06
24-Feb-10	5	0.5																							
3-Mar-10	6	0.5	3.9E-03	8.5E-06	2.0E-04	4.8E-02	5.7E-03	6.5E-07	1.7E-03	1.2E-04	1.3E-03	3.3E-01	3.8E-04	1.5E+00	6.5E-07	5.7E+00	1.6E-03	4.3E+00	1.3E-05	4.6E-05	5.2E-05	8.5E-05	9.8E-06	1.2E-03	4.6E-06
10-Mar-10	7	0.5																							
17-Mar-10	8	0.5	2.3E-03	7.4E-06	1.7E-04	3.8E-02	4.6E-03	4.0E-06	1.3E-03	6.3E-05	1.1E-03	2.6E-01	2.4E-04	1.4E+00	1.1E-06	4.3E+00	1.3E-03	3.4E+00	1.1E-05	5.7E-07	4.6E-05	5.1E-05	5.1E-06	7.4E-04	2.3E-06
24-Mar-10	9	0.5																							
31-Mar-10	10	0.5	1.9E-03	4.3E-06	1.2E-04	3.8E-02	4.3E-03	4.3E-06	1.4E-03	7.4E-05	2.5E-03	2.7E-01	2.6E-04	1.3E+00	3.7E-06	6.0E+00	1.3E-03	3.4E+00	1.2E-05	9.9E-06	5.6E-05	5.4E-05	5.0E-06	1.1E-03	3.1E-06
7-Apr-10	11	0.5																							
14-Apr-10	12	0.5	1.9E-03	1.1E-05	1.2E-04	3.4E-02	4.0E-03	6.2E-07	1.2E-03	6.8E-05	2.5E-03	2.8E-01	2.6E-04	1.3E+00	2.5E-06	3.6E+00	1.2E-03	2.9E+00	1.2E-05	1.1E-05	2.5E-05	5.9E-05	8.1E-06	9.3E-04	3.7E-06
21-Apr-10	13	0.5																							
28-Apr-10	14	0.5	1.5E-03	5.9E-05	7.7E-05	3.5E-02	4.0E-03	2.3E-06	1.4E-03	6.2E-05	2.3E-03	2.5E-01	2.6E-04	1.2E+00	2.3E-06	3.4E+00	1.3E-03	2.7E+00	1.5E-05	1.2E-05	3.1E-05	4.9E-05	5.4E-06	8.5E-04	1.5E-06
5-May-10	15	0.5																							
12-May-10	16	0.5	1.2E-03	1.9E-06	6.4E-05	2.9E-02	3.2E-03	1.3E-06	1.2E-03	7.7E-05	2.6E-03	2.3E-01	1.9E-04	1.3E+00	4.2E-05	3.1E+00	9.9E-04	2.5E+00	1.3E-05	1.4E-05	2.6E-05	3.8E-05	3.2E-06	6.4E-04	3.8E-06
19-May-10	17	0.5																							
26-May-10	18	0.5	9.5E-04	3.4E-06	1.4E-04	2.7E-02	3.1E-03	2.0E-06	1.3E-03	4.8E-05	2.7E-03	2.1E-01	1.8E-04	1.2E+00	2.7E-06	2.6E+00	9.5E-04	2.1E+00	1.4E-05	2.2E-05	2.0E-05	4.1E-05	4.8E-06	7.5E-04	1.4E-06
2-Jun-10	19	0.5																							
9-Jun-10	20	0.5	8.7E-04	4.3E-06	6.2E-05	2.8E-02	2.8E-03	6.2E-07	1.1E-03	5.0E-05	8.7E-04	2.0E-01	1.5E-04	1.1E+00	9.9E-06	2.5E+00	1.1E-03	2.0E+00	1.2E-05	3.2E-05	1.9E-05	2.7E-05	6.2E-06	8.7E-04	2.5E-06
16-Jun-10	21	0.5																							
23-Jun-10	22	0.5	1.0E-03	1.7E-05	1.1E-04	2.6E-02	3.0E-03	5.7E-07	1.2E-03	6.8E-05	1.3E-03	2.2E-01	1.5E-04	1.2E+00	8.6E-06	2.3E+00	9.3E-04	1.9E+00	1.1E-05	6.3E-05	2.3E-05	2.4E-05	4.0E-06	6.8E-04	1.7E-06
30-Jun-10	23	0.5																							
7-Jul-10	24	0.5	9.1E-04	1.0E-05	1.3E-04	2.7E-02	3.2E-03	6.5E-07	1.1E-03	1.4E-04	2.5E-03	2.3E-01	1.8E-04	1.2E+00	8.5E-06	2.2E+00	1.0E-03	1.9E+00	1.3E-05	3.6E-05	2.6E-05	2.6E-05	2.6E-06	7.2E-04	1.3E-06
14-Jul-10	25	0.5																							
21-Jul-10	26	0.5	6.6E-04	3.6E-06	6.0E-05	2.6E-02	2.9E-03	6.0E-07	9.8E-04	6.0E-05	1.9E-03	2.3E-01	1.3E-04	1.2E+00	8.4E-06	1.9E+00	9.5E-04	1.6E+00	1.2E-05	8.9E-05	1.8E-05	2.2E-05	2.4E-06	6.6E-04	1.2E-06
28-Jul-10	27	0.5																							
4-Aug-10	28	0.5	6.4E-04	1.7E-06	1.2E-04	2.5E-02	2.8E-03	1.2E-06	9.2E-04	4.1E-05	1.6E-03	2.0E-01	1.0E-04	1.1E+00	2.3E-06	1.8E+00	9.2E-04	1.5E+00	1.2E-05	8.7E-05	1.7E-05	2.2E-05	6.4E-06	5.8E-04	5.8E-07
11-Aug-10	29	0.5																							
18-Aug-10	30	0.5	2.4E-04	4.8E-06	1.2E-04	2.5E-02	2.8E-03	6.0E-07	9.2E-04	4.8E-05	8.4E-04	2.1E-01	9.8E-05	1.2E+00	3.6E-06	1.7E+00	8.9E-04	2.0E+00	1.2E-05	7.4E-05	1.8E-05	2.3E-05	6.0E-06	7.2E-04	6.0E-07
25-Aug-10	31	0.5																							
1-Sep-10	32	0.5	1.2E-04	6.7E-06	6.1E-05	2.4E-02	2.3E-03	6.1E-07	8.7E-04	4.9E-05	1.6E-03	2.2E-01	9.1E-05	1.2E+00	7.3E-06	1.3E+00	8.2E-04	1.4E+00	1.2E-05	8.1E-05	2.4E-05	2.1E-05	4.3E-06	7.9E-04	6.1E-07
8-Sep-10	33	0.5																							
15-Sep-10	34	0.5	5.7E-04	2.7E-05	1.3E-04	2.8E-02	3.2E-03	6.3E-07	8.1E-04	4.4E-05	5.7E-04	2.0E-01	8.8E-05	1.1E+00	6.3E-06	1.3E+00	9.8E-04	1.3E+00	1.3E-05	8.1E-05	1.9E-05	2.1E-05	1.9E-06	6.9E-04	1.9E-06
22-Sep-10	35	0.5																							
29-Sep-10	36	0.5	1.3E-04	2.1E-05	1.3E-04	2.9E-02	3.3E-03	1.3E-06	7.7E-04	7.8E-05	2.0E-03	2.4E-01	1.2E-04	1.3E+00	7.2E-06	1.4E+00	1.0E-03	1.5E+00	1.3E-05	1.3E-04	7.8E-05	2.1E-05	2.6E-06	1.2E-03	2.0E-06
6-Oct-10	37	0.5																							
13-Oct-10	38	0.5	5.9E-04	3.9E-05	5.9E-05	3.3E-02	3.9E-03	5.9E-07	8.1E-04	5.3E-05	2.2E-03	2.3E-01	7.6E-05	1.3E+00	3.5E-06	1.2E+00	1.1E-03	1.2E+00	1.2E-05	9.3E-05	2.2E-04	1.8E-05	3.5E-06	7.1E-04	4.7E-06
20-Oct-10	39	0.5																							
27-Oct-10	40	0.5	2.1E-03	1.8E-05	7.0E-05	2.9E-02	3.3E-03	7.0E-07	8.6E-04	9.8E-05	1.8E-03	2.2E-01	1.2E-04	1.2E+00	2.1E-06	1.2E+00	1.1E-03	1.2E+00	1.4E-05	8.4E-05	2.9E-04	2.0E-05	2.1E-06	1.3E-03	7.0E-07
3-Nov-10	41	0.5																							
10-Nov-10	42	0.5																							
17-Nov-10	43	0.5																							
24-Nov-10	44	0.5	4.1E-04	4.1E-06	6.8E-05	3.0E-02	3.6E-03	6.8E-07	6.5E-04	4.8E-05	6.1E-04	2.1E-01	8.4E-05	1.1E+00	3.4E-06	9.7E-01	1.1E-03	9.2E-01	1.4E-05	5.3E-05	4.1E-05	1.9E-05	2.0E-06	1.2E-03	6.8E-07
1-Dec-10	45	0.5																							
8-Dec-10	46	0.5																							
15-Dec-10	47	0.5																							
22-Dec-10	48	0.5	3.9E-04	3.9E-04	1.3E-04	3.5E-02	3.9E-03	6.5E-07	6.6E-04	6.5E-05	2.8E-03	2.4E-01	6.4E-05	1.3E+00	3.3E-06	8.0E-01	1.3E-03	1.2E+00	1.3E-05	9.2E-05	3.3E-05	2.0E-05	3.9E-06	1.4E-03	6.5E-07
29-Dec-10	49	0.5																							
5-Jan-11	50	0.5																							
12-Jan-11	51	0.5																							
19-Jan-11	52	0.5	4.1E-04	3.4E-06	1.4E-04	3.7E-02	4.3E-03	6.8E-07	4.8E-04	6.8E-05	1.4E-03	2.3E-01	1.7E-05	1.1E+00	2.7E-06	5.4E-01	1.4E-03	7.3E-01	1.4E-05	4.4E-05	1.4E-05	1.8E-05	3.4E-06	1.0E-03	6.8E-07
26-Jan-11	53	0.5																							
2-Feb-11	54	0.5																							
9-Feb-11	55	0.5																							

Col 1

Sample = FB2 +#4 + FB2 -#4 Composite

Date	Cycle No.	Approxi. Flow Rate (mL/min)	Fe mg/kg	Pb mg/kg	Li mg/kg	Mg mg/kg	Mn mg/kg	Hg mg/kg	Mo mg/kg	Ni mg/kg	P mg/kg	K mg/kg	Se mg/kg	Si mg/kg	Ag mg/kg	Na mg/kg	Sr mg/kg	S mg/kg	Tl mg/kg	Sn mg/kg	Ti mg/kg	U mg/kg	V mg/kg	Zn mg/kg	Zr mg/kg
16-Feb-11	56	0.5	3.8E-04	1.3E-04	1.5E-04	4.2E-02	4.8E-03	7.5E-07	4.6E-04	7.5E-05	6.8E-04	2.3E-01	3.1E-05	1.1E+00	3.0E-06	4.4E-01	1.6E-03	6.6E-01	1.5E-05	3.5E-05	1.5E-05	2.0E-05	2.3E-06	1.7E-03	7.5E-07
23-Feb-11	57	0.5																							
2-Mar-11	58	0.5																							
9-Mar-11	59	0.5																							
16-Mar-11	60	0.5	2.0E-04	6.8E-05	1.3E-04	4.2E-02	4.6E-03	6.5E-07	3.4E-04	1.0E-04	1.2E-03	2.1E-01	2.9E-05	9.8E-01	2.6E-06	2.2E-01	1.6E-03	5.8E-01	1.3E-05	4.3E-05	1.3E-05	1.9E-05	2.0E-06	1.1E-03	6.5E-07
23-Mar-11	61	0.5																							
30-Mar-11	62	0.5																							
6-Apr-11	63	0.5																							
13-Apr-11	64	0.5	1.8E-04	1.4E-04	1.2E-04	5.2E-02	6.1E-03	6.0E-07	3.2E-04	1.2E-04	1.5E-03	2.4E-01	2.8E-05	9.5E-01	2.4E-06	1.7E-01	1.9E-03	5.7E-01	1.2E-05	1.7E-05	1.1E-04	2.3E-05	1.8E-06	1.4E-03	6.0E-07
20-Apr-11	65	0.5																							
27-Apr-11	66	0.5																							
4-May-11	67	0.5																							
11-May-11	68	0.5	4.6E-04	1.0E-05	1.3E-04	7.2E-02	8.3E-03	6.5E-07	6.1E-04	1.4E-04	5.9E-04	2.9E-01	2.0E-05	1.1E+00	5.9E-06	1.4E-01	2.7E-03	7.0E-01	1.3E-05	3.3E-05	2.6E-05	3.4E-05	2.0E-06	2.1E-03	1.3E-06
18-May-11	69	0.5																							
25-May-11	70	0.5																							
1-Jun-11	71	0.5																							
8-Jun-11	72	0.5	8.5E-04	9.1E-06	2.0E-04	8.3E-02	9.7E-03	6.5E-07	3.5E-04	1.8E-04	3.8E-03	3.1E-01	4.7E-05	1.2E+00	5.2E-06	1.2E-01	3.0E-03	7.4E-01	1.2E-05	2.6E-05	2.0E-05	3.4E-05	4.6E-06	2.7E-03	2.0E-06
15-Jun-11	73	0.5																							
22-Jun-11	74	0.5																							
29-Jun-11	75	0.5																							
6-Jul-11	76	0.5	3.9E-04	6.5E-06	2.0E-04	1.0E-01	1.1E-02	6.5E-07	3.6E-04	1.8E-04	5.9E-04	3.5E-01	4.8E-05	1.2E+00	2.6E-06	9.8E-02	3.7E-03	8.4E-01	1.2E-05	1.5E-05	1.3E-05	3.5E-05	2.0E-06	2.7E-03	6.5E-07
13-Jul-11	77	0.5																							
20-Jul-11	78	0.5																							
27-Jul-11	79	0.5																							
3-Aug-11	80	0.5	8.0E-05	5.8E-05	1.2E-04	6.4E-02	7.4E-03	4.0E-07	2.0E-04	1.3E-04	3.6E-04	2.0E-01	2.4E-05	6.2E-01	2.0E-06	4.5E-02	2.4E-03	5.0E-01	6.4E-06	7.2E-06	1.2E-05	2.3E-05	1.2E-06	1.7E-03	4.0E-07
10-Aug-11	81	0.5																							
17-Aug-11	82	0.5																							
24-Aug-11	83	0.5																							
31-Aug-11	84	0.5	4.8E-04	1.0E-05	2.0E-04	1.1E-01	1.2E-02	6.8E-07	4.1E-04	2.4E-04	6.1E-04	3.6E-01	8.8E-06	1.0E+00	1.1E-05	7.2E-02	4.1E-03	9.4E-01	1.3E-05	2.2E-05	3.4E-05	3.8E-05	2.0E-06	3.5E-03	6.8E-07
7-Sep-11	85	0.5																							
14-Sep-11	86	0.5																							
21-Sep-11	87	0.5																							
28-Sep-11	88	0.5	4.1E-04	1.5E-05	1.8E-04	9.8E-02	1.2E-02	5.9E-07	2.9E-04	1.9E-04	5.3E-04	2.9E-01	5.0E-05	8.8E-01	3.0E-06	5.5E-02	3.6E-03	7.8E-01	1.1E-05	1.9E-05	1.8E-05	3.5E-05	1.8E-06	2.6E-03	2.4E-06
5-Oct-11	89	0.5																							
12-Oct-11	90	0.5																							
19-Oct-11	91	0.5																							
26-Oct-11	92	0.5	8.1E-04	3.1E-06	1.9E-04	1.1E-01	1.3E-02	6.2E-07	3.1E-04	2.0E-04	5.6E-04	3.3E-01	4.0E-05	8.9E-01	3.1E-06	5.5E-02	4.1E-03	8.9E-01	1.2E-05	2.2E-05	2.5E-05	4.5E-05	1.9E-06	3.0E-03	6.2E-07
2-Nov-11	93	0.5																							
9-Nov-11	94	0.5																							
16-Nov-11	95	0.5																							
23-Nov-11	96	0.5	3.3E-04	9.0E-05	2.0E-04	1.1E-01	1.3E-02	6.6E-07	3.5E-04	2.1E-04	5.9E-04	3.2E-01	4.6E-05	9.2E-01	4.6E-06	5.1E-02	3.9E-03	8.2E-01	1.3E-05	1.6E-05	3.3E-05	7.0E-05	2.6E-05	3.0E-03	6.6E-07
30-Nov-11	97	0.5																							
7-Dec-11	98	0.5																							
14-Dec-11	99	0.5																							
21-Dec-11	100	0.5	3.9E-04	5.9E-06	2.0E-04	1.1E-01	1.2E-02	6.5E-07	2.8E-04	2.1E-04	5.9E-04	3.1E-01	2.7E-05	8.6E-01	3.3E-06	4.7E-02	4.0E-03	8.4E-01	1.0E-05	3.3E-06	3.3E-05	3.9E-05	2.2E-05	3.1E-03	6.5E-07
28-Dec-11	101	0.5																							
4-Jan-12	102	0.5																							
11-Jan-12	103	0.5																							
18-Jan-12	104	0.5	4.1E-04	2.0E-06	2.0E-04	1.1E-01	1.3E-02	1.4E-06	2.9E-04	1.9E-04	6.1E-04	3.0E-01	4.9E-05	8.5E-01	4.1E-06	4.6E-02	4.1E-03	8.5E-01	1.1E-05	1.5E-05	3.4E-05	4.1E-05	2.8E-05	2.9E-03	6.8E-07
25-Jan-12	105	0.5																							
1-Feb-12	106	0.5																							
8-Feb-12	107	0.5																							
15-Feb-12	108	0.5	3.0E-04	2.0E-04	2.4E-04	1.1E-01	1.3E-02	6.0E-07	2.6E-04	2.9E-04	6.0E-04	3.1E-01	4.3E-05	9.9E-01	3.6E-06	4.4E-02	4.1E-03	8.2E-01	1.1E-05	6.6E-06	5.4E-05	5.3E-05	2.6E-05	2.7E-03	6.0E-07
22-Feb-12	109	0.5																							
29-Feb-12	110	0.5																							
7-Mar-12	111	0.5																							

Col 1

Sample = FB2 +#4 + FB2 -#4 Composite

Date	Cycle No.	Approxi. Flow Rate (mL/min)	Fe mg/kg	Pb mg/kg	Li mg/kg	Mg mg/kg	Mn mg/kg	Hg mg/kg	Mo mg/kg	Ni mg/kg	P mg/kg	K mg/kg	Se mg/kg	Si mg/kg	Ag mg/kg	Na mg/kg	Sr mg/kg	S mg/kg	Tl mg/kg	Sn mg/kg	Ti mg/kg	U mg/kg	V mg/kg	Zn mg/kg	Zr mg/kg
14-Mar-12	112	0.5	3.6E-04	7.8E-06	1.8E-04	1.1E-01	1.3E-02	6.0E-07	2.9E-04	2.0E-04	7.8E-04	3.1E-01	4.3E-05	8.6E-01	4.2E-06	4.5E-02	4.1E-03	8.2E-01	1.0E-05	2.3E-05	6.0E-06	4.2E-05	1.8E-06	2.8E-03	6.0E-07
21-Mar-12	113	0.5																							
28-Mar-12	114	0.5																							
4-Apr-12	115	0.5																							
11-Apr-12	116	0.5	2.4E-04	1.7E-05	2.4E-04	1.1E-01	1.2E-02	1.2E-06	3.7E-04	2.6E-04	5.4E-04	3.0E-01	1.1E-03	8.9E-01	7.8E-06	5.0E-02	3.9E-03	8.1E-01	1.1E-05	2.0E-05	5.4E-05	4.2E-05	1.6E-05	3.0E-03	6.0E-07
18-Apr-12	117	0.5																							
25-Apr-12	118	0.5																							
2-May-12	119	0.5																							
9-May-12	120	0.5	4.0E-04	1.2E-05	2.0E-04	1.1E-01	1.3E-02	6.7E-07	2.8E-04	2.1E-04	6.0E-04	2.9E-01	4.2E-05	7.8E-01	4.0E-06	4.4E-02	4.2E-03	8.0E-01	1.1E-05	3.1E-05	2.0E-05	4.2E-05	2.3E-05	2.9E-03	6.7E-07
16-May-12	121	0.5																							
23-May-12	122	0.5																							
30-May-12	123	0.5																							
6-Jun-12	124	0.5	3.8E-04	1.3E-06	1.9E-04	1.1E-01	1.3E-02	6.4E-07	2.4E-04	2.0E-04	5.8E-04	3.0E-01	4.3E-05	8.8E-01	3.2E-06	4.5E-02	4.2E-03	8.4E-01	1.0E-05	7.0E-06	1.9E-05	4.2E-05	2.7E-05	2.7E-03	6.4E-07
13-Jun-12	125	0.5																							
20-Jun-12	126	0.5																							
27-Jun-12	127	0.5																							
4-Jul-12	128	0.5	2.4E-04	6.6E-06	1.8E-04	9.8E-02	1.2E-02	6.0E-07	2.4E-04	2.0E-04	5.4E-04	2.8E-01	3.8E-05	8.7E-01	4.8E-06	4.3E-02	3.9E-03	7.5E-01	1.1E-05	3.6E-05	1.2E-05	5.1E-05	2.0E-05	2.8E-03	6.0E-07
11-Jul-12	129	0.5																							
18-Jul-12	130	0.5																							
25-Jul-12	131	0.5																							
1-Aug-12	132	0.5	6.6E-04	7.2E-06	1.8E-04	1.0E-01	1.2E-02	6.0E-07	2.0E-04	2.2E-04	5.4E-04	2.8E-01	3.6E-05	1.0E+00	4.2E-06	4.4E-02	4.0E-03	8.5E-01	9.6E-06	1.9E-05	1.8E-05	4.1E-05	3.1E-05	2.6E-03	6.0E-07
8-Aug-12	133	0.5																							
15-Aug-12	134	0.5																							
22-Aug-12	135	0.5																							
29-Aug-12	136	0.5	5.0E-04	6.4E-06	2.1E-04	1.1E-01	1.4E-02	2.1E-06	2.7E-04	2.3E-04	6.4E-04	2.9E-01	4.8E-05	9.2E-01	4.3E-06	4.8E-02	4.4E-03	8.4E-01	1.1E-05	2.3E-05	1.4E-05	4.6E-05	2.5E-05	3.2E-03	2.8E-06
5-Sep-12	137	0.5																							
12-Sep-12	138	0.5																							
19-Sep-12	139	0.5																							
26-Sep-12	140	0.5	1.9E-04	7.7E-06	1.9E-04	1.1E-01	1.2E-02	6.4E-07	4.9E-04	2.8E-04	5.8E-04	2.5E-01	2.6E-06	8.3E-01	2.6E-06	5.1E-02	4.0E-03	7.9E-01	1.9E-06	3.5E-05	1.3E-05	4.0E-05	3.3E-05	2.8E-03	1.9E-06
3-Oct-12	141	0.5																							
10-Oct-12	142	0.5																							
17-Oct-12	143	0.5																							
24-Oct-12	144	0.5	1.9E-04	1.9E-06	1.9E-04	1.0E-01	1.2E-02	6.2E-07	2.5E-04	2.6E-04	5.6E-04	2.6E-01	3.4E-05	9.0E-01	1.2E-06	4.7E-02	3.9E-03	7.8E-01	8.1E-06	2.3E-05	3.1E-05	3.9E-05	3.0E-05	2.7E-03	6.2E-07
31-Oct-12	145	0.5																							
7-Nov-12	146	0.5																							
14-Nov-12	147	0.5																							
21-Nov-12	148	0.5	2.5E-04	1.4E-04	1.5E-04	9.3E-02	1.1E-02	5.0E-07	1.9E-04	2.0E-04	4.5E-04	2.0E-01	2.4E-05	6.5E-01	5.5E-06	4.1E-02	3.6E-03	6.4E-01	7.5E-06	2.9E-05	4.0E-05	3.8E-05	2.7E-05	2.9E-03	5.0E-07
28-Nov-12	149	0.5																							
5-Dec-12	150	0.5																							
12-Dec-12	151	0.5																							
19-Dec-12	152	0.5	2.9E-04	5.1E-06	1.7E-04	9.6E-02	1.2E-02	5.7E-07	2.0E-04	2.1E-04	5.1E-04	2.2E-01	2.9E-05	6.0E-01	5.7E-06	4.5E-02	3.7E-03	6.9E-01	9.1E-06	1.5E-05	1.1E-05	4.1E-05	6.8E-06	2.7E-03	5.7E-07
26-Dec-12	153	0.5																							
2-Jan-13	154	0.5																							
9-Jan-13	155	0.5																							
16-Jan-13	156	0.5	3.7E-04	2.5E-06	1.9E-04	1.0E-01	1.2E-02	6.2E-07	4.1E-04	2.2E-04	5.6E-04	2.4E-01	3.0E-05	7.6E-01	4.3E-06	4.1E-02	4.0E-03	8.2E-01	9.3E-06	7.9E-05	1.2E-05	4.6E-05	2.3E-05	2.9E-03	2.2E-05
23-Jan-13	157	0.5																							
30-Jan-13	158	0.5																							
6-Feb-13	159	0.5																							
13-Feb-13	160	0.5	1.8E-04	5.3E-06	1.8E-04	1.0E-01	1.2E-02	5.9E-07	2.0E-04	2.1E-04	5.3E-04	2.4E-01	3.3E-05	8.2E-01	2.4E-06	4.7E-02	3.9E-03	6.9E-01	8.9E-06	7.7E-06	5.9E-06	4.5E-05	5.9E-06	3.0E-03	5.9E-07
20-Feb-13	161	0.5																							
27-Feb-13	162	0.5																							
6-Mar-13	163	0.5																							
13-Mar-13	164	0.5	2.4E-04	1.8E-06	1.8E-04	1.0E-01	1.2E-02	5.9E-07	2.1E-04	1.9E-04	5.3E-04	2.3E-01	6.9E-05	7.6E-01	1.2E-06	4.6E-02	3.8E-03	7.6E-01	8.3E-06	7.7E-06	5.9E-06	3.8E-05	2.4E-06	2.5E-03	5.9E-07
20-Mar-13	165	0.5																							
27-Mar-13	166	0.5																							
3-Apr-13	167	0.5																							

Col 1

Sample = FB2 +#4 + FB2 -#4 Composite

Date	Cycle No.	Approxi. Flow Rate (mL/min)	Fe mg/kg	Pb mg/kg	Li mg/kg	Mg mg/kg	Mn mg/kg	Hg mg/kg	Mo mg/kg	Ni mg/kg	P mg/kg	K mg/kg	Se mg/kg	Si mg/kg	Ag mg/kg	Na mg/kg	Sr mg/kg	S mg/kg	Tl mg/kg	Sn mg/kg	Ti mg/kg	U mg/kg	V mg/kg	Zn mg/kg	Zr mg/kg
10-Apr-13	168	0.5	2.4E-04	1.1E-05	1.8E-04	9.8E-02	1.2E-02	6.1E-07	1.9E-04	2.0E-04	5.5E-04	2.2E-01	3.8E-05	8.2E-01	1.8E-06	5.3E-02	3.8E-03	7.2E-01	1.0E-05	1.7E-05	6.1E-06	3.9E-05	1.8E-06	2.8E-03	6.1E-07
17-Apr-13	169	0.5																							
24-Apr-13	170	0.5																							
1-May-13	171	0.5																							
8-May-13	172	0.5	2.4E-04	3.0E-06	1.8E-04	9.7E-02	1.2E-02	5.9E-07	1.8E-04	1.7E-04	1.1E-03	2.1E-01	2.6E-05	7.0E-01	3.0E-06	4.4E-02	3.8E-03	6.9E-01	7.7E-06	3.5E-06	1.8E-05	3.8E-05	3.0E-06	2.2E-03	5.9E-07
15-May-13	173	0.5																							
22-May-13	174	0.5																							
29-May-13	175	0.5																							
5-Jun-13	176	0.5	1.8E-04	7.8E-06	1.8E-04	9.9E-02	1.2E-02	6.0E-07	3.1E-04	3.3E-04	6.0E-04	2.2E-01	3.1E-05	7.7E-01	1.2E-06	4.6E-02	3.9E-03	7.0E-01	8.4E-06	7.8E-06	6.0E-06	4.3E-05	3.0E-06	2.8E-03	6.0E-07
12-Jun-13	177	0.5																							
19-Jun-13	178	0.5																							
26-Jun-13	179	0.5																							
3-Jul-13	180	0.5	1.8E-04	3.6E-06	1.8E-04	9.7E-02	1.2E-02	6.0E-07	1.8E-04	1.9E-04	5.4E-04	2.1E-01	2.9E-05	7.3E-01	2.4E-06	5.0E-02	3.9E-03	6.9E-01	7.2E-06	7.2E-06	6.0E-06	3.5E-05	3.0E-06	2.5E-03	6.0E-07
10-Jul-13	181	0.5																							
17-Jul-13	182	0.5																							
24-Jul-13	183	0.5																							
31-Jul-13	184	0.5	1.8E-04	4.2E-06	1.8E-04	9.6E-02	1.2E-02	6.0E-07	1.9E-04	2.0E-04	5.4E-04	2.0E-01	2.8E-04	7.8E-01	1.8E-06	4.6E-02	3.9E-03	7.0E-01	7.2E-06	1.1E-05	6.0E-06	3.8E-05	3.0E-06	2.9E-03	6.0E-07
7-Aug-13	185	0.5																							
14-Aug-13	186	0.5																							
21-Aug-13	187	0.5																							
28-Aug-13	188	0.5	1.8E-04	4.2E-06	1.8E-04	9.2E-02	1.1E-02	6.0E-07	1.8E-04	1.9E-04	5.4E-04	1.9E-01	3.1E-05	7.4E-01	3.0E-06	4.6E-02	3.9E-03	6.2E-01	6.6E-06	1.9E-04	6.0E-06	3.6E-05	1.4E-05	2.5E-03	6.0E-07
4-Sep-13	189	0.5																							
11-Sep-13	190	0.5																							
18-Sep-13	191	0.5																							
25-Sep-13	192	0.5	1.7E-04	3.7E-04	1.7E-04	9.0E-02	1.1E-02	5.8E-07	1.9E-04	2.0E-04	7.5E-04	1.9E-01	2.6E-05	6.8E-01	2.9E-06	4.6E-02	3.5E-03	6.4E-01	7.5E-06	9.3E-06	5.8E-06	3.9E-05	2.9E-06	2.5E-03	5.8E-07
2-Oct-13	193	0.5																							
9-Oct-13	194	0.5																							
16-Oct-13	195	0.5																							
23-Oct-13	196	0.5	2.4E-04	9.9E-04	1.8E-04	9.0E-02	1.1E-02	6.1E-07	1.8E-04	2.1E-04	5.5E-04	1.8E-01	3.1E-05	7.4E-01	1.8E-06	4.7E-02	3.5E-03	6.5E-01	7.3E-06	9.8E-06	6.1E-06	3.8E-05	3.7E-06	2.6E-03	6.1E-07
30-Oct-13	197	0.5																							
6-Nov-13	198	0.5																							
13-Nov-13	199	0.5																							
20-Nov-13	200	0.5	1.8E-04	1.7E-05	1.8E-04	9.3E-02	1.1E-02	5.9E-07	1.6E-04	2.8E-04	5.3E-04	1.8E-01	4.0E-05	7.2E-01	2.4E-06	4.8E-02	3.5E-03	6.2E-01	1.7E-05	2.4E-05	1.2E-05	3.4E-05	3.0E-06	2.5E-03	5.9E-07
27-Nov-13	201	0.5																							
4-Dec-13	202	0.5																							
11-Dec-13	203	0.5																							
18-Dec-13	204	0.5	4.1E-04	1.8E-06	1.8E-04	9.0E-02	1.0E-02	5.9E-07	2.1E-04	1.5E-04	5.3E-04	1.8E-01	2.6E-05	7.4E-01	1.8E-06	5.4E-02	3.4E-03	6.2E-01	7.1E-06	1.1E-05	1.2E-05	3.4E-05	3.0E-06	2.4E-03	5.9E-07
25-Dec-13	205	0.5																							
1-Jan-14	206	0.5																							
8-Jan-14	207	0.5																							
15-Jan-14	208	0.5	3.1E-04	5.5E-06	1.8E-04	9.5E-02	1.1E-02	6.1E-07	1.5E-04	2.2E-04	5.5E-04	1.8E-01	2.7E-05	7.5E-01	3.1E-06	5.6E-02	3.8E-03	7.3E-01	7.3E-06	6.7E-06	1.2E-05	4.6E-05	4.9E-06	2.4E-03	6.1E-07
22-Jan-14	209	0.5																							
29-Jan-14	210	0.5																							
5-Feb-14	211	0.5																							
12-Feb-14	212	0.5	1.8E-04	2.2E-05	1.8E-04	8.7E-02	1.0E-02	5.9E-07	1.5E-04	1.9E-04	6.5E-04	1.7E-01	2.0E-05	7.4E-01	2.4E-06	4.9E-02	3.3E-03	6.1E-01	5.9E-06	4.7E-06	1.8E-05	3.1E-05	5.3E-06	2.4E-03	5.9E-07
19-Feb-14	213	0.5																							
26-Feb-14	214	0.5	1.8E-04	1.8E-06	1.2E-04	8.9E-02	1.0E-02	6.0E-07	1.5E-04	1.7E-04	6.0E-04	1.7E-01	3.1E-05	7.7E-01	3.0E-06	5.2E-02	3.4E-03	6.2E-01	6.0E-06	1.0E-05	6.0E-06	3.0E-05	1.8E-06	2.1E-03	6.0E-07

Col 2A

Sample = (08-135 to 08-263) Composite

Date	Cycle	Approxi.	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Cl	F	Br	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Flow Rate	Input	Output		umhos/cm	(pH 4.5)	(pH 8.3)						CaCO3												
		(mL/min)					mgCaCO3/L	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
27-Jan-10	1	0.5	960	415	4.77	1.1E+03	#N/A	4.8E+01	<0.1	5.4E+02	6.8E+01	1.1E+00	8.0E-01	1.3E+02	2.3E+00	1.5E-02	3.4E-03	4.3E-02	1.9E-04	8.0E-05	8.5E-02	1.4E-03	3.9E+01	1.6E-02	2.1E-02	7.4E-01
3-Feb-10	2	0.5	300	340	5.62	4.9E+02	#N/A	1.0E+01	3.4E+00	2.3E+02	1.8E+01	2.9E-01	3.0E-01	2.9E+01	3.2E-01	8.3E-03	2.0E-03	2.8E-02	5.0E-05	2.0E-05	5.7E-02	4.4E-04	8.5E+00	7.7E-03	7.0E-03	2.3E-01
10-Feb-10	3	0.5	300	265	5.23	5.3E+02	#N/A	9.1E+00	1.3E+00	2.2E+02	7.4E+00	1.7E-01	3.0E-01	2.9E+01	1.5E-01	5.8E-03	1.2E-03	2.9E-02	6.0E-05	1.0E-05	6.7E-02	3.9E-04	8.5E+00	4.0E-03	7.2E-03	1.5E-01
17-Feb-10	4	0.5	300	300	5.03	4.2E+02	#N/A	8.6E+00	5.5E-01	1.9E+02	3.2E+00	1.5E-01	3.0E-01	2.4E+01	1.1E-01	4.8E-03	1.1E-03	2.7E-02	2.0E-05	2.0E-05	6.4E-02	3.6E-04	7.2E+00	3.1E-03	7.0E-03	1.4E-01
24-Feb-10	5	0.5	300	300	5.01	3.8E+02				1.6E+02																
3-Mar-10	6	0.5	300	295	5.17	3.3E+02	#N/A	6.9E+00	5.2E-01	1.5E+02	1.3E+00	1.2E-01	3.0E-01	1.7E+01	6.9E-02	3.2E-03	8.0E-04	2.5E-02	5.0E-05	1.0E-05	4.9E-02	2.3E-04	4.9E+00	2.7E-03	5.1E-03	1.1E-01
10-Mar-10	7	0.5	300	295	5.60	2.9E+02				1.2E+02																
17-Mar-10	8	0.5	300	320	4.96	2.7E+02	#N/A	7.8E+00	1.1E+00	1.0E+02	1.2E+00	1.0E-01	3.0E-01	1.4E+01	6.9E-02	2.4E-03	6.0E-04	2.8E-02	5.0E-05	1.0E-05	4.0E-02	2.3E-04	4.2E+00	1.9E-03	3.9E-03	8.8E-02
24-Mar-10	9	0.5	300	310	5.45	2.3E+02				1.0E+02																
31-Mar-10	10	0.5	300	315	5.23	2.0E+02	#N/A	6.9E+00	6.5E-01	1.0E+02	6.0E-01	1.0E-01	3.0E-01	1.2E+01	5.7E-02	2.2E-03	8.0E-04	3.1E-02	4.0E-05	1.0E-05	2.8E-02	1.8E-04	3.4E+00	2.2E-03	3.2E-03	9.1E-02
7-Apr-10	11	0.5	300	310	5.58	1.9E+02				7.8E+01																
14-Apr-10	12	0.5	300	295	5.12	1.7E+02	#N/A	7.4E+00	4.8E-01	6.8E+01	5.0E-01	9.0E-02	3.0E-01	1.0E+01	7.5E-02	2.0E-03	6.0E-04	3.7E-02	5.0E-05	3.0E-05	2.7E-02	2.3E-04	3.0E+00	1.5E-03	3.1E-03	9.4E-02
21-Apr-10	13	0.5	300	335	5.19	1.8E+02				7.6E+01																
28-Apr-10	14	0.5	300	330	4.93	1.7E+02	#N/A	4.4E+00	3.2E-01	6.8E+01	5.0E-01	8.0E-02	3.0E-01	1.2E+01	8.7E-02	1.7E-03	7.0E-04	4.1E-02	4.0E-05	1.0E-05	2.5E-02	1.8E-04	3.5E+00	1.7E-03	3.6E-03	9.6E-02
5-May-10	15	0.5	300	275	4.81	1.9E+02				8.1E+01																
12-May-10	16	0.5	300	300	5.46	2.0E+02	#N/A	6.4E+00	9.3E-01	7.8E+01	5.0E-01	1.1E-01	3.0E-01	2.0E+01	7.7E-02	1.7E-03	4.0E-04	4.6E-02	6.0E-05	1.0E-05	2.9E-02	3.0E-04	5.8E+00	1.7E-03	5.6E-03	1.4E-01
19-May-10	17	0.5	300	280	5.30	2.0E+02				6.5E+01																
26-May-10	18	0.5	300	310	5.38	1.9E+02	#N/A	9.6E+00	1.2E+00	6.5E+01	5.0E-01	1.1E-01	3.0E-01	2.4E+01	9.7E-02	1.4E-03	1.1E-03	5.1E-02	8.0E-05	1.0E-05	2.7E-02	3.8E-04	7.1E+00	1.6E-03	7.8E-03	1.9E-01
2-Jun-10	19	0.5	300	345	5.36	1.8E+02				5.6E+01																
9-Jun-10	20	0.5	300	335	5.48	1.9E+02	#N/A	7.5E+00	2.0E+00	6.4E+01	4.0E-01	1.3E-01	3.0E-01	2.8E+01	1.3E-01	1.1E-03	6.0E-04	5.6E-02	1.0E-04	1.0E-05	2.3E-02	4.7E-04	8.4E+00	1.4E-03	9.1E-03	2.7E-01
16-Jun-10	21	0.5	300	350	5.48	1.8E+02				4.9E+01																
23-Jun-10	22	0.5	300	290	5.35	2.1E+02	#N/A	8.1E+00	9.1E-01	6.9E+01	5.0E-01	6.0E-02	3.0E-01	3.8E+01	1.6E-01	1.5E-03	3.0E-04	4.9E-02	1.5E-04	1.0E-05	2.4E-02	6.4E-04	1.1E+01	1.5E-03	1.2E-02	3.8E-01
30-Jun-10	23	0.5	300	365	5.62	1.7E+02				6.8E+01																
7-Jul-10	24	0.5	300	290	5.55	1.9E+02	#N/A	6.9E+00	1.1E+00	5.9E+01	4.0E-01	1.4E-01	3.0E-01	3.5E+01	1.4E-01	1.1E-03	5.0E-04	4.6E-02	1.6E-04	1.0E-05	2.1E-02	6.8E-04	9.9E+00	1.4E-03	1.3E-02	3.9E-01
14-Jul-10	25	0.5	300	275	5.44	1.8E+02				5.1E+01																
21-Jul-10	26	0.5	300	300	5.28	1.8E+02	#N/A	1.0E+01	1.1E+00	5.7E+01	4.0E-01	1.4E-01	3.0E-01	4.1E+01	1.8E-01	8.0E-04	5.0E-04	4.3E-02	1.8E-04	1.0E-05	1.8E-02	7.9E-04	1.2E+01	1.3E-03	1.5E-02	4.4E-01
28-Jul-10	27	0.5	300	285	5.54	1.8E+02				4.7E+01																
4-Aug-10	28	0.5	300	285	5.66	1.7E+02	#N/A	9.2E+00	1.1E+00	5.9E+01	4.0E-01	1.6E-01	3.0E-01	4.4E+01	1.7E-01	9.0E-04	3.0E-04	4.3E-02	1.7E-04	1.0E-05	3.9E-02	7.6E-04	1.3E+01	1.3E-03	1.5E-02	4.5E-01
11-Aug-10	29	0.5	300	360	5.81	1.6E+02				6.1E+01																
18-Aug-10	30	0.5	300	340	5.69	1.4E+02	#N/A	1.0E+01	1.3E+00	4.7E+01	3.0E-01	1.1E-01	3.0E-01	3.4E+01	1.5E-01	8.0E-04	5.0E-04	4.7E-02	1.6E-04	1.0E-05	1.7E-02	6.0E-04	1.0E+01	8.0E-04	1.2E-02	3.8E-01
25-Aug-10	31	0.5	300	370	5.55	1.3E+02				3.8E+01																
1-Sep-10	32	0.5	300	365	5.73	1.3E+02	#N/A	7.9E+00	1.6E+00	5.8E+01	4.0E-01	1.1E-01	3.0E-01	3.6E+01	1.4E-01	7.0E-04	3.0E-04	5.5E-02	1.6E-04	1.0E-05	1.5E-02	6.8E-04	1.1E+01	6.0E-04	1.3E-02	3.8E-01
8-Sep-10	33	0.5	300	360	5.53	1.5E+02				5.9E+01																
15-Sep-10	34	0.5	300	345	5.19	1.4E+02	#N/A	7.4E+00	5.1E-01	6.2E+01	4.0E-01	1.4E-01	3.0E-01	4.1E+01	1.8E-01	1.0E-03	2.0E-04	5.9E-02	1.7E-04	2.0E-05	1.5E-02	7.1E-04	1.2E+01	1.2E-03	1.4E-02	4.5E-01
22-Sep-10	35	0.5	300	365	5.43	1.3E+02				6.5E+01																
29-Sep-10	36	0.5	300	340	5.43	1.2E+02	#N/A	6.4E+00	1.2E+00	5.9E+01	4.0E-01	1.5E-01	3.0E-01	4.1E+01	1.6E-01	3.8E-03	7.0E-04	5.4E-02	1.9E-04	1.0E-05	1.6E-02	8.3E-04	1.2E+01	8.0E-04	1.6E-02	5.2E-01
6-Oct-10	37	0.5	300	305	5.42	1.5E+02				5.7E+01																
13-Oct-10	38	0.5	300	330	5.19	1.4E+02	#N/A	7.3E+00	4.4E-01	5.0E+01	3.0E-01	1.3E-01	3.0E-01	4.0E+01	1.4E-01	9.0E-04	2.0E-04	6.0E-02	2.0E-04	1.0E-05	1.7E-02	7.1E-04	1.2E+01	5.0E-04	1.4E-02	4.6E-01
20-Oct-10	39	0.5	300	300	5.46	1.4E+02				5.3E+01																
27-Oct-10	40	0.5	300	400	5.50	1.2E+02	#N/A	5.0E+00	7.6E-01	4.7E+01	2.0E-01	1.3E-01	3.0E-01	3.1E+01	1.3E-01	6.0E-04	2.0E-04	4.9E-02	1.5E-04	1.0E-05	1.5E-02	6.2E-04	9.2E+00	5.0E-04	1.3E-02	4.2E-01
3-Nov-10	41	0.5	300	300	5.69	1.5E+02																				
10-Nov-10	42	0.5	300	375	5.30	1.3E+02																				
17-Nov-10	43	0.5	300	400	5.67	1.5E+02																				
24-Nov-10	44	0.5	300	380	5.41	1.1E+02	#N/A	5.6E+00	6.7E-01	4.4E+01	2.0E-01	1.1E-01	3.0E-01	2.9E+01	1.2E-01	6.0E-04	4.0E-04	6.4E-02	1.5E-04	1.0E-05	1.3E-02	5.9E-04	8.9E+00	7.0E-04	1.1E-02	4.0E-01
1-Dec-10	45	0.5	300	345	5.63	1.2E+02																				
8-Dec-10	46	0.5	300	370	5.34	1.1E+02																				
15-Dec-10	47	0.5	300	380	5.64	1.0E+02																				
22-Dec-10	48	0.5	300	375	5.85	1.0E+02	#N/A	6.8E+00	2.4E+00	4.1E+01	2.0E-01	1.2E-01	3.0E-01	3.0E+01	1.1E-01	1.3E-03	3.0E-04	7.0E-02	1.4E-04	1.0E-05	1.3E-02	5.4E-04	8.9E+00	6.0E-04	1.0E-02	3.7E-01
29-Dec-10	49	0.5	300	380	5.67	7.8E+01																				
5-Jan-11	50	0.5	300	400	5.51	9.3E+01																				
12-Jan-11	51	0.5	300	360	5.58	8.9E+01																				
19-Jan-11	52	0.5	300	330	5.60	9.3E+01	#N/A	6.5E+00	1.9E+00	3.7E+01	2.0E-01	1.1E-01	3.0E-01	2.7E+01	9.7E-02	7.0E-04	3.0E-04	7.4E-02	1.2E-04	1.0E-05	9.8E-03	4.8E-04	8.1E+00	5.0E-04	9.3E-03	3.3E-01
26-Jan-11	53	0.5	300	285	5.60	9.9E+01																				
2-Feb-11	54	0.5	300	315	5.30	8.8E+01																				
9-Feb-11	55	0.5	300	370	5.52	7.8E+01																				
16-Feb-11	56	0.5	300	420	5.65	7.3E+01	#N/A	4.6E+00	7.9E-01	2.5E+01	3.0E-01	6.0E-02	3.0E-01	1.9E+01	6.6E-02	4.0E-04	2.0E-04	6.7E-02	1.0E-04	1.0E-05	1.3E-02	3.7E-04	5.8E+00	6.0E-04	6.7E-03	2.4E-01
23-Feb-11	57	0.5	300	505	5.81	6.2E+01																				
2-Mar-11	58	0.5	300	365	5.44	7.1E+01																				
9-Mar-11	59	0.5	300	455	5.74	6.4E+01																				
16-Mar-11	60	0.5	300	305	5.86	7.2E+01	#N/A	5.8E+00	1.3E+00	2.2E+01	2.0E-01	8.0E-02	3.0E-01	1.8E+01	6.5E-02	8.0E-04	2.0E-04	1.8E-01	9.0E-05	1.0E-05	6.9E-03	3.4E-04	5.4E+00	7.0E-04	5.8E-03	2.2E-01
23-Mar-11	61	0.5	300	395	5.95	7.1E+01																				
30-Mar-11	62	0.5	300	360	6.18	6.5E+01																				
6-Apr-11	63	0.5	300	280	6.00	8.1E+01																				
13-Apr-11	64	0.5	300	290	5.89	7.9E+01	#N/A	5.4E+00	1.3E+00	2.5E+01	2.0E-01	9.0E-02	3.0E-01	2.0E+01	7.8E-02	5.0E-04	2.0E-04	1.0E-01	9.0E-05	1.0E-05	1.1E-02	3.7E-04	6.0E+00	5.0E-04	6.9E-03	2.6E-01
20-Apr-11	65	0.5	300	325	6.20	7.9E+01																				

Col 2A

Sample = (08-135 to 08-263) Composite

Date	Cycle	Approxi.	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Cl	F	Br	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Flow Rate	Input	Output		umhos/cm	(pH 4.5)	(pH 8.3)						CaCO3												
		(mL/min)					mgCaCO3/L	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
27-Apr-11	66	0.5	300	355	6.02	7.3E+01																				
4-May-11	67	0.5	300	305	5.94	7.4E+01																				
11-May-11	68	0.5	300	340	5.95	6.9E+01	#N/A	5.3E+00	1.4E+00	2.1E+01	2.0E-01	8.0E-02	3.0E-01	1.7E+01	6.8E-02	2.0E-04	6.0E-04	8.9E-02	9.0E-05	1.0E-05	9.1E-03	3.2E-04	5.1E+00	5.0E-04	6.4E-03	2.3E-01
18-May-11	69	0.5	300	330	5.93	8.9E+01																				
25-May-11	70	0.5	300	325	6.19	6.5E+01																				
1-Jun-11	71	0.5	300	340	6.20	6.9E+01																				
8-Jun-11	72	0.5	300	325	6.34	6.8E+01	#N/A	6.3E+00	2.5E+00	2.1E+01	3.0E-01	8.0E-02	3.0E-01	1.6E+01	7.2E-02	6.0E-04	2.0E-04	1.0E-01	9.0E-05	2.0E-05	1.0E-02	3.2E-04	5.0E+00	5.0E-04	6.0E-03	2.4E-01
15-Jun-11	73	0.5	300	320	6.19	6.9E+01																				
22-Jun-11	74	0.5	300	360	6.04	6.6E+01																				
29-Jun-11	75	0.5	300	310	6.02	7.0E+01																				
6-Jul-11	76	0.5	300	330	6.00	7.0E+01	#N/A	6.7E+00	1.5E+00	2.3E+01	2.0E-01	7.0E-02	3.0E-01	1.8E+01	7.1E-02	4.0E-04	2.0E-04	8.1E-02	8.0E-05	1.0E-05	1.1E-02	3.3E-04	5.5E+00	5.0E-04	6.5E-03	2.4E-01
13-Jul-11	77	0.5	300	180	6.35	6.9E+01																				
20-Jul-11	78	0.5	300	340	5.77	6.4E+01																				
27-Jul-11	79	0.5	300	340	5.80	6.2E+01																				
3-Aug-11	80	0.5	300	245	5.79	5.8E+01	#N/A	7.2E+00	1.7E+00	1.8E+01	2.0E-01	7.0E-02	3.0E-01	1.4E+01	5.3E-02	4.0E-04	3.0E-04	7.6E-02	7.0E-05	1.0E-05	8.9E-03	2.8E-04	4.4E+00	5.0E-04	5.3E-03	1.9E-01
10-Aug-11	81	0.5	300	350	6.22	5.4E+01																				
17-Aug-11	82	0.5	300	355	6.34	5.3E+01																				
24-Aug-11	83	0.5	300	290	6.47	5.7E+01																				
31-Aug-11	84	0.5	300	375	6.54	5.4E+01	#N/A	7.1E+00	2.7E+00	2.0E+01	2.0E-01	6.0E-02	3.0E-01	1.4E+01	6.2E-02	5.0E-04	3.0E-04	7.9E-02	7.0E-05	1.0E-05	1.0E-02	2.9E-04	4.2E+00	7.0E-04	5.6E-03	2.1E-01
7-Sep-11	85	0.5	300	330	6.19	5.0E+01																				
14-Sep-11	86	0.5	300	335	6.17	5.3E+01																				
21-Sep-11	87	0.5	300	295	6.09	5.5E+01																				
28-Sep-11	88	0.5	300	295	6.50	5.7E+01	#N/A	7.0E+00	2.1E+00	1.9E+01	2.0E-01	7.0E-02	3.0E-01	1.4E+01	6.0E-02	4.0E-04	2.0E-04	7.8E-02	9.0E-05	1.0E-05	5.2E-03	2.9E-04	4.3E+00	1.3E-03	5.3E-03	2.0E-01
5-Oct-11	89	0.5	300	335	6.16	5.0E+01																				
12-Oct-11	90	0.5	300	295	6.81	5.3E+01																				
19-Oct-11	91	0.5	300	325	6.11	5.2E+01																				
26-Oct-11	92	0.5	300	340	6.09	5.1E+01	#N/A	5.2E+00	1.2E+00	1.6E+01	2.0E-01	8.0E-02	3.0E-01	1.3E+01	5.4E-02	3.0E-04	2.0E-04	8.2E-02	8.0E-05	1.0E-05	9.1E-03	2.5E-04	3.8E+00	7.0E-04	4.5E-03	1.7E-01
2-Nov-11	93	0.5	300	330	6.61	5.0E+01																				
9-Nov-11	94	0.5	300	310	6.65	5.1E+01																				
16-Nov-11	95	0.5	300	315	6.22	5.2E+01																				
23-Nov-11	96	0.5	300	345	6.54	4.6E+01	#N/A	5.9E+00	2.6E+00	1.4E+01	2.0E-01	8.0E-02	3.0E-01	1.1E+01	7.0E-02	7.0E-04	3.0E-04	7.0E-02	6.0E-05	1.0E-05	1.1E-02	2.3E-04	3.4E+00	5.0E-04	3.9E-03	1.5E-01
30-Nov-11	97	0.5	300	325	6.81	4.8E+01																				
7-Dec-11	98	0.5	300	345	6.76	4.5E+01																				
14-Dec-11	99	0.5	300	330	6.25	4.4E+01																				
21-Dec-11	100	0.5	300	330	6.71	4.4E+01	#N/A	5.6E+00	2.1E+00	1.3E+01	2.0E-01	6.0E-02	3.0E-01	1.1E+01	6.7E-02	5.0E-04	2.0E-04	7.8E-02	5.0E-05	1.0E-05	8.1E-03	2.3E-04	3.4E+00	5.0E-04	3.9E-03	1.5E-01
28-Dec-11	101	0.5	300	305	5.81	4.5E+01																				
4-Jan-12	102	0.5	300	310	6.06	4.5E+01																				
11-Jan-12	103	0.5	300	335	5.99	4.5E+01																				
18-Jan-12	104	0.5	300	340	5.52	4.1E+01	#N/A	4.9E+00	5.3E-01	1.3E+01	2.0E-01	7.0E-02	3.0E-01	1.0E+01	7.6E-02	4.0E-04	2.0E-04	7.9E-02	6.0E-05	1.0E-05	1.9E-02	1.7E-04	3.1E+00	5.0E-04	3.4E-03	1.4E-01
25-Jan-12	105	0.5	300	330	5.41	4.5E+01																				
1-Feb-12	106	0.5	300	315	5.72	4.3E+01																				
8-Feb-12	107	0.5	300	310	6.92	4.7E+01																				
15-Feb-12	108	0.5	300	300	5.59	4.5E+01	#N/A	6.9E+00	1.1E+00	1.6E+01	2.0E-01	6.0E-02	3.0E-01	1.0E+01	5.7E-02	7.0E-04	3.0E-04	8.3E-02	5.0E-05	1.0E-05	6.9E-03	2.0E-04	3.2E+00	5.0E-04	3.5E-03	1.4E-01
22-Feb-12	109	0.5	300	310	5.85	4.4E+01																				
29-Feb-12	110	0.5	300	315	5.63	4.1E+01																				
7-Mar-12	111	0.5	300	325	6.46	3.9E+01																				
14-Mar-12	112	0.5	300	300	5.54	4.2E+01	#N/A	5.9E+00	8.5E-01	1.6E+01	3.0E-01	6.0E-02	3.0E-01	1.0E+01	4.7E-02	4.0E-04	2.0E-04	8.5E-02	4.0E-05	5.0E-05	6.8E-03	1.9E-04	3.1E+00	5.0E-04	3.5E-03	1.3E-01
21-Mar-12	113	0.5	300	290	5.73	4.3E+01																				
28-Mar-12	114	0.5	300	290	5.50	4.0E+01																				
4-Apr-12	115	0.5	300	325	5.67	4.0E+01																				
11-Apr-12	116	0.5	300	290	5.47	4.2E+01	#N/A	5.7E+00	7.4E-01	1.8E+01	2.0E-01	6.0E-02	3.0E-01	9.9E+00	1.0E-01	5.0E-04	5.0E-04	8.5E-02	4.0E-05	1.0E-05	7.5E-03	1.5E-04	3.1E+00	5.0E-04	4.2E-03	1.6E-01
18-Apr-12	117	0.5	300	315	5.79	3.8E+01																				
25-Apr-12	118	0.5	300	300	5.73	3.8E+01																				
2-May-12	119	0.5	300	315	4.85	4.6E+01																				
9-May-12	120	0.5	300	320	5.63	3.9E+01	#N/A	5.9E+00	9.9E-01	1.1E+01	2.0E-01	6.0E-02	3.0E-01	8.8E+00	5.5E-02	5.0E-04	2.0E-04	8.3E-02	4.0E-05	1.0E-05	7.5E-03	1.3E-04	2.7E+00	5.0E-04	3.1E-03	1.2E-01
16-May-12	121	0.5	300	315	5.71	4.1E+01																				
23-May-12	122	0.5	300	300	5.71	3.8E+01																				
30-May-12	123	0.5	300	315	5.96	3.4E+01																				
6-Jun-12	124	0.5	300	320	5.69	3.9E+01	#N/A	6.3E+00	1.2E+00	9.0E+00	4.0E-01	6.0E-02	3.0E-01	9.1E+00	9.6E-02	4.0E-04	2.0E-04	9.5E-02	5.0E-05	1.0E-05	1.2E-02	1.5E-04	2.8E+00	5.0E-04	3.2E-03	1.2E-01
13-Jun-12	125	0.5	300	320	5.82	3.8E+01																				
20-Jun-12	126	0.5	300	305	5.76	3.9E+01																				
27-Jun-12	127	0.5	300	300	5.42	4.0E+01																				
4-Jul-12	128	0.5	300	300	5.81	4.0E+01	#N/A	6.8E+00	1.2E+00	1.2E+01	2.0E-01	6.0E-02	3.0E-01	8.6E+00	9.3E-02	5.0E-04	2.0E-04	9.7E-02	5.0E-05	3.0E-05	9.7E-03	1.6E-04	2.7E+00	5.0E-04	3.2E-03	1.2E-01
11-Jul-12	129	0.5	300	320	5.64	3.9E+01																				
18-Jul-12	130	0.5	300	350	5.59	3.1E+01																				
25-Jul-12	131	0.5	300	330	5.54	3.6E+01																				
1-Aug-12	132	0.5	300	310	5.73	3.7E+01	#N/A	5.6E+00	1.0E+00	9.0E+00	2.0E-01	6.0E-02	3.0E-01	7.9E+00	1.2E-01	7.0E-04	2.0E-04	9.1E-02	4.0E-05	1.0E-05	9.3E-03	1.4E-04	2.4E+00	5.0E-04	2.9E-03	9.9E-02

Col 2A

Sample = (08-135 to 08-263) Composite

Date	Cycle	Approxi.	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Cl	F	Br	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Flow Rate	Input	Output		umhos/cm	(pH 4.5)	(pH 8.3)						CaCO3												
		(mL/min)					mgCaCO3/L	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
8-Aug-12	133	0.5	300	310	5.91	3.6E+01																				
15-Aug-12	134	0.5	300	325	5.61	3.6E+01																				
22-Aug-12	135	0.5	300	335	5.91	3.1E+01																				
29-Aug-12	136	0.5	300	335	5.58	3.4E+01	#N/A	7.1E+00	9.7E-01	9.0E+00	2.0E-01	6.0E-02	3.0E-01	7.0E+00	1.2E-01	7.0E-04	2.0E-04	9.5E-02	5.0E-05	2.0E-05	8.1E-03	1.3E-04	2.2E+00	5.0E-04	2.8E-03	1.0E-01
5-Sep-12	137	0.5	300	315	5.83	4.0E+01																				
12-Sep-12	138	0.5	300	310	5.60	3.1E+01																				
19-Sep-12	139	0.5	300	270	5.87	3.8E+01																				
26-Sep-12	140	0.5	300	345	5.54	3.4E+01	#N/A	5.7E+00	9.9E-01	1.2E+01	2.0E-01	6.0E-02	3.0E-01	7.1E+00	8.6E-02	5.0E-04	6.0E-04	9.7E-02	3.0E-05	1.0E-05	1.1E-02	1.3E-04	2.2E+00	5.0E-04	2.8E-03	9.5E-02
3-Oct-12	141	0.5	300	330	5.61	3.5E+01																				
10-Oct-12	142	0.5	300	330	5.61	3.4E+01																				
17-Oct-12	143	0.5	300	305	5.60	3.5E+01																				
24-Oct-12	144	0.5	300	315	5.69	3.6E+01	#N/A	6.8E+00	1.5E+00	1.2E+01	2.0E-01	6.0E-02	3.0E-01	7.1E+00	1.0E-01	4.0E-04	2.0E-04	9.6E-02	4.0E-05	1.0E-05	9.1E-03	2.0E-04	2.2E+00	5.0E-04	2.7E-03	9.9E-02
31-Oct-12	145	0.5	300	340	5.71	4.3E+01																				
7-Nov-12	146	0.5	300	335	5.58	2.9E+01																				
14-Nov-12	147	0.5	300	305	6.01	3.3E+01																				
21-Nov-12	148	0.5	300	280	5.93	3.3E+01	#N/A	6.3E+00	1.1E+00	8.0E+00	2.0E-01	8.0E-02	3.0E-01	7.1E+00	6.1E-02	5.0E-04	4.0E-04	1.0E-01	4.0E-05	1.0E-05	6.9E-03	1.7E-04	2.2E+00	5.0E-04	3.0E-03	9.8E-02
28-Nov-12	149	0.5	300	305	5.81	4.5E+01																				
5-Dec-12	150	0.5	300	300	6.23	2.9E+01																				
12-Dec-12	151	0.5	300	325	5.72	2.9E+01																				
19-Dec-12	152	0.5	300	280	5.83	3.1E+01	#N/A	5.3E+00	8.3E-01	8.0E+00	2.0E-01	6.0E-02	3.0E-01	7.2E+00	7.1E-02	6.0E-04	2.0E-04	1.0E-01	5.0E-05	1.0E-05	7.5E-03	1.5E-04	2.2E+00	5.0E-04	2.7E-03	8.4E-02
26-Dec-12	153	0.5	300	305	6.76	3.0E+01																				
2-Jan-13	154	0.5	300	280	6.04	2.8E+01																				
9-Jan-13	155	0.5	300	295	6.67	3.1E+01																				
16-Jan-13	156	0.5	300	295	5.96	3.1E+01	#N/A	5.1E+00	1.8E+00	1.2E+01	2.0E-01	7.0E-02	3.0E-01	6.5E+00	7.9E-02	5.0E-04	2.0E-04	1.0E-01	4.0E-05	1.0E-05	7.6E-03	1.2E-04	2.0E+00	5.0E-04	2.6E-03	8.8E-02
23-Jan-13	157	0.5	300	300	6.31	3.1E+01																				
30-Jan-13	158	0.5	300	290	5.69	3.1E+01																				
6-Feb-13	159	0.5	300	300	6.29	3.1E+01																				
13-Feb-13	160	0.5	300	295	6.46	3.1E+01	#N/A	7.3E+00	2.3E+00	1.1E+01	2.0E-01	7.0E-02	3.0E-01	6.4E+00	5.6E-02	5.0E-04	3.0E-04	9.4E-02	4.0E-05	1.0E-05	7.4E-03	1.4E-04	2.0E+00	5.0E-04	2.9E-03	9.4E-02
20-Feb-13	161	0.5	300	290	6.15	3.2E+01																				
27-Feb-13	162	0.5	300	285	5.84	3.0E+01																				
6-Mar-13	163	0.5	300	315	5.89	3.0E+01																				
13-Mar-13	164	0.5	300	315	5.55	3.0E+01	#N/A	7.0E+00	1.2E+00	6.0E+00	2.0E-01	6.0E-02	3.0E-01	6.5E+00	6.7E-02	5.0E-04	2.0E-04	1.0E-01	3.0E-05	1.0E-05	6.4E-03	1.3E-04	2.0E+00	5.0E-04	2.4E-03	8.1E-02
20-Mar-13	165	0.5	300	270	6.51	2.9E+01																				
27-Mar-13	166	0.5	300	315	5.79	3.0E+01																				
3-Apr-13	167	0.5	300	285	6.23	2.9E+01																				
10-Apr-13	168	0.5	300	310	5.71	3.0E+01	#N/A	6.7E+00	1.2E+00	8.0E+00	2.0E-01	6.0E-02	3.0E-01	6.1E+00	6.1E-02	5.0E-04	3.0E-04	9.1E-02	3.0E-05	1.0E-05	7.6E-03	1.8E-04	1.9E+00	5.0E-04	2.4E-03	6.9E-02
17-Apr-13	169	0.5	300	295	6.27	2.8E+01																				
24-Apr-13	170	0.5	300	290	6.01	2.9E+01																				
1-May-13	171	0.5	300	300	6.34	2.8E+01																				
8-May-13	172	0.5	300	295	6.71	2.8E+01	#N/A	8.4E+00	3.0E+00	1.2E+01	2.0E-01	6.0E-02	3.0E-01	5.7E+00	5.7E-02	5.0E-04	2.0E-04	1.0E-01	4.0E-05	1.0E-05	8.7E-03	1.2E-04	1.8E+00	5.0E-04	2.4E-03	7.5E-02
15-May-13	173	0.5	300	345	6.70	2.4E+01																				
22-May-13	174	0.5	300	310	6.26	2.6E+01																				
29-May-13	175	0.5	300	295	6.29	2.8E+01																				
5-Jun-13	176	0.5	300	285	5.76	2.8E+01	#N/A	6.6E+00	1.3E+00	1.1E+01	2.0E-01	6.0E-02	3.0E-01	5.9E+00	6.3E-02	5.0E-04	3.0E-04	1.1E-01	3.0E-05	1.0E-05	8.6E-03	1.3E-04	1.9E+00	5.0E-04	2.3E-03	7.5E-02
12-Jun-13	177	0.5	300	295	5.26	2.5E+01																				
19-Jun-13	178	0.5	300	310	6.00	2.7E+01																				
26-Jun-13	179	0.5	300	290	5.80	2.7E+01																				
3-Jul-13	180	0.5	300	300	5.80	2.8E+01	#N/A	7.2E+00	1.0E+00	8.0E+00	2.0E-01	8.0E-02	3.0E-01	5.5E+00	5.0E-02	5.0E-04	4.0E-04	1.0E-01	3.0E-05	1.0E-05	2.5E-02	1.1E-04	1.7E+00	5.0E-04	2.0E-03	6.7E-02
10-Jul-13	181	0.5	300	300	6.77	2.6E+01																				
17-Jul-13	182	0.5	300	270	5.69	2.7E+01																				

Col 2A

Sample = (08-135 to 08-263) Composite

Date	Cycle	Approxi.	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Cl	F	Br	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Flow Rate	Input	Output		umhos/cm	(pH 4.5)	(pH 8.3)						CaCO3												
		(mL/min)					mgCaCO3/L	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
24-Jul-13	183	0.5	300	335	6.47	2.4E+01																				
31-Jul-13	184	0.5	300	300	5.83	2.6E+01	#N/A	6.3E+00	1.8E+00	8.0E+00	2.0E-01	6.0E-02	3.0E-01	5.5E+00	6.7E-02	5.0E-04	2.0E-04	9.8E-02	4.0E-05	1.0E-05	1.7E-02	1.2E-04	1.7E+00	5.0E-04	2.0E-03	6.9E-02
7-Aug-13	185	0.5	300	310	6.31	2.5E+01																				
14-Aug-13	186	0.5	300	300	5.71	2.5E+01																				
21-Aug-13	187	0.5	300	305	6.57	2.5E+01																				
28-Aug-13	188	0.5	300	310	5.56	2.1E+01	#N/A	4.5E+00	7.7E-01	7.0E+00	2.0E-01	6.0E-02	3.0E-01	5.2E+00	5.8E-02	5.0E-04	2.0E-04	1.0E-01	3.0E-05	1.0E-05	1.7E-02	1.1E-04	1.7E+00	5.0E-04	1.9E-03	6.5E-02
4-Sep-13	189	0.5	300	295	5.90	2.4E+01																				
11-Sep-13	190	0.5	300	305	5.62	2.2E+01																				
18-Sep-13	191	0.5	300	305	6.49	2.5E+01																				
25-Sep-13	192	0.5	300	295	6.00	2.4E+01	#N/A	3.9E+00	7.7E-01	8.0E+00	2.0E-01	6.0E-02	3.0E-01	5.4E+00	4.8E-02	5.0E-04	2.0E-04	1.2E-01	4.0E-05	1.0E-05	1.7E-02	1.5E-04	1.7E+00	5.0E-04	2.0E-03	6.6E-02
2-Oct-13	193	0.5	300	300	5.71	2.5E+01																				
9-Oct-13	194	0.5	300	305	5.77	2.4E+01																				
16-Oct-13	195	0.5	300	305	5.38	2.4E+01																				
23-Oct-13	196	0.5	300	300	5.22	2.5E+01	#N/A	5.2E+00	5.0E-02	1.0E+01	2.0E-01	7.0E-02	3.0E-01	5.1E+00	5.1E-02	6.0E-04	3.0E-04	1.2E-01	3.0E-05	1.0E-05	1.4E-02	1.1E-04	1.6E+00	5.0E-04	2.0E-03	7.1E-02
30-Oct-13	197	0.5	300	305	5.47	2.5E+01																				
6-Nov-13	198	0.5	300	310	5.62	2.4E+01																				
13-Nov-13	199	0.5	300	300	6.30	2.3E+01																				
20-Nov-13	200	0.5	300	295	5.73	2.5E+01	#N/A	3.2E+00	5.2E-01	7.0E+00	2.0E-01	6.0E-02	3.0E-01	4.9E+00	6.0E-02	5.0E-04	2.0E-04	1.2E-01	3.0E-05	1.0E-05	1.3E-02	3.0E-04	1.6E+00	5.0E-04	2.7E-03	6.8E-02
27-Nov-13	201	0.5	300	300	5.63	2.4E+01																				
4-Dec-13	202	0.5	300	305	5.62	2.2E+01																				
11-Dec-13	203	0.5	300	310	5.63	2.4E+01																				
18-Dec-13	204	0.5	300	300	5.63	2.4E+01	#N/A	4.0E+00	6.5E-01	6.0E+00	2.0E-01	6.0E-02	3.0E-01	4.9E+00	6.3E-02	5.0E-04	2.0E-04	1.2E-01	3.0E-05	1.0E-05	1.2E-02	9.7E-05	1.5E+00	5.0E-04	1.8E-03	6.4E-02
25-Dec-13	205	0.5	300	305	6.16	2.4E+01																				
1-Jan-14	206	0.5	300	290	5.66	2.3E+01																				
8-Jan-14	207	0.5	300	270	5.55	2.3E+01																				
15-Jan-14	208	0.5	300	280	5.92	2.2E+01	#N/A	4.7E+00	9.6E-01	8.0E+00	2.0E-01	6.0E-02	3.0E-01	5.0E+00	8.2E-02	7.0E-04	2.0E-04	1.1E-01	5.0E-05	1.0E-05	1.3E-02	2.3E-04	1.6E+00	5.0E-04	1.8E-03	5.4E-02
22-Jan-14	209	0.5	300	285	5.67	2.3E+01																				
29-Jan-14	210	0.5	300	270	5.64	2.4E+01																				
5-Feb-14	211	0.5	300	275	5.93	2.3E+01																				
12-Feb-14	212	0.5	300	265	5.71	2.1E+01	#N/A	3.6E+00	8.5E-01	6.0E+00	2.0E-01	6.0E-02	3.0E-01	6.6E+00	7.0E-02	4.0E-04	5.0E-04	1.1E-01	4.0E-05	1.0E-05	1.0E-02	1.0E-04	1.6E+00	5.0E-04	5.8E-03	5.1E-02
19-Feb-14	213	0.5	300	240	5.94	2.4E+01																				
26-Feb-14	214	0.5	300	255	6.17	2.3E+01																				
5-Mar-14	215	0.5	300	285	5.91	2.8E+01	#N/A	5.9E+00	2.5E+00	8.0E+00	2.0E-01	6.0E-02	3.0E-01	4.8E+00	4.8E-02	5.0E-04	2.0E-04	1.2E-01	3.0E-05	1.0E-05	9.7E-03	9.0E-05	1.5E+00	5.0E-04	1.6E-03	4.9E-02
12-Mar-14	216	0.5	300	265	6.31	2.1E+01	#N/A	4.4E+00	3.2E+00	7.0E+00	2.0E-01	6.0E-02	3.0E-01	5.4E+00	5.0E-02	2.0E-04	2.0E-04	1.2E-01	3.0E-05	1.0E-05	5.5E-03	9.2E-05	1.7E+00	5.0E-04	2.0E-03	5.0E-02
19-Mar-14	217	0.5	300	285	6.19	2.1E+01	#N/A	6.5E+00	2.1E+00	7.0E+00	2.0E-01	6.0E-02	3.0E-01	4.7E+00	7.3E-02	5.0E-04	2.0E-04	1.2E-01	2.0E-05	5.0E-05	2.9E-03	8.8E-05	1.5E+00	5.0E-04	1.7E-03	4.9E-02
26-Mar-14	218	0.5	300	270	6.24	2.0E+01	#N/A	4.6E+00	1.5E+00	6.0E+00	2.0E-01	7.0E-02	3.0E-01	4.3E+00	3.6E-02	3.0E-04	2.0E-04	1.0E-01	2.0E-05	1.0E-05	6.0E-04	1.2E-04	1.4E+00	5.0E-04	1.6E-03	4.6E-02
2-Apr-14	219	0.5	300	285	6.31	1.9E+01	#N/A	5.6E+00	1.7E+00	7.0E+00	2.0E-01	7.0E-02	3.0E-01	4.3E+00	4.0E-02	2.0E-04	2.0E-04	8.9E-02	2.0E-05	1.0E-05	1.9E-03	6.4E-05	1.3E+00	5.0E-04	1.5E-03	4.2E-02
9-Apr-14	220	0.5	300	300	6.29	1.6E+01																				
16-Apr-14	221	0.5	300	240	6.31	1.6E+01																				
23-Apr-14	222	0.5	300	285	6.51	1.5E+01																				
30-Apr-14	223	0.5	300	245	6.71	1.2E+01	#N/A	6.3E+00	2.8E+00	5.0E+00	2.0E-01	6.0E-02	3.0E-01	3.8E+00	4.2E-02	3.0E-04	2.0E-04	9.1E-02	1.6E-05	7.0E-06	3.6E-03	6.6E-05	1.2E+00	3.0E-05	1.4E-03	4.4E-02
7-May-14	224	0.5	300	280	6.20	1.4E+01																				
14-May-14	225	0.5	300	290	6.09	1.5E+01																				
21-May-14	226	0.5	300	295	6.72	1.4E+01																				
28-May-14	227	0.5	300	315	6.15	1.3E+01	#N/A	5.7E+00	1.7E+00	4.0E+00	2.0E-01	6.0E-02	3.0E-01	3.4E+00	6.1E-02	2.0E-04	2.0E-04	7.1E-02	9.0E-06	7.0E-06	1.9E-03	5.4E-05	1.1E+00	5.0E-05	1.3E-03	3.5E-02
4-Jun-14	228	0.5	300	295	6.41	1.3E+01																				
11-Jun-14	229	0.5	300	285	6.31	1.3E+01																				
18-Jun-14	230	0.5	300	275	6.77	1.5E+01																				
25-Jun-14	231	0.5	300	290	6.77	1.4E+01	#N/A	6.1E+00	4.4E+00	4.0E+00	2.0E-01	6.0E-02	3.0E-01	3.0E+00	2.7E-02	3.0E-04	3.0E-04	7.5E-02	7.0E-06	7.0E-06	8.0E-03	5.0E-05	9.5E-01	1.5E-04	1.2E-03	3.3E-02
2-Jul-14	232	0.5	300	315	6.11	9.6E+00																				
9-Jul-14	233	0.5	300	275	6.11	1.2E+01																				
16-Jul-14	234	0.5	300	475	6.44	8.9E+00																				
23-Jul-14	235	0.5	300	275	6.63	1.2E+01	#N/A	3.9E+00	2.4E+00	3.0E+00	2.0E-01	6.0E-02	3.0E-01	2.9E+00	3.0E-02	3.0E-04	2.0E-04	7.0E-02	7.0E-06	7.0E-06	1.8E-03	4.6E-05	9.1E-01	3.0E-05	1.2E-03	3.2E-02
30-Jul-14	236	0.5	300	265	6.21	1.2E+01																				
6-Aug-14	237	0.5	300	275	6.39	1.1E+01																				
13-Aug-14	238	0.5	300	270	6.41	1.1E+01																				
20-Aug-14	239	0.5	300	280	6.18	8.8E+00	#N/A	2.3E+00	1.5E+00	5.0E+00	2.0E-01	7.0E-02	3.0E-01	2.9E+00	2.8E-02	2.0E-04	2.0E-04	6.9E-02	7.0E-06	7.0E-06	7.1E-03	8.1E-05	9.2E-01	3.3E-04	9.9E-04	3.1E-02

Feb 12/14 Metals being rerun

Feb 24/14 Change in analytical schedule

March 5/14 Moved into the cooler at 4° C at Cycle 215

Col 2A

Sample = (08-135 to 08-263) Composite

Date	Cycle No.	Approxi. Flow Rate (mL/min)	Fe mg/L	Pb mg/L	Li mg/L	Mg mg/L	Mn mg/L	Hg ug/L	Mo mg/L	Ni mg/L	P mg/L	K mg/L	Se mg/L	Si mg/L	Ag mg/L	Na mg/L	Sr mg/L	S mg/L	Tl mg/L	Sn mg/L	Ti mg/L	U mg/L	V mg/L	Zn mg/L	Zr mg/L	Major Anions	Major Cations	Diff	Diff (%)
27-Jan-10	1	0.5	2.7E-01	2.9E-03	8.0E-03	8.7E+00	6.8E-01	4.0E-02	6.3E-03	6.2E-03	5.0E-02	2.4E+01	3.8E-02	2.7E+01	6.0E-05	1.8E+02	3.3E-01	1.5E+02	2.0E-04	1.0E-04	2.7E-03	3.0E-03	5.1E-04	6.9E-02	1.8E-02	1.3E+01	1.1E+01	-1.7E+00	-7.0%
3-Feb-10	2	0.5	8.0E-02	6.7E-04	4.0E-03	1.8E+00	1.7E-01	1.3E-01	4.0E-03	2.2E-03	1.0E-02	1.0E+01	1.9E-02	2.5E+01	3.0E-05	9.0E+01	7.9E-02	5.9E+01	2.0E-04	6.4E-04	1.7E-03	8.8E-04	1.4E-04	2.8E-02	5.4E-03	5.4E+00	4.8E+00	-6.0E-01	-5.9%
10-Feb-10	3	0.5	5.0E-02	5.2E-04	4.0E-03	1.8E+00	1.9E-01	1.0E-02	3.1E-03	1.6E-03	1.0E-02	1.1E+01	1.7E-02	2.7E+01	4.0E-05	8.7E+01	8.6E-02	7.2E+01	2.0E-04	1.5E-04	1.7E-03	5.6E-04	1.0E-04	2.4E-02	2.5E-03	4.7E+00	4.7E+00	-2.5E-02	-0.3%
17-Feb-10	4	0.5	3.0E-02	3.9E-04	3.0E-03	1.5E+00	1.7E-01	1.0E-02	3.0E-03	1.7E-03	1.0E-02	1.1E+01	1.6E-02	2.9E+01	3.0E-05	7.3E+01	7.3E-02	6.4E+01	2.0E-04	1.2E-04	1.9E-03	4.6E-04	1.5E-04	2.4E-02	1.6E-03	4.0E+00	4.0E+00	-5.2E-02	-0.6%
24-Feb-10	5	0.5																											
3-Mar-10	6	0.5	2.0E-02	2.4E-04	3.0E-03	1.0E+00	1.2E-01	1.0E-02	2.1E-03	1.1E-03	1.0E-02	8.3E+00	9.5E-03	2.5E+01	1.0E-05	5.3E+01	5.2E-02	4.6E+01	2.0E-04	8.2E-04	6.0E-04	2.7E-04	6.0E-05	1.7E-02	8.2E-04	3.1E+00	2.9E+00	-2.4E-01	-4.0%
10-Mar-10	7	0.5																											
17-Mar-10	8	0.5	2.0E-02	5.7E-04	3.0E-03	9.0E-01	1.1E-01	1.0E-02	1.4E-03	1.7E-03	1.0E-02	6.9E+00	6.1E-03	2.6E+01	1.0E-05	3.9E+01	4.5E-02	3.6E+01	2.0E-04	8.0E-05	5.0E-04	2.5E-04	3.0E-05	1.7E-02	4.5E-04	2.2E+00	2.2E+00	-2.7E-02	-0.6%
24-Mar-10	9	0.5																											
31-Mar-10	10	0.5	1.0E-02	1.5E-04	2.0E-03	7.3E-01	9.0E-02	2.0E-02	1.7E-03	8.0E-04	1.0E-02	6.0E+00	5.0E-03	2.2E+01	4.0E-05	3.3E+01	3.7E-02	3.0E+01	2.0E-04	3.0E-04	9.0E-04	2.5E-04	3.0E-05	1.4E-02	3.4E-04	2.2E+00	1.9E+00	-3.3E-01	-8.2%
7-Apr-10	11	0.5																											
14-Apr-10	12	0.5	1.0E-02	2.7E-03	2.0E-03	6.4E-01	7.5E-02	1.0E-02	1.4E-03	1.0E-03	1.0E-02	5.9E+00	4.5E-03	2.1E+01	3.0E-05	2.2E+01	3.3E-02	2.3E+01	2.0E-04	3.7E-04	3.0E-04	2.1E-04	3.0E-05	2.0E-02	2.9E-04	1.4E+00	1.3E+00	-9.8E-02	-3.5%
21-Apr-10	13	0.5																											
28-Apr-10	14	0.5	1.0E-02	1.3E-03	2.0E-03	7.5E-01	8.8E-02	1.0E-02	8.8E-04	1.6E-03	1.0E-02	5.5E+00	4.6E-03	1.9E+01	3.0E-05	2.1E+01	3.8E-02	2.1E+01	2.0E-04	6.5E-04	4.0E-04	1.7E-04	3.0E-05	3.6E-02	2.5E-04	1.4E+00	1.3E+00	-1.5E-01	-5.5%
5-May-10	15	0.5																											
12-May-10	16	0.5	1.2E-02	4.8E-04	3.0E-03	1.2E+00	1.4E-01	1.0E-02	1.2E-03	1.3E-03	9.0E-03	7.6E+00	4.0E-03	2.7E+01	1.1E-04	2.3E+01	6.4E-02	2.4E+01	2.0E-04	6.9E-04	3.0E-04	1.7E-04	3.0E-05	2.2E-02	2.6E-04	1.7E+00	1.6E+00	-5.4E-02	-1.7%
19-May-10	17	0.5																											
26-May-10	18	0.5	9.0E-03	1.2E-04	4.0E-03	1.5E+00	1.8E-01	1.0E-02	1.1E-03	1.7E-03	9.0E-03	7.5E+00	4.2E-03	2.3E+01	2.0E-05	1.9E+01	7.9E-02	2.5E+01	2.0E-04	1.2E-03	2.0E-04	2.4E-04	3.0E-05	3.8E-02	2.3E-04	1.4E+00	1.5E+00	1.2E-01	4.2%
2-Jun-10	19	0.5																											
9-Jun-10	20	0.5	5.0E-03	2.0E-04	3.0E-03	1.7E+00	2.2E-01	1.0E-02	7.9E-04	2.2E-03	9.0E-03	7.1E+00	3.1E-03	2.2E+01	8.0E-05	1.6E+01	9.3E-02	2.4E+01	2.0E-04	1.4E-03	3.0E-04	2.4E-04	4.0E-05	4.8E-02	2.2E-04	1.4E+00	1.5E+00	9.8E-02	3.4%
16-Jun-10	21	0.5																											
23-Jun-10	22	0.5	5.0E-03	2.0E-04	5.0E-03	2.4E+00	3.0E-01	1.0E-02	1.2E-03	2.2E-03	9.0E-03	9.3E+00	3.2E-03	2.5E+01	5.0E-05	1.5E+01	1.2E-01	2.7E+01	2.0E-04	1.7E-03	3.0E-04	2.9E-04	3.0E-05	5.0E-02	1.9E-04	1.5E+00	1.7E+00	2.1E-01	6.6%
30-Jun-10	23	0.5																											
7-Jul-10	24	0.5	7.0E-03	1.8E-04	5.0E-03	2.4E+00	3.1E-01	1.0E-02	7.3E-04	2.7E-03	2.6E-02	9.2E+00	2.7E-03	2.3E+01	6.0E-05	1.1E+01	1.3E-01	2.5E+01	2.0E-04	1.5E-03	3.0E-04	3.4E-04	3.0E-05	5.1E-02	1.9E-04	1.3E+00	1.4E+00	1.7E-01	6.3%
14-Jul-10	25	0.5																											
21-Jul-10	26	0.5	2.3E-02	2.9E-04	4.0E-03	2.6E+00	3.3E-01	2.0E-02	5.8E-04	2.4E-03	9.0E-03	9.2E+00	2.7E-03	2.4E+01	5.0E-05	7.8E+00	1.3E-01	2.4E+01	2.0E-04	1.5E-03	3.0E-04	3.4E-04	3.0E-05	5.5E-02	1.4E-04	1.2E+00	1.4E+00	2.1E-01	8.0%
28-Jul-10	27	0.5																											
4-Aug-10	28	0.5	5.0E-03	1.6E-04	4.0E-03	2.7E+00	3.5E-01	2.0E-02	8.5E-04	2.2E-03	1.2E-02	8.3E+00	2.3E-03	2.4E+01	3.0E-05	6.6E+00	1.4E-01	2.3E+01	2.0E-04	1.3E-03	2.0E-04	3.6E-04	3.0E-05	5.4E-02	1.2E-04	1.3E+00	1.4E+00	1.7E-01	6.3%
11-Aug-10	29	0.5																											
18-Aug-10	30	0.5	2.0E-03	1.7E-04	4.0E-03	2.1E+00	2.6E-01	1.0E-02	6.6E-04	2.2E-03	9.0E-03	7.3E+00	1.5E-03	1.8E+01	2.4E-04	4.1E+00	1.1E-01	2.4E+01	2.0E-04	6.8E-04	2.0E-04	3.0E-04	3.0E-05	5.1E-02	1.0E-04	1.0E+00	1.1E+00	6.7E-02	3.2%
25-Aug-10	31	0.5																											
1-Sep-10	32	0.5	2.0E-03	1.6E-04	4.0E-03	2.2E+00	2.7E-01	1.0E-02	1.3E-03	3.2E-03	9.0E-03	6.9E+00	1.8E-03	1.9E+01	2.1E-04	3.9E+00	1.1E-01	1.9E+01	2.0E-04	4.5E-04	3.0E-04	3.1E-04	3.0E-05	7.6E-02	8.0E-05	1.3E+00	1.1E+00	-1.5E-01	-6.3%
8-Sep-10	33	0.5																											
15-Sep-10	34	0.5	6.0E-03	2.5E-04	4.0E-03	2.5E+00	3.2E-01	1.0E-02	6.5E-04	2.3E-03	9.0E-03	6.7E+00	1.7E-03	1.9E+01	1.1E-04	2.8E+00	1.3E-01	2.0E+01	2.0E-04	9.9E-04	3.0E-04	3.4E-04	3.0E-05	5.3E-02	1.2E-04	1.3E+00	1.2E+00	-1.5E-01	-6.2%
22-Sep-10	35	0.5																											
29-Sep-10	36	0.5	2.0E-03	5.5E-04	4.0E-03	2.6E+00	3.3E-01	1.0E-02	1.1E-03	3.3E-03	1.6E-02	7.3E+00	2.0E-03	2.1E+01	8.0E-05	2.9E+00	1.3E-01	2.2E+01	2.0E-04	1.7E-03	7.0E-04	9.6E-04	3.0E-05	6.7E-02	1.0E-04	1.3E+00	1.2E+00	-7.9E-02	-3.2%
6-Oct-10	37	0.5																											
13-Oct-10	38	0.5	3.0E-03	2.0E-04	4.0E-03	2.5E+00	3.2E-01	1.0E-02	9.4E-04	2.4E-03	9.0E-03	6.7E+00	1.5E-03	2.2E+01	7.0E-05	2.4E+00	1.3E-01	1.8E+01	2.0E-04	5.4E-04	3.4E-03	3.1E-04	3.0E-05	5.2E-02	9.0E-05	1.1E+00	1.1E+00	6.1E-02	2.8%
20-Oct-10	39	0.5																											
27-Oct-10	40	0.5	5.0E-03	1.8E-03	3.0E-03	1.9E+00	2.3E-01	1.0E-02	1.3E-03	3.0E-03	1.7E-02	5.1E+00	2.4E-03	1.7E+01	1.2E-04	2.3E+00	1.0E-01	1.6E+01	2.0E-04	2.1E-04	3.7E-03	2.6E-04	3.0E-05	6.7E-02	5.0E-05	1.0E+00	8.9E-01	-1.2E-01	-6.4%
3-Nov-10	41	0.5																											
10-Nov-10	42	0.5																											
17-Nov-10	43	0.5																											
24-Nov-10	44	0.5	2.0E-03	1.6E-04	3.0E-03	1.8E+00	2.2E-01	1.0E-02	6.4E-04	1.6E-03	9.0E-03	4.6E+00	1.1E-03	1.6E+01	5.0E-05	1.5E+00	9.8E-02	1.3E+01	2.0E-04	3.8E-04	6.0E-04	3.9E-04	3.0E-05	4.6E-02	6.0E-05	9.4E-01	8.1E-01	-1.3E-01	-7.6%
1-Dec-10	45	0.5																											
8-Dec-10	46	0.5																											
15-Dec-10	47	0.5																											
22-Dec-10	48	0.5	2.0E-03	7.8E-04	3.0E-03	1.8E+00	2.2E-01	1.0E-02	9.3E-04	2.2E-03	2.4E-02	4.8E+00	1.4E-03	1.9E+01	1.6E-04	1.8E+00	1.0E-01	1.6E+01	2.0E-04	6.1E-04	4.0E-04	6.3E-04	3.0E-05	5.4E-02	5.0E-05	9.1E-01	8.4E-01	-7.9E-02	-4.5%
29-Dec-10	49	0.5																											
5-Jan-11	50	0.5																											
12-Jan-11	51	0.5																											
19-Jan-11	52	0.5	3.0E-03	1.2E-04	3.0E-03	1.6E+00	1.9E-01	1.0E-02	5.7E-04	2.0E-03	2.4E-02	4.2E+00	1.1E-03	1.7E+01	6.0E-05	1.5E+00	9.0E-02	1.2E+01	2.0E-04	4.0E-04	2.0E-04	1.9E-04	3.0E-05	4.3E-02	4.0E-05	8.2E-01	7.4E-01	-7.7E-02	-4.9%
26-Jan-11	53	0.5																											
2-Feb-11	54	0.5																											
9-Feb-11	55	0.5																											
16-Feb-11	56	0.5	3.0E-03	9.9E-04	2.0E-03	1.2E+00	1.3E-01	1.0E-02	7.4E-04	2.1E-03	2.6E-02	3.1E+00	8.0E-04	1.4E+01	6.0E-05	1.9E+00	6.3E-02	9.1E+00	2.0E-04	4.2E-04	2.0E-04	1.7E-04	3.0E-05	6.3E-02	5.0E-05	5.5E-01	5.7E-01	2.5E-02	2.2%
23-Feb-11	57	0.5																											
2-Mar-11	58	0.5																											
9-Mar-11	59	0.5																											
16-Mar-11	60	0.5	4.0E-03	1.7E-04	2.0E-03	1.1E+00	1.1E-01	1.0E-02	3.2E-04	1.1E-03	9.0E-03	2.9E+00	7.6E-04	1.5E+01	5.0E-05	9.2E-01	6.2E-02	8.3E+00	2.0E-04	8.2E-04	2.0E-04	1.3E-04	3.0E-05	2.6E-02	3.0E-05	4.9E-01	4.9E-01	4.8E-03	0.5%
23-Mar-11	61	0.5																											
30-Mar-11	62	0.5																											
6-Apr-11	63	0.5																											
13-Apr-11	64	0.5	2.0E-03	1.0E-04	2.0E-03	1.2E+00	1.4E-01	1.0E-02	3.6E-04	1.3E-03	9.0E-03	3.3E+00	1.1E-03	1.6E+01	5.0E-05	1.0E+00	6.6E-02	9.2E+00	2.0E-04	4.1E-04	1.8E-03	1.4E-04	3.0E-05	2.7E-02	1.0E-05	5.6E-01	5.5E-01	-9.8E-03	-0.9%
20-Apr-11	65	0.5																											

Col 2A

Sample = (08-135 to 08-263) Composite

Date	Cycle	Approxi.	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Major	Major	Diff	Diff
	No.	Flow Rate																								Anions	Cations		(%)
		(mL/min)	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L				
27-Apr-11	66	0.5																											
4-May-11	67	0.5																											
11-May-11	68	0.5	2.0E-03	1.7E-04	2.0E-03	9.9E-01	1.1E-01	1.0E-02	1.7E-03	1.1E-03	9.0E-03	2.7E+00	4.5E-04	1.4E+01	7.0E-05	9.1E-01	5.8E-02	7.9E+00	2.0E-04	5.3E-04	3.0E-04	1.6E-04	3.0E-05	2.9E-02	2.0E-05	4.7E-01	4.7E-01	-7.1E-03	-0.7%
18-May-11	69	0.5																											
25-May-11	70	0.5																											
1-Jun-11	71	0.5																											
8-Jun-11	72	0.5	2.0E-03	1.0E-04	2.0E-03	9.7E-01	1.1E-01	1.0E-02	3.5E-04	1.3E-03	3.4E-02	2.7E+00	7.9E-04	1.6E+01	5.0E-05	1.0E+00	5.5E-02	7.6E+00	4.0E-05	4.9E-04	2.0E-04	1.3E-04	3.0E-05	2.8E-02	3.0E-05	5.0E-01	4.7E-01	-3.5E-02	-3.6%
15-Jun-11	73	0.5																											
22-Jun-11	74	0.5																											
29-Jun-11	75	0.5																											
6-Jul-11	76	0.5	5.0E-03	1.1E-04	2.0E-03	1.1E+00	1.3E-01	1.0E-02	2.9E-04	1.1E-03	9.0E-03	2.9E+00	7.3E-04	1.7E+01	3.0E-05	1.1E+00	6.2E-02	8.4E+00	3.0E-05	3.5E-04	1.0E-04	1.1E-04	3.0E-05	2.8E-02	1.0E-05	5.2E-01	5.1E-01	-8.0E-03	-0.8%
13-Jul-11	77	0.5																											
20-Jul-11	78	0.5																											
27-Jul-11	79	0.5																											
3-Aug-11	80	0.5	2.0E-03	2.6E-04	2.0E-03	8.3E-01	1.0E-01	1.0E-02	4.1E-04	9.0E-04	9.0E-03	2.3E+00	5.4E-04	1.3E+01	4.0E-05	8.7E-01	5.0E-02	6.5E+00	2.0E-05	3.4E-04	2.0E-04	9.6E-05	3.0E-05	2.4E-02	3.0E-05	4.1E-01	4.0E-01	-9.8E-03	-1.2%
10-Aug-11	81	0.5																											
17-Aug-11	82	0.5																											
24-Aug-11	83	0.5																											
31-Aug-11	84	0.5	2.0E-03	1.4E-04	2.0E-03	8.2E-01	9.9E-02	1.0E-02	4.3E-04	1.1E-03	9.0E-03	2.4E+00	4.0E-05	1.3E+01	4.0E-05	9.4E-01	4.9E-02	7.4E+00	3.0E-05	3.3E-04	2.0E-04	8.9E-05	3.0E-05	2.7E-02	2.0E-05	4.7E-01	4.0E-01	-7.4E-02	-8.4%
7-Sep-11	85	0.5																											
14-Sep-11	86	0.5																											
21-Sep-11	87	0.5																											
28-Sep-11	88	0.5	2.0E-03	1.5E-04	2.0E-03	8.2E-01	1.0E-01	1.0E-02	2.9E-04	1.0E-03	9.0E-03	2.4E+00	6.5E-04	1.4E+01	4.0E-05	1.0E+00	4.9E-02	6.9E+00	3.0E-05	4.0E-04	2.0E-04	9.5E-05	3.0E-05	2.4E-02	3.0E-05	4.5E-01	4.1E-01	-3.9E-02	-4.6%
5-Oct-11	89	0.5																											
12-Oct-11	90	0.5																											
19-Oct-11	91	0.5																											
26-Oct-11	92	0.5	6.0E-03	3.5E-04	2.0E-03	7.3E-01	8.9E-02	1.0E-02	2.1E-04	8.0E-04	9.0E-03	2.3E+00	3.6E-04	1.2E+01	2.0E-05	9.1E-01	4.5E-02	6.3E+00	2.0E-05	3.4E-04	1.0E-04	1.1E-04	3.0E-05	2.0E-02	1.0E-05	3.6E-01	3.7E-01	4.3E-03	0.6%
2-Nov-11	93	0.5																											
9-Nov-11	94	0.5																											
16-Nov-11	95	0.5																											
23-Nov-11	96	0.5	3.0E-03	3.8E-03	2.0E-03	6.5E-01	7.7E-02	1.0E-02	2.8E-04	9.0E-04	9.0E-03	2.0E+00	2.8E-04	1.2E+01	3.0E-05	8.5E-01	4.0E-02	5.2E+00	3.0E-05	3.6E-04	4.0E-04	2.0E-04	3.6E-04	1.9E-02	1.0E-05	3.5E-01	3.3E-01	-1.8E-02	-2.6%
30-Nov-11	97	0.5																											
7-Dec-11	98	0.5																											
14-Dec-11	99	0.5																											
21-Dec-11	100	0.5	3.0E-03	2.6E-03	1.0E-03	6.5E-01	7.7E-02	1.0E-02	2.9E-04	8.0E-04	9.0E-03	2.0E+00	1.4E-04	1.2E+01	3.0E-05	8.8E-01	4.0E-02	5.6E+00	2.0E-05	1.9E-04	2.0E-04	6.4E-05	1.9E-04	1.7E-02	1.0E-05	3.1E-01	3.3E-01	2.2E-02	3.4%
28-Dec-11	101	0.5																											
4-Jan-12	102	0.5																											
11-Jan-12	103	0.5																											
18-Jan-12	104	0.5	3.0E-03	5.0E-05	1.0E-03	5.6E-01	6.6E-02	1.0E-02	2.4E-04	7.0E-04	9.0E-03	1.7E+00	4.0E-04	1.1E+01	4.0E-05	8.1E-01	3.5E-02	4.8E+00	2.0E-05	3.2E-04	3.0E-04	6.6E-05	4.2E-04	1.6E-02	1.0E-05	2.9E-01	3.0E-01	8.8E-03	1.5%
25-Jan-12	105	0.5																											
1-Feb-12	106	0.5																											
8-Feb-12	107	0.5																											
15-Feb-12	108	0.5	3.0E-03	4.4E-04	1.0E-03	5.9E-01	7.3E-02	1.0E-02	2.3E-04	7.0E-04	9.0E-03	1.9E+00	5.2E-04	1.3E+01	3.0E-05	9.5E-01	3.7E-02	5.0E+00	2.0E-05	2.9E-04	2.0E-04	8.0E-05	2.0E-04	1.6E-02	3.0E-05	3.6E-01	3.1E-01	-4.6E-02	-6.8%
22-Feb-12	109	0.5																											
29-Feb-12	110	0.5																											
7-Mar-12	111	0.5																											
14-Mar-12	112	0.5	3.0E-03	7.0E-05	1.0E-03	5.7E-01	7.2E-02	1.0E-02	2.7E-04	5.0E-04	9.0E-03	1.8E+00	4.8E-04	1.2E+01	5.0E-05	9.4E-01	3.6E-02	4.9E+00	2.0E-05	5.3E-04	1.0E-04	6.9E-05	3.0E-05	1.5E-02	4.0E-05	3.6E-01	3.0E-01	-5.9E-02	-9.0%
21-Mar-12	113	0.5																											
28-Mar-12	114	0.5																											
4-Apr-12	115	0.5																											
11-Apr-12	116	0.5	3.0E-03	1.2E-04	1.0E-03	5.5E-01	6.9E-02	5.0E-02	4.9E-04	1.0E-03	9.0E-03	1.8E+00	9.3E-03	1.3E+01	6.0E-05	1.1E+00	3.5E-02	4.9E+00	3.0E-05	4.0E-04	6.0E-04	7.9E-05	3.2E-04	1.9E-02	3.0E-05	3.9E-01	3.1E-01	-8.1E-02	-11.5%
18-Apr-12	117	0.5																											
25-Apr-12	118	0.5																											
2-May-12	119	0.5																											
9-May-12	120	0.5	5.0E-03	9.0E-05	1.0E-03	5.0E-01	6.1E-02	1.0E-02	3.1E-04	6.0E-04	9.0E-03	1.7E+00	4.8E-04	1.1E+01	5.0E-05	9.7E-01	3.2E-02	4.2E+00	2.0E-05	6.6E-04	2.0E-04	5.7E-05	2.4E-04	1.6E-02	3.0E-05	2.5E-01	2.8E-01	2.4E-02	4.5%
16-May-12	121	0.5																											
23-May-12	122	0.5																											
30-May-12	123	0.5																											
6-Jun-12	124	0.5	4.0E-03	7.0E-05	1.0E-03	5.0E-01	6.3E-02	1.0E-02	2.4E-04	5.0E-04	9.0E-03	1.7E+00	5.1E-04	1.3E+01	3.0E-05	1.0E+00	3.4E-02	4.6E+00	2.0E-05	3.0E-04	2.0E-04	5.2E-05	4.1E-04	1.5E-02	3.0E-05	2.2E-01	2.9E-01	6.6E-02	13.0%
13-Jun-12	125	0.5																											
20-Jun-12	126	0.5																											
27-Jun-12	127	0.5																											
4-Jul-12	128	0.5	3.0E-03	6.0E-05	1.0E-03	4.7E-01	6.2E-02	1.0E-02	2.5E-04	4.0E-04	9.0E-03	1.7E+00	4.4E-04	1.4E+01	4.0E-05	1.1E+00	3.3E-02	4.5E+00	2.0E-05	5.7E-04	3.0E-04	5.5E-05	4.0E-04	1.6E-02	4.0E-05	2.8E-01	2.8E-01	1.2E-03	0.2%
11-Jul-12	129	0.5																											
18-Jul-12	130	0.5																											
25-Jul-12	131	0.5																											
1-Aug-12	132	0.5	4.0E-03	8.0E-05	1.0E-03	4.4E-01	5.7E-02	1.0E-02	2.9E-04	6.0E-04	1.0E-02	1.5E+00	3.6E-04	1.4E+01	3.0E-05	1.1E+00	3.0E-02	4.6E+00	2.0E-05	6.4E-04	2.0E-04	4.6E-05	3.7E-04	1.4E-02	5.0E-05	2.1E-01	2.7E-01	5.8E-02	12.2%

Col 2A

Sample = (08-135 to 08-263) Composite

Date	Cycle	Approxi.	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Major	Major	Diff	Diff
	No.	Flow Rate																								Anions	Cations		(%)
		(mL/min)	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L				
8-Aug-12	133	0.5																											
15-Aug-12	134	0.5																											
22-Aug-12	135	0.5																											
29-Aug-12	136	0.5	5.0E-03	7.4E-04	1.0E-03	3.9E-01	5.2E-02	1.0E-01	5.8E-04	7.0E-04	9.0E-03	1.4E+00	3.8E-04	1.2E+01	3.0E-05	1.1E+00	2.7E-02	3.8E+00	2.0E-05	7.6E-04	2.0E-04	5.4E-05	4.1E-04	1.7E-02	8.0E-05	2.1E-01	2.4E-01	3.5E-02	7.8%
5-Sep-12	137	0.5																											
12-Sep-12	138	0.5																											
19-Sep-12	139	0.5																											
26-Sep-12	140	0.5	3.0E-03	6.0E-05	1.0E-03	3.9E-01	5.1E-02	1.0E-02	2.1E-04	7.0E-04	9.0E-03	1.3E+00	5.3E-04	1.3E+01	3.0E-05	1.2E+00	2.7E-02	3.9E+00	2.0E-05	1.5E-03	5.0E-04	4.2E-05	4.7E-04	1.2E-02	7.0E-05	2.7E-01	2.4E-01	-2.5E-02	-4.9%
3-Oct-12	141	0.5																											
10-Oct-12	142	0.5																											
17-Oct-12	143	0.5																											
24-Oct-12	144	0.5	3.0E-03	1.1E-04	1.0E-03	3.9E-01	5.0E-02	1.0E-02	2.6E-04	6.0E-04	9.0E-03	1.4E+00	4.7E-04	1.4E+01	1.0E-05	1.2E+00	2.7E-02	4.0E+00	2.0E-05	5.6E-04	2.0E-04	1.9E-04	3.3E-04	1.2E-02	3.0E-05	2.8E-01	2.5E-01	-3.4E-02	-6.5%
31-Oct-12	145	0.5																											
7-Nov-12	146	0.5																											
14-Nov-12	147	0.5																											
21-Nov-12	148	0.5	4.0E-03	1.9E-04	1.0E-03	3.9E-01	5.3E-02	1.0E-02	5.8E-04	7.0E-04	9.0E-03	1.3E+00	3.4E-04	1.1E+01	6.0E-05	1.2E+00	2.8E-02	3.7E+00	2.0E-05	7.6E-04	4.0E-04	4.3E-05	3.3E-04	1.5E-02	4.0E-05	1.9E-01	2.4E-01	4.9E-02	11.2%
28-Nov-12	149	0.5																											
5-Dec-12	150	0.5																											
12-Dec-12	151	0.5																											
19-Dec-12	152	0.5	4.0E-03	8.0E-05	1.0E-03	3.9E-01	5.2E-02	1.0E-02	2.5E-04	5.0E-04	9.0E-03	1.3E+00	3.6E-04	1.0E+01	7.0E-05	1.2E+00	2.8E-02	3.8E+00	3.0E-05	6.5E-04	2.0E-04	5.4E-05	1.2E-04	1.2E-02	1.0E-04	1.8E-01	2.5E-01	6.4E-02	14.9%
26-Dec-12	153	0.5																											
2-Jan-13	154	0.5																											
9-Jan-13	155	0.5																											
16-Jan-13	156	0.5	9.0E-03	6.0E-05	1.0E-03	3.5E-01	4.6E-02	1.0E-02	1.0E-03	5.0E-04	9.0E-03	1.2E+00	4.1E-04	1.1E+01	3.0E-05	9.6E-01	2.4E-02	3.9E+00	2.0E-05	9.9E-04	2.0E-04	4.6E-05	2.8E-04	1.2E-02	8.0E-05	2.9E-01	2.2E-01	-7.0E-02	-13.8%
23-Jan-13	157	0.5																											
30-Jan-13	158	0.5																											
6-Feb-13	159	0.5																											
13-Feb-13	160	0.5	3.0E-03	9.0E-05	1.0E-03	3.6E-01	4.6E-02	1.0E-02	2.4E-04	5.0E-04	9.0E-03	1.3E+00	3.6E-04	1.3E+01	2.0E-05	1.2E+00	2.6E-02	3.5E+00	2.0E-05	4.8E-04	1.0E-04	4.9E-05	1.8E-04	1.1E-02	7.0E-05	2.8E-01	2.3E-01	-5.3E-02	-10.6%
20-Feb-13	161	0.5																											
27-Feb-13	162	0.5																											
6-Mar-13	163	0.5																											
13-Mar-13	164	0.5	8.0E-03	6.0E-05	1.0E-03	3.4E-01	4.5E-02	1.0E-02	2.6E-04	4.0E-04	9.0E-03	1.2E+00	1.1E-03	1.2E+01	2.0E-05	1.0E+00	2.4E-02	3.5E+00	2.0E-05	4.5E-04	2.0E-04	3.4E-05	3.0E-05	1.0E-02	8.0E-05	1.5E-01	2.2E-01	6.7E-02	18.1%
20-Mar-13	165	0.5																											
27-Mar-13	166	0.5																											
3-Apr-13	167	0.5																											
10-Apr-13	168	0.5	4.0E-03	1.3E-04	1.0E-03	3.4E-01	4.5E-02	1.0E-02	2.1E-04	5.0E-04	9.0E-03	1.2E+00	6.9E-04	1.3E+01	2.0E-05	1.1E+00	2.4E-02	3.5E+00	2.0E-05	4.9E-04	1.0E-04	3.2E-05	3.0E-05	1.1E-02	8.0E-05	1.9E-01	2.2E-01	2.1E-02	5.1%
17-Apr-13	169	0.5																											
24-Apr-13	170	0.5																											
1-May-13	171	0.5																											
8-May-13	172	0.5	6.0E-03	9.0E-05	1.0E-03	3.1E-01	4.2E-02	1.0E-02	2.8E-04	5.0E-04	9.0E-03	1.1E+00	3.0E-04	1.0E+01	3.0E-05	9.7E-01	2.3E-02	3.2E+00	2.0E-05	4.9E-04	2.0E-04	3.8E-05	7.0E-05	1.1E-02	9.0E-05	3.1E-01	2.0E-01	-1.1E-01	-21.6%
15-May-13	173	0.5																											
22-May-13	174	0.5																											
29-May-13	175	0.5																											
5-Jun-13	176	0.5	9.2E-01	8.0E-05	1.0E-03	3.1E-01	4.5E-02	1.0E-02	8.4E-04	1.4E-03	9.0E-03	1.1E+00	4.0E-04	1.1E+01	3.0E-05	9.8E-01	2.3E-02	3.1E+00	2.0E-05	6.1E-04	2.0E-04	3.5E-05	7.0E-05	1.0E-02	7.0E-05	2.6E-01	2.0E-01	-5.2E-02	-11.2%
12-Jun-13	177	0.5																											
19-Jun-13	178	0.5																											
26-Jun-13	179	0.5																											
3-Jul-13	180	0.5	3.0E-03	5.0E-05	1.0E-03	3.0E-01	4.0E-02	1.0E-02	2.0E-04	4.0E-04	1.0E-02	1.0E+00	3.6E-04	1.1E+01	2.0E-05	1.1E+00	2.3E-02	3.1E+00	2.0E-05	5.2E-04	1.0E-04	2.9E-05	3.0E-05	9.0E-03	5.0E-05	1.9E-01	2.0E-01	1.5E-02	3.9%
10-Jul-13	181	0.5																											
17-Jul-13	182	0.5																											

Col 2A

Sample = (08-135 to 08-263) Composite

Date	Cycle	Approxi.	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Major	Major	Diff	Diff
	No.	Flow Rate																								Anions	Cations		(%)
		(mL/min)	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L				
24-Jul-13	183	0.5																											
31-Jul-13	184	0.5	3.0E-03	1.0E-03	1.0E-03	2.9E-01	3.9E-02	1.0E-02	3.6E-04	4.0E-04	9.0E-03	1.0E+00	3.6E-04	1.1E+01	1.0E-05	9.2E-01	2.2E-02	3.1E+00	2.0E-05	5.6E-04	2.0E-04	4.1E-05	8.0E-05	1.1E-02	9.0E-05	2.0E-01	1.9E-01	-8.2E-03	-2.1%
7-Aug-13	185	0.5																											
14-Aug-13	186	0.5																											
21-Aug-13	187	0.5																											
28-Aug-13	188	0.5	3.0E-03	8.0E-05	1.0E-03	2.7E-01	3.6E-02	1.0E-02	2.8E-04	3.0E-04	9.0E-03	9.8E-01	4.0E-04	1.0E+01	2.0E-05	9.0E-01	2.1E-02	2.7E+00	2.0E-05	1.4E-03	1.0E-04	3.1E-05	7.0E-05	1.0E-02	6.0E-05	1.6E-01	1.8E-01	2.3E-02	6.8%
4-Sep-13	189	0.5																											
11-Sep-13	190	0.5																											
18-Sep-13	191	0.5																											
25-Sep-13	192	0.5	3.0E-03	6.0E-04	1.0E-03	2.8E-01	3.6E-02	1.0E-02	2.9E-04	4.0E-04	9.0E-03	1.0E+00	3.4E-04	1.0E+01	2.0E-05	9.7E-01	2.1E-02	3.0E+00	2.0E-05	6.8E-04	1.0E-04	2.4E-05	6.0E-05	1.5E-02	6.0E-05	1.8E-01	1.9E-01	9.1E-03	2.4%
2-Oct-13	193	0.5																											
9-Oct-13	194	0.5																											
16-Oct-13	195	0.5																											
23-Oct-13	196	0.5	4.0E-03	1.7E-04	1.0E-03	2.6E-01	3.4E-02	1.0E-02	6.1E-04	4.0E-04	9.0E-03	9.2E-01	3.3E-04	1.1E+01	2.0E-05	9.0E-01	2.0E-02	2.9E+00	2.0E-05	7.1E-04	1.0E-04	3.8E-05	8.0E-05	9.0E-03	8.0E-05	2.1E-01	1.8E-01	-3.0E-02	-7.8%
30-Oct-13	197	0.5																											
6-Nov-13	198	0.5																											
13-Nov-13	199	0.5																											
20-Nov-13	200	0.5	3.0E-03	1.1E-04	1.0E-03	2.6E-01	3.3E-02	1.0E-02	2.7E-04	8.0E-04	9.0E-03	8.9E-01	4.3E-04	1.1E+01	2.0E-05	1.0E+00	2.0E-02	2.7E+00	5.0E-05	7.0E-04	1.0E-04	2.6E-05	4.0E-05	1.0E-02	6.0E-05	1.6E-01	1.8E-01	2.5E-02	7.4%
27-Nov-13	201	0.5																											
4-Dec-13	202	0.5																											
11-Dec-13	203	0.5																											
18-Dec-13	204	0.5	7.0E-03	7.0E-05	1.0E-03	2.6E-01	3.3E-02	1.0E-02	2.4E-03	4.0E-04	9.0E-03	9.7E-01	3.3E-04	1.1E+01	2.0E-05	1.0E+00	1.9E-02	2.8E+00	2.0E-05	7.0E-04	2.0E-04	3.6E-05	3.0E-05	9.0E-03	7.0E-05	1.4E-01	1.8E-01	4.6E-02	14.2%
25-Dec-13	205	0.5																											
1-Jan-14	206	0.5																											
8-Jan-14	207	0.5																											
15-Jan-14	208	0.5	1.0E-01	9.0E-05	1.0E-03	2.6E-01	3.5E-02	1.0E-02	3.4E-04	5.0E-04	9.0E-03	9.1E-01	3.2E-04	1.1E+01	2.0E-05	1.1E+00	2.0E-02	3.1E+00	2.0E-05	8.3E-04	1.0E-04	8.9E-05	7.0E-05	9.0E-03	1.1E-04	1.9E-01	1.9E-01	2.4E-03	0.6%
22-Jan-14	209	0.5																											
29-Jan-14	210	0.5																											
5-Feb-14	211	0.5																											
12-Feb-14	212	0.5	1.2E+00	5.0E-05	1.0E-03	6.6E-01	7.1E-02	1.0E-02	2.2E-04	6.4E-03	9.0E-03	8.7E-01	2.8E-04	1.1E+01	2.0E-05	1.0E+00	1.9E-02	4.3E+00	2.0E-05	7.5E-04	1.0E-04	4.4E-05	3.1E-04	1.5E-02	2.0E-05	1.4E-01	2.1E-01	7.2E-02	20.3%
19-Feb-14	213	0.5																											
26-Feb-14	214	0.5																											
5-Mar-14	215	0.5	6.0E-03	5.0E-05	1.0E-03	2.5E-01	3.1E-02	1.0E-02	5.6E-03	1.0E-04	9.0E-03	9.0E-01	2.9E-04	1.1E+01	2.0E-05	1.0E+00	1.9E-02	2.9E+00	2.0E-05	8.1E-04	1.0E-04	2.7E-05	4.0E-05	7.0E-03	9.0E-05	2.2E-01	1.8E-01	-4.0E-02	-10.2%
12-Mar-14	216	0.5	8.0E-03	8.0E-05	1.0E-03	2.9E-01	3.4E-02	1.0E-02	2.1E-02	7.0E-04	9.0E-03	5.5E-01	2.9E-04	8.4E+00	2.0E-05	9.1E-01	2.1E-02	2.7E+00	2.0E-05	5.3E-04	2.0E-04	3.5E-05	3.0E-05	1.1E-02	7.0E-05	2.1E-01	1.7E-01	-3.6E-02	-9.4%
19-Mar-14	217	0.5	4.0E-03	8.0E-05	1.0E-03	2.5E-01	3.0E-02	1.0E-02	5.1E-04	3.0E-04	1.0E-02	5.3E-01	4.4E-04	7.5E+00	2.0E-05	8.2E-01	1.9E-02	2.4E+00	2.0E-05	7.5E-04	3.0E-04	2.1E-05	4.0E-05	8.0E-03	1.2E-04	1.9E-01	1.6E-01	-3.1E-02	-8.9%
26-Mar-14	218	0.5	1.6E-02	4.0E-05	1.0E-03	2.3E-01	2.8E-02	1.0E-02	2.4E-04	1.0E-04	9.0E-03	4.9E-01	2.3E-04	6.3E+00	1.0E-05	7.5E-01	1.8E-02	2.2E+00	2.0E-05	5.1E-04	1.0E-04	2.4E-05	3.0E-05	7.0E-03	5.0E-05	1.6E-01	1.4E-01	-1.5E-02	-5.2%
2-Apr-14	219	0.5	3.0E-03	4.0E-05	1.0E-03	2.3E-01	2.7E-02	1.0E-02	2.7E-04	3.0E-04	9.0E-03	4.9E-01	2.9E-04	5.9E+00	1.0E-05	7.3E-01	1.7E-02	2.2E+00	2.0E-05	8.4E-04	1.0E-04	2.0E-05	3.0E-05	8.0E-03	6.0E-05	1.8E-01	1.4E-01	-4.2E-02	-13.2%
9-Apr-14	220	0.5																											
16-Apr-14	221	0.5																											
23-Apr-14	222	0.5																											
30-Apr-14	223	0.5	2.0E-03	4.0E-05	2.7E-04	1.9E-01	2.4E-02	1.0E-02	2.6E-04	3.0E-04	9.0E-03	5.1E-01	1.8E-04	6.6E+00	1.5E-05	6.6E-01	1.5E-02	1.9E+00	6.0E-06	6.1E-04	1.4E-04	1.3E-05	3.0E-05	7.0E-03	2.0E-03	1.6E-01	1.3E-01	-3.3E-02	-11.5%
7-May-14	224	0.5																											
14-May-14	225	0.5																											
21-May-14	226	0.5																											
28-May-14	227	0.5	7.0E-03	7.0E-05	2.3E-04	1.7E-01	2.2E-02	1.0E-02	5.1E-04	2.0E-04	9.0E-03	4.3E-01	1.8E-04	4.9E+00	8.0E-06	5.5E-01	1.3E-02	1.6E+00	5.0E-06	4.6E-04	2.7E-04	1.3E-05	2.0E-05	6.0E-03	2.0E-03	1.2E-01	1.1E-01	-2.2E-03	-0.9%
4-Jun-14	228	0.5																											
11-Jun-14	229	0.5																											
18-Jun-14	230	0.5																											
25-Jun-14	231	0.5	2.0E-03	5.0E-05	4.4E-04	1.5E-01	1.9E-02	1.0E-02	3.3E-04	5.0E-04	9.0E-03	3.6E-01	3.7E-04	4.1E+00	2.0E-06	4.7E-01	1.9E-02	1.4E+00	5.0E-06	5.3E-04	2.7E-04	1.1E-04	4.0E-05	5.0E-03	2.0E-03	1.7E-01	9.8E-02	-7.2E-02	-0.2693084
2-Jul-14	232	0.5																											
9-Jul-14	233	0.5																											
16-Jul-14	234	0.5																											
23-Jul-14	235	0.5	3.6E-02	3.0E-05	2.0E-04	1.5E-01	1.8E-02	1.0E-02	2.7E-04	3.0E-04	1.5E-02	3.6E-01	2.2E-04	3.8E+00	1.7E-05	4.2E-01	1.2E-02	1.4E+00	5.0E-06	3.9E-04	1.3E-04	9.0E-06	1.0E-05	5.0E-03	2.0E-03	1.1E-01	9.2E-02	-1.8E-02	-0.0912056
30-Jul-14	236	0.5																											
6-Aug-14	237	0.5																											
13-Aug-14	238	0.5																											
20-Aug-14	239	0.5	2.0E-03	4.0E-05	1.8E-04	1.5E-01	1.9E-02	1.0E-02	3.9E-04	2.0E-04	1.0E-02	3.5E-01	1.4E-04	3.5E+00	2.0E-06	4.1E-01	1.2E-02	1.3E+00	5.0E-06	5.6E-04	1.4E-04	1.7E-05	6.0E-05	7.0E-03	2.0E-03	1.3E-01	9.3E-02	-4.1E-02	-0.1801733

Feb 12/14 Metals being rerun

Feb 24/14 Change in analytical schedule

March 5/14 Moved into the cooler at 4° C at Cycle 215

Col 2A

Sample = (08-135 to 08-263) Composite

Date	Cycle	Approxi.	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Cl	F	Br	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Flow Rate	Input	Output		umhos/cm	(pH 4.5)	(pH 8.3)						CaCO3													
		(mL/min)					mgCaCO3/kg	mgCaCO3/kg	mgCaCO3/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
27-Jan-10	1	0.5	960	415	4.77	1.1E+03	#N/A	4.0E+00	#VALUE!	4.5E+01	5.6E+00	8.7E-02	6.6E-02	1.1E+01	1.9E-01	1.2E-03	2.8E-04	3.5E-03	1.6E-05	6.6E-06	7.1E-03	1.2E-04	3.2E+00	1.3E-03	1.7E-03	6.1E-02
3-Feb-10	2	0.5	300	340	5.62	4.9E+02	#N/A	6.9E-01	2.3E-01	1.6E+01	1.2E+00	2.0E-02	2.0E-02	2.0E+00	2.1E-02	5.6E-04	1.4E-04	1.9E-03	3.4E-06	1.4E-06	3.9E-03	3.0E-05	5.8E-01	5.2E-04	4.8E-04	1.6E-02
10-Feb-10	3	0.5	300	265	5.23	5.3E+02	#N/A	4.8E-01	6.6E-02	1.1E+01	3.9E-01	9.0E-03	1.6E-02	1.5E+00	7.8E-03	3.1E-04	6.4E-05	1.6E-03	3.2E-06	5.3E-07	3.6E-03	2.1E-05	4.5E-01	2.1E-04	3.8E-04	7.8E-03
17-Feb-10	4	0.5	300	300	5.03	4.2E+02	#N/A	5.2E-01	3.3E-02	1.1E+01	1.9E-01	9.0E-03	1.8E-02	1.5E+00	6.8E-03	2.9E-04	6.6E-05	1.6E-03	1.2E-06	1.2E-06	3.8E-03	2.1E-05	4.3E-01	1.9E-04	4.2E-04	8.6E-03
24-Feb-10	5	0.5	300	300	5.01	3.8E+02				9.8E+00																
3-Mar-10	6	0.5	300	295	5.17	3.3E+02	#N/A	4.1E-01	3.1E-02	8.7E+00	7.7E-02	7.1E-03	1.8E-02	9.7E-01	4.0E-03	1.9E-04	4.7E-05	1.5E-03	3.0E-06	5.9E-07	2.9E-03	1.4E-05	2.9E-01	1.6E-04	3.0E-04	6.5E-03
10-Mar-10	7	0.5	300	295	5.60	2.9E+02				6.9E+00																
17-Mar-10	8	0.5	300	320	4.96	2.7E+02	#N/A	5.0E-01	6.8E-02	6.6E+00	7.7E-02	6.4E-03	1.9E-02	9.2E-01	4.4E-03	1.5E-04	3.8E-05	1.8E-03	3.2E-06	6.4E-07	2.5E-03	1.5E-05	2.7E-01	1.2E-04	2.5E-04	5.6E-03
24-Mar-10	9	0.5	300	310	5.45	2.3E+02				6.2E+00																
31-Mar-10	10	0.5	300	315	5.23	2.0E+02	#N/A	4.4E-01	4.1E-02	6.5E+00	3.8E-02	6.3E-03	1.9E-02	7.2E-01	3.6E-03	1.4E-04	5.0E-05	1.9E-03	2.5E-06	6.3E-07	1.8E-03	1.2E-05	2.1E-01	1.4E-04	2.0E-04	5.7E-03
7-Apr-10	11	0.5	300	310	5.58	1.9E+02				4.8E+00																
14-Apr-10	12	0.5	300	295	5.12	1.7E+02	#N/A	4.3E-01	2.8E-02	4.0E+00	3.0E-02	5.3E-03	1.8E-02	6.0E-01	4.4E-03	1.2E-04	3.5E-05	2.2E-03	3.0E-06	1.8E-06	1.6E-03	1.4E-05	1.8E-01	8.9E-05	1.8E-04	5.6E-03
21-Apr-10	13	0.5	300	335	5.19	1.8E+02				5.1E+00																
28-Apr-10	14	0.5	300	330	4.93	1.7E+02	#N/A	2.9E-01	2.1E-02	4.5E+00	3.3E-02	5.3E-03	2.0E-02	7.8E-01	5.8E-03	1.1E-04	4.6E-05	2.7E-03	2.6E-06	6.6E-07	1.7E-03	1.2E-05	2.3E-01	1.1E-04	2.4E-04	6.4E-03
5-May-10	15	0.5	300	275	4.81	1.9E+02				4.5E+00																
12-May-10	16	0.5	300	300	5.46	2.0E+02	#N/A	3.8E-01	5.6E-02	4.7E+00	3.0E-02	6.6E-03	1.8E-02	1.2E+00	4.6E-03	1.0E-04	2.4E-05	2.8E-03	3.6E-06	6.0E-07	1.7E-03	1.8E-05	3.5E-01	1.0E-04	3.4E-04	8.6E-03
19-May-10	17	0.5	300	280	5.30	2.0E+02				3.6E+00																
26-May-10	18	0.5	300	310	5.38	1.9E+02	#N/A	6.0E-01	7.1E-02	4.0E+00	3.1E-02	6.8E-03	1.9E-02	1.5E+00	6.0E-03	8.7E-05	6.8E-05	3.2E-03	5.0E-06	6.2E-07	1.7E-03	2.3E-05	4.4E-01	9.9E-05	4.8E-04	1.2E-02
2-Jun-10	19	0.5	300	345	5.36	1.8E+02				3.9E+00																
9-Jun-10	20	0.5	300	335	5.48	1.9E+02	#N/A	5.0E-01	1.3E-01	4.3E+00	2.7E-02	8.7E-03	2.0E-02	1.9E+00	8.4E-03	7.4E-05	4.0E-05	3.8E-03	6.7E-06	6.7E-07	1.5E-03	3.1E-05	5.6E-01	9.4E-05	6.1E-04	1.8E-02
16-Jun-10	21	0.5	300	350	5.48	1.8E+02				3.4E+00																
23-Jun-10	22	0.5	300	290	5.35	2.1E+02	#N/A	4.7E-01	5.3E-02	4.0E+00	2.9E-02	3.5E-03	1.7E-02	2.2E+00	9.3E-03	8.7E-05	1.7E-05	2.9E-03	8.7E-06	5.8E-07	1.4E-03	3.7E-05	6.6E-01	8.7E-05	7.1E-04	2.2E-02
30-Jun-10	23	0.5	300	365	5.62	1.7E+02				5.0E+00																
7-Jul-10	24	0.5	300	290	5.55	1.9E+02	#N/A	4.0E-01	6.6E-02	3.4E+00	2.3E-02	8.1E-03	1.7E-02	2.0E+00	8.0E-03	6.4E-05	2.9E-05	2.6E-03	9.3E-06	5.8E-07	1.2E-03	3.9E-05	5.7E-01	8.1E-05	7.7E-04	2.3E-02
14-Jul-10	25	0.5	300	275	5.44	1.8E+02				2.8E+00																
21-Jul-10	26	0.5	300	300	5.28	1.8E+02	#N/A	6.1E-01	6.8E-02	3.4E+00	2.4E-02	8.4E-03	1.8E-02	2.5E+00	1.1E-02	4.8E-05	3.0E-05	2.6E-03	1.1E-05	6.0E-07	1.1E-03	4.8E-05	7.2E-01	7.8E-05	8.8E-04	2.6E-02
28-Jul-10	27	0.5	300	285	5.54	1.8E+02				2.7E+00																
4-Aug-10	28	0.5	300	285	5.66	1.7E+02	#N/A	5.2E-01	6.3E-02	3.4E+00	2.3E-02	9.1E-03	1.7E-02	2.5E+00	9.8E-03	5.1E-05	1.7E-05	2.4E-03	9.7E-06	5.7E-07	2.2E-03	4.3E-05	7.5E-01	7.4E-05	8.4E-04	2.5E-02
11-Aug-10	29	0.5	300	360	5.81	1.6E+02				4.4E+00																
18-Aug-10	30	0.5	300	340	5.69	1.4E+02	#N/A	6.8E-01	8.6E-02	3.2E+00	2.0E-02	7.5E-03	2.0E-02	2.3E+00	9.9E-03	5.4E-05	3.4E-05	3.2E-03	1.1E-05	6.8E-07	1.1E-03	4.1E-05	6.9E-01	5.4E-05	8.0E-04	2.6E-02
25-Aug-10	31	0.5	300	370	5.55	1.3E+02				2.8E+00																
1-Sep-10	32	0.5	300	365	5.73	1.3E+02	#N/A	5.7E-01	1.2E-01	4.2E+00	2.9E-02	8.0E-03	2.2E-02	2.6E+00	1.0E-02	5.1E-05	2.2E-05	4.0E-03	1.2E-05	7.3E-07	1.1E-03	5.0E-05	7.9E-01	4.4E-05	9.3E-04	2.8E-02
8-Sep-10	33	0.5	300	360	5.53	1.5E+02				4.2E+00																
15-Sep-10	34	0.5	300	345	5.19	1.4E+02	#N/A	5.1E-01	3.5E-02	4.3E+00	2.8E-02	9.7E-03	2.1E-02	2.8E+00	1.2E-02	6.9E-05	1.4E-05	4.1E-03	1.2E-05	1.4E-06	1.0E-03	4.9E-05	8.5E-01	8.3E-05	9.5E-04	3.1E-02
22-Sep-10	35	0.5	300	365	5.43	1.3E+02				4.7E+00																
29-Sep-10	36	0.5	300	340	5.43	1.2E+02	#N/A	4.3E-01	7.9E-02	4.0E+00	2.7E-02	1.0E-02	2.0E-02	2.8E+00	1.1E-02	2.6E-04	4.8E-05	3.7E-03	1.3E-05	6.8E-07	1.1E-03	5.6E-05	8.4E-01	5.4E-05	1.1E-03	3.6E-02
6-Oct-10	37	0.5	300	305	5.42	1.5E+02				3.5E+00																
13-Oct-10	38	0.5	300	330	5.19	1.4E+02	#N/A	4.8E-01	2.9E-02	3.3E+00	2.0E-02	8.6E-03	2.0E-02	2.6E+00	9.0E-03	5.9E-05	1.3E-05	4.0E-03	1.3E-05	6.6E-07	1.1E-03	4.7E-05	7.9E-01	3.3E-05	9.3E-04	3.0E-02
20-Oct-10	39	0.5	300	300	5.46	1.4E+02				3.2E+00																
27-Oct-10	40	0.5	300	400	5.50	1.2E+02	#N/A	4.0E-01	6.1E-02	3.8E+00	1.6E-02	1.0E-02	2.4E-02	2.5E+00	1.0E-02	4.8E-05	1.6E-05	3.9E-03	1.2E-05	8.0E-07	1.2E-03	5.0E-05	7.4E-01	4.0E-05	1.0E-03	3.4E-02
3-Nov-10	41	0.5	300	300	5.69	1.5E+02																				
10-Nov-10	42	0.5	300	375	5.30	1.3E+02																				
17-Nov-10	43	0.5	300	400	5.67	1.5E+02																				
24-Nov-10	44	0.5	300	380	5.41	1.1E+02	#N/A	4.3E-01	5.1E-02	3.3E+00	1.5E-02	8.4E-03	2.3E-02	2.2E+00	9.0E-03	4.6E-05	3.0E-05	4.8E-03	1.1E-05	7.6E-07	9.8E-04	4.5E-05	6.7E-01	5.3E-05	8.3E-04	3.0E-02
1-Dec-10	45	0.5	300	345	5.63	1.2E+02																				
8-Dec-10	46	0.5	300	370	5.34	1.1E+02																				
15-Dec-10	47	0.5	300	380	5.64	1.0E+02																				
22-Dec-10	48	0.5	300	375	5.85	1.0E+02	#N/A	5.1E-01	1.8E-01	3.1E+00	1.5E-02	9.0E-03	2.3E-02	2.2E+00	8.2E-03	9.8E-05	2.3E-05	5.3E-03	1.1E-05	7.5E-07	1.0E-03	4.0E-05	6.7E-01	4.5E-05	7.8E-04	2.8E-02
29-Dec-10	49	0.5	300	380	5.67	7.8E+01																				
5-Jan-11	50	0.5	300	400	5.51	9.3E+01																				
12-Jan-11	51	0.5	300	360	5.58	8.9E+01																				
19-Jan-11	52	0.5	300	330	5.60	9.3E+01	#N/A	4.3E-01	1.3E-01	2.4E+00	1.3E-02	7.3E-03	2.0E-02	1.8E+00	6.4E-03	4.6E-05	2.0E-05	4.9E-03	7.9E-06	6.6E-07	6.5E-04	3.2E-05	5.3E-01	3.3E-05	6.2E-04	2.2E-02
26-Jan-11	53	0.5	300	285	5.60	9.9E+01																				
2-Feb-11	54	0.5	300	315	5.30	8.8E+01																				
9-Feb-11	55	0.5	300	370	5.52	7.8E+01																				
16-Feb-11	56	0.5	300	420	5.65	7.3E+01	#N/A	3.9E-01	6.6E-02	2.1E+00	2.5E-02	5.0E-03	2.5E-02	1.6E+00	5.6E-03	3.4E-05	1.7E-05	5.6E-03	8.4E-06	8.4E-07	1.1E-03	3.1E-05	4.9E-01	5.0E-05	5.6E-04	2.0E-02

Col 2A

Sample = (08-135 to 08-263) Composite

Date	Cycle	Approxi.	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Cl	F	Br	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Flow Rate	Input	Output		umhos/cm	(pH 4.5)	(pH 8.3)						CaCO3												
		(mL/min)					mgCaCO3/kg	mgCaCO3/kg	mgCaCO3/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
23-Feb-11	57	0.5	300	505	5.81	6.2E+01																				
2-Mar-11	58	0.5	300	365	5.44	7.1E+01																				
9-Mar-11	59	0.5	300	455	5.74	6.4E+01																				
16-Mar-11	60	0.5	300	305	5.86	7.2E+01	#N/A	3.5E-01	7.9E-02	1.3E+00	1.2E-02	4.9E-03	1.8E-02	1.1E+00	4.0E-03	4.9E-05	1.2E-05	1.1E-02	5.5E-06	6.1E-07	4.2E-04	2.0E-05	3.3E-01	4.3E-05	3.5E-04	1.4E-02
23-Mar-11	61	0.5	300	395	5.95	7.1E+01																				
30-Mar-11	62	0.5	300	360	6.18	6.5E+01																				
6-Apr-11	63	0.5	300	280	6.00	8.1E+01																				
13-Apr-11	64	0.5	300	290	5.89	7.9E+01	#N/A	3.1E-01	7.5E-02	1.5E+00	1.2E-02	5.2E-03	1.7E-02	1.1E+00	4.5E-03	2.9E-05	1.2E-05	5.9E-03	5.2E-06	5.8E-07	6.1E-04	2.1E-05	3.5E-01	2.9E-05	4.0E-04	1.5E-02
20-Apr-11	65	0.5	300	325	6.20	7.9E+01																				
27-Apr-11	66	0.5	300	355	6.02	7.3E+01																				
4-May-11	67	0.5	300	305	5.94	7.4E+01																				
11-May-11	68	0.5	300	340	5.95	6.9E+01	#N/A	3.6E-01	9.2E-02	1.4E+00	1.4E-02	5.4E-03	2.0E-02	1.1E+00	4.6E-03	1.4E-05	4.1E-05	6.1E-03	6.1E-06	6.8E-07	6.2E-04	2.2E-05	3.5E-01	3.4E-05	4.4E-04	1.6E-02
18-May-11	69	0.5	300	330	5.93	8.9E+01																				
25-May-11	70	0.5	300	325	6.19	6.5E+01																				
1-Jun-11	71	0.5	300	340	6.20	6.9E+01																				
8-Jun-11	72	0.5	300	325	6.34	6.8E+01	#N/A	4.1E-01	1.6E-01	1.4E+00	2.0E-02	5.2E-03	2.0E-02	1.1E+00	4.7E-03	3.9E-05	1.3E-05	6.5E-03	5.9E-06	1.3E-06	6.6E-04	2.1E-05	3.2E-01	3.3E-05	3.9E-04	1.6E-02
15-Jun-11	73	0.5	300	320	6.19	6.9E+01																				
22-Jun-11	74	0.5	300	360	6.04	6.6E+01																				
29-Jun-11	75	0.5	300	310	6.02	7.0E+01																				
6-Jul-11	76	0.5	300	330	6.00	7.0E+01	#N/A	4.4E-01	9.7E-02	1.5E+00	1.3E-02	4.6E-03	2.0E-02	1.2E+00	4.7E-03	2.6E-05	1.3E-05	5.3E-03	5.3E-06	6.6E-07	7.1E-04	2.2E-05	3.6E-01	3.3E-05	4.3E-04	1.6E-02
13-Jul-11	77	0.5	300	180	6.35	6.9E+01																				
20-Jul-11	78	0.5	300	340	5.77	6.4E+01																				
27-Jul-11	79	0.5	300	340	5.80	6.2E+01																				
3-Aug-11	80	0.5	300	245	5.79	5.8E+01	#N/A	3.5E-01	8.4E-02	8.8E-01	9.8E-03	3.4E-03	1.5E-02	7.1E-01	2.6E-03	2.0E-05	1.5E-05	3.7E-03	3.4E-06	4.9E-07	4.4E-04	1.4E-05	2.1E-01	2.5E-05	2.6E-04	9.3E-03
10-Aug-11	81	0.5	300	350	6.22	5.4E+01																				
17-Aug-11	82	0.5	300	355	6.34	5.3E+01																				
24-Aug-11	83	0.5	300	290	6.47	5.7E+01																				
31-Aug-11	84	0.5	300	375	6.54	5.4E+01	#N/A	5.3E-01	2.0E-01	1.5E+00	1.5E-02	4.5E-03	2.3E-02	1.0E+00	4.7E-03	3.8E-05	2.3E-05	6.0E-03	5.3E-06	7.5E-07	7.7E-04	2.2E-05	3.2E-01	5.3E-05	4.2E-04	1.5E-02
7-Sep-11	85	0.5	300	330	6.19	5.0E+01																				
14-Sep-11	86	0.5	300	335	6.17	5.3E+01																				
21-Sep-11	87	0.5	300	295	6.09	5.5E+01																				
28-Sep-11	88	0.5	300	295	6.50	5.7E+01	#N/A	4.1E-01	1.2E-01	1.1E+00	1.2E-02	4.1E-03	1.8E-02	8.4E-01	3.5E-03	2.4E-05	1.2E-05	4.6E-03	5.3E-06	5.9E-07	3.1E-04	1.7E-05	2.5E-01	7.7E-05	3.1E-04	1.2E-02
5-Oct-11	89	0.5	300	335	6.16	5.0E+01																				
12-Oct-11	90	0.5	300	295	6.81	5.3E+01																				
19-Oct-11	91	0.5	300	325	6.11	5.2E+01																				
26-Oct-11	92	0.5	300	340	6.09	5.1E+01	#N/A	3.6E-01	8.4E-02	1.1E+00	1.4E-02	5.4E-03	2.0E-02	8.6E-01	3.7E-03	2.0E-05	1.4E-05	5.6E-03	5.4E-06	6.8E-07	6.2E-04	1.7E-05	2.6E-01	4.8E-05	3.1E-04	1.2E-02
2-Nov-11	93	0.5	300	330	6.61	5.0E+01																				
9-Nov-11	94	0.5	300	310	6.65	5.1E+01																				
16-Nov-11	95	0.5	300	315	6.22	5.2E+01																				
23-Nov-11	96	0.5	300	345	6.54	4.6E+01	#N/A	4.1E-01	1.8E-01	9.7E-01	1.4E-02	5.5E-03	2.1E-02	7.7E-01	4.9E-03	4.8E-05	2.1E-05	4.8E-03	4.1E-06	6.9E-07	7.4E-04	1.6E-05	2.4E-01	3.5E-05	2.7E-04	1.1E-02
30-Nov-11	97	0.5	300	325	6.81	4.8E+01																				
7-Dec-11	98	0.5	300	345	6.76	4.5E+01																				
14-Dec-11	99	0.5	300	330	6.25	4.4E+01																				
21-Dec-11	100	0.5	300	330	6.71	4.4E+01	#N/A	3.7E-01	1.4E-01	8.6E-01	1.3E-02	4.0E-03	2.0E-02	7.5E-01	4.4E-03	3.3E-05	1.3E-05	5.1E-03	3.3E-06	6.6E-07	5.3E-04	1.5E-05	2.3E-01	3.3E-05	2.5E-04	1.0E-02
28-Dec-11	101	0.5	300	305	5.81	4.5E+01																				
4-Jan-12	102	0.5	300	310	6.06	4.5E+01																				
11-Jan-12	103	0.5	300	335	5.99	4.5E+01																				
18-Jan-12	104	0.5	300	340	5.52	4.1E+01	#N/A	3.3E-01	3.6E-02	8.8E-01	1.4E-02	4.8E-03	2.0E-02	6.8E-01	5.2E-03	2.7E-05	1.4E-05	5.4E-03	4.1E-06	6.8E-07	1.3E-03	1.2E-05	2.1E-01	3.4E-05	2.3E-04	9.5E-03
25-Jan-12	105	0.5	300	330	5.41	4.5E+01																				
1-Feb-12	106	0.5	300	315	5.72	4.3E+01																				
8-Feb-12	107	0.5	300	310	6.92	4.7E+01																				
15-Feb-12	108	0.5	300	300	5.59	4.5E+01	#N/A	4.2E-01	6.4E-02	9.6E-01	1.2E-02	3.6E-03	1.8E-02	6.2E-01	3.4E-03	4.2E-05	1.8E-05	5.0E-03	3.0E-06	6.0E-07	4.1E-04	1.2E-05	1.9E-01	3.0E-05	2.1E-04	8.5E-03
22-Feb-12	109	0.5	300	310	5.85	4.4E+01																				
29-Feb-12	110	0.5	300	315	5.63	4.1E+01																				
7-Mar-12	111	0.5	300	325	6.46	3.9E+01																				
14-Mar-12	112	0.5	300	300	5.54	4.2E+01	#N/A	3.5E-01	5.1E-02	9.6E-01	1.8E-02	3.6E-03	1.8E-02	6.0E-01	2.8E-03	2.4E-05	1.2E-05	5.1E-03	2.4E-06	3.0E-06	4.1E-04	1.2E-05	1.8E-01	3.0E-05	2.1E-04	8.0E-03
21-Mar-12	113	0.5	300	290	5.73	4.3E+01																				
28-Mar-12	114	0.5	300	290	5.50	4.0E+01																				
4-Apr-12	115	0.5	300	325	5.67	4.0E+01																				
11-Apr-12	116	0.5	300	290	5.47	4.2E+01	#N/A	3.3E-01	4.3E-02	1.0E+00	1.2E-02	3.5E-03	1.7E-02	5.7E-01	5.8E-03	2.9E-05	2.9E-05	4.9E-03	2.3E-06	5.8E-07	4.4E-04	8.4E-06	1.8E-01	2.9E-05	2.4E-04	9.5E-03
18-Apr-12	117	0.5	300	315	5.79	3.8E+01																				

Col 2A

Sample = (08-135 to 08-263) Composite

Date	Cycle	Approxi.	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Cl	F	Br	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Flow Rate	Input	Output		umhos/cm	(pH 4.5)	(pH 8.3)						CaCO3												
		(mL/min)					mgCaCO3/kg	mgCaCO3/kg	mgCaCO3/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
25-Apr-12	118	0.5	300	300	5.73	3.8E+01																				
2-May-12	119	0.5	300	315	4.85	4.6E+01																				
9-May-12	120	0.5	300	320	5.63	3.9E+01	#N/A	3.8E-01	6.3E-02	7.0E-01	1.3E-02	3.8E-03	1.9E-02	5.6E-01	3.5E-03	3.2E-05	1.3E-05	5.3E-03	2.6E-06	6.4E-07	4.8E-04	8.1E-06	1.7E-01	3.2E-05	2.0E-04	7.7E-03
16-May-12	121	0.5	300	315	5.71	4.1E+01																				
23-May-12	122	0.5	300	300	5.71	3.8E+01																				
30-May-12	123	0.5	300	315	5.96	3.4E+01																				
6-Jun-12	124	0.5	300	320	5.69	3.9E+01	#N/A	4.0E-01	7.6E-02	5.8E-01	2.6E-02	3.8E-03	1.9E-02	5.8E-01	6.2E-03	2.6E-05	1.3E-05	6.1E-03	3.2E-06	6.4E-07	7.4E-04	9.3E-06	1.8E-01	3.2E-05	2.0E-04	7.6E-03
13-Jun-12	125	0.5	300	320	5.82	3.8E+01																				
20-Jun-12	126	0.5	300	305	5.76	3.9E+01																				
27-Jun-12	127	0.5	300	300	5.42	4.0E+01																				
4-Jul-12	128	0.5	300	300	5.81	4.0E+01	#N/A	4.1E-01	7.4E-02	7.2E-01	1.2E-02	3.6E-03	1.8E-02	5.2E-01	5.6E-03	3.0E-05	1.2E-05	5.8E-03	3.0E-06	1.8E-06	5.8E-04	9.5E-06	1.6E-01	3.0E-05	1.9E-04	7.3E-03
11-Jul-12	129	0.5	300	320	5.64	3.9E+01																				
18-Jul-12	130	0.5	300	350	5.59	3.1E+01																				
25-Jul-12	131	0.5	300	330	5.54	3.6E+01																				
1-Aug-12	132	0.5	300	310	5.73	3.7E+01	#N/A	3.5E-01	6.3E-02	5.6E-01	1.2E-02	3.7E-03	1.9E-02	4.9E-01	7.1E-03	4.3E-05	1.2E-05	5.6E-03	2.5E-06	6.2E-07	5.8E-04	8.9E-06	1.5E-01	3.1E-05	1.8E-04	6.1E-03
8-Aug-12	133	0.5	300	310	5.91	3.6E+01																				
15-Aug-12	134	0.5	300	325	5.61	3.6E+01																				
22-Aug-12	135	0.5	300	335	5.91	3.1E+01																				
29-Aug-12	136	0.5	300	335	5.58	3.4E+01	#N/A	4.8E-01	6.5E-02	6.0E-01	1.3E-02	4.0E-03	2.0E-02	4.7E-01	8.2E-03	4.7E-05	1.3E-05	6.3E-03	3.4E-06	1.3E-06	5.4E-04	8.6E-06	1.5E-01	3.4E-05	1.9E-04	6.7E-03
5-Sep-12	137	0.5	300	315	5.83	4.0E+01																				
12-Sep-12	138	0.5	300	310	5.60	3.1E+01																				
19-Sep-12	139	0.5	300	270	5.87	3.8E+01																				
26-Sep-12	140	0.5	300	345	5.54	3.4E+01	#N/A	3.9E-01	6.8E-02	8.3E-01	1.4E-02	4.1E-03	2.1E-02	4.9E-01	6.0E-03	3.5E-05	4.1E-05	6.7E-03	2.1E-06	6.9E-07	7.7E-04	9.2E-06	1.5E-01	3.5E-05	1.9E-04	6.6E-03
3-Oct-12	141	0.5	300	330	5.61	3.5E+01																				
10-Oct-12	142	0.5	300	330	5.61	3.4E+01																				
17-Oct-12	143	0.5	300	305	5.60	3.5E+01																				
24-Oct-12	144	0.5	300	315	5.69	3.6E+01	#N/A	4.3E-01	9.3E-02	7.6E-01	1.3E-02	3.8E-03	1.9E-02	4.5E-01	6.4E-03	2.5E-05	1.3E-05	6.1E-03	2.5E-06	6.3E-07	5.7E-04	1.2E-05	1.4E-01	3.2E-05	1.7E-04	6.2E-03
31-Oct-12	145	0.5	300	340	5.71	4.3E+01																				
7-Nov-12	146	0.5	300	335	5.58	2.9E+01																				
14-Nov-12	147	0.5	300	305	6.01	3.3E+01																				
21-Nov-12	148	0.5	300	280	5.93	3.3E+01	#N/A	3.5E-01	6.2E-02	4.5E-01	1.1E-02	4.5E-03	1.7E-02	4.0E-01	3.4E-03	2.8E-05	2.2E-05	5.8E-03	2.2E-06	5.6E-07	3.9E-04	9.5E-06	1.2E-01	2.8E-05	1.7E-04	5.5E-03
28-Nov-12	149	0.5	300	305	5.81	4.5E+01																				
5-Dec-12	150	0.5	300	300	6.23	2.9E+01																				
12-Dec-12	151	0.5	300	325	5.72	2.9E+01																				
19-Dec-12	152	0.5	300	280	5.83	3.1E+01	#N/A	3.0E-01	4.6E-02	4.5E-01	1.1E-02	3.4E-03	1.7E-02	4.0E-01	4.0E-03	3.4E-05	1.1E-05	5.8E-03	2.8E-06	5.6E-07	4.2E-04	8.5E-06	1.3E-01	2.8E-05	1.5E-04	4.7E-03
26-Dec-12	153	0.5	300	305	6.76	3.0E+01																				
2-Jan-13	154	0.5	300	280	6.04	2.8E+01																				
9-Jan-13	155	0.5	300	295	6.67	3.1E+01																				
16-Jan-13	156	0.5	300	295	5.96	3.1E+01	#N/A	3.0E-01	1.1E-01	7.1E-01	1.2E-02	4.1E-03	1.8E-02	3.8E-01	4.7E-03	3.0E-05	1.2E-05	6.0E-03	2.4E-06	5.9E-07	4.5E-04	7.3E-06	1.2E-01	3.0E-05	1.5E-04	5.2E-03
23-Jan-13	157	0.5	300	300	6.31	3.1E+01																				
30-Jan-13	158	0.5	300	290	5.69	3.1E+01																				
6-Feb-13	159	0.5	300	300	6.29	3.1E+01																				
13-Feb-13	160	0.5	300	295	6.46	3.1E+01	#N/A	4.3E-01	1.4E-01	6.5E-01	1.2E-02	4.1E-03	1.8E-02	3.8E-01	3.3E-03	3.0E-05	1.8E-05	5.5E-03	2.4E-06	5.9E-07	4.4E-04	8.1E-06	1.2E-01	3.0E-05	1.7E-04	5.6E-03
20-Feb-13	161	0.5	300	290	6.15	3.2E+01																				
27-Feb-13	162	0.5	300	285	5.84	3.0E+01																				
6-Mar-13	163	0.5	300	315	5.89	3.0E+01																				
13-Mar-13	164	0.5	300	315	5.55	3.0E+01	#N/A	4.4E-01	7.7E-02	3.8E-01	1.3E-02	3.8E-03	1.9E-02	4.1E-01	4.2E-03	3.2E-05	1.3E-05	6.4E-03	1.9E-06	6.3E-07	4.0E-04	8.0E-06	1.3E-01	3.2E-05	1.5E-04	5.1E-03
20-Mar-13	165	0.5	300	270	6.51	2.9E+01																				
27-Mar-13	166	0.5	300	315	5.79	3.0E+01																				
3-Apr-13	167	0.5	300	285	6.23	2.9E+01																				
10-Apr-13	168	0.5	300	310	5.71	3.0E+01	#N/A	4.2E-01	7.6E-02	5.0E-01	1.2E-02	3.7E-03	1.9E-02	3.8E-01	3.8E-03	3.1E-05	1.9E-05	5.7E-03	1.9E-06	6.2E-07	4.7E-04	1.1E-05	1.2E-01	3.1E-05	1.5E-04	4.3E-03
17-Apr-13	169	0.5	300	295	6.27	2.8E+01																				
24-Apr-13	170	0.5	300	290	6.01	2.9E+01																				
1-May-13	171	0.5	300	300	6.34	2.8E+01																				
8-May-13	172	0.5	300	295	6.71	2.8E+01	#N/A	4.9E-01	1.7E-01	7.1E-01	1.2E-02	3.5E-03	1.8E-02	3.4E-01	3.4E-03	3.0E-05	1.2E-05	6.1E-03	2.4E-06	5.9E-07	5.1E-04	7.3E-06	1.1E-01	3.0E-05	1.4E-04	4.4E-03
15-May-13	173	0.5	300	345	6.70	2.4E+01																				
22-May-13	174	0.5	300	310	6.26	2.6E+01																				
29-May-13	175	0.5	300	295	6.29	2.8E+01																				
5-Jun-13	176	0.5	300	285	5.76	2.8E+01	#N/A	3.7E-01	7.5E-02	6.3E-01	1.1E-02	3.4E-03	1.7E-02	3.4E-01	3.6E-03	2.9E-05	1.7E-05	6.3E-03	1.7E-06	5.7E-07	4.9E-04	7.2E-06	1.1E-01	2.9E-05	1.3E-04	4.3E-03
12-Jun-13	177	0.5	300	295	5.26	2.5E+01																				
19-Jun-13	178	0.5	300	310	6.00	2.7E+01																				

Col 2A

Sample = (08-135 to 08-263) Composite

Date	Cycle	Approxi.	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Cl	F	Br	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Flow Rate	Input	Output		umhos/cm	(pH 4.5)	(pH 8.3)						CaCO3												
		(mL/min)					mgCaCO3/kg	mgCaCO3/kg	mgCaCO3/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
26-Jun-13	179	0.5	300	290	5.80	2.7E+01																				
3-Jul-13	180	0.5	300	300	5.80	2.8E+01	#N/A	4.3E-01	6.2E-02	4.8E-01	1.2E-02	4.8E-03	1.8E-02	3.3E-01	3.0E-03	3.0E-05	2.4E-05	6.0E-03	1.8E-06	6.0E-07	1.5E-03	6.4E-06	1.0E-01	3.0E-05	1.2E-04	4.0E-03
10-Jul-13	181	0.5	300	300	6.77	2.6E+01																				
17-Jul-13	182	0.5	300	270	5.69	2.7E+01																				
24-Jul-13	183	0.5	300	335	6.47	2.4E+01																				
31-Jul-13	184	0.5	300	300	5.83	2.6E+01	#N/A	3.8E-01	1.1E-01	4.8E-01	1.2E-02	3.6E-03	1.8E-02	3.3E-01	4.0E-03	3.0E-05	1.2E-05	5.9E-03	2.4E-06	6.0E-07	1.0E-03	7.1E-06	1.0E-01	3.0E-05	1.2E-04	4.1E-03
7-Aug-13	185	0.5	300	310	6.31	2.5E+01																				
14-Aug-13	186	0.5	300	300	5.71	2.5E+01																				
21-Aug-13	187	0.5	300	305	6.57	2.5E+01																				
28-Aug-13	188	0.5	300	310	5.56	2.1E+01	#N/A	2.8E-01	4.8E-02	4.3E-01	1.2E-02	3.7E-03	1.9E-02	3.2E-01	3.6E-03	3.1E-05	1.2E-05	6.3E-03	1.9E-06	6.2E-07	1.0E-03	6.6E-06	1.0E-01	3.1E-05	1.2E-04	4.1E-03
4-Sep-13	189	0.5	300	295	5.90	2.4E+01																				
11-Sep-13	190	0.5	300	305	5.62	2.2E+01																				
18-Sep-13	191	0.5	300	305	6.49	2.5E+01																				
25-Sep-13	192	0.5	300	295	6.00	2.4E+01	#N/A	2.3E-01	4.5E-02	4.7E-01	1.2E-02	3.5E-03	1.8E-02	3.2E-01	2.9E-03	3.0E-05	1.2E-05	6.8E-03	2.4E-06	5.9E-07	1.0E-03	8.6E-06	9.9E-02	3.0E-05	1.2E-04	3.9E-03
2-Oct-13	193	0.5	300	300	5.71	2.5E+01																				
9-Oct-13	194	0.5	300	305	5.77	2.4E+01																				
16-Oct-13	195	0.5	300	305	5.38	2.4E+01																				
23-Oct-13	196	0.5	300	300	5.22	2.5E+01	#N/A	3.1E-01	3.0E-03	6.0E-01	1.2E-02	4.2E-03	1.8E-02	3.0E-01	3.0E-03	3.6E-05	1.8E-05	7.4E-03	1.8E-06	6.0E-07	8.6E-04	6.4E-06	9.6E-02	3.0E-05	1.2E-04	4.2E-03
30-Oct-13	197	0.5	300	305	5.47	2.5E+01																				
6-Nov-13	198	0.5	300	310	5.62	2.4E+01																				
13-Nov-13	199	0.5	300	300	6.30	2.3E+01																				
20-Nov-13	200	0.5	300	295	5.73	2.5E+01	#N/A	1.9E-01	3.1E-02	4.1E-01	1.2E-02	3.5E-03	1.8E-02	2.9E-01	3.6E-03	3.0E-05	1.2E-05	6.8E-03	1.8E-06	5.9E-07	7.8E-04	1.8E-05	9.1E-02	3.0E-05	1.6E-04	4.0E-03
27-Nov-13	201	0.5	300	300	5.63	2.4E+01																				
4-Dec-13	202	0.5	300	305	5.62	2.2E+01																				
11-Dec-13	203	0.5	300	310	5.63	2.4E+01																				
18-Dec-13	204	0.5	300	300	5.63	2.4E+01	#N/A	2.4E-01	3.9E-02	3.6E-01	1.2E-02	3.6E-03	1.8E-02	2.9E-01	3.8E-03	3.0E-05	1.2E-05	7.1E-03	1.8E-06	6.0E-07	7.3E-04	5.8E-06	9.2E-02	3.0E-05	1.1E-04	3.8E-03
25-Dec-13	205	0.5	300	305	6.16	2.4E+01																				
1-Jan-14	206	0.5	300	290	5.66	2.3E+01																				
8-Jan-14	207	0.5	300	270	5.55	2.3E+01																				
15-Jan-14	208	0.5	300	280	5.92	2.2E+01	#N/A	2.6E-01	5.4E-02	4.5E-01	1.1E-02	3.4E-03	1.7E-02	2.8E-01	4.6E-03	3.9E-05	1.1E-05	6.3E-03	2.8E-06	5.6E-07	7.0E-04	1.3E-05	8.9E-02	2.8E-05	1.0E-04	3.0E-03
22-Jan-14	209	0.5	300	285	5.67	2.3E+01																				
29-Jan-14	210	0.5	300	270	5.64	2.4E+01																				
5-Feb-14	211	0.5	300	275	5.93	2.3E+01																				
12-Feb-14	212	0.5	300	265	5.71	2.1E+01	#N/A	1.9E-01	4.5E-02	3.2E-01	1.1E-02	3.2E-03	1.6E-02	3.5E-01	3.7E-03	2.1E-05	2.7E-05	5.9E-03	2.1E-06	5.3E-07	5.5E-04	5.5E-06	8.2E-02	2.7E-05	3.1E-04	2.7E-03
19-Feb-14	213	0.5	300	240	5.94	2.4E+01																				
26-Feb-14	214	0.5	300	255	6.17	2.3E+01																				
5-Mar-14	215	0.5	300	285	5.91	2.8E+01	#N/A	3.4E-01	1.4E-01	4.6E-01	1.1E-02	3.4E-03	1.7E-02	2.7E-01	2.7E-03	2.9E-05	1.1E-05	6.7E-03	1.7E-06	5.7E-07	5.5E-04	5.1E-06	8.6E-02	2.9E-05	9.3E-05	2.8E-03
12-Mar-14	216	0.5	300	265	6.31	2.1E+01	#N/A	2.4E-01	1.7E-01	3.7E-01	1.1E-02	3.2E-03	1.6E-02	2.9E-01	2.7E-03	1.1E-05	1.1E-05	6.2E-03	1.6E-06	5.3E-07	2.9E-04	4.9E-06	9.0E-02	2.7E-05	1.0E-04	2.7E-03
19-Mar-14	217	0.5	300	285	6.19	2.1E+01	#N/A	3.7E-01	1.2E-01	4.0E-01	1.1E-02	3.4E-03	1.7E-02	2.7E-01	4.1E-03	2.9E-05	1.1E-05	6.7E-03	1.1E-06	2.9E-06	1.7E-04	5.0E-06	8.5E-02	2.9E-05	9.8E-05	2.8E-03
26-Mar-14	218	0.5	300	270	6.24	2.0E+01	#N/A	2.5E-01	8.3E-02	3.2E-01	1.1E-02	3.8E-03	1.6E-02	2.3E-01	1.9E-03	1.6E-05	1.1E-05	5.6E-03	1.1E-06	5.4E-07	3.2E-05	6.3E-06	7.3E-02	2.7E-05	8.5E-05	2.5E-03
2-Apr-14	219	0.5	300	285	6.31	1.9E+01	#N/A	3.2E-01	9.8E-02	4.0E-01	1.1E-02	4.0E-03	1.7E-02	2.5E-01	2.3E-03	1.1E-05	1.1E-05	5.1E-03	1.1E-06	5.7E-07	1.1E-04	3.6E-06	7.6E-02	2.9E-05	8.4E-05	2.4E-03
9-Apr-14	220	0.5	300	300	6.29	1.6E+01																				
16-Apr-14	221	0.5	300	240	6.31	1.6E+01																				
23-Apr-14	222	0.5	300	285	6.51	1.5E+01																				
30-Apr-14	223	0.5	300	245	6.71	1.2E+01	#N/A	3.1E-01	1.4E-01	2.5E-01	9.8E-03	2.9E-03	1.5E-02	1.9E-01	2.0E-03	1.5E-05	9.8E-06	4.5E-03	7.8E-07	3.4E-07	1.8E-04	3.2E-06	5.9E-02	1.5E-06	6.7E-05	2.2E-03
7-May-14	224	0.5	300	280	6.20	1.4E+01																				
14-May-14	225	0.5	300	290	6.09	1.5E+01																				
21-May-14	226	0.5	300	295	6.72	1.4E+01																				
28-May-14	227	0.5	300	315	6.15	1.3E+01	#N/A	3.6E-01	1.0E-01	2.5E-01	1.3E-02	3.8E-03	1.9E-02	2.1E-01	3.8E-03	1.3E-05	1.3E-05	4.5E-03	5.7E-07	4.4E-07	1.2E-04	3.4E-06	6.9E-02	3.2E-06	8.0E-05	2.2E-03
4-Jun-14	228	0.5	300	295	6.41	1.3E+01																				
11-Jun-14	229	0.5	300	285	6.31	1.3E+01																				
18-Jun-14	230	0.5	300	275	6.77	1.5E+01																				
25-Jun-14	231	0.5	300	290	6.77	1.4E+01	#N/A	3.5E-01	2.5E-01	2.3E-01	1.2E-02	3.5E-03	1.7E-02	1.7E-01	1.6E-03	1.7E-05	1.7E-05	4.3E-03	4.1E-07	4.1E-07	4.6E-04	2.9E-06	5.5E-02	8.7E-06	6.8E-05	1.9E-03
2-Jul-14	232	0.5	300	315	6.11	9.6E+00																				
9-Jul-14	233	0.5	300	275	6.11	1.2E+01																				
16-Jul-14	234	0.5	300	475	6.44	8.9E+00																				
23-Jul-14	235	0.5	300	275	6.63	1.2E+01	#N/A	2.1E-01	1.3E-01	1.7E-01	1.1E-02	3.3E-03	1.7E-02	1.6E-01	1.6E-03	1.7E-05	1.1E-05	3.9E-03	3.9E-07	3.9E-07	9.9E-05	2.5E-06	5.0E-02	1.7E-06	6.3E-05	1.7E-03
30-Jul-14	236	0.5	300	265	6.21	1.2E+01																				
6-Aug-14	237	0.5	300	275	6.39	1.1E+01																				
13-Aug-14	238	0.5	300	270	6.41	1.1E+01																				
20-Aug-14	239	0.5	300	280	6.18	8.8E+00	#N/A	1.3E-01	8.2E-02	2.8E-01	1.1E-02	3.9E-03	1.7E-02	1.6E-01	1.6E-03	1.1E-05	1.1E-05	3.9E-03	3.9E-07	3.9E-07	4.0E-04	4.5E-06	5.2E-02	1.8E-05	5.6E-05	1.7E-03

Col 2A

Sample = (08-135 to 08-263) Composite

Date	Cycle	Approxi.	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
	No.	Flow Rate																							
		(mL/min)	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
27-Jan-10	1	0.5	2.2E-02	2.4E-04	6.6E-04	7.2E-01	5.6E-02	3.3E-06	5.3E-04	5.1E-04	4.2E-03	2.0E+00	3.1E-03	2.2E+00	5.0E-06	1.5E+01	2.7E-02	1.2E+01	1.7E-05	8.3E-06	2.2E-04	2.5E-04	4.2E-05	5.7E-03	1.5E-03
3-Feb-10	2	0.5	5.4E-03	4.6E-05	2.7E-04	1.2E-01	1.1E-02	8.8E-06	2.7E-04	1.5E-04	6.8E-04	6.8E-01	1.3E-03	1.7E+00	2.0E-06	6.1E+00	5.4E-03	4.0E+00	1.4E-05	4.4E-05	1.2E-04	6.0E-05	9.5E-06	1.9E-03	3.6E-04
10-Feb-10	3	0.5	2.7E-03	2.8E-05	2.1E-04	9.6E-02	9.9E-03	5.3E-07	1.6E-04	8.5E-05	5.3E-04	6.0E-01	9.2E-04	1.5E+00	2.1E-06	4.6E+00	4.6E-03	3.8E+00	1.1E-05	8.0E-06	9.0E-05	2.9E-05	5.3E-06	1.3E-03	1.3E-04
17-Feb-10	4	0.5	1.8E-03	2.3E-05	1.8E-04	9.2E-02	1.0E-02	6.0E-07	1.8E-04	1.0E-04	6.0E-04	6.4E-01	9.4E-04	1.7E+00	1.8E-06	4.4E+00	4.4E-03	3.9E+00	1.2E-05	7.2E-06	1.1E-04	2.8E-05	9.0E-06	1.4E-03	9.8E-05
24-Feb-10	5	0.5																							
3-Mar-10	6	0.5	1.2E-03	1.4E-05	1.8E-04	6.1E-02	7.1E-03	5.9E-07	1.3E-04	6.5E-05	5.9E-04	4.9E-01	5.6E-04	1.5E+00	5.9E-07	3.1E+00	3.0E-03	2.7E+00	1.2E-05	4.8E-05	3.5E-05	1.6E-05	3.5E-06	1.0E-03	4.8E-05
10-Mar-10	7	0.5																							
17-Mar-10	8	0.5	1.3E-03	3.6E-05	1.9E-04	5.8E-02	6.8E-03	6.4E-07	9.2E-05	1.1E-04	6.4E-04	4.4E-01	3.9E-04	1.6E+00	6.4E-07	2.5E+00	2.9E-03	2.3E+00	1.3E-05	5.1E-06	3.2E-05	1.6E-05	1.9E-06	1.1E-03	2.9E-05
24-Mar-10	9	0.5																							
31-Mar-10	10	0.5	6.3E-04	9.5E-06	1.3E-04	4.6E-02	5.7E-03	1.3E-06	1.1E-04	5.0E-05	6.3E-04	3.8E-01	3.2E-04	1.4E+00	2.5E-06	2.1E+00	2.3E-03	1.9E+00	1.3E-05	1.9E-05	5.7E-05	1.6E-05	1.9E-06	8.8E-04	2.1E-05
7-Apr-10	11	0.5																							
14-Apr-10	12	0.5	5.9E-04	1.6E-04	1.2E-04	3.7E-02	4.4E-03	5.9E-07	8.5E-05	5.9E-05	5.9E-04	3.5E-01	2.6E-04	1.2E+00	1.8E-06	1.3E+00	1.9E-03	1.3E+00	1.2E-05	2.2E-05	1.8E-05	1.3E-05	1.8E-06	1.2E-03	1.7E-05
21-Apr-10	13	0.5																							
28-Apr-10	14	0.5	6.6E-04	8.4E-05	1.3E-04	4.9E-02	5.8E-03	6.6E-07	5.8E-05	1.1E-04	6.6E-04	3.7E-01	3.1E-04	1.2E+00	2.0E-06	1.4E+00	2.5E-03	1.4E+00	1.3E-05	4.3E-05	2.6E-05	1.1E-05	2.0E-06	2.4E-03	1.7E-05
5-May-10	15	0.5																							
12-May-10	16	0.5	7.2E-04	2.9E-05	1.8E-04	7.3E-02	8.6E-03	6.0E-07	7.3E-05	7.8E-05	5.4E-04	4.6E-01	2.4E-04	1.6E+00	6.6E-06	1.4E+00	3.8E-03	1.5E+00	1.2E-05	4.1E-05	1.8E-05	1.0E-05	1.8E-06	1.3E-03	1.6E-05
19-May-10	17	0.5																							
26-May-10	18	0.5	5.6E-04	7.4E-06	2.5E-04	9.2E-02	1.1E-02	6.2E-07	6.6E-05	1.1E-04	5.6E-04	4.7E-01	2.6E-04	1.4E+00	1.2E-06	1.2E+00	4.9E-03	1.5E+00	1.2E-05	7.6E-05	1.2E-05	1.5E-05	1.9E-06	2.4E-03	1.4E-05
2-Jun-10	19	0.5																							
9-Jun-10	20	0.5	3.4E-04	1.3E-05	2.0E-04	1.2E-01	1.5E-02	6.7E-07	5.3E-05	1.5E-04	6.0E-04	4.7E-01	2.1E-04	1.4E+00	5.4E-06	1.1E+00	6.2E-03	1.6E+00	1.3E-05	9.6E-05	2.0E-05	1.6E-05	2.7E-06	3.2E-03	1.5E-05
16-Jun-10	21	0.5																							
23-Jun-10	22	0.5	2.9E-04	1.2E-05	2.9E-04	1.4E-01	1.7E-02	5.8E-07	6.9E-05	1.3E-04	5.2E-04	5.4E-01	1.9E-04	1.5E+00	2.9E-06	8.4E-01	7.0E-03	1.6E+00	1.2E-05	1.0E-04	1.7E-05	1.7E-05	1.7E-06	2.9E-03	1.1E-05
30-Jun-10	23	0.5																							
7-Jul-10	24	0.5	4.1E-04	1.0E-05	2.9E-04	1.4E-01	1.8E-02	5.8E-07	4.2E-05	1.6E-04	1.5E-03	5.4E-01	1.6E-04	1.4E+00	3.5E-06	6.2E-01	7.7E-03	1.4E+00	1.2E-05	8.8E-05	1.7E-05	2.0E-05	1.7E-06	3.0E-03	1.1E-05
14-Jul-10	25	0.5																							
21-Jul-10	26	0.5	1.4E-03	1.7E-05	2.4E-04	1.6E-01	2.0E-02	1.2E-06	3.5E-05	1.4E-04	5.4E-04	5.5E-01	1.6E-04	1.5E+00	3.0E-06	4.7E-01	8.0E-03	1.4E+00	1.2E-05	8.8E-05	1.8E-05	2.1E-05	1.8E-06	3.3E-03	8.4E-06
28-Jul-10	27	0.5																							
4-Aug-10	28	0.5	2.9E-04	9.1E-06	2.3E-04	1.5E-01	2.0E-02	1.1E-06	4.8E-05	1.3E-04	6.8E-04	4.7E-01	1.3E-04	1.3E+00	1.7E-06	3.8E-01	7.9E-03	1.3E+00	1.1E-05	7.5E-05	1.1E-05	2.0E-05	1.7E-06	3.1E-03	6.8E-06
11-Aug-10	29	0.5																							
18-Aug-10	30	0.5	1.4E-04	1.2E-05	2.7E-04	1.4E-01	1.8E-02	6.8E-07	4.5E-05	1.5E-04	6.1E-04	5.0E-01	1.0E-04	1.2E+00	1.6E-05	2.8E-01	7.3E-03	1.6E+00	1.4E-05	4.6E-05	1.4E-05	2.0E-05	2.0E-06	3.5E-03	6.8E-06
25-Aug-10	31	0.5																							
1-Sep-10	32	0.5	1.5E-04	1.2E-05	2.9E-04	1.6E-01	1.9E-02	7.3E-07	9.1E-05	2.3E-04	6.6E-04	5.1E-01	1.3E-04	1.4E+00	1.5E-05	2.8E-01	8.2E-03	1.4E+00	1.5E-05	3.3E-05	2.2E-05	2.3E-05	2.2E-06	5.5E-03	5.8E-06
8-Sep-10	33	0.5																							
15-Sep-10	34	0.5	4.1E-04	1.7E-05	2.8E-04	1.7E-01	2.2E-02	6.9E-07	4.5E-05	1.6E-04	6.2E-04	4.6E-01	1.2E-04	1.3E+00	7.6E-06	2.0E-01	9.0E-03	1.3E+00	1.4E-05	6.8E-05	2.1E-05	2.4E-05	2.1E-06	3.7E-03	8.3E-06
22-Sep-10	35	0.5																							
29-Sep-10	36	0.5	1.4E-04	3.7E-05	2.7E-04	1.7E-01	2.2E-02	6.8E-07	7.6E-05	2.2E-04	1.1E-03	5.0E-01	1.3E-04	1.4E+00	5.4E-06	2.0E-01	8.9E-03	1.5E+00	1.4E-05	1.2E-04	4.8E-05	6.5E-05	2.0E-06	4.6E-03	6.8E-06
6-Oct-10	37	0.5																							
13-Oct-10	38	0.5	2.0E-04	1.3E-05	2.6E-04	1.7E-01	2.1E-02	6.6E-07	6.2E-05	1.6E-04	5.9E-04	4.4E-01	1.0E-04	1.4E+00	4.6E-06	1.6E-01	8.4E-03	1.2E+00	1.3E-05	3.6E-05	2.2E-04	2.0E-05	2.0E-06	3.4E-03	5.9E-06
20-Oct-10	39	0.5																							
27-Oct-10	40	0.5	4.0E-04	1.4E-04	2.4E-04	1.5E-01	1.9E-02	8.0E-07	1.1E-04	2.4E-04	1.4E-03	4.1E-01	1.9E-04	1.3E+00	9.6E-06	1.8E-01	8.0E-03	1.3E+00	1.6E-05	1.7E-05	3.0E-04	2.1E-05	2.4E-06	5.4E-03	4.0E-06
3-Nov-10	41	0.5																							
10-Nov-10	42	0.5																							
17-Nov-10	43	0.5																							
24-Nov-10	44	0.5	1.5E-04	1.2E-05	2.3E-04	1.3E-01	1.7E-02	7.6E-07	4.9E-05	1.2E-04	6.8E-04	3.5E-01	8.5E-05	1.2E+00	3.8E-06	1.1E-01	7.4E-03	9.7E-01	1.5E-05	2.9E-05	4.6E-05	3.0E-05	2.3E-06	3.5E-03	4.6E-06
1-Dec-10	45	0.5																							
8-Dec-10	46	0.5																							
15-Dec-10	47	0.5																							
22-Dec-10	48	0.5	1.5E-04	5.9E-05	2.3E-04	1.4E-01	1.7E-02	7.5E-07	7.0E-05	1.7E-04	1.8E-03	3.6E-01	1.1E-04	1.4E+00	1.2E-05	1.4E-01	7.5E-03	1.2E+00	1.5E-05	4.6E-05	3.0E-05	4.7E-05	2.3E-06	4.1E-03	3.8E-06
29-Dec-10	49	0.5																							
5-Jan-11	50	0.5																							
12-Jan-11	51	0.5																							
19-Jan-11	52	0.5	2.0E-04	7.9E-06	2.0E-04	1.1E-01	1.3E-02	6.6E-07	3.8E-05	1.3E-04	1.6E-03	2.8E-01	7.0E-05	1.1E+00	4.0E-06	9.9E-02	5.9E-03	7.9E-01	1.3E-05	2.6E-05	1.3E-05	1.2E-05	2.0E-06	2.8E-03	2.6E-06
26-Jan-11	53	0.5																							
2-Feb-11	54	0.5																							
9-Feb-11	55	0.5																							
16-Feb-11	56	0.5	2.5E-04	8.3E-05	1.7E-04	9.7E-02	1.1E-02	8.4E-07	6.2E-05	1.8E-04	2.2E-03	2.6E-01	6.7E-05	1.2E+00	5.0E-06	1.6E-01	5.3E-03	7.7E-01	1.7E-05	3.5E-05	1.7E-05	1.4E-05	2.5E-06	5.3E-03	4.2E-06

Col 2A

Sample = (08-135 to 08-263) Composite

Date	Cycle No.	Approxi. Flow Rate (mL/min)	Fe mg/kg	Pb mg/kg	Li mg/kg	Mg mg/kg	Mn mg/kg	Hg mg/kg	Mo mg/kg	Ni mg/kg	P mg/kg	K mg/kg	Se mg/kg	Si mg/kg	Ag mg/kg	Na mg/kg	Sr mg/kg	S mg/kg	Tl mg/kg	Sn mg/kg	Ti mg/kg	U mg/kg	V mg/kg	Zn mg/kg	Zr mg/kg
23-Feb-11	57	0.5																							
2-Mar-11	58	0.5																							
9-Mar-11	59	0.5																							
16-Mar-11	60	0.5	2.4E-04	1.0E-05	1.2E-04	6.5E-02	7.0E-03	6.1E-07	2.0E-05	6.7E-05	5.5E-04	1.8E-01	4.6E-05	9.2E-01	3.1E-06	5.6E-02	3.8E-03	5.1E-01	1.2E-05	5.0E-05	1.2E-05	8.1E-06	1.8E-06	1.6E-03	1.8E-06
23-Mar-11	61	0.5																							
30-Mar-11	62	0.5																							
6-Apr-11	63	0.5																							
13-Apr-11	64	0.5	1.2E-04	5.8E-06	1.2E-04	6.7E-02	8.2E-03	5.8E-07	2.1E-05	7.5E-05	5.2E-04	1.9E-01	6.4E-05	9.2E-01	2.9E-06	6.0E-02	3.8E-03	5.3E-01	1.2E-05	2.4E-05	1.0E-04	8.3E-06	1.7E-06	1.6E-03	5.8E-07
20-Apr-11	65	0.5																							
27-Apr-11	66	0.5																							
4-May-11	67	0.5																							
11-May-11	68	0.5	1.4E-04	1.2E-05	1.4E-04	6.7E-02	7.3E-03	6.8E-07	1.2E-04	7.5E-05	6.1E-04	1.8E-01	3.1E-05	9.4E-01	4.8E-06	6.2E-02	3.9E-03	5.4E-01	1.4E-05	3.6E-05	2.0E-05	1.1E-05	2.0E-06	2.0E-03	1.4E-06
18-May-11	69	0.5																							
25-May-11	70	0.5																							
1-Jun-11	71	0.5																							
8-Jun-11	72	0.5	1.3E-04	6.5E-06	1.3E-04	6.3E-02	7.3E-03	6.5E-07	2.3E-05	8.5E-05	2.2E-03	1.8E-01	5.1E-05	1.0E+00	3.3E-06	6.6E-02	3.6E-03	4.9E-01	2.6E-06	3.2E-05	1.3E-05	8.2E-06	2.0E-06	1.8E-03	2.0E-06
15-Jun-11	73	0.5																							
22-Jun-11	74	0.5																							
29-Jun-11	75	0.5																							
6-Jul-11	76	0.5	3.3E-04	7.3E-06	1.3E-04	7.0E-02	8.4E-03	6.6E-07	1.9E-05	7.3E-05	5.9E-04	1.9E-01	4.8E-05	1.1E+00	2.0E-06	7.5E-02	4.1E-03	5.6E-01	2.0E-06	2.3E-05	6.6E-06	7.5E-06	2.0E-06	1.8E-03	6.6E-07
13-Jul-11	77	0.5																							
20-Jul-11	78	0.5																							
27-Jul-11	79	0.5																							
3-Aug-11	80	0.5	9.8E-05	1.3E-05	9.8E-05	4.1E-02	5.0E-03	4.9E-07	2.0E-05	4.4E-05	4.4E-04	1.1E-01	2.6E-05	6.4E-01	2.0E-06	4.3E-02	2.4E-03	3.2E-01	9.8E-07	1.7E-05	9.8E-06	4.7E-06	1.5E-06	1.2E-03	1.5E-06
10-Aug-11	81	0.5																							
17-Aug-11	82	0.5																							
24-Aug-11	83	0.5																							
31-Aug-11	84	0.5	1.5E-04	1.1E-05	1.5E-04	6.1E-02	7.4E-03	7.5E-07	3.2E-05	8.3E-05	6.8E-04	1.8E-01	3.0E-06	1.0E+00	3.0E-06	7.1E-02	3.7E-03	5.6E-01	2.3E-06	2.5E-05	1.5E-05	6.7E-06	2.3E-06	2.0E-03	1.5E-06
7-Sep-11	85	0.5																							
14-Sep-11	86	0.5																							
21-Sep-11	87	0.5																							
28-Sep-11	88	0.5	1.2E-04	8.9E-06	1.2E-04	4.8E-02	6.0E-03	5.9E-07	1.7E-05	5.9E-05	5.3E-04	1.4E-01	3.8E-05	8.3E-01	2.4E-06	6.0E-02	2.9E-03	4.0E-01	1.8E-06	2.4E-05	1.2E-05	5.6E-06	1.8E-06	1.4E-03	1.8E-06
5-Oct-11	89	0.5																							
12-Oct-11	90	0.5																							
19-Oct-11	91	0.5																							
26-Oct-11	92	0.5	4.1E-04	2.4E-05	1.4E-04	5.0E-02	6.0E-03	6.8E-07	1.4E-05	5.4E-05	6.1E-04	1.5E-01	2.4E-05	8.1E-01	1.4E-06	6.2E-02	3.0E-03	4.3E-01	1.4E-06	2.3E-05	6.8E-06	7.2E-06	2.0E-06	1.4E-03	6.8E-07
2-Nov-11	93	0.5																							
9-Nov-11	94	0.5																							
16-Nov-11	95	0.5																							
23-Nov-11	96	0.5	2.1E-04	2.6E-04	1.4E-04	4.5E-02	5.3E-03	6.9E-07	1.9E-05	6.2E-05	6.2E-04	1.4E-01	1.9E-05	8.3E-01	2.1E-06	5.9E-02	2.7E-03	3.6E-01	2.1E-06	2.5E-05	2.8E-05	1.4E-05	2.5E-05	1.3E-03	6.9E-07
30-Nov-11	97	0.5																							
7-Dec-11	98	0.5																							
14-Dec-11	99	0.5																							
21-Dec-11	100	0.5	2.0E-04	1.7E-04	6.6E-05	4.3E-02	5.1E-03	6.6E-07	1.9E-05	5.3E-05	5.9E-04	1.3E-01	9.2E-06	8.0E-01	2.0E-06	5.8E-02	2.6E-03	3.7E-01	1.3E-06	1.3E-05	1.3E-05	4.2E-06	1.3E-05	1.1E-03	6.6E-07
28-Dec-11	101	0.5																							
4-Jan-12	102	0.5																							
11-Jan-12	103	0.5																							
18-Jan-12	104	0.5	2.0E-04	3.4E-06	6.8E-05	3.8E-02	4.5E-03	6.8E-07	1.6E-05	4.8E-05	6.1E-04	1.1E-01	2.7E-05	7.5E-01	2.7E-06	5.5E-02	2.4E-03	3.3E-01	1.4E-06	2.2E-05	2.0E-05	4.5E-06	2.9E-05	1.1E-03	6.8E-07
25-Jan-12	105	0.5																							
1-Feb-12	106	0.5																							
8-Feb-12	107	0.5																							
15-Feb-12	108	0.5	1.8E-04	2.6E-05	6.0E-05	3.5E-02	4.4E-03	6.0E-07	1.4E-05	4.2E-05	5.4E-04	1.1E-01	3.1E-05	8.0E-01	1.8E-06	5.7E-02	2.2E-03	3.0E-01	1.2E-06	1.7E-05	1.2E-05	4.8E-06	1.2E-05	9.6E-04	1.8E-06
22-Feb-12	109	0.5																							
29-Feb-12	110	0.5																							
7-Mar-12	111	0.5																							
14-Mar-12	112	0.5	1.8E-04	4.2E-06	6.0E-05	3.4E-02	4.3E-03	6.0E-07	1.6E-05	3.0E-05	5.4E-04	1.1E-01	2.9E-05	7.3E-01	3.0E-06	5.6E-02	2.2E-03	2.9E-01	1.2E-06	3.2E-05	6.0E-06	4.1E-06	1.8E-06	9.0E-04	2.4E-06
21-Mar-12	113	0.5																							
28-Mar-12	114	0.5																							
4-Apr-12	115	0.5																							
11-Apr-12	116	0.5	1.7E-04	7.0E-06	5.8E-05	3.2E-02	4.0E-03	2.9E-06	2.8E-05	5.8E-05	5.2E-04	1.0E-01	5.4E-04	7.7E-01	3.5E-06	6.1E-02	2.0E-03	2.8E-01	1.7E-06	2.3E-05	3.5E-05	4.6E-06	1.9E-05	1.1E-03	1.7E-06
18-Apr-12	117	0.5																							

Col 2A

Sample = (08-135 to 08-263) Composite

Date	Cycle No.	Approxi. Flow Rate (mL/min)	Fe mg/kg	Pb mg/kg	Li mg/kg	Mg mg/kg	Mn mg/kg	Hg mg/kg	Mo mg/kg	Ni mg/kg	P mg/kg	K mg/kg	Se mg/kg	Si mg/kg	Ag mg/kg	Na mg/kg	Sr mg/kg	S mg/kg	Tl mg/kg	Sn mg/kg	Ti mg/kg	U mg/kg	V mg/kg	Zn mg/kg	Zr mg/kg
25-Apr-12	118	0.5																						
2-May-12	119	0.5																						
9-May-12	120	0.5	3.2E-04	5.8E-06	6.4E-05	3.2E-02	3.9E-03	6.4E-07	2.0E-05	3.8E-05	5.8E-04	1.1E-01	3.1E-05	7.1E-01	3.2E-06	6.2E-02	2.1E-03	2.7E-01	1.3E-06	4.2E-05	1.3E-05	3.6E-06	1.5E-05	1.0E-03	1.9E-06
16-May-12	121	0.5																						
23-May-12	122	0.5																						
30-May-12	123	0.5																						
6-Jun-12	124	0.5	2.6E-04	4.5E-06	6.4E-05	3.2E-02	4.1E-03	6.4E-07	1.5E-05	3.2E-05	5.8E-04	1.1E-01	3.3E-05	8.3E-01	1.9E-06	6.4E-02	2.2E-03	3.0E-01	1.3E-06	1.9E-05	1.3E-05	3.3E-06	2.6E-05	9.6E-04	1.9E-06
13-Jun-12	125	0.5																						
20-Jun-12	126	0.5																						
27-Jun-12	127	0.5																						
4-Jul-12	128	0.5	1.8E-04	3.6E-06	6.0E-05	2.8E-02	3.7E-03	6.0E-07	1.5E-05	2.4E-05	5.4E-04	1.0E-01	2.6E-05	8.5E-01	2.4E-06	6.5E-02	2.0E-03	2.7E-01	1.2E-06	3.4E-05	1.8E-05	3.3E-06	2.4E-05	9.6E-04	2.4E-06
11-Jul-12	129	0.5																						
18-Jul-12	130	0.5																						
25-Jul-12	131	0.5																						
1-Aug-12	132	0.5	2.5E-04	5.0E-06	6.2E-05	2.7E-02	3.6E-03	6.2E-07	1.8E-05	3.7E-05	6.2E-04	9.5E-02	2.2E-05	8.9E-01	1.9E-06	6.8E-02	1.8E-03	2.8E-01	1.2E-06	4.0E-05	1.2E-05	2.9E-06	2.3E-05	8.7E-04	3.1E-06
8-Aug-12	133	0.5																						
15-Aug-12	134	0.5																						
22-Aug-12	135	0.5																						
29-Aug-12	136	0.5	3.4E-04	5.0E-05	6.7E-05	2.6E-02	3.5E-03	6.7E-06	3.9E-05	4.7E-05	6.0E-04	9.0E-02	2.5E-05	8.2E-01	2.0E-06	7.0E-02	1.8E-03	2.5E-01	1.3E-06	5.1E-05	1.3E-05	3.6E-06	2.7E-05	1.1E-03	5.4E-06
5-Sep-12	137	0.5																						
12-Sep-12	138	0.5																						
19-Sep-12	139	0.5																						
26-Sep-12	140	0.5	2.1E-04	4.1E-06	6.9E-05	2.7E-02	3.5E-03	6.9E-07	1.4E-05	4.8E-05	6.2E-04	8.8E-02	3.7E-05	8.7E-01	2.1E-06	8.1E-02	1.9E-03	2.7E-01	1.4E-06	1.0E-04	3.5E-05	2.9E-06	3.2E-05	8.3E-04	4.8E-06
3-Oct-12	141	0.5																						
10-Oct-12	142	0.5																						
17-Oct-12	143	0.5																						
24-Oct-12	144	0.5	1.9E-04	6.9E-06	6.3E-05	2.4E-02	3.2E-03	6.3E-07	1.6E-05	3.8E-05	5.7E-04	8.6E-02	3.0E-05	8.6E-01	6.3E-07	7.4E-02	1.7E-03	2.5E-01	1.3E-06	3.5E-05	1.3E-05	1.2E-05	2.1E-05	7.6E-04	1.9E-06
31-Oct-12	145	0.5																						
7-Nov-12	146	0.5																						
14-Nov-12	147	0.5																						
21-Nov-12	148	0.5	2.2E-04	1.1E-05	5.6E-05	2.2E-02	3.0E-03	5.6E-07	3.2E-05	3.9E-05	5.0E-04	7.0E-02	1.9E-05	6.3E-01	3.4E-06	6.6E-02	1.6E-03	2.1E-01	1.1E-06	4.3E-05	2.2E-05	2.4E-06	1.8E-05	8.4E-04	2.2E-06
28-Nov-12	149	0.5																						
5-Dec-12	150	0.5																						
12-Dec-12	151	0.5																						
19-Dec-12	152	0.5	2.2E-04	4.5E-06	5.6E-05	2.2E-02	2.9E-03	5.6E-07	1.4E-05	2.8E-05	5.0E-04	7.3E-02	2.0E-05	5.8E-01	3.9E-06	6.9E-02	1.5E-03	2.1E-01	1.7E-06	3.6E-05	1.1E-05	3.0E-06	6.7E-06	6.7E-04	5.6E-06
26-Dec-12	153	0.5																						
2-Jan-13	154	0.5																						
9-Jan-13	155	0.5																						
16-Jan-13	156	0.5	5.3E-04	3.5E-06	5.9E-05	2.0E-02	2.7E-03	5.9E-07	6.0E-05	3.0E-05	5.3E-04	6.9E-02	2.4E-05	6.7E-01	1.8E-06	5.7E-02	1.4E-03	2.3E-01	1.2E-06	5.8E-05	1.2E-05	2.7E-06	1.7E-05	7.1E-04	4.7E-06
23-Jan-13	157	0.5																						
30-Jan-13	158	0.5																						
6-Feb-13	159	0.5																						
13-Feb-13	160	0.5	1.8E-04	5.3E-06	5.9E-05	2.1E-02	2.7E-03	5.9E-07	1.4E-05	3.0E-05	5.3E-04	7.6E-02	2.1E-05	7.8E-01	1.2E-06	6.8E-02	1.5E-03	2.1E-01	1.2E-06	2.8E-05	5.9E-06	2.9E-06	1.1E-05	6.5E-04	4.1E-06
20-Feb-13	161	0.5																						
27-Feb-13	162	0.5																						
6-Mar-13	163	0.5																						
13-Mar-13	164	0.5	5.0E-04	3.8E-06	6.3E-05	2.1E-02	2.8E-03	6.3E-07	1.6E-05	2.5E-05	5.7E-04	7.7E-02	6.9E-05	7.5E-01	1.3E-06	6.4E-02	1.5E-03	2.2E-01	1.3E-06	2.8E-05	1.3E-05	2.1E-06	1.9E-06	6.3E-04	5.0E-06
20-Mar-13	165	0.5																						
27-Mar-13	166	0.5																						
3-Apr-13	167	0.5																						
10-Apr-13	168	0.5	2.5E-04	8.1E-06	6.2E-05	2.1E-02	2.8E-03	6.2E-07	1.3E-05	3.1E-05	5.6E-04	7.3E-02	4.3E-05	7.8E-01	1.2E-06	6.8E-02	1.5E-03	2.2E-01	1.2E-06	3.0E-05	6.2E-06	2.0E-06	1.9E-06	6.8E-04	5.0E-06
17-Apr-13	169	0.5																						
24-Apr-13	170	0.5																						
1-May-13	171	0.5																						
8-May-13	172	0.5	3.5E-04	5.3E-06	5.9E-05	1.9E-02	2.5E-03	5.9E-07	1.7E-05	3.0E-05	5.3E-04	6.4E-02	1.8E-05	6.0E-01	1.8E-06	5.7E-02	1.4E-03	1.9E-01	1.2E-06	2.9E-05	1.2E-05	2.2E-06	4.1E-06	6.5E-04	5.3E-06
15-May-13	173	0.5																						
22-May-13	174	0.5																						
29-May-13	175	0.5																						
5-Jun-13	176	0.5	5.2E-02	4.6E-06	5.7E-05	1.8E-02	2.6E-03	5.7E-07	4.8E-05	8.0E-05	5.1E-04	6.2E-02	2.3E-05	6.5E-01	1.7E-06	5.6E-02	1.3E-03	1.8E-01	1.1E-06	3.5E-05	1.1E-05	2.0E-06	4.0E-06	5.7E-04	4.0E-06
12-Jun-13	177	0.5																						
19-Jun-13	178	0.5																						

Col 2A

Sample = (08-135 to 08-263) Composite

Date	Cycle No.	Approxi. Flow Rate (mL/min)	Fe mg/kg	Pb mg/kg	Li mg/kg	Mg mg/kg	Mn mg/kg	Hg mg/kg	Mo mg/kg	Ni mg/kg	P mg/kg	K mg/kg	Se mg/kg	Si mg/kg	Ag mg/kg	Na mg/kg	Sr mg/kg	S mg/kg	Tl mg/kg	Sn mg/kg	Ti mg/kg	U mg/kg	V mg/kg	Zn mg/kg	Zr mg/kg
26-Jun-13	179	0.5																						
3-Jul-13	180	0.5	1.8E-04	3.0E-06	6.0E-05	1.8E-02	2.4E-03	6.0E-07	1.2E-05	2.4E-05	6.0E-04	6.2E-02	2.2E-05	6.4E-01	1.2E-06	6.5E-02	1.4E-03	1.8E-01	1.2E-06	3.1E-05	6.0E-06	1.7E-06	1.8E-06	5.4E-04	3.0E-06
10-Jul-13	181	0.5																							
17-Jul-13	182	0.5																							
24-Jul-13	183	0.5																							
31-Jul-13	184	0.5	1.8E-04	6.1E-05	6.0E-05	1.7E-02	2.3E-03	6.0E-07	2.2E-05	2.4E-05	5.4E-04	6.2E-02	2.2E-05	6.7E-01	6.0E-07	5.5E-02	1.3E-03	1.8E-01	1.2E-06	3.4E-05	1.2E-05	2.5E-06	4.8E-06	6.6E-04	5.4E-06
7-Aug-13	185	0.5																							
14-Aug-13	186	0.5																							
21-Aug-13	187	0.5																							
28-Aug-13	188	0.5	1.9E-04	5.0E-06	6.2E-05	1.6E-02	2.3E-03	6.2E-07	1.7E-05	1.9E-05	5.6E-04	6.1E-02	2.5E-05	6.2E-01	1.2E-06	5.6E-02	1.3E-03	1.7E-01	1.2E-06	8.4E-05	6.2E-06	1.9E-06	4.3E-06	6.2E-04	3.7E-06
4-Sep-13	189	0.5																							
11-Sep-13	190	0.5																							
18-Sep-13	191	0.5																							
25-Sep-13	192	0.5	1.8E-04	3.5E-05	5.9E-05	1.7E-02	2.1E-03	5.9E-07	1.7E-05	2.4E-05	5.3E-04	6.0E-02	2.0E-05	6.1E-01	1.2E-06	5.7E-02	1.2E-03	1.8E-01	1.2E-06	4.0E-05	5.9E-06	1.4E-06	3.5E-06	8.9E-04	3.5E-06
2-Oct-13	193	0.5																							
9-Oct-13	194	0.5																							
16-Oct-13	195	0.5																							
23-Oct-13	196	0.5	2.4E-04	1.0E-05	6.0E-05	1.6E-02	2.0E-03	6.0E-07	3.7E-05	2.4E-05	5.4E-04	5.5E-02	2.0E-05	6.5E-01	1.2E-06	5.4E-02	1.2E-03	1.7E-01	1.2E-06	4.3E-05	6.0E-06	2.3E-06	4.8E-06	5.4E-04	4.8E-06
30-Oct-13	197	0.5																							
6-Nov-13	198	0.5																							
13-Nov-13	199	0.5																							
20-Nov-13	200	0.5	1.8E-04	6.5E-06	5.9E-05	1.5E-02	2.0E-03	5.9E-07	1.6E-05	4.7E-05	5.3E-04	5.2E-02	2.5E-05	6.3E-01	1.2E-06	6.0E-02	1.2E-03	1.6E-01	3.0E-06	4.1E-05	5.9E-06	1.5E-06	2.4E-06	5.9E-04	3.5E-06
27-Nov-13	201	0.5																							
4-Dec-13	202	0.5																							
11-Dec-13	203	0.5																							
18-Dec-13	204	0.5	4.2E-04	4.2E-06	6.0E-05	1.6E-02	2.0E-03	6.0E-07	1.5E-04	2.4E-05	5.4E-04	5.8E-02	2.0E-05	6.5E-01	1.2E-06	6.2E-02	1.1E-03	1.7E-01	1.2E-06	4.2E-05	1.2E-05	2.2E-06	1.8E-06	5.4E-04	4.2E-06
25-Dec-13	205	0.5																							
1-Jan-14	206	0.5																							
8-Jan-14	207	0.5																							
15-Jan-14	208	0.5	5.6E-03	5.0E-06	5.6E-05	1.4E-02	2.0E-03	5.6E-07	1.9E-05	2.8E-05	5.0E-04	5.1E-02	1.8E-05	5.9E-01	1.1E-06	6.0E-02	1.1E-03	1.7E-01	1.1E-06	4.6E-05	5.6E-06	5.0E-06	3.9E-06	5.0E-04	6.2E-06
22-Jan-14	209	0.5																							
29-Jan-14	210	0.5																							
5-Feb-14	211	0.5																							
12-Feb-14	212	0.5	6.5E-02	2.7E-06	5.3E-05	3.5E-02	3.7E-03	5.3E-07	1.2E-05	3.4E-04	4.8E-04	4.6E-02	1.5E-05	5.7E-01	1.1E-06	5.3E-02	9.8E-04	2.3E-01	1.1E-06	4.0E-05	5.3E-06	2.3E-06	1.6E-05	8.0E-04	1.1E-06
19-Feb-14	213	0.5																							
26-Feb-14	214	0.5																							
5-Mar-14	215	0.5	3.4E-04	2.9E-06	5.7E-05	1.4E-02	1.7E-03	5.7E-07	3.2E-04	5.7E-06	5.1E-04	5.1E-02	1.7E-05	6.5E-01	1.1E-06	5.9E-02	1.1E-03	1.6E-01	1.1E-06	4.6E-05	5.7E-06	1.5E-06	2.3E-06	4.0E-04	5.1E-06
12-Mar-14	216	0.5	4.2E-04	4.2E-06	5.3E-05	1.5E-02	1.8E-03	5.3E-07	1.1E-03	3.7E-05	4.8E-04	2.9E-02	1.5E-05	4.5E-01	1.1E-06	4.8E-02	1.1E-03	1.4E-01	1.1E-06	2.8E-05	1.1E-05	1.9E-06	1.6E-06	5.8E-04	3.7E-06
19-Mar-14	217	0.5	2.3E-04	4.6E-06	5.7E-05	1.4E-02	1.7E-03	5.7E-07	2.9E-05	1.7E-05	5.7E-04	3.0E-02	2.5E-05	4.3E-01	1.1E-06	4.7E-02	1.1E-03	1.4E-01	1.1E-06	4.3E-05	1.7E-05	1.2E-06	2.3E-06	4.6E-04	6.8E-06
26-Mar-14	218	0.5	8.6E-04	2.2E-06	5.4E-05	1.2E-02	1.5E-03	5.4E-07	1.3E-05	5.4E-06	4.9E-04	2.6E-02	1.2E-05	3.4E-01	5.4E-07	4.1E-02	9.8E-04	1.2E-01	1.1E-06	2.8E-05	5.4E-06	1.3E-06	1.6E-06	3.8E-04	2.7E-06
2-Apr-14	219	0.5	1.7E-04	2.3E-06	5.7E-05	1.3E-02	1.5E-03	5.7E-07	1.5E-05	1.7E-05	5.1E-04	2.8E-02	1.7E-05	3.3E-01	5.7E-07	4.2E-02	9.5E-04	1.2E-01	1.1E-06	4.8E-05	5.7E-06	1.1E-06	1.7E-06	4.6E-04	3.4E-06
9-Apr-14	220	0.5																							
16-Apr-14	221	0.5																							
23-Apr-14	222	0.5																							
30-Apr-14	223	0.5	9.8E-05	2.0E-06	1.3E-05	9.5E-03	1.2E-03	4.9E-07	1.3E-05	1.5E-05	4.4E-04	2.5E-02	8.8E-06	3.2E-01	7.4E-07	3.2E-02	7.4E-04	9.2E-02	2.9E-07	3.0E-05	6.9E-06	6.4E-07	1.5E-06	3.4E-04	9.8E-05
7-May-14	224	0.5																							
14-May-14	225	0.5																							
21-May-14	226	0.5																							
28-May-14	227	0.5	4.4E-04	4.4E-06	1.4E-05	1.1E-02	1.4E-03	6.3E-07	3.2E-05	1.3E-05	5.7E-04	2.7E-02	1.1E-05	3.1E-01	5.0E-07	3.5E-02	8.3E-04	1.0E-01	3.2E-07	2.9E-05	1.7E-05	8.2E-07	1.3E-06	3.8E-04	1.3E-04
4-Jun-14	228	0.5																							
11-Jun-14	229	0.5																							
18-Jun-14	230	0.5																							
25-Jun-14	231	0.5	1.2E-04	2.9E-06	2.6E-05	8.9E-03	1.1E-03	5.8E-07	1.9E-05	2.9E-05	5.2E-04	2.1E-02	2.1E-05	2.4E-01	1.2E-07	2.7E-02	1.1E-03	8.2E-02	2.9E-07	3.1E-05	1.6E-05	6.3E-06	2.3E-06	2.9E-04	1.2E-04
2-Jul-14	232	0.5																							
9-Jul-14	233	0.5																							
16-Jul-14	234	0.5																							
23-Jul-14	235	0.5	2.0E-03	1.7E-06	1.1E-05	8.1E-03	1.0E-03	5.5E-07	1.5E-05	1.7E-05	8.3E-04	2.0E-02	1.2E-05	2.1E-01	9.4E-07	2.3E-02	6.3E-04	7.8E-02	2.8E-07	2.1E-05	7.2E-06	5.0E-07	5.5E-07	2.8E-04	1.1E-04
30-Jul-14	236	0.5																							
6-Aug-14	237	0.5																							
13-Aug-14	238	0.5																							
20-Aug-14	239	0.5	1.1E-04	2.2E-06	1.0E-05	8.3E-03	1.0E-03	5.6E-07	2.2E-05	1.1E-05	5.6E-04	1.9E-02	7.8E-06	2.0E-01	1.1E-07	2.3E-02	6.6E-04	7.4E-02	2.8E-07	3.1E-05	7.8E-06	9.5E-07	3.4E-06	3.9E-04	1.1E-04

HC3

Sample = 08-276

Sulphate	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/L	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
29-Nov-11	0	500	400	7.31	8.5E+02	#N/A	8.5E+00	4.1E+01	3.5E+02	5.0E+00	1.2E+00	3.0E-01	3.4E+02	2.4E-02	8.0E-04	8.0E-04	1.9E-02	2.0E-05	1.0E-05	1.6E-02	4.3E-04	9.6E+01	5.0E-04	1.4E-03	1.4E-02
6-Dec-11	1	500	445	7.42	5.0E+02	#N/A	4.0E+00	2.9E+01	2.0E+02	3.4E+00	9.1E-01	3.0E-01	1.8E+02	3.5E-02	6.0E-04	6.0E-04	1.2E-02	2.0E-05	1.0E-05	5.1E-03	2.1E-04	4.9E+01	5.0E-04	6.3E-04	1.2E-02
13-Dec-11	2	500	450	7.37	4.1E+02	#N/A	3.8E+00	2.4E+01	1.6E+02	1.5E+00	9.7E-01	3.0E-01	1.7E+02	8.7E-02	4.0E-04	6.0E-04	1.1E-02	2.0E-05	1.0E-05	4.4E-03	1.9E-04	4.8E+01	1.8E-03	4.4E-04	8.7E-03
20-Dec-11	3	500	485	7.39	2.8E+02	#N/A	4.1E+00	2.7E+01	1.1E+02	4.0E-01	7.9E-01	3.0E-01	1.1E+02	4.8E-02	7.0E-04	5.0E-04	8.0E-03	2.0E-05	1.0E-05	3.9E-03	1.3E-04	3.2E+01	5.0E-04	2.8E-04	5.0E-03
27-Dec-11	4	500	430	8.60	2.4E+02																				
3-Jan-12	5	500	435	7.38	1.7E+02	#N/A	4.1E+00	2.3E+01	6.0E+01	2.0E-01	6.9E-01	3.0E-01	6.4E+01	8.6E-02	7.0E-04	1.1E-03	5.4E-03	2.0E-05	1.0E-05	3.4E-03	5.9E-05	1.9E+01	5.0E-04	1.5E-04	2.9E-03
10-Jan-12	6	500	415	7.56	1.7E+02																				
17-Jan-12	7	500	475	7.68	1.1E+02	#N/A	2.4E+00	3.1E+01	3.1E+01	2.0E-01	6.2E-01	3.0E-01	4.6E+01	6.2E-02	9.0E-04	8.0E-04	5.9E-03	2.0E-05	1.0E-05	3.6E-03	4.2E-05	1.3E+01	5.0E-04	7.7E-05	2.4E-03
24-Jan-12	8	500	505	7.74	1.2E+02																				
31-Jan-12	9	500	460	7.57	1.3E+02	#N/A	3.0E+00	2.8E+01	3.4E+01	2.0E-01	5.5E-01	3.0E-01	4.9E+01	5.7E-02	7.0E-04	3.0E-04	8.2E-03	2.0E-05	1.0E-05	2.6E-03	4.5E-05	1.4E+01	5.0E-04	8.2E-05	2.6E-03
7-Feb-12	10	500	465	7.72	1.2E+02																				
14-Feb-12	11	500	450	7.73	1.2E+02	#N/A	4.7E+00	2.5E+01	4.0E+01	2.0E-01	4.6E-01	3.0E-01	4.9E+01	4.3E-02	4.0E-04	1.8E-03	6.5E-03	2.0E-05	1.0E-05	2.3E-03	3.3E-05	1.4E+01	5.0E-04	6.5E-05	3.8E-03
21-Feb-12	12	500	465	7.71	1.1E+02																				
28-Feb-12	13	500	500	7.59	8.9E+01	#N/A	3.2E+00	2.3E+01	2.3E+01	2.0E-01	2.9E-01	3.0E-01	4.0E+01	3.8E-02	7.0E-04	3.7E-03	7.2E-03	2.0E-05	1.0E-05	3.4E-03	2.6E-04	1.1E+01	5.0E-04	8.4E-05	1.1E-03
6-Mar-12	14	500	495	7.75	9.7E+01																				
13-Mar-12	15	500	445	7.52	1.2E+02	#N/A	2.9E+00	2.2E+01	3.8E+01	2.0E-01	3.1E-01	3.0E-01	5.2E+01	5.0E-02	5.0E-04	3.0E-04	7.7E-03	2.0E-05	1.0E-05	2.0E-03	2.3E-05	1.5E+01	5.0E-04	4.2E-05	1.3E-03
20-Mar-12	16	500	475	7.57	1.2E+02																				
27-Mar-12	17	500	490	7.49	1.1E+02	#N/A	2.6E+00	2.3E+01	3.0E+01	2.0E-01	2.9E-01	3.0E-01	4.7E+01	5.0E-02	5.0E-04	2.0E-04	8.4E-03	2.0E-05	1.0E-05	1.9E-03	3.7E-05	1.4E+01	5.0E-04	4.4E-05	1.5E-03
3-Apr-12	18	500	515	7.50	7.2E+01																				
10-Apr-12	19	500	510	7.48	9.4E+01	#N/A	2.1E+00	1.8E+01	2.7E+01	2.0E-01	2.0E-01	3.0E-01	4.0E+01	4.6E-02	4.0E-04	2.0E-04	8.1E-03	2.0E-05	1.0E-05	1.9E-03	3.0E-06	1.1E+01	5.0E-04	6.5E-05	1.3E-03
17-Apr-12	20	500	460	7.44	1.1E+02																				
24-Apr-12	21	500	490	7.49	8.6E+01	#N/A	2.7E+00	2.1E+01	2.5E+01	2.0E-01	1.8E-01	3.0E-01	3.7E+01	5.5E-02	4.0E-04	2.0E-04	9.2E-03	2.0E-05	1.0E-05	1.6E-03	3.0E-06	1.1E+01	5.0E-04	6.0E-05	1.7E-03
1-May-12	22	500	510	7.66	8.8E+01																				
8-May-12	23	500	520	7.51	9.2E+01	#N/A	2.7E+00	2.0E+01	2.8E+01	2.0E-01	1.6E-01	3.0E-01	4.0E+01	3.3E-02	5.0E-04	9.0E-04	7.2E-03	2.0E-05	1.0E-05	1.9E-03	4.9E-05	1.1E+01	5.0E-04	5.9E-05	1.5E-03
15-May-12	24	500	505	7.53	1.0E+02																				
22-May-12	25	500	430	7.47	1.3E+02	#N/A	3.4E+00	2.0E+01	3.7E+01	2.0E-01	1.9E-01	3.0E-01	5.3E+01	8.9E-02	6.0E-04	3.0E-04	8.1E-03	2.0E-05	1.0E-05	1.7E-03	3.0E-06	1.5E+01	5.0E-04	5.3E-05	1.9E-03
29-May-12	26	500	460	7.42	9.5E+01																				
5-Jun-12	27	500	455	7.35	9.5E+01	#N/A	3.2E+00	1.7E+01	2.6E+01	2.0E-01	1.3E-01	3.0E-01	4.0E+01	5.9E-02	9.0E-04	7.0E-04	7.0E-03	2.0E-05	1.0E-05	2.3E-03	3.0E-06	1.2E+01	5.0E-04	6.3E-05	1.1E-03
12-Jun-12	28	500	465	7.42	9.1E+01																				
19-Jun-12	29	500	460	7.39	8.9E+01	#N/A	2.8E+00	1.5E+01	2.2E+01	2.0E-01	1.3E-01	3.0E-01	3.7E+01	6.4E-02	3.0E-04	2.0E-04	5.8E-03	2.0E-05	1.0E-05	1.2E-03	3.0E-06	1.0E+01	5.0E-04	4.4E-05	1.1E-03
26-Jun-12	30	500	460	7.45	9.0E+01																				
3-Jul-12	31	500	450	7.63	9.7E+01	#N/A	6.4E+00	2.3E+01	2.8E+01	2.0E-01	1.3E-01	3.0E-01	4.1E+01	5.1E-02	3.0E-04	3.0E-04	8.4E-03	2.0E-05	1.0E-05	1.1E-03	2.4E-05	1.1E+01	5.0E-04	6.5E-05	1.4E-03
10-Jul-12	32	500	465	7.44	9.1E+01																				
17-Jul-12	33	500	480	7.45	9.3E+01	#N/A	2.1E+00	1.7E+01	2.3E+01	2.0E-01	1.1E-01	3.0E-01	4.2E+01	4.3E-02	5.0E-04	4.2E-03	5.3E-03	2.0E-05	1.0E-05	4.6E-03	2.4E-05	1.2E+01	5.0E-04	4.1E-05	1.4E-03
24-Jul-12	34	500	480	7.36	1.0E+02																				
31-Jul-12	35	500	475	7.47	9.8E+01	#N/A	2.1E+00	1.7E+01	2.6E+01	2.0E-01	1.0E-01	3.0E-01	4.3E+01	5.3E-02	4.0E-04	4.0E-04	6.3E-03	2.0E-05	1.0E-05	2.6E-03	1.1E-04	1.2E+01	5.0E-04	7.2E-05	1.8E-03
7-Aug-12	36	500	465	7.52	8.9E+01																				
14-Aug-12	37	500	460	7.29	9.8E+01	#N/A	2.8E+00	1.4E+01	3.2E+01	2.0E-01	1.1E-01	3.0E-01	4.3E+01	6.0E-02	3.0E-04	4.2E-03	6.4E-03	2.0E-05	1.0E-05	1.9E-03	1.1E-05	1.2E+01	5.0E-04	3.5E-05	1.4E-03
21-Aug-12	38	500	465	7.21	9.5E+01																				
28-Aug-12	39	500	505	7.40	8.8E+01	#N/A	3.2E+00	1.7E+01	2.5E+01	2.0E-01	9.0E-02	3.0E-01	3.8E+01	5.3E-02	4.0E-04	9.0E-04	4.5E-03	2.0E-05	1.0E-05	1.9E-03	2.2E-05	1.0E+01	5.0E-04	8.4E-05	1.9E-03
4-Sep-12	40	500	470	7.32	7.2E+01																				
11-Sep-12	41	500	475	7.28	8.6E+01	#N/A	2.8E+00	1.3E+01	2.6E+01	2.0E-01	9.0E-02	3.0E-01	4.0E+01	2.7E-02	3.0E-04	1.1E-03	5.4E-03	2.0E-05	1.0E-05	1.4E-03	1.6E-05	1.1E+01	5.0E-04	4.3E-04	2.8E-03
18-Sep-12	42	500	515	7.27	1.0E+02																				
25-Sep-12	43	500	455	7.22	9.5E+01	#N/A	3.4E+00	1.4E+01	3.0E+01	2.0E-01	8.0E-02	3.0E-01	4.0E+01	5.3E-02	2.0E-04	2.0E-04	7.7E-03	2.0E-05	1.0E-05	3.0E-04	1.4E-04	1.1E+01	5.0E-04	5.9E-05	1.3E-03
2-Oct-12	44	500	460	7.31	8.0E+01																				
9-Oct-12	45	500	465	7.27	7.3E+01	#N/A	3.9E+00	1.3E+01	2.1E+01	2.0E-01	7.0E-02	3.0E-01	3.1E+01	4.4E-02	2.0E-04	2.0E-04	3.5E-03	2.0E-05	1.0E-05	1.1E-03	5.4E-05	8.7E+00	5.0E-04	2.0E-06	2.6E-03
16-Oct-12	46	500	465	7.23	7.7E+01																				
23-Oct-12	47	500	475	7.31	6.7E+01																				
30-Oct-12	48	500	470	7.39	8.9E+01																				
6-Nov-12	49	500	445	7.18	8.8E+01	#N/A	2.9E+00	1.4E+01	2.7E+01	2.0E-01	8.0E-02	3.0E-01	4.4E+01	3.1E-02	2.0E-04	3.0E-04	5.1E-03	2.0E-05	1.0E-05	2.5E-03	8.8E-05	1.2E+01	5.0E-04	2.2E-04	4.1E-03
13-Nov-12	50	500	450	7.18	8.8E+01																				
20-Nov-12	51	500	490	7.61	5.6E+01																				
27-Nov-12	52	500	490	7.19	1.1E+02																				
4-Dec-12	53	500	470	7.39	6.9E+01	#N/A	2.1E+00	1.3E+01	1.9E+01	2.0E-01	7.0E-02	3.0E-01	3.2E+01	2.5E-02	5.0E-04	2.0E-04	3.5E-03	2.0E-05	1.0E-05	1.0E-03	6.0E-05	8.5E+00	5.0E-04	1.4E-04	1.1E-03
11-Dec-12	54	500	475	7.23	1.1E+02																				
18-Dec-12	55	500	450	7.41	7.6E+01																				
25-Dec-12	56	500	445	7.21	1.1E+02																				
1-Jan-13	57	500	465	7.41	5.4E+01	#N/A	4.1E+00	1.5E+01	1.4E+01	2.0E-01	6.0E-02	3.0E-01	2.5E+01	2.2E-02	2.0E-04	3.0E-04	3.5E-03	2.0E-05	1.0E-05	8.0E-04	1.3E-05	6.8E+00	5.0E-04	6.6E-05	5.0E-04
8-Jan-13	58	500	450	7.31	9.5E+01																				
15-Jan-13	59	500	450	7.36	5.6E+01																				
22-Jan-13	60	500	465	7.35	8.0E+01																				
29-Jan-13	61	500	470	7.38	6.0E+01	#N/A	2.5E+00	1.3E+01	1.8E+01	2.0E-01	6.0E-02	3.0E-01	2.7E+01	3.5E-02	2.0E-04	2.0E-04	2.9E-03	2.0E-05	1.0E-05	1.0E-03	2.3E-05	7.5E+00	5.0E-04	2.9E-05	1.0E-03
5-Feb-13	62	500	470	7.55	6.0E+01																				
12-Feb-13	63	500	440	7.67	5.0E+01																				

HC3

Sample = 08-276

Sulphate	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/L	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
19-Feb-13	64	500	480	7.47	5.2E+01																				
26-Feb-13	65	500	435	7.39	7.0E+01	#N/A	3.4E+00	1.4E+01	1.7E+01	2.0E-01	6.0E-02	3.0E-01	2.6E+01	2.0E-02	2.0E-04	4.0E-04	3.1E-03	2.0E-05	1.0E-05	1.0E-03	4.4E-05	7.1E+00	5.0E-04	2.7E-04	1.1E-03
5-Mar-13	66	500	445	7.68	7.0E+01																				
12-Mar-13	67	500	455	7.52	7.0E+01																				
19-Mar-13	68	500	465	7.79	5.6E+01																				
26-Mar-13	69	500	465	7.67	6.1E+01	#N/A	4.0E+00	1.4E+01	1.4E+01	2.0E-01	6.0E-02	3.0E-01	2.6E+01	1.8E-02	2.0E-04	1.0E-03	2.9E-03	2.0E-05	1.0E-05	1.6E-03	1.9E-04	7.0E+00	5.0E-04	2.6E-04	8.0E-04
2-Apr-13	70	500	450	7.57	6.1E+01																				
9-Apr-13	71	500	435	7.51	9.0E+01																				
16-Apr-13	72	500	445	7.52	9.0E+01																				
23-Apr-13	73	500	450	7.68	6.0E+01	#N/A	4.2E+00	1.4E+01	1.2E+01	2.0E-01	6.0E-02	3.0E-01	2.4E+01	1.7E-02	2.0E-04	2.0E-04	2.9E-03	2.0E-05	1.0E-05	1.4E-03	1.2E-05	6.3E+00	5.0E-04	5.5E-05	1.3E-03
30-Apr-13	74	500	450	7.58	5.9E+01																				
7-May-13	75	500	425	7.56	1.1E+02																				
14-May-13	76	500	455	7.58	5.9E+01																				
21-May-13	77	500	450	7.65	6.1E+01	#N/A	3.7E+00	1.2E+01	1.7E+01	2.0E-01	6.0E-02	3.0E-01	2.4E+01	1.7E-02	2.0E-04	2.0E-04	2.8E-03	2.0E-05	1.0E-05	1.3E-03	1.3E-05	6.4E+00	5.0E-04	4.2E-05	1.1E-03
28-May-13	78	500	450	7.57	2.3E+02	#N/A	4.8E+00	1.3E+01		2.0E-01	8.0E-02	3.0E-01	1.1E+02	1.3E-02	2.0E-04	2.0E-04	6.7E-03	2.0E-05	1.0E-05	2.4E-03	8.0E-06	4.0E+01	5.0E-04	5.4E-05	7.0E-04
4-Jun-13	79	500	445	7.56	5.4E+01	#N/A	3.8E+00	1.4E+01	1.5E+01	2.0E-01	6.0E-02	3.0E-01	2.3E+01	1.3E-02	2.0E-04	2.0E-04	3.7E-03	2.0E-05	1.0E-05	4.9E-03	4.0E-06	6.5E+00	5.0E-04	7.2E-05	1.2E-03
11-Jun-13	80	500	470	7.76	3.8E+01	#N/A	5.7E+00	1.5E+01	7.0E+00	2.0E-01	6.0E-02	3.0E-01	1.7E+01	1.0E-02	2.0E-04	2.0E-04	2.3E-03	2.0E-05	1.0E-05	4.1E-03	9.0E-06	4.5E+00	5.0E-04	4.8E-05	5.0E-04
18-Jun-13	81	500	465	7.51	3.4E+01	#N/A	4.2E+00	1.3E+01	7.0E+00	2.0E-01	9.0E-02	3.0E-01	1.6E+01	1.4E-02	2.0E-04	2.0E-04	3.0E-03	2.0E-05	1.0E-05	3.1E-03	3.0E-06	4.3E+00	5.0E-04	1.2E-04	9.0E-04
25-Jun-13	82	500	470	7.64	6.1E+01																				
2-Jul-13	83	500	465	7.56	2.7E+01	#N/A	5.7E+00	1.5E+01	5.0E+00	2.0E-01	6.0E-02	3.0E-01	1.2E+01	1.0E-02	2.0E-04	2.0E-04	1.8E-03	2.0E-05	1.0E-05	6.0E-04	9.0E-06	3.3E+00	5.0E-04	3.3E-05	1.1E-03
9-Jul-13	84	500	450	7.68	4.2E+01																				
16-Jul-13	85	500	475	7.44	3.3E+01	#N/A	3.2E+00	1.2E+01	6.0E+00	2.0E-01	6.0E-02	3.0E-01	1.5E+01	1.5E-02	2.0E-04	2.0E-04	2.0E-03	2.0E-05	1.0E-05	2.2E-03	8.0E-06	4.1E+00	5.0E-04	6.0E-05	8.0E-04
23-Jul-13	86	500	475	7.66	3.1E+01																				
30-Jul-13	87	500	470	7.45	2.7E+01	#N/A	3.7E+00	1.2E+01	6.0E+00	2.0E-01	6.0E-02	3.0E-01	1.3E+01	9.3E-03	2.0E-04	2.0E-04	1.8E-03	2.0E-05	1.0E-05	3.6E-03	7.0E-06	3.4E+00	5.0E-04	5.0E-06	6.0E-04
6-Aug-13	88	500	500	7.72	3.2E+01																				
13-Aug-13	89	500	470	7.36	2.9E+01	#N/A	2.8E+00	1.1E+01	4.0E+00	2.0E-01	6.0E-02	3.0E-01	1.4E+01	1.1E-02	2.0E-04	2.0E-04	2.1E-03	2.0E-05	1.0E-05	2.1E-03	4.0E-05	3.8E+00	5.0E-04	7.7E-05	4.7E-03
20-Aug-13	90	500	475	7.43	2.7E+01																				
27-Aug-13	91	500	470	7.47	2.8E+01																				
3-Sep-13	92	500	475	7.60	2.5E+01																				
10-Sep-13	93	500	470	7.43	3.0E+01	#N/A	3.3E+00	1.1E+01	3.0E+00	2.0E-01	6.0E-02	3.0E-01	1.9E+01	1.0E-02	2.0E-04	2.0E-04	2.4E-03	2.0E-05	1.0E-05	4.2E-03	2.4E-05	4.7E+00	5.0E-04	1.2E-04	9.0E-04
17-Sep-13	94	500	475	7.50	2.9E+01																				
24-Sep-13	95	500	495	7.34	2.8E+01																				
1-Oct-13	96	500	475	7.73	3.1E+01																				
8-Oct-13	97	500	460	7.36	2.9E+01	#N/A	1.7E+00	1.2E+01	3.0E+00	2.0E-01	6.0E-02	3.0E-01	1.5E+01	8.1E-03	2.0E-04	2.0E-04	2.5E-03	2.0E-05	1.0E-05	4.1E-03	1.3E-05	4.0E+00	5.0E-04	6.9E-05	6.0E-04
15-Oct-13	98	500	480	7.27	2.8E+01																				
22-Oct-13	99	500	470	7.41	3.0E+01																				
29-Oct-13	100	500	475	7.48	3.2E+01																				
5-Nov-13	101	500	480	7.51	3.0E+01	#N/A	1.8E+00	1.1E+01	4.0E+00	2.0E-01	6.0E-02	3.0E-01	1.4E+01	4.7E-03	2.0E-04	2.0E-04	2.4E-03	2.0E-05	1.0E-05	1.3E-03	6.0E-06	3.9E+00	5.0E-04	4.5E-05	6.0E-04
12-Nov-13	102	500	465	7.69	2.7E+01																				
19-Nov-13	103	500	470	7.34	3.0E+01																				
26-Nov-13	104	500	470	7.70	2.8E+01																				
3-Dec-13	105	500	475	7.77	2.9E+01	#N/A	6.7E-01	1.1E+01	4.0E+00	2.0E-01	6.0E-02	3.0E-01	1.4E+01	7.1E-03	2.0E-04	2.0E-04	2.6E-03	2.0E-05	1.0E-05	1.0E-03	1.4E-05	3.9E+00	5.0E-04	5.4E-05	5.0E-04
10-Dec-13	106	500	480	7.56	2.9E+01																				
17-Dec-13	107	500	480	7.62	3.1E+01																				
24-Dec-13	108	500	470	7.73	2.8E+01																				
31-Dec-13	109	500	480	7.58	2.9E+01	#N/A	1.5E+00	1.1E+01	3.0E+00	2.0E-01	6.0E-02	3.0E-01	1.4E+01	6.1E-03	2.0E-04	2.0E-04	3.1E-03	2.0E-05	1.0E-05	9.0E-04	8.0E-06	3.7E+00	5.0E-04	5.6E-05	7.0E-04
7-Jan-14	110	500	475	7.47	2.9E+01																				
14-Jan-14	111	500	475	7.79	2.6E+01																				
21-Jan-14	112	500	480	7.60	2.9E+01																				
28-Jan-14	113	500	470	7.56	2.9E+01	#N/A	1.8E+00	1.2E+01	3.0E+00	2.0E-01	6.0E-02	3.0E-01	1.4E+01	5.9E-03	2.0E-04	2.0E-04	2.8E-03	2.0E-05	1.0E-05	1.7E-03	3.0E-06	3.9E+00	5.0E-04	1.0E-05	5.0E-04
4-Feb-14	114	500	485	7.77	3.0E+01																				
11-Feb-14	115	500	480	7.71	2.7E+01																				
18-Feb-14	116	500	475	7.75	2.9E+01																				
25-Feb-14	117	500	485	7.71	2.6E+01	#N/A	2.9E+00	1.3E+01	4.0E+00	2.0E-01	6.0E-02	3.0E-01	1.3E+01	6.5E-03	2.0E-04	2.0E-04	2.8E-03	2.0E-05	1.0E-05	2.1E-03	5.0E-06	3.6E+00	5.0E-04	5.0E-05	6.0E-04

HC3

Sample = 08-276

Sulphate	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Major	Major	Diff	Diff
	No.																								Anions	Cations		(%)
		mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L				
29-Nov-11	0	3.0E-03	2.0E-05	5.0E-03	2.4E+01	1.6E-01	2.0E-02	7.3E-02	4.5E-03	9.0E-03	1.5E+01	2.8E-03	5.1E+00	1.0E-05	3.6E+01	2.6E-01	1.2E+02	4.0E-05	3.7E-04	4.0E-04	5.1E-02	3.5E-04	3.0E-03	5.8E-04	8.3E+00	8.7E+00	3.7E-01	2.2%
6-Dec-11	1	3.0E-03	2.0E-05	3.0E-03	1.5E+01	8.6E-02	2.0E-02	6.7E-02	3.0E-03	9.0E-03	9.0E+00	1.8E-03	8.5E-01	4.0E-05	2.5E+01	1.4E-01	7.2E+01	2.0E-05	5.0E-05	3.0E-04	4.2E-02	3.4E-04	2.0E-03	2.6E-04	4.9E+00	5.0E+00	2.7E-02	0.3%
13-Dec-11	2	7.9E-02	1.4E-04	2.0E-03	1.1E+01	6.8E-02	2.0E-02	5.3E-02	2.9E-03	2.3E-02	7.0E+00	1.0E-03	9.8E-01	1.0E-05	1.5E+01	1.5E-01	5.7E+01	2.0E-05	1.6E-04	1.8E-03	4.1E-02	2.3E-04	3.0E-03	2.4E-04	3.9E+00	4.2E+00	2.8E-01	3.5%
20-Dec-11	3	3.0E-03	2.0E-05	2.0E-03	8.0E+00	6.4E-02	1.0E-02	4.1E-02	1.9E-03	1.2E-02	5.1E+00	6.6E-04	1.1E+00	1.0E-05	7.5E+00	9.4E-02	3.8E+01	2.0E-05	1.0E-05	1.0E-04	5.5E-02	2.7E-04	2.0E-03	9.0E-05	2.9E+00	2.7E+00	-1.9E-01	-3.4%
27-Dec-11	4																											
3-Jan-12	5	6.0E-03	2.0E-05	1.0E-03	4.1E+00	2.6E-02	1.0E-02	3.0E-02	1.5E-03	9.0E-03	3.2E+00	1.4E-04	7.5E-01	1.0E-05	3.6E+00	5.8E-02	2.0E+01	2.0E-05	1.0E-04	4.0E-04	2.7E-02	6.7E-04	2.0E-03	5.0E-05	1.7E+00	1.5E+00	-2.2E-01	-6.7%
10-Jan-12	6																											
17-Jan-12	7	3.0E-03	2.0E-05	1.0E-03	3.4E+00	2.3E-02	1.0E-02	2.2E-02	4.0E-04	9.0E-03	2.8E+00	1.5E-04	9.2E-01	1.0E-05	1.8E+00	3.9E-02	1.0E+01	2.0E-05	2.0E-05	3.0E-04	3.3E-02	4.0E-04	2.0E-03	4.0E-05	1.3E+00	1.1E+00	-2.2E-01	-9.2%
24-Jan-12	8																											
31-Jan-12	9	6.0E-03	9.0E-05	1.0E-03	3.4E+00	2.5E-02	1.0E-02	1.8E-02	1.0E-04	9.0E-03	2.6E+00	2.9E-04	8.5E-01	1.0E-05	1.3E+00	4.3E-02	1.2E+01	2.0E-05	2.2E-04	5.0E-04	2.6E-02	5.8E-04	2.0E-03	2.0E-05	1.3E+00	1.1E+00	-2.0E-01	-8.2%
7-Feb-12	10																											
14-Feb-12	11	5.0E-03	2.0E-05	1.0E-03	3.4E+00	2.2E-02	1.0E-02	1.3E-02	5.0E-04	9.0E-03	2.2E+00	2.3E-04	8.0E-01	1.0E-05	8.7E-01	4.4E-02	1.1E+01	2.0E-05	3.0E-05	3.0E-04	2.3E-02	2.0E-04	1.0E-03	2.0E-05	1.4E+00	1.1E+00	-2.7E-01	-11.1%
21-Feb-12	12																											
28-Feb-12	13	3.0E-03	2.0E-05	1.0E-03	2.7E+00	2.6E-02	1.0E-02	7.7E-03	1.0E-04	9.0E-03	1.6E+00	2.7E-04	6.5E-01	1.0E-05	4.8E-01	3.5E-02	7.5E+00	2.0E-05	3.0E-05	2.0E-04	2.2E-02	3.1E-04	2.0E-03	1.0E-05	9.6E-01	8.6E-01	-1.0E-01	-5.7%
6-Mar-12	14																											
13-Mar-12	15	3.0E-03	2.0E-05	1.0E-03	3.5E+00	2.0E-02	1.0E-02	9.6E-03	2.0E-04	9.0E-03	1.9E+00	9.0E-05	7.4E-01	1.0E-05	5.0E-01	4.5E-02	1.2E+01	2.0E-05	2.1E-04	1.0E-04	2.3E-02	1.8E-04	1.0E-03	2.0E-05	1.2E+00	1.1E+00	-1.3E-01	-5.7%
20-Mar-12	16																											
27-Mar-12	17	3.0E-03	2.0E-05	1.0E-03	3.1E+00	2.4E-02	1.0E-02	7.6E-03	2.0E-04	9.0E-03	1.8E+00	7.0E-05	7.3E-01	1.0E-05	3.9E-01	4.0E-02	1.0E+01	2.0E-05	1.0E-05	2.0E-04	2.2E-02	3.0E-04	1.0E-03	1.0E-05	1.1E+00	1.0E+00	-8.7E-02	-4.1%
3-Apr-12	18																											
10-Apr-12	19	3.0E-03	2.0E-05	1.0E-03	2.7E+00	2.3E-02	2.0E-02	6.5E-03	1.0E-04	9.0E-03	1.3E+00	1.2E-04	6.2E-01	1.0E-05	2.7E-01	3.3E-02	8.6E+00	2.0E-05	5.0E-05	1.0E-04	1.6E-02	2.9E-04	1.0E-03	1.0E-05	9.3E-01	8.4E-01	-8.5E-02	-4.8%
17-Apr-12	20																											
24-Apr-12	21	3.0E-03	3.0E-05	1.0E-03	2.5E+00	2.1E-02	3.0E-02	5.8E-03	3.0E-04	9.0E-03	1.2E+00	9.0E-05	5.5E-01	1.0E-05	2.5E-01	3.0E-02	7.8E+00	2.0E-05	7.0E-05	2.0E-04	1.6E-02	3.6E-04	3.0E-03	1.0E-05	9.5E-01	7.8E-01	-1.6E-01	-9.5%
1-May-12	22																											
8-May-12	23	3.0E-03	2.8E-04	1.0E-03	2.9E+00	2.5E-02	1.0E-02	1.5E-02	3.0E-04	9.0E-03	1.2E+00	7.0E-05	5.4E-01	1.0E-05	2.5E-01	3.0E-02	8.6E+00	2.0E-05	2.2E-04	1.0E-04	1.9E-02	3.0E-04	6.0E-03	1.0E-05	9.9E-01	8.4E-01	-1.5E-01	-8.2%
15-May-12	24																											
22-May-12	25	3.0E-03	2.0E-05	1.0E-03	3.9E+00	2.1E-02	5.0E-02	9.4E-03	3.0E-04	9.0E-03	1.7E+00	1.5E-04	7.1E-01	1.0E-05	3.1E-01	4.5E-02	1.3E+01	2.0E-05	1.2E-04	4.0E-04	2.9E-02	5.6E-04	2.0E-03	2.0E-05	1.2E+00	1.1E+00	-5.7E-02	-2.4%
29-May-12	26																											
5-Jun-12	27	7.0E-03	2.0E-05	1.0E-03	2.8E+00	2.1E-02	1.0E-02	5.5E-03	1.0E-04	9.0E-03	1.2E+00	1.4E-04	5.3E-01	1.0E-05	2.3E-01	3.3E-02	9.4E+00	2.0E-05	2.0E-04	3.0E-04	1.5E-02	5.4E-04	1.0E-03	1.0E-05	8.8E-01	8.5E-01	-3.1E-02	-1.8%
12-Jun-12	28																											
19-Jun-12	29	3.0E-03	2.0E-05	1.0E-03	2.6E+00	1.9E-02	1.0E-02	2.3E-01	2.0E-04	9.0E-03	1.0E+00	2.0E-04	5.0E-01	1.0E-05	1.9E-01	2.9E-02	8.0E+00	2.0E-05	2.4E-04	5.0E-04	1.6E-02	5.5E-04	3.0E-03	1.0E-05	7.7E-01	7.7E-01	-1.6E-03	-0.1%
26-Jun-12	30																											
3-Jul-12	31	3.0E-03	3.0E-05	1.0E-03	3.0E+00	2.0E-02	1.0E-02	5.7E-03	1.0E-04	9.0E-03	1.1E+00	4.0E-05	4.8E-01	1.0E-05	2.1E-01	3.3E-02	9.5E+00	2.0E-05	3.1E-04	2.0E-04	1.5E-02	3.2E-04	2.0E-03	1.0E-05	1.1E+00	8.6E-01	-2.0E-01	-10.4%
10-Jul-12	32																											
17-Jul-12	33	3.0E-03	2.0E-05	3.0E-03	3.1E+00	2.2E-02	7.0E-02	6.8E-03	1.0E-04	9.0E-03	1.0E+00	3.8E-04	6.8E-01	1.2E-04	2.1E-01	3.2E-02	9.5E+00	2.0E-05	5.7E-04	3.0E-04	1.3E-02	3.1E-04	2.0E-03	1.0E-05	8.2E-01	8.7E-01	5.3E-02	3.1%
24-Jul-12	34																											
31-Jul-12	35	4.0E-03	2.6E-04	1.0E-03	3.1E+00	2.4E-02	1.0E-02	5.5E-03	1.0E-04	9.0E-03	9.8E-01	5.9E-04	6.8E-01	1.0E-05	2.1E-01	3.4E-02	9.6E+00	2.0E-05	4.5E-04	1.0E-04	1.3E-02	3.2E-04	3.0E-03	1.0E-05	8.9E-01	9.1E-01	1.9E-02	1.1%
7-Aug-12	36																											
14-Aug-12	37	3.0E-03	2.0E-05	1.0E-03	3.2E+00	2.3E-02	1.0E-02	5.6E-03	4.0E-04	9.0E-03	9.5E-01	1.9E-04	5.2E-01	1.0E-05	2.1E-01	3.2E-02	1.1E+01	2.0E-05	1.5E-04	4.0E-04	1.2E-02	6.2E-04	2.0E-03	1.0E-05	9.5E-01	8.9E-01	-6.1E-02	-3.3%
21-Aug-12	38																											
28-Aug-12	39	4.0E-03	5.0E-05	1.0E-03	3.0E+00	2.8E-02	1.0E-02	4.7E-03	3.0E-04	9.0E-03	8.0E-01	6.0E-05	5.4E-01	1.0E-05	1.7E-01	2.7E-02	8.3E+00	2.0E-05	2.6E-04	2.0E-04	1.6E-02	3.1E-04	2.0E-03	1.0E-05	8.7E-01	7.9E-01	-8.2E-02	-5.0%
4-Sep-12	40																											
11-Sep-12	41	3.0E-03	2.0E-05	1.0E-03	3.0E+00	2.5E-02	1.0E-02	4.0E-03	7.7E-02	9.0E-03	7.6E-01	1.0E-04	4.5E-01	1.0E-05	2.1E-01	2.9E-02	1.0E+01	2.0E-05	1.0E-04	1.0E-04	1.1E-02	1.4E-04	1.0E-03	2.0E-05	8.1E-01	8.4E-01	2.2E-02	1.4%
18-Sep-12	42																											
25-Sep-12	43	8.0E-03	3.0E-05	1.0E-03	3.0E+00	2.0E-02	1.0E-02	2.5E-01	2.0E-04	9.0E-03	7.1E-01	7.6E-04	3.8E-01	1.0E-05	1.7E-01	2.8E-02	1.0E+01	2.0E-05	3.4E-04	1.0E-04	2.5E-02	3.3E-04	2.0E-03	1.0E-05	9.1E-01	8.3E-01	-8.3E-02	-4.8%
2-Oct-12	44																											
9-Oct-12	45	1.8E-02	3.5E-04	1.0E-03	2.3E+00	2.0E-02	1.0E-02	4.0E-03	2.0E-04	9.0E-03	5.7E-01	1.3E-04	3.3E-01	1.0E-05	1.2E-01	2.2E-02	7.4E+00	2.0E-05	2.1E-04	2.0E-04	8.8E-03	2.6E-04	5.0E-03	1.0E-05	7.0E-01	6.5E-01	-5.5E-02	-4.0%
16-Oct-12	46																											
23-Oct-12	47																											
30-Oct-12	48																											
6-Nov-12	49	4.0E-03	3.0E-05	1.0E-03	3.3E+00	2.2E-02	1.0E-02	4.8E-03	6.0E-04	1.2E-02	6.7E-01	1.0E-04	3.6E-01	1.0E-05	2.0E-01	3.1E-02	1.1E+01	2.0E-05	1.2E-03	2.0E-04	1.1E-02	2.4E-04	8.0E-03	1.0E-05	8.4E-01	9.2E-01	7.9E-02	4.5%
13-Nov-12	50																											
20-Nov-12	51																											
27-Nov-12	52																											
4-Dec-12	53	3.0E-03	8.0E-05	1.0E-03	2.6E+00	1.8E-02	1.0E-02	3.6E-03	2.0E-04	9.0E-03	5.6E-01	4.9E-04	3.1E-01	1.0E-05	1.2E-01	2.1E-02	7.3E+00	2.0E-05	1.5E-04	1.0E-04	1.4E-02	1.8E-04	6.0E-03	1.0E-05	6.7E-01	6.6E-01	-5.8E-03	-0.4%
11-Dec-12	54																											
18-Dec-12	55																											
25-Dec-12	56																											
1-Jan-13	57	3.0E-03	2.0E-05	1.0E-03	2.0E+00	1.9E-02	1.0E-02	3.0E-03	1.0E-04	3.4E-02	4.2E-01	8.0E-05	3.8E-01	1.0E-05	1.0E-01	1.7E-02	4.8E+00	2.0E-05	3.1E-04	2.0E-04	8.7E-03	1.6E-04	2.0E-03	1.0E-05	5.9E-01	5.2E-01	-6.9E-02	-6.2%
8-Jan-13	58																											
15-Jan-13	59																											
22-Jan-13	60																											
29-Jan-13	61	3.0E-03	2.0E-05	1.0E-03	2.1E+00	1.7E-02	1.0E-02	2.9E-03	1.0E-04	1.1E-02	3.9E-01	9.0E-05	4.3E-01	1.0E-05	1.1E-01	1.8E-02	6.1E+00	2.0E-05	2.5E-04	2.0E-04	7.8E-03	2.2E-04	1.0E-03	1.0E-05	6.4E-01	5.6E-01	-8.1E-02	-6.7%
5-Feb-13	62																											
12-Feb-13	63																											

HC3

Sample = 08-276

Sulphate	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Major	Major	Diff	Diff
	No.																								Anions	Cations		(%)
		mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L				
19-Feb-13	64																											
26-Feb-13	65	3.0E-03	3.0E-05	1.0E-03	2.0E+00	1.6E-02	1.0E-02	2.8E-03	1.0E-04	1.0E-02	4.1E-01	1.0E-04	2.7E-01	1.0E-05	1.0E-01	1.6E-02	5.9E+00	2.0E-05	1.0E-04	1.0E-04	6.3E-03	4.0E-05	1.0E-03	1.0E-05	6.3E-01	5.4E-01	-8.4E-02	-7.2%
5-Mar-13	66																											
12-Mar-13	67																											
19-Mar-13	68																											
26-Mar-13	69	3.0E-03	5.9E-04	1.0E-03	2.1E+00	1.9E-02	1.0E-02	2.7E-03	7.0E-04	9.0E-03	3.8E-01	5.0E-05	3.5E-01	1.0E-05	1.0E-01	1.6E-02	5.8E+00	5.0E-05	1.4E-04	1.0E-04	6.2E-03	7.0E-05	1.0E-03	1.0E-05	5.7E-01	5.4E-01	-3.3E-02	-3.0%
2-Apr-13	70																											
9-Apr-13	71																											
16-Apr-13	72																											
23-Apr-13	73	3.0E-03	2.0E-05	1.0E-03	2.1E+00	1.7E-02	1.0E-02	2.7E-03	1.0E-04	9.0E-03	3.8E-01	4.0E-05	2.7E-01	1.0E-05	8.0E-02	1.4E-02	5.1E+00	2.0E-05	3.0E-05	1.0E-04	5.7E-03	3.0E-05	1.0E-03	1.0E-05	5.3E-01	5.0E-01	-2.3E-02	-2.2%
30-Apr-13	74																											
7-May-13	75																											
14-May-13	76																											
21-May-13	77	3.0E-03	4.0E-05	1.0E-03	2.0E+00	1.5E-02	1.0E-02	3.3E-03	1.0E-04	9.0E-03	4.0E-01	6.0E-05	3.0E-01	1.0E-05	8.0E-02	1.4E-02	5.5E+00	2.0E-05	2.6E-04	1.0E-04	5.5E-03	4.0E-05	1.0E-03	1.0E-05	6.0E-01	5.1E-01	-9.1E-02	-8.2%
28-May-13	78	3.0E-03	2.0E-05	1.0E-03	3.1E+00	1.4E-02	1.0E-02	4.3E-03	3.0E-04	9.0E-03	6.1E-01	9.0E-05	3.6E-01	1.0E-05	1.4E-01	1.0E-01	3.2E+01	2.0E-05	1.2E-04	1.0E-04	1.1E-02	6.0E-05	1.0E-03	1.0E-05	2.7E-01	2.3E+00	2.0E+00	78.8%
4-Jun-13	79	3.0E-03	2.0E-05	1.0E-03	1.7E+00	1.5E-02	1.0E-02	2.0E-03	5.0E-04	9.0E-03	3.4E-01	4.0E-05	2.3E-01	1.0E-05	1.0E-01	1.5E-02	3.9E+00	2.0E-05	2.3E-04	1.0E-04	9.0E-03	6.0E-05	2.0E-03	1.0E-05	5.9E-01	4.8E-01	-1.0E-01	-9.5%
11-Jun-13	80	3.0E-03	2.0E-05	1.0E-03	1.4E+00	1.4E-02	1.0E-02	3.5E-03	1.0E-04	9.0E-03	2.8E-01	5.0E-05	1.8E-01	1.0E-05	8.0E-02	1.1E-02	2.2E+00	2.0E-05	2.7E-04	1.0E-04	7.6E-03	3.0E-05	1.0E-03	1.0E-05	4.5E-01	3.6E-01	-9.1E-02	-11.3%
18-Jun-13	81	3.0E-03	2.0E-05	1.0E-03	1.3E+00	1.6E-02	1.0E-02	1.3E-03	2.0E-04	9.0E-03	2.4E-01	4.0E-05	1.5E-01	1.0E-05	8.0E-02	9.9E-03	1.8E+00	2.0E-05	7.1E-04	1.0E-04	6.3E-03	5.0E-05	1.0E-03	1.0E-05	4.0E-01	3.3E-01	-7.0E-02	-9.5%
25-Jun-13	82																											
2-Jul-13	83	3.0E-03	2.0E-05	1.0E-03	1.0E+00	1.3E-02	1.0E-02	7.3E-04	1.0E-04	9.0E-03	2.1E-01	4.0E-05	1.3E-01	1.0E-05	3.0E-02	7.8E-03	1.2E+00	2.0E-05	3.1E-04	1.0E-04	4.9E-03	9.0E-05	1.0E-03	1.0E-05	4.0E-01	2.5E-01	-1.4E-01	-21.7%
9-Jul-13	84																											
16-Jul-13	85	3.0E-03	3.0E-05	1.0E-03	1.3E+00	1.6E-02	2.0E-02	9.0E-04	1.0E-04	9.0E-03	2.0E-01	4.0E-05	1.2E-01	1.0E-05	4.0E-02	9.4E-03	1.5E+00	2.0E-05	2.9E-04	1.0E-04	6.0E-03	3.0E-05	2.0E-03	1.0E-05	3.6E-01	3.2E-01	-4.2E-02	-6.2%
23-Jul-13	86																											
30-Jul-13	87	3.0E-03	2.0E-05	1.0E-03	1.0E+00	1.4E-02	1.0E-02	9.1E-04	1.0E-04	9.0E-03	1.7E-01	4.0E-05	1.0E-01	1.0E-05	3.0E-02	8.4E-03	1.2E+00	2.0E-05	7.5E-04	1.0E-04	5.1E-03	5.0E-05	1.0E-03	1.0E-05	3.6E-01	2.6E-01	-1.0E-01	-16.2%
6-Aug-13	88																											
13-Aug-13	89	1.7E-02	2.7E-04	1.0E-03	1.1E+00	1.8E-02	1.0E-02	6.5E-04	2.0E-04	9.0E-03	1.9E-01	4.0E-05	1.5E-01	1.0E-05	4.0E-02	8.8E-03	1.4E+00	2.0E-05	3.8E-04	1.0E-04	4.7E-03	3.0E-05	6.0E-03	1.0E-05	3.0E-01	2.9E-01	-1.2E-02	-2.0%
20-Aug-13	90																											
27-Aug-13	91																											
3-Sep-13	92																											
10-Sep-13	93	3.0E-03	2.0E-05	1.0E-03	1.3E+00	2.3E-02	1.0E-02	8.9E-04	2.0E-04	9.0E-03	2.1E-01	4.0E-05	1.5E-01	1.0E-05	6.0E-02	1.4E-02	2.4E+00	2.0E-05	8.4E-04	1.0E-04	5.3E-03	6.0E-05	4.0E-03	1.0E-05	2.8E-01	3.5E-01	7.0E-02	11.0%
17-Sep-13	94																											
24-Sep-13	95																											
1-Oct-13	96																											
8-Oct-13	97	3.0E-03	2.0E-05	1.0E-03	1.1E+00	1.8E-02	1.0E-02	5.9E-04	1.0E-04	9.0E-03	1.8E-01	4.0E-05	1.4E-01	1.0E-05	2.0E-02	9.0E-03	1.3E+00	2.0E-05	6.0E-05	1.0E-04	4.7E-03	3.0E-05	1.0E-03	1.0E-05	2.9E-01	3.0E-01	4.7E-03	0.8%
15-Oct-13	98																											
22-Oct-13	99																											
29-Oct-13	100																											
5-Nov-13	101	3.0E-03	2.0E-05	1.0E-03	1.0E+00	1.8E-02	1.0E-02	5.1E-04	1.0E-04	9.0E-03	1.6E-01	4.0E-05	1.1E-01	1.0E-05	2.0E-02	9.3E-03	1.2E+00	2.0E-05	1.9E-04	1.0E-04	4.9E-03	3.0E-05	1.0E-03	1.0E-05	3.1E-01	2.9E-01	-2.5E-02	-4.2%
12-Nov-13	102																											
19-Nov-13	103																											
26-Nov-13	104																											
3-Dec-13	105	3.0E-03	2.0E-05	1.0E-03	1.1E+00	1.7E-02	1.0E-02	6.5E-04	1.0E-04	9.0E-03	1.7E-01	4.0E-05	1.2E-01	1.0E-05	2.0E-02	9.2E-03	1.2E+00	2.0E-05	8.0E-05	1.0E-04	5.4E-03	4.0E-05	1.0E-03	1.0E-05	3.1E-01	2.9E-01	-1.4E-02	-2.3%
10-Dec-13	106																											
17-Dec-13	107																											
24-Dec-13	108																											
31-Dec-13	109	3.0E-03	2.0E-05	1.0E-03	1.0E+00	1.8E-02	1.0E-02	9.4E-04	1.0E-04	9.0E-03	1.6E-01	4.0E-05	1.2E-01	1.0E-05	2.0E-02	9.0E-03	1.3E+00	2.0E-05	1.5E-04	1.0E-04	4.8E-03	5.0E-05	1.0E-03	1.0E-05	2.8E-01	2.8E-01	-4.6E-03	-0.8%
7-Jan-14	110																											
14-Jan-14	111																											
21-Jan-14	112																											
28-Jan-14	113	4.0E-03	2.0E-05	1.0E-03	1.0E+00	1.9E-02	1.0E-02	4.3E-04	1.0E-04	9.0E-03	1.5E-01	4.0E-05	1.2E-01	1.0E-05	2.0E-02	8.8E-03	1.1E+00	2.0E-05	1.0E-03	1.0E-04	3.9E-03	3.0E-05	1.0E-03	1.0E-05	3.0E-01	2.8E-01	-1.3E-02	-2.3%
4-Feb-14	114																											
11-Feb-14	115																											
18-Feb-14	116																											
25-Feb-14	117	3.0E-03	2.0E-05	1.0E-03	9.5E-01	1.8E-02	1.0E-02	5.6E-04	1.0E-04	9.0E-03	1.4E-01	4.0E-05	1.2E-01	1.0E-05	2.0E-02	8.4E-03	1.0E+00	2.0E-05	1.5E-03	1.0E-04	4.0E-03	3.0E-05	1.0E-03	1.0E-05	3.5E-01	2.7E-01	-8.7E-02	-14.1%

HC3

Sample = 08-276

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/L	mgCaCO3/kg	mgCaCO3/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
29-Nov-11	0	500	400	7.31	8.5E+02	#N/A	3.4E+00	1.6E+01	1.4E+02	2.0E+00	4.6E-01	1.2E-01	1.3E+02	9.6E-03	3.2E-04	3.2E-04	7.6E-03	8.0E-06	4.0E-06	6.2E-03	1.7E-04	3.8E+01	2.0E-04	5.6E-04	5.5E-03
6-Dec-11	1	500	445	7.42	5.0E+02	#N/A	1.8E+00	1.3E+01	9.0E+01	1.5E+00	4.0E-01	1.3E-01	8.1E+01	1.6E-02	2.7E-04	2.7E-04	5.3E-03	8.9E-06	4.5E-06	2.3E-03	9.4E-05	2.2E+01	2.2E-04	2.8E-04	5.2E-03
13-Dec-11	2	500	450	7.37	4.1E+02	#N/A	1.7E+00	1.1E+01	7.1E+01	6.8E-01	4.4E-01	1.4E-01	7.4E+01	3.9E-02	1.8E-04	2.7E-04	5.0E-03	9.0E-06	4.5E-06	2.0E-03	8.6E-05	2.1E+01	8.1E-04	2.0E-04	3.9E-03
20-Dec-11	3	500	485	7.39	2.8E+02	#N/A	2.0E+00	1.3E+01	5.4E+01	1.9E-01	3.8E-01	1.5E-01	5.5E+01	2.3E-02	3.4E-04	2.4E-04	3.9E-03	9.7E-06	4.9E-06	1.9E-03	6.1E-05	1.6E+01	2.4E-04	1.4E-04	2.4E-03
27-Dec-11	4	500	430	8.60	2.4E+02																				
3-Jan-12	5	500	435	7.38	1.7E+02	#N/A	1.8E+00	9.8E+00	2.6E+01	8.7E-02	3.0E-01	1.3E-01	2.8E+01	3.7E-02	3.0E-04	4.8E-04	2.3E-03	8.7E-06	4.4E-06	1.5E-03	2.6E-05	8.1E+00	2.2E-04	6.4E-05	1.3E-03
10-Jan-12	6	500	415	7.56	1.7E+02																				
17-Jan-12	7	500	475	7.68	1.1E+02	#N/A	1.1E+00	1.5E+01	1.5E+01	9.5E-02	2.9E-01	1.4E-01	2.2E+01	2.9E-02	4.3E-04	3.8E-04	2.8E-03	9.5E-06	4.8E-06	1.7E-03	2.0E-05	6.1E+00	2.4E-04	3.7E-05	1.1E-03
24-Jan-12	8	500	505	7.74	1.2E+02																				
31-Jan-12	9	500	460	7.57	1.3E+02	#N/A	1.4E+00	1.3E+01	1.6E+01	9.2E-02	2.5E-01	1.4E-01	2.2E+01	2.6E-02	3.2E-04	1.4E-04	3.8E-03	9.2E-06	4.6E-06	1.2E-03	2.1E-05	6.4E+00	2.3E-04	3.8E-05	1.2E-03
7-Feb-12	10	500	465	7.72	1.2E+02																				
14-Feb-12	11	500	450	7.73	1.2E+02	#N/A	2.1E+00	1.1E+01	1.8E+01	9.0E-02	2.1E-01	1.4E-01	2.2E+01	2.0E-02	1.8E-04	8.1E-04	2.9E-03	9.0E-06	4.5E-06	1.0E-03	1.5E-05	6.3E+00	2.3E-04	2.9E-05	1.7E-03
21-Feb-12	12	500	465	7.71	1.1E+02																				
28-Feb-12	13	500	500	7.59	8.9E+01	#N/A	1.6E+00	1.2E+01	1.2E+01	1.0E-01	1.5E-01	1.5E-01	2.0E+01	1.9E-02	3.5E-04	1.9E-03	3.6E-03	1.0E-05	5.0E-06	1.7E-03	1.3E-04	5.7E+00	2.5E-04	4.2E-05	5.5E-04
6-Mar-12	14	500	495	7.75	9.7E+01																				
13-Mar-12	15	500	445	7.52	1.2E+02	#N/A	1.3E+00	9.8E+00	1.7E+01	8.9E-02	1.4E-01	1.3E-01	2.3E+01	2.2E-02	2.2E-04	1.3E-04	3.4E-03	8.9E-06	4.5E-06	8.9E-04	1.0E-05	6.7E+00	2.2E-04	1.9E-05	5.8E-04
20-Mar-12	16	500	475	7.57	1.2E+02																				
27-Mar-12	17	500	490	7.49	1.1E+02	#N/A	1.3E+00	1.1E+01	1.5E+01	9.8E-02	1.4E-01	1.5E-01	2.3E+01	2.5E-02	2.5E-04	9.8E-05	4.1E-03	9.8E-06	4.9E-06	9.3E-04	1.8E-05	6.7E+00	2.5E-04	2.2E-05	7.4E-04
3-Apr-12	18	500	515	7.50	7.2E+01																				
10-Apr-12	19	500	510	7.48	9.4E+01	#N/A	1.1E+00	9.0E+00	1.4E+01	1.0E-01	1.0E-01	1.5E-01	2.0E+01	2.4E-02	2.0E-04	1.0E-04	4.1E-03	1.0E-05	5.1E-06	9.7E-04	1.5E-06	5.8E+00	2.6E-04	3.3E-05	6.6E-04
17-Apr-12	20	500	460	7.44	1.1E+02																				
24-Apr-12	21	500	490	7.49	8.6E+01	#N/A	1.3E+00	1.0E+01	1.2E+01	9.8E-02	8.8E-02	1.5E-01	1.8E+01	2.7E-02	2.0E-04	9.8E-05	4.5E-03	9.8E-06	4.9E-06	7.8E-04	1.5E-06	5.1E+00	2.5E-04	2.9E-05	8.3E-04
1-May-12	22	500	510	7.66	8.8E+01																				
8-May-12	23	500	520	7.51	9.2E+01	#N/A	1.4E+00	1.0E+01	1.5E+01	1.0E-01	8.3E-02	1.6E-01	2.1E+01	1.7E-02	2.6E-04	4.7E-04	3.7E-03	1.0E-05	5.2E-06	9.9E-04	2.5E-05	5.8E+00	2.6E-04	3.1E-05	7.8E-04
15-May-12	24	500	505	7.53	1.0E+02																				
22-May-12	25	500	430	7.47	1.3E+02	#N/A	1.5E+00	8.8E+00	1.6E+01	8.6E-02	8.2E-02	1.3E-01	2.3E+01	3.8E-02	2.6E-04	1.3E-04	3.5E-03	8.6E-06	4.3E-06	7.3E-04	1.3E-06	6.4E+00	2.2E-04	2.3E-05	8.2E-04
29-May-12	26	500	460	7.42	9.5E+01																				
5-Jun-12	27	500	455	7.35	9.5E+01	#N/A	1.5E+00	7.6E+00	1.2E+01	9.1E-02	5.9E-02	1.4E-01	1.8E+01	2.7E-02	4.1E-04	3.2E-04	3.2E-03	9.1E-06	4.6E-06	1.0E-03	1.4E-06	5.2E+00	2.3E-04	2.9E-05	5.0E-04
12-Jun-12	28	500	465	7.42	9.1E+01																				
19-Jun-12	29	500	460	7.39	8.9E+01	#N/A	1.3E+00	7.1E+00	1.0E+01	9.2E-02	6.0E-02	1.4E-01	1.7E+01	2.9E-02	1.4E-04	9.2E-05	2.7E-03	9.2E-06	4.6E-06	5.5E-04	1.4E-06	4.7E+00	2.3E-04	2.0E-05	5.1E-04
26-Jun-12	30	500	460	7.45	9.0E+01																				
3-Jul-12	31	500	450	7.63	9.7E+01	#N/A	2.9E+00	1.1E+01	1.3E+01	9.0E-02	5.9E-02	1.4E-01	1.8E+01	2.3E-02	1.4E-04	1.4E-04	3.8E-03	9.0E-06	4.5E-06	5.0E-04	1.1E-05	5.1E+00	2.3E-04	2.9E-05	6.3E-04
10-Jul-12	32	500	465	7.44	9.1E+01																				
17-Jul-12	33	500	480	7.45	9.3E+01	#N/A	1.0E+00	8.0E+00	1.1E+01	9.6E-02	5.3E-02	1.4E-01	2.0E+01	2.1E-02	2.4E-04	2.0E-03	2.5E-03	9.6E-06	4.8E-06	2.2E-03	1.2E-05	5.5E+00	2.4E-04	2.0E-05	6.7E-04
24-Jul-12	34	500	480	7.36	1.0E+02																				
31-Jul-12	35	500	475	7.47	9.8E+01	#N/A	1.0E+00	8.1E+00	1.2E+01	9.5E-02	4.8E-02	1.4E-01	2.1E+01	2.5E-02	1.9E-04	1.9E-04	3.0E-03	9.5E-06	4.8E-06	1.2E-03	5.1E-05	5.8E+00	2.4E-04	3.4E-05	8.6E-04
7-Aug-12	36	500	465	7.52	8.9E+01																				
14-Aug-12	37	500	460	7.29	9.8E+01	#N/A	1.3E+00	6.4E+00	1.5E+01	9.2E-02	5.1E-02	1.4E-01	2.0E+01	2.8E-02	1.4E-04	1.9E-03	2.9E-03	9.2E-06	4.6E-06	8.7E-04	5.1E-06	5.4E+00	2.3E-04	1.6E-05	6.4E-04
21-Aug-12	38	500	465	7.21	9.5E+01																				
28-Aug-12	39	500	505	7.40	8.8E+01	#N/A	1.6E+00	8.8E+00	1.3E+01	1.0E-01	4.5E-02	1.5E-01	1.9E+01	2.7E-02	2.0E-04	4.5E-04	2.3E-03	1.0E-05	5.1E-06	9.6E-04	1.1E-05	5.2E+00	2.5E-04	4.2E-05	9.6E-04
4-Sep-12	40	500	470	7.32	7.2E+01																				
11-Sep-12	41	500	475	7.28	8.6E+01	#N/A	1.3E+00	6.3E+00	1.2E+01	9.5E-02	4.3E-02	1.4E-01	1.9E+01	1.3E-02	1.4E-04	5.2E-04	2.6E-03	9.5E-06	4.8E-06	6.7E-04	7.6E-06	5.3E+00	2.4E-04	2.1E-04	1.3E-03
18-Sep-12	42	500	515	7.27	1.0E+02																				
25-Sep-12	43	500	455	7.22	9.5E+01	#N/A	1.5E+00	6.4E+00	1.4E+01	9.1E-02	3.6E-02	1.4E-01	1.8E+01	2.4E-02	9.1E-05	9.1E-05	3.5E-03	9.1E-06	4.6E-06	1.4E-04	6.4E-05	5.0E+00	2.3E-04	2.7E-05	5.9E-04
2-Oct-12	44	500	460	7.31	8.0E+01																				
9-Oct-12	45	500	465	7.27	7.3E+01	#N/A	1.8E+00	6.1E+00	9.8E+00	9.3E-02	3.3E-02	1.4E-01	1.5E+01	2.1E-02	9.3E-05	9.3E-05	1.6E-03	9.3E-06	4.7E-06	5.1E-04	2.5E-05	4.1E+00	2.3E-04	9.3E-07	1.2E-03
16-Oct-12	46	500	465	7.23	7.7E+01																				
23-Oct-12	47	500	475	7.31	6.7E+01																				
30-Oct-12	48	500	470	7.39	8.9E+01																				
6-Nov-12	49	500	445	7.18	8.8E+01	#N/A	1.3E+00	6.0E+00	1.2E+01	8.9E-02	3.6E-02	1.3E-01	2.0E+01	1.4E-02	8.9E-05	1.3E-04	2.2E-03	8.9E-06	4.5E-06	1.1E-03	3.9E-05	5.5E+00	2.2E-04	9.8E-05	1.8E-03
13-Nov-12	50	500	450	7.18	8.8E+01																				
20-Nov-12	51	500	490	7.61	5.6E+01																				
27-Nov-12	52	500	490	7.19	1.1E+02																				
4-Dec-12	53	500	470	7.39	6.9E+01	#N/A	1.0E+00	6.3E+00	8.9E+00	9.4E-02	3.3E-02	1.4E-01	1.5E+01	1.2E-02	2.4E-04	9.4E-05	1.7E-03	9.4E-06	4.7E-06	4.7E-04	2.8E-05	4.0E+00	2.4E-04	6.3E-05	5.2E-04
11-Dec-12	54	500	475	7.23	1.1E+02																				
18-Dec-12	55	500	450	7.41	7.6E+01																				
25-Dec-12	56	500	445	7.21	1.1E+02																				

HC3

Sample = 08-276

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/L	mgCaCO3/kg	mgCaCO3/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
1-Jan-13	57	500	465	7.41	5.4E+01	#N/A	1.9E+00	6.9E+00	6.5E+00	9.3E-02	2.8E-02	1.4E-01	1.2E+01	1.0E-02	9.3E-05	1.4E-04	1.6E-03	9.3E-06	4.7E-06	3.7E-04	6.0E-06	3.1E+00	2.3E-04	3.1E-05	2.3E-04
8-Jan-13	58	500	450	7.31	9.5E+01																				
15-Jan-13	59	500	450	7.36	5.6E+01																				
22-Jan-13	60	500	465	7.35	8.0E+01																				
29-Jan-13	61	500	470	7.38	6.0E+01	#N/A	1.2E+00	6.3E+00	8.5E+00	9.4E-02	2.8E-02	1.4E-01	1.3E+01	1.6E-02	9.4E-05	9.4E-05	1.3E-03	9.4E-06	4.7E-06	4.7E-04	1.1E-05	3.5E+00	2.4E-04	1.4E-05	4.7E-04
5-Feb-13	62	500	470	7.55	6.0E+01																				
12-Feb-13	63	500	440	7.67	5.0E+01																				
19-Feb-13	64	500	480	7.47	5.2E+01																				
26-Feb-13	65	500	435	7.39	7.0E+01	#N/A	1.5E+00	5.9E+00	7.4E+00	8.7E-02	2.6E-02	1.3E-01	1.1E+01	8.8E-03	8.7E-05	1.7E-04	1.4E-03	8.7E-06	4.4E-06	4.4E-04	1.9E-05	3.1E+00	2.2E-04	1.2E-04	4.8E-04
5-Mar-13	66	500	445	7.68	7.0E+01																				
12-Mar-13	67	500	455	7.52	7.0E+01																				
19-Mar-13	68	500	465	7.79	5.6E+01																				
26-Mar-13	69	500	465	7.67	6.1E+01	#N/A	1.9E+00	6.6E+00	6.5E+00	9.3E-02	2.8E-02	1.4E-01	1.2E+01	8.4E-03	9.3E-05	4.7E-04	1.3E-03	9.3E-06	4.7E-06	7.4E-04	8.7E-05	3.3E+00	2.3E-04	1.2E-04	3.7E-04
2-Apr-13	70	500	450	7.57	6.1E+01																				
9-Apr-13	71	500	435	7.51	9.0E+01																				
16-Apr-13	72	500	445	7.52	9.0E+01																				
23-Apr-13	73	500	450	7.68	6.0E+01	#N/A	1.9E+00	6.2E+00	5.4E+00	9.0E-02	2.7E-02	1.4E-01	1.1E+01	7.7E-03	9.0E-05	9.0E-05	1.3E-03	9.0E-06	4.5E-06	6.3E-04	5.4E-06	2.8E+00	2.3E-04	2.5E-05	5.9E-04
30-Apr-13	74	500	450	7.58	5.9E+01																				
7-May-13	75	500	425	7.56	1.1E+02																				
14-May-13	76	500	455	7.58	5.9E+01																				
21-May-13	77	500	450	7.65	6.1E+01	#N/A	1.6E+00	5.4E+00	7.7E+00	9.0E-02	2.7E-02	1.4E-01	1.1E+01	7.8E-03	9.0E-05	9.0E-05	1.3E-03	9.0E-06	4.5E-06	5.9E-04	5.9E-06	2.9E+00	2.3E-04	1.9E-05	5.0E-04
28-May-13	78	500	450	7.57	2.3E+02		2.2E+00	6.1E+00		9.0E-02	3.6E-02	1.4E-01	5.0E+01	5.7E-03	9.0E-05	9.0E-05	3.0E-03	9.0E-06	4.5E-06	1.1E-03	3.6E-06	1.8E+01	2.3E-04	2.4E-05	3.2E-04
4-Jun-13	79	500	445	7.56	5.4E+01		1.7E+00	6.1E+00	6.7E+00	8.9E-02	2.7E-02	1.3E-01	1.0E+01	5.9E-03	8.9E-05	8.9E-05	1.7E-03	8.9E-06	4.5E-06	2.2E-03	1.8E-06	2.9E+00	2.2E-04	3.2E-05	5.3E-04
11-Jun-13	80	500	470	7.76	3.8E+01		2.7E+00	7.1E+00	3.3E+00	9.4E-02	2.8E-02	1.4E-01	8.0E+00	4.9E-03	9.4E-05	9.4E-05	1.1E-03	9.4E-06	4.7E-06	1.9E-03	4.2E-06	2.1E+00	2.4E-04	2.3E-05	2.4E-04
18-Jun-13	81	500	465	7.51	3.4E+01	#N/A	1.9E+00	5.9E+00	3.3E+00	9.3E-02	4.2E-02	1.4E-01	7.4E+00	6.3E-03	9.3E-05	9.3E-05	1.4E-03	9.3E-06	4.7E-06	1.4E-03	1.4E-06	2.0E+00	2.3E-04	5.7E-05	4.2E-04
25-Jun-13	82	500	470	7.64	6.1E+01																				
2-Jul-13	83	500	465	7.56	2.7E+01		2.6E+00	6.8E+00	2.3E+00	9.3E-02	2.8E-02	1.4E-01	5.7E+00	4.7E-03	9.3E-05	9.3E-05	8.3E-04	9.3E-06	4.7E-06	2.8E-04	4.2E-06	1.5E+00	2.3E-04	1.5E-05	5.1E-04
9-Jul-13	84	500	450	7.68	4.2E+01																				
16-Jul-13	85	500	475	7.44	3.3E+01	#N/A	1.5E+00	5.5E+00	2.9E+00	9.5E-02	2.9E-02	1.4E-01	7.3E+00	7.1E-03	9.5E-05	9.5E-05	9.7E-04	9.5E-06	4.8E-06	1.0E-03	3.8E-06	1.9E+00	2.4E-04	2.9E-05	3.8E-04
23-Jul-13	86	500	475	7.66	3.1E+01																				
30-Jul-13	87	500	470	7.45	2.7E+01		1.7E+00	5.5E+00	2.8E+00	9.4E-02	2.8E-02	1.4E-01	5.9E+00	4.4E-03	9.4E-05	9.4E-05	8.3E-04	9.4E-06	4.7E-06	1.7E-03	3.3E-06	1.6E+00	2.4E-04	2.4E-06	2.8E-04
6-Aug-13	88	500	500	7.72	3.2E+01																				
13-Aug-13	89	500	470	7.36	2.9E+01	#N/A	1.3E+00	5.1E+00	1.9E+00	9.4E-02	2.8E-02	1.4E-01	6.6E+00	5.3E-03	9.4E-05	9.4E-05	9.6E-04	9.4E-06	4.7E-06	9.9E-04	1.9E-05	1.8E+00	2.4E-04	3.6E-05	2.2E-03
20-Aug-13	90	500	475	7.43	2.7E+01																				
27-Aug-13	91	500	470	7.47	2.8E+01																				
3-Sep-13	92	500	475	7.60	2.5E+01																				
10-Sep-13	93	500	470	7.43	3.0E+01	#N/A	1.5E+00	5.2E+00	1.4E+00	9.4E-02	2.8E-02	1.4E-01	9.1E+00	4.7E-03	9.4E-05	9.4E-05	1.1E-03	9.4E-06	4.7E-06	2.0E-03	1.1E-05	2.2E+00	2.4E-04	5.7E-05	4.2E-04
17-Sep-13	94	500	475	7.50	2.9E+01																				
24-Sep-13	95	500	495	7.34	2.8E+01																				
1-Oct-13	96	500	475	7.73	3.1E+01																				
8-Oct-13	97	500	460	7.36	2.9E+01	#N/A	8.0E-01	5.3E+00	1.4E+00	9.2E-02	2.8E-02	1.4E-01	6.7E+00	3.7E-03	9.2E-05	9.2E-05	1.1E-03	9.2E-06	4.6E-06	1.9E-03	6.0E-06	1.8E+00	2.3E-04	3.2E-05	2.8E-04
15-Oct-13	98	500	480	7.27	2.8E+01																				
22-Oct-13	99	500	470	7.41	3.0E+01																				
29-Oct-13	100	500	475	7.48	3.2E+01																				
5-Nov-13	101	500	480	7.51	3.0E+01	#N/A	8.8E-01	5.5E+00	1.9E+00	9.6E-02	2.9E-02	1.4E-01	6.7E+00	2.3E-03	9.6E-05	9.6E-05	1.1E-03	9.6E-06	4.8E-06	6.2E-04	2.9E-06	1.9E+00	2.4E-04	2.2E-05	2.9E-04
12-Nov-13	102	500	465	7.69	2.7E+01																				
19-Nov-13	103	500	470	7.34	3.0E+01																				
26-Nov-13	104	500	470	7.70	2.8E+01																				
3-Dec-13	105	500	475	7.77	2.9E+01	#N/A	3.2E-01	5.3E+00	1.9E+00	9.5E-02	2.9E-02	1.4E-01	6.7E+00	3.4E-03	9.5E-05	9.5E-05	1.2E-03	9.5E-06	4.8E-06	4.8E-04	6.7E-06	1.9E+00	2.4E-04	2.6E-05	2.4E-04
10-Dec-13	106	500	480	7.56	2.9E+01																				
17-Dec-13	107	500	480	7.62	3.1E+01																				
24-Dec-13	108	500	470	7.73	2.8E+01																				
31-Dec-13	109	500	480	7.58	2.9E+01	#N/A	7.0E-01	5.3E+00	1.4E+00	9.6E-02	2.9E-02	1.4E-01	6.5E+00	2.9E-03	9.6E-05	9.6E-05	1.5E-03	9.6E-06	4.8E-06	4.3E-04	3.8E-06	1.8E+00	2.4E-04	2.7E-05	3.4E-04
7-Jan-14	110	500	475	7.47	2.9E+01																				
14-Jan-14	111	500	475	7.79	2.6E+01																				
21-Jan-14	112	500	480	7.60	2.9E+01																				
28-Jan-14	113	500	470	7.56	2.9E+01	#N/A	8.4E-01	5.5E+00	1.4E+00	9.4E-02	2.8E-02	1.4E-01	6.5E+00	2.8E-03	9.4E-05	9.4E-05	1.3E-03	9.4E-06	4.7E-06	8.0E-04	1.4E-06	1.8E+00	2.4E-04	4.7E-06	2.4E-04
4-Feb-14	114	500	485	7.77	3.0E+01																				
11-Feb-14	115	500	480	7.71	2.7E+01																				
18-Feb-14	116	500	475	7.75	2.9E+01																				
25-Feb-14	117	500	485	7.71	2.6E+01	#N/A	1.4E+00	6.5E+00	1.9E+00	9.7E-02	2.9E-02	1.5E-01	6.3E+00	3.2E-03	9.7E-05	9.7E-05	1.4E-03	9.7E-06	4.9E-06	1.0E-03	2.4E-06	1.8E+00	2.4E-04	2.4E-05	2.9E-04

June 4/2013 Moved into the Fridge at 4°C on Cycle 79
Temperature Sensitivity

HC3
Sample = 08-276

Date	Cycle No.	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
29-Nov-11	0	1.2E-03	8.0E-06	2.0E-03	9.4E+00	6.4E-02	8.0E-06	2.9E-02	1.8E-03	3.6E-03	6.0E+00	1.1E-03	2.0E+00	4.0E-06	1.4E+01	1.1E-01	4.9E+01	1.6E-05	1.5E-04	1.6E-04	2.0E-02	1.4E-04	1.2E-03	2.3E-04
6-Dec-11	1	1.3E-03	8.9E-06	1.3E-03	6.5E+00	3.8E-02	8.9E-06	3.0E-02	1.3E-03	4.0E-03	4.0E+00	7.9E-04	3.8E-01	1.8E-05	1.1E+01	6.2E-02	3.2E+01	8.9E-06	2.2E-05	1.3E-04	1.9E-02	1.5E-04	8.9E-04	1.2E-04
13-Dec-11	2	3.6E-02	6.3E-05	9.0E-04	5.0E+00	3.1E-02	9.0E-06	2.4E-02	1.3E-03	1.0E-02	3.2E+00	4.5E-04	4.4E-01	4.5E-06	6.8E+00	6.6E-02	2.6E+01	9.0E-06	7.2E-05	8.1E-04	1.8E-02	1.0E-04	1.4E-03	1.1E-04
20-Dec-11	3	1.5E-03	9.7E-06	9.7E-04	3.9E+00	3.1E-02	4.9E-06	2.0E-02	9.2E-04	5.8E-03	2.5E+00	3.2E-04	5.2E-01	4.9E-06	3.7E+00	4.6E-02	1.8E+01	9.7E-06	4.9E-06	4.9E-05	2.6E-02	1.3E-04	9.7E-04	4.4E-05
27-Dec-11	4																							
3-Jan-12	5	2.6E-03	8.7E-06	4.4E-04	1.8E+00	1.1E-02	4.4E-06	1.3E-02	6.5E-04	3.9E-03	1.4E+00	6.1E-05	3.3E-01	4.4E-06	1.5E+00	2.5E-02	8.6E+00	8.7E-06	4.4E-05	1.7E-04	1.2E-02	2.9E-04	8.7E-04	2.2E-05
10-Jan-12	6																							
17-Jan-12	7	1.4E-03	9.5E-06	4.8E-04	1.6E+00	1.1E-02	4.8E-06	1.0E-02	1.9E-04	4.3E-03	1.3E+00	7.1E-05	4.4E-01	4.8E-06	8.3E-01	1.8E-02	4.7E+00	9.5E-06	9.5E-06	1.4E-04	1.5E-02	1.9E-04	9.5E-04	1.9E-05
24-Jan-12	8																							
31-Jan-12	9	2.8E-03	4.1E-05	4.6E-04	1.6E+00	1.2E-02	4.6E-06	8.1E-03	4.6E-05	4.1E-03	1.2E+00	1.3E-04	3.9E-01	4.6E-06	5.8E-01	2.0E-02	5.4E+00	9.2E-06	1.0E-04	2.3E-04	1.2E-02	2.7E-04	9.2E-04	9.2E-06
7-Feb-12	10																							
14-Feb-12	11	2.3E-03	9.0E-06	4.5E-04	1.5E+00	1.0E-02	4.5E-06	5.9E-03	2.3E-04	4.1E-03	1.0E+00	1.0E-04	3.6E-01	4.5E-06	3.9E-01	2.0E-02	4.9E+00	9.0E-06	1.4E-05	1.4E-04	1.0E-02	9.0E-05	4.5E-04	9.0E-06
21-Feb-12	12																							
28-Feb-12	13	1.5E-03	1.0E-05	5.0E-04	1.3E+00	1.3E-02	5.0E-06	3.9E-03	5.0E-05	4.5E-03	8.2E-01	1.4E-04	3.3E-01	5.0E-06	2.4E-01	1.8E-02	3.7E+00	1.0E-05	1.5E-05	1.0E-04	1.1E-02	1.6E-04	1.0E-03	5.0E-06
6-Mar-12	14																							
13-Mar-12	15	1.3E-03	8.9E-06	4.5E-04	1.6E+00	9.0E-03	4.5E-06	4.3E-03	8.9E-05	4.0E-03	8.3E-01	4.0E-05	3.3E-01	4.5E-06	2.2E-01	2.0E-02	5.3E+00	8.9E-06	9.3E-05	4.5E-05	1.0E-02	8.0E-05	4.5E-04	8.9E-06
20-Mar-12	16																							
27-Mar-12	17	1.5E-03	9.8E-06	4.9E-04	1.5E+00	1.2E-02	4.9E-06	3.7E-03	9.8E-05	4.4E-03	8.6E-01	3.4E-05	3.6E-01	4.9E-06	1.9E-01	2.0E-02	5.0E+00	9.8E-06	4.9E-06	9.8E-05	1.1E-02	1.5E-04	4.9E-04	4.9E-06
3-Apr-12	18																							
10-Apr-12	19	1.5E-03	1.0E-05	5.1E-04	1.4E+00	1.2E-02	1.0E-05	3.3E-03	5.1E-05	4.6E-03	6.7E-01	6.1E-05	3.2E-01	5.1E-06	1.4E-01	1.7E-02	4.4E+00	1.0E-05	2.6E-05	5.1E-05	8.3E-03	1.5E-04	5.1E-04	5.1E-06
17-Apr-12	20																							
24-Apr-12	21	1.5E-03	1.5E-05	4.9E-04	1.2E+00	1.0E-02	1.5E-05	2.8E-03	1.5E-04	4.4E-03	6.0E-01	4.4E-05	2.7E-01	4.9E-06	1.2E-01	1.5E-02	3.8E+00	9.8E-06	3.4E-05	9.8E-05	8.0E-03	1.8E-04	1.5E-03	4.9E-06
1-May-12	22																							
8-May-12	23	1.6E-03	1.5E-04	5.2E-04	1.5E+00	1.3E-02	5.2E-06	7.9E-03	1.6E-04	4.7E-03	6.3E-01	3.6E-05	2.8E-01	5.2E-06	1.3E-01	1.6E-02	4.5E+00	1.0E-05	1.1E-04	5.2E-05	9.8E-03	1.6E-04	3.1E-03	5.2E-06
15-May-12	24																							
22-May-12	25	1.3E-03	8.6E-06	4.3E-04	1.7E+00	8.9E-03	2.2E-05	4.0E-03	1.3E-04	3.9E-03	7.2E-01	6.5E-05	3.1E-01	4.3E-06	1.3E-01	1.9E-02	5.7E+00	8.6E-06	5.2E-05	1.7E-04	1.2E-02	2.4E-04	8.6E-04	8.6E-06
29-May-12	26																							
5-Jun-12	27	3.2E-03	9.1E-06	4.6E-04	1.3E+00	9.6E-03	4.6E-06	2.5E-03	4.6E-05	4.1E-03	5.6E-01	6.4E-05	2.4E-01	4.6E-06	1.0E-01	1.5E-02	4.3E+00	9.1E-06	9.1E-05	1.4E-04	7.0E-03	2.5E-04	4.6E-04	4.6E-06
12-Jun-12	28																							
19-Jun-12	29	1.4E-03	9.2E-06	4.6E-04	1.2E+00	8.8E-03	4.6E-06	1.0E-01	9.2E-05	4.1E-03	4.8E-01	9.2E-05	2.3E-01	4.6E-06	8.7E-02	1.3E-02	3.7E+00	9.2E-06	1.1E-04	2.3E-04	7.4E-03	2.5E-04	1.4E-03	4.6E-06
26-Jun-12	30																							
3-Jul-12	31	1.4E-03	1.4E-05	4.5E-04	1.3E+00	9.0E-03	4.5E-06	2.6E-03	4.5E-05	4.1E-03	5.1E-01	1.8E-05	2.2E-01	4.5E-06	9.5E-02	1.5E-02	4.3E+00	9.0E-06	1.4E-04	9.0E-05	6.7E-03	1.4E-04	9.0E-04	4.5E-06
10-Jul-12	32																							
17-Jul-12	33	1.4E-03	9.6E-06	1.4E-03	1.5E+00	1.1E-02	3.4E-05	3.3E-03	4.8E-05	4.3E-03	4.9E-01	1.8E-04	3.3E-01	5.8E-05	1.0E-01	1.5E-02	4.6E+00	9.6E-06	2.7E-04	1.4E-04	6.3E-03	1.5E-04	9.6E-04	4.8E-06
24-Jul-12	34																							
31-Jul-12	35	1.9E-03	1.2E-04	4.8E-04	1.5E+00	1.1E-02	4.8E-06	2.6E-03	4.8E-05	4.3E-03	4.7E-01	2.8E-04	3.2E-01	4.8E-06	1.0E-01	1.6E-02	4.5E+00	9.5E-06	2.1E-04	4.8E-05	6.1E-03	1.5E-04	1.4E-03	4.8E-06
7-Aug-12	36																							
14-Aug-12	37	1.4E-03	9.2E-06	4.6E-04	1.5E+00	1.1E-02	4.6E-06	2.6E-03	1.8E-04	4.1E-03	4.4E-01	8.7E-05	2.4E-01	4.6E-06	9.7E-02	1.5E-02	5.1E+00	9.2E-06	6.9E-05	1.8E-04	5.3E-03	2.9E-04	9.2E-04	4.6E-06
21-Aug-12	38																							
28-Aug-12	39	2.0E-03	2.5E-05	5.1E-04	1.5E+00	1.4E-02	5.1E-06	2.4E-03	1.5E-04	4.5E-03	4.0E-01	3.0E-05	2.7E-01	5.1E-06	8.6E-02	1.4E-02	4.2E+00	1.0E-05	1.3E-04	1.0E-04	8.2E-03	1.6E-04	1.0E-03	5.1E-06
4-Sep-12	40																							
11-Sep-12	41	1.4E-03	9.5E-06	4.8E-04	1.4E+00	1.2E-02	4.8E-06	1.9E-03	3.6E-02	4.3E-03	3.6E-01	4.8E-05	2.1E-01	4.8E-06	1.0E-01	1.4E-02	4.8E+00	9.5E-06	4.8E-05	4.8E-05	5.3E-03	6.7E-05	4.8E-04	9.5E-06
18-Sep-12	42																							
25-Sep-12	43	3.6E-03	1.4E-05	4.6E-04	1.4E+00	9.2E-03	4.6E-06	1.1E-01	9.1E-05	4.1E-03	3.2E-01	3.5E-04	1.7E-01	4.6E-06	7.7E-02	1.3E-02	4.6E+00	9.1E-06	1.5E-04	4.6E-05	1.1E-02	1.5E-04	9.1E-04	4.6E-06
2-Oct-12	44																							
9-Oct-12	45	8.4E-03	1.6E-04	4.7E-04	1.1E+00	9.3E-03	4.7E-06	1.8E-03	9.3E-05	4.2E-03	2.6E-01	6.0E-05	1.5E-01	4.7E-06	5.6E-02	1.0E-02	3.4E+00	9.3E-06	9.8E-05	9.3E-05	4.1E-03	1.2E-04	2.3E-03	4.7E-06
16-Oct-12	46																							
23-Oct-12	47																							
30-Oct-12	48																							
6-Nov-12	49	1.8E-03	1.3E-05	4.5E-04	1.5E+00	9.7E-03	4.5E-06	2.1E-03	2.7E-04	5.3E-03	3.0E-01	4.5E-05	1.6E-01	4.5E-06	8.9E-02	1.4E-02	4.7E+00	8.9E-06	5.3E-04	8.9E-05	4.9E-03	1.1E-04	3.6E-03	4.5E-06
13-Nov-12	50																							
20-Nov-12	51																							
27-Nov-12	52																							
4-Dec-12	53	1.4E-03	3.8E-05	4.7E-04	1.2E+00	8.6E-03	4.7E-06	1.7E-03	9.4E-05	4.2E-03	2.6E-01	2.3E-04	1.5E-01	4.7E-06	5.6E-02	9.9E-03	3.4E+00	9.4E-06	7.1E-05	4.7E-05	6.6E-03	8.5E-05	2.8E-03	4.7E-06
11-Dec-12	54																							
18-Dec-12	55																							
25-Dec-12	56																							

HC3
Sample = 08-276

Date	Cycle No.	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
1-Jan-13	57	1.4E-03	9.3E-06	4.7E-04	9.3E-01	8.7E-03	4.7E-06	1.4E-03	4.7E-05	1.6E-02	2.0E-01	3.7E-05	1.8E-01	4.7E-06	4.7E-02	7.9E-03	2.2E+00	9.3E-06	1.4E-04	9.3E-05	4.0E-03	7.4E-05	9.3E-04	4.7E-06
8-Jan-13	58																							
15-Jan-13	59																							
22-Jan-13	60																							
29-Jan-13	61	1.4E-03	9.4E-06	4.7E-04	9.6E-01	7.9E-03	4.7E-06	1.4E-03	4.7E-05	5.2E-03	1.8E-01	4.2E-05	2.0E-01	4.7E-06	5.2E-02	8.3E-03	2.8E+00	9.4E-06	1.2E-04	9.4E-05	3.7E-03	1.0E-04	4.7E-04	4.7E-06
5-Feb-13	62																							
12-Feb-13	63																							
19-Feb-13	64																							
26-Feb-13	65	1.3E-03	1.3E-05	4.4E-04	8.9E-01	6.9E-03	4.4E-06	1.2E-03	4.4E-05	4.4E-03	1.8E-01	4.4E-05	1.2E-01	4.4E-06	4.4E-02	7.0E-03	2.6E+00	8.7E-06	4.4E-05	4.4E-05	2.7E-03	1.7E-05	4.4E-04	4.4E-06
5-Mar-13	66																							
12-Mar-13	67																							
19-Mar-13	68																							
26-Mar-13	69	1.4E-03	2.7E-04	4.7E-04	9.8E-01	8.6E-03	4.7E-06	1.2E-03	3.3E-04	4.2E-03	1.8E-01	2.3E-05	1.6E-01	4.7E-06	4.7E-02	7.2E-03	2.7E+00	2.3E-05	6.5E-05	4.7E-05	2.9E-03	3.3E-05	4.7E-04	4.7E-06
2-Apr-13	70																							
9-Apr-13	71																							
16-Apr-13	72																							
23-Apr-13	73	1.4E-03	9.0E-06	4.5E-04	9.5E-01	7.5E-03	4.5E-06	1.2E-03	4.5E-05	4.1E-03	1.7E-01	1.8E-05	1.2E-01	4.5E-06	3.6E-02	6.5E-03	2.3E+00	9.0E-06	1.4E-05	4.5E-05	2.5E-03	1.4E-05	4.5E-04	4.5E-06
30-Apr-13	74																							
7-May-13	75																							
14-May-13	76																							
21-May-13	77	1.4E-03	1.8E-05	4.5E-04	9.2E-01	6.5E-03	4.5E-06	1.5E-03	4.5E-05	4.1E-03	1.8E-01	2.7E-05	1.4E-01	4.5E-06	3.6E-02	6.5E-03	2.5E+00	9.0E-06	1.2E-04	4.5E-05	2.5E-03	1.8E-05	4.5E-04	4.5E-06
28-May-13	78	1.4E-03	9.0E-06	4.5E-04	1.4E+00	6.4E-03	4.5E-06	1.9E-03	1.4E-04	4.1E-03	2.7E-01	4.1E-05	1.6E-01	4.5E-06	6.3E-02	4.7E-02	1.5E+01	9.0E-06	5.4E-05	4.5E-05	5.0E-03	2.7E-05	4.5E-04	4.5E-06
4-Jun-13	79	1.3E-03	8.9E-06	4.5E-04	7.7E-01	6.5E-03	4.5E-06	9.0E-04	2.2E-04	4.0E-03	1.5E-01	1.8E-05	1.0E-01	4.5E-06	4.5E-02	6.6E-03	1.7E+00	8.9E-06	1.0E-04	4.5E-05	4.0E-03	2.7E-05	8.9E-04	4.5E-06
11-Jun-13	80	1.4E-03	9.4E-06	4.7E-04	6.6E-01	6.3E-03	4.7E-06	1.6E-03	4.7E-05	4.2E-03	1.3E-01	2.4E-05	8.5E-02	4.7E-06	3.8E-02	5.0E-03	1.1E+00	9.4E-06	1.3E-04	4.7E-05	3.6E-03	1.4E-05	4.7E-04	4.7E-06
18-Jun-13	81	1.4E-03	9.3E-06	4.7E-04	6.0E-01	7.3E-03	4.7E-06	6.1E-04	9.3E-05	4.2E-03	1.1E-01	1.9E-05	7.0E-02	4.7E-06	3.7E-02	4.6E-03	8.3E-01	9.3E-06	3.3E-04	4.7E-05	2.9E-03	2.3E-05	4.7E-04	4.7E-06
25-Jun-13	82																							
2-Jul-13	83	1.4E-03	9.3E-06	4.7E-04	4.6E-01	5.9E-03	4.7E-06	3.4E-04	4.7E-05	4.2E-03	9.8E-02	1.9E-05	6.0E-02	4.7E-06	1.4E-02	3.6E-03	5.6E-01	9.3E-06	1.4E-04	4.7E-05	2.3E-03	4.2E-05	4.7E-04	4.7E-06
9-Jul-13	84																							
16-Jul-13	85	1.4E-03	1.4E-05	4.8E-04	6.0E-01	7.6E-03	9.5E-06	4.3E-04	4.8E-05	4.3E-03	9.3E-02	1.9E-05	5.7E-02	4.8E-06	1.9E-02	4.5E-03	7.2E-01	9.5E-06	1.4E-04	4.8E-05	2.9E-03	1.4E-05	9.5E-04	4.8E-06
23-Jul-13	86																							
30-Jul-13	87	1.4E-03	9.4E-06	4.7E-04	4.7E-01	6.7E-03	4.7E-06	4.3E-04	4.7E-05	4.2E-03	7.8E-02	1.9E-05	4.7E-02	4.7E-06	1.4E-02	3.9E-03	5.5E-01	9.4E-06	3.5E-04	4.7E-05	2.4E-03	2.4E-05	4.7E-04	4.7E-06
6-Aug-13	88																							
13-Aug-13	89	8.0E-03	1.3E-04	4.7E-04	5.3E-01	8.4E-03	4.7E-06	3.1E-04	9.4E-05	4.2E-03	8.8E-02	1.9E-05	7.1E-02	4.7E-06	1.9E-02	4.1E-03	6.5E-01	9.4E-06	1.8E-04	4.7E-05	2.2E-03	1.4E-05	2.8E-03	4.7E-06
20-Aug-13	90																							
27-Aug-13	91																							
3-Sep-13	92																							
10-Sep-13	93	1.4E-03	9.4E-06	4.7E-04	6.1E-01	1.1E-02	4.7E-06	4.2E-04	9.4E-05	4.2E-03	1.0E-01	1.9E-05	7.1E-02	4.7E-06	2.8E-02	6.6E-03	1.1E+00	9.4E-06	3.9E-04	4.7E-05	2.5E-03	2.8E-05	1.9E-03	4.7E-06
17-Sep-13	94																							
24-Sep-13	95																							
1-Oct-13	96																							
8-Oct-13	97	1.4E-03	9.2E-06	4.6E-04	5.1E-01	8.1E-03	4.6E-06	2.7E-04	4.6E-05	4.1E-03	8.2E-02	1.8E-05	6.4E-02	4.6E-06	9.2E-03	4.1E-03	6.2E-01	9.2E-06	2.8E-05	4.6E-05	2.1E-03	1.4E-05	4.6E-04	4.6E-06
15-Oct-13	98																							
22-Oct-13	99																							
29-Oct-13	100																							
5-Nov-13	101	1.4E-03	9.6E-06	4.8E-04	5.0E-01	8.6E-03	4.8E-06	2.4E-04	4.8E-05	4.3E-03	7.8E-02	1.9E-05	5.3E-02	4.8E-06	9.6E-03	4.5E-03	5.8E-01	9.6E-06	9.1E-05	4.8E-05	2.3E-03	1.4E-05	4.8E-04	4.8E-06
12-Nov-13	102																							
19-Nov-13	103																							
26-Nov-13	104																							
3-Dec-13	105	1.4E-03	9.5E-06	4.8E-04	5.2E-01	8.2E-03	4.8E-06	3.1E-04	4.8E-05	4.3E-03	8.0E-02	1.9E-05	5.7E-02	4.8E-06	9.5E-03	4.4E-03	5.8E-01	9.5E-06	3.8E-05	4.8E-05	2.5E-03	1.9E-05	4.8E-04	4.8E-06
10-Dec-13	106																							
17-Dec-13	107																							
24-Dec-13	108																							
31-Dec-13	109	1.4E-03	9.6E-06	4.8E-04	5.0E-01	8.5E-03	4.8E-06	4.5E-04	4.8E-05	4.3E-03	7.5E-02	1.9E-05	5.8E-02	4.8E-06	9.6E-03	4.3E-03	6.2E-01	9.6E-06	7.2E-05	4.8E-05	2.3E-03	2.4E-05	4.8E-04	4.8E-06
7-Jan-14	110																							
14-Jan-14	111																							
21-Jan-14	112																							
28-Jan-14	113	1.9E-03	9.4E-06	4.7E-04	4.8E-01	8.7E-03	4.7E-06	2.0E-04	4.7E-05	4.2E-03	6.8E-02	1.9E-05	5.6E-02	4.7E-06	9.4E-03	4.1E-03	5.1E-01	9.4E-06	4.7E-04	4.7E-05	1.8E-03	1.4E-05	4.7E-04	4.7E-06
4-Feb-14	114																							
11-Feb-14	115																							
18-Feb-14	116																							
25-Feb-14	117	1.5E-03	9.7E-06	4.9E-04	4.6E-01	8.6E-03	4.9E-06	2.7E-04	4.9E-05	4.4E-03	6.8E-02	1.9E-05	5.8E-02	4.9E-06	9.7E-03	4.1E-03	4.9E-01	9.7E-06	7.3E-04	4.9E-05	1.9E-03	1.5E-05	4.9E-04	4.9E-06

June 4/2013 Moved into the Fridge at 4°C on Cycle 79
Temperature Sensitivity

HC4

Sample = 08-294

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/L	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
29-Nov-11	0	500	300	7.69	6.6E+02	#N/A	6.7E+00	5.4E+01	2.5E+02	5.3E+00	1.4E+00	3.0E-01	1.4E+02	5.3E-02	2.9E-03	4.0E-03	2.4E-02	2.0E-05	1.0E-05	1.2E-02	3.0E-05	4.8E+01	6.0E-04	3.0E-04	1.2E-02
6-Dec-11	1	500	485	7.87	5.1E+02	#N/A	3.5E+00	6.2E+01	1.6E+02	2.4E+00	2.4E+00	3.0E-01	1.0E+02	3.9E-02	3.7E-03	4.4E-03	1.6E-02	2.0E-05	1.0E-05	1.4E-02	3.3E-05	3.5E+01	5.0E-04	1.6E-04	1.1E-02
13-Dec-11	2	500	445	7.76	2.1E+02	#N/A	3.0E+00	3.7E+01	5.3E+01	5.0E-01	1.4E+00	3.0E-01	4.6E+01	3.1E-02	2.0E-03	2.1E-03	1.1E-02	2.0E-05	3.0E-05	6.9E-03	2.2E-05	1.6E+01	7.0E-04	7.1E-05	4.4E-03
20-Dec-11	3	500	495	7.88	1.8E+02	#N/A	3.4E+00	4.6E+01	4.4E+01	2.0E-01	1.3E+00	3.0E-01	3.7E+01	5.1E-02	2.8E-03	2.0E-03	9.8E-03	2.0E-05	1.0E-05	8.0E-03	3.0E-06	1.3E+01	5.0E-04	4.9E-05	3.2E-03
27-Dec-11	4	500	445	8.31	2.0E+02																				
3-Jan-12	5	500	455	7.64	2.6E+02	#N/A	4.6E+00	4.6E+01	8.9E+01	2.0E-01	1.9E+00	3.0E-01	5.7E+01	7.2E-02	3.7E-03	2.0E-03	1.6E-02	2.0E-05	1.0E-05	9.7E-03	3.0E-06	2.0E+01	5.0E-04	7.5E-05	3.1E-03
10-Jan-12	6	500	425	7.69	3.2E+02																				
17-Jan-12	7	500	435	7.64	2.6E+02	#N/A	3.1E+00	4.7E+01	9.3E+01	2.0E-01	1.3E+00	3.0E-01	7.9E+01	3.6E-02	4.2E-03	1.4E-03	2.1E-02	2.0E-05	1.0E-05	8.8E-03	5.0E-06	2.7E+01	5.0E-04	4.8E-05	2.5E-03
24-Jan-12	8	500	435	7.72	2.5E+02																				
31-Jan-12	9	500	455	7.60	2.4E+02	#N/A	3.4E+00	4.2E+01	8.2E+01	2.0E-01	9.6E-01	3.0E-01	8.2E+01	4.9E-02	3.7E-03	1.1E-03	2.0E-02	2.0E-05	1.0E-05	6.8E-03	3.0E-06	2.8E+01	5.0E-04	6.0E-05	2.4E-03
7-Feb-12	10	500	450	7.74	1.8E+02																				
14-Feb-12	11	500	455	7.68	1.8E+02	#N/A	4.5E+00	3.6E+01	5.8E+01	2.0E-01	5.5E-01	3.0E-01	6.9E+01	3.5E-02	2.3E-03	1.2E-03	1.6E-02	2.0E-05	1.0E-05	4.4E-03	3.0E-06	2.4E+01	5.0E-04	4.3E-05	1.5E-03
21-Feb-12	12	500	455	7.68	1.7E+02																				
28-Feb-12	13	500	470	7.55	1.5E+02	#N/A	3.7E+00	3.1E+01	4.2E+01	2.0E-01	4.7E-01	3.0E-01	6.3E+01	3.6E-02	2.1E-03	2.5E-03	1.6E-02	2.0E-05	1.0E-05	4.8E-03	6.0E-06	2.2E+01	5.0E-04	2.9E-05	1.1E-03
6-Mar-12	14	500	470	7.69	1.7E+02																				
13-Mar-12	15	500	465	7.49	1.3E+02	#N/A	2.6E+00	2.6E+01	3.6E+01	2.0E-01	4.3E-01	3.0E-01	5.3E+01	3.5E-02	1.9E-03	7.0E-04	1.4E-02	2.0E-05	1.0E-05	3.5E-03	3.0E-06	1.8E+01	5.0E-04	1.5E-05	9.0E-04
20-Mar-12	16	500	475	7.61	1.3E+02																				
27-Mar-12	17	500	475	7.52	1.3E+02	#N/A	2.9E+00	2.8E+01	3.7E+01	2.0E-01	4.1E-01	3.0E-01	5.6E+01	4.2E-02	1.8E-03	7.0E-04	1.5E-02	2.0E-05	1.0E-05	3.4E-03	1.2E-05	1.9E+01	5.0E-04	1.1E-05	1.3E-03
3-Apr-12	18	500	490	7.58	1.4E+02																				
10-Apr-12	19	500	480	7.60	1.4E+02	#N/A	2.2E+00	2.9E+01	3.8E+01	2.0E-01	3.8E-01	3.0E-01	5.5E+01	3.6E-02	2.0E-03	8.0E-04	1.4E-02	2.0E-05	1.0E-05	3.6E-03	3.0E-06	1.9E+01	5.0E-04	2.7E-05	1.2E-03
17-Apr-12	20	500	420	7.54	2.0E+02																				
24-Apr-12	21	500	475	7.61	1.4E+02	#N/A	2.8E+00	3.2E+01	3.8E+01	2.0E-01	4.4E-01	3.0E-01	5.5E+01	4.9E-02	2.9E-03	8.0E-04	1.6E-02	2.0E-05	1.0E-05	3.9E-03	1.6E-05	1.9E+01	5.0E-04	3.3E-05	1.6E-03
1-May-12	22	500	470	7.60	1.3E+02																				
8-May-12	23	500	475	7.65	1.6E+02	#N/A	3.0E+00	3.5E+01	4.5E+01	2.0E-01	5.4E-01	3.0E-01	6.8E+01	6.7E-02	3.2E-03	8.0E-04	1.9E-02	2.0E-05	1.0E-05	1.8E-02	1.2E-05	2.3E+01	5.0E-04	4.0E-04	4.1E-03
15-May-12	24	500	475	7.64	1.3E+02																				
22-May-12	25	500	430	7.52	1.3E+02	#N/A	3.1E+00	2.9E+01	3.4E+01	2.0E-01	3.3E-01	3.0E-01	5.4E+01	8.5E-02	2.0E-03	9.0E-04	1.4E-02	2.0E-05	1.0E-05	2.7E-03	3.0E-06	1.9E+01	5.0E-04	2.3E-05	1.1E-03
29-May-12	26	500	465	7.52	1.3E+02																				
5-Jun-12	27	500	465	7.53	1.5E+02	#N/A	3.3E+00	3.4E+01	3.6E+01	2.0E-01	3.9E-01	3.0E-01	6.3E+01	4.7E-02	3.0E-03	1.2E-03	1.7E-02	2.0E-05	1.0E-05	4.6E-03	3.0E-06	2.1E+01	5.0E-04	3.9E-05	1.2E-03
12-Jun-12	28	500	460	7.61	1.5E+02																				
19-Jun-12	29	500	460	7.61	1.4E+02	#N/A	2.9E+00	3.6E+01	2.9E+01	2.0E-01	4.2E-01	3.0E-01	5.8E+01	5.0E-02	2.7E-03	6.0E-04	1.7E-02	2.0E-05	1.0E-05	3.5E-03	3.0E-06	1.9E+01	5.0E-04	3.8E-05	1.1E-03
26-Jun-12	30	500	455	7.63	1.3E+02																				
3-Jul-12	31	500	455	7.59	1.3E+02	#N/A	7.4E+00	3.7E+01	2.9E+01	2.0E-01	3.8E-01	3.0E-01	5.3E+01	4.2E-02	3.0E-03	1.1E-03	1.7E-02	2.0E-05	1.0E-05	3.1E-03	3.0E-06	1.8E+01	5.0E-04	2.3E-05	1.6E-03
10-Jul-12	32	500	460	7.60	1.4E+02																				
17-Jul-12	33	500	450	7.63	1.4E+02	#N/A	2.7E+00	3.8E+01	3.0E+01	2.0E-01	3.1E-01	3.0E-01	6.0E+01	4.9E-02	3.8E-03	1.7E-03	1.8E-02	2.0E-05	1.0E-05	3.9E-03	3.0E-06	2.0E+01	5.0E-04	1.7E-04	1.2E-03
24-Jul-12	34	500	450	7.63	1.5E+02																				
31-Jul-12	35	500	455	7.59	1.2E+02	#N/A	2.2E+00	2.8E+01	2.5E+01	2.0E-01	2.0E-01	3.0E-01	5.0E+01	4.8E-02	2.7E-03	5.0E-04	1.5E-02	2.0E-05	1.0E-05	3.4E-03	6.6E-05	1.7E+01	5.0E-04	2.1E-05	1.1E-03
7-Aug-12	36	500	440	7.59	1.0E+02																				
14-Aug-12	37	500	450	7.39	1.4E+02	#N/A	3.3E+00	2.4E+01	3.6E+01	2.0E-01	2.1E-01	3.0E-01	5.5E+01	7.1E-02	3.7E-03	9.9E-03	1.6E-02	2.0E-05	1.0E-05	6.8E-03	3.0E-06	1.9E+01	5.0E-04	5.9E-05	2.3E-03
21-Aug-12	38	500	450	7.38	1.1E+02																				
28-Aug-12	39	500	495	7.47	1.2E+02	#N/A	3.3E+00	2.7E+01	3.2E+01	2.0E-01	1.3E-01	3.0E-01	5.0E+01	5.9E-02	2.0E-03	3.0E-04	1.5E-02	2.0E-05	1.0E-05	2.5E-03	3.0E-06	1.7E+01	5.0E-04	8.0E-05	1.4E-03
4-Sep-12	40	500	490	7.44	9.9E+01																				
11-Sep-12	41	500	460	7.49	1.4E+02	#N/A	2.9E+00	3.0E+01	3.5E+01	2.0E-01	1.9E-01	3.0E-01	5.9E+01	3.8E-02	2.4E-03	6.0E-04	1.5E-02	2.0E-05	1.0E-05	3.0E-03	3.0E-06	2.0E+01	5.0E-04	6.1E-05	1.7E-03
18-Sep-12	42	500	505	7.60	1.3E+02																				
25-Sep-12	43	500	450	7.46	1.2E+02	#N/A	3.7E+00	3.2E+01	3.0E+01	2.0E-01	1.4E-01	3.0E-01	5.2E+01	4.8E-02	2.4E-03	3.6E-03	1.6E-02	2.0E-05	1.0E-05	2.3E-03	1.4E-05	1.7E+01	5.0E-04	1.8E-04	2.5E-03
2-Oct-12	44	500	460	7.41	1.2E+02																				
9-Oct-12	45	500	480	7.36	8.6E+01	#N/A	4.1E+00	2.7E+01	2.0E+01	2.0E-01	1.1E-01	3.0E-01	3.8E+01	5.2E-02	1.7E-03	4.0E-04	1.3E-02	2.0E-05	1.0E-05	1.9E-03	3.0E-06	1.3E+01	5.0E-04	9.7E-05	1.6E-03
16-Oct-12	46	500	480	7.45	1.1E+02																				
23-Oct-12	47	500	495	7.61	1.4E+02																				
30-Oct-12	48	500	480	7.49	1.4E+02																				
6-Nov-12	49	500	455	7.59	1.1E+02	#N/A	2.7E+00	3.8E+01	2.4E+01	2.0E-01	1.2E-01	3.0E-01	5.7E+01	2.6E-02	2.7E-03	9.0E-04	1.6E-02	2.0E-05	1.0E-05	2.9E-03	2.7E-05	1.9E+01	5.0E-04	9.4E-05	2.7E-03
13-Nov-12	50	500	460	7.50	1.1E+02																				
20-Nov-12	51	500	485	7.62	9.9E+01																				
27-Nov-12	52	500	500	7.40	1.2E+02																				
4-Dec-12	53	500	445	7.52	8.2E+01	#N/A	2.1E+00	2.2E+01	2.0E+01	2.0E-01	6.0E-02	3.0E-01	3.7E+01	4.0E-02	1.4E-03	5.0E-04	1.0E-02	2.0E-05	1.0E-05	1.6E-03	3.2E-05	1.3E+01	5.0E-04	8.7E-05	1.4E-03
11-Dec-12	54	500	470	7.41	8.5E+01																				
18-Dec-12	55	500	460	7.49	8.4E+01																				
25-Dec-12	56	500	445	7.43	9.0E+01																				
1-Jan-13	57	500	480	7.58	9.7E+01	#N/A	4.3E+00	3.0E+01	2.5E+01	2.0E-01	1.0E-01	3.0E-01	4.2E+01	3.4E-02	2.3E-03	1.5E-03	1.4E-02	2.0E-05	1.0E-05	1.5E-03	3.0E-06	1.4E+01	5.0E-04	2.2E-05	7.0E-04
8-Jan-13	58	500	465	7.51	8.5E+01																				
15-Jan-13	59	500	465	7.49	8.5E+01																				

HC4

Sample = 08-294

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/L	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
22-Jan-13	60	500	470	7.62	8.3E+01																				
29-Jan-13	61	500	465	7.49	7.8E+01	#N/A	2.7E+00	2.2E+01	2.2E+01	2.0E-01	6.0E-02	3.0E-01	4.0E+01	4.5E-02	1.1E-03	4.0E-04	1.0E-02	2.0E-05	1.0E-05	1.4E-03	3.5E-05	1.4E+01	5.0E-04	2.0E-06	1.0E-03
5-Feb-13	62	500	480	7.63	9.7E+01																				
12-Feb-13	63	500	445	7.50	9.0E+01																				
19-Feb-13	64	500	485	7.56	8.8E+01																				
26-Feb-13	65	500	440	7.50	9.4E+01	#N/A	3.5E+00	2.5E+01	2.0E+01	2.0E-01	6.0E-02	3.0E-01	3.7E+01	2.8E-02	1.1E-03	6.0E-04	1.1E-02	2.0E-05	1.0E-05	1.5E-03	3.9E-05	1.3E+01	5.0E-04	2.6E-04	9.0E-04
5-Mar-13	66	500	450	7.61	9.4E+01																				
12-Mar-13	67	500	445	7.60	9.6E+01																				
19-Mar-13	68	500	470	7.86	8.6E+01																				
26-Mar-13	69	500	450	7.55	8.7E+01	#N/A	4.3E+00	2.1E+01	2.1E+01	2.0E-01	6.0E-02	3.0E-01	3.9E+01	2.5E-02	1.0E-03	7.0E-04	1.0E-02	2.0E-05	1.0E-05	1.7E-03	3.2E-05	1.3E+01	5.0E-04	3.4E-04	7.0E-04
2-Apr-13	70	500	455	7.56	8.0E+01																				
9-Apr-13	71	500	445	7.52	8.5E+01																				
16-Apr-13	72	500	450	7.52	8.0E+01																				
23-Apr-13	73	500	465	7.50	1.1E+02	#N/A	4.9E+00	2.6E+01	3.0E+01	2.0E-01	6.0E-02	3.0E-01	4.6E+01	3.4E-02	1.6E-03	4.0E-04	1.4E-02	2.0E-05	1.0E-05	2.2E-03	3.0E-06	1.6E+01	5.0E-04	2.1E-05	1.5E-03
30-Apr-13	74	500	450	7.64	9.2E+01																				
7-May-13	75	500	435	7.51	9.5E+01																				
14-May-13	76	500	465	7.60	1.1E+02																				
21-May-13	77	500	445	7.62	1.1E+02	#N/A	3.9E+00	3.1E+01	2.6E+01	2.0E-01	6.0E-02	3.0E-01	4.8E+01	2.0E-02	2.1E-03	4.0E-04	1.3E-02	2.0E-05	1.0E-05	2.1E-03	3.0E-06	1.6E+01	5.0E-04	1.6E-05	1.0E-03
28-May-13	78	500	460	7.71	9.4E+01	#N/A	4.1E+00	2.6E+01	2.5E+01	2.0E-01	6.0E-02	3.0E-01	4.5E+01	2.9E-02	1.7E-03	3.0E-04	1.2E-02	2.0E-05	1.0E-05	2.3E-03	5.0E-06	1.5E+01	5.0E-04	1.3E-05	9.0E-04
4-Jun-13	79	500	440	7.57	9.2E+01	#N/A	4.3E+00	3.3E+01	1.5E+01	2.0E-01	6.0E-02	3.0E-01	4.2E+01	1.8E-02	1.2E-03	2.0E-04	1.2E-02	2.0E-05	1.0E-05	5.2E-03	3.0E-06	1.4E+01	5.0E-04	4.8E-05	1.6E-03
11-Jun-13	80	500	490	7.63	6.9E+01	#N/A	7.0E+00	3.0E+01	7.0E+00	2.0E-01	6.0E-02	3.0E-01	3.2E+01	1.3E-02	9.0E-04	2.0E-04	9.4E-03	2.0E-05	1.0E-05	3.9E-03	3.0E-06	1.1E+01	5.0E-04	1.2E-05	5.0E-04
18-Jun-13	81	500	485	7.46	6.8E+01	#N/A	4.5E+00	2.9E+01	8.0E+00	2.0E-01	6.0E-02	3.0E-01	3.2E+01	1.4E-02	1.1E-03	2.0E-04	8.6E-03	2.0E-05	1.0E-05	3.2E-03	7.0E-06	1.1E+01	5.0E-04	6.1E-05	7.0E-04
25-Jun-13	82	500	475	7.50	4.9E+01																				
2-Jul-13	83	500	475	7.44	8.4E+01	#N/A	7.5E+00	4.5E+01	8.0E+00	2.0E-01	6.0E-02	3.0E-01	3.8E+01	1.5E-02	1.5E-03	2.0E-04	1.2E-02	2.0E-05	1.0E-05	9.0E-04	3.0E-06	1.3E+01	5.0E-04	2.0E-06	1.3E-03
9-Jul-13	84	500	475	7.61	6.2E+01																				
16-Jul-13	85	500	505	7.56	6.4E+01	#N/A	3.4E+00	2.8E+01	5.0E+00	2.0E-01	6.0E-02	3.0E-01	3.1E+01	9.5E-03	1.0E-03	3.0E-04	9.5E-03	2.0E-05	1.0E-05	2.5E-03	3.0E-06	1.1E+01	5.0E-04	2.1E-05	8.0E-04
23-Jul-13	86	500	490	7.57	5.8E+01																				
30-Jul-13	87	500	485	7.41	4.9E+01	#N/A	4.4E+00	2.3E+01	6.0E+00	2.0E-01	6.0E-02	3.0E-01	2.4E+01	1.0E-02	7.0E-04	2.0E-04	7.7E-03	2.0E-05	1.0E-05	3.0E-03	3.0E-06	8.1E+00	5.0E-04	2.0E-06	1.4E-03
6-Aug-13	88	500	515	7.55	5.8E+01																				
13-Aug-13	89	500	485	7.52	6.0E+01	#N/A	3.1E+00	2.6E+01	5.0E+00	2.0E-01	6.0E-02	3.0E-01	2.9E+01	2.0E-02	9.0E-04	2.0E-04	1.1E-02	2.0E-05	1.0E-05	2.5E-03	1.0E-05	1.0E+01	5.0E-04	3.6E-05	9.0E-04
20-Aug-13	90	500	485	7.44	5.5E+01																				
27-Aug-13	91	500	520	7.62	5.5E+01																				
3-Sep-13	92	500	480	7.57	5.8E+01																				
10-Sep-13	93	500	480	7.50	6.2E+01	#N/A	3.5E+00	2.8E+01	4.0E+00	2.0E-01	6.0E-02	3.0E-01	3.2E+01	1.4E-02	9.0E-04	2.0E-04	1.1E-02	2.0E-05	1.0E-05	3.6E-03	4.0E-06	1.1E+01	5.0E-04	4.2E-05	1.0E-03
17-Sep-13	94	500	490	7.63	6.3E+01																				
24-Sep-13	95	500	495	7.60	6.6E+01																				
1-Oct-13	96	500	470	7.69	6.6E+01																				
8-Oct-13	97	500	470	7.61	5.8E+01	#N/A	1.7E+00	2.7E+01	4.0E+00	2.0E-01	6.0E-02	3.0E-01	2.9E+01	1.3E-02	8.0E-04	2.0E-04	1.0E-02	2.0E-05	1.0E-05	5.1E-03	3.0E-06	1.0E+01	5.0E-04	3.3E-05	7.0E-04
15-Oct-13	98	500	485	7.55	6.9E+01																				
22-Oct-13	99	500	480	7.58	7.0E+01																				
29-Oct-13	100	500	470	7.67	6.1E+01																				
5-Nov-13	101	500	485	7.61	5.5E+01	#N/A	1.7E+00	2.3E+01	4.0E+00	2.0E-01	6.0E-02	3.0E-01	2.6E+01	7.3E-03	7.0E-04	2.0E-04	1.0E-02	2.0E-05	1.0E-05	1.9E-03	3.0E-06	9.1E+00	5.0E-04	1.8E-05	9.0E-04
12-Nov-13	102	500	480	7.58	5.0E+01																				
19-Nov-13	103	500	465	7.47	5.0E+01																				
26-Nov-13	104	500	470	7.47	5.0E+01																				
3-Dec-13	105	500	475	7.63	5.0E+01	#N/A	6.2E-01	2.6E+01	4.0E+00	2.0E-01	6.0E-02	3.0E-01	2.5E+01	9.9E-03	7.0E-04	2.0E-04	1.0E-02	2.0E-05	1.0E-05	1.3E-03	5.0E-06	8.7E+00	5.0E-04	2.2E-05	6.0E-04
10-Dec-13	106	500	475	7.83	5.7E+01																				
17-Dec-13	107	500	475	7.72	5.9E+01																				
24-Dec-13	108	500	485	7.77	5.6E+01																				
31-Dec-13	109	500	490	7.73	5.3E+01	#N/A	1.5E+00	2.3E+01	3.0E+00	2.0E-01	6.0E-02	3.0E-01	2.5E+01	9.4E-03	6.0E-04	2.0E-04	1.1E-02	2.0E-05	1.0E-05	1.4E-03	3.0E-06	8.5E+00	5.0E-04	2.0E-05	1.0E-03
7-Jan-14	110	500	490	7.66	5.7E+01																				
14-Jan-14	111	500	485	7.76	6.4E+01																				
21-Jan-14	112	500	485	7.64	7.0E+01																				
28-Jan-14	113	500	485	7.78	7.3E+01	#N/A	1.8E+00	3.5E+01	3.0E+00	2.0E-01	6.0E-02	3.0E-01	3.7E+01	1.0E-02	1.0E-03	2.0E-04	1.5E-02	2.0E-05	1.0E-05	2.1E-03	3.0E-06	1.3E+01	5.0E-04	2.0E-06	5.0E-04
4-Feb-14	114	500	485	7.82	6.8E+01																				
11-Feb-14	115	500	465	7.81	6.7E+01																				
18-Feb-14	116	500	485	7.73	5.7E+01																				
25-Feb-14	117	500	485	7.80	5.5E+01	#N/A	2.9E+00	3.1E+01	5.0E+00	2.0E-01	6.0E-02	3.0E-01	2.7E+01	9.4E-03	6.0E-04	2.0E-04	1.2E-02	2.0E-05	1.0E-05	1.5E-03	3.0E-06	9.5E+00	5.0E-04	1.2E-05	7.0E-04

HC4

Sample = 08-294

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Major	Major	Diff	Diff
	No.																								Anions	Cations		(%)
		mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L				
29-Nov-11	0	4.0E-03	1.0E-04	2.0E-03	5.1E+00	6.4E-03	2.0E-02	5.9E-02	1.7E-03	9.0E-03	8.7E+00	2.4E-02	3.1E+00	1.0E-05	7.0E+01	7.0E-01	7.9E+01	4.0E-05	1.9E-04	6.0E-04	6.9E-02	1.9E-03	3.0E-03	4.1E-04	6.4E+00	6.1E+00	-3.4E-01	-2.7E-02
6-Dec-11	1	3.0E-03	2.0E-05	2.0E-03	3.5E+00	2.7E-03	2.0E-02	8.4E-02	7.0E-04	9.0E-03	9.0E+00	1.5E-02	1.7E+00	1.0E-05	6.6E+01	5.0E-01	6.2E+01	2.0E-05	2.0E-05	3.0E-04	1.4E-01	1.8E-03	2.0E-03	1.8E-04	4.8E+00	5.1E+00	3.5E-01	3.5E-02
13-Dec-11	2	3.0E-03	1.0E-03	1.0E-03	1.4E+00	2.7E-03	2.0E-02	3.9E-02	6.0E-04	9.0E-03	4.2E+00	4.3E-03	9.7E-01	1.0E-05	2.4E+01	2.2E-01	2.0E+01	2.0E-05	1.2E-04	2.0E-04	5.6E-02	1.1E-03	3.0E-03	8.0E-05	1.9E+00	2.1E+00	1.2E-01	3.1E-02
20-Dec-11	3	3.0E-03	2.0E-05	1.0E-03	1.3E+00	2.7E-03	1.0E-02	3.1E-02	4.0E-04	9.0E-03	3.9E+00	2.8E-03	1.3E+00	1.0E-05	1.9E+01	1.8E-01	1.5E+01	2.0E-05	3.0E-05	2.0E-04	7.4E-02	1.3E-03	2.0E-03	5.0E-05	1.9E+00	1.7E+00	-2.2E-01	-6.1E-02
27-Dec-11	4																											
3-Jan-12	5	3.0E-03	2.0E-05	1.0E-03	2.0E+00	2.4E-03	1.0E-02	1.8E-02	1.0E-03	9.0E-03	5.8E+00	2.0E-03	1.4E+00	1.0E-05	2.6E+01	2.9E-01	2.7E+01	2.0E-05	5.0E-05	3.0E-04	5.7E-02	1.7E-03	2.0E-03	4.0E-05	2.9E+00	2.4E+00	-4.4E-01	-8.3E-02
10-Jan-12	6																											
17-Jan-12	7	3.0E-03	2.0E-05	1.0E-03	2.8E+00	1.9E-03	1.0E-02	9.0E-03	2.0E-04	9.0E-03	7.0E+00	1.6E-03	1.4E+00	1.0E-05	1.5E+01	4.1E-01	2.8E+01	2.0E-05	2.0E-05	4.0E-04	6.2E-02	1.3E-03	1.0E-03	5.0E-05	3.0E+00	2.4E+00	-5.2E-01	-9.6E-02
24-Jan-12	8																											
31-Jan-12	9	6.0E-03	2.0E-05	1.0E-03	3.0E+00	3.3E-03	1.0E-02	7.7E-03	1.0E-04	9.0E-03	6.3E+00	1.7E-03	1.2E+00	1.0E-05	7.9E+00	4.1E-01	2.5E+01	2.0E-05	7.0E-05	3.0E-04	4.7E-02	1.2E-03	2.0E-03	1.0E-05	2.6E+00	2.2E+00	-4.4E-01	-9.3E-02
7-Feb-12	10																											
14-Feb-12	11	3.0E-03	2.0E-05	1.0E-03	2.5E+00	2.8E-03	1.0E-02	5.4E-03	7.0E-04	9.0E-03	4.3E+00	1.9E-03	8.8E-01	1.0E-05	3.1E+00	3.4E-01	1.7E+01	2.0E-05	3.0E-05	2.0E-04	4.0E-02	6.9E-04	1.0E-03	6.0E-05	2.0E+00	1.6E+00	-3.2E-01	-9.0E-02
21-Feb-12	12																											
28-Feb-12	13	3.0E-03	2.0E-05	1.0E-03	2.2E+00	3.7E-03	1.0E-02	5.1E-03	1.0E-04	9.0E-03	3.7E+00	1.1E-03	7.6E-01	1.0E-05	1.8E+00	3.1E-01	1.4E+01	2.0E-05	6.0E-05	2.0E-04	3.1E-02	6.7E-04	2.0E-03	1.0E-05	1.5E+00	1.4E+00	-8.0E-02	-2.7E-02
6-Mar-12	14																											
13-Mar-12	15	4.0E-03	2.0E-05	1.0E-03	1.8E+00	2.6E-03	1.0E-02	4.4E-03	1.0E-04	9.0E-03	3.3E+00	8.5E-04	7.1E-01	1.0E-05	1.1E+00	2.5E-01	1.2E+01	2.0E-05	1.4E-04	2.0E-04	2.3E-02	4.6E-04	1.0E-03	2.0E-05	1.3E+00	1.2E+00	-1.0E-01	-4.2E-02
20-Mar-12	16																											
27-Mar-12	17	3.0E-03	4.0E-05	1.0E-03	1.8E+00	2.7E-03	1.0E-02	4.2E-03	2.0E-04	9.0E-03	3.1E+00	6.1E-04	7.0E-01	1.0E-05	7.9E-01	2.5E-01	1.2E+01	2.0E-05	1.0E-05	1.0E-04	2.1E-02	5.6E-04	1.0E-03	1.0E-05	1.4E+00	1.2E+00	-1.2E-01	-4.5E-02
3-Apr-12	18																											
10-Apr-12	19	3.0E-03	2.0E-05	1.0E-03	1.9E+00	2.0E-03	2.0E-02	5.0E-03	1.0E-04	9.0E-03	3.0E+00	1.1E-03	7.3E-01	1.0E-05	6.9E-01	2.6E-01	1.2E+01	2.0E-05	1.6E-04	1.0E-04	1.9E-02	6.2E-04	2.0E-03	1.0E-05	1.4E+00	1.2E+00	-1.8E-01	-6.7E-02
17-Apr-12	20																											
24-Apr-12	21	3.0E-03	2.0E-05	1.0E-03	2.0E+00	2.3E-03	3.0E-02	5.2E-03	3.0E-04	9.0E-03	3.6E+00	3.5E-04	8.2E-01	1.0E-05	5.8E-01	2.6E-01	1.2E+01	2.0E-05	5.0E-05	3.0E-04	2.6E-02	6.5E-04	2.0E-03	1.0E-05	1.5E+00	1.2E+00	-2.2E-01	-8.3E-02
1-May-12	22																											
8-May-12	23	3.0E-03	1.4E-04	1.0E-03	2.6E+00	1.9E-03	1.0E-02	1.1E-02	1.5E-03	9.0E-03	4.3E+00	9.1E-04	9.0E-01	1.0E-05	6.5E-01	3.1E-01	1.5E+01	2.0E-05	1.7E-04	1.0E-04	2.9E-02	5.7E-04	7.0E-03	1.0E-05	1.7E+00	1.5E+00	-1.6E-01	-5.0E-02
15-May-12	24																											
22-May-12	25	7.0E-03	2.0E-05	1.0E-03	1.9E+00	2.2E-03	2.0E-02	6.1E-03	2.0E-04	9.0E-03	3.0E+00	8.1E-04	7.4E-01	1.0E-05	3.9E-01	2.5E-01	1.2E+01	2.0E-05	1.0E-04	6.0E-04	2.1E-02	7.3E-04	1.0E-03	1.0E-05	1.3E+00	1.2E+00	-1.2E-01	-4.7E-02
29-May-12	26																											
5-Jun-12	27	4.0E-03	2.0E-05	1.0E-03	2.4E+00	2.6E-03	1.0E-02	6.6E-03	1.0E-04	9.0E-03	3.6E+00	1.1E-03	8.8E-01	1.0E-05	4.1E-01	3.0E-01	1.4E+01	2.0E-05	3.4E-04	2.0E-04	2.4E-02	8.7E-04	2.0E-03	1.0E-05	1.5E+00	1.4E+00	-6.5E-02	-2.3E-02
12-Jun-12	28																											
19-Jun-12	29	3.0E-03	2.0E-05	1.0E-03	2.2E+00	2.0E-03	1.0E-02	5.8E-03	1.2E-03	9.0E-03	3.4E+00	8.8E-04	9.3E-01	1.0E-05	3.3E-01	2.7E-01	1.1E+01	2.0E-05	2.5E-04	1.0E-04	2.4E-02	7.4E-04	2.0E-03	1.0E-05	1.3E+00	1.3E+00	-8.0E-02	-3.1E-02
26-Jun-12	30																											
3-Jul-12	31	3.0E-03	2.0E-05	1.0E-03	2.1E+00	2.6E-03	1.0E-02	5.1E-03	1.0E-04	9.0E-03	3.6E+00	1.0E-03	9.4E-01	1.0E-05	2.6E-01	2.5E-01	1.0E+01	2.0E-05	2.2E-04	2.0E-04	2.0E-02	8.1E-04	1.0E-03	2.0E-05	1.4E+00	1.2E+00	-1.9E-01	-7.6E-02
10-Jul-12	32																											
17-Jul-12	33	1.7E-02	9.0E-05	1.0E-03	2.5E+00	2.1E-03	2.0E-02	6.6E-03	1.0E-04	9.0E-03	3.9E+00	1.5E-03	1.2E+00	1.0E-05	4.2E-01	2.9E-01	1.2E+01	2.0E-05	5.5E-04	2.0E-04	2.2E-02	7.7E-04	2.0E-03	1.0E-05	1.4E+00	1.3E+00	-7.3E-02	-2.7E-02
24-Jul-12	34																											
31-Jul-12	35	3.0E-03	7.6E-04	1.0E-03	2.0E+00	2.0E-03	1.0E-02	3.5E-03	1.0E-04	9.0E-03	2.7E+00	9.1E-04	8.6E-01	1.0E-05	2.0E-01	2.4E-01	9.3E+00	2.0E-05	1.3E-04	1.0E-04	1.4E-02	6.7E-04	1.0E-02	1.0E-05	1.1E+00	1.1E+00	-1.7E-02	-7.8E-03
7-Aug-12	36																											
14-Aug-12	37	3.0E-03	2.0E-05	1.0E-03	2.1E+00	3.0E-03	1.0E-02	3.9E-03	4.0E-04	9.0E-03	2.7E+00	1.0E-03	7.5E-01	1.0E-05	2.0E-01	2.6E-01	1.3E+01	2.0E-05	6.1E-04	5.0E-04	1.2E-02	9.5E-04	2.0E-03	1.0E-05	1.2E+00	1.2E+00	-5.2E-02	-2.1E-02
21-Aug-12	38																											
28-Aug-12	39	3.0E-03	2.0E-05	1.0E-03	2.0E+00	2.6E-03	1.0E-02	3.5E-03	7.0E-04	9.0E-03	2.2E+00	1.1E-03	6.7E-01	1.0E-05	1.4E-01	2.3E-01	1.1E+01	2.0E-05	2.4E-04	2.0E-04	1.7E-02	5.5E-04	2.0E-03	1.0E-05	1.2E+00	1.1E+00	-1.4E-01	-6.3E-02
4-Sep-12	40																											
11-Sep-12	41	3.0E-03	2.0E-05	1.0E-03	2.4E+00	1.9E-03	1.0E-02	4.6E-03	3.0E-04	9.0E-03	2.9E+00	1.2E-03	8.3E-01	1.0E-05	2.1E-01	2.7E-01	1.3E+01	2.0E-05	1.7E-04	9.0E-04	1.7E-02	8.1E-04	1.0E-03	2.0E-05	1.3E+00	1.3E+00	-6.7E-02	-2.6E-02
18-Sep-12	42																											
25-Sep-12	43	4.0E-03	2.0E-05	1.0E-03	2.0E+00	1.9E-03	1.0E-02	4.1E-03	7.0E-04	9.0E-03	2.3E+00	9.3E-04	6.9E-01	1.0E-05	6.6E-01	2.3E-01	1.0E+01	2.0E-05	1.8E-04	1.0E-04	1.9E-02	5.6E-04	2.0E-03	1.0E-05	1.3E+00	1.1E+00	-1.5E-01	-6.2E-02
2-Oct-12	44																											
9-Oct-12	45	1.2E-02	2.0E-05	1.0E-03	1.4E+00	2.9E-03	1.0E-02	2.4E-03	1.0E-04	9.0E-03	1.7E+00	5.9E-04	5.8E-01	1.0E-05	1.0E-01	1.6E-01	6.6E+00	2.0E-05	1.8E-04	2.0E-04	1.2E-02	4.4E-04	2.0E-03	1.0E-05	9.6E-01	8.1E-01	-1.5E-01	-8.5E-02
16-Oct-12	46																											
23-Oct-12	47																											
30-Oct-12	48																											
6-Nov-12	49	3.0E-03	8.0E-05	1.0E-03	2.3E+00	1.9E-03	1.0E-02	3.9E-03	3.0E-04	9.0E-03	2.3E+00	9.7E-04	8.4E-01	1.0E-05	2.2E-01	2.6E-01	9.7E+00	2.0E-05	7.4E-04	1.0E-04	1.7E-02	5.2E-04	4.0E-03	1.0E-05	1.3E+00	1.2E+00	-3.6E-02	-1.5E-02
13-Nov-12	50																											
20-Nov-12	51																											
27-Nov-12	52																											
4-Dec-12	53	4.0E-03	1.9E-04	1.0E-03	1.3E+00	1.7E-03	1.0E-02	3.2E-03	1.0E-04	9.0E-03	1.2E+00	9.0E-05	3.9E-01	1.0E-05	1.0E-01	1.6E-01	7.4E+00	2.0E-05	1.0E-04	2.0E-04	1.1E-02	3.5E-04	2.0E-03	1.0E-05	8.6E-01	7.8E-01	-8.8E-02	-5.4E-02
11-Dec-12	54																											
18-Dec-12	55																											
25-Dec-12	56																											
1-Jan-13	57	3.0E-03	2.0E-05	1.0E-03	1.6E+00	1.8E-03	1.0E-02	4.7E-03	1.0E-04	9.0E-03	1.3E+00	5.9E-04	5.8E-01	1.0E-05	9.0E-02	1.8E-01	7.8E+00	2.0E-05	2.3E-04	2.0E-04	1.5E-02	3.6E-04	2.0E-03	1.0E-05	1.1E+00	8.8E-01	-2.3E-01	-1.2E-01
8-Jan-13	58																											
15-Jan-13	59																											

HC4

Sample = 08-294

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Major	Major	Diff	Diff
	No.																								Anions	Cations		(%)
		mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L				
22-Jan-13	60																											
29-Jan-13	61	4.0E-03	2.0E-05	1.0E-03	1.4E+00	2.7E-03	1.0E-02	2.8E-03	3.0E-04	2.6E-02	1.0E+00	5.4E-04	4.8E-01	1.0E-05	1.1E-01	1.6E-01	7.9E+00	2.0E-05	2.9E-04	5.0E-04	8.1E-03	4.1E-04	2.0E-03	1.0E-05	9.0E-01	8.3E-01	-7.2E-02	-4.2E-02
5-Feb-13	62																											
12-Feb-13	63																											
19-Feb-13	64																											
26-Feb-13	65	3.0E-03	3.0E-05	1.0E-03	1.3E+00	1.6E-03	1.0E-02	2.9E-03	2.0E-04	1.4E-02	1.1E+00	6.3E-04	4.0E-01	1.0E-05	9.0E-02	1.5E-01	7.5E+00	2.0E-05	7.0E-05	1.0E-04	7.9E-03	2.1E-04	1.0E-03	1.0E-05	9.2E-01	7.8E-01	-1.5E-01	-8.6E-02
5-Mar-13	66																											
12-Mar-13	67																											
19-Mar-13	68																											
26-Mar-13	69	3.0E-03	5.2E-04	1.0E-03	1.3E+00	1.6E-03	1.0E-02	2.7E-03	2.0E-04	9.0E-03	9.0E-01	4.5E-04	4.2E-01	1.0E-05	1.1E-01	1.5E-01	7.9E+00	2.0E-05	5.0E-05	1.0E-04	6.9E-03	1.9E-04	5.0E-03	1.0E-05	8.6E-01	8.1E-01	-5.3E-02	-3.2E-02
2-Apr-13	70																											
9-Apr-13	71																											
16-Apr-13	72																											
23-Apr-13	73	7.0E-03	1.1E-04	1.0E-03	1.7E+00	1.7E-03	1.0E-02	3.0E-03	1.0E-04	9.0E-03	1.3E+00	5.2E-04	6.4E-01	1.0E-05	9.0E-02	1.9E-01	1.0E+01	2.0E-05	7.0E-05	2.0E-04	1.0E-02	2.0E-04	1.0E-03	1.0E-05	1.2E+00	9.7E-01	-1.8E-01	-8.7E-02
30-Apr-13	74																											
7-May-13	75																											
14-May-13	76																											
21-May-13	77	3.0E-03	2.0E-05	1.0E-03	1.8E+00	1.4E-03	1.0E-02	3.2E-03	1.0E-04	9.0E-03	1.5E+00	6.5E-04	7.1E-01	1.0E-05	1.2E-01	2.0E-01	8.3E+00	2.0E-05	1.1E-04	1.0E-04	1.2E-02	2.6E-04	1.0E-03	1.0E-05	1.2E+00	1.0E+00	-1.7E-01	-7.6E-02
28-May-13	78	3.0E-03	2.0E-05	1.0E-03	1.6E+00	1.5E-03	1.0E-02	2.5E-03	1.0E-04	9.0E-03	1.4E+00	6.3E-04	5.6E-01	1.0E-05	1.2E-01	1.9E-01	7.4E+00	2.0E-05	8.0E-05	3.0E-04	9.6E-03	2.7E-04	1.0E-03	6.0E-05	1.0E+00	9.5E-01	-9.5E-02	-4.8E-02
4-Jun-13	79	7.0E-03	2.0E-05	1.0E-03	1.5E+00	2.0E-03	1.0E-02	1.8E-03	1.6E-03	9.0E-03	1.1E+00	3.9E-04	4.7E-01	1.0E-05	8.0E-02	1.7E-01	4.6E+00	2.0E-05	2.7E-03	1.0E-04	1.7E-02	1.9E-04	2.0E-03	1.0E-05	9.6E-01	8.8E-01	-8.6E-02	-4.7E-02
11-Jun-13	80	3.0E-03	2.0E-05	1.0E-03	1.1E+00	1.2E-03	1.0E-02	1.4E-03	1.0E-04	9.0E-03	7.5E-01	2.0E-04	3.5E-01	1.0E-05	6.0E-02	1.3E-01	2.9E+00	2.0E-05	2.9E-03	1.0E-04	1.4E-02	8.0E-05	1.0E-03	1.0E-05	7.5E-01	6.7E-01	-7.2E-02	-5.1E-02
18-Jun-13	81	3.0E-03	2.0E-05	1.0E-03	1.2E+00	2.0E-03	1.0E-02	8.9E-04	1.0E-04	9.0E-03	7.8E-01	2.1E-04	3.7E-01	1.0E-05	9.0E-02	1.3E-01	2.7E+00	2.0E-05	1.9E-03	1.0E-04	1.4E-02	9.0E-05	1.0E-03	1.0E-05	7.5E-01	6.7E-01	-7.1E-02	-5.0E-02
25-Jun-13	82																											
2-Jul-13	83	3.0E-03	2.0E-05	1.0E-03	1.5E+00	1.3E-03	2.0E-02	1.5E-03	1.0E-04	9.0E-03	1.1E+00	3.0E-04	4.8E-01	1.0E-05	6.0E-02	1.6E-01	2.3E+00	2.0E-05	1.6E-03	1.0E-04	1.6E-02	2.1E-04	1.0E-03	1.0E-05	1.1E+00	8.0E-01	-2.6E-01	-1.4E-01
9-Jul-13	84																											
16-Jul-13	85	3.0E-03	2.0E-05	1.0E-03	1.1E+00	2.0E-03	2.0E-02	4.8E-04	1.0E-04	9.0E-03	6.3E-01	2.3E-04	3.2E-01	1.0E-05	6.0E-02	1.2E-01	1.7E+00	2.0E-05	1.6E-03	1.0E-04	1.1E-02	9.0E-05	1.0E-03	1.0E-05	6.7E-01	6.4E-01	-2.6E-02	-2.0E-02
23-Jul-13	86																											
30-Jul-13	87	3.0E-03	3.0E-05	1.0E-03	8.1E-01	2.0E-03	1.0E-02	4.3E-04	1.0E-04	9.0E-03	5.0E-01	1.5E-04	2.4E-01	1.0E-05	3.0E-02	9.1E-02	1.3E+00	2.0E-05	1.3E-03	1.0E-04	8.8E-03	7.0E-05	1.0E-03	1.0E-05	5.8E-01	4.9E-01	-8.8E-02	-8.3E-02
6-Aug-13	88																											
13-Aug-13	89	7.0E-03	3.0E-05	1.0E-03	9.9E-01	2.6E-03	1.0E-02	4.6E-04	2.0E-04	1.2E-02	5.9E-01	1.8E-04	3.2E-01	1.0E-05	5.0E-02	1.1E-01	1.7E+00	2.0E-05	1.7E-03	1.0E-04	9.7E-03	6.0E-05	2.0E-03	1.0E-05	6.2E-01	6.0E-01	-2.2E-02	-1.8E-02
20-Aug-13	90																											
27-Aug-13	91																											
3-Sep-13	92																											
10-Sep-13	93	6.0E-03	2.0E-05	1.0E-03	1.1E+00	2.6E-03	1.0E-02	4.7E-04	1.0E-04	9.0E-03	6.9E-01	2.2E-04	3.7E-01	1.0E-05	3.0E-02	1.2E-01	2.0E+00	2.0E-05	2.5E-03	1.0E-04	1.1E-02	1.1E-04	1.0E-03	1.0E-05	6.5E-01	6.5E-01	7.1E-03	5.5E-03
17-Sep-13	94																											
24-Sep-13	95																											
1-Oct-13	96																											
8-Oct-13	97	3.0E-03	2.0E-05	1.0E-03	9.3E-01	2.5E-03	1.0E-02	3.3E-04	2.0E-04	9.0E-03	5.7E-01	1.6E-04	3.2E-01	1.0E-05	3.0E-02	1.0E-01	1.5E+00	2.0E-05	1.2E-03	1.0E-04	8.7E-03	8.0E-05	1.0E-03	1.0E-05	6.2E-01	6.0E-01	-2.2E-02	-1.8E-02
15-Oct-13	98																											
22-Oct-13	99																											
29-Oct-13	100																											
5-Nov-13	101	3.0E-03	2.0E-05	1.0E-03	8.7E-01	1.8E-03	1.0E-02	3.0E-04	1.0E-04	9.0E-03	5.2E-01	1.7E-04	2.6E-01	1.0E-05	2.0E-02	1.0E-01	1.4E+00	2.0E-05	6.4E-04	1.0E-04	8.3E-03	7.0E-05	1.0E-03	1.0E-05	5.5E-01	5.4E-01	-1.1E-02	-1.0E-02
12-Nov-13	102																											
19-Nov-13	103																											
26-Nov-13	104																											
3-Dec-13	105	3.0E-03	2.0E-05	1.0E-03	8.0E-01	1.7E-03	1.0E-02	3.8E-04	1.0E-04	9.0E-03	4.8E-01	1.5E-04	2.2E-01	1.0E-05	1.0E-02	9.3E-02	1.4E+00	2.0E-05	5.3E-04	1.0E-04	7.9E-03	1.1E-04	1.0E-03	1.0E-05	6.0E-01	5.2E-01	-8.3E-02	-7.5E-02
10-Dec-13	106																											
17-Dec-13	107																											
24-Dec-13	108																											
31-Dec-13	109	4.0E-03	2.0E-05	1.0E-03	8.1E-01	1.7E-03	1.0E-02	3.8E-04	2.0E-04	9.0E-03	4.8E-01	1.8E-04	2.6E-01	1.0E-05	3.0E-02	9.4E-02	1.3E+00	2.0E-05	1.5E-03	1.0E-04	6.9E-03	8.0E-05	1.0E-03	1.0E-05	5.1E-01	5.1E-01	-5.1E-03	-5.0E-03
7-Jan-14	110																											
14-Jan-14	111																											
21-Jan-14	112																											
28-Jan-14	113	3.0E-03	2.0E-05	1.0E-03	1.2E+00	2.1E-03	1.0E-02	3.8E-04	2.0E-04	9.0E-03	6.9E-01	1.8E-04	3.6E-01	1.0E-05	3.0E-02	1.4E-01	1.6E+00	2.0E-05	1.2E-03	1.0E-04	8.6E-03	5.0E-05	1.0E-03	1.0E-05	7.6E-01	7.5E-01	-6.9E-03	-4.6E-03
4-Feb-14	114																											
11-Feb-14	115																											
18-Feb-14	116																											
25-Feb-14	117	3.0E-03	2.0E-05	1.0E-03	8.5E-01	1.3E-03	1.0E-02	2.7E-04	1.0E-04	9.0E-03	5.0E-01	1.5E-04	2.7E-01	1.0E-05	2.0E-02	1.0E-01	1.1E+00	2.0E-05	7.8E-04	1.0E-04	6.4E-03	6.0E-05	1.0E-03	1.0E-05	7.3E-01	5.6E-01	-1.7E-01	-1.3E-01

HC4

Sample = 08-294

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/kg	mgCaCO3/kg	mgCaCO3/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
29-Nov-11	0	500	300	7.69	6.6E+02	#N/A	2.0E+00	1.6E+01	7.4E+01	1.6E+00	4.2E-01	9.0E-02	4.2E+01	1.6E-02	8.7E-04	1.2E-03	7.1E-03	6.0E-06	3.0E-06	3.5E-03	9.0E-06	1.4E+01	1.8E-04	9.0E-05	3.5E-03
6-Dec-11	1	500	485	7.87	5.1E+02	#N/A	1.7E+00	3.0E+01	7.8E+01	1.2E+00	1.2E+00	1.5E-01	4.9E+01	1.9E-02	1.8E-03	2.1E-03	7.7E-03	9.7E-06	4.9E-06	6.5E-03	1.6E-05	1.7E+01	2.4E-04	7.5E-05	5.4E-03
13-Dec-11	2	500	445	7.76	2.1E+02	#N/A	1.4E+00	1.6E+01	2.4E+01	2.2E-01	6.2E-01	1.3E-01	2.0E+01	1.4E-02	8.9E-04	9.3E-04	4.9E-03	8.9E-06	1.3E-05	3.1E-03	9.8E-06	7.2E+00	3.1E-04	3.2E-05	2.0E-03
20-Dec-11	3	500	495	7.88	1.8E+02	#N/A	1.7E+00	2.3E+01	2.2E+01	9.9E-02	6.3E-01	1.5E-01	1.8E+01	2.5E-02	1.4E-03	9.9E-04	4.9E-03	9.9E-06	5.0E-06	4.0E-03	1.5E-06	6.4E+00	2.5E-04	2.4E-05	1.6E-03
27-Dec-11	4	500	445	8.31	2.0E+02																				
3-Jan-12	5	500	455	7.64	2.6E+02	#N/A	2.1E+00	2.1E+01	4.0E+01	9.1E-02	8.7E-01	1.4E-01	2.6E+01	3.3E-02	1.7E-03	9.1E-04	7.1E-03	9.1E-06	4.6E-06	4.4E-03	1.4E-06	9.0E+00	2.3E-04	3.4E-05	1.4E-03
10-Jan-12	6	500	425	7.69	3.2E+02																				
17-Jan-12	7	500	435	7.64	2.6E+02	#N/A	1.3E+00	2.1E+01	4.0E+01	8.7E-02	5.7E-01	1.3E-01	3.4E+01	1.6E-02	1.8E-03	6.1E-04	9.1E-03	8.7E-06	4.4E-06	3.8E-03	2.2E-06	1.2E+01	2.2E-04	2.1E-05	1.1E-03
24-Jan-12	8	500	435	7.72	2.5E+02																				
31-Jan-12	9	500	455	7.60	2.4E+02	#N/A	1.6E+00	1.9E+01	3.7E+01	9.1E-02	4.4E-01	1.4E-01	3.7E+01	2.2E-02	1.7E-03	5.0E-04	8.9E-03	9.1E-06	4.6E-06	3.1E-03	1.4E-06	1.3E+01	2.3E-04	2.7E-05	1.1E-03
7-Feb-12	10	500	450	7.74	1.8E+02																				
14-Feb-12	11	500	455	7.68	1.8E+02	#N/A	2.0E+00	1.6E+01	2.6E+01	9.1E-02	2.5E-01	1.4E-01	3.1E+01	1.6E-02	1.0E-03	5.5E-04	7.1E-03	9.1E-06	4.6E-06	2.0E-03	1.4E-06	1.1E+01	2.3E-04	2.0E-05	6.8E-04
21-Feb-12	12	500	455	7.68	1.7E+02																				
28-Feb-12	13	500	470	7.55	1.5E+02	#N/A	1.7E+00	1.5E+01	2.0E+01	9.4E-02	2.2E-01	1.4E-01	3.0E+01	1.7E-02	9.9E-04	1.2E-03	7.4E-03	9.4E-06	4.7E-06	2.3E-03	2.8E-06	1.0E+01	2.4E-04	1.4E-05	5.2E-04
6-Mar-12	14	500	470	7.69	1.7E+02																				
13-Mar-12	15	500	465	7.49	1.3E+02	#N/A	1.2E+00	1.2E+01	1.7E+01	9.3E-02	2.0E-01	1.4E-01	2.5E+01	1.6E-02	8.8E-04	3.3E-04	6.4E-03	9.3E-06	4.7E-06	1.6E-03	1.4E-06	8.4E+00	2.3E-04	7.0E-06	4.2E-04
20-Mar-12	16	500	475	7.61	1.3E+02																				
27-Mar-12	17	500	475	7.52	1.3E+02	#N/A	1.4E+00	1.3E+01	1.8E+01	9.5E-02	1.9E-01	1.4E-01	2.7E+01	2.0E-02	8.6E-04	3.3E-04	7.3E-03	9.5E-06	4.8E-06	1.6E-03	5.7E-06	9.2E+00	2.4E-04	5.2E-06	6.2E-04
3-Apr-12	18	500	490	7.58	1.4E+02																				
10-Apr-12	19	500	480	7.60	1.4E+02	#N/A	1.0E+00	1.4E+01	1.8E+01	9.6E-02	1.8E-01	1.4E-01	2.7E+01	1.7E-02	9.6E-04	3.8E-04	6.5E-03	9.6E-06	4.8E-06	1.7E-03	1.4E-06	9.1E+00	2.4E-04	1.3E-05	5.8E-04
17-Apr-12	20	500	420	7.54	2.0E+02																				
24-Apr-12	21	500	475	7.61	1.4E+02	#N/A	1.3E+00	1.5E+01	1.8E+01	9.5E-02	2.1E-01	1.4E-01	2.6E+01	2.3E-02	1.4E-03	3.8E-04	7.7E-03	9.5E-06	4.8E-06	1.9E-03	7.6E-06	8.9E+00	2.4E-04	1.6E-05	7.6E-04
1-May-12	22	500	470	7.60	1.3E+02																				
8-May-12	23	500	475	7.65	1.6E+02	#N/A	1.4E+00	1.7E+01	2.1E+01	9.5E-02	2.6E-01	1.4E-01	3.2E+01	3.2E-02	1.5E-03	3.8E-04	8.9E-03	9.5E-06	4.8E-06	8.4E-03	5.7E-06	1.1E+01	2.4E-04	1.9E-04	1.9E-03
15-May-12	24	500	475	7.64	1.3E+02																				
22-May-12	25	500	430	7.52	1.3E+02	#N/A	1.3E+00	1.2E+01	1.5E+01	8.6E-02	1.4E-01	1.3E-01	2.3E+01	3.7E-02	8.6E-04	3.9E-04	6.0E-03	8.6E-06	4.3E-06	1.2E-03	1.3E-06	8.0E+00	2.2E-04	9.9E-06	4.7E-04
29-May-12	26	500	465	7.52	1.3E+02																				
5-Jun-12	27	500	465	7.53	1.5E+02	#N/A	1.5E+00	1.6E+01	1.7E+01	9.3E-02	1.8E-01	1.4E-01	2.9E+01	2.2E-02	1.4E-03	5.6E-04	7.8E-03	9.3E-06	4.7E-06	2.1E-03	1.4E-06	1.0E+01	2.3E-04	1.8E-05	5.6E-04
12-Jun-12	28	500	460	7.61	1.5E+02																				
19-Jun-12	29	500	460	7.61	1.4E+02	#N/A	1.3E+00	1.7E+01	1.3E+01	9.2E-02	1.9E-01	1.4E-01	2.6E+01	2.3E-02	1.2E-03	2.8E-04	7.9E-03	9.2E-06	4.6E-06	1.6E-03	1.4E-06	8.9E+00	2.3E-04	1.7E-05	5.1E-04
26-Jun-12	30	500	455	7.63	1.3E+02																				
3-Jul-12	31	500	455	7.59	1.3E+02	#N/A	3.4E+00	1.7E+01	1.3E+01	9.1E-02	1.7E-01	1.4E-01	2.4E+01	1.9E-02	1.4E-03	5.0E-04	7.5E-03	9.1E-06	4.6E-06	1.4E-03	1.4E-06	8.1E+00	2.3E-04	1.0E-05	7.3E-04
10-Jul-12	32	500	460	7.60	1.4E+02																				
17-Jul-12	33	500	450	7.63	1.4E+02	#N/A	1.2E+00	1.7E+01	1.4E+01	9.0E-02	1.4E-01	1.4E-01	2.7E+01	2.2E-02	1.7E-03	7.7E-04	8.2E-03	9.0E-06	4.5E-06	1.8E-03	1.4E-06	9.0E+00	2.3E-04	7.5E-05	5.4E-04
24-Jul-12	34	500	450	7.63	1.5E+02																				
31-Jul-12	35	500	455	7.59	1.2E+02	#N/A	1.0E+00	1.3E+01	1.1E+01	9.1E-02	9.1E-02	1.4E-01	2.3E+01	2.2E-02	1.2E-03	2.3E-04	6.6E-03	9.1E-06	4.6E-06	1.5E-03	3.0E-05	7.6E+00	2.3E-04	9.6E-06	5.0E-04
7-Aug-12	36	500	440	7.59	1.0E+02																				
14-Aug-12	37	500	450	7.39	1.4E+02	#N/A	1.5E+00	1.1E+01	1.6E+01	9.0E-02	9.5E-02	1.4E-01	2.5E+01	3.2E-02	1.7E-03	4.5E-03	7.2E-03	9.0E-06	4.5E-06	3.1E-03	1.4E-06	8.4E+00	2.3E-04	2.7E-05	1.0E-03
21-Aug-12	38	500	450	7.38	1.1E+02																				
28-Aug-12	39	500	495	7.47	1.2E+02	#N/A	1.6E+00	1.3E+01	1.6E+01	9.9E-02	6.4E-02	1.5E-01	2.5E+01	2.9E-02	9.9E-04	1.5E-04	7.2E-03	9.9E-06	5.0E-06	1.2E-03	1.5E-06	8.3E+00	2.5E-04	4.0E-05	6.9E-04
4-Sep-12	40	500	490	7.44	9.9E+01																				
11-Sep-12	41	500	460	7.49	1.4E+02	#N/A	1.3E+00	1.4E+01	1.6E+01	9.2E-02	8.7E-02	1.4E-01	2.7E+01	1.7E-02	1.1E-03	2.8E-04	6.9E-03	9.2E-06	4.6E-06	1.4E-03	1.4E-06	9.1E+00	2.3E-04	2.8E-05	7.8E-04
18-Sep-12	42	500	505	7.60	1.3E+02																				
25-Sep-12	43	500	450	7.46	1.2E+02	#N/A	1.7E+00	1.5E+01	1.4E+01	9.0E-02	6.3E-02	1.4E-01	2.3E+01	2.2E-02	1.1E-03	1.6E-03	7.2E-03	9.0E-06	4.5E-06	1.0E-03	6.3E-06	7.8E+00	2.3E-04	8.0E-05	1.1E-03
2-Oct-12	44	500	460	7.41	1.2E+02																				
9-Oct-12	45	500	480	7.36	8.6E+01	#N/A	1.9E+00	1.3E+01	9.6E+00	9.6E-02	5.3E-02	1.4E-01	1.8E+01	2.5E-02	8.2E-04	1.9E-04	6.0E-03	9.6E-06	4.8E-06	9.1E-04	1.4E-06	6.1E+00	2.4E-04	4.7E-05	7.7E-04
16-Oct-12	46	500	480	7.45	1.1E+02																				
23-Oct-12	47	500	495	7.61	1.4E+02																				
30-Oct-12	48	500	480	7.49	1.4E+02																				
6-Nov-12	49	500	455	7.59	1.1E+02	#N/A	1.2E+00	1.7E+01	1.1E+01	9.1E-02	5.5E-02	1.4E-01	2.6E+01	1.2E-02	1.2E-03	4.1E-04	7.3E-03	9.1E-06	4.6E-06	1.3E-03	1.2E-05	8.7E+00	2.3E-04	4.3E-05	1.2E-03
13-Nov-12	50	500	460	7.50	1.1E+02																				
20-Nov-12	51	500	485	7.62	9.9E+01																				
27-Nov-12	52	500	500	7.40	1.2E+02																				
4-Dec-12	53	500	445	7.52	8.2E+01	#N/A	9.4E-01	9.9E+00	8.9E+00	8.9E-02	2.7E-02	1.3E-01	1.6E+01	1.8E-02	6.2E-04	2.2E-04	4.6E-03	8.9E-06	4.5E-06	7.1E-04	1.4E-05	5.6E+00	2.2E-04	3.9E-05	6.2E-04
11-Dec-12	54	500	470	7.41	8.5E+01																				
18-Dec-12	55	500	460	7.49	8.4E+01																				
25-Dec-12	56	500	445	7.43	9.0E+01																				
1-Jan-13	57	500	480	7.58	9.7E+01	#N/A	2.0E+00	1.4E+01	1.2E+01	9.6E-02	4.8E-02	1.4E-01	2.0E+01	1.6E-02	1.1E-03	7.2E-04	6.7E-03	9.6E-06	4.8E-06	7.2E-04	1.4E-06	6.8E+00	2.4E-04	1.1E-05	3.4E-04
8-Jan-13	58	500	465	7.51	8.5E+01																				
15-Jan-13	59	500	465	7.49	8.5E+01																				

HC4

Sample = 08-294

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/kg	mgCaCO3/kg	mgCaCO3/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
22-Jan-13	60	500	470	7.62	8.3E+01																				
29-Jan-13	61	500	465	7.49	7.8E+01	#N/A	1.2E+00	1.0E+01	1.0E+01	9.3E-02	2.8E-02	1.4E-01	1.8E+01	2.1E-02	5.1E-04	1.9E-04	4.7E-03	9.3E-06	4.7E-06	6.5E-04	1.6E-05	6.3E+00	2.3E-04	9.3E-07	4.7E-04
5-Feb-13	62	500	480	7.63	9.7E+01																				
12-Feb-13	63	500	445	7.50	9.0E+01																				
19-Feb-13	64	500	485	7.56	8.8E+01																				
26-Feb-13	65	500	440	7.50	9.4E+01	#N/A	1.5E+00	1.1E+01	8.8E+00	8.8E-02	2.6E-02	1.3E-01	1.6E+01	1.2E-02	4.8E-04	2.6E-04	4.9E-03	8.8E-06	4.4E-06	6.6E-04	1.7E-05	5.5E+00	2.2E-04	1.2E-04	4.0E-04
5-Mar-13	66	500	450	7.61	9.4E+01																				
12-Mar-13	67	500	445	7.60	9.6E+01																				
19-Mar-13	68	500	470	7.86	8.6E+01																				
26-Mar-13	69	500	450	7.55	8.7E+01	#N/A	2.0E+00	9.5E+00	9.5E+00	9.0E-02	2.7E-02	1.4E-01	1.7E+01	1.1E-02	4.5E-04	3.2E-04	4.5E-03	9.0E-06	4.5E-06	7.7E-04	1.4E-05	6.0E+00	2.3E-04	1.5E-04	3.2E-04
2-Apr-13	70	500	455	7.56	8.0E+01																				
9-Apr-13	71	500	445	7.52	8.5E+01																				
16-Apr-13	72	500	450	7.52	8.0E+01																				
23-Apr-13	73	500	465	7.50	1.1E+02	#N/A	2.3E+00	1.2E+01	1.4E+01	9.3E-02	2.8E-02	1.4E-01	2.2E+01	1.6E-02	7.4E-04	1.9E-04	6.6E-03	9.3E-06	4.7E-06	1.0E-03	1.4E-06	7.3E+00	2.3E-04	9.8E-06	7.0E-04
30-Apr-13	74	500	450	7.64	9.2E+01																				
7-May-13	75	500	435	7.51	9.5E+01																				
14-May-13	76	500	465	7.60	1.1E+02																				
21-May-13	77	500	445	7.62	1.1E+02	#N/A	1.8E+00	1.4E+01	1.2E+01	8.9E-02	2.7E-02	1.3E-01	2.1E+01	8.7E-03	9.3E-04	1.8E-04	5.6E-03	8.9E-06	4.5E-06	9.3E-04	1.3E-06	7.2E+00	2.2E-04	7.1E-06	4.5E-04
28-May-13	78	500	460	7.71	9.4E+01		1.9E+00	1.2E+01	1.2E+01	9.2E-02	2.8E-02	1.4E-01	2.1E+01	1.4E-02	7.8E-04	1.4E-04	5.4E-03	9.2E-06	4.6E-06	1.1E-03	2.3E-06	7.1E+00	2.3E-04	6.0E-06	4.1E-04
4-Jun-13	79	500	440	7.57	9.2E+01		1.9E+00	1.4E+01	6.6E+00	8.8E-02	2.6E-02	1.3E-01	1.8E+01	8.1E-03	5.3E-04	8.8E-05	5.4E-03	8.8E-06	4.4E-06	2.3E-03	1.3E-06	6.3E+00	2.2E-04	2.1E-05	7.0E-04
11-Jun-13	80	500	490	7.63	6.9E+01		3.4E+00	1.5E+01	3.4E+00	9.8E-02	2.9E-02	1.5E-01	1.6E+01	6.3E-03	4.4E-04	9.8E-05	4.6E-03	9.8E-06	4.9E-06	1.9E-03	1.5E-06	5.4E+00	2.5E-04	5.9E-06	2.5E-04
18-Jun-13	81	500	485	7.46	6.8E+01	#N/A	2.2E+00	1.4E+01	3.9E+00	9.7E-02	2.9E-02	1.5E-01	1.6E+01	6.9E-03	5.3E-04	9.7E-05	4.2E-03	9.7E-06	4.9E-06	1.6E-03	3.4E-06	5.3E+00	2.4E-04	3.0E-05	3.4E-04
25-Jun-13	82	500	475	7.50	4.9E+01																				
2-Jul-13	83	500	475	7.44	8.4E+01		3.6E+00	2.1E+01	3.8E+00	9.5E-02	2.9E-02	1.4E-01	1.8E+01	7.0E-03	7.1E-04	9.5E-05	5.5E-03	9.5E-06	4.8E-06	4.3E-04	1.4E-06	6.1E+00	2.4E-04	9.5E-07	6.2E-04
9-Jul-13	84	500	475	7.61	6.2E+01																				
16-Jul-13	85	500	505	7.56	6.4E+01	#N/A	1.7E+00	1.4E+01	2.5E+00	1.0E-01	3.0E-02	1.5E-01	1.6E+01	4.8E-03	5.1E-04	1.5E-04	4.8E-03	1.0E-05	5.1E-06	1.3E-03	1.5E-06	5.4E+00	2.5E-04	1.1E-05	4.0E-04
23-Jul-13	86	500	490	7.57	5.8E+01																				
30-Jul-13	87	500	485	7.41	4.9E+01		2.1E+00	1.1E+01	2.9E+00	9.7E-02	2.9E-02	1.5E-01	1.1E+01	4.9E-03	3.4E-04	9.7E-05	3.7E-03	9.7E-06	4.9E-06	1.5E-03	1.5E-06	3.9E+00	2.4E-04	9.7E-07	6.8E-04
6-Aug-13	88	500	515	7.55	5.8E+01																				
13-Aug-13	89	500	485	7.52	6.0E+01	#N/A	1.5E+00	1.3E+01	2.4E+00	9.7E-02	2.9E-02	1.5E-01	1.4E+01	9.5E-03	4.4E-04	9.7E-05	5.1E-03	9.7E-06	4.9E-06	1.2E-03	4.9E-06	4.8E+00	2.4E-04	1.7E-05	4.4E-04
20-Aug-13	90	500	485	7.44	5.5E+01																				
27-Aug-13	91	500	520	7.62	5.5E+01																				
3-Sep-13	92	500	480	7.57	5.8E+01																				
10-Sep-13	93	500	480	7.50	6.2E+01	#N/A	1.7E+00	1.4E+01	1.9E+00	9.6E-02	2.9E-02	1.4E-01	1.5E+01	6.8E-03	4.3E-04	9.6E-05	5.1E-03	9.6E-06	4.8E-06	1.7E-03	1.9E-06	5.2E+00	2.4E-04	2.0E-05	4.8E-04
17-Sep-13	94	500	490	7.63	6.3E+01																				
24-Sep-13	95	500	495	7.60	6.6E+01																				
1-Oct-13	96	500	470	7.69	6.6E+01																				
8-Oct-13	97	500	470	7.61	5.8E+01	#N/A	8.0E-01	1.3E+01	1.9E+00	9.4E-02	2.8E-02	1.4E-01	1.4E+01	5.9E-03	3.8E-04	9.4E-05	4.9E-03	9.4E-06	4.7E-06	2.4E-03	1.4E-06	4.7E+00	2.4E-04	1.6E-05	3.3E-04
15-Oct-13	98	500	485	7.55	6.9E+01																				
22-Oct-13	99	500	480	7.58	7.0E+01																				
29-Oct-13	100	500	470	7.67	6.1E+01																				
5-Nov-13	101	500	485	7.61	5.5E+01	#N/A	8.4E-01	1.1E+01	1.9E+00	9.7E-02	2.9E-02	1.5E-01	1.3E+01	3.5E-03	3.4E-04	9.7E-05	5.0E-03	9.7E-06	4.9E-06	9.2E-04	1.5E-06	4.4E+00	2.4E-04	8.7E-06	4.4E-04
12-Nov-13	102	500	480	7.58	5.0E+01																				
19-Nov-13	103	500	465	7.47	5.0E+01																				
26-Nov-13	104	500	470	7.47	5.0E+01																				
3-Dec-13	105	500	475	7.63	5.0E+01	#N/A	2.9E-01	1.2E+01	1.9E+00	9.5E-02	2.9E-02	1.4E-01	1.2E+01	4.7E-03	3.3E-04	9.5E-05	4.8E-03	9.5E-06	4.8E-06	6.2E-04	2.4E-06	4.1E+00	2.4E-04	1.0E-05	2.9E-04
10-Dec-13	106	500	475	7.83	5.7E+01																				
17-Dec-13	107	500	475	7.72	5.9E+01																				
24-Dec-13	108	500	485	7.77	5.6E+01																				
31-Dec-13	109	500	490	7.73	5.3E+01	#N/A	7.4E-01	1.1E+01	1.5E+00	9.8E-02	2.9E-02	1.5E-01	1.2E+01	4.6E-03	2.9E-04	9.8E-05	5.6E-03	9.8E-06	4.9E-06	6.9E-04	1.5E-06	4.2E+00	2.5E-04	9.8E-06	4.9E-04
7-Jan-14	110	500	490	7.66	5.7E+01																				
14-Jan-14	111	500	485	7.76	6.4E+01																				
21-Jan-14	112	500	485	7.64	7.0E+01																				
28-Jan-14	113	500	485	7.78	7.3E+01	#N/A	8.6E-01	1.7E+01	1.5E+00	9.7E-02	2.9E-02	1.5E-01	1.8E+01	5.0E-03	4.9E-04	9.7E-05	7.3E-03	9.7E-06	4.9E-06	1.0E-03	1.5E-06	6.1E+00	2.4E-04	9.7E-07	2.4E-04
4-Feb-14	114	500	485	7.82	6.8E+01																				
11-Feb-14	115	500	465	7.81	6.7E+01																				
18-Feb-14	116	500	485	7.73	5.7E+01																				
25-Feb-14	117	500	485	7.80	5.5E+01	#N/A	1.4E+00	1.5E+01	2.4E+00	9.7E-02	2.9E-02	1.5E-01	1.3E+01	4.6E-03	2.9E-04	9.7E-05	6.0E-03	9.7E-06	4.9E-06	7.3E-04	1.5E-06	4.6E+00	2.4E-04	5.8E-06	3.4E-04

HC4

Sample = 08-294

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
	No.																							
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
29-Nov-11	0	1.2E-03	3.0E-05	6.0E-04	1.5E+00	1.9E-03	6.0E-06	1.8E-02	5.1E-04	2.7E-03	2.6E+00	7.1E-03	9.2E-01	3.0E-06	2.1E+01	2.1E-01	2.4E+01	1.2E-05	5.7E-05	1.8E-04	2.1E-02	5.6E-04	9.0E-04	1.2E-04
6-Dec-11	1	1.5E-03	9.7E-06	9.7E-04	1.7E+00	1.3E-03	9.7E-06	4.1E-02	3.4E-04	4.4E-03	4.3E+00	7.4E-03	8.2E-01	4.9E-06	3.2E+01	2.4E-01	3.0E+01	9.7E-06	9.7E-06	1.5E-04	6.5E-02	8.6E-04	9.7E-04	8.7E-05
13-Dec-11	2	1.3E-03	4.5E-04	4.5E-04	6.1E-01	1.2E-03	8.9E-06	1.7E-02	2.7E-04	4.0E-03	1.9E+00	1.9E-03	4.3E-01	4.5E-06	1.0E+01	9.7E-02	8.9E+00	8.9E-06	5.3E-05	8.9E-05	2.5E-02	4.9E-04	1.3E-03	3.6E-05
20-Dec-11	3	1.5E-03	9.9E-06	5.0E-04	6.2E-01	1.3E-03	5.0E-06	1.6E-02	2.0E-04	4.5E-03	1.9E+00	1.4E-03	6.2E-01	5.0E-06	9.5E+00	8.9E-02	7.5E+00	9.9E-06	1.5E-05	9.9E-05	3.7E-02	6.6E-04	9.9E-04	2.5E-05
27-Dec-11	4																							
3-Jan-12	5	1.4E-03	9.1E-06	4.6E-04	8.9E-01	1.1E-03	4.6E-06	8.3E-03	4.6E-04	4.1E-03	2.6E+00	8.9E-04	6.4E-01	4.6E-06	1.2E+01	1.3E-01	1.2E+01	9.1E-06	2.3E-05	1.4E-04	2.6E-02	7.6E-04	9.1E-04	1.8E-05
10-Jan-12	6																							
17-Jan-12	7	1.3E-03	8.7E-06	4.4E-04	1.2E+00	8.3E-04	4.4E-06	3.9E-03	8.7E-05	3.9E-03	3.0E+00	7.0E-04	6.2E-01	4.4E-06	6.6E+00	1.8E-01	1.2E+01	8.7E-06	8.7E-06	1.7E-04	2.7E-02	5.6E-04	4.4E-04	2.2E-05
24-Jan-12	8																							
31-Jan-12	9	2.7E-03	9.1E-06	4.6E-04	1.3E+00	1.5E-03	4.6E-06	3.5E-03	4.6E-05	4.1E-03	2.9E+00	7.9E-04	5.4E-01	4.6E-06	3.6E+00	1.8E-01	1.1E+01	9.1E-06	3.2E-05	1.4E-04	2.1E-02	5.4E-04	9.1E-04	4.6E-06
7-Feb-12	10																							
14-Feb-12	11	1.4E-03	9.1E-06	4.6E-04	1.1E+00	1.3E-03	4.6E-06	2.4E-03	3.2E-04	4.1E-03	2.0E+00	8.6E-04	4.0E-01	4.6E-06	1.4E+00	1.6E-01	7.7E+00	9.1E-06	1.4E-05	9.1E-05	1.8E-02	3.1E-04	4.6E-04	2.7E-05
21-Feb-12	12																							
28-Feb-12	13	1.4E-03	9.4E-06	4.7E-04	1.0E+00	1.7E-03	4.7E-06	2.4E-03	4.7E-05	4.2E-03	1.8E+00	5.1E-04	3.6E-01	4.7E-06	8.2E-01	1.4E-01	6.7E+00	9.4E-06	2.8E-05	9.4E-05	1.4E-02	3.1E-04	9.4E-04	4.7E-06
6-Mar-12	14																							
13-Mar-12	15	1.9E-03	9.3E-06	4.7E-04	8.6E-01	1.2E-03	4.7E-06	2.0E-03	4.7E-05	4.2E-03	1.5E+00	4.0E-04	3.3E-01	4.7E-06	5.1E-01	1.2E-01	5.5E+00	9.3E-06	6.5E-05	9.3E-05	1.1E-02	2.1E-04	4.7E-04	9.3E-06
20-Mar-12	16																							
27-Mar-12	17	1.4E-03	1.9E-05	4.8E-04	8.7E-01	1.3E-03	4.8E-06	2.0E-03	9.5E-05	4.3E-03	1.5E+00	2.9E-04	3.3E-01	4.8E-06	3.8E-01	1.2E-01	5.8E+00	9.5E-06	4.8E-06	4.8E-05	1.0E-02	2.7E-04	4.8E-04	4.8E-06
3-Apr-12	18																							
10-Apr-12	19	1.4E-03	9.6E-06	4.8E-04	9.1E-01	9.6E-04	9.6E-06	2.4E-03	4.8E-05	4.3E-03	1.5E+00	5.2E-04	3.5E-01	4.8E-06	3.3E-01	1.2E-01	6.0E+00	9.6E-06	7.7E-05	4.8E-05	8.9E-03	3.0E-04	9.6E-04	4.8E-06
17-Apr-12	20																							
24-Apr-12	21	1.4E-03	9.5E-06	4.8E-04	9.6E-01	1.1E-03	1.4E-05	2.5E-03	1.4E-04	4.3E-03	1.7E+00	1.7E-04	3.9E-01	4.8E-06	2.8E-01	1.2E-01	5.5E+00	9.5E-06	2.4E-05	1.4E-04	1.2E-02	3.1E-04	9.5E-04	4.8E-06
1-May-12	22																							
8-May-12	23	1.4E-03	6.7E-05	4.8E-04	1.2E+00	9.0E-04	4.8E-06	5.3E-03	7.1E-04	4.3E-03	2.1E+00	4.3E-04	4.3E-01	4.8E-06	3.1E-01	1.5E-01	7.2E+00	9.5E-06	8.1E-05	4.8E-05	1.4E-02	2.7E-04	3.3E-03	4.8E-06
15-May-12	24																							
22-May-12	25	3.0E-03	8.6E-06	4.3E-04	8.1E-01	9.5E-04	8.6E-06	2.6E-03	8.6E-05	3.9E-03	1.3E+00	3.5E-04	3.2E-01	4.3E-06	1.7E-01	1.1E-01	5.1E+00	8.6E-06	4.3E-05	2.6E-04	8.9E-03	3.1E-04	4.3E-04	4.3E-06
29-May-12	26																							
5-Jun-12	27	1.9E-03	9.3E-06	4.7E-04	1.1E+00	1.2E-03	4.7E-06	3.1E-03	4.7E-05	4.2E-03	1.7E+00	4.9E-04	4.1E-01	4.7E-06	1.9E-01	1.4E-01	6.3E+00	9.3E-06	1.6E-04	9.3E-05	1.1E-02	4.0E-04	9.3E-04	4.7E-06
12-Jun-12	28																							
19-Jun-12	29	1.4E-03	9.2E-06	4.6E-04	1.0E+00	9.2E-04	4.6E-06	2.7E-03	5.5E-04	4.1E-03	1.6E+00	4.0E-04	4.3E-01	4.6E-06	1.5E-01	1.2E-01	4.9E+00	9.2E-06	1.2E-04	4.6E-05	1.1E-02	3.4E-04	9.2E-04	4.6E-06
26-Jun-12	30																							
3-Jul-12	31	1.4E-03	9.1E-06	4.6E-04	9.7E-01	1.2E-03	4.6E-06	2.3E-03	4.6E-05	4.1E-03	1.6E+00	4.6E-04	4.3E-01	4.6E-06	1.2E-01	1.1E-01	4.6E+00	9.1E-06	1.0E-04	9.1E-05	9.2E-03	3.7E-04	4.6E-04	9.1E-06
10-Jul-12	32																							
17-Jul-12	33	7.7E-03	4.1E-05	4.5E-04	1.1E+00	9.5E-04	9.0E-06	3.0E-03	4.5E-05	4.1E-03	1.8E+00	6.5E-04	5.2E-01	4.5E-06	1.9E-01	1.3E-01	5.2E+00	9.0E-06	2.5E-04	9.0E-05	9.9E-03	3.5E-04	9.0E-04	4.5E-06
24-Jul-12	34																							
31-Jul-12	35	1.4E-03	3.5E-04	4.6E-04	8.9E-01	9.1E-04	4.6E-06	1.6E-03	4.6E-05	4.1E-03	1.2E+00	4.1E-04	3.9E-01	4.6E-06	9.1E-02	1.1E-01	4.2E+00	9.1E-06	5.9E-05	4.6E-05	6.4E-03	3.0E-04	4.6E-03	4.6E-06
7-Aug-12	36																							
14-Aug-12	37	1.4E-03	9.0E-06	4.5E-04	9.5E-01	1.4E-03	4.5E-06	1.8E-03	1.8E-04	4.1E-03	1.2E+00	4.7E-04	3.4E-01	4.5E-06	9.0E-02	1.2E-01	5.9E+00	9.0E-06	2.7E-04	2.3E-04	5.6E-03	4.3E-04	9.0E-04	4.5E-06
21-Aug-12	38																							
28-Aug-12	39	1.5E-03	9.9E-06	5.0E-04	9.7E-01	1.3E-03	5.0E-06	1.7E-03	3.5E-04	4.5E-03	1.1E+00	5.3E-04	3.3E-01	5.0E-06	6.9E-02	1.1E-01	5.3E+00	9.9E-06	1.2E-04	9.9E-05	8.5E-03	2.7E-04	9.9E-04	5.0E-06
4-Sep-12	40																							
11-Sep-12	41	1.4E-03	9.2E-06	4.6E-04	1.1E+00	8.7E-04	4.6E-06	2.1E-03	1.4E-04	4.1E-03	1.3E+00	5.6E-04	3.8E-01	4.6E-06	9.7E-02	1.2E-01	6.1E+00	9.2E-06	7.8E-05	4.1E-04	7.7E-03	3.7E-04	4.6E-04	9.2E-06
18-Sep-12	42																							
25-Sep-12	43	1.8E-03	9.0E-06	4.5E-04	9.0E-01	8.6E-04	4.5E-06	1.8E-03	3.2E-04	4.1E-03	1.0E+00	4.2E-04	3.1E-01	4.5E-06	3.0E-01	1.1E-01	4.7E+00	9.0E-06	8.1E-05	4.5E-05	8.4E-03	2.5E-04	9.0E-04	4.5E-06
2-Oct-12	44																							
9-Oct-12	45	5.8E-03	9.6E-06	4.8E-04	6.8E-01	1.4E-03	4.8E-06	1.1E-03	4.8E-05	4.3E-03	8.1E-01	2.8E-04	2.8E-01	4.8E-06	4.8E-02	7.9E-02	3.2E+00	9.6E-06	8.6E-05	9.6E-05	6.0E-03	2.1E-04	9.6E-04	4.8E-06
16-Oct-12	46																							
23-Oct-12	47																							
30-Oct-12	48																							
6-Nov-12	49	1.4E-03	3.6E-05	4.6E-04	1.0E+00	8.6E-04	4.6E-06	1.8E-03	1.4E-04	4.1E-03	1.0E+00	4.4E-04	3.8E-01	4.6E-06	1.0E-01	1.2E-01	4.4E+00	9.1E-06	3.4E-04	4.6E-05	7.7E-03	2.4E-04	1.8E-03	4.6E-06
13-Nov-12	50																							
20-Nov-12	51																							
27-Nov-12	52																							
4-Dec-12	53	1.8E-03	8.5E-05	4.5E-04	5.8E-01	7.6E-04	4.5E-06	1.4E-03	4.5E-05	4.0E-03	5.5E-01	4.0E-05	1.7E-01	4.5E-06	4.5E-02	7.0E-02	3.3E+00	8.9E-06	4.5E-05	8.9E-05	5.0E-03	1.6E-04	8.9E-04	4.5E-06
11-Dec-12	54																							
18-Dec-12	55																							
25-Dec-12	56																							
1-Jan-13	57	1.4E-03	9.6E-06	4.8E-04	7.5E-01	8.6E-04	4.8E-06	2.3E-03	4.8E-05	4.3E-03	6.4E-01	2.8E-04	2.8E-01	4.8E-06	4.3E-02	8.6E-02	3.8E+00	9.6E-06	1.1E-04	9.6E-05	7.0E-03	1.7E-04	9.6E-04	4.8E-06
8-Jan-13	58																							
15-Jan-13	59																							

HC4

Sample = 08-294

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
	No.																							
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
22-Jan-13	60																							
29-Jan-13	61	1.9E-03	9.3E-06	4.7E-04	6.4E-01	1.3E-03	4.7E-06	1.3E-03	1.4E-04	1.2E-02	4.7E-01	2.5E-04	2.2E-01	4.7E-06	5.1E-02	7.6E-02	3.7E+00	9.3E-06	1.3E-04	2.3E-04	3.8E-03	1.9E-04	9.3E-04	4.7E-06
5-Feb-13	62																							
12-Feb-13	63																							
19-Feb-13	64																							
26-Feb-13	65	1.3E-03	1.3E-05	4.4E-04	5.9E-01	7.0E-04	4.4E-06	1.3E-03	8.8E-05	6.2E-03	4.8E-01	2.8E-04	1.8E-01	4.4E-06	4.0E-02	6.4E-02	3.3E+00	8.8E-06	3.1E-05	4.4E-05	3.5E-03	9.2E-05	4.4E-04	4.4E-06
5-Mar-13	66																							
12-Mar-13	67																							
19-Mar-13	68																							
26-Mar-13	69	1.4E-03	2.3E-04	4.5E-04	5.9E-01	7.2E-04	4.5E-06	1.2E-03	9.0E-05	4.1E-03	4.0E-01	2.0E-04	1.9E-01	4.5E-06	5.0E-02	6.7E-02	3.5E+00	9.0E-06	2.3E-05	4.5E-05	3.1E-03	8.6E-05	2.3E-03	4.5E-06
2-Apr-13	70																							
9-Apr-13	71																							
16-Apr-13	72																							
23-Apr-13	73	3.3E-03	5.1E-05	4.7E-04	8.0E-01	7.9E-04	4.7E-06	1.4E-03	4.7E-05	4.2E-03	5.9E-01	2.4E-04	3.0E-01	4.7E-06	4.2E-02	8.9E-02	4.6E+00	9.3E-06	3.3E-05	9.3E-05	4.8E-03	9.3E-05	4.7E-04	4.7E-06
30-Apr-13	74																							
7-May-13	75																							
14-May-13	76																							
21-May-13	77	1.3E-03	8.9E-06	4.5E-04	8.0E-01	6.2E-04	4.5E-06	1.4E-03	4.5E-05	4.0E-03	6.9E-01	2.9E-04	3.2E-01	4.5E-06	5.3E-02	8.9E-02	3.7E+00	8.9E-06	4.9E-05	4.5E-05	5.1E-03	1.2E-04	4.5E-04	4.5E-06
28-May-13	78	1.4E-03	9.2E-06	4.6E-04	7.5E-01	6.9E-04	4.6E-06	1.1E-03	4.6E-05	4.1E-03	6.4E-01	2.9E-04	2.6E-01	4.6E-06	5.5E-02	8.6E-02	3.4E+00	9.2E-06	3.7E-05	1.4E-04	4.4E-03	1.2E-04	4.6E-04	2.8E-05
4-Jun-13	79	3.1E-03	8.8E-06	4.4E-04	6.6E-01	8.8E-04	4.4E-06	7.9E-04	7.0E-04	4.0E-03	4.8E-01	1.7E-04	2.1E-01	4.4E-06	3.5E-02	7.4E-02	2.0E+00	8.8E-06	1.2E-03	4.4E-05	7.4E-03	8.4E-05	8.8E-04	4.4E-06
11-Jun-13	80	1.5E-03	9.8E-06	4.9E-04	5.5E-01	5.9E-04	4.9E-06	6.8E-04	4.9E-05	4.4E-03	3.7E-01	9.8E-05	1.7E-01	4.9E-06	2.9E-02	6.1E-02	1.4E+00	9.8E-06	1.4E-03	4.9E-05	6.8E-03	3.9E-05	4.9E-04	4.9E-06
18-Jun-13	81	1.5E-03	9.7E-06	4.9E-04	5.7E-01	9.7E-04	4.9E-06	4.3E-04	4.9E-05	4.4E-03	3.8E-01	1.0E-04	1.8E-01	4.9E-06	4.4E-02	6.2E-02	1.3E+00	9.7E-06	9.4E-04	4.9E-05	6.5E-03	4.4E-05	4.9E-04	4.9E-06
25-Jun-13	82																							
2-Jul-13	83	1.4E-03	9.5E-06	4.8E-04	6.9E-01	6.2E-04	9.5E-06	6.9E-04	4.8E-05	4.3E-03	5.1E-01	1.4E-04	2.3E-01	4.8E-06	2.9E-02	7.4E-02	1.1E+00	9.5E-06	7.6E-04	4.8E-05	7.6E-03	1.0E-04	4.8E-04	4.8E-06
9-Jul-13	84																							
16-Jul-13	85	1.5E-03	1.0E-05	5.1E-04	5.5E-01	1.0E-03	1.0E-05	2.4E-04	5.1E-05	4.5E-03	3.2E-01	1.2E-04	1.6E-01	5.1E-06	3.0E-02	5.8E-02	8.3E-01	1.0E-05	8.3E-04	5.1E-05	5.4E-03	4.5E-05	5.1E-04	5.1E-06
23-Jul-13	86																							
30-Jul-13	87	1.5E-03	1.5E-05	4.9E-04	3.9E-01	9.7E-04	4.9E-06	2.1E-04	4.9E-05	4.4E-03	2.4E-01	7.3E-05	1.2E-01	4.9E-06	1.5E-02	4.4E-02	6.5E-01	9.7E-06	6.5E-04	4.9E-05	4.3E-03	3.4E-05	4.9E-04	4.9E-06
6-Aug-13	88																							
13-Aug-13	89	3.4E-03	1.5E-05	4.9E-04	4.8E-01	1.3E-03	4.9E-06	2.2E-04	9.7E-05	5.8E-03	2.8E-01	8.7E-05	1.6E-01	4.9E-06	2.4E-02	5.4E-02	8.2E-01	9.7E-06	8.0E-04	4.9E-05	4.7E-03	2.9E-05	9.7E-04	4.9E-06
20-Aug-13	90																							
27-Aug-13	91																							
3-Sep-13	92																							
10-Sep-13	93	2.9E-03	9.6E-06	4.8E-04	5.3E-01	1.2E-03	4.8E-06	2.3E-04	4.8E-05	4.3E-03	3.3E-01	1.1E-04	1.8E-01	4.8E-06	1.4E-02	5.7E-02	9.6E-01	9.6E-06	1.2E-03	4.8E-05	5.1E-03	5.3E-05	4.8E-04	4.8E-06
17-Sep-13	94																							
24-Sep-13	95																							
1-Oct-13	96																							
8-Oct-13	97	1.4E-03	9.4E-06	4.7E-04	4.4E-01	1.2E-03	4.7E-06	1.6E-04	9.4E-05	4.2E-03	2.7E-01	7.5E-05	1.5E-01	4.7E-06	1.4E-02	4.8E-02	6.9E-01	9.4E-06	5.7E-04	4.7E-05	4.1E-03	3.8E-05	4.7E-04	4.7E-06
15-Oct-13	98																							
22-Oct-13	99																							
29-Oct-13	100																							
5-Nov-13	101	1.5E-03	9.7E-06	4.9E-04	4.2E-01	8.7E-04	4.9E-06	1.5E-04	4.9E-05	4.4E-03	2.5E-01	8.2E-05	1.3E-01	4.9E-06	9.7E-03	4.8E-02	6.9E-01	9.7E-06	3.1E-04	4.9E-05	4.0E-03	3.4E-05	4.9E-04	4.9E-06
12-Nov-13	102																							
19-Nov-13	103																							
26-Nov-13	104																							
3-Dec-13	105	1.4E-03	9.5E-06	4.8E-04	3.8E-01	8.1E-04	4.8E-06	1.8E-04	4.8E-05	4.3E-03	2.3E-01	7.1E-05	1.0E-01	4.8E-06	4.8E-03	4.4E-02	6.5E-01	9.5E-06	2.5E-04	4.8E-05	3.8E-03	5.2E-05	4.8E-04	4.8E-06
10-Dec-13	106																							
17-Dec-13	107																							
24-Dec-13	108																							
31-Dec-13	109	2.0E-03	9.8E-06	4.9E-04	4.0E-01	8.3E-04	4.9E-06	1.9E-04	9.8E-05	4.4E-03	2.3E-01	8.8E-05	1.3E-01	4.9E-06	1.5E-02	4.6E-02	6.4E-01	9.8E-06	7.4E-04	4.9E-05	3.4E-03	3.9E-05	4.9E-04	4.9E-06
7-Jan-14	110																							
14-Jan-14	111																							
21-Jan-14	112																							
28-Jan-14	113	1.5E-03	9.7E-06	4.9E-04	5.9E-01	1.0E-03	4.9E-06	1.8E-04	9.7E-05	4.4E-03	3.3E-01	8.7E-05	1.7E-01	4.9E-06	1.5E-02	6.7E-02	7.9E-01	9.7E-06	5.8E-04	4.9E-05	4.2E-03	2.4E-05	4.9E-04	4.9E-06
4-Feb-14	114																							
11-Feb-14	115																							
18-Feb-14	116																							
25-Feb-14	117	1.5E-03	9.7E-06	4.9E-04	4.1E-01	6.3E-04	4.9E-06	1.3E-04	4.9E-05	4.4E-03	2.4E-01	7.3E-05	1.3E-01	4.9E-06	9.7E-03	4.8E-02	5.5E-01	9.7E-06	3.8E-04	4.9E-05	3.1E-03	2.9E-05	4.9E-04	4.9E-06

HC5

Sample = 08-277

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/L	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
29-Nov-11	0	500	375	7.40	1.3E+03	#N/A	8.3E+00	4.1E+01	5.7E+02	6.2E+00	1.2E+00	3.0E-01	5.8E+02	2.3E-02	7.0E-04	1.6E-03	3.9E-02	2.0E-05	1.0E-05	9.1E-03	1.4E-04	1.9E+02	8.0E-04	1.5E-03	1.6E-02
6-Dec-11	1	500	450	7.55	7.4E+02	#N/A	4.5E+00	2.9E+01	3.0E+02	3.9E+00	8.8E-01	3.0E-01	3.2E+02	3.7E-02	5.0E-04	7.0E-04	1.6E-02	2.0E-05	1.0E-05	6.0E-03	1.3E-04	9.9E+01	5.0E-04	8.7E-04	1.4E-02
13-Dec-11	2	500	460	7.48	7.1E+02	#N/A	3.7E+00	2.6E+01	3.1E+02	2.1E+00	1.0E+00	3.0E-01	3.3E+02	3.7E-02	4.0E-04	9.0E-04	2.4E-02	2.0E-05	1.0E-05	5.3E-03	4.3E-05	1.0E+02	1.0E-03	5.1E-04	9.3E-03
20-Dec-11	3	500	495	7.47	6.2E+02	#N/A	5.1E+00	2.7E+01	2.7E+02	8.0E-01	8.3E-01	3.0E-01	2.8E+02	5.4E-02	6.0E-04	7.0E-04	1.5E-02	2.0E-05	1.0E-05	5.1E-03	1.4E-05	8.8E+01	5.0E-04	3.6E-04	6.6E-03
27-Dec-11	4	500	450	7.79	4.7E+02																				
3-Jan-12	5	500	450	7.48	4.2E+02	#N/A	4.9E+00	2.2E+01	1.8E+02	3.0E-01	6.1E-01	3.0E-01	1.8E+02	8.5E-02	5.0E-04	4.0E-04	1.1E-02	2.0E-05	1.0E-05	3.7E-03	1.3E-05	5.6E+01	5.0E-04	2.3E-04	3.4E-03
10-Jan-12	6	500	435	7.38	4.4E+02																				
17-Jan-12	7	500	445	7.43	4.0E+02	#N/A	3.2E+00	2.4E+01	1.7E+02	2.0E-01	6.4E-01	3.0E-01	1.8E+02	4.9E-02	6.0E-04	4.0E-04	1.1E-02	2.0E-05	1.0E-05	3.8E-03	1.5E-05	5.8E+01	5.0E-04	1.3E-04	2.7E-03
24-Jan-12	8	500	445	7.58	3.6E+02																				
31-Jan-12	9	500	465	7.47	3.6E+02	#N/A	3.3E+00	2.4E+01	1.6E+02	2.0E-01	5.5E-01	3.0E-01	1.6E+02	5.5E-02	5.0E-04	4.0E-04	1.0E-02	2.0E-05	1.0E-05	3.1E-03	5.0E-06	5.2E+01	5.0E-04	1.3E-04	2.2E-03
7-Feb-12	10	500	460	7.59	3.7E+02																				
14-Feb-12	11	500	465	7.61	3.5E+02	#N/A	5.1E+00	2.5E+01	1.7E+02	2.0E-01	5.7E-01	3.0E-01	1.6E+02	4.4E-02	5.0E-04	5.0E-04	9.8E-03	2.0E-05	1.0E-05	2.7E-03	1.0E-05	5.2E+01	5.0E-04	1.1E-04	1.7E-03
21-Feb-12	12	500	470	7.53	3.2E+02																				
28-Feb-12	13	500	475	7.45	2.9E+02	#N/A	4.1E+00	2.4E+01	1.1E+02	2.0E-01	4.7E-01	3.0E-01	1.4E+02	4.6E-02	7.0E-04	6.0E-04	8.6E-03	2.0E-05	1.0E-05	3.0E-03	1.1E-05	4.6E+01	5.0E-04	9.6E-05	1.5E-03
6-Mar-12	14	500	465	7.58	2.5E+02																				
13-Mar-12	15	500	455	7.39	2.3E+02	#N/A	3.0E+00	2.0E+01	9.1E+01	2.0E-01	4.7E-01	3.0E-01	1.0E+02	5.4E-02	6.0E-04	3.0E-04	7.7E-03	2.0E-05	1.0E-05	2.3E-03	3.0E-06	3.4E+01	5.0E-04	5.7E-05	1.2E-03
20-Mar-12	16	500	450	7.46	2.2E+02																				
27-Mar-12	17	500	435	7.41	2.1E+02	#N/A	2.9E+00	2.2E+01	7.6E+01	2.0E-01	4.7E-01	3.0E-01	9.0E+01	5.9E-02	5.0E-04	4.0E-04	7.7E-03	2.0E-05	1.0E-05	2.4E-03	1.3E-05	3.1E+01	5.0E-04	4.3E-05	1.0E-03
3-Apr-12	18	500	440	7.51	1.9E+02																				
10-Apr-12	19	500	430	7.48	1.6E+02	#N/A	2.4E+00	2.2E+01	6.0E+01	2.0E-01	4.4E-01	3.0E-01	6.8E+01	6.3E-02	5.0E-04	2.0E-04	7.0E-03	2.0E-05	1.0E-05	2.0E-03	3.0E-06	2.3E+01	5.0E-04	4.4E-05	9.0E-04
17-Apr-12	20	500	410	7.51	1.8E+02																				
24-Apr-12	21	500	450	7.53	1.5E+02	#N/A	2.4E+00	2.3E+01	4.8E+01	2.0E-01	4.2E-01	3.0E-01	6.0E+01	7.1E-02	7.0E-04	2.0E-04	8.5E-03	2.0E-05	1.0E-05	2.2E-03	3.0E-06	2.0E+01	5.0E-04	4.6E-05	1.2E-03
1-May-12	22	500	430	7.60	1.3E+02																				
8-May-12	23	500	440	7.53	1.2E+02	#N/A	2.5E+00	2.2E+01	3.5E+01	2.0E-01	3.2E-01	3.0E-01	4.9E+01	5.3E-02	5.0E-04	5.0E-04	7.6E-03	2.0E-05	1.0E-05	2.2E-03	3.0E-06	1.6E+01	5.0E-04	3.5E-05	2.0E-02
15-May-12	24	500	430	7.53	1.2E+02																				
22-May-12	25	500	405	7.52	1.4E+02	#N/A	3.3E+00	2.8E+01	3.9E+01	2.0E-01	3.6E-01	3.0E-01	5.8E+01	9.3E-02	1.0E-03	3.0E-04	9.7E-03	2.0E-05	1.0E-05	2.5E-03	3.0E-06	1.9E+01	5.0E-04	3.9E-05	1.3E-03
29-May-12	26	500	435	7.44	9.9E+01																				
5-Jun-12	27	500	450	7.44	1.0E+02	#N/A	3.1E+00	2.3E+01	2.2E+01	2.0E-01	2.9E-01	3.0E-01	4.3E+01	7.5E-02	4.0E-04	4.0E-04	7.3E-03	2.0E-05	1.0E-05	2.8E-03	3.0E-06	1.4E+01	5.0E-04	3.9E-05	8.0E-04
12-Jun-12	28	500	445	7.49	9.4E+01																				
19-Jun-12	29	500	435	7.44	8.9E+01	#N/A	2.6E+00	2.0E+01	2.2E+01	2.0E-01	2.7E-01	3.0E-01	3.6E+01	6.7E-02	4.0E-04	2.0E-04	6.2E-03	2.0E-05	1.0E-05	1.5E-03	3.0E-06	1.2E+01	5.0E-04	4.3E-05	8.0E-04
26-Jun-12	30	500	450	7.49	9.5E+01																				
3-Jul-12	31	500	450	7.65	1.0E+02	#N/A	7.1E+00	2.7E+01	2.3E+01	2.0E-01	3.1E-01	3.0E-01	4.2E+01	8.0E-02	4.0E-04	4.0E-04	7.9E-03	2.0E-05	1.0E-05	1.1E-03	3.0E-06	1.4E+01	5.0E-04	2.9E-05	9.0E-04
10-Jul-12	32	500	440	7.53	1.1E+02																				
17-Jul-12	33	500	435	7.50	9.1E+01	#N/A	2.4E+00	2.1E+01	2.0E+01	2.0E-01	2.7E-01	3.0E-01	3.7E+01	6.8E-02	4.0E-04	1.6E-03	7.1E-03	2.0E-05	1.0E-05	1.6E-03	3.0E-06	1.2E+01	5.0E-04	1.7E-04	9.0E-04
24-Jul-12	34	500	445	7.44	9.5E+01																				
31-Jul-12	35	500	435	7.51	8.5E+01	#N/A	2.0E+00	2.0E+01	1.7E+01	2.0E-01	2.7E-01	3.0E-01	3.7E+01	6.3E-02	4.0E-04	3.0E-04	6.3E-03	2.0E-05	1.0E-05	2.2E-03	2.9E-05	1.2E+01	5.0E-04	4.2E-05	1.7E-03
7-Aug-12	36	500	470	7.57	8.8E+01																				
14-Aug-12	37	500	445	7.49	9.4E+01	#N/A	2.8E+00	2.5E+01	2.1E+01	2.0E-01	2.6E-01	3.0E-01	4.0E+01	1.1E-01	7.0E-04	3.0E-03	6.9E-03	2.0E-05	1.0E-05	4.6E-03	3.0E-06	1.2E+01	5.0E-04	2.0E-06	1.8E-03
21-Aug-12	38	500	445	7.33	9.1E+01																				
28-Aug-12	39	500	500	7.46	1.0E+02	#N/A	3.5E+00	2.5E+01	2.5E+01	2.0E-01	2.9E-01	3.0E-01	4.2E+01	6.8E-02	3.0E-04	2.0E-04	7.6E-03	2.0E-05	1.0E-05	2.1E-03	7.6E-05	1.3E+01	5.0E-04	1.3E-04	1.1E-03
4-Sep-12	40	500	475	7.35	7.8E+01																				
11-Sep-12	41	500	460	7.44	8.4E+01	#N/A	2.6E+00	2.2E+01	2.0E+01	2.0E-01	3.0E-01	3.0E-01	3.8E+01	4.6E-02	3.0E-04	2.0E-04	6.1E-03	2.0E-05	1.0E-05	2.1E-03	3.0E-06	1.2E+01	5.0E-04	5.4E-05	1.1E-03
18-Sep-12	42	500	505	7.45	8.9E+01																				
25-Sep-12	43	500	445	7.42	8.2E+01	#N/A	3.2E+00	2.3E+01	1.9E+01	2.0E-01	2.4E-01	3.0E-01	3.3E+01	5.1E-02	2.0E-04	8.0E-04	5.9E-03	2.0E-05	1.0E-05	4.2E-03	3.0E-06	1.0E+01	5.0E-04	5.1E-05	7.0E-04
2-Oct-12	44	500	455	7.31	8.0E+01																				
9-Oct-12	45	500	465	7.35	7.0E+01	#N/A	4.0E+00	2.1E+01	1.5E+01	2.0E-01	2.1E-01	3.0E-01	3.0E+01	4.6E-02	2.0E-04	2.0E-04	5.4E-03	2.0E-05	1.0E-05	1.4E-03	3.0E-06	9.2E+00	5.0E-04	8.0E-05	8.0E-04
16-Oct-12	46	500	465	7.44	8.1E+01																				
23-Oct-12	47	500	485	7.52	8.9E+01																				
30-Oct-12	48	500	460	7.33	8.5E+01																				
6-Nov-12	49	500	430	7.55	7.4E+01	#N/A	2.6E+00	2.4E+01	1.4E+01	2.0E-01	2.4E-01	3.0E-01	3.8E+01	4.7E-02	2.0E-04	2.0E-04	6.1E-03	2.0E-05	1.0E-05	2.0E-03	1.7E-05	1.2E+01	5.0E-04	6.9E-05	1.3E-03
13-Nov-12	50	500	435	7.28	8.5E+01																				
20-Nov-12	51	500	490	7.77	8.0E+01																				
27-Nov-12	52	500	490	7.21	9.5E+01																				
4-Dec-12	53	500	455	7.51	7.3E+01	#N/A	1.9E+00	2.8E+01	1.3E+01	2.0E-01	2.1E-01	3.0E-01	3.3E+01	6.1E-02	3.0E-04	2.0E-04	5.3E-03	2.0E-05	1.0E-05	1.4E-03	3.0E-06	9.7E+00	5.0E-04	9.0E-05	8.0E-04
11-Dec-12	54	500	450	7.23	7.5E+01																				
18-Dec-12	55	500	450	7.57	7.3E+01																				

HC5

Sample = 08-277

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/L	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
25-Dec-12	56	500	445	7.29	8.5E+01																				
1-Jan-13	57	500	455	7.65	6.9E+01	#N/A	3.9E+00	2.6E+01	1.4E+01	2.0E-01	2.0E-01	3.0E-01	3.8E+01	4.6E-02	3.0E-04	3.0E-04	5.6E-03	2.0E-05	1.0E-05	1.0E-03	3.0E-06	1.1E+01	5.0E-04	2.8E-05	2.9E-03
8-Jan-13	58	500	455	7.53	7.5E+01																				
15-Jan-13	59	500	460	7.49	6.9E+01																				
22-Jan-13	60	500	455	7.53	7.2E+01																				
29-Jan-13	61	500	450	7.56	6.8E+01	#N/A	2.5E+00	2.5E+01	1.3E+01	2.0E-01	1.9E-01	3.0E-01	3.6E+01	5.9E-02	2.0E-04	2.0E-04	5.3E-03	2.0E-05	1.0E-05	1.4E-03	1.1E-05	1.0E+01	5.0E-04	3.0E-06	9.0E-04
5-Feb-13	62	500	460	7.60	6.8E+01																				
12-Feb-13	63	500	455	7.62	6.9E+01																				
19-Feb-13	64	500	445	7.60	6.8E+01																				
26-Feb-13	65	500	440	7.49	7.1E+01	#N/A	3.5E+00	2.4E+01	1.1E+01	2.0E-01	1.7E-01	3.0E-01	2.9E+01	3.2E-02	2.0E-04	3.0E-04	5.2E-03	2.0E-05	1.0E-05	1.2E-03	2.4E-05	8.2E+00	5.0E-04	2.6E-04	6.0E-04
5-Mar-13	66	500	440	7.66	6.5E+01																				
12-Mar-13	67	500	450	7.56	6.9E+01																				
19-Mar-13	68	500	450	7.72	6.3E+01																				
26-Mar-13	69	500	460	7.56	6.4E+01	#N/A	4.7E+00	2.1E+01	1.2E+01	2.0E-01	1.5E-01	3.0E-01	2.9E+01	3.1E-02	2.0E-04	4.0E-04	4.6E-03	2.0E-05	1.0E-05	1.4E-03	1.3E-05	8.4E+00	5.0E-04	2.3E-04	5.0E-04
2-Apr-13	70	500	435	7.59	6.2E+01																				
9-Apr-13	71	500	445	7.53	6.3E+01																				
16-Apr-13	72	500	440	7.51	6.0E+01																				
23-Apr-13	73	500	450	7.60	7.3E+01	#N/A	5.1E+00	2.3E+01	1.4E+01	2.0E-01	1.5E-01	3.0E-01	3.0E+01	4.0E-02	2.0E-04	2.0E-04	5.4E-03	2.0E-05	1.0E-05	1.4E-03	3.0E-06	8.2E+00	5.0E-04	2.8E-05	7.0E-04
30-Apr-13	74	500	445	7.65	6.7E+01																				
7-May-13	75	500	445	7.53	8.5E+01																				
14-May-13	76	500	450	7.53	7.0E+01																				
21-May-13	77	500	440	7.65	7.0E+01	#N/A	3.3E+00	2.2E+01	1.6E+01	2.0E-01	1.5E-01	3.0E-01	3.1E+01	3.1E-02	2.0E-04	2.0E-04	4.6E-03	2.0E-05	1.0E-05	1.7E-03	1.0E-05	8.7E+00	5.0E-04	1.6E-05	5.0E-04
28-May-13	78	500	440	7.67	7.5E+01	#N/A	3.9E+00	2.5E+01	1.7E+01	2.0E-01	1.7E-01	3.0E-01	3.8E+01	3.7E-02	2.0E-04	2.0E-04	5.1E-03	2.0E-05	1.0E-05	1.9E-03	4.0E-06	1.1E+01	5.0E-04	1.8E-05	5.0E-04
4-Jun-13	79	500	440	7.58	6.7E+01	#N/A	4.1E+00	2.5E+01	1.1E+01	2.0E-01	1.2E-01	3.0E-01	3.2E+01	2.0E-02	2.0E-04	2.0E-04	4.9E-03	2.0E-05	1.0E-05	5.3E-03	3.0E-06	8.8E+00	5.0E-04	6.8E-05	9.0E-04
11-Jun-13	80	500	450	7.67	5.5E+01	#N/A	6.7E+00	2.6E+01	7.0E+00	2.0E-01	9.0E-02	3.0E-01	2.5E+01	1.3E-02	2.0E-04	2.0E-04	4.7E-03	2.0E-05	1.0E-05	3.4E-03	3.0E-06	7.2E+00	5.0E-04	2.8E-05	5.0E-04
18-Jun-13	81	500	495	7.50	6.1E+01	#N/A	4.5E+00	2.6E+01	9.0E+00	2.0E-01	9.0E-02	3.0E-01	2.9E+01	1.1E-02	2.0E-04	2.0E-04	4.1E-03	2.0E-05	1.0E-05	4.0E-03	3.0E-06	8.4E+00	5.0E-04	7.7E-05	5.0E-04
25-Jun-13	82	500	450	7.49	4.9E+01																				
2-Jul-13	83	500	490	7.50	5.4E+01	#N/A	7.0E+00	2.9E+01	6.0E+00	2.0E-01	8.0E-02	3.0E-01	2.5E+01	1.4E-02	2.0E-04	2.0E-04	3.8E-03	2.0E-05	1.0E-05	1.0E-03	3.0E-06	7.2E+00	5.0E-04	1.6E-05	5.0E-04
9-Jul-13	84	500	480	7.67	5.8E+01																				
16-Jul-13	85	500	500	7.52	5.3E+01	#N/A	3.3E+00	2.4E+01	6.0E+00	2.0E-01	6.0E-02	3.0E-01	2.6E+01	1.3E-02	2.0E-04	2.0E-04	3.7E-03	2.0E-05	1.0E-05	2.6E-03	3.0E-06	7.6E+00	5.0E-04	3.7E-05	7.0E-04
23-Jul-13	86	500	485	7.62	4.9E+01																				
30-Jul-13	87	500	485	7.41	4.9E+01	#N/A	4.1E+00	2.2E+01	6.0E+00	2.0E-01	7.0E-02	3.0E-01	2.4E+01	1.0E-02	2.0E-04	2.0E-04	3.4E-03	2.0E-05	1.0E-05	2.7E-03	3.0E-06	7.1E+00	5.0E-04	6.0E-06	5.0E-04
6-Aug-13	88	500	535	7.64	5.6E+01																				
13-Aug-13	89	500	485	7.46	4.8E+01	#N/A	2.7E+00	2.1E+01	5.0E+00	2.0E-01	6.0E-02	3.0E-01	2.4E+01	1.1E-02	2.0E-04	2.0E-04	4.2E-03	2.0E-05	1.0E-05	2.3E-03	7.0E-06	7.0E+00	5.0E-04	4.5E-05	5.0E-04
20-Aug-13	90	500	485	7.45	4.8E+01																				
27-Aug-13	91	500	500	7.54	4.5E+01																				
3-Sep-13	92	500	475	7.55	4.3E+01																				
10-Sep-13	93	500	480	7.46	5.0E+01	#N/A	3.3E+00	2.1E+01	4.0E+00	2.0E-01	6.0E-02	3.0E-01	2.5E+01	1.1E-02	2.0E-04	2.0E-04	4.1E-03	2.0E-05	1.0E-05	3.2E-03	1.0E-05	7.7E+00	5.0E-04	5.8E-05	5.0E-04
17-Sep-13	94	500	510	7.55	5.2E+01																				
24-Sep-13	95	500	490	7.49	4.6E+01																				
1-Oct-13	96	500	480	7.65	4.6E+01																				
8-Oct-13	97	500	470	7.45	4.3E+01	#N/A	1.7E+00	1.8E+01	3.0E+00	2.0E-01	6.0E-02	3.0E-01	2.2E+01	1.0E-02	2.0E-04	2.0E-04	3.4E-03	2.0E-05	1.0E-05	4.4E-03	3.0E-06	6.5E+00	5.0E-04	4.4E-05	5.0E-04
15-Oct-13	98	500	515	7.42	4.5E+01																				
22-Oct-13	99	500	480	7.47	4.7E+01																				
29-Oct-13	100	500	475	7.60	4.8E+01																				
5-Nov-13	101	500	485	7.55	4.8E+01	#N/A	1.8E+00	2.0E+01	5.0E+00	2.0E-01	6.0E-02	3.0E-01	2.3E+01	8.2E-03	2.0E-04	2.0E-04	4.1E-03	2.0E-05	1.0E-05	1.7E-03	3.0E-06	6.9E+00	5.0E-04	2.6E-05	5.0E-04
12-Nov-13	102	500	490	7.58	5.0E+01																				
19-Nov-13	103	500	475	7.42	4.5E+01																				
26-Nov-13	104	500	490	7.74	4.8E+01																				
3-Dec-13	105	500	485	7.61	4.4E+01	#N/A	5.9E-01	2.3E+01	3.0E+00	2.0E-01	6.0E-02	3.0E-01	2.2E+01	9.4E-03	2.0E-04	2.0E-04	4.0E-03	2.0E-05	1.0E-05	1.4E-03	3.0E-06	6.7E+00	5.0E-04	2.6E-05	5.0E-04
10-Dec-13	106	500	485	7.75	4.7E+01																				
17-Dec-13	107	500	485	7.68	4.7E+01																				
24-Dec-13	108	500	510	7.69	4.9E+01																				
31-Dec-13	109	500	480	7.67	4.8E+01	#N/A	1.6E+00	2.0E+01	3.0E+00	2.0E-01	6.0E-02	3.0E-01	2.3E+01	9.2E-03	2.0E-04	2.0E-04	4.5E-03	2.0E-05	1.0E-05	9.0E-04	3.0E-06	6.7E+00	5.0E-04	2.5E-05	8.0E-04
7-Jan-14	110	500	490	7.55	5.1E+01																				
14-Jan-14	111	500	485	7.70	4.7E+01																				
21-Jan-14	112	500	485	7.66	5.1E+01																				
28-Jan-14	113	500	490	7.63	5.0E+01	#N/A	1.7E+00	2.2E+01	4.0E+00	2.0E-01	6.0E-02	3.0E-01	2.5E+01	6.5E-03	2.0E-04	2.0E-04	4.5E-03	2.0E-05	1.0E-05	1.7E-03	3.0E-06	7.6E+00	5.0E-04	2.0E-06	5.0E-04
4-Feb-14	114	500	485	7.73	4.6E+01																				
11-Feb-14	115	500	485	7.88	4.7E+01																				
18-Feb-14	116	500	480	7.67	4.4E+01																				
25-Feb-14	117	500	485	7.80	4.4E+01	#N/A	2.9E+00	2.5E+01	5.0E+00	2.0E-01	6.0E-02	3.0E-01	2.2E+01	6.0E-03	2.0E-04	2.0E-04	3.9E-03	2.0E-05	1.0E-05	1.3E-03	3.0E-06	6.5E+00	5.0E-04	2.5E-05	5.0E-04

HC5

Sample = 08-277

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Major	Major	Diff	Diff
	No.																								Anions	Cations		(%)
		mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L				
29-Nov-11	0	4.0E-03	3.0E-05	6.0E-03	2.7E+01	3.6E-02	2.0E-02	6.7E-02	4.2E-03	9.0E-03	1.8E+01	3.3E-03	1.7E+00	1.0E-05	4.1E+01	2.2E+00	2.0E+02	5.0E-05	9.0E-05	5.0E-04	1.6E-02	4.9E-04	2.0E-03	1.1E-03	12.82	13.85	1.03	3.9%
6-Dec-11	1	3.0E-03	6.0E-05	3.0E-03	1.7E+01	2.1E-02	2.0E-02	4.5E-02	3.3E-03	9.0E-03	9.5E+00	2.3E-03	8.4E-01	3.0E-05	2.6E+01	1.2E+00	1.2E+02	3.0E-05	5.0E-05	3.0E-04	2.7E-02	3.9E-04	2.4E-02	3.8E-04	6.98	7.76	0.78	5.3%
13-Dec-11	2	3.0E-03	9.0E-05	3.0E-03	1.6E+01	1.2E-02	1.0E-02	3.3E-02	4.6E-03	9.0E-03	9.5E+00	1.5E-03	9.9E-01	1.0E-05	2.1E+01	1.4E+00	1.1E+02	2.0E-05	1.0E-04	2.0E-04	2.2E-02	1.5E-04	2.0E-03	1.8E-04	7.06	7.69	0.62	4.2%
20-Dec-11	3	3.0E-03	2.0E-05	3.0E-03	1.4E+01	8.2E-03	1.0E-02	2.4E-02	4.2E-03	9.0E-03	7.0E+00	1.2E-03	1.1E+00	1.0E-05	1.2E+01	1.1E+00	9.7E+01	2.0E-05	2.0E-05	3.0E-04	2.2E-02	3.4E-04	3.0E-03	9.0E-05	6.16	6.27	0.11	0.9%
27-Dec-11	4																											
3-Jan-12	5	4.0E-03	2.0E-05	2.0E-03	9.1E+00	8.1E-03	1.0E-02	1.5E-02	3.4E-03	9.0E-03	4.7E+00	2.5E-04	6.5E-01	1.0E-05	5.6E+00	7.7E-01	6.0E+01	2.0E-05	3.0E-05	4.0E-04	1.2E-02	6.0E-04	2.0E-03	3.0E-05	4.27	3.93	-0.34	-4.1%
10-Jan-12	6																											
17-Jan-12	7	6.0E-03	2.0E-05	2.0E-03	8.6E+00	8.8E-03	1.0E-02	1.2E-02	5.0E-04	9.0E-03	4.6E+00	4.2E-04	7.5E-01	1.0E-05	3.2E+00	8.3E-01	5.8E+01	2.0E-05	3.0E-05	2.0E-04	1.2E-02	3.4E-04	2.0E-03	3.0E-05	4.15	3.87	-0.28	-3.5%
24-Jan-12	8																											
31-Jan-12	9	3.0E-03	2.0E-05	1.0E-03	7.3E+00	1.1E-02	1.0E-02	9.5E-03	3.0E-04	9.0E-03	3.9E+00	3.3E-04	6.9E-01	1.0E-05	1.8E+00	7.6E-01	5.0E+01	2.0E-05	5.0E-05	4.0E-04	9.8E-03	4.8E-04	2.0E-03	1.0E-05	3.75	3.39	-0.36	-5.1%
7-Feb-12	10																											
14-Feb-12	11	3.0E-03	2.0E-05	1.0E-03	6.8E+00	1.1E-02	1.0E-02	1.1E-02	1.4E-03	9.0E-03	3.6E+00	2.1E-04	7.7E-01	1.0E-05	1.3E+00	8.1E-01	4.5E+01	2.0E-05	1.0E-05	1.0E-04	8.6E-03	1.5E-04	1.0E-03	1.0E-05	4.03	3.31	-0.71	-9.7%
21-Feb-12	12																											
28-Feb-12	13	3.0E-03	2.0E-05	1.0E-03	5.6E+00	1.3E-02	1.0E-02	1.4E-02	1.0E-04	9.0E-03	3.2E+00	2.4E-04	6.9E-01	1.0E-05	8.4E-01	7.5E-01	3.9E+01	2.0E-05	1.0E-04	2.0E-04	7.7E-03	2.8E-04	2.0E-03	1.0E-05	2.83	2.88	0.05	0.8%
6-Mar-12	14																											
13-Mar-12	15	9.0E-03	3.0E-05	1.0E-03	4.0E+00	8.9E-03	1.0E-02	1.6E-02	3.0E-04	9.0E-03	2.6E+00	6.0E-05	7.0E-01	1.0E-05	6.1E-01	6.0E-01	2.9E+01	2.0E-05	1.7E-04	5.0E-04	4.8E-03	1.1E-04	2.0E-03	3.0E-05	2.33	2.15	-0.18	-4.1%
20-Mar-12	16																											
27-Mar-12	17	3.0E-03	3.0E-05	1.0E-03	3.3E+00	7.9E-03	1.0E-02	1.7E-02	3.0E-04	9.0E-03	2.2E+00	4.0E-05	6.5E-01	1.0E-05	5.5E-01	5.5E-01	2.5E+01	2.0E-05	1.0E-05	1.0E-04	4.2E-03	2.6E-04	2.0E-03	1.0E-05	2.05	1.91	-0.14	-3.5%
3-Apr-12	18																											
10-Apr-12	19	3.0E-03	2.0E-05	1.0E-03	2.6E+00	5.7E-03	2.0E-02	1.7E-02	1.0E-04	9.0E-03	1.9E+00	9.0E-05	5.9E-01	1.0E-05	4.4E-01	4.6E-01	1.8E+01	2.0E-05	2.0E-05	1.0E-04	2.9E-03	2.9E-04	1.0E-03	1.0E-05	1.70	1.45	-0.25	-8.0%
17-Apr-12	20																											
24-Apr-12	21	3.0E-03	2.0E-05	1.0E-03	2.4E+00	5.1E-03	5.0E-02	1.3E-02	4.0E-04	9.0E-03	2.5E+00	1.2E-04	6.5E-01	1.0E-05	4.5E-01	4.3E-01	1.5E+01	2.0E-05	3.0E-05	1.0E-04	3.5E-03	3.1E-04	1.0E-03	1.0E-05	1.48	1.30	-0.18	-6.6%
1-May-12	22																											
8-May-12	23	3.0E-03	2.7E-04	1.0E-03	2.1E+00	4.7E-03	1.0E-02	1.0E-02	6.0E-04	9.0E-03	2.1E+00	8.0E-05	5.3E-01	1.0E-05	3.9E-01	3.6E-01	1.2E+01	2.0E-05	9.2E-04	2.0E-04	2.7E-03	2.6E-04	9.0E-03	1.0E-05	1.19	1.06	-0.12	-5.5%
15-May-12	24																											
22-May-12	25	3.0E-03	2.0E-05	1.0E-03	2.8E+00	5.3E-03	3.0E-02	1.2E-02	3.0E-04	9.0E-03	2.8E+00	1.1E-04	8.2E-01	1.0E-05	5.1E-01	4.7E-01	1.4E+01	2.0E-05	3.7E-04	3.0E-04	5.5E-03	4.8E-04	1.0E-03	1.0E-05	1.38	1.28	-0.10	-3.9%
29-May-12	26																											
5-Jun-12	27	3.0E-03	3.0E-05	1.0E-03	1.9E+00	6.4E-03	1.0E-02	5.8E-03	1.0E-04	9.0E-03	1.9E+00	1.2E-04	5.6E-01	1.0E-05	3.5E-01	3.5E-01	9.4E+00	2.0E-05	2.7E-04	2.0E-04	2.5E-03	4.9E-04	1.0E-03	1.0E-05	0.93	0.95	0.02	0.9%
12-Jun-12	28																											
19-Jun-12	29	3.0E-03	2.0E-05	1.0E-03	1.7E+00	5.5E-03	1.0E-02	4.9E-03	5.0E-04	9.0E-03	1.6E+00	1.2E-04	4.4E-01	1.0E-05	2.9E-01	2.9E-01	7.7E+00	2.0E-05	1.5E-04	4.0E-04	2.1E-03	6.4E-04	2.0E-03	1.0E-05	0.88	0.78	-0.10	-6.0%
26-Jun-12	30																											
3-Jul-12	31	3.0E-03	3.0E-05	1.0E-03	2.0E+00	6.6E-03	1.0E-02	5.2E-03	1.0E-04	9.0E-03	1.8E+00	4.0E-05	5.3E-01	1.0E-05	3.5E-01	3.4E-01	8.9E+00	2.0E-05	2.7E-04	3.0E-04	1.9E-03	3.1E-04	3.0E-03	1.0E-05	1.04	0.92	-0.12	-6.1%
10-Jul-12	32																											
17-Jul-12	33	3.0E-03	6.3E-04	1.0E-03	1.8E+00	6.0E-03	1.0E-02	5.0E-03	1.0E-04	9.0E-03	1.6E+00	2.3E-04	4.9E-01	1.0E-05	4.2E-01	3.0E-01	7.8E+00	2.0E-05	2.1E-04	1.0E-04	1.8E-03	3.7E-04	2.0E-03	1.0E-05	0.85	0.82	-0.03	-2.1%
24-Jul-12	34																											
31-Jul-12	35	3.0E-03	1.7E-04	1.0E-03	1.9E+00	6.2E-03	1.0E-02	4.2E-03	1.0E-04	9.0E-03	1.5E+00	1.4E-04	5.1E-01	1.0E-05	3.3E-01	3.1E-01	7.1E+00	2.0E-05	1.9E-04	1.0E-04	1.7E-03	3.3E-04	5.0E-03	1.0E-05	0.78	0.81	0.03	2.1%
7-Aug-12	36																											
14-Aug-12	37	3.0E-03	2.0E-05	1.0E-03	2.1E+00	6.3E-03	1.0E-02	4.2E-03	2.0E-04	9.0E-03	1.6E+00	1.0E-04	5.1E-01	1.0E-05	3.5E-01	3.1E-01	8.2E+00	2.0E-05	3.1E-04	4.0E-04	1.6E-03	6.5E-04	2.0E-03	1.0E-05	0.94	0.87	-0.08	-4.2%
21-Aug-12	38																											
28-Aug-12	39	3.0E-03	2.0E-05	1.0E-03	2.3E+00	8.9E-03	1.0E-02	3.8E-03	9.0E-04	9.0E-03	1.4E+00	1.9E-04	4.7E-01	1.0E-05	3.2E-01	3.3E-01	8.3E+00	2.0E-05	2.1E-04	2.0E-04	2.7E-03	3.6E-04	9.0E-03	1.0E-05	1.04	0.90	-0.14	-7.0%
4-Sep-12	40																											
11-Sep-12	41	2.2E-02	2.0E-05	1.0E-03	2.1E+00	7.8E-03	4.0E-02	3.9E-03	1.0E-04	9.0E-03	1.3E+00	1.5E-04	3.8E-01	1.0E-05	3.1E-01	2.9E-01	7.8E+00	2.0E-05	2.0E-04	2.0E-04	1.7E-03	2.4E-04	3.0E-03	4.0E-05	0.86	0.81	-0.05	-3.2%
18-Sep-12	42																											
25-Sep-12	43	3.0E-03	2.0E-05	1.0E-03	1.9E+00	5.4E-03	1.0E-02	4.1E-03	2.0E-04	9.0E-03	1.1E+00	2.1E-04	3.2E-01	1.0E-05	2.7E-01	2.6E-01	6.4E+00	2.0E-05	1.3E-04	1.0E-04	1.5E-03	2.6E-04	1.0E-03	2.0E-05	0.88	0.71	-0.16	-10.2%
2-Oct-12	44																											
9-Oct-12	45	5.0E-03	2.0E-05	1.0E-03	1.8E+00	6.6E-03	1.0E-02	3.1E-03	6.0E-04	9.0E-03	9.8E-01	1.4E-04	2.9E-01	1.0E-05	2.2E-01	2.3E-01	5.5E+00	2.0E-05	1.4E-04	2.0E-04	1.3E-03	2.1E-04	1.0E-03	1.0E-05	0.73	0.65	-0.09	-6.1%
16-Oct-12	46																											
23-Oct-12	47																											
30-Oct-12	48																											
6-Nov-12	49	6.0E-03	4.0E-05	1.0E-03	2.1E+00	7.1E-03	1.0E-02	4.1E-03	2.0E-04	9.0E-03	9.7E-01	1.2E-04	3.2E-01	1.0E-05	2.6E-01	2.8E-01	6.0E+00	2.0E-05	4.5E-04	1.0E-04	1.2E-03	1.9E-04	5.0E-03	1.0E-05	0.79	0.80	0.01	0.6%
13-Nov-12	50																											
20-Nov-12	51																											
27-Nov-12	52																											
4-Dec-12	53	3.0E-03	2.0E-05	1.0E-03	2.0E+00	4.1E-03	1.0E-02	3.8E-03	1.0E-04	9.0E-03	8.7E-01	9.0E-05	3.0E-01	1.0E-05	1.9E-01	2.2E-01	4.8E+00	2.0E-05	1.1E-04	3.0E-04	1.5E-03	1.9E-04	2.0E-03	1.0E-05	0.84	0.70	-0.14	-9.4%
11-Dec-12	54																											
18-Dec-12	55																											

HC5

Sample = 08-277

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Major	Major	Diff	Diff
	No.																								Anions	Cations		(%)
		mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L				
25-Dec-12	56																											
1-Jan-13	57	4.0E-03	2.0E-05	1.0E-03	2.5E+00	6.0E-03	1.0E-02	4.6E-03	1.0E-04	1.0E-02	9.4E-01	1.0E-04	4.0E-01	1.0E-05	2.3E-01	2.8E-01	5.7E+00	2.0E-05	2.2E-04	3.0E-04	1.3E-03	1.5E-04	1.0E-03	1.0E-05	0.83	0.81	-0.02	-1.3%
8-Jan-13	58																											
15-Jan-13	59																											
22-Jan-13	60																											
29-Jan-13	61	3.0E-03	1.1E-04	1.0E-03	2.4E+00	6.4E-03	1.0E-02	4.0E-03	2.0E-04	1.5E-02	8.6E-01	1.3E-04	3.6E-01	1.0E-05	2.4E-01	2.5E-01	5.5E+00	2.0E-05	2.1E-04	2.0E-04	1.1E-03	2.1E-04	2.0E-03	1.0E-05	0.78	0.76	-0.02	-1.1%
5-Feb-13	62																											
12-Feb-13	63																											
19-Feb-13	64																											
26-Feb-13	65	3.0E-03	5.0E-05	1.0E-03	2.0E+00	3.8E-03	1.0E-02	4.4E-03	2.0E-04	9.0E-03	7.5E-01	1.1E-04	2.4E-01	1.0E-05	1.8E-01	2.0E-01	4.7E+00	2.0E-05	8.0E-05	1.0E-04	8.7E-04	3.0E-05	1.0E-03	1.0E-05	0.72	0.61	-0.11	-8.5%
5-Mar-13	66																											
12-Mar-13	67																											
19-Mar-13	68																											
26-Mar-13	69	3.0E-03	2.5E-04	1.0E-03	2.1E+00	3.5E-03	1.0E-02	4.6E-03	1.0E-04	9.0E-03	6.6E-01	5.0E-05	2.6E-01	1.0E-05	1.7E-01	2.0E-01	4.6E+00	2.0E-05	4.0E-05	1.0E-04	7.7E-04	9.0E-05	2.0E-03	1.0E-05	0.68	0.62	-0.06	-4.6%
2-Apr-13	70																											
9-Apr-13	71																											
16-Apr-13	72																											
23-Apr-13	73	1.8E-02	1.1E-04	1.0E-03	2.4E+00	3.0E-03	1.0E-02	5.6E-03	1.0E-04	9.0E-03	6.6E-01	7.0E-05	2.8E-01	1.0E-05	1.5E-01	2.0E-01	4.6E+00	2.0E-05	3.0E-05	9.0E-04	8.2E-04	3.0E-05	1.0E-03	1.0E-05	0.76	0.64	-0.13	-9.1%
30-Apr-13	74																											
7-May-13	75																											
14-May-13	76																											
21-May-13	77	3.0E-03	2.0E-05	1.0E-03	2.3E+00	2.9E-03	1.0E-02	6.7E-03	1.0E-04	1.0E-02	6.4E-01	7.0E-05	2.6E-01	1.0E-05	1.5E-01	2.1E-01	4.8E+00	2.0E-05	6.0E-05	1.0E-04	6.8E-04	4.0E-05	1.0E-03	1.0E-05	0.78	0.66	-0.12	-8.7%
28-May-13	78	3.0E-03	2.0E-05	1.0E-03	2.8E+00	3.7E-03	1.0E-02	7.8E-03	1.0E-04	9.0E-03	8.0E-01	1.0E-04	2.6E-01	1.0E-05	1.8E-01	2.5E-01	5.3E+00	2.0E-05	1.1E-04	1.0E-04	8.4E-04	5.0E-05	1.0E-03	1.0E-05	0.86	0.80	-0.06	-3.9%
4-Jun-13	79	3.0E-03	2.0E-05	1.0E-03	2.4E+00	5.6E-03	1.0E-02	5.5E-03	3.1E-03	9.0E-03	5.5E-01	5.0E-05	2.1E-01	1.0E-05	1.4E-01	2.0E-01	3.5E+00	2.0E-05	8.0E-05	1.0E-04	8.3E-04	3.0E-05	2.0E-03	1.0E-05	0.74	0.66	-0.08	-5.5%
11-Jun-13	80	3.0E-03	2.0E-05	1.0E-03	1.8E+00	4.3E-03	1.0E-02	3.0E-03	1.0E-04	9.0E-03	3.9E-01	6.0E-05	1.5E-01	1.0E-05	1.0E-01	1.6E-01	2.3E+00	2.0E-05	8.0E-05	1.0E-04	6.1E-04	3.0E-05	1.0E-03	1.0E-05	0.67	0.53	-0.14	-11.6%
18-Jun-13	81	3.0E-03	2.0E-05	1.0E-03	2.0E+00	6.4E-03	1.0E-02	2.7E-03	1.0E-04	9.0E-03	4.1E-01	4.0E-05	1.6E-01	1.0E-05	1.0E-01	1.9E-01	2.5E+00	2.0E-05	1.3E-04	1.0E-04	7.7E-04	3.0E-05	1.0E-03	1.0E-05	0.72	0.61	-0.11	-8.5%
25-Jun-13	82																											
2-Jul-13	83	3.0E-03	2.0E-05	1.0E-03	1.7E+00	5.3E-03	1.0E-02	2.5E-03	1.0E-04	9.0E-03	3.9E-01	4.0E-05	1.6E-01	1.0E-05	6.0E-02	1.5E-01	1.8E+00	2.0E-05	8.0E-05	1.0E-04	5.6E-04	6.0E-05	1.0E-03	1.0E-05	0.72	0.52	-0.20	-16.3%
9-Jul-13	84																											
16-Jul-13	85	4.0E-03	5.0E-05	1.0E-03	1.7E+00	6.1E-03	1.0E-02	1.8E-03	1.0E-04	9.0E-03	3.2E-01	4.0E-05	1.4E-01	1.0E-05	7.0E-02	1.5E-01	1.6E+00	2.0E-05	1.5E-04	1.0E-04	5.3E-04	3.0E-05	2.0E-03	1.0E-05	0.60	0.53	-0.07	-6.3%
23-Jul-13	86																											
30-Jul-13	87	3.0E-03	2.0E-05	1.0E-03	1.5E+00	5.9E-03	1.0E-02	1.7E-03	1.0E-04	9.0E-03	3.0E-01	4.0E-05	1.3E-01	1.0E-05	5.0E-02	1.4E-01	1.5E+00	2.0E-05	1.1E-04	1.0E-04	5.7E-04	3.0E-05	1.0E-03	1.0E-05	0.58	0.49	-0.08	-7.8%
6-Aug-13	88																											
13-Aug-13	89	3.0E-03	2.0E-05	1.0E-03	1.5E+00	6.0E-03	1.0E-02	1.4E-03	2.0E-04	9.0E-03	2.8E-01	4.0E-05	1.4E-01	1.0E-05	6.0E-02	1.4E-01	1.4E+00	2.0E-05	1.6E-04	1.0E-04	5.4E-04	4.0E-05	3.0E-03	1.0E-05	0.54	0.49	-0.05	-4.5%
20-Aug-13	90																											
27-Aug-13	91																											
3-Sep-13	92																											
10-Sep-13	93	3.0E-03	2.0E-05	1.0E-03	1.6E+00	6.3E-03	1.0E-02	1.4E-03	1.0E-04	9.0E-03	2.9E-01	6.0E-05	1.3E-01	1.0E-05	4.0E-02	1.4E-01	2.2E+00	2.0E-05	1.3E-04	1.0E-04	7.6E-04	3.0E-05	1.0E-03	1.0E-05	0.50	0.52	0.02	2.1%
17-Sep-13	94																											
24-Sep-13	95																											
1-Oct-13	96																											
8-Oct-13	97	3.0E-03	2.0E-05	1.0E-03	1.3E+00	5.2E-03	1.0E-02	1.1E-03	1.0E-04	1.0E-02	2.4E-01	4.0E-05	1.3E-01	1.0E-05	4.0E-02	1.2E-01	1.4E+00	2.0E-05	5.0E-05	1.0E-04	5.3E-04	3.0E-05	2.0E-03	1.0E-05	0.42	0.44	0.02	2.4%
15-Oct-13	98																											
22-Oct-13	99																											
29-Oct-13	100																											
5-Nov-13	101	3.0E-03	2.0E-05	1.0E-03	1.4E+00	5.6E-03	1.0E-02	1.2E-03	1.0E-04	9.0E-03	2.7E-01	4.0E-05	1.4E-01	1.0E-05	4.0E-02	1.3E-01	1.3E+00	2.0E-05	8.0E-05	1.0E-04	5.9E-04	3.0E-05	1.0E-03	1.0E-05	0.51	0.48	-0.04	-3.6%
12-Nov-13	102																											
19-Nov-13	103																											
26-Nov-13	104																											
3-Dec-13	105	3.0E-03	2.0E-05	1.0E-03	1.4E+00	4.5E-03	1.0E-02	1.3E-03	1.0E-04	9.0E-03	2.6E-01	4.0E-05	1.2E-01	1.0E-05	3.0E-02	1.3E-01	1.1E+00	2.0E-05	1.6E-04	1.0E-04	5.7E-04	7.0E-05	1.0E-03	1.0E-05	0.52	0.46	-0.06	-6.6%
10-Dec-13	106																											
17-Dec-13	107																											
24-Dec-13	108																											
31-Dec-13	109	4.0E-03	2.0E-05	1.0E-03	1.4E+00	4.7E-03	1.0E-02	1.3E-03	1.0E-04	9.0E-03	2.7E-01	4.0E-05	1.4E-01	1.0E-05	4.0E-02	1.3E-01	1.3E+00	2.0E-05	1.4E-04	1.0E-04	6.0E-04	4.0E-05	1.0E-03	1.0E-05	0.47	0.46	-0.01	-0.8%
7-Jan-14	110																											
14-Jan-14	111																											
21-Jan-14	112																											
28-Jan-14	113	3.0E-03	2.0E-05	1.0E-03	1.5E+00	5.2E-03	1.0E-02	9.5E-04	1.0E-04	9.0E-03	2.5E-01	4.0E-05	1.3E-01	1.0E-05	4.0E-02	1.5E-01	1.6E+00	2.0E-05	1.5E-04	1.0E-04	7.1E-04	3.0E-05	1.0E-03	1.0E-05	0.52	0.52	-0.01	-0.5%
4-Feb-14	114																											
11-Feb-14	115																											
18-Feb-14	116																											
25-Feb-14	117	3.0E-03	2.0E-05	1.0E-03	1.3E+00	3.7E-03	1.0E-02	1.1E-03	1.0E-04	9.0E-03	2.4E-01	4.0E-05	1.3E-01	1.0E-05	3.0E-02	1.3E-01	1.1E+00	2.0E-05	6.0E-05	1.0E-04	4.9E-04	3.0E-05	1.0E-03	1.0E-05	0.61	0.44	-0.17	-15.8%

HC5
Sample = 08-277

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/kg	mgCaCO3/kg	mgCaCO3/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
29-Nov-11	0	500	375	7.40	1.3E+03	#N/A	3.1E+00	1.5E+01	2.1E+02	2.3E+00	4.4E-01	1.1E-01	2.2E+02	8.5E-03	2.6E-04	6.0E-04	1.5E-02	7.5E-06	3.8E-06	3.4E-03	5.1E-05	7.1E+01	3.0E-04	5.6E-04	6.1E-03
6-Dec-11	1	500	450	7.55	7.4E+02	#N/A	2.0E+00	1.3E+01	1.4E+02	1.8E+00	4.0E-01	1.4E-01	1.4E+02	1.7E-02	2.3E-04	3.2E-04	7.2E-03	9.0E-06	4.5E-06	2.7E-03	5.9E-05	4.5E+01	2.3E-04	3.9E-04	6.1E-03
13-Dec-11	2	500	460	7.48	7.1E+02	#N/A	1.7E+00	1.2E+01	1.4E+02	9.7E-01	4.8E-01	1.4E-01	1.5E+02	1.7E-02	1.8E-04	4.1E-04	1.1E-02	9.2E-06	4.6E-06	2.4E-03	2.0E-05	4.8E+01	4.6E-04	2.4E-04	4.3E-03
20-Dec-11	3	500	495	7.47	6.2E+02	#N/A	2.5E+00	1.4E+01	1.3E+02	4.0E-01	4.1E-01	1.5E-01	1.4E+02	2.6E-02	3.0E-04	3.5E-04	7.5E-03	9.9E-06	5.0E-06	2.5E-03	6.9E-06	4.4E+01	2.5E-04	1.8E-04	3.3E-03
27-Dec-11	4	500	450	7.79	4.7E+02																				
3-Jan-12	5	500	450	7.48	4.2E+02	#N/A	2.2E+00	9.8E+00	8.2E+01	1.4E-01	2.7E-01	1.4E-01	8.0E+01	3.8E-02	2.3E-04	1.8E-04	4.9E-03	9.0E-06	4.5E-06	1.7E-03	5.9E-06	2.5E+01	2.3E-04	1.0E-04	1.5E-03
10-Jan-12	6	500	435	7.38	4.4E+02																				
17-Jan-12	7	500	445	7.43	4.0E+02	#N/A	1.4E+00	1.1E+01	7.7E+01	8.9E-02	2.8E-01	1.3E-01	8.0E+01	2.2E-02	2.7E-04	1.8E-04	4.8E-03	8.9E-06	4.5E-06	1.7E-03	6.7E-06	2.6E+01	2.2E-04	5.8E-05	1.2E-03
24-Jan-12	8	500	445	7.58	3.6E+02																				
31-Jan-12	9	500	465	7.47	3.6E+02	#N/A	1.5E+00	1.1E+01	7.2E+01	9.3E-02	2.6E-01	1.4E-01	7.4E+01	2.5E-02	2.3E-04	1.9E-04	4.8E-03	9.3E-06	4.7E-06	1.4E-03	2.3E-06	2.4E+01	2.3E-04	6.1E-05	1.0E-03
7-Feb-12	10	500	460	7.59	3.7E+02																				
14-Feb-12	11	500	465	7.61	3.5E+02	#N/A	2.4E+00	1.2E+01	7.8E+01	9.3E-02	2.7E-01	1.4E-01	7.3E+01	2.0E-02	2.3E-04	2.3E-04	4.6E-03	9.3E-06	4.7E-06	1.3E-03	4.7E-06	2.4E+01	2.3E-04	5.2E-05	7.9E-04
21-Feb-12	12	500	470	7.53	3.2E+02																				
28-Feb-12	13	500	475	7.45	2.9E+02	#N/A	1.9E+00	1.1E+01	5.3E+01	9.5E-02	2.2E-01	1.4E-01	6.5E+01	2.2E-02	3.3E-04	2.9E-04	4.1E-03	9.5E-06	4.8E-06	1.4E-03	5.2E-06	2.2E+01	2.4E-04	4.6E-05	7.1E-04
6-Mar-12	14	500	465	7.58	2.5E+02																				
13-Mar-12	15	500	455	7.39	2.3E+02	#N/A	1.4E+00	9.3E+00	4.1E+01	9.1E-02	2.1E-01	1.4E-01	4.6E+01	2.5E-02	2.7E-04	1.4E-04	3.5E-03	9.1E-06	4.6E-06	1.0E-03	1.4E-06	1.6E+01	2.3E-04	2.6E-05	5.5E-04
20-Mar-12	16	500	450	7.46	2.2E+02																				
27-Mar-12	17	500	435	7.41	2.1E+02	#N/A	1.3E+00	9.5E+00	3.3E+01	8.7E-02	2.0E-01	1.3E-01	3.9E+01	2.6E-02	2.2E-04	1.7E-04	3.3E-03	8.7E-06	4.4E-06	1.0E-03	5.7E-06	1.3E+01	2.2E-04	1.9E-05	4.4E-04
3-Apr-12	18	500	440	7.51	1.9E+02																				
10-Apr-12	19	500	430	7.48	1.6E+02	#N/A	1.0E+00	9.2E+00	2.6E+01	8.6E-02	1.9E-01	1.3E-01	2.9E+01	2.7E-02	2.2E-04	8.6E-05	3.0E-03	8.6E-06	4.3E-06	8.6E-04	1.3E-06	9.9E+00	2.2E-04	1.9E-05	3.9E-04
17-Apr-12	20	500	410	7.51	1.8E+02																				
24-Apr-12	21	500	450	7.53	1.5E+02	#N/A	1.1E+00	1.0E+01	2.2E+01	9.0E-02	1.9E-01	1.4E-01	2.7E+01	3.2E-02	3.2E-04	9.0E-05	3.8E-03	9.0E-06	4.5E-06	9.9E-04	1.4E-06	9.0E+00	2.3E-04	2.1E-05	5.4E-04
1-May-12	22	500	430	7.60	1.3E+02																				
8-May-12	23	500	440	7.53	1.2E+02	#N/A	1.1E+00	9.8E+00	1.5E+01	8.8E-02	1.4E-01	1.3E-01	2.1E+01	2.3E-02	2.2E-04	2.2E-04	3.3E-03	8.8E-06	4.4E-06	9.7E-04	1.3E-06	7.1E+00	2.2E-04	1.5E-05	8.9E-03
15-May-12	24	500	430	7.53	1.2E+02																				
22-May-12	25	500	405	7.52	1.4E+02	#N/A	1.3E+00	1.1E+01	1.6E+01	8.1E-02	1.5E-01	1.2E-01	2.4E+01	3.8E-02	4.1E-04	1.2E-04	3.9E-03	8.1E-06	4.1E-06	1.0E-03	1.2E-06	7.6E+00	2.0E-04	1.6E-05	5.3E-04
29-May-12	26	500	435	7.44	9.9E+01																				
5-Jun-12	27	500	450	7.44	1.0E+02	#N/A	1.4E+00	1.0E+01	9.9E+00	9.0E-02	1.3E-01	1.4E-01	1.9E+01	3.4E-02	1.8E-04	1.8E-04	3.3E-03	9.0E-06	4.5E-06	1.3E-03	1.4E-06	6.4E+00	2.3E-04	1.8E-05	3.6E-04
12-Jun-12	28	500	445	7.49	9.4E+01																				
19-Jun-12	29	500	435	7.44	8.9E+01	#N/A	1.1E+00	8.9E+00	9.6E+00	8.7E-02	1.2E-01	1.3E-01	1.6E+01	2.9E-02	1.7E-04	8.7E-05	2.7E-03	8.7E-06	4.4E-06	6.5E-04	1.3E-06	5.0E+00	2.2E-04	1.9E-05	3.5E-04
26-Jun-12	30	500	450	7.49	9.5E+01																				
3-Jul-12	31	500	450	7.65	1.0E+02	#N/A	3.2E+00	1.2E+01	1.0E+01	9.0E-02	1.4E-01	1.4E-01	1.9E+01	3.6E-02	1.8E-04	1.8E-04	3.6E-03	9.0E-06	4.5E-06	5.0E-04	1.4E-06	6.2E+00	2.3E-04	1.3E-05	4.1E-04
10-Jul-12	32	500	440	7.53	1.1E+02																				
17-Jul-12	33	500	435	7.50	9.1E+01	#N/A	1.0E+00	9.1E+00	8.7E+00	8.7E-02	1.2E-01	1.3E-01	1.6E+01	3.0E-02	1.7E-04	7.0E-04	3.1E-03	8.7E-06	4.4E-06	7.0E-04	1.3E-06	5.2E+00	2.2E-04	7.5E-05	3.9E-04
24-Jul-12	34	500	445	7.44	9.5E+01																				
31-Jul-12	35	500	435	7.51	8.5E+01	#N/A	8.6E-01	8.9E+00	7.4E+00	8.7E-02	1.2E-01	1.3E-01	1.6E+01	2.8E-02	1.7E-04	1.3E-04	2.7E-03	8.7E-06	4.4E-06	9.6E-04	1.3E-05	5.1E+00	2.2E-04	1.8E-05	7.4E-04
7-Aug-12	36	500	470	7.57	8.8E+01																				
14-Aug-12	37	500	445	7.49	9.4E+01	#N/A	1.2E+00	1.1E+01	9.3E+00	8.9E-02	1.2E-01	1.3E-01	1.8E+01	4.7E-02	3.1E-04	1.3E-03	3.1E-03	8.9E-06	4.5E-06	2.0E-03	1.3E-06	5.5E+00	2.2E-04	8.9E-07	8.0E-04
21-Aug-12	38	500	445	7.33	9.1E+01																				
28-Aug-12	39	500	500	7.46	1.0E+02	#N/A	1.7E+00	1.3E+01	1.3E+01	1.0E-01	1.5E-01	1.5E-01	2.1E+01	3.4E-02	1.5E-04	1.0E-04	3.8E-03	1.0E-05	5.0E-06	1.1E-03	3.8E-05	6.5E+00	2.5E-04	6.3E-05	5.5E-04
4-Sep-12	40	500	475	7.35	7.8E+01																				
11-Sep-12	41	500	460	7.44	8.4E+01	#N/A	1.2E+00	9.9E+00	9.2E+00	9.2E-02	1.4E-01	1.4E-01	1.7E+01	2.1E-02	1.4E-04	9.2E-05	2.8E-03	9.2E-06	4.6E-06	9.7E-04	1.4E-06	5.3E+00	2.3E-04	2.5E-05	5.1E-04
18-Sep-12	42	500	505	7.45	8.9E+01																				
25-Sep-12	43	500	445	7.42	8.2E+01	#N/A	1.4E+00	1.0E+01	8.5E+00	8.9E-02	1.1E-01	1.3E-01	1.5E+01	2.3E-02	8.9E-05	3.6E-04	2.6E-03	8.9E-06	4.5E-06	1.9E-03	1.3E-06	4.5E+00	2.2E-04	2.3E-05	3.1E-04
2-Oct-12	44	500	455	7.31	8.0E+01																				
9-Oct-12	45	500	465	7.35	7.0E+01	#N/A	1.9E+00	9.6E+00	7.0E+00	9.3E-02	9.8E-02	1.4E-01	1.4E+01	2.2E-02	9.3E-05	9.3E-05	2.5E-03	9.3E-06	4.7E-06	6.5E-04	1.4E-06	4.3E+00	2.3E-04	3.7E-05	3.7E-04
16-Oct-12	46	500	465	7.44	8.1E+01																				
23-Oct-12	47	500	485	7.52	8.9E+01																				
30-Oct-12	48	500	460	7.33	8.5E+01																				
6-Nov-12	49	500	430	7.55	7.4E+01	#N/A	1.1E+00	1.0E+01	6.0E+00	8.6E-02	1.0E-01	1.3E-01	1.6E+01	2.0E-02	8.6E-05	8.6E-05	2.6E-03	8.6E-06	4.3E-06	8.6E-04	7.3E-06	5.0E+00	2.2E-04	3.0E-05	5.6E-04
13-Nov-12	50	500	435	7.28	8.5E+01																				
20-Nov-12	51	500	490	7.77	8.0E+01																				
27-Nov-12	52	500	490	7.21	9.5E+01																				
4-Dec-12	53	500	455	7.51	7.3E+01	#N/A	8.8E-01	1.3E+01	5.9E+00	9.1E-02	9.6E-02	1.4E-01	1.5E+01	2.8E-02	1.4E-04	9.1E-05	2.4E-03	9.1E-06	4.6E-06	6.4E-04	1.4E-06	4.4E+00	2.3E-04	4.1E-05	3.6E-04
11-Dec-12	54	500	450	7.23	7.5E+01																				
18-Dec-12	55	500	450	7.57	7.3E+01																				
25-Dec-12	56	500	445	7.29	8.5E+01																				
1-Jan-13	57	500	455	7.65	6.9E+01	#N/A	1.8E+00	1.2E+01	6.4E+00	9.1E-02	9.1E-02	1.4E-01	1.7E+01	2.1E-02	1.4E-04	1.4E-04	2.5E-03	9.1E-06	4.6E-06	4.6E-04	1.4E-06	5.1E+00	2.3E-04	1.3E-05	1.3E-03

HC5
Sample = 08-277

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/kg	mgCaCO3/kg	mgCaCO3/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
8-Jan-13	58	500	455	7.53	7.5E+01																				
15-Jan-13	59	500	460	7.49	6.9E+01																				
22-Jan-13	60	500	455	7.53	7.2E+01																				
29-Jan-13	61	500	450	7.56	6.8E+01	#N/A	1.1E+00	1.1E+01	5.9E+00	9.0E-02	8.6E-02	1.4E-01	1.6E+01	2.7E-02	9.0E-05	9.0E-05	2.4E-03	9.0E-06	4.5E-06	6.3E-04	5.0E-06	4.7E+00	2.3E-04	1.4E-06	4.1E-04
5-Feb-13	62	500	460	7.60	6.8E+01																				
12-Feb-13	63	500	455	7.62	6.9E+01																				
19-Feb-13	64	500	445	7.60	6.8E+01																				
26-Feb-13	65	500	440	7.49	7.1E+01	#N/A	1.5E+00	1.1E+01	4.8E+00	8.8E-02	7.5E-02	1.3E-01	1.3E+01	1.4E-02	8.8E-05	1.3E-04	2.3E-03	8.8E-06	4.4E-06	5.3E-04	1.1E-05	3.6E+00	2.2E-04	1.2E-04	2.6E-04
5-Mar-13	66	500	440	7.66	6.5E+01																				
12-Mar-13	67	500	450	7.56	6.9E+01																				
19-Mar-13	68	500	450	7.72	6.3E+01																				
26-Mar-13	69	500	460	7.56	6.4E+01	#N/A	2.2E+00	9.7E+00	5.5E+00	9.2E-02	6.9E-02	1.4E-01	1.4E+01	1.4E-02	9.2E-05	1.8E-04	2.1E-03	9.2E-06	4.6E-06	6.4E-04	6.0E-06	3.9E+00	2.3E-04	1.1E-04	2.3E-04
2-Apr-13	70	500	435	7.59	6.2E+01																				
9-Apr-13	71	500	445	7.53	6.3E+01																				
16-Apr-13	72	500	440	7.51	6.0E+01																				
23-Apr-13	73	500	450	7.60	7.3E+01	#N/A	2.3E+00	1.0E+01	6.3E+00	9.0E-02	6.8E-02	1.4E-01	1.4E+01	1.8E-02	9.0E-05	9.0E-05	2.4E-03	9.0E-06	4.5E-06	6.3E-04	1.4E-06	3.7E+00	2.3E-04	1.3E-05	3.2E-04
30-Apr-13	74	500	445	7.65	6.7E+01																				
7-May-13	75	500	445	7.53	8.5E+01																				
14-May-13	76	500	450	7.53	7.0E+01																				
21-May-13	77	500	440	7.65	7.0E+01	#N/A	1.5E+00	9.6E+00	7.0E+00	8.8E-02	6.6E-02	1.3E-01	1.4E+01	1.4E-02	8.8E-05	8.8E-05	2.0E-03	8.8E-06	4.4E-06	7.5E-04	4.4E-06	3.8E+00	2.2E-04	7.0E-06	2.2E-04
28-May-13	78	500	440	7.67	7.5E+01		1.7E+00	1.1E+01	7.5E+00	8.8E-02	7.5E-02	1.3E-01	1.7E+01	1.6E-02	8.8E-05	8.8E-05	2.3E-03	8.8E-06	4.4E-06	8.4E-04	1.8E-06	4.6E+00	2.2E-04	7.9E-06	2.2E-04
4-Jun-13	79	500	440	7.58	6.7E+01		1.8E+00	1.1E+01	4.8E+00	8.8E-02	5.3E-02	1.3E-01	1.4E+01	9.0E-03	8.8E-05	8.8E-05	2.2E-03	8.8E-06	4.4E-06	2.3E-03	1.3E-06	3.9E+00	2.2E-04	3.0E-05	4.0E-04
11-Jun-13	80	500	450	7.67	5.5E+01		3.0E+00	1.2E+01	3.2E+00	9.0E-02	4.1E-02	1.4E-01	1.1E+01	5.8E-03	9.0E-05	9.0E-05	2.1E-03	9.0E-06	4.5E-06	1.5E-03	1.4E-06	3.2E+00	2.3E-04	1.3E-05	2.3E-04
18-Jun-13	81	500	495	7.50	6.1E+01	#N/A	2.2E+00	1.3E+01	4.5E+00	9.9E-02	4.5E-02	1.5E-01	1.5E+01	5.2E-03	9.9E-05	9.9E-05	2.0E-03	9.9E-06	5.0E-06	2.0E-03	1.5E-06	4.2E+00	2.5E-04	3.8E-05	2.5E-04
25-Jun-13	82	500	450	7.49	4.9E+01																				
2-Jul-13	83	500	490	7.50	5.4E+01		3.4E+00	1.4E+01	2.9E+00	9.8E-02	3.9E-02	1.5E-01	1.2E+01	6.6E-03	9.8E-05	9.8E-05	1.8E-03	9.8E-06	4.9E-06	4.9E-04	1.5E-06	3.5E+00	2.5E-04	7.8E-06	2.5E-04
9-Jul-13	84	500	480	7.67	5.8E+01																				
16-Jul-13	85	500	500	7.52	5.3E+01	#N/A	1.6E+00	1.2E+01	3.0E+00	1.0E-01	3.0E-02	1.5E-01	1.3E+01	6.3E-03	1.0E-04	1.0E-04	1.9E-03	1.0E-05	5.0E-06	1.3E-03	1.5E-06	3.8E+00	2.5E-04	1.9E-05	3.5E-04
23-Jul-13	86	500	485	7.62	4.9E+01																				
30-Jul-13	87	500	485	7.41	4.9E+01		2.0E+00	1.1E+01	2.9E+00	9.7E-02	3.4E-02	1.5E-01	1.2E+01	5.0E-03	9.7E-05	9.7E-05	1.7E-03	9.7E-06	4.9E-06	1.3E-03	1.5E-06	3.4E+00	2.4E-04	2.9E-06	2.4E-04
6-Aug-13	88	500	535	7.64	5.6E+01																				
13-Aug-13	89	500	485	7.46	4.8E+01	#N/A	1.3E+00	1.0E+01	2.4E+00	9.7E-02	2.9E-02	1.5E-01	1.1E+01	5.3E-03	9.7E-05	9.7E-05	2.0E-03	9.7E-06	4.9E-06	1.1E-03	3.4E-06	3.4E+00	2.4E-04	2.2E-05	2.4E-04
20-Aug-13	90	500	485	7.45	4.8E+01																				
27-Aug-13	91	500	500	7.54	4.5E+01																				
3-Sep-13	92	500	475	7.55	4.3E+01																				
10-Sep-13	93	500	480	7.46	5.0E+01	#N/A	1.6E+00	1.0E+01	1.9E+00	9.6E-02	2.9E-02	1.4E-01	1.2E+01	5.1E-03	9.6E-05	9.6E-05	2.0E-03	9.6E-06	4.8E-06	1.5E-03	4.8E-06	3.7E+00	2.4E-04	2.8E-05	2.4E-04
17-Sep-13	94	500	510	7.55	5.2E+01																				
24-Sep-13	95	500	490	7.49	4.6E+01																				
1-Oct-13	96	500	480	7.65	4.6E+01																				
8-Oct-13	97	500	470	7.45	4.3E+01	#N/A	8.1E-01	8.5E+00	1.4E+00	9.4E-02	2.8E-02	1.4E-01	1.0E+01	4.8E-03	9.4E-05	9.4E-05	1.6E-03	9.4E-06	4.7E-06	2.1E-03	1.4E-06	3.1E+00	2.4E-04	2.1E-05	2.4E-04
15-Oct-13	98	500	515	7.42	4.5E+01																				
22-Oct-13	99	500	480	7.47	4.7E+01																				
29-Oct-13	100	500	475	7.60	4.8E+01																				
5-Nov-13	101	500	485	7.55	4.8E+01	#N/A	8.8E-01	9.9E+00	2.4E+00	9.7E-02	2.9E-02	1.5E-01	1.1E+01	4.0E-03	9.7E-05	9.7E-05	2.0E-03	9.7E-06	4.9E-06	8.2E-04	1.5E-06	3.4E+00	2.4E-04	1.3E-05	2.4E-04
12-Nov-13	102	500	490	7.58	5.0E+01																				
19-Nov-13	103	500	475	7.42	4.5E+01																				
26-Nov-13	104	500	490	7.74	4.8E+01																				
3-Dec-13	105	500	485	7.61	4.4E+01	#N/A	2.9E-01	1.1E+01	1.5E+00	9.7E-02	2.9E-02	1.5E-01	1.1E+01	4.6E-03	9.7E-05	9.7E-05	1.9E-03	9.7E-06	4.9E-06	6.8E-04	1.5E-06	3.2E+00	2.4E-04	1.3E-05	2.4E-04
10-Dec-13	106	500	485	7.75	4.7E+01																				
17-Dec-13	107	500	485	7.68	4.7E+01																				
24-Dec-13	108	500	510	7.69	4.9E+01																				
31-Dec-13	109	500	480	7.67	4.8E+01	#N/A	7.7E-01	9.8E+00	1.4E+00	9.6E-02	2.9E-02	1.4E-01	1.1E+01	4.4E-03	9.6E-05	9.6E-05	2.2E-03	9.6E-06	4.8E-06	4.3E-04	1.4E-06	3.2E+00	2.4E-04	1.2E-05	3.8E-04
7-Jan-14	110	500	490	7.55	5.1E+01																				
14-Jan-14	111	500	485	7.70	4.7E+01																				
21-Jan-14	112	500	485	7.66	5.1E+01																				
28-Jan-14	113	500	490	7.63	5.0E+01	#N/A	8.2E-01	1.1E+01	2.0E+00	9.8E-02	2.9E-02	1.5E-01	1.2E+01	3.2E-03	9.8E-05	9.8E-05	2.2E-03	9.8E-06	4.9E-06	8.3E-04	1.5E-06	3.7E+00	2.5E-04	9.8E-07	2.5E-04
4-Feb-14	114	500	485	7.73	4.6E+01																				
11-Feb-14	115	500	485	7.88	4.7E+01																				
18-Feb-14	116	500	480	7.67	4.4E+01																				
25-Feb-14	117	500	485	7.80	4.4E+01	#N/A	1.4E+00	1.2E+01	2.4E+00	9.7E-02	2.9E-02	1.5E-01	1.1E+01	2.9E-03	9.7E-05	9.7E-05	1.9E-03	9.7E-06	4.9E-06	6.3E-04	1.5E-06	3.1E+00	2.4E-04	1.2E-05	2.4E-04

HC5
Sample = 08-277

Date	Cycle No.	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
29-Nov-11	0	1.5E-03	1.1E-05	2.3E-03	1.0E+01	1.4E-02	7.5E-06	2.5E-02	1.6E-03	3.4E-03	6.6E+00	1.2E-03	6.2E-01	3.8E-06	1.5E+01	8.1E-01	7.7E+01	1.9E-05	3.4E-05	1.9E-04	6.1E-03	1.8E-04	7.5E-04	4.0E-04
6-Dec-11	1	1.4E-03	2.7E-05	1.4E-03	7.7E+00	9.3E-03	9.0E-06	2.0E-02	1.5E-03	4.1E-03	4.3E+00	1.1E-03	3.8E-01	1.4E-05	1.2E+01	5.4E-01	5.4E+01	1.4E-05	2.3E-05	1.4E-04	1.2E-02	1.8E-04	1.1E-02	1.7E-04
13-Dec-11	2	1.4E-03	4.1E-05	1.4E-03	7.4E+00	5.3E-03	4.6E-06	1.5E-02	2.1E-03	4.1E-03	4.4E+00	6.8E-04	4.6E-01	4.6E-06	9.5E+00	6.4E-01	5.2E+01	9.2E-06	4.6E-05	9.2E-05	9.9E-03	6.9E-05	9.2E-04	8.3E-05
20-Dec-11	3	1.5E-03	9.9E-06	1.5E-03	6.8E+00	4.1E-03	5.0E-06	1.2E-02	2.1E-03	4.5E-03	3.4E+00	5.8E-04	5.3E-01	5.0E-06	5.8E+00	5.6E-01	4.8E+01	9.9E-06	9.9E-06	1.5E-04	1.1E-02	1.7E-04	1.5E-03	4.5E-05
27-Dec-11	4																							
3-Jan-12	5	1.8E-03	9.0E-06	9.0E-04	4.1E+00	3.6E-03	4.5E-06	6.7E-03	1.5E-03	4.1E-03	2.1E+00	1.1E-04	2.9E-01	4.5E-06	2.5E+00	3.5E-01	2.7E+01	9.0E-06	1.4E-05	1.8E-04	5.2E-03	2.7E-04	9.0E-04	1.4E-05
10-Jan-12	6																							
17-Jan-12	7	2.7E-03	8.9E-06	8.9E-04	3.8E+00	3.9E-03	4.5E-06	5.4E-03	2.2E-04	4.0E-03	2.1E+00	1.9E-04	3.3E-01	4.5E-06	1.4E+00	3.7E-01	2.6E+01	8.9E-06	1.3E-05	8.9E-05	5.3E-03	1.5E-04	8.9E-04	1.3E-05
24-Jan-12	8																							
31-Jan-12	9	1.4E-03	9.3E-06	4.7E-04	3.4E+00	5.0E-03	4.7E-06	4.4E-03	1.4E-04	4.2E-03	1.8E+00	1.5E-04	3.2E-01	4.7E-06	8.4E-01	3.5E-01	2.3E+01	9.3E-06	2.3E-05	1.9E-04	4.6E-03	2.2E-04	9.3E-04	4.7E-06
7-Feb-12	10																							
14-Feb-12	11	1.4E-03	9.3E-06	4.7E-04	3.2E+00	5.2E-03	4.7E-06	5.2E-03	6.5E-04	4.2E-03	1.7E+00	9.8E-05	3.6E-01	4.7E-06	6.2E-01	3.7E-01	2.1E+01	9.3E-06	4.7E-06	4.7E-05	4.0E-03	7.0E-05	4.7E-04	4.7E-06
21-Feb-12	12																							
28-Feb-12	13	1.4E-03	9.5E-06	4.8E-04	2.6E+00	6.4E-03	4.8E-06	6.7E-03	4.8E-05	4.3E-03	1.5E+00	1.1E-04	3.3E-01	4.8E-06	4.0E-01	3.6E-01	1.8E+01	9.5E-06	4.8E-05	9.5E-05	3.6E-03	1.3E-04	9.5E-04	4.8E-06
6-Mar-12	14																							
13-Mar-12	15	4.1E-03	1.4E-05	4.6E-04	1.8E+00	4.0E-03	4.6E-06	7.4E-03	1.4E-04	4.1E-03	1.2E+00	2.7E-05	3.2E-01	4.6E-06	2.8E-01	2.7E-01	1.3E+01	9.1E-06	7.7E-05	2.3E-04	2.2E-03	5.0E-05	9.1E-04	1.4E-05
20-Mar-12	16																							
27-Mar-12	17	1.3E-03	1.3E-05	4.4E-04	1.4E+00	3.4E-03	4.4E-06	7.2E-03	1.3E-04	3.9E-03	9.7E-01	1.7E-05	2.8E-01	4.4E-06	2.4E-01	2.4E-01	1.1E+01	8.7E-06	4.4E-06	4.4E-05	1.8E-03	1.1E-04	8.7E-04	4.4E-06
3-Apr-12	18																							
10-Apr-12	19	1.3E-03	8.6E-06	4.3E-04	1.1E+00	2.5E-03	8.6E-06	7.2E-03	4.3E-05	3.9E-03	8.2E-01	3.9E-05	2.5E-01	4.3E-06	1.9E-01	2.0E-01	7.9E+00	8.6E-06	8.6E-06	4.3E-05	1.2E-03	1.2E-04	4.3E-04	4.3E-06
17-Apr-12	20																							
24-Apr-12	21	1.4E-03	9.0E-06	4.5E-04	1.1E+00	2.3E-03	2.3E-05	5.6E-03	1.8E-04	4.1E-03	1.1E+00	5.4E-05	2.9E-01	4.5E-06	2.0E-01	2.0E-01	6.8E+00	9.0E-06	1.4E-05	4.5E-05	1.6E-03	1.4E-04	4.5E-04	4.5E-06
1-May-12	22																							
8-May-12	23	1.3E-03	1.2E-04	4.4E-04	9.1E-01	2.1E-03	4.4E-06	4.5E-03	2.6E-04	4.0E-03	9.3E-01	3.5E-05	2.3E-01	4.4E-06	1.7E-01	1.6E-01	5.1E+00	8.8E-06	4.0E-04	8.8E-05	1.2E-03	1.1E-04	4.0E-03	4.4E-06
15-May-12	24																							
22-May-12	25	1.2E-03	8.1E-06	4.1E-04	1.1E+00	2.1E-03	1.2E-05	4.9E-03	1.2E-04	3.6E-03	1.1E+00	4.5E-05	3.3E-01	4.1E-06	2.1E-01	1.9E-01	5.5E+00	8.1E-06	1.5E-04	1.2E-04	2.2E-03	1.9E-04	4.1E-04	4.1E-06
29-May-12	26																							
5-Jun-12	27	1.4E-03	1.4E-05	4.5E-04	8.6E-01	2.9E-03	4.5E-06	2.6E-03	4.5E-05	4.1E-03	8.7E-01	5.4E-05	2.5E-01	4.5E-06	1.6E-01	1.6E-01	4.2E+00	9.0E-06	1.2E-04	9.0E-05	1.1E-03	2.2E-04	4.5E-04	4.5E-06
12-Jun-12	28																							
19-Jun-12	29	1.3E-03	8.7E-06	4.4E-04	7.2E-01	2.4E-03	4.4E-06	2.1E-03	2.2E-04	3.9E-03	6.8E-01	5.2E-05	1.9E-01	4.4E-06	1.3E-01	1.3E-01	3.4E+00	8.7E-06	6.5E-05	1.7E-04	9.1E-04	2.8E-04	8.7E-04	4.4E-06
26-Jun-12	30																							
3-Jul-12	31	1.4E-03	1.4E-05	4.5E-04	8.8E-01	3.0E-03	4.5E-06	2.3E-03	4.5E-05	4.1E-03	8.1E-01	1.8E-05	2.4E-01	4.5E-06	1.6E-01	1.5E-01	4.0E+00	9.0E-06	1.2E-04	1.4E-04	8.6E-04	1.4E-04	1.4E-03	4.5E-06
10-Jul-12	32																							
17-Jul-12	33	1.3E-03	2.7E-04	4.4E-04	7.9E-01	2.6E-03	4.4E-06	2.2E-03	4.4E-05	3.9E-03	6.8E-01	1.0E-04	2.1E-01	4.4E-06	1.8E-01	1.3E-01	3.4E+00	8.7E-06	9.1E-05	4.4E-05	7.8E-04	1.6E-04	8.7E-04	4.4E-06
24-Jul-12	34																							
31-Jul-12	35	1.3E-03	7.4E-05	4.4E-04	8.4E-01	2.7E-03	4.4E-06	1.8E-03	4.4E-05	3.9E-03	6.5E-01	6.1E-05	2.2E-01	4.4E-06	1.4E-01	1.3E-01	3.1E+00	8.7E-06	8.3E-05	4.4E-05	7.2E-04	1.4E-04	2.2E-03	4.4E-06
7-Aug-12	36																							
14-Aug-12	37	1.3E-03	8.9E-06	4.5E-04	9.3E-01	2.8E-03	4.5E-06	1.9E-03	8.9E-05	4.0E-03	7.0E-01	4.5E-05	2.3E-01	4.5E-06	1.6E-01	1.4E-01	3.7E+00	8.9E-06	1.4E-04	1.8E-04	7.0E-04	2.9E-04	8.9E-04	4.5E-06
21-Aug-12	38																							
28-Aug-12	39	1.5E-03	1.0E-05	5.0E-04	1.2E+00	4.5E-03	5.0E-06	1.9E-03	4.5E-04	4.5E-03	7.0E-01	9.5E-05	2.4E-01	5.0E-06	1.6E-01	1.7E-01	4.1E+00	1.0E-05	1.1E-04	1.0E-04	1.3E-03	1.8E-04	4.5E-03	5.0E-06
4-Sep-12	40																							
11-Sep-12	41	1.0E-02	9.2E-06	4.6E-04	9.6E-01	3.6E-03	1.8E-05	1.8E-03	4.6E-05	4.1E-03	6.1E-01	6.9E-05	1.7E-01	4.6E-06	1.4E-01	1.3E-01	3.6E+00	9.2E-06	9.2E-05	9.2E-05	7.9E-04	1.1E-04	1.4E-03	1.8E-05
18-Sep-12	42																							
25-Sep-12	43	1.3E-03	8.9E-06	4.5E-04	8.5E-01	2.4E-03	4.5E-06	1.8E-03	8.9E-05	4.0E-03	4.9E-01	9.3E-05	1.4E-01	4.5E-06	1.2E-01	1.1E-01	2.8E+00	8.9E-06	5.8E-05	4.5E-05	6.8E-04	1.2E-04	4.5E-04	8.9E-06
2-Oct-12	44																							
9-Oct-12	45	2.3E-03	9.3E-06	4.7E-04	8.2E-01	3.1E-03	4.7E-06	1.5E-03	2.8E-04	4.2E-03	4.5E-01	6.5E-05	1.3E-01	4.7E-06	1.0E-01	1.1E-01	2.6E+00	9.3E-06	6.5E-05	9.3E-05	6.0E-04	9.8E-05	4.7E-04	4.7E-06
16-Oct-12	46																							
23-Oct-12	47																							
30-Oct-12	48																							
6-Nov-12	49	2.6E-03	1.7E-05	4.3E-04	9.1E-01	3.1E-03	4.3E-06	1.8E-03	8.6E-05	3.9E-03	4.2E-01	5.2E-05	1.4E-01	4.3E-06	1.1E-01	1.2E-01	2.6E+00	8.6E-06	1.9E-04	4.3E-05	4.9E-04	8.2E-05	2.2E-03	4.3E-06
13-Nov-12	50																							
20-Nov-12	51																							
27-Nov-12	52																							
4-Dec-12	53	1.4E-03	9.1E-06	4.6E-04	9.3E-01	1.9E-03	4.6E-06	1.7E-03	4.6E-05	4.1E-03	4.0E-01	4.1E-05	1.4E-01	4.6E-06	8.6E-02	1.0E-01	2.2E+00	9.1E-06	5.0E-05	1.4E-04	6.7E-04	8.6E-05	9.1E-04	4.6E-06
11-Dec-12	54																							
18-Dec-12	55																							
25-Dec-12	56																							
1-Jan-13	57	1.8E-03	9.1E-06	4.6E-04	1.1E+00	2.7E-03	4.6E-06	2.1E-03	4.6E-05	4.6E-03	4.3E-01	4.6E-05	1.8E-01	4.6E-06	1.0E-01	1.3E-01	2.6E+00	9.1E-06	1.0E-04	1.4E-04	5.8E-04	6.8E-05	4.6E-04	4.6E-06

HC5
Sample = 08-277

Date	Cycle No.	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
8-Jan-13	58																							
15-Jan-13	59																							
22-Jan-13	60																							
29-Jan-13	61	1.4E-03	5.0E-05	4.5E-04	1.1E+00	2.9E-03	4.5E-06	1.8E-03	9.0E-05	6.8E-03	3.9E-01	5.9E-05	1.6E-01	4.5E-06	1.1E-01	1.1E-01	2.5E+00	9.0E-06	9.5E-05	9.0E-05	4.7E-04	9.5E-05	9.0E-04	4.5E-06
5-Feb-13	62																							
12-Feb-13	63																							
19-Feb-13	64																							
26-Feb-13	65	1.3E-03	2.2E-05	4.4E-04	8.8E-01	1.7E-03	4.4E-06	1.9E-03	8.8E-05	4.0E-03	3.3E-01	4.8E-05	1.1E-01	4.4E-06	7.9E-02	8.7E-02	2.1E+00	8.8E-06	3.5E-05	4.4E-05	3.8E-04	1.3E-05	4.4E-04	4.4E-06
5-Mar-13	66																							
12-Mar-13	67																							
19-Mar-13	68																							
26-Mar-13	69	1.4E-03	1.2E-04	4.6E-04	9.5E-01	1.6E-03	4.6E-06	2.1E-03	4.6E-05	4.1E-03	3.0E-01	2.3E-05	1.2E-01	4.6E-06	7.8E-02	9.0E-02	2.1E+00	9.2E-06	1.8E-05	4.6E-05	3.6E-04	4.1E-05	9.2E-04	4.6E-06
2-Apr-13	70																							
9-Apr-13	71																							
16-Apr-13	72																							
23-Apr-13	73	8.1E-03	5.0E-05	4.5E-04	1.1E+00	1.4E-03	4.5E-06	2.5E-03	4.5E-05	4.1E-03	3.0E-01	3.2E-05	1.3E-01	4.5E-06	6.8E-02	9.0E-02	2.1E+00	9.0E-06	1.4E-05	4.1E-04	3.7E-04	1.4E-05	4.5E-04	4.5E-06
30-Apr-13	74																							
7-May-13	75																							
14-May-13	76																							
21-May-13	77	1.3E-03	8.8E-06	4.4E-04	1.0E+00	1.3E-03	4.4E-06	3.0E-03	4.4E-05	4.4E-03	2.8E-01	3.1E-05	1.1E-01	4.4E-06	6.6E-02	9.3E-02	2.1E+00	8.8E-06	2.6E-05	4.4E-05	3.0E-04	1.8E-05	4.4E-04	4.4E-06
28-May-13	78	1.3E-03	8.8E-06	4.4E-04	1.2E+00	1.6E-03	4.4E-06	3.4E-03	4.4E-05	4.0E-03	3.5E-01	4.4E-05	1.1E-01	4.4E-06	7.9E-02	1.1E-01	2.3E+00	8.8E-06	4.8E-05	4.4E-05	3.7E-04	2.2E-05	4.4E-04	4.4E-06
4-Jun-13	79	1.3E-03	8.8E-06	4.4E-04	1.1E+00	2.5E-03	4.4E-06	2.4E-03	1.4E-03	4.0E-03	2.4E-01	2.2E-05	9.2E-02	4.4E-06	6.2E-02	8.8E-02	1.5E+00	8.8E-06	3.5E-05	4.4E-05	3.6E-04	1.3E-05	8.8E-04	4.4E-06
11-Jun-13	80	1.4E-03	9.0E-06	4.5E-04	8.2E-01	1.9E-03	4.5E-06	1.4E-03	4.5E-05	4.1E-03	1.8E-01	2.7E-05	6.8E-02	4.5E-06	4.5E-02	7.1E-02	1.0E+00	9.0E-06	3.6E-05	4.5E-05	2.7E-04	1.4E-05	4.5E-04	4.5E-06
18-Jun-13	81	1.5E-03	9.9E-06	5.0E-04	1.0E+00	3.2E-03	5.0E-06	1.3E-03	5.0E-05	4.5E-03	2.0E-01	2.0E-05	7.9E-02	5.0E-06	5.0E-02	9.3E-02	1.3E+00	9.9E-06	6.4E-05	5.0E-05	3.8E-04	1.5E-05	5.0E-04	5.0E-06
25-Jun-13	82																							
2-Jul-13	83	1.5E-03	9.8E-06	4.9E-04	8.4E-01	2.6E-03	4.9E-06	1.2E-03	4.9E-05	4.4E-03	1.9E-01	2.0E-05	7.8E-02	4.9E-06	2.9E-02	7.5E-02	8.6E-01	9.8E-06	3.9E-05	4.9E-05	2.7E-04	2.9E-05	4.9E-04	4.9E-06
9-Jul-13	84																							
16-Jul-13	85	2.0E-03	2.5E-05	5.0E-04	8.4E-01	3.1E-03	5.0E-06	9.0E-04	5.0E-05	4.5E-03	1.6E-01	2.0E-05	7.0E-02	5.0E-06	3.5E-02	7.7E-02	8.1E-01	1.0E-05	7.5E-05	5.0E-05	2.6E-04	1.5E-05	1.0E-03	5.0E-06
23-Jul-13	86																							
30-Jul-13	87	1.5E-03	9.7E-06	4.9E-04	7.4E-01	2.9E-03	4.9E-06	8.1E-04	4.9E-05	4.4E-03	1.4E-01	1.9E-05	6.3E-02	4.9E-06	2.4E-02	6.8E-02	7.1E-01	9.7E-06	5.3E-05	4.9E-05	2.8E-04	1.5E-05	4.9E-04	4.9E-06
6-Aug-13	88																							
13-Aug-13	89	1.5E-03	9.7E-06	4.9E-04	7.5E-01	2.9E-03	4.9E-06	6.9E-04	9.7E-05	4.4E-03	1.4E-01	1.9E-05	6.8E-02	4.9E-06	2.9E-02	6.7E-02	6.7E-01	9.7E-06	7.8E-05	4.9E-05	2.6E-04	1.9E-05	1.5E-03	4.9E-06
20-Aug-13	90																							
27-Aug-13	91																							
3-Sep-13	92																							
10-Sep-13	93	1.4E-03	9.6E-06	4.8E-04	7.4E-01	3.0E-03	4.8E-06	6.7E-04	4.8E-05	4.3E-03	1.4E-01	2.9E-05	6.2E-02	4.8E-06	1.9E-02	6.9E-02	1.0E+00	9.6E-06	6.2E-05	4.8E-05	3.6E-04	1.4E-05	4.8E-04	4.8E-06
17-Sep-13	94																							
24-Sep-13	95																							
1-Oct-13	96																							
8-Oct-13	97	1.4E-03	9.4E-06	4.7E-04	6.0E-01	2.4E-03	4.7E-06	5.4E-04	4.7E-05	4.7E-03	1.1E-01	1.9E-05	6.1E-02	4.7E-06	1.9E-02	5.5E-02	6.4E-01	9.4E-06	2.4E-05	4.7E-05	2.5E-04	1.4E-05	9.4E-04	4.7E-06
15-Oct-13	98																							
22-Oct-13	99																							
29-Oct-13	100																							
5-Nov-13	101	1.5E-03	9.7E-06	4.9E-04	7.0E-01	2.7E-03	4.9E-06	5.8E-04	4.9E-05	4.4E-03	1.3E-01	1.9E-05	6.8E-02	4.9E-06	1.9E-02	6.4E-02	6.1E-01	9.7E-06	3.9E-05	4.9E-05	2.9E-04	1.5E-05	4.9E-04	4.9E-06
12-Nov-13	102																							
19-Nov-13	103																							
26-Nov-13	104																							
3-Dec-13	105	1.5E-03	9.7E-06	4.9E-04	6.7E-01	2.2E-03	4.9E-06	6.2E-04	4.9E-05	4.4E-03	1.3E-01	1.9E-05	5.8E-02	4.9E-06	1.5E-02	6.2E-02	5.5E-01	9.7E-06	7.8E-05	4.9E-05	2.8E-04	3.4E-05	4.9E-04	4.9E-06
10-Dec-13	106																							
17-Dec-13	107																							
24-Dec-13	108																							
31-Dec-13	109	1.9E-03	9.6E-06	4.8E-04	6.8E-01	2.3E-03	4.8E-06	6.3E-04	4.8E-05	4.3E-03	1.3E-01	1.9E-05	6.7E-02	4.8E-06	1.9E-02	6.4E-02	6.2E-01	9.6E-06	6.7E-05	4.8E-05	2.9E-04	1.9E-05	4.8E-04	4.8E-06
7-Jan-14	110																							
14-Jan-14	111																							
21-Jan-14	112																							
28-Jan-14	113	1.5E-03	9.8E-06	4.9E-04	7.4E-01	2.5E-03	4.9E-06	4.7E-04	4.9E-05	4.4E-03	1.2E-01	2.0E-05	6.4E-02	4.9E-06	2.0E-02	7.3E-02	7.7E-01	9.8E-06	7.4E-05	4.9E-05	3.5E-04	1.5E-05	4.9E-04	4.9E-06
4-Feb-14	114																							
11-Feb-14	115																							
18-Feb-14	116																							
25-Feb-14	117	1.5E-03	9.7E-06	4.9E-04	6.5E-01	1.8E-03	4.9E-06	5.4E-04	4.9E-05	4.4E-03	1.1E-01	1.9E-05	6.3E-02	4.9E-06	1.5E-02	6.1E-02	5.1E-01	9.7E-06	2.9E-05	4.9E-05	2.4E-04	1.5E-05	4.9E-04	4.9E-06

HC6

Sample = 08-028

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/L	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
29-Nov-11	0	500	400	7.51	1.0E+03	#N/A	7.5E+00	2.4E+01	4.7E+02	2.2E+00	9.6E-01	3.0E-01	4.9E+02	1.8E-02	5.0E-04	1.1E-03	1.0E-02	2.0E-05	1.0E-05	8.9E-03	5.3E-05	1.7E+02	5.0E-04	7.0E-04	7.3E-03
6-Dec-11	1	500	470	7.55	5.2E+02	#N/A	3.9E+00	2.3E+01	2.2E+02	1.1E+00	7.5E-01	3.0E-01	2.4E+02	2.5E-02	3.0E-04	9.0E-04	1.1E-02	2.0E-05	1.0E-05	4.1E-03	2.6E-05	7.9E+01	5.0E-04	2.3E-04	4.1E-03
13-Dec-11	2	500	455	7.53	3.7E+02	#N/A	3.3E+00	2.1E+01	1.4E+02	4.0E-01	6.6E-01	3.0E-01	1.7E+02	1.6E-02	2.0E-04	8.0E-04	9.2E-03	2.0E-05	1.0E-05	3.3E-03	1.7E-05	5.7E+01	8.0E-04	1.4E-04	1.9E-03
20-Dec-11	3	500	500	7.65	3.5E+02	#N/A	4.7E+00	2.4E+01	1.5E+02	2.0E-01	6.2E-01	3.0E-01	1.6E+02	2.8E-02	3.0E-04	8.0E-04	8.1E-03	2.0E-05	1.0E-05	3.5E-03	2.6E-05	5.3E+01	5.0E-04	1.8E-04	1.8E-03
27-Dec-11	4	500	435	7.90	2.0E+02																				
3-Jan-12	5	500	450	7.61	1.3E+02	#N/A	3.9E+00	2.2E+01	4.2E+01	2.0E-01	4.3E-01	3.0E-01	5.3E+01	6.6E-02	3.0E-04	1.1E-03	4.2E-03	2.0E-05	1.0E-05	2.4E-03	5.0E-06	1.8E+01	5.0E-04	6.5E-05	1.1E-03
10-Jan-12	6	500	450	7.53	1.2E+02																				
17-Jan-12	7	500	445	7.58	8.5E+01	#N/A	2.6E+00	2.4E+01	2.3E+01	2.0E-01	3.9E-01	3.0E-01	3.7E+01	4.8E-02	4.0E-04	5.0E-04	4.5E-03	2.0E-05	1.0E-05	2.7E-03	6.0E-06	1.3E+01	5.0E-04	4.4E-05	1.6E-03
24-Jan-12	8	500	455	7.75	8.0E+01																				
31-Jan-12	9	500	455	7.62	7.3E+01	#N/A	3.0E+00	2.6E+01	1.3E+01	2.0E-01	3.4E-01	3.0E-01	2.8E+01	4.7E-02	2.0E-04	5.0E-04	4.3E-03	2.0E-05	1.0E-05	1.9E-03	5.0E-06	9.7E+00	5.0E-04	3.4E-05	1.9E-03
7-Feb-12	10	500	475	7.76	7.1E+01																				
14-Feb-12	11	500	460	7.74	6.7E+01	#N/A	4.0E+00	2.3E+01	1.7E+01	2.0E-01	3.1E-01	3.0E-01	2.8E+01	3.6E-02	2.0E-04	7.0E-04	4.4E-03	2.0E-05	1.0E-05	1.6E-03	3.0E-06	9.7E+00	5.0E-04	3.2E-05	1.6E-03
21-Feb-12	12	500	470	7.69	6.7E+01																				
28-Feb-12	13	500	470	7.59	6.0E+01	#N/A	3.2E+00	2.1E+01	1.0E+01	2.0E-01	2.4E-01	3.0E-01	2.6E+01	8.0E-02	3.0E-04	5.0E-04	4.9E-03	2.0E-05	1.0E-05	1.9E-03	4.0E-06	9.1E+00	5.0E-04	2.9E-05	2.7E-03
6-Mar-12	14	500	450	7.69	6.8E+01																				
13-Mar-12	15	500	445	7.48	6.4E+01	#N/A	2.6E+00	2.1E+01	1.0E+01	2.0E-01	2.6E-01	3.0E-01	2.8E+01	4.9E-02	3.0E-04	8.0E-04	5.1E-03	2.0E-05	1.0E-05	1.7E-03	3.0E-06	9.7E+00	5.0E-04	1.6E-05	1.5E-03
20-Mar-12	16	500	445	7.57	6.1E+01																				
27-Mar-12	17	500	445	7.45	5.3E+01	#N/A	2.5E+00	2.0E+01	8.0E+00	2.0E-01	2.0E-01	3.0E-01	2.3E+01	5.9E-02	3.0E-04	6.0E-04	4.7E-03	2.0E-05	1.0E-05	1.7E-03	1.6E-05	8.0E+00	5.0E-04	1.1E-05	2.0E-03
3-Apr-12	18	500	455	7.45	5.0E+01																				
10-Apr-12	19	500	440	7.47	5.0E+01	#N/A	2.0E+00	1.7E+01	7.0E+00	2.0E-01	1.7E-01	3.0E-01	2.1E+01	4.6E-02	2.0E-04	4.0E-04	4.7E-03	2.0E-05	1.0E-05	1.6E-03	3.0E-06	7.3E+00	5.0E-04	2.1E-05	1.4E-03
17-Apr-12	20	500	440	7.50	6.3E+01																				
24-Apr-12	21	500	445	7.54	4.9E+01	#N/A	2.2E+00	2.1E+01	7.0E+00	2.0E-01	1.7E-01	3.0E-01	2.0E+01	1.1E-01	3.0E-04	6.0E-04	5.9E-03	2.0E-05	1.0E-05	1.2E-03	3.0E-06	7.0E+00	5.0E-04	2.5E-04	4.9E-03
1-May-12	22	500	455	7.65	5.1E+01																				
8-May-12	23	500	490	7.50	5.1E+01	#N/A	2.4E+00	1.7E+01	7.0E+00	2.0E-01	1.2E-01	3.0E-01	2.1E+01	3.6E-02	3.0E-04	4.0E-04	5.8E-03	2.0E-05	1.0E-05	5.0E-03	3.0E-06	7.4E+00	5.0E-04	1.2E-04	2.2E-03
15-May-12	24	500	480	7.51	5.0E+01																				
22-May-12	25	500	465	7.45	5.0E+01	#N/A	3.1E+00	1.6E+01	6.0E+00	2.0E-01	1.2E-01	3.0E-01	2.0E+01	6.5E-02	2.0E-04	1.4E-03	5.0E-03	2.0E-05	1.0E-05	1.7E-03	3.0E-06	7.0E+00	5.0E-04	2.2E-05	1.2E-03
29-May-12	26	500	435	7.42	4.7E+01																				
5-Jun-12	27	500	450	7.38	4.6E+01	#N/A	2.7E+00	2.1E+01	4.0E+00	2.0E-01	1.2E-01	3.0E-01	2.0E+01	6.3E-02	2.0E-04	5.0E-04	5.2E-03	2.0E-05	1.0E-05	1.3E-02	3.0E-06	6.9E+00	1.5E-03	5.8E-04	3.9E-03
12-Jun-12	28	500	445	7.44	4.5E+01																				
19-Jun-12	29	500	440	7.44	4.4E+01	#N/A	2.4E+00	1.7E+01	4.0E+00	2.0E-01	1.2E-01	3.0E-01	1.8E+01	6.4E-02	3.0E-04	6.0E-04	5.1E-03	2.0E-05	1.0E-05	2.3E-03	3.0E-06	6.4E+00	5.0E-04	1.6E-04	3.4E-03
26-Jun-12	30	500	445	7.48	4.8E+01																				
3-Jul-12	31	500	450	7.63	4.6E+01	#N/A	6.1E+00	2.4E+01	5.0E+00	2.0E-01	1.1E-01	3.0E-01	1.9E+01	5.3E-02	3.0E-04	6.0E-04	5.7E-03	2.0E-05	1.0E-05	1.3E-03	3.0E-06	6.5E+00	5.0E-04	2.8E-05	1.8E-03
10-Jul-12	32	500	440	7.43	4.7E+01																				
17-Jul-12	33	500	435	7.45	4.5E+01	#N/A	2.1E+00	1.7E+01	5.0E+00	2.0E-01	1.0E-01	3.0E-01	1.9E+01	6.4E-02	4.0E-04	1.6E-03	5.6E-03	2.0E-05	1.0E-05	3.4E-03	3.0E-06	6.6E+00	5.0E-04	7.0E-06	1.8E-03
24-Jul-12	34	500	440	7.39	4.7E+01																				
31-Jul-12	35	500	435	7.46	4.4E+01	#N/A	2.1E+00	1.6E+01	5.0E+00	2.0E-01	9.0E-02	3.0E-01	1.9E+01	5.5E-02	3.0E-04	5.0E-04	5.7E-03	2.0E-05	1.0E-05	1.8E-03	4.2E-05	6.6E+00	5.0E-04	2.3E-05	1.5E-03
7-Aug-12	36	500	440	7.51	4.3E+01																				
14-Aug-12	37	500	465	7.36	4.6E+01	#N/A	2.3E+00	1.6E+01	7.0E+00	2.0E-01	9.0E-02	3.0E-01	1.9E+01	6.2E-02	2.0E-04	1.7E-03	5.3E-03	2.0E-05	1.0E-05	1.7E-03	3.0E-06	6.6E+00	5.0E-04	5.0E-06	1.3E-03
21-Aug-12	38	500	455	7.27	5.0E+01																				
28-Aug-12	39	500	485	7.35	4.8E+01	#N/A	3.1E+00	1.6E+01	8.0E+00	2.0E-01	8.0E-02	3.0E-01	2.0E+01	4.7E-02	2.0E-04	6.0E-04	5.2E-03	2.0E-05	1.0E-05	1.6E-03	3.0E-06	7.2E+00	5.0E-04	2.8E-05	1.4E-03
4-Sep-12	40	500	475	7.29	4.2E+01																				
11-Sep-12	41	500	445	7.36	4.3E+01	#N/A	2.4E+00	1.5E+01	9.0E+00	2.0E-01	9.0E-02	3.0E-01	2.0E+01	7.9E-02	2.0E-04	7.0E-04	6.2E-03	2.0E-05	1.0E-05	1.4E-03	3.0E-06	6.9E+00	5.0E-04	2.2E-04	2.9E-03
18-Sep-12	42	500	500	7.31	4.5E+01																				
25-Sep-12	43	500	445	7.31	4.5E+01	#N/A	3.1E+00	1.6E+01	7.0E+00	2.0E-01	8.0E-02	3.0E-01	1.8E+01	6.8E-02	2.0E-04	3.0E-04	6.5E-03	2.0E-05	1.0E-05	1.3E-03	3.0E-06	6.2E+00	5.0E-04	2.0E-05	1.2E-03
2-Oct-12	44	500	440	7.21	4.3E+01																				
9-Oct-12	45	500	470	7.24	3.6E+01	#N/A	3.5E+00	1.3E+01	6.0E+00	2.0E-01	6.0E-02	3.0E-01	1.5E+01	4.6E-02	2.0E-04	4.0E-04	4.4E-03	2.0E-05	1.0E-05	1.2E-03	3.0E-06	5.3E+00	5.0E-04	2.0E-06	1.4E-03
16-Oct-12	46	500	460	7.26	4.0E+01																				
23-Oct-12	47	500	480	7.33	4.2E+01																				
30-Oct-12	48	500	460	7.27	4.7E+01																				
6-Nov-12	49	500	445	7.43	3.9E+01	#N/A	2.7E+00	1.5E+01	5.0E+00	2.0E-01	6.0E-02	3.0E-01	2.0E+01	3.4E-02	2.0E-04	5.0E-04	5.6E-03	2.0E-05	1.0E-05	2.0E-03	2.2E-05	7.1E+00	5.0E-04	9.4E-05	2.2E-03
13-Nov-12	50	500	445	7.14	4.0E+01																				
20-Nov-12	51	500	490	7.75	3.9E+01																				
27-Nov-12	52	500	490	7.31	4.5E+01																				
4-Dec-12	53	500	495	7.43	4.2E+01	#N/A	1.9E+00	1.5E+01	8.0E+00	2.0E-01	6.0E-02	3.0E-01	1.9E+01	1.8E-02	2.0E-04	2.0E-04	5.2E-03	2.0E-05	1.0E-05	1.1E-03	3.0E-06	6.8E+00	5.0E-04	5.2E-05	7.0E-04
11-Dec-12	54	500	470	7.33	4.5E+01																				
18-Dec-12	55	500	455	7.40	3.3E+01																				
25-Dec-12	56	500	460	7.35	5.0E+01																				
1-Jan-13	57	500	450	7.59	3.6E+01	#N/A	3.5E+00	1.6E+01	4.0E+00	2.0E-01	6.0E-02	3.0E-01	1.9E+01	6.2E-02	3.0E-04	9.0E-04	5.7E-03	2.0E-05	1.0E-05	7.0E-04	9.0E-06	6.6E+00	5.0E-04	2.7E-05	1.3E-03
8-Jan-13	58	500	495	7.51	4.5E+01																				
15-Jan-13	59	500	465	7.35	3.6E+01																				
22-Jan-13	60	500	455	7.51	4.4E+01																				
29-Jan-13	61	500	455	7.42	3.2E+01	#N/A	2.4E+00	1.3E+01	6.0E+00	2.0E-01	6.0E-02	3.0E-01	1.6E+01	4.6E-02	2.0E-04	2.0E-04	3.9E-03	2.0E-05	1.0E-05	9.0E-04	1.7E-05	5.7E+00	5.0E-04	2.0E-06	1.2E-03
5-Feb-13	62	500	455	7.48	3.1E+01																				
12-Feb-13	63	500	465	7.57	3.6E+01																				
19-Feb-13	64	500	445	7.44	3.4E+01																				
26-Feb-13	65	500	450	7.44	3.6E+01	#N/A	3.5E+00	1.3E+01	6.0E+00	2.0E-01	6.0E-02	3.0E-01	1.4E+01	5.2E-02	2.0E-04	4.0E-04	4.7E-03	2.0E-05	1.0E-05	8.0E-04	8.0E-06	5.0E+00	5.0E-04	2.4E-04	1.6E-03

HC6

Sample = 08-028

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/L	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
5-Mar-13	66	500	450	7.60	3.5E+01																				
12-Mar-13	67	500	445	7.40	3.6E+01																				
19-Mar-13	68	500	450	7.69	3.4E+01																				
26-Mar-13	69	500	445	7.50	3.5E+01	#N/A	4.3E+00	1.3E+01	5.0E+00	2.0E-01	6.0E-02	3.0E-01	1.5E+01	2.5E-02	2.0E-04	5.0E-04	3.7E-03	2.0E-05	1.0E-05	9.0E-04	6.0E-06	5.2E+00	5.0E-04	1.2E-04	8.0E-04
2-Apr-13	70	500	440	7.50	3.3E+01																				
9-Apr-13	71	500	450	7.49	3.4E+01																				
16-Apr-13	72	500	450	7.39	3.0E+01																				
23-Apr-13	73	500	430	7.52	4.2E+01	#N/A	4.4E+00	1.4E+01	7.0E+00	2.0E-01	6.0E-02	3.0E-01	1.6E+01	3.7E-02	2.0E-04	4.0E-04	4.9E-03	2.0E-05	1.0E-05	1.2E-03	3.0E-06	5.7E+00	5.0E-04	2.4E-05	1.7E-03
30-Apr-13	74	500	435	7.55	3.6E+01																				
7-May-13	75	500	445	7.54	3.5E+01																				
14-May-13	76	500	450	7.54	3.7E+01																				
21-May-13	77	500	435	7.51	3.5E+01	#N/A	3.3E+00	1.2E+01	7.0E+00	2.0E-01	6.0E-02	3.0E-01	1.4E+01	3.5E-02	2.0E-04	2.0E-04	4.1E-03	2.0E-05	1.0E-05	1.3E-03	1.3E-05	4.9E+00	5.0E-04	2.0E-05	1.6E-03
28-May-13	78	500	445	7.57	3.3E+01	#N/A	3.5E+00	1.2E+01	6.0E+00	2.0E-01	6.0E-02	3.0E-01	1.5E+01	4.2E-02	2.0E-04	2.0E-04	4.4E-03	2.0E-05	1.0E-05	1.3E-03	3.0E-06	5.1E+00	5.0E-04	1.6E-05	1.5E-03
4-Jun-13	79	500	455	7.45	3.4E+01	#N/A	4.0E+00	1.3E+01	5.0E+00	2.0E-01	6.0E-02	3.0E-01	1.5E+01	2.8E-02	2.0E-04	3.0E-04	4.8E-03	2.0E-05	1.0E-05	4.8E-03	1.0E-05	5.3E+00	5.0E-04	7.3E-05	2.0E-03
11-Jun-13	80	500	485	7.68	2.9E+01	#N/A	6.1E+00	1.5E+01	6.0E+00	2.0E-01	6.0E-02	3.0E-01	1.3E+01	1.2E-02	2.0E-04	2.0E-04	3.7E-03	2.0E-05	1.0E-05	3.3E-03	3.0E-06	4.8E+00	5.0E-04	1.3E-05	5.0E-04
18-Jun-13	81	500	490	7.40	2.9E+01	#N/A	4.2E+00	1.3E+01	6.0E+00	2.0E-01	6.0E-02	3.0E-01	1.4E+01	8.9E-03	2.0E-04	2.0E-04	3.4E-03	2.0E-05	1.0E-05	3.2E-03	3.0E-06	4.9E+00	5.0E-04	6.0E-05	5.0E-04
25-Jun-13	82	500	460	7.43	2.5E+01																				
2-Jul-13	83	500	470	7.86	3.6E+01	#N/A	5.1E+00	2.3E+01	4.0E+00	2.0E-01	6.0E-02	3.0E-01	1.1E+01	1.1E-02	2.0E-04	2.0E-04	2.8E-03	2.0E-05	1.0E-05	3.0E-04	3.0E-06	3.8E+00	5.0E-04	3.0E-06	7.0E-04
9-Jul-13	84	500	475	7.61	4.0E+01																				
16-Jul-13	85	500	495	7.34	2.9E+01	#N/A	3.2E+00	1.3E+01	3.0E+00	2.0E-01	6.0E-02	3.0E-01	1.4E+01	1.1E-02	2.0E-04	3.0E-04	3.6E-03	2.0E-05	1.0E-05	2.2E-03	3.0E-06	4.8E+00	5.0E-04	2.3E-05	9.0E-04
23-Jul-13	86	500	490	7.54	2.9E+01																				
30-Jul-13	87	500	490	7.30	2.7E+01	#N/A	3.8E+00	1.3E+01	5.0E+00	2.0E-01	6.0E-02	3.0E-01	1.3E+01	1.1E-02	2.0E-04	2.0E-04	3.2E-03	2.0E-05	1.0E-05	2.2E-03	3.0E-06	4.5E+00	5.0E-04	2.0E-06	6.0E-04
6-Aug-13	88	500	490	7.62	2.9E+01																				
13-Aug-13	89	500	485	7.28	2.5E+01	#N/A	2.7E+00	1.2E+01	3.0E+00	2.0E-01	6.0E-02	3.0E-01	1.3E+01	1.2E-02	2.0E-04	2.0E-04	3.4E-03	2.0E-05	1.0E-05	2.1E-03	7.0E-06	4.5E+00	5.0E-04	3.3E-05	6.0E-04
20-Aug-13	90	500	485	7.21	2.6E+01																				
27-Aug-13	91	500	490	7.37	2.3E+01																				
3-Sep-13	92	500	475	7.50	2.2E+01																				
10-Sep-13	93	500	465	7.33	2.5E+01	#N/A	3.1E+00	1.1E+01	3.0E+00	2.0E-01	6.0E-02	3.0E-01	1.2E+01	1.1E-02	2.0E-04	2.0E-04	3.1E-03	2.0E-05	1.0E-05	1.6E-03	3.0E-06	4.5E+00	5.0E-04	4.2E-05	8.0E-04
17-Sep-13	94	500	495	7.44	2.8E+01																				
24-Sep-13	95	500	490	7.30	2.6E+01																				
1-Oct-13	96	500	465	7.57	2.5E+01																				
8-Oct-13	97	500	475	7.29	2.5E+01	#N/A	1.6E+00	1.2E+01	3.0E+00	2.0E-01	6.0E-02	3.0E-01	1.3E+01	9.7E-03	2.0E-04	2.0E-04	3.3E-03	2.0E-05	1.0E-05	4.3E-03	3.0E-06	4.7E+00	5.0E-04	3.3E-05	6.0E-04
15-Oct-13	98	500	500	7.26	2.6E+01																				
22-Oct-13	99	500	470	7.31	2.6E+01																				
29-Oct-13	100	500	470	7.40	2.6E+01																				
5-Nov-13	101	500	490	7.40	2.8E+01	#N/A	1.7E+00	1.2E+01	4.0E+00	2.0E-01	6.0E-02	3.0E-01	1.4E+01	6.5E-03	2.0E-04	2.0E-04	3.7E-03	2.0E-05	1.0E-05	1.4E-03	3.0E-06	4.9E+00	5.0E-04	1.8E-05	7.0E-04
12-Nov-13	102	500	470	7.46	2.4E+01																				
19-Nov-13	103	500	465	7.26	2.6E+01																				
26-Nov-13	104	500	470	7.64	2.5E+01																				
3-Dec-13	105	500	470	7.53	2.4E+01	#N/A	6.6E-01	1.1E+01	3.0E+00	2.0E-01	6.0E-02	3.0E-01	1.2E+01	1.2E-02	2.0E-04	2.0E-04	3.4E-03	2.0E-05	1.0E-05	1.1E-03	3.0E-06	4.3E+00	5.0E-04	2.0E-05	6.0E-04
10-Dec-13	106	500	480	7.50	2.4E+01																				
17-Dec-13	107	500	460	7.58	2.4E+01																				
24-Dec-13	108	500	490	7.51	2.9E+01																				
31-Dec-13	109	500	500	7.52	2.7E+01	#N/A	1.5E+00	1.2E+01	2.0E+00	2.0E-01	6.0E-02	3.0E-01	1.3E+01	1.0E-02	2.0E-04	2.0E-04	3.7E-03	2.0E-05	1.0E-05	1.7E-03	3.0E-06	4.6E+00	5.0E-04	1.8E-05	8.0E-04
7-Jan-14	110	500	490	7.31	2.7E+01																				
14-Jan-14	111	500	485	7.64	2.2E+01																				
21-Jan-14	112	500	480	7.54	2.5E+01																				
28-Jan-14	113	500	485	7.45	2.7E+01	#N/A	1.7E+00	1.2E+01	3.0E+00	2.0E-01	6.0E-02	3.0E-01	1.3E+01	8.6E-03	2.0E-04	2.0E-04	3.5E-03	2.0E-05	1.0E-05	1.6E-03	3.0E-06	4.7E+00	5.0E-04	2.0E-06	5.0E-04
4-Feb-14	114	500	480	7.61	2.5E+01																				
11-Feb-14	115	500	470	7.61	2.1E+01																				
18-Feb-14	116	500	485	7.63	2.5E+01																				
25-Feb-14	117	500	485	7.61	2.3E+01	#N/A	2.7E+00	1.4E+01	5.0E+00	2.0E-01	6.0E-02	3.0E-01	1.2E+01	8.1E-03	2.0E-04	2.0E-04	3.2E-03	2.0E-05	1.0E-05	1.3E-03	3.0E-06	4.2E+00	5.0E-04	1.8E-05	5.0E-04

HC6

Sample = 08-028

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Major	Major	Diff	Diff
	No.																								Anions	Cations		(%)
		mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L				
29-Nov-11	0	3.0E-03	1.0E-04	3.0E-03	1.7E+01	2.6E-02	1.0E-02	1.8E-02	4.3E-03	1.3E-02	1.7E+01	2.7E-03	1.6E+00	1.0E-05	1.0E+01	3.7E-01	1.7E+02	4.0E-05	1.0E-05	2.0E-04	9.9E-03	2.5E-04	2.0E-03	5.0E-05	10.36	10.66	0.30	1.5%
6-Dec-11	1	3.0E-03	2.0E-05	2.0E-03	9.8E+00	1.8E-02	1.0E-02	2.6E-02	3.0E-04	9.0E-03	1.0E+01	1.6E-03	1.2E+00	1.0E-05	6.5E+00	1.7E-01	8.2E+01	2.0E-05	1.0E-05	2.0E-04	8.9E-03	3.1E-04	3.0E-03	1.0E-05	5.11	5.30	0.19	1.9%
13-Dec-11	2	3.0E-03	1.1E-04	1.0E-03	6.7E+00	1.3E-02	1.0E-02	1.7E-02	1.6E-03	9.0E-03	7.9E+00	1.2E-03	9.9E-01	1.0E-05	3.8E+00	1.3E-01	5.3E+01	2.0E-05	7.0E-05	1.0E-04	6.0E-03	1.5E-04	3.0E-03	2.0E-05	3.44	3.77	0.33	4.6%
20-Dec-11	3	3.0E-03	2.0E-05	1.0E-03	5.7E+00	1.5E-02	1.0E-02	1.6E-02	1.8E-03	9.0E-03	6.3E+00	6.2E-04	1.2E+00	1.0E-05	2.3E+00	1.2E-01	5.1E+01	2.0E-05	1.0E-05	2.0E-04	7.3E-03	3.1E-04	2.0E-03	1.0E-05	3.53	3.40	-0.13	-1.9%
27-Dec-11	4																											
3-Jan-12	5	3.0E-03	2.0E-05	1.0E-03	1.8E+00	5.9E-03	1.0E-02	9.7E-03	9.0E-04	9.0E-03	3.3E+00	2.0E-04	7.2E-01	1.0E-05	8.6E-01	4.0E-02	1.4E+01	2.0E-05	5.0E-05	4.0E-04	3.0E-03	6.2E-04	1.0E-03	1.0E-05	1.33	1.19	-0.15	-5.8%
10-Jan-12	6																											
17-Jan-12	7	6.0E-03	5.0E-05	1.0E-03	1.2E+00	4.9E-03	1.0E-02	8.0E-03	2.0E-04	9.0E-03	2.7E+00	1.6E-04	8.1E-01	1.0E-05	5.0E-01	2.8E-02	7.8E+00	2.0E-05	4.0E-05	5.0E-04	2.4E-03	4.1E-04	2.0E-03	2.0E-05	0.97	0.83	-0.14	-7.6%
24-Jan-12	8																											
31-Jan-12	9	5.0E-03	1.0E-04	1.0E-03	9.6E-01	4.2E-03	1.0E-02	6.9E-03	1.0E-04	9.0E-03	2.4E+00	1.4E-04	7.7E-01	1.0E-05	3.5E-01	2.2E-02	5.0E+00	2.0E-05	3.0E-05	4.0E-04	2.2E-03	4.4E-04	2.0E-03	1.0E-05	0.80	0.64	-0.16	-11.0%
7-Feb-12	10																											
14-Feb-12	11	7.0E-03	2.0E-05	1.0E-03	9.5E-01	3.7E-03	1.0E-02	6.7E-03	4.0E-04	9.0E-03	2.1E+00	2.5E-04	7.8E-01	1.0E-05	3.3E-01	2.3E-02	4.6E+00	2.0E-05	2.0E-05	5.0E-04	2.0E-03	2.0E-04	1.0E-03	1.0E-05	0.83	0.64	-0.19	-13.3%
21-Feb-12	12																											
28-Feb-12	13	3.0E-03	2.0E-05	1.0E-03	8.5E-01	4.5E-03	1.0E-02	5.3E-03	1.0E-04	9.0E-03	2.0E+00	6.0E-05	7.1E-01	1.0E-05	2.0E-01	2.1E-02	3.8E+00	2.0E-05	7.0E-05	7.0E-04	2.0E-03	3.5E-04	4.0E-03	2.0E-05	0.64	0.59	-0.05	-3.9%
6-Mar-12	14																											
13-Mar-12	15	8.0E-03	2.0E-05	1.0E-03	8.9E-01	3.0E-03	1.0E-02	5.5E-03	1.0E-04	9.0E-03	2.2E+00	4.0E-05	8.6E-01	1.0E-05	2.1E-01	2.3E-02	4.5E+00	2.0E-05	1.8E-04	3.0E-04	2.1E-03	2.1E-04	3.0E-03	2.0E-05	0.64	0.63	-0.02	-1.4%
20-Mar-12	16																											
27-Mar-12	17	5.0E-03	2.5E-04	1.0E-03	7.4E-01	3.5E-03	1.0E-02	4.1E-03	1.0E-04	9.0E-03	1.9E+00	7.0E-05	8.1E-01	1.0E-05	1.7E-01	1.8E-02	2.9E+00	2.0E-05	1.0E-05	4.0E-04	2.2E-03	4.3E-04	1.0E-03	1.0E-05	0.58	0.53	-0.06	-5.3%
3-Apr-12	18																											
10-Apr-12	19	5.0E-03	3.0E-05	1.0E-03	6.5E-01	2.9E-03	2.0E-02	4.0E-03	1.0E-04	9.0E-03	1.6E+00	7.0E-05	6.6E-01	1.0E-05	1.3E-01	1.7E-02	2.9E+00	2.0E-05	4.0E-05	3.0E-04	1.4E-03	3.4E-04	2.0E-03	1.0E-05	0.49	0.47	-0.02	-2.6%
17-Apr-12	20																											
24-Apr-12	21	1.4E-02	5.0E-05	1.0E-03	6.5E-01	3.5E-03	3.0E-02	3.8E-03	1.0E-04	9.0E-03	2.2E+00	1.1E-04	8.5E-01	1.0E-05	1.5E-01	1.7E-02	2.5E+00	2.0E-05	4.0E-05	1.0E-03	2.1E-03	4.4E-04	2.0E-03	3.0E-05	0.57	0.48	-0.09	-8.6%
1-May-12	22																											
8-May-12	23	3.6E-02	8.0E-05	1.0E-03	6.9E-01	3.1E-03	1.0E-02	4.9E-03	5.0E-04	9.0E-03	2.0E+00	1.3E-04	7.1E-01	1.0E-05	1.2E-01	1.7E-02	2.9E+00	2.0E-05	3.5E-04	2.0E-04	2.6E-03	3.3E-04	5.0E-03	1.0E-05	0.50	0.49	-0.01	-1.1%
15-May-12	24																											
22-May-12	25	4.0E-03	2.0E-05	1.0E-03	6.5E-01	3.1E-03	2.0E-02	7.1E-03	3.0E-04	9.0E-03	1.8E+00	4.0E-05	6.8E-01	1.0E-05	1.2E-01	1.6E-02	2.9E+00	2.0E-05	6.9E-04	8.0E-04	2.1E-03	5.4E-04	1.0E-03	1.0E-05	0.46	0.46	0.00	0.5%
29-May-12	26																											
5-Jun-12	27	1.5E-01	2.0E-05	1.0E-03	6.2E-01	6.1E-03	1.0E-02	4.2E-03	6.2E-03	9.0E-03	2.0E+00	1.3E-04	8.0E-01	1.0E-05	1.3E-01	1.6E-02	2.3E+00	2.0E-05	1.0E-04	6.0E-04	2.2E-03	6.5E-04	2.0E-03	8.0E-05	0.50	0.47	-0.03	-3.4%
12-Jun-12	28																											
19-Jun-12	29	6.0E-03	6.5E-04	1.0E-03	5.8E-01	3.0E-03	1.0E-02	3.0E-03	2.0E-04	9.0E-03	1.9E+00	9.0E-05	7.8E-01	1.0E-05	1.1E-01	1.5E-02	2.0E+00	2.0E-05	3.4E-04	4.0E-04	2.3E-03	4.8E-04	6.0E-03	1.0E-05	0.43	0.43	0.00	0.3%
26-Jun-12	30																											
3-Jul-12	31	1.0E-02	4.0E-05	1.0E-03	5.9E-01	4.0E-03	1.0E-02	3.0E-03	1.0E-04	9.0E-03	2.1E+00	8.0E-05	8.3E-01	1.0E-05	1.1E-01	1.6E-02	2.0E+00	2.0E-05	3.9E-04	4.0E-04	2.7E-03	3.5E-04	2.0E-03	1.0E-05	0.59	0.44	-0.15	-14.6%
10-Jul-12	32																											
17-Jul-12	33	7.0E-03	7.0E-05	1.0E-03	5.8E-01	3.2E-03	1.0E-02	3.3E-03	1.0E-04	9.0E-03	2.0E+00	2.7E-04	8.3E-01	1.2E-04	1.5E-01	1.6E-02	2.3E+00	2.0E-05	2.8E-04	6.0E-04	2.2E-03	5.3E-04	2.0E-03	2.0E-05	0.45	0.44	-0.01	-1.1%
24-Jul-12	34																											
31-Jul-12	35	1.1E-02	1.0E-04	1.0E-03	5.7E-01	3.0E-03	1.0E-02	2.7E-03	1.0E-04	9.0E-03	1.8E+00	1.9E-04	8.4E-01	1.0E-05	1.1E-01	1.6E-02	2.2E+00	2.0E-05	1.5E-04	3.0E-04	1.7E-03	4.3E-04	2.0E-03	1.0E-05	0.44	0.43	0.00	-0.4%
7-Aug-12	36																											
14-Aug-12	37	3.0E-03	2.0E-05	1.0E-03	5.6E-01	3.0E-03	1.0E-02	2.9E-03	1.0E-04	9.0E-03	1.6E+00	1.0E-04	7.2E-01	1.0E-05	1.0E-01	1.5E-02	3.0E+00	2.0E-05	1.8E-04	3.0E-04	1.5E-03	6.8E-04	2.0E-03	1.0E-05	0.47	0.43	-0.04	-4.0%
21-Aug-12	38																											
28-Aug-12	39	4.0E-03	2.0E-05	1.0E-03	5.9E-01	3.9E-03	2.0E-02	2.7E-03	2.0E-04	9.0E-03	1.4E+00	4.0E-05	6.5E-01	1.0E-05	8.0E-02	1.6E-02	2.9E+00	2.0E-05	3.7E-04	2.0E-04	2.2E-03	3.5E-04	2.0E-03	1.0E-05	0.49	0.45	-0.04	-4.1%
4-Sep-12	40																											
11-Sep-12	41	1.4E-02	3.0E-05	1.0E-03	5.8E-01	2.7E-03	4.0E-02	2.4E-03	3.2E-03	9.0E-03	1.5E+00	1.3E-04	7.7E-01	1.0E-05	9.0E-02	1.6E-02	2.8E+00	2.0E-05	5.0E-05	1.1E-03	1.5E-03	2.6E-04	1.0E-03	2.0E-05	0.49	0.44	-0.05	-5.0%
18-Sep-12	42																											
25-Sep-12	43	1.2E-02	2.0E-05	1.0E-03	5.5E-01	2.2E-03	1.0E-02	6.4E-03	1.0E-04	9.0E-03	1.3E+00	1.5E-04	6.3E-01	1.0E-05	8.0E-02	1.5E-02	2.5E+00	2.0E-05	1.0E-04	5.0E-04	1.6E-03	3.5E-04	1.0E-03	2.0E-05	0.46	0.40	-0.06	-7.1%
2-Oct-12	44																											
9-Oct-12	45	3.0E-03	2.0E-05	1.0E-03	4.3E-01	3.2E-03	1.0E-02	1.9E-03	2.0E-04	9.0E-03	9.9E-01	1.5E-04	4.7E-01	1.0E-05	7.0E-02	1.2E-02	2.1E+00	2.0E-05	1.4E-04	4.0E-04	1.0E-03	3.4E-04	2.0E-03	1.0E-05	0.39	0.33	-0.05	-7.2%
16-Oct-12	46																											
23-Oct-12	47																											
30-Oct-12	48																											
6-Nov-12	49	5.0E-03	3.0E-05	1.0E-03	5.6E-01	2.7E-03	1.0E-02	2.2E-03	3.0E-04	9.0E-03	1.2E+00	1.2E-04	6.6E-01	1.0E-05	1.0E-01	1.6E-02	2.7E+00	2.0E-05	6.0E-04	2.0E-04	1.4E-03	1.6E-04	3.0E-03	1.0E-05	0.39	0.44	0.04	5.3%
13-Nov-12	50																											
20-Nov-12	51																											
27-Nov-12	52																											
4-Dec-12	53	3.0E-03	2.0E-05	1.0E-03	5.6E-01	2.5E-03	1.0E-02	2.1E-03	1.0E-04	9.0E-03	1.1E+00	1.3E-03	5.2E-01	1.0E-05	6.0E-02	1.5E-02	2.8E+00	2.0E-05	9.0E-05	1.0E-04	2.6E-03	2.0E-04	2.0E-03	1.0E-05	0.46	0.42	-0.04	-4.6%
11-Dec-12	54																											
18-Dec-12	55																											
25-Dec-12	56																											
1-Jan-13	57	1.5E-02	4.0E-05	1.0E-03	5.4E-01	2.7E-03	1.0E-02	1.9E-03	1.0E-04	1.2E-02	1.1E+00	6.0E-05	7.0E-01	1.0E-05	6.0E-02	1.5E-02	2.2E+00	2.0E-05	1.6E-04	1.0E-03	1.4E-03	2.9E-04	2.0E-03	3.0E-05	0.40	0.41	0.01	1.0%
8-Jan-13	58																											
15-Jan-13	59																											
22-Jan-13	60																											
29-Jan-13	61	4.0E-03	2.0E-05	1.0E-03	4.6E-01	2.6E-03	1.0E-02	1.5E-03	1.0E-04	9.0E-03	8.2E-01	6.0E-05	4.9E-01	1.0E-05	9.0E-02	1.2E-02	2.1E+00	2.0E-05	1.4E-04	4.0E-04	1.1E-03	3.1E-04	1.0E-03	5.0E-05	0.39	0.35	-0.03	-4.5%
5-Feb-13	62																											
12-Feb-13	63																											
19-Feb-13	64																											
26-Feb-13	65	9.0E-03	5.0E-05	1.0E-03	4.3E-01	2.3E-03	1.0E-02	1.6E-03	1.0E-04	1.2E-02	8.2E-01	7.0E-05	4.8E-01	1.0E-05	5.0E-02	1.1E-02	2.0E+00	2.0E-05	1.0E-05	7.0E-04	9.1E-04	1.1E-04	1.0E-03	1.0E-05	0.39	0.32	-0.08	-10.8%

HC6

Sample = 08-028

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Major	Major	Diff	Diff
	No.																								Anions	Cations		(%)
		mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L				
5-Mar-13	66																											
12-Mar-13	67																											
19-Mar-13	68																											
26-Mar-13	69	4.0E-03	1.6E-04	1.0E-03	4.3E-01	1.6E-03	2.0E-02	1.4E-03	1.0E-04	9.0E-03	7.3E-01	4.0E-05	4.4E-01	1.0E-05	5.0E-02	1.1E-02	1.9E+00	2.0E-05	2.0E-05	1.0E-04	9.2E-04	1.3E-04	1.0E-03	1.0E-05	0.37	0.32	-0.05	-7.4%
2-Apr-13	70																											
9-Apr-13	71																											
16-Apr-13	72																											
23-Apr-13	73	1.4E-02	4.0E-05	1.0E-03	4.8E-01	1.9E-03	1.0E-02	1.5E-03	1.0E-04	9.0E-03	8.0E-01	4.0E-05	5.9E-01	1.0E-05	6.0E-02	1.3E-02	2.2E+00	2.0E-05	2.0E-05	5.0E-04	1.0E-03	1.1E-04	1.0E-03	2.0E-05	0.43	0.35	-0.08	-10.6%
30-Apr-13	74																											
7-May-13	75																											
14-May-13	76																											
21-May-13	77	1.5E-02	2.0E-05	1.0E-03	3.7E-01	2.2E-03	1.0E-02	1.4E-03	1.0E-04	9.0E-03	9.3E-01	5.0E-05	4.9E-01	1.0E-05	5.0E-02	1.1E-02	1.7E+00	2.0E-05	4.0E-05	4.0E-04	8.7E-04	1.3E-04	1.0E-03	2.0E-05	0.39	0.30	-0.08	-12.2%
28-May-13	78	1.0E-02	3.0E-05	1.0E-03	4.0E-01	2.1E-03	1.0E-02	1.5E-03	1.0E-04	9.0E-03	9.7E-01	8.0E-05	4.3E-01	1.0E-05	5.0E-02	1.2E-02	1.8E+00	2.0E-05	4.0E-05	4.0E-04	9.4E-04	1.0E-04	1.0E-03	1.0E-05	0.37	0.32	-0.05	-7.0%
4-Jun-13	79	9.0E-03	2.0E-05	1.0E-03	3.9E-01	2.6E-03	1.0E-02	1.4E-03	2.1E-03	9.0E-03	7.7E-01	4.0E-05	3.8E-01	1.0E-05	5.0E-02	1.1E-02	1.3E+00	2.0E-05	1.4E-04	3.0E-04	1.4E-03	7.0E-05	3.0E-03	2.0E-05	0.37	0.32	-0.05	-6.8%
11-Jun-13	80	3.0E-03	2.0E-05	1.0E-03	3.5E-01	1.6E-03	1.0E-02	8.7E-04	1.0E-04	9.0E-03	6.3E-01	5.0E-05	2.9E-01	1.0E-05	4.0E-02	1.0E-02	9.7E-01	2.0E-05	7.0E-05	1.0E-04	1.6E-03	3.0E-05	1.0E-03	1.0E-05	0.43	0.29	-0.14	-19.4%
18-Jun-13	81	3.0E-03	2.0E-05	1.0E-03	3.5E-01	3.1E-03	1.0E-02	6.9E-04	1.0E-04	9.0E-03	6.2E-01	4.0E-05	2.6E-01	1.0E-05	5.0E-02	1.0E-02	8.8E-01	2.0E-05	9.0E-05	1.0E-04	1.6E-03	4.0E-05	1.0E-03	1.0E-05	0.39	0.29	-0.10	-14.5%
25-Jun-13	82																											
2-Jul-13	83	3.0E-03	2.0E-05	1.0E-03	2.8E-01	1.8E-03	1.0E-02	6.8E-04	1.0E-04	9.0E-03	5.6E-01	4.0E-05	2.3E-01	1.0E-05	2.0E-02	8.2E-03	6.9E-01	2.0E-05	2.0E-05	1.0E-04	1.6E-03	1.0E-04	1.0E-03	1.0E-05	0.54	0.23	-0.31	-40.2%
9-Jul-13	84																											
16-Jul-13	85	3.0E-03	3.0E-05	1.0E-03	3.4E-01	3.0E-03	1.0E-02	4.5E-04	1.0E-04	1.0E-02	5.3E-01	4.0E-05	2.5E-01	1.0E-05	3.0E-02	9.9E-03	6.5E-01	2.0E-05	3.0E-05	1.0E-04	1.6E-03	3.0E-05	2.0E-03	1.0E-05	0.32	0.29	-0.04	-6.1%
23-Jul-13	86																											
30-Jul-13	87	3.0E-03	2.0E-05	1.0E-03	3.1E-01	2.7E-03	1.0E-02	4.4E-04	1.0E-04	9.0E-03	5.0E-01	4.0E-05	2.4E-01	1.0E-05	5.0E-02	9.2E-03	6.4E-01	2.0E-05	1.5E-04	1.0E-04	1.6E-03	3.0E-05	1.0E-03	1.0E-05	0.37	0.27	-0.10	-15.9%
6-Aug-13	88																											
13-Aug-13	89	3.0E-03	4.0E-05	1.0E-03	3.1E-01	2.9E-03	1.0E-02	3.7E-04	2.0E-04	9.0E-03	4.6E-01	4.0E-05	2.8E-01	1.0E-05	4.0E-02	9.2E-03	6.1E-01	2.0E-05	1.4E-04	1.0E-04	1.4E-03	3.0E-05	3.0E-03	< 0.00001	0.30	0.27	-0.04	-6.7%
20-Aug-13	90																											
27-Aug-13	91																											
3-Sep-13	92																											
10-Sep-13	93	3.0E-03	2.0E-05	1.0E-03	3.2E-01	2.6E-03	1.0E-02	4.0E-04	1.0E-04	9.0E-03	4.7E-01	4.0E-05	2.6E-01	1.0E-05	2.0E-02	9.3E-03	8.1E-01	2.0E-05	1.3E-04	1.0E-04	1.5E-03	3.0E-05	1.0E-03	1.0E-05	0.29	0.27	-0.03	-4.8%
17-Sep-13	94																											
24-Sep-13	95																											
1-Oct-13	96																											
8-Oct-13	97	3.0E-03	2.0E-05	1.0E-03	3.1E-01	2.8E-03	1.0E-02	3.4E-04	1.0E-04	9.0E-03	4.2E-01	4.0E-05	2.7E-01	1.0E-05	2.0E-02	9.0E-03	6.7E-01	2.0E-05	7.0E-05	1.0E-04	1.5E-03	3.0E-05	2.0E-03	1.0E-05	0.29	0.27	-0.02	-3.5%
15-Oct-13	98																											
22-Oct-13	99																											
29-Oct-13	100																											
5-Nov-13	101	3.0E-03	2.0E-05	1.0E-03	3.3E-01	2.2E-03	1.0E-02	3.5E-04	1.0E-04	9.0E-03	4.2E-01	4.0E-05	2.4E-01	1.0E-05	2.0E-02	9.9E-03	7.0E-01	2.0E-05	5.0E-05	1.0E-04	1.5E-03	3.0E-05	1.0E-03	1.0E-05	0.32	0.28	-0.04	-6.0%
12-Nov-13	102																											
19-Nov-13	103																											
26-Nov-13	104																											
3-Dec-13	105	3.0E-03	2.0E-05	1.0E-03	2.9E-01	2.0E-03	1.0E-02	4.0E-04	1.0E-04	9.0E-03	4.0E-01	4.0E-05	2.1E-01	1.0E-05	1.0E-02	8.8E-03	5.1E-01	2.0E-05	1.6E-04	1.0E-04	1.4E-03	8.0E-05	1.0E-03	1.0E-05	0.28	0.25	-0.03	-5.3%
10-Dec-13	106																											
17-Dec-13	107																											
24-Dec-13	108																											
31-Dec-13	109	6.0E-03	2.0E-05	1.0E-03	3.1E-01	2.0E-03	1.0E-02	3.4E-04	1.0E-04	9.0E-03	3.7E-01	4.0E-05	2.5E-01	1.0E-05	1.0E-02	9.4E-03	5.8E-01	2.0E-05	1.7E-04	1.0E-04	1.3E-03	5.0E-05	1.0E-03	1.0E-05	0.27	0.27	-0.01	-1.3%
7-Jan-14	110																											
14-Jan-14	111																											
21-Jan-14	112																											
28-Jan-14	113	3.0E-03	2.0E-05	1.0E-03	3.1E-01	2.5E-03	1.0E-02	3.5E-04	1.0E-04	9.0E-03	3.4E-01	4.0E-05	2.2E-01	1.0E-05	2.0E-02	9.7E-03	6.8E-01	2.0E-05	2.2E-04	1.0E-04	1.2E-03	3.0E-05	2.0E-03	1.0E-05	0.30	0.27	-0.03	-4.9%
4-Feb-14	114																											
11-Feb-14	115																											
18-Feb-14	116																											
25-Feb-14	117	3.0E-03	2.0E-05	1.0E-03	2.7E-01	1.9E-03	1.0E-02	2.9E-04	1.0E-04	9.0E-03	3.1E-01	4.0E-05	2.0E-01	1.0E-05	1.0E-02	8.3E-03	4.9E-01	2.0E-05	9.0E-05	1.0E-04	1.0E-03	3.0E-05	1.0E-03	1.0E-05	0.38	0.24	-0.14	-22.2%

HC6
Sample = 08-028

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/kg	mgCaCO3/kg	mgCaCO3/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
29-Nov-11	0	500	400	7.51	1.0E+03	#N/A	3.0E+00	9.5E+00	1.9E+02	8.8E-01	3.8E-01	1.2E-01	2.0E+02	7.1E-03	2.0E-04	4.4E-04	4.1E-03	8.0E-06	4.0E-06	3.6E-03	2.1E-05	6.7E+01	2.0E-04	2.8E-04	2.9E-03
6-Dec-11	1	500	470	7.55	5.2E+02	#N/A	1.8E+00	1.1E+01	1.0E+02	5.2E-01	3.5E-01	1.4E-01	1.1E+02	1.2E-02	1.4E-04	4.2E-04	5.0E-03	9.4E-06	4.7E-06	1.9E-03	1.2E-05	3.7E+01	2.4E-04	1.1E-04	1.9E-03
13-Dec-11	2	500	455	7.53	3.7E+02	#N/A	1.5E+00	9.5E+00	6.5E+01	1.8E-01	3.0E-01	1.4E-01	7.7E+01	7.1E-03	9.1E-05	3.6E-04	4.2E-03	9.1E-06	4.6E-06	1.5E-03	7.7E-06	2.6E+01	3.6E-04	6.6E-05	8.6E-04
20-Dec-11	3	500	500	7.65	3.5E+02	#N/A	2.4E+00	1.2E+01	7.3E+01	1.0E-01	3.1E-01	1.5E-01	7.9E+01	1.4E-02	1.5E-04	4.0E-04	4.1E-03	1.0E-05	5.0E-06	1.8E-03	1.3E-05	2.7E+01	2.5E-04	9.2E-05	9.0E-04
27-Dec-11	4	500	435	7.90	2.0E+02																				
3-Jan-12	5	500	450	7.61	1.3E+02	#N/A	1.8E+00	9.8E+00	1.9E+01	9.0E-02	1.9E-01	1.4E-01	2.4E+01	3.0E-02	1.4E-04	5.0E-04	1.9E-03	9.0E-06	4.5E-06	1.1E-03	2.3E-06	8.2E+00	2.3E-04	2.9E-05	5.0E-04
10-Jan-12	6	500	450	7.53	1.2E+02																				
17-Jan-12	7	500	445	7.58	8.5E+01	#N/A	1.1E+00	1.0E+01	1.0E+01	8.9E-02	1.7E-01	1.3E-01	1.6E+01	2.1E-02	1.8E-04	2.2E-04	2.0E-03	8.9E-06	4.5E-06	1.2E-03	2.7E-06	5.7E+00	2.2E-04	2.0E-05	7.1E-04
24-Jan-12	8	500	455	7.75	8.0E+01																				
31-Jan-12	9	500	455	7.62	7.3E+01	#N/A	1.4E+00	1.2E+01	5.9E+00	9.1E-02	1.5E-01	1.4E-01	1.3E+01	2.1E-02	9.1E-05	2.3E-04	2.0E-03	9.1E-06	4.6E-06	8.6E-04	2.3E-06	4.4E+00	2.3E-04	1.5E-05	8.6E-04
7-Feb-12	10	500	475	7.76	7.1E+01																				
14-Feb-12	11	500	460	7.74	6.7E+01	#N/A	1.8E+00	1.1E+01	7.8E+00	9.2E-02	1.4E-01	1.4E-01	1.3E+01	1.7E-02	9.2E-05	3.2E-04	2.0E-03	9.2E-06	4.6E-06	7.4E-04	1.4E-06	4.5E+00	2.3E-04	1.5E-05	7.4E-04
21-Feb-12	12	500	470	7.69	6.7E+01																				
28-Feb-12	13	500	470	7.59	6.0E+01	#N/A	1.5E+00	9.9E+00	4.7E+00	9.4E-02	1.1E-01	1.4E-01	1.2E+01	3.8E-02	1.4E-04	2.4E-04	2.3E-03	9.4E-06	4.7E-06	8.9E-04	1.9E-06	4.3E+00	2.4E-04	1.4E-05	1.3E-03
6-Mar-12	14	500	450	7.69	6.8E+01																				
13-Mar-12	15	500	445	7.48	6.4E+01	#N/A	1.2E+00	9.4E+00	4.5E+00	8.9E-02	1.2E-01	1.3E-01	1.2E+01	2.2E-02	1.3E-04	3.6E-04	2.3E-03	8.9E-06	4.5E-06	7.6E-04	1.3E-06	4.3E+00	2.2E-04	7.1E-06	6.7E-04
20-Mar-12	16	500	445	7.57	6.1E+01																				
27-Mar-12	17	500	445	7.45	5.3E+01	#N/A	1.1E+00	9.0E+00	3.6E+00	8.9E-02	8.9E-02	1.3E-01	1.0E+01	2.6E-02	1.3E-04	2.7E-04	2.1E-03	8.9E-06	4.5E-06	7.6E-04	7.1E-06	3.6E+00	2.2E-04	4.9E-06	8.9E-04
3-Apr-12	18	500	455	7.45	5.0E+01																				
10-Apr-12	19	500	440	7.47	5.0E+01	#N/A	8.9E-01	7.4E+00	3.1E+00	8.8E-02	7.5E-02	1.3E-01	9.2E+00	2.0E-02	8.8E-05	1.8E-04	2.1E-03	8.8E-06	4.4E-06	7.0E-04	1.3E-06	3.2E+00	2.2E-04	9.2E-06	6.2E-04
17-Apr-12	20	500	440	7.50	6.3E+01																				
24-Apr-12	21	500	445	7.54	4.9E+01	#N/A	9.7E-01	9.3E+00	3.1E+00	8.9E-02	7.6E-02	1.3E-01	9.0E+00	5.1E-02	1.3E-04	2.7E-04	2.6E-03	8.9E-06	4.5E-06	5.3E-04	1.3E-06	3.1E+00	2.2E-04	1.1E-04	2.2E-03
1-May-12	22	500	455	7.65	5.1E+01																				
8-May-12	23	500	490	7.50	5.1E+01	#N/A	1.2E+00	8.5E+00	3.4E+00	9.8E-02	5.9E-02	1.5E-01	1.0E+01	1.8E-02	1.5E-04	2.0E-04	2.8E-03	9.8E-06	4.9E-06	2.5E-03	1.5E-06	3.6E+00	2.5E-04	5.7E-05	1.1E-03
15-May-12	24	500	480	7.51	5.0E+01																				
22-May-12	25	500	465	7.45	5.0E+01	#N/A	1.4E+00	7.5E+00	2.8E+00	9.3E-02	5.6E-02	1.4E-01	9.3E+00	3.0E-02	9.3E-05	6.5E-04	2.3E-03	9.3E-06	4.7E-06	7.9E-04	1.4E-06	3.2E+00	2.3E-04	1.0E-05	5.6E-04
29-May-12	26	500	435	7.42	4.7E+01																				
5-Jun-12	27	500	450	7.38	4.6E+01	#N/A	1.2E+00	9.3E+00	1.8E+00	9.0E-02	5.4E-02	1.4E-01	8.9E+00	2.8E-02	9.0E-05	2.3E-04	2.3E-03	9.0E-06	4.5E-06	5.9E-03	1.4E-06	3.1E+00	6.8E-04	2.6E-04	1.8E-03
12-Jun-12	28	500	445	7.44	4.5E+01																				
19-Jun-12	29	500	440	7.44	4.4E+01	#N/A	1.1E+00	7.4E+00	1.8E+00	8.8E-02	5.3E-02	1.3E-01	8.1E+00	2.8E-02	1.3E-04	2.6E-04	2.2E-03	8.8E-06	4.4E-06	1.0E-03	1.3E-06	2.8E+00	2.2E-04	6.9E-05	1.5E-03
26-Jun-12	30	500	445	7.48	4.8E+01																				
3-Jul-12	31	500	450	7.63	4.6E+01	#N/A	2.8E+00	1.1E+01	2.3E+00	9.0E-02	5.0E-02	1.4E-01	8.4E+00	2.4E-02	1.4E-04	2.7E-04	2.6E-03	9.0E-06	4.5E-06	5.9E-04	1.4E-06	2.9E+00	2.3E-04	1.3E-05	8.1E-04
10-Jul-12	32	500	440	7.43	4.7E+01																				
17-Jul-12	33	500	435	7.45	4.5E+01	#N/A	9.0E-01	7.4E+00	2.2E+00	8.7E-02	4.4E-02	1.3E-01	8.1E+00	2.8E-02	1.7E-04	7.0E-04	2.4E-03	8.7E-06	4.4E-06	1.5E-03	1.3E-06	2.8E+00	2.2E-04	3.0E-06	7.8E-04
24-Jul-12	34	500	440	7.39	4.7E+01																				
31-Jul-12	35	500	435	7.46	4.4E+01	#N/A	8.9E-01	7.1E+00	2.2E+00	8.7E-02	3.9E-02	1.3E-01	8.2E+00	2.4E-02	1.3E-04	2.2E-04	2.5E-03	8.7E-06	4.4E-06	7.8E-04	1.8E-05	2.9E+00	2.2E-04	1.0E-05	6.5E-04
7-Aug-12	36	500	440	7.51	4.3E+01																				
14-Aug-12	37	500	465	7.36	4.6E+01	#N/A	1.1E+00	7.3E+00	3.3E+00	9.3E-02	4.2E-02	1.4E-01	8.8E+00	2.9E-02	9.3E-05	7.9E-04	2.5E-03	9.3E-06	4.7E-06	7.9E-04	1.4E-06	3.1E+00	2.3E-04	2.3E-06	6.0E-04
21-Aug-12	38	500	455	7.27	5.0E+01																				
28-Aug-12	39	500	485	7.35	4.8E+01	#N/A	1.5E+00	7.8E+00	3.9E+00	9.7E-02	3.9E-02	1.5E-01	9.8E+00	2.3E-02	9.7E-05	2.9E-04	2.5E-03	9.7E-06	4.9E-06	7.8E-04	1.5E-06	3.5E+00	2.4E-04	1.4E-05	6.8E-04
4-Sep-12	40	500	475	7.29	4.2E+01																				
11-Sep-12	41	500	445	7.36	4.3E+01	#N/A	1.0E+00	6.6E+00	4.0E+00	8.9E-02	4.0E-02	1.3E-01	8.7E+00	3.5E-02	8.9E-05	3.1E-04	2.8E-03	8.9E-06	4.5E-06	6.2E-04	1.3E-06	3.1E+00	2.2E-04	9.8E-05	1.3E-03
18-Sep-12	42	500	500	7.31	4.5E+01																				
25-Sep-12	43	500	445	7.31	4.5E+01	#N/A	1.4E+00	7.0E+00	3.1E+00	8.9E-02	3.6E-02	1.3E-01	7.9E+00	3.0E-02	8.9E-05	1.3E-04	2.9E-03	8.9E-06	4.5E-06	5.8E-04	1.3E-06	2.8E+00	2.2E-04	8.9E-06	5.3E-04
2-Oct-12	44	500	440	7.21	4.3E+01																				
9-Oct-12	45	500	470	7.24	3.6E+01	#N/A	1.6E+00	6.1E+00	2.8E+00	9.4E-02	2.8E-02	1.4E-01	7.1E+00	2.1E-02	9.4E-05	1.9E-04	2.1E-03	9.4E-06	4.7E-06	5.6E-04	1.4E-06	2.5E+00	2.4E-04	9.4E-07	6.6E-04
16-Oct-12	46	500	460	7.26	4.0E+01																				
23-Oct-12	47	500	480	7.33	4.2E+01																				
30-Oct-12	48	500	460	7.27	4.7E+01																				
6-Nov-12	49	500	445	7.43	3.9E+01	#N/A	1.2E+00	6.5E+00	2.2E+00	8.9E-02	2.7E-02	1.3E-01	8.9E+00	1.5E-02	8.9E-05	2.2E-04	2.5E-03	8.9E-06	4.5E-06	8.9E-04	9.8E-06	3.1E+00	2.2E-04	4.2E-05	9.8E-04
13-Nov-12	50	500	445	7.14	4.0E+01																				
20-Nov-12	51	500	490	7.75	3.9E+01																				
27-Nov-12	52	500	490	7.31	4.5E+01																				
4-Dec-12	53	500	495	7.43	4.2E+01	#N/A	9.6E-01	7.3E+00	4.0E+00	9.9E-02	3.0E-02	1.5E-01	9.6E+00	8.8E-03	9.9E-05	9.9E-05	2.6E-03	9.9E-06	5.0E-06	5.4E-04	1.5E-06	3.4E+00	2.5E-04	2.6E-05	3.5E-04
11-Dec-12	54	500	470	7.33	4.5E+01																				
18-Dec-12	55	500	455	7.40	3.3E+01																				
25-Dec-12	56	500	460	7.35	5.0E+01																				
1-Jan-13	57	500	450	7.59	3.6E+01	#N/A	1.6E+00	7.2E+00	1.8E+00	9.0E-02	2.7E-02	1.4E-01	8.4E+00	2.8E-02	1.4E-04	4.1E-04	2.5E-03	9.0E-06	4.5E-06	3.2E-04	4.1E-06	3.0E+00	2.3E-04	1.2E-05	5.9E-04
8-Jan-13	58	500	495	7.51	4.5E+01																				
15-Jan-13	59	500	465	7.35	3.6E+01																				
22-Jan-13	60	500	455	7.51	4.4E+01																				
29-Jan-13	61	500	455	7.42	3.2E+01	#N/A	1.1E+00	5.9E+00	2.7E+00	9.1E-02	2.7E-02	1.4E-01	7.3E+00	2.1E-02	9.1E-05	9.1E-05	1.8E-03	9.1E-06	4.6E-06	4.1E-04	7.7E-06	2.6E+00	2.3E-04	9.1E-07	5.5E-04
5-Feb-13	62	500	455	7.48	3.1E+01																				
12-Feb-13	63	500	465	7.57	3.6E+01																				

HC6
Sample = 08-028

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/kg	mgCaCO3/kg	mgCaCO3/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
19-Feb-13	64	500	445	7.44	3.4E+01																				
26-Feb-13	65	500	450	7.44	3.6E+01	#N/A	1.6E+00	6.0E+00	2.7E+00	9.0E-02	2.7E-02	1.4E-01	6.4E+00	2.3E-02	9.0E-05	1.8E-04	2.1E-03	9.0E-06	4.5E-06	3.6E-04	3.6E-06	2.3E+00	2.3E-04	1.1E-04	7.2E-04
5-Mar-13	66	500	450	7.60	3.5E+01																				
12-Mar-13	67	500	445	7.40	3.6E+01																				
19-Mar-13	68	500	450	7.69	3.4E+01																				
26-Mar-13	69	500	445	7.50	3.5E+01	#N/A	1.9E+00	6.0E+00	2.2E+00	8.9E-02	2.7E-02	1.3E-01	6.6E+00	1.1E-02	8.9E-05	2.2E-04	1.7E-03	8.9E-06	4.5E-06	4.0E-04	2.7E-06	2.3E+00	2.2E-04	5.2E-05	3.6E-04
2-Apr-13	70	500	440	7.50	3.3E+01																				
9-Apr-13	71	500	450	7.49	3.4E+01																				
16-Apr-13	72	500	450	7.39	3.0E+01																				
23-Apr-13	73	500	430	7.52	4.2E+01	#N/A	1.9E+00	6.2E+00	3.0E+00	8.6E-02	2.6E-02	1.3E-01	7.0E+00	1.6E-02	8.6E-05	1.7E-04	2.1E-03	8.6E-06	4.3E-06	5.2E-04	1.3E-06	2.4E+00	2.2E-04	1.0E-05	7.3E-04
30-Apr-13	74	500	435	7.55	3.6E+01																				
7-May-13	75	500	445	7.54	3.5E+01																				
14-May-13	76	500	450	7.54	3.7E+01																				
21-May-13	77	500	435	7.51	3.5E+01	#N/A	1.4E+00	5.3E+00	3.0E+00	8.7E-02	2.6E-02	1.3E-01	6.0E+00	1.5E-02	8.7E-05	8.7E-05	1.8E-03	8.7E-06	4.4E-06	5.7E-04	5.7E-06	2.1E+00	2.2E-04	8.7E-06	7.0E-04
28-May-13	78	500	445	7.57	3.3E+01		1.6E+00	5.5E+00	2.7E+00	8.9E-02	2.7E-02	1.3E-01	6.5E+00	1.9E-02	8.9E-05	8.9E-05	1.9E-03	8.9E-06	4.5E-06	5.8E-04	1.3E-06	2.3E+00	2.2E-04	7.1E-06	6.7E-04
4-Jun-13	79	500	455	7.45	3.4E+01		1.8E+00	6.1E+00	2.3E+00	9.1E-02	2.7E-02	1.4E-01	6.8E+00	1.3E-02	9.1E-05	1.4E-04	2.2E-03	9.1E-06	4.6E-06	2.2E-03	4.6E-06	2.4E+00	2.3E-04	3.3E-05	9.1E-04
11-Jun-13	80	500	485	7.68	2.9E+01		3.0E+00	7.3E+00	2.9E+00	9.7E-02	2.9E-02	1.5E-01	6.5E+00	5.6E-03	9.7E-05	9.7E-05	1.8E-03	9.7E-06	4.9E-06	1.6E-03	1.5E-06	2.3E+00	2.4E-04	6.3E-06	2.4E-04
18-Jun-13	81	500	490	7.40	2.9E+01	#N/A	2.0E+00	6.6E+00	2.9E+00	9.8E-02	2.9E-02	1.5E-01	6.7E+00	4.4E-03	9.8E-05	9.8E-05	1.7E-03	9.8E-06	4.9E-06	1.6E-03	1.5E-06	2.4E+00	2.5E-04	2.9E-05	2.5E-04
25-Jun-13	82	500	460	7.43	2.5E+01																				
2-Jul-13	83	500	470	7.86	3.6E+01		2.4E+00	1.1E+01	1.9E+00	9.4E-02	2.8E-02	1.4E-01	5.0E+00	5.4E-03	9.4E-05	9.4E-05	1.3E-03	9.4E-06	4.7E-06	1.4E-04	1.4E-06	1.8E+00	2.4E-04	1.4E-06	3.3E-04
9-Jul-13	84	500	475	7.61	4.0E+01																				
16-Jul-13	85	500	495	7.34	2.9E+01	#N/A	1.6E+00	6.5E+00	1.5E+00	9.9E-02	3.0E-02	1.5E-01	6.7E+00	5.3E-03	9.9E-05	1.5E-04	1.8E-03	9.9E-06	5.0E-06	1.1E-03	1.5E-06	2.4E+00	2.5E-04	1.1E-05	4.5E-04
23-Jul-13	86	500	490	7.54	2.9E+01																				
30-Jul-13	87	500	490	7.30	2.7E+01		1.8E+00	6.4E+00	2.5E+00	9.8E-02	2.9E-02	1.5E-01	6.1E+00	5.1E-03	9.8E-05	9.8E-05	1.6E-03	9.8E-06	4.9E-06	1.1E-03	1.5E-06	2.2E+00	2.5E-04	9.8E-07	2.9E-04
6-Aug-13	88	500	490	7.62	2.9E+01																				
13-Aug-13	89	500	485	7.28	2.5E+01	#N/A	1.3E+00	5.9E+00	1.5E+00	9.7E-02	2.9E-02	1.5E-01	6.1E+00	6.0E-03	9.7E-05	9.7E-05	1.6E-03	9.7E-06	4.9E-06	1.0E-03	3.4E-06	2.2E+00	2.4E-04	1.6E-05	2.9E-04
20-Aug-13	90	500	485	7.21	2.6E+01																				
27-Aug-13	91	500	490	7.37	2.3E+01																				
3-Sep-13	92	500	475	7.50	2.2E+01																				
10-Sep-13	93	500	465	7.33	2.5E+01	#N/A	1.4E+00	5.3E+00	1.4E+00	9.3E-02	2.8E-02	1.4E-01	5.8E+00	5.0E-03	9.3E-05	9.3E-05	1.5E-03	9.3E-06	4.7E-06	7.4E-04	1.4E-06	2.1E+00	2.3E-04	2.0E-05	3.7E-04
17-Sep-13	94	500	495	7.44	2.8E+01																				
24-Sep-13	95	500	490	7.30	2.6E+01																				
1-Oct-13	96	500	465	7.57	2.5E+01																				
8-Oct-13	97	500	475	7.29	2.5E+01	#N/A	7.6E-01	5.5E+00	1.4E+00	9.5E-02	2.9E-02	1.4E-01	6.1E+00	4.6E-03	9.5E-05	9.5E-05	1.6E-03	9.5E-06	4.8E-06	2.0E-03	1.4E-06	2.2E+00	2.4E-04	1.6E-05	2.9E-04
15-Oct-13	98	500	500	7.26	2.6E+01																				
22-Oct-13	99	500	470	7.31	2.6E+01																				
29-Oct-13	100	500	470	7.40	2.6E+01																				
5-Nov-13	101	500	490	7.40	2.8E+01	#N/A	8.5E-01	5.8E+00	2.0E+00	9.8E-02	2.9E-02	1.5E-01	6.7E+00	3.2E-03	9.8E-05	9.8E-05	1.8E-03	9.8E-06	4.9E-06	6.9E-04	1.5E-06	2.4E+00	2.5E-04	8.8E-06	3.4E-04
12-Nov-13	102	500	470	7.46	2.4E+01																				
19-Nov-13	103	500	465	7.26	2.6E+01																				
26-Nov-13	104	500	470	7.64	2.5E+01																				
3-Dec-13	105	500	470	7.53	2.4E+01	#N/A	3.1E-01	5.1E+00	1.4E+00	9.4E-02	2.8E-02	1.4E-01	5.6E+00	5.8E-03	9.4E-05	9.4E-05	1.6E-03	9.4E-06	4.7E-06	5.2E-04	1.4E-06	2.0E+00	2.4E-04	9.4E-06	2.8E-04
10-Dec-13	106	500	480	7.50	2.4E+01																				
17-Dec-13	107	500	460	7.58	2.4E+01																				
24-Dec-13	108	500	490	7.51	2.9E+01																				
31-Dec-13	109	500	500	7.52	2.7E+01	#N/A	7.3E-01	5.8E+00	1.0E+00	1.0E-01	3.0E-02	1.5E-01	6.4E+00	5.2E-03	1.0E-04	1.0E-04	1.8E-03	1.0E-05	5.0E-06	8.5E-04	1.5E-06	2.3E+00	2.5E-04	9.0E-06	4.0E-04
7-Jan-14	110	500	490	7.31	2.7E+01																				
14-Jan-14	111	500	485	7.64	2.2E+01																				
21-Jan-14	112	500	480	7.54	2.5E+01																				
28-Jan-14	113	500	485	7.45	2.7E+01	#N/A	8.2E-01	5.8E+00	1.5E+00	9.7E-02	2.9E-02	1.5E-01	6.4E+00	4.2E-03	9.7E-05	9.7E-05	1.7E-03	9.7E-06	4.9E-06	7.8E-04	1.5E-06	2.3E+00	2.4E-04	9.7E-07	2.4E-04
4-Feb-14	114	500	480	7.61	2.5E+01																				
11-Feb-14	115	500	470	7.61	2.1E+01																				
18-Feb-14	116	500	485	7.63	2.5E+01																				
25-Feb-14	117	500	485	7.61	2.3E+01	#N/A	1.3E+00	6.6E+00	2.4E+00	9.7E-02	2.9E-02	1.5E-01	5.6E+00	3.9E-03	9.7E-05	9.7E-05	1.5E-03	9.7E-06	4.9E-06	6.3E-04	1.5E-06	2.0E+00	2.4E-04	8.7E-06	2.4E-04

HC6
Sample = 08-028

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
	No.																							
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
29-Nov-11	0	1.2E-03	4.0E-05	1.2E-03	6.8E+00	1.0E-02	4.0E-06	7.0E-03	1.7E-03	5.2E-03	6.6E+00	1.1E-03	6.4E-01	4.0E-06	4.2E+00	1.5E-01	6.9E+01	1.6E-05	4.0E-06	8.0E-05	3.9E-03	1.0E-04	8.0E-04	2.0E-05
6-Dec-11	1	1.4E-03	9.4E-06	9.4E-04	4.6E+00	8.3E-03	4.7E-06	1.2E-02	1.4E-04	4.2E-03	4.7E+00	7.7E-04	5.5E-01	4.7E-06	3.1E+00	8.2E-02	3.9E+01	9.4E-06	4.7E-06	9.4E-05	4.2E-03	1.5E-04	1.4E-03	4.7E-06
13-Dec-11	2	1.4E-03	5.0E-05	4.6E-04	3.0E+00	6.0E-03	4.6E-06	7.9E-03	7.3E-04	4.1E-03	3.6E+00	5.6E-04	4.5E-01	4.6E-06	1.7E+00	5.9E-02	2.4E+01	9.1E-06	3.2E-05	4.6E-05	2.7E-03	6.8E-05	1.4E-03	9.1E-06
20-Dec-11	3	1.5E-03	1.0E-05	5.0E-04	2.8E+00	7.4E-03	5.0E-06	8.1E-03	9.0E-04	4.5E-03	3.1E+00	3.1E-04	5.9E-01	5.0E-06	1.2E+00	6.0E-02	2.5E+01	1.0E-05	5.0E-06	1.0E-04	3.6E-03	1.6E-04	1.0E-03	5.0E-06
27-Dec-11	4																							
3-Jan-12	5	1.4E-03	9.0E-06	4.5E-04	8.1E-01	2.7E-03	4.5E-06	4.4E-03	4.1E-04	4.1E-03	1.5E+00	9.0E-05	3.2E-01	4.5E-06	3.9E-01	1.8E-02	6.5E+00	9.0E-06	2.3E-05	1.8E-04	1.3E-03	2.8E-04	4.5E-04	4.5E-06
10-Jan-12	6																							
17-Jan-12	7	2.7E-03	2.2E-05	4.5E-04	5.2E-01	2.2E-03	4.5E-06	3.6E-03	8.9E-05	4.0E-03	1.2E+00	7.1E-05	3.6E-01	4.5E-06	2.2E-01	1.2E-02	3.5E+00	8.9E-06	1.8E-05	2.2E-04	1.1E-03	1.8E-04	8.9E-04	8.9E-06
24-Jan-12	8																							
31-Jan-12	9	2.3E-03	4.6E-05	4.6E-04	4.4E-01	1.9E-03	4.6E-06	3.1E-03	4.6E-05	4.1E-03	1.1E+00	6.4E-05	3.5E-01	4.6E-06	1.6E-01	1.0E-02	2.3E+00	9.1E-06	1.4E-05	1.8E-04	9.8E-04	2.0E-04	9.1E-04	4.6E-06
7-Feb-12	10																							
14-Feb-12	11	3.2E-03	9.2E-06	4.6E-04	4.4E-01	1.7E-03	4.6E-06	3.1E-03	1.8E-04	4.1E-03	9.6E-01	1.2E-04	3.6E-01	4.6E-06	1.5E-01	1.1E-02	2.1E+00	9.2E-06	9.2E-06	2.3E-04	9.3E-04	9.2E-05	4.6E-04	4.6E-06
21-Feb-12	12																							
28-Feb-12	13	1.4E-03	9.4E-06	4.7E-04	4.0E-01	2.1E-03	4.7E-06	2.5E-03	4.7E-05	4.2E-03	9.4E-01	2.8E-05	3.3E-01	4.7E-06	9.4E-02	1.0E-02	1.8E+00	9.4E-06	3.3E-05	3.3E-04	9.3E-04	1.6E-04	1.9E-03	9.4E-06
6-Mar-12	14																							
13-Mar-12	15	3.6E-03	8.9E-06	4.5E-04	4.0E-01	1.3E-03	4.5E-06	2.4E-03	4.5E-05	4.0E-03	9.7E-01	1.8E-05	3.8E-01	4.5E-06	9.3E-02	1.0E-02	2.0E+00	8.9E-06	8.0E-05	1.3E-04	9.3E-04	9.3E-05	1.3E-03	8.9E-06
20-Mar-12	16																							
27-Mar-12	17	2.2E-03	1.1E-04	4.5E-04	3.3E-01	1.6E-03	4.5E-06	1.8E-03	4.5E-05	4.0E-03	8.4E-01	3.1E-05	3.6E-01	4.5E-06	7.6E-02	8.0E-03	1.3E+00	8.9E-06	4.5E-06	1.8E-04	9.8E-04	1.9E-04	4.5E-04	4.5E-06
3-Apr-12	18																							
10-Apr-12	19	2.2E-03	1.3E-05	4.4E-04	2.8E-01	1.3E-03	8.8E-06	1.7E-03	4.4E-05	4.0E-03	7.2E-01	3.1E-05	2.9E-01	4.4E-06	5.7E-02	7.3E-03	1.3E+00	8.8E-06	1.8E-05	1.3E-04	6.0E-04	1.5E-04	8.8E-04	4.4E-06
17-Apr-12	20																							
24-Apr-12	21	6.2E-03	2.2E-05	4.5E-04	2.9E-01	1.6E-03	1.3E-05	1.7E-03	4.5E-05	4.0E-03	9.7E-01	4.9E-05	3.8E-01	4.5E-06	6.7E-02	7.4E-03	1.1E+00	8.9E-06	1.8E-05	4.5E-04	9.4E-04	2.0E-04	8.9E-04	1.3E-05
1-May-12	22																							
8-May-12	23	1.8E-02	3.9E-05	4.9E-04	3.4E-01	1.5E-03	4.9E-06	2.4E-03	2.5E-04	4.4E-03	9.6E-01	6.4E-05	3.5E-01	4.9E-06	5.9E-02	8.3E-03	1.4E+00	9.8E-06	1.7E-04	9.8E-05	1.3E-03	1.6E-04	2.5E-03	4.9E-06
15-May-12	24																							
22-May-12	25	1.9E-03	9.3E-06	4.7E-04	3.0E-01	1.4E-03	9.3E-06	3.3E-03	1.4E-04	4.2E-03	8.1E-01	1.9E-05	3.2E-01	4.7E-06	5.6E-02	7.5E-03	1.4E+00	9.3E-06	3.2E-04	3.7E-04	9.9E-04	2.5E-04	4.7E-04	4.7E-06
29-May-12	26																							
5-Jun-12	27	6.6E-02	9.0E-06	4.5E-04	2.8E-01	2.7E-03	4.5E-06	1.9E-03	2.8E-03	4.1E-03	9.0E-01	5.9E-05	3.6E-01	4.5E-06	5.9E-02	7.4E-03	1.0E+00	9.0E-06	4.5E-05	2.7E-04	9.9E-04	2.9E-04	9.0E-04	3.6E-05
12-Jun-12	28																							
19-Jun-12	29	2.6E-03	2.9E-04	4.4E-04	2.6E-01	1.3E-03	4.4E-06	1.3E-03	8.8E-05	4.0E-03	8.4E-01	4.0E-05	3.4E-01	4.4E-06	4.8E-02	6.6E-03	8.9E-01	8.8E-06	1.5E-04	1.8E-04	1.0E-03	2.1E-04	2.6E-03	4.4E-06
26-Jun-12	30																							
3-Jul-12	31	4.5E-03	1.8E-05	4.5E-04	2.7E-01	1.8E-03	4.5E-06	1.3E-03	4.5E-05	4.1E-03	9.5E-01	3.6E-05	3.7E-01	4.5E-06	5.0E-02	7.2E-03	9.0E-01	9.0E-06	1.8E-04	1.8E-04	1.2E-03	1.6E-04	9.0E-04	4.5E-06
10-Jul-12	32																							
17-Jul-12	33	3.0E-03	3.0E-05	4.4E-04	2.5E-01	1.4E-03	4.4E-06	1.4E-03	4.4E-05	3.9E-03	8.6E-01	1.2E-04	3.6E-01	5.2E-05	6.5E-02	6.8E-03	1.0E+00	8.7E-06	1.2E-04	2.6E-04	9.4E-04	2.3E-04	8.7E-04	8.7E-06
24-Jul-12	34																							
31-Jul-12	35	4.8E-03	4.4E-05	4.4E-04	2.5E-01	1.3E-03	4.4E-06	1.2E-03	4.4E-05	3.9E-03	7.7E-01	8.3E-05	3.7E-01	4.4E-06	4.8E-02	6.7E-03	9.4E-01	8.7E-06	6.5E-05	1.3E-04	7.3E-04	1.9E-04	8.7E-04	4.4E-06
7-Aug-12	36																							
14-Aug-12	37	1.4E-03	9.3E-06	4.7E-04	2.6E-01	1.4E-03	4.7E-06	1.4E-03	4.7E-05	4.2E-03	7.4E-01	4.7E-05	3.3E-01	4.7E-06	4.7E-02	7.2E-03	1.4E+00	9.3E-06	8.4E-05	1.4E-04	7.0E-04	3.2E-04	9.3E-04	4.7E-06
21-Aug-12	38																							
28-Aug-12	39	1.9E-03	9.7E-06	4.9E-04	2.9E-01	1.9E-03	9.7E-06	1.3E-03	9.7E-05	4.4E-03	6.9E-01	1.9E-05	3.2E-01	4.9E-06	3.9E-02	7.9E-03	1.4E+00	9.7E-06	1.8E-04	9.7E-05	1.1E-03	1.7E-04	9.7E-04	4.9E-06
4-Sep-12	40																							
11-Sep-12	41	6.2E-03	1.3E-05	4.5E-04	2.6E-01	1.2E-03	1.8E-05	1.1E-03	1.4E-03	4.0E-03	6.5E-01	5.8E-05	3.4E-01	4.5E-06	4.0E-02	7.3E-03	1.2E+00	8.9E-06	2.2E-05	4.9E-04	6.5E-04	1.2E-04	4.5E-04	8.9E-06
18-Sep-12	42																							
25-Sep-12	43	5.3E-03	8.9E-06	4.5E-04	2.4E-01	9.8E-04	4.5E-06	2.8E-03	4.5E-05	4.0E-03	5.9E-01	6.7E-05	2.8E-01	4.5E-06	3.6E-02	6.5E-03	1.1E+00	8.9E-06	4.5E-05	2.2E-04	6.9E-04	1.6E-04	4.5E-04	8.9E-06
2-Oct-12	44																							
9-Oct-12	45	1.4E-03	9.4E-06	4.7E-04	2.0E-01	1.5E-03	4.7E-06	8.9E-04	9.4E-05	4.2E-03	4.6E-01	7.1E-05	2.2E-01	4.7E-06	3.3E-02	5.6E-03	9.6E-01	9.4E-06	6.6E-05	1.9E-04	4.7E-04	1.6E-04	9.4E-04	4.7E-06
16-Oct-12	46																							
23-Oct-12	47																							
30-Oct-12	48																							
6-Nov-12	49	2.2E-03	1.3E-05	4.5E-04	2.5E-01	1.2E-03	4.5E-06	9.6E-04	1.3E-04	4.0E-03	5.3E-01	5.3E-05	2.9E-01	4.5E-06	4.5E-02	7.2E-03	1.2E+00	8.9E-06	2.7E-04	8.9E-05	6.4E-04	7.1E-05	1.3E-03	4.5E-06
13-Nov-12	50																							
20-Nov-12	51																							
27-Nov-12	52																							
4-Dec-12	53	1.5E-03	9.9E-06	5.0E-04	2.7E-01	1.2E-03	5.0E-06	1.0E-03	5.0E-05	4.5E-03	5.4E-01	6.4E-04	2.6E-01	5.0E-06	3.0E-02	7.6E-03	1.4E+00	9.9E-06	4.5E-05	5.0E-05	1.3E-03	9.9E-05	9.9E-04	5.0E-06
11-Dec-12	54																							
18-Dec-12	55																							
25-Dec-12	56																							
1-Jan-13	57	6.8E-03	1.8E-05	4.5E-04	2.4E-01	1.2E-03	4.5E-06	8.6E-04	4.5E-05	5.4E-03	4.9E-01	2.7E-05	3.2E-01	4.5E-06	2.7E-02	6.7E-03	1.0E+00	9.0E-06	7.2E-05	4.5E-04	6.3E-04	1.3E-04	9.0E-04	1.4E-05
8-Jan-13	58																							
15-Jan-13	59																							
22-Jan-13	60																							
29-Jan-13	61	1.8E-03	9.1E-06	4.6E-04	2.1E-01	1.2E-03	4.6E-06	7.0E-04	4.6E-05	4.1E-03	3.7E-01	2.7E-05	2.2E-01	4.6E-06	4.1E-02	5.6E-03	9.5E-01	9.1E-06	6.4E-05	1.8E-04	5.1E-04	1.4E-04	4.6E-04	2.3E-05
5-Feb-13	62																							
12-Feb-13	63																							

HC6
Sample = 08-028

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
	No.																							
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
19-Feb-13	64																							
26-Feb-13	65	4.1E-03	2.3E-05	4.5E-04	1.9E-01	1.0E-03	4.5E-06	7.0E-04	4.5E-05	5.4E-03	3.7E-01	3.2E-05	2.2E-01	4.5E-06	2.3E-02	5.0E-03	9.0E-01	9.0E-06	4.5E-06	3.2E-04	4.1E-04	5.0E-05	4.5E-04	4.5E-06
5-Mar-13	66																							
12-Mar-13	67																							
19-Mar-13	68																							
26-Mar-13	69	1.8E-03	7.1E-05	4.5E-04	1.9E-01	7.1E-04	8.9E-06	6.3E-04	4.5E-05	4.0E-03	3.2E-01	1.8E-05	2.0E-01	4.5E-06	2.2E-02	5.1E-03	8.5E-01	8.9E-06	8.9E-06	4.5E-05	4.1E-04	5.8E-05	4.5E-04	4.5E-06
2-Apr-13	70																							
9-Apr-13	71																							
16-Apr-13	72																							
23-Apr-13	73	6.0E-03	1.7E-05	4.3E-04	2.1E-01	8.2E-04	4.3E-06	6.3E-04	4.3E-05	3.9E-03	3.4E-01	1.7E-05	2.5E-01	4.3E-06	2.6E-02	5.6E-03	9.6E-01	8.6E-06	8.6E-06	2.2E-04	4.5E-04	4.7E-05	4.3E-04	8.6E-06
30-Apr-13	74																							
7-May-13	75																							
14-May-13	76																							
21-May-13	77	6.5E-03	8.7E-06	4.4E-04	1.6E-01	9.6E-04	4.4E-06	6.2E-04	4.4E-05	3.9E-03	4.0E-01	2.2E-05	2.1E-01	4.4E-06	2.2E-02	4.9E-03	7.5E-01	8.7E-06	1.7E-05	1.7E-04	3.8E-04	5.7E-05	4.4E-04	8.7E-06
28-May-13	78	4.5E-03	1.3E-05	4.5E-04	1.8E-01	9.3E-04	4.5E-06	6.6E-04	4.5E-05	4.0E-03	4.3E-01	3.6E-05	1.9E-01	4.5E-06	2.2E-02	5.1E-03	7.8E-01	8.9E-06	1.8E-05	1.8E-04	4.2E-04	4.5E-05	4.5E-04	4.5E-06
4-Jun-13	79	4.1E-03	9.1E-06	4.6E-04	1.8E-01	1.2E-03	4.6E-06	6.5E-04	9.6E-04	4.1E-03	3.5E-01	1.8E-05	1.7E-01	4.6E-06	2.3E-02	5.1E-03	6.1E-01	9.1E-06	6.4E-05	1.4E-04	6.3E-04	3.2E-05	1.4E-03	9.1E-06
11-Jun-13	80	1.5E-03	9.7E-06	4.9E-04	1.7E-01	7.8E-04	4.9E-06	4.2E-04	4.9E-05	4.4E-03	3.1E-01	2.4E-05	1.4E-01	4.9E-06	1.9E-02	4.9E-03	4.7E-01	9.7E-06	3.4E-05	4.9E-05	7.7E-04	1.5E-05	4.9E-04	4.9E-06
18-Jun-13	81	1.5E-03	9.8E-06	4.9E-04	1.7E-01	1.5E-03	4.9E-06	3.4E-04	4.9E-05	4.4E-03	3.0E-01	2.0E-05	1.3E-01	4.9E-06	2.5E-02	4.9E-03	4.3E-01	9.8E-06	4.4E-05	4.9E-05	8.0E-04	2.0E-05	4.9E-04	4.9E-06
25-Jun-13	82																							
2-Jul-13	83	1.4E-03	9.4E-06	4.7E-04	1.3E-01	8.5E-04	4.7E-06	3.2E-04	4.7E-05	4.2E-03	2.6E-01	1.9E-05	1.1E-01	4.7E-06	9.4E-03	3.9E-03	3.2E-01	9.4E-06	9.4E-06	4.7E-05	7.5E-04	4.7E-05	4.7E-04	4.7E-06
9-Jul-13	84																							
16-Jul-13	85	1.5E-03	1.5E-05	5.0E-04	1.7E-01	1.5E-03	5.0E-06	2.2E-04	5.0E-05	5.0E-03	2.6E-01	2.0E-05	1.2E-01	5.0E-06	1.5E-02	4.9E-03	3.2E-01	9.9E-06	1.5E-05	5.0E-05	8.1E-04	1.5E-05	9.9E-04	5.0E-06
23-Jul-13	86																							
30-Jul-13	87	1.5E-03	9.8E-06	4.9E-04	1.5E-01	1.3E-03	4.9E-06	2.2E-04	4.9E-05	4.4E-03	2.4E-01	2.0E-05	1.2E-01	4.9E-06	2.5E-02	4.5E-03	3.1E-01	9.8E-06	7.4E-05	4.9E-05	7.9E-04	1.5E-05	4.9E-04	4.9E-06
6-Aug-13	88																							
13-Aug-13	89	1.5E-03	1.9E-05	4.9E-04	1.5E-01	1.4E-03	4.9E-06	1.8E-04	9.7E-05	4.4E-03	2.2E-01	1.9E-05	1.4E-01	4.9E-06	1.9E-02	4.5E-03	3.0E-01	9.7E-06	6.8E-05	4.9E-05	6.9E-04	1.5E-05	1.5E-03	#VALUE!
20-Aug-13	90																							
27-Aug-13	91																							
3-Sep-13	92																							
10-Sep-13	93	1.4E-03	9.3E-06	4.7E-04	1.5E-01	1.2E-03	4.7E-06	1.9E-04	4.7E-05	4.2E-03	2.2E-01	1.9E-05	1.2E-01	4.7E-06	9.3E-03	4.3E-03	3.8E-01	9.3E-06	6.0E-05	4.7E-05	7.0E-04	1.4E-05	4.7E-04	4.7E-06
17-Sep-13	94																							
24-Sep-13	95																							
1-Oct-13	96																							
8-Oct-13	97	1.4E-03	9.5E-06	4.8E-04	1.5E-01	1.3E-03	4.8E-06	1.6E-04	4.8E-05	4.3E-03	2.0E-01	1.9E-05	1.3E-01	4.8E-06	9.5E-03	4.3E-03	3.2E-01	9.5E-06	3.3E-05	4.8E-05	7.1E-04	1.4E-05	9.5E-04	4.8E-06
15-Oct-13	98																							
22-Oct-13	99																							
29-Oct-13	100																							
5-Nov-13	101	1.5E-03	9.8E-06	4.9E-04	1.6E-01	1.1E-03	4.9E-06	1.7E-04	4.9E-05	4.4E-03	2.1E-01	2.0E-05	1.2E-01	4.9E-06	9.8E-03	4.9E-03	3.4E-01	9.8E-06	2.5E-05	4.9E-05	7.4E-04	1.5E-05	4.9E-04	4.9E-06
12-Nov-13	102																							
19-Nov-13	103																							
26-Nov-13	104																							
3-Dec-13	105	1.4E-03	9.4E-06	4.7E-04	1.4E-01	9.4E-04	4.7E-06	1.9E-04	4.7E-05	4.2E-03	1.9E-01	1.9E-05	9.9E-02	4.7E-06	4.7E-03	4.1E-03	2.4E-01	9.4E-06	7.5E-05	4.7E-05	6.4E-04	3.8E-05	4.7E-04	4.7E-06
10-Dec-13	106																							
17-Dec-13	107																							
24-Dec-13	108																							
31-Dec-13	109	3.0E-03	1.0E-05	5.0E-04	1.6E-01	1.0E-03	5.0E-06	1.7E-04	5.0E-05	4.5E-03	1.9E-01	2.0E-05	1.3E-01	5.0E-06	5.0E-03	4.7E-03	2.9E-01	1.0E-05	8.5E-05	5.0E-05	6.3E-04	2.5E-05	5.0E-04	5.0E-06
7-Jan-14	110																							
14-Jan-14	111																							
21-Jan-14	112																							
28-Jan-14	113	1.5E-03	9.7E-06	4.9E-04	1.5E-01	1.2E-03	4.9E-06	1.7E-04	4.9E-05	4.4E-03	1.7E-01	1.9E-05	1.1E-01	4.9E-06	9.7E-03	4.7E-03	3.3E-01	9.7E-06	1.1E-04	4.9E-05	5.8E-04	1.5E-05	9.7E-04	4.9E-06
4-Feb-14	114																							
11-Feb-14	115																							
18-Feb-14	116																							
25-Feb-14	117	1.5E-03	9.7E-06	4.9E-04	1.3E-01	9.2E-04	4.9E-06	1.4E-04	4.9E-05	4.4E-03	1.5E-01	1.9E-05	9.7E-02	4.9E-06	4.9E-03	4.0E-03	2.4E-01	9.7E-06	4.4E-05	4.9E-05	5.0E-04	1.5E-05	4.9E-04	4.9E-06

HC7

Sample = 50% '08-080-043/ 50% 08-225

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/L	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
29-Nov-11	0	500	385	7.28	1.4E+03	#N/A	1.5E+01	1.0E+02	6.9E+02	4.0E+00	2.8E-01	3.0E-01	7.1E+02	2.4E-02	2.2E-03	4.9E-03	4.8E-02	2.0E-05	2.0E-05	1.5E-02	3.5E-03	2.3E+02	5.0E-04	4.0E-02	9.4E-01
6-Dec-11	1	500	475	7.48	8.1E+02	#N/A	4.4E+00	3.0E+01	3.7E+02	2.1E+00	3.7E-01	3.0E-01	4.4E+02	1.9E-02	1.8E-03	2.5E-03	3.0E-02	2.0E-05	1.0E-05	5.7E-03	4.1E-04	1.5E+02	5.0E-04	2.6E-03	7.4E-02
13-Dec-11	2	500	450	7.45	6.5E+02	#N/A	3.5E+00	1.7E+01	2.6E+02	1.0E+00	4.2E-01	3.0E-01	3.3E+02	2.9E-02	1.5E-03	2.2E-03	3.1E-02	2.0E-05	1.0E-05	4.0E-03	2.0E-04	1.1E+02	1.3E-03	8.0E-04	1.4E-02
20-Dec-11	3	500	495	7.51	5.7E+02	#N/A	4.5E+00	1.8E+01	2.7E+02	3.0E-01	3.8E-01	3.0E-01	2.9E+02	4.5E-02	1.4E-03	2.1E-03	2.6E-02	2.0E-05	1.0E-05	4.6E-03	1.8E-04	9.7E+01	5.0E-04	7.5E-04	1.0E-02
27-Dec-11	4	500	525	7.53	4.4E+02																				
3-Jan-12	5	500	530	7.38	4.0E+02	#N/A	4.7E+00	1.8E+01	1.8E+02	2.0E-01	2.7E-01	3.0E-01	1.9E+02	5.4E-02	1.1E-03	1.4E-03	3.0E-02	2.0E-05	1.0E-05	3.7E-03	8.8E-05	6.4E+01	5.0E-04	3.8E-04	5.4E-03
10-Jan-12	6	500	480	7.28	4.1E+02																				
17-Jan-12	7	500	510	7.34	3.8E+02	#N/A	3.1E+00	1.7E+01	1.7E+02	2.0E-01	2.9E-01	3.0E-01	1.8E+02	4.4E-02	1.5E-03	1.7E-03	3.6E-02	2.0E-05	1.0E-05	3.4E-03	9.5E-05	6.3E+01	5.0E-04	2.7E-04	4.9E-03
24-Jan-12	8	500	440	7.44	3.6E+02																				
31-Jan-12	9	500	455	7.31	3.4E+02	#N/A	3.9E+00	1.6E+01	1.5E+02	2.0E-01	3.0E-01	3.0E-01	1.5E+02	4.5E-02	1.5E-03	1.6E-03	2.1E-02	2.0E-05	1.0E-05	2.5E-03	6.0E-05	5.4E+01	5.0E-04	2.5E-04	4.4E-03
7-Feb-12	10	500	480	7.46	3.4E+02																				
14-Feb-12	11	500	450	7.47	3.4E+02	#N/A	4.9E+00	2.2E+01	1.6E+02	3.0E-01	3.5E-01	3.0E-01	1.6E+02	4.7E-02	1.4E-03	2.9E-03	2.4E-02	2.0E-05	1.0E-05	2.2E-03	3.6E-05	5.8E+01	5.0E-04	1.9E-04	3.8E-03
21-Feb-12	12	500	465	7.43	2.9E+02																				
28-Feb-12	13	500	495	7.28	2.4E+02	#N/A	3.8E+00	1.5E+01	9.6E+01	4.0E-01	2.3E-01	3.0E-01	1.1E+02	2.8E-02	1.4E-03	2.1E-03	3.3E-02	2.0E-05	1.0E-05	2.1E-03	6.7E-05	4.1E+01	5.0E-04	1.9E-04	5.0E-03
6-Mar-12	14	500	485	7.50	2.6E+02																				
13-Mar-12	15	500	445	7.29	2.6E+02	#N/A	3.1E+00	1.5E+01	9.9E+01	6.0E-01	2.9E-01	3.0E-01	1.2E+02	4.1E-02	1.7E-03	2.5E-03	2.3E-02	2.0E-05	1.0E-05	2.1E-03	2.8E-05	4.4E+01	5.0E-04	1.2E-04	4.2E-03
20-Mar-12	16	500	430	7.29	2.0E+02																				
27-Mar-12	17	500	450	7.22	1.9E+02	#N/A	2.8E+00	1.3E+01	7.5E+01	5.0E-01	2.1E-01	3.0E-01	8.3E+01	4.2E-02	1.4E-03	2.2E-03	2.4E-02	2.0E-05	1.0E-05	1.9E-03	3.2E-05	3.0E+01	5.0E-04	1.3E-04	3.8E-03
3-Apr-12	18	500	465	7.26	1.7E+02																				
10-Apr-12	19	500	450	7.27	1.7E+02	#N/A	2.2E+00	1.3E+01	6.3E+01	5.0E-01	2.0E-01	3.0E-01	7.0E+01	5.4E-02	1.4E-03	2.2E-03	2.3E-02	2.0E-05	1.0E-05	2.1E-03	3.0E-06	2.6E+01	5.0E-04	1.2E-04	2.9E-03
17-Apr-12	20	500	425	7.22	1.8E+02																				
24-Apr-12	21	500	470	7.29	1.6E+02	#N/A	2.6E+00	1.4E+01	5.8E+01	5.0E-01	1.9E-01	3.0E-01	6.5E+01	5.2E-02	1.6E-03	2.3E-03	2.4E-02	2.0E-05	1.0E-05	1.8E-03	1.0E-05	2.4E+01	5.0E-04	1.3E-04	3.5E-03
1-May-12	22	500	445	7.39	1.5E+02																				
8-May-12	23	500	455	7.25	1.3E+02	#N/A	3.1E+00	1.1E+01	4.4E+01	5.0E-01	1.4E-01	3.0E-01	5.6E+01	3.0E-02	1.3E-03	2.0E-03	2.0E-02	2.0E-05	1.0E-05	1.9E-03	1.9E-05	2.0E+01	5.0E-04	1.2E-04	3.9E-03
15-May-12	24	500	455	7.26	1.4E+02																				
22-May-12	25	500	360	7.23	1.8E+02	#N/A	3.6E+00	1.4E+01	5.4E+01	4.0E-01	1.9E-01	3.0E-01	7.2E+01	8.7E-02	1.7E-03	2.8E-03	2.2E-02	2.0E-05	1.0E-05	1.8E-03	3.0E-06	2.7E+01	5.0E-04	1.1E-04	4.5E-03
29-May-12	26	500	435	7.19	1.4E+02																				
5-Jun-12	27	500	450	7.22	1.1E+02	#N/A	3.1E+00	1.2E+01	3.9E+01	4.0E-01	1.4E-01	3.0E-01	4.6E+01	5.9E-02	1.1E-03	2.3E-03	2.8E-02	2.0E-05	1.0E-05	2.5E-03	3.0E-06	1.7E+01	5.0E-04	1.1E-04	3.0E-03
12-Jun-12	28	500	460	7.31	1.1E+02																				
19-Jun-12	29	500	480	7.25	1.1E+02	#N/A	2.8E+00	1.2E+01	3.3E+01	4.0E-01	1.3E-01	3.0E-01	4.4E+01	5.4E-02	1.0E-03	2.1E-03	2.8E-02	2.0E-05	1.0E-05	1.5E-03	3.0E-06	1.6E+01	5.0E-04	1.2E-04	3.5E-03
26-Jun-12	30	500	475	7.25	1.0E+02																				
3-Jul-12	31	500	445	7.39	1.2E+02	#N/A	6.5E+00	1.7E+01	3.6E+01	5.0E-01	1.9E-01	3.0E-01	5.1E+01	6.7E-02	1.3E-03	2.7E-03	3.2E-02	2.0E-05	1.0E-05	1.2E-03	2.4E-05	1.9E+01	5.0E-04	1.0E-04	3.7E-03
10-Jul-12	32	500	445	7.20	1.1E+02																				
17-Jul-12	33	500	465	7.25	1.1E+02	#N/A	2.1E+00	1.3E+01	3.0E+01	3.0E-01	1.7E-01	3.0E-01	4.6E+01	4.2E-02	1.5E-03	3.2E-03	2.6E-02	2.0E-05	1.0E-05	1.9E-03	1.2E-05	1.7E+01	5.0E-04	2.3E-04	2.6E-03
24-Jul-12	34	500	425	7.12	1.0E+02																				
31-Jul-12	35	500	460	7.27	9.3E+01	#N/A	2.1E+00	1.2E+01	2.5E+01	3.0E-01	1.2E-01	3.0E-01	4.1E+01	5.2E-02	1.2E-03	2.1E-03	2.4E-02	2.0E-05	1.0E-05	2.0E-03	4.7E-05	1.5E+01	5.0E-04	9.9E-05	2.9E-03
7-Aug-12	36	500	445	7.37	1.0E+02																				
14-Aug-12	37	500	440	7.20	9.8E+01	#N/A	2.7E+00	1.2E+01	3.3E+01	4.0E-01	1.3E-01	3.0E-01	4.1E+01	8.4E-02	1.2E-03	3.6E-03	2.0E-02	2.0E-05	1.0E-05	3.7E-03	3.0E-06	1.5E+01	5.0E-04	3.9E-05	4.0E-03
21-Aug-12	38	500	445	7.07	9.9E+01																				
28-Aug-12	39	500	505	7.13	9.6E+01	#N/A	3.3E+00	1.1E+01	3.0E+01	4.0E-01	1.1E-01	3.0E-01	3.9E+01	4.6E-02	1.0E-03	1.5E-03	2.0E-02	2.0E-05	1.0E-05	2.0E-03	3.9E-05	1.4E+01	5.0E-04	1.4E-04	3.1E-03
4-Sep-12	40	500	480	7.02	9.2E+01																				
11-Sep-12	41	500	480	7.15	9.7E+01	#N/A	2.7E+00	1.1E+01	3.1E+01	2.0E-01	1.2E-01	3.0E-01	4.4E+01	3.5E-02	1.0E-03	1.9E-03	2.4E-02	2.0E-05	1.0E-05	1.8E-03	1.1E-05	1.6E+01	5.0E-04	1.2E-04	2.6E-03
18-Sep-12	42	500	535	7.13	9.6E+01																				
25-Sep-12	43	500	490	7.16	9.5E+01	#N/A	3.3E+00	1.1E+01	3.1E+01	2.0E-01	1.0E-01	3.0E-01	3.9E+01	3.4E-02	8.0E-04	2.0E-03	3.0E-02	2.0E-05	1.0E-05	2.4E-03	1.1E-05	1.4E+01	5.0E-04	1.1E-04	2.6E-03
2-Oct-12	44	500	495	7.13	9.9E+01																				
9-Oct-12	45	500	515	7.09	7.3E+01	#N/A	4.1E+00	9.4E+00	2.3E+01	2.0E-01	9.0E-02	3.0E-01	3.0E+01	3.3E-02	7.0E-04	1.3E-03	2.4E-02	2.0E-05	1.0E-05	1.1E-03	3.6E-05	1.1E+01	5.0E-04	1.5E-04	4.4E-03
16-Oct-12	46	500	510	7.16	8.6E+01																				
23-Oct-12	47	500	505	7.10	8.8E+01																				
30-Oct-12	48	500	510	7.19	1.0E+02																				
6-Nov-12	49	500	490	7.20	7.5E+01	#N/A	2.8E+00	1.0E+01	2.6E+01	2.0E-01	8.0E-02	3.0E-01	3.6E+01	1.5E-02	7.0E-04	1.4E-03	2.7E-02	2.0E-05	1.0E-05	1.6E-03	3.5E-05	1.3E+01	5.0E-04	1.5E-04	4.0E-03
13-Nov-12	50	500	495	7.21	8.6E+01																				
20-Nov-12	51	500	490	7.41	7.7E+01																				
27-Nov-12	52	500	495	7.22	8.5E+01																				
4-Dec-12	53	500	420	7.36	1.1E+02	#N/A	2.1E+00	1.5E+01	3.7E+01	2.0E-01	9.0E-02	3.0E-01	4.6E+01	3.2E-02	1.7E-03	2.6E-03	2.1E-02	2.0E-05	1.0E-05	1.1E-03	2.9E-05	1.7E+01	5.0E-04	2.0E-04	4.3E-03
11-Dec-12	54	500	445	7.21	1.1E+02																				
18-Dec-12	55	500	445	7.25	7.8E+01																				

HC7

Sample = 50% '08-080-043/ 50% 08-225

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/L	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
25-Dec-12	56	500	465	7.31	1.1E+02																				
1-Jan-13	57	500	490	7.45	7.5E+01	#N/A	3.8E+00	1.2E+01	2.4E+01	2.0E-01	9.0E-02	3.0E-01	3.1E+01	2.9E-02	1.0E-03	1.9E-03	2.3E-02	2.0E-05	1.0E-05	8.0E-04	1.5E-05	1.2E+01	5.0E-04	1.0E-04	1.9E-03
8-Jan-13	58	500	465	7.41	8.5E+01																				
15-Jan-13	59	500	465	7.24	8.0E+01																				
22-Jan-13	60	500	460	7.43	7.5E+01																				
29-Jan-13	61	500	460	7.27	7.4E+01	#N/A	2.6E+00	1.2E+01	2.7E+01	2.0E-01	8.0E-02	3.0E-01	3.7E+01	5.5E-02	8.0E-04	1.9E-03	1.7E-02	2.0E-05	1.0E-05	8.0E-04	1.6E-05	1.4E+01	5.0E-04	6.9E-05	2.5E-03
5-Feb-13	62	500	460	7.32	8.2E+01																				
12-Feb-13	63	500	460	7.35	8.1E+01																				
19-Feb-13	64	500	455	7.32	8.3E+01																				
26-Feb-13	65	500	450	7.30	8.0E+01	#N/A	4.0E+00	1.2E+01	2.6E+01	2.0E-01	8.0E-02	3.0E-01	3.2E+01	2.9E-02	8.0E-04	2.1E-03	1.4E-02	2.0E-05	1.0E-05	6.0E-04	1.5E-05	1.2E+01	5.0E-04	2.7E-04	2.1E-03
5-Mar-13	66	500	440	7.47	6.9E+01																				
12-Mar-13	67	500	445	7.28	6.7E+01																				
19-Mar-13	68	500	460	7.57	7.4E+01																				
26-Mar-13	69	500	460	7.40	7.6E+01	#N/A	4.3E+00	1.3E+01	2.2E+01	2.0E-01	6.0E-02	3.0E-01	3.3E+01	3.6E-02	8.0E-04	2.0E-03	1.4E-02	2.0E-05	1.0E-05	1.0E-03	6.0E-06	1.2E+01	5.0E-04	1.6E-04	1.7E-03
2-Apr-13	70	500	440	7.39	7.9E+01																				
9-Apr-13	71	500	460	7.39	7.9E+01																				
16-Apr-13	72	500	455	7.41	8.0E+01																				
23-Apr-13	73	500	445	7.41	8.4E+01	#N/A	4.7E+00	1.2E+01	2.9E+01	2.0E-01	6.0E-02	3.0E-01	3.1E+01	2.5E-02	8.0E-04	1.7E-03	1.4E-02	2.0E-05	1.0E-05	9.0E-04	8.0E-06	1.1E+01	5.0E-04	7.6E-05	2.4E-03
30-Apr-13	74	500	440	7.37	7.2E+01																				
7-May-13	75	500	445	7.41	8.5E+01																				
14-May-13	76	500	430	7.40	7.5E+01																				
21-May-13	77	500	435	7.34	6.8E+01	#N/A	3.9E+00	1.0E+01	2.4E+01	2.0E-01	6.0E-02	3.0E-01	2.8E+01	3.0E-02	9.0E-04	1.9E-03	1.4E-02	2.0E-05	1.0E-05	1.6E-03	7.0E-06	1.1E+01	5.0E-04	7.4E-05	2.5E-03
28-May-13	78	500	445	7.45	7.2E+01	#N/A	3.6E+00	1.1E+01	2.6E+01	2.0E-01	6.0E-02	3.0E-01	3.3E+01	3.4E-02	8.0E-04	2.0E-03	1.4E-02	2.0E-05	1.0E-05	1.5E-03	1.1E-05	1.2E+01	5.0E-04	9.1E-05	2.3E-03
4-Jun-13	79	500	460	7.30	6.1E+01	#N/A	4.0E+00	1.1E+01	1.8E+01	2.0E-01	6.0E-02	3.0E-01	2.7E+01	1.4E-02	5.0E-04	1.3E-03	1.2E-02	2.0E-05	1.0E-05	3.7E-03	6.0E-06	9.9E+00	5.0E-04	1.3E-04	3.0E-03
11-Jun-13	80	500	480	7.47	5.0E+01	#N/A	6.1E+00	1.3E+01	1.3E+01	2.0E-01	6.0E-02	3.0E-01	2.3E+01	1.4E-02	4.0E-04	1.1E-03	9.9E-03	2.0E-05	1.0E-05	2.6E-03	7.0E-06	8.4E+00	5.0E-04	9.4E-05	1.0E-03
18-Jun-13	81	500	480	7.26	5.1E+01	#N/A	4.2E+00	1.2E+01	1.4E+01	2.0E-01	6.0E-02	3.0E-01	2.3E+01	1.5E-02	5.0E-04	1.1E-03	1.1E-02	2.0E-05	1.0E-05	2.4E-03	3.0E-06	8.3E+00	5.0E-04	1.3E-04	2.8E-03
25-Jun-13	82	500	470	7.34	4.4E+01																				
2-Jul-13	83	500	475	7.39	4.2E+01	#N/A	6.1E+00	1.5E+01	1.0E+01	2.0E-01	6.0E-02	3.0E-01	1.9E+01	1.8E-02	4.0E-04	1.3E-03	1.2E-02	2.0E-05	1.0E-05	2.0E-04	1.0E-05	6.8E+00	5.0E-04	6.5E-05	2.2E-03
9-Jul-13	84	500	470	7.43	5.0E+01																				
16-Jul-13	85	500	485	7.17	4.0E+01	#N/A	3.1E+00	1.1E+01	9.0E+00	2.0E-01	6.0E-02	3.0E-01	1.8E+01	1.5E-02	3.0E-04	1.0E-03	1.1E-02	2.0E-05	1.0E-05	1.8E-03	9.0E-06	6.6E+00	5.0E-04	8.1E-05	2.3E-03
23-Jul-13	86	500	485	7.40	3.8E+01																				
30-Jul-13	87	500	485	7.14	3.5E+01	#N/A	3.7E+00	1.0E+01	1.0E+01	2.0E-01	6.0E-02	3.0E-01	1.6E+01	1.0E-02	3.0E-04	7.0E-04	1.1E-02	2.0E-05	1.0E-05	1.7E-03	3.0E-06	5.8E+00	5.0E-04	5.6E-05	1.8E-03
6-Aug-13	88	500	515	7.50	3.6E+01																				
13-Aug-13	89	500	485	7.16	3.5E+01	#N/A	2.5E+00	9.3E+00	7.0E+00	2.0E-01	6.0E-02	3.0E-01	1.6E+01	1.2E-02	3.0E-04	8.0E-04	1.2E-02	2.0E-05	1.0E-05	1.5E-03	1.2E-05	5.9E+00	5.0E-04	8.9E-05	1.8E-03
20-Aug-13	90	500	485	7.17	3.6E+01																				
27-Aug-13	91	500	485	7.26	3.6E+01																				
3-Sep-13	92	500	475	7.37	3.3E+01																				
10-Sep-13	93	500	475	7.22	3.7E+01	#N/A	3.2E+00	1.1E+01	7.0E+00	2.0E-01	6.0E-02	3.0E-01	1.8E+01	1.2E-02	3.0E-04	1.0E-03	1.3E-02	2.0E-05	1.0E-05	1.6E-03	6.0E-06	6.6E+00	5.0E-04	1.0E-04	2.1E-03
17-Sep-13	94	500	500	7.35	3.9E+01																				
24-Sep-13	95	500	500	7.20	3.6E+01																				
1-Oct-13	96	500	465	7.37	3.9E+01																				
8-Oct-13	97	500	475	7.21	3.7E+01	#N/A	1.6E+00	1.0E+01	6.0E+00	2.0E-01	6.0E-02	3.0E-01	1.8E+01	1.3E-02	3.0E-04	1.0E-03	1.4E-02	2.0E-05	1.0E-05	3.3E-03	4.0E-06	6.7E+00	5.0E-04	8.8E-05	1.7E-03
15-Oct-13	98	500	500	7.12	3.2E+01																				
22-Oct-13	99	500	475	7.24	3.8E+01																				
29-Oct-13	100	500	470	7.34	3.9E+01																				
5-Nov-13	101	500	495	7.36	4.0E+01	#N/A	1.9E+00	1.2E+01	7.0E+00	2.0E-01	6.0E-02	3.0E-01	1.8E+01	1.2E-02	3.0E-04	1.0E-03	1.5E-02	2.0E-05	1.0E-05	1.4E-03	5.0E-06	6.8E+00	5.0E-04	6.9E-05	1.7E-03
12-Nov-13	102	500	470	7.41	3.6E+01																				
19-Nov-13	103	500	480	7.20	3.6E+01																				
26-Nov-13	104	500	475	7.53	3.9E+01																				
3-Dec-13	105	500	470	7.63	3.4E+01	#N/A	9.7E-01	9.8E+00	4.0E+00	2.0E-01	6.0E-02	3.0E-01	1.6E+01	1.4E-02	3.0E-04	9.0E-04	1.4E-02	2.0E-05	1.0E-05	9.0E-04	4.0E-06	5.9E+00	5.0E-04	6.5E-05	1.8E-03
10-Dec-13	106	500	470	7.39	3.3E+01																				
17-Dec-13	107	500	475	7.46	3.5E+01																				
24-Dec-13	108	500	495	7.68	3.6E+01																				
31-Dec-13	109	500	500	7.39	3.2E+01	#N/A	1.6E+00	9.8E+00	6.0E+00	2.0E-01	6.0E-02	3.0E-01	1.4E+01	8.9E-03	2.0E-04	7.0E-04	1.4E-02	2.0E-05	1.0E-05	2.0E-03	5.0E-06	5.4E+00	5.0E-04	7.6E-05	1.9E-03
7-Jan-14	110	500	480	7.28	3.5E+01																				
14-Jan-14	111	500	480	7.54	3.2E+01																				
21-Jan-14	112	500	480	7.44	3.4E+01																				
28-Jan-14	113	500	490	7.35	3.5E+01	#N/A	1.8E+00	1.1E+01	4.0E+00	2.0E-01	6.0E-02	3.0E-01	1.6E+01	9.0E-03	3.0E-04	6.0E-04	1.4E-02	2.0E-05	1.0E-05	1.3E-03	3.0E-06	5.9E+00	5.0E-04	3.3E-05	9.0E-04
4-Feb-14	114	500	480	7.54	3.7E+01																				
11-Feb-14	115	500	465	7.51	3.3E+01																				
18-Feb-14	116	500	480	7.54	3.3E+01																				
25-Feb-14	117	500	480	7.70	3.3E+01	#N/A	2.8E+00	1.4E+01	6.0E+00	2.0E-01	6.0E-02	3.0E-01	1.6E+01	1.1E-02	3.0E-04	8.0E-04	1.5E-02	2.0E-05	1.0E-05	1.0E-03	3.0E-06	6.0E+00	5.0E-04	6.5E-05	1.4E-03

HC7

Sample = 50% '08-080-043/ 50% 08-225

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Major	Major	Diff	Diff
	No.																								Anions	Cations		(%)
		mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L				
29-Nov-11	0	3.0E-03	3.2E-04	5.0E-03	3.1E+01	1.6E+00	4.0E-02	6.6E-02	2.0E-02	1.4E-02	1.9E+01	1.5E-01	9.9E-01	1.0E-05	1.3E+01	1.4E+00	2.2E+02	2.0E-04	5.0E-05	5.0E-04	4.2E-02	7.4E-04	4.8E-02	6.7E-04	16.58	15.30	-1.28	-4.0%
6-Dec-11	1	3.0E-03	6.0E-05	1.0E-03	1.9E+01	3.6E-01	3.0E-02	4.1E-02	1.2E-03	9.0E-03	1.0E+01	7.9E-02	4.8E-01	1.0E-05	7.1E+00	8.9E-01	1.4E+02	7.0E-05	1.0E-05	1.0E-04	1.3E-02	1.7E-04	1.1E-02	1.0E-04	8.40	9.43	1.03	5.8%
13-Dec-11	2	5.0E-03	2.6E-04	1.0E-03	1.4E+01	1.7E-01	2.0E-02	2.5E-02	3.2E-03	6.0E-02	7.6E+00	4.8E-02	4.3E-01	1.0E-05	4.1E+00	6.8E-01	1.0E+02	4.0E-05	9.0E-05	2.0E-04	4.8E-03	1.1E-04	5.0E-03	8.0E-05	5.83	6.96	1.12	8.8%
20-Dec-11	3	3.0E-03	2.0E-05	1.0E-03	1.1E+01	1.5E-01	1.0E-02	2.3E-02	3.5E-03	4.4E-02	5.7E+00	2.2E-02	5.2E-01	1.0E-05	2.0E+00	5.8E-01	9.5E+01	4.0E-05	5.0E-05	2.0E-04	3.8E-03	3.2E-04	6.0E-03	4.0E-05	5.90	5.98	0.08	0.7%
27-Dec-11	4																											
3-Jan-12	5	3.0E-03	2.0E-05	1.0E-03	6.0E+00	6.9E-02	1.0E-02	1.2E-02	2.6E-03	3.8E-02	3.6E+00	7.2E-03	3.9E-01	1.0E-05	7.3E-01	3.8E-01	6.0E+01	2.0E-05	2.0E-05	2.0E-04	2.1E-03	3.5E-04	2.0E-03	1.0E-05	4.20	3.83	-0.37	-4.5%
10-Jan-12	6																											
17-Jan-12	7	3.0E-03	7.0E-05	1.0E-03	5.3E+00	5.6E-02	1.0E-02	1.2E-02	3.0E-04	3.9E-02	3.3E+00	5.9E-03	4.7E-01	1.0E-05	4.3E-01	3.6E-01	5.6E+01	2.0E-05	2.0E-05	2.0E-04	2.8E-03	2.8E-04	1.3E-02	2.0E-05	3.94	3.67	-0.27	-3.5%
24-Jan-12	8																											
31-Jan-12	9	3.0E-03	2.0E-05	1.0E-03	4.5E+00	5.0E-02	1.0E-02	1.0E-02	1.0E-04	4.6E-02	2.7E+00	3.5E-03	4.5E-01	1.0E-05	2.9E-01	3.1E-01	4.8E+01	2.0E-05	2.0E-05	2.0E-04	2.9E-03	4.3E-04	2.0E-03	1.0E-05	3.42	3.15	-0.26	-4.0%
7-Feb-12	10																											
14-Feb-12	11	3.0E-03	2.0E-05	1.0E-03	4.0E+00	4.7E-02	1.0E-02	9.5E-03	1.3E-03	7.1E-02	3.2E+00	4.3E-03	5.1E-01	1.0E-05	2.9E-01	3.3E-01	4.6E+01	2.0E-05	1.0E-05	2.0E-04	2.8E-03	1.2E-04	1.0E-03	1.0E-05	3.70	3.33	-0.37	-5.2%
21-Feb-12	12																											
28-Feb-12	13	3.0E-03	3.0E-05	1.0E-03	2.6E+00	4.6E-02	1.0E-02	5.7E-03	1.0E-04	5.3E-02	1.9E+00	2.7E-03	4.3E-01	1.0E-05	1.5E-01	2.5E-01	3.3E+01	2.0E-05	1.0E-05	1.0E-04	1.0E-03	1.6E-04	6.0E-03	1.0E-05	2.31	2.33	0.02	0.4%
6-Mar-12	14																											
13-Mar-12	15	3.0E-03	3.0E-05	1.0E-03	2.4E+00	3.4E-02	1.0E-02	7.4E-03	3.0E-04	6.6E-02	1.9E+00	2.8E-03	4.8E-01	1.0E-05	1.3E-01	2.5E-01	3.5E+01	2.0E-05	1.7E-04	1.0E-04	2.0E-03	1.0E-04	2.0E-03	2.0E-05	2.38	2.44	0.07	1.4%
20-Mar-12	16																											
27-Mar-12	17	3.0E-03	2.0E-05	1.0E-03	1.7E+00	3.2E-02	1.0E-02	6.4E-03	3.0E-04	5.4E-02	1.3E+00	2.7E-03	3.9E-01	1.0E-05	1.2E-01	1.9E-01	2.4E+01	2.0E-05	1.0E-05	1.0E-04	1.6E-03	2.4E-04	1.0E-03	1.0E-05	1.83	1.70	-0.13	-3.6%
3-Apr-12	18																											
10-Apr-12	19	3.0E-03	2.0E-05	1.0E-03	1.5E+00	2.9E-02	2.0E-02	5.6E-03	1.0E-04	4.9E-02	1.1E+00	2.1E-03	3.4E-01	1.0E-05	1.0E-01	1.8E-01	2.0E+01	2.0E-05	3.0E-05	1.0E-04	1.1E-03	2.6E-04	2.0E-03	1.0E-05	1.58	1.44	-0.13	-4.5%
17-Apr-12	20																											
24-Apr-12	21	3.0E-03	6.0E-05	1.0E-03	1.4E+00	2.8E-02	3.0E-02	5.5E-03	4.0E-04	4.8E-02	1.1E+00	1.9E-03	3.5E-01	1.0E-05	1.1E-01	1.7E-01	1.8E+01	2.0E-05	4.0E-05	1.0E-04	1.6E-03	3.2E-04	4.0E-03	1.0E-05	1.49	1.34	-0.15	-5.3%
1-May-12	22																											
8-May-12	23	3.0E-03	2.6E-04	1.0E-03	1.2E+00	2.7E-02	1.0E-02	5.1E-03	1.0E-04	5.0E-02	1.0E+00	1.5E-03	3.0E-01	1.0E-05	1.0E-01	1.5E-01	1.6E+01	2.0E-05	1.7E-04	1.0E-04	1.2E-03	1.9E-04	4.0E-03	1.0E-05	1.15	1.15	0.00	0.1%
15-May-12	24																											
22-May-12	25	3.0E-03	3.0E-05	1.0E-03	1.5E+00	2.5E-02	2.0E-02	7.5E-03	4.0E-04	6.6E-02	1.2E+00	1.6E-03	3.9E-01	1.0E-05	1.2E-01	1.9E-01	2.1E+01	2.0E-05	1.2E-04	2.0E-04	2.2E-03	5.0E-04	3.0E-03	1.0E-05	1.41	1.50	0.09	3.0%
29-May-12	26																											
5-Jun-12	27	3.0E-03	2.0E-05	1.0E-03	8.6E-01	2.2E-02	2.0E-02	4.0E-03	1.0E-04	4.4E-02	7.8E-01	1.4E-03	3.0E-01	1.0E-05	1.0E-01	1.4E-01	1.2E+01	2.0E-05	7.0E-05	2.0E-04	1.2E-03	3.9E-04	3.0E-03	1.0E-05	1.07	0.96	-0.11	-5.3%
12-Jun-12	28																											
19-Jun-12	29	3.0E-03	6.0E-05	1.0E-03	8.9E-01	2.5E-02	1.0E-02	4.9E-03	3.0E-04	4.6E-02	6.9E-01	1.0E-03	3.1E-01	1.0E-05	1.1E-01	1.3E-01	1.1E+01	2.0E-05	1.0E-03	2.0E-04	1.2E-03	3.5E-04	3.0E-03	1.0E-05	0.94	0.91	-0.03	-1.4%
26-Jun-12	30																											
3-Jul-12	31	3.0E-03	1.3E-04	1.0E-03	1.1E+00	2.5E-02	1.0E-02	5.0E-03	1.0E-04	5.4E-02	9.1E-01	2.6E-03	3.5E-01	1.0E-05	1.0E-01	1.6E-01	1.3E+01	2.0E-05	6.4E-04	2.0E-04	1.2E-03	3.1E-04	6.0E-03	2.0E-05	1.10	1.06	-0.04	-1.8%
10-Jul-12	32																											
17-Jul-12	33	3.0E-03	2.0E-05	1.0E-03	9.5E-01	2.3E-02	1.0E-02	5.0E-03	1.0E-04	5.2E-02	8.2E-01	2.6E-03	3.7E-01	1.0E-05	1.3E-01	1.5E-01	1.2E+01	2.0E-05	1.0E-05	1.0E-04	1.4E-03	1.7E-04	1.0E-03	1.0E-05	0.89	0.96	0.07	3.6%
24-Jul-12	34																											
31-Jul-12	35	3.0E-03	1.4E-04	1.0E-03	8.2E-01	2.0E-02	2.0E-02	3.8E-03	1.0E-04	6.0E-02	6.6E-01	1.5E-03	3.5E-01	1.0E-05	9.0E-02	1.4E-01	9.8E+00	2.0E-05	5.0E-05	1.0E-04	1.0E-03	3.6E-04	3.0E-03	1.0E-05	0.76	0.85	0.08	5.1%
7-Aug-12	36																											
14-Aug-12	37	3.0E-03	2.0E-05	1.0E-03	8.5E-01	1.8E-02	1.0E-02	4.5E-03	3.0E-04	4.8E-02	7.2E-01	1.4E-03	3.1E-01	1.0E-05	1.0E-01	1.4E-01	1.1E+01	2.0E-05	2.3E-04	4.0E-04	1.0E-03	6.6E-04	2.0E-03	1.0E-05	0.93	0.86	-0.07	-3.6%
21-Aug-12	38																											
28-Aug-12	39	3.0E-03	2.0E-05	1.0E-03	8.6E-01	2.4E-02	1.0E-02	4.0E-03	4.0E-04	3.2E-02	6.2E-01	1.3E-03	3.0E-01	1.0E-05	8.0E-02	1.3E-01	1.0E+01	2.0E-05	4.0E-04	1.0E-04	1.2E-03	3.3E-04	4.0E-03	1.0E-05	0.86	0.80	-0.05	-3.3%
4-Sep-12	40																											
11-Sep-12	41	3.0E-03	2.0E-05	1.0E-03	8.2E-01	2.1E-02	1.0E-02	3.1E-03	3.0E-04	3.9E-02	6.2E-01	1.4E-03	2.7E-01	1.0E-05	9.0E-02	1.5E-01	1.1E+01	2.0E-05	2.0E-05	1.0E-04	8.0E-04	1.1E-04	2.0E-03	1.0E-05	0.87	0.90	0.03	1.8%
18-Sep-12	42																											
25-Sep-12	43	3.0E-03	2.0E-05	1.0E-03	7.2E-01	2.1E-02	1.0E-02	4.0E-03	2.0E-04	2.4E-02	5.0E-01	1.1E-03	2.5E-01	1.0E-05	1.1E-01	1.4E-01	1.0E+01	2.0E-05	1.0E-04	1.0E-04	1.1E-03	2.0E-04	2.0E-03	1.0E-05	0.88	0.80	-0.08	-4.6%
2-Oct-12	44																											
9-Oct-12	45	3.0E-03	7.0E-05	1.0E-03	6.1E-01	2.1E-02	1.0E-02	3.0E-03	7.0E-04	3.1E-02	4.3E-01	1.1E-03	2.2E-01	1.0E-05	6.0E-02	1.0E-01	7.8E+00	2.0E-05	1.2E-04	5.0E-04	7.4E-04	3.3E-04	3.0E-03	1.0E-05	0.67	0.62	-0.05	-3.7%
16-Oct-12	46																											
23-Oct-12	47																											
30-Oct-12	48																											
6-Nov-12	49	3.0E-03	4.0E-05	1.0E-03	6.7E-01	2.5E-02	1.0E-02	4.3E-03	3.0E-04	3.8E-02	4.1E-01	7.5E-04	2.4E-01	1.0E-05	1.1E-01	1.2E-01	8.8E+00	2.0E-05	1.6E-04	1.0E-04	8.3E-04	3.0E-05	2.0E-03	1.0E-05	0.75	0.74	-0.01	-0.6%
13-Nov-12	50																											
20-Nov-12	51																											
27-Nov-12	52																											
4-Dec-12	53	3.0E-03	3.0E-05	1.0E-03	1.1E+00	2.8E-02	1.0E-02	7.5E-03	1.0E-04	4.9E-02	8.2E-01	5.9E-04	3.3E-01	1.0E-05	9.0E-02	1.6E-01	1.2E+01	2.0E-05	1.2E-04	3.0E-04	3.1E-03	1.9E-04	3.0E-03	1.0E-05	1.08	0.95	-0.13	-6.5%
11-Dec-12	54																											
18-Dec-12	55																											

HC7

Sample = 50% '08-080-043/ 50% 08-225

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Major	Major	Diff	Diff
	No.																								Anions	Cations		(%)
		mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L				
25-Dec-12	56																											
1-Jan-13	57	3.0E-03	2.0E-05	1.0E-03	6.4E-01	1.9E-02	1.0E-02	4.3E-03	1.0E-04	3.8E-02	5.4E-01	7.7E-04	2.8E-01	1.0E-05	6.0E-02	1.2E-01	7.7E+00	2.0E-05	1.1E-04	2.0E-04	1.2E-03	1.7E-04	1.0E-03	1.0E-05	0.75	0.65	-0.11	-7.5%
8-Jan-13	58																											
15-Jan-13	59																											
22-Jan-13	60																											
29-Jan-13	61	3.0E-03	2.0E-05	1.0E-03	7.3E-01	1.9E-02	1.0E-02	3.8E-03	2.0E-04	6.0E-02	5.3E-01	9.2E-04	2.5E-01	1.0E-05	9.0E-02	1.5E-01	9.2E+00	2.0E-05	1.4E-04	2.0E-04	9.1E-04	2.8E-04	1.0E-03	1.0E-05	0.80	0.77	-0.04	-2.4%
5-Feb-13	62																											
12-Feb-13	63																											
19-Feb-13	64																											
26-Feb-13	65	3.0E-03	4.0E-05	1.0E-03	6.5E-01	1.3E-02	1.0E-02	4.7E-03	1.0E-04	5.1E-02	5.3E-01	9.4E-04	1.9E-01	1.0E-05	7.0E-02	1.2E-01	8.3E+00	2.0E-05	2.0E-05	1.0E-04	1.1E-03	4.0E-05	1.0E-03	1.0E-05	0.79	0.66	-0.13	-9.0%
5-Mar-13	66																											
12-Mar-13	67																											
19-Mar-13	68																											
26-Mar-13	69	3.0E-03	7.0E-05	1.0E-03	6.6E-01	1.5E-02	1.0E-02	4.5E-03	1.0E-04	3.7E-02	4.6E-01	7.5E-04	2.2E-01	1.0E-05	5.0E-02	1.3E-01	8.1E+00	2.0E-05	3.0E-05	1.0E-04	9.7E-04	6.0E-05	1.0E-03	1.0E-05	0.71	0.69	-0.02	-1.5%
2-Apr-13	70																											
9-Apr-13	71																											
16-Apr-13	72																											
23-Apr-13	73	3.0E-03	3.0E-05	1.0E-03	6.8E-01	1.3E-02	1.0E-02	4.8E-03	1.0E-04	3.6E-02	4.5E-01	7.2E-04	2.2E-01	1.0E-05	5.0E-02	1.3E-01	8.2E+00	2.0E-05	2.0E-05	1.0E-04	1.1E-03	3.0E-05	1.0E-03	3.0E-05	0.84	0.64	-0.20	-13.2%
30-Apr-13	74																											
7-May-13	75																											
14-May-13	76																											
21-May-13	77	3.0E-03	2.0E-05	1.0E-03	5.5E-01	1.2E-02	1.0E-02	4.1E-03	1.0E-04	4.1E-02	5.0E-01	6.4E-04	2.3E-01	1.0E-05	5.0E-02	1.2E-01	7.4E+00	2.0E-05	5.0E-05	1.0E-04	9.4E-04	6.0E-05	1.0E-03	1.0E-05	0.70	0.59	-0.11	-8.4%
28-May-13	78	3.0E-03	2.0E-05	1.0E-03	6.4E-01	1.3E-02	1.0E-02	4.4E-03	1.0E-04	4.1E-02	5.7E-01	8.1E-04	2.1E-01	1.0E-05	5.0E-02	1.4E-01	7.6E+00	2.0E-05	6.0E-05	1.0E-04	1.2E-03	6.0E-05	1.0E-03	1.0E-05	0.77	0.68	-0.09	-5.9%
4-Jun-13	79	3.0E-03	2.0E-05	1.0E-03	4.8E-01	1.7E-02	1.0E-02	2.6E-03	2.0E-04	3.2E-02	3.7E-01	4.4E-04	2.0E-01	1.0E-05	5.0E-02	1.2E-01	5.5E+00	2.0E-05	7.0E-04	1.0E-04	1.1E-03	7.0E-05	2.0E-03	1.0E-05	0.59	0.55	-0.04	-3.4%
11-Jun-13	80	3.0E-03	2.0E-05	1.0E-03	4.4E-01	1.6E-02	1.0E-02	2.1E-03	1.0E-04	3.1E-02	3.4E-01	4.0E-04	1.6E-01	1.0E-05	4.0E-02	9.7E-02	4.2E+00	2.0E-05	8.3E-04	1.0E-04	1.2E-03	3.0E-05	1.0E-03	1.0E-05	0.53	0.47	-0.06	-6.1%
18-Jun-13	81	3.0E-03	2.0E-05	1.0E-03	4.4E-01	1.6E-02	1.0E-02	1.9E-03	1.0E-04	2.9E-02	3.4E-01	4.2E-04	1.5E-01	1.0E-05	5.0E-02	1.0E-01	4.1E+00	2.0E-05	4.8E-04	1.0E-04	1.3E-03	3.0E-05	1.0E-03	1.0E-05	0.53	0.47	-0.06	-6.3%
25-Jun-13	82																											
2-Jul-13	83	3.0E-03	2.0E-05	1.0E-03	3.7E-01	1.3E-02	1.0E-02	1.8E-03	1.0E-04	2.2E-02	3.1E-01	3.1E-04	1.4E-01	1.0E-05	2.0E-02	8.5E-02	3.1E+00	2.0E-05	4.0E-05	1.0E-04	1.1E-03	9.0E-05	1.0E-03	1.0E-05	0.52	0.38	-0.13	-14.9%
9-Jul-13	84																											
16-Jul-13	85	3.0E-03	2.0E-05	1.0E-03	3.5E-01	1.4E-02	1.0E-02	1.4E-03	1.0E-04	2.2E-02	2.4E-01	2.7E-04	1.1E-01	1.0E-05	2.0E-02	8.4E-02	2.6E+00	2.0E-05	4.3E-04	1.0E-04	1.0E-03	3.0E-05	2.0E-03	1.0E-05	0.40	0.37	-0.03	-3.7%
23-Jul-13	86																											
30-Jul-13	87	3.0E-03	2.0E-05	1.0E-03	2.9E-01	1.2E-02	1.0E-02	1.1E-03	1.0E-04	1.8E-02	1.9E-01	2.3E-04	1.0E-01	1.0E-05	2.0E-02	7.5E-02	2.4E+00	2.0E-05	3.9E-04	1.0E-04	9.0E-04	3.0E-05	1.0E-03	1.0E-05	0.42	0.32	-0.09	-12.6%
6-Aug-13	88																											
13-Aug-13	89	3.0E-03	4.0E-05	1.0E-03	3.1E-01	1.3E-02	1.0E-02	1.1E-03	2.0E-04	2.9E-02	2.0E-01	2.5E-04	1.3E-01	1.0E-05	3.0E-02	7.8E-02	2.4E+00	2.0E-05	6.7E-04	1.0E-04	9.1E-04	3.0E-05	3.0E-03	1.0E-05	0.33	0.33	0.00	-0.4%
20-Aug-13	90																											
27-Aug-13	91																											
3-Sep-13	92																											
10-Sep-13	93	3.0E-03	2.0E-05	1.0E-03	3.4E-01	1.3E-02	1.0E-02	1.3E-03	1.0E-04	2.9E-02	2.3E-01	2.6E-04	1.3E-01	1.0E-05	1.0E-02	8.4E-02	2.8E+00	2.0E-05	9.6E-04	1.0E-04	1.1E-03	3.0E-05	1.0E-03	1.0E-05	0.36	0.37	0.01	1.1%
17-Sep-13	94																											
24-Sep-13	95																											
1-Oct-13	96																											
8-Oct-13	97	3.0E-03	2.0E-05	1.0E-03	3.3E-01	1.3E-02	1.0E-02	1.2E-03	1.0E-04	1.7E-02	2.2E-01	2.6E-04	1.6E-01	1.0E-05	2.0E-02	8.7E-02	2.7E+00	2.0E-05	4.4E-04	1.0E-04	1.0E-03	3.0E-05	1.0E-03	1.0E-05	0.33	0.37	0.04	6.4%
15-Oct-13	98																											
22-Oct-13	99																											
29-Oct-13	100																											
5-Nov-13	101	3.0E-03	2.0E-05	1.0E-03	3.3E-01	1.4E-02	1.0E-02	1.2E-03	1.0E-04	1.2E-02	2.2E-01	2.9E-04	1.3E-01	1.0E-05	2.0E-02	9.2E-02	2.3E+00	2.0E-05	1.6E-03	1.0E-04	1.1E-03	3.0E-05	1.0E-03	1.0E-05	0.39	0.38	-0.01	-0.9%
12-Nov-13	102																											
19-Nov-13	103																											
26-Nov-13	104																											
3-Dec-13	105	3.0E-03	2.0E-05	1.0E-03	2.9E-01	1.1E-02	1.0E-02	1.2E-03	1.0E-04	1.7E-02	1.9E-01	2.4E-04	1.1E-01	1.0E-05	1.0E-02	8.2E-02	2.0E+00	2.0E-05	6.6E-04	1.0E-04	9.7E-04	8.0E-05	1.0E-03	1.0E-05	0.28	0.33	0.05	7.7%
10-Dec-13	106																											
17-Dec-13	107																											
24-Dec-13	108																											
31-Dec-13	109	4.0E-03	3.0E-05	1.0E-03	2.6E-01	1.2E-02	1.0E-02	1.1E-03	1.0E-04	1.5E-02	1.7E-01	2.4E-04	1.1E-01	1.0E-05	2.0E-02	7.8E-02	1.9E+00	2.0E-05	9.2E-04	1.0E-04	8.2E-04	4.0E-05	1.0E-03	1.0E-05	0.32	0.30	-0.02	-4.0%
7-Jan-14	110																											
14-Jan-14	111																											
21-Jan-14	112																											
28-Jan-14	113	3.0E-03	2.0E-05	1.0E-03	2.9E-01	1.3E-02	4.0E-02	1.1E-03	1.0E-04	9.0E-03	1.7E-01	1.9E-04	1.0E-01	1.0E-05	1.0E-02	8.6E-02	2.0E+00	2.0E-05	9.3E-04	1.0E-04	9.5E-04	3.0E-05	1.0E-03	1.0E-05	0.30	0.33	0.03	4.8%
4-Feb-14	114																											
11-Feb-14	115																											
18-Feb-14	116																											
25-Feb-14	117	3.0E-03	2.0E-05	1.0E-03	2.9E-01	1.2E-02	1.0E-02	1.3E-03	1.0E-04	1.7E-02	1.8E-01	2.2E-04	1.1E-01	1.0E-05	1.0E-02	9.0E-02	1.9E+00	2.0E-05	4.3E-04	1.0E-04	9.9E-04	3.0E-05	1.0E-03	1.0E-05	0.40	0.33	-0.06	-8.9%

HC7
Sample = 50% '08-080-043/ 50% 08-225

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/kg	mgCaCO3/kg	mgCaCO3/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
29-Nov-11	0	500	385	7.28	1.4E+03	#N/A	5.9E+00	3.9E+01	2.7E+02	1.5E+00	1.1E-01	1.2E-01	2.7E+02	9.0E-03	8.5E-04	1.9E-03	1.8E-02	7.7E-06	7.7E-06	5.6E-03	1.4E-03	8.9E+01	1.9E-04	1.5E-02	3.6E-01
6-Dec-11	1	500	475	7.48	8.1E+02	#N/A	2.1E+00	1.4E+01	1.8E+02	1.0E+00	1.8E-01	1.4E-01	2.1E+02	9.1E-03	8.6E-04	1.2E-03	1.4E-02	9.5E-06	4.8E-06	2.7E-03	2.0E-04	6.9E+01	2.4E-04	1.2E-03	3.5E-02
13-Dec-11	2	500	450	7.45	6.5E+02	#N/A	1.6E+00	7.8E+00	1.2E+02	4.5E-01	1.9E-01	1.4E-01	1.5E+02	1.3E-02	6.8E-04	9.9E-04	1.4E-02	9.0E-06	4.5E-06	1.8E-03	9.1E-05	4.9E+01	5.9E-04	3.6E-04	6.1E-03
20-Dec-11	3	500	495	7.51	5.7E+02	#N/A	2.2E+00	8.7E+00	1.3E+02	1.5E-01	1.9E-01	1.5E-01	1.4E+02	2.2E-02	6.9E-04	1.0E-03	1.3E-02	9.9E-06	5.0E-06	2.3E-03	8.7E-05	4.8E+01	2.5E-04	3.7E-04	5.0E-03
27-Dec-11	4	500	525	7.53	4.4E+02																				
3-Jan-12	5	500	530	7.38	4.0E+02	#N/A	2.5E+00	9.3E+00	9.8E+01	1.1E-01	1.4E-01	1.6E-01	9.8E+01	2.8E-02	5.8E-04	7.4E-04	1.6E-02	1.1E-05	5.3E-06	2.0E-03	4.7E-05	3.4E+01	2.7E-04	2.0E-04	2.9E-03
10-Jan-12	6	500	480	7.28	4.1E+02																				
17-Jan-12	7	500	510	7.34	3.8E+02	#N/A	1.6E+00	8.8E+00	8.8E+01	1.0E-01	1.5E-01	1.5E-01	9.1E+01	2.2E-02	7.7E-04	8.7E-04	1.8E-02	1.0E-05	5.1E-06	1.7E-03	4.8E-05	3.2E+01	2.6E-04	1.4E-04	2.5E-03
24-Jan-12	8	500	440	7.44	3.6E+02																				
31-Jan-12	9	500	455	7.31	3.4E+02	#N/A	1.8E+00	7.2E+00	6.7E+01	9.1E-02	1.4E-01	1.4E-01	7.0E+01	2.0E-02	6.8E-04	7.3E-04	9.6E-03	9.1E-06	4.6E-06	1.1E-03	2.7E-05	2.5E+01	2.3E-04	1.2E-04	2.0E-03
7-Feb-12	10	500	480	7.46	3.4E+02																				
14-Feb-12	11	500	450	7.47	3.4E+02	#N/A	2.2E+00	9.7E+00	7.0E+01	1.4E-01	1.6E-01	1.4E-01	7.2E+01	2.1E-02	6.3E-04	1.3E-03	1.1E-02	9.0E-06	4.5E-06	9.9E-04	1.6E-05	2.6E+01	2.3E-04	8.7E-05	1.7E-03
21-Feb-12	12	500	465	7.43	2.9E+02																				
28-Feb-12	13	500	495	7.28	2.4E+02	#N/A	1.9E+00	7.4E+00	4.8E+01	2.0E-01	1.1E-01	1.5E-01	5.6E+01	1.4E-02	6.9E-04	1.0E-03	1.6E-02	9.9E-06	5.0E-06	1.0E-03	3.3E-05	2.0E+01	2.5E-04	9.2E-05	2.5E-03
6-Mar-12	14	500	485	7.50	2.6E+02																				
13-Mar-12	15	500	445	7.29	2.6E+02	#N/A	1.4E+00	6.6E+00	4.4E+01	2.7E-01	1.3E-01	1.3E-01	5.3E+01	1.8E-02	7.6E-04	1.1E-03	1.0E-02	8.9E-06	4.5E-06	9.3E-04	1.2E-05	1.9E+01	2.2E-04	5.4E-05	1.9E-03
20-Mar-12	16	500	430	7.29	2.0E+02																				
27-Mar-12	17	500	450	7.22	1.9E+02	#N/A	1.3E+00	5.8E+00	3.4E+01	2.3E-01	9.5E-02	1.4E-01	3.7E+01	1.9E-02	6.3E-04	9.9E-04	1.1E-02	9.0E-06	4.5E-06	8.6E-04	1.4E-05	1.4E+01	2.3E-04	5.9E-05	1.7E-03
3-Apr-12	18	500	465	7.26	1.7E+02																				
10-Apr-12	19	500	450	7.27	1.7E+02	#N/A	9.7E-01	5.7E+00	2.8E+01	2.3E-01	9.0E-02	1.4E-01	3.2E+01	2.4E-02	6.3E-04	9.9E-04	1.0E-02	9.0E-06	4.5E-06	9.5E-04	1.4E-06	1.2E+01	2.3E-04	5.2E-05	1.3E-03
17-Apr-12	20	500	425	7.22	1.8E+02																				
24-Apr-12	21	500	470	7.29	1.6E+02	#N/A	1.2E+00	6.3E+00	2.7E+01	2.4E-01	8.9E-02	1.4E-01	3.0E+01	2.5E-02	7.5E-04	1.1E-03	1.1E-02	9.4E-06	4.7E-06	8.5E-04	4.7E-06	1.1E+01	2.4E-04	5.9E-05	1.6E-03
1-May-12	22	500	445	7.39	1.5E+02																				
8-May-12	23	500	455	7.25	1.3E+02	#N/A	1.4E+00	5.1E+00	2.0E+01	2.3E-01	6.4E-02	1.4E-01	2.5E+01	1.3E-02	5.9E-04	9.1E-04	9.0E-03	9.1E-06	4.6E-06	8.6E-04	8.6E-06	9.2E+00	2.3E-04	5.5E-05	1.8E-03
15-May-12	24	500	455	7.26	1.4E+02																				
22-May-12	25	500	360	7.23	1.8E+02	#N/A	1.3E+00	4.9E+00	1.9E+01	1.4E-01	6.8E-02	1.1E-01	2.6E+01	3.1E-02	6.1E-04	1.0E-03	8.0E-03	7.2E-06	3.6E-06	6.5E-04	1.1E-06	9.5E+00	1.8E-04	4.0E-05	1.6E-03
29-May-12	26	500	435	7.19	1.4E+02																				
5-Jun-12	27	500	450	7.22	1.1E+02	#N/A	1.4E+00	5.6E+00	1.8E+01	1.8E-01	6.3E-02	1.4E-01	2.1E+01	2.6E-02	5.0E-04	1.0E-03	1.3E-02	9.0E-06	4.5E-06	1.1E-03	1.4E-06	7.7E+00	2.3E-04	4.9E-05	1.4E-03
12-Jun-12	28	500	460	7.31	1.1E+02																				
19-Jun-12	29	500	480	7.25	1.1E+02	#N/A	1.3E+00	5.9E+00	1.6E+01	1.9E-01	6.2E-02	1.4E-01	2.1E+01	2.6E-02	4.8E-04	1.0E-03	1.4E-02	9.6E-06	4.8E-06	7.2E-04	1.4E-06	7.8E+00	2.4E-04	5.7E-05	1.7E-03
26-Jun-12	30	500	475	7.25	1.0E+02																				
3-Jul-12	31	500	445	7.39	1.2E+02	#N/A	2.9E+00	7.6E+00	1.6E+01	2.2E-01	8.5E-02	1.3E-01	2.3E+01	3.0E-02	5.8E-04	1.2E-03	1.4E-02	8.9E-06	4.5E-06	5.3E-04	1.1E-05	8.3E+00	2.2E-04	4.6E-05	1.6E-03
10-Jul-12	32	500	445	7.20	1.1E+02																				
17-Jul-12	33	500	465	7.25	1.1E+02	#N/A	9.6E-01	6.0E+00	1.4E+01	1.4E-01	7.9E-02	1.4E-01	2.1E+01	1.9E-02	7.0E-04	1.5E-03	1.2E-02	9.3E-06	4.7E-06	8.8E-04	5.6E-06	7.9E+00	2.3E-04	1.1E-04	1.2E-03
24-Jul-12	34	500	425	7.12	1.0E+02																				
31-Jul-12	35	500	460	7.27	9.3E+01	#N/A	9.5E-01	5.5E+00	1.2E+01	1.4E-01	5.5E-02	1.4E-01	1.9E+01	2.4E-02	5.5E-04	9.7E-04	1.1E-02	9.2E-06	4.6E-06	9.2E-04	2.2E-05	6.9E+00	2.3E-04	4.6E-05	1.3E-03
7-Aug-12	36	500	445	7.37	1.0E+02																				
14-Aug-12	37	500	440	7.20	9.8E+01	#N/A	1.2E+00	5.1E+00	1.5E+01	1.8E-01	5.7E-02	1.3E-01	1.8E+01	3.7E-02	5.3E-04	1.6E-03	8.8E-03	8.8E-06	4.4E-06	1.6E-03	1.3E-06	6.6E+00	2.2E-04	1.7E-05	1.8E-03
21-Aug-12	38	500	445	7.07	9.9E+01																				
28-Aug-12	39	500	505	7.13	9.6E+01	#N/A	1.7E+00	5.7E+00	1.5E+01	2.0E-01	5.6E-02	1.5E-01	2.0E+01	2.3E-02	5.1E-04	7.6E-04	1.0E-02	1.0E-05	5.1E-06	1.0E-03	2.0E-05	7.1E+00	2.5E-04	7.2E-05	1.6E-03
4-Sep-12	40	500	480	7.02	9.2E+01																				
11-Sep-12	41	500	480	7.15	9.7E+01	#N/A	1.3E+00	5.2E+00	1.5E+01	9.6E-02	5.8E-02	1.4E-01	2.1E+01	1.7E-02	4.8E-04	9.1E-04	1.1E-02	9.6E-06	4.8E-06	8.6E-04	5.3E-06	7.7E+00	2.4E-04	5.6E-05	1.2E-03
18-Sep-12	42	500	535	7.13	9.6E+01																				
25-Sep-12	43	500	490	7.16	9.5E+01	#N/A	1.6E+00	5.6E+00	1.5E+01	9.8E-02	4.9E-02	1.5E-01	1.9E+01	1.7E-02	3.9E-04	9.8E-04	1.5E-02	9.8E-06	4.9E-06	1.2E-03	5.4E-06	7.1E+00	2.5E-04	5.2E-05	1.3E-03
2-Oct-12	44	500	495	7.13	9.9E+01																				
9-Oct-12	45	500	515	7.09	7.3E+01	#N/A	2.1E+00	4.9E+00	1.2E+01	1.0E-01	4.6E-02	1.5E-01	1.6E+01	1.7E-02	3.6E-04	6.7E-04	1.2E-02	1.0E-05	5.2E-06	5.7E-04	1.9E-05	5.7E+00	2.6E-04	7.8E-05	2.3E-03
16-Oct-12	46	500	510	7.16	8.6E+01																				
23-Oct-12	47	500	505	7.10	8.8E+01																				
30-Oct-12	48	500	510	7.19	1.0E+02																				
6-Nov-12	49	500	490	7.20	7.5E+01	#N/A	1.4E+00	5.0E+00	1.3E+01	9.8E-02	3.9E-02	1.5E-01	1.8E+01	7.4E-03	3.4E-04	6.9E-04	1.3E-02	9.8E-06	4.9E-06	7.8E-04	1.7E-05	6.5E+00	2.5E-04	7.4E-05	2.0E-03
13-Nov-12	50	500	495	7.21	8.6E+01																				
20-Nov-12	51	500	490	7.41	7.7E+01																				
27-Nov-12	52	500	495	7.22	8.5E+01																				
4-Dec-12	53	500	420	7.36	1.1E+02	#N/A	8.9E-01	6.3E+00	1.6E+01	8.4E-02	3.8E-02	1.3E-01	1.9E+01	1.4E-02	7.1E-04	1.1E-03	8.8E-03	8.4E-06	4.2E-06	4.6E-04	1.2E-05	6.9E+00	2.1E-04	8.4E-05	1.8E-03
11-Dec-12	54	500	445	7.21	1.1E+02																				
18-Dec-12	55	500	445	7.25	7.8E+01																				
25-Dec-12	56	500	465	7.31	1.1E+02																				
1-Jan-13	57	500	490	7.45	7.5E+01	#N/A	1.9E+00	6.1E+00	1.2E+01	9.8E-02	4.4E-02	1.5E-01	1.5E+01	1.4E-02	4.9E-04	9.3E-04	1.1E-02	9.8E-06	4.9E-06	3.9E-04	7.4E-06	5.6E+00	2.5E-04	5.1E-05	9.3E-04

HC7
Sample = 50% '08-080-043/ 50% 08-225

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/kg	mgCaCO3/kg	mgCaCO3/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
8-Jan-13	58	500	465	7.41	8.5E+01																				
15-Jan-13	59	500	465	7.24	8.0E+01																				
22-Jan-13	60	500	460	7.43	7.5E+01																				
29-Jan-13	61	500	460	7.27	7.4E+01	#N/A	1.2E+00	5.5E+00	1.2E+01	9.2E-02	3.7E-02	1.4E-01	1.7E+01	2.5E-02	3.7E-04	8.7E-04	8.0E-03	9.2E-06	4.6E-06	3.7E-04	7.4E-06	6.3E+00	2.3E-04	3.2E-05	1.2E-03
5-Feb-13	62	500	460	7.32	8.2E+01																				
12-Feb-13	63	500	460	7.35	8.1E+01																				
19-Feb-13	64	500	455	7.32	8.3E+01																				
26-Feb-13	65	500	450	7.30	8.0E+01	#N/A	1.8E+00	5.4E+00	1.2E+01	9.0E-02	3.6E-02	1.4E-01	1.4E+01	1.3E-02	3.6E-04	9.5E-04	6.5E-03	9.0E-06	4.5E-06	2.7E-04	6.8E-06	5.2E+00	2.3E-04	1.2E-04	9.5E-04
5-Mar-13	66	500	440	7.47	6.9E+01																				
12-Mar-13	67	500	445	7.28	6.7E+01																				
19-Mar-13	68	500	460	7.57	7.4E+01																				
26-Mar-13	69	500	460	7.40	7.6E+01	#N/A	2.0E+00	5.8E+00	1.0E+01	9.2E-02	2.8E-02	1.4E-01	1.5E+01	1.7E-02	3.7E-04	9.2E-04	6.3E-03	9.2E-06	4.6E-06	4.6E-04	2.8E-06	5.7E+00	2.3E-04	7.2E-05	7.8E-04
2-Apr-13	70	500	440	7.39	7.9E+01																				
9-Apr-13	71	500	460	7.39	7.9E+01																				
16-Apr-13	72	500	455	7.41	8.0E+01																				
23-Apr-13	73	500	445	7.41	8.4E+01	#N/A	2.1E+00	5.3E+00	1.3E+01	8.9E-02	2.7E-02	1.3E-01	1.4E+01	1.1E-02	3.6E-04	7.6E-04	6.2E-03	8.9E-06	4.5E-06	4.0E-04	3.6E-06	5.1E+00	2.2E-04	3.4E-05	1.1E-03
30-Apr-13	74	500	440	7.37	7.2E+01																				
7-May-13	75	500	445	7.41	8.5E+01																				
14-May-13	76	500	430	7.40	7.5E+01																				
21-May-13	77	500	435	7.34	6.8E+01	#N/A	1.7E+00	4.3E+00	1.0E+01	8.7E-02	2.6E-02	1.3E-01	1.2E+01	1.3E-02	3.9E-04	8.3E-04	6.0E-03	8.7E-06	4.4E-06	7.0E-04	3.0E-06	4.6E+00	2.2E-04	3.2E-05	1.1E-03
28-May-13	78	500	445	7.45	7.2E+01		1.6E+00	5.0E+00	1.2E+01	8.9E-02	2.7E-02	1.3E-01	1.5E+01	1.5E-02	3.6E-04	8.9E-04	6.0E-03	8.9E-06	4.5E-06	6.7E-04	4.9E-06	5.4E+00	2.2E-04	4.0E-05	1.0E-03
4-Jun-13	79	500	460	7.30	6.1E+01		1.8E+00	4.9E+00	8.3E+00	9.2E-02	2.8E-02	1.4E-01	1.2E+01	6.2E-03	2.3E-04	6.0E-04	5.4E-03	9.2E-06	4.6E-06	1.7E-03	2.8E-06	4.5E+00	2.3E-04	6.0E-05	1.4E-03
11-Jun-13	80	500	480	7.47	5.0E+01		2.9E+00	6.3E+00	6.2E+00	9.6E-02	2.9E-02	1.4E-01	1.1E+01	6.6E-03	1.9E-04	5.3E-04	4.8E-03	9.6E-06	4.8E-06	1.2E-03	3.4E-06	4.0E+00	2.4E-04	4.5E-05	4.8E-04
18-Jun-13	81	500	480	7.26	5.1E+01	#N/A	2.0E+00	5.7E+00	6.7E+00	9.6E-02	2.9E-02	1.4E-01	1.1E+01	7.2E-03	2.4E-04	5.3E-04	5.3E-03	9.6E-06	4.8E-06	1.2E-03	1.4E-06	4.0E+00	2.4E-04	6.4E-05	1.3E-03
25-Jun-13	82	500	470	7.34	4.4E+01																				
2-Jul-13	83	500	475	7.39	4.2E+01		2.9E+00	7.3E+00	4.8E+00	9.5E-02	2.9E-02	1.4E-01	8.8E+00	8.6E-03	1.9E-04	6.2E-04	5.8E-03	9.5E-06	4.8E-06	9.5E-05	4.8E-06	3.2E+00	2.4E-04	3.1E-05	1.0E-03
9-Jul-13	84	500	470	7.43	5.0E+01																				
16-Jul-13	85	500	485	7.17	4.0E+01	#N/A	1.5E+00	5.1E+00	4.4E+00	9.7E-02	2.9E-02	1.5E-01	8.7E+00	7.1E-03	1.5E-04	4.9E-04	5.3E-03	9.7E-06	4.9E-06	8.7E-04	4.4E-06	3.2E+00	2.4E-04	3.9E-05	1.1E-03
23-Jul-13	86	500	485	7.40	3.8E+01																				
30-Jul-13	87	500	485	7.14	3.5E+01		1.8E+00	5.1E+00	4.9E+00	9.7E-02	2.9E-02	1.5E-01	7.7E+00	4.9E-03	1.5E-04	3.4E-04	5.1E-03	9.7E-06	4.9E-06	8.2E-04	1.5E-06	2.8E+00	2.4E-04	2.7E-05	8.7E-04
6-Aug-13	88	500	515	7.50	3.6E+01																				
13-Aug-13	89	500	485	7.16	3.5E+01	#N/A	1.2E+00	4.5E+00	3.4E+00	9.7E-02	2.9E-02	1.5E-01	7.7E+00	5.8E-03	1.5E-04	3.9E-04	5.9E-03	9.7E-06	4.9E-06	7.3E-04	5.8E-06	2.8E+00	2.4E-04	4.3E-05	8.7E-04
20-Aug-13	90	500	485	7.17	3.6E+01																				
27-Aug-13	91	500	485	7.26	3.6E+01																				
3-Sep-13	92	500	475	7.37	3.3E+01																				
10-Sep-13	93	500	475	7.22	3.7E+01	#N/A	1.5E+00	5.0E+00	3.3E+00	9.5E-02	2.9E-02	1.4E-01	8.4E+00	5.7E-03	1.4E-04	4.8E-04	6.4E-03	9.5E-06	4.8E-06	7.6E-04	2.9E-06	3.1E+00	2.4E-04	4.8E-05	1.0E-03
17-Sep-13	94	500	500	7.35	3.9E+01																				
24-Sep-13	95	500	500	7.20	3.6E+01																				
1-Oct-13	96	500	465	7.37	3.9E+01																				
8-Oct-13	97	500	475	7.21	3.7E+01	#N/A	7.7E-01	4.8E+00	2.9E+00	9.5E-02	2.9E-02	1.4E-01	8.6E+00	6.1E-03	1.4E-04	4.8E-04	6.6E-03	9.5E-06	4.8E-06	1.6E-03	1.9E-06	3.2E+00	2.4E-04	4.2E-05	8.1E-04
15-Oct-13	98	500	500	7.12	3.2E+01																				
22-Oct-13	99	500	475	7.24	3.8E+01																				
29-Oct-13	100	500	470	7.34	3.9E+01																				
5-Nov-13	101	500	495	7.36	4.0E+01	#N/A	9.2E-01	5.9E+00	3.5E+00	9.9E-02	3.0E-02	1.5E-01	9.1E+00	5.8E-03	1.5E-04	5.0E-04	7.5E-03	9.9E-06	5.0E-06	6.9E-04	2.5E-06	3.4E+00	2.5E-04	3.4E-05	8.4E-04
12-Nov-13	102	500	470	7.41	3.6E+01																				
19-Nov-13	103	500	480	7.20	3.6E+01																				
26-Nov-13	104	500	475	7.53	3.9E+01																				
3-Dec-13	105	500	470	7.63	3.4E+01	#N/A	4.6E-01	4.6E+00	1.9E+00	9.4E-02	2.8E-02	1.4E-01	7.5E+00	6.6E-03	1.4E-04	4.2E-04	6.8E-03	9.4E-06	4.7E-06	4.2E-04	1.9E-06	2.8E+00	2.4E-04	3.1E-05	8.5E-04
10-Dec-13	106	500	470	7.39	3.3E+01																				
17-Dec-13	107	500	475	7.46	3.5E+01																				
24-Dec-13	108	500	495	7.68	3.6E+01																				
31-Dec-13	109	500	500	7.39	3.2E+01	#N/A	8.1E-01	4.9E+00	3.0E+00	1.0E-01	3.0E-02	1.5E-01	7.2E+00	4.5E-03	1.0E-04	3.5E-04	7.1E-03	1.0E-05	5.0E-06	1.0E-03	2.5E-06	2.7E+00	2.5E-04	3.8E-05	9.5E-04
7-Jan-14	110	500	480	7.28	3.5E+01																				
14-Jan-14	111	500	480	7.54	3.2E+01																				
21-Jan-14	112	500	480	7.44	3.4E+01																				
28-Jan-14	113	500	490	7.35	3.5E+01	#N/A	8.9E-01	5.2E+00	2.0E+00	9.8E-02	2.9E-02	1.5E-01	7.8E+00	4.4E-03	1.5E-04	2.9E-04	6.7E-03	9.8E-06	4.9E-06	6.4E-04	1.5E-06	2.9E+00	2.5E-04	1.6E-05	4.4E-04
4-Feb-14	114	500	480	7.54	3.7E+01																				
11-Feb-14	115	500	465	7.51	3.3E+01																				
18-Feb-14	116	500	480	7.54	3.3E+01																				
25-Feb-14	117	500	480	7.70	3.3E+01	#N/A	1.3E+00	6.5E+00	2.9E+00	9.6E-02	2.9E-02	1.4E-01	7.8E+00	5.4E-03	1.4E-04	3.8E-04	7.1E-03	9.6E-06	4.8E-06	4.8E-04	1.4E-06	2.9E+00	2.4E-04	3.1E-05	6.7E-04

HC7
Sample = 50% '08-080-043/ 50% 08-225

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
	No.																							
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
29-Nov-11	0	1.2E-03	1.2E-04	1.9E-03	1.2E+01	6.2E-01	1.5E-05	2.5E-02	7.7E-03	5.4E-03	7.1E+00	5.9E-02	3.8E-01	3.9E-06	5.1E+00	5.3E-01	8.5E+01	7.7E-05	1.9E-05	1.9E-04	1.6E-02	2.8E-04	1.8E-02	2.6E-04
6-Dec-11	1	1.4E-03	2.9E-05	4.8E-04	9.1E+00	1.7E-01	1.4E-05	2.0E-02	5.7E-04	4.3E-03	4.9E+00	3.7E-02	2.3E-01	4.8E-06	3.4E+00	4.2E-01	6.8E+01	3.3E-05	4.8E-06	4.8E-05	6.0E-03	8.1E-05	5.2E-03	4.8E-05
13-Dec-11	2	2.3E-03	1.2E-04	4.5E-04	6.1E+00	7.7E-02	9.0E-06	1.1E-02	1.4E-03	2.7E-02	3.4E+00	2.2E-02	1.9E-01	4.5E-06	1.8E+00	3.1E-01	4.7E+01	1.8E-05	4.1E-05	9.0E-05	2.1E-03	5.0E-05	2.3E-03	3.6E-05
20-Dec-11	3	1.5E-03	9.9E-06	5.0E-04	5.3E+00	7.2E-02	5.0E-06	1.2E-02	1.7E-03	2.2E-02	2.8E+00	1.1E-02	2.6E-01	5.0E-06	1.0E+00	2.8E-01	4.7E+01	2.0E-05	2.5E-05	9.9E-05	1.9E-03	1.6E-04	3.0E-03	2.0E-05
27-Dec-11	4																							
3-Jan-12	5	1.6E-03	1.1E-05	5.3E-04	3.2E+00	3.7E-02	5.3E-06	6.3E-03	1.4E-03	2.0E-02	1.9E+00	3.8E-03	2.1E-01	5.3E-06	3.9E-01	2.0E-01	3.2E+01	1.1E-05	1.1E-05	1.1E-04	1.1E-03	1.9E-04	1.1E-03	5.3E-06
10-Jan-12	6																							
17-Jan-12	7	1.5E-03	3.6E-05	5.1E-04	2.7E+00	2.9E-02	5.1E-06	5.9E-03	1.5E-04	2.0E-02	1.7E+00	3.0E-03	2.4E-01	5.1E-06	2.2E-01	1.9E-01	2.8E+01	1.0E-05	1.0E-05	1.0E-04	1.4E-03	1.4E-04	6.6E-03	1.0E-05
24-Jan-12	8																							
31-Jan-12	9	1.4E-03	9.1E-06	4.6E-04	2.0E+00	2.3E-02	4.6E-06	4.5E-03	4.6E-05	2.1E-02	1.2E+00	1.6E-03	2.0E-01	4.6E-06	1.3E-01	1.4E-01	2.2E+01	9.1E-06	9.1E-06	9.1E-05	1.3E-03	2.0E-04	9.1E-04	4.6E-06
7-Feb-12	10																							
14-Feb-12	11	1.4E-03	9.0E-06	4.5E-04	1.8E+00	2.1E-02	4.5E-06	4.3E-03	5.9E-04	3.2E-02	1.5E+00	1.9E-03	2.3E-01	4.5E-06	1.3E-01	1.5E-01	2.1E+01	9.0E-06	4.5E-06	9.0E-05	1.3E-03	5.4E-05	4.5E-04	4.5E-06
21-Feb-12	12																							
28-Feb-12	13	1.5E-03	1.5E-05	5.0E-04	1.3E+00	2.3E-02	5.0E-06	2.8E-03	5.0E-05	2.6E-02	9.2E-01	1.3E-03	2.1E-01	5.0E-06	7.4E-02	1.2E-01	1.6E+01	9.9E-06	5.0E-06	5.0E-05	4.9E-04	7.9E-05	3.0E-03	5.0E-06
6-Mar-12	14																							
13-Mar-12	15	1.3E-03	1.3E-05	4.5E-04	1.1E+00	1.5E-02	4.5E-06	3.3E-03	1.3E-04	2.9E-02	8.2E-01	1.2E-03	2.1E-01	4.5E-06	5.8E-02	1.1E-01	1.5E+01	8.9E-06	7.6E-05	4.5E-05	9.1E-04	4.5E-05	8.9E-04	8.9E-06
20-Mar-12	16																							
27-Mar-12	17	1.4E-03	9.0E-06	4.5E-04	7.7E-01	1.4E-02	4.5E-06	2.9E-03	1.4E-04	2.4E-02	5.8E-01	1.2E-03	1.8E-01	4.5E-06	5.4E-02	8.5E-02	1.1E+01	9.0E-06	4.5E-06	4.5E-05	7.2E-04	1.1E-04	4.5E-04	4.5E-06
3-Apr-12	18																							
10-Apr-12	19	1.4E-03	9.0E-06	4.5E-04	6.6E-01	1.3E-02	9.0E-06	2.5E-03	4.5E-05	2.2E-02	5.1E-01	9.2E-04	1.5E-01	4.5E-06	4.5E-02	7.9E-02	9.0E+00	9.0E-06	1.4E-05	4.5E-05	4.8E-04	1.2E-04	9.0E-04	4.5E-06
17-Apr-12	20																							
24-Apr-12	21	1.4E-03	2.8E-05	4.7E-04	6.3E-01	1.3E-02	1.4E-05	2.6E-03	1.9E-04	2.3E-02	5.3E-01	9.0E-04	1.6E-01	4.7E-06	5.2E-02	8.0E-02	8.6E+00	9.4E-06	1.9E-05	4.7E-05	7.6E-04	1.5E-04	1.9E-03	4.7E-06
1-May-12	22																							
8-May-12	23	1.4E-03	1.2E-04	4.6E-04	5.4E-01	1.2E-02	4.6E-06	2.3E-03	4.6E-05	2.3E-02	4.6E-01	6.7E-04	1.4E-01	4.6E-06	4.6E-02	6.6E-02	7.1E+00	9.1E-06	7.7E-05	4.6E-05	5.5E-04	8.6E-05	1.8E-03	4.6E-06
15-May-12	24																							
22-May-12	25	1.1E-03	1.1E-05	3.6E-04	5.3E-01	9.0E-03	7.2E-06	2.7E-03	1.4E-04	2.4E-02	4.2E-01	5.7E-04	1.4E-01	3.6E-06	4.3E-02	6.9E-02	7.5E+00	7.2E-06	4.3E-05	7.2E-05	8.1E-04	1.8E-04	1.1E-03	3.6E-06
29-May-12	26																							
5-Jun-12	27	1.4E-03	9.0E-06	4.5E-04	3.9E-01	9.8E-03	9.0E-06	1.8E-03	4.5E-05	2.0E-02	3.5E-01	6.1E-04	1.4E-01	4.5E-06	4.5E-02	6.5E-02	5.6E+00	9.0E-06	3.2E-05	9.0E-05	5.3E-04	1.8E-04	1.4E-03	4.5E-06
12-Jun-12	28																							
19-Jun-12	29	1.4E-03	2.9E-05	4.8E-04	4.3E-01	1.2E-02	4.8E-06	2.4E-03	1.4E-04	2.2E-02	3.3E-01	4.9E-04	1.5E-01	4.8E-06	5.3E-02	6.4E-02	5.3E+00	9.6E-06	5.0E-04	9.6E-05	5.9E-04	1.7E-04	1.4E-03	4.8E-06
26-Jun-12	30																							
3-Jul-12	31	1.3E-03	5.8E-05	4.5E-04	4.8E-01	1.1E-02	4.5E-06	2.2E-03	4.5E-05	2.4E-02	4.0E-01	1.2E-03	1.6E-01	4.5E-06	4.5E-02	7.0E-02	6.0E+00	8.9E-06	2.8E-04	8.9E-05	5.3E-04	1.4E-04	2.7E-03	8.9E-06
10-Jul-12	32																							
17-Jul-12	33	1.4E-03	9.3E-06	4.7E-04	4.4E-01	1.1E-02	4.7E-06	2.3E-03	4.7E-05	2.4E-02	3.8E-01	1.2E-03	1.7E-01	4.7E-06	6.0E-02	6.7E-02	5.7E+00	9.3E-06	4.7E-06	4.7E-05	6.6E-04	7.9E-05	4.7E-04	4.7E-06
24-Jul-12	34																							
31-Jul-12	35	1.4E-03	6.4E-05	4.6E-04	3.7E-01	9.2E-03	9.2E-06	1.7E-03	4.6E-05	2.8E-02	3.0E-01	7.0E-04	1.6E-01	4.6E-06	4.1E-02	6.4E-02	4.5E+00	9.2E-06	2.3E-05	4.6E-05	4.8E-04	1.7E-04	1.4E-03	4.6E-06
7-Aug-12	36																							
14-Aug-12	37	1.3E-03	8.8E-06	4.4E-04	3.7E-01	7.8E-03	4.4E-06	2.0E-03	1.3E-04	2.1E-02	3.2E-01	6.2E-04	1.4E-01	4.4E-06	4.4E-02	6.2E-02	5.0E+00	8.8E-06	1.0E-04	1.8E-04	4.4E-04	2.9E-04	8.8E-04	4.4E-06
21-Aug-12	38																							
28-Aug-12	39	1.5E-03	1.0E-05	5.1E-04	4.3E-01	1.2E-02	5.1E-06	2.0E-03	2.0E-04	1.6E-02	3.1E-01	6.5E-04	1.5E-01	5.1E-06	4.0E-02	6.8E-02	5.2E+00	1.0E-05	2.0E-04	5.1E-05	6.2E-04	1.7E-04	2.0E-03	5.1E-06
4-Sep-12	40																							
11-Sep-12	41	1.4E-03	9.6E-06	4.8E-04	3.9E-01	9.9E-03	4.8E-06	1.5E-03	1.4E-04	1.9E-02	3.0E-01	6.6E-04	1.3E-01	4.8E-06	4.3E-02	7.1E-02	5.4E+00	9.6E-06	9.6E-06	4.8E-05	3.8E-04	5.3E-05	9.6E-04	4.8E-06
18-Sep-12	42																							
25-Sep-12	43	1.5E-03	9.8E-06	4.9E-04	3.5E-01	1.0E-02	4.9E-06	2.0E-03	9.8E-05	1.2E-02	2.5E-01	5.3E-04	1.2E-01	4.9E-06	5.4E-02	6.6E-02	5.0E+00	9.8E-06	4.9E-05	4.9E-05	5.2E-04	9.8E-05	9.8E-04	4.9E-06
2-Oct-12	44																							
9-Oct-12	45	1.5E-03	3.6E-05	5.2E-04	3.1E-01	1.1E-02	5.2E-06	1.6E-03	3.6E-04	1.6E-02	2.2E-01	5.5E-04	1.1E-01	5.2E-06	3.1E-02	5.3E-02	4.0E+00	1.0E-05	6.2E-05	2.6E-04	3.8E-04	1.7E-04	1.5E-03	5.2E-06
16-Oct-12	46																							
23-Oct-12	47																							
30-Oct-12	48																							
6-Nov-12	49	1.5E-03	2.0E-05	4.9E-04	3.3E-01	1.2E-02	4.9E-06	2.1E-03	1.5E-04	1.9E-02	2.0E-01	3.7E-04	1.2E-01	4.9E-06	5.4E-02	6.1E-02	4.3E+00	9.8E-06	7.8E-05	4.9E-05	4.0E-04	1.5E-05	9.8E-04	4.9E-06
13-Nov-12	50																							
20-Nov-12	51																							
27-Nov-12	52																							
4-Dec-12	53	1.3E-03	1.3E-05	4.2E-04	4.6E-01	1.2E-02	4.2E-06	3.1E-03	4.2E-05	2.1E-02	3.4E-01	2.5E-04	1.4E-01	4.2E-06	3.8E-02	6.6E-02	4.9E+00	8.4E-06	5.0E-05	1.3E-04	1.3E-03	8.0E-05	1.3E-03	4.2E-06
11-Dec-12	54																							
18-Dec-12	55																							
25-Dec-12	56																							
1-Jan-13	57	1.5E-03	9.8E-06	4.9E-04	3.1E-01	9.1E-03	4.9E-06	2.1E-03	4.9E-05	1.9E-02	2.6E-01	3.8E-04	1.4E-01	4.9E-06	2.9E-02	6.1E-02	3.8E+00	9.8E-06	5.4E-05	9.8E-05	5.9E-04	8.3E-05	4.9E-04	4.9E-06

HC7
Sample = 50% '08-080-043/ 50% 08-225

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
	No.																							
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
8-Jan-13	58																							
15-Jan-13	59																							
22-Jan-13	60																							
29-Jan-13	61	1.4E-03	9.2E-06	4.6E-04	3.4E-01	8.8E-03	4.6E-06	1.7E-03	9.2E-05	2.8E-02	2.4E-01	4.2E-04	1.2E-01	4.6E-06	4.1E-02	6.7E-02	4.2E+00	9.2E-06	6.4E-05	9.2E-05	4.2E-04	1.3E-04	4.6E-04	4.6E-06
5-Feb-13	62																							
12-Feb-13	63																							
19-Feb-13	64																							
26-Feb-13	65	1.4E-03	1.8E-05	4.5E-04	2.9E-01	6.0E-03	4.5E-06	2.1E-03	4.5E-05	2.3E-02	2.4E-01	4.2E-04	8.6E-02	4.5E-06	3.2E-02	5.5E-02	3.7E+00	9.0E-06	9.0E-06	4.5E-05	4.7E-04	1.8E-05	4.5E-04	4.5E-06
5-Mar-13	66																							
12-Mar-13	67																							
19-Mar-13	68																							
26-Mar-13	69	1.4E-03	3.2E-05	4.6E-04	3.1E-01	6.7E-03	4.6E-06	2.0E-03	4.6E-05	1.7E-02	2.1E-01	3.5E-04	1.0E-01	4.6E-06	2.3E-02	6.1E-02	3.7E+00	9.2E-06	1.4E-05	4.6E-05	4.5E-04	2.8E-05	4.6E-04	4.6E-06
2-Apr-13	70																							
9-Apr-13	71																							
16-Apr-13	72																							
23-Apr-13	73	1.3E-03	1.3E-05	4.5E-04	3.0E-01	5.7E-03	4.5E-06	2.1E-03	4.5E-05	1.6E-02	2.0E-01	3.2E-04	9.8E-02	4.5E-06	2.2E-02	5.9E-02	3.6E+00	8.9E-06	8.9E-06	4.5E-05	4.9E-04	1.3E-05	4.5E-04	1.3E-05
30-Apr-13	74																							
7-May-13	75																							
14-May-13	76																							
21-May-13	77	1.3E-03	8.7E-06	4.4E-04	2.4E-01	5.3E-03	4.4E-06	1.8E-03	4.4E-05	1.8E-02	2.2E-01	2.8E-04	1.0E-01	4.4E-06	2.2E-02	5.4E-02	3.2E+00	8.7E-06	2.2E-05	4.4E-05	4.1E-04	2.6E-05	4.4E-04	4.4E-06
28-May-13	78	1.3E-03	8.9E-06	4.5E-04	2.9E-01	5.9E-03	4.5E-06	2.0E-03	4.5E-05	1.8E-02	2.6E-01	3.6E-04	9.3E-02	4.5E-06	2.2E-02	6.3E-02	3.4E+00	8.9E-06	2.7E-05	4.5E-05	5.1E-04	2.7E-05	4.5E-04	4.5E-06
4-Jun-13	79	1.4E-03	9.2E-06	4.6E-04	2.2E-01	7.6E-03	4.6E-06	1.2E-03	9.2E-05	1.5E-02	1.7E-01	2.0E-04	9.2E-02	4.6E-06	2.3E-02	5.3E-02	2.5E+00	9.2E-06	3.2E-04	4.6E-05	5.2E-04	3.2E-05	9.2E-04	4.6E-06
11-Jun-13	80	1.4E-03	9.6E-06	4.8E-04	2.1E-01	7.4E-03	4.8E-06	1.0E-03	4.8E-05	1.5E-02	1.7E-01	1.9E-04	7.7E-02	4.8E-06	1.9E-02	4.7E-02	2.0E+00	9.6E-06	4.0E-04	4.8E-05	5.6E-04	1.4E-05	4.8E-04	4.8E-06
18-Jun-13	81	1.4E-03	9.6E-06	4.8E-04	2.1E-01	7.8E-03	4.8E-06	9.1E-04	4.8E-05	1.4E-02	1.6E-01	2.0E-04	7.2E-02	4.8E-06	2.4E-02	4.8E-02	2.0E+00	9.6E-06	2.3E-04	4.8E-05	6.1E-04	1.4E-05	4.8E-04	4.8E-06
25-Jun-13	82																							
2-Jul-13	83	1.4E-03	9.5E-06	4.8E-04	1.7E-01	5.9E-03	4.8E-06	8.5E-04	4.8E-05	1.0E-02	1.5E-01	1.5E-04	6.7E-02	4.8E-06	9.5E-03	4.0E-02	1.5E+00	9.5E-06	1.9E-05	4.8E-05	5.4E-04	4.3E-05	4.8E-04	4.8E-06
9-Jul-13	84																							
16-Jul-13	85	1.5E-03	9.7E-06	4.9E-04	1.7E-01	6.5E-03	4.9E-06	6.5E-04	4.9E-05	1.1E-02	1.1E-01	1.3E-04	5.3E-02	4.9E-06	9.7E-03	4.1E-02	1.3E+00	9.7E-06	2.1E-04	4.9E-05	4.8E-04	1.5E-05	9.7E-04	4.9E-06
23-Jul-13	86																							
30-Jul-13	87	1.5E-03	9.7E-06	4.9E-04	1.4E-01	6.0E-03	4.9E-06	5.5E-04	4.9E-05	8.7E-03	9.4E-02	1.1E-04	4.9E-02	4.9E-06	9.7E-03	3.6E-02	1.1E+00	9.7E-06	1.9E-04	4.9E-05	4.3E-04	1.5E-05	4.9E-04	4.9E-06
6-Aug-13	88																							
13-Aug-13	89	1.5E-03	1.9E-05	4.9E-04	1.5E-01	6.1E-03	4.9E-06	5.5E-04	9.7E-05	1.4E-02	9.6E-02	1.2E-04	6.3E-02	4.9E-06	1.5E-02	3.8E-02	1.1E+00	9.7E-06	3.2E-04	4.9E-05	4.4E-04	1.5E-05	1.5E-03	4.9E-06
20-Aug-13	90																							
27-Aug-13	91																							
3-Sep-13	92																							
10-Sep-13	93	1.4E-03	9.5E-06	4.8E-04	1.6E-01	6.0E-03	4.8E-06	6.0E-04	4.8E-05	1.4E-02	1.1E-01	1.2E-04	6.2E-02	4.8E-06	4.8E-03	4.0E-02	1.3E+00	9.5E-06	4.6E-04	4.8E-05	5.2E-04	1.4E-05	4.8E-04	4.8E-06
17-Sep-13	94																							
24-Sep-13	95																							
1-Oct-13	96																							
8-Oct-13	97	1.4E-03	9.5E-06	4.8E-04	1.6E-01	6.2E-03	4.8E-06	5.8E-04	4.8E-05	8.1E-03	1.0E-01	1.2E-04	7.6E-02	4.8E-06	9.5E-03	4.1E-02	1.3E+00	9.5E-06	2.1E-04	4.8E-05	4.9E-04	1.4E-05	4.8E-04	4.8E-06
15-Oct-13	98																							
22-Oct-13	99																							
29-Oct-13	100																							
5-Nov-13	101	1.5E-03	9.9E-06	5.0E-04	1.6E-01	7.0E-03	5.0E-06	5.9E-04	5.0E-05	5.9E-03	1.1E-01	1.4E-04	6.4E-02	5.0E-06	9.9E-03	4.6E-02	1.1E+00	9.9E-06	7.9E-04	5.0E-05	5.5E-04	1.5E-05	5.0E-04	5.0E-06
12-Nov-13	102																							
19-Nov-13	103																							
26-Nov-13	104																							
3-Dec-13	105	1.4E-03	9.4E-06	4.7E-04	1.4E-01	5.4E-03	4.7E-06	5.7E-04	4.7E-05	8.0E-03	8.9E-02	1.1E-04	5.2E-02	4.7E-06	4.7E-03	3.8E-02	9.6E-01	9.4E-06	3.1E-04	4.7E-05	4.5E-04	3.8E-05	4.7E-04	4.7E-06
10-Dec-13	106																							
17-Dec-13	107																							
24-Dec-13	108																							
31-Dec-13	109	2.0E-03	1.5E-05	5.0E-04	1.3E-01	6.0E-03	5.0E-06	5.6E-04	5.0E-05	7.5E-03	8.7E-02	1.2E-04	5.5E-02	5.0E-06	1.0E-02	3.9E-02	9.5E-01	1.0E-05	4.6E-04	5.0E-05	4.1E-04	2.0E-05	5.0E-04	5.0E-06
7-Jan-14	110																							
14-Jan-14	111																							
21-Jan-14	112																							
28-Jan-14	113	1.5E-03	9.8E-06	4.9E-04	1.4E-01	6.1E-03	2.0E-05	5.5E-04	4.9E-05	4.4E-03	8.2E-02	9.3E-05	4.9E-02	4.9E-06	4.9E-03	4.2E-02	9.6E-01	9.8E-06	4.6E-04	4.9E-05	4.6E-04	1.5E-05	4.9E-04	4.9E-06
4-Feb-14	114																							
11-Feb-14	115																							
18-Feb-14	116																							
25-Feb-14	117	1.4E-03	9.6E-06	4.8E-04	1.4E-01	5.7E-03	4.8E-06	6.3E-04	4.8E-05	8.2E-03	8.8E-02	1.1E-04	5.3E-02	4.8E-06	4.8E-03	4.3E-02	9.2E-01	9.6E-06	2.1E-04	4.8E-05	4.7E-04	1.4E-05	4.8E-04	4.8E-06

HC8

Sample = 08-143

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/L	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
29-Nov-11	0	500	340	4.13	7.4E+02	3.5E+01	2.5E+02	#N/A	3.4E+02	2.2E+00	7.3E-01	3.0E-01	1.1E+02	4.5E+01	6.0E-04	1.6E-03	4.5E-02	3.5E-03	1.0E-05	6.4E-03	5.3E-03	3.2E+01	2.5E-03	8.5E-02	9.0E+01
6-Dec-11	1	500	475	4.08	6.4E+02	2.8E+01	2.2E+02	#N/A	3.2E+02	1.4E+00	6.0E-02	3.0E-01	9.3E+01	2.5E+01	5.0E-04	1.4E-03	7.7E-03	3.6E-03	1.0E-05	5.1E-03	4.7E-03	2.8E+01	2.4E-03	8.2E-02	4.7E+01
13-Dec-11	2	500	455	4.16	4.6E+02	1.7E+01	1.5E+02	#N/A	2.0E+02	8.0E-01	6.8E-01	3.0E-01	6.0E+01	1.6E+01	3.0E-04	1.4E-03	4.0E-03	2.3E-03	2.0E-05	4.8E-03	3.0E-03	1.8E+01	2.9E-03	6.6E-02	3.4E+01
20-Dec-11	3	500	510	4.21	3.6E+02	1.2E+01	1.2E+02	#N/A	1.9E+02	6.0E-01	6.7E-01	3.0E-01	4.2E+01	1.4E+01	4.0E-04	1.4E-03	2.3E-03	2.3E-03	1.0E-05	4.2E-03	2.2E-03	1.3E+01	1.0E-03	3.2E-02	2.7E+01
27-Dec-11	4	500	420	4.40	2.7E+02																				
3-Jan-12	5	500	450	4.18	2.3E+02	9.5E+00	7.6E+01	#N/A	1.1E+02	1.0E+00	4.3E-01	3.0E-01	1.8E+01	9.9E+00	3.0E-04	8.0E-04	1.6E-03	1.5E-03	1.0E-05	3.1E-03	1.7E-03	5.9E+00	6.0E-04	1.8E-02	1.5E+01
10-Jan-12	6	500	420	4.24	1.8E+02																				
17-Jan-12	7	500	450	4.38	1.5E+02	2.7E+00	4.1E+01	#N/A	6.9E+01	2.0E-01	3.4E-01	3.0E-01	7.9E+00	7.5E+00	4.0E-04	6.0E-04	1.9E-03	1.3E-03	1.0E-05	3.1E-03	4.8E-03	2.6E+00	5.0E-04	8.1E-03	9.1E+00
24-Jan-12	8	500	435	4.27	1.4E+02																				
31-Jan-12	9	500	445	4.23	1.1E+02	4.8E+00	3.3E+01	#N/A	3.8E+01	2.0E-01	2.8E-01	3.0E-01	2.9E+00	3.8E+00	2.0E-04	8.0E-04	1.4E-03	9.2E-04	1.0E-05	2.2E-03	3.9E-04	9.7E-01	5.0E-04	5.0E-03	5.2E+00
7-Feb-12	10	500	460	4.36	9.9E+01																				
14-Feb-12	11	500	445	4.30	1.1E+02	6.3E+00	4.1E+01	#N/A	4.0E+01	2.0E-01	2.5E-01	3.0E-01	1.9E+00	6.9E+00	2.0E-04	6.0E-04	1.2E-03	7.9E-04	1.0E-05	2.3E-03	4.0E-04	6.4E-01	5.0E-04	3.9E-03	5.8E+00
21-Feb-12	12	500	465	4.30	1.4E+02																				
28-Feb-12	13	500	460	4.18	1.5E+02	8.6E+00	5.2E+01	#N/A	6.0E+01	1.0E+00	2.8E-01	3.0E-01	1.9E+00	7.5E+00	1.2E-03	1.0E-03	2.0E-03	1.0E-03	1.0E-05	3.4E-03	6.5E-04	6.4E-01	5.0E-04	5.8E-03	6.1E+00
6-Mar-12	14	500	435	4.23	1.6E+02																				
13-Mar-12	15	500	465	4.15	1.5E+02	1.3E+01	6.4E+01	#N/A	6.7E+01	1.0E+00	2.6E-01	3.0E-01	1.4E+00	1.0E+00	4.0E-04	5.0E-04	1.5E-03	1.0E-03	1.0E-05	2.8E-03	5.1E-04	4.7E-01	5.0E-04	5.8E-03	6.9E-01
20-Mar-12	16	500	430	4.21	1.5E+02																				
27-Mar-12	17	500	435	4.11	1.6E+02	1.3E+01	6.1E+01	#N/A	7.0E+01	1.0E+00	2.3E-01	3.0E-01	1.1E+00	8.9E+00	2.0E-04	4.0E-04	1.0E-03	1.3E-03	1.0E-05	3.0E-03	4.8E-04	4.0E-01	5.0E-04	4.7E-03	5.5E+00
3-Apr-12	18	500	445	4.08	1.6E+02																				
10-Apr-12	19	500	450	3.95	2.1E+02	3.2E+01	8.8E+01	#N/A	1.0E+02	2.0E-01	2.5E-01	3.0E-01	1.3E+00	1.3E+01	3.0E-04	4.0E-04	1.3E-03	1.9E-03	1.0E-05	3.0E-03	7.1E-04	4.5E-01	7.0E-04	7.4E-03	9.1E+00
17-Apr-12	20	500	410	3.98	2.4E+02																				
24-Apr-12	21	500	450	4.00	1.7E+02	2.1E+01	7.1E+01	#N/A	7.7E+01	1.0E+00	1.8E-01	3.0E-01	9.1E-01	9.7E+00	4.0E-04	5.0E-04	3.0E-03	1.5E-03	1.0E-05	2.2E-03	5.3E-04	3.1E-01	6.0E-04	4.9E-03	5.4E+00
1-May-12	22	500	455	4.06	1.8E+02																				
8-May-12	23	500	455	3.95	1.9E+02	2.7E+01	7.4E+01	#N/A	7.9E+01	1.0E+00	1.3E-01	3.0E-01	8.3E-01	9.1E+00	3.0E-04	4.0E-04	1.8E-03	1.5E-03	1.0E-05	4.6E-03	5.6E-04	2.8E-01	6.0E-04	5.6E-03	5.5E+00
15-May-12	24	500	445	3.95	1.8E+02																				
22-May-12	25	500	405	3.89	2.5E+02	4.6E+01	1.1E+02	#N/A	1.1E+02	1.0E+00	1.6E-01	3.0E-01	1.8E+00	1.6E+01	5.0E-04	8.0E-04	3.9E-03	2.0E-03	1.0E-05	2.6E-03	9.4E-04	6.4E-01	1.1E-03	7.8E-03	8.6E+00
29-May-12	26	500	415	4.01	1.6E+02																				
5-Jun-12	27	500	430	4.01	1.6E+02	2.0E+01	7.1E+01	#N/A	5.5E+01	1.0E+00	1.2E-01	3.0E-01	1.0E+00	8.9E+00	2.0E-04	4.0E-04	1.2E-03	1.3E-03	1.0E-05	6.2E-03	5.1E-04	3.7E-01	5.0E-04	5.0E-03	4.3E+00
12-Jun-12	28	500	445	3.98	1.7E+02																				
19-Jun-12	29	500	440	3.99	1.5E+02	2.0E+01	6.0E+01	#N/A	5.2E+01	2.0E-01	9.0E-02	3.0E-01	5.3E-01	7.8E+00	2.0E-04	5.0E-04	1.4E-03	1.2E-03	1.0E-05	2.0E-03	4.3E-04	1.8E-01	5.0E-04	4.5E-03	3.6E+00
26-Jun-12	30	500	440	4.04	1.5E+02																				
3-Jul-12	31	500	440	4.02	1.9E+02	3.5E+01	9.2E+01	#N/A	8.0E+01	1.0E+00	9.0E-02	3.0E-01	8.0E-01	1.1E+01	3.0E-04	5.0E-04	1.5E-03	1.4E-03	1.0E-05	1.5E-03	6.8E-04	2.7E-01	6.0E-04	6.0E-03	5.0E+00
10-Jul-12	32	500	475	3.80	2.3E+02																				
17-Jul-12	33	500	445	3.77	2.0E+02	4.3E+01	8.2E+01	#N/A	8.2E+01	1.0E+00	9.0E-02	3.0E-01	6.6E-01	9.9E+00	4.0E-04	9.0E-04	1.6E-03	1.8E-03	1.0E-05	3.9E-03	9.3E-04	2.1E-01	6.0E-04	7.2E-03	5.7E+00
24-Jul-12	34	500	440	3.93	2.0E+02																				
31-Jul-12	35	500	445	3.76	2.2E+02	4.5E+01	8.8E+01	#N/A	9.8E+01	2.0E-01	9.0E-02	3.0E-01	6.5E-01	1.1E+01	3.0E-04	5.0E-04	1.7E-03	1.7E-03	1.0E-05	2.5E-03	1.0E-03	2.0E-01	9.0E-04	6.9E-03	5.9E+00
7-Aug-12	36	500	445	3.68	2.6E+02																				
14-Aug-12	37	500	440	3.62	2.6E+02	5.8E+01	1.1E+02	#N/A	9.0E+01	1.0E+00	8.0E-02	3.0E-01	8.5E-01	1.6E+01	3.0E-04	8.0E-04	2.0E-03	2.0E-03	1.0E-05	2.4E-03	1.1E-03	2.6E-01	1.2E-03	8.2E-03	6.1E+00
21-Aug-12	38	500	445	3.63	2.5E+02																				
28-Aug-12	39	500	490	3.55	3.0E+02	6.2E+01	1.3E+02	#N/A	1.2E+02	1.0E+00	8.0E-02	3.0E-01	9.2E-01	1.6E+01	5.0E-04	4.0E-04	2.4E-03	1.9E-03	1.0E-05	3.1E-03	1.2E-03	2.8E-01	1.3E-03	9.0E-03	5.9E+00
4-Sep-12	40	500	470	3.66	2.3E+02																				
11-Sep-12	41	500	450	3.59	2.6E+02	4.9E+01	1.1E+02	#N/A	8.6E+01	1.0E+00	7.0E-02	3.0E-01	8.6E-01	1.2E+01	3.0E-04	4.0E-04	2.4E-03	1.3E-03	1.0E-05	1.8E-03	9.1E-04	2.8E-01	1.2E-03	7.3E-03	4.6E+00
18-Sep-12	42	500	505	3.59	2.7E+02																				
25-Sep-12	43	500	450	3.58	2.6E+02	4.3E+01	9.1E+01	#N/A	9.3E+01	2.0E-01	6.0E-02	3.0E-01	8.7E-01	1.2E+01	2.0E-04	2.0E-04	2.7E-03	1.1E-03	1.0E-05	4.0E-04	9.7E-04	2.9E-01	1.6E-03	7.4E-03	4.2E+00
2-Oct-12	44	500	455	3.61	3.3E+02																				
9-Oct-12	45	500	460	3.55	2.4E+02	3.9E+01	8.5E+01	#N/A	8.8E+01	1.0E+00	6.0E-02	3.0E-01	8.5E-01	1.2E+01	3.0E-04	4.0E-04	2.2E-03	1.0E-03	1.0E-05	1.4E-03	7.9E-04	2.8E-01	1.4E-03	7.0E-03	3.9E+00
16-Oct-12	46	500	460	3.46	2.7E+02																				
23-Oct-12	47	500	485	3.41	3.0E+02																				
30-Oct-12	48	500	460	3.51	2.7E+02																				
6-Nov-12	49	500	430	3.46	2.5E+02	3.9E+01	9.1E+01	#N/A	8.1E+01	1.0E+00	6.0E-02	3.0E-01	1.1E+00	1.1E+01	3.0E-04	3.0E-04	2.4E-03	8.6E-04	1.0E-05	1.7E-03	7.8E-04	3.6E-01	2.1E-03	7.0E-03	3.5E+00
13-Nov-12	50	500	435	3.40	2.6E+02																				
20-Nov-12	51	500	485	3.45	2.9E+02																				
27-Nov-12	52	500	490	3.30	2.8E+02																				
4-Dec-12	53	500	490	3.37	3.1E+02	3.8E+01	8.5E+01	#N/A	9.3E+01	1.0E+00	6.0E-02	3.0E-01	1.0E+00	9.1E+00	4.0E-04	4.0E-04	3.5E-03	6.7E-04	1.0E-05	1.2E-03	7.4E-04	3.6E-01	1.6E-03	7.2E-03	3.8E+00
11-Dec-12	54	500	440	3.35	3.1E+02																				
18-Dec-12	55	500	435	3.35	3.0E+02																				
25-Dec-12	56	500	445	3.31	3.2E+02																				
1-Jan-13	57	500	460	3.34	3.2E+02	5.0E+01	9.8E+01	#N/A	1.1E+02	1.0E+00	6.0E-02	3.0E-01	1.1E+00	7.8E+00	4.0E-04	2.0E-04	3.3E-03	6.0E-04	1.0E-05	7.0E-04	7.0E-04	3.8E-01	2.3E-03	7.7E-03	3.4E+00
8-Jan-13	58	500	465	3.35	3.2E+02																				
15-Jan-13	59	500	465	3.27	3.2E+02																				

HC8

Sample = 08-143

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/L	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
22-Jan-13	60	500	455	3.41	3.2E+02																				
29-Jan-13	61	500	460	3.24	3.4E+02	5.1E+01	9.5E+01	#N/A	1.2E+02	1.0E+00	6.0E-02	3.0E-01	1.3E+00	1.0E+01	3.0E-04	3.0E-04	3.5E-03	5.7E-04	1.0E-05	8.0E-04	7.8E-04	4.4E-01	3.0E-03	8.3E-03	3.7E+00
5-Feb-13	62	500	460	3.30	3.5E+02																				
12-Feb-13	63	500	455	3.27	3.4E+02																				
19-Feb-13	64	500	460	3.26	3.5E+02																				
26-Feb-13	65	500	450	3.23	3.7E+02	5.2E+01	8.9E+01	#N/A	1.0E+02	1.0E+00	6.0E-02	3.0E-01	1.5E+00	7.7E+00	2.0E-04	5.0E-04	3.3E-03	5.4E-04	1.0E-05	6.0E-04	7.0E-04	5.3E-01	2.9E-03	8.4E-03	3.4E+00
5-Mar-13	66	500	455	3.23	3.8E+02																				
12-Mar-13	67	500	450	3.23	3.7E+02																				
19-Mar-13	68	500	450	3.32	3.6E+02																				
26-Mar-13	69	500	455	3.19	3.8E+02	7.5E+01	1.2E+02	#N/A	1.2E+02	1.0E+00	6.0E-02	3.0E-01	9.4E-01	7.9E+00	2.0E-04	6.0E-04	3.0E-03	4.4E-04	2.0E-05	8.0E-04	6.1E-04	3.1E-01	2.8E-03	8.6E-03	3.1E+00
2-Apr-13	70	500	440	3.22	3.6E+02																				
9-Apr-13	71	500	455	3.31	3.8E+02																				
16-Apr-13	72	500	455	3.33	3.9E+02																				
23-Apr-13	73	500	445	3.15	4.7E+02	8.0E+01	1.2E+02	#N/A	1.4E+02	1.0E+00	6.0E-02	3.0E-01	9.1E-01	8.7E+00	2.0E-04	5.0E-04	3.1E-03	4.1E-04	1.0E-05	1.0E-03	6.6E-04	2.9E-01	2.8E-03	9.3E-03	2.8E+00
30-Apr-13	74	500	440	3.17	4.0E+02																				
7-May-13	75	500	445	3.32	3.7E+02																				
14-May-13	76	500	405	3.18	3.9E+02																				
21-May-13	77	500	440	3.16	3.8E+02	7.3E+01	1.1E+02	#N/A	1.2E+02	1.0E+00	6.0E-02	3.0E-01	1.2E+00	6.2E+00	2.0E-04	2.0E-04	2.3E-03	3.8E-04	1.0E-05	9.0E-04	5.1E-04	3.8E-01	3.1E-03	8.3E-03	1.8E+00
28-May-13	78	500	445	3.15	4.2E+02																				
4-Jun-13	79	500	470	3.14	4.3E+02																				
11-Jun-13	80	500	470	3.21	4.5E+02																				
18-Jun-13	81	500	460	3.16	4.6E+02	8.4E+01	1.3E+02	#N/A	1.3E+02	1.0E+00	6.0E-02	3.0E-01	1.1E+00	6.3E+00	2.0E-04	2.0E-04	2.9E-03	3.8E-04	1.0E-05	1.9E-03	4.9E-04	3.5E-01	3.0E-03	8.8E-03	1.6E+00
25-Jun-13	82	500	470	3.18	4.6E+02																				
2-Jul-13	83	500	470	3.12	4.7E+02																				
9-Jul-13	84	500	480	3.15	5.3E+02																				
16-Jul-13	85	500	460	3.07	4.8E+02	8.9E+01	1.3E+02	#N/A	1.3E+02	1.0E+00	6.0E-02	3.0E-01	1.0E+00	6.3E+00	2.0E-04	5.0E-04	2.9E-03	3.3E-04	1.0E-05	1.5E-03	4.4E-04	3.1E-01	3.2E-03	9.2E-03	1.4E+00
23-Jul-13	86	500	440	3.06	4.9E+02																				
30-Jul-13	87	500	455	3.07	5.0E+02																				
6-Aug-13	88	500	485	3.02	5.7E+02																				
13-Aug-13	89	500	475	2.88	7.5E+02	1.5E+02	2.0E+02	#N/A	1.9E+02	2.0E+00	6.0E-02	3.0E-01	1.6E+00	8.3E+00	2.0E-04	1.0E-03	4.1E-03	4.4E-04	1.0E-05	1.6E-03	6.1E-04	5.0E-01	4.7E-03	1.3E-02	1.8E+00
20-Aug-13	90	500	460	2.99	6.2E+02																				
27-Aug-13	91	500	475	2.96	6.1E+02																				
3-Sep-13	92	500	450	2.98	5.6E+02																				
10-Sep-13	93	500	460	2.86	7.4E+02	1.7E+02	2.3E+02	#N/A	2.2E+02	1.0E+00	6.0E-02	3.0E-01	1.3E+00	8.5E+00	2.0E-04	1.8E-03	2.8E-03	3.6E-04	1.0E-05	1.6E-03	5.2E-04	4.0E-01	4.3E-03	1.4E-02	1.3E+00
17-Sep-13	94	500	435	2.97	6.2E+02																				
24-Sep-13	95	500	440	2.98	6.0E+02																				
1-Oct-13	96	500	480	2.98	6.0E+02																				
8-Oct-13	97	500	435	2.88	7.7E+02	1.7E+02	2.1E+02	#N/A	2.2E+02	1.0E+00	6.0E-02	3.0E-01	1.6E+00	6.8E+00	2.0E-04	2.1E-03	2.7E-03	3.6E-04	1.0E-05	2.9E-03	4.9E-04	4.9E-01	4.1E-03	1.4E-02	1.2E+00
15-Oct-13	98	500	465	2.75	7.4E+02																				
22-Oct-13	99	500	455	2.95	6.4E+02																				
29-Oct-13	100	500	480	3.02	6.2E+02																				
5-Nov-13	101	500	475	2.94	7.1E+02	1.4E+02	1.9E+02	#N/A	1.7E+02	1.0E+00	6.0E-02	3.0E-01	1.1E+00	4.6E+00	2.0E-04	2.1E-03	2.6E-03	2.8E-04	1.0E-05	1.4E-03	4.2E-04	3.1E-01	3.5E-03	1.3E-02	1.0E+00
12-Nov-13	102	500	470	2.98	7.1E+02																				
19-Nov-13	103	500	470	3.07	6.7E+02																				
26-Nov-13	104	500	470	2.84	8.2E+02																				
3-Dec-13	105	500	475	3.31	6.9E+02	1.3E+02	1.8E+02	#N/A	2.1E+02	1.0E+00	6.0E-02	3.0E-01	1.2E+00	5.4E+00	2.0E-04	3.1E-03	2.6E-03	2.6E-04	1.0E-05	9.0E-04	3.8E-04	3.8E-01	3.3E-03	1.3E-02	9.9E-01
10-Dec-13	106	500	435	2.98	6.4E+02																				
17-Dec-13	107	500	445	2.85	7.2E+02																				
24-Dec-13	108	500	430	2.94	7.6E+02																				
31-Dec-13	109	500	435	2.91	7.5E+02	1.4E+02	1.9E+02	#N/A	1.7E+02	1.0E+00	6.0E-02	3.0E-01	3.4E+00	4.2E+00	2.0E-04	2.4E-03	2.3E-03	2.7E-04	1.0E-05	1.1E-03	3.7E-04	1.2E+00	3.3E-03	1.3E-02	9.1E-01
7-Jan-14	110	500	440	2.93	7.3E+02																				
14-Jan-14	111	500	425	2.92	6.9E+02																				
21-Jan-14	112	500	430	2.94	7.6E+02																				
28-Jan-14	113	500	430	2.91	7.2E+02	1.6E+02	2.0E+02	#N/A	1.9E+02	1.0E+00	6.0E-02	3.0E-01	2.8E+00	4.8E+00	2.0E-04	2.5E-03	2.1E-03	2.5E-04	1.0E-05	1.2E-03	3.9E-04	9.6E-01	3.4E-03	1.5E-02	9.0E-01
4-Feb-14	114	500	435	2.90	7.3E+02																				

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Sample = 08-143

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/L	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
11-Feb-14	115	500	440	2.80	7.6E+02																				
18-Feb-14	116	500	435	2.87	7.5E+02																				
25-Feb-14	117	500	485	2.82	8.7E+02	1.6E+02	2.2E+02	#N/A	2.3E+02	1.0E+00	6.0E-02	3.0E-01	2.9E+00	4.6E+00	2.0E-04	1.7E-03	3.1E-03	2.8E-04	1.0E-05	1.0E-03	4.9E-04	1.0E+00	3.5E-03	1.7E-02	1.3E+00
4-Mar-14	118	500	465	3.07	4.4E+02	7.4E+01	1.0E+02	#N/A	1.2E+02	2.0E-01	6.0E-02	3.0E-01	1.5E+00	2.8E+00	2.0E-04	1.9E-03	1.1E-03	1.2E-04	1.0E-05	1.0E-03	1.9E-04	4.2E-01	1.9E-03	7.1E-03	6.0E-01
11-Mar-14	119	500	500	3.10	4.5E+02	7.7E+01	1.0E+02	#N/A	1.1E+02	2.0E-01	6.0E-02	3.0E-01	4.2E-01	2.6E+00	2.0E-04	7.0E-04	1.3E-03	1.0E-04	1.0E-05	1.2E-03	1.6E-04	1.3E-01	1.6E-03	7.6E-03	5.7E-01
18-Mar-14	120	500	475	3.18	3.3E+02	5.1E+01	6.7E+01	#N/A	6.0E+01	2.0E-01	6.0E-02	3.0E-01	1.1E+00	1.5E+00	2.0E-04	3.0E-04	1.3E-03	5.0E-05	5.0E-05	6.0E-04	1.0E-04	4.0E-01	9.0E-04	4.6E-03	3.8E-01
25-Mar-14	121	500	495	3.34	3.1E+02	4.3E+01	5.9E+01	#N/A	5.9E+01	2.0E-01	6.0E-02	3.0E-01	8.4E-01	1.3E+00	2.0E-04	2.0E-04	2.1E-03	4.0E-05	1.0E-05	1.4E-03	7.1E-05	3.2E-01	6.0E-04	4.3E-03	3.6E-01
1-Apr-14	122	500	495	3.29	3.0E+02																				
8-Apr-14	123	500	495	3.30	2.8E+02																				
15-Apr-14	124	500	480	3.35	2.7E+02																				
22-Apr-14	125	500	445	3.29	2.8E+02	3.9E+01	5.4E+01	#N/A	4.9E+01	2.0E-01	6.0E-02	3.0E-01	4.6E-01	8.5E-01	2.0E-04	3.0E-04	1.9E-03	2.9E-05	7.0E-06	2.2E-03	6.1E-05	1.8E-01	4.0E-04	3.3E-03	2.6E-01
29-Apr-14	126	500	485	3.33	2.9E+02																				
6-May-14	127	500	480	3.33	2.3E+02																				
13-May-14	128	500	500	3.37	2.6E+02																				
20-May-14	129	500	480	3.37	2.1E+02	3.3E+01	4.8E+01	#N/A	3.6E+01	2.0E-01	6.0E-02	3.0E-01	4.4E-01	6.1E-01	2.0E-04	2.0E-04	1.8E-03	2.7E-05	7.0E-06	1.0E-03	5.1E-05	1.6E-01	2.6E-04	3.3E-03	2.5E-01
27-May-14	130	500	480	3.41	2.2E+02																				
3-Jun-14	131	500	480	3.39	2.1E+02																				
10-Jun-14	132	500	485	3.30	2.5E+02																				
17-Jun-14	133	500	505	3.40	2.2E+02	3.1E+01	4.3E+01	#N/A	3.5E+01	2.0E-01	6.0E-02	3.0E-01	3.3E-01	3.8E-01	2.0E-04	2.0E-04	1.1E-03	2.0E-05	7.0E-06	3.2E-03	5.5E-05	1.3E-01	2.3E-04	2.6E-03	1.8E-01
24-Jun-14	134	500	495	3.43	2.1E+02																				
1-Jul-14	135	500	495	3.49	2.2E+02																				
8-Jul-14	136	500	490	3.43	2.4E+02																				
15-Jul-14	137	500	475	3.35	2.6E+02	3.5E+01	4.7E+01	#N/A	3.9E+01	2.0E-01	6.0E-02	3.0E-01	3.4E-01	4.0E-01	2.0E-04	2.0E-04	1.1E-03	1.1E-05	7.0E-06	2.3E-03	4.8E-05	1.3E-01	1.6E-04	3.0E-03	1.8E-01
22-Jul-14	138	500	495	3.37	2.9E+02																				
29-Jul-14	139	500	485	3.27	2.8E+02																				
5-Aug-14	140	500	455	3.21	2.6E+02																				
12-Aug-14	141	500	485	3.34	2.6E+02	3.4E+01	4.7E+01	#N/A	4.1E+01	2.0E-01	6.0E-02	3.0E-01	4.2E-01	3.9E-01	2.0E-04	2.0E-04	1.3E-03	1.5E-05	7.0E-06	1.6E-03	4.1E-05	1.6E-01	2.3E-04	3.0E-03	1.8E-01
19-Aug-14	142	500	500	3.41	2.6E+02																				
26-Aug-14	143	500	500	3.40	2.4E+02																				
2-Sep-14	144	500	470	3.37	2.4E+02																				
9-Sep-14	145	500	505	3.46	2.2E+02	3.4E+01	4.6E+01	#N/A	3.6E+01	< 0.2	< 0.06	< 0.3	2.0E-01	3.7E-01	< 0.0002	1.0E-03	1.4E-03	1.4E-05	< 0.000007	5.3E-03	4.7E-05	7.0E-02	1.5E-04	3.0E-03	1.8E-01
16-Sep-14	146	500	470	3.47	2.2E+02																				
23-Sep-14	147	500	480	3.42	2.2E+02																				
30-Sep-14	148	500	475																						

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Sample = 08-143

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Major	Major	Diff	Diff
	No.																								Anions	Cations		(%)
		mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L				
29-Nov-11	0	1.1E+00	2.5E-03	8.0E-03	6.2E+00	4.8E-01	2.0E-02	2.9E-03	8.2E-02	3.2E-01	1.9E+01	8.4E-03	5.5E-01	1.0E-04	1.4E+01	9.5E-02	1.3E+02	4.3E-04	1.3E-04	6.0E-04	3.1E-02	1.4E-03	8.4E-01	8.0E-05	7.2E+00	1.1E+01	3.9E+00	21.2%
6-Dec-11	1	8.5E-01	3.6E-03	9.0E-03	5.5E+00	4.6E-01	2.0E-02	2.6E-03	7.7E-02	3.2E-01	1.4E+01	6.0E-03	2.3E+00	1.0E-04	1.1E+01	9.6E-02	1.2E+02	3.1E-04	1.0E-05	7.0E-04	1.8E-02	1.6E-03	8.4E-01	3.0E-05	6.7E+00	6.9E+00	2.3E-01	1.7%
13-Dec-11	2	5.0E-01	5.1E-04	8.0E-03	3.4E+00	2.9E-01	3.0E-02	1.8E-03	6.5E-02	2.9E-01	9.2E+00	1.1E-02	1.7E+00	5.0E-05	5.5E+00	7.4E-02	7.6E+01	1.6E-04	9.3E-04	7.0E-04	1.2E-02	1.0E-03	5.7E-01	3.0E-05	4.3E+00	4.6E+00	3.0E-01	3.4%
20-Dec-11	3	5.8E-01	1.4E-04	4.0E-03	2.2E+00	1.9E-01	1.0E-02	1.2E-03	3.2E-02	4.1E-01	7.4E+00	5.3E-03	2.6E+00	2.0E-05	3.2E+00	6.2E-02	6.0E+01	1.7E-04	1.0E-05	6.0E-04	8.2E-03	8.6E-04	3.9E-01	1.0E-05	3.9E+00	3.7E+00	-2.5E-01	-3.3%
27-Dec-11	4																											
3-Jan-12	5	2.7E-01	4.0E-03	3.0E-03	8.3E-01	7.5E-02	1.0E-02	6.5E-04	1.8E-02	1.2E-01	3.6E+00	2.4E-03	7.8E-01	2.0E-05	9.2E-01	3.5E-02	3.1E+01	9.0E-05	1.7E-04	7.0E-04	6.2E-03	8.6E-04	2.8E-01	2.0E-05	2.4E+00	2.1E+00	-2.4E-01	-5.3%
10-Jan-12	6																											
17-Jan-12	7	3.5E-01	2.7E-02	2.0E-03	3.4E-01	3.3E-02	1.0E-02	6.2E-04	8.4E-03	1.2E-01	2.5E+00	1.7E-03	7.0E-01	2.0E-05	2.9E-01	2.1E-02	2.1E+01	7.0E-05	9.0E-05	5.0E-04	4.7E-03	6.4E-04	5.8E-01	1.0E-05	1.5E+00	1.4E+00	-3.7E-02	-1.3%
24-Jan-12	8																											
31-Jan-12	9	2.9E-01	2.2E-04	2.0E-03	1.2E-01	1.3E-02	1.0E-02	5.0E-04	5.2E-03	9.0E-03	1.3E+00	1.6E-03	5.7E-01	1.0E-05	1.3E-01	1.3E-02	1.4E+01	4.0E-05	1.0E-05	4.0E-04	3.5E-03	6.5E-04	7.7E-02	1.0E-05	8.1E-01	7.6E-01	-4.4E-02	-2.8%
7-Feb-12	10																											
14-Feb-12	11	2.8E-01	1.0E-04	1.0E-03	7.0E-02	8.2E-03	1.0E-02	1.3E-03	4.1E-03	1.1E-01	1.1E+00	1.2E-03	5.5E-01	1.0E-05	8.0E-02	1.1E-02	1.3E+01	3.0E-05	2.0E-05	3.0E-04	4.1E-03	2.7E-04	7.2E-02	1.0E-05	8.6E-01	1.1E+00	2.3E-01	11.7%
21-Feb-12	12																											
28-Feb-12	13	3.6E-01	7.3E-04	3.0E-03	6.8E-02	8.6E-03	1.0E-02	5.9E-04	1.1E-02	1.0E-01	1.3E+00	1.1E-03	7.8E-01	4.0E-05	7.0E-02	1.4E-02	1.9E+01	4.7E-04	9.0E-05	2.0E-04	5.7E-03	4.4E-04	1.1E-01	1.0E-05	1.3E+00	1.2E+00	-8.1E-02	-3.3%
6-Mar-12	14																											
13-Mar-12	15	4.6E-01	1.5E-04	1.0E-03	5.0E-02	6.2E-03	1.0E-02	5.0E-04	6.0E-03	1.1E-01	1.1E+00	1.3E-03	1.0E+00	2.0E-05	6.0E-02	1.2E-02	2.1E+01	4.0E-05	1.7E-04	2.0E-04	6.8E-03	2.8E-04	1.1E-01	2.0E-05	1.4E+00	3.0E-01	-1.1E+00	-65.6%
20-Mar-12	16																											
27-Mar-12	17	4.4E-01	4.6E-03	1.0E-03	3.7E-02	4.7E-03	1.0E-02	3.6E-04	5.1E-03	1.8E-01	1.4E+00	1.5E-03	5.6E-01	9.0E-04	1.2E-01	1.0E-02	2.1E+01	4.0E-05	1.0E-05	2.0E-04	7.0E-03	3.2E-04	6.5E-02	1.0E-05	1.5E+00	1.3E+00	-1.5E-01	-5.4%
3-Apr-12	18																											
10-Apr-12	19	7.0E-01	2.9E-04	1.0E-03	4.9E-02	6.1E-03	2.0E-02	6.6E-03	8.0E-03	9.6E-02	1.2E+00	1.6E-03	9.2E-01	2.0E-05	6.0E-02	1.4E-02	3.1E+01	4.0E-05	5.0E-05	2.0E-04	1.1E-02	4.7E-04	1.4E-01	1.0E-05	2.1E+00	2.0E+00	-1.5E-01	-3.6%
17-Apr-12	20																											
24-Apr-12	21	7.4E-01	1.6E-03	1.0E-03	3.3E-02	5.6E-03	3.0E-02	5.6E-04	5.7E-03	9.4E-02	1.0E+00	1.2E-03	9.1E-01	1.0E-05	6.0E-02	1.3E-02	2.3E+01	3.0E-05	3.0E-05	1.0E-04	1.0E-02	4.6E-04	1.0E-01	1.0E-05	1.6E+00	1.4E+00	-1.9E-01	-6.1%
1-May-12	22																											
8-May-12	23	8.9E-01	1.9E-04	1.0E-03	3.3E-02	4.4E-03	1.0E-02	1.1E-03	6.5E-03	2.4E-02	9.4E-01	1.2E-03	1.1E+00	3.0E-05	6.0E-02	1.2E-02	2.6E+01	3.0E-05	2.5E-04	1.0E-04	9.6E-03	4.8E-04	1.1E-01	1.0E-05	1.7E+00	1.4E+00	-2.7E-01	-8.7%
15-May-12	24																											
22-May-12	25	1.5E+00	3.1E-04	1.0E-03	5.0E-02	6.3E-03	2.0E-02	1.9E-03	9.0E-03	9.0E-03	1.3E+00	1.7E-03	6.5E-01	1.0E-05	7.0E-02	2.2E-02	3.8E+01	4.0E-05	1.2E-04	2.0E-04	1.6E-02	6.3E-04	1.4E-01	2.0E-05	2.3E+00	2.4E+00	1.2E-01	2.6%
29-May-12	26																											
5-Jun-12	27	8.1E-01	3.8E-04	1.0E-03	3.0E-02	4.1E-03	2.0E-02	4.0E-04	8.9E-03	1.8E-02	8.0E-01	1.1E-03	7.1E-01	1.0E-05	5.0E-02	1.3E-02	2.2E+01	2.0E-05	4.0E-05	7.0E-04	8.7E-03	8.4E-04	8.2E-02	1.0E-05	1.2E+00	1.3E+00	1.7E-01	6.7%
12-Jun-12	28																											
19-Jun-12	29	7.7E-01	5.0E-05	1.0E-03	2.1E-02	3.3E-03	1.0E-02	5.6E-02	5.2E-03	1.8E-02	5.8E-01	1.1E-03	7.4E-01	1.0E-05	6.0E-02	8.7E-03	1.8E+01	2.0E-05	2.0E-04	2.0E-04	9.5E-03	5.9E-04	8.7E-02	1.0E-05	1.1E+00	1.2E+00	6.2E-02	2.8%
26-Jun-12	30																											
3-Jul-12	31	1.2E+00	2.6E-04	1.0E-03	3.4E-02	4.6E-03	1.0E-02	4.1E-04	6.9E-03	9.0E-03	7.2E-01	1.8E-03	9.4E-01	3.0E-05	5.0E-02	1.1E-02	2.6E+01	3.0E-05	1.5E-04	2.0E-04	1.2E-02	5.4E-04	9.7E-02	1.0E-05	1.7E+00	1.6E+00	-1.0E-01	-3.1%
10-Jul-12	32																											
17-Jul-12	33	1.9E+00	9.0E-05	1.0E-03	3.5E-02	5.6E-03	1.0E-02	5.7E-04	6.9E-03	9.0E-03	7.5E-01	1.4E-03	1.4E+00	1.6E-04	6.0E-02	1.2E-02	2.8E+01	3.0E-05	1.5E-04	2.0E-04	1.4E-02	6.4E-04	1.3E-01	1.0E-05	1.7E+00	1.6E+00	-1.3E-01	-3.8%
24-Jul-12	34																											
31-Jul-12	35	2.3E+00	4.4E-04	1.0E-03	3.6E-02	6.7E-03	1.0E-02	4.4E-04	7.7E-03	2.4E-02	6.7E-01	1.1E-03	1.4E+00	4.0E-05	4.0E-02	1.2E-02	2.9E+01	2.0E-05	9.0E-05	2.0E-04	1.7E-02	9.5E-04	1.4E-01	1.0E-05	2.0E+00	1.8E+00	-2.8E-01	-7.4%
7-Aug-12	36																											
14-Aug-12	37	3.0E+00	2.8E-04	1.0E-03	4.7E-02	8.7E-03	1.0E-02	4.6E-04	9.3E-03	9.0E-03	8.0E-01	1.3E-03	1.8E+00	5.0E-05	7.0E-02	1.2E-02	3.7E+01	3.0E-05	2.8E-04	6.0E-04	2.3E-02	1.4E-03	1.6E-01	1.0E-05	1.9E+00	2.4E+00	5.6E-01	13.0%
21-Aug-12	38																											
28-Aug-12	39	4.2E+00	1.5E-04	1.0E-03	5.0E-02	1.1E-02	2.0E-02	4.7E-04	1.0E-02	7.4E-02	8.6E-01	1.2E-03	3.3E+00	5.0E-05	5.0E-02	1.5E-02	4.0E+01	4.0E-05	2.5E-04	3.0E-04	3.2E-02	1.4E-03	1.4E-01	1.0E-05	2.4E+00	2.5E+00	1.2E-01	2.3%
4-Sep-12	40																											
11-Sep-12	41	3.3E+00	4.3E-04	1.0E-03	3.9E-02	7.9E-03	1.0E-02	5.2E-04	9.4E-03	3.3E-02	6.0E-01	1.0E-03	1.9E+00	4.0E-05	5.0E-02	1.2E-02	3.1E+01	3.0E-05	1.4E-04	2.0E-04	2.7E-02	8.7E-04	1.0E-01	1.0E-05	1.8E+00	2.0E+00	2.0E-01	5.2%
18-Sep-12	42																											
25-Sep-12	43	3.2E+00	3.4E-04	1.0E-03	3.6E-02	7.1E-03	1.0E-02	2.4E-02	7.9E-03	2.7E-02	5.2E-01	7.7E-04	1.6E+00	3.0E-05	1.3E-01	1.1E-02	3.1E+01	2.0E-05	3.4E-04	1.0E-04	2.7E-02	1.0E-03	1.0E-01	2.0E-05	1.9E+00	2.0E+00	4.3E-02	1.1%
2-Oct-12	44																											
9-Oct-12	45	3.0E+00	1.0E-03	1.0E-03	3.3E-02	7.4E-03	1.0E-02	4.0E-04	7.8E-03	3.4E-02	4.3E-01	7.8E-04	1.5E+00	3.0E-05	5.0E-02	9.4E-03	2.9E+01	2.0E-05	1.6E-04	2.0E-04	2.7E-02	8.9E-04	8.9E-02	1.0E-05	1.8E+00	1.9E+00	1.1E-01	2.8%
16-Oct-12	46																											
23-Oct-12	47																											
30-Oct-12	48																											
6-Nov-12	49	4.3E+00	1.1E-04	1.0E-03	3.8E-02	9.3E-03	1.0E-02	4.1E-04	7.7E-03	1.3E-02	3.9E-01	5.9E-04	1.3E+00	1.0E-05	6.0E-02	9.7E-03	2.9E+01	2.0E-05	1.9E-04	1.0E-04	3.4E-02	7.2E-04	7.7E-02	1.0E-05	1.7E+00	1.9E+00	2.1E-01	5.9%
13-Nov-12	50																											
20-Nov-12	51																											
27-Nov-12	52																											
4-Dec-12	53	7.6E+00	2.4E-04	1.0E-03	3.2E-02	1.4E-02	1.0E-02	3.7E-04	7.8E-03	2.6E-02	5.1E-01	3.3E-04	2.3E+00	5.0E-05	5.0E-02	1.1E-02	3.1E+01	3.0E-05	1.4E-04	2.0E-04	3.3E-02	1.2E-03	8.6E-02	1.0E-05	1.9E+00	2.0E+00	6.6E-02	1.7%
11-Dec-12	54																											
18-Dec-12	55																											
25-Dec-12	56																											
1-Jan-13	57	8.6E+00	1.5E-03	1.0E-03	3.7E-02	1.6E-02	1.0E-02	4.7E-04	8.5E-03	1.8E-02	3.7E-01	4.5E-04	1.7E+00	4.0E-05	5.0E-02	1.0E-02	3.3E+01	3.0E-05	1.3E-04	1.0E-04	4.1E-02	1.2E-03	7.2E-02	1.0E-05	2.3E+00	1.9E+00	-3.2E-01	-7.6%
8-Jan-13	58																											
15-Jan-13	59																											

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Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Major	Major	Diff	Diff
	No.																								Anions	Cations		(%)
		mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L				
22-Jan-13	60																											
29-Jan-13	61	1.2E+01	2.8E-04	1.0E-03	4.6E-02	1.8E-02	1.0E-02	4.3E-04	8.8E-03	6.2E-02	3.5E-01	4.8E-04	1.5E+00	1.3E-04	1.0E-01	1.0E-02	3.9E+01	2.0E-05	2.5E-04	2.0E-04	4.3E-02	1.4E-03	7.4E-02	1.0E-05	2.4E+00	2.5E+00	5.7E-02	1.2%
5-Feb-13	62																											
12-Feb-13	63																											
19-Feb-13	64																											
26-Feb-13	65	1.2E+01	1.6E-04	1.0E-03	3.9E-02	1.8E-02	1.0E-02	4.8E-04	8.6E-03	5.5E-02	3.1E-01	4.2E-04	1.5E+00	9.0E-05	6.0E-02	7.5E-03	3.4E+01	2.0E-05	3.0E-05	1.0E-04	4.1E-02	1.1E-03	6.5E-02	1.0E-05	2.2E+00	2.2E+00	7.2E-02	1.6%
5-Mar-13	66																											
12-Mar-13	67																											
19-Mar-13	68																											
26-Mar-13	69	1.6E+01	4.6E-04	1.0E-03	4.1E-02	2.3E-02	1.0E-02	4.2E-04	9.0E-03	6.0E-02	2.8E-01	3.4E-04	1.6E+00	1.6E-04	6.0E-02	7.9E-03	3.7E+01	3.0E-05	3.0E-05	2.0E-04	4.0E-02	9.2E-04	6.1E-02	2.0E-05	2.5E+00	2.5E+00	3.3E-02	0.7%
2-Apr-13	70																											
9-Apr-13	71																											
16-Apr-13	72																											
23-Apr-13	73	1.6E+01	8.0E-04	1.0E-03	4.6E-02	2.4E-02	1.0E-02	5.0E-04	9.7E-03	7.6E-02	2.6E-01	3.3E-04	1.5E+00	1.2E-04	4.0E-02	6.9E-03	3.9E+01	2.0E-05	3.0E-05	1.0E-04	4.0E-02	8.4E-04	6.4E-02	3.0E-05	2.9E+00	2.7E+00	-2.2E-01	-3.9%
30-Apr-13	74																											
7-May-13	75																											
14-May-13	76																											
21-May-13	77	1.5E+01	2.0E-04	1.0E-03	5.3E-02	2.4E-02	2.0E-02	3.3E-04	8.9E-03	5.8E-02	2.2E-01	3.4E-04	1.2E+00	5.0E-05	4.0E-02	6.1E-03	3.7E+01	2.0E-05	7.0E-05	1.0E-04	3.5E-02	5.5E-04	5.0E-02	2.0E-05	2.6E+00	2.3E+00	-3.3E-01	-6.8%
28-May-13	78																											
4-Jun-13	79																											
11-Jun-13	80																											
18-Jun-13	81	1.9E+01	8.0E-05	1.0E-03	5.3E-02	2.9E-02	1.0E-02	3.0E-04	9.4E-03	9.0E-03	2.5E-01	3.6E-04	1.5E+00	8.0E-05	1.1E-01	6.9E-03	4.0E+01	2.0E-05	3.0E-05	1.0E-04	3.7E-02	8.0E-04	4.7E-02	1.0E-05	2.7E+00	2.5E+00	-2.1E-01	-4.1%
25-Jun-13	82																											
2-Jul-13	83																											
9-Jul-13	84																											
16-Jul-13	85	2.2E+01	2.5E-04	1.0E-03	5.6E-02	3.1E-02	1.0E-02	3.1E-04	9.8E-03	8.0E-02	2.1E-01	3.9E-04	1.5E+00	1.3E-04	5.0E-02	6.5E-03	4.2E+01	2.0E-05	1.0E-05	1.0E-04	3.4E-02	7.7E-04	3.9E-02	1.0E-05	2.7E+00	2.8E+00	8.6E-02	1.6%
23-Jul-13	86																											
30-Jul-13	87																											
6-Aug-13	88																											
13-Aug-13	89	3.9E+01	3.6E-04	1.0E-03	8.8E-02	5.9E-02	1.0E-02	6.7E-04	1.5E-02	2.3E-01	2.9E-01	5.0E-04	2.6E+00	2.0E-04	6.0E-02	9.2E-03	6.2E+01	2.0E-05	1.0E-04	4.0E-04	4.9E-02	1.7E-03	5.5E-02	4.0E-05	3.9E+00	4.5E+00	5.8E-01	7.0%
20-Aug-13	90																											
27-Aug-13	91																											
3-Sep-13	92																											
10-Sep-13	93	4.7E+01	1.1E-04	1.0E-03	9.0E-02	6.8E-02	1.0E-02	8.8E-04	1.5E-02	4.6E-01	2.7E-01	5.9E-04	2.9E+00	1.9E-04	6.0E-02	8.3E-03	7.4E+01	2.0E-05	1.5E-04	4.0E-04	4.2E-02	1.9E-03	4.4E-02	4.0E-05	4.6E+00	4.9E+00	3.4E-01	3.5%
17-Sep-13	94																											
24-Sep-13	95																											
1-Oct-13	96																											
8-Oct-13	97	4.6E+01	7.0E-05	1.0E-03	9.2E-02	6.7E-02	7.0E-02	7.7E-04	1.6E-02	4.6E-01	2.4E-01	5.9E-04	2.5E+00	1.9E-04	5.0E-02	7.2E-03	7.1E+01	2.0E-05	2.0E-05	4.0E-04	3.7E-02	1.6E-03	4.8E-02	6.0E-05	4.5E+00	4.7E+00	1.3E-01	1.4%
15-Oct-13	98																											
22-Oct-13	99																											
29-Oct-13	100																											
5-Nov-13	101	4.2E+01	5.0E-05	1.0E-03	6.5E-02	6.0E-02	1.0E-02	8.4E-04	1.3E-02	3.9E-01	2.0E-01	5.2E-04	2.4E+00	2.3E-04	4.0E-02	6.7E-03	5.8E+01	2.0E-05	3.0E-05	4.0E-04	2.9E-02	1.7E-03	3.7E-02	3.0E-05	3.6E+00	4.0E+00	4.0E-01	5.3%
12-Nov-13	102																											
19-Nov-13	103																											
26-Nov-13	104																											
3-Dec-13	105	4.1E+01	3.0E-05	1.0E-03	6.7E-02	5.5E-02	1.0E-02	9.3E-04	1.3E-02	4.9E-01	2.0E-01	5.3E-04	9.5E-01	2.1E-04	4.0E-02	6.5E-03	6.0E+01	2.0E-05	6.0E-05	5.0E-04	2.8E-02	1.6E-03	3.2E-02	4.0E-05	4.3E+00	3.3E+00	-9.8E-01	-12.9%
10-Dec-13	106																											
17-Dec-13	107																											
24-Dec-13	108																											
31-Dec-13	109	4.5E+01	1.2E-04	1.0E-03	8.4E-02	6.3E-02	1.0E-02	9.2E-04	1.4E-02	4.2E-01	2.0E-01	5.9E-04	1.9E+00	2.0E-04	5.0E-02	6.1E-03	6.5E+01	2.0E-05	7.0E-05	6.0E-04	2.4E-02	1.8E-03	3.5E-02	4.0E-05	3.6E+00	4.2E+00	6.2E-01	7.9%
7-Jan-14	110																											
14-Jan-14	111																											
21-Jan-14	112																											
28-Jan-14	113	4.7E+01	2.0E-05	1.0E-03	8.6E-02	6.0E-02	1.0E-02	9.7E-04	1.5E-02	4.7E-01	1.9E-01	5.5E-04	7.9E-01	1.9E-04	5.0E-02	6.0E-03	6.5E+01	2.0E-05	1.8E-04	6.0E-04	2.4E-02	1.3E-03	3.6E-02	2.0E-05	4.0E+00	4.4E+00	4.1E-01	5.0%
4-Feb-14	114																											

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Sample = 08-143

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Major	Major	Diff	Diff
	No.																								Anions	Cations		(%)
		mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L				
11-Feb-14	115																											
18-Feb-14	116																											
25-Feb-14	117	5.5E+01	3.0E-05	1.0E-03	7.8E-02	7.3E-02	1.0E-02	1.1E-03	1.7E-02	3.4E-01	2.2E-01	5.8E-04	1.6E+00	2.5E-04	5.0E-02	7.5E-03	7.6E+01	2.0E-05	4.0E-05	3.0E-04	2.7E-02	2.5E-03	4.8E-02	1.0E-05	4.8E+00	5.1E+00	3.0E-01	3.0%
4-Mar-14	118	2.1E+01	3.0E-05	1.0E-03	1.0E-01	3.0E-02	1.0E-02	4.5E-04	7.3E-03	2.7E-01	1.1E-01	2.9E-04	3.6E-01	5.0E-05	3.0E-02	6.3E-03	3.5E+01	2.0E-05	1.3E-04	2.0E-04	1.0E-02	5.9E-04	1.9E-02	1.0E-05	2.4E+00	2.3E+00	-1.1E-01	-2.4%
11-Mar-14	119	2.1E+01	1.4E-04	1.0E-03	2.4E-02	2.6E-02	1.0E-02	3.8E-04	7.8E-03	1.6E-01	8.7E-02	2.3E-04	7.2E-01	4.0E-05	8.0E-02	3.1E-03	3.4E+01	2.0E-05	4.7E-04	1.0E-04	9.6E-03	3.3E-04	1.9E-02	1.0E-05	2.2E+00	2.2E+00	2.8E-02	0.6%
18-Mar-14	120	1.3E+01	1.9E-04	1.0E-03	1.4E-02	1.6E-02	1.0E-02	2.3E-04	5.0E-03	6.9E-02	6.8E-02	1.7E-04	2.2E-01	2.0E-05	3.0E-02	2.3E-03	2.2E+01	2.0E-05	6.0E-05	1.0E-04	5.9E-03	1.8E-04	1.8E-02	1.0E-05	1.3E+00	1.6E+00	3.0E-01	10.7%
25-Mar-14	121	1.2E+01	4.0E-05	1.0E-03	8.0E-03	1.5E-02	1.0E-02	2.3E-04	4.0E-03	5.5E-02	6.8E-02	1.6E-04	2.0E-01	2.0E-05	2.0E-02	2.0E-03	2.1E+01	2.0E-05	3.4E-04	1.0E-04	4.8E-03	1.2E-04	1.1E-02	1.0E-05	1.2E+00	1.3E+00	2.8E-02	1.1%
1-Apr-14	122																											
8-Apr-14	123																											
15-Apr-14	124																											
22-Apr-14	125	1.1E+01	1.2E-04	3.1E-05	6.0E-03	1.4E-02	1.0E-02	2.0E-04	3.9E-03	3.1E-02	6.3E-02	1.2E-04	1.7E-01	1.6E-05	7.0E-02	2.1E-03	1.7E+01	5.0E-06	1.4E-04	5.0E-05	2.8E-03	8.0E-05	1.2E-02	2.0E-03	1.0E+00	1.2E+00	1.7E-01	7.7%
29-Apr-14	126																											
6-May-14	127																											
13-May-14	128																											
20-May-14	129	8.5E+00	4.0E-05	1.1E-04	8.0E-03	1.1E-02	1.0E-02	5.5E-04	3.1E-03	2.0E-02	5.0E-02	1.3E-04	1.8E-01	1.7E-05	1.0E-02	1.5E-03	1.4E+01	5.0E-06	2.6E-04	6.0E-05	2.2E-03	4.0E-05	6.0E-03	2.0E-03	7.5E-01	9.7E-01	2.2E-01	12.7%
27-May-14	130																											
3-Jun-14	131																											
10-Jun-14	132																											
17-Jun-14	133	7.4E+00	1.8E-04	3.6E-05	4.0E-03	9.8E-03	1.0E-02	9.0E-05	2.7E-03	1.9E-02	5.6E-02	8.0E-05	1.4E-01	5.0E-06	2.0E-02	1.3E-03	1.3E+01	6.0E-06	3.6E-04	5.0E-05	1.9E-03	3.0E-05	7.0E-03	2.0E-03	7.3E-01	8.5E-01	1.2E-01	7.8%
24-Jun-14	134																											
1-Jul-14	135																											
8-Jul-14	136																											
15-Jul-14	137	8.8E+00	8.0E-05	5.0E-05	4.0E-03	1.1E-02	1.0E-02	1.8E-04	3.1E-03	1.2E-02	5.5E-02	9.0E-05	1.8E-01	1.0E-05	2.0E-02	1.4E-03	1.5E+01	5.0E-06	1.6E-04	5.0E-05	2.0E-03	4.0E-05	9.0E-03	2.0E-03	8.1E-01	9.8E-01	1.7E-01	0.092929797
22-Jul-14	138																											
29-Jul-14	139																											
5-Aug-14	140																											
12-Aug-14	141	8.0E+00	1.4E-04	1.4E-05	5.0E-03	1.1E-02	1.0E-02	2.2E-04	3.1E-03	9.0E-03	5.9E-02	1.1E-04	1.5E-01	8.0E-06	2.0E-02	1.4E-03	1.4E+01	6.0E-06	1.3E-04	5.0E-05	2.0E-03	1.0E-05	6.0E-03	2.0E-03	8.5E-01	9.5E-01	9.2E-02	0.050975552
19-Aug-14	142																											
26-Aug-14	143																											
2-Sep-14	144																											
9-Sep-14	145	7.7E+00	8.0E-05	3.3E-05	4.0E-03	2.9E-04	< 0.01	3.0E-05	2.8E-03	7.0E-03	6.2E-02	1.0E-04	1.4E-01	3.0E-06	3.0E-02	1.7E-03	1.5E+01	5.0E-06	2.4E-04	< 0.00005	1.8E-03	4.0E-05	6.0E-03	< 0.002	7.5E-01	8.1E-01	6.4E-02	0.040727076
16-Sep-14	146																											
23-Sep-14	147																											
30-Sep-14	148																											

HC8

Sample = 08-143

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/kg	mgCaCO3/kg	mgCaCO3/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
29-Nov-11	0	500	340	4.13	7.4E+02	1.2E+01	8.4E+01	#N/A	1.2E+02	7.5E-01	2.5E-01	1.0E-01	3.6E+01	1.5E+01	2.0E-04	5.4E-04	1.5E-02	1.2E-03	3.4E-06	2.2E-03	1.8E-03	1.1E+01	8.5E-04	2.9E-02	3.1E+01
6-Dec-11	1	500	475	4.08	6.4E+02	1.3E+01	1.0E+02	#N/A	1.5E+02	6.7E-01	2.9E-02	1.4E-01	4.4E+01	1.2E+01	2.4E-04	6.7E-04	3.7E-03	1.7E-03	4.8E-06	2.4E-03	2.2E-03	1.3E+01	1.1E-03	3.9E-02	2.2E+01
13-Dec-11	2	500	455	4.16	4.6E+02	7.7E+00	6.8E+01	#N/A	9.2E+01	3.6E-01	3.1E-01	1.4E-01	2.7E+01	7.4E+00	1.4E-04	6.4E-04	1.8E-03	1.0E-03	9.1E-06	2.2E-03	1.4E-03	8.4E+00	1.3E-03	3.0E-02	1.6E+01
20-Dec-11	3	500	510	4.21	3.6E+02	5.9E+00	6.2E+01	#N/A	9.5E+01	3.1E-01	3.4E-01	1.5E-01	2.2E+01	7.2E+00	2.0E-04	7.1E-04	1.2E-03	1.2E-03	5.1E-06	2.1E-03	1.1E-03	6.8E+00	5.1E-04	1.6E-02	1.4E+01
27-Dec-11	4	500	420	4.40	2.7E+02																				
3-Jan-12	5	500	450	4.18	2.3E+02	4.3E+00	3.4E+01	#N/A	5.1E+01	4.5E-01	1.9E-01	1.4E-01	8.1E+00	4.4E+00	1.4E-04	3.6E-04	7.2E-04	6.7E-04	4.5E-06	1.4E-03	7.4E-04	2.6E+00	2.7E-04	7.9E-03	6.7E+00
10-Jan-12	6	500	420	4.24	1.8E+02																				
17-Jan-12	7	500	450	4.38	1.5E+02	1.2E+00	1.9E+01	#N/A	3.1E+01	9.0E-02	1.5E-01	1.4E-01	3.6E+00	3.4E+00	1.8E-04	2.7E-04	8.5E-04	5.7E-04	4.5E-06	1.4E-03	2.2E-03	1.2E+00	2.3E-04	3.6E-03	4.1E+00
24-Jan-12	8	500	435	4.27	1.4E+02																				
31-Jan-12	9	500	445	4.23	1.1E+02	2.2E+00	1.5E+01	#N/A	1.7E+01	8.9E-02	1.2E-01	1.3E-01	1.3E+00	1.7E+00	8.9E-05	3.6E-04	6.2E-04	4.1E-04	4.5E-06	9.8E-04	1.7E-04	4.3E-01	2.2E-04	2.2E-03	2.3E+00
7-Feb-12	10	500	460	4.36	9.9E+01																				
14-Feb-12	11	500	445	4.30	1.1E+02	2.8E+00	1.8E+01	#N/A	1.8E+01	8.9E-02	1.1E-01	1.3E-01	8.3E-01	3.1E+00	8.9E-05	2.7E-04	5.3E-04	3.5E-04	4.5E-06	1.0E-03	1.8E-04	2.8E-01	2.2E-04	1.7E-03	2.6E+00
21-Feb-12	12	500	465	4.30	1.4E+02																				
28-Feb-12	13	500	460	4.18	1.5E+02	4.0E+00	2.4E+01	#N/A	2.8E+01	4.6E-01	1.3E-01	1.4E-01	8.6E-01	3.5E+00	5.5E-04	4.6E-04	9.2E-04	4.6E-04	4.6E-06	1.6E-03	3.0E-04	2.9E-01	2.3E-04	2.7E-03	2.8E+00
6-Mar-12	14	500	435	4.23	1.6E+02																				
13-Mar-12	15	500	465	4.15	1.5E+02	5.8E+00	3.0E+01	#N/A	3.1E+01	4.7E-01	1.2E-01	1.4E-01	6.4E-01	4.8E-01	1.9E-04	2.3E-04	7.0E-04	4.7E-04	4.7E-06	1.3E-03	2.4E-04	2.2E-01	2.3E-04	2.7E-03	3.2E-01
20-Mar-12	16	500	430	4.21	1.5E+02																				
27-Mar-12	17	500	435	4.11	1.6E+02	5.7E+00	2.6E+01	#N/A	3.0E+01	4.4E-01	1.0E-01	1.3E-01	5.0E-01	3.9E+00	8.7E-05	1.7E-04	4.4E-04	5.7E-04	4.4E-06	1.3E-03	2.1E-04	1.7E-01	2.2E-04	2.1E-03	2.4E+00
3-Apr-12	18	500	445	4.08	1.6E+02																				
10-Apr-12	19	500	450	3.95	2.1E+02	1.4E+01	4.0E+01	#N/A	4.5E+01	9.0E-02	1.1E-01	1.4E-01	6.0E-01	5.9E+00	1.4E-04	1.8E-04	5.9E-04	8.7E-04	4.5E-06	1.4E-03	3.2E-04	2.0E-01	3.2E-04	3.3E-03	4.1E+00
17-Apr-12	20	500	410	3.98	2.4E+02																				
24-Apr-12	21	500	450	4.00	1.7E+02	9.6E+00	3.2E+01	#N/A	3.5E+01	4.5E-01	8.1E-02	1.4E-01	4.1E-01	4.4E+00	1.8E-04	2.3E-04	1.4E-03	6.9E-04	4.5E-06	9.9E-04	2.4E-04	1.4E-01	2.7E-04	2.2E-03	2.4E+00
1-May-12	22	500	455	4.06	1.8E+02																				
8-May-12	23	500	455	3.95	1.9E+02	1.2E+01	3.4E+01	#N/A	3.6E+01	4.6E-01	5.9E-02	1.4E-01	3.8E-01	4.1E+00	1.4E-04	1.8E-04	8.2E-04	7.0E-04	4.6E-06	2.1E-03	2.6E-04	1.3E-01	2.7E-04	2.5E-03	2.5E+00
15-May-12	24	500	445	3.95	1.8E+02																				
22-May-12	25	500	405	3.89	2.5E+02	1.9E+01	4.6E+01	#N/A	4.4E+01	4.1E-01	6.5E-02	1.2E-01	7.3E-01	6.6E+00	2.0E-04	3.2E-04	1.6E-03	8.0E-04	4.1E-06	1.1E-03	3.8E-04	2.6E-01	4.5E-04	3.2E-03	3.5E+00
29-May-12	26	500	415	4.01	1.6E+02																				
5-Jun-12	27	500	430	4.01	1.6E+02	8.6E+00	3.1E+01	#N/A	2.4E+01	4.3E-01	5.2E-02	1.3E-01	4.5E-01	3.8E+00	8.6E-05	1.7E-04	5.2E-04	5.7E-04	4.3E-06	2.7E-03	2.2E-04	1.6E-01	2.2E-04	2.1E-03	1.9E+00
12-Jun-12	28	500	445	3.98	1.7E+02																				
19-Jun-12	29	500	440	3.99	1.5E+02	8.8E+00	2.6E+01	#N/A	2.3E+01	8.8E-02	4.0E-02	1.3E-01	2.3E-01	3.4E+00	8.8E-05	2.2E-04	6.2E-04	5.1E-04	4.4E-06	8.8E-04	1.9E-04	7.9E-02	2.2E-04	2.0E-03	1.6E+00
26-Jun-12	30	500	440	4.04	1.5E+02																				
3-Jul-12	31	500	440	4.02	1.9E+02	1.5E+01	4.0E+01	#N/A	3.5E+01	4.4E-01	4.0E-02	1.3E-01	3.5E-01	4.8E+00	1.3E-04	2.2E-04	6.6E-04	6.3E-04	4.4E-06	6.6E-04	3.0E-04	1.2E-01	2.6E-04	2.7E-03	2.2E+00
10-Jul-12	32	500	475	3.80	2.3E+02																				
17-Jul-12	33	500	445	3.77	2.0E+02	1.9E+01	3.6E+01	#N/A	3.6E+01	4.5E-01	4.0E-02	1.3E-01	2.9E-01	4.4E+00	1.8E-04	4.0E-04	7.1E-04	8.0E-04	4.5E-06	1.7E-03	4.2E-04	9.3E-02	2.7E-04	3.2E-03	2.5E+00
24-Jul-12	34	500	440	3.93	2.0E+02																				
31-Jul-12	35	500	445	3.76	2.2E+02	2.0E+01	3.9E+01	#N/A	4.4E+01	8.9E-02	4.0E-02	1.3E-01	2.9E-01	5.0E+00	1.3E-04	2.2E-04	7.6E-04	7.4E-04	4.5E-06	1.1E-03	4.4E-04	8.9E-02	4.0E-04	3.0E-03	2.6E+00
7-Aug-12	36	500	445	3.68	2.6E+02																				
14-Aug-12	37	500	440	3.62	2.6E+02	2.6E+01	4.8E+01	#N/A	4.0E+01	4.4E-01	3.5E-02	1.3E-01	3.7E-01	7.1E+00	1.3E-04	3.5E-04	9.0E-04	8.6E-04	4.4E-06	1.1E-03	5.0E-04	1.1E-01	5.3E-04	3.6E-03	2.7E+00
21-Aug-12	38	500	445	3.63	2.5E+02																				
28-Aug-12	39	500	490	3.55	3.0E+02	3.0E+01	6.3E+01	#N/A	5.7E+01	4.9E-01	3.9E-02	1.5E-01	4.5E-01	7.9E+00	2.5E-04	2.0E-04	1.2E-03	9.1E-04	4.9E-06	1.5E-03	6.0E-04	1.4E-01	6.4E-04	4.4E-03	2.9E+00
4-Sep-12	40	500	470	3.66	2.3E+02																				
11-Sep-12	41	500	450	3.59	2.6E+02	2.2E+01	4.9E+01	#N/A	3.9E+01	4.5E-01	3.2E-02	1.4E-01	3.9E-01	5.6E+00	1.4E-04	1.8E-04	1.1E-03	6.0E-04	4.5E-06	8.1E-04	4.1E-04	1.3E-01	5.4E-04	3.3E-03	2.1E+00
18-Sep-12	42	500	505	3.59	2.7E+02																				
25-Sep-12	43	500	450	3.58	2.6E+02	1.9E+01	4.1E+01	#N/A	4.2E+01	9.0E-02	2.7E-02	1.4E-01	3.9E-01	5.6E+00	9.0E-05	9.0E-05	1.2E-03	4.8E-04	4.5E-06	1.8E-04	4.3E-04	1.3E-01	7.2E-04	3.3E-03	1.9E+00
2-Oct-12	44	500	455	3.61	3.3E+02																				
9-Oct-12	45	500	460	3.55	2.4E+02	1.8E+01	3.9E+01	#N/A	4.0E+01	4.6E-01	2.8E-02	1.4E-01	3.9E-01	5.6E+00	1.4E-04	1.8E-04	1.0E-03	4.7E-04	4.6E-06	6.4E-04	3.6E-04	1.3E-01	6.4E-04	3.2E-03	1.8E+00
16-Oct-12	46	500	460	3.46	2.7E+02																				
23-Oct-12	47	500	485	3.41	3.0E+02																				
30-Oct-12	48	500	460	3.51	2.7E+02																				

HC8

Sample = 08-143

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/kg	mgCaCO3/kg	mgCaCO3/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
6-Nov-12	49	500	430	3.46	2.5E+02	1.7E+01	3.9E+01	#N/A	3.5E+01	4.3E-01	2.6E-02	1.3E-01	4.6E-01	4.6E+00	1.3E-04	1.3E-04	1.0E-03	3.7E-04	4.3E-06	7.3E-04	3.4E-04	1.5E-01	9.0E-04	3.0E-03	1.5E+00
13-Nov-12	50	500	435	3.40	2.6E+02																				
20-Nov-12	51	500	485	3.45	2.9E+02																				
27-Nov-12	52	500	490	3.30	2.8E+02																				
4-Dec-12	53	500	490	3.37	3.1E+02	1.9E+01	4.2E+01	#N/A	4.6E+01	4.9E-01	2.9E-02	1.5E-01	4.9E-01	4.5E+00	2.0E-04	2.0E-04	1.7E-03	3.3E-04	4.9E-06	5.9E-04	3.6E-04	1.8E-01	7.8E-04	3.5E-03	1.9E+00
11-Dec-12	54	500	440	3.35	3.1E+02																				
18-Dec-12	55	500	435	3.35	3.0E+02																				
25-Dec-12	56	500	445	3.31	3.2E+02																				
1-Jan-13	57	500	460	3.34	3.2E+02	2.3E+01	4.5E+01	#N/A	5.0E+01	4.6E-01	2.8E-02	1.4E-01	5.0E-01	3.6E+00	1.8E-04	9.2E-05	1.5E-03	2.8E-04	4.6E-06	3.2E-04	3.2E-04	1.7E-01	1.1E-03	3.5E-03	1.6E+00
8-Jan-13	58	500	465	3.35	3.2E+02																				
15-Jan-13	59	500	465	3.27	3.2E+02																				
22-Jan-13	60	500	455	3.41	3.2E+02																				
29-Jan-13	61	500	460	3.24	3.4E+02	2.3E+01	4.4E+01	#N/A	5.4E+01	4.6E-01	2.8E-02	1.4E-01	5.9E-01	4.7E+00	1.4E-04	1.4E-04	1.6E-03	2.6E-04	4.6E-06	3.7E-04	3.6E-04	2.0E-01	1.4E-03	3.8E-03	1.7E+00
5-Feb-13	62	500	460	3.30	3.5E+02																				
12-Feb-13	63	500	455	3.27	3.4E+02																				
19-Feb-13	64	500	460	3.26	3.5E+02																				
26-Feb-13	65	500	450	3.23	3.7E+02	2.3E+01	4.0E+01	#N/A	4.6E+01	4.5E-01	2.7E-02	1.4E-01	6.7E-01	3.5E+00	9.0E-05	2.3E-04	1.5E-03	2.4E-04	4.5E-06	2.7E-04	3.1E-04	2.4E-01	1.3E-03	3.8E-03	1.5E+00
5-Mar-13	66	500	455	3.23	3.8E+02																				
12-Mar-13	67	500	450	3.23	3.7E+02																				
19-Mar-13	68	500	450	3.32	3.6E+02																				
26-Mar-13	69	500	455	3.19	3.8E+02	3.4E+01	5.6E+01	#N/A	5.4E+01	4.6E-01	2.7E-02	1.4E-01	4.3E-01	3.6E+00	9.1E-05	2.7E-04	1.4E-03	2.0E-04	9.1E-06	3.6E-04	2.8E-04	1.4E-01	1.3E-03	3.9E-03	1.4E+00
2-Apr-13	70	500	440	3.22	3.6E+02																				
9-Apr-13	71	500	455	3.31	3.8E+02																				
16-Apr-13	72	500	455	3.33	3.9E+02																				
23-Apr-13	73	500	445	3.15	4.7E+02	3.5E+01	5.5E+01	#N/A	6.1E+01	4.5E-01	2.7E-02	1.3E-01	4.0E-01	3.9E+00	8.9E-05	2.2E-04	1.4E-03	1.8E-04	4.5E-06	4.5E-04	3.0E-04	1.3E-01	1.2E-03	4.1E-03	1.3E+00
30-Apr-13	74	500	440	3.17	4.0E+02																				
7-May-13	75	500	445	3.32	3.7E+02																				
14-May-13	76	500	405	3.18	3.9E+02																				
21-May-13	77	500	440	3.16	3.8E+02	3.2E+01	5.1E+01	#N/A	5.5E+01	4.4E-01	2.6E-02	1.3E-01	5.2E-01	2.7E+00	8.8E-05	8.8E-05	1.0E-03	1.7E-04	4.4E-06	4.0E-04	2.3E-04	1.7E-01	1.4E-03	3.7E-03	8.1E-01
28-May-13	78	500	445	3.15	4.2E+02																				
4-Jun-13	79	500	470	3.14	4.3E+02																				
11-Jun-13	80	500	470	3.21	4.5E+02																				
18-Jun-13	81	500	460	3.16	4.6E+02	3.9E+01	5.9E+01	#N/A	6.0E+01	4.6E-01	2.8E-02	1.4E-01	5.0E-01	2.9E+00	9.2E-05	9.2E-05	1.3E-03	1.7E-04	4.6E-06	8.7E-04	2.2E-04	1.6E-01	1.4E-03	4.1E-03	7.4E-01
25-Jun-13	82	500	470	3.18	4.6E+02																				
2-Jul-13	83	500	470	3.12	4.7E+02																				
9-Jul-13	84	500	480	3.15	5.3E+02																				
16-Jul-13	85	500	460	3.07	4.8E+02	4.1E+01	5.9E+01	#N/A	6.0E+01	4.6E-01	2.8E-02	1.4E-01	4.6E-01	2.9E+00	9.2E-05	2.3E-04	1.3E-03	1.5E-04	4.6E-06	6.9E-04	2.0E-04	1.4E-01	1.5E-03	4.2E-03	6.6E-01
23-Jul-13	86	500	440	3.06	4.9E+02																				
30-Jul-13	87	500	455	3.07	5.0E+02																				
6-Aug-13	88	500	485	3.02	5.7E+02																				
13-Aug-13	89	500	475	2.88	7.5E+02	7.0E+01	9.5E+01	#N/A	8.8E+01	9.5E-01	2.9E-02	1.4E-01	7.6E-01	3.9E+00	9.5E-05	4.8E-04	2.0E-03	2.1E-04	4.8E-06	7.6E-04	2.9E-04	2.4E-01	2.2E-03	6.2E-03	8.6E-01
20-Aug-13	90	500	460	2.99	6.2E+02																				
27-Aug-13	91	500	475	2.96	6.1E+02																				
3-Sep-13	92	500	450	2.98	5.6E+02																				
10-Sep-13	93	500	460	2.86	7.4E+02	8.0E+01	1.1E+02	#N/A	1.0E+02	4.6E-01	2.8E-02	1.4E-01	6.0E-01	3.9E+00	9.2E-05	8.3E-04	1.3E-03	1.7E-04	4.6E-06	7.4E-04	2.4E-04	1.8E-01	2.0E-03	6.6E-03	6.2E-01
17-Sep-13	94	500	435	2.97	6.2E+02																				
24-Sep-13	95	500	440	2.98	6.0E+02																				
1-Oct-13	96	500	480	2.98	6.0E+02																				
8-Oct-13	97	500	435	2.88	7.7E+02	7.3E+01	9.2E+01	#N/A	9.4E+01	4.4E-01	2.6E-02	1.3E-01	7.0E-01	3.0E+00	8.7E-05	9.1E-04	1.2E-03	1.6E-04	4.4E-06	1.3E-03	2.1E-04	2.1E-01	1.8E-03	6.1E-03	5.2E-01
15-Oct-13	98	500	465	2.75	7.4E+02																				

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Sample = 08-143

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/kg	mgCaCO3/kg	mgCaCO3/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
22-Oct-13	99	500	455	2.95	6.4E+02																				
29-Oct-13	100	500	480	3.02	6.2E+02																				
5-Nov-13	101	500	475	2.94	7.1E+02	6.8E+01	9.0E+01	#N/A	8.1E+01	4.8E-01	2.9E-02	1.4E-01	5.0E-01	2.2E+00	9.5E-05	1.0E-03	1.2E-03	1.3E-04	4.8E-06	6.7E-04	2.0E-04	1.5E-01	1.7E-03	5.9E-03	4.8E-01
12-Nov-13	102	500	470	2.98	7.1E+02																				
19-Nov-13	103	500	470	3.07	6.7E+02																				
26-Nov-13	104	500	470	2.84	8.2E+02																				
3-Dec-13	105	500	475	3.31	6.9E+02	6.1E+01	8.5E+01	#N/A	9.7E+01	4.8E-01	2.9E-02	1.4E-01	5.8E-01	2.5E+00	9.5E-05	1.5E-03	1.2E-03	1.2E-04	4.8E-06	4.3E-04	1.8E-04	1.8E-01	1.6E-03	6.1E-03	4.7E-01
10-Dec-13	106	500	435	2.98	6.4E+02																				
17-Dec-13	107	500	445	2.85	7.2E+02																				
24-Dec-13	108	500	430	2.94	7.6E+02																				
31-Dec-13	109	500	435	2.91	7.5E+02	6.1E+01	8.1E+01	#N/A	7.4E+01	4.4E-01	2.6E-02	1.3E-01	1.5E+00	1.8E+00	8.7E-05	1.0E-03	1.0E-03	1.2E-04	4.4E-06	4.8E-04	1.6E-04	5.4E-01	1.4E-03	5.7E-03	4.0E-01
7-Jan-14	110	500	440	2.93	7.3E+02																				
14-Jan-14	111	500	425	2.92	6.9E+02																				
21-Jan-14	112	500	430	2.94	7.6E+02																				
28-Jan-14	113	500	430	2.91	7.2E+02	6.9E+01	8.8E+01	#N/A	8.1E+01	4.3E-01	2.6E-02	1.3E-01	1.2E+00	2.1E+00	8.6E-05	1.1E-03	9.0E-04	1.1E-04	4.3E-06	5.2E-04	1.7E-04	4.1E-01	1.5E-03	6.3E-03	3.9E-01
4-Feb-14	114	500	435	2.90	7.3E+02																				
11-Feb-14	115	500	440	2.80	7.6E+02																				
18-Feb-14	116	500	435	2.87	7.5E+02																				
25-Feb-14	117	500	485	2.82	8.7E+02	7.9E+01	1.0E+02	#N/A	1.1E+02	4.9E-01	2.9E-02	1.5E-01	1.4E+00	2.2E+00	9.7E-05	8.2E-04	1.5E-03	1.4E-04	4.9E-06	4.9E-04	2.4E-04	5.0E-01	1.7E-03	8.1E-03	6.1E-01
4-Mar-14	118	500	465	3.07	4.4E+02	3.5E+01	4.7E+01	#N/A	5.4E+01	9.3E-02	2.8E-02	1.4E-01	7.0E-01	1.3E+00	9.3E-05	8.8E-04	5.0E-04	5.6E-05	4.7E-06	4.7E-04	8.6E-05	2.0E-01	8.8E-04	3.3E-03	2.8E-01
11-Mar-14	119	500	500	3.10	4.5E+02	3.9E+01	5.1E+01	#N/A	5.3E+01	1.0E-01	3.0E-02	1.5E-01	2.1E-01	1.3E+00	1.0E-04	3.5E-04	6.7E-04	5.0E-05	5.0E-06	6.0E-04	7.9E-05	6.5E-02	8.0E-04	3.8E-03	2.8E-01
18-Mar-14	120	500	475	3.18	3.3E+02	2.4E+01	3.2E+01	#N/A	2.9E+01	9.5E-02	2.9E-02	1.4E-01	5.2E-01	7.0E-01	9.5E-05	1.4E-04	6.1E-04	2.4E-05	2.4E-05	2.9E-04	4.9E-05	1.9E-01	4.3E-04	2.2E-03	1.8E-01
25-Mar-14	121	500	495	3.34	3.1E+02	2.1E+01	2.9E+01	#N/A	2.9E+01	9.9E-02	3.0E-02	1.5E-01	4.2E-01	6.2E-01	9.9E-05	9.9E-05	1.0E-03	2.0E-05	5.0E-06	6.9E-04	3.5E-05	1.6E-01	3.0E-04	2.1E-03	1.8E-01
1-Apr-14	122	500	495	3.29	3.0E+02																				
8-Apr-14	123	500	495	3.30	2.8E+02																				
15-Apr-14	124	500	480	3.35	2.7E+02																				
22-Apr-14	125	500	445	3.29	2.8E+02	1.8E+01	2.4E+01	#N/A	2.2E+01	8.9E-02	2.7E-02	1.3E-01	2.0E-01	3.8E-01	8.9E-05	1.3E-04	8.5E-04	1.3E-05	3.1E-06	9.8E-04	2.7E-05	8.0E-02	1.8E-04	1.5E-03	1.1E-01
29-Apr-14	126	500	485	3.33	2.9E+02																				
6-May-14	127	500	480	3.33	2.3E+02																				
13-May-14	128	500	500	3.37	2.6E+02																				
20-May-14	129	500	480	3.37	2.1E+02	1.6E+01	2.3E+01	#N/A	1.7E+01	9.6E-02	2.9E-02	1.4E-01	2.1E-01	2.9E-01	9.6E-05	9.6E-05	8.6E-04	1.3E-05	3.4E-06	4.8E-04	2.4E-05	7.7E-02	1.2E-04	1.6E-03	1.2E-01
27-May-14	130	500	480	3.41	2.2E+02																				
3-Jun-14	131	500	480	3.39	2.1E+02																				
10-Jun-14	132	500	485	3.30	2.5E+02																				
17-Jun-14	133	500	505	3.40	2.2E+02	1.6E+01	2.2E+01	#N/A	1.8E+01	1.0E-01	3.0E-02	1.5E-01	1.7E-01	1.9E-01	1.0E-04	1.0E-04	5.8E-04	1.0E-05	3.5E-06	1.6E-03	2.8E-05	6.6E-02	1.2E-04	1.3E-03	9.0E-02
24-Jun-14	134	500	495	3.43	2.1E+02																				
1-Jul-14	135	500	495	3.49	2.2E+02																				
8-Jul-14	136	500	490	3.43	2.4E+02																				
15-Jul-14	137	500	475	3.35	2.6E+02	1.7E+01	2.2E+01	#N/A	1.9E+01	9.5E-02	2.9E-02	1.4E-01	1.6E-01	1.9E-01	9.5E-05	9.5E-05	5.2E-04	5.2E-06	3.3E-06	1.1E-03	2.3E-05	6.2E-02	7.6E-05	1.4E-03	8.6E-02
22-Jul-14	138	500	495	3.37	2.9E+02																				
29-Jul-14	139	500	485	3.27	2.8E+02																				
5-Aug-14	140	500	455	3.21	2.6E+02																				
12-Aug-14	141	500	485	3.34	2.6E+02	1.6E+01	2.3E+01	#N/A	2.0E+01	9.7E-02	2.9E-02	1.5E-01	2.0E-01	1.9E-01	9.7E-05	9.7E-05	6.2E-04	7.3E-06	3.4E-06	7.8E-04	2.0E-05	7.8E-02	1.1E-04	1.5E-03	8.5E-02
19-Aug-14	142	500	500	3.41	2.6E+02																				
26-Aug-14	143	500	500	3.40	2.4E+02																				
2-Sep-14	144	500	470	3.37	2.4E+02																				

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Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
	No.																							
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
29-Nov-11	0	3.8E-01	8.4E-04	2.7E-03	2.1E+00	1.6E-01	6.8E-06	9.9E-04	2.8E-02	1.1E-01	6.4E+00	2.9E-03	1.9E-01	3.4E-05	4.6E+00	3.2E-02	4.3E+01	1.5E-04	4.4E-05	2.0E-04	1.1E-02	4.7E-04	2.9E-01	2.7E-05
6-Dec-11	1	4.0E-01	1.7E-03	4.3E-03	2.6E+00	2.2E-01	9.5E-06	1.2E-03	3.7E-02	1.5E-01	6.6E+00	2.9E-03	1.1E+00	4.8E-05	5.0E+00	4.5E-02	5.7E+01	1.5E-04	4.8E-06	3.3E-04	8.3E-03	7.7E-04	4.0E-01	1.4E-05
13-Dec-11	2	2.3E-01	2.3E-04	3.6E-03	1.5E+00	1.3E-01	1.4E-05	8.4E-04	3.0E-02	1.3E-01	4.2E+00	4.9E-03	7.6E-01	2.3E-05	2.5E+00	3.4E-02	3.5E+01	7.3E-05	4.2E-04	3.2E-04	5.3E-03	4.6E-04	2.6E-01	1.4E-05
20-Dec-11	3	3.0E-01	7.1E-05	2.0E-03	1.1E+00	9.6E-02	5.1E-06	6.1E-04	1.6E-02	2.1E-01	3.8E+00	2.7E-03	1.3E+00	1.0E-05	1.6E+00	3.1E-02	3.1E+01	8.7E-05	5.1E-06	3.1E-04	4.2E-03	4.4E-04	2.0E-01	5.1E-06
27-Dec-11	4																							
3-Jan-12	5	1.2E-01	1.8E-03	1.4E-03	3.8E-01	3.4E-02	4.5E-06	2.9E-04	8.1E-03	5.3E-02	1.6E+00	1.1E-03	3.5E-01	9.0E-06	4.1E-01	1.6E-02	1.4E+01	4.1E-05	7.7E-05	3.2E-04	2.8E-03	3.9E-04	1.3E-01	9.0E-06
10-Jan-12	6																							
17-Jan-12	7	1.6E-01	1.2E-02	9.0E-04	1.5E-01	1.5E-02	4.5E-06	2.8E-04	3.8E-03	5.2E-02	1.1E+00	7.5E-04	3.2E-01	9.0E-06	1.3E-01	9.5E-03	9.5E+00	3.2E-05	4.1E-05	2.3E-04	2.1E-03	2.9E-04	2.6E-01	4.5E-06
24-Jan-12	8																							
31-Jan-12	9	1.3E-01	9.8E-05	8.9E-04	5.2E-02	5.6E-03	4.5E-06	2.2E-04	2.3E-03	4.0E-03	5.9E-01	7.0E-04	2.5E-01	4.5E-06	5.8E-02	5.7E-03	6.0E+00	1.8E-05	4.5E-06	1.8E-04	1.5E-03	2.9E-04	3.4E-02	4.5E-06
7-Feb-12	10																							
14-Feb-12	11	1.2E-01	4.5E-05	4.5E-04	3.1E-02	3.6E-03	4.5E-06	5.6E-04	1.8E-03	5.0E-02	4.7E-01	5.3E-04	2.4E-01	4.5E-06	3.6E-02	5.1E-03	5.7E+00	1.3E-05	8.9E-06	1.3E-04	1.8E-03	1.2E-04	3.2E-02	4.5E-06
21-Feb-12	12																							
28-Feb-12	13	1.7E-01	3.4E-04	1.4E-03	3.1E-02	4.0E-03	4.6E-06	2.7E-04	4.9E-03	4.8E-02	5.8E-01	5.2E-04	3.6E-01	1.8E-05	3.2E-02	6.5E-03	8.7E+00	2.2E-04	4.1E-05	9.2E-05	2.6E-03	2.0E-04	4.9E-02	4.6E-06
6-Mar-12	14																							
13-Mar-12	15	2.1E-01	7.0E-05	4.7E-04	2.3E-02	2.9E-03	4.7E-06	2.3E-04	2.8E-03	5.0E-02	5.3E-01	6.0E-04	4.7E-01	9.3E-06	2.8E-02	5.5E-03	9.8E+00	1.9E-05	7.9E-05	9.3E-05	3.2E-03	1.3E-04	4.9E-02	9.3E-06
20-Mar-12	16																							
27-Mar-12	17	1.9E-01	2.0E-03	4.4E-04	1.6E-02	2.0E-03	4.4E-06	1.6E-04	2.2E-03	7.7E-02	6.2E-01	6.6E-04	2.4E-01	3.9E-04	5.2E-02	4.4E-03	9.0E+00	1.7E-05	4.4E-06	8.7E-05	3.0E-03	1.4E-04	2.8E-02	4.4E-06
3-Apr-12	18																							
10-Apr-12	19	3.2E-01	1.3E-04	4.5E-04	2.2E-02	2.7E-03	9.0E-06	3.0E-03	3.6E-03	4.3E-02	5.4E-01	7.2E-04	4.1E-01	9.0E-06	2.7E-02	6.1E-03	1.4E+01	1.8E-05	2.3E-05	9.0E-05	4.9E-03	2.1E-04	6.5E-02	4.5E-06
17-Apr-12	20																							
24-Apr-12	21	3.3E-01	7.3E-04	4.5E-04	1.5E-02	2.5E-03	1.4E-05	2.5E-04	2.6E-03	4.2E-02	4.7E-01	5.4E-04	4.1E-01	4.5E-06	2.7E-02	5.8E-03	1.0E+01	1.4E-05	1.4E-05	4.5E-05	4.5E-03	2.1E-04	4.5E-02	4.5E-06
1-May-12	22																							
8-May-12	23	4.1E-01	8.6E-05	4.6E-04	1.5E-02	2.0E-03	4.6E-06	4.8E-04	3.0E-03	1.1E-02	4.3E-01	5.3E-04	4.8E-01	1.4E-05	2.7E-02	5.3E-03	1.2E+01	1.4E-05	1.1E-04	4.6E-05	4.4E-03	2.2E-04	4.8E-02	4.6E-06
15-May-12	24																							
22-May-12	25	5.9E-01	1.3E-04	4.1E-04	2.0E-02	2.6E-03	8.1E-06	7.5E-04	3.6E-03	3.6E-03	5.3E-01	6.9E-04	2.6E-01	4.1E-06	2.8E-02	9.0E-03	1.5E+01	1.6E-05	4.9E-05	8.1E-05	6.6E-03	2.6E-04	5.7E-02	8.1E-06
29-May-12	26																							
5-Jun-12	27	3.5E-01	1.6E-04	4.3E-04	1.3E-02	1.8E-03	8.6E-06	1.7E-04	3.8E-03	7.7E-03	3.4E-01	4.7E-04	3.1E-01	4.3E-06	2.2E-02	5.5E-03	9.4E+00	8.6E-06	1.7E-05	3.0E-04	3.7E-03	3.6E-04	3.5E-02	4.3E-06
12-Jun-12	28																							
19-Jun-12	29	3.4E-01	2.2E-05	4.4E-04	9.2E-03	1.5E-03	4.4E-06	2.5E-02	2.3E-03	7.9E-03	2.6E-01	4.8E-04	3.3E-01	4.4E-06	2.6E-02	3.8E-03	7.7E+00	8.8E-06	8.8E-05	8.8E-05	4.2E-03	2.6E-04	3.8E-02	4.4E-06
26-Jun-12	30																							
3-Jul-12	31	5.4E-01	1.1E-04	4.4E-04	1.5E-02	2.0E-03	4.4E-06	1.8E-04	3.0E-03	4.0E-03	3.2E-01	7.8E-04	4.1E-01	1.3E-05	2.2E-02	4.9E-03	1.1E+01	1.3E-05	6.6E-05	8.8E-05	5.3E-03	2.4E-04	4.3E-02	4.4E-06
10-Jul-12	32																							
17-Jul-12	33	8.5E-01	4.0E-05	4.5E-04	1.6E-02	2.5E-03	4.5E-06	2.5E-04	3.1E-03	4.0E-03	3.3E-01	6.1E-04	6.2E-01	7.1E-05	2.7E-02	5.3E-03	1.3E+01	1.3E-05	6.7E-05	8.9E-05	6.4E-03	2.8E-04	5.7E-02	4.5E-06
24-Jul-12	34																							
31-Jul-12	35	1.0E+00	2.0E-04	4.5E-04	1.6E-02	3.0E-03	4.5E-06	2.0E-04	3.4E-03	1.1E-02	3.0E-01	4.9E-04	6.1E-01	1.8E-05	1.8E-02	5.2E-03	1.3E+01	8.9E-06	4.0E-05	8.9E-05	7.7E-03	4.2E-04	6.2E-02	4.5E-06
7-Aug-12	36																							
14-Aug-12	37	1.3E+00	1.2E-04	4.4E-04	2.1E-02	3.8E-03	4.4E-06	2.0E-04	4.1E-03	4.0E-03	3.5E-01	5.7E-04	8.0E-01	2.2E-05	3.1E-02	5.5E-03	1.6E+01	1.3E-05	1.2E-04	2.6E-04	1.0E-02	6.3E-04	6.9E-02	4.4E-06
21-Aug-12	38																							
28-Aug-12	39	2.1E+00	7.4E-05	4.9E-04	2.5E-02	5.1E-03	9.8E-06	2.3E-04	4.9E-03	3.6E-02	4.2E-01	5.9E-04	1.6E+00	2.5E-05	2.5E-02	7.3E-03	2.0E+01	2.0E-05	1.2E-04	1.5E-04	1.5E-02	6.7E-04	6.8E-02	4.9E-06
4-Sep-12	40																							
11-Sep-12	41	1.5E+00	1.9E-04	4.5E-04	1.8E-02	3.6E-03	4.5E-06	2.3E-04	4.2E-03	1.5E-02	2.7E-01	4.5E-04	8.6E-01	1.8E-05	2.3E-02	5.2E-03	1.4E+01	1.4E-05	6.3E-05	9.0E-05	1.2E-02	3.9E-04	4.7E-02	4.5E-06
18-Sep-12	42																							
25-Sep-12	43	1.4E+00	1.5E-04	4.5E-04	1.6E-02	3.2E-03	4.5E-06	1.1E-02	3.6E-03	1.2E-02	2.3E-01	3.5E-04	7.2E-01	1.4E-05	5.9E-02	4.8E-03	1.4E+01	9.0E-06	1.5E-04	4.5E-05	1.2E-02	4.5E-04	4.5E-02	9.0E-06
2-Oct-12	44																							
9-Oct-12	45	1.4E+00	4.6E-04	4.6E-04	1.5E-02	3.4E-03	4.6E-06	1.8E-04	3.6E-03	1.6E-02	2.0E-01	3.6E-04	6.8E-01	1.4E-05	2.3E-02	4.3E-03	1.3E+01	9.2E-06	7.4E-05	9.2E-05	1.2E-02	4.1E-04	4.1E-02	4.6E-06
16-Oct-12	46																							
23-Oct-12	47																							
30-Oct-12	48																							

HC8

Sample = 08-143

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
	No.																							
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
6-Nov-12	49	1.8E+00	4.7E-05	4.3E-04	1.6E-02	4.0E-03	4.3E-06	1.8E-04	3.3E-03	5.6E-03	1.7E-01	2.5E-04	5.6E-01	4.3E-06	2.6E-02	4.2E-03	1.2E+01	8.6E-06	8.2E-05	4.3E-05	1.4E-02	3.1E-04	3.3E-02	4.3E-06
13-Nov-12	50																							
20-Nov-12	51																							
27-Nov-12	52																							
4-Dec-12	53	3.7E+00	1.2E-04	4.9E-04	1.6E-02	6.8E-03	4.9E-06	1.8E-04	3.8E-03	1.3E-02	2.5E-01	1.6E-04	1.1E+00	2.5E-05	2.5E-02	5.5E-03	1.5E+01	1.5E-05	6.9E-05	9.8E-05	1.6E-02	5.8E-04	4.2E-02	4.9E-06
11-Dec-12	54																							
18-Dec-12	55																							
25-Dec-12	56																							
1-Jan-13	57	4.0E+00	6.9E-04	4.6E-04	1.7E-02	7.2E-03	4.6E-06	2.2E-04	3.9E-03	8.3E-03	1.7E-01	2.1E-04	7.7E-01	1.8E-05	2.3E-02	4.7E-03	1.5E+01	1.4E-05	6.0E-05	4.6E-05	1.9E-02	5.7E-04	3.3E-02	4.6E-06
8-Jan-13	58																							
15-Jan-13	59																							
22-Jan-13	60																							
29-Jan-13	61	5.4E+00	1.3E-04	4.6E-04	2.1E-02	8.3E-03	4.6E-06	2.0E-04	4.0E-03	2.9E-02	1.6E-01	2.2E-04	7.0E-01	6.0E-05	4.6E-02	4.8E-03	1.8E+01	9.2E-06	1.2E-04	9.2E-05	2.0E-02	6.4E-04	3.4E-02	4.6E-06
5-Feb-13	62																							
12-Feb-13	63																							
19-Feb-13	64																							
26-Feb-13	65	5.3E+00	7.2E-05	4.5E-04	1.8E-02	8.0E-03	4.5E-06	2.2E-04	3.9E-03	2.5E-02	1.4E-01	1.9E-04	6.8E-01	4.1E-05	2.7E-02	3.4E-03	1.5E+01	9.0E-06	1.4E-05	4.5E-05	1.8E-02	5.1E-04	2.9E-02	4.5E-06
5-Mar-13	66																							
12-Mar-13	67																							
19-Mar-13	68																							
26-Mar-13	69	7.1E+00	2.1E-04	4.6E-04	1.9E-02	1.1E-02	4.6E-06	1.9E-04	4.1E-03	2.7E-02	1.3E-01	1.5E-04	7.1E-01	7.3E-05	2.7E-02	3.6E-03	1.7E+01	1.4E-05	1.4E-05	9.1E-05	1.8E-02	4.2E-04	2.8E-02	9.1E-06
2-Apr-13	70																							
9-Apr-13	71																							
16-Apr-13	72																							
23-Apr-13	73	7.3E+00	3.6E-04	4.5E-04	2.0E-02	1.1E-02	4.5E-06	2.2E-04	4.3E-03	3.4E-02	1.2E-01	1.5E-04	6.5E-01	5.3E-05	1.8E-02	3.1E-03	1.7E+01	8.9E-06	1.3E-05	4.5E-05	1.8E-02	3.7E-04	2.8E-02	1.3E-05
30-Apr-13	74																							
7-May-13	75																							
14-May-13	76																							
21-May-13	77	6.5E+00	8.8E-05	4.4E-04	2.3E-02	1.0E-02	8.8E-06	1.5E-04	3.9E-03	2.6E-02	9.7E-02	1.5E-04	5.3E-01	2.2E-05	1.8E-02	2.7E-03	1.6E+01	8.8E-06	3.1E-05	4.4E-05	1.6E-02	2.4E-04	2.2E-02	8.8E-06
28-May-13	78																							
4-Jun-13	79																							
11-Jun-13	80																							
18-Jun-13	81	8.7E+00	3.7E-05	4.6E-04	2.4E-02	1.3E-02	4.6E-06	1.4E-04	4.3E-03	4.1E-03	1.1E-01	1.7E-04	6.7E-01	3.7E-05	5.1E-02	3.2E-03	1.8E+01	9.2E-06	1.4E-05	4.6E-05	1.7E-02	3.7E-04	2.2E-02	4.6E-06
25-Jun-13	82																							
2-Jul-13	83																							
9-Jul-13	84																							
16-Jul-13	85	1.0E+01	1.2E-04	4.6E-04	2.6E-02	1.4E-02	4.6E-06	1.4E-04	4.5E-03	3.7E-02	9.8E-02	1.8E-04	7.1E-01	6.0E-05	2.3E-02	3.0E-03	1.9E+01	9.2E-06	4.6E-06	4.6E-05	1.5E-02	3.5E-04	1.8E-02	4.6E-06
23-Jul-13	86																							
30-Jul-13	87																							
6-Aug-13	88																							
13-Aug-13	89	1.9E+01	1.7E-04	4.8E-04	4.2E-02	2.8E-02	4.8E-06	3.2E-04	6.9E-03	1.1E-01	1.4E-01	2.4E-04	1.3E+00	9.5E-05	2.9E-02	4.4E-03	3.0E+01	9.5E-06	4.8E-05	1.9E-04	2.3E-02	7.9E-04	2.6E-02	1.9E-05
20-Aug-13	90																							
27-Aug-13	91																							
3-Sep-13	92																							
10-Sep-13	93	2.1E+01	5.1E-05	4.6E-04	4.1E-02	3.1E-02	4.6E-06	4.0E-04	6.8E-03	2.1E-01	1.3E-01	2.7E-04	1.3E+00	8.7E-05	2.8E-02	3.8E-03	3.4E+01	9.2E-06	6.9E-05	1.8E-04	1.9E-02	8.6E-04	2.0E-02	1.8E-05
17-Sep-13	94																							
24-Sep-13	95																							
1-Oct-13	96																							
8-Oct-13	97	2.0E+01	3.0E-05	4.4E-04	4.0E-02	2.9E-02	3.0E-05	3.3E-04	6.9E-03	2.0E-01	1.0E-01	2.6E-04	1.1E+00	8.3E-05	2.2E-02	3.1E-03	3.1E+01	8.7E-06	8.7E-06	1.7E-04	1.6E-02	6.9E-04	2.1E-02	2.6E-05
15-Oct-13	98																							

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Sample = 08-143

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
	No.																							
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
22-Oct-13	99																							
29-Oct-13	100																							
5-Nov-13	101	2.0E+01	2.4E-05	4.8E-04	3.1E-02	2.9E-02	4.8E-06	4.0E-04	6.1E-03	1.8E-01	9.3E-02	2.5E-04	1.1E+00	1.1E-04	1.9E-02	3.2E-03	2.8E+01	9.5E-06	1.4E-05	1.9E-04	1.4E-02	8.0E-04	1.8E-02	1.4E-05
12-Nov-13	102																							
19-Nov-13	103																							
26-Nov-13	104																							
3-Dec-13	105	1.9E+01	1.4E-05	4.8E-04	3.2E-02	2.6E-02	4.8E-06	4.4E-04	6.4E-03	2.3E-01	9.3E-02	2.5E-04	4.5E-01	1.0E-04	1.9E-02	3.1E-03	2.8E+01	9.5E-06	2.9E-05	2.4E-04	1.3E-02	7.7E-04	1.5E-02	1.9E-05
10-Dec-13	106																							
17-Dec-13	107																							
24-Dec-13	108																							
31-Dec-13	109	2.0E+01	5.2E-05	4.4E-04	3.7E-02	2.7E-02	4.4E-06	4.0E-04	5.9E-03	1.8E-01	8.8E-02	2.6E-04	8.4E-01	8.7E-05	2.2E-02	2.7E-03	2.8E+01	8.7E-06	3.0E-05	2.6E-04	1.0E-02	8.0E-04	1.5E-02	1.7E-05
7-Jan-14	110																							
14-Jan-14	111																							
21-Jan-14	112																							
28-Jan-14	113	2.0E+01	8.6E-06	4.3E-04	3.7E-02	2.6E-02	4.3E-06	4.2E-04	6.4E-03	2.0E-01	8.0E-02	2.4E-04	3.4E-01	8.2E-05	2.2E-02	2.6E-03	2.8E+01	8.6E-06	7.7E-05	2.6E-04	1.0E-02	5.6E-04	1.5E-02	8.6E-06
4-Feb-14	114																							
11-Feb-14	115																							
18-Feb-14	116																							
25-Feb-14	117	2.7E+01	1.5E-05	4.9E-04	3.8E-02	3.5E-02	4.9E-06	5.1E-04	8.4E-03	1.6E-01	1.1E-01	2.8E-04	8.0E-01	1.2E-04	2.4E-02	3.6E-03	3.7E+01	9.7E-06	1.9E-05	1.5E-04	1.3E-02	1.2E-03	2.3E-02	4.9E-06
4-Mar-14	118	9.6E+00	1.4E-05	4.7E-04	4.7E-02	1.4E-02	4.7E-06	2.1E-04	3.4E-03	1.2E-01	5.0E-02	1.3E-04	1.7E-01	2.3E-05	1.4E-02	2.9E-03	1.6E+01	9.3E-06	6.0E-05	9.3E-05	4.8E-03	2.7E-04	8.8E-03	4.7E-06
11-Mar-14	119	1.0E+01	7.0E-05	5.0E-04	1.2E-02	1.3E-02	5.0E-06	1.9E-04	3.9E-03	8.1E-02	4.4E-02	1.2E-04	3.6E-01	2.0E-05	4.0E-02	1.6E-03	1.7E+01	1.0E-05	2.4E-04	5.0E-05	4.8E-03	1.7E-04	9.5E-03	5.0E-06
18-Mar-14	120	6.1E+00	9.0E-05	4.8E-04	6.7E-03	7.7E-03	4.8E-06	1.1E-04	2.4E-03	3.3E-02	3.2E-02	8.1E-05	1.0E-01	9.5E-06	1.4E-02	1.1E-03	1.1E+01	9.5E-06	2.9E-05	4.8E-05	2.8E-03	8.6E-05	8.6E-03	4.8E-06
25-Mar-14	121	5.8E+00	2.0E-05	5.0E-04	4.0E-03	7.6E-03	5.0E-06	1.1E-04	2.0E-03	2.7E-02	3.4E-02	7.9E-05	9.9E-02	9.9E-06	9.9E-03	9.9E-04	1.0E+01	9.9E-06	1.7E-04	5.0E-05	2.4E-03	5.9E-05	5.4E-03	5.0E-06
1-Apr-14	122																							
8-Apr-14	123																							
15-Apr-14	124																							
22-Apr-14	125	4.7E+00	5.3E-05	1.4E-05	2.7E-03	6.3E-03	4.5E-06	8.9E-05	1.7E-03	1.4E-02	2.8E-02	5.3E-05	7.6E-02	7.1E-06	3.1E-02	9.3E-04	7.6E+00	2.2E-06	6.2E-05	2.2E-05	1.2E-03	3.6E-05	5.3E-03	8.9E-04
29-Apr-14	126																							
6-May-14	127																							
13-May-14	128																							
20-May-14	129	4.1E+00	1.9E-05	5.1E-05	3.8E-03	5.2E-03	4.8E-06	2.6E-04	1.5E-03	9.6E-03	2.4E-02	6.2E-05	8.6E-02	8.2E-06	4.8E-03	7.2E-04	6.6E+00	2.4E-06	1.2E-04	2.9E-05	1.1E-03	1.9E-05	2.9E-03	9.6E-04
27-May-14	130																							
3-Jun-14	131																							
10-Jun-14	132																							
17-Jun-14	133	3.7E+00	9.1E-05	1.8E-05	2.0E-03	4.9E-03	5.1E-06	4.5E-05	1.4E-03	9.6E-03	2.8E-02	4.0E-05	7.1E-02	2.5E-06	1.0E-02	6.6E-04	6.7E+00	3.0E-06	1.8E-04	2.5E-05	9.4E-04	1.5E-05	3.5E-03	1.0E-03
24-Jun-14	134																							
1-Jul-14	135																							
8-Jul-14	136																							
15-Jul-14	137	4.2E+00	3.8E-05	2.4E-05	1.9E-03	5.2E-03	4.8E-06	8.6E-05	1.5E-03	5.7E-03	2.6E-02	4.3E-05	8.6E-02	4.8E-06	9.5E-03	6.7E-04	7.0E+00	2.4E-06	7.6E-05	2.4E-05	9.6E-04	1.9E-05	4.3E-03	9.5E-04
22-Jul-14	138																							
29-Jul-14	139																							
5-Aug-14	140																							
12-Aug-14	141	3.9E+00	6.8E-05	6.8E-06	2.4E-03	5.1E-03	4.9E-06	1.1E-04	1.5E-03	4.4E-03	2.9E-02	5.3E-05	7.3E-02	3.9E-06	9.7E-03	6.8E-04	6.9E+00	2.9E-06	6.3E-05	2.4E-05	9.9E-04	4.9E-06	2.9E-03	9.7E-04
19-Aug-14	142																							
26-Aug-14	143																							
2-Sep-14	144																							

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Sample = 08-260

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/L	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
29-Nov-11	0	500	385	6.72	2.7E+02	#N/A	6.4E+00	8.2E+00	9.3E+01	3.0E+00	9.0E-02	3.0E-01	5.9E+01	4.2E-02	3.0E-04	9.0E-04	2.8E-02	2.0E-05	1.0E-05	8.4E-03	2.1E-04	1.9E+01	5.0E-04	6.7E-03	7.1E-01
6-Dec-11	1	500	455	6.71	2.1E+02	#N/A	4.7E+00	4.5E+00	7.5E+01	2.6E+00	6.0E-02	3.0E-01	5.3E+01	1.4E-02	2.0E-04	6.0E-04	1.0E-02	2.0E-05	1.0E-05	7.3E-03	1.1E-04	1.7E+01	7.0E-04	4.3E-03	6.1E-02
13-Dec-11	2	500	470	6.21	1.5E+02	#N/A	4.6E+00	3.1E+00	5.8E+01	1.4E+00	6.0E-02	3.0E-01	3.9E+01	4.4E-03	2.0E-04	5.0E-04	7.3E-03	2.0E-05	1.0E-05	5.2E-03	5.9E-05	1.3E+01	8.0E-04	2.7E-03	4.4E-02
20-Dec-11	3	500	480	6.69	9.8E+01	#N/A	5.0E+00	4.0E+00	4.0E+01	6.0E-01	6.0E-02	3.0E-01	2.5E+01	1.7E-02	2.0E-04	5.0E-04	4.5E-03	2.0E-05	1.0E-05	5.1E-03	5.6E-05	8.4E+00	5.0E-04	2.3E-03	3.8E-02
27-Dec-11	4	500	455	6.73	8.0E+01																				
3-Jan-12	5	500	455	6.27	6.3E+01	#N/A	4.8E+00	2.5E+00	2.5E+01	3.0E-01	6.0E-02	3.0E-01	1.5E+01	4.7E-02	2.0E-04	3.0E-04	3.4E-03	2.0E-05	1.0E-05	3.8E-03	3.2E-05	5.1E+00	5.0E-04	1.3E-03	3.0E-02
10-Jan-12	6	500	435	6.17	5.5E+01																				
17-Jan-12	7	500	450	6.37	4.0E+01	#N/A	3.1E+00	2.3E+00	1.5E+01	2.0E-01	6.0E-02	3.0E-01	1.2E+01	1.9E-02	2.0E-04	2.0E-04	3.5E-03	2.0E-05	1.0E-05	4.5E-03	2.9E-05	4.0E+00	5.0E-04	1.2E-03	3.4E-02
24-Jan-12	8	500	450	6.11	3.5E+01																				
31-Jan-12	9	500	460	6.18	3.1E+01	#N/A	4.0E+00	1.8E+00	1.1E+01	2.0E-01	6.0E-02	3.0E-01	8.1E+00	2.4E-02	2.0E-04	2.0E-04	3.4E-03	2.0E-05	1.0E-05	2.8E-03	2.5E-05	2.7E+00	5.0E-04	1.2E-03	3.7E-02
7-Feb-12	10	500	450	6.50	2.9E+01																				
14-Feb-12	11	500	490	6.18	2.8E+01	#N/A	4.8E+00	2.2E+00	1.3E+01	2.0E-01	6.0E-02	3.0E-01	8.9E+00	2.9E-03	2.0E-04	3.0E-04	4.3E-03	2.0E-05	1.0E-05	2.8E-03	2.8E-05	3.0E+00	5.0E-04	1.4E-03	4.3E-02
21-Feb-12	12	500	455	6.24	2.6E+01																				
28-Feb-12	13	500	505	5.93	2.6E+01	#N/A	4.2E+00	1.7E+00	9.0E+00	2.0E-01	6.0E-02	3.0E-01	7.8E+00	1.4E-02	2.0E-04	3.0E-04	3.8E-03	2.0E-05	1.0E-05	2.6E-03	2.8E-05	2.6E+00	5.0E-04	1.3E-03	4.9E-02
6-Mar-12	14	500	450	6.24	2.9E+01																				
13-Mar-12	15	500	440	5.83	2.5E+01	#N/A	3.8E+00	1.8E+00	8.0E+00	2.0E-01	6.0E-02	3.0E-01	7.6E+00	4.9E-03	2.0E-04	2.0E-04	3.9E-03	2.0E-05	1.0E-05	2.1E-03	2.8E-05	2.5E+00	5.0E-04	1.3E-03	5.1E-02
20-Mar-12	16	500	470	5.95	2.6E+01																				
27-Mar-12	17	500	455	5.80	2.6E+01	#N/A	3.5E+00	9.5E-01	9.0E+00	2.0E-01	6.0E-02	3.0E-01	8.0E+00	1.8E-02	2.0E-04	3.0E-04	4.1E-03	2.0E-05	1.0E-05	2.1E-03	4.5E-05	2.7E+00	5.0E-04	1.5E-03	6.5E-02
3-Apr-12	18	500	455	5.88	2.8E+01																				
10-Apr-12	19	500	450	5.78	3.0E+01	#N/A	3.4E+00	1.4E+00	1.1E+01	2.0E-01	6.0E-02	3.0E-01	8.6E+00	1.6E-02	2.0E-04	2.0E-04	4.7E-03	2.0E-05	1.0E-05	2.5E-03	7.0E-06	2.9E+00	5.0E-04	1.9E-03	6.4E-02
17-Apr-12	20	500	425	5.87	3.6E+01																				
24-Apr-12	21	500	445	5.78	2.5E+01	#N/A	3.8E+00	1.4E+00	7.0E+00	2.0E-01	6.0E-02	3.0E-01	7.0E+00	2.6E-02	2.0E-04	2.0E-04	4.6E-03	2.0E-05	1.0E-05	2.0E-03	3.0E-06	2.4E+00	5.0E-04	1.7E-03	6.0E-02
1-May-12	22	500	435	6.15	2.5E+01																				
8-May-12	23	500	440	5.69	2.2E+01	#N/A	4.0E+00	9.6E-01	7.0E+00	2.0E-01	6.0E-02	3.0E-01	6.2E+00	1.1E-02	2.0E-04	2.0E-04	4.2E-03	2.0E-05	1.0E-05	2.2E-03	1.4E-05	2.1E+00	5.0E-04	1.6E-03	6.2E-02
15-May-12	24	500	450	5.79	2.3E+01																				
22-May-12	25	500	420	5.92	2.7E+01	#N/A	4.5E+00	1.8E+00	8.0E+00	2.0E-01	6.0E-02	3.0E-01	7.6E+00	4.0E-02	2.0E-04	2.0E-04	6.0E-03	2.0E-05	1.0E-05	1.9E-03	3.4E-05	2.6E+00	5.0E-04	2.0E-03	7.8E-02
29-May-12	26	500	420	5.95	1.9E+01																				
5-Jun-12	27	500	430	5.74	1.9E+01	#N/A	4.4E+00	1.6E+00	5.0E+00	2.0E-01	6.0E-02	3.0E-01	5.8E+00	4.3E-02	2.0E-04	6.0E-04	4.4E-03	2.0E-05	1.0E-05	2.6E-03	3.0E-06	2.0E+00	5.0E-04	1.8E-03	7.0E-02
12-Jun-12	28	500	445	5.87	1.9E+01																				
19-Jun-12	29	500	435	5.73	1.8E+01	#N/A	3.7E+00	7.0E-01	6.0E+00	2.0E-01	6.0E-02	3.0E-01	5.0E+00	3.8E-02	2.0E-04	2.0E-04	4.1E-03	2.0E-05	1.0E-05	1.4E-03	3.0E-06	1.7E+00	5.0E-04	1.9E-03	7.7E-02
26-Jun-12	30	500	435	5.97	1.9E+01																				
3-Jul-12	31	500	440	6.08	2.0E+01	#N/A	7.5E+00	2.5E+00	7.0E+00	2.0E-01	6.0E-02	3.0E-01	5.6E+00	2.2E-02	2.0E-04	2.0E-04	4.6E-03	2.0E-05	1.0E-05	1.0E-03	5.1E-05	1.9E+00	5.0E-04	2.3E-03	1.0E-01
10-Jul-12	32	500	445	5.75	2.1E+01																				
17-Jul-12	33	500	435	5.61	2.1E+01	#N/A	3.0E+00	1.2E+00	6.0E+00	2.0E-01	6.0E-02	3.0E-01	6.0E+00	2.6E-02	2.0E-04	4.0E-04	5.6E-03	2.0E-05	1.0E-05	1.7E-03	4.3E-05	2.0E+00	5.0E-04	2.7E-03	1.4E-01
24-Jul-12	34	500	430	5.67	2.3E+01																				
31-Jul-12	35	500	440	5.60	2.2E+01	#N/A	3.5E+00	7.9E-01	7.0E+00	2.0E-01	6.0E-02	3.0E-01	6.4E+00	3.3E-02	2.0E-04	2.0E-04	5.8E-03	2.0E-05	1.0E-05	1.9E-03	6.2E-05	2.1E+00	5.0E-04	3.3E-03	1.7E-01
7-Aug-12	36	500	440	5.77	2.3E+01																				
14-Aug-12	37	500	450	5.56	2.4E+01	#N/A	4.4E+00	1.1E+00	8.0E+00	2.0E-01	6.0E-02	3.0E-01	6.6E+00	3.6E-02	2.0E-04	7.0E-04	7.0E-03	2.0E-05	1.0E-05	3.2E-03	6.8E-05	2.2E+00	5.0E-04	4.0E-03	2.7E-01
21-Aug-12	38	500	435	5.47	2.5E+01																				
28-Aug-12	39	500	495	5.66	2.3E+01	#N/A	5.1E+00	1.4E+00	8.0E+00	2.0E-01	6.0E-02	3.0E-01	6.1E+00	4.4E-02	2.0E-04	2.0E-04	7.4E-03	2.0E-05	1.0E-05	2.4E-03	7.5E-05	2.1E+00	5.0E-04	3.3E-03	3.4E-01
4-Sep-12	40	500	475	5.62	2.2E+01																				
11-Sep-12	41	500	490	5.45	2.3E+01	#N/A	4.9E+00	9.6E-01	9.0E+00	2.0E-01	6.0E-02	3.0E-01	6.5E+00	1.3E-02	2.0E-04	2.0E-04	8.3E-03	2.0E-05	2.0E-05	2.0E-03	6.9E-05	2.2E+00	5.0E-04	4.0E-03	4.2E-01
18-Sep-12	42	500	495	5.54	2.5E+01																				
25-Sep-12	43	500	445	5.39	2.5E+01	#N/A	5.2E+00	8.7E-01	8.0E+00	2.0E-01	6.0E-02	3.0E-01	6.5E+00	2.0E-02	2.0E-04	3.0E-04	8.9E-03	2.0E-05	1.0E-05	2.0E-03	8.6E-05	2.2E+00	5.0E-04	4.7E-03	5.7E-01
2-Oct-12	44	500	455	5.61	3.9E+01																				
9-Oct-12	45	500	460	5.48	2.1E+01	#N/A	5.3E+00	7.2E-01	6.0E+00	2.0E-01	6.0E-02	3.0E-01	5.1E+00	2.4E-02	2.0E-04	2.0E-04	7.7E-03	2.0E-05	1.0E-05	1.2E-03	8.4E-05	1.7E+00	5.0E-04	4.1E-03	6.2E-01
30-Oct-12	48	500	465	5.53	3.7E+01																				
6-Nov-12	49	500	425	5.36	2.4E+01	#N/A	4.8E+00	4.2E-01	7.0E+00	2.0E-01	6.0E-02	3.0E-01	6.9E+00	2.0E-02	2.0E-04	2.0E-04	1.0E-02	2.0E-05	1.0E-05	1.8E-03	1.1E-04	2.4E+00	5.0E-04	4.7E-03	9.1E-01
13-Nov-12	50	500	435	5.68	2.8E+01																				
20-Nov-12	51	500	490	5.57	2.0E+01																				
27-Nov-12	52	500	495	5.61	3.0E+01																				

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Sample = 08-260

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/L	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
4-Dec-12	53	500	450	5.35	2.4E+01	#N/A	4.8E+00	3.5E-01	8.0E+00	2.0E-01	6.0E-02	3.0E-01	5.9E+00	2.0E-02	2.0E-04	2.0E-04	1.2E-02	2.0E-05	1.0E-05	8.0E-04	1.1E-04	2.0E+00	5.0E-04	5.4E-03	1.3E+00
11-Dec-12	54	500	450	5.71	3.5E+01																				
18-Dec-12	55	500	465	5.34	2.4E+01																				
25-Dec-12	56	500	485	5.61	3.0E+01																				
1-Jan-13	57	500	465	5.35	1.8E+01	#N/A	6.5E+00	8.6E-01	5.0E+00	2.0E-01	6.0E-02	3.0E-01	4.7E+00	2.0E-02	2.0E-04	2.0E-04	1.2E-02	2.0E-05	1.0E-05	7.0E-04	9.1E-05	1.7E+00	5.0E-04	3.6E-03	1.1E+00
8-Jan-13	58	500	480	5.51	2.5E+01																				
15-Jan-13	59	500	460	5.41	2.5E+01																				
22-Jan-13	60	500	460	5.62	2.7E+01																				
29-Jan-13	61	500	455	5.24	2.1E+01	#N/A	5.4E+00	3.8E-01	9.0E+00	2.0E-01	6.0E-02	3.0E-01	4.4E+00	3.8E-02	2.0E-04	2.0E-04	1.2E-02	2.0E-05	1.0E-05	8.0E-04	1.0E-04	1.5E+00	5.0E-04	4.1E-03	1.5E+00
5-Feb-13	62	500	475	5.34	2.4E+01																				
12-Feb-13	63	500	480	5.35	2.5E+01																				
19-Feb-13	64	500	460	5.23	2.6E+01																				
26-Feb-13	65	500	450	5.23	2.6E+01	#N/A	7.2E+00	3.9E-01	8.0E+00	2.0E-01	6.0E-02	3.0E-01	4.6E+00	3.4E-02	2.0E-04	4.0E-04	1.5E-02	4.0E-05	1.0E-05	7.0E-04	1.5E-04	1.6E+00	5.0E-04	5.4E-03	2.3E+00
5-Mar-13	66	500	450	5.29	2.5E+01																				
12-Mar-13	67	500	455	5.23	2.5E+01																				
19-Mar-13	68	500	425	5.45	2.9E+01																				
26-Mar-13	69	500	475	5.34	2.4E+01	#N/A	7.6E+00	1.3E+00	1.4E+01	2.0E-01	6.0E-02	3.0E-01	3.5E+00	3.8E-02	2.0E-04	4.0E-04	1.3E-02	4.0E-05	1.0E-05	8.0E-04	1.2E-04	1.2E+00	5.0E-04	4.2E-03	2.1E+00
2-Apr-13	70	500	445	5.35	2.4E+01																				
9-Apr-13	71	500	445	5.61	2.5E+01																				
16-Apr-13	72	500	440	5.73	2.5E+01																				
23-Apr-13	73	500	455	5.26	2.7E+01	#N/A	8.1E+00	2.0E+00	1.2E+01	2.0E-01	6.0E-02	3.0E-01	3.4E+00	5.7E-02	2.0E-04	2.0E-04	1.5E-02	5.0E-05	1.0E-05	1.1E-03	1.2E-04	1.2E+00	5.0E-04	4.2E-03	2.3E+00
30-Apr-13	74	500	460	5.35	2.3E+01																				
7-May-13	75	500	460	5.61	3.1E+01																				
14-May-13	76	500	445	5.27	2.9E+01																				
21-May-13	77	500	450	5.10	2.8E+01	#N/A	8.2E+00	3.7E-01	1.1E+01	2.0E-01	6.0E-02	3.0E-01	3.6E+00	7.9E-02	2.0E-04	2.0E-04	1.3E-02	6.0E-05	1.0E-05	1.2E-03	2.4E-04	1.2E+00	5.0E-04	4.5E-03	2.3E+00
28-May-13	78	500	455	5.12	2.7E+01																				
4-Jun-13	79	500	485	5.10	3.0E+01																				
11-Jun-13	80	500	480	5.07	2.8E+01																				
18-Jun-13	81	500	470	4.91	3.0E+01	#N/A	1.0E+01	5.1E-01	1.1E+01	< 1	6.0E-02	3.0E-01	3.6E+00	1.1E-01	2.0E-04	2.0E-04	1.6E-02	8.0E-05	1.0E-05	1.5E-03	1.2E-04	1.2E+00	5.0E-04	4.5E-03	2.4E+00
25-Jun-13	82	500	460	5.08	2.7E+01																				
2-Jul-13	83	500	465	5.05	2.4E+01																				
9-Jul-13	84	500	475	5.09	2.8E+01																				
16-Jul-13	85	500	460	4.91	2.8E+01	#N/A	8.1E+00	1.0E-01	8.0E+00	< 1	6.0E-02	3.0E-01	3.3E+00	1.4E-01	2.0E-04	3.0E-04	1.5E-02	8.0E-05	1.0E-05	1.1E-03	1.2E-04	1.1E+00	5.0E-04	4.3E-03	2.5E+00
23-Jul-13	86	500	460	4.77	2.9E+01																				
30-Jul-13	87	500	455	4.73	2.7E+01																				
6-Aug-13	88	500	475	4.77	3.0E+01																				
13-Aug-13	89	500	470	4.61	3.2E+01	#N/A	8.9E+00	1.0E-01	1.0E+01	< 1	6.0E-02	3.0E-01	3.4E+00	2.2E-01	2.0E-04	2.0E-04	1.7E-02	1.1E-04	1.0E-05	1.3E-03	1.4E-04	1.1E+00	5.0E-04	4.5E-03	2.7E+00
20-Aug-13	90	500	460	4.68	3.1E+01																				
27-Aug-13	91	500	435	4.54	3.7E+01																				
3-Sep-13	92	500	435	4.61	3.0E+01																				
10-Sep-13	93	500	455	4.66	3.6E+01	#N/A	1.1E+01	1.0E-01	9.0E+00	2.0E-01	8.0E-02	3.0E-01	3.0E+00	3.2E-01	2.0E-04	2.0E-04	1.8E-02	1.5E-04	1.0E-05	1.5E-03	1.4E-04	1.0E+00	5.0E-04	4.6E-03	2.8E+00
17-Sep-13	94	500	435	4.63	3.3E+01																				
24-Sep-13	95	500	435	4.60	3.1E+01																				
1-Oct-13	96	500	455	4.69	2.9E+01																				
8-Oct-13	97	500	465	4.58	3.2E+01	#N/A	9.1E+00	1.0E-01	8.0E+00	2.0E-01	7.0E-02	3.0E-01	2.8E+00	3.5E-01	2.0E-04	2.0E-04	1.9E-02	1.7E-04	1.0E-05	3.3E-03	1.2E-04	9.3E-01	5.0E-04	4.4E-03	2.4E+00
15-Oct-13	98	500	455	4.65	2.7E+01																				
22-Oct-13	99	500	450	4.66	3.1E+01																				

HC9

Sample = 08-260

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/L	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
29-Oct-13	100	500	455	4.69	3.3E+01																				
5-Nov-13	101	500	465	4.69	3.8E+01	#N/A	1.0E+01	1.0E-01	6.0E+00	2.0E-01	9.0E-02	3.0E-01	2.9E+00	3.8E-01	2.0E-04	2.0E-04	1.9E-02	1.9E-04	1.0E-05	1.3E-03	1.3E-04	9.4E-01	5.0E-04	4.8E-03	2.4E+00
12-Nov-13	102	500	460	4.66	3.1E+01																				
19-Nov-13	103	500	450	4.56	3.5E+01																				
26-Nov-13	104	500	455	4.85	4.0E+01																				
3-Dec-13	105	500	460	4.95	3.4E+01	#N/A	9.2E+00	1.0E-01	8.0E+00	2.0E-01	6.0E-02	3.0E-01	2.5E+00	4.7E-01	2.0E-04	2.0E-04	1.8E-02	1.9E-04	1.0E-05	8.0E-04	1.1E-04	8.1E-01	5.0E-04	4.2E-03	2.4E+00
10-Dec-13	106	500	430	4.58	4.3E+01																				
17-Dec-13	107	500	440	4.59	3.6E+01																				
24-Dec-13	108	500	430	4.54	4.2E+01																				
31-Dec-13	109	500	435	4.47	4.0E+01	2.8E-01	1.0E+01	#N/A	1.0E+01	2.0E-01	7.0E-02	3.0E-01	2.3E+00	4.9E-01	2.0E-04	2.0E-04	1.9E-02	2.5E-04	1.0E-05	1.4E-03	1.2E-04	7.5E-01	5.0E-04	4.3E-03	2.5E+00
7-Jan-14	110	500	435	4.48	3.9E+01																				
14-Jan-14	111	500	420	4.45	3.4E+01																				
21-Jan-14	112	500	445	4.49	3.9E+01																				
28-Jan-14	113	500	435	4.47	4.1E+01	3.1E-01	1.1E+01	#N/A	7.0E+00	2.0E-01	7.0E-02	3.0E-01	2.4E+00	6.1E-01	2.0E-04	2.0E-04	1.8E-02	2.3E-04	1.0E-05	1.4E-03	1.1E-04	7.7E-01	5.0E-04	4.5E-03	2.3E+00
4-Feb-14	114	500	435	4.53	4.1E+01																				
11-Feb-14	115	500	415	4.63	3.5E+01																				
18-Feb-14	116	500	445	4.61	4.0E+01																				
25-Feb-14	117	500	440	4.60	4.1E+01	#N/A	1.3E+01	1.0E-01	9.0E+00	2.0E-01	6.0E-02	3.0E-01	2.4E+00	7.5E-01	2.0E-04	2.0E-04	2.2E-02	2.4E-04	1.0E-05	1.5E-03	1.2E-04	7.7E-01	5.0E-04	4.7E-03	2.7E+00
4-Mar-14	118	500	440	4.61	3.6E+01																				
11-Mar-14	119	500	435	4.55	4.0E+01																				
18-Mar-14	120	500	430	4.74	3.6E+01																				
25-Mar-14	121	500	435	4.61	4.1E+01	#N/A	1.0E+01	1.0E-01	8.0E+00	2.0E-01	6.0E-02	3.0E-01	2.2E+00	7.7E-01	2.0E-04	2.0E-04	2.1E-02	2.3E-04	1.0E-05	1.4E-03	1.1E-04	7.2E-01	5.0E-04	4.5E-03	2.5E+00
1-Apr-14	122	500	430	4.54	4.1E+01																				
8-Apr-14	123	500	430	4.40	4.3E+01																				
15-Apr-14	124	500	435	4.46	4.2E+01																				
22-Apr-14	125	500	435	4.41	4.1E+01	8.5E-01	1.3E+01	#N/A	9.0E+00	2.0E-01	6.0E-02	3.0E-01	2.2E+00	7.7E-01	2.0E-04	2.0E-04	2.0E-02	2.2E-04	7.0E-06	1.6E-03	1.1E-04	7.0E-01	3.0E-05	4.2E-03	2.5E+00
29-Apr-14	126	500	430	4.52	3.9E+01																				
6-May-14	127	500	440	4.34	4.1E+01																				
13-May-14	128	500	450	4.49	4.2E+01																				
20-May-14	129	500	445	4.55	3.8E+01	#N/A	1.4E+01	1.0E-01	8.0E+00	2.0E-01	6.0E-02	3.0E-01	2.4E+00	7.0E-01	2.0E-04	2.0E-04	1.8E-02	2.1E-04	7.0E-06	6.0E-04	9.0E-05	7.9E-01	3.0E-05	4.2E-03	2.2E+00
27-May-14	130	500	435	4.53	3.9E+01																				
3-Jun-14	131	500	495	4.32	4.2E+01																				
10-Jun-14	132	500	490	4.28	4.8E+01																				
17-Jun-14	133	500	445	4.39	4.0E+01	1.1E+00	1.5E+01	#N/A	9.0E+00	2.0E-01	6.0E-02	3.0E-01	2.3E+00	7.7E-01	2.0E-04	2.0E-04	1.9E-02	2.0E-04	7.0E-06	2.0E-03	1.0E-04	7.5E-01	3.0E-05	4.5E-03	2.5E+00
24-Jun-14	134	500	440	4.30	4.8E+01																				
1-Jul-14	135	500	430	4.35	4.8E+01																				
8-Jul-14	136	500	425	4.39	4.7E+01																				
15-Jul-14	137	500	435	4.34	4.0E+01	1.1E+00	1.2E+01	#N/A	1.0E+01	2.0E-01	6.0E-02	3.0E-01	1.9E+00	7.4E-01	2.0E-04	2.0E-04	1.7E-02	2.0E-04	7.0E-06	2.3E-03	1.1E-04	6.1E-01	3.0E-05	3.7E-03	1.9E+00
22-Jul-14	138	500	430	4.35	4.6E+01																				
29-Jul-14	139	500	425	4.30	4.6E+01																				
5-Aug-14	140	500	430	4.68	4.5E+01																				
12-Aug-14	141	500	435	4.39	4.5E+01	1.2E+00	1.4E+01	#N/A	8.0E+00	2.0E-01	6.0E-02	3.0E-01	2.2E+00	8.9E-01	2.0E-04	2.0E-04	1.7E-02	2.1E-04	7.0E-06	2.1E-03	9.5E-05	7.0E-01	3.0E-05	4.4E-03	2.0E+00
19-Aug-14	142	500	435	4.33	5.0E+01																				
26-Aug-14	143	500	410	4.35	5.1E+01																				
2-Sep-14	144	500	460	4.32	5.3E+01																				
9-Sep-14	145	500	435	4.37	4.7E+01	1.3E+00	1.5E+01	#N/A	1.3E+01	< 0.2	< 0.06	< 0.3	2.5E+00	1.1E+00	< 0.0002	1.2E-03	1.8E-02	2.1E-04	< 0.000007	3.5E-03	9.9E-05	8.2E-01	< 0.00003	4.9E-03	2.3E+00
16-Sep-14	146	500	425	4.26	5.0E+01																				
23-Sep-14	147	500	430	4.37	5.1E+01																				
30-Sep-14	148	500	430																						

HC9

Sample = 08-260

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Major	Major	Diff	Diff
	No.																								Anions	Cations		(%)
		mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L				
29-Nov-11	0	4.0E-03	1.3E-03	2.0E-03	2.9E+00	8.0E-02	2.0E-02	1.4E-02	2.9E-03	9.0E-03	9.3E+00	1.7E-03	1.1E+00	1.0E-05	1.9E+01	1.2E-01	3.3E+01	4.0E-05	6.0E-05	8.0E-04	3.2E-04	7.8E-04	1.7E-02	2.0E-05	2.2E+00	2.3E+00	7.6E-02	1.7%
6-Dec-11	1	3.0E-03	2.0E-05	1.0E-03	2.3E+00	6.8E-02	2.0E-02	1.3E-02	6.0E-04	9.0E-03	5.8E+00	1.4E-03	1.3E+00	2.0E-05	1.6E+01	6.9E-02	2.9E+01	2.0E-05	3.0E-05	2.0E-04	5.0E-04	4.9E-04	7.0E-03	1.0E-05	1.7E+00	1.9E+00	1.7E-01	4.7%
13-Dec-11	2	3.0E-03	1.1E-04	1.0E-03	1.7E+00	4.9E-02	2.0E-02	9.9E-03	7.0E-04	1.4E-02	4.3E+00	1.1E-03	1.2E+00	1.0E-05	9.9E+00	5.0E-02	2.0E+01	2.0E-05	7.0E-05	2.0E-04	9.2E-05	2.9E-04	1.6E-02	1.0E-05	1.3E+00	1.3E+00	2.2E-02	0.8%
20-Dec-11	3	3.0E-03	2.0E-05	1.0E-03	1.0E+00	3.7E-02	1.0E-02	8.3E-03	4.0E-04	9.0E-03	2.9E+00	7.5E-04	1.6E+00	1.0E-05	5.1E+00	3.1E-02	1.3E+01	2.0E-05	1.0E-05	2.0E-04	3.2E-05	3.9E-04	3.0E-03	1.0E-05	9.3E-01	8.1E-01	-1.3E-01	-7.3%
27-Dec-11	4																											
3-Jan-12	5	3.0E-03	2.0E-05	1.0E-03	6.4E-01	2.0E-02	1.0E-02	5.5E-03	5.0E-04	9.0E-03	2.0E+00	2.9E-04	1.0E+00	1.0E-05	3.1E+00	1.9E-02	7.9E+00	2.0E-05	4.0E-05	3.0E-04	5.3E-05	5.8E-04	3.0E-03	1.0E-05	5.8E-01	5.0E-01	-8.0E-02	-7.4%
10-Jan-12	6																											
17-Jan-12	7	3.0E-03	2.0E-05	1.0E-03	4.3E-01	1.6E-02	1.0E-02	4.3E-03	3.0E-04	9.0E-03	1.6E+00	1.9E-04	1.1E+00	1.0E-05	1.7E+00	1.4E-02	5.0E+00	2.0E-05	2.0E-05	2.0E-04	5.6E-05	4.3E-04	3.0E-03	1.0E-05	3.6E-01	3.5E-01	-4.7E-03	-0.7%
24-Jan-12	8																											
31-Jan-12	9	3.0E-03	2.0E-05	1.0E-03	3.4E-01	1.4E-02	1.0E-02	3.6E-03	1.0E-04	9.0E-03	1.3E+00	2.9E-04	1.2E+00	1.0E-05	1.2E+00	1.1E-02	3.7E+00	2.0E-05	3.0E-05	2.0E-04	5.6E-05	5.1E-04	3.0E-03	1.0E-05	2.6E-01	2.5E-01	-1.4E-02	-2.8%
7-Feb-12	10																											
14-Feb-12	11	3.0E-03	2.0E-05	1.0E-03	3.7E-01	1.7E-02	1.0E-02	3.1E-03	3.0E-04	9.0E-03	1.2E+00	2.2E-04	1.4E+00	1.0E-05	1.1E+00	1.3E-02	3.6E+00	2.0E-05	1.0E-05	1.0E-04	1.9E-05	2.5E-04	2.0E-03	1.0E-05	3.1E-01	2.6E-01	-5.7E-02	-9.9%
21-Feb-12	12																											
28-Feb-12	13	3.0E-03	2.0E-05	1.0E-03	3.1E-01	1.6E-02	1.0E-02	2.4E-03	2.0E-04	9.0E-03	1.0E+00	2.5E-04	1.3E+00	1.0E-05	7.1E-01	1.2E-02	3.0E+00	2.0E-05	4.0E-05	1.0E-04	1.4E-04	3.5E-04	3.0E-03	1.0E-05	2.2E-01	2.2E-01	-3.1E-03	-0.7%
6-Mar-12	14																											
13-Mar-12	15	3.0E-03	2.0E-05	1.0E-03	3.0E-01	1.4E-02	1.0E-02	2.2E-03	2.0E-04	9.0E-03	1.0E+00	2.3E-04	1.2E+00	1.0E-05	6.6E-01	1.1E-02	3.1E+00	2.0E-05	2.0E-04	1.0E-04	5.4E-05	1.6E-04	3.0E-03	1.0E-05	2.0E-01	2.1E-01	7.1E-03	1.7%
20-Mar-12	16																											
27-Mar-12	17	3.0E-03	1.2E-03	1.0E-03	3.1E-01	1.5E-02	1.0E-02	1.9E-03	3.0E-04	9.0E-03	1.0E+00	1.5E-04	1.2E+00	1.0E-05	6.3E-01	1.1E-02	3.2E+00	2.0E-05	1.0E-05	1.0E-04	4.0E-05	3.0E-04	4.0E-03	1.0E-05	2.1E-01	2.2E-01	1.3E-02	3.0%
3-Apr-12	18																											
10-Apr-12	19	3.0E-03	2.0E-05	1.0E-03	3.3E-01	1.7E-02	1.0E-02	2.0E-03	3.0E-04	9.0E-03	1.2E+00	3.1E-04	1.4E+00	1.0E-05	6.3E-01	1.3E-02	3.5E+00	2.0E-05	5.0E-05	1.0E-04	4.6E-05	3.1E-04	5.0E-03	1.0E-05	2.6E-01	2.3E-01	-2.3E-02	-4.6%
17-Apr-12	20																											
24-Apr-12	21	3.0E-03	3.0E-05	1.0E-03	2.7E-01	1.5E-02	2.0E-02	2.0E-03	5.0E-04	9.0E-03	1.2E+00	1.4E-04	1.3E+00	1.0E-05	5.6E-01	1.1E-02	3.0E+00	2.0E-05	3.0E-05	1.0E-04	4.9E-05	4.2E-04	5.0E-03	1.0E-05	1.7E-01	2.0E-01	2.7E-02	7.3%
1-May-12	22																											
8-May-12	23	3.0E-03	6.0E-05	1.0E-03	2.3E-01	1.4E-02	1.0E-02	1.9E-03	4.0E-04	9.0E-03	1.1E+00	2.0E-04	1.2E+00	1.0E-05	4.5E-01	1.0E-02	2.6E+00	2.0E-05	1.3E-04	1.0E-04	3.9E-05	2.9E-04	5.0E-03	1.0E-05	1.7E-01	1.8E-01	1.0E-02	3.1%
15-May-12	24																											
22-May-12	25	3.0E-03	2.0E-05	1.0E-03	3.1E-01	2.0E-02	1.0E-02	2.1E-03	4.0E-04	9.0E-03	1.3E+00	2.2E-04	1.7E+00	1.0E-05	5.0E-01	1.3E-02	3.2E+00	2.0E-05	6.0E-05	4.0E-04	1.0E-04	5.7E-04	5.0E-03	1.0E-05	2.0E-01	2.2E-01	1.4E-02	3.5%
29-May-12	26																											
5-Jun-12	27	3.0E-03	2.0E-05	1.0E-03	2.2E-01	1.5E-02	1.0E-02	1.5E-03	1.0E-04	9.0E-03	9.5E-01	1.6E-04	1.2E+00	1.0E-05	3.8E-01	1.0E-02	2.5E+00	2.0E-05	6.0E-05	1.0E-04	6.3E-05	5.1E-04	5.0E-03	1.0E-05	1.4E-01	1.6E-01	2.9E-02	9.6%
12-Jun-12	28																											
19-Jun-12	29	3.0E-03	2.0E-05	1.0E-03	1.9E-01	1.4E-02	1.0E-02	1.9E-03	3.0E-04	9.0E-03	7.9E-01	2.3E-04	1.1E+00	1.0E-05	2.9E-01	9.3E-03	2.1E+00	2.0E-05	1.9E-04	1.0E-04	5.2E-05	4.6E-04	4.0E-03	1.0E-05	1.4E-01	1.4E-01	2.1E-03	0.8%
26-Jun-12	30																											
3-Jul-12	31	3.0E-03	4.0E-05	1.0E-03	2.2E-01	1.7E-02	1.0E-02	1.2E-03	6.0E-04	9.0E-03	8.9E-01	1.6E-04	1.0E+00	1.0E-05	3.4E-01	1.1E-02	2.3E+00	2.0E-05	9.0E-05	3.7E-03	3.6E-05	1.7E-03	5.0E-03	1.0E-05	2.0E-01	1.6E-01	-4.0E-02	-11.4%
10-Jul-12	32																											
17-Jul-12	33	3.0E-03	7.4E-04	1.0E-03	2.4E-01	1.9E-02	1.0E-02	1.2E-03	1.0E-04	9.0E-03	9.5E-01	2.5E-04	1.2E+00	1.0E-05	3.4E-01	1.2E-02	2.6E+00	2.0E-05	1.0E-05	1.0E-04	4.4E-05	5.0E-04	7.0E-03	1.0E-05	1.5E-01	1.7E-01	2.0E-02	6.4%
24-Jul-12	34																											
31-Jul-12	35	3.0E-03	3.0E-05	1.0E-03	2.6E-01	2.2E-02	3.0E-02	1.1E-03	4.0E-04	9.0E-03	9.5E-01	3.4E-04	1.3E+00	1.0E-05	3.5E-01	1.3E-02	2.6E+00	2.0E-05	3.0E-05	1.0E-04	5.3E-05	4.0E-04	8.0E-03	1.0E-05	1.6E-01	1.8E-01	1.6E-02	4.7%
7-Aug-12	36																											
14-Aug-12	37	3.0E-03	5.0E-05	1.0E-03	2.7E-01	2.4E-02	1.0E-02	9.6E-04	7.0E-04	9.0E-03	1.0E+00	1.7E-04	1.4E+00	1.0E-05	3.6E-01	1.4E-02	3.1E+00	2.0E-05	4.1E-04	2.0E-04	6.2E-05	5.8E-04	1.2E-02	1.0E-05	1.9E-01	1.9E-01	6.2E-04	0.2%
21-Aug-12	38																											
28-Aug-12	39	7.0E-03	3.4E-04	1.0E-03	2.1E-01	2.0E-02	1.0E-02	7.3E-04	8.0E-04	9.0E-03	7.7E-01	2.4E-04	1.8E+00	1.0E-05	2.8E-01	1.4E-02	2.6E+00	2.0E-05	4.9E-04	1.0E-04	6.1E-05	3.8E-04	1.0E-02	1.0E-05	1.9E-01	1.7E-01	-2.3E-02	-6.4%
4-Sep-12	40																											
11-Sep-12	41	5.0E-03	5.0E-05	1.0E-03	2.3E-01	2.2E-02	5.0E-02	7.5E-04	8.0E-04	9.0E-03	8.7E-01	2.2E-04	1.3E+00	1.0E-05	3.0E-01	1.6E-02	2.8E+00	2.0E-05	1.5E-04	2.0E-04	1.4E-04	2.3E-04	1.1E-02	1.0E-05	2.1E-01	1.8E-01	-2.4E-02	-6.2%
18-Sep-12	42																											
25-Sep-12	43	5.0E-03	2.0E-05	1.0E-03	2.5E-01	2.3E-02	1.0E-02	8.4E-04	9.0E-04	9.0E-03	9.0E-01	3.5E-04	1.3E+00	1.0E-05	2.9E-01	1.6E-02	3.0E+00	2.0E-05	6.0E-05	2.0E-04	6.7E-05	2.1E-04	1.2E-02	1.0E-05	1.8E-01	1.9E-01	2.5E-03	0.7%
2-Oct-12	44																											
9-Oct-12	45	5.0E-03	3.0E-05	1.0E-03	2.0E-01	2.1E-02	1.0E-02	4.7E-04	1.3E-03	1.0E-02	7.6E-01	3.4E-04	1.0E+00	1.0E-05	2.3E-01	1.3E-02	2.4E+00	2.0E-05	1.9E-04	2.0E-04	5.4E-05	2.4E-04	1.3E-02	1.0E-05	1.4E-01	1.5E-01	1.5E-02	5.2%
30-Oct-12	48																											
6-Nov-12	49	4.0E-03	6.0E-05	1.0E-03	2.2E-01	2.4E-02	1.0E-02	3.9E-04	1.1E-03	9.0E-03	8.1E-01	3.0E-04	1.2E+00	1.0E-05	2.7E-01	1.8E-02	3.0E+00	2.0E-05	5.6E-04	1.0E-04	2.6E-04	2.2E-04	1.5E-02	1.0E-05	1.5E-01	2.0E-01	4.8E-02	13.4%
13-Nov-12	50																											
20-Nov-12	51																											
27-Nov-12	52																											

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Sample = 08-260

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Major	Major	Diff	Diff
	No.																								Anions	Cations		(%)
		mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L				
4-Dec-12	53	9.0E-03	2.0E-05	1.0E-03	2.1E-01	2.3E-02	1.0E-02	3.8E-04	1.3E-03	1.0E-02	8.9E-01	1.4E-03	1.5E+00	1.0E-05	2.4E-01	1.7E-02	3.0E+00	2.0E-05	1.2E-04	1.0E-04	2.8E-04	1.7E-04	1.7E-02	1.0E-05	1.7E-01	2.0E-01	2.2E-02	6.1%
11-Dec-12	54																											
18-Dec-12	55																											
25-Dec-12	56																											
1-Jan-13	57	9.0E-03	2.0E-05	1.0E-03	1.4E-01	1.5E-02	1.0E-02	3.6E-04	1.0E-03	9.0E-03	6.0E-01	2.6E-04	1.5E+00	1.0E-05	1.7E-01	1.4E-02	2.5E+00	2.0E-05	2.3E-04	1.0E-04	3.5E-04	1.4E-04	1.1E-02	1.0E-05	1.2E-01	1.5E-01	3.2E-02	11.8%
8-Jan-13	58																											
15-Jan-13	59																											
22-Jan-13	60																											
29-Jan-13	61	8.0E-03	2.0E-05	1.0E-03	1.4E-01	1.6E-02	1.0E-02	2.0E-04	1.2E-03	9.0E-03	5.9E-01	3.2E-04	1.1E+00	1.0E-05	2.3E-01	1.4E-02	2.7E+00	2.0E-05	2.4E-04	1.0E-04	3.1E-04	2.3E-04	1.3E-02	1.0E-05	2.0E-01	1.7E-01	-2.9E-02	-8.1%
5-Feb-13	62																											
12-Feb-13	63																											
19-Feb-13	64																											
26-Feb-13	65	1.6E-02	3.0E-05	1.0E-03	1.7E-01	1.6E-02	1.0E-02	1.7E-04	1.6E-03	9.0E-03	7.7E-01	5.0E-04	1.3E+00	1.0E-05	2.3E-01	1.5E-02	3.3E+00	2.0E-05	5.0E-05	1.0E-04	3.4E-04	3.0E-05	1.4E-02	1.0E-05	1.7E-01	2.0E-01	2.6E-02	7.0%
5-Mar-13	66																											
12-Mar-13	67																											
19-Mar-13	68																											
26-Mar-13	69	1.9E-02	2.5E-04	1.0E-03	1.3E-01	1.3E-02	1.0E-02	1.2E-04	1.3E-03	1.6E-02	5.7E-01	3.0E-04	1.4E+00	1.0E-05	1.7E-01	1.3E-02	2.7E+00	2.0E-05	2.0E-05	1.0E-04	4.2E-04	6.0E-05	1.1E-02	1.0E-05	3.2E-01	1.7E-01	-1.5E-01	-31.5%
2-Apr-13	70																											
9-Apr-13	71																											
16-Apr-13	72																											
23-Apr-13	73	3.0E-02	5.0E-05	1.0E-03	1.2E-01	1.2E-02	1.0E-02	1.0E-04	1.3E-03	9.0E-03	5.8E-01	2.7E-04	1.4E+00	1.0E-05	1.6E-01	1.3E-02	2.8E+00	2.0E-05	4.0E-05	1.0E-04	4.6E-04	3.0E-05	1.1E-02	1.0E-05	2.9E-01	1.7E-01	-1.2E-01	-25.2%
30-Apr-13	74																											
7-May-13	75																											
14-May-13	76																											
21-May-13	77	3.9E-02	2.0E-05	1.0E-03	1.3E-01	1.3E-02	1.0E-02	1.2E-04	1.5E-03	1.4E-02	5.4E-01	3.7E-04	1.1E+00	1.0E-05	1.7E-01	1.4E-02	3.1E+00	2.0E-05	4.0E-05	1.0E-04	5.3E-04	3.0E-05	1.8E-02	1.0E-05	2.4E-01	1.8E-01	-5.7E-02	-13.8%
28-May-13	78																											
4-Jun-13	79																											
11-Jun-13	80																											
18-Jun-13	81	5.8E-02	2.0E-05	1.0E-03	1.3E-01	1.2E-02	1.0E-02	8.0E-05	1.5E-03	9.0E-03	5.7E-01	4.3E-04	1.5E+00	1.0E-05	2.4E-01	1.5E-02	3.2E+00	2.0E-05	4.0E-05	1.0E-04	7.7E-04	3.0E-05	1.0E-02	1.0E-05	2.4E-01	1.9E-01	-5.1E-02	-11.9%
25-Jun-13	82																											
2-Jul-13	83																											
9-Jul-13	84																											
16-Jul-13	85	7.7E-02	3.0E-05	1.0E-03	1.3E-01	1.1E-02	1.0E-02	5.0E-05	1.5E-03	9.0E-03	5.3E-01	4.4E-04	1.3E+00	1.0E-05	2.0E-01	1.4E-02	3.2E+00	2.0E-05	4.0E-05	1.0E-04	7.2E-04	3.0E-05	9.0E-03	1.0E-05	1.7E-01	1.9E-01	2.2E-02	6.1%
23-Jul-13	86																											
30-Jul-13	87																											
6-Aug-13	88																											
13-Aug-13	89	1.3E-01	5.0E-05	1.0E-03	1.3E-01	1.2E-02	1.0E-02	6.0E-05	1.8E-03	9.0E-03	5.6E-01	4.9E-04	1.7E+00	1.0E-05	2.2E-01	1.5E-02	3.5E+00	2.0E-05	1.0E-04	1.0E-04	1.2E-03	3.0E-05	1.3E-02	1.0E-05	2.1E-01	2.1E-01	1.7E-03	0.4%
20-Aug-13	90																											
27-Aug-13	91																											
3-Sep-13	92																											
10-Sep-13	93	1.1E-01	6.0E-05	1.0E-03	1.3E-01	1.2E-02	1.0E-02	6.0E-05	1.9E-03	9.0E-03	7.1E-01	5.9E-04	2.1E+00	1.0E-05	2.7E-01	1.5E-02	3.9E+00	2.0E-05	9.0E-05	1.0E-04	1.8E-03	3.0E-05	1.0E-02	1.0E-05	1.9E-01	2.2E-01	3.3E-02	8.2%
17-Sep-13	94																											
24-Sep-13	95																											
1-Oct-13	96																											
8-Oct-13	97	1.8E-01	2.0E-05	1.0E-03	1.1E-01	1.1E-02	1.0E-02	4.0E-05	1.9E-03	2.0E-02	5.9E-01	4.9E-04	2.0E+00	1.0E-05	2.0E-01	1.3E-02	3.6E+00	2.0E-05	2.0E-05	1.0E-04	2.0E-03	3.0E-05	8.0E-03	1.0E-05	1.7E-01	2.1E-01	3.9E-02	10.5%
15-Oct-13	98																											
22-Oct-13	99																											

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Sample = 08-260

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Major	Major	Diff	Diff
	No.																								Anions	Cations		(%)
		mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L				
29-Oct-13	100																											
5-Nov-13	101	1.7E-01	2.0E-05	1.0E-03	1.2E-01	1.1E-02	1.0E-02	5.0E-05	1.7E-03	9.0E-03	5.6E-01	6.1E-04	1.8E+00	1.0E-05	2.3E-01	1.4E-02	3.7E+00	2.0E-05	3.0E-05	1.0E-04	2.0E-03	3.0E-05	8.0E-03	1.0E-05	1.3E-01	2.1E-01	8.4E-02	25.1%
12-Nov-13	102																											
19-Nov-13	103																											
26-Nov-13	104																											
3-Dec-13	105	1.6E-01	2.0E-05	1.0E-03	1.0E-01	8.7E-03	1.0E-02	6.0E-05	1.8E-03	9.0E-03	5.1E-01	5.7E-04	1.4E+00	1.0E-05	1.8E-01	1.2E-02	3.5E+00	2.0E-05	8.0E-05	1.0E-04	2.2E-03	3.0E-05	7.0E-03	1.0E-05	1.7E-01	2.1E-01	4.0E-02	10.8%
10-Dec-13	106																											
17-Dec-13	107																											
24-Dec-13	108																											
31-Dec-13	109	1.8E-01	4.0E-05	1.0E-03	1.1E-01	9.0E-03	1.0E-02	6.0E-05	1.9E-03	9.0E-03	5.6E-01	6.5E-04	1.4E+00	1.0E-05	2.2E-01	1.2E-02	4.1E+00	2.0E-05	1.6E-04	1.0E-04	2.3E-03	3.0E-05	7.0E-03	1.0E-05	2.1E-01	2.1E-01	4.5E-03	1.1%
7-Jan-14	110																											
14-Jan-14	111																											
21-Jan-14	112																											
28-Jan-14	113	2.5E-01	2.0E-05	1.0E-03	1.1E-01	9.0E-03	1.0E-02	1.0E-05	2.0E-03	9.0E-03	5.6E-01	5.9E-04	1.3E+00	2.0E-05	2.3E-01	1.2E-02	4.3E+00	2.0E-05	1.7E-04	1.0E-04	2.4E-03	3.0E-05	7.0E-03	1.0E-05	1.5E-01	2.3E-01	8.1E-02	21.8%
4-Feb-14	114																											
11-Feb-14	115																											
18-Feb-14	116																											
25-Feb-14	117	2.4E-01	2.0E-05	1.0E-03	1.1E-01	8.4E-03	1.0E-02	2.0E-05	2.2E-03	9.0E-03	5.9E-01	6.6E-04	1.5E+00	1.0E-05	2.4E-01	1.3E-02	4.4E+00	2.0E-05	6.0E-05	1.0E-04	2.8E-03	3.0E-05	8.0E-03	1.0E-05	1.9E-01	2.6E-01	6.8E-02	15.3%
4-Mar-14	118																											
11-Mar-14	119																											
18-Mar-14	120																											
25-Mar-14	121	1.4E-01	2.0E-05	1.0E-03	1.1E-01	7.9E-03	1.0E-02	5.0E-05	1.7E-03	8.2E-02	5.3E-01	5.7E-04	1.2E+00	1.0E-05	2.3E-01	1.2E-02	4.2E+00	2.0E-05	1.3E-04	2.0E-04	2.7E-03	3.0E-05	7.0E-03	1.0E-05	1.7E-01	2.4E-01	7.2E-02	17.8%
1-Apr-14	122																											
8-Apr-14	123																											
15-Apr-14	124																											
22-Apr-14	125	2.7E-01	1.0E-05	7.2E-04	1.0E-01	7.7E-03	2.0E-02	3.0E-05	2.1E-03	1.8E-02	4.9E-01	5.6E-04	1.2E+00	2.0E-06	2.6E-01	1.2E-02	4.1E+00	8.0E-06	1.3E-04	7.0E-05	2.3E-03	1.0E-05	7.0E-03	2.0E-03	1.9E-01	2.5E-01	5.9E-02	13.6%
29-Apr-14	126																											
6-May-14	127																											
13-May-14	128																											
20-May-14	129	8.7E-02	3.0E-05	7.5E-04	1.1E-01	8.3E-03	1.0E-02	2.7E-04	2.0E-03	6.8E-02	5.8E-01	4.9E-04	1.5E+00	1.8E-05	2.7E-01	1.2E-02	4.5E+00	1.0E-05	1.9E-04	1.5E-04	2.4E-03	1.0E-05	6.0E-03	2.0E-03	1.7E-01	2.3E-01	6.1E-02	15.4%
27-May-14	130																											
3-Jun-14	131																											
10-Jun-14	132																											
17-Jun-14	133	8.8E-02	3.0E-05	7.8E-04	1.1E-01	8.7E-03	1.0E-02	1.0E-05	2.2E-03	3.3E-02	5.2E-01	5.3E-04	1.6E+00	4.0E-06	2.4E-01	1.2E-02	4.6E+00	1.2E-05	8.0E-05	6.0E-05	2.6E-03	1.0E-05	7.0E-03	2.0E-03	1.9E-01	2.4E-01	5.4E-02	12.5%
24-Jun-14	134																											
1-Jul-14	135																											
8-Jul-14	136																											
15-Jul-14	137	8.1E-02	2.0E-05	8.1E-04	9.5E-02	6.7E-03	1.0E-02	3.0E-05	1.8E-03	3.6E-02	4.9E-01	8.1E-04	1.5E+00	8.0E-06	2.4E-01	1.1E-02	4.1E+00	1.0E-05	6.0E-04	5.0E-05	2.7E-03	1.0E-05	6.0E-03	2.0E-03	2.1E-01	2.1E-01	7.4E-04	0.001768728
22-Jul-14	138																											
29-Jul-14	139																											
5-Aug-14	140																											
12-Aug-14	141	7.9E-02	1.3E-04	8.4E-04	1.0E-01	7.8E-03	1.0E-02	1.0E-04	2.1E-03	3.9E-02	5.1E-01	6.1E-04	1.2E+00	4.0E-06	2.4E-01	1.2E-02	4.5E+00	1.2E-05	6.0E-05	6.0E-05	3.0E-03	1.0E-05	7.0E-03	2.0E-03	1.7E-01	2.4E-01	6.9E-02	0.170673279
19-Aug-14	142																											
26-Aug-14	143																											
2-Sep-14	144																											
9-Sep-14	145	7.1E-02	7.0E-05	9.5E-04	1.1E-01	8.0E-03	1.0E-02	1.0E-05	2.2E-03	< 0.003	5.6E-01	7.2E-04	1.3E+00	4.0E-06	2.6E-01	1.2E-02	5.7E+00	1.3E-05	1.2E-04	< 0.00005	3.2E-03	2.0E-05	7.0E-03	< 0.002	2.7E-01	2.8E-01	9.7E-03	0.017572083
16-Sep-14	146																											
23-Sep-14	147																											
30-Sep-14	148																											

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Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/kg	mgCaCO3/kg	mgCaCO3/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
29-Nov-11	0	500	385	6.72	2.7E+02	#N/A	2.5E+00	3.1E+00	3.6E+01	1.2E+00	3.5E-02	1.2E-01	2.3E+01	1.6E-02	1.2E-04	3.5E-04	1.1E-02	7.7E-06	3.9E-06	3.2E-03	8.1E-05	7.3E+00	1.9E-04	2.6E-03	2.7E-01
6-Dec-11	1	500	455	6.71	2.1E+02	#N/A	2.1E+00	2.1E+00	3.4E+01	1.2E+00	2.7E-02	1.4E-01	2.4E+01	6.3E-03	9.1E-05	2.7E-04	4.7E-03	9.1E-06	4.6E-06	3.3E-03	4.9E-05	7.9E+00	3.2E-04	2.0E-03	2.8E-02
13-Dec-11	2	500	470	6.21	1.5E+02	#N/A	2.1E+00	1.5E+00	2.7E+01	6.6E-01	2.8E-02	1.4E-01	1.9E+01	2.1E-03	9.4E-05	2.4E-04	3.4E-03	9.4E-06	4.7E-06	2.4E-03	2.8E-05	6.1E+00	3.8E-04	1.3E-03	2.1E-02
20-Dec-11	3	500	480	6.69	9.8E+01	#N/A	2.4E+00	1.9E+00	1.9E+01	2.9E-01	2.9E-02	1.4E-01	1.2E+01	8.0E-03	9.6E-05	2.4E-04	2.2E-03	9.6E-06	4.8E-06	2.4E-03	2.7E-05	4.0E+00	2.4E-04	1.1E-03	1.8E-02
27-Dec-11	4	500	455	6.73	8.0E+01																				
3-Jan-12	5	500	455	6.27	6.3E+01	#N/A	2.2E+00	1.1E+00	1.1E+01	1.4E-01	2.7E-02	1.4E-01	7.0E+00	2.1E-02	9.1E-05	1.4E-04	1.5E-03	9.1E-06	4.6E-06	1.7E-03	1.5E-05	2.3E+00	2.3E-04	5.9E-04	1.4E-02
10-Jan-12	6	500	435	6.17	5.5E+01																				
17-Jan-12	7	500	450	6.37	4.0E+01	#N/A	1.4E+00	1.0E+00	6.8E+00	9.0E-02	2.7E-02	1.4E-01	5.2E+00	8.3E-03	9.0E-05	9.0E-05	1.6E-03	9.0E-06	4.5E-06	2.0E-03	1.3E-05	1.8E+00	2.3E-04	5.5E-04	1.5E-02
24-Jan-12	8	500	450	6.11	3.5E+01																				
31-Jan-12	9	500	460	6.18	3.1E+01	#N/A	1.8E+00	8.1E-01	5.1E+00	9.2E-02	2.8E-02	1.4E-01	3.7E+00	1.1E-02	9.2E-05	9.2E-05	1.6E-03	9.2E-06	4.6E-06	1.3E-03	1.2E-05	1.2E+00	2.3E-04	5.3E-04	1.7E-02
7-Feb-12	10	500	450	6.50	2.9E+01																				
14-Feb-12	11	500	490	6.18	2.8E+01	#N/A	2.3E+00	1.1E+00	6.4E+00	9.8E-02	2.9E-02	1.5E-01	4.3E+00	1.4E-03	9.8E-05	1.5E-04	2.1E-03	9.8E-06	4.9E-06	1.4E-03	1.4E-05	1.4E+00	2.5E-04	6.7E-04	2.1E-02
21-Feb-12	12	500	455	6.24	2.6E+01																				
28-Feb-12	13	500	505	5.93	2.6E+01	#N/A	2.1E+00	8.7E-01	4.5E+00	1.0E-01	3.0E-02	1.5E-01	4.0E+00	7.1E-03	1.0E-04	1.5E-04	1.9E-03	1.0E-05	5.1E-06	1.3E-03	1.4E-05	1.3E+00	2.5E-04	6.7E-04	2.5E-02
6-Mar-12	14	500	450	6.24	2.9E+01																				
13-Mar-12	15	500	440	5.83	2.5E+01	#N/A	1.7E+00	7.9E-01	3.5E+00	8.8E-02	2.6E-02	1.3E-01	3.3E+00	2.2E-03	8.8E-05	8.8E-05	1.7E-03	8.8E-06	4.4E-06	9.2E-04	1.2E-05	1.1E+00	2.2E-04	5.9E-04	2.2E-02
20-Mar-12	16	500	470	5.95	2.6E+01																				
27-Mar-12	17	500	455	5.80	2.6E+01	#N/A	1.6E+00	4.3E-01	4.1E+00	9.1E-02	2.7E-02	1.4E-01	3.7E+00	8.3E-03	9.1E-05	1.4E-04	1.9E-03	9.1E-06	4.6E-06	9.6E-04	2.0E-05	1.2E+00	2.3E-04	7.0E-04	2.9E-02
3-Apr-12	18	500	455	5.88	2.8E+01																				
10-Apr-12	19	500	450	5.78	3.0E+01	#N/A	1.5E+00	6.3E-01	5.0E+00	9.0E-02	2.7E-02	1.4E-01	3.8E+00	7.4E-03	9.0E-05	9.0E-05	2.1E-03	9.0E-06	4.5E-06	1.1E-03	3.2E-06	1.3E+00	2.3E-04	8.4E-04	2.9E-02
17-Apr-12	20	500	425	5.87	3.6E+01																				
24-Apr-12	21	500	445	5.78	2.5E+01	#N/A	1.7E+00	6.2E-01	3.1E+00	8.9E-02	2.7E-02	1.3E-01	3.1E+00	1.1E-02	8.9E-05	8.9E-05	2.0E-03	8.9E-06	4.5E-06	8.9E-04	1.3E-06	1.0E+00	2.2E-04	7.6E-04	2.7E-02
1-May-12	22	500	435	6.15	2.5E+01																				
8-May-12	23	500	440	5.69	2.2E+01	#N/A	1.8E+00	4.2E-01	3.1E+00	8.8E-02	2.6E-02	1.3E-01	2.7E+00	4.8E-03	8.8E-05	8.8E-05	1.8E-03	8.8E-06	4.4E-06	9.7E-04	6.2E-06	9.2E-01	2.2E-04	7.0E-04	2.7E-02
15-May-12	24	500	450	5.79	2.3E+01																				
22-May-12	25	500	420	5.92	2.7E+01	#N/A	1.9E+00	7.4E-01	3.4E+00	8.4E-02	2.5E-02	1.3E-01	3.2E+00	1.7E-02	8.4E-05	8.4E-05	2.5E-03	8.4E-06	4.2E-06	8.0E-04	1.4E-05	1.1E+00	2.1E-04	8.4E-04	3.3E-02
29-May-12	26	500	420	5.95	1.9E+01																				
5-Jun-12	27	500	430	5.74	1.9E+01	#N/A	1.9E+00	6.8E-01	2.2E+00	8.6E-02	2.6E-02	1.3E-01	2.5E+00	1.9E-02	8.6E-05	2.6E-04	1.9E-03	8.6E-06	4.3E-06	1.1E-03	1.3E-06	8.4E-01	2.2E-04	7.7E-04	3.0E-02
12-Jun-12	28	500	445	5.87	1.9E+01																				
19-Jun-12	29	500	435	5.73	1.8E+01	#N/A	1.6E+00	3.0E-01	2.6E+00	8.7E-02	2.6E-02	1.3E-01	2.2E+00	1.7E-02	8.7E-05	8.7E-05	1.8E-03	8.7E-06	4.4E-06	6.1E-04	1.3E-06	7.4E-01	2.2E-04	8.2E-04	3.4E-02
26-Jun-12	30	500	435	5.97	1.9E+01																				
3-Jul-12	31	500	440	6.08	2.0E+01	#N/A	3.3E+00	1.1E+00	3.1E+00	8.8E-02	2.6E-02	1.3E-01	2.5E+00	9.8E-03	8.8E-05	8.8E-05	2.0E-03	8.8E-06	4.4E-06	4.4E-04	2.2E-05	8.2E-01	2.2E-04	1.0E-03	4.4E-02
10-Jul-12	32	500	445	5.75	2.1E+01																				
17-Jul-12	33	500	435	5.61	2.1E+01	#N/A	1.3E+00	5.0E-01	2.6E+00	8.7E-02	2.6E-02	1.3E-01	2.6E+00	1.1E-02	8.7E-05	1.7E-04	2.4E-03	8.7E-06	4.4E-06	7.4E-04	1.9E-05	8.8E-01	2.2E-04	1.2E-03	5.9E-02
24-Jul-12	34	500	430	5.67	2.3E+01																				
31-Jul-12	35	500	440	5.60	2.2E+01	#N/A	1.5E+00	3.5E-01	3.1E+00	8.8E-02	2.6E-02	1.3E-01	2.8E+00	1.4E-02	8.8E-05	8.8E-05	2.6E-03	8.8E-06	4.4E-06	8.4E-04	2.7E-05	9.4E-01	2.2E-04	1.4E-03	7.7E-02
7-Aug-12	36	500	440	5.77	2.3E+01																				
14-Aug-12	37	500	450	5.56	2.4E+01	#N/A	2.0E+00	4.8E-01	3.6E+00	9.0E-02	2.7E-02	1.4E-01	3.0E+00	1.6E-02	9.0E-05	3.2E-04	3.1E-03	9.0E-06	4.5E-06	1.4E-03	3.1E-05	9.9E-01	2.3E-04	1.8E-03	1.2E-01
21-Aug-12	38	500	435	5.47	2.5E+01																				
28-Aug-12	39	500	495	5.66	2.3E+01	#N/A	2.5E+00	6.8E-01	4.0E+00	9.9E-02	3.0E-02	1.5E-01	3.0E+00	2.2E-02	9.9E-05	9.9E-05	3.7E-03	9.9E-06	5.0E-06	1.2E-03	3.7E-05	1.0E+00	2.5E-04	1.6E-03	1.7E-01
4-Sep-12	40	500	475	5.62	2.2E+01																				
11-Sep-12	41	500	490	5.45	2.3E+01	#N/A	2.4E+00	4.7E-01	4.4E+00	9.8E-02	2.9E-02	1.5E-01	3.2E+00	6.4E-03	9.8E-05	9.8E-05	4.1E-03	9.8E-06	9.8E-06	9.8E-04	3.4E-05	1.1E+00	2.5E-04	2.0E-03	2.1E-01
18-Sep-12	42	500	495	5.54	2.5E+01																				
25-Sep-12	43	500	445	5.39	2.5E+01	#N/A	2.3E+00	3.9E-01	3.6E+00	8.9E-02	2.7E-02	1.3E-01	2.9E+00	8.9E-03	8.9E-05	1.3E-04	4.0E-03	8.9E-06	4.5E-06	8.9E-04	3.8E-05	9.7E-01	2.2E-04	2.1E-03	2.5E-01
2-Oct-12	44	500	455	5.61	3.9E+01																				

HC9

Sample = 08-260

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/kg	mgCaCO3/kg	mgCaCO3/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
9-Oct-12	45	500	460	5.48	2.1E+01	#N/A	2.4E+00	3.3E-01	2.8E+00	9.2E-02	2.8E-02	1.4E-01	2.3E+00	1.1E-02	9.2E-05	9.2E-05	3.5E-03	9.2E-06	4.6E-06	5.5E-04	3.9E-05	7.9E-01	2.3E-04	1.9E-03	2.8E-01
16-Oct-12	46	500	455	5.40	2.3E+01																				
23-Oct-12	47	500	480	5.31	2.3E+01																				
30-Oct-12	48	500	465	5.53	3.7E+01																				
6-Nov-12	49	500	425	5.36	2.4E+01	#N/A	2.0E+00	1.8E-01	3.0E+00	8.5E-02	2.6E-02	1.3E-01	2.9E+00	8.7E-03	8.5E-05	8.5E-05	4.2E-03	8.5E-06	4.3E-06	7.7E-04	4.5E-05	1.0E+00	2.1E-04	2.0E-03	3.9E-01
13-Nov-12	50	500	435	5.68	2.8E+01																				
20-Nov-12	51	500	490	5.57	2.0E+01																				
27-Nov-12	52	500	495	5.61	3.0E+01																				
4-Dec-12	53	500	450	5.35	2.4E+01	#N/A	2.2E+00	1.6E-01	3.6E+00	9.0E-02	2.7E-02	1.4E-01	2.7E+00	9.0E-03	9.0E-05	9.0E-05	5.3E-03	9.0E-06	4.5E-06	3.6E-04	5.0E-05	9.1E-01	2.3E-04	2.4E-03	5.9E-01
11-Dec-12	54	500	450	5.71	3.5E+01																				
18-Dec-12	55	500	465	5.34	2.4E+01																				
25-Dec-12	56	500	485	5.61	3.0E+01																				
1-Jan-13	57	500	465	5.35	1.8E+01	#N/A	3.0E+00	4.0E-01	2.3E+00	9.3E-02	2.8E-02	1.4E-01	2.2E+00	9.1E-03	9.3E-05	9.3E-05	5.4E-03	9.3E-06	4.7E-06	3.3E-04	4.2E-05	7.8E-01	2.3E-04	1.7E-03	4.9E-01
8-Jan-13	58	500	480	5.51	2.5E+01																				
15-Jan-13	59	500	460	5.41	2.5E+01																				
22-Jan-13	60	500	460	5.62	2.7E+01																				
29-Jan-13	61	500	455	5.24	2.1E+01	#N/A	2.5E+00	1.7E-01	4.1E+00	9.1E-02	2.7E-02	1.4E-01	2.0E+00	1.7E-02	9.1E-05	9.1E-05	5.3E-03	9.1E-06	4.6E-06	3.6E-04	4.6E-05	6.9E-01	2.3E-04	1.9E-03	6.9E-01
5-Feb-13	62	500	475	5.34	2.4E+01																				
12-Feb-13	63	500	480	5.35	2.5E+01																				
19-Feb-13	64	500	460	5.23	2.6E+01																				
26-Feb-13	65	500	450	5.23	2.6E+01	#N/A	3.2E+00	1.8E-01	3.6E+00	9.0E-02	2.7E-02	1.4E-01	2.1E+00	1.5E-02	9.0E-05	1.8E-04	6.7E-03	1.8E-05	4.5E-06	3.2E-04	6.7E-05	7.1E-01	2.3E-04	2.4E-03	1.0E+00
5-Mar-13	66	500	450	5.29	2.5E+01																				
12-Mar-13	67	500	455	5.23	2.5E+01																				
19-Mar-13	68	500	425	5.45	2.9E+01																				
26-Mar-13	69	500	475	5.34	2.4E+01	#N/A	3.6E+00	5.9E-01	6.7E+00	9.5E-02	2.9E-02	1.4E-01	1.7E+00	1.8E-02	9.5E-05	1.9E-04	6.1E-03	1.9E-05	4.8E-06	3.8E-04	5.6E-05	5.7E-01	2.4E-04	2.0E-03	9.9E-01
2-Apr-13	70	500	445	5.35	2.4E+01																				
9-Apr-13	71	500	445	5.61	2.5E+01																				
16-Apr-13	72	500	440	5.73	2.5E+01																				
23-Apr-13	73	500	455	5.26	2.7E+01	#N/A	3.7E+00	9.0E-01	5.5E+00	9.1E-02	2.7E-02	1.4E-01	1.6E+00	2.6E-02	9.1E-05	9.1E-05	6.9E-03	2.3E-05	4.6E-06	5.0E-04	5.6E-05	5.3E-01	2.3E-04	1.9E-03	1.1E+00
30-Apr-13	74	500	460	5.35	2.3E+01																				
7-May-13	75	500	460	5.61	3.1E+01																				
14-May-13	76	500	445	5.27	2.9E+01																				
21-May-13	77	500	450	5.10	2.8E+01	#N/A	3.7E+00	1.7E-01	5.0E+00	9.0E-02	2.7E-02	1.4E-01	1.6E+00	3.6E-02	9.0E-05	9.0E-05	6.0E-03	2.7E-05	4.5E-06	5.4E-04	1.1E-04	5.6E-01	2.3E-04	2.0E-03	1.1E+00
28-May-13	78	500	455	5.12	2.7E+01																				
4-Jun-13	79	500	485	5.10	3.0E+01																				
11-Jun-13	80	500	480	5.07	2.8E+01																				
18-Jun-13	81	500	470	4.91	3.0E+01	#N/A	4.7E+00	2.4E-01	5.2E+00	#VALUE!	2.8E-02	1.4E-01	1.7E+00	5.3E-02	9.4E-05	9.4E-05	7.7E-03	3.8E-05	4.7E-06	7.1E-04	5.6E-05	5.8E-01	2.4E-04	2.1E-03	1.1E+00
25-Jun-13	82	500	460	5.08	2.7E+01																				
2-Jul-13	83	500	465	5.05	2.4E+01																				
9-Jul-13	84	500	475	5.09	2.8E+01																				
16-Jul-13	85	500	460	4.91	2.8E+01	#N/A	3.7E+00	4.6E-02	3.7E+00	#VALUE!	2.8E-02	1.4E-01	1.5E+00	6.3E-02	9.2E-05	1.4E-04	6.7E-03	3.7E-05	4.6E-06	5.1E-04	5.4E-05	5.1E-01	2.3E-04	2.0E-03	1.2E+00
23-Jul-13	86	500	460	4.77	2.9E+01																				
30-Jul-13	87	500	455	4.73	2.7E+01																				
6-Aug-13	88	500	475	4.77	3.0E+01																				
13-Aug-13	89	500	470	4.61	3.2E+01	#N/A	4.2E+00	4.7E-02	4.7E+00	#VALUE!	2.8E-02	1.4E-01	1.6E+00	1.0E-01	9.4E-05	9.4E-05	8.1E-03	5.2E-05	4.7E-06	6.1E-04	6.3E-05	5.4E-01	2.4E-04	2.1E-03	1.3E+00
20-Aug-13	90	500	460	4.68	3.1E+01																				
27-Aug-13	91	500	435	4.54	3.7E+01																				
3-Sep-13	92	500	435	4.61	3.0E+01																				
10-Sep-13	93	500	455	4.66	3.6E+01	#N/A	4.8E+00	4.6E-02	4.1E+00	9.1E-02	3.6E-02	1.4E-01	1.4E+00	1.5E-01	9.1E-05	9.1E-05	8.0E-03	6.8E-05	4.6E-06	6.8E-04	6.2E-05	4.6E-01	2.3E-04	2.1E-03	1.3E+00
17-Sep-13	94	500	435	4.63	3.3E+01																				

HC9

Sample = 08-260

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/kg	mgCaCO3/kg	mgCaCO3/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
24-Sep-13	95	500	435	4.60	3.1E+01																				
1-Oct-13	96	500	455	4.69	2.9E+01																				
8-Oct-13	97	500	465	4.58	3.2E+01	#N/A	4.3E+00	4.7E-02	3.7E+00	9.3E-02	3.3E-02	1.4E-01	1.3E+00	1.6E-01	9.3E-05	9.3E-05	8.8E-03	7.9E-05	4.7E-06	1.5E-03	5.7E-05	4.3E-01	2.3E-04	2.0E-03	1.1E+00
15-Oct-13	98	500	455	4.65	2.7E+01																				
22-Oct-13	99	500	450	4.66	3.1E+01																				
29-Oct-13	100	500	455	4.69	3.3E+01																				
5-Nov-13	101	500	465	4.69	3.8E+01	#N/A	4.8E+00	4.7E-02	2.8E+00	9.3E-02	4.2E-02	1.4E-01	1.3E+00	1.8E-01	9.3E-05	9.3E-05	8.7E-03	8.8E-05	4.7E-06	6.0E-04	5.8E-05	4.4E-01	2.3E-04	2.2E-03	1.1E+00
12-Nov-13	102	500	460	4.66	3.1E+01																				
19-Nov-13	103	500	450	4.56	3.5E+01																				
26-Nov-13	104	500	455	4.85	4.0E+01																				
3-Dec-13	105	500	460	4.95	3.4E+01	#N/A	4.3E+00	4.6E-02	3.7E+00	9.2E-02	2.8E-02	1.4E-01	1.1E+00	2.2E-01	9.2E-05	9.2E-05	8.4E-03	8.7E-05	4.6E-06	3.7E-04	4.8E-05	3.7E-01	2.3E-04	1.9E-03	1.1E+00
10-Dec-13	106	500	430	4.58	4.3E+01																				
17-Dec-13	107	500	440	4.59	3.6E+01																				
24-Dec-13	108	500	430	4.54	4.2E+01																				
31-Dec-13	109	500	435	4.47	4.0E+01	1.2E-01	4.5E+00	#N/A	4.4E+00	8.7E-02	3.0E-02	1.3E-01	1.0E+00	2.1E-01	8.7E-05	8.7E-05	8.3E-03	1.1E-04	4.4E-06	6.1E-04	5.0E-05	3.3E-01	2.2E-04	1.9E-03	1.1E+00
7-Jan-14	110	500	435	4.48	3.9E+01																				
14-Jan-14	111	500	420	4.45	3.4E+01																				
21-Jan-14	112	500	445	4.49	3.9E+01																				
28-Jan-14	113	500	435	4.47	4.1E+01	1.3E-01	4.8E+00	#N/A	3.0E+00	8.7E-02	3.0E-02	1.3E-01	1.0E+00	2.7E-01	8.7E-05	8.7E-05	7.9E-03	1.0E-04	4.4E-06	6.1E-04	4.7E-05	3.3E-01	2.2E-04	1.9E-03	1.0E+00
4-Feb-14	114	500	435	4.53	4.1E+01																				
11-Feb-14	115	500	415	4.63	3.5E+01																				
18-Feb-14	116	500	445	4.61	4.0E+01																				
25-Feb-14	117	500	440	4.60	4.1E+01	#N/A	5.5E+00	4.4E-02	4.0E+00	8.8E-02	2.6E-02	1.3E-01	1.1E+00	3.3E-01	8.8E-05	8.8E-05	9.8E-03	1.1E-04	4.4E-06	6.6E-04	5.2E-05	3.4E-01	2.2E-04	2.1E-03	1.2E+00
4-Mar-14	118	500	440	4.61	3.6E+01																				
11-Mar-14	119	500	435	4.55	4.0E+01																				
18-Mar-14	120	500	430	4.74	3.6E+01																				
25-Mar-14	121	500	435	4.61	4.1E+01	#N/A	4.5E+00	4.4E-02	3.5E+00	8.7E-02	2.6E-02	1.3E-01	9.6E-01	3.3E-01	8.7E-05	8.7E-05	9.2E-03	1.0E-04	4.4E-06	6.1E-04	4.8E-05	3.1E-01	2.2E-04	1.9E-03	1.1E+00
1-Apr-14	122	500	430	4.54	4.1E+01																				
8-Apr-14	123	500	430	4.40	4.3E+01																				
15-Apr-14	124	500	435	4.46	4.2E+01																				
22-Apr-14	125	500	435	4.41	4.1E+01	3.7E-01	5.5E+00	#N/A	3.9E+00	8.7E-02	2.6E-02	1.3E-01	9.6E-01	3.3E-01	8.7E-05	8.7E-05	8.9E-03	9.4E-05	3.0E-06	7.0E-04	4.6E-05	3.0E-01	1.3E-05	1.8E-03	1.1E+00
29-Apr-14	126	500	430	4.52	3.9E+01																				
6-May-14	127	500	440	4.34	4.1E+01																				
13-May-14	128	500	450	4.49	4.2E+01																				
20-May-14	129	500	445	4.55	3.8E+01	#N/A	6.3E+00	4.5E-02	3.6E+00	8.9E-02	2.7E-02	1.3E-01	1.1E+00	3.1E-01	8.9E-05	8.9E-05	8.1E-03	9.3E-05	3.1E-06	2.7E-04	4.0E-05	3.5E-01	1.3E-05	1.9E-03	9.7E-01
27-May-14	130	500	435	4.53	3.9E+01																				
3-Jun-14	131	500	495	4.32	4.2E+01																				
10-Jun-14	132	500	490	4.28	4.8E+01																				
17-Jun-14	133	500	445	4.39	4.0E+01	5.1E-01	6.5E+00	#N/A	4.0E+00	8.9E-02	2.7E-02	1.3E-01	1.0E+00	3.4E-01	8.9E-05	8.9E-05	8.3E-03	8.9E-05	3.1E-06	8.9E-04	4.5E-05	3.3E-01	1.3E-05	2.0E-03	1.1E+00
24-Jun-14	134	500	440	4.30	4.8E+01																				
1-Jul-14	135	500	430	4.35	4.8E+01																				
8-Jul-14	136	500	425	4.39	4.7E+01																				
15-Jul-14	137	500	435	4.34	4.0E+01	4.6E-01	5.2E+00	#N/A	4.4E+00	8.7E-02	2.6E-02	1.3E-01	8.3E-01	3.2E-01	8.7E-05	8.7E-05	7.4E-03	8.7E-05	3.0E-06	1.0E-03	4.6E-05	2.7E-01	1.3E-05	1.6E-03	8.3E-01
22-Jul-14	138	500	430	4.35	4.6E+01																				
29-Jul-14	139	500	425	4.30	4.6E+01																				
5-Aug-14	140	500	430	4.68	4.5E+01																				
12-Aug-14	141	500	435	4.39	4.5E+01	5.2E-01	6.0E+00	#N/A	3.5E+00	8.7E-02	2.6E-02	1.3E-01	9.6E-01	3.9E-01	8.7E-05	8.7E-05	7.5E-03	8.9E-05	3.0E-06	9.1E-04	4.1E-05	3.0E-01	1.3E-05	1.9E-03	8.9E-01
19-Aug-14	142	500	435	4.33	5.0E+01																				
26-Aug-14	143	500	410	4.35	5.1E+01																				
2-Sep-14	144	500	460																						

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Sample = 08-260

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
	No.																							
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
29-Nov-11	0	1.5E-03	4.9E-04	7.7E-04	1.1E+00	3.1E-02	7.7E-06	5.3E-03	1.1E-03	3.5E-03	3.6E+00	6.6E-04	4.3E-01	3.9E-06	7.1E+00	4.5E-02	1.3E+01	1.5E-05	2.3E-05	3.1E-04	1.2E-04	3.0E-04	6.5E-03	7.7E-06
6-Dec-11	1	1.4E-03	9.1E-06	4.6E-04	1.0E+00	3.1E-02	9.1E-06	5.9E-03	2.7E-04	4.1E-03	2.6E+00	6.2E-04	5.8E-01	9.1E-06	7.2E+00	3.1E-02	1.3E+01	9.1E-06	1.4E-05	9.1E-05	2.3E-04	2.2E-04	3.2E-03	4.6E-06
13-Dec-11	2	1.4E-03	5.2E-05	4.7E-04	7.8E-01	2.3E-02	9.4E-06	4.6E-03	3.3E-04	6.6E-03	2.0E+00	4.9E-04	5.7E-01	4.7E-06	4.6E+00	2.4E-02	9.4E+00	9.4E-06	3.3E-05	9.4E-05	4.3E-05	1.4E-04	7.5E-03	4.7E-06
20-Dec-11	3	1.4E-03	9.6E-06	4.8E-04	4.9E-01	1.8E-02	4.8E-06	4.0E-03	1.9E-04	4.3E-03	1.4E+00	3.6E-04	7.7E-01	4.8E-06	2.5E+00	1.5E-02	6.1E+00	9.6E-06	4.8E-06	9.6E-05	1.5E-05	1.9E-04	1.4E-03	4.8E-06
27-Dec-11	4																							
3-Jan-12	5	1.4E-03	9.1E-06	4.6E-04	2.9E-01	9.3E-03	4.6E-06	2.5E-03	2.3E-04	4.1E-03	9.1E-01	1.3E-04	4.6E-01	4.6E-06	1.4E+00	8.6E-03	3.6E+00	9.1E-06	1.8E-05	1.4E-04	2.4E-05	2.6E-04	1.4E-03	4.6E-06
10-Jan-12	6																							
17-Jan-12	7	1.4E-03	9.0E-06	4.5E-04	1.9E-01	7.1E-03	4.5E-06	1.9E-03	1.4E-04	4.1E-03	7.1E-01	8.6E-05	5.0E-01	4.5E-06	7.8E-01	6.2E-03	2.2E+00	9.0E-06	9.0E-06	9.0E-05	2.5E-05	1.9E-04	1.4E-03	4.5E-06
24-Jan-12	8																							
31-Jan-12	9	1.4E-03	9.2E-06	4.6E-04	1.5E-01	6.3E-03	4.6E-06	1.6E-03	4.6E-05	4.1E-03	5.8E-01	1.3E-04	5.3E-01	4.6E-06	5.4E-01	4.9E-03	1.7E+00	9.2E-06	1.4E-05	9.2E-05	2.6E-05	2.3E-04	1.4E-03	4.6E-06
7-Feb-12	10																							
14-Feb-12	11	1.5E-03	9.8E-06	4.9E-04	1.8E-01	8.2E-03	4.9E-06	1.5E-03	1.5E-04	4.4E-03	6.0E-01	1.1E-04	6.8E-01	4.9E-06	5.1E-01	6.2E-03	1.8E+00	9.8E-06	4.9E-06	4.9E-05	9.3E-06	1.2E-04	9.8E-04	4.9E-06
21-Feb-12	12																							
28-Feb-12	13	1.5E-03	1.0E-05	5.1E-04	1.6E-01	7.8E-03	5.1E-06	1.2E-03	1.0E-04	4.5E-03	5.2E-01	1.3E-04	6.4E-01	5.1E-06	3.6E-01	5.8E-03	1.5E+00	1.0E-05	2.0E-05	5.1E-05	7.2E-05	1.8E-04	1.5E-03	5.1E-06
6-Mar-12	14																							
13-Mar-12	15	1.3E-03	8.8E-06	4.4E-04	1.3E-01	6.0E-03	4.4E-06	9.5E-04	8.8E-05	4.0E-03	4.5E-01	1.0E-04	5.2E-01	4.4E-06	2.9E-01	4.8E-03	1.3E+00	8.8E-06	8.8E-05	4.4E-05	2.4E-05	7.0E-05	1.3E-03	4.4E-06
20-Mar-12	16																							
27-Mar-12	17	1.4E-03	5.4E-04	4.6E-04	1.4E-01	6.9E-03	4.6E-06	8.8E-04	1.4E-04	4.1E-03	4.6E-01	6.8E-05	5.3E-01	4.6E-06	2.9E-01	5.0E-03	1.5E+00	9.1E-06	4.6E-06	4.6E-05	1.8E-05	1.4E-04	1.8E-03	4.6E-06
3-Apr-12	18																							
10-Apr-12	19	1.4E-03	9.0E-06	4.5E-04	1.5E-01	7.7E-03	4.5E-06	9.2E-04	1.4E-04	4.1E-03	5.4E-01	1.4E-04	6.4E-01	4.5E-06	2.8E-01	5.8E-03	1.6E+00	9.0E-06	2.3E-05	4.5E-05	2.1E-05	1.4E-04	2.3E-03	4.5E-06
17-Apr-12	20																							
24-Apr-12	21	1.3E-03	1.3E-05	4.5E-04	1.2E-01	6.9E-03	8.9E-06	8.7E-04	2.2E-04	4.0E-03	5.4E-01	6.2E-05	5.9E-01	4.5E-06	2.5E-01	5.0E-03	1.3E+00	8.9E-06	1.3E-05	4.5E-05	2.2E-05	1.9E-04	2.2E-03	4.5E-06
1-May-12	22																							
8-May-12	23	1.3E-03	2.6E-05	4.4E-04	1.0E-01	6.2E-03	4.4E-06	8.4E-04	1.8E-04	4.0E-03	4.7E-01	8.8E-05	5.3E-01	4.4E-06	2.0E-01	4.4E-03	1.1E+00	8.8E-06	5.7E-05	4.4E-05	1.7E-05	1.3E-04	2.2E-03	4.4E-06
15-May-12	24																							
22-May-12	25	1.3E-03	8.4E-06	4.2E-04	1.3E-01	8.2E-03	4.2E-06	8.9E-04	1.7E-04	3.8E-03	5.5E-01	9.2E-05	7.2E-01	4.2E-06	2.1E-01	5.5E-03	1.3E+00	8.4E-06	2.5E-05	1.7E-04	4.4E-05	2.4E-04	2.1E-03	4.2E-06
29-May-12	26																							
5-Jun-12	27	1.3E-03	8.6E-06	4.3E-04	9.5E-02	6.5E-03	4.3E-06	6.6E-04	4.3E-05	3.9E-03	4.1E-01	6.9E-05	4.9E-01	4.3E-06	1.6E-01	4.4E-03	1.1E+00	8.6E-06	2.6E-05	4.3E-05	2.7E-05	2.2E-04	2.2E-03	4.3E-06
12-Jun-12	28																							
19-Jun-12	29	1.3E-03	8.7E-06	4.4E-04	8.4E-02	6.1E-03	4.4E-06	8.4E-04	1.3E-04	3.9E-03	3.4E-01	1.0E-04	4.6E-01	4.4E-06	1.3E-01	4.0E-03	8.9E-01	8.7E-06	8.3E-05	4.4E-05	2.3E-05	2.0E-04	1.7E-03	4.4E-06
26-Jun-12	30																							
3-Jul-12	31	1.3E-03	1.8E-05	4.4E-04	9.9E-02	7.4E-03	4.4E-06	5.4E-04	2.6E-04	4.0E-03	3.9E-01	7.0E-05	4.5E-01	4.4E-06	1.5E-01	4.6E-03	1.0E+00	8.8E-06	4.0E-05	1.6E-03	1.6E-05	7.4E-04	2.2E-03	4.4E-06
10-Jul-12	32																							
17-Jul-12	33	1.3E-03	3.2E-04	4.4E-04	1.0E-01	8.1E-03	4.4E-06	5.2E-04	4.4E-05	3.9E-03	4.1E-01	1.1E-04	5.4E-01	4.4E-06	1.5E-01	5.3E-03	1.1E+00	8.7E-06	4.4E-06	4.4E-05	1.9E-05	2.2E-04	3.0E-03	4.4E-06
24-Jul-12	34																							
31-Jul-12	35	1.3E-03	1.3E-05	4.4E-04	1.1E-01	9.6E-03	1.3E-05	4.7E-04	1.8E-04	4.0E-03	4.2E-01	1.5E-04	5.7E-01	4.4E-06	1.5E-01	5.9E-03	1.1E+00	8.8E-06	1.3E-05	4.4E-05	2.3E-05	1.8E-04	3.5E-03	4.4E-06
7-Aug-12	36																							
14-Aug-12	37	1.4E-03	2.3E-05	4.5E-04	1.2E-01	1.1E-02	4.5E-06	4.3E-04	3.2E-04	4.1E-03	4.6E-01	7.7E-05	6.1E-01	4.5E-06	1.6E-01	6.5E-03	1.4E+00	9.0E-06	1.8E-04	9.0E-05	2.8E-05	2.6E-04	5.4E-03	4.5E-06
21-Aug-12	38																							
28-Aug-12	39	3.5E-03	1.7E-04	5.0E-04	1.1E-01	1.0E-02	5.0E-06	3.6E-04	4.0E-04	4.5E-03	3.8E-01	1.2E-04	8.9E-01	5.0E-06	1.4E-01	7.0E-03	1.3E+00	9.9E-06	2.4E-04	5.0E-05	3.0E-05	1.9E-04	5.0E-03	5.0E-06
4-Sep-12	40																							
11-Sep-12	41	2.5E-03	2.5E-05	4.9E-04	1.1E-01	1.1E-02	2.5E-05	3.7E-04	3.9E-04	4.4E-03	4.2E-01	1.1E-04	6.3E-01	4.9E-06	1.5E-01	7.6E-03	1.4E+00	9.8E-06	7.4E-05	9.8E-05	6.8E-05	1.1E-04	5.4E-03	4.9E-06
18-Sep-12	42																							
25-Sep-12	43	2.2E-03	8.9E-06	4.5E-04	1.1E-01	1.0E-02	4.5E-06	3.7E-04	4.0E-04	4.0E-03	4.0E-01	1.6E-04	5.6E-01	4.5E-06	1.3E-01	7.0E-03	1.3E+00	8.9E-06	2.7E-05	8.9E-05	3.0E-05	9.3E-05	5.3E-03	4.5E-06
2-Oct-12	44																							

HC9

Sample = 08-260

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
	No.																							
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
9-Oct-12	45	2.3E-03	1.4E-05	4.6E-04	9.2E-02	9.5E-03	4.6E-06	2.2E-04	6.0E-04	4.6E-03	3.5E-01	1.6E-04	4.7E-01	4.6E-06	1.1E-01	5.9E-03	1.1E+00	9.2E-06	8.7E-05	9.2E-05	2.5E-05	1.1E-04	6.0E-03	4.6E-06
16-Oct-12	46																							
23-Oct-12	47																							
30-Oct-12	48																							
6-Nov-12	49	1.7E-03	2.6E-05	4.3E-04	9.4E-02	1.0E-02	4.3E-06	1.7E-04	4.7E-04	3.8E-03	3.4E-01	1.3E-04	4.9E-01	4.3E-06	1.1E-01	7.7E-03	1.3E+00	8.5E-06	2.4E-04	4.3E-05	1.1E-04	9.4E-05	6.4E-03	4.3E-06
13-Nov-12	50																							
20-Nov-12	51																							
27-Nov-12	52																							
4-Dec-12	53	4.1E-03	9.0E-06	4.5E-04	9.4E-02	1.0E-02	4.5E-06	1.7E-04	5.9E-04	4.5E-03	4.0E-01	6.1E-04	6.5E-01	4.5E-06	1.1E-01	7.6E-03	1.4E+00	9.0E-06	5.4E-05	4.5E-05	1.2E-04	7.7E-05	7.7E-03	4.5E-06
11-Dec-12	54																							
18-Dec-12	55																							
25-Dec-12	56																							
1-Jan-13	57	4.2E-03	9.3E-06	4.7E-04	6.3E-02	7.0E-03	4.7E-06	1.7E-04	4.7E-04	4.2E-03	2.8E-01	1.2E-04	6.7E-01	4.7E-06	7.9E-02	6.6E-03	1.2E+00	9.3E-06	1.1E-04	4.7E-05	1.6E-04	6.5E-05	5.1E-03	4.7E-06
8-Jan-13	58																							
15-Jan-13	59																							
22-Jan-13	60																							
29-Jan-13	61	3.6E-03	9.1E-06	4.6E-04	6.4E-02	7.1E-03	4.6E-06	9.1E-05	5.5E-04	4.1E-03	2.7E-01	1.5E-04	5.2E-01	4.6E-06	1.0E-01	6.2E-03	1.2E+00	9.1E-06	1.1E-04	4.6E-05	1.4E-04	1.0E-04	5.9E-03	4.6E-06
5-Feb-13	62																							
12-Feb-13	63																							
19-Feb-13	64																							
26-Feb-13	65	7.2E-03	1.4E-05	4.5E-04	7.6E-02	7.4E-03	4.5E-06	7.7E-05	7.2E-04	4.1E-03	3.5E-01	2.3E-04	6.0E-01	4.5E-06	1.0E-01	6.7E-03	1.5E+00	9.0E-06	2.3E-05	4.5E-05	1.5E-04	1.4E-05	6.3E-03	4.5E-06
5-Mar-13	66																							
12-Mar-13	67																							
19-Mar-13	68																							
26-Mar-13	69	9.0E-03	1.2E-04	4.8E-04	6.0E-02	6.1E-03	4.8E-06	5.7E-05	6.2E-04	7.6E-03	2.7E-01	1.4E-04	6.5E-01	4.8E-06	8.1E-02	5.9E-03	1.3E+00	9.5E-06	9.5E-06	4.8E-05	2.0E-04	2.9E-05	5.2E-03	4.8E-06
2-Apr-13	70																							
9-Apr-13	71																							
16-Apr-13	72																							
23-Apr-13	73	1.4E-02	2.3E-05	4.6E-04	5.6E-02	5.2E-03	4.6E-06	4.6E-05	5.9E-04	4.1E-03	2.6E-01	1.2E-04	6.2E-01	4.6E-06	7.3E-02	6.0E-03	1.3E+00	9.1E-06	1.8E-05	4.6E-05	2.1E-04	1.4E-05	5.0E-03	4.6E-06
30-Apr-13	74																							
7-May-13	75																							
14-May-13	76																							
21-May-13	77	1.8E-02	9.0E-06	4.5E-04	5.6E-02	5.7E-03	4.5E-06	5.4E-05	6.8E-04	6.3E-03	2.4E-01	1.7E-04	5.1E-01	4.5E-06	7.7E-02	6.3E-03	1.4E+00	9.0E-06	1.8E-05	4.5E-05	2.4E-04	1.4E-05	8.1E-03	4.5E-06
28-May-13	78																							
4-Jun-13	79																							
11-Jun-13	80																							
18-Jun-13	81	2.7E-02	9.4E-06	4.7E-04	6.0E-02	5.7E-03	4.7E-06	3.8E-05	7.1E-04	4.2E-03	2.7E-01	2.0E-04	6.9E-01	4.7E-06	1.1E-01	7.0E-03	1.5E+00	9.4E-06	1.9E-05	4.7E-05	3.6E-04	1.4E-05	4.7E-03	4.7E-06
25-Jun-13	82																							
2-Jul-13	83																							
9-Jul-13	84																							
16-Jul-13	85	3.5E-02	1.4E-05	4.6E-04	5.8E-02	5.2E-03	4.6E-06	2.3E-05	6.9E-04	4.1E-03	2.5E-01	2.0E-04	6.1E-01	4.6E-06	9.2E-02	6.3E-03	1.5E+00	9.2E-06	1.8E-05	4.6E-05	3.3E-04	1.4E-05	4.1E-03	4.6E-06
23-Jul-13	86																							
30-Jul-13	87																							
6-Aug-13	88																							
13-Aug-13	89	6.2E-02	2.4E-05	4.7E-04	6.3E-02	5.6E-03	4.7E-06	2.8E-05	8.5E-04	4.2E-03	2.6E-01	2.3E-04	7.8E-01	4.7E-06	1.0E-01	6.9E-03	1.6E+00	9.4E-06	4.7E-05	4.7E-05	5.8E-04	1.4E-05	6.1E-03	4.7E-06
20-Aug-13	90																							
27-Aug-13	91																							
3-Sep-13	92																							
10-Sep-13	93	5.1E-02	2.7E-05	4.6E-04	6.0E-02	5.4E-03	4.6E-06	2.7E-05	8.6E-04	4.1E-03	3.2E-01	2.7E-04	9.5E-01	4.6E-06	1.2E-01	6.8E-03	1.8E+00	9.1E-06	4.1E-05	4.6E-05	8.1E-04	1.4E-05	4.6E-03	4.6E-06
17-Sep-13	94																							

HC9

Sample = 08-260

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
	No.																							
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
24-Sep-13	95																							
1-Oct-13	96																							
8-Oct-13	97	8.5E-02	9.3E-06	4.7E-04	5.3E-02	5.0E-03	4.7E-06	1.9E-05	8.8E-04	9.3E-03	2.7E-01	2.3E-04	9.3E-01	4.7E-06	9.3E-02	6.0E-03	1.7E+00	9.3E-06	9.3E-06	4.7E-05	9.1E-04	1.4E-05	3.7E-03	4.7E-06
15-Oct-13	98																							
22-Oct-13	99																							
29-Oct-13	100																							
5-Nov-13	101	8.0E-02	9.3E-06	4.7E-04	5.8E-02	4.9E-03	4.7E-06	2.3E-05	7.9E-04	4.2E-03	2.6E-01	2.8E-04	8.3E-01	4.7E-06	1.1E-01	6.3E-03	1.7E+00	9.3E-06	1.4E-05	4.7E-05	9.1E-04	1.4E-05	3.7E-03	4.7E-06
12-Nov-13	102																							
19-Nov-13	103																							
26-Nov-13	104																							
3-Dec-13	105	7.5E-02	9.2E-06	4.6E-04	4.6E-02	4.0E-03	4.6E-06	2.8E-05	8.3E-04	4.1E-03	2.3E-01	2.6E-04	6.3E-01	4.6E-06	8.3E-02	5.3E-03	1.6E+00	9.2E-06	3.7E-05	4.6E-05	9.9E-04	1.4E-05	3.2E-03	4.6E-06
10-Dec-13	106																							
17-Dec-13	107																							
24-Dec-13	108																							
31-Dec-13	109	7.9E-02	1.7E-05	4.4E-04	4.7E-02	3.9E-03	4.4E-06	2.6E-05	8.3E-04	3.9E-03	2.5E-01	2.8E-04	6.1E-01	4.4E-06	9.6E-02	5.1E-03	1.8E+00	8.7E-06	7.0E-05	4.4E-05	1.0E-03	1.3E-05	3.0E-03	4.4E-06
7-Jan-14	110																							
14-Jan-14	111																							
21-Jan-14	112																							
28-Jan-14	113	1.1E-01	8.7E-06	4.4E-04	5.0E-02	3.9E-03	4.4E-06	4.4E-06	8.7E-04	3.9E-03	2.4E-01	2.6E-04	5.7E-01	8.7E-06	1.0E-01	5.3E-03	1.9E+00	8.7E-06	7.4E-05	4.4E-05	1.1E-03	1.3E-05	3.0E-03	4.4E-06
4-Feb-14	114																							
11-Feb-14	115																							
18-Feb-14	116																							
25-Feb-14	117	1.0E-01	8.8E-06	4.4E-04	4.7E-02	3.7E-03	4.4E-06	8.8E-06	9.7E-04	4.0E-03	2.6E-01	2.9E-04	6.5E-01	4.4E-06	1.1E-01	5.6E-03	1.9E+00	8.8E-06	2.6E-05	4.4E-05	1.2E-03	1.3E-05	3.5E-03	4.4E-06
4-Mar-14	118																							
11-Mar-14	119																							
18-Mar-14	120																							
25-Mar-14	121	6.0E-02	8.7E-06	4.4E-04	4.6E-02	3.4E-03	4.4E-06	2.2E-05	7.4E-04	3.6E-02	2.3E-01	2.5E-04	5.0E-01	4.4E-06	1.0E-01	5.3E-03	1.8E+00	8.7E-06	5.7E-05	8.7E-05	1.2E-03	1.3E-05	3.0E-03	4.4E-06
1-Apr-14	122																							
8-Apr-14	123																							
15-Apr-14	124																							
22-Apr-14	125	1.2E-01	4.4E-06	3.1E-04	4.4E-02	3.3E-03	8.7E-06	1.3E-05	9.1E-04	7.8E-03	2.1E-01	2.4E-04	5.1E-01	8.7E-07	1.1E-01	5.1E-03	1.8E+00	3.5E-06	5.7E-05	3.0E-05	9.9E-04	4.4E-06	3.0E-03	8.7E-04
29-Apr-14	126																							
6-May-14	127																							
13-May-14	128																							
20-May-14	129	3.9E-02	1.3E-05	3.3E-04	4.9E-02	3.7E-03	4.5E-06	1.2E-04	8.9E-04	3.0E-02	2.6E-01	2.2E-04	6.5E-01	8.0E-06	1.2E-01	5.3E-03	2.0E+00	4.5E-06	8.5E-05	6.7E-05	1.1E-03	4.5E-06	2.7E-03	8.9E-04
27-May-14	130																							
3-Jun-14	131																							
10-Jun-14	132																							
17-Jun-14	133	3.9E-02	1.3E-05	3.5E-04	4.9E-02	3.9E-03	4.5E-06	4.5E-06	9.8E-04	1.5E-02	2.3E-01	2.4E-04	7.2E-01	1.8E-06	1.1E-01	5.5E-03	2.0E+00	5.3E-06	3.6E-05	2.7E-05	1.2E-03	4.5E-06	3.1E-03	8.9E-04
24-Jun-14	134																							
1-Jul-14	135																							
8-Jul-14	136																							
15-Jul-14	137	3.5E-02	8.7E-06	3.5E-04	4.1E-02	2.9E-03	4.4E-06	1.3E-05	7.8E-04	1.6E-02	2.1E-01	3.5E-04	6.3E-01	3.5E-06	1.0E-01	4.6E-03	1.8E+00	4.4E-06	2.6E-04	2.2E-05	1.2E-03	4.4E-06	2.6E-03	8.7E-04
22-Jul-14	138																							
29-Jul-14	139																							
5-Aug-14	140																							
12-Aug-14	141	3.4E-02	5.7E-05	3.6E-04	4.5E-02	3.4E-03	4.4E-06	4.4E-05	9.1E-04	1.7E-02	2.2E-01	2.7E-04	5.4E-01	1.7E-06	1.0E-01	5.1E-03	1.9E+00	5.2E-06	2.6E-05	2.6E-05	1.3E-03	4.4E-06	3.0E-03	8.7E-04
19-Aug-14	142																							
26-Aug-14	143																							
2-Sep-14	144																							

HC10

Sample = 50% '08-059/ 50% '08-178

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/L	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
29-Nov-11	0	500	385	4.48	1.0E+03	3.4E+00	2.1E+02	#N/A	516.00	3.7E+00	2.1E+00	3.0E-01	2.5E+02	2.0E+01	7.6E-03	3.6E-03	3.4E-02	4.2E-03	1.0E-05	3.3E-02	2.3E-02	7.4E+01	7.2E-03	7.8E-01	1.4E+02
6-Dec-11	1	500	470	4.43	6.9E+02	2.0E+00	1.3E+02	#N/A	306.00	2.1E+00	6.0E-02	3.0E-01	1.5E+02	1.0E+01	6.9E-03	1.9E-03	1.9E-02	3.6E-03	1.0E-05	6.6E-02	1.6E-02	4.0E+01	6.5E-03	5.5E-01	5.9E+01
13-Dec-11	2	500	435	4.55	4.2E+02	#N/A	8.0E+01	1.0E-01	180.00	1.3E+00	1.1E+00	3.0E-01	8.8E+01	5.0E+00	4.5E-03	1.7E-03	1.8E-02	1.9E-03	1.0E-05	4.9E-02	9.2E-03	2.5E+01	5.1E-03	4.2E-01	3.6E+01
20-Dec-11	3	500	520	4.65	3.0E+02	#N/A	5.8E+01	1.0E-01	151.00	6.0E-01	8.6E-01	3.0E-01	6.7E+01	3.2E+00	5.3E-03	1.5E-03	1.7E-02	1.6E-03	1.0E-05	3.9E-02	5.6E-03	2.1E+01	2.6E-03	1.9E-01	2.6E+01
27-Dec-11	4	500	435	4.78	2.2E+02																				
3-Jan-12	5	500	445	4.67	1.6E+02	#N/A	3.0E+01	1.0E-01	72.00	4.0E-01	5.0E-01	3.0E-01	2.9E+01	2.2E+00	3.3E-03	1.0E-03	1.7E-02	9.9E-04	1.0E-05	2.2E-02	3.6E-03	8.8E+00	1.2E-03	1.0E-01	1.4E+01
10-Jan-12	6	500	430	4.58	1.5E+02																				
17-Jan-12	7	500	445	4.73	1.2E+02	#N/A	2.5E+01	1.0E-01	55.00	2.0E-01	4.0E-01	3.0E-01	2.1E+01	1.6E+00	3.5E-03	1.1E-03	2.1E-02	9.7E-04	1.0E-05	1.7E-02	2.8E-03	6.5E+00	1.1E-03	6.3E-02	1.2E+01
24-Jan-12	8	500	440	4.67	1.2E+02																				
31-Jan-12	9	500	450	4.63	1.1E+02	#N/A	2.1E+01	1.0E-01	47.00	2.0E-01	3.9E-01	3.0E-01	1.4E+01	1.0E+00	2.7E-03	9.0E-04	2.2E-02	9.2E-04	1.0E-05	1.3E-02	1.5E-03	4.4E+00	8.0E-04	4.9E-02	1.1E+01
7-Feb-12	10	500	455	4.63	1.1E+02																				
14-Feb-12	11	500	450	4.56	1.2E+02	#N/A	3.2E+01	1.0E-01	51.00	2.0E-01	4.2E-01	3.0E-01	1.4E+01	1.8E+00	2.0E-03	9.0E-04	1.8E-02	1.0E-03	1.0E-05	1.2E-02	1.6E-03	4.2E+00	6.0E-04	5.0E-02	1.3E+01
21-Feb-12	12	500	465	4.61	1.2E+02																				
28-Feb-12	13	500	465	4.46	1.1E+02	1.2E+00	3.0E+01	#N/A	42.00	2.0E-01	4.1E-01	3.0E-01	1.1E+01	2.0E+00	2.0E-03	8.0E-04	1.7E-02	9.6E-04	1.0E-05	1.1E-02	1.3E-03	3.2E+00	6.0E-04	3.8E-02	1.0E+01
6-Mar-12	14	500	445	4.47	1.4E+02																				
13-Mar-12	15	500	450	4.33	1.3E+02	2.6E+00	4.0E+01	#N/A	53.00	2.0E-01	4.8E-01	3.0E-01	1.0E+01	2.6E+00	2.2E-03	8.0E-04	1.3E-02	1.1E-03	1.0E-05	1.0E-02	1.6E-03	3.2E+00	8.0E-04	4.8E-02	1.2E+01
20-Mar-12	16	500	445	4.36	1.3E+02																				
27-Mar-12	17	500	450	4.20	1.4E+02	3.9E+00	4.4E+01	#N/A	63.00	2.0E-01	4.8E-01	3.0E-01	8.6E+00	4.0E+00	1.5E-03	6.0E-04	9.8E-03	1.7E-03	1.0E-05	8.1E-03	1.3E-03	2.7E+00	7.0E-04	3.7E-02	1.1E+01
3-Apr-12	18	500	460	4.16	1.4E+02																				
10-Apr-12	19	500	450	4.57	1.2E+02	#N/A	3.7E+01	1.0E-01	58.00	2.0E-01	4.4E-01	3.0E-01	6.1E+00	3.8E+00	1.7E-03	6.0E-04	1.8E-02	1.7E-03	1.0E-05	7.0E-03	1.3E-03	2.0E+00	8.0E-04	3.4E-02	9.8E+00
17-Apr-12	20	500	455	4.16	1.6E+02																				
24-Apr-12	21	500	460	4.10	1.3E+02	6.6E+00	4.4E+01	#N/A	53.00	1.0E+00	3.7E-01	3.0E-01	4.7E+00	4.0E+00	1.9E-03	8.0E-04	1.5E-02	1.7E-03	1.0E-05	6.1E-03	1.2E-03	1.5E+00	9.0E-04	2.5E-02	8.4E+00
1-May-12	22	500	440	4.16	1.4E+02																				
8-May-12	23	500	460	4.09	1.4E+02	8.0E+00	4.6E+01	#N/A	53.00	1.0E+00	2.5E-01	3.0E-01	4.4E+00	3.9E+00	1.7E-03	9.0E-04	1.7E-02	1.4E-03	1.0E-05	6.8E-03	1.2E-03	1.4E+00	8.0E-04	2.4E-02	7.1E+00
15-May-12	24	500	445	3.98	1.5E+02																				
22-May-12	25	500	430	4.08	1.8E+02	1.2E+01	7.0E+01	#N/A	72.00	1.0E+00	3.9E-01	3.0E-01	4.4E+00	7.4E+00	3.3E-03	1.5E-03	1.0E-02	2.0E-03	1.0E-05	6.9E-03	1.5E-03	1.3E+00	1.9E-03	2.9E-02	9.6E+00
29-May-12	26	500	435	4.05	1.4E+02																				
5-Jun-12	27	500	440	4.11	1.3E+02	7.4E+00	4.7E+01	#N/A	51.00	1.0E+00	3.0E-01	3.0E-01	3.7E+00	4.8E+00	1.4E-03	7.0E-04	9.9E-03	1.6E-03	1.0E-05	7.0E-03	9.5E-04	1.1E+00	1.0E-03	2.4E-02	5.6E+00
12-Jun-12	28	500	455	4.08	1.3E+02																				
19-Jun-12	29	500	445	4.03	1.3E+02	9.2E+00	4.8E+01	#N/A	51.00	2.0E-01	2.7E-01	3.0E-01	2.8E+00	4.9E+00	1.2E-03	8.0E-04	8.9E-03	1.5E-03	1.0E-05	4.6E-03	8.9E-04	8.1E-01	1.0E-03	2.2E-02	5.2E+00
26-Jun-12	30	500	445	4.04	1.4E+02																				
3-Jul-12	31	500	445	4.12	1.5E+02	1.4E+01	6.2E+01	#N/A	59.00	1.0E+00	2.8E-01	3.0E-01	2.9E+00	5.9E+00	1.5E-03	8.0E-04	1.3E-02	1.5E-03	1.0E-05	3.2E-03	1.0E-03	8.3E-01	1.0E-03	2.3E-02	5.7E+00
10-Jul-12	32	500	445	3.89	1.7E+02																				
17-Jul-12	33	500	445	3.84	1.7E+02	2.3E+01	6.2E+01	#N/A	70.00	1.0E+00	3.0E-01	3.0E-01	3.1E+00	6.8E+00	1.8E-03	1.5E-03	7.9E-03	1.9E-03	1.0E-05	5.4E-03	1.5E-03	8.4E-01	1.4E-03	2.9E-02	6.6E+00
24-Jul-12	34	500	440	3.86	1.9E+02																				
31-Jul-12	35	500	445	3.82	1.8E+02	2.5E+01	7.1E+01	#N/A	81.00	2.0E-01	3.0E-01	3.0E-01	2.9E+00	7.2E+00	1.7E-03	1.0E-03	7.4E-03	1.6E-03	1.0E-05	3.8E-03	1.5E-03	7.6E-01	1.7E-03	2.5E-02	6.6E+00
7-Aug-12	36	500	460	3.80	2.0E+02																				
14-Aug-12	37	500	445	3.75	2.2E+02	3.9E+01	9.6E+01	#N/A	98.00	1.0E+00	3.2E-01	3.0E-01	3.4E+00	1.2E+01	1.6E-03	1.6E-03	6.8E-03	1.7E-03	1.0E-05	3.2E-03	1.9E-03	8.4E-01	2.1E-03	3.0E-02	7.4E+00
21-Aug-12	38	500	450	3.71	2.3E+02																				
28-Aug-12	39	500	490	3.69	2.5E+02	3.5E+01	9.6E+01	#N/A	107.00	1.0E+00	3.1E-01	3.0E-01	3.6E+00	1.2E+01	1.8E-03	1.1E-03	6.3E-03	1.6E-03	1.0E-05	4.1E-03	2.0E-03	9.1E-01	2.6E-03	3.1E-02	6.8E+00
4-Sep-12	40	500	480	3.65	2.6E+02																				
11-Sep-12	41	500	450	3.56	3.2E+02	6.4E+01	1.4E+02	#N/A	126.00	1.0E+00	3.5E-01	3.0E-01	4.4E+00	1.7E+01	1.5E-03	1.0E-03	5.3E-03	1.5E-03	1.0E-05	1.8E-03	2.6E-03	9.5E-01	4.1E-03	4.0E-02	8.3E+00
18-Sep-12	42	500	505	3.49	3.4E+02																				
25-Sep-12	43	500	450	3.49	3.5E+02	6.4E+01	1.3E+02	#N/A	123.00	2.0E-01	3.1E-01	3.0E-01	4.9E+00	1.9E+01	2.0E-04	8.0E-04	4.6E-03	1.6E-03	1.0E-05	4.0E-04	2.7E-03	8.7E-01	6.6E-03	4.7E-02	7.9E+00
2-Oct-12	44	500	460	3.62	2.6E+02																				
9-Oct-12	45	500	470	3.28	3.8E+02	7.6E+01	1.4E+02	#N/A	134.00	1.0E+00	3.0E-01	3.0E-01	4.6E+00	1.7E+01	4.0E-04	7.0E-04	4.4E-03	8.5E-04	1.0E-05	1.3E-03	2.4E-03	7.3E-01	6.2E-03	4.0E-02	6.0E+00
16-Oct-12	46	500	455	3.49	4.3E+02																				
23-Oct-12	47	500	480	3.14	5.0E+02																				
30-Oct-12	48	500	465	3.51	3.0E+02																				
6-Nov-12	49	500	435	3.22	4.4E+02	7.7E+01	1.5E+02	#N/A	163.00	1.0E+00	3.8E-01	3.0E-01	8.5E+00	2.0E+01	5.0E-04	1.1E-03	4.2E-03	1.2E-03	1.0E-05	1.3E-03	2.6E-03	1.2E+00	6.0E-03	5.6E-02	6.3E+00
13-Nov-12	50	500	450	3.34	3.5E+02																				
20-Nov-12	51	500	490	3.16	4.8E+02																				
27-Nov-12	52	500	490	3.31	4.1E+02																				
4-Dec-12	53	500	455	3.10	5.8E+02	9.7E+01	1.8E+02	#N/A	154.00	1.0E+00	3.0E-01	3.0E-01	6.8E+00	1.7E+01	6.0E-04	1.9E-03	7.3E-03	1.0E-03	1.0E-05	1.5E-03	2.8E-03	9.4E-01	5.8E-03	5.3E-02	5.4E+00
11-Dec-12	54	500	460	3.30	4.7E+02																				
18-Dec-12	55	500	465	3.09	5.1E+02																				
25-Dec-12	56	500	455	3.35	4.6E+02																				
1-Jan-13	57	500	455	3.12	5.1E+02	8.2E+01	1.5E+02	#N/A	165.00	1.0E+00	3.6E-01	3.0E-01	6.9E+00	1.2E+01	4.0E-04	1.8E-03	6.0E-03	8.3E-04	1.0E-05	6.0E-04	2.0E-03	9.5E-01	5.1E-03	4.2E-02	4.0E+00
8-Jan-13	58	500	470	3.19	4.9E+02																				
15-Jan-13	59	500	480	3.13	4.4E+02																				
22-Jan-13	60	500	465	3.21	4.8E+02																				

HC10

Sample = 50% '08-059/ 50% '08-178

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
29-Jan-13	61	500	450	3.10	4.8E+02	8.1E+01	1.4E+02	#N/A	170.00	1.0E+00	4.0E-01	3.0E-01	7.6E+00	1.5E+01	4.0E-04	1.8E-03	5.1E-03	9.3E-04	1.0E-05	1.0E-03	1.8E-03	1.0E+00	4.8E-03	4.4E-02	4.0E+00
5-Feb-13	62	500	435	3.15	5.0E+02																				
12-Feb-13	63	500	480	3.08	5.3E+02																				
19-Feb-13	64	500	460	3.11	5.1E+02																				
26-Feb-13	65	500	450	3.11	4.9E+02	8.2E+01	1.4E+02	#N/A	167.00	1.0E+00	4.7E-01	3.0E-01	7.9E+00	1.7E+01	4.0E-04	2.7E-03	4.2E-03	9.3E-04	1.0E-05	4.0E-04	1.9E-03	1.1E+00	5.2E-03	4.5E-02	3.9E+00
5-Mar-13	66	500	455	3.23	4.2E+02																				
12-Mar-13	67	500	420	3.27	3.6E+02																				
19-Mar-13	68	500	480	3.28	4.0E+02																				
26-Mar-13	69	500	460	3.18	4.2E+02	8.2E+01	1.4E+02	#N/A	159.00	1.0E+00	4.1E-01	3.0E-01	5.7E+00	1.3E+01	4.0E-04	1.5E-03	5.9E-03	6.9E-04	1.0E-05	9.0E-04	1.3E-03	7.4E-01	3.6E-03	3.5E-02	3.1E+00
2-Apr-13	70	500	445	3.17	4.1E+02																				
9-Apr-13	71	500	455	3.21	4.3E+02																				
16-Apr-13	72	500	450	3.31	4.3E+02																				
23-Apr-13	73	500	450	3.21	4.2E+02	6.5E+01	1.2E+02	#N/A	125.00	1.0E+00	3.9E-01	3.0E-01	5.3E+00	1.2E+01	3.0E-04	1.1E-03	5.7E-03	6.4E-04	1.0E-05	1.1E-03	1.2E-03	6.2E-01	2.6E-03	3.1E-02	2.7E+00
30-Apr-13	74	500	445	3.25	3.6E+02																				
7-May-13	75	500	450	3.19	4.3E+02																				
14-May-13	76	500	450	3.28	3.5E+02																				
21-May-13	77	500	445	3.36	2.4E+02	3.6E+01	6.9E+01	#N/A	70.00	1.0E+00	2.7E-01	3.0E-01	3.5E+00	4.7E+00	2.0E-04	6.0E-04	5.6E-03	3.7E-04	1.0E-05	1.5E-03	5.8E-04	5.3E-01	1.5E-03	1.8E-02	1.4E+00
28-May-13	78	500	445	3.34	2.8E+02	4.6E+01	8.5E+01	#N/A	95.00	1.0E+00	3.4E-01	3.0E-01	4.9E+00	7.9E+00	2.0E-04	5.0E-04	4.6E-03	5.0E-04	1.0E-05	1.3E-03	7.0E-04	7.2E-01	1.9E-03	2.3E-02	1.7E+00
4-Jun-13	79	500	450	3.51	2.1E+02	3.5E+01	6.8E+01	#N/A	58.00	2.0E-01	2.5E-01	3.0E-01	3.8E+00	6.4E+00	8.0E-04	1.0E-03	6.5E-03	2.7E-04	1.0E-05	4.6E-03	4.8E-04	6.6E-01	1.7E-03	1.8E-02	1.3E+00
11-Jun-13	80	500	425	3.65	1.9E+02	3.2E+01	6.8E+01	#N/A	62.00	1.0E+00	2.4E-01	3.0E-01	3.5E+00	5.6E+00	7.0E-04	6.0E-04	4.8E-03	2.8E-04	1.0E-05	2.5E-03	4.4E-04	5.5E-01	1.4E-03	1.6E-02	1.2E+00
18-Jun-13	81	500	525	3.56	2.2E+02	3.4E+01	7.0E+01	#N/A	71.00	1.0E+00	2.1E-01	3.0E-01	3.3E+00	5.8E+00	8.0E-04	7.0E-04	4.1E-03	3.4E-04	1.0E-05	2.6E-03	5.6E-04	5.2E-01	1.4E-03	1.8E-02	1.4E+00
25-Jun-13	82	500	465	3.73	1.3E+02																				
2-Jul-13	83	500	440	3.80	1.0E+02	1.3E+01	2.7E+01	#N/A	26.00	1.0E+00	8.0E-02	3.0E-01	9.5E-01	1.9E+00	5.0E-04	4.0E-04	3.5E-03	1.2E-04	1.0E-05	2.0E-04	1.8E-04	1.6E-01	5.0E-04	5.9E-03	5.5E-01
9-Jul-13	84	500	500	3.75	1.4E+02																				
16-Jul-13	85	500	490	3.71	1.1E+02	1.5E+01	3.0E+01	#N/A	25.00	1.0E+00	8.0E-02	3.0E-01	1.2E+00	1.6E+00	6.0E-04	6.0E-04	5.4E-03	1.2E-04	1.0E-05	1.9E-03	1.7E-04	2.7E-01	5.0E-04	5.7E-03	5.5E-01
23-Jul-13	86	500	495	3.76	1.1E+02																				
30-Jul-13	87	500	480	3.71	1.1E+02	1.6E+01	2.8E+01	#N/A	26.00	1.0E+00	7.0E-02	3.0E-01	9.8E-01	1.8E+00	5.0E-04	3.0E-04	6.3E-03	1.0E-04	1.0E-05	1.8E-03	1.5E-04	2.3E-01	5.0E-04	5.1E-03	4.8E-01
6-Aug-13	88	500	520	3.74	1.2E+02																				
13-Aug-13	89	500	485	3.66	1.1E+02	1.5E+01	2.8E+01	#N/A	28.00	1.0E+00	6.0E-02	3.0E-01	1.1E+00	1.6E+00	5.0E-04	4.0E-04	8.4E-03	1.1E-04	1.0E-05	1.9E-03	1.7E-04	2.9E-01	5.0E-04	5.1E-03	5.1E-01
20-Aug-13	90	500	485	3.68	1.2E+02																				
27-Aug-13	91	500	490	3.64	1.1E+02																				
3-Sep-13	92	500	485	3.73	1.1E+02																				
10-Sep-13	93	500	480	3.68	1.2E+02	1.7E+01	3.2E+01	#N/A	29.00	2.0E-01	7.0E-02	3.0E-01	7.9E-01	1.6E+00	4.0E-04	5.0E-04	7.7E-03	1.1E-04	1.0E-05	2.0E-03	2.6E-04	1.6E-01	5.0E-04	6.1E-03	5.3E-01
17-Sep-13	94	500	470	3.72	1.1E+02																				
24-Sep-13	95	500	505	3.61	1.3E+02																				
1-Oct-13	96	500	465	3.65	1.3E+02																				
8-Oct-13	97	500	475	3.64	1.2E+02	1.5E+01	2.7E+01	#N/A	23.00	2.0E-01	6.0E-02	3.0E-01	9.0E-01	1.3E+00	3.0E-04	5.0E-04	7.3E-03	9.0E-05	1.0E-05	3.4E-03	1.7E-04	2.2E-01	5.0E-04	5.3E-03	4.7E-01
15-Oct-13	98	500	500	3.54	1.2E+02																				
22-Oct-13	99	500	480	3.68	1.2E+02																				
29-Oct-13	100	500	460	3.68	1.3E+02																				
5-Nov-13	101	500	495	3.74	1.1E+02	1.3E+01	2.4E+01	#N/A	18.00	2.0E-01	6.0E-02	3.0E-01	7.9E-01	9.4E-01	3.0E-04	3.0E-04	8.0E-03	8.0E-05	1.0E-05	1.3E-03	1.5E-04	1.9E-01	5.0E-04	4.5E-03	4.2E-01
12-Nov-13	102	500	470	3.79	1.1E+02																				
19-Nov-13	103	500	475	3.86	1.1E+02																				
26-Nov-13	104	500	475	3.85	1.1E+02																				
3-Dec-13	105	500	480	3.89	1.1E+02	8.2E+00	2.4E+01	#N/A	20.00	2.0E-01	6.0E-02	3.0E-01	8.0E-01	1.1E+00	3.0E-04	4.0E-04	7.7E-03	7.0E-05	1.0E-05	1.1E-03	1.7E-04	1.9E-01	5.0E-04	5.0E-03	4.5E-01
10-Dec-13	106	500	475	3.75	1.1E+02																				
17-Dec-13	107	500	475	3.67	1.0E+02																				
24-Dec-13	108	500	505	3.80	9.9E+01																				
31-Dec-13	109	500	455	3.80	8.3E+01	8.3E+00	1.7E+01	#N/A	12.00	2.0E-01	6.0E-02	3.0E-01	5.6E-01	4.9E-01	2.0E-04	3.0E-04	9.3E-03	5.0E-05	1.0E-05	1.7E-03	1.1E-04	1.4E-01	5.0E-04	3.0E-03	3.2E-01
7-Jan-14	110	500	500	3.65	1.1E+02																				
14-Jan-14	111	500	475	3.67	9.8E+01																				
21-Jan-14	112	500	480	3.74	1.1E+02																				
28-Jan-14	113	500	480	3.73	1.0E+02	1.1E+01	2.3E+01	#N/A	11.00	2.0E-01	6.0E-02	3.0E-01	7.8E-01	8.3E-01	3.0E-04	3.0E-04	7.7E-03	4.0E-05	1.0E-05	1.2E-03	1.6E-04	1.8E-01	5.0E-04	4.4E-03	4.1E-01
4-Feb-14	114	500	475	3.72	1.1E+02																				
11-Feb-14	115	500	470	3.73	1.0E+02																				

HC10

Sample = 50% '08-059/ 50% '08-178

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
18-Feb-14	116	500	480	3.72	1.0E+02																				
25-Feb-14	117	500	470	3.76	1.0E+02	1.2E+01	2.4E+01	#N/A	16.00	2.0E-01	6.0E-02	3.0E-01	6.6E-01	7.8E-01	2.0E-04	2.0E-04	8.2E-03	5.0E-05	1.0E-05	8.0E-04	1.6E-04	1.4E-01	5.0E-04	4.2E-03	4.2E-01
4-Mar-14	118	500	490	3.72	1.1E+02																				
11-Mar-14	119	500	485	3.72	1.1E+02																				
18-Mar-14	120	500	465	3.70	1.1E+02																				
25-Mar-14	121	500	475	3.82	1.1E+02	9.5E+00	2.0E+01	#N/A	17.00	2.0E-01	6.0E-02	3.0E-01	7.6E-01	8.9E-01	2.0E-04	2.0E-04	8.4E-03	5.0E-05	1.0E-05	6.0E-04	1.6E-04	1.8E-01	5.0E-04	4.5E-03	4.5E-01
1-Apr-14	122	500	500	3.77	1.0E+02																				
8-Apr-14	123	500	460	3.69	1.0E+02																				
15-Apr-14	124	500	480	3.72	1.1E+02																				
22-Apr-14	125	500	470	3.68	1.1E+02	1.1E+01	2.2E+01	#N/A	17.00	2.0E-01	6.0E-02	3.0E-01	6.9E-01	9.0E-01	4.0E-04	3.0E-04	6.4E-03	5.5E-05	7.0E-06	6.0E-04	1.7E-04	1.5E-01	2.7E-04	4.4E-03	5.1E-01
29-Apr-14	126	500	480	3.76	1.1E+02																				
6-May-14	127	500	485	3.67	9.4E+01																				
13-May-14	128	500	500	3.83	9.2E+01																				
20-May-14	129	500	480	3.76	8.9E+01	1.1E+01	2.4E+01	#N/A	14.00	2.0E-01	6.0E-02	3.0E-01	6.9E-01	6.9E-01	6.0E-04	3.0E-04	6.9E-03	4.4E-05	7.0E-06	2.0E-04	1.5E-04	1.6E-01	1.9E-04	4.0E-03	4.2E-01
27-May-14	130	500	480	3.79	9.1E+01																				
3-Jun-14	131	500	480	3.68	8.2E+01																				
10-Jun-14	132	500	495	3.67	1.0E+02																				
17-Jun-14	133	500	490	3.74	8.7E+01	1.0E+01	2.0E+01	#N/A	12.00	2.0E-01	6.0E-02	3.0E-01	5.6E-01	5.4E-01	4.0E-04	3.0E-04	8.8E-03	3.9E-05	7.0E-06	2.0E-03	1.3E-04	1.2E-01	2.0E-04	3.5E-03	3.9E-01
24-Jun-14	134	500	505	3.73	1.0E+02																				
1-Jul-14	135	500	475	3.77	9.3E+01																				
8-Jul-14	136	500	500	3.74	1.2E+02																				
15-Jul-14	137	500	475	3.69	1.1E+02	1.1E+01	2.2E+01	#N/A	16.00	2.0E-01	6.0E-02	3.0E-01	7.2E-01	6.8E-01	2.0E-04	3.0E-04	6.8E-03	5.2E-05	7.0E-06	1.5E-03	1.6E-04	1.6E-01	1.8E-04	4.4E-03	4.6E-01
22-Jul-14	138	500	470	3.82	9.5E+01																				
29-Jul-14	139	500	505	3.58	1.2E+02																				
5-Aug-14	140	500	485	3.53	1.2E+02																				
12-Aug-14	141	500	490	3.71	1.0E+02	1.2E+01	2.3E+01	#N/A	11.00	2.0E-01	6.0E-02	3.0E-01	6.3E-01	5.8E-01	2.0E-04	3.0E-04	6.6E-03	4.2E-05	7.0E-06	1.8E-03	1.5E-04	1.4E-01	1.9E-04	3.8E-03	3.9E-01
19-Aug-14	142	500	485	3.77	1.0E+02																				
26-Aug-14	143	500	500	3.74	1.1E+02																				
2-Sep-14	144	500	415																						
9-Sep-14	145	500	505						23.00	< 0.2	< 0.06	< 0.3	1.0E+00	1.2E+00	3.0E-04	4.0E-04	8.9E-03	7.0E-05	< 0.000007	3.0E-03	2.7E-04	2.3E-01	2.9E-04	6.6E-03	7.8E-01
16-Sep-14	146	500	475																						
23-Sep-14	147	500	485																						
30-Sep-14	148	500	485																						

HC10

Sample = 50% '08-059/ 50% '08-178

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Major	Major	Diff	Diff
	No.																								Anions	Cations		(%)
		mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L				
29-Nov-11	0	2.0E+00	1.1E-03	2.0E-02	1.5E+01	1.9E+00	3.0E-02	6.3E-03	6.4E-01	5.4E-02	1.5E+01	1.9E-02	8.0E-01	5.0E-05	4.6E+01	2.2E-01	1.8E+02	2.3E-03	6.0E-05	4.0E-04	6.4E-02	5.4E-04	3.1E+00	2.0E-03	1.1E+01	1.4E+01	3.1E+00	12.4%
6-Dec-11	1	8.1E-01	4.7E-04	2.0E-02	1.2E+01	1.4E+00	3.0E-02	4.2E-03	4.6E-01	5.8E-02	8.5E+00	1.4E-02	2.3E+00	1.0E-04	2.7E+01	1.2E-01	1.2E+02	1.6E-03	1.0E-05	4.0E-04	3.5E-02	4.6E-04	2.5E+00	1.1E-03	6.4E+00	7.4E+00	9.8E-01	7.0%
13-Dec-11	2	4.7E-01	6.0E-03	1.4E-02	6.5E+00	8.6E-01	2.0E-02	3.0E-03	3.7E-01	4.6E-02	5.4E+00	1.2E-02	1.6E+00	2.0E-05	1.2E+01	7.6E-02	6.6E+01	9.6E-04	5.1E-04	3.0E-04	1.9E-02	2.1E-04	1.6E+00	4.6E-04	3.8E+00	4.1E+00	3.0E-01	3.8%
20-Dec-11	3	4.5E-01	8.0E-05	9.0E-03	3.6E+00	5.0E-01	1.0E-02	2.0E-03	1.6E-01	2.1E-01	3.8E+00	5.3E-03	2.5E+00	1.0E-05	4.6E+00	6.3E-02	4.6E+01	8.3E-04	1.0E-05	7.0E-04	1.1E-02	3.9E-04	8.1E-01	2.5E-04	3.2E+00	2.9E+00	-2.9E-01	-4.8%
27-Dec-11	4																											
3-Jan-12	5	2.5E-01	2.3E-03	6.0E-03	1.6E+00	2.4E-01	1.0E-02	1.1E-03	9.0E-02	2.4E-02	2.3E+00	2.4E-03	7.2E-01	1.0E-05	1.1E+00	3.1E-02	2.1E+01	4.3E-04	7.0E-05	5.0E-04	6.5E-03	5.7E-04	4.8E-01	1.3E-04	1.5E+00	1.4E+00	-9.2E-02	-3.1%
10-Jan-12	6																											
17-Jan-12	7	3.4E-01	4.5E-03	5.0E-03	1.1E+00	1.6E-01	1.0E-02	1.2E-03	5.7E-02	1.2E-01	2.0E+00	1.7E-03	7.2E-01	1.0E-05	3.8E-01	2.5E-02	1.6E+01	3.2E-04	3.0E-05	2.0E-04	5.0E-03	2.8E-04	3.6E-01	9.0E-05	1.2E+00	1.1E+00	-7.1E-02	-3.1%
24-Jan-12	8																											
31-Jan-12	9	3.8E-01	3.8E-04	4.0E-03	8.0E-01	1.3E-01	1.0E-02	9.1E-04	4.5E-02	9.0E-03	1.5E+00	2.1E-03	7.6E-01	1.0E-05	2.3E-01	1.9E-02	1.4E+01	2.2E-04	2.0E-05	2.0E-04	4.8E-03	3.5E-04	2.8E-01	4.0E-05	1.0E+00	8.7E-01	-1.3E-01	-7.0%
7-Feb-12	10																											
14-Feb-12	11	6.1E-01	7.0E-05	3.0E-03	7.3E-01	1.4E-01	1.0E-02	9.9E-04	4.6E-02	1.1E-01	1.3E+00	1.7E-03	7.4E-01	1.0E-05	1.9E-01	2.0E-02	1.4E+01	2.1E-04	1.0E-05	2.0E-04	6.7E-03	1.9E-04	2.8E-01	2.0E-05	1.1E+00	1.0E+00	-8.6E-02	-4.1%
21-Feb-12	12																											
28-Feb-12	13	7.4E-01	2.1E-04	3.0E-03	5.8E-01	1.3E-01	1.0E-02	7.2E-04	3.8E-02	1.1E-01	1.3E+00	1.4E-03	7.7E-01	1.0E-05	1.6E-01	1.8E-02	1.3E+01	2.9E-04	6.0E-05	2.0E-04	7.0E-03	2.2E-04	2.6E-01	3.0E-05	9.0E-01	8.9E-01	-5.1E-03	-0.3%
6-Mar-12	14																											
13-Mar-12	15	1.2E+00	1.3E-04	2.0E-03	5.3E-01	1.5E-01	1.0E-02	7.3E-04	4.1E-02	6.5E-02	1.1E+00	1.8E-03	7.9E-01	2.0E-05	1.2E-01	1.7E-02	1.7E+01	1.9E-04	1.7E-04	1.0E-04	1.1E-02	5.0E-05	3.2E-01	4.0E-05	1.1E+00	1.0E+00	-8.5E-02	-3.9%
20-Mar-12	16																											
27-Mar-12	17	1.7E+00	1.2E-03	3.0E-03	4.3E-01	1.5E-01	1.0E-02	5.8E-04	3.3E-02	5.4E-02	9.4E-01	1.7E-03	7.6E-01	2.0E-05	1.1E-01	1.4E-02	1.9E+01	1.9E-04	1.0E-05	1.0E-04	1.5E-02	2.2E-04	2.7E-01	3.0E-05	1.3E+00	1.2E+00	-1.6E-01	-6.5%
3-Apr-12	18																											
10-Apr-12	19	1.8E+00	3.8E-04	3.0E-03	3.1E-01	1.2E-01	2.0E-02	2.1E-03	2.9E-02	4.9E-02	7.5E-01	1.9E-03	8.0E-01	2.0E-05	1.0E-01	1.1E-02	1.7E+01	1.4E-04	3.0E-05	2.0E-04	1.5E-02	2.0E-04	2.9E-01	3.0E-05	1.2E+00	1.0E+00	-2.1E-01	-9.2%
17-Apr-12	20																											
24-Apr-12	21	2.1E+00	1.3E-03	3.0E-03	2.4E-01	1.0E-01	3.0E-02	6.9E-04	2.3E-02	4.2E-02	6.6E-01	1.5E-03	9.0E-01	1.0E-05	1.0E-01	9.6E-03	1.6E+01	1.3E-04	3.0E-05	1.0E-04	1.7E-02	2.8E-04	2.7E-01	2.0E-05	1.1E+00	1.0E+00	-9.2E-02	-4.2%
1-May-12	22																											
8-May-12	23	2.3E+00	9.3E-03	2.0E-03	2.1E-01	1.1E-01	1.0E-02	9.2E-04	2.1E-02	9.0E-03	5.8E-01	1.6E-03	7.8E-01	1.0E-05	9.0E-02	8.5E-03	1.7E+01	1.1E-04	2.0E-04	1.0E-04	1.7E-02	1.7E-04	2.6E-01	2.0E-05	1.1E+00	9.8E-01	-1.4E-01	-6.5%
15-May-12	24																											
22-May-12	25	4.0E+00	2.5E-04	4.0E-03	2.7E-01	1.4E-01	2.0E-02	1.2E-03	2.5E-02	9.0E-03	1.1E+00	2.1E-03	1.1E+00	1.0E-05	1.3E-01	8.9E-03	2.4E+01	2.0E-04	1.2E-04	3.0E-04	2.6E-02	3.9E-04	3.3E-01	8.0E-05	1.5E+00	1.6E+00	4.5E-02	1.5%
29-May-12	26																											
5-Jun-12	27	2.5E+00	3.0E-05	3.0E-03	2.1E-01	1.0E-01	2.0E-02	5.3E-04	2.5E-02	4.2E-02	6.0E-01	1.7E-03	7.6E-01	1.0E-05	1.2E-01	7.0E-03	1.7E+01	1.1E-04	5.0E-05	4.0E-04	1.6E-02	4.6E-04	2.3E-01	4.0E-05	1.1E+00	1.0E+00	-4.4E-02	-2.1%
12-Jun-12	28																											
19-Jun-12	29	2.4E+00	2.2E-04	3.0E-03	1.8E-01	9.7E-02	1.0E-02	2.7E-02	1.9E-02	1.8E-02	4.6E-01	1.7E-03	8.0E-01	1.0E-05	9.0E-02	5.9E-03	1.6E+01	1.0E-04	1.2E-04	2.0E-04	1.9E-02	4.1E-04	2.1E-01	2.0E-05	1.1E+00	1.0E+00	-6.4E-02	-3.1%
26-Jun-12	30																											
3-Jul-12	31	3.0E+00	1.3E-04	2.0E-03	1.9E-01	1.1E-01	1.0E-02	5.6E-04	1.8E-02	9.0E-03	4.3E-01	1.7E-03	7.2E-01	1.0E-05	7.0E-02	5.8E-03	1.9E+01	9.0E-05	1.2E-04	1.0E-04	2.1E-02	3.0E-04	2.5E-01	6.0E-05	1.2E+00	1.2E+00	-8.1E-02	-3.4%
10-Jul-12	32																											
17-Jul-12	33	4.0E+00	7.0E-05	3.0E-03	2.4E-01	1.4E-01	1.0E-02	7.4E-04	2.2E-02	9.0E-03	4.3E-01	2.4E-03	9.7E-01	1.4E-04	8.0E-02	6.4E-03	2.3E+01	1.0E-04	1.5E-04	1.0E-04	3.0E-02	3.1E-04	3.5E-01	3.0E-05	1.5E+00	1.4E+00	-6.2E-02	-2.1%
24-Jul-12	34																											
31-Jul-12	35	4.4E+00	1.4E-04	3.0E-03	2.5E-01	1.4E-01	2.0E-02	5.5E-04	2.0E-02	9.0E-03	3.6E-01	2.1E-03	1.1E+00	2.0E-05	7.0E-02	6.0E-03	2.3E+01	9.0E-05	1.2E-04	2.0E-04	3.2E-02	4.3E-04	3.6E-01	2.0E-05	1.7E+00	1.5E+00	-2.2E-01	-6.9%
7-Aug-12	36																											
14-Aug-12	37	4.6E+00	1.2E-03	3.0E-03	3.2E-01	1.7E-01	1.0E-02	6.0E-04	2.4E-02	9.0E-03	3.5E-01	1.8E-03	1.2E+00	3.0E-05	8.0E-02	6.4E-03	3.0E+01	9.0E-05	1.0E-04	5.0E-04	4.0E-02	6.7E-04	4.9E-01	3.0E-05	2.1E+00	2.0E+00	-9.9E-03	-0.2%
21-Aug-12	38																											
28-Aug-12	39	4.3E+00	6.0E-05	3.0E-03	3.3E-01	1.8E-01	1.0E-02	4.8E-04	2.3E-02	4.3E-02	3.4E-01	1.7E-03	2.8E+00	4.0E-05	7.0E-02	7.9E-03	3.2E+01	9.0E-05	2.3E-04	1.0E-03	5.0E-02	3.5E-04	4.2E-01	4.0E-05	2.2E+00	2.1E+00	-1.5E-01	-3.6%
4-Sep-12	40																											
11-Sep-12	41	4.5E+00	1.7E-04	3.0E-03	5.0E-01	2.0E-01	1.0E-02	5.3E-04	2.8E-02	9.0E-03	3.0E-01	2.1E-03	1.6E+00	4.0E-05	8.0E-02	7.2E-03	4.3E+01	9.0E-05	1.4E-04	2.0E-04	7.0E-02	2.0E-04	6.5E-01	6.0E-05	2.6E+00	2.8E+00	1.5E-01	2.8%
18-Sep-12	42																											
25-Sep-12	43	5.1E+00	1.3E-04	4.0E-03	6.6E-01	1.9E-01	3.0E-02	1.3E-02	3.1E-02	6.6E-02	2.6E-01	1.3E-03	1.8E+00	1.0E-05	8.0E-02	6.7E-03	4.9E+01	2.0E-05	2.9E-04	1.0E-04	7.3E-02	2.8E-04	6.2E-01	9.0E-05	2.6E+00	3.1E+00	5.6E-01	9.8%
2-Oct-12	44																											
9-Oct-12	45	4.8E+00	3.6E-04	3.0E-03	6.8E-01	1.7E-01	1.0E-02	1.0E-05	1.8E-02	5.7E-02	2.3E-01	2.3E-03	2.0E+00	2.0E-05	6.0E-02	6.1E-03	4.6E+01	7.0E-05	1.6E-04	1.0E-04	5.7E-02	3.0E-05	4.9E-01	9.0E-05	2.8E+00	3.0E+00	2.2E-01	3.8%
16-Oct-12	46																											
23-Oct-12	47																											
30-Oct-12	48																											
6-Nov-12	49	9.1E+00	9.0E-05	3.0E-03	1.3E+00	3.0E-01	1.0E-02	1.6E-04	3.4E-02	8.3E-02	2.2E-01	1.4E-03	1.6E+00	1.0E-05	6.0E-02	7.6E-03	6.0E+01	6.0E-05	1.8E-04	2.0E-04	6.2E-02	3.0E-05	5.6E-01	1.8E-04	3.4E+00	3.7E+00	3.1E-01	4.3%
13-Nov-12	50																											
20-Nov-12	51																											
27-Nov-12	52																											
4-Dec-12	53	1.6E+01	9.0E-03	3.0E-03	1.1E+00	2.5E-01	2.0E-02	3.9E-04	3.0E-02	4.5E-02	2.2E-01	3.8E-04	2.6E+00	5.0E-05	7.0E-02	1.1E-02	6.5E+01	7.0E-05	1.6E-04	2.0E-04	5.0E-02	3.9E-04	5.6E-01	1.2E-04	3.2E+00	3.9E+00	6.8E-01	9.6%
11-Dec-12	54																											
18-Dec-12	55																											
25-Dec-12	56																											
1-Jan-13	57	1.1E+01	9.2E-03	2.0E-03	1.1E+00	1.8E-01	1.0E-02	2.0E-04	2.4E-02	1.3E-02	1.8E-01	1.1E-03	2.3E+00	5.0E-05	6.0E-02	8.8E-03	5.2E+01	5.0E-05	2.0E-04	7.0E-04	4.2E-02	2.8E-04	4.2E-01	1.4E-04	3.5E+00	3.0E+00	-4.6E-01	-7.1%
8-Jan-13	58																											
15-Jan-13	59																											
22-Jan-13	60																											

HC10

Sample = 50% '08-059/ 50% '08-178

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Major	Major	Diff	Diff
	No.																								Anions	Cations		(%)
29-Jan-13	61	1.1E+01	1.7E-04	3.0E-03	1.2E+00	1.4E-01	1.0E-02	2.0E-04	2.2E-02	4.1E-02	1.7E-01	1.1E-03	1.9E+00	3.0E-05	1.0E-01	8.5E-03	5.4E+01	5.0E-05	2.0E-04	1.0E-04	4.0E-02	3.6E-04	3.6E-01	1.4E-04	3.6E+00	3.4E+00	-1.9E-01	-2.8%
5-Feb-13	62																											
12-Feb-13	63																											
19-Feb-13	64																											
26-Feb-13	65	1.1E+01	2.6E-04	3.0E-03	1.2E+00	1.0E-01	1.0E-02	2.8E-04	2.3E-02	5.0E-02	1.5E-01	1.1E-03	1.6E+00	3.0E-05	5.0E-02	6.6E-03	5.1E+01	4.0E-05	3.0E-05	1.0E-04	3.9E-02	6.1E-04	3.6E-01	1.2E-04	3.5E+00	3.5E+00	3.0E-02	0.4%
5-Mar-13	66																											
12-Mar-13	67																											
19-Mar-13	68																											
26-Mar-13	69	9.2E+00	1.9E-04	2.0E-03	9.5E-01	7.2E-02	1.0E-02	1.6E-04	1.8E-02	2.1E-02	1.5E-01	8.9E-04	2.0E+00	1.1E-04	6.0E-02	7.7E-03	4.4E+01	4.0E-05	3.0E-05	1.0E-04	3.0E-02	2.5E-04	2.6E-01	6.0E-05	3.3E+00	2.9E+00	-4.8E-01	-7.7%
2-Apr-13	70																											
9-Apr-13	71																											
16-Apr-13	72																											
23-Apr-13	73	7.1E+00	3.1E-04	3.0E-03	9.0E-01	5.9E-02	1.0E-02	1.2E-04	1.6E-02	9.0E-03	1.5E-01	8.2E-04	1.4E+00	5.0E-05	5.0E-02	7.1E-03	3.6E+01	4.0E-05	3.0E-05	1.0E-04	2.4E-02	3.0E-04	2.3E-01	4.0E-05	2.6E+00	2.5E+00	-1.3E-01	-2.5%
30-Apr-13	74																											
7-May-13	75																											
14-May-13	76																											
21-May-13	77	2.8E+00	4.0E-05	2.0E-03	5.4E-01	3.5E-02	1.0E-02	9.0E-05	1.1E-02	9.0E-03	1.6E-01	4.8E-04	1.1E+00	2.0E-05	4.0E-02	5.7E-03	2.2E+01	4.0E-05	6.0E-05	1.0E-04	1.3E-02	1.0E-04	1.3E-01	2.0E-05	1.5E+00	1.2E+00	-2.4E-01	-8.8%
28-May-13	78	3.9E+00	1.1E-04	2.0E-03	7.6E-01	4.8E-02	1.0E-02	1.9E-04	1.3E-02	9.0E-03	1.7E-01	7.4E-04	8.6E-01	2.0E-05	4.0E-02	6.7E-03	2.6E+01	4.0E-05	9.0E-05	1.0E-04	1.7E-02	1.4E-04	1.5E-01	2.0E-05	2.0E+00	1.7E+00	-2.9E-01	-7.9%
4-Jun-13	79	3.6E+00	4.0E-04	2.0E-03	5.3E-01	3.6E-02	1.0E-02	3.7E-04	1.1E-02	2.0E-02	1.5E-01	5.9E-04	7.4E-01	1.0E-04	5.0E-02	5.7E-03	2.0E+01	3.0E-05	1.1E-03	1.0E-04	1.2E-02	4.6E-04	1.2E-01	3.0E-05	1.2E+00	1.3E+00	1.2E-01	4.9%
11-Jun-13	80	3.3E+00	1.3E-04	1.0E-03	5.0E-01	3.3E-02	1.0E-02	3.0E-04	8.6E-03	9.0E-03	1.1E-01	6.2E-04	9.3E-01	1.0E-05	4.0E-02	5.2E-03	2.0E+01	2.0E-05	1.3E-03	1.0E-04	1.1E-02	4.6E-04	1.0E-01	1.0E-05	1.3E+00	1.1E+00	-1.7E-01	-6.8%
18-Jun-13	81	4.5E+00	2.0E-04	1.0E-03	4.9E-01	3.6E-02	1.0E-02	2.6E-04	9.0E-03	9.0E-03	1.0E-01	6.1E-04	1.6E+00	1.0E-05	5.0E-02	6.9E-03	2.2E+01	2.0E-05	3.0E-04	1.0E-04	1.3E-02	4.5E-04	1.1E-01	2.0E-05	1.5E+00	1.3E+00	-2.1E-01	-7.5%
25-Jun-13	82																											
2-Jul-13	83	1.6E+00	2.5E-04	1.0E-03	1.3E-01	1.2E-02	1.0E-02	2.0E-04	2.8E-03	9.0E-03	6.8E-02	2.8E-04	4.9E-01	1.0E-05	2.0E-02	3.4E-03	8.6E+00	2.0E-05	3.5E-04	1.0E-04	4.1E-03	1.7E-04	4.1E-02	1.0E-05	5.5E-01	5.0E-01	-4.9E-02	-4.7%
9-Jul-13	84																											
16-Jul-13	85	2.1E+00	2.1E-04	1.0E-03	1.2E-01	1.4E-02	1.0E-02	9.0E-05	2.7E-03	9.0E-03	6.9E-02	2.8E-04	6.3E-01	1.0E-05	3.0E-02	4.7E-03	8.9E+00	2.0E-05	6.4E-04	1.0E-04	3.9E-03	8.0E-05	3.8E-02	1.0E-05	5.3E-01	5.3E-01	6.3E-03	0.6%
23-Jul-13	86																											
30-Jul-13	87	1.9E+00	9.0E-05	1.0E-03	9.8E-02	1.2E-02	1.0E-02	1.0E-04	2.3E-03	9.0E-03	6.9E-02	2.4E-04	5.1E-01	1.0E-05	2.0E-02	4.3E-03	7.9E+00	2.0E-05	5.2E-04	1.0E-04	3.6E-03	7.0E-05	3.3E-02	1.0E-05	5.5E-01	5.4E-01	-9.0E-03	-0.8%
6-Aug-13	88																											
13-Aug-13	89	2.2E+00	1.1E-04	1.0E-03	1.0E-01	1.4E-02	1.0E-02	7.0E-05	2.5E-03	9.0E-03	6.3E-02	2.6E-04	5.9E-01	1.0E-05	4.0E-02	5.1E-03	8.1E+00	2.0E-05	8.6E-04	1.0E-04	3.5E-03	3.0E-05	4.1E-02	1.0E-05	5.9E-01	5.5E-01	-3.2E-02	-2.8%
20-Aug-13	90																											
27-Aug-13	91																											
3-Sep-13	92																											
10-Sep-13	93	2.8E+00	1.0E-04	1.0E-03	1.0E-01	1.3E-02	1.0E-02	7.0E-05	2.5E-03	9.0E-03	6.5E-02	2.8E-04	6.7E-01	1.0E-05	2.0E-02	4.9E-03	9.5E+00	2.0E-05	2.4E-03	1.0E-04	3.6E-03	1.1E-04	3.8E-02	1.0E-05	6.1E-01	5.7E-01	-4.0E-02	-3.4%
17-Sep-13	94																											
24-Sep-13	95																											
1-Oct-13	96																											
8-Oct-13	97	2.4E+00	1.1E-04	1.0E-03	8.7E-02	1.1E-02	1.0E-02	4.0E-05	2.4E-03	9.0E-03	7.1E-02	2.5E-04	6.0E-01	1.0E-05	6.0E-02	4.5E-03	8.6E+00	2.0E-05	6.7E-04	1.0E-04	3.3E-03	4.0E-05	3.6E-02	1.0E-05	4.8E-01	5.4E-01	5.6E-02	5.5%
15-Oct-13	98																											
22-Oct-13	99																											
29-Oct-13	100																											
5-Nov-13	101	2.1E+00	4.0E-05	1.0E-03	7.8E-02	9.4E-03	1.0E-02	2.0E-05	1.7E-03	9.0E-03	6.6E-02	2.5E-04	6.8E-01	1.0E-05	2.0E-02	4.2E-03	7.1E+00	2.0E-05	2.2E-03	1.0E-04	2.6E-03	4.0E-05	3.1E-02	1.0E-05	3.8E-01	4.3E-01	5.9E-02	7.3%
12-Nov-13	102																											
19-Nov-13	103																											
26-Nov-13	104																											
3-Dec-13	105	2.3E+00	3.0E-05	1.0E-03	8.1E-02	8.9E-03	1.0E-02	4.0E-05	2.1E-03	9.0E-03	6.3E-02	2.3E-04	3.5E-01	1.0E-05	3.0E-02	3.9E-03	7.5E+00	2.0E-05	2.7E-03	1.0E-04	2.7E-03	6.0E-05	3.2E-02	1.0E-05	4.2E-01	4.1E-01	-4.2E-03	-0.5%
10-Dec-13	106																											
17-Dec-13	107																											
24-Dec-13	108																											
31-Dec-13	109	1.2E+00	1.7E-04	1.0E-03	5.3E-02	5.6E-03	1.0E-02	4.0E-05	1.4E-03	9.0E-03	5.9E-02	1.8E-04	3.3E-01	1.0E-05	3.0E-02	2.9E-03	5.2E+00	2.0E-05	6.7E-04	1.0E-04	1.6E-03	5.0E-05	2.4E-02	1.0E-05	2.5E-01	3.0E-01	5.0E-02	9.0%
7-Jan-14	110																											
14-Jan-14	111																											
21-Jan-14	112																											
28-Jan-14	113	2.1E+00	2.0E-05	1.0E-03	8.4E-02	8.1E-03	1.0E-02	1.0E-05	1.9E-03	9.0E-03	6.3E-02	1.9E-04	3.9E-01	1.0E-05	3.0E-02	3.7E-03	7.2E+00	2.0E-05	3.8E-04	1.0E-04	2.3E-03	3.0E-05	3.0E-02	1.0E-05	2.3E-01	4.2E-01	1.9E-01	29.6%
4-Feb-14	114																											
11-Feb-14	115																											

HC10

Sample = 50% '08-059/ 50% '08-178

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Major	Major	Diff	Diff
	No.																								Anions	Cations		(%)
18-Feb-14	116																											
25-Feb-14	117	1.7E+00	3.0E-05	1.0E-03	7.2E-02	6.6E-03	1.0E-02	3.0E-05	1.8E-03	9.0E-03	6.4E-02	1.7E-04	3.6E-01	1.0E-05	3.0E-02	3.4E-03	6.4E+00	2.0E-05	4.1E-04	1.0E-04	2.1E-03	3.0E-05	3.0E-02	1.0E-05	3.3E-01	3.8E-01	4.7E-02	6.6%
4-Mar-14	118																											
11-Mar-14	119																											
18-Mar-14	120																											
25-Mar-14	121	1.8E+00	3.0E-05	1.0E-03	7.4E-02	7.0E-03	1.0E-02	8.0E-05	1.5E-03	2.5E-02	5.8E-02	1.8E-04	3.6E-01	1.0E-05	3.0E-02	3.4E-03	6.6E+00	2.0E-05	1.3E-03	1.0E-04	2.2E-03	3.0E-05	3.2E-02	1.0E-05	3.5E-01	3.8E-01	2.6E-02	3.5%
1-Apr-14	122																											
8-Apr-14	123																											
15-Apr-14	124																											
22-Apr-14	125	2.5E+00	2.0E-05	1.9E-04	7.9E-02	7.9E-03	1.0E-02	1.0E-04	2.0E-03	9.0E-03	6.2E-02	1.8E-04	4.0E-01	6.0E-06	6.0E-02	3.6E-03	6.8E+00	1.1E-05	1.6E-04	5.0E-05	2.0E-03	1.4E-04	3.4E-02	2.0E-03	3.5E-01	4.8E-01	1.3E-01	15.2%
29-Apr-14	126																											
6-May-14	127																											
13-May-14	128																											
20-May-14	129	2.0E+00	4.5E-04	2.0E-04	7.2E-02	6.9E-03	1.0E-02	1.7E-04	1.6E-03	9.0E-03	5.4E-02	1.4E-04	4.1E-01	1.8E-05	3.0E-02	3.4E-03	5.8E+00	1.3E-05	7.4E-04	5.0E-05	1.9E-03	7.0E-05	2.9E-02	2.0E-03	2.9E-01	3.9E-01	9.7E-02	14.3%
27-May-14	130																											
3-Jun-14	131																											
10-Jun-14	132																											
17-Jun-14	133	1.7E+00	4.0E-05	1.7E-04	6.2E-02	6.3E-03	1.0E-02	2.0E-05	1.5E-03	9.0E-03	5.8E-02	1.6E-04	4.6E-01	8.0E-06	3.0E-02	3.1E-03	5.6E+00	1.4E-05	2.0E-03	5.0E-05	1.7E-03	3.0E-05	2.7E-02	2.0E-03	2.5E-01	3.6E-01	1.1E-01	17.9%
24-Jun-14	134																											
1-Jul-14	135																											
8-Jul-14	136																											
15-Jul-14	137	2.2E+00	3.0E-05	2.1E-04	7.8E-02	7.4E-03	1.0E-02	3.0E-05	1.7E-03	1.3E-02	6.6E-02	1.9E-04	4.6E-01	1.2E-05	3.0E-02	3.5E-03	6.7E+00	1.2E-05	3.9E-04	5.0E-05	2.1E-03	4.0E-05	3.3E-02	2.0E-03	3.3E-01	4.3E-01	9.9E-02	13.0%
22-Jul-14	138																											
29-Jul-14	139																											
5-Aug-14	140																											
12-Aug-14	141	1.8E+00	6.0E-05	1.7E-04	6.8E-02	6.3E-03	1.0E-02	8.0E-05	1.4E-03	9.0E-03	5.9E-02	1.6E-04	4.7E-01	8.0E-06	3.0E-02	3.1E-03	5.9E+00	1.4E-05	2.0E-03	5.0E-05	1.9E-03	2.0E-05	2.9E-02	2.0E-03	2.3E-01	3.9E-01	1.6E-01	25.4%
19-Aug-14	142																											
26-Aug-14	143																											
2-Sep-14	144																											
9-Sep-14	145	2.8E+00	8.0E-05	2.8E-04	1.1E-01	6.5E-03	< 0.01	3.0E-05	2.2E-03	< 0.003	7.6E-02	2.8E-04	8.4E-01	1.3E-05	3.0E-02	4.6E-03	9.8E+00	1.9E-05	1.6E-04	< 0.00005	3.4E-03	4.0E-05	5.3E-02	< 0.002				
16-Sep-14	146																											
23-Sep-14	147																											
30-Sep-14	148																											

HC10

Sample = 50% '08-059/ 50% '08-178

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/kg	mgCaCO3/kg	mgCaCO3/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
29-Nov-11	0	500	385	4.48	1.0E+03	1.3E+00	8.0E+01	#N/A	198.66	1.4E+00	7.9E-01	1.2E-01	9.5E+01	7.7E+00	2.9E-03	1.4E-03	1.3E-02	1.6E-03	3.9E-06	1.3E-02	9.0E-03	2.9E+01	2.8E-03	3.0E-01	5.4E+01
6-Dec-11	1	500	470	4.43	6.9E+02	9.2E-01	5.9E+01	#N/A	143.82	9.9E-01	2.8E-02	1.4E-01	7.0E+01	4.9E+00	3.2E-03	8.9E-04	9.1E-03	1.7E-03	4.7E-06	3.1E-02	7.4E-03	1.9E+01	3.1E-03	2.6E-01	2.7E+01
13-Dec-11	2	500	435	4.55	4.2E+02	#N/A	3.5E+01	4.4E-02	78.30	5.7E-01	4.9E-01	1.3E-01	3.8E+01	2.2E+00	2.0E-03	7.4E-04	8.0E-03	8.4E-04	4.4E-06	2.1E-02	4.0E-03	1.1E+01	2.2E-03	1.8E-01	1.5E+01
20-Dec-11	3	500	520	4.65	3.0E+02	#N/A	3.0E+01	5.2E-02	78.52	3.1E-01	4.5E-01	1.6E-01	3.5E+01	1.7E+00	2.8E-03	7.8E-04	9.0E-03	8.1E-04	5.2E-06	2.0E-02	2.9E-03	1.1E+01	1.4E-03	1.0E-01	1.3E+01
27-Dec-11	4	500	435	4.78	2.2E+02																				
3-Jan-12	5	500	445	4.67	1.6E+02	#N/A	1.3E+01	4.5E-02	32.04	1.8E-01	2.2E-01	1.3E-01	1.3E+01	9.8E-01	1.5E-03	4.5E-04	7.6E-03	4.4E-04	4.5E-06	9.7E-03	1.6E-03	3.9E+00	5.3E-04	4.5E-02	6.4E+00
10-Jan-12	6	500	430	4.58	1.5E+02																				
17-Jan-12	7	500	445	4.73	1.2E+02	#N/A	1.1E+01	4.5E-02	24.48	8.9E-02	1.8E-01	1.3E-01	9.1E+00	6.9E-01	1.6E-03	4.9E-04	9.5E-03	4.3E-04	4.5E-06	7.4E-03	1.3E-03	2.9E+00	4.9E-04	2.8E-02	5.4E+00
24-Jan-12	8	500	440	4.67	1.2E+02																				
31-Jan-12	9	500	450	4.63	1.1E+02	#N/A	9.5E+00	4.5E-02	21.15	9.0E-02	1.8E-01	1.4E-01	6.3E+00	4.7E-01	1.2E-03	4.1E-04	9.9E-03	4.1E-04	4.5E-06	5.8E-03	6.8E-04	2.0E+00	3.6E-04	2.2E-02	5.1E+00
7-Feb-12	10	500	455	4.63	1.1E+02																				
14-Feb-12	11	500	450	4.56	1.2E+02	#N/A	1.4E+01	4.5E-02	22.95	9.0E-02	1.9E-01	1.4E-01	6.1E+00	8.1E-01	9.0E-04	4.1E-04	8.3E-03	4.6E-04	4.5E-06	5.2E-03	7.1E-04	1.9E+00	2.7E-04	2.3E-02	5.8E+00
21-Feb-12	12	500	465	4.61	1.2E+02																				
28-Feb-12	13	500	465	4.46	1.1E+02	5.3E-01	1.4E+01	#N/A	19.53	9.3E-02	1.9E-01	1.4E-01	4.9E+00	9.4E-01	9.3E-04	3.7E-04	7.8E-03	4.5E-04	4.7E-06	4.9E-03	6.0E-04	1.5E+00	2.8E-04	1.8E-02	4.8E+00
6-Mar-12	14	500	445	4.47	1.4E+02																				
13-Mar-12	15	500	450	4.33	1.3E+02	1.2E+00	1.8E+01	#N/A	23.85	9.0E-02	2.2E-01	1.4E-01	4.6E+00	1.2E+00	9.9E-04	3.6E-04	5.9E-03	5.0E-04	4.5E-06	4.5E-03	7.1E-04	1.4E+00	3.6E-04	2.1E-02	5.6E+00
20-Mar-12	16	500	445	4.36	1.3E+02																				
27-Mar-12	17	500	450	4.20	1.4E+02	1.8E+00	2.0E+01	#N/A	28.35	9.0E-02	2.2E-01	1.4E-01	3.9E+00	1.8E+00	6.8E-04	2.7E-04	4.4E-03	7.7E-04	4.5E-06	3.6E-03	6.0E-04	1.2E+00	3.2E-04	1.7E-02	5.1E+00
3-Apr-12	18	500	460	4.16	1.4E+02																				
10-Apr-12	19	500	450	4.57	1.2E+02	#N/A	1.7E+01	4.5E-02	26.10	9.0E-02	2.0E-01	1.4E-01	2.8E+00	1.7E+00	7.7E-04	2.7E-04	8.1E-03	7.7E-04	4.5E-06	3.2E-03	6.0E-04	8.8E-01	3.6E-04	1.5E-02	4.4E+00
17-Apr-12	20	500	455	4.16	1.6E+02																				
24-Apr-12	21	500	460	4.10	1.3E+02	3.0E+00	2.0E+01	#N/A	24.38	4.6E-01	1.7E-01	1.4E-01	2.2E+00	1.9E+00	8.7E-04	3.7E-04	6.7E-03	7.7E-04	4.6E-06	2.8E-03	5.4E-04	6.8E-01	4.1E-04	1.1E-02	3.8E+00
1-May-12	22	500	440	4.16	1.4E+02																				
8-May-12	23	500	460	4.09	1.4E+02	3.7E+00	2.1E+01	#N/A	24.38	4.6E-01	1.2E-01	1.4E-01	2.0E+00	1.8E+00	7.8E-04	4.1E-04	7.8E-03	6.6E-04	4.6E-06	3.1E-03	5.4E-04	6.4E-01	3.7E-04	1.1E-02	3.3E+00
15-May-12	24	500	445	3.98	1.5E+02																				
22-May-12	25	500	430	4.08	1.8E+02	5.0E+00	3.0E+01	#N/A	30.96	4.3E-01	1.7E-01	1.3E-01	1.9E+00	3.2E+00	1.4E-03	6.5E-04	4.4E-03	8.4E-04	4.3E-06	3.0E-03	6.5E-04	5.7E-01	8.2E-04	1.3E-02	4.1E+00
29-May-12	26	500	435	4.05	1.4E+02																				
5-Jun-12	27	500	440	4.11	1.3E+02	3.3E+00	2.1E+01	#N/A	22.44	4.4E-01	1.3E-01	1.3E-01	1.6E+00	2.1E+00	6.2E-04	3.1E-04	4.4E-03	7.0E-04	4.4E-06	3.1E-03	4.2E-04	4.9E-01	4.4E-04	1.1E-02	2.5E+00
12-Jun-12	28	500	455	4.08	1.3E+02																				
19-Jun-12	29	500	445	4.03	1.3E+02	4.1E+00	2.1E+01	#N/A	22.70	8.9E-02	1.2E-01	1.3E-01	1.2E+00	2.2E+00	5.3E-04	3.6E-04	4.0E-03	6.5E-04	4.5E-06	2.0E-03	3.9E-04	3.6E-01	4.5E-04	9.8E-03	2.3E+00
26-Jun-12	30	500	445	4.04	1.4E+02																				
3-Jul-12	31	500	445	4.12	1.5E+02	6.2E+00	2.7E+01	#N/A	26.26	4.5E-01	1.2E-01	1.3E-01	1.3E+00	2.6E+00	6.7E-04	3.6E-04	5.6E-03	6.6E-04	4.5E-06	1.4E-03	4.6E-04	3.7E-01	4.5E-04	1.0E-02	2.6E+00
10-Jul-12	32	500	445	3.89	1.7E+02																				
17-Jul-12	33	500	445	3.84	1.7E+02	1.0E+01	2.8E+01	#N/A	31.15	4.5E-01	1.3E-01	1.3E-01	1.4E+00	3.0E+00	8.0E-04	6.7E-04	3.5E-03	8.5E-04	4.5E-06	2.4E-03	6.6E-04	3.7E-01	6.2E-04	1.3E-02	3.0E+00
24-Jul-12	34	500	440	3.86	1.9E+02																				
31-Jul-12	35	500	445	3.82	1.8E+02	1.1E+01	3.2E+01	#N/A	36.05	8.9E-02	1.3E-01	1.3E-01	1.3E+00	3.2E+00	7.6E-04	4.5E-04	3.3E-03	7.3E-04	4.5E-06	1.7E-03	6.7E-04	3.4E-01	7.6E-04	1.1E-02	2.9E+00
7-Aug-12	36	500	460	3.80	2.0E+02																				
14-Aug-12	37	500	445	3.75	2.2E+02	1.7E+01	4.3E+01	#N/A	43.61	4.5E-01	1.4E-01	1.3E-01	1.5E+00	5.2E+00	7.1E-04	7.1E-04	3.0E-03	7.6E-04	4.5E-06	1.4E-03	8.3E-04	3.7E-01	9.3E-04	1.3E-02	3.3E+00
21-Aug-12	38	500	450	3.71	2.3E+02																				
28-Aug-12	39	500	490	3.69	2.5E+02	1.7E+01	4.7E+01	#N/A	52.43	4.9E-01	1.5E-01	1.5E-01	1.8E+00	5.9E+00	8.8E-04	5.4E-04	3.1E-03	7.8E-04	4.9E-06	2.0E-03	9.8E-04	4.5E-01	1.3E-03	1.5E-02	3.3E+00
4-Sep-12	40	500	480	3.65	2.6E+02																				
11-Sep-12	41	500	450	3.56	3.2E+02	2.9E+01	6.4E+01	#N/A	56.70	4.5E-01	1.6E-01	1.4E-01	2.0E+00	7.7E+00	6.8E-04	4.5E-04	2.4E-03	6.9E-04	4.5E-06	8.1E-04	1.2E-03	4.3E-01	1.8E-03	1.8E-02	3.7E+00
18-Sep-12	42	500	505	3.49	3.4E+02																				
25-Sep-12	43	500	450	3.49	3.5E+02	2.9E+01	6.1E+01	#N/A	55.35	9.0E-02	1.4E-01	1.4E-01	2.2E+00	8.7E+00	9.0E-05	3.6E-04	2.0E-03	7.2E-04	4.5E-06	1.8E-04	1.2E-03	3.9E-01	3.0E-03	2.1E-02	3.6E+00
2-Oct-12	44	500	460	3.62	2.6E+02																				
9-Oct-12	45	500	470	3.28	3.8E+02	3.6E+01	6.8E+01	#N/A	62.98	4.7E-01	1.4E-01	1.4E-01	2.2E+00	8.2E+00	1.9E-04	3.3E-04	2.0E-03	4.0E-04	4.7E-06	6.1E-04	1.1E-03	3.4E-01	2.9E-03	1.9E-02	2.8E+00
16-Oct-12	46	500	455	3.49	4.3E+02																				
23-Oct-12	47	500	480	3.14	5.0E+02																				

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Sample = 50% '08-059/ 50% '08-178

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/kg	mgCaCO3/kg	mgCaCO3/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
30-Oct-12	48	500	465	3.51	3.0E+02																				
6-Nov-12	49	500	435	3.22	4.4E+02	3.4E+01	6.6E+01	#N/A	70.91	4.4E-01	1.7E-01	1.3E-01	3.7E+00	8.7E+00	2.2E-04	4.8E-04	1.8E-03	5.1E-04	4.4E-06	5.7E-04	1.1E-03	5.2E-01	2.6E-03	2.5E-02	2.8E+00
13-Nov-12	50	500	450	3.34	3.5E+02																				
20-Nov-12	51	500	490	3.16	4.8E+02																				
27-Nov-12	52	500	490	3.31	4.1E+02																				
4-Dec-12	53	500	455	3.10	5.8E+02	4.4E+01	8.0E+01	#N/A	70.07	4.6E-01	1.4E-01	1.4E-01	3.1E+00	7.9E+00	2.7E-04	8.6E-04	3.3E-03	4.6E-04	4.6E-06	6.8E-04	1.3E-03	4.3E-01	2.6E-03	2.4E-02	2.5E+00
11-Dec-12	54	500	460	3.30	4.7E+02																				
18-Dec-12	55	500	465	3.09	5.1E+02																				
25-Dec-12	56	500	455	3.35	4.6E+02																				
1-Jan-13	57	500	455	3.12	5.1E+02	3.7E+01	6.7E+01	#N/A	75.08	4.6E-01	1.6E-01	1.4E-01	3.1E+00	5.5E+00	1.8E-04	8.2E-04	2.7E-03	3.8E-04	4.6E-06	2.7E-04	9.2E-04	4.3E-01	2.3E-03	1.9E-02	1.8E+00
8-Jan-13	58	500	470	3.19	4.9E+02																				
15-Jan-13	59	500	480	3.13	4.4E+02																				
22-Jan-13	60	500	465	3.21	4.8E+02																				
29-Jan-13	61	500	450	3.10	4.8E+02	3.7E+01	6.3E+01	#N/A	76.50	4.5E-01	1.8E-01	1.4E-01	3.4E+00	6.8E+00	1.8E-04	8.1E-04	2.3E-03	4.2E-04	4.5E-06	4.5E-04	8.1E-04	4.6E-01	2.2E-03	2.0E-02	1.8E+00
5-Feb-13	62	500	435	3.15	5.0E+02																				
12-Feb-13	63	500	480	3.08	5.3E+02																				
19-Feb-13	64	500	460	3.11	5.1E+02																				
26-Feb-13	65	500	450	3.11	4.9E+02	3.7E+01	6.2E+01	#N/A	75.15	4.5E-01	2.1E-01	1.4E-01	3.5E+00	7.6E+00	1.8E-04	1.2E-03	1.9E-03	4.2E-04	4.5E-06	1.8E-04	8.6E-04	5.1E-01	2.3E-03	2.0E-02	1.8E+00
5-Mar-13	66	500	455	3.23	4.2E+02																				
12-Mar-13	67	500	420	3.27	3.6E+02																				
19-Mar-13	68	500	480	3.28	4.0E+02																				
26-Mar-13	69	500	460	3.18	4.2E+02	3.8E+01	6.6E+01	#N/A	73.14	4.6E-01	1.9E-01	1.4E-01	2.6E+00	6.1E+00	1.8E-04	6.9E-04	2.7E-03	3.2E-04	4.6E-06	4.1E-04	6.0E-04	3.4E-01	1.7E-03	1.6E-02	1.4E+00
2-Apr-13	70	500	445	3.17	4.1E+02																				
9-Apr-13	71	500	455	3.21	4.3E+02																				
16-Apr-13	72	500	450	3.31	4.3E+02																				
23-Apr-13	73	500	450	3.21	4.2E+02	2.9E+01	5.3E+01	#N/A	56.25	4.5E-01	1.8E-01	1.4E-01	2.4E+00	5.2E+00	1.4E-04	5.0E-04	2.6E-03	2.9E-04	4.5E-06	5.0E-04	5.2E-04	2.8E-01	1.2E-03	1.4E-02	1.2E+00
30-Apr-13	74	500	445	3.25	3.6E+02																				
7-May-13	75	500	450	3.19	4.3E+02																				
14-May-13	76	500	450	3.28	3.5E+02																				
21-May-13	77	500	445	3.36	2.4E+02	1.6E+01	3.1E+01	#N/A	31.15	4.5E-01	1.2E-01	1.3E-01	1.6E+00	2.1E+00	8.9E-05	2.7E-04	2.5E-03	1.6E-04	4.5E-06	6.7E-04	2.6E-04	2.4E-01	6.7E-04	8.1E-03	6.1E-01
28-May-13	78	500	445	3.34	2.8E+02		3.8E+01	#N/A	42.28	4.5E-01	1.5E-01	1.3E-01	2.2E+00	3.5E+00	8.9E-05	2.2E-04	2.0E-03	2.2E-04	4.5E-06	5.8E-04	3.1E-04	3.2E-01	8.5E-04	1.0E-02	7.3E-01
4-Jun-13	79	500	450	3.51	2.1E+02		3.1E+01	#N/A	26.10	9.0E-02	1.1E-01	1.4E-01	1.7E+00	2.9E+00	3.6E-04	4.5E-04	2.9E-03	1.2E-04	4.5E-06	2.1E-03	2.2E-04	3.0E-01	7.7E-04	8.0E-03	5.9E-01
11-Jun-13	80	500	425	3.65	1.9E+02		2.9E+01	#N/A	26.35	4.3E-01	1.0E-01	1.3E-01	1.5E+00	2.4E+00	3.0E-04	2.6E-04	2.0E-03	1.2E-04	4.3E-06	1.1E-03	1.9E-04	2.3E-01	6.0E-04	6.7E-03	5.0E-01
18-Jun-13	81	500	525	3.56	2.2E+02	1.8E+01	3.6E+01	#N/A	37.28	5.3E-01	1.1E-01	1.6E-01	1.7E+00	3.0E+00	4.2E-04	3.7E-04	2.1E-03	1.8E-04	5.3E-06	1.4E-03	2.9E-04	2.7E-01	7.4E-04	9.2E-03	7.5E-01
25-Jun-13	82	500	465	3.73	1.3E+02																				
2-Jul-13	83	500	440	3.80	1.0E+02		1.2E+01	#N/A	11.44	4.4E-01	3.5E-02	1.3E-01	4.2E-01	8.3E-01	2.2E-04	1.8E-04	1.5E-03	5.3E-05	4.4E-06	8.8E-05	7.7E-05	7.0E-02	2.2E-04	2.6E-03	2.4E-01
9-Jul-13	84	500	500	3.75	1.4E+02																				
16-Jul-13	85	500	490	3.71	1.1E+02	7.2E+00	1.5E+01	#N/A	12.25	4.9E-01	3.9E-02	1.5E-01	5.8E-01	7.8E-01	2.9E-04	2.9E-04	2.7E-03	5.9E-05	4.9E-06	9.3E-04	8.3E-05	1.3E-01	2.5E-04	2.8E-03	2.7E-01
23-Jul-13	86	500	495	3.76	1.1E+02																				
30-Jul-13	87	500	480	3.71	1.1E+02		1.4E+01	#N/A	12.48	4.8E-01	3.4E-02	1.4E-01	4.7E-01	8.7E-01	2.4E-04	1.4E-04	3.0E-03	4.8E-05	4.8E-06	8.6E-04	7.3E-05	1.1E-01	2.4E-04	2.5E-03	2.3E-01
6-Aug-13	88	500	520	3.74	1.2E+02																				
13-Aug-13	89	500	485	3.66	1.1E+02	7.4E+00	1.4E+01	#N/A	13.58	4.9E-01	2.9E-02	1.5E-01	5.5E-01	7.6E-01	2.4E-04	1.9E-04	4.1E-03	5.3E-05	4.9E-06	9.2E-04	8.2E-05	1.4E-01	2.4E-04	2.5E-03	2.5E-01
20-Aug-13	90	500	485	3.68	1.2E+02																				
27-Aug-13	91	500	490	3.64	1.1E+02																				
3-Sep-13	92	500	485	3.73	1.1E+02																				
10-Sep-13	93	500	480	3.68	1.2E+02	7.9E+00	1.5E+01	#N/A	13.92	9.6E-02	3.4E-02	1.4E-01	3.8E-01	7.4E-01	1.9E-04	2.4E-04	3.7E-03	5.3E-05	4.8E-06	9.6E-04	1.3E-04	7.7E-02	2.4E-04	2.9E-03	2.5E-01
17-Sep-13	94	500	470	3.72	1.1E+02																				
24-Sep-13	95	500	505	3.61	1.3E+02																				
1-Oct-13	96	500	465	3.65	1.3E+02																				
8-Oct-13	97	500	475	3.64	1.2E+02	7.0E+00	1.3E+01	#N/A	10.93	9.5E-02	2.9E-02	1.4E-01	4.3E-01	5.9E-01	1.4E-04	2.4E-04	3.5E-03	4.3E-05	4.8E-06	1.6E-03	7.9E-05	1.0E-01	2.4E-04	2.5E-03	2.3E-01
15-Oct-13	98	500	500	3.54	1.2E+02																				
22-Oct-13	99	500	480	3.68	1.2E+02																				
29-Oct-13	100	500	460	3.68	1.3E+02																				

HC10

Sample = 50% '08-059/ 50% '08-178

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/kg	mgCaCO3/kg	mgCaCO3/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
5-Nov-13	101	500	495	3.74	1.1E+02	6.2E+00	1.2E+01	#N/A	8.91	9.9E-02	3.0E-02	1.5E-01	3.9E-01	4.6E-01	1.5E-04	1.5E-04	3.9E-03	4.0E-05	5.0E-06	6.4E-04	7.3E-05	9.4E-02	2.5E-04	2.2E-03	2.1E-01
12-Nov-13	102	500	470	3.79	1.1E+02																				
19-Nov-13	103	500	475	3.86	1.1E+02																				
26-Nov-13	104	500	475	3.85	1.1E+02																				
3-Dec-13	105	500	480	3.89	1.1E+02	3.9E+00	1.2E+01	#N/A	9.60	9.6E-02	2.9E-02	1.4E-01	3.8E-01	5.5E-01	1.4E-04	1.9E-04	3.7E-03	3.4E-05	4.8E-06	5.3E-04	8.3E-05	9.1E-02	2.4E-04	2.4E-03	2.2E-01
10-Dec-13	106	500	475	3.75	1.1E+02																				
17-Dec-13	107	500	475	3.67	1.0E+02																				
24-Dec-13	108	500	505	3.80	9.9E+01																				
31-Dec-13	109	500	455	3.80	8.3E+01	3.8E+00	7.6E+00	#N/A	5.46	9.1E-02	2.7E-02	1.4E-01	2.5E-01	2.2E-01	9.1E-05	1.4E-04	4.2E-03	2.3E-05	4.6E-06	7.7E-04	4.9E-05	6.4E-02	2.3E-04	1.4E-03	1.4E-01
7-Jan-14	110	500	500	3.65	1.1E+02																				
14-Jan-14	111	500	475	3.67	9.8E+01																				
21-Jan-14	112	500	480	3.74	1.1E+02																				
28-Jan-14	113	500	480	3.73	1.0E+02	5.5E+00	1.1E+01	#N/A	5.28	9.6E-02	2.9E-02	1.4E-01	3.7E-01	4.0E-01	1.4E-04	1.4E-04	3.7E-03	1.9E-05	4.8E-06	5.8E-04	7.5E-05	8.6E-02	2.4E-04	2.1E-03	1.9E-01
4-Feb-14	114	500	475	3.72	1.1E+02																				
11-Feb-14	115	500	470	3.73	1.0E+02																				
18-Feb-14	116	500	480	3.72	1.0E+02																				
25-Feb-14	117	500	470	3.76	1.0E+02	5.7E+00	1.1E+01	#N/A	7.52	9.4E-02	2.8E-02	1.4E-01	3.1E-01	3.7E-01	9.4E-05	9.4E-05	3.9E-03	2.4E-05	4.7E-06	3.8E-04	7.3E-05	6.6E-02	2.4E-04	2.0E-03	2.0E-01
4-Mar-14	118	500	490	3.72	1.1E+02																				
11-Mar-14	119	500	485	3.72	1.1E+02																				
18-Mar-14	120	500	465	3.70	1.1E+02																				
25-Mar-14	121	500	475	3.82	1.1E+02	4.5E+00	9.7E+00	#N/A	8.08	9.5E-02	2.9E-02	1.4E-01	3.6E-01	4.2E-01	9.5E-05	9.5E-05	4.0E-03	2.4E-05	4.8E-06	2.9E-04	7.5E-05	8.6E-02	2.4E-04	2.1E-03	2.1E-01
1-Apr-14	122	500	500	3.77	1.0E+02																				
8-Apr-14	123	500	460	3.69	1.0E+02																				
15-Apr-14	124	500	480	3.72	1.1E+02																				
22-Apr-14	125	500	470	3.68	1.1E+02	5.3E+00	1.0E+01	#N/A	7.99	9.4E-02	2.8E-02	1.4E-01	3.2E-01	4.2E-01	1.9E-04	1.4E-04	3.0E-03	2.6E-05	3.3E-06	2.8E-04	7.8E-05	7.1E-02	1.3E-04	2.1E-03	2.4E-01
29-Apr-14	126	500	480	3.76	1.1E+02																				
6-May-14	127	500	485	3.67	9.4E+01																				
13-May-14	128	500	500	3.83	9.2E+01																				
20-May-14	129	500	480	3.76	8.9E+01	5.4E+00	1.2E+01	#N/A	6.72	9.6E-02	2.9E-02	1.4E-01	3.3E-01	3.3E-01	2.9E-04	1.4E-04	3.3E-03	2.1E-05	3.4E-06	9.6E-05	7.0E-05	7.7E-02	9.1E-05	1.9E-03	2.0E-01
27-May-14	130	500	480	3.79	9.1E+01																				
3-Jun-14	131	500	480	3.68	8.2E+01																				
10-Jun-14	132	500	495	3.67	1.0E+02																				
17-Jun-14	133	500	490	3.74	8.7E+01	4.9E+00	9.7E+00	#N/A	5.88	9.8E-02	2.9E-02	1.5E-01	2.7E-01	2.6E-01	2.0E-04	1.5E-04	4.3E-03	1.9E-05	3.4E-06	9.8E-04	6.4E-05	5.9E-02	9.8E-05	1.7E-03	1.9E-01
24-Jun-14	134	500	505	3.73	1.0E+02																				
1-Jul-14	135	500	475	3.77	9.3E+01																				
8-Jul-14	136	500	500	3.74	1.2E+02																				
15-Jul-14	137	500	475	3.69	1.1E+02	5.3E+00	1.0E+01	#N/A	7.60	9.5E-02	2.9E-02	1.4E-01	3.4E-01	3.2E-01	9.5E-05	1.4E-04	3.2E-03	2.5E-05	3.3E-06	7.1E-04	7.6E-05	7.6E-02	8.6E-05	2.1E-03	2.2E-01
22-Jul-14	138	500	470	3.82	9.5E+01																				
29-Jul-14	139	500	505	3.58	1.2E+02																				
5-Aug-14	140	500	485	3.53	1.2E+02																				
12-Aug-14	141	500	490	3.71	1.0E+02	5.7E+00	1.1E+01	#N/A	5.39	9.8E-02	2.9E-02	1.5E-01	3.1E-01	2.9E-01	9.8E-05	1.5E-04	3.2E-03	2.1E-05	3.4E-06	8.8E-04	7.4E-05	6.9E-02	9.3E-05	1.9E-03	1.9E-01
19-Aug-14	142	500	485	3.77	1.0E+02																				
26-Aug-14	143	500	500	3.74	1.1E+02																				
2-Sep-14	144	500	415																						

HC10

Sample = 50% '08-059/ 50% '08-178

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
	No.																							
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
29-Nov-11	0	7.5E-01	4.3E-04	7.7E-03	5.7E+00	7.2E-01	1.2E-05	2.4E-03	2.5E-01	2.1E-02	5.7E+00	7.3E-03	3.1E-01	1.9E-05	1.8E+01	8.4E-02	6.8E+01	8.8E-04	2.3E-05	1.5E-04	2.5E-02	2.1E-04	1.2E+00	7.7E-04
6-Dec-11	1	3.8E-01	2.2E-04	9.4E-03	5.4E+00	6.5E-01	1.4E-05	2.0E-03	2.2E-01	2.7E-02	4.0E+00	6.4E-03	1.1E+00	4.7E-05	1.3E+01	5.7E-02	5.6E+01	7.7E-04	4.7E-06	1.9E-04	1.6E-02	2.2E-04	1.2E+00	4.9E-04
13-Dec-11	2	2.0E-01	2.6E-03	6.1E-03	2.8E+00	3.7E-01	8.7E-06	1.3E-03	1.6E-01	2.0E-02	2.4E+00	5.1E-03	7.0E-01	8.7E-06	5.2E+00	3.3E-02	2.8E+01	4.2E-04	2.2E-04	1.3E-04	8.4E-03	9.1E-05	6.8E-01	2.0E-04
20-Dec-11	3	2.4E-01	4.2E-05	4.7E-03	1.9E+00	2.6E-01	5.2E-06	1.1E-03	8.5E-02	1.1E-01	2.0E+00	2.8E-03	1.3E+00	5.2E-06	2.4E+00	3.3E-02	2.4E+01	4.3E-04	5.2E-06	3.6E-04	5.5E-03	2.0E-04	4.2E-01	1.3E-04
27-Dec-11	4																							
3-Jan-12	5	1.1E-01	1.0E-03	2.7E-03	7.3E-01	1.1E-01	4.5E-06	5.0E-04	4.0E-02	1.1E-02	1.0E+00	1.1E-03	3.2E-01	4.5E-06	4.7E-01	1.4E-02	9.4E+00	1.9E-04	3.1E-05	2.2E-04	2.9E-03	2.5E-04	2.1E-01	5.8E-05
10-Jan-12	6																							
17-Jan-12	7	1.5E-01	2.0E-03	2.2E-03	4.7E-01	7.0E-02	4.5E-06	5.4E-04	2.5E-02	5.3E-02	8.7E-01	7.6E-04	3.2E-01	4.5E-06	1.7E-01	1.1E-02	7.1E+00	1.4E-04	1.3E-05	8.9E-05	2.2E-03	1.2E-04	1.6E-01	4.0E-05
24-Jan-12	8																							
31-Jan-12	9	1.7E-01	1.7E-04	1.8E-03	3.6E-01	6.0E-02	4.5E-06	4.1E-04	2.0E-02	4.1E-03	6.6E-01	9.3E-04	3.4E-01	4.5E-06	1.0E-01	8.7E-03	6.1E+00	9.9E-05	9.0E-06	9.0E-05	2.2E-03	1.6E-04	1.2E-01	1.8E-05
7-Feb-12	10																							
14-Feb-12	11	2.7E-01	3.2E-05	1.4E-03	3.3E-01	6.3E-02	4.5E-06	4.5E-04	2.1E-02	4.9E-02	5.6E-01	7.7E-04	3.3E-01	4.5E-06	8.6E-02	9.0E-03	6.4E+00	9.5E-05	4.5E-06	9.0E-05	3.0E-03	8.6E-05	1.3E-01	9.0E-06
21-Feb-12	12																							
28-Feb-12	13	3.4E-01	9.8E-05	1.4E-03	2.7E-01	6.1E-02	4.7E-06	3.3E-04	1.7E-02	5.1E-02	6.0E-01	6.3E-04	3.6E-01	4.7E-06	7.4E-02	8.2E-03	5.9E+00	1.3E-04	2.8E-05	9.3E-05	3.3E-03	1.0E-04	1.2E-01	1.4E-05
6-Mar-12	14																							
13-Mar-12	15	5.6E-01	5.9E-05	9.0E-04	2.4E-01	6.6E-02	4.5E-06	3.3E-04	1.8E-02	2.9E-02	4.8E-01	8.1E-04	3.6E-01	9.0E-06	5.4E-02	7.4E-03	7.5E+00	8.6E-05	7.7E-05	4.5E-05	5.0E-03	2.3E-05	1.4E-01	1.8E-05
20-Mar-12	16																							
27-Mar-12	17	7.5E-01	5.6E-04	1.4E-03	1.9E-01	6.6E-02	4.5E-06	2.6E-04	1.5E-02	2.4E-02	4.2E-01	7.4E-04	3.4E-01	9.0E-06	5.0E-02	6.3E-03	8.3E+00	8.6E-05	4.5E-06	4.5E-05	6.8E-03	9.9E-05	1.2E-01	1.4E-05
3-Apr-12	18																							
10-Apr-12	19	8.2E-01	1.7E-04	1.4E-03	1.4E-01	5.3E-02	9.0E-06	9.2E-04	1.3E-02	2.2E-02	3.4E-01	8.4E-04	3.6E-01	9.0E-06	4.5E-02	5.0E-03	7.7E+00	6.3E-05	1.4E-05	9.0E-05	6.7E-03	9.0E-05	1.3E-01	1.4E-05
17-Apr-12	20																							
24-Apr-12	21	9.4E-01	5.9E-04	1.4E-03	1.1E-01	4.6E-02	1.4E-05	3.2E-04	1.0E-02	1.9E-02	3.1E-01	7.0E-04	4.1E-01	4.6E-06	4.6E-02	4.4E-03	7.2E+00	6.0E-05	1.4E-05	4.6E-05	8.0E-03	1.3E-04	1.3E-01	9.2E-06
1-May-12	22																							
8-May-12	23	1.1E+00	4.3E-03	9.2E-04	9.8E-02	4.8E-02	4.6E-06	4.2E-04	9.6E-03	4.1E-03	2.7E-01	7.3E-04	3.6E-01	4.6E-06	4.1E-02	3.9E-03	7.6E+00	5.1E-05	9.2E-05	4.6E-05	7.7E-03	7.8E-05	1.2E-01	9.2E-06
15-May-12	24																							
22-May-12	25	1.7E+00	1.1E-04	1.7E-03	1.2E-01	6.2E-02	8.6E-06	5.0E-04	1.1E-02	3.9E-03	4.5E-01	9.0E-04	4.6E-01	4.3E-06	5.6E-02	3.8E-03	1.0E+01	8.6E-05	5.2E-05	1.3E-04	1.1E-02	1.7E-04	1.4E-01	3.4E-05
29-May-12	26																							
5-Jun-12	27	1.1E+00	1.3E-05	1.3E-03	9.4E-02	4.5E-02	8.8E-06	2.3E-04	1.1E-02	1.8E-02	2.6E-01	7.3E-04	3.3E-01	4.4E-06	5.3E-02	3.1E-03	7.4E+00	4.8E-05	2.2E-05	1.8E-04	7.2E-03	2.0E-04	1.0E-01	1.8E-05
12-Jun-12	28																							
19-Jun-12	29	1.1E+00	9.8E-05	1.3E-03	8.1E-02	4.3E-02	4.5E-06	1.2E-02	8.5E-03	8.0E-03	2.1E-01	7.6E-04	3.6E-01	4.5E-06	4.0E-02	2.6E-03	6.9E+00	4.5E-05	5.3E-05	8.9E-05	8.3E-03	1.8E-04	9.3E-02	8.9E-06
26-Jun-12	30																							
3-Jul-12	31	1.3E+00	5.8E-05	8.9E-04	8.5E-02	4.9E-02	4.5E-06	2.5E-04	8.0E-03	4.0E-03	1.9E-01	7.7E-04	3.2E-01	4.5E-06	3.1E-02	2.6E-03	8.2E+00	4.0E-05	5.3E-05	4.5E-05	9.5E-03	1.3E-04	1.1E-01	2.7E-05
10-Jul-12	32																							
17-Jul-12	33	1.8E+00	3.1E-05	1.3E-03	1.1E-01	6.1E-02	4.5E-06	3.3E-04	9.6E-03	4.0E-03	1.9E-01	1.1E-03	4.3E-01	6.2E-05	3.6E-02	2.8E-03	1.0E+01	4.5E-05	6.7E-05	4.5E-05	1.3E-02	1.4E-04	1.6E-01	1.3E-05
24-Jul-12	34																							
31-Jul-12	35	2.0E+00	6.2E-05	1.3E-03	1.1E-01	6.3E-02	8.9E-06	2.4E-04	9.0E-03	4.0E-03	1.6E-01	9.3E-04	4.8E-01	8.9E-06	3.1E-02	2.7E-03	1.0E+01	4.0E-05	5.3E-05	8.9E-05	1.4E-02	1.9E-04	1.6E-01	8.9E-06
7-Aug-12	36																							
14-Aug-12	37	2.0E+00	5.5E-04	1.3E-03	1.4E-01	7.3E-02	4.5E-06	2.7E-04	1.1E-02	4.0E-03	1.5E-01	8.1E-04	5.4E-01	1.3E-05	3.6E-02	2.8E-03	1.3E+01	4.0E-05	4.5E-05	2.2E-04	1.8E-02	3.0E-04	2.2E-01	1.3E-05
21-Aug-12	38																							
28-Aug-12	39	2.1E+00	2.9E-05	1.5E-03	1.6E-01	8.6E-02	4.9E-06	2.4E-04	1.1E-02	2.1E-02	1.7E-01	8.4E-04	1.4E+00	2.0E-05	3.4E-02	3.9E-03	1.6E+01	4.4E-05	1.1E-04	4.9E-04	2.4E-02	1.7E-04	2.1E-01	2.0E-05
4-Sep-12	40																							
11-Sep-12	41	2.0E+00	7.7E-05	1.4E-03	2.3E-01	9.0E-02	4.5E-06	2.4E-04	1.3E-02	4.1E-03	1.3E-01	9.5E-04	7.3E-01	1.8E-05	3.6E-02	3.2E-03	1.9E+01	4.1E-05	6.3E-05	9.0E-05	3.2E-02	9.0E-05	2.9E-01	2.7E-05
18-Sep-12	42																							
25-Sep-12	43	2.3E+00	5.9E-05	1.8E-03	3.0E-01	8.6E-02	1.4E-05	5.9E-03	1.4E-02	3.0E-02	1.2E-01	5.8E-04	7.9E-01	4.5E-06	3.6E-02	3.0E-03	2.2E+01	9.0E-06	1.3E-04	4.5E-05	3.3E-02	1.3E-04	2.8E-01	4.1E-05
2-Oct-12	44																							
9-Oct-12	45	2.2E+00	1.7E-04	1.4E-03	3.2E-01	8.2E-02	4.7E-06	4.7E-06	8.5E-03	2.7E-02	1.1E-01	1.1E-03	9.2E-01	9.4E-06	2.8E-02	2.9E-03	2.2E+01	3.3E-05	7.5E-05	4.7E-05	2.7E-02	1.4E-05	2.3E-01	4.2E-05
16-Oct-12	46																							
23-Oct-12	47																							

HC10

Sample = 50% '08-059/ 50% '08-178

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
	No.																							
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
30-Oct-12	48																							
6-Nov-12	49	3.9E+00	3.9E-05	1.3E-03	5.8E-01	1.3E-01	4.4E-06	7.0E-05	1.5E-02	3.6E-02	9.7E-02	6.0E-04	6.8E-01	4.4E-06	2.6E-02	3.3E-03	2.6E+01	2.6E-05	7.8E-05	8.7E-05	2.7E-02	1.3E-05	2.4E-01	7.8E-05
13-Nov-12	50																							
20-Nov-12	51																							
27-Nov-12	52																							
4-Dec-12	53	7.1E+00	4.1E-03	1.4E-03	4.9E-01	1.2E-01	9.1E-06	1.8E-04	1.4E-02	2.0E-02	1.0E-01	1.7E-04	1.2E+00	2.3E-05	3.2E-02	5.0E-03	3.0E+01	3.2E-05	7.3E-05	9.1E-05	2.3E-02	1.8E-04	2.6E-01	5.5E-05
11-Dec-12	54																							
18-Dec-12	55																							
25-Dec-12	56																							
1-Jan-13	57	5.1E+00	4.2E-03	9.1E-04	5.0E-01	8.0E-02	4.6E-06	9.1E-05	1.1E-02	5.9E-03	8.3E-02	4.9E-04	1.0E+00	2.3E-05	2.7E-02	4.0E-03	2.4E+01	2.3E-05	9.1E-05	3.2E-04	1.9E-02	1.3E-04	1.9E-01	6.4E-05
8-Jan-13	58																							
15-Jan-13	59																							
22-Jan-13	60																							
29-Jan-13	61	4.9E+00	7.7E-05	1.4E-03	5.5E-01	6.4E-02	4.5E-06	9.0E-05	9.9E-03	1.8E-02	7.7E-02	4.8E-04	8.6E-01	1.4E-05	4.5E-02	3.8E-03	2.4E+01	2.3E-05	9.0E-05	4.5E-05	1.8E-02	1.6E-04	1.6E-01	6.3E-05
5-Feb-13	62																							
12-Feb-13	63																							
19-Feb-13	64																							
26-Feb-13	65	4.8E+00	1.2E-04	1.4E-03	5.5E-01	4.6E-02	4.5E-06	1.3E-04	1.0E-02	2.3E-02	6.8E-02	5.0E-04	7.0E-01	1.4E-05	2.3E-02	3.0E-03	2.3E+01	1.8E-05	1.4E-05	4.5E-05	1.8E-02	2.7E-04	1.6E-01	5.4E-05
5-Mar-13	66																							
12-Mar-13	67																							
19-Mar-13	68																							
26-Mar-13	69	4.2E+00	8.7E-05	9.2E-04	4.4E-01	3.3E-02	4.6E-06	7.4E-05	8.1E-03	9.7E-03	6.8E-02	4.1E-04	9.4E-01	5.1E-05	2.8E-02	3.5E-03	2.0E+01	1.8E-05	1.4E-05	4.6E-05	1.4E-02	1.2E-04	1.2E-01	2.8E-05
2-Apr-13	70																							
9-Apr-13	71																							
16-Apr-13	72																							
23-Apr-13	73	3.2E+00	1.4E-04	1.4E-03	4.1E-01	2.7E-02	4.5E-06	5.4E-05	7.2E-03	4.1E-03	6.8E-02	3.7E-04	6.1E-01	2.3E-05	2.3E-02	3.2E-03	1.6E+01	1.8E-05	1.4E-05	4.5E-05	1.1E-02	1.4E-04	1.0E-01	1.8E-05
30-Apr-13	74																							
7-May-13	75																							
14-May-13	76																							
21-May-13	77	1.2E+00	1.8E-05	8.9E-04	2.4E-01	1.6E-02	4.5E-06	4.0E-05	4.8E-03	4.0E-03	7.1E-02	2.1E-04	4.7E-01	8.9E-06	1.8E-02	2.5E-03	9.7E+00	1.8E-05	2.7E-05	4.5E-05	5.7E-03	4.5E-05	5.7E-02	8.9E-06
28-May-13	78	1.7E+00	4.9E-05	8.9E-04	3.4E-01	2.1E-02	4.5E-06	8.5E-05	5.6E-03	4.0E-03	7.4E-02	3.3E-04	3.8E-01	8.9E-06	1.8E-02	3.0E-03	1.2E+01	1.8E-05	4.0E-05	4.5E-05	7.6E-03	6.2E-05	6.5E-02	8.9E-06
4-Jun-13	79	1.6E+00	1.8E-04	9.0E-04	2.4E-01	1.6E-02	4.5E-06	1.7E-04	4.7E-03	9.0E-03	6.8E-02	2.7E-04	3.3E-01	4.5E-05	2.3E-02	2.6E-03	8.8E+00	1.4E-05	4.9E-04	4.5E-05	5.4E-03	2.1E-04	5.3E-02	1.4E-05
11-Jun-13	80	1.4E+00	5.5E-05	4.3E-04	2.1E-01	1.4E-02	4.3E-06	1.3E-04	3.7E-03	3.8E-03	4.5E-02	2.6E-04	4.0E-01	4.3E-06	1.7E-02	2.2E-03	8.4E+00	8.5E-06	5.7E-04	4.3E-05	4.7E-03	2.0E-04	4.4E-02	4.3E-06
18-Jun-13	81	2.4E+00	1.1E-04	5.3E-04	2.6E-01	1.9E-02	5.3E-06	1.4E-04	4.7E-03	4.7E-03	5.5E-02	3.2E-04	8.6E-01	5.3E-06	2.6E-02	3.6E-03	1.1E+01	1.1E-05	1.6E-04	5.3E-05	6.9E-03	2.4E-04	6.0E-02	1.1E-05
25-Jun-13	82																							
2-Jul-13	83	7.2E-01	1.1E-04	4.4E-04	5.8E-02	5.5E-03	4.4E-06	8.8E-05	1.2E-03	4.0E-03	3.0E-02	1.2E-04	2.2E-01	4.4E-06	8.8E-03	1.5E-03	3.8E+00	8.8E-06	1.5E-04	4.4E-05	1.8E-03	7.5E-05	1.8E-02	4.4E-06
9-Jul-13	84																							
16-Jul-13	85	1.0E+00	1.0E-04	4.9E-04	6.1E-02	6.8E-03	4.9E-06	4.4E-05	1.3E-03	4.4E-03	3.4E-02	1.4E-04	3.1E-01	4.9E-06	1.5E-02	2.3E-03	4.3E+00	9.8E-06	3.1E-04	4.9E-05	1.9E-03	3.9E-05	1.9E-02	4.9E-06
23-Jul-13	86																							
30-Jul-13	87	8.9E-01	4.3E-05	4.8E-04	4.7E-02	6.0E-03	4.8E-06	4.8E-05	1.1E-03	4.3E-03	3.3E-02	1.2E-04	2.4E-01	4.8E-06	9.6E-03	2.1E-03	3.8E+00	9.6E-06	2.5E-04	4.8E-05	1.7E-03	3.4E-05	1.6E-02	4.8E-06
6-Aug-13	88																							
13-Aug-13	89	1.1E+00	5.3E-05	4.9E-04	5.0E-02	6.8E-03	4.9E-06	3.4E-05	1.2E-03	4.4E-03	3.1E-02	1.3E-04	2.9E-01	4.9E-06	1.9E-02	2.5E-03	3.9E+00	9.7E-06	4.2E-04	4.9E-05	1.7E-03	1.5E-05	2.0E-02	4.9E-06
20-Aug-13	90																							
27-Aug-13	91																							
3-Sep-13	92																							
10-Sep-13	93	1.3E+00	4.8E-05	4.8E-04	4.9E-02	6.2E-03	4.8E-06	3.4E-05	1.2E-03	4.3E-03	3.1E-02	1.3E-04	3.2E-01	4.8E-06	9.6E-03	2.4E-03	4.5E+00	9.6E-06	1.1E-03	4.8E-05	1.7E-03	5.3E-05	1.8E-02	4.8E-06
17-Sep-13	94																							
24-Sep-13	95																							
1-Oct-13	96																							
8-Oct-13	97	1.1E+00	5.2E-05	4.8E-04	4.1E-02	5.4E-03	4.8E-06	1.9E-05	1.1E-03	4.3E-03	3.4E-02	1.2E-04	2.9E-01	4.8E-06	2.9E-02	2.1E-03	4.1E+00	9.5E-06	3.2E-04	4.8E-05	1.6E-03	1.9E-05	1.7E-02	4.8E-06
15-Oct-13	98																							
22-Oct-13	99																							
29-Oct-13	100																							

HC10

Sample = 50% '08-059/ 50% '08-178

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
	No.																							
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
5-Nov-13	101	1.1E+00	2.0E-05	5.0E-04	3.9E-02	4.7E-03	5.0E-06	9.9E-06	8.4E-04	4.5E-03	3.3E-02	1.2E-04	3.4E-01	5.0E-06	9.9E-03	2.1E-03	3.5E+00	9.9E-06	1.1E-03	5.0E-05	1.3E-03	2.0E-05	1.5E-02	5.0E-06
12-Nov-13	102																							
19-Nov-13	103																							
26-Nov-13	104																							
3-Dec-13	105	1.1E+00	1.4E-05	4.8E-04	3.9E-02	4.3E-03	4.8E-06	1.9E-05	1.0E-03	4.3E-03	3.0E-02	1.1E-04	1.7E-01	4.8E-06	1.4E-02	1.9E-03	3.6E+00	9.6E-06	1.3E-03	4.8E-05	1.3E-03	2.9E-05	1.5E-02	4.8E-06
10-Dec-13	106																							
17-Dec-13	107																							
24-Dec-13	108																							
31-Dec-13	109	5.2E-01	7.7E-05	4.6E-04	2.4E-02	2.5E-03	4.6E-06	1.8E-05	6.4E-04	4.1E-03	2.7E-02	8.2E-05	1.5E-01	4.6E-06	1.4E-02	1.3E-03	2.3E+00	9.1E-06	3.0E-04	4.6E-05	7.1E-04	2.3E-05	1.1E-02	4.6E-06
7-Jan-14	110																							
14-Jan-14	111																							
21-Jan-14	112																							
28-Jan-14	113	9.8E-01	9.6E-06	4.8E-04	4.0E-02	3.9E-03	4.8E-06	4.8E-06	9.1E-04	4.3E-03	3.0E-02	9.1E-05	1.9E-01	4.8E-06	1.4E-02	1.8E-03	3.5E+00	9.6E-06	1.8E-04	4.8E-05	1.1E-03	1.4E-05	1.4E-02	4.8E-06
4-Feb-14	114																							
11-Feb-14	115																							
18-Feb-14	116																							
25-Feb-14	117	7.8E-01	1.4E-05	4.7E-04	3.4E-02	3.1E-03	4.7E-06	1.4E-05	8.5E-04	4.2E-03	3.0E-02	8.0E-05	1.7E-01	4.7E-06	1.4E-02	1.6E-03	3.0E+00	9.4E-06	1.9E-04	4.7E-05	9.9E-04	1.4E-05	1.4E-02	4.7E-06
4-Mar-14	118																							
11-Mar-14	119																							
18-Mar-14	120																							
25-Mar-14	121	8.5E-01	1.4E-05	4.8E-04	3.5E-02	3.3E-03	4.8E-06	3.8E-05	7.1E-04	1.2E-02	2.8E-02	8.6E-05	1.7E-01	4.8E-06	1.4E-02	1.6E-03	3.1E+00	9.5E-06	5.9E-04	4.8E-05	1.1E-03	1.4E-05	1.5E-02	4.8E-06
1-Apr-14	122																							
8-Apr-14	123																							
15-Apr-14	124																							
22-Apr-14	125	1.2E+00	9.4E-06	9.0E-05	3.7E-02	3.7E-03	4.7E-06	4.7E-05	9.4E-04	4.2E-03	2.9E-02	8.5E-05	1.9E-01	2.8E-06	2.8E-02	1.7E-03	3.2E+00	5.2E-06	7.5E-05	2.4E-05	9.3E-04	6.6E-05	1.6E-02	9.4E-04
29-Apr-14	126																							
6-May-14	127																							
13-May-14	128																							
20-May-14	129	9.6E-01	2.2E-04	9.5E-05	3.5E-02	3.3E-03	4.8E-06	8.2E-05	7.7E-04	4.3E-03	2.6E-02	6.7E-05	2.0E-01	8.6E-06	1.4E-02	1.6E-03	2.8E+00	6.2E-06	3.6E-04	2.4E-05	9.0E-04	3.4E-05	1.4E-02	9.6E-04
27-May-14	130																							
3-Jun-14	131																							
10-Jun-14	132																							
17-Jun-14	133	8.2E-01	2.0E-05	8.1E-05	3.0E-02	3.1E-03	4.9E-06	9.8E-06	7.4E-04	4.4E-03	2.8E-02	7.8E-05	2.3E-01	3.9E-06	1.5E-02	1.5E-03	2.7E+00	6.9E-06	9.8E-04	2.5E-05	8.1E-04	1.5E-05	1.3E-02	9.8E-04
24-Jun-14	134																							
1-Jul-14	135																							
8-Jul-14	136																							
15-Jul-14	137	1.1E+00	1.4E-05	9.9E-05	3.7E-02	3.5E-03	4.8E-06	1.4E-05	8.1E-04	6.2E-03	3.1E-02	9.0E-05	2.2E-01	5.7E-06	1.4E-02	1.7E-03	3.2E+00	5.7E-06	1.9E-04	2.4E-05	1.0E-03	1.9E-05	1.6E-02	9.5E-04
22-Jul-14	138																							
29-Jul-14	139																							
5-Aug-14	140																							
12-Aug-14	141	8.8E-01	2.9E-05	8.5E-05	3.3E-02	3.1E-03	4.9E-06	3.9E-05	6.9E-04	4.4E-03	2.9E-02	7.8E-05	2.3E-01	3.9E-06	1.5E-02	1.5E-03	2.9E+00	6.9E-06	9.7E-04	2.5E-05	9.4E-04	9.8E-06	1.4E-02	9.8E-04
19-Aug-14	142																							
26-Aug-14	143																							
2-Sep-14	144																							

HC11

Sample = 08-068

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/L	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
29-Nov-11	0	500	395	7.28	7.9E+02	#N/A	8.0E+00	3.4E+01	3.5E+02	2.1E+00	1.9E+00	3.0E-01	3.6E+02	5.4E-02	1.9E-03	1.8E-03	2.7E-02	2.0E-05	2.0E-05	6.8E-03	1.6E-04	1.2E+02	5.0E-04	4.6E-03	3.2E-02
6-Dec-11	1	500	480	7.52	3.9E+02	#N/A	4.6E+00	2.9E+01	1.5E+02	1.2E+00	1.9E+00	3.0E-01	1.6E+02	3.8E-02	1.2E-03	1.3E-03	2.2E-02	2.0E-05	1.0E-05	3.8E-03	2.0E-05	5.6E+01	1.1E-03	4.2E-04	8.2E-03
13-Dec-11	2	500	510	7.40	2.1E+02	#N/A	4.1E+00	2.7E+01	5.9E+01	2.0E-01	1.6E+00	3.0E-01	8.2E+01	2.3E-02	8.0E-04	8.0E-04	3.2E-02	2.0E-05	2.0E-05	3.0E-03	6.0E-06	2.9E+01	7.0E-04	1.9E-04	4.2E-03
20-Dec-11	3	500	500	7.45	1.4E+02	#N/A	4.7E+00	3.0E+01	4.2E+01	2.0E-01	1.9E+00	3.0E-01	6.5E+01	4.5E-02	1.3E-03	1.2E-03	3.0E-02	2.0E-05	1.0E-05	3.0E-03	2.0E-05	2.3E+01	5.0E-04	1.6E-04	4.1E-03
27-Dec-11	4	500	525	7.47	6.9E+01																				
3-Jan-12	5	500	475	7.47	8.1E+01	#N/A	4.1E+00	2.8E+01	1.6E+01	2.0E-01	1.6E+00	3.0E-01	2.8E+01	5.4E-02	1.4E-03	1.1E-03	3.6E-02	2.0E-05	1.0E-05	2.6E-03	3.0E-06	9.7E+00	5.0E-04	8.5E-05	2.8E-03
10-Jan-12	6	500	445	7.40	8.3E+01																				
17-Jan-12	7	500	425	7.45	8.6E+01	#N/A	3.1E+00	3.4E+01	1.1E+01	2.0E-01	1.7E+00	3.0E-01	3.6E+01	5.9E-02	3.5E-03	1.4E-03	3.7E-02	2.0E-05	1.0E-05	3.7E-03	9.0E-06	1.2E+01	5.0E-04	9.5E-05	4.7E-03
24-Jan-12	8	500	465	7.46	7.7E+01																				
31-Jan-12	9	500	475	7.44	8.1E+01	#N/A	3.3E+00	3.2E+01	1.4E+01	2.0E-01	1.4E+00	3.0E-01	3.1E+01	3.8E-02	1.9E-03	1.2E-03	4.0E-02	2.0E-05	1.0E-05	2.3E-03	3.0E-06	1.0E+01	5.0E-04	7.2E-05	2.6E-03
7-Feb-12	10	500	485	7.41	7.8E+01																				
14-Feb-12	11	500	485	7.44	7.8E+01	#N/A	4.6E+00	2.7E+01	1.9E+01	2.0E-01	1.2E+00	3.0E-01	3.2E+01	2.7E-02	1.5E-03	1.3E-03	3.7E-02	2.0E-05	1.0E-05	1.8E-03	3.0E-06	1.1E+01	5.0E-04	6.0E-05	1.8E-03
21-Feb-12	12	500	475	7.36	7.9E+01																				
28-Feb-12	13	500	450	7.28	7.1E+01	#N/A	3.9E+00	2.5E+01	1.1E+01	2.0E-01	9.7E-01	3.0E-01	3.0E+01	3.3E-02	1.4E-03	1.1E-03	3.1E-02	2.0E-05	1.0E-05	1.9E-03	3.0E-06	1.0E+01	5.0E-04	5.7E-05	2.6E-03
6-Mar-12	14	500	450	7.34	7.3E+01																				
13-Mar-12	15	500	445	7.28	6.9E+01	#N/A	3.0E+00	2.4E+01	1.3E+01	2.0E-01	8.9E-01	3.0E-01	3.0E+01	2.6E-02	1.5E-03	1.1E-03	3.1E-02	2.0E-05	1.0E-05	1.9E-03	3.0E-06	1.0E+01	5.0E-04	4.1E-05	1.5E-03
20-Mar-12	16	500	460	7.26	7.4E+01																				
27-Mar-12	17	500	445	7.20	7.1E+01	#N/A	3.2E+00	2.2E+01	1.4E+01	2.0E-01	7.7E-01	3.0E-01	3.1E+01	3.8E-02	1.5E-03	1.3E-03	3.1E-02	2.0E-05	1.0E-05	1.7E-03	8.0E-06	1.1E+01	5.0E-04	5.3E-05	2.1E-03
3-Apr-12	18	500	455	7.19	6.7E+01																				
10-Apr-12	19	500	445	7.26	7.3E+01	#N/A	2.9E+00	2.2E+01	1.5E+01	2.0E-01	6.9E-01	3.0E-01	3.0E+01	3.6E-02	1.6E-03	1.0E-03	2.6E-02	2.0E-05	1.0E-05	2.0E-03	3.0E-06	1.1E+01	5.0E-04	6.0E-05	2.0E-03
17-Apr-12	20	500	455	7.19	7.6E+01																				
24-Apr-12	21	500	470	7.23	7.0E+01	#N/A	3.2E+00	2.2E+01	1.2E+01	2.0E-01	6.1E-01	3.0E-01	3.0E+01	4.2E-02	1.7E-03	1.0E-03	3.3E-02	2.0E-05	1.0E-05	1.7E-03	3.0E-06	1.0E+01	5.0E-04	5.8E-05	2.6E-03
1-May-12	22	500	440	7.19	7.0E+01																				
8-May-12	23	500	430	7.17	6.7E+01	#N/A	3.3E+00	2.2E+01	1.2E+01	1.0E+00	4.9E-01	3.0E-01	2.9E+01	3.6E-02	1.7E-03	1.0E-03	2.5E-02	2.0E-05	1.0E-05	1.8E-03	3.0E-06	9.9E+00	5.0E-04	6.4E-05	2.9E-03
15-May-12	24	500	430	7.17	6.7E+01																				
22-May-12	25	500	435	7.16	6.7E+01	#N/A	3.9E+00	2.1E+01	9.0E+00	2.0E-01	5.2E-01	3.0E-01	2.8E+01	6.7E-02	1.4E-03	9.0E-04	2.5E-02	2.0E-05	1.0E-05	1.4E-03	3.0E-06	9.8E+00	5.0E-04	5.1E-05	1.7E-03
29-May-12	26	500	420	7.13	6.5E+01																				
5-Jun-12	27	500	450	7.17	6.4E+01	#N/A	4.0E+00	2.2E+01	9.0E+00	2.0E-01	4.5E-01	3.0E-01	2.9E+01	6.8E-02	1.6E-03	1.2E-03	2.6E-02	2.0E-05	1.0E-05	2.5E-03	3.0E-06	9.8E+00	5.0E-04	8.7E-05	2.0E-03
12-Jun-12	28	500	435	7.13	6.0E+01																				
19-Jun-12	29	500	435	7.11	5.9E+01	#N/A	3.2E+00	1.6E+01	9.0E+00	2.0E-01	4.5E-01	3.0E-01	2.5E+01	7.0E-02	1.5E-03	9.0E-04	2.1E-02	2.0E-05	1.0E-05	1.3E-03	3.0E-06	8.7E+00	5.0E-04	8.5E-05	5.4E-03
26-Jun-12	30	500	440	7.14	5.9E+01																				
3-Jul-12	31	500	435	7.10	6.0E+01	#N/A	7.5E+00	2.3E+01	9.0E+00	2.0E-01	4.5E-01	3.0E-01	2.6E+01	4.8E-02	2.1E-03	1.2E-03	2.9E-02	2.0E-05	1.0E-05	1.2E-03	3.0E-06	8.7E+00	5.0E-04	3.9E-05	2.7E-03
10-Jul-12	32	500	440	7.10	6.3E+01																				
17-Jul-12	33	500	445	7.07	6.3E+01	#N/A	3.0E+00	2.0E+01	1.0E+01	2.0E-01	3.7E-01	3.0E-01	2.8E+01	4.1E-02	1.8E-03	1.1E-03	2.9E-02	2.0E-05	1.0E-05	1.6E-03	3.0E-06	9.6E+00	5.0E-04	1.6E-04	1.5E-03
24-Jul-12	34	500	425	7.07	6.5E+01																				
31-Jul-12	35	500	435	7.09	6.0E+01	#N/A	2.8E+00	1.7E+01	9.0E+00	2.0E-01	3.6E-01	3.0E-01	2.6E+01	4.8E-02	1.8E-03	9.0E-04	2.8E-02	2.0E-05	1.0E-05	2.0E-03	3.0E-06	9.0E+00	5.0E-04	6.0E-05	2.5E-03
7-Aug-12	36	500	455	7.17	6.0E+01																				
14-Aug-12	37	500	490	7.00	6.9E+01	#N/A	3.8E+00	1.7E+01	1.5E+01	2.0E-01	3.5E-01	3.0E-01	2.9E+01	5.2E-02	1.8E-03	1.2E-03	2.7E-02	2.0E-05	1.0E-05	3.4E-03	3.0E-06	1.0E+01	5.0E-04	1.3E-05	3.8E-03
21-Aug-12	38	500	445	7.01	6.7E+01																				
28-Aug-12	39	500	435	7.05	6.6E+01	#N/A	4.2E+00	2.1E+01	1.3E+01	2.0E-01	3.2E-01	3.0E-01	2.7E+01	5.6E-02	1.7E-03	7.0E-04	2.9E-02	2.0E-05	1.0E-05	2.3E-03	3.0E-06	9.5E+00	5.0E-04	4.4E-05	3.8E-03
4-Sep-12	40	500	475	6.96	5.4E+01																				
11-Sep-12	41	500	485	6.99	6.3E+01	#N/A	3.8E+00	1.7E+01	1.3E+01	2.0E-01	2.9E-01	3.0E-01	2.8E+01	2.4E-02	1.6E-03	8.0E-04	2.8E-02	2.0E-05	1.0E-05	2.9E-03	3.0E-06	9.6E+00	5.0E-04	7.1E-05	3.3E-03
18-Sep-12	42	500	495	7.03	6.5E+01																				
25-Sep-12	43	500	445	7.03	6.4E+01	#N/A	4.5E+00	2.1E+01	1.2E+01	2.0E-01	2.6E-01	3.0E-01	2.7E+01	3.7E-02	1.5E-03	1.0E-03	2.4E-02	2.0E-05	1.0E-05	2.1E-03	3.0E-06	9.2E+00	5.0E-04	4.6E-05	4.9E-03
2-Oct-12	44	500	450	7.11	6.0E+01																				
9-Oct-12	45	500	445	6.92	5.4E+01	#N/A	4.6E+00	1.6E+01	9.0E+00	2.0E-01	2.1E-01	3.0E-01	2.3E+01	3.8E-02	1.2E-03	6.0E-04	1.9E-02	2.0E-05	1.0E-05	1.1E-03	3.0E-06	7.9E+00	5.0E-04	7.1E-05	3.8E-03
16-Oct-12	46	500	450	7.10	7.8E+01																				
23-Oct-12	47	500	510	7.13	7.5E+01																				
30-Oct-12	48	500	500	7.12	7.0E+01																				
6-Nov-12	49	500	480	7.05	6.4E+01	#N/A	3.7E+00	2.1E+01	1.1E+01	2.0E-01	2.1E-01	3.0E-01	3.1E+01	2.5E-02	1.8E-03	8.0E-04	2.4E-02	2.0E-05	1.0E-05	2.0E-03	1.6E-05	1.1E+01	5.0E-04	2.5E-04	4.5E-03
13-Nov-12	50	500	460	7.08	6.3E+01																				
20-Nov-12	51	500	490	7.07	6.6E+01																				
27-Nov-12	52	500	490	7.10	6.5E+01																				
4-Dec-12	53	500	455	7.07	6.2E+01	#N/A	3.4E+00	1.7E+01	1.3E+01	2.0E-01	1.9E-01	3.0E-01	2.8E+01	3.2E-02	1.7E-03	9.0E-04	2.1E-02	2.0E-05	1.0E-05	9.0E-04	1.9E-05	9.6E+00	5.0E-04	6.2E-04	3.7E-03
11-Dec-12	54	500	470	7.20	6.5E+01																				
18-Dec-12	55	500	470	7.03	5.8E+01																				
25-Dec-12	56	500	455	7.21	6.0E+01																				
1-Jan-13	57	500	525	7.10	5.1E+01	#N/A	4.9E+00	2.5E+01	5.0E+00	2.0E-01	2.0E-01	3.0E-01	2.5E+01	3.2E-02	2.0E-03	1.2E-03	3.1E-02	2.0E-05	1.0E-05	1.7E-03	8.0E-06	8.7E+00	5.0E-04	2.1E-04	2.8E-03
8-Jan-13	58	500	465	7.21	6.5E+01																				
15-Jan-13	59	500	465	6.98	5.5E+01																				
22-Jan-13	60	500	450	7.19	6.0E+01																				
29-Jan-13	61	500	450	7.02	5.4E+01	#N/A	3.4E+00	1.7E+01	9.0E+00	2.0E-01	1.5E-01	3.0E-01	2.7E+01	4.0E-02	1.5E-03	8.0E-04	1.8E-02	2.0E-05	1.0E-05	9.0E-04	6.0E-06	9.4E+00	5.0E-04	1.8E-04	6.0E-03

HC11

Sample = 08-068

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/L	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
5-Feb-13	62	500	460	7.07	5.8E+01																				
12-Feb-13	63	500	450	7.15	5.9E+01																				
19-Feb-13	64	500	455	6.95	5.7E+01																				
26-Feb-13	65	500	450	7.06	5.5E+01	#N/A	4.6E+00	2.1E+01	1.0E+01	2.0E-01	1.2E-01	3.0E-01	2.2E+01	2.7E-02	1.4E-03	1.1E-03	1.9E-02	2.0E-05	1.0E-05	8.0E-04	1.1E-05	7.8E+00	5.0E-04	3.5E-04	7.0E-03
5-Mar-13	66	500	460	7.16	5.4E+01																				
12-Mar-13	67	500	450	7.07	5.4E+01																				
19-Mar-13	68	500	440	6.82	5.6E+01																				
26-Mar-13	69	500	460	6.81	5.6E+01	#N/A	5.8E+00	1.7E+01	1.7E+01	2.0E-01	1.1E-01	3.0E-01	2.4E+01	2.0E-02	1.4E-03	1.0E-03	1.7E-02	2.0E-05	1.0E-05	1.0E-03	4.0E-06	8.4E+00	5.0E-04	2.2E-04	4.5E-03
2-Apr-13	70	500	430	6.89	5.4E+01																				
9-Apr-13	71	500	460	6.81	5.6E+01																				
16-Apr-13	72	500	460	6.92	6.0E+01																				
23-Apr-13	73	500	450	6.67	5.7E+01	#N/A	5.3E+00	1.7E+01	1.1E+01	2.0E-01	1.0E-01	3.0E-01	2.2E+01	2.6E-02	1.5E-03	8.0E-04	1.9E-02	2.0E-05	1.0E-05	1.2E-03	3.0E-06	7.7E+00	5.0E-04	6.4E-05	2.2E-03
30-Apr-13	74	500	450	6.81	5.3E+01																				
7-May-13	75	500	435	6.83	6.5E+01																				
14-May-13	76	500	440	6.95	5.2E+01																				
21-May-13	77	500	440	6.78	5.2E+01	#N/A	4.3E+00	1.6E+01	1.0E+01	2.0E-01	1.0E-01	3.0E-01	2.2E+01	3.0E-02	1.6E-03	7.0E-04	2.3E-02	2.0E-05	1.0E-05	1.3E-03	7.0E-06	7.7E+00	5.0E-04	2.2E-05	2.0E-03
28-May-13	78	500	440	6.73	4.8E+01	#N/A	4.5E+00	1.4E+01	1.0E+01	2.0E-01	9.0E-02	3.0E-01	2.2E+01	2.9E-02	1.6E-03	8.0E-04	2.3E-02	2.0E-05	1.0E-05	1.8E-03	3.0E-06	7.6E+00	5.0E-04	5.0E-05	1.9E-03
4-Jun-13	79	500	430	6.96	4.6E+01	#N/A	4.7E+00	1.6E+01	7.0E+00	2.0E-01	8.0E-02	3.0E-01	2.2E+01	3.1E-02	1.2E-03	6.0E-04	2.5E-02	2.0E-05	1.0E-05	5.1E-03	1.7E-05	7.7E+00	9.0E-04	9.0E-05	1.8E-03
11-Jun-13	80	500	480	6.87	3.9E+01	#N/A	6.9E+00	1.8E+01	6.0E+00	2.0E-01	6.0E-02	3.0E-01	1.9E+01	9.6E-03	9.0E-04	4.0E-04	2.0E-02	2.0E-05	1.0E-05	3.0E-03	3.0E-06	6.6E+00	5.0E-04	9.3E-05	1.3E-03
18-Jun-13	81	500	480	6.83	3.8E+01	#N/A	5.3E+00	1.5E+01	6.0E+00	1.0E+00	6.0E-02	3.0E-01	1.8E+01	7.3E-03	1.0E-03	3.0E-04	2.1E-02	2.0E-05	1.0E-05	2.5E-03	7.0E-06	6.2E+00	5.0E-04	1.2E-04	7.0E-04
25-Jun-13	82	500	480	6.97	3.8E+01																				
2-Jul-13	83	500	450	6.96	3.4E+01	#N/A	6.6E+00	1.7E+01	5.0E+00	1.0E+00	6.0E-02	3.0E-01	1.6E+01	2.2E-02	9.0E-04	3.0E-04	2.1E-02	2.0E-05	1.0E-05	2.0E-04	3.0E-06	5.6E+00	5.0E-04	2.8E-05	2.7E-03
9-Jul-13	84	500	475	7.01	4.6E+01																				
16-Jul-13	85	500	490	6.87	3.6E+01	#N/A	3.6E+00	1.5E+01	5.0E+00	1.0E+00	6.0E-02	3.0E-01	1.8E+01	8.5E-03	8.0E-04	4.0E-04	2.6E-02	2.0E-05	1.0E-05	1.9E-03	3.0E-06	6.2E+00	5.0E-04	3.4E-05	1.1E-03
23-Jul-13	86	500	460	6.74	3.6E+01																				
30-Jul-13	87	500	480	6.79	3.3E+01	#N/A	4.4E+00	1.5E+01	6.0E+00	2.0E-01	6.0E-02	3.0E-01	1.6E+01	8.1E-03	7.0E-04	2.0E-04	2.5E-02	2.0E-05	1.0E-05	1.8E-03	3.0E-06	5.7E+00	5.0E-04	2.0E-05	8.0E-04
6-Aug-13	88	500	485	6.78	3.8E+01																				
13-Aug-13	89	500	490	6.86	3.5E+01	#N/A	3.3E+00	1.4E+01	4.0E+00	1.0E+00	6.0E-02	3.0E-01	1.7E+01	7.9E-03	7.0E-04	3.0E-04	2.7E-02	2.0E-05	1.0E-05	1.9E-03	3.0E-06	5.9E+00	5.0E-04	7.3E-05	1.1E-03
20-Aug-13	90	500	485	6.79	3.5E+01																				
27-Aug-13	91	500	480	6.85	3.0E+01																				
3-Sep-13	92	500	475	6.76	3.3E+01																				
10-Sep-13	93	500	470	6.78	3.5E+01	#N/A	3.9E+00	1.5E+01	3.0E+00	2.0E-01	6.0E-02	3.0E-01	1.6E+01	1.2E-02	7.0E-04	4.0E-04	2.6E-02	2.0E-05	1.0E-05	1.5E-03	4.0E-06	5.9E+00	5.0E-04	8.4E-05	1.1E-03
17-Sep-13	94	500	500	6.87	3.5E+01																				
24-Sep-13	95	500	475	6.92	3.1E+01																				
1-Oct-13	96	500	470	6.70	3.4E+01																				
8-Oct-13	97	500	475	6.95	3.3E+01	#N/A	2.4E+00	1.4E+01	4.0E+00	2.0E-01	6.0E-02	3.0E-01	1.7E+01	1.9E-02	7.0E-04	3.0E-04	2.7E-02	2.0E-05	1.0E-05	3.4E-03	3.0E-06	6.0E+00	5.0E-04	1.1E-04	4.0E-03
15-Oct-13	98	500	480	6.91	3.3E+01																				
22-Oct-13	99	500	475	6.91	3.7E+01																				
29-Oct-13	100	500	485	7.11	3.7E+01																				
5-Nov-13	101	500	475	7.02	3.7E+01	#N/A	2.3E+00	1.5E+01	4.0E+00	2.0E-01	6.0E-02	3.0E-01	1.8E+01	1.3E-02	7.0E-04	2.0E-04	2.7E-02	2.0E-05	1.0E-05	1.0E-03	3.0E-06	6.3E+00	5.0E-04	5.9E-05	9.0E-04
12-Nov-13	102	500	470	6.91	3.8E+01																				
19-Nov-13	103	500	465	7.08	3.5E+01																				
26-Nov-13	104	500	455	7.33	3.6E+01																				
3-Dec-13	105	500	480	7.43	4.0E+01	#N/A	1.5E+00	2.1E+01	3.0E+00	2.0E-01	6.0E-02	3.0E-01	2.0E+01	1.7E-02	7.0E-04	3.0E-04	2.9E-02	2.0E-05	1.0E-05	8.0E-04	3.0E-06	7.1E+00	5.0E-04	7.4E-05	1.1E-03
10-Dec-13	106	500	475	7.16	3.5E+01																				
17-Dec-13	107	500	485	7.01	3.8E+01																				
24-Dec-13	108	500	495	6.90	3.8E+01																				
31-Dec-13	109	500	490	7.16	3.6E+01	#N/A	2.1E+00	1.4E+01	4.0E+00	2.0E-01	6.0E-02	3.0E-01	1.7E+01	1.0E-02	6.0E-04	3.0E-04	2.9E-02	2.0E-05	1.0E-05	1.6E-03	3.0E-06	6.0E+00	5.0E-04	6.0E-05	6.2E-03
7-Jan-14	110	500	490	7.08	3.6E+01																				
14-Jan-14	111	500	480	6.98	3.1E+01																				
21-Jan-14	112	500	485	7.06	3.6E+01																				
28-Jan-14	113	500	485	7.14	3.8E+01	#N/A	2.5E+00	1.6E+01	4.0E+00	2.0E-01	6.0E-02	3.0E-01	1.8E+01	1.5E-02	7.0E-04	2.0E-04	2.9E-02	2.0E-05	1.0E-05	1.3E-03	3.0E-06	6.4E+00	5.0E-04	3.5E-05	7.7E-03
4-Feb-14	114	500	470	7.27	3.8E+01																				
11-Feb-14	115	500	475	7.18	3.3E+01																				
18-Feb-14	116	500	480	7.18	3.4E+01																				
25-Feb-14	117	500	485	7.20	3.3E+01	#N/A	3.7E+00	1.6E+01	6.0E+00	2.0E-01	6.0E-02	3.0E-01	1.6E+01	7.4E-03	6.0E-04	2.0E-04	2.7E-02	2.0E-05	1.0E-05	1.1E-03	3.0E-06	5.8E+00	5.0E-04	4.8E-05	1.6E-03

HC11

Sample = 08-068

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Major	Major	Diff	Diff
	No.																								Anions	Cations		(%)
		mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L				
29-Nov-11	0	3.0E-03	5.0E-05	2.0E-03	1.2E+01	3.5E-02	1.0E-02	1.3E-02	5.4E-03	9.0E-03	7.1E+00	1.7E-02	1.4E+00	1.0E-05	2.3E+01	5.2E-01	1.2E+02	6.0E-05	6.0E-05	3.0E-04	2.5E-02	5.6E-04	1.8E-02	2.5E-04	8.18	8.35	0.17	1.0%
6-Dec-11	1	3.0E-03	2.0E-05	1.0E-03	5.8E+00	1.8E-02	1.0E-02	1.7E-02	2.0E-04	9.0E-03	4.1E+00	1.0E-02	1.2E+00	1.0E-05	1.4E+01	2.4E-01	5.6E+01	2.0E-05	1.0E-05	4.0E-04	1.8E-02	2.9E-04	3.0E-03	1.3E-04	3.92	4.02	0.10	1.3%
13-Dec-11	2	3.0E-03	1.0E-04	1.0E-03	2.5E+00	9.8E-03	1.0E-02	1.2E-02	8.0E-04	1.0E-02	2.7E+00	4.3E-03	8.8E-01	1.0E-05	7.2E+00	1.3E-01	2.4E+01	2.0E-05	1.6E-04	3.0E-04	1.3E-02	2.5E-04	6.0E-03	8.0E-05	1.86	2.02	0.16	4.2%
20-Dec-11	3	8.0E-03	2.0E-05	1.0E-03	2.0E+00	1.1E-02	1.0E-02	1.1E-02	7.0E-04	9.0E-03	2.4E+00	2.0E-03	1.4E+00	1.0E-05	6.2E+00	9.6E-02	1.7E+01	2.0E-05	1.0E-05	9.0E-04	1.3E-02	3.9E-04	4.0E-03	7.0E-05	1.57	1.64	0.07	2.3%
27-Dec-11	4																											
3-Jan-12	5	4.0E-03	2.0E-05	1.0E-03	9.9E-01	3.9E-03	1.0E-02	7.4E-03	5.0E-04	9.0E-03	1.7E+00	7.2E-04	9.3E-01	1.0E-05	3.1E+00	4.4E-02	5.3E+00	2.0E-05	2.0E-05	6.0E-04	1.3E-02	5.7E-04	1.0E-03	4.0E-05	0.98	0.75	-0.22	-12.9%
10-Jan-12	6																											
17-Jan-12	7	7.0E-03	2.0E-05	1.0E-03	1.3E+00	3.8E-03	1.0E-02	6.8E-03	2.0E-04	9.0E-03	2.0E+00	1.1E-03	1.4E+00	1.0E-05	3.0E+00	5.5E-02	5.4E+00	2.0E-05	1.0E-05	1.8E-03	2.7E-02	5.9E-04	1.0E-03	1.3E-04	1.01	0.90	-0.11	-5.5%
24-Jan-12	8																											
31-Jan-12	9	3.0E-03	2.0E-05	1.0E-03	1.1E+00	3.2E-03	1.0E-02	4.7E-03	1.0E-04	9.0E-03	1.9E+00	7.5E-04	1.0E+00	1.0E-05	2.0E+00	4.9E-02	4.5E+00	2.0E-05	4.0E-05	3.0E-04	1.4E-02	5.9E-04	2.0E-03	3.0E-05	1.01	0.75	-0.26	-14.7%
7-Feb-12	10																											
14-Feb-12	11	3.0E-03	2.0E-05	1.0E-03	1.2E+00	4.2E-03	1.0E-02	3.8E-03	3.0E-04	9.0E-03	1.7E+00	1.2E-03	9.5E-01	1.0E-05	1.5E+00	5.3E-02	4.8E+00	2.0E-05	1.0E-05	4.0E-04	1.2E-02	5.2E-04	3.0E-03	3.0E-05	1.00	0.76	-0.24	-13.4%
21-Feb-12	12																											
28-Feb-12	13	4.0E-03	4.0E-05	1.0E-03	1.1E+00	3.5E-03	1.0E-02	2.5E-03	1.0E-04	9.0E-03	1.9E+00	4.1E-04	8.7E-01	1.0E-05	1.2E+00	4.6E-02	4.1E+00	2.0E-05	2.0E-05	5.0E-04	8.9E-03	4.4E-04	2.0E-03	2.0E-05	0.79	0.70	-0.09	-5.8%
6-Mar-12	14																											
13-Mar-12	15	3.0E-03	2.0E-05	1.0E-03	1.0E+00	3.1E-03	1.0E-02	2.6E-03	1.0E-04	9.0E-03	1.6E+00	3.3E-04	9.6E-01	1.0E-05	8.9E-01	4.8E-02	4.6E+00	2.0E-05	1.6E-04	4.0E-04	9.0E-03	2.9E-04	1.0E-03	3.0E-05	0.80	0.69	-0.11	-7.3%
20-Mar-12	16																											
27-Mar-12	17	3.0E-03	1.0E-04	1.0E-03	1.1E+00	2.9E-03	1.0E-02	2.3E-03	1.0E-04	1.2E-02	1.6E+00	3.2E-04	9.1E-01	1.0E-05	7.5E-01	4.7E-02	4.9E+00	2.0E-05	1.0E-05	4.0E-04	9.2E-03	4.5E-04	1.0E-03	3.0E-05	0.77	0.71	-0.06	-4.4%
3-Apr-12	18																											
10-Apr-12	19	3.0E-03	2.0E-05	1.0E-03	1.0E+00	2.8E-03	3.0E-02	2.3E-03	1.0E-04	9.0E-03	1.5E+00	2.9E-04	8.6E-01	1.0E-05	5.9E-01	4.8E-02	5.3E+00	2.0E-05	3.0E-05	3.0E-04	7.0E-03	4.1E-04	1.0E-03	2.0E-05	0.79	0.68	-0.11	-7.3%
17-Apr-12	20																											
24-Apr-12	21	3.0E-03	3.0E-05	1.0E-03	9.9E-01	3.1E-03	2.0E-02	2.0E-03	3.0E-04	9.0E-03	1.5E+00	7.0E-05	8.1E-01	1.0E-05	4.6E-01	4.7E-02	4.7E+00	2.0E-05	2.0E-05	3.0E-04	7.4E-03	4.8E-04	2.0E-03	1.0E-05	0.73	0.66	-0.07	-4.9%
1-May-12	22																											
8-May-12	23	1.7E-01	1.0E-04	1.0E-03	9.8E-01	4.0E-03	1.0E-02	2.0E-03	4.0E-04	9.0E-03	1.5E+00	3.3E-04	8.0E-01	1.0E-05	4.2E-01	4.5E-02	4.5E+00	2.0E-05	3.1E-04	8.0E-04	7.1E-03	3.7E-04	3.0E-03	1.0E-05	0.71	0.64	-0.07	-5.5%
15-May-12	24																											
22-May-12	25	6.0E-03	2.0E-05	1.0E-03	9.7E-01	2.6E-03	1.0E-02	1.9E-03	2.0E-04	9.0E-03	1.4E+00	3.2E-04	8.2E-01	1.0E-05	3.4E-01	4.5E-02	4.7E+00	2.0E-05	5.0E-05	7.0E-04	6.8E-03	5.5E-04	2.0E-03	2.0E-05	0.64	0.63	-0.01	-1.1%
29-May-12	26																											
5-Jun-12	27	6.0E-03	3.0E-05	1.0E-03	9.7E-01	2.5E-03	3.0E-02	1.8E-03	1.0E-04	9.0E-03	1.4E+00	4.8E-04	8.5E-01	1.0E-05	3.0E-01	4.7E-02	4.4E+00	2.0E-05	4.0E-05	6.0E-04	8.2E-03	6.3E-04	2.0E-03	1.0E-05	0.65	0.63	-0.02	-1.5%
12-Jun-12	28																											
19-Jun-12	29	7.0E-03	4.0E-05	1.0E-03	8.7E-01	2.3E-03	1.0E-02	2.0E-03	2.0E-04	9.0E-03	1.1E+00	4.4E-04	7.9E-01	1.0E-05	2.8E-01	4.1E-02	3.7E+00	2.0E-05	1.6E-04	1.0E-03	6.6E-03	5.1E-04	2.0E-03	2.0E-05	0.54	0.55	0.01	1.2%
26-Jun-12	30																											
3-Jul-12	31	5.0E-03	2.0E-05	1.0E-03	9.0E-01	2.8E-03	1.0E-02	1.7E-03	1.0E-04	9.0E-03	1.4E+00	5.5E-04	9.0E-01	1.0E-05	2.4E-01	4.2E-02	3.6E+00	2.0E-05	1.2E-04	5.0E-04	8.5E-03	4.6E-04	1.0E-03	3.0E-05	0.67	0.56	-0.11	-8.8%
10-Jul-12	32																											
17-Jul-12	33	3.0E-03	2.0E-05	1.0E-03	9.4E-01	2.4E-03	1.0E-02	1.6E-03	1.0E-04	9.0E-03	1.4E+00	6.2E-04	8.4E-01	1.0E-05	2.2E-01	4.6E-02	4.6E+00	2.0E-05	2.0E-05	4.0E-04	6.3E-03	4.4E-04	1.0E-03	1.0E-05	0.63	0.61	-0.02	-1.5%
24-Jul-12	34																											
31-Jul-12	35	3.0E-03	2.0E-05	1.0E-03	8.8E-01	2.2E-03	1.0E-02	1.4E-03	1.0E-04	9.0E-03	1.4E+00	5.6E-04	8.5E-01	1.0E-05	2.1E-01	4.4E-02	3.7E+00	2.0E-05	4.0E-05	5.0E-04	6.0E-03	5.5E-04	2.0E-03	1.0E-05	0.55	0.57	0.03	2.4%
7-Aug-12	36																											
14-Aug-12	37	3.0E-03	2.0E-05	1.0E-03	9.7E-01	2.3E-03	1.0E-02	2.0E-03	2.0E-04	9.0E-03	1.4E+00	4.2E-04	9.2E-01	1.0E-05	2.1E-01	4.7E-02	5.5E+00	2.0E-05	1.5E-04	3.0E-04	6.2E-03	7.8E-04	2.0E-03	1.0E-05	0.67	0.64	-0.03	-2.4%
21-Aug-12	38																											
28-Aug-12	39	6.0E-03	2.0E-05	1.0E-03	8.8E-01	2.4E-03	1.0E-02	1.3E-03	2.0E-04	9.0E-03	1.2E+00	4.1E-04	8.2E-01	1.0E-05	1.7E-01	4.5E-02	4.4E+00	2.0E-05	4.1E-04	5.0E-04	6.1E-03	5.1E-04	2.0E-03	1.0E-05	0.70	0.60	-0.10	-7.9%
4-Sep-12	40																											
11-Sep-12	41	8.0E-03	2.0E-05	1.0E-03	8.9E-01	1.7E-03	2.0E-02	1.6E-03	2.0E-04	9.0E-03	1.2E+00	5.6E-04	8.0E-01	1.0E-05	1.8E-01	4.4E-02	4.5E+00	2.0E-05	1.2E-04	2.0E-04	6.5E-03	4.6E-04	1.0E-03	8.0E-05	0.62	0.59	-0.03	-2.4%
18-Sep-12	42																											
25-Sep-12	43	7.0E-03	2.0E-05	1.0E-03	8.7E-01	1.0E-03	2.0E-02	1.4E-03	2.0E-04	9.0E-03	1.2E+00	5.9E-04	7.6E-01	1.0E-05	1.7E-01	4.4E-02	4.4E+00	2.0E-05	7.0E-05	5.0E-04	6.0E-03	4.6E-04	1.0E-03	1.0E-05	0.69	0.58	-0.11	-9.0%
2-Oct-12	44																											
9-Oct-12	45	6.0E-03	2.0E-05	1.0E-03	7.4E-01	1.2E-03	1.0E-02	9.4E-04	8.0E-04	9.0E-03	1.1E+00	3.5E-04	6.3E-01	1.0E-05	1.2E-01	3.7E-02	3.7E+00	2.0E-05	1.7E-04	7.0E-04	5.0E-03	3.7E-04	1.0E-03	1.0E-05	0.51	0.49	-0.02	-1.7%
16-Oct-12	46																											
23-Oct-12	47																											
30-Oct-12	48																											
6-Nov-12	49	3.0E-03	2.0E-05	1.0E-03	9.6E-01	1.4E-03	1.0E-02	1.3E-03	2.0E-04	9.0E-03	1.1E+00	4.2E-04	7.1E-01	1.0E-05	1.1E-01	4.8E-02	5.1E+00	2.0E-05	1.2E-04	1.0E-04	5.9E-03	2.8E-04	4.0E-03	1.0E-05	0.65	0.66	0.01	0.5%
13-Nov-12	50																											
20-Nov-12	51																											
27-Nov-12	52																											
4-Dec-12	53	7.0E-03	4.0E-05	1.0E-03	8.5E-01	1.8E-03	1.0E-02	1.3E-03	3.0E-04	9.0E-03	1.0E+00	1.1E-03	6.2E-01	1.0E-05	1.0E-01	4.2E-02	4.6E+00	2.0E-05	1.9E-04	4.0E-04	6.5E-03	2.8E-04	5.0E-03	1.0E-05	0.61	0.59	-0.03	-2.2%
11-Dec-12	54																											
18-Dec-12	55																											
25-Dec-12	56																											
1-Jan-13	57	3.0E-03	5.0E-05	1.0E-03	7.5E-01	1.6E-03	1.0E-02	9.6E-04	2.0E-04	9.0E-03	1.0E+00	4.7E-04	8.1E-01	1.0E-05	9.0E-02	4.0E-02	2.4E+00	2.0E-05	1.8E-04	4.0E-04	5.8E-03	3.9E-04	3.0E-03	1.0E-05	0.62	0.53	-0.09	-7.9%
8-Jan-13	58																											
15-Jan-13	59																											
22-Jan-13	60																											
29-Jan-13	61	6.0E-03	2.0E-05	1.0E-03	8.0E-01	1.6E-03	1.0E-02	1.3E-03	2.0E-04	1.4E-02	9.3E-01	4.3E-04	6.1E-01	1.0E-05	1.2E-01	4.1E-02	4.1E+00	2.0E-05	1.5E-04	3.0E-04	4.5E-03	3.9E-04	3.0E-03	1.0E-05	0.54	0.57	0.03	2.4%

HC11

Sample = 08-068

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Major	Major	Diff	Diff
	No.																								Anions	Cations		(%)
		mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L				
5-Feb-13	62																											
12-Feb-13	63																											
19-Feb-13	64																											
26-Feb-13	65	5.0E-03	3.0E-05	1.0E-03	7.0E-01	9.0E-04	1.0E-02	1.6E-03	2.0E-04	9.0E-03	8.9E-01	4.6E-04	5.7E-01	1.0E-05	9.0E-02	3.4E-02	3.8E+00	2.0E-05	7.0E-05	3.0E-04	4.3E-03	1.9E-04	1.0E-03	1.0E-05	0.62	0.48	-0.15	-13.4%
5-Mar-13	66																											
12-Mar-13	67																											
19-Mar-13	68																											
26-Mar-13	69	4.0E-03	5.0E-05	1.0E-03	7.2E-01	8.0E-04	1.0E-02	1.7E-03	1.0E-04	9.0E-03	8.4E-01	2.5E-04	6.1E-01	1.0E-05	8.0E-02	3.6E-02	3.7E+00	2.0E-05	1.0E-05	1.0E-04	4.4E-03	1.7E-04	2.0E-03	1.0E-05	0.70	0.51	-0.20	-16.1%
2-Apr-13	70																											
9-Apr-13	71																											
16-Apr-13	72																											
23-Apr-13	73	3.0E-03	3.0E-05	1.0E-03	7.1E-01	1.0E-03	1.0E-02	1.7E-03	1.0E-04	9.0E-03	7.9E-01	2.7E-04	6.6E-01	1.0E-05	7.0E-02	3.5E-02	3.4E+00	2.0E-05	2.0E-05	6.0E-04	3.9E-03	1.6E-04	1.0E-03	1.0E-05	0.57	0.47	-0.10	-9.7%
30-Apr-13	74																											
7-May-13	75																											
14-May-13	76																											
21-May-13	77	6.0E-03	2.0E-05	1.0E-03	6.5E-01	8.0E-04	1.0E-02	1.2E-03	1.0E-04	9.0E-03	8.9E-01	2.9E-04	6.5E-01	1.0E-05	8.0E-02	3.5E-02	3.2E+00	2.0E-05	3.0E-05	6.0E-04	4.2E-03	2.4E-04	1.0E-03	1.0E-05	0.53	0.47	-0.06	-6.2%
28-May-13	78	4.0E-03	2.0E-05	1.0E-03	6.6E-01	1.0E-03	1.0E-02	1.2E-03	1.0E-04	9.0E-03	8.8E-01	3.5E-04	5.6E-01	1.0E-05	7.0E-02	3.5E-02	2.9E+00	2.0E-05	3.0E-05	5.0E-04	4.3E-03	2.0E-04	1.0E-03	1.0E-05	0.50	0.46	-0.03	-3.5%
4-Jun-13	79	8.0E-03	3.0E-05	1.0E-03	6.8E-01	2.8E-03	1.0E-02	2.2E-03	6.3E-03	9.0E-03	7.4E-01	2.1E-04	5.4E-01	2.0E-05	8.0E-02	3.4E-02	2.3E+00	2.0E-05	8.4E-03	8.0E-04	6.1E-03	1.3E-04	2.0E-03	1.0E-05	0.47	0.47	0.00	0.1%
11-Jun-13	80	3.0E-03	2.0E-05	1.0E-03	5.6E-01	1.4E-03	1.0E-02	5.3E-04	1.0E-04	9.0E-03	6.0E-01	1.4E-04	4.3E-01	1.0E-05	6.0E-02	2.9E-02	1.3E+00	2.0E-05	6.9E-03	1.0E-04	7.3E-03	7.0E-05	1.0E-03	1.0E-05	0.48	0.39	-0.09	-9.9%
18-Jun-13	81	3.0E-03	2.0E-05	1.0E-03	5.3E-01	2.3E-03	1.0E-02	3.5E-04	1.0E-04	9.0E-03	5.8E-01	1.3E-04	3.8E-01	1.0E-05	6.0E-02	2.8E-02	1.1E+00	2.0E-05	5.0E-03	1.0E-04	7.1E-03	8.0E-05	1.0E-03	1.0E-05	0.43	0.37	-0.06	-7.2%
25-Jun-13	82																											
2-Jul-13	83	3.0E-03	2.0E-05	1.0E-03	4.8E-01	1.5E-03	1.0E-02	3.0E-04	1.0E-04	9.0E-03	5.7E-01	1.3E-04	3.8E-01	1.0E-05	4.0E-02	2.5E-02	1.0E+00	2.0E-05	1.8E-04	1.0E-04	6.2E-03	1.4E-04	1.0E-03	1.0E-05	0.45	0.34	-0.11	-13.9%
9-Jul-13	84																											
16-Jul-13	85	3.0E-03	2.0E-05	1.0E-03	5.2E-01	2.0E-03	2.0E-02	2.0E-04	1.0E-04	9.0E-03	4.8E-01	1.1E-04	3.3E-01	1.0E-05	4.0E-02	2.6E-02	1.0E+00	2.0E-05	3.9E-03	1.0E-04	5.8E-03	6.0E-05	1.0E-03	1.0E-05	0.40	0.37	-0.03	-3.9%
23-Jul-13	86																											
30-Jul-13	87	3.0E-03	2.0E-05	1.0E-03	4.6E-01	2.1E-03	1.0E-02	1.8E-04	1.0E-04	9.0E-03	4.5E-01	9.0E-05	3.3E-01	1.0E-05	3.0E-02	2.4E-02	8.8E-01	2.0E-05	4.1E-03	1.0E-04	5.5E-03	7.0E-05	1.0E-03	1.0E-05	0.42	0.33	-0.08	-10.8%
6-Aug-13	88																											
13-Aug-13	89	3.0E-03	2.0E-05	1.0E-03	4.9E-01	2.0E-03	1.0E-02	1.7E-04	2.0E-04	9.0E-03	4.5E-01	1.2E-04	3.4E-01	1.0E-05	4.0E-02	2.5E-02	9.6E-01	2.0E-05	5.3E-03	1.0E-04	5.4E-03	3.0E-05	2.0E-03	1.0E-05	0.36	0.35	-0.01	-2.0%
20-Aug-13	90																											
27-Aug-13	91																											
3-Sep-13	92																											
10-Sep-13	93	4.0E-03	2.0E-05	1.0E-03	4.7E-01	1.6E-03	1.0E-02	1.6E-04	1.0E-04	9.0E-03	4.5E-01	1.1E-04	3.5E-01	1.0E-05	3.0E-02	2.4E-02	1.0E+00	2.0E-05	2.6E-03	1.0E-04	5.0E-03	5.0E-05	1.0E-03	1.0E-05	0.35	0.35	-0.01	-1.0%
17-Sep-13	94																											
24-Sep-13	95																											
1-Oct-13	96																											
8-Oct-13	97	3.0E-03	2.0E-05	1.0E-03	4.6E-01	2.1E-03	1.0E-02	1.4E-04	1.0E-04	9.0E-03	4.3E-01	7.0E-05	3.6E-01	1.0E-05	3.0E-02	2.5E-02	1.0E+00	2.0E-05	3.7E-03	1.0E-04	4.9E-03	5.0E-05	1.0E-03	1.0E-05	0.36	0.35	0.00	-0.6%
15-Oct-13	98																											
22-Oct-13	99																											
29-Oct-13	100																											
5-Nov-13	101	3.0E-03	2.0E-05	1.0E-03	4.9E-01	1.7E-03	1.0E-02	1.1E-04	1.0E-04	9.0E-03	4.5E-01	1.0E-04	3.2E-01	1.0E-05	3.0E-02	2.7E-02	1.0E+00	2.0E-05	1.2E-04	1.0E-04	4.9E-03	4.0E-05	1.0E-03	1.0E-05	0.39	0.37	-0.02	-2.2%
12-Nov-13	102																											
19-Nov-13	103																											
26-Nov-13	104																											
3-Dec-13	105	4.0E-03	2.0E-05	1.0E-03	5.4E-01	1.9E-03	1.0E-02	1.5E-04	1.0E-04	9.0E-03	4.7E-01	1.2E-04	3.1E-01	1.0E-05	2.0E-02	3.0E-02	1.2E+00	2.0E-05	1.2E-04	1.0E-04	5.9E-03	6.0E-05	1.0E-03	1.0E-05	0.48	0.42	-0.06	-6.7%
10-Dec-13	106																											
17-Dec-13	107																											
24-Dec-13	108																											
31-Dec-13	109	7.0E-03	3.0E-05	1.0E-03	4.7E-01	1.9E-03	1.0E-02	1.3E-04	1.0E-04	9.0E-03	4.3E-01	1.0E-04	3.2E-01	1.0E-05	2.0E-02	2.6E-02	1.1E+00	2.0E-05	4.2E-03	1.0E-04	4.2E-03	6.0E-05	1.0E-03	1.0E-05	0.37	0.35	-0.02	-2.8%
7-Jan-14	110																											
14-Jan-14	111																											
21-Jan-14	112																											
28-Jan-14	113	3.0E-03	2.0E-05	1.0E-03	5.0E-01	1.8E-03	1.0E-02	7.0E-05	1.0E-04	9.0E-03	4.1E-01	6.0E-05	2.9E-01	1.0E-05	3.0E-02	2.7E-02	1.1E+00	2.0E-05	2.1E-03	1.0E-04	4.0E-03	3.0E-05	1.0E-03	1.0E-05	0.40	0.38	-0.02	-2.6%
4-Feb-14	114																											
11-Feb-14	115																											
18-Feb-14	116																											
25-Feb-14	117	3.0E-03	2.0E-05	1.0E-03	4.5E-01	1.6E-03	1.0E-02	1.2E-04	1.0E-04	9.0E-03	3.9E-01	9.0E-05	2.9E-01	1.0E-05	3.0E-02	2.4E-02	1.0E+00	2.0E-05	2.3E-03	1.0E-04	3.6E-03	4.0E-05	1.0E-03	1.0E-05	0.45	0.34	-0.11	-14.3%

HC11
Sample = 08-068

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/kg	mgCaCO3/kg	mgCaCO3/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
29-Nov-11	0	500	395	7.28	7.9E+02	#N/A	3.1E+00	1.4E+01	1.4E+02	8.3E-01	7.7E-01	1.2E-01	1.4E+02	2.1E-02	7.5E-04	7.1E-04	1.1E-02	7.9E-06	7.9E-06	2.7E-03	6.2E-05	4.9E+01	2.0E-04	1.8E-03	1.2E-02
6-Dec-11	1	500	480	7.52	3.9E+02	#N/A	2.2E+00	1.4E+01	7.4E+01	5.8E-01	8.9E-01	1.4E-01	7.9E+01	1.8E-02	5.8E-04	6.2E-04	1.1E-02	9.6E-06	4.8E-06	1.8E-03	9.6E-06	2.7E+01	5.3E-04	2.0E-04	3.9E-03
13-Dec-11	2	500	510	7.40	2.1E+02	#N/A	2.1E+00	1.4E+01	3.0E+01	1.0E-01	8.1E-01	1.5E-01	4.2E+01	1.2E-02	4.1E-04	4.1E-04	1.7E-02	1.0E-05	1.0E-05	1.5E-03	3.1E-06	1.5E+01	3.6E-04	9.5E-05	2.1E-03
20-Dec-11	3	500	500	7.45	1.4E+02	#N/A	2.4E+00	1.5E+01	2.1E+01	1.0E-01	9.3E-01	1.5E-01	3.3E+01	2.3E-02	6.5E-04	6.0E-04	1.5E-02	1.0E-05	5.0E-06	1.5E-03	1.0E-05	1.1E+01	2.5E-04	8.0E-05	2.1E-03
27-Dec-11	4	500	525	7.47	6.9E+01																				
3-Jan-12	5	500	475	7.47	8.1E+01	#N/A	2.0E+00	1.3E+01	7.6E+00	9.5E-02	7.6E-01	1.4E-01	1.3E+01	2.6E-02	6.7E-04	5.2E-04	1.7E-02	9.5E-06	4.8E-06	1.2E-03	1.4E-06	4.6E+00	2.4E-04	4.0E-05	1.3E-03
10-Jan-12	6	500	445	7.40	8.3E+01																				
17-Jan-12	7	500	425	7.45	8.6E+01	#N/A	1.3E+00	1.5E+01	4.7E+00	8.5E-02	7.3E-01	1.3E-01	1.5E+01	2.5E-02	1.5E-03	6.0E-04	1.6E-02	8.5E-06	4.3E-06	1.6E-03	3.8E-06	5.2E+00	2.1E-04	4.0E-05	2.0E-03
24-Jan-12	8	500	465	7.46	7.7E+01																				
31-Jan-12	9	500	475	7.44	8.1E+01	#N/A	1.6E+00	1.5E+01	6.7E+00	9.5E-02	6.7E-01	1.4E-01	1.4E+01	1.8E-02	9.0E-04	5.7E-04	1.9E-02	9.5E-06	4.8E-06	1.1E-03	1.4E-06	4.9E+00	2.4E-04	3.4E-05	1.2E-03
7-Feb-12	10	500	485	7.41	7.8E+01																				
14-Feb-12	11	500	485	7.44	7.8E+01	#N/A	2.2E+00	1.3E+01	9.2E+00	9.7E-02	5.9E-01	1.5E-01	1.6E+01	1.3E-02	7.3E-04	6.3E-04	1.8E-02	9.7E-06	4.9E-06	8.7E-04	1.5E-06	5.4E+00	2.4E-04	2.9E-05	8.7E-04
21-Feb-12	12	500	475	7.36	7.9E+01																				
28-Feb-12	13	500	450	7.28	7.1E+01	#N/A	1.7E+00	1.1E+01	5.0E+00	9.0E-02	4.4E-01	1.4E-01	1.3E+01	1.5E-02	6.3E-04	5.0E-04	1.4E-02	9.0E-06	4.5E-06	8.6E-04	1.4E-06	4.5E+00	2.3E-04	2.6E-05	1.2E-03
6-Mar-12	14	500	450	7.34	7.3E+01																				
13-Mar-12	15	500	445	7.28	6.9E+01	#N/A	1.3E+00	1.1E+01	5.8E+00	8.9E-02	4.0E-01	1.3E-01	1.4E+01	1.2E-02	6.7E-04	4.9E-04	1.4E-02	8.9E-06	4.5E-06	8.5E-04	1.3E-06	4.6E+00	2.2E-04	1.8E-05	6.7E-04
20-Mar-12	16	500	460	7.26	7.4E+01																				
27-Mar-12	17	500	445	7.20	7.1E+01	#N/A	1.4E+00	9.8E+00	6.2E+00	8.9E-02	3.4E-01	1.3E-01	1.4E+01	1.7E-02	6.7E-04	5.8E-04	1.4E-02	8.9E-06	4.5E-06	7.6E-04	3.6E-06	4.8E+00	2.2E-04	2.4E-05	9.3E-04
3-Apr-12	18	500	455	7.19	6.7E+01																				
10-Apr-12	19	500	445	7.26	7.3E+01	#N/A	1.3E+00	9.8E+00	6.7E+00	8.9E-02	3.1E-01	1.3E-01	1.4E+01	1.6E-02	7.1E-04	4.5E-04	1.1E-02	8.9E-06	4.5E-06	8.9E-04	1.3E-06	4.7E+00	2.2E-04	2.7E-05	8.9E-04
17-Apr-12	20	500	455	7.19	7.6E+01																				
24-Apr-12	21	500	470	7.23	7.0E+01	#N/A	1.5E+00	1.0E+01	5.6E+00	9.4E-02	2.9E-01	1.4E-01	1.4E+01	2.0E-02	8.0E-04	4.7E-04	1.5E-02	9.4E-06	4.7E-06	8.0E-04	1.4E-06	4.8E+00	2.4E-04	2.7E-05	1.2E-03
1-May-12	22	500	440	7.19	7.0E+01																				
8-May-12	23	500	430	7.17	6.7E+01	#N/A	1.4E+00	9.4E+00	5.2E+00	4.3E-01	2.1E-01	1.3E-01	1.2E+01	1.5E-02	7.3E-04	4.3E-04	1.1E-02	8.6E-06	4.3E-06	7.7E-04	1.3E-06	4.3E+00	2.2E-04	2.8E-05	1.2E-03
15-May-12	24	500	430	7.17	6.7E+01																				
22-May-12	25	500	435	7.16	6.7E+01	#N/A	1.7E+00	9.3E+00	3.9E+00	8.7E-02	2.3E-01	1.3E-01	1.2E+01	2.9E-02	6.1E-04	3.9E-04	1.1E-02	8.7E-06	4.4E-06	6.1E-04	1.3E-06	4.2E+00	2.2E-04	2.2E-05	7.4E-04
29-May-12	26	500	420	7.13	6.5E+01																				
5-Jun-12	27	500	450	7.17	6.4E+01	#N/A	1.8E+00	9.8E+00	4.1E+00	9.0E-02	2.0E-01	1.4E-01	1.3E+01	3.1E-02	7.2E-04	5.4E-04	1.1E-02	9.0E-06	4.5E-06	1.1E-03	1.4E-06	4.4E+00	2.3E-04	3.9E-05	9.0E-04
12-Jun-12	28	500	435	7.13	6.0E+01																				
19-Jun-12	29	500	435	7.11	5.9E+01	#N/A	1.4E+00	7.2E+00	3.9E+00	8.7E-02	2.0E-01	1.3E-01	1.1E+01	3.0E-02	6.5E-04	3.9E-04	9.0E-03	8.7E-06	4.4E-06	5.7E-04	1.3E-06	3.8E+00	2.2E-04	3.7E-05	2.3E-03
26-Jun-12	30	500	440	7.14	5.9E+01																				
3-Jul-12	31	500	435	7.10	6.0E+01	#N/A	3.2E+00	1.0E+01	3.9E+00	8.7E-02	2.0E-01	1.3E-01	1.1E+01	2.1E-02	9.1E-04	5.2E-04	1.3E-02	8.7E-06	4.4E-06	5.2E-04	1.3E-06	3.8E+00	2.2E-04	1.7E-05	1.2E-03
10-Jul-12	32	500	440	7.10	6.3E+01																				
17-Jul-12	33	500	445	7.07	6.3E+01	#N/A	1.3E+00	8.9E+00	4.5E+00	8.9E-02	1.6E-01	1.3E-01	1.2E+01	1.8E-02	8.0E-04	4.9E-04	1.3E-02	8.9E-06	4.5E-06	7.1E-04	1.3E-06	4.3E+00	2.2E-04	6.9E-05	6.7E-04
24-Jul-12	34	500	425	7.07	6.5E+01																				
31-Jul-12	35	500	435	7.09	6.0E+01	#N/A	1.2E+00	7.4E+00	3.9E+00	8.7E-02	1.6E-01	1.3E-01	1.1E+01	2.1E-02	7.8E-04	3.9E-04	1.2E-02	8.7E-06	4.4E-06	8.7E-04	1.3E-06	3.9E+00	2.2E-04	2.6E-05	1.1E-03
7-Aug-12	36	500	455	7.17	6.0E+01																				
14-Aug-12	37	500	490	7.00	6.9E+01	#N/A	1.9E+00	8.3E+00	7.4E+00	9.8E-02	1.7E-01	1.5E-01	1.4E+01	2.6E-02	8.8E-04	5.9E-04	1.3E-02	9.8E-06	4.9E-06	1.7E-03	1.5E-06	4.9E+00	2.5E-04	6.4E-06	1.9E-03
21-Aug-12	38	500	445	7.01	6.7E+01																				
28-Aug-12	39	500	435	7.05	6.6E+01	#N/A	1.8E+00	8.9E+00	5.7E+00	8.7E-02	1.4E-01	1.3E-01	1.2E+01	2.5E-02	7.4E-04	3.0E-04	1.2E-02	8.7E-06	4.4E-06	1.0E-03	1.3E-06	4.1E+00	2.2E-04	1.9E-05	1.7E-03
4-Sep-12	40	500	475	6.96	5.4E+01																				
11-Sep-12	41	500	485	6.99	6.3E+01	#N/A	1.8E+00	8.2E+00	6.3E+00	9.7E-02	1.4E-01	1.5E-01	1.3E+01	1.2E-02	7.8E-04	3.9E-04	1.4E-02	9.7E-06	4.9E-06	1.4E-03	1.5E-06	4.6E+00	2.4E-04	3.4E-05	1.6E-03
18-Sep-12	42	500	495	7.03	6.5E+01																				
25-Sep-12	43	500	445	7.03	6.4E+01	#N/A	2.0E+00	9.5E+00	5.3E+00	8.9E-02	1.2E-01	1.3E-01	1.2E+01	1.6E-02	6.7E-04	4.5E-04	1.0E-02	8.9E-06	4.5E-06	9.3E-04	1.3E-06	4.1E+00	2.2E-04	2.0E-05	2.2E-03
2-Oct-12	44	500	450	7.11	6.0E+01																				
9-Oct-12	45	500	445	6.92	5.4E+01	#N/A	2.0E+00	6.9E+00	4.0E+00	8.9E-02	9.3E-02	1.3E-01	1.0E+01	1.7E-02	5.3E-04	2.7E-04	8.5E-03	8.9E-06	4.5E-06	4.9E-04	1.3E-06	3.5E+00	2.2E-04	3.2E-05	1.7E-03
16-Oct-12	46	500	450	7.10	7.8E+01																				
23-Oct-12	47	500	510	7.13	7.5E+01																				
30-Oct-12	48	500	500	7.12	7.0E+01																				
6-Nov-12	49	500	480	7.05	6.4E+01	#N/A	1.8E+00	9.9E+00	5.3E+00	9.6E-02	1.0E-01	1.4E-01	1.5E+01	1.2E-02	8.6E-04	3.8E-04	1.1E-02	9.6E-06	4.8E-06	9.6E-04	7.7E-06	5.2E+00	2.4E-04	1.2E-04	2.2E-03
13-Nov-12	50	500	460	7.08	6.3E+01																				
20-Nov-12	51	500	490	7.07	6.6E+01																				
27-Nov-12	52	500	490	7.10	6.5E+01																				
4-Dec-12	53	500	455	7.07	6.2E+01	#N/A	1.5E+00	7.5E+00	5.9E+00	9.1E-02	8.6E-02	1.4E-01	1.3E+01	1.5E-02	7.7E-04	4.1E-04	9.4E-03	9.1E-06	4.6E-06	4.1E-04	8.6E-06	4.4E+00	2.3E-04	2.8E-04	1.7E-03
11-Dec-12	54	500	470	7.20	6.5E+01																				
18-Dec-12	55	500	470	7.03	5.8E+01																				
25-Dec-12	56	500	455	7.21	6.0E+01																				
1-Jan-13	57	500	525	7.10	5.1E+01	#N/A	2.6E+00	1.3E+01	2.6E+00	1.1E-01	1.1E-01	1.6E-01	1.3E+01	1.7E-02	1.1E-03	6.3E-04	1.6E-02	1.1E-05	5.3E-06	8.9E-04	4.2E-06	4.6E+00	2.6E-04	1.1E-04	1.5E-03
8-Jan-13	58	500	465	7.21	6.5E+01																				
15-Jan-13	59	500	465	6.98	5.5E+01																				
22-Jan-13	60	500	450	7.19	6.0E+01																				
29-Jan-13	61	500	450	7.02	5.4E+01	#N/A	1.5E+00	7.8E+00	4.1E+00	9.0E-02	6.8E-02	1.4E-01	1.2E+01	1.8E-02	6.8E-04	3.6E-04	8.3E-03	9.0E-06	4.5E-06	4.1E-04	2.7E-06	4.2E+00	2.3E-04	8.0E-05	2.7E-03
5-Feb-13	62	500	460	7.07	5.8E+01																				
12-Feb-13	63	500	450	7.15	5.9E+01																				
19-Feb-13	64	500	455	6.95	5.7E+01																				
26-Feb-13	65	500	450	7.06	5.5E+01	#N/A	2.1E+00	9.2E+00	4.5E+00	9.0E-02	5.4E-02	1.4E-01	1.0E+01	1.2E-02	6.3E-04	5.0E-04	8.7E-03	9.0E-06	4.5E-06	3.6E-04	5.0E-06	3.5E+00	2.3E-04	1.6E-04	3.2E-03
5-Mar-13	66	500	460	7.16	5.4E+01																				

HC11
Sample = 08-068

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/kg	mgCaCO3/kg	mgCaCO3/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
12-Mar-13	67	500	450	7.07	5.4E+01																				
19-Mar-13	68	500	440	6.82	5.6E+01																				
26-Mar-13	69	500	460	6.81	5.6E+01	#N/A	2.7E+00	7.9E+00	7.8E+00	9.2E-02	5.1E-02	1.4E-01	1.1E+01	9.1E-03	6.4E-04	4.6E-04	8.0E-03	9.2E-06	4.6E-06	4.6E-04	1.8E-06	3.9E+00	2.3E-04	1.0E-04	2.1E-03
2-Apr-13	70	500	430	6.89	5.4E+01																				
9-Apr-13	71	500	460	6.81	5.6E+01																				
16-Apr-13	72	500	460	6.92	6.0E+01																				
23-Apr-13	73	500	450	6.67	5.7E+01	#N/A	2.4E+00	7.6E+00	5.0E+00	9.0E-02	4.5E-02	1.4E-01	1.0E+01	1.2E-02	6.8E-04	3.6E-04	8.4E-03	9.0E-06	4.5E-06	5.4E-04	1.4E-06	3.5E+00	2.3E-04	2.9E-05	9.9E-04
30-Apr-13	74	500	450	6.81	5.3E+01																				
7-May-13	75	500	435	6.83	6.5E+01																				
14-May-13	76	500	440	6.95	5.2E+01																				
21-May-13	77	500	440	6.78	5.2E+01	#N/A	1.9E+00	6.9E+00	4.4E+00	8.8E-02	4.4E-02	1.3E-01	9.6E+00	1.3E-02	7.0E-04	3.1E-04	1.0E-02	8.8E-06	4.4E-06	5.7E-04	3.1E-06	3.4E+00	2.2E-04	9.7E-06	8.8E-04
28-May-13	78	500	440	6.73	4.8E+01		2.0E+00	6.3E+00	4.4E+00	8.8E-02	4.0E-02	1.3E-01	9.5E+00	1.3E-02	7.0E-04	3.5E-04	1.0E-02	8.8E-06	4.4E-06	7.9E-04	1.3E-06	3.3E+00	2.2E-04	2.2E-05	8.4E-04
4-Jun-13	79	500	430	6.96	4.6E+01		2.0E+00	6.8E+00	3.0E+00	8.6E-02	3.4E-02	1.3E-01	9.4E+00	1.3E-02	5.2E-04	2.6E-04	1.1E-02	8.6E-06	4.3E-06	2.2E-03	7.3E-06	3.3E+00	3.9E-04	3.9E-05	7.7E-04
11-Jun-13	80	500	480	6.87	3.9E+01		3.3E+00	8.5E+00	2.9E+00	9.6E-02	2.9E-02	1.4E-01	9.0E+00	4.6E-03	4.3E-04	1.9E-04	9.4E-03	9.6E-06	4.8E-06	1.4E-03	1.4E-06	3.2E+00	2.4E-04	4.5E-05	6.2E-04
18-Jun-13	81	500	480	6.83	3.8E+01	#N/A	2.6E+00	7.3E+00	2.9E+00	4.8E-01	2.9E-02	1.4E-01	8.4E+00	3.5E-03	4.8E-04	1.4E-04	1.0E-02	9.6E-06	4.8E-06	1.2E-03	3.4E-06	3.0E+00	2.4E-04	6.0E-05	3.4E-04
25-Jun-13	82	500	480	6.97	3.8E+01																				
2-Jul-13	83	500	450	6.96	3.4E+01		3.0E+00	7.8E+00	2.3E+00	4.5E-01	2.7E-02	1.4E-01	7.2E+00	1.0E-02	4.1E-04	1.4E-04	9.6E-03	9.0E-06	4.5E-06	9.0E-05	1.4E-06	2.5E+00	2.3E-04	1.3E-05	1.2E-03
9-Jul-13	84	500	475	7.01	4.6E+01																				
16-Jul-13	85	500	490	6.87	3.6E+01	#N/A	1.7E+00	7.2E+00	2.5E+00	4.9E-01	2.9E-02	1.5E-01	8.6E+00	4.2E-03	3.9E-04	2.0E-04	1.3E-02	9.8E-06	4.9E-06	9.3E-04	1.5E-06	3.0E+00	2.5E-04	1.7E-05	5.4E-04
23-Jul-13	86	500	460	6.74	3.6E+01																				
30-Jul-13	87	500	480	6.79	3.3E+01		2.1E+00	7.0E+00	2.9E+00	9.6E-02	2.9E-02	1.4E-01	7.7E+00	3.9E-03	3.4E-04	9.6E-05	1.2E-02	9.6E-06	4.8E-06	8.6E-04	1.4E-06	2.7E+00	2.4E-04	9.6E-06	3.8E-04
6-Aug-13	88	500	485	6.78	3.8E+01																				
13-Aug-13	89	500	490	6.86	3.5E+01	#N/A	1.6E+00	6.9E+00	2.0E+00	4.9E-01	2.9E-02	1.5E-01	8.2E+00	3.9E-03	3.4E-04	1.5E-04	1.3E-02	9.8E-06	4.9E-06	9.3E-04	1.5E-06	2.9E+00	2.5E-04	3.6E-05	5.4E-04
20-Aug-13	90	500	485	6.79	3.5E+01																				
27-Aug-13	91	500	480	6.85	3.0E+01																				
3-Sep-13	92	500	475	6.76	3.3E+01																				
10-Sep-13	93	500	470	6.78	3.5E+01	#N/A	1.8E+00	6.8E+00	1.4E+00	9.4E-02	2.8E-02	1.4E-01	7.7E+00	5.5E-03	3.3E-04	1.9E-04	1.2E-02	9.4E-06	4.7E-06	7.1E-04	1.9E-06	2.8E+00	2.4E-04	3.9E-05	5.2E-04
17-Sep-13	94	500	500	6.87	3.5E+01																				
24-Sep-13	95	500	475	6.92	3.1E+01																				
1-Oct-13	96	500	470	6.70	3.4E+01																				
8-Oct-13	97	500	475	6.95	3.3E+01	#N/A	1.1E+00	6.5E+00	1.9E+00	9.5E-02	2.9E-02	1.4E-01	8.0E+00	8.8E-03	3.3E-04	1.4E-04	1.3E-02	9.5E-06	4.8E-06	1.6E-03	1.4E-06	2.8E+00	2.4E-04	5.1E-05	1.9E-03
15-Oct-13	98	500	480	6.91	3.3E+01																				
22-Oct-13	99	500	475	6.91	3.7E+01																				
29-Oct-13	100	500	485	7.11	3.7E+01																				
5-Nov-13	101	500	475	7.02	3.7E+01	#N/A	1.1E+00	7.2E+00	1.9E+00	9.5E-02	2.9E-02	1.4E-01	8.5E+00	6.0E-03	3.3E-04	9.5E-05	1.3E-02	9.5E-06	4.8E-06	4.8E-04	1.4E-06	3.0E+00	2.4E-04	2.8E-05	4.3E-04
12-Nov-13	102	500	470	6.91	3.8E+01																				
19-Nov-13	103	500	465	7.08	3.5E+01																				
26-Nov-13	104	500	455	7.33	3.6E+01																				
3-Dec-13	105	500	480	7.43	4.0E+01	#N/A	7.1E-01	9.9E+00	1.4E+00	9.6E-02	2.9E-02	1.4E-01	9.6E+00	7.9E-03	3.4E-04	1.4E-04	1.4E-02	9.6E-06	4.8E-06	3.8E-04	1.4E-06	3.4E+00	2.4E-04	3.6E-05	5.3E-04
10-Dec-13	106	500	475	7.16	3.5E+01																				
17-Dec-13	107	500	485	7.01	3.8E+01																				
24-Dec-13	108	500	495	6.90	3.8E+01																				
31-Dec-13	109	500	490	7.16	3.6E+01	#N/A	1.0E+00	7.0E+00	2.0E+00	9.8E-02	2.9E-02	1.5E-01	8.2E+00	4.9E-03	2.9E-04	1.5E-04	1.4E-02	9.8E-06	4.9E-06	7.8E-04	1.5E-06	2.9E+00	2.5E-04	2.9E-05	3.0E-03
7-Jan-14	110	500	490	7.08	3.6E+01																				
14-Jan-14	111	500	480	6.98	3.1E+01																				
21-Jan-14	112	500	485	7.06	3.6E+01																				
28-Jan-14	113	500	485	7.14	3.8E+01	#N/A	1.2E+00	7.6E+00	1.9E+00	9.7E-02	2.9E-02	1.5E-01	8.7E+00	7.2E-03	3.4E-04	9.7E-05	1.4E-02	9.7E-06	4.9E-06	6.3E-04	1.5E-06	3.1E+00	2.4E-04	1.7E-05	3.7E-03
4-Feb-14	114	500	470	7.27	3.8E+01																				
11-Feb-14	115	500	475	7.18	3.3E+01																				
18-Feb-14	116	500	480	7.18	3.4E+01																				
25-Feb-14	117	500	485	7.20	3.3E+01	#N/A	1.8E+00	8.0E+00	2.9E+00	9.7E-02	2.9E-02	1.5E-01	8.0E+00	3.6E-03	2.9E-04	9.7E-05	1.3E-02	9.7E-06	4.9E-06	5.3E-04	1.5E-06	2.8E+00	2.4E-04	2.3E-05	7.8E-04

HC11
Sample = 08-068

Date	Cycle No.	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
29-Nov-11	0	1.2E-03	2.0E-05	7.9E-04	4.8E+00	1.4E-02	4.0E-06	5.3E-03	2.1E-03	3.6E-03	2.8E+00	6.7E-03	5.5E-01	4.0E-06	9.2E+00	2.0E-01	4.9E+01	2.4E-05	2.4E-05	1.2E-04	1.0E-02	2.2E-04	7.1E-03	9.9E-05
6-Dec-11	1	1.4E-03	9.6E-06	4.8E-04	2.8E+00	8.6E-03	4.8E-06	8.2E-03	9.6E-05	4.3E-03	2.0E+00	4.8E-03	5.7E-01	4.8E-06	6.9E+00	1.1E-01	2.7E+01	9.6E-06	4.8E-06	1.9E-04	8.5E-03	1.4E-04	1.4E-03	6.2E-05
13-Dec-11	2	1.5E-03	5.1E-05	5.1E-04	1.3E+00	5.0E-03	5.1E-06	6.2E-03	4.1E-04	5.1E-03	1.4E+00	2.2E-03	4.5E-01	5.1E-06	3.6E+00	6.4E-02	1.2E+01	1.0E-05	8.2E-05	1.5E-04	6.6E-03	1.3E-04	3.1E-03	4.1E-05
20-Dec-11	3	4.0E-03	1.0E-05	5.0E-04	1.0E+00	5.3E-03	5.0E-06	5.6E-03	3.5E-04	4.5E-03	1.2E+00	1.0E-03	7.0E-01	5.0E-06	3.1E+00	4.8E-02	8.6E+00	1.0E-05	5.0E-06	4.5E-04	6.5E-03	2.0E-04	2.0E-03	3.5E-05
27-Dec-11	4																							
3-Jan-12	5	1.9E-03	9.5E-06	4.8E-04	4.7E-01	1.9E-03	4.8E-06	3.5E-03	2.4E-04	4.3E-03	7.9E-01	3.4E-04	4.4E-01	4.8E-06	1.5E+00	2.1E-02	2.5E+00	9.5E-06	9.5E-06	2.9E-04	6.0E-03	2.7E-04	4.8E-04	1.9E-05
10-Jan-12	6																							
17-Jan-12	7	3.0E-03	8.5E-06	4.3E-04	5.3E-01	1.6E-03	4.3E-06	2.9E-03	8.5E-05	3.8E-03	8.6E-01	4.5E-04	5.8E-01	4.3E-06	1.3E+00	2.4E-02	2.3E+00	8.5E-06	4.3E-06	7.7E-04	1.1E-02	2.5E-04	4.3E-04	5.5E-05
24-Jan-12	8																							
31-Jan-12	9	1.4E-03	9.5E-06	4.8E-04	5.2E-01	1.5E-03	4.8E-06	2.2E-03	4.8E-05	4.3E-03	8.9E-01	3.6E-04	4.8E-01	4.8E-06	9.5E-01	2.3E-02	2.1E+00	9.5E-06	1.9E-05	1.4E-04	6.7E-03	2.8E-04	9.5E-04	1.4E-05
7-Feb-12	10																							
14-Feb-12	11	1.5E-03	9.7E-06	4.9E-04	5.6E-01	2.0E-03	4.9E-06	1.8E-03	1.5E-04	4.4E-03	8.1E-01	5.9E-04	4.6E-01	4.9E-06	7.4E-01	2.6E-02	2.3E+00	9.7E-06	4.9E-06	1.9E-04	5.9E-03	2.5E-04	1.5E-03	1.5E-05
21-Feb-12	12																							
28-Feb-12	13	1.8E-03	1.8E-05	4.5E-04	4.8E-01	1.6E-03	4.5E-06	1.1E-03	4.5E-05	4.1E-03	8.6E-01	1.8E-04	3.9E-01	4.5E-06	5.5E-01	2.1E-02	1.9E+00	9.0E-06	9.0E-06	2.3E-04	4.0E-03	2.0E-04	9.0E-04	9.0E-06
6-Mar-12	14																							
13-Mar-12	15	1.3E-03	8.9E-06	4.5E-04	4.6E-01	1.4E-03	4.5E-06	1.2E-03	4.5E-05	4.0E-03	7.3E-01	1.5E-04	4.3E-01	4.5E-06	4.0E-01	2.1E-02	2.0E+00	8.9E-06	7.1E-05	1.8E-04	4.0E-03	1.3E-04	4.5E-04	1.3E-05
20-Mar-12	16																							
27-Mar-12	17	1.3E-03	4.5E-05	4.5E-04	4.8E-01	1.3E-03	4.5E-06	1.0E-03	4.5E-05	5.3E-03	7.0E-01	1.4E-04	4.0E-01	4.5E-06	3.3E-01	2.1E-02	2.2E+00	8.9E-06	4.5E-06	1.8E-04	4.1E-03	2.0E-04	4.5E-04	1.3E-05
3-Apr-12	18																							
10-Apr-12	19	1.3E-03	8.9E-06	4.5E-04	4.6E-01	1.2E-03	1.3E-05	1.0E-03	4.5E-05	4.0E-03	6.8E-01	1.3E-04	3.8E-01	4.5E-06	2.6E-01	2.1E-02	2.4E+00	8.9E-06	1.3E-05	1.3E-04	3.1E-03	1.8E-04	4.5E-04	8.9E-06
17-Apr-12	20																							
24-Apr-12	21	1.4E-03	1.4E-05	4.7E-04	4.6E-01	1.5E-03	9.4E-06	9.3E-04	1.4E-04	4.2E-03	6.9E-01	3.3E-05	3.8E-01	4.7E-06	2.2E-01	2.2E-02	2.2E+00	9.4E-06	9.4E-06	1.4E-04	3.5E-03	2.3E-04	9.4E-04	4.7E-06
1-May-12	22																							
8-May-12	23	7.2E-02	4.3E-05	4.3E-04	4.2E-01	1.7E-03	4.3E-06	8.6E-04	1.7E-04	3.9E-03	6.5E-01	1.4E-04	3.4E-01	4.3E-06	1.8E-01	1.9E-02	2.0E+00	8.6E-06	1.3E-04	3.4E-04	3.0E-03	1.6E-04	1.3E-03	4.3E-06
15-May-12	24																							
22-May-12	25	2.6E-03	8.7E-06	4.4E-04	4.2E-01	1.1E-03	4.4E-06	8.4E-04	8.7E-05	3.9E-03	6.0E-01	1.4E-04	3.6E-01	4.4E-06	1.5E-01	2.0E-02	2.1E+00	8.7E-06	2.2E-05	3.0E-04	3.0E-03	2.4E-04	8.7E-04	8.7E-06
29-May-12	26																							
5-Jun-12	27	2.7E-03	1.4E-05	4.5E-04	4.4E-01	1.1E-03	1.4E-05	8.0E-04	4.5E-05	4.1E-03	6.3E-01	2.2E-04	3.8E-01	4.5E-06	1.4E-01	2.1E-02	2.0E+00	9.0E-06	1.8E-05	2.7E-04	3.7E-03	2.8E-04	9.0E-04	4.5E-06
12-Jun-12	28																							
19-Jun-12	29	3.0E-03	1.7E-05	4.4E-04	3.8E-01	1.0E-03	4.4E-06	8.8E-04	8.7E-05	3.9E-03	5.0E-01	1.9E-04	3.4E-01	4.4E-06	1.2E-01	1.8E-02	1.6E+00	8.7E-06	7.0E-05	4.4E-04	2.9E-03	2.2E-04	8.7E-04	8.7E-06
26-Jun-12	30																							
3-Jul-12	31	2.2E-03	8.7E-06	4.4E-04	3.9E-01	1.2E-03	4.4E-06	7.4E-04	4.4E-05	3.9E-03	6.0E-01	2.4E-04	3.9E-01	4.4E-06	1.0E-01	1.8E-02	1.6E+00	8.7E-06	5.2E-05	2.2E-04	3.7E-03	2.0E-04	4.4E-04	1.3E-05
10-Jul-12	32																							
17-Jul-12	33	1.3E-03	8.9E-06	4.5E-04	4.2E-01	1.1E-03	4.5E-06	7.1E-04	4.5E-05	4.0E-03	6.4E-01	2.8E-04	3.7E-01	4.5E-06	9.8E-02	2.1E-02	2.0E+00	8.9E-06	8.9E-06	1.8E-04	2.8E-03	2.0E-04	4.5E-04	4.5E-06
24-Jul-12	34																							
31-Jul-12	35	1.3E-03	8.7E-06	4.4E-04	3.8E-01	9.6E-04	4.4E-06	6.1E-04	4.4E-05	3.9E-03	5.9E-01	2.4E-04	3.7E-01	4.4E-06	9.1E-02	1.9E-02	1.6E+00	8.7E-06	1.7E-05	2.2E-04	2.6E-03	2.4E-04	8.7E-04	4.4E-06
7-Aug-12	36																							
14-Aug-12	37	1.5E-03	9.8E-06	4.9E-04	4.8E-01	1.1E-03	4.9E-06	9.8E-04	9.8E-05	4.4E-03	7.0E-01	2.1E-04	4.5E-01	4.9E-06	1.0E-01	2.3E-02	2.7E+00	9.8E-06	7.4E-05	1.5E-04	3.0E-03	3.8E-04	9.8E-04	4.9E-06
21-Aug-12	38																							
28-Aug-12	39	2.6E-03	8.7E-06	4.4E-04	3.8E-01	1.0E-03	4.4E-06	5.7E-04	8.7E-05	3.9E-03	5.4E-01	1.8E-04	3.6E-01	4.4E-06	7.4E-02	1.9E-02	1.9E+00	8.7E-06	1.8E-04	2.2E-04	2.6E-03	2.2E-04	8.7E-04	4.4E-06
4-Sep-12	40																							
11-Sep-12	41	3.9E-03	9.7E-06	4.9E-04	4.3E-01	8.2E-04	9.7E-06	7.5E-04	9.7E-05	4.4E-03	6.0E-01	2.7E-04	3.9E-01	4.9E-06	8.7E-02	2.2E-02	2.2E+00	9.7E-06	5.8E-05	9.7E-05	3.2E-03	2.2E-04	4.9E-04	3.9E-05
18-Sep-12	42																							
25-Sep-12	43	3.1E-03	8.9E-06	4.5E-04	3.9E-01	4.5E-04	8.9E-06	6.1E-04	8.9E-05	4.0E-03	5.3E-01	2.6E-04	3.4E-01	4.5E-06	7.6E-02	1.9E-02	2.0E+00	8.9E-06	3.1E-05	2.2E-04	2.7E-03	2.0E-04	4.5E-04	4.5E-06
2-Oct-12	44																							
9-Oct-12	45	2.7E-03	8.9E-06	4.5E-04	3.3E-01	5.3E-04	4.5E-06	4.2E-04	3.6E-04	4.0E-03	4.7E-01	1.6E-04	2.8E-01	4.5E-06	5.3E-02	1.7E-02	1.7E+00	8.9E-06	7.6E-05	3.1E-04	2.2E-03	1.6E-04	4.5E-04	4.5E-06
16-Oct-12	46																							
23-Oct-12	47																							
30-Oct-12	48																							
6-Nov-12	49	1.4E-03	9.6E-06	4.8E-04	4.6E-01	6.7E-04	4.8E-06	6.3E-04	9.6E-05	4.3E-03	5.1E-01	2.0E-04	3.4E-01	4.8E-06	5.3E-02	2.3E-02	2.5E+00	9.6E-06	5.8E-05	4.8E-05	2.8E-03	1.3E-04	1.9E-03	4.8E-06
13-Nov-12	50																							
20-Nov-12	51																							
27-Nov-12	52																							
4-Dec-12	53	3.2E-03	1.8E-05	4.6E-04	3.9E-01	8.2E-04	4.6E-06	6.1E-04	1.4E-04	4.1E-03	4.6E-01	4.8E-04	2.8E-01	4.6E-06	4.6E-02	1.9E-02	2.1E+00	9.1E-06	8.6E-05	1.8E-04	2.9E-03	1.3E-04	2.3E-03	4.6E-06
11-Dec-12	54																							
18-Dec-12	55																							
25-Dec-12	56																							
1-Jan-13	57	1.6E-03	2.6E-05	5.3E-04	3.9E-01	8.4E-04	5.3E-06	5.0E-04	1.1E-04	4.7E-03	5.4E-01	2.5E-04	4.3E-01	5.3E-06	4.7E-02	2.1E-02	1.3E+00	1.1E-05	9.5E-05	2.1E-04	3.1E-03	2.0E-04	1.6E-03	5.3E-06
8-Jan-13	58																							
15-Jan-13	59																							
22-Jan-13	60																							
29-Jan-13	61	2.7E-03	9.0E-06	4.5E-04	3.6E-01	7.2E-04	4.5E-06	5.6E-04	9.0E-05	6.3E-03	4.2E-01	1.9E-04	2.7E-01	4.5E-06	5.4E-02	1.9E-02	1.8E+00	9.0E-06	6.8E-05	1.4E-04	2.0E-03	1.8E-04	1.4E-03	4.5E-06
5-Feb-13	62																							
12-Feb-13	63																							
19-Feb-13	64																							
26-Feb-13	65	2.3E-03	1.4E-05	4.5E-04	3.1E-01	4.1E-04	4.5E-06	7.2E-04	9.0E-05	4.1E-03	4.0E-01	2.1E-04	2.6E-01	4.5E-06	4.1E-02	1.5E-02	1.7E+00	9.0E-06	3.2E-05	1.4E-04	1.9E-03	8.6E-05	4.5E-04	4.5E-06
5-Mar-13	66																							

HC11
Sample = 08-068

Date	Cycle No.	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
12-Mar-13	67																							
19-Mar-13	68																							
26-Mar-13	69	1.8E-03	2.3E-05	4.6E-04	3.3E-01	3.7E-04	4.6E-06	7.9E-04	4.6E-05	4.1E-03	3.9E-01	1.2E-04	2.8E-01	4.6E-06	3.7E-02	1.7E-02	1.7E+00	9.2E-06	4.6E-06	4.6E-05	2.0E-03	7.8E-05	9.2E-04	4.6E-06
2-Apr-13	70																							
9-Apr-13	71																							
16-Apr-13	72																							
23-Apr-13	73	1.4E-03	1.4E-05	4.5E-04	3.2E-01	4.5E-04	4.5E-06	7.5E-04	4.5E-05	4.1E-03	3.6E-01	1.2E-04	3.0E-01	4.5E-06	3.2E-02	1.6E-02	1.5E+00	9.0E-06	9.0E-06	2.7E-04	1.7E-03	7.2E-05	4.5E-04	4.5E-06
30-Apr-13	74																							
7-May-13	75																							
14-May-13	76																							
21-May-13	77	2.6E-03	8.8E-06	4.4E-04	2.9E-01	3.5E-04	4.4E-06	5.4E-04	4.4E-05	4.0E-03	3.9E-01	1.3E-04	2.9E-01	4.4E-06	3.5E-02	1.6E-02	1.4E+00	8.8E-06	1.3E-05	2.6E-04	1.9E-03	1.1E-04	4.4E-04	4.4E-06
28-May-13	78	1.8E-03	8.8E-06	4.4E-04	2.9E-01	4.4E-04	4.4E-06	5.1E-04	4.4E-05	4.0E-03	3.9E-01	1.5E-04	2.5E-01	4.4E-06	3.1E-02	1.5E-02	1.3E+00	8.8E-06	1.3E-05	2.2E-04	1.9E-03	8.8E-05	4.4E-04	4.4E-06
4-Jun-13	79	3.4E-03	1.3E-05	4.3E-04	2.9E-01	1.2E-03	4.3E-06	9.4E-04	2.7E-03	3.9E-03	3.2E-01	9.0E-05	2.3E-01	8.6E-06	3.4E-02	1.5E-02	1.0E+00	8.6E-06	3.6E-03	3.4E-04	2.6E-03	5.6E-05	8.6E-04	4.3E-06
11-Jun-13	80	1.4E-03	9.6E-06	4.8E-04	2.7E-01	6.7E-04	4.8E-06	2.5E-04	4.8E-05	4.3E-03	2.9E-01	6.7E-05	2.1E-01	4.8E-06	2.9E-02	1.4E-02	6.2E-01	9.6E-06	3.3E-03	4.8E-05	3.5E-03	3.4E-05	4.8E-04	4.8E-06
18-Jun-13	81	1.4E-03	9.6E-06	4.8E-04	2.6E-01	1.1E-03	4.8E-06	1.7E-04	4.8E-05	4.3E-03	2.8E-01	6.2E-05	1.8E-01	4.8E-06	2.9E-02	1.3E-02	5.3E-01	9.6E-06	2.4E-03	4.8E-05	3.4E-03	3.8E-05	4.8E-04	4.8E-06
25-Jun-13	82																							
2-Jul-13	83	1.4E-03	9.0E-06	4.5E-04	2.2E-01	6.8E-04	4.5E-06	1.4E-04	4.5E-05	4.1E-03	2.6E-01	5.9E-05	1.7E-01	4.5E-06	1.8E-02	1.1E-02	4.6E-01	9.0E-06	8.1E-05	4.5E-05	2.8E-03	6.3E-05	4.5E-04	4.5E-06
9-Jul-13	84																							
16-Jul-13	85	1.5E-03	9.8E-06	4.9E-04	2.5E-01	9.8E-04	9.8E-06	9.8E-05	4.9E-05	4.4E-03	2.3E-01	5.4E-05	1.6E-01	4.9E-06	2.0E-02	1.3E-02	5.0E-01	9.8E-06	1.9E-03	4.9E-05	2.9E-03	2.9E-05	4.9E-04	4.9E-06
23-Jul-13	86																							
30-Jul-13	87	1.4E-03	9.6E-06	4.8E-04	2.2E-01	1.0E-03	4.8E-06	8.6E-05	4.8E-05	4.3E-03	2.2E-01	4.3E-05	1.6E-01	4.8E-06	1.4E-02	1.2E-02	4.2E-01	9.6E-06	2.0E-03	4.8E-05	2.7E-03	3.4E-05	4.8E-04	4.8E-06
6-Aug-13	88																							
13-Aug-13	89	1.5E-03	9.8E-06	4.9E-04	2.4E-01	9.8E-04	4.9E-06	8.3E-05	9.8E-05	4.4E-03	2.2E-01	5.9E-05	1.7E-01	4.9E-06	2.0E-02	1.2E-02	4.7E-01	9.8E-06	2.6E-03	4.9E-05	2.6E-03	1.5E-05	9.8E-04	4.9E-06
20-Aug-13	90																							
27-Aug-13	91																							
3-Sep-13	92																							
10-Sep-13	93	1.9E-03	9.4E-06	4.7E-04	2.2E-01	7.5E-04	4.7E-06	7.5E-05	4.7E-05	4.2E-03	2.1E-01	5.2E-05	1.6E-01	4.7E-06	1.4E-02	1.1E-02	4.8E-01	9.4E-06	1.2E-03	4.7E-05	2.4E-03	2.4E-05	4.7E-04	4.7E-06
17-Sep-13	94																							
24-Sep-13	95																							
1-Oct-13	96																							
8-Oct-13	97	1.4E-03	9.5E-06	4.8E-04	2.2E-01	1.0E-03	4.8E-06	6.7E-05	4.8E-05	4.3E-03	2.1E-01	3.3E-05	1.7E-01	4.8E-06	1.4E-02	1.2E-02	4.8E-01	9.5E-06	1.8E-03	4.8E-05	2.3E-03	2.4E-05	4.8E-04	4.8E-06
15-Oct-13	98																							
22-Oct-13	99																							
29-Oct-13	100																							
5-Nov-13	101	1.4E-03	9.5E-06	4.8E-04	2.3E-01	8.1E-04	4.8E-06	5.2E-05	4.8E-05	4.3E-03	2.1E-01	4.8E-05	1.5E-01	4.8E-06	1.4E-02	1.3E-02	4.8E-01	9.5E-06	5.7E-05	4.8E-05	2.3E-03	1.9E-05	4.8E-04	4.8E-06
12-Nov-13	102																							
19-Nov-13	103																							
26-Nov-13	104																							
3-Dec-13	105	1.9E-03	9.6E-06	4.8E-04	2.6E-01	9.1E-04	4.8E-06	7.2E-05	4.8E-05	4.3E-03	2.3E-01	5.8E-05	1.5E-01	4.8E-06	9.6E-03	1.4E-02	5.5E-01	9.6E-06	5.8E-05	4.8E-05	2.8E-03	2.9E-05	4.8E-04	4.8E-06
10-Dec-13	106																							
17-Dec-13	107																							
24-Dec-13	108																							
31-Dec-13	109	3.4E-03	1.5E-05	4.9E-04	2.3E-01	9.3E-04	4.9E-06	6.4E-05	4.9E-05	4.4E-03	2.1E-01	4.9E-05	1.6E-01	4.9E-06	9.8E-03	1.3E-02	5.2E-01	9.8E-06	2.0E-03	4.9E-05	2.0E-03	2.9E-05	4.9E-04	4.9E-06
7-Jan-14	110																							
14-Jan-14	111																							
21-Jan-14	112																							
28-Jan-14	113	1.5E-03	9.7E-06	4.9E-04	2.4E-01	8.7E-04	4.9E-06	3.4E-05	4.9E-05	4.4E-03	2.0E-01	2.9E-05	1.4E-01	4.9E-06	1.5E-02	1.3E-02	5.3E-01	9.7E-06	1.0E-03	4.9E-05	2.0E-03	1.5E-05	4.9E-04	4.9E-06
4-Feb-14	114																							
11-Feb-14	115																							
18-Feb-14	116																							
25-Feb-14	117	1.5E-03	9.7E-06	4.9E-04	2.2E-01	7.8E-04	4.9E-06	5.8E-05	4.9E-05	4.4E-03	1.9E-01	4.4E-05	1.4E-01	4.9E-06	1.5E-02	1.2E-02	4.9E-01	9.7E-06	1.1E-03	4.9E-05	1.8E-03	1.9E-05	4.9E-04	4.9E-06

HC12

Sample = 08-058

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/L	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
29-Nov-11	0	470	375	4.73	1.6E+03	#N/A	2.0E+02	#N/A	9.4E+02	4.8E+00	2.0E+00	3.0E-01	4.4E+02	1.0E+01	7.4E-03	2.2E-03	3.5E-02	1.3E-03	1.0E-05	5.5E-03	8.4E-03	1.4E+02	9.0E-04	2.2E-01	1.9E+02
6-Dec-11	1	500	470	4.81	8.4E+02	#N/A	1.0E+02	#N/A	2.7E+02	2.2E+00	6.0E-02	3.0E-01	2.1E+02	2.7E+00	5.7E-03	9.0E-04	1.3E-02	8.8E-04	1.0E-05	6.8E-03	4.2E-03	6.0E+01	1.6E-03	1.2E-01	5.9E+01
13-Dec-11	2	500	435	4.90	6.0E+02	#N/A	7.7E+01	#N/A	2.7E+02	2.0E+00	8.4E-01	3.0E-01	1.6E+02	1.9E+00	4.2E-03	5.0E-04	9.3E-03	5.3E-04	5.0E-05	6.1E-03	2.8E-03	4.6E+01	2.0E-03	1.1E-01	4.0E+01
20-Dec-11	3	500	420	4.91	5.2E+02	#N/A	7.5E+01	#N/A	2.7E+02	7.0E-01	9.6E-01	3.0E-01	1.4E+02	1.9E+00	6.6E-03	1.3E-03	7.9E-03	5.7E-04	1.0E-05	5.4E-03	2.8E-03	4.1E+01	5.0E-04	7.5E-02	4.0E+01
27-Dec-11	4	500	535	5.52	1.3E+02																				
3-Jan-12	5	500	450	5.36	1.2E+02	#N/A	1.2E+01	8.9E-01	5.1E+01	2.0E-01	1.5E-01	3.0E-01	3.3E+01	2.8E-01	2.9E-03	3.0E-04	4.4E-03	1.3E-04	1.0E-05	4.4E-03	9.1E-04	1.1E+01	5.0E-04	1.0E-02	5.6E+00
10-Jan-12	6	500	425	5.25	1.1E+02																				
17-Jan-12	7	500	435	5.29	1.1E+02	#N/A	1.2E+01	7.0E-01	4.6E+01	2.0E-01	1.5E-01	3.0E-01	3.0E+01	2.8E-01	8.0E-03	4.0E-04	4.6E-03	1.9E-04	1.0E-05	7.4E-03	7.0E-04	9.8E+00	5.0E-04	1.1E-02	6.6E+00
24-Jan-12	8	500	435	5.40	9.0E+01																				
31-Jan-12	9	500	465	5.31	7.5E+01	#N/A	8.4E+00	7.8E-01	3.1E+01	2.0E-01	1.1E-01	3.0E-01	1.8E+01	1.3E-01	2.3E-03	3.0E-04	3.4E-03	1.2E-04	1.0E-05	3.7E-03	2.8E-04	6.1E+00	5.0E-04	6.6E-03	3.8E+00
7-Feb-12	10	500	460	5.29	8.3E+01																				
14-Feb-12	11	500	465	5.27	8.8E+01	#N/A	1.4E+01	8.8E-01	3.7E+01	2.0E-01	1.4E-01	3.0E-01	2.2E+01	1.8E-01	1.2E-03	2.0E-04	2.9E-03	1.4E-04	1.0E-05	3.3E-03	3.8E-04	7.2E+00	5.0E-04	9.0E-03	5.2E+00
21-Feb-12	12	500	420	5.23	1.2E+02																				
28-Feb-12	13	500	445	5.08	1.0E+02	#N/A	1.3E+01	9.3E-01	3.8E+01	2.0E-01	1.5E-01	3.0E-01	2.6E+01	2.5E-01	1.8E-03	2.0E-04	3.1E-03	1.6E-04	1.0E-05	2.9E-03	3.8E-04	8.8E+00	5.0E-04	8.9E-03	4.9E+00
6-Mar-12	14	500	440	5.30	9.7E+01																				
13-Mar-12	15	500	440	4.99	1.0E+02	#N/A	1.5E+01	8.8E-01	4.2E+01	2.0E-01	1.7E-01	3.0E-01	2.5E+01	2.3E-01	1.7E-03	4.0E-04	2.3E-03	6.3E-04	1.0E-05	2.4E-03	5.0E-04	8.2E+00	5.0E-04	1.2E-02	6.6E+00
20-Mar-12	16	500	465	5.17	8.8E+01																				
27-Mar-12	17	500	450	5.22	9.9E+01	#N/A	1.4E+01	1.1E+00	4.2E+01	2.0E-01	1.8E-01	3.0E-01	2.5E+01	3.5E-01	1.1E-03	2.0E-04	3.0E-03	2.4E-04	1.0E-05	3.0E-03	4.8E-04	8.3E+00	5.0E-04	1.1E-02	5.7E+00
3-Apr-12	18	500	440	4.87	8.9E+01																				
10-Apr-12	19	500	465	4.91	1.0E+02	#N/A	1.5E+01	3.7E-01	3.9E+01	2.0E-01	2.0E-01	3.0E-01	2.2E+01	3.8E-01	9.0E-04	2.0E-04	2.3E-03	2.8E-04	1.0E-05	2.5E-03	5.2E-04	7.0E+00	5.0E-04	1.2E-02	6.4E+00
17-Apr-12	20	500	450	4.80	1.2E+02																				
24-Apr-12	21	500	455	4.66	1.1E+02	#N/A	1.9E+01	1.0E-01	4.3E+01	2.0E-01	2.2E-01	3.0E-01	2.2E+01	4.6E-01	9.0E-04	2.0E-04	1.7E-03	3.4E-04	1.0E-05	1.8E-03	6.9E-04	7.1E+00	5.0E-04	1.2E-02	6.8E+00
1-May-12	22	500	450	4.80	1.2E+02																				
8-May-12	23	500	440	4.61	1.2E+02	#N/A	2.2E+01	1.0E-01	4.6E+01	2.0E-01	2.0E-01	3.0E-01	2.4E+01	5.0E-01	8.0E-04	2.0E-04	1.3E-03	3.6E-04	1.0E-05	1.7E-03	8.3E-04	7.6E+00	5.0E-04	1.5E-02	6.9E+00
15-May-12	24	500	450	4.52	1.1E+02																				
22-May-12	25	500	440	4.63	1.1E+02	#N/A	2.2E+01	1.0E-01	3.8E+01	2.0E-01	2.7E-01	3.0E-01	2.1E+01	7.3E-01	6.0E-04	3.0E-04	1.1E-03	3.8E-04	1.0E-05	1.7E-03	8.4E-04	6.8E+00	5.0E-04	1.3E-02	6.7E+00
29-May-12	26	500	440	4.44	1.2E+02																				
5-Jun-12	27	500	450	4.53	1.1E+02	#N/A	2.2E+01	1.0E-01	3.7E+01	2.0E-01	2.7E-01	3.0E-01	2.0E+01	7.5E-01	5.0E-04	2.0E-04	1.0E-03	4.4E-04	1.0E-05	2.9E-03	1.0E-03	6.4E+00	5.0E-04	1.4E-02	6.4E+00
12-Jun-12	28	500	455	4.51	1.0E+02																				
19-Jun-12	29	500	450	4.44	1.1E+02	1.6E+00	2.2E+01	#N/A	3.7E+01	4.0E-01	3.1E-01	3.0E-01	1.7E+01	8.4E-01	5.0E-04	4.0E-04	5.0E-03	4.6E-04	1.0E-05	2.2E-03	1.1E-03	5.3E+00	5.0E-04	1.4E-02	6.4E+00
26-Jun-12	30	500	450	4.40	1.1E+02																				
3-Jul-12	31	500	465	4.59	1.2E+02	#N/A	3.4E+01	1.0E-01	4.0E+01	1.0E+00	3.7E-01	3.0E-01	1.6E+01	1.2E+00	5.0E-04	2.0E-04	1.0E-03	5.3E-04	1.0E-05	1.1E-03	1.7E-03	4.9E+00	5.0E-04	1.5E-02	7.3E+00
10-Jul-12	32	500	450	4.25	1.3E+02																				
17-Jul-12	33	500	460	4.10	1.4E+02	5.0E+00	3.5E+01	#N/A	4.6E+01	2.0E-01	4.3E-01	3.0E-01	1.7E+01	1.8E+00	7.0E-04	6.0E-04	8.0E-04	8.2E-04	1.0E-05	3.4E-03	2.7E-03	5.0E+00	5.0E-04	2.0E-02	8.6E+00
24-Jul-12	34	500	470	4.15	1.3E+02																				
31-Jul-12	35	500	450	4.12	1.3E+02	4.4E+00	3.0E+01	#N/A	4.4E+01	2.0E-01	4.1E-01	3.0E-01	1.5E+01	1.8E+00	6.0E-04	2.0E-04	9.0E-04	6.5E-04	1.0E-05	1.8E-03	2.5E-03	4.5E+00	5.0E-04	1.4E-02	7.4E+00
7-Aug-12	36	500	485	4.05	1.4E+02																				
14-Aug-12	37	500	460	4.03	1.4E+02	7.3E+00	4.1E+01	#N/A	5.2E+01	2.0E-01	4.6E-01	3.0E-01	1.3E+01	2.7E+00	5.0E-04	4.0E-04	1.0E-03	7.4E-04	1.0E-05	2.0E-03	3.0E-03	4.0E+00	5.0E-04	1.5E-02	7.7E+00
21-Aug-12	38	500	465	4.02	1.6E+02																				
28-Aug-12	39	500	460	4.05	1.5E+02	8.4E+00	4.7E+01	#N/A	6.0E+01	2.0E-01	4.5E-01	3.0E-01	1.2E+01	3.2E+00	5.0E-04	5.0E-04	9.3E-04	7.2E-04	1.0E-05	2.2E-03	3.5E-03	3.6E+00	5.0E-04	1.4E-02	7.7E+00
4-Sep-12	40	500	480	4.02	1.5E+02																				
11-Sep-12	41	500	475	4.01	1.9E+02	1.2E+01	5.5E+01	#N/A	7.0E+01	2.0E-01	5.0E-01	3.0E-01	1.5E+01	4.3E+00	4.0E-04	3.0E-04	7.9E-04	8.5E-04	1.0E-05	1.9E-03	4.4E-03	4.7E+00	5.0E-04	1.6E-02	8.7E+00
18-Sep-12	42	500	520	3.90	1.6E+02																				
25-Sep-12	43	500	495	3.90	1.7E+02	1.1E+01	5.1E+01	#N/A	5.3E+01	2.0E-01	3.7E-01	3.0E-01	9.6E+00	4.0E+00	2.0E-04	2.0E-04	7.4E-04	6.2E-04	1.0E-05	9.0E-04	3.9E-03	3.1E+00	7.0E-04	1.2E-02	7.0E+00
2-Oct-12	44	500	485	4.01	1.6E+02																				
9-Oct-12	45	500	480	3.88	1.5E+02	1.0E+01	4.5E+01	#N/A	5.2E+01	2.0E-01	3.2E-01	3.0E-01	7.7E+00	3.6E+00	2.0E-04	2.0E-04	1.0E-03	5.7E-04	1.0E-05	1.5E-03	3.4E-03	2.5E+00	5.0E-04	1.1E-02	6.2E+00
16-Oct-12	46	500	465	3.91	1.7E+02																				
23-Oct-12	47	500	475	3.89	1.2E+02																				
30-Oct-12	48	500	485	3.92	1.8E+02																				
6-Nov-12	49	500	465	3.88	1.1E+02	7.6E+00	3.1E+01	#N/A	3.5E+01	2.0E-01	2.1E-01	3.0E-01	5.5E+00	2.2E+00	2.0E-04	3.0E-04	7.7E-04	3.2E-04	1.0E-05	1.8E-03	2.1E-03	1.9E+00	5.0E-04	6.5E-03	3.6E+00
13-Nov-12	50	500	505	3.99	1.6E+02																				
20-Nov-12	51	500	495	3.74	1.9E+02																				
27-Nov-12	52	500	455	4.01	2.1E+02																				
4-Dec-12	53	500	425	4.21	1.1E+02	1.0E-01	2.3E+01	#N/A	4.3E+01	2.0E-01	2.0E-01	3.0E-01	5.4E+00	2.9E+00	2.0E-04	2.0E-04	1.3E-03	3.9E-04	1.0E-05	8.0E-04	2.5E-03	1.8E+00	5.0E-04	8.3E-03	4.4E+00
11-Dec-12	54	500	430	4.31	1.1E+02																				
18-Dec-12	55	500	445	3.81	1.9E+02																				

HC12

Sample = 08-058

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/L	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
25-Dec-12	56	500	405	4.32	1.1E+02																				
1-Jan-13	57	500	420	3.62	2.0E+02	2.2E+01	5.9E+01	#N/A	5.9E+01	2.0E-01	2.3E-01	3.0E-01	3.7E+00	3.7E+00	2.0E-04	3.0E-04	1.4E-03	3.8E-04	1.0E-05	6.0E-04	2.9E-03	1.2E+00	5.0E-04	8.9E-03	4.3E+00
8-Jan-13	58	500	435	3.81	1.4E+02																				
15-Jan-13	59	500	435	3.51	2.5E+02																				
22-Jan-13	60	500	415	3.83	1.6E+02																				
29-Jan-13	61	500	455	3.41	2.9E+02	3.8E+01	8.1E+01	#N/A	8.8E+01	1.0E+00	2.4E-01	3.0E-01	4.4E+00	7.4E+00	2.0E-04	3.0E-04	7.6E-04	4.8E-04	1.0E-05	6.0E-04	3.5E-03	1.5E+00	1.3E-03	1.2E-02	5.3E+00
5-Feb-13	62	500	430	3.41	3.2E+02																				
12-Feb-13	63	500	425	3.26	3.5E+02																				
19-Feb-13	64	500	425	3.28	3.5E+02																				
26-Feb-13	65	500	420	3.21	3.8E+02	4.9E+01	9.1E+01	#N/A	1.1E+02	1.0E+00	2.4E-01	3.0E-01	4.4E+00	7.5E+00	2.0E-04	5.0E-04	8.5E-04	5.1E-04	1.0E-05	6.0E-04	4.1E-03	1.5E+00	1.8E-03	1.4E-02	5.7E+00
5-Mar-13	66	500	425	3.22	4.2E+02																				
12-Mar-13	67	500	425	3.27	3.5E+02																				
19-Mar-13	68	500	410	3.27	4.2E+02																				
26-Mar-13	69	500	430	3.21	3.7E+02	6.1E+01	1.1E+02	#N/A	1.0E+02	1.0E+00	2.3E-01	3.0E-01	3.2E+00	7.9E+00	2.0E-04	5.0E-04	6.4E-04	4.2E-04	1.0E-05	8.0E-04	3.3E-03	1.0E+00	9.0E-04	1.3E-02	4.7E+00
2-Apr-13	70	500	415	3.15	4.2E+02																				
9-Apr-13	71	500	420	3.30	3.9E+02																				
16-Apr-13	72	500	410	3.33	3.8E+02																				
23-Apr-13	73	500	420	3.08	5.3E+02	8.0E+01	1.3E+02	#N/A	1.5E+02	1.0E+00	2.6E-01	3.0E-01	3.6E+00	1.1E+01	2.0E-04	5.0E-04	6.6E-04	4.6E-04	1.0E-05	7.0E-04	4.2E-03	1.2E+00	1.9E-03	1.7E-02	5.5E+00
30-Apr-13	74	500	415	3.12	4.7E+02																				
7-May-13	75	500	410	3.18	4.4E+02																				
14-May-13	76	500	405	3.11	4.6E+02																				
21-May-13	77	500	415	3.13	4.2E+02	7.0E+01	1.2E+02	#N/A	1.3E+02	1.0E+00	2.3E-01	3.0E-01	3.6E+00	6.5E+00	2.0E-04	2.0E-04	7.0E-04	3.8E-04	1.0E-05	1.0E-03	3.3E-03	1.2E+00	2.0E-03	1.5E-02	3.8E+00
28-May-13	78	500	410	3.13	4.4E+02																				
4-Jun-13	79	500	405	3.10	4.8E+02																				
11-Jun-13	80	500	425	3.22	4.6E+02																				
18-Jun-13	81	500	400	3.17	4.8E+02	8.0E+01	1.3E+02	#N/A	1.3E+02	1.0E+00	2.3E-01	3.0E-01	4.0E+00	7.3E+00	2.0E-04	3.0E-04	1.0E-03	4.5E-04	1.0E-05	1.5E-03	2.9E-03	1.3E+00	2.4E-03	1.6E-02	3.2E+00
25-Jun-13	82	500	415	3.19	4.6E+02																				
2-Jul-13	83	500	415	3.08	5.1E+02																				
9-Jul-13	84	500	415	3.22	4.5E+02																				
16-Jul-13	85	500	495	3.26	3.2E+02	4.9E+01	8.3E+01	#N/A	7.7E+01	1.0E+00	1.7E-01	3.0E-01	2.9E+00	4.2E+00	2.0E-04	4.0E-04	1.4E-03	3.3E-04	1.0E-05	1.5E-03	1.6E-03	9.6E-01	2.5E-03	1.1E-02	2.0E+00
23-Jul-13	86	500	405	3.39	2.6E+02																				
30-Jul-13	87	500	435	3.34	2.7E+02																				
6-Aug-13	88	500	405	3.34	2.9E+02																				
13-Aug-13	89	500	455	3.24	3.2E+02	4.7E+01	8.0E+01	#N/A	9.0E+01	1.0E+00	2.2E-01	3.0E-01	3.1E+00	4.8E+00	2.0E-04	3.0E-04	8.5E-04	3.4E-04	1.0E-05	1.5E-03	1.3E-03	1.1E+00	2.0E-03	9.8E-03	1.6E+00
20-Aug-13	90	500	415	3.36	2.8E+02																				
27-Aug-13	91	500	455	3.30	2.8E+02																				
3-Sep-13	92	500	415	3.39	2.2E+02																				
10-Sep-13	93	500	410	3.29	3.0E+02	4.7E+01	8.2E+01	#N/A	8.6E+01	1.0E+00	2.4E-01	3.0E-01	6.3E+00	4.4E+00	2.0E-04	3.0E-04	1.2E-03	2.7E-04	1.0E-05	1.9E-03	1.1E-03	2.4E+00	2.1E-03	9.9E-03	1.4E+00
17-Sep-13	94	500	395	3.26	3.2E+02																				
24-Sep-13	95	500	415	3.28	3.1E+02																				
1-Oct-13	96																								
8-Oct-13	97																								
15-Oct-13	98																								
22-Oct-13	99																								
29-Oct-13	100																								
5-Nov-13	101	500	530	3.05	7.1E+02	1.3E+02	2.6E+02	#N/A	2.5E+02	2.0E+00	6.1E-01	3.0E-01	8.6E+00	2.1E+01	3.0E-04	6.0E-04	7.1E-04	8.7E-04	1.0E-05	2.9E-03	5.1E-03	3.0E+00	5.0E-03	3.0E-02	4.9E+00
12-Nov-13	102	500	435	3.34	3.6E+02																				
19-Nov-13	103	500	460	3.52	2.4E+02																				
26-Nov-13	104	500	470	3.49	2.2E+02																				
3-Dec-13	105	500	455	3.39	2.2E+02	2.2E+01	5.5E+01	#N/A	4.1E+01	1.0E+00	1.6E-01	3.0E-01	2.7E+00	3.4E+00	2.0E-04	2.0E-04	6.2E-04	2.3E-04	1.0E-05	2.4E-03	1.0E-03	9.3E-01	9.0E-04	7.8E-03	1.2E+00
10-Dec-13	106	500	395	3.43	2.4E+02																				
17-Dec-13	107	500	425	3.33	2.6E+02																				
24-Dec-13	108	500	410	3.42	2.6E+02																				
31-Dec-13	109	500	410	3.48	1.9E+02	2.1E+01	4.3E+01	#N/A	4.0E+01	2.0E-01	1.6E-01	3.0E-01	1.5E+00	2.5E+00	2.0E-04	2.0E-04	8.1E-04	2.4E-04	1.0E-05	1.6E-03	6.2E-04	5.1E-01	1.5E-03	6.0E-03	8.9E-01
7-Jan-14	110	500	440	3.37	2.5E+02																				
14-Jan-14	111	500	425	3.35	2.4E+02																				
21-Jan-14	112	500	455	3.45	2.3E+02																				
28-Jan-14	113	500	425	3.42	2.1E+02	2.6E+01	5.0E+01	#N/A	4.4E+01	1.0E+00	1.8E-01	3.0E-01	2.0E+00	3.1E+00	2.0E-04	2.0E-04	6.5E-04	2.0E-04	1.0E-05	1.7E-03	5.4E-04	6.8E-01	1.4E-03	6.8E-03	7.2E-01

HC12

Sample = 08-058

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/L	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
4-Feb-14	114	500	420	3.40	2.2E+02																				
11-Feb-14	115	500	435	3.41	2.3E+02																				
18-Feb-14	116	500	435	3.38	2.3E+02																				
25-Feb-14	117	500	450	3.38	2.5E+02	3.2E+01	6.4E+01	#N/A	5.9E+01	2.0E-01	2.1E-01	3.0E-01	2.8E+00	6.2E+00	2.0E-04	3.0E-04	7.4E-04	2.9E-04	6.0E-05	1.6E-03	6.8E-04	1.0E+00	2.3E-03	8.9E-03	8.0E-01
4-Mar-14	118	500	435	3.49	2.0E+02	2.4E+01	5.4E+01	#N/A	5.8E+01	2.0E-01	1.8E-01	3.0E-01	3.0E+00	4.6E+00	2.0E-04	2.0E-04	5.3E-04	2.4E-04	1.0E-05	1.1E-03	5.2E-04	1.0E+00	2.0E-03	7.8E-03	7.6E-01
11-Mar-14	119	500	465	3.55	1.9E+02	2.3E+01	5.4E+01	#N/A	4.0E+01	2.0E-01	1.4E-01	3.0E-01	1.8E+00	4.0E+00	2.0E-04	2.0E-04	3.2E-03	2.3E-04	1.0E-05	1.5E-03	4.9E-04	5.8E-01	1.7E-03	8.4E-03	7.0E-01
18-Mar-14	120	500	445	3.59	1.5E+02	2.0E+01	4.0E+01	#N/A	2.6E+01	2.0E-01	1.1E-01	3.0E-01	1.3E+00	3.0E+00	2.0E-04	2.0E-04	7.8E-04	1.3E-04	5.0E-05	8.0E-04	3.3E-04	4.5E-01	1.0E-03	5.5E-03	4.9E-01
25-Mar-14	121	500	460	3.74	1.3E+02	1.3E+01	3.1E+01	#N/A	2.3E+01	2.0E-01	7.0E-02	3.0E-01	7.9E-01	2.1E+00	2.0E-04	2.0E-04	4.0E-04	1.1E-04	1.0E-05	5.0E-04	2.3E-04	2.7E-01	5.0E-04	4.0E-03	3.6E-01
1-Apr-14	122	500	465	3.70	1.2E+02																				
8-Apr-14	123	500	470	3.61	1.3E+02																				
15-Apr-14	124	500	450	3.70	1.2E+02																				
22-Apr-14	125	500	440	3.69	1.1E+02	1.2E+01	2.6E+01	#N/A	1.8E+01	2.0E-01	6.0E-02	3.0E-01	7.6E-01	1.4E+00	2.0E-04	2.0E-04	9.9E-04	7.2E-05	7.0E-06	2.2E-03	1.6E-04	2.8E-01	3.9E-04	2.9E-03	3.0E-01
29-Apr-14	126	500	460	3.74	1.1E+02																				
6-May-14	127	500	455	3.61	1.1E+02																				
13-May-14	128	500	465	3.79	9.8E+01																				
20-May-14	129	500	460	3.71	9.3E+01	1.2E+01	2.5E+01	#N/A	1.5E+01	2.0E-01	6.0E-02	3.0E-01	5.0E-01	9.6E-01	2.0E-04	2.0E-04	1.1E-03	4.1E-05	7.0E-06	3.0E-04	1.3E-04	1.8E-01	2.7E-04	2.3E-03	2.3E-01
27-May-14	130	500	450	3.74	1.0E+02																				
3-Jun-14	131	500	480	3.62	8.9E+01																				
10-Jun-14	132	500	465	3.63	1.2E+02																				
17-Jun-14	133	500	475	3.65	1.0E+02	1.2E+01	2.4E+01	#N/A	1.5E+01	2.0E-01	6.0E-02	3.0E-01	4.3E-01	7.2E-01	2.0E-04	2.0E-04	1.0E-03	3.9E-05	7.0E-06	2.9E-03	1.1E-04	1.6E-01	2.5E-04	2.1E-03	2.2E-01
24-Jun-14	134	500	480	3.70	1.0E+02																				
1-Jul-14	135	500	455	3.69	1.1E+02																				
8-Jul-14	136	500	470	3.74	1.1E+02																				
15-Jul-14	137	500	405	3.66	1.2E+02	1.3E+01	2.4E+01	#N/A	1.4E+01	2.0E-01	6.0E-02	3.0E-01	4.4E-01	7.7E-01	2.0E-04	2.0E-04	9.4E-04	3.4E-05	7.0E-06	1.6E-03	1.3E-04	1.7E-01	1.8E-04	2.2E-03	2.2E-01
22-Jul-14	138	500	475	3.65	1.4E+02																				
29-Jul-14	139	500	455	3.58	1.2E+02																				
5-Aug-14	140	500	460	3.61	1.4E+02																				
12-Aug-14	141	500	450	3.66	1.1E+02	1.2E+01	2.4E+01	#N/A	1.4E+01	2.0E-01	6.0E-02	3.0E-01	4.6E-01	7.7E-01	2.0E-04	2.0E-04	9.9E-04	2.9E-05	7.0E-06	1.5E-03	1.4E-04	1.7E-01	2.4E-04	2.3E-03	2.2E-01
19-Aug-14	142	500	460	3.71	1.1E+02																				
26-Aug-14	143	500	470	3.69	1.1E+02																				
2-Sep-14	144	500	480																						
9-Sep-14	145	500	470						1.6E+01	< 0.2	< 0.06	< 0.3	3.9E-01	7.5E-01	< 0.0002	< 0.0002	1.1E-03	3.1E-05	< 0.000007	4.2E-03	1.2E-04	1.5E-01	1.9E-04	2.2E-03	2.2E-01
16-Sep-14	146	500	440																						
23-Sep-14	147	500	445																						
30-Sep-14	148	500	445																						

Sept 24/13. HC 12 put on humid air only until cycle 100.
Mar 4/14 Moved to fridge at 4°C Cycle 118

HC12

Sample = 08-058

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Major	Major	Diff	Diff
	No.																								Anions	Cations		(%)
		mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L				
29-Nov-11	0	2.6E+00	6.9E-03	1.8E-02	2.4E+01	1.2E+00	3.0E-02	7.9E-04	5.9E-02	4.4E-02	1.3E+01	4.7E-02	7.6E-01	8.0E-05	9.9E+01	4.5E-01	2.8E+02	3.2E-04	9.0E-05	3.0E-04	1.0E-01	3.9E-04	1.9E+00	1.1E-03	2.0E+01	2.1E+01	8.7E-01	2.1%
6-Dec-11	1	3.5E-01	1.8E-03	1.5E-02	1.4E+01	6.6E-01	2.0E-02	3.6E-04	2.0E-02	1.5E-02	8.9E+00	2.5E-02	1.5E+00	9.0E-05	5.4E+01	2.1E-01	1.5E+02	1.9E-04	1.0E-05	2.0E-04	4.5E-02	2.4E-04	1.2E+00	4.6E-04	8.9E+00	8.9E+00	1.5E-02	0.1%
13-Dec-11	2	2.2E-01	1.0E-03	1.1E-02	9.5E+00	4.6E-01	2.0E-02	3.5E-04	3.4E-02	9.0E-03	6.7E+00	1.6E-02	9.1E-01	2.0E-05	2.9E+01	1.6E-01	9.5E+01	1.2E-04	3.7E-04	3.0E-04	3.0E-02	1.2E-04	8.8E-01	2.6E-04	5.7E+00	6.0E+00	3.0E-01	2.6%
20-Dec-11	3	2.4E-01	1.1E-04	1.0E-02	8.4E+00	4.1E-01	1.0E-02	1.7E-04	2.2E-02	9.0E-03	6.4E+00	8.7E-03	7.5E-01	1.0E-05	1.5E+01	1.4E-01	8.3E+01	1.1E-04	3.0E-05	3.0E-04	2.4E-02	4.0E-04	7.1E-01	2.7E-04	5.7E+00	5.1E+00	-6.1E-01	-5.7%
27-Dec-11	4																											
3-Jan-12	5	5.6E-02	1.2E-03	4.0E-03	9.7E-01	4.6E-02	1.0E-02	7.0E-05	3.9E-03	9.0E-03	1.9E+00	2.0E-03	6.4E-01	1.0E-05	8.1E-01	3.7E-02	1.5E+01	3.0E-05	9.0E-05	3.0E-04	3.6E-03	4.7E-04	1.6E-01	3.0E-05	1.1E+00	9.5E-01	-1.2E-01	-5.8%
10-Jan-12	6																											
17-Jan-12	7	1.2E-01	8.3E-04	6.0E-03	1.2E+00	5.8E-02	1.0E-02	1.0E-04	3.7E-03	2.6E-02	3.0E+00	2.4E-03	8.9E-01	1.0E-05	4.8E-01	3.3E-02	1.5E+01	3.0E-05	3.0E-05	2.0E-04	4.1E-03	2.6E-04	1.5E-01	6.0E-05	9.7E-01	9.4E-01	-2.2E-02	-1.2%
24-Jan-12	8																											
31-Jan-12	9	9.1E-02	4.6E-03	3.0E-03	7.3E-01	3.6E-02	1.0E-02	7.0E-05	2.5E-03	9.0E-03	1.6E+00	1.8E-03	7.9E-01	1.0E-05	1.6E-01	2.2E-02	9.0E+00	2.0E-05	1.0E-05	3.0E-04	2.4E-03	3.5E-04	7.1E-02	1.0E-05	6.5E-01	5.5E-01	-9.8E-02	-8.2%
7-Feb-12	10																											
14-Feb-12	11	2.1E-01	2.4E-04	3.0E-03	9.7E-01	4.8E-02	1.0E-02	1.4E-04	2.9E-03	4.3E-02	1.3E+00	1.6E-03	9.0E-01	1.0E-05	1.2E-01	2.8E-02	1.0E+01	2.0E-05	1.0E-05	4.0E-04	4.4E-03	2.4E-04	9.1E-02	1.0E-05	7.8E-01	6.8E-01	-1.0E-01	-6.9%
21-Feb-12	12																											
28-Feb-12	13	2.0E-01	9.0E-05	3.0E-03	1.0E+00	4.8E-02	1.0E-02	5.0E-05	4.5E-03	2.4E-02	2.0E+00	1.7E-03	6.7E-01	1.0E-05	1.2E-01	3.2E-02	1.2E+01	6.0E-05	4.0E-05	1.0E-04	5.0E-03	2.3E-04	9.2E-02	1.0E-05	8.0E-01	7.7E-01	-2.5E-02	-1.6%
6-Mar-12	14																											
13-Mar-12	15	3.2E-01	4.0E-05	6.0E-03	1.2E+00	5.7E-02	1.0E-02	5.0E-05	3.9E-03	4.6E-02	1.6E+00	2.0E-03	7.4E-01	1.0E-05	7.0E-02	2.9E-02	1.3E+01	2.0E-05	1.9E-04	1.0E-04	7.6E-03	3.0E-05	1.2E-01	2.0E-05	8.8E-01	8.0E-01	-8.0E-02	-4.7%
20-Mar-12	16																											
27-Mar-12	17	4.3E-01	1.9E-03	3.0E-03	1.1E+00	5.5E-02	1.0E-02	3.0E-05	3.5E-03	3.4E-02	1.3E+00	1.5E-03	7.5E-01	1.0E-05	7.0E-02	2.8E-02	1.3E+01	2.0E-05	1.0E-05	1.0E-04	8.6E-03	1.4E-04	7.4E-02	1.0E-05	8.8E-01	7.8E-01	-1.0E-01	-6.1%
3-Apr-12	18																											
10-Apr-12	19	5.4E-01	1.1E-04	3.0E-03	1.1E+00	5.4E-02	2.0E-02	4.7E-04	3.9E-03	2.0E-02	9.9E-01	1.6E-03	9.0E-01	1.0E-05	5.0E-02	2.6E-02	1.2E+01	2.0E-05	3.0E-05	1.0E-04	9.4E-03	1.4E-04	1.2E-01	1.0E-05	8.2E-01	7.4E-01	-8.1E-02	-5.2%
17-Apr-12	20																											
24-Apr-12	21	7.3E-01	2.1E-04	3.0E-03	1.1E+00	5.9E-02	3.0E-02	8.0E-05	4.0E-03	4.2E-02	9.0E-01	1.8E-03	7.6E-01	1.0E-05	6.0E-02	2.5E-02	1.3E+01	2.0E-05	2.0E-05	1.0E-04	1.5E-02	1.2E-04	1.5E-01	1.0E-05	9.1E-01	7.8E-01	-1.2E-01	-7.3%
1-May-12	22																											
8-May-12	23	8.1E-01	9.0E-05	3.0E-03	1.2E+00	6.4E-02	1.0E-02	1.8E-04	4.8E-03	1.6E-02	8.7E-01	1.9E-03	6.1E-01	1.0E-05	6.0E-02	2.2E-02	1.5E+01	2.0E-05	1.8E-04	1.0E-04	1.7E-02	1.3E-04	1.7E-01	1.0E-05	9.7E-01	8.3E-01	-1.4E-01	-7.8%
15-May-12	24																											
22-May-12	25	1.0E+00	1.0E-04	3.0E-03	1.1E+00	6.0E-02	1.0E-02	3.4E-04	4.7E-03	9.0E-03	6.4E-01	1.7E-03	6.4E-01	1.0E-05	5.0E-02	2.0E-02	1.4E+01	2.0E-05	7.0E-05	1.6E-03	1.8E-02	6.9E-04	1.6E-01	1.0E-05	8.1E-01	8.0E-01	-3.9E-03	-0.2%
29-May-12	26																											
5-Jun-12	27	1.1E+00	2.0E-05	3.0E-03	1.0E+00	5.6E-02	1.0E-02	4.0E-05	5.8E-03	9.0E-03	5.5E-01	2.0E-03	7.0E-01	1.0E-05	5.0E-02	1.8E-02	1.4E+01	2.0E-05	6.0E-05	2.0E-04	2.0E-02	3.4E-04	1.9E-01	1.0E-05	7.9E-01	7.7E-01	-1.3E-02	-0.9%
12-Jun-12	28																											
19-Jun-12	29	1.3E+00	2.7E-04	3.0E-03	9.0E-01	5.1E-02	1.0E-02	9.5E-04	4.8E-03	9.0E-03	4.7E-01	2.1E-03	7.1E-01	1.0E-05	6.0E-02	1.6E-02	1.2E+01	2.0E-05	1.0E-04	1.0E-04	2.3E-02	2.3E-04	1.9E-01	1.0E-05	7.9E-01	7.2E-01	-6.3E-02	-4.2%
26-Jun-12	30																											
3-Jul-12	31	1.8E+00	2.6E-04	3.0E-03	9.5E-01	5.4E-02	1.0E-02	9.0E-05	5.0E-03	9.0E-03	3.6E-01	2.1E-03	6.9E-01	1.0E-05	5.0E-02	1.5E-02	1.4E+01	2.0E-05	2.5E-04	1.0E-04	2.9E-02	2.1E-04	2.4E-01	2.0E-05	8.5E-01	8.0E-01	-5.3E-02	-3.2%
10-Jul-12	32																											
17-Jul-12	33	3.0E+00	5.0E-05	4.0E-03	9.9E-01	5.8E-02	1.0E-02	8.0E-05	5.7E-03	1.1E-02	3.5E-01	2.3E-03	9.9E-01	1.3E-04	6.0E-02	1.6E-02	1.7E+01	2.0E-05	1.1E-04	2.0E-04	4.0E-02	2.3E-04	3.7E-01	1.0E-05	9.8E-01	9.8E-01	1.2E-03	0.1%
24-Jul-12	34																											
31-Jul-12	35	2.9E+00	1.5E-03	3.0E-03	8.0E-01	4.7E-02	6.0E-02	4.0E-05	5.0E-03	9.0E-03	2.7E-01	1.6E-03	8.7E-01	1.0E-05	5.0E-02	1.3E-02	1.5E+01	2.0E-05	7.0E-05	1.0E-04	3.4E-02	2.9E-04	3.3E-01	1.0E-05	9.4E-01	9.0E-01	-4.1E-02	-2.3%
7-Aug-12	36																											
14-Aug-12	37	3.3E+00	9.0E-05	3.0E-03	7.6E-01	4.5E-02	1.0E-02	2.2E-03	5.7E-03	9.0E-03	2.4E-01	1.9E-03	1.0E+00	1.0E-05	7.0E-02	1.2E-02	1.7E+01	2.0E-05	1.9E-04	3.0E-04	3.7E-02	4.9E-04	4.4E-01	1.0E-05	1.1E+00	1.0E+00	-9.5E-02	-4.5%
21-Aug-12	38																											
28-Aug-12	39	3.3E+00	2.3E-04	3.0E-03	6.5E-01	4.0E-02	4.0E-02	2.0E-05	5.3E-03	1.3E-02	2.0E-01	2.0E-03	9.2E-01	1.0E-05	4.0E-02	1.1E-02	1.7E+01	2.0E-05	1.5E-04	1.0E-04	4.2E-02	2.0E-04	3.9E-01	1.0E-05	1.3E+00	1.1E+00	-1.6E-01	-6.8%
4-Sep-12	40																											
11-Sep-12	41	5.3E+00	1.1E-04	3.0E-03	6.7E-01	4.2E-02	1.0E-02	1.2E-04	6.3E-03	9.0E-03	2.2E-01	2.4E-03	1.7E+00	2.0E-05	7.0E-02	1.5E-02	2.2E+01	2.0E-05	4.0E-05	1.0E-04	3.7E-02	6.0E-05	4.9E-01	1.0E-05	1.5E+00	1.4E+00	-3.9E-02	-1.3%
18-Sep-12	42																											
25-Sep-12	43	4.5E+00	7.0E-05	3.0E-03	4.5E-01	2.8E-02	5.0E-02	8.5E-03	4.9E-03	2.6E-02	1.7E-01	1.8E-03	1.2E+00	1.0E-05	5.0E-02	1.1E-02	1.9E+01	2.0E-05	4.2E-04	1.0E-04	3.8E-02	2.4E-04	4.0E-01	2.0E-05	1.1E+00	1.2E+00	1.2E-01	5.0%
2-Oct-12	44																											
9-Oct-12	45	3.8E+00	5.3E-04	3.0E-03	3.6E-01	2.4E-02	1.0E-02	1.3E-04	3.9E-03	6.5E-02	1.6E-01	1.7E-03	1.1E+00	3.0E-05	4.0E-02	9.5E-03	1.7E+01	2.0E-05	2.0E-04	2.0E-04	3.1E-02	2.1E-04	3.9E-01	3.0E-05	1.1E+00	1.1E+00	1.9E-03	0.1%
16-Oct-12	46																											
23-Oct-12	47																											
30-Oct-12	48																											
6-Nov-12	49	3.3E+00	7.0E-05	1.0E-03	2.1E-01	1.5E-02	1.0E-02	2.0E-05	2.7E-03	9.0E-03	1.3E-01	9.8E-04	6.9E-01	1.0E-05	4.0E-02	8.1E-03	1.2E+01	2.0E-05	3.3E-04	1.0E-04	2.0E-02	1.1E-04	2.1E-01	1.0E-05	7.4E-01	7.9E-01	4.9E-02	3.2%
13-Nov-12	50																											
20-Nov-12	51																											
27-Nov-12	52																											
4-Dec-12	53	3.7E+00	1.1E-04	2.0E-03	2.1E-01	1.6E-02	1.0E-02	3.0E-05	3.1E-03	1.3E-02	1.5E-01	1.0E-02	7.6E-01	2.0E-05	4.0E-02	9.0E-03	1.5E+01	2.0E-05	1.6E-04	1.0E-04	2.5E-02	1.1E-04	2.7E-01	1.0E-05	9.1E-01	8.5E-01	-5.9E-02	-3.4%
11-Dec-12	54																											
18-Dec-12	55																											

HC12

Sample = 08-058

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Major	Major	Diff	Diff
	No.																								Anions	Cations		(%)
		mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L				
25-Dec-12	56																											
1-Jan-13	57	4.0E+00	4.8E-04	2.0E-03	1.8E-01	1.5E-02	1.0E-02	6.0E-05	3.2E-03	9.0E-03	1.1E-01	1.2E-03	8.0E-01	1.0E-05	4.0E-02	7.2E-03	1.7E+01	2.0E-05	1.8E-04	1.0E-04	3.4E-02	8.0E-05	2.9E-01	1.0E-05	1.2E+00	1.1E+00	-1.6E-01	-6.8%
8-Jan-13	58																											
15-Jan-13	59																											
22-Jan-13	60																											
29-Jan-13	61	6.3E+00	1.7E-04	2.0E-03	2.0E-01	1.7E-02	1.0E-02	2.0E-05	3.9E-03	3.1E-02	1.2E-01	1.4E-03	8.9E-01	2.0E-05	8.0E-02	8.3E-03	2.9E+01	2.0E-05	1.4E-04	1.0E-04	4.1E-02	1.2E-04	3.0E-01	1.0E-05	1.8E+00	1.8E+00	-2.6E-02	-0.7%
5-Feb-13	62																											
12-Feb-13	63																											
19-Feb-13	64																											
26-Feb-13	65	8.5E+00	1.2E-04	2.0E-03	1.9E-01	1.9E-02	1.0E-02	3.0E-05	3.9E-03	7.3E-02	1.1E-01	1.4E-03	1.2E+00	2.0E-05	6.0E-02	7.5E-03	3.5E+01	2.0E-05	5.0E-05	1.0E-04	4.7E-02	3.0E-05	3.4E-01	1.0E-05	2.2E+00	2.2E+00	-4.4E-02	-1.0%
5-Mar-13	66																											
12-Mar-13	67																											
19-Mar-13	68																											
26-Mar-13	69	9.4E+00	7.0E-05	2.0E-03	1.5E-01	1.8E-02	1.0E-02	2.0E-05	3.2E-03	2.5E-02	9.6E-02	8.6E-04	1.2E+00	2.0E-05	5.0E-02	6.4E-03	3.4E+01	2.0E-05	2.0E-05	1.0E-04	3.9E-02	3.0E-05	2.8E-01	1.0E-05	2.1E+00	2.2E+00	1.3E-01	3.1%
2-Apr-13	70																											
9-Apr-13	71																											
16-Apr-13	72																											
23-Apr-13	73	1.4E+01	4.0E-04	2.0E-03	1.7E-01	2.4E-02	1.0E-02	6.0E-05	3.7E-03	1.5E-02	9.4E-02	8.1E-04	1.4E+00	2.0E-05	4.0E-02	6.9E-03	4.5E+01	2.0E-05	4.0E-05	1.0E-04	4.4E-02	4.0E-05	3.5E-01	2.0E-05	3.2E+00	3.0E+00	-1.7E-01	-2.8%
30-Apr-13	74																											
7-May-13	75																											
14-May-13	76																											
21-May-13	77	1.2E+01	6.0E-05	2.0E-03	1.4E-01	2.3E-02	1.0E-02	7.0E-05	3.3E-03	1.7E-02	8.7E-02	7.4E-04	1.0E+00	2.0E-05	3.0E-02	5.7E-03	3.9E+01	2.0E-05	1.1E-04	1.0E-04	3.4E-02	1.3E-04	2.8E-01	2.0E-05	2.7E+00	2.3E+00	-4.4E-01	-8.6%
28-May-13	78																											
4-Jun-13	79																											
11-Jun-13	80																											
18-Jun-13	81	1.4E+01	6.1E-04	2.0E-03	1.5E-01	2.5E-02	1.0E-02	3.0E-05	3.2E-03	9.0E-03	1.1E-01	8.5E-04	1.0E+00	1.0E-05	6.0E-02	6.9E-03	4.1E+01	2.0E-05	6.0E-05	1.0E-04	3.3E-02	1.2E-04	2.4E-01	1.0E-05	2.7E+00	2.4E+00	-2.6E-01	-5.0%
25-Jun-13	82																											
2-Jul-13	83																											
9-Jul-13	84																											
16-Jul-13	85	1.2E+01	1.4E-04	2.0E-03	1.2E-01	1.9E-02	1.0E-02	1.0E-05	2.8E-03	9.0E-03	3.2E-01	7.7E-04	7.9E-01	2.0E-05	7.0E-02	6.9E-03	2.7E+01	2.0E-05	4.0E-05	1.0E-04	1.8E-02	1.0E-04	1.3E-01	1.0E-05	1.6E+00	1.8E+00	1.6E-01	4.7%
23-Jul-13	86																											
30-Jul-13	87																											
6-Aug-13	88																											
13-Aug-13	89	1.1E+01	9.0E-05	2.0E-03	1.2E-01	1.9E-02	2.0E-02	1.0E-05	2.7E-03	9.0E-03	1.6E-01	9.7E-04	9.5E-01	2.0E-05	4.0E-02	6.8E-03	2.5E+01	2.0E-05	1.1E-04	1.0E-04	1.9E-02	8.0E-05	1.0E-01	1.0E-05	1.9E+00	1.8E+00	-8.7E-02	-2.4%
20-Aug-13	90																											
27-Aug-13	91																											
3-Sep-13	92																											
10-Sep-13	93	8.4E+00	7.9E-04	2.0E-03	1.1E-01	1.7E-02	1.0E-02	2.0E-05	2.1E-03	9.0E-03	1.9E-01	1.1E-03	9.2E-01	2.0E-05	4.0E-02	1.0E-02	2.9E+01	2.0E-05	1.1E-04	1.0E-04	1.9E-02	9.0E-05	8.5E-02	1.0E-05	1.8E+00	1.6E+00	-1.7E-01	-4.9%
17-Sep-13	94																											
24-Sep-13	95																											
1-Oct-13	96																											
8-Oct-13	97																											
15-Oct-13	98																											
22-Oct-13	99																											
29-Oct-13	100																											
5-Nov-13	101	3.7E+01	7.0E-05	5.0E-03	3.0E-01	6.5E-02	1.0E-02	1.0E-05	6.7E-03	2.3E-02	1.2E-01	2.8E-03	5.6E+00	1.2E-04	1.3E-01	2.0E-02	7.9E+01	2.0E-05	1.3E-04	2.0E-04	7.6E-02	2.9E-04	3.5E-01	3.0E-05	5.2E+00	5.6E+00	3.7E-01	3.4%
12-Nov-13	102																											
19-Nov-13	103																											
26-Nov-13	104																											
3-Dec-13	105	5.0E+00	3.0E-05	2.0E-03	8.0E-02	9.8E-03	1.0E-02	1.0E-05	1.7E-03	9.0E-03	1.7E-01	6.9E-04	6.6E-01	1.0E-05	3.0E-02	5.4E-03	1.8E+01	2.0E-05	7.0E-05	1.0E-04	1.4E-02	3.0E-05	8.2E-02	1.0E-05	8.6E-01	1.2E+00	2.9E-01	14.4%
10-Dec-13	106																											
17-Dec-13	107																											
24-Dec-13	108																											
31-Dec-13	109	3.5E+00	1.2E-04	2.0E-03	6.5E-02	7.5E-03	1.0E-02	1.0E-05	1.3E-03	9.0E-03	2.2E-01	7.4E-04	4.8E-01	1.0E-05	4.0E-02	3.8E-03	1.5E+01	2.0E-05	1.0E-04	1.0E-04	9.7E-03	4.0E-05	5.6E-02	1.0E-05	8.4E-01	8.7E-01	3.0E-02	1.7%
7-Jan-14	110																											
14-Jan-14	111																											
21-Jan-14	112																											
28-Jan-14	113	3.0E+00	2.0E-05	1.0E-03	6.5E-02	6.1E-03	1.0E-02	1.0E-05	1.3E-03	9.0E-03	2.2E-01	7.0E-04	5.4E-01	1.0E-05	5.0E-02	5.3E-03	1.7E+01	2.0E-05	2.0E-05	1.0E-04	1.1E-02	3.0E-05	4.5E-02	1.0E-05	9.3E-01	9.6E-01	3.6E-02	1.9%

HC12

Sample = 08-058

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Major	Major	Diff	Diff
	No.																								Anions	Cations		(%)
		mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L				
4-Feb-14	114																											
11-Feb-14	115																											
18-Feb-14	116																											
25-Feb-14	117	4.0E+00	1.3E-04	2.0E-03	7.6E-02	7.8E-03	1.0E-02	1.0E-05	1.7E-03	9.0E-03	1.8E-01	1.0E-03	5.4E-01	2.0E-05	3.0E-02	6.4E-03	2.1E+01	1.0E-04	8.0E-05	1.0E-04	1.4E-02	1.3E-04	4.9E-02	1.0E-05	1.2E+00	1.4E+00	1.7E-01	6.5%
4-Mar-14	118	4.6E+00	4.0E-05	1.0E-03	9.1E-02	9.3E-03	1.0E-02	2.0E-05	1.0E-03	1.9E-02	1.4E-01	7.6E-04	2.8E-01	1.0E-05	7.0E-02	7.0E-03	1.9E+01	2.0E-05	1.4E-03	1.0E-04	1.2E-02	1.4E-04	4.2E-02	1.0E-05	1.2E+00	1.2E+00	-4.8E-02	-2.0%
11-Mar-14	119	3.7E+00	2.0E-05	1.0E-03	7.5E-02	7.4E-03	1.0E-02	3.0E-05	1.5E-03	3.5E-02	1.1E-01	6.9E-04	4.9E-01	1.0E-05	3.0E-02	4.6E-03	1.8E+01	2.0E-05	7.1E-03	1.0E-04	1.1E-02	3.0E-05	4.7E-02	1.0E-05	8.4E-01	9.9E-01	1.5E-01	8.1%
18-Mar-14	120	2.4E+00	1.3E-04	1.0E-03	5.0E-02	6.2E-03	1.0E-02	1.0E-05	9.0E-04	3.2E-02	8.3E-02	4.1E-04	2.9E-01	1.0E-05	4.0E-02	3.2E-03	1.2E+01	2.0E-05	5.5E-04	1.0E-04	7.3E-03	3.0E-05	3.5E-02	1.0E-05	5.5E-01	7.7E-01	2.2E-01	16.6%
25-Mar-14	121	1.9E+00	4.0E-05	1.0E-03	2.8E-02	3.5E-03	1.0E-02	3.0E-05	4.0E-04	2.2E-02	7.3E-02	3.7E-04	2.3E-01	1.0E-05	1.0E-02	2.2E-03	9.3E+00	2.0E-05	2.4E-04	1.0E-04	5.0E-03	3.0E-05	2.2E-02	1.0E-05	4.8E-01	5.4E-01	6.1E-02	5.9%
1-Apr-14	122																											
8-Apr-14	123																											
15-Apr-14	124																											
22-Apr-14	125	2.3E+00	8.0E-05	2.8E-04	1.4E-02	3.1E-03	1.0E-02	2.0E-05	6.0E-04	9.0E-03	6.2E-02	2.5E-04	2.0E-01	2.0E-06	6.0E-02	2.5E-03	7.4E+00	5.0E-06	1.6E-04	5.0E-05	3.1E-03	2.0E-05	2.0E-02	2.0E-03	3.8E-01	5.1E-01	1.4E-01	15.6%
29-Apr-14	126																											
6-May-14	127																											
13-May-14	128																											
20-May-14	129	2.1E+00	9.0E-05	2.2E-04	1.0E-02	2.9E-03	1.0E-02	9.0E-05	3.0E-04	9.0E-03	4.8E-02	2.3E-04	2.0E-01	1.0E-05	1.0E-02	2.1E-03	6.3E+00	5.0E-06	2.3E-03	5.0E-05	2.5E-03	1.0E-05	1.3E-02	2.0E-03	3.1E-01	4.3E-01	1.2E-01	0.15895093
27-May-14	130																											
3-Jun-14	131																											
10-Jun-14	132																											
17-Jun-14	133	2.0E+00	4.0E-05	1.6E-04	7.0E-03	2.7E-03	1.0E-02	1.0E-05	3.0E-04	9.0E-03	4.8E-02	2.2E-04	2.1E-01	3.0E-06	2.0E-02	2.0E-03	6.4E+00	5.0E-06	7.6E-03	5.0E-05	2.2E-03	1.0E-05	1.3E-02	2.0E-03	3.1E-01	4.3E-01	1.2E-01	0.159962103
24-Jun-14	134																											
1-Jul-14	135																											
8-Jul-14	136																											
15-Jul-14	137	2.4E+00	4.0E-05	1.5E-04	7.0E-03	3.3E-03	1.0E-02	1.0E-05	3.0E-04	1.0E-02	4.6E-02	2.5E-04	1.9E-01	4.0E-06	2.0E-02	2.0E-03	6.7E+00	5.0E-06	1.1E-03	5.0E-05	2.2E-03	1.0E-05	1.3E-02	2.0E-03	2.9E-01	4.5E-01	1.6E-01	0.218348819
22-Jul-14	138																											
29-Jul-14	139																											
5-Aug-14	140																											
12-Aug-14	141	2.3E+00	3.1E-04	1.4E-04	6.0E-03	3.4E-03	1.0E-02	4.0E-05	3.0E-04	9.0E-03	4.3E-02	2.3E-04	1.8E-01	4.0E-06	3.0E-02	2.2E-03	6.7E+00	5.0E-06	9.4E-04	5.0E-05	2.3E-03	1.0E-05	1.4E-02	2.0E-03	2.9E-01	4.5E-01	1.6E-01	0.21014613
19-Aug-14	142																											
26-Aug-14	143																											
2-Sep-14	144																											
9-Sep-14	145	2.2E+00	5.0E-05	1.4E-04	5.0E-03	3.2E-04	< 0.01	< 0.00001	2.0E-04	< 0.003	4.7E-02	2.5E-04	1.5E-01	6.0E-06	2.0E-02	1.9E-03	7.1E+00	< 0.000005	3.3E-03	< 0.00005	2.0E-03	2.0E-05	1.4E-02	< 0.002				
16-Sep-14	146																											
23-Sep-14	147																											
30-Sep-14	148																											

Sept 24/13. HC 12 put on humid ai

Mar 4/14 Moved to fridge at 4°C C

HC12

Sample = 08-058

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/kg	mgCaCO3/kg	mgCaCO3/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
29-Nov-11	0	470	375	4.73	1.6E+03	#N/A	7.4E+01	#N/A	3.5E+02	1.8E+00	7.3E-01	1.1E-01	1.7E+02	3.9E+00	2.8E-03	8.3E-04	1.3E-02	4.8E-04	3.8E-06	2.1E-03	3.2E-03	5.2E+01	3.4E-04	8.1E-02	7.2E+01
6-Dec-11	1	500	470	4.81	8.4E+02	#N/A	4.7E+01	#N/A	1.3E+02	1.0E+00	2.8E-02	1.4E-01	9.6E+01	1.3E+00	2.7E-03	4.2E-04	6.3E-03	4.1E-04	4.7E-06	3.2E-03	2.0E-03	2.8E+01	7.5E-04	5.8E-02	2.8E+01
13-Dec-11	2	500	435	4.90	6.0E+02	#N/A	3.3E+01	#N/A	1.2E+02	8.7E-01	3.7E-01	1.3E-01	6.7E+01	8.4E-01	1.8E-03	2.2E-04	4.0E-03	2.3E-04	2.2E-05	2.7E-03	1.2E-03	2.0E+01	8.7E-04	4.7E-02	1.7E+01
20-Dec-11	3	500	420	4.91	5.2E+02	#N/A	3.1E+01	#N/A	1.1E+02	2.9E-01	4.0E-01	1.3E-01	5.8E+01	8.1E-01	2.8E-03	5.5E-04	3.3E-03	2.4E-04	4.2E-06	2.3E-03	1.2E-03	1.7E+01	2.1E-04	3.2E-02	1.7E+01
27-Dec-11	4	500	535	5.52	1.3E+02																				
3-Jan-12	5	500	450	5.36	1.2E+02	#N/A	5.2E+00	4.0E-01	2.3E+01	9.0E-02	6.8E-02	1.4E-01	1.5E+01	1.3E-01	1.3E-03	1.4E-04	2.0E-03	5.9E-05	4.5E-06	2.0E-03	4.1E-04	5.1E+00	2.3E-04	4.5E-03	2.5E+00
10-Jan-12	6	500	425	5.25	1.1E+02																				
17-Jan-12	7	500	435	5.29	1.1E+02	#N/A	5.2E+00	3.0E-01	2.0E+01	8.7E-02	6.5E-02	1.3E-01	1.3E+01	1.2E-01	3.5E-03	1.7E-04	2.0E-03	8.3E-05	4.4E-06	3.2E-03	3.0E-04	4.3E+00	2.2E-04	4.9E-03	2.9E+00
24-Jan-12	8	500	435	5.40	9.0E+01																				
31-Jan-12	9	500	465	5.31	7.5E+01	#N/A	3.9E+00	3.6E-01	1.4E+01	9.3E-02	5.1E-02	1.4E-01	8.5E+00	5.9E-02	1.1E-03	1.4E-04	1.6E-03	5.6E-05	4.7E-06	1.7E-03	1.3E-04	2.8E+00	2.3E-04	3.1E-03	1.7E+00
7-Feb-12	10	500	460	5.29	8.3E+01																				
14-Feb-12	11	500	465	5.27	8.8E+01	#N/A	6.3E+00	4.1E-01	1.7E+01	9.3E-02	6.5E-02	1.4E-01	1.0E+01	8.2E-02	5.6E-04	9.3E-05	1.3E-03	6.5E-05	4.7E-06	1.5E-03	1.7E-04	3.3E+00	2.3E-04	4.2E-03	2.4E+00
21-Feb-12	12	500	420	5.23	1.2E+02																				
28-Feb-12	13	500	445	5.08	1.0E+02	#N/A	5.8E+00	4.1E-01	1.7E+01	8.9E-02	6.7E-02	1.3E-01	1.2E+01	1.1E-01	8.0E-04	8.9E-05	1.4E-03	7.1E-05	4.5E-06	1.3E-03	1.7E-04	3.9E+00	2.2E-04	4.0E-03	2.2E+00
6-Mar-12	14	500	440	5.30	9.7E+01																				
13-Mar-12	15	500	440	4.99	1.0E+02	#N/A	6.7E+00	3.9E-01	1.8E+01	8.8E-02	7.5E-02	1.3E-01	1.1E+01	1.0E-01	7.5E-04	1.8E-04	1.0E-03	2.8E-04	4.4E-06	1.1E-03	2.2E-04	3.6E+00	2.2E-04	5.4E-03	2.9E+00
20-Mar-12	16	500	465	5.17	8.8E+01																				
27-Mar-12	17	500	450	5.22	9.9E+01	#N/A	6.2E+00	5.0E-01	1.9E+01	9.0E-02	8.1E-02	1.4E-01	1.1E+01	1.6E-01	5.0E-04	9.0E-05	1.4E-03	1.1E-04	4.5E-06	1.4E-03	2.2E-04	3.7E+00	2.3E-04	4.7E-03	2.6E+00
3-Apr-12	18	500	440	4.87	8.9E+01																				
10-Apr-12	19	500	465	4.91	1.0E+02	#N/A	7.1E+00	1.7E-01	1.8E+01	9.3E-02	9.3E-02	1.4E-01	1.0E+01	1.8E-01	4.2E-04	9.3E-05	1.1E-03	1.3E-04	4.7E-06	1.2E-03	2.4E-04	3.3E+00	2.3E-04	5.6E-03	3.0E+00
17-Apr-12	20	500	450	4.80	1.2E+02																				
24-Apr-12	21	500	455	4.66	1.1E+02	#N/A	8.6E+00	4.6E-02	2.0E+01	9.1E-02	1.0E-01	1.4E-01	1.0E+01	2.1E-01	4.1E-04	9.1E-05	7.7E-04	1.5E-04	4.6E-06	8.2E-04	3.1E-04	3.2E+00	2.3E-04	5.6E-03	3.1E+00
1-May-12	22	500	450	4.80	1.2E+02																				
8-May-12	23	500	440	4.61	1.2E+02	#N/A	9.7E+00	4.4E-02	2.0E+01	8.8E-02	8.8E-02	1.3E-01	1.1E+01	2.2E-01	3.5E-04	8.8E-05	5.7E-04	1.6E-04	4.4E-06	7.5E-04	3.6E-04	3.3E+00	2.2E-04	6.4E-03	3.0E+00
15-May-12	24	500	450	4.52	1.1E+02																				
22-May-12	25	500	440	4.63	1.1E+02	#N/A	9.8E+00	4.4E-02	1.7E+01	8.8E-02	1.2E-01	1.3E-01	9.4E+00	3.2E-01	2.6E-04	1.3E-04	4.8E-04	1.7E-04	4.4E-06	7.5E-04	3.7E-04	3.0E+00	2.2E-04	5.9E-03	3.0E+00
29-May-12	26	500	440	4.44	1.2E+02																				
5-Jun-12	27	500	450	4.53	1.1E+02	#N/A	9.9E+00	4.5E-02	1.7E+01	9.0E-02	1.2E-01	1.4E-01	9.0E+00	3.4E-01	2.3E-04	9.0E-05	4.5E-04	2.0E-04	4.5E-06	1.3E-03	4.5E-04	2.9E+00	2.3E-04	6.3E-03	2.9E+00
12-Jun-12	28	500	455	4.51	1.0E+02																				
19-Jun-12	29	500	450	4.44	1.1E+02	7.2E-01	1.0E+01	#N/A	1.7E+01	1.8E-01	1.4E-01	1.4E-01	7.6E+00	3.8E-01	2.3E-04	1.8E-04	2.3E-03	2.1E-04	4.5E-06	9.9E-04	5.1E-04	2.4E+00	2.3E-04	6.1E-03	2.9E+00
26-Jun-12	30	500	450	4.40	1.1E+02																				
3-Jul-12	31	500	465	4.59	1.2E+02	#N/A	1.6E+01	4.7E-02	1.9E+01	4.7E-01	1.7E-01	1.4E-01	7.5E+00	5.3E-01	2.3E-04	9.3E-05	4.7E-04	2.5E-04	4.7E-06	5.1E-04	7.7E-04	2.3E+00	2.3E-04	6.8E-03	3.4E+00
10-Jul-12	32	500	450	4.25	1.3E+02																				
17-Jul-12	33	500	460	4.10	1.4E+02	2.3E+00	1.6E+01	#N/A	2.1E+01	9.2E-02	2.0E-01	1.4E-01	7.6E+00	8.1E-01	3.2E-04	2.8E-04	3.7E-04	3.8E-04	4.6E-06	1.6E-03	1.2E-03	2.3E+00	2.3E-04	9.0E-03	4.0E+00
24-Jul-12	34	500	470	4.15	1.3E+02																				
31-Jul-12	35	500	450	4.12	1.3E+02	2.0E+00	1.4E+01	#N/A	2.0E+01	9.0E-02	1.8E-01	1.4E-01	6.5E+00	8.0E-01	2.7E-04	9.0E-05	4.1E-04	2.9E-04	4.5E-06	8.1E-04	1.1E-03	2.0E+00	2.3E-04	6.5E-03	3.3E+00
7-Aug-12	36	500	485	4.05	1.4E+02																				
14-Aug-12	37	500	460	4.03	1.4E+02	3.3E+00	1.9E+01	#N/A	2.4E+01	9.2E-02	2.1E-01	1.4E-01	6.0E+00	1.3E+00	2.3E-04	1.8E-04	4.7E-04	3.4E-04	4.6E-06	9.2E-04	1.4E-03	1.8E+00	2.3E-04	6.9E-03	3.5E+00
21-Aug-12	38	500	465	4.02	1.6E+02																				
28-Aug-12	39	500	460	4.05	1.5E+02	3.9E+00	2.2E+01	#N/A	2.8E+01	9.2E-02	2.1E-01	1.4E-01	5.3E+00	1.5E+00	2.3E-04	2.3E-04	4.3E-04	3.3E-04	4.6E-06	1.0E-03	1.6E-03	1.6E+00	2.3E-04	6.4E-03	3.5E+00
4-Sep-12	40	500	480	4.02	1.5E+02																				
11-Sep-12	41	500	475	4.01	1.9E+02	5.5E+00	2.6E+01	#N/A	3.3E+01	9.5E-02	2.4E-01	1.4E-01	6.9E+00	2.0E+00	1.9E-04	1.4E-04	3.8E-04	4.0E-04	4.8E-06	9.0E-04	2.1E-03	2.2E+00	2.4E-04	7.5E-03	4.1E+00
18-Sep-12	42	500	520	3.90	1.6E+02																				
25-Sep-12	43	500	495	3.90	1.7E+02	5.3E+00	2.5E+01	#N/A	2.6E+01	9.9E-02	1.8E-01	1.5E-01	4.8E+00	2.0E+00	9.9E-05	9.9E-05	3.7E-04	3.1E-04	5.0E-06	4.5E-04	1.9E-03	1.5E+00	3.5E-04	6.1E-03	3.5E+00
2-Oct-12	44	500	485	4.01	1.6E+02																				
9-Oct-12	45	500	480	3.88	1.5E+02	4.8E+00	2.1E+01	#N/A	2.5E+01	9.6E-02	1.5E-01	1.4E-01	3.7E+00	1.7E+00	9.6E-05	9.6E-05	4.8E-04	2.7E-04	4.8E-06	7.2E-04	1.6E-03	1.2E+00	2.4E-04	5.1E-03	3.0E+00

HC12

Sample = 08-058

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/kg	mgCaCO3/kg	mgCaCO3/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
16-Oct-12	46	500	465	3.91	1.7E+02																				
23-Oct-12	47	500	475	3.89	1.2E+02																				
30-Oct-12	48	500	485	3.92	1.8E+02																				
6-Nov-12	49	500	465	3.88	1.1E+02	3.5E+00	1.4E+01	#N/A	1.6E+01	9.3E-02	9.8E-02	1.4E-01	2.6E+00	1.0E+00	9.3E-05	1.4E-04	3.6E-04	1.5E-04	4.7E-06	8.4E-04	9.7E-04	8.7E-01	2.3E-04	3.0E-03	1.7E+00
13-Nov-12	50	500	505	3.99	1.6E+02																				
20-Nov-12	51	500	495	3.74	1.9E+02																				
27-Nov-12	52	500	455	4.01	2.1E+02																				
4-Dec-12	53	500	425	4.21	1.1E+02	4.3E-02	9.9E+00	#N/A	1.8E+01	8.5E-02	8.5E-02	1.3E-01	2.3E+00	1.2E+00	8.5E-05	8.5E-05	5.4E-04	1.7E-04	4.3E-06	3.4E-04	1.1E-03	7.8E-01	2.1E-04	3.5E-03	1.9E+00
11-Dec-12	54	500	430	4.31	1.1E+02																				
18-Dec-12	55	500	445	3.81	1.9E+02																				
25-Dec-12	56	500	405	4.32	1.1E+02																				
1-Jan-13	57	500	420	3.62	2.0E+02	9.3E+00	2.5E+01	#N/A	2.5E+01	8.4E-02	9.7E-02	1.3E-01	1.6E+00	1.5E+00	8.4E-05	1.3E-04	5.7E-04	1.6E-04	4.2E-06	2.5E-04	1.2E-03	5.0E-01	2.1E-04	3.7E-03	1.8E+00
8-Jan-13	58	500	435	3.81	1.4E+02																				
15-Jan-13	59	500	435	3.51	2.5E+02																				
22-Jan-13	60	500	415	3.83	1.6E+02																				
29-Jan-13	61	500	455	3.41	2.9E+02	1.7E+01	3.7E+01	#N/A	4.0E+01	4.6E-01	1.1E-01	1.4E-01	2.0E+00	3.3E+00	9.1E-05	1.4E-04	3.5E-04	2.2E-04	4.6E-06	2.7E-04	1.6E-03	6.6E-01	5.9E-04	5.2E-03	2.4E+00
5-Feb-13	62	500	430	3.41	3.2E+02																				
12-Feb-13	63	500	425	3.26	3.5E+02																				
19-Feb-13	64	500	425	3.28	3.5E+02																				
26-Feb-13	65	500	420	3.21	3.8E+02	2.1E+01	3.8E+01	#N/A	4.5E+01	4.2E-01	1.0E-01	1.3E-01	1.9E+00	3.2E+00	8.4E-05	2.1E-04	3.6E-04	2.1E-04	4.2E-06	2.5E-04	1.7E-03	6.1E-01	7.6E-04	5.9E-03	2.4E+00
5-Mar-13	66	500	425	3.22	4.2E+02																				
12-Mar-13	67	500	425	3.27	3.5E+02																				
19-Mar-13	68	500	410	3.27	4.2E+02																				
26-Mar-13	69	500	430	3.21	3.7E+02	2.6E+01	4.7E+01	#N/A	4.3E+01	4.3E-01	9.9E-02	1.3E-01	1.4E+00	3.4E+00	8.6E-05	2.2E-04	2.8E-04	1.8E-04	4.3E-06	3.4E-04	1.4E-03	4.5E-01	3.9E-04	5.5E-03	2.0E+00
2-Apr-13	70	500	415	3.15	4.2E+02																				
9-Apr-13	71	500	420	3.30	3.9E+02																				
16-Apr-13	72	500	410	3.33	3.8E+02																				
23-Apr-13	73	500	420	3.08	5.3E+02	3.4E+01	5.6E+01	#N/A	6.4E+01	4.2E-01	1.1E-01	1.3E-01	1.5E+00	4.5E+00	8.4E-05	2.1E-04	2.8E-04	1.9E-04	4.2E-06	2.9E-04	1.8E-03	4.8E-01	8.0E-04	7.0E-03	2.3E+00
30-Apr-13	74	500	415	3.12	4.7E+02																				
7-May-13	75	500	410	3.18	4.4E+02																				
14-May-13	76	500	405	3.11	4.6E+02																				
21-May-13	77	500	415	3.13	4.2E+02	2.9E+01	4.9E+01	#N/A	5.4E+01	4.2E-01	9.5E-02	1.2E-01	1.5E+00	2.7E+00	8.3E-05	8.3E-05	2.9E-04	1.6E-04	4.2E-06	4.2E-04	1.3E-03	4.9E-01	8.3E-04	6.3E-03	1.6E+00
28-May-13	78	500	410	3.13	4.4E+02																				
4-Jun-13	79	500	405	3.10	4.8E+02																				
11-Jun-13	80	500	425	3.22	4.6E+02																				
18-Jun-13	81	500	400	3.17	4.8E+02	3.2E+01	5.3E+01	#N/A	5.2E+01	4.0E-01	9.2E-02	1.2E-01	1.6E+00	2.9E+00	8.0E-05	1.2E-04	4.1E-04	1.8E-04	4.0E-06	6.0E-04	1.1E-03	5.4E-01	9.6E-04	6.2E-03	1.3E+00
25-Jun-13	82	500	415	3.19	4.6E+02																				
2-Jul-13	83	500	415	3.08	5.1E+02																				
9-Jul-13	84	500	415	3.22	4.5E+02																				
16-Jul-13	85	500	495	3.26	3.2E+02	2.4E+01	4.1E+01	#N/A	3.8E+01	5.0E-01	8.4E-02	1.5E-01	1.4E+00	2.1E+00	9.9E-05	2.0E-04	7.0E-04	1.6E-04	5.0E-06	7.4E-04	8.1E-04	4.8E-01	1.2E-03	5.3E-03	1.0E+00
23-Jul-13	86	500	405	3.39	2.6E+02																				
30-Jul-13	87	500	435	3.34	2.7E+02																				
6-Aug-13	88	500	405	3.34	2.9E+02																				
13-Aug-13	89	500	455	3.24	3.2E+02	2.1E+01	3.7E+01	#N/A	4.1E+01	4.6E-01	1.0E-01	1.4E-01	1.4E+00	2.2E+00	9.1E-05	1.4E-04	3.9E-04	1.5E-04	4.6E-06	6.8E-04	5.9E-04	4.8E-01	9.1E-04	4.5E-03	7.5E-01
20-Aug-13	90	500	415	3.36	2.8E+02																				
27-Aug-13	91	500	455	3.30	2.8E+02																				
3-Sep-13	92	500	415	3.39	2.2E+02																				
10-Sep-13	93	500	410	3.29	3.0E+02	1.9E+01	3.4E+01	#N/A	3.5E+01	4.1E-01	9.8E-02	1.2E-01	2.6E+00	1.8E+00	8.2E-05	1.2E-04	4.7E-04	1.1E-04	4.1E-06	7.8E-04	4.4E-04	9.8E-01	8.6E-04	4.0E-03	5.7E-01
17-Sep-13	94	500	395	3.26	3.2E+02																				
24-Sep-13	95	500	415	3.28	3.1E+02																				

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Sample = 08-058

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Fluoride	Bromide	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
					umhos/cm	mgCaCO3/kg	mgCaCO3/kg	mgCaCO3/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
1-Oct-13	96																								
8-Oct-13	97																								
15-Oct-13	98																								
22-Oct-13	99																								
29-Oct-13	100																								
5-Nov-13	101	500	530	3.05	7.1E+02	7.1E+01	1.4E+02	#N/A	1.3E+02	1.1E+00	3.2E-01	1.6E-01	4.6E+00	1.1E+01	1.6E-04	3.2E-04	3.8E-04	4.6E-04	5.3E-06	1.5E-03	2.7E-03	1.6E+00	2.7E-03	1.6E-02	2.6E+00
12-Nov-13	102	500	435	3.34	3.6E+02																				
19-Nov-13	103	500	460	3.52	2.4E+02																				
26-Nov-13	104	500	470	3.49	2.2E+02																				
3-Dec-13	105	500	455	3.39	2.2E+02	1.0E+01	2.5E+01	#N/A	1.9E+01	4.6E-01	7.3E-02	1.4E-01	1.2E+00	1.5E+00	9.1E-05	9.1E-05	2.8E-04	1.0E-04	4.6E-06	1.1E-03	4.6E-04	4.2E-01	4.1E-04	3.5E-03	5.6E-01
10-Dec-13	106	500	395	3.43	2.4E+02																				
17-Dec-13	107	500	425	3.33	2.6E+02																				
24-Dec-13	108	500	410	3.42	2.6E+02																				
31-Dec-13	109	500	410	3.48	1.9E+02	8.7E+00	1.8E+01	#N/A	1.6E+01	8.2E-02	6.6E-02	1.2E-01	6.2E-01	1.0E+00	8.2E-05	8.2E-05	3.3E-04	9.8E-05	4.1E-06	6.6E-04	2.5E-04	2.1E-01	6.2E-04	2.4E-03	3.6E-01
7-Jan-14	110	500	440	3.37	2.5E+02																				
14-Jan-14	111	500	425	3.35	2.4E+02																				
21-Jan-14	112	500	455	3.45	2.3E+02																				
28-Jan-14	113	500	425	3.42	2.1E+02	1.1E+01	2.1E+01	#N/A	1.9E+01	4.3E-01	7.7E-02	1.3E-01	8.5E-01	1.3E+00	8.5E-05	8.5E-05	2.8E-04	8.5E-05	4.3E-06	7.2E-04	2.3E-04	2.9E-01	6.0E-04	2.9E-03	3.1E-01
4-Feb-14	114	500	420	3.40	2.2E+02																				
11-Feb-14	115	500	435	3.41	2.3E+02																				
18-Feb-14	116	500	435	3.38	2.3E+02																				
25-Feb-14	117	500	450	3.38	2.5E+02	1.5E+01	2.9E+01	#N/A	2.7E+01	9.0E-02	9.5E-02	1.4E-01	1.3E+00	2.8E+00	9.0E-05	1.4E-04	3.3E-04	1.3E-04	2.7E-05	7.2E-04	3.1E-04	4.5E-01	1.0E-03	4.0E-03	3.6E-01
4-Mar-14	118	500	435	3.49	2.0E+02	1.1E+01	2.4E+01	#N/A	2.5E+01	8.7E-02	7.8E-02	1.3E-01	1.3E+00	2.0E+00	8.7E-05	8.7E-05	2.3E-04	1.0E-04	4.4E-06	4.8E-04	2.2E-04	4.5E-01	8.7E-04	3.4E-03	3.3E-01
11-Mar-14	119	500	465	3.55	1.9E+02	1.1E+01	2.5E+01	#N/A	1.9E+01	9.3E-02	6.5E-02	1.4E-01	8.4E-01	1.9E+00	9.3E-05	9.3E-05	1.5E-03	1.1E-04	4.7E-06	7.0E-04	2.3E-04	2.7E-01	7.9E-04	3.9E-03	3.3E-01
18-Mar-14	120	500	445	3.59	1.5E+02	8.9E+00	1.8E+01	#N/A	1.2E+01	8.9E-02	4.9E-02	1.3E-01	5.8E-01	1.3E+00	8.9E-05	8.9E-05	3.5E-04	5.8E-05	2.2E-05	3.6E-04	1.5E-04	2.0E-01	4.5E-04	2.5E-03	2.2E-01
25-Mar-14	121	500	460	3.74	1.3E+02	5.9E+00	1.4E+01	#N/A	1.1E+01	9.2E-02	3.2E-02	1.4E-01	3.6E-01	9.6E-01	9.2E-05	9.2E-05	1.8E-04	5.1E-05	4.6E-06	2.3E-04	1.0E-04	1.2E-01	2.3E-04	1.8E-03	1.6E-01
1-Apr-14	122	500	465	3.70	1.2E+02																				
8-Apr-14	123	500	470	3.61	1.3E+02																				
15-Apr-14	124	500	450	3.70	1.2E+02																				
22-Apr-14	125	500	440	3.69	1.1E+02	5.3E+00	1.1E+01	#N/A	7.9E+00	8.8E-02	2.6E-02	1.3E-01	3.3E-01	6.2E-01	8.8E-05	8.8E-05	4.4E-04	3.2E-05	3.1E-06	9.7E-04	7.0E-05	1.2E-01	1.7E-04	1.3E-03	1.3E-01
29-Apr-14	126	500	460	3.74	1.1E+02																				
6-May-14	127	500	455	3.61	1.1E+02																				
13-May-14	128	500	465	3.79	9.8E+01																				
20-May-14	129	500	460	3.71	9.3E+01	5.5E+00	1.1E+01	#N/A	6.9E+00	9.2E-02	2.8E-02	1.4E-01	2.3E-01	4.4E-01	9.2E-05	9.2E-05	5.1E-04	1.9E-05	3.2E-06	1.4E-04	5.9E-05	8.3E-02	1.2E-04	1.0E-03	1.1E-01
27-May-14	130	500	450	3.74	1.0E+02																				
3-Jun-14	131	500	480	3.62	8.9E+01																				
10-Jun-14	132	500	465	3.63	1.2E+02																				
17-Jun-14	133	500	475	3.65	1.0E+02	5.8E+00	1.1E+01	#N/A	7.1E+00	9.5E-02	2.9E-02	1.4E-01	2.0E-01	3.4E-01	9.5E-05	9.5E-05	4.9E-04	1.9E-05	3.3E-06	1.4E-03	5.4E-05	7.6E-02	1.2E-04	1.0E-03	1.0E-01
24-Jun-14	134	500	480	3.70	1.0E+02																				
1-Jul-14	135	500	455	3.69	1.1E+02																				
8-Jul-14	136	500	470	3.74	1.1E+02																				
15-Jul-14	137	500	405	3.66	1.2E+02	5.2E+00	9.7E+00	#N/A	5.7E+00	8.1E-02	2.4E-02	1.2E-01	1.8E-01	3.1E-01	8.1E-05	8.1E-05	3.8E-04	1.4E-05	2.8E-06	6.5E-04	5.4E-05	6.9E-02	7.3E-05	9.1E-04	9.0E-02
22-Jul-14	138	500	475	3.65	1.4E+02																				
29-Jul-14	139	500	455	3.58	1.2E+02																				
5-Aug-14	140	500	460	3.61	1.4E+02																				
12-Aug-14	141	500	450	3.66	1.1E+02	5.4E+00	1.1E+01	#N/A	6.3E+00	9.0E-02	2.7E-02	1.4E-01	2.1E-01	3.5E-01	9.0E-05	9.0E-05	4.5E-04	1.3E-05	3.2E-06	6.8E-04	6.4E-05	7.7E-02	1.1E-04	1.0E-03	9.9E-02
19-Aug-14	142	500	460	3.71	1.1E+02																				
26-Aug-14	143	500	470	3.69	1.1E+02																				
2-Sep-14	144	500	480																						

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Sample = 08-058

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
	No.																							
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
29-Nov-11	0	9.7E-01	2.6E-03	6.8E-03	8.9E+00	4.4E-01	1.1E-05	3.0E-04	2.2E-02	1.7E-02	4.7E+00	1.8E-02	2.9E-01	3.0E-05	3.7E+01	1.7E-01	1.1E+02	1.2E-04	3.4E-05	1.1E-04	3.7E-02	1.5E-04	7.0E-01	4.0E-04
6-Dec-11	1	1.6E-01	8.6E-04	7.1E-03	6.4E+00	3.1E-01	9.4E-06	1.7E-04	9.5E-03	7.1E-03	4.2E+00	1.2E-02	6.9E-01	4.2E-05	2.5E+01	1.0E-01	7.0E+01	8.9E-05	4.7E-06	9.4E-05	2.1E-02	1.1E-04	5.8E-01	2.2E-04
13-Dec-11	2	9.7E-02	4.5E-04	4.8E-03	4.1E+00	2.0E-01	8.7E-06	1.5E-04	1.5E-02	3.9E-03	2.9E+00	6.7E-03	4.0E-01	8.7E-06	1.3E+01	7.1E-02	4.1E+01	5.2E-05	1.6E-04	1.3E-04	1.3E-02	5.2E-05	3.8E-01	1.1E-04
20-Dec-11	3	1.0E-01	4.6E-05	4.2E-03	3.5E+00	1.7E-01	4.2E-06	7.1E-05	9.3E-03	3.8E-03	2.7E+00	3.7E-03	3.2E-01	4.2E-06	6.1E+00	5.7E-02	3.5E+01	4.6E-05	1.3E-05	1.3E-04	1.0E-02	1.7E-04	3.0E-01	1.1E-04
27-Dec-11	4																							
3-Jan-12	5	2.5E-02	5.2E-04	1.8E-03	4.4E-01	2.1E-02	4.5E-06	3.2E-05	1.8E-03	4.1E-03	8.6E-01	8.9E-04	2.9E-01	4.5E-06	3.6E-01	1.7E-02	6.8E+00	1.4E-05	4.1E-05	1.4E-04	1.6E-03	2.1E-04	7.1E-02	1.4E-05
10-Jan-12	6																							
17-Jan-12	7	5.3E-02	3.6E-04	2.6E-03	5.4E-01	2.5E-02	4.4E-06	4.4E-05	1.6E-03	1.1E-02	1.3E+00	1.0E-03	3.9E-01	4.4E-06	2.1E-01	1.4E-02	6.5E+00	1.3E-05	1.3E-05	8.7E-05	1.8E-03	1.1E-04	6.4E-02	2.6E-05
24-Jan-12	8																							
31-Jan-12	9	4.2E-02	2.2E-03	1.4E-03	3.4E-01	1.7E-02	4.7E-06	3.3E-05	1.2E-03	4.2E-03	7.4E-01	8.3E-04	3.7E-01	4.7E-06	7.4E-02	1.0E-02	4.2E+00	9.3E-06	4.7E-06	1.4E-04	1.1E-03	1.6E-04	3.3E-02	4.7E-06
7-Feb-12	10																							
14-Feb-12	11	9.6E-02	1.1E-04	1.4E-03	4.5E-01	2.2E-02	4.7E-06	6.5E-05	1.3E-03	2.0E-02	6.0E-01	7.5E-04	4.2E-01	4.7E-06	5.6E-02	1.3E-02	4.8E+00	9.3E-06	4.7E-06	1.9E-04	2.1E-03	1.1E-04	4.2E-02	4.7E-06
21-Feb-12	12																							
28-Feb-12	13	8.8E-02	4.0E-05	1.3E-03	4.4E-01	2.1E-02	4.5E-06	2.2E-05	2.0E-03	1.1E-02	8.8E-01	7.3E-04	3.0E-01	4.5E-06	5.3E-02	1.4E-02	5.2E+00	2.7E-05	1.8E-05	4.5E-05	2.2E-03	1.0E-04	4.1E-02	4.5E-06
6-Mar-12	14																							
13-Mar-12	15	1.4E-01	1.8E-05	2.6E-03	5.1E-01	2.5E-02	4.4E-06	2.2E-05	1.7E-03	2.0E-02	7.0E-01	8.9E-04	3.3E-01	4.4E-06	3.1E-02	1.3E-02	5.7E+00	8.8E-06	8.4E-05	4.4E-05	3.3E-03	1.3E-05	5.4E-02	8.8E-06
20-Mar-12	16																							
27-Mar-12	17	2.0E-01	8.3E-04	1.4E-03	4.8E-01	2.5E-02	4.5E-06	1.4E-05	1.6E-03	1.5E-02	5.7E-01	6.8E-04	3.4E-01	4.5E-06	3.2E-02	1.3E-02	5.9E+00	9.0E-06	4.5E-06	4.5E-05	3.9E-03	6.3E-05	3.3E-02	4.5E-06
3-Apr-12	18																							
10-Apr-12	19	2.5E-01	5.1E-05	1.4E-03	4.9E-01	2.5E-02	9.3E-06	2.2E-04	1.8E-03	9.3E-03	4.6E-01	7.5E-04	4.2E-01	4.7E-06	2.3E-02	1.2E-02	5.7E+00	9.3E-06	1.4E-05	4.7E-05	4.4E-03	6.5E-05	5.4E-02	4.7E-06
17-Apr-12	20																							
24-Apr-12	21	3.3E-01	9.6E-05	1.4E-03	5.0E-01	2.7E-02	1.4E-05	3.6E-05	1.8E-03	1.9E-02	4.1E-01	8.1E-04	3.5E-01	4.6E-06	2.7E-02	1.1E-02	6.0E+00	9.1E-06	9.1E-06	4.6E-05	6.7E-03	5.5E-05	6.9E-02	4.6E-06
1-May-12	22																							
8-May-12	23	3.5E-01	4.0E-05	1.3E-03	5.2E-01	2.8E-02	4.4E-06	7.9E-05	2.1E-03	7.0E-03	3.8E-01	8.3E-04	2.7E-01	4.4E-06	2.6E-02	9.8E-03	6.4E+00	8.8E-06	7.9E-05	4.4E-05	7.6E-03	5.7E-05	7.4E-02	4.4E-06
15-May-12	24																							
22-May-12	25	4.4E-01	4.4E-05	1.3E-03	4.8E-01	2.6E-02	4.4E-06	1.5E-04	2.1E-03	4.0E-03	2.8E-01	7.3E-04	2.8E-01	4.4E-06	2.2E-02	8.6E-03	6.0E+00	8.8E-06	3.1E-05	7.0E-04	8.0E-03	3.0E-04	6.9E-02	4.4E-06
29-May-12	26																							
5-Jun-12	27	5.1E-01	9.0E-06	1.4E-03	4.6E-01	2.5E-02	4.5E-06	1.8E-05	2.6E-03	4.1E-03	2.5E-01	8.9E-04	3.2E-01	4.5E-06	2.3E-02	7.9E-03	6.1E+00	9.0E-06	2.7E-05	9.0E-05	9.1E-03	1.5E-04	8.5E-02	4.5E-06
12-Jun-12	28																							
19-Jun-12	29	5.8E-01	1.2E-04	1.4E-03	4.0E-01	2.3E-02	4.5E-06	4.3E-04	2.2E-03	4.1E-03	2.1E-01	9.4E-04	3.2E-01	4.5E-06	2.7E-02	7.3E-03	5.4E+00	9.0E-06	4.5E-05	4.5E-05	1.0E-02	1.0E-04	8.6E-02	4.5E-06
26-Jun-12	30																							
3-Jul-12	31	8.5E-01	1.2E-04	1.4E-03	4.4E-01	2.5E-02	4.7E-06	4.2E-05	2.3E-03	4.2E-03	1.7E-01	9.7E-04	3.2E-01	4.7E-06	2.3E-02	6.9E-03	6.3E+00	9.3E-06	1.2E-04	4.7E-05	1.3E-02	9.8E-05	1.1E-01	9.3E-06
10-Jul-12	32																							
17-Jul-12	33	1.4E+00	2.3E-05	1.8E-03	4.5E-01	2.7E-02	4.6E-06	3.7E-05	2.6E-03	5.1E-03	1.6E-01	1.0E-03	4.6E-01	6.0E-05	2.8E-02	7.5E-03	7.6E+00	9.2E-06	5.1E-05	9.2E-05	1.8E-02	1.1E-04	1.7E-01	4.6E-06
24-Jul-12	34																							
31-Jul-12	35	1.3E+00	6.6E-04	1.4E-03	3.6E-01	2.1E-02	2.7E-05	1.8E-05	2.3E-03	4.1E-03	1.2E-01	7.0E-04	3.9E-01	4.5E-06	2.3E-02	6.0E-03	6.5E+00	9.0E-06	3.2E-05	4.5E-05	1.5E-02	1.3E-04	1.5E-01	4.5E-06
7-Aug-12	36																							
14-Aug-12	37	1.5E+00	4.1E-05	1.4E-03	3.5E-01	2.1E-02	4.6E-06	1.0E-03	2.6E-03	4.1E-03	1.1E-01	8.8E-04	4.6E-01	4.6E-06	3.2E-02	5.6E-03	7.9E+00	9.2E-06	8.7E-05	1.4E-04	1.7E-02	2.3E-04	2.0E-01	4.6E-06
21-Aug-12	38																							
28-Aug-12	39	1.5E+00	1.1E-04	1.4E-03	3.0E-01	1.8E-02	1.8E-05	9.2E-06	2.4E-03	6.0E-03	9.4E-02	9.1E-04	4.2E-01	4.6E-06	1.8E-02	5.1E-03	7.9E+00	9.2E-06	6.9E-05	4.6E-05	1.9E-02	9.2E-05	1.8E-01	4.6E-06
4-Sep-12	40																							
11-Sep-12	41	2.5E+00	5.2E-05	1.4E-03	3.2E-01	2.0E-02	4.8E-06	5.7E-05	3.0E-03	4.3E-03	1.1E-01	1.1E-03	8.1E-01	9.5E-06	3.3E-02	7.0E-03	1.1E+01	9.5E-06	1.9E-05	4.8E-05	1.8E-02	2.9E-05	2.3E-01	4.8E-06
18-Sep-12	42																							
25-Sep-12	43	2.2E+00	3.5E-05	1.5E-03	2.2E-01	1.4E-02	2.5E-05	4.2E-03	2.4E-03	1.3E-02	8.5E-02	8.7E-04	5.7E-01	5.0E-06	2.5E-02	5.5E-03	9.3E+00	9.9E-06	2.1E-04	5.0E-05	1.9E-02	1.2E-04	2.0E-01	9.9E-06
2-Oct-12	44																							
9-Oct-12	45	1.8E+00	2.5E-04	1.4E-03	1.7E-01	1.2E-02	4.8E-06	6.2E-05	1.9E-03	3.1E-02	7.4E-02	8.2E-04	5.1E-01	1.4E-05	1.9E-02	4.6E-03	8.0E+00	9.6E-06	9.6E-05	9.6E-05	1.5E-02	1.0E-04	1.8E-01	1.4E-05

HC12

Sample = 08-058

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
	No.																							
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
16-Oct-12	46																							
23-Oct-12	47																							
30-Oct-12	48																							
6-Nov-12	49	1.5E+00	3.3E-05	4.7E-04	9.6E-02	7.2E-03	4.7E-06	9.3E-06	1.3E-03	4.2E-03	6.2E-02	4.6E-04	3.2E-01	4.7E-06	1.9E-02	3.8E-03	5.3E+00	9.3E-06	1.5E-04	4.7E-05	9.3E-03	5.1E-05	9.6E-02	4.7E-06
13-Nov-12	50																							
20-Nov-12	51																							
27-Nov-12	52																							
4-Dec-12	53	1.6E+00	4.7E-05	8.5E-04	8.9E-02	6.7E-03	4.3E-06	1.3E-05	1.3E-03	5.5E-03	6.5E-02	4.3E-03	3.2E-01	8.5E-06	1.7E-02	3.8E-03	6.5E+00	8.5E-06	6.8E-05	4.3E-05	1.1E-02	4.7E-05	1.1E-01	4.3E-06
11-Dec-12	54																							
18-Dec-12	55																							
25-Dec-12	56																							
1-Jan-13	57	1.7E+00	2.0E-04	8.4E-04	7.7E-02	6.3E-03	4.2E-06	2.5E-05	1.3E-03	3.8E-03	4.7E-02	5.1E-04	3.4E-01	4.2E-06	1.7E-02	3.0E-03	7.3E+00	8.4E-06	7.6E-05	4.2E-05	1.4E-02	3.4E-05	1.2E-01	4.2E-06
8-Jan-13	58																							
15-Jan-13	59																							
22-Jan-13	60																							
29-Jan-13	61	2.9E+00	7.7E-05	9.1E-04	9.1E-02	7.6E-03	4.6E-06	9.1E-06	1.8E-03	1.4E-02	5.2E-02	6.4E-04	4.0E-01	9.1E-06	3.6E-02	3.8E-03	1.3E+01	9.1E-06	6.4E-05	4.6E-05	1.8E-02	5.5E-05	1.4E-01	4.6E-06
5-Feb-13	62																							
12-Feb-13	63																							
19-Feb-13	64																							
26-Feb-13	65	3.6E+00	5.0E-05	8.4E-04	8.1E-02	7.8E-03	4.2E-06	1.3E-05	1.6E-03	3.1E-02	4.7E-02	6.0E-04	4.9E-01	8.4E-06	2.5E-02	3.2E-03	1.5E+01	8.4E-06	2.1E-05	4.2E-05	2.0E-02	1.3E-05	1.4E-01	4.2E-06
5-Mar-13	66																							
12-Mar-13	67																							
19-Mar-13	68																							
26-Mar-13	69	4.0E+00	3.0E-05	8.6E-04	6.5E-02	7.9E-03	4.3E-06	8.6E-06	1.4E-03	1.1E-02	4.1E-02	3.7E-04	5.3E-01	8.6E-06	2.2E-02	2.8E-03	1.5E+01	8.6E-06	8.6E-06	4.3E-05	1.7E-02	1.3E-05	1.2E-01	4.3E-06
2-Apr-13	70																							
9-Apr-13	71																							
16-Apr-13	72																							
23-Apr-13	73	5.8E+00	1.7E-04	8.4E-04	7.3E-02	1.0E-02	4.2E-06	2.5E-05	1.6E-03	6.3E-03	3.9E-02	3.4E-04	6.0E-01	8.4E-06	1.7E-02	2.9E-03	1.9E+01	8.4E-06	1.7E-05	4.2E-05	1.8E-02	1.7E-05	1.5E-01	8.4E-06
30-Apr-13	74																							
7-May-13	75																							
14-May-13	76																							
21-May-13	77	4.9E+00	2.5E-05	8.3E-04	6.0E-02	9.3E-03	4.2E-06	2.9E-05	1.4E-03	7.1E-03	3.6E-02	3.1E-04	4.3E-01	8.3E-06	1.2E-02	2.4E-03	1.6E+01	8.3E-06	4.6E-05	4.2E-05	1.4E-02	5.4E-05	1.1E-01	8.3E-06
28-May-13	78																							
4-Jun-13	79																							
11-Jun-13	80																							
18-Jun-13	81	5.7E+00	2.4E-04	8.0E-04	6.2E-02	1.0E-02	4.0E-06	1.2E-05	1.3E-03	3.6E-03	4.6E-02	3.4E-04	4.0E-01	4.0E-06	2.4E-02	2.8E-03	1.6E+01	8.0E-06	2.4E-05	4.0E-05	1.3E-02	4.8E-05	9.5E-02	4.0E-06
25-Jun-13	82																							
2-Jul-13	83																							
9-Jul-13	84																							
16-Jul-13	85	5.7E+00	6.9E-05	9.9E-04	5.8E-02	9.5E-03	5.0E-06	5.0E-06	1.4E-03	4.5E-03	1.6E-01	3.8E-04	3.9E-01	9.9E-06	3.5E-02	3.4E-03	1.4E+01	9.9E-06	2.0E-05	5.0E-05	9.0E-03	5.0E-05	6.6E-02	5.0E-06
23-Jul-13	86																							
30-Jul-13	87																							
6-Aug-13	88																							
13-Aug-13	89	4.8E+00	4.1E-05	9.1E-04	5.3E-02	8.7E-03	9.1E-06	4.6E-06	1.2E-03	4.1E-03	7.5E-02	4.4E-04	4.3E-01	9.1E-06	1.8E-02	3.1E-03	1.1E+01	9.1E-06	5.0E-05	4.6E-05	8.6E-03	3.6E-05	4.7E-02	4.6E-06
20-Aug-13	90																							
27-Aug-13	91																							
3-Sep-13	92																							
10-Sep-13	93	3.4E+00	3.2E-04	8.2E-04	4.4E-02	6.8E-03	4.1E-06	8.2E-06	8.6E-04	3.7E-03	7.7E-02	4.7E-04	3.8E-01	8.2E-06	1.6E-02	4.2E-03	1.2E+01	8.2E-06	4.5E-05	4.1E-05	7.6E-03	3.7E-05	3.5E-02	4.1E-06
17-Sep-13	94																							
24-Sep-13	95																							

HC12

Sample = 08-058

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
	No.																							
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
1-Oct-13	96																							
8-Oct-13	97																							
15-Oct-13	98																							
22-Oct-13	99																							
29-Oct-13	100																							
5-Nov-13	101	2.0E+01	3.7E-05	2.7E-03	1.6E-01	3.4E-02	5.3E-06	5.3E-06	3.6E-03	1.2E-02	6.1E-02	1.5E-03	3.0E+00	6.4E-05	6.9E-02	1.1E-02	4.2E+01	1.1E-05	6.9E-05	1.1E-04	4.0E-02	1.5E-04	1.9E-01	1.6E-05
12-Nov-13	102																							
19-Nov-13	103																							
26-Nov-13	104																							
3-Dec-13	105	2.3E+00	1.4E-05	9.1E-04	3.6E-02	4.5E-03	4.6E-06	4.6E-06	7.7E-04	4.1E-03	7.6E-02	3.1E-04	3.0E-01	4.6E-06	1.4E-02	2.5E-03	8.2E+00	9.1E-06	3.2E-05	4.6E-05	6.5E-03	1.4E-05	3.7E-02	4.6E-06
10-Dec-13	106																							
17-Dec-13	107																							
24-Dec-13	108																							
31-Dec-13	109	1.4E+00	4.9E-05	8.2E-04	2.7E-02	3.1E-03	4.1E-06	4.1E-06	5.3E-04	3.7E-03	9.1E-02	3.0E-04	2.0E-01	4.1E-06	1.6E-02	1.6E-03	6.1E+00	8.2E-06	4.1E-05	4.1E-05	4.0E-03	1.6E-05	2.3E-02	4.1E-06
7-Jan-14	110																							
14-Jan-14	111																							
21-Jan-14	112																							
28-Jan-14	113	1.3E+00	8.5E-06	4.3E-04	2.8E-02	2.6E-03	4.3E-06	4.3E-06	5.5E-04	3.8E-03	9.5E-02	3.0E-04	2.3E-01	4.3E-06	2.1E-02	2.3E-03	7.2E+00	8.5E-06	8.5E-06	4.3E-05	4.5E-03	1.3E-05	1.9E-02	4.3E-06
4-Feb-14	114																							
11-Feb-14	115																							
18-Feb-14	116																							
25-Feb-14	117	1.8E+00	5.9E-05	9.0E-04	3.4E-02	3.5E-03	4.5E-06	4.5E-06	7.7E-04	4.1E-03	8.2E-02	4.6E-04	2.4E-01	9.0E-06	1.4E-02	2.9E-03	9.6E+00	4.5E-05	3.6E-05	4.5E-05	6.5E-03	5.9E-05	2.2E-02	4.5E-06
4-Mar-14	118	2.0E+00	1.7E-05	4.4E-04	4.0E-02	4.0E-03	4.4E-06	8.7E-06	4.4E-04	8.3E-03	6.2E-02	3.3E-04	1.2E-01	4.4E-06	3.0E-02	3.0E-03	8.3E+00	8.7E-06	6.0E-04	4.4E-05	5.0E-03	6.1E-05	1.8E-02	4.4E-06
11-Mar-14	119	1.7E+00	9.3E-06	4.7E-04	3.5E-02	3.4E-03	4.7E-06	1.4E-05	7.0E-04	1.6E-02	5.3E-02	3.2E-04	2.3E-01	4.7E-06	1.4E-02	2.1E-03	8.6E+00	9.3E-06	3.3E-03	4.7E-05	5.3E-03	1.4E-05	2.2E-02	4.7E-06
18-Mar-14	120	1.1E+00	5.8E-05	4.5E-04	2.2E-02	2.8E-03	4.5E-06	4.5E-06	4.0E-04	1.4E-02	3.7E-02	1.8E-04	1.3E-01	4.5E-06	1.8E-02	1.4E-03	5.2E+00	8.9E-06	2.4E-04	4.5E-05	3.3E-03	1.3E-05	1.6E-02	4.5E-06
25-Mar-14	121	8.6E-01	1.8E-05	4.6E-04	1.3E-02	1.6E-03	4.6E-06	1.4E-05	1.8E-04	1.0E-02	3.4E-02	1.7E-04	1.1E-01	4.6E-06	4.6E-03	1.0E-03	4.3E+00	9.2E-06	1.1E-04	4.6E-05	2.3E-03	1.4E-05	1.0E-02	4.6E-06
1-Apr-14	122																							
8-Apr-14	123																							
15-Apr-14	124																							
22-Apr-14	125	9.9E-01	3.5E-05	1.2E-04	6.2E-03	1.4E-03	4.4E-06	8.8E-06	2.6E-04	4.0E-03	2.7E-02	1.1E-04	8.8E-02	8.8E-07	2.6E-02	1.1E-03	3.3E+00	2.2E-06	7.0E-05	2.2E-05	1.4E-03	8.8E-06	8.8E-03	8.8E-04
29-Apr-14	126																							
6-May-14	127																							
13-May-14	128																							
20-May-14	129	9.4E-01	4.1E-05	9.9E-05	4.6E-03	1.3E-03	4.6E-06	4.1E-05	1.4E-04	4.1E-03	2.2E-02	1.1E-04	9.2E-02	4.6E-06	4.6E-03	9.7E-04	2.9E+00	2.3E-06	1.0E-03	2.3E-05	1.1E-03	4.6E-06	6.0E-03	9.2E-04
27-May-14	130																							
3-Jun-14	131																							
10-Jun-14	132																							
17-Jun-14	133	9.6E-01	1.9E-05	7.8E-05	3.3E-03	1.3E-03	4.8E-06	4.8E-06	1.4E-04	4.3E-03	2.3E-02	1.0E-04	1.0E-01	1.4E-06	9.5E-03	9.5E-04	3.0E+00	2.4E-06	3.6E-03	2.4E-05	1.0E-03	4.8E-06	6.2E-03	9.5E-04
24-Jun-14	134																							
1-Jul-14	135																							
8-Jul-14	136																							
15-Jul-14	137	9.9E-01	1.6E-05	6.1E-05	2.8E-03	1.3E-03	4.1E-06	4.1E-06	1.2E-04	4.1E-03	1.9E-02	1.0E-04	7.7E-02	1.6E-06	8.1E-03	8.1E-04	2.7E+00	2.0E-06	4.3E-04	2.0E-05	9.0E-04	4.1E-06	5.3E-03	8.1E-04
22-Jul-14	138																							
29-Jul-14	139																							
5-Aug-14	140																							
12-Aug-14	141	1.0E+00	1.4E-04	6.2E-05	2.7E-03	1.5E-03	4.5E-06	1.8E-05	1.4E-04	4.1E-03	1.9E-02	1.0E-04	8.1E-02	1.8E-06	1.4E-02	9.9E-04	3.0E+00	2.3E-06	4.2E-04	2.3E-05	1.0E-03	4.5E-06	6.3E-03	9.0E-04
19-Aug-14	142																							
26-Aug-14	143																							
2-Sep-14	144																							

T4
Sample = KM 2459-10 Comp 1 + KM2459-09 Comp 2 + KM2459-08 Comp 3

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Fluoride	Chloride	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output		umhos/cm	(pH 4.5)	(pH 8.3)					CaCO3												
						mgCaCO3/L	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
15-Dec-09	**0**	**750**	**460**	**7.97**	**1.7E+03**	**#N/A**	**4.4E+00**	**4.1E+01**	**1.1E+03**		**5.7E+01**	**9.8E+02**	**7.8E+00**	**7.9E-03**	**7.2E-03**	**9.3E-02**	**5.0E-05**	**3.0E-05**	**3.0E-01**	**8.0E-05**	**3.8E+02**	**5.0E-04**	**7.0E-05**	**3.2E-03**
22-Dec-09	1	500	525	7.28	5.5E+02	#N/A	3.5E+00	2.5E+01	3.2E+02		1.9E+01	3.0E+02	4.1E-01	3.8E-03	3.8E-02	2.8E-02	5.0E-05	3.0E-05	3.0E-01	4.0E-05	1.2E+02	5.0E-04	3.0E-05	4.6E-03
29-Dec-09	2	500	490	7.42	4.7E+02	#N/A	4.8E+00	4.1E+01	2.0E+02		3.8E+00	2.0E+02	2.4E-01	5.0E-03	2.2E-02	2.9E-02	5.0E-05	3.0E-05	3.0E-01	3.0E-05	7.6E+01	5.0E-04	3.0E-05	4.1E-03
5-Jan-10	3	500	495	7.15	4.5E+02	#N/A	7.3E+00	5.1E+01	2.0E+02		2.6E+00	2.1E+02	1.4E-01	5.3E-03	1.9E-02	3.2E-02	1.0E-05	5.0E-06	5.0E-02	3.3E-05	7.8E+01	1.0E-04	4.8E-05	2.4E-03
12-Jan-10	4	500	460	7.50	4.5E+02				2.1E+02															
19-Jan-10	5	500	445	7.75	8.1E+02	#N/A	6.0E+00	5.8E+01	4.3E+02		2.1E+00	4.3E+02	7.4E-02	4.0E-03	1.0E-02	2.2E-02	1.0E-05	5.0E-06	5.0E-02	7.9E-05	1.4E+02	1.0E-04	2.1E-04	2.4E-03
26-Jan-10	6	500	430	7.86	6.3E+02				3.8E+02															
2-Feb-10	7	500	455	7.88	4.4E+02	#N/A	3.6E+00	8.3E+01	2.5E+02		5.0E-01	2.8E+02	5.1E-02	4.2E-03	6.7E-03	2.5E-02	1.0E-05	5.0E-06	5.0E-02	5.0E-05	9.0E+01	1.0E-04	1.6E-04	2.8E-03
9-Feb-10	8	500	450	7.94	4.6E+02				1.8E+02															
16-Feb-10	9	500	460	7.59	3.7E+02	#N/A	4.6E+00	7.9E+01	1.5E+02		5.0E-01	2.0E+02	5.9E-02	4.0E-03	4.6E-03	3.3E-02	1.0E-05	5.0E-06	5.0E-02	1.9E-05	6.5E+01	1.0E-04	1.2E-04	1.2E-03
23-Feb-10	10	500	465	8.01	3.0E+02				1.2E+02															
2-Mar-10	11	500	435	8.03	3.4E+02	#N/A	1.9E+00	7.3E+01	1.2E+02		5.0E-01	1.8E+02	6.5E-02	4.0E-03	3.7E-03	4.1E-02	1.0E-05	5.0E-06	5.0E-02	1.8E-05	5.9E+01	1.0E-04	8.9E-05	1.8E-03
9-Mar-10	12	500	320	7.87	3.7E+02				1.4E+02															
16-Mar-10	13	500	500	7.61	2.9E+02	#N/A	4.4E+00	7.1E+01	8.9E+01		5.0E-01	1.7E+02	7.2E-02	3.4E-03	3.2E-03	4.1E-02	1.0E-05	5.0E-06	5.0E-02	5.2E-05	5.5E+01	1.0E-04	1.1E-04	2.1E-03
23-Mar-10	14	500	480	7.90	3.0E+02				1.0E+02															
30-Mar-10	15	500	450	7.94	2.8E+02	#N/A	2.3E+00	6.9E+01	9.6E+01		5.0E-01	1.4E+02	5.8E-02	4.2E-03	3.7E-03	4.8E-02	1.0E-05	5.0E-06	5.0E-02	6.7E-05	4.6E+01	1.0E-04	1.0E-04	2.1E-03
6-Apr-10	16	500	445	7.87	2.6E+02				6.3E+01															
13-Apr-10	17	500	450	8.00	2.5E+02	#N/A	3.2E+00	7.3E+01	6.4E+01		5.0E-01	1.2E+02	6.7E-02	4.8E-03	3.1E-03	5.7E-02	1.0E-05	5.0E-06	5.0E-02	3.6E-05	4.1E+01	1.0E-04	9.8E-05	2.4E-03
20-Apr-10	18	500	445	7.94	2.5E+02				7.4E+01															
27-Apr-10	19	500	465	7.95	2.3E+02	#N/A	2.9E+00	6.8E+01	6.0E+01		5.0E-01	1.2E+02	6.8E-02	4.8E-03	3.3E-03	6.3E-02	1.0E-05	5.0E-06	5.0E-02	3.9E-05	3.8E+01	1.0E-04	6.9E-05	2.3E-03
4-May-10	20	500	460	7.86	2.1E+02				5.8E+01															
11-May-10	21	500	445	8.03	2.2E+02	#N/A	2.2E+00	6.8E+01	4.7E+01		5.0E+00	1.0E+02	7.2E-03	5.4E-03	3.3E-03	7.5E-02	1.0E-05	5.0E-06	5.0E-02	2.2E-05	3.4E+01	1.0E-04	4.2E-05	8.2E-04
18-May-10	22	500	445	7.79	2.1E+02				4.1E+01															
25-May-10	23	500	455	7.80	1.9E+02	#N/A	4.5E+00	6.6E+01	2.5E+01		5.0E-01	1.0E+02	6.5E-02	4.7E-03	3.7E-03	7.6E-02	1.0E-05	5.0E-06	5.0E-02	2.4E-05	3.4E+01	1.0E-04	4.8E-05	1.5E-03
1-Jun-10	24	500	435	7.88	1.9E+02				1.8E+01															
8-Jun-10	25	500	480	7.95	2.0E+02	#N/A	2.9E+00	7.5E+01	2.1E+01		5.0E-01	1.0E+02	5.9E-02	4.5E-03	3.3E-03	9.1E-02	1.0E-05	5.0E-06	5.0E-02	2.6E-05	3.4E+01	9.0E-04	6.2E-05	2.0E-03
15-Jun-10	26	500	450	7.90	1.8E+02				1.9E+01															
22-Jun-10	27	500	430	8.07	1.7E+02	#N/A	1.8E+00	6.3E+01	2.7E+01		5.0E-01	8.0E+01	6.0E-02	4.2E-03	3.3E-03	8.4E-02	1.0E-05	5.0E-06	5.0E-02	2.4E-05	2.6E+01	1.0E-04	4.8E-05	2.2E-03
29-Jun-10	28	500	440	7.79	1.7E+02				2.2E+01															
6-Jul-10	29	500	470	7.89	1.6E+02	#N/A	2.4E+00	6.3E+01	1.8E+01		5.0E-01	8.3E+01	5.8E-02	3.3E-03	3.0E-03	8.7E-02	1.0E-05	5.0E-06	5.0E-02	1.4E-05	2.8E+01	1.0E-04	3.8E-05	1.9E-03
13-Jul-10	30	500	460	7.81	1.6E+02				1.1E+01															
20-Jul-10	31	500	465	7.85	1.6E+02	#N/A	3.7E+00	6.6E+01	1.8E+01		3.0E+00	7.6E+01	4.9E-02	3.0E-03	2.7E-03	9.8E-02	1.0E-05	5.0E-06	5.0E-02	2.5E-05	2.6E+01	1.0E-04	4.4E-05	2.0E-03
27-Jul-10	32	500	440	7.70	1.6E+02				2.1E+01															
3-Aug-10	33	500	440	7.99	1.5E+02	#N/A	3.1E+00	6.5E+01	1.6E+01		5.0E-01	7.6E+01	5.7E-02	3.0E-03	3.1E-03	1.1E-01	1.0E-05	5.0E-06	5.0E-02	1.3E-05	2.6E+01	1.0E-04	2.9E-05	1.3E-03
10-Aug-10	34	500	435	7.83	1.5E+02				2.3E+01															
17-Aug-10	35	500	430	8.01	1.5E+02	#N/A	2.8E+00	6.2E+01	1.5E+01		1.1E+00	7.1E+01	6.8E-02	3.0E-03	3.0E-03	1.1E-01	1.0E-05	5.0E-06	5.0E-02	2.2E-05	2.4E+01	1.0E-04	2.4E-05	1.6E-03
24-Aug-10	36	500	485	7.86	1.6E+02				3.9E+01															
31-Aug-10	37	500	500	8.00	1.4E+02	#N/A	5.8E+00	7.1E+01	2.0E+01		5.0E-01	7.1E+01	4.9E-02	2.8E-03	2.8E-03	1.2E-01	1.0E-05	5.0E-06	5.0E-02	1.7E-05	2.4E+01	1.0E-04	4.0E-05	1.1E-03
7-Sep-10	38	500	450	7.60	1.5E+02				2.0E+01															
14-Sep-10	39	500	435	7.74	1.4E+02	#N/A	3.2E+00	6.4E+01	1.8E+01		5.0E-01	7.3E+01	5.7E-02	2.4E-03	2.8E-03	1.1E-01	1.0E-05	5.0E-06	5.0E-02	3.3E-04	2.4E+01	1.0E-04	3.6E-05	2.8E-03
21-Sep-10	40	500	465	7.80	1.3E+02				2.0E+01															
28-Sep-10	41	500	425	7.89	1.5E+02	#N/A	2.5E+00	6.6E+01	2.4E+01		8.0E-01	7.5E+01	6.6E-02	2.7E-03	3.8E-03	1.3E-01	1.0E-05	5.0E-06	5.0E-02	1.7E-05	2.5E+01	1.0E-04	3.3E-05	1.3E-03
5-Oct-10	42	500	395	7.71	1.5E+02				2.5E+01															
12-Oct-10	43	500	490	7.87	1.7E+02	#N/A	2.8E+00	7.4E+01	2.3E+01		5.0E-01	8.5E+01	6.4E-02	2.5E-03	2.8E-03	1.6E-01	1.0E-05	5.0E-06	5.0E-02	1.5E-05	2.8E+01	1.0E-04	2.9E-05	1.3E-03
19-Oct-10	44	500	415	7.73	1.6E+02				2.2E+01															
26-Oct-10	45	500	485	7.82	1.5E+02	#N/A	2.7E+00	6.6E+01	1.9E+01		5.0E-01	7.3E+01	5.7E-02	1.8E-03	2.4E-03	1.5E-01	1.0E-05	5.0E-06	5.0E-02	8.0E-06	2.4E+01	1.0E-04	4.1E-05	8.7E-04
2-Nov-10	46	500	440	7.81	1.5E+02																			
9-Nov-10	47	500	485	7.93	1.8E+02																			
16-Nov-10	48	500	385	7.93	1.4E+02																			
23-Nov-10	49	500	515	7.74	1.5E+02	#N/A	3.0E+00	6.8E+01	1.9E+01		5.0E-01	7.2E+01	5.6E-02	1.9E-03	2.4E-03	1.8E-01	1.0E-05	5.0E-06	5.0E-02	3.5E-05	2.4E+01	1.0E-04	3.5E-05	1.3E-03
30-Nov-10	50	500	445	7.71	1.4E+02																			
7-Dec-10	51	500	415	7.70	1.5E+02																			
14-Dec-10	52	500	425	7.58	1.4E+02																			
21-Dec-10	53	500	395	7.71	1.5E+02	#N/A	5.5E+00	6.4E+01	2.0E+01		5.0E-01	6.6E+01	5.4E-02	1.7E-03	2.5E-03	1.9E-01	1.0E-05	5.0E-06	5.0E-02	1.2E-05	2.2E+01	1.0E-04	3.3E-05	1.2E-03
28-Dec-10	54	500	480	7.53	1.2E+02																			
4-Jan-11	55	500	435	7.71	1.3E+02																			
11-Jan-11	56	500	410	7.64	1.3E+02																			
18-Jan-11	57	500	410	7.76	1.4E+02	#N/A	3.3E+00	5.9E+01	1.9E+01		5.0E-01	7.1E+01	6.1E-02	1.7E-03	2.5E-03	1.7E-01	1.0E-05	5.0E-06	5.0E-02	1.4E-05	2.4E+01	1.0E-04	5.4E-05	1.2E-03
25-Jan-11	58	500	390	7.62	1.4E+02																			
1-Feb-11	59	500	435	7.81	1.4E+02																			
8-Feb-11	60	500	430	7.75	1.3E+02																			
15-Feb-11	61	500	400	7.76	1.4E+02	#N/A	3.1E+00	5.9E+01	1.2E+01		1.8E+00	6.0E+01	5.2E-02	1.5E-03	2.2E-03	1.6E-01	1.0E-05	5.0E-06	5.0E-02	1.6E-05	2.0E+01	1.0E-04	4.6E-05	1.2E-03
22-Feb-11	62	500	465	7.74	1.5E+02																			
1-Mar-11	63	500	445	7.86	1.5E+02																			
8-Mar-11	64	500	435	7.66	1.5E+02																			
15-Mar-11	65	500	425	7.84	1.4E+02	#N/A	2.8E+00	6.2E+01	1.2E+01		5.0E-01	7.4E+01	5.3E-02	1.4E-03	2.1E-03	1.8E-01	1.0E-05	5.0E-06	5.0E-02	2.7E-05	2.4E+01	1.0E-04	4.0E-05	1.5E-03
22-Mar-11	66	500	450	7.68	1.4E+02																			

T4
Sample = KM 2459-10 Comp 1 + KM2459-09 Comp 2 + KM2459-08 Comp 3

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Fluoride	Chloride	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output		umhos/cm	(pH 4.5)	(pH 8.3)					CaCO3												
						mgCaCO3/L	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
29-Mar-11	67	500	465	7.91	1.5E+02																			
5-Apr-11	68	500	430	7.62	1.5E+02																			
12-Apr-11	69	500	435	7.73	1.4E+02	#N/A	3.8E+00	6.0E+01	1.6E+01		1.4E+00	6.6E+01	5.1E-02	1.2E-03	2.0E-03	1.7E-01	1.0E-05	5.0E-06	5.0E-02	1.4E-05	2.1E+01	1.0E-04	2.9E-05	2.7E-03
19-Apr-11	70	500	451	7.60	1.4E+02																			
26-Apr-11	71	500	410	7.87	1.5E+02																			
3-May-11	72	500	450	7.73	1.4E+02																			
10-May-11	73	500	435	7.84	1.4E+02	#N/A	3.6E+00	6.3E+01	1.7E+01		5.0E-01	6.6E+01	5.1E-02	1.2E-03	2.1E-03	1.7E-01	1.0E-05	2.7E-05	5.0E-02	5.0E-06	2.1E+01	1.0E-04	2.2E-05	1.6E-03
17-May-11	74	500	415	7.85	1.4E+02																			
24-May-11	75	500	395	7.76	1.4E+02																			
31-May-11	76	500	335	7.66	1.4E+02																			
7-Jun-11	77	500	380	7.91	1.5E+02	#N/A	2.7E+00	6.0E+01	1.7E+01		6.0E-01	7.0E+01	5.5E-02	1.3E-03	2.2E-03	1.7E-01	1.0E-05	5.0E-06	5.0E-02	5.7E-05	2.3E+01	3.0E-04	3.9E-05	2.0E-03
14-Jun-11	78	500	400	7.83	1.4E+02																			
21-Jun-11	79	500	450	8.05	1.5E+02																			
28-Jun-11	80	500	415	7.92	1.5E+02																			
5-Jul-11	81	500	415	7.78	1.4E+02	#N/A	4.4E+00	6.3E+01	2.0E+01		5.0E-01	7.0E+01	5.4E-02	1.2E-03	2.6E-03	1.8E-01	1.0E-05	5.0E-06	5.0E-02	1.1E-05	2.2E+01	1.0E-04	8.9E-05	1.5E-03
12-Jul-11	82	500	425	7.71	1.4E+02																			
19-Jul-11	83	500	430	7.81	1.5E+02																			
26-Jul-11	84	500	425	7.76	1.5E+02																			
2-Aug-11	85	500	405	7.91	1.3E+02	#N/A	5.6E+00	5.6E+01	1.8E+01	1.1E-01	1.3E+00	6.3E+01	5.1E-02	1.0E-03	1.9E-03	1.7E-01	1.0E-05	5.0E-06	5.0E-02	2.1E-05	2.0E+01	1.0E-04	3.0E-05	1.3E-03
9-Aug-11	86	500	440	7.74	1.4E+02																			
16-Aug-11	87	500	440	7.85	1.4E+02																			
23-Aug-11	88	500	415	7.67	1.4E+02																			
30-Aug-11	89	500	435	7.83	1.4E+02	#N/A	6.2E+00	5.9E+01	2.1E+01	1.2E-01	5.0E-01	6.7E+01	5.2E-02	1.1E-03	2.0E-03	1.8E-01	1.0E-05	5.0E-06	5.0E-02	7.0E-06	2.1E+01	1.0E-04	4.1E-05	1.0E-03
6-Sep-11	90	500	415	7.61	1.4E+02																			
13-Sep-11	91	500	405	7.87	1.3E+02																			
20-Sep-11	92	500	440	7.74	1.4E+02																			
27-Sep-11	93	500	440	7.76	1.4E+02	#N/A	6.2E+00	5.9E+01	2.3E+01	1.1E-01	8.0E-01	6.6E+01	4.8E-02	9.7E-04	2.0E-03	1.7E-01	2.0E-05	5.0E-06	5.0E-02	5.5E-05	2.0E+01	1.0E-04	2.9E-05	8.5E-04
4-Oct-11	94	500	455	7.77	1.4E+02																			
11-Oct-11	95	500	420	7.82	1.4E+02																			
18-Oct-11	96	500	420	7.78	1.4E+02																			
25-Oct-11	97	500	405	7.71	1.3E+02	#N/A	4.2E+00	4.9E+01	2.0E+01	1.1E-01	5.0E-01	6.0E+01	4.9E-02	9.2E-04	1.9E-03	1.6E-01	1.0E-05	5.0E-06	5.0E-02	1.3E-05	1.8E+01	1.0E-04	3.3E-05	1.3E-03
1-Nov-11	98	500	455	7.75	1.4E+02																			
8-Nov-11	99	500	445	7.76	1.4E+02																			
15-Nov-11	100	500	415	7.69	1.4E+02																			
22-Nov-11	101	500	445	7.80	1.4E+02	#N/A	5.9E+00	6.1E+01	1.8E+01	1.0E-01	5.0E-01	6.9E+01	4.5E-02	9.1E-04	2.0E-03	1.9E-01	1.0E-05	5.0E-06	5.0E-02	6.2E-05	2.1E+01	1.0E-04	2.6E-05	1.5E-03
29-Nov-11	102	500	425	7.77	1.4E+02																			
6-Dec-11	103	500	495	7.57	1.4E+02																			
13-Dec-11	104	500	475	7.78	1.5E+02																			
20-Dec-11	105	500	495	7.83	1.4E+02	#N/A	5.6E+00	6.1E+01	1.8E+01	1.2E-01	5.0E-01	6.7E+01	6.8E-02	9.3E-04	1.7E-03	1.9E-01	1.0E-05	5.0E-06	5.0E-02	7.0E-06	2.0E+01	1.0E-04	2.4E-05	9.2E-04
27-Dec-11	106	500	480	7.78	1.4E+02																			
3-Jan-12	107	500	415	7.68	1.3E+02																			
10-Jan-12	108	500	475	7.70	1.5E+02																			
17-Jan-12	109	500	495	7.72	1.4E+02	#N/A	3.0E+00	6.8E+01	2.2E+01	1.1E-01	5.0E-01	6.7E+01	4.9E-02	1.0E-03	1.7E-03	1.8E-01	1.0E-05	5.0E-06	5.0E-02	5.0E-06	1.9E+01	1.0E-04	2.6E-05	1.2E-03
24-Jan-12	110	500	480	7.76	1.5E+02																			
31-Jan-12	111	500	505	7.58	1.5E+02																			
7-Feb-12	112	500	430	7.75	1.6E+02																			
14-Feb-12	113	500	435	7.81	1.5E+02	#N/A	5.0E+00	6.0E+01	3.4E+01	1.1E-01	1.0E+00	7.0E+01	4.4E-02	1.2E-03	2.0E-03	2.0E-01	1.0E-05	5.0E-06	5.0E-02	5.0E-06	2.0E+01	1.0E-04	1.7E-05	9.3E-04
21-Feb-12	114	500	440	7.73	1.6E+02																			
28-Feb-12	115	500	445	7.62	1.5E+02																			
6-Mar-12	116	500	440	7.67	1.6E+02																			
13-Mar-12	117	500	410	7.74	1.4E+02	#N/A	3.6E+00	5.3E+01	2.1E+01	1.0E-01	5.0E-01	6.6E+01	4.0E-02	1.0E-03	1.5E-03	1.6E-01	1.0E-05	5.0E-06	5.0E-02	1.2E-05	1.9E+01	1.0E-04	2.4E-05	1.4E-03
20-Mar-12	118	500	450	7.72	1.6E+02																			
27-Mar-12	119	500	440	7.63	1.6E+02																			
3-Apr-12	120	500	450	7.74	1.5E+02																			
10-Apr-12	121	500	425	7.74	1.5E+02	#N/A	3.0E+00	5.4E+01	3.4E+01	5.0E-01	1.1E-01	7.5E+01	4.3E-02	1.2E-03	1.4E-03	1.8E-01	1.0E-05	5.0E-06	5.0E-02	1.9E-05	2.1E+01	1.0E-04	1.5E-05	8.3E-04
17-Apr-12	122	500	435	7.77	1.6E+02																			
24-Apr-12	123	500	420	7.68	1.5E+02																			
1-May-12	124	500	475	7.62	1.6E+02																			
8-May-12	125	500	445	7.70	1.4E+02	#N/A	3.3E+00	5.3E+01	2.5E+01	8.9E-02	5.0E-01	6.3E+01	4.3E-02	9.7E-04	1.5E-03	1.5E-01	1.0E-05	5.0E-06	5.0E-02	3.6E-05	1.7E+01	1.0E-04	1.4E-05	9.5E-04
15-May-12	126	500	480	7.85	1.6E+02																			
22-May-12	127	500	450	7.65	1.5E+02																			
29-May-12	128	500	510	7.75	1.5E+02																			
5-Jun-12	129	500	475	7.62	1.4E+02	#N/A	3.6E+00	5.2E+01	2.3E+01	9.4E-02	5.2E-01	6.3E+01	5.1E-02	8.8E-04	1.5E-03	1.6E-01	1.0E-05	5.0E-06	5.0E-02	1.4E-05	1.6E+01	1.0E-04	1.5E-05	9.0E-04
12-Jun-12	130	500	460	7.74	1.6E+02																			
19-Jun-12	131	500	480	7.65	1.5E+02																			
26-Jun-12	132	500	455	7.84	1.7E+02																			
3-Jul-12	133	500	475	7.52	1.6E+02	#N/A	8.4E+00	6.1E+01	2.3E+01	1.1E-01	5.0E-01	7.2E+01	3.7E-02	9.6E-04	1.5E-03	1.6E-01	1.0E-05	5.0E-06	5.0E-02	1.1E-05	1.8E+01	1.0E-04	1.7E-05	1.4E-03

T4
Sample = KM 2459-10 Comp 1 + KM2459-09 Comp 2 + KM2459-08 Comp 3

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Fluoride	Chloride	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output		umhos/cm	(pH 4.5)	(pH 8.3)					CaCO3												
						mgCaCO3/L	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
10-Jul-12	134	500	470	7.70	1.7E+02																			
17-Jul-12	135	500	440	7.66	1.4E+02																			
24-Jul-12	136	500	495	7.73	1.6E+02																			
31-Jul-12	137	500	470	7.75	1.4E+02	#N/A	3.1E+00	5.3E+01	2.0E+01	1.1E-01	5.0E-01	7.1E+01	7.9E-02	8.5E-04	1.7E-03	1.5E-01	1.0E-05	5.0E-06	5.0E-02	9.0E-06	1.8E+01	1.0E-04	1.5E-05	7.6E-04
7-Aug-12	138	500	455	7.75	1.6E+02																			
14-Aug-12	139	500	465	7.61	1.4E+02																			
21-Aug-12	140	500	475	7.60	1.6E+02																			
28-Aug-12	141	500	455	7.60	1.3E+02	#N/A	3.9E+00	4.5E+01	2.6E+01	9.7E-02	5.0E-01	6.1E+01	8.3E-02	7.3E-04	1.4E-03	1.2E-01	1.0E-05	5.0E-06	5.0E-02	1.7E-05	1.5E+01	1.0E-04	2.6E-05	1.1E-03
4-Sep-12	142	500	460	7.58	1.5E+02																			
11-Sep-12	143	500	475	7.55	1.5E+02																			
18-Sep-12	144	500	435	7.68	1.8E+02																			
25-Sep-12	145	500	520	7.64	1.9E+02	#N/A	3.5E+00	5.3E+01	5.1E+01	9.8E-02	5.0E-01	9.2E+01	3.0E-02	8.0E-04	1.3E-03	1.3E-01	1.0E-05	5.0E-06	5.0E-02	7.0E-06	2.3E+01	1.9E-04	1.7E-05	1.1E-03
2-Oct-12	146	500	460	7.60	1.5E+02																			
9-Oct-12	147	500	440	7.39	1.9E+02																			
16-Oct-12	148	500	465	7.53	1.9E+02																			
23-Oct-12	149	500	460	7.56	1.8E+02	#N/A	3.2E+00	4.6E+01	5.4E+01	6.3E-01	5.0E-01	8.4E+01	3.2E-02	7.2E-04	1.3E-03	8.5E-02	1.0E-05	5.0E-06	5.0E-02	1.4E-05	2.0E+01	1.0E-04	1.9E-05	1.3E-03
30-Oct-12	150	500	450	7.61	1.6E+02																			
6-Nov-12	151	500	435	7.51	1.4E+02																			
13-Nov-12	152	500	460	7.47	1.6E+02																			
20-Nov-12	153	500	455	7.56	1.5E+02	#N/A	8.5E+00	4.8E+01	3.5E+01	9.6E-02	5.0E-01	7.4E+01	4.0E-02	6.5E-04	1.2E-03	8.1E-02	1.0E-05	5.0E-06	5.0E-02	8.0E-06	1.8E+01	1.0E-04	1.8E-05	9.6E-04
27-Nov-12	154	500	470	7.41	1.7E+02																			
4-Dec-12	155	500	485	7.56	1.4E+02																			
11-Dec-12	156	500	420	7.42	1.5E+02																			
18-Dec-12	157	500	415	7.49	1.5E+02	#N/A	3.5E+00	4.4E+01	4.0E+01	1.2E-01	5.0E-01	7.5E+01	3.5E-02	6.3E-04	1.3E-03	8.5E-02	1.0E-05	5.0E-06	5.0E-02	8.0E-06	1.8E+01	1.0E-04	1.0E-05	6.3E-04
25-Dec-12	158	500	435	7.41	1.7E+02																			
1-Jan-13	159	500	445	7.56	1.5E+02																			
8-Jan-13	160	500	455	7.46	1.6E+02																			
15-Jan-13	161	500	420	7.49	1.4E+02	#N/A	3.5E+00	4.8E+01	4.1E+01	9.6E-02	6.3E-01	7.5E+01	3.4E-02	5.9E-04	1.2E-03	8.3E-02	1.0E-05	5.0E-06	5.0E-02	8.0E-06	1.7E+01	1.0E-04	1.7E-05	1.7E-03
22-Jan-13	162	500	440	7.45	1.4E+02																			
29-Jan-13	163	500	475	7.59	1.8E+02																			
5-Feb-13	164	500	465	7.57	1.9E+02																			
12-Feb-13	165	500	450	7.52	1.9E+02	#N/A	6.2E+00	4.7E+01	5.7E+01	1.1E-01	5.6E-01	9.3E+01	2.8E-02	6.5E-04	1.1E-03	9.4E-02	1.0E-05	5.0E-06	5.0E-02	1.0E-05	2.2E+01	1.0E-04	3.8E-05	1.3E-03
19-Feb-13	166	500	480	7.64	1.8E+02																			
26-Feb-13	167	500	440	7.41	1.9E+02																			
5-Mar-13	168	500	420	7.53	1.6E+02																			
12-Mar-13	169	500	455	7.46	2.2E+02	#N/A	5.9E+00	4.6E+01	4.8E+01	1.1E-01	7.0E-01	9.0E+01	2.8E-02	5.7E-04	1.1E-03	9.3E-02	1.0E-05	5.0E-06	5.0E-02	1.2E-05	2.1E+01	1.0E-04	2.5E-05	7.6E-04
19-Mar-13	170	500	425	7.58	1.7E+02																			
26-Mar-13	171	500	460	7.49	1.9E+02																			
2-Apr-13	172	500	435	7.55	1.7E+02																			
9-Apr-13	173	500	450	7.58	2.2E+02	#N/A	6.0E+00	4.5E+01	5.4E+01	1.1E-01	5.0E-01	8.6E+01	2.6E-02	5.4E-04	1.0E-03	8.8E-02	1.0E-05	8.0E-06	5.0E-02	1.1E-05	2.0E+01	1.0E-04	2.2E-05	7.7E-04
16-Apr-13	174	500	440	7.55	1.8E+02																			
23-Apr-13	175	500	425	7.42	2.0E+02																			
30-Apr-13	176	500	440	7.58	1.8E+02																			
7-May-13	177	500	465	7.78	2.1E+02	#N/A	9.0E+00	4.6E+01	5.6E+01	1.0E-01	5.0E-01	9.7E+01	2.5E-02	5.1E-04	9.7E-04	7.9E-02	1.0E-05	5.0E-06	5.0E-02	1.6E-05	2.2E+01	1.0E-04	2.1E-05	9.9E-04
14-May-13	178	500	440	7.64	1.8E+02																			
21-May-13	179	500	435	7.51	2.0E+02																			
28-May-13	180	500	460	7.51	1.8E+02																			
4-Jun-13	181	500	450	7.58	1.9E+02	#N/A	5.2E+00	4.3E+01	5.2E+01	1.2E-01	5.0E-01	8.6E+01	2.5E-02	5.2E-04	9.8E-04	7.4E-02	1.0E-05	5.0E-06	5.0E-02	1.6E-05	1.9E+01	1.6E-04	2.3E-05	6.9E-04
11-Jun-13	182	500	445	7.51	1.8E+02																			
18-Jun-13	183	500	435	7.41	1.8E+02																			
25-Jun-13	184	500	440	7.53	1.7E+02																			
2-Jul-13	185	500	420	7.55	1.9E+02	#N/A	8.5E+00	4.9E+01	5.2E+01	1.1E-01	5.0E-01	8.0E+01	2.6E-02	5.1E-04	9.6E-04	6.9E-02	1.0E-05	5.0E-06	5.0E-02	1.1E-05	1.8E+01	1.0E-04	2.1E-05	6.0E-04
9-Jul-13	186	500	405	7.61	1.7E+02																			
16-Jul-13	187	500	430	7.52	1.9E+02																			
23-Jul-13	188	500	445	7.52	1.5E+02																			
30-Jul-13	189	500	435	7.63	1.8E+02	#N/A	5.0E+00	3.9E+01	4.8E+01	1.2E-01	5.0E-01	7.8E+01	2.8E-02	4.6E-04	9.7E-04	7.3E-02	1.0E-05	5.0E-06	5.0E-02	9.0E-06	1.8E+01	1.0E-04	2.8E-05	7.8E-04
6-Aug-13	190	500	425	7.58	1.7E+02																			
13-Aug-13	191	500	445	7.52	1.9E+02																			
20-Aug-13	192	500	430	7.52	1.9E+02																			
27-Aug-13	193	500	425	7.73	2.0E+02	#N/A	3.5E+00	4.1E+01	5.2E+01	1.1E-01	5.0E-01	9.0E+01	2.5E-02	4.4E-04	9.3E-04	7.7E-02	1.0E-05	5.0E-06	5.0E-02	1.1E-05	2.1E+01	1.0E-04	3.0E-05	7.4E-04
3-Sep-13	194	500	440	7.55	1.8E+02																			

T4
Sample = KM 2459-10 Comp 1 + KM2459-09 Comp 2 + KM2459-08 Comp 3

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Fluoride	Chloride	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output		umhos/cm	(pH 4.5)	(pH 8.3)					CaCO3												
						mgCaCO3/L	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
10-Sep-13	195	500	445	7.47	2.0E+02																			
17-Sep-13	196	500	410	7.61	1.8E+02																			
24-Sep-13	197	500	435	7.80	2.0E+02	#N/A	2.5E+00	3.7E+01	5.2E+01	1.2E-01	5.0E-01	8.9E+01	2.9E-02	4.5E-04	9.6E-04	7.1E-02	1.0E-05	5.0E-06	5.0E-02	5.0E-06	2.1E+01	1.0E-04	1.9E-05	8.4E-04
1-Oct-13	198	500	430	7.63	1.8E+02																			
8-Oct-13	199	500	425	7.57	2.0E+02																			
15-Oct-13	200	500	405	7.54	1.8E+02																			
22-Oct-13	201	500	435	7.82	2.0E+02	#N/A	3.5E+00	3.7E+01	5.8E+01	1.1E-01	6.0E-01	9.3E+01	2.5E-02	4.1E-04	8.6E-04	7.0E-02	1.0E-05	5.0E-06	5.0E-02	9.0E-06	2.1E+01	1.0E-04	2.2E-05	1.2E-03
29-Oct-13	202	500	430	7.65	2.0E+02																			
5-Nov-13	203	500	460	7.66	1.9E+02																			
12-Nov-13	204	500	435	7.62	2.4E+02																			
19-Nov-13	205	500	450	7.81	2.1E+02	#N/A	1.8E+00	3.9E+01	4.8E+01	9.3E-02	5.0E-01	8.8E+01	3.3E-02	3.8E-04	8.0E-04	6.9E-02	1.0E-05	5.0E-06	5.0E-02	9.0E-06	2.0E+01	1.0E-04	2.5E-05	7.5E-04
26-Nov-13	206	500	440	7.81	2.1E+02																			
3-Dec-13	207	500	450	7.91	2.0E+02																			
10-Dec-13	208	500	420	7.77	2.0E+02																			
17-Dec-13	209	500	435	7.91	2.2E+02	#N/A	2.4E+00	3.7E+01	5.7E+01	1.2E-01	5.0E-01	9.8E+01	2.4E-02	3.9E-04	8.4E-04	6.5E-02	1.0E-05	5.0E-06	5.0E-02	1.4E-05	2.2E+01	1.0E-04	2.8E-05	8.6E-04
24-Dec-13	210	500	420	7.62	2.2E+02																			
31-Dec-13	211	500	405	7.71	2.1E+02																			
7-Jan-14	212	500	435	7.72	2.3E+02																			
14-Jan-14	213	500	435	7.81	2.5E+02	#N/A	2.4E+00	3.8E+01	5.8E+01	9.7E-02	5.0E-01	1.0E+02	2.4E-02	3.8E-04	1.3E-03	6.7E-02	1.0E-05	5.0E-06	5.0E-02	9.0E-06	2.3E+01	1.0E-04	2.5E-05	8.3E-04
21-Jan-14	214	500	455	7.73	2.4E+02																			
28-Jan-14	215	500	415	7.72	2.0E+02																			
4-Feb-14	216	500	430	7.76	2.1E+02																			
11-Feb-14	217	500	475	7.87	2.4E+02	#N/A	3.6E+00	5.0E+01	5.7E+01	1.1E-01	5.0E-01	1.0E+02	1.7E-02	3.8E-04	7.3E-04	7.0E-02	1.0E-05	5.0E-06	5.0E-02	1.0E-05	2.3E+01	1.0E-04	2.9E-05	6.9E-04
18-Feb-14	218	500	440	7.72	2.1E+02																			
25-Feb-14	219	500	420	7.64	2.1E+02	#N/A	4.3E+00	3.8E+01	6.0E+01	1.2E-01	5.0E-01	1.0E+02	1.8E-02	3.4E-04	7.3E-04	6.2E-02	1.0E-05	5.0E-06	5.0E-02	1.2E-05	2.3E+01	1.0E-04	2.4E-05	6.4E-04
4-Mar-14	220	500	445	7.65	1.7E+02	#N/A	4.9E+00	4.0E+01	3.3E+01	7.8E-02	5.0E-01	7.9E+01	7.4E-03	2.2E-04	4.6E-04	4.2E-02	1.0E-05	5.0E-06	5.0E-02	6.0E-06	1.8E+01	4.9E-04	2.2E-05	5.9E-04
11-Mar-14	221	500	475	7.71	1.3E+02	#N/A	1.8E+00	4.0E+01	1.9E+01	1.0E-01	5.0E-01	5.4E+01	1.1E-02	2.2E-04	4.8E-04	3.2E-02	1.0E-05	5.0E-06	5.0E-02	5.0E-06	1.2E+01	1.0E-04	1.3E-05	3.3E-04
18-Mar-14	222	500	480	7.66	9.7E+01	#N/A	6.0E+00	3.5E+01	1.0E+01	9.3E-02	5.0E-01	4.5E+01	1.3E-02	2.1E-04	4.8E-04	2.9E-02	1.0E-05	5.0E-06	5.0E-02	5.0E-06	1.0E+01	1.0E-04	1.4E-05	6.6E-04
25-Mar-14	223	500	450	7.71	9.9E+01	#N/A	2.6E+00	3.6E+01	1.2E+01	8.7E-02	5.0E-01	4.8E+01	1.0E-02	2.2E-04	4.8E-04	3.6E-02	1.0E-05	5.0E-06	5.0E-02	5.0E-06	1.1E+01	1.0E-04	1.1E-05	3.9E-04
1-Apr-14	224	500	460	7.70	9.4E+01																			
8-Apr-14	225	500	520	7.61	1.1E+02																			
15-Apr-14	226	500	475	7.61	9.2E+01																			
22-Apr-14	227	500	470	7.51	9.2E+01	#N/A	3.8E+00	3.4E+01	1.0E+01	8.7E-02	5.0E-01	4.4E+01	1.3E-02	1.9E-04	5.4E-04	4.7E-02	1.0E-05	5.0E-06	5.0E-02	5.0E-06	1.0E+01	1.0E-04	1.0E-05	4.2E-04
29-Apr-14	228	500	455	7.75	8.5E+01																			
6-May-14	229	500	485	7.81	1.0E+02																			
13-May-14	230	500	470	7.65	8.0E+01																			
20-May-14	231	500	495	7.69	7.8E+01	#N/A	6.4E+00	3.1E+01	8.0E+00	7.8E-02	5.0E-01	4.3E+01	1.1E-02	2.0E-04	7.8E-04	5.6E-02	1.0E-05	5.0E-06	5.0E-02	5.0E-06	9.7E+00	1.0E-04	2.0E-05	6.4E-04
27-May-14	232	500	475	7.60	7.5E+01																			
3-Jun-14	233	500	470	7.72	7.7E+01																			
10-Jun-14	234	500	480	7.66	8.0E+01																			
17-Jun-14	235	500	460	7.60	8.5E+01	#N/A	5.9E+00	3.3E+01	1.2E+01	8.1E-02	5.0E-01	4.6E+01	9.6E-03	2.0E-04	5.0E-04	6.9E-02	1.0E-05	5.0E-06	5.0E-02	5.0E-06	1.0E+01	1.0E-04	1.2E-05	2.1E-04
24-Jun-14	236	500	465	7.94	8.9E+01																			
1-Jul-14	237	500	440	7.73	8.8E+01																			
1-Jul-14	237	500	440	7.73	8.8E+01																			
8-Jul-14	238	500	470	7.65	9.0E+01																			
15-Jul-14	239	500	460	7.61	9.1E+01	#N/A	2.4E+00	3.3E+01	1.0E+01	7.2E-02	5.0E-01	4.8E+01	1.7E-02	1.9E-04	5.1E-04	7.3E-02	1.0E-05	5.0E-06	5.0E-02	6.0E-06	1.0E+01	1.0E-04	1.5E-05	3.9E-04
22-Jul-14	240	500	475	7.62	9.5E+01																			
29-Jul-14	241	500	475	7.81	9.3E+01																			
5-Aug-14	242	500	485	7.52	8.2E+01																			
12-Aug-14	243	500	485	7.57	8.2E+01	#N/A	4.9E+00	3.2E+01	7.0E+00	8.1E-02	5.0E-01	4.2E+01	1.3E-02	1.7E-04	5.9E-04	7.0E-02	1.0E-05	5.0E-06	2.0E-02	5.0E-06	9.5E+00	1.0E-04	2.0E-05	1.8E-04
19-Aug-14	244	500	480	7.58	8.7E+01																			
26-Aug-14	245	500	480	7.65	8.3E+01																			
2-Sep-14	246	500	465																					

T4
Sample = KM 2459-10 Comp 1 + KM2459-09 Comp 2 + KM2459-08 Comp 3

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Major	Major	Diff	Diff
	No.																								Anions	Cations		(%)
		mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L				
15-Dec-09	**0**	**1.1E-02**	**1.2E-04**	**3.0E-03**	**5.6E+00**	**9.6E-03**	**1.4E-01**	**3.1E-02**	**9.0E-04**	**4.0E-01**	**6.5E+01**	**7.6E-03**	**8.8E-01**	**1.4E-04**	**1.7E+01**	**1.1E+00**	**3.2E+02**	**1.1E-04**	**7.8E-03**	**3.0E-03**	**9.5E-03**	**1.0E-03**	**1.6E-03**	**5.0E-04**	**2.6E+01**	**2.3E+01**	**-3.1E+00**	**-6.3%**
22-Dec-09	1	5.0E-03	8.0E-05	3.0E-03	2.1E+00	1.2E-02	9.0E-02	1.3E-02	2.6E-03	1.6E-01	2.2E+01	1.4E-03	4.2E+00	1.0E-04	4.3E+00	3.8E-01	1.1E+02	6.0E-05	6.6E-03	3.0E-03	2.8E-03	1.0E-03	1.9E-03	5.0E-04	7.7E+00	6.7E+00	-9.9E-01	-6.9%
29-Dec-09	2	5.0E-03	3.0E-05	3.0E-03	2.3E+00	1.1E-02	5.0E-02	7.8E-03	1.3E-03	8.3E-02	1.5E+01	1.1E-03	3.0E+00	3.0E-05	1.8E+00	2.6E-01	6.5E+01	4.0E-05	7.7E-03	3.0E-03	2.9E-03	1.0E-03	8.0E-04	5.0E-04	5.1E+00	4.5E+00	-6.5E-01	-6.8%
5-Jan-10	3	4.0E-03	5.7E-05	5.0E-04	4.0E+00	1.8E-02	2.0E-02	8.6E-03	2.5E-04	6.5E-02	1.3E+01	1.1E-03	3.5E+00	9.0E-06	1.2E+00	2.7E-01	6.3E+01	4.5E-05	9.4E-03	5.0E-04	4.1E-03	2.0E-04	1.9E-03	1.0E-04	5.2E+00	4.6E+00	-5.6E-01	-5.8%
12-Jan-10	4																											
19-Jan-10	5	8.0E-03	1.1E-04	5.0E-04	1.7E+01	5.8E-02	1.0E-02	1.0E-02	3.4E-04	6.5E-01	1.1E+01	2.2E-03	3.2E+00	7.0E-06	1.0E+00	4.4E-01	1.4E+02	3.7E-05	7.4E-03	5.0E-04	1.3E-02	2.0E-04	1.3E-03	1.0E-04	1.0E+01	8.9E+00	-1.2E+00	-6.5%
26-Jan-10	6																											
2-Feb-10	7	2.0E-03	4.7E-05	5.0E-04	1.3E+01	4.3E-02	1.0E-02	9.8E-03	2.9E-04	3.5E-02	7.2E+00	2.6E-03	3.5E+00	5.0E-06	4.6E-01	2.8E-01	7.1E+01	4.2E-05	6.4E-03	5.0E-04	1.1E-02	2.0E-04	3.0E-03	1.0E-04	6.8E+00	5.8E+00	-1.0E+00	-8.2%
9-Feb-10	8																											
16-Feb-10	9	2.0E-03	2.3E-05	5.0E-04	9.4E+00	3.0E-02	1.0E-02	7.6E-03	1.3E-04	3.2E-02	5.3E+00	2.0E-03	3.2E+00	5.0E-06	3.2E-01	2.3E-01	4.7E+01	2.6E-05	6.2E-03	5.0E-04	8.4E-03	2.0E-04	6.0E-04	1.0E-04	4.7E+00	4.2E+00	-5.0E-01	-5.6%
23-Feb-10	10																											
2-Mar-10	11	4.0E-03	3.1E-05	5.0E-04	8.3E+00	2.7E-02	1.0E-02	8.8E-03	1.9E-04	3.6E-02	4.4E+00	2.2E-03	3.1E+00	5.0E-06	2.4E-01	2.0E-01	4.2E+01	2.4E-05	6.3E-03	5.0E-04	7.7E-03	2.0E-04	7.0E-04	1.0E-04	3.9E+00	3.8E+00	-1.2E-01	-1.6%
9-Mar-10	12																											
16-Mar-10	13	2.0E-03	1.9E-04	5.0E-04	7.7E+00	3.3E-02	1.0E-02	8.8E-03	2.0E-04	3.3E-02	3.8E+00	2.0E-03	3.1E+00	5.0E-06	2.2E-01	1.8E-01	3.6E+01	2.4E-05	4.9E-03	5.0E-04	7.2E-03	2.0E-04	1.0E-03	1.0E-04	3.3E+00	3.5E+00	2.2E-01	3.2%
23-Mar-10	14																											
30-Mar-10	15	2.0E-03	1.2E-04	5.0E-04	6.5E+00	3.0E-02	1.0E-02	1.1E-02	3.2E-04	3.4E-02	3.2E+00	2.3E-03	3.2E+00	5.0E-06	2.0E-01	1.6E-01	3.1E+01	3.9E-05	5.7E-03	5.0E-04	6.4E-03	2.0E-04	4.6E-03	1.0E-04	3.4E+00	2.9E+00	-4.4E-01	-7.0%
6-Apr-10	16																											
13-Apr-10	17	3.0E-03	8.3E-05	5.0E-04	5.4E+00	2.8E-02	1.0E-02	1.8E-02	2.3E-04	3.4E-02	2.9E+00	1.8E-03	3.1E+00	5.0E-06	1.7E-01	1.4E-01	2.1E+01	2.2E-05	5.7E-03	5.0E-04	5.0E-03	3.0E-04	7.0E-04	1.0E-04	2.8E+00	2.6E+00	-2.3E-01	-4.3%
20-Apr-10	18																											
27-Apr-10	19	1.0E-03	1.8E-05	5.0E-04	5.1E+00	2.4E-02	1.0E-02	2.4E-02	1.7E-04	3.9E-02	2.7E+00	1.5E-03	3.2E+00	5.0E-06	1.6E-01	1.3E-01	2.0E+01	1.7E-05	4.9E-03	5.0E-04	4.2E-03	2.0E-04	1.0E-03	1.0E-04	2.6E+00	2.4E+00	-2.0E-01	-3.9%
4-May-10	20																											
11-May-10	21	2.0E-03	5.0E-06	5.0E-04	4.2E+00	2.1E-02	1.0E-02	2.4E-02	5.0E-05	2.8E-02	2.5E+00	1.3E-03	3.3E+00	5.0E-06	1.7E-01	1.3E-01	1.7E+01	2.1E-05	6.3E-04	5.0E-04	3.5E-04	2.0E-04	2.0E-04	1.0E-04	2.3E+00	2.1E+00	-2.2E-01	-4.9%
18-May-10	22																											
25-May-10	23	8.0E-03	3.2E-05	5.0E-04	4.2E+00	2.0E-02	1.0E-02	1.7E-02	1.7E-04	4.0E-02	2.5E+00	1.2E-03	3.1E+00	5.0E-06	1.3E-01	1.2E-01	1.5E+01	1.9E-05	4.9E-03	5.0E-04	3.4E-03	2.0E-04	1.0E-03	1.0E-04	1.8E+00	2.1E+00	2.8E-01	7.1%
1-Jun-10	24																											
8-Jun-10	25	2.0E-03	1.3E-03	5.0E-04	4.3E+00	2.4E-02	1.0E-02	1.4E-02	7.0E-05	3.9E-02	2.4E+00	1.1E-03	3.9E+00	5.0E-06	1.3E-01	1.2E-01	1.2E+01	2.0E-05	7.4E-03	5.0E-04	3.2E-03	2.0E-04	7.0E-04	1.0E-04	1.9E+00	2.1E+00	1.7E-01	4.1%
15-Jun-10	26																											
22-Jun-10	27	1.0E-03	1.8E-05	5.0E-04	3.5E+00	1.7E-02	1.0E-02	1.2E-02	1.5E-04	4.2E-02	2.2E+00	1.1E-03	3.0E+00	5.0E-06	1.3E-01	1.1E-01	1.3E+01	1.8E-05	5.2E-03	5.0E-04	2.5E-03	3.0E-04	7.0E-04	1.0E-04	1.8E+00	1.7E+00	-1.6E-01	-4.6%
29-Jun-10	28																											
6-Jul-10	29	1.0E-03	5.2E-05	5.0E-04	3.5E+00	1.7E-02	1.0E-02	8.4E-03	2.4E-04	4.0E-02	2.0E+00	1.0E-03	3.1E+00	5.0E-06	1.3E-01	9.9E-02	1.0E+01	1.5E-05	4.8E-03	5.0E-04	2.4E-03	3.0E-04	8.0E-04	1.0E-04	1.6E+00	1.7E+00	8.5E-02	2.5%
13-Jul-10	30																											
20-Jul-10	31	2.0E-03	3.6E-05	5.0E-04	2.9E+00	1.6E-02	1.0E-02	7.0E-03	1.7E-04	3.2E-02	1.6E+00	1.0E-03	2.5E+00	5.0E-06	1.0E-01	9.9E-02	1.0E+01	1.6E-05	4.9E-03	5.0E-04	2.4E-03	2.0E-04	8.0E-04	1.0E-04	1.7E+00	1.6E+00	-1.2E-01	-3.8%
27-Jul-10	32																											
3-Aug-10	33	1.0E-03	2.0E-05	5.0E-04	3.1E+00	1.6E-02	2.0E-02	7.1E-03	1.2E-04	4.2E-02	1.8E+00	1.1E-03	2.9E+00	5.0E-06	1.3E-01	9.8E-02	1.0E+01	1.5E-05	5.1E-03	5.0E-04	2.5E-03	2.0E-04	7.0E-04	1.0E-04	1.6E+00	1.6E+00	-4.6E-02	-1.4%
10-Aug-10	34																											
17-Aug-10	35	1.0E-03	1.2E-05	5.0E-04	3.0E+00	1.4E-02	1.0E-02	6.8E-03	1.2E-04	4.0E-02	1.7E+00	1.2E-03	2.5E+00	5.0E-06	1.6E-01	9.4E-02	1.0E+01	1.8E-05	4.7E-03	5.0E-04	2.1E-03	2.0E-04	3.0E-04	1.0E-04	1.5E+00	1.5E+00	-5.6E-02	-1.9%
24-Aug-10	36																											
31-Aug-10	37	1.0E-03	8.3E-05	5.0E-04	2.9E+00	1.7E-02	1.0E-02	6.3E-03	1.5E-04	3.5E-02	1.5E+00	1.3E-03	2.7E+00	5.0E-06	1.0E-01	9.9E-02	1.0E+01	2.1E-05	5.9E-03	5.0E-04	1.8E-03	2.0E-04	6.0E-04	1.0E-04	1.8E+00	1.5E+00	-3.5E-01	-10.6%
7-Sep-10	38																											
14-Sep-10	39	5.0E-03	2.0E-05	5.0E-04	2.9E+00	1.4E-02	1.0E-02	6.3E-03	1.4E-04	4.1E-02	1.5E+00	1.1E-03	2.6E+00	5.0E-06	1.4E-01	8.9E-02	1.0E+01	2.0E-05	5.6E-03	9.0E-04	2.2E-03	4.0E-04	3.2E-02	1.0E-04	1.7E+00	1.5E+00	-1.4E-01	-4.5%
21-Sep-10	40																											
28-Sep-10	41	3.0E-03	4.6E-05	5.0E-04	3.2E+00	1.6E-02	1.0E-02	7.0E-03	1.8E-04	4.3E-02	1.7E+00	1.2E-03	2.8E+00	5.0E-06	1.5E-01	9.2E-02	1.0E+01	1.8E-05	5.9E-03	5.0E-04	2.3E-03	3.0E-04	7.0E-04	1.0E-04	1.8E+00	1.6E+00	-2.8E-01	-8.2%
5-Oct-10	42																											
12-Oct-10	43	1.0E-03	1.5E-05	5.0E-04	3.5E+00	2.1E-02	1.0E-02	6.9E-03	1.5E-04	4.3E-02	1.7E+00	1.2E-03	3.2E+00	5.0E-06	1.2E-01	9.7E-02	1.0E+01	1.9E-05	5.7E-03	5.0E-04	2.7E-03	3.0E-04	6.0E-04	1.0E-04	2.0E+00	1.7E+00	-2.1E-01	-5.7%
19-Oct-10	44																											
26-Oct-10	45	1.0E-03	2.8E-05	5.0E-04	2.9E+00	1.7E-02	1.0E-02	6.0E-03	1.3E-04	4.1E-02	1.3E+00	1.8E-03	2.5E+00	5.0E-06	1.0E-01	8.0E-02	1.0E+01	1.9E-05	5.1E-03	5.0E-04	1.8E-03	2.0E-04	4.0E-04	1.0E-04	1.7E+00	1.5E+00	-2.2E-01	-6.7%
2-Nov-10	46																											
9-Nov-10	47																											
16-Nov-10	48																											
23-Nov-10	49	1.0E-03	6.7E-05	5.0E-04	3.0E+00	1.9E-02	1.0E-02	8.6E-03	2.6E-04	4.3E-02	1.3E+00	9.7E-04	2.5E+00	5.0E-06	9.0E-02	8.3E-02	1.0E+01	1.5E-05	7.8E-03	5.0E-04	2.3E-03	2.0E-04	5.3E-03	1.0E-04	1.8E+00	1.5E+00	-2.6E-01	-8.2%
30-Nov-10	50																											
7-Dec-10	51																											
14-Dec-10	52																											
21-Dec-10	53	1.0E-03	1.9E-05	5.0E-04	2.8E+00	1.7E-02	1.0E-02	7.9E-03	1.4E-04	4.5E-02	1.3E+00	8.5E-04	2.3E+00	5.0E-06	8.0E-02	7.6E-02	1.0E+01	1.4E-05	6.2E-03	5.0E-04	2.0E-03	2.0E-04	7.0E-04	1.0E-04	1.7E+00	1.4E+00	-3.4E-01	-11.1%
28-Dec-10	54																											
4-Jan-11	55																											
11-Jan-11	56																											
18-Jan-11	57	2.0E-03	2.3E-05	5.0E-04	2.9E+00	1.9E-02	1.0E-02	7.6E-03	1.7E-04	3.9E-02	1.2E+00	9.5E-04	2.3E+00	5.0E-06	9.0E-02	7.3E-02	1.0E+01	1.4E-05	5.9E-03	5.0E-04	2.5E-02	2.0E-04	6.0E-04	1.0E-04	1.6E+00	1.5E+00	-1.1E-01	-3.6%
25-Jan-11	58																											
1-Feb-11	59																											
8-Feb-11	60																											
15-Feb-11	61	3.0E-03	1.3E-05	5.0E-04	2.7E+00	1.8E-02	1.0E-02	5.9E-03	1.7E-04	3.9E-02	1.1E+00	9.5E-04	2.0E+00	5.0E-06	7.0E-02	6.5E-02	1.0E+01	1.7E-05	6.3E-03	5.0E-04	1.8E-03	4.0E-04	5.0E-04	1.0E-04	1.4E+00	1.2E+00	-1.8E-01	-6.9%
22-Feb-11	62																											
1-Mar-11	63																											
8-Mar-11	64																											
15-Mar-11	65	1.0E-03	2.3E-05	5.0E-04	3.2E+00	1.9E-02	1.0E-02	5.3E-03	1.5E-04	4.4E-02	1.1E+00	8.4E-04	2.4E+00	5.0E-06	7.0E-02	6.6E-02	1.0E+01	1.0E-05	5.8E-03	5.0E-04	2.0E-03	3.0E-04	7.0E-04	1.0E-04	1.5E+00	1.5E+00	2.6E-02	0.9%
22-Mar-11	66																											

T4
Sample = KM 2459-10 Comp 1 + KM2459-09 Comp 2 + KM2459-08 Comp 3

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Major	Major	Diff	Diff
	No.																								Anions	Cations		(%)
		mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L				
29-Mar-11	67																											
5-Apr-11	68																											
12-Apr-11	69	1.0E-03	3.4E-05	5.0E-04	3.1E+00	2.1E-02	1.0E-02	5.3E-03	1.1E-04	4.2E-02	1.0E+00	8.1E-04	2.1E+00	5.0E-06	8.0E-02	6.3E-02	1.0E+01	9.0E-06	5.2E-03	5.0E-04	2.0E-03	4.0E-04	7.0E-04	1.0E-04	1.5E+00	1.3E+00	-1.9E-01	-6.6%
19-Apr-11	70																											
26-Apr-11	71																											
3-May-11	72																											
10-May-11	73	1.0E-03	1.8E-04	5.0E-04	3.0E+00	1.8E-02	1.0E-02	5.4E-03	1.2E-04	3.6E-02	8.8E-01	1.0E-03	2.2E+00	5.0E-06	7.0E-02	5.9E-02	1.0E+01	1.2E-05	5.0E-03	5.0E-04	1.8E-03	3.0E-04	7.0E-04	1.0E-04	1.6E+00	1.4E+00	-2.7E-01	-9.0%
17-May-11	74																											
24-May-11	75																											
31-May-11	76																											
7-Jun-11	77	5.0E-03	7.2E-04	5.0E-04	3.5E+00	1.8E-02	1.0E-02	6.8E-03	1.2E-04	4.0E-02	9.8E-01	8.2E-04	2.3E+00	5.0E-06	9.0E-02	5.8E-02	1.0E+01	1.2E-05	4.6E-03	5.0E-04	2.2E-03	5.0E-04	2.0E-03	1.0E-04	1.6E+00	1.4E+00	-1.0E-01	-3.4%
14-Jun-11	78																											
21-Jun-11	79																											
28-Jun-11	80																											
5-Jul-11	81	1.0E-03	1.7E-05	5.0E-04	3.8E+00	1.8E-02	1.0E-02	5.4E-03	1.5E-04	4.3E-02	9.8E-01	9.7E-04	2.4E+00	5.0E-06	7.0E-02	5.7E-02	1.0E+01	1.8E-05	4.8E-03	5.0E-04	2.0E-03	3.0E-04	6.0E-04	1.0E-04	1.7E+00	1.4E+00	-2.3E-01	-7.4%
12-Jul-11	82																											
19-Jul-11	83																											
26-Jul-11	84																											
2-Aug-11	85	1.0E-03	1.0E-05	5.0E-04	3.2E+00	1.6E-02	1.0E-02	5.6E-03	8.0E-05	4.2E-02	8.4E-01	7.4E-04	2.2E+00	5.0E-06	6.0E-02	5.0E-02	1.0E+01	1.0E-05	4.8E-03	5.0E-04	1.6E-03	4.0E-04	8.0E-04	1.0E-04	1.5E+00	1.3E+00	-2.1E-01	-7.5%
9-Aug-11	86																											
16-Aug-11	87																											
23-Aug-11	88																											
30-Aug-11	89	1.0E-03	1.6E-05	5.0E-04	3.7E+00	1.5E-02	1.0E-02	8.8E-03	7.0E-05	4.2E-02	8.8E-01	7.5E-04	2.2E+00	5.0E-06	6.0E-02	5.2E-02	1.0E+01	1.7E-05	4.2E-03	5.0E-04	2.1E-03	4.0E-04	5.0E-04	1.0E-04	1.6E+00	1.4E+00	-2.4E-01	-8.1%
6-Sep-11	90																											
13-Sep-11	91																											
20-Sep-11	92																											
27-Sep-11	93	1.0E-03	1.1E-04	5.0E-04	3.9E+00	1.6E-02	1.0E-02	1.5E-02	1.9E-04	4.1E-02	8.3E-01	7.3E-04	2.0E+00	5.0E-06	6.0E-02	4.9E-02	1.0E+01	1.5E-05	5.7E-03	5.0E-04	1.9E-03	3.0E-04	1.3E-02	1.0E-04	1.7E+00	1.4E+00	-3.0E-01	-10.0%
4-Oct-11	94																											
11-Oct-11	95																											
18-Oct-11	96																											
25-Oct-11	97	1.0E-03	3.2E-05	5.0E-04	3.8E+00	1.4E-02	1.0E-02	1.5E-02	6.0E-05	4.1E-02	7.6E-01	8.0E-04	1.8E+00	5.0E-06	7.0E-02	4.2E-02	1.0E+01	1.0E-05	4.0E-03	5.0E-04	1.4E-03	3.0E-04	8.0E-04	1.0E-04	1.4E+00	1.2E+00	-1.6E-01	-6.2%
1-Nov-11	98																											
8-Nov-11	99																											
15-Nov-11	100																											
22-Nov-11	101	1.0E-03	1.3E-04	5.0E-04	4.3E+00	1.6E-02	1.0E-02	1.3E-02	1.4E-04	4.3E-02	8.1E-01	6.6E-04	1.9E+00	5.0E-06	7.0E-02	4.5E-02	1.0E+01	1.1E-05	4.7E-03	5.0E-04	2.0E-03	4.0E-04	3.0E-03	1.0E-04	1.6E+00	1.4E+00	-1.7E-01	-5.6%
29-Nov-11	102																											
6-Dec-11	103																											
13-Dec-11	104																											
20-Dec-11	105	1.0E-03	2.3E-05	5.0E-04	4.3E+00	1.2E-02	1.0E-02	2.4E-02	1.5E-04	3.5E-02	7.1E-01	6.9E-04	1.8E+00	5.0E-06	7.0E-02	4.5E-02	1.0E+01	1.0E-05	5.3E-03	5.0E-04	1.9E-03	6.0E-04	1.5E-03	1.0E-04	1.6E+00	1.4E+00	-2.3E-01	-7.7%
27-Dec-11	106																											
3-Jan-12	107																											
10-Jan-12	108																											
17-Jan-12	109	1.0E-03	1.7E-05	5.0E-04	4.9E+00	6.4E-03	1.0E-02	4.7E-02	1.8E-04	4.5E-02	7.7E-01	6.3E-04	1.7E+00	5.0E-06	7.0E-02	3.9E-02	1.0E+01	9.0E-06	4.8E-03	5.0E-04	1.8E-03	7.0E-04	1.4E-03	1.0E-04	1.8E+00	1.4E+00	-4.6E-01	-14.5%
24-Jan-12	110																											
31-Jan-12	111																											
7-Feb-12	112																											
14-Feb-12	113	1.0E-03	5.0E-06	5.0E-04	5.1E+00	4.1E-03	1.0E-02	5.5E-02	7.0E-05	4.6E-02	7.9E-01	8.0E-04	1.7E+00	5.0E-06	8.0E-02	4.1E-02	1.0E+01	1.0E-05	4.7E-03	5.0E-04	2.2E-03	4.0E-04	4.0E-04	1.0E-04	1.9E+00	1.4E+00	-4.9E-01	-14.7%
21-Feb-12	114																											
28-Feb-12	115																											
6-Mar-12	116																											
13-Mar-12	117	1.0E-02	5.0E-06	5.0E-04	4.9E+00	3.9E-03	1.0E-02	4.4E-02	8.0E-05	4.6E-02	7.1E-01	7.6E-04	1.7E+00	5.0E-06	8.0E-02	3.4E-02	1.0E+01	9.0E-06	4.2E-03	5.0E-04	1.8E-03	4.0E-04	2.0E-04	1.0E-04	1.5E+00	1.4E+00	-1.4E-01	-5.1%
20-Mar-12	118																											
27-Mar-12	119																											
3-Apr-12	120																											
10-Apr-12	121	1.0E-03	5.0E-06	5.0E-04	5.5E+00	3.7E-03	1.0E-02	5.2E-02	1.2E-04	4.3E-02	7.4E-01	9.1E-04	2.0E+00	5.0E-06	6.0E-02	3.7E-02	1.0E+01	1.0E-05	4.9E-03	5.0E-04	2.2E-03	3.0E-04	8.0E-04	1.0E-04	1.8E+00	1.5E+00	-2.6E-01	-7.8%
17-Apr-12	122																											
24-Apr-12	123																											
1-May-12	124																											
8-May-12	125	3.0E-03	2.5E-05	5.0E-04	5.0E+00	3.4E-03	1.0E-02	3.0E-02	9.6E-05	4.3E-02	7.3E-01	8.7E-04	1.8E+00	5.0E-06	6.0E-02	3.1E-02	1.0E+01	1.1E-05	3.6E-03	5.0E-04	1.5E-03	5.3E-04	3.8E-03	1.0E-04	1.6E+00	1.3E+00	-2.9E-01	-10.2%
15-May-12	126																											
22-May-12	127																											
29-May-12	128																											
5-Jun-12	129	4.0E-03	8.4E-06	5.0E-04	5.5E+00	4.8E-03	1.0E-02	2.7E-02	6.2E-05	4.2E-02	6.7E-01	7.5E-04	1.5E+00	5.0E-06	5.4E-02	3.0E-02	1.0E+01	8.6E-06	4.0E-03	5.0E-04	2.0E-03	3.3E-04	4.1E-04	1.0E-04	1.5E+00	1.3E+00	-2.4E-01	-8.6%
12-Jun-12	130																											
19-Jun-12	131																											
26-Jun-12	132																											
3-Jul-12	133	1.0E-03	1.5E-05	5.0E-04	6.2E+00	5.4E-03	1.0E-02	2.4E-02	5.8E-05	4.4E-02	7.1E-01	7.9E-04	1.8E+00	5.0E-06	5.6E-02	3.0E-02	1.0E+01	9.1E-06	4.3E-03	5.0E-04	1.9E-03	6.4E-04	5.6E-04	1.0E-04	1.7E+00	1.5E+00	-2.5E-01	-7.8%

T4
Sample = KM 2459-10 Comp 1 + KM2459-09 Comp 2 + KM2459-08 Comp 3

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Major	Major	Diff	Diff
	No.																								Anions	Cations		(%)
		mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L				
10-Jul-12	134																											
17-Jul-12	135																											
24-Jul-12	136																											
31-Jul-12	137	2.1E-03	1.7E-05	5.0E-04	6.2E+00	4.7E-03	1.0E-02	1.7E-02	6.0E-05	4.7E-02	7.5E-01	8.4E-04	1.8E+00	5.0E-06	6.0E-02	2.9E-02	1.0E+01	1.1E-05	5.2E-03	5.0E-04	1.6E-03	6.8E-04	1.3E-03	1.0E-04	1.5E+00	1.5E+00	-3.5E-02	-1.2%
7-Aug-12	138																											
14-Aug-12	139																											
21-Aug-12	140																											
28-Aug-12	141	3.0E-03	4.0E-05	5.0E-04	5.5E+00	3.3E-03	1.0E-02	1.5E-02	1.5E-04	4.1E-02	5.1E-01	1.5E-03	1.5E+00	5.0E-06	1.8E-01	2.4E-02	1.0E+01	3.0E-06	3.8E-03	5.0E-04	1.3E-03	1.1E-03	1.8E-03	1.0E-04	1.4E+00	1.2E+00	-2.0E-01	-7.3%
4-Sep-12	142																											
11-Sep-12	143																											
18-Sep-12	144																											
25-Sep-12	145	1.0E-03	6.0E-06	5.0E-04	8.4E+00	4.8E-03	1.0E-02	1.6E-02	1.5E-04	4.3E-02	7.1E-01	5.7E-04	1.8E+00	5.0E-06	8.6E-02	3.1E-02	1.7E+01	1.0E-05	3.6E-03	5.0E-04	2.6E-03	4.3E-04	6.2E-04	1.0E-04	2.1E+00	1.9E+00	-2.6E-01	-6.5%
2-Oct-12	146																											
9-Oct-12	147																											
16-Oct-12	148																											
23-Oct-12	149	2.2E-03	1.2E-05	5.0E-04	8.3E+00	4.0E-03	1.0E-02	1.5E-02	7.7E-05	4.2E-02	6.6E-01	7.2E-04	1.7E+00	5.0E-06	6.3E-02	2.4E-02	1.6E+01	8.0E-06	4.3E-03	5.0E-04	1.9E-03	3.7E-04	1.5E-03	1.0E-04	2.0E+00	1.7E+00	-3.4E-01	-9.1%
30-Oct-12	150																											
6-Nov-12	151																											
13-Nov-12	152																											
20-Nov-12	153	1.0E-03	1.1E-05	5.0E-04	7.4E+00	4.0E-03	1.0E-02	1.1E-02	1.3E-04	5.0E-02	6.9E-01	5.4E-04	1.6E+00	5.0E-06	6.1E-02	2.1E-02	1.2E+01	8.0E-06	3.4E-03	5.0E-04	1.7E-03	4.4E-04	2.0E-03	1.0E-04	1.7E+00	1.5E+00	-1.7E-01	-5.2%
27-Nov-12	154																											
4-Dec-12	155																											
11-Dec-12	156																											
18-Dec-12	157	1.8E-03	8.0E-06	5.0E-04	7.6E+00	4.0E-03	1.0E-02	9.7E-03	9.2E-05	5.1E-02	6.6E-01	6.2E-04	1.6E+00	5.0E-06	5.8E-02	2.0E-02	1.3E+01	9.0E-06	3.9E-03	5.0E-04	1.6E-03	4.6E-04	3.5E-04	1.0E-04	1.7E+00	1.5E+00	-1.9E-01	-5.9%
25-Dec-12	158																											
1-Jan-13	159																											
8-Jan-13	160																											
15-Jan-13	161	1.1E-02	8.9E-05	5.0E-04	7.8E+00	4.4E-03	1.0E-02	7.1E-03	1.7E-04	4.7E-02	6.7E-01	4.4E-04	1.5E+00	5.0E-06	5.6E-02	2.0E-02	1.3E+01	7.0E-06	3.8E-03	5.0E-04	1.6E-03	3.8E-04	5.6E-03	1.0E-04	1.8E+00	1.5E+00	-3.2E-01	-9.6%
22-Jan-13	162																											
29-Jan-13	163																											
5-Feb-13	164																											
12-Feb-13	165	2.8E-03	1.4E-04	5.0E-04	9.4E+00	6.6E-03	1.0E-02	6.8E-03	2.8E-04	4.6E-02	7.4E-01	3.7E-04	1.6E+00	5.0E-06	1.3E-01	2.4E-02	1.8E+01	9.0E-06	3.5E-03	5.0E-04	2.3E-03	4.2E-04	8.6E-04	1.0E-04	2.2E+00	1.9E+00	-2.6E-01	-6.5%
19-Feb-13	166																											
26-Feb-13	167																											
5-Mar-13	168																											
12-Mar-13	169	3.4E-03	6.2E-05	5.0E-04	9.3E+00	7.6E-03	1.0E-02	5.8E-03	8.0E-05	4.3E-02	7.6E-01	4.6E-04	1.5E+00	5.0E-06	7.1E-02	2.2E-02	1.7E+01	6.0E-06	4.3E-03	5.0E-04	2.2E-03	3.3E-04	1.0E-03	1.0E-04	1.9E+00	1.8E+00	-1.1E-01	-2.8%
19-Mar-13	170																											
26-Mar-13	171																											
2-Apr-13	172																											
9-Apr-13	173	1.0E-03	9.0E-06	5.0E-04	9.0E+00	7.5E-03	1.0E-02	5.3E-03	6.9E-05	3.5E-02	7.4E-01	4.4E-04	1.5E+00	5.0E-06	6.3E-02	2.1E-02	1.6E+01	8.0E-06	4.5E-03	5.0E-04	1.9E-03	7.1E-04	7.2E-04	1.0E-04	2.0E+00	1.7E+00	-3.0E-01	-7.8%
16-Apr-13	174																											
23-Apr-13	175																											
30-Apr-13	176																											
7-May-13	177	1.0E-03	2.3E-05	5.0E-04	1.0E+01	7.2E-03	1.0E-02	4.9E-03	9.2E-05	4.0E-02	7.4E-01	4.0E-04	1.6E+00	5.0E-06	7.0E-02	2.1E-02	2.0E+01	6.0E-06	4.7E-03	5.0E-04	2.2E-03	6.2E-04	8.4E-04	1.0E-04	2.1E+00	2.0E+00	-1.3E-01	-3.2%
14-May-13	178																											
21-May-13	179																											
28-May-13	180																											
4-Jun-13	181	5.2E-03	1.4E-05	5.0E-04	9.2E+00	5.5E-03	1.0E-02	4.5E-03	1.3E-03	3.9E-02	6.9E-01	5.2E-04	1.4E+00	9.0E-06	6.7E-02	1.9E-02	1.7E+01	9.0E-06	4.5E-03	5.0E-04	1.9E-03	7.0E-04	4.4E-04	1.0E-04	2.0E+00	1.7E+00	-2.1E-01	-5.7%
11-Jun-13	182																											
18-Jun-13	183																											
25-Jun-13	184																											
2-Jul-13	185	1.0E-03	1.1E-05	5.0E-04	8.4E+00	5.0E-03	1.0E-02	4.0E-03	6.4E-05	4.0E-02	6.8E-01	4.6E-04	1.6E+00	5.0E-06	5.8E-02	1.7E-02	1.6E+01	8.0E-06	4.2E-03	5.0E-04	1.6E-03	2.0E-04	6.2E-04	1.0E-04	2.1E+00	1.6E+00	-4.3E-01	-11.6%
9-Jul-13	186																											
16-Jul-13	187																											
23-Jul-13	188																											
30-Jul-13	189	1.0E-03	2.3E-05	5.0E-04	8.1E+00	6.1E-03	1.0E-02	4.0E-03	6.7E-05	3.8E-02	7.2E-01	4.0E-04	1.4E+00	5.0E-06	7.3E-02	1.7E-02	1.4E+01	1.2E-05	4.0E-03	5.0E-04	1.5E-03	3.2E-04	5.4E-04	1.0E-04	1.8E+00	1.6E+00	-2.0E-01	-6.1%
6-Aug-13	190																											
13-Aug-13	191																											
20-Aug-13	192																											
27-Aug-13	193	5.2E-03	1.4E-05	5.0E-04	9.2E+00	8.1E-03	1.0E-02	3.5E-03	8.4E-05	3.9E-02	7.2E-01	3.8E-04	1.6E+00	5.0E-06	7.1E-02	1.8E-02	1.9E+01	6.0E-06	3.8E-03	5.0E-04	1.6E-03	3.2E-04	5.9E-04	1.0E-04	1.9E+00	1.8E+00	-9.5E-02	-2.5%
3-Sep-13	194																											

T4
Sample = KM 2459-10 Comp 1 + KM2459-09 Comp 2 + KM2459-08 Comp 3

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Major	Major	Diff	Diff
	No.																								Anions	Cations		(%)
		mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L				
10-Sep-13	195																											
17-Sep-13	196																											
24-Sep-13	197	1.0E-03	1.8E-05	5.0E-04	8.8E+00	8.0E-03	1.0E-02	3.2E-03	7.4E-05	3.7E-02	7.1E-01	3.5E-04	1.6E+00	5.0E-06	7.5E-02	1.7E-02	1.7E+01	6.0E-06	3.7E-03	5.0E-04	1.5E-03	3.7E-04	4.6E-04	1.0E-04	1.8E+00	1.8E+00	-2.0E-02	-0.5%
1-Oct-13	198																											
8-Oct-13	199																											
15-Oct-13	200																											
22-Oct-13	201	1.1E-03	4.8E-05	5.0E-04	9.8E+00	1.0E-02	2.0E-03	3.1E-03	1.0E-04	3.5E-02	7.4E-01	2.7E-04	1.5E+00	5.0E-06	6.4E-02	1.8E-02	1.9E+01	7.0E-06	4.0E-03	5.0E-04	1.5E-03	3.8E-04	4.7E-04	1.0E-04	2.0E+00	1.9E+00	-7.2E-02	-1.9%
29-Oct-13	202																											
5-Nov-13	203																											
12-Nov-13	204																											
19-Nov-13	205	1.0E-03	2.0E-05	5.0E-04	9.5E+00	1.0E-02	2.0E-03	2.8E-03	7.3E-05	3.3E-02	6.9E-01	3.8E-04	1.3E+00	5.0E-06	6.9E-02	1.7E-02	1.6E+01	8.0E-06	3.8E-03	5.0E-04	1.4E-03	4.3E-04	1.4E-03	1.0E-04	1.8E+00	1.8E+00	7.5E-03	0.2%
26-Nov-13	206																											
3-Dec-13	207																											
10-Dec-13	208																											
17-Dec-13	209	2.1E-03	1.1E-05	5.0E-04	1.0E+01	1.0E-02	1.0E-02	2.9E-03	7.2E-05	3.7E-02	7.5E-01	3.0E-04	1.5E+00	5.0E-06	8.9E-02	1.7E-02	2.4E+01	6.0E-06	3.7E-03	5.0E-04	1.4E-03	4.4E-04	1.1E-03	1.0E-04	1.9E+00	2.0E+00	5.6E-02	1.4%
24-Dec-13	210																											
31-Dec-13	211																											
7-Jan-14	212																											
14-Jan-14	213	1.0E-03	1.4E-05	5.0E-04	1.1E+01	9.3E-03	1.0E-02	3.1E-03	7.8E-05	3.1E-02	7.9E-01	2.5E-04	1.5E+00	1.6E-05	1.0E-01	1.8E-02	2.3E+01	1.6E-05	4.2E-03	5.0E-04	1.5E-03	3.7E-04	7.2E-04	1.0E-04	2.0E+00	2.1E+00	9.7E-02	2.4%
21-Jan-14	214																											
28-Jan-14	215																											
4-Feb-14	216																											
11-Feb-14	217	1.5E-03	7.0E-06	5.0E-04	1.1E+01	1.1E-02	1.0E-02	2.7E-03	5.6E-05	3.3E-02	8.0E-01	3.4E-04	1.5E+00	5.0E-06	5.6E-02	1.8E-02	2.1E+01	5.0E-06	4.6E-03	5.0E-04	1.7E-03	4.8E-04	5.5E-04	1.0E-04	2.2E+00	2.1E+00	-1.1E-01	-2.6%
18-Feb-14	218																											
25-Feb-14	219	1.0E-03	1.3E-05	5.0E-04	1.1E+01	9.8E-03	1.0E-02	2.6E-03	4.3E-05	3.3E-02	7.9E-01	2.8E-04	1.6E+00	5.0E-06	6.9E-02	1.6E-02	2.3E+01	1.2E-05	4.1E-03	5.0E-04	1.2E-03	3.7E-04	6.8E-04	1.0E-04	2.0E+00	2.1E+00	3.1E-02	0.8%
4-Mar-14	220	1.0E-03	8.0E-06	5.0E-04	8.3E+00	7.4E-03	1.0E-02	2.0E-03	6.1E-05	2.8E-02	4.3E-01	3.4E-04	9.8E-01	5.0E-06	1.1E-01	1.2E-02	1.5E+01	3.0E-06	4.4E-03	5.0E-04	1.2E-03	2.0E-04	5.2E-04	1.0E-04	1.5E+00	1.6E+00	9.9E-02	3.2%
11-Mar-14	221	1.1E-03	1.0E-05	5.0E-04	5.8E+00	5.9E-03	1.0E-02	1.7E-03	2.0E-05	2.8E-02	3.7E-01	1.1E-04	8.4E-01	1.2E-05	5.0E-02	8.3E-03	8.6E+00	6.0E-06	5.2E-03	5.0E-04	5.9E-04	2.0E-04	1.6E-04	1.0E-04	1.2E+00	1.1E+00	-1.0E-01	-4.4%
18-Mar-14	222	3.3E-03	1.5E-05	5.0E-04	4.8E+00	5.6E-03	1.0E-02	1.3E-03	1.2E-04	2.8E-02	3.4E-01	9.6E-05	7.8E-01	5.0E-06	5.0E-02	7.3E-03	5.9E+00	2.0E-06	4.5E-03	5.0E-04	4.0E-04	2.0E-04	1.5E-03	1.0E-04	9.1E-01	9.1E-01	2.8E-03	0.2%
25-Mar-14	223	1.0E-03	7.8E-05	5.0E-04	5.1E+00	5.7E-03	1.0E-02	1.2E-03	6.7E-05	3.1E-02	3.7E-01	1.0E-04	8.5E-01	5.0E-06	5.0E-02	7.6E-03	6.0E+00	2.0E-06	4.1E-03	5.0E-04	3.8E-04	2.0E-04	8.0E-04	1.0E-04	9.7E-01	9.7E-01	-6.1E-04	0.0%
1-Apr-14	224																											
8-Apr-14	225																											
15-Apr-14	226																											
22-Apr-14	227	2.5E-03	9.0E-06	5.0E-04	4.6E+00	6.6E-03	1.0E-02	8.4E-04	3.3E-05	3.3E-02	3.5E-01	9.1E-05	8.2E-01	5.0E-06	5.0E-02	7.6E-03	4.3E+00	4.0E-06	4.5E-03	5.0E-04	3.0E-04	2.8E-04	2.4E-04	1.0E-04	9.0E-01	8.8E-01	-1.6E-02	-0.9%
29-Apr-14	228																											
6-May-14	229																											
13-May-14	230																											
20-May-14	231	1.9E-03	8.0E-06	5.0E-04	4.4E+00	8.8E-03	1.0E-02	6.6E-04	1.3E-04	3.5E-02	3.5E-01	7.7E-05	7.2E-01	5.0E-06	5.0E-02	7.9E-03	4.3E+00	2.0E-06	4.9E-03	5.0E-04	3.0E-04	2.1E-04	1.0E-03	1.0E-04	7.8E-01	8.6E-01	7.5E-02	4.6%
27-May-14	232																											
3-Jun-14	233																											
10-Jun-14	234																											
17-Jun-14	235	4.7E-03	1.7E-05	5.0E-04	5.1E+00	1.1E-02	1.0E-02	6.7E-04	8.6E-05	3.2E-02	3.4E-01	8.9E-05	7.0E-01	1.0E-05	5.0E-02	8.8E-03	4.0E+00	6.0E-05	6.0E-03	5.0E-04	3.3E-04	2.0E-04	9.2E-04	1.0E-04	9.2E-01	9.3E-01	7.6E-03	0.4%
24-Jun-14	236																											
1-Jul-14	237																											
1-Jul-14	237																											
8-Jul-14	238																											
15-Jul-14	239	4.2E-03	1.7E-05	5.0E-04	5.4E+00	1.2E-02	1.0E-02	6.5E-04	7.7E-05	3.9E-02	4.9E-01	9.4E-05	7.8E-01	5.0E-06	5.0E-02	9.5E-03	5.8E+00	2.0E-06	4.6E-03	5.0E-04	3.3E-04	2.4E-04	5.9E-04	1.0E-04	8.6E-01	9.6E-01	1.0E-01	5.6%
22-Jul-14	240																											
29-Jul-14	241																											
5-Aug-14	242																											
12-Aug-14	243	2.9E-03	7.0E-06	5.0E-04	4.5E+00	1.4E-02	1.0E-02	5.1E-04	2.4E-05	3.5E-02	3.7E-01	8.4E-05	7.5E-01	5.0E-06	5.0E-02	8.8E-03	3.7E+00	4.0E-06	4.2E-03	5.0E-04	2.7E-04	2.4E-04	1.4E-03	1.0E-04	7.9E-01	8.6E-01	6.1E-02	3.7%
19-Aug-14	244																											
26-Aug-14	245																											
2-Sep-14	246																											

T4

Sample = KM 2459-10 Comp 1 + KM2459-09 Comp 2 + KM2459-08 Comp 3

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Fluoride	Chloride	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output		umhos/cm	(pH 4.5)	(pH 8.3)					CaCO3												
						mgCaCO3/kg	mgCaCO3/kg	mgCaCO3/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
15-Dec-09	0	750	460	7.97	1.7E+03	#N/A	2.0E+00	1.9E+01	5.2E+02	0.0E+00	2.6E+01	4.5E+02	3.6E+00	3.6E-03	3.3E-03	4.3E-02	2.3E-05	1.4E-05	1.4E-01	3.7E-05	1.8E+02	2.3E-04	3.2E-05	1.5E-03
22-Dec-09	1	500	525	7.28	5.5E+02	#N/A	1.8E+00	1.3E+01	1.7E+02	0.0E+00	1.0E+01	1.6E+02	2.2E-01	2.0E-03	2.0E-02	1.5E-02	2.6E-05	1.6E-05	1.6E-01	2.1E-05	6.0E+01	2.6E-04	1.6E-05	2.4E-03
29-Dec-09	2	500	490	7.42	4.7E+02	#N/A	2.3E+00	2.0E+01	9.8E+01	0.0E+00	1.9E+00	9.7E+01	1.2E-01	2.5E-03	1.1E-02	1.4E-02	2.5E-05	1.5E-05	1.5E-01	1.5E-05	3.7E+01	2.5E-04	1.5E-05	2.0E-03
5-Jan-10	3	500	495	7.15	4.5E+02	#N/A	3.6E+00	2.5E+01	9.7E+01	0.0E+00	1.3E+00	1.0E+02	6.8E-02	2.6E-03	9.4E-03	1.6E-02	5.0E-06	2.5E-06	2.5E-02	1.6E-05	3.8E+01	5.0E-05	2.4E-05	1.2E-03
12-Jan-10	4	500	460	7.50	4.5E+02				9.6E+01															
19-Jan-10	5	500	445	7.75	8.1E+02	#N/A	2.7E+00	2.6E+01	1.9E+02	0.0E+00	9.3E-01	1.9E+02	3.3E-02	1.8E-03	4.4E-03	1.0E-02	4.5E-06	2.2E-06	2.2E-02	3.5E-05	6.4E+01	4.5E-05	9.5E-05	1.1E-03
26-Jan-10	6	500	430	7.86	6.3E+02				1.6E+02															
2-Feb-10	7	500	455	7.88	4.4E+02	#N/A	1.6E+00	3.8E+01	1.1E+02	0.0E+00	2.3E-01	1.3E+02	2.3E-02	1.9E-03	3.0E-03	1.1E-02	4.6E-06	2.3E-06	2.3E-02	2.3E-05	4.1E+01	4.6E-05	7.3E-05	1.3E-03
9-Feb-10	8	500	450	7.94	4.6E+02				8.2E+01															
16-Feb-10	9	500	460	7.59	3.7E+02	#N/A	2.1E+00	3.6E+01	6.9E+01	0.0E+00	2.3E-01	9.3E+01	2.7E-02	1.8E-03	2.1E-03	1.5E-02	4.6E-06	2.3E-06	2.3E-02	8.7E-06	3.0E+01	4.6E-05	5.3E-05	5.5E-04
23-Feb-10	10	500	465	8.01	3.0E+02				5.4E+01															
2-Mar-10	11	500	435	8.03	3.4E+02	#N/A	8.0E-01	3.2E+01	5.1E+01	0.0E+00	2.2E-01	7.9E+01	2.8E-02	1.8E-03	1.6E-03	1.8E-02	4.4E-06	2.2E-06	2.2E-02	7.8E-06	2.6E+01	4.4E-05	3.9E-05	7.7E-04
9-Mar-10	12	500	320	7.87	3.7E+02				4.4E+01															
16-Mar-10	13	500	500	7.61	2.9E+02	#N/A	2.2E+00	3.6E+01	4.5E+01	0.0E+00	2.5E-01	8.5E+01	3.6E-02	1.7E-03	1.6E-03	2.1E-02	5.0E-06	2.5E-06	2.5E-02	2.6E-05	2.8E+01	5.0E-05	5.6E-05	1.1E-03
23-Mar-10	14	500	480	7.90	3.0E+02				5.0E+01															
30-Mar-10	15	500	450	7.94	2.8E+02	#N/A	1.0E+00	3.1E+01	4.3E+01	0.0E+00	2.3E-01	6.4E+01	2.6E-02	1.9E-03	1.7E-03	2.2E-02	4.5E-06	2.3E-06	2.3E-02	3.0E-05	2.1E+01	4.5E-05	4.5E-05	9.4E-04
6-Apr-10	16	500	445	7.87	2.6E+02				2.8E+01															
13-Apr-10	17	500	450	8.00	2.5E+02	#N/A	1.5E+00	3.3E+01	2.9E+01	0.0E+00	2.3E-01	5.6E+01	3.0E-02	2.1E-03	1.4E-03	2.5E-02	4.5E-06	2.3E-06	2.3E-02	1.6E-05	1.8E+01	4.5E-05	4.4E-05	1.1E-03
20-Apr-10	18	500	445	7.94	2.5E+02				3.3E+01															
27-Apr-10	19	500	465	7.95	2.3E+02	#N/A	1.4E+00	3.1E+01	2.8E+01	0.0E+00	2.3E-01	5.4E+01	3.2E-02	2.2E-03	1.5E-03	2.9E-02	4.7E-06	2.3E-06	2.3E-02	1.8E-05	1.8E+01	4.7E-05	3.2E-05	1.1E-03
4-May-10	20	500	460	7.86	2.1E+02				2.7E+01															
11-May-10	21	500	445	8.03	2.2E+02	#N/A	9.6E-01	3.0E+01	2.1E+01	0.0E+00	2.2E+00	4.5E+01	3.2E-03	2.4E-03	1.5E-03	3.3E-02	4.5E-06	2.2E-06	2.2E-02	9.8E-06	1.5E+01	4.5E-05	1.9E-05	3.6E-04
18-May-10	22	500	445	7.79	2.1E+02				1.8E+01															
25-May-10	23	500	455	7.80	1.9E+02	#N/A	2.0E+00	3.0E+01	1.1E+01	0.0E+00	2.3E-01	4.6E+01	3.0E-02	2.1E-03	1.7E-03	3.5E-02	4.6E-06	2.3E-06	2.3E-02	1.1E-05	1.5E+01	4.6E-05	2.2E-05	6.6E-04
1-Jun-10	24	500	435	7.88	1.9E+02				7.8E+00															
8-Jun-10	25	500	480	7.95	2.0E+02	#N/A	1.4E+00	3.6E+01	1.0E+01	0.0E+00	2.4E-01	4.9E+01	2.8E-02	2.2E-03	1.6E-03	4.4E-02	4.8E-06	2.4E-06	2.4E-02	1.2E-05	1.6E+01	4.3E-04	3.0E-05	9.5E-04
15-Jun-10	26	500	450	7.90	1.8E+02				8.6E+00															
22-Jun-10	27	500	430	8.07	1.7E+02	#N/A	7.9E-01	2.7E+01	1.2E+01	0.0E+00	2.2E-01	3.4E+01	2.6E-02	1.8E-03	1.4E-03	3.6E-02	4.3E-06	2.2E-06	2.2E-02	1.0E-05	1.1E+01	4.3E-05	2.1E-05	9.2E-04
29-Jun-10	28	500	440	7.79	1.7E+02				9.7E+00															
6-Jul-10	29	500	470	7.89	1.6E+02	#N/A	1.1E+00	3.0E+01	8.5E+00	0.0E+00	2.4E-01	3.9E+01	2.7E-02	1.6E-03	1.4E-03	4.1E-02	4.7E-06	2.4E-06	2.4E-02	6.6E-06	1.3E+01	4.7E-05	1.8E-05	8.7E-04
13-Jul-10	30	500	460	7.81	1.6E+02				5.1E+00															
20-Jul-10	31	500	465	7.85	1.6E+02	#N/A	1.7E+00	3.1E+01	8.4E+00	0.0E+00	1.4E+00	3.5E+01	2.3E-02	1.4E-03	1.3E-03	4.5E-02	4.7E-06	2.3E-06	2.3E-02	1.2E-05	1.2E+01	4.7E-05	2.0E-05	9.5E-04
27-Jul-10	32	500	440	7.70	1.6E+02				9.2E+00															
3-Aug-10	33	500	440	7.99	1.5E+02	#N/A	1.4E+00	2.9E+01	7.0E+00	0.0E+00	2.2E-01	3.4E+01	2.5E-02	1.3E-03	1.3E-03	4.8E-02	4.4E-06	2.2E-06	2.2E-02	5.7E-06	1.1E+01	4.4E-05	1.3E-05	5.5E-04
10-Aug-10	34	500	435	7.83	1.5E+02				1.0E+01															
17-Aug-10	35	500	430	8.01	1.5E+02	#N/A	1.2E+00	2.7E+01	6.5E+00	0.0E+00	4.7E-01	3.1E+01	2.9E-02	1.3E-03	1.3E-03	4.5E-02	4.3E-06	2.2E-06	2.2E-02	9.5E-06	1.0E+01	4.3E-05	1.0E-05	6.7E-04
24-Aug-10	36	500	485	7.86	1.6E+02				1.9E+01															
31-Aug-10	37	500	500	8.00	1.4E+02	#N/A	2.9E+00	3.5E+01	1.0E+01	0.0E+00	2.5E-01	3.6E+01	2.5E-02	1.4E-03	1.4E-03	5.8E-02	5.0E-06	2.5E-06	2.5E-02	8.5E-06	1.2E+01	5.0E-05	2.0E-05	5.4E-04
7-Sep-10	38	500	450	7.60	1.5E+02				9.0E+00															
14-Sep-10	39	500	435	7.74	1.4E+02	#N/A	1.4E+00	2.8E+01	7.8E+00	0.0E+00	2.2E-01	3.2E+01	2.5E-02	1.0E-03	1.2E-03	4.8E-02	4.4E-06	2.2E-06	2.2E-02	1.4E-04	1.1E+01	4.4E-05	1.6E-05	1.2E-03
21-Sep-10	40	500	465	7.80	1.3E+02				9.3E+00															
28-Sep-10	41	500	425	7.89	1.5E+02	#N/A	1.1E+00	2.8E+01	1.0E+01	0.0E+00	3.4E-01	3.2E+01	2.8E-02	1.2E-03	1.6E-03	5.3E-02	4.3E-06	2.1E-06	2.1E-02	7.2E-06	1.0E+01	4.3E-05	1.4E-05	5.4E-04
5-Oct-10	42	500	395	7.71	1.5E+02				9.9E+00															
12-Oct-10	43	500	490	7.87	1.7E+02	#N/A	1.4E+00	3.6E+01	1.1E+01	0.0E+00	2.5E-01	4.1E+01	3.1E-02	1.2E-03	1.4E-03	7.9E-02	4.9E-06	2.5E-06	2.5E-02	7.4E-06	1.4E+01	4.9E-05	1.4E-05	6.4E-04
19-Oct-10	44	500	415	7.73	1.6E+02				9.1E+00															
26-Oct-10	45	500	485	7.82	1.5E+02	#N/A	1.3E+00	3.2E+01	9.2E+00	0.0E+00	2.4E-01	3.5E+01	2.8E-02	8.9E-04	1.2E-03	7.3E-02	4.9E-06	2.4E-06	2.4E-02	3.9E-06	1.2E+01	4.9E-05	2.0E-05	4.2E-04
2-Nov-10	46	500	440	7.81	1.5E+02																			
9-Nov-10	47	500	485	7.93	1.8E+02																			
16-Nov-10	48	500	385	7.93	1.4E+02																			
23-Nov-10	49	500	515	7.74	1.5E+02	#N/A	1.5E+00	3.5E+01	9.8E+00	0.0E+00	2.6E-01	3.7E+01	2.9E-02	9.6E-04	1.2E-03	9.3E-02	5.2E-06	2.6E-06	2.6E-02	1.8E-05	1.2E+01	5.2E-05	1.8E-05	6.8E-04
30-Nov-10	50	500	445	7.71	1.4E+02																			
7-Dec-10	51	500	415	7.70	1.5E+02																			
14-Dec-10	52	500	425	7.58	1.4E+02																			
21-Dec-10	53	500	395	7.71	1.5E+02	#N/A	2.2E+00	2.5E+01	7.9E+00	0.0E+00	2.0E-01	2.6E+01	2.1E-02	6.7E-04	9.7E-04	7.3E-02	4.0E-06	2.0E-06	2.0E-02	4.7E-06	8.6E+00	4.0E-05	1.3E-05	4.7E-04
28-Dec-10	54	500	480	7.53	1.2E+02																			
4-Jan-11	55	500	435	7.71	1.3E+02																			
11-Jan-11	56	500	410	7.64	1.3E+02																			
18-Jan-11	57	500	410	7.76	1.4E+02	#N/A	1.4E+00	2.4E+01	7.8E+00	0.0E+00	2.1E-01	2.9E+01	2.5E-02	7.1E-04	1.0E-03	7.1E-02	4.1E-06	2.1E-06	2.1E-02	5.7E-06	9.7E+00	4.1E-05	2.2E-05	5.0E-04
25-Jan-11	58	500	390	7.62	1.4E+02																			
1-Feb-11	59	500	435	7.81	1.4E+02																			
8-Feb-11	60	500	430	7.75	1.3E+02																			
15-Feb-11	61	500	400	7.76	1.4E+02	#N/A	1.2E+00	2.4E+01	4.8E+00	0.0E+00	7.2E-01	2.4E+01	2.1E-02	5.8E-04	8.9E-04	6.5E-02	4.0E-06	2.0E-06	2.0E-02	6.4E-06	7.9E+00	4.0E-05	1.8E-05	4.7E-04
22-Feb-11	62	500	465	7.74	1.5E+02																			
1-Mar-11	63	500	445	7.86	1.5E+02																			
8-Mar-11	64	500	435	7.66	1.5E+02																			
15-Mar-11	65	500	425	7.84	1.4E+02	#N/A	1.2E+00	2.6E+01	5.1E+00	0.0E+00	2.1E-01	3.1E+01	2.2E-02	6.0E-04	9.1E-04	7.4E-02	4.3E-06	2.1E-06	2.1E-02	1.1E-05	1.0E+01	4.3E-05	1.7E-05	6.5E-04
22-Mar-11	66	500	450	7.68	1.4E+02																			
29-Mar-11	67	500	465	7.91	1.5E+02																			

T4

Sample = KM 2459-10 Comp 1 + KM2459-09 Comp 2 + KM2459-08 Comp 3

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Fluoride	Chloride	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output		umhos/cm	(pH 4.5)	(pH 8.3)					CaCO3												
						mgCaCO3/kg	mgCaCO3/kg	mgCaCO3/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
5-Apr-11	68	500	430	7.62	1.5E+02																			
12-Apr-11	69	500	435	7.73	1.4E+02	#N/A	1.7E+00	2.6E+01	7.0E+00	0.0E+00	6.1E-01	2.9E+01	2.2E-02	5.4E-04	8.6E-04	7.6E-02	4.4E-06	2.2E-06	2.2E-02	6.1E-06	9.2E+00	4.4E-05	1.3E-05	1.2E-03
19-Apr-11	70	500	451	7.60	1.4E+02																			
26-Apr-11	71	500	410	7.87	1.5E+02																			
3-May-11	72	500	450	7.73	1.4E+02																			
10-May-11	73	500	435	7.84	1.4E+02	#N/A	1.5E+00	2.8E+01	7.4E+00	0.0E+00	2.2E-01	2.9E+01	2.2E-02	5.3E-04	8.9E-04	7.3E-02	4.4E-06	1.2E-05	2.2E-02	2.2E-06	9.3E+00	4.4E-05	9.6E-06	6.7E-04
17-May-11	74	500	415	7.85	1.4E+02																			
24-May-11	75	500	395	7.76	1.4E+02																			
31-May-11	76	500	335	7.66	1.4E+02																			
7-Jun-11	77	500	380	7.91	1.5E+02	#N/A	1.0E+00	2.3E+01	6.5E+00	0.0E+00	2.3E-01	2.7E+01	2.1E-02	4.8E-04	8.5E-04	6.6E-02	3.8E-06	1.9E-06	1.9E-02	2.2E-05	8.6E+00	1.1E-04	1.5E-05	7.5E-04
14-Jun-11	78	500	400	7.83	1.4E+02																			
21-Jun-11	79	500	450	8.05	1.5E+02																			
28-Jun-11	80	500	415	7.92	1.5E+02																			
5-Jul-11	81	500	415	7.78	1.4E+02	#N/A	1.8E+00	2.6E+01	8.3E+00	0.0E+00	2.1E-01	2.9E+01	2.2E-02	4.8E-04	1.1E-03	7.4E-02	4.2E-06	2.1E-06	2.1E-02	4.6E-06	9.1E+00	4.2E-05	3.7E-05	6.2E-04
12-Jul-11	82	500	425	7.71	1.4E+02																			
19-Jul-11	83	500	430	7.81	1.5E+02																			
26-Jul-11	84	500	425	7.76	1.5E+02																			
2-Aug-11	85	500	405	7.91	1.3E+02	#N/A	2.2E+00	2.3E+01	7.3E+00	4.5E-02	5.3E-01	2.5E+01	2.0E-02	4.2E-04	7.7E-04	6.7E-02	4.1E-06	2.0E-06	2.0E-02	8.5E-06	8.0E+00	4.1E-05	1.2E-05	5.1E-04
9-Aug-11	86	500	440	7.74	1.4E+02																			
16-Aug-11	87	500	440	7.85	1.4E+02																			
23-Aug-11	88	500	415	7.67	1.4E+02																			
30-Aug-11	89	500	435	7.83	1.4E+02	#N/A	2.7E+00	2.6E+01	9.1E+00	5.2E-02	2.2E-01	2.9E+01	2.2E-02	4.8E-04	8.5E-04	7.9E-02	4.4E-06	2.2E-06	2.2E-02	3.0E-06	9.1E+00	4.4E-05	1.8E-05	4.5E-04
6-Sep-11	90	500	415	7.61	1.4E+02																			
13-Sep-11	91	500	405	7.87	1.3E+02																			
20-Sep-11	92	500	440	7.74	1.4E+02																			
27-Sep-11	93	500	440	7.76	1.4E+02	#N/A	2.7E+00	2.6E+01	1.0E+01	4.8E-02	3.5E-01	2.9E+01	2.1E-02	4.3E-04	8.6E-04	7.6E-02	8.8E-06	2.2E-06	2.2E-02	2.4E-05	8.8E+00	4.4E-05	1.3E-05	3.7E-04
4-Oct-11	94	500	455	7.77	1.4E+02																			
11-Oct-11	95	500	420	7.82	1.4E+02																			
18-Oct-11	96	500	420	7.78	1.4E+02																			
25-Oct-11	97	500	405	7.71	1.3E+02	#N/A	1.7E+00	2.0E+01	8.1E+00	4.5E-02	2.0E-01	2.4E+01	2.0E-02	3.7E-04	7.8E-04	6.3E-02	4.1E-06	2.0E-06	2.0E-02	5.3E-06	7.2E+00	4.1E-05	1.3E-05	5.1E-04
1-Nov-11	98	500	455	7.75	1.4E+02																			
8-Nov-11	99	500	445	7.76	1.4E+02																			
15-Nov-11	100	500	415	7.69	1.4E+02																			
22-Nov-11	101	500	445	7.80	1.4E+02	#N/A	2.6E+00	2.7E+01	8.0E+00	4.5E-02	2.2E-01	3.1E+01	2.0E-02	4.0E-04	9.0E-04	8.3E-02	4.5E-06	2.2E-06	2.2E-02	2.8E-05	9.2E+00	4.5E-05	1.2E-05	6.5E-04
29-Nov-11	102	500	425	7.77	1.4E+02																			
6-Dec-11	103	500	495	7.57	1.4E+02																			
13-Dec-11	104	500	475	7.78	1.5E+02																			
20-Dec-11	105	500	495	7.83	1.4E+02	#N/A	2.8E+00	3.0E+01	8.9E+00	5.9E-02	2.5E-01	3.3E+01	3.4E-02	4.6E-04	8.2E-04	9.6E-02	5.0E-06	2.5E-06	2.5E-02	3.5E-06	9.8E+00	5.0E-05	1.2E-05	4.6E-04
27-Dec-11	106	500	480	7.78	1.4E+02																			
3-Jan-12	107	500	415	7.68	1.3E+02																			
10-Jan-12	108	500	475	7.70	1.5E+02																			
17-Jan-12	109	500	495	7.72	1.4E+02	#N/A	1.5E+00	3.4E+01	1.1E+01	5.4E-02	2.5E-01	3.3E+01	2.4E-02	5.0E-04	8.3E-04	8.7E-02	5.0E-06	2.5E-06	2.5E-02	2.5E-06	9.3E+00	5.0E-05	1.3E-05	5.7E-04
24-Jan-12	110	500	480	7.76	1.5E+02																			
31-Jan-12	111	500	505	7.58	1.5E+02																			
7-Feb-12	112	500	430	7.75	1.6E+02																			
14-Feb-12	113	500	435	7.81	1.5E+02	#N/A	2.2E+00	2.6E+01	1.5E+01	4.8E-02	4.4E-01	3.0E+01	1.9E-02	5.0E-04	8.5E-04	8.6E-02	4.4E-06	2.2E-06	2.2E-02	2.2E-06	8.5E+00	4.4E-05	7.4E-06	4.0E-04
21-Feb-12	114	500	440	7.73	1.6E+02																			
28-Feb-12	115	500	445	7.62	1.5E+02																			
6-Mar-12	116	500	440	7.67	1.6E+02																			
13-Mar-12	117	500	410	7.74	1.4E+02	#N/A	1.5E+00	2.2E+01	8.6E+00	4.1E-02	2.1E-01	2.7E+01	1.6E-02	4.3E-04	6.2E-04	6.6E-02	4.1E-06	2.1E-06	2.1E-02	4.9E-06	7.6E+00	4.1E-05	9.8E-06	5.9E-04
20-Mar-12	118	500	450	7.72	1.6E+02																			
27-Mar-12	119	500	440	7.63	1.6E+02																			
3-Apr-12	120	500	450	7.74	1.5E+02																			
10-Apr-12	121	500	425	7.74	1.5E+02	#N/A	1.3E+00	2.3E+01	1.4E+01	2.1E-01	4.7E-02	3.2E+01	1.8E-02	5.0E-04	6.0E-04	7.4E-02	4.3E-06	2.1E-06	2.1E-02	8.1E-06	8.9E+00	4.3E-05	6.4E-06	3.5E-04
17-Apr-12	122	500	435	7.77	1.6E+02																			
24-Apr-12	123	500	420	7.68	1.5E+02																			
1-May-12	124	500	475	7.62	1.6E+02																			
8-May-12	125	500	445	7.70	1.4E+02	#N/A	1.5E+00	2.3E+01	1.1E+01	4.0E-02	2.2E-01	2.8E+01	1.9E-02	4.3E-04	6.5E-04	6.8E-02	4.5E-06	2.2E-06	2.2E-02	1.6E-05	7.5E+00	4.5E-05	6.2E-06	4.2E-04
15-May-12	126	500	480	7.85	1.6E+02																			
22-May-12	127	500	450	7.65	1.5E+02																			
29-May-12	128	500	510	7.75	1.5E+02																			
5-Jun-12	129	500	475	7.62	1.4E+02	#N/A	1.7E+00	2.5E+01	1.1E+01	4.5E-02	2.5E-01	3.0E+01	2.4E-02	4.2E-04	7.0E-04	7.6E-02	4.8E-06	2.4E-06	2.4E-02	6.5E-06	7.6E+00	4.8E-05	7.2E-06	4.3E-04
12-Jun-12	130	500	460	7.74	1.6E+02																			
19-Jun-12	131	500	480	7.65	1.5E+02																			
26-Jun-12	132	500	455	7.84	1.7E+02																			
3-Jul-12	133	500	475	7.52	1.6E+02	#N/A	4.0E+00	2.9E+01	1.1E+01	5.2E-02	2.4E-01	3.4E+01	1.7E-02	4.6E-04	7.2E-04	7.6E-02	4.8E-06	2.4E-06	2.4E-02	5.0E-06	8.7E+00	4.8E-05	8.1E-06	6.7E-04
10-Jul-12	134	500	470	7.70	1.7E+02																			
17-Jul-12	135	500	440	7.66	1.4E+02																			

T4

Sample = KM 2459-10 Comp 1 + KM2459-09 Comp 2 + KM2459-08 Comp 3

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Fluoride	Chloride	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output		umhos/cm	(pH 4.5)	(pH 8.3)					CaCO3												
						mgCaCO3/kg	mgCaCO3/kg	mgCaCO3/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
24-Jul-12	136	500	495	7.73	1.6E+02																			
31-Jul-12	137	500	470	7.75	1.4E+02	#N/A	1.5E+00	2.5E+01	9.4E+00	5.2E-02	2.4E-01	3.3E+01	3.7E-02	4.0E-04	7.8E-04	7.1E-02	4.7E-06	2.4E-06	2.4E-02	4.2E-06	8.6E+00	4.7E-05	7.1E-06	3.6E-04
7-Aug-12	138	500	455	7.75	1.6E+02																			
14-Aug-12	139	500	465	7.61	1.4E+02																			
21-Aug-12	140	500	475	7.60	1.6E+02																			
28-Aug-12	141	500	455	7.60	1.3E+02	#N/A	1.8E+00	2.0E+01	1.2E+01	4.4E-02	2.3E-01	2.8E+01	3.8E-02	3.3E-04	6.3E-04	5.6E-02	4.6E-06	2.3E-06	2.3E-02	7.7E-06	6.9E+00	4.6E-05	1.2E-05	5.0E-04
4-Sep-12	142	500	460	7.58	1.5E+02																			
11-Sep-12	143	500	475	7.55	1.5E+02																			
18-Sep-12	144	500	435	7.68	1.8E+02																			
25-Sep-12	145	500	520	7.64	1.9E+02	#N/A	1.8E+00	2.7E+01	2.7E+01	5.1E-02	2.6E-01	4.8E+01	1.6E-02	4.1E-04	6.6E-04	6.7E-02	5.2E-06	2.6E-06	2.6E-02	3.6E-06	1.2E+01	9.9E-05	8.8E-06	5.8E-04
2-Oct-12	146	500	460	7.60	1.5E+02																			
9-Oct-12	147	500	440	7.39	1.9E+02																			
16-Oct-12	148	500	465	7.53	1.9E+02																			
23-Oct-12	149	500	460	7.56	1.8E+02	#N/A	1.5E+00	2.1E+01	2.5E+01	2.9E-01	2.3E-01	3.9E+01	1.5E-02	3.3E-04	6.1E-04	3.9E-02	4.6E-06	2.3E-06	2.3E-02	6.4E-06	9.2E+00	4.6E-05	8.7E-06	5.8E-04
30-Oct-12	150	500	450	7.61	1.6E+02																			
6-Nov-12	151	500	435	7.51	1.4E+02																			
13-Nov-12	152	500	460	7.47	1.6E+02																			
20-Nov-12	153	500	455	7.56	1.5E+02	#N/A	3.9E+00	2.2E+01	1.6E+01	4.4E-02	2.3E-01	3.4E+01	1.8E-02	3.0E-04	5.5E-04	3.7E-02	4.6E-06	2.3E-06	2.3E-02	3.6E-06	8.0E+00	4.6E-05	8.2E-06	4.4E-04
27-Nov-12	154	500	470	7.41	1.7E+02																			
4-Dec-12	155	500	485	7.56	1.4E+02																			
11-Dec-12	156	500	420	7.42	1.5E+02																			
18-Dec-12	157	500	415	7.49	1.5E+02	#N/A	1.4E+00	1.8E+01	1.7E+01	5.0E-02	2.1E-01	3.1E+01	1.4E-02	2.6E-04	5.6E-04	3.5E-02	4.2E-06	2.1E-06	2.1E-02	3.3E-06	7.3E+00	4.2E-05	4.2E-06	2.6E-04
25-Dec-12	158	500	435	7.41	1.7E+02																			
1-Jan-13	159	500	445	7.56	1.5E+02																			
8-Jan-13	160	500	455	7.46	1.6E+02																			
15-Jan-13	161	500	420	7.49	1.4E+02	#N/A	1.5E+00	2.0E+01	1.7E+01	4.0E-02	2.6E-01	3.1E+01	1.4E-02	2.5E-04	4.9E-04	3.5E-02	4.2E-06	2.1E-06	2.1E-02	3.4E-06	7.1E+00	4.2E-05	7.1E-06	7.0E-04
22-Jan-13	162	500	440	7.45	1.4E+02																			
29-Jan-13	163	500	475	7.59	1.8E+02																			
5-Feb-13	164	500	465	7.57	1.9E+02																			
12-Feb-13	165	500	450	7.52	1.9E+02	#N/A	2.8E+00	2.1E+01	2.6E+01	5.0E-02	2.5E-01	4.2E+01	1.2E-02	2.9E-04	4.8E-04	4.2E-02	4.5E-06	2.3E-06	2.3E-02	4.5E-06	9.8E+00	4.5E-05	1.7E-05	5.7E-04
19-Feb-13	166	500	480	7.64	1.8E+02																			
26-Feb-13	167	500	440	7.41	1.9E+02																			
5-Mar-13	168	500	420	7.53	1.6E+02																			
12-Mar-13	169	500	455	7.46	2.2E+02	#N/A	2.7E+00	2.1E+01	2.2E+01	5.0E-02	3.2E-01	4.1E+01	1.3E-02	2.6E-04	5.1E-04	4.2E-02	4.6E-06	2.3E-06	2.3E-02	5.5E-06	9.5E+00	4.6E-05	1.1E-05	3.5E-04
19-Mar-13	170	500	425	7.58	1.7E+02																			
26-Mar-13	171	500	460	7.49	1.9E+02																			
2-Apr-13	172	500	435	7.55	1.7E+02																			
9-Apr-13	173	500	450	7.58	2.2E+02	#N/A	2.7E+00	2.0E+01	2.4E+01	5.0E-02	2.3E-01	3.9E+01	1.2E-02	2.4E-04	4.7E-04	3.9E-02	4.5E-06	3.6E-06	2.3E-02	5.0E-06	8.8E+00	4.5E-05	9.9E-06	3.5E-04
16-Apr-13	174	500	440	7.55	1.8E+02																			
23-Apr-13	175	500	425	7.42	2.0E+02																			
30-Apr-13	176	500	440	7.58	1.8E+02																			
7-May-13	177	500	465	7.78	2.1E+02	#N/A	4.2E+00	2.1E+01	2.6E+01	4.7E-02	2.3E-01	4.5E+01	1.2E-02	2.4E-04	4.5E-04	3.7E-02	4.7E-06	2.3E-06	2.3E-02	7.4E-06	1.0E+01	4.7E-05	9.8E-06	4.6E-04
14-May-13	178	500	440	7.64	1.8E+02																			
21-May-13	179	500	435	7.51	2.0E+02																			
28-May-13	180	500	460	7.51	1.8E+02																			
4-Jun-13	181	500	450	7.58	1.9E+02	#N/A	2.3E+00	2.0E+01	2.3E+01	5.4E-02	2.3E-01	3.9E+01	1.1E-02	2.3E-04	4.4E-04	3.3E-02	4.5E-06	2.3E-06	2.3E-02	7.2E-06	8.7E+00	7.2E-05	1.0E-05	3.1E-04
11-Jun-13	182	500	445	7.51	1.8E+02																			
18-Jun-13	183	500	435	7.41	1.8E+02																			
25-Jun-13	184	500	440	7.53	1.7E+02																			
2-Jul-13	185	500	420	7.55	1.9E+02	#N/A	3.6E+00	2.0E+01	2.2E+01	4.6E-02	2.1E-01	3.4E+01	1.1E-02	2.1E-04	4.0E-04	2.9E-02	4.2E-06	2.1E-06	2.1E-02	4.6E-06	7.7E+00	4.2E-05	8.8E-06	2.5E-04
9-Jul-13	186	500	405	7.61	1.7E+02																			
16-Jul-13	187	500	430	7.52	1.9E+02																			
23-Jul-13	188	500	445	7.52	1.5E+02																			
30-Jul-13	189	500	435	7.63	1.8E+02	#N/A	2.2E+00	1.7E+01	2.1E+01	5.2E-02	2.2E-01	3.4E+01	1.2E-02	2.0E-04	4.2E-04	3.2E-02	4.4E-06	2.2E-06	2.2E-02	3.9E-06	7.8E+00	4.4E-05	1.2E-05	3.4E-04
6-Aug-13	190	500	425	7.58	1.7E+02																			
13-Aug-13	191	500	445	7.52	1.9E+02																			
20-Aug-13	192	500	430	7.52	1.9E+02																			
27-Aug-13	193	500	425	7.73	2.0E+02	#N/A	1.5E+00	1.8E+01	2.2E+01	4.7E-02	2.1E-01	3.8E+01	1.0E-02	1.9E-04	3.9E-04	3.3E-02	4.3E-06	2.1E-06	2.1E-02	4.7E-06	8.8E+00	4.3E-05	1.3E-05	3.1E-04
3-Sep-13	194	500	440	7.55	1.8E+02																			
10-Sep-13	195	500	445	7.47	2.0E+02																			
17-Sep-13	196	500	410	7.61	1.8E+02																			
24-Sep-13	197	500	435	7.80	2.0E+02	#N/A	1.1E+00	1.6E+01	2.3E+01	5.2E-02	2.2E-01	3.9E+01	1.3E-02	1.9E-04	4.2E-04	3.1E-02	4.4E-06	2.2E-06	2.2E-02	2.2E-06	9.2E+00	4.4E-05	8.3E-06	3.6E-04
1-Oct-13	198	500	430	7.63	1.8E+02																			
8-Oct-13	199	500	425	7.57	2.0E+02																			
15-Oct-13	200	500	405	7.54	1.8E+02																			
22-Oct-13	201	500	435	7.82	2.0E+02	#N/A	1.5E+00	1.6E+01	2.5E+01	4.8E-02	2.6E-01	4.1E+01	1.1E-02	1.8E-04	3.7E-04	3.0E-02	4.4E-06	2.2E-06	2.2E-02	3.9E-06	9.2E+00	4.4E-05	9.6E-06	5.0E-04
29-Oct-13	202	500	430	7.65	2.0E+02																			
5-Nov-13	203	500	460	7.66	1.9E+02																			

T4

Sample = KM 2459-10 Comp 1 + KM2459-09 Comp 2 + KM2459-08 Comp 3

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Fluoride	Chloride	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output		umhos/cm	(pH 4.5)	(pH 8.3)					CaCO3												
						mgCaCO3/kg	mgCaCO3/kg	mgCaCO3/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
12-Nov-13	204	500	435	7.62	2.4E+02																			
19-Nov-13	205	500	450	7.81	2.1E+02	#N/A	8.1E-01	1.7E+01	2.2E+01	4.2E-02	2.3E-01	4.0E+01	1.5E-02	1.7E-04	3.6E-04	3.1E-02	4.5E-06	2.3E-06	2.3E-02	4.1E-06	8.8E+00	4.5E-05	1.1E-05	3.4E-04
26-Nov-13	206	500	440	7.81	2.1E+02																			
3-Dec-13	207	500	450	7.91	2.0E+02																			
10-Dec-13	208	500	420	7.77	2.0E+02																			
17-Dec-13	209	500	435	7.91	2.2E+02	#N/A	1.0E+00	1.6E+01	2.5E+01	5.2E-02	2.2E-01	4.3E+01	1.1E-02	1.7E-04	3.7E-04	2.8E-02	4.4E-06	2.2E-06	2.2E-02	6.1E-06	9.7E+00	4.4E-05	1.2E-05	3.8E-04
24-Dec-13	210	500	420	7.62	2.2E+02																			
31-Dec-13	211	500	405	7.71	2.1E+02																			
7-Jan-14	212	500	435	7.72	2.3E+02																			
14-Jan-14	213	500	435	7.81	2.5E+02	#N/A	1.0E+00	1.6E+01	2.5E+01	4.2E-02	2.2E-01	4.4E+01	1.0E-02	1.6E-04	5.6E-04	2.9E-02	4.4E-06	2.2E-06	2.2E-02	3.9E-06	1.0E+01	4.4E-05	1.1E-05	3.6E-04
21-Jan-14	214	500	455	7.73	2.4E+02																			
28-Jan-14	215	500	415	7.72	2.0E+02																			
4-Feb-14	216	500	430	7.76	2.1E+02																			
11-Feb-14	217	500	475	7.87	2.4E+02	#N/A	1.7E+00	2.4E+01	2.7E+01	5.2E-02	2.4E-01	4.8E+01	8.0E-03	1.8E-04	3.5E-04	3.3E-02	4.8E-06	2.4E-06	2.4E-02	4.8E-06	1.1E+01	4.8E-05	1.4E-05	3.3E-04
18-Feb-14	218	500	440	7.72	2.1E+02																			
25-Feb-14	219	500	420	7.64	2.1E+02	#N/A	1.8E+00	1.6E+01	2.5E+01	5.0E-02	2.1E-01	4.2E+01	7.4E-03	1.4E-04	3.1E-04	2.6E-02	4.2E-06	2.1E-06	2.1E-02	5.0E-06	9.5E+00	4.2E-05	1.0E-05	2.7E-04
4-Mar-14	220	500	445	7.65	1.7E+02	#N/A	2.2E+00	1.8E+01	1.5E+01	3.5E-02	2.2E-01	3.5E+01	3.3E-03	9.7E-05	2.1E-04	1.9E-02	4.5E-06	2.2E-06	2.2E-02	2.7E-06	7.9E+00	2.2E-04	9.8E-06	2.6E-04
11-Mar-14	221	500	475	7.71	1.3E+02	#N/A	8.6E-01	1.9E+01	9.0E+00	4.8E-02	2.4E-01	2.6E+01	5.4E-03	1.0E-04	2.3E-04	1.5E-02	4.8E-06	2.4E-06	2.4E-02	2.4E-06	5.7E+00	4.8E-05	6.2E-06	1.6E-04
18-Mar-14	222	500	480	7.66	9.7E+01	#N/A	2.9E+00	1.7E+01	4.8E+00	4.5E-02	2.4E-01	2.2E+01	6.3E-03	1.0E-04	2.3E-04	1.4E-02	4.8E-06	2.4E-06	2.4E-02	2.4E-06	4.8E+00	4.8E-05	6.7E-06	3.1E-04
25-Mar-14	223	500	450	7.71	9.9E+01	#N/A	1.2E+00	1.6E+01	5.4E+00	3.9E-02	2.3E-01	2.2E+01	4.5E-03	9.8E-05	2.1E-04	1.6E-02	4.5E-06	2.3E-06	2.3E-02	2.3E-06	4.9E+00	4.5E-05	5.0E-06	1.8E-04
1-Apr-14	224	500	460	7.70	9.4E+01																			
8-Apr-14	225	500	520	7.61	1.1E+02																			
15-Apr-14	226	500	475	7.61	9.2E+01																			
22-Apr-14	227	500	470	7.51	9.2E+01	#N/A	1.8E+00	1.6E+01	4.7E+00	4.1E-02	2.4E-01	2.1E+01	6.1E-03	9.0E-05	2.5E-04	2.2E-02	4.7E-06	2.4E-06	2.4E-02	2.4E-06	4.7E+00	4.7E-05	4.7E-06	2.0E-04
29-Apr-14	228	500	455	7.75	8.5E+01																			
6-May-14	229	500	485	7.81	1.0E+02																			
13-May-14	230	500	470	7.65	8.0E+01																			
20-May-14	231	500	495	7.69	7.8E+01	#N/A	3.2E+00	1.5E+01	4.0E+00	3.9E-02	2.5E-01	2.1E+01	5.5E-03	9.8E-05	3.9E-04	2.7E-02	5.0E-06	2.5E-06	2.5E-02	2.5E-06	4.8E+00	5.0E-05	9.9E-06	3.1E-04
27-May-14	232	500	475	7.60	7.5E+01																			
3-Jun-14	233	500	470	7.72	7.7E+01																			
10-Jun-14	234	500	480	7.66	8.0E+01																			
17-Jun-14	235	500	460	7.60	8.5E+01	#N/A	2.7E+00	1.5E+01	5.5E+00	3.7E-02	2.3E-01	2.1E+01	4.4E-03	9.0E-05	2.3E-04	3.2E-02	4.6E-06	2.3E-06	2.3E-02	2.3E-06	4.6E+00	4.6E-05	5.5E-06	9.5E-05
24-Jun-14	236	500	465	7.94	8.9E+01																			
1-Jul-14	237	500	440	7.73	8.8E+01																			
1-Jul-14	237	500	440	7.73	8.8E+01																			
8-Jul-14	238	500	470	7.65	9.0E+01																			
15-Jul-14	239	500	460	7.61	9.1E+01	#N/A	1.1E+00	1.5E+01	4.6E+00	3.3E-02	2.3E-01	2.2E+01	7.8E-03	8.7E-05	2.4E-04	3.3E-02	4.6E-06	2.3E-06	2.3E-02	2.8E-06	4.7E+00	4.6E-05	6.9E-06	1.8E-04
22-Jul-14	240	500	475	7.62	9.5E+01																			
29-Jul-14	241	500	475	7.81	9.3E+01																			
5-Aug-14	242	500	485	7.52	8.2E+01																			
12-Aug-14	243	500	485	7.57	8.2E+01	#N/A	2.4E+00	1.6E+01	3.4E+00	3.9E-02	2.4E-01	2.0E+01	6.5E-03	8.4E-05	2.9E-04	3.4E-02	4.9E-06	2.4E-06	9.7E-03	2.4E-06	4.6E+00	4.9E-05	9.7E-06	8.7E-05
19-Aug-14	244	500	480	7.58	8.7E+01																			
26-Aug-14	245	500	480	7.65	8.3E+01																			
2-Sep-14	246	500	465																					

T4

Sample = KM 2459-10 Comp 1 + KM2459-09 Comp 2 + KM2459-08 Comp 3

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
	No.																							
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
15-Dec-09	0	5.1E-03	5.5E-05	1.4E-03	2.6E+00	4.4E-03	6.4E-05	1.4E-02	4.1E-04	1.8E-01	3.0E+01	3.5E-03	4.1E-01	6.4E-05	8.0E+00	5.2E-01	1.5E+02	5.1E-05	3.6E-03	1.4E-03	4.4E-03	4.6E-04	7.4E-04	2.3E-04
22-Dec-09	1	2.6E-03	4.2E-05	1.6E-03	1.1E+00	6.0E-03	4.7E-05	6.9E-03	1.4E-03	8.6E-02	1.1E+01	7.4E-04	2.2E+00	5.3E-05	2.3E+00	2.0E-01	5.7E+01	3.2E-05	3.5E-03	1.6E-03	1.5E-03	5.3E-04	1.0E-03	2.6E-04
29-Dec-09	2	2.5E-03	1.5E-05	1.5E-03	1.1E+00	5.2E-03	2.5E-05	3.8E-03	6.4E-04	4.1E-02	7.2E+00	5.4E-04	1.5E+00	1.5E-05	8.8E-01	1.3E-01	3.2E+01	2.0E-05	3.8E-03	1.5E-03	1.4E-03	4.9E-04	3.9E-04	2.5E-04
5-Jan-10	3	2.0E-03	2.8E-05	2.5E-04	2.0E+00	8.7E-03	9.9E-06	4.3E-03	1.2E-04	3.2E-02	6.3E+00	5.6E-04	1.7E+00	4.5E-06	6.1E-01	1.3E-01	3.1E+01	2.2E-05	4.7E-03	2.5E-04	2.0E-03	9.9E-05	9.4E-04	5.0E-05
12-Jan-10	4																							
19-Jan-10	5	3.6E-03	5.1E-05	2.2E-04	7.5E+00	2.6E-02	4.5E-06	4.5E-03	1.5E-04	2.9E-01	5.0E+00	1.0E-03	1.4E+00	3.1E-06	4.5E-01	1.9E-01	6.3E+01	1.6E-05	3.3E-03	2.2E-04	5.6E-03	8.9E-05	5.8E-04	4.5E-05
26-Jan-10	6																							
2-Feb-10	7	9.1E-04	2.1E-05	2.3E-04	6.1E+00	2.0E-02	4.6E-06	4.4E-03	1.3E-04	1.6E-02	3.3E+00	1.2E-03	1.6E+00	2.3E-06	2.1E-01	1.3E-01	3.2E+01	1.9E-05	2.9E-03	2.3E-04	5.1E-03	9.1E-05	1.4E-03	4.6E-05
9-Feb-10	8																							
16-Feb-10	9	9.2E-04	1.1E-05	2.3E-04	4.3E+00	1.4E-02	4.6E-06	3.5E-03	6.0E-05	1.5E-02	2.4E+00	9.3E-04	1.5E+00	2.3E-06	1.5E-01	1.0E-01	2.2E+01	1.2E-05	2.8E-03	2.3E-04	3.9E-03	9.2E-05	2.8E-04	4.6E-05
23-Feb-10	10																							
2-Mar-10	11	1.7E-03	1.3E-05	2.2E-04	3.6E+00	1.2E-02	4.4E-06	3.8E-03	8.3E-05	1.6E-02	1.9E+00	9.4E-04	1.4E+00	2.2E-06	1.0E-01	8.7E-02	1.8E+01	1.0E-05	2.7E-03	2.2E-04	3.4E-03	8.7E-05	3.0E-04	4.4E-05
9-Mar-10	12																							
16-Mar-10	13	1.0E-03	9.4E-05	2.5E-04	3.8E+00	1.6E-02	5.0E-06	4.4E-03	1.0E-04	1.7E-02	1.9E+00	1.0E-03	1.6E+00	2.5E-06	1.1E-01	8.9E-02	1.8E+01	1.2E-05	2.4E-03	2.5E-04	3.6E-03	1.0E-04	5.0E-04	5.0E-05
23-Mar-10	14																							
30-Mar-10	15	9.0E-04	5.2E-05	2.3E-04	2.9E+00	1.3E-02	4.5E-06	4.8E-03	1.4E-04	1.5E-02	1.4E+00	1.1E-03	1.4E+00	2.3E-06	9.0E-02	7.1E-02	1.4E+01	1.8E-05	2.6E-03	2.3E-04	2.9E-03	9.0E-05	2.1E-03	4.5E-05
6-Apr-10	16																							
13-Apr-10	17	1.4E-03	3.7E-05	2.3E-04	2.4E+00	1.2E-02	4.5E-06	7.9E-03	1.0E-04	1.5E-02	1.3E+00	8.0E-04	1.4E+00	2.3E-06	7.7E-02	6.3E-02	9.5E+00	9.9E-06	2.6E-03	2.3E-04	2.3E-03	1.4E-04	3.2E-04	4.5E-05
20-Apr-10	18																							
27-Apr-10	19	4.7E-04	8.4E-06	2.3E-04	2.4E+00	1.1E-02	4.7E-06	1.1E-02	7.9E-05	1.8E-02	1.3E+00	7.2E-04	1.5E+00	2.3E-06	7.4E-02	5.9E-02	9.3E+00	7.9E-06	2.3E-03	2.3E-04	1.9E-03	9.3E-05	4.7E-04	4.7E-05
4-May-10	20																							
11-May-10	21	8.9E-04	2.2E-06	2.2E-04	1.9E+00	9.3E-03	4.5E-06	1.1E-02	2.2E-05	1.2E-02	1.1E+00	5.9E-04	1.5E+00	2.2E-06	7.6E-02	5.7E-02	7.6E+00	9.3E-06	2.8E-04	2.2E-04	1.6E-04	8.9E-05	8.9E-05	4.5E-05
18-May-10	22																							
25-May-10	23	3.6E-03	1.5E-05	2.3E-04	1.9E+00	9.0E-03	4.6E-06	7.9E-03	7.7E-05	1.8E-02	1.1E+00	5.3E-04	1.4E+00	2.3E-06	5.9E-02	5.6E-02	6.8E+00	8.6E-06	2.2E-03	2.3E-04	1.6E-03	9.1E-05	4.6E-04	4.6E-05
1-Jun-10	24																							
8-Jun-10	25	9.6E-04	6.3E-04	2.4E-04	2.0E+00	1.1E-02	4.8E-06	6.6E-03	3.4E-05	1.9E-02	1.2E+00	5.2E-04	1.9E+00	2.4E-06	6.2E-02	5.7E-02	5.8E+00	9.6E-06	3.6E-03	2.4E-04	1.5E-03	9.6E-05	3.4E-04	4.8E-05
15-Jun-10	26																							
22-Jun-10	27	4.3E-04	7.7E-06	2.2E-04	1.5E+00	7.1E-03	4.3E-06	5.0E-03	6.5E-05	1.8E-02	9.2E-01	4.7E-04	1.3E+00	2.2E-06	5.6E-02	4.5E-02	5.6E+00	7.7E-06	2.2E-03	2.2E-04	1.1E-03	1.3E-04	3.0E-04	4.3E-05
29-Jun-10	28																							
6-Jul-10	29	4.7E-04	2.4E-05	2.4E-04	1.6E+00	7.8E-03	4.7E-06	3.9E-03	1.1E-04	1.9E-02	9.2E-01	4.7E-04	1.4E+00	2.4E-06	6.1E-02	4.7E-02	4.7E+00	7.1E-06	2.2E-03	2.4E-04	1.1E-03	1.4E-04	3.8E-04	4.7E-05
13-Jul-10	30																							
20-Jul-10	31	9.3E-04	1.7E-05	2.3E-04	1.3E+00	7.5E-03	4.7E-06	3.3E-03	7.9E-05	1.5E-02	7.4E-01	4.8E-04	1.2E+00	2.3E-06	4.7E-02	4.6E-02	4.7E+00	7.4E-06	2.3E-03	2.3E-04	1.1E-03	9.3E-05	3.7E-04	4.7E-05
27-Jul-10	32																							
3-Aug-10	33	4.4E-04	8.8E-06	2.2E-04	1.4E+00	6.9E-03	8.8E-06	3.1E-03	5.3E-05	1.8E-02	7.7E-01	4.8E-04	1.3E+00	2.2E-06	5.7E-02	4.3E-02	4.4E+00	6.6E-06	2.3E-03	2.2E-04	1.1E-03	8.8E-05	3.1E-04	4.4E-05
10-Aug-10	34																							
17-Aug-10	35	4.3E-04	5.2E-06	2.2E-04	1.3E+00	5.8E-03	4.3E-06	2.9E-03	5.2E-05	1.7E-02	7.4E-01	5.1E-04	1.1E+00	2.2E-06	6.9E-02	4.0E-02	4.3E+00	7.7E-06	2.0E-03	2.2E-04	8.9E-04	8.6E-05	1.3E-04	4.3E-05
24-Aug-10	36																							
31-Aug-10	37	5.0E-04	4.2E-05	2.5E-04	1.4E+00	8.6E-03	5.0E-06	3.2E-03	7.5E-05	1.8E-02	7.5E-01	6.6E-04	1.3E+00	2.5E-06	5.0E-02	4.9E-02	5.0E+00	1.1E-05	2.9E-03	2.5E-04	9.2E-04	1.0E-04	3.0E-04	5.0E-05
7-Sep-10	38																							
14-Sep-10	39	2.2E-03	8.7E-06	2.2E-04	1.3E+00	6.3E-03	4.4E-06	2.8E-03	6.1E-05	1.8E-02	6.4E-01	4.8E-04	1.1E+00	2.2E-06	6.1E-02	3.9E-02	4.4E+00	8.7E-06	2.4E-03	3.9E-04	9.4E-04	1.7E-04	1.4E-02	4.4E-05
21-Sep-10	40																							
28-Sep-10	41	1.3E-03	2.0E-05	2.1E-04	1.4E+00	6.7E-03	4.3E-06	3.0E-03	7.7E-05	1.8E-02	7.4E-01	5.1E-04	1.2E+00	2.1E-06	6.4E-02	3.9E-02	4.3E+00	7.7E-06	2.5E-03	2.1E-04	9.9E-04	1.3E-04	3.0E-04	4.3E-05
5-Oct-10	42																							
12-Oct-10	43	4.9E-04	7.4E-06	2.5E-04	1.7E+00	1.0E-02	4.9E-06	3.4E-03	7.4E-05	2.1E-02	8.2E-01	6.0E-04	1.5E+00	2.5E-06	5.9E-02	4.8E-02	4.9E+00	9.3E-06	2.8E-03	2.5E-04	1.3E-03	1.5E-04	2.9E-04	4.9E-05
19-Oct-10	44																							
26-Oct-10	45	4.9E-04	1.4E-05	2.4E-04	1.4E+00	8.1E-03	4.9E-06	2.9E-03	6.3E-05	2.0E-02	6.3E-01	8.8E-04	1.2E+00	2.4E-06	4.9E-02	3.9E-02	4.9E+00	9.2E-06	2.5E-03	2.4E-04	8.9E-04	9.7E-05	1.9E-04	4.9E-05
2-Nov-10	46																							
9-Nov-10	47																							
16-Nov-10	48																							
23-Nov-10	49	5.2E-04	3.5E-05	2.6E-04	1.6E+00	9.8E-03	5.2E-06	4.4E-03	1.3E-04	2.2E-02	6.9E-01	5.0E-04	1.3E+00	2.6E-06	4.6E-02	4.3E-02	5.2E+00	7.7E-06	4.0E-03	2.6E-04	1.2E-03	1.0E-04	2.7E-03	5.2E-05
30-Nov-10	50																							
7-Dec-10	51																							
14-Dec-10	52																							
21-Dec-10	53	4.0E-04	7.5E-06	2.0E-04	1.1E+00	6.8E-03	4.0E-06	3.1E-03	5.5E-05	1.8E-02	5.3E-01	3.4E-04	9.2E-01	2.0E-06	3.2E-02	3.0E-02	4.0E+00	5.5E-06	2.5E-03	2.0E-04	7.8E-04	7.9E-05	2.8E-04	4.0E-05
28-Dec-10	54																							
4-Jan-11	55																							
11-Jan-11	56																							
18-Jan-11	57	8.2E-04	9.4E-06	2.1E-04	1.2E+00	8.0E-03	4.1E-06	3.1E-03	7.0E-05	1.6E-02	4.8E-01	3.9E-04	9.6E-01	2.1E-06	3.7E-02	3.0E-02	4.1E+00	5.7E-06	2.4E-03	2.1E-04	1.0E-02	8.2E-05	2.5E-04	4.1E-05
25-Jan-11	58																							
1-Feb-11	59																							
8-Feb-11	60																							
15-Feb-11	61	1.2E-03	5.2E-06	2.0E-04	1.1E+00	7.1E-03	4.0E-06	2.3E-03	6.8E-05	1.6E-02	4.3E-01	3.8E-04	8.0E-01	2.0E-06	2.8E-02	2.6E-02	4.0E+00	6.8E-06	2.5E-03	2.0E-04	7.2E-04	1.6E-04	2.0E-04	4.0E-05
22-Feb-11	62																							
1-Mar-11	63																							
8-Mar-11	64																							
15-Mar-11	65	4.3E-04	9.8E-06	2.1E-04	1.3E+00	8.2E-03	4.3E-06	2.2E-03	6.4E-05	1.9E-02	4.6E-01	3.6E-04	1.0E+00	2.1E-06	3.0E-02	2.8E-02	4.3E+00	4.3E-06	2.5E-03	2.1E-04	8.7E-04	1.3E-04	3.0E-04	4.3E-05
22-Mar-11	66																							
29-Mar-11	67																							

T4

Sample = KM 2459-10 Comp 1 + KM2459-09 Comp 2 + KM2459-08 Comp 3

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
	No.																							
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
5-Apr-11	68																							
12-Apr-11	69	4.4E-04	1.5E-05	2.2E-04	1.3E+00	9.2E-03	4.4E-06	2.3E-03	4.8E-05	1.8E-02	4.4E-01	3.5E-04	9.2E-01	2.2E-06	3.5E-02	2.8E-02	4.4E+00	3.9E-06	2.2E-03	2.2E-04	8.5E-04	1.7E-04	3.0E-04	4.4E-05
19-Apr-11	70																							
26-Apr-11	71																							
3-May-11	72																							
10-May-11	73	4.4E-04	7.6E-05	2.2E-04	1.3E+00	7.7E-03	4.4E-06	2.4E-03	5.2E-05	1.6E-02	3.8E-01	4.5E-04	9.6E-01	2.2E-06	3.0E-02	2.6E-02	4.4E+00	5.2E-06	2.2E-03	2.2E-04	7.9E-04	1.3E-04	3.0E-04	4.4E-05
17-May-11	74																							
24-May-11	75																							
31-May-11	76																							
7-Jun-11	77	1.9E-03	2.7E-04	1.9E-04	1.3E+00	6.7E-03	3.8E-06	2.6E-03	4.6E-05	1.5E-02	3.7E-01	3.1E-04	8.9E-01	1.9E-06	3.4E-02	2.2E-02	3.8E+00	4.6E-06	1.8E-03	1.9E-04	8.4E-04	1.9E-04	7.6E-04	3.8E-05
14-Jun-11	78																							
21-Jun-11	79																							
28-Jun-11	80																							
5-Jul-11	81	4.2E-04	7.1E-06	2.1E-04	1.6E+00	7.6E-03	4.2E-06	2.2E-03	6.2E-05	1.8E-02	4.1E-01	4.0E-04	9.8E-01	2.1E-06	2.9E-02	2.4E-02	4.2E+00	7.5E-06	2.0E-03	2.1E-04	8.4E-04	1.2E-04	2.5E-04	4.2E-05
12-Jul-11	82																							
19-Jul-11	83																							
26-Jul-11	84																							
2-Aug-11	85	4.1E-04	4.1E-06	2.0E-04	1.3E+00	6.4E-03	4.1E-06	2.3E-03	3.2E-05	1.7E-02	3.4E-01	3.0E-04	9.0E-01	2.0E-06	2.4E-02	2.0E-02	4.1E+00	4.1E-06	2.0E-03	2.0E-04	6.6E-04	1.6E-04	3.2E-04	4.1E-05
9-Aug-11	86																							
16-Aug-11	87																							
23-Aug-11	88																							
30-Aug-11	89	4.4E-04	7.0E-06	2.2E-04	1.6E+00	6.7E-03	4.4E-06	3.8E-03	3.0E-05	1.8E-02	3.8E-01	3.3E-04	9.4E-01	2.2E-06	2.6E-02	2.3E-02	4.4E+00	7.4E-06	1.8E-03	2.2E-04	9.1E-04	1.7E-04	2.2E-04	4.4E-05
6-Sep-11	90																							
13-Sep-11	91																							
20-Sep-11	92																							
27-Sep-11	93	4.4E-04	4.9E-05	2.2E-04	1.7E+00	6.9E-03	4.4E-06	6.4E-03	8.4E-05	1.8E-02	3.7E-01	3.2E-04	8.7E-01	2.2E-06	2.6E-02	2.1E-02	4.4E+00	6.6E-06	2.5E-03	2.2E-04	8.4E-04	1.3E-04	5.6E-03	4.4E-05
4-Oct-11	94																							
11-Oct-11	95																							
18-Oct-11	96																							
25-Oct-11	97	4.1E-04	1.3E-05	2.0E-04	1.5E+00	5.5E-03	4.1E-06	5.9E-03	2.4E-05	1.7E-02	3.1E-01	3.2E-04	7.2E-01	2.0E-06	2.8E-02	1.7E-02	4.1E+00	4.1E-06	1.6E-03	2.0E-04	5.8E-04	1.2E-04	3.2E-04	4.1E-05
1-Nov-11	98																							
8-Nov-11	99																							
15-Nov-11	100																							
22-Nov-11	101	4.5E-04	5.7E-05	2.2E-04	1.9E+00	7.0E-03	4.5E-06	5.7E-03	6.2E-05	1.9E-02	3.6E-01	2.9E-04	8.5E-01	2.2E-06	3.1E-02	2.0E-02	4.5E+00	4.9E-06	2.1E-03	2.2E-04	8.7E-04	1.8E-04	1.3E-03	4.5E-05
29-Nov-11	102																							
6-Dec-11	103																							
13-Dec-11	104																							
20-Dec-11	105	5.0E-04	1.1E-05	2.5E-04	2.1E+00	5.8E-03	5.0E-06	1.2E-02	7.4E-05	1.7E-02	3.5E-01	3.4E-04	8.8E-01	2.5E-06	3.5E-02	2.2E-02	5.0E+00	5.0E-06	2.6E-03	2.5E-04	9.6E-04	3.0E-04	7.4E-04	5.0E-05
27-Dec-11	106																							
3-Jan-12	107																							
10-Jan-12	108																							
17-Jan-12	109	5.0E-04	8.4E-06	2.5E-04	2.4E+00	3.2E-03	5.0E-06	2.3E-02	8.9E-05	2.2E-02	3.8E-01	3.1E-04	8.2E-01	2.5E-06	3.5E-02	2.0E-02	5.0E+00	4.5E-06	2.4E-03	2.5E-04	8.9E-04	3.5E-04	6.9E-04	5.0E-05
24-Jan-12	110																							
31-Jan-12	111																							
7-Feb-12	112																							
14-Feb-12	113	4.4E-04	2.2E-06	2.2E-04	2.2E+00	1.8E-03	4.4E-06	2.4E-02	3.0E-05	2.0E-02	3.4E-01	3.5E-04	7.5E-01	2.2E-06	3.5E-02	1.8E-02	4.4E+00	4.4E-06	2.0E-03	2.2E-04	9.5E-04	1.7E-04	1.7E-04	4.4E-05
21-Feb-12	114																							
28-Feb-12	115																							
6-Mar-12	116																							
13-Mar-12	117	4.1E-03	2.1E-06	2.1E-04	2.0E+00	1.6E-03	4.1E-06	1.8E-02	3.3E-05	1.9E-02	2.9E-01	3.1E-04	6.8E-01	2.1E-06	3.3E-02	1.4E-02	4.1E+00	3.7E-06	1.7E-03	2.1E-04	7.3E-04	1.6E-04	8.2E-05	4.1E-05
20-Mar-12	118																							
27-Mar-12	119																							
3-Apr-12	120																							
10-Apr-12	121	4.3E-04	2.1E-06	2.1E-04	2.3E+00	1.6E-03	4.3E-06	2.2E-02	5.1E-05	1.8E-02	3.1E-01	3.9E-04	8.4E-01	2.1E-06	2.6E-02	1.6E-02	4.3E+00	4.3E-06	2.1E-03	2.1E-04	9.3E-04	1.3E-04	3.4E-04	4.3E-05
17-Apr-12	122																							
24-Apr-12	123																							
1-May-12	124																							
8-May-12	125	1.3E-03	1.1E-05	2.2E-04	2.2E+00	1.5E-03	4.5E-06	1.3E-02	4.3E-05	1.9E-02	3.3E-01	3.9E-04	8.0E-01	2.2E-06	2.7E-02	1.4E-02	4.5E+00	4.9E-06	1.6E-03	2.2E-04	6.7E-04	2.4E-04	1.7E-03	4.5E-05
15-May-12	126																							
22-May-12	127																							
29-May-12	128																							
5-Jun-12	129	1.9E-03	4.0E-06	2.4E-04	2.6E+00	2.3E-03	4.8E-06	1.3E-02	2.9E-05	2.0E-02	3.2E-01	3.6E-04	7.1E-01	2.4E-06	2.6E-02	1.4E-02	4.8E+00	4.1E-06	1.9E-03	2.4E-04	9.5E-04	1.6E-04	1.9E-04	4.8E-05
12-Jun-12	130																							
19-Jun-12	131																							
26-Jun-12	132																							
3-Jul-12	133	4.8E-04	7.3E-06	2.4E-04	3.0E+00	2.6E-03	4.8E-06	1.1E-02	2.8E-05	2.1E-02	3.4E-01	3.8E-04	8.5E-01	2.4E-06	2.7E-02	1.4E-02	4.8E+00	4.3E-06	2.0E-03	2.4E-04	9.2E-04	3.0E-04	2.7E-04	4.8E-05
10-Jul-12	134																							
17-Jul-12	135																							

T4

Sample = KM 2459-10 Comp 1 + KM2459-09 Comp 2 + KM2459-08 Comp 3

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
	No.																							
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
24-Jul-12	136																							
31-Jul-12	137	9.9E-04	8.0E-06	2.4E-04	2.9E+00	2.2E-03	4.7E-06	8.1E-03	2.8E-05	2.2E-02	3.5E-01	3.9E-04	8.5E-01	2.4E-06	2.8E-02	1.4E-02	4.7E+00	5.2E-06	2.4E-03	2.4E-04	7.7E-04	3.2E-04	5.9E-04	4.7E-05
7-Aug-12	138																							
14-Aug-12	139																							
21-Aug-12	140																							
28-Aug-12	141	1.4E-03	1.8E-05	2.3E-04	2.5E+00	1.5E-03	4.6E-06	6.9E-03	7.0E-05	1.8E-02	2.3E-01	7.0E-04	6.8E-01	2.3E-06	8.0E-02	1.1E-02	4.6E+00	1.4E-06	1.7E-03	2.3E-04	5.9E-04	4.8E-04	8.3E-04	4.6E-05
4-Sep-12	142																							
11-Sep-12	143																							
18-Sep-12	144																							
25-Sep-12	145	5.2E-04	3.1E-06	2.6E-04	4.4E+00	2.5E-03	5.2E-06	8.5E-03	7.8E-05	2.2E-02	3.7E-01	3.0E-04	9.2E-01	2.6E-06	4.5E-02	1.6E-02	8.8E+00	5.2E-06	1.9E-03	2.6E-04	1.3E-03	2.2E-04	3.2E-04	5.2E-05
2-Oct-12	146																							
9-Oct-12	147																							
16-Oct-12	148																							
23-Oct-12	149	1.0E-03	5.5E-06	2.3E-04	3.8E+00	1.8E-03	4.6E-06	6.9E-03	3.5E-05	1.9E-02	3.0E-01	3.3E-04	7.7E-01	2.3E-06	2.9E-02	1.1E-02	7.4E+00	3.7E-06	2.0E-03	2.3E-04	8.9E-04	1.7E-04	6.9E-04	4.6E-05
30-Oct-12	150																							
6-Nov-12	151																							
13-Nov-12	152																							
20-Nov-12	153	4.6E-04	5.0E-06	2.3E-04	3.4E+00	1.8E-03	4.6E-06	5.0E-03	6.0E-05	2.3E-02	3.1E-01	2.5E-04	7.2E-01	2.3E-06	2.8E-02	9.6E-03	5.5E+00	3.6E-06	1.5E-03	2.3E-04	7.6E-04	2.0E-04	8.9E-04	4.6E-05
27-Nov-12	154																							
4-Dec-12	155																							
11-Dec-12	156																							
18-Dec-12	157	7.5E-04	3.3E-06	2.1E-04	3.1E+00	1.6E-03	4.2E-06	4.0E-03	3.8E-05	2.1E-02	2.7E-01	2.6E-04	6.6E-01	2.1E-06	2.4E-02	8.3E-03	5.6E+00	3.7E-06	1.6E-03	2.1E-04	6.8E-04	1.9E-04	1.5E-04	4.2E-05
25-Dec-12	158																							
1-Jan-13	159																							
8-Jan-13	160																							
15-Jan-13	161	4.4E-03	3.7E-05	2.1E-04	3.3E+00	1.8E-03	4.2E-06	3.0E-03	7.1E-05	2.0E-02	2.8E-01	1.8E-04	6.4E-01	2.1E-06	2.4E-02	8.3E-03	5.6E+00	2.9E-06	1.6E-03	2.1E-04	6.5E-04	1.6E-04	2.3E-03	4.2E-05
22-Jan-13	162																							
29-Jan-13	163																							
5-Feb-13	164																							
12-Feb-13	165	1.3E-03	6.1E-05	2.3E-04	4.2E+00	3.0E-03	4.5E-06	3.0E-03	1.3E-04	2.0E-02	3.3E-01	1.7E-04	7.0E-01	2.3E-06	5.9E-02	1.1E-02	8.2E+00	4.1E-06	1.6E-03	2.3E-04	1.0E-03	1.9E-04	3.9E-04	4.5E-05
19-Feb-13	166																							
26-Feb-13	167																							
5-Mar-13	168																							
12-Mar-13	169	1.5E-03	2.8E-05	2.3E-04	4.2E+00	3.5E-03	4.6E-06	2.6E-03	3.6E-05	2.0E-02	3.4E-01	2.1E-04	6.8E-01	2.3E-06	3.2E-02	1.0E-02	7.8E+00	2.7E-06	2.0E-03	2.3E-04	9.8E-04	1.5E-04	4.7E-04	4.6E-05
19-Mar-13	170																							
26-Mar-13	171																							
2-Apr-13	172																							
9-Apr-13	173	4.5E-04	4.1E-06	2.3E-04	4.1E+00	3.4E-03	4.5E-06	2.4E-03	3.1E-05	1.6E-02	3.3E-01	2.0E-04	6.6E-01	2.3E-06	2.8E-02	9.5E-03	7.2E+00	3.6E-06	2.0E-03	2.3E-04	8.3E-04	3.2E-04	3.2E-04	4.5E-05
16-Apr-13	174																							
23-Apr-13	175																							
30-Apr-13	176																							
7-May-13	177	4.7E-04	1.1E-05	2.3E-04	4.8E+00	3.4E-03	4.7E-06	2.3E-03	4.3E-05	1.8E-02	3.4E-01	1.9E-04	7.2E-01	2.3E-06	3.3E-02	9.7E-03	9.4E+00	2.8E-06	2.2E-03	2.3E-04	1.0E-03	2.9E-04	3.9E-04	4.7E-05
14-May-13	178																							
21-May-13	179																							
28-May-13	180																							
4-Jun-13	181	2.3E-03	6.3E-06	2.3E-04	4.2E+00	2.5E-03	4.5E-06	2.0E-03	5.7E-04	1.7E-02	3.1E-01	2.3E-04	6.2E-01	4.1E-06	3.0E-02	8.5E-03	7.4E+00	4.1E-06	2.0E-03	2.3E-04	8.4E-04	3.2E-04	2.0E-04	4.5E-05
11-Jun-13	182																							
18-Jun-13	183																							
25-Jun-13	184																							
2-Jul-13	185	4.2E-04	4.6E-06	2.1E-04	3.5E+00	2.1E-03	4.2E-06	1.7E-03	2.7E-05	1.7E-02	2.9E-01	1.9E-04	6.6E-01	2.1E-06	2.4E-02	7.1E-03	6.5E+00	3.4E-06	1.8E-03	2.1E-04	6.6E-04	8.4E-05	2.6E-04	4.2E-05
9-Jul-13	186																							
16-Jul-13	187																							
23-Jul-13	188																							
30-Jul-13	189	4.4E-04	1.0E-05	2.2E-04	3.5E+00	2.6E-03	4.4E-06	1.7E-03	2.9E-05	1.6E-02	3.1E-01	1.8E-04	6.0E-01	2.2E-06	3.2E-02	7.5E-03	6.3E+00	5.2E-06	1.8E-03	2.2E-04	6.7E-04	1.4E-04	2.3E-04	4.4E-05
6-Aug-13	190																							
13-Aug-13	191																							
20-Aug-13	192																							
27-Aug-13	193	2.2E-03	6.0E-06	2.1E-04	3.9E+00	3.4E-03	4.3E-06	1.5E-03	3.6E-05	1.7E-02	3.1E-01	1.6E-04	6.8E-01	2.1E-06	3.0E-02	7.6E-03	8.0E+00	2.6E-06	1.6E-03	2.1E-04	6.6E-04	1.4E-04	2.5E-04	4.3E-05
3-Sep-13	194																							
10-Sep-13	195																							
17-Sep-13	196																							
24-Sep-13	197	4.4E-04	7.8E-06	2.2E-04	3.8E+00	3.5E-03	4.4E-06	1.4E-03	3.2E-05	1.6E-02	3.1E-01	1.5E-04	7.0E-01	2.2E-06	3.3E-02	7.5E-03	7.5E+00	2.6E-06	1.6E-03	2.2E-04	6.5E-04	1.6E-04	2.0E-04	4.4E-05
1-Oct-13	198																							
8-Oct-13	199																							
15-Oct-13	200																							
22-Oct-13	201	4.8E-04	2.1E-05	2.2E-04	4.2E+00	4.4E-03	8.7E-07	1.4E-03	4.5E-05	1.5E-02	3.2E-01	1.2E-04	6.7E-01	2.2E-06	2.8E-02	7.7E-03	8.2E+00	3.0E-06	1.7E-03	2.2E-04	6.4E-04	1.7E-04	2.0E-04	4.4E-05
29-Oct-13	202																							
5-Nov-13	203																							

T4

Sample = KM 2459-10 Comp 1 + KM2459-09 Comp 2 + KM2459-08 Comp 3

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
	No.																							
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
12-Nov-13	204																							
19-Nov-13	205	4.5E-04	9.0E-06	2.3E-04	4.3E+00	4.5E-03	9.0E-07	1.3E-03	3.3E-05	1.5E-02	3.1E-01	1.7E-04	6.0E-01	2.3E-06	3.1E-02	7.6E-03	7.1E+00	3.6E-06	1.7E-03	2.3E-04	6.4E-04	1.9E-04	6.3E-04	4.5E-05
26-Nov-13	206																							
3-Dec-13	207																							
10-Dec-13	208																							
17-Dec-13	209	9.1E-04	4.8E-06	2.2E-04	4.5E+00	4.4E-03	4.4E-06	1.3E-03	3.1E-05	1.6E-02	3.3E-01	1.3E-04	6.5E-01	2.2E-06	3.9E-02	7.3E-03	1.0E+01	2.6E-06	1.6E-03	2.2E-04	6.1E-04	1.9E-04	4.7E-04	4.4E-05
24-Dec-13	210																							
31-Dec-13	211																							
7-Jan-14	212																							
14-Jan-14	213	4.4E-04	6.1E-06	2.2E-04	4.7E+00	4.0E-03	4.4E-06	1.4E-03	3.4E-05	1.4E-02	3.4E-01	1.1E-04	6.4E-01	7.0E-06	4.4E-02	7.9E-03	9.9E+00	7.0E-06	1.8E-03	2.2E-04	6.5E-04	1.6E-04	3.1E-04	4.4E-05
21-Jan-14	214																							
28-Jan-14	215																							
4-Feb-14	216																							
11-Feb-14	217	7.1E-04	3.3E-06	2.4E-04	5.3E+00	5.2E-03	4.8E-06	1.3E-03	2.7E-05	1.6E-02	3.8E-01	1.6E-04	7.0E-01	2.4E-06	2.7E-02	8.6E-03	1.0E+01	2.4E-06	2.2E-03	2.4E-04	8.3E-04	2.3E-04	2.6E-04	4.8E-05
18-Feb-14	218																							
25-Feb-14	219	4.2E-04	5.5E-06	2.1E-04	4.6E+00	4.1E-03	4.2E-06	1.1E-03	1.8E-05	1.4E-02	3.3E-01	1.2E-04	6.6E-01	2.1E-06	2.9E-02	6.6E-03	9.7E+00	5.0E-06	1.7E-03	2.1E-04	5.0E-04	1.6E-04	2.9E-04	4.2E-05
4-Mar-14	220	4.5E-04	3.6E-06	2.2E-04	3.7E+00	3.3E-03	4.5E-06	8.9E-04	2.7E-05	1.2E-02	1.9E-01	1.5E-04	4.4E-01	2.2E-06	4.7E-02	5.4E-03	6.6E+00	1.3E-06	2.0E-03	2.2E-04	5.3E-04	8.9E-05	2.3E-04	4.5E-05
11-Mar-14	221	5.2E-04	4.8E-06	2.4E-04	2.7E+00	2.8E-03	4.8E-06	7.8E-04	9.5E-06	1.3E-02	1.7E-01	5.4E-05	4.0E-01	5.7E-06	2.4E-02	4.0E-03	4.1E+00	2.9E-06	2.5E-03	2.4E-04	2.8E-04	9.5E-05	7.6E-05	4.8E-05
18-Mar-14	222	1.6E-03	7.2E-06	2.4E-04	2.3E+00	2.7E-03	4.8E-06	6.1E-04	6.0E-05	1.3E-02	1.6E-01	4.6E-05	3.7E-01	2.4E-06	2.4E-02	3.5E-03	2.8E+00	9.6E-07	2.2E-03	2.4E-04	1.9E-04	9.6E-05	7.1E-04	4.8E-05
25-Mar-14	223	4.5E-04	3.5E-05	2.3E-04	2.3E+00	2.6E-03	4.5E-06	5.4E-04	3.0E-05	1.4E-02	1.7E-01	4.7E-05	3.8E-01	2.3E-06	2.3E-02	3.4E-03	2.7E+00	9.0E-07	1.8E-03	2.3E-04	1.7E-04	9.0E-05	3.6E-04	4.5E-05
1-Apr-14	224																							
8-Apr-14	225																							
15-Apr-14	226																							
22-Apr-14	227	1.2E-03	4.2E-06	2.4E-04	2.1E+00	3.1E-03	4.7E-06	3.9E-04	1.6E-05	1.5E-02	1.6E-01	4.3E-05	3.8E-01	2.4E-06	2.4E-02	3.6E-03	2.0E+00	1.9E-06	2.1E-03	2.4E-04	1.4E-04	1.3E-04	1.1E-04	4.7E-05
29-Apr-14	228																							
6-May-14	229																							
13-May-14	230																							
20-May-14	231	9.4E-04	4.0E-06	2.5E-04	2.2E+00	4.3E-03	5.0E-06	3.3E-04	6.3E-05	1.7E-02	1.7E-01	3.8E-05	3.6E-01	2.5E-06	2.5E-02	3.9E-03	2.1E+00	9.9E-07	2.4E-03	2.5E-04	1.5E-04	1.0E-04	5.0E-04	5.0E-05
27-May-14	232																							
3-Jun-14	233																							
10-Jun-14	234																							
17-Jun-14	235	2.2E-03	7.8E-06	2.3E-04	2.3E+00	5.0E-03	4.6E-06	3.1E-04	4.0E-05	1.5E-02	1.6E-01	4.1E-05	3.2E-01	4.6E-06	2.3E-02	4.0E-03	1.8E+00	2.8E-05	2.8E-03	2.3E-04	1.5E-04	9.2E-05	4.2E-04	4.6E-05
24-Jun-14	236																							
1-Jul-14	237																							
1-Jul-14	237																							
8-Jul-14	238																							
15-Jul-14	239	1.9E-03	7.8E-06	2.3E-04	2.5E+00	5.4E-03	4.6E-06	3.0E-04	3.5E-05	1.8E-02	2.2E-01	4.3E-05	3.6E-01	2.3E-06	2.3E-02	4.4E-03	2.7E+00	9.2E-07	2.1E-03	2.3E-04	1.5E-04	1.1E-04	2.7E-04	4.6E-05
22-Jul-14	240																							
29-Jul-14	241																							
5-Aug-14	242																							
12-Aug-14	243	1.4E-03	3.4E-06	2.4E-04	2.2E+00	7.0E-03	4.9E-06	2.4E-04	1.2E-05	1.7E-02	1.8E-01	4.1E-05	3.6E-01	2.4E-06	2.4E-02	4.2E-03	1.8E+00	1.9E-06	2.1E-03	2.4E-04	1.3E-04	1.2E-04	6.9E-04	4.9E-05
19-Aug-14	244																							
26-Aug-14	245																							
2-Sep-14	246																							

T7

Sample = HYP-PyRo Tails Whole

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Cl	F	Br	Total CN	WAD CN	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)								CaCO3												
					umhos/cm	mgCaCO3/L	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
5-Mar-13	**0**	**750**	**420**	**7.30**	**1.8E+03**	**#N/A**	**1.2E+01**	**5.7E+01**	**8.5E+02**	**2.2E+01**	**6.5E-01**	**3.0E-01**	**1.0E-02**	**1.0E-02**	**8.2E+02**	**2.9E-02**	**1.4E-03**	**#N/A**	**2.8E-02**	**2.0E-05**	**1.0E-05**	**4.1E-02**	**2.2E-05**	**3.0E+02**	**5.0E-04**	**3.0E-04**	**1.3E-03**
12-Mar-13	1	500	475	7.26	7.2E+02	#N/A	8.5E+00	5.2E+01	2.7E+02	4.0E+00	7.4E-01	3.0E-01	1.0E-02	1.0E-02	3.1E+02	4.0E-02	1.2E-03	#N/A	1.6E-02	2.0E-05	1.0E-05	3.7E-02	2.1E-05	1.1E+02	5.0E-04	8.2E-05	1.1E-03
19-Mar-13	2	500	450	7.33	6.7E+02	#N/A	1.2E+01	6.7E+01	2.7E+02	1.5E+00	8.3E-01	3.0E-01	1.0E-02	1.0E-02	2.7E+02	2.8E-02	1.3E-03	#N/A	2.1E-02	2.0E-05	1.0E-05	3.5E-02	< 0.000003	9.4E+01	5.0E-04	1.5E-04	1.3E-03
26-Mar-13	3	500	455	7.69	4.4E+02	#N/A	7.9E+00	6.2E+01	1.4E+02	5.0E-01	7.3E-01	3.0E-01	1.0E-02	1.0E-02	1.9E+02	5.2E-02	1.0E-03	#N/A	1.7E-02	2.0E-05	1.0E-05	2.5E-02	2.4E-05	6.5E+01	5.0E-04	2.3E-04	2.0E-03
2-Apr-13	4	500	430	7.45	3.8E+02																						
9-Apr-13	5	500	425	7.78	3.7E+02	#N/A	6.6E+00	6.9E+01	1.1E+02	2.0E-01	8.9E-01	3.0E-01	1.0E-02	1.0E-02	1.4E+02	2.7E-02	1.3E-03	#N/A	2.4E-02	2.0E-05	1.0E-05	2.5E-02	1.1E-05	5.0E+01	5.0E-04	1.4E-04	5.0E-04
16-Apr-13	6	500	440	7.45	3.8E+02																						
23-Apr-13	7	500	415	7.78	2.6E+02	#N/A	6.4E+00	6.6E+01	6.5E+01	2.0E-01	8.7E-01	3.0E-01	1.0E-02	1.0E-02	9.8E+01	3.3E-02	1.7E-03	#N/A	3.0E-02	2.0E-05	1.0E-05	1.8E-02	1.2E-05	3.3E+01	5.0E-04	5.8E-05	1.0E-03
30-Apr-13	8	500	400	7.56	2.7E+02																						
7-May-13	9	500	465	7.78	2.9E+02	#N/A	1.1E+01	8.4E+01	7.3E+01	3.0E-01	6.4E-01	3.0E-01	1.0E-02	1.0E-02	1.3E+02	1.9E-02	2.3E-03	#N/A	5.2E-02	2.0E-05	1.0E-05	1.6E-02	1.2E-05	4.4E+01	5.0E-04	1.5E-04	5.0E-04
14-May-13	10	500	425	7.41	2.7E+02																						
21-May-13	11	500	430	7.84	2.6E+02	#N/A	6.3E+00	7.3E+01	5.6E+01	3.0E-01	6.1E-01	3.0E-01	1.0E-02	1.0E-02	1.1E+02	2.2E-02	2.8E-03	#N/A	5.0E-02	2.0E-05	1.0E-05	1.2E-02	4.0E-06	3.6E+01	5.0E-04	3.7E-05	6.0E-04
28-May-13	12	500	485	7.31	2.4E+02																						
4-Jun-13	13	500	445	7.81	2.2E+02	#N/A	6.0E+00	7.6E+01	4.0E+01	3.0E-01	5.2E-01	3.0E-01	1.0E-02	1.0E-02	1.0E+02	2.0E-02	2.7E-03	#N/A	5.9E-02	2.0E-05	1.0E-05	9.7E-03	1.7E-05	3.4E+01	5.0E-04	7.4E-05	1.4E-02
11-Jun-13	14	500	445	7.28	2.1E+02																						
18-Jun-13	15	500	420	7.74	1.9E+02	#N/A	7.4E+00	7.1E+01	3.1E+01	6.0E-01	4.6E-01	3.0E-01	#N/A	#N/A	9.0E+01	1.8E-02	3.2E-03	#N/A	6.5E-02	2.0E-05	1.0E-05	9.4E-03	2.1E-05	3.0E+01	5.0E-04	1.5E-04	5.0E-04
25-Jun-13	16	500	430	7.42	1.9E+02																						
2-Jul-13	17	500	430	7.73	1.9E+02	#N/A	1.0E+01	8.0E+01	2.7E+01	4.0E-01	4.0E-01	3.0E-01	#N/A	#N/A	8.2E+01	2.7E-02	3.2E-03	#N/A	7.4E-02	2.0E-05	1.0E-05	8.2E-03	8.0E-06	2.8E+01	5.0E-04	2.7E-05	7.0E-04
9-Jul-13	18	500	420	7.76	1.8E+02																						
16-Jul-13	19	500	425	7.80	1.9E+02	#N/A	5.1E+00	7.1E+01	2.2E+01	1.0E+00	3.3E-01	3.0E-01	#N/A	#N/A	8.7E+01	2.5E-02	2.9E-03	#N/A	8.2E-02	2.0E-05	1.0E-05	7.3E-03	1.1E-05	2.9E+01	5.0E-04	4.7E-05	2.7E-03
23-Jul-13	20	500	430	7.77	1.6E+02																						
30-Jul-13	21	500	435	7.77	1.8E+02	#N/A	6.4E+00	7.1E+01	2.1E+01	3.0E-01	3.2E-01	3.0E-01	#N/A	#N/A	7.9E+01	2.4E-02	2.8E-03	#N/A	8.9E-02	2.0E-05	1.0E-05	7.7E-03	9.0E-06	2.6E+01	5.0E-04	1.9E-05	6.0E-04
6-Aug-13	22	500	430	7.79	1.7E+02																						
13-Aug-13	23	500	435	7.80	1.8E+02	#N/A	5.5E+00	7.0E+01	1.4E+01	1.0E+00	2.9E-01	3.0E-01	#N/A	#N/A	7.9E+01	2.2E-02	2.7E-03	#N/A	1.1E-01	2.0E-05	1.0E-05	6.4E-03	2.3E-05	2.6E+01	5.0E-04	1.4E-04	7.0E-04
20-Aug-13	24	500	365	7.68	1.8E+02																						
27-Aug-13	25	500	430	7.83	1.5E+02	#N/A	3.8E+00	6.4E+01	1.3E+01	4.0E-01	2.2E-01	3.0E-01	#N/A	#N/A	7.0E+01	3.0E-02	2.2E-03	#N/A	1.2E-01	2.0E-05	1.0E-05	3.0E-02	< 0.000003	2.3E+01	5.0E-04	3.8E-05	1.0E-03
3-Sep-13	26	500	435	7.78	1.5E+02																						
10-Sep-13	27	500	420	7.75	1.5E+02	#N/A	4.8E+00	6.2E+01	1.1E+01	3.0E-01	2.4E-01	3.0E-01	#N/A	#N/A	7.2E+01	4.0E-02	2.1E-03	#N/A	1.2E-01	2.0E-05	1.0E-05	1.6E-02	1.0E-05	2.5E+01	5.0E-04	1.2E-04	9.0E-04
17-Sep-13	28	500	425	7.81	1.6E+02																						
24-Sep-13	29	500	440	7.85	1.7E+02	#N/A	3.0E+00	6.5E+01	1.3E+01	4.0E-01	2.1E-01	3.0E-01	#N/A	#N/A	8.2E+01	2.2E-02	2.5E-03	#N/A	1.4E-01	2.0E-05	1.0E-05	1.4E-02	7.0E-06	2.7E+01	5.0E-04	3.9E-05	9.0E-04
1-Oct-13	30	500	435	7.88	1.7E+02																						
8-Oct-13	31	500	420	7.87	1.8E+02	#N/A	2.6E+00	6.9E+01	1.7E+01	3.0E-01	2.3E-01	3.0E-01	#N/A	#N/A	8.3E+01	2.2E-02	2.5E-03	#N/A	1.3E-01	2.0E-05	1.0E-05	1.3E-02	< 0.000003	2.8E+01	5.0E-04	5.6E-05	1.9E-03
15-Oct-13	32	500	400	7.79	1.6E+02																						
22-Oct-13	33	500	425	7.83	1.7E+02	#N/A	3.7E+00	6.6E+01	1.9E+01	3.0E-01	2.3E-01	3.0E-01	#N/A	#N/A	7.6E+01	1.8E-02	2.4E-03	#N/A	1.3E-01	2.0E-05	1.0E-05	8.4E-03	4.0E-06	2.5E+01	5.0E-04	1.0E-05	5.0E-04
29-Oct-13	34	500	445	7.95	1.7E+02																						
5-Nov-13	35	500	410	7.85	1.7E+02	#N/A	2.2E+00	5.8E+01	1.4E+01	3.0E-01	2.3E-01	3.0E-01	#N/A	#N/A	7.6E+01	2.3E-02	2.4E-03	#N/A	1.2E-01	2.0E-05	1.0E-05	7.8E-03	7.0E-06	2.5E+01	5.0E-04	2.9E-05	8.0E-04
12-Nov-13	36	500	435	7.95	1.8E+02																						
19-Nov-13	37	500	400	7.98	1.6E+02	#N/A	2.0E+00	6.0E+01	1.2E+01	2.0E-01	2.1E-01	3.0E-01	#N/A	#N/A	7.6E+01	2.4E-02	2.5E-03	#N/A	1.3E-01	2.0E-05	1.0E-05	1.0E-02	1.5E-05	2.5E+01	5.0E-04	1.8E-04	7.0E-04
26-Nov-13	38	500	430	8.05	1.7E+02																						
3-Dec-13	39	500	455	7.81	1.7E+02	#N/A	2.3E-01	7.1E+01	1.2E+01	3.0E-01	1.9E-01	3.0E-01	#N/A	#N/A	8.3E+01	3.5E-02	2.0E-03	#N/A	1.4E-01	2.0E-05	1.0E-05	5.7E-03	1.8E-05	2.7E+01	5.0E-04	8.3E-05	5.0E-04
10-Dec-13	40	500	430	7.91	1.6E+02																						
17-Dec-13	41	500	425	7.92	1.6E+02	#N/A	2.4E+00	6.7E+01	1.1E+01	2.0E-01	2.0E-01	3.0E-01	#N/A	#N/A	7.6E+01	1.9E-02	2.2E-03	#N/A	1.3E-01	2.0E-05	1.0E-05	7.2E-03	1.4E-05	2.5E+01	5.0E-04	2.4E-05	6.0E-04
24-Dec-13	42	500	415	8.02	1.7E+02																						
31-Dec-13	43	500	410	8.05	1.6E+02	#N/A	1.7E+00	6.1E+01	9.0E+00	2.0E-01	1.9E-01	3.0E-01	#N/A	#N/A	7.2E+01	3.4E-02	1.8E-03	#N/A	1.3E-01	2.0E-05	1.0E-05	4.8E-03	9.0E-06	2.3E+01	5.0E-04	7.0E-05	6.8E-03
7-Jan-14	44	500	425	8.03	1.8E+02																						
14-Jan-14	45	500	430	8.07	1.8E+02	#N/A	2.6E+00	7.0E+01	9.0E+00	2.0E-01	1.9E-01	3.0E-01	#N/A	#N/A	7.9E+01	1.6E-02	1.8E-03	#N/A	1.4E-01	2.0E-05	1.0E-05	5.7E-03	1.2E-05	2.6E+01	5.0E-04	3.3E-05	5.0E-04
21-Jan-14	46	500	450	8.04	2.0E+02																						
28-Jan-14	47	500	405	8.03	1.7E+02																						
4-Feb-14	48	500	440	8.08	1.9E+02																						
11-Feb-14	49	500	460	8.04	1.9E+02	#N/A	3.4E+00	8.8E+01	1.1E+01	2.0E-01	1.8E-01	3.0E-01	#N/A	#N/A	9.2E+01	1.6E-02	1.9E-03	#N/A	1.8E-01	2.0E-05	1.0E-05	4.7E-03	1.5E-04	3.0E+01	5.0E-04	8.3E-05	7.0E-04
18-Feb-14	50	500	445	8.03	1.6E+02																						
25-Feb-14	51	500	410	8.00	1.7E+02																						
4-Mar-14	52	500	435	7.94	1.8E+02																						
11-Mar-14	53	500	440	8.04	1.9E+02	#N/A	2.2E+00	8.6E+01	1.5E+01	2.0E-01	1.8E-01	3.0E-01	#N/A	#N/A	9.5E+01	1.1E-02	1.4E-03	#N/A	1.7E-01	2.0E-05	1.0E-05	4.4E-03	1.5E-05	3.1E+01	5.0E-04	5.9E-05	5.0E-04
18-Mar-14	54	500	460	7.88	1.9E+02																						
25-Mar-14	55	500	420	8.06	1.9E+02																						
1-Apr-14	56	500	445	8.02	1.9E+02																						
8-Apr-14	57	500	400	7.93	1.7E+02	#N/A	4.8E+00	7.9E+01	1.3E+01	3.0E-01	2.0E-01	3.0E-01	#N/A	#N/A	8.2E+01	1.3E-02	1.4E-03	#N/A	1.4E-01	1.0E-05	1.0E-05	5.3E-03	1.7E-05	2.6E+01	4.0E-05	2.1E-05	7.4E-04
15-Apr-14	58	500	445	7.94	1.8E+02																						
22-Apr-14	59	500	435	7.92	1.8E+02																						
29-Apr-14	60	500	420	7.88	1.5E+02																						
6-May-14	61	500	435	7.91	1.6E+02	#N/A	4.3E+00	7.0E+01	9.0E+00	5.0E-01	1.7E-01	3.0E-01	#N/A	#N/A	8.1E+01	1.7E-02	1.4E-03	#N/A	1.5E-01	7.0E-06	3.6E-05	4.7E-03	6.0E-06	2.6E+01	1.0E-04	2.8E-05	6.8E-04
13-May-14	62	500	440	7.90	1.7E+02																						
20-May-14	63	500	465	7.91	1.7E+02																						
27-May-14	64	500	420	7.90	1.6E+02																						
3-Jun-14	65	500	440	8.02	1.7E+02	#N/A	4.7E+00	8.3E+01	7.0E+00	5.0E-01	1.9E-01	3.0E-01	#N/A	#N/A	8.6E+01	1.2E-02	1.1E-03	#N/A	1.5E-01	7.0E-06	7.0E-06	5.0E-03	3.0E-06	2.8E+01	1.0E-04	9.9E-05	6.5E-04
10-Jun-14	66	500	440	7.91	1.7E+02																						
17-Jun-14	67	500	415	7.88	1.7E+02																						
24-Jun-14	68	500	425	7.78	1.7E+02																						
1-Jul-14	69	500	445	7.90	1.7E+02	#N/A	6.3E+00	8.7E+01	9.0E+00	5.0E-01	1.6E-01	3.0E-01	#N/A	#N/A	8.7E+01	1.1E-02	1.0E-03	#N/A	1.8E-01	7.0E-06	7.0E-06	6.2E-03	1.1E-05	2.8E+01	3.0E-05	7.0E-05	9.4E-04
8-Jul-14	70	500	420	7.99	1.8E+02																						
15-Jul-14	71	500	430	7.94	1.9E+02																						
22-Jul-14	72	500	430	7.92	1.9E+02																						
29-Jul-14	73	500	430	7.96	1.7E+02	#N/A	2.9E+00	9.0E+01	7.0E+00	5.0E-01	1.9E-01	3.0E-01	#N/A	#N/A	8.6E+01	1.2E-02	1.2E-03	2.0E-04	1.8E-01	7.0E-06	7.0E-06	6.2E-03	1.1E-05	2.7E+01	7.0E-05	2.0E-04	9.5E-04
5-Aug-14	74	500	425	7.88	1.7E+02																						
12-Aug-14	75	500	460	7.86	1.7E+02																						
19-Aug-14	76	500	410	7.95	1.6E+02																						
26-Aug-14	77	500	425	7.90	1.6E+02	#N/A	2.8E+00	7.5E+01	7.0E+00																		

T7

Sample = HYP-PyRo Tails Whole

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Major	Major	Diff	Diff
	No.																							Anions	Cations		(%)
		mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L				
5-Mar-13	**0**	3.0E-03	**1.8E-04**	**4.0E-03**	**1.5E+01**	**6.9E-02**	1.0E-02	**1.9E-02**	**1.5E-03**	**3.5E-01**	**6.4E+01**	**2.7E-03**	**1.3E+01**	**1.0E-05**	**3.3E+01**	**1.3E+00**	**3.2E+02**	**1.0E-04**	**1.7E-02**	**2.0E-04**	**4.3E-02**	**1.4E-04**	**2.0E-03**	**1.9E+01**	**2.0E+01**	**8.5E-02**	**0.2%**
12-Mar-13	1	7.0E-03	1.2E-04	2.0E-03	7.4E+00	3.7E-02	1.0E-02	1.2E-02	7.0E-04	1.1E-01	3.3E+01	1.2E-03	3.1E+01	1.0E-05	9.2E+00	5.1E-01	1.1E+02	5.0E-05	1.5E-02	4.0E-04	2.1E-02	1.4E-04	1.0E-03	6.9E+00	7.5E+00	6.3E-01	4.4%
19-Mar-13	2	3.0E-03	1.1E-04	2.0E-03	7.6E+00	2.5E-02	1.0E-02	1.3E-02	4.0E-04	7.6E-02	2.9E+01	1.0E-03	1.7E+01	1.0E-05	5.9E+00	4.6E-01	8.9E+01	5.0E-05	1.5E-02	2.0E-04	2.6E-02	3.0E-05	1.0E-03	7.0E+00	6.3E+00	-7.0E-01	-5.3%
26-Mar-13	3	3.0E-03	7.0E-05	1.0E-03	5.6E+00	1.8E-02	1.0E-02	7.6E-03	3.0E-04	4.8E-02	1.9E+01	5.9E-04	1.2E+01	1.0E-05	2.6E+00	3.1E-01	5.2E+01	3.0E-05	1.3E-02	1.0E-04	2.0E-02	1.5E-04	1.0E-03	4.2E+00	4.3E+00	1.4E-01	1.7%
2-Apr-13	4																										
9-Apr-13	5	3.0E-03	7.0E-05	1.0E-03	4.9E+00	1.6E-02	1.0E-02	9.8E-03	2.0E-04	1.8E-02	1.6E+01	1.7E-03	9.2E+00	1.0E-05	1.6E+00	2.6E-01	3.5E+01	3.0E-05	1.7E-02	1.0E-04	1.7E-02	1.4E-04	1.0E-03	3.6E+00	3.4E+00	-2.7E-01	-3.9%
16-Apr-13	6																										
23-Apr-13	7	6.0E-03	8.0E-05	1.0E-03	3.8E+00	1.0E-02	1.0E-02	9.5E-03	3.0E-04	2.0E-02	1.2E+01	3.5E-04	8.0E+00	1.0E-05	8.4E-01	1.9E-01	1.9E+01	2.0E-05	2.4E-02	1.0E-04	1.1E-02	1.4E-04	4.0E-03	2.7E+00	2.3E+00	-4.1E-01	-8.2%
30-Apr-13	8																										
7-May-13	9	3.0E-03	3.0E-05	1.0E-03	4.8E+00	1.7E-02	1.0E-02	2.3E-02	1.0E-04	1.9E-02	1.2E+01	3.1E-04	7.2E+00	1.0E-05	6.9E-01	2.6E-01	2.3E+01	3.0E-05	2.7E-02	1.0E-04	1.7E-02	2.0E-04	1.0E-03	3.2E+00	2.9E+00	-3.2E-01	-5.2%
14-May-13	10																										
21-May-13	11	3.0E-03	2.0E-05	1.0E-03	4.0E+00	1.2E-02	1.0E-02	3.3E-02	1.0E-04	1.9E-02	8.8E+00	2.6E-04	6.2E+00	1.0E-05	4.7E-01	2.1E-01	1.8E+01	3.0E-05	3.9E-02	2.0E-04	1.4E-02	1.8E-04	1.0E-03	2.7E+00	2.4E+00	-3.1E-01	-6.1%
28-May-13	12																										
4-Jun-13	13	3.0E-03	2.0E-05	1.0E-03	3.9E+00	1.1E-02	1.0E-02	3.0E-02	2.9E-03	1.6E-02	8.4E+00	3.5E-04	5.9E+00	1.0E-05	3.8E-01	2.0E-01	1.2E+01	2.0E-05	3.1E-02	1.0E-04	1.1E-02	1.7E-04	1.0E-03	2.4E+00	2.3E+00	-1.3E-01	-2.8%
11-Jun-13	14																										
18-Jun-13	15	5.0E-03	2.0E-05	1.0E-03	3.5E+00	9.4E-03	1.0E-02	2.8E-02	2.0E-04	1.7E-02	7.1E+00	5.4E-04	5.9E+00	1.0E-05	3.7E-01	1.9E-01	1.1E+01	2.0E-05	4.0E-02	1.0E-04	1.0E-02	1.7E-04	1.0E-03	2.1E+00	2.0E+00	-9.6E-02	-2.3%
25-Jun-13	16																										
2-Jul-13	17	3.0E-03	2.0E-05	1.0E-03	3.2E+00	7.1E-03	1.0E-02	2.7E-02	3.0E-04	1.5E-02	6.4E+00	2.6E-04	4.1E+00	1.0E-05	2.9E-01	1.7E-01	9.4E+00	2.0E-05	3.1E-02	2.0E-04	9.1E-03	2.7E-04	1.0E-03	2.2E+00	1.8E+00	-3.7E-01	-9.2%
9-Jul-13	18																										
16-Jul-13	19	3.0E-03	3.0E-05	1.0E-03	3.4E+00	5.0E-03	1.0E-02	2.4E-02	3.0E-04	1.6E-02	5.5E+00	3.1E-04	4.6E+00	1.0E-05	3.1E-01	1.8E-01	8.0E+00	2.0E-05	3.7E-02	1.0E-04	8.2E-03	1.8E-04	2.0E-03	1.9E+00	1.9E+00	-3.5E-04	0.0%
23-Jul-13	20																										
30-Jul-13	21	3.0E-03	2.0E-05	1.0E-03	3.2E+00	3.6E-03	1.0E-02	1.9E-02	1.0E-04	2.0E-02	5.0E+00	3.1E-04	4.3E+00	1.0E-05	2.6E-01	1.6E-01	5.9E+00	2.0E-05	3.6E-02	1.0E-04	7.3E-03	1.8E-04	1.0E-03	1.9E+00	1.7E+00	-1.5E-01	-4.2%
6-Aug-13	22																										
13-Aug-13	23	1.0E-02	2.0E-05	1.0E-03	3.3E+00	3.4E-03	1.0E-02	1.7E-02	6.0E-04	1.8E-02	4.6E+00	3.7E-04	4.2E+00	1.0E-05	2.5E-01	1.7E-01	5.3E+00	2.0E-05	4.0E-02	1.0E-04	6.9E-03	1.6E-04	2.0E-03	1.7E+00	1.7E+00	8.7E-03	0.3%
20-Aug-13	24																										
27-Aug-13	25	3.0E-03	3.0E-05	1.0E-03	2.8E+00	2.3E-03	1.0E-02	1.4E-02	2.0E-04	9.0E-03	4.0E+00	1.7E-04	1.6E+00	1.0E-05	3.1E-01	1.5E-01	4.5E+00	2.0E-05	1.3E-02	1.0E-04	6.4E-03	2.4E-04	1.0E-03	1.6E+00	1.5E+00	-4.2E-02	-1.4%
3-Sep-13	26																										
10-Sep-13	27	1.2E-02	2.0E-05	1.0E-03	3.0E+00	4.0E-04	1.0E-02	1.6E-02	1.0E-04	9.0E-03	3.8E+00	2.9E-04	1.6E+00	1.0E-05	2.7E-01	1.5E-01	5.0E+00	2.0E-05	6.6E-03	1.0E-04	6.9E-03	2.1E-04	1.0E-03	1.5E+00	1.6E+00	9.4E-02	3.0%
17-Sep-13	28																										
24-Sep-13	29	3.0E-03	7.0E-05	1.0E-03	3.4E+00	2.1E-03	1.0E-02	2.2E-02	1.0E-04	9.0E-03	4.0E+00	4.1E-04	1.6E+00	1.0E-05	2.8E-01	1.7E-01	6.8E+00	2.0E-05	3.0E-03	1.0E-04	8.7E-03	1.8E-04	1.0E-03	1.6E+00	1.8E+00	1.7E-01	5.0%
1-Oct-13	30																										
8-Oct-13	31	3.0E-03	2.0E-05	1.0E-03	3.5E+00	5.0E-04	1.0E-02	3.1E-02	4.0E-04	9.0E-03	3.6E+00	3.1E-04	1.6E+00	1.0E-05	2.5E-01	1.7E-01	7.1E+00	2.0E-05	1.3E-03	1.0E-04	9.5E-03	1.9E-04	1.0E-03	1.7E+00	1.8E+00	2.7E-02	0.8%
15-Oct-13	32																										
22-Oct-13	33	3.0E-03	2.0E-05	1.0E-03	3.2E+00	2.0E-04	1.0E-02	3.3E-02	2.0E-04	9.0E-03	3.2E+00	3.0E-04	1.6E+00	1.0E-05	2.1E-01	1.6E-01	6.0E+00	2.0E-05	8.6E-04	1.0E-04	8.1E-03	2.0E-04	1.0E-03	1.7E+00	1.6E+00	-1.1E-01	-3.4%
29-Oct-13	34																										
5-Nov-13	35	3.0E-03	2.0E-05	1.0E-03	3.2E+00	3.0E-04	1.0E-02	4.5E-02	5.0E-04	9.0E-03	2.8E+00	3.4E-04	1.3E+00	1.0E-05	2.2E-01	1.6E-01	6.3E+00	2.0E-05	7.5E-04	1.0E-04	7.8E-03	2.6E-04	1.0E-03	1.5E+00	1.6E+00	1.3E-01	4.1%
12-Nov-13	36																										
19-Nov-13	37	3.0E-03	7.0E-05	1.0E-03	3.2E+00	2.1E-03	1.0E-02	5.0E-02	5.0E-04	9.0E-03	2.7E+00	3.0E-04	1.6E+00	1.0E-05	2.6E-01	1.5E-01	5.9E+00	2.0E-05	6.3E-03	1.0E-04	1.0E-02	2.0E-04	1.0E-03	1.5E+00	1.6E+00	1.4E-01	4.4%
26-Nov-13	38																										
3-Dec-13	39	4.0E-03	2.0E-05	1.0E-03	3.6E+00	3.0E-04	1.0E-02	5.6E-02	4.0E-04	9.0E-03	2.9E+00	3.2E-04	1.4E+00	1.0E-05	1.9E-01	1.6E-01	5.8E+00	2.0E-05	4.9E-04	1.0E-04	8.8E-03	2.3E-04	1.0E-03	1.7E+00	1.7E+00	5.7E-02	1.7%
10-Dec-13	40																										
17-Dec-13	41	3.0E-03	2.0E-05	1.0E-03	3.4E+00	1.2E-03	1.0E-02	6.2E-02	1.0E-04	9.0E-03	2.7E+00	1.1E-03	1.4E+00	1.0E-05	2.2E-01	1.5E-01	4.6E+00	2.0E-05	5.7E-03	1.0E-04	7.7E-03	1.8E-04	1.0E-03	1.6E+00	1.6E+00	3.3E-03	0.1%
24-Dec-13	42																										
31-Dec-13	43	7.0E-03	2.0E-05	1.0E-03	3.2E+00	1.1E-03	1.0E-02	6.1E-02	3.0E-04	9.0E-03	2.5E+00	3.5E-04	1.4E+00	1.0E-05	1.7E-01	1.4E-01	4.4E+00	2.0E-05	4.9E-04	1.0E-04	6.1E-03	2.2E-04	1.0E-03	1.4E+00	1.5E+00	9.8E-02	3.4%
7-Jan-14	44																										
14-Jan-14	45	3.0E-03	2.0E-05	1.0E-03	3.6E+00	3.0E-04	1.0E-02	7.4E-02	2.0E-04	9.0E-03	2.5E+00	3.1E-04	1.5E+00	1.0E-05	1.8E-01	1.6E-01	5.1E+00	2.0E-05	3.7E-04	1.0E-04	7.8E-03	2.1E-04	1.0E-03	1.6E+00	1.7E+00	6.3E-02	1.9%
21-Jan-14	46																										
28-Jan-14	47																										
4-Feb-14	48																										
11-Feb-14	49	3.0E-03	4.0E-05	1.0E-03	4.1E+00	9.0E-04	1.0E-02	1.1E-01	5.0E-04	9.0E-03	2.4E+00	4.2E-04	1.5E+00	1.0E-05	1.7E-01	1.6E-01	5.7E+00	2.0E-05	5.8E-04	1.0E-04	9.8E-03	2.0E-04	1.0E-03	2.0E+00	1.9E+00	-9.3E-02	-2.4%
18-Feb-14	50																										
25-Feb-14	51																										
4-Mar-14	52																										
11-Mar-14	53	5.0E-03	2.0E-05	1.0E-03	4.4E+00	8.0E-04	1.0E-02	1.1E-01	3.0E-04	1.4E-02	2.3E+00	2.8E-04	1.5E+00	1.0E-05	1.7E-01	1.6E-01	5.7E+00	2.0E-05	4.3E-04	1.0E-04	9.1E-03	1.3E-04	1.0E-03	2.0E+00	2.0E+00	-7.2E-02	-1.8%
18-Mar-14	54																										
25-Mar-14	55																										
1-Apr-14	56																										
8-Apr-14	57	2.0E-03	1.0E-05	8.0E-04	3.8E+00	7.0E-04	1.0E-02	1.2E-01	3.0E-04	9.0E-03	2.1E+00	2.3E-04	1.4E+00	2.0E-06	1.5E-01	1.4E-01	5.0E+00	8.0E-06	3.8E-04	9.0E-05	7.7E-03	1.6E-04	1.0E-03	1.9E+00	1.7E+00	-1.5E-01	-4.3%
15-Apr-14	58																										
22-Apr-14	59																										
29-Apr-14	60																										
6-May-14	61	2.0E-03	2.0E-05	6.9E-04	3.9E+00	7.0E-04	1.0E-02	1.2E-01	5.0E-04	1.4E-02	1.9E+00	2.8E-04	1.3E+00	2.0E-06	1.6E-01	1.3E-01	4.1E+00	1.4E-05	8.8E-04	7.0E-05	6.9E-03	1.8E-04	1.0E-03	1.6E+00	1.7E+00	7.4E-02	2.2%
13-May-14	62																										
20-May-14	63																										
27-May-14	64																										
3-Jun-14	65	6.0E-03	1.0E-05	7.2E-04	4.2E+00	9.0E-04	1.0E-02	1.1E-01	1.0E-04	9.0E-03	1.9E+00	2.5E-04	1.4E+00	3.0E-06	1.7E-01	1.3E-01	3.7E+00	8.0E-06	1.2E-03	5.0E-05	6.2E-03	1.2E-04	1.0E-03	1.8E+00	1.8E+00	-4.5E-02	-1.2%
10-Jun-14	66																										
17-Jun-14	67																										
24-Jun-14	68																										
1-Jul-14	69	2.0E-03	2.0E-05	8.3E-04	4.3E+00	9.0E-04	1.0E-02	1.0E-01	1.0E-04	9.0E-03	1.7E+00	2.7E-04	1.3E+00	3.0E-06	1.6E-01	1.3E-01	3.0E+00	9.0E-06	1.4E-03	5.0E-05	6.1E-03	1.0E-04	1.0E-03	1.9E+00	1.8E+00	-1.5E-01	-0.040481198
8-Jul-14	70																										
15-Jul-14	71																										
22-Jul-14	72																										
29-Jul-14	73	3.0E-03	3.0E-05	8.3E-04	4.3E+00	9.0E-04	1.0E-02	1.1E-01	3.0E-04	9.0E-03	1.7E+00	2.4E-04	1.2E+00	3.0E-06	1.5E-01	1.2E-01	3.1E+00	9.0E-06	1.3E-03	8.0E-05	6.2E-03	1.9E-04	1.0E-03	2.0E+00	1.8E+00	-2.0E-01	-5.3%
5-Aug-14	74																										
12-Aug-14	75																										
19-Aug-14	76																										
26-Aug-14	77																										

T7

Sample = HYP-PyRo Tails Whole

Date	Cycle	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Cl	F	Br	Total CN	WAD CN	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Input	Output			(pH 4.5)	(pH 8.3)								CaCO3												
					umhos/cm	mgCaCO3/kg	mgCaCO3/kg	mgCaCO3/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
19-Mar-13	2	500	450	7.33	6.7E+02	#N/A	5.3E+00	3.0E+01	1.2E+02	6.8E-01	3.7E-01	1.4E-01	4.5E-03	4.5E-03	1.2E+02	1.3E-02	5.9E-04	#N/A	9.4E-03	9.0E-06	4.5E-06	1.6E-02	#VALUE!	4.2E+01	2.3E-04	6.9E-05	5.9E-04
26-Mar-13	**3**	**500**	**455**	**7.69**	**4.4E+02**	**#N/A**	**3.6E+00**	**2.8E+01**	**6.3E+01**	**2.3E-01**	**3.3E-01**	**1.4E-01**	**4.6E-03**	**4.6E-03**	**8.4E+01**	**2.4E-02**	**4.6E-04**	**#N/A**	**7.9E-03**	**9.1E-06**	**4.6E-06**	**1.2E-02**	**1.1E-05**	**2.9E+01**	**2.3E-04**	**1.0E-04**	**9.1E-04**
2-Apr-13	**4**	**500**	**430**	**7.45**	**3.8E+02**																						
9-Apr-13	**5**	**500**	**425**	**7.78**	**3.7E+02**	**#N/A**	**2.8E+00**	**2.9E+01**	**4.5E+01**	**8.5E-02**	**3.8E-01**	**1.3E-01**	**4.3E-03**	**4.3E-03**	**6.1E+01**	**1.1E-02**	**5.5E-04**	**#N/A**	**1.0E-02**	**8.5E-06**	**4.3E-06**	**1.0E-02**	**4.7E-06**	**2.1E+01**	**2.1E-04**	**5.8E-05**	**2.1E-04**
16-Apr-13	6	500	440	7.45	3.8E+02																						
23-Apr-13	7	500	415	7.78	2.6E+02	#N/A	2.7E+00	2.7E+01	2.7E+01	8.3E-02	3.6E-01	1.2E-01	4.2E-03	4.2E-03	4.1E+01	1.3E-02	7.1E-04	#N/A	1.3E-02	8.3E-06	4.2E-06	7.4E-03	5.0E-06	1.4E+01	2.1E-04	2.4E-05	4.2E-04
30-Apr-13	8	500	400	7.56	2.7E+02																						
7-May-13	9	500	465	7.78	2.9E+02	#N/A	5.3E+00	3.9E+01	3.4E+01	1.4E-01	3.0E-01	1.4E-01	4.7E-03	4.7E-03	6.0E+01	8.9E-03	1.1E-03	#N/A	2.4E-02	9.3E-06	4.7E-06	7.6E-03	5.6E-06	2.0E+01	2.3E-04	7.1E-05	2.3E-04
14-May-13	10	500	425	7.41	2.7E+02																						
21-May-13	11	500	430	7.84	2.6E+02	#N/A	2.7E+00	3.2E+01	2.4E+01	1.3E-01	2.6E-01	1.3E-01	4.3E-03	4.3E-03	4.5E+01	9.3E-03	1.2E-03	#N/A	2.1E-02	8.6E-06	4.3E-06	5.1E-03	1.7E-06	1.5E+01	2.2E-04	1.6E-05	2.6E-04
28-May-13	12	500	485	7.31	2.4E+02																						
4-Jun-13	13	500	445	7.81	2.2E+02	#N/A	2.7E+00	3.4E+01	1.8E+01	1.3E-01	2.3E-01	1.3E-01	4.5E-03	4.5E-03	4.5E+01	8.9E-03	1.2E-03	#N/A	2.6E-02	8.9E-06	4.5E-06	4.3E-03	7.6E-06	1.5E+01	2.2E-04	3.3E-05	6.2E-03
11-Jun-13	14	500	445	7.28	2.1E+02																						
18-Jun-13	15	500	420	7.74	1.9E+02	#N/A	3.1E+00	3.0E+01	1.3E+01	2.5E-01	1.9E-01	1.3E-01	#N/A	#N/A	3.8E+01	7.5E-03	1.3E-03	#N/A	2.7E-02	8.4E-06	4.2E-06	3.9E-03	8.8E-06	1.3E+01	2.1E-04	6.3E-05	2.1E-04
25-Jun-13	16	500	430	7.42	1.9E+02																						
2-Jul-13	17	500	430	7.73	1.9E+02	#N/A	4.3E+00	3.4E+01	1.2E+01	1.7E-01	1.7E-01	1.3E-01	#N/A	#N/A	3.5E+01	1.1E-02	1.4E-03	#N/A	3.2E-02	8.6E-06	4.3E-06	3.5E-03	3.4E-06	1.2E+01	2.2E-04	1.2E-05	3.0E-04
9-Jul-13	18	500	420	7.76	1.8E+02																						
16-Jul-13	19	500	425	7.80	1.9E+02	#N/A	2.2E+00	3.0E+01	9.4E+00	4.3E-01	1.4E-01	1.3E-01	#N/A	#N/A	3.7E+01	1.1E-02	1.2E-03	#N/A	3.5E-02	8.5E-06	4.3E-06	3.1E-03	4.7E-06	1.2E+01	2.1E-04	2.0E-05	1.1E-03
23-Jul-13	20	500	430	7.77	1.6E+02																						
30-Jul-13	21	500	435	7.77	1.8E+02	#N/A	2.8E+00	3.1E+01	9.1E+00	1.3E-01	1.4E-01	1.3E-01	#N/A	#N/A	3.4E+01	1.0E-02	1.2E-03	#N/A	3.9E-02	8.7E-06	4.4E-06	3.3E-03	3.9E-06	1.1E+01	2.2E-04	8.3E-06	2.6E-04
6-Aug-13	22	500	430	7.79	1.7E+02																						
13-Aug-13	23	500	435	7.80	1.8E+02	#N/A	2.4E+00	3.1E+01	6.1E+00	4.4E-01	1.3E-01	1.3E-01	#N/A	#N/A	3.5E+01	9.6E-03	1.2E-03	#N/A	4.7E-02	8.7E-06	4.4E-06	2.8E-03	1.0E-05	1.1E+01	2.2E-04	6.2E-05	3.0E-04
20-Aug-13	24	500	365	7.68	1.8E+02																						
27-Aug-13	25	500	430	7.83	1.5E+02	#N/A	1.6E+00	2.7E+01	5.6E+00	1.7E-01	9.5E-02	1.3E-01	#N/A	#N/A	3.0E+01	1.3E-02	9.5E-04	#N/A	5.0E-02	8.6E-06	4.3E-06	1.3E-02	#VALUE!	1.0E+01	2.2E-04	1.6E-05	4.3E-04
3-Sep-13	26	500	435	7.78	1.5E+02																						
10-Sep-13	27	500	420	7.75	1.5E+02	#N/A	2.0E+00	2.6E+01	4.6E+00	1.3E-01	1.0E-01	1.3E-01	#N/A	#N/A	3.0E+01	1.7E-02	8.8E-04	#N/A	5.1E-02	8.4E-06	4.2E-06	6.9E-03	4.2E-06	1.0E+01	2.1E-04	5.0E-05	3.8E-04
17-Sep-13	28	500	425	7.81	1.6E+02																						
24-Sep-13	29	500	440	7.85	1.7E+02	#N/A	1.3E+00	2.9E+01	5.7E+00	1.8E-01	9.2E-02	1.3E-01	#N/A	#N/A	3.6E+01	9.7E-03	1.1E-03	#N/A	6.2E-02	8.8E-06	4.4E-06	6.2E-03	3.1E-06	1.2E+01	2.2E-04	1.7E-05	4.0E-04
1-Oct-13	30	500	435	7.88	1.7E+02																						
8-Oct-13	31	500	420	7.87	1.8E+02	#N/A	1.1E+00	2.9E+01	7.1E+00	1.3E-01	9.7E-02	1.3E-01	#N/A	#N/A	3.5E+01	9.4E-03	1.1E-03	#N/A	5.5E-02	8.4E-06	4.2E-06	5.6E-03	#VALUE!	1.2E+01	2.1E-04	2.4E-05	8.0E-04
15-Oct-13	32	500	400	7.79	1.6E+02																						
22-Oct-13	33	500	425	7.83	1.7E+02	#N/A	1.6E+00	2.8E+01	8.1E+00	1.3E-01	9.8E-02	1.3E-01	#N/A	#N/A	3.2E+01	7.8E-03	1.0E-03	#N/A	5.4E-02	8.5E-06	4.3E-06	3.6E-03	1.7E-06	1.1E+01	2.1E-04	4.3E-06	2.1E-04
29-Oct-13	34	500	445	7.95	1.7E+02																						
5-Nov-13	35	500	410	7.85	1.7E+02	#N/A	9.0E-01	2.4E+01	5.7E+00	1.2E-01	9.4E-02	1.2E-01	#N/A	#N/A	3.1E+01	9.3E-03	9.8E-04	#N/A	5.0E-02	8.2E-06	4.1E-06	3.2E-03	2.9E-06	1.0E+01	2.1E-04	1.2E-05	3.3E-04
12-Nov-13	36	500	435	7.95	1.8E+02																						
19-Nov-13	37	500	400	7.98	1.6E+02	#N/A	7.9E-01	2.4E+01	4.8E+00	8.0E-02	8.4E-02	1.2E-01	#N/A	#N/A	3.0E+01	9.4E-03	1.0E-03	#N/A	5.3E-02	8.0E-06	4.0E-06	4.0E-03	6.0E-06	1.0E+01	2.0E-04	7.4E-05	2.8E-04
26-Nov-13	38	500	430	8.05	1.7E+02																						
3-Dec-13	39	500	455	7.81	1.7E+02	#N/A	1.0E-01	3.2E+01	5.5E+00	1.4E-01	8.6E-02	1.4E-01	#N/A	#N/A	3.8E+01	1.6E-02	9.1E-04	#N/A	6.5E-02	9.1E-06	4.6E-06	2.6E-03	8.2E-06	1.2E+01	2.3E-04	3.8E-05	2.3E-04
10-Dec-13	40	500	430	7.91	1.6E+02																						
17-Dec-13	41	500	425	7.92	1.6E+02	#N/A	1.0E+00	2.9E+01	4.7E+00	8.5E-02	8.5E-02	1.3E-01	#N/A	#N/A	3.2E+01	8.2E-03	9.4E-04	#N/A	5.6E-02	8.5E-06	4.3E-06	3.1E-03	6.0E-06	1.0E+01	2.1E-04	1.0E-05	2.6E-04
24-Dec-13	42	500	415	8.02	1.7E+02																						
31-Dec-13	43	500	410	8.05	1.6E+02	#N/A	6.8E-01	2.5E+01	3.7E+00	8.2E-02	7.8E-02	1.2E-01	#N/A	#N/A	2.9E+01	1.4E-02	7.4E-04	#N/A	5.5E-02	8.2E-06	4.1E-06	2.0E-03	3.7E-06	9.6E+00	2.1E-04	2.9E-05	2.8E-03
7-Jan-14	44	500	425	8.03	1.8E+02																						
14-Jan-14	45	500	430	8.07	1.8E+02	#N/A	1.1E+00	3.0E+01	3.9E+00	8.6E-02	8.2E-02	1.3E-01	#N/A	#N/A	3.4E+01	6.8E-03	7.7E-04	#N/A	6.1E-02	8.6E-06	4.3E-06	2.5E-03	5.2E-06	1.1E+01	2.2E-04	1.4E-05	2.2E-04
21-Jan-14	46	500	450	8.04	2.0E+02																						
28-Jan-14	47	500	405	8.03	1.7E+02																						
4-Feb-14	48	500	440	8.08	1.9E+02																						
11-Feb-14	49	500	460	8.04	1.9E+02	#N/A	1.6E+00	4.1E+01	5.1E+00	9.2E-02	8.3E-02	1.4E-01	#N/A	#N/A	4.2E+01	7.5E-03	8.7E-04	#N/A	8.1E-02	9.2E-06	4.6E-06	2.2E-03	6.7E-05	1.4E+01	2.3E-04	3.8E-05	3.2E-04
18-Feb-14	50	500	445	8.03	1.6E+02																						
25-Feb-14	51	500	410	8.00	1.7E+02																						
4-Mar-14	52	500	435	7.94	1.8E+02																						
11-Mar-14	53	500	440	8.04	1.9E+02	#N/A	9.5E-01	3.8E+01	6.6E+00	8.8E-02	7.9E-02	1.3E-01	#N/A	#N/A	4.2E+01	4.7E-03	6.2E-04	#N/A	7.4E-02	8.8E-06	4.4E-06	1.9E-03	6.6E-06	1.4E+01	2.2E-04	2.6E-05	2.2E-04
18-Mar-14	54	500	460	7.88	1.9E+02																						
25-Mar-14	55	500	420	8.06	1.9E+02																						
1-Apr-14	56	500	445	8.02	1.9E+02																						
8-Apr-14	57	500	400	7.93	1.7E+02	#N/A	1.9E+00	3.1E+01	5.2E+00	1.2E-01	8.0E-02	1.2E-01	#N/A	#N/A	3.3E+01	5.3E-03	5.6E-04	#N/A	5.6E-02	4.0E-06	4.0E-06	2.1E-03	6.8E-06	1.1E+01	1.6E-05	8.4E-06	3.0E-04
15-Apr-14	58	500	445	7.94	1.8E+02																						
22-Apr-14	59	500	435	7.92	1.8E+02																						
29-Apr-14	60	500	420	7.88	1.5E+02																						
6-May-14	61	500	435	7.91	1.6E+02	#N/A	1.9E+00	3.0E+01	3.9E+00	2.2E-01	7.4E-02	1.3E-01	#N/A	#N/A	3.5E+01	7.5E-03	6.1E-04	#N/A	6.6E-02	3.0E-06	1.6E-05	2.0E-03	2.6E-06	1.1E+01	4.4E-05	1.2E-05	3.0E-04
13-May-14	62	500	440	7.90	1.7E+02																						
20-May-14	63	500	465	7.91	1.7E+02																						
27-May-14	64	500	420	7.90	1.6E+02																						
3-Jun-14	65	500	440	8.02	1.7E+02	#N/A	2.1E+00	3.6E+01	3.1E+00	2.2E-01	8.4E-02	1.3E-01	#N/A	#N/A	3.8E+01	5.1E-03	4.8E-04	#N/A	6.6E-02	3.1E-06	3.1E-06	2.2E-03	1.3E-06	1.2E+01	4.4E-05	4.4E-05	2.9E-04
10-Jun-14	66	500	440	7.91	1.7E+02																						
17-Jun-14	67	500	415	7.88	1.7E+02																						
24-Jun-14	68	500	425	7.78	1.7E+02																						
1-Jul-14	69	500	445	7.90	1.7E+02	#N/A	2.8E+00	3.9E+01	4.0E+00	2.2E-01	7.1E-02	1.3E-01	#N/A	#N/A	3.9E+01	4.8E-03	4.5E-04	#N/A	8.0E-02	3.1E-06	3.1E-06	2.8E-03	4.9E-06	1.2E+01	1.3E-05	3.1E-05	4.2E-04
8-Jul-14	70	500	420	7.99	1.8E+02																						
15-Jul-14	71	500	430	7.94	1.9E+02																						
22-Jul-14	72	500	430	7.92	1.9E+02																						
29-Jul-14	73	500	430	7.96	1.7E+02	#N/A	1.3E+00	3.9E+01	3.0E+00	2.2E-01	8.2E-02	1.3E-01	#N/A	#N/A	3.7E+01	5.3E-03	5.2E-04	8.6E-05	7.6E-02	3.0E-06	3.0E-06	2.7E-03	4.7E-06	1.2E+01	3.0E-05	8.6E-05	4.1E-04

T7

Sample = HYP-PyRo Tails Whole

Date	Cycle No.	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
19-Mar-13	2	1.4E-03	5.0E-05	9.0E-04	3.4E+00	1.1E-02	4.5E-06	5.7E-03	1.8E-04	3.4E-02	1.3E+01	4.6E-04	7.6E+00	4.5E-06	2.7E+00	2.1E-01	4.0E+01	2.3E-05	6.9E-03	9.0E-05	1.2E-02	1.4E-05	4.5E-04
26-Mar-13	**3**	**1.4E-03**	**3.2E-05**	**4.6E-04**	**2.5E+00**	**8.4E-03**	**4.6E-06**	**3.5E-03**	**1.4E-04**	**2.2E-02**	**8.6E+00**	**2.7E-04**	**5.2E+00**	**4.6E-06**	**1.2E+00**	**1.4E-01**	**2.4E+01**	**1.4E-05**	**6.1E-03**	**4.6E-05**	**9.1E-03**	**6.8E-05**	**4.6E-04**
2-Apr-13	**4**																						
9-Apr-13	**5**	**1.3E-03**	**3.0E-05**	**4.3E-04**	**2.1E+00**	**6.8E-03**	**4.3E-06**	**4.2E-03**	**8.5E-05**	**7.7E-03**	**6.7E+00**	**7.2E-04**	**3.9E+00**	**4.3E-06**	**6.6E-01**	**1.1E-01**	**1.5E+01**	**1.3E-05**	**7.2E-03**	**4.3E-05**	**7.1E-03**	**6.0E-05**	**4.3E-04**
16-Apr-13	6																						
23-Apr-13	7	2.5E-03	3.3E-05	4.2E-04	1.6E+00	4.3E-03	4.2E-06	3.9E-03	1.2E-04	8.3E-03	5.1E+00	1.5E-04	3.3E+00	4.2E-06	3.5E-01	8.0E-02	7.9E+00	8.3E-06	9.8E-03	4.2E-05	4.6E-03	5.8E-05	1.7E-03
30-Apr-13	8																						
7-May-13	9	1.4E-03	1.4E-05	4.7E-04	2.2E+00	7.9E-03	4.7E-06	1.1E-02	4.7E-05	8.8E-03	5.4E+00	1.4E-04	3.3E+00	4.7E-06	3.2E-01	1.2E-01	1.1E+01	1.4E-05	1.3E-02	4.7E-05	7.8E-03	9.3E-05	4.7E-04
14-May-13	10																						
21-May-13	11	1.3E-03	8.6E-06	4.3E-04	1.7E+00	5.2E-03	4.3E-06	1.4E-02	4.3E-05	8.2E-03	3.8E+00	1.1E-04	2.7E+00	4.3E-06	2.0E-01	9.1E-02	7.7E+00	1.3E-05	1.7E-02	8.6E-05	5.8E-03	7.7E-05	4.3E-04
28-May-13	12																						
4-Jun-13	13	1.3E-03	8.9E-06	4.5E-04	1.7E+00	4.9E-03	4.5E-06	1.3E-02	1.3E-03	7.1E-03	3.7E+00	1.6E-04	2.6E+00	4.5E-06	1.7E-01	8.9E-02	5.5E+00	8.9E-06	1.4E-02	4.5E-05	5.1E-03	7.6E-05	4.5E-04
11-Jun-13	14																						
18-Jun-13	15	2.1E-03	8.4E-06	4.2E-04	1.5E+00	3.9E-03	4.2E-06	1.2E-02	8.4E-05	7.1E-03	3.0E+00	2.3E-04	2.5E+00	4.2E-06	1.6E-01	7.8E-02	4.5E+00	8.4E-06	1.7E-02	4.2E-05	4.3E-03	7.1E-05	4.2E-04
25-Jun-13	16																						
2-Jul-13	17	1.3E-03	8.6E-06	4.3E-04	1.4E+00	3.1E-03	4.3E-06	1.2E-02	1.3E-04	6.5E-03	2.8E+00	1.1E-04	1.8E+00	4.3E-06	1.2E-01	7.4E-02	4.0E+00	8.6E-06	1.3E-02	8.6E-05	3.9E-03	1.2E-04	4.3E-04
9-Jul-13	18																						
16-Jul-13	19	1.3E-03	1.3E-05	4.3E-04	1.5E+00	2.1E-03	4.3E-06	1.0E-02	1.3E-04	6.8E-03	2.4E+00	1.3E-04	2.0E+00	4.3E-06	1.3E-01	7.5E-02	3.4E+00	8.5E-06	1.6E-02	4.3E-05	3.5E-03	7.7E-05	8.5E-04
23-Jul-13	20																						
30-Jul-13	21	1.3E-03	8.7E-06	4.4E-04	1.4E+00	1.6E-03	4.4E-06	8.3E-03	4.4E-05	8.7E-03	2.2E+00	1.3E-04	1.9E+00	4.4E-06	1.1E-01	7.0E-02	2.6E+00	8.7E-06	1.6E-02	4.4E-05	3.2E-03	7.8E-05	4.4E-04
6-Aug-13	22																						
13-Aug-13	23	4.4E-03	8.7E-06	4.4E-04	1.4E+00	1.5E-03	4.4E-06	7.4E-03	2.6E-04	7.8E-03	2.0E+00	1.6E-04	1.8E+00	4.4E-06	1.1E-01	7.5E-02	2.3E+00	8.7E-06	1.7E-02	4.4E-05	3.0E-03	7.0E-05	8.7E-04
20-Aug-13	24																						
27-Aug-13	25	1.3E-03	1.3E-05	4.3E-04	1.2E+00	9.9E-04	4.3E-06	6.0E-03	8.6E-05	3.9E-03	1.7E+00	7.3E-05	6.9E-01	4.3E-06	1.3E-01	6.5E-02	1.9E+00	8.6E-06	5.5E-03	4.3E-05	2.7E-03	1.0E-04	4.3E-04
3-Sep-13	26																						
10-Sep-13	27	5.0E-03	8.4E-06	4.2E-04	1.2E+00	1.7E-04	4.2E-06	6.5E-03	4.2E-05	3.8E-03	1.6E+00	1.2E-04	6.6E-01	4.2E-06	1.1E-01	6.3E-02	2.1E+00	8.4E-06	2.8E-03	4.2E-05	2.9E-03	8.8E-05	4.2E-04
17-Sep-13	28																						
24-Sep-13	29	1.3E-03	3.1E-05	4.4E-04	1.5E+00	9.2E-04	4.4E-06	9.7E-03	4.4E-05	4.0E-03	1.8E+00	1.8E-04	7.2E-01	4.4E-06	1.2E-01	7.4E-02	3.0E+00	8.8E-06	1.3E-03	4.4E-05	3.8E-03	7.9E-05	4.4E-04
1-Oct-13	30																						
8-Oct-13	31	1.3E-03	8.4E-06	4.2E-04	1.4E+00	2.1E-04	4.2E-06	1.3E-02	1.7E-04	3.8E-03	1.5E+00	1.3E-04	6.6E-01	4.2E-06	1.1E-01	7.0E-02	3.0E+00	8.4E-06	5.6E-04	4.2E-05	4.0E-03	8.0E-05	4.2E-04
15-Oct-13	32																						
22-Oct-13	33	1.3E-03	8.5E-06	4.3E-04	1.4E+00	8.5E-05	4.3E-06	1.4E-02	8.5E-05	3.8E-03	1.4E+00	1.3E-04	6.6E-01	4.3E-06	8.9E-02	6.6E-02	2.5E+00	8.5E-06	3.7E-04	4.3E-05	3.5E-03	8.5E-05	4.3E-04
29-Oct-13	34																						
5-Nov-13	35	1.2E-03	8.2E-06	4.1E-04	1.3E+00	1.2E-04	4.1E-06	1.8E-02	2.1E-04	3.7E-03	1.2E+00	1.4E-04	5.4E-01	4.1E-06	9.0E-02	6.4E-02	2.6E+00	8.2E-06	3.1E-04	4.1E-05	3.2E-03	1.1E-04	4.1E-04
12-Nov-13	36																						
19-Nov-13	37	1.2E-03	2.8E-05	4.0E-04	1.3E+00	8.4E-04	4.0E-06	2.0E-02	2.0E-04	3.6E-03	1.1E+00	1.2E-04	6.2E-01	4.0E-06	1.0E-01	5.9E-02	2.4E+00	8.0E-06	2.5E-03	4.0E-05	4.0E-03	8.0E-05	4.0E-04
26-Nov-13	38																						
3-Dec-13	39	1.8E-03	9.1E-06	4.6E-04	1.6E+00	1.4E-04	4.6E-06	2.5E-02	1.8E-04	4.1E-03	1.3E+00	1.5E-04	6.1E-01	4.6E-06	8.6E-02	7.2E-02	2.6E+00	9.1E-06	2.2E-04	4.6E-05	4.0E-03	1.0E-04	4.6E-04
10-Dec-13	40																						
17-Dec-13	41	1.3E-03	8.5E-06	4.3E-04	1.4E+00	5.1E-04	4.3E-06	2.6E-02	4.3E-05	3.8E-03	1.1E+00	4.6E-04	6.0E-01	4.3E-06	9.4E-02	6.3E-02	2.0E+00	8.5E-06	2.4E-03	4.3E-05	3.3E-03	7.7E-05	4.3E-04
24-Dec-13	42																						
31-Dec-13	43	2.9E-03	8.2E-06	4.1E-04	1.3E+00	4.5E-04	4.1E-06	2.5E-02	1.2E-04	3.7E-03	1.0E+00	1.4E-04	5.7E-01	4.1E-06	7.0E-02	5.6E-02	1.8E+00	8.2E-06	2.0E-04	4.1E-05	2.5E-03	9.0E-05	4.1E-04
7-Jan-14	44																						
14-Jan-14	45	1.3E-03	8.6E-06	4.3E-04	1.5E+00	1.3E-04	4.3E-06	3.2E-02	8.6E-05	3.9E-03	1.1E+00	1.3E-04	6.2E-01	4.3E-06	7.7E-02	6.7E-02	2.2E+00	8.6E-06	1.6E-04	4.3E-05	3.3E-03	9.0E-05	4.3E-04
21-Jan-14	46																						
28-Jan-14	47																						
4-Feb-14	48																						
11-Feb-14	49	1.4E-03	1.8E-05	4.6E-04	1.9E+00	4.1E-04	4.6E-06	5.2E-02	2.3E-04	4.1E-03	1.1E+00	1.9E-04	6.7E-01	4.6E-06	7.8E-02	7.4E-02	2.6E+00	9.2E-06	2.7E-04	4.6E-05	4.5E-03	9.2E-05	4.6E-04
18-Feb-14	50																						
25-Feb-14	51																						
4-Mar-14	52																						
11-Mar-14	53	2.2E-03	8.8E-06	4.4E-04	1.9E+00	3.5E-04	4.4E-06	4.8E-02	1.3E-04	6.2E-03	1.0E+00	1.2E-04	6.8E-01	4.4E-06	7.5E-02	7.0E-02	2.5E+00	8.8E-06	1.9E-04	4.4E-05	4.0E-03	5.7E-05	4.4E-04
18-Mar-14	54																						
25-Mar-14	55																						
1-Apr-14	56																						
8-Apr-14	57	8.0E-04	4.0E-06	3.2E-04	1.5E+00	2.8E-04	4.0E-06	4.7E-02	1.2E-04	3.6E-03	8.2E-01	9.2E-05	5.4E-01	8.0E-07	6.0E-02	5.4E-02	2.0E+00	3.2E-06	1.5E-04	3.6E-05	3.1E-03	6.4E-05	4.0E-04
15-Apr-14	58																						
22-Apr-14	59																						
29-Apr-14	60																						
6-May-14	61	8.7E-04	8.7E-06	3.0E-04	1.7E+00	3.0E-04	4.4E-06	5.2E-02	2.2E-04	6.1E-03	8.1E-01	1.2E-04	5.7E-01	8.7E-07	7.0E-02	5.6E-02	1.8E+00	6.1E-06	3.8E-04	3.0E-05	3.0E-03	7.8E-05	4.4E-04
13-May-14	62																						
20-May-14	63																						
27-May-14	64																						
3-Jun-14	65	2.6E-03	4.4E-06	3.2E-04	1.9E+00	4.0E-04	4.4E-06	4.9E-02	4.4E-05	4.0E-03	8.3E-01	1.1E-04	6.2E-01	1.3E-06	7.5E-02	5.9E-02	1.6E+00	3.5E-06	5.1E-04	2.2E-05	2.7E-03	5.3E-05	4.4E-04
10-Jun-14	66																						
17-Jun-14	67																						
24-Jun-14	68																						
1-Jul-14	69	8.9E-04	8.9E-06	3.7E-04	1.9E+00	4.0E-04	4.5E-06	4.5E-02	4.5E-05	4.0E-03	7.6E-01	1.2E-04	5.9E-01	1.3E-06	7.1E-02	5.7E-02	1.3E+00	4.0E-06	6.1E-04	2.2E-05	2.7E-03	4.5E-05	4.5E-04
8-Jul-14	70																						
15-Jul-14	71																						
22-Jul-14	72																						
29-Jul-14	73	1.3E-03	1.3E-05	3.6E-04	1.8E+00	3.9E-04	4.3E-06	4.7E-02	1.3E-04	3.9E-03	7.2E-01	1.0E-04	5.3E-01	1.3E-06	6.5E-02	5.3E-02	1.3E+00	3.9E-06	5.6E-04	3.4E-05	2.7E-03	8.2E-05	4.3E-04

Col 6

Sample = HPY Pyrite Rougher Sands

Date	Cycle	Approxi.	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Cl	F	Br	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Flow Rate	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
		(mL/min)				umhos/cm	mgCaCO3/L	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
19-Dec-12	**1**	**1.0**	**300**	**220**	**7.66**	**2.1E+03**	**#N/A**	**1.1E+01**	**1.5E+02**	**1.2E+03**	**4.2E+01**	**5.2E-01**	**3.0E-01**	**1.3E+03**	**3.3E-02**	**3.0E-03**	**3.3E-03**	**5.5E-02**	**2.0E-05**	**1.0E-05**	**3.5E-02**	**4.1E-04**	**4.6E+02**	**5.0E-04**	**4.8E-04**	**6.3E-03**
26-Dec-12	2	1.0	300	330	7.72	9.0E+02	#N/A	9.9E+00	1.2E+02	2.8E+02	5.3E+00	6.5E-01	3.0E-01	4.1E+02	2.3E-02	2.9E-03	2.5E-03	2.5E-02	2.0E-05	1.0E-05	4.0E-02	1.7E-04	1.4E+02	5.0E-04	2.2E-04	1.8E-03
2-Jan-13	3	1.0	300	275	7.73	7.5E+02	#N/A	8.7E+00	1.1E+02	2.7E+02	1.6E+00	6.7E-01	3.0E-01	3.2E+02	3.6E-02	3.0E-03	2.3E-03	2.9E-02	2.0E-05	1.0E-05	3.2E-02	1.2E-04	1.1E+02	5.0E-04	1.9E-04	1.1E-03
9-Jan-13	4	1.0	300	300	7.74	7.5E+02	#N/A	1.1E+01	1.1E+02	3.1E+02	8.0E-01	6.4E-01	3.0E-01	3.5E+02	3.1E-02	3.4E-03	2.3E-03	3.5E-02	2.0E-05	1.0E-05	3.3E-02	1.3E-04	1.2E+02	5.0E-04	2.3E-04	2.4E-03
16-Jan-13	5	1.0	300	295	7.83	7.4E+02																				
23-Jan-13	6	1.0	300	300	7.71	7.1E+02	#N/A	1.2E+01	1.1E+02	2.9E+02	6.0E-01	6.0E-01	3.0E-01	3.2E+02	3.4E-02	6.8E-03	2.4E-03	3.3E-02	2.0E-05	1.0E-05	2.8E-02	1.6E-04	1.1E+02	5.0E-04	3.1E-04	2.7E-03
30-Jan-13	7	1.0	300	300	7.81	6.5E+02																				
6-Feb-13	8	1.0	300	270	7.75	5.8E+02	#N/A	1.0E+01	1.1E+02	1.6E+02	1.0E+00	6.6E-01	3.0E-01	2.4E+02	1.2E-02	1.2E-02	2.9E-03	3.3E-02	2.0E-05	1.0E-05	3.0E-02	1.4E-04	8.3E+01	5.0E-04	2.7E-04	3.0E-03
13-Feb-13	9	1.0	300	295	7.71	4.8E+02																				
20-Feb-13	10	1.0	300	290	7.83	4.3E+02	#N/A	7.9E+00	1.3E+02	1.0E+02	9.0E-01	7.7E-01	3.0E-01	2.1E+02	1.5E-02	1.5E-02	2.9E-03	3.0E-02	2.0E-05	1.0E-05	2.3E-02	1.2E-04	7.5E+01	5.0E-04	1.9E-04	4.8E-03
27-Feb-13	11	1.0	300	295	7.79	3.9E+02																				
6-Mar-13	12	1.0	300	300	7.64	3.8E+02	#N/A	8.2E+00	1.3E+02	6.5E+01	8.0E-01	8.0E-01	3.0E-01	1.7E+02	1.4E-02	2.1E-02	3.3E-03	3.8E-02	2.0E-05	1.0E-05	2.0E-02	1.4E-04	5.9E+01	5.0E-04	2.5E-04	3.2E-03
13-Mar-13	13	1.0	300	295	7.86	3.4E+02																				
20-Mar-13	14	1.0	300	305	7.98	3.2E+02	#N/A	8.1E+00	1.2E+02	6.1E+01	8.0E-01	7.5E-01	3.0E-01	1.5E+02	1.0E-02	2.1E-02	4.0E-03	4.4E-02	2.0E-05	1.0E-05	1.5E-02	1.2E-04	5.2E+01	5.0E-04	2.4E-04	3.5E-03
27-Mar-13	15	1.0	300	295	7.96	3.2E+02																				
3-Apr-13	16	1.0	300	290	7.86	3.1E+02	#N/A	9.1E+00	1.2E+02	4.6E+01	8.0E-01	7.1E-01	3.0E-01	1.5E+02	1.4E-02	2.1E-02	3.0E-03	5.0E-02	2.0E-05	1.0E-05	1.4E-02	1.2E-04	5.2E+01	5.0E-04	2.3E-04	3.5E-03
10-Apr-13	17	1.0	300	290	7.92	3.0E+02																				
17-Apr-13	18	1.0	300	290	7.63	3.0E+02	#N/A	#N/A	9.2E+01	5.2E+01	7.0E-01	6.5E-01	3.0E-01	1.4E+02	1.6E-02	2.2E-02	3.3E-03	5.8E-02	2.0E-05	1.0E-05	1.7E-02	1.1E-04	4.7E+01	5.0E-04	5.3E-04	4.0E-03
24-Apr-13	19	1.0	300	300	7.83	3.0E+02																				
1-May-13	20	1.0	300	295	7.88	2.8E+02	#N/A	8.6E+00	1.1E+02	4.9E+01	6.0E-01	5.8E-01	3.0E-01	1.3E+02	1.2E-02	1.8E-02	2.7E-03	5.1E-02	2.0E-05	1.0E-05	1.8E-02	9.3E-05	4.6E+01	5.0E-04	2.2E-04	3.9E-03
8-May-13	21	1.0	300	300	7.71	2.8E+02																				
15-May-13	22	1.0	300	300	7.76	2.5E+02	#N/A	1.1E+01	1.1E+02	3.9E+01	7.0E-01	5.2E-01	3.0E-01	1.3E+02	1.3E-02	1.9E-02	2.7E-03	6.3E-02	2.0E-05	1.0E-05	1.6E-02	1.4E-04	4.6E+01	5.0E-04	1.8E-04	3.8E-03
22-May-13	23	1.0	300	300	7.82	2.6E+02																				
29-May-13	24	1.0	300	300	7.82	2.6E+02	#N/A	9.6E+00	1.1E+02	3.3E+01	6.0E-01	4.7E-01	3.0E-01	1.2E+02	1.4E-02	1.7E-02	2.5E-03	6.7E-02	2.0E-05	1.0E-05	1.2E-02	1.0E-04	4.1E+01	5.0E-04	1.6E-04	6.0E-03
5-Jun-13	25	1.0	300	295	7.76	2.7E+02																				
12-Jun-13	26	1.0	300	295	7.70	2.6E+02	#N/A	1.4E+01	1.1E+02	2.9E+01	6.0E-01	4.5E-01	3.0E-01	1.2E+02	8.2E-03	1.7E-02	2.5E-03	7.2E-02	2.0E-05	1.0E-05	9.0E-03	9.8E-05	4.0E+01	5.0E-04	1.7E-04	4.6E-03
19-Jun-13	27	1.0	300	295	7.75	2.8E+02																				
26-Jun-13	28	1.0	300	295	7.85	2.7E+02	#N/A	6.3E+00	1.1E+02	3.0E+01	7.0E-01	4.2E-01	3.0E-01	1.2E+02	1.1E-02	1.5E-02	2.3E-03	7.5E-02	2.0E-05	1.0E-05	1.0E-02	7.1E-05	4.2E+01	5.0E-04	1.7E-04	4.2E-03
3-Jul-13	29	1.0	300	305	7.80	2.6E+02																				
10-Jul-13	30	1.0	300	300	7.69	2.6E+02	#N/A	1.3E+01	1.1E+02	3.1E+01	7.0E-01	3.9E-01	3.0E-01	1.3E+02	1.2E-02	1.5E-02	2.4E-03	8.0E-02	2.0E-05	1.0E-05	1.1E-02	1.0E-04	4.3E+01	5.0E-04	2.6E-04	4.6E-03
17-Jul-13	31	1.0	300	295	7.80	2.6E+02																				
24-Jul-13	32	1.0	300	305	7.65	2.6E+02	#N/A	1.3E+01	1.1E+02	2.8E+01	7.0E-01	3.7E-01	3.0E-01	1.2E+02	1.1E-02	1.4E-02	2.1E-03	7.6E-02	2.0E-05	1.0E-05	1.2E-02	1.0E-04	4.1E+01	5.0E-04	1.8E-04	4.3E-03
31-Jul-13	33	1.0	300	300	7.75	2.7E+02																				
7-Aug-13	34	1.0	300	300	7.67	2.7E+02	#N/A	1.2E+01	1.1E+02	3.2E+01	6.0E-01	3.3E-01	3.0E-01	1.2E+02	9.9E-03	1.4E-02	2.1E-03	8.1E-02	2.0E-05	1.0E-05	1.0E-02	9.6E-05	4.0E+01	5.0E-04	1.9E-04	4.5E-03
14-Aug-13	35	1.0	300	300	7.80	2.7E+02																				
21-Aug-13	36	1.0	300	295	7.69	2.7E+02	#N/A	1.1E+01	1.0E+02	2.7E+01	6.0E-01	3.4E-01	3.0E-01	1.2E+02	1.3E-02	1.3E-02	1.9E-03	7.7E-02	2.0E-05	1.0E-05	1.5E-02	1.2E-04	4.2E+01	5.0E-04	1.6E-04	4.8E-03
28-Aug-13	37	1.0	300	295	7.88	2.5E+02																				
4-Sep-13	38	1.0	300	295	7.78	2.5E+02	#N/A	7.9E+00	1.0E+02	2.5E+01	6.0E-01	2.9E-01	3.0E-01	1.3E+02	9.7E-03	1.2E-02	1.7E-03	7.8E-02	2.0E-05	1.0E-05	1.9E-02	1.0E-04	4.3E+01	5.0E-04	1.7E-04	4.9E-03
11-Sep-13	39	1.0	300	305	7.81	2.5E+02																				
18-Sep-13	40	1.0	300	300	7.79	2.6E+02	#N/A	8.8E+00	1.0E+02	2.7E+01	6.0E-01	3.3E-01	3.0E-01	1.3E+02	4.2E-02	1.2E-02	2.0E-03	8.3E-02	2.0E-05	1.0E-05	1.8E-02	8.0E-05	4.3E+01	5.0E-04	2.6E-04	4.5E-03
25-Sep-13	41	1.0	300	300	8.06	2.6E+02																				
2-Oct-13	42	1.0	300	295	7.93	2.6E+02																				
9-Oct-13	43	1.0	300	295	7.93	2.6E+02																				
16-Oct-13	44	1.0	300	300	7.93	2.6E+02	#N/A	3.5E+00	1.0E+02	2.2E+01	6.0E-01	2.5E-01	3.0E-01	1.3E+02	8.1E-03	1.2E-02	1.9E-03	9.7E-02	2.0E-05	1.0E-05	1.2E-02	1.2E-04	4.3E+01	6.0E-04	2.2E-04	6.1E-03
23-Oct-13	45	1.0	300	295	7.88	2.6E+02																				
30-Oct-13	46	1.0	300	305	8.05	2.6E+02																				
6-Nov-13	47	1.0	300	300	8.05	2.6E+02																				

Col 6

Sample = HPY Pyrite Rougher Sands

Date	Cycle	Approxi.	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Cl	F	Br	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Flow Rate	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
		(mL/min)				umhos/cm	mgCaCO3/L	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
13-Nov-13	48	1.0	300	300	7.90	2.7E+02	#N/A	5.3E+00	1.0E+02	2.1E+01	5.0E-01	2.5E-01	3.0E-01	1.2E+02	9.2E-03	1.1E-02	2.0E-03	9.2E-02	2.0E-05	1.0E-05	9.0E-03	1.1E-04	4.0E+01	5.0E-04	2.2E-04	6.1E-03
20-Nov-13	49	1.0	300	295	8.36	2.6E+02																				
27-Nov-13	50	1.0	300	300	7.41	2.6E+02																				
4-Dec-13	51	1.0	300	310	8.27	2.6E+02																				
11-Dec-13	52	1.0	300	290	8.08	2.4E+02	#N/A	2.1E+00	1.1E+02	1.7E+01	6.0E-01	2.3E-01	3.0E-01	1.2E+02	8.8E-03	1.0E-02	1.6E-03	9.2E-02	2.0E-05	1.0E-05	1.6E-02	1.3E-04	4.0E+01	5.0E-04	2.7E-04	6.3E-03
18-Dec-13	53	1.0	300	310	8.10	2.5E+02																				
25-Dec-13	54	1.0	300	285	7.96	2.6E+02																				
1-Jan-14	55	1.0	300	310	8.06	2.6E+02																				
8-Jan-14	56	1.0	300	295	8.12	2.7E+02	#N/A	1.7E+00	1.1E+02	1.6E+01	4.0E-01	2.2E-01	3.0E-01	1.2E+02	1.0E-02	1.0E-02	1.5E-03	9.6E-02	2.0E-05	1.0E-05	9.0E-03	1.0E-04	4.0E+01	5.0E-04	2.1E-04	6.5E-03
15-Jan-14	57	1.0	300	290	8.00	2.8E+02																				
22-Jan-14	58	1.0	300	295	8.07	2.8E+02																				
29-Jan-14	59	1.0	300	290	8.06	2.4E+02																				
5-Feb-14	60	1.0	300	300	8.02	2.5E+02	#N/A	3.1E+00	1.2E+02	2.2E+01	4.0E-01	2.3E-01	3.0E-01	1.3E+02	1.9E-02	1.0E-02	2.3E-03	9.3E-02	2.0E-05	1.0E-05	8.2E-03	1.3E-04	4.2E+01	5.0E-04	4.1E-04	7.5E-03
12-Feb-14	61	1.0	300	295	8.09	2.4E+02																				
19-Feb-14	62	1.0	300	300	8.03	2.5E+02																				
26-Feb-14	63	1.0	300	295	8.00	2.4E+02																				
5-Mar-14	64	1.0	300	295	7.94	2.5E+02	#N/A	5.4E+00	1.2E+02	1.7E+01	4.0E-01	2.2E-01	3.0E-01	1.3E+02	6.8E-03	9.0E-03	1.2E-03	9.2E-02	2.0E-05	1.0E-05	8.3E-03	9.1E-05	4.4E+01	5.0E-04	2.4E-04	6.6E-03
12-Mar-14	65	1.0	300	295	8.01	2.6E+02																				
19-Mar-14	66	1.0	300	300	7.91	2.4E+02																				
26-Mar-14	67	1.0	300	300	8.04	2.5E+02																				
2-Apr-14	68	1.0	300	295	7.93	2.5E+02	#N/A	5.6E+00	1.2E+02	2.0E+01	4.0E-01	2.5E-01	3.0E-01	1.3E+02	1.5E-02	8.6E-03	1.1E-03	9.7E-02	2.0E-05	1.0E-05	8.7E-03	1.4E-04	4.2E+01	5.0E-04	3.9E-04	8.1E-03
9-Apr-14	69	1.0	300	300	8.00	2.6E+02																				
16-Apr-14	70	1.0	300	295	7.96	2.5E+02																				
23-Apr-14	71	1.0	300	300	8.03	2.6E+02																				
30-Apr-14	72	1.0	300	300	7.75	2.4E+02	#N/A	9.0E+00	1.0E+02	1.8E+01	4.0E-01	2.2E-01	3.0E-01	1.2E+02	5.6E-03	7.5E-03	1.1E-03	1.0E-01	7.0E-06	7.0E-06	7.6E-03	1.1E-04	4.0E+01	5.0E-05	2.4E-04	7.8E-03
7-May-14	73	1.0	300	305	8.02	2.4E+02																				
14-May-14	74	1.0	300	300	7.80	2.3E+02																				
21-May-14	75	1.0	300	290	7.66	2.3E+02																				
28-May-14	76	1.0	300	310	7.94	2.2E+02	#N/A	6.7E+00	1.1E+02	1.5E+01	4.0E-01	2.1E-01	3.0E-01	1.2E+02	7.1E-03	9.3E-03	1.1E-03	1.0E-01	7.0E-06	7.0E-06	8.4E-03	1.1E-04	4.1E+01	1.3E-04	3.8E-04	9.3E-03
4-Jun-14	77	1.0	300	305	8.06	2.4E+02																				
11-Jun-14	78	1.0	300	290	7.93	2.4E+02																				
18-Jun-14	79	1.0	300	295	7.83	2.4E+02																				
25-Jun-14	80	1.0	300	300	7.70	2.4E+02	#N/A	1.2E+01	1.1E+02	1.6E+01	3.0E-01	2.1E-01	3.0E-01	1.2E+02	5.5E-03	7.6E-03	1.1E-03	1.1E-01	7.0E-06	7.0E-06	1.1E-02	1.1E-04	4.1E+01	9.0E-05	2.9E-04	8.9E-03
2-Jul-14	81	1.0	300	295	7.92	2.5E+02																				
9-Jul-14	82	1.0	300	295	8.00	2.6E+02																				
16-Jul-14	83	1.0	300	295	8.07	2.6E+02																				
23-Jul-14	84	1.0	300	300	8.01	2.4E+02	#N/A	3.8E+00	1.1E+02	1.3E+01	3.0E-01	2.2E-01	3.0E-01	1.2E+02	8.2E-03	7.8E-03	1.0E-03	1.1E-01	7.0E-06	7.0E-06	9.7E-03	1.1E-04	4.0E+01	5.0E-05	3.5E-04	8.8E-03
30-Jul-14	85	1.0	300	305	8.06	2.5E+02																				
6-Aug-14	86	1.0	300	300	8.11	2.4E+02																				
13-Aug-14	87	1.0	300	290	8.00	2.5E+02																				
20-Aug-14	88	1.0	300	305	8.06	2.5E+02	#N/A	2.9E+00	1.1E+02	1.3E+01	4.0E-01	2.2E-01	3.0E-01	1.2E+02	7.4E-03	7.1E-03	9.0E-04	1.2E-01	7.0E-06	7.0E-06	8.7E-03	1.2E-04	4.0E+01	3.0E-05	2.5E-04	9.2E-03

Col 6

Sample = HPY Pyrite Rougher Sands

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Major	Major	Diff	Diff
	No.																								Anions	Cations		(%)
		mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L				
19-Dec-12	**1**	**3.0E-03**	**1.6E-03**	**2.0E-03**	**4.0E+01**	**1.9E-01**	**1.0E-02**	**4.8E-02**	**7.0E-04**	**2.4E-01**	**3.9E+01**	**3.2E-03**	**3.1E+00**	**7.0E-05**	**4.7E+01**	**1.8E+00**	**4.1E+02**	**5.0E-05**	**4.2E-04**	**5.0E-04**	**2.5E-01**	**8.9E-04**	**4.0E-03**	**1.0E-04**	**2.9E+01**	**2.9E+01**	**3.2E-01**	**0.5%**
26-Dec-12	2	3.0E-03	4.7E-04	1.0E-03	1.4E+01	6.4E-02	1.0E-02	3.3E-02	1.4E-03	1.4E-01	2.0E+01	8.1E-04	2.7E+00	2.0E-05	1.6E+01	7.5E-01	1.2E+02	3.0E-05	2.6E-04	2.0E-04	8.5E-02	6.1E-04	2.0E-03	2.0E-05	8.3E+00	9.4E+00	1.2E+00	6.5%
2-Jan-13	3	5.0E-03	2.8E-04	1.0E-03	1.0E+01	5.7E-02	1.0E-02	2.6E-02	9.0E-04	1.1E-01	1.8E+01	4.4E-04	3.0E+00	8.0E-05	9.8E+00	6.2E-01	9.2E+01	3.0E-05	3.8E-04	5.0E-04	7.7E-02	8.5E-04	3.0E-03	3.0E-05	7.9E+00	7.3E+00	-5.8E-01	-3.9%
9-Jan-13	4	3.0E-03	2.0E-04	1.0E-03	1.1E+01	6.8E-02	1.0E-02	2.5E-02	1.8E-03	9.2E-02	1.9E+01	5.2E-04	2.7E+00	1.0E-05	6.8E+00	6.9E-01	8.3E+01	3.0E-05	3.1E-04	3.0E-04	8.4E-02	8.1E-04	2.0E-03	4.0E-05	8.7E+00	7.8E+00	-8.8E-01	-5.3%
16-Jan-13	5																											
23-Jan-13	6	3.0E-03	1.8E-04	1.0E-03	1.0E+01	7.5E-02	1.0E-02	3.5E-02	3.2E-03	8.6E-02	1.7E+01	4.9E-04	3.0E+00	1.3E-04	2.9E+00	6.8E-01	8.7E+01	3.0E-05	6.2E-04	5.0E-04	7.8E-02	7.6E-04	2.0E-03	6.0E-05	8.3E+00	7.0E+00	-1.4E+00	-9.0%
30-Jan-13	7																											
6-Feb-13	8	4.0E-03	2.1E-04	1.0E-03	8.5E+00	7.1E-02	1.0E-02	5.5E-02	9.0E-04	6.4E-02	1.5E+01	5.8E-04	3.2E+00	1.0E-05	1.7E+00	5.9E-01	6.1E+01	3.0E-05	1.1E-03	2.0E-04	7.3E-02	4.9E-04	2.0E-03	5.0E-05	5.7E+00	5.3E+00	-3.3E-01	-3.0%
13-Feb-13	9																											
20-Feb-13	10	3.0E-03	1.4E-04	1.0E-03	6.5E+00	6.0E-02	1.0E-02	8.0E-02	4.0E-04	8.3E-02	1.3E+01	7.0E-04	3.0E+00	1.0E-05	1.3E+00	4.7E-01	3.7E+01	3.0E-05	1.8E-03	2.0E-04	4.7E-02	5.8E-04	4.0E-03	5.0E-05	4.9E+00	4.7E+00	-1.9E-01	-2.0%
27-Feb-13	11																											
6-Mar-13	12	3.0E-03	1.4E-04	1.0E-03	5.7E+00	5.9E-02	1.0E-02	1.2E-01	4.0E-04	7.2E-02	1.2E+01	8.7E-04	3.1E+00	1.0E-05	8.8E-01	4.3E-01	2.6E+01	3.0E-05	2.4E-03	1.0E-04	3.7E-02	5.8E-04	1.0E-03	6.0E-05	4.0E+00	3.7E+00	-2.7E-01	-3.5%
13-Mar-13	13																											
20-Mar-13	14	3.0E-03	1.1E-04	1.0E-03	5.2E+00	5.6E-02	1.0E-02	1.4E-01	2.0E-04	7.0E-02	1.2E+01	8.1E-04	3.0E+00	1.0E-05	8.0E-01	3.9E-01	2.0E+01	3.0E-05	3.3E-03	1.0E-04	3.3E-02	3.1E-04	1.0E-03	2.0E-05	3.7E+00	3.4E+00	-3.0E-01	-4.2%
27-Mar-13	15																											
3-Apr-13	16	3.0E-03	1.1E-04	1.0E-03	5.1E+00	5.5E-02	1.0E-02	1.3E-01	3.0E-04	7.0E-02	1.1E+01	5.2E-04	3.1E+00	1.0E-05	6.6E-01	3.9E-01	1.8E+01	3.0E-05	4.5E-03	1.0E-04	2.9E-02	4.6E-04	1.0E-03	2.0E-05	3.4E+00	3.3E+00	-1.8E-02	-0.3%
10-Apr-13	17																											
17-Apr-13	18	3.0E-03	1.2E-04	1.0E-03	5.0E+00	5.4E-02	1.0E-02	1.4E-01	5.0E-04	7.5E-02	1.1E+01	7.9E-04	3.1E+00	1.0E-05	6.2E-01	3.9E-01	1.6E+01	3.0E-05	5.5E-03	1.0E-04	3.3E-02	5.4E-04	2.0E-03	1.0E-05	3.0E+00	3.1E+00	1.2E-01	1.9%
24-Apr-13	19																											
1-May-13	20	3.0E-03	6.0E-05	1.0E-03	4.7E+00	5.3E-02	1.0E-02	1.2E-01	4.0E-04	5.8E-02	9.7E+00	7.2E-04	3.0E+00	1.0E-05	5.6E-01	3.6E-01	1.4E+01	2.0E-05	6.2E-03	1.0E-04	2.6E-02	5.9E-04	1.0E-03	1.0E-05	3.3E+00	2.9E+00	-4.0E-01	-6.4%
8-May-13	21																											
15-May-13	22	3.0E-03	3.6E-04	1.0E-03	4.6E+00	5.2E-02	1.0E-02	8.8E-02	5.0E-04	6.2E-02	9.7E+00	7.8E-04	2.9E+00	1.0E-05	4.7E-01	3.5E-01	1.2E+01	3.0E-05	7.8E-03	1.0E-04	2.6E-02	5.1E-04	2.0E-03	1.0E-05	3.1E+00	2.9E+00	-2.1E-01	-3.4%
22-May-13	23																											
29-May-13	24	1.1E-02	1.9E-04	1.0E-03	4.5E+00	5.5E-02	1.0E-02	7.7E-02	1.0E-03	6.0E-02	9.0E+00	6.3E-04	2.8E+00	1.0E-05	4.5E-01	3.5E-01	1.1E+01	2.0E-05	9.2E-03	3.0E-04	2.3E-02	5.0E-04	2.0E-03	1.0E-05	3.0E+00	2.7E+00	-3.1E-01	-5.5%
5-Jun-13	25																											
12-Jun-13	26	3.0E-03	5.0E-05	1.0E-03	4.2E+00	4.6E-02	1.0E-02	6.6E-02	3.0E-04	6.0E-02	7.9E+00	6.9E-04	2.7E+00	1.0E-05	3.8E-01	3.2E-01	9.1E+00	3.0E-05	9.4E-03	1.0E-04	2.2E-02	4.6E-04	4.0E-03	1.0E-05	2.9E+00	2.5E+00	-3.6E-01	-6.5%
19-Jun-13	27																											
26-Jun-13	28	3.0E-03	2.0E-04	1.0E-03	4.5E+00	5.1E-02	1.0E-02	5.8E-02	4.0E-04	5.7E-02	8.3E+00	8.0E-04	2.9E+00	1.0E-05	4.0E-01	3.5E-01	1.1E+01	2.0E-05	9.7E-03	1.0E-04	2.0E-02	4.5E-04	1.0E-03	1.0E-05	2.8E+00	2.7E+00	-7.0E-02	-1.3%
3-Jul-13	29																											
10-Jul-13	30	3.0E-03	4.0E-05	1.0E-03	4.7E+00	5.4E-02	1.0E-02	5.5E-02	6.0E-04	5.2E-02	8.2E+00	7.8E-04	3.0E+00	1.0E-05	3.8E-01	3.6E-01	1.1E+01	3.0E-05	1.0E-02	1.0E-04	2.3E-02	4.8E-04	2.0E-03	2.0E-05	2.9E+00	2.8E+00	-1.3E-01	-2.3%
17-Jul-13	31																											
24-Jul-13	32	3.0E-03	6.0E-05	1.0E-03	4.5E+00	5.3E-02	1.0E-02	5.1E-02	6.0E-04	5.4E-02	7.5E+00	8.7E-04	2.8E+00	1.0E-05	3.4E-01	3.5E-01	1.0E+01	2.0E-05	9.4E-03	1.0E-04	2.3E-02	5.0E-04	2.0E-03	2.0E-05	2.8E+00	2.7E+00	-9.6E-02	-1.8%
31-Jul-13	33																											
7-Aug-13	34	3.0E-03	5.0E-05	1.0E-03	4.3E+00	5.1E-02	1.0E-02	4.9E-02	9.0E-04	3.8E-02	7.1E+00	9.8E-04	2.8E+00	1.0E-05	3.4E-01	3.4E-01	9.6E+00	2.0E-05	8.5E-03	1.0E-04	2.4E-02	3.6E-04	1.0E-03	1.0E-05	2.8E+00	2.6E+00	-2.5E-01	-4.7%
14-Aug-13	35																											
21-Aug-13	36	8.7E-02	3.0E-05	1.0E-03	4.8E+00	5.2E-02	1.0E-02	4.6E-02	1.0E-04	5.1E-02	6.1E+00	8.5E-04	2.7E+00	1.0E-05	4.3E-01	3.9E-01	9.8E+00	3.0E-05	7.7E-03	1.0E-04	2.2E-02	5.4E-04	1.0E-03	1.0E-05	2.6E+00	2.7E+00	1.7E-02	0.3%
28-Aug-13	37																											
4-Sep-13	38	3.0E-03	7.0E-05	1.0E-03	4.7E+00	5.6E-02	1.0E-02	3.9E-02	6.0E-04	5.7E-02	6.7E+00	8.0E-04	2.9E+00	1.0E-05	3.2E-01	3.6E-01	9.8E+00	2.0E-05	6.5E-03	1.0E-04	2.1E-02	4.3E-04	2.0E-03	1.0E-05	2.6E+00	2.7E+00	1.1E-01	2.1%
11-Sep-13	39																											
18-Sep-13	40	3.0E-03	5.0E-05	1.0E-03	4.8E+00	5.1E-02	1.0E-02	3.8E-02	3.0E-04	5.0E-02	6.4E+00	9.1E-04	2.8E+00	1.0E-05	3.7E-01	3.5E-01	9.7E+00	2.0E-05	7.0E-03	1.0E-04	2.3E-02	4.1E-04	1.0E-03	1.0E-05	2.7E+00	2.7E+00	5.1E-02	0.9%
25-Sep-13	41																											
2-Oct-13	42																											
9-Oct-13	43																											
16-Oct-13	44	3.0E-03	1.7E-04	1.0E-03	4.8E+00	5.8E-02	1.0E-02	3.3E-02	6.0E-04	4.8E-02	5.5E+00	8.6E-04	2.9E+00	1.0E-05	3.0E-01	3.5E-01	9.1E+00	2.0E-05	6.2E-03	1.0E-04	2.4E-02	7.0E-04	3.0E-03	1.0E-05	2.6E+00	2.7E+00	1.1E-01	2.1%
23-Oct-13	45																											
30-Oct-13	46																											
6-Nov-13	47																											

Col 6

Sample = HPY Pyrite Rougher Sands

Date	Cycle	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Major	Major	Diff	Diff
	No.																								Anions	Cations		(%)
		mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L				
13-Nov-13	48	3.0E-03	5.0E-05	1.0E-03	4.8E+00	5.8E-02	1.0E-02	2.7E-02	1.0E-03	3.7E-02	5.0E+00	7.8E-04	2.9E+00	1.0E-05	3.0E-01	3.4E-01	9.2E+00	2.0E-05	5.1E-03	2.0E-04	2.3E-02	4.9E-04	2.0E-03	1.0E-05	2.5E+00	2.6E+00	3.3E-02	0.7%
20-Nov-13	49																											
27-Nov-13	50																											
4-Dec-13	51																											
11-Dec-13	52	1.1E-02	4.0E-05	1.0E-03	4.5E+00	5.7E-02	1.0E-02	2.4E-02	1.0E-04	3.7E-02	4.1E+00	7.6E-04	2.6E+00	1.0E-05	2.6E-01	3.2E-01	7.9E+00	2.0E-05	4.1E-03	1.0E-04	2.3E-02	4.7E-04	2.0E-03	1.0E-05	2.5E+00	2.5E+00	-4.3E-03	-0.1%
18-Dec-13	53																											
25-Dec-13	54																											
1-Jan-14	55																											
8-Jan-14	56	1.0E-02	3.0E-05	1.0E-03	5.0E+00	6.2E-02	1.0E-02	3.2E-02	7.0E-04	3.7E-02	4.2E+00	7.5E-04	2.5E+00	1.0E-05	3.0E-01	3.3E-01	8.8E+00	2.0E-05	4.3E-03	2.0E-04	2.1E-02	5.5E-04	1.0E-03	1.0E-05	2.5E+00	2.6E+00	2.4E-02	0.5%
15-Jan-14	57																											
22-Jan-14	58																											
29-Jan-14	59																											
5-Feb-14	60	3.0E-03	5.4E-04	1.0E-03	5.0E+00	6.9E-02	1.0E-02	1.9E-02	1.2E-03	6.6E-02	3.8E+00	7.6E-04	2.8E+00	3.0E-05	2.6E-01	3.5E-01	7.5E+00	3.0E-05	3.7E-03	2.0E-04	2.0E-02	4.6E-04	3.0E-03	1.0E-05	2.8E+00	2.6E+00	-2.1E-01	-3.8%
12-Feb-14	61																											
19-Feb-14	62																											
26-Feb-14	63																											
5-Mar-14	64	3.0E-03	2.0E-05	1.0E-03	5.2E+00	6.8E-02	1.0E-02	1.8E-02	7.0E-04	3.5E-02	3.6E+00	6.3E-04	2.7E+00	1.0E-05	2.6E-01	3.5E-01	7.8E+00	2.0E-05	3.6E-03	1.0E-04	2.0E-02	4.6E-04	1.0E-03	1.0E-05	2.8E+00	2.7E+00	-1.0E-01	-1.9%
12-Mar-14	65																											
19-Mar-14	66																											
26-Mar-14	67																											
2-Apr-14	68	3.0E-03	2.0E-05	1.0E-03	5.1E+00	6.9E-02	1.0E-02	1.6E-02	9.0E-04	4.0E-02	3.3E+00	5.7E-04	2.6E+00	1.0E-05	2.5E-01	3.4E-01	7.2E+00	2.0E-05	3.7E-03	2.0E-04	2.0E-02	5.7E-04	4.0E-02	1.0E-05	2.8E+00	2.6E+00	-2.3E-01	-4.2%
9-Apr-14	69																											
16-Apr-14	70																											
23-Apr-14	71																											
30-Apr-14	72	2.0E-03	3.0E-05	1.0E-03	4.8E+00	6.9E-02	1.0E-02	1.5E-02	6.0E-04	3.2E-02	2.9E+00	5.7E-04	2.5E+00	2.0E-06	2.3E-01	3.2E-01	6.3E+00	1.6E-05	3.2E-03	1.1E-04	1.9E-02	4.2E-04	2.0E-03	2.0E-03	2.5E+00	2.5E+00	-2.0E-02	-0.4%
7-May-14	73																											
14-May-14	74																											
21-May-14	75																											
28-May-14	76	1.1E-02	3.0E-05	1.1E-03	5.3E+00	7.5E-02	1.0E-02	1.4E-02	4.0E-04	2.7E-02	2.9E+00	5.1E-04	2.5E+00	2.0E-06	2.5E-01	3.4E-01	6.9E+00	1.5E-05	3.6E-03	5.0E-05	1.9E-02	4.3E-04	1.0E-03	2.0E-03	2.5E+00	2.6E+00	5.5E-02	1.1%
4-Jun-14	77																											
11-Jun-14	78																											
18-Jun-14	79																											
25-Jun-14	80	2.0E-03	4.0E-05	1.2E-03	5.3E+00	7.7E-02	1.0E-02	1.5E-02	6.0E-04	3.8E-02	2.7E+00	6.5E-04	2.4E+00	2.0E-06	2.6E-01	3.3E-01	6.7E+00	1.7E-05	3.3E-03	1.0E-04	2.0E-02	4.2E-04	2.0E-03	2.0E-03	2.6E+00	2.6E+00	-4.9E-02	-0.00942846
2-Jul-14	81																											
9-Jul-14	82																											
16-Jul-14	83																											
23-Jul-14	84	2.0E-03	2.0E-05	1.2E-03	5.2E+00	7.7E-02	2.0E-02	1.5E-02	4.0E-04	3.8E-02	2.4E+00	6.1E-04	2.3E+00	8.0E-06	2.3E-01	3.3E-01	6.3E+00	1.2E-05	3.4E-03	8.0E-05	1.9E-02	4.7E-04	2.0E-03	2.0E-03	2.6E+00	2.5E+00	-7.7E-02	-0.01522579
30-Jul-14	85																											
6-Aug-14	86																											
13-Aug-14	87																											
20-Aug-14	88	2.0E-03	2.0E-05	1.2E-03	5.3E+00	8.1E-02	1.0E-02	1.4E-02	5.0E-04	3.7E-02	2.4E+00	5.6E-04	2.2E+00	2.0E-06	2.3E-01	3.3E-01	6.3E+00	1.0E-05	3.2E-03	1.0E-04	1.8E-02	4.2E-04	1.0E-03	2.0E-03	2.6E+00	2.5E+00	-5.3E-02	-0.01040559

Col 6

Sample = HPY Pyrite Rougher Sands

Date	Cycle	Approxi.	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Cl	F	Br	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Flow Rate	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
		(mL/min)				umhos/cm	mgCaCO3/kg	mgCaCO3/kg	mgCaCO3/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
19-Dec-12	1	1	300	220	7.66	2.1E+03	#N/A	4.9E-01	6.8E+00	5.2E+01	1.8E+00	2.3E-02	1.3E-02	5.7E+01	1.4E-03	1.3E-04	1.5E-04	2.4E-03	8.8E-07	4.4E-07	1.6E-03	1.8E-05	2.0E+01	2.2E-05	2.1E-05	2.8E-04
26-Dec-12	2	1	300	330	7.72	9.0E+02	#N/A	6.5E-01	7.7E+00	1.8E+01	3.5E-01	4.3E-02	2.0E-02	2.7E+01	1.5E-03	1.9E-04	1.7E-04	1.7E-03	1.3E-06	6.6E-07	2.6E-03	1.1E-05	9.3E+00	3.3E-05	1.4E-05	1.2E-04
2-Jan-13	3	1	300	275	7.73	7.5E+02	#N/A	4.8E-01	5.9E+00	1.5E+01	8.8E-02	3.7E-02	1.7E-02	1.8E+01	2.0E-03	1.7E-04	1.3E-04	1.6E-03	1.1E-06	5.5E-07	1.8E-03	6.8E-06	6.1E+00	2.8E-05	1.1E-05	6.1E-05
9-Jan-13	4	1	300	300	7.74	7.5E+02	#N/A	6.8E-01	6.6E+00	1.9E+01	4.8E-02	3.8E-02	1.8E-02	2.1E+01	1.8E-03	2.0E-04	1.4E-04	2.1E-03	1.2E-06	6.0E-07	2.0E-03	7.5E-06	7.3E+00	3.0E-05	1.4E-05	1.4E-04
16-Jan-13	5	1	300	295	7.83	7.4E+02																				
23-Jan-13	6	1	300	300	7.71	7.1E+02	#N/A	7.3E-01	6.9E+00	1.7E+01	3.6E-02	3.6E-02	1.8E-02	1.9E+01	2.1E-03	4.1E-04	1.4E-04	2.0E-03	1.2E-06	6.0E-07	1.7E-03	9.7E-06	6.7E+00	3.0E-05	1.9E-05	1.6E-04
30-Jan-13	7	1	300	300	7.81	6.5E+02																				
6-Feb-13	8	1	300	270	7.75	5.8E+02	#N/A	5.4E-01	6.2E+00	8.6E+00	5.4E-02	3.6E-02	1.6E-02	1.3E+01	6.5E-04	6.4E-04	1.6E-04	1.8E-03	1.1E-06	5.4E-07	1.6E-03	7.5E-06	4.5E+00	2.7E-05	1.5E-05	1.6E-04
13-Feb-13	9	1	300	295	7.71	4.8E+02																				
20-Feb-13	10	1	300	290	7.83	4.3E+02	#N/A	4.6E-01	7.7E+00	5.9E+00	5.2E-02	4.5E-02	1.7E-02	1.2E+01	8.8E-04	8.7E-04	1.7E-04	1.8E-03	1.2E-06	5.8E-07	1.3E-03	7.2E-06	4.3E+00	2.9E-05	1.1E-05	2.8E-04
27-Feb-13	11	1	300	295	7.79	3.9E+02																				
6-Mar-13	12	1	300	300	7.64	3.8E+02	#N/A	4.9E-01	7.8E+00	3.9E+00	4.8E-02	4.8E-02	1.8E-02	1.0E+01	8.3E-04	1.3E-03	2.0E-04	2.3E-03	1.2E-06	6.0E-07	1.2E-03	8.1E-06	3.5E+00	3.0E-05	1.5E-05	1.9E-04
13-Mar-13	13	1	300	295	7.86	3.4E+02																				
20-Mar-13	14	1	300	305	7.98	3.2E+02	#N/A	5.0E-01	7.1E+00	3.7E+00	4.9E-02	4.6E-02	1.8E-02	9.3E+00	6.3E-04	1.3E-03	2.4E-04	2.7E-03	1.2E-06	6.1E-07	8.9E-04	7.3E-06	3.2E+00	3.1E-05	1.4E-05	2.1E-04
27-Mar-13	15	1	300	295	7.96	3.2E+02																				
3-Apr-13	16	1	300	290	7.86	3.1E+02	#N/A	5.3E-01	6.8E+00	2.7E+00	4.6E-02	4.1E-02	1.7E-02	8.7E+00	8.2E-04	1.2E-03	1.7E-04	2.9E-03	1.2E-06	5.8E-07	8.0E-04	7.1E-06	3.0E+00	2.9E-05	1.3E-05	2.0E-04
10-Apr-13	17	1	300	290	7.92	3.0E+02																				
17-Apr-13	18	1	300	290	7.63	3.0E+02	#N/A	#N/A	5.3E+00	3.0E+00	4.1E-02	3.8E-02	1.7E-02	8.1E+00	9.2E-04	1.3E-03	1.9E-04	3.3E-03	1.2E-06	5.8E-07	1.0E-03	6.4E-06	2.7E+00	2.9E-05	3.1E-05	2.3E-04
24-Apr-13	19	1	300	300	7.83	3.0E+02																				
1-May-13	20	1	300	295	7.88	2.8E+02	#N/A	5.1E-01	6.7E+00	2.9E+00	3.5E-02	3.4E-02	1.8E-02	7.8E+00	7.0E-04	1.1E-03	1.6E-04	3.0E-03	1.2E-06	5.9E-07	1.1E-03	5.5E-06	2.7E+00	3.0E-05	1.3E-05	2.3E-04
8-May-13	21	1	300	300	7.71	2.8E+02																				
15-May-13	22	1	300	300	7.76	2.5E+02	#N/A	6.7E-01	6.8E+00	2.3E+00	4.2E-02	3.1E-02	1.8E-02	8.0E+00	7.9E-04	1.1E-03	1.6E-04	3.8E-03	1.2E-06	6.0E-07	9.4E-04	8.1E-06	2.7E+00	3.0E-05	1.1E-05	2.3E-04
22-May-13	23	1	300	300	7.82	2.6E+02																				
29-May-13	24	1	300	300	7.82	2.6E+02	#N/A	5.8E-01	6.8E+00	2.0E+00	3.6E-02	2.8E-02	1.8E-02	7.3E+00	8.2E-04	1.0E-03	1.5E-04	4.0E-03	1.2E-06	6.0E-07	7.2E-04	6.2E-06	2.5E+00	3.0E-05	9.4E-06	3.6E-04
5-Jun-13	25	1	300	295	7.76	2.7E+02																				
12-Jun-13	26	1	300	295	7.70	2.6E+02	#N/A	8.1E-01	6.7E+00	1.7E+00	3.5E-02	2.7E-02	1.8E-02	6.8E+00	4.8E-04	9.9E-04	1.5E-04	4.3E-03	1.2E-06	5.9E-07	5.3E-04	5.8E-06	2.3E+00	3.0E-05	9.9E-06	2.7E-04
19-Jun-13	27	1	300	295	7.75	2.8E+02																				
26-Jun-13	28	1	300	295	7.85	2.7E+02	#N/A	3.7E-01	6.2E+00	1.8E+00	4.1E-02	2.5E-02	1.8E-02	7.3E+00	6.4E-04	9.0E-04	1.4E-04	4.4E-03	1.2E-06	5.9E-07	6.0E-04	4.2E-06	2.5E+00	3.0E-05	9.9E-06	2.5E-04
3-Jul-13	29	1	300	305	7.80	2.6E+02																				
10-Jul-13	30	1	300	300	7.69	2.6E+02	#N/A	7.5E-01	6.7E+00	1.9E+00	4.2E-02	2.3E-02	1.8E-02	7.7E+00	7.4E-04	9.1E-04	1.4E-04	4.8E-03	1.2E-06	6.0E-07	6.4E-04	6.2E-06	2.6E+00	3.0E-05	1.6E-05	2.8E-04
17-Jul-13	31	1	300	295	7.80	2.6E+02																				
24-Jul-13	32	1	300	305	7.65	2.6E+02	#N/A	8.0E-01	6.5E+00	1.7E+00	4.3E-02	2.3E-02	1.8E-02	7.4E+00	6.5E-04	8.3E-04	1.3E-04	4.6E-03	1.2E-06	6.1E-07	7.6E-04	6.1E-06	2.5E+00	3.1E-05	1.1E-05	2.6E-04
31-Jul-13	33	1	300	300	7.75	2.7E+02																				
7-Aug-13	34	1	300	300	7.67	2.7E+02	#N/A	7.3E-01	6.3E+00	1.9E+00	3.6E-02	2.0E-02	1.8E-02	7.1E+00	5.9E-04	8.2E-04	1.3E-04	4.8E-03	1.2E-06	6.0E-07	6.2E-04	5.8E-06	2.4E+00	3.0E-05	1.1E-05	2.7E-04
14-Aug-13	35	1	300	300	7.80	2.7E+02																				
21-Aug-13	36	1	300	295	7.69	2.7E+02	#N/A	6.3E-01	6.0E+00	1.6E+00	3.5E-02	2.0E-02	1.8E-02	7.3E+00	7.6E-04	7.8E-04	1.1E-04	4.5E-03	1.2E-06	5.9E-07	8.6E-04	7.0E-06	2.5E+00	3.0E-05	9.4E-06	2.8E-04
28-Aug-13	37	1	300	295	7.88	2.5E+02																				
4-Sep-13	38	1	300	295	7.78	2.5E+02	#N/A	4.6E-01	6.0E+00	1.5E+00	3.5E-02	1.7E-02	1.8E-02	7.4E+00	5.7E-04	6.8E-04	1.0E-04	4.6E-03	1.2E-06	5.9E-07	1.1E-03	6.0E-06	2.5E+00	3.0E-05	1.0E-05	2.9E-04
11-Sep-13	39	1	300	305	7.81	2.5E+02																				
18-Sep-13	40	1	300	300	7.79	2.6E+02	#N/A	5.3E-01	6.2E+00	1.6E+00	3.6E-02	2.0E-02	1.8E-02	7.6E+00	2.5E-03	7.3E-04	1.2E-04	5.0E-03	1.2E-06	6.0E-07	1.1E-03	4.8E-06	2.6E+00	3.0E-05	1.5E-05	2.7E-04

Col 6

Sample = HPY Pyrite Rougher Sands

Date	Cycle	Approxi.	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Cl	F	Br	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
	No.	Flow Rate	Input	Output			(pH 4.5)	(pH 8.3)						CaCO3												
		(mL/min)				umhos/cm	mgCaCO3/kg	mgCaCO3/kg	mgCaCO3/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
25-Sep-13	41	1	300	300	8.06	2.6E+02																				
2-Oct-13	42	1	300	295	7.93	2.6E+02																				
9-Oct-13	43	1	300	295	7.93	2.6E+02																				
16-Oct-13	44	1	300	300	7.93	2.6E+02	#N/A	2.1E-01	6.3E+00	1.3E+00	3.6E-02	1.5E-02	1.8E-02	7.6E+00	4.9E-04	7.3E-04	1.1E-04	5.8E-03	1.2E-06	6.0E-07	7.3E-04	7.4E-06	2.6E+00	3.6E-05	1.3E-05	3.7E-04
23-Oct-13	45	1	300	295	7.88	2.6E+02																				
30-Oct-13	46	1	300	305	8.05	2.6E+02																				
6-Nov-13	47	1	300	300	8.05	2.6E+02																				
13-Nov-13	48	1	300	300	7.90	2.7E+02	#N/A	3.2E-01	6.2E+00	1.3E+00	3.0E-02	1.5E-02	1.8E-02	7.2E+00	5.5E-04	6.3E-04	1.2E-04	5.5E-03	1.2E-06	6.0E-07	5.4E-04	6.5E-06	2.4E+00	3.0E-05	1.3E-05	3.7E-04
20-Nov-13	49	1	300	295	8.36	2.6E+02																				
27-Nov-13	50	1	300	300	7.41	2.6E+02																				
4-Dec-13	51	1	300	310	8.27	2.6E+02																				
11-Dec-13	52	1	300	290	8.08	2.4E+02	#N/A	1.2E-01	6.1E+00	9.9E-01	3.5E-02	1.3E-02	1.7E-02	6.8E+00	5.1E-04	5.8E-04	9.3E-05	5.3E-03	1.2E-06	5.8E-07	9.2E-04	7.4E-06	2.3E+00	2.9E-05	1.5E-05	3.7E-04
18-Dec-13	53	1	300	310	8.10	2.5E+02																				
25-Dec-13	54	1	300	285	7.96	2.6E+02																				
1-Jan-14	55	1	300	310	8.06	2.6E+02																				
8-Jan-14	56	1	300	295	8.12	2.7E+02	#N/A	9.7E-02	6.4E+00	9.4E-01	2.4E-02	1.3E-02	1.8E-02	7.1E+00	6.1E-04	6.1E-04	8.9E-05	5.7E-03	1.2E-06	5.9E-07	5.3E-04	6.0E-06	2.4E+00	3.0E-05	1.3E-05	3.8E-04
15-Jan-14	57	1	300	290	8.00	2.8E+02																				
22-Jan-14	58	1	300	295	8.07	2.8E+02																				
29-Jan-14	59	1	300	290	8.06	2.4E+02																				
5-Feb-14	60	1	300	300	8.02	2.5E+02	#N/A	1.9E-01	7.1E+00	1.3E+00	2.4E-02	1.4E-02	1.8E-02	7.6E+00	1.1E-03	6.0E-04	1.4E-04	5.6E-03	1.2E-06	6.0E-07	4.9E-04	7.5E-06	2.5E+00	3.0E-05	2.4E-05	4.5E-04
12-Feb-14	61	1	300	295	8.09	2.4E+02																				
19-Feb-14	62	1	300	300	8.03	2.5E+02																				
26-Feb-14	63	1	300	295	8.00	2.4E+02																				
5-Mar-14	64	1	300	295	7.94	2.5E+02	#N/A	3.2E-01	7.2E+00	1.0E+00	2.4E-02	1.3E-02	1.8E-02	7.7E+00	4.0E-04	5.3E-04	7.1E-05	5.5E-03	1.2E-06	5.9E-07	4.9E-04	5.4E-06	2.6E+00	3.0E-05	1.4E-05	3.9E-04
12-Mar-14	65	1	300	295	8.01	2.6E+02																				
19-Mar-14	66	1	300	300	7.91	2.4E+02																				
26-Mar-14	67	1	300	300	8.04	2.5E+02																				
2-Apr-14	68	1	300	295	7.93	2.5E+02	#N/A	3.3E-01	7.1E+00	1.2E+00	2.4E-02	1.5E-02	1.8E-02	7.4E+00	8.6E-04	5.1E-04	6.5E-05	5.7E-03	1.2E-06	5.9E-07	5.1E-04	8.0E-06	2.5E+00	3.0E-05	2.3E-05	4.8E-04
9-Apr-14	69	1	300	300	8.00	2.6E+02																				
16-Apr-14	70	1	300	295	7.96	2.5E+02																				
23-Apr-14	71	1	300	300	8.03	2.6E+02																				
30-Apr-14	72	1	300	300	7.75	2.4E+02		5.4E-01	6.3E+00	1.1E+00	2.4E-02	1.3E-02	1.8E-02	7.1E+00	3.4E-04	4.5E-04	6.6E-05	6.2E-03	4.2E-07	4.2E-07	4.6E-04	6.4E-06	2.4E+00	3.0E-06	1.4E-05	4.7E-04
7-May-14	73	1	300	305	8.02	2.4E+02																				
14-May-14	74	1	300	300	7.80	2.3E+02																				
21-May-14	75	1	300	290	7.66	2.3E+02																				
28-May-14	76	1	300	310	7.94	2.2E+02		4.2E-01	6.8E+00	9.3E-01	2.5E-02	1.3E-02	1.9E-02	7.7E+00	4.4E-04	5.8E-04	6.8E-05	6.4E-03	4.3E-07	4.3E-07	5.2E-04	6.8E-06	2.5E+00	8.1E-06	2.4E-05	5.7E-04
4-Jun-14	77	1	300	305	8.06	2.4E+02																				
11-Jun-14	78	1	300	290	7.93	2.4E+02																				
18-Jun-14	79	1	300	295	7.83	2.4E+02																				
25-Jun-14	80	1	300	300	7.70	2.4E+02		6.9E-01	6.8E+00	9.6E-01																
2-Jul-14	81	1	300	295	7.92	2.5E+02																				

Col 6

Sample = HPY Pyrite Rougher Sands

Date	Cycle No.	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
19-Dec-12	1	1.3E-04	7.1E-05	8.8E-05	1.8E+00	8.5E-03	4.4E-07	2.1E-03	3.1E-05	1.0E-02	1.7E+00	1.4E-04	1.4E-01	3.1E-06	2.1E+00	7.7E-02	1.8E+01	2.2E-06	1.8E-05	2.2E-05	1.1E-02	3.9E-05	1.8E-04
26-Dec-12	2	2.0E-04	3.1E-05	6.6E-05	9.1E-01	4.2E-03	6.6E-07	2.2E-03	9.2E-05	8.9E-03	1.3E+00	5.3E-05	1.8E-01	1.3E-06	1.1E+00	4.9E-02	7.9E+00	2.0E-06	1.7E-05	1.3E-05	5.6E-03	4.0E-05	1.3E-04
2-Jan-13	3	2.8E-04	1.5E-05	5.5E-05	5.6E-01	3.2E-03	5.5E-07	1.4E-03	5.0E-05	6.2E-03	9.7E-01	2.4E-05	1.7E-01	4.4E-06	5.4E-01	3.4E-02	5.0E+00	1.7E-06	2.1E-05	2.8E-05	4.3E-03	4.7E-05	1.7E-04
9-Jan-13	4	1.8E-04	1.2E-05	6.0E-05	6.6E-01	4.1E-03	6.0E-07	1.5E-03	1.1E-04	5.5E-03	1.1E+00	3.1E-05	1.6E-01	6.0E-07	4.1E-01	4.2E-02	5.0E+00	1.8E-06	1.9E-05	1.8E-05	5.0E-03	4.9E-05	1.2E-04
16-Jan-13	5																						
23-Jan-13	6	1.8E-04	1.1E-05	6.0E-05	6.1E-01	4.5E-03	6.0E-07	2.1E-03	1.9E-04	5.2E-03	1.0E+00	2.9E-05	1.8E-01	7.8E-06	1.7E-01	4.1E-02	5.2E+00	1.8E-06	3.7E-05	3.0E-05	4.7E-03	4.6E-05	1.2E-04
30-Jan-13	7																						
6-Feb-13	8	2.2E-04	1.1E-05	5.4E-05	4.6E-01	3.8E-03	5.4E-07	3.0E-03	4.9E-05	3.5E-03	8.2E-01	3.1E-05	1.7E-01	5.4E-07	9.2E-02	3.2E-02	3.3E+00	1.6E-06	5.7E-05	1.1E-05	3.9E-03	2.6E-05	1.1E-04
13-Feb-13	9																						
20-Feb-13	10	1.7E-04	8.1E-06	5.8E-05	3.8E-01	3.5E-03	5.8E-07	4.6E-03	2.3E-05	4.8E-03	7.8E-01	4.1E-05	1.8E-01	5.8E-07	7.3E-02	2.7E-02	2.1E+00	1.7E-06	1.0E-04	1.2E-05	2.7E-03	3.4E-05	2.3E-04
27-Feb-13	11																						
6-Mar-13	12	1.8E-04	8.4E-06	6.0E-05	3.4E-01	3.5E-03	6.0E-07	7.1E-03	2.4E-05	4.3E-03	6.9E-01	5.2E-05	1.9E-01	6.0E-07	5.3E-02	2.6E-02	1.5E+00	1.8E-06	1.5E-04	6.0E-06	2.2E-03	3.5E-05	6.0E-05
13-Mar-13	13																						
20-Mar-13	14	1.8E-04	6.7E-06	6.1E-05	3.2E-01	3.4E-03	6.1E-07	8.4E-03	1.2E-05	4.3E-03	7.0E-01	4.9E-05	1.8E-01	6.1E-07	4.9E-02	2.4E-02	1.2E+00	1.8E-06	2.0E-04	6.1E-06	2.0E-03	1.9E-05	6.1E-05
27-Mar-13	15																						
3-Apr-13	16	1.7E-04	6.4E-06	5.8E-05	3.0E-01	3.2E-03	5.8E-07	7.6E-03	1.7E-05	4.1E-03	6.6E-01	3.0E-05	1.8E-01	5.8E-07	3.8E-02	2.3E-02	1.0E+00	1.7E-06	2.6E-04	5.8E-06	1.7E-03	2.7E-05	5.8E-05
10-Apr-13	17																						
17-Apr-13	18	1.7E-04	7.0E-06	5.8E-05	2.9E-01	3.1E-03	5.8E-07	8.3E-03	2.9E-05	4.4E-03	6.4E-01	4.6E-05	1.8E-01	5.8E-07	3.6E-02	2.3E-02	9.3E-01	1.7E-06	3.2E-04	5.8E-06	1.9E-03	3.1E-05	1.2E-04
24-Apr-13	19																						
1-May-13	20	1.8E-04	3.5E-06	5.9E-05	2.8E-01	3.1E-03	5.9E-07	7.1E-03	2.4E-05	3.4E-03	5.7E-01	4.2E-05	1.8E-01	5.9E-07	3.3E-02	2.1E-02	8.1E-01	1.2E-06	3.7E-04	5.9E-06	1.5E-03	3.5E-05	5.9E-05
8-May-13	21																						
15-May-13	22	1.8E-04	2.2E-05	6.0E-05	2.8E-01	3.1E-03	6.0E-07	5.3E-03	3.0E-05	3.7E-03	5.8E-01	4.7E-05	1.7E-01	6.0E-07	2.8E-02	2.1E-02	7.3E-01	1.8E-06	4.7E-04	6.0E-06	1.6E-03	3.1E-05	1.2E-04
22-May-13	23																						
29-May-13	24	6.6E-04	1.1E-05	6.0E-05	2.7E-01	3.3E-03	6.0E-07	4.6E-03	6.0E-05	3.6E-03	5.4E-01	3.8E-05	1.7E-01	6.0E-07	2.7E-02	2.1E-02	6.4E-01	1.2E-06	5.5E-04	1.8E-05	1.4E-03	3.0E-05	1.2E-04
5-Jun-13	25																						
12-Jun-13	26	1.8E-04	3.0E-06	5.9E-05	2.5E-01	2.7E-03	5.9E-07	3.9E-03	1.8E-05	3.5E-03	4.7E-01	4.1E-05	1.6E-01	5.9E-07	2.2E-02	1.9E-02	5.4E-01	1.8E-06	5.6E-04	5.9E-06	1.3E-03	2.7E-05	2.4E-04
19-Jun-13	27																						
26-Jun-13	28	1.8E-04	1.2E-05	5.9E-05	2.7E-01	3.0E-03	5.9E-07	3.4E-03	2.4E-05	3.4E-03	4.9E-01	4.7E-05	1.7E-01	5.9E-07	2.4E-02	2.0E-02	6.3E-01	1.2E-06	5.7E-04	5.9E-06	1.2E-03	2.7E-05	5.9E-05
3-Jul-13	29																						
10-Jul-13	30	1.8E-04	2.4E-06	6.0E-05	2.8E-01	3.3E-03	6.0E-07	3.3E-03	3.6E-05	3.1E-03	4.9E-01	4.7E-05	1.8E-01	6.0E-07	2.3E-02	2.1E-02	6.4E-01	1.8E-06	6.2E-04	6.0E-06	1.4E-03	2.9E-05	1.2E-04
17-Jul-13	31																						
24-Jul-13	32	1.8E-04	3.7E-06	6.1E-05	2.8E-01	3.3E-03	6.1E-07	3.1E-03	3.7E-05	3.3E-03	4.6E-01	5.3E-05	1.7E-01	6.1E-07	2.1E-02	2.1E-02	6.2E-01	1.2E-06	5.8E-04	6.1E-06	1.4E-03	3.1E-05	1.2E-04
31-Jul-13	33																						
7-Aug-13	34	1.8E-04	3.0E-06	6.0E-05	2.6E-01	3.1E-03	6.0E-07	2.9E-03	5.4E-05	2.3E-03	4.3E-01	5.9E-05	1.7E-01	6.0E-07	2.0E-02	2.0E-02	5.8E-01	1.2E-06	5.1E-04	6.0E-06	1.4E-03	2.2E-05	6.0E-05
14-Aug-13	35																						
21-Aug-13	36	5.1E-03	1.8E-06	5.9E-05	2.8E-01	3.1E-03	5.9E-07	2.7E-03	5.9E-06	3.0E-03	3.6E-01	5.0E-05	1.6E-01	5.9E-07	2.5E-02	2.3E-02	5.8E-01	1.8E-06	4.5E-04	5.9E-06	1.3E-03	3.2E-05	5.9E-05
28-Aug-13	37																						
4-Sep-13	38	1.8E-04	4.1E-06	5.9E-05	2.8E-01	3.3E-03	5.9E-07	2.3E-03	3.5E-05	3.4E-03	4.0E-01	4.7E-05	1.7E-01	5.9E-07	1.9E-02	2.1E-02	5.8E-01	1.2E-06	3.8E-04	5.9E-06	1.2E-03	2.5E-05	1.2E-04
11-Sep-13	39																						
18-Sep-13	40	1.8E-04	3.0E-06	6.0E-05	2.9E-01	3.1E-03	6.0E-07	2.3E-03	1.8E-05	3.0E-03	3.9E-01	5.5E-05	1.7E-01	6.0E-07	2.2E-02	2.1E-02	5.8E-01	1.2E-06	4.2E-04	6.0E-06	1.4E-03	2.5E-05	6.0E-05

Col 6

Sample = HPY Pyrite Rougher Sands

Date	Cycle No.	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
25-Sep-13	41																						
2-Oct-13	42																						
9-Oct-13	43																						
16-Oct-13	44	1.8E-04	1.0E-05	6.0E-05	2.9E-01	3.5E-03	6.0E-07	2.0E-03	3.6E-05	2.9E-03	3.3E-01	5.2E-05	1.8E-01	6.0E-07	1.8E-02	2.1E-02	5.5E-01	1.2E-06	3.7E-04	6.0E-06	1.4E-03	4.2E-05	1.8E-04
23-Oct-13	45																						
30-Oct-13	46																						
6-Nov-13	47																						
13-Nov-13	48	1.8E-04	3.0E-06	6.0E-05	2.9E-01	3.5E-03	6.0E-07	1.6E-03	6.0E-05	2.2E-03	3.0E-01	4.7E-05	1.7E-01	6.0E-07	1.8E-02	2.1E-02	5.5E-01	1.2E-06	3.1E-04	1.2E-05	1.4E-03	2.9E-05	1.2E-04
20-Nov-13	49																						
27-Nov-13	50																						
4-Dec-13	51																						
11-Dec-13	52	6.4E-04	2.3E-06	5.8E-05	2.6E-01	3.3E-03	5.8E-07	1.4E-03	5.8E-06	2.1E-03	2.4E-01	4.4E-05	1.5E-01	5.8E-07	1.5E-02	1.8E-02	4.6E-01	1.2E-06	2.4E-04	5.8E-06	1.3E-03	2.7E-05	1.2E-04
18-Dec-13	53																						
25-Dec-13	54																						
1-Jan-14	55																						
8-Jan-14	56	5.9E-04	1.8E-06	5.9E-05	3.0E-01	3.7E-03	5.9E-07	1.9E-03	4.1E-05	2.2E-03	2.4E-01	4.4E-05	1.5E-01	5.9E-07	1.8E-02	2.0E-02	5.2E-01	1.2E-06	2.5E-04	1.2E-05	1.3E-03	3.2E-05	5.9E-05
15-Jan-14	57																						
22-Jan-14	58																						
29-Jan-14	59																						
5-Feb-14	60	1.8E-04	3.2E-05	6.0E-05	3.0E-01	4.2E-03	6.0E-07	1.1E-03	7.2E-05	4.0E-03	2.3E-01	4.6E-05	1.7E-01	1.8E-06	1.6E-02	2.1E-02	4.5E-01	1.8E-06	2.2E-04	1.2E-05	1.2E-03	2.8E-05	1.8E-04
12-Feb-14	61																						
19-Feb-14	62																						
26-Feb-14	63																						
5-Mar-14	64	1.8E-04	1.2E-06	5.9E-05	3.1E-01	4.0E-03	5.9E-07	1.1E-03	4.1E-05	2.1E-03	2.1E-01	3.7E-05	1.6E-01	5.9E-07	1.5E-02	2.1E-02	4.6E-01	1.2E-06	2.1E-04	5.9E-06	1.2E-03	2.7E-05	5.9E-05
12-Mar-14	65																						
19-Mar-14	66																						
26-Mar-14	67																						
2-Apr-14	68	1.8E-04	1.2E-06	5.9E-05	3.0E-01	4.1E-03	5.9E-07	9.4E-04	5.3E-05	2.4E-03	1.9E-01	3.4E-05	1.5E-01	5.9E-07	1.5E-02	2.0E-02	4.2E-01	1.2E-06	2.2E-04	1.2E-05	1.2E-03	3.4E-05	2.4E-03
9-Apr-14	69																						
16-Apr-14	70																						
23-Apr-14	71																						
30-Apr-14	72	1.2E-04	1.8E-06	6.2E-05	2.9E-01	4.1E-03	6.0E-07	9.1E-04	3.6E-05	1.9E-03	1.7E-01	3.4E-05	1.5E-01	1.2E-07	1.4E-02	1.9E-02	3.8E-01	9.6E-07	1.9E-04	6.6E-06	1.2E-03	2.5E-05	1.2E-04
7-May-14	73																						
14-May-14	74																						
21-May-14	75																						
28-May-14	76	6.8E-04	1.9E-06	6.8E-05	3.3E-01	4.7E-03	6.2E-07	8.5E-04	2.5E-05	1.7E-03	1.8E-01	3.2E-05	1.6E-01	1.2E-07	1.6E-02	2.1E-02	4.3E-01	9.3E-07	2.2E-04	3.1E-06	1.2E-03	2.7E-05	6.2E-05
4-Jun-14	77																						
11-Jun-14	78																						
18-Jun-14	79																						
25-Jun-14	80																						
2-Jul-14	81																						

Appendix D:
Kinetic Test Static Testing Results

CASiNO

Kineitc test static testing ABA results: Pre and post kinetic testing

	Parameters	Paste pH	TIC	Total C	Total S	Sulphate S	Sulphide S	Insoluble S	Non-SO_4 S	TAP	Non-SO_4 AP
	Units	s.u.	%	%	%	%	%	%	%	mg $CaCO_3$/ kg	mg $CaCO_3$/ kg
Sample ID	**Sample ID / Lab ID**										
Sat Col 12&14 (HYP)	upper layers	8.20	0.77	0.78	2.70	0.03	2.50	0.13	2.60	83.0	82.0
Col 12 Residue Top		7.77	0.72		2.37	0.02	2.20	0.15	2.35	74.1	73.4
Col 12 Residue Middle		7.58	0.67		2.46	0.05	2.43	-0.05	2.38	76.9	74.4
Col 14 Residue Top		7.83	0.78		2.40	0.02	2.14	0.24	2.38	75.0	74.4
Col 14 Residue Middle		7.76	0.63		2.42	0.02	2.31	0.09	2.40	75.6	75.0
Sat Col12,13&14 (acidic SUP)	lower layers	4.00	<0.01	0.02	1.40	0.35	0.83	0.24	1.10	44.0	33.0
Col 12 Residue Bottom		4.27	<0.01		1.44	0.23	0.95	0.26	1.21	45.0	37.8
Col 14 Residue Bottom		5.12	0.02		1.44	0.20	1.16	0.08	1.24	45.0	38.8
Sat Col 13&15 (neutral SUP)	Sat Col 13 (upper), Sat Col 15 (full)	7.70	0.08	0.10	1.00	0.02	0.88	0.1	0.98	31.0	31.0
Col 15 Residue		7.79	0.07		0.87	0.01	0.75	0.11	0.86	27.2	26.9
Col 15 Precip		-	-		0.67	0.01	-	-	0.66	20.9	20.6
T7, Sat Col 16	HYP-PyRo-Tails-Whole	8.30	0.34	0.35	0.11	0.03	0.05	0.03	0.08	3.4	2.5
Col 16 Residue		7.83	0.31		0.14	0.01	0.07	0.06	0.13	4.4	4.1
Sat Col 17	HYP-PyRo-Con	7.70	0.30	0.33	11.00	0.10	9.90	0.78	11.00	338.0	334.0
Col 17 Residue		7.12	0.28		12.70	0.06	11.50	1.14	12.64	396.9	395.0
HC3	08-276	8.40	0.27	0.28	4.20	0.03	4.00	0.23	4.20	132.0	131.0
HC 3 Residue		7.71	0.32	0.34	3.54	0.02	3.49	0.03	3.52	110.6	110.0
HC4	08-294	8.30	0.69	0.72	4.30	0.03	4.20	0.04	4.30	134.0	133.0
HC 4 Residue		7.61	0.52	0.56	3.99	0.02	3.97	<0.01	3.97	124.7	124.1
HC5	08-277	8.10	0.21	0.21	2.20	0.07	2.10	0.03	2.10	69.0	67.0
HC 5 Residue		7.86	0.21	0.23	2.16	0.02	2.07	0.1	2.15	67.3	67.2
HC6	08-028	8.10	0.19	0.20	1.80	0.02	1.70	0.14	1.80	57.0	56.0
HC 6 Residue		7.72	0.17	0.19	1.66	0.01	1.61	0.04	1.65	51.9	51.6
HC7	08-043	7.90	0.48	0.51	2.90	0.12	2.70	0.04	2.80	90.0	87.0
HC7	08-225	6.30	0.10	0.10	3.60	0.03	3.60	0.01	3.60	113.0	112.0
HC7 Residue		7.53	0.25	0.28	2.97	0.03	2.81	0.1	2.94	92.8	91.9
HC11	08-068	8.20	0.22	0.23	2.30	0.03	2.00	0.29	2.20	71.0	70.0
HC 11 Residue		7.74	0.20	0.22	1.61	0.03	1.52	0.06	1.58	50.3	49.4
Col 1	Low S CAP (duplicate of FB2)	4.40	<0.01	0.07	0.19	0.15	0.05	<0.01	0.04	5.9	1.3
Col 1 Residue		4.54	<0.01	0.05	0.22	0.14	0.06	0.03	0.08	6.9	2.5

Kineitc test static testing ABA results: Pre and post kinetic testing

	Parameters	SAP	CaNP	ScNP	NPR	NPR	NPR	NPR	Net
	Units	mg $CaCO_3$/ kg	mg $CaCO_3$/ kg	mg $CaCO_3$/ kg	CaNP/non-SO_4 AP	CaNP/ TAP	ScNP/ non-SO_4 AP	ScNP/ TAP	NP
Sample ID	**Sample ID / Lab ID**								
Sat Col 12&14 (HYP)	upper layers	78.0	64.0	62.0	0.8	0.8	0.7	0.8	-16.0
Col 12 Residue Top		68.8	60.0	54.7	0.8	0.8	0.7	0.7	-14.1
Col 12 Residue Middle		75.9	55.8	51.0	0.7	0.8	0.7	0.7	-24.9
Col 14 Residue Top		66.9	65.0	59.1	0.9	0.9	0.8	0.8	-7.6
Col 14 Residue Middle		72.2	52.5	48.8	0.7	0.7	0.7	0.6	-23.4
Sat Col12,13&14 (acidic SUP)	lower layers	26.0	0.8	3.8	0.02	0.02	0.1	0.1	-22.0
Col 12 Residue Bottom		29.7	<0.8	0.9	0.02	0.02	0.02	0.02	-28.8
Col 14 Residue Bottom		36.3	1.7	2.6	0.04	0.04	0.1	0.1	-33.7
Sat Col 13&15 (neutral SUP)	Sat Col 13 (upper), Sat Col 15 (full)	28.0	6.7	17.0	0.2	0.2	0.5	0.5	-11.0
Col 15 Residue		23.4	5.8	11.2	0.2	0.2	0.4	0.4	-12.2
Col 15 Precip		-	-	-	-	-	-	-	-
T7, Sat Col 16	HYP-PyRo-Tails-Whole	1.6	28.0	34.0	11.0	8.2	9.9	14.0	33.0
Col 16 Residue		2.2	25.8	27.8	11.8	6.4	6.8	12.7	25.6
Sat Col 17	HYP-PyRo-Con	310.0	25.0	30.0	0.1	0.1	0.1	0.1	-280.0
Col 17 Residue		359.4	23.3	24.6	0.1	0.1	0.1	0.1	-334.8
HC3	08-276	124.0	23.0	32.0	0.2	0.2	0.2	0.2	-92.0
HC 3 Residue		109.1	26.7	37.3	0.2	0.2	0.3	0.3	-71.4
HC4	08-294	132.0	58.0	68.0	0.4	0.4	0.5	0.5	-64.0
HC 4 Residue		124.1	43.3	55.6	0.3	0.3	0.4	0.4	-68.5
HC5	08-277	66.0	18.0	27.0	0.3	0.3	0.4	0.4	-39.0
HC 5 Residue		64.7	16.7	31.2	0.2	0.2	0.5	0.5	-33.5
HC6	08-028	52.0	16.0	27.0	0.3	0.3	0.5	0.5	-25.0
HC 6 Residue		50.3	14.2	30.4	0.3	0.3	0.6	0.6	-19.9
HC7	08-043	85.0	40.0	48.0	0.4	0.5	0.5	0.6	-37.0
HC7	08-225	112.0	8.3	9.2	0.1	0.1	0.1	0.1	-103.0
HC7 Residue		87.8	20.8	26.8	0.2	0.2	0.3	0.3	-61.0
HC11	08-068	61.0	18.0	33.0	0.3	0.3	0.5	0.5	-28.0
HC 11 Residue		47.5	16.7	35.7	0.3	0.3	0.7	0.7	-11.8
Col 1	Low S CAP (duplicate of FB2)	1.6	0.8	5.8	0.1	0.6	1.0	4.6	4.2
Col 1 Residue		1.6	<0.8	-0.1	0.3	0.1	-0.04	0.0	-1.7

Kineitc test static testing metals results: Pre and post kinetic testing

		Ag	Al	As	B	Ba	Bi	Ca	Cd	Co	Cr	Cu	Fe	Ga	Hg	K	La	Mg
		ppm	%	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	%	ppm	ppm	%	ppm	%
Sample ID	**Sample ID / Lab ID**																	
Sat Col12,13&14 (HYP)	upper layers	0.45	0.82	10	40	143	2.50	1.80	0.10	19.0	83	495	3.90	2.8	0.02	0.37	17.0	0.72
Col 12 Residue Top		0.50	0.76	10	30	143	1.95	1.87	0.18	19.3	111	636	3.79	2.6	0.01	0.35	15.7	0.76
Col 12 Residue Middle		0.40	0.79	11	30	135	2.39	1.74	0.16	19.2	111	878	4.05	2.7	0.01	0.36	16.1	0.74
Col 14 Residue Top		0.43	0.78	9	30	151	2.46	2.02	0.18	17.6	106	478	3.96	2.7	0.01	0.37	17.5	0.78
Col 14 Residue Middle		0.59	0.79	9	20	155	1.81	1.58	0.22	20.5	114	851	3.80	2.9	0.01	0.36	16.5	0.73
Sat Col 12&14 (acidic SUP)	lower layers	0.96	0.86	8	40	267	1.70	0.09	0.09	10.0	76	813	2.50	2.0	0.02	0.33	21.0	0.26
Col 12 Residue Bottom		0.87	0.79	9	30	218	1.52	0.11	0.03	9.1	126	630	2.63	2.0	0.01	0.36	19.5	0.29
Col 14 Residue Bottom		0.85	0.76	8	30	256	1.64	0.16	0.03	10.0	129	580	2.66	2.0	0.01	0.35	19.1	0.28
Sat Col 13&15 (neutral SUP)	Sat Col 13 (upper), Sat Col 15 (full)	0.46	1.20	5	40	147	1.00	0.30	0.19	9.4	83	455	2.90	5.1	0.03	0.32	14.0	0.76
Col 15 Residue		0.42	1.07	5	30	162	0.93	0.34	0.15	8.1	125	449	2.90	4.8	0.01	0.30	13.9	0.79
Col 15 Precip		0.44	1.22	4	30	192	0.75	0.29	0.51	7.6	376	414	2.78	5.2	0.01	0.38	12.3	0.78
T7, Sat Col 16	HYP-PyRo-Tails-Whole	0.27	1.00	3	40	244	0.60	0.90	0.41	4.3	121	195	1.70	3.6	0.03	0.49	35.0	0.64
Col 16 Residue		0.33	0.81	3	30	238	0.41	0.88	0.35	4.0	134	275	1.62	2.8	0.01	0.43	30.7	0.58
Sat Col 17	HYP-PyRo-Con	3.30	0.87	36	45	0.4	5.00	0.72	1.20	95.0	133	2940	9.80	2.7	0.12	0.39	27.0	0.51
Col 17 Residue		3.32	0.73	42	20	62	5.76	0.75	0.69	95.8	134	3170	12.90	2.3	0.06	0.35	26.0	0.48
HC3	08-276	0.80	1.40	2	20	37	0.50	0.98	0.20	22.0	78	845	4.70	5.0	0.01	0.54	20.0	0.95
HC 3 Residue		0.94	1.52	2	30	162	0.50	1.09	0.24	24.4	119	1100	5.24	5.1	0.09	0.60	21.2	1.15
HC4	08-294	0.30	2.30	1	20	13	0.20	2.60	0.10	63.0	44	809	5.30	5.0	0.01	0.72	12.0	1.30
HC 4 Residue		0.35	2.29	4	40	137	0.16	2.23	0.10	55.9	116	957	5.95	6.1	0.07	0.79	12.4	1.53
HC5	08-277	0.60	1.80	3	20	93	0.70	0.88	0.10	22.0	80	580	4.20	6.0	0.01	0.78	32.0	1.30
HC 5 Residue		0.71	1.74	4	40	110	0.68	0.80	0.02	20.8	173	666	4.45	6.5	0.02	0.73	27.8	1.35
HC6	08-028	0.70	1.30	14	20	87	1.60	0.86	0.10	12.0	107	557	2.50	4.0	0.01	0.58	28.0	0.91
HC 6 Residue		0.64	1.38	13	50	114	1.52	0.77	0.07	11.5	156	636	2.66	4.1	0.01	0.70	25.4	0.97
HC7	08-043	0.40	0.75	33	20	102	1.30	2.00	0.20	39.0	101	455	2.90	2.0	0.01	0.20	13.0	0.56
HC7	08-225	1.10	0.35	23	20	107	3.10	0.22	0.30	12.0	35	645	3.50	1.0	0.01	0.21	25.0	0.10
HC 7 Residue		0.79	0.73	24	40	210	2.07	0.96	0.18	20.1	147	537	3.30	2.2	0.04	0.29	24.4	0.40
HC11	08-068	0.40	2.20	8	20	102	0.60	1.20	0.10	27.0	92	840	4.10	8.0	0.01	0.67	17.0	1.60
HC 11 Residue		0.30	2.62	6	45	338	0.42	1.10	0.07	19.7	114	668	3.97	8.5	0.03	0.79	17.8	1.79
Col 1		1.20	2.80	17	20	498	0.90	0.06	0.10	3.1	45	318	3.00	6.0	0.01	0.53	15.0	0.96
Col 1 Residue		1.40	3.08	19	40	610	1.08	0.06	0.01	3.0	128	345	3.11	6.2	0.03	0.56	15.4	0.96
		0.80	0.82	9	20	328	2.10	0.11	0.10	1.30	72	124	1.50	3.0	0.10	0.31	16.0	0.15
Col 2B Residue		0.98	0.79	10	30	369	1.96	0.10	0.08	1.50	86	119	1.48	3.1	0.03	0.33	27.2	0.14
Col 3		1.00	0.94	12	20	181	1.40	0.08	0.10	3.50	59	308	2.60	2.0	0.10	0.52	16.0	0.2
Col 3 Residue		1.07	0.74	13	20	307	1.23	0.04	0.03	3.00	64	140	2.64	2.2	0.01	0.53	20.1	0.16
Col 4A	Oxide pH >6.0	0.70	1.70	12	20	389	1.20	0.33	0.20	6.10	60	461	2.50	4.0	0.03	0.33	17.0	0.65
Col 4A Residue		0.70	1.76	14	30	402	1.02	0.35	0.18	5.60	76	443	2.52	5.4	0.04	0.375	21.8	0.65
Col 5 and T6	>74um #2	0.20	1.00	3	ND	216	0.80	0.35	0.30	3.70	8	283	1.20	3.0	0.01	0.40	18.0	0.62
	<74 um #3	0.20	1.60	5	ND	350	1.80	0.69	0.80	5.7	17	339	1.70	4.0	0.01	0.50	39.0	0.77
	Py Rougher Concentrate	2.20	1.00	45	ND	32	6.50	0.40	0.50	75.0	10	1146	11.00	3.0	0.03	0.33	20.0	0.53
	Cleaner Tail	1.90	1.30	47	ND	33	5.60	0.66	0.80	72.0	165	906	11.00	3.0	0.03	0.41	27.0	0.61
Col 5 Residue		0.27	1.54	4	30	319	0.83	0.35	0.4	4.10	76	292	1.36	4.3	0.01	0.56	22.4	0.71
T6 Residue		0.26	1.50	4	30	316	0.79	0.28	0.4	4.00	83	298	1.33	4.3	0.01	0.53	22.5	0.69
T5, Sat Col 10	Whole #1	0.30	0.97	4	ND	227	0.80	0.36	0.30	3.5	9	283	1.20	3.0	0.01	0.38	18.0	0.60
T5 Residue		0.24	1.70	4	30	316	1.03	0.35	0.5	4.50	70	319	1.47	4.6	0.01	0.56	28.5	0.76

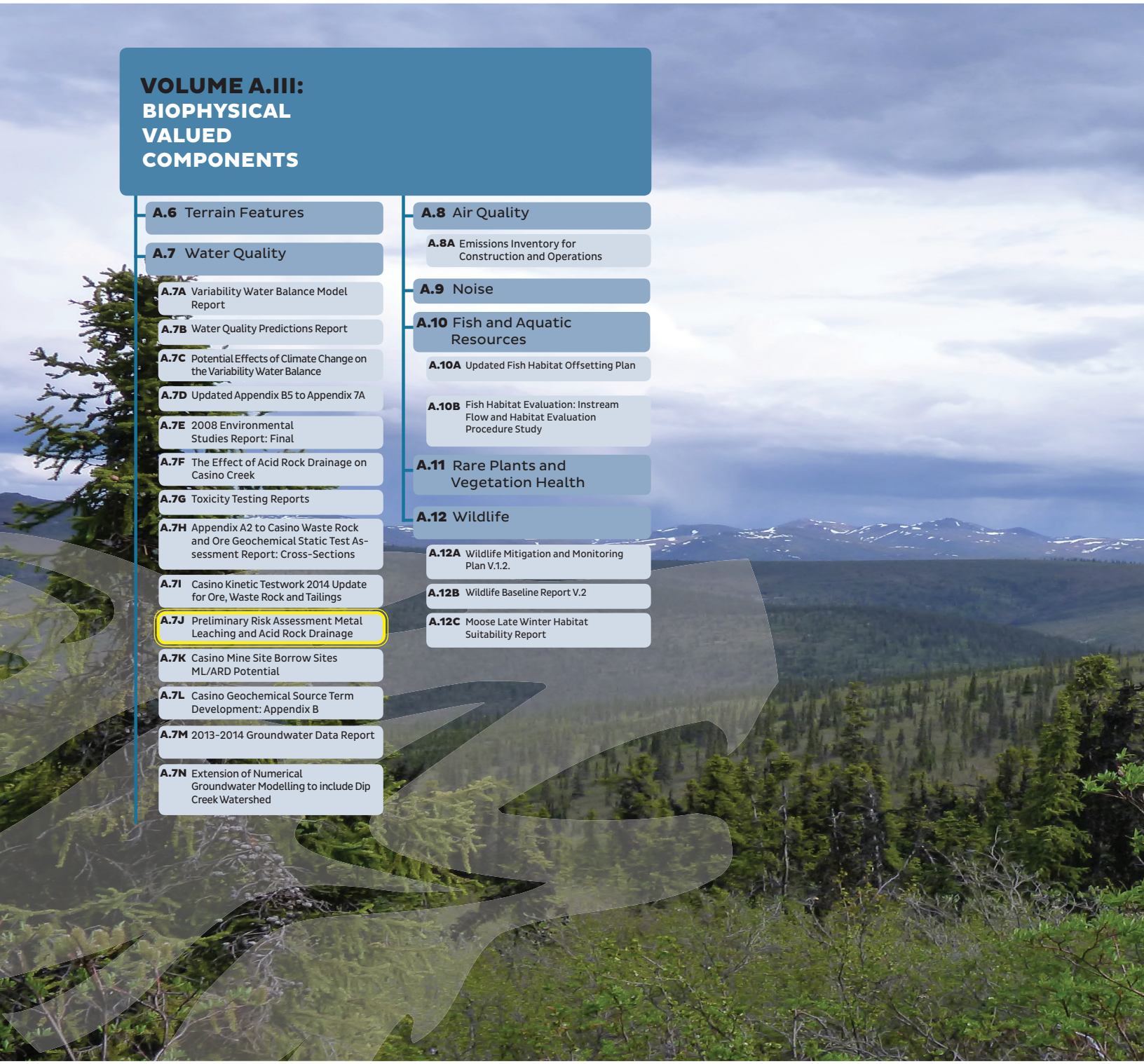
Notes: Values in blue text were below the detection limit; ND also means not detected.

Kineitc test static testing metals results: Pre and post kinetic testing

		Mn	Mo	Na	Ni	P	Pb	S	Sb	Se	Sn	Sr	Th	Ti	Tl	U	V	Zn
		ppm	ppm	%	ppm	%	ppm	%	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm
Sample ID	**Sample ID / Lab ID**																	
Sat Col12,13&14 (HYP)	upper layers	175	30.0	0.02	10.0	0.06	6.9	3.00	0.73	2.0		63	12.0	0.02	0.23	3.90	26	19
Col 12 Residue Top		180	25.4	0.02	6.9	0.06	7.1	2.47	1.87	2.0	0.3	62	10.2	0.02	0.21	2.90	25	22
Col 12 Residue Middle		172	21.0	0.02	7.9	0.06	7.3	2.57	0.77	2.0	0.3	54	9.9	0.02	0.22	3.65	26	24
Col 14 Residue Top		180	27.6	0.02	7.0	0.06	7.7	2.47	1.01	2.0	0.4	63	10.3	0.02	0.24	2.95	27	24
Col 14 Residue Middle		170	33.5	0.02	7.0	0.06	6.8	2.37	1.16	2.0	0.4	47	10.5	0.02	0.24	3.27	28	24
Sat Col 12&14 (acidic SUP)	lower layers	46	120.0	0.02	7.7	0.04	5.5	1.60	1.30	1.0		11	16.0	0.01	0.22	4.30	13	14
Col 12 Residue Bottom		48	87.8	0.02	10.6	0.04	5.9	1.41	1.47	1.0	0.3	12	13.5	0.02	0.24	3.48	16	15
Col 14 Residue Bottom		56	76.7	0.02	5.2	0.04	5.5	1.42	1.26	1.0	0.3	15	13.2	0.01	0.23	3.68	15	15
Sat Col 13&15 (neutral SUP)	Sat Col 13 (upper), Sat Col 15 (full)	222	60.0	0.04	12.0	0.06	4.1	1.10	0.30	1.0		18	13.0	0.06	0.20	3.30	33	48
Col 15 Residue		203	60.1	0.03	10.2	0.06	3.9	0.89	0.28	1.0	0.4	17	11.0	0.05	0.19	2.57	31	53
Col 15 Precip		205	64.6	0.07	13.3	0.05	4.8	0.71	0.34	1.0	0.5	23	10.1	0.05	0.21	2.51	32	57
T7, Sat Col 16	HYP-PyRo-Tails-Whole	213	38.0	0.02	27.0	0.05	5.0	0.11	0.37	1.0		26	16.0	0.04	0.31	5.30	35	36
Col 16 Residue		193	51.8	0.02	21.3	0.05	4.6	0.14	0.45	1.0	0.6	23	11.1	0.03	0.25	3.87	29	36
Sat Col 17	HYP-PyRo-Con	183	634.0	0.02	52.0	0.04	21.0	>5	2.60	9.0		21	17.0	0.03	0.44	8.70	23	58
Col 17 Residue		186	776.0	0.02	47.3	0.04	25.0	>5	2.56	13.0	0.9	20	13.4	0.02	0.42	7.41	29	68
HC3	08-276	188	71.0	0.02	20.0	0.07	2.7	3.80	0.20	1.9		25	6.8	0.03	0.30	18.00	25	31
HC 3 Residue		207	86.2	0.03	21.5	0.08	3.1	3.72	0.40	2.0	0.6	29	7.6	0.03	0.39	10.20	30	36
HC4	08-294	155	14.0	0.06	7.2	0.10	5.8	4.20	0.40	8.4		57	6.0	0.08	0.60	5.70	76	23
HC 4 Residue		142	19.0	0.07	6.6	0.12	4.7	4.24	0.61	9.0	0.9	47	7.1	0.10	0.67	3.36	86	26
HC5	08-277	205	73.0	0.04	19.0	0.08	1.8	2.20	0.20	1.6		49	7.1	0.06	0.40	4.60	31	23
HC 5 Residue		201	75.6	0.04	18.4	0.09	1.5	2.30	0.27	2.0	0.9	33	7.6	0.05	0.50	5.21	30	26
HC6	08-028	110	11.0	0.02	14.0	0.07	3.4	1.90	0.20	1.7		16	8.0	0.03	0.60	2.60	21	13
HC 6 Residue		109	17.7	0.03	13.8	0.08	3.0	1.74	0.21	1.0	0.5	17	8.4	0.03	0.60	2.23	21	15
HC7	08-043	268	13.0	0.01	5.1	0.06	11.0	2.90	0.50	2.0		111	12.0	0.00	0.10	7.20	9	26
HC7	08-225	122	70.0	0.01	8.9	0.05	22.0	3.50	0.60	2.7		13	13.0	0.00	0.20	2.90	2	21
HC 7 Residue		181	43.5	0.03	7.0	0.05	12.5	2.95	1.03	2.0	0.3	68	11.9	0.01	0.20	4.38	6	25
HC11	08-068	163	4.3	0.05	4.8	0.10	3.9	2.30	0.30	4.3		31	7.2	0.07	0.50	5.00	89	29
HC 11 Residue		161	5.2	0.06	3.6	0.10	3.2	1.67	0.31	3.0	1.3	36	8.0	0.10	0.77	3.55	95	29
Col 1		93	396	0.03	6.0	0.06	9.1	0.18	0.90	1.2		74	8.9	0.09	0.30	7.20	62	22
Col 1 Residue		83	393	0.04	6.3	0.08	9.1	0.20	2.93	1.0	1.5	83	8.4	0.08	0.46	7.02	55	27
		33	16.0	0.04	2.8	0.02	23.0	0.32	1.2	1.7		21	8.6	0.01	0.20	1.30	11	12
Col 2B Residue		35	23.5	0.04	2.2	0.02	24.4	0.31	2.3	2.0	0.80	20	11.0	0.01	0.21	1.30	11	15
Col 3		34	77.0	0.02	3.8	0.021	19.0	1.3	0.1	3.7		22	8.9	0.003	0.20	1.20	10	9
Col 3 Residue		27	93.8	0.02	2.7	0.03	19.3	1.03	0.4	3.0	0.60	26	9.8	0.01	0.23	0.80	9	8
Col 4A	Oxide pH >6.0	118	91.0	0.06	6.4	0.049	15.0	0.15	2.2	1.2		29	8.4	0.06	0.30	3.00	42	44
Col 4A Residue		109	89.1	0.06	6.0	0.05	15.1	0.15	3.5	1.0	3.85	30	10.3	0.06	0.27	2.60	44	48
Col 5 and T6	>74um #2	159	96.0	0.01	4.2	0.06	3.7	0.07	0.30	3.5	0.05	35.0	9.4	0.05	0.30	ND	35	8
	<74 um #3	246	20.0	0.01	8.4	0.12	8.4	0.05	0.30	4.8	0.05	81.0	18.0	0.04	0.30	ND	41	15
	Py Rougher Concentrate	164	228	0.01	28.0	0.06	13.0	>10	1.30	3.1	7.5	45.0	13.0	0.04	0.40	ND	30	8
	Cleaner Tail	197	657	0.02	146.0	0.08	20.0	>10	1.40	4.0	7.6	74.0	16.0	0.04	0.40	ND	36	12
Col 5 Residue		158	126	0.03	6.1	0.07	6.0	0.09	0.4	1.0	1.40	38	8.9	0.05	0.42	5.21	43	37
T6 Residue		157	116	0.03	6.6	0.07	5.6	0.08	0.4	1.0	1.00	35	9.1	0.05	0.40	5.11	44	38
T5, Sat Col 10	Whole #1	156	137	0.01	3.8	0.07	4.4	0.07	0.50	3.3	0.5	37.0	8.0	0.05	0.30	ND	32	9
T5 Residue		181	108	0.03	7.6	0.08	6.4	0.07	0.4	1.0	1.00	45	10.8	0.05	0.41	6.75	43	40

Notes: Values in blue text were below the detection limit; ND also means not detected.

APPENDIX A.7J: Preliminary Risk Assessment Metal Leaching and Acid Rock Drainage



western
COPPER AND GOLD

Western Copper and Gold Corporation

Casino Road:
Preliminary Risk Assessment
Metal Leaching and Acid Rock Drainage



January 2012

LORAX
ENVIRONMENTAL

Executive Summary

western
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Executive Summary

The proposed Casino Access Road will connect Western Copper and Gold Corporation's Casino property with the existing Yukon road system. As road construction has the potential to produce metal leaching / acid rock drainage (ML / ARD), Lorax Environmental Services Ltd. has completed a risk assessment in order to assess the ML / ARD potential along the proposed road alignment. This allows for areas of higher ML / ARD potential to be determined, in order to highlight areas where further work may be needed.

The risk assessment indicates that the majority of the road is low risk for ML / ARD; however, there are 16 sections of road over 38.25 km of the total 133 km long alignment that are deemed to have moderate-low risk or greater. These sections are generally in the final 50 km of the road alignment: from kilometer station 86+500 to 98+300 and 108+030 to 124+430. There are three exceptions to this, kilometer station 1+290 to 5+960, 13+420 to 18+400 and 78+420 to 79+010 also have an overall risk that is considered moderate-low or greater.

These sections were found to have a high enough ML / ARD risk potential that further work in these areas is recommended. This should include further sampling along these 16 sections of road, ideally by drilling in areas where bedrock will be disturbed. As fish sampling has not taken place in the westernmost sections, over a distance of roughly 50 km of the proposed road alignment, further characterization of the streams along this section of the road alignment will allow for an improved understanding of the risk to aquatic ecosystems in this area, and may reduce the potential risk of some of the road sections in this area. Additional rock and surficial material sampling will also be necessary once quarry locations are finalized in order to ensure that the material will not cause ML / ARD.

The risk assessment was completed by defining a stressor (ML / ARD), a pathway (surface water runoff) and a receptor (the aquatic ecosystems). The road was divided into sections based on the geology, the major watersheds, the type of cut and the stream crossings in order to keep the stressor, pathway and receptor consistent. The stressor rating was defined by the geology and the cut volume along sections of road. Each of the bedrock units was assigned a rock type rating, which was modified by the type of surficial material. The cut volume was used to determine the amount of disturbance, as areas of higher disturbance have a greater ML / ARD risk. The pathway was defined by the drainage area of the catchment up-gradient from the road, to determine an approximation for surface water volume. This term was modified using the cut volume

to determine a pathway ratio, which was used to determine the pathway rating. The receptor rating takes both the sensitivity of the species present and the flow regime in the aquatic ecosystem directly downstream of the road.

Each of these terms is given a risk rating. These ratings are multiplied to determine the overall risk for each road section. Sections of road with an overall risk rating of greater than 100 are considered moderate-low risk or greater and are highlighted for further work. Sections with an overall risk rating less than 100 are considered to have sufficiently low risk and no further consideration of these sections is required.

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western
COPPER AND GOLD

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1. Introduction

1. Introduction

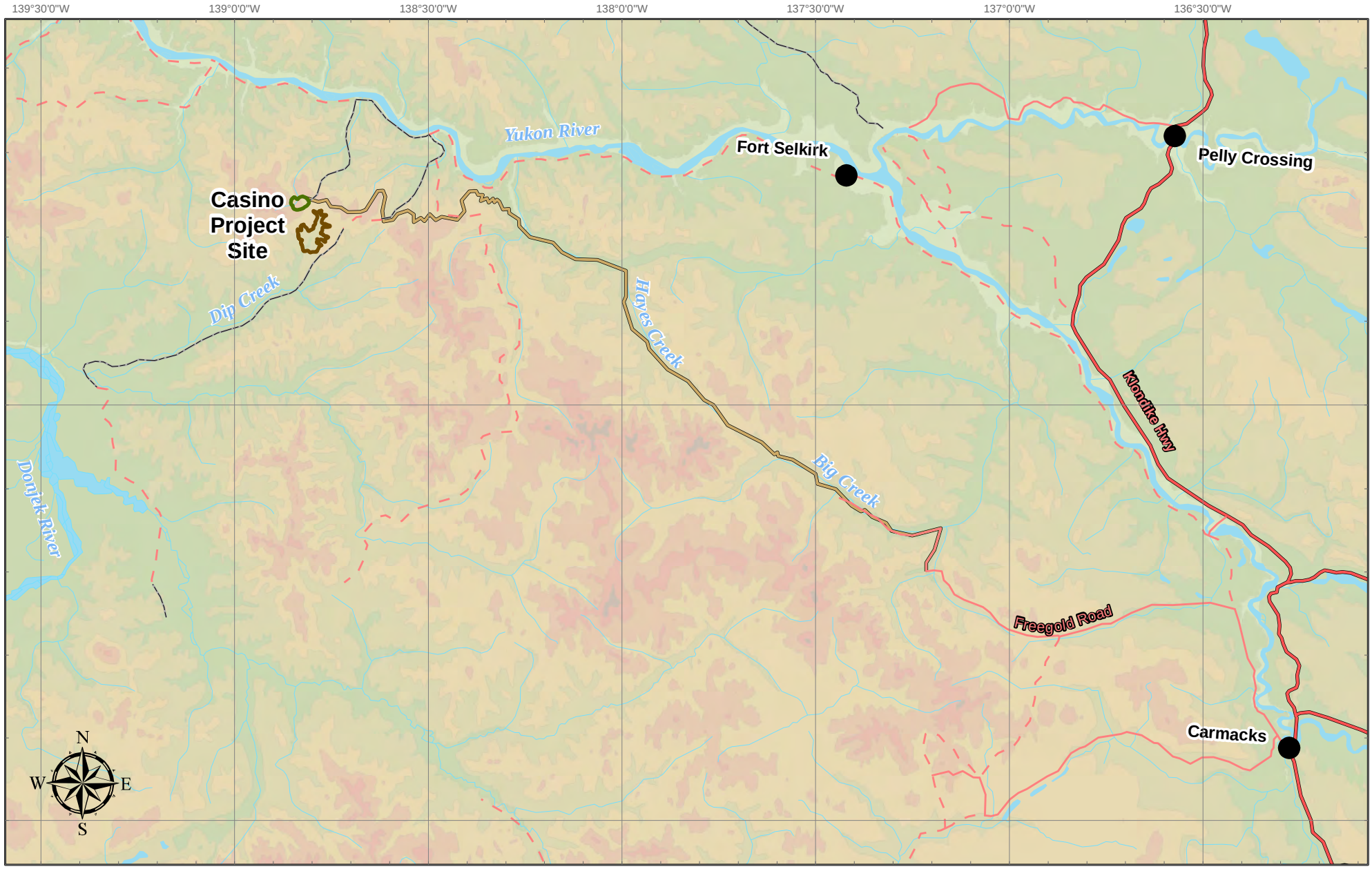
Western Copper and Gold Corporation retained Lorax Environmental Services Ltd. (Lorax) to undertake a preliminary assessment of the risk of potential metal leaching / acid rock drainage (ML / ARD) associated with the construction of a new road required for the further development of the Casino property in the Yukon. The proposed road is required to provide access between the Casino mineral deposit and the port of Skagway, Alaska via the Freegold Road and the Klondike Highway (M3 Engineering, 2011; see Figure 1-1).

This study is based on readily available information supplemented by an initial round of geochemical sampling and analysis. The analysis is considered adequate to indicate areas where the risk associated with ML / ARD is low, and areas where the potential risk or level of uncertainty are higher, and additional work may be warranted.

1.1 Study Objectives

The specific objectives of this study are to:

- Provide a general and preliminary indication of the level of risk associated with ML / ARD along the road alignment;
- Undertake the most robust analysis possible given the information available;
- Describe the methodology and results of the study in a way that is procedurally transparent, intuitive and easy to understand, reproducible, and appropriate given the information available to base the assessment on; and
- Provide the basis for more detailed investigation, where warranted.



Legend

- Cities/Communities
- Open Pit
- Tailings Storage Facility
- Proposed Road Corridor
- Existing Road
- Resource Road/Trail
- Historical Road
- Highway

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VERSION:	4

Coordinate System: *World Mercator*
Projection: *Mercator*
Datum: *WGS 1984*
Units: *Meter*

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0 10 20 30 Km

CLIENT: western COPPER AND GOLD

LORAX ENVIRONMENTAL

PROJECT:

Casino 2010 Project

TITLE: Proposed Casino Access Road Location

PROJECT #: J862-3

FIGURE: 1-1

P:\J862 (Casino)\Road\Drafting\MXDs\LocationMap of Proposed RoadV4.mxd

1.2 Project Description

Western Copper and Gold Corporation is developing its Casino property, which hosts a gold-copper-molybdenum porphyry. The property is located approximately 300 km northwest of Whitehorse, Yukon. An access road is proposed as an extension of the existing Freegold Road, a gravel road which originates at the Klondike Highway at Carmacks, and extends northwest for a distance of roughly 70 km, currently terminating at Freegold Ventures Limited mineral tenures (M3 Engineering, 2011; see Figure 1-1). The Freegold Road is currently maintained by the Yukon government. The proposed extension of the road to the Casino property will be maintained primarily by Western Copper and Gold (M3 Engineering, 2011).

The proposed road would be approximately 133 km long and reach the Casino mineral exploration camp. Current access to the site is by air, by barge or winter routes from either Burwash Landing or Carmacks (M3 Engineering, 2011; see Figure 1-1). The proposed road would provide a year-round access route for delivering supplies to the mine site and for transporting copper concentrate from the mine to the port of Skagway during operations.

The proposed route can be divided into eastern, central and western sections:

> The Eastern Section: From the Freegold Road the road descends through the Bow and Seymour drainages, reaching Big Creek approximately 40 km upstream of its confluence with the Yukon River, at an elevation of approximately 700m above sea level (asl). The road then ascends the Big Creek valley running alongside the river, and then ascends to the height of land that separates the Big Creek drainage from the Hayes Creek drainage, at an elevation of approximately 1100 m asl. The eastern section is approximately 43 km in length.
>
> The Central Section: The central section descends through the Hayes Creek Valley and runs along the creek for approximately 44 km to an elevation of 500 m asl. After this point, Hayes Creek continues northward to its confluence with the Yukon River, while the road would continue westward, towards a ridge to the northwest up to a watershed divide at approximately 1000 m asl. The central section is 53 km long.
>
> The Western Section: The western section continues westward along the ridge from an elevation of approximately 1000 m asl to 1300 m asl. It passes through three main watersheds: Mascot Creek, Idaho/Isaac/Sunshine Creeks and Casino Creek, before joining an existing road on the Casino property. This section is approximately 37 km in length.

Surficial material in the Eastern and Central Sections is mainly colluvium, with some fluvial material (alluvium) (Summit, 2011). The route traverses through colluvium and exposed bedrock through the Western Section.

1.3 Risk Assessment Overview

The basic approach for this risk assessment is to evaluate the risk associated with a specific stressor (ML / ARD), entering a pathway (surface water runoff and flow in watercourses that the road crosses) that could impact specific receptors (aquatic ecosystems at and immediately downstream of the road crossing).

There have been several examples where road construction has lead to the development of ML / ARD in Canada and the United States. The potential for the development of ML / ARD is dependent on the geology and the amount of disturbance. For example, bedrock with high sulphide content and low calcium carbonate content will have a greater ML / ARD potential than rock that contains little or no sulphide. In addition, the ML / ARD risk will vary depending on the type of material. ML / ARD is greatest for bedrock, followed by colluvium, followed by alluvium. Unconsolidated colluvial and alluvial deposits have been exposed to the elements and have often undergone extensive weathering and oxidation that has already depleted any acid generating sulphide minerals that may have been present in the parent bedrock from which the colluvium or alluvium was derived. This is particularly true of alluvial deposits that have been exposed. A second variable that contributes to ML / ARD impact is the volume of material that is disturbed with ML / ARD potential. Increasing the amount of disturbance increases the ML / ARD potential.

This study does not consider the potential effects of other stressors that may be associated with road construction, such as erosion, or the release of hydrocarbons or other contaminants from any other source. Nor does this study consider the cumulative effects of potential ML / ARD with other stressors.

The pathway as defined in this study considers surface water runoff generated up-gradient of a given section of road that mixes with runoff from exposed material from the road and transports any contaminants derived from ML / ARD to a downstream receptor. Other potential pathways through which ML / ARD could affect the receiving environment, such as through groundwater, for example, are assumed to ultimately report to the same surface water pathway in this assessment.

The receptors defined in this study are based on an initial consideration of aquatic ecosystems at and downstream of each section of road. The details of this consideration are described in more detail below.

Following this introduction, Chapter 2 provides an overview of the study approach and methodology. Chapter 3 discusses the rating system used in the risk assessment. Chapter 4 discusses the results of the risk assessment, highlighting areas with a higher risk. Recommendations are presented in Chapter 5.

2. Methodology

2. Methodology

Western Copper and Gold Corporation is undertaking work in preparation for detailed mine planning and permitting for its Casino property. It is anticipated that development of the mine will require approvals pursuant to the Yukon Environmental and Socioeconomic Assessment Act (YESAA), potentially the Canadian Environmental Assessment Act (CEAA), the Yukon Water Act, and other relevant legislation and regulations. It is anticipated that assessment of the potential for ML / ARD will be required for every aspect of the Project, including construction of the new access road, in support of permit applications. As the first step in addressing this requirement, the work summarized here is intended to identify areas that will require excavation and placement of native soil and rock ('cut' and 'fill') that represent a higher risk with respect to potential ML / ARD, and therefore may warrant some further investigation.

2.1 ML / ARD Approach

Based on MEM & MOE (1998) and MEND (2009), it is generally recognized that ML / ARD programs follow three main steps:

1. Determine the lithology or material type of the material that will be disturbed.
2. Determine the ML / ARD potential of this material. This may include static and/or kinetic testing.
3. Create mitigation and monitoring plans based on the ML / ARD potential to minimize impacts to the environment.

This study addresses the first step, by providing a description of the geology along the proposed road alignment. The second and third steps are addressed at a preliminary level. For the second step, static tests were conducted for an initial round of sampling completed along the proposed road alignment. The third step was initiated by identifying areas of lower risk where mitigation and monitoring may not be warranted, and areas where the risk is higher or uncertainty greater, which may warrant additional investigation, mitigation and/or monitoring.

In the absence of specific regulations and guidance for the Yukon, the approach for this study has taken MEM & MOE (1998), Price & Errington (1998), MEND (2009) and MOT (2004) guidelines for ML / ARD sampling into account, as well as the general methodology for ML / ARD studies along road routes proposed by Gusek *et al.* (2008), from the lithological determination stage to the monitoring stage. These include:

- Policy for Metal Leaching and Acid Rock Drainage at Minesites in British Columbia (MEM & MOE, 1998);
- Guidelines for Metal Leaching and Acid Rock Drainage at Minesites in British Columbia (Price & Errington, 1998);
- Policy for ARD Testing at Quarry and Rock Cut Sites (MOT, 2004);
- Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials (MEND, 2009); and
- A New Guidance Document for Mitigating Impacts from Acid-Producing Rock Formations in Tennessee Road Construction Projects (Gusek *et al.*, 2008).

2.2 Information Sources

In order to assess the ML / ARD potential along the proposed road alignment, relevant information was obtained from the following sources:

- Yukon Geological Survey Bedrock Geology base map (Gordey and Makepeace, 1999)
- Geological Descriptions of units along the proposed road alignment (Carlson, 1987; Payne *et al.*, 1987)
- Proposed Casino Road Alignment and Surficial Material polygons from Summit Environmental Consultants (2011)
- Geochemical results from sampling completed by Lorax personnel along the proposed road route and geochemical results from work completed for the Casino deposit
- Cut and Fill information from Associated Engineering (2011)
- Drainage Areas calculated based on topography
- Fish Presence and Stream data (Summit, 2011; supplemented by 2011 work by EDI (Kearns, pers. comm., 2011)

2.3 Risk Assessment Framework

The general risk assessment framework proposed by Pollard *et al.* (1995) was adopted. The stressor, pathway and receptors were characterized as follows:

- Stressor: the stressor that was the focus of this study was metal leaching / acid rock drainage (ML / ARD). The information available included the bedrock geology and surficial material along the road alignment, the results of an initial

round of static tests on rock, colluvium and alluvium samples, and preliminary estimates of the excavated volume of rock and soil.

- Pathway: Surface water drainage provides the main pathway through which any products of ML / ARD may interact with excavated ('cut') or permanent disposal ('fill') of soil and rock, and then be conveyed into the receiving environment. Information available included the size of catchments and the location of watercourses. A very general characterization of flow volumes was available for the purpose of this assessment.
- Receptor: The receptor of interest is the aquatic ecosystems in the watercourses in the vicinity of the proposed road. Information available was based on the results of preliminary studies in the major watercourses, some opportunistic efforts to characterize species presence by electrofishing, and information in the public domain.

This level of analysis corresponds with a preliminary quantitative ecological risk assessment (ERA) as defined by CCME (1996), as field data is combined with information from the literature. This is the second stage of assessment outlined in the CCME document. It is an intermediate step between a screening assessment, which relies solely on data in the literature, and a detailed quantitative ERA, which primarily uses field data. These three levels vary from simply describing the situation (screening assessment) to creating predictions on the outcomes (detailed quantitative ERA). In a risk assessment, each category must be defined qualitatively and, in quantitative risk assessments, it will also be assigned a numerical value representing the level of risk (Pollard *et al.*, 1995).

3. Analysis and Risk Ratings

3. Analysis and Risk Ratings

The analysis for this study was undertaken as a series of five major steps, as follows:

1. Dividing the proposed road alignment into sections that are homogenous with respect to the geology, type of cut (soil or rock), and aquatic receiving environment;
2. Assigning a risk rating for ML / ARD potential that considers both geological characteristics as well as the level of disturbance (*i.e*. the volume of cut and fill);
3. Assigning a rating for the pathway reflecting the amount of dilution that can be anticipated;
4. Assigning a rating for the aquatic receiving environment reflecting its importance and sensitivity (*i.e.* likely presence of fish species of commercial or recreational importance, and/or species at risk); and
5. Using the assigned ratings to determine an overall risk rating for each section of road, which is appropriate to serve as the basis for recommendations.

Each of these principal steps in the analysis and associated risk considerations and assumptions are described in the sections below.

3.1 Road Sections

For the purposes of this assessment, the road was divided into discrete sections to ensure that the stressor, pathway and receptor were generally consistent. The divisions were based on:

- Changes in geology
- Major watershed divides
- Changes in type of cut (soil or rock)
- The road route crossing a stream

The procedure is as follows:

1. The geological boundaries along the road were determined and used to subdivide the road based on data obtained from the Yukon Geological Survey (YGS) website;

2. The divides between the "soil cut" and "rock cut" zones were determined based on information provided as part of the preliminary road design (Associated Engineering, 2011) and were used to further subdivide the road;
3. The major watershed divides were determined based on topographical and watercourse mapping obtained from Canadian Digital Elevation Data and the National Hydro Network (www.GeoBase.ca), and were used to further subdivide the road; and
4. The locations where the road crosses a major stream were determined, and used to further subdivide the road.

Using this procedure, the proposed road alignment is divided into 81 sections, each of which is homogenous with respect to underlying geology, the nature of material that will be disturbed (bedrock, colluvium or alluvium), and the drainage basin through which they traverse. The shortest road section is 40m, while the longest is 9,040m.

The up-gradient catchment area for each road section was then defined (see Section 3.4 for further discussion). An overview of the road route and the bedrock geology is provided in Figure 3-1. The road sections, and associated road section catchments, are show in Figure 3-2a to 3-2c.

138°40'0"W 138°20'0"W 138°0'0"W 137°40'0"W 137°20'0"W 137°0'0"W

62°40'0"N

62°30'0"N

62°20'0"N

LX-C-26 LX-C-27 LX-C-31 LX-C-30 LX-C-32 LX-C-9 LX-C-57 LX-C-55 LX-C-28 LX-C-6 LX-C-59 LX-C-54 LX-C-10 LX-C-29 LX-C-56 LX-C-60 LX-C-2 LX-C-1 LX-C-52 LX-C-58 LX-C-11 LX-C-8 LX-C-7 LX-C-5 LX-C-53 LX-C-51 LX-C-4 LX-C-3 LX-C-12 LX-C-50 LX-C-13 LX-C-49 LX-C-48 LX-C-14 LX-C-47 LX-C-16 LX-C-15 LX-C-19 LX-C-17 LX-C-20 LX-C-18 LX-C-44 LX-C-46 LX-C-22 LX-C-45 LX-C-25 LX-C-21 LX-C-41 LX-C-42 LX-C-24 LX-C-39 LX-C-23 LX-C-37 LX-C-43 LX-C-38 LX-C-34 LX-C-40 LX-C-36 LX-C-33 LX-C-35

130 km 120 km 110 km 100 km 90 km 80 km 70 km 60 km 50 km 40 km 30 km 20 km 10 km 0 km

N

LEGEND

- Proposed Road Corridor
- Optional Road Alignment
- 1 Km Markers
- 10 Km Markers
- Sample Locations
- Open Pit
- Tailings Storage Facility
- Elevations (100m)

Q	Unconsolidated glacial, glaciofluvial and glaciolacustrine deposits
TQS	Vesicular to massive basalt flows; minor pillow basalt; basaltic tuff and breccia
lES2	Hornblende-feldspar porphyritic tuff, flow breccia; volcaniclastic mudstone, sandstone and conglomerate; dacite flows and dykes; flow-banded rhyolite and felsic dykes and sills
ETqN	Leucocratic, biotite granite; miarolitic alaskite; mafic-poor biotite granite; biotite-hornblende granite to leucocratic granodiorite; biotite quartz monzonite
LKdP	Coarsely crystalline gabbro and diorite
LKfP	Quartz-feldspar porphyry
LKqP	Quartz monzonite, biotite quartz-rich granite; porphyritic alaskite; biotite and hornblende quartz monzodiorite, granite and leucocratic granodiorite
LKyP	Syenite
uKC1	Augite olivine basalt and breccia; hornblende feldspar porphyry andesite and dacite flows
uKC2	Vitric crystal tuff, lapilli tuff and welded tuff; felsic volcanic flow rocks
uKC3	Poorly sorted, coarse to fine grained sandstone, pebble conglomerate, shale, tuff and coal
uKW	Quartz-phyric dacite flows, ash and lapilli tuff; dacite and basalt flows
mKdW	Hornblende diorite, biotite-hornblende quartz diorite and hypersthene-hornblende diorite, quartz diorite and gabbro
mKgW	Biotite-hornblende granodiorite, hornblende quartz diorite and hornblende diorite
mKqW	Biotite quartz-monzonite, biotite granite and leucogranite, granophyric quartz monzonite
mKN	Andesite to dacite flows, breccia and tuff
uJKT	Massive to thickly bedded chert pebble conglomerate and quartz-chert-feldspar sandstone
EJgA	Medium- to coarse- grained, foliated biotite-hornblende granodiorite and hornblende diorite to monzodiorite
EJqL	Fine to coarse grained biotite, biotite-muscovite and biotite-hornblende quartz monzonite to granite
EJyL	Coarse to very coarse grained mesocratic hornblende syenite
uTrP	Augite or feldspar phyric andesitic basalt flows, breccia, tuff, sandstone and argillite
CPA1	Variably altered and foliated oceanic mafic volcanics
DMgPW	Biotite granite gneiss to biotite or hornblende granodiorite gneiss
DMN2	Marble
DMN3	Quartzite, micaceous quartzite, quartz muscovite schist and minor metaconglomerate and metagrit
DMN5	Dark grey to black strongly graphitic quartzite with lesser grey micaceous quartzite and quartz mica schist
PPN1	Dark grey to brown, biotite-muscovite-quartz-feldspar schist, quartzite and micaceous quartzite and felsic chlorite-biotite orthogneiss
PPa	Metamorphosed mafic rocks, including amphibolite and ultramafic rocks
	Unclassified

Bedrock Geology

Gordey, S.P. and Makepeace, A.J. (comp.) 1999: Yukon bedrock geology in Yukon digital geology, S.P. Gordey and A.J. Makepeace (comp.); Geological Survey of Canada Open File D3826 and Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, Open File 1999-1(D)

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Projection: *Mercator*
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Units: *Metres*

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CLIENT:

western COPPER AND GOLD

LORAX ENVIRONMENTAL

PROJECT:

Casino 2010 Project

TITLE:

Casino Road With Bedrock Geology

PROJECT #: J862-3 *FIGURE:* 3-1

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137°50'0"W 137°40'0"W 137°30'0"W 137°20'0"W 137°10'0"W

62°30'0"N 62°25'0"N 62°20'0"N 62°15'0"N

50 km
40 km
30 km
20 km
10 km
0 km

Big Creek
Bow Creek
Seymour Creek

N

LEGEND

- Proposed Road Corridor
- Optional Road Alignment
- 1 Km Markers
- 10 Km Markers
- River
- Elevations (100m)
- Lake
- Road Section Catchments

Bedrock Geology

LKdP	EJgA
LKfP	EJqL
LKqP	EJyL
uKC1	DMgPW
mKgW	DMN3
mKqW	DMN5
mKN	

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0 5 10 Km

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LORAX ENVIRONMENTAL

PROJECT:

Casino 2010 Project

TITLE:

Eastern Section
Road Section Catchments

PROJECT #: J862-3 *FIGURE:* 3-2a

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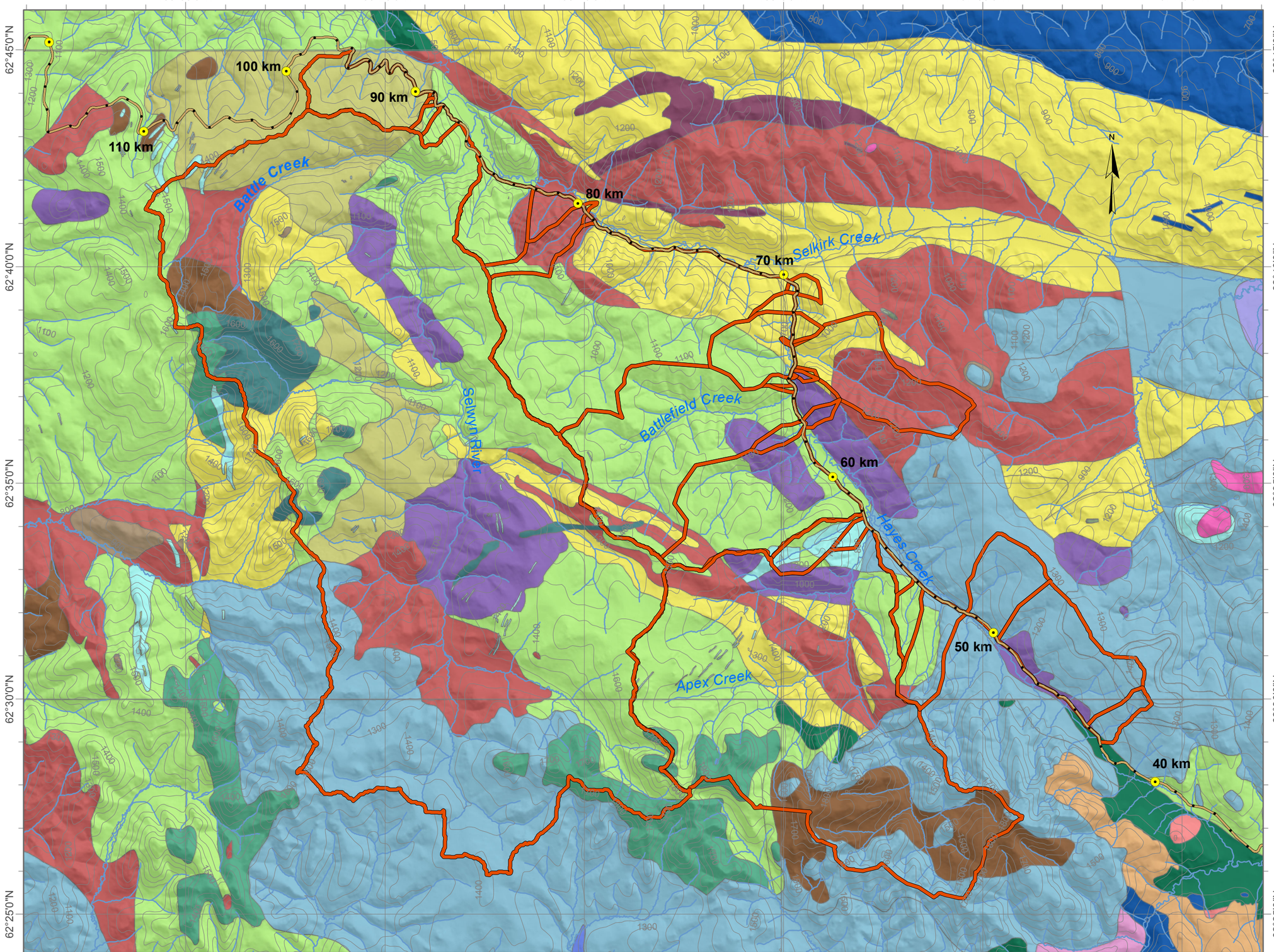

LEGEND

- Proposed Road Corridor
- River
- Elevations (100m)
- Lake
- Road Section Catchments
- 1 Km Markers
- 10 Km Markers

Bedrock Geology

TQS	mKgW
LKdP	mKqW
LKfP	mKN
LKqP	EJgA
LKyP	EJqL
uKC1	EJyL
uKC2	DMgPW
uKC3	DMN3
uKW	DMN5
mKdW	PPa

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Units: *Metres*

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LORAX ENVIRONMENTAL

PROJECT:

Casino 2010 Project

TITLE:

Central Section
Road Section Catchments

PROJECT #: J862-3 *FIGURE:* 3-2b

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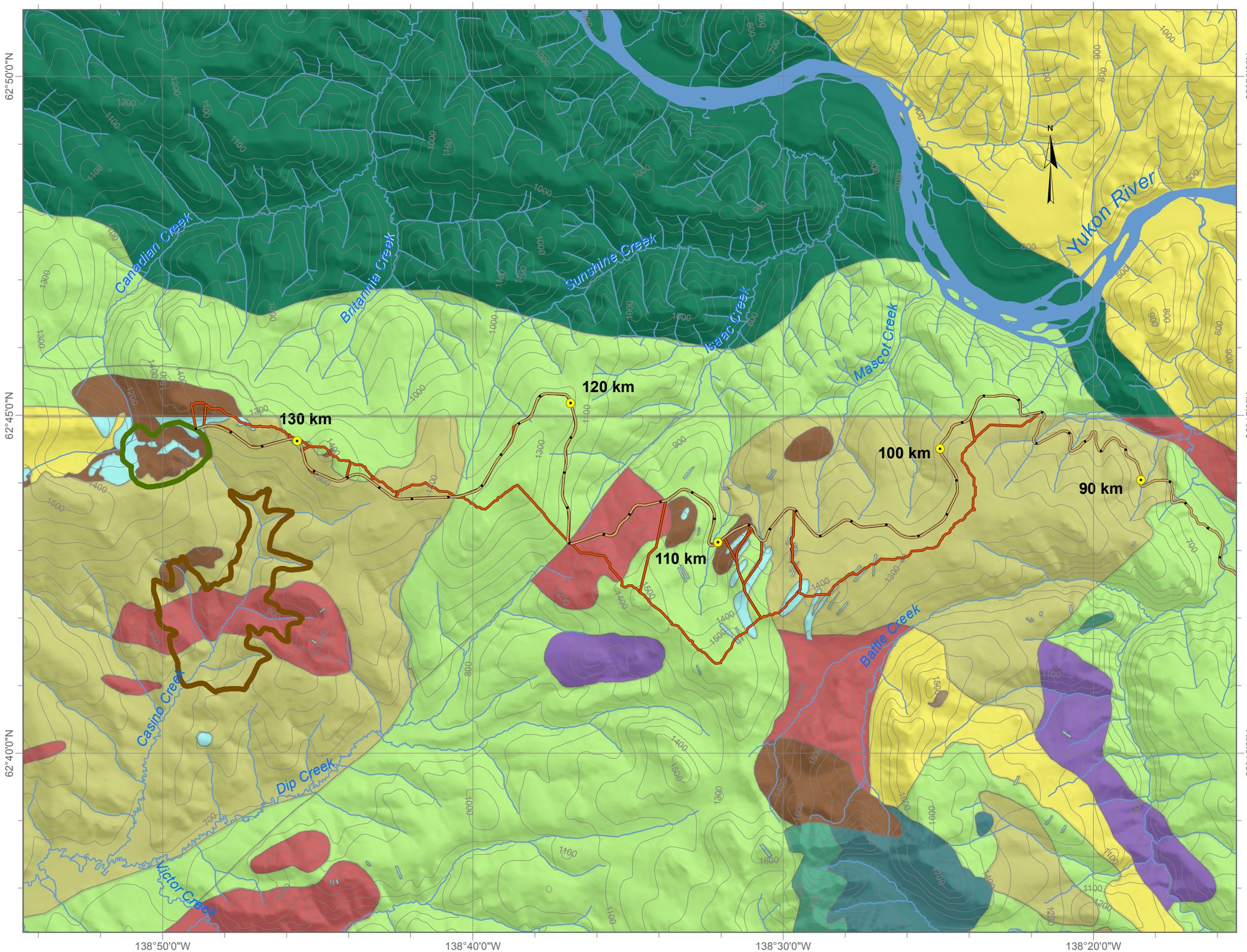

LEGEND

- Proposed Road Corridor
- 1 Km Markers
- 10 Km Markers
- Elevations (100m)
- River
- Lake
- Open Pit
- Tailings Storage Facility
- Road Section Catchments

Bedrock Geology

- LKdP
- LKfP
- LKqP
- uKC2
- uKC3
- mKdW
- mKgW
- mKqW
- DMgPW
- DMN3
- DMN5

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CLIENT:

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LORAX ENVIRONMENTAL

PROJECT:

Casino 2010 Project

TITLE:

Western Section
Road Section Catchments

PROJECT #:	*FIGURE:*
J862-3	3-2c

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3.2 Stressor Rating

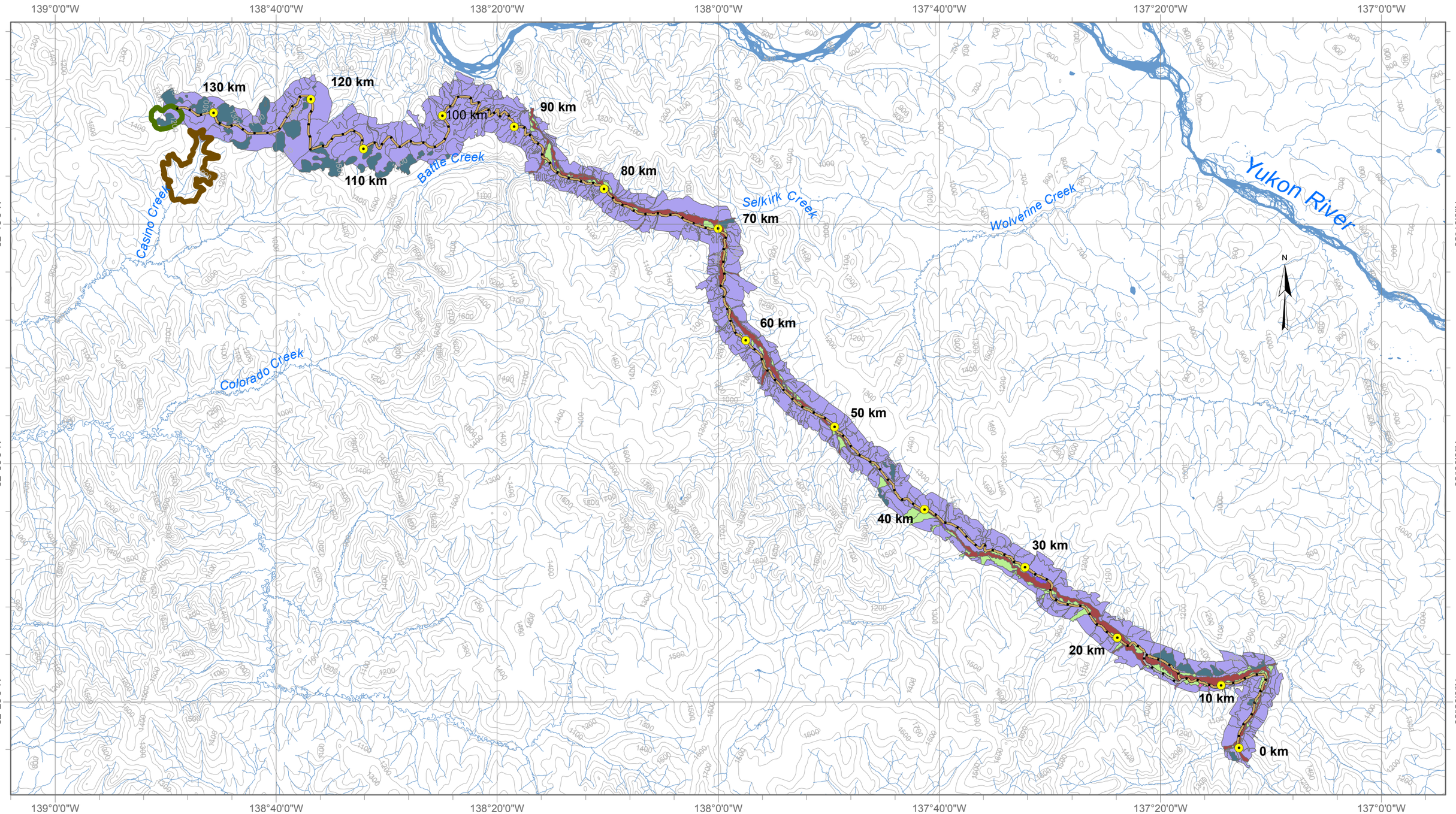
The stressor rating was calculated based on the designated risk posed by each geologic unit, and a risk rating assigned corresponding with the volume of material anticipated to be disturbed. The overall geology rating and the cut rating were multiplied to determine the stressor rating for each section of road

Each geologic unit was given a risk rating based on the expected mineral assemblage with each lithologic / stratigraphic unit and the available geochemical data. The cut volume is also included as part of the stressor risk as it is a measure of disturbance along each section of the proposed road. Areas of greater disturbance have a higher ML / ARD risk, as a greater area is exposed.

3.2.1 Geology

The development of ML / ARD from road construction is primarily controlled by the mineral composition of the construction material. The most critical mineral relationship is the relative amounts of sulphide and carbonate minerals (*i.e.*, the dominant acid-generating and acid neutralizing minerals). Determination of the likely mineral assemblages, specifically the sulphide abundance, that are typically associated with the predominant lithologies in a stratigraphic unit provides a method to qualitatively assess ML / ARD potential.

For the current study, the bedrock geology has been assessed from the geological map created from data from the Yukon Geological Survey website (Figure 3-1). More detailed descriptions of the geological units were reviewed from Carlson (1987) and Payne *et al.* (1987). The surficial material has been assessed from geology terrain maps from Summit Environmental Consultants (2011). An overview of the general surficial geology (bedrock, colluvium or alluvium) along the proposed road alignment is provided in Figure 3-3.



LEGEND

- Proposed Road Corridor
- Optional Road Alignment
- 1 Km Markers
- 10 Km Markers
- Elevations (100m)
- River
- Lake
- Open Pit
- Tailings Storage Facility

SURFICIAL MATERIAL

- Anthropogenic
- Colluvium
- Old fluvial deposits
- Active fluvial deposits
- Organic
- Bedrock

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LORAX ENVIRONMENTAL

PROJECT: **Casino 2010 Project**

TITLE: Casino Road With Surficial Geology

PROJECT #: J862-3 FIGURE: 3-3

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The proposed road route crosses seven geological units. The Whitehorse Suite (mKW) is divided into three subunits so nine rock types are considered in all. These units are:

1. Nasina Unit (DMN3, DMN5)
2. Pelly Gneiss Suite (DMgPW)
3. Long Lake Suite (EJyL)
4. Whitehorse Suite - Diorite (mKdW)
5. Whitehorse Suite – Granodiorite (mKgW)
6. Whitehorse Suite – Granodiorite to quartz monzonite (mKqW)
7. Mount Nansen Unit (mKN)
8. Carmacks Unit (uKC1)
9. Prospector Mountain Suite (LKfP, LKqP)

Table 3-1 provides a summary of each of the units. The Nasina Unit (DMN) includes both DMN3 and DMN5. Due to a lack of information on the lithological description of the subunits, they were combined as DMN for the purposes of this study. However, both units are shown on the bedrock geology maps. The Prospector Mountain Suite (LKP) includes the stock (LKqP) and the dykes (LKfP). In addition to these bedrock units, the proposed route will cross areas covered by colluvium and fluvial material.

A ML / ARD risk value from 1 to 5 was assigned to each unit, with 1 being the lowest risk and 5 being the highest risk. A brief rationale for the ML / ARD risk rating for each unit is provided in Table 3-1. This provides the rock type rating. It is typically based on the presence or absence of carbonates and pyrite, taking any available geochemistry data into account, as described below. The 1 to 5 scoring method of characterization was deemed appropriate to reflect the range and variation in the level of risk that could potentially result from the rock and soil types present. A simpler system, such as a low-moderate-high rating system would not have fully captured the ability to differentiate the ML / ARD risk associated with these rock types given the information available.

The Nasina Unit (DMN) and Whitehorse Suite Granodiorite to Quartz Monzonite (mKqw) were rated as having the highest ML / ARD potential of the rock types that occur along the road, 4 out of 5. The Pelly Gneiss Suite (DMgPW), Whitehorse Suite “Casino Granodiorite” (MKgW) and Prospector Mountain Suite (LKP) were rated as having moderate ML / ARD potential, (3 out of 5), and the Long Lake Unit (EJyL), Whitehorse Suite Diorite (mKdW), and Carmacks Unit (mKN) were rated low (2 out of 5).

Table 3-1:
Summary of Geology and Geology Risk

Map Code	Unit (YGS name)	Name (original document)	Rock Type (based on Carlson, 1987 and Payne *et al.*, 1987)	Alteration and pyrite/calcite presence from petrographic description in Carlson (1987)	ARD risk	Reasoning for ARD risk
DMN (DMN3 / DMN5)	Nasina	Yukon Metamorphic Complex (Payne *et al.*, 1987) / Wolverine Creek Metamorphic Suite (Johnston, 1995)	Meta-sedimentary quartzite and quartz-mica schist. The composition varies in the amount of mica. Generally banded. General composition: quartz (50-80%), mica (20-50%), feldspar (1-5%) and opaques (0-5%).	sericitic alteration, no mention of any pyrite or calcite	4	Unit includes variable lithologies which increases the potential variability and risk. Includes gneiss and schists, which may have elevated S content in the parent rock.
DMgPW	Pelly Gneiss Suite	Wolverine Creek Metamorphic Suite (Johnston, 1995) / Simpson Allochthonous Assemblage - Selwyn Gneiss (Tempelman-Kluit, 1984)	Meta-igneous schist and gneiss. Amount of metamorphism varies. Plagioclase is the dominant mineral (60-75%), with lesser K-feldspar, quartz, hornblende and biotite.	plagioclase to sericite alteration common, occasionally epidote and calcite alteration, pyrite: none to 0.3% calcite: none to 4%	3	Sulphide minerals reported, but sericitic alteration often includes carbonates. Some subunits include limestone.
EJyL	Long Lake Suite	Big Creek Syenite (Tempelman-Kluit, 1984)	Syenitic granitic rocks, monzonite to granodiorite and hornblendite. General composition of syenite: K-feldspar (30-50%), hornblende (20-75%), plagioclase (10-30%), quartz (0-20%) and minor sphene and apatite.	sericitic alteration, no mention of any pyrite or calcite	2	Presence of mafic silicate minerals which provide buffering capacity for low levels of acidity and sericitic alteration which may include carbonate minerals.
mKdW	Whitehorse Suite	Dawson Range Batholith (Johnston, 1995)	Diorite. General composition: plagioclase (50-60%), mafic minerals (25-30%), quartz (15%) and minor K-feldspar.		2	Phyllic alteration of hypogene samples in the Casino deposit typically contain > 1% carbonate content. Lower sulphide content is expected in this unit outside the deposit. Contains mafic minerals that can buffer low levels of acidity.

Map Code	Unit (YGS name)	Name (original document)	Rock Type (based on Carlson, 1987 and Payne *et al.*, 1987)	Alteration and pyrite/calcite presence from petrographic description in Carlson (1987)	ARD risk	Reasoning for ARD risk
mKgW	Whitehorse Suite	Casino granodiorite (Tempelman-Kluit, 1984) / Dawson Range Batholith (Johnston, 1995) / Dawson Range Suite (Payne, 1987) / Hornblende granodiorite (Tempelman-Kluit, 1984)	Granodiorite. General composition: plagioclase (50-60%), quartz (15-20%), K-feldspar (15-20%), biotite & hornblende (15%).	plagioclase altered to sericite, biotite altered to chlorite, no mention of pyrite or calcite	3	Lower levels of mafic silicate minerals from granodiorite than diorite.
mKqW	Whitehorse Suite	Coffee Creek Granite (Tempelman-Kluit, 1984) / Dawson Range Batholith (Johnston, 1995)	Granodiorite to quartz monzonite. General composition: quartz (25-35%), plagioclase (20-40%), K-feldspar (25-40%), biotite (5-10%), hornblende (<5%), minor pyrite, apatite, sphene and zircon.	plagioclase altered to sericite and clay, no mention of pyrite or calcite	4	Lower levels of mafic silicate minerals in quartz monzonite. Carbonate content would likely be restricted in this more silicate rich rock type, particularly in clay altered zones.
mKN	Mount Nansen	Mount Nansen Group (Tempelman-Kluit, 1984)	Volcanic flows and subvolcanic intrusions. The main rock type is an andesite typically with a fine grained matrix and visible plagioclase, hornblende, clinopyroxene and biotite. Phenocrysts are dominantly plagioclase and make up 35-55% of the rock. Groundmass is plagioclase, quartz, K-feldspar, chlorite and opaques.	sericite and clay alteration, some calcite, chlorite and epidote alteration pyrite: none to minor calcite: none to minor	2	Calcite content in mafic flows typically more abundant than sulphide content.

Map Code	Unit (YGS name)	Name (original document)	Rock Type (based on Carlson, 1987 and Payne *et al.*, 1987)	Alteration and pyrite/calcite presence from petrographic description in Carlson (1987)	ARD risk	Reasoning for ARD risk
uKC1	Carmacks	Carmacks Suite (Payne, 1987) / Carmacks Group (Johnston, 1995)	A volcanic sequence with a lower rhyolite to rhyodacite subunit, a middle andesite subunit and an upper basalt subunit.	plagioclase alters to clay or sericite, clinopyroxene alters to ankerite or calcite, pyrite: not mentioned, calcite: none, one sample has 7-8% ankerite, another sample has 2-3% calcite	2	Carbonate is typically reported in this unit. Basalt containing mafic silicate minerals capable of buffering low levels of acid production.
LKP (LKfP / LKqP)	Prospector Mountain Suite	Prospector Mountain Plutonic Suite (Johnston, 1995)	Quartz-rich monzonite stock (LKqP) with porphyritic latite and quartz-rich latite dykes (LKfP).		3	Limited mafic silicate content. Unit likely has variable ARD risk. In the Casino deposit typically contains carbonate but has elevated S content, which makes this unit PAG.
Surficial material			**Description**			
Colluvium			Clay to cobble sized fragments from past mass movements.		Bedrock rating -1	Moderate but variable risk dependent on the parent rock type.
Fluvial			Clay to cobble sized fragments. Includes both present river banks and old floodplains.		1	Low risk due to high degree of physical and chemical weathering.

The rock type rating was reduced for colluvium and alluvium. The risk factor for colluvium is lower than that of the parent rock type (the rating was reduced by 1, from 3 out of 5 in the case of the Pelly Gneiss Suite, to 2 out of 5 for colluvium derived from it, for example) as colluvium has been exposed to the elements for a longer period of time and will, therefore, be more weathered with the acid generating minerals depleted. This rationale depends on the assumption that the colluvium has not been transported a great distance so the parent rock type is the same as that of the underlying bedrock. The risk rating for alluvium is low (1) based on the same principle of advanced weathering and associated oxidation. In cases where both colluvium and alluvium are present in a particular section of road, the more conservative risk factor for colluvium is used.

Based on preliminary road design (Associated Engineering, 2011) the road will require excavation of soil (alluvium and colluvium) only, through the Eastern and Central section, from station 0-316 to station 86+120. In contrast, excavations are entirely in bedrock in the Western Section from station 86+120 (from roughly the western boundary of the Hayes Creek drainage basin) to station 132+410, where the new access road will join with the existing road on the Casino property.

3.2.2 Geochemical Analytical Results

In determining the ML / ARD risk described above, geochemical results were taken into consideration. Geochemical data is available both from data obtained as part of previous work at the Casino deposit itself, and preliminary sampling completed along the route for this 2011 study.

The geochemical testing from work completed in the Casino deposit was part of other Lorax studies and is not presented here. However, as the geological units encountered in the proposed pit also have restricted occurrence along the road alignment, the results were considered in determining the ML / ARD risk for the road assessment. However, the Casino ore deposit is unique in that it is a highly mineralized zone that would contain higher sulphide content than occurrences of the same stratigraphic units along the road alignment. The data includes mineral assemblages and static test results.

In June 2011, sixty samples were collected along the proposed route in support of this study. In total, thirty-nine bedrock samples, fifteen colluvium samples and six alluvium samples were collected (Appendix I). All samples were 1-5 kg, to allow for sufficient sample volume to complete all testing, as outlined in MEND (2009).

In order to obtain a preliminary characterization of the material along the proposed road route, an effort was made to collect samples from the main bedrock units and along a good distribution along the proposed road route. Where possible, samples were collected

in areas where a large amount of disturbance is expected, including areas of high cut and fill for colluvium and bedrock and at river crossings in the case of fluvial material. In some cases this was not possible, as permafrost prevented sediment sampling in several areas. This made it difficult to sample colluvium, as only areas without permafrost could be sampled, such as old cuts and areas with heavier vegetation. When quarry sites are finalized, further sampling may be required, based on the MEND (2009) sampling guidelines for tonnes of material disturbed.

The 2011 samples from along the road alignment were sent to SGS-CEMI in Burnaby, B.C for static testing. All samples were analyzed for rinse and paste pH, Acid-Base Accounting tests and Metals by Aqua Regia Digestion with ICP-MS Finish. The median values for ABA results for the different units are included in Table 3-2.

Table 3-2:
Summary of ABA results from the samples collected along the proposed road route (values presented are medians)

Median	Rinse pH	CaNP	C(T) %	S(T) %	Modified NP	NPR NP/AP	n
Rock Type							
DMN	9.12	11.7	0.15	0.02	11.4	18.2	3
DMgPW	9.07	4.17	0.06	0.01	8.30	27.7	4
mKW	7.25	0.83	0.06	0.01	5.90	18.5	28
mKN	9.14	118	1.49	0.01	72.6	242	1
uKC1	8.71	14.2	0.18	0.01	41.8	139	3
Surficial Material							
Colluvium	6.72	0.83	0.19	0.02	5.60	12.7	15
Alluvium	6.71	0.83	0.28	0.01	9.45	31.5	6

Note: DMN – Nasina, DMgPW – Pelly Gneiss Suite, mKW – Whitehorse Suite, mKN – Mount Nansen, uKC1 – Carmacks

Based on the geochemistry results, all samples were determined to be low risk due to low sulphur values (Table 3-2 and Appendix II-A). In general, the concentration of metals found in the rock samples is below three times the continental crustal abundance (Appendix II-B).

One notable exception is the concentration of arsenic measured in colluvium and alluvium samples (Appendix II-B). Although elevated concentrations of a parameter in the solid-phase may identify potential parameters of concern it does not necessarily mean that the parameter will be a source of metal leaching. Notwithstanding, the potential for arsenic leaching from these unconsolidated materials will be evaluated in Phase II testing.

The geology rating was not based solely on the data collected from sampling along the road, as the rock samples collected along the proposed road route were all collected from

the surface of outcrops and would have been exposed to more weathering relative to samples at a greater depth. Although all the samples have low ML / ARD risk, rock cuts will be made during road construction that may expose "fresher" material which hasn't been weathered, and potentially has a greater ML / ARD potential. Drilling along the proposed route in order to collect unweathered samples was not deemed necessary at this stage. Using a combination of the geologic description, the road sampling geochemistry, and the data from core samples from near the Casino deposit, allowed for a ML / ARD risk rating to be assigned with precision reasonable level of confidence for the purpose of this preliminary risk assessment.

3.2.3 Cut Volume

In general, the potential for ML / ARD increases in proportion with the amount of soil or rock that is disturbed, as the surface area of material exposed to air and water increases, and there is an increasing probability of higher variability in lithology. It is for this reason that the guidelines require more samples for a greater area or volume (Price & Errington, 1998; MEND, 2009).

This factor was included in the risk assessment by categorizing the total disturbance within a given road section (with uniform bedrock geology and confined to a given catchment area as explained above). Preliminary estimates of cut and fill volumes are available for the entire road alignment.

The cut volumes were provided for each 20m section of road. These values were added together to generate a total estimate for each of the 81 road sections which have been defined for the purposes of this risk assessment (See Table 4-1 and Appendix III). It was assumed that all of the cut volume would be placed ('filled') within the same road section, and if additional fill is required within any section, it was assumed that it will be sourced from a quarry with low ML / ARD potential. Consequently, fill volume is not directly included in the analysis.

A value between 1 and 5 was assigned for the cut volume based on guidelines from MEND (2009) and MEM & MOE (1998). The analysis takes swell factors and average densities into consideration. The soil cut volume (noted as excavated m^3 or em^3 in the table below) was calculated by multiplying the mass of disturbed material (the estimate provided as part of the preliminary road design in metric tonnes) by a swell factor of 1.05, and then dividing by an average soil density of 1350 kg/m^3 (1.35 g/cm^3). The soil density is based on Yu *et al.* (1993). Rock cut volume was calculated by multiplying the mass of disturbed material (given in tonnes) by a swell factor of 1.35, and then dividing by an average rock specific gravity of 2.7 (*i.e.* 2.7 tonnes per m^3) (www.edumine.com). The rating system is summarized in the table below.

Table 3-3:
Cut Volume Rating System

Mass of Disturbed Material (tonnes)	Soil Cut Volume (em^3)[a]	Rock Cut Volume (em^3)[b]	Cut Volume Rating	Rationale
0	0	0	0	No risk, as there is no disturbed material
< 1,000	< 780	< 500	1	Based on the minimum mass for which ML / ARD prediction is required (MEM & MOE, 1998)
1,000-10,000	780 - 7800	500 - 5000	2	
10,000-100,000	7800 - 78000	5000 - 50000	3	Based on the MEND (2009) mass for requiring 3 samples (10,000 tonnes)
100,000-1,000,000	78000 - 780000	50000 - 500000	4	Based on the MEND (2009) mass for requiring 8 samples (100,000 tonnes)
> 1,000,000	> 780000	> 500000	5	Based on the MEND (2009) mass for requiring 26 samples (1,000,000 tonnes)

[a] Soil cut volume was calculated based on an average soil density of 1.35 g/cm^3 (Yu *et al.*, 1993) and a swell factor of 1.05
[b] Rock cut volume was calculated based on an average rock specific gravity of 2.7 (www.edumine.com) and a swell factor of 1.35

3.3 Pathway Rating

It was assumed that the main pathway by which ML / ARD products would be exposed to receptors is via surface water drainage. The catchment area up-gradient of a given road section, as far as the nearest height of land, is the area over which precipitation will collect and interact with any ML / ARD products, whether through overland ('sheet') flow or water flowing in a watercourse to which drainage from the road is discharged (whether free-flowing or through constructed road ditches).

The surface area of up-gradient catchments (in hectares) was used as a proxy for surface water volume, based on the assumption that precipitation does not vary significantly along the road alignment. This was considered to be a reasonable assumption, given that the road traverses semi-arid terrain, across the northeast-facing slopes of the Dawson Range in the rain shadow of the St. Elias Mountains. There is some variation in elevation, which could cause some variability in the amount of precipitation across the road alignment, but this is considered to be a minor variable in the context of this analysis.

The volume of water interacting with any potential ML / ARD products establishes the pathway, but would also dilute metal concentrations and reduce acidity. Consequently, it was assumed that the worst case scenario would be a large cut volume with a small up-gradient catchment area. The best case scenario would be a small cut volume with a large up-gradient catchment area.

With these considerations in mind, the pathway rating was determined based on a ratio of the total cut in a section of road (in em^3) to the drainage area (in hectares). While this

provides a general indication of the affect of various pathways along the road alignment, it is imprecise. Consequently, it was deemed appropriate to assign a pathway rating, from 0 to 4, based on the order of magnitude of the ratio. Areas with a very low cut volume relative to the size of the up-gradient catchment area have a very low ratio, less than one in several cases. Areas with a very large cut volume relative to the up-gradient catchment area have a very high ratio. The highest ratio is 5973, and there are 20 sections of the road where the ratio is 101 or higher, equivalent to a pathway rating of 3 or higher.

This rating system is shown in the table below, along with the range in ratios, and number of road sections included in each pathway rating (Table 3-4). The ratio, and corresponding 'pathway rating', for each of the 81 road sections is included as Table 4-1.

Table 3-4:
Pathway Rating System

Pathway Ratio	Pathway Rating	No. of Road Sections	Range: Lowest and Highest Ratio
0	0	20	n/a
>0-10	1	17	0.0307 – 7.54
11-100	2	24	10.5 – 94.5
101-1000	3	15	133 - 781
1001-10000	4	5	1155 - 5973
TOTAL	**n/a**	**81**	**n/a**

The drainage area for each section was determined as the area upslope of the road to the height of land, as noted above, and these areas are shown in Figures 3-2a to 3-2c. In order to do this, Digital Elevation Model (DEM) data was downloaded at 1:50,000 scale (GeoBase.ca) and divided into watersheds using MapWindow GIS. The watersheds were subdivided into smaller areas manually in AutoCAD while following topography contours uphill to the height of land and then back down to the road. These subdivisions were based on changes in geology intersecting the road, watershed boundaries, streams intersecting the road and cut type (soil or rock).

This approach is considered adequate for an initial consideration of pathways in this preliminary risk assessment. While other pathways, including most notably groundwater, will ultimately influence the amount and concentration of potential ML / ARD products that may affect receptors, it is assumed for the purposes of this report that groundwater impacted by the stressor will report to the surface water pathway at a similar point as surface drainage from the road. The analysis summarized above helps to identify those areas where the inherent risk of ML / ARD due to bedrock geology, larger cut volumes, and relatively little dilution, coincide.

3.4 Receptor Rating

An important consideration is the importance of the aquatic ecosystems that may be affected by ML / ARD products through surface water drainage. These may range from benthic invertebrate communities excluding fish in the case of small, ephemeral headwater streams, to habitat that is critical for spawning and early life stages of important commercial species such as Chinook salmon, in the case of larger streams that are accessible to anadromous salmonids.

The importance and sensitivity of receptors has been evaluated based on the DFO Practitioners Guide to the Risk Management Framework (n.d.). This guide proposes that receptors be evaluated based on four primary considerations: (1) species sensitivity, (2) species' dependence on habitat, (3) species rarity, and (4) habitat resiliency. Species sensitivity is the sensitivity of the fish species present to changes in the environment. Species' dependence on habitat is how the habitat is used. For example, a section of stream that is only used for migration will have a lower value than a section of stream that is used for spawning. Rarity includes both species and habitat rarity. A rare species is defined as one that is listed as rare or endangered on the Species at Risk Public Registry. Rare habitat could be any type of habitat that is uncommon in the system and that is required for all or part of the year or for one or more life stages. Habitat resiliency can take both thermal regime and flow regime into account.

Of these four categories, only species sensitivity and habitat resiliency are included, as there was not sufficient information available with respect to the other two considerations. Species sensitivity and habitat resiliency were rated independently, as described below, and were added to derive an overall receptor rating.

The two factors that were used to characterize receptors (aquatic ecosystems) in the vicinity of the proposed road were incorporated to derive a receptor rating from 1 to 3. The rating system is summarized in the table below.

Table 3-5:
Receptor Rating System

Receptor Rating	Species Presence	Habitat Resiliency (Flow Regime)
1 - Low	Benthic Invertebrates and/or arctic grayling only	Ephemeral flow – stream only contains water after a rainstorm
2 - Moderate	Fish community including arctic grayling and slimy sculpin, overwintering habitat	Intermittent flow – stream only contains water seasonally
3 - High	Fish community including Chinook salmon, spawning and overwintering habitat	Permanent flow – stream contains water year-round

3.4.1 Species Sensitivity

Species sensitivity was rated based on the fish species present in the streams (Table 3-5). There are no species that are listed in the Species At Risk public registry found in the area around the proposed road. Salmon are the most sensitive species in the area; therefore, areas where they are known to be present are assigned a higher rating. A moderate rating is assigned to areas where slimy sculpin occur, as these fish remain in areas that provide overwintering habitat, and often coincide with other species including arctic grayling. A low risk rating is assigned to areas where only arctic grayling are present, as they use small ephemeral and intermittent streams as summer rearing habitat, or there are likely no fish present, based on no fish being caught during electrofishing surveys. In determining the receptor rating, an assumption was made that the furthest known upstream occurrence is the extent of the range and the particular species will not be found upstream of this point.

Data for fish presence was obtained from a recent report documenting the results of a preliminary habitat assessment (Summit, 2011), as well as the results of recent supplemental field work (Kearns, pers. comm., 2011). These information sources include what is known of fish presence in the streams that the road intersects from previous studies and field work completed in August 2010. These sources provide information on the section of road up to approximately station 90+000. Data for the Western Section of the road (the westernmost 40 km) is limited. Additional information on this section of road was provided by the Casino Project team, based on inspection of satellite imagery available for the area. In this way, it was determined that several of the Hayes Creek and Isaac Creek tributaries have potential for fish habitat, but the Sunshine Creek tributary is unlikely to support fish. However, uncertainty still remains for several sections of road. In these areas, the most conservative rating, corresponding to a more sensitive and/or diverse ecosystem was assigned.

3.4.2 Habitat Resiliency

Habitat resiliency was rated based on the flow regime (Table 3-5). The main stems of both Big Creek and Hayes Creek are considered to have permanent flow as they are both major streams in the area. Sections of the headwaters for both of these creeks are rated as ephemeral based on field photos provided by the Casino Project team. In areas where the flow regime is uncertain, a conservatively high rating of 3 was assigned, corresponding with permanent flow that could support fish populations year round. The thermal regime was not considered as it is assumed that all streams in the area are cold water streams and that thermal conditions are not a limiting factor.

3.4.3 Summary of Receptor Ratings

Based on the criteria outlined above, all 81 sections of the road were rated for Species Sensitivity and Habitat Resiliency. A summary of these ratings is provided in Table 3-6. These were added to determine the overall receptor rating. A summary of the receptor ratings is shown in Table 3-7. The majority of the road sections (72 of 81) have high receptor ratings (5 or 6).

Table 3-6:
Summary of Species Sensitivity and Habitat Resiliency Ratings

Rating	Species Sensitivity (Number of Sections)	Habitat Resiliency (Number of Sections)
1 (Low Importance or Sensitivity)	9	5
2	33	0
3	39	76
Total	**81**	**81**

Table 3-7:
Summary of Receptor Ratings

Receptor Rating	No of Road Sections (of 81)
1	0
2	5
3	0
4	4
5	33
6	39
Total	**81**

3.5 Overall Risk Rating System

Ratings were then assigned for each section of road to reflect available information about:

- The stressor: the risk associated with the ML / ARD potential of the underlying bedrock, together with the volume of soil or rock that is anticipated to be disturbed, based on the preliminary road design;
- The pathway: the amount of dilution that is expected, given the size of the up-gradient surface water catchment area;

- The receptors: the fish species anticipated to be present at, and immediately downstream, of the road, as well as the nature of the flow regime in each section (permanent flow, intermittent (*i.e*. seasonal) flow, or ephemeral flow (*i.e*. flow during storm events only).

A risk rating was derived for each section of the road, based on the following formula:

Stressor Risk (0 to 25) x Pathway (0 to 4) x Receptor Sensitivity (2 to 6)

The lowest possible outcome is 0 (0x0x2), while the highest possible outcome is 600 (25x4x6). The actual results of the analysis range from 0 to 288. These numerical results are equated with risk as shown in the following table (Table 3-8).

Table 3-8:
Risk Rating and Corresponding Risk Category

Overall Risk Rating	Risk Category
0-49	Very low risk
50-99	Low risk
100-149	Moderate-low risk
150-199	Moderate risk
>200	Moderate-high risk

4. Results

4. Results

All relevant values, ratings and results are presented in the Risk Assessment Matrix for each of the sections of road (Table 4-1).

A total of 16 road sections are considered to have moderate-low risk or greater (an overall risk rating of 100 or greater), representing a total road length of 38.25 km (or 29% of the 133 km total alignment). These road sections are summarized in Tables 4-2 and 4-3 and are discussed in greater detail below. The low risk sections have an overall risk less than 100 and cover 94.7 km (approximately 71%) of the proposed road alignment.

These 16 sections with moderate-low risk or greater are first presented in order from the Freegold Road to the Casino Property, for reference purposes. They are then described in more detail in order from the highest risk to the lowest, for the purpose of further describing the results, and for providing recommendations.

The 16 sections with moderate-low risk or greater are generally located in two main sections of road: (1) an 11.8 km section from 86+500 to 98+300, and (2) a 16.4 km section from 108+030 to 124+430. These sections are both in areas where rock cuts will be required (as opposed to excavating soil). In addition, there are three other road sections where the ML / ARD risk is considered to be moderate-low or greater: (3) 1+290 to 5+960, (4) 13+420 to 18+400, and (5) 78+420 to 79+010. The moderate-low risk and higher road sections are discussed in greater detail in sections 4.1-4.3.

The majority of the road (94.68 km) can be considered to have low risk for ML / ARD and no further work is recommended for these sections. These sections were determined to have little ML / ARD potential based on a low stressor, pathway or receptor rating, or a combination of the three. These sections have an overall risk of less than 100. The low risk sections are briefly addressed in section 4.5.

Table 4-1:
Risk Assessment Matrix

Chainage			**Overall Risk**		**Stressors**						**Stressor**			**Pathway**			**Receptor**		**Receptor**
From	To				Rock Code	Rock Type Rating	Colluvium (c), alluvium (a) or bedrock (r)	Overall Geology Rating	Total cut (Soil or Rock) (em^3)	Cut Rating	**Rating**		Drainage Area (hectares)	Pathway Ratio	**Rating**		Species Sensitivity	Habitat resiliency	**Rating**
Bow Creek																			
0-316	0-150		72		mKgW	3	a/c	2	807	2	**4**		1.09	741	**3**		3	3	**6**
0-150	0+260		72		mKgW	3	a/c	2	2,461	2	**4**		3.85	639	**3**		3	3	**6**
0+260	0+410		24		mKgW	3	a/c	2	846	2	**4**		15,778	0.05	**1**		3	3	**6**
Seymour Creek																			
0+410	1+250		72		mKgW	3	a/c	2	12,699	3	**6**		136	94	**2**		3	3	**6**
1+250	1+290		0		mKqW	4	a/c	3	0	0	**0**		5.21	0	**0**		3	3	**6**
1+290	5+960		108		DMgPW	3	a/c	2	50,032	3	**6**		376	133	**3**		3	3	**6**
Big Creek (main stem)																			
5+960	11+860		72		DMgPW	3	a/c	2	17,689	3	**6**		1,396	13	**2**		3	3	**6**
11+860	12+280		6		mKqW	4	a	1	33	1	**1**		19.6	2	**1**		3	3	**6**
12+280	12+520		0		mKqW	4	a	1	0	0	**0**		11.9	0	**0**		3	3	**6**
12+520	13+420		6		mKqW	4	a	1	363	1	**1**		1,603	0.23	**1**		3	3	**6**
13+420	18+400		144		mKqW	4	a/c/r	4	42,061	3	**12**		1,730	24	**2**		3	3	**6**
18+400	18+570		0		mKqW	4	a/c	3	0	0	**0**		83.2	0	**0**		3	3	**6**
18+570	19+180		6		mKN	2	a	1	161	1	**1**		4,068	0.040	**1**		3	3	**6**
19+180	20+010		24		EJyL	2	a/c	1	2,344	2	**2**		142	17	**2**		3	3	**6**
20+010	22+600		36		mKN	2	a/c	1	22,086	3	**3**		1,126	20	**2**		3	3	**6**
22+600	23+890		18		mKqW	4	a/c	3	279	1	**3**		3,424	0.082	**1**		3	3	**6**
23+890	26+780		36		mKN	2	a/c	1	11,742	3	**3**		811	14	**2**		3	3	**6**
26+780	26+840		0		mKN	2	c	1	0	0	**0**		14.4	0	**0**		3	3	**6**
26+840	26+880		0		mKqW	4	a/c	3	0	0	**0**		21.0	0	**0**		2	3	**5**
26+880	27+500		45		mKqW	4	a/c	3	10,368	3	**9**		1,962	5	**1**		2	3	**5**
27+500	33+250		60		mKgW	3	a/c	2	25,257	3	**6**		1,907	13	**2**		2	3	**5**
Big Creek headwaters																			
33+250	34+240		30		mKgW	3	a/c	2	8,414	3	**6**		1,116	8	**1**		2	3	**5**
34+240	34+640		30		DMN	4	c	3	234	1	**3**		7.91	30	**2**		2	3	**5**
34+640	37+280		40		mKgW	3	c	2	6,095	2	**4**		192	32	**2**		2	3	**5**
37+280	37+360		0		uKC1	2	c	1	0	0	**0**		95.7	0	**0**		2	3	**5**
37+360	40+100		8		mKgW	3	a/c	2	7,416	2	**4**		987	8	**1**		1	1	**2**
40+100	40+300		0		uKC1	2	c	1	0	0	**0**		34.2	0	**0**		1	1	**2**
40+300	42+820		12		DMN	4	c	3	880	2	**6**		508	2	**1**		1	1	**2**
Hayes Creek headwaters																			
42+820	43+750		0		DMN	4	c	3	0	0	**0**		268	0	**0**		1	1	**2**
43+750	49+240		36		mKqW	4	a/c	3	36,759	3	**9**		1,841	20	**2**		1	1	**2**
49+240	51+200		8		uKC1	2	a/c	1	6,633	2	**2**		925	7	**1**		1	3	**4**
51+200	53+280		24		uKC1	2	a/c	1	20,518	3	**3**		744	28	**2**		1	3	**4**
53+280	53+900		16		mKgW	3	a/c	2	1,796	2	**4**		273	7	**1**		1	3	**4**
53+900	56+570		36		uKC1	2	a/c	1	27,549	3	**3**		139	198	**3**		1	3	**4**
56+570	56+920		0		uKC1	2	c	1	0	0	**0**		14,314	0	**0**		2	3	**5**
56+920	57+340		0		LKfP	3	a/c	2	0	0	**0**		102	0	**0**		2	3	**5**
57+340	57+480		0		mKgW	3	a	1	0	0	**0**		446	0	**0**		2	3	**5**
Hayes Creek (valley bottom)																			
57+480	62+260		30		mKgW	3	a/c	2	18,292	3	**6**		2,770	7	**1**		2	3	**5**
62+260	62+650		20		mKgW	3	a	1	2,033	2	**2**		86.5	24	**2**		2	3	**5**
62+650	64+000		30		mKgW	3	a/c	2	19,790	3	**6**		4,414	4	**1**		2	3	**5**
64+000	64+300		90		mKqW	4	a/c	3	6,610	2	**6**		18.9	350	**3**		2	3	**5**
64+300	64+740		0		mKgW	3	a/c	2	0	0	**0**		43.9	0	**0**		2	3	**5**
64+740	64+930		0		mKgw	3	a/c	2	0	0	**0**		3.49	0	**0**		2	3	**5**
64+930	65+100		0		DMgPW	3	a/c	2	0	0	**0**		26.7	0	**0**		2	3	**5**
65+100	65+260		0		mKqW	4	a/c	3	0	0	**0**		18.8	0	**0**		2	3	**5**
65+260	66+210		10		DMgPW	3	a/c	2	60	1	**2**		1,951	0.031	**1**		2	3	**5**

Chainage			**Overall Risk**		**Stressors**						**Stressor**				**Pathway**		**Receptor**		**Receptor**
From	To				Rock Code	Rock Type Rating	Colluvium (c), alluvium (a) or bedrock (r)	Overall Geology Rating	Total cut (Soil or Rock) (em^3)	Cut Rating	**Rating**		Drainage Area (hectares)	Pathway Ratio	**Rating**		Species Sensitivity	Habitat resiliency	**Rating**
Hayes Creek (valley bottom), continued																			
66+210	66+320		0		DMgPW	3	a	1	0	0	**0**		5.63	0	**0**		2	3	**5**
66+320	67+780		0		DMgPW	3	a	1	0	0	**0**		101	0	**0**		2	3	**5**
67+780	68+500		5		DMgPW	3	a	1	91	1	**1**		104	1	**1**		2	3	**5**
68+500	69+380		20		DMgPW	3	a	1	976	2	**2**		90.8	11	**2**		2	3	**5**
69+380	78+420		60		DMgPW	3	a/c	2	65,716	3	**6**		6,232	11	**2**		2	3	**5**
78+420	79+010		135		DMN	4	a/c	3	8,023	3	**9**		16.4	489	**3**		2	3	**5**
79+010	79+400		0		DMN	4	a	1	0	0	**0**		12.3	0	**0**		3	3	**6**
79+400	81+740		0		DMN	4	a/c	3	0	0	**0**		272	0	**0**		3	3	**6**
81+740	84+750		72		mKgW	3	a/c	2	17,603	3	**6**		984	18	**2**		3	3	**6**
84+750	86+120		24		mKgW	3	a/c	2	1,403	2	**4**		39,611	0.035	**1**		3	3	**6**
Rock Cut																			
Hayes Creek (rock cut area)																			
86+120	86+500		72		mKgW	3	r	3	2,663	2	**6**		34.9	76	**2**		3	3	**6**
86+500	87+750		162		mKgW	3	r	3	46,159	3	**9**		136.5	338	**3**		3	3	**6**
87+750	87+900		144		mKdW	2	r	2	11,090	3	**6**		2.05	5,409	**4**		3	3	**6**
87+900	88+040		72		mKgW	3	r	3	4,390	2	**6**		73.2	60	**2**		3	3	**6**
88+040	88+280		144		mKdW	2	r	2	13,616	3	**6**		10.5	1,293	**4**		3	3	**6**
88+280	88+720		216		mKgW	3	r	3	7,435	3	**9**		6.43	1,156	**4**		3	3	**6**
88+720	95+460		144		mKdW	2	r	2	360,110	4	**8**		1,162	310	**3**		3	3	**6**
95+460	95+650		216		mKgW	3	r	3	21,110	3	**9**		3.53	5,973	**4**		3	3	**6**
Mascot Creek																			
95+650	98+300		162		mKgW	3	r	3	23,394	3	**9**		120	195	**3**		3	3	**6**
98+300	106+670		72		mKdW	2	r	2	34,819	3	**6**		631	55	**2**		3	3	**6**
Idaho/Isaac/Sunshine Creek																			
106+670	108+030		72		mKdW	2	r	2	16,677	3	**6**		270	62	**2**		3	3	**6**
108+030	108+410		162		mKgW	3	r	3	12,156	3	**9**		64.0	190	**3**		3	3	**6**
108+410	108+490		108		LKqP	3	r	3	914	2	**6**		1.17	781	**3**		3	3	**6**
108+490	108+540		36		LKfP	3	r	3	72	1	**3**		0.849	85	**2**		3	3	**6**
108+540	109+380		288		LKqP	3	r	3	51,831	4	**12**		30.1	1,721	**4**		3	3	**6**
109+380	112+460		108		mKgW	3	r	3	41,383	3	**9**		873	47	**2**		3	3	**6**
112+460	115+640		216		DMN	4	r	4	37,436	3	**12**		275	136	**3**		3	3	**6**
115+640	124+430		180		mKgW	3	r	3	86,893	4	**12**		551	158	**3**		2	3	**5**
Casino Creek																			
124+430	126+060		40		mKdW	2	r	2	3,369	2	**4**		43.1	78	**2**		2	3	**5**
126+060	126+920		0		mKdW	2	r	2	0	0	**0**		12.4	0	**0**		2	3	**5**
126+920	127+660		15		mKgW	3	r	3	18	1	**3**		17.4	1	**1**		2	3	**5**
127+660	129+300		90		mKdW	2	r	2	15,573	3	**6**		78.6	198	**3**		2	3	**5**
129+300	129+840		30		mKgW	3	r	3	266	1	**3**		5.74	46	**2**		2	3	**5**
129+840	132+410		60		mKdW	2	r	2	10,605	3	**6**		112	94	**2**		2	3	**5**
132+410	132+610		90		LKfP	3	r	3	2,824	2	**6**		20.2	140	**3**		2	3	**5**
	average								15,567				1,456						
	median								2,663				112						
	median (ignore 0)								8,414				-						
	min								0				0.85						
	min (ignore 0)								17.7				-						
	max								360,110				39,611						
	Total								1,260,920				117,911						

Overall Risk Rating

<49 - Very low risk
50-99 - Low risk
100-149 - Moderate-low risk
150-199 - Moderate risk
>200 - Moderate-high risk

Rating is uncertain, conservative

Rock Codes	
DMN	Nasina - quartzite and quartz-mica schist
DMgPW	Pelly Gneiss suite - schist and gneiss
EJyL	Long Lake suite - syenitic granitc rocks
mKdW	Whitehorse suite - diorite
mKgW	Whitehorse suite - granodiorite
mKqW	Whitehorse suite - granodiorite to quartz monzonite
mKN	Mount Nansen - volcanic flows and subvolcanic intrusions
uKC1	Carmacks - volcanic sequence
LKP	Prospector Mountain suite - quartz-rich monzonite stock (LKqP) with latite dykes (LKfP)

Table 4-2:
Road Sections with Moderate-Low Risk or Greater, from Freegold Road to Casino Property

Ref. No.	Chainage		Length (km)	Overall Risk
	From	To		
1	1+290	5+960	4.67	108
2	13+420	18+400	4.98	144
3	78+420	79+010	0.59	135
4	86+500	87+750	1.25	162
5	87+750	87+900	0.15	144
6	88+040	88+280	0.24	144
7	88+280	88+720	0.44	216
8	88+720	95+460	6.74	144
9	95+460	95+650	0.19	216
10	95+650	98+300	2.65	162
11	108+030	108+410	0.38	162
12	108+410	108+490	0.08	108
13	108+540	109+380	0.84	288
14	109+380	112+460	3.08	108
15	112+460	115+640	3.18	216
16	115+640	124+430	8.79	180

Table 4-3:
Moderate-low to Moderate-high Risk Road Sections

Chainage		Length (km)	Drainage Basin	Overall Risk	Risk
From	To				
108+540	109+380	0.84	Idaho/Isaac/Sunshine	288	Moderate-High
88+280	88+720	0.44	Hayes Creek	216	
95+460	95+650	0.19	Hayes Creek	216	
112+460	115+640	3.18	Idaho/Isaac/Sunshine	216	
115+640	124+430	8.79	Idaho/Isaac/Sunshine	180	Moderate
86+500	87+750	1.25	Hayes Creek	162	
95+650	98+300	2.65	Mascot Creek	162	
108+030	108+410	0.38	Idaho/Isaac/Sunshine	162	
87+750	87+900	0.15	Hayes Creek	144	Moderate-Low (Rock Cut)
88+040	88+280	0.24	Hayes Creek	144	
88+720	95+460	6.74	Hayes Creek	144	
108+410	108+490	0.08	Idaho/Isaac/Sunshine	108	
109+380	112+460	3.08	Idaho/Isaac/Sunshine	108	
13+420	18+400	4.98	Big Creek	144	Moderate-Low (Soil Cut)
78+420	79+010	0.59	Hayes Creek	135	
1+290	5+960	4.67	Seymour Creek	108	

4.1 Moderate-High Risk (4) Sections

There are four sections with an overall risk rating greater than 200. These are all in the section of road where all the cut volume is in rock. There is uncertainty in both the species sensitivity and the habitat resiliency through this section, so the receptor rating may be reduced if it is found that the streams in this area do not support fish or are not permanent watercourses (these have been assigned conservatively high values, with a receptor rating of 6).

The section with the highest risk (288) is a 0.84 km section from 108+540 to 109+380. This section is through the Prospector Mountain Suite (LKqP), with an overall geology rating of 3. There is also a high volume cut rating (4) which results in a stressor rating of 12. The pathway rating is high as well (4), due to a high cut volume in the context of the small catchment area.

The remaining moderate-high risk sections have an overall risk rating of 216. The second (88+280 to 88+720) and third (95+460 to 95+650) sections are through the Whitehorse Suite granodiorite (mKgW). These sections have a moderate geology rating of 3, but the amount of cut is fairly high (3), as is the pathway rating (4).

The fourth section (112+460 to 115+640) with a moderate-high risk rating is through the Nasina quartzite and quartz-mica schist (DMN), which has a high risk rating (4). Both the cut rating and the pathway rating are moderate (3).

4.2 Moderate Risk (4) Sections

There are four moderate risk sections. These are within the rock cut section, where there is uncertainty in the receptor rating. As is the case with the sections in the moderate-high risk category, the receptor rating may be reduced based on the results from further fieldwork.

All of these sections are through the Whitehorse Suite granodiorite (mKgW), with an overall geology rating of 3. The road section from 115+640 to 124+430 has an overall risk rating of 180, with a high cut rating (4) and a moderate pathway rating (3). The species sensitivity rating is estimated conservatively as a 2, based on the assessment of satellite imagery of the area. It was concluded that the tributaries in this area are unlikely to support fish; however, fish sampling has not been completed in this area, and so a conservatively high rating was assigned to this section of road. The overall receptor rating for this section of road is 5.

The other three moderate risk sections listed in Table 4-1 have an overall risk rating of 162 with a moderate cut rating (3), a moderate pathway rating (3) and a conservatively high receptor rating (6).

4.3 Moderate-Low Risk (8) Sections

4.3.1 Rock Cut: 86+120 to 132+610

There are five sections within the rock cut section which have a moderate risk rating. The first three cross the Whitehorse Suite diorite (mKdW) and all have an overall risk rating of 144. These have a relatively low geology rating (2) but a moderate to high (3-4) cut rating. The pathway rating is also moderate to high (3-4), depending on the section. There is uncertainty in the fish species present in this area as well as uncertainty in the flow regime, which results in a conservatively high receptor risk rating (6). The section from 108+410 to 108+490 has an overall risk rating of 108 and crosses the Prospector Mountain suite (LKqP). It has a geology rating of 3 and a cut rating of 2. The pathway rating is moderate (3). The receptor rating is conservatively high, due to uncertainty. The final section (109+380 to 112+460) also has an overall risk rating of 108. It crosses the Whitehorse Suite granodiorite (mKgW) and has a moderate stressor rating of 9 (3x3). The pathway rating is low (2) as the drainage area is large relative to the cut volume. The receptor rating is high (6), again due to the uncertainty in the fish presence and the flow regime in the area.

4.3.2 Soil Cut: 0-316 to 86+120

There are three sections with a moderate-low risk rating in the first section of road where all the cut is predicted to be soil. These are (1) section 13+420 to 18+400, (2) from 78+420 to 79+010, and (3) from 1+290 to 5+960.

The highest rating (144) for these three sections is for the section from 13+420 to 18+400. This section is through the Whitehorse Suite granodiorite to quartz-monzonite (mKqW). The surficial geology air photos indicate that there is bedrock in this section, resulting in a high (4) overall geology rating. The cut rating is moderate (3), which results in a high (12) stressor rating. As this section of road runs along the main stem of Big Creek, the receptor rating is high (6). The overall rating is kept down by a relatively low pathway rating (2), as the cut volume is low relative to the up gradient catchment area.

Within this road section from approximately kilometre mark 12+800 to 17+000, there are two possible road route options. The route to the north of Big Creek, which includes the section discussed above, is currently considered the primary option. However, both

routes are shown on the maps (see Figures 3-1 and 3-2a). However, the secondary route will likely have a lower ML / ARD risk, based on the geology and the absence of bedrock at surface along this alignment. This option crosses the Long Lake Suite (EJyL) and the Carmacks unit (mKN). Both of these units have a low (2) ARD risk and this risk will be reduced further to 1 as colluvium and alluvium are the surficial materials in this area. The section of road from 17+000 to 18+400 is through the Whitehorse Suite granodiorite to quartz-monzonite (mKqW) and must be re-evaluated if this option is chosen to determine its overall risk, as the drainage area will be smaller, relative to the larger drainage area for the section through mKqW in the primary option. However, there is no bedrock in this area, so the geology rating would be reduced to 3.

The next highest risk section is in the Hayes Creek (valley bottom) drainage (78+420 to 79+010), with an overall risk rating of 135. It is through the Nasina quartzite and quartz-mica schist (DMN). This unit has a rock type rating of 4, which is modified to an overall geology rating of 3 as the surficial material in the area includes colluvium. The cut and pathway ratings are moderate (3) and the receptor rating is fairly high (5), due to the presence of slimy sculpin and Arctic grayling and the permanent flow in Hayes Creek.

The third section (1+290 to 5+960) is through the Pelly Gneiss suite (DMgPW). It has an overall risk rating of 108. The overall geology rating is fairly low (2), since the rock type rating is modified by colluvium being present. The cut rating is moderate (3), as is the pathway rating (3). The receptor rating is high (6), as Chinook salmon are present in Seymour Creek and flow is likely permanent.

4.4 Uncertainty

While the 16 road sections with moderate-low risk or greater are deemed to have a higher ML / ARD risk, including consideration of the surface water pathway and aquatic ecosystem receptors, there is a high degree of uncertainty in the results. This uncertainty can be reduced by obtaining additional information related to all three aspects of the risk assessment, and recommendations for additional work to achieve this objective are provided below. Further characterization will be required for the sections rated as having moderate-low risk or greater, in order to determine if there will be any ML / ARD issues during or following road construction.

4.5 Low Risk Sections

The low risk sections have an overall risk less than 100 and cover 94.7 km (approximately 71%) of the proposed road alignment. In general, these sections are in the first 87 km of the road where it's predicted to be all soil (and no rock) cut. The stressor rating is generally fairly low through this section as alluvium and colluvium

generally have a lower risk rating relative to bedrock. Furthermore, this section generally has lower cut volumes and lower pathway ratios relative to the rock cut section. The final section of the road route from 124+430 to 132+610 is considered low risk, due to moderate to low stressor and pathway ratings. No further work is recommended for these sections, as the overall risk is low enough to determine that ML / ARD will not be an issue during or following road construction.

5. Recommendations

5. Recommendations

The ML / ARD risk assessment of the proposed Casino access road identified 16 sections representing 38.25 km (29 %) of the road alignment with potential for ML / ARD issues. Thirteen of the 16 sections are located in two areas: 86+500 to 98+300 and 108+030 to 124+430. These sections are both within the rock cut area. The three remaining sections are 1+290 to 5+960, 13+420 to 18+400 and 78+420 to 79+010.

Further work is recommended for all of these road sections in order to fully assess the level of ML / ARD risk to aquatic ecosystems during and following road construction. In addition, the ML / ARD potential of the quarry locations must be assessed.

Further work should include:

1. Further characterization of the streams. Further work from 86+120 to the Casino property may reduce the receptor rating, and the overall risk, if it is determined that the streams in this area are not fish-bearing and/or do not have permanent flow. This may reduce the overall risk in some sections to less than 100 and decrease the area of further sampling along the proposed road.
2. Collecting bedrock or surficial material samples from along these 16 sections. In areas where there will be rock cut, the ideal sampling method would be by drilling, in order to fully characterize the weathering at different depths and to obtain “fresh” rock samples. For surficial material samples, sampling from below the organic layer would be sufficient. The number of samples collected should be based on the excavated volume of material, as per the MEND (2009) guidelines. These samples should be submitted for the same suite of static tests which were completed on the initial 60 samples. In addition, the arsenic leaching potential of colluvial and alluvial materials should be evaluated by conducting shake flask extractions on a sub-set of representative samples. This will allow for a more complete characterization of the ML / ARD potential of the rock or surficial material along the higher risk sections of road and it will determine if mitigation strategies are required.
3. Finalizing the proposed road alignment between 12+800 and 17+000, in order to assess the ML / ARD risk along this section and to determine which option has a lower ML / ARD risk.
4. Finalizing quarry locations. Quarry locations should take the overall geology risk rating into account. The three bedrock units with the lowest ML / ARD risk rating (2) are the Long Lake Suite (EJyL), the Whitehorse Suite diorite (mKdW)

and the Carmacks volcanics (uKC1). Where possible, bedrock quarries should be located in these units. If granular quarries are required, alluvial material has a lower risk rating relative to colluvium, and colluvium lower than bedrock. However, based on the results of the risk assessment, excavation of colluvium generally has a low risk when the excavated volume remains relatively low (less than about 10,000 m^3) or the bedrock geology rating is 3 or lower. This would result in an overall geology rating of 2. Based on this, areas should be avoided where the colluvial parent material is from the Nasina unit (DMN) or the Whitehorse Suite granodiorite to quartz monzonite (mKqW).

5. Sampling quarry locations, once they are finalized. The number of samples should be based on the MEND (2009) and the MOT (2004) guidelines. This will ensure that the material to be used as fill will have a low ML / ARD risk

In the event that further testing determines that certain areas are potentially acid producing, there are several possible mitigation measures that may be employed to minimize the development of ML / ARD along the proposed road alignment. Ideally, material with high acid generating potential will be avoided during road construction, in favour of selecting an alignment and construction materials that have a low acid generating potential.

In cases where this is not possible, the two main options are (1) mixing potentially acid generating material with acid consuming material and (2) placing the material away from important aquatic ecosystems. The first option allows for neutral pH to be maintained in runoff, which will result in a lower concentration of metals and other geochemical parameters. The second option requires placing any potentially acid producing material in a location where the pathway rating is low (*e.g.* in an area where there is little or no connection between the stressor and the receptor), reducing the concentrations of ML / ARD products in the aquatic environment. Both of these options will minimize the impact on the aquatic ecosystem.

ML / ARD monitoring should continue during the construction phase for any areas which are determined to be potentially acid generating. This should include sampling and static testing of geotechnical drill core or blasted rock from these sections of road. Prior to receiving the testing results, any material which may have acid generating potential should be placed in a location away from streams, to minimize impact to aquatic ecosystems. The results of this secondary testing will determine how the material must ultimately be handled.

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Appendix I: Selected Photos of Rock, Colluvium and Alluvium Samples

western
COPPER AND GOLD

Appendix I: Selected Photos of Rock, Colluvium and Alluvium Samples

Nasina Unit (DMN)





Pelly Gneiss Suite (DMgPW)





Whitehorse Suite (mKw)






Mount Nansen Unit (mKN)




Carmacks Unit (uKC1)





Colluvium





Alluvium





Appendix II: Geochemical Results from Samples Collected Along the Proposed Road Alignment

APPENDIX IIA: ABA RESULTS

APPENDIX IIB: METALS BY AQUA REGIA WITH ICP-MS FINISH

western
COPPER AND GOLD

APPENDIX IIA: ABA RESULTS



Appendix II-A: ABA Results

Sample ID	Approx. Location (km)	Sample Type	Rock Code	Rinse* pH	Paste pH	TIC %	CaCO3 NP	C(T) %	S(T) %	S(SO4) %	S(S-2) %	Insoluble S %	AP	Modified NP	NPR NP/AP	Net NP	CaNP/AP	Fizz Test
Method Code				Sobek	Sobek	CSB02V	Calc	CSA01V	CSA06V	CSA07V	CSA08V	Calc	Calc	Modified		Sobek		Sobek
LOD				0.20	0.20	0.01	#N/A	0.01	0.01	0.01	0.01	#N/A	#N/A	0.50		Calc		#N/A
LX-C-54	82	orthogneiss	DMN	9.12	9.28	0.14	11.7	0.15	0.02	<0.01	0.02	<0.01	0.6	11.4	18.2	10.8	18.7	Slight
LX-C-55	89	metamorphic rock	DMN?	9.19	8.60	12	1000.0	12.2	<0.01	<0.01	<0.01	<0.01	<0.3	1020.1	3400.3	1020.1	3333.3	Strong
LX-C-8	115	gneiss	DMN	7.14	8.18	<0.01	<0.8	0.04	0.02	<0.01	<0.01	0.02	<0.3	3.3	11.0	3.3	2.7	None
LX-C-34	5	metamorphic diorite	DMgPW	9.11	9.44	0.07	5.8	0.07	<0.01	<0.01	<0.01	<0.01	<0.3	10.2	34.0	10.2	19.4	None
LX-C-43	6	foliated granodiorite	DMgPW	9.03	9.09	0.03	2.5	0.04	<0.01	<0.01	<0.01	<0.01	<0.3	6.4	21.3	6.4	8.3	None
LX-C-52	72	gneiss	DMgPW	9.19	9.12	0.22	18.3	0.26	0.01	<0.01	0.01	<0.01	0.3	17.2	55.0	16.9	58.7	None
LX-C-53	76	meta-igneous rock	DMgPW	6.24	7.79	0.01	0.8	0.05	0.12	<0.01	0.1	0.02	3.1	2.4	0.8	-0.7	0.3	None
LX-C-39	16	leucocratic granodiorite	mKW	9.21	9.59	0.11	9.2	0.11	<0.01	<0.01	<0.01	<0.01	<0.3	8.9	29.7	8.9	30.6	Slight
LX-C-24	27	granite/granodiorite	mKW	7.27	8.67	0.01	0.8	0.02	<0.01	<0.01	<0.01	<0.01	<0.3	3.9	13.0	3.9	2.8	None
LX-C-44	36	granite/granodiorite	mKW	6.97	7.45	<0.01	<0.8	0.03	<0.01	<0.01	<0.01	<0.01	<0.3	3.4	11.3	3.4	2.7	None
LX-C-45	39	leucocratic granitoid	mKW	6.59	7.64	<0.01	<0.8	0.01	<0.01	<0.01	<0.01	<0.01	<0.3	0.6	2.0	0.6	2.7	None
LX-C-20	40	granitic rock	mKW	8.77	9.36	<0.01	<0.8	<0.01	<0.01	<0.01	<0.01	<0.01	<0.3	1.5	5.0	1.5	2.7	None
LX-C-19	45	granodiorite	mKW	7.16	8.41	<0.01	<0.8	0.03	<0.01	<0.01	<0.01	<0.01	<0.3	3.9	13.0	3.9	2.7	None
LX-C-17	46	granodiorite	mKW	6.65	8.47	<0.01	<0.8	0.02	<0.01	<0.01	<0.01	<0.01	<0.3	2.8	9.3	2.8	2.7	None
LX-C-13	62	granodiorite	mKW	7.25	8.97	0.02	1.7	0.05	<0.01	<0.01	<0.01	<0.01	<0.3	5.4	18.0	5.4	5.6	None
LX-C-50	62	granodiorite	mKW	8.43	8.92	0.02	1.7	0.04	<0.01	<0.01	<0.01	<0.01	<0.3	4.5	15.0	4.5	5.6	None
LX-C-12	63	granodiorite	mKW	8.38	9.03	0.05	4.2	0.16	<0.01	<0.01	<0.01	<0.01	<0.3	6.6	22.0	6.6	13.9	None
LX-C-56	92	granodiorite	mKW	7.68	8.50	0.01	0.8	0.04	0.02	<0.01	0.01	0.02	0.3	6.4	20.5	6.1	2.7	None
LX-C-57	93	granodiorite	mKW	8.83	8.99	0.08	6.7	0.08	0.05	<0.01	0.05	<0.01	1.6	11.2	7.2	9.6	4.3	None
LX-C-9	97	granodiorite	mKW	6.05	8.07	<0.01	<0.8	0.06	<0.01	<0.01	<0.01	<0.01	<0.3	5.6	18.7	5.6	2.7	None
LX-C-1	103	granodiorite	mKW	7.20	8.20	<0.01	<0.8	0.05	<0.01	<0.01	<0.01	<0.01	<0.3	6.1	20.3	6.1	2.7	None
LX-C-2	104	granodiorite	mKW	7.25	8.77	<0.01	<0.8	0.03	0.02	<0.01	<0.01	0.02	<0.3	5.8	19.3	5.8	2.7	None
LX-C-4	106	diorite	mKW	6.50	8.15	<0.01	<0.8	0.31	0.03	<0.01	<0.01	0.03	<0.3	6.6	22.0	6.6	2.7	None
LX-C-58	110	granodiorite	mKW	6.57	7.73	<0.01	<0.8	0.06	<0.01	<0.01	<0.01	<0.01	<0.3	1.1	3.7	1.1	2.7	None
LX-C-59	111	granodiorite	mKW	8.58	9.13	0.05	4.2	0.09	<0.01	<0.01	<0.01	<0.01	<0.3	6.5	21.7	6.5	13.9	None
LX-C-6	112	diorite	mKW	8.16	8.84	0.05	4.2	0.14	0.02	<0.01	0.02	<0.01	0.6	8.8	14.1	8.2	6.7	None
LX-C-7	114	granodiorite	mKW	8.33	8.44	0.04	3.3	0.18	0.03	<0.01	0.02	0.01	0.6	8.0	12.8	7.4	5.3	None
LX-C-32	119	granodiorite	mKW	8.41	8.83	0.01	0.8	0.07	0.02	<0.01	<0.01	0.02	<0.3	6.1	20.3	6.1	2.8	None
LX-C-30	121	granodiorite	mKW	5.99	7.91	<0.01	<0.8	0.07	<0.01	<0.01	<0.01	<0.01	<0.3	6.0	20.0	6.0	2.7	None
LX-C-31	122	granodiorite	mKW	6.60	8.46	0.01	0.8	0.06	0.01	<0.01	<0.01	0.01	<0.3	5.8	19.3	5.8	2.8	None
LX-C-29	124	granodiorite	mKW	6.16	8.04	<0.01	<0.8	0.06	0.02	<0.01	<0.01	0.02	<0.3	6.4	21.3	6.4	2.7	None
LX-C-60	124	granodiorite	mKW	7.31	8.32	0.01	0.8	0.04	0.01	<0.01	<0.01	0.01	<0.3	5.1	17.0	5.1	2.8	None
LX-C-28	128	diorite/granodiorite	mKW	6.65	8.33	0.01	0.8	0.05	<0.01	<0.01	<0.01	<0.01	<0.3	9.1	30.3	9.1	2.8	None
LX-C-27	130	diorite	mKW	8.00	8.91	0.07	5.8	0.08	0.05	<0.01	0.03	0.02	0.9	17.1	18.2	16.2	6.2	None
LX-C-26	131	granodiorite	mKW	5.71	8.27	<0.01	<0.8	0.02	0.02	<0.01	<0.01	0.02	<0.3	5.6	18.7	5.6	2.7	None
LX-C-42	22	fine grained matrix, visible plagioclase	mKN	9.14	8.74	1.41	117.5	1.49	<0.01	<0.01	<0.01	<0.01	<0.3	72.6	242.0	72.6	391.7	Slight
LX-C-18	45	volcanic rock	uKC	8.61	8.84	0.17	14.2	0.18	0.05	<0.01	0.04	0.01	1.3	19.7	15.8	18.5	11.3	Slight
LX-C-47	50	vesicular basalt	uKC	8.71	8.70	<0.01	<0.8	0.01	<0.01	<0.01	<0.01	<0.01	<0.3	41.8	139.3	41.8	2.7	None
LX-C-14	52	volcanic rock	uKC	9.13	8.76	1.12	93.3	1.19	0.01	<0.01	<0.01	0.01	<0.3	96.3	321.0	96.3	311.1	Slight

Appendix II-A: ABA Results

Sample ID	Approx. Location (km)	Sample Type	Rock Code	Rinse* pH	Paste pH	TIC %	CaCO3 NP	C(T) %	S(T) %	S(SO4) %	S(S-2) %	Insoluble S %	AP	Modified NP	NPR NP/AP	Net NP	CaNP/AP	Fizz Test
			Underlying bedrock type															
LX-C-33	1	colluvium	mKgW	6.72	7.75	0.01	0.8	0.16	<0.01	<0.01	<0.01	<0.01	<0.3	8.1	27.0	8.1	2.8	None
LX-C-35	4	ash		6.89	7.72	<0.01	<0.8	0.1	0.02	<0.01	<0.01	0.02	<0.3	2.9	9.7	2.9	2.7	None
LX-C-36	4	colluvium	DMgPW	6.54	7.84	0.22	18.3	0.93	0.03	<0.01	0.02	-0.02	0.6	18.0	28.8	17.4	29.3	Slight
LX-C-37	10	soil	DMgPW	5.40	5.68	0.02	1.7	8.04	0.06	0.03	0.02	0.01	0.6	-4.6	-7.4	-5.2	2.7	None
LX-C-40	16	colluvium	mKqW	7.08	8.44	0.18	15.0	0.24	0.02	<0.01	<0.01	0.02	<0.3	15.4	51.3	15.4	50.0	Slight
LX-C-38	17	colluvium	mKqW	7.68	8.20	0.02	1.7	0.35	<0.01	<0.01	<0.01	<0.01	<0.3	4.9	16.3	4.9	5.6	None
LX-C-23	27	colluvium	mKqW	7.79	8.23	0.01	0.8	0.06	<0.01	<0.01	<0.01	<0.01	<0.3	3.5	11.7	3.5	2.8	None
LX-C-22	30	colluvium	mKgW	8.63	8.78	0.05	4.2	0.08	<0.01	<0.01	<0.01	<0.01	<0.3	5.6	18.7	5.6	13.9	None
LX-C-21	34	colluvium	mKgW	8.56	8.17	0.24	20.0	0.28	0.18	<0.01	0.15	0.03	4.7	21.9	4.7	17.2	4.3	Slight
LX-C-46	42	colluvium	DMN	5.09	5.62	<0.01	<0.8	1.4	0.01	<0.01	<0.01	0.01	<0.3	8.4	28.0	8.4	2.7	None
LX-C-16	48	sandy soil & rock fragments	mKqW	5.81	7.05	<0.01	<0.8	0.07	0.02	0.01	<0.01	0.01	<0.3	1.1	3.7	1.1	2.7	None
LX-C-48	58	colluvium	mKgW	6.37	7.28	<0.01	<0.8	0.19	<0.01	<0.01	<0.01	<0.01	<0.3	3.8	12.7	3.8	2.7	None
LX-C-51	68	colluvium	DMgPW	7.43	7.56	0.03	2.5	0.48	0.45	0.43	0.02	<0.01	0.6	6.0	9.6	5.4	4.0	None
LX-C-3	105	colluvium	mKdW	5.93	8.18	<0.01	<0.8	0.08	<0.01	<0.01	<0.01	<0.01	<0.3	5.8	19.3	5.8	2.7	None
LX-C-5	107	colluvium	mKdW	6.36	7.91	<0.01	<0.8	0.1	0.02	<0.01	<0.01	0.02	<0.3	1.8	6.0	1.8	2.7	None
LX-C-41	23	fluvial		6.54	6.57	0.01	0.8	0.82	0.02	<0.01	<0.01	0.02	<0.3	7.6	25.3	7.6	2.8	None
LX-C-25	27	fluvial		6.88	8.23	0.01	0.8	0.08	<0.01	<0.01	<0.01	<0.01	<0.3	11.3	37.7	11.3	2.8	None
LX-C-15	51	fluvial		7.03	8.14	0.01	0.8	0.29	<0.01	<0.01	<0.01	<0.01	<0.3	12.5	41.7	12.5	2.8	None
LX-C-49	58	fluvial		6.45	7.67	0.01	0.8	0.25	0.03	<0.01	0.03	<0.01	0.9	5.4	5.8	4.5	0.9	None
LX-C-11	68	fluvial		5.84	6.76	<0.01	<0.8	0.64	<0.01	<0.01	<0.01	<0.01	<0.3	4.2	14.0	4.2	2.7	None
LX-C-10	80	fluvial		8.40	8.86	0.16	13.3	0.27	<0.01	<0.01	<0.01	<0.01	<0.3	17.6	58.7	17.6	44.4	Slight
Duplicates																		
LX-C-1					8.36									5.2				None
LX-C-11										<0.01								
LX-C-13											<0.01							
LX-C-20					9.32									2.1				None
LX-C-21					8.07									21.9				Slight
LX-C-30								0.07	0.01									
LX-C-40					8.51	0.18								15.8				Slight
LX-C-41					6.62									8.1				None
LX-C-54										<0.01	0.02							
LX-C-56								0.04	0.02									
LX-C-60					8.34	0.01								6.3				None
QC																		
RTS-1									1.67									
SY-4						0.91		1.04										
RTS-3A											2.3							
PD-1										4.39								
NBM-!														43.0				Slight
NBM-!														43.9				Slight
Expected Value						0.95		1.00	1.66	4.27	2.34			42.0				Slight
Tolerance +/-						0.06		0.2	0.08	0.43	0.23			3.0				

Note:

AP = Acid potential in tonnes CaCO3 equivalent per 1000 tonnes of material. AP is determined from sulphide sulphur content.

NP = Neutralization potential in tonnes CaCO3 equivalent per 1000 tonnes of material. Acid addition based on TIC content.

NET NP = Modified NP - AP

Carbonate NP is calculated from TIC originating from carbonates and is expressed in kg CaCO3/tonne.

Sulphate Sulphur determined by 25% HCL with S by ICP Finish

Sulphide Sulphur determined by Sobek 1:7 Nitric Acid with Gravimetric Finish

Insoluble S is acid insoluble S (Total S - (Sulphate S + Sulphide S)).

Rinse pH on the -2 mm fraction.

APPENDIX IIB: METALS BY AQUA REGIA WITH ICP-MS FINISH



Appendix II-B: Metals by Aqua Regia with ICP-MS Finish

Sample ID	Approx. Location (km)	Sample Type	Rock Code	Ag	Al	As	Au	B	Ba	Bi	Ca	Cd	Co	Cr	Cu	Fe	Ga	Hg	K	La	Mg	Mn	Mo	Na	Ni	P	Pb	S	Sb	Sc	Se	Sr	Te	Th	Ti	Tl	V	W	Zn
				ppm	%	ppm	ppb	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	%	ppm	ppm	%	ppm	%	ppm	ppm	%	ppm	%	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm
Method Code				1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX
LOD				0.1	0.01	0.5	0.5	20	1	0.1	0.01	0.1	0.1	1	0.1	0.01	1	0.01	0.01	1	0.01	1	1	0.001	0.1	0.001	0.5	1	0.001	0.1	0.05	0.1	0.1	0.5	1	0.2	0.1	0.001	0.1	2	0.1	1
LX-C-54	82	orthogneiss	DMN	*0.1*	0.3	*0.5*	*0.5*	*20*	29	0.2	0.45	*0.1*	1.6	85	2.9	0.75	1	*0.01*	0.15	50	0.08	189	0.6	0.032	3.7	0.018	5.9	*0.05*	0.4	0.8	*0.5*	12	*0.2*	28.3	0.003	*0.1*	2	0.2	15
LX-C-55	89	metamorphic rock	DMN?	*0.1*	*0.01*	5.7	1.1	*20*	43	*0.1*	35.58	0.2	0.3	3	0.5	0.09	*1*	*0.01*	*0.01*	*1*	0.19	116	*0.1*	*0.001*	2.9	0.008	0.9	0.13	*0.1*	0.2	0.5	231	*0.2*	*0.1*	*0.001*	*0.1*	*2*	*0.1*	2
LX-C-8	115	gneiss	DMN	*0.1*	0.44	2.1	1.3	*20*	27	0.2	0.06	*0.1*	2.8	88	8.2	1.17	3	*0.01*	0.26	26	0.19	147	0.5	0.039	4.3	0.02	8	*0.05*	0.5	2	*0.5*	4	*0.2*	33.7	0.05	0.2	10	*0.1*	18
LX-C-34	5	metamorphic diorite	DMgPW	*0.1*	1.55	1.7	1.7	*20*	299	*0.1*	0.87	0.1	13.3	57	2.5	3.13	6	*0.01*	0.61	5	1.28	635	0.1	0.096	4.9	0.06	2.9	*0.05*	*0.1*	6.3	*0.5*	14	*0.2*	2	0.235	*0.1*	93	*0.1*	62
LX-C-43	6	foliated granodiorite	DMgPW	*0.1*	1.13	*0.5*	*0.5*	*20*	226	*0.1*	0.29	*0.1*	8.1	93	2	2.44	5	*0.01*	0.73	26	0.59	444	0.3	0.06	4.2	0.038	1.9	*0.05*	*0.1*	2.4	*0.5*	17	*0.2*	7.9	0.151	0.2	37	*0.1*	49
LX-C-52	72	gneiss	DMgPW	*0.1*	0.26	1.1	0.6	*20*	38	0.2	0.7	*0.1*	2.7	128	6.3	0.54	1	*0.01*	0.08	6	0.14	385	0.7	0.012	8.7	0.011	4.8	*0.05*	*0.1*	0.8	*0.5*	10	*0.2*	1.9	0.005	*0.1*	5	*0.1*	13
LX-C-53	76	meta-igneous rock	DMgPW	*0.1*	0.49	2.3	*0.5*	*20*	50	0.3	0.13	*0.1*	2.8	76	8.2	1.05	2	*0.01*	0.15	14	0.21	101	0.9	0.035	4.7	0.017	3.6	0.12	0.3	0.9	*0.5*	8	*0.2*	18.1	0.006	*0.1*	3	*0.1*	17
LX-C-39	16	leucocratic granodiorite	mKW	*0.1*	0.18	4.7	*0.5*	*20*	61	0.1	0.29	*0.1*	0.8	78	10.2	0.52	*1*	*0.01*	0.15	25	0.01	213	0.9	0.034	2.6	0.007	14.9	*0.05*	0.1	0.4	*0.5*	10	*0.2*	17.3	*0.001*	*0.1*	*2*	*0.1*	8
LX-C-24	27	granite/granodiorite	mKW	*0.1*	0.5	*0.5*	*0.5*	*20*	65	*0.1*	0.13	*0.1*	3.1	95	2.4	1.23	3	*0.01*	0.18	24	0.3	555	0.4	0.044	5.6	0.038	4	*0.05*	*0.1*	2.6	*0.5*	8	*0.2*	29.9	0.04	0.2	19	*0.1*	31
LX-C-44	36	granite/granodiorite	mKW	*0.1*	0.31	4.5	*0.5*	*20*	49	*0.1*	0.09	*0.1*	3.3	94	4.5	1.41	1	0.18	0.14	20	0.08	692	0.3	0.042	4.7	0.037	4.3	*0.05*	0.8	3.3	*0.5*	6	*0.2*	25.4	0.019	0.3	19	*0.1*	28
LX-C-45	39	leucocratic granitoid	mKW	*0.1*	0.17	5.1	*0.5*	*20*	24	0.1	0.02	*0.1*	2.4	79	3.3	0.22	*1*	0.08	0.07	2	*0.01*	118	5.6	0.025	2.8	0.003	15.1	*0.05*	1.1	1.3	*0.5*	17	*0.2*	17.5	0.002	0.1	*2*	0.1	5
LX-C-20	40	granitic rock	mKW	*0.1*	0.13	8.7	0.8	*20*	17	*0.1*	0.02	*0.1*	0.4	78	1.9	0.17	*1*	0.01	0.09	3	*0.01*	777	0.5	0.033	2.3	0.002	5.8	*0.05*	0.3	0.6	*0.5*	13	*0.2*	10	*0.001*	*0.1*	*2*	0.2	3
LX-C-19	45	granodiorite	mKW	*0.1*	0.63	*0.5*	0.9	*20*	84	*0.1*	0.14	*0.1*	4.4	89	6	1.62	3	*0.01*	0.37	18	0.44	568	0.3	0.052	5.1	0.03	2.4	*0.05*	*0.1*	4.4	*0.5*	8	*0.2*	14.6	0.09	0.3	33	*0.1*	37
LX-C-17	46	granodiorite	mKW	*0.1*	0.65	*0.5*	*0.5*	*20*	58	*0.1*	0.08	*0.1*	3.8	83	3.1	1.47	3	*0.01*	0.38	15	0.41	502	0.2	0.051	2.8	0.025	2.2	*0.05*	*0.1*	4.3	*0.5*	5	*0.2*	17.5	0.084	0.4	29	*0.1*	32
LX-C-13	62	granodiorite	mKW	*0.1*	0.64	*0.5*	0.8	*20*	98	*0.1*	0.15	*0.1*	5.2	77	1.9	1.68	4	*0.01*	0.34	17	0.44	617	0.5	0.055	3.1	0.033	2.2	*0.05*	*0.1*	4.8	*0.5*	6	*0.2*	14.9	0.065	0.2	34	*0.1*	41
LX-C-50	62	granodiorite	mKW	*0.1*	0.59	0.5	0.7	*20*	105	*0.1*	0.17	*0.1*	4.3	91	1.9	1.57	3	*0.01*	0.37	14	0.39	530	0.5	0.064	3.2	0.03	2.5	*0.05*	*0.1*	4.3	*0.5*	6	*0.2*	12.6	0.077	0.2	33	*0.1*	36
LX-C-12	63	granodiorite	mKW	*0.1*	0.59	*0.5*	1	*20*	126	*0.1*	0.27	*0.1*	4.8	72	2.5	1.58	3	*0.01*	0.26	24	0.38	661	0.4	0.042	3	0.033	4.1	*0.05*	0.2	4.1	*0.5*	10	*0.2*	18.4	0.037	0.1	26	*0.1*	37
LX-C-56	92	granodiorite	mKW	*0.1*	1.84	*0.5*	*0.5*	*20*	986	*0.1*	0.52	*0.1*	12.8	67	18.4	3.02	5	*0.01*	0.87	9	1.03	495	0.7	0.17	5.9	0.074	1.8	*0.05*	*0.1*	4.3	*0.5*	43	*0.2*	7.7	0.217	0.4	108	1.1	44
LX-C-57	93	granodiorite	mKW	*0.1*	1.51	*0.5*	*0.5*	*20*	618	*0.1*	0.77	*0.1*	11.1	74	21	2.66	5	*0.01*	0.59	13	0.94	450	0.7	0.141	5.4	0.078	1.8	0.06	*0.1*	4.2	*0.5*	38	*0.2*	11	0.168	0.3	85	0.2	39
LX-C-9	97	granodiorite	mKW	*0.1*	1.34	*0.5*	*0.5*	*20*	1562	*0.1*	0.38	*0.1*	8.4	76	7.5	2.37	4	*0.01*	0.73	6	0.72	396	0.3	0.116	4.2	0.056	1.8	*0.05*	*0.1*	1.9	*0.5*	26	*0.2*	5.9	0.227	0.3	66	0.1	38
LX-C-1	103	granodiorite	mKW	*0.1*	1.31	0.9	3.4	*20*	339	0.1	0.49	*0.1*	7.8	76	6.8	2.58	5	*0.01*	0.74	15	0.74	526	0.3	0.124	4	0.062	5.8	*0.05*	*0.1*	2.6	*0.5*	22	*0.2*	15.9	0.219	0.4	66	*0.1*	48
LX-C-2	104	granodiorite	mKW	*0.1*	1.1	*0.5*	2	*20*	272	*0.1*	0.38	*0.1*	6.1	85	3.1	2.12	4	*0.01*	0.57	15	0.59	385	0.3	0.117	4.4	0.041	3.9	*0.05*	*0.1*	2.4	*0.5*	24	*0.2*	8.9	0.178	0.3	52	*0.1*	36
LX-C-4	106	diorite	mKW	*0.1*	1.91	0.7	1.9	*20*	650	0.2	0.71	*0.1*	6.9	68	17.7	2.49	6	*0.01*	0.75	11	0.66	522	1	0.198	3.9	0.058	3.6	*0.05*	*0.1*	3.1	*0.5*	77	*0.2*	9.8	0.174	0.6	55	0.4	46
LX-C-58	110	granodiorite	mKW	*0.1*	0.27	*0.5*	*0.5*	*20*	33	*0.1*	0.02	*0.1*	0.4	106	1.7	0.73	2	0.02	0.15	11	0.03	105	0.5	0.037	3.1	0.004	5.5	*0.05*	0.4	1.3	*0.5*	2	*0.2*	16.3	0.004	0.1	*2*	0.2	14
LX-C-59	111	granodiorite	mKW	*0.1*	1.24	*0.5*	*0.5*	*20*	447	0.1	0.37	*0.1*	7.5	77	8.2	2.42	5	*0.01*	0.7	19	0.76	647	0.2	0.109	4.1	0.043	3.2	*0.05*	*0.1*	4.9	*0.5*	22	*0.2*	16.7	0.164	0.8	62	0.7	47
LX-C-6	112	diorite	mKW	*0.1*	1.51	*0.5*	*0.5*	*20*	767	*0.1*	0.72	*0.1*	6.8	73	17.5	2.43	5	*0.01*	0.57	17	0.67	460	1.3	0.163	4.8	0.069	4.6	*0.05*	*0.1*	2.8	*0.5*	68	*0.2*	12.4	0.171	0.3	55	0.4	42
LX-C-7	114	granodiorite	mKW	*0.1*	1.12	*0.5*	*0.5*	*20*	362	*0.1*	0.42	0.1	6.8	78	3.2	2.3	5	*0.01*	0.58	21	0.71	453	0.3	0.1	3.9	0.043	4.5	*0.05*	0.1	2.8	*0.5*	21	*0.2*	27.6	0.191	0.4	61	*0.1*	43
LX-C-32	119	granodiorite	mKW	*0.1*	1.44	*0.5*	1.3	*20*	362	*0.1*	0.67	0.1	10	78	16.9	2.39	5	*0.01*	0.37	15	0.87	442	0.4	0.095	5	0.058	4.6	*0.05*	0.5	2.6	*0.5*	31	*0.2*	10.2	0.187	0.2	65	0.3	41
LX-C-30	121	granodiorite	mKW	*0.1*	1.67	*0.5*	0.8	*20*	1010	*0.1*	0.56	*0.1*	10.6	74	11.7	2.78	5	*0.01*	0.68	9	0.93	389	0.2	0.141	5	0.072	3	*0.05*	*0.1*	3.1	*0.5*	57	*0.2*	6	0.239	0.3	84	*0.1*	42
LX-C-31	122	granodiorite	mKW	*0.1*	1.41	*0.5*	1.6	*20*	419	*0.1*	0.58	*0.1*	10	70	17.2	2.37	5	*0.01*	0.46	13	0.8	357	1.3	0.139	5.4	0.058	3	*0.05*	*0.1*	2.7	*0.5*	37	*0.2*	12.7	0.175	0.3	73	*0.1*	37
LX-C-29	124	granodiorite	mKW	*0.1*	2.48	*0.5*	*0.5*	*20*	1643	*0.1*	1.1	*0.1*	8.2	63	13.9	2.46	6	*0.01*	0.64	10	0.69	254	0.2	0.29	3.4	0.078	2	*0.05*	*0.1*	3.9	*0.5*	108	*0.2*	4.9	0.234	0.3	58	*0.1*	33
LX-C-60	124	granodiorite	mKW	*0.1*	2.5	*0.5*	*0.5*	*20*	900	*0.1*	1.35	*0.1*	5.8	66	11.1	1.73	6	*0.01*	0.31	15	0.51	178	0.2	0.356	3.5	0.048	2.3	*0.05*	*0.1*	3.3	*0.5*	141	*0.2*	8.8	0.163	0.2	35	0.3	26
LX-C-28	128	diorite/granodiorite	mKW	*0.1*	3.12	*0.5*	*0.5*	*20*	641	*0.1*	1.42	*0.1*	13.7	48	7.2	2.41	6	*0.01*	0.89	6	1.36	349	0.2	0.193	9.2	0.07	2.2	*0.05*	*0.1*	2.6	*0.5*	108	*0.2*	7.7	0.236	0.4	81	*0.1*	32
LX-C-27	130	diorite	mKW	0.1	4.33	0.8	1.2	*20*	511	*0.1*	2.57	*0.1*	16.8	41	32.2	3.81	9	0.01	0.3	8	1.26	353	0.7	0.326	8.9	0.156	3.9	*0.05*	*0.1*	2.4	*0.5*	240	*0.2*	2.6	0.167	*0.1*	124	*0.1*	38
LX-C-26	131	granodiorite	mKW	*0.1*	1.52	2	0.7	*20*	384	0.1	0.59	*0.1*	10.5	71	18.5	2.61	5	*0.01*	0.51	13	0.89	407	0.7	0.134	5	0.064	5.1	*0.05*	0.3	2.9	*0.5*	36	*0.2*	10.4	0.22	0.3	82	0.2	51
LX-C-42	22	fine grained matrix, visible plagioclase	mKN	*0.1*	0.89	2.1	0.7	*20*	115	*0.1*	2.35	*0.1*	11.4	42	21.5	3.35	2	*0.01*	0.15	20	1.2	815	0.8	0.074	15.5	0.228	2.8	*0.05*	*0.1*	6.8	*0.5*	164	*0.2*	3.2	0.014	*0.1*	81	*0.1*	64
LX-C-18	45	volcanic rock	uKC	*0.1*	1.38	3.3	0.6	*20*	399	0.1	1.16	0.1	10.3	63	14.6	3.02	7	*0.01*	0.08	13	0.95	966	1.3	0.09	14.2	0.142	6.2	0.07	0.1	3.8	*0.5*	72	*0.2*	3.2	0.085	*0.1*	55	0.1	42
LX-C-47	50	vesicular basalt	uKC	*0.1*	0.96	*0.5*	1.8	*20*	54	*0.1*	0.89	*0.1*	14.3	55	19.6	2.74	3	*0.01*	0.09	22	1.47	379	1	0.127	49.7	0.186	4.2	*0.05*	*0.1*	1.7	*0.5*	101	*0.2*	4.2	0.098	*0.1*	81	*0.1*	62
LX-C-14	52	volcanic rock	uKC	*0.1*	1.16	1.3	1.5	*20*	61	*0.1*	3.12	*0.1*	19.2	107	36.2	3.53	4	*0.01*	0.08	21	1.71	808	0.6	0.13	61.3	0.18	2.6	*0.05*	*0.1*	7.5	*0.5*	212	*0.2*	3.1	0.034	*0.1*	88	*0.1*	65
Surficial material sample			**Underlying bedrock type**																																				
LX-C-33	1	colluvium	mKgW	0.2	1.13	13.5	5.3	*20*	122	0.7	0.4	0.3	10.1	77	37.9	2.68	6	*0.01*	0.21	21	0.7	460	0.8	0.041	9.3	0.083	21.8	*0.05*	0.3	4.6	*0.5*	22	*0.2*	18.8	0.095	0.2	63	0.6	55
LX-C-35	4	ash		*0.1*	0.24	*0.5*	1.8	*20*	28	*0.1*	0.2	*0.1*	1.7	21	3.7	0.54	1	*0.01*	0.07	1	0.07	42	*0.1*	0.125	1.5	0.032	0.3	*0.05*	*0.1*	*0.1*	*0.5*	29	*0.2*	0.2	0.035	*0.1*	19	*0.1*	8
LX-C-36	4	colluvium	DMgPW	0.2	0.59	125.7	11.1	*20*	121	0.5	0.74	1.1	7	71	23	2.36	2	0.01	0.15	13	0.36	303	1	0.014	8.6	0.055	27.5	*0.05*	2.4	2.2	*0.5*	22	*0.2*	6.8	0.006	0.1	23	0.3	128
LX-C-37	10	soil	DMgPW	0.1	0.84	23.2	7.9	*20*	186	0.9	0.7	0.1	7.5	53	57.7	2	3	0.03	0.11	13	0.35	293	1.8	0.028	12.6	0.066	5.4	0.05	0.7	2.8	*0.5*	43	*0.2*	2.9	0.052	0.2	40	0.7	31
LX-C-40	16	colluvium	mKqW	0.3	0.54	6.8	1.4	*20*	320	0.4	0.66	0.2	5.3	73	10.2	1.5	2	*0.01*	0.19	35	0.18	651	2.3	0.015	11.3	0.03	21.4	*0.05*	0.3	1.5	*0.5*	28	*0.2*	15.6	0.004	0.1	10	*0.1*	42
LX-C-38	17	colluvium	mKqW	*0.1*	0.83	7.9	1.9	*20*	169	0.2	0.31	0.1	7.4	93	13.8	2.03	3	*0.01*	0.15	16	0.38	634	1.5	0.048	17.2	0.042	8.4	*0.05*	0.3	3.1	*0.5*	26	*0.2*	11.7	0.046	*0.1*	40	0.4	34
LX-C-23	27	colluvium	mKgW	*0.1*	0.53	2.6	1.1	*20*	62	*0.1*	0.15	*0.1*	3.6	97	6.3	1.21	3	*0.01*	0.11	25	0.3	427	0.3	0.032	6.5	0.035	6.1	*0.05*	0.2	2	*0.5*	8	*0.2*	27.2	0.007	*0.1*	14	0.7	30
LX-C-22	30	colluvium	mKgW	*0.1*	0.29	1.3	0.8	*20*	118	*0.1*	0.25	*0.1*	2.5	84	2.1	0.96	1	*0.01*	0.12	23	0.08	621	0.3	0.029	4.8	0.03	10.1	*0.05*	*0.1*	1.9	*0.5*	9	*0.2*	26.2	0.002	*0.1*	8	0.2	23
LX-C-21	34	colluvium	mKgW	*0.1*	0.85	20.8	*0.5*	*20*	52	*0.1*	1.01	0.1	8	52	12.3	1.86	3	*0.01*	0.09	15	0.48	314	0.9	0.023	7.6	0.065	12.1	0.19	0.4	1.8	*0.5*	38	*0.2*	2.9	*0.001*	*0.1*	14	*0.1*	58
LX-C-46	42	colluvium	DMN	*0.1*	1.53	3.2	2.2	*20*	106	*0.1*	0.49	*0.1*	22.8	86	32.3	3.27	4	*0.01*	0.06	12	2.02	470	0.5	0.053	147.6	0.11	4	*0.05*	*0.1*	2.6	*0.5*	50	*0.2*	1.2	0.051	*0.1*	72	*0.1*	43
LX-C-16	48	sandy soil & rock fragments	mKqW	*0.1*	0.4	178.7	0.8	*20*	57	*0.1*	0.11	*0.1*	3.6	83	3.9	1.09	1	0.12	0.11	16	0.12	431	0.3	0.013	5.3	0.028	10.3	*0.05*	5.7	2	*0.5*	10	*0.2*	20	0.008	0.2	11	0.3	23
LX-C-48	58	colluvium	mKgW	0.2	0.85	15.3	2.4	*20*	132	0.2	0.35	0.7	5.8	63	13.9	1.69	4	0.01	0.1	11	0.31	434	0.9	0.068	9.9	0.061	22.1	*0.05*	0.3	1.9	*0.5*	35	*0.2*	4.5	0.041	*0.1*	30	*0.1*	74
LX-C-51	68	colluvium	DMgPW	0.6	0.87	21.6	60.8	*20*	104	2.7	0.71	0.3	12.5	97	151.8	2.6	3	*0.01*	0.32	29	0.9	222	1.1	0.037	88.7	0.022	14	0.45	1.9	1.9	*0.5*	17	0.3	15.4	0.042	0.2	17	2.5	35
LX-C-3	105	colluvium	mKdW	*0.1*	1.07	1.3	1.7	*20*	268	0.4	0.53	*0.1*	6.5	69	5.8	2.24	4	*0.01*	0.23	19	0.5	436	0.4	0.096	6.7	0.085	16.7	*0.05*	0.2	1.8	*0.5*	45	*0.2*	12.4	0.112	0.3	41	0.8	43
LX-C-5	107	colluvium	mKdW	*0.1*	0.42	4	2	*20*	125	*0.1*	0.08	*0.1*	2.3	93	6.3	1.17	2	*0.01*	0.13	19	0.09	312	0.5	0.029	5.1	0.009	5.5	*0.05*	0.8	1.4	*0.5*	8	*0.2*	15.9	0.017	0.1	7	0.1	18
LX-C-41	23	fluvial		0.1	0.75	13.4	3	*20*	116	0.3	0.46	0.3	8.6	82	15.3	2.33	3	0.02	0.09	9	0.47	407	0.9	0.053	23.2	0.081	13.5	*0.05*	0.7	2.1	*0.5*	49	*0.2*	3.5	0.057	*0.1*	63	0.3	56
LX-C-25	27	fluvial		*0.1*	1.15	9.2	1	*20*	118	0.4	0.72	0.2	10.9	91	37.5	2.53	5	*0.01*	0.18	12	0.94	496	1	0.086	37.7	0.144	10.8	*0.05*	0.7	2.6	*0.5*	61	*0.2*	5.8	0.099	*0.1*	65	0.2	62
LX-C-15	51	fluvial		*0.1*	1.06	10.6	1.8	*20*	80	0.5	0.57	0.2	13.8	84	34.7	2.89	5	*0.01*	0.11	17	1.15	646	1	0.041	48.7	0.16	14.2	*0.05*	0.5	2.3	*0.5*	46	*0.2*	7	0.103	*0.1*	74	0.4	66
LX-C-49	58	fluvial		0.2	0.75	14.7	*0.5*	*20*	121	0.5	0.31	0.4	6.3	81	23.9	1.75	3	*0.01*	0.15	14	0.42	479	2	0.039	12.9	0.071	21.9	*0.05*	0.5	1.8	*0.5*	23	*0.2*	9.1	0.054	0.1	38	0.3	69
LX-C-11	68	fluvial		0.1	0.83	16.8	1.4	*20*	131	0.4	0.3	0.3	7.6	83	16.7	2.01	3	*0.01*	0.12	15	0.46	497	1.7	0.032	18.6	0.065	20.5	*0.05*	0.5	2	*0.5*	32	*0.2*	8.3	0.048	*0.1*	41	0.4	65
LX-C-10	80	fluvial		*0.1*	1.16	6.2	*0.5*	*20*	134	0.8	1	*0.1*	11.4	88	19.4	2.27	4	*0.01*	0.08	8	0.88	436	0.7	0.035	19.4	0.074	6.7	*0.05*	0.2	2.7	*0.5*	47	*0.2*	4.5	0.104	*0.1*	51	0.1	46
Cont. Crust Abundance				0.075	8.23	1.8	4	-	425	0.0085	4.15	0.15	25	102	60	5.6	19	0.085	2.09	39	2.3	950	1.2	2.36	84	0.105	14	0.035	0.2	22	0.05	370	-	9.6	0.565	0.85	120	1.25	70
3xs				0.225	24.69	5.4	12	-	1275	0.0255	12.45	0.45	75	306	180	16.8	57	0.255	6.255	117	6.9	2850	3.6	7.065	252	0.315	42	0.105	0.6	66	0.15	1110	-	28.8	1.695	2.55	360	3.75	210
10xs				0.75	82.3	18	40	-	4250	0.085	41.5	1.5	250	1020	600	56	190	0.85	20.85	390	23	9500	12	23.55	840	1.05	140	0.35	2	220	0.5	3700	-	96	5.65	8.5	1200	12.5	700
100xs				7.5	823	180	400	-	42500	0.85	415	15	2500	10200	6000	560	1900	8.5	208.5	3900	230	95000	120	235.5	8400	10.5	1400	3.5	20	2200	5	37000	-	960	56.5	85	12000	125	7000
Duplicates																																							
LX-C-16				*0.1*	0.41	183	0.7	*20*	55	*0.1*	0.13	*0.1*	3.7	83	4.2	1.13	2	0.14	0.12	15	0.12	445	0.3	0.014	6	0.03	9.8	*0.05*	5.6	2.4	*0.5*	11	*0.2*	19.9	0.008	0.2	11	0.3	23
LX-C-50				*0.1*	0.59	0.6	1.2	96	109	*0.1*	0.16	*0.1*	4.2	89	1.6	1.54	3	*0.01*	0.38	14	0.39	486	0.3	0.063	3.1	0.029	2.6	*0.05*	*0.1*	4.3	*0.5*	7	*0.2*	12.9	0.078	0.2	33	*0.1*	36
QC																																							
DS8				1.8	0.92	26.4	91	*20*	303	6.1	0.71	2.4	7.9	111	119.1	2.47	5	0.22	0.4	14	0.64	604	13.9	0.087	40.7	0.091	114.6	0.17	4.3	2.1	5.7	61	5.3	6.5	0.105	5.5	42	2.8	328
DS8				1.6	0.88	23.5	88.2	*20*	273	5.9	0.7	2.2	7.5	119	111.4	2.38	5	0.17	0.37	14	0.58	590	14.4	0.086	39.3	0.074	118.2	0.16	3.7	2	4.9	63	5.1	6.1	0.115	5	41	2.5	297
DS8	

Appendix III: Expanded Stressor Term

western
COPPER AND GOLD

Appendix III: Expanded Stressor Term

Chainage		Stressors													Stressor
						Rock				Soil					
From	To	Rock Code	Rock Type rating	Colluvium (c), alluvium (a) or bedrock (r)	Overall Geology Rating	Cut (bm^3)	Cut (em^3)	Fill (em^3)	Net (cut-fill, em^3)	Cut (bm^3)	Cut (em^3)	Fill (em^3)	Net (cut-fill, em^3)	Total cut (Soil or Rock) (em^3)	Cut Rating	**Rating**
Bow Creek															
0-316	0-150	mKgW	3	a/c	2	0	0	0	0	769	807	916	-109	807	2	**4**
0-150	0+260	mKgW	3	a/c	2	0	0	0	0	2,344	2,461	6,697	-4,236	2,461	2	**4**
0+260	0+410	mKgW	3	a/c	2	0	0	0	0	806	846	607	239	846	2	**4**
Seymour Creek															
0+410	1+250	mKgW	3	a/c	2	0	0	0	0	12,094	12,699	10,530	2,169	12,699	3	**6**
1+250	1+290	mKqW	4	a/c	3	0	0	0	0	0	0	1,719	-1,719	0	0	**0**
1+290	5+960	DMgPW	3	a/c	2	0	0	0	0	47,650	50,032	82,666	-32,634	50,032	3	**6**
Big Creek (main stem)															
5+960	11+860	DMgPW	3	a/c	2	0	0	0	0	16,846	17,689	75,351	-57,662	17,689	3	**6**
11+860	12+280	mKqW	4	a	1	0	0	0	0	32	33	1,788	-1,755	33	1	**1**
12+280	12+520	mKqW	4	a	1	0	0	0	0	0	0	2,870	-2,870	0	0	**0**
12+520	13+420	mKqW	4	a	1	0	0	0	0	346	363	11,190	-10,827	363	1	**1**
13+420	18+400	mKqW	4	a/c/r	4	0	0	14,388	-14,388	40,058	42,061	93,661	-51,599	42,061	3	**12**
18+400	18+570	mKqW	4	a/c	3	0	0	0	0	0	0	4,317	-4,317	0	0	**0**
18+570	19+180	mKN	2	a	1	0	0	1,443	-1,443	153	161	11,538	-11,377	161	1	**1**
19+180	20+010	EJyL	2	a/c	1	0	0	11,090	-11,090	2,232	2,344	4,010	-1,666	2,344	2	**2**
20+010	22+600	mKN	2	a/c	1	0	0	8,545	-8,545	21,035	22,086	43,405	-21,318	22,086	3	**3**
22+600	23+890	mKqW	4	a/c	3	0	0	23,264	-23,264	266	279	3,740	-3,461	279	1	**3**
23+890	26+780	mKN	2	a/c	1	0	0	25,613	-25,613	11,183	11,742	27,388	-15,647	11,742	3	**3**
26+780	26+840	mKN	2	c	1	0	0	0	0	0	0	1,002	-1,002	0	0	**0**
26+840	26+880	mKqW	4	a/c	3	0	0	0	0	0	0	474	-474	0	0	**0**
26+880	27+500	mKqW	4	a/c	3	0	0	0	0	9,875	10,368	4,836	5,533	10,368	3	**9**
27+500	33+250	mKgW	3	a/c	2	0	0	62,948	-62,948	24,055	25,257	62,360	-37,103	25,257	3	**6**
Big Creek headwaters															
33+250	34+240	mKgW	3	a/c	2	0	0	20,070	-20,070	8,013	8,414	7,295	1,119	8,414	3	**6**
34+240	34+640	DMN	4	c	3	0	0	4,660	-4,660	223	234	453	-219	234	1	**3**
34+640	37+280	mKgW	3	c	2	0	0	19,327	-19,327	5,805	6,095	14,433	-8,338	6,095	2	**4**
37+280	37+360	uKC1	2	c	1	0	0	0	0	0	0	1,112	-1,112	0	0	**0**
37+360	40+100	mKgW	3	a/c	2	0	0	32,565	-32,565	7,063	7,416	32,745	-25,329	7,416	2	**4**
40+100	40+300	uKC1	2	c	1	0	0	4,000	-4,000	0	0	0	0	0	0	**0**
40+300	42+820	DMN	4	c	3	0	0	42,963	-42,963	838	880	9,003	-8,124	880	2	**6**
Hayes Creek headwaters															
42+820	43+750	DMN	4	c	3	0	0	3,591	-3,591	0	0	14,409	-14,409	0	0	**0**
43+750	49+240	mKqW	4	a/c	3	0	0	0	0	35,009	36,759	83,766	-47,007	36,759	3	**9**
49+240	51+200	uKC1	2	a/c	1	0	0	0	0	6,317	6,633	49,263	-42,630	6,633	2	**2**
51+200	53+280	uKC1	2	a/c	1	0	0	0	0	19,541	20,518	29,521	-9,002	20,518	3	**3**
53+280	53+900	mKgW	3	a/c	2	0	0	7,497	-7,497	1,711	1,796	4,315	-2,519	1,796	2	**4**
53+900	56+570	uKC1	2	a/c	1	0	0	3,056	-3,056	26,237	27,549	29,443	-1,894	27,549	3	**3**
56+570	56+920	uKC1	2	c	1	0	0	2,890	-2,890	0	0	4,784	-4,784	0	0	**0**
56+920	57+340	LKfP	3	a/c	2	0	0	9,367	-9,367	0	0	0	0	0	0	**0**
57+340	57+480	mKgW	3	a	1	0	0	2,834	-2,834	0	0	0	0	0	0	**0**
Hayes Creek (valley bottom)															
57+480	62+260	mKgW	3	a/c	2	0	0	28,196	-28,196	17,421	18,292	52,524	-34,232	18,292	3	**6**
62+260	62+650	mKgW	3	a	1	0	0	0	0	1,936	2,033	9,311	-7,278	2,033	2	**2**
62+650	64+000	mKgW	3	a/c	2	0	0	0	0	18,848	19,790	18,419	1,371	19,790	3	**6**
64+000	64+300	mKqW	4	a/c	3	0	0	0	0	6,295	6,610	5,248	1,361	6,610	2	**6**
64+300	64+740	mKgW	3	a/c	2	0	0	2,136	-2,136	0	0	9,821	-9,821	0	0	**0**
64+740	64+930	mKgw	3	a/c	2	0	0	0	0	0	0	4,544	-4,544	0	0	**0**
64+930	65+100	DMgPW	3	a/c	2	0	0	0	0	0	0	3,678	-3,678	0	0	**0**
65+100	65+260	mKqW	4	a/c	3	0	0	0	0	0	0	3,895	-3,895	0	0	**0**
65+260	66+210	DMgPW	3	a/c	2	0	0	4,940	-4,940	57	60	14,590	-14,530	60	1	**2**
66+210	66+320	DMgPW	3	a	1	0	0	0	0	0	0	4,308	-4,308	0	0	**0**
66+320	67+780	DMgPW	3	a	1	0	0	0	0	0	0	42,002	-42,002	0	0	**0**
67+780	68+500	DMgPW	3	a	1	0	0	0	0	86	91	16,832	-16,741	91	1	**1**
68+500	69+380	DMgPW	3	a	1	0	0	0	0	929	976	16,165	-15,190	976	2	**2**
69+380	78+420	DMgPW	3	a/c	2	0	0	33,440	-33,440	62,587	65,716	184,188	-118,473	65,716	3	**6**
78+420	79+010	DMN	4	a/c	3	0	0	0	0	7,641	8,023	14,583	-6,561	8,023	3	**9**
79+010	79+400	DMN	4	a	1	0	0	1,698	-1,698	0	0	7,529	-7,529	0	0	**0**
79+400	81+740	DMN	4	a/c	3	0	0	60,946	-60,946	0	0	3,497	-3,497	0	0	**0**
81+740	84+750	mKgW	3	a/c	2	0	0	20,149	-20,149	16,765	17,603	37,884	-20,282	17,603	3	**6**
84+750	86+120	mKgW	3	a/c	2	0	0	19,589	-19,589	1,336	1,403	6,208	-4,805	1,403	2	**4**

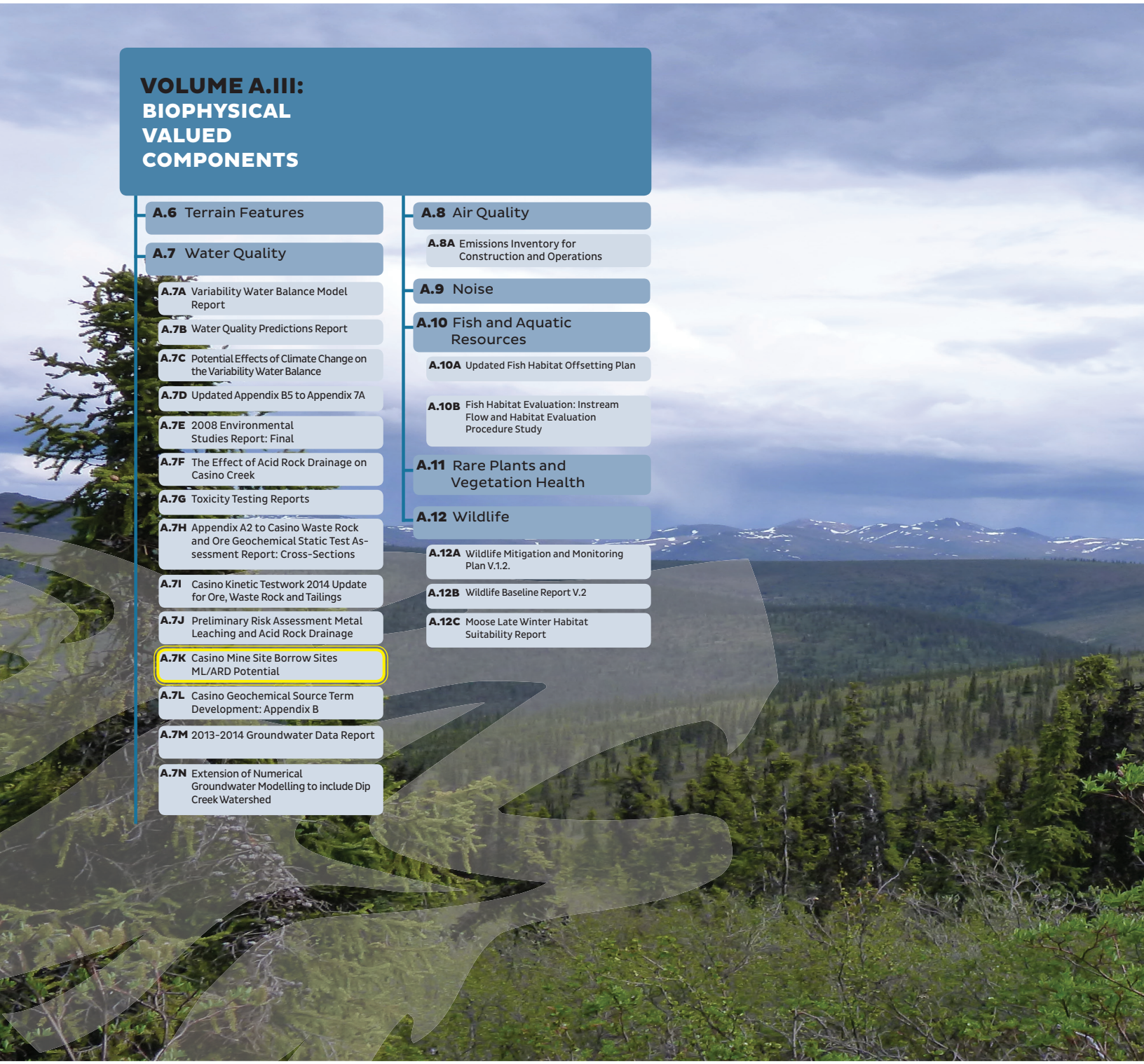
Appendix III: Expanded Stressor Term

Chainage		Stressors														Stressor
						Rock				Soil				Total cut (Soil or Rock) (em^3)	Cut Rating	
From	To	Rock Code	Rock Type rating	Colluvium (c), alluvium (a) or bedrock (r)	Overall Geology Rating	Cut (bm^3)	Cut (em^3)	Fill (em^3)	Net (cut-fill, em^3)	Cut (bm^3)	Cut (em^3)	Fill (em^3)	Net (cut-fill, em^3)			**Rating**
Rock Cut																
Hayes Creek (rock cut area)																
86+120	86+500	mKgW	3	r	3	1,973	2,663	3,533	-870	0	0	0	0	2,663	2	**6**
86+500	87+750	mKgW	3	r	3	34,192	46,159	10,193	35,966	0	0	0	0	46,159	3	**9**
87+750	87+900	mKdW	2	r	2	8,215	11,090	0	11,090	0	0	0	0	11,090	3	**6**
87+900	88+040	mKgW	3	r	3	3,252	4,390	224	4,166	0	0	0	0	4,390	2	**6**
88+040	88+280	mKdW	2	r	2	10,086	13,616	1,606	12,010	0	0	0	0	13,616	3	**6**
88+280	88+720	mKgW	3	r	3	5,507	7,435	6,312	1,123	0	0	0	0	7,435	3	**9**
88+720	95+460	mKdW	2	r	2	266,748	360,110	57,701	302,409	0	0	0	0	360,110	4	**8**
95+460	95+650	mKgW	3	r	3	15,637	21,110	151	20,959	0	0	0	0	21,110	3	**9**
Mascot Creek																
95+650	98+300	mKgW	3	r	3	17,329	23,394	23,803	-410	0	0	0	0	23,394	3	**9**
98+300	106+670	mKdW	2	r	2	25,792	34,819	121,949	-87,130	0	0	0	0	34,819	3	**6**
Idaho/Isaac/Sunshine Creek																
106+670	108+030	mKdW	2	r	2	12,354	16,677	22,113	-5,436	0	0	0	0	16,677	3	**6**
108+030	108+410	mKgW	3	r	3	9,004	12,156	3,221	8,935	0	0	0	0	12,156	3	**9**
108+410	108+490	LKqP	3	r	3	677	914	669	245	0	0	0	0	914	2	**6**
108+490	108+540	LKfP	3	r	3	53	72	957	-886	0	0	0	0	72	1	**3**
108+540	109+380	LKqP	3	r	3	38,393	51,831	931	50,900	0	0	0	0	51,831	4	**12**
109+380	112+460	mKgW	3	r	3	30,654	41,383	42,633	-1,250	0	0	0	0	41,383	3	**9**
112+460	115+640	DMN	4	r	4	27,731	37,436	29,613	7,823	0	0	0	0	37,436	3	**12**
115+640	124+430	mKgW	3	r	3	64,365	86,893	87,916	-1,023	0	0	0	0	86,893	4	**12**
Casino Creek																
124+430	126+060	mKdW	2	r	2	2,495	3,369	24,500	-21,131	0	0	0	0	3,369	2	**4**
126+060	126+920	mKdW	2	r	2	0	0	13,157	-13,157	0	0	0	0	0	0	**0**
126+920	127+660	mKgW	3	r	3	13	18	10,781	-10,763	0	0	0	0	18	1	**3**
127+660	129+300	mKdW	2	r	2	11,535	15,573	18,532	-2,959	0	0	0	0	15,573	3	**6**
129+300	129+840	mKgW	3	r	3	197	266	5,987	-5,721	0	0	0	0	266	1	**3**
129+840	132+410	mKdW	2	r	2	7,855	10,605	34,000	-23,396	0	0	0	0	10,605	3	**6**
132+410	132+610	LKfP	3	r	3	2,092	2,824	274	2,550	0	0	0	0	2,824	2	**6**
	average					7,360	9,936	12,246		5,363	5,631	14,652		15,567		
	median					0	0	2,834		0	0	3,895		2,663		
	median (ignore 0)					9,545	12,886	10,781		6,317	6,633	9,311		8,414		
	min					0	0	0		0	0	0		0		
	min (ignore 0)					13	18	151		32	33	453		18		
	max					266,748	360,110	121,949		62,587	65,716	184,188		360,110		
	Total					596,149	804,801	991,960		434,398	456,118	1,186,832		1,260,920		

Rock Codes

DMN	Nasina - quartzite and quartz-mica schist
DMgPW	Pelly Gneiss suite - schist and gneiss
EJyL	Long Lake suite - syenitic granitc rocks
mKdW	Whitehorse suite - diorite
mKgW	Whitehorse suite - granodiorite
mKqW	Whitehorse suite - granodiorite to quartz monzonite
mKN	Mount Nansen - volcanic flows and subvolcanic intrusions
uKC1	Carmacks - volcanic sequence
LKP	Prospector Mountain suite - quartz-rich monzonite stock (LKqP) with latite dykes (LKfP)

APPENDIX A.7K: Casino Mine Site Borrow Sites ML/ARD Potential



MEMORANDUM

To:	**Casino Copper Corp.**	**Date: July 22, 2014**
From:	**Jennifer Owen, Bruce Mattson**	**Project #: J862-6**
Subject:	**Casino Mine Site Borrow Sites ML/ARD Potential**	

1. Introduction

A review of the available geochemical results for borrow material samples was completed to characterize the Metal Leaching and Acid Rock Drainage (ML/ARD) potential of the borrow material in the Casino Mine area. The relevant borrow material data included acid-base accounting (ABA) results and Metals by Aqua Regia Digestion results for 49 samples. Additionally, shake flask extraction (SFE) tests were completed on the 7 borrow material samples from the Open Pit area. A brief description of the test pit samples and a discussion of the geochemical results for these samples are provided below.

The results indicate that the borrow material from the majority of locations has a very low ML/ARD potential as the majority of samples have total sulphur values < 0.1% and little or no sulphide-sulphur mineralization. However, there is very little carbonate content and portions of the borrow material from the areas underlying the low grade stockpiles, the heap leach facility and the main power plant, may initially have mildly acidic paste pH values (PpH < 5). Organic acidity rather than sulphide acidity appears to be responsible for the depressed pH from these samples as demonstrated by the organic carbon content. These materials will not be a source of ARD.

There is moderate ML/ARD potential for the borrow material from the Open Pit area as some samples had total sulphur values greater than 0.1% and all samples show a lack of carbonate content available to provide neutralization potential. Although sulphide mineralization is lacking in the Open Pit borrow material samples, mildly acidic runoff could be generated from the dissolution of jarosite, similar to what has been documented in CAP waste rock, as some of the samples had mildly acidic paste pH values (PpH < 5). Shake flask extraction results indicate that Cu leaching may occur from borrow material from the Open Pit area.

2. Description of the Samples

The test pit samples are from the following areas at the Casino Property (Figure 1):

- The Open Pit,
- The Low Grade Ore Stockpiles,
- The Gold Ore Stockpile,
- The Heap Leach Facility,

- The Main Power Plant site,
- The Tailings Management Facility (TMF),
- The airstrip borrow area, and
- The barge landing access road borrow areas.

The results and conclusions presented in this memo are associated with borrow materials found above the bedrock layer. The samples were generally collected from test pits at depths ranging from 0.3 m to 4 m below surface, although 3 of the 7 samples collected from the open pit area were collected from between 7.5 m and 20 m below surface (Appendix A). The greater depth of the overburden at the Casino site is due to a lack of glaciation in the area.

The test pit samples generally range from silt to gravel and generally contain a trace of clay. In addition to the test pit samples, weathered granodiorite samples were collected near the TMF, the main power plant site, and the airstrip borrow area and one sample of blasted rock was collected at one of the barge landing access road borrow areas.

608,000 612,000 616,000

6,968,000 6,964,000 6,960,000 6,956,000 6,952,000 6,948,000

TP13-01

N

TP13-84

39-1
TP12-PIT-04
TP12-PIT-06
38-3
38-4
TP12-PIT-01
Open Pit
TP12-PIT-05
Marginal Grade Stockpile
Gold Ore Stockpile
TP11-04
TP13-48
Low Grade Stockpile
TP11-NAG-08
TP11-NAG-02
TP11-11
TP11-10
TP11-20
Main Power Plant
TP11-18
TP11-06
TP11-NAG-07
TP11-NAG-06
TP11-HLF-01
TP11-HLF-05
TP13-04
TP13-03
TP11-HLF-16
TP11-HLF-21
TP11-HLF-13
TP11-HLF-41
Heach Leap Facility
Low Grade Stockpile
Tailings Management Facility (TMF)
TP11-TMF-99
TP11-TMF-94
TP11-TMF-05
TP13-14
TP11-TMF-01
TP11-TMF-10
TP11-TMF-09
TP11-TMF-34
TP11-TMF-12
TP13-33
TP11-TMF-13
TP11-TMF-100
TP13-27
TMF Embankment
TP13-28

Airstrip Borrow Area
TP13-76
TP13-78
TP13-76

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LEGEND

Test Pit Sample

- Paste pH <5.0, Total S > 0.1%
- Paste < 5.0, Total S < 0.1%
- Paste pH > 5.0, Total S > 0.1%
- Paste pH > 5.0, Total S < 0.1%
- Site Facility Maximum Footprint
- 20m Elevation Contour

DATE SAVED:	Jul 07, 2014
DRAWN BY:	AL
REVIEWED:	BM
VERSION:	1

Coordinate System: *NAD 1983 UTM Zone 7N*
Projection: *Transverse Mercator*
Datum: *North American 1983*
Units: *Meter*

1:60,000

0 0.5 1 Km

CLIENT:

western COPPER AND GOLD

LORAX ENVIRONMENTAL

PROJECT:

Casino Project

TITLE:

Test Pit
Sampling Locations

PROJECT #: J862-6

FIGURE: 1

P:\J862 (Casino)\Road\Drafting\MXDs\Figure 2 Casino Test Pit Sampling Locations_2014605_AL.mxd

3. Geochemical Results

The geochemical risk of the borrow materials is determined from the paste pH (PpH) and total sulphur (S_{TOT}) content of the samples rather than from a calculation of the net potential ratio (NPR), which is the standard method for sulphide-bearing waste rock at mining projects. The direct assessment of paste pH and total sulphur is more appropriate for weathered overburden that may contain low amounts of residual acidity associated with metastable oxidation products such as jarosite. The ABA criteria used to identify materials with ML/ARD potential are:

- PpH < 5.0 and
- S_{TOT} > 0.1 %S.

3.1 Open Pit

Four of the 7 test pit samples from the Open Pit area had paste pH values less than 5 (Table 1 and Appendix B.1). This result indicates that this material may produce mildly acidic runoff immediately after excavation. Two of the samples with low paste pH also had relatively high total sulphur content (1.04% and 0.1%), indicating that there is some longer term acid generating potential from borrow material from the Open Pit area. There were two additional samples with total sulphur values greater than 0.1%, although the paste pH was greater than 5. Although the sulphur is in the form of sulphate rather than sulphide in the Open Pit borrow material samples, mildly acidic runoff could be generated from the dissolution of the sulphate-mineral jarosite, similar to what has been documented in CAP waste rock. In addition, due to some enrichment of metals relative to average continental crustal abundance (*e.g.* Cu, Mo), there may be some metal leaching from borrow material from the Open Pit area (Table 2 and Appendix B.2). Based on these results, borrow material from the Open Pit area is considered to have moderate ML/ARD risk.

3.1.1 Shake Flask Extractions

Metal contents measured in SFE provide a measure of the mass of readily soluble metals which will be immediately available for leaching upon exposure to infiltrating water. SFE tests were conducted on the samples from the Open Pit area since 4 of the 7 samples had total sulphur contents greater than or equal to 0.1%. As discussed above, these higher sulphur values indicate a higher potential for ML/ARD.

In order to highlight the significance of various SFE results, the results are compared to Metal Mining Effluent Regulations (MMER, 2002) and Yukon Contaminated Sites Regulation, Schedule 3 (Yukon CSR, 2002) water quality standards for aquatic life (Table 3). Hardness dependent guidelines, including Cd, Cu, Ni and Pb, were calculated based on the mean water hardness of 111.4 mg $CaCO_3$/L measured at the water quality station on lower Casino Creek.

The only parameter to exceed MMER guidelines in the SFE tests is dissolved Cu in one sample (TP12-PIT-05). This sample had a lower solid phase Cu concentration relative to several of the other borrow samples from the open pit, indicating that Cu release is likely due to its relatively low SFE pH. The Yukon CSR standard for Cu (0.05 mg/L) is exceeded in 5 of 7 samples (1.3 to 9.8 times above the guideline), indicating that Cu is the main parameter of concern for metal leaching from the borrow material. Additional parameters which exceed the Yukon CSR standards include Cd (2 samples) and Co (4 samples). These exceedances are generally marginal, the Cd values are 1.2 to 2.1 times the guideline and the Co values are 1.0 to 5.5 times the guideline.

3.2 Ore Stockpiles, Heap Leach Facility and Main Power Plant

The low grade ore stockpiles, gold ore stockpile, heap leach facility and main power plant site are located adjacent to the Open Pit. Seven of 19 samples have paste pH values less than 5, indicating that there may be some mildly acidic runoff following excavation (Table 1 and Appendix B.1). However, the total sulphur values for all of the borrow material samples collected in these areas remain low (range: <0.01 to 0.09%, median: 0.01%). The lower paste pH values are expected to be related to higher organic C values. The samples with paste pH less than 5 have organic C values between 0.46 and 3.16% (median: 1.23%), while the samples with a higher paste pH typically have lower organic C (range: 0.03% to 0.97%, median: 0.17%). These results indicate that the borrow material from these areas has a low ARD risk.

3.3 Tailings Management Facility

The samples from the TMF area were collected from the embankment area at the southern end of the TMF. These test pit samples typically have higher paste pH values relative to the samples collected closer to the Open Pit area. Only one of 14 samples had a paste pH value below pH 5 (Table 1 and Appendix B.1). In addition, total sulphur values remain low for all samples (range: <0.01 to 0.07%, median: 0.01%). Based on these results, these samples are classified as non-acid generating.

3.4 Airstrip and Barge Landing Access Road Borrow Areas

Four samples were collected from the airstrip borrow area, located south of the project area and 5 samples were collected from two locations along the proposed barge landing access road, to the north of the project area. The samples indicate that the borrow material in these areas are non-acid generating as the paste pH values are high (> PpH 7) and the total sulphur values are low (0.01% or lower) (Table 1 and Appendix B.1).

4. Recommendations

The geochemical results indicate that there is some potential for ML/ARD from the borrow material from the Open Pit area and low to no ML/ARD potential from the other areas. Based on these findings, it is expected that borrow with a low ML/ARD risk can be derived from all the borrow areas identified except within the proposed open pit limits. However, it is recommended that a ML/ARD Management Plan be developed for each area prior to the excavation of borrow material to confirm these preliminary findings. The ML/ARD Management Plans should include the following:

- An accounting of the quantity of material expected to be excavated from each site subdivided into the quantity of bedrock, weathered bedrock, alluvium and colluvium that would be removed at each site, in addition to the lithologic composition and stratigraphic affiliation if applicable.
- At least three test pit samples should be collected from each borrow site and submitted for geochemical analysis, including ABA and total metals analysis, prior to excavation. Increased sampling and sample planning should be conducted in proposed borrow areas within the open pit extents and immediately adjacent to the open pit where a higher degree of ML/ARD risk was identified.

This approach will ensure that all borrow material used for construction will have a low ML/ARD potential.

5. References

Metal Mining Effluent Regulations (MMER) (2002). Analytical Requirements for Metal Mining Effluent, Schedule 3, Subsections 1(1), 12(2) and 20(5), Fisheries Act, Department of Justice Canada, Registration June 6, 2002. Last amended on March 2, 2012.

Yukon Contaminated Site Regulation, Schedule 3 (Yukon CSR) (2002). Environment Act Contaminated Sites Regulations Schedule 3, O.I.C. 2002/171, September 30, 2002.

Table 1:
Summary of ABA Results

Parameter	Units	Borrow Location											
		Open Pit			Low Grade Stockpiles, Gold Ore Stockpile, Heap Leach Facility and Power Plant Site			Tailings Management Facility			Airstrip Borrow Area and Barge Access Road Borrow Areas		
Number of Samples		7			19			14			9		
		Min	**Median**	**Max**	**Min**	**Median**	**Max**	**Min**	**Median**	**Max**	**Min**	**Median**	**Max**
Rinse pH	-	3.57	4.54	5.08	4.14	4.92	6.86	4.19	5.23	6.71	5.32	6.54	7.77
Paste pH	-	3.71	4.85	5.67	4.26	5.34	7.59	4.89	6.02	7.6	7.01	7.9	9.09
TIC	%	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	<0.01	0.01	0.17	<0.01	<0.01	0.01
$CaCO_3$ NP	see note	<0.8	<0.8	<0.8	<0.8	<0.8	2.50	<0.8	0.82	14.17	<0.8	<0.8	0.83
C(T)	%	0.04	0.15	0.78	<0.01	0.38	3.17	0.04	0.48	2.37	<0.01	0.05	0.08
S(T)	%	0.04	0.1	1.04	<0.01	0.01	0.09	<0.01	0.01	0.07	<0.01	<0.01	0.01
$S(SO_4)$	%	0.02	0.11	1.13	<0.01	<0.01	0.1	<0.01	0.01	0.08	<0.01	<0.01	<0.01
$S(S^{-2})$	%	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Insoluble S	%	<0.01	<0.01	0.02	<0.01	<0.01	0.02	<0.01	0.01	0.01	<0.01	<0.01	0.01
SAP	see note	<0.3	<0.3	<0.3	<0.3	<0.3	0.31	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Non-SO_4 AP	see note	0.08	0.08	0.63	0.08	0.08	0.63	0	0.08	0.31	0.08	0.08	0.08
Sobek NP	see note	5	11	28	12	16	25	13.1	15	39	14	19	22
Net NP	see note	5	11	28	12	16	25	13.1	15	39	14	19	22
Fizz Test		-	-	-	-	-	-	-	-	-	-	-	-

Note:

SAP = Acid potential in tonnes $CaCO_3$ equivalent per 1000 tonnes of material. AP is determined from the measured sulphide sulphur content.

Non-SO4 AP = Acid potential in tonnes $CaCO_3$ equivalent per 1000 tonnes of material. AP calculated from non-sulphate sulphur (total sulphur - sulphate sulphur).

NP = Neutralization potential in tonnes $CaCO_3$ equivalent per 1000 tonnes of material.

NET NP = NP – SAP

Carbonate NP is calculated from TIC originating from carbonates and is expressed in kg $CaCO_3$/tonne.

Sulphate Sulphur determined by 25% HCl Leach with S by ICP Finish

Sulphide Sulphur determined by 1:7 Nitric Acid Leach with S by ICP-MS Finish

Insoluble S is acid insoluble S (Total S - (Sulphate S + Sulphide S)).

Table 2:
Summary of Metals by Aqua Regia Disgestion Results

Parameter	Units	Average Continental Crustal Abundance	Borrow Location											
			Open Pit			Low Grade Stockpiles, Gold Ore Stockpile, Heap Leach Facility and Power Plant Site			Tailings Management Facility			Airstrip Borrow Area and Barge Access Road Borrow Areas		
Number of Samples			7			19			14			9		
			Min	**Median**	**Max**	**Min**	**Median**	**Max**	**Min**	**Median**	**Max**	**Min**	**Median**	**Max**
Ag	ppm	0.075	***0.33***	***0.73***	***1.6***	0.06	***0.43***	***50.3***	0.02	0.06	***0.6***	<0.01	0.05	***0.32***
Al	%	8.23	1.0	1.4	3.4	0.5	1.7	2.0	0.68	1.6	2.3	0.8	1.0	2.1
As	ppm	1.8	***10***	***18***	***41***	<1	***19***	***694***	1	***8***	***672***	<1	1	***25***
B	ppm	-	40	50	60	<10	50	60	10	55	60	<10	<10	<10
Ba	ppm	425	183	353	***435***	201	311	***1730***	58	181	***2130***	119	254	***647***
Be	ppm	-	0.2	0.4	0.8	0.3	0.5	0.8	0.3	0.5	1.3	0.2	0.3	0.4
Bi	ppm	0.0085	***0.23***	***1.5***	***1.9***	***0.06***	***0.36***	***5.33***	***0.08***	***0.17***	***0.67***	***0.0***	***0.1***	***0.62***
Ca	%	4.15	0.06	0.23	0.68	0.17	0.38	0.48	0.23	0.41	1.49	0.31	0.39	0.58
Cd	ppm	0.15	<0.01	***0.22***	***0.42***	0.14	***1.0***	***10.3***	0.04	0.11	***2.92***	0.03	0.07	***0.44***
Ce	ppm	-	24	50	110	31	43	60	24.8	42	85	23	37	54
Co	ppm	25	2.8	7.9	***177***	6.2	9.8	12.9	5.6	10.15	***29***	4.2	9.2	11.6
Cr	ppm	102	59	66	***116***	80	***115***	***160***	46	***117***	***169***	***104***	***120***	***187***
Cs	ppm	-	1.2	2.0	4.3	1.3	3.0	11.5	0.93	3.1	14.2	0.8	1.3	2.6
Cu	ppm	60	***116***	***1010***	***2510***	7	20	***565***	6.1	27	***97***	4.1	9.6	36.4
Fe	%	5.63	2.5	3.7	***9.2***	1.73	3.4	4.3	1.96	2.9	***5.87***	1.9	2.1	4.0
Ga	ppm	19	3.9	5.5	9.9	1.7	5.2	6.8	2.4	5.4	9.3	2.4	4.4	7.5
Ge	ppm	-	<0.1	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	<0.1	<0.1	0.1
Hf	ppm	-	0.05	0.19	0.58	<0.05	0.06	0.17	<0.05	0.16	0.34	0.08	0.18	0.52
Hg	ppm	0.085	<0.01	<0.01	0.03	<0.01	0.03	***0.2***	<0.01	0.02	***0.58***	<0.01	0.02	0.08
In	ppm	-	0.02	0.03	0.13	<0.02	0.06	2.57	<0.02	0.02	0.06	<0.02	0.02	0.04
K	%	2.085	0.15	0.32	0.73	0.09	0.2	0.73	0.12	0.19	0.52	0.15	0.29	0.78
La	ppm	39	13	28	***57***	12	22	34	13.1	23	***75***	12	21	36
Li	ppm	-	3	6	11	1	9	12	4	11	16	4	14	21
Lu	ppm	-	0.03	0.12	0.51	0.09	0.16	0.25	0.09	0.16	0.31	0.07	0.14	0.29
Mg	%	2.33	0.24	0.41	1.4	0.08	0.48	0.77	0.18	0.55	1.04	0.4	0.80	1.31
Mn	ppm	950	94	275	***3450***	499	***1280***	***5730***	434	550	***2380***	334	553	837

Parameter	Units	Average Continental Crustal Abundance	Borrow Location											
			Open Pit			Low Grade Stockpiles, Gold Ore Stockpile, Heap Leach Facility and Power Plant Site			Tailings Management Facility			Airstrip Borrow Area and Barge Access Road Borrow Areas		
Number of Samples			7			19			14			9		
			Min	**Median**	**Max**	**Min**	**Median**	**Max**	**Min**	**Median**	**Max**	**Min**	**Median**	**Max**
Mo	ppm	1.2	***2.8***	***51***	***435***	0.5	***1.4***	***7.2***	0.7	***1.9***	***5.6***	***3***	***3.8***	***11.3***
Na	%	2.355	0.02	0.06	0.07	0.01	0.04	0.06	0.02	0.05	0.08	0.05	0.07	0.15
Nb	ppm	-	0.2	0.44	0.95	0.1	1.08	1.6	0.24	1.3	2.4	0.43	0.52	2.01
Ni	ppm	84	3.1	7.2	16	3	10	20	4.5	11	***85***	2.7	3.4	28.2
P	ppm	1050	0.035	0.050	0.127	0.029	0.057	0.069	0.021	0.042	0.154	0.037	0.047	0.069
Pb	ppm	14	11	***20***	***33.1***	9.7	***68.8***	***10000***	5.8	8.0	***73.4***	3.6	6.5	***45.6***
Rb	ppm	-	12	22	47	12	19	52	10.2	20	59	12	24	46
S	%	0.035	<0.01	***0.1***	***1.05***	<0.01	<0.01	***0.09***	<0.01	<0.01	***0.05***	<0.01	<0.01	<0.01
Sb	ppm	0.2	***1.45***	***1.8***	***7.7***	***0.34***	***1.9***	***137.0***	***0.24***	***0.73***	***17.50***	0.1	0.15	***1.64***
Sc	ppm	22	2.1	4.8	11.5	3.1	5.6	12.5	3.2	6.2	14.2	2.6	3.7	12.1
Se	ppm	0.05	***1***	***1***	***2***	<1	<1	<1	<1	<1	***2***	<1	<1	<1
Sn	ppm	-	0.4	0.6	1.2	<0.3	0.7	2.1	0.5	0.7	1.1	0.5	0.9	1.5
Sr	ppm	370	15	36	61	10	24	32	10.8	23	57	22	25	36
Ta	ppm	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.27
Tb	ppm	-	0.18	0.29	2.19	0.19	0.35	0.57	0.2	0.38	1.19	0.2	0.29	0.67
Te	ppm	-	<0.05	0.18	0.27	<0.05	<0.05	0.31	<0.05	<0.05	0.13	<0.05	<0.05	<0.05
Th	ppm	1.2	***7***	***10***	***18***	***6.4***	***12***	***27***	***3.8***	***9.8***	***22.3***	***8***	***11***	***17***
Ti	%	0.565	0.03	0.07	0.1	<0.01	0.08	0.23	0.01	0.12	0.17	0.05	0.11	0.26
Tl	ppm	0.85	0.18	0.25	0.69	0.17	0.30	0.64	0.12	0.22	***5.11***	0.11	0.2	0.42
U	ppm	2.7	1.7	***3.1***	***8.7***	1.8	***3.5***	***9.1***	0.62	1.8	***6.0***	0.7	0.9	***3.9***
V	ppm	120	27	45	100	15	75	83	35	66	***162***	33	41	104
W	ppm	1.3	0.7	***1.9***	***106***	<0.1	0.3	1.2	0.1	0.7	***7.9***	<0.1	0.2	0.6
Y	ppm	-	3	6.7	56	5	9.7	15.3	5.9	11	27	5.1	8	20
Yb	ppm	-	0.2	0.80	3.70	0.5	1.0	1.7	0.6	1.2	2.1	0.50	0.8	1.8
Zn	ppm	70	18	60	***150***	51	***193***	***1810***	42	60	***629***	36	50	67
Zr	ppm	-	1.8	8.3	23.8	1.0	2.9	7.1	3.4	8.0	13.0	1.7	5.4	10.0

Notes:
Bold italics indicate a value greater than the average continental crustal abundance
Light grey shading indicates a value greater than 5x the average continental crustal abundance
Dark grey shading indicates a value greater than 10x the average continental crustal abundance

Table 3:
Shake Flask Extraction Results for Open Pit Samples

Parameter	Units	MMER			Yukon CSR	38-3	38-4	39-1	TP-PIT-01	TP-PIT-04	TP-PIT-05	TP-PIT-06
		MMM	MCS	MGS								
Volume Nanopure Water	mL	*NP*	*NP*	*NP*	*NP*	690	630	750	750	750	750	750
Sample Weight	g	*NP*	*NP*	*NP*	*NP*	230	210	250	250	250	250	250
pH		*NP*	*NP*	*NP*	*NP*	6.50	6.20	6.39	5.46	6.72	5.12	7.18
Redox	mV	*NP*	*NP*	*NP*	*NP*	394	378	341	290	296	396	349
Conductivity	µS/cm	*NP*	*NP*	*NP*	*NP*	231	241	756	23	15	37	16
Acidity (to pH 4.5)	mg $CaCO_3$/L	*NP*	*NP*	*NP*	*NP*	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Total Acidity (to pH 8.3)	mg $CaCO_3$/L	*NP*	*NP*	*NP*	*NP*	4.0	4.3	8.2	6.9	2.4	4.8	2.8
Alkalinity	mg $CaCO_3$/L	*NP*	*NP*	*NP*	*NP*	2.4	1.6	4.4	1.2	2.3	0.3	3.9
Sulphate	mg/L	*NP*	*NP*	*NP*	1000	89	95	276	4	3	10	6
Ion Balance												
Major Anions	meq/L	*NP*	*NP*	*NP*	*NP*	1.90	2.01	5.84	0.11	0.11	0.21	0.20
Major Cations	meq/L	*NP*	*NP*	*NP*	*NP*	2.05	2.15	6.82	0.21	0.18	0.27	0.18
Difference	meq/L	*NP*	*NP*	*NP*	*NP*	-0.15	-0.14	-0.98	-0.10	-0.07	-0.06	0.02
Balance (%)	%	*NP*	*NP*	*NP*	*NP*	-3.8%	-3.4%	-7.7%	-31.3%	-24.7%	-12.2%	5.2%
Dissolved Metals												
Hardness CaCO3	mg/L	*NP*	*NP*	*NP*	*NP*	26.2	37.3	216	3.45	3.26	6.84	4.69
Aluminum Al	mg/L	*NP*	*NP*	*NP*	*NP*	0.0266	0.0051	0.0967	0.502	0.407	0.0908	0.167
Antimony Sb	mg/L	*NP*	*NP*	*NP*	0.2	< 0.0002	< 0.0002	0.0029	0.0003	< 0.0002	< 0.0002	0.0011
Arsenic As	mg/L	0.5	0.75	1	0.05	< 0.0002	< 0.0002	0.0180	0.0002	< 0.0002	0.0002	0.0011
Barium Ba	mg/L	*NP*	*NP*	*NP*	10	0.0104	0.0139	0.116	0.0293	0.00870	0.142	0.0300
Beryllium Be	mg/L	*NP*	*NP*	*NP*	0.053	0.00003	0.00005	< 0.00002	0.00004	< 0.00002	0.00012	< 0.00002
Bismuth Bi	mg/L	*NP*	*NP*	*NP*	*NP*	< 0.00001	< 0.00001	0.00028	0.00017	0.00018	< 0.00001	0.00001
Boron B	mg/L	*NP*	*NP*	*NP*	*NP*	0.0054	0.0157	0.0105	0.0032	0.0051	0.0099	0.0097
Cadmium Cd*	mg/L	*NP*	*NP*	*NP*	0.0005	0.000592	0.000244	0.00106	0.000126	0.000066	0.000483	0.000087
Calcium Ca	mg/L	*NP*	*NP*	*NP*	*NP*	8.55	12.4	67.6	0.94	0.80	2.00	1.17
Chromium Cr (Cr^{+6})	mg/L	*NP*	*NP*	*NP*	0.01	< 0.0005	< 0.0005	0.0009	0.0005	< 0.0005	< 0.0005	< 0.0005
Cobalt Co	mg/L	*NP*	*NP*	*NP*	0.009	0.0499	0.0117	0.00940	0.00175	0.000119	0.0115	0.000136
Copper Cu*	mg/L	0.3	0.45	0.6	0.05	0.130	0.0968	0.113	0.0154	0.0268	***0.492***	0.0652
Iron Fe	mg/L	*NP*	*NP*	*NP*	*NP*	0.034	0.004	0.095	0.379	0.834	0.007	0.132
Lead Pb*	mg/L	0.2	0.3	0.4	0.06	0.00006	< 0.00002	0.00057	0.00023	0.00098	0.00004	0.00017

Parameter	Units	MMER			Yukon CSR	38-3	38-4	39-1	TP-PIT-01	TP-PIT-04	TP-PIT-05	TP-PIT-06
		MMM	MCS	MGS								
Lithium Li	mg/L	*NP*	*NP*	*NP*	*NP*	0.004	0.002	0.002	< 0.001	< 0.001	0.001	< 0.001
Magnesium Mg	mg/L	*NP*	*NP*	*NP*	*NP*	1.18	1.56	11.4	0.267	0.306	0.449	0.431
Manganese Mn	mg/L	*NP*	*NP*	*NP*	*NP*	1.84	0.470	5.14	0.0532	0.0087	0.538	0.0101
Mercury Hg	ug/L	*NP*	*NP*	*NP*	1	< 0.01	< 0.01	< 0.01	0.02	< 0.01	< 0.01	< 0.01
Molybdenum Mo	mg/L	*NP*	*NP*	*NP*	10	0.00311	0.00075	0.00169	0.00255	0.00939	0.00007	0.166
Nickel Ni*	mg/L	0.5	0.75	1	0.65	0.0011	0.0006	0.0052	0.0012	0.0003	0.0024	0.0004
Phosphorus P	mg/L	*NP*	*NP*	*NP*	*NP*	0.014	0.025	0.079	0.022	0.027	0.012	0.068
Potassium K	mg/L	*NP*	*NP*	*NP*	*NP*	1.75	3.13	23.0	2.22	0.854	1.85	1.12
Selenium Se	mg/L	*NP*	*NP*	*NP*	0.01	0.00017	0.00022	0.00636	0.00034	0.00058	0.00026	0.00053
Silicon Si	mg/L	*NP*	*NP*	*NP*	*NP*	8.94	7.69	3.89	2.90	5.73	3.46	3.21
Silver Ag*	mg/L	*NP*	*NP*	*NP*	0.015	0.00005	0.00005	0.00004	< 0.00001	0.00001	0.00005	0.00005
Sodium Na	mg/L	*NP*	*NP*	*NP*	*NP*	32.5	30.0	39.3	0.55	1.11	0.96	0.78
Strontium Sr	mg/L	*NP*	*NP*	*NP*	*NP*	0.0710	0.0454	0.223	0.0088	0.0663	0.0199	0.0071
Sulphur (S)	mg/L	*NP*	*NP*	*NP*	*NP*	29.4	32.7	106	1.77	0.86	4.02	0.55
Thallium Tl	mg/L	*NP*	*NP*	*NP*	0.003	0.00002	0.00003	0.00017	0.00005	< 0.00002	0.00005	< 0.00002
Tin Sn	mg/L	*NP*	*NP*	*NP*	*NP*	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001
Titanium Ti	mg/L	*NP*	*NP*	*NP*	1	0.0016	0.0004	0.0025	0.0017	0.0043	0.0002	0.0035
Uranium U	mg/L	*NP*	*NP*	*NP*	3	0.000183	0.000084	0.000424	0.000154	0.000226	0.000144	0.000130
Vanadium V	mg/L	*NP*	*NP*	*NP*	*NP*	0.00015	0.00012	0.00048	0.00015	0.00064	0.00004	0.00087
Zinc Zn*	mg/L	0.5	0.75	1	0.9	0.020	0.011	0.033	0.016	0.003	0.015	0.002
Zirconium Zr	mg/L	*NP*	*NP*	*NP*	*NP*	0.00002	< 0.00001	0.00141	0.00241	0.00049	0.00014	0.00049

Notes:
NP = none proposed
MMER = Metal Mining Effluent Regulations (MMER, 2002);
MMM = Maximum authorized monthly mean;
MCS = Maximum authorized concentration in a composite sample; and
MGS = Maximum authorized concentration in a grab sample.
Yukon CSR = Yukon Contaminated Sites Regulation, Schedule 3 - Generic Numerical Water Standards, Aquatic Life (Yukon CSR, 2002)
*Hardness dependent guidelines were calculated based on a mean water hardness of 111.4 mg $CaCO_3$/L for the water quality station on Lower Casino Creek
Light grey shading indicates an exceedance of the MMER MMM guideline
Medium grey shading indicates an exceedance of the MMER MCS guideline
Dark grey shading indicates an exceedance of the MMER MGS guideline
Blue shading indicates an exceedance of the maximum Yukon CSR standard

Appendix A: Overburden Sample Description

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Sample ID	Depth (m)	Description	Soil Type	Comments
Open Pit				
38-3	15.24-16.76	Silty sand, trace gravel, trace cla	Colluvium	
38-4	18.29-19.81	Sand and silt, trace clay, trace grave	Residual soil	
39-1	7.62-7.80	Silty sand, fine to coarse	Colluvium	
TP12-PIT-01	0.80-1.00	Sand and gravel, some cobble	Residual soil to highly weathered bedroc	Collected above permafros
TP12-PIT-04	3.00-3.20	Silty sand, some grave	Residual soil to highly weathered bedroc	Collected above bedrock
TP12-PIT-05	3.80-4.00	Gravelly sand, some cobbles, trace silt, coarse graine	Residual soil to highly weathered bedroc	Collected above bedrock
TP12-PIT-06	1.60-1.80	Silty sand, some grave	Residual soil to highly weathered bedroc	Collected above permafros
Low Grade Stockpiles				
TP11-04	0.77-0.97	Silt and sand, trace clay, trace grave	Colluvium	Collected above permafros
TP11-NAG-02	1.20-1.40	Silty sand, some gravel, trace cla	Colluvium	Boulders left out of sample
TP11-NAG-06	3.20-3.40	Gravelly sand, some silt, trace cla	Granodiorite, completely weathered	Collected above bedrock
TP11-NAG-07	0.70-0.90	Sand and silt, some gravel, trace cla	Colluvium	Collected above permafros
TP11-NAG-08	0.60-0.80	Silty, gravelly sand, trace cla	Colluvium	
Gold Ore Stockpile				
TP13-48 BU-1	2.5-2.7	Gravelly sand, trace to some silt, some cobble	Residual soil	
Heap Leach Facility				
TP11-HLF-01	2.00-2.10	Silty sand, some gravel, trace cla	Colluvium	Collected above permafros
TP11-HLF-05	1.50-1.90	Gravelly sand, some sil	Colluvium	Collected above permafros
TP11-HLF-13	1.80-2.00	Gravelly sand, some silt, trace cla	Colluvium	Collected from a road cu
TP11-HLF-16	2.80-3.00	Gravel and sand, some silt, trace cla	Highly weathered bedrock	Collected above permafros
TP11-HLF-21	0.80-1.00	Silty sand, some gravel, trace cla	Colluvium	Collected above boulders
TP11-HLF-41	1.50-1.70	Gravelly sand, some silt, trace cla	Colluvium	
Main Power Plant				
TP11-06	0.84-1.04	Sandy silt, some gravel, trace cla	Colluvium	Collected above permafros
TP11-10	0.30-0.65	Sandy silt, some gravel, trace cla	Colluvium	Collected above large boulder
TP11-11	1.10-1.30	Sand and gravel, some silt, trace cla	Colluvium	Collected above permafros
TP11-18	1.20-1.40	Silty sand, trace clay, trace grave	Residual soil	Collected above permafros
TP11-20	1.25-1.45	Sandy silt, some gravel, trace cla	Residual soil	Collected above bedrock
TP13-03 BU-1	2.0-2.2	Sand, some gravel, trace silt and cla	Residual soil	Collected from an existing exposur
TP13-04 BU-1	2.8-3.0	Weathered granodiorite, coarse graine	Granodiorite, completely weathered	Collected from an existing exposur
Tailings Management Facility				
TP11-TMF-01	1.22-1.42	Gravel, some sand, some silt, trace cla	Colluvium	Collected above bedrock
TP11-TMF-05	2.10-2.30	Sand, some silt, trace gravel, trace cla	Residual Soil	Collected above bedrock/permafros
TP11-TMF-09	0.85-1.05	Silt, trace clay, trace sand	Alluvium - Floodplain Deposi	Collected above permafros
TP11-TMF-10	1.00-1.20	Gravel, some sand, some silt, trace cla	Colluvium	Collected above bedrock
TP11-TMF-12	0.90-1.10	Gravelly sand, some silt, trace cla	Residual Soil	Collected above permafros
TP11-TMF-13	1.35-1.55	Sandy gravel, trace silt, trace cla	Colluvium	Collected above weathered bedrock
TP11-TMF-34	0.80-1.00	Silt and sand, some gravel, trace cla	Colluvium	Collected above permafros
TP11-TMF-94	1.30-1.50	Sandy, silty gravel, trace cla	Colluvium	Collected above bedrock
TP11-TMF-99	0.50-0.70	Silty sand and gravel, trace cla	Colluvium	Collected above bedrock
TP11-TMF-100	1.00-1.20	Sand and gravel, some silt, trace cla	May be weathered bedrock	Collected above bedrock
TP13-14 BU-1	3.0-4.0	Gravelly sands and cobble	Alluvium - riverbed deposi	Collected from frozen ground
TP13-27 BU-1	2.6-2.8	Weathered granodiorite, sand to grave	Granodiorite, completely weathered	Collected above bedrock
TP13-28 BU-1	1.4-1.6	Gravel and sand, some silt, few cobble	Residual soil	Collected above weathered bedrock
TP13-33 BU-1	2.0-2.3	Gravelly sand, some cobbles, trace sil	Residual soil	Collected above permafros
Airstrip Borrow Area				
TP13-76 BU-1	1.0-1.2	Sand and gravel, trace sil	Residual soil	
TP13-76 BU-2	1.7-2.0	Weathered granodiorite, coarse graine	Granodiorite, completely weathered	
TP13-77 BU-1	2.0-2.2	Granodiorite, coarse grained	Dawson Range Batholith granodiorit	Collected bedrock
TP13-78 BU-1	1.0-1.2	Gravelly sand, trace sil	Residual soil	Collected above weathered granodiorit
Barge Landing Access Road				
TP13-01 BU-0	0.6-0.8	Sand, trace to some gravel, trace sil	Alluvium - creek deposi	Collected from an existing exposur
TP13-01 BU-1	1.2-1.4	Sand and gravel, many cobbles, no to trace si	Colluvium	Collected from an existing exposur
TP13-01 BU-2	2.5-2.7	Sand and gravel, many cobbles, no to trace si	Colluvium	Collected from an existing exposur
TP13-01 BU-3	1.0-1.2	Sand and gravel, many cobbles, no to trace si	Colluvium	Collected from an existing exposur
TP13-84 BU-1	n/a	Granodiorite, medium grained (blasted rock	Dawson Range Batholith granodiorit	Collected from existing blasting sit

Appendix B: ABA and Metals Results

Appendix B.1: Static Test Results for Overburden Samples - Static Test ABA Results

Appendix B.2: Static Test Results for Overburden Samples - Static Test Aqua Regia Metals Results

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APPENDIX B.1: STATIC TEST RESULTS FOR OVERBURDEN SAMPLES - STATIC TEST ABA RESULTS

Sample ID	Rinse pH	Paste pH	TIC %	$CaCO_3$ NP	C(T) %	S(T) %	$S(SO_4)$ %	$S(S^{-2})$ %	Insoluble S %	SAP $mgCaCO_3/kg$	Non-SO_4 AP $mgCaCO_3/kg$	NP $mgCaCO_3/kg$	Net NP	NPR (NP/SAP)	Fizz Test
Open Pit															
38-3	4.54	5.00	<0.01	<0.8	0.05	0.05	0.05	<0.01	<0.01	<0.3	0.08	12.8	12.8	42.7	None
38-4	4.38	4.85	<0.01	<0.8	0.04	0.04	0.02	<0.01	0.02	<0.3	0.63	28.1	28.1	93.7	None
39-1	5.06	5.37	<0.01	<0.8	0.4	0.11	0.13	<0.01	<0.01	<0.3	0.08	11.2	11.2	37.3	None
TP12-PIT-01	3.57	3.71	<0.01	<0.8	0.78	1.04	1.13	<0.01	<0.01	<0.3	0.08	4.8	4.8	16.0	None
TP12-PIT-04	4.58	4.76	<0.01	<0.8	0.27	0.08	0.1	<0.01	<0.01	<0.3	0.08	9.4	9.4	31.3	None
TP12-PIT-05	3.72	4.06	<0.01	<0.8	0.12	0.1	0.11	<0.01	<0.01	<0.3	0.08	10.1	10.1	33.7	None
TP12-PIT-06	5.08	5.67	<0.01	<0.8	0.15	0.12	0.12	<0.01	<0.01	<0.3	0.08	13.2	13.2	44.0	None
Low Grade Stockpiles															
TP11-04	4.31	4.45	<0.01	<0.8	1.24	<0.01	<0.01	<0.01	<0.01	<0.3	0.08	11.6	11.6	38.7	None
TP11-NAG-02	4.69	5.12	<0.01	<0.8	0.98	0.03	0.01	<0.01	0.02	<0.3	0.63	16.4	16.4	54.7	None
TP11-NAG-06	5.10	5.90	<0.01	<0.8	0.08	<0.01	<0.01	0.01	<0.01	0.3	0.08	25.2	24.9	80.6	Slight
TP11-NAG-07	4.54	4.88	<0.01	<0.8	1.13	0.02	0.01	<0.01	0.01	<0.3	0.31	15.5	15.5	51.7	None
TP11-NAG-08	4.43	4.92	<0.01	<0.8	0.91	0.02	0.01	0.01	<0.01	0.3	0.31	15.4	15.1	49.3	None
Gold Ore Stockpile															
TP13-48 BU-1	6.12	7.29	<0.01	<0.8	0.04	<0.01	<0.01	<0.01	<0.01	<0.3	0.08	17.0	17.0	56.7	None
Heap Leach Facility															
TP11-HLF-01	4.74	4.89	<0.01	<0.8	1.27	0.01	0.01	<0.01	<0.01	<0.3	0.08	16.0	16.0	53.3	None
TP11-HLF-05	4.53	5.34	<0.01	<0.8	0.38	<0.01	<0.01	<0.01	<0.01	<0.3	0.08	13.4	13.4	44.7	None
TP11-HLF-13	5.34	5.86	0.01	0.8	0.18	<0.01	<0.01	<0.01	<0.01	<0.3	0.08	12.1	12.1	40.3	None
TP11-HLF-16	4.92	6.00	0.01	0.8	0.18	<0.01	<0.01	<0.01	<0.01	<0.3	0.08	13.2	13.2	44.0	None
TP11-HLF-21	5.90	5.81	0.02	1.7	0.97	0.01	<0.01	<0.01	0.01	<0.3	0.16	18.6	18.6	62.0	None
TP11-HLF-41	6.86	6.22	0.01	0.8	0.1	<0.01	<0.01	<0.01	<0.01	<0.3	0.08	12.6	12.6	42.0	None
Main Power Plant															
TP11-06	4.48	4.37	0.01	0.8	3.17	0.03	0.02	<0.01	0.01	<0.3	0.31	11.7	11.7	39.0	None
TP11-10	4.14	4.26	<0.01	<0.8	1.35	0.02	0.01	<0.01	0.01	<0.3	0.31	13.4	13.4	44.7	None
TP11-11	4.98	5.47	<0.01	<0.8	0.2	<0.01	<0.01	<0.01	<0.01	<0.3	0.08	17.0	17.0	56.7	None
TP11-18	5.47	5.34	0.01	0.8	0.36	0.09	0.1	0.01	<0.01	0.3	0.08	14.8	14.5	47.4	None
TP11-20	4.50	4.95	<0.01	<0.8	0.47	<0.01	<0.01	<0.01	<0.01	<0.3	0.08	17.1	17.1	57.0	None
TP13-03 BU-1	5.23	6.15	0.03	2.5	0.2	0.06	0.04	<0.01	0.02	<0.3	0.63	18.1	18.1	60.3	None
TP13-04 BU-1	6.18	7.59	<0.01	<0.8	<0.01	0.01	<0.01	<0.01	0.01	<0.3	0.08	16.7	16.7	55.7	None
Tailings Management Facility															
TP11-TMF-01	4.99	5.35	0.02	1.7	0.58	0.07	0.06	<0.01	0.01	<0.3	0.31	14.8	14.8	49.3	None
TP11-TMF-05	5.64	6.67	<0.01	<0.8	0.06	<0.01	<0.01	<0.01	<0.01	<0.3	0.08	15.1	15.1	50.3	None
TP11-TMF-09	6.66	6.59	0.17	14.2	2.24	0.02	0.02	<0.01	<0.01	<0.3	0.08	38.8	38.8	129.3	Slight
TP11-TMF-10	4.97	5.38	0.01	0.8	0.58	<0.01	<0.01	<0.01	<0.01	<0.3	0.08	17.4	17.4	58.0	None
TP11-TMF-12	4.19	4.89	<0.01	<0.8	0.75	0.01	<0.01	<0.01	0.01	<0.3	0.08	13.1	13.1	43.7	None
TP11-TMF-13	6.71	6.73	0.05	4.2	0.17	<0.01	<0.01	<0.01	<0.01	<0.3	0.08	14.2	14.2	47.3	None
TP11-TMF-34	5.09	5.30	0.01	0.8	2.37	0.02	0.01	<0.01	0.01	<0.3	0.31	19.1	19.1	63.7	None
TP11-TMF-94	5.14	5.45	0.03	2.5	0.69	0.07	0.08	<0.01	<0.01	<0.3	0.08	22.2	22.2	74.0	None
TP11-TMF-99	4.25	5.11	<0.01	<0.8	0.37	<0.01	<0.01	<0.01	<0.01	<0.3	0.08	15.3	15.3	51.0	None
TP11-TMF-100	5.15	5.23	0.01	0.8	2.32	0.02	0.01	<0.01	0.01	<0.3	0.31	18.5	18.5	61.7	None

Sample ID	Rinse pH	Paste pH	TIC %	$CaCO_3$ NP	C(T) %	S(T) %	$S(SO_4)$ %	$S(S^{-2})$ %	Insoluble S %	SAP $mgCaCO_3/kg$	Non-SO_4 AP $mgCaCO_3/kg$	NP $mgCaCO_3/kg$	Net NP	NPR (NP/SAP)	Fizz Test
TP13-14 BU-1	6.15	7.08	<0.01	<0.8	0.24	0.02	0.01	<0.01	0.01	<0.3	0.31	14.9	14.9	49.7	None
TP13-27 BU-1	6.31	7.60	<0.01	<0.8	0.04	<0.01	<0.01	<0.01	<0.01	<0.3	0.08	14.3	14.3	47.7	None
TP13-28 BU-1	5.40	6.78	<0.01	<0.8	0.08	<0.01	<0.01	<0.01	<0.01	<0.3	0.08	13.9	13.9	46.3	None
TP13-33 BU-1	5.31	6.87	<0.01	<0.8	0.09	<0.01	<0.01	<0.01	<0.01	<0.3	0.08	16.7	16.7	55.7	None
Airstrip Borrow Area															
TP13-76 BU-1	5.63	7.11	<0.01	<0.8	0.06	<0.01	<0.01	<0.01	<0.01	<0.3	0.08	18.9	18.9	63.0	None
TP13-76 BU-2	6.21	7.82	<0.01	<0.8	0.02	0.01	<0.01	<0.01	0.01	<0.3	0.08	21.7	21.7	72.3	None
TP13-77 BU-1	6.54	8.49	<0.01	<0.8	<0.01	<0.01	<0.01	<0.01	<0.01	<0.3	0.08	20.5	20.5	68.3	None
TP13-78 BU-1	5.90	7.16	<0.01	<0.8	0.06	<0.01	<0.01	<0.01	<0.01	<0.3	0.08	20.0	20.0	66.7	None
Barge Landing Access Road Borrow Areas															
TP13-01 BU-0	7.43	7.90	<0.01	<0.8	0.08	<0.01	<0.01	<0.01	<0.01	<0.3	0.08	14.4	14.4	48.0	None
TP13-01 BU-1	6.80	8.23	0.01	0.8	0.05	0.01	<0.01	<0.01	0.01	<0.3	0.08	21.5	21.5	71.7	None
TP13-01 BU-2	7.10	8.19	<0.01	<0.8	0.04	<0.01	<0.01	<0.01	<0.01	<0.3	0.08	18.4	18.4	61.3	None
TP13-01 BU-3	5.32	7.01	<0.01	<0.8	0.07	<0.01	<0.01	<0.01	<0.01	<0.3	0.08	13.8	13.8	46.0	None
TP13-84 BU-1	7.77	9.09	0.01	0.8	0.02	<0.01	<0.01	<0.01	<0.01	<0.3	0.08	17.4	17.4	58.0	None

Note:

AP = Acid potential in tonnes $CaCO_3$ equivalent per 1000 tonnes of material. SAP is determined from the measured sulphide sulphur content, Non-SO4 AP is determined from the non-SO_4 sulphur content.

NP = Neutralization potential in tonnes $CaCO_3$ equivalent per 1000 tonnes of material.

NET NP = NP - SAP

Carbonate NP is calculated from TIC originating from carbonates and is expressed in kg $CaCO_3$/tonne.

Sulphate Sulphur determined by 25% HCL with Gravimetric Finish

Sulphide Sulphur determined by Sobek 1:7 Nitric Acid with S by ICP-MS Finish

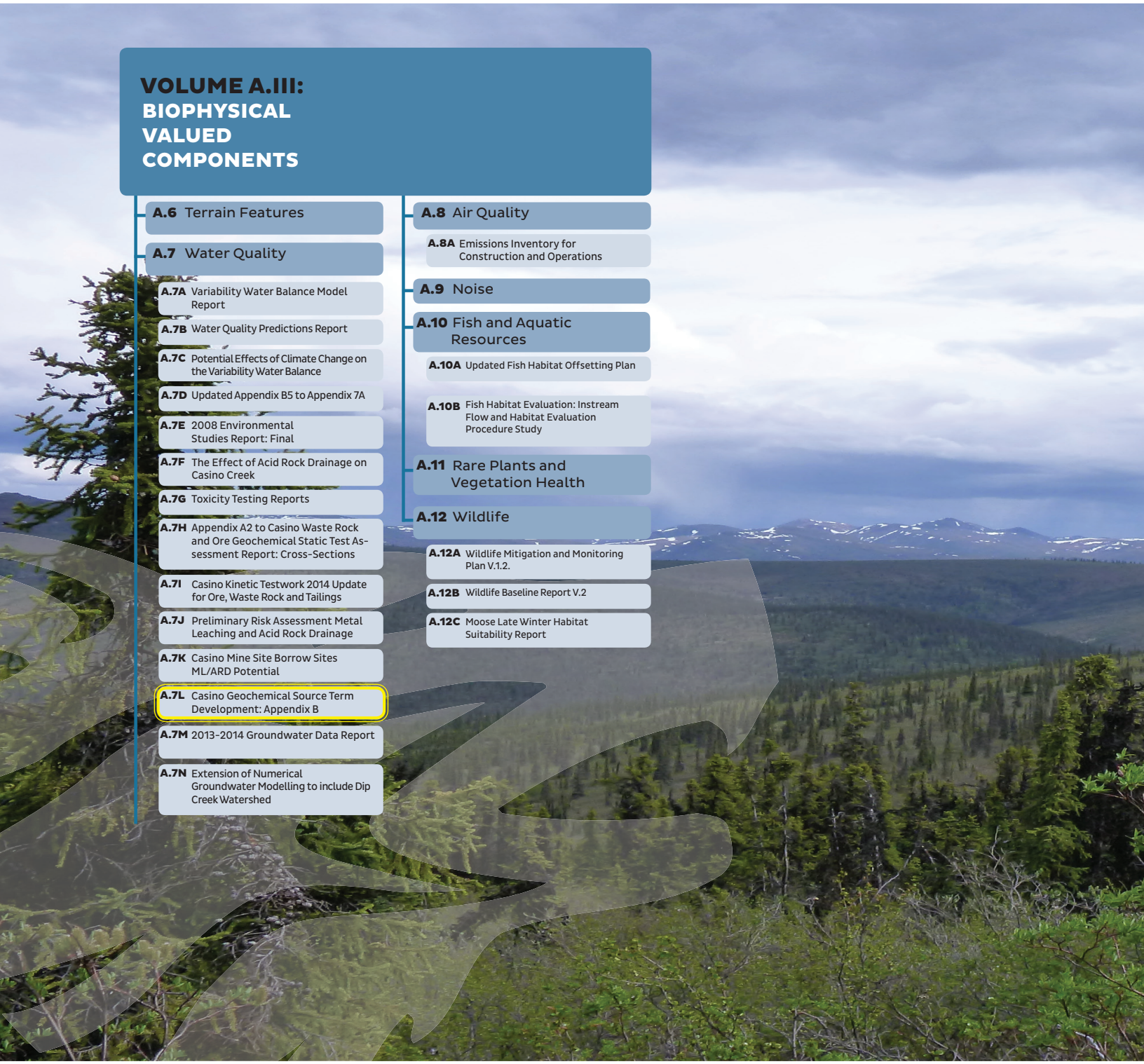
Insoluble S is acid insoluble S (Total S - (Sulphate S + Sulphide S)).

For the 1994 samples, total S and sulphate S results were switched from the original result sheet because S(SO_4) was greater than S(T) for all samples.

APPENDIX B.2: STATIC TEST RESULTS FOR OVERBURDEN SAMPLES - STATIC TEST AQUA REGIA METALS RESULTS

Sample ID	Ag	Al	As	B	Ba	Be	Bi	Ca	Cd	Ce	Co	Cr	Cs	Cu	Fe	Ga	Ge	Hf	Hg	In	K	La	Li	Lu	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	Rb	S	Sb	Sc	Se	Sn	Sr	Ta	Tb	Te	Th	Ti	Tl	U	V	W	Y	Yb	Zn	Zr
	ppm	%	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	%	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Open Pit																																																						
38-3	0.33	2.93	10	60	383	0.7	0.43	0.24	0.33	110	92.9	65	2.37	2510	2.5	6.4	0.2	0.19	<0.01	0.02	0.15	50.5	8	0.35	0.49	1630	29.2	0.06	0.42	7.2	0.035	15	17.1	0.03	1.45	4.8	1	0.7	35.5	<0.05	1.82	0.07	9.1	0.09	0.24	7.76	45	1	33.8	2.8	85	5.7
38-4	0.96	3.36	12	50	435	0.8	0.23	0.68	0.42	80.7	177	59	4.3	1540	3.75	9.9	0.2	0.1	<0.01	0.02	0.58	56.5	11	0.51	1.4	3450	50.8	0.05	0.22	3.9	0.05	17.1	47.3	<0.01	1.58	11.5	1	1.2	36.6	<0.05	2.19	<0.05	6.9	0.07	0.69	5.87	100	0.7	56	3.7	150	1.8
39-1	0.73	1.23	41	50	335	0.3	1.72	0.23	0.22	34.8	5.7	116	1.82	116	2.85	3.9	<0.1	0.18	0.01	0.03	0.19	18.8	4	0.08	0.3	275	2.83	0.07	0.5	8.5	0.044	33.1	11.9	0.12	3.76	2.9	1	0.5	50.3	<0.05	0.27	0.27	12.4	0.03	0.18	1.91	29	0.7	5.48	0.5	60	9.5
TP12-PIT-01	0.64	0.95	14	50	404	0.2	1.3	0.06	<0.01	50.3	2.8	66	1.22	129	4.75	3.9	<0.1	<0.05	<0.01	0.02	0.73	28.4	4	0.03	0.24	94	208	0.06	0.41	3.1	0.095	10.7	37	1.05	1.81	2.1	2	0.4	60.8	<0.05	0.18	0.14	7.1	0.03	0.4	1.67	27	106	2.65	0.2	18	3.7
TP12-PIT-04	1.04	1.66	18	40	183	0.7	1.48	0.09	0.13	23.6	4.9	64	1.99	1110	9.18	7.1	<0.1	0.58	0.03	0.04	0.32	12.5	3	0.15	0.35	168	435	0.02	0.44	5.6	0.127	20	22.2	0.09	1.69	6.5	2	0.5	15.3	<0.05	0.29	0.18	18.1	0.04	0.25	8.74	46	2.3	6.7	0.9	33	23.8
TP12-PIT-05	0.58	1.36	22	60	353	0.3	1.53	0.23	0.21	35.5	15.2	89	1.39	353	2.92	4.5	<0.1	0.2	<0.01	0.05	0.23	19.2	6	0.09	0.41	434	47.2	0.06	0.71	9.4	0.048	21.1	18	0.1	2.38	3.8	<1	0.6	29.7	<0.05	0.27	0.25	10.1	0.07	0.22	1.88	41	2.3	6.14	0.6	55	8.3
TP12-PIT-06	1.6	1.36	24	60	230	0.4	1.94	0.25	0.41	57.8	7.9	110	2.5	1010	3.65	5.5	<0.1	0.23	<0.01	0.13	0.49	30.8	7	0.12	0.72	220	303	0.04	0.95	16	0.07	30.2	42.7	0.1	7.69	6.3	1	1	26.1	<0.05	0.39	0.24	11.7	0.1	0.42	3.12	64	1.9	9.39	0.8	99	9.7
Low Grade Stockpiles																																																						
TP11-04	0.17	1.82	80	50	214	0.4	0.2	0.38	0.48	31.4	11.5	118	2.14	16.8	3.4	5.9	<0.1	<0.05	0.01	0.11	0.13	15.7	12	0.09	0.55	945	1.09	0.04	1.6	16.3	0.057	32.3	16	<0.01	0.61	5.2	<1	0.7	22.5	<0.05	0.26	<0.05	8.2	0.12	0.21	1.76	75	0.2	6.55	0.6	150	2.3
TP11-NAG-02	0.8	1.43	14	60	221	0.4	1.01	0.43	0.64	31.8	11.1	143	1.43	27.2	3.38	5	<0.1	<0.05	0.02	0.06	0.13	15.2	9	0.12	0.52	1010	1.43	0.06	1.46	14.4	0.063	53.2	15.3	<0.01	1.03	5.6	<1	0.8	24.4	<0.05	0.28	<0.05	8.2	0.11	0.21	2.14	75	0.2	7.67	0.7	140	2.3
TP11-NAG-06	0.4	1.87	27	50	437	0.6	0.11	0.41	2.71	48	9.4	105	4.98	11.6	3.67	6.5	<0.1	0.1	0.01	0.09	0.43	22.6	9	0.18	0.72	2070	0.76	0.03	0.51	4.8	0.056	282	31.5	<0.01	1.88	8.2	<1	0.8	19.6	<0.05	0.37	<0.05	18.6	0.07	0.39	3.92	75	0.2	10.5	1.2	452	2.2
TP11-NAG-07	2.66	1.69	31	60	308	0.6	1.37	0.39	2.02	46.2	12.9	121	2.39	54.8	3.91	5.7	<0.1	<0.05	0.03	0.11	0.17	23.4	10	0.19	0.53	1990	1.15	0.04	1.46	18	0.062	178	21	<0.01	3.57	7.1	<1	0.9	23.9	<0.05	0.44	<0.05	10.1	0.11	0.3	4.62	77	0.3	12.7	1.2	253	3.7
TP11-NAG-08	1.76	1.76	14	60	264	0.4	1.95	0.43	1.16	41.7	11.9	127	1.98	50.8	3.55	5.9	<0.1	<0.05	0.02	0.08	0.15	20.7	11	0.14	0.59	1280	1.22	0.05	1.42	17.3	0.062	87	18.9	<0.01	1.18	6.9	<1	0.8	25.1	<0.05	0.36	<0.05	9.9	0.12	0.26	3.19	81	0.3	9.88	0.9	245	2.7
Gold Ore Stockpile																																																					
TP13-48 BU-1	0.07	0.95	27	<10	335	0.4	0.09	0.28	0.59	41.1	9.1	105	2.89	10.7	3.02	3.4	<0.1	0.08	0.03	0.02	0.2	25.4	4	0.18	0.36	743	3.18	0.03	0.08	4.5	0.069	13.5	11.9	<0.01	2.16	4.9	<1	<0.3	16.7	<0.05	0.42	<0.05	14.1	0.01	0.17	1.89	40	<0.1	11.2	1.2	73	2.9
Heap Leach Facility																																																					
TP11-HLF-01	0.5	1.75	33	50	310	0.4	0.47	0.48	3.25	43.2	11.3	116	3.32	22.3	3.64	5.8	<0.1	0.06	0.03	0.08	0.19	22.3	11	0.16	0.62	1160	1.16	0.04	1.46	12.8	0.062	114	21.9	<0.01	2.02	7.1	<1	0.7	29.2	<0.05	0.4	<0.05	10.5	0.1	0.31	3.94	75	0.5	11.3	1.1	566	4
TP11-HLF-05	0.26	1.1	43	60	201	0.3	0.36	0.31	2.22	32.8	9.4	160	1.25	9.6	2.67	3.8	<0.1	<0.05	<0.01	0.04	0.14	12.4	7	0.09	0.4	1410	0.96	0.05	0.98	9.6	0.043	42.5	15.3	<0.01	0.96	3.7	<1	0.5	19.1	<0.05	0.19	<0.05	9.6	0.07	0.18	1.8	52	0.4	5.09	0.5	188	1.5
TP11-HLF-13	0.37	0.62	16	50	353	0.8	0.58	0.19	3.63	46.1	6.2	136	11.5	9.9	2.42	2.1	<0.1	0.08	0.05	0.14	0.28	25	2	0.16	0.11	1940	2.96	0.02	0.2	5.8	0.041	157	18	<0.01	1.86	3.6	<1	0.4	13.5	<0.05	0.34	<0.05	18.8	<0.01	0.42	4.31	16	0.3	9.31	1.1	481	4.2
TP11-HLF-16	0.47	0.57	8	50	367	0.7	1.1	0.21	2.3	51.7	7.4	84	8.64	16.2	2.5	2.1	<0.1	0.1	0.05	<0.02	0.26	26.2	1	0.14	0.1	2180	7.17	0.02	0.15	7.9	0.042	33.4	20.7	<0.01	2.32	3.7	<1	<0.3	11.3	<0.05	0.31	<0.05	23.3	<0.01	0.49	5.53	20	0.2	8.13	1	280	5.3
TP11-HLF-21	0.43	1.2	19	60	311	0.5	5.01	0.48	1.04	45.1	10.4	107	5.1	30.1	3.22	4.5	<0.1	0.06	0.04	0.04	0.2	21.8	8	0.14	0.45	1580	4.07	0.04	1.1	12.6	0.052	63.5	21.6	<0.01	1.88	5.7	<1	0.5	32.3	<0.05	0.34	<0.05	11.9	0.08	0.41	2.34	60	0.7	8.94	0.9	193	3.7
TP11-HLF-41	0.65	0.53	10	50	418	0.7	0.36	0.17	0.69	51.2	7.1	115	5.15	12.3	1.73	1.7	<0.1	0.17	0.08	<0.02	0.2	24.6	2	0.16	0.08	1790	3.48	0.01	0.21	6.7	0.029	111	14.6	<0.01	1.88	3.1	<1	0.4	10	<0.05	0.31	<0.05	27.1	<0.01	0.28	5.78	15	0.5	7.84	1	259	7.1
Main Power Plant																																																					
TP11-06	0.39	1.7	31	50	216	0.4	0.27	0.38	0.69	30.7	10.3	80	2.07	23.2	2.95	5.2	<0.1	<0.05	0.05	0.07	0.09	14.8	10	0.13	0.42	805	1.94	0.03	1.48	16.7	0.057	43.5	12.1	0.02	0.71	5.1	<1	0.6	24.9	<0.05	0.33	0.06	7.4	0.08	0.21	3.45	64	0.2	8.96	0.9	143	1.9
TP11-10	0.36	1.9	17	50	234	0.5	0.24	0.35	0.63	34	10.9	115	2.61	19.5	3.45	6.2	<0.1	<0.05	0.03	0.06	0.13	17.4	9	0.13	0.48	767	1.02	0.03	1.21	17.4	0.061	87	16.6	<0.01	0.94	6.7	<1	0.7	24.5	<0.05	0.35	<0.05	6.4	0.09	0.28	2.36	76	0.2	9.5	0.9	181	1
TP11-11	0.12	1.76	5	60	538	0.4	0.09	0.38	0.14	60.3	9.8	106	9.09	8.5	3.53	6.8	<0.1	0.16	0.02	0.04	0.43	34.2	12	0.25	0.63	846	0.52	0.04	1.08	6.5	0.054	13.7	41.2	<0.01	0.59	12.5	<1	1.2	20.2	<0.05	0.57	<0.05	22.8	0.13	0.46	4.28	83	0.2	15.3	1.7	82	6.3
TP11-18	0.94	1	694	40	233	0.7	0.49	0.25	9.45	45	8.9	132	3.62	21.7	3.55	3.1	<0.1	<0.05	0.1	0.79	0.24	24.7	4	0.22	0.2	1900	2.01	0.02	0.43	7.3	0.052	68.8	16	0.09	3.61	5.1	<1	0.5	26	<0.05	0.4	<0.05	16.7	0.02	0.64	5.28	34	0.3	12.2	1.4	1100	1.3
TP11-20	0.48	1.97	12	60	333	0.5	0.21	0.44	0.77	43.6	11.9	97	2.83	26.8	3.53	6.4	<0.1	0.06	0.03	0.04	0.18	22.9	11	0.19	0.6	1060	0.84	0.04	1.13	20.1	0.058	88.3	22.1	<0.01	1.29	8.3	<1	0.8	31.3	<0.05	0.46	<0.05	10.7	0.14	0.28	2.57	83	1	12.9	1.3	145	4.8
TP13-03 BU-1	50.3	1.13	73	<10	1730	0.7	5.33	0.18	10.3	37.8	9.7	105	6.09	565	4.3	3.5	<0.1	<0.05	0.2	2.57	0.29	21.4	4	0.19	0.29	5730	3.52	0.01	0.37	3.7	0.058	>10000	21.6	0.04	137	6.4	<1	2.1	26.4	<0.05	0.42	0.31	14.1	0.03	0.6	9.08	42	0.6	12.2	1.3	1810	2.3
TP13-04 BU-1	0.06	1.71	<1	<10	450	0.3	0.06	0.37	0.56	34.5	8.1	119	3.04	7.4	3.01	5.8	<0.1	0.16	0.02	0.02	0.73	19.3	12	0.15	0.77	499	2.97	0.06	0.9	2.6	0.062	9.7	52.1	<0.01	0.34	5.5	<1	1	20.4	<0.05	0.31	<0.05	15.8	0.23	0.48	1.81	78	1.2	9.7	0.9	51	3
Tailings Management Facility																																																					
TP11-TMF-01	0.31	1.54	672	50	1050	1.1	0.67	0.25	2.92	50.2	22.7	122	4.07	65.2	5	5.7	<0.1	0.06	0.58	0.04	0.26	23.5	13	0.22	0.38	2380	2.1	0.02	0.79	58.8	0.07	73.4	22.3	0.05	17.5	8.7	<1	0.9	23	<0.05	0.65	0.13	7.9	0.07	3.85	1.75	67	1	18.6	1.5	629	4.1
TP11-TMF-05	0.05	1.16	3	60	125	0.5	0.17	0.28	0.04	48.3	5.6	116	4.35	16.2	1.96	5	<0.1	0.34	0.01	<0.02	0.35	30.5	10	0.17	0.43	508	1.02	0.05	0.99	4.9	0.021	6.3	46.5	<0.01	0.28	5.2	<1	1.1	13.9	<0.05	0.3	<0.05	22.3	0.07	0.33	1.17	43	0.2	9.34	2	42	9.9
TP11-TMF-09	0.1	1.74	10	60	187	0.5	0.14	1.49	0.25	29.7	13	46	0.93	39.4	3.41	5.4	<0.1	0.17	0.02	0.03	0.12	14.6	13	0.13	0.76	580	0.84	0.06	1.89	29.8	0.087	7.9	10.2	0.01	0.46	6	<1	0.5	56.6	<0.05	0.41	<0.05	3.8	0.16	0.12	0.62	89	0.2	11.1	1	76	8.7
TP11-TMF-10	0.27	2.32	10	60	120	0.5	0.2	0.89	0.1	41.2	10.9	81	1.65	17	3.02	7.3	<0.1	0.27	0.03	0.02	0.19	23.1	13	0.14	0.64	468	1.9	0.08	1.56	12.3	0.04	8.7	22.5	<0.01	0.65	6.8	<1	0.7	43.8	<0.05	0.34	<0.05	10.7	0.17	0.21	1.45	85	1.6	9.6	0.9	58	13
TP11-TMF-12	0.04	1.6	3	60	177	0.3	0.08	0.39	0.08	24.8	8.9	97	1.89	23	2.46	5.4	<0.1	0.08	<0.01	<0.02	0.29	13.1	10	0.09	0.52	434	1.52	0.07	1.6	5.9	0.032	5.8	28	<0.01	0.31	4.6	<1	0.7	19.2	<0.05	0.2	<0.05	9.6	0.11	0.2	1.14	65	7.9	5.9	0.6	44	4.6
TP11-TMF-13	0.25	0.85	5	50	58	0.7	0.2	0.31	0.09	65.4	6.8	73	5.66	6.1	2.9	4.1	<0.1	0.27	0.02	<0.02	0.16	38.7	4	0.24	0.19	440	0.87	0.03	0.24	4.6	0.023	15.4	15.7	<0.01	1.09	6.8	<1	0.7	12	<0.05	0.49	<0.05	20	0.01	0.13	2.37	59	1.4	14	1.6	42	12.3
TP11-TMF-34	0.05	1.85	12	60	153	0.4	0.13	0.73	0.13	32.2	10.3	87	1.7	28.3	2.95	5.7	<0.1	0.15	0.03	0.02	0.16	17.2	12	0.14	0.58	519	0.78	0.07	1.86	15.3	0.038	6.8	20.3	<0.01	0.56	6.2	<1	0.7	35.5	<0.05	0.34	<0.05	8.2	0.12	0.19	1.83	72	0.3	10.1	0.9	61	8.1
TP11-TMF-94	0.6	2.15	366	50	2130	0.9	0.25	0.51	1.05	53.8	29	169	8.99	97.4	5.87	8.9	0.1	<0.05	0.42	0.06	0.49	25.3	16	0.23	1.04	1420	4.05	0.03	2.39	84.9	0.154	16.5	36	0.04	12.2	14.2	2	0.9	32.1	<0.05	0.73	0.1	5.8	0.14	5.11	2.66	162	1.2	19.9	1.6	203	4.1
TP11-TMF-99	0.07	2.03	35	60	335	1.3	0.44	0.37	0.1	84.7	12.4	143	5.03	29.4	3.87	9.3	0.2	0.15	0.02	0.05	0.52	74.8	13	0.31	0.66	658	1.99	0.05	2.28	32.3	0.053	11.3	59.4	<0.01	0.8	12.1	1	0.9	22.6	<0.05	1.19	0.06	13.1	0.15	0.57	2.66	78	0.3	26.7	2.1	93	7.1
TP11-TMF-100	0.05	1.84	5	60	150	0.4	0.14	0.74	0.11	32.4	10	95	1.71	78.7	2.9	5.7	<0.1	0.14	0.02	0.02	0.15	17.3	12	0.13	0.57	491	0.7	0.08	2.03	14.7	0.038	6.5	20	<0.01	0.41	6.2	<1	0.7	36.4	<0.05	0.33	<0.05	8.2	0.13	0.17	1.81	73	0.2	9.78	0.9	67	7.8
TP13-14 BU-1	0.28	0.99	27	<10	302	0.4	0.27	0.42	0.69	27.7	10.3	132	2.16	58.6	2.49	3.3	<0.1	<0.05	0.02	0.02	0.15	15.1	7	0.13	0.28	611	5.59	0.05	0.76	9.5	0.041	42.7	14.3	0.01	1.46	3.2	<1	0.5	34.1	<0.05	0.3	<0.05	9.9	0.04	0.22	6.04	42	1.7	8.52	0.8	88	3.4
TP13-27 BU-1	0.03	0.77	<1	<10	177	0.5	0.08	0.25	0.06	41.8	6	121	4.24	7.6	2.25	3.3	<0.1	0.3	0.04	0.02	0.19	23.4	7	0.21	0.33	618	3.89	0.03	0.41	4.5	0.065	6.9	17.5	<0.01	1.45	4.1	<1	0.5	12.1	<0.05	0.44	<0.05	17.7	0.03	0.23	2.98	35	0.4	12.3	1.3	43	9.2
TP13-28 BU-1	0.02	0.68	6	<10	191	0.7	0.11	0.23	0.06	44.1	6.5	117	14.2	11.9	2.48	2.4	<0.1	0.31	0.33	0.03	0.15	24.4	4	0.23	0.18	627	3.3	0.03	0.36	5.8	0.067	8	17.1	<0.01	1.78	6.5	<1	0.5	10.8	<0.05	0.53	<0.05	16.9	0.03	1.03	2.42	40	0.1	14.3	1.5	49	11.2
TP13-33 BU-1	0.02	1.61	<1	<10	184	0.3	0.16	0.44	0.11	33.5	9.3	119	1.57	25.1	2.45	5.2	<0.1	0.25	0.01	<0.02	0.25	19.2	9	0.13	0.58	458	3.14	0.06	0.86	9	0.042	6.6	19.5	<0.01	0.24	4.5	<1	0.6	19.8	<0.05	0.28	<0.05	9.5	0.15	0.15	0.8	65	1.2	7.08	0.7	43	7.4
Airstrip Borrow Area																																																					
TP13-76 BU-1	0.05	1.82	1	<10	353	0.3	0.06	0.41	0.05	32.9	10.3	112	1.61	9.5	3.56	6.5	<0.1	0.1	0.01	0.03	0.36	21.4	14	0.14	0.91	760	3	0.1	0.5	3.4	0.062	3.6	25.5	<0.01	0.14	9	<1	1	32.1	<0.05	0.35	<0.05	8.3	0.11	0.2	0.87	81	0.2	8.38	0.9	53	2.7
TP13-76 BU-2	0.02	2.1	1	<10	488	0.3	0.06	0.48	0.07	48.7	11.6	129	1.77	9.3	4.02	7.5	<0.1	0.15	0.02	0.04	0.75	28.6	20	0.29	1.31	837	3.27	0.13	0.43	3.1	0.069	3.8	42.8	<0.01	0.12	12.1	<1	1.3	35.8	<0.05	0.67	<0.05	13.6	0.21	0.33	0.73	104	0.1	20.2	1.8	67	2.6
TP13-77 BU-1	<0.01	1.7	<1	<10	521	0.2	0.04	0.58	0.03	37.1	9.2	111	2.2	4.6	3.3	6.2	0.1	0.11	0.02	<0.02	0.78	21.9	18	0.12	0.93	547	2.86	0.15	0.87	2.8	0.063	3.6	46.1	<0.01	0.15	5.2	<1	0.9	34.6	<0.05	0.29	<0.05	11.2	0.26	0.34	1.2	89	<0.1	8.29	0.8	51	2.1
TP13-78 BU-1	0.02	1.92	<1	<10	240	0.4	0.07	0.39	0.05	54	10.2	104	1.29	9.6	3.68	6.9	<0.1	0.08	0.02	0.03	0.29	35.5	15	0.24	0.96	766	2.71	0.07	0.53	2.7	0.05	5.1	24.2	<0.01	0.12	8.4	<1	1	28.9	<0.05	0.57	<0.05	16	0.11	0.21	1.25	81	<0.1	15.5	1.5	53	1.7
Barge Landing Access Road Borrow Areas																																																					
TP13-01 BU-0	0.09	0.83	25	<10	165	0.3	0.43	0.34	0.21	22.9	7.8	130	1.02	18.5	1.96	2.6	<0.1	0.33	0.08	<0.02	0.15	11.6	4	0.17	0.4	334	5.19	0.05	1.01	16.3	0.043	11	12.3	<0.01	1.57	2.6	<1	0.5	22.5	0.27	0.25	<0.05	7.6	0.05	0.13	0.69	36	0.6	5.2	0.6	46	6.3
TP13-01 BU-1	0.06	0.87	11	<10	119	0.3	0.18	0.39	0.2	23.5	8.9	116	0.79	22.4	2.02	2.9	<0.1	0.23	0.04	<0.02	0.16	12.7	4	0.09	0.8	408	3.81	0.05	0.49	24.4	0.037	7.7	13.8	<0.01	0.63	3	<1	0.5	22	<0.05	0.22	<0.05	11.9	0.06	0.11	0.81	33	0.4	5.59	0.6	36	5.4
TP13-01 BU-2	0.32	0.75	15	<10	186	0.3	0.45	0.4	0.44	24	9.5	187	0.86	25.5	1.89	2.4	<0.1	0.18	0.04	0.03	0.15	12.1	4	0.07	0.63	553	4.81	0.06	0.43	28.2	0.04	45.6	11.7	<0.01	1.64	3.2	<1	0.6	23	<0.05	0.2	<0.05	8.3	0.05	0.12	0.78	37	0.5	5.1	0.5	50	6.8
TP13-01 BU-3	0.13	1.03	15	<10	254	0.3	0.62	0.31	0.34	38.9	7.4	120	1.13	36.4	2.08	3	<0.1	0.21	0.04	0.02	0.2	18.1	4	0.08	0.42	554	11.3	0.05	0.52	17.5	0.045	11.5	16.5	<0.01	0.96	3.3	<1	0.5	24.7	<0.05	0.28	<0.05	11.4	0.06	0.18	1.05	41	0.6	6.25	0.6	42	8.6
TP13-84 BU-1	0.03	0.93	1	<10	647	0.3	0.1	0.37	0.04	53.1	4.2	156	2.58	4.1	2.06	4.4	<0.1	0.52	<0.01	<0.02	0.49	31	21	0.21	0.45	456	4.74	0.08	2.01	3.1	0.047	6.5	37.7	<0.01	0.15	3.7	<1	1.5	22.8	<0.05	0.49	<0.05	16.8	0.16	0.42	3.93	35	0.2	13.9	1.4	45	10

APPENDIX A.7L: Casino Geochemical Source Term Development: Appendix B



T7

Sample = HYP-PyRo Tails Whole															
Date	**Cycle**	**Volume mL**		**pH**	**Cond.**	**Acidity**	**Acidity**	**Alkalinity**	**Sulphate**	**Cl**	**F**	**Br**	**Total CN**	**WAD CN**	**Hardness**
	No.	**Input**	**Output**			**(pH 4.5)**	**(pH 8.3)**								**CaCO3**
					umhos/cm	**mgCaCO3/L**	**mgCaCO3/L**	**mgCaCO3/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
5-Mar-13	0	750	420	7.30	1829	#N/A	12.5	57.4	847	22	0.65	0.3	< 0.01	< 0.01	822
12-Mar-13	1	500	475	7.26	719	#N/A	8.5	52.4	273	4.0	0.74	< 0.3	< 0.01	< 0.01	312
19-Mar-13	2	500	450	7.33	666	#N/A	11.8	66.8	268	1.5	0.83	< 0.3	< 0.01	< 0.01	265
26-Mar-13	3	500	455	7.69	443	#N/A	7.9	61.8	138	0.5	0.73	< 0.3	< 0.01	< 0.01	185
2-Apr-13	4	500	430	7.45	376										
9-Apr-13	5	500	425	7.78	371	#N/A	6.6	69.2	106	< 0.2	0.89	< 0.3	< 0.01	< 0.01	144
16-Apr-13	6	500	440	7.45	376										
23-Apr-13	7	500	415	7.78	256	#N/A	6.4	66.2	65	0.2	0.87	< 0.3	< 0.01	< 0.01	97.7
30-Apr-13	8	500	400	7.56	271										
7-May-13	9	500	465	7.78	289	#N/A	11.4	83.7	73	0.3	0.64	< 0.3	< 0.01	< 0.01	129
14-May-13	10	500	425	7.41	266										
21-May-13	11	500	430	7.84	261	#N/A	6.3	73.3	56	0.3	0.61	< 0.3	< 0.01	< 0.01	105
28-May-13	12	500	485	7.31	242										
4-Jun-13	13	500	445	7.81	223	#N/A	6.0	76.2	40	0.3	0.52	< 0.3	< 0.01	< 0.01	101
11-Jun-13	14	500	445	7.28	212										
18-Jun-13	15	500	420	7.74	194	#N/A	7.4	70.6	31	0.6	0.46	< 0.3	#N/A	#N/A	89.8
25-Jun-13	16	500	430	7.42	189										
2-Jul-13	17	500	430	7.73	194	#N/A	10.0	80.1	27	0.4	0.40	< 0.3	#N/A	#N/A	81.9
9-Jul-13	18	500	420	7.76	185										
16-Jul-13	19	500	425	7.80	192	#N/A	5.1	71.2	22	< 1	0.33	< 0.3	#N/A	#N/A	86.7
23-Jul-13	20	500	430	7.77	161										
30-Jul-13	21	500	435	7.77	175	#N/A	6.4	70.6	21	0.3	0.32	< 0.3	#N/A	#N/A	79.0
6-Aug-13	22	500	430	7.79	166										
13-Aug-13	23	500	435	7.80	180	#N/A	5.5	70.5	14	< 1	0.29	< 0.3	#N/A	#N/A	79.4
20-Aug-13	24	500	365	7.68	178										
27-Aug-13	25	500	430	7.83	153	#N/A	3.8	63.8	13	0.4	0.22	< 0.3	#N/A	#N/A	69.7
3-Sep-13	26	500	435	7.78	146										
10-Sep-13	27	500	420	7.75	152	#N/A	4.8	62.5	11	0.3	0.24	< 0.3	#N/A	#N/A	72.4
17-Sep-13	28	500	425	7.81	159										
24-Sep-13	29	500	440	7.85	174	#N/A	3.0	65.3	13	0.4	0.21	< 0.3	#N/A	#N/A	81.9
1-Oct-13	30	500	435	7.88	171										
8-Oct-13	31	500	420	7.87	178	#N/A	2.6	68.7							

Mar 5/13 to July 30/13 As removed due to As contamination from silicon sealant.
Aug 20/13 New cell constructed using new sealant.

T7

Sample = HYP-PyRo Tails Whole															
Date	**Cycle**	**Al**	**Sb**	**As**	**Ba**	**Be**	**Bi**	**B**	**Cd**	**Ca**	**Cr**	**Co**	**Cu**	**Fe**	**Pb**
	No.														
		mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
5-Mar-13	0	0.0288	0.0014	#N/A	0.0278	< 0.00002	< 0.00001	0.0411	0.000022	304	< 0.0005	0.000304	0.0013	< 0.003	0.00018
12-Mar-13	1	0.0399	0.0012	#N/A	0.0158	< 0.00002	< 0.00001	0.0368	0.000021	113	< 0.0005	0.000082	0.0011	0.007	0.00012
19-Mar-13	2	0.0279	0.0013	#N/A	0.0209	< 0.00002	< 0.00001	0.0348	< 0.000003	93.5	< 0.0005	0.000153	0.0013	< 0.003	0.00011
26-Mar-13	3	0.0518	0.0010	#N/A	0.0174	< 0.00002	< 0.00001	0.0253	0.000024	64.8	< 0.0005	0.000225	0.0020	< 0.003	0.00007
2-Apr-13	4														
9-Apr-13	5	0.0266	0.0013	#N/A	0.0235	< 0.00002	< 0.00001	0.0246	0.000011	49.7	< 0.0005	0.000137	< 0.0005	< 0.003	0.00007
16-Apr-13	6														
23-Apr-13	7	0.0325	0.0017	#N/A	0.0303	< 0.00002	< 0.00001	0.0179	0.000012	32.9	< 0.0005	0.000058	0.0010	0.006	0.00008
30-Apr-13	8														
7-May-13	9	0.0192	0.0023	#N/A	0.0516	< 0.00002	< 0.00001	0.0163	0.000012	43.7	< 0.0005	0.000153	0.0005	< 0.003	0.00003
14-May-13	10														
21-May-13	11	0.0217	0.0028	#N/A	0.0497	< 0.00002	< 0.00001	0.0119	0.000004	35.7	< 0.0005	0.000037	0.0006	< 0.003	< 0.00002
28-May-13	12														
4-Jun-13	13	0.0201	0.0027	#N/A	0.0590	< 0.00002	< 0.00001	0.0097	0.000017	34.2	< 0.0005	0.000074	0.0139	< 0.003	< 0.00002
11-Jun-13	14														
18-Jun-13	15	0.0179	0.0032	#N/A	0.0653	< 0.00002	< 0.00001	0.0094	0.000021	30.2	< 0.0005	0.000150	< 0.0005	0.005	< 0.00002
25-Jun-13	16														
2-Jul-13	17	0.0265	0.0032	#N/A	0.0738	< 0.00002	< 0.00001	0.0082	0.000008	27.5	< 0.0005	0.000027	0.0007	< 0.003	< 0.00002
9-Jul-13	18														
16-Jul-13	19	0.0253	0.0029	#N/A	0.0821	< 0.00002	< 0.00001	0.0073	0.000011	29.1	< 0.0005	0.000047	0.0027	< 0.003	0.00003
23-Jul-13	20														
30-Jul-13	21	0.0235	0.0028	#N/A	0.0888	< 0.00002	< 0.00001	0.0077	0.000009	26.4	< 0.0005	0.000019	0.0006	< 0.003	0.00002
6-Aug-13	22														
13-Aug-13	23	0.0220	0.0027	#N/A	0.107	< 0.00002	< 0.00001	0.0064	0.000023	26.4	< 0.0005	0.000142	0.0007	0.010	0.00002
20-Aug-13	24														
27-Aug-13	25	0.0302	0.0022	#N/A	0.117	< 0.00002	< 0.00001	0.0298	< 0.000003	23.3	< 0.0005	0.000038	0.0010	< 0.003	0.00003
3-Sep-13	26														
10-Sep-13	27	0.0397	0.0021	#N/A	0.122	< 0.00002	< 0.00001	0.0164	0.000010	24.6	< 0.0005	0.000119	0.0009	0.012	0.00002
17-Sep-13	28														
24-Sep-13	29	0.0220	0.0025	#N/A	0.141	< 0.00002	< 0.00001	0.0140	0.000007	27.3	< 0.0005	0.000039	0.0009	< 0.003	0.00007
1-Oct-13	30														
8-Oct-13	31														

Mar 5/13 to July 30/13 As removed due to As contamination from silicon sealant.
Aug 20/13 New cell constructed using new sealant.

T7

Sample = HYP-PyRo Tails Whole															
Date	**Cycle**	**Li**	**Mg**	**Mn**	**Hg**	**Mo**	**Ni**	**P**	**K**	**Se**	**Si**	**Ag**	**Na**	**Sr**	**S**
	No.														
		mg/L	**mg/L**	**mg/L**	**ug/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
5-Mar-13	0	0.004	15.3	0.0685	< 0.01	0.0189	0.0015	0.346	63.7	0.00267	13.4	0.00001	33.0	1.27	318
12-Mar-13	1	0.002	7.41	0.0365	< 0.01	0.0117	0.0007	0.105	32.8	0.00116	31.4	< 0.00001	9.18	0.508	112
19-Mar-13	2	0.002	7.59	0.0248	< 0.01	0.0126	0.0004	0.076	28.6	0.00102	16.8	< 0.00001	5.93	0.461	88.6
26-Mar-13	3	0.001	5.55	0.0184	< 0.01	0.00763	0.0003	0.048	18.8	0.00059	11.5	< 0.00001	2.64	0.312	51.9
2-Apr-13	4														
9-Apr-13	5	0.001	4.89	0.0161	< 0.01	0.00982	0.0002	0.018	15.7	0.00169	9.16	< 0.00001	1.56	0.260	35.4
16-Apr-13	6														
23-Apr-13	7	0.001	3.77	0.0103	< 0.01	0.00947	0.0003	0.020	12.3	0.00035	8.02	< 0.00001	0.84	0.192	19.1
30-Apr-13	8														
7-May-13	9	0.001	4.83	0.0169	< 0.01	0.0226	< 0.0001	0.019	11.7	0.00031	7.16	< 0.00001	0.69	0.259	22.9
14-May-13	10														
21-May-13	11	0.001	3.97	0.0121	< 0.01	0.0326	< 0.0001	0.019	8.83	0.00026	6.24	< 0.00001	0.47	0.212	17.9
28-May-13	12														
4-Jun-13	13	< 0.001	3.85	0.0111	< 0.01	0.0298	0.0029	0.016	8.35	0.00035	5.88	0.00001	0.38	0.199	12.4
11-Jun-13	14														
18-Jun-13	15	0.001	3.50	0.0094	< 0.01	0.0279	0.0002	0.017	7.14	0.00054	5.91	< 0.00001	0.37	0.185	10.6
25-Jun-13	16														
2-Jul-13	17	< 0.001	3.24	0.0071	< 0.01	0.0274	0.0003	0.015	6.40	0.00026	4.09	< 0.00001	0.29	0.171	9.39
9-Jul-13	18														
16-Jul-13	19	< 0.001	3.43	0.0050	< 0.01	0.0240	0.0003	0.016	5.53	0.00031	4.64	< 0.00001	0.31	0.176	8.00
23-Jul-13	20														
30-Jul-13	21	< 0.001	3.15	0.0036	0.01	0.0190	0.0001	0.020	5.01	0.00031	4.29	< 0.00001	0.26	0.162	5.87
6-Aug-13	22														
13-Aug-13	23	< 0.001	3.27	0.0034	< 0.01	0.0169	0.0006	0.018	4.59	0.00037	4.16	< 0.00001	0.25	0.172	5.29
20-Aug-13	24														
27-Aug-13	25	< 0.001	2.82	0.0023	0.01	0.0139	0.0002	< 0.009	4.04	0.00017	1.60	< 0.00001	0.31	0.150	4.49
3-Sep-13	26														
10-Sep-13	27	< 0.001	2.95	0.0004	< 0.01	0.0155	< 0.0001	< 0.009	3.80	0.00029	1.58	< 0.00001	0.27	0.151	4.96
17-Sep-13	28														
24-Sep-13	29	< 0.001	3.36	0.0021	< 0.01	0.0220	< 0.0001	< 0.009	4.00	0.00041	1.64	< 0.00001	0.28	0.168	6.76
1-Oct-13	30														
8-Oct-13	31														

Mar 5/13 to July 30/13 As removed due to As contamination from silicon sealant.
Aug 20/13 New cell constructed using new sealant.

T7

Sample = HYP-PyRo Tails Whole													
Date	**Cycle**	**Tl**	**Sn**	**Ti**	**U**	**V**	**Zn**	**Zr**		**Major**	**Major**	**Diff**	**Diff**
	No.								**SGS File #**	**Anions**	**Cations**		**(%)**
		mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**					
5-Mar-13	0	0.00010	0.0168	0.0002	0.0431	0.00014	0.002	0.00007	CA15116-MAR13	19.45	19.54	0.09	0.2%
12-Mar-13	1	0.00005	0.0145	0.0004	0.0206	0.00014	0.001	< 0.00001	CA15226-MAR13	6.89	7.51	0.63	4.4%
19-Mar-13	2	0.00005	0.0153	0.0002	0.0263	< 0.00003	0.001	0.00001	CA15327-MAR13	7.00	6.30	-0.70	-5.3%
26-Mar-13	3	0.00003	0.0133	0.0001	0.0199	0.00015	0.001	0.00002	CA15431-MAR13	4.16	4.31	0.14	1.7%
2-Apr-13	4												
9-Apr-13	5	0.00003	0.0169	0.0001	0.0166	0.00014	< 0.001	< 0.00001	CA15189-APR13	3.64	3.37	-0.27	-3.9%
16-Apr-13	6												
23-Apr-13	7	0.00002	0.0236	0.0001	0.0112	0.00014	0.004	0.00003	CA15318-APR13	2.73	2.32	-0.41	-8.2%
30-Apr-13	8												
7-May-13	9	0.00003	0.0271	0.0001	0.0168	0.00020	0.001	< 0.00001	CA15169-MAY13	3.24	2.92	-0.32	-5.2%
14-May-13	10												
21-May-13	11	0.00003	0.0389	0.0002	0.0136	0.00018	< 0.001	0.00002	CA15297-MAY13	2.67	2.37	-0.31	-6.1%
28-May-13	12												
4-Jun-13	13	< 0.00002	0.0314	0.0001	0.0114	0.00017	< 0.001	0.00004	CA15027-JUN13	2.39	2.26	-0.13	-2.8%
11-Jun-13	14												
18-Jun-13	15	< 0.00002	0.0397	< 0.0001	0.0102	0.00017	0.001	< 0.00001	CA15260-JUN13	2.10	2.00	-0.10	-2.3%
25-Jun-13	16												
2-Jul-13	17	< 0.00002	0.0312	0.0002	0.00910	0.00027	0.001	< 0.00001	CA15072-JUL13	2.20	1.82	-0.37	-9.2%
9-Jul-13	18												
16-Jul-13	19	< 0.00002	0.0372	0.0001	0.00815	0.00018	0.002	0.00001	CA15331-JUL13	1.90	1.90	0.00	0.0%
23-Jul-13	20												
30-Jul-13	21	< 0.00002	0.0363	< 0.0001	0.00732	0.00018	< 0.001	< 0.00001	CA15571-JUL13	1.87	1.72	-0.15	-4.2%
6-Aug-13	22												
13-Aug-13	23	< 0.00002	0.04007	< 0.0001	0.00694	0.00016	0.002	< 0.00001	CA15169-AUG13	1.72	1.72	0.01	0.3%
20-Aug-13	24												
27-Aug-13	25	< 0.00002	0.0128	< 0.0001	0.00639	0.00024	< 0.001	< 0.00001	CA15350-AUG13	1.57	1.53	-0.04	-1.4%
3-Sep-13	26												
10-Sep-13	27	< 0.00002	0.00660	< 0.0001	0.00687	0.00021	0.001	< 0.00001	CA15108-SEP13	1.50	1.59	0.09	3.0%
17-Sep-13	28												
24-Sep-13	29	< 0.00002	0.00300	< 0.0001	0.00873	0.00018	< 0.001	< 0.00001	CA15308-SEP13	1.60	1.77	0.17	5.0%
1-Oct-13	30												
8-Oct-13	31												

Mar 5/13 to July 30/13 As removed due to As contamination from silicon sealant.
Aug 20/13 New cell constructed using new sealant.

Col 5

Sample = Pyrite Rougher Tails (>75 µm)																	
Date	**Cycle**	**Approxi.**	**Volume mL**		**pH**	**Cond.**	**Acidity**	**Acidity**	**Alkalinity**	**Sulphate**	**Cl**	**F**	**Br**	**Total CN**	**WAD CN**	**Hardness**	**Al**	**Sb**
	No.	**Flow Rate**	**Input**	**Output**		**umhos/cm**	**(pH 4.5)**	**(pH 8.3)**								**CaCO3**		
		(mL/min)					**mgCaCO3/L**	**mgCaCO3/L**	**mgCaCO3/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
4-May-11	1	0.5	1505	325	7.68	2297	#N/A	8.4	89.1	1224	62	< 0.06	< 0.3	< 0.01	< 0.01	1170	0.0462	0.0031
11-May-11	2	0.5	300	280	7.66	878	#N/A	5.1	82.7	363	2.5	0.06	< 0.3	< 0.01	< 0.01	313	0.0503	0.0030
18-May-11	3	0.5	300	305	#N/A	#N/A	#N/A	#N/A	#N/A	180	0.8	0.06	< 0.3	< 0.01	< 0.01	195	0.0642	0.0033
25-May-11	4	0.5	300	285	7.83	481	#N/A	5.9	81.6	131	0.6	< 0.06	< 0.3	< 0.01	< 0.01	157	0.0540	0.0033
1-Jun-11	5	0.5	300	290	7.81	436	#N/A	7.3	81.7									
8-Jun-11	6	0.5	350	300	7.66	418	#N/A	7.7	89.6	115	0.4	< 0.06	< 0.3	< 0.01	< 0.01	129	0.0521	0.0034
15-Jun-11	7	0.5	300	305	7.79	431												
22-Jun-11	8	0.5	300	305	8.01	355	#N/A	3.5	94.2	90	< 0.2	< 0.06	< 0.3	< 0.01	< 0.01	124	0.0504	0.0032
29-Jun-11	9	0.5	300	300	7.89	338												
6-Jul-11	10	0.5	300	300	7.79	330	#N/A	5.7	97.4	76	0.2	< 0.06	< 0.3	< 0.01	< 0.01	120	0.0693	0.0029
13-Jul-11	11	0.5	300	285	7.74	318												
20-Jul-11	12	0.5	300	290	7.88	310	#N/A	4.8	94.7	66	0.2	0.06	< 0.3	< 0.01	< 0.01	120	0.0404	0.0033
27-Jul-11	13	0.5	300	290	7.89	306												
3-Aug-11	14	0.5	300	190	7.79	299	#N/A	7.9	104.6	58	< 0.2	< 0.06	< 0.3	< 0.01	< 0.01	115	0.0380	0.0029
10-Aug-11	15	0.5	300	300	7.85	291												
17-Aug-11	16	0.5	300	295	7.88	292	#N/A	5.2	107.4	36	< 0.2	< 0.06	< 0.3	< 0.01	< 0.01	106	0.0379	0.0031
24-Aug-11	17	0.5	300	290	7.82	291												
31-Aug-11	18	0.5	300	300	7.88	301	#N/A	9.2	117.2	46	< 0.2	< 0.06	< 0.3	< 0.01	< 0.01	124	0.0472	0.0036
7-Sep-11	19	0.5	300	295	8.03	290												
14-Sep-11	20	0.5	300	310	7.97	282	#N/A	6.6	114.5	44	< 0.2	< 0.06	< 0.3	< 0.01	< 0.01	111	0.0391	0.0029
21-Sep-11	21	0.5	300	295	7.86	284												
28-Sep-11	22	0.5	300	295	7.92	283	#N/A	7.2	118.8	38	< 0.2	< 0.06	< 0.3	< 0.01	< 0.01	112	0.0659	0.0030
5-Oct-11	23	0.5	300	305	7.95	289												
12-Oct-11	24	0.5	300	305	8.03	288	#N/A	3.9	119.4	39	< 0.2	< 0.06	< 0.3	< 0.01	< 0.01	122	0.0331	0.0032
19-Oct-11	25	0.5	300	300	8.00	296												
26-Oct-11	26	0.5	300	300	7.94	292	#N/A	7.7	123.3	38	< 0.2	< 0.06	< 0.3	< 0.01	< 0.01	119	0.0602	0.0029
2-Nov-11	27	0.5	300	305	7.92	288												
9-Nov-11	28	0.5	300	290	7.89	290	#N/A	7.7	122.6	35	< 0.2	< 0.06	< 0.3	< 0.01	< 0.01	118	0.0436	0.0031
16-Nov-11	29	0.5	300	310	7.98	290												
23-Nov-11	30	0.5	300	300	7.94	285	#N/A	7.2	124.8	31	< 0.2	0.10	< 0.3	< 0.01	< 0.01	112	0.0643	0.0031
30-Nov-11	31	0.5	300	285	7.91	289												
7-Dec-11	32	0.5	300	305	7.95	282	#N/A	6.4	123.0	28	< 0.2	< 0.06	< 0.3	< 0.01	< 0.01	118	0.0458	0.0031
14-Dec-11	33	0.5	300	320	7.92	283												
21-Dec-11	34	0.5	300	260	7.93	279	#N/A	7.6	125.4	31	< 0.2	< 0.06	< 0.3	< 0.01	< 0.01	121	0.0762	0.0034
28-Dec-11	35	0.5	300	300	7.94	285												
4-Jan-12	36	0.5	300	295	7.91	281	#N/A	7.6	141.0	33	< 0.2	< 0.06	< 0.3	< 0.01	< 0.01	111	0.0889	0.0036
11-Jan-12	37	0.5	300	270	7.93	283												
18-Jan-12	38	0.5	300	305	7.91	282	#N/A	4.0	140.7	34	< 0.2	< 0.06	< 0.3	< 0.01	< 0.01	115	0.0567	0.0032
25-Jan-12	39	0.5	300	295	7.89	281												
1-Feb-12	40	0.5	300	290	7.89	284	#N/A	4.9	141.2	33	< 0.2	< 0.06	< 0.3	0.02	< 0.01	116	0.0570	0.0040
8-Feb-12	41	0.5	300	300	7.93	287												

Col 5

Sample = Pyrite Rougher Tails (>75 µm)																		
Date	**Cycle**	**Approxi.**	**Volume mL**		**pH**	**Cond.**	**Acidity**	**Acidity**	**Alkalinity**	**Sulphate**	**Cl**	**F**	**Br**	**Total CN**	**WAD CN**	**Hardness**	**Al**	**Sb**
	No.	**Flow Rate**	**Input**	**Output**		**umhos/cm**	**(pH 4.5)**	**(pH 8.3)**								**CaCO3**		
		(mL/min)					**mgCaCO3/L**	**mgCaCO3/L**	**mgCaCO3/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
15-Feb-12	42	0.5	300	290	7.89	285												
22-Feb-12	43	0.5	300	285	7.91	274												
29-Feb-12	44	0.5	300	300	7.89	273	#N/A	5.1	125.9	44	< 0.2	< 0.06	< 0.3	< 0.01	< 0.01	116	0.0365	0.0037
7-Mar-12	45	0.5	300	300	7.87	275												
14-Mar-12	46	0.5	300	305	7.88	279												
21-Mar-12	47	0.5	300	315	7.86	282												
28-Mar-12	48	0.5	300	340	7.91	289	#N/A	5.0	125.2	29	< 1	< 0.06	< 0.3	< 0.01	< 0.01	123	0.0555	0.0038
4-Apr-12	49	0.5	300	295	7.90	274												
11-Apr-12	50	0.5	300	290	8.01	278												
18-Apr-12	51	0.5	300	275	7.90	272												
25-Apr-12	52	0.5	300	310	7.94	277	#N/A	6.3	122.7	32	< 0.2	< 0.06	< 0.3	< 0.01	< 0.01	127	0.0686	0.0045
2-May-12	53	0.5	300	290	8.16	301												
9-May-12	54	0.5	300	290	7.99	272												
16-May-12	55	0.5	300	285	7.35	91												
23-May-12	56	0.5	300	290	7.85	269	#N/A	5.7	119.6	25	0.3	< 0.06	< 0.3	< 0.01	< 0.01	113	0.107	0.0039
30-May-12	57	0.5	300	295	7.94	274												
6-Jun-12	58	0.5	300	300	7.88	267												
13-Jun-12	59	0.5	300	295	7.86	267												
20-Jun-12	60	0.5	300	295	7.94	269	#N/A	6.1	125.7	24	< 0.2	< 0.06	< 0.3	< 0.01	< 0.01	120	0.0833	0.0041
27-Jun-12	61	0.5	300	295	7.67	273												
4-Jul-12	62	0.5	300	290	7.84	275												
11-Jul-12	63	0.5	300	290	7.95	268												
18-Jul-12	64	0.5	300	290	7.91	254	#N/A	5.3	121.7	21	< 0.2	< 0.06	< 0.3	< 0.01	< 0.01	115	0.0696	0.0042
25-Jul-12	65	0.5	300	300	7.79	262												
1-Aug-12	66	0.5	300	300	8.00	263												
8-Aug-12	67	0.5	300	295	7.96	260												
15-Aug-12	68	0.5	300	290	7.92	255	#N/A	5.4	116.9	20	< 0.2	< 0.06	< 0.3	< 0.01	< 0.01	111	0.0771	0.0044
22-Aug-12	69	0.5	300	290	7.88	255												
29-Aug-12	70	0.5	300	295	7.90	251												
5-Sep-12	71	0.5	300	300	7.91	261												
12-Sep-12	72	0.5	300	285	7.90	261	#N/A	5.4	118.2	22	< 0.2	< 0.06	< 0.3	< 0.01	< 0.01	111	0.0362	0.0043
19-Sep-12	73	0.5	300	295	7.87	257												
26-Sep-12	74	0.5	300	300	7.91	260												
3-Oct-12	75	0.5	300	295	7.91	260												
10-Oct-12	76	0.5	300	295	7.75	253	#N/A	9.5	128.1	21	< 0.2	< 0.06	< 0.3	< 0.01	< 0.01	111	0.0567	0.0048
17-Oct-12	77	0.5	300	305	7.93	260												
24-Oct-12	78	0.5	300	295	7.95	270												
31-Oct-12	79	0.5	300	300	7.98	253												
7-Nov-12	80	0.5	300	295	7.85	235	#N/A	6.5	123.1	22	< 0.2	< 0.06	< 0.3	< 0.01	< 0.01	112	0.0295	0.0044
14-Nov-12	81	0.5	300	290	7.87	253												
21-Nov-12	82	0.5	300	300	7.90	237												
28-Nov-12	83	0.5	300	295	7.81	261												
5-Dec-12	84	0.5	300	305	7.87	246	#N/A	11.6	124.7	19	< 0.2	< 0.06	< 0.3	< 0.01	< 0.01	112	0.0301	0.0046

Cell Terminated
May 18/11 Titrator malfunction, samples being repeated.
Feb, 2012 Change in analytical schedule.

Col 5

Sample = Pyrite Rougher Tails (>75 µm)																				
Date	**Cycle**	**As**	**Ba**	**Be**	**Bi**	**B**	**Cd**	**Ca**	**Cr**	**Co**	**Cu**	**Fe**	**Pb**	**Li**	**Mg**	**Mn**	**Hg**	**Mo**	**Ni**	**P**	**K**
	No.																				
		mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**ug/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
4-May-11	1	0.0049	0.0799	< 0.00002	< 0.00001	0.0735	0.00332	445	0.0011	0.0031	0.316	0.003	0.00244	< 0.001	14.8	0.109	0.03	1.10	0.0178	1.32	69.9
11-May-11	2	0.0036	0.0288	< 0.00002	0.00008	0.0663	0.00112	118	< 0.0005	0.0014	0.173	< 0.002	0.00028	< 0.001	4.30	0.0367	0.01	0.559	0.0010	0.196	33.9
18-May-11	3	0.0035	0.0266	< 0.00002	0.00004	0.0720	0.000634	72.0	0.0008	0.0008	0.138	< 0.002	0.00017	< 0.001	3.74	0.0276	0.01	0.425	0.0024	0.280	29.1
25-May-11	4	0.0035	0.0295	< 0.00002	0.00002	0.0654	0.000488	58.7	< 0.0005	0.0008	0.115	< 0.002	0.00010	< 0.001	2.44	0.0221	< 0.01	0.365	0.0029	0.276	23.8
1-Jun-11	5																				
8-Jun-11	6	0.0037	0.0281	< 0.00002	0.00002	0.0690	0.000472	48.2	< 0.0005	0.0006	0.0949	< 0.002	0.00019	< 0.001	2.21	0.0208	0.01	0.308	0.0016	0.278	21.4
15-Jun-11	7																				
22-Jun-11	8	0.0032	0.0281	< 0.00002	0.00003	0.0667	0.000386	46.2	< 0.0005	0.0004	0.0739	< 0.002	0.00014	< 0.001	2.15	0.0202	0.01	0.262	0.0001	0.174	20.4
29-Jun-11	9																				
6-Jul-11	10	0.0030	0.0326	< 0.00002	< 0.00001	0.0672	0.000318	44.6	< 0.0005	0.0005	0.0980	0.002	0.00037	< 0.001	2.16	0.0197	< 0.01	0.238	0.0011	0.141	19.7
13-Jul-11	11																				
20-Jul-11	12	0.0034	0.0382	< 0.00002	0.00001	0.0609	0.000431	44.3	< 0.0005	0.0003	0.0515	< 0.002	0.00008	< 0.001	2.20	0.0206	< 0.01	0.209	0.0015	0.125	19.2
27-Jul-11	13																				
3-Aug-11	14	0.0043	0.0384	< 0.00002	< 0.00001	0.0647	0.000229	42.7	0.0023	0.0004	0.0460	< 0.002	0.00013	< 0.001	2.13	0.0209	0.01	0.152	0.0001	0.096	18.9
10-Aug-11	15																				
17-Aug-11	16	0.0032	0.0450	< 0.00002	0.00001	0.0623	0.000183	39.0	0.0018	0.0003	0.0413	0.009	0.00008	< 0.001	2.05	0.0193	0.01	0.134	0.0002	0.098	18.1
24-Aug-11	17																				
31-Aug-11	18	0.0041	0.0516	< 0.00002	< 0.00001	0.0726	0.000190	45.7	0.0014	0.0003	0.0428	0.002	0.00019	< 0.001	2.40	0.0231	0.01	0.118	0.0016	0.070	21.4
7-Sep-11	19																				
14-Sep-11	20	0.0033	0.0507	< 0.00002	< 0.00001	0.0607	0.000172	40.8	0.0014	0.0003	0.0356	< 0.002	0.00020	< 0.001	2.22	0.0197	< 0.01	0.103	< 0.0001	0.074	18.2
21-Sep-11	21																				
28-Sep-11	22	0.0033	0.0534	< 0.00002	< 0.00001	0.0506	0.000184	41.0	0.0016	0.00036	0.0336	0.002	0.00021	< 0.001	2.28	0.0225	< 0.01	0.0927	0.0001	0.074	18.7
5-Oct-11	23																				
12-Oct-11	24	0.0037	0.0592	< 0.00002	< 0.00001	0.0556	0.000151	44.5	0.0017	0.000200	0.0321	0.002	0.00015	< 0.001	2.54	0.0239	< 0.01	0.0987	0.0011	0.086	21.0
19-Oct-11	25																				
26-Oct-11	26	0.0033	0.0635	< 0.00002	< 0.00001	0.0537	0.000127	43.4	0.0092	0.000309	0.0323	0.008	0.00010	< 0.001	2.53	0.0246	0.01	0.0842	0.0012	0.093	19.4
2-Nov-11	27																				
9-Nov-11	28	0.0033	0.0606	< 0.00002	< 0.00001	0.0434	0.000140	42.8	< 0.0005	0.000252	0.0292	< 0.003	0.00006	< 0.001	2.61	0.0287	< 0.01	0.0913	0.0018	0.091	18.1
16-Nov-11	29																				
23-Nov-11	30	0.0032	0.0610	< 0.00002	0.00001	0.0430	0.000148	40.9	< 0.0005	0.000302	0.0297	< 0.003	0.00006	< 0.001	2.45	0.0266	< 0.01	0.0852	0.0012	0.076	17.1
30-Nov-11	31																				
7-Dec-11	32	0.0032	0.0635	< 0.00002	< 0.00001	0.0410	0.000131	42.8	< 0.0005	0.000195	0.0279	< 0.003	< 0.00002	< 0.001	2.65	0.0279	0.01	0.0890	0.0003	0.087	18.1
14-Dec-11	33																				
21-Dec-11	34	0.0033	0.0647	< 0.00002	< 0.00001	0.0367	0.000103	43.8	< 0.0005	0.000212	0.0266	< 0.003	< 0.00002	< 0.001	2.75	0.0285	< 0.01	0.0748	0.0012	0.093	19.1
28-Dec-11	35																				
4-Jan-12	36	0.0033	0.0652	< 0.00002	< 0.00001	0.0379	0.000105	40.1	< 0.0005	0.000219	0.0237	< 0.003	0.00003	< 0.001	2.61	0.0278	< 0.01	0.0809	0.0020	0.071	17.4
11-Jan-12	37																				
18-Jan-12	38	0.0039	0.0655	< 0.00002	< 0.00001	0.0376	0.000097	41.7	< 0.0005	0.000301	0.0272	< 0.003	0.00004	< 0.001	2.62	0.0294	0.01	0.0732	0.0002	0.085	15.5
25-Jan-12	39																				
1-Feb-12	40	0.0033	0.0680	< 0.00002	< 0.00001	0.0314	0.000103	42.1	< 0.0005	0.000173	0.0209	< 0.003	0.00004	< 0.001	2.73	0.0311	< 0.01	0.0768	0.0008	0.081	17.1
8-Feb-12	41																				

Col 5

Sample = Pyrite Rougher Tails (>75 µm)																				
Date	**Cycle**	**As**	**Ba**	**Be**	**Bi**	**B**	**Cd**	**Ca**	**Cr**	**Co**	**Cu**	**Fe**	**Pb**	**Li**	**Mg**	**Mn**	**Hg**	**Mo**	**Ni**	**P**	**K**
	No.																				
		mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**ug/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
15-Feb-12	42																				
22-Feb-12	43																				
29-Feb-12	44	0.0034	0.0676	< 0.00002	< 0.00001	0.0254	0.000085	41.6	< 0.0005	0.0002	0.0194	< 0.003	0.00035	< 0.001	2.83	0.0317	< 0.01	0.0700	0.0004	0.079	16.2
7-Mar-12	45																				
14-Mar-12	46																				
21-Mar-12	47																				
28-Mar-12	48	0.0033	0.0717	< 0.00002	< 0.00001	0.0256	0.000075	44.3	0.0017	0.000142	0.0178	0.080	0.00032	< 0.001	3.02	0.0354	< 0.01	0.0662	0.0010	0.076	16.4
4-Apr-12	49																				
11-Apr-12	50																				
18-Apr-12	51																				
25-Apr-12	52	0.0034	0.0780	< 0.00002	< 0.00001	0.0241	0.000050	45.7	< 0.0005	0.000134	0.0173	< 0.003	0.00013	< 0.001	3.10	0.0372	0.02	0.0642	0.0006	0.077	15.8
2-May-12	53																				
9-May-12	54																				
16-May-12	55																				
23-May-12	56	0.0033	0.0707	< 0.00002	< 0.00001	0.0217	0.000040	40.7	< 0.0005	0.000140	0.0145	< 0.003	0.00004	< 0.001	2.86	0.0351	0.01	0.0634	0.0016	0.083	14.1
30-May-12	57																				
6-Jun-12	58																				
13-Jun-12	59																				
20-Jun-12	60	0.0032	0.0822	< 0.00002	< 0.00001	0.0253	0.000039	43.1	< 0.0005	0.000138	0.0139	< 0.003	0.00003	< 0.001	2.98	0.0378	< 0.01	0.0602	0.0009	0.085	12.9
27-Jun-12	61																				
4-Jul-12	62																				
11-Jul-12	63																				
18-Jul-12	64	0.0032	0.0777	< 0.00002	< 0.00001	0.0147	0.000053	41.2	< 0.0005	0.000167	0.0125	< 0.003	< 0.00002	< 0.001	2.94	0.0377	0.02	0.0588	0.0003	0.085	10.5
25-Jul-12	65																				
1-Aug-12	66																				
8-Aug-12	67																				
15-Aug-12	68	0.0028	0.0820	< 0.00002	< 0.00001	0.0138	< 0.000003	39.7	< 0.0005	0.000123	0.0113	0.004	< 0.00002	< 0.001	2.89	0.0375	0.01	0.0608	0.0004	0.071	10.6
22-Aug-12	69																				
29-Aug-12	70																				
5-Sep-12	71																				
12-Sep-12	72	0.0028	0.0808	< 0.00002	< 0.00001	0.0130	0.000076	39.8	< 0.0005	0.000101	0.0110	< 0.003	0.00006	< 0.001	2.87	0.0388	< 0.01	0.0595	0.0005	0.066	9.22
19-Sep-12	73																				
26-Sep-12	74																				
3-Oct-12	75																				
10-Oct-12	76	0.0048	0.0874	< 0.00002	< 0.00001	0.0211	0.000064	39.8	< 0.0005	0.000138	0.0115	< 0.003	0.00002	< 0.001	2.91	0.0411	< 0.01	0.0598	0.0002	0.070	9.20
17-Oct-12	77																				
24-Oct-12	78																				
31-Oct-12	79																				
7-Nov-12	80	0.0027	0.0804	< 0.00002	< 0.00001	0.0112	0.000059	39.8	< 0.0005	0.000127	0.0102	< 0.003	0.00037	< 0.001	2.98	0.0427	< 0.01	0.0580	0.0003	0.076	7.97
14-Nov-12	81																				
21-Nov-12	82																				
28-Nov-12	83																				
5-Dec-12	84	0.0031	0.0874	< 0.00002	< 0.00001	0.0116	0.000078	39.9	< 0.0005	0.000193	0.0118	< 0.003	0.00006	< 0.001	3.05	0.0433	< 0.01	0.0593	0.0004	0.073	8.39

Cell Terminated
May 18/11 Titrator malfunction, samples being repeated.
Feb, 2012 Change in analytical schedule.

Col 5

Sample = Pyrite Rougher Tails (>75 µm)																			
Date	**Cycle**	**Se**	**Si**	**Ag**	**Na**	**Sr**	**S**	**Tl**	**Sn**	**Ti**	**U**	**V**	**Zn**	**Zr**		**Major**	**Major**	**Diff**	**Diff**
	No.														**SGS File #**	**Anions**	**Cations**		**(%)**
		mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**					
4-May-11	1	0.0255	2.31	0.00061	89.7	1.52	458	< 0.0002	0.00402	0.0021	0.136	0.00128	0.039	0.00005	CA14310-MAY11	29.03	29.19	0.16	0.3%
11-May-11	2	0.00105	1.66	0.00007	35.8	0.413	129	< 0.0002	0.00220	0.0007	0.0262	0.00128	0.004	0.00003	CA14451-MAY11	9.29	8.71	-0.58	-3.2%
18-May-11	3	0.00099	1.83	0.00087	32.3	0.270	77.0	< 0.0002	0.00291	0.0006	0.0155	0.00163	0.002	0.00001	CA14792-MAY11	#N/A	6.09	#N/A	#N/A
25-May-11	4	0.00145	1.57	0.00003	19.8	0.222	56.0	< 0.0002	0.00944	0.0008	0.0131	0.00144	0.002	0.00001	CA10944-JUN11	4.38	4.63	0.25	2.8%
1-Jun-11	5																		
8-Jun-11	6	0.00034	1.61	0.00004	13.1	0.190	38.2	0.00006	0.0651	0.0006	0.0120	0.00147	0.004	0.00002	CA11140-JUN11	4.20	3.74	-0.46	-5.8%
15-Jun-11	7																		
22-Jun-11	8	0.00025	1.47	< 0.00001	7.89	0.184	30.8	0.00005	0.197	0.0005	0.0103	0.00147	0.011	0.00001	CA10468-JUN11	3.76	3.39	-0.37	-5.2%
29-Jun-11	9																		
6-Jul-11	10	0.00026	1.55	< 0.00001	4.55	0.183	25.0	0.00006	0.390	0.0004	0.00904	0.00136	0.004	< 0.00001	CA15474-JUL11	3.54	3.15	-0.38	-5.7%
13-Jul-11	11																		
20-Jul-11	12	0.00094	1.48	< 0.00001	3.30	0.186	21.8	0.00005	0.381	0.0004	0.00920	0.00150	0.002	0.00001	CA16183-JUL11	3.28	3.07	-0.21	-3.3%
27-Jul-11	13																		
3-Aug-11	14	0.00056	1.46	< 0.00001	2.38	0.180	18.2	0.00006	0.380	0.0003	0.00905	0.00135	0.002	0.00001	CA14195-AUG11	3.30	2.93	-0.36	-5.8%
10-Aug-11	15																		
17-Aug-11	16	0.00023	1.26	< 0.00001	2.21	0.166	17.4	0.00005	0.466	0.0004	0.00944	0.00131	< 0.001	0.00001	CA14769-AUG11	2.90	2.72	-0.18	-3.2%
24-Aug-11	17																		
31-Aug-11	18	0.00036	1.59	< 0.00001	1.86	0.200	16.9	0.00006	0.454	0.0004	0.00873	0.00147	0.003	0.00001	CA14272-SEP11	3.30	3.15	-0.15	-2.3%
7-Sep-11	19																		
14-Sep-11	20	0.00034	1.35	< 0.00001	1.39	0.179	14.1	0.00005	0.414	0.0004	0.00910	0.00133	0.002	0.00001	CA17319-SEP11	3.21	2.79	-0.42	-7.0%
21-Sep-11	21																		
28-Sep-11	22	0.00043	1.39	< 0.00001	1.22	0.181	13.1	0.00006	0.418	0.0003	0.00899	0.00127	0.003	0.00002	CA18914-SEP11	3.17	2.81	-0.36	-6.0%
5-Oct-11	23																		
12-Oct-11	24	0.00039	1.57	< 0.00001	1.23	0.201	13.9	0.00006	0.427	0.0003	0.00906	0.00131	0.003	0.00003	CA14526-OCT11	3.20	3.06	-0.14	-2.2%
19-Oct-11	25																		
26-Oct-11	26	0.00035	1.38	< 0.00001	1.11	0.197	13.5	0.00006	0.411	0.0003	0.00944	0.00130	0.004	0.00002	CA18601-OCT11	3.26	2.96	-0.30	-4.8%
2-Nov-11	27																		
9-Nov-11	28	0.00062	1.39	< 0.00001	1.13	0.198	11.9	0.00006	0.396	0.0005	0.00895	0.00150	0.002	< 0.00001	CA18507-NOV11	3.18	2.90	-0.28	-4.6%
16-Nov-11	29																		
23-Nov-11	30	0.00009	1.39	< 0.00001	0.83	0.188	11.2	0.00006	0.435	0.0004	0.00818	0.00184	0.003	< 0.00001	CA18847-NOV11	3.14	2.76	-0.39	-6.5%
30-Nov-11	31																		
7-Dec-11	32	0.00045	1.42	0.00005	0.83	0.197	12.4	0.00006	0.394	0.0003	0.00810	0.00147	0.002	0.00001	CA14307-DEC11	3.04	2.89	-0.15	-2.6%
14-Dec-11	33																		
21-Dec-11	34	< 0.00004	1.39	< 0.00001	0.84	0.198	12.2	0.00005	0.416	0.0006	0.00855	0.00174	0.004	< 0.00001	CA10461-DEC11	3.15	2.98	-0.18	-2.9%
28-Dec-11	35																		
4-Jan-12	36	0.00038	1.40	< 0.00001	0.75	0.193	10.8	0.00006	0.377	0.0006	0.00825	0.00178	0.002	0.00001	CA10145-JAN12	3.51	2.73	-0.77	-12.4%
11-Jan-12	37																		
18-Jan-12	38	0.00035	1.33	< 0.00001	0.74	0.190	11.0	0.00007	0.364	0.0005	0.00796	0.00175	0.002	< 0.00001	CA11259-JAN12	3.52	2.76	-0.76	-12.1%
25-Jan-12	39																		
1-Feb-12	40	0.00037	1.49	< 0.00001	0.70	0.197	11.3	0.00005	0.361	0.0003	0.00776	0.00178	0.002	< 0.00001	CA14084-FEB12	3.51	2.83	-0.68	-10.8%
8-Feb-12	41																		

Col 5

Sample = Pyrite Rougher Tails (>75 µm)																			
Date	**Cycle**	**Se**	**Si**	**Ag**	**Na**	**Sr**	**S**	**Tl**	**Sn**	**Ti**	**U**	**V**	**Zn**	**Zr**		**Major**	**Major**	**Diff**	**Diff**
	No.														**SGS File #**	**Anions**	**Cations**		**(%)**
		mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**					
15-Feb-12	42																		
22-Feb-12	43																		
29-Feb-12	44	0.00031	2.01	< 0.00001	0.70	0.197	10.3	0.00005	0.302	0.0004	0.00780	0.00155	0.003	< 0.00001	CA14028-MAR12	3.43	2.78	-0.65	-10.5%
7-Mar-12	45																		
14-Mar-12	46																		
21-Mar-12	47																		
28-Mar-12	48	0.00039	1.63	< 0.00001	0.90	0.214	10.7	0.00007	0.387	0.0003	0.00834	0.00158	0.001	< 0.00001	CA14955-MAR12	3.11	2.95	-0.16	-2.6%
4-Apr-12	49																		
11-Apr-12	50																		
18-Apr-12	51																		
25-Apr-12	52	0.00036	1.68	< 0.00001	0.66	0.222	10.6	0.00005	0.326	0.0004	0.00729	0.00205	0.003	< 0.00001	CA15000-APR12	3.12	3.00	-0.12	-1.9%
2-May-12	53																		
9-May-12	54																		
16-May-12	55																		
23-May-12	56	0.00024	1.56	< 0.00001	0.53	0.202	9.70	0.00006	0.278	0.0004	0.00763	0.00200	0.010	< 0.00001	CA14956-MAY12	2.91	2.68	-0.23	-4.1%
30-May-12	57																		
6-Jun-12	58																		
13-Jun-12	59																		
20-Jun-12	60	0.00049	1.68	< 0.00001	0.57	0.216	9.42	0.00006	0.260	0.0003	0.00763	0.00186	0.006	< 0.00001	CA15313-JUN12	3.01	2.78	-0.23	-4.0%
27-Jun-12	61																		
4-Jul-12	62																		
11-Jul-12	63																		
18-Jul-12	64	0.00039	1.53	< 0.00001	0.53	0.202	9.17	0.00004	0.251	0.0003	0.00697	0.00177	0.002	0.00004	CA15227-JUL12	2.87	2.62	-0.25	-4.6%
25-Jul-12	65																		
1-Aug-12	66																		
8-Aug-12	67																		
15-Aug-12	68	0.00045	1.52	< 0.00001	0.49	0.201	8.62	0.00005	0.210	0.0003	0.00679	0.00169	0.003	0.00002	CA15197-AUG12	2.75	2.54	-0.22	-4.1%
22-Aug-12	69																		
29-Aug-12	70																		
5-Sep-12	71																		
12-Sep-12	72	0.00032	1.49	< 0.00001	0.52	0.202	8.46	0.00006	0.196	0.0002	0.00719	0.00128	0.003	0.00010	CA15471-SEP12	2.82	2.50	-0.32	-6.0%
19-Sep-12	73																		
26-Sep-12	74																		
3-Oct-12	75																		
10-Oct-12	76	0.00035	1.65	< 0.00001	0.47	0.204	8.17	0.00005	0.194	0.0003	0.00665	0.00159	0.002	< 0.00001	CA15509-OCT12	3.00	2.51	-0.49	-8.9%
17-Oct-12	77																		
24-Oct-12	78																		
31-Oct-12	79																		
7-Nov-12	80	0.00025	1.46	< 0.00001	0.42	0.209	7.86	0.00005	0.161	0.0002	0.00544	0.00135	0.002	< 0.00001	CA15211-NOV12	2.92	2.47	-0.45	-8.3%
14-Nov-12	81																		
21-Nov-12	82																		
28-Nov-12	83																		
5-Dec-12	84	0.00030	1.48	< 0.00001	0.44	0.210	7.95	0.00005	0.140	0.0002	0.00616	0.00140	0.002	< 0.00001	CA15126-DEC12	2.89	2.50	-0.39	-7.3%

Cell Terminated
May 18/11 Titrator malfunction, samples being repeated.
Feb, 2012 Change in analytical schedule.

Col 6

Sample = HPY Pyrite Rougher Sands																	
Date	**Cycle**	**Approx.**	**Volume mL**		**pH**	**Cond.**	**Acidity**	**Acidity**	**Alkalinity**	**Sulphate**	**Cl**	**F**	**Br**	**Hardness**	**Al**	**Sb**	**As**
	No.	**Flow Rate**	**Input**	**Output**			**(pH 4.5)**	**(pH 8.3)**						**CaCO3**			
		(mL/min)				**umhos/cm**	**mgCaCO3/L**	**mgCaCO3/L**	**mgCaCO3/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
19-Dec-12	1	1.0	300	220	7.66	2145	#N/A	11.1	154.2	1177	42	0.52	< 0.3	1300	0.0328	0.0030	0.0033
26-Dec-12	2	1.0	300	330	7.72	896	#N/A	9.9	116.2	276	5.3	0.65	< 0.3	409	0.0228	0.0029	0.0025
2-Jan-13	3	1.0	300	275	7.73	745	#N/A	8.7	107.6	270	1.6	0.67	< 0.3	319	0.0363	0.0030	0.0023
9-Jan-13	4	1.0	300	300	7.74	753	#N/A	11.3	109.4	309	0.8	0.64	< 0.3	351	0.0306	0.0034	0.0023
16-Jan-13	5	1.0	300	295	7.83	744											
23-Jan-13	6	1.0	300	300	7.71	715	#N/A	12.2	114.6	288	0.6	0.60	< 0.3	319	0.0344	0.0068	0.0024
30-Jan-13	7	1.0	300	300	7.81	646											
6-Feb-13	8	1.0	300	270	7.75	584	#N/A	10.1	114.0	159	1.0	0.66	< 0.3	242	0.0120	0.0119	0.0029
13-Feb-13	9	1.0	300	295	7.71	476											
20-Feb-13	10	1.0	300	290	7.83	431	#N/A	7.9	133.6	102	0.9	0.77	< 0.3	213	0.0151	0.0150	0.0029
27-Feb-13	11	1.0	300	295	7.79	391											
6-Mar-13	12	1.0	300	300	7.64	380	#N/A	8.2	129.6	65	0.8	0.80	< 0.3	170	0.0138	0.0212	0.0033
13-Mar-13	13	1.0	300	295	7.86	336											
20-Mar-13	14	1.0	300	305	7.98	319	#N/A	8.1	117.1	61	0.8	0.75	< 0.3	152	0.0103	0.0205	0.0040
27-Mar-13	15	1.0	300	295	7.96	318											
3-Apr-13	16	1.0	300	290	7.86	313	#N/A	9.1	116.6	46	0.8	0.71	< 0.3	150	0.0141	0.0205	0.0030
10-Apr-13	17	1.0	300	290	7.92	301											
17-Apr-13	18	1.0	300	290	7.63	301	#N/A	#N/A	92.1	52	0.7	0.65	< 0.3	139	0.0159	0.0218	0.0033
24-Apr-13	19	1.0	300	300	7.83	296											
1-May-13	20	1.0	300	295	7.88	284	#N/A	8.6	113.8	49	0.6	0.58	< 0.3	133	0.0118	0.0182	0.0027
8-May-13	21	1.0	300	300	7.71	275											
15-May-13	22	1.0	300	300	7.76	248	#N/A	11.2	114.1	39	0.7	0.52	< 0.3	133	0.0132	0.0188	0.0027
22-May-13	23	1.0	300	300	7.82	258											
29-May-13	24	1.0	300	300	7.82	262	#N/A	9.6	113.0	33	0.6	0.47	< 0.3	121	0.0136	0.0170	0.0025
5-Jun-13	25	1.0	300	295	7.76	268											
12-Jun-13	26	1.0	300	295	7.70	260	#N/A	13.7	112.9	29	0.6	0.45	< 0.3	116	0.0082	0.0167	0.0025
19-Jun-13	27	1.0	300	295	7.75	275											
26-Jun-13	28	1.0	300	295	7.85	272	#N/A	6.3	105.8	30	0.7	0.42	< 0.3	124	0.0109	0.0153	0.0023
3-Jul-13	29	1.0	300	305	7.80	261											
10-Jul-13	30	1.0	300	300	7.69	259	#N/A	12.6	111.9	31	0.7	0.39	< 0.3	128	0.0124	0.0152	0.0024
17-Jul-13	31	1.0	300	295	7.80	261											
24-Jul-13	32	1.0	300	305	7.65	261	#N/A	13.2	106.4	28	0.7	0.37	< 0.3	122	0.0107	0.0136	0.0021
31-Jul-13	33	1.0	300	300	7.75	267											
7-Aug-13	34	1.0	300	300	7.67	268	#N/A	12.2	105.8	32	0.6	0.33	< 0.3	118	0.0099	0.0137	0.0021
14-Aug-13	35	1.0	300	300	7.80	273											
21-Aug-13	36	1.0	300	295	7.69	275	#N/A	10.7	102.4	27	0.6	0.34	< 0.3	124	0.0128	0.0132	0.0019
28-Aug-13	37	1.0	300	295	7.88	253											
4-Sep-13	38	1.0	300	295	7.78	249	#N/A	7.9	102.5	25	0.6	0.29	< 0.3	126	0.0097	0.0116	0.0017
11-Sep-13	39	1.0	300	305	7.81	250											
18-Sep-13	40	1.0	300	300	7.79	258	#N/A	8.8	103.4	27	0.6	0.33	< 0.3	126	0.0418	0.0122	0.0020
25-Sep-13	41	1.0	300	300	8.06	259											
2-Oct-13	42	1.0	300	295	7.93	259	#N/A	5.0	105.4								
9-Oct-13	43	1.0	300	295	7.93	257											

Apr 17/13. Acidity 33.1 Suspect instrumental error, not repeated.

Col 6

Sample = HPY Pyrite Rougher Sands																		
Date	**Cycle**	**Ba**	**Be**	**Bi**	**B**	**Cd**	**Ca**	**Cr**	**Co**	**Cu**	**Fe**	**Pb**	**Li**	**Mg**	**Mn**	**Hg**	**Mo**	**Ni**
	No.																	
		mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**ug/L**	**mg/L**	**mg/L**
19-Dec-12	1	0.0550	< 0.00002	< 0.00001	0.0354	0.000406	457	< 0.0005	0.000475	0.0063	< 0.003	0.00162	0.002	39.8	0.194	< 0.01	0.0482	0.0007
26-Dec-12	2	0.0253	< 0.00002	< 0.00001	0.0398	0.000173	141	< 0.0005	0.000218	0.0018	< 0.003	0.00047	0.001	13.8	0.0640	< 0.01	0.0329	0.0014
2-Jan-13	3	0.0292	< 0.00002	< 0.00001	0.0320	0.000123	111	< 0.0005	0.000192	0.0011	0.005	0.00028	0.001	10.1	0.0574	< 0.01	0.0258	0.0009
9-Jan-13	4	0.0349	< 0.00002	< 0.00001	0.0332	0.000125	122	< 0.0005	0.000232	0.0024	< 0.003	0.00020	0.001	11.0	0.0675	< 0.01	0.0253	0.0018
16-Jan-13	5																	
23-Jan-13	6	0.0329	< 0.00002	0.00001	0.0282	0.000162	111	< 0.0005	0.000313	0.0027	< 0.003	0.00018	0.001	10.2	0.0749	< 0.01	0.0351	0.0032
30-Jan-13	7																	
6-Feb-13	8	0.0332	< 0.00002	< 0.00001	0.0303	0.000138	83.1	< 0.0005	0.000270	0.0030	0.004	0.00021	0.001	8.50	0.0709	< 0.01	0.0553	0.0009
13-Feb-13	9																	
20-Feb-13	10	0.0304	< 0.00002	< 0.00001	0.0231	0.000124	74.6	< 0.0005	0.000185	0.0048	< 0.003	0.00014	0.001	6.48	0.0601	< 0.01	0.0800	0.0004
27-Feb-13	11																	
6-Mar-13	12	0.0377	< 0.00002	< 0.00001	0.0204	0.000135	58.5	< 0.0005	0.000248	0.0032	< 0.003	0.00014	0.001	5.72	0.0587	< 0.01	0.119	0.0004
13-Mar-13	13																	
20-Mar-13	14	0.0440	< 0.00002	< 0.00001	0.0146	0.000119	52.2	< 0.0005	0.000236	0.0035	< 0.003	0.00011	0.001	5.21	0.0556	< 0.01	0.137	0.0002
27-Mar-13	15																	
3-Apr-13	16	0.0495	< 0.00002	< 0.00001	0.0138	0.000122	51.7	< 0.0005	0.000227	0.0035	< 0.003	0.00011	0.001	5.09	0.0553	< 0.01	0.131	0.0003
10-Apr-13	17																	
17-Apr-13	18	0.0576	< 0.00002	< 0.00001	0.0174	0.000111	47.2	< 0.0005	0.000527	0.0040	< 0.003	0.00012	0.001	5.02	0.0537	< 0.01	0.143	0.0005
24-Apr-13	19																	
1-May-13	20	0.0511	< 0.00002	< 0.00001	0.0178	0.000093	45.5	< 0.0005	0.000221	0.0039	< 0.003	0.00006	0.001	4.70	0.0529	< 0.01	0.121	0.0004
8-May-13	21																	
15-May-13	22	0.0627	< 0.00002	< 0.00001	0.0157	0.000135	45.5	< 0.0005	0.000182	0.0038	< 0.003	0.00036	0.001	4.62	0.0520	< 0.01	0.0878	0.0005
22-May-13	23																	
29-May-13	24	0.0668	< 0.00002	< 0.00001	0.0120	0.000103	40.9	< 0.0005	0.000157	0.0060	0.011	0.00019	0.001	4.53	0.0548	< 0.01	0.0774	0.0010
5-Jun-13	25																	
12-Jun-13	26	0.0721	< 0.00002	< 0.00001	0.0090	0.000098	39.5	< 0.0005	0.000168	0.0046	< 0.003	0.00005	0.001	4.19	0.0457	< 0.01	0.0655	0.0003
19-Jun-13	27																	
26-Jun-13	28	0.0747	< 0.00002	< 0.00001	0.0102	0.000071	42.1	< 0.0005	0.000168	0.0042	< 0.003	0.00020	0.001	4.50	0.0514	< 0.01	0.0580	0.0004
3-Jul-13	29																	
10-Jul-13	30	0.0801	< 0.00002	< 0.00001	0.0106	0.000103	43.4	< 0.0005	0.000261	0.0046	< 0.003	0.00004	0.001	4.67	0.0543	< 0.01	0.0546	0.0006
17-Jul-13	31																	
24-Jul-13	32	0.0762	< 0.00002	< 0.00001	0.0124	0.000100	41.3	< 0.0005	0.000178	0.0043	< 0.003	0.00006	0.001	4.52	0.0534	< 0.01	0.0506	0.0006
31-Jul-13	33																	
7-Aug-13	34	0.0807	< 0.00002	< 0.00001	0.0103	0.000096	40.1	< 0.0005	0.000190	0.0045	< 0.003	0.00005	0.001	4.30	0.0512	< 0.01	0.0488	0.0009
14-Aug-13	35																	
21-Aug-13	36	0.0768	< 0.00002	< 0.00001	0.0146	0.000119	41.6	< 0.0005	0.000160	0.0048	0.087	0.00003	0.001	4.79	0.0520	< 0.01	0.0455	< 0.0001
28-Aug-13	37																	
4-Sep-13	38	0.0781	< 0.00002	< 0.00001	0.0194	0.000102	42.6	< 0.0005	0.000171	0.0049	< 0.003	0.00007	0.001	4.70	0.0563	< 0.01	0.0389	0.0006
11-Sep-13	39																	
18-Sep-13	40	0.0832	< 0.00002	< 0.00001	0.0176	0.000080	42.5	< 0.0005	0.000255	0.0045	< 0.003	0.00005	0.001	4.79	0.0512	< 0.01	0.0378	0.0003
25-Sep-13	41																	
2-Oct-13	42																	
9-Oct-13	43																	

Apr 17/13. Acidity 33.1 Suspect instrumental error, not repeated.

Col 6

Sample = HPY Pyrite Rougher Sands																					
Date	**Cycle**	**P**	**K**	**Se**	**Si**	**Ag**	**Na**	**Sr**	**S**	**Tl**	**Sn**	**Ti**	**U**	**V**	**Zn**	**Zr**		**Major**	**Major**	**Diff**	**Diff**
	No.																**SGS File #**	**Anions**	**Cations**		**(%)**
		mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**					
19-Dec-12	1	0.235	38.5	0.00316	3.11	0.00007	46.7	1.76	414	0.00005	0.00042	0.0005	0.254	0.00089	0.004	0.00010	CA15305-DEC12	28.82	29.13	0.32	0.5%
26-Dec-12	2	0.135	20.3	0.00081	2.73	0.00002	16.2	0.748	120	0.00003	0.00026	0.0002	0.0851	0.00061	0.002	0.00002	CA15366-DEC12	8.26	9.41	1.16	6.5%
2-Jan-13	3	0.112	17.7	0.00044	3.02	0.00008	9.76	0.621	91.6	0.00003	0.00038	0.0005	0.0773	0.00085	0.003	0.00003	CA15062-JAN13	7.86	7.27	-0.58	-3.9%
9-Jan-13	4	0.092	19.0	0.00052	2.73	< 0.00001	6.78	0.692	82.5	0.00003	0.00031	0.0003	0.0838	0.00081	0.002	0.00004	CA15248-JAN13	8.68	7.80	-0.88	-5.3%
16-Jan-13	5																				
23-Jan-13	6	0.086	17.1	0.00049	2.95	0.00013	2.85	0.676	86.8	0.00003	0.00062	0.0005	0.0780	0.00076	0.002	0.00006	CA15419-JAN13	8.34	6.97	-1.37	-9.0%
30-Jan-13	7																				
6-Feb-13	8	0.064	15.1	0.00058	3.22	< 0.00001	1.70	0.591	60.6	0.00003	0.00105	0.0002	0.0728	0.00049	0.002	0.00005	CA15098-FEB13	5.66	5.33	-0.33	-3.0%
13-Feb-13	9																				
20-Feb-13	10	0.083	13.4	0.00070	3.03	< 0.00001	1.26	0.470	36.9	0.00003	0.00179	0.0002	0.0466	0.00058	0.004	0.00005	CA15261-FEB13	4.86	4.67	-0.19	-2.0%
27-Feb-13	11																				
6-Mar-13	12	0.072	11.5	0.00087	3.13	< 0.00001	0.88	0.426	25.6	0.00003	0.00242	< 0.0001	0.0371	0.00058	< 0.001	0.00006	CA15116-MAR13	4.01	3.74	-0.27	-3.5%
13-Mar-13	13																				
20-Mar-13	14	0.070	11.5	0.00081	2.98	< 0.00001	0.80	0.393	20.0	0.00003	0.00329	0.0001	0.0328	0.00031	0.001	0.00002	CA15327-MAR13	3.68	3.38	-0.30	-4.2%
27-Mar-13	15																				
3-Apr-13	16	0.070	11.3	0.00052	3.08	< 0.00001	0.66	0.392	17.5	0.00003	0.00445	0.0001	0.0290	0.00046	< 0.001	0.00002	CA15081-APR13	3.35	3.33	-0.02	-0.3%
10-Apr-13	17																				
17-Apr-13	18	0.075	11.1	0.00079	3.13	< 0.00001	0.62	0.391	16.1	0.00003	0.00546	0.0001	0.0327	0.00054	0.002	< 0.00001	CA15252-APR13	2.98	3.10	0.12	1.9%
24-Apr-13	19																				
1-May-13	20	0.058	9.66	0.00072	3.00	< 0.00001	0.56	0.364	13.8	0.00002	0.00620	0.0001	0.0260	0.00059	0.001	0.00001	CA15086-MAY13	3.34	2.94	-0.40	-6.4%
8-May-13	21																				
15-May-13	22	0.062	9.66	0.00078	2.90	< 0.00001	0.47	0.354	12.1	0.00003	0.00783	0.0001	0.0260	0.00051	0.002	< 0.00001	CA15254-MAY13	3.14	2.93	-0.21	-3.4%
22-May-13	23																				
29-May-13	24	0.060	9.00	0.00063	2.78	< 0.00001	0.45	0.349	10.7	0.00002	0.00923	0.0003	0.0229	0.00050	0.002	0.00001	CA15422-MAY13	2.99	2.68	-0.31	-5.5%
5-Jun-13	25																				
12-Jun-13	26	0.060	7.93	0.00069	2.73	< 0.00001	0.38	0.320	9.08	0.00003	0.00942	< 0.0001	0.0224	0.00046	0.004	< 0.00001	CA15169-JUN13	2.90	2.55	-0.36	-6.5%
19-Jun-13	27																				
26-Jun-13	28	0.057	8.25	0.00080	2.90	< 0.00001	0.40	0.347	10.6	0.00002	0.00971	< 0.0001	0.0202	0.00045	< 0.001	< 0.00001	CA15012-JUL13	2.78	2.71	-0.07	-1.3%
3-Jul-13	29																				
10-Jul-13	30	0.052	8.20	0.00078	2.97	< 0.00001	0.38	0.358	10.6	0.00003	0.0104	< 0.0001	0.0227	0.00048	0.002	0.00002	CA15234-JUL13	2.92	2.79	-0.13	-2.3%
17-Jul-13	31																				
24-Jul-13	32	0.054	7.50	0.00087	2.84	< 0.00001	0.34	0.345	10.1	0.00002	0.00943	0.0001	0.0225	0.00050	0.002	0.00002	CA15472-JUL13	2.75	2.65	-0.10	-1.8%
31-Jul-13	33																				
7-Aug-13	34	0.038	7.10	0.00098	2.84	< 0.00001	0.34	0.335	9.60	0.00002	0.00854	< 0.0001	0.0236	0.00036	< 0.001	< 0.00001	CA15097-AUG13	2.82	2.56	-0.25	-4.7%
14-Aug-13	35																				
21-Aug-13	36	0.051	6.12	0.00085	2.72	0.00001	0.43	0.388	9.84	0.00003	0.00768	< 0.0001	0.0222	0.00054	0.001	0.00001	CA15287-AUG13	2.64	2.66	0.02	0.3%
28-Aug-13	37																				
4-Sep-13	38	0.057	6.70	0.00080	2.90	< 0.00001	0.32	0.358	9.75	0.00002	0.00646	< 0.0001	0.0209	0.00043	0.002	0.00001	CA15053-SEP13	2.60	2.71	0.11	2.1%
11-Sep-13	39																				
18-Sep-13	40	0.050	6.44	0.00091	2.77	< 0.00001	0.37	0.349	9.72	< 0.00002	0.00701	< 0.0001	0.0230	0.00041	0.001	< 0.00001	CA15265-SEP13	2.66	2.72	0.05	0.9%
25-Sep-13	41																				
2-Oct-13	42																				
9-Oct-13	43																				

Apr 17/13. Acidity 33.1 Suspect instrumental error, not repeated.

Col 7

Sample = CL-01 L Residue															
Date	**Cycle**	**Approx.**	**Volume mL**		**pH**	**Cond.**	**Acidity**	**Acidity**	**Alkalinity**	**Sulphate**	**Total CN**	**WAD CN**	**SCN**	**CNO**	**Nitrate**
	No.	**Flow Rate**	**Input**	**Output**			**(pH 4.5)**	**(pH 8.3)**							
		(mL/min)				**umhos/cm**	**mgCaCO3/L**	**mgCaCO3/L**	**mgCaCO3/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
20-Mar-13	1	1.0	470	490	7.51	3710	#N/A	17.1	69.2	2010	0.13	< 0.01	< 2	< 1	60.8
27-Mar-13	2	1.0	470	480	7.58	3765	#N/A	13.7	65.3	1851	0.15	0.02	< 1	< 2	60.8
3-Apr-13	3	1.0	495	475	7.55	3257	#N/A	15.7	61.8	1428	0.12	0.02	< 2	< 1	36.4
10-Apr-13	4	1.0	470	480	7.57	2729	#N/A	12.2	53.1	1716	0.06	< 0.01	< 2	< 1	20.1
17-Apr-13	5	1.0	470	560	7.56	2183									
24-Apr-13	6	1.0	470	460	7.65	1943	#N/A	12.4	52.3	991	0.11	< 0.01	< 1	< 2	6.28
1-May-13	7	1.0	470	460	7.59	1789									
8-May-13	8	1.0	470	485	7.60	1513	#N/A	15.4	48.2	1011	0.03	< 0.01	< 2	< 1	2.87
15-May-13	9	1.0	470	520	7.55	1335									
22-May-13	10	1.0	470	520	7.62	1302	#N/A	11.5	48.6	779	0.03	< 0.01	< 2	< 1	1.59
29-May-13	11	1.0	470	490	7.62	1396									
5-Jun-13	12	1.0	470	490	7.58	1206	#N/A	11.6	51.4	704	0.03	#N/A	#N/A	#N/A	1.06
12-Jun-13	13	1.0	470	490	7.71	1182									
19-Jun-13	14	1.0	470	520	7.58	1202	#N/A	9.6	46.9	583	0.02	#N/A	#N/A	#N/A	< 0.6
26-Jun-13	15	1.0	470	520	7.66	1068									
3-Jul-13	16	1.0	470	455	7.61	978	#N/A	10.9	48.4	506	0.02	#N/A	#N/A	#N/A	1.16
10-Jul-13	17	1.0	470	495	7.69	908									
17-Jul-13	18	1.0	470	495	7.30	854	#N/A	9.0	43.3	433	0.02	#N/A	#N/A	#N/A	1.17
24-Jul-13	19	1.0	470	515	7.66	790									
31-Jul-13	20	1.0	470	495	7.66	728	#N/A	9.2	46.3	294	0.01	#N/A	#N/A	#N/A	0.77
7-Aug-13	21	1.0	470	490	7.63	716									
14-Aug-13	22	1.0	470	490	7.64	702	#N/A	7.8	43.7	312	0.02	#N/A	#N/A	#N/A	0.56
21-Aug-13	23	1.0	470	500	7.65	696									
28-Aug-13	24	1.0	470	490	7.70	630	#N/A	5.7	43.0	251	0.02	#N/A	#N/A	#N/A	0.43
4-Sep-13	25	1.0	470	480	7.70	606									
11-Sep-13	26	1.0	470	495	7.68	581	#N/A	7.4	48.2	251	0.01	#N/A	#N/A	#N/A	0.27
18-Sep-13	27	1.0	470	500	7.71	537									
25-Sep-13	28	1.0	470	495	7.79	561	#N/A	4.1	46.8	212	0.02	#N/A	#N/A	#N/A	0.20
2-Oct-13	29	1.0	470	500	7.78	537									
9-Oct-13	30	1.0	470	475	7.75	518	#N/A	7.2	49.7						

May 22/13 Change in analytical schedule

Col 7

Sample = CL-01 L Residue																
Date	**Cycle**	**Nitrite**	**Ammonia**	**Cl**	**F**	**Br**	**Hardness**	**Al**	**Sb**	**As**	**Ba**	**Be**	**Bi**	**B**	**Cd**	**Ca**
	No.						**CaCO3**									
		mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
20-Mar-13	1	0.90	< 0.1	130	0.52	< 0.3	1270	0.0046	0.0076	0.0094	0.0117	< 0.00002	< 0.00001	0.0845	0.000433	476
27-Mar-13	2	0.12	0.1	130	0.55	< 0.3	1310	0.0072	0.0091	0.0089	0.0113	< 0.00002	< 0.00001	0.0858	0.000035	490
3-Apr-13	3	< 0.3	< 0.1	80	0.61	< 3	1210	0.0062	0.0096	0.0091	0.0111	< 0.00002	< 0.00001	0.0634	0.000063	455
10-Apr-13	4	< 0.3	< 0.1	43	0.60	< 3	1040	0.0052	0.0079	0.0077	0.00966	< 0.00002	0.00001	0.0579	0.000060	390
17-Apr-13	5															
24-Apr-13	6	< 0.3	0.1	19	0.58	< 3	742	0.0066	0.0068	0.0084	0.00946	< 0.00002	< 0.00001	0.0415	0.000068	279
1-May-13	7															
8-May-13	8	< 0.3	< 0.1	11	0.54	< 3	614	0.0077	0.0055	0.0073	0.00906	< 0.00002	< 0.00001	0.0360	0.000043	232
15-May-13	9															
22-May-13	10	< 0.3	< 0.1	6.3	0.55	< 3	590	0.0067	0.0059	0.0075	0.0110	< 0.00002	< 0.00001	0.0270	0.000035	223
29-May-13	11															
5-Jun-13	12	#N/A	#N/A	4.6	0.52	< 3	536	0.0056	0.0051	0.0076	0.0101	< 0.00002	< 0.00001	0.0289	0.000178	203
12-Jun-13	13															
19-Jun-13	14	#N/A	#N/A	4.3	0.53	< 3	509	0.0061	0.0050	0.0074	0.0102	< 0.00002	< 0.00001	0.0326	0.000015	194
26-Jun-13	15															
3-Jul-13	16	#N/A	#N/A	3.0	0.46	< 3	428	0.0073	0.0048	0.0074	0.00928	< 0.00002	< 0.00001	0.0268	0.000036	163
10-Jul-13	17															
17-Jul-13	18	#N/A	#N/A	2.7	0.44	< 3	354	0.0111	0.0048	0.0085	0.00989	< 0.00002	< 0.00001	0.0189	0.000028	135
24-Jul-13	19															
31-Jul-13	20	#N/A	#N/A	2.0	0.46	< 0.3	309	0.0108	0.0042	0.0074	0.00939	< 0.00002	< 0.00001	0.0276	0.000030	118
7-Aug-13	21															
14-Aug-13	22	#N/A	#N/A	1.9	0.47	< 0.3	285	0.0112	0.0043	0.0063	0.00978	< 0.00002	< 0.00001	0.0223	0.000065	109
21-Aug-13	23															
28-Aug-13	24	#N/A	#N/A	1.6	0.49	< 0.3	266	0.0098	0.0045	0.0079	0.0108	< 0.00002	< 0.00001	0.0261	0.000032	102
4-Sep-13	25															
11-Sep-13	26	#N/A	#N/A	1.7	0.55	< 0.3	251	0.0089	0.0047	0.0081	0.0111	< 0.00002	< 0.00001	0.0232	0.000033	96.8
18-Sep-13	27															
25-Sep-13	28	#N/A	#N/A	1.4	0.53	< 0.3	242	0.0103	0.0052	0.0089	0.0136	< 0.00002	< 0.00001	0.0245	0.000031	92.8
2-Oct-13	29															
9-Oct-13	30															

May 22/13 Change in analytical schedule

Col 7

Sample = CL-01 L Residue																	
Date	**Cycle**	**Cr**	**Co**	**Cu**	**Fe**	**Pb**	**Li**	**Mg**	**Mn**	**Hg**	**Mo**	**Ni**	**P**	**K**	**Se**	**Si**	**Ag**
	No.																
		mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**ug/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
20-Mar-13	1	0.0008	0.390	0.0213	0.014	0.00005	0.003	20.8	0.0210	0.01	1.90	0.0019	< 0.009	8.89	0.0581	16.7	< 0.00001
27-Mar-13	2	< 0.0005	0.404	0.0211	0.014	0.00008	0.003	21.8	0.0189	0.02	2.10	0.0020	< 0.009	7.94	0.0529	19.5	0.00001
3-Apr-13	3	< 0.0005	0.272	0.0178	0.005	0.00007	0.002	19.2	0.0183	< 0.01	1.88	0.0015	< 0.009	8.15	0.0382	19.9	< 0.00001
10-Apr-13	4	< 0.0005	0.178	0.0133	0.005	0.00008	0.002	16.3	0.0142	< 0.01	1.42	0.0011	< 0.009	6.00	0.0259	20.3	< 0.00001
17-Apr-13	5																
24-Apr-13	6	< 0.0005	0.111	0.0093	< 0.003	0.00007	0.002	10.8	0.0094	< 0.01	1.16	0.0020	0.017	4.18	0.0128	17.8	0.00001
1-May-13	7																
8-May-13	8	< 0.0005	0.0696	0.0151	< 0.003	0.00002	0.001	8.66	0.0069	< 0.01	0.831	0.0013	0.018	3.21	0.00860	15.9	0.00002
15-May-13	9																
22-May-13	10	< 0.0005	0.0577	0.0054	< 0.003	< 0.00002	0.001	8.12	0.0055	< 0.01	0.697	0.0016	0.025	2.52	0.00638	16.2	< 0.00001
29-May-13	11																
5-Jun-13	12	0.0007	0.0482	0.0041	0.006	0.00004	0.001	7.03	0.0045	< 0.01	0.654	0.0021	0.013	2.08	0.00445	15.6	0.00006
12-Jun-13	13																
19-Jun-13	14	< 0.0005	0.0452	0.0049	< 0.003	< 0.00002	0.001	6.35	0.0046	< 0.01	0.663	0.0012	0.015	1.95	0.00526	17.4	0.00002
26-Jun-13	15																
3-Jul-13	16	< 0.0005	0.0367	0.0057	< 0.003	0.00013	< 0.001	5.06	0.0039	< 0.01	0.560	0.0016	0.031	1.62	0.00401	15.3	0.00002
10-Jul-13	17																
17-Jul-13	18	< 0.0005	0.0373	0.0042	< 0.003	0.00004	< 0.001	4.17	0.0030	< 0.01	0.622	0.0005	0.009	1.18	0.00294	14.9	0.00007
24-Jul-13	19																
31-Jul-13	20	< 0.0005	0.0311	0.0046	< 0.003	0.00004	< 0.001	3.43	0.0029	< 0.01	0.540	0.0015	0.015	1.26	0.00229	16.1	0.00002
7-Aug-13	21																
14-Aug-13	22	< 0.0005	0.0285	0.0052	< 0.003	0.00065	< 0.001	3.13	0.0030	< 0.01	0.469	0.0024	0.020	1.20	0.00195	15.7	< 0.00001
21-Aug-13	23																
28-Aug-13	24	< 0.0005	0.0272	0.0060	< 0.003	< 0.00002	< 0.001	2.77	0.0031	< 0.01	0.490	0.0004	0.018	1.10	0.00185	15.4	< 0.00001
4-Sep-13	25																
11-Sep-13	26	< 0.0005	0.0138	0.0032	< 0.003	< 0.00002	< 0.001	2.60	0.0026	< 0.01	0.484	< 0.0001	0.012	1.08	0.00148	16.6	< 0.00001
18-Sep-13	27																
25-Sep-13	28	< 0.0005	0.0190	0.0032	< 0.003	0.00034	< 0.001	2.50	0.0027	< 0.01	0.523	0.0011	0.011	1.10	0.00143	17.0	< 0.00001
2-Oct-13	29																
9-Oct-13	30																

May 22/13 Change in analytical schedule

Col 7

Sample = CL-01 L Residue																
Date	**Cycle**	**Na**	**Sr**	**S**	**Tl**	**Sn**	**Ti**	**U**	**V**	**Zn**	**Zr**		**Major**	**Major**	**Diff**	**Diff**
	No.											**SGS File #**	**Anions**	**Cations**		**(%)**
		mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**					
20-Mar-13	1	416	0.256	625	0.00010	0.00012	0.0005	0.0207	0.00041	0.003	0.00004	CA15325-MAR13	46.95	43.87	3.08	3.4%
27-Mar-13	2	429	0.260	623	0.00008	0.00019	0.0006	0.0273	0.00046	0.003	0.00003	CA15432-MAR13	43.56	45.19	-1.63	-1.8%
3-Apr-13	3	322	0.240	575	0.00008	0.00017	0.0004	0.0212	0.00052	0.002	0.00002	CA15081-APR13	33.27	38.57	-5.30	-7.4%
10-Apr-13	4	241	0.205	486	0.00007	0.00033	0.0004	0.0148	0.00044	0.002	0.00003	CA15189-APR13	38.06	31.50	6.55	9.4%
17-Apr-13	5															
24-Apr-13	6	146	0.146	342	0.00006	0.00041	0.0005	0.0114	0.00052	0.003	0.00001	CA15395-APR13	22.26	21.31	0.94	2.2%
1-May-13	7															
8-May-13	8	98.3	0.117	259	0.00004	0.00004	0.0005	0.00829	0.00048	0.003	0.00002	CA15170-MAY13	22.36	16.68	5.68	14.5%
15-May-13	9															
22-May-13	10	73.8	0.106	234	0.00003	0.00015	0.0005	0.00796	0.00049	0.002	< 0.00001	CA15349-MAY13	17.41	15.10	2.30	7.1%
29-May-13	11															
5-Jun-13	12	59.1	0.102	220	0.00002	0.00006	0.0004	0.00785	0.00045	0.004	< 0.00001	CA15084-JUN13	15.85	13.36	2.49	8.5%
12-Jun-13	13															
19-Jun-13	14	47.9	0.0959	192	< 0.00002	0.00010	0.0005	0.00620	0.00037	0.002	0.00002	CA15342-JUN13	13.23	12.37	0.86	3.4%
26-Jun-13	15															
3-Jul-13	16	36.7	0.0800	156	< 0.00002	0.00015	0.0006	0.00528	0.00044	0.003	0.00003	CA15109-JUL13	11.62	10.21	1.40	6.4%
10-Jul-13	17															
17-Jul-13	18	25.6	0.0741	129	< 0.00002	0.00005	0.0004	0.00463	0.00045	0.002	0.00003	CA15360-JUL13	9.99	8.25	1.74	9.5%
24-Jul-13	19															
31-Jul-13	20	22.6	0.0606	108	< 0.00002	0.00013	0.0007	0.00392	0.00041	0.001	0.00003	CA15038-AUG13	7.13	7.21	-0.08	-0.5%
7-Aug-13	21															
14-Aug-13	22	19.6	0.0554	93.8	0.00004	0.00008	0.0012	0.00374	0.00038	0.002	0.00001	CA15209-AUG13	7.45	6.60	0.85	6.1%
21-Aug-13	23															
28-Aug-13	24	15.2	0.0531	81.2	< 0.00002	0.00030	0.0004	0.00365	0.00045	0.001	< 0.00001	CA15449-AUG13	6.16	6.03	0.13	1.1%
4-Sep-13	25															
11-Sep-13	26	15.0	0.0489	77.8	< 0.00002	0.00010	0.0006	0.00415	0.00044	0.001	0.00004	CA15177-SEP13	6.27	5.74	0.53	4.4%
18-Sep-13	27															
25-Sep-13	28	15.3	0.0473	73.5	< 0.00002	0.00035	0.0005	0.00390	0.00048	0.004	0.00002	CA15348-SEP13	5.42	5.55	-0.13	-1.2%
2-Oct-13	29															
9-Oct-13	30															

May 22/13 Change in analytical schedulei

Col 8

Sample = CL-01 L Residue																			
Date	Cycle	Approx.	Volume mL		pH	Cond.	Acidity	Acidity	Alkalinity	Sulphate	Total CN	WAD CN	Thiocyanate	Cyanate	Nitrate	Nitrite	Ammonia	Cl	F	Br
	No.	Flow Rate	Input	Output			(pH 4.5)	(pH 8.3)												
		(mL/min)				umhos/cm	mgCaCO3/L	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
20-Mar-13	1	1.0	470	850	7.65	4170	#N/A	18.1	57.1	2187	0.12	< 0.01	< 2	< 1	68.1	2.05	0.1	140	0.55	< 0.3
27-Mar-13	2	1.0	570	480	7.67	4128	#N/A	15.8	70.1	2095	0.12	0.01	< 1	< 2	68.9	0.71	< 0.1	150	0.52	< 0.3
3-Apr-13	3	1.0	495	480	7.75	4275	#N/A	15.8	70.6	1658	0.20	0.03	< 2	< 1	82.3	< 0.3	< 0.1	180	0.52	< 3
10-Apr-13	4	1.0	470	485	7.69	3748	#N/A	12.7	65.5	2852	0.11	0.02	< 2	< 1	56.3	< 0.3	< 0.1	110	0.53	< 3
17-Apr-13	5	1.0	470	490	7.61	3169														
24-Apr-13	6	1.0	470	500	7.66	2957	#N/A	11.9	52.0	1967	0.12	0.01	< 1	< 2	28.7	< 0.3	0.2	56	0.53	< 3
1-May-13	7	1.0	470	555	7.69	2588														
8-May-13	8	1.0	470	460	7.69	2437	#N/A	16.3	54.4	2437	0.06	< 0.01	< 2	< 1	16.7	< 0.3	0.2	37	0.49	< 3
15-May-13	9	1.0	470	460	7.56	2353														
22-May-13	10	1.0	470	480	7.57	2421	#N/A	14.1	54.3	1489	0.06	< 0.01	< 2	< 1	14.5	< 0.3	< 0.1	33	0.55	< 3
29-May-13	11	1.0	470	470	7.64	2353														
5-Jun-13	12	1.0	470	470	7.58	2280	#N/A	13.2	52.6	1435	0.06	#N/A	#N/A	#N/A	11.7	#N/A	#N/A	21	0.52	< 3
12-Jun-13	13	1.0	470	465	7.73	2022														
19-Jun-13	14	1.0	470	440	7.62	2169	#N/A	12.1	51.5	1219	0.05	#N/A	#N/A	#N/A	9.42	#N/A	#N/A	< 20	0.52	< 3

Cell Terminated

May 22/13 Change in analytical schedule.

Col 8

Sample = CL-01 L Residue																						
Date	**Cycle**	**Hardness**	**Al**	**Sb**	**As**	**Ba**	**Be**	**Bi**	**B**	**Cd**	**Ca**	**Cr**	**Co**	**Cu**	**Fe**	**Pb**	**Li**	**Mg**	**Mn**	**Hg**	**Mo**	**Ni**
	No.	**CaCO3**																				
		mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**ug/L**	**mg/L**	**mg/L**
20-Mar-13	1	1520	0.0053	0.0074	0.0096	0.0126	< 0.00002	< 0.00001	0.0709	0.000342	551	0.0010	0.311	0.0308	0.017	0.00011	0.005	24.6	0.0207	0.02	1.59	0.0021
27-Mar-13	2	1540	0.0083	0.0077	0.0089	0.0131	< 0.00002	< 0.00001	0.0755	< 0.000003	576	< 0.0005	0.318	0.0265	0.016	0.00006	0.004	24.0	0.0178	< 0.01	1.71	0.0023
3-Apr-13	3	1460	0.0073	0.0078	0.0098	0.0145	< 0.00002	< 0.00001	0.0646	< 0.000003	543	0.0006	0.393	0.0251	0.017	0.00011	0.004	25.3	0.0251	0.01	2.02	0.0016
10-Apr-13	4	1490	0.0057	0.0070	0.0081	0.0124	< 0.00002	< 0.00001	0.0609	0.000035	558	< 0.0005	0.289	0.0187	0.018	0.00007	0.004	22.9	0.0191	0.01	1.78	0.0014
17-Apr-13	5																					
24-Apr-13	6	1070	0.0046	0.0058	0.0076	0.0113	< 0.00002	< 0.00001	0.0411	0.000026	400	< 0.0005	0.224	0.0123	0.007	0.00006	0.003	16.6	0.0146	< 0.01	1.52	0.0025
1-May-13	7																					
8-May-13	8	960	0.0087	0.0056	0.0072	0.0110	< 0.00002	< 0.00001	0.0418	0.000047	362	< 0.0005	0.162	0.0262	0.003	0.00002	0.003	13.4	0.0130	< 0.01	1.24	0.0020
15-May-13	9																					
22-May-13	10	998	0.0057	0.0068	0.0078	0.0127	< 0.00002	< 0.00001	0.0302	0.000061	378	< 0.0005	0.161	0.0097	0.004	0.00015	0.002	13.1	0.0120	< 0.01	1.26	0.0022
29-May-13	11																					
5-Jun-13	12	921	0.0068	0.0061	0.0082	0.0118	< 0.00002	< 0.00001	0.0330	0.000016	348	< 0.0005	0.155	0.0101	< 0.003	< 0.00002	0.002	12.5	0.0110	< 0.01	1.21	0.0024
12-Jun-13	13																					
19-Jun-13	14	923	0.0046	0.0058	0.0076	0.0131	< 0.00002	< 0.00001	0.0385	0.000041	349	< 0.0005	0.131	0.0093	< 0.003	< 0.00002	0.003	12.3	0.0119	< 0.01	1.22	0.0020

Cell Terminated

May 22/13 Change in analytical schedule.

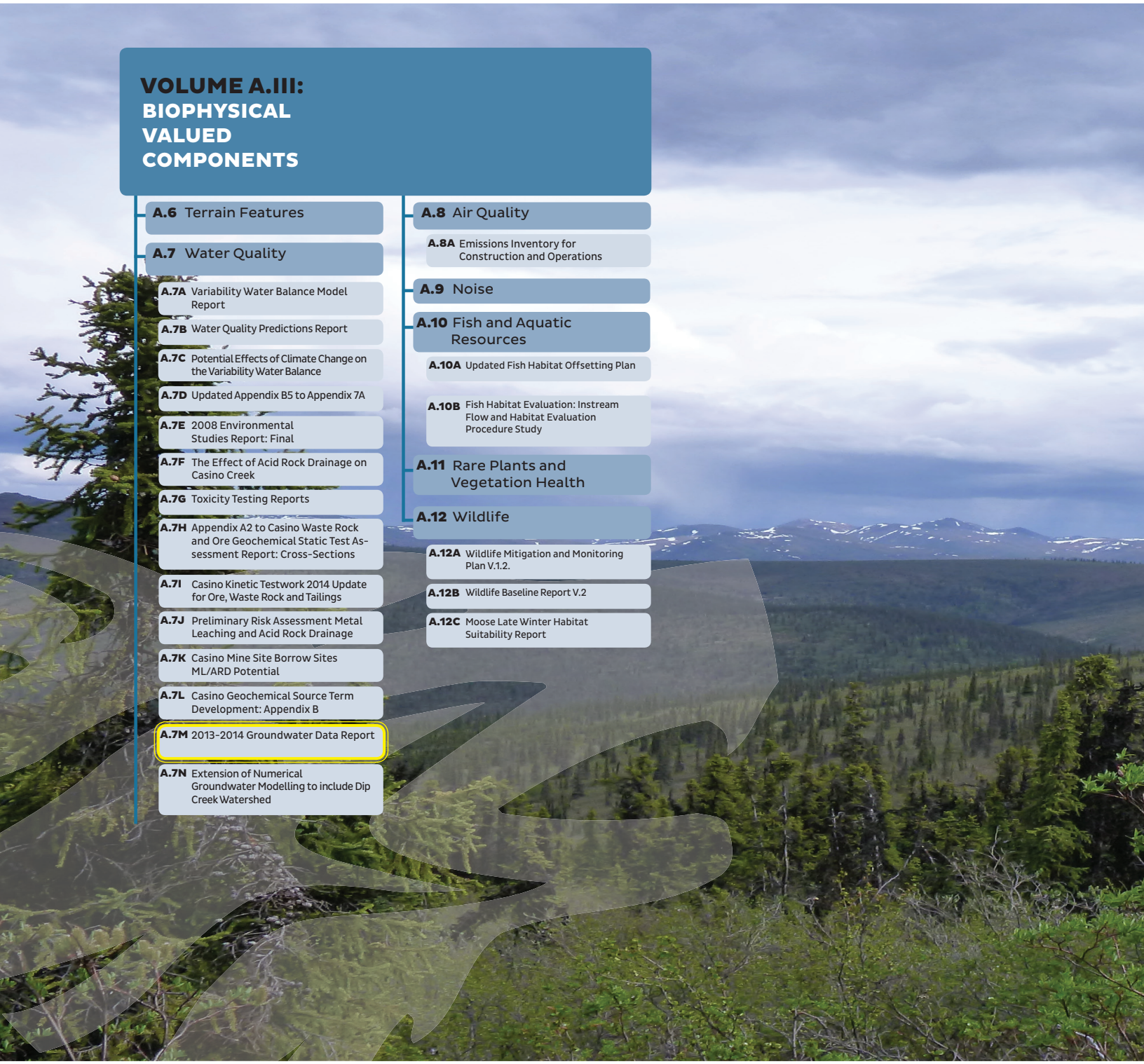
Col 8

Sample = CL-01 LResidue																					
Date	**Cycle**	**P**	**K**	**Se**	**Si**	**Ag**	**Na**	**Sr**	**S**	**Tl**	**Sn**	**Ti**	**U**	**V**	**Zn**	**Zr**		**Major**	**Major**	**Diff**	**Diff**
	No.																**SGS File #**	**Anions**	**Cations**		**(%)**
		mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**					
20-Mar-13	1	< 0.009	10.7	0.0662	15.8	< 0.00001	469	0.315	703	0.00011	0.00009	0.0004	0.0226	0.00046	0.003	0.00004	CA15325-MAR13	50.68	50.26	-0.42	-0.4%
27-Mar-13	2	< 0.009	9.07	0.0593	16.9	0.00002	473	0.303	687	0.00009	0.00016	0.0005	0.0372	0.00057	0.002	0.00002	CA15432-MAR13	49.30	51.60	2.29	2.3%
3-Apr-13	3	< 0.009	11.2	0.0753	17.5	0.00001	461	0.339	673	0.00011	0.00021	0.0004	0.0339	0.00057	0.002	0.00002	CA15081-APR13	41.05	49.60	8.55	9.4%
10-Apr-13	4	< 0.009	9.04	0.0646	18.6	< 0.00001	441	0.304	689	0.00008	0.00064	0.0004	0.0261	0.00048	0.012	0.00002	CA15189-APR13	63.85	49.21	-14.64	-13.0%
17-Apr-13	5																				
24-Apr-13	6	< 0.009	6.88	0.0392	16.1	< 0.00001	278	0.235	498	0.00007	0.00017	0.0005	0.0168	0.00052	0.001	< 0.00001	CA15395-APR13	43.63	33.65	-9.97	-12.9%
1-May-13	7																				
8-May-13	8	0.022	5.71	0.0313	15.8	< 0.00001	219	0.198	436	0.00007	0.00006	0.0006	0.0144	0.00059	0.002	0.00001	CA15170-MAY13	52.93	28.89	-24.04	-29.4%
15-May-13	9																				
22-May-13	10	0.023	4.91	0.0278	17.1	< 0.00001	207	0.188	436	0.00006	0.00009	0.0005	0.0143	0.00055	0.001	< 0.00001	CA15349-MAY13	33.07	29.12	-3.95	-6.4%
29-May-13	11																				
5-Jun-13	12	0.026	4.61	0.0235	17.4	< 0.00001	185	0.174	382	0.00005	0.00009	0.0004	0.0143	0.00055	0.002	0.00001	CA15084-JUN13	31.57	26.60	-4.96	-8.5%
12-Jun-13	13																				
19-Jun-13	14	0.018	3.99	0.0243	18.8	0.00001	344	0.175	393	0.00004	0.00012	0.0006	0.0117	0.00047	0.002	< 0.00001	CA15342-JUN13	26.45	33.54	7.08	11.8%

Cell Terminated

May 22/13 Change in analytical schedule.

APPENDIX A.7M: 2013-2014 Groundwater Data Report



CASINO MINING CORPORATION
CASINO PROJECT





2013-2014 GROUNDWATER DATA REPORT

PREPARED FOR:

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VA101-325/17-1
Rev 0
March 6, 2015

Knight Piésold
CONSULTING
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ISO 9001 - FS 64925
ISO 14001 - EMS 550121
OHSAS 18001 - OHS 550122

CASINO MINING CORPORATION
CASINO PROJECT

2013-2014 GROUNDWATER DATA REPORT
VA101-325/17-1

Rev	Description	Date
0	Issued in Final	March 6, 2015

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EXECUTIVE SUMMARY

Knight Piésold Ltd. (KP) was contracted by Casino Mining Corporation (CMC) to perform a supplemental hydrogeological site investigation in the summer of 2013 to install monitoring wells and further advance baseline data collection. This data report documents the 2013 hydrogeological site investigation and presents baseline groundwater data collected across the site in 2013 and 2014.

The 2013 site investigation program included the drilling and installation of 11 monitoring wells at 6 locations. Overburden encountered during drilling generally consisted of silty sands and gravels of up to 7 m thick. The overburden deposits were interpreted to be colluvial deposits. Bedrock encountered during drilling included granodiorite and quartzite. Bedrock was weathered to at least 20 m below ground surface.

Monitoring well development, response testing, groundwater sampling and installation of pressure transducers for long-term water level monitoring were carried out in August 2013. A Waterra inertial pumping system was used to develop the monitoring wells where possible. Response testing was completed following monitoring well development. Hydraulic conductivity estimates from response testing ranged from less than $1x10^{-8}$ m/s to $2x10^{-4}$ m/s. Pressure transducers were installed in all monitoring wells and are programmed to record water level data every three hours.

Hydrogeology data were collected at the site during six site visits during 2013 and 2014, including continuous groundwater level and ground temperature monitoring, groundwater quality sampling, and re-development of select historic monitoring wells.

Water quality samples and *in situ* data were collected from 16 monitoring wells located throughout the project area in 2013 and 2014. Samples were collected three times per year targeting seasonal representation (spring, summer, and fall). The baseline groundwater quality datasets for all wells are provided in this report along with the assessment of the data quality for data collected since 2013.

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1 – INTRODUCTION

1.1 PROJECT DESCRIPTION

Casino Mining Corporation (CMC) is proposing to develop the Casino Project (the Project), a proposed copper-gold-molybdenum mine, in Yukon Territory. The project is located in the Dawson Range Mountains of the Klondike Plateau approximately 300 km northwest of Whitehorse, as shown on Figure 1.1.

Knight Piésold Ltd. (KP) previously completed a baseline hydrogeology and groundwater quality study for the Project, detailed in the 2012 Baseline Hydrogeology Report (KP 2013). The report presented the understanding of the existing groundwater regime and summarized groundwater-related data collected during site investigations conducted from 1993 through 2012. Subsequent to the baseline report, KP was retained to carry out a 2013 hydrogeological site investigation to further advance baseline data collection in key areas of the Project and to continue baseline groundwater monitoring and collection of groundwater data in 2013 and 2014. The results of the 2013 site investigation and 2013 and 2014 data collection are presented in this report. This information will ultimately be used to support the understanding of the existing groundwater regime.

In addition to the 2013 site investigation and data collection work documented in this report, groundwater-related data was collected during a geotechnical site investigation in 2013 (KP 2014). A total of nine drillholes were advanced and two standpipes and two thermistors were installed during the geotechnical site investigation. Data collected from these installation sites are included in this report.

1.2 SCOPE OF REPORT

The objective of this data report is to describe the methodology and results of the 2013 hydrogeological site investigation and to present baseline groundwater data collected at the site in 2013 and 2014. Baseline groundwater data was collected during a total of six site visits in 2013 and 2014:

- June, August and September 2013, and
- May, July and September 2014.

The work described in this report includes:

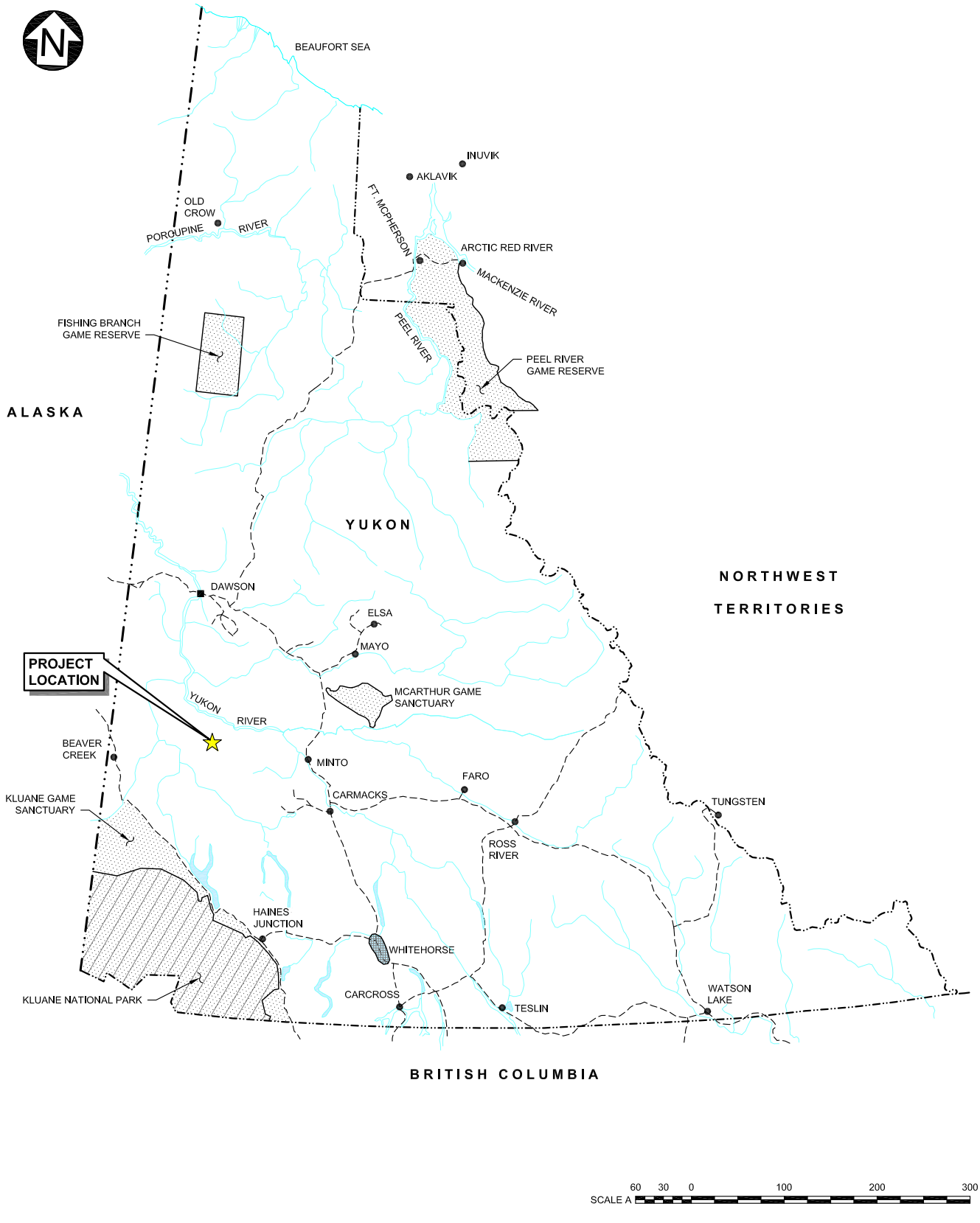
2013 Hydrogeology Site Investigation:

- Supervising the drilling and installation of 11 monitoring wells at 6 locations,
- Developing the new monitoring wells,
- Response testing the new monitoring wells,
- Installing pressure transducers to collect long-term water level data at each location, and
- Groundwater sampling the new monitoring wells.

2013-2014 Data Collection Program (to October 2014):

- Collecting manual and continuous time-series water level data from monitoring wells, standpipe piezometers and vibrating wire piezometers (VWPs),
- Collecting ground temperature data from thermistor and VWP installations,
- Re-developing select monitoring wells installed prior to 2013, and
- Collecting groundwater samples at select monitoring wells.

Site investigation and groundwater monitoring methodology is presented in Section 2. Site investigation results and data collected during the site visits are presented in Section 3. Drillhole logs and monitoring well installation details are provided in Appendix A, response testing data are provided in Appendix B, water level data are provided in Appendix C, and ground temperature data are provided in Appendix D. Groundwater sampling methodology and results are presented in Appendices E through G.



CASINO MINING CORPORATION

CASINO PROJECT

PROJECT LOCATION MAP

Knight Piésold CONSULTING

P/A NO. VA101-325/17

REF NO. 1

FIGURE 1.1

REV 0

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2 – METHODS

2.1 DRILLING AND MONITORING WELL INSTALLATIONS

Kluane Drilling Ltd., based out of Whitehorse, Yukon was contracted to carry out drilling and installation of the groundwater monitoring wells at the Casino Project under the supervision of KP. A KD1000 diamond coring rig was used to complete the drilling.

Drillholes were completed using one of two drill rod and casing sizes based on the availability of drilling equipment:

- The first four drillholes (MW13-01D/S and MW13-02D/S) were advanced through overburden using 11.4 cm (4.5 inch) diameter HWT drill casing. Drilling continued without casing using 9.1 cm (3.6 inch) diameter HT drill rods once stable bedrock was encountered. Overburden and rock samples were recovered using an HQ core barrel.
- The remaining seven drillholes were completed using 14 cm (5.5 inch) PW casing to advance through the overburden and 11.4 cm (4.5 inch) HWT drill rod through bedrock. The larger diameter rods provided a greater annular space to accommodate monitoring well installation. Overburden and rock samples were recovered using an HT core barrel.

Rock core was collected in five foot lengths as drilling progressed and logged and photographed to characterize stratigraphy and identify potentially permeable zones. Observations recorded during drilling included input from the driller (e.g. drill chatter) and notes on zones of drilling fluid circulation losses. Water level measurements were taken during pauses in drilling to assess the depth to water or if permafrost was present. Additional notes related to the presence of permafrost included observations of ice in the drill core and indications that drill rods were sticking (freezing) to the drillhole walls.

All drillholes were flushed with water prior to monitoring well installation. All monitoring wells were constructed with the following materials in accordance with best practices:

- A 3 m (10 feet) long, 49 mm inner diameter (ID) (nominal 2 inch) threaded Schedule 40 or 80 machine slotted PVC screen (washed and bagged), 0.5 mm (0.020 inch) slot size, fitted with a threaded bottom cap,
- 3 m (10 feet) lengths of 49 mm ID (nominal 2 inch) threaded Schedule 40 or 80 PVC solids (washed and bagged) to approximately 0.5 m above ground surface,
- Filter sand (10/20) placed approximately 1.5 m (5 feet) below and above the screen,
- A 2 m (6 feet) seal of slow-release bentonite pellets above the filter sand,
- A cement/bentonite grout backfill prepared as approximately 30 liters (8 gallons) of water per 43 kg (94 lbs) portland cement and 2 kg (5 lbs) bentonite powder,
- A PVC monitoring well cap and a locking monitoring well surface protector, and
- A concrete surface pad approximately 1.5 m x 1.5 m to direct surface flow away from the monitoring well.

2.2 MONITORING WELL DEVELOPMENT

The objective of well development is to minimize near-well disturbances resulting from drilling so that collected data (response tests, groundwater levels and groundwater quality) are defensible and representative. To minimize these potential drilling effects, well developments aids with removing

drilling debris and fine-grained sediment from the vicinity of the screened zone. The following equipment was used to carry out the well development activities:

- A high capacity Waterra inertial pumping system activated by a Waterra Power Pump (Power Pump), and
- HDPE Waterra tubing (2.54 cm (1-inch)) fitted with a foot valve and surge block.

The water level in the monitoring well was recorded at the beginning of well development. The foot valve and surge block were fitted to the end of the Waterra tubing and lowered down the monitoring well to 1 m above the base of the well screen. Development began at this depth and the foot valve and surge block were raised in 1 m increments until the top of the screen was reached. Water level measurements were taken during development to monitor the rate of water level recovery and prevent the water level from dropping below the top of the well screen. Well development continued until there was an observable improvement in water quality based on recorded in-situ measurements (temperature, pH, electrical conductivity and turbidity) and qualitative observations (water clarity and sediment).

The above approach was modified for monitoring wells where the water level recovery was too slow to maintain the water level above the top of the screen during development. In these instances, the well development was limited to slightly agitating fines from within the well screen by plugging the discharge end of the Waterra tubing at surface. The pumping/surging action of the foot valve/surge block being operated manually moved water back and forth through the screen and filter pack without removing water from the monitoring well. If there was sufficient water in the monitoring well, the Waterra tubing was unblocked and the Power Pump was briefly operated to remove as much of the loosened sediment from the monitoring well without dewatering the screen. This modified approach is less efficient but provides a means to complete some development for monitoring wells with relatively slow water level recovery.

2.3 RESPONSE TESTING

The monitoring wells were response tested (slug tested) after water levels had stabilized following development. Slug tests are an efficient and inexpensive method to estimate a hydraulic conductivity in the immediate vicinity of a drillhole.

A 1.07 m length of 0.025 m outer diameter (OD) Schedule 80 PVC pipe capped and filled with 10/20 filter sand was used as a slug. The slug was secured to a 60 m tagline (manufactured by Solinst) so it could be quickly lowered into and retrieved from the monitoring well. A pressure transducer manufactured by Schlumberger Water Services (Diver model DI502-20m or DI505-50m) was used to record the water level response during testing. Manual water level measurements were taken during testing using a 100 m water level meter (manufactured by Solinst).

The response test data for the monitoring wells were analyzed using the Hvorslev (1951) method, which involves matching field data to a theoretical solution to produce an estimate of the formation hydraulic conductivity near the drillhole.

2.4 GROUNDWATER LEVELS

Water levels were measured manually after monitoring well installation and before and after monitoring well development and response testing. A pressure transducer was installed in each monitoring well suspended on stainless steel aircraft cable following well installation. The pressure

transducers are manufactured by Solinst and were programmed to record water level data every three hours. An atmospheric pressure transducer is located near the existing camp and records atmospheric pressure at hourly intervals. The barometric data were used to compensate the groundwater elevation time-series data for fluctuations in barometric pressure.

WellBuster™ monitoring well packers were installed in 2014 in some of the wells that are artesian or have shallow water tables. The intent of the well packers is to supress the water levels in the wells below the freezing elevation to enable sampling earlier in the year by keeping the well from freezing and to prevent damage to the wells that may result from expansion of frozen water in the PVC. WellBuster™ packers are specifically built for installation in water wells and are constructed of rubber seals and stainless steel.

2.5 INSTALLATION OF HEAT TRACE

Electric heat trace (3 watt, 120 volt) was installed in the new monitoring wells immediately following well completion to allow the monitoring well to be thawed for development and sampling work in the event the water column in the well froze due to permafrost. The heat trace was cut to length after installation so that it extended the entire depth of the monitoring well. A waterproof end splice was applied to the down-well end to guard against water intrusion and short-circuiting of the submerged heat trace. A 120 volt grounded plug was installed to the free end of the heat trace located at the well head. When activated, the heat trace was powered by 120 volt power supplied from a portable gasoline generator. Heat trace remains installed at all of the 2013 monitoring wells except MW13-02D/S and MW13-06D/S which have been unfrozen during all sampling events in 2013 and 2014.

The heat trace in MW13-01D and MW13-03S was upgraded to a higher wattage heat trace (10 watt, 120 volt) to increase heat output in order to promote thawing of the water column in the well prior to sampling and well development work.

2.6 GROUNDWATER QUALITY SAMPLING

KP adapted well purging and sampling procedures employed during the field program from the following documents:

- British Columbia Field Sampling Manual for Continuous Monitoring and the Collection of Air, Air-emission, Water, Wastewater, Soil, Sediment and Biological Samples (BC Ministry of Water, Land, and Air Protection, 2003).
- United States Environmental Protection Agency Low-Flow (Minimum Drawdown) Ground-Water Sampling Procedures (US EPA, 1996).

The purging and sampling methods employed were dictated by the conditions of each individual well. Two approaches were applied to the groundwater wells as the wells fell into two categories: wells that recharged very quickly and a minimum drawdown could be maintained while purging, and wells with slow to very slow recharge where minimum drawdown could not be maintained (despite very low pumping rates). Methods common to both procedures are described in the following section and methods for each well purging scenario are provided in the two following sections.

2.6.1 General Sampling Method

Both methods (minimum drawdown method and low recharge method) required the use of a submersible pump, which was placed approximately 1 m above the top of the screen, and both required a low pump rate during sampling and purging to minimize turbulence in the well. Target pumping rates ranged from 0.2 L/min to 0.5 L/min (higher rates may be achieved where turbidity does not increase and the water level is maintained).

In situ parameters were monitored during the well purging process using a flow-thru cell attachment on a calibrated multi-parameter probe. Final *in situ* parameters were recorded for the sampling event immediately prior to collecting the sample.

Samples for dissolved metals analysis were field filtered using a 0.45 µm in-line filter and samples for dissolved organic carbon analysis were field filtered using a syringe with a 0.45 µm syringe filter. Any required preservatives were added immediately after sample collection. Syringe filters were used for dissolved organic carbon analysis because the in-line filters contain activated carbon, which is known to contaminate samples with organic carbon; these filters are only certified for use for filtration of inorganic parameters.

2.6.2 Low-Flow Minimum Drawdown Purging and Sampling Method

The low-flow minimum drawdown method was used to purge and sample the wells where hydraulic conductivity was high enough to do so. The primary objective of this sampling method is to match the pumping rate with that of the natural groundwater flow-rate across the screened interval. This was achieved by adjusting the pumping rate such that the water level in the well was stable and relatively close to the static water level prior to pumping. With a stable water level, the water entering the pump must be from the screened interval below the pump intake and not from the stagnant overlying water column.

The key advantages of the low-flow groundwater quality sampling method are:

- Reduced stress on the surrounding aquifer,
- More representative samples due to reduced turbidity, and
- Reduced purge volume.

Well purging was considered complete and samples were collected when all of the following objectives were met during the purging process:

- Minimum purge volume was removed (volume in drawdown plus the volume below the pump intake),
- In situ parameters were stable (temperature, pH, specific conductance, turbidity, and dissolved oxygen), and
- The water level was confirmed to be stable or rising.

2.6.3 Low Hydraulic Conductivity Formation Purging and Sampling Method

This second approach was used where the groundwater recovery rate was slower than the lowest pump rate and the water level continued to drop during the purging process. The pump was placed above the top of the screen and the stagnant water above the pump was purged until the water level dropped to the pump intake. The water level in the well was then allowed to recover overnight or longer. The pump was left in place and was used to collect a sample once the water level had

recovered, unless the water in the tubing was likely to freeze overnight. If freezing temperatures were expected, the pump was removed from the well and the water sample was collected using a bailer or by re-deploying the pump down the well, once the well had recovered to a sufficient water level. In both cases, *in situ* parameters were recorded before and after sampling.

The key disadvantages of this second purge and sample approach are:

- Potentially less representative samples due to mixing of stagnant water with formation water,
- Greater stress on the surrounding formation,
- Greater purge volume, and
- Longer sampling time.

2.6.4 Alternative Groundwater Sampling Methods

In some cases, neither of the standard methods could be used to collect samples and alternative methods were used. Circumstances where alternative methods were applicable included the following:

- Blockages in the groundwater monitoring well: in some wells, frost or other factors have resulted in partial blockages in the PVC, inhibiting the use of a submersible pump.
- Low water levels in wells that are slow to recover: in some wells, there is not enough of a water column above the well screen to purge and sample.

Sampling methods for these circumstances included the use of bailers or HDPE tubing with a foot valve. These sampling methods are more aggressive than low-flow methods with a submersible pump and can result in higher turbidity and can result in mixing of stagnant well water with fresh water from the screened interval of the well. Analytical results for samples collected using these alternative methods can provide information about groundwater quality in the formation around the well, however, the resulting data may not be of the same quality as that resulting from the standard groundwater sampling methods. Data collected using the alternative methods are always interpreted with consideration to the method used.

2.6.5 Description of Groundwater Quality Monitoring Locations and Sampling Events

Water quality samples have been collected at the site from 29 groundwater quality monitoring wells strategically located in the vicinity of and down-gradient of key proposed project facilities. Monitoring well locations are grouped for analysis into three general areas, which are listed in Table 2.1: Open Pit area (eight wells), Casino Creek valley area (nine wells) and hillslope area (12 wells).

Samples were collected three times per year targeting seasonal representation (spring, summer, and fall). The timing of each sampling event was chosen such that the annual sample set would be representative of the seasonal variability of groundwater levels. Groundwater sampling events were intended to coincide with the lowest groundwater levels (prior to freshet), the highest groundwater levels (after freshet), and intermediate groundwater levels (autumn).

Over the course of the baseline data collection program some monitoring wells have been dropped from the sampling program as a result of damage such as blockages, likely due to winter ground freezing conditions. New monitoring wells were installed in 2013 and added to the sampling program. Samples were not collected from a monitoring well if it was frozen, which was more likely to occur in the spring and early summer.

Knight Piésold CONSULTING

TABLE 2.1

CASINO MINING CORPORATION
CASINO PROJECT

2013-2014 GROUNDWATER DATA REPORT
GROUNDWATER QUALITY MONITORING LOCATIONS AND SAMPLE SUMMARY

Print Mar/06/15 15:52:49

Site Location	Site Description	Samples Collected	1994	1995		2008	2009	2010			2011			2012		2013			2014		
			Sep	Feb	May	Sep	Sep	Jun	Aug	Sep	May	Jul/ Aug	Sep	May	Sep	Jun	Aug	Sep/Oct	May	Jul	Sep/Oct
Open Pit Area																					
94-337	Open Pit Area	19	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
HG10-01	Proctor Gulch	11	-	-	-	-	-	-	1	1	-	1	1	1	-	1	1	1	1	1	1
HG10-02	Proctor Gulch	10	-	-	-	-	-	-	1	1	-	1	1	1	-	-	1	1	1	1	1
HG10-04	Proctor Gulch	13	-	-	-	-	-	-	1	1	1	1	1	1	1	1	1	1	1	1	1
HG10-05	Proctor Gulch	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
HG10-07	Open Pit Area	2	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-
MW13-02D	North of Open Pit near Canadian Creek	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	1	1
MW13-02S	North of Open Pit near Canadian Creek	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-		1 [2]	-	1	-
Casino Creek Area																					
94-340	Upper limits of TMF	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
94-342	Upper limits of TMF	7	1	1	-	1	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-
94-343	Upper limits of TMF	4	1	-	-	1	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-
94-345	Middle of TMF	10	1	1	1	-	1	1	1	1	-	1	1	1	-	-	-	-	-	-	-
94-346	Middle of TMF	8	-	-	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-	-
94-347	Middle of TMF	9	1	-	-	1	1	-	1	1	-	1	1	-	1	-	-	-	-	-	1
94-348	TMF Embankment	4	-	-	-	1	-	1	1	1	-	-	-	-	-	-	-	-	-	-	-
94-350	Downgradient of TMF	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
94-351	Downgradient of TMF	6	-	-	-	1	1	-	1	1	-	1	1	-	-	-	-	-	-	-	-
Hillslope Area																					
94-352	Heap Leach Facility	9	1	-	1	1	1	1	1	1	-	-	-	-	-	-	-	-	-	1	1
94-353	Heap Leach Facility	7	-	-	1	1	1	-	1	1	1	1	-	-	-	-	-	-	-	-	-
94-354	Heap Leach Facility	7	-	-	1	1	-	-	1	1	-	1	1	-	-	-	-	-	-	1	-
MW11-01A	Historic Meloy Creek mine adit area	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
MW11-01B	Historic Meloy Creek mine adit area	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
MW11-02A	Historic Meloy Creek mine adit area	9	-	-	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1	1
MW11-02B	Historic Meloy Creek mine adit area	9	-	-	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1	1
MW13-01D	Supergene Ox/ Low Grade Ore Stockpile	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 [3]	-
MW13-03S	North of Gold Ore Stockpile	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1 [3,4]	-
MW13-04S	South of Gold Ore Stockpile	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1	1	1
MW13-05	West of Tailings Management Facility	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1	1	1
MW13-06D	West of Tailings Management Facility	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	1	1

M:\1\01\00325\17\A\Report\1-2013 Hydrogeology\Rev 0\Tables\[2.1 Groundwater Quality Locations and Samples.xlsx]Tabl 2.1_GW Sample Locations

NOTES:
1. SAMPLE COUNT DOES NOT INCLUDE DUPLICATE SAMPLES COLLECTED AT A MONITORING SITE.
2. WELL DEVELOPMENT INCOMPLETE WHEN SAMPLE WAS COLLECTED.
3. SAMPLE COLLECTED AFTER WELL WAS THAWED.
4. RESULTS REJECTED BASED ON CONCLUSION THAT THEY WERE NOT REPRESENTATIVE OF FORMATION CONDITIONS.

REV	DATE	DESCRIPTION	PREP'D	APP'D
0	05MAR'15	ISSUED WITH REPORT	CJ	JEM

2.6.6 Laboratory Analysis

Groundwater samples were submitted to ALS Environmental in Burnaby. The following parameters were analyzed:

- Physical Tests – Hardness, pH, specific conductivity, total dissolved solids (TDS), total suspended solids (TSS), and turbidity.
- Dissolved Anions – Alkalinity (bicarbonate, carbonate, and hydroxide), bromide, chloride, fluoride, and sulphate.
- Nutrients – Ammonium nitrogen, nitrate, nitrite, dissolved orthophosphate, and total and dissolved phosphate.
- Total and Dissolved Metals – metals and metalloids analyzed at low levels to meet the B.C. Water Quality Guidelines (BCWQG) and the Canadian Environmental Quality Guidelines (CEQG) criteria values (low-levels): Aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, molybdenum, nickel, selenium, silver, sodium, thallium, uranium, vanadium, and zinc.
- Total and Dissolved Mercury – ultra-low detection limits.
- Cyanide - Free, total, and weak acid dissociable (WAD).
- Organics – Total organic carbon (TOC) and dissolved organic carbon (DOC).

2.6.7 Relevant Guidelines

Baseline water quality analytical and *in situ* data from the groundwater samples were examined and compared to relevant guidelines with respect to the most sensitive receptors in the downstream environment which are aquatic life. While groundwater is not considered aquatic life habitat, the results of the groundwater quality baseline program for the Project have been compared to aquatic life guidelines because groundwater may contribute to the streamflow of creeks that do support aquatic life in the project area. The guidelines are reported in territorial and federal guidance documents and include the following:

- Yukon Contaminated Sites Regulation (YCSR) Schedule 3 - Generic Numerical Water Standards – Aquatic Life – The aquatic life standards were developed for groundwater assuming a minimum 1:10 dilution ratio for groundwater to surface water. Pursuant to section 145 of the Yukon Environment Act (O.I.C. 2002/171).
- Canadian Environmental Quality Guidelines - Water Quality Guidelines for the Protection of Aquatic Life (Freshwater) (CCME).

The guidelines are provided in Table F1 of Appendix F. Guidelines for some parameters are hardness or pH dependent. In these cases, the guideline was assessed based on the measured hardness or pH in each sample.

2.6.8 Quality Assurance/Quality Control, Data Management and Data Analysis

The QA/QC procedure aids with the collection of representative data that are scientifically defensible, repeatable, and well documented. KP implemented these procedures from 2011 to present. During the time when KP has been responsible for overseeing the groundwater quality data collection, these procedures have been facilitated at the project management level through organization and planning and the enforcement of both external and internal quality control. The following lists summarize the QA/QC procedures and practices that have been followed from 2011 to present, which are described in detail in Appendix E:

Internal Quality Control:

- Staffing the project with experienced/trained individuals,
- Providing representative, meaningful data through planning and efficient research,
- Use of standard protocols for sample collection, preservation, and documentation,
- Regular calibration and maintenance of all field equipment, and
- Collection of duplicate, blank, filter and travel blank samples for submission for analysis (approximately 10% of overall samples).

External Quality Control:

- Employment of fully accredited analytical laboratories for the analysis of all samples, and
- Determination of analytical precision and accuracy through the interpretation of the analysis reports for the blind duplicate, blank, filter and travel blank samples.

The quality of project data was assessed based on the performance of the data when compared to the pre-set data quality objectives (DQOs). DQOs provide a means of assessing the QA/QC data and determining whether the data in question are precise, accurate, representative, and complete. The results from QA/QC samples were reviewed to determine if sample contamination occurred, and these data were further used to determine if the contamination occurred during collection, handling, storage, or shipping. Upon receipt from the laboratory the data were uploaded into the FULCRUM data management system, along with copies of field notes, photos, Sample Receipt Confirmations, Microsoft Excel data, and Certificates of Analysis. The data were then routinely reviewed, based on the following considerations:

- Duplicate sample analytical results,
- Blank sample analytical results,
- Total and dissolved metals comparison,
- Ion balance,
- Data validation,
- Detection limits,
- Analytical precision, and
- Analytical accuracy.

The DQOs and the results of the QA/QC program are described in detail in Appendix E.

3 – RESULTS

3.1 2013 HYDROGEOLOGY SITE INVESTIGATION

3.1.1 Drilling and Monitoring Well Installations

Eleven monitoring wells were completed at six locations during the 2013 site investigation. Paired monitoring wells were installed at five locations to support estimation of vertical hydraulic gradients and maximize monitoring zones (BC MOE 2012). MW13-01D/S and MW13-02D/S were installed using HT drill rods and the overburden was cased using HWT size rods. The remaining seven drillholes were drilled using HWT drill rods and the overburden was cased using PW size rods. Based on availability of materials at the site, eight monitoring wells were constructed using Schedule 40 PVC (MW13-01S/D, MW13-02S/D, MW13-03S/D, and MW13-04S/D). The remaining three monitoring wells were constructed using Schedule 80 PVC. Monitoring well installation details are summarized in Table 3.1. Monitoring well locations are shown on Figure 3.1.

Drillhole depths varied from approximately 15 to 50 meters below ground surface (mbgs). Monitoring well screens were 3 m long and the top of monitoring well screen placement ranged from 10 m to 46 mbgs. In general, the most permeable zone observed during drilling was selected as the depth at which to place the screen, with subsurface lithology, fracture spacing and degree of weathering taken into account. Drillhole logs and monitoring well installation details are provided in Appendix A1. Geologic logs of drill core provided by CMC are included in Appendix A2.

The overburden encountered during drilling generally consisted of silty and gravelly sands. Overburden ranged in thickness from about 0.6 m to 7 m and was interpreted to be colluvium at all drillholes except MW13-02D/S. Sandy and gravelly material was recovered from the full depth of drillholes MW13-02D/S, advanced to a maximum depth of 30 mbgs. The origin of the material in drillholes MW13-02D/S was interpreted to be a fault zone; however, the deposit may be alluvial in origin given the proximity of these drillholes to Canadian Creek. Poor recovery of subsurface material for the entire length of both drillholes made logging and classification of the subsurface material difficult. Based on the recovered samples, subsurface material at drillholes MW13-02D/S was described as silty sand with cobbles and gravels with weathered and oxidized surfaces.

Bedrock encountered during drilling consisted of granodiorite and quartzite. Bedrock was described as weathered at the bottom of all drillholes except MW13-01D and MW13-03D, where bedrock at the bottom of the drillhole was described as competent. Fault zones up to 3 m thick were encountered in drillholes MW13-01S/D and a narrow shear interval (0.2 m) was encountered at the bottom of drillhole MW13-03D.

The following observations during drilling and monitoring well installation indicated that permafrost was present at MW13-01D/S, MW13-02D/S and MW13-03D/S:

- A 2 cm thick ice lens was observed in rock core sampled from approximately 10 mbgs in drillhole MW13-01D. The water column in both MW13-01D and MW13-01S froze before the 2013 drilling program was completed.
- Water level recovery measured during pauses while drilling at MW13-02D/S was negligible or slow at depths above 10 mbgs and was rapid below 10 mbgs. The base of permafrost at these drillholes was inferred to be 10 mbgs based on the change in water level recovery in the drillholes.

- The drill rods started to freeze to the walls of drillholes MW13-03D/S. The rods freezing complicated the installation of monitoring well MW13-03D.

No indications of permafrost were noted at drillholes MW13-04D/S, MW13-05, or MW13-06D/S during drilling and monitoring well installation. Ice was not observed in drill core retrieved from any drillhole locations other than MW13-01D.

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XREF FILE(S): IMAGE FILE(S):

OPEN PIT AREA
SCALE B

FOR DETAILS SEE INSET

615 000 E
620 000 E
605 000 E
610 000 E
6 970 000 N
6 965 000 N
6 960 000 N
6 955 000 N
6 950 000 N
6 945 000 N

YUKON RIVER
BRITANNIA CREEK
CANADIAN CREEK
BRYNELSON CREEK
MELOY CREEK
AUSTIN CREEK
CASINO CREEK
DIP CREEK

MW13-02D/S
W7
MP10-01
DH11-39
HG10-07
HG10-08
94-321
94-326
94-334
DH11-38
93-145
94-298
CAS-036
94-288
OPEN PIT
CAS-033
P-39
HG10-10
94-310
94-331
94-305
94-337
CAS-037
93-226
94-332
DH11-37
HG10-06
HG10-01
HG10-04
HG10-05
HG10-02
HG10-09
HG10-03
94-333
DH10-18
CAS-034
DH11-36
DH11-PEG-01
DH11-PEG-02
DH11-PEG-03
DH11-PEG-04
W1
W14
W3
OPEN PIT
MW13-03D/S
GOLD ORE STOCKPILE
MW13-04D/S
94-340
MW13-01D/S
94-342
SUPERGENE OXIDE / LOW GRADE ORE STOCKPILE
DH11-34
DH11-33
DH11-32
LOW GRADE ORE STOCKPILES
DH12-05
94-353
94-355
MW11-02A/B
94-343
HEAP LEACH FACILITY
DH11-29
MW11-01A/B
94-344
DH12-04
A
94-352
94-351
MW13-05
94-346
94-345
DH10-01
94-347
TAILINGS MANAGEMENT FACILITY
DH10-02
DH11-21A/B
MW13-06D/S
DH10-03
94-348
DH11-22
DH11-24
DH10-04
DH12-01
DH12-02
DH11-23A/B
DH10-05
DH10-06
DH11-15
MP10-02
94-351
W11
DH11-25
DH12-03
94-349
94-350
W18
MP10-03
H18
DH11-14
DH11-13
MP10-04
W4
DH11-10
DH11-12
W9
DH11-09
DH11-11
R2
DH11-08
DH13-04
DH13-03
AIRSTRIP PROPOSED
DH11-01

LEGEND:

- MONITORING WELL
- THERMISTOR
- OPEN DRILLHOLE
- VIBRATING WIRE PIEZOMETER
- R2 HYDROLOGY STATION
- GEOTECHNICAL PIEZOMETER
- VIBRATING WIRE PIEZOMETER & THERMISTOR
- FAULT
- SEISMIC LINE
- A HISTORIC ADIT

NOTES:

1. CONTOUR INTERVAL IS 25 METERS.
2. DIMENSIONS ARE IN METRES UNLESS NOTED.
3. COORDINATE GRID IS UTM NAD 83 ZONE 7
4. OUTLINES ARE PROVIDED FOR PROPOSED FACILITIES.

SCALE B: 250 125 0 250 500 750 1000 1250 m

SCALE A: 800 400 0 1000 2000 3000 4000 m

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CASINO MINING CORPORATION

CASINO COPPER-GOLD PROJECT

PROJECT LAYOUT AND GROUNDWATER MONITORING LOCATIONS

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P/A NO. VA101-325/17

REF NO. 1

FIGURE 3.1

REV 0

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TABLE 3.1

CASINO MINING CORPORATION
CASINO PROJECT

2013 - 2014 GROUNDWATER DATA REPORT
2013 MONITORING WELL INSTALLATION SUMMARY

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Monitoring Well	Coordinates[1]			Drill hole Diameter	Total Depth	Depth to Bedrock	Monitoring Well Installation									Response Test Summary	
	Northing	Easting	Ground Elevation				Date Completed	PVC Schedule	PVC Stickup	Completion Zone		Screened Zone		Water Level After Installation	Date of Water Level Measurement	Date	Calculated Hydraulic Conductivity
	(m)	(m)	(masl)	Nominal (m)	(mbgs)	(mbgs)	dd-mmm-yr	-	(m)	From (mbgs)	To (mbgs)	From (mbgs)	To (mbgs)	(mbPVC)	dd-mmm-yr	dd-mmm-yr	(m/s)
MW13-01D	6,957,455	611,804	1,149	0.091	41.2	7.6	6-Jun-13	40	0.69	25.9	32.0	27.5	30.5	frozen at 2.6 m	27-Jun-13	28-Jul-14	- [3]
MW13-01S	6,957,450	611,802	1,150	0.091	15.2	4.6	7-Jun-13	40	0.68	10.0	15.2	10.7	13.7	frozen at 2.4 m	27-Jun-13	-	frozen
MW13-02D	6,959,341	609,888	1,193	0.091	30.3	>30.3	12-Jun-13	40	0.57	22.8	30.3	24.3	27.3	2.18	27-Jun-13	4-Aug-13	1E-05
MW13-02S	6,959,345	609,886	1,193	0.091	18.3	>18.3	9-Jun-13	40	0.57	10.0	16.2	11.8	14.8	1.57	26-Jun-13	-	-
MW13-03D	6,958,593	613,068	1,214	0.114	36.6	3.0	16-Jun-13	40	0.37	29.2	36.6	30.7	33.8	27.42	28-Jun-13	14-Aug-13	8E-08
MW13-03S	6,958,589	613,065	1,213	0.114	18.3	0.6	17-Jun-13	40	0.30	9.1	14.9	10.6	13.6	12.0	28-Jun-13	14-Aug-13	- [3]
MW13-04D	6,957,637	613,298	1,024	0.114	41.2	2.1	19-Jun-13	40	0.38	36.1	41.2	37.7	40.7	8.27	19-Jun-13	14-Aug-13	<1E-8
MW13-04S	6,957,633	613,297	1,024	0.114	21.2	1.8	19-Jun-13	40	0.69	16.0	21.2	18.0	21.0	10.89	27-Jun-13	5-Aug-13	3E-06
MW13-05	6,955,823	614,719	1,024	0.114	50.3	4.6	22-Jun-13	80	0.50	44.9	50.3	46.6	49.6	33.23	28-Jun-13	28-Jul-14	2E-04
MW13-06D	6,953,267	613,962	1,069	0.114	48.8	3.0	24-Jun-13	80	0.16	43.8	48.8	45.4	48.4	32.90	27-Jun-13	7-Aug-13	9E-06
MW13-06S	6,953,276	613,958	1,070	0.114	38.7	4.0	25-Jun-13	80	0.23	32.0	38.7	33.6	37.8	31.0	28-Jun-13	13-Aug-13	9E-07

M:\1\01\00325\17\A\Report\1-2013 Hydrogeology\Rev 0\Tables\[Table 3.1- Monitoring Well Summary_r0.xls]Well Summary

NOTES:

1. UTM COORDINATES AND ELEVATION WERE SURVEYED BY YUKON ENGINEERING SERVICES IN SEPT 2013 AND ARE IN NAD83 UTM ZONE 7V.
2. MONITORING WELLS COMPLETED WITH NOMINAL 2-INCH DIAMETER PVC .
3. RESPONSE TEST CONDUCTED BUT RESULTS NOT CONSIDERED REPRESENTATIVE OF NATURAL FORMATION DURE TO FROZEN SUBSURFACE CONDITIONS.

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0	06MAR'15	ISSUED WITH REPORT	KTD	CAS	KJB

3.1.2 Monitoring Well Development (2013 Monitoring Wells)

Eight of the eleven monitoring wells were developed using the methods described above. The column of water in monitoring wells MW13-01D/S froze within 20 days of installation and these wells could not be developed. Development of MW13-02S has been attempted over multiple site visits but has not been successfully completed due to an inflow of silt/sand through the well screen. Turbidity of water purged from MW13-02S remained above the recommended turbidity for groundwater sample collection.

Relatively high pH (above 9) was measured during well development at two locations, MW13-03D and MW13-04D, and likely indicates contamination from a bentonite or cement source. Slow groundwater recharge rates to these wells made development difficult. Efforts were made to purge as much water as possible from these monitoring wells to improve water quality, including purging the well completely dry. The pH remained above expected background levels at these wells.

Results of the monitoring well development are summarized in Table 3.2.

3.1.3 Response Testing

Response testing was carried out at nine of the eleven monitoring wells installed in 2013. Hydraulic conductivity values estimated from testing ranged from less than $1x10^{-8}$ m/s to $2x10^{-4}$ m/s. A response test was not conducted at monitoring well MW13-01S since the well is screened within permafrost or at MW13-02D since the well requires further development.

The water columns in monitoring wells MW13-01D and MW13-03S were thawed during the July 2014 site visit and a hydraulic conductivity was estimated using the water level recovery in the well following purging. Results of hydraulic conductivity testing at MW13-01D and MW13-03S were $<1x10^{-8}$ m/s and $2x10^{-8}$ m/s, respectively. The presence of frozen ground conditions are expected to reduce the hydraulic conductivity of the test interval and the results are not considered representative of formation conditions. Response test analyses at MW13-01D and MW13-03S are presented in Appendix C for qualitative purposes only and the hydraulic conductivity values are not included in Table 3.1.

Hydraulic conductivity values are summarized in Table 3.1 and response test analyses are presented in Appendix C.

3.2 2013 – 2014 DATA COLLECTION PROGRAM

Baseline hydrogeology data were collected during six site visits to the Project in 2013 and 2014. Data collected during these site visits are discussed in the sections that follow and include groundwater level monitoring, ground temperature monitoring, re-development of select historic monitoring wells and groundwater quality sampling.

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TABLE 3.2

CASINO MINING CORPORATION
CASINO PROJECT

2013-2014 GROUNDWATER DATA REPORT
MONITORING WELL DEVELOPMENT SUMMARY

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Monitoring Well	Well Development Summary								Notes
	Start Date	Finish Date	Water Level Before Development	Water Level After Development	pH	Conductivity	Turbidity	Total Volume Purged	
	dd-mmm-yr	dd-mmm-yr	(mbPVC)	(mbPVC)		uS/cm	NTU	L	
MW13-01D	-	-	-	-	-	-	-	-	Development not conducted. Water column is frozen.
MW13-01S	-	-	-	-	-	-	-	-	Development not conducted. Water column is frozen.
MW13-02D	3-Aug-13	4-Aug-13	0.75	3.28	5.8	67	261	1,770	
MW13-02S[2]	3-Aug-13	26-Jul-14	2.25	6.65	6.2	65	1,899	540	Development was not completed due to sand/silt influx to the monitoring well screen. In-situ parameters are presented for the last development attempt on July 26, 2014.
MW13-03D	8-Aug-13	Not Completed	11.25	dry	10.9	211	721	180	pH high after development (suspect grout contamination). Slow recharging well.
MW13-03S	8-Aug-13	9-Aug-13	12.01	13.51	8.2	285	100	160	
MW13-04D[2]	4-Aug-13	Not Completed	8.27	dry	10.2	310	1147	240	Water was used from MW13-04S for development in this well. pH high after development (suspect grout contamination). Slow recharging well.
MW13-04S	4-Aug-13	4-Aug-13	8.65	11.78	7.6	207	77	770	
MW13-05	8-Aug-13	8-Aug-13	41.78	41.80	7.5	225	14	660	Very good recharge
MW13-06D	5-Aug-13	5-Aug-13	31.89	33.22	6.9	512	25	680	Not developed with surge block
MW13-06S	6-Aug-13	8-Aug-13	32.72	33.12	7.2	457	65	280	Not developed with surge block.
HG10-01	8-Jun-13	8-Jun-13	Artesian	Artesian	6.8	1,006	1,050	1,900	Not developed with surge block.
HG10-04	9-Jun-13	11-Jun-13	4.42	9.93	8.6	547	10	310	
MW11-02A	9-Jun-13	11-Jun-13	7.15	7.67	7.7	195	39.4	790	Surge block hit blockage at 2.77 m, not developed with surge block
MW11-02B[2]	9-Jun-13	11-Jun-13	6.57	8.67	8.1	255	1,072	80	(Re)-Development not completed due to insufficient groundwater recharge to well. In-situ parameters taken from the time at which well development was stopped on Sept 30, 2014.

M:\1\01\00325\17\A\Report\1-2013 Hydrogeology\Rev 0\Tables\[Table 3.2 Well Development.xlsx]Table 3.2 Well Development

NOTES:

1. IN-SITU MEASUREMENTS ARE BASED ON THE LAST RECORDED VALUES (AT FINAL WELL SCREEN INTERVAL) DURING DEVELOPMENT.
2. DEVELOPMENT NOT COMPLETED. IN-SITU PARAMETERS TAKEN FROM THE TIME AT WHICH DEVELOPMENT WORK WAS STOPPED.
3. m IS METRES, mags IS METRES ABOVE GROUND SURFACE, mbgs IS METRES BELOW GROUND SURFACE, - IS NOT RECORDED, N/A IS NOT APPLICABLE.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
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3.2.1 Groundwater Levels

Manual water levels have been collected in monitoring wells and standpipe piezometers on site using a water level tape during all groundwater sampling events, after well installation/development and before and after response testing. Manual water levels measured at the 2013 monitoring wells soon after installation are presented in Table 3.1. All historic manual water level measurements at standpipes and monitoring wells across the site are presented in Appendix C1.

Pressure transducers were fitted in all 11 monitoring wells installed in 2013. Pressure transducers are also installed in seven additional monitoring wells across the project site and have been collecting water level data since 2010. Pressure transducers were removed from all wells in September 2012 by a third party consultant contracted to CMC and were re-installed in the monitoring wells in June 2013. Plots of long-term groundwater elevation data at the monitoring wells up to October 2014 are presented in Appendix C2. Transducer water level data collected at monitoring well MW13-06S is not included in Appendix C2 as the transducer was either unsaturated or suspect to be malfunctioning during the site visits. The transducer was replaced in September 2014.

Continuous water level data have been collected at six vibrating wire piezometers (VWPs) on site since 2009. A plot showing groundwater elevations calculated at the six VWPs is provided in Appendix C3.

3.2.2 Ground Temperature Data

Ground temperature data were collected from ten thermistor strings and six VWPs on site. In addition to the thermistor sites reported in the 2012 baseline report (KP 2013), two 10-node thermistor strings were installed as part of the 2013 geotechnical site investigation program (KP 2014). A summary of current thermistor installations is presented in Table 3.3 and includes details on permafrost presence and depth to the base of permafrost at each site. The depth of the active layer at thermistor locations, which is the uppermost layer of ground which freezes in the winter and thaws in the summer, is also included in Table 3.3. Plots of temperature versus time and temperature versus depth are presented in Appendix D1 for each thermistor string installation.

Temperature data were additionally recorded at temperature sensors at the six VWPs installed on site. Temperature data collected from the VWPs is presented in Appendix D2.

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TABLE 3.3

CASINO MINING CORPORATION
CASINO PROJECT

2013-2014 GROUNDWATER DATA REPORT
THERMISTOR DATA SUMMARY

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Thermistor	Location	Inferred Depth of Active Layer	Inferred Depth of Permafrost
		(mbgs)	(mbgs)
CAS-034	Deposit	3	104
CAS-036	Deposit	-	-
DH11-21B	Casino Creek	9	50
DH11-23B	Casino Creek	2	68
DH12-01	Casino Creek	4	62
DH12-02	Casino Creek	5	46
DH12-03	Casino Creek	4	43
DH12-05	Hillslope	-	-
DH13-03	Dip Creek Valley	All frozen	138
DH13-04	Dip Creek Valley	1	111

M:\1\01\00325\17\A\Report\1-2013 Hydrogeology\Rev 0\Tables\[Table 3.3 Thermistor Summary.xlsx]Table 3.2

NOTES:

1. THERMISTORS INSTALLED AT CAS-036 AND DH12-05 DID NOT REPORT TEMPERATURES BELOW ZERO DEGREES CELCIUS.

REV	DATE	DESCRIPTION	PREP'	CHK'	APP'
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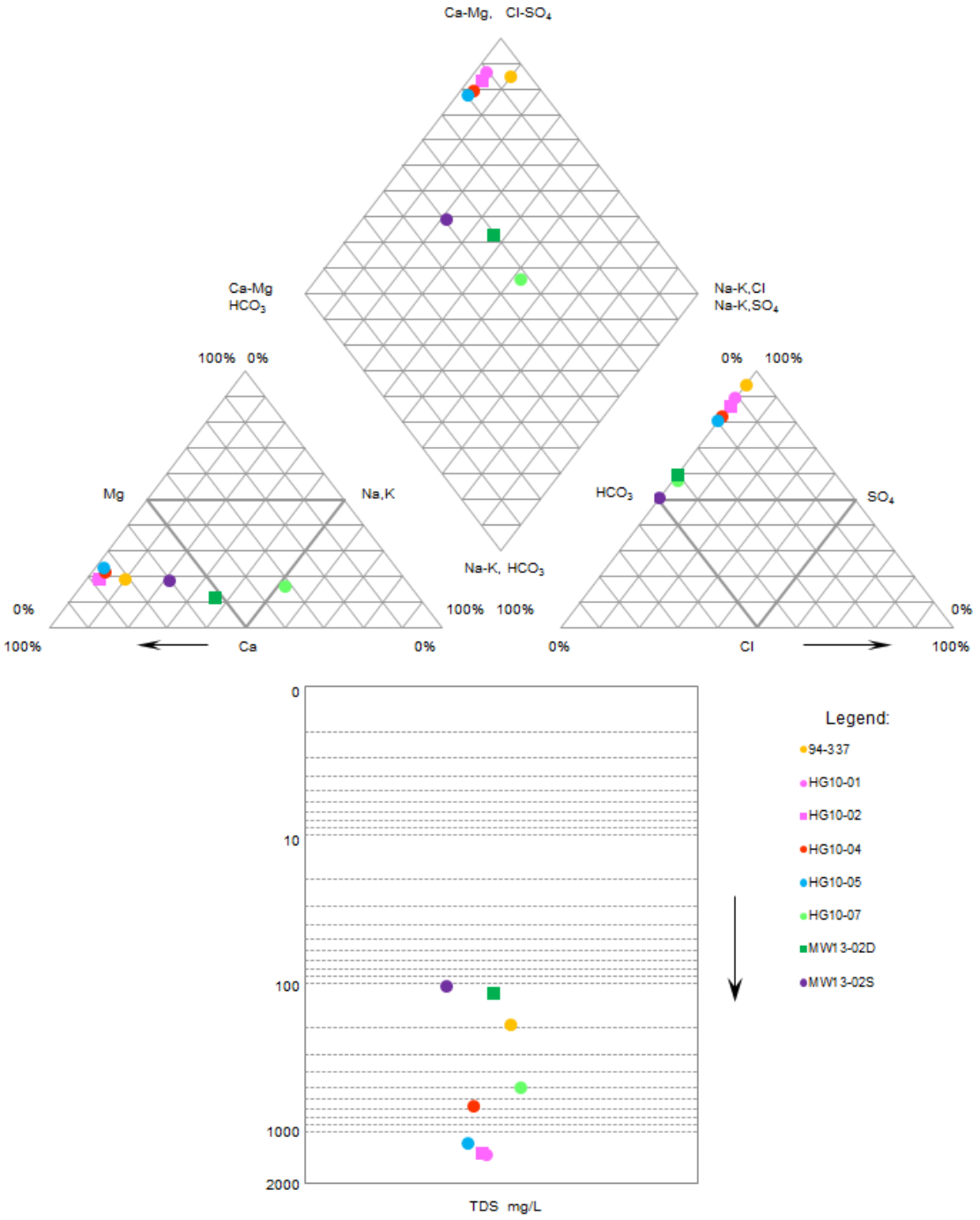
3.2.3 Monitoring Well Development (Monitoring Wells Installed Prior to 2013)

Groundwater samples have been collected by various consultants since the program began in 1993 and sampling and development methods have not always been clearly documented. It has been assumed that the groundwater sampling methods have been in accordance with the best practices for the time that they were sampled and likely ranged from hand or mechanical pump purging methods (three well volume) to low flow / minimum drawdowns (submersible pumps) methods. Turbidity is generally a good indicator of sample condition and higher turbidity samples tend to arise when pumping rates are greater than the natural flow through the screened interval of the well and sediments in the well are mobilized. Turbid conditions can also be an indicator that the wells were not sufficiently developed. The majority of the groundwater sample collected from monitoring wells prior to 2013 reported turbidity values below 50 NTU. Monitoring wells that reported groundwater sample turbidity values higher than 50 NTU even when sampled using the low flow submersible pumps were re-developed in the summer of 2013. Monitoring wells HG10-01, HG10-04, and MW11-02A were re-developed in June 2013 and MW11-02B was re-developed in September 2014. Results of the monitoring well development are presented on Table 3.2.

3.2.4 Groundwater Quality

Baseline analytical and *in situ* data have been compared to the relevant water quality guidelines for the Project. Data tables with guideline comparisons are provided in Appendix F. The data tables are inclusive of all data collected from 1994 to 2014; however, the QA/QC analysis (Appendix E) is limited to the data collected in 2013 and 2014. The QA/QC of preceding data are provided in the 2012 Baseline Hydrogeology Report (KP 2013). To remain consistent with the format of the previous report, data are presented by project area: Open Pit area, hillslope area, and Casino Creek valley area.

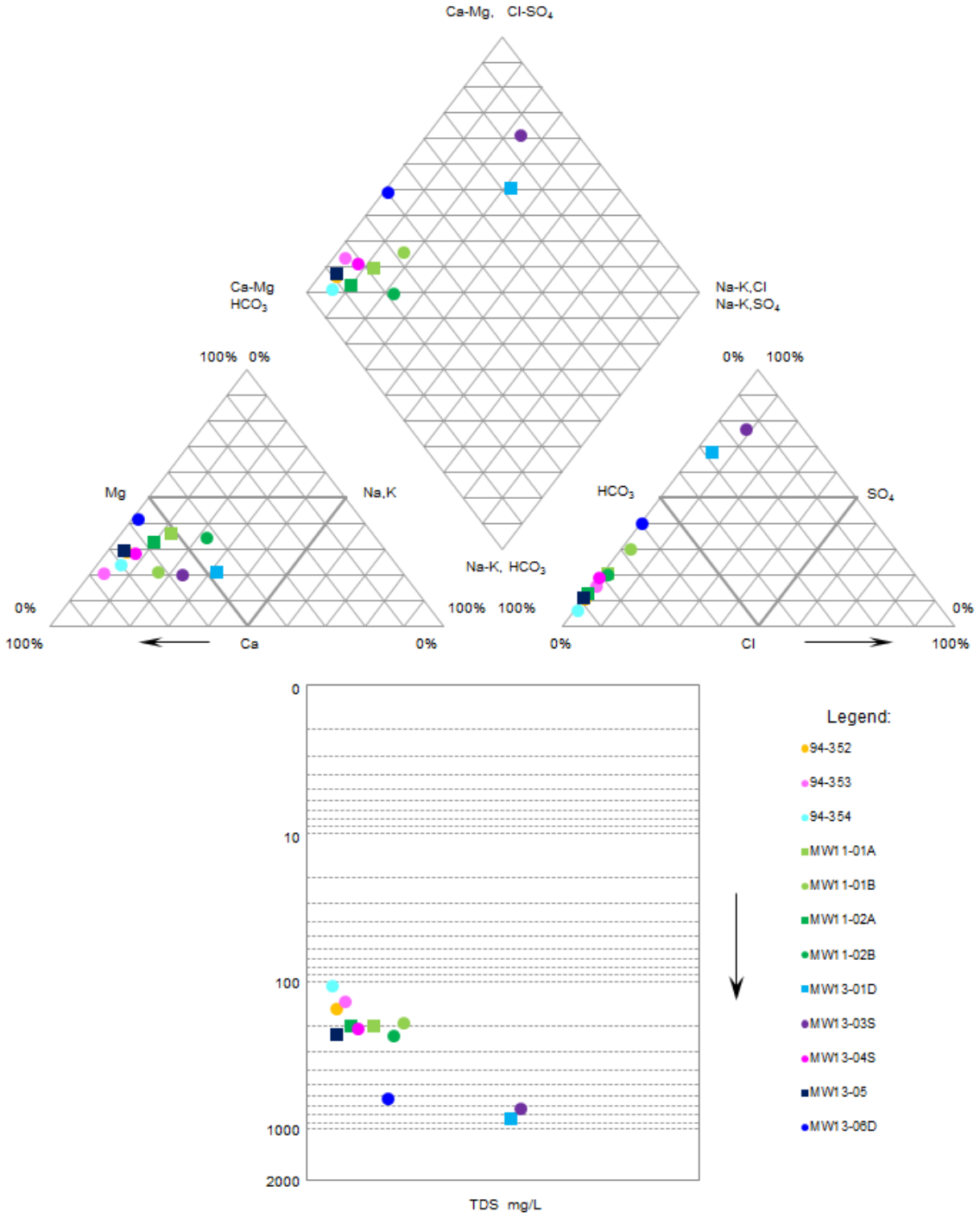
Piper diagrams were used to assist in characterizing groundwater quality in the project area and to compare major water types. A Piper diagram is a trilinear plot of the relative concentrations of the major dissolved ions in water, which provides a visual interpretation of the similarities and differences in the water throughout the project area. Piper diagrams were prepared for each of the three main project areas, using average analytical results for all samples collected from 1994 through 2014 from each monitoring site for major anion (bicarbonate, chloride, and sulphate) and cation (calcium, magnesium, sodium, and potassium) concentrations. These diagrams are provided on Figure 3.2 (Open Pit area), Figure 3.3 (hillslope area), and Figure 3.4 (Casino Creek Valley area). Piper diagrams showing individual samples for each well are provided in Appendix G.



NOTES:

1. DATA USED FOR THIS PLOT ARE AVERAGE VALUES.
2. PIPER DATA ARE PLOTTED IN PERCENT MILLI-EQUIVALENTS PER LITRE (%meq/L).
3. TOTAL ALKALINITY WAS USED FOR BICARBONATE VALUE, IF REQUIRED.

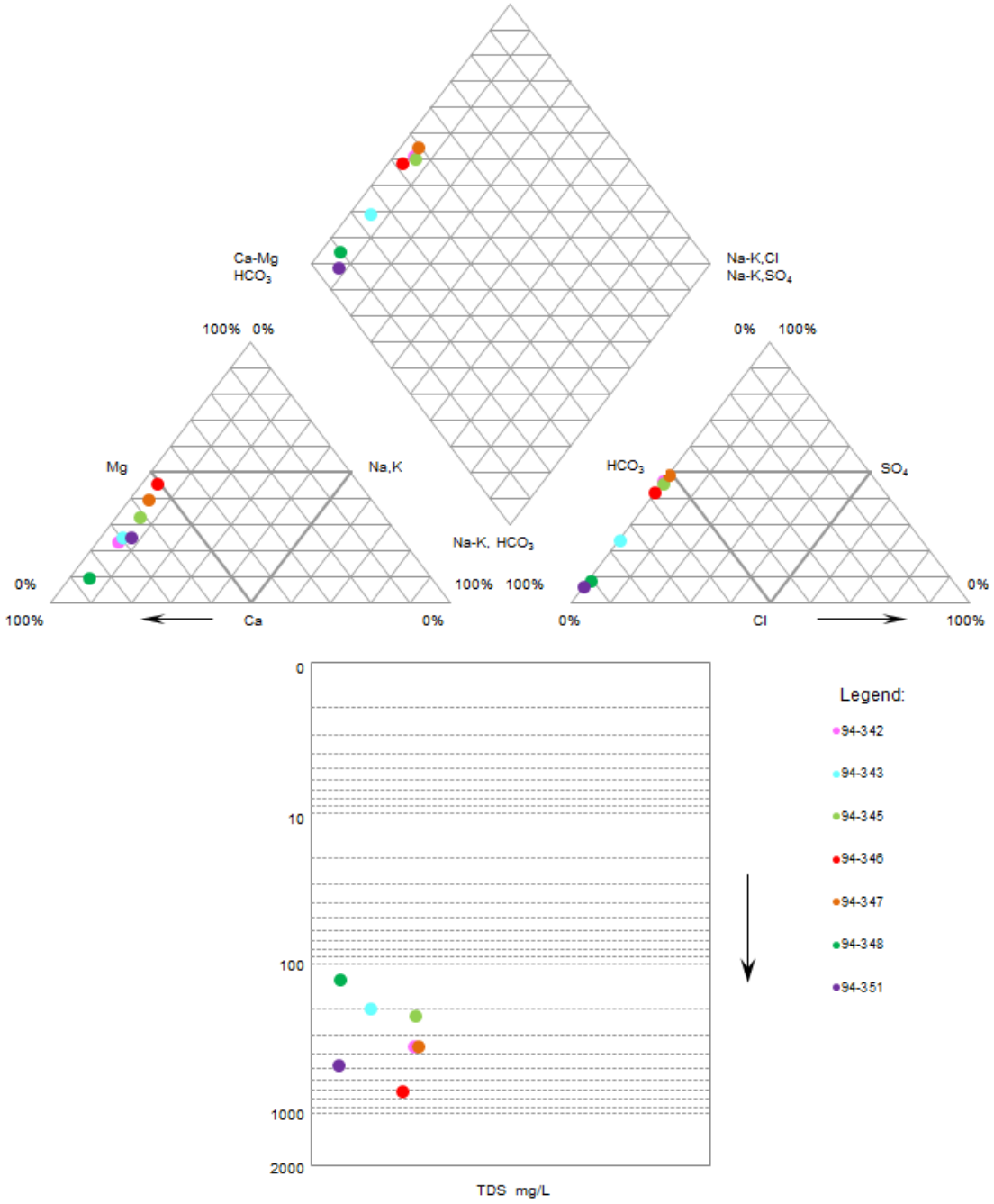
Figure 3.2 Trilinear Piper Diagram – Open Pit Area



NOTES:

1. DATA USED FOR THIS PLOT ARE AVERAGE VALUES.
2. PIPER DATA ARE PLOTTED IN PERCENT MILLI-EQUIVALENTS PER LITRE (%meq/L).
3. 94-352 DATA FOR 1994 AND 1995 WERE EXCLUDED.

Figure 3.3 Trilinear Piper Diagram – Hillslope Area



NOTES:

1. DATA USED FOR THIS PLOT ARE AVERAGE VALUES.
2. PIPER DATA ARE PLOTTED IN PERCENT MILLI-EQUIVALENTS PER LITRE (%meq/L).
3. GROUNDWATER CHEMISTRY DATA FOR SAMPLES COLLECTED PRIOR TO 2008 WERE EXCLUDED FOR THE CHARACTERIZATION OF 94-342 AND 94-345.

Figure 3.4 Trilinear Piper Diagram – Casino Creek Valley Area

4 – REFERENCES

BC Ministry of Water, Land and Air Protection. 2003. *British Columbia Field Sampling Manual for Continuous Monitoring and the Collection of Air, Air-emission, Water, Wastewater, Soil, Sediment and Biological Samples.*

Hvorslev, M.J. 1951. Time Lag and Soil Permeability in Ground-Water Observations. Waterways Exper. Sta. Corps of Engrs, U.S. Army. Bull. No. 36: 1-50.

Knight Piésold Ltd. (KP), 2013. Casino Copper-Gold Project. 2012 Baseline Hydrogeology Report (Ref. No. VA101-325/14-4).

Knight Piésold Ltd. (KP), 2014. Casino Project. 2013 Geotechnical Site Investigation Data Report, Mine Site (Ref. No. VA101-325/16-1).

Ministry of Environment, British Columbia (BC MOE). 2012. Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators.

United States Environmental Protection Agency. 1996. Low-Flow (Minimum Drawdown) Ground-Water Sampling Procedures. EPA/540/S-95/504.

5 – CERTIFICATION

This report was prepared, reviewed and approved by the undersigned.

Groundwater Quality Prepared:

for Kevin Davenport, EIT
Staff Engineer

Groundwater Quality Prepared:

Catriona Jackson, EIT
Staff Engineer

PROFESSIONAL ENGINEER YUKON TERRITORY DR. CYNTHIA STARZYK

Groundwater Quality Reviewed:

Cindy Starzyk, Ph.D. P.Eng.
Senior Engineer

Groundwater Quality Reviewed:

Jessica Mackie, EP
Senior Environmental Scientist

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Approval that this document adheres to Knight Piésold Quality Systems:

APPENDIX A

DRILLHOLE AND MONITORING WELL COMPLETION LOGS

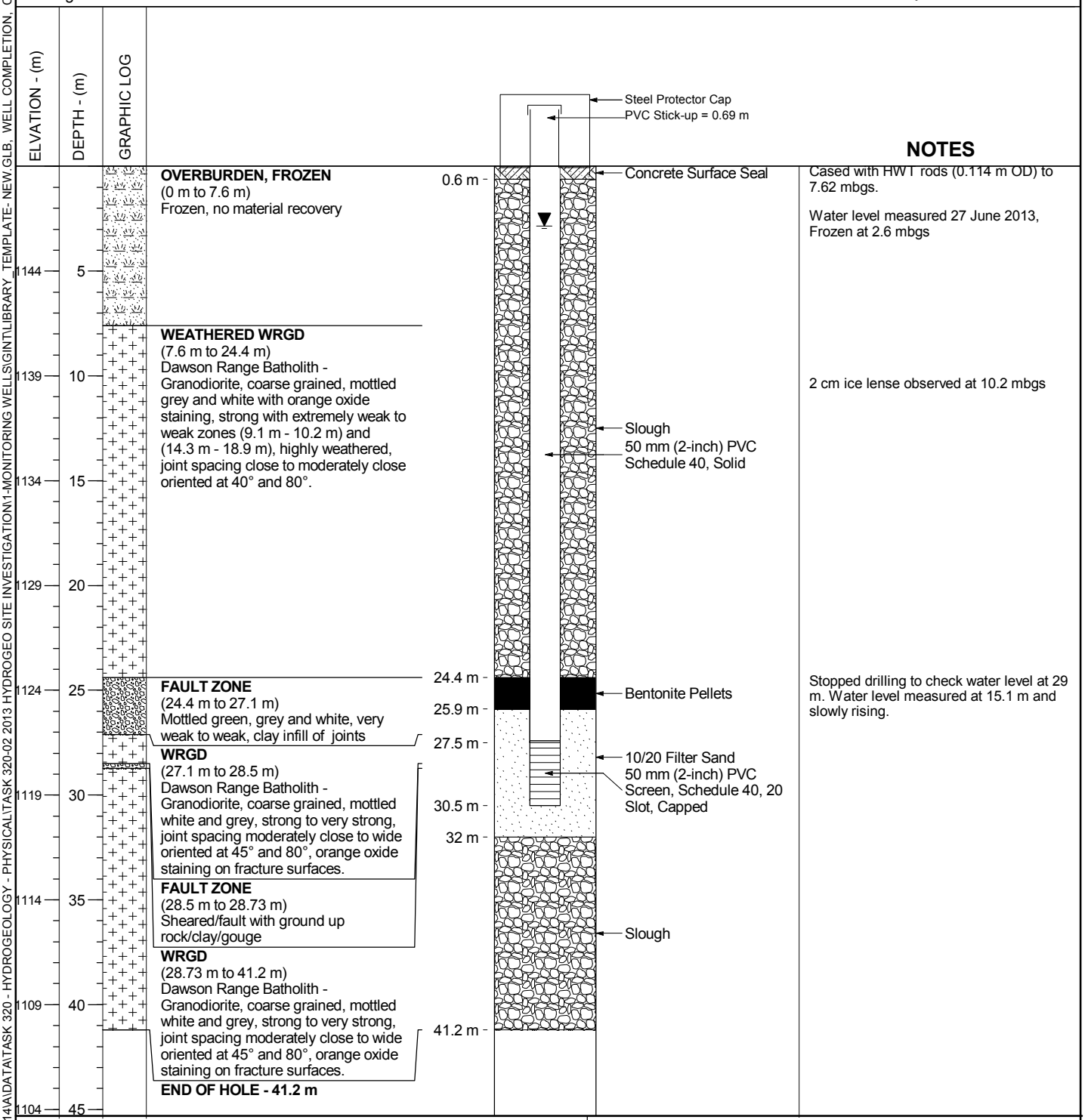
Appendix A1 Drillhole and Monitoring Well Completion Logs
Appendix A2 Geological Logs from CMC

APPENDIX A1

DRILLHOLE AND MONITORING WELL COMPLETION LOGS

(Pages A1-1 to A1-11)

Project:	**CASINO PROJECT**	Drill Hole No.	**MW13-01D**	**PAGE**	1 of 1
Contractor:	**Kluane Drilling Ltd.**	In Situ Sampler:	**N/A**	Date Started:	**5 Jun 13**
Location:	**Supergene Ox / Low Grade Ore Stockpile**	Total Depth:	**41.2 m**	Date Completed:	**6 Jun 13**
Coordinates:	**6,957,455 N, 611,804 E, UTM NAD83**	Elevation:	**1149 m**	Date Well Installed:	**6 Jun 13**
Drilling Rig:	**KD1000 Exploration**	"Inclination":	**-90°**	Logged by:	**KTD/CAS**
Drilling Method:	**Diamond Coring**	Hole size:	**0.091 m**	Reviewed by:	**CAS**



NOTES

Cased with HWT rods (0.114 m OD) to 7.62 mbgs.

Water level measured 27 June 2013, Frozen at 2.6 mbgs

2 cm ice lense observed at 10.2 mbgs

Stopped drilling to check water level at 29 m. Water level measured at 15.1 m and slowly rising.

GENERAL REMARKS:

COORDINATES WERE SURVEYED BY YUKON ENGINEERING SERVICES IN SEPT 2013.

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CASINO MINING CORPORATION
CASINO PROJECT
MONITORING WELL DETAILS FOR MW13-01D

Knight Piésold CONSULTING

PROJECT/ASSIGNMENT NO. **VA101-325/17** | REF. NO. **1**

FIGURE. **Figure A1.1** | REV. **1**

Logging conducted according to the Canadian Foundation Engineering Manual, 4th Edition, 2006.

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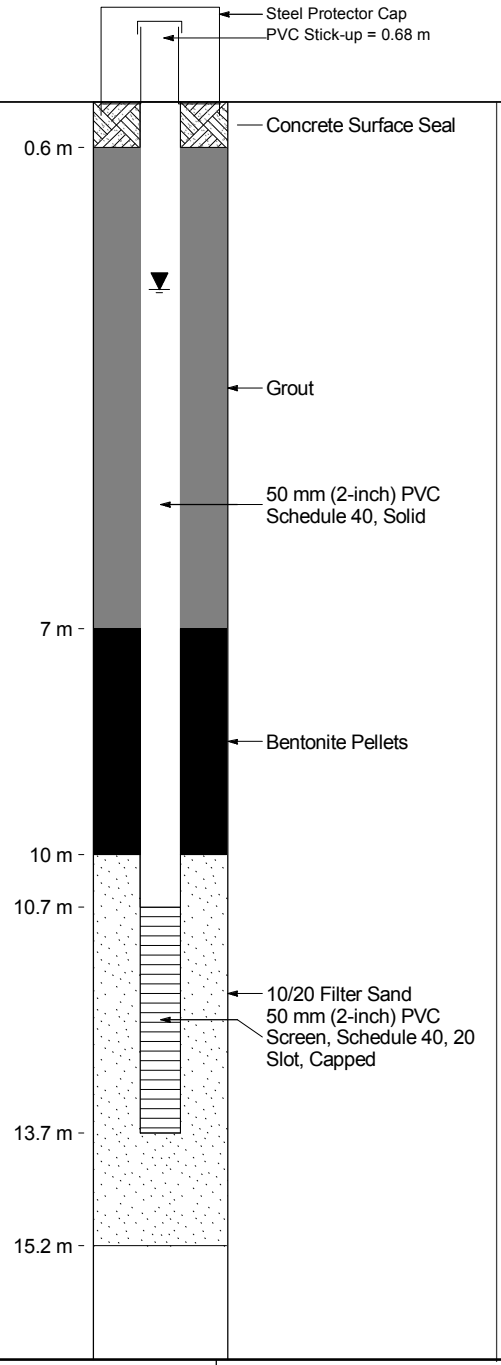
Library: M:\1101\00325114\A\DATA\TASK 320 - HYDROGEOLOGY - PHYSICAL\TASK 320-02 2013 HYDROGEO SITE INVESTIGATION\1-MONITORING WELLS\GINT\LIBRARY_TEMPLATE- NEW.GLB, WELL COMPLETION, CASINO 2013 DATA TEMPLATE.GDT, 6 I

Project:	**CASINO PROJECT**	Drill Hole No.	**MW13-01S**	**PAGE**	1 of 1
Contractor:	**Kluane Drilling Ltd.**	In Situ Sampler:	**N/A**	Date Started:	**7 Jun 13**
Location:	**Supergene Ox / Low Grade Ore Stockpile**	Total Depth:	**15.2 m**	Date Completed:	**7 Jun 13**
Coordinates:	**6,957,450 N, 611,802 E, UTM NAD83**	Elevation:	**1150 m**	Date Well Installed:	**7 Jun 13**
Drilling Rig:	**KD1000 Exploration**	"Inclination":	**-90°**	Logged by:	**KTD/CAS**
Drilling Method:	**Diamond Coring**	Hole size:	**0.091 m**	Reviewed by:	**CAS**

ELVATION - (m)	DEPTH - (m)	GRAPHIC LOG	
			SILTY SAND, FROZEN (0 m to 1.2 m) Angular, fine to coarse grained, well graded, brown, wet
			SAND AND SILT, FROZEN (1.2 m to 4.6 m) Angular, fine to coarse grained, well graded, frozen (Residual Soil)
1145	5		**WEATHERED WRGD** (4.6 m to 9.1 m) Dawson Range Batholith - Granodiorite, coarse grained, mottled white and grey, strong to very strong, moderately to highly weathered, joint spacing close to moderately close oriented at 45° and 80° with orange oxide on joint surfaces.
1140	10		**FAULT ZONE** (9.1 m to 13.6 m) Fault zone, highly fractured to <10 cm pieces, clay altered with orange oxide staining
1135	15		**WEATHERED WRGD** (13.6 m to 15.2 m) Dawson Range Batholith - Granodiorite, coarse grained, mottled white and grey, strong to very strong, orange oxidation of joints, slight to moderate weathering, calcite and quartz infilled veins. **END OF HOLE - 15.2 m**



NOTES

Cased with HWT rods (0.114 m OD) to 4.57 mbgs

Water level measured June 27, 2013, Frozen at 2.4 mbgs

GENERAL REMARKS:

COORDINATES WERE SURVEYED BY YUKON ENGINEERING SERVICES IN SEPT 2013.

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CASINO MINING CORPORATION
CASINO PROJECT
MONITORING WELL DETAILS FOR MW13-01S

Knight Piésold CONSULTING

PROJECT/ASSIGNMENT NO. **VA101-325/17** | REF. NO. **1**

FIGURE. **Figure A1.2** | REV. **1**

Logging conducted according to the Canadian Foundation Engineering Manual, 4th Edition, 2006.

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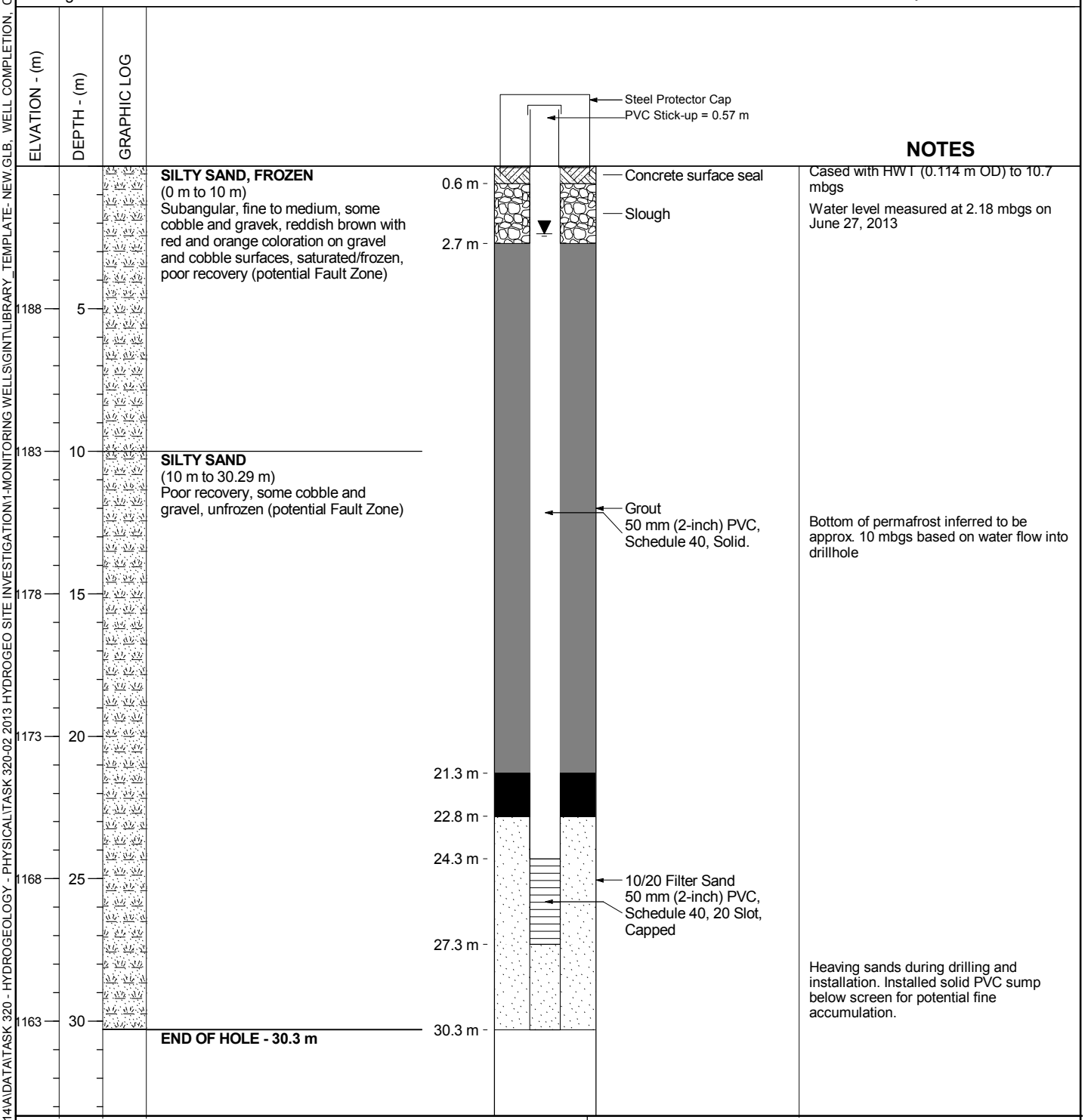
Project:	**CASINO PROJECT**	Drill Hole No.	**MW13-02D**	**PAGE**	1 of 1
Contractor:	**Kluane Drilling Ltd.**	In Situ Sampler:	**N/A**	Date Started:	**12 Jun 13**
Location:	**North of Open Pit**	Total Depth:	**30.3 m**	Date Completed:	**12 Jun 13**
Coordinates:	**6,959,341 N, 609,888 E, UTM NAD83**	Elevation:	**1193 m**	Date Well Installed:	**12 Jun 13**
Drilling Rig:	**KD1000 Exploration**	"Inclination":	**-90°**	Logged by:	**KTD**
Drilling Method:	**Diamond Coring**	Hole size:	**0.091 m**	Reviewed by:	**CAS**



NOTES

Cased with HW1 (0.114 m OD) to 10.7 mbgs

Water level measured at 2.18 mbgs on June 27, 2013

Bottom of permafrost inferred to be approx. 10 mbgs based on water flow into drillhole

Heaving sands during drilling and installation. Installed solid PVC sump below screen for potential fine accumulation.

GENERAL REMARKS:

COORDINATES WERE SURVEYED BY YUKON ENGINEERING SERVICES IN SEPT 2013.

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CASINO MINING CORPORATION
CASINO PROJECT
MONITORING WELL DETAILS FOR MW13-02D

Knight Piésold CONSULTING

PROJECT/ASSIGNMENT NO. **VA101-325/17** | REF. NO. **1**

FIGURE. **Figure A1.3** | REV. **1**

Logging conducted according to the Canadian Foundation Engineering Manual, 4th Edition, 2006.

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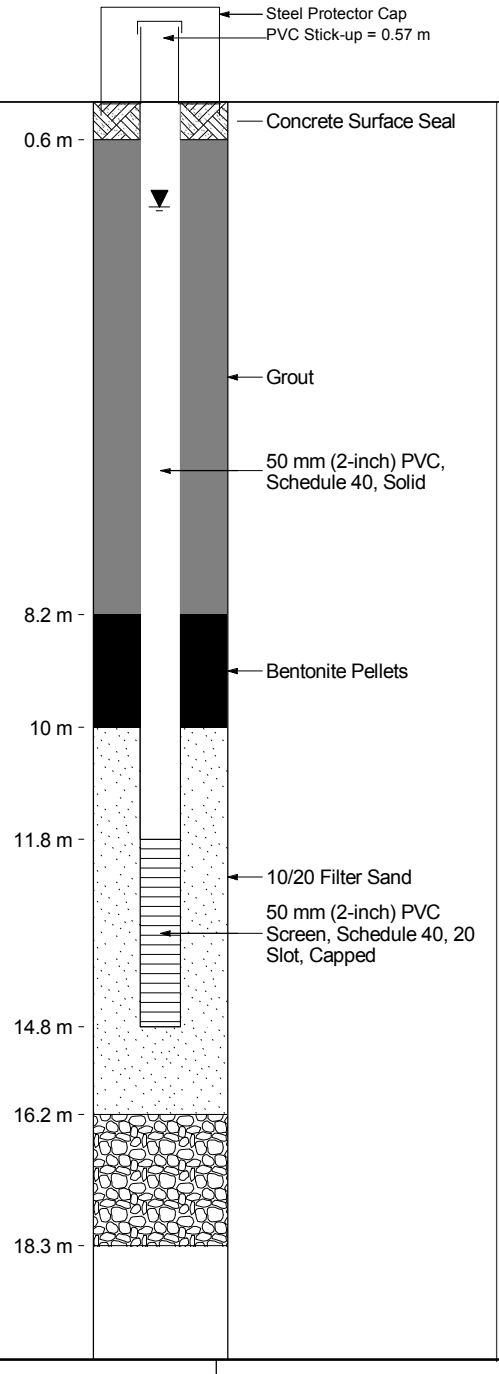
Project:	**CASINO PROJECT**	Drill Hole No.	**MW13-02S**	**PAGE**	1 of 1
Contractor:	**Kluane Drilling Ltd.**	In Situ Sampler:	**N/A**	Date Started:	**8 Jun 13**
Location:	**North of Open Pit**	Total Depth:	**18.3 m**	Date Completed:	**8 Jun 13**
Coordinates:	**6,959,345 N, 609,886 E, UTM NAD83**	Elevation:	**1193 m**	Date Well Installed:	**9 Jun 13**
Drilling Rig:	**KD1000 Exploration**	"Inclination":	**-90°**	Logged by:	**KTD/CAS**
Drilling Method:	**Diamond Coring**	Hole size:	**0.091 m**	Reviewed by:	**CAS**

ELVATION - (m)	DEPTH - (m)	GRAPHIC LOG	
1188	5		**SILTY SAND, FROZEN** (0 m to 10 m) Subangular, fine to medium, some cobbles and gravel, well graded, reddish brown with red and orange coloration on gravel and cobble surfaces, saturated, frozen, poor recovery (potential Fault Zone)
1183	10		**SILTY SAND** (10 m to 18.3 m) Poor recovery, some cobble and gravel, unfrozen (potential Fault Zone)
1178	15		
1173	20		**END OF HOLE - 18.3 m**



NOTES

Cased with HWT rods (0.114 m OD) to 10.6 mbgs

Water level measured at 1.57 mbgs on June 26, 2013

Bottom of permafrost inferred to be approx. 10 mbgs based on water flow into drillhole

Heaving Sands into drillhole during installation

GENERAL REMARKS:

COORDINATES WERE SURVEYED BY YUKON ENGINEERING SERVICES IN SEPT 2013.

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CASINO PROJECT
MONITORING WELL DETAILS FOR MW13-02S

Knight Piésold CONSULTING

PROJECT/ASSIGNMENT NO. **VA101-325/17** | REF. NO. **1**

FIGURE. **Figure A1.4** | REV. **1**

Logging conducted according to the Canadian Foundation Engineering Manual, 4th Edition, 2006.

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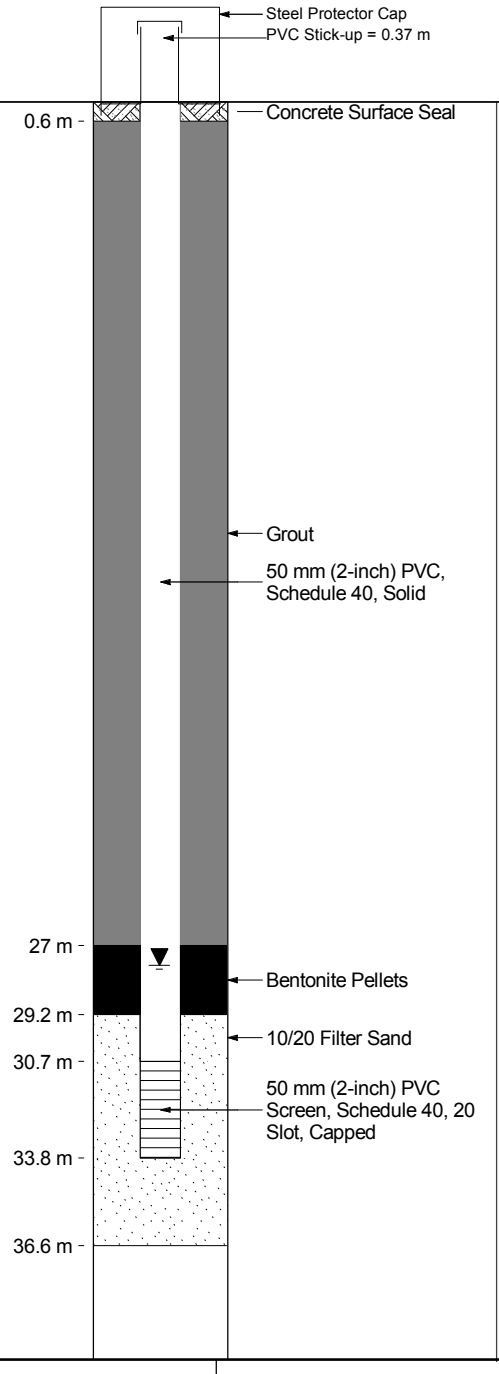
Project:	**CASINO PROJECT**	Drill Hole No.	**MW13-03D**	**PAGE**	1 of 1
Contractor:	**Kluane Drilling Ltd.**	In Situ Sampler:	**N/A**	Date Started:	**14 Jun 13**
Location:	**North of Gold Ore Stockpile**	Total Depth:	**36.6 m**	Date Completed:	**16 Jun 13**
Coordinates:	**6,958,593 N, 613,068 E, UTM NAD83**	Elevation:	**1214 m**	Date Well Installed:	**16 Jun 13**
Drilling Rig:	**KD1000 Exploration**	"Inclination":	**-90°**	Logged by:	**KTD**
Drilling Method:	**Diamond Coring**	Hole size:	**0.114 m**	Reviewed by:	**CAS**

ELVATION - (m)	DEPTH - (m)	GRAPHIC LOG	
1209	5		**SAND** (0 m to 3 m) Subangular, fine to medium, some silt, cobbles and gravel, well graded, reddish brown.
			WEATHERED WRGD (3 m to 27.4 m) Dawson Range Batholith - Granodiorite, coarse grained, mottled black and white, strong to very strong, moderately to highly weathered, joint spacing close oriented at 45° and 80°, orange oxide staining of joints. Clay matrix from 9.1 to 9.8 mbgs
1204	10		@ 9.8 to 27.4 m Slightly weathered
			@ 13.7 to 14.1 m Zone of gravel sized broken rock
1199	15		
1194	20		
1189	25		
			WRGD (27.4 m to 36.6 m) Dawson Range Batholith - Granodiorite, coarse grained, mottled black and white, very strong, fresh, joint spacing moderately close to wide oriented at 45° and 80°.
1184	30		
1179	35		@ 36.3 to 36.5 m Clay gouge in narrow shear interval
1174	40		**END OF HOLE - 36.6 m**



NOTES

Cased with PW rods (0.140 m OD) to 12.2 mbgs

Water level measured at 27.4 mbgs on June 28, 2013

GENERAL REMARKS:

COORDINATES WERE SURVEYED BY YUKON ENGINEERING SERVICES IN SEPT 2013.
DIFFICULTY REMOVING RODS DURING INSTALLATION DUE TO FREEZING TO DRILLHOLE WALLS.

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MONITORING WELL DETAILS FOR MW13-03D

Knight Piésold CONSULTING

PROJECT/ASSIGNMENT NO. **VA101-325/17** | REF. NO. **1**
FIGURE. **Figure A1.5** | REV. **1**

Logging conducted according to the Canadian Foundation Engineering Manual, 4th Edition, 2006.

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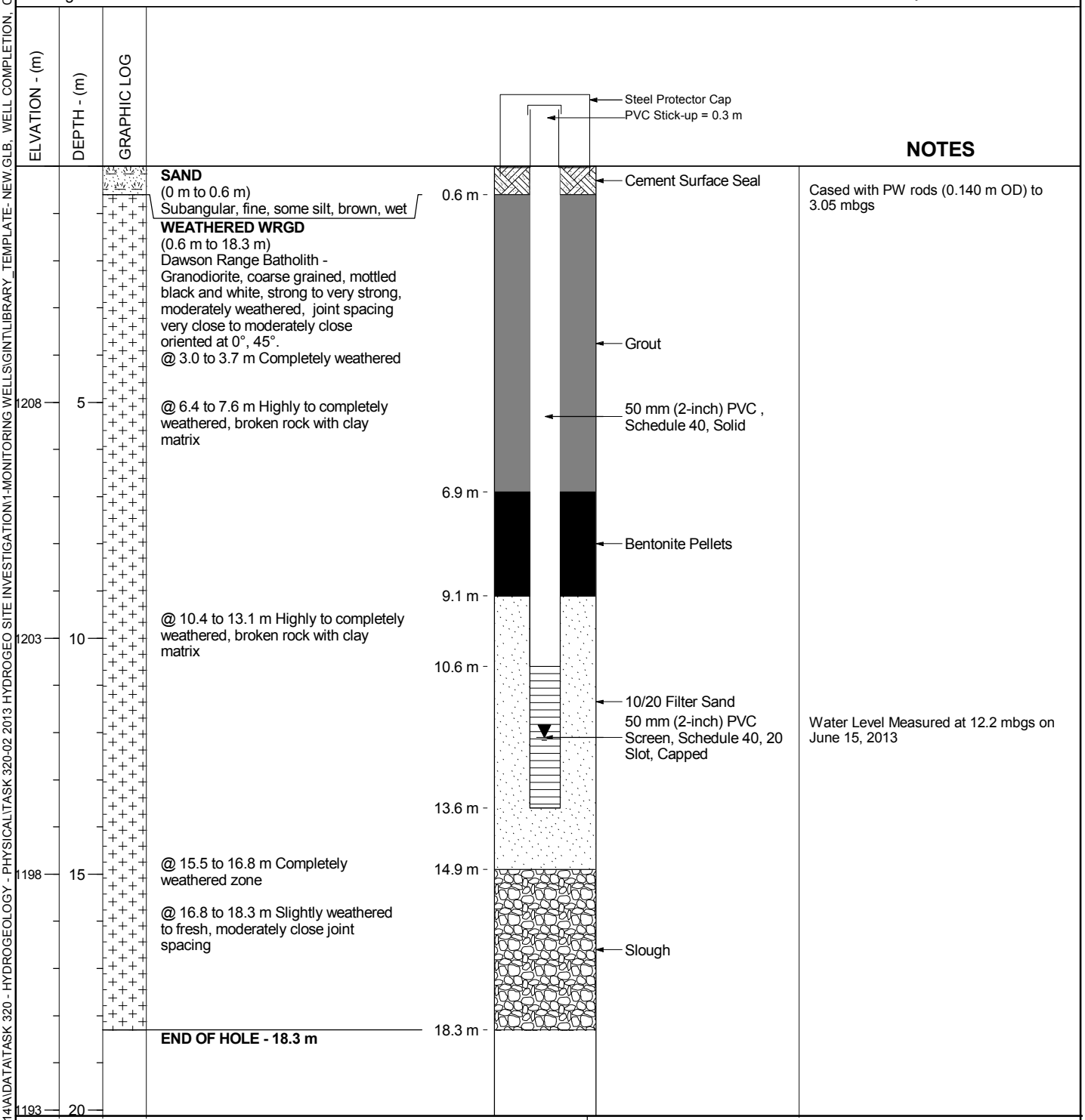
Project:	**CASINO PROJECT**	Drill Hole No.	**MW13-03S**	**PAGE**	1 of 1
Contractor:	**Kluane Drilling Ltd.**	In Situ Sampler:	**N/A**	Date Started:	**17 Jun 13**
Location:	**North of Gold Ore Stockpile**	Total Depth:	**18.3 m**	Date Completed:	**17 Jun 13**
Coordinates:	**6,958,589 N, 613,065 E, UTM NAD83**	Elevation:	**1213 m**	Date Well Installed:	**17 Jun 13**
Drilling Rig:	**KD1000 Exploration**	"Inclination":	**-90°**	Logged by:	**KTD**
Drilling Method:	**Diamond Coring**	Hole size:	**0.114 m**	Reviewed by:	**CAS**



NOTES

Cased with PW rods (0.140 m OD) to 3.05 mbgs

Water Level Measured at 12.2 mbgs on June 15, 2013

GENERAL REMARKS:

COORDINATES WERE SURVEYED BY YUKON ENGINEERING SERVICES IN SEPT 2013.

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CASINO MINING CORPORATION
CASINO PROJECT
MONITORING WELL DETAILS FOR MW13-03S

Knight Piésold CONSULTING

PROJECT/ASSIGNMENT NO. **VA101-325/17** | REF. NO. **1**

FIGURE. **Figure A1.6** | REV. **1**

Logging conducted according to the Canadian Foundation Engineering Manual, 4th Edition, 2006.

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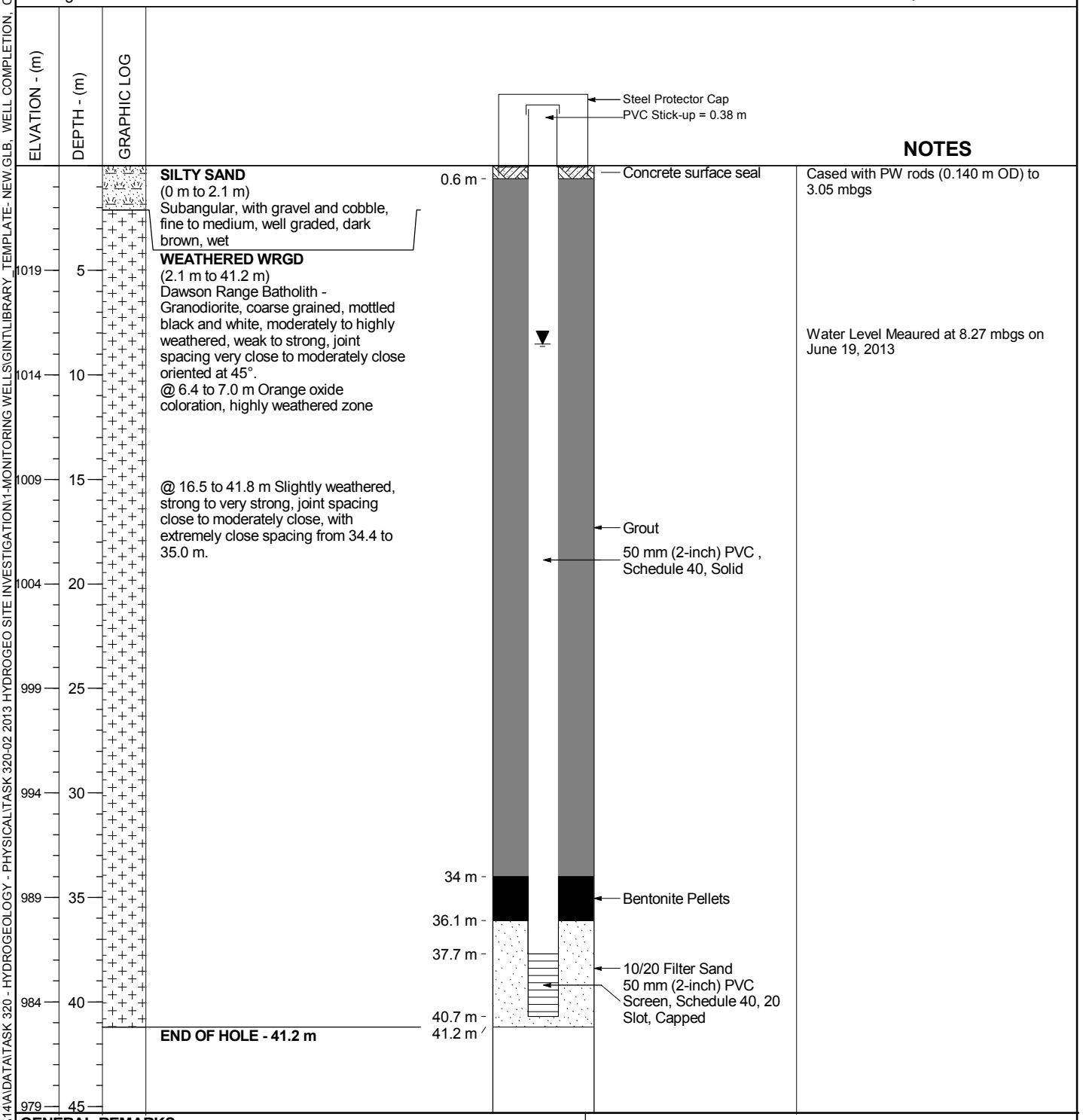
Project:	**CASINO PROJECT**	Drill Hole No.	**MW13-04D**	**PAGE**	1 of 1
Contractor:	**Kluane Drilling Ltd.**	In Situ Sampler:	**N/A**	Date Started:	**18 Jun 13**
Location:	**South of Gold Ore Stockpile**	Total Depth:	**41.2 m**	Date Completed:	**19 Jun 13**
Coordinates:	**6,957,637 N, 613,298 E, UTM NAD83**	Elevation:	**1024 m**	Date Well Installed:	**19 Jun 13**
Drilling Rig:	**KD1000 Exploration**	"Inclination":	**-90°**	Logged by:	**KTD**
Drilling Method:	**Diamond Coring**	Hole size:	**0.114 m**	Reviewed by:	**CAS**



NOTES

Cased with PW rods (0.140 m OD) to 3.05 mbgs

Water Level Meaured at 8.27 mbgs on June 19, 2013

GENERAL REMARKS:

COORDINATES WERE SURVEYED BY YUKON ENGINEERING SERVICES IN SEPT 2013.

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CASINO MINING CORPORATION
CASINO PROJECT
MONITORING WELL DETAILS FOR MW13-04D

Knight Piésold CONSULTING

PROJECT/ASSIGNMENT NO. **VA101-325/17** | REF. NO. **1**

FIGURE. **Figure A1.7** | REV. **1**

Logging conducted according to the Canadian Foundation Engineering Manual, 4th Edition, 2006.

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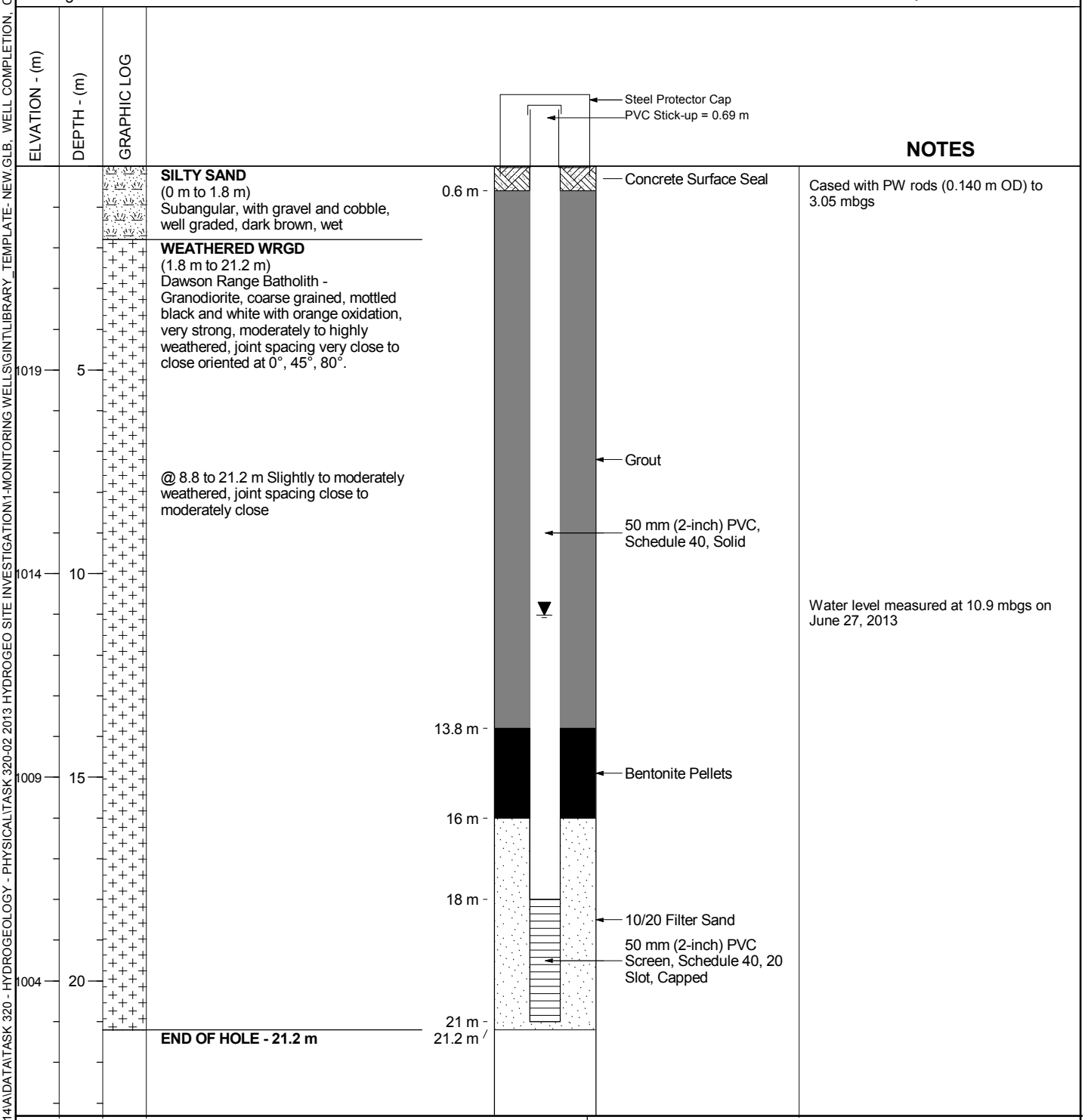
Project:	**CASINO PROJECT**	Drill Hole No.	**MW13-04S**	**PAGE**	1 of 1
Contractor:	**Kluane Drilling Ltd.**	In Situ Sampler:	**N/A**	Date Started:	**19 Jun 13**
Location:	**South of Gold Ore Stockpile**	Total Depth:	**21.2 m**	Date Completed:	**19 Jun 13**
Coordinates:	**6,957,633 N, 613,297 E, UTM NAD83**	Elevation:	**1024 m**	Date Well Installed:	**19 Jun 13**
Drilling Rig:	**KD1000 Exploration**	"Inclination":	**-90°**	Logged by:	**KTD**
Drilling Method:	**Diamond Coring**	Hole size:	**0.114 m**	Reviewed by:	**CAS**



GENERAL REMARKS:

COORDINATES WERE SURVEYED BY YUKON ENGINEERING SERVICES IN SEPT 2013.

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CASINO MINING CORPORATION
CASINO PROJECT
MONITORING WELL DETAILS FOR MW13-04S

Knight Piésold CONSULTING

PROJECT/ASSIGNMENT NO. **VA101-325/17** | REF. NO. **1**

FIGURE. **Figure A1.8** | REV. **1**

Logging conducted according to the Canadian Foundation Engineering Manual, 4th Edition, 2006.

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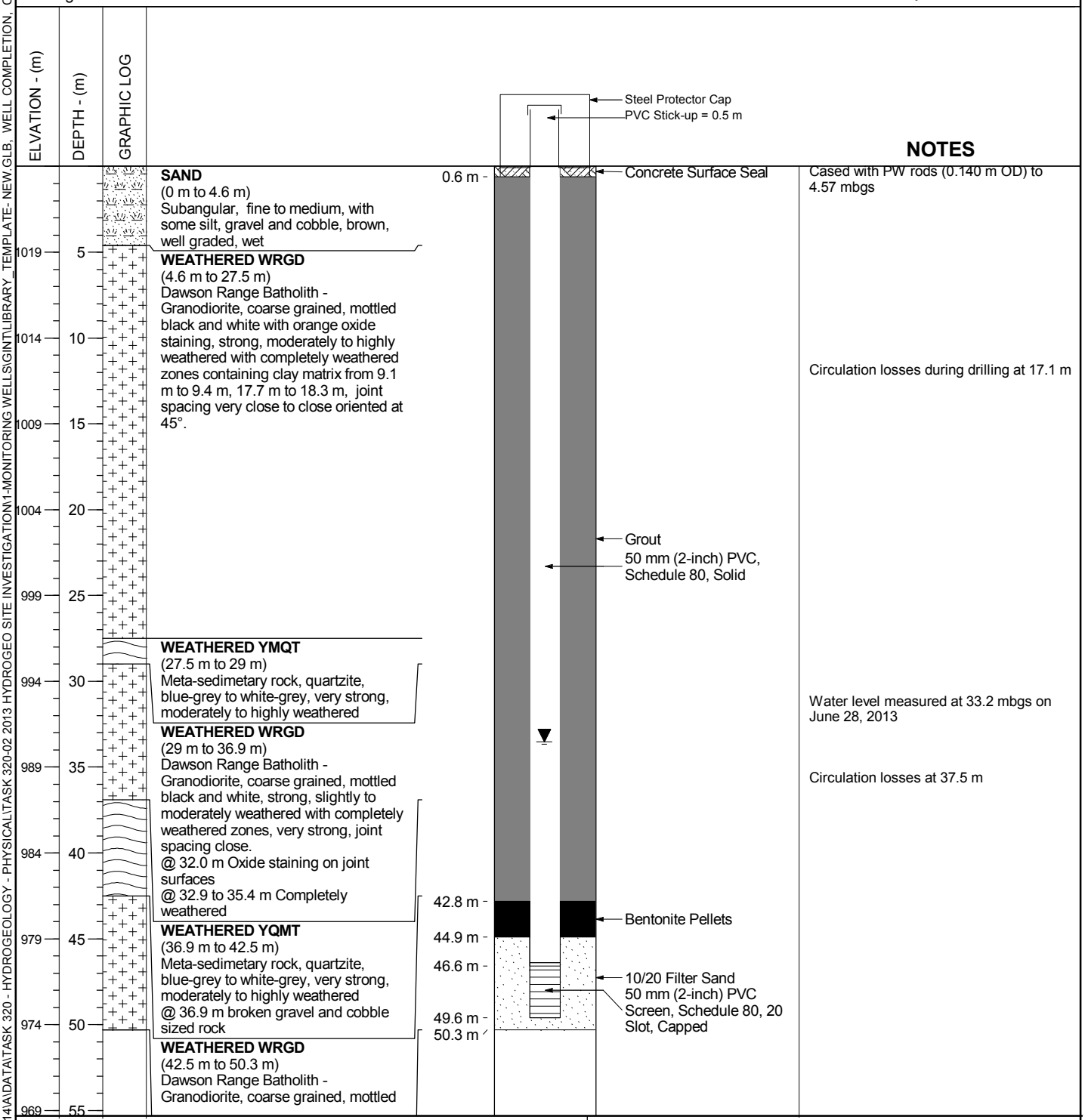
Project:	**CASINO PROJECT**	Drill Hole No.	**MW13-05**	**PAGE**	1 of 1
Contractor:	**Kluane Drilling Ltd.**	In Situ Sampler:	**N/A**	Date Started:	**20 Jun 13**
Location:	**Tailing Management Facility**	Total Depth:	**50.3 m**	Date Completed:	**20 Jun 13**
Coordinates:	**6,955,823 N, 614,719 E, UTM NAD83**	Elevation:	**1024 m**	Date Well Installed:	**22 Jun 13**
Drilling Rig:	**KD1000 Exploration**	"Inclination":	**-90°**	Logged by:	**KTD**
Drilling Method:	**Diamond Coring**	Hole size:	**0.114 m**	Reviewed by:	**CAS**



GENERAL REMARKS:

COORDINATES WERE SURVEYED BY YUKON ENGINEERING SERVICES IN SEPT 2013.

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CASINO MINING CORPORATION
CASINO PROJECT
MONITORING WELL DETAILS FOR MW13-05

Knight Piésold CONSULTING

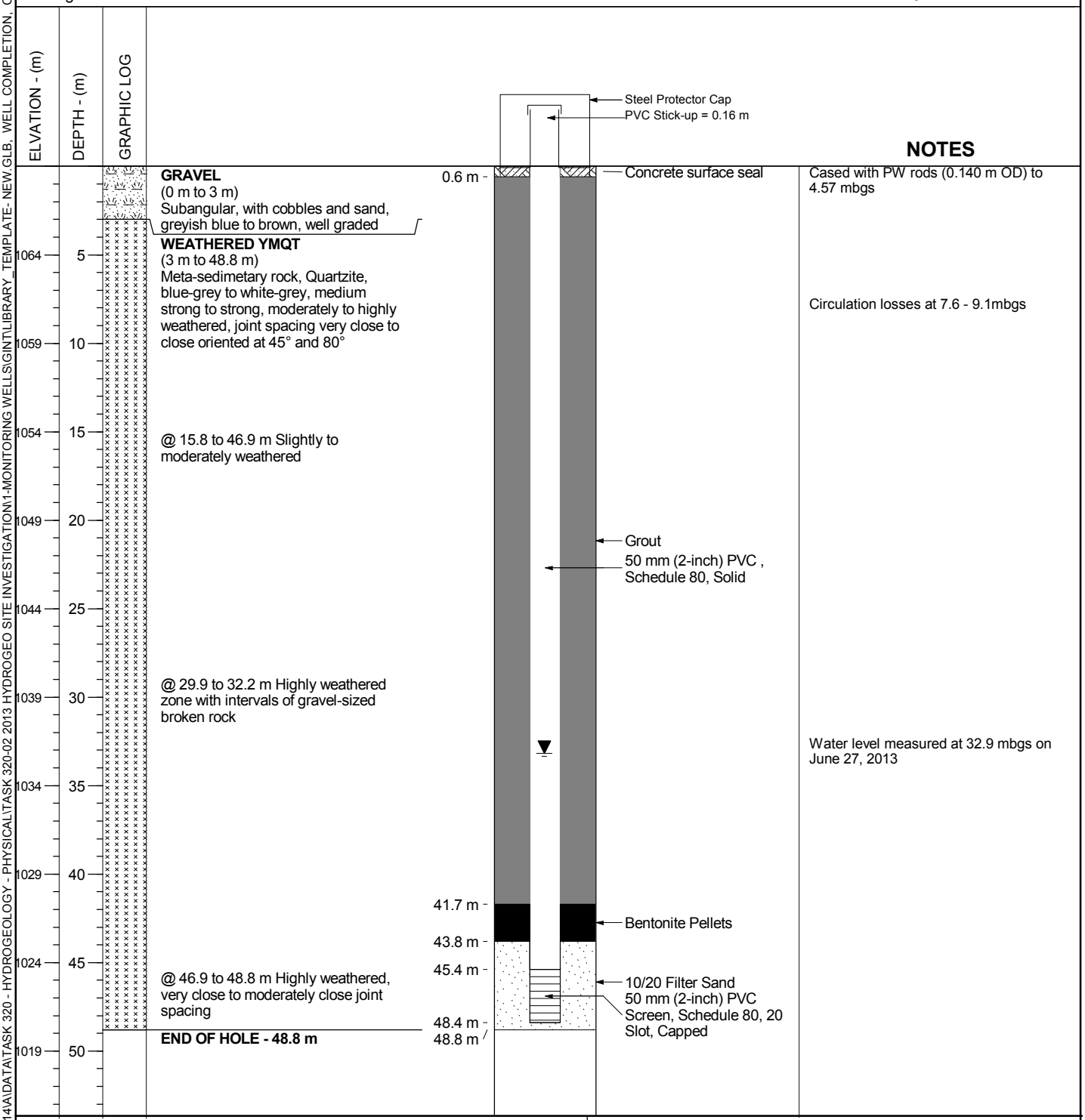
PROJECT/ASSIGNMENT NO. **VA101-325/17** | REF. NO. **1**

FIGURE. **Figure A1.9** | REV. **1**

Logging conducted according to the Canadian Foundation Engineering Manual, 4th Edition, 2006.

File:M:\1101\00325114\A\DATA\TASK 320 - HYDROGEOLOGY - PHYSICAL\TASK 320-02 2013 HYDROGEO SITE INVESTIGATION\1-MONITORING WELLS\GINT\CASINO 2013 HYDROGEO SITE INVESTIGATION.GPJ
Library: M:\1101\00325114\A\DATA\TASK 320 - HYDROGEOLOGY - PHYSICAL\TASK 320-02 2013 HYDROGEO SITE INVESTIGATION\1-MONITORING WELLS\GINT\LIBRARY_TEMPLATE- NEW.GLB, WELL COMPLETION, CASINO 2013 DATA TEMPLATE.GDT, 6 I

Project:	**CASINO PROJECT**	Drill Hole No.	**MW13-06D**	**PAGE**	1 of 1
Contractor:	**Kluane Drilling Ltd.**	In Situ Sampler:	**N/A**	Date Started:	**23 Jun 13**
Location:	**Tailing Management Facility**	Total Depth:	**48.8 m**	Date Completed:	**24 Jun 13**
Coordinates:	**6,953,267 N, 613,962 E, UTM NAD83**	Elevation:	**1069 m**	Date Well Installed:	**24 Jun 13**
Drilling Rig:	**KD1000 Exploration**	"Inclination":	**-90°**	Logged by:	**KTD**
Drilling Method:	**Diamond Coring**	Hole size:	**0.114 m**	Reviewed by:	**CAS**



GENERAL REMARKS:

COORDINATES WERE SURVEYED BY YUKON ENGINEERING SERVICES IN SEPT 2013.

REV. 1 - Issued with Report

CASINO MINING CORPORATION
CASINO PROJECT
MONITORING WELL DETAILS FOR MW13-06D

Knight Piésold CONSULTING

PROJECT/ASSIGNMENT NO. **VA101-325/17** | REF. NO. **1**

FIGURE. **Figure A1.10** | REV. **1**

Logging conducted according to the Canadian Foundation Engineering Manual, 4th Edition, 2006.

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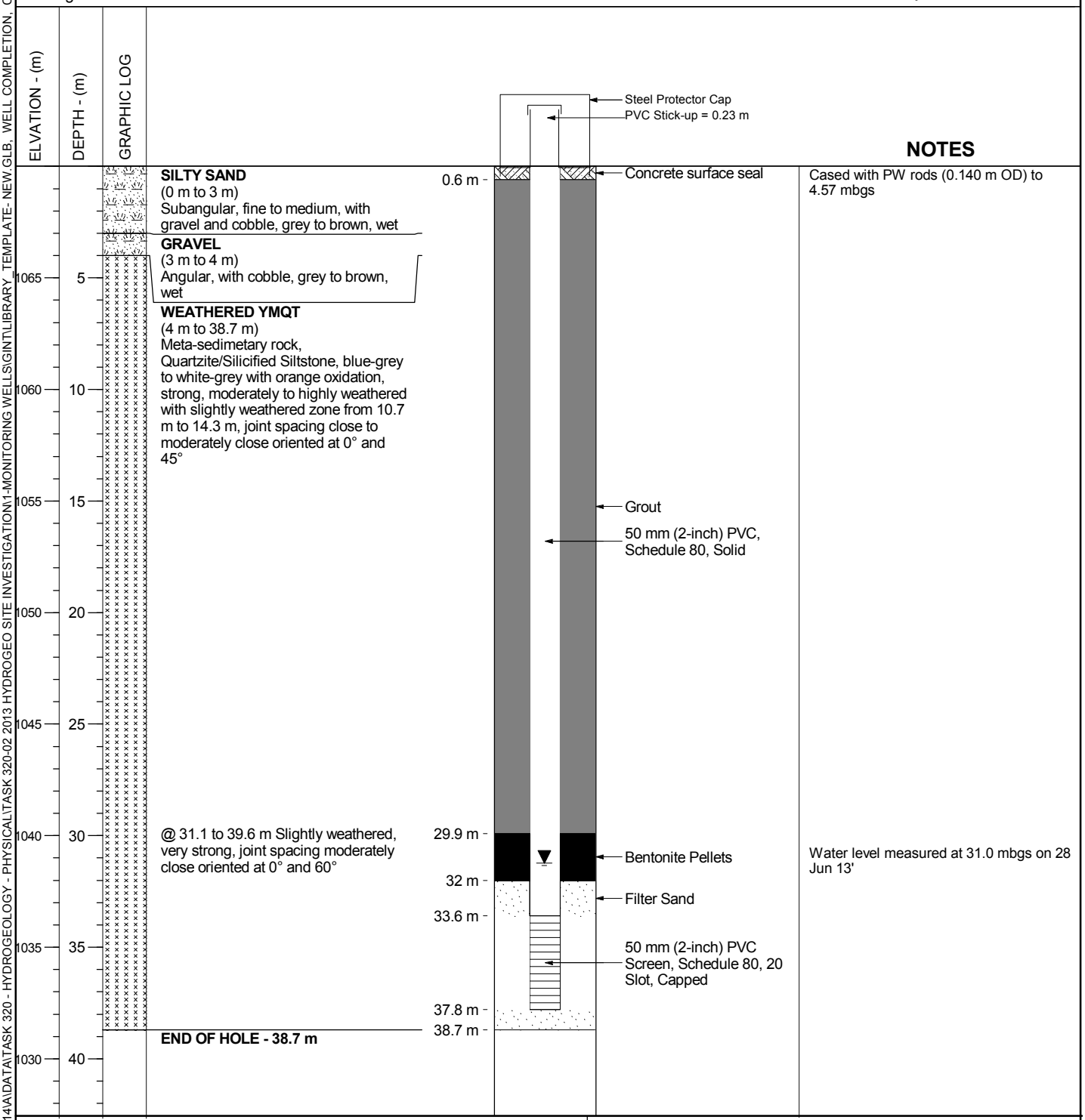
Project:	**CASINO PROJECT**	Drill Hole No.	**MW13-06S**	**PAGE**	1 of 1
Contractor:	**Kluane Drilling Ltd.**	In Situ Sampler:	**N/A**	Date Started:	**25 Jun 13**
Location:	**Tailing Management Facility**	Total Depth:	**38.7 m**	Date Completed:	**25 Jun 13**
Coordinates:	**6,953,276 N, 613,958 E, UTM NAD83**	Elevation:	**1070 m**	Date Well Installed:	**25 Jun 13**
Drilling Rig:	**KD1000 Exploration**	"Inclination":	**-90°**	Logged by:	**KTD**
Drilling Method:	**Diamond Coring**	Hole size:	**0.114 m**	Reviewed by:	**CAS**



NOTES

Cased with PW rods (0.140 m OD) to 4.57 mbgs

Water level measured at 31.0 mbgs on 28 Jun 13'

GENERAL REMARKS:

COORDINATES WERE SURVEYED BY YUKON ENGINEERING SERVICES IN SEPT 2013.

REV. 1 - Issued with Report

CASINO MINING CORPORATION
CASINO PROJECT
MONITORING WELL DETAILS FOR MW13-06S

Knight Piésold CONSULTING

PROJECT/ASSIGNMENT NO. **VA101-325/17** | REF. NO. **1**

FIGURE. **Figure A1.11** | REV. **1**

Logging conducted according to the Canadian Foundation Engineering Manual, 4th Edition, 2006.

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Library: M:\101\00325114\A\DATA\TASK 320 - HYDROGEOLOGY - PHYSICAL\TASK 320-02 2013 HYDROGEO SITE INVESTIGATION\1-MONITORING WELLS\GINT\LIBRARY_TEMPLATE- NEW.GLB, WELL COMPLETION, CASINO 2013 DATA TEMPLATE.GDT, 6 I

APPENDIX A2

GEOLOGICAL LOGS FROM CASINO MINING CORPORATION

(Pages A2-1 to A2-18)

HOLE # : MW13-01D

WESTERN COPPER CORPORATION
CASINO PROJECT
DIAMOND DRILL LOG

HOLE # : MW13-01D

UTM Coordinates NAD 83, Zone 7
Collar Survey Type: **Yukon Engineering**
Northing : **6957454.626 mN**
Easting : **611803.918 mE**
Elevation (m) : **1149.196 m**

Zone Legend
CAP
SOX
SUS
HYP

Hole Length : **41.15 m**
Azimuth (true) : **0**
Dip : **-90**
NTS : 115J/10
Core Size: **HTW**

Overburden : **6.84 m**
Contractor : Kluane Drilling Ltd.
Logged By : **S. Casselman**
Date Hole Started : **June 5, 2013**
Date Hole Completed : **June 6, 2013**

Depth (m)	R.Q.D. weak / strong	Zone	Pyrite 0% / 10%	From (m)	To (m)	DESCRIPTION
0				0.00	6.84	OVB: Overburden, no recovery
5				6.84	14.17	WRGD: Granodiorite. Intensely wheathered and bleached, fractured to pieces < 10 cm long. Aboundant iron oxide staining, orange-white colour.
10				14.17	41.15	WRGD: Granodiorite. Gradually becomes more competent and less wheathered down to 21.5 m. Then becomes fresh, competent granodiorite. Grey-white colour with 10% hornbelnde laths to 0.5 cm. Traces of fine-grained cubic pyrite. Sheared/fault with ground up rock/clay/gouge at 24.38 - 27.42 m and 28.53 - 28.73 m.
15						
20						

Sample Data

From (m)	To (m)	Wdth (m)	Sample	Cu %	Mo %	Au (g/t)	Ag (g/t)

HOLE # : **MW13-01D**

WESTERN COPPER CORPORATION
CASINO PROJECT
DIAMOND DRILL LOG



HOLE # : MW13-01S

WESTERN COPPER CORPORATION
CASINO PROJECT
DIAMOND DRILL LOG

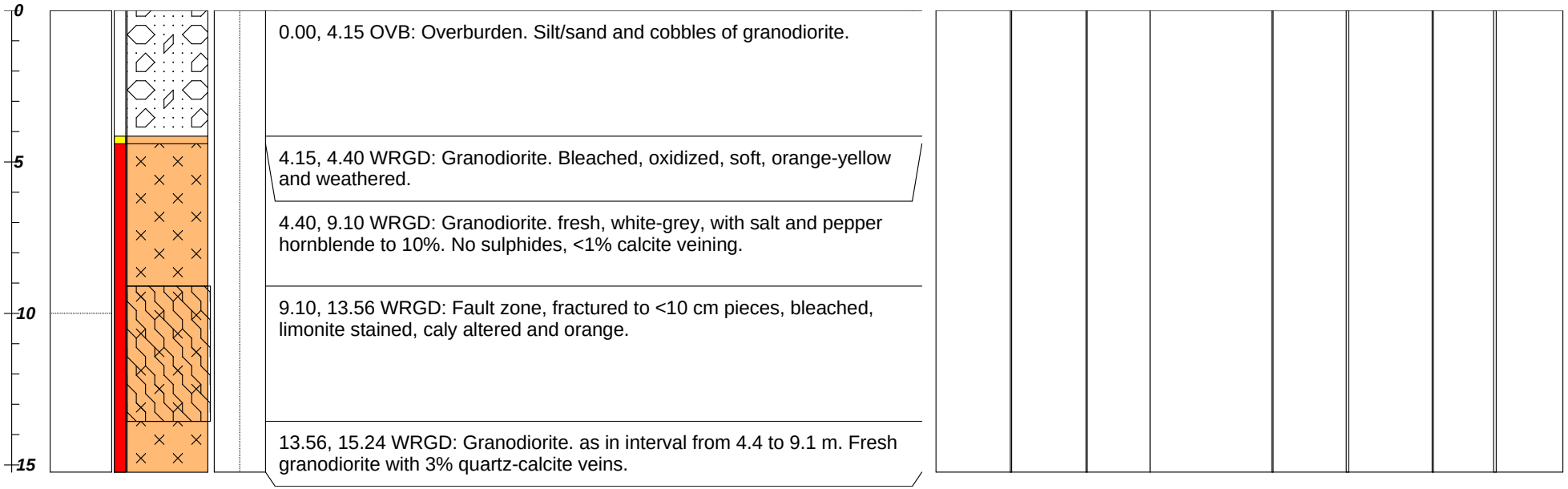
HOLE # : MW13-01S

UTM Coordinates NAD 83, Zone 7
Collar Survey Type: **Yukon Engineering**
Northing : **6957449.506 mN**
Easting : **611801.731 mE**
Elevation (m) : **1149.709 m**

Zone Legend
CAP
SOX
SUS
HYP

Hole Length : **15.24 m**
Azimuth (true) : **0**
Dip : **-90**
NTS : 115J/10
Core Size: **HTW**

Overburden : **4.15 m**
Contractor : Kluane Drilling Ltd.
Logged By : **S. Casselman**
Date Hole Started : **June 7, 2013**
Date Hole Completed : **June 8, 2013**



---------- Sample Data ----------

From (m)	To (m)	Wdth (m)	Sample	Cu %	Mo %	Au (g/t)	Ag (g/t)

HOLE # : MW13-02D

WESTERN COPPER CORPORATION
CASINO PROJECT
DIAMOND DRILL LOG

HOLE # : MW13-02D

UTM Coordinates NAD 83, Zone 7
Collar Survey Type: **Yukon Engineering**
Northing : **6959340.83 mN**
Easting : **609887.935 mE**
Elevation (m) : **1193.08 m**

Zone Legend
CAP
SOX
SUS
HYP

Hole Length : **30.29**
Azimuth (true) : **0**
Dip : **-90**
NTS : 115J/10
Core Size: **HW**

Overburden :
Contractor : Kluane Drilling Ltd.
Logged By : **S. Casselman**
Date Hole Started : **June 12, 2013**
Date Hole Completed : **June 13, 2013**

Depth (m)	R.Q.D. weak / strong	Zone	Pyrite 0% / 10%	From (m)	To (m)	DESCRIPTION
0				0.00	30.29	OVB: Overburden. No recovery.

---------- Sample Data ----------

From (m)	To (m)	Wdth (m)	Sample	Cu %	Mo %	Au (g/t)	Ag (g/t)

HOLE # : MW13-02D

WESTERN COPPER CORPORATION
CASINO PROJECT
DIAMOND DRILL LOG



HOLE # : MW13-02S

WESTERN COPPER CORPORATION
CASINO PROJECT
DIAMOND DRILL LOG

HOLE # : MW13-02S

UTM Coordinates NAD 83, Zone 7
Collar Survey Type: **Yukon Engineering**
Northing : **6959345.499 mN**
Easting : **609886.187 mE**
Elevation (m) : **1192.658 m**

Zone Legend
CAP
SOX
SUS
HYP

Hole Length : **18.29 m**
Azimuth (true) : **0**
Dip : **-90**
NTS : 115J/10
Core Size: **HW**

Overburden :
Contractor : Kluane Drilling Ltd.
Logged By : **S. Casselman**
Date Hole Started : **June 8, 2013**
Date Hole Completed : **June 9, 2013**

Depth (m)	R.Q.D. weak / strong	Zone	Pyrite 0% / 10%	From (m)	To (m)	DESCRIPTION
0				0.00	18.29	0.00, 18.29 OVB: Overburden. Mixed gravel, cobbles of grabodiorite and silt.
5						
10						
15						

---------- Sample Data ----------

From (m)	To (m)	Wdth (m)	Sample	Cu %	Mo %	Au (g/t)	Ag (g/t)

HOLE # : MW13-03D

WESTERN COPPER CORPORATION
CASINO PROJECT
DIAMOND DRILL LOG

HOLE # : MW13-03D

UTM Coordinates NAD 83, Zone 7
Collar Survey Type: **Yukon Engineering**
Northing : **6958593.441 mN**
Easting : **613067.9832 mE**
Elevation (m) : **1213.5847m**

Zone Legend
CAP
SOX
SUS
HYP

Hole Length : **36.58 m**
Azimuth (true) : **0**
Dip : **-90**
NTS : 115J/10
Core Size: **HWT**

Overburden : **2.63 m**
Contractor : Kluane Drilling Ltd.
Logged By : **S. Casselman**
Date Hole Started : **June 13, 2013**
Date Hole Completed : **June 15, 2013**

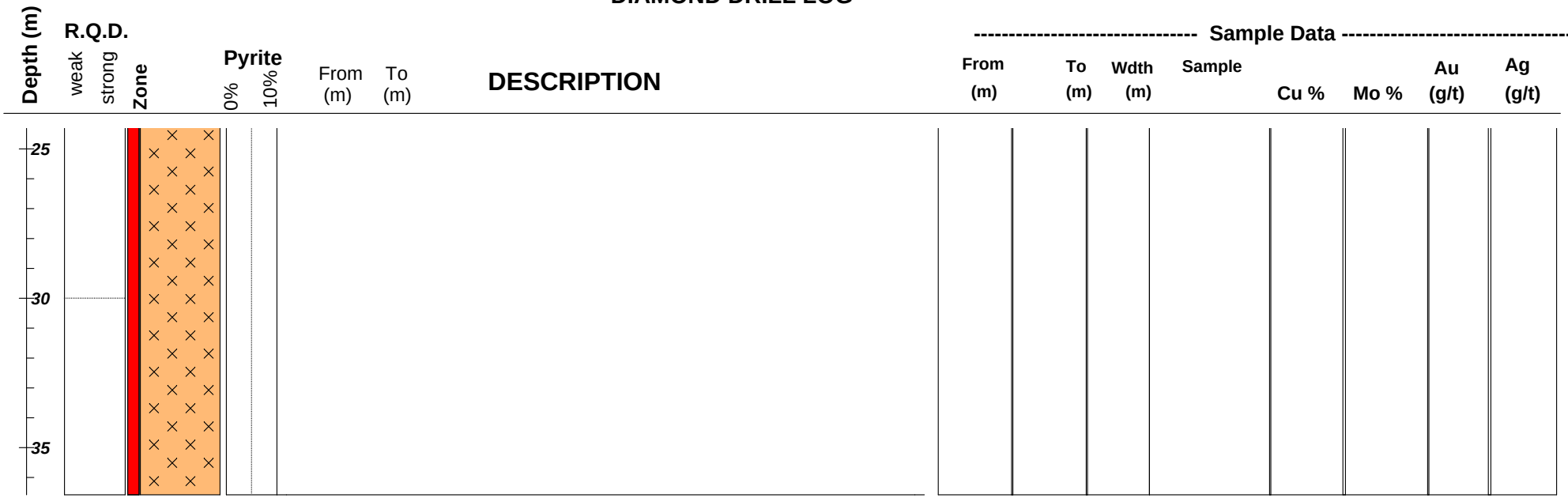
Depth (m)	R.Q.D. weak / strong	Zone	Pyrite 0% / 10%	From (m)	To (m)	DESCRIPTION
0				0.00	2.63	OVB: Overburden. No recovery
5				2.63	10.97	WRGD: Granodiorite. Weathered and fractured with moderate to strong limonite staining, weak clay alteration of plagioclase.
10				10.97	36.58	WRGD: Granodiorite. Fresh, realtively competent, <1% calcite veining, occassional pyrite on fracture surfaces to 1%. From 36.3 to 36.45 m have clayey gouge in narrow shear. At 26.10 m have 25 cm zone of clay-silica alteration cored by 0.8 cm pyrite veinlet.
15						
20						

---------- Sample Data ----------

From (m)	To (m)	Wdth (m)	Sample	Cu %	Mo %	Au (g/t)	Ag (g/t)

HOLE # : **MW13-03D**

WESTERN COPPER CORPORATION
CASINO PROJECT
DIAMOND DRILL LOG



HOLE # : MW13-03S

WESTERN COPPER CORPORATION
CASINO PROJECT
DIAMOND DRILL LOG

HOLE # : MW13-03S

UTM Coordinates NAD 83, Zone 7
Collar Survey Type: **Yukon Engineering**
Northing : **6958588.546 mN**
Easting : **613065.4492 mE**
Elevation (m) : **1212.9567 m**

Zone Legend
CAP
SOX
SUS
HYP

Hole Length : **18.29 m**
Azimuth (true) : **0**
Dip : **-90**
NTS : 115J/10
Core Size: **HWT**

Overburden : **1.50 m**
Contractor : Kluane Drilling Ltd.
Logged By : **S. Casselman**
Date Hole Started : **June 13, 2013**
Date Hole Completed : **June 16, 2013**

Depth (m)	R.Q.D. weak / strong	Zone	Pyrite 0% / 10%	From (m)	To (m)	DESCRIPTION
0				0.00	1.50	OVB: Overburden. No recovery
5				1.50	8.22	WRGD: Granodiorite. Highly oxidized and fractured with 5 to 10% orange limonitic clay on fractures.
10				8.22	18.29	WRGD: Granodiorite. Becomes much more competent, white to grey, medium to coarse grained with minor limonite on fractures. Rare pyrite (<<1%), 15 to 20% hornblende laths to 8 mm.
15						

---------- Sample Data ----------

From (m)	To (m)	Wdth (m)	Sample	Cu %	Mo %	Au (g/t)	Ag (g/t)

HOLE # : MW13-04D

WESTERN COPPER CORPORATION
CASINO PROJECT
DIAMOND DRILL LOG

HOLE # : MW13-04D

UTM Coordinates NAD 83, Zone 7
Collar Survey Type: **Yukon Engineering**
Northing : **6957637.117 mN**
Easting : **613297.7722 mE**
Elevation (m) : **1023.8557 m**

Zone Legend
CAP
SOX
SUS
HYP

Hole Length : **41.15 m**
Azimuth (true) : **0**
Dip : **-90**
NTS : 115J/10
Core Size: **HWT**

Overburden : **2.33 m**
Contractor : Kluane Drilling Ltd.
Logged By : **S. Casselman**
Date Hole Started : **June 17, 2013**
Date Hole Completed : **June 18, 2013**

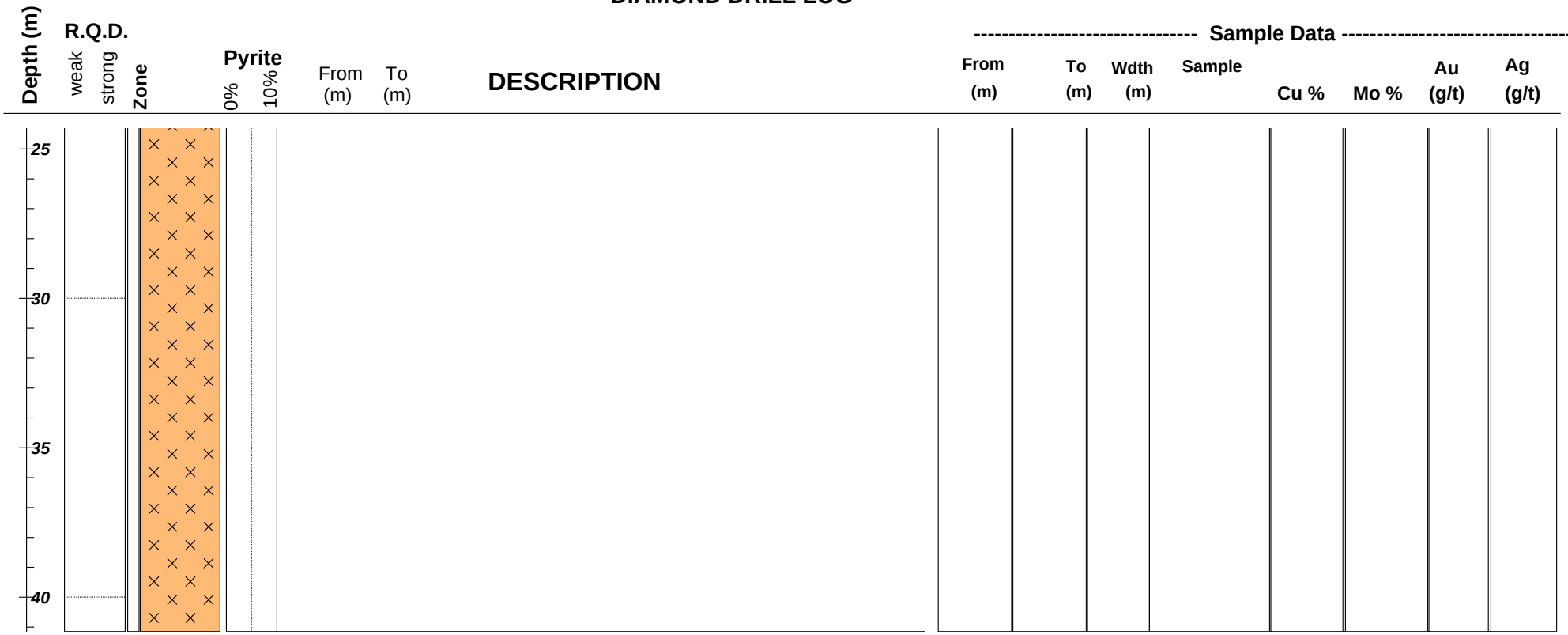
Depth (m)	R.Q.D. weak / strong	Zone	Pyrite 0% / 10%	From (m)	To (m)	DESCRIPTION
0				0.00	2.33	OVB: Overburden. No recovery
				2.33	4.00	WRGD: Granodiorite. Quite fractured and weathered with pieces < 15 cm long.
5				4.00	41.15	WRGD: Granodiorite. Becomes more competent, fresh with minimal weathering. Minor iron oxide staining on fracture surfaces to 35.0 m. Medium to coarse-grained, white to grey with salt and pepper hornblende phenocrysts to 0.6 cm. Trace of pyrite, <0.5mm cubes. << 1% calcite veilets.
10						
15						
20						

Sample Data

From (m)	To (m)	Wdth (m)	Sample	Cu %	Mo %	Au (g/t)	Ag (g/t)

HOLE # : **MW13-04D**

WESTERN COPPER CORPORATION
CASINO PROJECT
DIAMOND DRILL LOG



HOLE # : MW13-04S

WESTERN COPPER CORPORATION
CASINO PROJECT
DIAMOND DRILL LOG

HOLE # : MW13-04S

UTM Coordinates NAD 83, Zone 7
Collar Survey Type: **Yukon Engineering**
Northing : **6957632.744 mN**
Easting : **613296.7022 mE**
Elevation (m) : **1023.8357 m**

Zone Legend
CAP
SOX
SUS
HYP

Hole Length : **21.20 m**
Azimuth (true) : **0**
Dip : **-90**
NTS : 115J/10
Core Size: **HWT**

Overburden : **2.77 m**
Contractor : Kluane Drilling Ltd.
Logged By : **S. Casselman**
Date Hole Started : **June 19, 2013**
Date Hole Completed : **June 19, 2013**

Depth (m)	R.Q.D. weak / strong	Zone	Pyrite 0% / 10%	From (m)	To (m)	DESCRIPTION
0				0.00	2.77	OVB: Overburden. no recovery
				2.77	3.10	WRGD: Granodiorite. Quite fractured and bleached regolith.
5				3.10	21.20	WRGD: Granodiorite. Becomes much more competent over the top 5 m, still has iron oxide staining on fractures, but less bleached. From 8.0 m down becomes much more competent, less iron on fractures, white to light grey salt and pepper, medium grained granodiorite with 10% hornblende laths.
10						
15						
20						

Sample Data

From (m)	To (m)	Wdth (m)	Sample	Cu %	Mo %	Au (g/t)	Ag (g/t)

HOLE # : MW13-05

WESTERN COPPER CORPORATION
CASINO PROJECT
DIAMOND DRILL LOG

HOLE # : MW13-05

UTM Coordinates NAD 83, Zone 7
Collar Survey Type: **Yukon Engineering**
Northing : **6955822.543 mN**
Easting : **614718.9042 mE**
Elevation (m) : **1023.9847 m**

Zone Legend
CAP
SOX
SUS
HYP

Hole Length : **50.29 m**
Azimuth (true) : **0**
Dip : **-90**
NTS : 115J/10
Core Size: **HWT**

Overburden : **4.33 m**
Contractor : Kluane Drilling Ltd.
Logged By : **S. Casselman**
Date Hole Started : **June 20, 2013**
Date Hole Completed : **June 22, 2013**

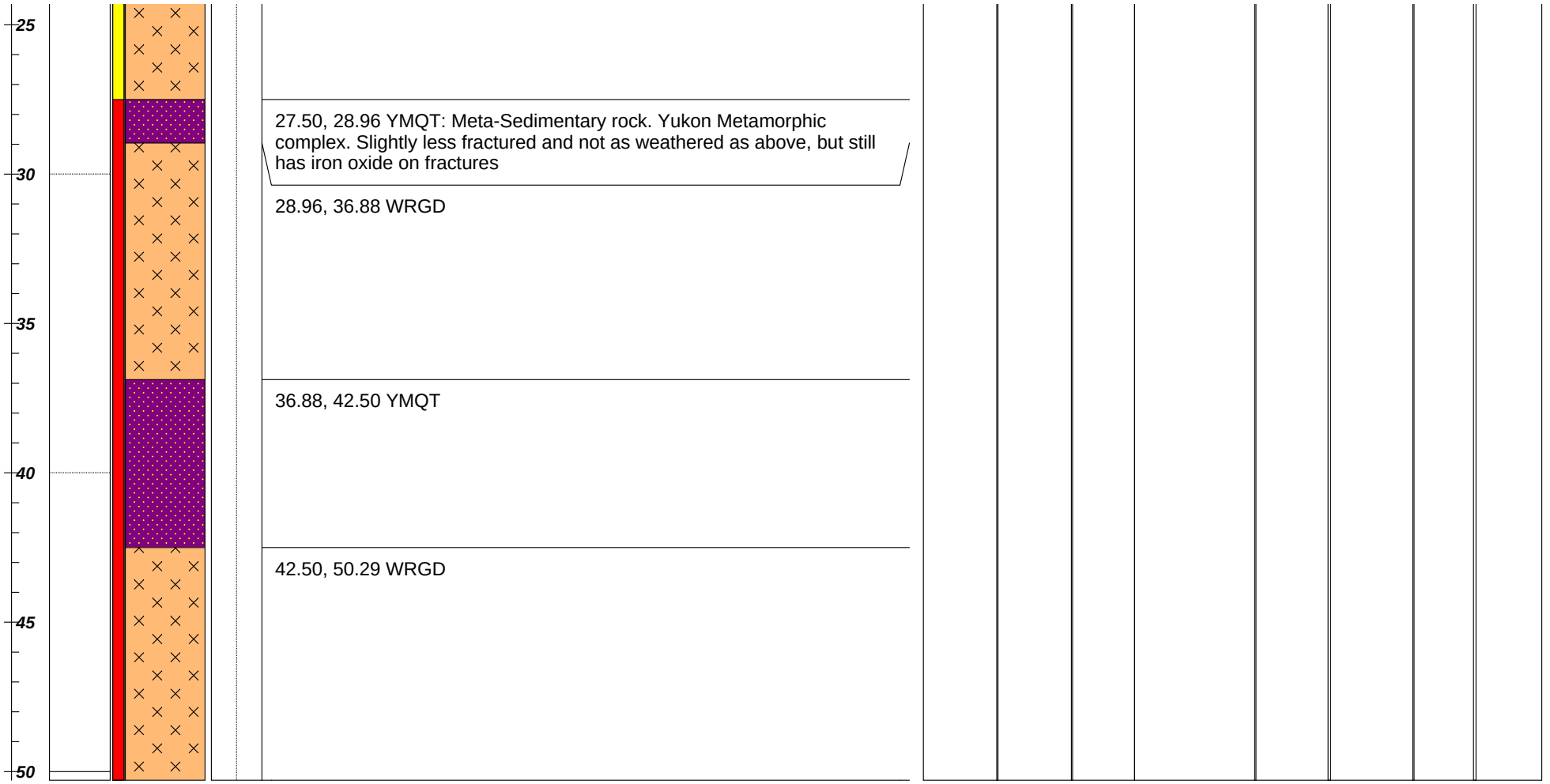
Depth (m)	R.Q.D. weak / strong	Zone	Pyrite 0% / 10%	From (m)	To (m)	DESCRIPTION
0				0.00	4.33	OVB: Overburden. no recovery
5				4.33	27.50	WRGD: Granodiorite. Intensely weathered and bleached with orange-grey colour due to iron staining. Pieces <15 cm long with abundant gravel and clay/sand from weathered granodiorite. No sulphides.
10						
15						
20						

Sample Data

From (m)	To (m)	Wdth (m)	Sample	Cu %	Mo %	Au (g/t)	Ag (g/t)

HOLE # : MW13-05

WESTERN COPPER CORPORATION
CASINO PROJECT
DIAMOND DRILL LOG



HOLE # : MW13-06D

WESTERN COPPER CORPORATION
CASINO PROJECT
DIAMOND DRILL LOG

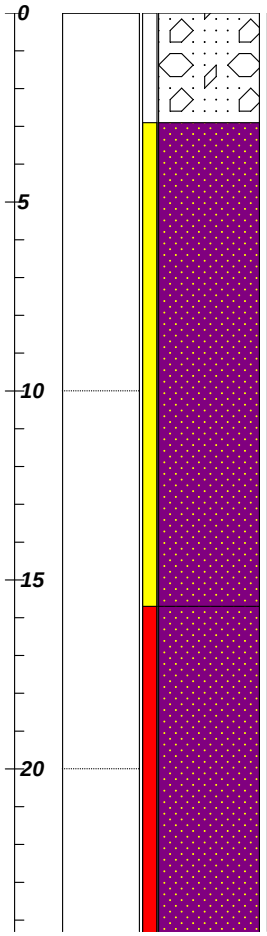
HOLE # : MW13-06D

UTM Coordinates NAD 83, Zone 7
Collar Survey Type: **Yukon Engineering**
Northing : **6953267.365 mN**
Easting : **613961.8672 mE**
Elevation (m) : **1069.4677 m**

Zone Legend
CAP
SOX
SUS
HYP

Hole Length : **48.77 m**
Azimuth (true) : **0**
Dip : **-90**
NTS : 115J/10
Core Size: **HWT**

Overburden : **2.90 m**
Contractor : Kluane Drilling Ltd.
Logged By : **S. Casselman**
Date Hole Started : **June 23, 2013**
Date Hole Completed : **June 24, 2013**



R.Q.D. weak strong | Zone | Pyrite 0% 10% | From (m) | To (m)

DESCRIPTION

0.00, 2.90 OVB: Overburden. Very little recovery, minor rounded pebbles.

2.90, 15.70 YMQT: Meta-sedimetary rock, Quartzite. Intensely weathered and fractured, bleached and limonite stained.

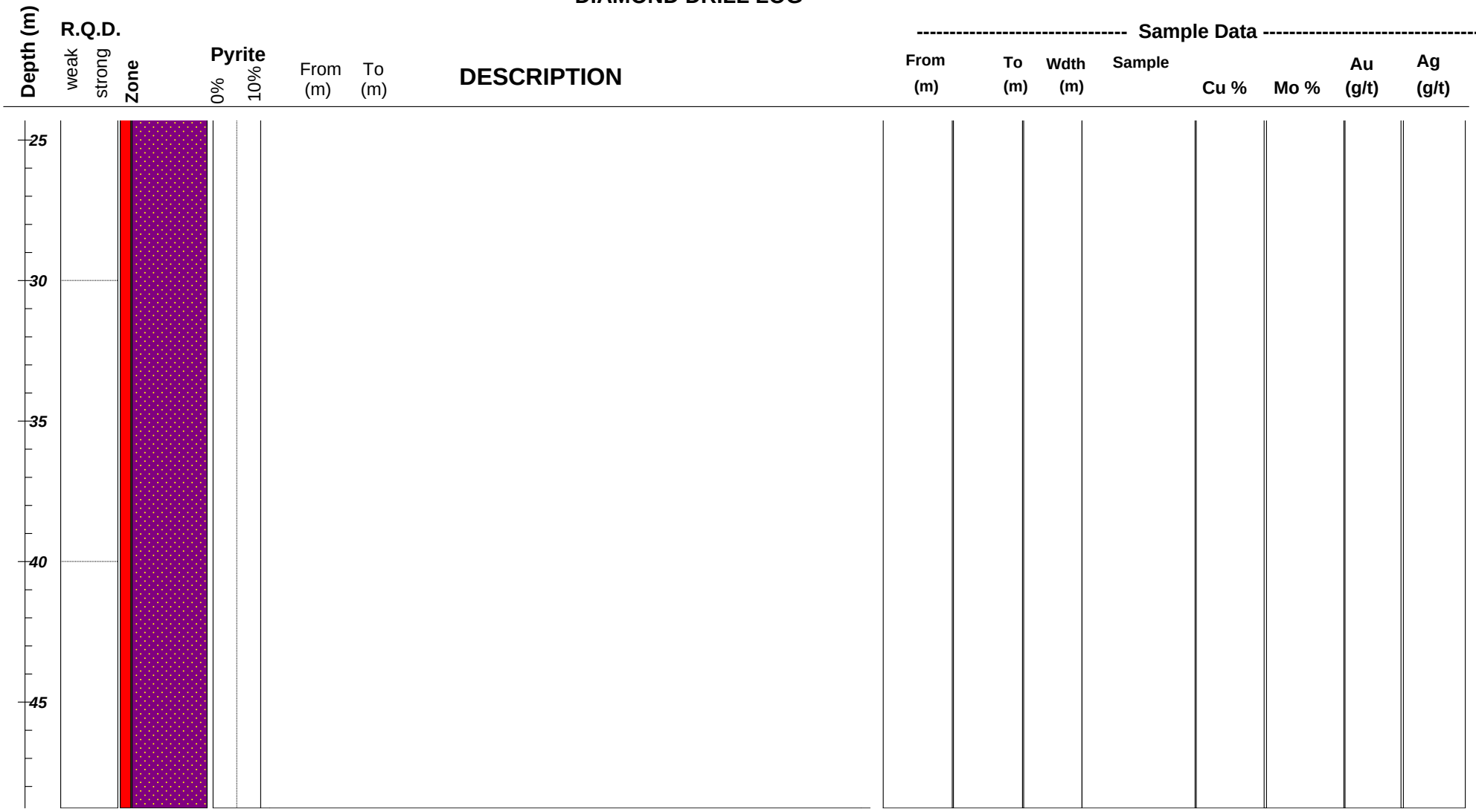
15.70, 48.77 YMQT: Meta-sedimentary rock, Quartzite. jBecomes more competent and less weathered. Blue-grey to white-grey, variably bedded, laminated meta-seds. Bedding variable, with folds, but at a high angle to core axis. Iron oxide on fractures decreases down hole. No sulphides.

---------- Sample Data ----------

From (m)	To (m)	Wdth (m)	Sample	Cu %	Mo %	Au (g/t)	Ag (g/t)

HOLE # : **MW13-06D**

WESTERN COPPER CORPORATION
CASINO PROJECT
DIAMOND DRILL LOG



HOLE # : MW13-06S

WESTERN COPPER CORPORATION
CASINO PROJECT
DIAMOND DRILL LOG

HOLE # : MW13-06S

UTM Coordinates NAD 83, Zone 7
Collar Survey Type: **Yukon Engineering**
Northing : **6953275.724 mN**
Easting : **613957.9722 mE**
Elevation (m) : **1069.7017 m**

Zone Legend
CAP
SOX
SUS
HYP

Hole Length : **38.70 m**
Azimuth (true) : **0**
Dip : **-90**
NTS : 115J/10
Core Size: **HW**

Overburden : **2.75 m**
Contractor : Kluane Drilling Ltd.
Logged By : **S. Casselman**
Date Hole Started : **June 25, 2013**
Date Hole Completed : **June 26, 2013**

Depth (m) | **R.Q.D.** weak strong | **Zone** | **Pyrite** 0% 10% | From (m) | To (m) | **DESCRIPTION**

0.00, 2.75 OVB: Overburden - no recovery

2.75, 11.92 YMQT: Quartzite/silicified siltstone. Intensely fractured to pieces < 10 cm long. Slightly bleached and iron stained.

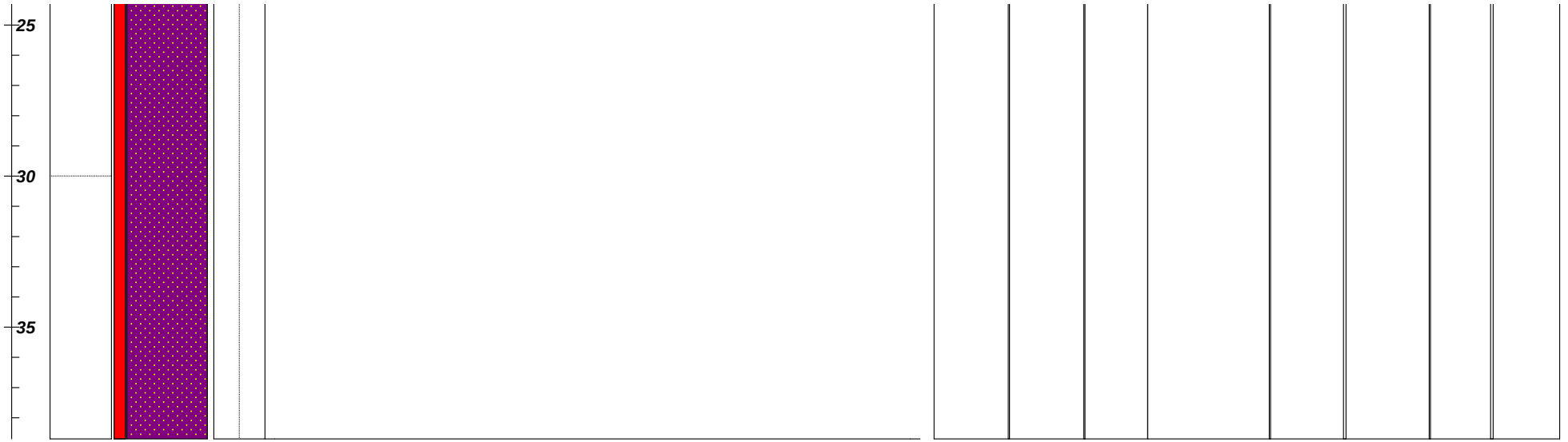
11.29, 38.70 YMQT: Quartzite/silicified siltstone. variably oxidized and iron stained. Folded and brecciated, obvious evidence of tectonism. Traces of pyrite deeper down hole towards the bottom. Becomes more competent and less iron oxide towards bottom.

Sample Data

From (m)	To (m)	Wdth (m)	Sample	Cu %	Mo %	Au (g/t)	Ag (g/t)

HOLE # : **MW13-06S**

WESTERN COPPER CORPORATION
CASINO PROJECT
DIAMOND DRILL LOG



APPENDIX B

RESPONSE TEST DATA

(Pages B-1 to B-9)

Knight Piésold CONSULTING

CASINO MINING CORPORATION
CASINO PROJECT

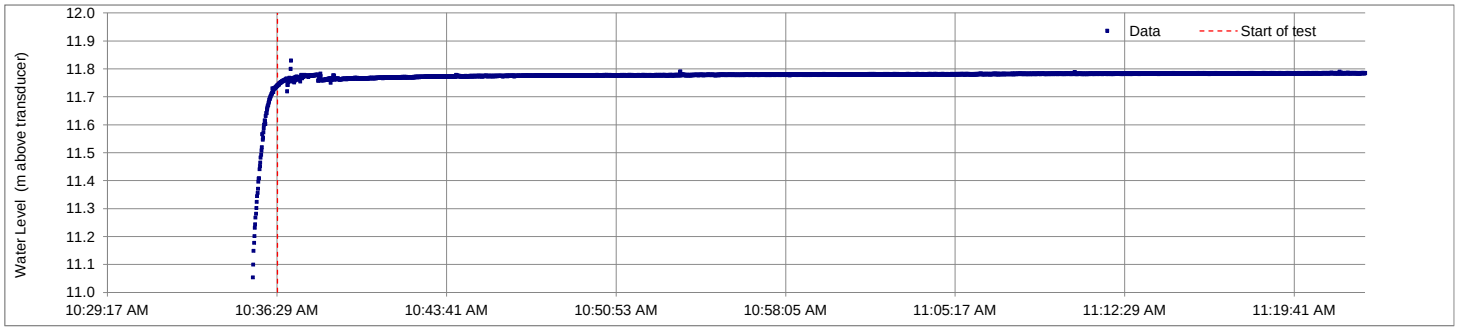
HYDRAULIC CONDUCTIVITY CALCULATION
USING HVORSLEV (1951) METHOD

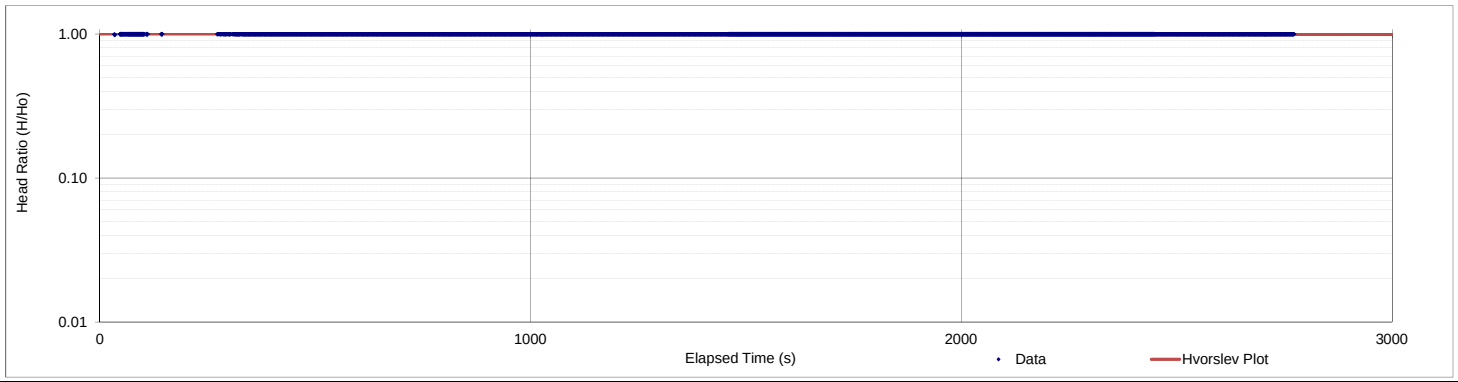
Print 03/06/15 8:23

Project No.	VA101-325/17	**Monitoring Well/Piezometer**	**MW13-01D**
Field Technician	CKJ		
Analyst	KTD		
Monitoring Instrument Type	Transducer		
Slug Dimensions and Type	Purged for sampling		
Test Date	28-Jul-14		

Drill-hole diameter, D	0.091	**m**	**Slug Injected, Time = 0**	10:36:30 AM	
Effective diameter of PVC riser pipe, d_e	0.053	**m**	**Initial water level**	16.62	**m above transducer**
Top of test zone	27.5	**mbgs**	**Water level after slug**	11.77	**m above transducer**
Bottom of test zone	30.5	**mbgs**	**Change In Water Level, H_o**	-4.85	**m**
Test Length, L	3.0	**m**	**Expected Change In Water Level, H_o**	-	**m**
PVC type	Schedule 40				
Slot size	20 Slot				

Transmissivity, T	-	**m^2/s**		
Hydraulic Conductivity, K	<1E-8	**m/s**	H/H_o Intercept	1.00





TEST COMMENTS: The water column in the well was thawed in order to sample the well and the test analysis is based on water level recovery following sampling. The well was sampled 1.5 hour priors to conducting the slug test and a 3L slug of water was injected to the well at the test start time. Manually measured water level was 27m below the top of PVC at the test start time. The water level recovery over the monitored interval suggests that test results may be influenced by frozen conditions around the screen. Results are provided for qualitative purposes only in order to document the slow water level recovery.

M:\1\01\00325\17\A\Data\Task 200 - 2013 Hydrogeology Adendum\3-Response Tests\[1. MW13-01D.xlsx]Hvorslev

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	06MAR'15	ISSUED WITH REPORT	KTD	CAS	KJB

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CASINO PROJECT

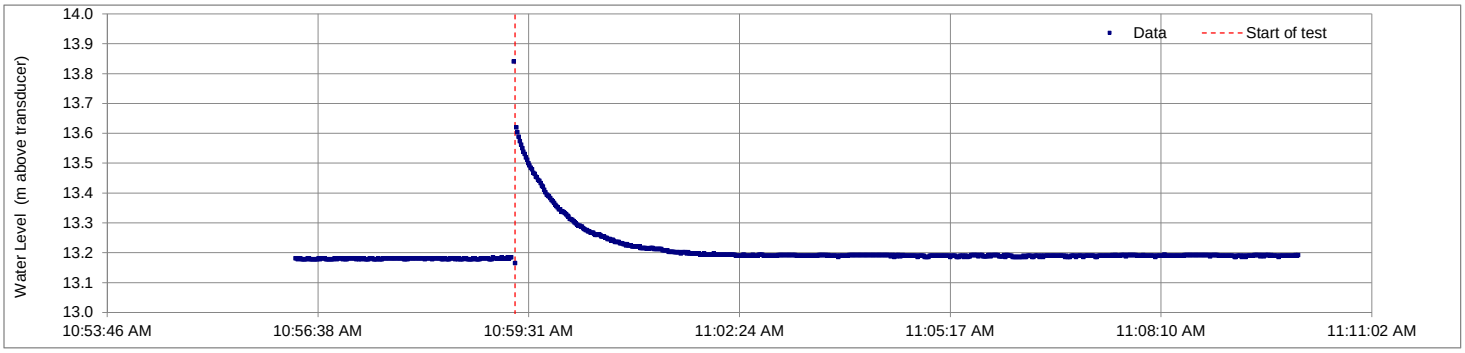
HYDRAULIC CONDUCTIVITY CALCULATION
USING HVORSLEV (1951) METHOD

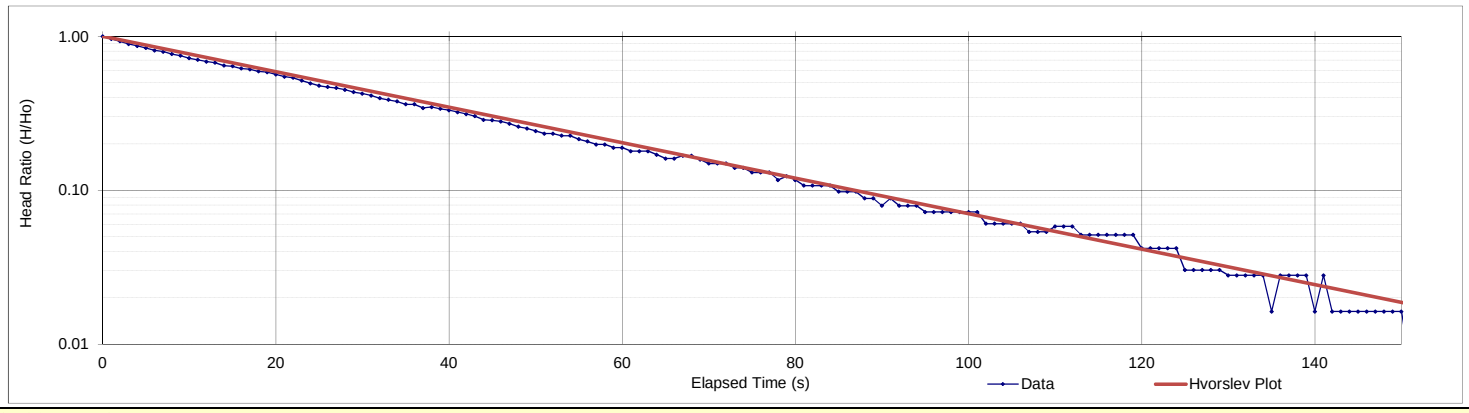
Print 03/06/15 8:23

Project No.	VA101-325/17	**Monitoring Well/Piezometer**	**MW13-02D**
Field Technician	KTD		
Analyst	KTD		
Monitoring Instrument Type	Transducer		
Slug Dimensions and Type	RST Solid Slug (Vol=1061ml)		
Test Date	04-Aug-13		

Drill-hole diameter, D	0.091	**m**	**Slug Injected, Time = 0**	10:59:20 AM	
Effective diameter of PVC riser pipe, d_e	0.053	**m**	**Initial water level**	13.19	**m above transducer**
Top of test zone	24.3	**mbgs**	**Water level after slug**	13.62	**m above transducer**
Bottom of test zone	27.3	**mbgs**	**Change In Water Level, H_o**	0.43	**m**
Test Length, L	3.0	**m**	**Expected Change In Water Level, H_o**	0.48	**m**
PVC type	Schedule 40				
Slot size	20 Slot				

Transmissivity, T	4E-05	**m^2/s**		
Hydraulic Conductivity, K	1E-05	**m/s**	H/H_o Intercept	1.00





TEST COMMENTS:

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REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	06MAR'15	ISSUED WITH REPORT	KTD	CAS	KJB

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CASINO PROJECT

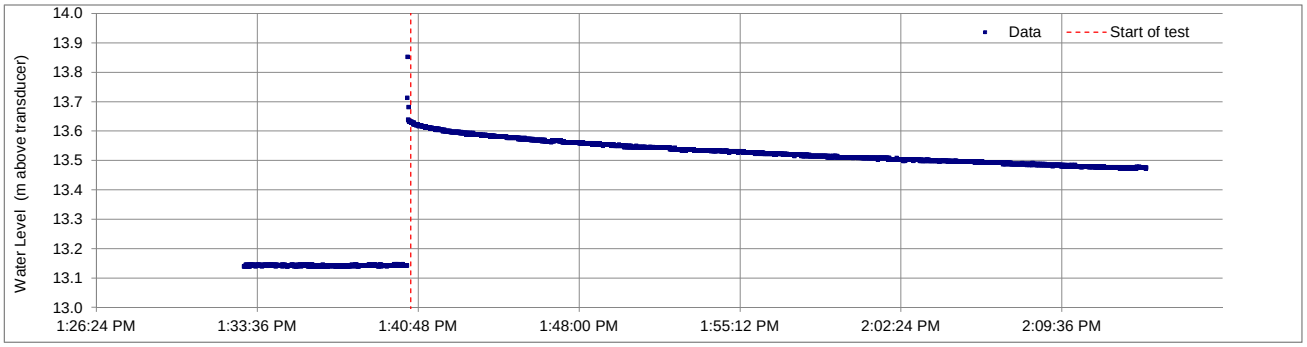
HYDRAULIC CONDUCTIVITY CALCULATION
USING HVORSLEV (1951) METHOD

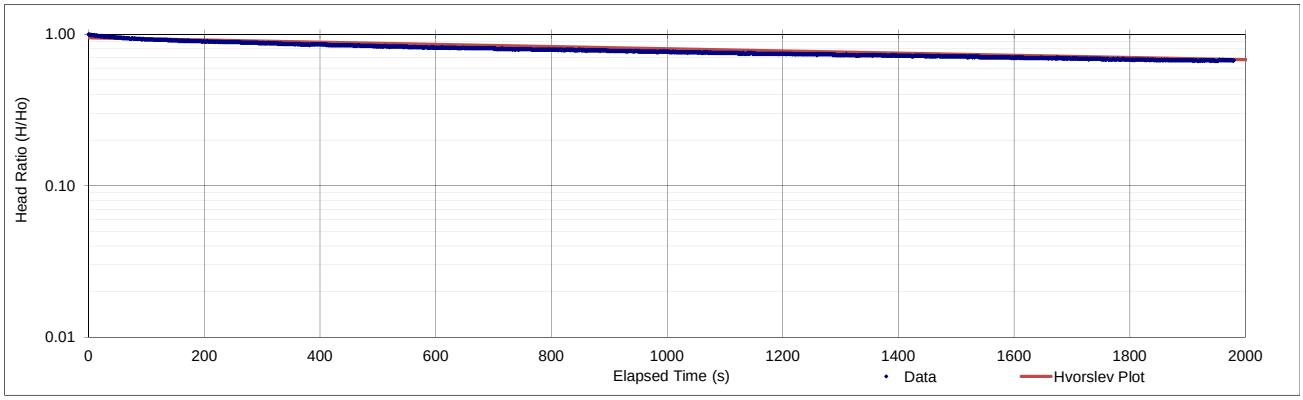
Print 03/06/15 8:23

Project No.	VA101-325/17	**Monitoring Well/Piezometer**	**MW13-03D**
Field Technician	CM		
Analyst	KTD		
Monitoring Instrument Type	Transducer		
Slug Dimensions and Type	RST Solid Slug (Vol=1061ml)		
Test Date	14-Aug-13		

Drill-hole diameter, D	0.091	**m**	**Slug Injected, Time = 0**	1:40:28 PM	
Effective diameter of PVC riser pipe, d_e	0.053	**m**	**Initial water level**	13.15	**m above transducer**
Top of test zone	30.7	**mbgs**	**Water level after slug**	13.64	**m above transducer**
Bottom of test zone	33.8	**mbgs**	**Change In Water Level, H_o**	0.49	**m**
Test Length, L	3.1	**m**	**Expected Change In Water Level, H_o**	0.48	**m**
PVC type	Schedule 40				
Slot size	20 Slot				

Transmissivity, T	2E-07	**m^2/s**		
Hydraulic Conductivity, K	8E-08	**m/s**	H/H_o Intercept	0.95





TEST COMMENTS: The test was stopped prior to full recovery to the pre-testing water level because the slow water level recovery over this monitoring period was sufficient to constrain that the formation has a relatively low hydraulic conductivity value.

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REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	06MAR'15	ISSUED WITH REPORT	KTD	CAS	KJB

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HYDRAULIC CONDUCTIVITY CALCULATION
USING HVORSLEV (1951) METHOD

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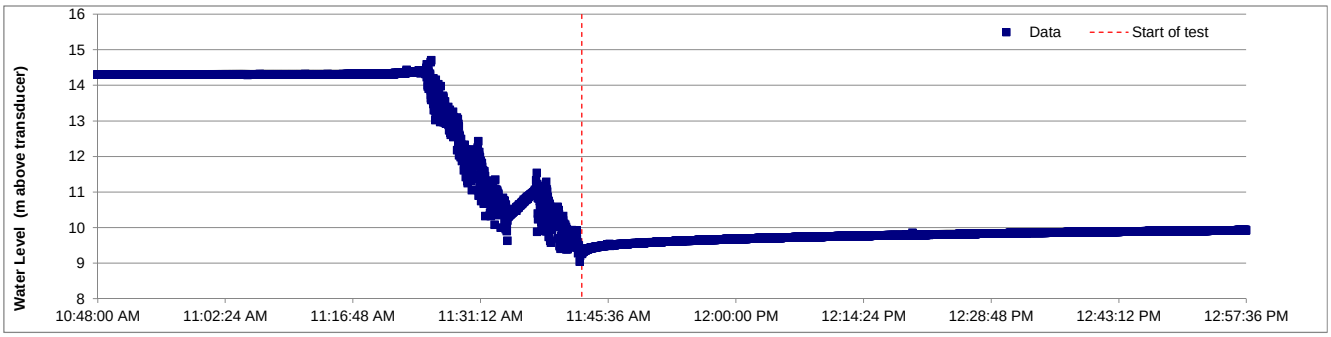
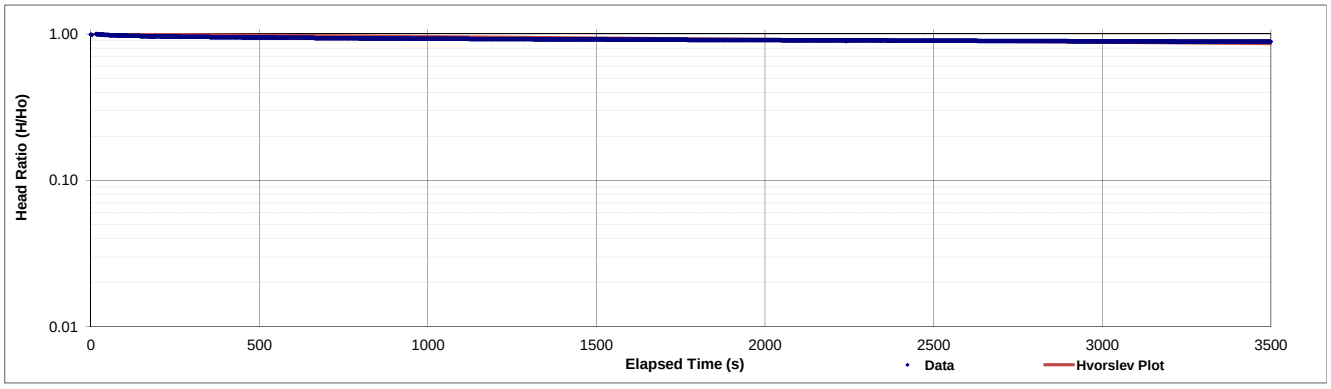
Project No.	VA101-325/17	**Monitoring Well/Piezometer**	**MW13-03S**
Field Technician	CMJ		
Analyst	KTD		
Monitoring Instrument Type	Transducer		
Slug Dimensions and Type	Water purged from well		
Test Date	27-Jul-14		
Drillhole diameter, D	0.114 m	**Slug Injected, Time = 0**	11:42:37 AM
Effective diameter of PVC riser pipe, d_e	0.053 m	**Initial water level**	14.10 m above transducer
Top of test zone	10.6 m	**Water level after slug**	9.33 m above transducer
Bottom of test zone	13.6 m	**Change In Water Level, H_o**	-4.77 m
Test Length, L	3.05 m	**Expected Change In Water Level, H_o**	- m
PVC type	Schedule 40		
Slot size	20 Slot		
Transmissivity, T	6E-08 m^2/s		
Hydraulic Conductivity, K	2E-08 m/s	Intercept	1.0





TEST COMMENTS: Analysis conducted on water level recovery following purging and sampling of well. The water column was thawed prior to conducting the test and results are assumed to be influenced by frozen ground conditions surrounding the screen. Test value reported for qualitative purposes.

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REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	06MAR'15	ISSUED WITH REPORT	KTD	CAS	KJB

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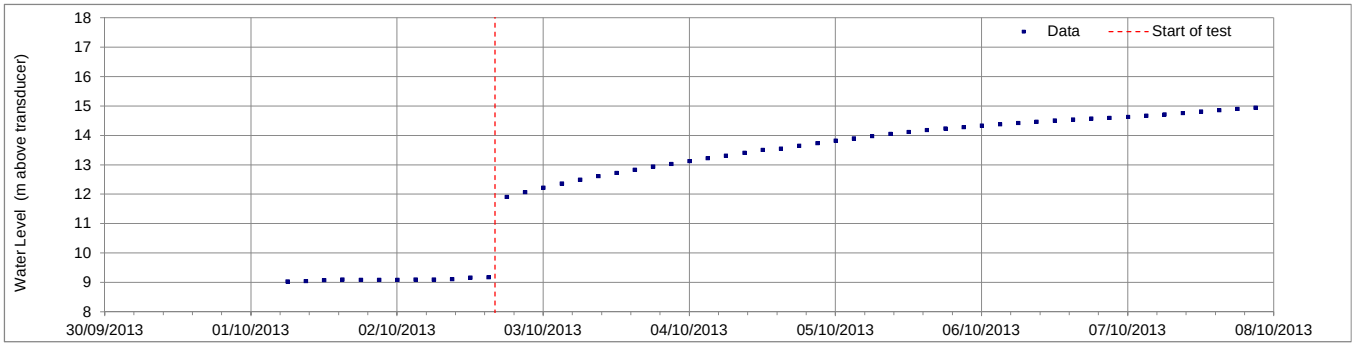
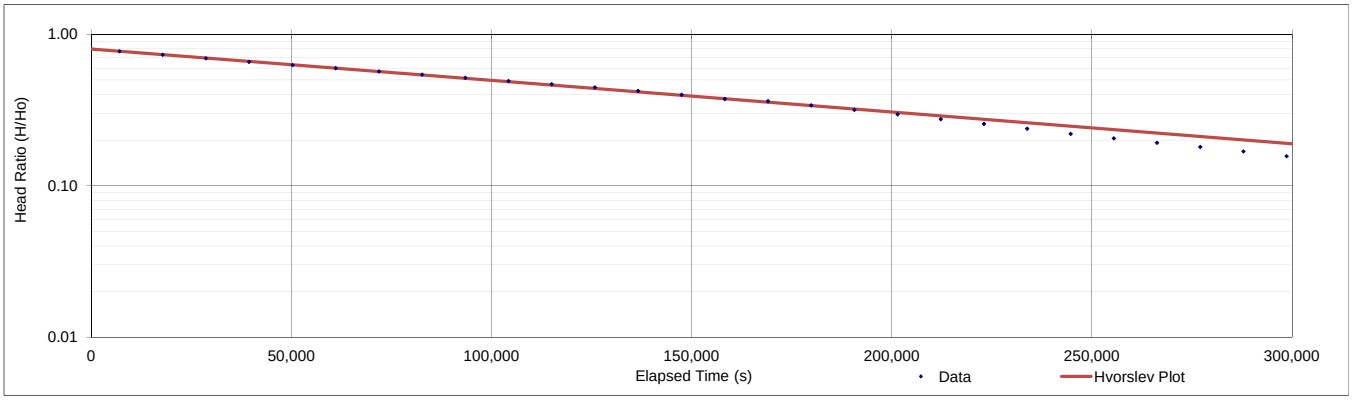
HYDRAULIC CONDUCTIVITY CALCULATION
USING HVORSLEV (1951) METHOD

Print 03/06/15 8:28

Project No.	VA101-325/17		**Monitoring Well/Piezometer**	**MW13-04D**	
Field Technician	CKJ				
Analyst	KTD				
Monitoring Instrument Type	Transducer				
Slug Dimensions and Type	Purged for sampling				
Test Date	02-Oct-13				
Drill-hole diameter, D	0.114	m	**Slug Injected, Time = 0**	4:05:00 PM	
Effective diameter of PVC riser pipe, d_e	0.053	m	**Initial water level**	15.00	m above transducer
Top of test zone	37.7	mbgs	**Water level after slug**	11.00	m above transducer
Bottom of test zone	40.7	mbgs	**Change In Water Level, H_o**	-4.00	m
Test Length, L	3.0	m	**Expected Change In Water Level, H_o**	-	m
PVC type	Schedule 40				
Slot size	20 Slot				
Transmissivity, T	-	m^2/s			
Hydraulic Conductivity, K	<1E-8	m/s	H/H_o Intercept	0.80	





TEST COMMENTS:

Hydraulic conductivity estimated as less than 1E-08 m/s using water level recovery following sampling. Water level data was recorded at 12 hr intervals.

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REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	06MAR'15	ISSUED WITH REPORT	KTD	CAS	KJB

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HYDRAULIC CONDUCTIVITY CALCULATION
USING HVORSLEV (1951) METHOD

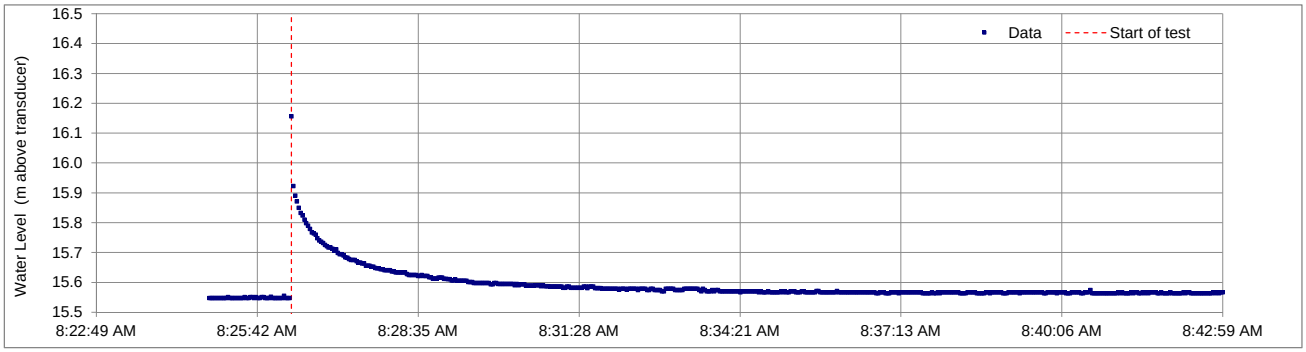
Print 03/06/15 8:58

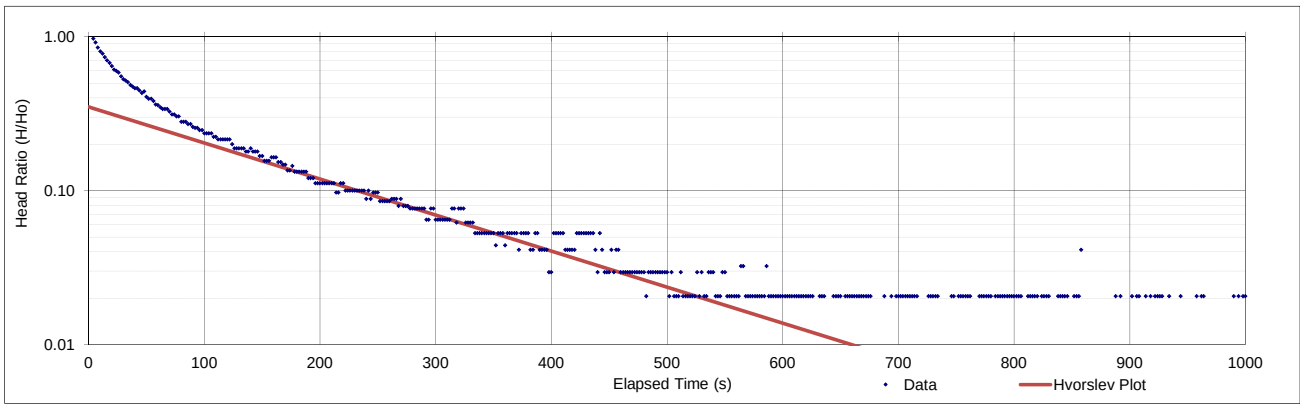
Project No.	VA101-325/17	**Monitoring Well/Piezometer**	**MW13-04S**
Field Technician	CM		
Analyst	KTD		
Monitoring Instrument Type	Transducer		
Slug Dimensions and Type	RST Solid Slug (Vol=1061ml)		
Test Date	05-Aug-13		

Drill-hole diameter, D	0.114	**m**	**Slug Injected, Time = 0**	8:26:19 AM	
Effective diameter of PVC riser pipe, d_e	0.053	**m**	**Initial water level**	15.56	**m above transducer**
Top of test zone	18.0	**mbgs**	**Water level after slug**	15.90	**m above transducer**
Bottom of test zone	21.0	**mbgs**	**Change In Water Level, H_o**	0.34	**m**
Test Length, L	3.0	**m**	**Expected Change In Water Level, H_o**	0.48	**m**
PVC type	Schedule 40				
Slot size	20 Slot				

Transmissivity, T	8E-06	**m^2/s**
Hydraulic Conductivity, K	3E-06	**m/s**

H/H_o Intercept 0.35





TEST COMMENTS:

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REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	06MAR'15	ISSUED WITH REPORT	KTD	CAS	KJB

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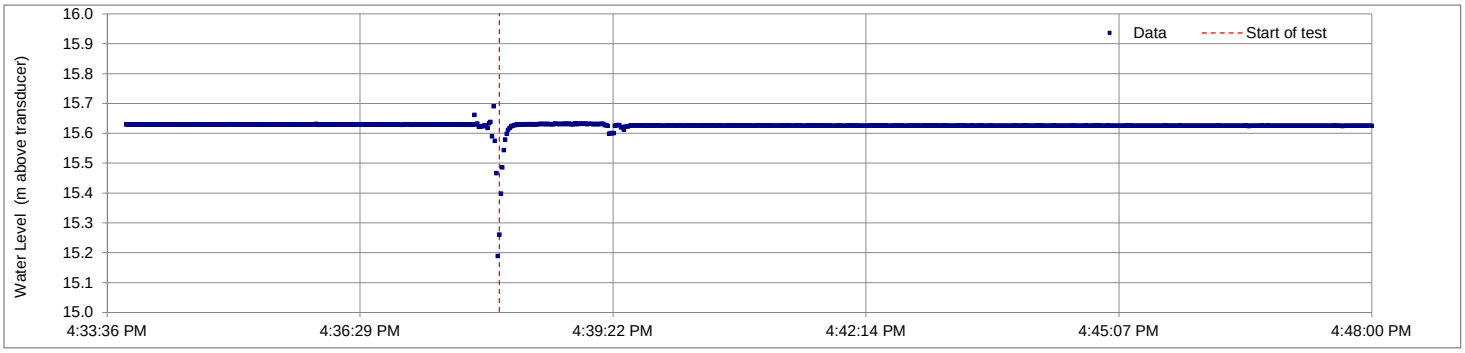
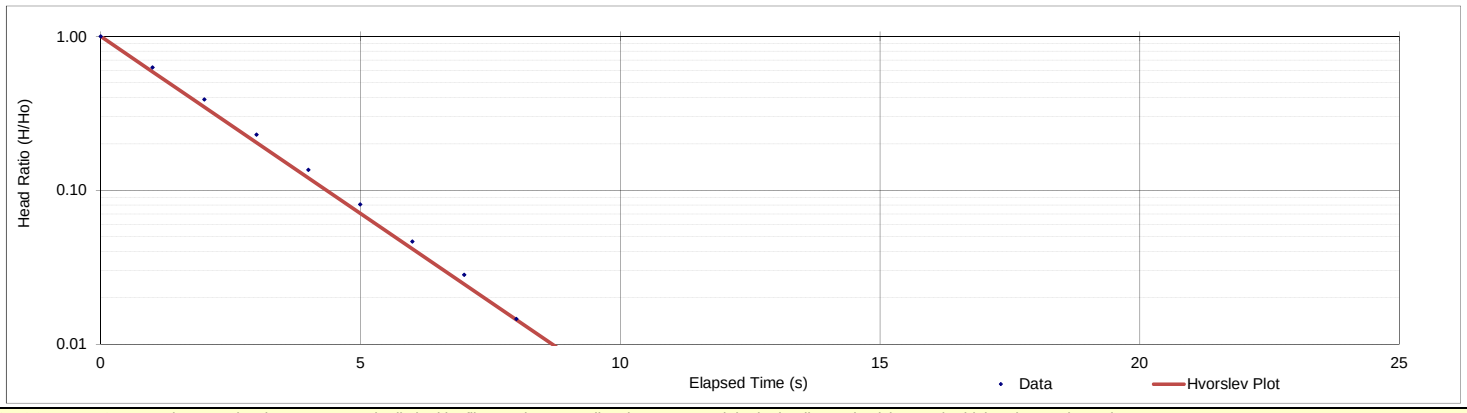
CASINO PROJECT

HYDRAULIC CONDUCTIVITY CALCULATION
USING HVORSLEV (1951) METHOD

Print 03/06/15 8:33

Project No.	VA101-325/17	**Monitoring Well/Piezometer**	**MW13-05**
Field Technician	CMJ		
Analyst	MCW		
Monitoring Instrument Type	Transducer		
Slug Dimensions and Type	1.4m of 1" PVC		
Test Date	28-Jul-14		
Drill-hole diameter, D	0.114 **m**	**Slug Injected, Time = 0**	4:38:04 PM
Effective diameter of PVC riser pipe, d_e	0.049 **m**	**Initial water level**	15.63 **m above transducer**
Top of test zone	46.6 **mbgs**	**Water level after slug**	15.26 **m above transducer**
Bottom of test zone	49.6 **mbgs**	**Change In Water Level, H_o**	-0.37 **m**
Test Length, L	3.0 **m**	**Expected Change In Water Level, H_o**	0.33 **m**
PVC type	Schedule 80		
Slot size	20 Slot		
Transmissivity, T	6E-04 **m^2/s**		
Hydraulic Conductivity, K	2E-04 **m/s**	H/H_o Intercept	1.0





TEST COMMENTS: The water level response may be limited by filter pack surrounding the screen and the hydrauilc conductivity may be higher than estimated.

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REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	06MAR'15	ISSUED WITH REPORT	KTD	CAS	KJB

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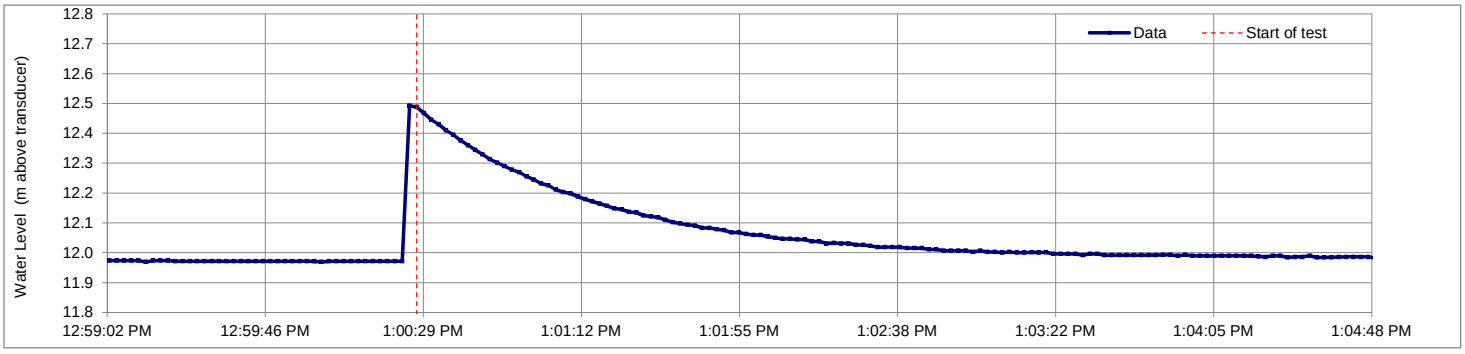
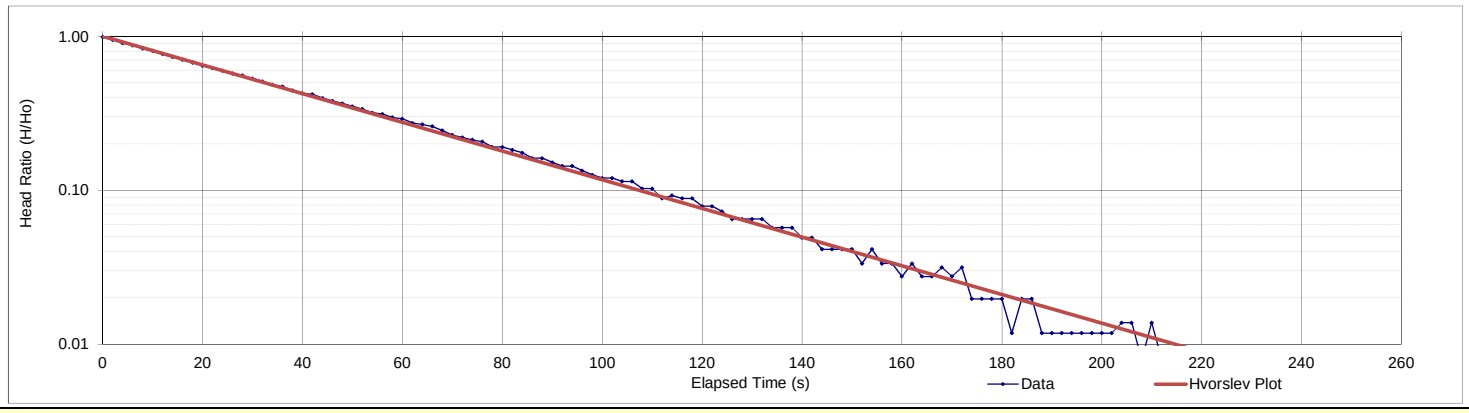
CASINO PROJECT

HYDRAULIC CONDUCTIVITY CALCULATION
USING HVORSLEV (1951) METHOD

Print 03/06/15 8:58

Project No.	VA101-325/17	**Monitoring Well/Piezometer**	**MW13-06D**
Field Technician	KTD		
Analyst	KTD		
Monitoring Instrument Type	Transducer		
Slug Dimensions and Type	RST Slug (Vol=1061ml)		
Test Date	07-Aug-13		
Drill-hole diameter, D	0.114 **m**	**Slug Injected, Time = 0**	1:00:27 PM
Effective diameter of PVC riser pipe, d_e	0.049 **m**	**Initial water level**	11.99 **m above transducer**
Top of test zone	45.4 **mbgs**	**Water level after slug**	12.49 **m above transducer**
Bottom of test zone	48.4 **mbgs**	**Change In Water Level, H_o**	0.51 **m**
Test Length, L	3.0 **m**	**Expected Change In Water Level, H_o**	0.56
PVC type	Schedule 80		
Slot size	20 Slot		
Transmissivity, T	3E-05 **m^2/s**		
Hydraulic Conductivity, K	9E-06 **m/s**	H/H_o Intercept	1.0





TEST COMMENTS:

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REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	06MAR'15	ISSUED WITH REPORT	KTD	CAS	KJB

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CASINO MINING CORPORATION
CASINO PROJECT

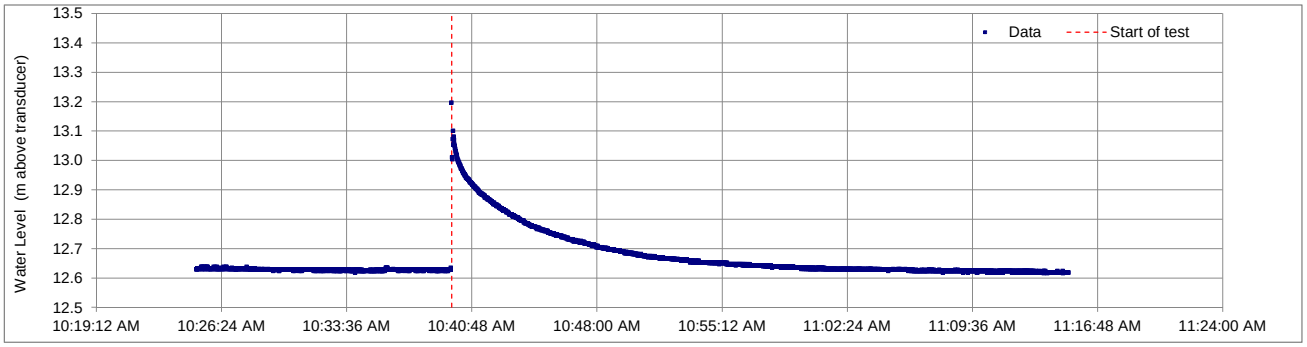
HYDRAULIC CONDUCTIVITY CALCULATION
USING HVORSLEV (1951) METHOD

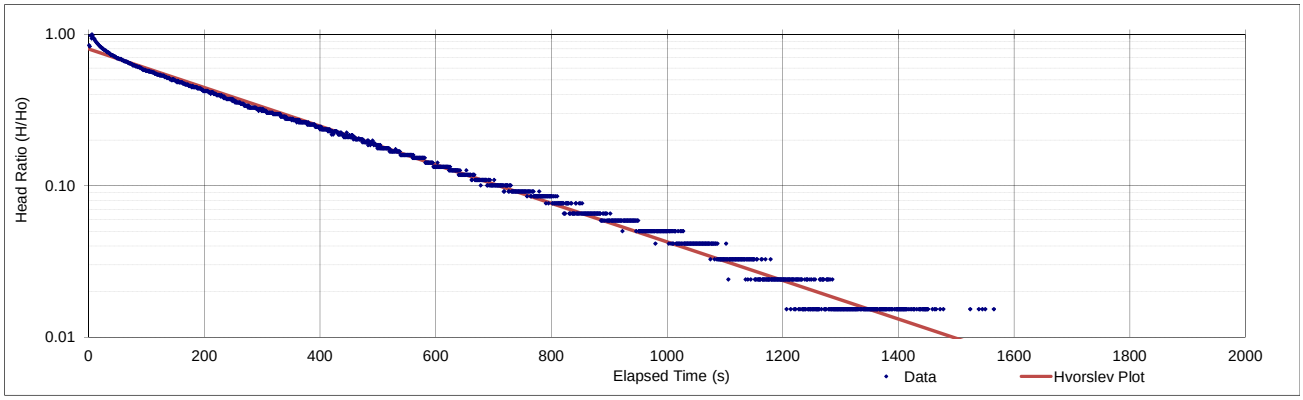
Print 03/06/15 8:58

Project No.	VA101-325/17	**Monitoring Well/Piezometer**	**MW13-06S**
Field Technician	CM		
Analyst	KTD		
Monitoring Instrument Type	Transducer		
Slug Dimensions and Type	RST Solid Slug (Vol=1061ml)		
Test Date	13-Aug-13		

Drill-hole diameter, D	0.114	**m**	**Slug Injected, Time = 0**	10:39:39 AM	
Effective diameter of PVC riser pipe, d_e	0.049	**m**	**Initial water level**	12.62	**m above transducer**
Top of test zone	33.6	**mbgs**	**Water level after slug**	13.08	**m above transducer**
Bottom of test zone	37.8	**mbgs**	**Change In Water Level, H_o**	0.46	**m**
Test Length, L	4.2	**m**	**Expected Change In Water Level, H_o**	0.56	**m**
PVC type	Schedule 80				
Slot size	20 Slot				

Transmissivity, T	4E-06	**m^2/s**		
Hydraulic Conductivity, K	9E-07	**m/s**	H/H_o Intercept	0.80





TEST COMMENTS:

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REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	06MAR'15	ISSUED WITH REPORT	KTD	CAS	KJB

APPENDIX C

WATER LEVEL DATA

Appendix C1 Manual Water Level Measurements
Appendix C2 Time-Series Measurements from Pressure Transducers
Appendix C3 Time-Series Measurements from Vibrating Wire Piezometers

APPENDIX C1

MANUAL WATER LEVEL MEASUREMENTS

(Table C1)

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TABLE C1

CASINO MINING CORPORATION
CASINO PROJECT

20113-2014 GROUNDWATER DATA REPORT
MEASURED DEPTH TO GROUNDWATER

Print Mar/06/15 15:47:12

Location	Well ID	Top of Piezometer Elevation[1]	Screened Interval		Groundwater Levels																								Notes
			Top	Bottom	June 1, 1994	July 1, 1994	Sept. 1, 1994	Oct. 1, 1994	Dec. 1, 1994	May 23-25, 1995	May 20-25, 2008	Sept. 9-11, 2008	Sept 21 - Oct 3, 2009	May 22-26, 2010	June 5-10, 2010	July 10-27, 2010	August 17-20, 2010	Sept. 13-16, 2010	May 21-22, 2011	July 15-17, 2011	Aug. 17-29, 2011	Sept. 17-28, 2011	May 25-28, 2012	Sept. 13-17, 2012	June 10-30 2013	Aug. 3-16, 2013	Sept. 26-29, 2013	May 22-25, 2014	July 22-30, 2014	Sept. 27-Oct. 2, 2014	
		masl	mbgs	mbgs	mbPVC	mbPVC	mbPVC	mbPVC	mbPVC	mbPVC	mbPVC	mbPVC	mbPVC	mbPVC	mbPVC	mbPVC	mbPVC	mbPVC	mbPVC	mbPVC	mbPVC	mbPVC	mbPVC	mbPVC	mbPVC	mbPVC	mbPVC	mbPVC	mbPVC	
Open Pit	93-145[9]	1272	-	-	-	-	-	-	-	-	-	4.78	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	93-226[9]	1171	-	-	-	-	-	-	-	-	-	-	-	-	-	14.64	13.36	-	-	-	-	-	16.95	-	-	-	-	-	-	
	94-326	1253	73.2	76.2	-	-	-	-	-	D at 6.9	-	D/F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Blocked or damaged by frost jacking (Sept. 2009)
	94-332	1324	102.7	105.8	-	-	-	-	-	D at 23.29	-	-	-	-	D at 23.2	-	D at 23.2	D at 23.2	-	-	-	-	F/B at 4.63	F/B at 4.6	F/B at 4.57	-	-	-	-	Suspect damaged
	94-337	1143	32.3	35.4	12.70	16.20	-	14.50	16.81	18.31	18.38	8.45	11.47	-	17.03	13.49	9.27	9.22	19.20	7.73	-	10.49	15.22	12.04	15.00	6.92	10.50	16.70	15.39	9.16	Suspect damaged based on transducer data
	P39	1145	46.3	49.4	-	-	-	-	-	-	-	-	-	-	-	-	6.28	6.56	-	-	-	-	-	9.52	-	-	-	-	-	-	
	CAS-051[8]	1206	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.89	4.55	-	-	-	-	-	5.62	-	-	-	-	-	-	
	CAS-061[8]	1219	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8.43	6.33	-	-	-	-	-	8.46	-	-	-	-	-	-	
	HG10-01	1168	89.4	92.4	-	-	-	-	-	-	-	-	-	-	-	6.79 m atop	8.43 m atop	9.89 m atop	F	Artesian	-	Artesian	Artesian	Artesian	Artesian	Artesian	Artesian	Artesian	Artesian	Artesian	
	HG10-02	1168	42.4	45.3	-	-	-	-	-	-	-	-	-	-	-	0.58 m atop	1.43 m atop	2.79 m atop	F	Artesian	-	Artesian	1.78	0.47	Artesian	Artesian	Artesian	2.91	1.43	0.18	
	HG10-03[7]	1172	16.1	19.1	-	-	-	-	-	-	-	-	-	-	-	4.25	4.35	3.54	7.74	-	-	-	6.68	4.32	-	-	-	-	-	-	
	HG10-04	1139	15.2	18.2	-	-	-	-	-	-	-	-	-	-	-	2.01	4.24	3.43	4.76	3.688	-	4.52	4.26	3.84	4.25	3.46	3.54	4.24	4.13	3.74	
	HG10-05	1183	43.4	46.3	-	-	-	-	-	-	-	-	-	-	-	3.98	6.05	D/F at 5.757	F	D/F at 5.321	-	-	F	F at 5.18	F at 2.8	F	-	-	F at 3.73	-	Frozen water column
	HG10-06	1182	19.8	22.8	-	-	-	-	-	-	-	-	-	-	-	D/F	20.67	D/F	-	-	-	-	F	F	F	-	-	-	F at 3.92	-	Frozen water column
	HG10-07	1214	19.8	22.8	-	-	-	-	-	-	-	-	-	-	-	0.6	1.72	1.82	F at 13.88	F at 13.071	-	F at 10.41	F	F at 10.41	F	-	-	-	F at 7.91	-	Frozen water column
	DH11-36	1399	7.9	10.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F at 4.77	-	F at 4.78	F at 1.71	Frozen water column
	DH11-39[7]	1225	80.8	86.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	27.02	-	-	-	-	F at 1.65	-	F at 0.73	F at 4.78	Frozen water column
	MW13-02D	1194	24.3	27.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.18	0.79	0.93	F at 1.62	2.01	0.93	
	MW13-02S	1193	11.8	14.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.57	1.67	2.00	F at 1.95	2.02	1.74	
Casino Creek Valley	94-342	947	20.4	23.5	-	-	-	-	-	-	D/F	0.95	7.85	-	1.8	-	1.02	1.00	F at 13.0	F at 13.297	-	F at 1.2	-	1.05[11]	1.02[11]	-	-	-	-	-	Frost jacked/damaged (AECOM, 2011); Well casing appears cracked, blocked at 13 mbgs (May 2012/June 2013)
	94-343	864	25.0	28.0	Artesian	-	-	Artesian	D/F	F at 1.09	Artesian	Artesian	Artesian	-	Artesian	-	-	-	-	-	-	-	F	2.28[11]	1.49[11]	-	-	-	-	-	Frost jacked and severed below ground (June 2010)
	94-345	759	14.9	18.0	-	-	2.99	-	3.07	2.88	18.49[12]	2.72	2.7	-	3.05	-	2.38	2.74	F at 6.76	D/F at ~6	-	D/F at ~6	F at 6.69	2.93[11]	2.82[11]	-	-	-	-	-	Blockage at 6 mbgs (Sept. 2012/June 2013)
	94-346	779	30.5	33.5	-	-	23.20	-	23.28	23.1	D/F at 33.7	22.1	22.62	-	23.2	-	22.27	22.19	23.28	21.613	-	22.41	22.73	22.62	22.73	-	-	-	-	-	Blockage at 3 mbgs (Sept. 2012/June 2013)
	94-347	755	19.8	22.9	-	-	1.20	-	D/F at 1.2	F at 1.6	D/F at 0.86	2.053	1.57	-	1.26	2.02	1.55	1.46	D/F at 1.2	1.815	-	0.8	F at 1.49	1.48	F at 1.58	-	-	-	-	1.15	
	94-348	732	22.0	25.1	-	-	-	-	-	F at 1.47	-	1.2	1.69	-	1.1	-	1.68	1.52	D/F at 1.67	F at 6.723	-	-	F at 1.80	F at 6.8	F at 1.82	-	-	-	-	F at 7.06	Frozen water column
	94-350	702	62.5	65.5	-	-	4.12	-	D/F at 4.12	D/F at 4.15	D/F at 1.90	2.01	D/F	-	6.165	-	D/F	D/F	D/F at 6.14	-	-	D/F	D/F at 6.16	-	F at 6.17	F at 6.16	-	F at 6.62	F at 6.16	F at 5.90	Frozen water column
	94-351	719	15.9	19.0	-	-	11.80	-	D/F at 11.8	D/F at 11.77	-	1.24[12]	2.14	-	4.4	-	2.84	1.73	D/F at 5.92	F at 5.924	-	-	F at 6.3	F at 6.53	F at 6.51	F at 5.77	-	F at 3.00	F at 5.70	-	Frozen water column
	DH10-01	978	8.2	11.2	-	-	-	-	-	-	-	-	-	10.95[10]	-	-	-	-	-	-	-	-	-	-	-	-	10.75	-	11.06	11.39	
	DH10-02	921	34.1	40.2	-	-	-	-	-	-	-	-	-	30.4[10]	-	-	-	-	-	-	-	-	-	-	-	-	37.38	-	37.09	37.78	
	DH10-03	812	31.6	36.9	-	-	-	-	-	-	-	-	-	30.4[10]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	DH10-04	723	18.0	21.0	-	-	-	-	-	-	-	-	-	0.84	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	DH10-05	783	2.9	5.9	-	-	-	-	-	-	-	-	-	3.45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.87	
	DH10-06	908	2.7	5.8	-	-	-	-	-	-	-	-	-	3.16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.11	
	DH11-14	673	22.9	25.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F at 2.21	-	F at 2.30	F at 1.35	Frozen water column
	DH11-21A	819	37.4	43.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	>44.3	>44.3	>44.3	
	DH11-22	807	17.9	20.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14.63[10]	-	-	-	-	-	-	-	-	
	DH11-23A	728	20.9	24.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F at 3.00	F at 2.16	F at 1.12	Frozen water column
	DH11-24	838	32.8	35.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	>36.6	
	DH11-25S	783	6.1	9.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.08[10]	-	-	-	-	F/B at 6.00	-	F/B at 5.05	F/B at 6.96	Frozen water column
	DH11-25D	783	18.4	21.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19.55[10]	-	-	-	-	F/B at 16.34	-	F/B at 16.34	F/B at 16.34	Frozen water column
	MW13-05	1024	46.6	49.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	33.23[10]	41.78	41.15	43.44	43.11	42.26	
	MW13-06D	1070	45.4	48.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	32.97	31.89	37.47	44.36	41.81	38.42	
	MW13-06S	1070	33.6	37.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	32.33	32.72	37.44	37.44	37.45	36.42	
Hillslope Area	94-352	1190	14.1	17.2	-	-	3.20	-	9.65	4.62	D/F at 17.46	0.96	2.7	-	4.29	-	2.81	1.63	11.68[11]	-	-	-	-	-	5.07	1.73	-	6.09	1.00	1.81	
	94-353	1210	11.6	14.6	-	-	-	-	-	13.17	D/F at 12.14	11.61	12.55	-	15.09	-	12.55	11.27	12.83	9.44	-	11.55	-	-	13.46	1.03	-	13.45	10.30	12.18	PVC damaged at ground surface Aug 2011, repaired June 2012
	94-354	1098	18.2	21.3	-	-	-	-	-	18.82	D/F at 22.8	18.04	21.9	-	22.23	-	20.48	19	22.50	18.80	-	17.11	22.23	21.25	Dry (>22.8)	Dry (>22.8)	-	Dry (>22.8)	19.48	20.48	
	DH12-04A	1232	18.8	21.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F/B at 6.20	F/B at 8.01	
	MW11-01A	1084	27.5	30.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13.76	26.38	-	20.23	-	-	23.03	-	-	Could not pass surge block down well, not developed
	MW11-01B	1087	14.5	17.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13.59	D at 16.81	D (>16.7)		12.80	-	Dry (>16.7)	-	-	
	MW11-02A	1082	23.0	26.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.72	5.58	7.16	7.68	5.77	-	7.63	7.49	5.75	
	MW11-02B	1083	14.6	18.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.98	6.29	5.42	8.68	4.25	-	6.74	6.30	4.28	
	MW13-01D	1150	27.5	30.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	F at 3.03	F	F	F	Frozen water column
	MW13-01S	1150	10.7	13.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	F at 3.22	F	F	F	Frozen water column
	MW13-03D	1214	30.7	33.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	27.42	11.25	9.78	F at 7.01	F at 16.43	F at 11.73	Frozen water column
	MW13-03S	1213	10.6	13.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8.17	F at 9.14	F at 1.50	F at 9.98	F at 3.09	Frozen water column
	MW13-04D	1024	37.7	40.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10.28[10]	18.95	17.99	24.41	18.92	17.91	
	MW13-04S	1025	18.0	21.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10.89	8.52	10.99	17.74	13.05	10.30	
Plant Site	DH11-32	1191	9.0	12.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.33	-	-	-	-	B/F at 1.2	-	B/F at 1.184	F at 1.19	Frozen water column
	DH11-33	1195	6.5	9.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.61	-	-	-	-	6.37	-	5.90	Dry (>10.5)	
	DH11-34	1181	17.3	20.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.45[10]	-	-	-	-	F/B at 4.76	-	F/B at 3.5	F/B at 5.12	Frozen water column
Dip Creek Valley	DH11-09	632	33.7	39.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F at 3.6	-	-	-	-	-	-	-	-	
	DH11-10[9]	642	11.7	17.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	-	-	-	-	-	-	-	-	
	DH11-11	653	3.7	6.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	-	-	-	-	-	-	-	-	
	DH11-12	652	21.9	30.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	-	-	-	-	-	-	-	-	
	DH11-13[8]	662	19.3	25.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	-	-	-	-	-	-	-	-	
Brynelson Creek	DH11-15	717	20.6	23.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.45	-	-	-	-	F at 1.53	-	F at 0.52	F at Artesian	
Britannia Creek	DH11-PEG-01	394	6.9	9.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.45	-	-	-	-	-	-	-	-	
	DH11-PEG-02	395	11.0	14.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.91	-	-	-	-	-	-	-	-	
	DH11-PEG-03	404	8.3	11.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.53	-	-	-	-	-	-	-	-	
	DH11-PEG-04	429	8.2	11.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.74	-	-	-	-	-	-	-	-	

M:\2010\03\20117A\Data\Task 200 - 2011 Hydrogeology Addendum\1- Water level\Manual Water Level\[TABLE C1 - Measured GW levels and elevations.xlsx]C1- GW levels

NOTES:

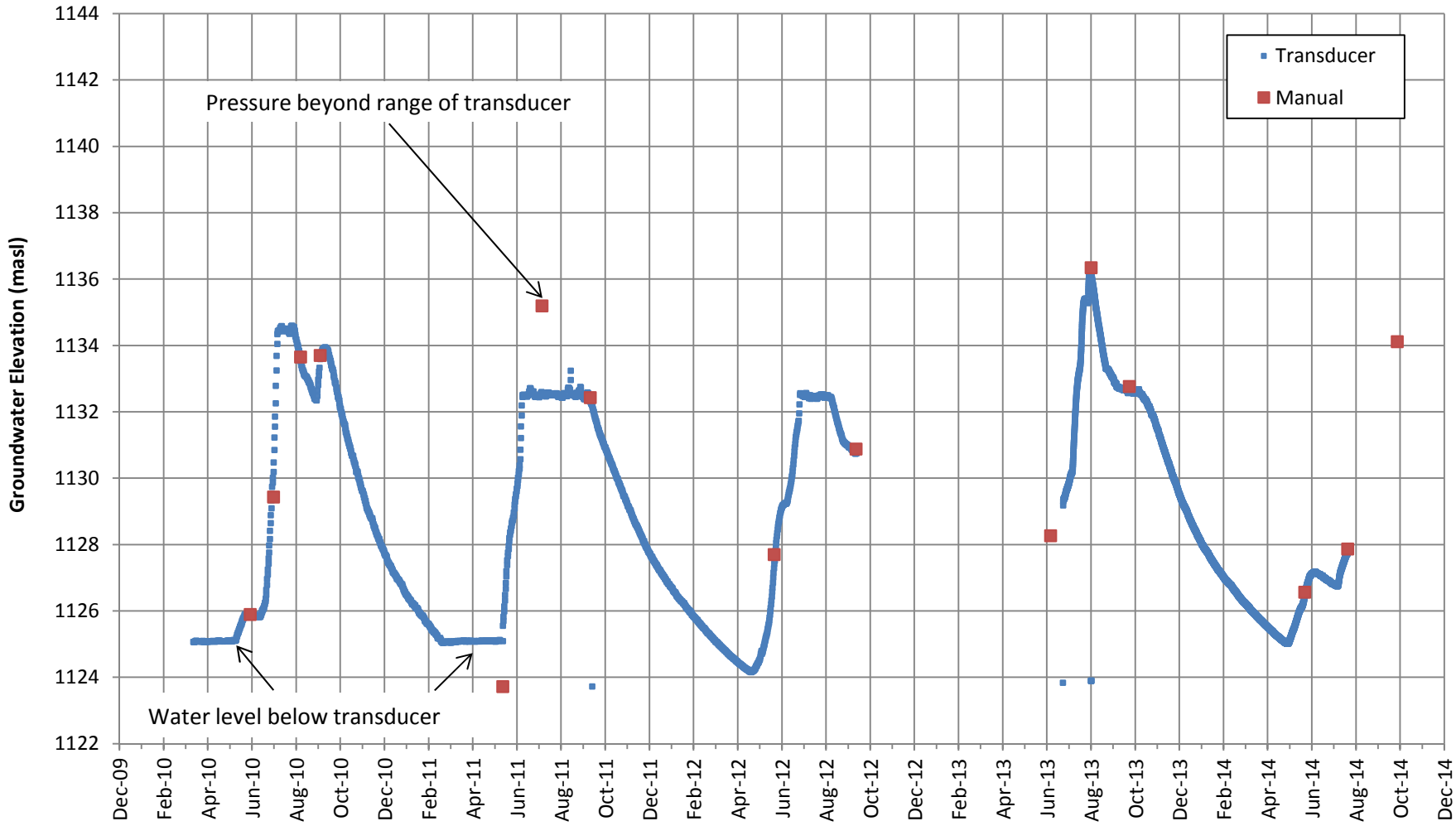
1. 2011, 2012 AND 2013 LOCATIONS WERE SURVEYED BY YUKON ENGINEERING SERVICES IN SEPTEMBER 2013. COORDINATES PRESENTED IN UTM NAD83 ZONE 7.
2. ANGLED PIEZOMETER, DEPTHS ARE MEASURED ALONG HOLE.
3. mbPVC: METERS BELOW TOP OF PVC.
4. mbgs: METERS BELOW GROUND SURFACE.
5. DRY: DRY WELL.
6. F: FROZEN WELL.
7. atop: ABOVE TOP OF PIPE
8. OPEN BOREHOLE, DEPTH IS MEASURED FROM GROUND SURFACE.
9. B: BLOCKED.
10. WATER LEVEL MEASURED IMMEDIATELY AFTER WELL INSTALLATION AND MAY NOT REPRESENT STATIC WATER LEVEL CONDITIONS.
11. THE WELL MAY BE DAMAGED AND THE WATER LEVEL MAY NOT BE REPRESENTATIVE OF HYDROLOGIC CONDITIONS AT THE SCREEN DEPTH.
12. WATER LEVEL MEASUREMENT IS NOTICABLY DIFFERENT THAN PREVIOUS MEASUREMENTS.

0	20MAR15	ISSUED WITH REPORT	KTD	CAS	KJB
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

APPENDIX C2

TIME-SERIES MEASUREMENTS FROM PRESSURE TRANSDUCERS

(Pages C2-1 to C2-14)



NOTES:

1. GROUND SURFACE ELEVATION IS 1142.8 m.
2. THE WELL IS SCREENED BETWEEN 1110.2 masl AND 1107.1 masl.
3. TRANSDUCER WAS INSTALLED AT 1125.3 masl UNTIL MAY 22, 2011 WHEN THE TRANSDUCER WAS LOWERED 2 m TO 1123.3 masl.
4. THE TRANSDUCER WAS REMOVED FROM THE WELL IN SEPTEMBER 2012 AND WAS REPLACED WITH A TRANSDUCER WITH A GREATER RANGE OF MEASUREMENT JUNE 2013 .
5. TRANSDUCER WAS TEMPORARILY REMOVED FROM THE WELL BETWEEN JULY AND OCTOBER 2014.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	06MAR'15	ISSUED WITH REPORT	KTD	CAS	KJB

CASINO MINING CORPORATION

CASINO PROJECT

94-337
GROUNDWATER ELEVATION

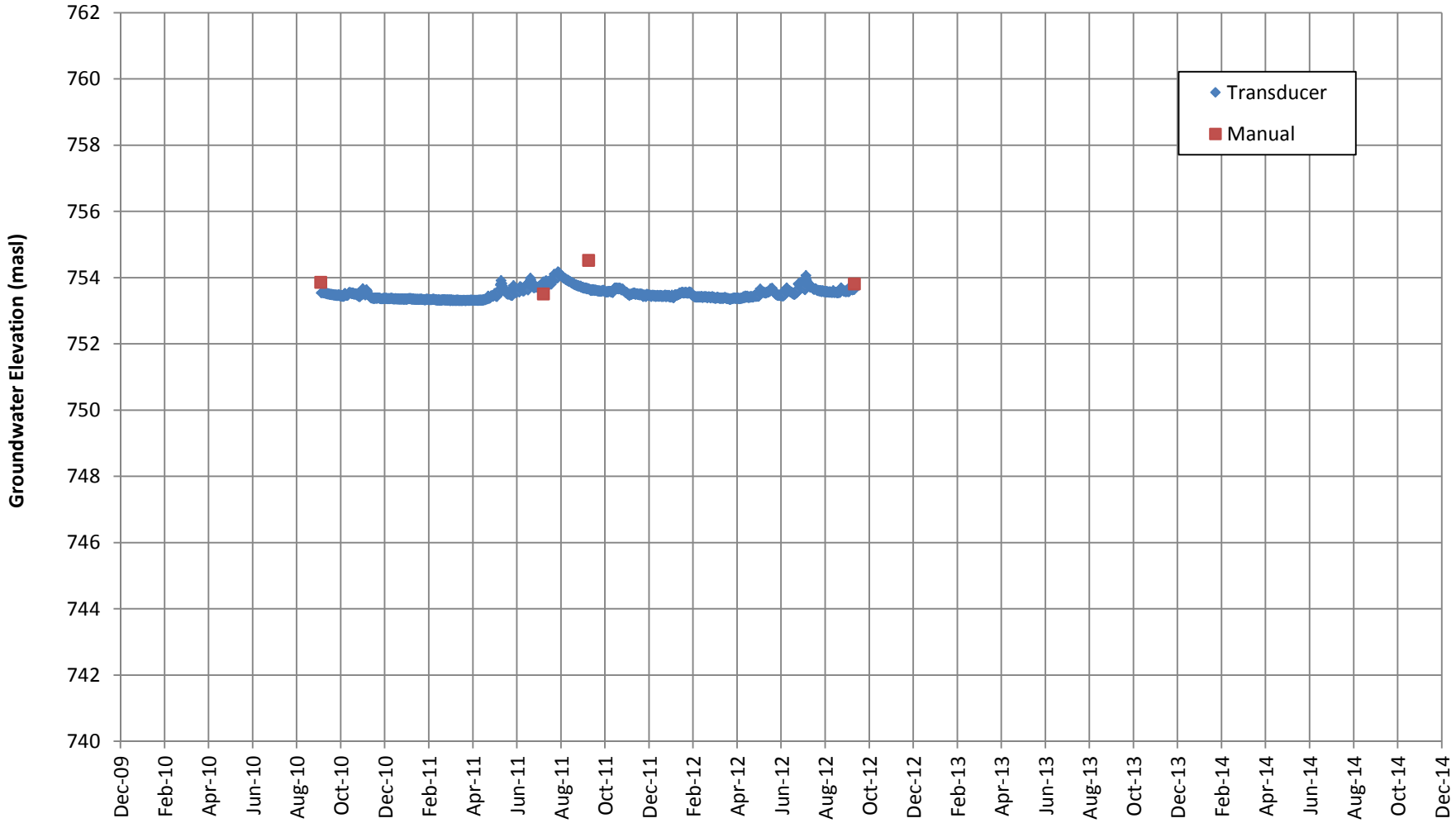
Knight Piésold CONSULTING

P/A NO. VA101-325/17

REF. NO. 1

FIGURE C2.1

REV 0



NOTES:

1. GROUND SURFACE ELEVATION IS 754.2 m.
2. WELL IS SCREENED BETWEEN 734.4 masl AND 731.1 masl.
3. WATER IN WELL APPEARS TO FREEZE FROM APPROXIMATELY DECEMBER TO MAY BASED ON MANUAL WATER LEVEL MEASUREMENTS.
4. TRANSDUCER REMOVED FROM WELL SEPTEMBER 2012 AND NOT RE-INSTALLED.

CASINO MINING CORPORATION

CASINO PROJECT

94-347
GROUNDWATER ELEVATION

Knight Piésold CONSULTING

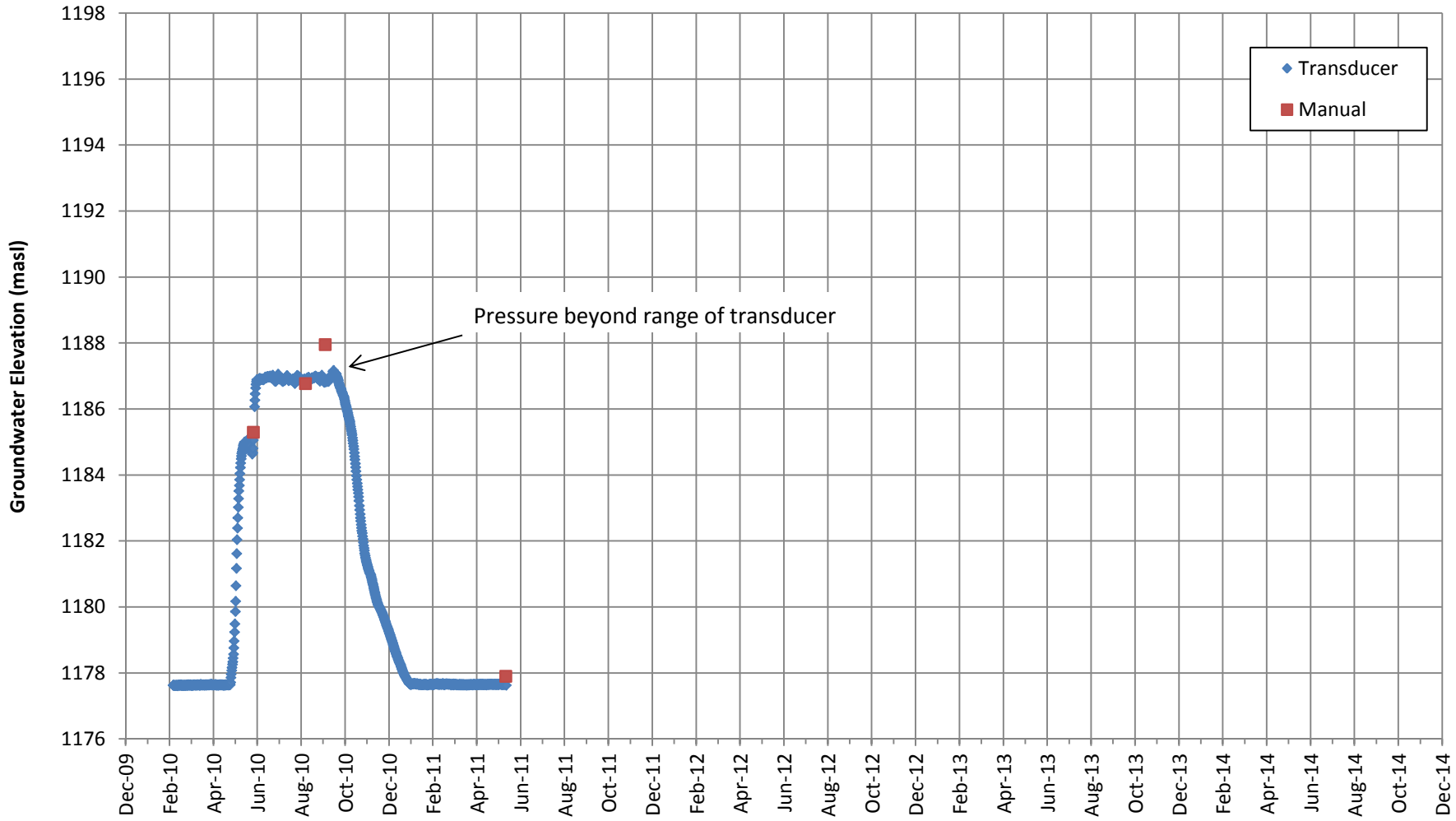
P/A NO. VA101-325/17

REF. NO. 1

FIGURE C2.2

REV 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	06MAR'15	ISSUED WITH REPORT	KTD	CAS	KJB



NOTES:

1. GROUND SURFACE ELEVATION IS 1188.6 m.
2. WELL IS SCREENED BETWEEN 1174.5 masl AND 1171.4 masl.
3. IN MAY 2011 THE PVC WAS NOTED TO BE DAMAGED AT 3 mbgs AND THE TRANSDUCER WAS REMOVED FROM THE WELL. THE WELL IS SUSPECTED TO BE DAMAGED OVER THE PERIOD OF RECORD SHOWN ON THE PLOT.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	06MAR'15	ISSUED WITH REPORT	KTD	CAS	KJB

CASINO MINING CORPORATION

CASINO PROJECT

94-352
GROUNDWATER ELEVATION

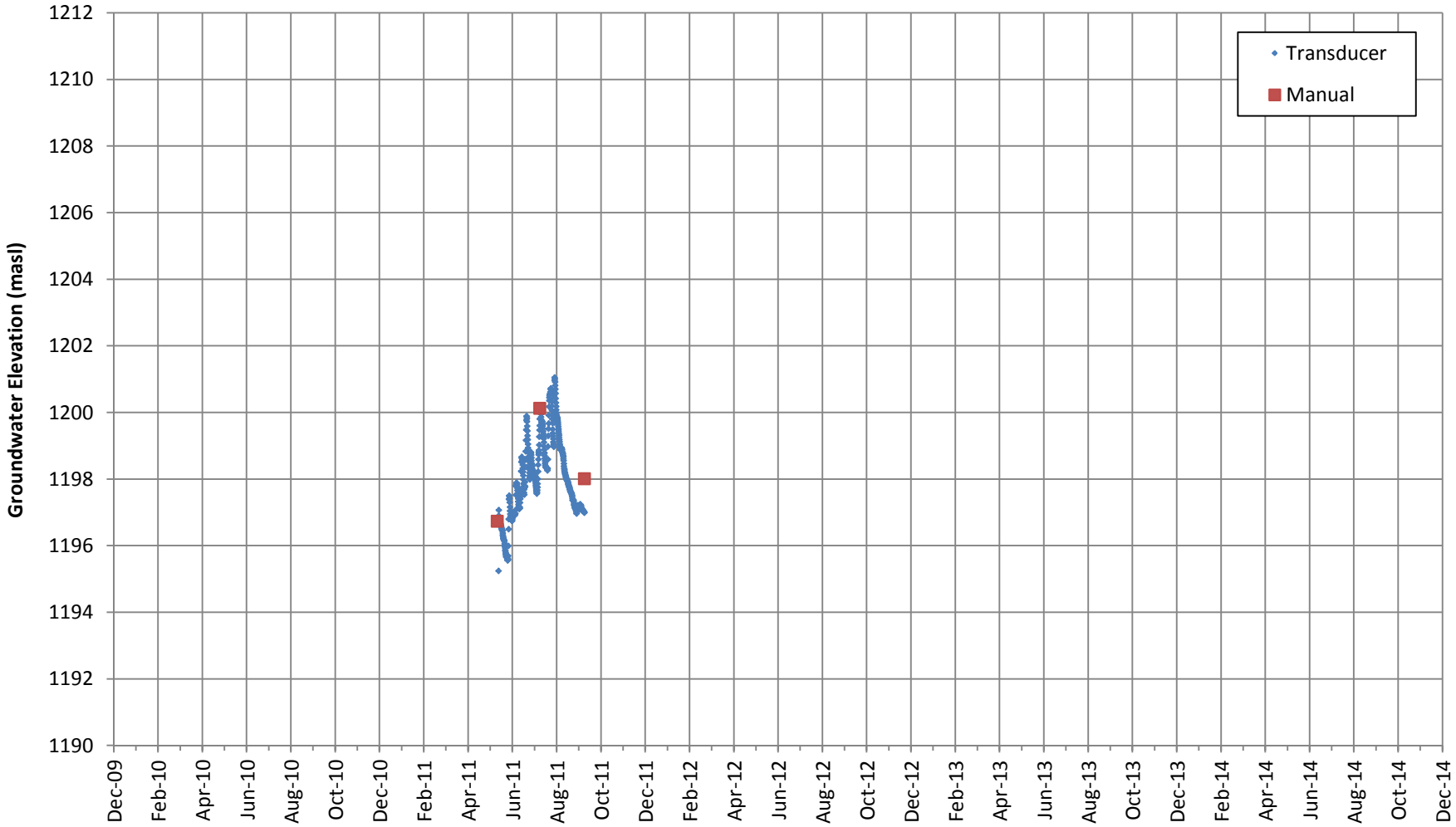
Knight Piésold CONSULTING

P/A NO. VA101-325/17

REF. NO. 1

FIGURE C2.3

REV 0



NOTES:

1. GROUND SURFACE ELEVATION IS 1208.6 m.
2. WELL IS SCREENED BETWEEN 1197.0 masl AND 1194.0 masl.
3. TRANSDUCER WAS REMOVED FROM THE WELL IN SEPTEMBER 2011 WHEN THE PVC WAS DAMAGED AT GROUND SURFACE.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	06MAR'15	ISSUED WITH REPORT	KTD	CAS	KJB

CASINO MINING CORPORATION

CASINO PROJECT

94-353
GROUNDWATER ELEVATION

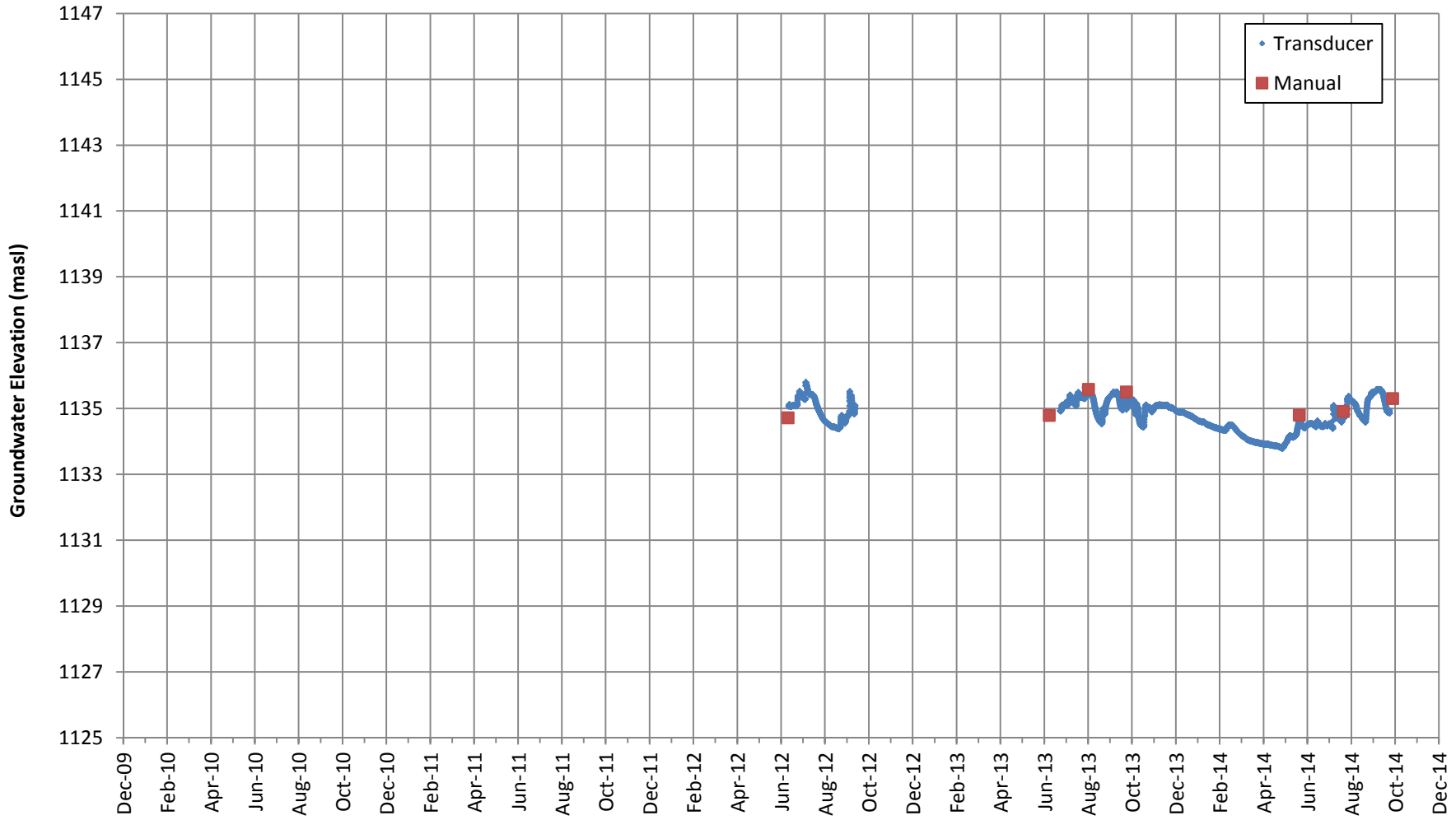
Knight Piésold CONSULTING

P/A NO. VA101-325/17

REF. NO. 1

FIGURE C2.4

REV 0



NOTES:

1. GROUND SURFACE ELEVATION IS 1138.7 m.
2. WELL IS SCREENED BETWEEN 1123.6 masl AND 1120.6 masl.
3. THE LEVELOGGER WAS REMOVED IN SEPTEMBER 2012 AND REPLACED JUNE 2013.

CASINO MINING CORPORATION

CASINO PROJECT

HG10-04
GROUNDWATER ELEVATION

Knight Piésold CONSULTING

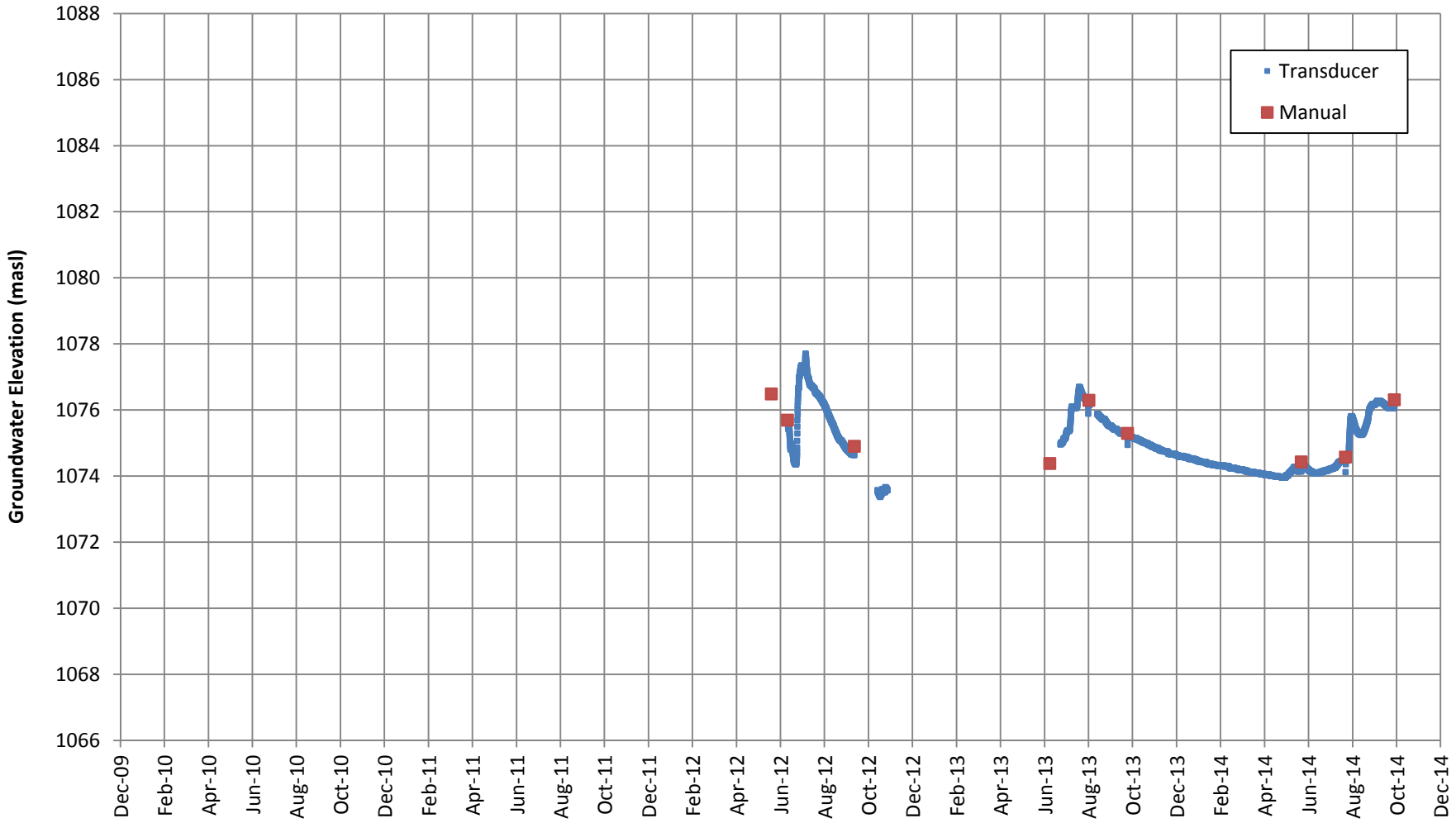
P/A NO. VA101-325/17

REF. NO. 1

FIGURE C2.5

REV 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	06MAR'15	ISSUED WITH REPORT	KTD	CAS	KJB



NOTES:

1. GROUND SURFACE ELEVATION IS 1081.1 masl.
2. WELL IS SCREENED BETWEEN 1058.1 masl AND 1055.1 masl.
3. TRANSDUCER WAS REMOVED FROM THE WELL SEPTEMBER 2012 AND REPLACED JUNE 2013.

CASINO MINING CORPORATION

CASINO PROJECT

MW11-02A
GROUNDWATER ELEVATION

Knight Piésold CONSULTING

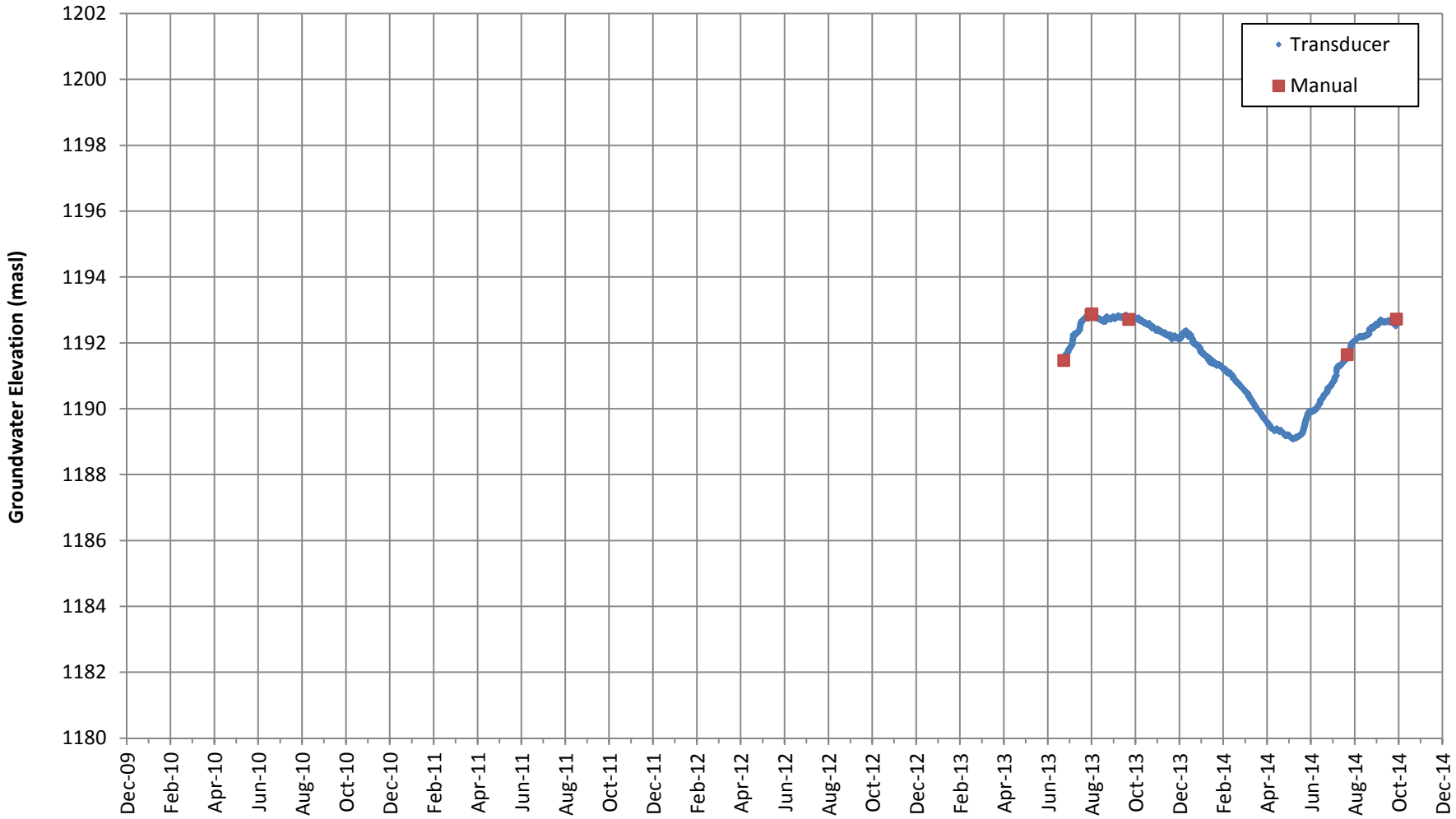
P/A NO. VA101-325/17

REF. NO. 1

FIGURE C2.6

REV 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	06MAR'15	ISSUED WITH REPORT	KTD	CAS	KJB



NOTES:
1. GROUND SURFACE ELEVATION IS 1193.1 masl.
2. WELL IS SCREENED BETWEEN 1168.8 masl AND 1165.8 masl.
3. WELL FROZEN DURING MAY 2014 SITE VISIT AND MANUAL MEASUREMENT IS NOT SHOWN.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	06MAR'15	ISSUED WITH REPORT	KTD	CAS	KJB

CASINO MINING CORPORATION

CASINO PROJECT

MW13-02D
GROUNDWATER ELEVATION

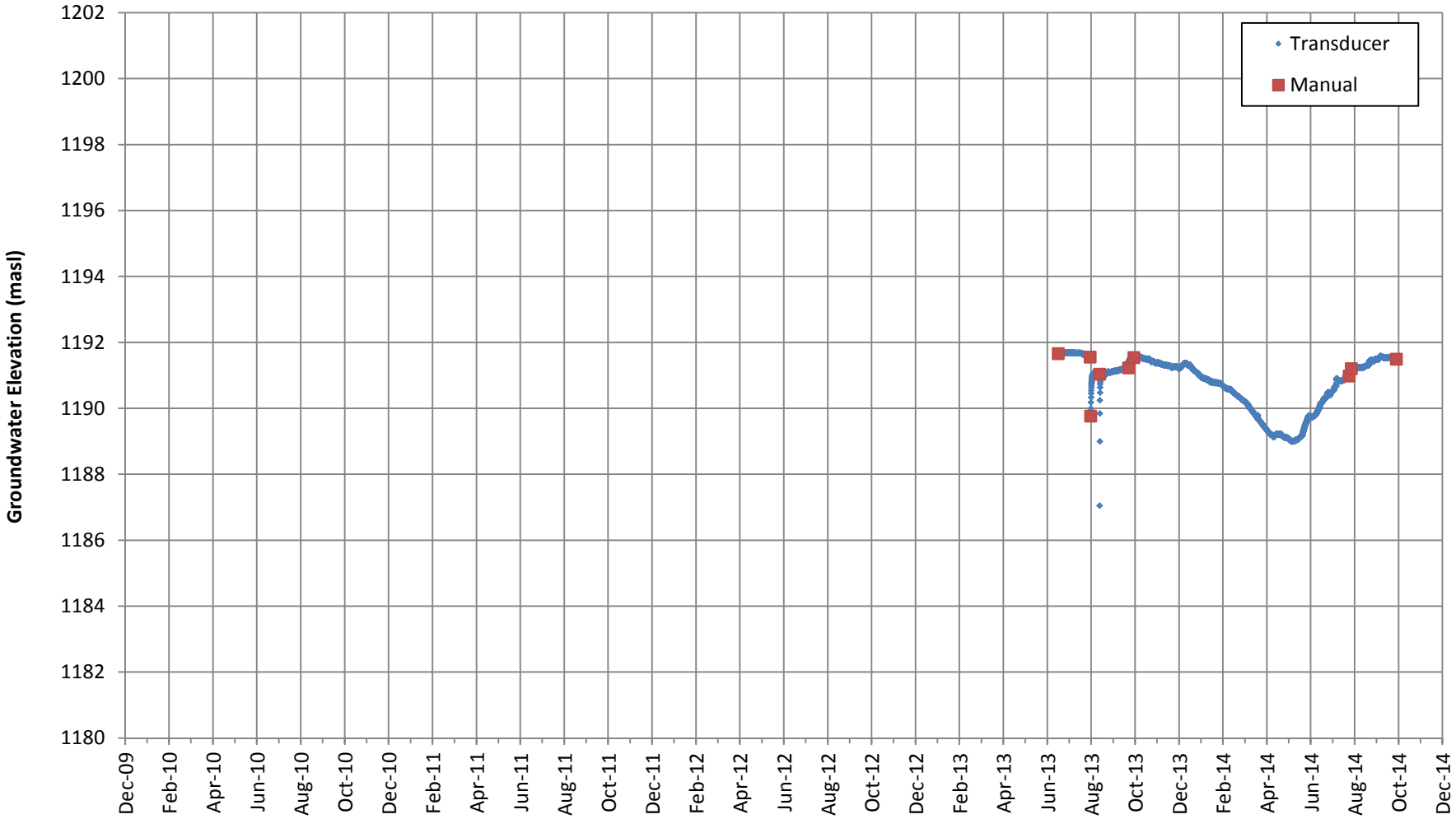
Knight Piésold CONSULTING

P/A NO. VA101-325/17

REF. NO. 1

FIGURE C2.7

REV 0



NOTES:

1. GROUND SURFACE ELEVATION IS 1192.7 m.
2. WELL IS SCREENED BETWEEN 1180.9 masl AND 1177.9 masl.
3. WATER COLUMN IN WELL FROZEN DURING SITE VISIT IN MAY 2014 AND MANUAL MEASUREMENT NOT SHOWN.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	06MAR'15	ISSUED WITH REPORT	KTD	CAS	KJB

CASINO MINING CORPORATION

CASINO PROJECT

MW13-02S
GROUNDWATER ELEVATION

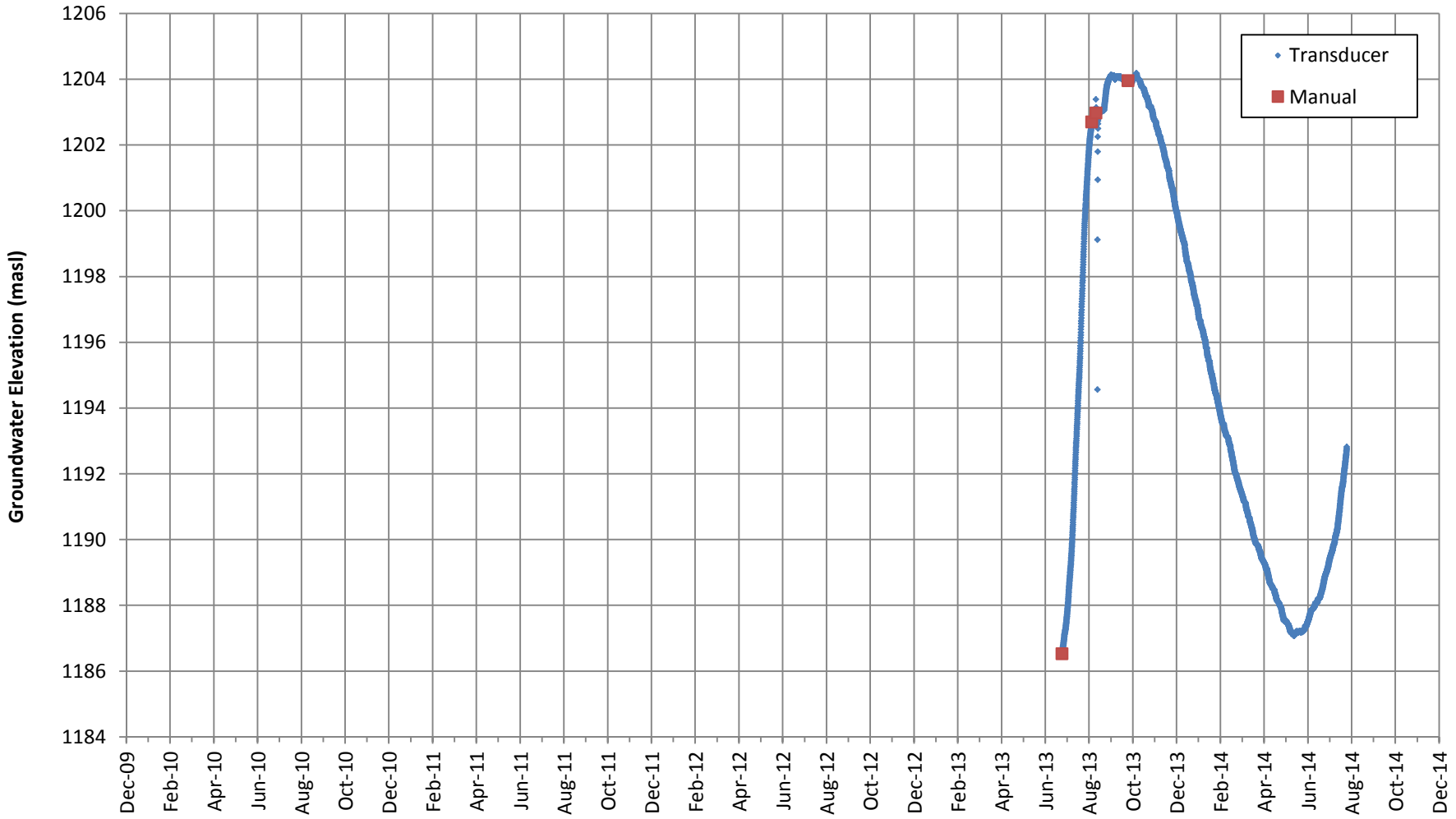
Knight Piésold CONSULTING

P/A NO. VA101-325/17

REF. NO. 1

FIGURE C2.8

REV 0



NOTES:

1. GROUND SURFACE ELEVATION IS 1213.6 masl.
2. WELL IS SCREENED BETWEEN 1182.9 masl AND 1179.8 masl.
3. WATER COLUMN IN WELL FROZEN DURING MAY, JUNE, AND SEPTEMBER 2014 SITE VISITS AND MANUAL MEASUREMENTS ARE NOT SHOWN. WATER COLUMN THAWED IN JULY 2014 AND TRANSDUCER DOWNLOADED.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	06MAR'15	ISSUED WITH REPORT	KTD	CAS	KJB

CASINO MINING CORPORATION

CASINO PROJECT

MW13-03D
GROUNDWATER ELEVATION

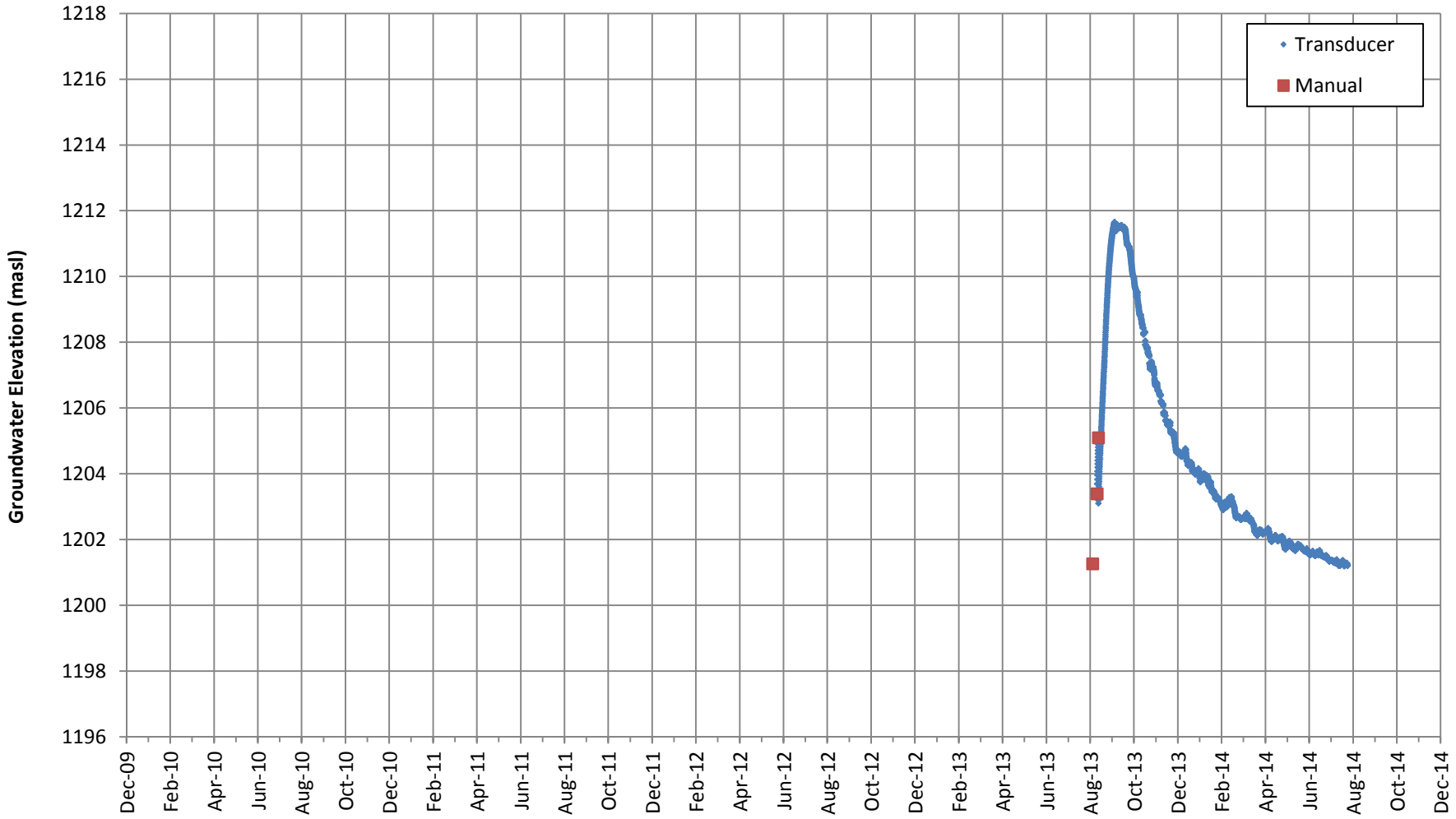
Knight Piésold CONSULTING

P/A NO. VA101-325/17

REF. NO. 1

FIGURE C2.9

REV 0



NOTES:

1. GROUND SURFACE ELEVATION IS 1213.0 masl.
2. WELL IS SCREENED BETWEEN 1202.4 masl AND 1199.4 masl.
3. WELL FROZEN DURING SITE VISITS FROM SEPTEMBER 2013 THROUGH SEPTEMBER 2014 AND MANUAL WATER LEVEL MEASUREMENTS NOT SHOWN.
4. ICE IN WELL THAWED DURING JULY 2014 SITE VISIT AND TRANSDUCER DOWNLOADED.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	06MAR'15	ISSUED WITH REPORT	KTD	CAS	KJB

CASINO MINING CORPORATION

CASINO PROJECT

MW13-03S
GROUNDWATER ELEVATION

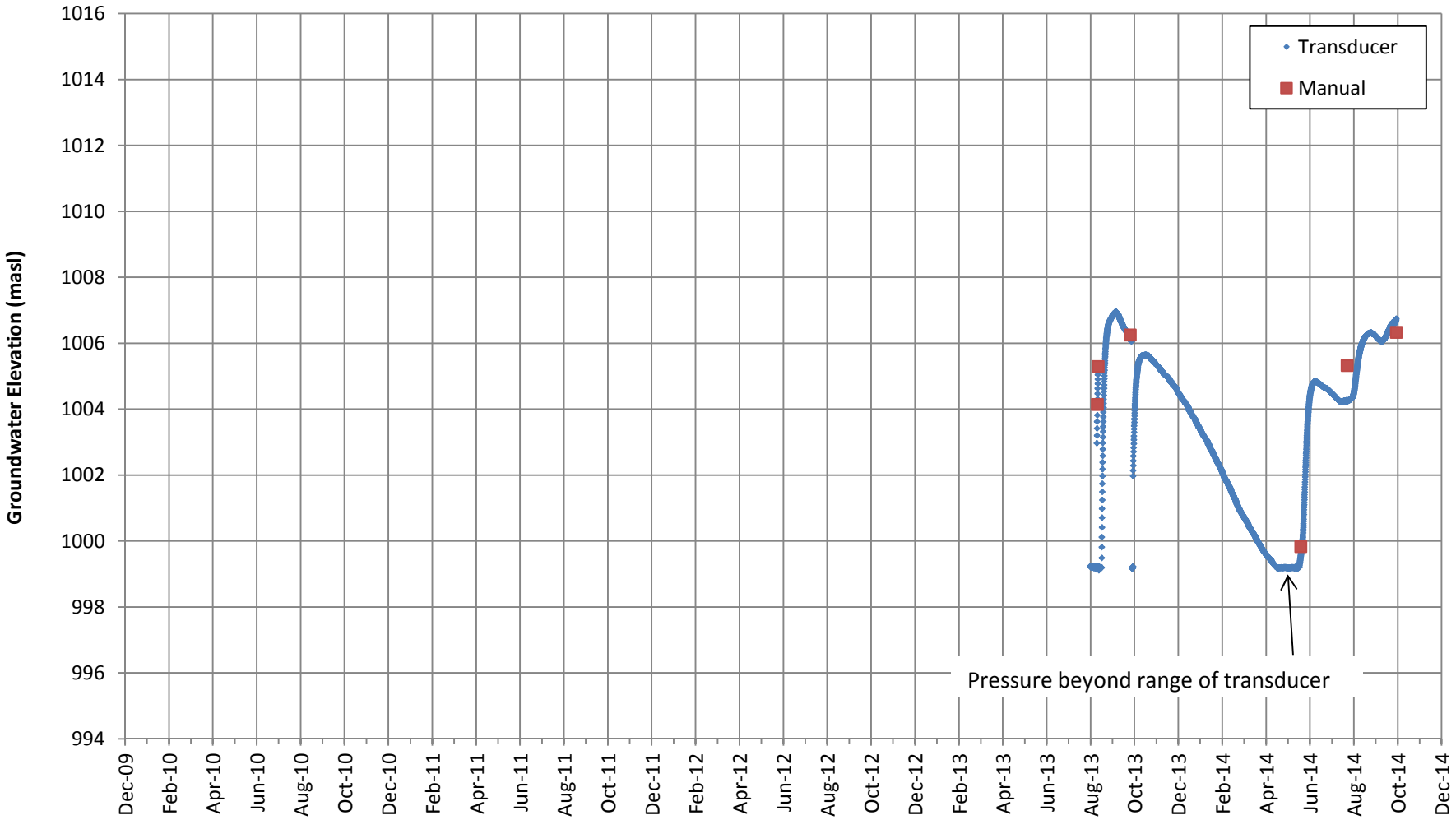
Knight Piésold CONSULTING

P/A NO. VA101-325/17

REF. NO. 1

FIGURE C2.10

REV 0



NOTES:
1. GROUND SURFACE ELEVATION IS 1023.9 masl.
2. WELL IS SCREENED BETWEEN 986.2 masl AND 983.2 masl.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	06MAR'15	ISSUED WITH REPORT	KTD	CAS	KJB

CASINO MINING CORPORATION

CASINO PROJECT

MW13-04D
GROUNDWATER ELEVATION

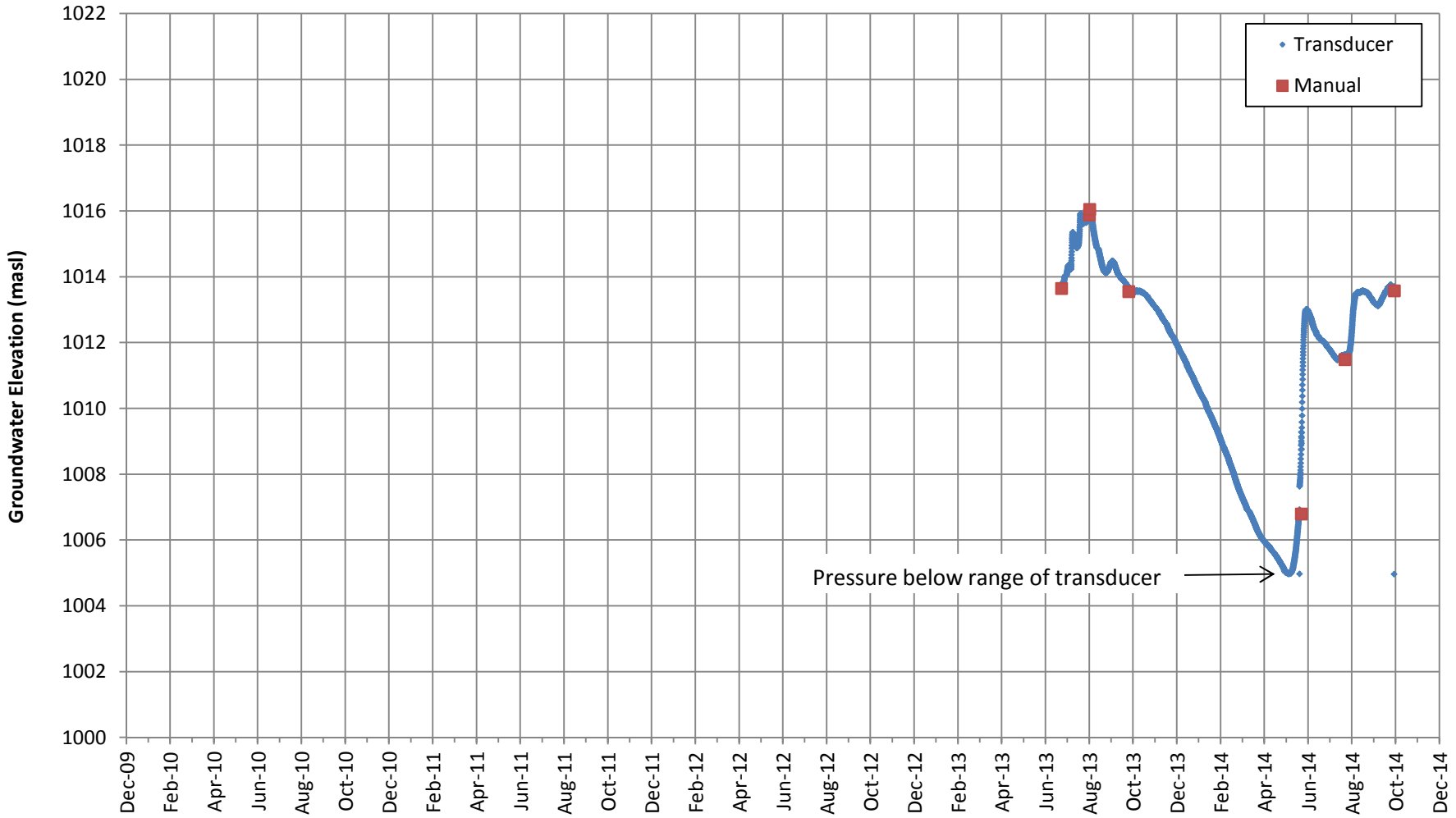
Knight Piésold CONSULTING

P/A NO. VA101-325/12

REF. NO. 1

FIGURE C2.11

REV 0



NOTES:
1. GROUND SURFACE ELEVATION IS 1023.8 masl.
2. WELL IS SCREENED BETWEEN 1005.8 masl AND 1002.8 masl.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	06MAR'15	ISSUED WITH REPORT	KTD	CAS	KJB

CASINO MINING CORPORATION

CASINO PROJECT

MW13-04S
GROUNDWATER ELEVATION

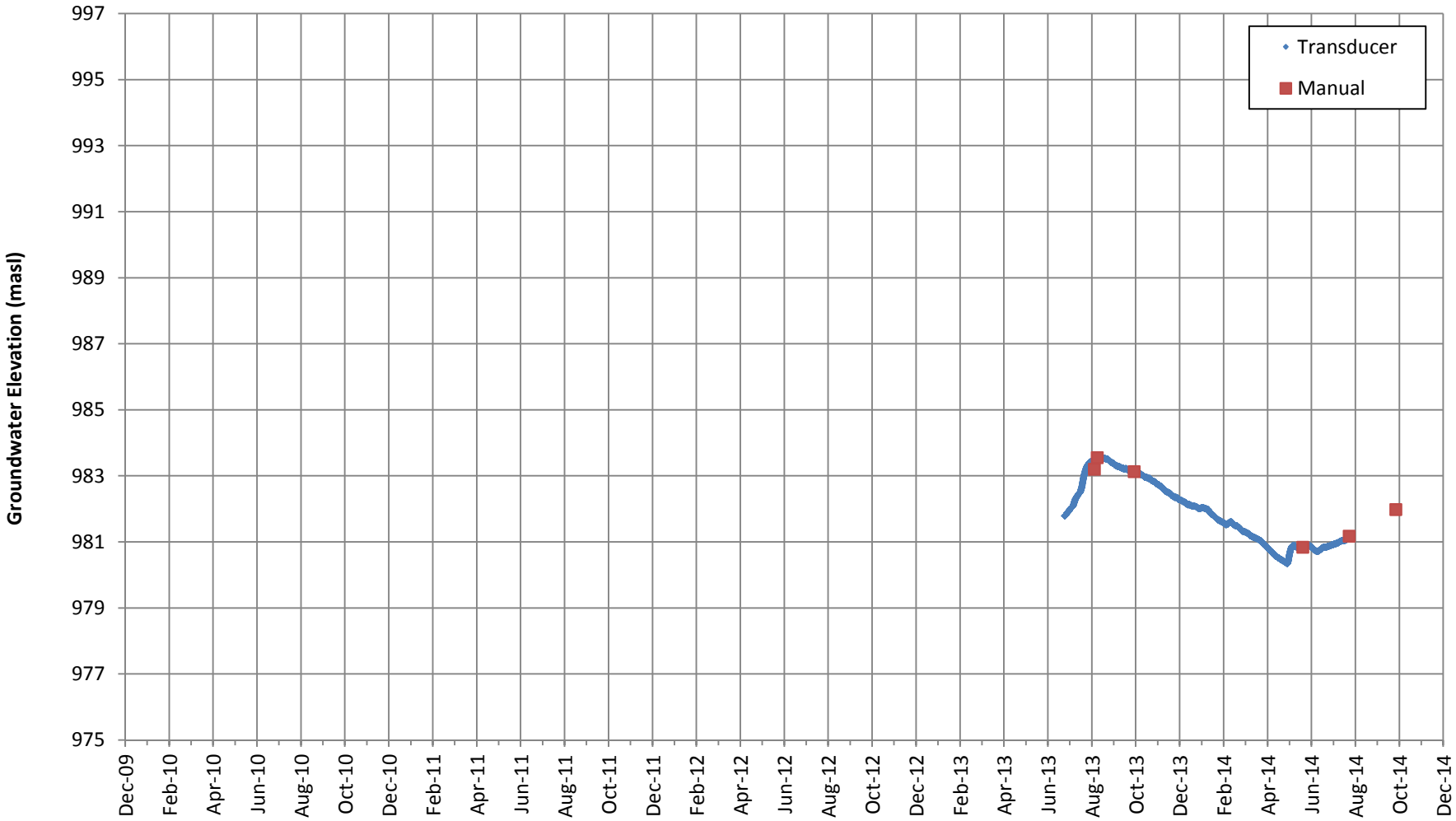
Knight Piésold CONSULTING

P/A NO. VA101-325/12

REF. NO. 1

FIGURE C2.12

REV 0



NOTES:
1. GROUND SURFACE ELEVATION IS 1024.0 masl.
2. WELL IS SCREENED BETWEEN 977.4 masl AND 974.4 masl.
3. TRANSDUCER TEMPORARILY REMOVED FROM WELL FROM JULY TO SEPTEMBER 2014.

CASINO MINING CORPORATION

CASINO PROJECT

MW13-05
GROUNDWATER ELEVATION

Knight Piésold CONSULTING

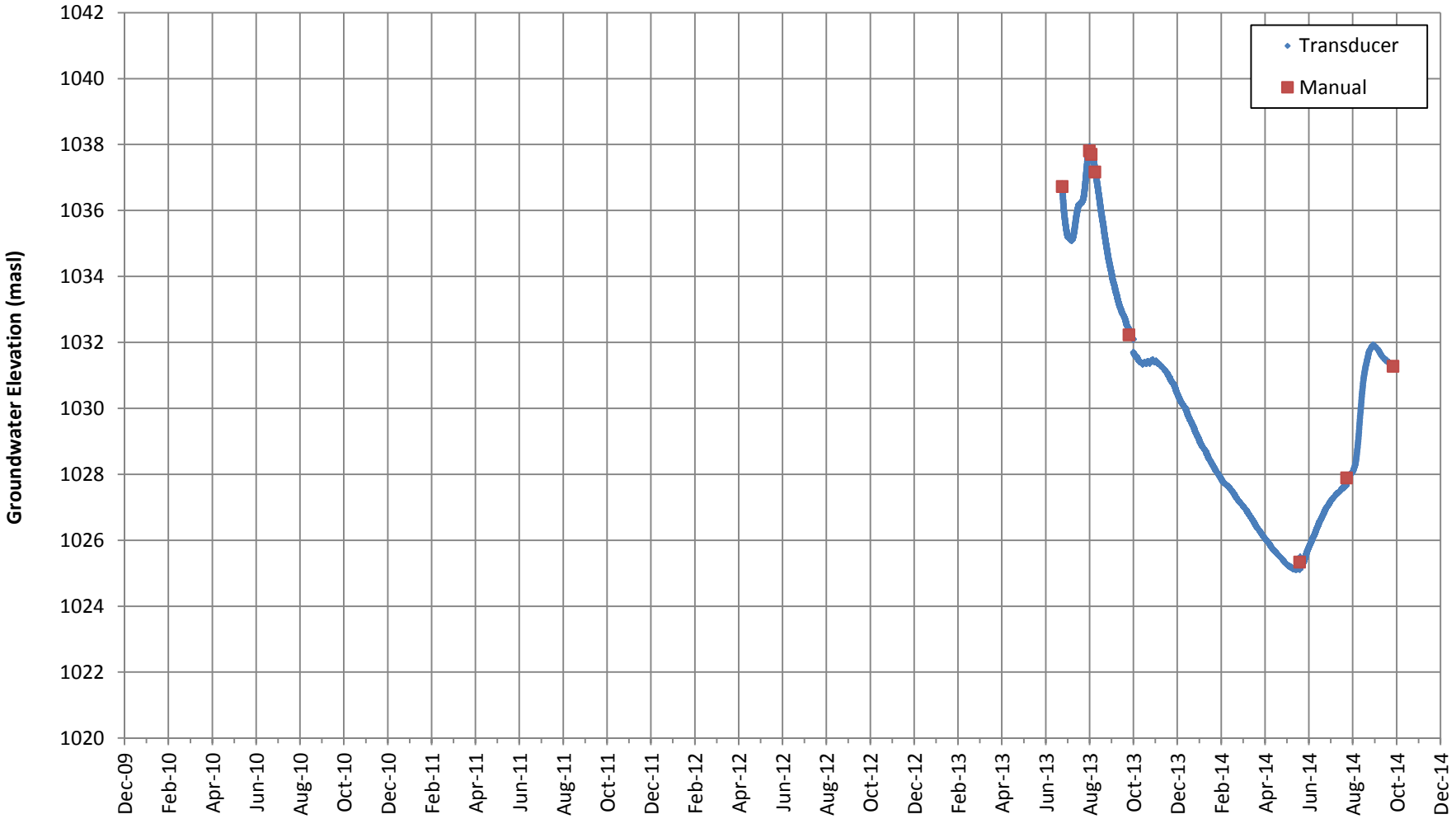
P/A NO. VA101-325/17

REF. NO. 1

FIGURE C2.13

REV 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	06MAR'15	ISSUED WITH REPORT	KTD	CAS	KJB



NOTES:
1. GROUND SURFACE ELEVATION IS 1069.5 masl.
2. WELL IS SCREENED BETWEEN 1024.1 masl AND 1021.1 masl.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	06MAR'15	ISSUED WITH REPORT	KTD	CAS	KJB

CASINO MINING CORPORATION

CASINO PROJECT

MW13-06D
GROUNDWATER ELEVATION

Knight Piésold CONSULTING

P/A NO. VA101-325/17

REF. NO. 1

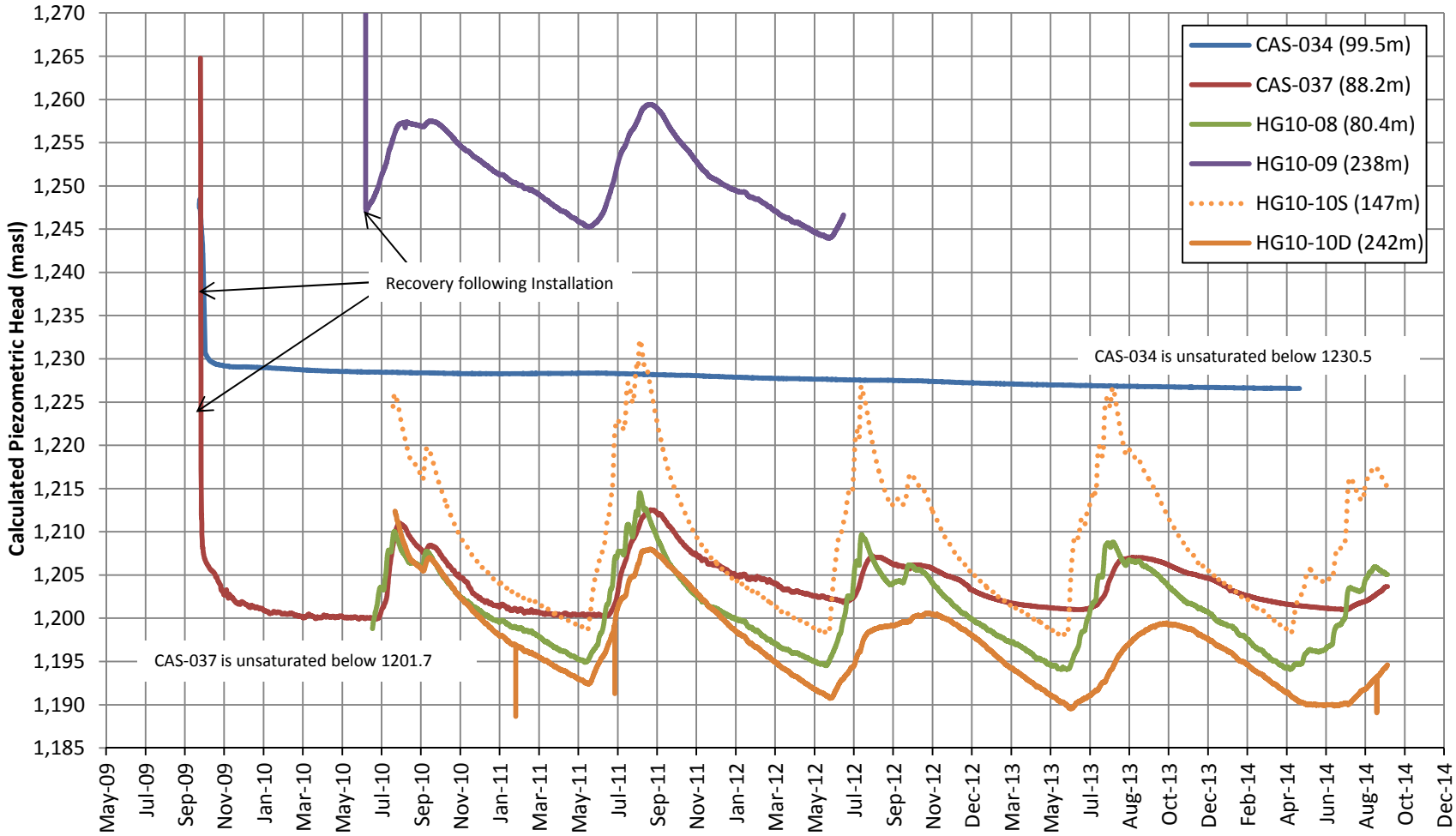
FIGURE C2.14

REV 0

APPENDIX C3

TIME-SERIES MEASUREMENTS FROM VIBRATING WIRE PIEZOMETERS

(Figure C3)



NOTES:
1. DEPTH OF INSTALLATION IS SHOWN IN LEGEND BESIDE PIEZOMETER NAME.
2. HG10-09 HAS NOT BEEN DOWNLOADED SINCE 2012, AND
3. CAS-034 WAS LAST DOWNLOADED IN MAY 2014.

CASINO MINING CORPORATION

CASINO PROJECT

VIBRATING WIRE PIEZOMETERS
CALCULATED PIEZOMETERIC HEAD

Knight Piésold CONSULTING

P/A NO. VA101-325/17

REF. NO. 1

FIGURE C3

REV 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	17DEC'14	ISSUED WITH REPORT	KTD	CAS	KJB

APPENDIX D

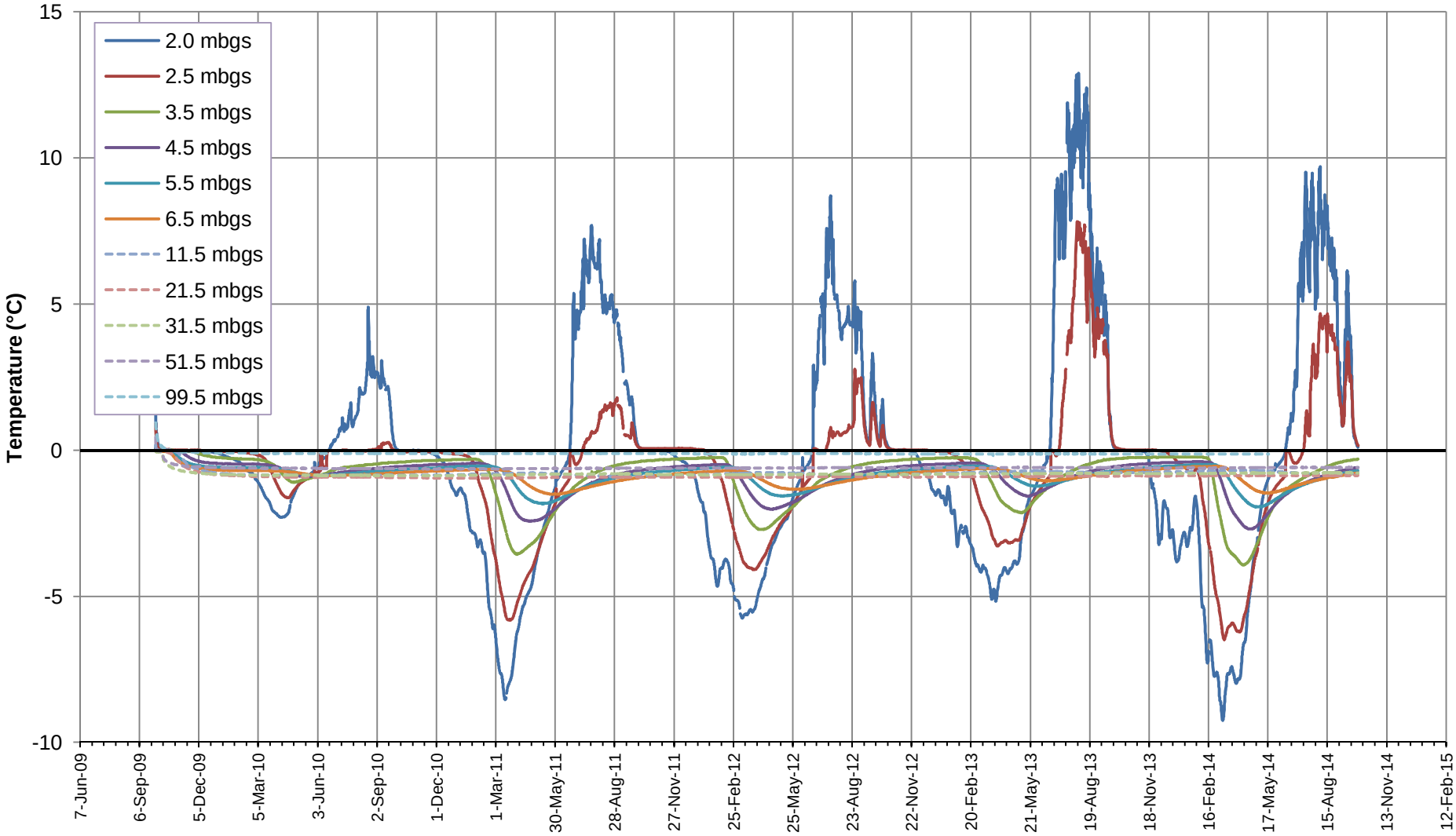
GROUND TEMPERATURE MEASUREMENTS

Appendix D1 Thermistor Temperature Data
Appendix D2 Vibrating Wire Piezometer Temperature Data

APPENDIX D1

THERMISTOR TEMPERATURE DATA

(Pages D1-1 to D1-20)



NOTES:

1. TEMPERATURE MEASUREMENTS AT 99.5 mbgs WERE RECORDED WITH A VIBRATING WIRE PIEZOMETER INSTALLED IN THE DRILLHOLE

CASINO MINING CORPORATION

CASINO PROJECT

GROUND TEMPERATURE OVER TIME CAS-034

Knight Piésold CONSULTING

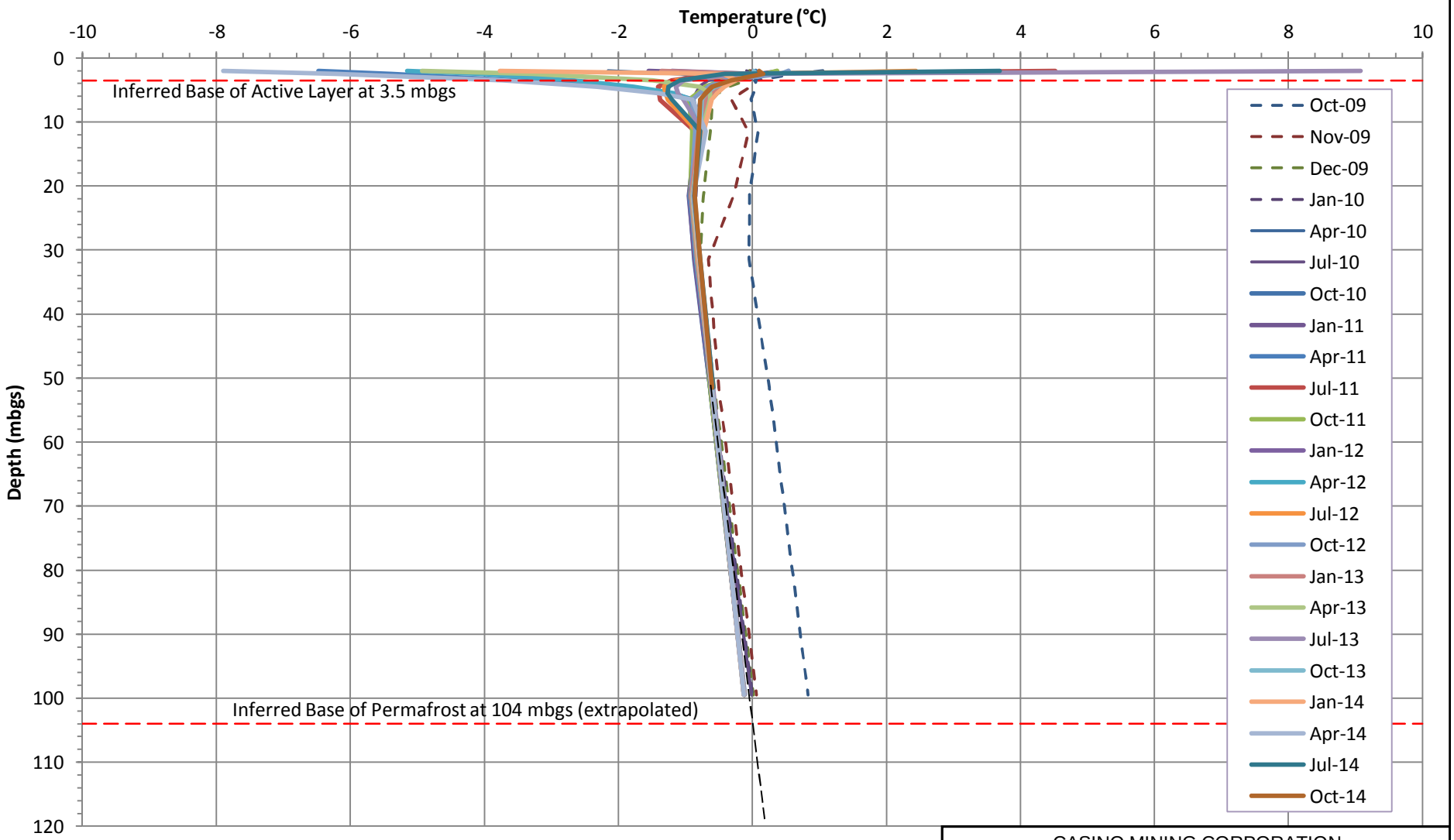
P/A NO. VA101-325/17

REF. NO. 1

FIGURE D1.1

REV 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	17DEC'14	ISSUED WITH REPORT	KTD	CAS	KJB



NOTES:

1. THERMISTORS WERE INSTALLED IN SEPTEMBER 2009. OCTOBER THROUGH DECEMBER 2009 DATA ARE INTERPRETED TO BE UNREPRESENTATIVE OF NATURAL GROUND CONDITIONS.

2. TEMPERATURE MEASUREMENTS AT 99.5 mbgs WERE RECORDED WITH A VIBRATING WIRE PIEZOMETER INSTALLED IN THE DRILL HOLE.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	17DEC'14	ISSUED WITH REPORT	KTD	CAS	KJB

CASINO MINING CORPORATION

CASINO PROJECT

GROUND TEMPERATURE WITH DEPTH AT CAS-034

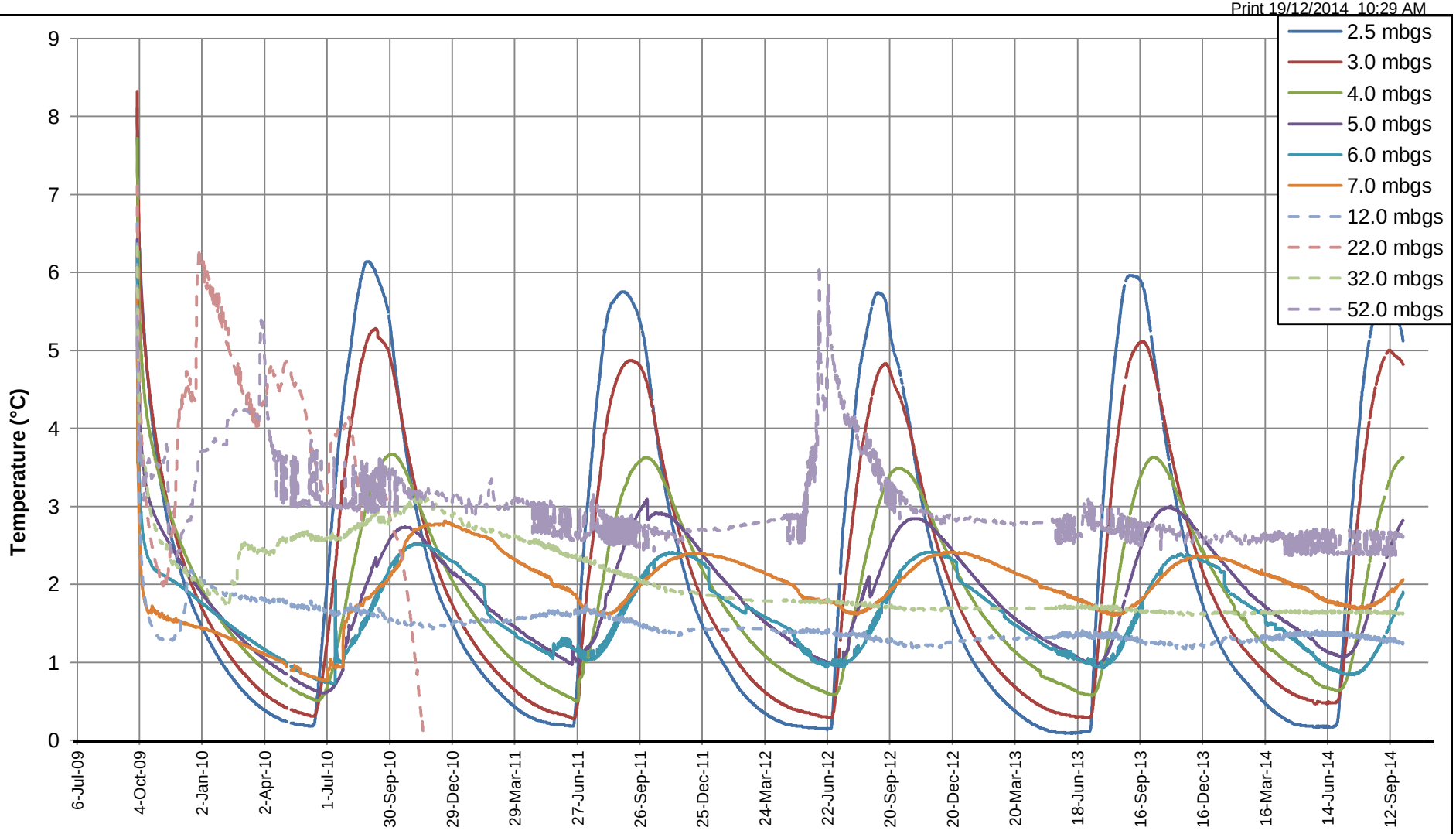
Knight Piésold CONSULTING

P/A NO. VA101-325/17

REF. NO. 1

FIGURE D1.2

REV 0



NOTES:

1. SENSOR INSTALLED AT 22 mbgs MALFUNCTIONED.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	17DEC14	ISSUED WITH REPORT	KTD	CAS	KJB

CASINO MINING CORPORATION

CASINO PROJECT

GROUND TEMPERATURE OVER TIME AT CAS-036

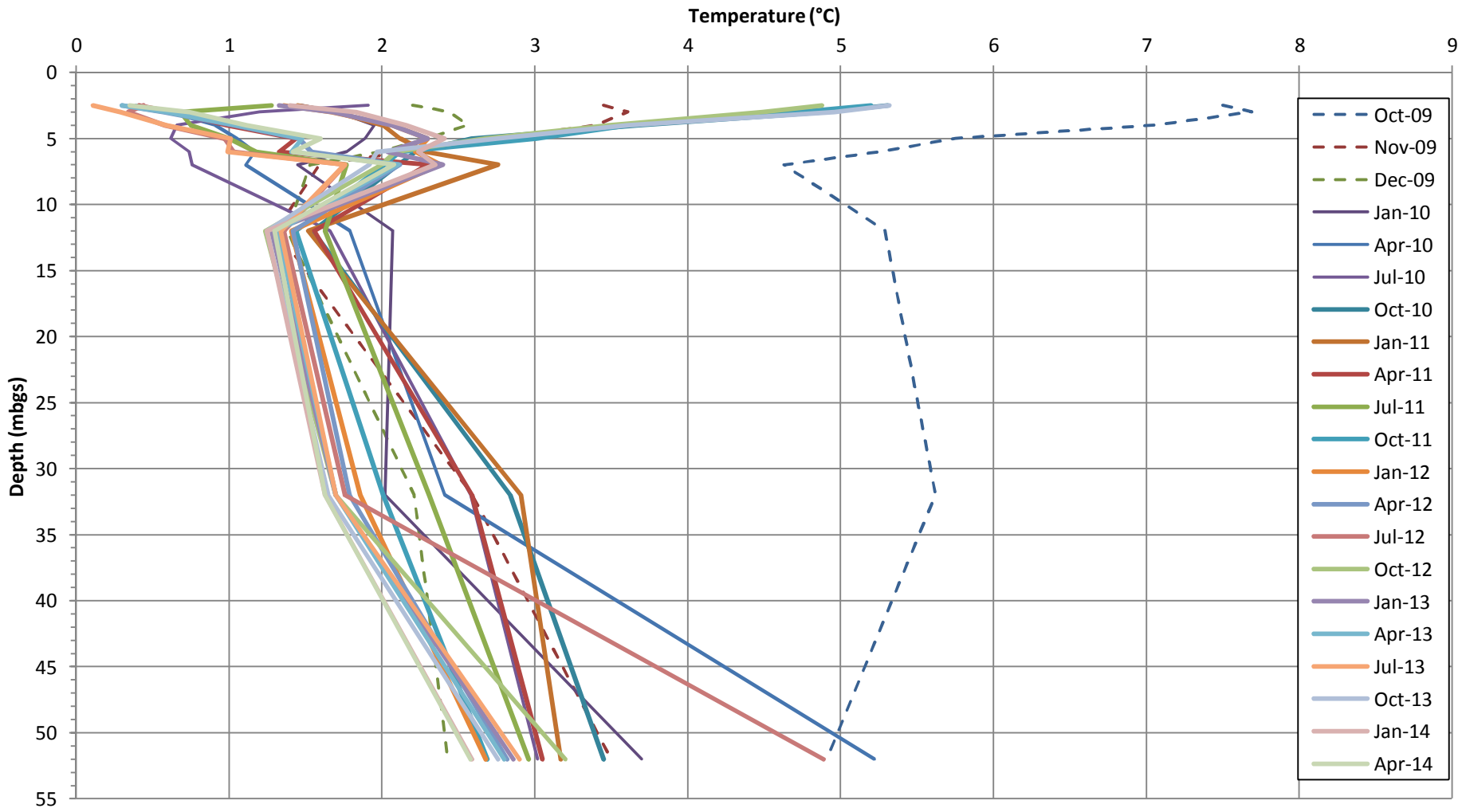
Knight Piésold CONSULTING

P/A NO. VA101-325/17

REF. NO. 1

FIGURE D1.3

REV 0



NOTES:

1. THERMISTORS WERE INSTALLED IN SEPTEMBER 2009. OCTOBER AND NOVEMBER 2009 DATA ARE INTERPRETED TO BE UNREPRESENTATIVE OF NATURAL GROUND CONDITIONS.
2. SENSOR INSTALLED AT 22 mbgs MALFUNCTIONED AND DATA IS NOT PRESENTED.

CASINO MINING CORPORATION

CASINO PROJECT

GROUND TEMPERATURE WITH DEPTH AT CAS-036

Knight Piésold CONSULTING

P/A NO. VA101-325/17

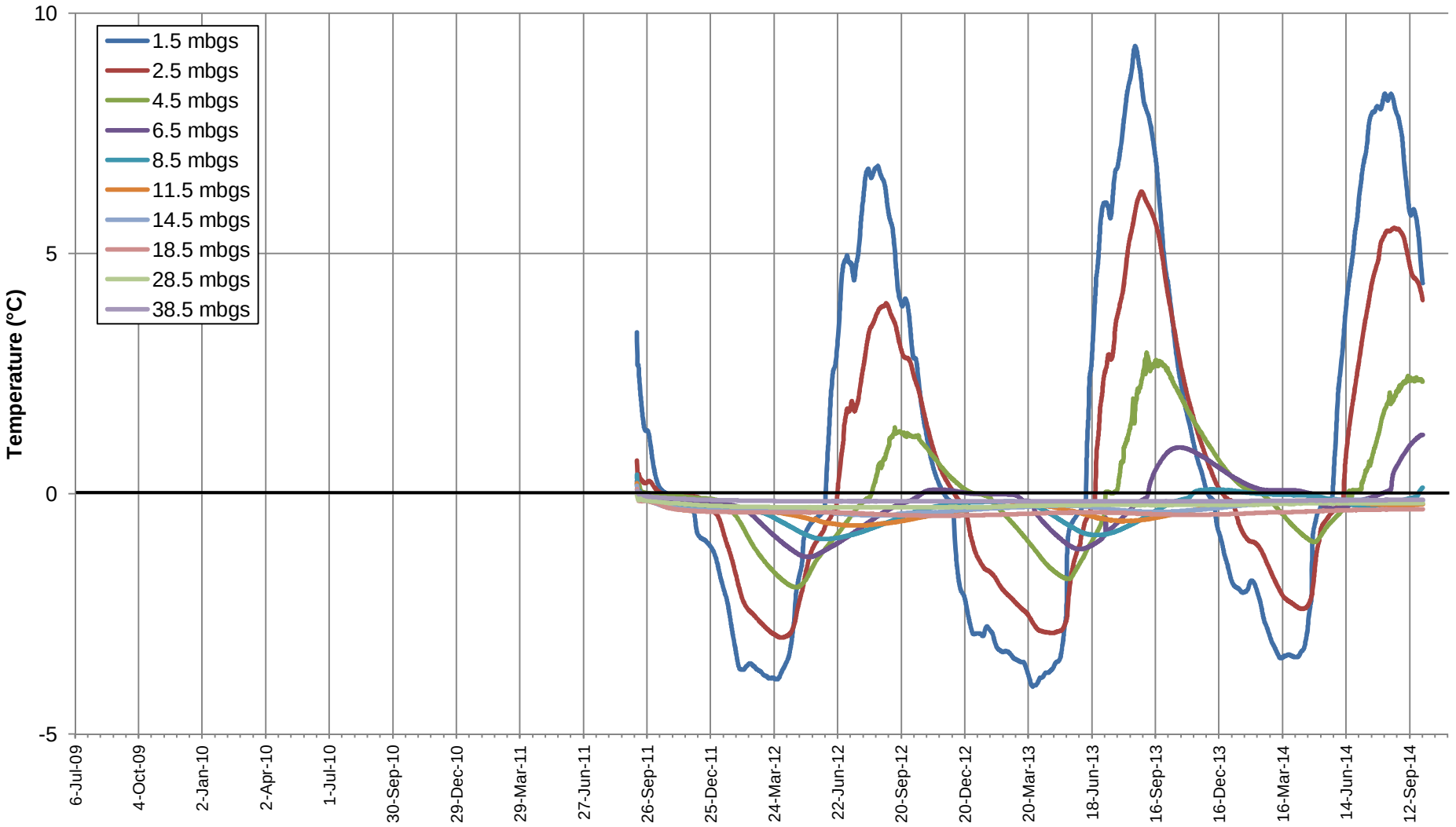
REF. NO. 1

FIGURE D1.4

REV 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	17DEC'14	ISSUED WITH REPORT	KTD	CAS	KJB

Print 19/12/2014 10:30 AM



CASINO MINING CORPORATION

CASINO PROJECT

GROUND TEMPERATURE OVER TIME AT DH11-21B

Knight Piésold CONSULTING

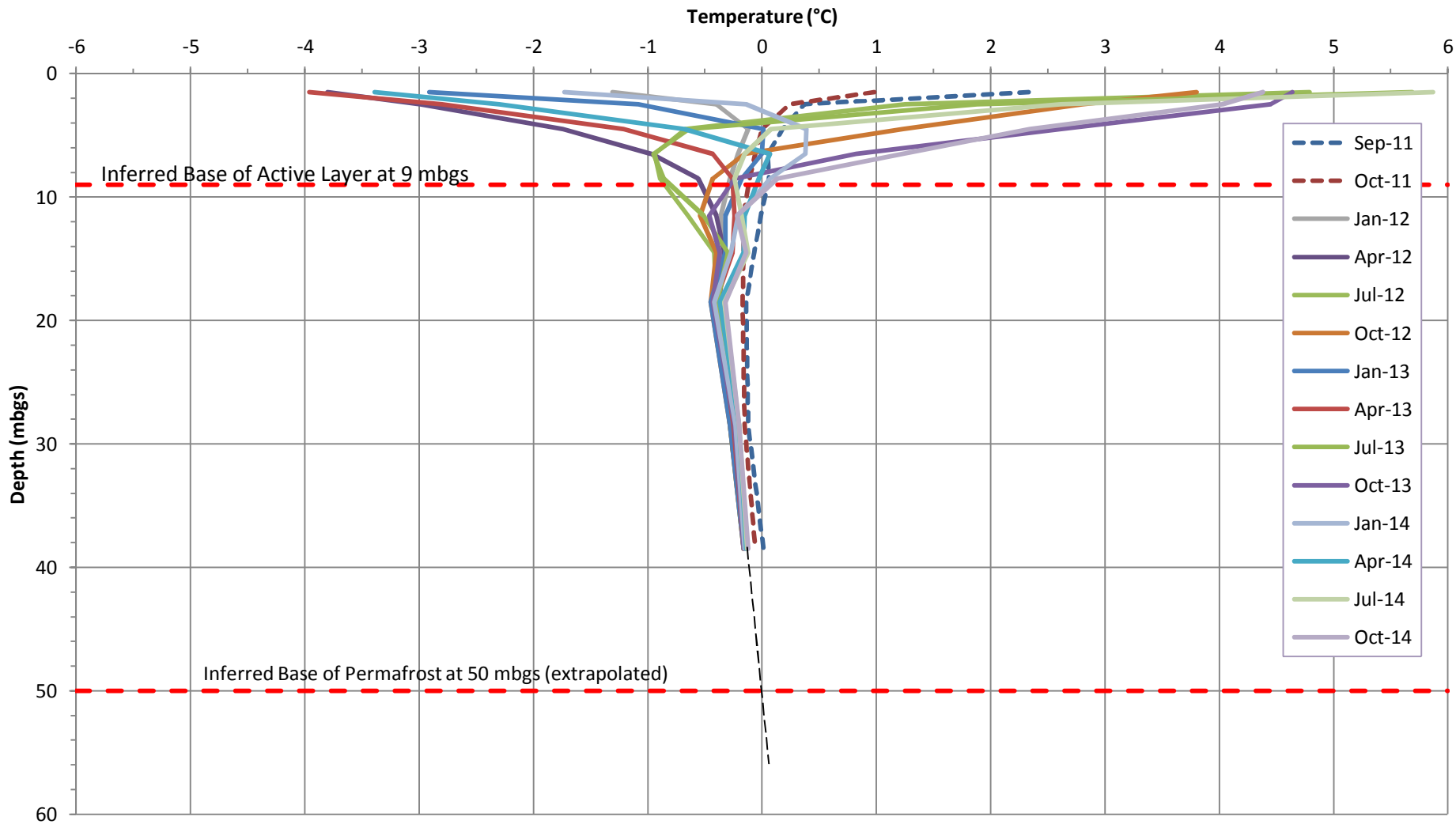
P/A NO. VA101-325/17

REF. NO. 1

FIGURE D1.5

REV 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	17DEC'14	ISSUED WITH REPORT	KTD	CAS	KJB



NOTES:

1. THERMISTORS WERE INSTALLED IN SEPTEMBER 2011. SEPTEMBER AND OCTOBER 2011 DATA ARE INTERPRETED TO BE UNREPRESENTATIVE OF NATURAL GROUND CONDITIONS.

CASINO MINING CORPORATION

CASINO PROJECT

GROUND TEMPERATURE WITH DEPTH AT DH11-21B

Knight Piésold CONSULTING

P/A NO. VA101-325/17

REF. NO. 1

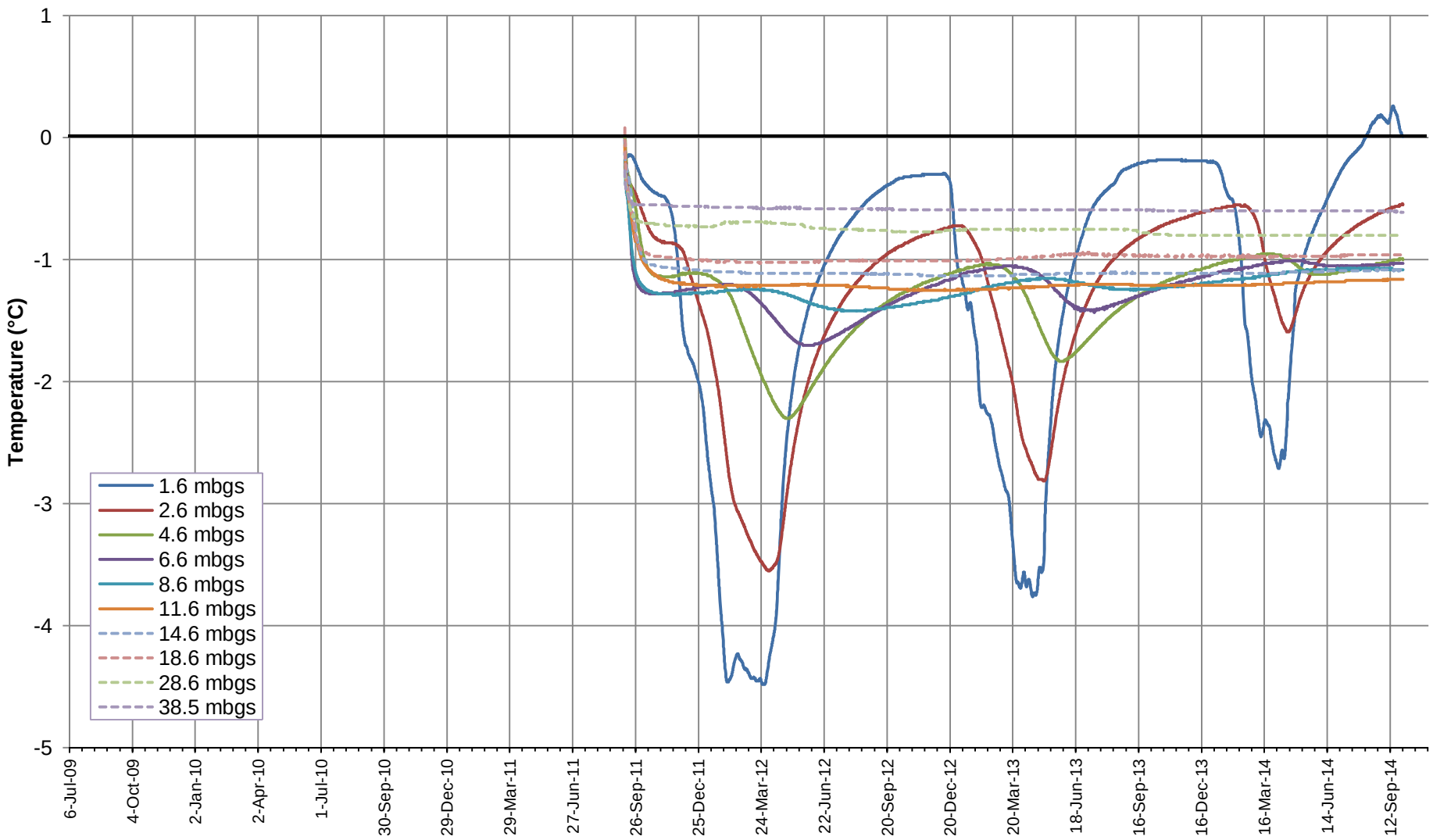
FIGURE D1.6

REV 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	17DEC'14	ISSUED WITH REPORT	KTD	CAS	KJB

M:\1\01\00325\17\A\Data\Task 200 - 2013 Hydrogeology Adendum\2- Thermistor data\[4. Ground Temperature over Time DH11-23B.xls]Figure D1.7

Print 19/12/2014 10:31 AM



CASINO MINING CORPORATION

CASINO PROJECT

GROUND TEMPERATURE OVER TIME DH11-23B

Knight Piésold CONSULTING

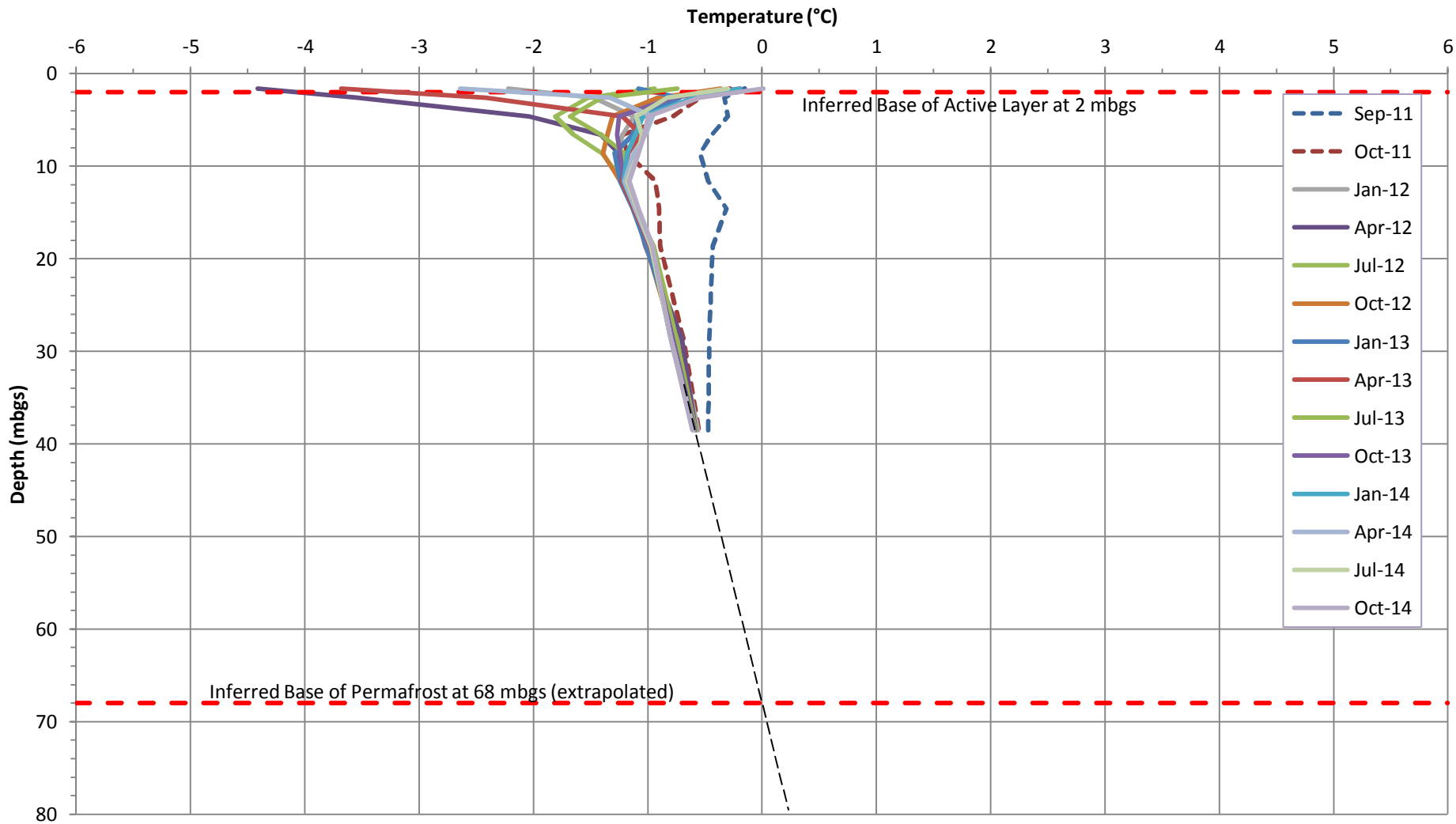
P/A NO. VA101-325/17

REF. NO. 1

FIGURE D1.7

REV 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	17DEC'14	ISSUED WITH REPORT	ktd	CAS	KJB



NOTES:

1. THERMISTORS WERE INSTALLED IN SEPTEMBER 2011. SEPTEMBER AND OCTOBER 2011 DATA ARE INTERPRETED TO BE UNREPRESENTATIVE OF NATURAL GROUND CONDITIONS.

CASINO MINING CORPORATION

CASINO PROJECT

GROUND TEMPERATURE WITH DEPTH AT DH11-23B

Knight Piésold CONSULTING

P/A NO. VA101-325/17

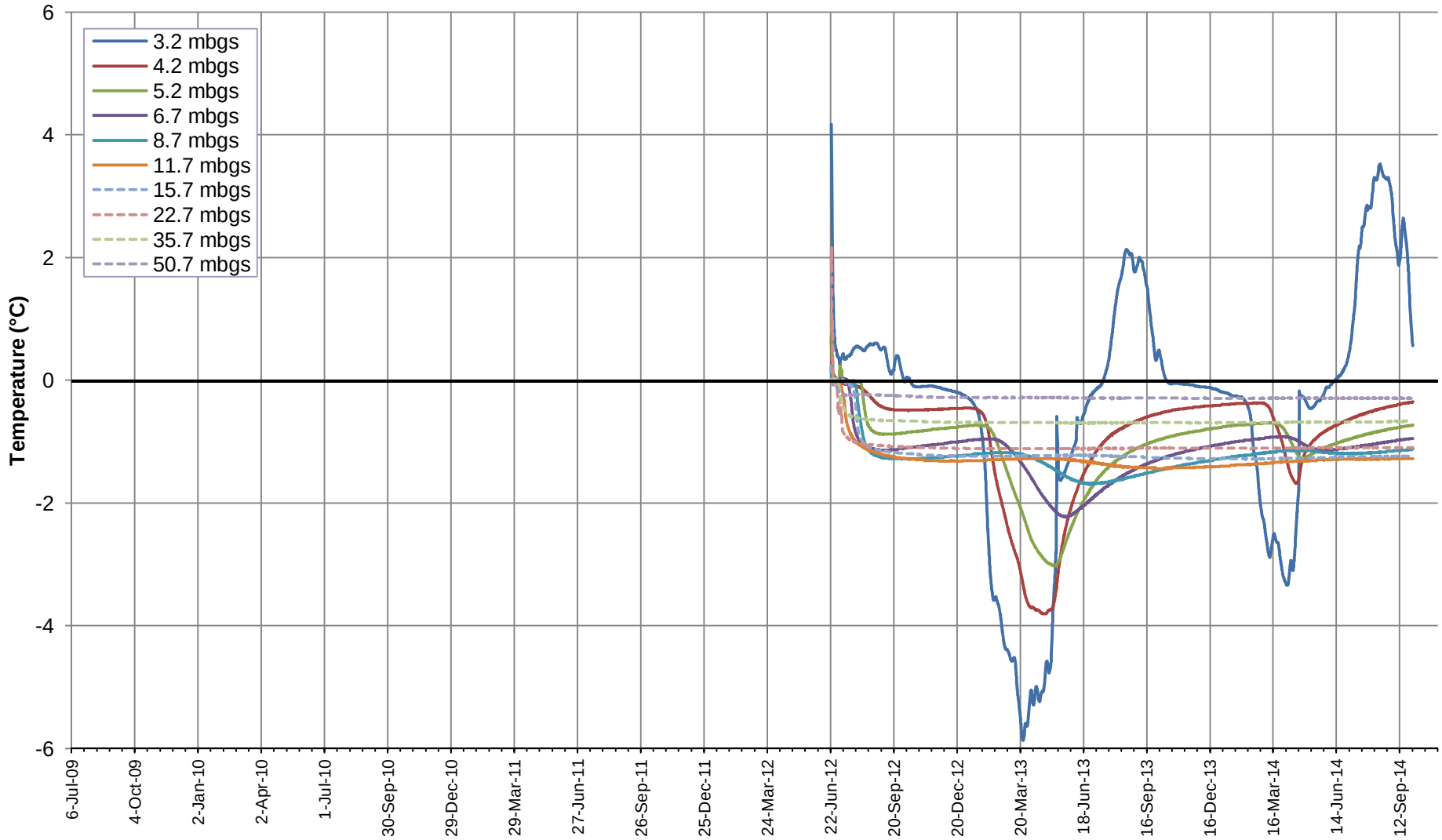
REF. NO. 1

FIGURE D1.8

REV 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	17DEC'14	ISSUED WITH REPORT	KTD	CAS	KJB

Print 06/03/2015 10:39 AM



CASINO MINING CORPORATION

CASINO PROJECT

GROUND TEMPERATURE OVER TIME DH12-01

Knight Piésold CONSULTING

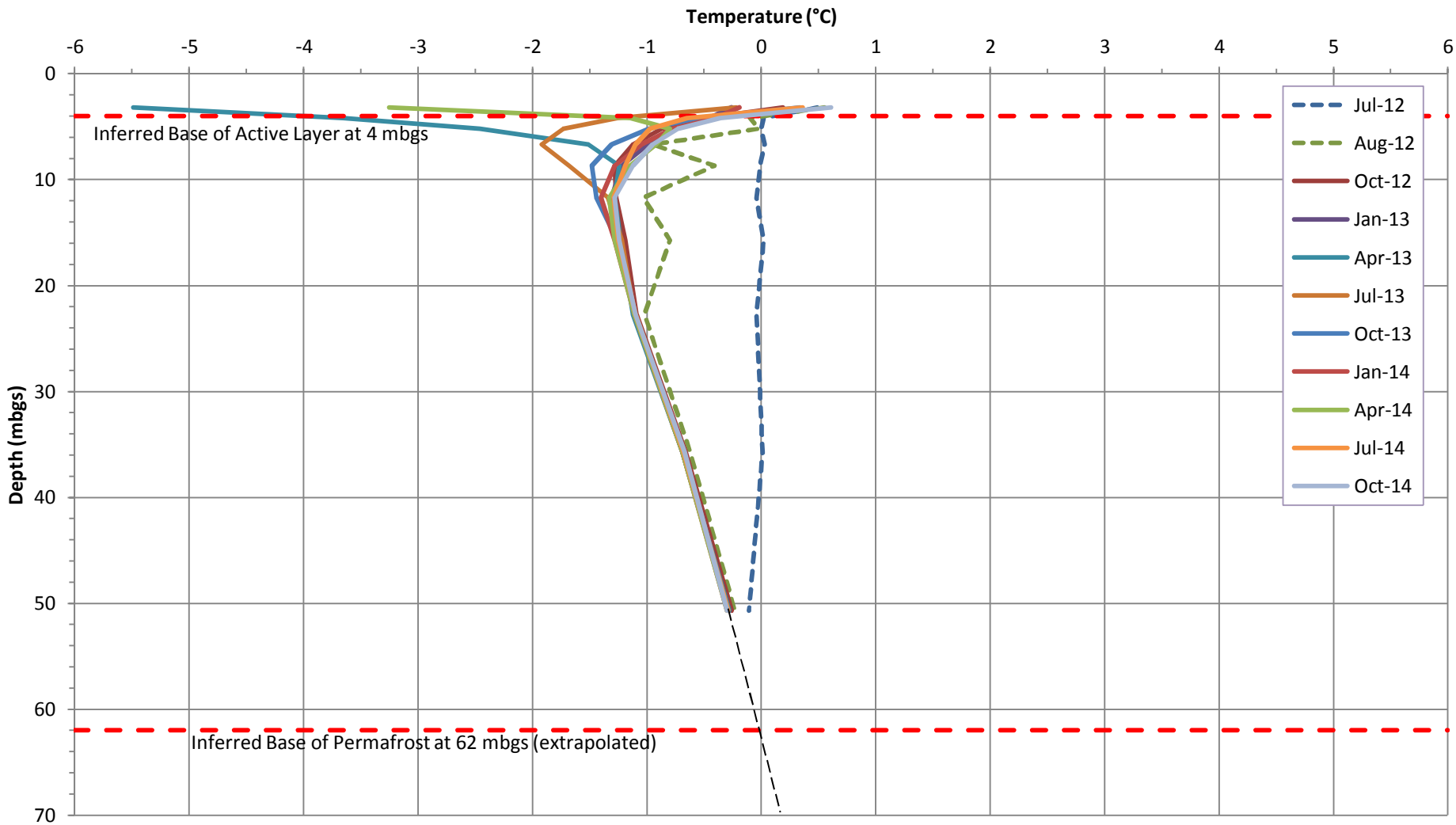
P/A NO. VA101-325/17

REF. NO. 1

FIGURE D1.9

REV 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	17DEC'14	ISSUED WITH REPORT	KTD	CAS	KJB



NOTES:

1. THERMISTORS WERE INSTALLED IN JUNE 2012. JULY AND AUGUST 2012 DATA ARE INTERPRETED TO BE UNREPRESENTATIVE OF NATURAL GROUND CONDITIONS.

CASINO MINING CORPORATION

CASINO PROJECT

GROUND TEMPERATURE WITH DEPTH AT DH12-01

Knight Piésold CONSULTING

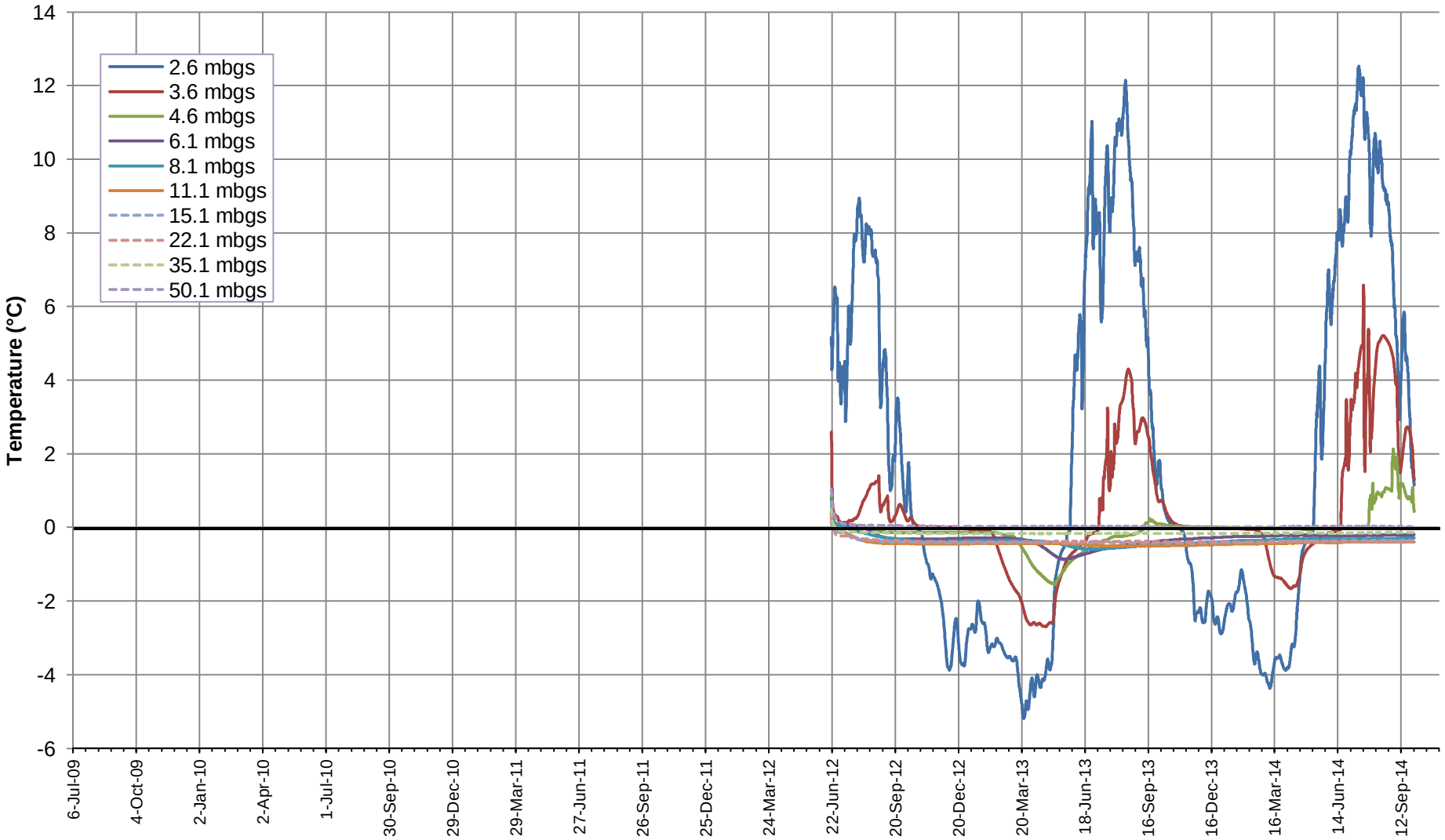
P/A NO. VA101-325/17

REF. NO. 1

FIGURE D1.10

REV 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	17DEC'14	ISSUED WITH REPORT	KTD	CAS	KJB



CASINO MINING CORPORATION

CASINO PROJECT

GROUND TEMPERATURE OVER TIME DH12-02

Knight Piésold CONSULTING

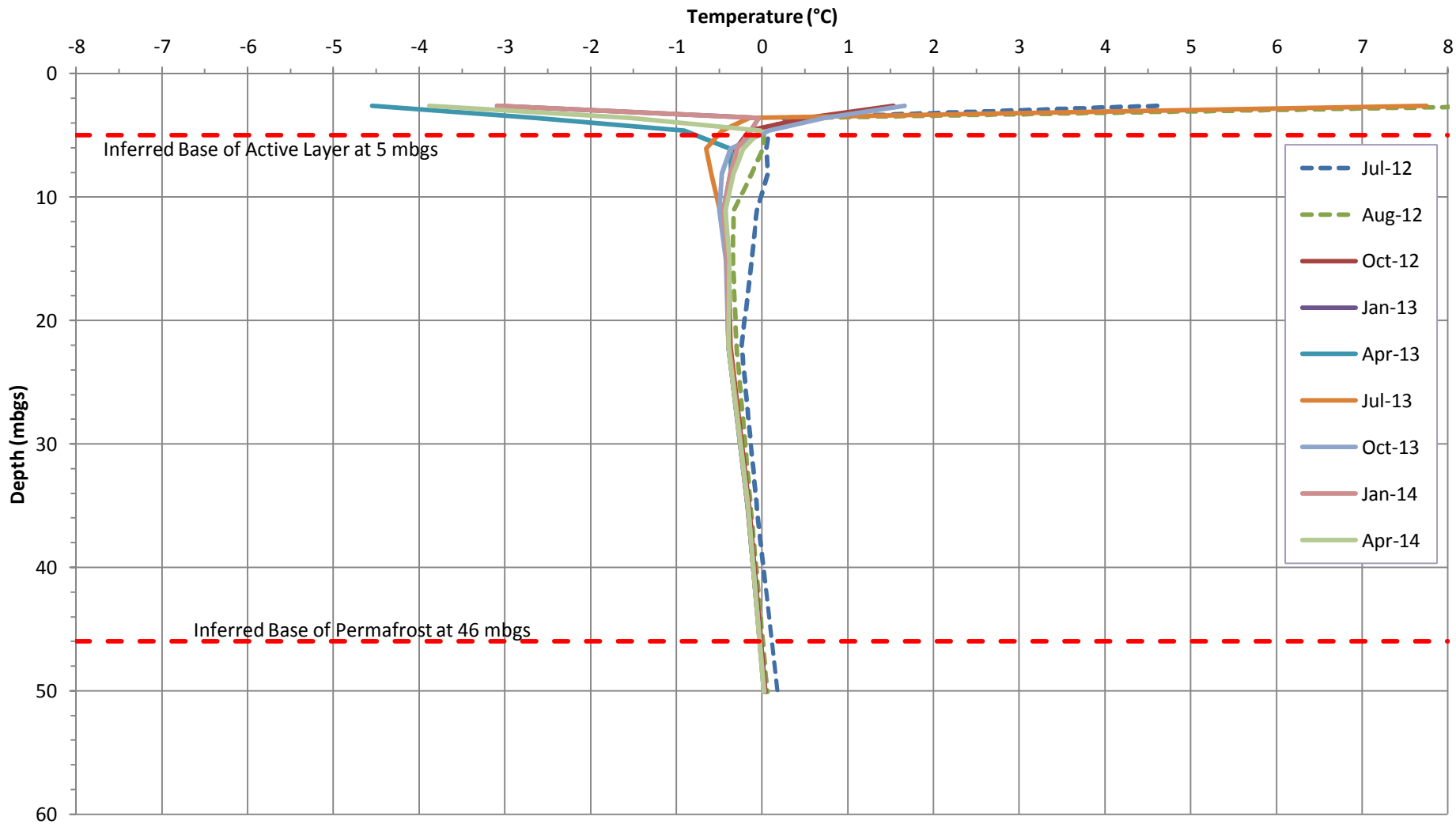
P/A NO. VA101-325/17

REF. NO. 1

FIGURE D1.11

REV 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	17DEC'14	ISSUED WITH REPORT	KTD	CAS	KJB



NOTES:

1. THERMISTORS WERE INSTALLED IN JUNE 2012. JULY AND AUGUST 2012 DATA ARE INTERPRETED TO BE UNREPRESENTATIVE OF NATURAL GROUND CONDITIONS.

CASINO MINING CORPORATION

CASINO PROJECT

GROUND TEMPERATURE WITH DEPTH AT DH12-02

Knight Piésold CONSULTING

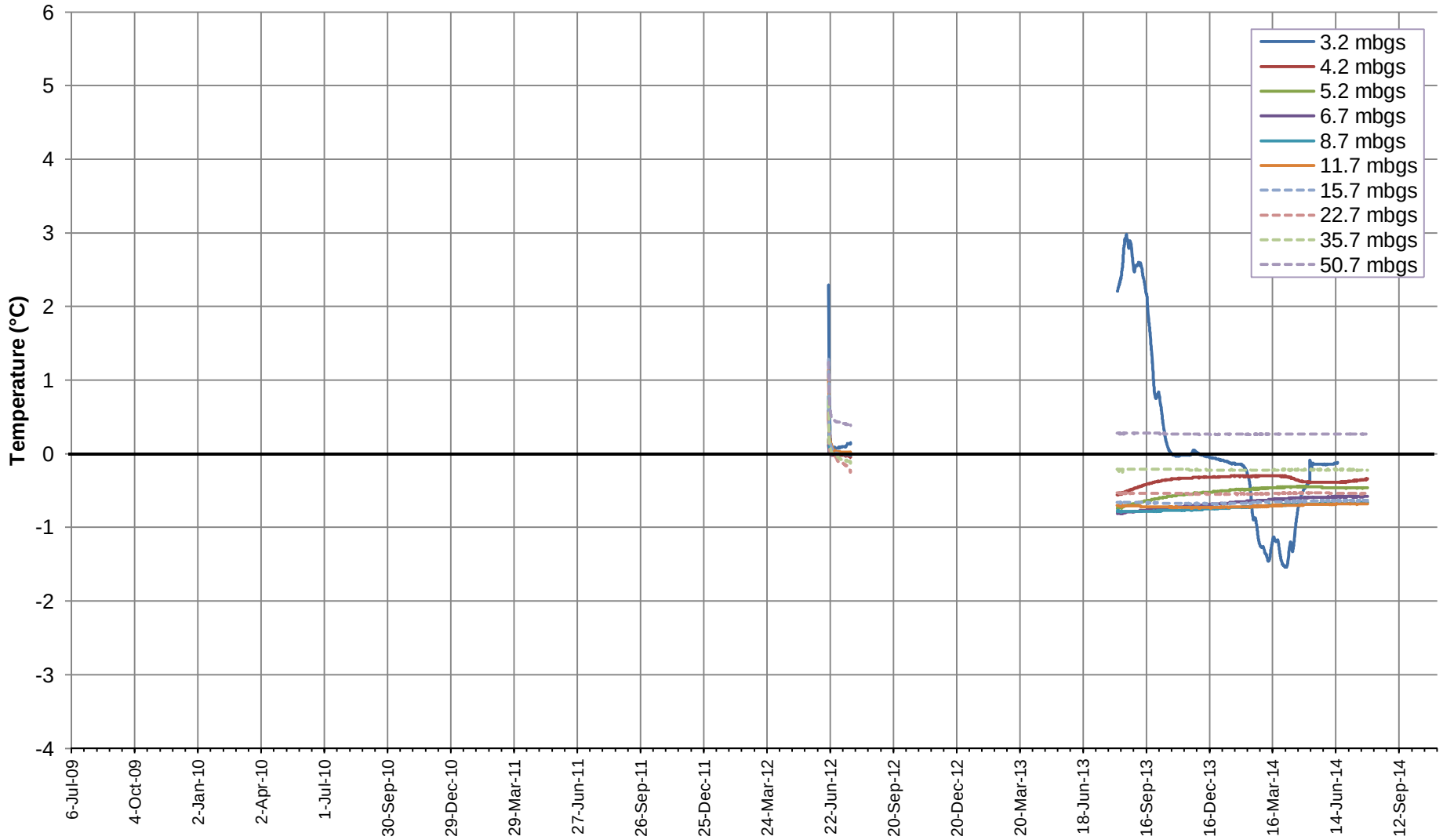
P/A NO. VA101-325/17

REF. NO. 1

FIGURE D1.12

REV 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	17DEC'14	ISSUED WITH REPORT	KTD	CAS	KJB



NOTES:

1. DATA LOGGER NON-FUNCTIONAL FROM JULY 23, 2012 TO AUGUST 6, 2014.

CASINO MINING CORPORATION

CASINO PROJECT

GROUND TEMPERATURE OVER TIME DH12-03

Knight Piésold CONSULTING

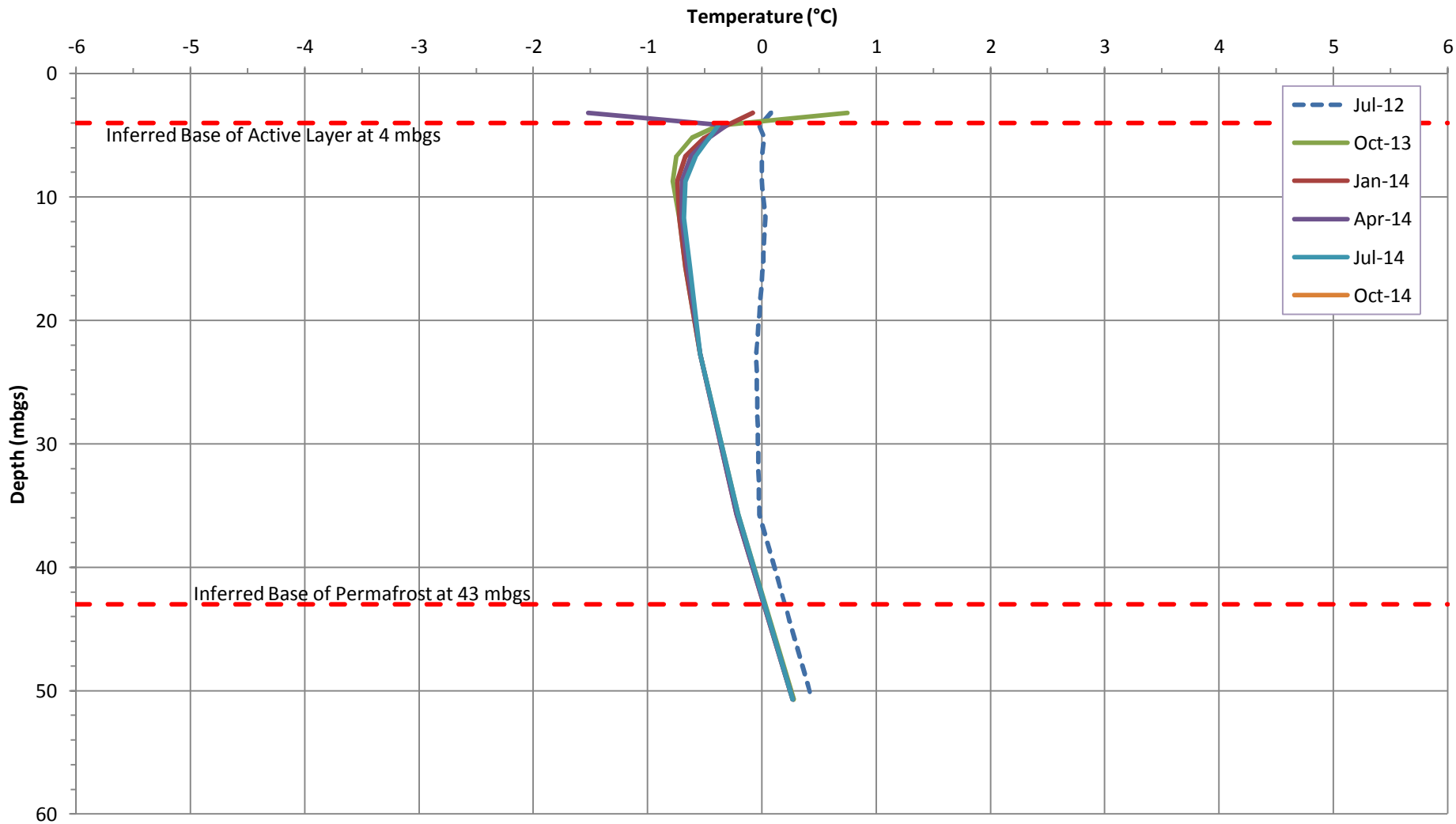
P/A NO. VA101-325/17

REF. NO. 1

FIGURE D1.13

REV 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	17DEC'14	ISSUED WITH REPORT	KTD	CAS	KJB



NOTES:

1. THERMISTORS WERE INSTALLED IN JUNE 2012. JULY 2012 DATA IS INTERPRETED TO BE UNREPRESENTATIVE OF NATURAL GROUND CONDITIONS.
2. DATA UNAVAILABLE FROM JULY 2012 TO AUGUST 2013 DUE TO DATA LOGGER MALFUNCTION.

CASINO MINING CORPORATION

CASINO PROJECT

GROUND TEMPERATURE WITH DEPTH AT DH12-03

Knight Piésold CONSULTING

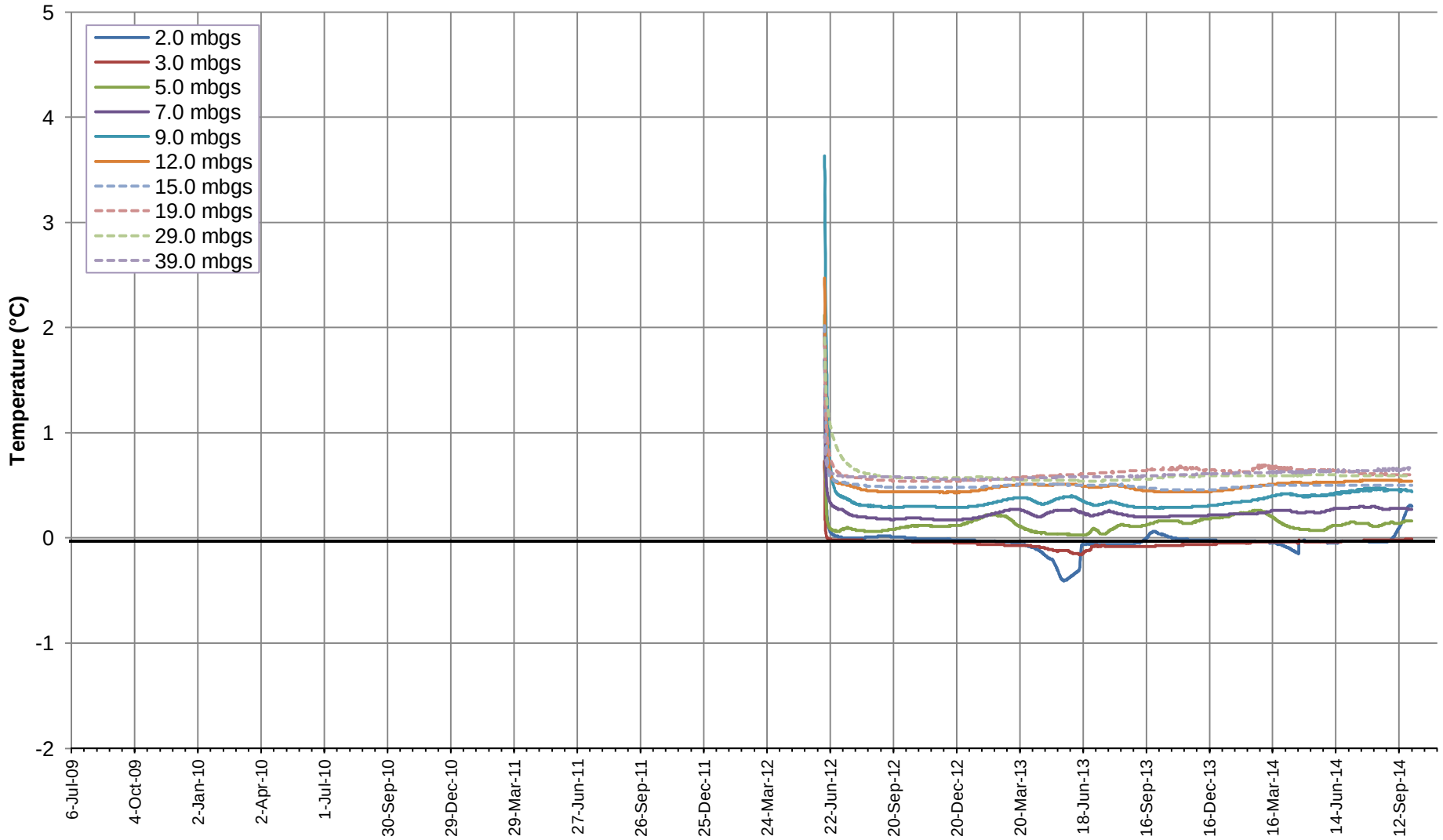
P/A NO. VA101-325/17

REF. NO. 1

FIGURE D1.14

REV 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	17DEC'14	ISSUED WITH REPORT	KTD	CAS	KJB



CASINO MINING CORPORATION

CASINO PROJECT

GROUND TEMPERATURE OVER TIME DH12-05

Knight Piésold CONSULTING

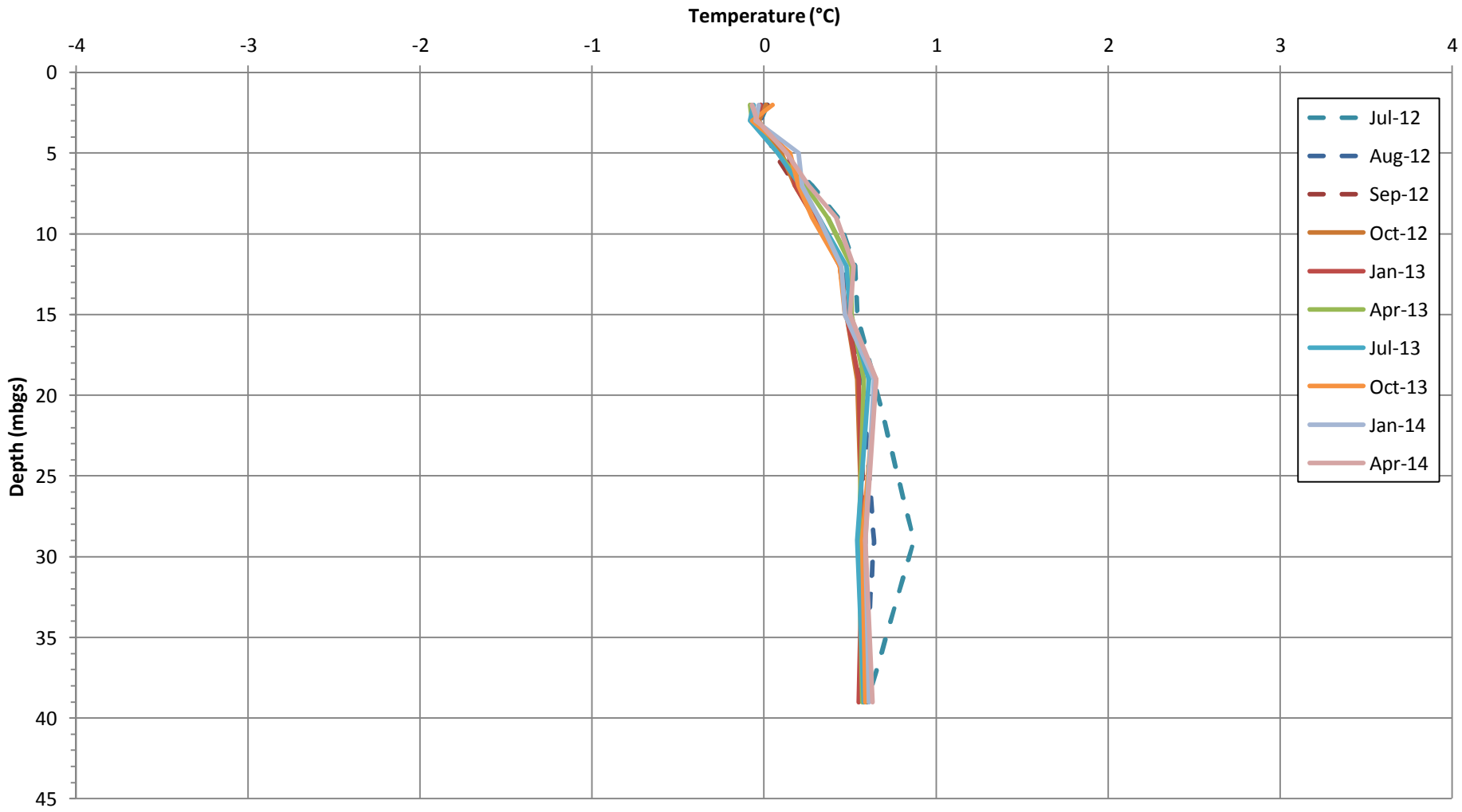
P/A NO. VA101-325/17

REF. NO. 1

FIGURE D1.15

REV 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	17DEC'14	ISSUED WITH REPORT	KTD	CAS	KJB



NOTES:

1. THERMISTORS WERE INSTALLED IN JUNE 2012. JULY, AUGUST AND SEPTEMBER 2012 DATA ARE INTERPRETED TO BE UNREPRESENTATIVE OF NATURAL GROUND CONDITIONS.

CASINO MINING CORPORATION

CASINO PROJECT

GROUND TEMPERATURE WITH DEPTH AT DH12-05

Knight Piésold CONSULTING

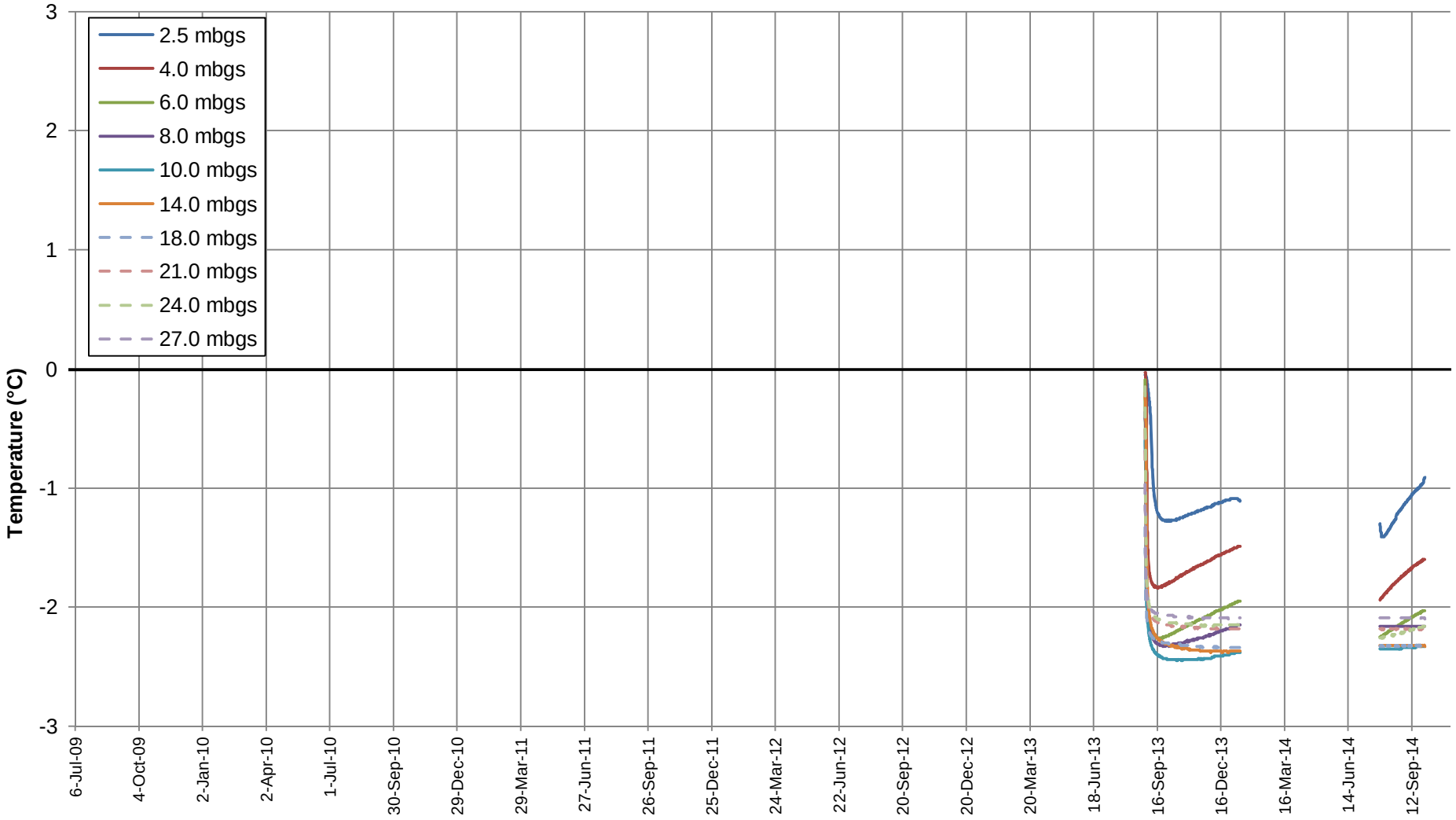
P/A NO. VA101-325/17

REF. NO. 1

FIGURE D1.16

REV 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	17DEC'14	ISSUED WITH REPORT	KTD	CAS	KJB



NOTES:

1. CABLE DAMAGED ON JANUARY 13, 2014 AND RESPLICED ON JULY 29, 2014.

CASINO MINING CORPORATION

CASINO PROJECT

GROUND TEMPERATURE OVER TIME AT DH13-03

Knight Piésold CONSULTING

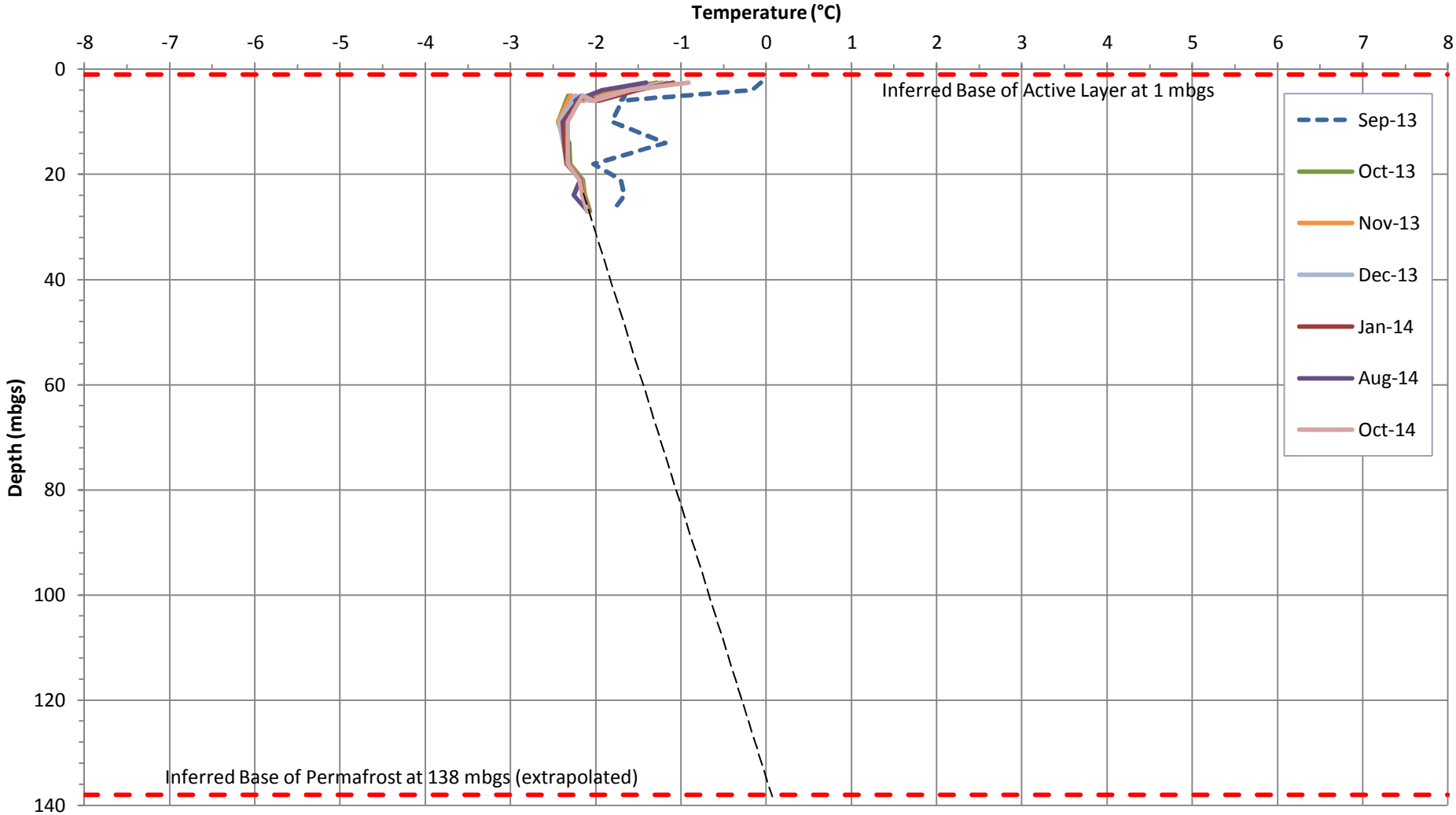
P/A NO. VA101-325/17

REF. NO. 1

FIGURE D1.17

REV 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	17DEC"14	ISSUED WITH REPORT	KTD	CAS	KJB



NOTES:

1. THERMISTORS WERE INSTALLED IN AUGUST 2013. SEPTEMBER 2013 DATA ARE INTERPRETED TO BE UNREPRESENTATIVE OF NATURAL GROUND CONDITIONS.
2. DATA LOGGER CABLE DAMAGED IN JANUARY 2014 AND RESPLICED IN JULY 2014.

CASINO MINING CORPORATION

CASINO PROJECT

GROUND TEMPERATURE WITH DEPTH AT DH13-03

Knight Piésold CONSULTING

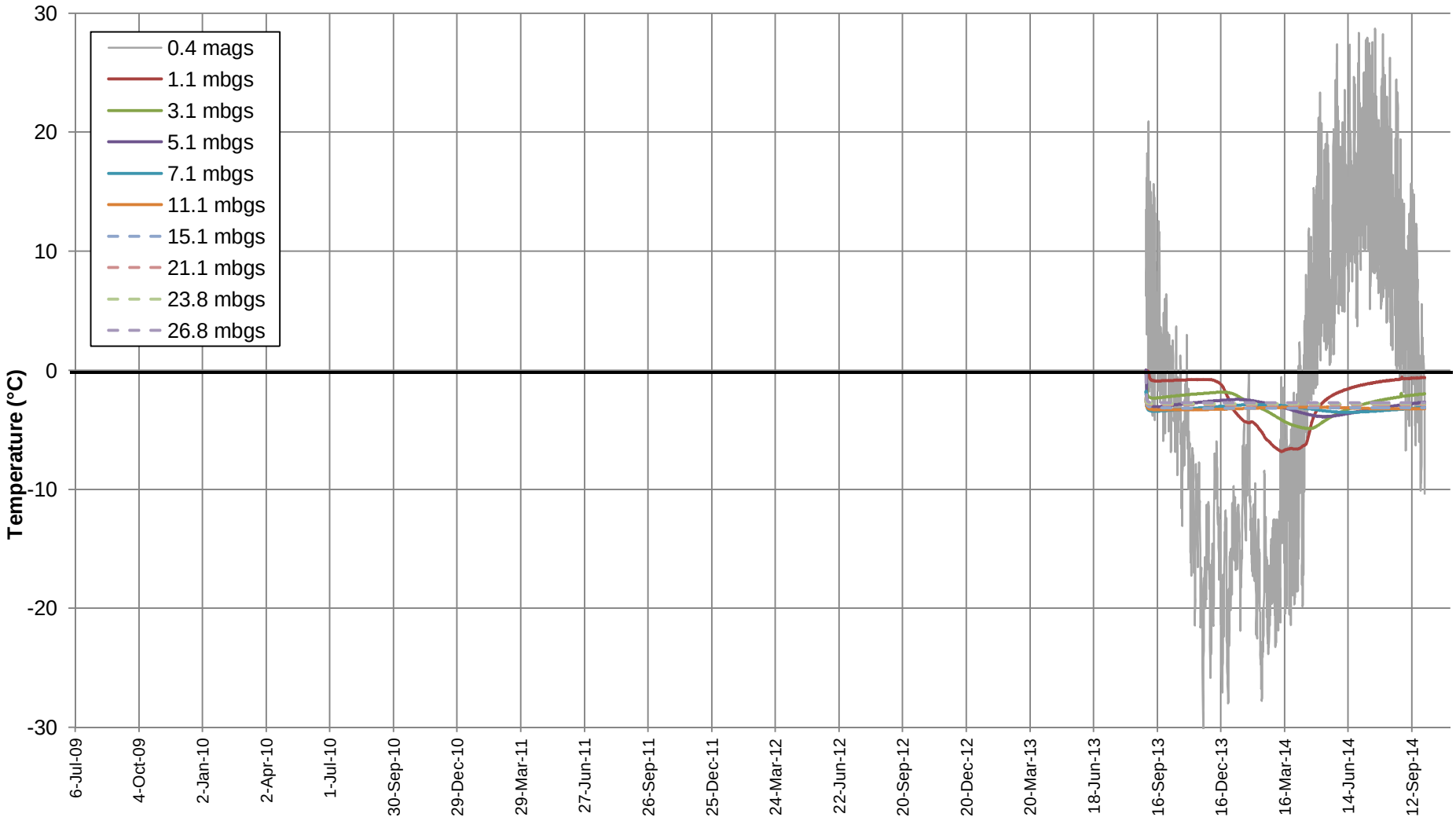
P/A NO. VA101-325/17

REF. NO. 1

FIGURE D1.18

REV 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	17DEC'14	ISSUED WITH REPORT	KTD	CAS	KJB



NOTES:

1. THERMISTOR #1 IS INSTALLED AT 0.4m ABOVE GROUND SURFACE AND IS RECORDING AMBIENT TEMPERATURE.

CASINO MINING CORPORATION

CASINO PROJECT

GROUND TEMPERATURE OVER TIME AT DH13-04

Knight Piésold CONSULTING

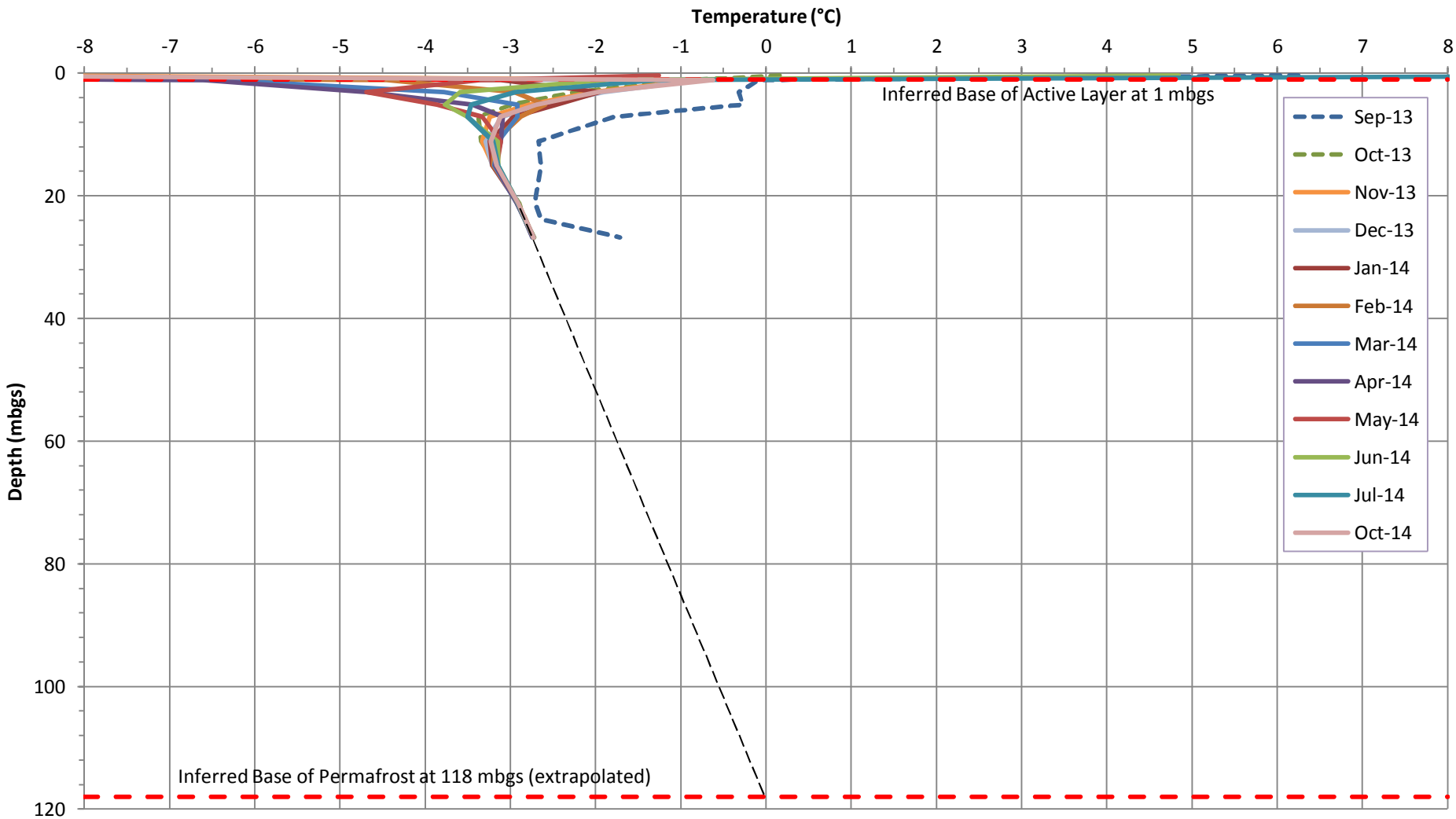
P/A NO. VA101-325/17

REF. NO. 1

FIGURE D1.19

REV 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	17DEC'14	ISSUED WITH REPORT	KTD	CAS	KJB



NOTES:

1. THERMISTORS WERE INSTALLED IN AUGUST 2013. SEPTEMBER AND OCTOBER 2013 DATA ARE INTERPRETED TO BE UNREPRESENTATIVE OF NATURAL GROUND CONDITIONS.

CASINO MINING CORPORATION

CASINO PROJECT

GROUND TEMPERATURE WITH DEPTH AT DH13-04

Knight Piésold CONSULTING

P/A NO. VA101-325/17

REF. NO. 1

FIGURE D1.20

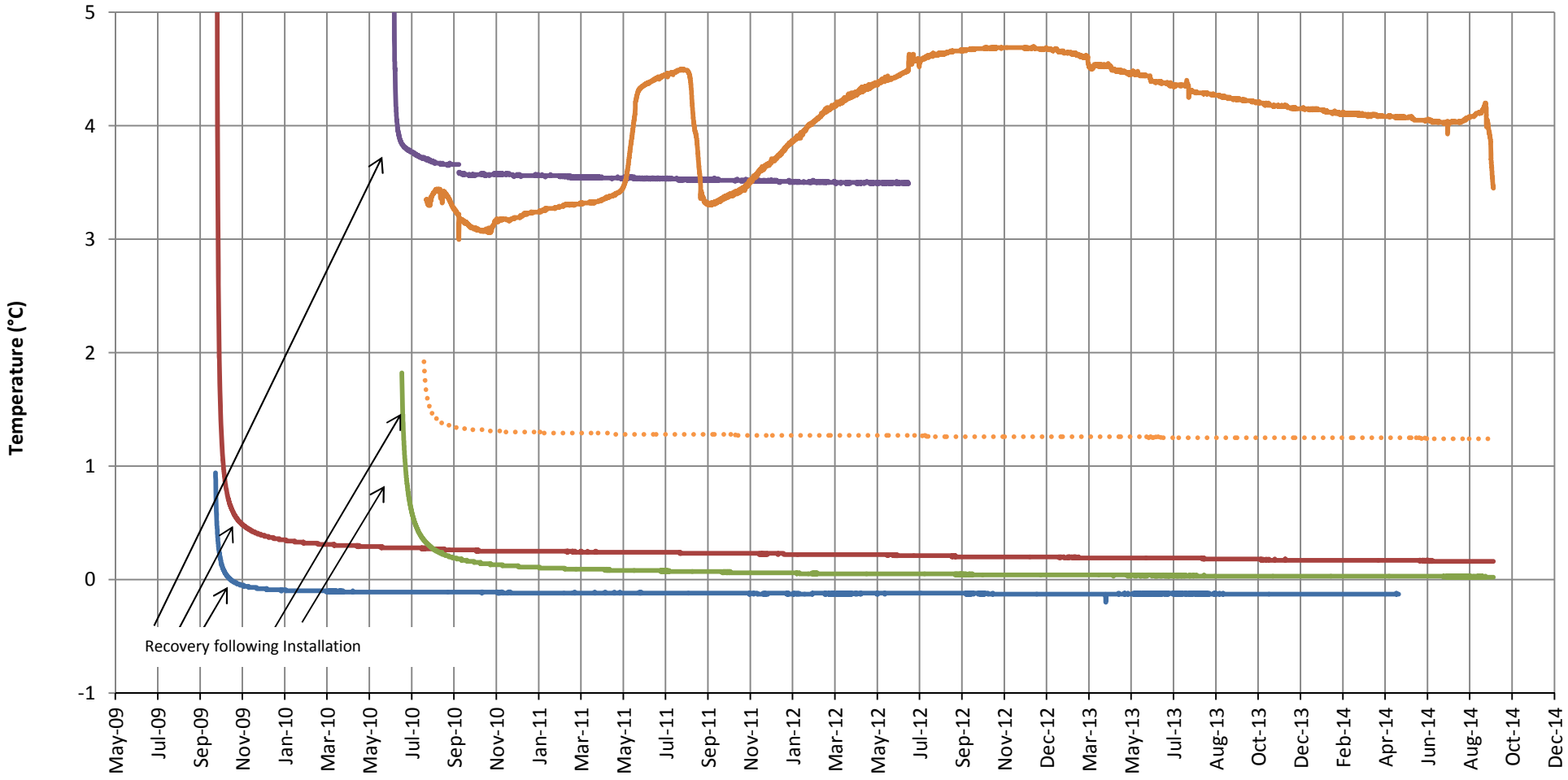
REV 0

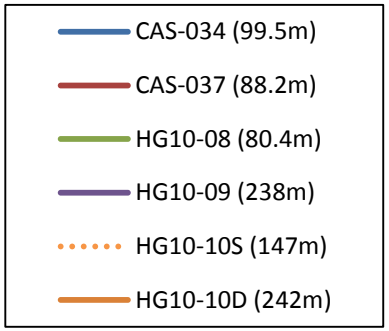
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	17DEC'14	ISSUED WITH REPORT	KTD	CAS	KJB

APPENDIX D2

VIBRATING WIRE PIEZOMETER TEMPERATURE DATA

(Figure D2)





NOTES:

1. DEPTH OF INSTALLATION IS SHOWN IN LEGEND BESIDE PIEZOMETER NAME.
2. HG10-09 HAS NOT BEEN DOWNLOADED SINCE 2012.
3. CAS-034 WAS LAST DOWNLOADED IN MAY 2014.
4. THE TEMPERATURE SENSOR IN HG10-10D IS SUSPECTED TO BE FAULTY.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	17DEC'14	ISSUED WITH REPORT	KTD	CAS	KJB

CASINO MINING CORPORATION

CASINO PROJECT

VIBRATING WIRE PIEZOMETERS
GROUND TEMPERATURE

Knight Piésold CONSULTING

P/A NO. VA101-325/17

REF. NO. 1

FIGURE D2

REV 0

APPENDIX E

GROUNDWATER QUALITY – QUALITY ASSURANCE/QUALITY CONTROL

(Pages E-1 to E-16)

APPENDIX E – 2013 QUALITY ASSURANCE AND QUALITY CONTROL ANALYSIS

1 – OVERVIEW

The quality assurance and quality control (QA/QC) analysis within Appendix F includes review of data collected from June 2013 onwards. This appendix builds on the previous QA/QC reports generated for earlier data (Table E.1). As stated in the 2012 Baseline Hydrogeology Report (KP Ref. No. VA101-325/14-4), groundwater samples have been collected by various consultants and sub-consultants since the program began in 1993 and sampling methods have not been clearly documented. This report will detail the methods used to collect sample data from June 2013 onwards.

The quality of the data obtained for a project is assessed via adherence to a set of pre-defined data quality objectives (DQOs) for the project. DQOs provide a means of assessing whether the data in question are precise, accurate, representative, and complete. This 2013 QA/QC analysis covers three areas of operations: field data collection, laboratory analysis and office data management.

The results from QA/QC samples are reviewed to determine if sample contamination occurred. The data for any contaminated samples are then reviewed to determine if the contamination occurred during collection, handling, storage, shipping, or analysis.

The QA/QC Protocol and DQOs were compiled with reference to the following Canadian guidance documents:

- Guidance Document for the Sampling and Analysis of Metal Mining Effluents (Environment Canada, 2011).
- Canadian Council of Ministers of the Environment (CCME) Protocols Manual for Water Quality Sampling in Canada (CCME, 2011). This document is based on the Alberta and British Columbia sampling manuals (Alberta Environment, 2006; BC MWLAP, 2003).

Procedures for each area of operations are summarized in Section 2 and are described in detail within the internal manuals and during staff training to ensure the proper collection, analysis, and management of data that will meet the DQOs. A summary of the results obtained during the QA/QC analysis are provided in Section 3.

Table E.1 Historic Quality Assurance and Quality Control Reports

Data Range	Primary Consultant	Location of QA/QC Analysis
June 2012 – Current	Knight Piésold	Current Appendix
2011- June 2012	Knight Piésold	Appendix F1: 2012 Baseline Hydrogeology Report (KP Report VA101-325/14-4 Rev 1)
1993-2011	AECOM	Appendix G1: 2012 Baseline Hydrogeology Report (KP Report VA101-325/14-4 Rev 1)

2 – PROCEDURES

2.1 FIELD DATA COLLECTION QA/QC PROCEDURES

2.1.1 Equipment

Field water quality meters (YSI6820 or YSI6920) for measuring *in situ* parameters are rented from Pine Environmental, where they are maintained and calibrated between water sampling events. Each YSI is calibrated daily for dissolved oxygen and, in cases where water quality sampling events take more than two days, each YSI is recalibrated every three days for other *in situ* parameters using standard solutions specific to each parameter (i.e. pH, turbidity, conductivity, and ORP). The YSI is recalibrated more often if parameter readings are suspect (ex. pH values that are inconsistent with the rest of the data for a given monitoring well).

All equipment used in water quality sampling is rinsed or cleaned with a shop towel between sites. Each YSI is rinsed with distilled water or well water between sites for the collection of surface water samples. The YSI is stored overnight in a sheltered environment. Equipment used for processing samples (i.e gloves, filters, and syringes) is disposable and new packaged equipment is used at each site.

2.1.2 Field Procedures

Specific work instructions were provided in KP sampling manuals, which were based on the CCME Protocols Manual for Water Quality Sampling in Canada (CCME, 2011), as well as office presentations, and on-the-job training. All staff engaged in this work were required to read the sampling manuals prior to conducting any water or sediment quality work on-site. Staff were also required to work with more experienced personnel during their first site visit.

Field notes and *in situ* data were recorded on waterproof paper. At the end of each day, field personnel checked their field notes and sample labels to ensure that no samples were missing and that notes were complete. The laboratories provided protocols for sample labelling, preservation, and shipment. Bottles and preservatives were shipped with labels, chain of custody (COC) forms, and specific instructions. Water quality samples were labelled with their actual site name rather than an identification code since the samples are re-labelled by the lab prior to analysis.

2.1.3 QA/QC Samples

The repeatability and reliability of sample results was evaluated by submitting duplicate water samples, field blanks, and travel blanks for the same parameters for which the primary samples are analyzed. This allows for the detection and reduction of errors that may occur due to contamination of samples. The QA/QC samples conformed to standard sampling methods, outlined by the CCME and were labelled as QA/QC samples because the laboratory adds their own labels upon sample receipt (CCME, 2011). Details regarding each type of QA/QC sample are outlined below:

Duplicate Samples - The purpose of a duplicate sample is to estimate sampling and laboratory analytical precision. At least one duplicate sample is collected for every sampling event and the total number of duplicate samples is maintained at least 10% of the total number of samples. Duplicate samples are the same as their primary sample in collection and handling and are collected at the same time or a few minutes apart from their primary sample.

Field Blank Sample - The purpose of a field blank is to identify potential sources of contamination with preservatives, field filtration, sample handling or transportation, as well as any potential contamination from analytical procedures. Field blanks were prepared from distilled/deionized water provided by the laboratory. The distilled/deionized water was added to sample bottles using the same field techniques as other samples, including field filtration and field preservation. The DDW is filtered and preserved using the same methods as for sampling site groundwater.

Travel Blank Sample - The purpose of a travel blank is to identify potential sources of contamination associated with sample containers, shipping, storage, and analysis. These samples are prepared by the laboratory with distilled/deionized water and are never opened. Travel blanks travel with the sample bottles sent from the laboratory to the field site, and back to the laboratory.

2.2 EXTERNAL LABORATORY ANALYSIS QA/QC PROCEDURES

ALS Environmental (ALS) was retained for the analysis of the samples collected from the project site. ALS is an accredited laboratory for water quality analysis with rigorous internal QA/QC procedures. In the event of a failed internal QA/QC test, both laboratories re-run all analyses affected by the same factors as the failed internal QA/QC sample.

Sample integrity issues are highlighted on the sample receipt confirmation (SRC) reports that were provided to Knight Piésold Ltd. in a timely manner following receipt of samples at the laboratory. Where sample integrity issues were identified, the laboratories and Knight Piésold Ltd. followed up to provide corrective actions or clarity.

2.3 OFFICE DATA MANAGEMENT QA/QC PROCEDURES

The FULCRUM data management system is used to organize and store data received from ALS laboratories. In FULCRUM, data are transferred electronically into the database through the use of electronic data files.

Upon receipt of laboratory results, several data validation checks are conducted and any QA/QC issues are recorded in a tracking document. If the QA/QC results do not meet the DQOs, results associated with the QA/QC samples in question are flagged and further inspected. If the issue with the QA/QC sample is determined to potentially affect the validity of the sample results associated with it, data are rejected. Rejected results are not used in the statistical analysis of the data, but are presented in Appendix B with the rest of the data. Data are also rejected when the QA/QC issue indicates that the analytical result is not representative of the sample (ex. the blank sample is contaminated and the primary sample contains elevated concentrations of the same parameter that was observed in the blank sample). Data rejected due to potential contamination concerns are excluded from the final data tables and summary statistics. The validation checks used to determine whether data should be qualified are outlined below:

Hold time exceedances – hold time exceedances occur when the time period between the sample collection time and the sample analysis time is greater than the recommended maximum holding time. These time frames range from 0.25 hr to 6 months and represent the maximum length of time that should not be exceeded or sample degradation may occur. Reasons for hold time exceedances are determined and wherever possible revised to prevent future exceedances. The validity of the results is determined on a case by case basis. Where the holding time exceedance was significant and likely to have an effect on the quality of the result, the results were rejected.

Sample Blanks – results of blank samples are used to assess the potential sources of contamination associated with the sample containers, preservatives, and sample handling and transportation, as well as any potential contamination from the analytical procedures. For each batch of samples collected in the field, at least one field blank and one travel blank sample was analyzed. Blank sample results are flagged if any analyte exceeds the method detection limit (MDL). The sample blank data are assessed and any MDL exceedances are noted and investigated to determine the source of error. Field sampling and handling procedures may be modified to prevent similar errors from occurring in future sampling events. Blank sample results that exceed five times the MDL are considered invalid. In these cases, all site sample analyses associated with the blank sample in question are rejected unless the detected concentration in the blank is significantly (i.e. one order of magnitude) lower than the concentrations observed in the samples. Blank sample results that are greater than the MDL, but lower than five times the MDL may not always indicate potential contamination because of the uncertainty of results near the MDL. These values usually result in discussions with the lab about uncertainty. The decision matrix used to assess the QA/QC results are provided in Table E.2.

Table E.2 Decision Matrix for Flagged Blank Samples

Case	Travel Blank	Field Blank (unfiltered)	Field Blank (filtered)	Likely Cause	Actions Taken
1	>5xMDL	>5xMDL	>5xMDL	Contamination during transport, storage, or analysis of samples.	If the results were greater than 10% of the average of the results for samples collected on site, data were rejected.
2	>MDL	>MDL	>MDL	Some uncertainty associated with the MDL and the analysis.	Data were accepted, but the lab was consulted for a discussion on the uncertainty.
3	>5xMDL	-	-	Contamination at the laboratory or contamination of DDW	Discussions with laboratory on potential contamination of DDW. Results were accepted.
4	-	>5xMDL	-	Contamination due to sampling procedures or leaching from bottles.	See Case 1
5	-	-	>5xMDL	Contamination due to filters or filtering process.	See Case 1
6	>5xMDL	>5xMDL	-	Potential contamination of DDW, contamination from the bottles, or a combination of contamination sources.	See Case 1
7		>5xMDL	>5xMDL	Contamination due to sampling methods or contaminated DDW water.	See Case 1
8	>5xMDL		>5xMDL	Contamination from two sources.	See Case 1

Duplicate Samples – duplicate samples are used to estimate sampling and laboratory precision. Analytical results obtained for two samples collected from the same site at the same time are flagged if the relative percent difference (RPD) is greater than 20% and the measured concentrations are greater than five times the MDL. The RPD is the absolute difference in concentrations of the two duplicate samples divided by the average of the two values. Flagged results are further reviewed and to determine whether the high RPD is a result of naturally variable conditions or sampling error. If the latter case is suspected, efforts are made to prevent similar errors from occurring in the future and results associated with the result in question may be rejected. If the high RPD is most likely a result of natural variability in the water body from which the duplicate samples are collected, flagged data are noted as a point of discussion, but are not rejected.

Detection Limits – detection limits are examined on a regular basis to ensure that they coincide with guideline limits. If detection limits exceed the guideline limits, the laboratory is contacted and efforts are made to adjust the analytical procedures to achieve lower detection limits. Detection limits are often increased due to sample matrix interference and all efforts are made to adjust methodology, though results may not improve.

Dissolved and Total Metals Concentrations – dissolved and totals metal concentrations in all site samples are compared and flagged if the reported concentration of a dissolved metal was greater than reported concentration of the total metal. These sample results are further investigated and if the sample concentration exceeds five times the MDL and RPD between the total metal and the dissolved metal is greater than 30%.

2.3.1 Data Analysis

Data from FULCRUM was used for statistical calculations. Results that are below the MDL are set to equal the MDL for the statistical analysis. *In situ* and laboratory results are compared with previous results for the same sites and with expected data trends. Any data outliers are confirmed with the laboratory for validity. Results that do not fit within the realistic expected range are flagged and may be rejected if the likely cause of the discrepancy is determined to be a methodology error. For all analytes, annual statistics and monthly mean values are calculated. Several of the calculations are checked at random using a calculator to proof the Excel spreadsheet calculations.

3 – RESULTS

QA/QC results are used to verify data and identify any data that should be rejected. These results are divided into two categories: procedural results and results of the analysis of QA/QC samples. Procedural results included the analysis of field, laboratory, and office procedures that were part of the QA/QC process. Results of the analysis of the QA/QC samples are quantitative results that were used to identify specific data that did not meet the DQOs.

A total of 74 samples were collected since June 2013, including 11 blank samples and six duplicate samples; QA/QC samples represent 22% of the total. A summary of the samples collected is shown in Table E.3.

Table E.3 Summary of Samples Collected

Site ID	2013			2014			Total Samples
	Jun	Aug	Sep/Oct	May	Jul	Sep/Oct	
94-337	1	1	1	1	1	1	6
94-347	-	-	-	-	-	1	1
94-352	-	-	-	-	1	1	2
94-354	-	-	-	-	1	-	1
HG10-01	1	1	1	1	1	1	6
HG10-02	-	1	1	1	1	1	5
HG10-04	1	1	1	1	1	1	6
MW11-02A	1	1	1	1	1	1	6
MW11-02B	1	1	1	1	1	1	6
MW13-01D	-	-	-	-	1	-	1
MW13-02D	-	1	1	-	1	1	4
MW13-02S	-	1	1	-	1	-	3
MW13-03S	-	1	-	-	1	-	2
MW13-04S	-	1	1	1	1	1	5
MW13-05	-	1	1	1	1	1	5
MW13-06D	-	1	1	-	1	1	4
MW13-06S	-	1	-	-	-	-	1
Camp Well	-	-	-	-	1	-	1
WR Well	-	-	-	-	1	-	1

NOTES:

1. SAMPLES SHOWN ON THIS TABLE INDICATE SAMPLING EVENTS AND DO NOT INCLUDE QA/QC SAMPLES.
2. ONE DUPLICATE AND ONE FIELD BLANK SAMPLE WERE COLLECTED FOR EACH OF THE SIX SITE VISITS.
2. A TOTAL OF FIVE TRAVEL BLANK SAMPLES WERE ANALYSED.

3.1 OPERATIONAL QA/QC RESULTS

Issues related to field, laboratory, or office procedures that could affect the validity of the data collected were flagged and evaluated in a QA/QC tracking document. If the issue was likely to affect the integrity of the data, the data was rejected.

3.1.1 Field Operations

3.1.1.1 Field Equipment

Field equipment was maintained either in the field or at Pine Environmental, where equipment was rented. In-situ probes were calibrated at Pine Environmental prior to shipping to site. Calibration records have been stored with the field notes. Dissolved oxygen was calibrated on site at the beginning of each sampling event and every time the atmospheric pressure or elevation of the sampling site changed significantly. Other parameters were recalibrated every three to five days, or when the probes detected readings that were unexpected and did not fit within the range of other samples collected from the same site. Probes were rinsed with distilled water or surface water between sampling sites. All other equipment used in sampling (ex. syringes, filters, gloves) was disposable and new equipment was used at each site.

3.1.1.2 Field Procedures

Site specific challenges, including permafrost, low water levels, damaged wells, and very low groundwater recharge rates, resulted in the need to use alternative groundwater sampling methods to collect samples from some wells. The quality of data collected using the alternative methods is not equal to that collected using the standard minimum drawdown or low recharge methods; however, these methods were used only when conditions made it impossible to collect groundwater samples using a submersible pump. The samples collected are not considered to be as representative of the baseline groundwater as the samples collected using the standard methods; however, the results may be used to support conclusions if specific considerations are made to the QA/QC analysis of such samples. The following samples, collected using alternative methods, should be flagged for potential QA/QC issues:

- MW13-03S (August 2013): this sample was collected several days after development and was not purged sufficiently for the standard methods due to low recharge. The water type of this sample is defined as containing more sulphate and less bicarbonate than other samples collected from the hillslope area.
- MW13-03S (July 2014): the well was frozen upon arrival and was thawed using hot tap water. The tap water was then purged using a foot valve and HDPE tubing until the water level was at the top of the screen. The water level was left to recover overnight before a sample was collected using a bailer. The water type of this sample is similar to that of other samples collected from the hillslope area, but is different from the other sample collected from the same well (August 2013). This July 2014 sample was collected using unconventional methods and is likely to represent a combination of groundwater and residual hot tap water. The sample was excluded from the dataset based on the metals analysis (see Section 3.2.3 – Metals Analysis).
- MW13-01D (July 2014): the well was frozen upon arrival and was thawed using hot tap water. The tap water was then purged using a foot valve and HDPE tubing until the water level was at the top of the screen. The water level recovered very slowly and a sample was collected a few

days later, after minimal recharge. The water type of this sample contains less bicarbonate and calcium and more sulphate than other samples collected from the hillslope area.

3.1.1.3 Monitoring Wells Excluded from Groundwater Quality Characterization Program

The pH of the water from monitoring wells MW13-04D and MW13-03D was high after well development and grout contamination is suspected. The low recharge rates of these wells poses a challenge for further well development; it is unlikely that further development could result in the clearing of the grout contamination. Data associated with samples collected from these wells have been excluded from the data set and samples are not proposed to be collected in future sampling events.

Permafrost conditions were observed in the vicinity of monitoring wells MW13-03S and MW13-01D and the wells were frozen when sampling was attempted in July 2014. The wells were thawed using hot tap water, which was purged prior to sampling; however, the low recharge conditions of these wells did not allow for sufficient purging. The sample quality for MW13-03S was poor and the July 2014 sample was rejected, as describe further in section 3.2.3 of this QA/QC summary. The sample quality for MW13-01D did not get flagged through the assessment of the DQOs, however, the sampling technique was similar to that used to collect the sample from monitoring well MW13-03S, and future sampling of both of these wells is not recommended.

3.1.2 Laboratory Operations

ALS has their own internal QA/QC methods for verifying data. Laboratory QA/QC results were reported for matrix spikes, method blanks, laboratory control samples, reference materials, and duplicates/replicates. ALS laboratory reports also provided details regarding sampling hold times.

3.1.2.1 Laboratory Qualifiers

Very few of the results reported by the laboratories were categorized as rejected. In most cases where data were flagged by the laboratory, the issue resulted in an adjustment of the MDL and did not result in the exclusion of results from the statistical analysis. Reasons for the MDL adjustment included the requirement of further dilution of samples prior to analysis, the detection of an analyte in the Method Blank, and sample matrix effects.

3.1.3 Office Data Management Operations

In the office, all *in situ* data and laboratory results from ALS laboratories were entered into FULCRUM. This task was completed by the field personnel who collected the samples and the entered data was checked regularly by other staff members. On the few occasions where an error in data entry was noted, the error was most commonly a unit conversion error. In these cases, the field personnel were informed of the non-conformance and the error was corrected.

3.2 QA/QC SAMPLE RESULTS

3.2.1 Blank Samples

Very few blank sample analyses were flagged. A summary of flagged blank sample results is shown in Table E.4 and all field blank and travel blank analytical results are shown in Table E.7 and Table

E.8, respectively. The flagged travel blank results indicate possible ammonia contamination at the laboratory or contamination of the DDI water. The latter is a more likely possibility, since laboratory contamination was checked with laboratory QA/QC protocols, which did not indicate contamination of ammonia. Dissolved organic carbon had a detectable concentration within the May 25, 2014 field blank. This detectable concentration is suspected to be as a result of the filtration device used for the dissolved samples, since the total samples are unaffected. The corrective action was to use a different filtering apparatus for future sampling.

Table E.4 Flagged Blank Results

Analyte (MDL)	Date	Blank Concentration (mg/L)	MDL (mg/L)	Holding Time	Type of Blank Sample
Ammonia	10-Jun-13	0.0121	0.005	28 days	Travel Blank
	26-Sep-13	0.0138	0.005		Travel Blank
	26-Sep-13	0.0238	0.005		Travel Blank
Dissolved Organic Carbon	25-May-14	0.01	0.5	28 days	Field Blank

NOTES:

1. THIS TABLE INCLUDES ONLY BLANK RESULTS WITH DETECTABLE CONCENTRATIONS.

3.2.2 Duplicate Samples

A summary of duplicate sample results for which the relative percent difference (RPD) between samples was greater than 20%, where one or both sample concentrations was greater than five times the MDL are listed in Table E.5. All duplicate analytical results from ALS Laboratories are shown in

Table E.9. A total of five duplicates were collected since June 2013. Each duplicate tested between 92 to 102 parameters. Over 450 individual samples were queried, and seven analytes reported RPDs in excess of 20%.

There are several possible reasons for duplicate sample RPDs exceeding 20%. Natural variability in groundwater quality data indicates the possibility that certain wells are not achieving a uniform steady state. Inconsistent sampling methods are another possibility.

All data associated with duplicate samples exceeding the acceptable RPD of 20% for analyses that were greater than five times the MDL were flagged and further examined. Two wells had more than one analyte that exceeded the acceptable RPD (HG10-04 and HG10-02). One sampling event (June 22, 2013) was responsible for three of the seven duplicates with elevated RPDs and a second sampling event (August 5, 2013) was responsible for two of the seven elevated duplicates. It is likely that the minimal variability shown in the duplicate data is both as a result of natural variability within groundwater, and inconsistencies in sampling methodology. Neither the site sample data nor the site data associated with the flagged duplicates were removed from the dataset used in the statistical analysis of results.

Table E.5 Flagged Groundwater Quality Duplicate Results

Site	Parameter	Date	Sample Concentrations		RPD (%)
			Sample	Duplicate	
HG10-04	Turbidity (NTU)	22-Jun-13	3.58	6.42	57%
	Total Aluminum (mg/L)	05-Aug-13	0.56	0.38	117%
	Total Lead (mg/L)	05-Aug-13	0.021	0.0054	117%
HG10-02	Sulphate (mg/L)	22-Jul-13	836	82.1	164%
	Total Zinc (mg/L)	22-Jul-13	0.087	0.05	54%
HG10-01	Turbidity (NTU)	23-May-13	2.32	8.53	115%
94-337	Total Lead (mg/L)	26-Sep-13	0.0037	0.0015	83%
MW13-04S	Lithium (Dissolved)	30-Sep-14	0.00623	0.00303	69%
	Manganese (Dissolved)		0.000537	0.000425	23%
	Molybdenum (Dissolved)		0.000841	0.00057	38%
	Potassium (Dissolved)		2.59	1.6	47%
	Sodium (Dissolved)		9.03	4.69	63%
	Manganese (Total)		0.000827	0.00109	27%

NOTES:

1. DUPLICATE SAMPLES WERE FLAGGED WHEN THE RPD WAS GREATER THAN 20% AND CONCENTRATIONS WERE GREATER THAN FIVE TIMES THE MDL.

3.2.3 Metals Analysis

Relative percent differences between total and dissolved metals concentrations were calculated for samples for which the dissolved concentrations of metals exceeded total concentrations of the same metals and one or both concentrations exceeded five times the MDL. Data were flagged when the RPD was greater than 20%. In cases where the flagged analytical result was different from the rest of the dataset (e.g., total concentration was lower and dissolved concentration was higher than the other data), both the total and dissolved data were rejected. A summary of the sample analyses that

were flagged is shown in Table E.6. Most of the flagged metals analyses were observed in the sample collected from MW13-03S in July, 2014 and are likely related to the unconventional methods used in sampling this well (see Section 3.1.1.2 – Field Procedures). Monitoring well MW13-03S is installed in a permafrost area and was frozen at the time of sampling. The ice inside the well was thawed using hot tap water, which was purged prior to sampling; however, the low recharge conditions of this well did not allow for sufficient purging. The sample likely represents a combination of tap water and groundwater. In addition, the sample was collected using a bailer because a low flow pump could not fit inside the well. The use of bailers can increase the turbidity in the well and stir sediments at the bottom. This could have resulted in a non-uniform sample, which would account for the discrepancies between total and dissolved metals. The data for the sample collected from MW13-03S in July, 2014 has been rejected for these two reasons.

Table E.6 Flagged Metals Analyses

Site	Date	Analyte	MDL	Dissolved	Total	RPD
94-352	30/09/2014	Zinc (Zn)	0.001	0.0139	0.0106	27%
94-352	30/07/2014	Zinc (Zn)	0.001	0.0185	0.0127	37%
MW13-03S	28/07/2014	Strontium (Sr)	0.0002	0.461	0.337	31%
MW13-03S	28/07/2014	Uranium (U)	0.00001	0.00869	0.00564	43%
MW13-03S	28/07/2014	Sodium (Na)	0.05	79	49.6	46%
MW13-03S	28/07/2014	Magnesium (Mg)	0.1	39.5	19.2	69%
MW13-03S	28/07/2014	Manganese (Mn)	0.00005	4.71	1.66	96%
MW13-03S	28/07/2014	Nickel (Ni)	0.0005	0.0252	0.00871	97%
MW13-03S	28/07/2014	Cobalt (Co)	0.0001	0.0162	0.00333	132%
MW13-03S	28/07/2014	Sulphur (S)	0.5	124	13.4	161%
MW13-03S	28/07/2014	Zinc (Zn)	0.001	0.527	0.0461	168%
MW13-04S	30/09/2014	Molybdenum (Mo)	0.00005	0.000841	0.000564	39%
MW13-04S	30/09/2014	Sodium (Na)	0.05	9.03	4.61	65%
MW13-04S	30/09/2014	Potassium (K)	0.1	2.59	1.31	66%

NOTES:

1. UNITS ARE mg/L UNLESS STATED OTHERWISE.
2. RESULTS ARE SHOWN FOR SAMPLES FOR WHICH A DISSOLVED METAL CONCENTRATION EXCEEDED THE TOTAL CONCENTRATION BY MORE THAN 20% AND THE CONCENTRATION EXCEEDED FIVE TIMES THE MDL.

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TABLE E.7 - FIELD BLANKS
(PAGE 1 OF 1)

Sample ID	FIELD BLANK	FIELD BLANK	FIELD BLANK	FIELD BLANK	FIELD BLANK	FIELD BLANK
Date Sampled	26-Sep-13	13-Jun-13	16-Aug-13	25-May-14	25-Jul-14	2-Oct-14
Lab ID	L1370205-8	L1316836-4	L1350241-2	L1460749-5	L1493225-6	L1527854-5
Calculated Parameters						
Anions Sum meq/L	<0.1		<0.1		<0.1	<0.1
Cations Sum meq/L	<0.1		<0.1		<0.1	<0.1
Physical Tests						
Acidity to pH 8.3 (as CaCO3)						
Alkalinity (Total as CaCO3)	<2	<2	<2	<1	<2	<1
Bicarbonate Alkalinity	<2	<2	<2	<1	<2	<1
Carbonate Alkalinity	<2	<2	<2	<1	<2	<1
Color TCU	<5	<5	<5	<5	<5	<5
Conductivity µS/cm	<2	<2	<2	<2	<2	<2
Hardness as CaCO3 (Dissolved)	<0.0005	<0.0005	<0.0005	<0.5	<0.5	<0.5
Hardness as CaCO3 (Total)						
Hydroxide Alkalinity	<2	<2	<2	<1	<2	<1
Ion Balance %	0		0		0	0
pH pH	5.57	5.59	5.93	5.89	5.42	5.51
Total Dissolved Solids	<10	<10	<1	<10	<10	<10
Total Suspended Solids	<3	<3	<3	<3	<3	<3
Turbidity NTU	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Dissolved Anions						
Bromide (Dissolved)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Chloride (Dissolved)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Fluoride (Dissolved)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Sulphate (Dissolved)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Nutrients						
Ammonia (Total)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Nitrate (as N)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Nitrite (as N)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nitrogen (Total)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Nitrogen Kjeldahl (Total)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Orthophosphate (Dissolved)		<0.001	<0.001	<0.001		<0.001
Phosphate (Dissolved)			<0.002			
Phosphorus (Nutrient) Dissolved	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Phosphorus (Nutrient) Total	<0.002	<0.002		<0.002	<0.002	<0.002
Cyanide						
Cyanide (Free)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Cyanide (Total)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Cyanide (WAD)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Dissolved Metals						
Aluminum (Dissolved	<0.001	<0.001		<0.001	<0.001	<0.001
Antimony (Dissolved)	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001
Arsenic (Dissolved)	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001
Barium (Dissolved)	<0.00005	<0.00005		<0.00005	<0.00005	<0.00005
Beryllium (Dissolved)	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001
Bismuth (Dissolved)	<0.0005	<0.0005		<0.0005	<0.0005	<0.0005
Boron (Dissolved)	<0.01	<0.01		<0.01	<0.01	<0.01
Cadmium (Dissolved)	<0.00001	<0.00001		<0.00001	<0.00001	<0.00001
Calcium (Dissolved)	<0.05	<0.05		<0.05	<0.05	<0.05
Chromium (Dissolved	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001
Cobalt (Dissolved)	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001
Copper (Dissolved)	<0.0002	<0.0002		<0.0002	<0.0002	<0.0002
Iron (Dissolved)	<0.01	<0.01		<0.01	<0.01	<0.01
Lead (Dissolved)	<0.00005	<0.00005		<0.00005	<0.00005	<0.00005
Lithium (Dissolved)	<0.0005	<0.0005		<0.0005	<0.0005	<0.0005
Magnesium (Dissolved)	<0.1	<0.1		<0.1	<0.1	<0.1
Manganese (Dissolved)	<0.00005	<0.00005		<0.00005	<0.00005	<0.00005
Mercury (Dissolved)	<0.00001	<0.00001		<0.00001	<0.00001	<0.00001
Molybdenum (Dissolved)	<0.00005	<0.00005		<0.00005	<0.00005	<0.00005
Nickel (Dissolved)	<0.0005	<0.0005		<0.0005	<0.0005	<0.0005
Phosphorus (Metal) Dissolved	<0.05	<0.05		<0.05	<0.05	<0.05
Potassium (Dissolved)	<0.1	<0.1		<0.1	<0.1	<0.1
Selenium (Dissolved	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001
Silicon (Dissolved)	<0.05	<0.05		<0.05	<0.05	<0.05
Silver (Dissolved)	<0.00001	<0.00001		<0.00001	<0.00001	<0.00001
Sodium (Dissolved)	<0.05	<0.05		<0.05	<0.05	<0.05
Strontium (Dissolved)	<0.0002	<0.0002		<0.0002	<0.0002	<0.0002
Sulphur (Dissolved	<0.5	<0.5		<0.5	<0.5	<0.5
Thallium (Dissolved	<0.00001	<0.00001		<0.00001	<0.00001	<0.00001
Tin (Dissolved)	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001
Titanium (Dissolved)	<0.01	<0.01		<0.01	<0.01	<0.01
Uranium (Dissolved	<0.00001	<0.00001		<0.00001	<0.00001	<0.00001
Vanadium (Dissolved	<0.001	<0.001		<0.001	<0.001	<0.001
Zinc (Dissolved)	<0.001	<0.001		<0.001	<0.001	<0.001
Total Metals						
Aluminum (Total)	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Antimony (Total)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Arsenic (Total)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Barium (Total)	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Beryllium (Total)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Bismuth (Total)	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Boron (Total)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cadmium (Total)	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Calcium (Total)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Chromium (Total)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cobalt (Total)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Copper (Total)	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Iron (Total)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Lead (Total)	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Lithium (Total)	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Magnesium (Total)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Manganese (Total)	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Mercury (Total)	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum (Total)	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Nickel (Total)	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Phosphorus (Metal) Total	<0.05	<0.05	<0.05	<0.05	<0.00005	<0.05
Potassium (Total)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Selenium (Total)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Silicon (Total)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Silver (Total)	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Sodium (Total)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Strontium (Total)	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Sulphur (Total)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Thallium (Total)	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Tin (Total)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Titanium (Total)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium (Total)	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Vanadium (Total)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc (Total)	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Organics						
Carbon Organic (Dissolved)	<0.5	<0.5		**1.01**	<0.5	<0.5
Carbon Organic (Total)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Percent of sample > MDL	**0.00%**	**0.00%**	**0.00%**	**1.05%**	**0.00%**	**0.00%**

NOTES:
1. UNITS ARE mg/L UNLESS OTHERWISE STATED
2. BOLD RED INDICATES THE RESULT EXCEEDS THE MDL FOR THAT ANALYTE
3. MDL EXCEEDANCE CALCULATION DOES NOT INCLUDE PH; WILL ALWAYS BE ABOVE THE MDL

APPENDIX E - QUALITY ASSURANCE/QUALITY CONTROL

TABLE E.8 - TRAVEL BLANKS
(PAGE 1 OF 1)

Sample ID	TRAVEL BLANK	TRAVEL BLANK	TRAVEL BLANK	TRAVEL BLANK	TRAVEL BLANK
Date Sampled	10-Jun-13	16-Aug-13	26-Sep-13	24-Jul-14	2-Oct-14
Lab ID	L1314790-3	L1350241-3	L1370205-7	L1493225-7	L1527854-6
Calculated Parameters					
Anions Sum meq/L	<0.1	<0.1	<0.1	<0.1	<0.1
Cations Sum meq/L	<0.1	<0.1	<0.1	<0.1	<0.1
Physical Tests					
Acidity to pH 8.3 (as CaCO3)	1.8				
Alkalinity (Total as CaCO3)	<2	<2	<2	<2	<1
Bicarbonate Alkalinity	<2	<2	<2	<2	<1
Carbonate Alkalinity	<2	<2	<2	<2	<1
Color TCU	<5	<5	<5	<5	<5
Conductivity µS/cm	<2	<2	<2	<2	<2
Hardness as CaCO3 (Dissolved)	<0.0005	<0.0005		<0.5	<0.5
Hydroxide Alkalinity	<2	<2	<2	<2	<1
Ion Balance %	0	0	0	0	0
pH pH	5.63	5.78	5.6	5.48	5.45
Total Dissolved Solids	<10	<1	<10	<10	<10
Total Suspended Solids	<3	<3	<3	<3	<3
Turbidity NTU	<0.1	<0.1	<0.1	<0.1	<0.1
Dissolved Anions					
Bromide (Dissolved)	<0.05	<0.05	<0.05	<0.05	<0.05
Chloride (Dissolved)	<0.5	<0.5	<0.5	<0.5	<0.5
Fluoride (Dissolved)	<0.02	<0.02	<0.02	<0.02	<0.02
Sulphate (Dissolved)	<0.5	<0.5	<0.5	<0.5	<0.5
Nutrients					
Ammonia (Total)	**0.0121**	<0.005	**0.0138**	<0.005	**0.0238**
Nitrate (as N)	<0.005	<0.005	<0.005	<0.005	<0.005
Nitrite (as N)	<0.001	<0.001	<0.001	<0.001	<0.001
Nitrogen (Total)	<0.05	<0.05	<0.05	<0.05	<0.05
Nitrogen Kjeldahl (Total)	<0.05	<0.05	<0.05	<0.05	<0.05
Orthophosphate (Dissolved)	<0.001	<0.001			<0.001
Phosphate (Dissolved)		<0.002			
Phosphorus (Nutrient) Dissolved	<0.002	<0.002	<0.002	<0.002	<0.002
Phosphorus (Nutrient) Total	<0.002		<0.002	<0.002	<0.002
Cyanide					
Cyanide (Free)	<0.005	<0.005	<0.005	<0.005	<0.005
Cyanide (Total)	<0.005	<0.005	<0.005	<0.005	<0.005
Cyanide (WAD)	<0.005	<0.005	<0.005	<0.005	<0.005
Total Metals					
Aluminum (Total)	<0.003	<0.003	<0.003	<0.003	<0.003
Antimony (Total)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Arsenic (Total)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Barium (Total)	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Beryllium (Total)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Bismuth (Total)	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Boron (Total)	<0.01	<0.01	<0.01	<0.01	<0.01
Cadmium (Total)	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Calcium (Total)	<0.05	<0.05	<0.05	<0.05	<0.05
Chromium (Total)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cobalt (Total)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Copper (Total)	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Iron (Total)	<0.01	<0.01	<0.01	<0.01	<0.01
Lead (Total)	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Lithium (Total)	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Magnesium (Total)	<0.1	<0.1	<0.1	<0.1	<0.1
Manganese (Total)	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Mercury (Total)	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum (Total)	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Nickel (Total)	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Phosphorus (Metal) Total	<0.05	<0.05	<0.05	<0.00005	<0.05
Potassium (Total)	<0.1	<0.1	<0.1	<0.1	<0.1
Selenium (Total)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Silicon (Total)	<0.05	<0.05	<0.05	<0.05	<0.05
Silver (Total)	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Sodium (Total)	<0.05	<0.05	<0.05	<0.05	<0.05
Strontium (Total)	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Sulphur (Total)	<0.5	<0.5	<0.5	<0.5	<0.5
Thallium (Total)	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Tin (Total)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Titanium (Total)	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium (Total)	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Vanadium (Total)	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc (Total)	<0.003	<0.003	<0.003	<0.003	<0.003
Organics					
Carbon Organic (Dissolved)					
Carbon Organic (Total)	<0.5	<0.5	<0.5	<0.5	<0.5
Percent of sample > MDL	**3.17%**	**0.00%**	**1.67%**	**0.00%**	**1.61%**

NOTES:
1. UNITS ARE mg/L UNLESS OTHERWISE STATED.
2. BOLD RED INDICATES THE RESULT EXCEEDS THE MDL FOR THAT ANALYTE.
3. MDL EXCEEDANCE CALCULATION DOES NOT INCLUDE pH; WILL ALWAYS BE ABOVE THE MDL.

APPENDIX E - QUALITY ASSURANCE/QUALITY CONTROL

TABLE E.9 - DUPLICATE SAMPLES
(PAGE 1 OF 2)

Site	MDL	94-337	Duplicate	RPD	MDL	HG10-01	Duplicate	RPD	MDL	HG10-02	Duplicate	RPD
Date Sampled		26-Sep-13		(%)		23-May-14		(%)		22-Jul-14		(%)
Physical Tests												
Alkalinity (Total as CaCO3)	2	10.2	9.3		2	126	126	0.00%	2	176	172	2.30%
Bicarbonate Alkalinity	2	10.2	9.3		2	126	126	0.00%				
Carbonate Alkalinity	2	<2	<2		2	<2	<2					
Color TCU	5	15.5	26.1		5	20.6	21.8		5	<5	<5	
Conductivity µS/cm	2	229	233	1.73%	2	1520	1530	0.66%	2	1570	1570	0.00%
Hardness as CaCO3 (Dissolved)	0.0005	0.082	0.0799	2.59%	0.5	959	953	0.63%	0.5	940	951	1.16%
Hydroxide Alkalinity	2	<2	<2		2	<2	<2					
Ion Balance %		0.8	0			3	2.4					
pH pH	0.1	6.55	6.84	4.33%	0.1	7.15	7.12	0.42%	0.1	7.36	7.52	2.15%
Total Dissolved Solids	10	184	187	1.62%	10	1370	1360	0.73%	10	1300	1320	1.53%
Total Suspended Solids	3	<3	<3		3	13.6	16.2		3	8.8	15.7	
Turbidity NTU	0.1	6.94	7.14	2.84%	0.1	2.32	8.53	**114.47%**	0.1	44.2	41.2	7.03%
Dissolved Anions												
Bromide (Dissolved)	0.05	<0.05	<0.05		0.5	<0.5	<0.5		0.5	<0.5	<0.05	
Chloride (Dissolved)	0.5	<0.5	<0.5		5	<5	<5		5	<5	<0.5	
Fluoride (Dissolved)	0.02	1.34	1.28	4.58%	0.2	0.58	0.58		0.2	0.71	0.07	
Sulphate (Dissolved)	0.5	95.6	96.1	0.52%	5	832	838	0.72%	5	836	82.1	**164.23%**
Nutrients												
Ammonia (Total)	0.005	0.0106	0.0098		0.005	0.0324	0.032	1.24%	0.005	0.0314	0.0305	2.91%
Nitrate (as N)	0.005	<0.005	<0.005		0.05	<0.05	<0.05		0.05	<0.05	<0.005	
Nitrate+Nitrite (Dissolved)												
Nitrite (as N)	0.001	<0.001	<0.001		0.01	<0.01	<0.01		0.01	<0.01	0.0011	
Nitrogen (Total)	0.05	<0.05	<0.05		0.071	0.086	0.085		0.071	0.101	0.085	
Nitrogen Kjeldahl (Total)	0.05	<0.05	<0.05		0.05	0.086	0.085		0.05	0.101	0.084	
Orthophosphate (Dissolved)					0.01	<0.01	<0.01					
Phosphate (Dissolved)												
Phosphorus (Nutrient) Dissolved	0.002	<0.002	<0.02		0.02	<0.02	<0.02		0.002	<0.002	<0.002	
Phosphorus (Nutrient) Total	0.002	<0.002	<0.02						0.002	<0.002	<0.002	
Cyanide												
Cyanide (Free)	0.005	<0.005	<0.005		0.005	<0.005	<0.005		0.005	<0.005	<0.005	
Cyanide (SAD)												
Cyanide (Total)	0.005	<0.005	<0.005		0.005	<0.005	<0.005		0.005	<0.005	<0.005	
Cyanide (WAD)	0.005	<0.005	<0.005		0.005	<0.005	<0.005		0.005	<0.005	<0.005	
Dissolved Metals												
Aluminum (Dissolved	0.001	0.632	0.619	2.08%	0.001	0.018	0.0198	9.52%	0.002	0.0049	0.0056	
Antimony (Dissolved)	0.0001	<0.0001	<0.0001		0.0001	<0.0001	<0.0001		0.0002	<0.0002	<0.0002	
Arsenic (Dissolved)	0.0001	0.0006	0.0006	0.00%	0.0001	0.0182	0.0188	3.24%	0.0002	0.0134	0.014	4.38%
Barium (Dissolved)	0.00005	0.0117	0.0113	3.48%	0.00005	0.00547	0.00545	0.37%	0.0001	0.00471	0.00458	2.80%
Beryllium (Dissolved)	0.0001	0.00126	0.00124	1.60%	0.0001	<0.0001	<0.0001		0.0002	<0.0002	<0.0002	
Bismuth (Dissolved)	0.0005	<0.0005	<0.0005		0.0005	<0.0005	<0.0005		0.001	<0.001	<0.001	
Boron (Dissolved)	0.01	<0.01	<0.01		0.01	<0.01	<0.01		0.02	<0.02	<0.02	
Cadmium (Dissolved)	0.00001	0.00581	0.00563	3.15%	0.00001	<0.00001	0.000012		0.00002	<0.00002	<0.00002	
Calcium (Dissolved)	0.05	26	25.4	2.33%	0.05	310	309	0.32%	0.05	303	307	1.31%
Chromium (Dissolved	0.0001	0.0018	0.00167	7.49%	0.0001	<0.0001	<0.0001		0.0002	0.0002	<0.0002	
Cobalt (Dissolved)	0.0001	0.0663	0.066	0.45%	0.0001	0.0315	0.032	1.57%	0.0002	0.0188	0.0194	3.14%
Copper (Dissolved)	0.0002	1.88	1.85	1.61%	0.0002	<0.0002	<0.0002		0.0004	<0.0004	<0.0004	
Iron (Dissolved)	0.01	5.17	5.06	2.15%	0.01	23.3	23.2	0.43%	0.01	12.1	12.3	1.64%
Lead (Dissolved)	0.00005	0.00157	0.00134	15.81%	0.00005	0.000061	0.000062		0.0001	<0.0001	<0.0001	
Lithium (Dissolved)	0.0005	0.0185	0.0176	4.99%	0.0005	0.0063	0.0067	6.15%	0.001	0.0027	0.0025	
Magnesium (Dissolved)	0.1	4.13	4.02	2.70%	0.1	44.9	43.9	2.25%	0.1	44.3	44.5	0.45%
Manganese (Dissolved)	0.00005	0.625	0.628	0.48%	0.00005	0.973	0.981	0.82%	0.0001	0.661	0.666	0.75%
Mercury (Dissolved) unitless	0.00001	<0.00001	<0.00001		0.00001	<0.00001	<0.00001		0.00001	<0.00001	<0.00001	
Molybdenum (Dissolved)	0.00005	0.00136	0.00135	0.74%	0.00005	0.0165	0.0161	2.45%	0.0001	0.0262	0.0265	1.14%
Nickel (Dissolved)	0.0005	0.0159	0.0157	1.27%	0.0005	0.0031	0.00313	0.96%	0.001	0.0012	0.0013	
Phosphorus (Metal) Dissolved	0.05	<0.05	<0.05		0.05	<0.05	<0.05		0.05	<0.05	<0.05	
Potassium (Dissolved)	0.1	1.5	1.39	7.61%	0.1	3.5	3.45	1.44%	0.1	3.24	3.33	2.74%
Selenium (Dissolved	0.0001	0.00012	0.00011		0.0001	<0.0001	<0.0001		0.0002	<0.0002	<0.0002	
Silicon (Dissolved)	0.05	9.5	9.15	3.75%	0.05	4.53	4.53	0.00%	0.05	4.27	4.33	1.40%
Silver (Dissolved)	0.00001	<0.00001	<0.00001		0.00001	<0.00001	<0.00001		0.00002	<0.00002	<0.00002	
Sodium (Dissolved)	0.05	4.22	4.27	1.18%	0.05	12.6	12.8	1.57%	0.1	14.3	14.4	0.70%
Strontium (Dissolved)	0.0002	0.166	0.161	3.06%	0.0002	1.56	1.54	1.29%	0.0004	1.64	1.59	3.10%
Sulphur (Dissolved	0.5	32	30.9	3.50%	0.5	259	256	1.17%	0.5	256	256	0.00%
Thallium (Dissolved	0.00001	0.000039	0.000038		0.00001	<0.00001	0.000015		0.00002	0.000029	0.000028	
Tin (Dissolved)	0.0001	<0.0001	<0.0001		0.0001	<0.0001	<0.0001		0.0002	<0.0002	<0.0002	
Titanium (Dissolved)	0.01	<0.01	<0.01		0.01	<0.01	<0.01		0.02	<0.02	<0.02	
Uranium (Dissolved	0.00001	0.000897	0.000908	1.22%	0.00001	0.036	0.0343	4.84%	0.00002	0.0414	0.0421	1.68%
Vanadium (Dissolved	0.001	<0.001	<0.001		0.001	<0.001	<0.001		0.002	<0.002	<0.002	
Zinc (Dissolved)	0.001	0.378	0.376	0.53%	0.001	0.095	0.0965	1.57%	0.002	0.0513	0.0533	3.82%
Total Metals												
Aluminum (Total)	0.003	0.705	0.643	9.20%	0.003	0.0199	0.0179	10.58%	0.006	0.0095	0.0096	
Antimony (Total)	0.0001	<0.0001	<0.0001		0.0001	0.0001	<0.0001		0.0002	<0.0002	<0.0002	
Arsenic (Total)	0.0001	0.00071	0.00065	8.82%	0.0001	0.019	0.0191	0.52%	0.0002	0.0137	0.0142	3.58%
Barium (Total)	0.00005	0.0133	0.0119	11.11%	0.00005	0.00559	0.00548	1.99%	0.0001	0.00473	0.00467	1.28%
Beryllium (Total)	0.0001	0.00132	0.0012	9.52%	0.0001	0.00013	<0.0001		0.0002	<0.0002	<0.0002	
Bismuth (Total)	0.0005	<0.0005	<0.0005		0.0005	<0.0005	<0.0005		0.001	<0.001	<0.001	
Boron (Total)	0.01	<0.01	<0.01		0.01	0.011	<0.01		0.02	<0.02	<0.02	
Cadmium (Total)	0.00001	0.00603	0.00579	4.06%	0.00001	0.000016	<0.00001		0.00002	<0.00002	<0.00002	
Calcium (Total)	0.05	27.3	27.8	1.81%	0.05	311	306	1.62%	0.05	312	309	0.97%
Chromium (Total)	0.0001	0.00345	0.00299	14.29%	0.0001	0.00015	<0.0001		0.0002	0.00053	0.00056	
Cobalt (Total)	0.0001	0.0692	0.0706	2.00%	0.0001	0.0326	0.0323	0.92%	0.0002	0.0186	0.0192	3.17%
Copper (Total)	0.0005	2.05	1.99	2.97%	0.0005	<0.0005	<0.0005		0.001	<0.001	<0.001	
Iron (Total)	0.01	5.62	5.43	3.44%	0.01	23.7	23.1	2.56%	0.01	12.5	12.4	0.80%
Lead (Total)	0.00005	0.00366	0.00152	**82.63%**	0.00005	0.000111	0.000053		0.0001	<0.0001	<0.0001	
Lithium (Total)	0.0005	0.0192	0.0176	8.70%	0.0005	0.00703	0.00613	13.68%	0.001	0.0027	0.0025	
Magnesium (Total)	0.1	4.35	4.29	1.39%	0.1	45.2	44.4	1.79%	0.1	45.2	45.3	0.22%
Manganese (Total)	0.00005	0.663	0.66	0.45%	0.00005	1.02	0.988	3.19%	0.0001	0.647	0.664	2.59%
Mercury (Total)	0.00001	0.000011	<0.00001		0.00001	<0.00001	<0.00001		0.00001	<0.00001	<0.00001	
Molybdenum (Total)	0.00005	0.0017	0.00151	11.84%	0.00005	0.0172	0.0168	2.35%	0.0001	0.0254	0.0266	4.62%
Nickel (Total)	0.0005	0.0171	0.0169	1.18%	0.0005	0.00321	0.00319	0.63%	0.001	0.0013	0.0013	
Phosphorus (Metal) Total	0.05	<0.05	<0.05		0.05	<0.05	<0.05		0.00005	<0.00005	<0.00005	
Potassium (Total)	0.1	1.63	1.56	4.39%	0.1	3.53	3.42	3.17%	0.1	3.37	3.34	0.89%
Selenium (Total)	0.0001	0.00012	0.00011		0.0001	0.00015	<0.0001		0.0002	<0.0002	<0.0002	
Silicon (Total)	0.05	9.89	9.55	3.50%	0.05	4.62	4.51	2.41%	0.05	4.43	4.39	0.91%
Silver (Total)	0.00001	<0.00001	<0.00001		0.00001	0.000011	<0.00001		0.00002	0.000693	<0.00002	
Sodium (Total)	0.05	4.35	4.43	1.82%	0.05	13.3	12.8	3.83%	0.1	14.1	14.5	2.80%
Strontium (Total)	0.0002	0.173	0.164	5.34%	0.0002	1.66	1.57	5.57%	0.0004	1.58	1.66	4.94%
Sulphur (Total)	0.5	32.9	32.4	1.53%	0.5	265	261	1.52%	0.5	268	265	1.13%
Thallium (Total)	0.00001	0.000039	0.00004		0.00001	0.000018	<0.00001		0.00002	0.000028	0.000026	
Tin (Total)	0.0001	0.00014	<0.0001		0.0001	<0.0001	<0.0001		0.0002	<0.0002	<0.0002	
Titanium (Total)	0.01	<0.01	<0.01		0.01	<0.01	<0.01		0.02	<0.02	<0.02	
Uranium (Total)	0.00001	0.00101	0.000983	2.71%	0.00001	0.0366	0.0361	1.38%	0.00002	0.0396	0.0427	7.53%
Vanadium (Total)	0.001	<0.001	<0.001		0.001	<0.001	<0.001		0.002	<0.002	<0.002	
Zinc (Total)	0.003	0.383	0.389	1.55%	0.003	0.0986	0.0976	1.02%	0.006	0.0874	0.0501	**54.25%**
Organics												
Carbon Organic (Dissolved)	0.5	1.16	1.21		0.5	1.3	1.08		0.5	1.22	1.03	
Carbon Organic (Total)	0.5	1.11	0.93		0.5	0.97	1.05		0.5	1.12	1.03	

NOTES:
1. UNITS ARE mg/L UNLESS OTHERWISE STATED.
2. BOLD RED INDICATES THE RPD [RELATIVE PERCENT DIFFERENCE] EXCEEDS THE 20% DATA QUALITY OBJECTIVE FOR VALUES GREATER THAN 5 TIMES THE MDL.

TABLE E.9 - DUPLICATE SAMPLES
(PAGE 2 OF 2)

Site Date Sampled	MDL	HG10-04 12-Jun-13	Duplicate	RPD (%)	MDL	HG10-04 5-Aug-13	Duplicate	RPD (%)	MDL	MW13-04S 30-Sep-14	Duplicate	RPD (%)
Physical Tests												
Alkalinity (Total as CaCO3)	1	94.9	104	9.15%	2	101	102	0.99%	1	168	168	0.00%
Bicarbonate Alkalinity	1	94.9	104	9.15%	2	101	102	0.99%	1	168	168	0.00%
Carbonate Alkalinity	1	<1	<2		2	<2	<2		1	<1	<1	
Color TCU	5	60.1	55.6	7.78%	5	69.8	71.3	2.13%	5	<5	<5	
Conductivity µS/cm	2	852	844	0.94%	2	872	875	0.34%	2	344	343	0.29%
Hardness as CaCO3 (Dissolved)	0.0005	0.457	0.461	0.87%	0.0005	0.456	0.447	1.99%	0.5	174	185	6.13%
Hydroxide Alkalinity	1	<1	<2		2	<2	<2		1	<1	<1	
Ion Balance %						5.8	5.5			-0.8	-0.8	
pH pH	0.1	6.65	6.56	1.36%	0.1	6.85	6.82	0.44%	0.1	8.17	8.25	0.97%
Total Dissolved Solids	10	698	648	7.43%	10	690	732	5.91%	10	202	211	4.36%
Total Suspended Solids	3	25.2	23.9	5.30%	3	40.1	34.3	15.59%	3	14	6	
Turbidity NTU	0.1	78.9	71.1	10.40%	0.1	3.58	6.42	**56.80%**	0.1	2.2	0.86	**87.58%**
Dissolved Anions												
Bromide (Dissolved)	0.5	<0.5	<0.5		0.5	<0.5	<0.5		0.05	<0.05	<0.05	
Chloride (Dissolved)	5	<5	<5		5	<5	<5		0.5	<0.5	<0.5	
Fluoride (Dissolved)	0.2	0.53	0.58		0.2	0.62	0.61		0.02	0.099	0.107	
Sulphate (Dissolved)	5	390	382	2.07%	5	399	392	1.77%	0.5	30.4	30.6	0.66%
Nutrients												
Ammonia (Total)	0.005	0.0536	0.0569	5.97%	0.005	0.0528	0.0537	1.69%	0.005	<0.005	<0.005	
Nitrate (as N)	0.05	<0.05	<0.05		0.05	<0.05	<0.05		0.005	0.0838	0.0841	0.36%
Nitrate+Nitrite (Dissolved)												
Nitrite (as N)	0.01	<0.01	<0.01		0.01	0.01	0.013		0.001	<0.001	<0.001	
Nitrogen (Total)	0.05	<0.05	<0.05		0.05	<0.05	<0.05		0.05	0.165	0.17	
Nitrogen Kjeldahl (Total)	0.05	0.107	0.103		0.05	0.097	0.094		0.05	0.081	0.086	
Orthophosphate (Dissolved)	0.001	<0.001	<0.001						0.001	<0.001	<0.001	
Phosphate (Dissolved)												
Phosphorus (Nutrient) Dissolved	0.02	0.025	<0.02		0.002	<0.002	<0.002		0.002	0.0025	0.002	
Phosphorus (Nutrient) Total	0.02	<0.02	<0.02		0.002	0.0078	0.0046		0.002	0.0025	0.0023	
Cyanide												
Cyanide (Free)	0.005	<0.005	<0.005		0.005	<0.005	<0.005		0.005	<0.005	<0.005	
Cyanide (SAD)												
Cyanide (Total)	0.005	<0.005	<0.005		0.005	<0.005	<0.005		0.005	<0.005	<0.005	
Cyanide (WAD)	0.005	<0.005	<0.005		0.005	<0.005	<0.005		0.005	<0.005	<0.005	
Dissolved Metals												
Aluminum (Dissolved	0.001	0.0234	0.0227	3.04%	0.001	0.0208	0.0203	2.43%	0.001	0.0013	<0.001	
Antimony (Dissolved)	0.0001	<0.0001	<0.0001		0.0001	<0.0001	<0.0001		0.0001	<0.0001	<0.0001	
Arsenic (Dissolved)	0.0001	0.00191	0.00197	3.09%	0.0001	0.0019	0.00208	9.05%	0.0001	0.00539	0.00528	2.06%
Barium (Dissolved)	0.00005	0.0102	0.00995	2.48%	0.00005	0.0106	0.0103	2.87%	0.00005	0.0242	0.023	5.08%
Beryllium (Dissolved)	0.0001	0.00033	0.00033		0.0001	0.00031	0.00031		0.0001	<0.0001	<0.0001	
Bismuth (Dissolved)	0.0005	<0.0005	<0.0005		0.0005	<0.0005	<0.0005		0.0005	<0.0005	<0.0005	
Boron (Dissolved)	0.01	<0.01	<0.01		0.01	<0.01	<0.01		0.01	<0.01	<0.01	
Cadmium (Dissolved)	0.00001	0.000788	0.000761	3.49%	0.00001	0.000447	0.000491	9.38%	0.00001	0.000334	0.000379	12.62%
Calcium (Dissolved)	0.05	143	144	0.70%	0.05	141	139	1.43%	0.05	48.7	52.1	6.75%
Chromium (Dissolved	0.0001	0.00012	0.00015		0.0001	<0.0001	<0.0001		0.0001	0.00091	0.00041	
Cobalt (Dissolved)	0.0001	0.0383	0.0384	0.26%	0.0001	0.0361	0.0368	1.92%	0.0001	<0.0001	<0.0001	
Copper (Dissolved)	0.0002	0.00043	0.0003		0.0002	<0.0002	<0.0002		0.0002	0.00075	0.00063	
Iron (Dissolved)	0.01	35.2	35.7	1.41%	0.01	36	35.4	1.68%	0.01	<0.01	<0.01	
Lead (Dissolved)	0.00005	0.000938	0.000918	2.16%	0.00005	0.000587	0.000605	3.02%	0.00005	<0.00005	<0.00005	
Lithium (Dissolved)	0.0005	0.00198	0.00182		0.0005	0.00129	0.00102		0.0005	0.00623	0.00303	**69.11%**
Magnesium (Dissolved)	0.1	24.6	24.5	0.41%	0.1	24.9	24.5	1.62%	0.1	12.8	13.3	3.83%
Manganese (Dissolved)	0.00005	3.85	3.78	1.83%	0.00005	3.99	4.01	0.50%	0.00005	0.000537	0.000425	**23.28%**
Mercury (Dissolved) unitless	0.00001	<0.00001	<0.00001		0.00001	<0.00001	<0.00001		0.00001	<0.00001	<0.00001	
Molybdenum (Dissolved)	0.00005	0.000126	0.000123		0.00005	0.000119	0.000112		0.00005	0.000841	0.00057	**38.41%**
Nickel (Dissolved)	0.0005	0.00288	0.00287	0.35%	0.0005	0.00265	0.00257	3.07%	0.0005	<0.0005	<0.0005	
Phosphorus (Metal) Dissolved	0.05	<0.05	<0.05		0.05	<0.05	<0.05		0.05	<0.05	<0.05	
Potassium (Dissolved)	0.1	2.58	2.5	3.15%	0.1	2.34	2.25	3.92%	0.1	2.59	1.6	**47.26%**
Selenium (Dissolved	0.0001	<0.0001	<0.0001		0.0001	<0.0001	<0.0001		0.0001	<0.0001	<0.0001	
Silicon (Dissolved)	0.05	3.81	3.82	0.26%	0.05	3.69	3.6	2.47%	0.05	4.02	4.03	0.25%
Silver (Dissolved)	0.00001	<0.00001	<0.00001		0.00001	<0.00001	<0.00001		0.00001	<0.00001	<0.00001	
Sodium (Dissolved)	0.05	7.59	7.68	1.18%	0.05	8.45	8.55	1.18%	0.05	9.03	4.69	**63.27%**
Strontium (Dissolved)	0.0002	0.365	0.374	2.44%	0.0002	0.361	0.36	0.28%	0.0002	0.201	0.198	1.50%
Sulphur (Dissolved	0.5	122	124	1.63%	0.5	125	125	0.00%	0.5	10.4	10.1	2.93%
Thallium (Dissolved	0.00001	0.000017	0.000016		0.00001	0.000016	0.000016		0.00001	<0.00001	<0.00001	
Tin (Dissolved)	0.0001	<0.0001	<0.0001		0.0001	<0.0001	<0.0001		0.0001	<0.0001	<0.0001	
Titanium (Dissolved)	0.01	<0.01	<0.01		0.01	<0.01	<0.01		0.01	<0.01	<0.01	
Uranium (Dissolved	0.00001	0.00669	0.00662	1.05%	0.00001	0.00829	0.00822	0.85%	0.00001	0.00677	0.00711	4.90%
Vanadium (Dissolved	0.001	<0.001	<0.001		0.001	<0.001	<0.001		0.001	<0.001	<0.001	
Zinc (Dissolved)	0.001	0.138	0.138	0.00%	0.001	0.106	0.109	2.79%	0.001	0.0302	0.0329	8.56%
Total Metals												
Aluminum (Total)	0.003	0.0584	0.0575	1.55%	0.003	0.559	0.384	**37.12%**	0.003	0.0042	0.0131	
Antimony (Total)	0.0001	<0.0001	<0.0001		0.0001	0.00011	<0.0001		0.0001	<0.0001	<0.0001	
Arsenic (Total)	0.0001	0.002	0.002	0.00%	0.0001	0.00241	0.00242	0.41%	0.0001	0.00553	0.00553	0.00%
Barium (Total)	0.00005	0.0103	0.0103	0.00%	0.00005	0.0167	0.0176	5.25%	0.00005	0.0259	0.0291	11.64%
Beryllium (Total)	0.0001	0.00035	0.00033		0.0001	0.00037	0.00035		0.0001	<0.0001	<0.0001	
Bismuth (Total)	0.0005	<0.0005	<0.0005		0.0005	<0.0005	<0.0005		0.0005	<0.0005	<0.0005	
Boron (Total)	0.01	<0.01	<0.01		0.01	<0.01	<0.01		0.01	0.01	<0.01	
Cadmium (Total)	0.00001	0.0008	0.000844	5.35%	0.00001	0.00115	0.000943	19.78%	0.00001	0.000376	0.00038	1.06%
Calcium (Total)	0.05	145	144	0.69%	0.05	143	143	0.00%	0.05	52.3	53.1	1.52%
Chromium (Total)	0.0001	0.00032	0.00031		0.0001	0.00046	0.0004		0.0001	0.00087	0.00096	9.84%
Cobalt (Total)	0.0001	0.04	0.0397	0.75%	0.0001	0.038	0.0387	1.83%	0.0001	<0.0001	<0.0001	
Copper (Total)	0.0005	0.00096	0.0012		0.0005	0.00277	0.00198		0.0005	0.00106	0.0011	
Iron (Total)	0.01	36.1	36.1	0.00%	0.01	37.1	37.7	1.60%	0.01	<0.01	0.011	
Lead (Total)	0.00005	0.00118	0.0012	1.68%	0.00005	0.0209	0.00543	**117.51%**	0.00005	0.000071	0.000087	
Lithium (Total)	0.0005	0.00234	0.00199		0.0005	0.00175	0.00153		0.0005	0.0023	0.00255	
Magnesium (Total)	0.1	25.7	25.8	0.39%	0.1	25.3	25.7	1.57%	0.1	13.4	13.6	1.48%
Manganese (Total)	0.00005	4	3.92	2.02%	0.00005	4.2	4.17	0.72%	0.00005	0.000827	0.00109	**27.44%**
Mercury (Total)	0.00001	<0.00001	<0.00001		0.00001	<0.00001	<0.00001		0.00001	<0.00001	<0.00001	
Molybdenum (Total)	0.00005	0.000208	0.000153		0.00005	0.0002	0.000175		0.00005	0.000564	0.00059	4.51%
Nickel (Total)	0.0005	0.00304	0.00301	0.99%	0.0005	0.0031	0.00298	3.95%	0.0005	<0.0005	<0.0005	
Phosphorus (Metal) Total	0.05	<0.05	<0.05		0.05	<0.05	<0.05		0.05	<0.05	<0.05	
Potassium (Total)	0.1	2.81	2.91	3.50%	0.1	2.45	2.48	1.22%	0.1	1.31	1.46	10.83%
Selenium (Total)	0.0001	<0.0001	<0.0001		0.0001	<0.0001	<0.0001		0.0001	<0.0001	<0.0001	
Silicon (Total)	0.05	3.98	4	0.50%	0.05	5.21	4.81	7.98%	0.05	4	4.11	2.71%
Silver (Total)	0.00001	<0.00001	<0.00001		0.00001	0.000046	0.000033		0.00001	<0.00001	<0.00001	
Sodium (Total)	0.05	8.03	7.77	3.29%	0.05	9.07	9.12	0.55%	0.05	4.61	4.4	4.66%
Strontium (Total)	0.0002	0.383	0.389	1.55%	0.0002	0.385	0.373	3.17%	0.0002	0.207	0.213	2.86%
Sulphur (Total)	0.5	127	126	0.79%	0.5	131	131	0.00%	0.5	10.1	10.2	0.99%
Thallium (Total)	0.00001	0.000016	0.000016		0.00001	0.000025	0.000023		0.00001	<0.00001	<0.00001	
Tin (Total)	0.0001	<0.0001	<0.0001		0.0001	<0.0001	<0.0001		0.0001	<0.0001	<0.0001	
Titanium (Total)	0.01	<0.01	<0.01		0.01	0.014	<0.01		0.01	<0.01	<0.01	
Uranium (Total)	0.00001	0.00698	0.00679	2.76%	0.00001	0.00933	0.00903	3.27%	0.00001	0.00752	0.00772	2.62%
Vanadium (Total)	0.001	<0.001	<0.001		0.001	<0.001	<0.001		0.001	<0.001	<0.001	
Zinc (Total)	0.003	0.139	0.143	2.84%	0.003	0.119	0.119	0.00%	0.003	0.0366	0.0354	3.33%
Organics												
Carbon Organic (Dissolved)	0.5	1.61	1.37		0.5	1.38	1.36		0.001	<0.001	<0.001	
Carbon Organic (Total)	0.5	1.52	1.1		0.5	1.73	1.59		0.003	0.0366	0.0354	3.33%

NOTES:
1. UNITS ARE mg/L UNLESS OTHERWISE STATED.
2. BOLD RED INDICATES THE RPD [RELATIVE PERCENT DIFFERENCE] EXCEEDS THE 20% DATA QUALITY OBJECTIVE FOR VALUES GREATER THAN 5 TIMES THE MDL.

APPENDIX F

GROUNDWATER QUALITY DATA TABLES

(Pages F-1 to F-17)

APPENDIX F - GROUNDWATER QUALITY DATA

CASINO COPPER-GOLD PROJECT
TABLE F1 - GUIDELINES AND STANDARDS

	CCME[2]	YCSR [3,4]
Physical Tests		
pH (pH)	6.5 to 9	
Dissolved Anions		
Chloride	640	
Fluoride	0.12	2 @ H < 50 [5] 3 @ H >= 50 [5]
Sulphate		1000
Nutrients		
Ammonia (Total)	0.017 to 192 [6,7]	1.31 to 200 [6,7]
Nitrate (as N)	3 (LTE) [11] / 124 (STE) [10]	400
Nitrate+Nitrite (Dissolved)		400
Nitrite (as N)	0.06	0.2 to 2 [8]
Cyanide		
Cyanide (WAD)		0.05
Metals		
Aluminum	0.005 to 0.1 [6]	
Antimony		0.2
Arsenic	0.005	0.05
Barium		10
Beryllium		0.053
Cadmium	0.000036 to $10^{(0.83*(\log(H)-2.46)}$/1000 to 0.000373 [11,5] 0.000106 to $10^{(1.016*(\log(H)-1.71)}$/1000 to 0.0077 [10,5]	0.0001 to 0.0006 [5]
Chromium	0.001 (Cr VI) [9] 0.0089 (Cr III)	0.006 (Cr VI) [9] 0.090 (Cr III)
Cobalt		0.009
Copper	$e^{(0.8545*\ln(H)-1.465)}$ 0.2/1000 to 0.004 [5]	0.020 to 0.090 [5]
Iron	0.3	
Lead	0.001 to $e^{1.273*\ln(H)-4.705}$/1000 to 0.007 [5]	0.040 to 0.160 [5]
Mercury	0.000026	0.001
Molybdenum	0.073	10
Nickel	e $^{((0.76*\ln(H)+1.06))}$ /1000 to 0.15 [5]	0.250 to 1.5 [5]
Selenium	0.001	0.01
Silver	0.0001	0.0005 to 0.015 [5]
Thallium	0.0008	0.003
Uranium	0.015	3
Zinc	0.03	0.075 to 2.4 [5]

M:\1\01\00325\17\A\Report\1-2013 Hydrogeology\Appendices\Appendix F - Groundwater Quality Data Tables\[Tables F1-F4 - Updated2014.xlsx]F1 - GUIDELINES AND STANDARDS

NOTES:

1. UNITS ARE IN mg/L UNLESS OTHERWISE STATED.
2. CCME - CANADIAN COUNCIL OF MINSTERS FOR THE ENVIRONMENT - CANADIAN ENVIRONMENTAL QUALITY GUIDELINES - WATER QUALITY GUIDELINE FOR THE PROTECTION OF AQUATIC LIFE (CEQG-PAL) - FRESHWATER.
3. YCSR - YUKON CONTAMINATED SITES REGULATION - GENERIC NUMERICAL WATER STANDARDS - SCHEDULE 3 - COLUMN 2 - YUKON ENVIRONMENT ACT (O.I.C. 2002/171).
4. YCSR AQUATIC LIFE STANDARDS ASSUME A MINIMUM 1:10 DILUTION IS AVAILABLE.
5. HARDNESS (H) DEPENDENT GUIDELINE LIMIT (DISSOLVED).
6. pH DEPENDENT GUIDELINE LIMIT (*IN SITU* VALUE PREFFERED).
7. TEMPERATURE DEPENDENT GUIDELINE LIMIT.
8. CHLORIDE (DISSOLVED) DEPENDENT GUIDELINE LIMIT.
9. Cr III (TRIVALENT CHROMIUM) GUIDELINES WERE ASSUMED FOR COMPARISON TO THE GROUNDWATER CHEMISTRY DATA.
10. STE - SHORT TERM EXPOSURE LIMIT.
11. LTE - LONG-TERM EXPOSURE LIMIT.
12. THIS SHADING INDICATES THAT THE VALUE EXCEEDS THE CCME LIMIT.
13. THIS SHADING INDICATES THAT THE VALUE EXCEEDS THE LIMITS OF THE YCSR.
14. THIS SHADING INDICATES THAT THE VALUE EXCEEDS BOTH THE CCME AND YCSR LIMITS.
15. ITALICIZED TEXT INDICATES SAMPLES THAT WERE COLLECTED IN 2013 AND 2014.

Site ID Date/Time Sampled	MDL	94-337 24-Sep-94	94-337 3-Feb-95	94-337 24-May-95	94-337 10-Sep-08	94-337 21-Sep-09	94-337 6-Jun-10	94-337 18-Aug-10	94-337 14-Sep-10	94-337 22-May-11	94-337 15-Jul-11	94-337 19-Sep-11	94-337 28-May-12
Calculated Parameters													
Ion Balance Ratio	0.01					1.1							
Physical Tests													
Acidity to pH 4.5 (as CaCO3)	0.5					<0.5	<0.5	<0.5	<0.5				<0.5
Acidity to pH 8.3 (as CaCO3)	0.5					14.5	18.1	30.6	7.5				26
Alkalinity (PP as CaCO3)	0.5									<0.5	<0.5	<0.5	
Alkalinity (Total as CaCO3)	0.5	6	8.8	5.4	5	12	2.1	6.9	7.1	1.8	6.3	6.2	6.64
Bicarbonate Alkalinity	0.5									2.2	7.6	7.6	
Carbonate Alkalinity	0.5									<0.5	<0.5	<0.5	
Conductivity µS/cm	1	320	315	301	280	310	259	272	266	253	235	247	246
Hardness as CaCO3 (Dissolved)	0.5				101	103	99.6	94.5	93.5	92	94.2	86.7	82.3
Hardness as CaCO3 (Total)	0.5	121	125	121						97.7	91.1	45	91.2
Hydroxide Alkalinity	0.5									<0.5	<0.5	<0.5	
pH (pH)	0	5.32	5.62	5.31	6.2	6.16	5.89	5.74	5.98	5.82	7.05	6.02	5.95
Total Dissolved Solids	1.0 to 10.0	219	206	242	200	180	190	150	200	170	200	190	166
Total Suspended Solids	1	51	366	22	47					2	3	7	2.1
Turbidity (NTU)	0.1	51.6	257	29.8	50.2					16.6	8.2	10.3	16
Dissolved Anions													
Bromide	0.01 to 0.4				<0.1	<0.4	<0.4	<0.4	<0.4				<0.01
Chloride	0.5	<0.6	<0.5	<0.5	0.6	1.3	<0.5		<0.5	0.6	1	1.2	1.2
Fluoride	0.01	1.64	1.16	1.41	1.24	1.24	1.2	1	1.16	1.14	1.2	1.3	1.1
Sulphate	0.5 to 5.0	130	121	134	110	98	110	110	110	100	100	92	104
Thiocyanate	0.2						<0.2						
Nutrients													
Ammonia (Total)	0.005 to 0.01	0.019	<0.005	0.008	0.02	0.01	0.022	0.05	<0.005	0.014	0.036	0.058	0.02
Nitrate (as N)	0.002 to 0.02	<0.02	<0.02	<0.02	0.006	<0.002	0.007	<0.002	<0.002	<0.02	<0.02	<0.02	<0.002
Nitrate+Nitrite (Dissolved)	0.002 to 0.02				0.014	0.011	0.007	0.003	0.003	<0.02	<0.02	<0.02	<0.002
Nitrite (as N)	0.002 to 0.005	<0.005	<0.005	<0.005	0.008	0.011	<0.002	0.004	0.005	0.006	<0.005	<0.005	0.0051
Nitrogen (Total)	0.02				0.05	0.05	0.04	0.21	0.07				0.098
Nitrogen Kjeldahl (Total)	0.02				0.04	0.04	0.03	0.21	0.06				0.098
Orthophosphate (Dissolved)	0.001 to 0.005	<0.005	<0.005	<0.005	0.008	0.001	0.004	0.002	0.007	0.031	<0.005		0.0039
Phosphorus Dissolved	0.002 to 0.01	0.003	0.005	0.003	<0.002		0.005	0.003	0.005				
Cyanide													
Cyanide (SAD)	0.001					0.004							
Cyanide (WAD)	0.0005				<0.0005	<0.0005	<0.0005	<0.0005	<0.0005				<0.0005
Cyanide+Thiocyanate	0.0005 to 0.001	<0.001	<0.001	<0.001	<0.0005		<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0541	<0.0005
Dissolved Metals													
Aluminum	0.0002 to 0.003	0.971	0.753	0.904	0.515	0.686	0.683	0.63	0.628	0.6	0.665	0.633	0.611
Antimony	0.00002 to 0.0005	0.0001	<0.0001	<0.0001	0.00004	0.00005	0.00006	0.00006	0.00005	<0.0005	<0.0005	<0.0005	0.000054
Arsenic	0.00002 to 0.001	0.0011	0.0003	0.0009	0.00011	0.00071	0.00079	0.00077	0.00072	0.0007	0.0007	0.0006	0.000625
Barium	0.00002 to 0.001	0.029	0.035	0.019	0.0138	0.0111	0.011	0.011	0.0106	0.01		0.01	0.0105
Beryllium	0.00001 to 0.005	<0.005	<0.005	<0.005	0.00137	0.00141	0.0014	0.00143	0.00133	0.0013	0.0013	0.0012	0.00136
Bismuth	0.000005 to 0.1	<0.1	<0.1	<0.1	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.001	<0.001	<0.001	<0.000005
Boron	0.05 to 0.3	<0.1	<0.1	<0.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cadmium	0.000005 to 0.00003	0.0084	0.0085	0.0073	0.00714	0.00772	0.00743	0.00743	0.00717	0.007	0.00682	0.00633	0.00607
Calcium	0.05 to 0.3	38.2	39.5	38.1	32.1	32.7	30.8	29.7	29.4	29	29.7	27.5	25.9
Chromium	0.0001 to 0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.001	<0.001	<0.001	<0.0001
Cobalt	0.000005 to 0.001	0.1	0.107	0.081	0.0821	0.0814	0.0811	0.0794	0.0777	0.074	0.0772	0.0723	0.0691
Copper	0.00005 to 0.0003	2.39	1.69	2.07	1.89	1.94	1.82	1.73	1.77	1.67	1.84	1.92	1.81
Iron	0.001 to 0.03	5.3	1.89	6.81	2.16	6.03	6.2	6.12	5.96	5.81	5.9	5.24	5.41
Lead	0.000005 to 0.001	<0.001	0.002	0.002	0.000355	0.00194	0.00205	0.00176	0.00185	0.0018	0.0018	0.0015	0.00155
Lithium	0.0005 to 0.005				0.0202	0.0202	0.0202	0.0195	0.0203	0.018	0.019	0.019	0.0182
Magnesium	0.001 to 0.3	6.34	6.26	6.23	5.15	5.31	5.47	4.98	4.88	4.74	4.85	4.35	4.3
Manganese	0.00002 to 0.005	1.02	1.04	0.937	0.787	0.745	0.739	0.712	0.718	0.726		<0.00002	0.656
Mercury	0.00000001 to 0.00005				<0.00001		<0.00001	<0.00001	0.00001	<0.00002	<0.00002		<0.00001
Molybdenum	0.00005 to 0.001	<0.001	<0.001	<0.001	0.00008	0.00128	0.00132	0.00133	0.00134	0.001	0.001	0.001	0.00133
Nickel	0.00002 to 0.001	0.038	0.024	0.016	0.0165	0.0165	0.0163	0.0158	0.0156	0.015	0.016	0.015	0.0144
Phosphorus	0.002 to 0.01												0.0091
Potassium	0.05 to 0.3	1.91	2.03	1.96	1.55	1.61	1.58	1.51	1.52	1.55	1.58	1.91	1.44
Selenium	0.00004 to 0.0005	<0.0005	<0.0005	<0.0005	0.00013	0.00013	0.00012	0.00012	0.00011	0.0001	0.0001	0.0001	0.000116
Silicon	0.1 to 0.5	9.55	9.61	9.64	8.9	9.8	9.9	9	9.6	9.61	9.94	9.2	9.09
Silver	0.000005 to 0.0001	<0.0001	<0.0001	<0.0001	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.00002	<0.00002	<0.00002	<0.000005
Sodium	0.05 to 0.3	5.72	4.39	5.12	3.92	4.23	4.32	3.99	3.97	3.88	4.01	3.89	4.06
Strontium	0.00005 to 0.001	0.237	0.244	0.229	0.199	0.195	0.192	0.187	0.184	0.181		0.175	0.172
Sulphur	1.0 to 50.0				38	40	42	37	38	38	37	33	31
Thallium	0.000002 to 0.00005				0.000039	0.00004	0.000037	0.00004	0.000039	<0.00005	<0.00005	<0.00005	0.0000419
Tin	0.00001 to 0.005				0.00033	<0.00001	0.00002	<0.00001	<0.00001	<0.005	<0.005	<0.005	<0.0002
Titanium	0.0005 to 0.01		<0.01	<0.01	0.0008	<0.0005	<0.0005	<0.0005	0.001	<0.005	<0.005	<0.005	<0.0005
Uranium	0.000002 to 0.0001	0.00048	0.00036	0.00055	0.00063	0.00122	0.00121	0.00101	0.00114	0.0011	0.0011	0.0008	0.00101
Vanadium	0.0002 to 0.03	<0.03	<0.03	<0.03	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.005	<0.005	<0.005	<0.0002
Zinc	0.0001 to 0.005	0.503	0.496	0.528	0.434	0.444	0.452	0.43	0.427	0.419	0.428	0.505	0.391
Zirconium	0.0001 to 0.005				<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0005	<0.0005	<0.0005	<0.0001
Total Metals													
Aluminum	0.0002 to 0.006	1.5	4.49	1.44						0.676	0.643	0.95	0.678
Antimony	0.00002 to 0.001	0.0002	0.0014	<0.0005						<0.0005	<0.0005	<0.001	0.000062
Arsenic	0.00002 to 0.0002	0.0016	0.0092	0.0017						0.0007	0.0005	0.0002	0.000705
Barium	0.00002 to 0.002	0.047	0.159	0.029						0.011	0.01	0.012	0.0109
Beryllium	0.00001 to 0.005	<0.005	<0.005	<0.005						0.0013	0.0014	0.0015	0.0013
Bismuth	0.000005 to 0.1	<0.1	<0.1	<0.1						<0.001	<0.001	<0.002	<0.000005
Boron	0.05 to 0.25	<0.1	<0.1	<0.1						<0.05	<0.05	<0.1	<0.05
Cadmium	0.000005 to 0.00005	0.011	0.009	0.0077						0.00684	0.00625	0.00824	0.00623
Calcium	0.05 to 0.25	40.8	45.6	38.8						30.7	28.6	7.4	28.8
Chromium	0.0001 to 0.002	<0.001	0.018	<0.001						<0.001	<0.001	<0.002	<0.0001
Cobalt	0.000005 to 0.001	0.11	0.135	0.084						0.0832	0.0749	0.097	0.0748
Copper	0.00005 to 0.0004									1.98	1.84	2.7	1.96
Iron	0.001 to 0.01	7.18	1.76	7.36						6.64	5.89	7.24	5.76
Lead	0.000005 to 0.001	<0.001	0.125	0.006						0.002	0.0018	0.0031	0.00173
Lithium	0.0005 to 0.01									0.019	0.021	0.02	0.0187
Magnesium	0.001 to 0.25	6.7	8.22	6.45						5.09	0.707	6.4	4.67
Manganese	0.00005 to 0.002	1.08	1.24	0.958								0.928	0.702
Mercury	0.00001 to 0.00005	<0.00001	0.00016	<0.00001						<0.00002	<0.00002	<0.00002	<0.00001
Molybdenum	0.00005 to 0.002	0.003	0.007	<0.001						0.001	0.001	<0.002	0.00135
Nickel	0.00002 to 0.002	0.043	0.051	0.017						0.017	0.015	0.021	0.0158
Phosphorus	0.000002 to 0.01	0.000028	0.000118	0.000023									0.0066
Potassium	0.05 to 0.25									1.58	1.51	2	1.6
Selenium	0.00004 to 0.1	<0.0005	<0.0005	<0.0005						<0.0001	<0.0001	<0.0002	0.000147
Silicon	0.1 to 0.5	10.8	15.3	11						9.85		11.4	10.3
Silver	0.000005 to 0.0001	<0.0001	0.0002	<0.0001						<0.00002	<0.00002	<0.00004	0.0000189
Sodium	0.05 to 0.25									4.37	4.09	1840	4.4
Strontium	0.00005 to 0.002	0.246	0.288	0.238						0.2	0.183	0.13	0.174
Sulphur	3.0 to 50.0									36	34	41	37
Thallium	0.000002 to 0.0001									<0.00005	<0.00005	<0.0001	0.0000418
Tin	0.0002 to 0.01									<0.005	<0.005	<0.01	<0.0002
Titanium	0.0005 to 0.01		0.136	0.013								<0.01	<0.0005
Uranium	0.000002 to 0.0002	0.00114	0.00252	0.00078						0.0012	0.0011	0.0015	0.00108
Vanadium	0.0002 to 0.03	<0.03	<0.03	<0.03						<0.005	<0.005	<0.01	<0.0002
Zinc	0.0001 to 0.01	0.529	0.585	0.559						0.424	0.403	0.64	0.41
Zirconium	0.0001 to 0.001									<0.0005	<0.0005	<0.001	<0.0001
Organics													
Dissolved Organic Carbon													
Total Organic Carbon	0.5 to 5.0	0.9	2	0.8	1.6	2	1.5	0.7	1.1	0.8	1.1	1.2	<5

NOTES:
1. UNITS ARE IN mg/L UNLESS OTHERWISE STATED.
2. REFER TO TABLE F1 FOR DETAILED FOOTNOTES ON CELL SHADING.

Site ID Date/Time Sampled	MDL	94-337 17-Sep-12	94-337 10-Jun-13	94-337 5-Aug-13	94-337 26-Sep-13	94-337 24-May-14	94-337 22-Jul-14	94-337 28-Sep-14	HG10-01 19-Aug-10	HG10-01 14-Sep-10	HG10-01 15-Jul-11	HG10-01 18-Sep-11	HG10-01 28-May-12
Calculated Parameters													
Ion Balance Ratio	0.01	1.1						0.89					0.92
Physical Tests													
Acidity to pH 4.5 (as CaCO3)	0.5	<0.5							<0.5	<0.5			<0.5
Acidity to pH 8.3 (as CaCO3)	0.5	16.2	45.3	20.9					60.4	15			56
Alkalinity (PP as CaCO3)	0.5										<0.5	<0.5	
Alkalinity (Total as CaCO3)	0.5	6.36	6.5	6.4	10.2	5.2	10.1	4.8	110	120	120	120	125
Bicarbonate Alkalinity	0.5		6.5	6.4	10.2	5.2		4.8			150	150	
Carbonate Alkalinity	0.5		<2	<2	<2	<1		<1			<0.5	<0.5	
Conductivity µS/cm	1	240	225	235	229	233	244	233	1750	1700	1630	1610	1610
Hardness as CaCO3 (Dissolved)	0.5	88		83.6	82	87.3	92	84.5	992	1010	970	944	899
Hardness as CaCO3 (Total)	0.5	89.2	90.2								910	1060	917
Hydroxide Alkalinity	0.5		<2	<2	<2	<1		<1			<0.5	<0.5	
pH (pH)	0	5.98	5.99	6.06	6.55	6.11	6.03	5.97	7.04	7.13	7.05	7.18	7.04
Total Dissolved Solids	1.0 to 10.0	184	178	195	184	180	209	178	1500	1500	1500	1400	1380
Total Suspended Solids	1	14.2	16.4	<3	<3	5.7	<3	<3			10	16	5
Turbidity (NTU)	0.1	18.1	21.3	4.06	6.94	8.48	7.5	9.08			21.9	91.5	55.4
Dissolved Anions													
Bromide	0.01 to 0.4	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.4	0.4			<0.05
Chloride	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5		0.6	1	1.4	1.4
Fluoride	0.01	1.1	1.2	1.31	1.34	1.23	1.25	1.16	0.58	0.6	0.06	0.67	0.61
Sulphate	0.5 to 5.0	89.4	96.6	97.3	95.6	94.7	97.6	94	880	1000	850	830	900
Thiocyanate	0.2												
Nutrients													
Ammonia (Total)	0.005 to 0.01	0.032	0.0081	0.0121	0.0106	0.0109	0.0092	0.0097	0.074	0.025	0.054	0.077	0.043
Nitrate (as N)	0.002 to 0.02	<0.002	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.002	<0.002	<0.02	<0.02	<0.002
Nitrate+Nitrite (Dissolved)	0.002 to 0.02	0.0034						<0.001	0.005	0.002	<0.02	<0.02	<0.002
Nitrite (as N)	0.002 to 0.005	0.0078	<0.001	<0.001	<0.001	<0.001	<0.001	0.184	0.008	0.003	0.005	0.01	0.0041
Nitrogen (Total)	0.02	0.135	0.056	<0.05	<0.05	0.063	0.069	0.184	0.03	0.1			0.128
Nitrogen Kjeldahl (Total)	0.02	0.132	0.056	0.053	<0.05	0.063	0.069		0.03	0.1			0.128
Orthophosphate (Dissolved)	0.001 to 0.005	0.0029	<0.001			<0.001		<0.002	0.002	0.001	<0.005		0.0037
Phosphorus Dissolved	0.002 to 0.01		<0.02	<0.002	<0.002	<0.002	<0.002	<0.002	<0.01	<0.01			
Cyanide													
Cyanide (SAD)	0.001							<0.005					
Cyanide (WAD)	0.0005	<0.0005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.0005	<0.0005			<0.0005
Cyanide+Thiocyanate	0.0005 to 0.001	<0.0005						<0.005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Dissolved Metals													
Aluminum	0.0002 to 0.003	0.657	0.562	0.635	0.632	0.546	0.579	0.611	0.035	0.032	0.023	0.021	0.0271
Antimony	0.00002 to 0.0005	0.00006	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	0.0001	<0.0005	<0.0005	<0.0001
Arsenic	0.00002 to 0.001	0.000636	0.00073	0.00063	0.0006	0.00064	0.00066	0.00063	0.0172	0.0195	0.0158	0.0163	0.0168
Barium	0.00002 to 0.001	0.0156	0.0119	0.0118	0.0117	0.0124	0.0116	0.0115	0.0086	0.008		0.005	0.00745
Beryllium	0.00001 to 0.005	0.00131	0.00115	0.00126	0.00126	0.00117	0.00126	0.00127	<0.00005	<0.00005	<0.0001	<0.0001	<0.00005
Bismuth	0.000005 to 0.1	<0.000005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00003	<0.00003	<0.001	<0.001	<0.000025
Boron	0.05 to 0.3	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.3	<0.3	<0.05	<0.05	<0.25
Cadmium	0.000005 to 0.00003	0.00586	0.00587	0.00589	0.00581	0.00561	0.00599	0.00595	0.0001	0.00009	<0.00001	0.00003	<0.000025
Calcium	0.05 to 0.3	28.2	28.9	26.5	26	27.8	29.2	26.8	318	324	312	306	289
Chromium	0.0001 to 0.001	0.00519	0.00369	0.00184	0.0018	0.0035	0.00116	0.00195	<0.0005	<0.0005	<0.001	<0.001	<0.0005
Cobalt	0.000005 to 0.001	0.0708	0.0681	0.0694	0.0663	0.0661	0.0693	0.0705	0.0399	0.0403	0.0335	0.0271	0.0313
Copper	0.00005 to 0.0003	1.85	1.69	1.87	1.88	1.71	1.8	1.93	<0.0003	0.0003	<0.0002	0.0004	0.00203
Iron	0.001 to 0.03	5.78	5.52	5.32	5.17	5.32	5.69	5.26	28	28.1	23.5	22.3	22.9
Lead	0.000005 to 0.001	0.00112	0.00661	0.00143	0.00157	0.00213	0.000952	0.00165	0.00018	0.00017	<0.0002	<0.0002	0.000093
Lithium	0.0005 to 0.005	0.019	0.0165	0.0208	0.0185	0.0168	0.0176	0.0177	0.007	0.007	0.007	0.005	0.0081
Magnesium	0.001 to 0.3	4.26	4.41	4.25	4.13	4.35	4.64	4.25	47.7	47.9	46.5	44.1	43
Manganese	0.00002 to 0.005	0.668	0.638	0.626	0.625	0.658	0.662	0.624	1.12	1.17		<0.00002	0.959
Mercury	0.00000001 to 0.00005	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00005	<0.00005	<0.00002		<0.00005
Molybdenum	0.00005 to 0.001	0.00202	0.00187	0.0013	0.00136	0.00166	0.0014	0.00135	0.0167	0.0171	0.017	0.013	0.0157
Nickel	0.00002 to 0.001	0.0256	0.0185	0.0154	0.0159	0.0174	0.0152	0.0164	0.008	0.0041	0.003	0.003	0.00354
Phosphorus	0.002 to 0.01	0.0039	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05					0.019
Potassium	0.05 to 0.3	1.52	1.74	1.54	1.5	1.57	1.57	1.47	3.4	3.7	3.68	3.38	3.26
Selenium	0.00004 to 0.0005	0.000178	0.00012	0.00011	0.00012	<0.0001	0.0001	0.00011	<0.0002	<0.0002	<0.0001	<0.0001	<0.0002
Silicon	0.1 to 0.5	10.2	9.3	9.34	9.5	9.36	9.54	9.48	4.3	4.8	4.67	4.3	4.33
Silver	0.000005 to 0.0001	<0.000005	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00003	<0.00003	<0.00002	<0.00002	<0.000025
Sodium	0.05 to 0.3	4.2	3.83	4.63	4.22	3.89	4.34	4.32	14.1	14.5	13.9	13.3	13.9
Strontium	0.00005 to 0.001	0.175	0.167	0.159	0.166	0.166	0.173	0.161	1.71	1.65		1.69	1.67
Sulphur	1.0 to 50.0	32	32.5	31.4	32	31.5	32.9	32.2	311	332	311	288	280
Thallium	0.000002 to 0.00005	0.000041	0.000043	0.000039	0.000039	0.000041	0.000037	0.000041	0.00002	0.00001	<0.00005	<0.00005	<0.00001
Tin	0.00001 to 0.005	<0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.00005	<0.00005	<0.005	<0.005	<0.001
Titanium	0.0005 to 0.01	<0.0005	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.003	0.006	<0.005	<0.005	<0.0025
Uranium	0.000002 to 0.0001	0.000931	0.00103	0.000955	0.000897	0.000952	0.001	0.00094	0.0489	0.0393	0.0398	0.0324	0.0364
Vanadium	0.0002 to 0.03	<0.0002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.005	<0.001
Zinc	0.0001 to 0.005	0.407	0.382	0.489	0.378	0.359	0.391	0.392	0.156	0.159	0.08	0.096	0.0699
Zirconium	0.0001 to 0.005	<0.0001							<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Total Metals													
Aluminum	0.0002 to 0.006	0.793	0.787	0.67	0.705	0.572	0.591	0.598			0.022	0.025	0.0284
Antimony	0.00002 to 0.001	0.000127	0.00026	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001			<0.0005	<0.0005	<0.0001
Arsenic	0.00002 to 0.0002	0.000934	0.00117	0.00069	0.00071	0.00075	0.00071	0.00062			0.0172	0.018	0.0187
Barium	0.00002 to 0.002	0.0214	0.0161	0.0124	0.0133	0.0127	0.012	0.0116			0.006	0.006	0.00928
Beryllium	0.00001 to 0.005	0.00131	0.00116	0.00129	0.00132	0.00122	0.00119	0.00122			<0.0001	<0.0001	<0.00005
Bismuth	0.000005 to 0.1	0.000007	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005			<0.001	<0.001	<0.000025
Boron	0.05 to 0.25	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	0.01			<0.05	<0.05	<0.25
Cadmium	0.000005 to 0.00005	0.0057	0.00581	0.00621	0.00603	0.00573	0.00592	0.00594			<0.00001	<0.00005	<0.000025
Calcium	0.05 to 0.25	28.1	26.9	30.3	27.3	29.3	28.8	26.4			289	339	293
Chromium	0.0001 to 0.002	0.0456	0.00893	0.00396	0.00345	0.00561	0.00156	0.0025			<0.001	<0.001	<0.0005
Cobalt	0.000005 to 0.001	0.0725	0.0685	0.0751	0.0692	0.0688	0.0708	0.0701			0.0321	0.0345	0.0358
Copper	0.00005 to 0.0004	2.83	2.05	1.98	2.05	1.89	1.88	1.93			0.0002	<0.0002	0.00099
Iron	0.001 to 0.01	6.48	5.74	5.74	5.62	5.69	5.61	5.25			21.6	24.3	23.5
Lead	0.000005 to 0.001	0.00383	0.0139	0.0016	0.00366	0.00236	0.00104	0.00166			<0.0002	<0.0002	0.000172
Lithium	0.0005 to 0.01	0.019	0.0167	0.0213	0.0192	0.017	0.0174	0.0171			0.008	0.007	0.0074
Magnesium	0.001 to 0.25	4.63	4.58	4.61	4.35	4.58	4.55	4.22			45.8	51.8	45.2
Manganese	0.00005 to 0.002	0.688	0.642	0.671	0.663	0.651	0.671	0.614				1.05	1.03
Mercury	0.00001 to 0.00005	<0.00001	<0.00001	<0.00001	0.000011	<0.00001	<0.00001	<0.00001			<0.00002	<0.00002	<0.00005
Molybdenum	0.00005 to 0.002	0.0043	0.00276	0.00163	0.0017	0.00197	0.00155	0.00139			0.016	0.02	0.0163
Nickel	0.00002 to 0.002	0.0389	0.0204	0.0176	0.0171	0.019	0.0159	0.016			0.003	0.003	0.0056
Phosphorus	0.000002 to 0.01	0.0132	<0.05	<0.05	<0.05	<0.05	<0.00005	<0.05					<0.01
Potassium	0.05 to 0.25	1.63	2.04	1.77	1.63	1.5	1.53	1.46			3.46	3.86	3.45
Selenium	0.00004 to 0.1	0.000177	0.00013	0.00011	0.00012	0.00011	<0.0001	0.00011			<0.0001	<0.0001	<0.0002
Silicon	0.1 to 0.5	10.2	9.74	9.86	9.89	9.97	9.44	9.4				4.8	4.27
Silver	0.000005 to 0.0001	0.000017	0.00008	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001			<0.00002	<0.00002	<0.000025
Sodium	0.05 to 0.25	4.47	3.86	4.73	4.35	4.15	4.26	4.33			14	15.7	14.9
Strontium	0.00005 to 0.002	0.179	0.169	0.166	0.173	0.175	0.174	0.165			1.68	1.91	1.69
Sulphur	3.0 to 50.0	34	31.9	33.9	32.9	33.6	32.8	32.3			301	325	294
Thallium	0.000002 to 0.0001	0.000044	0.000049	0.000044	0.000039	0.000041	0.000039	0.000046			<0.00005	<0.00005	<0.00001
Tin	0.0002 to 0.01	0.00054	0.00024	<0.0001	0.00014	<0.0001	<0.0001	<0.0001			<0.005	<0.005	<0.001
Titanium	0.0005 to 0.01	0.0049	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01				<0.005	<0.0025
Uranium	0.000002 to 0.0002	0.00121	0.0014	0.00102	0.00101	0.00101	0.00109	0.000975			0.0366	0.041	0.0352
Vanadium	0.0002 to 0.03	0.0004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			<0.005	<0.005	<0.001
Zinc	0.0001 to 0.01	0.43	0.37	0.485	0.383	0.36	0.386	0.375			0.076	0.098	0.0973
Zirconium	0.0001 to 0.001	<0.0001									<0.0005	<0.0005	<0.0005
Organics													
Dissolved Organic Carbon								0.95					
Total Organic Carbon	0.5 to 5.0	1.2	1.07	0.82	1.11	0.94	0.93	1.07	7.1	1.7	1.1	1.1	<5

NOTES:
1. UNITS ARE IN mg/L UNLESS OTHERWISE STATED.
2. REFER TO TABLE F1 FOR DETAILED FOOTNOTES ON CELL SHADING.

Site ID Date/Time Sampled	MDL	HG10-01 10-Jun-13	HG10-01 4-Aug-13	HG10-01 26-Sep-13	HG10-01 23-May-14	HG10-01 22-Jul-14	HG10-01 28-Sep-14	HG10-02 20-Aug-10	HG10-02 14-Sep-10	HG10-02 16-Jul-11	HG10-02 18-Sep-11	HG10-02 27-May-12	HG10-02 4-Aug-13
Calculated Parameters													
Ion Balance Ratio	0.01						0.94					1	
Physical Tests													
Acidity to pH 4.5 (as CaCO3)	0.5							<0.5	<0.5			<0.5	
Acidity to pH 8.3 (as CaCO3)	0.5	29.1	35.3					12.6	5.2			16.2	15.3
Alkalinity (PP as CaCO3)	0.5									<0.5	<0.5		
Alkalinity (Total as CaCO3)	0.5	147	137	142	126	144	128	170	180	170	160	153	167
Bicarbonate Alkalinity	0.5	147	137	142	126		128			200	200		167
Carbonate Alkalinity	0.5	<2	<2	<2	<2		<1			<0.5	<0.5		<2
Conductivity µS/cm	1	1560	1570	1590	1520	1590	1590	1830	1800	1710	1670	1610	1550
Hardness as CaCO3 (Dissolved)	0.5		1010	964	959	956	982	1050	1040	1040	935	936	958
Hardness as CaCO3 (Total)	0.5	1010								921	1080	999	
Hydroxide Alkalinity	0.5	<2	<2	<2	<2		<1			<0.5	<0.5		<2
pH (pH)	0	6.92	7.05	7.42	7.15	7.09	7.29	7.36	7.55	7.46	7.5	7.58	7.45
Total Dissolved Solids	1.0 to 10.0	1420	1460	1460	1370	1380	1430	1600	1600	1400	1400	1350	1440
Total Suspended Solids	1	21.8	10.6	5.2	13.6	6.5	8			17	18	8.6	19.6
Turbidity (NTU)	0.1	94.7	14.2	9.3	2.32	26.8	32.8			43.9	86.4	126	32
Dissolved Anions													
Bromide	0.01 to 0.4	<1	<1	<0.5	<0.5	<0.5	<0.5	<0.4	<0.4			<0.05	<1
Chloride	0.5	<10	<10	<5	<5	<5	<5	<0.5	<0.5	0.8	1.9	1.2	<10
Fluoride	0.01	0.82	0.92	0.58	0.58	0.75	0.49	0.57	0.64	0.65	0.68	0.61	1.12
Sulphate	0.5 to 5.0	907	884	862	832	871	852	890	1100	880	840	812	840
Thiocyanate	0.2												
Nutrients													
Ammonia (Total)	0.005 to 0.01	0.0281	0.0359	0.0307	0.0324	0.0321	0.0344	0.046	0.024	0.068	0.056	0.047	0.0349
Nitrate (as N)	0.002 to 0.02	<0.1	<0.1	<0.05	<0.05	<0.05	<0.05	0.002	<0.002	<0.02	0.08	<0.002	<0.1
Nitrate+Nitrite (Dissolved)	0.002 to 0.02						<0.01	0.002	<0.002	<0.02	0.08	<0.002	
Nitrite (as N)	0.002 to 0.005	<0.02	0.022	<0.01	<0.01	<0.01	0.092	<0.002	<0.002	<0.005	<0.005	<0.002	0.028
Nitrogen (Total)	0.02	<0.11	<0.05	<0.05	0.086	0.085	0.092	0.05	0.11			0.102	<0.05
Nitrogen Kjeldahl (Total)	0.02	0.091	0.056	<0.05	0.086	0.085		0.04	0.11			0.102	0.082
Orthophosphate (Dissolved)	0.001 to 0.005	<0.001			<0.01		<0.002	0.002	0.001	0.31		0.0048	
Phosphorus Dissolved	0.002 to 0.01	<0.02	<0.02	<0.02	<0.02	<0.002	<0.02	<0.01	0.02				0.0036
Cyanide													
Cyanide (SAD)	0.001						<0.005						
Cyanide (WAD)	0.0005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.0005	0.0007			<0.0005	<0.005
Cyanide+Thiocyanate	0.0005 to 0.001						<0.005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	
Dissolved Metals													
Aluminum	0.0002 to 0.003	0.0175	0.0167	0.016	0.018	0.0223	0.0184	0.008	0.079	0.012	0.011	0.0087	0.0044
Antimony	0.00002 to 0.0005	<0.0001	<0.0002	<0.0001	<0.0001	<0.0002	<0.0002	0.0002	<0.0001	<0.0005	<0.0005	<0.0001	<0.0001
Arsenic	0.00002 to 0.001	0.0195	0.0189	0.0179	0.0182	0.0189	0.018	0.0143	0.0149	0.0132	0.0125	0.0147	0.0129
Barium	0.00002 to 0.001	0.00585	0.00576	0.00536	0.00547	0.00596	0.00562	0.0061	0.0067		0.004	0.00502	0.00427
Beryllium	0.00001 to 0.005	<0.0001	<0.0002	<0.0001	<0.0001	<0.0002	<0.0002	0.00006	0.00008	<0.0001	<0.0001	0.000088	<0.0001
Bismuth	0.000005 to 0.1	<0.0005	<0.001	<0.0005	<0.0005	<0.001	<0.001	<0.00003	0.00004	<0.001	<0.001	<0.000025	<0.0005
Boron	0.05 to 0.3	<0.01	<0.02	<0.01	<0.01	<0.02	<0.02	<0.3	<0.3	<0.05	<0.05	<0.25	<0.01
Cadmium	0.000005 to 0.00003	<0.00001	<0.00002	<0.00001	<0.00001	0.000023	<0.00002	0.00009	0.00013	0.00003	<0.00003	<0.000025	<0.00001
Calcium	0.05 to 0.3	327	324	307	310	308	317	335	335	337	303	302	306
Chromium	0.0001 to 0.001	<0.0001	<0.0002	<0.0001	<0.0001	<0.0002	<0.0002	<0.0005	<0.0005	<0.001	<0.001	<0.0005	0.00036
Cobalt	0.000005 to 0.001	0.0302	0.0284	0.0277	0.0315	0.0339	0.0304	0.0174	0.0187	0.0196	0.0155	0.0184	0.0179
Copper	0.00005 to 0.0003	0.00054	<0.0004	<0.0002	<0.0002	<0.0004	<0.0004	<0.0003	0.001	0.0004	0.0002	0.00064	<0.0002
Iron	0.001 to 0.03	21.6	21.3	20.8	23.3	24	21.6	11.1	10.9	12	11.5	11.9	12.3
Lead	0.000005 to 0.001	<0.00005	<0.0001	<0.00005	0.000061	<0.0001	<0.0001	0.00013	0.00138	<0.0002	<0.0002	0.000035	<0.00005
Lithium	0.0005 to 0.005	0.00557	0.0056	0.00617	0.0063	0.0064	0.006	0.003	<0.003	<0.005	<0.005	0.0041	0.00157
Magnesium	0.001 to 0.3	47.8	48.7	48.1	44.9	45.7	46.2	51.8	49.8	48.2	43.5	44.2	46.9
Manganese	0.00002 to 0.005	0.97	0.873	0.863	0.973	1.04	0.878	0.656	0.637		<0.00002	0.64	0.625
Mercury	0.00000001 to 0.00005	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00005	<0.00005	<0.00002		<0.00005	<0.00001
Molybdenum	0.00005 to 0.001	0.0171	0.017	0.0167	0.0165	0.0165	0.0175	0.0338	0.0325	0.032	0.021	0.0257	0.0247
Nickel	0.00002 to 0.001	0.00275	0.0024	0.0025	0.0031	0.0033	0.0027	0.0018	0.0011	0.001	<0.001	0.00108	0.00133
Phosphorus	0.002 to 0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05					0.023	<0.05
Potassium	0.05 to 0.3	3.76	3.72	3.54	3.5	3.52	3.56	3.6	3.4	3.6	3.14	3.09	3.34
Selenium	0.00004 to 0.0005	<0.0001	<0.0002	<0.0001	<0.0001	<0.0002	<0.0002	0.0003	<0.0002	<0.0001	<0.0001	<0.0002	<0.0001
Silicon	0.1 to 0.5	4.11	4.17	4.29	4.53	4.67	4.45	3.9	4.6	4.81	4.1	4.31	4.2
Silver	0.000005 to 0.0001	<0.00001	<0.00002	<0.00001	<0.00001	<0.00002	<0.00002	<0.00003	0.00003	<0.00002	<0.00002	<0.000025	<0.00001
Sodium	0.05 to 0.3	13	14.8	14.2	12.6	13.3	14.4	17.8	16.9	15.9	14.6	15.7	15.8
Strontium	0.00005 to 0.001	1.75	1.6	1.69	1.56	1.62	1.69	1.85	1.69		1.62	1.58	1.41
Sulphur	1.0 to 50.0	295	278	285	259	267	280	332	353	322	286	277	263
Thallium	0.000002 to 0.00005	<0.00001	<0.00002	<0.00001	<0.00001	<0.00002	<0.00002	0.00003	0.00004	<0.00005	<0.00005	0.000025	0.000027
Tin	0.00001 to 0.005	<0.0001	<0.0002	<0.0001	<0.0001	<0.0002	<0.0002	<0.00005	<0.00005	<0.005	<0.005	<0.001	<0.0001
Titanium	0.0005 to 0.01	<0.01	<0.02	<0.01	<0.01	<0.02	<0.02	0.003	0.008	<0.005	<0.005	<0.0025	<0.01
Uranium	0.000002 to 0.0001	0.0377	0.0363	0.0372	0.036	0.0325	0.0383	0.0668	0.0656	0.0621	0.0411	0.0495	0.0399
Vanadium	0.0002 to 0.03	<0.001	<0.002	<0.001	<0.001	<0.002	<0.002	<0.001	<0.001	<0.005	<0.005	<0.001	<0.001
Zinc	0.0001 to 0.005	0.0874	0.0886	0.0886	0.095	0.104	0.0966	0.038	0.0386	0.047	0.055	0.0259	0.053
Zirconium	0.0001 to 0.005							<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	
Total Metals													
Aluminum	0.0002 to 0.006	0.0174	0.0194	0.0178	0.0199	0.0234	0.0191			0.027	0.031	0.0169	0.124
Antimony	0.00002 to 0.001	<0.0001	<0.0002	<0.0001	0.0001	<0.0002	<0.0002			<0.0005	<0.0005	<0.0001	<0.0001
Arsenic	0.00002 to 0.0002	0.0201	0.0192	0.018	0.019	0.0199	0.0179			0.0135	0.0146	0.0144	0.0187
Barium	0.00002 to 0.002	0.00563	0.00582	0.00552	0.00559	0.00597	0.00569			0.005	0.006	0.00536	0.00515
Beryllium	0.00001 to 0.005	<0.0001	<0.0002	<0.0001	0.00013	<0.0002	<0.0002			<0.0001	<0.0001	0.000113	0.00012
Bismuth	0.000005 to 0.1	<0.0005	<0.001	<0.0005	<0.0005	<0.001	<0.001			<0.001	<0.001	<0.000025	<0.0005
Boron	0.05 to 0.25	0.011	<0.02	0.011	0.011	<0.02	<0.02			<0.05	<0.05	<0.25	<0.01
Cadmium	0.000005 to 0.00005	<0.00001	<0.00002	<0.00001	0.000016	<0.00002	<0.00002			0.00002	<0.00005	0.000049	0.000055
Calcium	0.05 to 0.25	310	329	310	311	311	306			292	349	322	300
Chromium	0.0001 to 0.002	<0.0001	<0.0002	<0.0001	0.00015	<0.0002	<0.0002			<0.001	<0.001	<0.0005	0.00243
Cobalt	0.000005 to 0.001	0.0305	0.0302	0.0284	0.0326	0.0351	0.0306			0.0176	0.0198	0.02	0.0193
Copper	0.00005 to 0.0004	0.00099	<0.001	<0.0005	<0.0005	<0.001	<0.001			0.0006	0.0004	0.0005	0.00184
Iron	0.001 to 0.01	21.3	22.1	21.3	23.7	24.6	20.9			10.6	13.3	12.6	13.1
Lead	0.000005 to 0.001	<0.00005	<0.0001	<0.00005	0.000111	<0.0001	<0.0001			<0.0002	0.0002	0.000194	0.0023
Lithium	0.0005 to 0.01	0.00604	0.0058	0.00625	0.00703	0.0065	0.0061			<0.005	<0.005	0.004	0.00195
Magnesium	0.001 to 0.25	47.6	49.8	48.7	45.2	46.3	46.4			0.628	50.9	47.4	46.6
Manganese	0.00005 to 0.002	0.967	0.909	0.9	1.02	1.08	0.886				0.723	0.677	0.648
Mercury	0.00001 to 0.00005	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001			<0.00002	<0.00002	<0.00005	<0.00001
Molybdenum	0.00005 to 0.002	0.0178	0.0176	0.0172	0.0172	0.0164	0.0171			0.029	0.034	0.0275	0.028
Nickel	0.00002 to 0.002	0.00275	0.0026	0.00273	0.00321	0.0034	0.0026			0.001	0.001	0.00106	0.00236
Phosphorus	0.000002 to 0.01	<0.05	<0.05	<0.05	<0.05	<0.00005	<0.05					<0.01	<0.05
Potassium	0.05 to 0.25	4.28	3.96	3.66	3.53	3.61	3.45			3.13	3.63	3.39	3.35
Selenium	0.00004 to 0.1	<0.0001	<0.0002	<0.0001	0.00015	<0.0002	<0.0002			<0.0001	<0.0001	<0.0002	<0.0001
Silicon	0.1 to 0.5	4.09	4.33	4.31	4.62	4.78	4.29				4.7	4.69	4.4
Silver	0.000005 to 0.0001	<0.00001	<0.00002	<0.00001	0.000011	<0.00002	<0.00002			<0.00002	<0.00002	<0.000025	0.000019
Sodium	0.05 to 0.25	13.1	16	14.3	13.3	13.7	14.5			14.9	17.1	16.9	16.1
Strontium	0.00005 to 0.002	1.79	1.67	1.7	1.66	1.6	1.65			1.63	1.86	1.62	1.56
Sulphur	3.0 to 50.0	294	296	296	265	278	284			283	322	299	279
Thallium	0.000002 to 0.0001	<0.00001	<0.00002	<0.00001	0.000018	<0.00002	<0.00002			<0.00005	<0.00005	0.000054	0.000267
Tin	0.0002 to 0.01	<0.0001	<0.0002	<0.0001	<0.0001	<0.0002	<0.0002			<0.005	<0.005	<0.001	0.0005
Titanium	0.0005 to 0.01	<0.01	<0.02	<0.01	<0.01	<0.02	<0.02				<0.005	<0.0025	<0.01
Uranium	0.000002 to 0.0002	0.037	0.0392	0.0392	0.0366	0.0327	0.0384			0.0553	0.0531	0.0492	0.0445
Vanadium	0.0002 to 0.03	<0.001	<0.002	<0.001	<0.001	<0.002	<0.002			<0.005	<0.005	<0.001	<0.001
Zinc	0.0001 to 0.01	0.0876	0.0929	0.0905	0.0986	0.105	0.0975			0.078	0.103	0.057	0.359
Zirconium	0.0001 to 0.001									<0.0005	<0.0005	<0.0005	
Organics													
Dissolved Organic Carbon							1.14						
Total Organic Carbon	0.5 to 5.0	1.05	0.94	1.08	0.97	1.05	1.18	4.1	1.5	1.7	1	<5	1.28

NOTES:
1. UNITS ARE IN mg/L UNLESS OTHERWISE STATED.
2. REFER TO TABLE F1 FOR DETAILED FOOTNOTES ON CELL SHADING.

Site ID Date/Time Sampled	MDL	HG10-02 26-Sep-13	HG10-02 23-May-14	HG10-02 22-Jul-14	HG10-02 28-Sep-14	HG10-04 19-Aug-10	HG10-04 13-Sep-10	HG10-04 22-May-11	HG10-04 15-Jul-11	HG10-04 18-Sep-11	HG10-04 28-May-12	HG10-04 17-Sep-12	HG10-04 12-Jun-13
Calculated Parameters													
Ion Balance Ratio	0.01				0.97						1.1	1.3	
Physical Tests													
Acidity to pH 4.5 (as CaCO3)	0.5					<0.5	<0.5				<0.5	<0.5	
Acidity to pH 8.3 (as CaCO3)	0.5					40.9	7.4				57.2	49.9	
Alkalinity (PP as CaCO3)	0.5							<0.5	<0.5	<0.5			
Alkalinity (Total as CaCO3)	0.5	175	166	176	158	88	120	98	120	120	93.2	107	94.9
Bicarbonate Alkalinity	0.5	175	166		158			120	150	140			94.9
Carbonate Alkalinity	0.5	<2	<2		<1			<0.5	<0.5	<0.5			<1
Conductivity µS/cm	1	1590	1510	1570	1580	812	885	885	955	937	897	909	852
Hardness as CaCO3 (Dissolved)	0.5	975	978	940	960	419	425	410	503	482	447	504	457
Hardness as CaCO3 (Total)	0.5							476	492	551	458	471	
Hydroxide Alkalinity	0.5	<2	<2		<1			<0.5	<0.5	<0.5			<1
pH (pH)	0	7.67	7.96	7.36	7.51	7.25	7.09	7.24	6.91	7.06	6.82	6.84	6.65
Total Dissolved Solids	1.0 to 10.0	1440	1360	1300	1380	550	650	660	750	700	676	696	698
Total Suspended Solids	1	12	18.6	8.8	17.3			18	23	42	21	32.8	25.2
Turbidity (NTU)	0.1	39.7	9.39	44.2	40.1			100	41.1	187	163	186	78.9
Dissolved Anions													
Bromide	0.01 to 0.4	<0.5	<0.5	<0.5	<0.5	<0.4	<0.4				<0.05	<0.05	<0.5
Chloride	0.5	<5	<5	<5	<5		1.9	1.8	0.9	1.5	2.7	1.4	<5
Fluoride	0.01	0.6	0.6	0.71	0.52	0.45	0.42	0.45	0.46	0.03	0.39	0.43	0.53
Sulphate	0.5 to 5.0	851	823	836	810	320	390	370	380	350	396	350	390
Thiocyanate	0.2												
Nutrients													
Ammonia (Total)	0.005 to 0.01	0.0335	0.0312	0.0314	0.0325	0.097	0.055	0.053	0.085	0.074	0.06	0.059	0.0536
Nitrate (as N)	0.002 to 0.02	<0.05	<0.05	<0.05	<0.05	<0.002	<0.002	<0.02	<0.02	<0.02	<0.002	0.0187	<0.05
Nitrate+Nitrite (Dissolved)	0.002 to 0.02				<0.01	0.004	0.004	<0.02	<0.02	<0.02	0.0052	0.0293	
Nitrite (as N)	0.002 to 0.005	<0.01	<0.01	<0.01	0.166	0.003	0.003	<0.005	<0.005	0.009	0.0043	0.0106	<0.01
Nitrogen (Total)	0.02	0.056	0.083	0.101	0.166	0.21	0.25				0.175	0.665	<0.05
Nitrogen Kjeldahl (Total)	0.02	0.058	0.083	0.101		0.21	0.25				0.17	0.636	0.107
Orthophosphate (Dissolved)	0.001 to 0.005		<0.01		<0.002	0.001	0.001	0.024	0.2		0.0024	0.0032	<0.001
Phosphorus Dissolved	0.002 to 0.01	<0.02	<0.002	<0.002	<0.002	0.002	<0.01						0.025
Cyanide													
Cyanide (SAD)	0.001				<0.005								
Cyanide (WAD)	0.0005	<0.005	<0.005	<0.005	<0.005	<0.0005	<0.0005				<0.0005	<0.0005	<0.005
Cyanide+Thiocyanate	0.0005 to 0.001				<0.005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	
Dissolved Metals													
Aluminum	0.0002 to 0.003	0.0049	0.004	0.0049	0.0055	0.0186	0.014	0.022	0.018	0.015	0.0327	0.0216	0.0234
Antimony	0.00002 to 0.0005	<0.0001	<0.0001	<0.0002	<0.0002	0.00007	<0.0001	<0.0005	<0.0005	<0.0005	0.000047	0.000024	<0.0001
Arsenic	0.00002 to 0.001	0.0129	0.013	0.0134	0.0129	0.00652	0.0018	0.0018	0.0052	0.0061	0.00215	0.00254	0.00191
Barium	0.00002 to 0.001	0.00422	0.00449	0.00471	0.00441	0.0201	0.02	0.01		0.01	0.00973	0.011	0.0102
Beryllium	0.00001 to 0.005	<0.0001	<0.0001	<0.0002	<0.0002	0.0002	0.00016	0.0003	0.0003	0.0002	0.000419	0.000284	0.00033
Bismuth	0.000005 to 0.1	<0.0005	<0.0005	<0.001	<0.001	<0.000005	<0.00003	<0.001	<0.001	<0.001	<0.000005	<0.000005	<0.0005
Boron	0.05 to 0.3	<0.01	<0.01	<0.02	<0.02	<0.05	<0.3	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01
Cadmium	0.000005 to 0.00003	0.000014	<0.00001	<0.00002	<0.00002	0.0234	0.0103	0.00177	0.00154	0.00144	0.00112	0.000727	0.000788
Calcium	0.05 to 0.3	312	319	303	312	131	130	126	157	151	139	163	143
Chromium	0.0001 to 0.001	0.00027	0.00096	0.0002	<0.0002	<0.0001	<0.0005	<0.001	<0.001	<0.001	0.00012	0.00221	0.00012
Cobalt	0.000005 to 0.001	0.0179	0.0187	0.0188	0.0191	0.0313	0.0327	0.0343	0.0392	0.0313	0.0394	0.0368	0.0383
Copper	0.00005 to 0.0003	0.00092	<0.0002	<0.0004	<0.0004	0.00086	0.0012	0.0011	<0.0002	0.0002	0.00108	0.0788	0.00043
Iron	0.001 to 0.03	12.3	12.6	12.1	12	26.6	28.1	32.1	36.1	34.7	38.8	43.5	35.2
Lead	0.000005 to 0.001	<0.00005	0.000081	<0.0001	<0.0001	0.000539	0.0002	0.0005	0.0006	0.0003	0.000795	0.000143	0.000938
Lithium	0.0005 to 0.005	0.00279	0.00337	0.0027	0.0034	0.0028	<0.003	<0.005	<0.005	<0.005	0.0024	0.00186	0.00198
Magnesium	0.001 to 0.3	47.6	44.2	44.3	44	22.3	24.3	23.2	26.9	25.7	24.5	23.5	24.6
Manganese	0.00002 to 0.005	0.634	0.661	0.661	0.65	3.07	3.48	3.7		<0.00002	4.24	4.06	3.85
Mercury	0.00000001 to 0.00005	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00005	<0.00002	<0.00002		<0.00001	<0.00000001	<0.00001
Molybdenum	0.00005 to 0.001	0.0263	0.0265	0.0262	0.0269	0.00042	0.0009	<0.001	<0.001	<0.001	0.000196	0.000748	0.000126
Nickel	0.00002 to 0.001	0.00109	0.00243	0.0012	0.0011	0.00444	0.0041	0.002	0.003	0.003	0.00252	0.00873	0.00288
Phosphorus	0.002 to 0.01	<0.05	<0.05	<0.05	<0.05						0.0083	<0.002	<0.05
Potassium	0.05 to 0.3	3.43	3.29	3.24	3.3	2.58	2.6	2.35	2.54	2.37	2.4	2.39	2.58
Selenium	0.00004 to 0.0005	<0.0001	<0.0001	<0.0002	<0.0002	0.00007	<0.0002	<0.0001	<0.0001	<0.0001	0.000106	0.000165	<0.0001
Silicon	0.1 to 0.5	4.44	4.43	4.27	4.37	3.7	4	3.61	4.39	3.8	3.82	4.34	3.81
Silver	0.000005 to 0.0001	<0.00001	<0.00001	<0.00002	<0.00002	<0.000005	<0.00003	<0.00002	<0.00002	<0.00002	<0.000005	<0.000005	<0.00001
Sodium	0.05 to 0.3	14.9	13.7	14.3	15	8.34	10.6	6.74	7.73	7.34	7.71	6.96	7.59
Strontium	0.00005 to 0.001	1.55	1.6	1.64	1.62	0.38	0.369	0.357		0.415	0.379	0.416	0.365
Sulphur	1.0 to 50.0	282	254	256	265	123	133	135	142	127	136	129	122
Thallium	0.000002 to 0.00005	0.000026	0.000031	0.000029	0.000027	0.000022	0.00002	<0.00005	<0.00005	<0.00005	0.0000197	0.000017	0.000017
Tin	0.00001 to 0.005	<0.0001	<0.0001	<0.0002	<0.0002	<0.00001	0.00006	<0.005	<0.005	<0.005	<0.0002	<0.0002	<0.0001
Titanium	0.0005 to 0.01	<0.01	<0.01	<0.02	<0.02	<0.0005	0.004	<0.005	<0.005	<0.005	<0.0005	<0.0005	<0.01
Uranium	0.000002 to 0.0001	0.0441	0.0442	0.0414	0.0434	0.0259	0.0221	0.0109	0.0163	0.0158	0.0106	0.012	0.00669
Vanadium	0.0002 to 0.03	<0.001	<0.001	<0.002	<0.002	<0.0002	<0.001	<0.005	<0.005	<0.005	<0.0002	<0.0002	<0.001
Zinc	0.0001 to 0.005	0.0355	0.0311	0.0513	0.0368	0.0937	0.107	0.12	0.119	0.154	0.131	0.153	0.138
Zirconium	0.0001 to 0.005					<0.0001	<0.0005	<0.0005	<0.0005	<0.0005	<0.0001	<0.0001	
Total Metals													
Aluminum	0.0002 to 0.006	0.0199	0.0157	0.0095	0.0094			0.027	0.023	0.027	0.0495	0.0495	0.0584
Antimony	0.00002 to 0.001	<0.0001	<0.0001	<0.0002	<0.0002			<0.0005	<0.0005	<0.0005	0.000037	0.000033	<0.0001
Arsenic	0.00002 to 0.0002	0.0138	0.0142	0.0137	0.0136			0.002	0.0056	0.0066	0.0021	0.00287	0.002
Barium	0.00002 to 0.002	0.00449	0.00494	0.00473	0.00435			0.011	0.012	0.014	0.00978	0.0126	0.0103
Beryllium	0.00001 to 0.005	<0.0001	<0.0001	<0.0002	<0.0002			0.0003	0.0003	0.0002	0.000378	0.000306	0.00035
Bismuth	0.000005 to 0.1	<0.0005	<0.0005	<0.001	<0.001			<0.001	<0.001	<0.001	<0.000005	<0.000005	<0.0005
Boron	0.05 to 0.25	0.01	<0.01	<0.02	<0.02			<0.05	<0.05	<0.05	<0.05	<0.05	<0.01
Cadmium	0.000005 to 0.00005	0.000027	0.000017	<0.00002	<0.00002			0.00185	0.00158	0.00177	0.00148	0.00113	0.0008
Calcium	0.05 to 0.25	306	318	312	308			147	152	170	141	146	145
Chromium	0.0001 to 0.002	0.00054	0.00222	0.00053	0.00032			<0.001	<0.001	<0.001	0.00013	0.0199	0.00032
Cobalt	0.000005 to 0.001	0.0181	0.0189	0.0186	0.019			0.0392	0.038	0.0413	0.0404	0.0386	0.04
Copper	0.00005 to 0.0004	0.0029	0.00095	<0.001	<0.001			0.0003	0.0004	0.0007	0.00116	0.17	0.00096
Iron	0.001 to 0.01	12.2	12.7	12.5	11.9			38.5	35.8	39	40	39.3	36.1
Lead	0.000005 to 0.001	0.000266	0.000225	<0.0001	<0.0001			0.0006	0.0007	0.0005	0.00101	0.000861	0.00118
Lithium	0.0005 to 0.01	0.00296	0.00334	0.0027	0.0038			<0.005	<0.005	<0.005	0.00211	0.00199	0.00234
Magnesium	0.001 to 0.25	46.7	43.8	45.2	44.2			26.6	27.4	30.7	26	26	25.7
Manganese	0.00005 to 0.002	0.642	0.657	0.647	0.652					4.77	4.22	4.29	4
Mercury	0.00001 to 0.00005	<0.00001	<0.00001	<0.00001	<0.00001			<0.00002	<0.00002	<0.00002	<0.00001	<0.00001	<0.00001
Molybdenum	0.00005 to 0.002	0.0274	0.0271	0.0254	0.0271			<0.001	<0.001	<0.001	0.000345	0.00244	0.000208
Nickel	0.00002 to 0.002	0.00121	0.00373	0.0013	0.001			0.003	0.003	0.003	0.00253	0.0132	0.00304
Phosphorus	0.000002 to 0.01	<0.05	<0.05	<0.00005	<0.05						0.0066	0.0058	<0.05
Potassium	0.05 to 0.25	3.44	3.34	3.37	3.26			2.51	2.49	2.85	2.43	2.57	2.81
Selenium	0.00004 to 0.1	<0.0001	<0.0001	<0.0002	<0.0002			<0.0001	<0.0001	<0.0001	0.0001	0.000143	<0.0001
Silicon	0.1 to 0.5	4.37	4.47	4.43	4.34			4.33		4.4	3.93	3.91	3.98
Silver	0.000005 to 0.0001	0.000011	0.000012	0.000693	<0.00002			<0.00002	<0.00002	<0.00002	<0.000005	0.000006	<0.00001
Sodium	0.05 to 0.25	15.1	14.1	14.1	15			7.8	7.86	9.01	7.94	7.74	8.03
Strontium	0.00005 to 0.002	1.6	1.65	1.58	1.6			0.402	0.421	0.484	0.379	0.419	0.383
Sulphur	3.0 to 50.0	284	255	268	271			138	137	149	141	142	127
Thallium	0.000002 to 0.0001	0.000066	0.000045	0.000028	0.000029			<0.00005	<0.00005	<0.00005	0.0000191	0.000018	0.000016
Tin	0.0002 to 0.01	<0.0001	<0.0001	<0.0002	<0.0002			<0.005	<0.005	<0.005	<0.0002	0.00035	<0.0001
Titanium	0.0005 to 0.01	<0.01	<0.01	<0.02	<0.02					<0.005	0.00054	0.00144	<0.01
Uranium	0.000002 to 0.0002	0.0447	0.045	0.0396	0.0422			0.012	0.0156	0.0196	0.0102	0.0122	0.00698
Vanadium	0.0002 to 0.03	<0.001	<0.001	<0.002	<0.002			<0.005	<0.005	<0.005	<0.0002	<0.0002	<0.001
Zinc	0.0001 to 0.01	0.0758	0.0415	0.0874	0.0388			0.131	0.116	0.197	0.132	0.187	0.139
Zirconium	0.0001 to 0.001							<0.0005	<0.0005	<0.0005	<0.0001	<0.0001	
Organics													
Dissolved Organic Carbon					1.16								
Total Organic Carbon	0.5 to 5.0	1.05	1.04	1.12	1.15	3.4	2.1	1.8	1.7	1.3	<5	8.86	1.52

NOTES:
1. UNITS ARE IN mg/L UNLESS OTHERWISE STATED.
2. REFER TO TABLE F1 FOR DETAILED FOOTNOTES ON CELL SHADING.

Site ID Date/Time Sampled	MDL	HG10-04 5-Aug-13	HG10-04 26-Sep-13	HG10-04 23-May-14	HG10-04 23-Jul-14	HG10-04 29-Sep-14	HG10-05 19-Aug-11	HG10-07 20-Aug-10	HG10-07 16-Sep-10	MW13-02D 5-Aug-13	MW13-02D 25-Sep-13	MW13-02D 23-Jul-14	MW13-02D 29-Sep-14
Calculated Parameters													
Ion Balance Ratio	0.01					0.83							0.86
Physical Tests													
Acidity to pH 4.5 (as CaCO3)	0.5						<0.5	<0.5	<0.5				
Acidity to pH 8.3 (as CaCO3)	0.5	45.8					23.4	5.4	7.8	7.7			
Alkalinity (PP as CaCO3)	0.5												
Alkalinity (Total as CaCO3)	0.5	101	86.3	87.5	106	89	200	160	190	37.1	22.8	29.6	14.5
Bicarbonate Alkalinity	0.5	101	86.3	87.5		89				37.1	22.8		14.5
Carbonate Alkalinity	0.5	<2	<2	<2		<1				<2	<2		<1
Conductivity µS/cm	1	872	865	880	911	882	1520	741	807	142	117	124	105
Hardness as CaCO3 (Dissolved)	0.5	456	440	475	481	473	913	171	184	379	30	32.7	31.1
Hardness as CaCO3 (Total)	0.5												
Hydroxide Alkalinity	0.5	<2	<2	<2		<1				<2	<2		<1
pH (pH)	0	6.85	7.47	6.96	6.71	7.09	7.71	7.58	7.98	6.93	7.94	6.98	6.85
Total Dissolved Solids	1.0 to 10.0	690	730	670	706	747	1200	480	530	138	110	117	105
Total Suspended Solids	1	40.1	18.5	38.5	8.2	20.7				378	53.6	346	22.7
Turbidity (NTU)	0.1	3.58	29.8	23.7	93.6	73.7				38.1	46.4	97.2	8.06
Dissolved Anions													
Bromide	0.01 to 0.4	<0.5	<0.5	<0.5	<0.5	<0.5	<0.4	<0.4	<0.4	<0.05	<0.05	<0.05	<0.05
Chloride	0.5	<5	<5	<5	<5	<2.5		3.8	3.6	<0.5	<0.5	<0.5	<0.5
Fluoride	0.01	0.62	0.43	0.4	0.54	0.37	0.26	0.36	0.43	0.202	0.19	0.172	0.158
Sulphate	0.5 to 5.0	399	394	406	407	398	660	190	190	30.7	31	30.4	29.4
Thiocyanate	0.2												
Nutrients													
Ammonia (Total)	0.005 to 0.01	0.0528	0.0504	0.047	0.0448	0.0477	0.057	0.67	0.58	0.0061	<0.005	<0.005	<0.005
Nitrate (as N)	0.002 to 0.02	<0.05	<0.05	<0.05	<0.05	<0.025	<0.002	<0.002	<0.002	<0.005	<0.005	<0.005	<0.005
Nitrate+Nitrite (Dissolved)	0.002 to 0.02					<0.005	<0.002	0.009	0.002				<0.001
Nitrite (as N)	0.002 to 0.005	0.01	<0.01	<0.01	<0.01	0.12	<0.002	0.012	0.002	<0.001	<0.001	<0.001	0.08
Nitrogen (Total)	0.02	<0.05	<0.05	0.127	0.118	0.12	0.07	0.96	1.46	<0.05	<0.05	0.078	0.08
Nitrogen Kjeldahl (Total)	0.02	0.097	0.088	0.127	0.118		0.07	0.95	1.45	<0.05	0.053	0.078	
Orthophosphate (Dissolved)	0.001 to 0.005			<0.01		<0.002	0.002	0.005	0.001				<0.002
Phosphorus Dissolved	0.002 to 0.01	<0.002	<0.002	<0.002	<0.002	<0.02	<0.002	0.036	0.093	0.0046	<0.002	0.0063	0.042
Cyanide													
Cyanide (SAD)	0.001					<0.005							<0.005
Cyanide (WAD)	0.0005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.0005	<0.0005	<0.0005	<0.005	<0.005	<0.005	<0.005
Cyanide+Thiocyanate	0.0005 to 0.001					<0.005	<0.0005	<0.0005	<0.0005				<0.005
Dissolved Metals													
Aluminum	0.0002 to 0.003	0.0208	0.0156	0.0305	0.0304	0.0271	0.0047	0.0059	0.544	0.0086	0.0147	0.0227	0.0232
Antimony	0.00002 to 0.0005	<0.0001	<0.0001	0.00013	<0.0001	<0.0001	0.00006	0.00032	0.0004	<0.0001	<0.0001	<0.0001	<0.0001
Arsenic	0.00002 to 0.001	0.0019	0.00127	0.00185	0.00188	0.00183	0.00757	0.00096	0.0037	0.00085	0.00147	0.0006	0.00118
Barium	0.00002 to 0.001	0.0106	0.0127	0.0089	0.00899	0.00924	0.0162	0.0575	0.0943	0.0219	0.0216	0.0274	0.03
Beryllium	0.00001 to 0.005	0.00031	0.00024	0.00061	0.0004	0.00037	0.00003	<0.00001	0.00015	<0.0001	0.00013	0.00017	0.0002
Bismuth	0.000005 to 0.1	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.000005	<0.000005	0.000172	<0.0005	<0.0005	<0.0005	<0.0005
Boron	0.05 to 0.3	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	<0.01	<0.01	<0.01	<0.01
Cadmium	0.000005 to 0.00003	0.000447	0.000234	0.000426	0.000435	0.000552	0.00011	0.000404	0.000338	0.000056	0.000062	0.000023	0.000209
Calcium	0.05 to 0.3	141	137	146	148	146	278	44.9	49.5	12.7	9.98	10.8	9.71
Chromium	0.0001 to 0.001	<0.0001	0.00028	0.00091	0.00037	0.0002	<0.0001	<0.0001	0.0059	0.00015	0.00027	0.00033	0.00013
Cobalt	0.000005 to 0.001	0.0361	0.0336	0.0388	0.0398	0.0404	0.00373	0.0228	0.0134	0.00439	0.00395	0.00436	0.00581
Copper	0.00005 to 0.0003	<0.0002	<0.0002	0.00027	0.00022	0.00123	0.00018	0.0134	0.0798	0.00048	<0.0002	<0.0002	0.00104
Iron	0.001 to 0.03	36	36.6	40.1	40.6	39.9	4.74	3.23	7.42	3.13	2.14	1.74	2.98
Lead	0.000005 to 0.001	0.000587	0.000115	0.000775	0.0005	0.000806	0.000011	0.000038	0.00345	<0.00005	<0.00005	<0.00005	<0.00005
Lithium	0.0005 to 0.005	0.00129	0.00202	0.00239	0.00181	0.00209	0.002	0.0027	0.0031	0.00288	0.00357	0.00343	0.00417
Magnesium	0.001 to 0.3	24.9	23.9	26.6	26.9	26.1	53.4	14.2	14.8	1.48	1.24	1.4	1.66
Manganese	0.00002 to 0.005	3.99	4.11	4.15	4.32	4.12	0.267	2.66	2.53	0.129	0.0872	0.0961	0.0957
Mercury	0.00000001 to 0.00005	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum	0.00005 to 0.001	0.000119	0.000138	0.000316	0.000148	0.000104	0.00052	0.0123	0.0125	0.00431	0.00496	0.00361	0.00366
Nickel	0.00002 to 0.001	0.00265	0.00328	0.00361	0.00288	0.00264	0.00123	0.00301	0.00374	0.00375	0.00255	0.0079	0.00246
Phosphorus	0.002 to 0.01	<0.05	<0.05	<0.05	<0.05	<0.05				<0.05	0.053	<0.05	0.068
Potassium	0.05 to 0.3	2.34	2.2	2.44	2.42	2.41	2.18	3.05	3.07	1.13	1.15	1.19	1.13
Selenium	0.00004 to 0.0005	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.00006	0.00157	0.00038	<0.0001	<0.0001	<0.0001	<0.0001
Silicon	0.1 to 0.5	3.69	3.54	3.93	3.81	3.81	1.9	6.6	7.5	14.9	15.3	14.7	15.5
Silver	0.000005 to 0.0001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.000005	<0.000005	0.000214	<0.00001	<0.00001	<0.00001	<0.00001
Sodium	0.05 to 0.3	8.45	7.73	7.11	7.31	7.54	11.1	87.1	89.2	9.77	10.8	6.66	5.5
Strontium	0.00005 to 0.001	0.361	0.381	0.373	0.391	0.344	2.98	0.268	0.29	0.11	0.117	0.198	0.0865
Sulphur	1.0 to 50.0	125	125	136	132	132	257	75	70	10	10.4	10	10.2
Thallium	0.000002 to 0.00005	0.000016	<0.00001	0.000035	0.000013	0.000014	0.000022	0.000006	0.00001	0.000014	0.000013	<0.00001	0.000028
Tin	0.00001 to 0.005	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.00001	0.00002	0.00011	<0.0001	<0.0001	<0.0001	<0.0001
Titanium	0.0005 to 0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.0005	0.0007	0.0153	<0.01	<0.01	<0.01	<0.01
Uranium	0.000002 to 0.0001	0.00829	0.00746	0.00667	0.00643	0.00617	0.0638	0.00288	0.00299	0.000156	0.000083	0.000045	0.00002
Vanadium	0.0002 to 0.03	<0.001	<0.001	<0.001	<0.001	<0.001	0.0003	<0.0002	0.0017	<0.001	<0.001	<0.001	<0.001
Zinc	0.0001 to 0.005	0.106	0.0794	0.125	0.144	0.132	0.0142	0.0068	0.0086	0.0254	0.0251	0.0454	0.0378
Zirconium	0.0001 to 0.005						<0.0001	<0.0001	<0.005				
Total Metals													
Aluminum	0.0002 to 0.006	0.559	0.269	0.111	0.0715	0.0434				6.78	5.44	2.86	0.533
Antimony	0.00002 to 0.001	0.00011	0.00012	<0.0001	<0.0001	<0.0001				<0.0001	<0.0001	<0.0001	<0.0001
Arsenic	0.00002 to 0.0002	0.00241	0.00219	0.00185	0.00206	0.00171				0.00225	0.00162	0.00108	0.00125
Barium	0.00002 to 0.002	0.0167	0.0171	0.0093	0.00959	0.00915				0.0441	0.0331	0.0452	0.0329
Beryllium	0.00001 to 0.005	0.00037	0.00028	0.00044	0.00043	0.00038				0.00072	0.00057	0.00051	0.00024
Bismuth	0.000005 to 0.1	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005				<0.0005	<0.0005	<0.0005	<0.0005
Boron	0.05 to 0.25	<0.01	<0.01	<0.01	<0.01	0.016				<0.01	0.01	<0.01	<0.01
Cadmium	0.000005 to 0.00005	0.00115	0.000586	0.00149	0.000637	0.000525				0.000093	0.000111	0.000149	0.00054
Calcium	0.05 to 0.25	143	138	145	151	134				18.4	12.2	14.5	9.65
Chromium	0.0001 to 0.002	0.00046	0.00315	0.00142	0.00093	0.0005				0.00378	0.00274	0.0486	0.00146
Cobalt	0.000005 to 0.001	0.038	0.0336	0.039	0.0406	0.038				0.0059	0.0061	0.00561	0.00614
Copper	0.00005 to 0.0004	0.00277	0.00492	0.00108	0.00133	0.00124				0.0149	0.00345	0.0101	0.00695
Iron	0.001 to 0.01	37.1	38.2	39.6	41.3	36.7				6.92	5.64	3.23	3.17
Lead	0.000005 to 0.001	0.0209	0.00326	0.00284	0.00121	0.000961				0.006	0.00273	0.00396	0.000439
Lithium	0.0005 to 0.01	0.00175	0.00215	0.00203	0.00225	0.00214				0.0051	0.00528	0.00467	0.00423
Magnesium	0.001 to 0.25	25.3	24.1	26.1	27.3	24.1				4.15	4.48	2.51	1.81
Manganese	0.00005 to 0.002	4.2	4.16	4.14	4.43	3.84				0.182	0.122	0.13	0.101
Mercury	0.00001 to 0.00005	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001				<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum	0.00005 to 0.002	0.0002	0.000651	0.000332	0.000213	0.000127				0.00505	0.00454	0.00816	0.00396
Nickel	0.00002 to 0.002	0.0031	0.00505	0.00406	0.00303	0.00253				0.00505	0.00469	0.0323	0.00277
Phosphorus	0.000002 to 0.01	<0.05	<0.05	<0.05	<0.00005	<0.05				0.095	0.069	0.00008	0.061
Potassium	0.05 to 0.25	2.45	2.32	2.4	2.49	2.2				1.78	1.36	1.45	1.17
Selenium	0.00004 to 0.1	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001				<0.0001	<0.0001	<0.0001	<0.0001
Silicon	0.1 to 0.5	5.21	4.05	4.04	3.97	3.53				49.8	53.8	24.2	16.9
Silver	0.000005 to 0.0001	0.000046	0.000033	<0.00001	<0.00001	<0.00001				0.000048	0.000016	0.000041	0.000025
Sodium	0.05 to 0.25	9.07	7.75	6.96	7.63	7.06				9.66	9.34	6.21	5.73
Strontium	0.00005 to 0.002	0.385	0.384	0.384	0.397	0.356				0.149	0.143	0.243	0.0865
Sulphur	3.0 to 50.0	131	128	135	135	124				9.92	10.3	9.83	10.3
Thallium	0.000002 to 0.0001	0.000025	0.000014	0.000018	0.000014	0.000013				0.000055	0.000028	0.000048	0.000035
Tin	0.0002 to 0.01	<0.0001	0.00018	<0.0001	<0.0001	<0.0001				0.00025	0.00034	0.00031	<0.0001
Titanium	0.0005 to 0.01	0.014	<0.01	<0.01	<0.01	<0.01				0.033	0.026	0.021	0.011
Uranium	0.000002 to 0.0002	0.00933	0.00796	0.0072	0.00698	0.00616				0.00158	0.000806	0.00102	0.00014
Vanadium	0.0002 to 0.03	<0.001	<0.001	<0.001	<0.001	<0.001				0.0031	0.0022	0.0019	<0.001
Zinc	0.0001 to 0.01	0.119	0.0926	0.126	0.167	0.125				0.0431	0.0441	0.0447	0.0407
Zirconium	0.0001 to 0.001												
Organics													
Dissolved Organic Carbon						1.48							0.91
Total Organic Carbon	0.5 to 5.0	1.73	1.46	1.32	1.44	1.48	4.4	34.3	45.7	1.57	1.36	1.48	1.02

NOTES:
1. UNITS ARE IN mg/L UNLESS OTHERWISE STATED.
2. REFER TO TABLE F1 FOR DETAILED FOOTNOTES ON CELL SHADING.

Site ID Date/Time Sampled	MDL	*MW13-02S* *2-Oct-13*	*MW13-02S* *29-Jul-14*
Calculated Parameters			
Ion Balance Ratio	0.01		
Physical Tests			
Acidity to pH 4.5 (as CaCO3)	0.5		
Acidity to pH 8.3 (as CaCO3)	0.5		
Alkalinity (PP as CaCO3)	0.5		
Alkalinity (Total as CaCO3)	0.5	*48.9*	*19.1*
Bicarbonate Alkalinity	0.5	*48.9*	*19.1*
Carbonate Alkalinity	0.5	*<2*	*<2*
Conductivity µS/cm	1	*168*	*104*
Hardness as CaCO3 (Dissolved)	0.5	*64.2*	*27*
Hardness as CaCO3 (Total)	0.5		
Hydroxide Alkalinity	0.5	*<2*	*<2*
pH (pH)	0	*8.02*	*6.69*
Total Dissolved Solids	1.0 to 10.0	*113*	*97*
Total Suspended Solids	1	*770*	*97.3*
Turbidity (NTU)	0.1	*922*	*73*
Dissolved Anions			
Bromide	0.01 to 0.4	*<0.05*	*<0.05*
Chloride	0.5	*<0.5*	*<0.5*
Fluoride	0.01	*0.504*	*0.118*
Sulphate	0.5 to 5.0	*31.4*	*23.6*
Thiocyanate	0.2		
Nutrients			
Ammonia (Total)	0.005 to 0.01	*0.045*	*<0.005*
Nitrate (as N)	0.002 to 0.02	*<0.005*	*0.179*
Nitrate+Nitrite (Dissolved)	0.002 to 0.02		
Nitrite (as N)	0.002 to 0.005	*0.0227*	*0.0022*
Nitrogen (Total)	0.02	*0.094*	*0.28*
Nitrogen Kjeldahl (Total)	0.02	*0.071*	*0.099*
Orthophosphate (Dissolved)	0.001 to 0.005		
Phosphorus Dissolved	0.002 to 0.01	*<0.002*	*0.0027*
Cyanide			
Cyanide (SAD)	0.001		
Cyanide (WAD)	0.0005	*<0.005*	*<0.005*
Cyanide+Thiocyanate	0.0005 to 0.001		
Dissolved Metals			
Aluminum	0.0002 to 0.003	*<0.001*	*0.0054*
Antimony	0.00002 to 0.0005	*<0.0001*	*<0.0001*
Arsenic	0.00002 to 0.001	*0.00043*	*0.0017*
Barium	0.00002 to 0.001	*0.0524*	*0.0662*
Beryllium	0.00001 to 0.005	*<0.0001*	*<0.0001*
Bismuth	0.000005 to 0.1	*<0.0005*	*<0.0005*
Boron	0.05 to 0.3	*<0.01*	*<0.01*
Cadmium	0.000005 to 0.00003	*0.000045*	*0.00005*
Calcium	0.05 to 0.3	*19.7*	*8.34*
Chromium	0.0001 to 0.001	*<0.0001*	*<0.0001*
Cobalt	0.000005 to 0.001	*0.00336*	*0.00496*
Copper	0.00005 to 0.0003	*0.00041*	*<0.0002*
Iron	0.001 to 0.03	*12.6*	*8*
Lead	0.000005 to 0.001	*<0.00005*	*<0.00005*
Lithium	0.0005 to 0.005	*0.0007*	*0.00135*
Magnesium	0.001 to 0.3	*3.65*	*1.5*
Manganese	0.00002 to 0.005	*1.04*	*0.246*
Mercury	0.00000001 to 0.00005	*<0.00001*	*<0.00001*
Molybdenum	0.00005 to 0.001	*0.0103*	*0.00368*
Nickel	0.00002 to 0.001	*0.00959*	*0.017*
Phosphorus	0.002 to 0.01	*<0.05*	*<0.05*
Potassium	0.05 to 0.3	*3.35*	*0.93*
Selenium	0.00004 to 0.0005	*<0.0001*	*<0.0001*
Silicon	0.1 to 0.5	*8.46*	*10.9*
Silver	0.000005 to 0.0001	*<0.00001*	*<0.00001*
Sodium	0.05 to 0.3	*4.73*	*4.45*
Strontium	0.00005 to 0.001	*0.128*	*0.0668*
Sulphur	1.0 to 50.0	*10.5*	*7.89*
Thallium	0.000002 to 0.00005	*<0.00001*	*<0.00001*
Tin	0.00001 to 0.005	*<0.0001*	*<0.0001*
Titanium	0.0005 to 0.01	*<0.01*	*<0.01*
Uranium	0.000002 to 0.0001	*0.000303*	*0.00015*
Vanadium	0.0002 to 0.03	*<0.001*	*<0.001*
Zinc	0.0001 to 0.005	*0.002*	*0.0183*
Zirconium	0.0001 to 0.005		
Total Metals			
Aluminum	0.0002 to 0.006	*24.6*	*1.87*
Antimony	0.00002 to 0.001	*0.00255*	*0.00045*
Arsenic	0.00002 to 0.0002	*0.0328*	*0.00411*
Barium	0.00002 to 0.002	*0.507*	*0.101*
Beryllium	0.00001 to 0.005	*0.00098*	*<0.0001*
Bismuth	0.000005 to 0.1	*0.00255*	*<0.0005*
Boron	0.05 to 0.25	*0.015*	*<0.01*
Cadmium	0.000005 to 0.00005	*0.000269*	*0.000078*
Calcium	0.05 to 0.25	*20.6*	*8.14*
Chromium	0.0001 to 0.002	*0.0257*	*0.00254*
Cobalt	0.000005 to 0.001	*0.0105*	*0.00526*
Copper	0.00005 to 0.0004	*0.513*	*0.0364*
Iron	0.001 to 0.01	*62*	*11.3*
Lead	0.000005 to 0.001	*0.0429*	*0.00325*
Lithium	0.0005 to 0.01	*0.00507*	*0.00163*
Magnesium	0.001 to 0.25	*7.05*	*1.73*
Manganese	0.00005 to 0.002	*1.28*	*0.251*
Mercury	0.00001 to 0.00005	*0.000012*	*<0.00001*
Molybdenum	0.00005 to 0.002	*0.0583*	*0.0072*
Nickel	0.00002 to 0.002	*0.0291*	*0.0177*
Phosphorus	0.000002 to 0.01	*0.714*	*0.000053*
Potassium	0.05 to 0.25	*8.07*	*1.44*
Selenium	0.00004 to 0.1	*0.00066*	*0.00014*
Silicon	0.1 to 0.5	*40*	*13.5*
Silver	0.000005 to 0.0001	*0.0118*	*0.000631*
Sodium	0.05 to 0.25	*5.7*	*4.42*
Strontium	0.00005 to 0.002	*0.176*	*0.0713*
Sulphur	3.0 to 50.0	*11.8*	*7.77*
Thallium	0.000002 to 0.0001	*0.0004*	*0.000044*
Tin	0.0002 to 0.01	*0.0026*	*0.00072*
Titanium	0.0005 to 0.01	*0.551*	*0.049*
Uranium	0.000002 to 0.0002	*0.00632*	*0.000625*
Vanadium	0.0002 to 0.03	*0.0377*	*0.0029*
Zinc	0.0001 to 0.01	*0.0717*	*0.027*
Zirconium	0.0001 to 0.001		
Organics			
Dissolved Organic Carbon			
Total Organic Carbon	0.5 to 5.0	*3.99*	*1.54*

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NOTES:
1. UNITS ARE IN mg/L UNLESS OTHERWISE STATED.
2. REFER TO TABLE F1 FOR DETAILED FOOTNOTES ON CELL SHADING.

Site ID Date/Time Sampled	MDL	94-352 29-Sep-94	94-352 24-May-95	94-352 11-Sep-08	94-352 25-Sep-09	94-352 7-Jun-10	94-352 18-Aug-10	94-352 13-Sep-10	*94-352* *30-Jul-14*	*94-352* *30-Sep-14*	94-353 24-May-95	94-353 11-Sep-08	94-353 23-Sep-09
Calculated Parameters													
Ion Balance Ratio	0.01				0.97	1				*0.99*			1
Physical Tests													
Acidity to pH 4.5 (as CaCO3)	0.5				<0.5	<0.5	<0.5	<0.5					<0.5
Acidity to pH 8.3 (as CaCO3)	0.5				<0.5	1.6	3.4	<0.5	*1.8*				1.8
Alkalinity (PP as CaCO3)	0.5												
Alkalinity (Total as CaCO3)	0.5	94.9	127	120	120	150	130	120	*131*	*118*	98.8	100	120
Bicarbonate Alkalinity	0.5								*131*	*118*			
Carbonate Alkalinity	0.5								*<2*	*<1*			
Conductivity µS/cm	1	216	255	250	251	303	259	244	*257*	*226*	214	230	273
Hardness as CaCO3 (Dissolved)	0.5			126	123	162	135	117	*144*	*123*		113	143
Hardness as CaCO3 (Total)	0.5	111	134								116		
Hydroxide Alkalinity	0.5								*<2*	*<1*			
pH (pH)	0	7.53	7.48	8.1	7.9	8.23	8.06	8.04	*8.07*	*8.13*	7.21	7.9	7.57
Total Dissolved Solids	1.0 - 10.0	128	175	160	140	190	130	150	*165*	*151*	145	160	170
Total Suspended Solids	1	71	36	36					*47.9*	*<3*	139	750	
Turbidity (NTU)	0.1	33.5	26.1	6.7					*17.3*	*1.51*	76.5	208	
Dissolved Anions													
Bromide	0.01 - 0.4			0.3	<0.4	<0.4	<0.4	<0.4	*<0.05*	*<0.05*		0.2	<0.4
Chloride	0.5	1.1	0.8	<0.5	1.2	<0.5		<0.5	*<0.5*	*<0.5*	0.9	1	0.9
Fluoride	0.01	0.06	0.05	0.04	0.04	0.09	0.05	0.04	*0.048*	*0.039*	0.04	0.03	0.04
Sulphate	0.5	11.9	14.1	13	9.7	10	11	10	*11.1*	*10.1*	8.8	19	19
Thiocyanate	0.2					<0.2							
Nutrients													
Ammonia (Total)	0.005 - 0.05	0.021	<0.005	0.01	0.06	0.009	<0.005	<0.005	*<0.005*	*<0.005*	0.016	<0.01	0.06
Nitrate (as N)	0.002 - 0.02	0.179	0.139	0.093	0.086	0.096	0.099	0.103	*0.145*	*0.121*	1.54	0.355	0.36
Nitrate+Nitrite (Dissolved)	0.002 - 0.02			0.098	0.086	0.096	0.102	0.106		*<0.001*		0.397	0.36
Nitrite (as N)	0.002 - 0.005	0.021	0.008	0.005	<0.002	<0.002	0.002	0.003	*<0.001*	*0.254*	0.002	0.042	<0.002
Nitrogen (Total)	0.02			0.23	1.18	0.19	0.3	0.24	*0.242*	*0.132*		0.4	0.52
Nitrogen Kjeldahl (Total)	0.02			0.13	1.1	0.09	0.2	0.14	*0.096*	*0.003*		<0.02	0.16
Orthophosphate (Dissolved)	0.001 - 0.005	0.007	0.035	0.009	0.002	0.007	0.009	0.002	*0.0021*	*0.0069*	0.011	0.067	0.002
Phosphorus Dissolved	0.002	0.007	0.035	0.017		0.016	0.017	0.015	*0.0024*	*0.0091*	0.011	0.003	
Cyanide													
Cyanide (SAD)	0.001				0.003					*<0.005*			0.009
Cyanide (WAD)	0.0005			<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	*<0.005*	*<0.005*		<0.0005	<0.0005
Cyanide+Thiocyanate	0.0005 - 0.001	<0.001	0.02	<0.0005		<0.0005	<0.0005	<0.0005		*<0.005*	0.01	0.0009	
Dissolved Metals													
Aluminum	0.0002 - 0.005	0.014	0.014	0.0081	0.0087	0.0108	0.0057	0.004	*0.0414*	*0.0023*	0.049	0.0547	0.0165
Antimony	0.00002 - 0.0005	0.0004	0.0004	0.0003	0.00025	0.00048	0.00029	0.00034	*0.00023*	*0.00018*	0.0002	0.0003	0.00032
Arsenic	0.00002 - 0.001	0.0009	0.0008	0.00023	0.00016	0.00028	0.00025	0.00024	*0.0002*	*0.00013*	0.0001	0.00016	0.00005
Barium	0.00002 - 0.001	0.035	0.058	0.0604	0.0579	0.0757	0.0609	0.0593	*0.0798*	*0.0635*	0.023	0.0167	0.0191
Beryllium	0.00001 - 0.005	<0.005	<0.005	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	*<0.0001*	*<0.0001*	<0.005	<0.00001	<0.00001
Bismuth	0.000005 - 0.1	<0.1	<0.1	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	*<0.0005*	*<0.0005*	<0.1	<0.000005	<0.000005
Boron	0.05 - 0.1	<0.1	<0.1	<0.05	<0.05	<0.05	<0.05	<0.05	*<0.01*	*<0.01*	<0.1	<0.05	<0.05
Cadmium	0.000005 - 0.0002	<0.0002	<0.0002	0.000069	0.000028	0.000006	0.000025	0.000014	*0.000072*	*0.000034*	<0.0002	0.000161	0.000331
Calcium	0.05	32.2	37.7	35	34.3	43.3	37.1	32.3	*40.7*	*34.3*	37.2	35.8	45.6
Chromium	0.0001 - 0.001	<0.001	<0.001	<0.0001	<0.0001	0.0002	<0.0001	0.0002	*0.0022*	*0.00011*	<0.001	<0.0001	<0.0001
Cobalt	0.000005 - 0.001	0.001	<0.001	0.000435	0.000041	0.00004	0.000018	0.000034	*0.00039*	*<0.0001*	<0.001	0.000017	0.000054
Copper	0.00005 - 0.001	0.005	0.003	0.00174	0.00425	0.001	0.00086	0.00087	*0.00383*	*0.00277*	0.005	0.00363	0.00093
Iron	0.001 - 0.03	<0.03	<0.03	0.002	0.003	0.017	0.002	0.004	*0.063*	*<0.01*	0.039	0.035	0.011
Lead	0.000005 - 0.001	<0.001	0.001	0.000054	0.000056	0.000028	0.00001	0.000032	*0.000708*	*<0.00005*	<0.001	0.000449	0.000259
Lithium	0.0005 - 0.005			0.0013	0.0017	0.0013	0.0012	0.0011	*0.00135*	*0.00124*		0.0011	0.0011
Magnesium	0.001 - 0.05	7.52	9.8	9.26	9.09	13.1	10.2	8.71	*10.4*	*8.97*	5.7	5.73	7.03
Manganese	0.00005 - 0.005	0.043	0.011	0.0229	0.00149	0.00145	0.00037	0.00218	*0.0166*	*0.00183*	0.02	0.00108	0.00174
Mercury	0.00000001 - 0.00002			<0.00001		<0.00001	<0.00001	<0.00001	*<0.00001*	*<0.00001*		<0.00001	
Molybdenum	0.00005 - 0.001	0.005	0.003	0.0037	0.0035	0.0043	0.00315	0.00341	*0.00686*	*0.00303*	<0.001	0.00017	0.00022
Nickel	0.00002 - 0.001	0.008	0.001	0.00267	0.00031	0.00051	0.00025	0.00036	*0.0135*	*<0.0005*	0.001	0.00018	0.00016
Phosphorus	0.002								*<0.05*	*<0.05*			
Potassium	0.05	840	0.94	1.11	0.91	0.91	0.85	0.74	*0.89*	*0.78*	0.86	0.6	0.72
Selenium	0.00004 - 0.0005	<0.0005	<0.0005	<0.00004	<0.00004	0.00004	<0.00004	<0.00004	*<0.0001*	*<0.0001*	<0.0005	0.00006	<0.00004
Silicon	0.00002 - 0.1	4.69	4.21	4.3	4.2	4.4	4.4	4.4	*4.22*	*4.4*	3.84	4.7	4.8
Silver	0.000005 - 0.0001	<0.0001	<0.0001	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	*<0.00001*	*<0.00001*	<0.0001	0.000011	<0.000005
Sodium	0.05	3	3460	2.23	2.43	2.57	2.26	1.98	*2.38*	*2.06*	1.6	1.44	1.63
Strontium	0.00005 - 0.001	0.183	0.221	0.184	0.18	0.251	0.193	0.176	*0.213*	*0.173*	0.203	0.195	0.231
Sulphur	1.0 - 10.0			5	4	<10	<10	<10	*4.04*	*3.5*		6	8
Thallium	0.000002 - 0.00005			0.000006	0.000002	0.000003	<0.000002	<0.000002	*<0.00001*	*<0.00001*		0.000005	0.000005
Tin	0.00001 - 0.005			0.00004	0.00004	0.00002	<0.00001	0.00003	*<0.0001*	*0.00015*		0.00037	0.00002
Titanium	0.0005 - 0.01		<0.01	0.0008	<0.0005	0.0006	<0.0005	<0.0005	*<0.01*	*<0.01*	<0.01	0.0019	<0.0005
Uranium	0.000002 - 0.0001	0.00226	0.00309	0.00534	0.005	0.0089	0.00627	0.00441	*0.006*	*0.00387*	0.00021	0.00139	0.00271
Vanadium	0.0002 - 0.03	<0.03	<0.03	<0.0002	<0.0002	0.0003	<0.0002	0.0004	*<0.001*	*<0.001*	<0.03	<0.0002	<0.0002
Zinc	0.0001 - 0.005	<0.005	<0.005	0.0395	0.0136	0.0009	0.0013	0.0017	*0.0185*	*0.0139*	0.011	0.0101	0.0322
Zirconium	0.0001 - 0.0005			<0.0001	<0.0001	<0.0001	<0.0001	<0.0001				<0.0001	<0.0001
Total Metals													
Aluminum	0.0002 - 0.003	1.43	0.504						*0.201*	*0.0279*	1.28		
Antimony	0.00002 - 0.0005	0.0005	0.0004						*0.00022*	*0.0002*	0.0003		
Arsenic	0.00002 - 0.0001	0.0013	0.0008						*0.00026*	*0.00018*	0.0008		
Barium	0.00002 - 0.001	0.05	0.07						*0.076*	*0.0647*	0.066		
Beryllium	0.00001 - 0.005	<0.005	<0.005						*<0.0001*	*<0.0001*	<0.005		
Bismuth	0.000005 - 0.1	<0.1	<0.1						*<0.0005*	*<0.0005*	<0.1		
Boron	0.05 - 0.1	<0.1	<0.1						*<0.01*	*0.011*	<0.1		
Cadmium	0.000005 - 0.0002	<0.0002	<0.0002						*0.000035*	*0.000037*	0.0002		
Calcium	0.05	32.6	39						*38.6*	*33.7*	38.6		
Chromium	0.0001 - 0.001	0.025	0.002						*0.0531*	*0.00063*	0.002		
Cobalt	0.000005 - 0.001	0.003	<0.001						*0.00093*	*<0.0001*	0.002		
Copper	0.00005 - 0.0002								*0.00652*	*0.00293*			
Iron	0.001 - 0.005	0.894	0.535						*0.536*	*0.051*	1.79		
Lead	0.000005 - 0.0002	0.005	0.003						*0.00139*	*0.000433*	0.028		
Lithium	0.0005 - 0.005								*0.0013*	*0.00119*			
Magnesium	0.001 - 0.05	7.77	10						*10.3*	*8.85*	6330		
Manganese	0.00005 - 0.001	0.061	0.027						*0.0181*	*0.00371*	0.127		
Mercury	0.00001 - 0.00002	<0.00001	<0.00001						*<0.00001*	*<0.00001*	<0.00001		
Molybdenum	0.00005 - 0.001	0.007	0.003						*0.0109*	*0.00331*	<0.001		
Nickel	0.00002 - 0.001	0.029	0.004						*0.0365*	*0.00057*	0.003		
Phosphorus	0.000002 - 0.002	0.000049	0.000122						*<0.00005*	*<0.05*	0.000118		
Potassium	0.05								*0.83*	*0.75*			
Selenium	0.00004 - 0.1	<0.0005	<0.0005						*<0.0001*	*<0.0001*	<0.0005		
Silicon	0.1	8	4.87						*4.56*	*4.4*	5.27		
Silver	0.000005 - 0.0001	<0.0001	<0.0001						*0.000037*	*<0.00001*	<0.0001		
Sodium	0.05								*2.11*	*2.02*			
Strontium	0.00005 - 0.001	0.183	0.221						*0.193*	*0.175*	0.214		
Sulphur	3.0 - 10.0								*3.62*	*3.46*			
Thallium	0.000002 - 0.00005								*<0.00001*	*<0.00001*			
Tin	0.0002 - 0.005								*0.00027*	*0.00028*			
Titanium	0.0005 - 0.01		0.026						*<0.01*	*<0.01*	0.056		
Uranium	0.000002 - 0.0001	0.00228	0.00317						*0.00564*	*0.00405*	0.00189		
Vanadium	0.0002 - 0.03	<0.03	<0.03						*<0.001*	*<0.001*	<0.03		
Zinc	0.0001 - 0.005	0.009	0.006						*0.0127*	*0.0106*	0.037		
Zirconium	0.0001 - 0.0005												
Organics													
Dissolved Organic Carbon										*1.49*			
Total Organic Carbon	0.5 - 5.0	2.3	2.5	2.3	1.5	1.7	4.5	1.5	*1.39*	*1.51*	10.5	2.8	1.7

NOTES:
1. UNITS ARE IN mg/L UNLESS OTHERWISE STATED.
2. REFER TO TABLE F1 FOR DETAILED FOOTNOTES ON CELL SHADING.

Site ID Date/Time Sampled	MDL	94-353 18-Aug-10	94-353 13-Sep-10	94-353 21-May-11	94-353 18-Jul-11	94-354 24-May-95	94-354 10-Sep-08	94-354 18-Aug-10	94-354 13-Sep-10	94-354 15-Jul-11	94-354 20-Sep-11	94-354 31-Jul-14	MW11-01A 24-Sep-11
Calculated Parameters													
Ion Balance Ratio	0.01												
Physical Tests													
Acidity to pH 4.5 (as CaCO3)	0.5	<0.5	<0.5					<0.5	<0.5				
Acidity to pH 8.3 (as CaCO3)	0.5	8.2	0.9					6.1	1			2.9	
Alkalinity (PP as CaCO3)	0.5			<0.5	<0.5					<0.5	<0.5		0.25
Alkalinity (Total as CaCO3)	0.5	110	120	41	110	55.2	77	88	66	54	84	81.8	150
Bicarbonate Alkalinity	0.5			50	130					65	100	81.8	180
Carbonate Alkalinity	0.5			<0.5	<0.5					<0.5	<0.5	<2	0.25
Conductivity µS/cm	1	251	273	86	239	127	160	186	134	111	180	168	348
Hardness as CaCO3 (Dissolved)	0.5	118	131	45.3	116		78.9	87.7	64.4	57.9	79.4	88.5	161
Hardness as CaCO3 (Total)	0.5			50.4	116	64.4				54.4			149
Hydroxide Alkalinity	0.5			<0.5	<0.5					<0.5	<0.5	<2	0.25
pH (pH)	0	7.71	7.79	7.17	7.57	6.91	7.8	7.69	7.67	7.48	7.74	7.83	8.04
Total Dissolved Solids	1.0 - 10.0	120	160	62	140	81	140	100	96	86	120	124	200
Total Suspended Solids	1			35	<1	101	81			4	45	52.8	120
Turbidity (NTU)	0.1			30	1.4	59.7	115			5.1	15.1	26.9	64.1
Dissolved Anions													
Bromide	0.01 - 0.4	<0.4	<0.4				0.2	<0.4	<0.4			<0.05	
Chloride	0.5		<0.5	0.6	0.6	1.1	<0.5		<0.5	0.7	0.5	<0.5	1.8
Fluoride	0.01	0.03	0.05	0.03	0.05	0.04	0.07	0.04	0.07	0.04	0.05	0.037	0.08
Sulphate	0.5	21	22	0.8	13	3.9	7.3	6.2	0.6	<0.5	7.5	1.51	31
Thiocyanate	0.2												
Nutrients													
Ammonia (Total)	0.005 - 0.05	<0.005	0.14	0.011	0.021	0.014	0.02	0.029	<0.005	0.03	0.02	0.0055	0.044
Nitrate (as N)	0.002 - 0.02	0.208	0.563	0.12	0.43	0.957	0.242	0.612	0.428	0.26	0.42	0.909	0.3
Nitrate+Nitrite (Dissolved)	0.002 - 0.02	0.208	0.572	0.13	0.43		0.285	0.621	0.433	0.26	0.42		0.32
Nitrite (as N)	0.002 - 0.005	<0.002	0.009	0.01	<0.005	0.002	0.043	0.009	0.005	<0.005	<0.005	<0.001	0.021
Nitrogen (Total)	0.02	0.21	0.73				0.33	0.57	0.6			1.17	
Nitrogen Kjeldahl (Total)	0.02	<0.02	0.16				0.05	<0.02	0.17			0.26	
Orthophosphate (Dissolved)	0.001 - 0.005	0.001	0.001	<0.005		0.003	0.047	0.002	0.001	<0.005		0.0032	
Phosphorus Dissolved	0.002	0.013	0.002			0.003	0.005	0.01	0.005			0.0042	
Cyanide													
Cyanide (SAD)	0.001												
Cyanide (WAD)	0.0005	<0.0005	<0.0005	0.0009			<0.0005	<0.0005	0.0005			<0.005	
Cyanide+Thiocyanate	0.0005 - 0.001	<0.0005	<0.0005	0.0012	<0.0005	0.01	0.0006	<0.0005	<0.0005	<0.0005	<0.0005		0.00025
Dissolved Metals													
Aluminum	0.0002 - 0.005	0.0031	0.006	0.078	0.006	0.08	0.0085	0.0054	0.009	0.033	0.009	0.0045	0.008
Antimony	0.00002 - 0.0005	0.00026	0.00026	<0.0005	<0.0005	<0.0001	0.00013	0.00015	0.00012	<0.0005	<0.0005	0.00013	0.00025
Arsenic	0.00002 - 0.001	0.00007	0.00008	0.0002	<0.0001	0.0001	0.00017	0.00016	0.00014	0.0002	<0.0001	0.00014	0.0003
Barium	0.00002 - 0.001	0.0159	0.0173	0.007		0.055	0.0455	0.0513	0.0401		0.054	0.0516	0.132
Beryllium	0.00001 - 0.005	<0.00001	<0.00001	<0.0001	<0.0001	<0.005	<0.00001	<0.00001	<0.00001	<0.0001	<0.0001	<0.0001	0.00005
Bismuth	0.000005 - 0.1	<0.000005	<0.000005	<0.001	<0.001	<0.1	<0.000005	<0.000005	<0.000005	<0.001	<0.001	<0.0005	0.0005
Boron	0.05 - 0.1	<0.05	<0.05	<0.05	<0.05	<0.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	0.025
Cadmium	0.000005 - 0.0002	0.000327	0.000311	0.00023	0.00027	<0.0002	0.000128	0.000134	0.000148	0.00016	0.00018	0.000184	0.00008
Calcium	0.05	36.8	41.3	14.4	36.1	19.5	23.6	26	19.3	17.2	25.3	26.5	38.1
Chromium	0.0001 - 0.001	<0.0001	<0.0001	0.001	<0.001	<0.001	<0.0001	<0.0001	0.0001	<0.001	<0.001	<0.0001	0.0005
Cobalt	0.000005 - 0.001	0.000021	0.000006	<0.0005	<0.0005	<0.001	0.00005	0.000058	0.00003	<0.0005	<0.0005	<0.0001	0.0005
Copper	0.00005 - 0.001	0.00144	0.00089	0.0056	0.0017	0.007	0.00244	0.0021	0.0021	0.0038	0.0008	0.00273	0.0011
Iron	0.001 - 0.03	0.002	0.006	0.083	0.009	0.05	0.011	0.006	0.007	0.024	0.014	<0.01	0.013
Lead	0.000005 - 0.001	0.000047	0.000069	0.0005	<0.0002	0.003	0.00119	0.00153	0.00113	0.0029	0.0014	0.00245	0.0001
Lithium	0.0005 - 0.005	0.0011	0.0011	<0.005	<0.005		0.0007	0.0005	0.0006	<0.005	<0.005	0.00063	0.0025
Magnesium	0.001 - 0.05	6.43	6.72	2.24	6.2	3.8	4.87	5.52	3.96	3.63	5.2	5.44	16.1
Manganese	0.00005 - 0.005	0.00026	0.00018	0.001		<0.005	0.00135	0.00069	0.00019		0.003	0.00122	0.14
Mercury	0.00000001 - 0.00002	<0.00001	<0.00001	<0.00002	<0.00002		<0.00001	<0.00001	<0.00001	<0.00002	<0.00002	<0.00001	0.00001
Molybdenum	0.00005 - 0.001	0.00017	0.00019	<0.001	<0.001	<0.001	0.0009	0.00096	0.00072	<0.001	<0.001	0.000721	0.003
Nickel	0.00002 - 0.001	0.00078	0.0002	0.001	<0.001	<0.001	0.00022	0.00052	0.0002	<0.001	<0.001	<0.0005	0.003
Phosphorus	0.002											<0.05	
Potassium	0.05	0.66	0.62	0.37	0.6	0.87	0.77	0.84	0.7	0.69	0.88	0.91	2.39
Selenium	0.00004 - 0.0005	<0.00004	<0.00004	<0.0001	<0.0001	<0.0005	<0.00004	<0.00004	<0.00004	<0.0001	<0.0001	<0.0001	0.0001
Silicon	0.00002 - 0.1	4.2	4.6	2.51	4.3	5.33	5.4	5.5	6	5.94	6	6.8	5.42
Silver	0.000005 - 0.0001	<0.000005	<0.000005		<0.00002	<0.0001	0.000013	<0.000005	0.000014	<0.00002	<0.00002	<0.00001	0.00001
Sodium	0.05	1.57	1.54	0.57	1.51	1.92	1.59	1.88	1.37	1.23	2.23	1.77	9.27
Strontium	0.00005 - 0.001	0.2	0.229	0.081		0.123	0.142	0.161	0.119		0.164	0.163	0.193
Sulphur	1.0 - 10.0	<10	<10	<3	5		<3	<10	<10	<3	3	0.63	11
Thallium	0.000002 - 0.00005	0.000003	0.000003	<0.00005	<0.00005		0.000007	0.000005	0.000007	<0.00005	<0.00005	<0.00001	0.000025
Tin	0.00001 - 0.005	<0.00001	<0.00001	<0.005	<0.005		0.00018	0.00005	0.00002	<0.005	<0.005	0.00013	0.0025
Titanium	0.0005 - 0.01	<0.0005	<0.0005	<0.005	<0.005	<0.01	0.0005	<0.0005	0.0006	<0.005	<0.005	<0.01	0.0025
Uranium	0.000002 - 0.0001	0.00173	0.00204	0.0004	0.0016	0.00124	0.00355	0.00403	0.0013	0.0016	0.0022	0.00257	0.0057
Vanadium	0.0002 - 0.03	<0.0002	<0.0002	<0.005	<0.005	<0.03	<0.0002	<0.0002	0.0002	<0.005	<0.005	<0.001	0.0025
Zinc	0.0001 - 0.005	0.033	0.0285	0.042	0.041	0.011	0.0066	0.0086	0.0077	0.025	0.018	0.0268	0.005
Zirconium	0.0001 - 0.0005	<0.0001	<0.0001	<0.0005	<0.0005		<0.0001	<0.0001	<0.0001	<0.0005	<0.0005		0.00025
Total Metals													
Aluminum	0.0002 - 0.003			1.68	0.058	0.603				0.094	0.703	0.586	2.41
Antimony	0.00002 - 0.0005			<0.0005	<0.0005	0.0001				<0.0005	<0.0005	0.00029	0.00025
Arsenic	0.00002 - 0.0001			0.0008	<0.0001	0.0005				<0.0001	0.0007	0.00075	0.001
Barium	0.00002 - 0.001			0.026	0.015	0.077				0.037	0.059	0.0616	0.217
Beryllium	0.00001 - 0.005			<0.0001	<0.0001	<0.005				<0.0001	<0.0001	<0.0001	0.00005
Bismuth	0.000005 - 0.1			<0.001	<0.001	<0.1				<0.001	<0.001	<0.0005	0.0005
Boron	0.05 - 0.1			<0.05	<0.05	<0.1				<0.05	<0.05	<0.01	0.025
Cadmium	0.000005 - 0.0002			0.0003	0.00031	<0.0002				0.00015	0.00021	0.000224	0.00014
Calcium	0.05			15.9	36.1	20.2				16	23.5	26.5	36.3
Chromium	0.0001 - 0.001			0.004	<0.001	0.002				<0.001	<0.001	0.00169	0.001
Cobalt	0.000005 - 0.001			<0.0005	<0.0005	0.002				<0.0005	0.0006	0.00041	0.0018
Copper	0.00005 - 0.0002			0.0074	0.0017					0.0042	0.0038	0.00788	0.0054
Iron	0.001 - 0.005			1.51	0.051	0.764				0.111	1.2	1.15	3.18
Lead	0.000005 - 0.0002			0.0039	0.0003	0.104				0.0079	0.04	0.0303	0.0023
Lithium	0.0005 - 0.005			<0.005	<0.005					<0.005	<0.005	0.00089	0.0025
Magnesium	0.001 - 0.05			2.56	6.16	3980				3.53	5.01	5.54	14.1
Manganese	0.00005 - 0.001			0.03		0.061					0.031	0.0253	0.359
Mercury	0.00001 - 0.00002			<0.00002	<0.00002	<0.00001				<0.00002	<0.00002	0.000026	0.00001
Molybdenum	0.00005 - 0.001			<0.001	<0.001	<0.001				<0.001	<0.001	0.000906	0.003
Nickel	0.00002 - 0.001			0.003	<0.001	0.002				<0.001	0.001	0.00149	0.004
Phosphorus	0.000002 - 0.002					0.00012						<0.00005	
Potassium	0.05			0.78	0.56					0.65	1.02	1.11	3.03
Selenium	0.00004 - 0.1			<0.0001	<0.0001	<0.0005				<0.0001	<0.0001	<0.0001	0.0001
Silicon	0.1			5.01		5.82					6.4	7.92	8.82
Silver	0.000005 - 0.0001			0.00033	0.00003	<0.0001				0.00018	0.00078	0.000794	0.00006
Sodium	0.05			1.03	1.42					1.18	2.1	1.76	7.28
Strontium	0.00005 - 0.001			0.089	0.208	0.128				0.105	0.159	0.162	0.174
Sulphur	3.0 - 10.0			<3	4					<3	<3	0.64	8
Thallium	0.000002 - 0.00005			<0.00005	<0.00005					<0.00005	<0.00005	0.000025	0.00015
Tin	0.0002 - 0.005			<0.005	<0.005					<0.005	<0.005	0.00093	0.0025
Titanium	0.0005 - 0.01			0.041		<0.01					0.026	0.018	0.07
Uranium	0.000002 - 0.0001			0.0006	0.0016	0.0015				0.0016	0.0028	0.00277	0.005
Vanadium	0.0002 - 0.03			<0.005	<0.005	<0.03				<0.005	<0.005	0.0016	0.0025
Zinc	0.0001 - 0.005			0.06	0.048	0.031				0.028	0.028	0.0357	0.014
Zirconium	0.0001 - 0.0005			0.0005	<0.0005					<0.0005	<0.0005		0.00025
Organics													
Dissolved Organic Carbon													3.7
Total Organic Carbon	0.5 - 5.0	5.1	2.3	15.1	3.6	12	5	6.1	5.3	8.6	1.2	6.13	

NOTES:
1. UNITS ARE IN mg/L UNLESS OTHERWISE STATED.
2. REFER TO TABLE F1 FOR DETAILED FOOTNOTES ON CELL SHADING.

Site ID Date/Time Sampled	MDL	MW11-01B 24-Sep-11	MW11-02A 24-Sep-11	MW11-02A 27-May-12	MW11-02A 17-Sep-12	MW11-02A 12-Jun-13	MW11-02A 5-Aug-13	MW11-02A 27-Sep-13	MW11-02A 24-May-14	MW11-02A 24-Jul-14	MW11-02A 29-Sep-14	MW11-02B 24-Sep-11	MW11-02B 27-May-12
Calculated Parameters													
Ion Balance Ratio	0.01			1	0.91						0.97		0.97
Physical Tests													
Acidity to pH 4.5 (as CaCO3)	0.5			<0.5	<0.5								<0.5
Acidity to pH 8.3 (as CaCO3)	0.5			2.14	1.34		1.1						0.81
Alkalinity (PP as CaCO3)	0.5	0.25	<0.5									<0.5	
Alkalinity (Total as CaCO3)	0.5	98	160	159	163	169	172	169	158	174	170	130	147
Bicarbonate Alkalinity	0.5	120	200			169	172	169	158	173	170	160	
Carbonate Alkalinity	0.5	0.25	<0.5			<2	<2	<2	<1	<1	<1	<0.5	
Conductivity µS/cm	1	276	355	340	340	333	327	332	326	340	337	403	331
Hardness as CaCO3 (Dissolved)	0.5	109	156	165	147	170	168	166	174	177	178	164	143
Hardness as CaCO3 (Total)	0.5	159	155	175	167							168	157
Hydroxide Alkalinity	0.5	0.25	<0.5			<2	<2	<2	<1	<1	<1	<0.5	
pH (pH)	0	7.43	8.16	7.98	8.04	8.23	8.21	7.95	8.17	8.33	8.22	8.13	8.13
Total Dissolved Solids	1.0 - 10.0	190	240	184	196	192	204	192	200	197	204	260	170
Total Suspended Solids	1	820	2	4.1	6.1	16	<3	4.5	4.5	5.5	3.3	33	8
Turbidity (NTU)	0.1	442	20.1	3.53	4.71	5.96	1.46	1.75	6.38	6.32	2.3	24.2	6.62
Dissolved Anions													
Bromide	0.01 - 0.4			<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05		0.011
Chloride	0.5	2.2	1.4	0.54	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	12	1.7
Fluoride	0.01	0.04	0.11	0.09	0.093	0.094	0.096	0.094	0.093	0.096	0.082	0.1	0.15
Sulphate	0.5	35	26	18.8	18.3	20.2	18.1	18.1	17.3	17.5	17.4	61	25.5
Thiocyanate	0.2												
Nutrients													
Ammonia (Total)	0.005 - 0.05	0.03	0.014	0.022	0.028	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.019	0.014
Nitrate (as N)	0.002 - 0.02	0.93	<0.02	<0.002	0.0144	1.8	<0.005	<0.005	<0.005	<0.005	<0.005	<0.02	<0.002
Nitrate+Nitrite (Dissolved)	0.002 - 0.02	0.96	<0.02	<0.002	0.0176						<0.001	<0.02	<0.002
Nitrite (as N)	0.002 - 0.005	0.033	<0.005	<0.002	0.0032	0.0015	<0.001	<0.001	<0.001	<0.001	0.07	0.009	<0.002
Nitrogen (Total)	0.02			0.033	0.08	1.78	0.073	<0.05	<0.05	0.062	0.07		0.149
Nitrogen Kjeldahl (Total)	0.02			0.033	0.062		<0.05	0.074	<0.05	0.062			0.149
Orthophosphate (Dissolved)	0.001 - 0.005			0.011	0.0061	0.0035			0.0021		0.0028		0.0012
Phosphorus Dissolved	0.002					0.0054	0.0024	0.0029	0.002	<0.002	<0.002		
Cyanide													
Cyanide (SAD)	0.001										<0.005		
Cyanide (WAD)	0.0005			<0.0005	<0.0005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005		<0.0005
Cyanide+Thiocyanate	0.0005 - 0.001	0.00025	<0.0005	<0.0005	<0.0005						<0.005	<0.0005	<0.0005
Dissolved Metals													
Aluminum	0.0002 - 0.005	0.007	0.006	0.00409	0.00339	0.0074	0.0036	0.0026	0.0024	0.0024	0.0025	0.008	0.00411
Antimony	0.00002 - 0.0005	0.00025	<0.0005	0.000043	0.00002	0.00021	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0035	0.000117
Arsenic	0.00002 - 0.001	0.00005	0.0006	0.00103	0.000955	0.00107	0.00093	0.00077	0.00101	0.00099	0.00104	0.0018	0.00238
Barium	0.00002 - 0.001	0.248	0.106	0.0911	0.0924	0.0843	0.0907	0.0999	0.0921	0.0954	0.0929	0.125	0.0952
Beryllium	0.00001 - 0.005	0.00005	<0.0001	<0.00001	<0.00001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.00001
Bismuth	0.000005 - 0.1	0.0005	<0.001	<0.000005	<0.000005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.001	<0.000005
Boron	0.05 - 0.1	0.025	<0.05	<0.05	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05
Cadmium	0.000005 - 0.0002	0.00123	0.00003	0.0000106	0.000009	0.000017	<0.00001	<0.00001	0.000012	<0.00001	<0.00001	0.00012	<0.000005
Calcium	0.05	32.8	39.4	42	35.7	44	43.1	42.3	44.2	45.1	45.6	39.5	32
Chromium	0.0001 - 0.001	0.0005	<0.001	<0.0001	0.00016	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.00023	<0.001	0.00011
Cobalt	0.000005 - 0.001	0.00025	<0.0005	0.000479	0.000354	0.00018	0.00022	0.0002	0.00023	0.00017	0.00016	<0.0005	0.000158
Copper	0.00005 - 0.001	0.0004	<0.0002	0.000274	0.0407	0.00131	<0.0002	<0.0002	0.00067	<0.0002	<0.0002	0.0022	0.00231
Iron	0.001 - 0.03	0.011	0.01	0.0373	0.0899	0.036	0.132	0.111	0.186	0.247	0.254	0.013	0.136
Lead	0.000005 - 0.001	0.0001	<0.0002	0.0000539	0.000016	0.00738	0.000101	0.000057	0.000067	0.000076	<0.00005	<0.0002	0.00032
Lithium	0.0005 - 0.005	0.0025	<0.005	0.00263	0.00252	0.00294	0.00189	0.00238	0.00269	0.00241	0.00293	<0.005	0.00281
Magnesium	0.001 - 0.05	6.66	14.1	14.5	14.1	14.5	14.7	14.7	15.4	15.7	15.5	16	15.4
Manganese	0.00005 - 0.005	0.054	0.087	0.6	0.447	0.208	0.334	0.52	0.37	0.437	0.358	0.143	0.938
Mercury	0.00000001 - 0.00002	0.00001	<0.00002	<0.00001	<0.00000001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00002	<0.00001
Molybdenum	0.00005 - 0.001	0.0005	0.001	0.00164	0.000904	0.000563	0.000692	0.00116	0.000643	0.000796	0.000722	0.016	0.0121
Nickel	0.00002 - 0.001	0.002	<0.001	0.000742	0.000794	0.00068	<0.0005	0.00055	0.00106	<0.0005	<0.0005	0.002	0.000407
Phosphorus	0.002			0.0156	0.0092	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05		0.0039
Potassium	0.05	1.72	1.79	1.55	1.51	1.6	1.44	1.41	1.6	1.54	1.51	3.96	2.04
Selenium	0.00004 - 0.0005	0.00005	<0.0001	<0.00004	<0.00004	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	<0.00004
Silicon	0.00002 - 0.1	8.5	4.57	5.01	4.18	4.85	4.74	4.62	4.92	4.86	4.88	2.71	3.44
Silver	0.000005 - 0.0001	0.00001	<0.00002	<0.000005	<0.000005	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00002	<0.000005
Sodium	0.05	9.21	11.3	6.86	7.1	6.9	7.68	7.48	6.53	6.98	6.64	14.3	10.7
Strontium	0.00005 - 0.001	0.332	0.558	0.583	0.56	0.559	0.54	0.539	0.561	0.582	0.585	0.528	0.514
Sulphur	1.0 - 10.0	12	9	<10	<10	6.04	5.9	5.98	5.93	6.04	6.09	21	<10
Thallium	0.000002 - 0.00005	0.000025	<0.00005	0.0000066	0.000006	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00005	<0.000002
Tin	0.00001 - 0.005	0.0025	<0.005	<0.0002	<0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.005	0.00042
Titanium	0.0005 - 0.01	0.0025	<0.005	<0.0005	<0.0005	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.005	<0.0005
Uranium	0.000002 - 0.0001	0.0008	0.0078	0.00596	0.00647	0.00727	0.00594	0.00497	0.00609	0.00576	0.0064	0.0031	0.000925
Vanadium	0.0002 - 0.03	0.0025	<0.005	<0.0002	<0.0002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.0002
Zinc	0.0001 - 0.005	0.024	0.007	0.00296	0.0415	0.0055	0.107	0.0497	0.0054	0.0038	0.0056	0.116	0.00234
Zirconium	0.0001 - 0.0005	0.00025	<0.0005	<0.0001	<0.0001							<0.0005	<0.0001
Total Metals													
Aluminum	0.0002 - 0.003	17.3	0.911	0.0416	0.0578	0.264	0.0884	0.0438	0.0361	0.0664	0.0128	0.991	0.0813
Antimony	0.00002 - 0.0005	0.0006	0.0011	0.000078	0.000033	0.00024	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0029	0.000198
Arsenic	0.00002 - 0.0001	0.0068	0.0015	0.00107	0.00103	0.00143	0.00121	0.00106	0.00119	0.00128	0.00114	0.0029	0.00298
Barium	0.00002 - 0.001	0.808	0.13	0.1	0.1	0.0967	0.0957	0.103	0.0983	0.1	0.0946	0.133	0.109
Beryllium	0.00001 - 0.005	0.001	<0.0001	<0.00001	<0.00001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.00001
Bismuth	0.000005 - 0.1	0.0005	<0.001	<0.000005	<0.000005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.001	<0.000005
Boron	0.05 - 0.1	0.025	<0.05	<0.05	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.05	<0.05
Cadmium	0.000005 - 0.0002	0.00489	0.00024	0.0000309	0.000022	0.000048	0.000023	0.000013	0.000013	0.000017	<0.00001	0.00013	0.0000268
Calcium	0.05	43.6	39.4	45.1	42.2	43.9	43.1	43.9	45.8	45.9	45.5	38.7	35.3
Chromium	0.0001 - 0.001	0.007	0.006	0.00017	0.00384	0.00037	0.0003	0.00019	0.00024	0.00059	0.00059	0.002	0.00021
Cobalt	0.000005 - 0.001	0.0092	0.0006	0.000649	0.000489	0.00026	0.00028	0.00023	0.00024	0.00023	0.00018	0.0005	0.00026
Copper	0.00005 - 0.0002	0.0164	0.0076	0.00163	0.0705	0.00294	0.00079	0.00054	0.00083	0.00104	0.00104	0.0046	0.00227
Iron	0.001 - 0.005	24.8	1.32	0.171	0.231	0.382	0.308	0.388	1.11	0.986	0.36	1.02	0.52
Lead	0.000005 - 0.0002	0.0255	0.0197	0.00107	0.000447	0.0113	0.00386	0.00242	0.00224	0.00308	0.000369	0.0062	0.00131
Lithium	0.0005 - 0.005	0.012	<0.005	0.00272	0.00285	0.00303	0.00204	0.00278	0.00273	0.00253	0.0027	<0.005	0.00293
Magnesium	0.001 - 0.05	12.3	13.6	15.2	14.9	14.9	14.9	15.3	16.1	15.9	15.5	17.3	16.7
Manganese	0.00005 - 0.001	0.948	0.128	0.784	0.474	0.239	0.367	0.46	0.395	0.474	0.348	0.161	1.03
Mercury	0.00001 - 0.00002	0.00001	<0.00002	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00002	<0.00001
Molybdenum	0.00005 - 0.001	0.001	0.001	0.00133	0.000923	0.000651	0.000785	0.000955	0.000698	0.000888	0.00073	0.014	0.0122
Nickel	0.00002 - 0.001	0.012	0.004	0.00089	0.00233	0.00069	<0.0005	0.00054	0.00094	<0.0005	0.00053	0.003	0.000427
Phosphorus	0.000002 - 0.002			0.0205	0.0186	<0.05	<0.05	<0.05	<0.05	<0.00005	<0.05		0.0122
Potassium	0.05	5.73	2.05	1.65	1.6	1.75	1.51	1.53	1.7	1.55	1.51	3.55	2.22
Selenium	0.00004 - 0.1	0.0002	<0.0001	<0.00004	<0.00004	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	<0.00004
Silicon	0.1	37.1	5.65	5.44	5.01	5.45	4.86	4.95	5.12	5.04	4.89	4.32	4.05
Silver	0.000005 - 0.0001	0.00025	0.00019	0.0000164	0.000005	0.000056	0.00001	<0.00001	<0.00001	<0.00001	<0.00001	0.00005	0.0000076
Sodium	0.05	11.3	11	7.14	7.77	7.23	7.68	7.24	6.92	7.16	6.84	14.3	11.5
Strontium	0.00005 - 0.001	0.421	0.501	0.611	0.631	0.591	0.568	0.587	0.62	0.603	0.579	0.507	0.536
Sulphur	3.0 - 10.0	12	9	<10	<10	6.27	6.16	6.28	6.22	6.16	6.19	20	<10
Thallium	0.000002 - 0.00005	0.00035	<0.00005	0.0000063	0.000009	0.000017	0.00001	<0.00001	<0.00001	<0.00001	<0.00001	0.00005	0.0000036
Tin	0.0002 - 0.005	0.0025	<0.005	<0.0002	<0.0002	0.00028	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.005	0.00036
Titanium	0.0005 - 0.01	0.476	0.042	0.00192	0.0013	0.014	<0.01	<0.01	<0.01	<0.01	<0.01	0.021	0.00298
Uranium	0.000002 - 0.0001	0.0043	0.007	0.00588	0.00672	0.00809	0.00641	0.0058	0.00647	0.00581	0.00676	0.0031	0.000941
Vanadium	0.0002 - 0.03	0.035	<0.005	0.00025	<0.0002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	0.00029
Zinc	0.0001 - 0.005	0.215	0.502	0.00456	0.0666	0.0135	0.136	0.0475	0.025	0.0265	0.008	0.104	0.00531
Zirconium	0.0001 - 0.0005	0.0017	<0.0005	<0.0001	<0.0001							<0.0005	<0.0001
Organics													
Dissolved Organic Carbon		2									0.76		
Total Organic Carbon	0.5 - 5.0		1.8	<5	0.67	0.91	0.98	1.33	0.93	0.6	0.86	6.9	<5

NOTES:
1. UNITS ARE IN mg/L UNLESS OTHERWISE STATED.
2. REFER TO TABLE F1 FOR DETAILED FOOTNOTES ON CELL SHADING.

Site ID Date/Time Sampled	MDL	MW11-02B 17-Sep-12	MW11-02B 12-Jun-13	MW11-02B 4-Aug-13	MW11-02B 27-Sep-13	MW11-02B 24-May-14	MW11-02B 24-Jul-14	MW11-02B 30-Sep-14	MW13-01D 28-Jul-14	MW13-03S 16-Aug-13	MW13-04S 5-Aug-13	MW13-04S 28-Sep-13	MW13-04S 25-May-14
Calculated Parameters													
Ion Balance Ratio	0.01	1						0.97					
Physical Tests													
Acidity to pH 4.5 (as CaCO3)	0.5	<0.5											
Acidity to pH 8.3 (as CaCO3)	0.5	0.85		<1							1.7		
Alkalinity (PP as CaCO3)	0.5												
Alkalinity (Total as CaCO3)	0.5	173	183	194	200	172	201	187	208	106	163	158	168
Bicarbonate Alkalinity	0.5		183	194	200	172	196	187	208	106	163	158	168
Carbonate Alkalinity	0.5		<1	<2	<2	<1	4	<1	<2	<2	<2	<2	<1
Conductivity µS/cm	1	527	394	379	387	361	386	370	1100	1070	331	333	353
Hardness as CaCO3 (Dissolved)	0.5	203	166	156	163	168	171	163	430	336	176	169	197
Hardness as CaCO3 (Total)	0.5	207											
Hydroxide Alkalinity	0.5		<1	<2	<2	<1	<1	<1	<2	<2	<2	<2	<1
pH (pH)	0	8.09	8.35	8.27	8.23	8.24	8.32	8.14	7.66	7.52	8.15	8.29	8.1
Total Dissolved Solids	1.0 - 10.0	316	222	240	204	225	233	218	849	731	209	194	222
Total Suspended Solids	1	26.4	25.1	4.5	9.9	28.9	10.9	3.3	1120	24.7	7.9	56.2	7.1
Turbidity (NTU)	0.1	13.8	16.3	3.04	6.08	14.4	10.8	2.85	637	24.1	6.28	18.9	2.15
Dissolved Anions													
Bromide	0.01 - 0.4	0.028	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.54	<0.5	<0.05	<0.05	<0.05
Chloride	0.5	5.1	0.56	<0.5	<0.5	0.52	<0.5	<0.5	19.9	36.5	<0.5	<0.5	<0.5
Fluoride	0.01	0.13	0.128	0.162	0.145	0.133	0.162	0.129	0.3	0.35	0.105	0.105	0.092
Sulphate	0.5	95	34.7	28.4	25.7	16.9	18.7	17.7	398	434	29.1	29.7	30.2
Thiocyanate	0.2												
Nutrients													
Ammonia (Total)	0.005 - 0.05	0.021	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0504	0.0218	<0.005	<0.005	<0.005
Nitrate (as N)	0.002 - 0.02	<0.002	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.05	<0.05	0.0695	0.0737	0.0489
Nitrate+Nitrite (Dissolved)	0.002 - 0.02	<0.002						<0.001					
Nitrite (as N)	0.002 - 0.005	0.0038	<0.001	<0.001	<0.001	<0.001	<0.001	0.098	<0.01	<0.01	<0.001	0.001	<0.001
Nitrogen (Total)	0.02	0.219	<0.05	<0.05	0.054	0.063	0.058	0.098	0.838	0.822	0.101	0.152	0.109
Nitrogen Kjeldahl (Total)	0.02	0.219	0.107	0.058	0.054	0.063	0.058		0.838	0.822	0.057	0.077	0.06
Orthophosphate (Dissolved)	0.001 - 0.005	0.0029	<0.001			0.0015		<0.002		<0.001			0.001
Phosphorus Dissolved	0.002		<0.002	<0.002	0.0029	<0.002	<0.002	<0.002	0.0041	0.0403	<0.002	<0.002	<0.002
Cyanide													
Cyanide (SAD)	0.001							<0.005					
Cyanide (WAD)	0.0005	<0.0005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Cyanide+Thiocyanate	0.0005 - 0.001	<0.0005						<0.005					
Dissolved Metals													
Aluminum	0.0002 - 0.005	0.00988	0.003	0.0017	0.0035	0.0016	0.0017	0.0012	0.004	0.021	0.0027	0.0021	0.0015
Antimony	0.00002 - 0.0005	0.000091	0.00044	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.00104	0.00124	<0.0001	<0.0001	<0.0001
Arsenic	0.00002 - 0.001	0.00207	0.00491	0.00398	0.006	0.00439	0.00456	0.00535	0.0147	0.00088	0.00488	0.00456	0.00531
Barium	0.00002 - 0.001	0.172	0.167	0.148	0.154	0.148	0.149	0.128	0.0764	0.0478	0.0224	0.0267	0.0232
Beryllium	0.00001 - 0.005	<0.00001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Bismuth	0.000005 - 0.1	<0.000005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Boron	0.05 - 0.1	<0.05	0.012	<0.01	0.01	<0.01	<0.01	<0.01	0.017	0.012	<0.01	<0.01	<0.01
Cadmium	0.000005 - 0.0002	0.00002	0.000019	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	0.000313	0.00057	0.000317	0.000242	0.000392
Calcium	0.05	47.5	36.5	34.4	36.3	36.3	37.3	35.8	119	99.8	49.2	46.3	54.7
Chromium	0.0001 - 0.001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.00012	0.00015	0.00222	0.00226	<0.0001
Cobalt	0.000005 - 0.001	0.000192	0.00023	<0.0001	<0.0001	0.00012	<0.0001	<0.0001	0.00713	0.0227	0.00014	0.0001	<0.0001
Copper	0.00005 - 0.001	0.0179	0.00028	<0.0002	<0.0002	0.00064	<0.0002	0.00029	0.00503	0.00688	0.00074	0.00024	0.00048
Iron	0.001 - 0.03	0.0379	<0.01	0.073	0.241	0.072	0.181	<0.01	<0.01	0.027	0.025	<0.01	<0.01
Lead	0.000005 - 0.001	0.000058	0.000207	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	0.000102	<0.00005	<0.00005	<0.00005	<0.00005
Lithium	0.0005 - 0.005	0.00194	0.00364	0.00216	0.00357	0.00328	0.00303	0.0033	0.00931	0.0039	<0.0005	0.00383	0.0011
Magnesium	0.001 - 0.05	20.6	18.1	17.1	17.6	18.9	18.9	17.8	32.4	21.1	12.8	12.9	14.6
Manganese	0.00005 - 0.005	1.48	0.898	0.94	1	0.839	0.87	0.774	1.77	2.51	0.00528	0.0025	0.00136
Mercury	0.00000001 - 0.00002	<0.00000001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum	0.00005 - 0.001	0.00997	0.013	0.00739	0.00454	0.00353	0.00312	0.00249	0.0102	0.00405	0.00348	0.00248	0.000485
Nickel	0.00002 - 0.001	0.00174	0.00213	<0.0005	0.00081	0.00368	<0.0005	<0.0005	0.0148	0.0403	0.00504	0.00469	<0.0005
Phosphorus	0.002	0.0038	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Potassium	0.05	2.33	1.92	1.81	2.05	1.92	1.92	1.76	3.15	5.32	1.28	3.63	0.92
Selenium	0.00004 - 0.0005	<0.00004	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.00046	0.00056	<0.0001	<0.0001	<0.0001
Silicon	0.00002 - 0.1	3.47	4.37	4.16	4.74	4.53	4.81	4.83	3.47	4.71	3.88	3.97	4.17
Silver	0.000005 - 0.0001	<0.000005	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	0.00001	<0.00001	<0.00001	<0.00001
Sodium	0.05	33.5	23.8	25.1	21.5	15.4	23.3	21.1	89.5	45	3.78	6.71	2.96
Strontium	0.00005 - 0.001	0.674	0.64	0.517	0.603	0.639	0.594	0.546	1.1	0.258	0.177	0.215	0.206
Sulphur	1.0 - 10.0	32	11.5	9.26	8.87	5.77	6.68	6.24	126	103	9.71	10	10.2
Thallium	0.000002 - 0.00005	<0.000002	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	0.000038	0.000027	<0.00001	<0.00001	<0.00001
Tin	0.00001 - 0.005	<0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0002	0.00011	0.00021	<0.0001	<0.0001	<0.0001
Titanium	0.0005 - 0.01	<0.0005	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium	0.000002 - 0.0001	0.00111	0.00248	0.00109	0.001	0.000808	0.000774	0.000993	0.0345	0.00134	0.00687	0.00642	0.00782
Vanadium	0.0002 - 0.03	<0.0002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	0.0001 - 0.005	0.00465	0.004	0.0012	0.0021	<0.001	<0.001	0.0028	0.255	0.0212	0.0239	0.0041	0.0309
Zirconium	0.0001 - 0.0005	<0.0001											
Total Metals													
Aluminum	0.0002 - 0.003	0.237	0.588	0.103	0.303	1.02	0.241	0.0587	17	0.669	0.361	0.0853	0.0446
Antimony	0.00002 - 0.0005	0.000145	0.00055	0.00012	0.00012	0.00027	0.00012	<0.0001	0.00209	0.00186	0.00058	0.00016	<0.0001
Arsenic	0.00002 - 0.0001	0.00298	0.00577	0.00436	0.00618	0.00585	0.00519	0.00632	0.0519	0.00216	0.0147	0.00635	0.00555
Barium	0.00002 - 0.001	0.186	0.168	0.157	0.157	0.164	0.149	0.142	0.357	0.0655	0.0519	0.0846	0.0322
Beryllium	0.00001 - 0.005	<0.00001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.00166	<0.0001	<0.0001	<0.0001	<0.0001
Bismuth	0.000005 - 0.1	<0.000005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.00072	<0.0005	<0.0005	<0.0005	<0.0005
Boron	0.05 - 0.1	<0.05	0.013	0.012	0.013	0.01	0.011	0.014	0.029	0.017	<0.01	<0.01	<0.01
Cadmium	0.000005 - 0.0002	0.000052	0.000176	0.000029	0.000059	0.000269	0.000105	0.000029	0.00176	0.000716	0.000712	0.000461	0.000429
Calcium	0.05	46.5	34.1	35.8	35.7	38.2	36	35.2	119	110	54.8	58.1	57.2
Chromium	0.0001 - 0.001	0.0167	0.00145	0.00038	0.00083	0.00258	0.00141	0.0005	0.0136	0.00101	0.0193	0.0137	0.00028
Cobalt	0.000005 - 0.001	0.000634	0.00042	0.00012	0.00016	0.00041	0.00018	0.00011	0.0134	0.0256	0.00046	0.00023	<0.0001
Copper	0.00005 - 0.0002	0.192	0.0027	0.00091	0.00155	0.00256	0.00268	0.00292	0.0669	0.0137	0.00474	0.00195	0.00085
Iron	0.001 - 0.005	0.759	0.74	0.355	0.55	0.984	0.587	0.38	15.2	1.25	0.651	0.173	0.04
Lead	0.000005 - 0.0002	0.00282	0.00855	0.00126	0.00276	0.0136	0.00573	0.00136	0.124	0.00114	0.0111	0.000745	0.000222
Lithium	0.0005 - 0.005	0.00233	0.00363	0.00208	0.00372	0.00328	0.00314	0.00323	0.0157	0.00434	0.00068	0.00428	0.00094
Magnesium	0.001 - 0.05	22.2	17.6	17.8	17.6	20	18.4	17.5	35.4	23	13.1	14.1	15
Manganese	0.00005 - 0.001	1.66	0.925	1.09	1.02	0.9	0.879	0.9	2.16	2.79	0.0836	0.00845	0.00322
Mercury	0.00001 - 0.00002	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	0.00002	0.000013	<0.00001	<0.00001	<0.00001
Molybdenum	0.00005 - 0.001	0.00995	0.0129	0.00734	0.00475	0.00361	0.00326	0.00269	0.0101	0.00372	0.00516	0.00292	0.00051
Nickel	0.00002 - 0.001	0.00914	0.00143	<0.0005	<0.0005	0.00718	<0.0005	<0.0005	0.0248	0.0481	0.0119	0.00836	<0.0005
Phosphorus	0.000002 - 0.002	0.0172	<0.05	<0.05	<0.05	<0.05	<0.05	<0.00005	<0.05	0.000354	0.053	<0.05	<0.05
Potassium	0.05	2.5	2.13	1.93	2.26	2.51	2	1.75	6.19	5.08	1.4	3.56	0.93
Selenium	0.00004 - 0.1	<0.00004	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.00045	0.00063	<0.0001	<0.0001	<0.0001
Silicon	0.1	3.55	5.28	4.52	5.3	6.72	5.14	4.88	36.1	5.88	4.65	4.39	4.22
Silver	0.000005 - 0.0001	0.000006	0.000044	<0.00001	0.00003	0.000072	0.000039	<0.00001	0.00568	0.000185	0.000322	0.000022	0.000017
Sodium	0.05	36.2	23.7	26.5	20.9	15.4	23.8	21.6	77.4	47.8	3.73	7.22	3.1
Strontium	0.00005 - 0.001	0.693	0.611	0.555	0.622	0.65	0.605	0.566	1.17	0.285	0.233	0.397	0.238
Sulphur	3.0 - 10.0	35	11.1	9.76	8.86	6.01	6.51	6.24	114	118	9.9	10.1	10.5
Thallium	0.000002 - 0.00005	0.000004	0.000028	<0.00001	0.000016	0.000043	0.000017	<0.00001	0.000458	0.000055	0.000014	<0.00001	<0.00001
Tin	0.0002 - 0.005	0.00682	0.00023	<0.0001	<0.0001	<0.0001	<0.0001	0.00038	0.00246	0.00078	0.00013	0.00011	<0.0001
Titanium	0.0005 - 0.01	0.00807	0.011	<0.01	<0.01	0.02	<0.01	<0.01	0.058	0.015	<0.01	<0.01	<0.01
Uranium	0.000002 - 0.0001	0.00115	0.00256	0.000993	0.00109	0.00104	0.000852	0.00101	0.0394	0.00156	0.00758	0.00809	0.00846
Vanadium	0.0002 - 0.03	0.00041	0.0015	<0.001	<0.001	0.0018	<0.001	<0.001	0.0208	0.0022	<0.001	<0.001	<0.001
Zinc	0.0001 - 0.005	0.025	0.0118	0.0038	0.0051	0.008	0.0065	0.0061	0.676	0.0266	0.0559	0.0382	0.0343
Zirconium	0.0001 - 0.0005	0.00017											
Organics													
Dissolved Organic Carbon								2.28					
Total Organic Carbon	0.5 - 5.0	8.69	4.12	3.07	3.48	2.52	3.38	2.89	42.3	23.2	2.05	4.21	1.51

NOTES:
1. UNITS ARE IN mg/L UNLESS OTHERWISE STATED.
2. REFER TO TABLE F1 FOR DETAILED FOOTNOTES ON CELL SHADING.

CASINO COPPER-GOLD PROJECT
TABLE F3 - HILLSLOPE AREA

Site ID Date/Time Sampled	MDL	MW13-04S 24-Jul-14	MW13-04S 30-Sep-14	MW13-05 12-Aug-13	MW13-05 2-Oct-13	MW13-05 22-May-14	MW13-05 25-Jul-14	MW13-05 27-Sep-14	MW13-06D 12-Aug-13	MW13-06D 28-Sep-13	MW13-06D 25-Jul-14	MW13-06D 27-Sep-14
Calculated Parameters												
Ion Balance Ratio	0.01		0.99					0.98				0.96
Physical Tests												
Acidity to pH 4.5 (as CaCO3)	0.5											
Acidity to pH 8.3 (as CaCO3)	0.5											
Alkalinity (PP as CaCO3)	0.5											
Alkalinity (Total as CaCO3)	0.5	168	168	203	194	203	202	205	285	372	393	381
Bicarbonate Alkalinity	0.5	165	168	203	194	203	202	205	285	372	393	381
Carbonate Alkalinity	0.5	2.8	<1	<2	<1	<2	<2	<1	<2	<2	<2	<1
Conductivity µS/cm	1	356	344	394	379	387	409	410	887	909	984	954
Hardness as CaCO3 (Dissolved)	0.5	190	174	204	200	222	227	224	511	553	612	592
Hardness as CaCO3 (Total)	0.5											
Hydroxide Alkalinity	0.5	<1	<1	<2	<1	<2	<2	<1	<2	<2	<2	<1
pH (pH)	0	8.4	8.17	8.24	8.29	8.12	8.27	8.17	7.95	8.09	7.91	7.98
Total Dissolved Solids	1.0 - 10.0	211	202	222	215	229	241	243	522	617	691	670
Total Suspended Solids	1	5.7	14	<3	<3	4	<3	<3	<3	3.5	12.8	3.3
Turbidity (NTU)	0.1	1.43	2.2	4.05	0.23	2.4	0.71	0.14	5.7	3.38	13.7	0.39
Dissolved Anions												
Bromide	0.01 - 0.4	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.5	<0.5	<0.05	<0.5
Chloride	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<5	<5	<0.5	<5
Fluoride	0.01	0.105	0.099	0.108	0.106	0.112	0.112	0.094	0.35	0.2	0.275	0.22
Sulphate	0.5	30.2	30.4	19	17	20.7	22.2	20.6	174	193	195	189
Thiocyanate	0.2											
Nutrients												
Ammonia (Total)	0.005 - 0.05	<0.005	<0.005	<0.005	<0.005	0.0095	<0.005	<0.005	<0.005	<0.005	0.0059	<0.005
Nitrate (as N)	0.002 - 0.02	0.0711	0.0838	0.447	0.468	0.348	0.363	0.469	0.083	0.079	0.0392	<0.05
Nitrate+Nitrite (Dissolved)	0.002 - 0.02		<0.001					<0.001				<0.01
Nitrite (as N)	0.002 - 0.005	<0.001	0.165	0.0024	0.0013	<0.001	<0.001	0.543	<0.01	<0.01	<0.001	<0.071
Nitrogen (Total)	0.02	0.143	0.081	0.53	0.558	0.432	0.43	0.074	0.137	0.14	0.105	<0.05
Nitrogen Kjeldahl (Total)	0.02	0.072	<0.001	0.08	0.089	0.083	0.067		0.054	0.062	0.065	
Orthophosphate (Dissolved)	0.001 - 0.005		0.0025	<0.001		<0.001		0.0021	<0.001			0.0026
Phosphorus Dissolved	0.002	<0.002	0.0025	<0.002	<0.002	0.0021	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Cyanide												
Cyanide (SAD)	0.001		<0.005					<0.005				<0.005
Cyanide (WAD)	0.0005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Cyanide+Thiocyanate	0.0005 - 0.001		<0.005					<0.005				<0.005
Dissolved Metals												
Aluminum	0.0002 - 0.005	0.0014	0.0013	0.0017	0.0017	0.0024	0.0011	0.0014	0.0023	0.0028	0.002	0.0013
Antimony	0.00002 - 0.0005	<0.0001	<0.0001	<0.0001	<0.0001	0.00012	<0.0001	<0.0001	<0.0001	0.00012	<0.0001	<0.0001
Arsenic	0.00002 - 0.001	0.00541	0.00539	0.00011	0.00011	<0.0001	0.0001	<0.0001	0.00017	0.00018	0.00017	0.00014
Barium	0.00002 - 0.001	0.0286	0.0242	0.0748	0.0692	0.0766	0.0772	0.077	0.0142	0.0159	0.0151	0.0121
Beryllium	0.00001 - 0.005	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Bismuth	0.000005 - 0.1	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Boron	0.05 - 0.1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.012	<0.01	<0.01
Cadmium	0.000005 - 0.0002	0.000385	0.000334	<0.00001	<0.00001	0.000026	<0.00001	<0.00001	0.000037	0.000057	0.000039	0.000029
Calcium	0.05	53.5	48.7	56.3	55.6	61.3	63	62.3	117	129	140	139
Chromium	0.0001 - 0.001	0.00032	0.00091	0.00181	0.00216	0.00151	0.0017	0.0013	0.0022	0.00497	0.0059	0.00176
Cobalt	0.000005 - 0.001	<0.0001	<0.0001	0.0004	0.00011	0.00041	<0.0001	<0.0001	0.0007	0.00079	0.00067	0.00023
Copper	0.00005 - 0.001	0.00029	0.00075	0.00049	0.001	0.00491	0.00083	0.00307	0.00052	0.00209	0.00202	0.00641
Iron	0.001 - 0.03	<0.01	<0.01	0.03	0.01	0.017	0.013	<0.01	0.045	0.05	0.105	0.015
Lead	0.000005 - 0.001	<0.00005	<0.00005	<0.00005	<0.00005	0.00033	<0.00005	0.000136	0.000058	<0.00005	<0.00005	0.000472
Lithium	0.0005 - 0.005	0.00407	0.00623	0.00114	0.00128	0.00129	0.00109	0.00179	0.0175	0.0205	0.022	0.0218
Magnesium	0.001 - 0.05	13.8	12.8	15.4	14.8	16.8	16.9	16.5	53	55.8	63.4	59.7
Manganese	0.00005 - 0.005	0.000551	0.000537	0.0253	0.0104	0.00777	0.00278	0.00172	0.057	0.0852	0.0561	0.0359
Mercury	0.00000001 - 0.00002	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum	0.00005 - 0.001	0.000511	0.000841	0.0065	0.00521	0.00732	0.00453	0.00438	0.00291	0.00421	0.00456	0.000908
Nickel	0.00002 - 0.001	<0.0005	<0.0005	0.00419	0.00225	0.0127	0.00179	0.00154	0.00659	0.0117	0.0181	0.00317
Phosphorus	0.002	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Potassium	0.05	2.27	2.59	0.84	0.98	0.92	0.88	0.85	1.66	2.13	1.81	1.76
Selenium	0.00004 - 0.0005	<0.0001	<0.0001	0.00018	0.00013	0.00011	0.00011	0.00015	0.00139	0.00158	0.00115	0.00125
Silicon	0.00002 - 0.1	4.03	4.02	4.65	4.87	5.15	4.98	4.85	3.69	4.08	4.2	4.11
Silver	0.000005 - 0.0001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Sodium	0.05	5.32	9.03	3.56	3.35	3.72	3.78	3.65	2.6	2.83	2.97	2.62
Strontium	0.00005 - 0.001	0.21	0.201	0.443	0.477	0.487	0.494	0.504	0.314	0.354	0.366	0.351
Sulphur	1.0 - 10.0	10	10.4	6.4	5.88	7.23	7.47	7.23	55.4	63.6	65	62.7
Thallium	0.000002 - 0.00005	<0.00001	<0.00001	0.000013	<0.00001	<0.00001	<0.00001	<0.00001	0.000259	0.000325	0.000456	0.000329
Tin	0.00001 - 0.005	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.00014	<0.0001	<0.0001
Titanium	0.0005 - 0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium	0.000002 - 0.0001	0.00697	0.00677	0.0123	0.0115	0.014	0.0134	0.0141	0.00377	0.0041	0.00444	0.00431
Vanadium	0.0002 - 0.03	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	0.0001 - 0.005	0.0321	0.0302	0.0013	0.0013	0.0083	0.01	0.0037	0.0063	0.0067	0.0165	0.0116
Zirconium	0.0001 - 0.0005											
Total Metals												
Aluminum	0.0002 - 0.003	0.0182	0.0042	0.0301	0.0078	0.0645	0.0237	0.0046	0.0772	0.0826	0.156	0.0166
Antimony	0.00002 - 0.0005	0.00012	<0.0001	0.00011	<0.0001	0.00033	0.00013	<0.0001	0.00014	0.00016	0.00015	<0.0001
Arsenic	0.00002 - 0.0001	0.00539	0.00553	0.00035	0.00017	0.0002	0.00018	0.00011	0.00085	0.00063	0.0012	0.00017
Barium	0.00002 - 0.001	0.0421	0.0259	0.0771	0.0727	0.0769	0.0796	0.0788	0.0191	0.0192	0.0326	0.0123
Beryllium	0.00001 - 0.005	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Bismuth	0.000005 - 0.1	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Boron	0.05 - 0.1	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.013	<0.01	0.015
Cadmium	0.000005 - 0.0002	0.000369	0.000376	0.000025	0.000011	0.000028	<0.00001	<0.00001	0.000061	0.00005	0.000058	0.000032
Calcium	0.05	49.1	52.3	56.2	55.9	61	64.4	62.3	119	132	136	136
Chromium	0.0001 - 0.001	0.00088	0.00087	0.00897	0.00373	0.0226	0.00604	0.00266	0.0116	0.0107	0.044	0.00442
Cobalt	0.000005 - 0.001	<0.0001	<0.0001	0.00099	0.00015	0.00074	0.00016	<0.0001	0.00134	0.00084	0.00115	0.00024
Copper	0.00005 - 0.0002	0.00105	0.00106	0.0017	0.00124	0.00758	0.00184	0.00358	0.00297	0.00278	0.0057	0.00636
Iron	0.001 - 0.005	0.04	<0.01	0.183	0.028	0.228	0.078	0.02	0.278	0.201	0.714	0.051
Lead	0.000005 - 0.0002	0.000358	0.000071	0.000683	<0.00005	0.00266	0.000109	<0.0002	0.00105	0.000259	0.000739	0.000637
Lithium	0.0005 - 0.005	0.00634	0.0023	0.00073	0.00121	0.0018	0.00132	0.00173	0.0175	0.0205	0.021	0.0188
Magnesium	0.001 - 0.05	12.6	13.4	15.3	15.2	16.6	17.1	16.6	53.7	56	60.9	58.7
Manganese	0.00005 - 0.001	0.00206	0.000827	0.0324	0.0111	0.0105	0.00386	0.002	0.0681	0.0928	0.0753	0.0343
Mercury	0.00001 - 0.00002	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum	0.00005 - 0.001	0.000612	0.000564	0.00692	0.0057	0.00858	0.00524	0.00434	0.00336	0.00366	0.00619	0.00103
Nickel	0.00002 - 0.001	<0.0005	<0.0005	0.00633	0.00254	0.0198	0.0043	0.00181	0.00848	0.00962	0.029	0.00392
Phosphorus	0.000002 - 0.002	<0.00005	<0.05	<0.05	<0.05	<0.05	<0.00005	<0.05	<0.05	<0.05	<0.00005	<0.05
Potassium	0.05	3.2	1.31	0.85	1.06	0.9	0.92	0.84	1.73	2.22	1.83	1.72
Selenium	0.00004 - 0.1	<0.0001	<0.0001	0.00018	0.00014	0.00012	0.00012	0.00014	0.00141	0.00135	0.00103	0.00106
Silicon	0.1	3.73	4	4.67	4.9	5.22	5.12	4.86	3.97	4.44	4.47	4.12
Silver	0.000005 - 0.0001	<0.00001	<0.00001	0.000777	0.00001	0.000022	0.000011	<0.00001	0.000757	0.000055	0.000202	<0.00001
Sodium	0.05	6.83	4.61	3.57	3.48	3.77	3.83	3.72	2.67	2.93	2.95	2.57
Strontium	0.00005 - 0.001	0.232	0.207	0.454	0.487	0.492	0.521	0.485	0.336	0.378	0.361	0.367
Sulphur	3.0 - 10.0	9.32	10.1	6.51	6.04	7.36	7.74	7.32	59	66.2	64.7	63.8
Thallium	0.000002 - 0.00005	<0.00001	<0.00001	0.000013	<0.00001	0.000011	0.000013	<0.00001	0.000334	0.000375	0.000574	0.000313
Tin	0.0002 - 0.005	<0.0001	<0.0001	<0.0001	<0.0001	0.00034	<0.0001	<0.0001	<0.0001	0.00022	0.00024	<0.0001
Titanium	0.0005 - 0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium	0.000002 - 0.0001	0.00678	0.00752	0.0128	0.0121	0.0141	0.0145	0.0137	0.00403	0.0043	0.00448	0.0042
Vanadium	0.0002 - 0.03	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	0.0001 - 0.005	0.0332	0.0366	0.0036	0.0032	0.01	0.0135	0.0049	0.0077	0.0081	0.0225	0.0118
Zirconium	0.0001 - 0.0005											
Organics												
Dissolved Organic Carbon			3.81					1.58				0.77
Total Organic Carbon	0.5 - 5.0	2.93	2.77	2.25	2.16	1.6	1.21	1.57	1.31	0.91	0.74	0.81

NOTES:
1. UNITS ARE IN mg/L UNLESS OTHERWISE STATED.
2. REFER TO TABLE F1 FOR DETAILED FOOTNOTES ON CELL SHADING.

CASINO COPPER-GOLD PROJECT
TABLE F4 - CASINO CREEK VALLEY AREA

Site ID	MDL	94-342	94-342	94-342	94-342	94-342	94-342	94-342	94-343	94-343	94-343	94-343	94-345
Date/Time Sampled		25-Sep-94	4-Feb-95	10-Sep-08	23-Sep-09	6-Jun-10	18-Aug-10	13-Sep-10	25-Sep-94	9-Sep-08	23-Sep-09	16-Sep-12	26-Sep-94
Calculated Parameters													
Ion Balance Ratio	0.01				1.1	1.1					1	1	
Physical Tests													
Acidity to pH 4.5 (as CaCO3)	0.5				<0.5	<0.5	<0.5	<0.5			<0.5	<0.5	
Acidity to pH 8.3 (as CaCO3)	0.5				2.1	4.6	7.1	1.7			1.9	5.44	
Alkalinity (PP as CaCO3)	0.5												
Alkalinity (Total as CaCO3)	0.5	233	236	130	140	150	140	130	124	140	140	132	158
Bicarbonate Alkalinity	0.5												
Carbonate Alkalinity	0.5												
Conductivity µS/cm	1	791	806	380	403	422	407	397	295	330	341	331	460
Hardness as CaCO3 (Dissolved)	0.5			184	206	232	188	187		161	172	168	
Hardness as CaCO3 (Total)	0.5	420	441						160			153	252
Hydroxide Alkalinity	0.5												
pH (pH)	0	7.59	7.59	8.1	7.82	8.21	7.75	7.94	6.91	8.1	7.62	7.76	6.91
Total Dissolved Solids	1.0 to 10.0	571	642	280	240	270	220	250	186	220	190	210	308
Total Suspended Solids	1	3	67	280					<1	7		66.8	1
Turbidity (NTU)	0.1	2.56	12.5	42					<0.1	0.5		14.1	0.59
Dissolved Anions													
Bromide	0.01 to 0.4			0.2	<0.4	<0.4	<0.4	<0.4		0.2	<0.4	<0.01	
Chloride	0.5	0.7	<0.5	<0.5	0.7	0.5		<0.5	0.5	0.7	0.7	<0.5	0.5
Fluoride	0.01	0.19	0.15	0.08	0.09	0.07	0.18	0.18	0.06	0.06	0.05	0.056	0.08
Sulphate	0.5 to 5.0	213	220	66	66	82	73	74	30.5	36	32	35.5	87.2
Thiocyanate	0.2					<0.2							
Nutrients													
Ammonia (Total)	0.005 to 0.05	0.005	<0.005	<0.01	0.01	<0.005	0.04	0.014	<0.005	<0.01	<0.01	0.0086	<0.005
Nitrate (as N)	0.002 to 0.02	<0.02	<0.02	<0.002	0.002	<0.002	<0.002	<0.002	0.185	0.454	0.269	0.369	0.042
Nitrate+Nitrite (Dissolved)	0.002 to 0.02			0.004	0.002	<0.002	<0.002	<0.002		0.456	0.269	0.375	
Nitrite (as N)	0.002 to 0.005	<0.005	<0.005	0.003	<0.002	<0.002	<0.002	<0.002	0.004	0.002	<0.002	0.0066	0.008
Nitrogen (Total)	0.02 to 0.2			0.05	0.11	0.06	0.06	0.46		0.48	0.38	0.431	
Nitrogen Kjeldahl (Total)	0.02 to 0.2			0.05	0.11	0.06	0.06	0.46		0.02	0.11	0.056	
Orthophosphate (Dissolved)	0.001 to 0.005	<0.005	0.011	0.005	0.001	0.002	0.002	0.001	0.001	0.002	0.002	0.0055	0.015
Phosphorus Dissolved	0.002 to 0.02	0.005	0.016	<0.002		<0.002	<0.002	0.003	0.005	0.002			0.02
Cyanide													
Cyanide (SAD)	0.001				0.004						0.006		
Cyanide (WAD)	0.0005			<0.0005	<0.0005	<0.0005	<0.0005	<0.0005		<0.0005	0.0005	<0.0005	
Cyanide+Thiocyanate	0.0005 to 0.001	0.001	<0.001	0.0008		<0.0005	<0.0005	<0.0005	0.001	<0.0005		<0.0005	0.002
Dissolved Metals													
Aluminum	0.0002 to 0.005	0.02	0.011	0.001	0.0026	0.0034	0.0027	0.0102	<0.005	0.0016	0.0041	0.00268	0.015
Antimony	0.00002 to 0.0005	0.0008	0.0005	0.0001	0.00011	0.00011	0.00011	0.00011	0.0003	0.00019	0.00022	0.000233	<0.0001
Arsenic	0.00002 to 0.001	0.0185	0.005	0.00251	0.00244	0.00257	0.0025	0.00246	0.0013	0.00149	0.00137	0.00146	0.0023
Barium	0.00002 to 0.001	0.044	0.041	0.0324	0.0359	0.0384	0.0347	0.033	0.055	0.048	0.0522	0.0595	0.064
Beryllium	0.00001 to 0.005	<0.005	<0.005	0.00002	0.00002	0.00002	0.00002	0.00002	<0.005	<0.00001	<0.00001	<0.00001	<0.005
Bismuth	0.000005 to 0.1	<0.1	<0.1	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.1	<0.000005	<0.000005	<0.000005	<0.1
Boron	0.05 to 0.5	<0.1	<0.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.1	<0.05	<0.05	<0.05	<0.1
Cadmium	0.000005 to 0.0002	<0.0002	<0.0002	0.000009	<0.000005	0.000009	0.000008	0.00001	<0.0002	0.000026	0.000013	0.000033	<0.0002
Calcium	0.05 to 0.5	127	134	56.2	63.2	69.7	56	56.4	47.3	47.2	50.6	50.3	65.5
Chromium	0.0001 to 0.001	<0.001	<0.001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.001	<0.0001	<0.0001	0.00033	<0.001
Cobalt	0.000005 to 0.001	0.001	0.002	0.000855	0.000879	0.000981	0.000901	0.000847	<0.001	0.000007	0.000013	0.000033	0.001
Copper	0.00005 to 0.001	0.001	0.002	0.00013	0.00352	0.00008	0.00025	0.00044	<0.001	0.00048	0.00132	0.147	0.002
Iron	0.001 to 0.03	0.454	<0.03	0.803	0.88	1.02	0.814	0.845	<0.03	0.001	0.007	0.0045	0.04
Lead	0.000005 to 0.001	0.001	<0.001	0.000459	0.000434	0.000427	0.000273	0.000829	<0.001	0.000015	0.000062	0.000099	<0.001
Lithium	0.0005 to 0.005			0.0019	0.0025	0.0021	0.0019	0.0019		0.0028	0.003	0.00255	
Magnesium	0.001 to 0.5	25.1	26	10.7	11.7	14	11.6	11.1	10.1	10.5	11.2	10.2	21.5
Manganese	0.00002 to 0.005	0.481	0.521	0.546	0.582	0.634	0.572	0.538	0.069	0.0124	0.0181	0.00169	0.466
Mercury	0.00000001 to 0.0001			<0.00001		<0.00001	<0.00001	<0.00001		<0.00001		<0.00000001	
Molybdenum	0.00005 to 0.001	<0.001	<0.001	0.00021	0.00019	0.00018	0.0002	0.00018	<0.001	0.00017	0.00019	0.000523	<0.001
Nickel	0.00002 to 0.001	<0.001	0.005	0.00031	0.00035	0.00034	0.00031	0.00031	<0.001	0.00005	0.00005	0.00051	0.001
Phosphorus	0.002											<0.002	
Potassium	0.05 to 0.5	2.07	2.13	1.01	1.14	1.21	1.05	1.03	0.77	0.81	0.84	0.845	1.29
Selenium	0.00004 to 0.0005	<0.0005	<0.0005	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	<0.0005	<0.00004	<0.00004	0.000045	<0.0005
Silicon	0.0 to 1.0	5.51	5.43	5	5.4	5.9	4.8	5.2	5.89	5.6	6	5.85	5.78
Silver	0.000005 to 0.0001	<0.0001	<0.0001	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.0001	<0.000005	<0.000005	<0.000005	<0.0001
Sodium	0.05 to 0.5	8.37	8.93	5.04	5.56	6.07	5.22	4.98	3.3	4.2	4.45	3.63	5.96
Strontium	0.00005 to 0.001	2	1.93	0.453	0.493	0.562	0.49	0.464	0.318	0.315	0.331	0.328	0.367
Sulphur	1.0 to 100.0			23	25	32	24	28		12	13	14	
Thallium	0.000002 to 0.00005			0.000003	0.000003	0.000002	0.000003	0.000004		0.000002	0.000002	<0.000002	
Tin	0.00001 to 0.005			0.00002	0.00001	0.00003	0.00002	0.00002		<0.00001	<0.00001	<0.0002	
Titanium	0.0005 to 0.01		<0.01	<0.0005	<0.0005	<0.0005	<0.0005	0.0007		<0.0005	<0.0005	<0.0005	
Uranium	0.000002 to 0.0001	0.0178	0.0147	0.00628	0.00781	0.00887	0.00647	0.00697	0.00945	0.0288	0.0314	0.0224	0.015
Vanadium	0.0002 to 0.03	<0.03	<0.03	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.03	<0.0002	<0.0002	<0.0002	<0.03
Zinc	0.0001 to 0.005	0.009	0.01	0.0199	0.0379	0.0242	0.0208	0.0219	<0.005	0.0027	0.0042	0.0275	<0.005
Zirconium	0.0001 to 0.002			<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001	
Total Metals													
Aluminum	0.0002 to 0.003	0.066	0.7						0.005			0.495	0.023
Antimony	0.00002 to 0.0005	0.0008	0.0005						0.0003			0.000269	<0.0001
Arsenic	0.00002 to 0.0001	0.0187	0.0066						0.0013			0.00775	0.0023
Barium	0.00002 to 0.001	0.044	0.049						0.06			0.073	0.065
Beryllium	0.00001 to 0.005	<0.005	<0.005						<0.005			0.000024	<0.005
Bismuth	0.000005 to 0.1	<0.1	<0.1						<0.1			0.000022	<0.1
Boron	0.05 to 0.1	<0.1	<0.1						<0.1			<0.05	<0.1
Cadmium	0.000005 to 0.0002	<0.0002	0.0002						<0.0002			0.00006	<0.0002
Calcium	0.05	129	140						49.7			42.8	66.8
Chromium	0.0001 to 0.001	0.001	0.001						<0.001			0.00356	<0.001
Cobalt	0.000005 to 0.001	0.002	0.003						<0.001			0.00114	0.001
Copper	0.00005 to 0.0002											0.145	
Iron	0.001 to 0.03	0.513	1.09						<0.03			0.871	0.055
Lead	0.000005 to 0.001	0.002	0.013						0.001			0.0107	<0.001
Lithium	0.0005 to 0.005											0.00281	
Magnesium	0.001 to 0.05	26	26.8						10.7			11.2	22.2
Manganese	0.00005 to 0.001	0.491	0.571						0.069			0.0379	0.482
Mercury	0.00001 to 0.00002	<0.00001	<0.00001						<0.00001			<0.00001	<0.00001
Molybdenum	0.00005 to 0.001	0.001	<0.001						<0.001			0.000568	0.001
Nickel	0.00002 to 0.001	0.002	0.005						<0.001			0.0028	0.001
Phosphorus	0.000002 to 0.002	0.000006	0.000047						0.000005			0.0228	0.00002
Potassium	0.05											0.987	
Selenium	0.00004 to 0.1	<0.0005	<0.0005						<0.0005			<0.00004	<0.0005
Silicon	0.1	5.82	5.92						6.19			5.32	5.93
Silver	0.000005 to 0.0001	<0.0001	<0.0001						<0.0001			0.000049	<0.0001
Sodium	0.05											4.03	
Strontium	0.00005 to 0.001	2.07	2						0.33			0.351	0.375
Sulphur	3.0 to 10.0											14	
Thallium	0.000002 to 0.00005											0.000013	
Tin	0.0002 to 0.005											<0.0002	
Titanium	0.0005 to 0.01		<0.01									0.0252	
Uranium	0.000002 to 0.0001	0.0211	0.0148						0.0136			0.0242	0.0161
Vanadium	0.0002 to 0.03	<0.03	<0.03						<0.03			0.00108	<0.03
Zinc	0.0001 to 0.005	0.009	0.016						<0.005			0.0262	<0.005
Zirconium	0.0001 to 0.0005											0.0001	
Organics													
Dissolved Organic Carbon													
Total Organic Carbon	0.5 to 5.0	1.7	2	2.4	2.7	2.5	2.9	5.4	1.7	1.5	2.1	1.46	2

M:\1\01\00325\12\A\Data\Task 330 - Groundwater Quality\baseline report\[results and exceedences.xlsx]Casino creek

NOTES:
1. UNITS ARE IN mg/L UNLESS OTHERWISE STATED.
2. REFER TO TABLE F1 FOR DETAILED FOOTNOTES ON CELL SHADING.

Site ID	MDL	94-345	94-345	94-345	94-345	94-345	94-345	94-345	94-345	94-345	94-346	94-346	94-346
Date/Time Sampled		4-Feb-95	24-May-95	22-Sep-09	8-Jun-10	20-Aug-10	15-Sep-10	17-Jul-11	17-Sep-11	26-May-12	24-May-95	9-Sep-08	22-Sep-09
Calculated Parameters													
Ion Balance Ratio	0.01			1	0.96								1
Physical Tests													
Acidity to pH 4.5 (as CaCO3)	0.5			<0.5	<0.5	<0.5	<0.5			<0.5			<0.5
Acidity to pH 8.3 (as CaCO3)	0.5			1.6	3	3	2.6			2.58			5.9
Alkalinity (PP as CaCO3)	0.5							<0.5	<0.5				
Alkalinity (Total as CaCO3)	0.5	146	158	86	87	74	84	77	97	63.1	368	390	380
Bicarbonate Alkalinity	0.5							94	120				
Carbonate Alkalinity	0.5							<0.5	<0.5				
Conductivity µS/cm	1	450	460	315	326	277	285	254	300	224	866	1000	1070
Hardness as CaCO3 (Dissolved)	0.5			148	157	129	140	127	145	103		616	618
Hardness as CaCO3 (Total)	0.5	231	252					120	164	110	517		
Hydroxide Alkalinity	0.5							<0.5	<0.5				
pH (pH)	0	7.14	6.91	7.65	7.84	7.98	7.98	7.55	7.59	7.56	7.23	8.1	7.84
Total Dissolved Solids	1.0 to 10.0	323	347	190	230	170	170	190	190	128	684	740	710
Total Suspended Solids	1	15	1					27	3	5.7	18	130	
Turbidity (NTU)	0.1	4.6	0.59					16	2.6	5.66	8.56	44.1	
Dissolved Anions													
Bromide	0.01 to 0.4			<0.4	<0.4	<0.4	<0.4			<0.01		0.2	<0.4
Chloride	0.5	<0.5	0.5	0.8	<0.5	1.3	<0.5	0.7	0.7	0.65	0.9	0.9	1.2
Fluoride	0.01	0.08	0.07	0.11	0.14	0.13	0.12	0.11	0.12	0.12	0.17	0.17	0.19
Sulphate	0.5 to 5.0	92.6	101	64	82	62	56	50	54	42.8	168	200	220
Thiocyanate	0.2				<0.2								
Nutrients													
Ammonia (Total)	0.005 to 0.05	<0.005	<0.005	0.04	0.11	0.026	<0.05	0.024	0.04	0.024	<0.005	<0.01	<0.01
Nitrate (as N)	0.002 to 0.02	0.069	0.139	0.178	0.142	0.147	0.139	0.12	0.18	0.0731	0.03	0.29	0.048
Nitrate+Nitrite (Dissolved)	0.002 to 0.02			0.178	0.156	0.147	0.148	0.12	0.18	0.0731		0.293	0.048
Nitrite (as N)	0.002 to 0.005	0.007	0.005	<0.002	0.013	<0.002	0.009	<0.005	<0.005	<0.002	<0.005	0.003	<0.002
Nitrogen (Total)	0.02 to 0.2			0.33	0.35	0.7	0.37			0.252		0.34	0.09
Nitrogen Kjeldahl (Total)	0.02 to 0.2			0.16	0.19	0.6	0.22			0.179		0.04	0.04
Orthophosphate (Dissolved)	0.001 to 0.005	0.008	0.004	0.001	0.001	0.008	0.001	<0.005		0.0022	0.005	0.016	0.001
Phosphorus Dissolved	0.002 to 0.02	0.01	0.004		<0.002	0.002	0.003				0.005	0.004	
Cyanide													
Cyanide (SAD)	0.001			0.016									0.004
Cyanide (WAD)	0.0005			<0.0005	<0.0005	<0.0005	<0.0005			<0.0005		<0.0005	<0.0005
Cyanide+Thiocyanate	0.0005 to 0.001	<0.001	0.002		<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.00061	<0.001	<0.0005	
Dissolved Metals													
Aluminum	0.0002 to 0.005	0.007	0.012	0.008	0.0118	0.047	0.0078	0.005	0.006	0.00523	0.029	0.0024	0.0129
Antimony	0.00002 to 0.0005	<0.0001	0.0001	0.00016	0.00016	0.00017	0.00015	<0.0005	<0.0005	0.000161	<0.0001	0.00006	0.00007
Arsenic	0.00002 to 0.001	0.0005	0.0004	0.00026	0.00027	0.00039	0.0003	0.0003	0.0003	0.000291	0.0009	0.00058	0.0005
Barium	0.00002 to 0.001	0.073	0.081	0.076	0.0813	0.067	0.0672		0.076	0.0521	0.031	0.0219	0.0221
Beryllium	0.00001 to 0.005	<0.005	<0.005	<0.00001	<0.00001	<0.00001	<0.00001	<0.0001	<0.0001	<0.00001	<0.005	<0.00001	<0.00001
Bismuth	0.000005 to 0.1	<0.1	<0.1	<0.000005	<0.000005	<0.000005	<0.000005	<0.001	<0.001	<0.000005	<0.1	<0.000005	<0.000005
Boron	0.05 to 0.5	<0.1	<0.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.1	<0.05	<0.05
Cadmium	0.000005 to 0.0002	<0.0002	<0.0002	0.000017	0.000031	0.00003	0.000024	0.00002	0.00004	0.0000189	<0.0002	0.000011	0.000032
Calcium	0.05 to 0.5	58	61.8	40.1	40.8	34.6	37.7	34.4	38.9	27.9	106	134	134
Chromium	0.0001 to 0.001	<0.001	<0.001	<0.0001	0.0001	0.0001	<0.0001	<0.001	<0.001	0.00028	<0.001	<0.0001	<0.0001
Cobalt	0.000005 to 0.001	0.002	<0.001	0.00002	0.000026	0.000055	0.000028	<0.0005	<0.0005	0.0000213	<0.001	0.000015	0.000013
Copper	0.00005 to 0.001	0.005	0.001	0.00625	0.00396	0.00473	0.00354	0.0043	0.0031	0.00495	0.002	0.00035	0.00561
Iron	0.001 to 0.03	<0.03	<0.03	0.021	0.07	0.156	0.025	<0.005	0.037	0.0052	<0.03	0.002	0.007
Lead	0.000005 to 0.001	<0.001	0.001	0.000113	0.000231	0.000437	0.000077	<0.0002	0.0003	0.0000298	<0.001	0.000031	0.000108
Lithium	0.0005 to 0.005			0.0024	0.0009	0.0008	0.0009	<0.005	<0.005	0.00075		0.0176	0.021
Magnesium	0.001 to 0.5	20.9	23.1	11.6	13.3	10.3	11.1	10.1	11.6	8.22	61.1	68.5	68.7
Manganese	0.00002 to 0.005	0.511	0.551	0.00142	0.00042	0.0022	0.00034		<0.00002	0.000124	0.126	0.00232	0.00123
Mercury	0.00000001 to 0.0001				<0.00001	0.00001	<0.00001	<0.00002		<0.00001		<0.00001	
Molybdenum	0.00005 to 0.001	<0.001	<0.001	0.00059	0.00063	0.00061	0.0006	<0.001	<0.001	0.00171	0.002	0.00095	0.00082
Nickel	0.00002 to 0.001	0.002	0.001	0.00045	0.00031	0.00041	0.00048	<0.001	<0.001	0.000316	0.002	0.00027	0.0003
Phosphorus	0.002									0.0041			
Potassium	0.05 to 0.5	1.36	1.34	1.1	0.94	0.92	0.9	0.88	0.95	0.739	2.21	1.82	1.9
Selenium	0.00004 to 0.0005	<0.0005	<0.0005	0.00014	0.00025	0.00014	0.00012	0.0002	<0.0001	0.00017	<0.0005	0.00019	0.00005
Silicon	0.0 to 1.0	5.33	5.35	5.7	4.7	5.4	5.7	5.64	5.3	4.79	6.33	7.2	7.4
Silver	0.000005 to 0.0001	<0.0001	<0.0001	<0.000005	<0.000005	0.000016	<0.000005	<0.00002	<0.00002	<0.000005	<0.0001	<0.000005	<0.000005
Sodium	0.05 to 0.5	5.47	5.6	4.13	4.13	3.52	3.72	3.55	4.22	3.25	9.39	9.87	9.79
Strontium	0.00005 to 0.001	0.345	0.367	0.243	0.277	0.212	0.222		0.251	0.172	0.833	0.967	0.987
Sulphur	1.0 to 100.0			27	27	22	21	19	20	16		77	89
Thallium	0.000002 to 0.00005			0.000003	<0.000002	0.000002	<0.000002	<0.00005	<0.00005	<0.000002		0.000005	0.000005
Tin	0.00001 to 0.005			0.00001	0.00003	0.00002	0.00003	<0.005	<0.005	<0.0002		0.00003	0.00002
Titanium	0.0005 to 0.01	<0.01	<0.01	<0.0005	0.0009	0.0021	<0.0005	0.021	<0.005	<0.0005	<0.01	0.0005	<0.0005
Uranium	0.000002 to 0.0001	0.0122	0.0145	0.00934	0.0159	0.00939	0.0109	0.0098	0.0127	0.00768	0.024	0.0427	0.0475
Vanadium	0.0002 to 0.03	<0.03	<0.03	<0.0002	<0.0002	<0.0002	0.0002	<0.005	<0.005	0.00023	<0.03	<0.0002	<0.0002
Zinc	0.0001 to 0.005	<0.005	<0.005	0.0159	0.0028	0.0019	0.0025	<0.005	0.006	0.00221	<0.005	0.0011	0.0172
Zirconium	0.0001 to 0.002			<0.0001	<0.0001	0.0001	<0.0001	<0.0005	<0.0005	<0.0001		<0.0001	<0.0001
Total Metals													
Aluminum	0.0002 to 0.003	0.185	0.45					0.323	0.171	0.0865	0.023		
Antimony	0.00002 to 0.0005	<0.0001	0.0002					<0.0005	<0.0005	0.000171	<0.0001		
Arsenic	0.00002 to 0.0001	0.0008	0.0013					0.0013	0.0007	0.00071	0.0016		
Barium	0.00002 to 0.001	0.073	0.089					0.073	0.085	0.0578	0.038		
Beryllium	0.00001 to 0.005	<0.005	<0.005					<0.0001	<0.0001	<0.00001	<0.005		
Bismuth	0.000005 to 0.1	<0.1	<0.1					<0.001	<0.001	<0.000005	<0.1		
Boron	0.05 to 0.1	<0.1	<0.1					<0.05	<0.05	<0.05	<0.1		
Cadmium	0.000005 to 0.0002	<0.0002	<0.0002					0.00011	0.00008	0.0000302	<0.0002		
Calcium	0.05	58.5	62.8					31.2	43	29.3	110		
Chromium	0.0001 to 0.001	0.001	<0.001					0.001	<0.001	0.00049	<0.001		
Cobalt	0.000005 to 0.001	0.002	0.001					0.0006	<0.0005	0.000111	<0.001		
Copper	0.00005 to 0.0002							0.0113	0.0051	0.0074			
Iron	0.001 to 0.03	0.266	0.446					1.14	0.315	0.386	0.381		
Lead	0.000005 to 0.001	0.002	0.003					0.0054	0.0011	0.00141	0.001		
Lithium	0.0005 to 0.005							<0.005	<0.005	0.00074			
Magnesium	0.001 to 0.05	21	23.4					10.2	13.7	8.98	62		
Manganese	0.00005 to 0.001	0.523	0.564						0.012	0.00383	0.134		
Mercury	0.00001 to 0.00002	<0.00001	<0.00001					<0.00002	<0.00002	<0.00001	<0.00001		
Molybdenum	0.00005 to 0.001	<0.001	<0.001					<0.001	<0.001	0.00158	0.002		
Nickel	0.00002 to 0.001	0.004	0.002					0.001	<0.001	0.000418	0.002		
Phosphorus	0.000002 to 0.002	0.000019	0.000019							0.006	0.000029		
Potassium	0.05							0.86	1.07	0.803			
Selenium	0.00004 to 0.1	<0.0005	<0.0005					0.0002	0.0001	0.000192	<0.0005		
Silicon	0.1	5.55	5.69						5.8	5.31	6.65		
Silver	0.000005 to 0.0001	<0.0001	<0.0001					0.00005	0.00002	0.0000125	<0.0001		
Sodium	0.05							3.5	4.79	3.53			
Strontium	0.00005 to 0.001	0.349	0.372					0.206	0.292	0.179	0.854		
Sulphur	3.0 to 10.0							19	20	17			
Thallium	0.000002 to 0.00005							<0.00005	<0.00005	<0.000002			
Tin	0.0002 to 0.005							<0.005	<0.005	<0.0002			
Titanium	0.0005 to 0.01	0.011	0.019						0.008	0.00507	0.014		
Uranium	0.000002 to 0.0001	0.0122	0.0153					0.0096	0.0169	0.00799	0.0245		
Vanadium	0.0002 to 0.03	<0.03	<0.03					<0.005	<0.005	0.00062	<0.03		
Zinc	0.0001 to 0.005	<0.005	0.006					0.008	0.016	0.00321	<0.005		
Zirconium	0.0001 to 0.0005							<0.0005	<0.0005	0.00015			
Organics													
Dissolved Organic Carbon													
Total Organic Carbon	0.5 to 5.0	2.1	2.1	5.7	12.5	9.3	5.2	4.1	3.5	<5	0.9	1.2	1.5

M:\1\01\00325\12\A\Data\Task 330 - Groundwater Quality\baseline report\[results a

NOTES:
1. UNITS ARE IN mg/L UNLESS OTHERWISE STATED.
2. REFER TO TABLE F1 FOR DETAILED FOOTNOTES ON CELL SHADING.

Site ID	MDL	94-346	94-346	94-346	94-346	94-346	94-347	94-347	94-347	94-347	94-347	94-347	94-347
Date/Time Sampled		8-Jun-10	20-Aug-10	15-Sep-10	21-May-11	18-Jul-11	26-Sep-94	9-Sep-08	22-Sep-09	17-Aug-10	15-Sep-10	17-Jul-11	17-Sep-11
Calculated Parameters													
Ion Balance Ratio	0.01	1.2							1				
Physical Tests													
Acidity to pH 4.5 (as CaCO3)	0.5	<0.5	<0.5	<0.5					<0.5	<0.5	<0.5		
Acidity to pH 8.3 (as CaCO3)	0.5	12.5	4.5	11.8					<0.5	11.1	2.2		
Alkalinity (PP as CaCO3)	0.5				<0.5	<0.5						<0.5	<0.5
Alkalinity (Total as CaCO3)	0.5	310	340	370	370	370	187	140	150	150	140	150	180
Bicarbonate Alkalinity	0.5				450	460						180	210
Carbonate Alkalinity	0.5				<0.5	<0.5						<0.5	<0.5
Conductivity µS/cm	1	949	997	1040	1090	918	555	460	485	488	494	503	595
Hardness as CaCO3 (Dissolved)	0.5	651	622	667	582	525		234	258	244	246	260	304
Hardness as CaCO3 (Total)	0.5				634	480	311					242	320
Hydroxide Alkalinity	0.5				<0.5	<0.5						<0.5	<0.5
pH (pH)	0	7.94	8.27	8.18	7.68	7.89	7	8	7.73	7.84	7.9	7.66	7.84
Total Dissolved Solids	1.0 to 10.0	780	730	710	680	620	412	290	290	290	310	350	390
Total Suspended Solids	1				<1	<1	55	120				5	2
Turbidity (NTU)	0.1				0.1	0.1	19.8	40.9				4.1	6.5
Dissolved Anions													
Bromide	0.01 to 0.4	<0.4	<0.4	<0.4				0.1	<0.4	<0.4	<0.4		
Chloride	0.5	0.7	<0.5	<0.5	<0.5	1.1	0.6	2.2	0.9		<0.5	0.7	1
Fluoride	0.01	0.18	0.17	0.2	0.19	0.18	0.12	0.11	0.12	0.13	0.12	0.11	0.13
Sulphate	0.5 to 5.0	240	250	220	220	150	114	100	110	120	110	120	140
Thiocyanate	0.2	<0.2											
Nutrients													
Ammonia (Total)	0.005 to 0.05	<0.05	<0.005	<0.05	0.005	0.032	0.011	<0.01	0.05	0.017	<0.05	0.032	0.033
Nitrate (as N)	0.002 to 0.02	0.058	0.123	0.195	0.07	0.37	<0.02	0.005	0.006	<0.002	0.002	<0.02	<0.02
Nitrate+Nitrite (Dissolved)	0.002 to 0.02	0.058	0.123	0.195	0.07	0.37		0.007	0.006	<0.002	0.002	<0.02	<0.02
Nitrite (as N)	0.002 to 0.005	<0.002	<0.002	<0.002	<0.005	<0.005	0.001	0.002	<0.002	<0.002	<0.002	<0.005	<0.005
Nitrogen (Total)	0.02 to 0.2	0.16	0.13	0.22				0.08	0.1	0.07	0.08		
Nitrogen Kjeldahl (Total)	0.02 to 0.2	0.1	<0.02	0.03				0.08	0.09	0.07	0.08		
Orthophosphate (Dissolved)	0.001 to 0.005	0.003	0.005	0.002	<0.005	<0.005	0.001	0.01	0.001	0.001	0.002	<0.005	
Phosphorus Dissolved	0.002 to 0.02	0.003	<0.002	0.004			0.004	<0.002		<0.002	<0.002		
Cyanide													
Cyanide (SAD)	0.001								0.004				
Cyanide (WAD)	0.0005	<0.0005	<0.0005	<0.0005	<0.0005			<0.0005	<0.0005	<0.0005	<0.0005		
Cyanide+Thiocyanate	0.0005 to 0.001	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.001	<0.0005		<0.0005	<0.0005	0.0007	<0.0005
Dissolved Metals													
Aluminum	0.0002 to 0.005	0.0055	0.0029	0.0045	0.004	<0.003	0.008	0.0033	0.002	0.0118	0.0028	<0.003	<0.003
Antimony	0.00002 to 0.0005	0.00006	0.00006	0.00006	<0.0005	<0.0005	<0.0001	0.00004	0.00003	0.00003	0.00002	<0.0005	<0.0005
Arsenic	0.00002 to 0.001	0.00056	0.00054	0.00057	0.0005	0.0005	0.0054	0.00232	0.003	0.00295	0.00304	0.0032	0.0036
Barium	0.00002 to 0.001	0.0217	0.0228	0.025	0.021		0.064	0.0489	0.0516	0.0499	0.0472		0.065
Beryllium	0.00001 to 0.005	<0.00001	<0.00001	<0.00001	<0.0001	<0.0001	<0.005	0.00001	0.00001	<0.00001	0.00001	<0.0001	<0.0001
Bismuth	0.000005 to 0.1	<0.000005	<0.000005	<0.000005	<0.001	<0.001	<0.1	<0.000005	<0.000005	<0.000005	<0.000005	<0.001	<0.001
Boron	0.05 to 0.5	<0.05	<0.05	<0.05	<0.05	<0.05	<0.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cadmium	0.000005 to 0.0002	0.000015	0.000008	0.000016	0.00001	0.00001	<0.0002	0.000028	0.000021	0.000112	0.000028	0.00003	0.00004
Calcium	0.05 to 0.5	135	130	140	121	107	73.6	55.5	62.4	56.7	58	60.1	72.7
Chromium	0.0001 to 0.001	<0.0001	<0.0001	<0.0001	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.0001	<0.0001	<0.001	<0.001
Cobalt	0.000005 to 0.001	0.000013	0.000008	0.000019	<0.0005	<0.0005	0.001	0.000761	0.000735	0.000781	0.000776	0.0008	0.0008
Copper	0.00005 to 0.001	0.00045	0.00035	0.00032	0.0006	0.0007	0.002	0.00024	0.00038	0.00099	0.00014	0.0003	<0.0002
Iron	0.001 to 0.03	0.012	0.003	0.005	0.008	<0.005	0.759	0.399	0.478	0.51	0.52	0.514	0.599
Lead	0.000005 to 0.001	0.00007	0.00003	0.00002	<0.0002	<0.0002	<0.001	0.000077	0.000046	0.000152	0.00004	<0.0002	<0.0002
Lithium	0.0005 to 0.005	0.0179	0.0173	0.0196	0.016	0.016		0.0067	0.007	0.0069	0.0066	0.007	0.007
Magnesium	0.001 to 0.5	76.4	72.2	76.9	67.7	62.4	30.8	23.2	24.8	25	24.7	26.6	29.9
Manganese	0.00002 to 0.005	0.00127	0.00129	0.00152	0.003		0.45	0.347	0.393	0.398	0.408		<0.00002
Mercury	0.00000001 to 0.0001	<0.00001	<0.00001	<0.00001	<0.00002	<0.00002		<0.00001		<0.00001	<0.00001	<0.00002	
Molybdenum	0.00005 to 0.001	0.00079	0.00084	0.00084	<0.001	<0.001	<0.001	0.00037	0.00033	0.00036	0.00041	<0.001	<0.001
Nickel	0.00002 to 0.001	0.00022	0.00021	0.00025	<0.001	<0.001	0.002	0.00047	0.00042	0.00044	0.0005	<0.001	<0.001
Phosphorus	0.002												
Potassium	0.05 to 0.5	1.88	1.81	1.97	1.69	1.77	1.53	1.02	1.09	1.05	1.03	1.12	1.33
Selenium	0.00004 to 0.0005	0.00005	0.00008	0.00013	<0.0001	0.0004	<0.0005	<0.00004	<0.00004	<0.00004	<0.00004	<0.0001	<0.0001
Silicon	0.0 to 1.0	7.5	7	8	6.67	7.76	6.69	6.2	6.9	6.2	6.7	7.03	6.8
Silver	0.000005 to 0.0001	<0.000005	<0.000005	<0.000005		<0.00002	<0.0001	<0.000005	<0.000005	<0.000005	<0.000005	<0.00002	<0.00002
Sodium	0.05 to 0.5	10.1	9.61	10.2	8.44	8.79	7.32	4.93	5.25	5.25	5.17	5.5	5.71
Strontium	0.00005 to 0.001	1.03	0.989	1.06	0.916		0.501	0.411	0.434	0.437	0.41		0.549
Sulphur	1.0 to 100.0	105	89	96	89	57		36	41	43	41	43	48
Thallium	0.000002 to 0.00005	0.000004	0.000004	0.000005	<0.00005	<0.00005		0.000027	0.000027	0.000028	0.000023	<0.00005	<0.00005
Tin	0.00001 to 0.005	<0.00001	0.00002	0.00001	<0.005	<0.005		<0.00001	<0.00001	0.00001	0.00001	<0.005	<0.005
Titanium	0.0005 to 0.01	0.0006	<0.0005	<0.0005	<0.005	<0.005		0.0006	<0.0005	0.0008	<0.0005	<0.005	<0.005
Uranium	0.000002 to 0.0001	0.0464	0.0489	0.0507	0.0443	0.0372	0.0146	0.00912	0.0101	0.00867	0.00963	0.011	0.0135
Vanadium	0.0002 to 0.03	<0.0002	<0.0002	<0.0002	<0.005	<0.005	<0.03	<0.0002	<0.0002	<0.0002	<0.0002	<0.005	<0.005
Zinc	0.0001 to 0.005	0.0012	0.0013	0.0011	0.007	0.01	0.007	0.0036	0.0044	0.0058	0.0039	0.032	<0.005
Zirconium	0.0001 to 0.002	<0.0001	<0.0001	0.0013	<0.0005	<0.0005		<0.0001	<0.0001	<0.0001	<0.0001	<0.0005	<0.0005
Total Metals													
Aluminum	0.0002 to 0.003				0.014	0.005	0.768					0.033	0.016
Antimony	0.00002 to 0.0005				<0.0005	<0.0005	<0.0001					<0.0005	<0.0005
Arsenic	0.00002 to 0.0001				0.0005	0.0004	0.0061					0.003	0.0035
Barium	0.00002 to 0.001				0.023	0.018	0.072					0.049	0.063
Beryllium	0.00001 to 0.005				<0.0001	<0.0001	<0.005					<0.0001	<0.0001
Bismuth	0.000005 to 0.1				<0.001	<0.001	<0.1					<0.001	<0.001
Boron	0.05 to 0.1				<0.05	<0.05	<0.1					<0.05	<0.05
Cadmium	0.000005 to 0.0002				0.00002	0.00002	<0.0002					0.00022	0.00005
Calcium	0.05				132	99.7	73.6					56	74.3
Chromium	0.0001 to 0.001				<0.001	<0.001	0.001					<0.001	<0.001
Cobalt	0.000005 to 0.001				<0.0005	<0.0005	0.001					0.0008	0.001
Copper	0.00005 to 0.0002				0.0005	0.0008						0.0007	0.0003
Iron	0.001 to 0.03				0.023	0.006	0.0016					0.559	0.637
Lead	0.000005 to 0.001				<0.0002	<0.0002	0.001					0.0003	<0.0002
Lithium	0.0005 to 0.005				0.016	0.017						0.007	0.007
Magnesium	0.001 to 0.05				74	56.1	31.6					24.7	32.6
Manganese	0.00005 to 0.001				0.005		0.465						0.497
Mercury	0.00001 to 0.00002				<0.00002	<0.00002	<0.00001					<0.00002	<0.00002
Molybdenum	0.00005 to 0.001				<0.001	<0.001	<0.001					<0.001	<0.001
Nickel	0.00002 to 0.001				<0.001	<0.001	0.003					<0.001	<0.001
Phosphorus	0.000002 to 0.002						0.000016						
Potassium	0.05				1.83	1.55						1	1.2
Selenium	0.00004 to 0.1				<0.0001	0.0004	<0.0005					<0.0001	<0.0001
Silicon	0.1				7.41		7.72						7
Silver	0.000005 to 0.0001				<0.00002	<0.00002	<0.0001					<0.00002	<0.00002
Sodium	0.05				9.84	8.15						5.11	6.39
Strontium	0.00005 to 0.001				1.04	0.787	0.501					0.433	0.557
Sulphur	3.0 to 10.0				93	53						40	51
Thallium	0.000002 to 0.00005				<0.00005	<0.00005						<0.00005	<0.00005
Tin	0.0002 to 0.005				<0.005	<0.005						<0.005	<0.005
Titanium	0.0005 to 0.01				<0.005								<0.005
Uranium	0.000002 to 0.0001				0.0491	0.0329	0.0179					0.0099	0.0158
Vanadium	0.0002 to 0.03				<0.005	<0.005	<0.03					<0.005	<0.005
Zinc	0.0001 to 0.005				0.006	0.008	0.009					0.037	0.006
Zirconium	0.0001 to 0.0005				<0.0005	<0.0005						<0.0005	<0.0005
Organics													
Dissolved Organic Carbon													
Total Organic Carbon	0.5 to 5.0	<0.5	3	1	1.8	3.6	1.7	2.2	2.2	1.8	2	2.1	1.7

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NOTES:
1. UNITS ARE IN mg/L UNLESS OTHERWISE STATED.
2. REFER TO TABLE F1 FOR DETAILED FOOTNOTES ON CELL SHADING.

CASINO COPPER-GOLD PROJECT
TABLE F4 - CASINO CREEK VALLEY AREA

Site ID	MDL	94-347	*94-347*	94-351	94-351	94-351	94-351	94-351	94-351	94-348	94-348	94-348	94-348
Date/Time Sampled		**16-Sep-12**	***2-Oct-14***	**9-Sep-08**	**22-Sep-09**	**17-Aug-10**	**15-Sep-10**	**17-Jul-11**	**18-Sep-11**	**9-Sep-08**	**8-Jun-10**	**20-Aug-10**	**15-Sep-10**
Calculated Parameters													
Ion Balance Ratio	0.01	0.96	*1.00*		1								
Physical Tests													
Acidity to pH 4.5 (as CaCO3)	0.5	<0.5			<0.5	<0.5	<0.5				<0.5	<0.5	<0.5
Acidity to pH 8.3 (as CaCO3)	0.5	10.6			<0.5	4.1	3.1				4.3	0.7	2.2
Alkalinity (PP as CaCO3)	0.5							<0.5	<0.5				
Alkalinity (Total as CaCO3)	0.5	188	*179*	630	380	240	280	290	660	62	78	99	72
Bicarbonate Alkalinity	0.5		*179*					350	810				
Carbonate Alkalinity	0.5		*<1*					<0.5	<0.5				
Conductivity µS/cm	1	638	*548*	1100	702	480	527	529	1140	130	168	207	148
Hardness as CaCO3 (Dissolved)	0.5	323	*307*	640	396	238	286	291	607	58.1	78.1	116	91
Hardness as CaCO3 (Total)	0.5	339						281	699				
Hydroxide Alkalinity	0.5		*<1*					<0.5	<0.5				
pH (pH)	0	7.7	*8*	8.3	8.06	8.1	8.32	8.03	7.96	8	7.86	7.93	7.78
Total Dissolved Solids	1.0 to 10.0	442	*425*	730	440	300	350	370	680	120	140	130	120
Total Suspended Solids	1	3.8	*4.5*	120				53	74	190			
Turbidity (NTU)	0.1	5.31	*3.05*	16.1				4.7	10.2	65.5			
Dissolved Anions													
Bromide	0.01 to 0.4	<0.01	*<0.05*	0.2	<0.4	<0.4	<0.4			0.1	<0.4	<0.4	<0.4
Chloride	0.5	<0.5	*<0.5*	1.5	1.6		0.5	1.1	1.6	1.2	0.6	<0.5	<0.5
Fluoride	0.01	0.11	*0.123*	0.23	0.24	0.21	0.24	0.14	0.17	0.03	0.02	0.02	0.07
Sulphate	0.5 to 5.0	159	*137*	51	25	14	17	5.6	10	<0.5	11	6.2	5.1
Thiocyanate	0.2										<0.2		
Nutrients													
Ammonia (Total)	0.005 to 0.05	0.015	*<0.005*	0.18	0.13	0.38	0.1	0.058	0.13	<0.01	0.07	0.33	<0.05
Nitrate (as N)	0.002 to 0.02	<0.002	*<0.005*	0.059	0.008	0.176	0.01	<0.02	<0.02	0.025	0.017	0.008	0.012
Nitrate+Nitrite (Dissolved)	0.002 to 0.02	<0.002	*<0.001*	0.076	0.015	0.228	0.019	<0.02	<0.02	0.067	0.017	0.008	0.014
Nitrite (as N)	0.002 to 0.005	<0.002	*0.108*	0.017	0.007	0.052	0.01	<0.005	<0.005	0.042	<0.002	<0.002	0.002
Nitrogen (Total)	0.02 to 0.2	0.084	*0.108*	1.32	1.04	1.01	0.77			0.28	0.27	0.41	0.41
Nitrogen Kjeldahl (Total)	0.02 to 0.2	0.084	*<0.001*	1.25	1.02	0.78	0.75			0.22	0.26	0.41	0.4
Orthophosphate (Dissolved)	0.001 to 0.005	0.0011	*0.0025*	0.011	0.001	0.002	0.007	0.011		0.008	0.005	0.005	0.001
Phosphorus Dissolved	0.002 to 0.02		*0.0029*	0.039		0.02	0.03			0.01	0.011	0.007	0.008
Cyanide													
Cyanide (SAD)	0.001		*<0.005*		0.034								
Cyanide (WAD)	0.0005	<0.0005	*<0.005*	0.0005	0.0007	0.0014	0.0011			0.001	0.0009	0.0012	0.0013
Cyanide+Thiocyanate	0.0005 to 0.001	<0.0005	*<0.005*	0.0022		0.001	0.0007	0.0009	0.0009	0.0018	0.0014	0.0006	0.0008
Dissolved Metals													
Aluminum	0.0002 to 0.005	0.00146	*0.0013*	0.015	0.0093	0.02	0.026	0.011	0.013	0.113	0.122	0.0429	0.0768
Antimony	0.00002 to 0.0005	0.000025	*<0.0001*	0.00103	0.00092	0.0007	0.0012	0.0006	0.0005	0.00025	0.00029	0.0004	0.00033
Arsenic	0.00002 to 0.001	0.00384	*0.0035*	0.00168	0.00149	0.0013	0.0014	0.0009	0.0013	0.00184	0.00168	0.00157	0.00137
Barium	0.00002 to 0.001	0.0743	*0.0598*	0.124	0.0829	0.041	0.0611		0.145	0.0299	0.0638	0.0467	0.0435
Beryllium	0.00001 to 0.005	0.000013	*<0.0001*	0.00001	<0.00001	<0.00005	<0.0001	<0.0001	<0.0001	0.00003	0.00002	0.00001	0.00002
Bismuth	0.000005 to 0.1	<0.000005	*<0.0005*	0.000007	<0.000005	<0.00003	<0.00005	<0.001	<0.001	<0.000005	<0.000005	<0.000005	<0.000005
Boron	0.05 to 0.5	<0.05	*<0.01*	0.08	<0.05	<0.3	<0.5	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cadmium	0.000005 to 0.0002	0.000034	*0.000029*	0.000047	0.000019	0.00018	0.00007	0.00002	0.00005	0.000029	0.000081	0.000147	0.000041
Calcium	0.05 to 0.5	74.4	*70.9*	165	112	72.9	83.6	89.9	178	21.5	27.6	42	33.1
Chromium	0.0001 to 0.001	<0.0001	*<0.0001*	0.0012	0.0008	<0.0005	<0.001	0.002	<0.001	0.0007	0.0005	0.0005	0.0007
Cobalt	0.000005 to 0.001	0.00102	*0.00084*	0.00119	0.00069	0.00053	0.00054	<0.0005	0.0006	0.00065	0.00101	0.00007	0.000161
Copper	0.00005 to 0.001	0.000338	*0.00088*	0.0445	0.0322	0.0194	0.0317	0.0224	0.0244	0.0216	0.0241	0.0168	0.0197
Iron	0.001 to 0.03	0.575	*0.494*	0.044	0.074	0.067	0.06	0.04	0.066	0.309	0.176	0.139	0.183
Lead	0.000005 to 0.001	0.000024	*<0.00005*	0.000435	0.000218	0.00031	0.00043	<0.0002	0.0003	0.00109	0.000819	0.000473	0.000721
Lithium	0.0005 to 0.005	0.00797	*0.00746*	0.0039	0.0068	<0.003	<0.005	<0.005	<0.005	0.0012	0.0016	0.0016	0.0014
Magnesium	0.001 to 0.5	33.2	*31.5*	55.6	28.3	13.6	18.7	0.031	39.8	1.07	2.25	2.67	2.02
Manganese	0.00002 to 0.005	0.521	*0.405*	0.406	0.239	0.109	0.0915		<0.00002	0.143	0.278	0.00455	0.0203
Mercury	0.00000001 to 0.0001	<0.00000001	*<0.00001*	<0.00001		<0.00005	<0.0001	<0.00002		<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum	0.00005 to 0.001	0.000387	*0.000322*	0.0173	0.0136	0.0069	0.0094	0.01	0.008	0.00204	0.0011	0.00115	0.00137
Nickel	0.00002 to 0.001	0.000598	*0.00058*	0.0218	0.0151	0.0094	0.0157	0.008	0.013	0.00431	0.00617	0.00362	0.00383
Phosphorus	0.002	<0.002	*<0.05*										
Potassium	0.05 to 0.5	1.21	*1.15*	7.02	4.57	3.3	3.3	4.42	7.01	0.79	1.08	1.21	0.91
Selenium	0.00004 to 0.0005	<0.00004	*<0.0001*	0.00051	0.00039	0.0004	<0.0004	0.0002	0.0004	0.0001	0.00009	0.00012	0.00013
Silicon	0.0 to 1.0	6.64	*6.56*	9.6	8.6	7.3	8	9.45	10.7	5.6	5.5	7.4	7.1
Silver	0.000005 to 0.0001	<0.000005	*<0.00001*	0.00002	0.000009	<0.00003	<0.00005	<0.00002	<0.00002	0.000021	0.000017	0.000023	0.000014
Sodium	0.05 to 0.5	6.14	*5.66*	34.7	10.3	3.8	5	3.58	16.3	0.99	1.59	1.81	1.56
Strontium	0.00005 to 0.001	0.618	*0.527*	0.676	0.45	0.256	0.327		0.699	0.0343	0.0567	0.0771	0.0586
Sulphur	1.0 to 100.0	57	*46.3*	18	10	<50	<100	358	6	<3	<10	<10	<10
Thallium	0.000002 to 0.00005	0.000029	*0.000025*	0.000004	<0.000002	<0.00001	<0.00002	<0.00005	<0.00005	0.000006	0.000009	0.000005	0.000006
Tin	0.00001 to 0.005	<0.0002	*<0.0001*	0.00014	0.00011	0.00022	0.0002	<0.005	<0.005	0.00016	0.00012	0.00027	0.00017
Titanium	0.0005 to 0.01	<0.0005	*<0.01*	0.0027	0.0019	<0.003	<0.005	<0.005	<0.005	0.0016	0.0019	0.0012	0.0011
Uranium	0.000002 to 0.0001	0.0208	*0.0151*	0.0156	0.00932	0.00449	0.00686	0.0091	0.0111	0.00186	0.00127	0.0024	0.00197
Vanadium	0.0002 to 0.03	<0.0002	*<0.001*	0.0036	0.0034	0.003	0.005	<0.005	<0.005	0.001	0.0006	0.0004	0.0007
Zinc	0.0001 to 0.005	0.0042	*0.0069*	0.0047	0.0117	0.007	0.005	0.059	0.156	0.0017	0.0064	0.0027	0.0041
Zirconium	0.0001 to 0.002	<0.0001		0.0041	0.0024	0.0011	<0.002	0.0012	0.0026	0.0012	0.0007	0.0007	<0.001
Total Metals													
Aluminum	0.0002 to 0.003	0.0262	*0.0766*					0.464	0.755				
Antimony	0.00002 to 0.0005	0.000024	*<0.0001*					<0.0005	0.0006				
Arsenic	0.00002 to 0.0001	0.00368	*0.00335*					0.0009	0.0016				
Barium	0.00002 to 0.001	0.0728	*0.0577*					0.066	0.173				
Beryllium	0.00001 to 0.005	0.000014	*<0.0001*					<0.0001	<0.0001				
Bismuth	0.000005 to 0.1	<0.000005	*<0.0005*					<0.001	<0.001				
Boron	0.05 to 0.1	<0.05	*0.012*					<0.05	<0.05				
Cadmium	0.000005 to 0.0002	0.000034	*0.000074*					0.00003	0.00014				
Calcium	0.05	78.4	*67.4*					87	201				
Chromium	0.0001 to 0.001	0.00082	*0.00053*					0.002	0.002				
Cobalt	0.000005 to 0.001	0.00103	*0.00081*					0.0007	0.0015				
Copper	0.00005 to 0.0002	0.00869	*0.00089*					0.0245	0.0367				
Iron	0.001 to 0.03	0.642	*0.567*					0.754	1.31				
Lead	0.000005 to 0.001	0.000063	*0.000206*					0.0018	0.0039				
Lithium	0.0005 to 0.005	0.00808	*0.00728*					<0.005	<0.005				
Magnesium	0.001 to 0.05	34.9	*30.1*					15.5	47.6				
Manganese	0.00005 to 0.001	0.512	*0.395*						0.273				
Mercury	0.00001 to 0.00002	<0.00001	*0.000014*					<0.00002	<0.00002				
Molybdenum	0.00005 to 0.001	0.000358	*0.000387*					0.009	0.012				
Nickel	0.00002 to 0.001	0.00127	*0.00067*					0.01	0.015				
Phosphorus	0.000002 to 0.002	0.0046	*<0.05*										
Potassium	0.05	1.25	*1.12*					4.12	7.01				
Selenium	0.00004 to 0.1	<0.00004	*<0.0001*					0.0002	0.0004				
Silicon	0.1	6.91	*6.46*						12.9				
Silver	0.000005 to 0.0001	<0.000005	*<0.00001*					<0.00002	0.00002				
Sodium	0.05	6.39	*5.41*					3.41	21				
Strontium	0.00005 to 0.001	0.639	*0.536*					0.328	0.813				
Sulphur	3.0 to 10.0	57	*44.7*					<3	8				
Thallium	0.000002 to 0.00005	0.000026	*0.000028*					<0.00005	<0.00005				
Tin	0.0002 to 0.005	<0.0002	*<0.0001*					<0.005	<0.005				
Titanium	0.0005 to 0.01	0.00092	*<0.01*						0.041				
Uranium	0.000002 to 0.0001	0.021	*0.015*					0.0088	0.0147				
Vanadium	0.0002 to 0.03	<0.0002	*<0.001*					<0.005	0.006				
Zinc	0.0001 to 0.005	0.00474	*0.0072*					0.05	0.111				
Zirconium	0.0001 to 0.0005	<0.0001						0.0013	0.0034				
Organics													
Dissolved Organic Carbon			*1.82*										
Total Organic Carbon	0.5 to 5.0	1.49	*1.9*	25.9	24.1	24.5	22.5	20	23.8	19.7	17.2	17.2	18.8

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NOTES:
1. UNITS ARE IN mg/L UNLESS OTHERWISE STATED.
2. REFER TO TABLE F1 FOR DETAILED FOOTNOTES ON CELL SHADING.

CASINO COPPER-GOLD PROJECT
TABLE F4 - CASINO CREEK VALLEY AREA

Site ID	MDL	94-340	94-350
Date/Time Sampled		25-Sep-94	27-Sep-94
Calculated Parameters			
Ion Balance Ratio	0.01		
Physical Tests			
Acidity to pH 4.5 (as CaCO3)	0.5		
Acidity to pH 8.3 (as CaCO3)	0.5		
Alkalinity (PP as CaCO3)	0.5		
Alkalinity (Total as CaCO3)	0.5	105	482
Bicarbonate Alkalinity	0.5		
Carbonate Alkalinity	0.5		
Conductivity µS/cm	1	330	1050
Hardness as CaCO3 (Dissolved)	0.5		
Hardness as CaCO3 (Total)	0.5	180	581
Hydroxide Alkalinity	0.5		
pH (pH)	0	7.22	7.28
Total Dissolved Solids	1.0 to 10.0	224	723
Total Suspended Solids	1	29	15
Turbidity (NTU)	0.1	13.6	11.4
Dissolved Anions			
Bromide	0.01 to 0.4		
Chloride	0.5	<0.5	1.1
Fluoride	0.01	0.08	0.1
Sulphate	0.5 to 5.0	68.6	140
Thiocyanate	0.2		
Nutrients			
Ammonia (Total)	0.005 to 0.05	0.007	0.011
Nitrate (as N)	0.002 to 0.02	<0.02	<0.005
Nitrate+Nitrite (Dissolved)	0.002 to 0.02		
Nitrite (as N)	0.002 to 0.005	<0.005	0.002
Nitrogen (Total)	0.02 to 0.2		
Nitrogen Kjeldahl (Total)	0.02 to 0.2		
Orthophosphate (Dissolved)	0.001 to 0.005	<0.005	<0.001
Phosphorus Dissolved	0.002 to 0.02	0.004	0.005
Cyanide			
Cyanide (SAD)	0.001		
Cyanide (WAD)	0.0005		
Cyanide+Thiocyanate	0.0005 to 0.001	<0.001	<0.001
Dissolved Metals			
Aluminum	0.0002 to 0.005	0.007	<0.005
Antimony	0.00002 to 0.0005	0.0001	0.0035
Arsenic	0.00002 to 0.001	0.0025	0.0061
Barium	0.00002 to 0.001	0.037	0.14
Beryllium	0.00001 to 0.005	<0.005	<0.005
Bismuth	0.000005 to 0.1	<0.1	<0.1
Boron	0.05 to 0.5	<0.1	<0.1
Cadmium	0.000005 to 0.0002	0.0002	<0.0002
Calcium	0.05 to 0.5	54.3	139
Chromium	0.0001 to 0.001	<0.001	<0.001
Cobalt	0.000005 to 0.001	0.001	0.001
Copper	0.00005 to 0.001	0.002	<0.001
Iron	0.001 to 0.03	0.677	<0.03
Lead	0.000005 to 0.001	<0.001	<0.001
Lithium	0.0005 to 0.005		
Magnesium	0.001 to 0.5	10.7	52.3
Manganese	0.00002 to 0.005	0.566	0.417
Mercury	0.00000001 to 0.0001		
Molybdenum	0.00005 to 0.001	<0.001	0.005
Nickel	0.00002 to 0.001	0.001	0.003
Phosphorus	0.002		
Potassium	0.05 to 0.5	0.98	2.45
Selenium	0.00004 to 0.0005	<0.0005	<0.0005
Silicon	0.0 to 1.0	4.94	6.58
Silver	0.000005 to 0.0001	<0.0001	<0.0001
Sodium	0.05 to 0.5	4.79	30.2
Strontium	0.00005 to 0.001	0.5	2.36
Sulphur	1.0 to 100.0		
Thallium	0.000002 to 0.00005		
Tin	0.00001 to 0.005		
Titanium	0.0005 to 0.01		
Uranium	0.000002 to 0.0001	0.00564	0.101
Vanadium	0.0002 to 0.03	<0.03	<0.03
Zinc	0.0001 to 0.005	0.015	<0.005
Zirconium	0.0001 to 0.002		
Total Metals			
Aluminum	0.0002 to 0.003	0.084	0.549
Antimony	0.00002 to 0.0005	0.0002	0.0035
Arsenic	0.00002 to 0.0001	0.0025	0.0077
Barium	0.00002 to 0.001	0.04	0.154
Beryllium	0.00001 to 0.005	<0.005	<0.005
Bismuth	0.000005 to 0.1	<0.1	<0.1
Boron	0.05 to 0.1	<0.1	<0.1
Cadmium	0.000005 to 0.0002	<0.0002	<0.0002
Calcium	0.05	60.3	154
Chromium	0.0001 to 0.001	0.001	0.002
Cobalt	0.000005 to 0.001	0.003	0.001
Copper	0.00005 to 0.0002		
Iron	0.001 to 0.03	0.814	1.3
Lead	0.000005 to 0.001	0.002	0.006
Lithium	0.0005 to 0.005		
Magnesium	0.001 to 0.05	11.9	56.8
Manganese	0.00005 to 0.001	0.566	0.464
Mercury	0.00001 to 0.00002	<0.00001	<0.00001
Molybdenum	0.00005 to 0.001	<0.001	0.007
Nickel	0.00002 to 0.001	0.001	0.004
Phosphorus	0.000002 to 0.002	0.00001	0.00001
Potassium	0.05		
Selenium	0.00004 to 0.1	<0.0005	<0.0005
Silicon	0.1	5.01	8.38
Silver	0.000005 to 0.0001	<0.0001	<0.0001
Sodium	0.05		
Strontium	0.00005 to 0.001	0.503	2.46
Sulphur	3.0 to 10.0		
Thallium	0.000002 to 0.00005		
Tin	0.0002 to 0.005		
Titanium	0.0005 to 0.01		
Uranium	0.000002 to 0.0001	0.00852	0.25
Vanadium	0.0002 to 0.03	<0.03	<0.03
Zinc	0.0001 to 0.005	0.015	<0.005
Zirconium	0.0001 to 0.0005		
Organics			
Dissolved Organic Carbon			
Total Organic Carbon	0.5 to 5.0	1.6	2.3

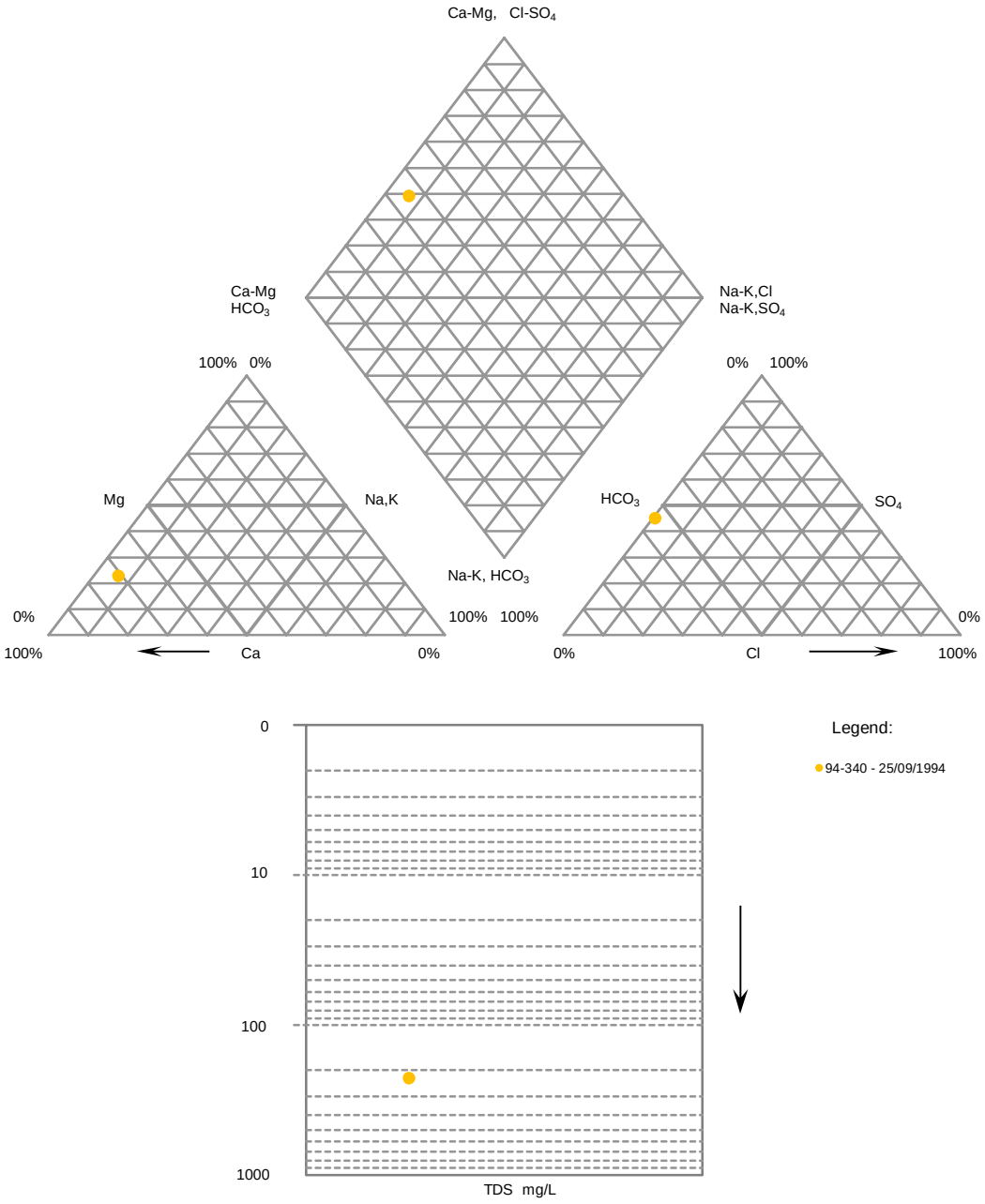
M:\1\01\00325\12\A\Data\Task 330 - Groundwater Quality\baseline report\[results a

NOTES:
1. UNITS ARE IN mg/L UNLESS OTHERWISE STATED.
2. REFER TO TABLE F1 FOR DETAILED FOOTNOTES ON CELL SHADING.

APPENDIX G

PIPER DIAGRAMS

(Pages G-1 to G-17)



NOTES:

1. PIPER DATA ARE PLOTTED IN %meq/L.
2. VALUES BELOW THE METHOD DETECTION LIMIT (MDL) WERE ASSUMED TO EQUAL HALF THE MDL.

REV	DATE	DESCRIPTION	PREP'D	APP'D
0	06MAR'15	ISSUED WITH REPORT	CJ	JEM

WESTERN COPPER

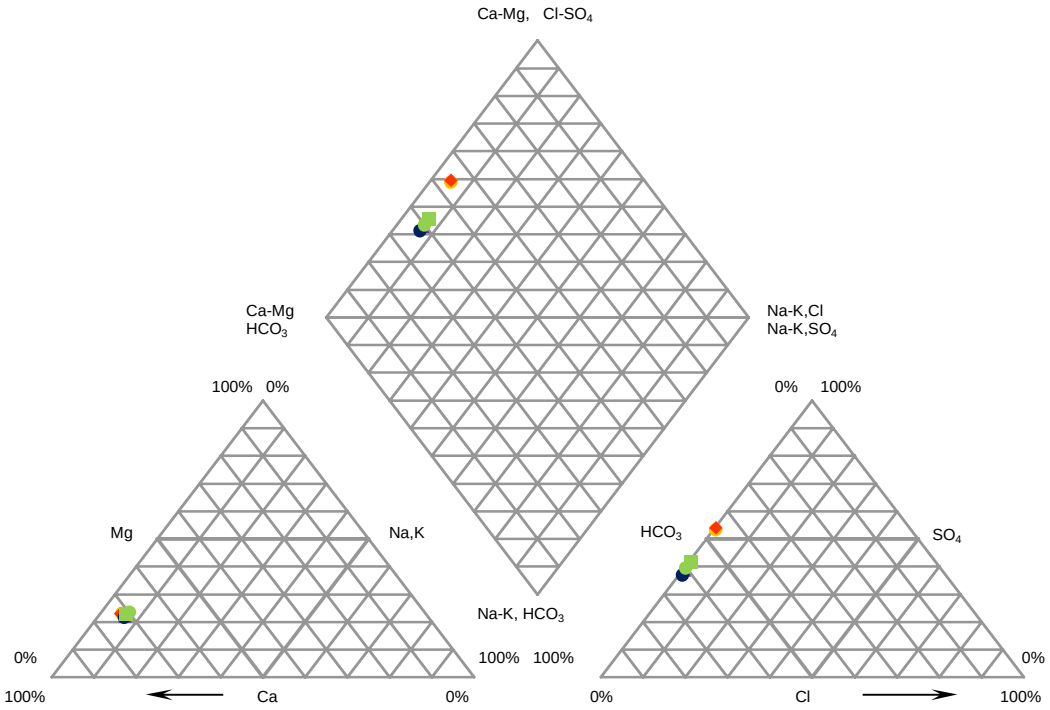
CASINO PROJECT

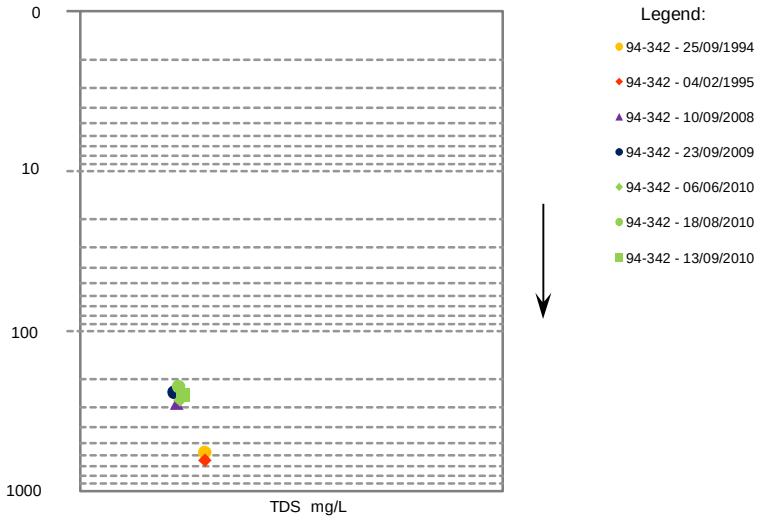
PIPER PLOT - CASINO CREEK AREA
94-340

Knight Piésold CONSULTING

P/A NO. VA101-325/17 | REF. NO. 1

FIGURE G1.1 | REV 0





NOTES:

1. PIPER DATA ARE PLOTTED IN %meq/L.
2. VALUES BELOW THE METHOD DETECTION LIMIT (MDL) WERE ASSUMED TO EQUAL HALF THE MDL.

REV	DATE	DESCRIPTION	PREP'D	APP'D
0	06MAR'15	ISSUED WITH REPORT	CJ	JEM

WESTERN COPPER

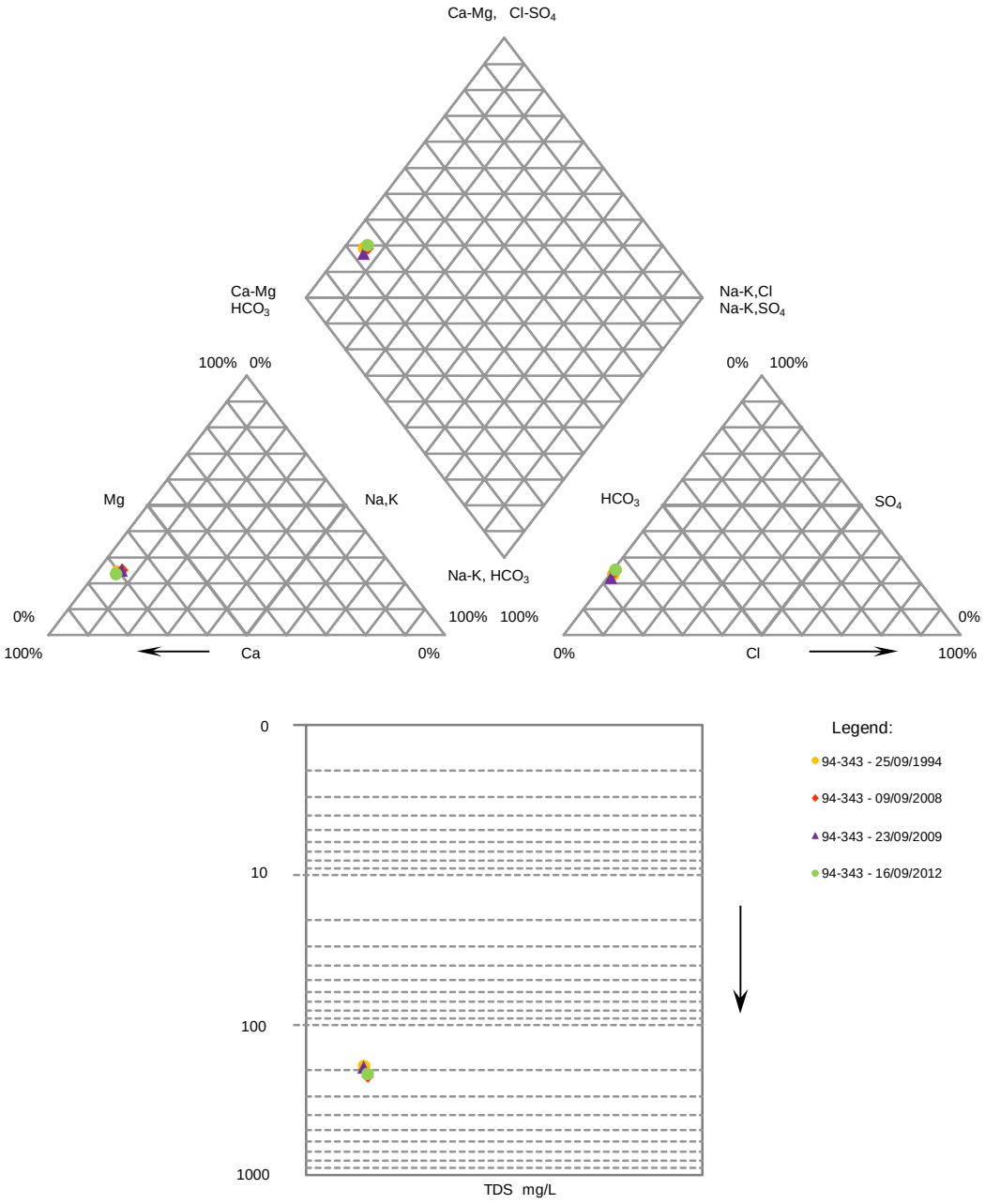
CASINO PROJECT

PIPER PLOT - CASINO CREEK AREA
94-342

Knight Piésold CONSULTING

P/A NO. VA101-325/17 | REF. NO. 1

FIGURE G1.2 | REV 0



NOTES:

1. PIPER DATA ARE PLOTTED IN %meq/L.
2. VALUES BELOW THE METHOD DETECTION LIMIT (MDL) WERE ASSUMED TO EQUAL HALF THE MDL.

REV	DATE	DESCRIPTION	PREP'D	APP'D
0	06MAR'15	ISSUED WITH REPORT	CJ	JEM

WESTERN COPPER

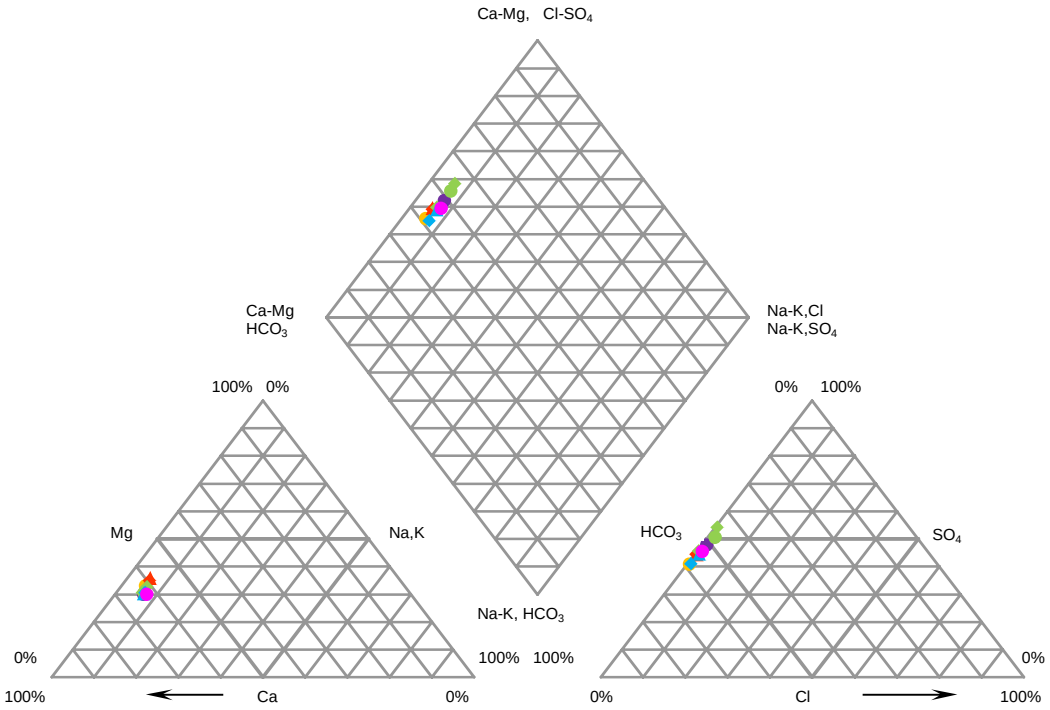
CASINO PROJECT

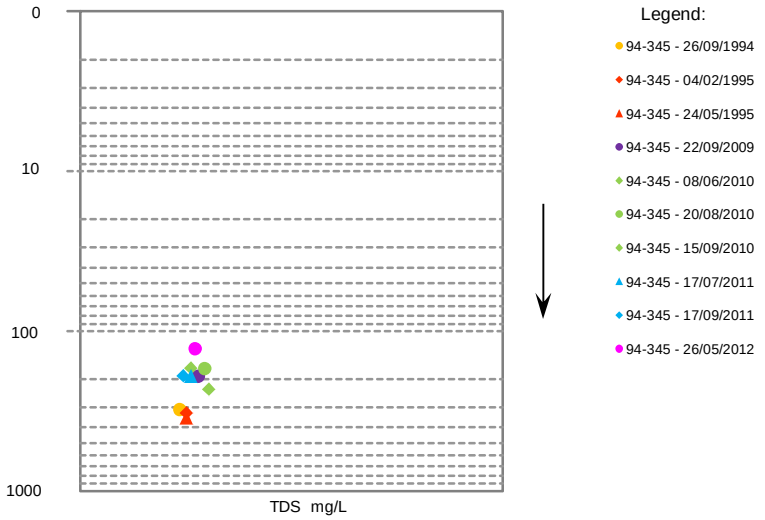
PIPER PLOT - CASINO CREEK AREA
94-343

Knight Piésold CONSULTING

P/A NO. VA101-325/17 | REF. NO. 1

FIGURE G1.3 | REV 0





NOTES:

1. PIPER DATA ARE PLOTTED IN %meq/L.
2. VALUES BELOW THE METHOD DETECTION LIMIT (MDL) WERE ASSUMED TO EQUAL HALF THE MDL.

REV	DATE	DESCRIPTION	PREP'D	APP'D
0	06MAR'15	ISSUED WITH REPORT	CJ	JEM

WESTERN COPPER

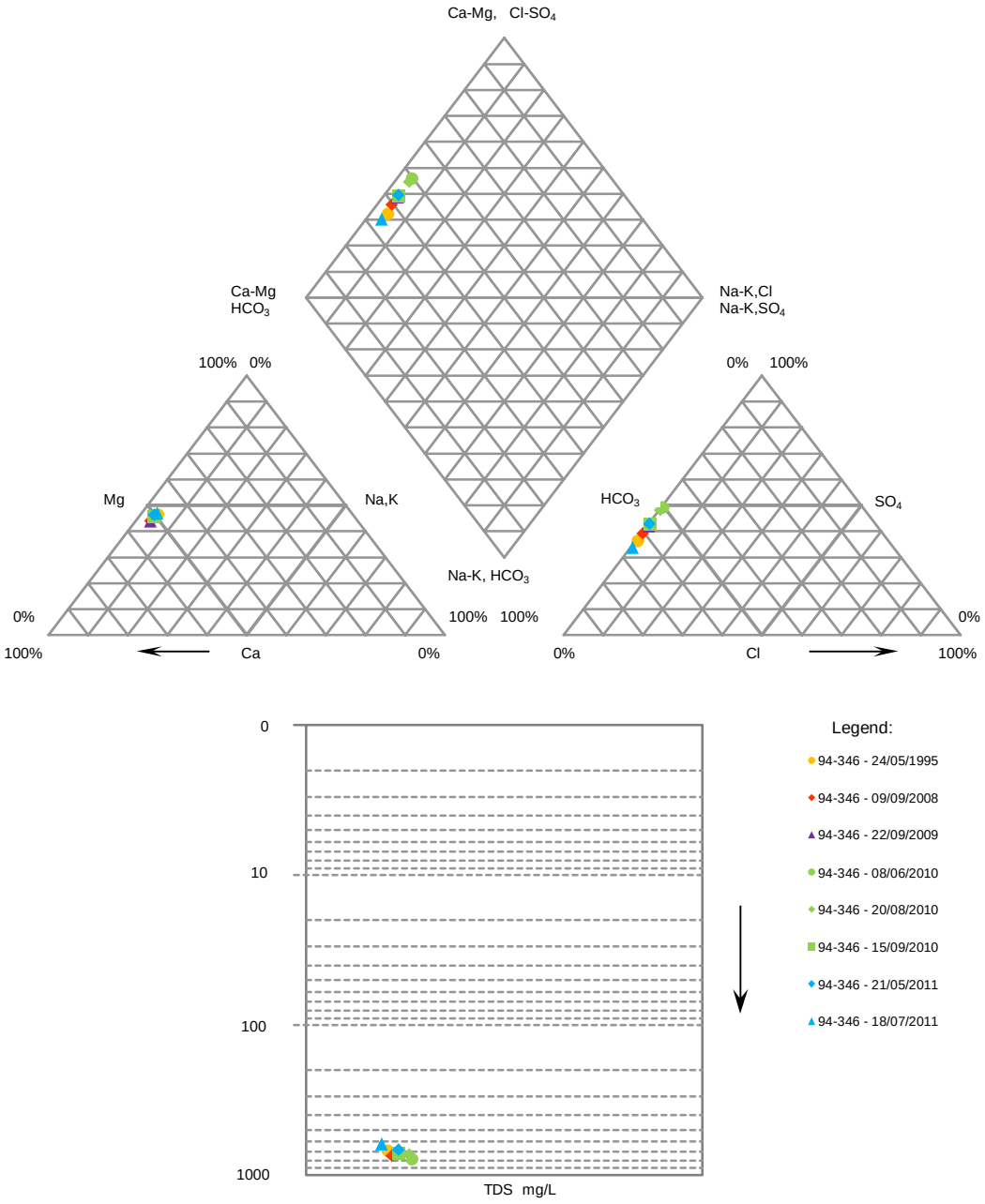
CASINO PROJECT

PIPER PLOT - CASINO CREEK AREA
94-345

Knight Piésold CONSULTING

P/A NO. VA101-325/17 | REF. NO. 1

FIGURE G1.4 | REV 0



NOTES:

1. PIPER DATA ARE PLOTTED IN %meq/L.
2. VALUES BELOW THE METHOD DETECTION LIMIT (MDL) WERE ASSUMED TO EQUAL HALF THE MDL.

REV	DATE	DESCRIPTION	PREP'D	APP'D
0	06MAR'15	ISSUED WITH REPORT	CJ	JEM

WESTERN COPPER

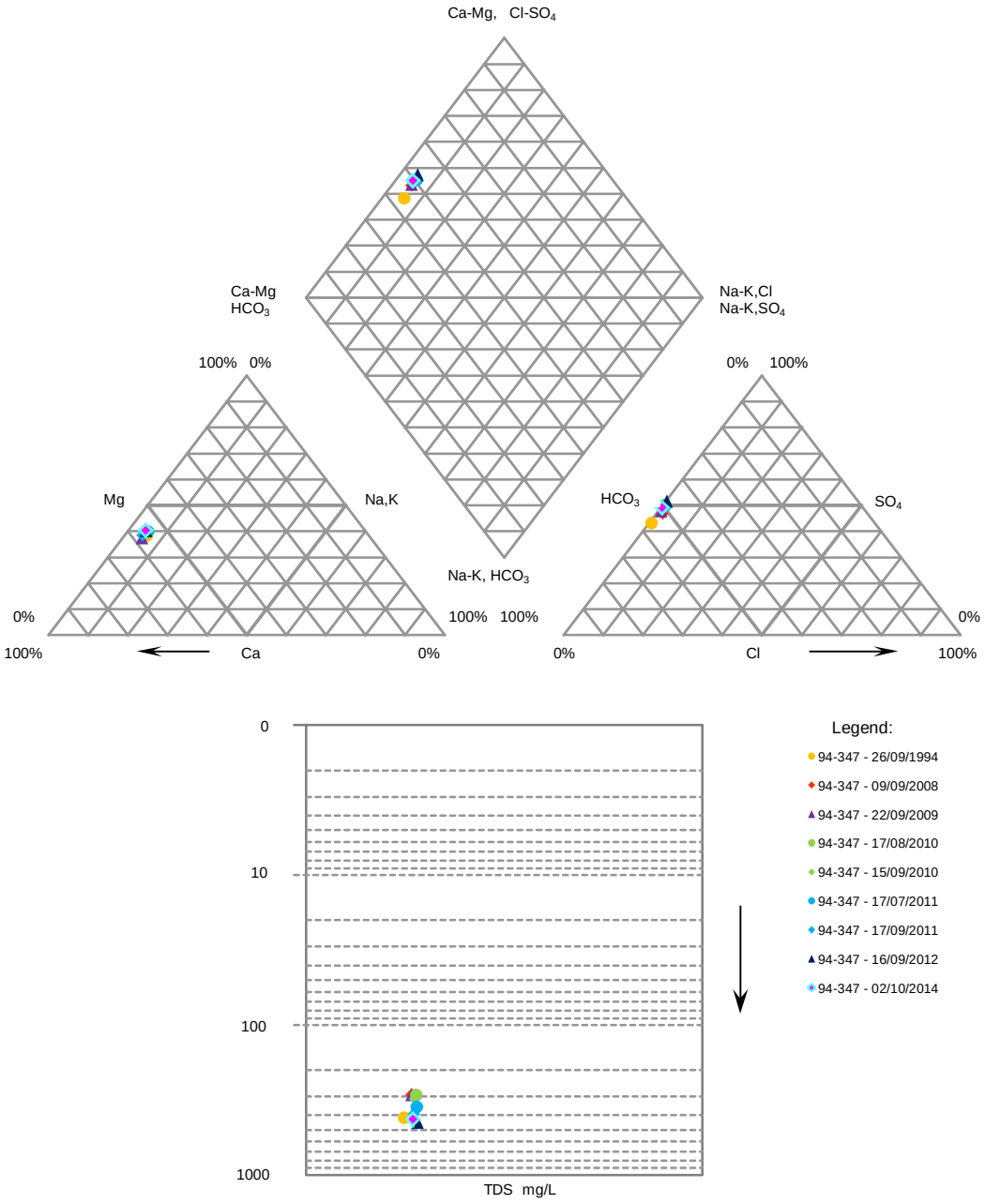
CASINO PROJECT

PIPER PLOT - CASINO CREEK AREA
94-346

Knight Piésold CONSULTING

P/A NO. VA101-325/17 | REF. NO. 1

FIGURE G1.5 | REV 0



NOTES:

1. PIPER DATA ARE PLOTTED IN %meq/L.
2. VALUES BELOW THE METHOD DETECTION LIMIT (MDL) WERE ASSUMED TO EQUAL HALF THE MDL.

REV	DATE	DESCRIPTION	PREP'D	APP'D
0	06MAR'15	ISSUED WITH REPORT	CJ	JEM

WESTERN COPPER

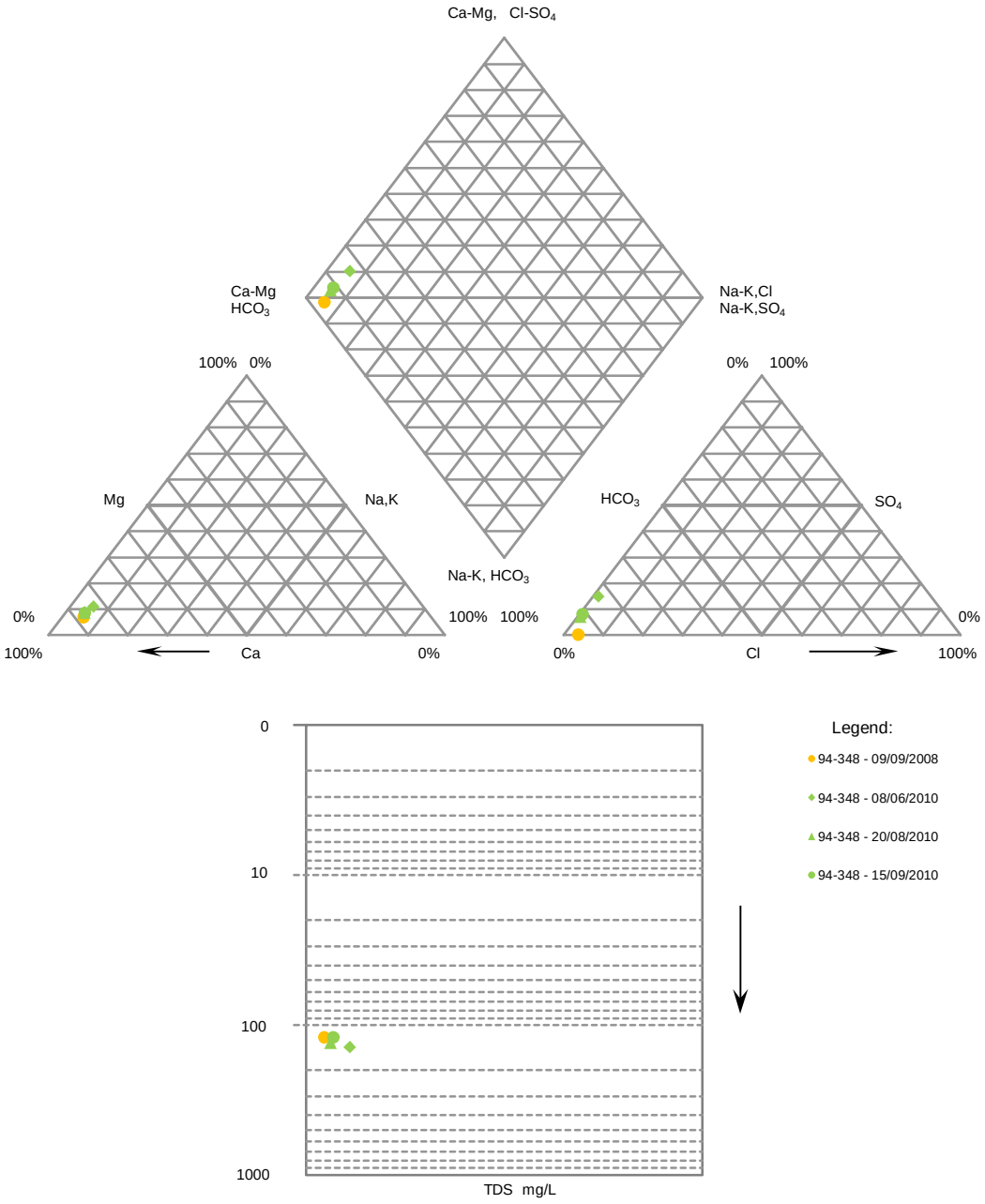
CASINO PROJECT

PIPER PLOT - CASINO CREEK AREA
94-347

Knight Piésold CONSULTING

P/A NO. VA101-325/17 | REF. NO. 1

FIGURE G1.6 | REV 0



NOTES:

1. PIPER DATA ARE PLOTTED IN %meq/L.
2. VALUES BELOW THE METHOD DETECTION LIMIT (MDL) WERE ASSUMED TO EQUAL HALF THE MDL.

REV	DATE	DESCRIPTION	PREP'D	APP'D
0	06MAR'15	ISSUED WITH REPORT	CJ	JEM

WESTERN COPPER

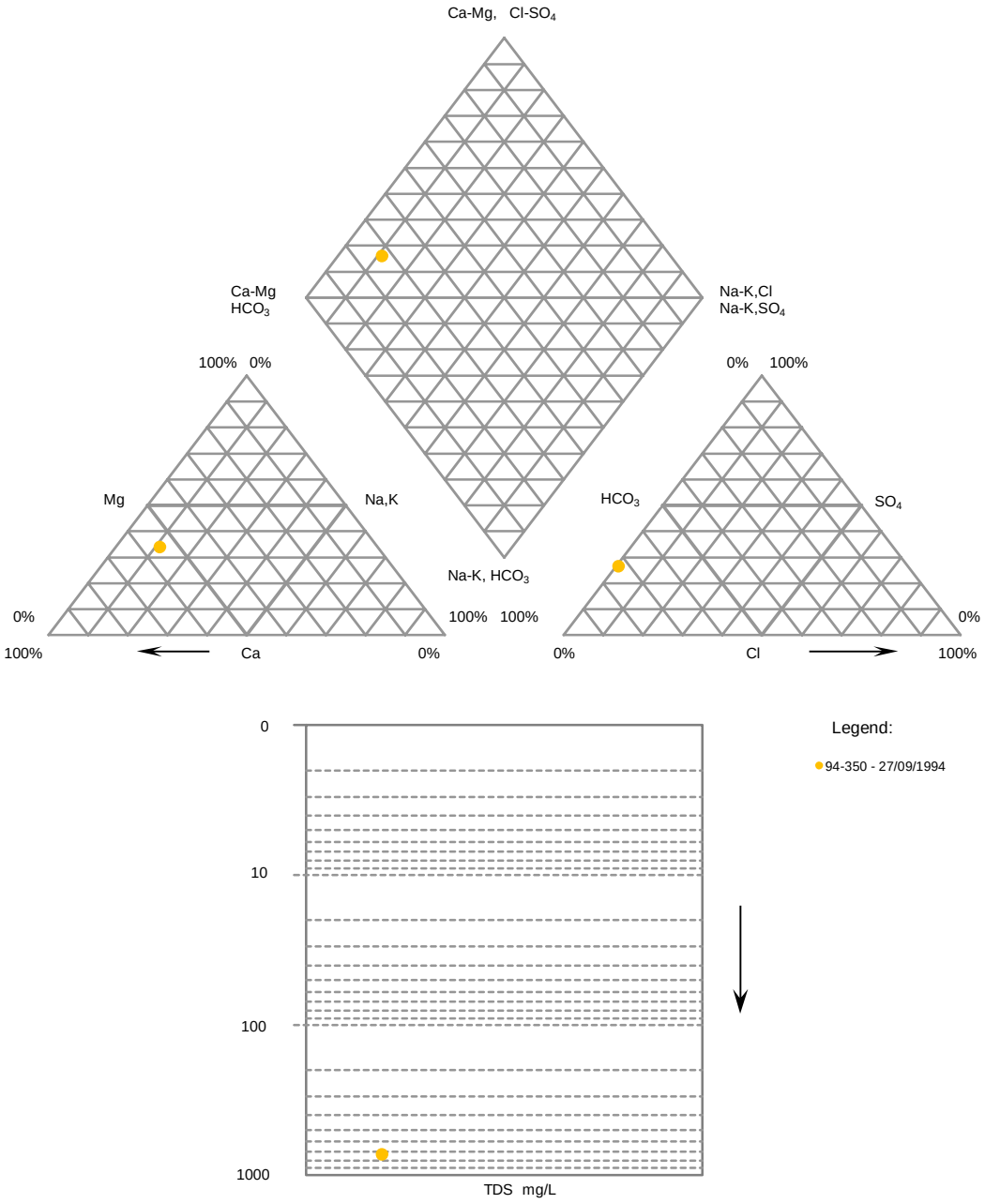
CASINO PROJECT

PIPER PLOT - CASINO CREEK AREA
94-348

Knight Piésold CONSULTING

P/A NO. VA101-325/17 | REF. NO. 1

FIGURE G1.7 | REV 0



NOTES:

1. PIPER DATA ARE PLOTTED IN %meq/L.
2. VALUES BELOW THE METHOD DETECTION LIMIT (MDL) WERE ASSUMED TO EQUAL HALF THE MDL.

REV	DATE	DESCRIPTION	PREP'D	CHK'D
0	06MAR'15	ISSUED WITH REPORT	CJ	JEM

WESTERN COPPER

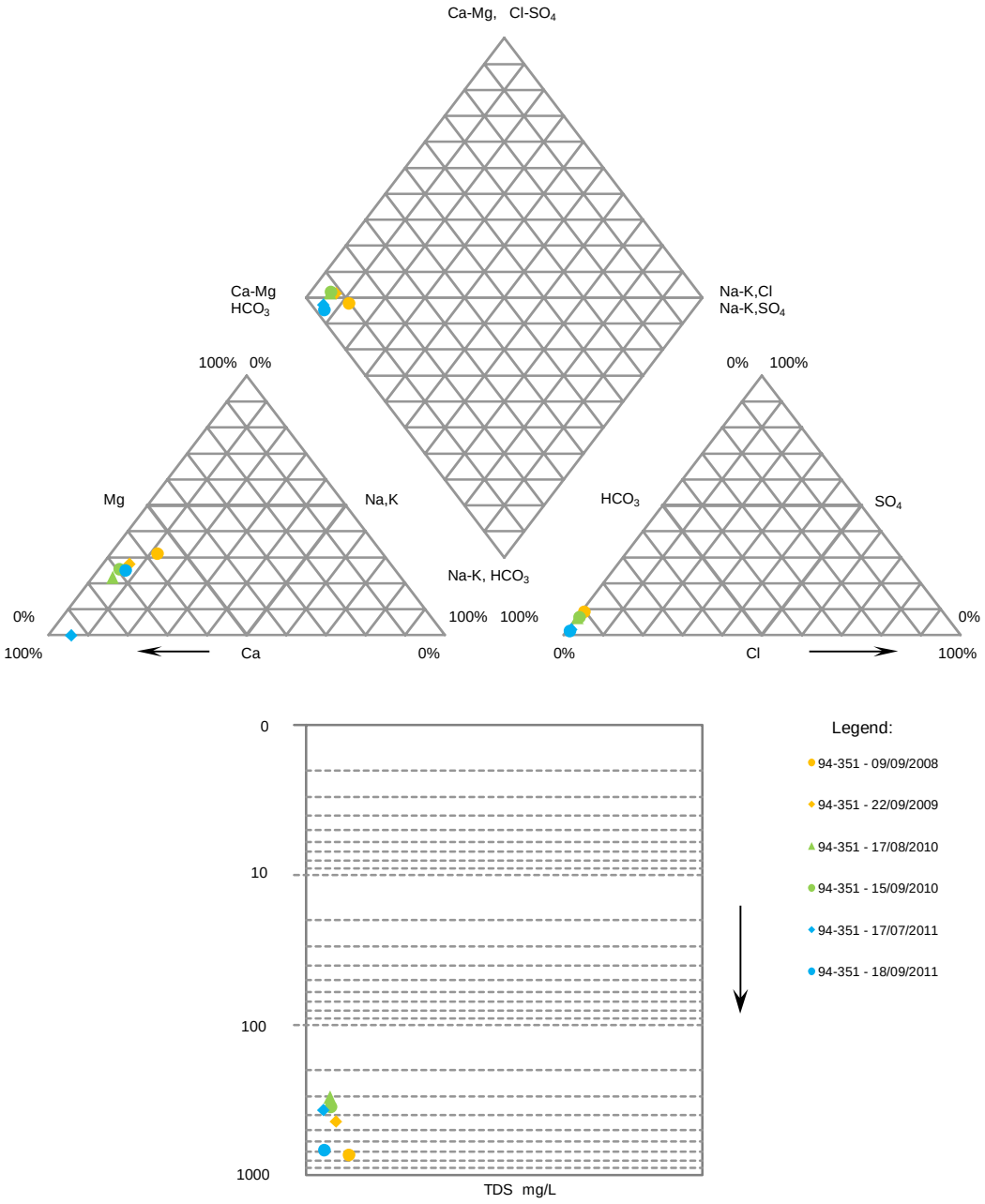
CASINO PROJECT

PIPER PLOT - CASINO CREEK AREA
94-350

Knight Piésold CONSULTING

P/A NO. VA101-325/17 | REF. NO. 1

FIGURE G1.8 | REV 0



NOTES:

1. PIPER DATA ARE PLOTTED IN %meq/L.
2. VALUES BELOW THE METHOD DETECTION LIMIT (MDL) WERE ASSUMED TO EQUAL HALF THE MDL.

REV	DATE	DESCRIPTION	PREP'D	APP'D
0	06MAR'15	ISSUED WITH REPORT	CJ	JEM

WESTERN COPPER

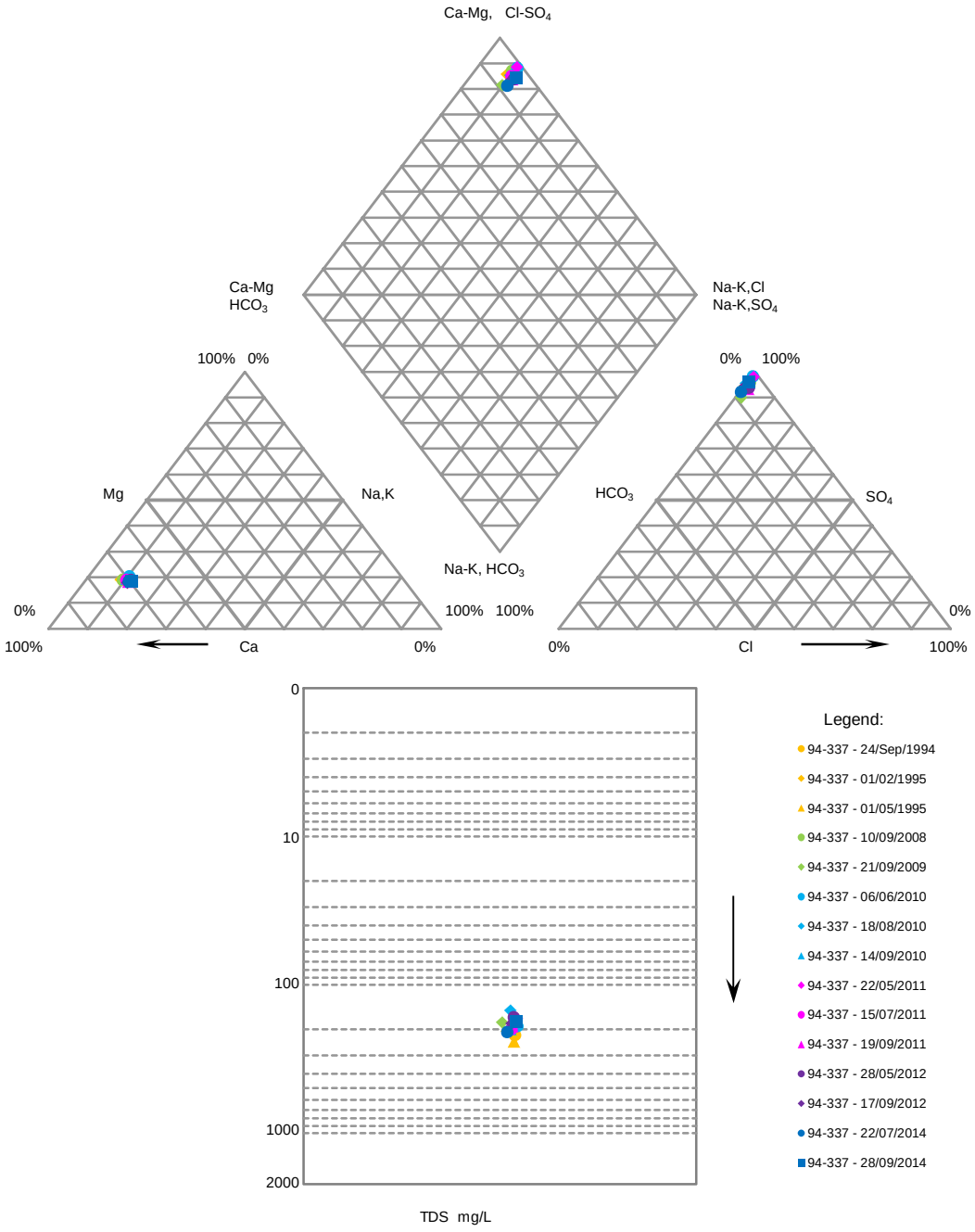
CASINO PROJECT

PIPER PLOT - CASINO CREEK AREA
94-351

Knight Piésold CONSULTING

P/A NO. VA101-325/17 | REF. NO. 1

FIGURE G1.9 | REV 0



NOTES:

1. PIPER DATA ARE PLOTTED IN %meq/L.
2. DATA USED FOR THESE PLOTS ARE AVERAGE VALUES, BASED ON SAMPLES COLLECTED FROM DECEMBER 2011 TO MAY 2014.
3. VALUES BELOW THE METHOD DETECTION LIMIT (MDL) WERE ASSUMED TO EQUAL HALF

REV	DATE	DESCRIPTION	PREP'D	APP'D
0	06MAR'15	ISSUED WITH REPORT	CJ	JEM

WESTERN COPPER

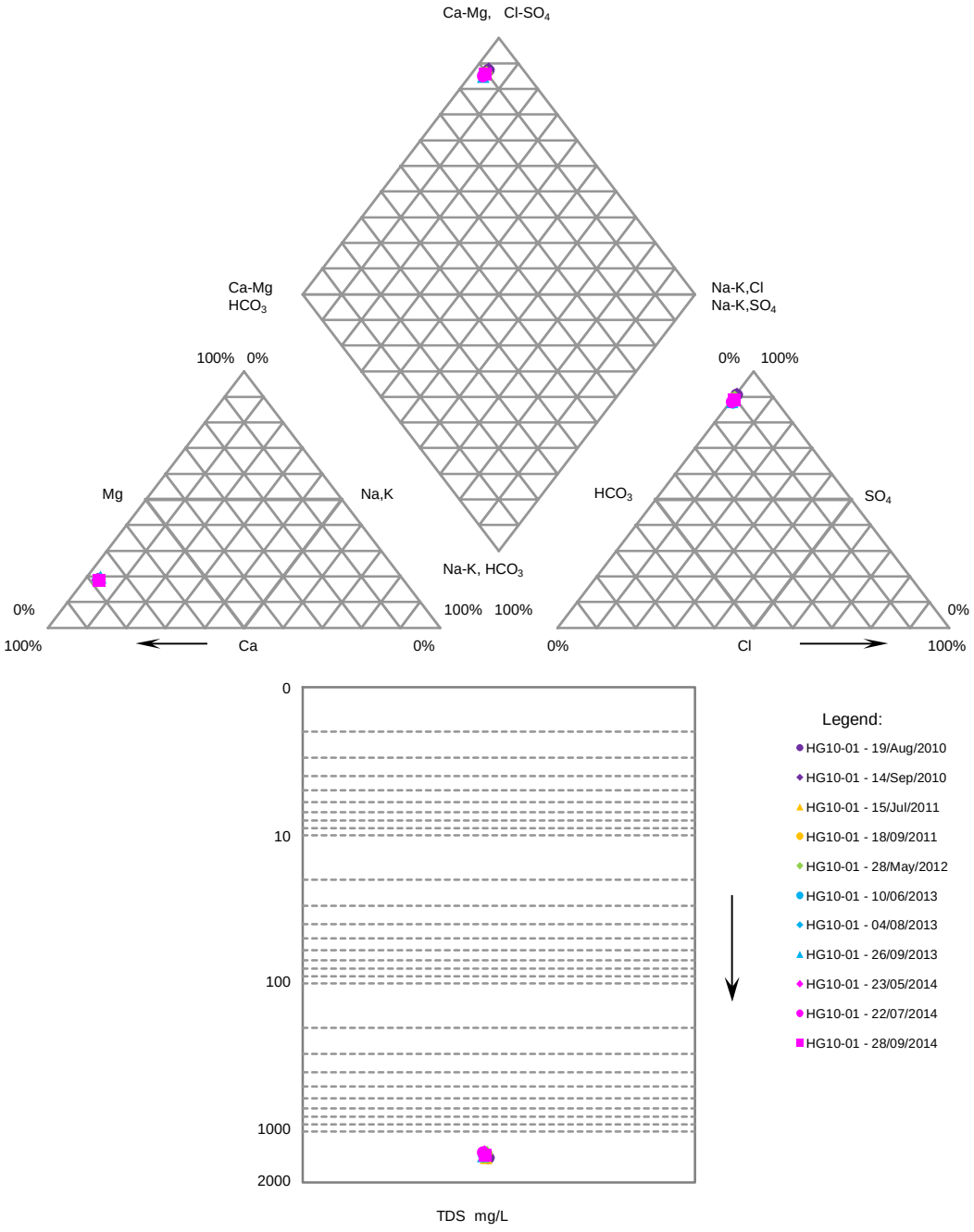
CASINO PROJECT

PIPER PLOT - OPEN PIT AREA
94-337

Knight Piésold CONSULTING

P/A NO. VA101-325/17 | REF. NO. 1

FIGURE G2.1 | REV 0



NOTES:

1. PIPER DATA ARE PLOTTED IN %meq/L.
2. DATA USED FOR THESE PLOTS ARE AVERAGE VALUES, BASED ON SAMPLES COLLECTED FROM DECEMBER 2011 TO MAY 2014.
3. VALUES BELOW THE METHOD DETECTION LIMIT (MDL) WERE ASSUMED TO EQUAL HALF THE MDL.

REV	DATE	DESCRIPTION	PREP'D	APP'D
0	06MAR'15	ISSUED WITH REPORT	CJ	JEM

WESTERN COPPER

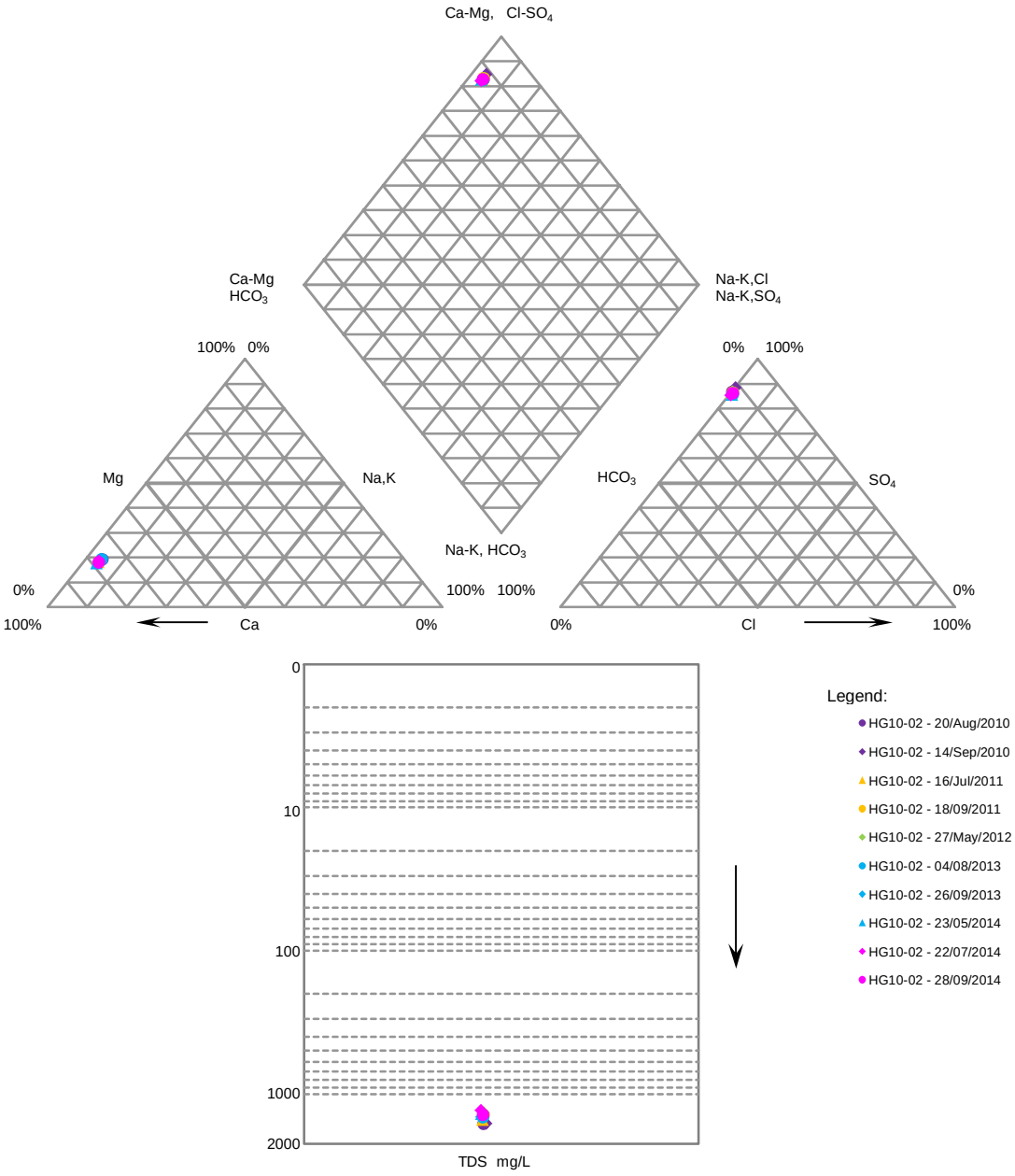
CASINO PROJECT

PIPER PLOT - OPEN PIT AREA
HG10-01

Knight Piésold CONSULTING

P/A NO. VA101-325/17 | REF. NO. 1

FIGURE G2.2 | REV 0



NOTES:

1. PIPER DATA ARE PLOTTED IN %meq/L.
2. DATA USED FOR THESE PLOTS ARE AVERAGE VALUES, BASED ON SAMPLES COLLECTED FROM DECEMBER 2011 TO MAY 2014.
3. VALUES BELOW THE METHOD DETECTION LIMIT (MDL) WERE ASSUMED TO EQUAL HALF THE MDL.
4. QA/QC ISSUE WITH SULPHATE AND ZINC FOR JUNE 22, 2013

REV	DATE	DESCRIPTION	PREP'D	APP'D
0	06MAR'15	ISSUED WITH REPORT	CJ	JEM

WESTERN COPPER

CASINO PROJECT

PIPER PLOT - OPEN PIT AREA
HG10-02

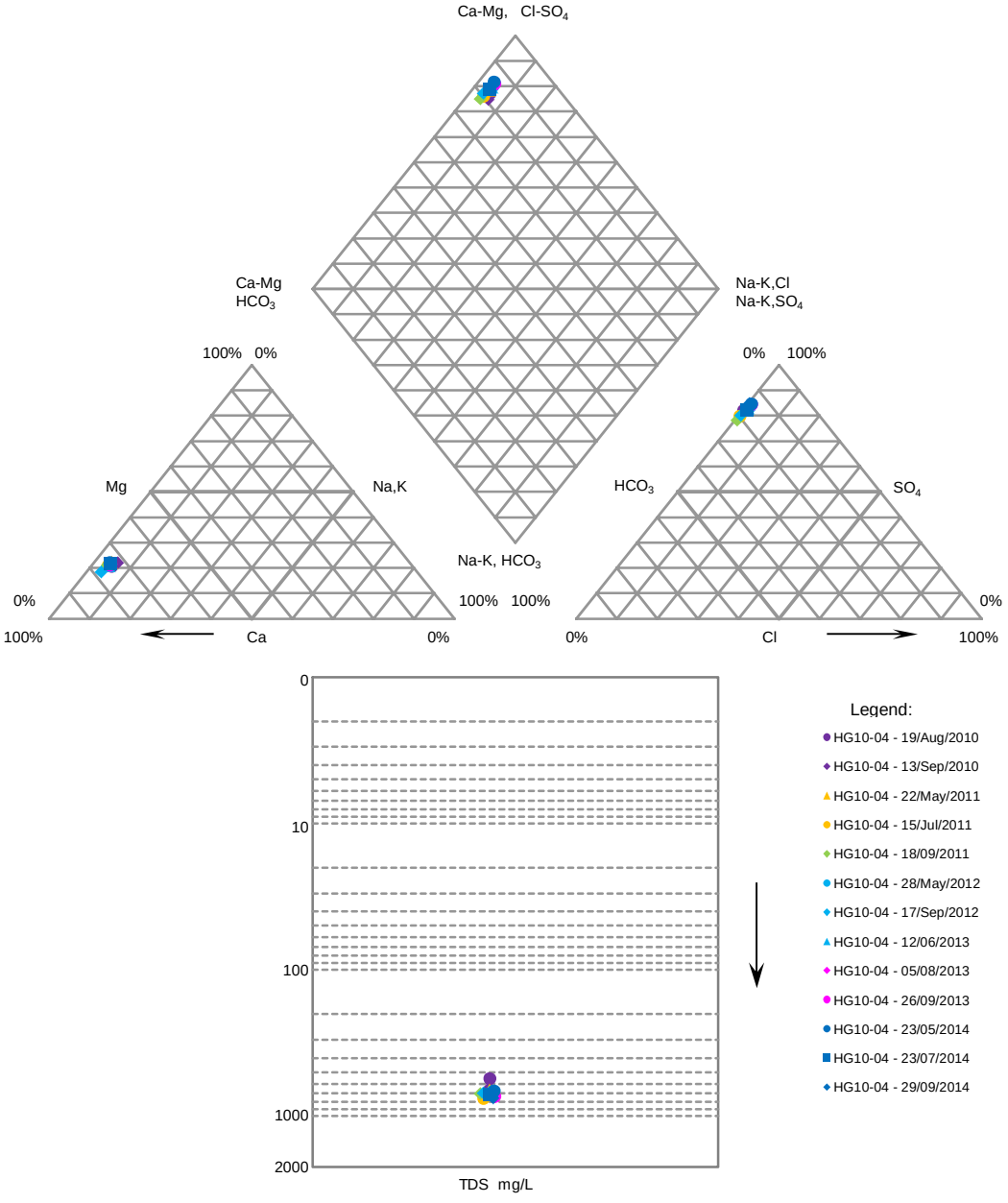
Knight Piésold CONSULTING

P/A NO. VA101-325/17

REF. NO. 1

FIGURE G2.2

REV 0



NOTES:

1. PIPER DATA ARE PLOTTED IN %meq/L.
2. DATA USED FOR THESE PLOTS ARE AVERAGE VALUES, BASED ON SAMPLES COLLECTED FROM DECEMBER 2011 TO MAY 2014.
3. VALUES BELOW THE METHOD DETECTION LIMIT (MDL) WERE ASSUMED TO EQUAL HALF THE MDL.
4. QA/QC ISSUE WITH ALUMINUM, LEAD AND TURBIDITY FOR JUNE 22,

REV	DATE	DESCRIPTION	PREP'D	APP'D
0	06MAR'15	ISSUED WITH REPORT	CJ	JEM

WESTERN COPPER

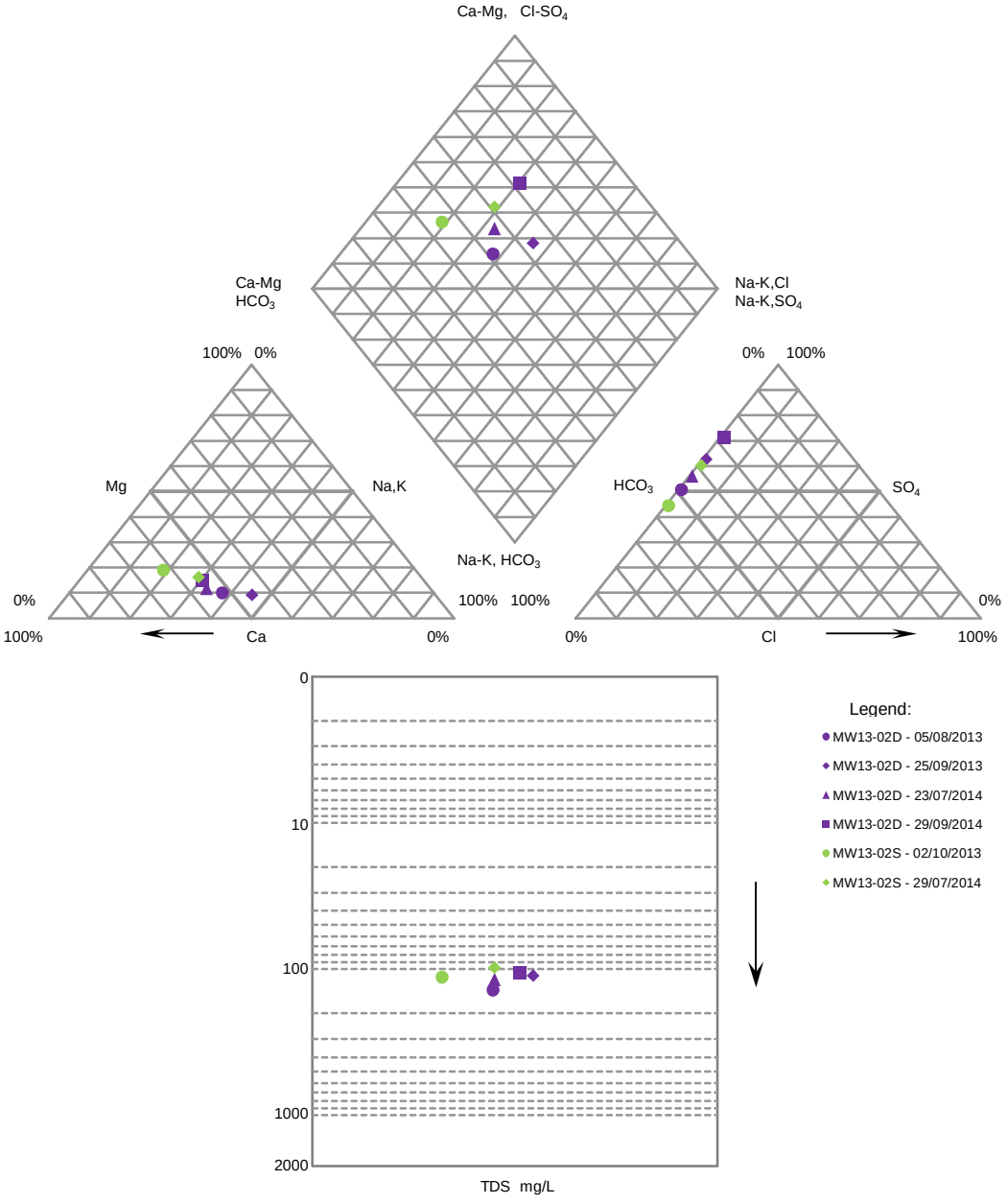
CASINO PROJECT

PIPER PLOT - OPEN PIT AREA
HG10-04

Knight Piésold CONSULTING

P/A NO. VA101-325/17 | REF. NO. 1

FIGURE G2.4 | REV 0



NOTES:

1. PIPER DATA ARE PLOTTED IN %meq/L.
2. DATA USED FOR THESE PLOTS ARE AVERAGE VALUES, BASED ON SAMPLES COLLECTED FROM DECEMBER 2011 TO MAY 2014.
3. VALUES BELOW THE METHOD DETECTION LIMIT (MDL) WERE ASSUMED TO EQUAL HALF THE MDL.

REV	DATE	DESCRIPTION	PREP'D	APP'D
0	06MAR'15	ISSUED WITH REPORT	CJ	JEM

WESTERN COPPER

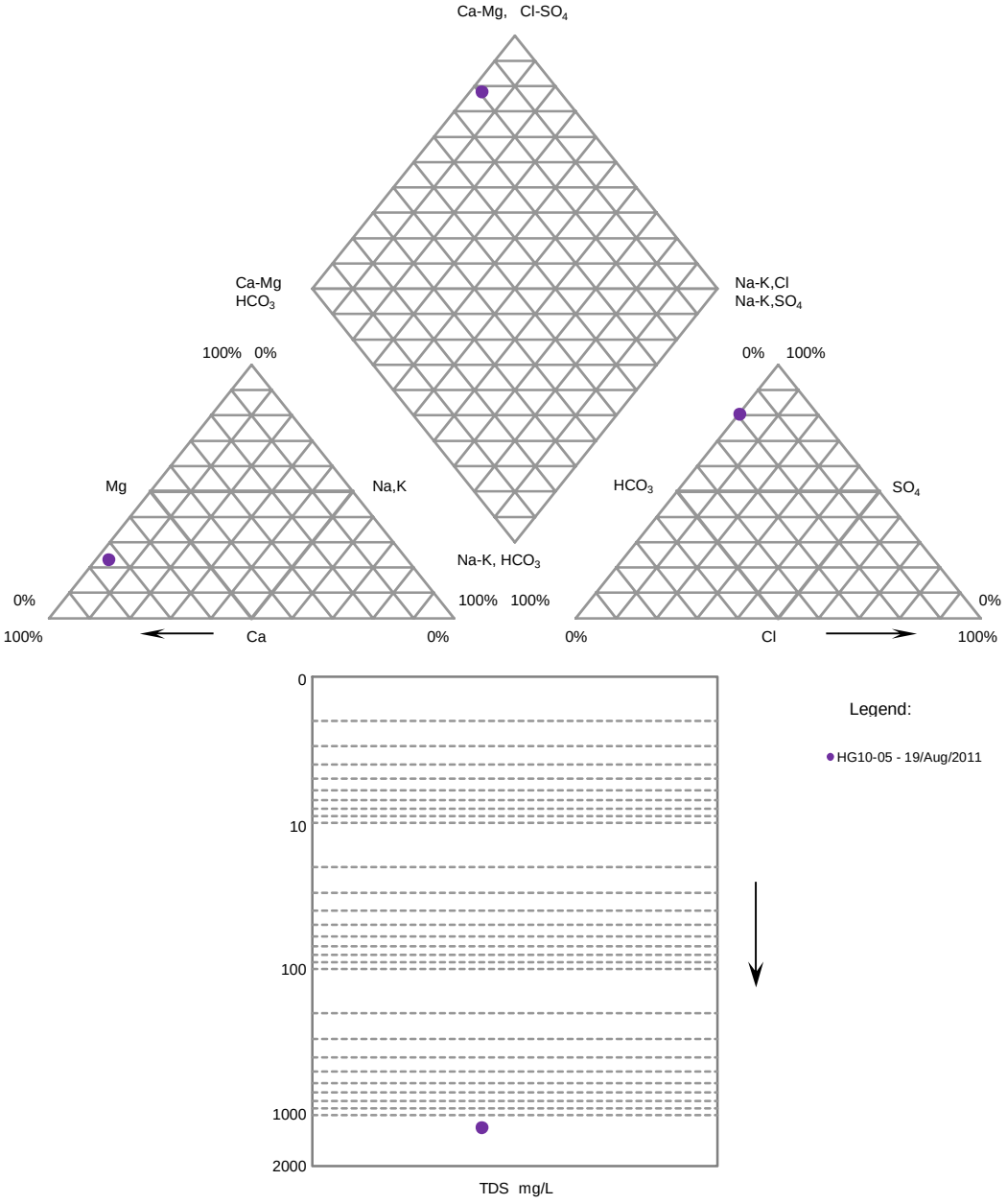
CASINO PROJECT

PIPER PLOT - OPEN PIT AREA
MW13-02D/S

Knight Piésold CONSULTING

P/A NO. VA101-325/17 | REF. NO. 1

FIGURE G2.5 | REV 0



NOTES:

1. PIPER DATA ARE PLOTTED IN %meq/L.
2. DATA USED FOR THESE PLOTS ARE AVERAGE VALUES, BASED ON SAMPLES COLLECTED FROM DECEMBER 2011 TO MAY 2014.
3. VALUES BELOW THE METHOD DETECTION LIMIT (MDL) WERE ASSUMED TO EQUAL HALF THE MDL.

REV	DATE	DESCRIPTION	PREP'D	APP'D
0	06MAR'15	ISSUED WITH REPORT	CJ	JEM

WESTERN COPPER

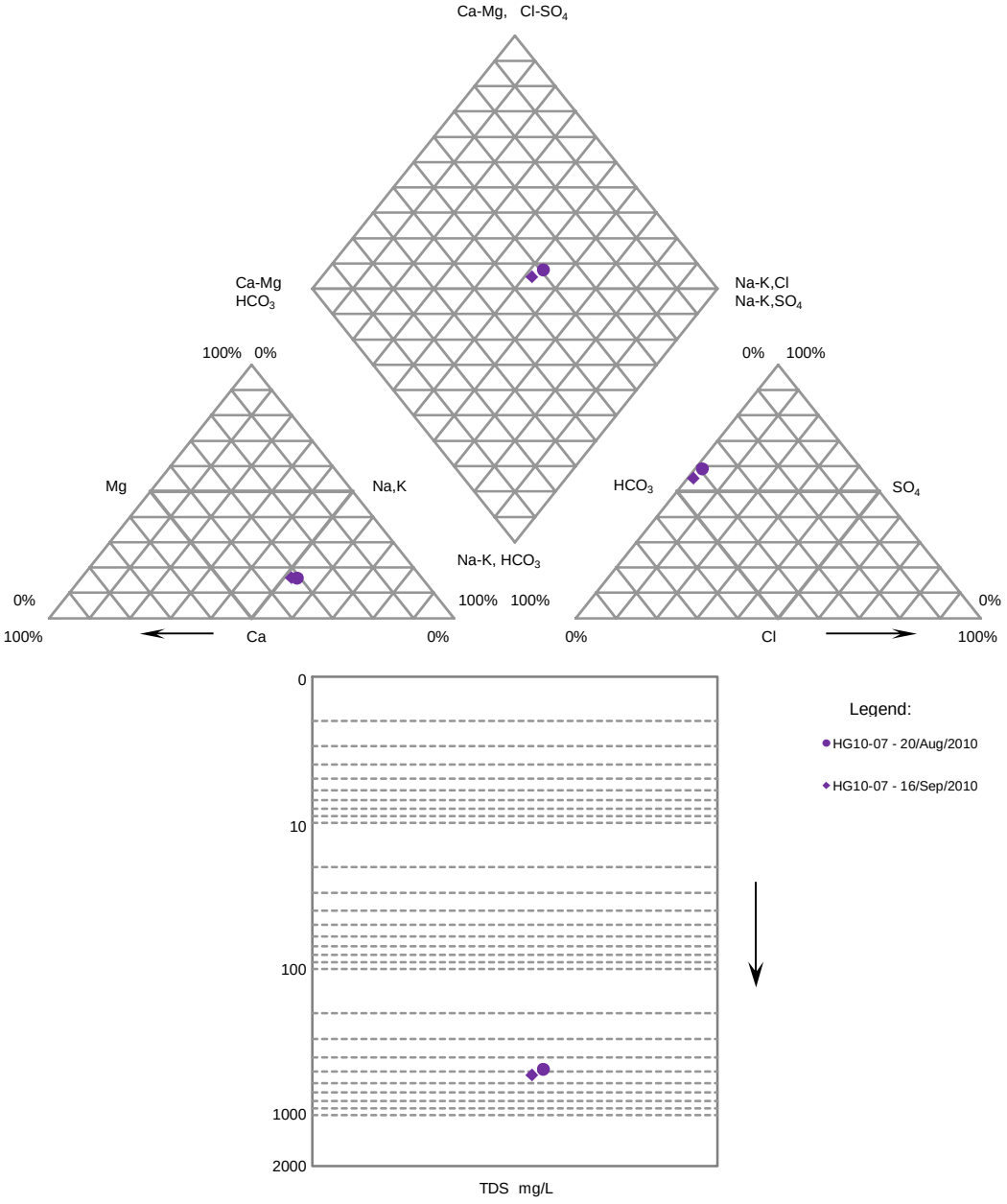
CASINO PROJECT

PIPER PLOT - OPEN PIT AREA
HG10-05

Knight Piésold CONSULTING

P/A NO. VA101-325/17 | REF. NO. 1

FIGURE G2.6 | REV 0



NOTES:

1. PIPER DATA ARE PLOTTED IN %meq/L.
2. DATA USED FOR THESE PLOTS ARE AVERAGE VALUES, BASED ON SAMPLES COLLECTED FROM DECEMBER 2011 TO MAY 2014.
3. VALUES BELOW THE METHOD DETECTION LIMIT (MDL) WERE ASSUMED TO EQUAL HALF THE MDL.

REV	DATE	DESCRIPTION	PREP'D	APP'D
0	06MAR'15	ISSUED WITH REPORT	CJ	JEM

WESTERN COPPER

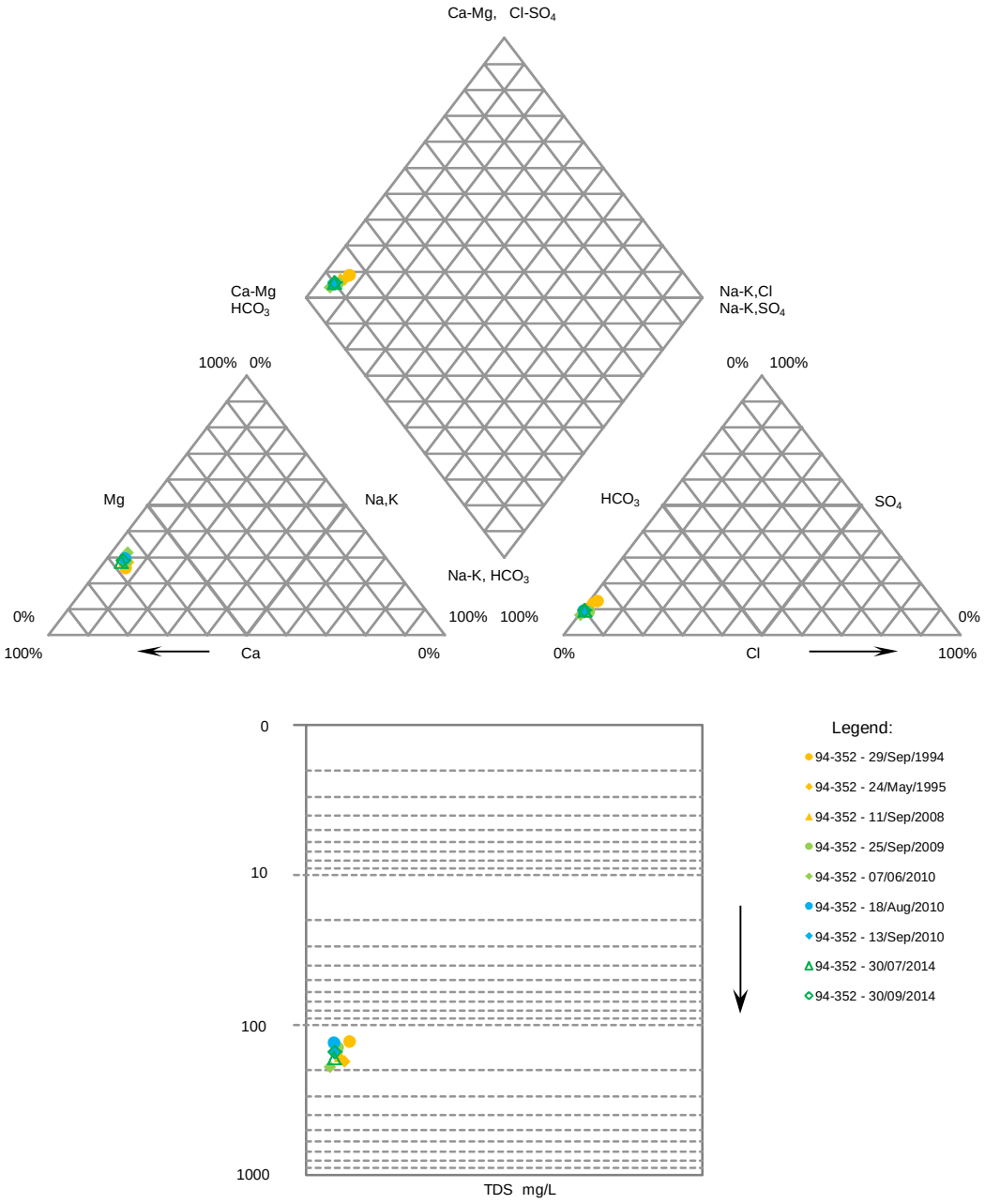
CASINO PROJECT

PIPER PLOT - OPEN PIT AREA
HG10-07

Knight Piésold CONSULTING

P/A NO. VA101-325/17 | REF. NO. 1

FIGURE G2.7 | REV 0



NOTES:

1. PIPER DATA ARE PLOTTED IN %meq/L.
2. VALUES BELOW THE METHOD DETECTION LIMIT (MDL) WERE ASSUMED TO EQUAL HALF THE MDL.

REV	DATE	DESCRIPTION	PREP'D	APP'D
0	06MAR'15	ISSUED WITH REPORT	CJ	JEM

WESTERN COPPER

CASINO PROJECT

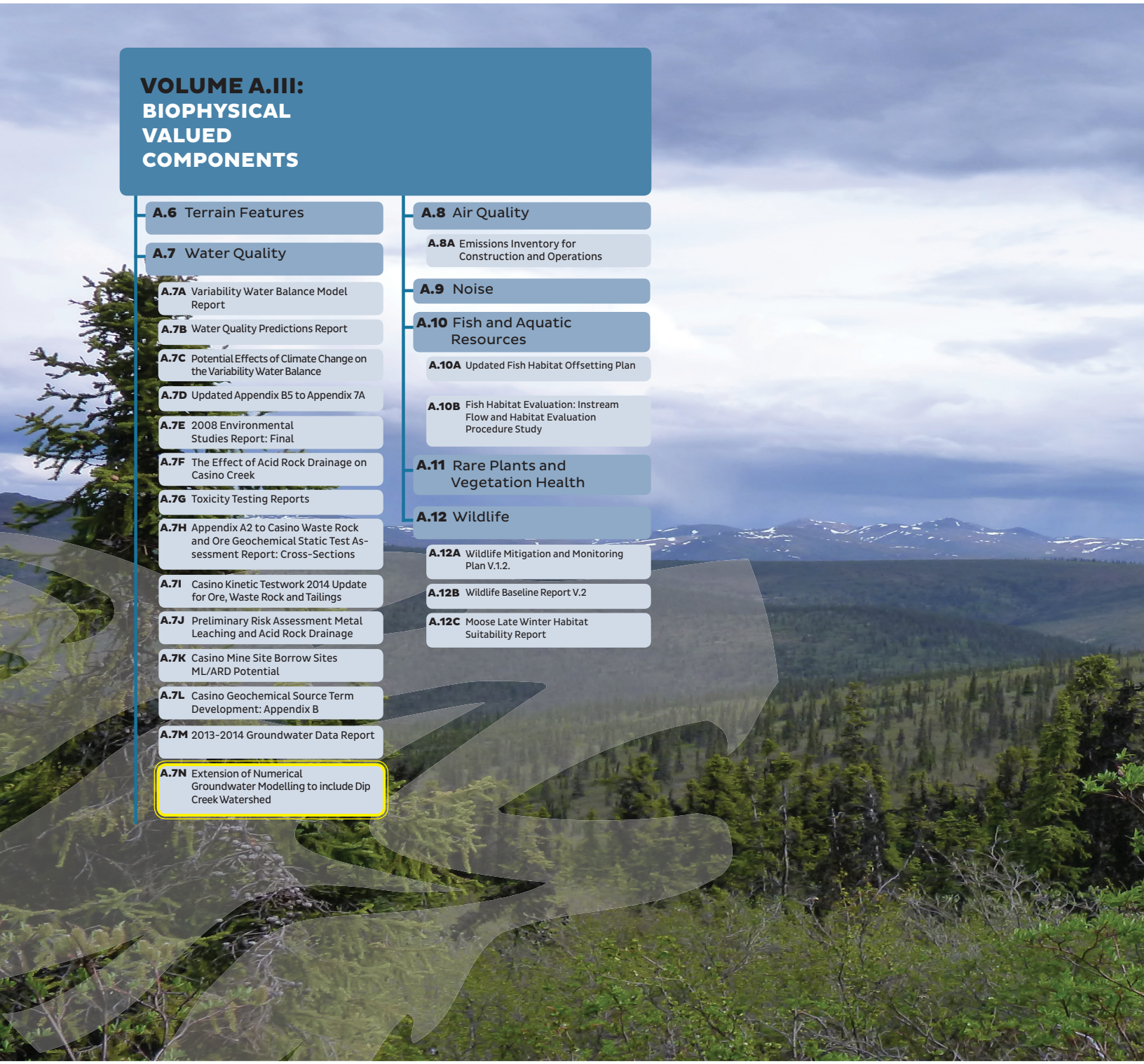
PIPER PLOT - HILLSLOPE AREA
94-352

Knight Piésold CONSULTING

P/A NO. VA101-325/17 | REF. NO. 1

FIGURE G3.1 | REV 0

APPENDIX A.7N: Extension of Numerical Groundwater Modelling to include Dip Creek Watershed



February 20, 2015

File No.:VA101-00325/17
Cont. No.:VA15-01965

Ms. Mary Mioska
Senior Environmental Manager
Casino Mining Corporation
570 Granville Street, Suite 1800
Vancouver, British Columbia
Canada, V6C 3P1

Dear Mary,

Re: Extension of Numerical Groundwater Modelling to Include Dip Creek Watershed, Casino Project

1 – INTRODUCTION

Knight Piésold Ltd. (KP) was contracted in 2013 by Casino Mining Corporation (CMC) to develop a series of numerical groundwater models for the Casino Project (the Project) to assess baseline hydrogeological conditions and to evaluate potential effects of mine development on baseline hydrogeological conditions. Numerical model development and results of the modelling are presented in the Numerical Groundwater Modelling Report (KP 2013a). One of the primary objectives of the study was to delineate potential seepage pathways and estimate seepage flow rates from the proposed Tailings Management Facility (TMF). The area encompassed in the groundwater models included the Casino Creek watershed and the Canadian and Britannia Creek watersheds extending to their point of confluence. The completed models and study findings were submitted as Appendix 7E of the Casino Mine Project proposal to the Yukon Environmental and Socio-economic Assessment Board (YESAB) in January 2014.

Subsequent to submission of the proposal, Natural Resources Canada (NRCan) was invited by YESAB to provide comments on the adequacy of the information contained in the proposal. NRCan's comments were provided to CMC in a letter titled *Adequacy Review – Casino Mine Project (Project No. 2014-0002): NR Can Comments*. Comment 13 d) in NRCan's letter states that,

"The Proponent should provide:

Numerical groundwater flow modelling that extends into the Dip Creek watershed and eliminates the assumption of a no-flow boundary. Modelling should consider the potential for sub-permafrost groundwater flow across the topographic divide. Modelling the seepage from the TMF should consider three dimensional flow from the TMF in order to consider not only vertical flow through or beneath the dam but also horizontal flow around the dam and potentially into Dip Creek tributaries."

To assess the potential for TMF seepage to flow through the watershed divide between Casino and Dip Creek watersheds, the numerical groundwater models presented in KP (2013a) were extended to include a portion of Dip Creek watershed in the modelled domain. A seepage assessment was then completed using the revised models. The modelling work was updated with the following steps:

1. The calibrated Baseline Model was extended to include a portion of the Dip Creek watershed.
2. The goodness-of-fit between simulated and observed hydraulic head and baseflow targets in the revised baseline model was checked. Hydraulic head and baseflow results from the revised baseline model were also compared against the original Baseline Model.
3. A Year 22 Mine Effects model was developed in order to complete the seepage assessment. The Year 22 Mine Effects model was developed by telescopically refining the revised baseline model to a region surrounding the mine site that included the Dip Creek watershed. The Year 22 model was selected for the seepage assessment because it represents the last year of mine operations and is expected to have the

highest TMF Supernatant Pond elevation and tailings elevation. The Supernatant Pond will subsequently be drawn down after Year 22 to build a wetland on top of the TMF.

4. A MODPATH particle trace analysis was completed to assess the potential for TMF seepage to flow through the ridge between Casino and Dip Creek watersheds. The sensitivity of TMF seepage to travel through the ridge to Dip Creek watershed was assessed by varying the hydraulic conductivity value assigned to the upper bedrock unit.

Development of the revised baseline and Year 22 Mine Effects models and seepage assessment results are presented below.

2 – BASELINE NUMERICAL MODEL

2.1 OVERVIEW

The Baseline Model presented in KP (2013a) was extended to include a portion of the Dip Creek Watershed in the model domain. The model grid, parameter values, and boundary conditions assigned to the area of the original Baseline Model remained unchanged in the revised baseline model. Boundary conditions and model parameters assigned to the model area extended into the Dip Creek Watershed are discussed below. The revised model domain is presented on Figure 2.1.

2.2 BASELINE MODEL GEOMETRY AND GRID

The revised baseline model encompasses an area of 224 km^2 with the Casino Project site located at its center as shown on Figure 2.1. The model domain extends north to include the Canadian and Britannia Creek watersheds to their point of confluence. The model domain extends south to include the confluence of Casino Creek with Dip Creek and east to include the eastern portion of the Dip Creek watershed.

The model grid was modified to include an additional two rows at the southern end of the model for a total of 153 rows and 122 columns. These two additional rows were added in order to extend the model domain south to the confluence of Dip and Casino Creeks. Vertical discretization of the revised baseline model remained unchanged from KP (2013a) and included four model layers that increased in thickness with depth. Cell size similarly remained unchanged and was 100 m by 100 m within the mine site and expanded to 200 m by 200 m at the edges of the model. The revised baseline model domain contained a total of a total of 73,932 cells, approximately 45,000 of which were active. The revised baseline model finite-difference grid is shown on Figure 2.1.

2.3 HYDRAULIC CONDUCTIVITY

Hydraulic conductivity zones assigned to bedrock layers in the original model area were extended laterally into the Dip Creek watershed. Alluvial deposits were assigned to the modelled Dip Creek watershed area according to surficial geologic mapping completed for the project (KP 2012). Alluvial deposits were assigned to model layer 1 and were assigned a hydraulic conductivity value of $1x10^{-5}$ m/s to match the alluvial zones in Casino, Canadian and Britannia Creek valleys. Plan and section views of the hydraulic conductivity zones for the revised model are presented on Figure 2.2. Hydraulic conductivity values assigned to the baseline model are presented in Table 3.1 in KP (2013a).

2.4 BOUNDARY CONDITIONS

The following boundary conditions were assigned in the model area extension into Dip Creek watershed:

1. No-flow boundaries along the model perimeter
2. Constant head boundaries to represent stream stage where a stream crossed the model boundary
3. Drain cells to represent creeks, and
4. Meteoric recharge.

Boundary conditions assigned to the revised baseline model domain are shown in Figure 2.1. Each boundary type assigned within the Dip Creek watershed model area is discussed in the subsections that follow. Further detail on boundary conditions assigned to the original baseline model domain is provided in KP (2013a).

2.4.1 No-Flow Boundary Conditions

The eastern boundary of the model was defined as a topographic ridge that separates two tributary sub-catchments to Dip Creek. The ridge was represented as a no-flow boundary based on the assumption that relatively steep topography at the site will cause groundwater divides to be the same as surface water divides, therefore groundwater flow across the ridge is not expected.

2.4.2 Constant Head Boundary Conditions

Constant head boundary conditions were specified along the channel alignment of Dip Creek and define the southeastern perimeter of the model as shown on Figure 2.1. Constant head cells were assigned an elevation equal to 1 meter below the ground surface of a given grid cell.

2.4.3 Drain Boundary Conditions

Drain boundary cells were used to represent five tributaries of Dip Creek within the extended model domain. Drain cells were assigned to stream channels in Layer 1 and drain stages were set as 1 meter below the ground surface of each grid cell. The rate of groundwater flux across a drain is dependent on a streambed conductance coefficient which is often a calibrated model parameter. Since streamflow measurements within the Dip Creek watershed were unavailable to use in calibration, Dip Creek tributaries were assigned conductance coefficients of approximately 10 m^2/day in order to be consistent with calibrated conductance values assigned in the original baseline model.

2.4.4 Meteoric Recharge

Recharge was specified to the extended model domain using the same methodology as the original baseline model domain presented in KP (2013a). Two groundwater recharge zones were defined based on inferred regions of permafrost and non-permafrost as presented in the 2012 Baseline Hydrogeology Report (KP 2013b). Regions of the model surface characterized as permafrost zones were assumed to have zero groundwater recharge. Non-permafrost regions were assigned a recharge rate of 124 mm/yr, which was the recharge value that provided the best fit between simulated and observed hydraulic heads and baseflows during calibration of the original baseline model. The spatial distribution of the two groundwater recharge zones applied to the baseline model is illustrated on Figure 2.3.

2.5 MODEL CALIBRATION

The baseline model was not re-calibrated and all parameter values assigned to the revised baseline model remained the same as values assigned in the original baseline model. Calibration of the extended model domain was not conducted since hydraulic head and baseflow measurements were unavailable to serve as calibration targets within this new area of the model.

The goodness-of-fit fit between simulated and observed hydraulic heads and baseflows at calibration targets was checked following construction of the revised model. Comparison of model simulated and observed hydraulic heads at the 17 calibration target locations in the revised baseline model is provided in Table 2.1. Comparison of simulated and observed baseflows at the six calibration target locations is provided in Table 2.2. Differences in simulated hydraulic heads and baseflows between the original and revised model were negligible and are discussed further in Section 2.6.

2.6 BASELINE MODEL RESULTS

A water table contour map for the revised baseline model is presented in Figure 2.5. The simulated water table generally mimics the surface topography with groundwater elevations ranging from 1,450 masl in the high

elevation region to the west of the mine site to 645 masl and 500 masl at the downstream extents of Casino Creek and Canadian/Britannia Creeks, respectively. Well-defined groundwater flow divides exist between the Casino and Canadian/Britannia Creek watersheds and along the ridgeline between Casino and Dip Creek watersheds where the newly added model domain meets the original model domain. Groundwater elevations along the ridgeline between Casino and Dip Creeks range from approximately 1,225 masl at the upper most extent to approximately 975 masl across from the eastern extent of the TMF Embankment.

Extending the modelled area to include a portion of Dip Creek watershed had a very minor effect on simulated hydraulic heads along the watershed divide between Casino and Canadian/Britannia Creek. Visual comparison between simulated hydraulic heads in the revised and original baseline models indicate that simulated water levels in the revised model along this watershed divide near and east of the deposit decreased slightly (as observed at the 1,150 m contour). Simulated hydraulic heads at calibration targets represented by monitoring wells HG10-04 and 94-337 located in within the proposed Open Pit near the divide decreased slightly from the original model (by approximately 0.1 meters and 0.2 meters, respectively; Table 2.1). Simulated water levels at monitoring well 94-350 and 94-351 locations in the lower reaches of Casino Creek watershed also decreased slightly (by approximately 0.2 meters and 0.7 meters, respectively). Simulated hydraulic heads remained unchanged from the original model at the other 13 calibration targets represented in the model. Simulated baseflow values at the six baseflow targets (hydrology stations) changed negligibly (<1 L/s) from values predicted using the original model in KP (2013a).

The revised baseline model simulates the same baseline groundwater flow system as that presented in KP (2013a). Where present, differences in simulated hydraulic heads and baseflows between the original and revised baseline models are minor. These differences are attributed to the change in boundary condition along the border to Dip Creek watershed as well as minor differences in the spatial distribution of properties that are assigned by importing GIS shapefiles, such as recharge.

3 – MINE EFFECTS (YEAR 22) NUMERICAL MODEL

3.1 OVERVIEW

The Year 22 Mine Effects model from KP (2013a) was updated in order to extend the model domain into the Dip Creek watershed. The model grid, hydraulic properties, boundary conditions, and representation of proposed mine facilities remained unchanged from the values and methodology presented in KP (2013a). Development and results of the Year 22 model are presented in the sections that follow.

3.2 YEAR 22 MINE EFFECTS MODEL DEVELOPMENT

The Year 22 Mine Effects model presented in KP (2013a) was initially developed by telescopically refining, or “cutting out”, a section of the Baseline Model domain centered on the mine site. This approach generates and assigns constant head boundary conditions along the perimeter of the telescopically refined model domain at locations where boundary conditions are not already assigned at perimeter cells. The constant head values are assigned to cells during the telescopic mesh refinement (TMR) based on the piezometric head distribution of the baseline model. This approach allows the Year 22 model to function independently of the regional Baseline Model. The boundary conditions, hydraulic properties and model grid were transferred directly from the regional Baseline Model to the telescopically refined Year 22 model.

The Year 22 Mine Effects model was updated as part of this work by re-generating the telescopically refined mesh using the revised baseline model as the parent model. The northern extent of the Year 22 model was refined during the TMR while the southern extent of the Year 22 model was the same as the revised baseline model. A constant head boundary condition was assigned along the northern model perimeter in all model layers as shown in Figure 3.1. As in the original model, the revised Year 22 model includes four additional layers added to the top of the model (Facilities Layers 1 through 4) to allow for the TMF to be specified in three-

dimensions. The model grid, layering and boundary conditions for the revised Year 22 model are presented in Figure 3.1.

Representation of major mine facilities in the revised Year 22 model was identical to the original Year 22 model presented in KP (2013a).

3.3 YEAR 22 MINE EFFECTS MODEL RESULTS

A simulated water table contour map from the revised Year 22 model is provided on Figure 3.2. Comparison of predicted water table contours in the Year 22 and baseline model indicate that groundwater elevations surrounding the TMF Supernatant Pond are predicted to increase adjacent to the TMF as supernatant water elevation in the TMF increases. Model results indicate the presence of a groundwater divide along the ridgeline separating Casino and Dip Creek watersheds. Groundwater to the northwest of the divide is expected to flow to the TMF or Casino Creek watersheds while groundwater to the southeast is expected to flow towards Dip Creek.

4 – TMF MODPATH SEEPAGE ASSESSMENT

4.1 MODPATH SEEPAGE ASSESSMENT

MODPATH particle tracking (Pollok 1994) was completed using the revised Year 22 model to delineate potential seepage pathways from the TMF. The main objective of the MODPATH simulation was to assess the potential for TMF seepage to travel through the ridgeline separating Casino and Dip Creek watersheds to the southeast of the TMF Embankment.

MODPATH particles were placed in all cells in the TMF Supernatant Pond and tailings beach (Facilities Layers 1 through 4) and particles were tracked forward indefinitely through the groundwater flow system to determine their discharge locations. MODPATH results are sensitive to specification of the “sink strength” input parameter, which defines the termination criterion for particle traces flowing through boundary cells. All MODPATH scenarios presented herein adopt a “stop at 50 percent strength” weak sink option to discontinue particle traces in boundary cells, meaning that the particle trace stops if the boundary condition removes 50 percent or more of the water in the cell. Conceptually this means that the model terminates a particle trace in a cell if >50% of the water in the cell is removed.

The MODPATH analysis using the revised baseline model indicates that seepage from the TMF is not expected to flow southeast through the ridgeline divide into the Dip Creek watershed. As in the original Year 22 model, the majority of seepage from the TMF is expected to flow southwest through the TMF Main Embankment or underlying foundation materials to discharge to the embankment drains or up-gradient of the TMF seepage collection pond. A small amount of unrecoverable seepage, approximately 7% of particle traces, is expected to discharge to Brynelson Creek and report to Casino Creek down-gradient of the seepage collection pond. The particle traces resulting from the TMF MODPATH simulation are presented in Figure 4.1.

4.2 SEEPAGE SENSITIVITY ANALYSIS

The sensitivity of simulated TMF seepage pathways to hydraulic conductivity was assessed by systematically varying the hydraulic conductivity value assigned to the weathered bedrock in Layers 1 through 5. For each sensitivity simulation, MODFLOW and MODPATH were re-run to generate a new set of particle traces defining predicted seepage pathways from the TMF. A predicted rate of seepage was calculated using the following steps for sensitivity scenarios with particle traces that travelled from the TMF to the Dip Creek watershed:

- A hydrostratigraphic unit (HSU) was defined in the TMF model area in Layers 1 through 4 outlining particle traces that were predicted to originate in the TMF and discharge to the Dip Creek watershed.
- The predicted rate of seepage to Dip Creek watershed was calculated using a water budget approach with the defined HSUs.
- The total foundation seepage rate for each sensitivity case was quantified using the HSUs defined in the original Year 22 model (KP 2013a) representing Non-PAG tailings, PAG tailings and waste rock in the TMF.

Results of the sensitivity analysis are presented on Figure 5.1. TMF seepage was not predicted to travel to Dip Creek watershed when the weathered bedrock was assigned a hydraulic conductivity value of $1x10^{-6}$ m/s or less. For hydraulic conductivity values greater than $1x10^{-6}$ m/s, simulated seepage rates to Dip Creek increased according to the trend shown on Figure 5.1. A hydraulic conductivity value of $2x10^{-6}$ m/s assigned to the weathered bedrock resulted in a seepage rate to Dip Creek watershed of less than 0.1 L/s or less than 0.1% of the total foundation seepage (52 L/s). Sensitivity simulations with the hydraulic conductivity value increased to $5x10^{-6}$ m/s and 1 $x10^{-5}$ m/s resulted in seepage rates to Dip Creek of 3.8 L/s and 12.1 L/s, respectively.

5 – CONCLUSIONS AND RECOMMENDATIONS

The Baseline and Year 22 groundwater models presented in KP (2013a) were revised to include a portion of the Dip Creek watershed within the active model domain. The objective of the model expansion was to assess the potential for seepage from the TMF through the ridge separating Casino and Dip Creeks to the southeast of the facility. MODPATH simulations completed for the TMF indicate that seepage is not expected to flow through the ridgeline divide into the Dip Creek watershed using the base case model.

The model parameters assigned to the Dip Creek watershed were not calibrated and assume that average hydrogeologic properties within this area are similar to those within the calibrated portion of the model. Based on results of the sensitivity assessment, seepage may travel to Dip Creek watershed if the bulk hydraulic conductivity of the weathered bedrock is higher than $1x10^{-6}$ m/s. This bulk hydraulic conductivity value is an order of magnitude higher than the calibrated hydraulic conductivity of the weathered bedrock unit in the base case baseline model. Available site data suggests that a hydraulic conductivity greater than $1x10^{-6}$ m/s is possible within localized zones across the Project but is considered high as a bulk hydraulic conductivity value. Based on bedrock geology mapping, geology in the ridge east of the proposed TMF Embankment consists of granodiorite (Ryan et al. 2013). Approximately 12% of the available 187 hydraulic conductivity tests conducted in the granodiorite unit across the site reported a hydraulic conductivity value of $2x10^{-6}$ m/s or higher (KP 2013b). The simulated water table depth within the east ridge was approximately 75 meters below ground surface (mbgs) using a hydraulic conductivity of $1x10^{-7}$ m/s. Water level data is not available along the ridge to compare against this estimated depth, but available baseline water levels from monitoring wells installed in 2013 along mid- to upper-slopes of the east side of the TMF valley (MW13-05 and MW13-06D/S) are approximately 30 to 40 mbgs. The simulated depth to water using the revised baseline model is approximately the same at MW13-05 and two times deeper than the measured water table at MW13-06D/S.

Please do not hesitate to contact the undersigned with any questions or comments.

Yours truly,
KNIGHT PIESOLD LTD.

PROFESSIONAL ENGINEER
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Approval that this document adheres to Knight Piésold Quality Systems: DJG

Attachments:

Table 2.1 Rev 0	Baseline Groundwater Model - Observed and Simulated Hydraulic Heads
Table 2.2 Rev 0	Baseline Groundwater Model - Baseflow Calibration Targets and Results
Figure 2.1 Rev 0	Baseline Groundwater Model - Numerical Grid, Model Layers and Boundary Conditions
Figure 2.2 Rev 0	Baseline Groundwater Model - Hydraulic Conductivity Zones
Figure 2.3 Rev 0	Baseline Groundwater Model - Groundwater Recharge Zones
Figure 2.4 Rev 0	Baseline Groundwater Model - Simulated Water Table Contour Map
Figure 3.1 Rev 0	Year 22 Mine Effects Model - Numerical Grid and Boundary Conditions
Figure 3.2 Rev 0	Year 22 Mine Effects Model - Simulated Water Table Contour Map
Figure 4.1 Rev 0	Year 22 Mine Effects Model - TMF MODPATH Forward Particle Trace Analysis
Figure 5.1 Rev 0	Simulated TMF Seepage to Dip Creek vs. Weathered Bedrock Hydraulic Conductivity

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Knight Piésold Ltd. (KP), 2013a. Casino Project. Numerical Groundwater Modelling Report (Ref. No. VA101-325/14-6 Rev1).

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Ryan, J.J., Zagorevski, A., Williams, S.P., Roots, C., Ciolkiewicz, W., Hayward, N., and Chapman, J.B., 2013. Geology, Stevenson Ridge (northeast part), Yukon; Geological Survey of Canada, Canadian Geoscience Map 116 (2nd edition, preliminary), scale 1:100 000.

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TABLE 2.1

CASINO MINING CORPORATION
CASINO PROJECT

BASELINE GROUNDWATER MODEL
OBSERVED AND SIMULATED HYDRAULIC HEADS

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Well I.D.	Measured Groundwater Elevation (masl)	Simulated Groundwater Elevation (masl)	Residual Head (m)
HG10-01	1,177	1,168	8.4
HG10-02	1,169	1,168	1.6
HG10-04	1,135	1,131	4.1
HG10-07	1,212	1,204	8.3
94-337	1,129	1,144	-14.2
94-342	939	946	-6.7
94-345	756	757	-1.0
94-346	756	756	0.0
94-347	753	753	0.4
94-348	731	736	-5.3
94-350	698	705	-6.8
94-351	715	712	2.3
94-352	1,185	1,176	8.7
94-353	1,197	1,195	2.7
94-354	1,078	1,075	2.9
MW11-01B	1,089	1,083	5.4
MW11-02A	1,088	1,085	3.3

MAE (m)	**4.8**
RMSE (m)	**6.0**
NRMSE	**1%**

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NOTES:

1. THE VALUES LISTED AS MEASURED GROUNDWATER ELEVATIONS ARE AVERAGE ELEVATIONS OVER THE AVAILABLE PERIOD OF MEASURED DATA.
2. MAE = MEAN ABSOLUTE ERROR.
3. RMSE = ROOT MEAN SQUARE ERROR.
4. NRMSE = NORMALIZED ROOT MEAN SQUARE ERROR.

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TABLE 2.2

CASINO MINING CORPORATION
CASINO PROJECT

BASELINE GROUNDWATER MODELLING
BASEFLOW CALIBRATION TARGETS AND RESULTS

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Hydrometric Station	Average Annual Baseflow from Watershed Model (l/s)	Average Annual Modflow Simulated Baseflow (l/s)	Residual Baseflow (l/s)	Relative Percent Difference (%)
Upper Casino Creek (W11)	66	64	-1	-2.0
Middle Casino Creek (H18)	105	111	7	6.1
Lower Casino Creek (W4)	144	143	-1	-0.6
Brynelsen Creek (W18)	39	42	3	6.8
Britannia Creek (W14)	71	74	3	4.0
Canadian Creek (W3)	104	102	-3	-2.5

MAE (L/s)	**2.8**
RMSE (L/s)	**3.4**
NRMSE	**3%**

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NOTES:

1. AVERAGE ANNUAL BASEFLOW VALUES ARE THE RESULT OF WATERSHED MODELLING CONDUCTED FOR THE PROJECT BY KPL (2013C).
2. MAE = MEAN ABSOLUTE ERROR
3. RMSE= ROOT MEAN SQUARE ERROR
4. NRMSE = NORMALIZED ROOT MEAN SQUARE ERROR

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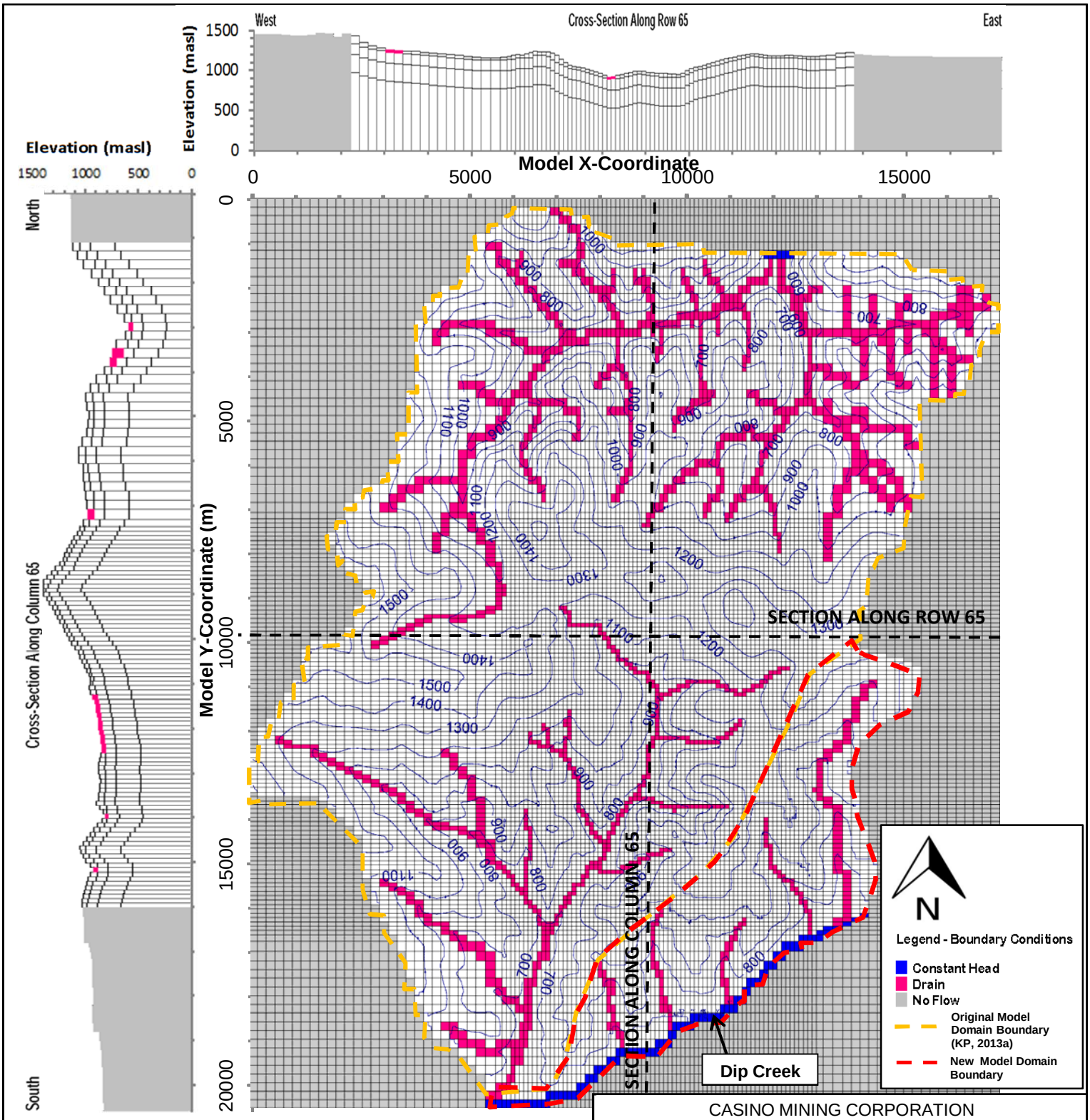

NOTES:

1. THE PLAN VIEW FIGURE SHOWS THE BOUNDARY CONDITIONS FOR LAYER 1 OF THE BASELINE MODEL.

2. THE CONTOURS SHOWN ABOVE ARE OF APPROXIMATE GROUND SURFACE ELEVATION IN MODEL LAYER 1.

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CASINO PROJECT

BASELINE GROUNDWATER MODEL NUMERICAL GRID, MODEL LAYERS AND BOUNDARY CONDITIONS

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P/A NO. VA101-325/17

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FIGURE 2.1

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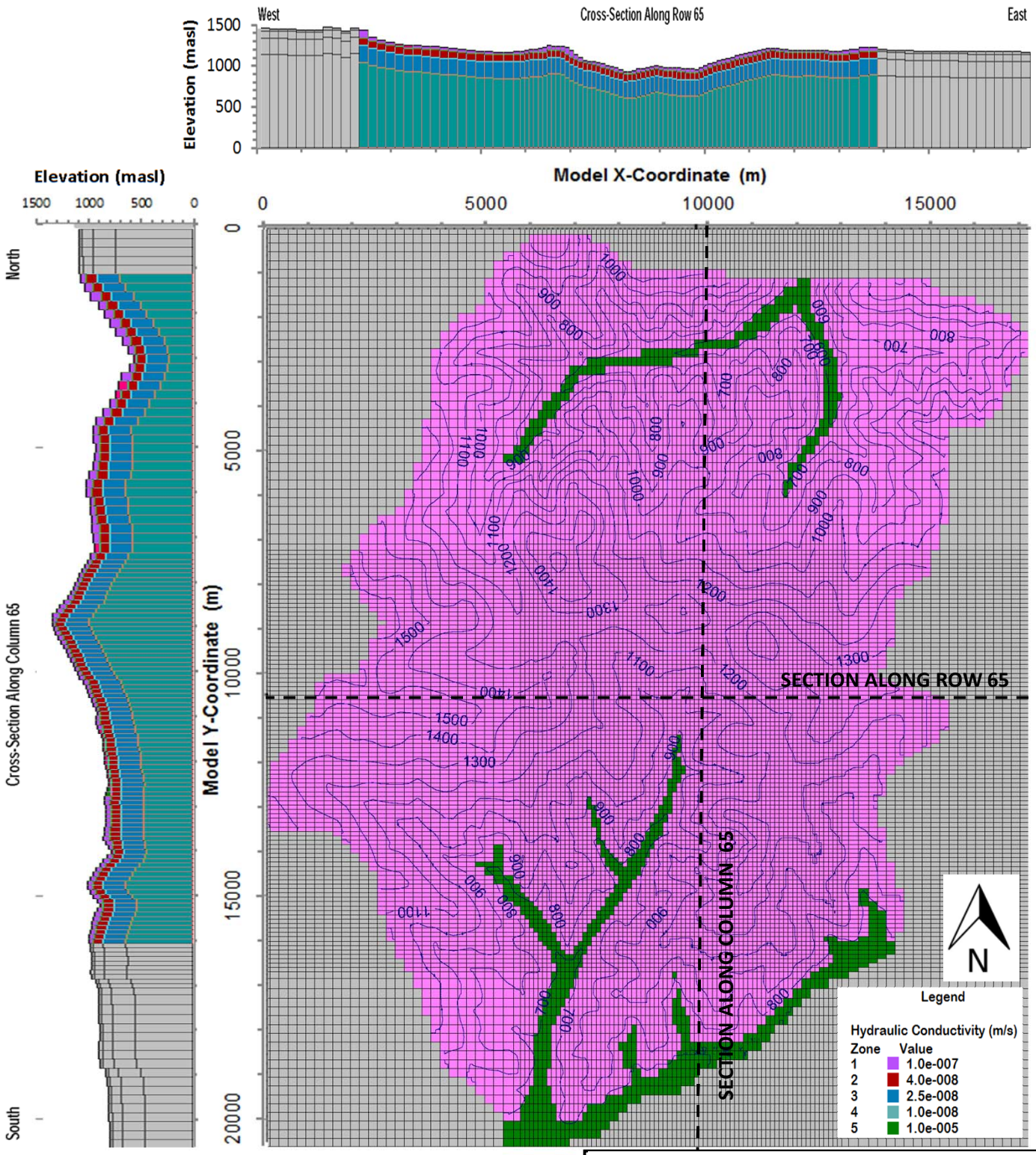

NOTES:

1. THE PLAN VIEW FIGURE DISPLAYS THE HYDRAULIC CONDUCTIVITY ZONES ASSIGNED TO MODEL LAYER 1. THE SECTION VIEWS DISPLAY THE HYDRAULIC CONDUCTIVITY ZONES IN MODEL LAYERS 1 THROUGH 4.

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CASINO PROJECT

BASELINE GROUNDWATER MODEL
HYDRAULIC CONDUCTIVITY ZONES

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FIGURE 2.2

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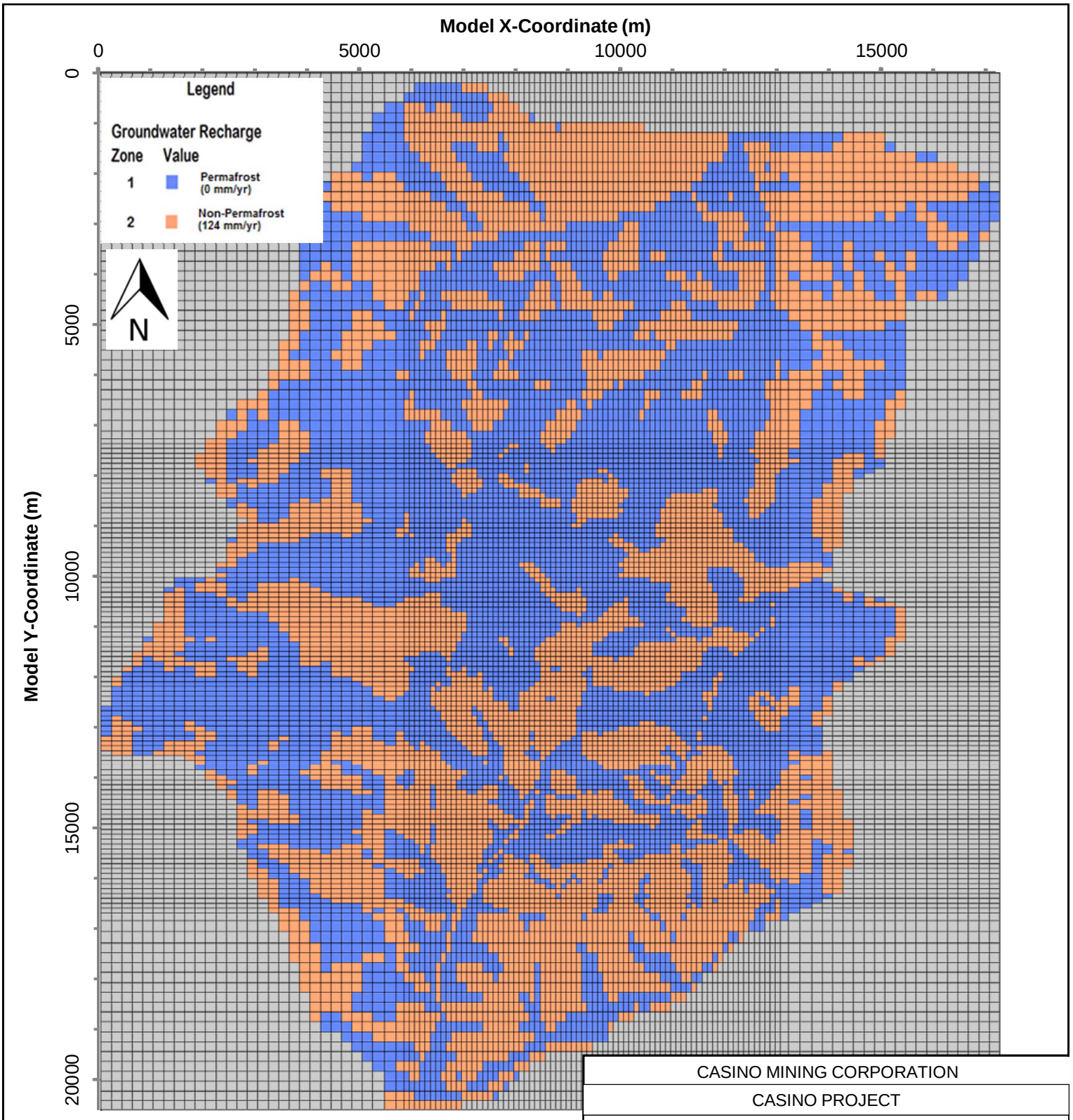

NOTES:

1. THE DISTRIBUTION OF PERMAFROST AND NON-PERMAFROST ZONES IS BASED ON KP (2012) AND PRESENTED IN KP (2013B).

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CASINO PROJECT

BASELINE GROUNDWATER MODEL
GROUNDWATER RECHARGE ZONES

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FIGURE 2.3

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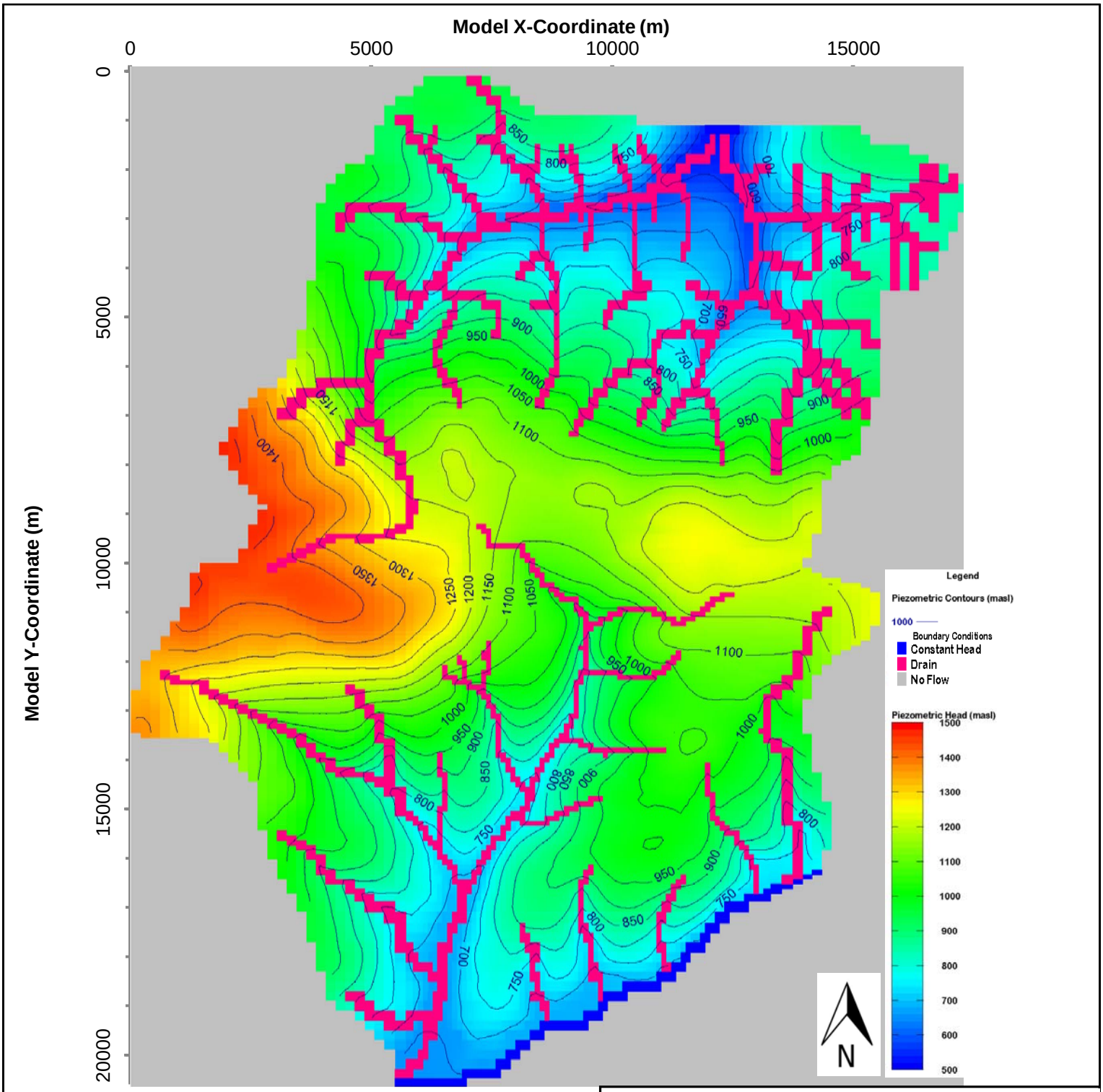

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CASINO PROJECT

BASELINE GROUNDWATER MODEL
SIMULATED WATER TABLE CONTOUR MAP

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CONT. NO. VA15-01965

FIGURE 2.4

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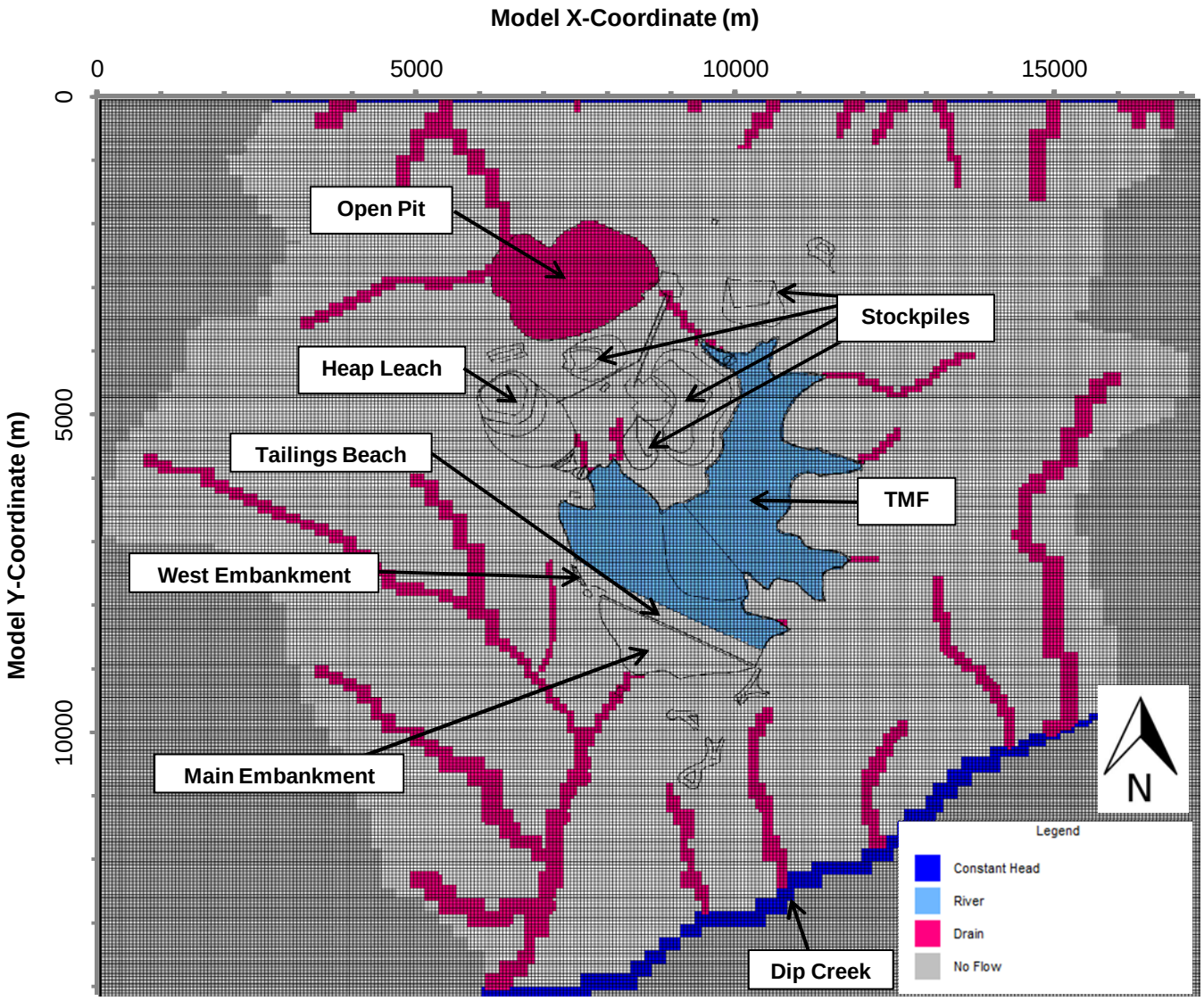

NOTES:

1. THE PLAN VIEW FIGURE SHOWS THE BOUNDARY CONDITIONS FOR LAYER 1 OF THE YEAR 22 MODEL.
2. THE MINE FACILITIES SHOWN ABOVE ARE FOR YEAR 22 OF THE CASINO PROJECT.

CASINO MINING CORPORATION

CASINO PROJECT

YEAR 22 MINE EFFECTS MODEL
NUMERICAL GRID AND BOUNDARY CONDITIONS

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P/A NO. VA101-325/17

CONT. NO. VA15-01965

FIGURE 3.1

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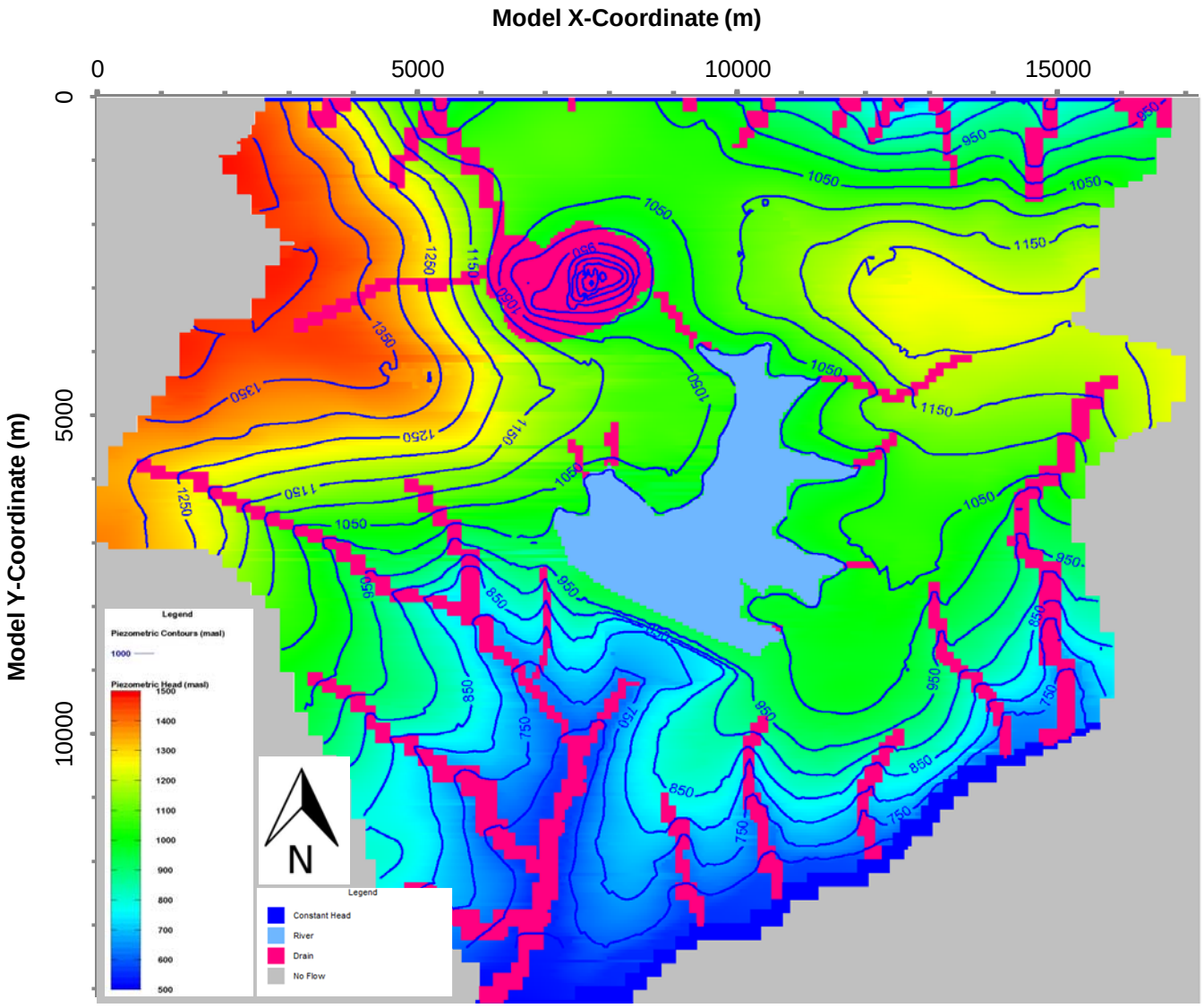

NOTES:

1. THE CONTOURS SHOWN ABOVE ARE OF SIMULATED WATER TABLE ELEVATION (masl)

2. THE MINE FACILITIES SHOWN ABOVE ARE FOR YEAR 22 OF THE CASINO PROJECT.

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CASINO PROJECT

YEAR 22 MINE EFFECTS MODEL
SIMULATED WATER TABLE CONTOUR MAP

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FIGURE 3.2 | REV 0

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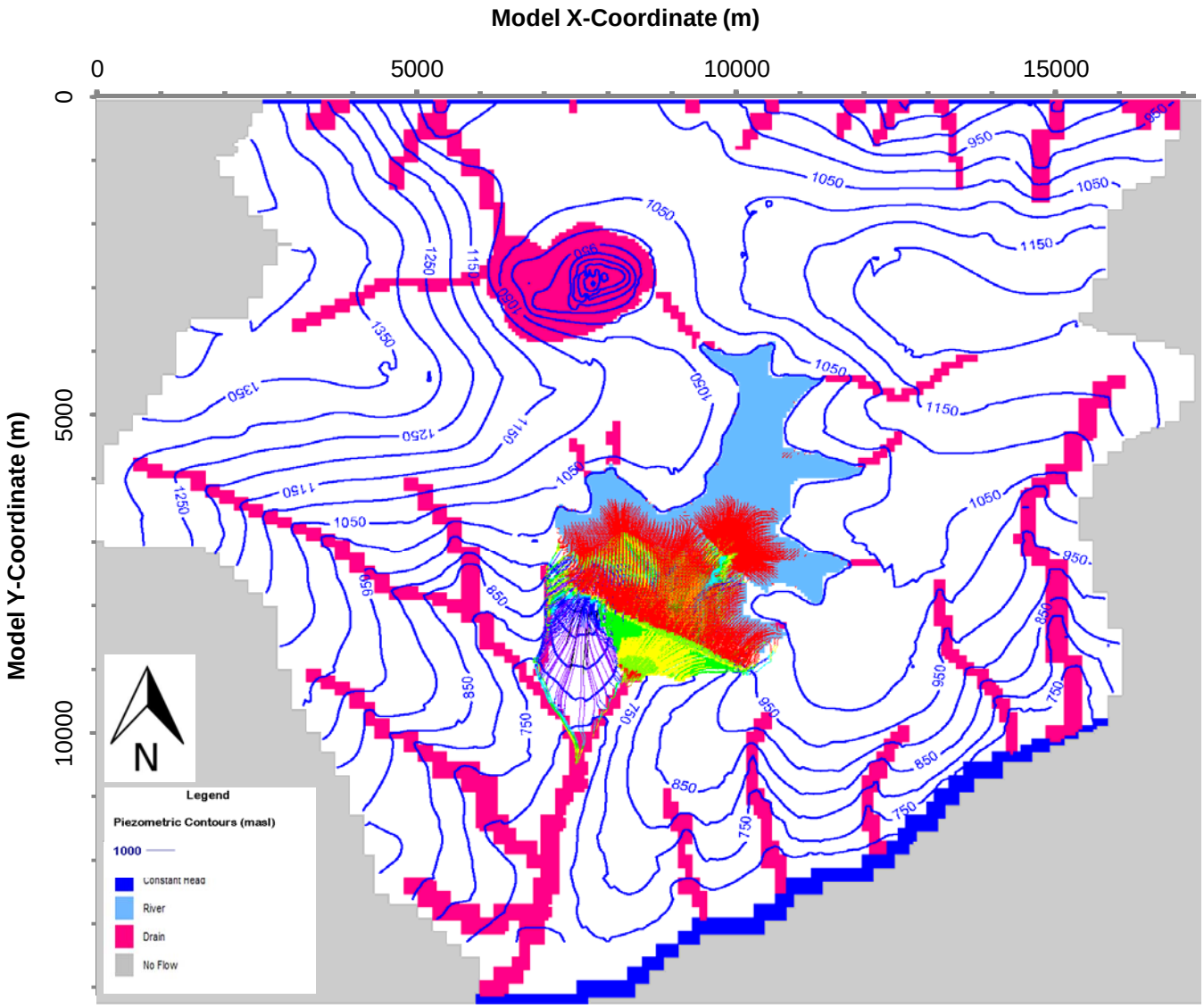

Trace Color	Layer
	Layer 1
	Layer 2
	Layer 3
	Layer 4
	Layer 5
	Layer 6
	Layer 7
	Layer 8

NOTES:

1. THE CONTOURS SHOWN ABOVE ARE OF SIMULATED GROUNDWATER TABLE ELEVATION (masl)

2. THE PARTICLE TRACES SHOWN ABOVE ARE COLOR CODED BY THE MODEL LAYER THEY ARE TRAVELLING IN.

CASINO MINING CORPORATION

CASINO PROJECT

YEAR 22 MINE EFFECTS MODEL
TMF MODPATH FORWARD PARTICLE TRACE ANALYSIS

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FIGURE 4.1

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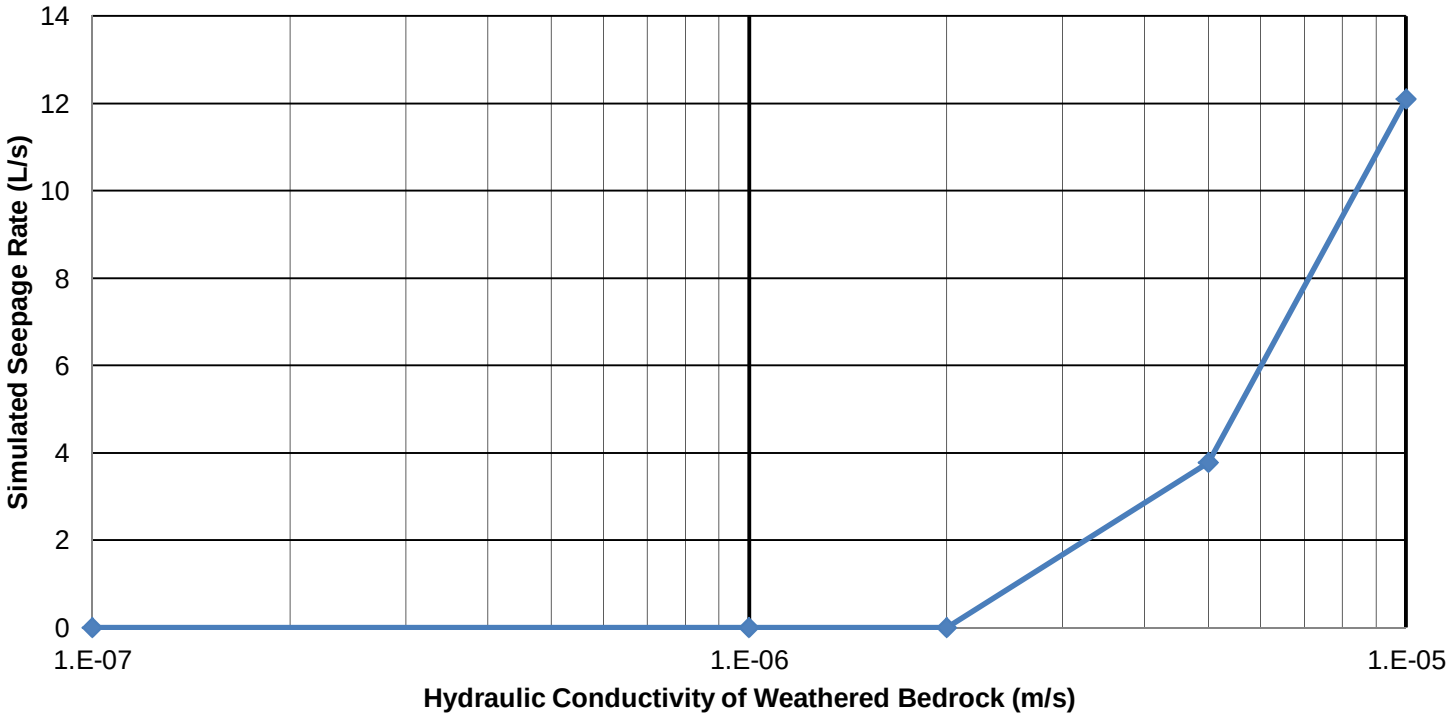
Sensitivity Analysis Results
Simulated TMF Seepage to Dip Creek Watershed

Case	Weathered Bedrok K-Value (m/s)	Simulated Seepage Rate to Dip Creek (L/s)	Simulated Seepage Rate through TMF Foundation (L/s)	Percentage of Seepage Reporting to Dip Creek
Base Case	1.E-07	0.0	16	0.0%
Case 1	1.E-06	0.0	35	0.0%
Case 2	2.E-06	0.0	52	0.0%
Case 3	5.E-06	3.8	94	4.0%
Case 4	1.E-05	12.1	150	8.0%



NOTES:

1. THE WEATHERED BEDROCK HYDRAULIC CONDUCTIVITY ZONE REPRESENTS WEATHERED BEDROCK UNITS IN MODEL LAYERS 1 THROUGH 5.

2. PRESENTED TMF SEEPAGE VALUES INCLUDE SEEPAGE THROUGH TMF FOUNDATION MATERIALS ONLY AND NOT THE EMBANKMENT.

CASINO MINING CORPORATION

CASINO PROJECT

SENSITIVITY ANALYSIS RESULTS
SIMULATED TMF SEEPAGE TO DIP CREEK
VS. WEATHERED BEDROCK HYDRAULIC CONDUCTIVITY

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CONT. NO. VA15-01965

FIGURE 5.1

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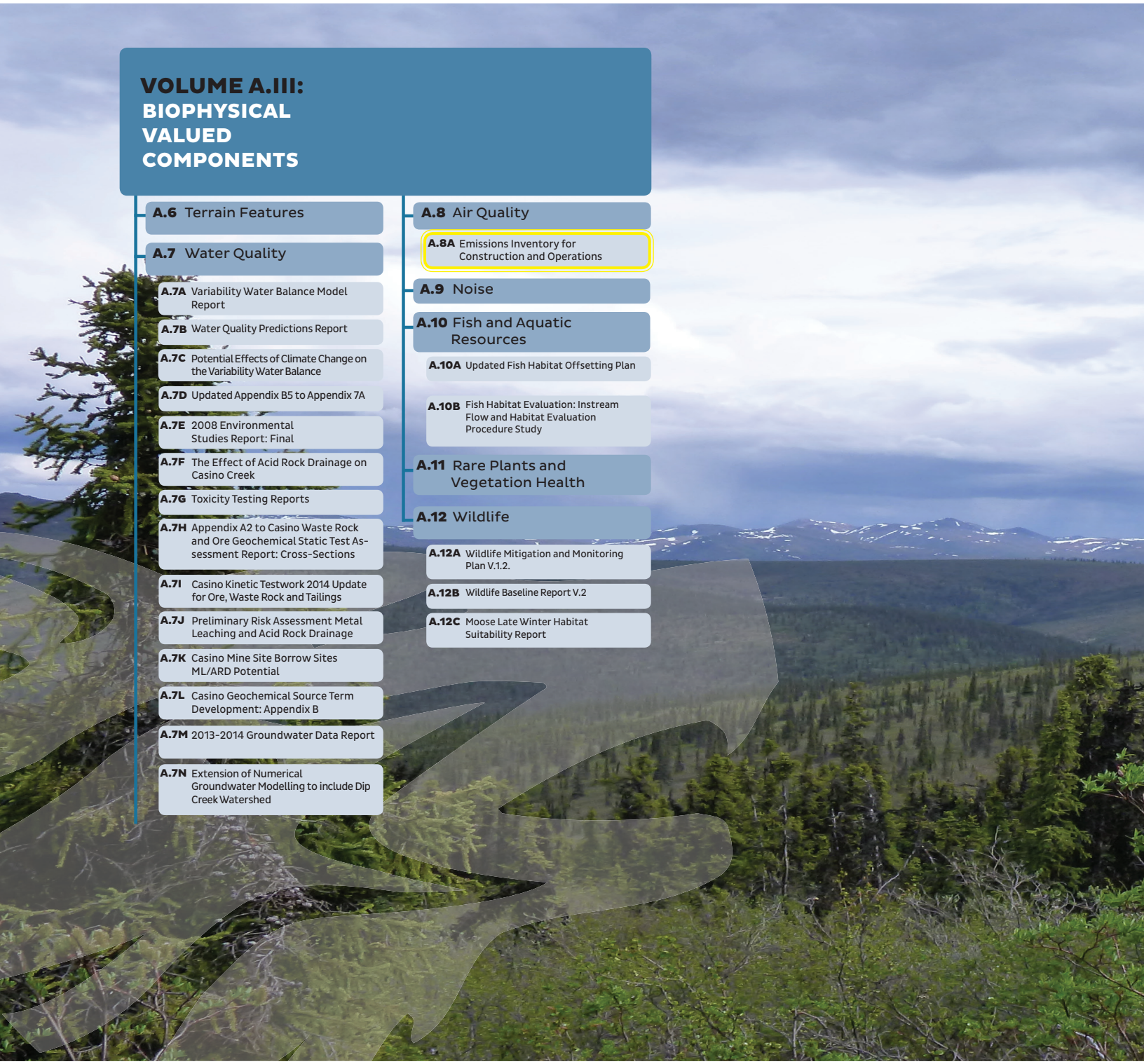
APPENDIX A.8A: Emissions Inventory for Construction and Operations



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A.8A EMISSIONS INVENTORY FOR CONSTRUCTION AND OPERATIONS

A.8A.1 CONSTRUCTION PHASE AIR EMISSIONS INVENTORY

The Casino project air emissions inventory was compiled from the feasibility study (M3 2013) and preliminary engineering design information provided in the Proposal for the Casino Project submitted by Casino Mining Corporation on January 3, 2014 to YESAB. The essential information was obtained from the following sections of the feasibility study:

- Mine production schedule;
- Mine major equipment fleet requirements;
- Project Schedule section 24.1.12; and
- Project Infrastructure Layouts.

Emissions of criteria air contaminants (CACs) associated with the construction were estimated for various types of combustion sources, including off road construction equipment (drills, dozers and graders, etc.), earth moving equipment (haul trucks, loaders and cranes, etc.), power generators, and motor vehicles. Air emissions of particulate matter were estimated for activities such as blasting, truck loading and unloading, drilling, processing, and hauling within the mine pit and along the Project haul roads, airport access road, explosive storage road and main access road. These emissions are named as fugitive emissions because they do not disperse into air from a specific point/area.

The emissions estimations were calculated by using emission factors which were developed by several regulatory agencies such as Environment Canada's Pits and Quarries Guidance (NPRI 2009), United States Environmental Protection Agency AP-42 (US EPA 1995), and Australian Mining Emission Estimation Technique Manuals (NPI 2008, NPI 2012). These emission factors are useful when there is no actual data collected such as stack measurements or manufacturer specifications and are therefore ideal for proposed industrial developments to estimate anticipated air emissions that could occur during the life time of the projects.

The temporary nature of construction differentiates it from operation phase emission sources because construction consists of a series of different operations, each with its own duration and potential for air emissions. Construction activities are expected to have a definable beginning and end and emissions are considerably variable over the different phases of the construction process. This is in contrast to the operations phase, where emissions are either relatively steady or follow a daily/hourly cycle.

Construction of the proposed mine is anticipated to be completed within 3 years and activity is expected to reach its maximum level during Project year -1 because the material movement and equipment use will be higher compared to other construction years. Earth moving and equipment use are considerably lower during construction years -2 and -3. Since a conceptual construction plan is not available, the air emissions were estimated by using an annual material movement summary and off road equipment requirements assuming that all activities would occur regularly within the proposed schedule and be relative to the amount of material movement. Direct mill feed is relatively low during year -1 therefore the majority of particulate matter emissions originated from unpaved roads. Top soil stockpiles were considered not vegetated during this period and are therefore considered sources of fugitive emissions during strong winds.

Table A.8A.1–1 summarizes the Project's mined material flow summary which was derived from the feasibility study.

Table A.8A.1-1 Construction Phase (year -1) Annual Material Movement

Mine Facility	Year - 1 (tonnes/year)	Truck Trips	One way Distance (km)	Annual Travel Distance (km)
To Waste Storage Area	5,262,000	14,496	9.648	279,712
Overburden	1,206,000	3,322		
Leach Cap	3,960,000	10,909		
Supergene Oxide And Unclassified	96,000	264		
To Supergene Oxide - Stockpile	9,950,000	27,410	4.105	225,040
To Gold Ore Stockpile	21,654,000	59,653	2.441	291,225
To Direct Mill Feed	4,510,000	12,424	3.550	88,220
Total Materials Moved	41,376,000	113,983		

Note: Leach Cap will be used for Embankment construction therefore included in road to Waste Storage Area

Open pit activities during construction are similar to those during the operations phase, and are based on blasting, drilling, loading and hauling activities. The blasting is assumed to take place once a day and ANFO will be used for explosive detonation. Table A.8A.1–2 summarizes the air emissions estimated for open pit activities and corresponding emission factors.

Table A.8A.1-2 Open Pit Particulate Matter Emissions during Construction

Mine Activity	Emission Factor	Units	Total Emissions (tonnes per blast)	Total Emissions (tonnes/year)
Blasting (AP-42 Table 11.9-2)				
Total Particulate Matter (TPM)	$= 0.00022 * Area^{1.5}$	kg/blast	0.22	80.3
PM_{10}	0.52 x TPM		0.1144	41.756
$PM_{2.5}$	0.03 x TPM		0.0066	2.409
# of blasts per day	1 per days, 7 per week			
Estimated area impacted per blast (m^2)	10,000	m^2		
Drilling (SCC 3-05-020-10)				
Total Particulate Matter (TPM)	8.46619×10^{-05}	(kg/Mg)		3.503
PM10	4.00428×10^{-05}	(kg/Mg)		1.657
PM2.5	6.06362×10^{-06}	(kg/Mg)		0.251
Haul Truck Loading(SCC 3-05-020-31)				
Total Particulate Matter (TPM)	0.000105714	(kg/Mg)		4.374
PM10	0.00005	(kg/Mg)		2.069
PM2.5	7.57143×10^{-06}	(kg/Mg)		0.313

Processing activities will start during year -1 with the commissioning of the sulphide ore flotation mill. Table A.8A.1–3 and Table A.8A.1–4 summarize the particulate matter emission estimates at these facilities.

Table A.8A.1-3 Particulate Emissions from the Primary Crusher Unit

Parameter	Reference	Emission Factor (kg/Mg)			Total Emissions Crusher 1 (tonnes/year)		
		Total Particulate Matter (TPM)	PM_{10}	$PM_{2.5}$	Total Particulate Matter (TPM)	PM_{10}	$PM_{2.5}$
Crusher*	SCC 3-03-024-01	0.2	0.02	0.02	90.20	9.02	9.02
Truck Unloading at Crusher Unit*	SCC 3-05-020-31	$2x10^{-05}$	$8 x10^{-06}$	$1 x10^{-06}$	0.008	0.004	0.001

*Mitigation Efficiency = 90%

Environment Canada Pits and Quarries Guidance, Crusher Emission Control Techniques, Enclosed Building Mitigation Efficiency

PM2.5 emission factor is not available therefore assumed to be same as PM10 as conservative approach, Project ore/waste considered as low-moisture because it is less than 4%

TPM and PM2.5 emission factors are not available for unloading therefore they were calculated by AP-42 general aerodynamic size distribution factors using PM10 EF.

Table A.8A.1-4 Oxide Ore Processing Facility Emissions

Mine Activity	Reference	Emission Factor (kg/Mg)			Total Emissions (tonnes/year)		
		Total Particulate Matter (TPM)	PM_{10}	$PM_{2.5}$	Total Particulate Matter (TPM)	PM_{10}	$PM_{2.5}$
Conveyor Drop-Off at Plant	SCC 3-05-020-06	0.0015	0.00055	0.00055	6.77	2.48	2.48
SAG Mill	SCC 3-03-024-10	1.2	0.16	0.16	closed circuit to secondary crushing		
Pebble Crushing	SCC 3-03-024-02	0.600	0.000	0.000	closed circuit to cyclone		
Cyclone	SCC 3-03-024-11	0.300	0.000	0.000	closed circuit to ball mill		
Ball Mill	SCC 3-03-024-10	1.2	0.16	0.16	27.06	3.61	3.61

Mitigation with Fabric Filter (AP-42 Table B.2.3) discharging from building

Site historical meteorological data indicate that the Project does not experience wind gusts very often. The wind speeds exceeded 5.4 metres/second hourly average for only 4.4% of the time from 2008 to 2012. Considering the gust speed and approximate silt contents, particulate matter emissions were estimated for each ore, waste, and topsoil stockpiles. Usually topsoil stockpiles are covered by grass however during the construction phase, it was assumed to be too early for vegetation growth and they are included in wind erosion estimations. Wind erosion emission estimates are summarized in Table A.8A.1–5.

Table A.8A.1-5 Wind Erosion Emissions

Mine Facility	Value (tonnes/year)		
	Total Particulate Matter (TPM)	PM_{10}	$PM_{2.5}$
Gold Ore Storage Area	1.64	0.82	0.33
Low Grade Supergene Oxide Pile	0.47	0.23	0.09
Supergene Oxide Ore Stockpile	1.87	0.94	0.37
Marginal Grade Ore pile	1.87	0.94	0.37

Mine Facility	Value (tonnes/year)		
Low Grade Supergene Sulphite	0.47	0.23	0.09
Waste Storage Area	0.29	0.14	0.03
Topsoil Piles	10.06	5.04	2.01
Topsoil Overburden Piles	13.00	6.50	2.60

Fugitive dust also occurs at stockpiles due to unloading and earth moving activities, and these emissions are summarized in Table A.8A.1–6 and Table A.8A.1–7.

Table A.8A.1-6 Earth Moving Air Emissions

Mine Facility	Value (tonnes/year)		
	Total Particulate Matter (TPM)	PM_{10}	$PM_{2.5}$
Gold Ore Stockpile Area	97.02	72.77	10.19
Supergene Oxide Ore Stockpile Area	164.36	123.27	17.26
Waste Storage Area	181.66	136.24	19.07

Emission factor is from USEPA AP-42 Table 11.9-2 Overburden Bulldozing
Silt content = 6.9 assumed for gold ore, moisture=3% feasibility study
Silt content = 6.9 assumed for supergene oxide ore, moisture=2% feasibility study
Silt content = 7.5 assumed for waste, moisture=2% feasibility study
Silt contents were used from AP-42 and moisture contents were taken from feasibility study

Table A.8A.1-7 Truck Loading/Unloading Emissions

Mine Facility	Reference	Emission Factor (kg/Mg)			Total Emissions (tonnes/year)		
		Total Particulate Matter (TPM)	PM_{10}	$PM_{2.5}$	Total Particulate Matter (TPM)	PM_{10}	$PM_{2.5}$
Gold Ore Stockpile	SCC-3-05-020-33	$1.06x10^{-04}$	$5.00x10^{-05}$	$7.57x10^{-06}$	2.29	1.08	0.16
Supergene Oxide Ore Stockpile	SCC-3-05-020-33	$1.06x10^{-04}$	$5.00x10^{-05}$	$7.57x10^{-06}$	1.05	0.50	0.08
Waste Storage Dump	SCC-3-05-020-33	$1.06x10^{-04}$	$5.00x10^{-05}$	$7.57x10^{-06}$	0.56	0.26	0.04

Note: Total Material dump at storage areas were derived from production schedule in feasibility study

Large unit construction activities are expected to have a beginning and an end and vary over the construction phase as activities change on a daily basis. Therefore, construction emissions are estimated area wide (e.g., power plant construction, concentrator area construction, crusher area construction, etc.) regardless of detailed construction activities. Since there is no conceptual plan for construction phase, general construction emission factors were used by assuming that each unit requiring erection would take around 90 days of heavy construction activity. This does not include mechanical and electrical installations which are negligible in terms of air emission estimates. Table A.8A.1–8 summarizes the estimated emissions for the largest unit construction activities.

Table A.8A.1-8 Other Construction Activities

Mine Facility	Value (tonnes/day)	Total Emissions (tonnes/year)*
Power Plant Construction =		
Total Particulate Matter (TPM)	0.404	36.31
PM_{10}	0.191	17.18
$PM_{2.5}$	0.029	2.60
Concentrator Construction =		
Total Particulate Matter (TPM)	0.269	24.21
PM_{10}	0.127	11.45
$PM_{2.5}$	0.019	1.73
Crusher Area =		
Total Particulate Matter (TPM)	0.022	2.02
PM_{10}	0.011	0.95
$PM_{2.5}$	0.002	0.14

Fugitive dust from haul roads is the largest and most contributor to particulate matter emissions during construction. AP-42 Section Unpaved Roads (US EPA 1995) was used as the main reference to calculate emissions during construction by using the following formula:

$$E = k\left(\frac{s}{12}\right)^{a}\left(\frac{W}{3}\right)^{b}$$

where:

- E is size specific emission factor (lb/VMT)
- s is surface material silt content (%)
- W is mean vehicle weight (tonnes)
- k (lb/VMT) is equal to 0.15 for $PM_{2.5}$, 1.5 for PM_{10} and 4.9 for TPM
- a is equal to 0.9 for $PM_{2.5}$ and PM_{10} and 0.7 for TPM
- b is equal to 0.45 for $PM_{2.5}$, PM_{10}, and TPM.

The truck trips were estimated by using the annual production schedule and the capacity of haul trucks. The summary of the unpaved road emissions are summarized in Table A.8A.1–9.

Table A.8A.1-9 Unpaved Road Emissions

Road Type	Average Weight (tonnes)	Daily Total Travelled Distance (km)	Total TPM (tonnes/year)	Total PM_{10} (tonnes/year)	Total $PM_{2.5}$ (tonnes/year)
Haul Road 1 To Waste Storage Area	443	766	184.4	48.8	4.9
Haul Road 2 To Supergene Oxide Stockpile	443	617	148.3	39.3	3.9
Haul Road 3	443	798	192.0	50.8	5.1

Road Type	Average Weight (tonnes)	Daily Total Travelled Distance (km)	Total TPM (tonnes/year)	Total PM_{10} (tonnes/year)	Total $PM_{2.5}$ (tonnes/year)
To Gold Ore Stockpile					
Haul Road 4 Direct Mill Feed	443	242	58.2	15.4	1.5
Haul Road 5 Explosive Building Access Road	30	5	0.4	0.1	0.03
Access Road	30	1,617	376.9	94.0	41.2
Airport Road	30	440	185.1	54.6	11.2

Table A.8A.1–10 summarizes the total particulate emissions from all mine facilities during the peak construction year.

Table A.8A.1-10 Total Particulate Matter Emissions During Peak Construction Year

Mine Facility	Total TPM (tonnes/year)	Total PM_{10} (tonnes/year)	Total $PM_{2.5}$ (tonnes/year)
Roads			
Haul Road 1	184.4	48.8	4.9
Haul Road 2	148.3	39.3	3.9
Haul Road 3	192.0	50.8	5.1
Haul Road 4	58.2	15.4	1.5
Haul Road 5	0.4	0.1	0.03
Access Road	376.9	94.0	41.2
Airport Road	185.1	54.6	11.2
Crusher Unit			
Crusher	90.2	9.0	9.0
Truck Unloading	0.008	0.004	0.001
Sulphite Ore Plant			
Conveyor Drop Off	0.026	0.008	0.002
Sag Mill	-	-	-
Pebble Crushing	-	-	-
Cyclone	-	-	-
Ball Mill (Before Mitigation)	268.2	71.5	71.5
General Construction Activities *			
Power Plant	36.3	17.2	2.6
Concentrator	24.2	11.5	1.7
Second Crusher	2.0	1.0	0.1
Earth Moving/Surfacing			
Gold Ore Stockpiles	97.0	72.8	10.2
Supergene Oxide Ore Stockpiles	164.4	123.3	17.3

Mine Facility	Total TPM (tonnes/year)	Total PM_{10} (tonnes/year)	Total $PM_{2.5}$ (tonnes/year)
Waste Storage Dump	181.7	136.2	19.1
Loading/Unloading			
Gold Ore Stockpiles	2.3	1.1	0.2
Supergene Oxide Ore Stockpiles	1.1	0.5	0.1
Waste Storage Dump	0.56	0.26	0.04
Wind Erosion			
Gold Ore Storage Area	1.6	0.8	0.3
Low Grade Supergene Oxide Pile	0.5	0.2	0.1
Supergene Oxide Ore Stockpile	1.9	0.9	0.4
Marginal Grade Ore Pile	1.9	0.9	0.4
Low Grade Supergene Sulphite	0.5	0.2	0.1
Waste Storage Area	0.3	0.1	0.0
Topsoil Piles	10.1	5.0	2.0
Topsoil Overburden Piles	12.5	6.5	2.6

*Assumed that construction at Power Plant, Concentrator Building and Second Crusher could take 90 days

Air emission estimates from fuel combustion were based on the power rating, utilization factor for each piece of equipment and emission factors from the NONROAD2008 model (US EPA 2008) or USEPA AP-42 Emission Factors (US EPA 2005).

US EPA has developed the NONROAD2008 model to provide emissions factors for predicting accurate and reproducible non-road emissions inventories. NONROAD2008 provides emissions estimates based on fuel-use in a diverse collection of vehicles and equipment. NONROAD2008 provides emission factors for each equipment type and power rating such as haul trucks, graders, dozers, pumps, etc. It was assumed that the sulphur content of the diesel fuel was 0.0015% (15 mg/kg). This is consistent with the *Sulphur in Diesel Fuel Regulations* – Regular Sulphur Diesel Fuel - Type A fuel that is mainly limited to off-road applications (Environment Canada 2010).

The estimates from NONROAD2008 are conservative. The outputs have built-in adjustments for in-use operation versus new engine test results (*e.g.,* deterioration and transient operation). The air emissions were estimated for equipment provided in the feasibility study and time allocations were estimated by considering the available information in the feasibility study.

Other emission factors used in the air dispersion modelling assessment are provided in the US EPA's AP-42 document such as Chapter 3.4 Large Stationary Diesel and All Stationary Duel-Fuel Engines and Chapter 13.3 Explosives Detonation (US EPA 1995). Table A.8A.1–11 summarizes the Project's mined material flow chart.

Detailed blasting data were not available, therefore the ANFO use was estimated by using 0.25 times the powder factor and material extracted from the open pit in a year. It was assumed that blasting emissions would disperse in one hour which is the shortest modelling time interval for this study. The blasting was also assumed to occur once a day. Table A.8A.1–12 summarizes the blasting emission estimates.

Table A.8A.1-11 Mine Fleet and Percentage of Working Locations

Mine Fleet Equipment	Type	Operating Time (hr/day)	# of vehicles	Percentage of Working Locations (%)										
				Open pit	Waste Storage	Supergene Oxide Stockpile	Gold Stockpile	Power Plant Construction	Concentrator Construction	Crusher Construction	HL1	HL2	HL3	HL4
P&H 320XPC Drill	Drill	18	1	100										
P&H 4100XPC Cable Shovel	Shovel	16	1	100										
Cat 797F Truck	Truck	21	8	15	5	5	5				22	18	23	7
Cat D11T Track Dozer	Dozer	16	2		25			25	25	25				
Cat D10T Track Dozer	Dozer	16	2			25		25	25	25				
Cat 854K Wheel Dozer	Dozer	16	2				25	25	25	25				
Cat 24M Motor Grader	Grader	12	2	30				10	10	10	10	10	10	10
Water Truck - 30,000 gal	Water Truck	12	2	20							20	20	20	20
Cat 345D Excavator	Excavator	12	1	25				25	25	25				
Atlas Copco ECM 720 Drill	Drill	16	1	70				20	20	20				
Cat 992K Wheel Loader	Loader	16	1	25				25	25	25				
Cat 777F Truck	Truck	21	3					20	20	20	10	10	10	10

Note: Definition of HL1 to HL 4 can be seen in Table A.8A.1–10

Table A.8A.1-12 Blasting Emissions

Species	Emission Factor [a] (kg/Mg ANFO)	Daily ANFO [b] (tonnes)	Daily Air Emissions (kg)	Emission Rate [c] (g/s/m^2)
CO	34	28.34	963.55	$1.12x10^{-03}$
NO_x	8	28.34	226.72	$2.62x10^{-04}$
SO_2	1	28.34	28.34	$3.28x10^{-05}$

[a] Source: US EPA AP-42 Section 13.3
[b] Assuming a powder factor of 0.250 Kg ANFO/tonnes with 41,376,000 tonnes extraction during year -1
[c] Assuming that blasting emissions will be released from 10,000 m^2 surface within one hour

The auxiliary power plant will be active during construction and is composed of three 6.7 MW large stationary diesel generators. An incinerator will be used for domestic refuse waste. An incinerator commonly used in the mining industry was assumed for this study. The emission rates are not available, therefore stack emissions were assumed to be equal to the Ontario Guideline A-7 emission limits (Ontario MOE 2010) as a conservative approach. The emissions rates for the auxiliary power plant and incinerator are summarized in Tables A.8A.1-13 and A.8A.1-14, respectively.

Table A.8A.1-13 Auxiliary Power Plant

Parameter	Value	Units	Reference
Stack Height	20	m	
Stack Diameter	1	m	
Stack Velocity at operating temperature	16.4	m/s	
Stack Gas Temp	518.3	°C (965°F)	
Efficiency	90%		
Installed Power	6.7	MW	
NO_X	18.356	g/s	AP-42 Table 3.4-1
CO	0.017	g/s	AP-42 Table 3.4-1
SO_2	0.098	g/s	Table 3.4-1 emission factor and ultra-low sulphur
TPM	0.714	g/s	AP-42 Table 3.4-2
PM_{10}	0.587	g/s	AP-42 Table 3.4-2
$PM_{2.5}$	0.569	g/s	AP-42 Table 3.4-2

Table A.8A.1-14 Incinerator Emissions

Parameter	Value	Units	Notes
Stack Height	11	m	
Stack Diameter	0.66	m	
Stack Velocity at operating temperature	3.3	m/s	
Stack Gas Temp	20	°C	Wet Scrubber reduces the stack temp
NO_X	0.223	g/s	
CO	0.045	g/s	
SO_2	0.063	g/s	
TPM	0.016	g/s	
PM_{10}	0.016	g/s	Assumed to be same as TPM
$PM_{2.5}$	0.016	g/s	Assumed to be same as TPM

A.8A.2 OPERATIONS PHASE AIR EMISSIONS INVENTORY

The air emissions inventory for the operations phase was generated from USEPA AP-42 document – Compilation of Air Pollutant Emission Factors, Volume 1 – Stationary Point and Area Sources, Environment Canada National Pollutants Inventory (NPRI) Pits and Quarries Guidance, and NONROAD2008a model. Supplemental emission factors were used from Australian Emission Estimation Technique Manual for Mining V 3.1 where there is insufficient data to estimate emissions.

The production schedule and mining equipment fleet activities formed the basis of year-by-year variations in the emissions model. As a conservative approach, the anticipated worst year was modelled for the operation phase.

Year 1, year 11 and year 12 were considered as the potential worst case air emissions as open pit depth is not very deep during year 1 and particulate matter might not be retained in the pit, waste amount and equipment use peak during year 11 and total material movement peaks during year 12. Due to the distance between the the waste storage area and the open pit, year 11 was chosen as the worst case year due to haulage distances and maximum equipment use during that year. Therefore, air emissions are predicted to be at their worst for all criteria air contaminants in year 11. Table A.8A.2–1 summarizes the Project's mined material flow summary derived from feasibility study.

Table A.8A.2-1 Material Movement Schedule Year 11

MINE FACILITY	Material Movement (tonnes/year)	Truck Trips	One way Distance (km)	Annual Travel Distance (km)
To Waste Storage Area	52,698,000	145,174	8.922	2,590,506
To Low Grade Ore - Hypogene Stockpile	1,642,000	4,523	6.082	55,025
To Low Grade Ore - Supergene Sulfide Stockpile	3,196,000	8,804	2.461	43,334
To Low Grade Ore - Supergene Oxide Stockpile	105,000	289	8.124	700
From Supergene Oxide - Stockpile	3,600,000	39,860	2.461	196,183
From Gold Ore Stockpile	7,862,000	87,050	0.894	155,680
To Direct Mill Feed	41,095,000	113,209	3.550	803,854
Total Materials Moved	**110,198,000**	**303,576**		

Note: Includes open pit activity and reclaim from stockpiles

Project emissions from mine fleet combustion sources were quantified based on information regarding the type, quantity and power rating provided in the feasibility study. The maximum operating time of equipment was estimated and air emissions from the diesel equipment were estimated by NONROAD2008a model based on the horsepower (hp) rating and utilization factor for each piece of equipment.

US EPA has developed the NONROAD2008 model (NONROAD) to provide emissions factors for predicting accurate and reproducible off road emissions inventories. The model provides emissions estimates based on fuel-use in a diverse collection of vehicles and equipment, classified categories.

The estimates from NONROAD are conservative. The model outputs have built in adjustments for in-use operation versus new engine test results (e.g., deterioration and transient operation). Given the inherent conservative estimations in NONORAD, the emission factors used for the Project air emissions inventory provide appropriate representation of a worst-case scenario.

Fugitive dust from haul roads is the largest source of particulate matter for the Project due to haul road distances from the open pit to ore stockpiles, crushers and waste storage area. Air emission factors for the crushers, waste rock dump area, ore stockpile, truck dump, process units (screen, mill, secondary crushing, etc.) are primarily derived from AP-42 emission factors. Some emission factors exist for only TPM or PM10 therefore other particulate matter emission factors could not be directly estimated. In these circumstances AP-42's generic aerodynamic particle size distribution was used to estimate other particulate matter emission factors. Overall, ore/waste moisture content was considered as dry because AP-42 considers materials below 4% as dry therefore low moisture emission factors were used for the assessment.

Precipitation normals were assumed to be the natural mitigation for particulate matter. The climate normals (1981-2010) were reviewed from Environment Canada's Burwash and Whitehorse meteorological stations and percentage of wet days were estimated as 68.2% and 67.9%, respectively (Table A.8A.2–2). As a conservative approach, the station with less precipitation (Whitehorse) was used as a natural mitigation factor (Table A.8A.2–2). The wet day estimation method was used from NPRI's pits and quarries guidance.

Table A.8A.2-2 Regional Data for Natural Mitigation Wet Day Estimation

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	% of Wet Days
Burwash														
Days >= 0.2 mm precipitation	7.8	6.4	5.4	4.1	8	10.8	13.7	10.7	8.7	9.2	9.9	7.6		
Days >= 1 cm snow on the ground	29.7	27.8	29.7	15.3	1.7	0.03	0	0.1	2	13.7	26.6	30.1		
Total number of mitigated days	**31**	**28**	**31**	**19.4**	**9.7**	**10.83**	**13.7**	**10.8**	**10.7**	**22.9**	**30**	**31**	**249.03**	**68.2%**
Whitehorse														
>= 0.2 mm precipitation	11.2	8.3	6.4	4.4	8	10.9	13.5	12.5	11.9	11.5	11.5	11.2		
>= 1 cm snow on the ground	31	28.2	29.2	14.4	0.26	0	0	0.08	0.96	8.5	28.3	30.3		
Total number of mitigated days	**31**	**28**	**31**	**18.8**	**8.26**	**10.9**	**13.5**	**12.58**	**12.86**	**20**	**30**	**31**	**247.9**	**67.9%**

Regular open pit activities are based on blasting, drilling, loading and hauling. Blasting was assumed to take place once a day using ANFO for explosive detonation. Table A.8A.2–3 show the air emission estimated for open pit activities and the corresponding emission factors used.

Table A.8A.2-3 Open Pit Particulate Matter Emissions

Open Pit Activity	Emission Factor	Unit	Total Emissions (tonnes per blast)	Total Emissions (tonnes/year)
Blasting (AP-42 Table 11.9-2)				
Total Particulate Matter (TPM)	$= 0.00022 * Area^{1.5}$	kg/blast	0.22	80.3
PM_{10}	0.52 x TPM	kg/blast	0.1144	41.7
$PM_{2.5}$	0.03 x TPM	kg/blast	0.0066	2.4
# of blasts	1 per day	blasts/day		
Area impacted per blast (m2)	10000	m^2		

Open Pit Activity	Emission Factor	Unit	Total Emissions (tonnes per blast)	Total Emissions (tonnes/year)
Drilling (SCC 3-05-020-10 and aerodynamic size distribution)				
Total Particulate Matter (TPM)	$8.46619x10^{-05}$	(kg/Mg)		8.4
PM_{10}	$4.00428x10^{-05}$	(kg/Mg)		3.9
$PM_{2.5}$	$6.06362x10^{-06}$	(kg/Mg)		0.6
Haul Truck Loading(SCC 3-05-020-31)				
Total Particulate Matter (TPM)	0.000105714	(kg/Mg)		10.4
PM_{10}	0.00005	(kg/Mg)		4.9
$PM_{2.5}$	$7.57143x10^{-06}$	(kg/Mg)		0.7

There are two primary crushers at site in an enclosed building as indicated in the feasibility study, the crushers units also include unloading emission sources. The estimated emissions from the crusher units are summarized in Table A.8A.2–4.

Table A.8A.2-4 Emissions from the Primary Crusher Units

Parameter	Emission Factor (kg/Mg)		Total Emissions Crusher 1 (tonnes/year)	Total Emissions Crusher 2 (tonnes/year)
Crusher	SCC 3-03-024-01	SCC 3-03-024-05		
	Low-moisture ore	High-moisture ore		
Total Particulate Matter (TPM)	0.2	0.01	893.9	155.1
PM_{10}	0.02	0.004	89.4	15.5
$PM_{2.5}$	0.02	$7.16x10^{-04}$	89.4	15.5
Crusher Mitigation Efficiency =	90%			
Environment Canada Pits and Quarries Guidance, Crusher Emission Control Techniques, Enclosed Building Mitigation Efficiency PM2.5 emission factor is not available therefore assumed to be same as PM10 as conservative approach, Project ore/waste considered as low-moisture because it is less than 4% therefore SC-3-03-024-05 was not used for estimations.				
Truck Unloading at Crusher Unit	SCC 3-05-020-31			
Total Particulate Matter (TPM)	$2.x10^{-05}$		0.076	0.062
PM_{10}	$8.x10^{-06}$		0.036	0.029
$PM_{2.5}$	$1.x10^{-06}$		0.005	0.004
Mitigation Efficiency =	90%			
Environment Canada Pits and Quarries Guidance, Crusher Emission Control Techniques, Enclosed Building Mitigation Efficiency. TPM and $PM_{2.5}$ emission factors are not available therefore they were calculated by generic aerodynamic size distribution factors using PM_{10} EF.				

Processing at the Project consists of two processing facilities, one for sulphide ore and one for oxide ore. The sulphide ore processing facility will produce mineral concentrates of copper and molybdenum using conventional flotation technology. The copper concentrate will be dewatered and transported as a filtered cake by highway trucks. The molybdenum concentrate will be dewatered and packaged in super sacks for transport. The feasibility study indicates that the unit will operate in a closed circuit, therefore secondary crushing, mill and cyclone emissions are within the process building and not released to atmosphere.

The oxide ore processing facility will produce gold and silver Doré bars via heap leach and carbon adsorption technology. Copper contained in the oxide ore will be recovered as a copper sulphide precipitate using SART technology. This facility includes conveyor drop off, secondary crushing and screening emission.

Table A.8A.2–5 and Table A.8A.2–6 summarize the emission estimations from the processing facilities.

Table A.8A.2-5 Sulphide Ore Processing Facility Emissions

Mine Facility	Reference	Emission Factor (kg/Mg)			Total Emissions (tonnes/year)		
		Total Particulate Matter (TPM)	PM_{10}	$PM_{2.5}$	Total Particulate Matter (TPM)	PM_{10}	$PM_{2.5}$
Conveyor Drop-Off Point at Plant	SCC 3-05-020-06 uncontrolled	0.0015	0.00055	0.00055	67.0	24.6	24.6
	SCC 3-05-020-06 controlled	$7.00x10^{-05}$	$2.30x10^{-05}$	$6.50x10^{-06}$			
SAG Mill	SCC 3-03-024-10	1.2	0.16	0.16	closed circuit to secondary crushing		
Pebble Crushing	SCC 3-03-024-02	0.600	0.284	0.043	closed circuit to cyclone		
Cyclone	SCC 3-03-024-11	0.300	0.142	0.021	closed circuit to ball mill		
Ball Mill	SCC 3-03-024-10	1.2	0.16	0.16	268.2	71.5	71.5

Mitigation with Fabric Filter (AP-42 Table B.2.3) discharging from building

Table A.8A.2-6 Oxide Ore Processing Facility Emissions

Mine Facility	Reference	Emission Factor (kg/Mg)			Total Emissions (tonnes/year)		
		Total Particulate Matter (TPM)	PM_{10}	$PM_{2.5}$	Total Particulate Matter (TPM)	PM_{10}	$PM_{2.5}$
Conveyor Drop-Off Point at Plant	SCC 3-05-020-06 uncontrolled	$1.50x10^{-03}$	$5.50x10^{-04}$	$5.50x10^{-04}$	11.8	4.3	4.3
Secondary Crushing*	SCC 3-03-024-02	$6.00x10^{-01}$	$2.84x10^{-01}$	$4.30x10^{-02}$	235.9	111.6	16.9
Screening	SCC 3-05-020-21	0.15	0.036	0.036	59	14.2	14.2

*Mitigation 90% as per EC P&Q section 8.6 Covered Screen with building filter

Site historical meteorological data indicate that the Project site does not experience wind gusts very often. The wind speeds exceed 5.4 metres/second hourly average for only 4.4% of the time from 2008 to 2012. However, the erosion related particulate emission were estimated and used in the model for exposed stockpiles and tailings beach. Table A.8A.2–7 summarizes the erosion emission estimations.

Table A.8A.2-7 Wind Erosion Emissions

Mine Facility	Emission Factor (tonnes/year)		
	Total Particulate Matter (TPM)	PM_{10}	$PM_{2.5}$
Gold Ore Stockpile (4ha)	1.87	0.94	0.37
Low Grade Supergene Stockpile (4ha)	1.87	0.94	0.37
Supergene Oxide Ore Stockpile (4ha)	1.87	0.94	0.37
Low Grade Hypogene Ore Stockpile (4 ha)	1.87	0.94	0.37
Low Grade Supergene Oxide Stockpile (1 ha)	0.47	0.23	0.09
Waste Storage (4 ha)	0.09	0.04	0.01
Tailings Beach (18 ha)	13.4	6.7	2.7

Earth moving activities such as bulldozing generate dust to move unloaded material at stockpile areas. Since ore/waste moisture content is low, the earth moving activities is included in the emissions inventory (Table A.8A.2–8). The air emissions predicted for loading/unloading activities are summarized in Table A.8A.2–9.

Table A.8A.2-8 Earth Moving Air Emissions

Mine Facility	Emission Factor (tonnes/year)		
	Total Particulate Matter (TPM)	PM_{10}	$PM_{2.5}$
Gold Ore Stockpile	97.0	72.8	10.2
Low Grade Supergene Stockpile	164.4	123.3	17.3
Supergene Oxide Ore Stockpile	164.4	123.3	17.3
Low Grade Hypogene Ore Stockpile	164.4	123.3	17.3
Low Grade Supergene Oxide Stockpile	82.2	61.6	8.6
Waste Storage	90.8	68.1	9.5

Table A.8A.2-9 Truck Loading/Unloading Emissions

Mine Facility	Reference	Emission Factor (kg/Mg)			Total Emissions (tonnes/year)		
		Total Particulate Matter (TPM)	PM_{10}	$PM_{2.5}$	Total Particulate Matter (TPM)	PM_{10}	$PM_{2.5}$
Low Grade Supergene Pile	SCC 3-05-020-31	$1.69x10^{-05}$	$8.00x10^{-06}$	$1.21x10^{-06}$	0.028	0.013	0.002
Gold Ore Stockpile	SCC-3-05-020-33	$1.06x10^{-04}$	$5.00x10^{-05}$	$7.57x10^{-06}$	0.831	0.393	0.060
Supergene Oxide Ore Stockpile	SCC-3-05-020-33	$1.06x10^{-04}$	$5.00x10^{-05}$	$7.57x10^{-06}$	0.006	0.003	0.0001
Low Grade Hypogene Ore Pile	SCC 3-05-020-31	$1.69x10^{-05}$	$8.00x10^{-06}$	$1.21x10^{-06}$	0.028	0.013	0.002
Low Grade Supergene Oxide	SCC 3-05-020-31	$1.69x10^{-05}$	$8.00x10^{-06}$	$1.21x10^{-06}$	0.0018	0.0008	0.0001
Waste Storage Dump	SCC 3-05-020-31	$1.69x10^{-05}$	$8.00x10^{-06}$	$1.21x10^{-06}$	0.891	0.013	0.004

Note: Total Material dump at storage areas were derived from production schedule in feasibility study

Fugitive emissions from haul roads were estimated based on U.S. EPA emission factors for unpaved roads. Haul roads are predicted to generate the majority of particulate emissions. It was assumed that a dust control program (i.e. applying water to control dust emissions) would be applied and would control fugitive dust emissions from haul roads by approximately 75%, and natural mitigation (precipitation and snow cover) would also aid to suppress fugitive dust. The Whitehorse and Burwash weather stations (Table A.8A.2-2) were considered for natural mitigation data and Whitehorse was used in calculations (67.9%) as a conservative approach. Regular activity consists of ore/waste hauling, explosive transport, airport transportation and access road materials supply and concentrate transport. Table A.8A.2–10 summarizes the fugitive emissions predicted for haul roads and overall particulate matter emissions are summarized in Table A.8A.2–11. Similar to the construction phase emissions calculations for haul roads, fugitive dust was calculated using AP-42 Section Unpaved Roads (US EPA 1995):

$$E = k\left(\frac{s}{12}\right)^{a}\left(\frac{W}{3}\right)^{b}$$

where:

- E is size specific emission factor (lb/VMT)
- s is surface material silt content (%)
- W is mean vehicle weight (tonnes)
- k (lb/VMT) is equal to 0.15 for PM2.5, 1.5 for PM10 and 4.9 for TPM
- a is equal to 0.9 for PM2.5 and PM10 and 0.7 for TPM
- b is equal to 0.45 for PM2.5, PM10, and TPM.

Table A.8A.2-10 Unpaved Road Emissions

Road Name	Average Weight (tonnes)	Daily Total Travelled Distance for all vehicles (km)	Daily Total TPM (tonnes/year)	Daily Total PM_{10} (tonnes/year)	Daily Total $PM_{2.5}$ (tonnes/year)
Haul Road 1 To Waste Storage Area	443	7097.3	1539	395	40
Haul Road 2 To Low Grade Ore – Hypogene Stockpile	443	150.8	33	8	1
Haul Road 3 To Low Grade Ore – Supergene Sulphide Stockpile	443	118.7	26	7	1
Haul Road 4 To Low Grade Ore – Supergene Oxide Stockpile	443	12.9	3	1	0.1
Haul Road 5 From Supergene Oxide – Stockpile	127	537.5	117	30	3
Haul Road 6 From Gold Ore Stockpile	127	426.5	92	24	2
Haul Road 7 Direct Mill Feed	443	2202.3	478	123	12
Haul Road 8 Explosive Storage Access Road	30	13.9	3	1	0.1
Access Road	30	6469.5	1508	1442	144
Airport Road	30	366.6	85	82	8

Table A.8A.2-11 Daily Total Emission During Operations

Mine Facility	Daily Total TPM (tonnes/year)	Daily Total PM10 (tonnes/year)	Daily Total PM2.5 (tonnes/year)
ROADS			
Haul Road 1	1539	395	40
Haul Road 2	33	8	1
Haul Road 3	26	7	1
Haul Road 4	3	1	0.1
Haul Road 5	117	30	3
Haul Road 6	92	24	2
Haul Road 7	478	123	12
Haul Road 8	3	1	0.1
Access Road	1508	1442	144
Airport Road	85	82	8
CRUSHER UNIT TO SULPHIDE ORE FACILITY			
Crusher	893.9	89.4	89.4
Truck Unloading	0.076	0.036	0.036
CRUSHER UNIT TO OXIDE ORE FACILITY			
Crusher	155.1	15.5	15.5
Truck Unloading	0.062	0.029	0.004
SULPHITE ORE PLANT			
Conveyor Drop Off	67.0	24.6	24.6
SAG Mill	-	-	-
Pebble Crushing	-	-	-
Cyclone	-	-	-
Ball Mill	268.2	71.5	71.5
OXIDE ORE PLANT			
Conveyor Drop-Off	11.8	4.3	4.3
Screening	59.0	14.2	14.2
Secondary Crushing	235.9	111.6	16.9
EARTH MOVING/SURFACING			
Low Grade Supergene Stockpiles	164.4	123.3	17.3
Gold Ore Stockpiles	97.0	72.8	10.2
Supergene Oxide Ore Stockpiles	164.4	123.3	17.3
Low Grade Hypogene Ore Stockpiles	164.4	123.3	17.3
Low Grade Supergene Oxide Stockpiles	82.2	61.6	8.6
Waste Storage Dump	90.8	68.1	9.5
LOADING/UNLOADING			
Low Grade Supergene Stockpiles	0.028	0.013	0.002

Mine Facility	Daily Total TPM (tonnes/year)	Daily Total PM10 (tonnes/year)	Daily Total PM2.5 (tonnes/year)
Gold Ore Stockpiles	0.831	0.393	0.060
Supergene Oxide Ore Stockpiles	0.006	0.003	0.0004
Low Grade Hypogene Ore Stockpiles	0.028	0.013	0.002
Low Grade Supergene Oxide Stockpiles	0.0018	0.0008	0.0001
Waste Storage Dump	0.891	0.013	0.004
WIND EROSION			
Gold Ore Storage Area	1.87	0.94	0.37
Low Grade Supergene Pile	1.87	0.94	0.37
Supergene Oxide Ore Stockpile	1.87	0.94	0.37
Low Grade Hypogene Ore pile	1.87	0.94	0.37
Low Grade Supergene Oxide	0.47	0.23	0.09
Waste Storage	0.09	0.04	0.01
Tailings Beach	13.42	6.72	2.68
ANNUAL TOTAL (tonnes)	**6362**	**3027**	**532**

Project emissions from mine fleet combustion sources were quantified based on information regarding the type, quantity and power rates of the equipment. Other large sources include the natural gas fired power plant and auxiliary power plant.

The mine fleet emissions were estimated using NONROAD2008a model, and the equipment type, function, and number of vehicles was obtained from the feasibility study (M3 2013). The allocations were estimated by professional judgement by considering material amounts moved during year 11. The mine fleet, models, number of vehicles and allocation used for modelling are summarized in Table A.8A.2–12 and resulting air emissions for the mine fleet are in Table A.8A.2–13.

Table A.8A.2-12 Mine Fleet and Percentage of Working Locations

Mine Fleet Equipment	Type	Operating Time (hr/day)	# of vehicles	Percentage of Working Locations (%)													
				Open pit	Low Grade SUP	SUP Oxide	Low Grade HYP	Low Grade SUP Oxide	Waste Storage	Gold Ore	HL1	HL2	HL3	HL4	HL5	HL6	HL7
P&H 320XPC Drill	Drill	15	3	100													
P&H 4100XPC Cable Shovel	Shovel	11	3	100													
Cat 994F Wheel Loader	Loader	5.5	2			100											
Cat 797F Truck	Truck	21	24	10	5		5	5	5		15	20	5	15	5	5	5
Cat D11T Track Dozer	Dozer	11	3		20	20	20	10	10	20							
Cat D10T Track Dozer	Dozer	11	3		20	20	20	10	10	20							
Cat 854K Wheel Dozer	Dozer	11	3		20	20	20	10	10	20							
Cat 24M Motor Grader	Grader	11	3	40	10	10	10	10	10	10							
Water Truck - 30,000 gal	Water Truck	5.5	3	30							10	10	10	10	10	10	10
Cat 345D Excavator	Excavator	5.5	1	100													
Atlas Copco ECM 720 Drill	Drill	15	1	100													
Cat 992K Wheel Loader	Loader	11	1							100							
Cat 777F Truck	Truck	17	10			10				10					40	40	

Table A.8A.2-13 Mine Fleet Air Emissions

Operating Time (hr/day)	Fleet Summary	Function	Power (hp)	Quantity	Emissions (g/hp-hour)				
					NOx	CO	PM10	PM2.5	SO2
15	P&H 320XPC Drill	Drill	1000	3	3.5465	1.078	0.1478	0.143366	0.0042
11	P&H 4100XPC Cable Shovel	Shovel	3973	3	2.7121	0.8347	0.0927	0.089919	0.0038
5.5	Cat 994F Wheel Loader	Loader	1463	2	3.9716	1.244	0.1747	0.169459	0.0043
21	Cat 797F Truck	Truck	4000	24	2.7121	0.8347	0.0927	0.089919	0.0038
11	Cat D11T Track Dozer	Dozer	850	3	3.5465	1.078	0.1478	0.143366	0.0042
11	Cat D10T Track Dozer	Dozer	580	3	1.9344	0.7839	0.12	0.1164	0.0042
11	Cat 854K Wheel Dozer	Dozer	907	3	3.5465	1.078	0.1478	0.143366	0.0042
11	Cat 24M Motor Grader	Grader	533	3	1.8859	0.7642	0.1177	0.114169	0.0042
5.5	Water Truck - 30,000 gal	Water Truck	1026	3	2.7121	0.8347	0.0927	0.089919	0.0038
5.5	Cat 345D Excavator	Excavator	380	1	1.6317	0.661	0.1041	0.100977	0.0041
15	Atlas Copco ECM 720 Drill	Drill	385	1	3.8949	1.1523	0.1812	0.175764	0.0044
11	Cat 992K Wheel Loader	Loader	814	1	3.9716	1.244	0.1747	0.169459	0.0043
17	Cat 777F Truck	Truck	1016	10	2.7121	0.8347	0.0927	0.089919	0.0038
2	Cat 345D Excavator	Excavator	380	1	1.6317	0.661	0.1041	0.100977	0.0041

Note: The list provided in feasibility study, power ratings and quantity provided in feasibility study (M3 2013).
Non-road model includes deterioration factors in the model.
Operating times estimated with professional judgement by considering material movement during year 11.

Detailed blasting data were not available, therefore the ANFO use was estimated by using 0.25 times the powder factor and material extracted from the open pit in a year. It was assumed that blasting emissions would disperse in one hour which is the shortest modelling time interval for this study. The blasting was also assumed to occur once a day. Table A.8A.2–14 summarizes the blasting emission estimations.

Table A.8A.2-14 Blasting Emissions

Species	Emission Factor [A] (kg/Mg ANFO)	Daily ANFO [B] (tonnes)	Daily Air Emissions (kg)	Emission Rate [c] ($g/s/m^2$)
CO	34	67.63	2299.33	1.18x10-03
NO_x	8	67.63	541.02	2.78x10-04
SO_2	1	67.63	67.63	3.48x10-05

[A] source: US EPA AP-42 Section 13.3
[B] Assuming a powder factor of 0.225 Kg ANFO/tonnes with 98736000 tonnes extraction during year 11
[c] Assuming that blasting emissions will be released from 10000 m^2 surface within one hour

During operations, power is provided by a natural gas fired power plant (two at 47 MW capacity each) with heat recovery steam generators, and supported by the auxiliary power plant, which is composed of three 6.7 MW generators. Combined gas plants show variable emissions characteristics depending on gas composition, heat recovery system, and changing power demand which changes air emission rates considerably. Since details such as design, fuel consumption, stack clusters, emission control techniques and heat recovery combination of this combined plant were not available, the emission rates were estimated by using power output ratings provided by Australia's emission estimation technique manual for combustion engines Combustion Engines version 3.0, Table 51. The emission factors are developed for uncontrolled natural gas turbines. It was assumed that gas turbines could provide 90% efficiency with an additional 5% preventive maintenance time. The resulting emissions predictions are summarized in Table A.8A.2–15 for the natural gas fired power plant. For the auxiliary power plant, emissions during operations are the same as during construction (Table A.8A.1-13)

Table A.8A.2-15 Natural Gas Power Plant Emission Rates

Parameter	Value	Unit	Reference
Stack Height	20	m	
Stack Diameter	3	m	
Stack Velocity at operating temperature	25.0	m/s	
Stack Gas Temp	312.15	°C	
Efficiency	90%		
Installed Power	2x47	MW	Nominal rates (kg/kWh)
NO_X	12.930	g/s	$4.95x10^{-04}$
CO	3.320	g/s	$1.27x10^{-04}$
SO_2	0.020	g/s	$7.86x10^{-07}$
TPM	$7.68x10^{-02}$	g/s	$2.94x10^{-06}$
PM_{10}	$7.68 x10^{-02}$	g/s	$2.94x10^{-06}$
$PM_{2.5}$	$7.68 x10^{-02}$	g/s	$2.94x10^{-06}$

Similarly to the construction phase, an incinerator will be used to manage domestic refuse waste. The incinerator emissions during operations were assumed to be the same as during construction, as summarized in Table A.8A.1-14.

A.8A.3 REFERENCES

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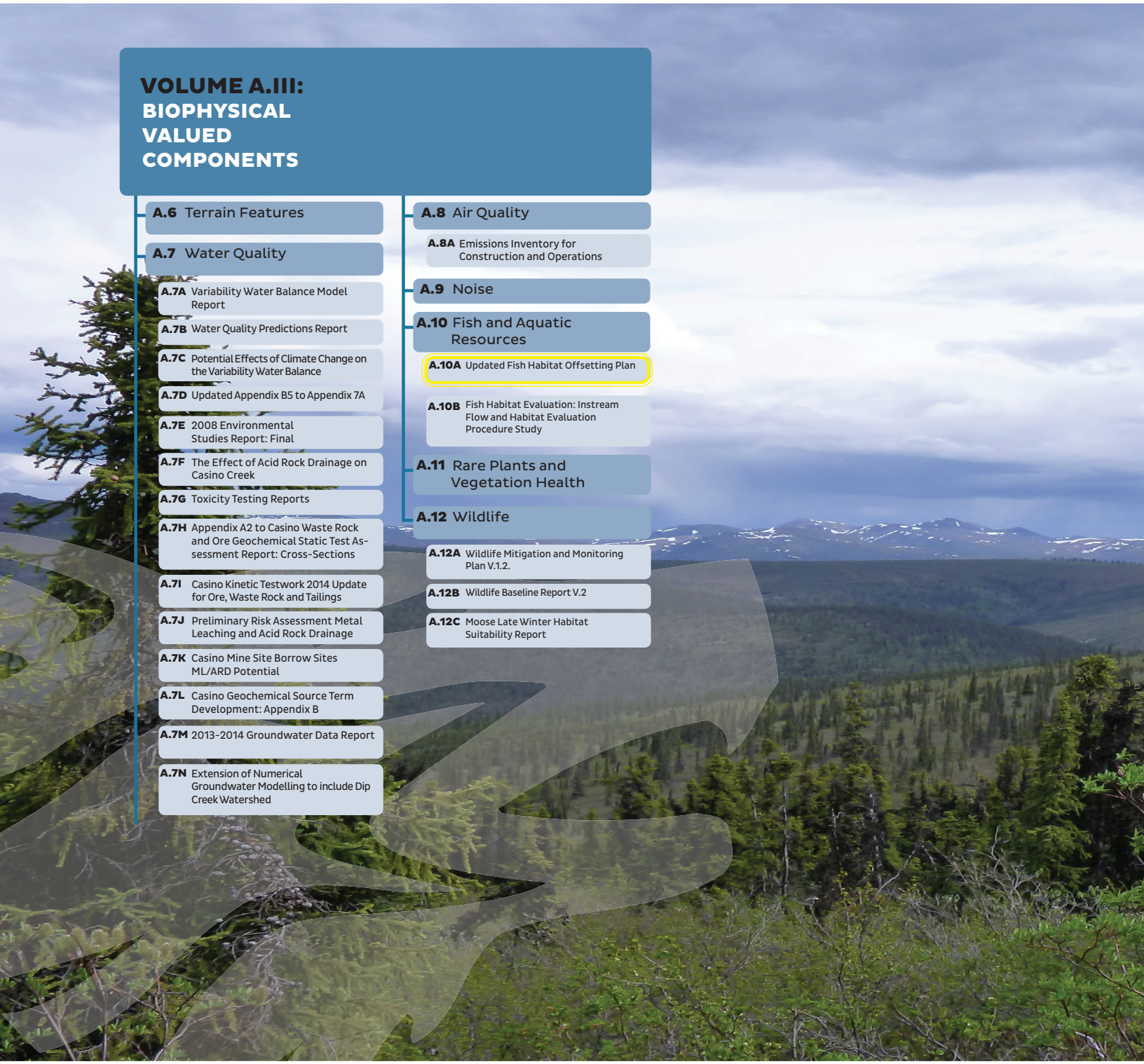
APPENDIX A.10A: Updated Fish Habitat Offsetting Plan



PALMER
ENVIRONMENTAL
CONSULTING
GROUP INC.

Casino Project

Preliminary Fish Habitat Offsetting Plan

Prepared for

Casino Mining Corporation

December 5, 2014

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

*470 Granville Street, Suite 630, Vancouver, BC V6C 1V5 **t** 604-629-9075*

December 5, 2014

Mary Mioska
Senior Environmental Manager
Casino Mining Corporation
1800 – 570 Granville Street
Vancouver, BC V6C 3P1

Dear Ms. Mioska,

Re: Casino Project, Preliminary Fish Habitat Offsetting Plan

Palmer Environmental Consulting Group Inc. is pleased to submit the attached Preliminary Fish Habitat Offsetting Plan for the Casino Project, in support of its Project Proposal to the Yukon Environmental and Socio-Economic Assessment Board.

This report has been updated in accordance with new fisheries protection provisions of the *Fisheries Act*. It describes how Casino Mining Corporation proposes to offset residual impacts to fish habitat in order to ensure the sustainability and ongoing productivity of Yukon fisheries. Following summaries of existing conditions and predicted impacts, it outlines the offsetting objectives and rationale, provides overviews of offsetting candidates, and describes how the proposed offsetting opportunities will restore, create or enhance fish habitat for long-term benefits in productivity.

If you or technical reviewers have any questions about this report, please feel free to contact Rick Palmer at 604-629-9075 or at rick@pecg.ca.

We appreciate the opportunity to work with you on this project.

Yours truly,

Palmer Environmental Consulting Group Inc.

R. Palmer

Rick Palmer, M.Sc. R.P.Bio.
President, Senior Fisheries Biologist

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Revision Log

Revision #	Revised By	Date	Issue / Revision Description
1 (original)	Rick Palmer	November 13, 2013	Senior Review
2 (original)	Don Toews	November 18, 2013	Associate Review
3 (original)	n/a	November 29, 2013	Submission to Client
4 (updated)	Al von Finster	November 26, 2014	Associate Review
5 (updated)	Rick Palmer	December 3, 2014	Senior Review

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Report Reviewed By:



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President, Senior Fisheries Biologist

Executive Summary

Casino Mining Corporation proposes to develop the Casino Project, a copper-gold-molybdenum-silver mine in west-central Yukon, approximately 300 km northwest of Whitehorse. The project is within the traditional territories of the Selkirk First Nation and Little Salmon / Carmacks First Nation, with elements of proposed habitat offsetting extending into the traditional territory of Tr'ondëk Hwëch'in First Nation. The proposed mine consists of an open pit, processing facilities, a heap leach facility, a tailings management facility and an airstrip, with access provided from Carmacks along the upgraded and extended Freegold Road. The Casino Project will process 120,000 t/d or 43.8 million t/y of material over 22 years of production. Based on comprehensive baseline and risk studies, Casino Mining Corporation has minimized predicted impacts of the project on fish and fish habitat through re-design, refinement and mitigation measures.

This document presents the Casino Project Preliminary Fish Habitat Offsetting Plan to address predicted residual impacts on fish habitat, pursuant to the *Yukon Environmental and Socio-economic Assessment Act* and the federal *Fisheries Act*. It has been updated from the previous Preliminary Fish Habitat Compensation Plan (November 29, 2013), in accordance with recent changes to the *Fisheries Act*, based on new data and feedback from DFO, First Nations and their technical advisors.

The Casino Project is located wholly within the Yukon River watershed. The proposed mine and associated facilities are situated in the upper watersheds of Casino Creek and Canadian Creek (a tributary to Britannia Creek), with the proposed airstrip located in the adjacent Dip Creek watershed. Slimy sculpin and Arctic grayling are the dominant species within the high-elevation mine area, where cold water temperatures, high gradients and velocities, a lack of overwintering habitat, and locally poor water quality and benthic communities greatly limit productive capacity. Low numbers of burbot and round whitefish are present in the lower watersheds. Juvenile Chinook salmon have been captured in lower Britannia Creek, near its confluence with the Yukon River. Fish habitat in the Project area predominantly supports rearing activities of local species, with limited opportunities for spawning, and overwintering restricted to larger, downstream watercourses with sufficient base flows and deep pools. Similar species and habitat types dominate the watercourses crossed by the Freegold Road upgrade and extension, between the mine site and Carmacks. However, chum salmon and Chinook salmon spawning habitat have also been documented in some of the largest creeks and rivers within this area.

The main impacts of the Casino Project on fish habitat are anticipated in the upper Casino Creek watershed, in association with tailings management facility construction. More modest in-stream impacts are also expected along lower Casino Creek and Dip Creek, due to flow reductions; along a small, unnamed tributary to Dip Creek, which will be diverted around the new airstrip using natural channel design principles; along lower Canadian Creek, once surface runoff in its headwaters is allowed to drain into the open pit; along lower Britannia Creek, in association with the reinstatement of its historical, meandering channel as an element of habitat offsetting; and within the small footprint of a single bridge pier in the Nordenskiold River. Impacts to riparian habitat are predicted in correspondence with these sites of in-stream impact, as well as in association with the abutments and approaches to clear-span bridges along the Freegold upgrade and extension, and the airstrip access road.

Potential impacts of the Casino Project on in-stream fish habitat were assessed using a Physical Habitat Simulation, where a partial loss of flow is predicted, and a Habitat Evaluation Procedure, where a complete loss of flow is anticipated. Both methods have been widely used across North America as a reliable model for quantifying habitat loss, including for recent environmental assessments for similar projects in Canada, because they provide a means of quantifying biologically-relevant habitat loss (or gain) by taking into account the habitat preferences and requirements of a species at varying life stages. Impacts to riparian habitat were determined based on the predicted areas of disturbance or loss of vegetation within stream-side buffers that reflect the type of vegetation and the suitability and sensitivities of adjacent, in-stream habitats. The assessments predict a loss of 23,632 m^2 of 'usable' in-stream habitat and a loss of 538,705 m^2 of riparian habitat alongside fish-bearing watercourses.

In order to offset the residual impacts outlined above, Casino Mining Corporation and Palmer Environmental Consulting Group Inc., in conjunction with Selkirk, Little Salmon / Carmacks and Tr'ondëk Hwëch'in First Nations, have identified and developed preliminary designs for fish habitat offsetting opportunities that address known limitations to fisheries productivity in the affected watersheds. A systematic inventory of offsetting opportunities in the project area identified 22 candidate sites for restoring, creating or enhancing in-stream and riparian habitat. Four of these candidates, plus a complementary research project, have been recommended as preferred offsetting opportunities; another four candidates have been identified as contingency opportunities. Implementation of some combination of the proposed offsetting opportunities will ensure that the unavoidable residual serious harm to fish is counterbalanced with a 2:1 offset ratio (except a 1:1 offset ratio for impacts in the uppermost Casino Creek watershed, where fish use is rare) to improve the productivity of local commercial, recreational or Aboriginal fisheries, in accordance with the *Fisheries Act*.

The reinstatement of the historical channel of lower Britannia Creek, within 2 km of its confluence with Yukon River, would re-establish approximately 14,870 m^2 of pre-existing, high quality habitat that exhibits tortuous meanders, gravel and cobble substrates, deep pools separated by low-gradient riffles, undercut banks and functional in-stream large woody debris. Bank morphology and riparian habitat would be restored at five abandoned fords along lower Britannia Creek, where vehicle tracking has led to bank erosion and continued sedimentation downstream, resulting in no gain (0 m^2) of in-stream habitat but complete restoration of the riparian buffer. Stocking of whitefish in fishless Diamain Lake, near the Selkirk First Nation community of Pelly Crossing, provides the opportunity to create a new Aboriginal fishery supported by a large area of usable habitat. The localized excavation of dredge piles east of Dawson would connect four large ponds to the adjacent Klondike River, creating at least 9,120 m^2 of usable off-line pool habitat to support rearing and overwintering of juvenile Chinook salmon. As a complementary measure to habitat offsets, a research project equivalent to 10% (3,840 m^2) of the total offsetting amount is proposed to study Chinook salmon stock of origin in natal and non-natal streams.

Contingency habitat offsetting opportunities include extending and enhancing a slope-toe side channel that parallels lower Britannia Creek, in order to create approximately 1,210 m^2 of rearing and overwintering habitat for Arctic grayling and juvenile Chinook salmon; enlarging a groundwater-fed side channel along lower Britannia Creek, by approximately 1,830 m^2, to increase the availability of off-line rearing and overwintering habitat for Arctic grayling and juvenile Chinook salmon; extending a groundwater-fed side channel of the Klondike River into a gallery of pool habitats (approximately 2,680 m^2) to ensure juvenile Chinook salmon that rear in the side channel are also able to survive winter beneath a thick ice cover; and excavating an interconnected gallery of pools (approximately 4,820 m^2)

within an area of shallow groundwater seepage across a meander of the Klondike River, in order to increase access by juvenile Chinook salmon to off-line rearing and overwintering habitat.

This document outlines a strategy for safely implementing the proposed offsetting measures, including consideration of the timing and phasing of construction, the installation and maintenance of erosion and sediment control measures, and the need for construction and effectiveness monitoring. The total cost of the fish habitat offsetting plan will be estimated once the exact combination of proposed offsetting opportunities to be implemented is finalized in consultation with First Nations, Fisheries and Oceans Canada, and other stakeholders. Subsequent detailed, multi-disciplinary design, the implementation of offsetting works before or in conjunction with impacts, and an allowance for adaptive management will ensure the long-term effectiveness of the proposed offsetting measures.

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Appendix A. Fish Habitat Offsetting Preliminary Design Drawings

1 Introduction

Casino Mining Corporation (CMC) proposes to develop the Casino Project ("the Project"), located in west central Yukon approximately 150 km northwest of Carmacks (**Figure 1-1**). The Project is a proposed open pit copper-gold-molybdenum-silver mine that is anticipated to process 120,000 t/d or 43.8 million t/y of material over 22 years of production. The Project is located on Crown land and is within the traditional territory of the Selkirk First Nation (SFN), with access proposed along an extension to the Freegold Road, which crosses the traditional territory of Little Salmon / Carmacks First Nation (LSCFN). Elements of proposed fish habitat offsetting are also within the traditional territory of Tr'ondëk Hwëch'in First Nation (THFN).

This document presents the Casino Project Preliminary Fish Habitat Offsetting Plan (FHOP) to address predicted impacts on fish habitat, as described in the "Fish and Aquatic Resources Effects Assessment" (Section 10) of the Project Proposal pursuant to the *Yukon Environmental and Socio-economic Assessment Act* (YESAA). The previous version of this document, the Casino Project Preliminary Fish Habitat Compensation Plan (Appendix 10C of the Project Proposal), was completed during a time of transition for the Canadian *Fisheries Act*, administered by Fisheries and Oceans Canada (DFO), and thus incorporated terminology and references relating to the older *Fisheries Act* provisions. In addition to the technical updates described in subsequent sections, this FHOP has been updated according to the new fisheries protection provisions, including amendments to Section 35 of the *Fisheries Act*. It also aligns with new guidelines provided by DFO's supporting documents, Fisheries Productivity Investment Policy: A Proponent's Guide to Offsetting (DFO, 2013a), and Fisheries Protection Policy Statement (DFO, 2013b). The new *Fisheries Act* is focused on avoiding "serious harm to fish", which is defined as "the death of fish or any permanent alteration to, or destruction of, fish habitat," where "fish" include any fish that are part of a commercial, recreational or Aboriginal (CRA) fishery, or fish that support such a fishery. To avoid contravening the *Fisheries Act*, proponents anticipating unavoidable serious harm to fish normally require an authorization under Section 35(2) of the *Fisheries Act*. In addition, proponents are required to submit an Offsetting Plan (DFO, 2013a) outlining how residual serious harm to fish will be counterbalanced in order to achieve DFO's overall goal of ensuring the sustainability and ongoing productivity of Canadian CRA fisheries.

CMC has completed comprehensive baseline and risk assessment studies to avoid and minimize predicted impacts of the Project on fish and fish habitat through re-design, refinement and mitigation measures. Offsetting measures and an authorization under Section 35(2) of the *Fisheries Act* will be required, however, where it is not possible to avoid all residual serious harm to fish. Accordingly, CMC understands that DFO will be identified by the Yukon Environmental and Socio-economic Board (YESAB) as a Decision Body under *YESAA*. The objective of the FHOP is to support DFO review of the Project Proposal, which will be submitted under *YESAA*. Detailed designs for fish habitat offsetting measures will be provided to DFO in association with CMC's subsequent request for *Fisheries Act* authorization.

1.1 Overview of Offsetting Approach

The objective of this FHOP is to outline the offsetting measures required to counterbalance unavoidable serious harm to fish resulting from the Project, with the goal of maintaining or improving the productivity of the CRA fishery, as outlined in DFO's *Fisheries Protection Policy Statement* (DFO, 2013b). A major focus of the new *Fisheries Act* is the integral role of fisheries management objectives in guiding impact assessments, and creating plans for offsetting. Thus, considerable efforts have been made to incorporate fisheries objectives from various partners and stakeholders in the region. Throughout the engagement process, fisheries partners have continually identified the high economic, cultural and ecological significance of Yukon River Chinook salmon (*Oncorhynchus tshawytscha*), which has had a major influence on the development of this FHOP. In addition to assessing their applicability to meeting fisheries objectives, all offsetting candidates were assessed relative to parameters that aimed to evaluate their potential for increasing fisheries productivity. These factors included the quality and rarity of the habitat types used in offsets, the distance between proposed impacts and offsetting sites, the risk of failure of offsetting measures, the potential for time lags and thus reduced fisheries productivity between project impacts and offsetting development, and the expected duration of offsetting benefits. The evaluation of all proposed offsetting candidates relative to these identified parameters is detailed in Section 4.

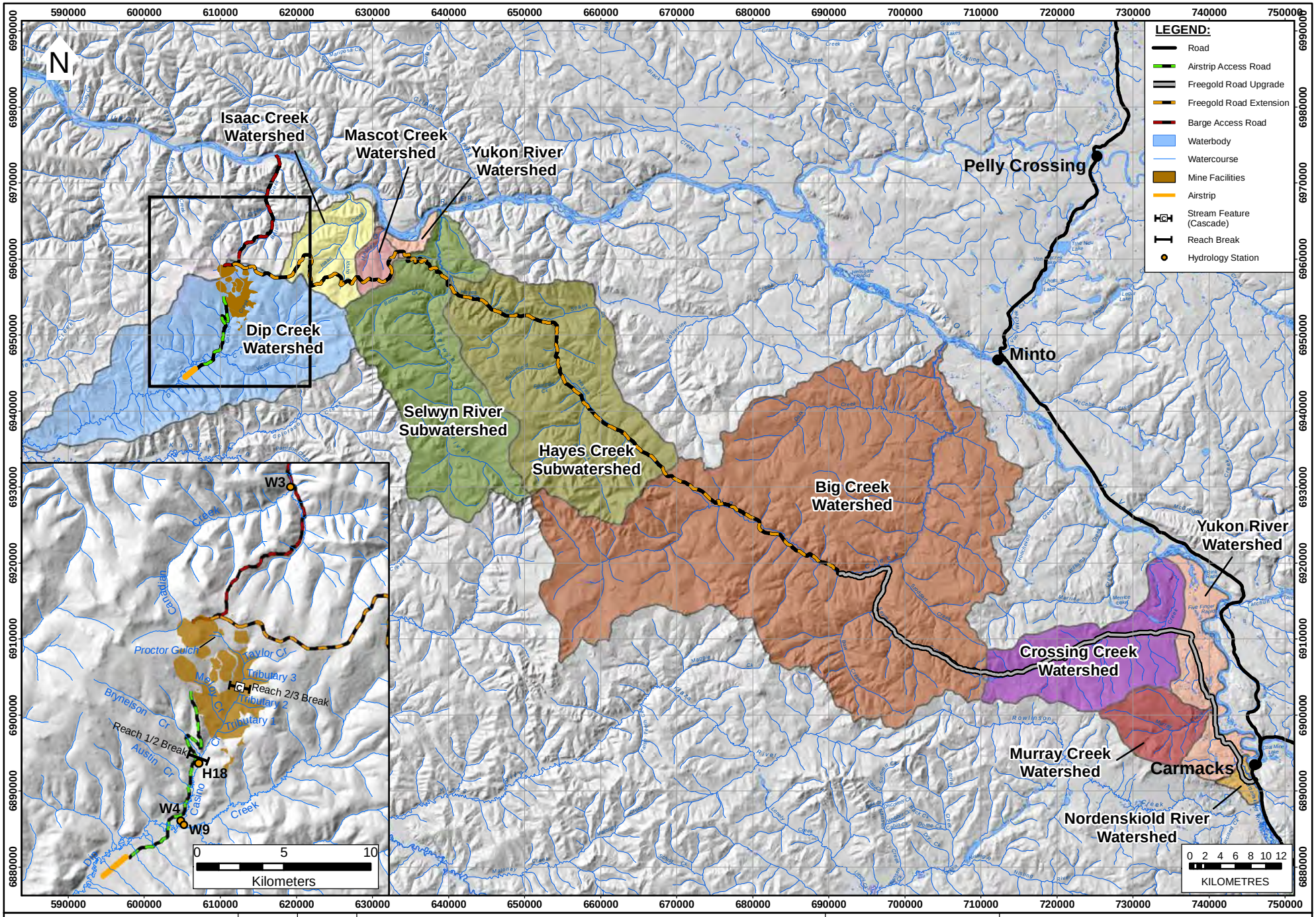
1.2 Casino Project Overview

1.2.1 Principal Mine Components and Infrastructure

This section provides an overview of eight principal mine components and associated infrastructure that have the potential to affect fish and fish habitat in the Project area (**Figures 1-1** and **1-2**):

- Open Pit;
- Ore stockpiles;
- Tailings Management Facility (TMF);
- Processing Facilities;
- Heap Leach Facility;
- Freegold Road Upgrade;
- Freegold Road Extension; and
- Airstrip and Airstrip Access Road.

Additional details on the mine components are presented in the "Project Description" in Section 4 of the Project Proposal.



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REV	R. Palmer
DATE	26Nov'14

NOTES:

1. BASE MAP: Digital Elevation Model and 1:250,000 and 1:50,000 Topographic Spatial Data provided by Geomatics - Yukon Government via online source (www.geomaticsyukon.ca)
2. PROJECTION: NAD 1983 UTM Zone 7N
3. COORDINATE GRID: METRES
4. SCALE: 1:650,000

CASINO

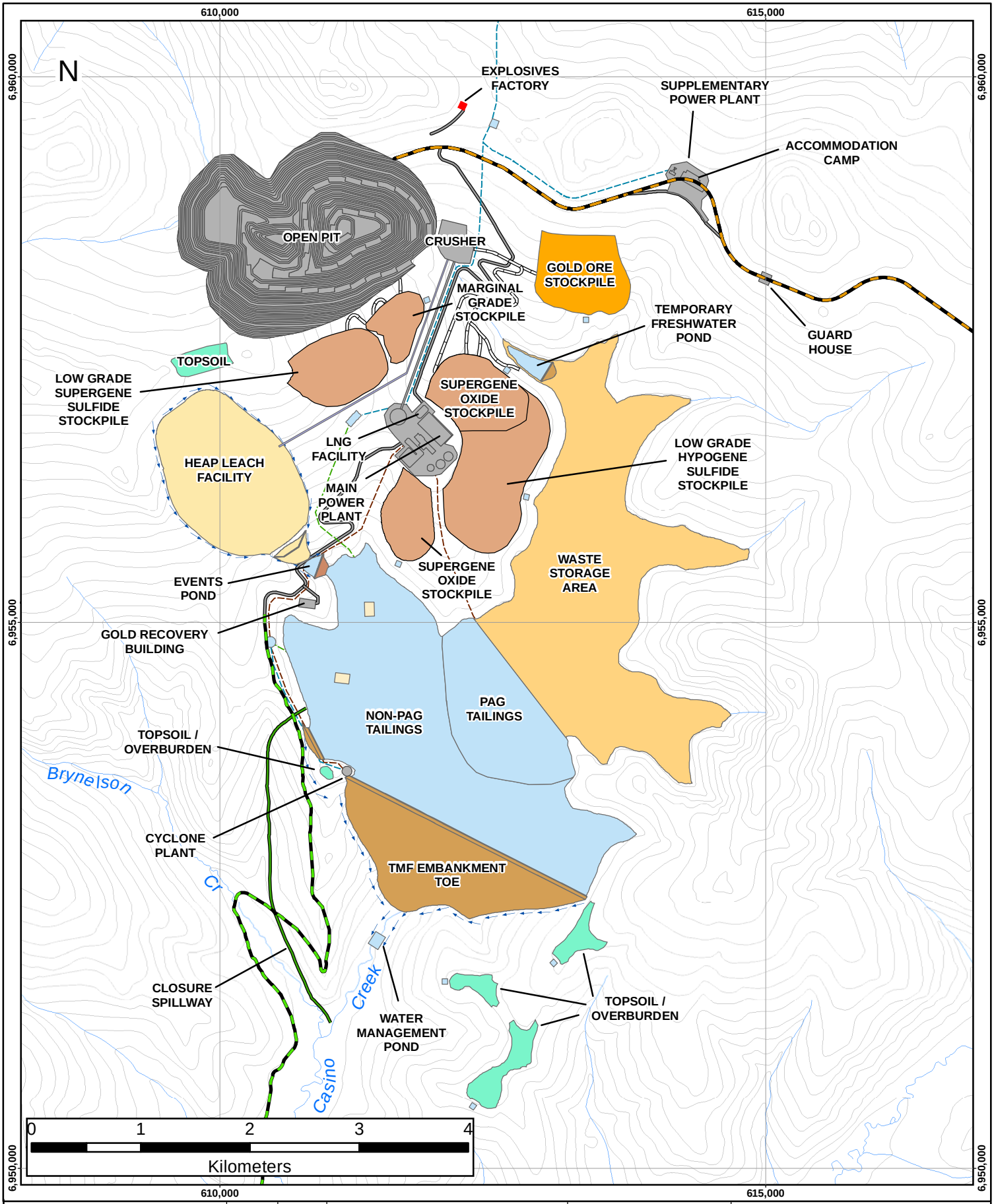
CASINO PROJECT

Overview Map of the Casino Project

FIGURE 1-1

FHOP REPORT

PN 10011



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REV	R. Palmer
DATE	30Oct2013

NOTES:

1. BASE MAP: 1:50,000 Topographic Spatial Data provided by Geomatics - Yukon Government via online source (www.geomaticsyukon.ca).
2. PROJECTION: NAD 1983 UTM Zone 7N
3. COORDINATE GRID: METRES
4. SCALE: 1:45,000
5. CONTOUR INTERVAL: 100 feet

CASINO

CASINO PROJECT

MINE SITE OVERVIEW: MAXIMUM EXTENT

FIGURE 1-2

FHOP REPORT

PN 10011

Casino Mine Open Pit

The proposed Open Pit straddles the headwaters of Casino Creek and Canadian Creek and is anticipated to produce an average 120,000 t/d of ore over 22 years of full production (**Figure 1-2**). The Open Pit will occupy an area of approximately 300 ha and will extend to a maximum depth of approximately 600 m below existing grade (Knight Piésold Ltd., 2012a). The Open Pit will contain two designated mining zones, the Main Pit and the West Pit, which will be developed concurrently during the operations phase of the Project using standard drill and blast technology.

Ore Stockpiles

During mine operations, approximately 144 million tonnes of Low Grade ore and 32 million tonnes of Supergene Oxide (SOX) ore will be stored in temporary stockpiles. The SOX ore will be stockpiled at a location between the open pit and plant site during the pre-production years and in Year 1 of mill operations, and report to the mill during Years 4 to 12 together with direct feed mill ore. Mined Low Grade ore will be stockpiled up to Year 17 in locations generally east and south of the plant site, on valley slopes above the TMF (**Figure 1-2**). Low Grade ore mined after Year 12 can also be stockpiled at the same location used for the SOX ore south of the open pit. The stockpiled Low Grade ore will be milled during the last four years of mine operations (Years 19 to 22). Gold ore will be stored in a temporary stockpile near the crusher on the valley slope east of the open pit and at the northern end of the TMF. This stockpiled ore will report to the heap leach facility over a period of about 18 years, starting in the pre-production years (3 years prior to mill start-up) and continuing up to Year 15 of mill operations.

Tailings Management Facility (TMF)

The Project TMF is located southeast of the Open Pit within the valley formed by the headwaters of Casino Creek (**Figure 1-2**). At its full extent, the TMF will cover approximately 1,120 ha of land within the Casino Creek valley. The objective of the TMF is to protect groundwater and surface waters from potentially reactive waste rock from the Open Pit, acidic supergene waste and supernatant water pond. The TMF has been designed to retain 974 Mt of tailings together with 598 Mt of potentially reactive waste rock and overburden, as well as 9 Mt of acidic supergene waste (Knight Piésold Ltd., 2012b, 2013a). The two embankments of the TMF – the Main Embankment and West Saddle Embankment – will be developed in stages throughout the duration of the Project using a combination of suitable non-reactive overburden, cyclone sand and waste rock materials from the plant site, Open Pit and local borrow sources (Knight Piésold Ltd., 2012b). The final heights of the Main Embankment and West Saddle Embankment will be 286 m (998 m elevation at crest) and 21 m (998 m elevation at crest), respectively.

Processing Facilities

The Project consists of two ore processing facilities, one for sulphide ore (producing molybdenum and copper concentrates) and one for oxide ore (producing gold and silver dore bars and copper concentrate) (**Figure 1-2**). Sulphide ore processing involves primary crushing followed by conventional single-line semi-autogenous (SAG) mill circuit and conventional copper molybdenum floatation. Oxide ore processing involves a heap leach with a carbon adsorption facility to recover gold and silver and a Sulphidization, Acidification, Recycling and Thickening (SART) process to recover copper.

Heap Leach Facility

The proposed heap leach facility is located south of the open pit within the small tributary valley of Meloy Creek (**Figures 1-1 and 1-2**). This facility utilizes heap leach to process oxide 'gold' ore. The heap leach facility is anticipated to process approximately 157.5 million tonnes of oxide ore over the life of the Project.

Freegold Road Upgrade

Access to the proposed Casino mine site is currently limited to fixed-wing aircraft, helicopter and Yukon River barge, with some limited winter access for heavy equipment available along the old Casino Trail. To provide year-round access for heavy equipment, fuel and haulage trucks, CMC plans to construct a new all-weather resource road that connects the Casino mine site with the western limit of the existing Freegold Road, located approximately 85 km northwest of Carmacks (**Figure 1-1**). The existing Freegold Road will be upgraded to a two-lane (8.2 m-wide) gravel resource road that can accommodate the anticipated traffic from the Casino mine (hereinafter referred to as the "Freegold Road Upgrade"). Existing bridge and culvert crossings along the Freegold Road Upgrade section will be expanded to accommodate larger construction vehicles (Associated Engineering (AE), 2013). Bridge upgrades will be required over Crossing Creek and Bow Creek, and a new bridge will be constructed across the Nordenskiold River.

Freegold Road Extension

Beginning where the Freegold Road Upgrade section ends, CMC proposes to construct a new, all-weather, gravel road to the Casino mine site, referred to as the "Freegold Road Extension" (**Figure 1-1**). The Freegold Road Extension is a 120 km-long, two-lane gravel resource road designed to accommodate mine traffic. There are 18 major bridge crossings proposed along the extension, including crossings of Big Creek, Hayes Creek and Selwyn River, as well as several larger tributaries and side channels. Small, clear-span bridges are proposed across all other fish-bearing watercourses, with culverts only proposed for non-fish-bearing watercourse crossings, although the use of bridges or culverts will be dependent on geotechnical conditions at the crossing.

Airstrip and Airstrip Access Road

The existing Casino Airstrip will be replaced with a larger facility located in the Dip Creek valley, approximately 12 km southwest of the Casino mine site (**Figure 1-1**). The airstrip will be 2,000 m long and 30 m wide, with an 80 m grade width and a run out of 60 m at each end, and will be oriented northeast to southwest (AE, 2013). A new Airstrip Access Road will be constructed between the new Airstrip and the Casino mine site. This access road will be a 14 km-long, single-lane gravel road, with two major bridge crossings and several minor crossings.

1.2.2 Project Phasing and Scheduling

The Project phases are defined as Construction, Operations, Closure and Decommissioning, and Post-Closure (**Table 1-1**). The construction phase of the Project will begin once required permits and financing are in place. This phase is anticipated to be four years in duration. Completion of the Freegold Road Upgrade, Freegold Road Extension and Airstrip and Airstrip Access Road are priorities for early in the construction phase. Soil removal and pre-stripping of the Open Pit will occur during this phase. Construction of the TMF and Processing Facilities (including the heap leach facility) will also occur during the construction phase and will be fully operational by Year 1 of the operations phase.

Table 1-1. Casino Project Phases and Schedule

Project Phase	Period	Anticipated Schedule	Project Year
Construction	4 years	2016 - 2019	Year -4 to Year -1
Operations	22 years	2020 - 2042	Year 1 to Year 22
Closure and Decommissioning	3 years	2043 - 2045	Year 23 to Year 25
Post-Closure	5 years	2046- 2050	Year 26 to Year 30

Note: From the "Project Description" (Section 4 of the Project Proposal)

The operations phase of the Project will begin at the commencement of sulphide ore processing and is projected to last 22 years (**Table 1-1**). In Year 1, the Casino Project is projected to operate at 75% capacity, with production increasing to the nominal daily production capacity of 120,000 t/d for the remainder of this phase. Open pit mining and ore processing (including both heap leaching and sulphide ore processing) will gradually increase to meet the nominal daily production capacity. Waste rock and tailings management will be a key element of the operations phase.

The closure and decommissioning phase (hereinafter referred to simply as "closure") is projected to commence in Year 23 and last three years (**Table 1-1**). During the closure phase, the surface facilities will be removed and the Casino mine site will be fully reclaimed according to the reclamation objectives established in the "Closure and Reclamation Plan" (Section 4B of the Project Proposal).

Post-Closure phase activities include annual inspections and monitoring of the Project area over a five-year timeframe to evaluate the predicted results of reclamation and ensure that reclamation objectives have been met (**Table 1-1**).

1.3 Consultation

CMC is committed to communicating clearly and openly about the planning of the Project, and to soliciting and incorporating feedback received through its consultation process. Since conception of the Project, CMC has regularly consulted regulatory agencies, First Nations and local communities, Renewable

Resource Councils and the public through a combination of site field tours and community meetings and workshops. Valuable insight into fisheries protection and enhancement opportunities has been provided by SFN, LSCFN and THFN through field reconnaissance visits, community meetings and technical workshops. CMC has made changes to project design based on feedback received from First Nations and agencies such as DFO (as outlined below in Section 3.3). Several fisheries-related meetings and site visits have been conducted in 2014 to engage and consult with regulators, third party reviewers, and First Nations (**Table 1-2**).

Table 1-2. Summary of FHOP-related Meetings and Site Visits in 2014

Date	Meeting/Site Visit	Objective
27/28-Jan-14	SFN Water and Fish Technical Session	Briefing of what SFN and technical water/fisheries advisors will be reviewing, following submission of Project Proposal to YESAB on January 3, 2014, including an overview of habitat modelling and components of FHOP
01-Apr-14	Meeting with THFN	Introduction to Project, with an emphasis on fisheries considerations and offsetting planning
26-May-14	Meeting with SFN, Environment Canada and DFO	Feedback regarding updates to offset planning to address new *Fisheries Act* and additional offsets
30-May-14	Reconnaissance site visits with SFN	Reconnaissance flight and site visits to identify and discuss offsetting candidates within SFN traditional territory
19-Jun-14	Meeting with LSCFN	Consultation regarding proposed Freegold Road upgrades and extension through LSCFN traditional territory, with an emphasis on fisheries considerations and offsetting planning
15-Jul-14	Meeting with FHOP Advisory Group	Discussion about existing offsetting candidates and feedback regarding newly identified candidates within SFN traditional territory
16-Jul-14	Site visit with SFN and LSCFN representatives	Reconnaissance flight and site visits to provide overview of Project area and to identify and discuss offsetting candidates primarily within SFN traditional territory
23/24-Sep-14	Meeting and reconnaissance site visits with THFN	Update on FHOP development and expression of interest in considering offsetting opportunities in THFN traditional territory, followed by reconnaissance site visits
07-Oct-14	Field survey assistance by THFN representative	Preliminary field investigations of offsetting candidates identified in THFN traditional territory, with assistance from a THFN representative with valuable local knowledge
04-Nov-14	Meeting with FHOP Advisory Group	Presentation and discussion on planned FHOP updates, as an opportunity to solicit feedback on technical/feasibility issues associated with each offsetting candidate
18-Nov-14	Meeting with FHOP Advisory Group	Presentation and discussion on proposed research program on Chinook salmon, as a complementary measure to habitat offsets

SFN, LSCFN and THFN have provided considerable support in the identification, evaluation and preliminary design of fish habitat offsetting opportunities for the Project. SFN Lands and Environment Director, William Sydney, participated in an on-site tour on May 30, 2014 to discuss offsetting options, in addition to several community meetings. The SFN prioritized offsetting opportunities targeting Chinook salmon and identified the important traditional use of lower Britannia Creek, where considerable offsetting efforts are now proposed. In 2014, SFN helped CMC identify additional, off-site offsetting candidates within its traditional territory.

CMC and its consulting team engaged DFO early in its Project planning and continued regular consultation throughout Project design, recognizing the valuable input DFO is able to provide to CMC's project team, technical advisors and local communities regarding priorities for fish habitat protection and offsetting strategies. CMC has hosted several YESAA workshops, in which DFO staff participated, and led on-site field tours and information sharing sessions aimed at identifying critical habitats for protection and opportunities for habitat restoration and enhancement. DFO has been regularly updated on project changes and implications to fish and fish habitat, and has had the opportunity to provide feedback on conceptual offsetting strategies.

1.3.1 FHOP Advisory Group

Since the Project Proposal submission in January 2014, an FHOP technical advisory group ("FHOP Advisory Group") was established comprising Palmer Environmental Consulting Group Inc. (PECG), CMC and members from SFN, LSCFN and THFN. The FHOP Advisory Group consists of First Nations community members, fish biologists, habitat restoration specialists and a water resources engineer. Each participant has contributed important ideas and feedback at key stages of FHOP development, drawing on individual experiences and expertise. The insight has not only been incorporated into this updated FHOP, but it has also helped prioritize on-site and off-site opportunities for habitat offsetting. Strong support and excellent ideas for proposed research, as a complementary measure to habitat offsetting, have been provided by the FHOP Advisory Group.

1.4 Report Organization

This document demonstrates how the FHOP will address DFO's requirement to ensure the sustainability and ongoing productivity of Canadian fisheries. Following this introduction (Section 1), it provides an overview of fish and fish habitat in the Project area (Section 2) and summarizes predicted habitat impacts (Section 3). Section 4 provides an overview of offsetting objectives and candidates, followed by a description and preliminary design drawing of each proposed offsetting opportunity (Section 5). Section 6 outlines the overall implementation strategy for the offsetting opportunities, and acknowledges uncertainties and next steps in offsetting planning and design.

2 Overview of Fish and Fish Habitat in the Project Area

Detailed descriptions of fish and fish habitat in the Project area are provided in the "Casino Project Fish and Aquatic Resources Baseline Report" for the mine area (Appendix 10A of the Project Proposal) and for the Freegold Road Extension, Freegold Road Upgrade and Casino Airstrip and Airstrip Access Road (Appendix 10B of the Project Proposal). A summary of the pertinent watersheds, general sampling methods, species distribution and habitat characteristics is provided below.

The Project, including the proposed mine area and its access roads, is wholly located within the Yukon River watershed (**Figure 1-1**). The proposed mine and associated facilities are situated in the upper watersheds of Casino Creek and Canadian Creek (a tributary to Britannia Creek), with the proposed Airstrip and its Access Road located in the adjacent Dip Creek watershed. The Freegold Road Upgrade and Extension cross several large and small watersheds between Carmacks and the mine site, including (from east to west) those of Nordenskiold River, Yukon River minor tributaries, Murray Creek, Crossing Creek, Big Creek, Hayes Creek, Selwyn River, Yukon River minor tributaries, Mascot Creek, Isaac Creek and Dip Creek. Fish and aquatic resource studies were conducted from 2008 to 2013 in the Project study area. Fish sampling and habitat assessment efforts were concentrated in the Casino and Canadian Creek watersheds, where potential near-field effects are anticipated. Backpack electrofishing and minnow trapping were the primary fish sampling methods used, and fish habitat assessments were conducted according to pre-established methods to characterize habitat quality including site-specific potential for supporting rearing, spawning and overwintering activities. In addition, multi-year Chinook spawning surveys were completed in the Britannia and Dip Creek watersheds. To further characterize local fisheries in the mine area, benthic invertebrate and periphyton studies were conducted in the Casino, Dip and Britannia Creek watersheds to assess the primary productivity, community characteristics and overall aquatic ecosystem health. Following initial reconnaissance completed in 2010 and 2011, fish and fish habitat assessments were completed at 61 locations along the Freegold Road Upgrade, 95 locations along the Freegold Road Extension and 12 locations along the Airstrip Access Road.

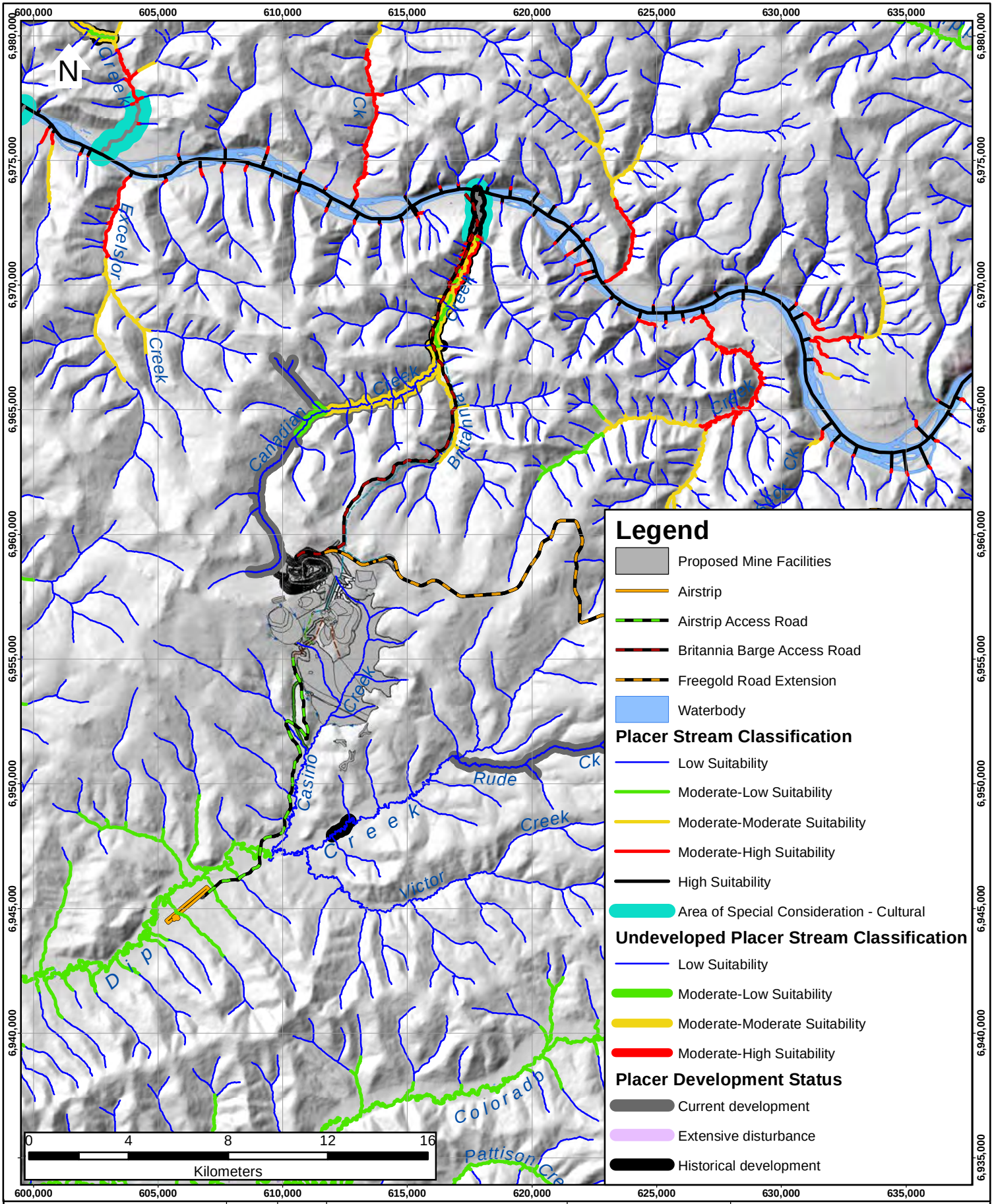
In the Casino, Britannia and Dip Creek watersheds encompassing the mine area, slimy sculpin (*Cottus cognatus)* and Arctic grayling (*Thymallus arcticus)* were the most dominant species captured, with low numbers of burbot (*Lota lota)* and round whitefish (*Prosopium cylindraceum)* also present in the lower watersheds. The greatest efforts were made to assess baseline conditions in upper Casino Creek (reaches 2 and 3, **Figure 1-1**), where most habitat loss is predicted, with an emphasis on characterizing habitat quality, fish abundance and life history usage. Cold water temperatures, high gradients and velocities, cascades (flow-dependent barriers) and poor water quality from natural and anthropogenic acid rock drainage in upper Casino Creek greatly limit its productive capacity. Despite four years of fish sampling in upper Casino Creek (Reach 3, **Figure 1-1**), only four Arctic grayling were ever captured (in 2013), during exceptionally clear and low-flow conditions (as outlined by PECG in Appendix 10A of the Project Proposal).

Fish abundance and species diversity generally increased downstream within the watersheds, particularly in close proximity to the Yukon River. Juvenile Chinook salmon were captured in lower Britannia Creek in 2009 and 2011, near its confluence with the Yukon River. The capture of only one juvenile Chinook salmon in Dip Creek (downstream of the confluence with Casino Creek), despite sampling from 2008 to 2013, indicates that Dip Creek may occasionally provide habitat for low abundances of juvenile Chinook salmon. Historically, juvenile Chinook salmon were also captured in the lowest 10 km of Dip Creek (DFO, 1994). No Chinook salmon spawning was observed in either the Britannia or Dip Creek watersheds despite multi-year surveying within the Chinook salmon spawning season.

Rearing habitat is the most common habitat type within all watersheds, with most sites providing moderate to good opportunities for juvenile rearing for all species present. In upper Casino Creek, however, moderately steep cascades limit rearing opportunities. There is minimal overwintering habitat in the mine area, except along portions of Dip Creek, due to a lack of deep pools and the widespread formation of anchor ice during the winter. The lack of young-of-the-year rearing in the majority of the Project area suggests that Arctic grayling spawning activities are correspondingly minimal.

The potential for spawning habitat throughout the Project area was mostly rated none to poor, consistent with the Yukon Mining Secretariat's designation of the watercourses as not supporting spawning activities or providing critical migratory corridors for spawning Chinook salmon. According to the Yukon Placer Stream Classification Model (Yukon Placer Secretariat, 2012), the entire Casino Creek watershed is classified as "low" suitability habitat, whereas most middle to lower reaches of Britannia Creek have been classified as "low-moderate" to "moderate" suitability (**Figure 2-1**). The lowermost reach of Britannia Creek has been designated as an "area of special consideration", subject to the most restrictive conditions for placer mining.

Within the watersheds crossed by the Freegold Road Extension and Upgrade, Chinook salmon, chum salmon (*Oncorhynchus keta*), Arctic grayling, slimy sculpin and round whitefish are known to be present. No aquatic species at risk exist within the Project study area. Fish abundance and diversity are greatest along large, meandering creeks and rivers (>third-order), where flow and groundwater discharge is sufficient to inhibit anchor ice formation, pool-riffle morphology is well developed, and bed material is dominated by gravel/cobble substrate (as outlined by PECG in Appendix 10B of the Project Proposal). Big Creek, Selwyn River and Nordenskiold River are known to be utilized by adult Chinook salmon for spawning habitat (DFO, 1985; Yukon River Panel, 2008a), and the tributaries of Seymour Creek, Bow Creek, Stoddart Creek, Hayes Creek and Dip Creek have all been shown to contain fry and juvenile Chinook (DFO, 1994; von Finster, 1998). Juvenile Chinook salmon have also been documented in the lower reaches of Britannia Creek, Isaac Creek, Mascot Creek, Crossing Creek and Murray Creek, near the confluence with the Yukon River (DFO, 1994; EDI Environmental Dynamics Inc. (EDI), 2011).



PREPARED BY:

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NOTES:

1. BASE MAP: 1:50,000 Topographic Spatial Data and Placer Stream Classification provided by Geomatics - Yukon Government via online source (www.geomaticsyukon.ca).
2. PROJECTION: NAD 1983 UTM Zone 7N
3. COORDINATE GRID: METRES
4. SCALE: 1:200,000

CASINO

CASINO PROJECT

PLACER STREAM CLASSIFICATIONS

FIGURE 2-1

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Along most first- and second-order tributaries crossed by the Freegold Road Extension and Upgrade, flows are generally intermittent and groundwater inputs are often insufficient to maintain ice-free conditions. Stream gradients along the tributaries at the crossing locations are generally less than 5%, but steepen dramatically immediately upstream. Bed material typically comprises cobbles to boulders, which in some cases become difficult for fish to negotiate during low-flow conditions. Pools are comparatively rare and, where present, relatively shallow. The lack of pool and overwintering habitat limits productivity in many small watercourses and suggests that many creeks in the study area may not provide critical habitat required for sustaining fish populations. Thawing permafrost in the summer months maintains cold water temperatures at many of the crossing locations, which also limits habitat productive capacity.

2.1 Contribution to Local Fisheries

The remoteness and inaccessibility of the Casino and Dip Creek watersheds probably limits any recreational or Aboriginal fishing in the mine site area. Also, watersheds draining directly into the Yukon River along the proposed road corridor, and north of the mine site, are generally remote waterways with limited access for fishing activities. However, watersheds in the Project area support important life history stages for subsistence, recreational and commercial species of Yukon River fish, including Arctic grayling and salmon.

Adult Chinook salmon are known to spawn in Big and Selwyn Creeks, which also provide important overwintering habitat for a variety of fish species. Historically, the Yukon River supported regionally significant CRA Chinook salmon fisheries, with recent population declines observed from 1998 onwards (Joint Technical Committee (JTC), 2013). Due to the noted run failures, there have been restrictive regulations applied on recent harvesting activities in order to help stocks recover, including complete fisheries closures over multiple years (JTC, 2013; Yukon Salmon Sub-Committee, 2014).

Yukon River fall chum salmon support both commercial and Aboriginal fisheries, with 63% and 37% of the catch occurring in the commercial and Aboriginal fisheries, respectively (Yukon River Panel, 2008b). Commercial fisheries for chum salmon are located in the Minto and Dawson areas (Appendix 19A of the Project Proposal).

There are no commercial fisheries for other fish species in the Project study area, however, recreational and Aboriginal fishing activities may occur along the nearby Yukon River and in adjacent accessible tributaries. Of note is the Arctic grayling fishery, as grayling is considered the most popular sport fish in the Yukon (Environment Yukon, 2010).

2.2 Habitat Requirements

Arctic grayling and slimy sculpin are the most dominant fish species in the Project area, followed by juvenile Chinook salmon. Arctic grayling primarily occupy areas with clear, slow-moving water, typically with velocities of 20 to 110 cm/s (Hubert et al., 1985; Vehanen et al., 2003; Stewart et al., 2007). As juveniles, Arctic grayling reside in shallow pools and side channels within the lower and middle reaches of small streams (Stewart et al., 2007). Adult Arctic grayling undergo seasonal migrations upstream, where

they occupy slow-moving shallows and deeper pools (Roberge et al., 2002; Stewart et al., 2007). The formation of anchor ice in shallow, lower-order tributaries within the Project area during the fall and winter forces Arctic grayling (and other species) to retreat downstream to higher-order creeks with deeper pools. Arctic grayling spawning occurs from April to mid-June around ice break-up, in streams with velocities of 30 to 80 cm/s, and over gravel substrates (Stewart et al., 2007).

The slimy sculpin is a bottom-dwelling species, residing under cobble or other in-stream habitat cover features. Slimy sculpins demonstrate very high site fidelity, generally remaining within a 50 m-radius home range throughout their lives (Gray et al., 2004). Thus, all life history stages, including overwintering and spawning, must be carried out within this limited home range. Spawning takes place in the spring when temperatures approach 5 to 10°C, in nests on the underside of rocks, submerged rocks or other available in-stream habitat (Roberge et al., 2002).

Juvenile Chinook salmon in Yukon rear in freshwater generally for 1 year before migrating to sea. During the winters in freshwater, overwintering habitat with adequate oxygen, flow and water quality is critical for juvenile survival. They generally occupy slow-moving pools and stream margins, and are often found around undercut banks and woody debris accumulations (Healey, 1991). The importance of small, non-natal streams within the Yukon River watershed as habitat for juvenile Chinook salmon has been previously documented, particularly where deeper pools and slow-moving water were available (Bradford et al., 2001). Chinook spawning in Yukon takes place in low gradient (<4-5%) streams that sustain sufficient overwinter incubation flows over gravel-cobble substrate from July to September (Healy, 1991).

2.3 Limitations to Fisheries Productivity in the Project Study Area

An understanding of the factors that limit fisheries productivity, where project impacts are predicted, enables proposed offsetting measures to be designed specifically to address these potential bottlenecks in production. Several important habitat limitations have been identified in the watersheds surrounding the mine site (where most project impacts are anticipated):

- **Lack of overwintering habitat** – Deep pools provide an important ecological function through their provision of overwintering habitat and low-velocity refuge for juvenile rearing. Within the study area, deep pools capable of providing overwintering and juvenile rearing habitat are uncommon. Winter air temperatures are too cold, and winter baseflows from groundwater are generally insufficient, to prevent the formation of anchor ice and full, frozen-to-bed conditions. Fish are forced to retreat downstream, and overwinter and rear in deep pools of larger creeks that remain unfrozen at depth, such as Dip Creek. This natural, lack of overwintering habitat is common throughout the headwater drainages encompassing the Project area.

- **Unsuitable spawning habitat** – Arctic grayling, the most widely distributed species in the study area, require particular sizes and areas of gravel substrates in which to spawn. Much of the substrate along upper Casino Creek has been derived from colluvial mass movements from the adjacent valley sides; it is comprised of angular cobbles and boulders and is generally unsuitable for spawning, which typically requires unembedded gravel with an approximate diameter of 2.5 cm (Stewart et al., 2007 and references therein). Although spring and summer flow conditions along portions of Casino Creek are amenable to spawning activity, the rarity of appropriate gravel substrates represents a natural limitation on productivity (recruitment back into the population).

  Chinook spawning requirements are even more stringent than Arctic grayling requirements as spawning occurs in the fall, and the eggs require flowing water with sufficient oxygen over the winter season. Many streams in the study area freeze to bottom during the winter, including Casino Creek where anchor ice formation has been documented. Incubating embryos and alevin survival are susceptible to both freezing temperatures and the formation of anchor ice, which can cause reduced flows or even complete de-watering (Bjornn and Reiser, 1991). According to the habitat suitability maps produced by the Yukon Placer Secretariat (2010a, 2010b, 2010c), watercourses within the project area do not support spawning activities or provide critical migratory corridors for spawning Chinook salmon.

- **Natural obstructions to fish passage** – Periodic obstructions or barriers to fish passage have been documented in both upper Casino and Canadian Creeks during baseline sampling. A barrier (20% gradient cascade) to fish passage was documented in upper Canadian Creek, more than 1 km downstream of the majority of predicted impacts in the watershed. Upper Casino Creek and its tributaries are predisposed to naturally forming obstructions to fish habitat, at least seasonally, due to their cobbley to bouldery substrates, moderately steep gradients and relatively low discharges. Casino Creek exhibits small cascades and step-pool morphology in its upper reaches. Some of the boulder-formed steps create vertical drops of 0.5 m or more across the full width of the channel. Over time, these bedforms evolve; a boulder cascade one year may collapse into a fish-passable riffle another year. The capture of very few Arctic grayling in upper Casino Creek, only once in four years of sampling, may relate to the natural formation and collapse of in-stream barriers (Appendix 10A of the Project Proposal). In the long-term, this process limits the quality and reliability of habitat.

3 Summary of Impact Assessment

The assessment of potential impacts of the proposed Project on fish habitat was completed using a combination of methods, depending on whether impacts were predicted to result in a partial loss of flow, complete loss of flow, or loss of riparian habitat. A *Physical Habitat Simulation* (PHABSIM) was used to predict the change in 'usable' in-stream habitat following a reduction of flow along lower Casino Creek (downstream of the TMF), Dip Creek (farther downstream of the TMF) and lower Canadian Creek (downstream of the open pit) (Section 3.1.1). A *Habitat Evaluation Procedure* (HEP) was used to quantify predicted impacts following a complete loss of flow along upper Casino Creek and its headwater tributaries, within and upstream of the TMF footprint; along lower Britannia Creek, in association with reinstatement of the historical, meandering channel as a form of habitat offsetting; and along an unnamed tributary of Dip Creek, which must be diverted around the proposed airstrip (Section 3.1.2). Both methods, originally developed by the U.S. Fish and Wildlife Service, have been widely used across North America as a reliable model for quantifying habitat loss. Recent environmental assessments for similar projects in Canada have successfully employed either PHABSIM or HEP (e.g., Mount Milligan, Kemess, Doris North). Detailed documentation of the comprehensive methods and results of the PHABSIM and HEP studies is provided by PECG and Normandeau Associates, Inc. (Normandeau) (2014) in the Project Proposal Supplementary Information Report (Appendix A.10B). Both PHABSIM and HEP are advantageous methods as they provide a means of quantifying biologically-relevant habitat loss, or gain, by taking into account the habitat preferences and requirements of a species at varying life stages. Further, the methods allow a standardized measurement of habitat loss, which facilitates an effective comparison with different potential offsetting opportunities, regardless of habitat type.

Predicted impacts to riparian habitat were quantified with consideration for the suitability and sensitivity of adjacent in-stream habitat (Section 3.1.3). Following the overview of habitat impact evaluation (Section 3.1), a summary is provided of predicted habitat impacts corresponding to each main component of the Project (Section 3.2). Section 3.3 highlights several ways in which Project design changes were made to avoid or significantly reduce potential impacts to habitat that might otherwise have occurred.

3.1 Habitat Impact Evaluation

3.1.1 Physical Habitat Simulation (PHABSIM)

Overview

PHABSIM is designed to characterize the amount of usable habitat available for a specific fish species at different ages and life history stages including rearing, spawning and overwintering. Measuring the area (m^2) of usable habitat is done by integrating habitat suitability indices (HSI curves) derived from scientific literature that define the range of age- and stage-specific optimal flows, depths and substrate types for a particular species, in this case Arctic grayling. Arctic grayling is one dominant species with widespread distribution in the Project area, and data for flow and habitat indices are available in the literature for this species. Thus, the usable habitat index is defined as a proportion of the total usable habitat (m^2/1000 m of stream length) at a specific flow. PHABSIM can be used further to predict habitat losses under

different flow scenarios, providing a range of potential responses over the Project life. Accordingly, it is possible to quantify the usable habitat index for each age and life history stage, both before and after development.

Methods and Results

Habitat type units were identified and mapped along Reach 1 of Casino Creek; along Dip Creek, from its confluence with Casino Creek downstream to its confluence with the next major tributary (beyond which effects would be undetectable); and along lower Canadian Creek (**Figure 1-1**, **Table 3-1**). Next, hydrology transect locations were chosen in different habitat type units on the basis of their relative abundance in the creek reach under investigation. Casino Creek was divided into two, 3.25 km-long sections, upper and lower, with ten transect sites in each section. Two groups of ten transects were selected in Dip Creek, starting just downstream of its confluence with Casino Creek. Twenty transects were originally selected in Canadian Creek, starting just upstream of the confluence with Britannia Creek. One transect was later removed as changes in the discharge rendered it inappropriate for the model.

Table 3-1. Descriptions of Habitat Types Characterized along Casino, Dip and Canadian Creeks

Habitat Type	Description
Pool	• Low velocity flow
	• Generally deep across the channel or scoured along one bank
	• Often contain eddies along one or both banks
	• Retains standing water as discharge approaches zero
Glide	• Shallow, uniform channel with smooth or laminar flow
	• Normally little or no exposed substrate
	• Typically do not have defined thalweg
	• May also occur in tailouts of pools or interspersed with runs
Run	• Generally deep, higher velocity flow
	• Can contain intermittent exposed boulders, bedrock or coarse substrate
	• Well-defined thalweg, often along one bank
Low Gradient Riffle	• Shallow and turbulent, white-water flow, exposed substrate at low flows
	• Usually composed of gravel/cobble substrate
	• Lacks any definitive thalweg
	• Generally act as controls for lower gradient habitat types
High Gradient Riffle	• Fast, high gradient (usually greater than 4%) habitat type
	• Substrate generally cobble or boulder dominated
	• May have interspersed steps and small pools at low flow
Cascade	• Steep, high gradient habitat type
	• May have interspersed pools at low flow
Other	• Includes any uncommon habitat type (e.g., falls, bedrock chutes, etc.)

Velocity, depth and water elevation measurements along each transect were recorded during one sampling event, and water surface elevations, along with one representative discharge measurement, were recorded during two more sampling events. Sampling events were conducted in order to obtain

three distinct flow regimes (Low, Mid, High) in the creek whenever possible. Bank elevations at each transect were also measured from the water level up to the estimated high water mark to facilitate a complete creek profile. The following substrate types were documented for aiding in the habitat suitability modeling:

- Organics/Silt/Mud
- Fines (<0.2 cm)
- Gravel (0.2 – 6.4 cm)
- Rubble (6.4 – 17.0 cm)
- Cobble (17.0 – 25.6 cm)
- Boulders (>25.6 cm)
- Bedrock

Habitat suitability indices for Arctic grayling were obtained from Hubert et al. (1985), a reference commonly used in habitat offsetting planning (e.g., Ruby Creek Molybdenum Project 2006, Adanac Moly Corporation). Although slimy sculpin is the most dominant fish species in Casino and Dip Creeks, the species was not used for in-stream flow modeling as it is a sedentary benthic species, and has no habitat suitability indices derived. Instead, Arctic grayling was chosen for modeling as it is also a dominant species in Casino and Dip Creeks, it has habitat suitability data available, and it has similar habitat requirements to one of the key species being targeted for offsetting: Chinook salmon.

Each hydrologic cross-section was subdivided into a minimum of 20 cells, with each cell conveying approximately 0 to 10% of the total flow. The area of each cell (m^2) was derived using water depth and a cross-section length interval at a specific flow. Each cross-section cell was designated a habitat score, depending on the measured habitat quality of the cell and how it compared with the habitat requirements for a specific Arctic grayling life stage (Hubert et al., 1985). The habitat score was multiplied with the total cell area to obtain the proportion of usable habitat in that cell. The usable habitat in each cross-section cell was combined to estimate the total usable habitat of the entire cross-section. The calculations were done for each Arctic grayling life stage separately, given their different habitat requirements.

Each cross-section represented a specific habitat type (e.g., run, pool, glide, riffle) found in Casino, Dip or Canadian Creek. The known proportion of each habitat type was used to extrapolate results from habitat usability calculations to the entire creek length. In Casino Creek, for example, Site 1-Transect 1 was recorded as a run. As runs in Reach 1 of Casino Creek comprised 36% of the total length, and a total of six run transects were measured, the representative contribution of Site 1-Transect 1 was 6% (0.36/6*100=6%). Thus, the calculated usable habitat at Site 1-Transect 1, for a specific flow, was used to represent 6% of the total length of Reach 1 of Casino Creek, or 0.39 km.

The usable habitat of a cross-section varies depending on the water stage. Thus, using the three sets of hydrologic measurements at each cross-section, the velocity and depth for Low, Mid and High flow conditions were calculated using the MANSQ channel conveyance method developed by Normandeau. Usable habitat for each Arctic grayling life stage was then calculated for a full range of potential flows, for example as shown below for Casino Creek (**Figure 3-1**).

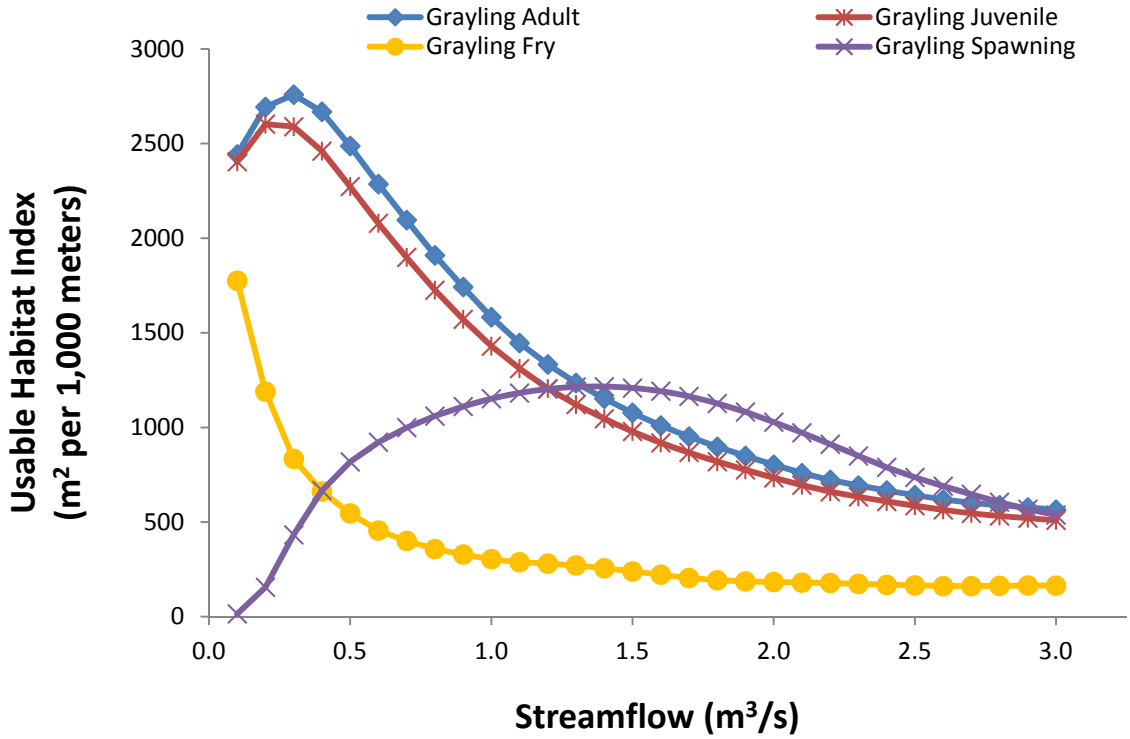


Figure 3-1. Habitat Index versus Flow for All Life Stages of Arctic Grayling in Casino Creek

As a basis for estimating the changes in usable habitat following project development, hydrological data from stream gauges recently installed in Casino, Dip and Canadian Creeks were combined with long-term flow records from nearby, permanent gauges (prorated according to watershed area) to generate long-term synthetic flow series (Knight Piésold, 2013b). To estimate the effect of each project phase on flows in Reach 1 of Casino Creek, flows from mid Casino Creek (H18) were subtracted from those in lower Casino Creek (W4). Baseline and project-phase flows were then entered into the in-stream flow model to estimate changes in usable habitat for each life stage during each project phase, averaged for the two flow stations (**Table 3-2**). As the net loss would still fluctuate depending on the time of year and thus flow chosen for the model, the amount of usable habitat available during 50% or more of the year was used in the final assessment.

In order to ensure all habitat impacts were represented in the predicted totals across all project phases, impacts to different life stages were added by project phase, and then the maximum phase-specific habitat loss was selected for the final impact value (residual serious harm to fisheries) for each affected area (**Table 3-3**). Adult and juvenile Arctic grayling usable habitat losses were not considered additive, because their HSI curves are almost identical, and it would be redundant to include both losses.

Table 3-2. Habitat Index Value (m^2/1000 m) for Arctic Grayling Life Stages at Selected Habitat Duration Percentages under Baseline and Project Phases for Casino Creek (H18 and W4 Average)

Duration	Usable Habitat (m^2/1000 m)					Change in Usable Habitat from Baseline (m^2/1000 m)				Percent Change in Usable Habitat from Baseline (m^2/1000 m)			
Percent	Baseline	Construction	Operation	Closure	Post-Closure	Construction	Operation	Closure	Post-Closure	Construction	Operation	Closure	Post-Closure
	Arctic Grayling Adult					Arctic Grayling Adult				Arctic Grayling Adult			
10	2732	2748	2748	2734	2726	16	16	2	-5	0.6%	0.6%	0.1%	-0.2%
25	2629	2717	2717	2672	2583	88	88	43	-46	3.3%	3.3%	1.6%	-1.7%
50	**2305**	**2606**	**2606**	**2413**	**2139**	**301**	**301**	**108**	**-167**	**13.1%**	**13.1%**	**4.7%**	**-7.2%**
75	1695	2377	2377	1822	1508	683	683	127	-187	40.3%	40.3%	7.5%	-11.0%
90	1026	1793	1786	1116	919	767	760	90	-108	74.8%	74.1%	8.8%	-10.5%
	Arctic Grayling Juvenile					Arctic Grayling Juvenile				Arctic Grayling Juvenile			
10	2592	2601	2601	2594	2575	9	9	1	-17	0.3%	0.3%	0.0%	-0.7%
25	2473	2590	2590	2506	2415	118	118	34	-58	4.8%	4.8%	1.4%	-2.3%
50	**2099**	**2492**	**2492**	**2219**	**1939**	**393**	**393**	**120**	**-160**	**18.7%**	**18.7%**	**5.7%**	**-7.6%**
75	1530	2249	2249	1646	1364	719	719	116	-167	47.0%	47.0%	7.6%	-10.9%
90	934	1655	1651	1014	837	721	717	80	-97	77.2%	76.8%	8.6%	-10.4%
	Arctic Grayling Fry					Arctic Grayling Fry				Arctic Grayling Fry			
10	1040	1735	1735	1154	945	696	695	114	-94	66.9%	66.8%	11.0%	-9.0%
25	698	1476	1475	764	636	779	778	66	-62	111.6%	111.5%	9.5%	-8.9%
50	**468**	**991**	**989**	**521**	**412**	**523**	**521**	**54**	**-55**	**111.8%**	**111.3%**	**11.5%**	**-11.8%**
75	322	664	664	344	296	342	342	22	-26	106.2%	106.2%	6.8%	-8.1%
90	225	432	431	244	204	207	206	20	-21	92.0%	91.6%	8.9%	-9.3%
	Arctic Grayling Spawning					Arctic Grayling Spawning				Arctic Grayling Spawning			
10	1170	1049	1053	1166	1157	-121	-117	-3	-13	-10.3%	-10.0%	-0.3%	-1.1%
25	990	694	702	1008	1022	-296	-288	17	31	-29.9%	-29.1%	1.7%	3.1%
50	**620**	**135**	**134**	**571**	**668**	**-485**	**-486**	**-49**	**48**	**-78.2%**	**-78.4%**	**-7.9%**	**7.7%**
75	312	15	16	229	368	-296	-296	-83	57	-94.9%	-94.9%	-26.6%	18.3%
90	133	10	10	98	163	-123	-123	-35	30	-92.5%	-92.5%	-26.3%	22.6%

Note: From PECG and Normandeau (2014)

Table 3-3. Total Adverse Impact to Usable Habitat (m^2) for Arctic Grayling Life Stages for Casino Creek (Average Values), Dip Creek and Canadian Creek under All Project Phases

Stream	Life Stage	Net Change in Usable Habitat from Baseline (m^2)			
		Construction	Operation	Closure	Post-Closure
Casino	Arctic Grayling Combined Rearing[a]	1956 (13.1%)	1956 (13.1%)	703 (4.7%)	-1083 (-7.2%)
	Arctic Grayling Fry	3402 (111.9%)	3389 (111.5%)	349 (11.5%)	-360 (-11.8%)
	Arctic Grayling Spawning	-3155 (-78.3%)	-3157 (-78.4%)	-320 (-7.9%)	311 (7.7%)
Total Adverse Impact[b]:		-3155 (-78.3%)	**-3157 (-78.4%)**	-320 (-7.9%)	-1443 (-8.0%)
Dip	Arctic Grayling Combined Rearing[a]	2579 (7.0%)	2579 (7.0%)	562 (1.7%)	-1001 (-2.7%)
	Arctic Grayling Fry	-164 (-3.2%)	-164 (-3.2%)	-13 (-0.3%)	54 (1.0%)
	Arctic Grayling Spawning	-147 (-1.9%)	-147 (-1.9%)	-90 (-1.1%)	38 (0.5%)
Total Adverse Impact[b]:		-311 (-2.3%)	-311 (-2.3%)	-103 (-0.8%)	**-1001 (-2.7%)**
Canadian	Arctic Grayling Combined Rearing[a]	0 (0.0%)	52 (0.05%)	-59 (-0.6%)	-59 (-0.6%)
	Arctic Grayling Fry	0 (0.0%)	272 (8.8%)	882 (28.7%)	882 (28.7%)
	Arctic Grayling Spawning	0 (0.0%)	-52 (-2.5%)	-240 (-11.4%)	-240 (-11.4%)
Total Adverse Impact[b]:		0 (0.0%)	-52 (-2.5%)	**-299 (-2.4%)**	**-299 (-2.4%)**

*Based on PECG and Normandeau (2014); bolded values are used in final habitat loss calculations (as shown below in **Table 3-8**)*

[a] Represents the most conservative estimate of impact from Artic Grayling Adult Rearing and Arctic Grayling Juvenile Rearing values

[b] Represents the sum of all adverse impacts to usable habitat that occur in any one Project phase, excluding net gains

A long-term synthetic flow series for Dip Creek, downstream of Casino Creek, was generated by Knight Piésold (2013b) based on the sum of flows at gauges W4 (Casino Creek, near mouth) and W9 (Dip Creek, immediately upstream of the confluence with Casino Creek) (**Figure 1-1**). Baseline and project-phase flows were then entered into the in-stream flow model for Dip Creek to assess predicted changes in usable habitat (**Table 3-4**). The final habitat loss values are provided in **Table 3-3**.

The long-term synthetic flow series for Canadian Creek was generated by Knight Piésold (2013b) based on flow records from the gauge in lower Canadian Creek (W3). Baseline and project-phase flows were then entered into the in-stream flow model for Canadian Creek to assess predicted changes in usable habitat (**Table 3-5**). The habitat loss values are provided in **Table 3-3**.

Table 3-4. Habitat Index Value (m^2/1000 m) for Arctic Grayling Life Stages at Selected Habitat Duration Percentages under Baseline and Project Phases for Dip Creek, Downstream of Casino Creek

Duration	Usable Habitat (m^2/1000 m)					Change in Usable Habitat from Baseline (m^2/1000 m)				Percent Change in Usable Habitat from Baseline (m^2/1000 m)			
Percent	Baseline	Construction	Operation	Closure	Post-Closure	Construction	Operation	Closure	Post-Closure	Construction	Operation	Closure	Post-Closure
	Arctic Grayling Adult					Arctic Grayling Adult				Arctic Grayling Adult			
10	6000	5978	5978	6021	6000	-22	-22	20	0	-0.4%	-0.4%	0.3%	0.0%
25	5248	5419	5419	5246	5188	171	171	-1	-59	3.3%	3.3%	0.0%	-1.1%
50	**4323**	**4626**	**4626**	**4394**	**4205**	**303**	**303**	**71**	**-118**	**7.0%**	**7.0%**	**1.6%**	**-2.7%**
75	2806	3047	3047	2818	2796	240	240	11	-10	8.6%	8.6%	0.4%	-0.4%
90	2562	2562	2562	2562	2562	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Arctic Grayling Juvenile					Arctic Grayling Juvenile				Arctic Grayling Juvenile			
10	5475	5457	5457	5487	5494	-18	-18	12	18	-0.3%	-0.3%	0.2%	0.3%
25	4752	4912	4912	4782	4679	161	161	30	-73	3.4%	3.4%	0.6%	-1.5%
50	**3879**	**4191**	**4191**	**3946**	**3780**	**312**	**312**	**66**	**-100**	**8.0%**	**8.0%**	**1.7%**	**-2.6%**
75	2557	2778	2778	2570	2552	221	221	12	-5	8.6%	8.6%	0.5%	-0.2%
90	2406	2406	2406	2407	2406	0	0	0	-1	0.0%	0.0%	0.0%	0.0%
	Arctic Grayling Fry					Arctic Grayling Fry				Arctic Grayling Fry			
10	716	716	716	719	714	0	0	3	-1	0.0%	0.0%	0.4%	-0.1%
25	692	686	686	692	694	-6	-6	-1	1	-0.9%	-0.9%	-0.1%	0.1%
50	**611**	**591**	**591**	**609**	**617**	**-19**	**-19**	**-2**	**6**	**-3.1%**	**-3.1%**	**-0.3%**	**1.0%**
75	560	555	555	561	559	-5	-5	1	-1	-0.9%	-0.9%	0.2%	-0.2%
90	536	534	534	536	538	-2	-2	1	2	-0.4%	-0.4%	0.2%	0.4%
	Arctic Grayling Spawning					Arctic Grayling Spawning				Arctic Grayling Spawning			
10	1223	1232	1232	1234	1236	9	9	11	12	0.7%	0.7%	0.9%	1.0%
25	1128	1095	1095	1129	1138	-33	-33	2	10	-2.9%	-2.9%	0.2%	0.9%
50	**933**	**916**	**916**	**922**	**937**	**-17**	**-17**	**-11**	**4**	**-1.8%**	**-1.8%**	**-1.2%**	**0.4%**
75	686	671	671	673	691	-15	-15	-13	5	-2.2%	-2.2%	-1.9%	0.7%
90	216	186	186	215	220	-31	-31	-2	3	-14.4%	-14.4%	-0.9%	1.4%

Note: From PECG and Normandeau (2014)

Table 3-5. Habitat Index Value (m^2/1000 m) for Arctic Grayling Life Stages at Selected Habitat Duration Percentages under Baseline and Project Phases for Canadian Creek (W3)

Duration	Usable Habitat (m^2/1000 m)					Change in Usable Habitat from Baseline (m^2/1000 m)				Percent Change in Usable Habitat from Baseline (m^2/1000 m)			
Percent	Baseline	Construction	Operation	Closure	Post-Closure	Construction	Operation	Closure	Post-Closure	Construction	Operation	Closure	Post-Closure
	Arctic Grayling Adult					Arctic Grayling Adult				Arctic Grayling Adult			
10	1831	1831	1830	1814	1814	0	-1	-17	-17	0.0%	-0.1%	-0.9%	-0.9%
25	1756	1756	1751	1724	1724	0	-5	-32	-32	0.0%	-0.3%	-1.8%	-1.8%
50	**1454**	**1454**	**1468**	**1446**	**1446**	**0**	**13**	**-8**	**-8**	**0.0%**	**0.9%**	**-0.6%**	**-0.6%**
75	959	959	977	1004	1004	0	18	45	45	0.0%	1.9%	4.7%	4.7%
90	478	478	507	589	589	0	29	111	111	0.0%	6.1%	23.2%	23.2%
	Arctic Grayling Juvenile					Arctic Grayling Juvenile				Arctic Grayling Juvenile			
10	1609	1609	1608	1593	1593	0	0	-16	-16	0.0%	0.0%	-1.0%	-1.0%
25	1547	1547	1544	1535	1535	0	-4	-12	-12	0.0%	-0.3%	-0.8%	-0.8%
50	**1299**	**1299**	**1307**	**1313**	**1313**	**0**	**7**	**13**	**13**	**0.0%**	**0.5%**	**1.0%**	**1.0%**
75	916	916	918	940	940	0	2	24	24	0.0%	0.2%	2.6%	2.6%
90	420	420	444	513	513	0	24	93	93	0.0%	5.7%	22.1%	22.1%
	Arctic Grayling Fry					Arctic Grayling Fry				Arctic Grayling Fry			
10	1714	1714	1752	1847	1847	0	37	133	133	0.0%	2.2%	7.8%	7.8%
25	915	915	1004	1188	1188	0	88	273	273	0.0%	9.6%	29.8%	29.8%
50	**439**	**439**	**478**	**565**	**565**	**0**	**39**	**126**	**126**	**0.0%**	**8.9%**	**28.7%**	**28.7%**
75	277	277	289	317	317	0	12	39	39	0.0%	4.3%	14.1%	14.1%
90	203	203	201	207	207	0	-2	4	4	0.0%	-1.0%	2.0%	2.0%
	Arctic Grayling Spawning					Arctic Grayling Spawning				Arctic Grayling Spawning			
10	522	522	526	526	526	0	4	4	4	0.0%	0.8%	0.8%	0.8%
25	471	471	469	451	451	0	-2	-20	-20	0.0%	-0.4%	-4.2%	-4.2%
50	**300**	**300**	**293**	**266**	**266**	**0**	**-7**	**-34**	**-34**	**0.0%**	**-2.3%**	**-11.3%**	**-11.3%**
75	208	208	181	135	135	0	-27	-73	-73	0.0%	-13.0%	-35.1%	-35.1%
90	108	108	92	72	72	0	-16	-36	-36	0.0%	-14.8%	-33.3%	-33.3%

Note: From PECG and Normandeau (2014)

Results from PHABSIM for Reach 1 of Casino Creek demonstrate that the usable habitat area for most life history stages will increase during the construction and operational phases of the project, with the exception of spawning habitat (**Table 3-6**). A small additional increase in usable habitat is noted for adult, juvenile and fry rearing during the closure phase. The increases in habitat can be mainly attributed to the lower flows predicted following TMF construction, which will facilitate a larger area of the creek being usable for Arctic grayling during both adult and juvenile rearing, with a higher net change in usable habitat predicted for the latter. As higher velocities are optimal for spawning, estimated reductions in flow are predicted to reduce the volume of usable habitat for this life stage during construction (3,155 m^2, or 78.3%), operation (3,157 m^2, or 78.4%) and closure (320 m^2, or 7.9%). As there is no evidence for spawning activities in Casino Creek, the net loss of spawning habitat is likely to have minimal impact on Arctic grayling production. However, the reduction in spawning habitat is noted as a conservative measure and included in the total calculation for habitat loss. During the post-closure phase, the largest habitat losses in lower Casino Creek are predicted for adult rearing (1,083 m^2, or 7.2%) and juvenile rearing (1,038 m^2, or 7.6%), followed by fry rearing (360 m^2, or 11.8%). A small increase in spawning habitat is predicted.

In Dip Creek, the amount of usable habitat is predicted to increase for adult and juvenile Arctic grayling during the construction, operation and closure phases of the project, reflecting slight reductions in velocity in association with reduced flow contributions from Casino Creek (**Table 3-6**). During the post-closure phase, small reductions in usable habitat of 1,001 m^2 (2.7%) and 847 m^2 (2.6%) are predicted for adult and juvenile rearing habitat, respectively, due to periodic increased discharges from the reclaimed TMF upstream. Fry rearing habitat is predicted to decrease by 164 m^2 (3.2%) during construction and operations, but by only 13 m^2 (0.3%) during closure. Spawning habitat is predicted to decrease by only 147 m^2 (1.9%) during construction and operations, and by only 90 m^2 (1.1%) during closure. Fry and spawning life stages are expected to return to baseline values during the post-closure phase.

In Canadian Creek, small increases in usable habitat are predicted for Arctic grayling adults, juveniles and fry during the operation phase of the project (**Table 3-6**). Spawning habitat is expected to decrease by 52 m^2 (2.5%) during operations. During closure and post-closure phases, a 59 m^2 (0.6%) decrease in adult rearing habitat is expected, while a slight increase in juvenile rearing and fry habitat is predicted. Usable spawning habitat is predicted to be reduced by 240 m^2 (11.4%).

Table 3-6. Usable Habitat (m^2), Total Available Habitat (m^2) and Net Change from Baseline for Arctic Grayling Life Stages for Lower Casino Creek, Dip Creek and Canadian Creek under All Project Phases

Stream	Usable Habitat (m^2)					Net Change in Usable Habitat from Baseline (m^2)			
	Baseline	Construction	Operation	Closure	Post-Closure	Construction	Operation	Closure	Post-Closure
	Arctic Grayling Adult					Arctic Grayling Adult			
Casino	14984	16940	16940	15687	13901	1956 (13.1%)	1956 (13.1%)	703 (4.7%)	-1083 (-7.2%)
Dip	36741	39321	39321	37346	35740	2579 (7.0%)	2579 (7.0%)	605 (1.6%)	**-1001 (-2.7%)**
Canadian	10179	10179	10273	10120	10120	0 (0.0%)	94 (0.9%)	-59 (-0.6%)	-59 (-0.6%)
	Arctic Grayling Juvenile					Arctic Grayling Juvenile			
Casino	13643	16197	16197	14423	12605	2555 (18.7%)	2555 (18.7%)	780 (5.7%)	-1038 (-7.6%)
Dip	32975	35623	35623	33537	32128	2648 (8.0%)	2648 (8.0%)	562 (1.7%)	-847 (-2.6%)
Canadian	9096	9096	9148	9189	9189	0 (0.0%)	52 (0.6%)	93 (1.0%)	93 (1.0%)
	Arctic Grayling Fry					Arctic Grayling Fry			
Casino	3040	6442	6428	3389	2679	3402 (111.9%)	3389 (111.5%)	349 (11.5%)	-360 (-11.8%)
Dip	5190	5027	5027	5178	5245	-164 (-3.2%)	-164 (-3.2%)	-13 (-0.3%)	54 (1.0%)
Canadian	3075	3075	3348	3957	3957	0 (0.0%)	272 (8.8%)	882 (28.7%)	882 (28.7%)
	Arctic Grayling Spawning					Arctic Grayling Spawning			
Casino	4029	874	872	3709	4340	-3155 (-78.3%)	**-3157 (-78.4%)**	-320 (-7.9%)	311 (7.7%)
Dip	7929	7783	7783	7839	7967	-147 (-1.9%)	-147 (-1.9%)	-90 (-1.1%)	38 (0.5%)
Canadian	2103	2103	2051	1863	1863	0 (0.0%)	-52 (-2.5%)	**-240 (-11.4%)**	**-240 (-11.4%)**
	Available Habitat (m^2)					**Net Change in Available Habitat from Baseline (m^2)**			
	Rearing (May 15 to Sept 30)					Rearing (May 15 to Sept 30)			
Casino	29959	28521	28523	29778	30203	-1438 (-4.8%)	-1437 (-4.8%)	-181 (-0.6%)	244 (0.8%)
Dip	90268	87926	87926	90022	90558	-2342 (-2.6%)	-2342 (-2.6%)	-245 (-0.3%)	291 (0.3%)
Canadian	35040	35040	34786	34239	34239	0 (0.0%)	-254 (-0.7%)	-801 (-2.3%)	-801 (-2.3%)
	Spawning (May 15 to June 30)					Spawning (May 15 to June 30)			
Casino	29426	27955	27985	29515	29662	-1472 (-5.0%)	-1441 (-4.9%)	89 (0.3%)	236 (0.8%)
Dip	87110	85139	85139	87283	87759	-1971 (-2.3%)	-1971 (-2.3%)	172 (0.2%)	648 (0.7%)
Canadian	36901	36901	36625	36123	36123	0 (0.0%)	-276 (-0.7%)	-778 (-2.1%)	-778 (-2.1%)

*Notes: From PECG and Normandeau (2014); bolded values used in final habitat loss calculation (as shown below in **Table 3-8**)*

3.1.2 Habitat Evaluation Procedure (HEP)

Overview

HEP is based on the rationale that the most limited but important habitat characteristic in a waterbody is restricting and therefore regulating fisheries capacity. The total amount of habitat lost calculated using stream measurements is then adjusted to the predicted area of habitat being used, which varies depending on the estimated magnitude of limitation.

Methods and Results

Habitat in reaches 2 and 3 of Casino Creek, which would be impacted by the construction of the TMF, was mapped over its entire 7.5 km length by habitat unit type and length (**Table 3-1**). The TMF's footprint also necessitated habitat mapping along Meloy Creek, lower Taylor Creek downstream of a natural fish barrier (vertical drop along a steep gradient), and three unnamed eastern tributaries of Casino Creek. Habitat mapping was completed along an unnamed tributary to Dip Creek, which would be abandoned when flow is diverted around the proposed airstrip (Section 3.3.3), and along the lower reach of Britannia Creek, in order to represent loss following the proposed reinstatement of the historical meandering channel in association with habitat offsetting (Section 5.1.1).

Within each habitat unit, several parameters were measured including mean depth, mean width, substrate, cover type and percentage, and maximum pool depth. In areas deemed suitable for Arctic grayling spawning, additional information was collected including the percentage of spawning substrate (e.g., gravel and rubble), the percentage of fine substrate (<0.2 cm diameter), area (m^2) of spawning habitat available, and estimated velocity.

Habitat data were analyzed to determine habitat features that may be limiting Arctic grayling productive capacity. From this analysis, five habitat variables were chosen as being potentially limiting: % spawning substrate, % fines in spawning areas, % total fines, overwintering habitat, and % pools and backwaters. Using habitat suitability indices (Hubert et al., 1985), a score was assigned to each habitat variable ranging from 0 to 1, with 1 representing the most optimal conditions for Arctic grayling and indicating that 100% of the available habitat is usable, and 0 indicating that no habitat is usable.

Results of all completed HEP studies in the Project area are summarized below in **Table 3-7**. HSI results were derived in Casino Creek and its small tributaries, Britannia Creek, and the unnamed tributary of Dip Creek from the lack of appropriate pool habitat, which is required for Arctic grayling rearing. It is also likely the greatest constraint to their production in these watersheds. The Meloy Creek HSI score of 0.0 reflects both the lack of available pool habitat in the creek and the predominance of fine sediment substrates.

Table 3-7. Results of HEP Studies Quantifying Predicted Habitat Loss

Watercourse Segment (project impact in parentheses)	Total Available Habitat (m^2)	HIS Score Applied	Net Habitat Loss[a] (m^2)
Casino Creek – Reach 2 (TMF footprint and influence)	19,499	0.26	5,070
Casino Creek – Reach 3 (TMF footprint)	19,653	0.26	5,110
Taylor Creek (below natural fish barrier) (TMF footprint)	553	0.20	111
Casino Creek Tributary 1 (below natural fish barrier) (TMF footprint)	149	0.0	0
Casino Creek Tributary 2 (TMF footprint)	1,514	0.5	757
Casino Creek Tributary 3 (TMF footprint)	3,679	1.0	3,679
Meloy Creek (TMF footprint)	4,222	0.0	0
Lower Britannia Creek Existing 'Roadway' Channel (reinstatement of historical channel for offsetting)	9,535	0.25	2,384
Lower Britannia Creek Existing 'Roadway' Channel Backwater Pool at Mouth (reinstatement of historical channel for offsetting)	1,728	1.0	1,728
Unnamed Tributary to Dip Creek (diversion around airstrip)	2,203	0.15	330
TOTAL	**62,735**		**19,169**

[a] *Based on analyses in Normandeau and PECG (2014); used in final habitat loss calculation (as shown below in* ***Table 3-8****)*

In order to estimate the anticipated *gain* in usable habitat associated with the reinstatement of the historical, meandering channel of lower Britannia Creek, in a manner that is consistent with the estimation of usable habitat loss along its existing lower channel, a 'reverse' HEP was completed. Fundamental to this approach is an understanding of the types, dimensions and distribution of different habitat units and substrates along the historical channel, but the current dry conditions necessitated modelling the flow parameters. Detailed topographic survey data collected along the channel using Trimble RTK GPS units established a digital elevation model of existing channel morphology. These data were analyzed in a River2D modelling program, assuming the same hydrology as in the adjacent existing channel, in order to generate a grid of two-dimensional flow parameters including depth and velocity vectors (magnitude and direction) (**Figure 3-2**). The resultant depth and velocity distribution provides an indication of the extent of different hydraulic habitats likely to be re-established once flow is diverted back into the historical channel.

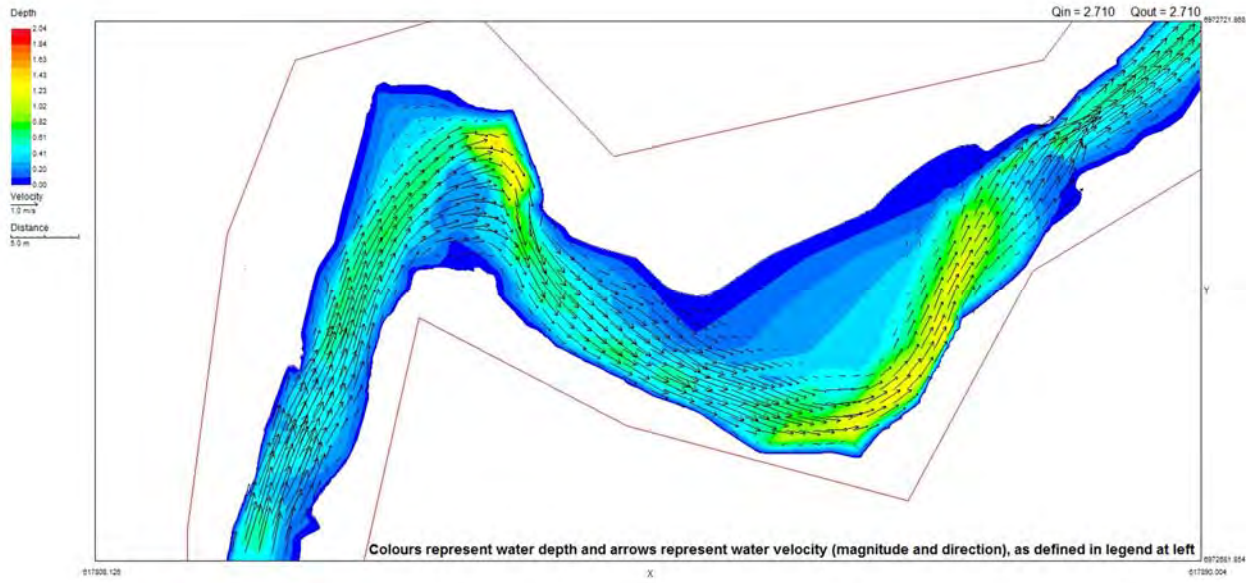


Figure 3-2. Typical River2D Modelling Results (2.71 m³/s) for Britannia Creek Historical Channel

Estimations of the length of each habitat unit were interpreted in ArcGIS based on River2D output rasters (grids) of depth and velocity, with reference to field photographs and notes, and consideration of typical flow dynamics through meanders. Habitat unit widths were determined by averaging multiple width measurements within each unit. Once completed, the habitat unit measurements were evaluated using the same HEP model used for other creeks in the Project area.

3.1.3 Riparian Habitat

Impacts to riparian habitat were calculated for the mine site area and along the access roads, wherever a project facility footprint or road crossing is predicted to result in a loss of riparian vegetation. Impacts were quantified by multiplying the length of stream alongside which the riparian habitat impacts are anticipated by one of three buffer widths, based on the suitability and sensitivity of fish habitat:

- 30 m riparian habitat buffer alongside stream sections that support Chinook salmon;
- 15 m riparian habitat buffer alongside stream sections that support fish other than Chinook salmon; and
- 5 m riparian habitat buffer alongside stream sections that do not support fish habitat, and within the upper Casino Creek watershed above the Reach 2/3 break where fish utilization is rare (i.e., Casino Creek Reach 3, lower Taylor Creek (downstream of a natural fish barrier) and the eastern Casino Creek Tributary 3 (**Figure 1-1**)).

Riparian habitat impacts may occur in association with corresponding in-stream habitat impacts, such as along upper Casino Creek within the TMF footprint, or they may occur independently, such as along watercourses proposed to be crossed by clear-span bridges along the access roads. Total riparian impacts were determined for both fish-bearing and non-fish bearing streams.

3.2 Habitat Impacts

Predicted impacts of the main Project components on in-stream and riparian habitat are summarized below in **Tables 3-8** and **3-9**, respectively, and described in Sections 3.2.1 to 3.2.6. The component-specific impacts are presented alphabetically for consistency with the detailed accounts of impacts provided in Section 10 of the Project Proposal.

3.2.1 Airstrip and Access Road

Construction of the airstrip and access road will require the clearing and grubbing of vegetation, the installation of culverts and bridges along the 14 km-long access road, and the construction of the airstrip and associated facilities. The 2000 m-long airstrip will be located in the Dip Creek valley approximately 12 km southwest of the mine site. A small, unnamed tributary crosses the proposed location of the airstrip. It is not feasible to convey streamflow from the watercourse beneath the airstrip through a culvert due to the risk of damage to the airstrip from irregular ground subsidence from thawing, ice-rich permafrost and from blockages by seasonal ice formation (AE, pers. comm., 2014). In order to safely convey streamflow around the airstrip and avoid the loss of upstream habitat, a naturalized diversion channel that accommodates fish passage is proposed to be constructed along an existing drainage path along the southern edge of the gentle alluvial fan on which the airstrip's southern portion is situated. This diversion will necessitate abandonment and loss of approximately 330 m^2 of usable in-stream habitat along the existing channel (based on a HEP), from its confluence at Dip Creek upstream to the proposed entrance to the diversion channel (**Table 3-8**). The proposed airstrip diversion channel will mimic existing channel morphology, minimize the risk of sedimentation to Dip Creek and provide connectivity to habitat upstream of the airstrip. Losses in riparian habitat (**Table 3-9**) will be offset by the proposed diversion channel's existing, mature riparian vegetation.

The airstrip access road will require the construction of six clear-span bridges over Dip Creek, Brynelson Creek and four unnamed fish-bearing creeks, and four major culverts along non-fish-bearing watercourses. As clear-span bridges will be installed on all fish-bearing creeks, only non-fish-bearing habitat will be lost along the access road due to culvert installations. In addition, riparian habitat loss and alteration will occur adjacent to both fish-bearing and non-fish-bearing crossings (**Table 3-9**).

3.2.2 Canadian Creek Diversion

The Canadian Creek diversion around the Open Pit is proposed for Year 10 of operations, when the Open Pit footprint intersects the creek. The upper section of Canadian Creek is non-fish bearing, with an identified high-gradient (>20%), cascade barrier located approximately 1.2 km downstream of the proposed diversion. Thus, there will be no fish-bearing habitat loss due to the diversion of Canadian Creek.

Table 3-8. Estimated In-stream Habitat Loss

Watercourse or Subwatershed (project impact in parentheses)	Impacted Stream Length (m)		Impacted Stream Area (m^2)		Impacted Modelled Area (m^2)	
	Fish-bearing	Non-fish-bearing	Fish-bearing	Non-fish-bearing	Fish-bearing	Non-fish-bearing
Total Habitat Loss within project footprint[a]						
Lower Britannia Creek (reinstatement of historical channel for offsetting)	1,405	0	11,263	0	4,112	n/a
Upper Canadian Creek (diversion into Open Pit)	0	3,483	0	17,415	n/a	n/a
Upper Casino Creek watershed above Reach 2/3 break (TMF footprint)[c]	7,217	4,509	19,375	7,572	8,900	n/a
Upper Casino Creek watershed below Reach 2/3 break (TMF footprint)[d]	12,832	0	25,384	0	5,827	n/a
95 watercourse crossings (Freegold Extension)	0	1,031	0	787	n/a	n/a
37 watercourse crossings (Freegold Upgrade)	0	30	6[f]	24	6[g]	n/a
Unnamed tributary of Dip Creek (diversion around Airstrip)	1,479	0	2,203	0	330	n/a
10 watercourse crossings (Airstrip Access Road)	0	91	0	54	n/a	n/a
Wetted Habitat Loss due to stream flow reductions[b]						
Lower Canadian Creek (downstream of open pit)	7,000	0	801	0	299	n/a
Lower Casino Creek (downstream of TMF)[e]	6,500	0	1,438	0	3,157	n/a
Dip Creek (downstream of TMF)	8,500	0	2,342	0	1,001	n/a
Total	**44,933**	**9,144**	**62,812**	**25,852**	**23,632***	**n/a**

[a] Areas experiencing "Total Habitat Loss" were obtained from a combination of field and 1:50,000 GIS base mapping measurements (Impacted Stream Area (m^2)), and from HEP analyses (Impacted Modelled Area (m^2)) (PECG and Normandeau, 2014), as summarized above in **Table 3-7**.

[b] Areas experiencing "Wetted Habitat Loss" were obtained from in-stream flow (PHABSIM) modelling results, where Impacted Stream Area (m^2) is the total change in rearing habitat as it represented the median loss of habitat for the entire ice-free season (May 15 – September 30); and Impacted Modelled Area (m^2) is based on the calculated change in usable Arctic grayling wetted habitat, where habitat loss was considered by project phase, with the maximum values by phase reported here (PECG and Normandeau, 2014).

[c] Includes Casino Creek Reach 3, Taylor Creek, Proctor Gulch and Tributary 3.

[d] Includes Casino Creek Reach 2, Meloy Creek, Tributary 1 and Tributary 2.

[e] Includes Casino Creek Reach 1 (i.e., downstream of Brynelson Creek).

[f] Habitat loss from the Nordenskiold River bridge pier.

[g] No modeled value available as there were no habitat limitation criteria identified.

* Denotes final *Fisheries Act* authorization value

Table 3-9. Estimated Riparian Habitat Loss

Watercourse or Subwatershed (Project Impact in parentheses)	Impacted Stream Length (m)		Impacted Riparian Area (m^2)		
	Fish-bearing	Non-fish-bearing	Fish-bearing	Non-fish-bearing	Total Area
Lower Britannia Creek (Reinstatement of Historical Channel for Offsetting)	1,405	0	46,495	0	46,495
Upper Canadian Creek (diversion into Open Pit)	0	3,483	0	34,830	34,830
Upper Casino Creek watershed (TMF footprint)	19,508	6,241	404,820	62,410	467,230
95 watercourse crossings (Freegold Extension)	728*	481	31,590	4,810	36,400
37 watercourse crossings (Freegold Upgrade)	286*	195	10,140	1,950	12,090
Unnamed tributary of Dip Creek (Diversion around Airstrip)	1,449	0	43,470	0	43,470
10 watercourse crossings (Airstrip Access Road)	73*	68	2,190	680	2,870
Total			**538,705**	**104,680**	**643,385**

Note: Riparian habitat setbacks were 30 m for Chinook salmon fish-bearing stream sections, 15 m for non-Chinook salmon fish-bearing streams, and 5 m for non-fish-bearing streams and the upper Casino Creek watershed where fish use is rare (i.e., upstream of the Reach 2/3 break). Asterisks (*) denote that only riparian habitat was impacted due to the installation of clear-span bridges on fish-bearing crossings.

During closure, the Canadian Creek diversion will be decommissioned, allowing headwaters to drain directly into the Open Pit. Non-fish-bearing in-stream and riparian habitat will be permanently lost within the footprint of the Open Pit and upstream to the creek headwaters (17,415 m^2 of in-stream habitat (**Table 3-8)** and 34,830 m^2 of riparian habitat (**Table 3-9**)).

The predicted change in usable fish habitat was assessed under closure conditions using a PHABSIM model (PECG and Normandeau, 2014). In lower Canadian Creek, usable habitat for Arctic grayling juvenile and fry rearing is predicted to increase under the new flow regime, while small decreases are predicted for adult rearing (59 m^2, or 0.6%) and spawning habitat (240 m^2, or 11.4%).

3.2.3 Fish Habitat Offsetting Construction

The reinstatement of the historical, meandering channel of lower Britannia Creek, an integral part of this FHOP, will result in habitat loss within the lowermost 1.4 km-long section of the existing, mostly straight channel of Britannia Creek (as described below in Section 5.1.1). A HEP analysis predicts a 4,112 m^2 loss of usable fish-bearing habitat in lower Britannia Creek (including assumed infilling and disconnection of the backwatered pool at its mouth) (**Table 3-8**). Losses in riparian habitat (**Table 3-9**) will be fully offset by reinstating the historical channel, which meanders through mature floodplain forest.

3.2.4 Freegold Road Extension

Construction of the Freegold Road extension will include 120 km of new road, including the installation of 39 culverts and 56 bridges at 95 stream crossings (**Figure 1-1**). This assessment assumes that clear-span bridges will be installed on all fish-bearing creeks, and therefore only non-fish-bearing aquatic habitat will be lost along the access road due to culvert installations (**Table 3-8**). In addition, riparian habitat loss and alteration will occur adjacent to both fish-bearing and non-fish-bearing crossings (**Table 3-9**).

3.2.5 Freegold Road Upgrade

The existing Freegold Road originates in Carmacks and extends approximately 85 km in a northwest direction towards the Casino mine site (**Figure 1-1**). The road crosses a total of 37 watercourses, 22 of which are fish-bearing. To accommodate Casino mine traffic, upgrades will include widening the road to two lanes with a design speed of 70 km/h; a 5 km by-pass around Carmacks; major new bridges over Nordenskiold River, Seymour Creek, Bow Creek and Crossing Creek; and nine short-span bridges to replace culverts requiring upgrading or relocation. All bridges will be single-lane, clear-span structures with the exception of the Nordenskiold River bridge, which will be two-span with a single pier located in the river.

This assessment assumes that clear-span bridges will be installed on all fish-bearing creeks, and therefore that only non-fish-bearing aquatic habitat will be lost along the access road due to culvert installations, with the sole exception of a 6 m^2 loss of in-stream habitat from the Nordenskiold River bridge pier (**Table 3-8**). Riparian habitat loss and alteration will occur adjacent to both fish-bearing and non-fish-bearing crossings (**Table 3-9**).

3.2.6 Tailings Management Facility

Construction of the TMF will cause direct habitat loss of the upper Casino Creek watershed, including main-stem Casino Creek from its headwaters to its confluence with Brynelson Creek, Proctor Gulch, Taylor Creek, Meloy Creek, and three unnamed tributaries that drain westward into Casino Creek (**Tables 3-8** and **3-9**). The majority of the upper watershed is considered fish-bearing with the exception of acidic Proctor Gulch; upper Taylor Creek, where a fish passage barrier is located approximately 275 m above its confluence with Casino Creek (1 m vertical drop within an 18% gradient segment); and upper Tributary 1, where permafrost-related slumping of the creek banks obstructs fish passage 179 m upstream of its confluence. While approximately 750 m of habitat will technically remain between the water management pond and the confluence of Casino and Brynelson Creeks (**Figure 1-1**), this section is included as lost habitat as the predicted flows are too low to support viable aquatic communities; this also allows for changes to the water management pond location and size, as required. A HEP analysis predicts a 14,727 m^2 loss of usable fish-bearing habitat in the upper watershed, which represents approximately 30% of the total habitat area (**Table 3-8**).

The reduction in stream flows in Casino Creek due to the construction of the TMF will alter downstream fish-bearing habitat. The reduction in flow will result in a net reduction of 1,438 m^2 (4.8%) of wetted area

in lower Casino Creek (**Table 3-8**). Farther downstream, Dip Creek will experience flow reductions from baseline values during the summer and winter months, resulting in predicted reductions in wetted area (3%), width (2%) and depth (3%) (as described in Section 10 of the Project Proposal). During the construction, operations and closure phases, in-stream flow modeling predicts an increase in usable habitat for all life stages of Arctic grayling in lower Casino Creek, with the exception of spawning habitat, which will be reduced by 3,157 m^2 (78.4%) (**Table 3-6**). PHABSIM models predict total adverse areal impacts of no more than 3% in Dip Creek due to reduced flows in Casino Creek (**Table 3-3**).

Following project closure, a spillway will periodically drain excess water from the reclaimed TMF to lower Casino Creek (**Figure 1-2**). Spillway discharge is predicted to produce modest increases in flow from baseline conditions in both lower Casino Creek and Dip Creek during the April-May period. During post-closure, the greatest habitat losses in lower Casino are predicted for adult rearing (1,083 m^2, or 7.2%) and juvenile rearing (1,038 m^2, or 7.6%), followed by fry rearing (360 m^2, or 11.8%) (**Table 3-6**).

In Dip Creek, small changes are predicted in Arctic grayling usable habitat during closure and post-closure (**Table 3-6**). During closure, adult and juvenile rearing usable habitat is predicted to increase relative to baseline conditions, whereas negligible decreases of 13 m^2 (0.3%) and 90 m^2 (1.1%) are predicted for fry rearing and spawning habitat, respectively. During post-closure, reductions in adult and juvenile rearing habitat are predicted to be 1,001 m^2 (2.7%) and 847 m^2 (2.6%), respectively, whereas minor increases are predicted for fry rearing and spawning.

3.3 Habitat Impacts Avoided or Mitigated by Project Re-Design

According to DFO's Hierarchy of Measures for Fisheries Protection (DFO, 2013a), proponents should initially place efforts on avoiding and mitigating potential serious harm to fish, prior to proposing offsetting measures for unavoidable residual effects. Thus, CMC has made several significant changes to the project design primarily to reduce or eliminate impacts to fish habitat that might otherwise have occurred. As suggested by DFO, these changes are briefly described below.

3.3.1 Bridges Instead of Culverts for Fish-Bearing Crossings

Large watercourses along the Freegold Road Upgrade, Freegold Road Extension and Airstrip Access Road, such as Hayes Creek, Big Creek and Dip Creek, have always been proposed to be crossed using clear-span bridges, both for technical reasons and to minimize impacts to aquatic habitat. This original plan has been carried through preliminary design, in association with this submission to YESAB.

Culverts (embedded or not) were originally proposed to convey all small watercourses beneath new or upgraded road crossings. During the late stages of preliminary design, however, CMC proposed to accommodate in its design and construction plan the crossing of all *fish-bearing* watercourses with short-span, precast concrete slab bridges ("short-span bridges"). AE (2013) cited several reasons for using short-span bridges instead of culverts, particularly in areas of permafrost, including "simple construction methods, faster construction schedule, robustness, and low maintenance requirements", in addition to a possible reduction in environmental impact. Non-fish bearing watercourses may still be crossed using conventional corrugated steel pipe culverts designed to convey water and bed material. The installation

of bridges or culverts at fish-bearing crossings will need to be confirmed during the detailed engineering phase of the Casino Project, as bridge installation is dependent on the appropriate geotechnical conditions at each crossing location.

The crossing of fish-bearing watercourses with short-span bridges instead of new or replacement culverts along all access roads avoids impacts to approximately 7,300 m^2 of total in-stream fish habitat (length times width), which would otherwise have potentially required Authorization (and offsetting). Furthermore, the bridge crossings have been designed to minimize risk to in-stream habitat. All bridge abutments will be set back from the tops of banks, in order to avoid projections into the channel and changes in flow or habitat area. Stone will be placed on the bank beneath the bridge deck, flush with adjacent bank sections, to inhibit irregular and potentially severe erosion that might otherwise occur when riparian vegetation is lost due to year-round shading, especially in areas of permafrost. Impacts to riparian vegetation cannot reasonably be avoided, but the need for any riparian habitat offsetting will be minimized by bank stabilization and re-vegetation to mitigate local erosion and sedimentation.

3.3.2 TMF Spillway By-pass of Brynelson Creek

In association with project closure (Years 23 to 25, **Table 1-1**), an overflow spillway is proposed to be constructed to the north of the west embankment of the TMF (**Figure 1-2**). Its purpose is to facilitate control and discharge of excess water accumulation within the TMF and to provide safe passage of storm water volumes from the TMF (Knight Piésold, 2012b). This spillway, which has been situated to follow a natural draw on the north side of Brynelson Creek, was originally proposed to discharge to Brynelson Creek, just upstream of its crossing by the Airstrip Access Road. An integrated hydraulic, fluvial geomorphological and fish habitat assessment of the capacity of lower Brynelson Creek to convey the additional flow from the spillway was completed. The results indicated that both the hydraulic capacity and erosion threshold of Brynelson Creek would be exceeded, potentially resulting in adverse effects on local and downstream fish habitat. In light of these findings, CMC approved the realignment of the spillway such that it is now proposed to by-pass Brynelson Creek altogether (**Figure 1-2**). This spillway re-design avoids direct impacts to approximately 8,500 m^2 of total fish habitat (length times width) and considerable indirect impacts through increased sedimentation downstream in lower Casino Creek.

The period during which excess water will be drained from the TMF has also now been extended from just two months (April-May) to the full spring-summer period, in order to reduce the magnitude of flows and avoid potentially adverse effects on fish habitat in lower Casino Creek (Section 10 of Project Proposal).

3.3.3 Naturalization of Airstrip Diversion Channel

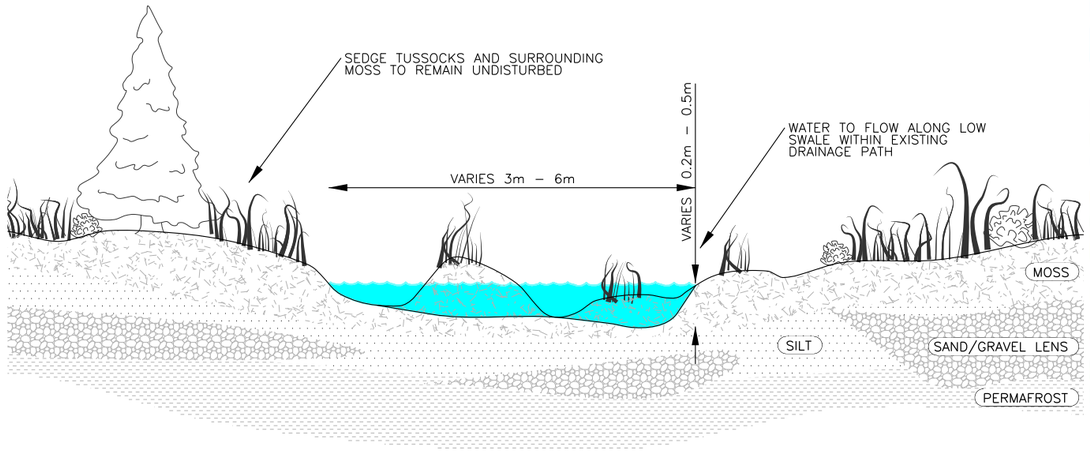
The proposed airstrip for the Project requires considerable length on level ground, with good approaches in either direction. One of the few locations where these criteria are met is within the Dip Creek valley. The airstrip is proposed to extend onto a gentle alluvial fan across which a small, unnamed tributary of Dip Creek flows (**Figure 1-1**). In order to ensure stability and safety of the airstrip, the small tributary must be diverted around it, rather than being conveyed beneath it through a culvert. The tributary and local surface runoff were originally going to directed around the airstrip along a straight, gravel-filled

interceptor drain along the toe of a berm, built about 120 m upslope from the airstrip. This local filling of fish habitat and disconnection of the watercourse upstream of the airstrip would have resulted in a substantial amount of lost fish habitat.

In order to avoid as much as 9,000 m^2 in total lost fish habitat (length times width), CMC has changed its surface water diversion strategy to create a naturalized airstrip diversion channel to by-pass the airstrip and drain into an existing, natural drainage path (another distributary channel on the alluvial fan) (**Figure 3-3**). The diversion will begin at the apex of the gentle alluvial fan on which the southern portion of the airstrip is proposed, and will follow a natural drainage path along the southern edge of the fan downstream to its confluence with Dip Creek, the outlet of an oxbow lake. The diversion channel will be constructed with a form that mimics existing, natural channel morphology, minimizes disturbance to surface organics and underlying permafrost, and mitigates the risk of downstream sedimentation to Dip Creek. A pilot swale will be carefully formed to accommodate fish passage, and low gravel 'ribs' will be placed amongst the mosses and sedges to allow for future recruitment of alluvial gravels and to promote sedimentation against their upstream flanks. This decision to construct a naturalized diversion channel will reduce the amount of lost usable habitat to 330 m^2.

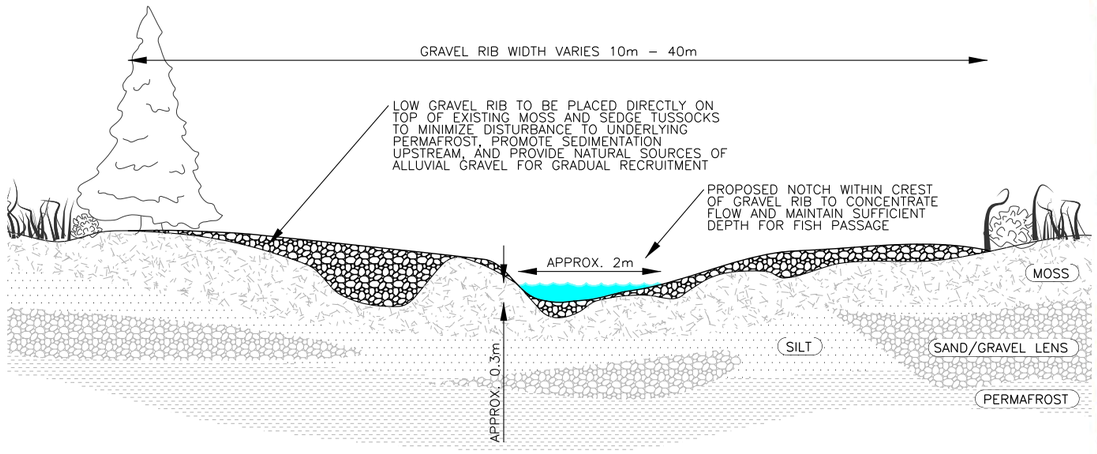
Surface runoff from the airstrip will flow overland through dense ground vegetation, where it will gradually infiltrate, thereby avoiding potential effects on in-stream water quality. Appropriate erosion and sediment control measures will be identified during detailed design and used during the construction of the diversion channel, consistent with procedures outlined below in Section 6.2, in order to protect the surrounding environment from off-site sedimentation.

TYPICAL SWALE SECTION A-A



1:100

TYPICAL GRAVEL RIB SECTION B-B



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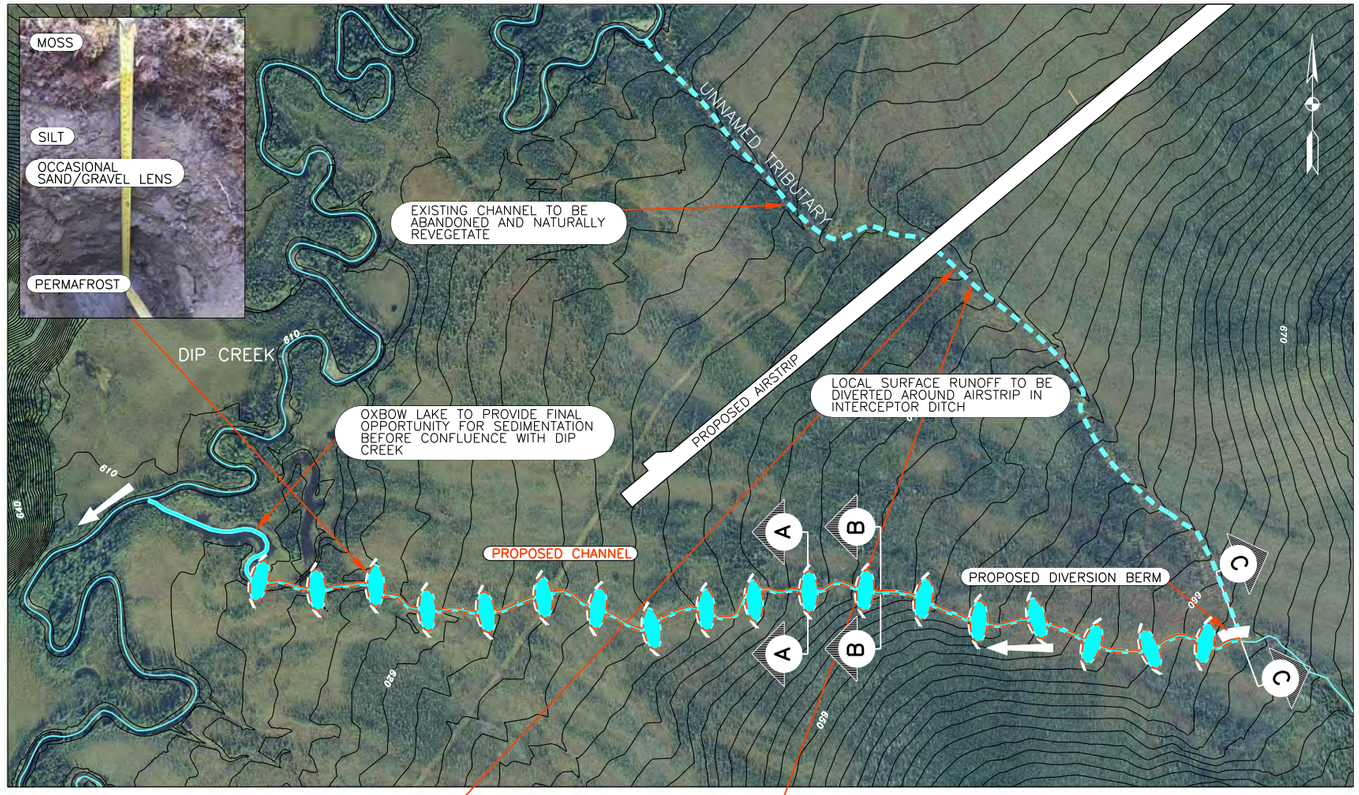
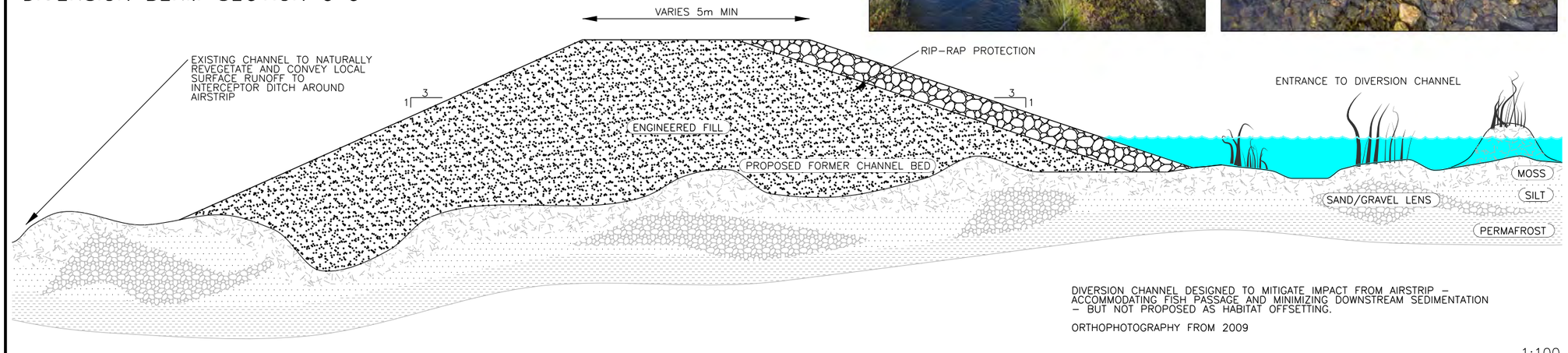






100 0 200 300 METERS SCALE 1:10000

DIVERSION BERM SECTION C-C



1:100

DIVERSION CHANNEL DESIGNED TO MITIGATE IMPACT FROM AIRSTRIP – ACCOMMODATING FISH PASSAGE AND MINIMIZING DOWNSTREAM SEDIMENTATION – BUT NOT PROPOSED AS HABITAT OFFSETTING.

ORTHOPHOTOGRAPHY FROM 2009

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

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DESIGN REVIEW AND DRAFTING BY GRECK AND ASSOCIATES LIMITED.

DATE	REVISION	BY
11/21/2014	DRAFT FOR REVIEW	E.G.

AIRSTRIP DIVERSION CHANNEL

CASINO PROJECT

CONCEPT DESIGN

DATE:	DESIGN BY	CHKD. BY	APPD. BY
NOVEMBER 21, 2014	E.G.	B.G.	R.M.
SCALE: AS SHOWN	DRAWING NO.		
	SHEET NO.	FIGURE 3–3	

4 Fish Habitat Offsetting Background

This section begins by outlining the objectives and rationale of the FHOP (Section 4.1), and then provides overviews and evaluations of each habitat offsetting candidate (Section 4.2). Full descriptions and preliminary design drawings of the offsetting opportunities considered for detailed design and ultimate implementation are provided in Section 5.

4.1 Objectives and Rationale

CMC has designed the Project to avoid serious harm to CRA fisheries, to the greatest extent possible, through project redesign, refinement and impact mitigation. Despite these efforts, some residual impacts (as described above in Section 3.2) are unavoidable and likely to require Authorization from DFO, pursuant to Section 35(2) of the *Fisheries Act*. Additionally, offsetting measures are necessary in order to counterbalance unavoidable serious harm to fish resulting from the Project with the goal of maintaining or improving the productivity of the CRA fishery, as outlined in DFO's *Fisheries Protection Policy Statement* (DFO, 2013b).

Three main categories of offsetting measures are described by DFO (2013a):

- Habitat restoration or enhancement;
- Habitat creation; and
- Chemical and biological manipulations (e.g., fish stocking, invasive species management).

In addition, the inclusion of complementary measures as a means for offsetting provides a new opportunity for proponents in cases where traditional offsetting measures are more difficult or less desirable to implement (DFO, 2013a). Complementary measures are described as "investments in data collection and scientific research related to maintaining or enhancing the productivity of commercial, recreational or Aboriginal fisheries", and are prescribed to make up to 10% of the total offsetting amount. DFO states that the use of complementary measures will be considered as an acceptable means of offsetting in areas where there are limited opportunities for habitat creation, restoration or enhancement, a demonstrated need for an increased understanding of fisheries productivity, and where program results would help facilitate the development and implementation of local fisheries management objectives. Further, any data collection and scientific research should take into account the DFO (2013a) guiding principles (presented below), and be undertaken in a transparent, and scientifically robust and timely manner by a qualified individual or organization approved by DFO.

The proponent's selection of offsetting measures should respect DFO's guiding principles, which are listed below and described further in the guidance document *Fisheries Productivity Investment Policy: A Proponent's Guide to Offsetting* (DFO, 2013a):

1. Offsetting measures must support fisheries management objectives or local restoration priorities.
2. Benefits from offsetting measures must balance project impacts.
3. Offsetting measures must provide additional benefits to the fishery.
4. Offsetting measures must generate self-sustaining benefits over the long term.

The following sections demonstrate how the offsetting opportunities proposed by CMC address each of these guiding principles, prior to describing each offsetting opportunity in detail (Sections 5.1 and 5.2).

4.1.1 Local and Regional Fisheries Objectives

Groups with a vested interest in the Project's local and regional fisheries resources include federal departments, provincial and territorial governments, First Nations, recreational fishing and angling groups, conservation organizations, and industry groups. Of particular importance to these partners and stakeholders is the Yukon River Chinook Salmon population, which has historically provided a significant ecological, cultural and economic contribution to Yukon communities and ecosystems, and has been plagued with drastic population declines in recent years (JTC, 2013). Given this context, the opportunity to focus habitat offsetting measures on creating, enhancing or investigating Chinook salmon fisheries and habitat is increasingly important, and is in accordance with local and regional fisheries objectives.

The following sub-sections outline the local and regional fisheries objectives in the project area by discussing regulatory and First Nations fisheries objectives, followed by the selection process for identifying Chinook salmon as the principal target species for offsetting.

Regulatory Context and Fisheries Management Objectives

Yukon freshwater fishery management is under the jurisdiction of the Fish and Wildlife branch of the Yukon Government. It has several principal objectives:

- To maintain and enhance the quality and integrity, including the biological diversity, of the aquatic environment for present and future generations;
- To ensure the sustainable use of fisheries resources through a balanced and integrated management of fish and their habitats;
- To manage resources in a manner that is collaborative and promotes environmental and socially responsible awareness, participation and stewardship; and
- To provide sustainable fish harvesting and viewing opportunities for social, cultural, recreational and, where appropriate, commercial purposes.

In addition, Status of Yukon Fisheries (Environment Yukon, 2010) outlined the need to focus on managing over-harvested species, such as potentially vulnerable populations of Arctic grayling, lake trout (*Salvelinus namaycush)*, northern pike (*Esox Lucius)* and burbot. Furthermore, recommendations were made to shift towards ecosystem or watershed-based management.

Anadromous fishes in the Yukon are managed and regulated by DFO. Additionally, the management of Yukon River salmon in the Yukon involves several coordinating and advisory agencies: the international Yukon River Panel, established under the USA/Canada Yukon River Salmon Agreement; and the Yukon Salmon Sub-Committee, established under the Yukon land claims' Umbrella Final Agreement. Both agencies provide recommendations to DFO regarding salmon harvest management, stock and habitat conservation, and the enhancement of renewable resource economies.

First Nations Fisheries Cultural Values

CMC has engaged the local First Nation communities with traditional territories encompassing the areas of predicted impacts early and regularly through the planning and development of the FHOP. The Project is of greatest interest to SFN, whose traditional territory encompasses the mine site area where greatest loss of fish habitat is anticipated. Negligible impacts to fish habitat are expected within the traditional territory of LSCFN, which encompasses the eastern end of the Freegold Road. The traditional territory of THFN overlaps a portion of the lower Britannia Creek watershed, where preferred offsetting measures are proposed (as described below in Section 5.1.1). CMC has hosted presentations and workshops within the communities and on-site to communicate the plans for the overall Project and its environmental supporting studies (Section 1.3). Specific input has been solicited from SFN on fish habitat offsetting objectives, strategies, sites and design priorities. Chinook salmon has consistently been identified as a highly valued species for all First Nations. SFN identified the lower reach of Britannia Creek as an area of cultural and ecological significance based mainly on traditional use and consideration of historical and potential Chinook spawning suitability. This reach was classified as an area of special consideration in the placer habitat suitability mapping process (**Figure 2-1**), with the most restrictive requirements and standards (Yukon Placer Secretariat, 2012).

Selection of Target Species

The high ecological, cultural and economic value of Chinook salmon in the Yukon makes it an ideal target species for habitat offsetting works. Although Chinook salmon do not reside in the primary impacted area of Casino Creek, they are found in nearby watercourses such as Dip Creek, lower Britannia Creek, in several major watercourses along the proposed Freegold Road, as well as in the adjacent Yukon River. Also, habitat offsetting that is designed to benefit Chinook salmon will also be advantageous to Arctic grayling and slimy sculpin, which are the dominant fish species residing in the proposed impacted area of the Project. Both Arctic grayling and slimy sculpin have habitat requirements in common with Chinook salmon, such as deep pools for juvenile rearing and overwintering.

4.1.2 Measuring Fisheries Impacts and Offsetting Outcomes

In accordance with the principles of the *Fisheries Act*, this FHOP aims to increase the productivity of fisheries by primarily focusing on improving Chinook salmon productivity, with additional benefits expected for other fish species such as Arctic grayling and slimy sculpin. A quantitative comparison of habitats at impact and offsetting sites is provided below in Section 5.4, following the descriptions of proposed in-stream and riparian habitat offsetting opportunities (Sections 5.1 to 5.3). To assess the relative contribution of impacts and offsetting measures to fisheries productivity, several factors were considered including the amount and type of habitat being lost or gained, distance between offsetting measures and the Project impacts, and the potential for risk of failure and time lags. Each of these factors is addressed below in relation to one of the principal opportunities for proposed habitat offsetting, reinstatement of the historical meandering channel of lower Britannia Creek (overviewed in Section 4.2.1 and detailed in Section 5.1.1):

1. *Variance in quality of habitat being replaced* – DFO recognizes two types of offsetting approaches: "in-kind" and "out-of-kind" offsetting (DFO, 2013a). While the first approach, "in-kind" offsetting, may provide the simpler route by replacing the same habitat type that was lost, there are several reasons why an "out-of-kind" approach may be the favourable choice. "Out-of-kind" approaches present the opportunity to offset common or poorer quality habitat types with habitat types that have been identified as limiting fisheries productivity. The *Fisheries Productivity Investment Policy: A Proponent's Guide to Offsetting* (DFO, 2013a) states the following:

   "The choice of appropriate offsetting measures will be guided by threats to fisheries productivity and fisheries management objectives. In some instances, the most desirable offsetting measures may be a replacement of the same type of habitat that is affected by the project. In other situations, better outcomes for fisheries may be achieved by undertaking offsetting in water bodies or for fish species other than those affected by the project."

   Accordingly, CMC proposes to offset impacts within the Casino Creek watershed off-site in the adjacent Britannia Creek watershed and elsewhere along major tributaries of the Yukon River. The proposed offsetting measures along lower Britannia Creek, a wider, higher-order reach in direct connection to the Yukon River, will benefit a much more diverse fish community, including Chinook salmon – a priority species for protection and restoration in Yukon. This restored channel will represent the highest suitability juvenile Chinook rearing habitat in the Project area, based on the placer stream classification (Yukon Placer Secretariat, 2012), and has some potential for Chinook salmon spawning. Pre-existing complex habitat features include sharp meanders; deep, asymmetric pools; undercut banks with overhanging trees; and diverse gravel bed material. The existing lower Britannia Creek channel follows a former road right-of-way (as explained in Section 5.1.1); its pattern is straight, its gradient is uniform and relatively steep, its flow is relatively fast over a uniform bed, and its bed is dominated by cobbles and boulders with little gravel.

   In comparison, Casino Creek and its tributaries are relatively isolated, occurring at high elevation far from the more productive reaches of Yukon River and its major tributaries. The impacted reaches also support only a few species (not Chinook salmon) or indirect, non-fish-bearing

habitat (tributaries), in part due to poor water quality, steep gradients, a lack of suitable substrate materials, and a lack of deep pools for rearing and overwintering (Section 2.3). Habitat offsetting along lower Britannia Creek, instead of within the Casino Creek watershed, is expected to yield far greater gains in fisheries productivity that will benefit more species and life history stages of these species. **Table 4-1** compares the types and supplies of different habitats at both the impact and offsetting sites, demonstrating that proposed offsetting habitats are generally less common and more productive than those at impact sites.

Table 4-1. Type and Supply of Habitat at Impact and Offsetting Sites

Habitat	Site	Type	Supply
IMPACTED	Lower Britannia Creek "Roadway" Channel (diversion of flow into historical channel)	Riffle-dominated, moderately steep, straight 4th-order channel (only 8% pools), with minimal functional large woody debris	N/A (Unnatural)
	Upper Casino Creek and its small tributaries (TMF footprint)	1st to 2nd order, straight to sinuous channels with cobble-boulder bed and riffle-dominated morphology; low seasonal usage based on high gradient, unsuitable substrates and lack of, and downstream distance to, overwintering habitats	Abundant in region
	Unnamed Tributary of Dip Creek (Airstrip)	1st order single- to multi-thread channel with irregular pool-riffle morphology	Abundant in watershed and region
	Lower Canadian Creek (flow reduction downstream of open pit)	3rd order meandering to braided channel (in areas of placer disturbance) with pool-riffle morphology	Abundant in region
	Lower Casino Creek (flow reduction downstream of TMF)	2nd order sinuous to meandering channel with gravel-cobble bed and pool-riffle morphology	Abundant in region
	Dip Creek (flow reduction downstream of TMF)	4th order tortuously meandering channel with gravel bed and pool-riffle morphology	Common in region
HABITAT OFFSETTING OPPORTUNITIES (Preferred and Contingency)	Reinstatement of Historical Lower Britannia Creek (Preferred)	Low-gradient, tortuously meandering, pool-riffle channel adjacent to Yukon River, with gravel-cobble substrate (30% pools) and abundant functional large woody debris	Limited in watershed and region
	Britannia Creek Ford Restoration (Preferred)	Riffles along 3rd to 4th order, irregularly meandering channel with gravel-cobble substrates	Common in watershed and region
	Diamain Lake Whitefish Fishery Creation (Preferred)	Large, fishless lake with large invertebrates	Common in watershed and region, except limited as mono-culture
	Dawson Dredge Pond Off-line Pool Habitat Creation (Preferred)	Interconnected seepage ponds within permafrost-free gravels (placer dredge piles) adjacent to major river	Limited in region
	Chinook Research Project (Preferred)	n/a	n/a
	Lower Britannia Creek Slope-toe Side Channel Extension and Enhancement (Contingency)	Off-line, groundwater-fed pools for rearing and overwintering	Limited in watershed
	Lower Britannia Creek Groundwater-fed Side Channel Extension and Enhancement (Contingency)	Off-line, groundwater-fed pools for rearing and overwintering	Limited in watershed
	Klondike River Side Channel Rearing Gallery at Germaine Creek (Contingency)	Off-line, groundwater-fed pools for rearing and overwintering	Limited in watershed
	Klondike River Side Channel Rearing Gallery at North Klondike River (Contingency)	Off-line, groundwater-fed pools for rearing and overwintering	Limited in watershed

2. *Geographical distance* – While the location of proposed impacts and offsetting are in adjacent watersheds, the distance via connected watercourses is substantial (commonly >200 km). Thus, it is not expected that realized productivity gains in lower Britannia Creek will resonate with populations in Casino or Dip Creeks where impacts will be concentrated. However, productivity gains are expected to be much greater by locating offsetting in Britannia Creek, for example, due to its proximity to the Yukon River (as discussed above). Thus, there is potential for a greater contribution to CRA fisheries.

3. *Risk of Failure* – This FHOP proposes more gains than losses and allows for the possibility that some habitat may not fully function as anticipated (**Table 4-2**). Focused monitoring and an allowance and expectation for adaptive management will ensure the long-term effectiveness of offsetting works. The proposed offsetting measures have been developed by a multi-disciplinary team with experience in fish habitat restoration and enhancement projects. All offsetting opportunities have been designed with consideration of local hydrology and hydraulics, geomorphology and fluvial processes, and ecological sensitivities and priorities. Therefore, the risk of failure is generally considered low. **Table 4-2** provides specific rationale for the interpreted risk of failure of each offsetting opportunity. For example, the reinstatement of the historical channel has a high certainty of success, given that it is relatively intact and was dynamically stable and provided high quality aquatic habitat for decades to centuries (based on analysis and extrapolation from historical aerial photographs), before the unnatural avulsion occurred along the historical access road right-of-way. Re-introduction of flow into the historical channel, once selectively 'cleaned' of woody obstructions, is expected to restore pre-existing, natural channel substrates and morphology, dynamic fluvial processes and complex micro-habitat features within a year or two of flow diversion. Riparian vegetation already consists of mature mixed forest of spruce and deciduous trees, which will immediately provide cover and important allocthonous inputs.

4. *Recognition of time lag* – DFO (2013a) specifies that "When a time delay is unavoidable, the offset must make up for fisheries productivity that has been lost because of the delay. For example, measures may include building more habitat than is lost so that once the habitat becomes functional it will produce enough fish to make up for the productivity lost during the time lag." Habitat offsetting works have been designed to minimize the time lag between implementation and full function. All habitat restoration, creation and enhancement measures will be completed at the start of construction of the Project, either before or in conjunction with the occurrence of authorized habitat loss (**Figure 4-1**). Habitat offsetting will greatly precede the minor impacts along lower Canadian Creek. **Table 4-2** anticipates the time lag associated with each habitat offsetting component. For example, the historical meandering channel already exists in mature form, from both a geomorphological and ecological perspective. Its reinstatement is proposed to occur before or in conjunction with the occurrence of the habitat loss in Casino Creek. Habitat is expected to be functional in less than two years, following the first post-reinstatement freshet.

Table 4-2. Risk of Failure and Time Lag for Habitat Offsetting

Habitat Offsetting Opportunity	Risk of Failure	Rationale	Lag Time	Rationale
Reinstatement of Historical Britannia Creek (Preferred)	Low	Channel dynamically stable for decades to centuries, with complex morphology and mature riparian vegetation	Short (<2 yr)	Complex in-stream and riparian habitat features already exist
Britannia Creek Ford Restoration (Preferred)	Low	Restoring natural (pre-existing) bank morphology and riparian vegetation	Short (<3 yrs)	Already surrounded by dense riparian vegetation and stable banks
Diamain Lake Whitefish Fishery Creation (Preferred)	Low - Moderate	Previous investigations documented large invertebrate populations (food source) and water quality consistent with whitefish habitat requirements	Moderate (<10 years)	Allowance for time before successful spawning and self-sustaining population growth
Dawson Dredge Pond Off-line Pool Habitat Creation (Preferred)	Low	Previous investigations already documented appropriate water quality and the presence of various species of fish, including Chinook salmon, in the dredge ponds to which a permanent connection is proposed to be established	Short (<3 yrs)	Fish already using some ponds, and riparian vegetation already colonizing shorelines
Chinook Research Project (Preferred)	Low	Clearly defined research objectives, methods and funding sources established by team experienced in research program development and implementation, with support from academic and other organizations	n/a	n/a
Lower Britannia Creek Slope-toe Side Channel Extension and Enhancement (Contingency)	Low	Spring-sourced side channel already exists, but with poor connection to main creek; proposed work will improve connection and expand habitat area around spring	Short (<3 yrs)	Rapid, natural stabilization following construction because only spring-fed (no erosion risk)
Lower Britannia Creek Groundwater-fed Side Channel Extension and Enhancement (Contingency)	Low	Spring-sourced side channel already exists, but with no surface connection to spring pond; proposed work will establish connection to spring pond and expand pool habitat upstream	Short (<3 yrs)	Rapid, natural stabilization following construction because only spring-fed (no erosion risk)
Klondike River Side Channel Rearing Gallery at Germaine Creek (Contingency)	Low	Spring-sourced side channel with documented use by juvenile Chinook salmon already exists; proposed work will expand and enhance opportunities for rearing and overwintering	Short (<3 yrs)	Rapid, natural stabilization following construction because only spring-fed (no erosion risk)
Klondike River Side Channel Rearing Gallery at North Klondike River (Contingency)	Low - Moderate	Groundwater-fed side channel already exists immediately upstream from proposed rearing gallery, demonstrating seepage flow through alluvial gravels, although connection to main river partially affected by meander dynamics	Short (<3 yrs)	Rapid, natural stabilization following construction because only spring-fed (no erosion risk)

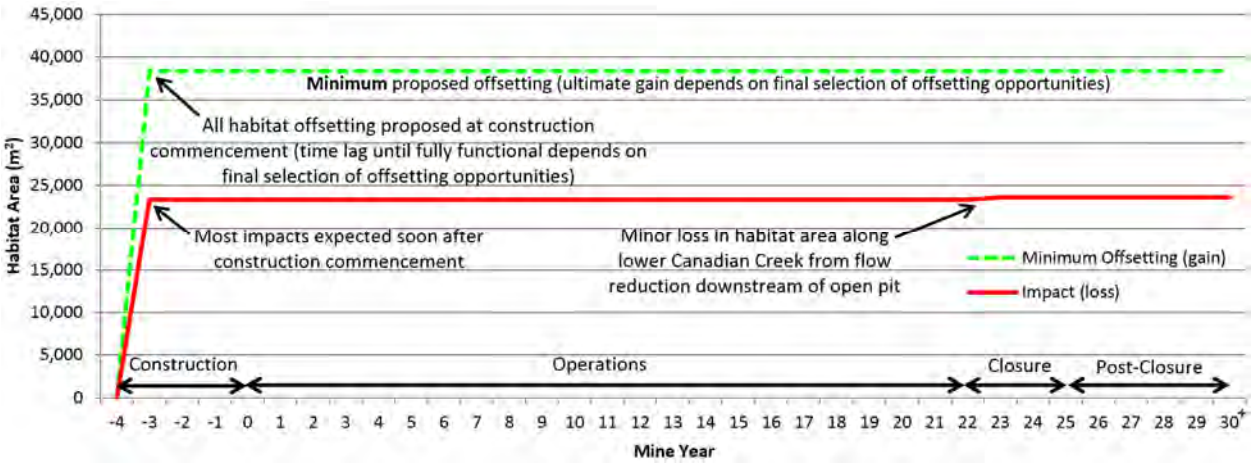

Figure 4-1. Schedule of Predicted Fish Habitat Impacts and Minimum Proposed Gains

4.1.3 Duration of Benefits

One of DFO's four key principles of offsetting is to "generate self-sustaining benefits over the long term" (DFO, 2013a). The intention is to encourage offsetting opportunities that are self-sustaining and do not require ongoing maintenance in order to maintain their effectiveness. All offsetting opportunities proposed in this FHOP meet this principle; each opportunity is designed to function within a setting of natural hydrologic, geomorphic and ecologic processes. Furthermore, all opportunities are designed to accommodate some degree of natural changes in the surrounding environment, over decades, without impacting their effectiveness. For example, the reinstatement of the historical channel of lower Britannia Creek allows for localized changes in channel dimensions and bank morphology, but minimizes the risk of avulsion back into the existing 'roadway' channel by incorporating a diversion berm and re-configured meander that will help guide flood flows along their original path.

4.2 Habitat Offsetting Candidates

Since the initiation of baseline aquatic studies for the Project in 2008, 22 fish habitat offsetting candidates have been identified through a comprehensive and systematic review of undisturbed and previously impacted aquatic ecosystems in the region encompassing the Project, giving priority to opportunities closest to the Project. Of the 22 candidates, 11 are within the relatively small watersheds directly affected by the Project (i.e., "on-site") (**Figure 4-2**), and 11 are elsewhere within the Yukon River watershed within the traditional territories of SFN, LSCFN and/or THFN (i.e., "off-site") (**Figure 4-3**). The naturalized airstrip diversion channel (described above in Section 3.3.3) is excluded from this summary because it is only a form of impact mitigation, not being considered as an element of habitat offsetting. The Chinook Research Project (described below in Section 5.1.5) is also excluded from this summary because it represents a complementary measure to habitat offsetting.

610,000 620,000

6,970,000 6,960,000 6,950,000

Legend

- Barge Access Road
- Airstrip Access Road
- Freegold Road Extension
- Waterbody
- Watercourse
- Airstrip
- Proposed Mine Facilities
- On-site Fish Habitat Offsetting Candidates

8. Groundwater-fed Pool near Britannia Creek Mouth
4. Lower Britannia Creek Rehabilitation
5. Lower Britannia Creek Groundwater Channel
6. Partial Flow Diversion into Historical Lower Britannia Creek
7. Reinstatement of Historical Lower Britannia Creek
9. Artificial Lower Britannia Creek Chinook Spawning Channel
10. Lower Britannia Creek Slope-toe Side Channel Extension and Enhancement
3. Britannia Creek Ford Restoration
11. Lower Britannia Creek Groundwater-fed Side Channel Extension and Enhancement
1. Lower Canadian Creek Placer Restoration
2. Dip Creek Pond Connections

A B C D E

Yukon River
Creek
Canadian Creek
Britannia Creek
Brynelson Cr
Rude Cr
Casino Creek
Victor Creek
Dip Creek

N

0 2 4 6 8
Kilometers

610,000 620,000

PREPARED BY:
PALMER ENVIRONMENTAL CONSULTING GROUP INC.

DESIGNED	R.McKillop
DRAWN	D. Turner
CHK'D	R. McKillop
APP'D	R. McKillop
REV	R. Palmer
DATE	19Nov'14

NOTES:
1. BASE MAP: Digital Elevation Model and 1:250,000 and 1:50,000 Topographic Spatial Data provided by Geomatics - Yukon Government via online source (www.geomaticsyukon.ca)
2. PROJECTION: NAD 1983 UTM Zone 7N
3. COORDINATE GRID: METRES
4. SCALE: 1:85,000

CASINO

On-site Fish Habitat Offsetting Candidates

CASINO PROJECT | **FIGURE 4-2** | FHOP REPORT | PN 10011

600,000 700,000

0 25 50
Kilometers

N

8. Klondike River Side Channel Restoration

10. Klondike River Side Channel Rearing Gallery at Germaine Creek

Dawson

11. Klondike River Side Channel Rearing Gallery at North Klondike River

9. Dawson Dredge Ponds Off-line Pool Habitat Creation

7,100,000

River

Stewart

Yukon River

Casino

Donjek

White River

2. Mica Creek Side Channel Creation

Pelly Crossing

Pelly River

4. Diamain Lake Whitefish Fishery Creation

3. Needlerock Side Channel Creation

5. von Wilczek Creek Side Channel Creation

7. Yukon River Slough Enhancement

6. Tatchun Creek Stabilization and Enhancement

1. Big Creek Side Channel Enhancement

Carmacks

7,000,000

6,900,000

600,000 700,000

Legend

- Off-site Fish Habitat Offsetting Candidates
- Highway
- Waterbody

First Nation Traditional Territory

- Champagne and Aishihik First Nations
- First Nation of Na-cho Ny k Dun
- Kluane and White River First Nations
- Little Salmon/Carmacks First Nation
- Selkirk First Nation
- Ta'an Kwach'an Council
- Tr'ondº k Hwº ch'in
- Kwanlin D n First Nation

PREPARED BY:

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2. PROJECTION: NAD 1983 UTM Zone 7N
3. COORDINATE GRID: METRES
4. SCALE: 1:1,000,000

CASiNO

Off-site Fish Habitat Offsetting Candidates

CASINO PROJECT | **FIGURE 4-3** | FHOP REPORT | PN 10011

Each on-site (**Table 4-3**) and off-site (**Table 4-4**) habitat offsetting candidate was assessed relative to DFO's key factors for consideration in offset planning (as outlined above in Section 4.1), in consultation with DFO and other stakeholders during the planning stages of the FHOP. Approximate construction cost, in comparison to potential long-term benefits to productivity, was also considered. The screening process facilitated a consistent and transparent evaluation of each offsetting candidate, and provided a mechanism for assessing and comparing the potential of each option to address the various offsetting objectives. The selection of preferred and contingency options that have now been advanced to preliminary design, in support of the submission to YESAB, incorporates valuable input from First Nations and local communities, regulatory agencies and the multi-disciplinary project team.

Each of the 22 candidates considered for fish habitat offsetting is briefly described below, with reference to key screening criteria, as appropriate.

4.2.1 On-site Candidates

1. Lower Canadian Creek Placer Restoration

Placer mining has occurred intermittently along Canadian Creek since 1911 (MacDonald, 2012). Its long-lasting and locally significant impacts on aquatic habitat along several kilometres of lower Canadian Creek are primarily the result of haphazard channel realignment, dredging of the channel bed and floodplain, and widespread removal of riparian vegetation. The extent of impact to fish habitat along lower Canadian Creek is unlike any other within the Project area watersheds. Consideration was given to reconstructing natural channel morphology or at least re-vegetating riparian and floodplain vegetation, in order to help restore channel stability and reduce sediment loading along the creek (**Figure 4-2**). Such restoration would benefit Arctic grayling and may result in long-terms benefits in productivity, although it may have little effect on Chinook salmon farther downstream. A significant deterrent to further consideration of this offsetting candidate is the potential for future placer mining to disrupt or destroy any restoration works, given its dominant classification by the Yukon Placer Secretariat (2012) as "low suitability" habitat and a lack of adequate measures to ensure future protection; active placer mining licenses currently cover all of lower Canadian Creek.

2. Dip Creek Pond Connections

Numerous ponds exist within the Dip Creek valley, mainly in the form of oxbows and thermokarst (thaw) lakes (**Figure 4-2**). Consideration was given to establishing permanent connections between one or more of these ponds and Dip Creek or its tributaries, via constructed channels, to provide off-line pond rearing and/or overwintering habitat for fish species. Pond habitat would provide low-flow refuge areas outside Dip Creek itself, and would increase riparian habitat and feeding opportunities. The potential addition of overwintering habitat would be critical, as deep pools required for overwintering in the Casino Creek watershed are very limited. The primary obstacle to this option is the extent of ice-rich permafrost along the valley bottom. The establishment of permanent pond-creek connections would require costly, engineered structures and mobilization of heavy equipment to remote sites, with a high likelihood to fill in with flood sediment, become abandoned following channel migration, or collapse through permafrost degradation.

Table 4-3. Summary Evaluation of On-site Fish Habitat Offsetting Candidates

Screening Criteria	1. Lower Canadian Creek Placer Restoration	2. Dip Creek Pond Connections	3. Britannia Creek Ford Restoration	4. Lower Britannia Creek Rehabilitation	5. Lower Britannia Creek Groundwater Channel	6. Partial Flow Diversion into Historical Lower Britannia Creek	7. Reinstatement of Historical Lower Britannia Creek	8. Groundwater-Fed Pool near Britannia Creek Mouth	9. Artificial Lower Britannia Creek Chinook Spawning Channel	10. Lower Britannia Creek Slope-toe Side Channel Extension and Enhancement	11. Lower Britannia Creek Groundwater-fed Side Channel Extension and Enhancement
1 - Fisheries management objectives	Low-Moderate relevance - would likely increase local productivity of Arctic grayling populations, but may have little impact on Chinook salmon farther downstream	Moderate-High relevance – creation of rearing and potentially overwintering habitat for Arctic grayling, maybe also juvenile Chinook salmon	Moderate relevance - improvements to local and downstream habitat for Arctic grayling and likely juvenile Chinook salmon	Moderate-High relevance – may enhance existing Chinook rearing or overwintering habitat	High relevance – creation of Chinook salmon rearing and overwintering habitat	High relevance – creation of Chinook salmon rearing and overwintering habitat	High relevance – creation of Chinook salmon rearing and overwintering habitat	High relevance – creation of Chinook salmon rearing and overwintering habitat	High relevance – creation of Chinook salmon spawning habitat, in addition to rearing and overwintering benefits	Moderate relevance - improvements to local and downstream habitat for Arctic grayling and likely juvenile Chinook salmon	Moderate relevance - improvements to local and downstream habitat for Arctic grayling and likely juvenile Chinook salmon
2 - First Nations traditional uses and knowledge	Low (Chinook priority)	Moderate (difficult access)	Moderate	Moderate	Moderate-High	High	Very High	High	Very High	Moderate	Moderate
3 - Quantity of habitat at offsetting sites	25,000 m^2 potential offsetting area	1,000 - 17,000 m^2 potential offsetting area	0 m^2 potential offsetting area (riparian only)	10,000 m^2 potential offsetting area	12,000 m^2 potential offsetting area	16,000 m^2 potential offsetting area	14,871 m^2 potential offsetting area*	9,200 m^2 potential offsetting area	2,500 - 10,000 m^2 potential offsetting area	1,213 m^2 potential offsetting area*	1,831 m^2 potential offsetting area*
4 – Type and supply of habitat at offsetting sites	Re-instating moderate to good quality rearing habitat for Arctic grayling; limited in watershed and fairly common in region	Good quality rearing and possibly overwintering habitat for Arctic grayling; pond habitats are limited in watershed and region	Riffles along 3rd to 4th order streams; common in watershed and region	Good quality juvenile Chinook salmon rearing and possibly overwintering habitat; limited in watershed and region	High quality juvenile Chinook salmon rearing and overwintering habitat; very limited in watershed; limited in region	High quality juvenile Chinook salmon rearing and overwintering habitat; very limited in watershed; limited in region	High quality juvenile Chinook salmon rearing and overwintering habitat; very limited in watershed; limited in region	High quality juvenile Chinook salmon rearing and overwintering habitat; very limited in watershed; limited in region	Chinook salmon spawning habitat; very limited in watershed and region	Good quality rearing and possibly overwintering habitat for Arctic grayling and juvenile Chinook salmon; pool habitats are limited in watershed and region	Good quality rearing and possibly overwintering habitat for Arctic grayling and juvenile Chinook salmon; pool habitats are limited in watershed and region
5 – Approx. watercourse distance between offsetting sites and main impacts	310 km	7 km	300 km	300 km	300 km	300 km	300 km	300 km	300 km	300 km	300 km
6 - Risk of failure and time lag until offsetting habitats functional	Moderate risk of failure (potential for re-activation of placer mining, which could destroy restoration efforts), <5 yr time lag	High risk of failure (potential for ponds to become disconnected through lateral channel migration, degradation of ice-rich permafrost beneath connector, or sedimentation into connector), <1 yr time lag	Low risk of failure (potential for placer miners to re-activate road in future), <3 yr time lag	Moderate risk of failure (potential for long-term channel instability in response to constructed meander pattern and in-stream structures, in addition to existing sediment pulse), <5 yr time lag	High risk of failure (potential for groundwater to drop below bottom of excavations, or for flowing water to exacerbate permafrost degradation and collapse banks), <3 yr time lag	High risk of failure (potential for seasonal impediments to fish passage due to reduced depths from flow split, and maintenance to address localized sedimentation at channel divergence), <2 yr time lag	Low risk of failure (long-term stability anticipated, given historical function, although monitoring will determine need for any localized adjustments through adaptive management), <2 yr time lag	High risk of failure (groundwater levels may be too low to maintain surface connection, and juveniles may be at risk of predation from adults in adjacent Yukon River), <5 yr time lag	Moderate risk of failure (requirement for monitoring and periodic maintenance, in perpetuity, and potential for equipment failures during critical periods (e.g., winter)), <3 yr time lag	Low risk of failure (potential for side channel mouth to become disconnected to main creek), <3 yr time lag	Low risk of failure (potential for side channel pool habitats to accumulate fine sediment during major floods), <3 yr time lag
7 - Expected duration of benefits	Decades to centuries	Years to decades	Decades to centuries	Years to decades	Decades to centuries	Decades	Decades to centuries	Decades	Decades	Decades to centuries	Decades to centuries
8 - Construction Cost (approx. $)	Several million	Few hundred thousand	Several tens of thousands	Million+	Few million	Hundred thousand	Several hundreds of thousands	Million+	Hundreds of thousands+	Several tens of thousands	Several tens of thousands
Overall relative rank	**Moderate**	**Moderate**	**High (watershed restoration)**	**Low**	**Moderate**	**Moderate**	**Very High**	**Low**	**Moderate**	**High**	**High**

** Indicates estimated usable habitat based on 'reverse' HEP for target species*

Table 4-4. Summary Evaluation of Off-site Fish Habitat Offsetting Candidates

Screening Criteria	1. Big Creek Side Channel Enhancement	2. Mica Creek Side Channel Creation	3. Needlerock Side Channel Creation	4. Diamain Lake Whitefish Fishery Creation	5. von Wilczek Creek Side Channel Creation	6. Tatchun Creek Stabilization and Enhancement	7. Yukon River Slough Enhancement	8. Klondike River Side Channel Restoration	9. Dawson Dredge Ponds Off-line Pool Habitat Creation	10. Klondike River Side Channel Rearing Gallery at Germaine Creek	11. Klondike River Side Channel Rearing Gallery at North Klondike River
1 - Fisheries management objectives	Moderate relevance – creation of year-round Chinook rearing habitat	Moderate-High relevance – creation of year-round Chinook rearing and potentially overwintering habitat	Moderate-High relevance – creation of year-round Chinook rearing and potentially overwintering habitat	High relevance – creation of whitefish fishery for the benefit of local First Nations	Moderate relevance – creation of year-round Chinook rearing habitat	High relevance – restoration of regionally significant Chinook salmon rearing and spawning habitat	Moderate relevance – creation of Chum salmon rearing and potentially spawning habitat	Moderate relevance – restoration of low to moderate quality Chinook salmon rearing habitat	High relevance – creation of juvenile Chinook salmon rearing and overwintering habitat	High relevance – creation of juvenile Chinook salmon rearing and overwintering habitat	High relevance – creation of juvenile Chinook salmon rearing and overwintering habitat
2 - First Nations traditional uses and knowledge	Moderate-High	High	Moderate-High	Moderate-High	Moderate-High	Very High	Moderate-High	Moderate-High	High	High	High
3 - Quantity of habitat at offsetting sites	5,000 m^2 potential offsetting area	4,000 m^2 potential offsetting area	4,000 m^2 potential offsetting area	8,400,000 m^2 potential offsetting area*	2,000 m^2 potential offsetting area	5,000 m^2 potential offsetting area	5,000 m^2 potential offsetting area	300 m^2 potential offsetting area	6,231 m^2 potential offsetting area*	2,000 m^2 potential offsetting area*	3,600 m^2 potential offsetting area*
4 – Type and supply of habitat at offsetting sites	High quality juvenile Chinook salmon rearing and overwintering habitat; limited in watershed and region	Moderate quality juvenile Chinook salmon rearing and overwintering habitat; limited in watershed and region	Moderate quality juvenile Chinook salmon rearing and overwintering habitat; limited in watershed and region	High quality whitefish lake habitat; common in watershed and region, except limited as mono-culture	Moderate quality juvenile Chinook salmon rearing habitat; limited in watershed	High quality Chinook salmon rearing and spawning habitat; limited in watershed and region	Moderate quality Chum salmon habitat; common in watershed and region	Moderate quality Chinook salmon rearing habitat; common in watershed and region	Moderate quality juvenile Chinook salmon rearing and overwintering habitat; limited in watershed and region	Moderate quality juvenile Chinook salmon rearing and overwintering habitat; limited in watershed and region	Moderate quality juvenile Chinook salmon rearing and overwintering habitat; limited in watershed and region
5 – Approx. watercourse distance between offsetting sites and main impacts	475 km	440 km	475 km	485 km	415 km	470 km	425 km	515 km	525 km	550 km	570 km
6 - Risk of failure and time lag until offsetting habitats functional	High risk of failure (potential for main stem of Big Creek to re-occupy side channel and destroy habitat enhancement efforts, given its lateral instability), <2 yr time lag	Moderate risk of failure (potential for main creek to avulse into side channel, or groundwater levels to drop too low to maintain overwintering habitat), <3 yr time lag	Moderate risk of failure (potential for main creek to avulse into side channel, or groundwater levels to drop too low to maintain overwintering habitat), <3 yr time lag	Low-Moderate risk of failure (previous investigations documented large invertebrate populations (food source) and water quality consistent with whitefish habitat requirements), <10 yr time lag	Moderate-High risk of failure (potential for water levels during summer to be insufficient to maintain usable habitat in both channels), <3 yr time lag	Moderate-High risk of failure (potential for sediment pulses from beaver dam breaches and landslides to directly or indirectly impact restoration efforts), <5 yr time lag	Moderate risk of failure (potential for natural meander migration or flood sedimentation to impact created, extended or enhanced sloughs, or for poor use by Chum salmon), <3 yr time lag	Moderate-High risk of failure (potential for side channel to again become perched, relative to main river level, following continued down-cutting along the main river), <3 yr time lag	Low risk of failure (previous investigations documented acceptable water quality and fish presence and overwinter survival within connected and isolated ponds), <3 yr time lag	Low risk of failure (spring-sourced side channel with documented use by juvenile Chinook salmon already exists), <3 yr time lag	Low-Moderate risk of failure (groundwater-fed side channel already exists immediately upstream from proposed rearing gallery, but connection to main creek depends on meander dynamics), <3 yr time lag
7 - Expected duration of benefits	Years to decades	Years to decades	Years to decades	Decades to centuries	Decades	Years to decades	Years to decades	Years to decades	Decades to centuries	Decades to centuries	Decades
8 - Construction Cost (approx. $)	Few hundred thousand	Hundred thousand	Hundred thousand	Hundred thousand	Hundred thousand	Million+	Several hundred thousand	Few tens of thousands	Few hundred thousand	Hundred thousand	Few hundred thousand
Overall relative rank	**Very low**	**Low**	**Very low**	**High**	**Low**	**Moderate**	**Low**	**Low**	**High**	**High**	**High**

** Indicates estimated usable habitat based on 'reverse' HEP for target species*

3. Britannia Creek Ford Restoration (detailed below in Section 5.1.2)

The original placer mining access road along the Britannia Creek valley, which was established prior to the earliest available aerial photography in the area (1948), crosses Britannia Creek and lowermost Canadian Creek at several locations (**Figure 4-2**). At each of the fords, vehicle tracking has caused the banks to collapse, erode and retreat. Channels have become locally over-widened, promoting local sedimentation and further widening, in turn. Fine sediments continue to be eroded from the unvegetated banks during moderate to high flows and transported downstream. With relatively minimal effort, channel morphology at the now-abandoned fords can be restored, and riparian vegetation can be re-established. Although no areal gain in in-stream habitat is anticipated, the reductions to local and downstream sediment loading and corresponding extended downstream fish habitat benefits warrant such offsetting efforts.

4. Lower Britannia Creek Rehabilitation

The existing, mostly straight channel through which lower Britannia Creek flows follows a former road right-of-way (**Figure 4-2**). The roadway channel has responded to the unnaturally straight course and steep gradient, since the avulsion from its natural, meandering channel sometime in the 1970s, by altering its channel morphology. Long, cobble-substrate riffle and run sections dominate its straight length, with few deep pools for velocity refuge or cover. Undercut banks are limited in extent and size, given the relatively uniform flow pattern along the straight channel. Log jams derived from previously eroded mature trees continue to form and create sudden, sometimes dramatic changes in channel morphology and aquatic habitat. Consideration was given to rehabilitating habitat along this unnaturally straight section of lower Britannia Creek, by reconstructing meanders with variable channel dimensions and incorporating in-stream habitat features such as boulders and appropriately situated root wads. Channel naturalization, in this manner, has significant uncertainty and potential for failure. Additionally, the time frame before natural stability would be restored in a creek of this size may be considerable.

5. Lower Britannia Creek Groundwater Channel

Consideration was given to constructing a groundwater-fed channel east of the existing lower Britannia Creek channel, either within or alongside the historical channel of Britannia Creek (**Figure 4-2**). The channel would consist of a series of deep ponds, excavated below the groundwater table, connected by short segments of channel. It would drain into Yukon River and therefore provide rearing and/or overwintering habitat for Arctic grayling and Chinook salmon. However, an integrated field and desktop assessment of groundwater levels and gradients within the valley bottom determined that the groundwater table is as much as 4 m below the bed of the historical channel along some of its length. The depth and area of excavation required to maintain hydraulic connections between the ponds and channel segments would be impractical and result in a significant corridor of disturbance to mature floodplain habitat.

6. Partial Flow Diversion into Historical Lower Britannia Creek

For decades to centuries before its unnatural avulsion onto the former road right-of-way, lower Britannia Creek exhibited a tortuously meandering channel in its lower 2 km before entering Yukon River (**Figure 4-2**). This historical, meandering channel had much higher quality habitat than exists along the current

roadway channel followed by Britannia Creek. Consideration was given to diverting part (e.g., 50%) of the flow within existing Britannia Creek into its historical channel, following restoration of its overgrown channel, at the point of divergence between the two channels. The objective would be to maintain existing fish habitat along lower Britannia Creek, while at the same time restoring habitat along the historical, meandering channel. The primary obstacle to the success of this option, however, is the relatively low stream flows that occur in this semi-arid environment, particularly during the late summer to winter months. Halving the flow to each channel may result in net gains in wetted area, but the associated reductions in flow depth may reduce the usable habitat and prolong periods of flow discontinuity across riffles. A greater disparity in flow apportionment between the two channels (e.g., 80% and 20%) may be possible, but would still be inconsistent with the natural morphology and ecological function of this lower valley.

7. Reinstatement of Historical Lower Britannia Creek (detailed below in Section 5.1.1)

Full reinstatement of the historical, meandering channel of lower Britannia Creek would result in substantial, immediate improvements in the quality of lower creek habitat available to Chinook salmon, Arctic grayling and other species that currently use the existing lower reach and mouth of Britannia Creek (**Figure 4-2**). It is anticipated that this restoration would lead to measurable increases in productive capacity based on the creation of high suitability habitat that is naturally limited and in low abundance in the watershed. The historical channel provides flow and gravel substrate diversity through meanders, dense cover of overhanging vegetation and undercut banks, and micro-habitats on and around in-stream large woody debris and large cobbles. Its naturally deep pools would provide velocity refuge and improved potential for overwintering. The anticipated, long-term benefits to aquatic habitat associated with full reinstatement far outweigh temporary habitat displacement associated with the necessary abandonment of the existing roadway channel.

8. Groundwater-Fed Pool near Britannia Creek Mouth

One of the greatest limitations to the productive capacity of fish habitat within the watersheds encompassing the Project is the lack of deep pools that provide overwintering habitat. A field investigation along the lower Britannia Creek valley identified a zone of groundwater discharge near the mouth of the historical channel of lower Britannia Creek. The creation of a groundwater-fed, backwater pool alongside the main creek, near the confluence with Yukon River, would provide sufficiently deep water to inhibit pond freeze-up during the winter months and support overwintering of Chinook salmon and Arctic grayling (**Figure 4-2**). The incorporation of a 'leaky' bank at the upper end of the pool would enable throughflow for the purposes of maintaining appropriate water quality (e.g., dissolved oxygen concentrations) and periodically flushing fine sediments that accumulate in the channel connection with the main creek. However, field data collected during the 2013-2014 winter revealed that groundwater levels at the proposed pool site drop lower than anticipated, creating a stranding risk for any fish taking refuge in the pool. Furthermore, the FHOP Advisory Group cited opportunistic predation of juveniles by large fish within the adjacent Yukon River as part of the rationale for not pursuing this option further.

9. Artificial Chinook Spawning Channel alongside Lower Britannia Creek

Consideration was given to creating a Chinook spawning channel alongside lower Britannia Creek, either in the historical channel itself or in an excavated tributary (**Figure 4-2**), given First Nations interests and

historical information, and a low abundance of suitable spawning habitat. The critical issue is to establish a source of flow that would continue to flow year-round, including over the winter months when many tributaries to the Yukon River are frozen to their beds. Establishing a passive source of flowing water capable of maintaining an open channel is not feasible, given the absence of lakes in the watershed and the impracticality of intercepting enough groundwater flow upslope and delivering it to the spawning channel. Therefore, only one or multiple pumping wells that withdraw groundwater from the aquifer along Yukon River would represent a potential year-round source of water. The need for pumping to continue in perpetuity, the maintenance requirements, and the risk of equipment failure during critical winter periods precluded further consideration of this option.

10. Lower Britannia Creek Slope-toe Side Channel Extension and Enhancement (detailed below in Section 5.2.1)

As mentioned previously, a lack of deep pools limits the productive capacity of habitats along many watercourses in the Project area. Field reconnaissance along lower Britannia Creek, just upstream of the divergence between the existing and historical channel, identified a side channel that originates in a spring at the edge of a clearing at the toe of the steep, western valley side. The slope-toe channel is poorly connected to the main creek, due to an accumulation of woody debris and organic litter, and disturbance along its western bank has removed all riparian shrubs and trees. The extension of this spring-fed side channel into enlarged pool habitat up-valley from the spring, entirely within the existing areas of disturbance, would support additional rearing and overwintering habitat for species such as Arctic grayling and likely juvenile Chinook salmon (**Figure 4-2**).

11. Lower Britannia Creek Groundwater-fed Side Channel Extension and Enhancement (detailed below in Section 5.2.2)

The rarity of deep pools along the Britannia Creek valley can be addressed through opportunities to create or enhance off-line pool habitats. Field reconnaissance along lower Britannia Creek identified a side channel that originates in a spring at the toe of a terrace scarp that roughly parallels the main creek. About 20 m up-valley from this spring is what appears to be an overgrown placer test pit now filled with groundwater to a level approximately 0.5-1.0 m above the adjacent creek. The connection of this side channel to the existing pond (placer test pit) and then its extension into new pool habitat up-valley along the toe of the terrace scarp would support additional rearing and overwintering habitat for species such as Arctic grayling and possibly juvenile Chinook salmon (**Figure 4-2**).

4.2.2 Off-site Candidates

1. Big Creek Side Channel Enhancement

An existing side channel (meander scar) of Big Creek, which is flooded only during peak flow conditions, would be modified to allow year-round accessibility (**Figure 4-3**). The development of a permanent side channel would create good quality rearing habitat for both Arctic grayling and Chinook salmon. The off-channel position would facilitate a habitat with lower flows during peak flow events, as well as good protective cover and feeding opportunities for juvenile fish. In-stream habitat features such as boulders and cobble substrate could be added to enhance protective cover and the colonization of species on which fish feed (e.g., benthic invertebrates, periphyton). The key constraints to this option are the

potential for the main stem of Big Creek to re-occupy the side channel, given its lateral instability, and the relatively small area of habitat gained.

2. Mica Creek Side Channel Creation

SFN identified Mica Creek as a potential candidate for fish habitat offsetting in part due to its proximity to Pelly Crossing, where its mouth is located, and in part because it provides important rearing and spawning habitat for Chinook salmon and many other freshwater fish, including slimy sculpin, lake chub (*Couesius plumbeus*), longnose sucker (*Catostomus catostomus*), Arctic grayling and round whitefish (**Figure 4-3**). The watercourse meanders through a broad valley that is almost entirely undisturbed, with the exception of a road crossing near its mouth. Beaver activity has been identified as a recent obstacle to upstream fish migration in the lower reaches, hence the area's consideration for possible complementary research measures. Consideration was also given to creating off-line, groundwater-fed side channels to provide additional rearing and overwintering habitat for juvenile Chinook. This type of habitat is already present in reasonable abundance.

3. Needlerock Creek Side Channel Creation

Needlerock Creek enters the south side of the Pelly River a short distance upstream from Pelly Crossing (**Figure 4-3**). It exhibits a tortuous to irregular meander pattern within an undisturbed valley. A reconnaissance flight was conducted over the watershed with a representative from SFN to identify any opportunities for fish habitat offsetting. As for Mica Creek, consideration was given to creating off-line, groundwater-fed side channels to provide additional rearing and overwintering habitat for juvenile Chinook. However, this option was not pursued any further because of the pristine conditions and the existing presence of this type of habitat.

4. Diamain Lake Whitefish Fishery Creation (detailed below in Section 5.1.3)

Diamain Lake is a moderately large lake (approx. 20 km^2) located about 17 km straight northeast of the SFN community of Pelly Crossing, or about 25 km by highway (4 km), gravel road (18 km) and ATV trail (3 km) (**Figure 4-3**). It drains into the Pelly River via an outlet channel that drops steeply through a bedrock canyon. The lake is fishless, according to previous investigations, despite having acceptable water quality and invertebrates whose large size is attributed to a lack of predation (Archibald 1977; Lindsey et al, 1981). Consideration is being given to stocking the lake with whitefish, a culturally important species to SFN, to create a local fishery for the benefit of current and future generations of the local community. The whitefish (or other species selected by SFN) would be sourced from within the Pelly River watershed and supported by a hatchery operation in the initial phases of the stocking and monitoring program. Additional limnological and ecological studies would be completed to confirm the appropriate conditions for the proposed stocking program.

5. von Wilczek Creek Side Channel Creation

von Wilczek Creek is a small watercourse that originates in the hills south of Pelly Crossing and enters the east side of Yukon River just north of Minto (**Figure 4-3**). The watercourse loses much of its flow where it leaves its valley confinement and crosses a broad alluvial fan-terrace complex composed of sand and gravel. The lowermost 800 m of the creek support Juvenile Chinook salmon rearing, except during

periods of drought when water levels are too low. Consideration was given to creating constructing another distributary or parallel channel near the mouth of the creek, in order to provide additional habitat for juvenile Chinook salmon. However, mid to late summer water levels may be compromised by an additional, adjacent channel.

6. Tatchun Creek Stabilization and Enhancement

Tatchun Creek provides important Chinook salmon spawning and rearing habitat along the 7 km reach between Tatchun Lake and Yukon River (**Figure 4-3**). A number of natural and anthropogenic disturbances in recent decades appear to have contributed to a decline in the numbers of Chinook salmon that are returning to the reach to spawn. Logging in the mid-1900s was followed by the introduction of beavers, which have significantly altered the flow and sediment regime through the construction and subsequent breaching of their dams. Several large meanders are now undercutting the base of steep valley sides, causing shallow to deep-seated landslides that are delivering significant volumes of fine and coarse sediment into the creek. The high sediment supply has locally transformed the single-thread, meandering channel into a wandering to braided channel. Substantial efforts would be required to stabilize the valley bottom, and the potential benefits to Chinook salmon can only be speculated without prior research. In addition to considering opportunities to help promote self-stabilization, opportunities for research as a complementary measure for offsetting have also been identified.

7. Yukon River Slough Enhancement

Numerous 'blind' side channels without upstream surface connections, locally known as sloughs, occupy the downstream portions of large bars and islands within and alongside Yukon River between Carmacks and the Project area (e.g., **Figure 4-3**). These sloughs can provide high quality habitat to fish species seeking refuge from the higher velocity and higher turbidity water within the main Yukon River channel. Surface water seeps into the bar head, slowly filters through the alluvial sand and gravel, and then emerges as clear water within the open, downstream segment of an old side channel (i.e., hyporheic exchange). Chum salmon spawn near the mouths of these sloughs, and opportunistic usage by juvenile Chinook salmon is believed to occur (Al von Finster, pers. comm., 2014). Some of the sloughs remain open and mostly free of ice cover during winter, likely in areas where there is sufficient through-flow of relatively warm, shallow groundwater that ice is unable to form where it emerges. Consideration was given to excavating, extending and enhancing slough habitats, but concerns expressed by the FHOP Advisory Group included their stability within a dynamic river, their limited attractiveness to Chinook salmon (the principal target species for offsetting), and the challenges to authorization along the heritage river.

8. Klondike River Side Channel Restoration

One of the members of THFN identified a small side channel of the Klondike River in which he recalls observing large numbers of fish aggregating when he was younger. The side channel is located immediately southeast of the town centre of Dawson City, on the north floodplain of the Klondike River (**Figure 4-3**). Recent field reconnaissance revealed that the side channel has become perched above the normal water level of the adjacent river, such that it is entirely dry and drops approximately 0.5 m at its outlet onto a wide, gravel side-bar. A small pond at its head, presumably an overgrown placer test pit, is

the only permanent water in this portion of the floodplain. Past modifications to the bed of the river, immediately downstream near the former water intake, may explain some of the changes in river bed (and therefore water level) elevation relative to the floodplain (Al von Finster, pers. comm., 2014); localized down-cutting may now be occurring in the absence of gravel augmentation. Consideration was given to reconnecting the small pond to the river by deepening the infilled side channel, especially given the opportunities such efforts would provide for interpretive signage and education for youth in the local community. However, the maintenance that would likely be required to maintain a surface connection between the pond and the river discouraged further consideration of this offsetting option.

9. Dawson Dredge Pond Off-line Pool Habitat Creation (detailed below in Section 5.1.4)

Undeniably the most conspicuous 'landforms' within the lower Klondike River valley are the vast complexes of dredge piles and ponds left by placer mining that began intensifying locally in the 1960s (**Figure 4-3**). A unique characteristic of the dredge ponds is their remarkable depth (commonly >5 m) and their continuous, year-round through-flow of water that seeps into and out of the cobbley berms that separate them. Various fisheries scientists have recognized the opportunities the dredge ponds provide for off-line habitat creation and enhancement, especially for rearing and overwintering of juvenile Chinook salmon and other Klondike River species (e.g., slimy sculpin, round whitefish and Arctic grayling). EDI (2005) studied and reported on the potential for connecting and using some of the dredge ponds to offset predicted habitat impacts associated with the previously proposed replacement of the car ferry at Dawson with a bridge. Its sampling of fish and water quality within a number of the ponds confirmed fish presence, even in some isolated ponds, and demonstrated the capacity of the waterbodies to support rearing and likely overwintering habitat. Building on this previous ecological work, a network of interconnected ponds is proposed to increase opportunities for off-line rearing and overwintering of juvenile Chinook salmon, among other Klondike River species.

10. Klondike River Side Channel Rearing Gallery at Germaine Creek (detailed below in Section 5.2.3)

Germaine Creek enters a side channel on the south side of the Klondike River, where a pair of meanders was intentionally cut-off by earth-moving equipment in the 1970s, presumably to mitigate further erosion of the highway embankment (**Figure 4-3**). A small, spring-sourced channel meets Germaine Creek, where it drains from the culvert beneath the Klondike Highway. Annual visits and monitoring by Al von Finster since 2004 provide a basis for documenting successful use of this groundwater-fed channel by juvenile Chinook salmon for rearing and overwintering. Only once in ten years, when late fall and winter water level in the Klondike River was unusually low, did stranded fish within the groundwater-fed channel not survive the winter, likely as a result of river water levels being so low that much of the intercepted groundwater originated from the oxygen-poor, thawing permafrost to the south. A rearing gallery consisting of a trunk channel with several river-side branches is proposed to extend and deepen the pool habitat beyond the spring, thereby inducing greater interception of comparatively oxygen-rich, shallow groundwater flow from the Klondike River.

11. Klondike River Side Channel Rearing Gallery at North Klondike River (detailed below in Section 5.2.4)

Amid the general instability along the Klondike River, just upstream of its confluence with the North Klondike River, there is a mature white spruce forest growing on a stable, low terrace situated on the inside of a large meander (**Figure 4-3**). A groundwater-fed channel, maintained only by seepage intercepted through the alluvial gravels, flows around this low terrace to meet a continuously flowing side channel with upstream and downstream surface connections to the main Klondike River. A broad, V-shaped clearing within the terrace forest is a result of past gravel excavation, long ago abandoned and left to regenerate naturally. The existing area of disturbance within the relatively stable inner portion of the meander provides an opportunity to construct a gallery of interconnected, groundwater-fed pool habitats that would support both rearing and overwintering of local fish species, including juvenile Chinook salmon.

5 Description of Proposed Fish Habitat Offsetting

Eight of the 22 habitat offsetting candidates described above, plus a complementary contribution to Chinook salmon research, represent proposed offsetting opportunities for the Project (**Figure 5-1**). Four of the candidates plus the research project represent *preferred* opportunities, and four of the candidates represent *contingency* opportunities. CMC has identified preferred opportunities as those which are most feasible and best align with DFO's objectives for ensuring the sustainability and ongoing productivity of Canadian CRA fisheries. The contingency opportunities are also feasible, but only to be pursued if authorization for the preferred opportunities is not expected, as they offer more modest opportunities to increase the productivity of target species. CMC commits to restoring, creating or enhancing enough fish habitat to fully offset the predicted residual impacts from the Project (as quantified below in Section 5.4), but exactly which combination of habitat offsetting opportunities will be advanced to detailed design will be confirmed following additional consultation with First Nations and DFO.

Each of the preferred (Section 5.1) and contingency (Section 5.2) habitat offsetting opportunities is detailed below. Proposed offsetting for impacts to riparian habitat is described in Section 5.3. The overall habitat balance is outlined in Section 5.4.

5.1 Preferred Habitat Offsetting Opportunities

5.1.1 Reinstatement of Historical Lower Britannia Creek

Lower Britannia Creek is well suited for fish habitat offsetting given its historical disturbances related to placer mining, which has occurred intermittently in the area and has impacted Britannia Creek and its major tributary, Canadian Creek, since 1911 (MacDonald, 2012). Lower Britannia Creek's classification by the Yukon Placer Secretariat as "Areas of Special Consideration – Cultural" virtually precludes future placer mining activity (**Figure 2-1**). A narrow road, presumably providing access to upstream mineral prospects, is visible along the Britannia Creek valley in the earliest available aerial photography in the region (1948) (**Figure 5-2**). It forded Britannia Creek at several locations downstream of its confluence with Canadian Creek, before continuing up the Britannia Creek valley (**Figure 5-1**). Sometime between 1965 and 1988, based on available historical aerial photography, lower Britannia Creek abandoned its natural, meandering channel to follow the straight, road right-of-way, which offered little resistance and a direct, downhill path. Anecdotal accounts from a local trapper indicate the avulsion likely occurred in the early 1970s. After following the roadway for about 900 m, the streamflow diverged eastward and carved a sinuous path, forming a new mouth about 150 m west of the original mouth (**Figure 5-2**).

610,000

620,000

6,970,000

6,960,000

6,950,000

Legend

- Preferred Fish Habitat Offsetting Opportunities
- Contingency Fish Habitat Offsetting Opportunities
- Partial Loss of Fish Bearing Habitat
- Total Loss of Fish Bearing Habitat
- Barge Access Road
- Airstrip Access Road
- Freegold Road Extension
- Freegold Road Upgrade
- Waterbody
- Watercourse
- Airstrip
- Proposed Mine Facilities

Habitat Impact: 4,112 m^2

Habitat Offsetting (historical channel): 14,870 m^2

Habitat Offsetting (slope-toe channel): 1,210 m^2

Habitat Offsetting (groundwater-fed channel): 1,830 m^2

Habitat Offsetting (all fords): 0 m^2 (riparian only)

Habitat Impact: 299 m^2

Habitat Offsetting (Chinook Research Project): 3,840 m^2 (equivalent to 10% of habitat offsets)

Habitat Impact:14,727 m^2

Habitat Impact: 3,157 m^2

Habitat Impact: 1,001 m^2

Habitat Impact: 330 m^2

Airstrip Diversion Channel (mitigation only)

Yukon River

Creek

Creek

Canadian

Britannia

Brynelson Cr

Cr

Casino

Rude Creek

0 2 4 6 8

Kilometers

N

Off-site Fish Habitat Offsetting Opportunities

Habitat Offsetting (Dredge Ponds): 9,120 m^2

Habitat Offsetting (Germaine Creek): 2,680 m^2

Habitat Offsetting (North Klondike River): 4,820 m^2

Habitat Offsetting (Diamain Lake): TBD

Dawson

Casino

Pelly Crossing

1:3,000,000

PREPARED BY:

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

DESIGNED	R.McKillop
DRAWN	D. Turner
CHK'D	R. McKillop
APP'D	R. McKillop
REV	R. Palmer
DATE	26Nov'14

NOTES:

1. BASE MAP: Digital Elevation Model and 1:250,000 and 1:50,000 Topographic Spatial Data provided by Geomatics - Yukon Government via online source (www.geomaticsyukon.ca)
2. PROJECTION: NAD 1983 UTM Zone 7N
3. COORDINATE GRID: METRES
4. SCALE: 1:85,000

CASiNO

CASINO PROJECT

Locations of Fish Habitat Impacts and Proposed Offsetting Opportunities

FIGURE 5-1

FHOP REPORT

PN 10011

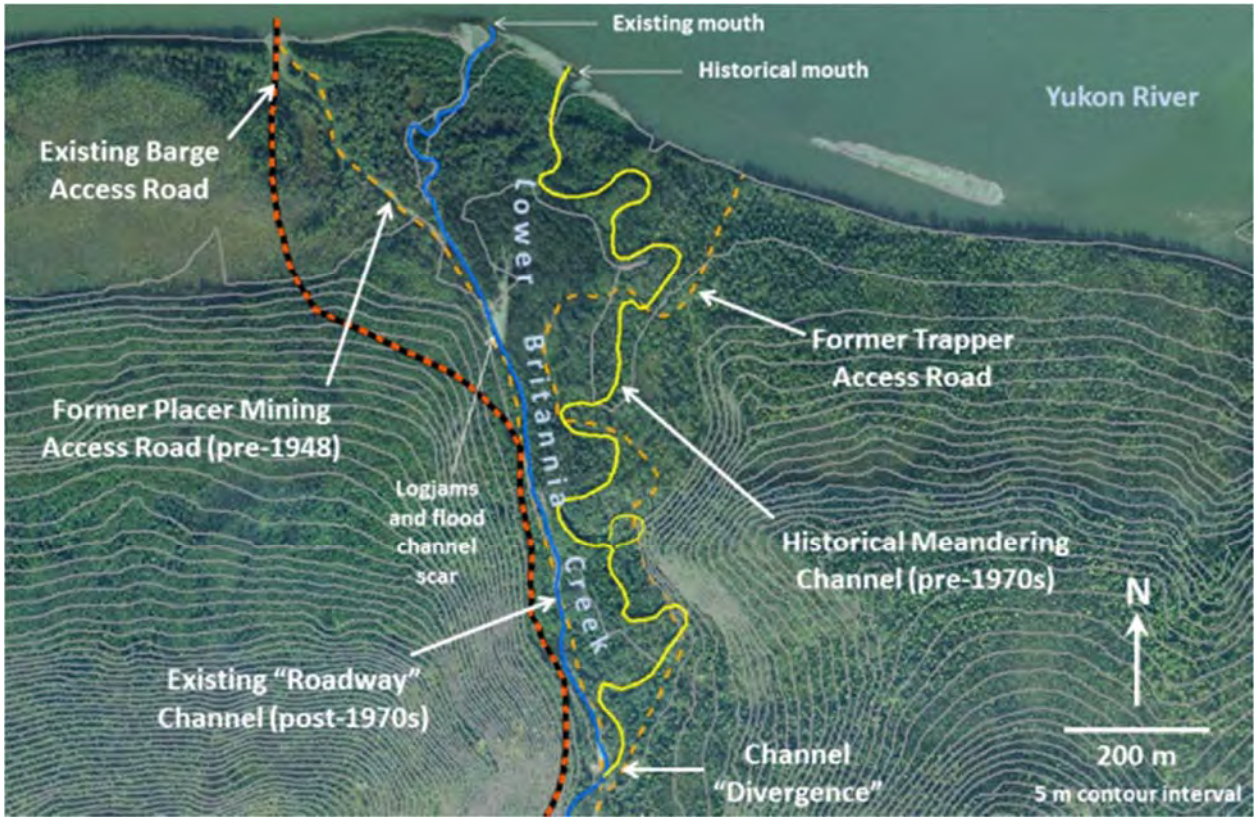

Figure 5-2. Existing and Historical Channels of Lower Britannia Creek

The unnatural avulsion of Britannia Creek onto the former road right-of-way resulted in a sudden and dramatic impact on fish habitat quality. Whereas the historical channel had a tortuous meander pattern, with deep, asymmetric pools along steep or undercut banks, the new roadway channel is mostly straight, shallow and comparatively steep with a large cobble bed and higher flow velocities (**Figure 5-3**). The historical channel, which was dynamically stable for decades to centuries, had regular sequences of riffles, runs and pools; the roadway channel is dominantly riffle-run habitat with few areas of refuge. The unstable roadway channel is expected to continue adjusting its pattern for decades, through irregular and locally severe bank erosion, until it re-adopts natural meander geometry. Logjams, major aggradation and a shallow, multi-thread channel near the divergence of the channel from the former road alignment are a testament to the continued instability of this roadway channel (**Figure 5-4**). Habitat offsetting is proposed along lower Britannia Creek to avoid this area of long-term instability and restore the lost, meandering habitat. Measures to address localized, upstream instabilities at abandoned fords are proposed as part of overall watershed restoration in Section 5.1.2.



Figure 5-3. Downstream View of 'Roadway' Channel of Lower Britannia Creek (Aug. 23, 2011)



Figure 5-4. Unstable, Debris-jammed 'Roadway' Channel of Lower Britannia Creek (Aug. 25, 2014)

At present, two distinct channels descend the gentle alluvial fan at the mouth of Britannia Creek: the mostly straight, roadway channel on the west side, which currently conveys all streamflow, and the dry, tortuously meandering historical channel on the east side (**Figure 5-2**). The reinstatement of the historical channel, which represents 14,870 m^2 of in-stream habitat[1] and 86,080 m^2 of riparian habitat, will be accomplished in two main steps: restoration of natural morphology free of obstructions, and re-introduction of flow (**Drawing 1, Appendix A**). Since its abandonment several decades ago, the historical channel has become locally overgrown with saplings and has accumulated woody debris and organic matter on its bed (**Figure 5-5**). This material, which otherwise would form major obstructions to flow, will be selectively removed through manual labour and/or the use of small equipment (e.g., Bobcat). Channel banks will be restored at four small fords, where a trapper access road crosses the (dry) historical channel (**Figure 5-2**). Once the natural morphology of the channel has been restored, entirely "in the dry", flow will be gradually re-introduced during a low to moderate flow, when water in Britannia Creek and the Yukon River is already naturally turbid (e.g., the waning stages of a freshet). This timing will minimize risk to downstream aquatic species and habitats. Further details, including the importance of conducting a fish salvage and release from the dewatered existing channel, are described below in Section 6.1.



Figure 5-5. Overgrown and Debris-littered Historical Channel of Lower Britannia Creek

[1] A 'reverse' HEP analysis of the historical channel of lower Britannia Creek, based on a two-dimensional hydraulic model combined with habitat indices for Arctic grayling (Hubert et al., 1985), determined that the total habitat area (length times width) is anticipated to be fully usable (HSI score of 1.0) (Section 3.1.2).

A permanent diversion berm is proposed at the divergence of the existing and historical channel in order to ensure in-stream and overbank flows are directed into the historical channel (**Drawing 2, Appendix A**). The most upstream meander of the historical channel will be realigned eastward in a way that approximately reflects its existing geometry, in order to avoid potential future avulsion back into the existing channel at the narrowing between the existing and historical channels. The cut-off meander will be abandoned to form a backwatered oxbow. The bed of the historical channel is elevated slightly (<0.5 m) relative to the bed of the existing channel, which has degraded (down-cut) slightly in response to the reduction in channel length and steepening of its gradient. Therefore, a riffle will form at the entrance to the historical channel, at the downstream end of a pool in the existing channel. A vegetated setback of at least 5 m is proposed for the berm from the channel bank, in order to provide a buffer for flood attenuation. Beyond the diversion berm, the existing channel will be abandoned and allowed to revegetate naturally with colonizing, pioneer species.

The restored historical channel will have the same gentle profile and localized, mid-reach steepening as it did prior to abandonment several decades ago (Profile, **Drawing 1, Appendix A**). The existing, natural cross-sectional shapes are distinct for pools and riffles, as would be expected. Pools typically exhibit strong asymmetry, which promotes scour and undercutting along the outer banks of meanders and deposition of gravel and fine sediments in point bars along the inside of the bends (Typical Pool Section, **Drawing 1, Appendix A**). Riffles tend to be shallower, slightly wider and composed of cobbles; they increase dissolved oxygen levels in water, provide critical habitats for benthic invertebrates, and form local sites of hydraulic grade control (Typical Riffle Section, **Drawing 1, Appendix A**). Runs exist as transitional features at the downstream ends of riffles and upstream limits of pools, typically located at inflection points between successive meanders.

5.1.2 Britannia Creek Ford Restoration

Historical access roads for placer mining forded lower Britannia Creek and lowermost Canadian Creek at six sites, in total (**Figure 5-1**[2]). Four of the fords cross lower Britannia Creek, one crosses Canadian Creek just upstream of its confluence with Britannia Creek, and one crosses Britannia Creek upstream of its confluence. All fords were formed historically at riffles (areas of natural widening and coarse bedload deposition), without regard for impacts to channel morphology and aquatic habitat, and are no longer required for access along the valley. The existing Barge Access Road is further elevated from the valley bottom, where no crossings of Britannia Creek are required, and has only one clear-span bridge over Canadian Creek and an adjacent side channel. The abandoned fords represent sites of localized instability and sources of fine sediment from road surface runoff.

CMC proposes to apply typical bank treatments to restore natural bank morphology and riparian vegetation at five of the six fords (Fords A to F, **Figure 5-1**), in order to reduce downstream sedimentation along the existing and historical channel (once flow is re-introduced) (**Drawing 4, Appendix A**). The sixth ford, located at the divergence of the existing and historical channels of lower Britannia Creek, will be addressed in association with the diversion berm construction (Section 5.1.1). Ford restoration is a measure without expected gains in in-stream habitat area (0 m^2), but it will restore 3,210 m^2 of riparian habitat and address a potential constraint on the success of the reinstatement of the historical

[2] Only the five fords where 'typical' bank and riparian restoration is proposed are explicitly identified.

meandering channel of lower Britannia Creek (Section 5.1.1). It also embodies the overall objective of restoring the channel and riparian vegetation along lower Britannia Creek. Ford restoration will be completed prior to re-introduction of flow into the historical channel.

Ford sites were originally selected for convenience at riffles, where the channel is naturally wide, flow depths are shallowest, the bed is flattest, and substrates are supportive to vehicle traffic. Therefore, the typical restoration plan in **Drawing 3** (**Appendix A**) reflects the restoration of bank morphology at a riffle. Small patches of fine sediment that have accumulated against the banks will be removed and used to re-build natural bank morphology. Brush layers will be constructed in both banks in order to slow channel-edge velocities and promote bank stability through deep rooting. Once the natural dimensions of the channel are restored to match upstream and downstream sections (as specified in the site-specific guidelines on **Drawing 3**, **Appendix A**), adjacent areas of floodplain will be replanted using live stakes of native willows and tree seedlings.

5.1.3 Diamain Lake Whitefish Fishery Creation

Diamain Lake is a 10 km-long, 2 km-wide, moderately deep (25 m maximum) oligotrophic lake located approximately 17 km northeast of the community of Pelly Crossing (**Drawing 4**, **Appendix A**). Historical limnological and fisheries surveys indicated that the lake was fishless despite having suitable conditions for supporting fish (Archibald, 1977; Lindsey et al., 1981). Fisheries sampling efforts consisted of bottom and surface overnight gillnet sets in 1970 and 1975, and seine net fishing in 1970 (Lindsey et al., 1981). Furthermore, the large plankton and invertebrates found in the lake suggested that fish predation was low or absent (Archibald, 1977). The lake drains via an unpassable, high-gradient outlet stream into the Pelly River, which drains west into the Yukon River (Lindsey et al., 1981).

Introducing fish to Diamain Lake provides an opportunity to create a high quality local fishery for SFN. Further, the newly modified *Fisheries Act* outlines the opportunity for biological manipulations, such as stocking, in order to offset serious harm to fish (DFO, 2013a). Diamain Lake is close to Pelly Crossing and can be accessed by an approximately 3 km long ATV trail on SFN land from a seasonal (gravel) road extending from the all-season (paved and maintained) Klondike Highway.

Whitefish are culturally important to the SFN, as traditional net fisheries existed on Tatlmain Lake, Towhata Lake and on Mica Creek near Pelly Crossing (Morrell, 1991; Pearse and Weinstein, 1998; Environment Yukon, 2010). While broad whitefish runs have declined in recent decades (Environment Yukon, 2010), lake whitefish are still commonly found in the Pelly River watershed (Selkirk Renewable Resources Council (SRRC), 2006). As there is an outlet stream that connects to the Pelly River, but prevents the upstream migration of fish, only native species will be released to the lake. Thus, whitefish from the Pelly River watershed or in nearby acceptable watersheds would be captured for facilitating a stocking program in conjunction with a local hatchery, such as the McIntyre Creek facility in Whitehorse. However, the choice of stocking species will ultimately be decided in consultation with SFN and DFO.

Prior to stocking, fisheries and limnological data will be collected in order to ensure that current lake conditions are still represented well by historical baseline studies. Specifically, field surveys will ensure fish absence using various fishing techniques over multiple days and seasons. They will also verify lake

conditions (e.g., water quality, primary productivity) are capable of supporting fish year-round. In addition, applications for the transfer or release of live fish will be submitted to YESAB and to DFO-Whitehorse/Yukon Government-Environment in accordance with Section 56 of the General Fishing Regulations[3]. Appropriate stocking methods (rate, timing, fish size) will be determined in consultation with regulatory agencies, and all released fish will adhere to the Fish Health Protection Regulations[4]. A monitoring program will be developed that will aim to evaluate the success of the introduction (fish abundance and health), and potential ecological effects on existing aquatic resources in the lake (e.g., plankton, benthos). It is anticipated that post-stocking monitoring will occur in cooperation with SFN to evaluate program success.

The determination of the anticipated gain in usable habitat in Diamain Lake, for the species of interest, requires more accurate limnological and physical habitat data than are currently available in existing publications (e.g., Archibald, 1977). If this Diamain Lake fishery opportunity is selected for advancement and ultimate implementation, bathymetric, water quality and ecological data will be collected to support its justification and the quantification of the expected gain in usable habitat.

5.1.4 Dawson Dredge Pond Off-line Pool Habitat Creation

The unusual dredge pile/pond morphology remaining following intensive placer mining operations along the lower Klondike River valley provides a unique opportunity to create important off-line rearing and overwintering habitat for a variety of fish species, including juvenile Chinook salmon, in an area that is otherwise of limited ecological value. The dredge piles are composed of rounded alluvial gravel and cobbles, generally in the form of long, sinuous berms with rippled crests (**Figure 5-6**). Many remain completely devoid of vegetation on their crests and flanks, despite decades of stability, due to their high permeability and lack of soil cover. The ponds amongst the dredge piles are relatively deep (commonly >5 m) and maintained at a level that is similar to, and primarily controlled by, the level in the adjacent Klondike River. A continuous, year-round through-flow of water seeps into and out of the cobbley berms, maintaining water quality capable of supporting fish habitat.

[3] http://www.pac.dfo-mpo.gc.ca/yukon/trans-eng.html
[4] http://laws-lois.justice.gc.ca/PDF/C.R.C.,_c._812.pdf



Figure 5-6. Dredge Pile/Pond Complex with Proposed Interconnected Pond Configuration

Approximately 7 km up-valley from the town centre of Dawson City, the Klondike River arcs northward around a vast complex of dredge piles and ponds (**Drawing 5**, **Appendix A**). This major bend in the river forms a drop in hydraulic head from the upstream to the downstream portions of the bend, which induces a down-valley seepage of water (hyporheic exchange) through the berms and ponds (dashed blue lines in **Drawing 5**, **Appendix A**). EDI (2005) first studied and reported on the potential for connecting and using dredge ponds in this area to offset predicted habitat impacts associated with the previously proposed bridge across Yukon River at Dawson City. It conducted fish sampling in October and December, 2005, using a combination of minnow traps (set for 24 hours) and short gill net sets (0.5 hours) for determining adult fish presence. Juvenile Chinook salmon and slimy sculpin were present within ponds with seasonal connections to the Klondike River, and a high density of juvenile Chinook salmon was documented in a pond with a permanent connection to the river – good evidence for the potential success of connecting other ponds to the Klondike. Even some ponds completely isolated from the river contained fish (i.e., slimy sculpin and juvenile burbot), reportedly from remnant populations that have survived since the original mining operations in the mid- to late-1900s enclosed the water body. No fish were captured in some of the smaller, isolated ponds. EDI (2005) notes that many of the ponds have significant fish habitat value, with the capacity to support overwintering beneath thick ice cover.

Subsequent field reconnaissance and research by PECG in association with the development of this FHOP has built on this initial work. Seepage flow was observed emerging from gravels at the water's edge of some ponds, colonizing riparian vegetation was observed to be providing cover and contributing woody debris and organic matter along pond shorelines. Beaver activity in the area has transient effects on water levels within the ponds, causing backwatering in some areas and driving faster berm through-

flow in areas of increased hydraulic head. The margins of the dredge pile/pond complex is gradually being eroded by floodwater and ice jams along the Klondike River, but at average rates of only a few centimetres per year (based on a comparison with historical aerial photography) (**Figure 5-7**).

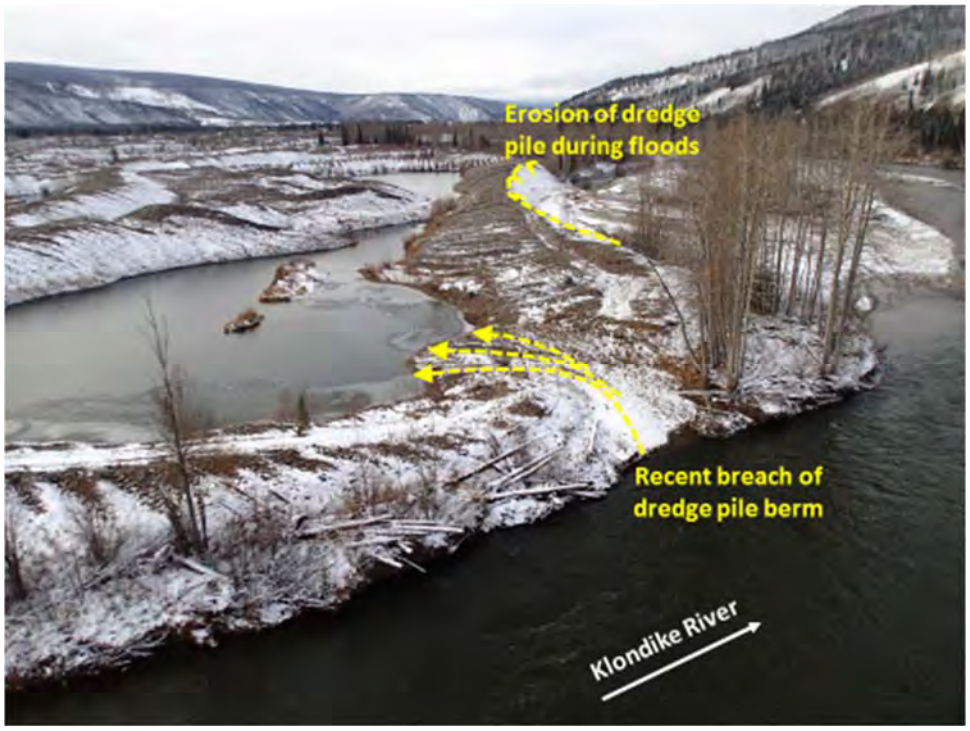

Figure 5-7. Localized Erosion along Edge of Dredge Pile/Pond Complex

A network of interconnected, off-line pool habitats is proposed to be created through the selective excavation of 'connector channels' through narrow dredge pile berms (**Drawing 5**, **Appendix A**). Four ponds that have no surface connection to one another or to the Klondike River are proposed to be connected, roughly in line with the natural pathway of seepage through the valley bottom dredge pile/pond complex. The four inter-pond excavations will form narrow connector channels at least 0.5 m below the low water level (to be determined by the collection of level logger data). The edges of the small channels will be benched and lined with locally sourced boulders in order to help maintain stability without planting riparian vegetation that attracts beaver activity. The narrow, channel-edge benches will accommodate minor raveling of the cut-slopes that is expected as a result of frost heave during natural freeze-thaw cycles. Material excavated from the berms will either be placed on nearby, unvegetated gentle ground, or will be incorporated strategically into shoreline habitat (e.g., beach-like shallows) to increase attractiveness for juvenile Chinook rearing. Typical riparian planting treatments (e.g., brush layers, rootwad/boulder complexes) will be implemented where shoreline gradients permit and with consideration for beaver activity. Regardless, there is likely to be an interest in monitoring and addressing beaver dams that may completely obstruct access between ponds.

The quantification of usable habitat expected to be gained through the creation of off-line pool habitats requires consideration of the habitat preferences of juvenile Chinook salmon, which is the main target species for habitat offsetting efforts in the Klondike River valley. Juvenile Chinook salmon have been documented to prefer water with depths of up to about 1 m for rearing (Martin et al., 2013), so only areas within the ponds with depths of 1 m or less were considered to represent a gain in usable habitat. Subaqueous shoreline slopes of approximately 2H:1V were observed in the field, so the area of a 2 m-wide buffer along the shorelines of each of the four ponds was measured as an indicator of existing high quality juvenile Chinook rearing habitat potential. Of the 43,790 m^2 of total pool area provided by the four newly connected dredge ponds, approximately 6,230 m^2 is currently less than or equal to 1 m in depth. In order to optimize more of the habitat for juvenile Chinook, gravels and cobbles excavated while creating the connector channels will be carefully placed in select areas of the ponds to provide additional shallow (<1 m) areas for rearing, bringing the total usable habitat to 9,120 m^2. Notwithstanding this, a principal objective of this offsetting opportunity is to increase access to reliable overwintering habitat, so deep (>1 m) areas of the ponds must be maintained. Follow-up field investigations and data analysis are anticipated to include bathymetric surveys, water quality monitoring and additional fish sampling (targeting both juvenile and adult fish species), as a basis for developing a more refined habitat suitability model for juvenile Chinook salmon rearing and overwintering in off-line pools in Yukon.

The entire area within which works are proposed in association with this habitat offsetting opportunity has been withdrawn from areas eligible for placer mining (Placer Mining Act) and bedrock mining (Quartz Mining Act), in accordance with Order in Council 2001/81 (Yukon Government, 2003). The land is in the traditional territory of THFN and is managed by the City of Dawson, which has considered different uses of this land. Two of the main considerations are to protect the land from development, establishing it as park land to preserve the heritage value of the unique landscape, or to expand new residential development into the area. Neither option precludes the development of the off-line pool habitat described above; in fact, such minor modifications may actually enhance the value of either park land or residential development.

5.1.5 Research Contribution: Chinook Salmon Stock of Origin in Natal and Non-natal Streams

Rationale

As described in Section 4.1, complementary measures are a new component of *Fisheries Act* policy, allowing proponents to undertake a more flexible approach for offsetting impacts (DFO, 2013a). The geographical location and limited ecological understanding of aquatic systems in northern environments make the Project an ideal candidate for pursuing alternate offsetting measures such as scientific research initiatives that will ultimately benefit local fisheries.

The Project is located in a relatively remote and pristine area of west-central Yukon with limited nearby opportunities for creating, restoring or enhancing habitat. While there are nearby abandoned sites that have been previously affected by industry (e.g., placer mining), these sites are often located in small and/or high elevation headwater valleys with minimal potential for increasing local fisheries productivity.

Further, locations with existing placer claims are at risk of future disturbances, precluding any potential long-term gains in fisheries productivity.

It has been well established that there is a growing and significant need to identify and understand the driving factors responsible for the drastic population decline of the Yukon River Chinook salmon population (Arctic-Yukon-Kuskokwim Sustainable Salmon Initiative Chinook Salmon Expert Panel (AYK), 2013). Due to their long-distance migrations, Yukon River Chinook salmon face a myriad of potential impacts over a wide geographical area, including habitat loss and alterations, climate change, overfishing, disease, reductions in productivity, changes in water chemistry and quality, and barriers to migration (AYK, 2013). Accordingly, understanding the stressors faced by Yukon River Chinook is an important ongoing focus of fisheries managers, First Nations, recreational fishing groups, and conservation organizations in the territory. Further, several collaborative working groups and expert panels have been founded with the specific purpose of facilitating research and management efforts for Yukon River Chinook salmon (e.g., Arctic-Yukon-Kuskokwim Sustainable Salmon Initiative, Yukon River Joint Technical Committee, Yukon Salmon Sub-Committee).

Given the demonstrated need for research, and the lack of potential opportunities for more traditional offsetting measures nearby, CMC proposes to allocate the maximum allowable proportion of the overall offsetting amount to research efforts (10%, the equivalent of 3,840 m^2 of habitat offsets), recognizing that the Project offers a unique case where a greater contribution to regional fisheries productivity may be made through research initiatives, rather than through localized habitat creation or modification initiatives. Exactly what funding commitment is required on CMC's part to facilitate the research program will be outlined in the final offsetting plan, in association with detailed design, based on the average cost per square metre estimated for the construction of the other project-specific habitat offsets. Research programs will be designed and conducted in consultation with DFO and First Nations, with the potential to consult with other partners (e.g., Yukon River Panel, Yukon Salmon Sub-Committee, Yukon College) in order to ensure that collective fisheries objectives are deeply rooted in study objectives. It is envisaged that local engagement is critical to this research, not only in the objectives of the study, but also in the collection and dissemination of data to provide learning opportunities and capacity building with local communities. Previous and ongoing consultations with several stakeholder groups, First Nations and fisheries experts in the region have led to the identification of one leading research proposal, which is described in the following sub-sections.

Background Information

Chinook salmon have a complex life cycle, similar to other anadromous salmonids, and stressors at certain life cycle stages may significantly affect recruitment back into the population. One of the potential bottlenecks to production for Yukon River Chinook salmon is the availability of suitable overwintering habitat. Juveniles need to not only survive the winter, but also to grow and attain the necessary size and fitness to be able to successfully migrate to the marine environment the following year. For a sustainable population, it is critical that sufficient numbers of healthy juveniles undergo this transformation and withstand additional stressors encountered in the marine environment so that they can return to freshwater as spawning adults.

For effective fisheries management and identification of local conservation priorities, it is important to understand the use of natal (stream of birth) and non-natal (non-spawning streams) creeks by juvenile salmon. Stock of origin genetic assessments for juvenile Chinook salmon can provide an understanding of juvenile migrations within a watershed, as well as the potential contribution of key physical and environmental factors influencing juvenile overwintering habitat. A study by the Alaska Sustainable Salmon Fund found that juvenile abundance (2003-2007) was significantly related to adult abundance for Canadian-origin Yukon River Chinook salmon (Murphy et al., 2014). This exemplifies the importance of the contribution of early freshwater life-history stages to the survival and production of Canadian-origin Chinook salmon.

There are a growing number of studies focused on using genetics to distinguish Chinook salmon populations in the Yukon River drainage (e.g., Bradford et al., 2009; Daum and Flannery, 2011; Beacham and Candy, 2012; Taylor, 2013). These studies help to address critical data gaps regarding the variation in population abundances, run timing and population composition (age, sex, length) that may differ among salmon stocks. An accurate understanding of stock characteristics underpins fisheries management and is the basis for setting fishery harvesting quotas that do not negatively affect the overall productivity of the fish stock.

Chinook salmon of Pelly River origin have been identified by SFN as a highly valued fishery. While genetic baselines have been identified for at least six of the 24 known sub-populations within the Pelly watershed (Beacham and Candy, 2012), there remains considerable opportunity to contribute to this growing database and support fisheries management within the area. Furthermore, no juvenile Chinook genetic studies have been conducted to date to determine the stock composition in any of the numerous natal or non-natal streams supporting juvenile overwintering activities in the Pelly River watershed.

Studies developed in the Pelly River watershed will be used in other areas of interest such as Tatchun Creek (**Figure 4-3**). Tatchun Creek is within the traditional territory of LSCFN, is easily accessible by road, and supports Chinook spawning and juvenile rearing activities.

Objectives and Hypotheses

The objectives of the study will be (1) to determine the genetic stock identification (GSI) of juvenile Chinook salmon within the lower Pelly River watershed and Tatchun Creek, (2) to investigate and compare the habitat and environmental qualities in natal and non-natal streams, and (3) to determine if habitat and environmental qualities are related to juvenile Chinook salmon habitat productivity. Both of the identified study areas support the rearing and overwintering of juvenile Chinook salmon that have originated from the same streams (natal origin) or have potentially left natal streams for non-natal streams downstream (Al von Finster, pers. comm., 2014). Factors influencing the selection of juvenile Chinook salmon habitat for rearing and overwintering will be investigated, such as migration distance and orientation, the presence of fish passage barriers, individual fish fitness (e.g., size), habitat quality and quantity, and environmental variability among streams and years. It is predicted that (1) watercourses in the lower Pelly watershed and Tatchun Creek will comprise mixed stocks from upstream spawning streams, (2) that juvenile Chinook salmon dispersal will be non-random and that juveniles will favour accessible streams with suitable overwintering conditions, and (3) that juveniles selecting higher quality overwintering habitats will demonstrate higher growth rates and freshwater survival.

This study will also investigate the feasibility of sampling the GSI and fitness of outmigrating salmon to the marine environment from these systems. The relationship to escapement for the identified stocks will be explored depending on the availability of long-term data sets for the area, and will provide some understanding of the influence of overwintering on population productivity.

General Methods

Target sampling areas will be identified in Tatchun Creek and in the Pelly River watershed for conducting fisheries studies. Live or recently deceased Chinook salmon adults will be captured in their natal spawning streams in the Pelly River watershed and sampled as described in the Yukon/Transboundary DNA Sampling Protocols (MacDonald, 2011). Juvenile Chinook salmon will be captured using baited minnow traps following the Yukon River Panel Protocol (Taylor, 2011), non-lethally sampled for DNA work, and then released (e.g., Taylor, 2013). All tissue samples will be preserved in 100% ethanol and sent to an analytic laboratory for genetic testing. Juvenile abundance will be measured relative to minnow trapping effort, and individual length and weight measurements will be collected for growth analyses. A minimum of two juvenile Chinook sampling periods per year will be completed, once in the spring to determine overwintering survival, and once at the end of the summer to determine young-of-the-year growth.

Fish habitat and environmental data (e.g., groundwater, ice conditions, food availability, distance to natal stream, stream temperature, flow) will be collected from selected juvenile Chinook sampling sites and analyzed relative to population densities, growth, survival and stock composition. Akaike's Information Criteria (i.e., a measure of the relative quality of a statistical model for a given set of data) may be applied to models of environmental factors to determine the influencing factors on juvenile overwintering habitat. Where possible, juvenile data will be related to knowledge of stock escapement quality using genetic linkages. There is currently a fish enumeration facility on one Pelly River population, Blind Creek, and more cost-effective aerial spawning surveys may be conducted on other major spawning areas in the watershed.

Community Participation

The lower Pelly River watershed is in the traditional territory of SFN. The community of Pelly Crossing is located adjacent to Mica Creek, which is the most downstream Chinook salmon spawning stream in the watershed. The community will continue to be engaged during the development and implementation of the research program to ensure that the program aligns with local fisheries objectives and cultural values. Opportunities for community participation in the investigation include the employment of community members in fisheries sampling activities, fish habitat assessments, environmental data collection, and trail development. Risk-averse sampling methods, such as use of baited minnow traps rather than electrofishing, will be used to facilitate the involvement of community members. In addition, demonstration projects such as juvenile Chinook capture and fin clipping may be showcased for students to gain insight into aquatic ecosystems and research methods. Program updates and study findings will be shared within the community via reports, presentations and workshops. Traditional knowledge is anticipated to play an important role in advancing specific hypotheses under this over-arching research theme.

Other Partnerships

CMC will engage other potential partners such as DFO, Genome BC, Yukon River Panel, Yukon Salmon Sub-Committee, Yukon College, or university researchers, and state and federal US agencies in order to broaden and strengthen the research program and its potential applications. Partners may provide additional value to the research program by providing "in-kind" support, such as personnel, equipment, training opportunities, producing technical reports or scientific publications, or presenting work at meetings or conferences. The Yukon River Panel provides annual funding for Yukon River restoration and enhancement projects, which have in the past included several baseline genetics studies (e.g., Beacham and Candy, 2012). DFO will be engaged to provide guidance on prioritizing additional genetic baseline collection data. Previous consultation has been conducted with the research organization Genome BC, which has expressed an interest in supporting projects that will use genomics to better understand the health of Chinook salmon, their interactions with their environment, and potential stressors that may impact Chinook salmon productivity.

PECG, on behalf of CMC, has discussed research opportunities with Dr. Scott Hinch (University of British Columbia), who is interesting in investigating the links between various stressors that may be operating in either the freshwater or marine environment (for example, dams and barriers to migration or by-catch from recreational or commercial fishing) and delayed effects. Dr. Hinch's group and collaborators have shown that delayed effects can result in impacts to the population, and that stressors from catch-and-release fishing, for example, may ultimately effect the fitness and fecundity of adults, and therefore ultimately recruitment back into the population. Even though the effects on the population may be most obvious in the freshwater (for example, spawning and egg survival), factors that are operating in the marine environment may be ultimately controlling these processes. There exist opportunities to conduct similar research studies on Yukon River Chinook salmon, depending on interest and availability of research funds under this offsetting fund.

Study Applications

The proposed study will considerably strengthen the genetic baseline of Pelly River Chinook salmon and support data already collected by DFO and others to inform fisheries management decisions. The results will provide a greater understanding of the relative contributions of populations within the watershed to the overall Pelly River stock, and subsequently identify the most important areas for supporting spawning, rearing and overwintering activities. Identification of important habitats is useful for watershed management, as the information can be used to determine specific habitats that may require protection, or candidate sites for future enhancement or restoration efforts. In addition, knowledge of the genetic origin of juveniles may provide insight into the physical and environmental variables driving productivity in the Pelly River watershed

Evidence for climate change effects on aquatic species is becoming increasingly prevalent, and effects are predicted to be greater at higher latitudes. Thus, a better understanding of how environmental variables (e.g., stream temperature, flow) affect juvenile Chinook productivity is essential for the future protection and management of northern stocks. In this study, environmental data collected in conjunction with fisheries sampling will investigate if differences in temperature or flow among streams or years relate to differences in productivity. Information about how environmental variability affects Chinook salmon

productivity may ultimately be applied to stock assessment models under varying future climate scenarios.

5.2 Contingency Habitat Offsetting Opportunities

5.2.1 Lower Britannia Creek Slope-toe Side Channel Extension and Enhancement

Candidates sites for restoring, creating or enhancing aquatic habitats were sought along lower Britannia Creek, downstream of its confluence with Canadian Creek. Priority was given to sites close to Yukon River, where potential gains in productivity are greatest, and to disturbed sites where additions to existing fish habitat could be made with minimal disturbance or risk to the natural environment. A small, but worthwhile opportunity to increase off-line rearing and overwintering habitat for Arctic grayling and potentially juvenile Chinook salmon was identified just 500 m upstream from the proposed diversion of Britannia Creek back into its historical meandering channel (Section 5.1.1). A small, spring-sourced side channel originating in a clearing on the west side of the existing Barge Access Road conveys water through a small (0.2 m-diameter), perched steel pipe culvert beneath the road, parallels the road with limited riparian vegetation, and then flows through mature floodplain vegetation to Britannia Creek (**Drawing 6**, **Appendix A**). Accumulated woody debris and organic matter at the confluence inhibits fish passage except during high flows.

Offsetting measures proposed along this side channel include establishing a permanent connection with Britannia Creek, through the removal of the woody obstruction; restoring a riparian buffer between the road and the channel edge; replacing the small, perched culvert beneath the road with a larger culvert that accommodates natural bed material; and extending the side channel into enlarged pool habitat up-valley from the spring, entirely within the existing area of disturbance (**Drawing 6**, **Appendix A**). Total usable habitat for Arctic grayling, which currently dominate this reach of Britannia Creek, will be approximately 1,210 m^2 (based on the assumption that the entire pool habitat will be usable by Arctic grayling). The pool habitat will be excavated below the groundwater table in order to intercept seepage flow within the valley bottom alluvium and support overwintering of local fish species, including juvenile Chinook salmon, which will have improved access to this site following reinstatement of the historical channel. Large woody debris and boulder structures will diversify pool-edge habitat and provide important cover features.

5.2.2 Lower Britannia Creek Groundwater-fed Side Channel Extension and Enhancement

Another 500 m farther upstream from the slope-toe side channel described above (Section 5.2.1), or approximately 1,000 m upstream from the diversion into the historical channel, is a second side channel well suited to extension and enhancement. The channel originates in a spring about 20 m downstream from what appears to be an overgrown placer test pit filled with groundwater. The channel follows the base of a terrace scarp that roughly parallels the meander of the main creek. At the time of survey in August 2014, about 10 L/s of water was flowing through this channel, which exhibits relatively deep pools (>0.5 m) and good cover beneath fallen trees.

The side channel is proposed to be extended to establish a surface connection with the existing pond and then further extended into pool habitat excavated along the toe of the continuation of the aforementioned terrace scarp (**Drawing 7**, **Appendix A**). The excavation of the pool below the groundwater table at the base of the terrace scarp will intercept groundwater within the alluvial terrace and will induce seepage from the main creek through the alluvial gravels comprising the valley bottom. Approximately 1,830 m^2 of new habitat usable by Arctic grayling and juvenile Chinook salmon for rearing and overwintering will be created (based on the assumption that the entire pool habitat will be usable by Arctic grayling). Trees felled within the footprint of excavation will be incorporated into the design of the pool shoreline as cover habitat in the form of boulder-buttressed rootwads. The existing forest canopy will contribute allocthonous inputs and further shelter the pool.

5.2.3 Klondike River Side Channel Rearing Gallery at Germaine Creek

A small, groundwater-fed channel flows along a flood-scoured meander scar alongside Klondike River, at the confluence with Germaine Creek, approximately 27 km up-valley from the town centre of Dawson. Water flowing through the side channel is sourced from a spring at its head, which intercepts shallow groundwater seeping through alluvial gravels alongside the Klondike River; from thawing permafrost underlying low terraces to the south; and from groundwater that discharges to surface at the base of the gentle alluvial fan of Germaine Creek. Annual monitoring of the uppermost portion of this groundwater-fed channel has revealed its use by numerous juvenile Chinook salmon seeking off-line rearing and overwintering habitat (Al von Finster, pers. comm., 2014). Only once in ten years did fish stranded in the spring-fed pool over the winter not survive, likely due to the unusually low water level in the Klondike River allowing a greater contribution of seepage inflow to originate in the relatively oxygen-poor, thawing permafrost to the south.

In order to improve and increase the availability of off-line rearing and overwintering habitat, a ‘gallery’ of pool habitat consisting of a trunk channel with several sub-perpendicular branch channels is proposed to be excavated up-valley and riverward of the existing spring (**Drawing 8**, **Appendix A**). The pools would be benched along their edges in order to maximize opportunities for juvenile Chinook rearing in shallow (<1 m depth) water. Deeper (~1.5 m) areas will be maintained along their centrelines to intercept groundwater originating in the alluvial gravels alongside the Klondike River, even during low water periods, and to support overwintering beneath ice cover. Trees felled within the footprint of the gallery will be incorporated into the pool-edge habitats as cover features, secured with locally sourced boulders. In total, the pool gallery will introduce approximately 4,000 m^2 of off-channel habitat, of which about 2,680 m^2 is anticipated to be preferred by juvenile Chinook salmon (<1 m), the target species for local offsetting initiatives.

5.2.4 Klondike River Side Channel Rearing Gallery at North Klondike River

An area of stable alluvial terrace exists along the inside of a large meander of the Klondike River, immediately upstream of its confluence with the North Klondike River. A side channel, active even during low flows in the main river (~200 L/s estimated), arcs around the low terrace and flows into a backwatered pool within a recently formed oxbow alongside the main river. A small groundwater-fed channel (~20 L/s estimated), which intercepts seepage within alluvial gravels, joins the surface channel near the edge of

the terrace. An overgrown, shallow borrow pit with direct highway access is the only disturbance in an otherwise mature white spruce and cottonwood forest growing on the terrace.

A 'gallery' of interconnected pool habitats is proposed to be excavated entirely within the existing area of disturbance (i.e., abandoned borrow pit) and the relative protection of the terrace (**Drawing 9**, **Appendix A**). Its purpose is to increase the availability of off-line rearing and overwintering habitat for juvenile Chinook salmon, as well as other Klondike River species. The grid-like pattern of the gallery, although unnatural in form, is designed to maximize edge habitat, where small fish can find shelter beneath overhanging vegetation and constructed rootwad features. It also maximizes the channel-like habitat area within the broad, V-shaped area of disturbance. The pools will be overdeepened along their centrelines in order to support overwintering and increase the interception of groundwater flowing between the upstream and downstream arms of the large meander. Along the edges, however, pool bottoms will be benched such that at least two-thirds of the pool area is less than 1 m in depth – the habitat preferences for juvenile Chinook salmon rearing. In total, the interconnected pools will create 7,200 m^2 of new pool habitat, of which 4,820 m^2 will be ideally suited to juvenile Chinook salmon rearing (<1 m).

5.3 Riparian Habitat Offsetting

Riparian vegetation, and the habitat it supports, helps maintain the productivity of adjacent and downstream fish habitat. Riparian habitat provides shading for cover, moderates fluctuations in water temperature, contributes allocthonous inputs, stabilizes banks and helps maintain overall channel morphology. Riparian habitat also has indirect value to fish habitat productivity by protecting water quality, temperature and stream hydrology, although these indirect values are more important in highly disturbed watersheds. In recognition of these important ecological functions, riparian habitat restoration, creation or enhancement is integrated into all proposed in-stream habitat offsetting opportunities.

Table 5-1 summarizes the gains in riparian habitat that can be achieved through the implementation of the proposed in-stream habitat offsetting opportunities outlined in Sections 5.1 and 5.2. A 30 m buffer of riparian habitat is assumed to be gained in association with in-stream habitat offsetting anticipated to support juvenile Chinook salmon use within a buffer of trees and dense shrubs. Narrower buffers of riparian habitat (i.e., 15 m or 5 m) are assumed to be created in association with other offsetting opportunities, as noted below in **Table 5-1**.

Table 5-1. Summary of Riparian Habitat Offsetting Opportunities

Opportunity	Riparian Habitat Area (m^2)	Description
Reinstatement of Lower Britannia Creek (Preferred)	86,080	Existing mature forest adjacent to historical channel, with localized placement of large woody debris structures along the banks (assumes 30 m buffer)
Britannia Creek Ford Restoration (Preferred)	3,210	Replanted riparian vegetation with live willow stakes and brush layers, and native tree seedlings (assumes 30 m buffer)
Diamain Lake Whitefish Fishery Creation (Preferred)	393,460	Existing mature forest along undisturbed lake shoreline (assumes 15 m buffer)
Dawson Dredge Pond Off-line Pool Habitat Creation (Preferred)	16,000	Mixture of existing shrubs and trees that have colonized the pond shorelines, and installed live willow stakes and brush layers, with some areas of large woody debris structures (assumes 5 m buffer, given local initiative to maintain form of landscape)
Lower Britannia Creek Slope-toe Side Channel Extension and Enhancement (Contingency)	9,600	Mixture of existing mature forest (edges of disturbance area) and planted native shrubs (within disturbance area), with large woody debris structures around perimeter of pool (assumes 30 m buffer)
Lower Britannia Creek Groundwater-fed Side Channel Extension and Enhancement (Contingency)	10,510	Existing mature forest and replanted shoreline embankments, with large woody debris structures, around perimeter of pool (assumes 30 m buffer)
Klondike River Side Channel Rearing Gallery at Germaine Creek (Contingency)	22,500	Existing mature forest and replanted shoreline embankments, with large woody debris structures, around perimeter of pool (assumes 30 m buffer)
Klondike River Side Channel Rearing Gallery at North Klondike River (Contingency)	18,900	Mixture of existing mature forest and naturally regenerating shrubs (to be supplemented with shoreline plantings), with large woody debris structures around perimeter of pool (assumes 30 m buffer)
Naturalized Airstrip Diversion Channel (Mitigation Only)	30,950	Existing mature forest and wetland vegetation encompassing area of proposed naturalized channel diversion (assumes 15 m buffer)
Total Opportunity:	**591,210**	**Final gain-to-loss ratio for riparian habitat along fish-bearing watercourses depends on final selection of offsetting opportunities**

Table 5-1 identifies opportunities for riparian habitat offsetting that, in combination, can fully offset the lost riparian habitat (assuming a gain-to-loss ratio of >1:1). The final amount of riparian habitat offsetting will depend on exactly which of the preferred and/or contingency opportunities are selected for detailed design and ultimate implementation. Combinations of riparian habitat offsetting measures that exclude the Diamain Lake opportunity cannot offset the impacts solely in association with the in-stream habitat offsetting opportunities outlined in Sections 5.1 and 5.2 for two main reasons. First, some impacts to riparian habitat are anticipated to occur without impact to adjacent in-stream fish habitat. For example, the abutments and approaches to clear-span bridges at new watercourse crossings along the access roads will impact riparian habitat but not in-stream habitat. Few to no opportunities for on-site or nearby offsetting exist in the undisturbed (natural) watersheds, although these crossing areas will have fully stabilized and re-vegetated banks to ensure that water quality degradation from erosion and surface runoff does not occur. Second, the creation of pool habitats, such as in the case of the Dawson dredge ponds opportunity (Section 5.1.4), does not provide the same opportunity for riparian habitat creation as would the buffer of a linear watercourse. The re-vegetation of the shoreline and incorporation of large woody debris structures will fully buffer the pool and provide the maximum benefit of riparian habitat to in-water habitat.

In the determination of requirements for riparian habitat offsetting, consideration must also be given to the suitability and sensitivity of fish habitat supported by adjacent riparian habitat. The majority of impacts to riparian habitat are expected to occur within the upper Casino Creek watershed, alongside non-fish-bearing watercourses or reaches of creek rarely frequented by fish. The contribution of the riparian habitat in the upper Casino Creek watershed to adjacent and downstream fish habitat productivity would be relatively low, given that the overall level of disturbance in the watershed is very low to negligible. Along the high-elevation reaches, riparian trees and shrubs are low, sparse or absent, and terrestrial insects are less abundant; the potential for allocthonous inputs is low. In comparison, the contributions of riparian habitat to fish habitat productivity are anticipated to be much higher in association with the proposed offsetting along lower Britannia Creek, among other higher-order watercourses where offsetting opportunities have been proposed. Within the low-elevation Britannia Creek reach, deciduous and coniferous trees are tall, forming a high, dense canopy that overhangs the historical channel, and terrestrial insects are more abundant.

In association with the placer restoration offsetting candidate along lower Canadian Creek (**Table 4-3**, Section 4.2.1), consideration was given to widespread restoration of riparian vegetation. Restoration and enhancement of riparian habitat alongside the 4 km-long reach of lower Canadian Creek most severely impacted by placer mining could yield gains of more than 100,000 m^2. Such efforts would also help mitigate the continued downstream migration of the sediment pulse in the unnaturally braided reach. However, the aforementioned risk of disturbance or destruction of the riparian zone in association with future placer mining activity justifies not considering this opportunity further at this time.

If necessary, impacts to riparian habitat beyond what can be offset in association with the ultimate implementation of the in-stream habitat offsetting opportunities can be considered through other opportunities identified in consultation with First Nations and DFO, or can be offset equivalently as part of the complementary research measures aimed at benefiting Chinook (Section 5.1.5).

5.4 Habitat Balance

A habitat balance has been prepared to summarize the predicted impacts to fish habitat from the Project and the potential gains from proposed fish habitat offsetting opportunities. **Table 5-2** provides a summary of the habitat balance between impacted in-stream fish habitat and proposed restoration, creation and enhancements of in-stream habitat. The total area of in-stream habitat impact, based on modeled losses of habitat area (where available, Section 3.2), is 23,632 m^2. The total area represented by preferred and contingency in-stream habitat offsetting opportunities is 38,370 m^2, excluding the currently undetermined, yet significant gain made possible by the Diamain Lake opportunity. These totals include an equivalent 10% of offsetting through a proposed research contribution aimed at benefiting knowledge of Chinook salmon populations in Yukon. The ultimate habitat offsetting ratio (gains:losses) will be determined based on the final selection of preferred and/or contingency opportunities that are advanced to detailed design and ultimately implemented. This selection will be made in consultation with First Nations, DFO and other stakeholders.

Regardless of which offsetting opportunities are advanced, CMC commits to offsetting in-stream habitat impacts with a 2:1 ratio for all impact sites with the exception of the uppermost Casino Creek watershed (above a transient fish barrier), where its markedly low baseline fisheries value justifies offsets with a 1:1 ratio for several reasons. Habitat in the upper Casino Creek watershed predominantly provides indirect, non-fish-bearing habitat, which was conservatively included in the habitat budget due to challenges associated with proving definitive fish absence in stream headwaters. Further, in areas where fish have been caught, they have generally been in low densities of exclusively adult or sub-adult Arctic grayling that have migrated upstream for temporary summer feeding activities. Summer feeding habitat for these older age-classes of Arctic grayling is common both locally and regionally, and the contribution of Casino Creek to the overall Arctic grayling production in this watershed (Casino/Dip Creek) is likely low. Fish use in Reach 3 of Casino Creek was only documented in one of four years of sampling, and fish were caught within the most downstream section of Reach 3 where habitat quality is relatively higher, and accessibility is greater for upstream migrating fish. No overwintering habitat has been observed in upper Casino Creek, and the potential for Arctic grayling spawning was similarly absent. In terms of fish food communities, sites in upper Casino Creek exhibited the lowest benthic invertebrate densities, richness, diversities, and EPT abundances within the project area, likely due to low water temperatures, high velocities and turbidity, low habitat complexity, and acid rock drainage present in the upper watershed.

Considering the new *Fisheries Act* is re-focused on improving fisheries productivity, rather than fish habitat, it is proposed that providing a 2:1 offsetting ratio for the majority of the Project impact sites, and a 1:1 ratio for uppermost Casino Creek watershed, appropriately counterbalances serious harm to fish in the Project study area. Even without inclusion of the preferred Diamain Lake opportunity (Section 5.1.3) in the preliminary habitat balance, sufficient opportunities exist to offset Project impacts (**Table 5-2**). In addition to proposing greater gains than losses in the quantity of habitat, this FHOP proposes to offset impacts to relatively low quality, low productivity habitat (e.g., upper Casino Creek) by restoring, creating or enhancing relatively high quality, high productivity habitat (e.g., lower Britannia Creek).

Table 5-2. Habitat Balance Summary

In-stream Habitat Impacts (losses)	**Usable Area (m^2)[a]**
Lower Britannia Creek "Roadway" Channel (diversion into historical channel)	4,112
Upper Casino Creek Watershed above Reach 2/3 Break (TMF footprint)	8,900[b]
Upper Casino Creek Watershed below Reach 2/3 Break (TMF footprint or influence)	5,827
Unnamed Tributary of Dip Creek (diversion around airstrip)	330
Lower Canadian Creek (flow reduction downstream of open pit)	299
Lower Casino Creek (flow reduction downstream of TMF)	3,157
Dip Creek (flow reduction downstream of TMF)	1,001
Nordenskiold River bridge (in-stream pier footprint)	6
Total Impact:	**23,632**
In-stream Habitat Offsetting Opportunities (gains)	**Usable Area (m^2)**
Reinstatement of Lower Britannia Creek (Preferred)	14,870
Britannia Creek Ford Restoration (Preferred)	0 (riparian)
Diamain Lake Whitefish Fishery Creation (Preferred)	TBD[c]
Dawson Dredge Pond Off-line Pool Habitat Creation (Preferred)	9,120
Research Contribution: Chinook Salmon Stock of Origin in Natal and Non-natal Streams	3,840[d]
Lower Britannia Creek Slope-toe Side Channel Extension and Enhancement (Contingency)	1,210
Lower Britannia Creek Groundwater-fed Side Channel Extension and Enhancement (Contingency)	1,830
Klondike River Side Channel Rearing Gallery at Germaine Creek (Contingency)	2,680
Klondike River Side Channel Rearing Gallery at North Klondike River (Contingency)	4,820
Total Offset Opportunity (excluding undetermined gain from Diamain Lake opportunity):	**38,370**

[a] *Footnotes below **Table 3-8** specify method by which each impact area was determined*
[b] *Only in-stream habitat impact proposed to be offset with a 1:1 offsetting ratio; all other impacts to be offset with a 2:1 ratio*
[c] *To be determined, if opportunity advanced, following collection of bathymetric, water quality and ecological data*
[d] *Complementary measure, equivalent to 10% of habitat offsets*

An area-for-area accounting of riparian habitat losses and gains is not necessarily appropriate, given that all in-stream habitat offsetting will incorporate riparian buffers to ensure full productivity. Based on such an area-by-area accounting, however, ample opportunities for creating or restoring riparian habitat are available to offset Project impacts to riparian vegetation in association with the preferred and contingency in-stream habitat offsetting opportunities (**Table 5-2**). Any remaining deficit in riparian habitat offsetting could be resolved if necessary through riparian plantings and habitat enhancement alongside impacted watercourses utilized by Chinook salmon, or through complementary research efforts.

6 Implementation Strategy

6.1 Timeline and Construction Phasing

The timing of proposed habitat offsetting relative to predicted impacts is an important consideration, given its determination of the potential for a temporal loss of productive capacity within the affected watersheds. As shown in **Figure 4-1**, offsetting measures are proposed to be implemented before or in conjunction with habitat impacts. The intention is to provide the greatest opportunity possible for offsetting measures to become fully functional, providing the designed benefits to aquatic ecosystems, prior to project impacts. All offsetting works will be completed at the commencement of project construction. All impacts will occur during the construction phase of the Project, except for the minor impacts to lower Canadian Creek, which are not anticipated to occur until project closure (Years 23-25) when flows from upper Canadian Creek are allowed to drain into the open pit.

Another important consideration in offsetting planning is the phasing, or sequencing, of construction of the offsetting measures. The proposed habitat restoration and enhancement measures will be completed in accordance with the applicable "reduced risk timing window" for in-water work, as established by DFO. This will minimize risk to Chinook salmon, Arctic grayling and other local fish species during activities within the channel and adjacent riparian zones. All channel works will be completed "in the dry", either by conducting work along sections of channel that are dry or completely frozen (preferred) or by isolating the work area from flowing water. The channel restoration and enhancement works will be completed as efficiently as possible, thereby minimizing the period during which a portion of habitat is isolated from the adjacent channel.

An overview of the proposed construction of each of the preferred and contingency offsetting opportunities is provided below in order to demonstrate to DFO the feasibility of protecting fish and fish habitat during implementation of offsetting works:

1. **Reinstatement of Historical Lower Britannia Creek** – The restoration of the historical channel is proposed to be completed through the following steps:

    i. Isolate historical (dry) channel by blocking upstream and then downstream ends with coffer dams.

    ii. Conduct a fish salvage, if necessary, from any remnant pools especially at the lower end of the channel near the Yukon River. After recording the fish species, release them into the Yukon River.

    iii. Selectively remove woody debris that does not have an important, well-established ecological role (including any existing logjams), in order to minimize channel obstructions during reintroduction of flow, or incorporate and anchor it for increased cover and rearing pool habitats.

    iv. Remove the downstream and then upstream coffer dams within the historical channel.

v. During a low to moderate flow when turbidity is still naturally high (e.g., tail-end of a freshet), divert a small portion of the flow (e.g., 10-20%) from the existing Britannia Creek 'roadway' channel into the historical channel, by temporarily placing appropriately sized rip-rap on the existing channel bed to form a riffle immediately downstream of the slightly raised entrance to the historical channel. Allow the back-water formed upstream of the artificial riffle in the existing channel to spill into the historical channel. Station field crews alongside the historical channel to monitor the reintroduction of flow and identify any areas where in-stream work is required once flows have subsided.

vi. Incrementally and gradually (over a period of a few days during which flows remain low to moderate) raise the height of the riffle with additional rip-rap, each time diverting a greater portion of flow into the historical channel. Continue raising the riffle until all of the flow (100%) has been diverted into the historical channel.

vii. Install a coffer dam immediately downstream of the artificial riffle, in order to inhibit throughflow and allow the roadway channel to passively dewater to its mouth.

viii. Conduct a fish salvage from remnant pools, walking downstream along the entire length of the straight reach to the Yukon River. After recording the fish species, release in Britannia Creek upstream of the flow diversion (or into Yukon River, whichever is closer).

ix. Construct a permanent flow diversion earth berm, armoured on its upstream face and ends with rip-rap, set back at least 5 m from the coffer dam.

x. Install a coffer dam along the upstream edge of the artificial riffle.

xi. Remove the coffer dam from the downstream side of the artificial riffle, then re-distribute the rip-rap forming the riffle along the toe of the diversion berm, and fill the former channel to its tie-in with the surrounding floodplain and bank of the reinstated historical channel.

xii. Remove the coffer dam that was built along the upstream edge of the riffle.

2. **Britannia Creek Ford Restoration** – Restoration of the fords will completed at or prior to project construction commencement, in order to stabilize and restore the banks to reduce downstream sedimentation. Coffer dams will be placed in the channel to isolate one half of the channel at a time, while allowing flow to continue in the other half. Any fish that become stranded in the isolated work area will be captured, identified and released upstream by a qualified fisheries technician with a collection license. Patches of channel-edge sand and gravel washed from the road surface will be used in the reconstruction of the channel banks. Once bank restoration on one side is complete, work will be completed on the other side of the channel in the same manner, with the same precautions for the protection of local and downstream habitat.

3. **Diamain Lake Whitefish Fishery Creation** – Minimal to no ground disturbance is required in the implementation of the proposed stocking program. However, any vehicles or equipment that must be stored along the existing access trail near the lakeshore will be set back at least 30 m within an area isolated by appropriate erosion and sediment control measures (e.g., silt fence, impermeable pad).

4. **Dawson Dredge Pond Off-line Pool Habitat Creation** – The extension of any access routes along the crests of the dredge pile berms will be completed only where necessary, following isolation of the road alignment with appropriate erosion and sediment control measures (e.g., silt fence). Only localized excavations through select dredge piles are required in order to connect adjacent ponds with a small stone-lined channel. At these locations, coffer dams or a silt curtain would be temporarily installed at the shoreline in order to isolate the excavation area and inhibit sedimentation in the adjacent lakes. All excavated gravel and cobbles will be incorporated into shoreline benches temporarily isolated by coffer dams (as described above in Section 5.1.4), placed with gentle slopes on level ground well away (>30 m) from any waterbodies, or trucked off-site. Only once the connector channels have been properly formed will the isolation barriers be removed and disposed of at an approved location off-site. Any materials or equipment stored on-site will be isolated from the surrounding environment with appropriate erosion and sediment controls.

5. **Lower Britannia Creek Slope-toe Side Channel Extension and Enhancement** – Most of the area within which offsetting works are proposed is already disturbed. Regardless, the area proposed for pool excavation will first be isolated within appropriate erosion and sediment control measures (e.g., silt fence) to minimize the potential for sediment to be washed into the existing side channel. A small coffer dam will be temporarily installed at the upstream end of the side channel to prevent sediments from continuing downstream during connection to the expanded pool habitat. The replacement of the small culvert beneath the existing gravel road will be completed within an isolated work area when the channel is dry (e.g., winter), removing the need for a flume or dam-and-pump by-pass.

6. **Lower Britannia Creek Groundwater-fed Side Channel Extension and Enhancement** – A narrow, temporary road will be required to provide site access for construction equipment. Both sides of the corridor will first be enclosed within appropriate erosion and sediment control measures (e.g., silt fence). Disturbance to vegetation and ground cover will be minimized through the use of small equipment, a carefully planned access route and matting (if necessary). The area encompassing the proposed channel extension and pool excavation will be isolated from the surrounding environment using erosion and sediment control measures (e.g., silt fence), in order to minimize the risk of sedimentation to the existing side channel or adjacent Britannia Creek. A small coffer dam will be temporarily installed at the upstream end of the side channel to prevent sediments from continuing downstream during connection to the existing pond. The access route will be fully restored following completion of the offsetting works.

7. **Klondike River Side Channel Rearing Gallery at Germaine Creek** – Good access to the area adjacent to the proposed rearing gallery already exists in the form of a 4x4 trail on the west side and a gentle gravel road on the east side. A bailey bridge may be used, if necessary, to cross the small, groundwater-fed channel. The area encompassing the proposed pool excavations will be isolated from the surrounding environment using appropriate erosion and sediment control measures (e.g., silt fence). Excavated material will be stockpiled within the isolated work area and placed on high ground well away (>30 m) from any waterbodies or trucked to an authorized location off-site. A small coffer dam will be temporarily installed at the upstream end of the groundwater-fed channel to prevent sediments from continuing downstream during connection to

the expanded pool habitat upstream. All work will be completed during a period of normal (low) water levels in the Klondike River, to minimize any access challenges during flood conditions.

8. **Klondike River Side Channel Rearing Gallery at North Klondike River** – Access to the area within which all work is proposed is excellent: a gravel road descends gently to the edge of the abandoned borrow pit. The area encompassing the proposed interconnected pool excavations will be isolated from the surrounding environment using appropriate erosion and sediment control measures (e.g., silt fence). Excavated material will be stockpiled within the isolated work area and placed on high ground well away (>30 m) from any waterbodies or trucked to an authorized location off-site. To facilitate the final connection to the active side channel, a small coffer dam will be temporarily installed at the edge of the side channel. Once the connection has been excavated, the coffer dam will be removed and disposed of at an appropriate location off-site. All work will be completed during a period of normal (low) water levels in the Klondike River, to minimize any access challenges during flood conditions.

6.2 Erosion and Sediment Control

An erosion and sediment control (ESC) plan will be developed as part of an overall environmental management plan, prior to initiation of habitat offsetting activities as a basis for protecting aquatic and riparian ecosystems during construction of habitat restoration, creation and enhancement measures. The plan will focus on controlling surface run-off and minimizing the extent and duration of exposed soils, in order to inhibit erosion and sedimentation along any watercourses. The plan will reflect best management practices as outlined in *Best Management Practices for Works Affecting Water in Yukon* (Environment Yukon, 2011) to fulfill Section 36(3) of the *Fisheries Act* and Section 9(1) of the *Yukon Waters Act*, which prohibit the deposit of any waste (i.e., any substance that is detrimental to people, animals, fish or plants), including sediment, into any water body. In addition to detailing all physical ESC measures, the plan will specify the necessary frequency of inspection, relative to key construction activities, weather conditions and site-specific environmental conditions. Inspection should be completed regularly during the construction process to ensure that ESC measures are functioning as intended and to provide for the timely cleaning, repair and ultimate removal of ESC measures (as further described below in Section 6.3).

The appropriate combination and distribution of ESC measures will be finalized during detailed design and specified on the ESC plan. All measures will be in place and operational prior to construction commencement. Key details of the plan may include, but not be limited to, the following:

- Strategies for preventing off-site water from entering the work area, and for managing on-site water;
- Erosion control strategies, including techniques, materials and installation methods;
- Sediment control strategies, including techniques, materials and installation methods;
- Delineation of areas of greatest ecological risk;
- Site restoration and re-vegetation prescriptions;

- Locations for storing and refueling all equipment (>30 m from any water feature);
- Contingency plans for unforeseen high flow events; and
- Monitoring program details.

6.3 Monitoring, Adaptive Management and Contingency Planning

In accordance with DFO's (2013b) guidelines, two main types of monitoring will be conducted to ensure the success of this FHOP: *construction monitoring* and *effectiveness monitoring*. Adaptive management is the process of promptly responding to and alleviating any identified deficiencies or failures in offsetting works, based on the results of monitoring.

The purpose of *construction monitoring*, as alluded above in Section 6.2, is to minimize risks to fish and fish habitat during implementation of the offsetting works. An environmental monitoring technician will be on-site throughout the period of in-water work to document compliance with all environmental protection measures and inspect and report on all ESC measures. It is recommended that field inspections be conducted periodically before and during construction to document and photograph site conditions associated with offsetting works. The field inspections should be conducted at least once prior to construction and weekly during the construction period. Photographs should be collected from the same vantage point and with the same field of view to allow for time series comparison. A qualified professional with experience in the supervision of channel restoration projects (e.g., fluvial geomorphologist, habitat restoration specialist) will visit the site at critical times during construction to ensure all elements of offsetting works are completed according to design specifications, and to assist with field-fit modifications, where required.

Key elements of construction to supervise include, but are not limited to, the following:

- Implementation of functional erosion and sediment control measures, including flow by-pass measures;
- Removal of existing vegetation within, and protection of vegetation in close proximity to, the works area and access route;
- Establishment of key profile (elevation) points and channel dimensions;
- Installation of habitat cover features (e.g., root wads, boulders, brush layers, live stakes); and
- Construction of transitions to the upstream and downstream tie-in points.

The purpose of *effectiveness monitoring* is to ensure that offsetting measures are functioning as designed, providing an opportunity for adaptive management where necessary, and achieving fisheries productivity goals over the long-term. Detailed site-specific monitoring plans will be created in consultation with DFO to determine the key indicators for monitoring and the criteria for evaluating 'ecological functionality'. An adaptive management approach will be adopted in order to periodically identify the need for any further mitigation or offsetting measures. The monitoring program will be designed to include various metrics for assessing fisheries productivity and habitat structural integrity and quality. For example, monitoring may include measurements of channel morphology and fish habitat

features, monitoring of water quality, sampling of fish communities, and riparian vegetation assessments. Maintenance may include selective irrigation, removal of invasive species, documentation and replacement of unsuccessful plantings, stabilization of erosion sites, and mitigation of animal intrusion or damage. To evaluate the overall changes in fisheries productivity, multi-year baseline fish and aquatic resources data in the proposed impacted areas (e.g., Casino Creek) may be compared to fisheries data collected in offsetting areas (e.g., Pearson et al., 2005). A general overview of the proposed post-construction monitoring plan is provided below:

Immediate Post-Construction

- Detailed as-built surveys and drawings should be completed immediately following construction by the contractor and habitat design consultant in order to assess the functionality and structural integrity of habitat relative to construction design specifications. In the reinstated historical lower Britannia Creek, multiple seasonal habitat assessments will be carried out, including immediately after freshet.
- Fish and aquatic resources summer sampling will be conducted in offsetting and reference sites to determine the state of key biological indicators as identified in a forthcoming site-specific detailed monitoring plan. Examples of biological indicators may include fish community composition, fish abundance and distribution, life history use, fish condition, and characterization of the lower food web (e.g., periphyton and benthic invertebrates).

Follow-up Monitoring

- Summer assessments of fish and fish habitat will continue with similar methods as before;
- Data collected will be compared to baseline and immediate post-construction data to ensure that offsetting goals are being met; and
- At this point, the need for any further mitigation or offsetting will be identified and implemented. Opportunities to rehabilitate offsetting sites, if needed, will be considered before considering new offsetting options.

The monitoring program will be concluded when habitat offsetting sites have reached the defined criteria for determining success, and thus when the goal of counterbalancing serious harm to fish has been achieved.

A specific trigger-response action plan will be established during detailed design in order to standardize how and when follow-up to particular identified conditions should be completed. This will allow remedial or adaptive measures to be taken at an appropriately early time. Contingency offsetting opportunities (Section 5.2) remain available for implementation should elements of the preferred offsetting opportunities function less effectively than intended.

6.4 Cost Estimate

A cost estimate will be provided in association with detailed design and the ultimate request for authorization of the proposed offsetting works, following additional consultation with First Nations, DFO and other stakeholders, at which time the exact combination of preferred and/or contingency offsetting opportunities will have been finalized. This approach is consistent with feedback recently received from DFO, indicating that its verification of the feasibility of the opportunities outlined above (Section 5) should precede consideration of opportunity-specific costs. As mentioned above in Section 5.1.5, the amount of funding CMC will make available to the complementary research opportunity (should it be selected for advancement) will be based on the product of the 10% equivalent of habitat offsets (in this case 3,840 m^2) and the average cost per square metre to construct the final section of offsetting opportunities.

6.5 Uncertainties and Next Steps

The success of habitat restoration and enhancement projects depends, in part, on the identification of uncertainties and strategies for their management. Key uncertainties and their management are outlined below:

- **Uncertainty in the final selection of offsetting opportunities** – A commitment to offsetting unavoidable, residual impacts of the Project has been made, but the exact combination of preferred and/or contingency offsetting opportunities is proposed to be finalized in consultation with First Nations, DFO and other stakeholders. This FHOP has demonstrated that ample, worthwhile and feasible opportunities to offset impacts exist. The intention is to ensure that the final selection of offsetting opportunities accounts for a variety of perspectives and local community objectives.
- **Uncertainty in the feasibility of offsetting opportunities** – The preliminary designs included in this FHOP have been prepared by multi-disciplinary teams, leveraging past experience on other similar habitat offsetting projects. During detailed design, more comprehensive, site-specific topographic and geomorphic information will be collected to support the development of construction drawings and specifications. An investigation into land access, rights and ownership encompassing the proposed offsetting sites has not revealed any significant obstacles to implementation.
- **Uncertainty in the quantity and quality of proposed offsetting habitats relative to impacted habitats** – This FHOP proposes net gains in habitat, with an offsetting ratio of 2:1 for most in-stream habitat impacts, in order to allow for the possibility that certain elements of the offsetting may not fully function as intended. In addition, proposed offsetting habitats have higher ecological value than impacted habitats, given an emphasis on addressing known limitations to the productive capacity of local habitats.
- **Uncertainty in the timeframe over which the benefits of offsetting will be realized** – Many of the offsetting habitats proposed in this project will take advantage of existing, mature riparian vegetation, thereby minimizing the period before which habitat is fully functional. Also, offsetting work will be completed before or in conjunction with occurrence of the impacts.

Hydrological, geomorphological and biological data have been collected over a period of several years to support the preparation of this FHOP. The level of detail provided is commensurate with that required by DFO and other review organizations to confirm the feasibility and appropriateness of the habitat offsetting opportunities outlined above. Additional information is still required to support detailed design and permitting in association with the FHOP.

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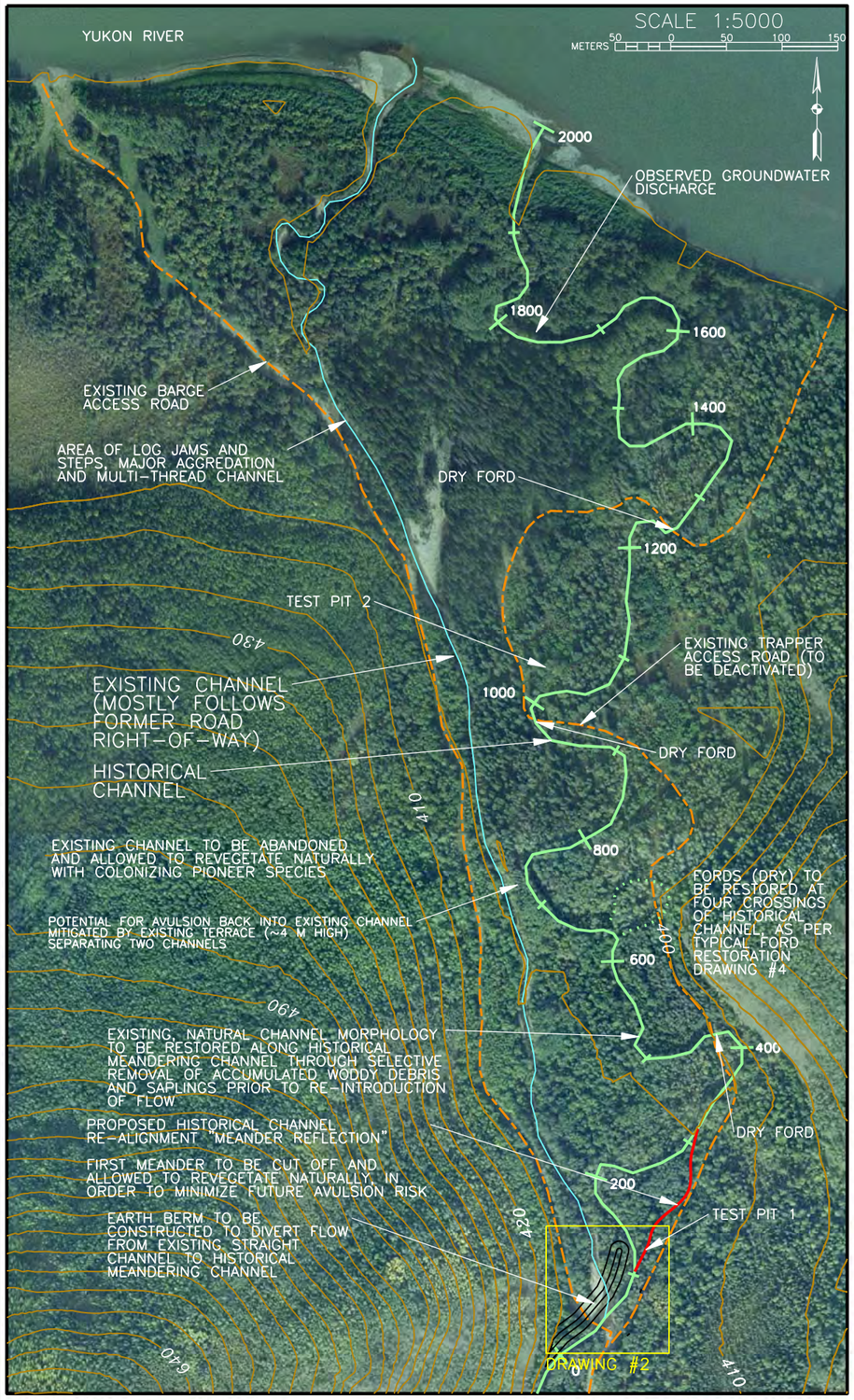
Appendix A

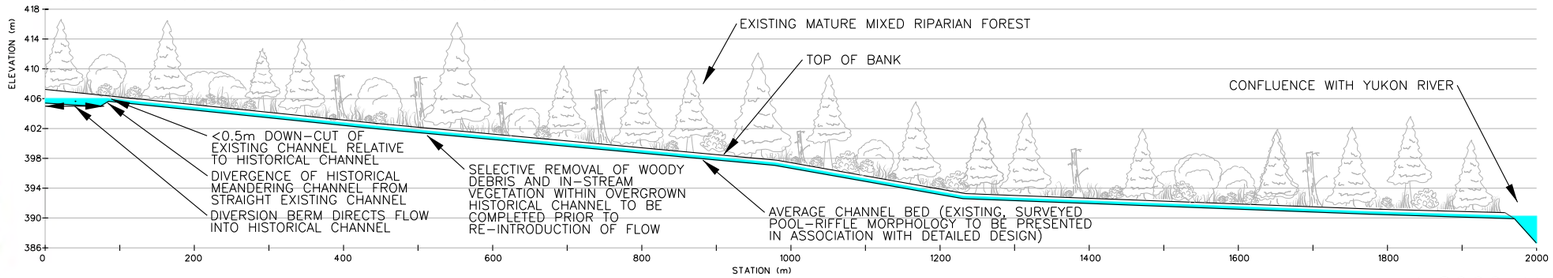
Fish Habitat Offsetting Preliminary Design Drawings

- **Drawing 1 – Reinstatement of Historical Lower Britannia Creek – Overview**
- **Drawing 2 – Reinstatement of Historical Lower Britannia Creek – Diversion Berm**
- **Drawing 3 – Britannia Creek Ford Restoration**
- **Drawing 4 – Diamain Lake Whitefish Fishery Creation**
- **Drawing 5 – Dawson Dredge Pond Off-line Pool Habitat Creation**
- **Drawing 6 – Lower Britannia Creek Slope-toe Side Channel Extension and Enhancement**
- **Drawing 7 – Lower Britannia Creek Groundwater-fed Side Channel Extension and Enhancement**
- **Drawing 8 – Klondike River Side Channel Rearing Gallery at Germaine Creek**
- **Drawing 9 – Klondike River Side Channel Rearing Gallery at North Klondike River**

PLAN-LOWER BRITANNIA CREEK



PROFILE-HISTORICAL MEANDERING CHANNEL



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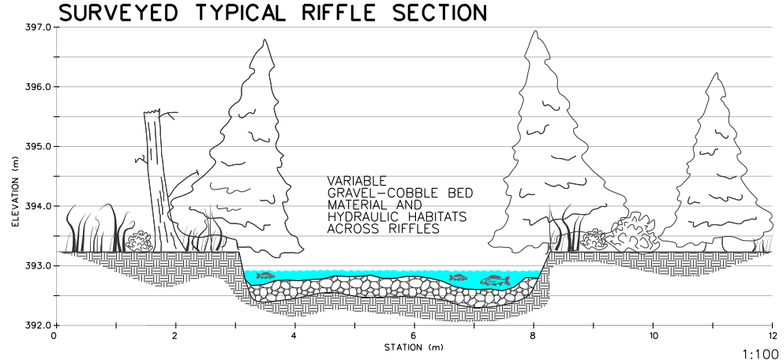
SURVEYED TYPICAL RIFFLE SECTION



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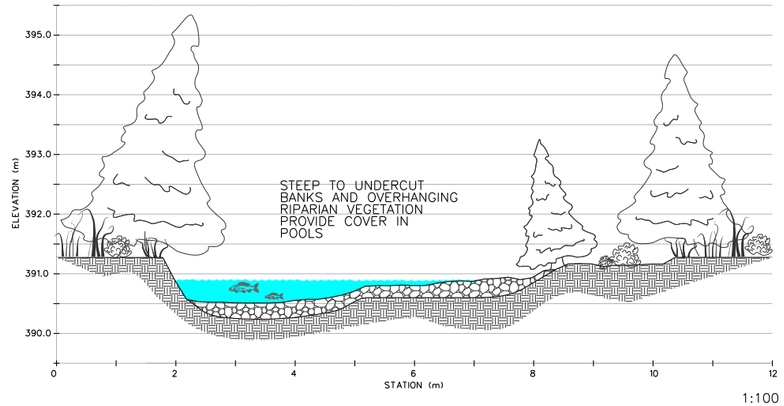
SURVEYED TYPICAL POOL SECTION



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REINSTATEMENT OF HISTORICAL BRITANNIA CREEK – OVERVIEW

CASINO PROJECT

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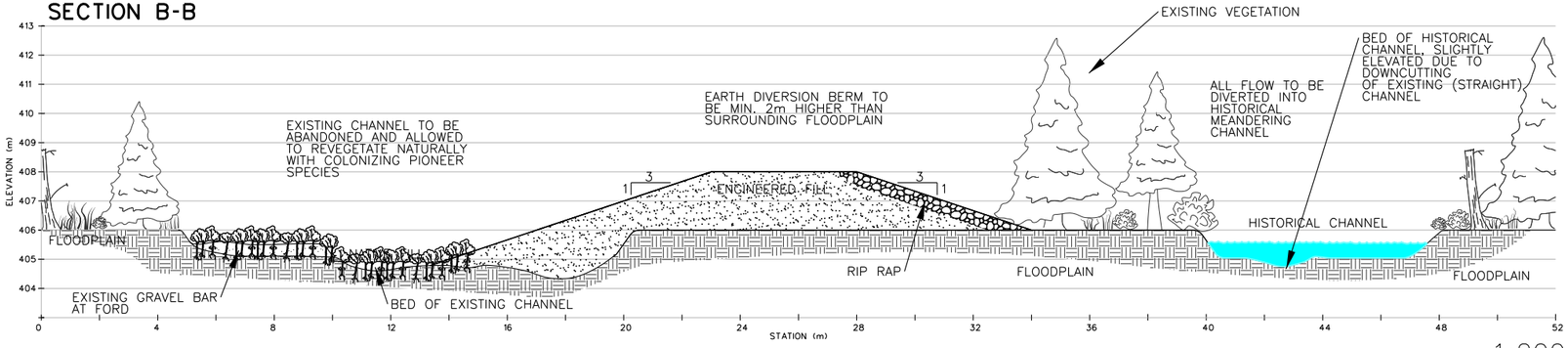
SECTION B-B



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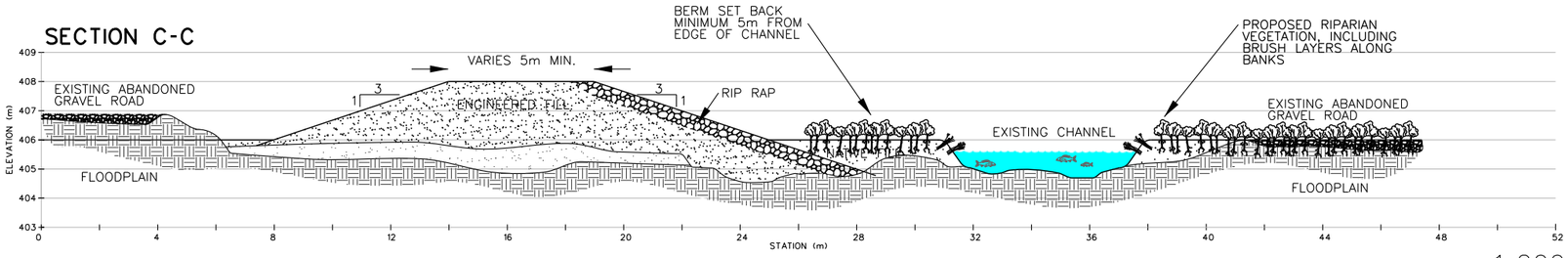
SECTION C-C



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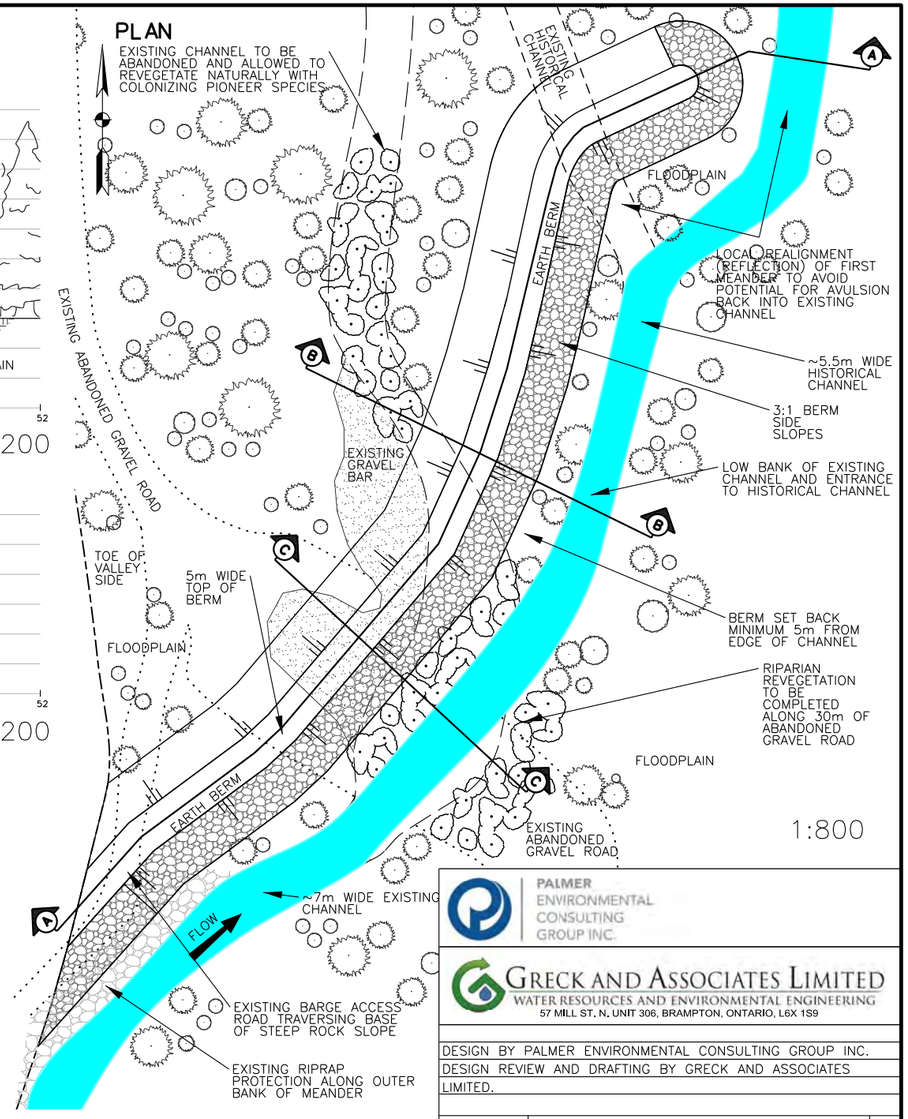
PLAN



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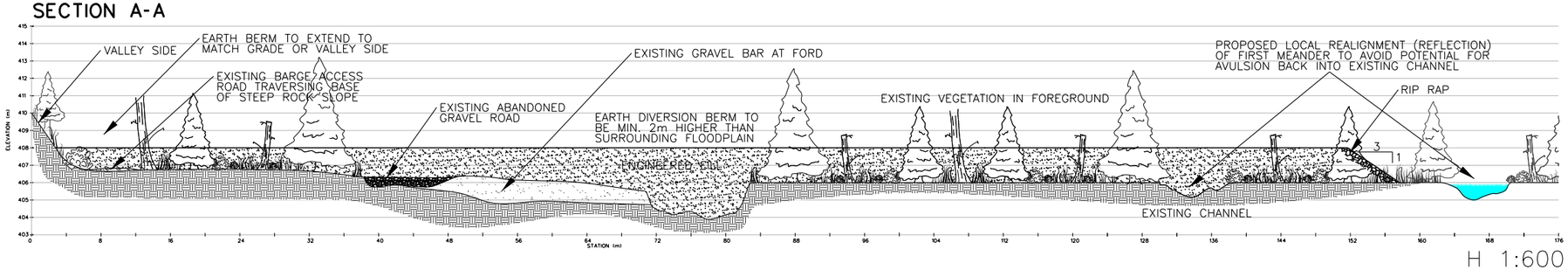
SECTION A-A



H 1:600
V 1:300

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REINSTATEMENT OF HISTORICAL BRITANNIA CREEK – DIVERSION BERM

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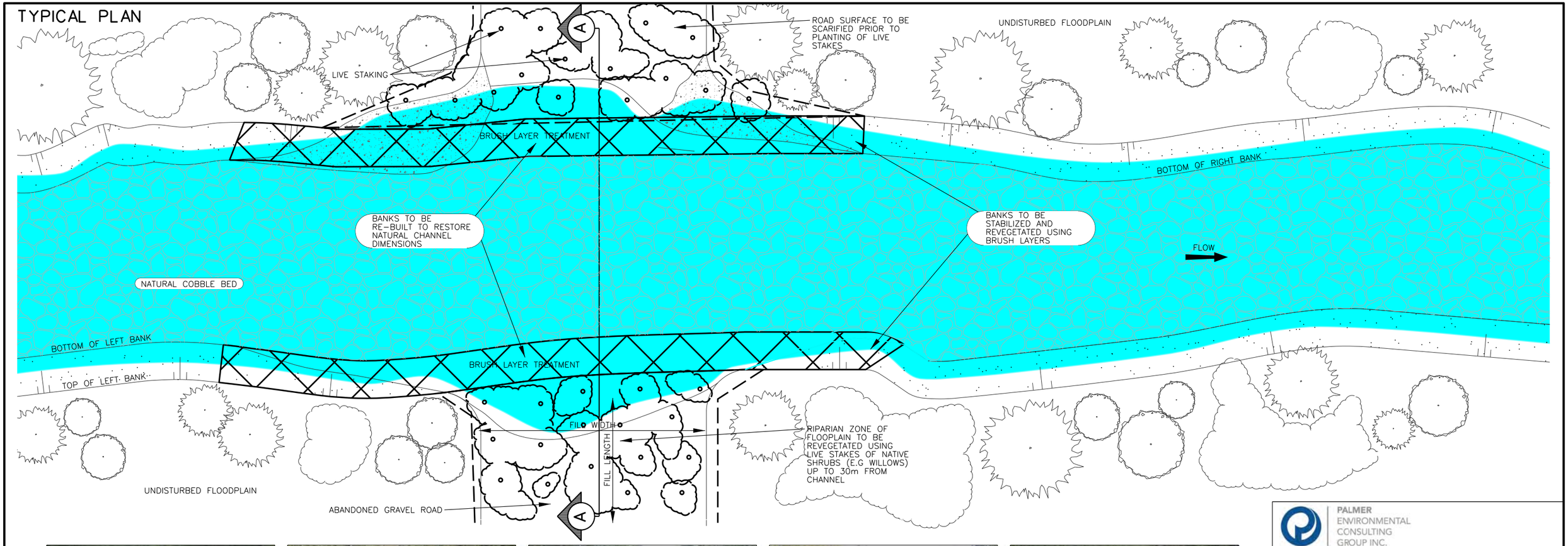
TYPICAL PLAN




FORD A

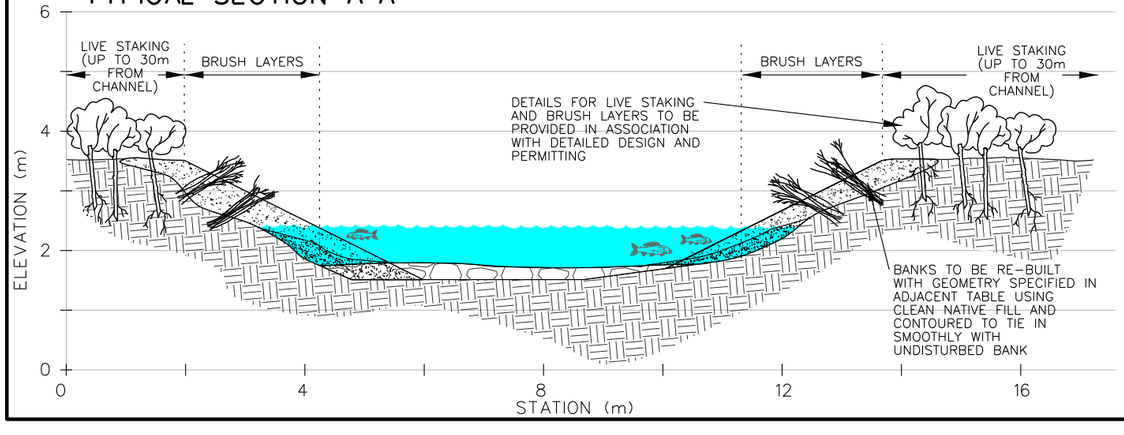

FORD B


FORD C


FORD D


FORD E

TYPICAL SECTION A-A



SITE-SPECIFIC GUIDELINES FOR BANK RESTORATION

Ford	Location[1]	Bank Height (m)	Bank Angle (H:V)	Left Bank[2]		Right Bank[2]		Notes
				Fill Width[3] (m)	Fill Length[4] (m)	Fill Width[3] (m)	Fill Length[4] (m)	
A	617740E 6972122N	0.5	3H:1V	7	6	9	10	Both banks to be restored to match adjacent conditions, without any channel narrowing
B	616063E 6967563N	1.0	1H:1V	9	150	6	15	Minor fill and live staking (revegetation) to be completed along left bank road surface due to periodic flooding from upstream
C	616206E 6966946N	0.5	1H:1V	4	15	4	30	Channel width and both banks to be restored to match adjacent conditions
D	616865E 6965029N	0.6	1H:1V	9	16	8	9	Channel width and both banks to be restored to match adjacent conditions
E	616029E 6966726N	0.6	1H:1V	6	10	6	12	Both banks to be restored to match adjacent conditions, without any channel narrowing; left bank restoration to avoid filling existing flood swale

Notes:
[1] UTM Zone 7 coordinates
[2] Viewed upstream
[3] Approximate width *across* road cut into floodplain
[4] Approximate length *along* road centreline from bottom of bank away from channel to limit of road cut

REFER TO FIGURE 4-4 FOR LOCATIONS OF ABANDONED FORDS TO BE RESTORED

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TYPICAL BANK AND RIPARIAN RESTORATION AT ABANDONED FORDS
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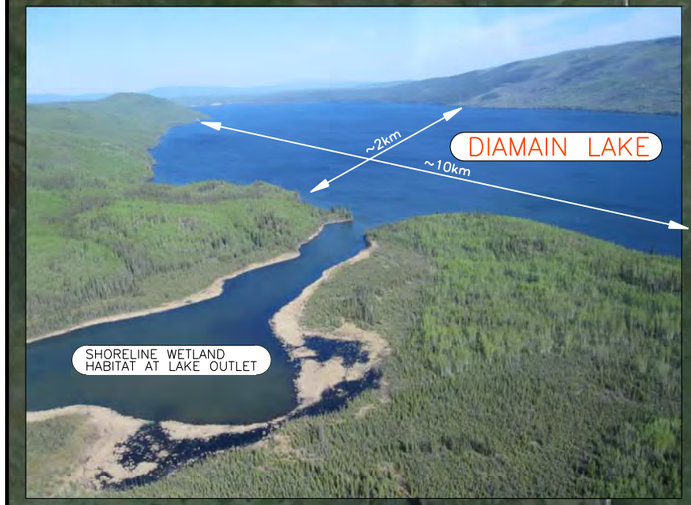

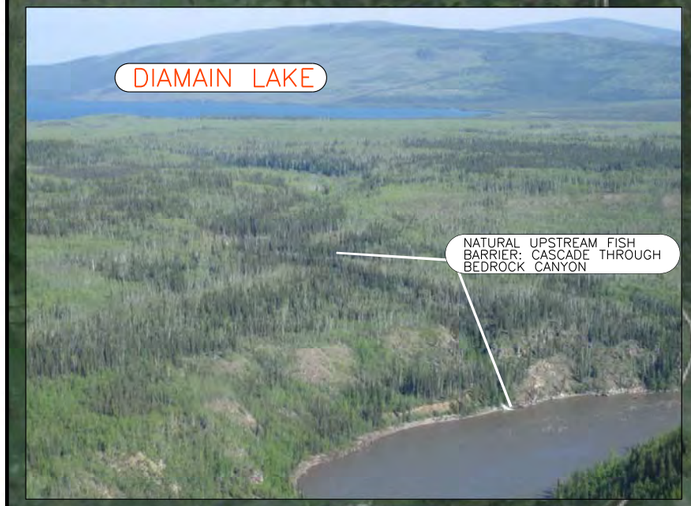

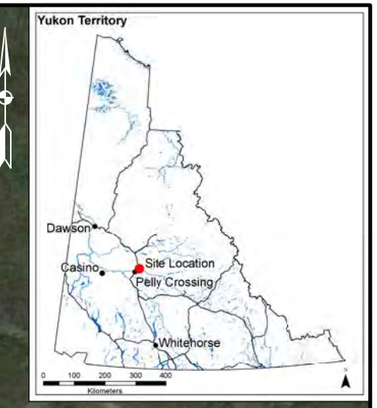

DIAMAIN LAKE

MACMILLAN RANGE

LAKE TO BE STOCKED WITH WHITEFISH FROM THE PELLY RIVER WATERSHED, WITH SUPPORT FROM A LOCAL HATCHERY

CASCADE THROUGH BEDROCK CANYON

EXISTING ACCESS ROAD/TRAIL

KLONDIKE HIGHWAY

PELLY RIVER

PELLY CROSSING

MICA CREEK

NEEDLEROCK CREEK

0 1000 5000 Metres 1:80000

BASE IMAGERY (2013) FROM DIGITALGLOBE AND GOOGLE EARTH

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DIAMAIN LAKE WHITEFISH FISHERY CREATION

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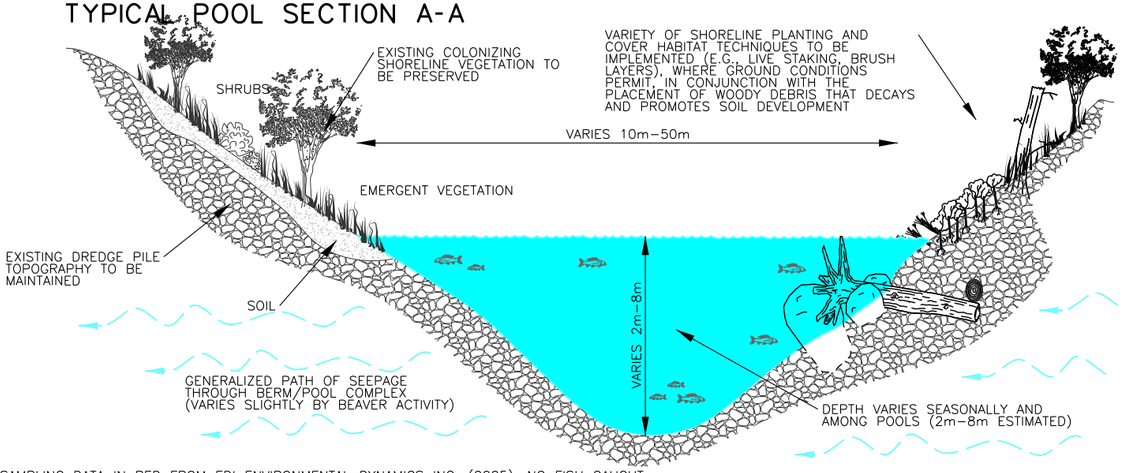
TYPICAL POOL SECTION A-A



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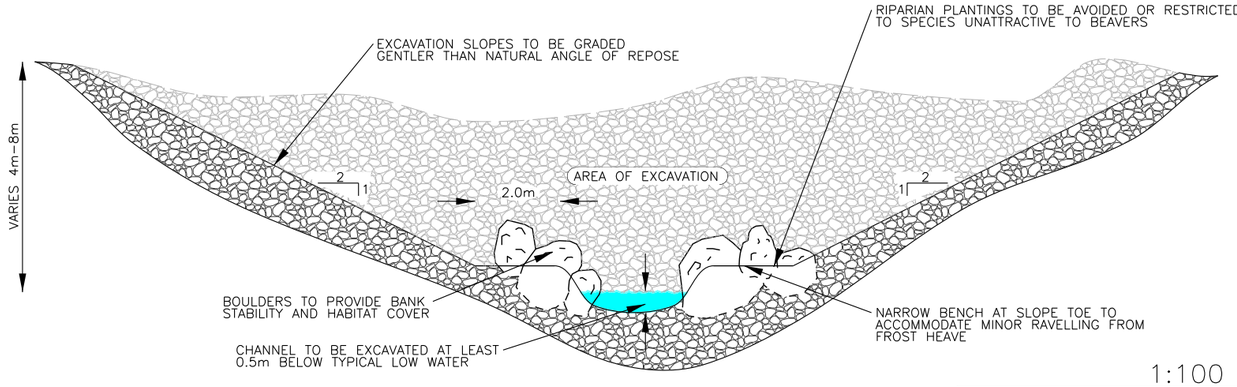
TYPICAL CONNECTOR CHANNEL SECTION B-B



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FISH SAMPLING DATA IN RED FROM EDI ENVIRONMENTAL DYNAMICS INC. (2005): NO FISH CAUGHT (NFC) OR NUMBER OF CHINOOK SALMON (CH), SLIMY SCULPIN (CCG), AND/OR BURBOT (BB)

NO PLACER/BEDROCK PROSPECTING OR MINING IS PERMITTED WITHIN AREA OF PROPOSED WORKS, WHICH IS REGULATED BY THE TOWN OF DAWSON, AS PER O.I.C. 2003/81

BASE IMAGERY (2012) FROM GOOGLE EARTH













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DAWSON DREDGE POND OFFLINE POOL HABITAT CREATION

CASINO PROJECT

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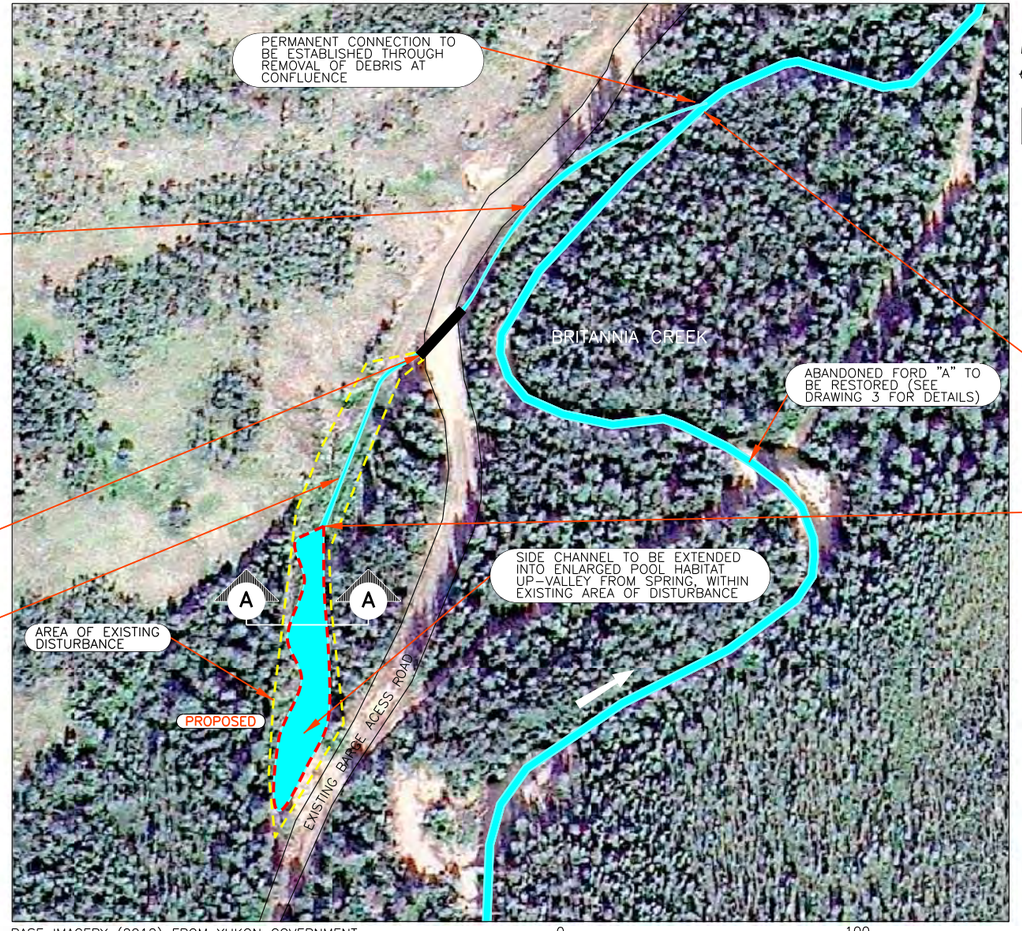
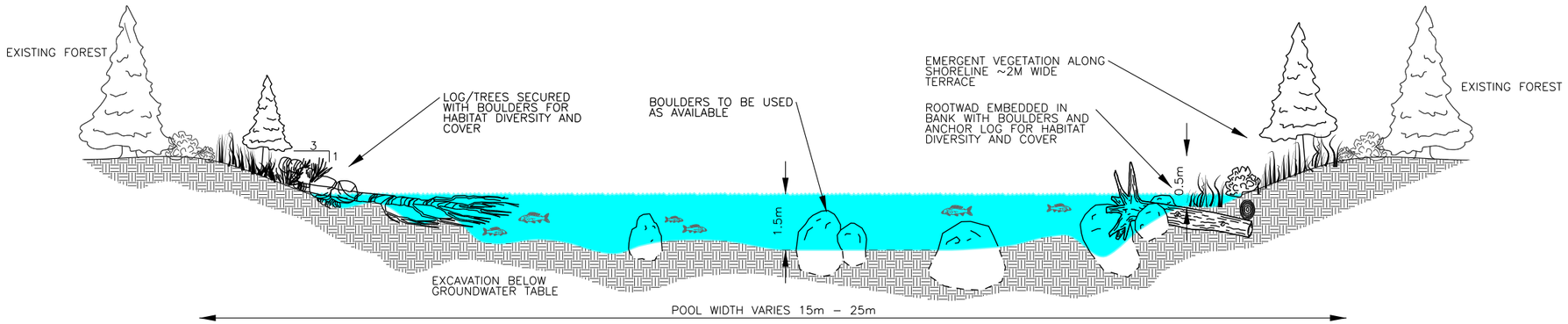






TYPICAL SECTION A-A



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LOWER BRITANNIA CREEK SLOPE-TOE SIDE CHANNEL EXTENSION AND ENHANCEMENT

CASINO PROJECT

CONCEPT DESIGN

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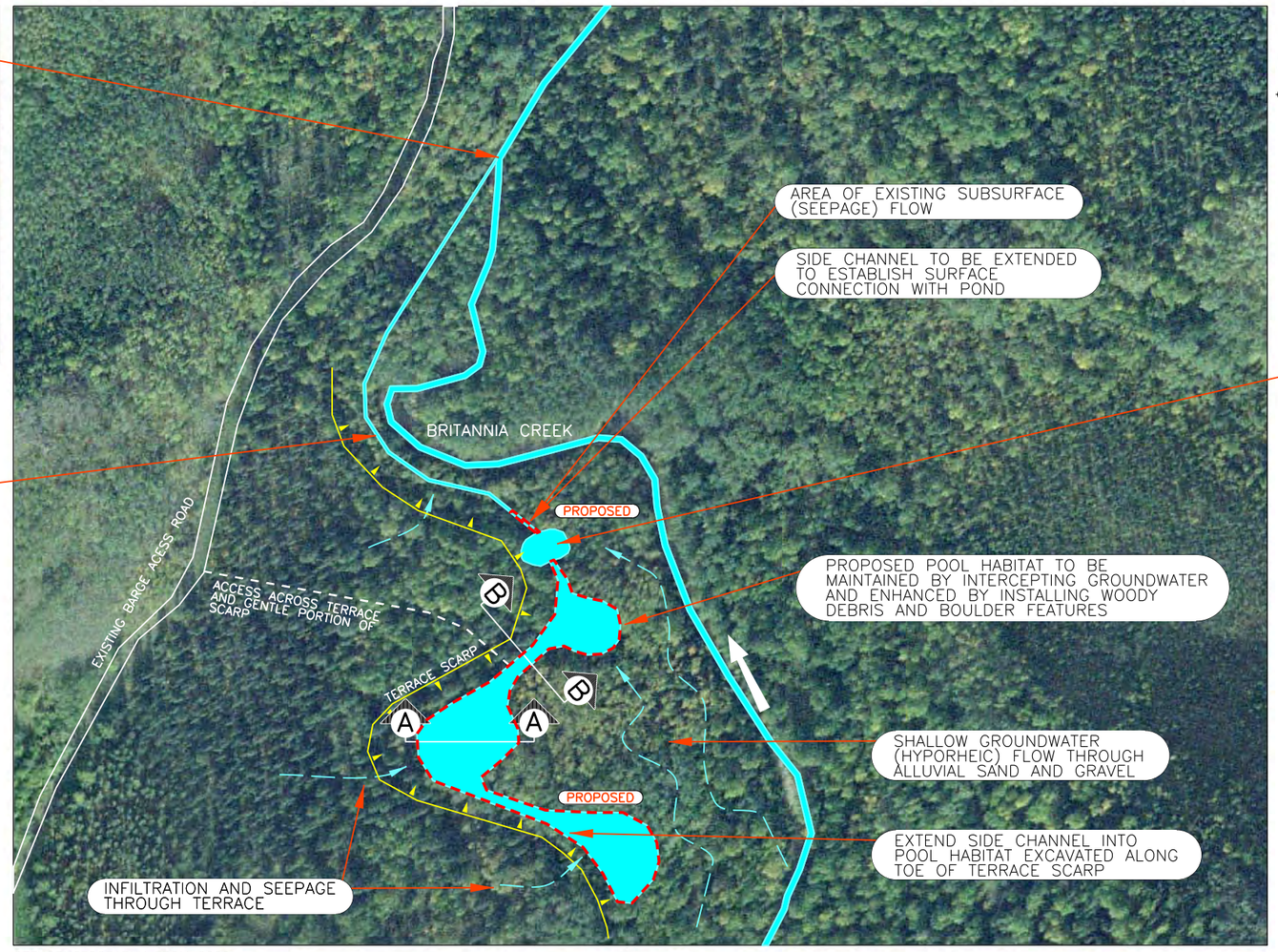

ORTHOPHOTOGRAPHY FROM 2009

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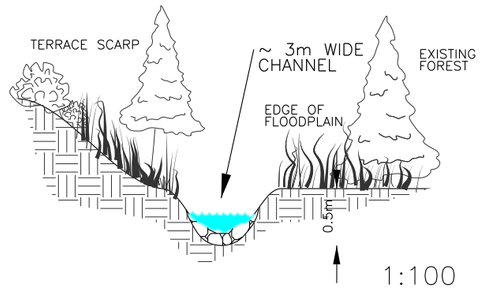
TYPICAL SECTION B-B



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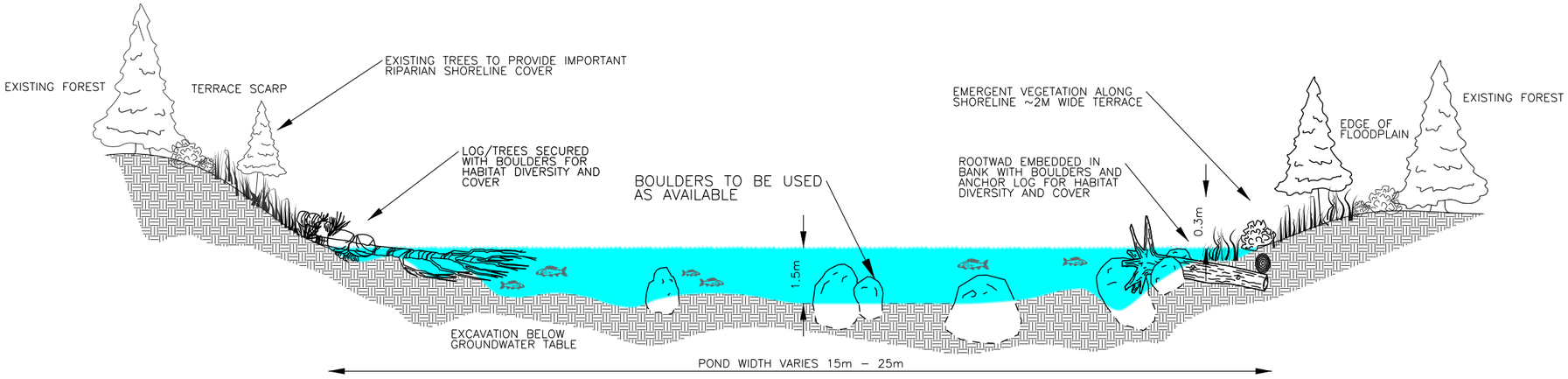
TYPICAL SECTION A-A



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LOWER BRITANNIA CREEK GROUNDWATER–FED SIDE CHANNEL EXTENSION AND ENHANCEMENT

CASINO PROJECT

CONCEPT DESIGN

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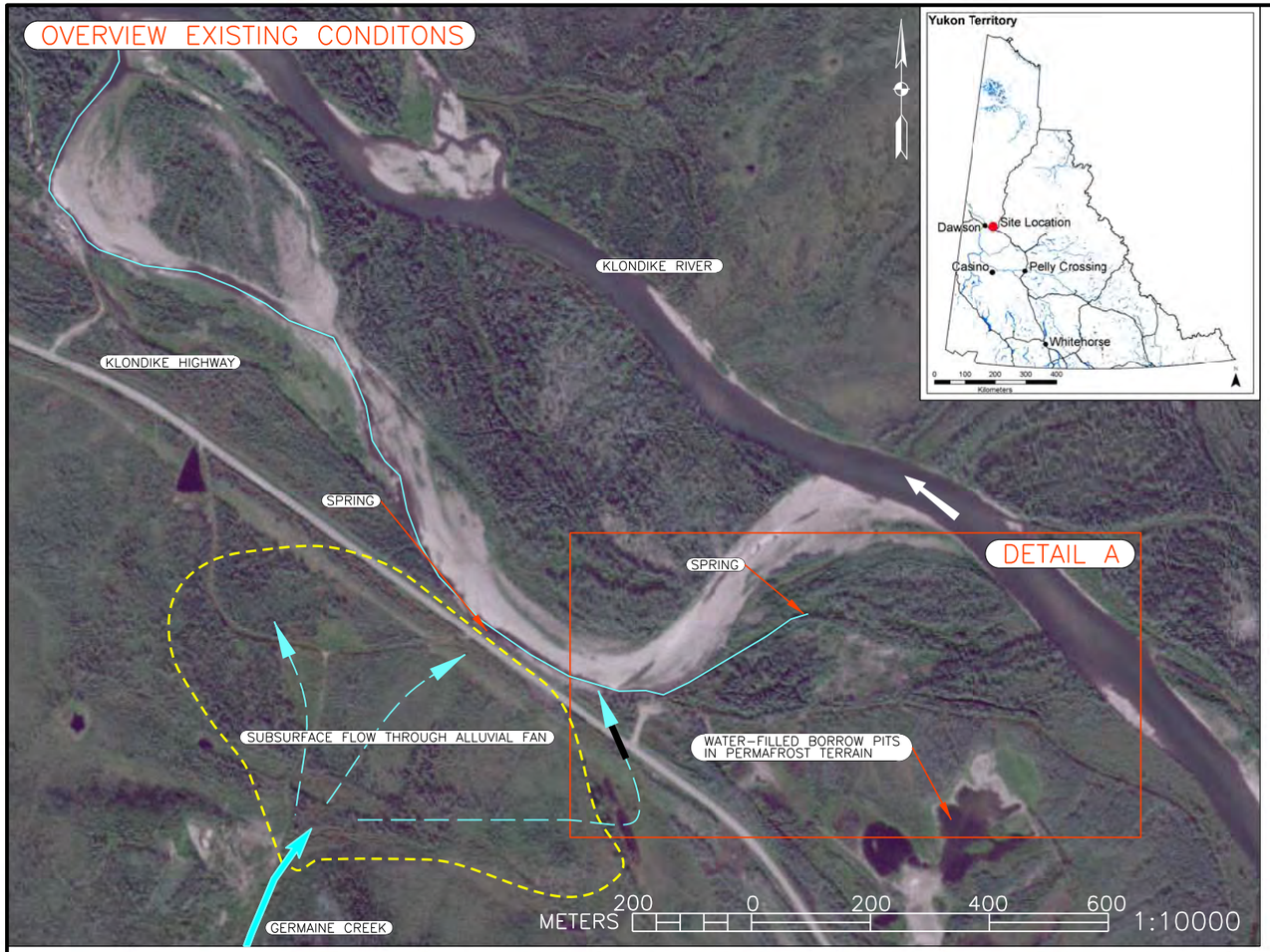
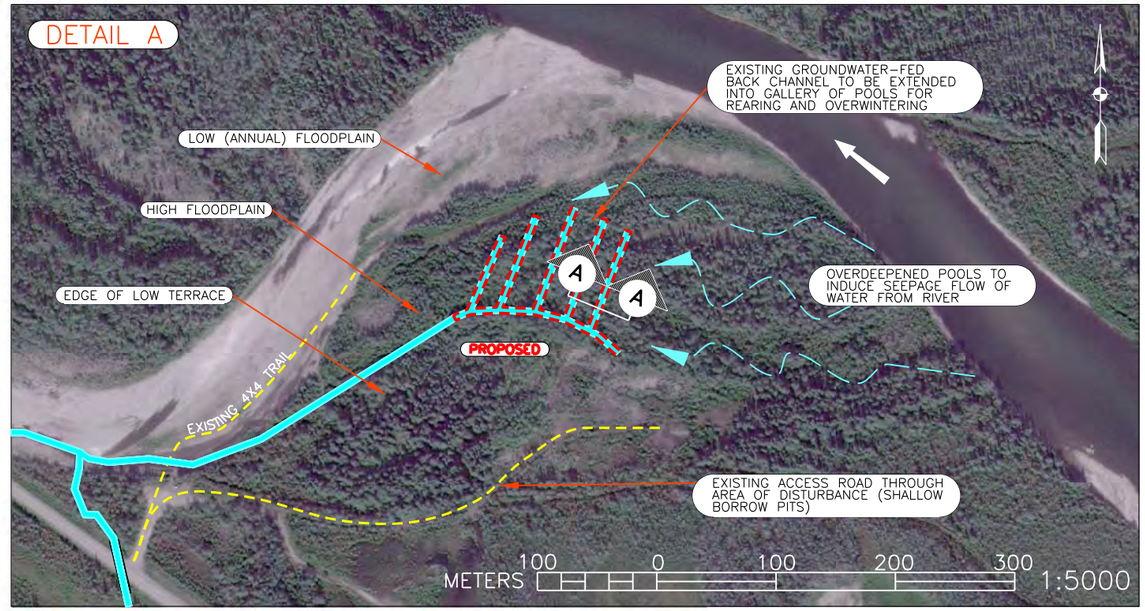
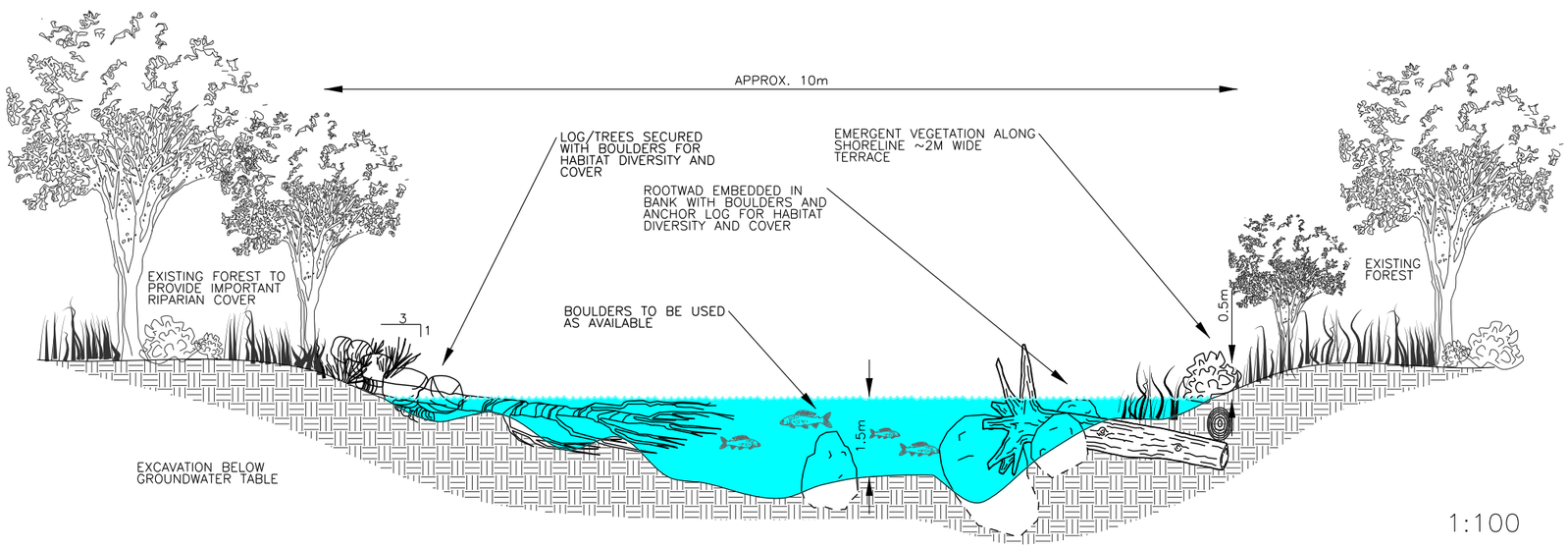




BASE IMAGERY (2009) FROM YUKON GOVERNMENT

TYPICAL GALLERY POOL SECTION A-A



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KLONDIKE RIVER SIDE CHANNEL REARING GALLERY AT GERMAINE CREEK
CASINO PROJECT

CONCEPT DESIGN

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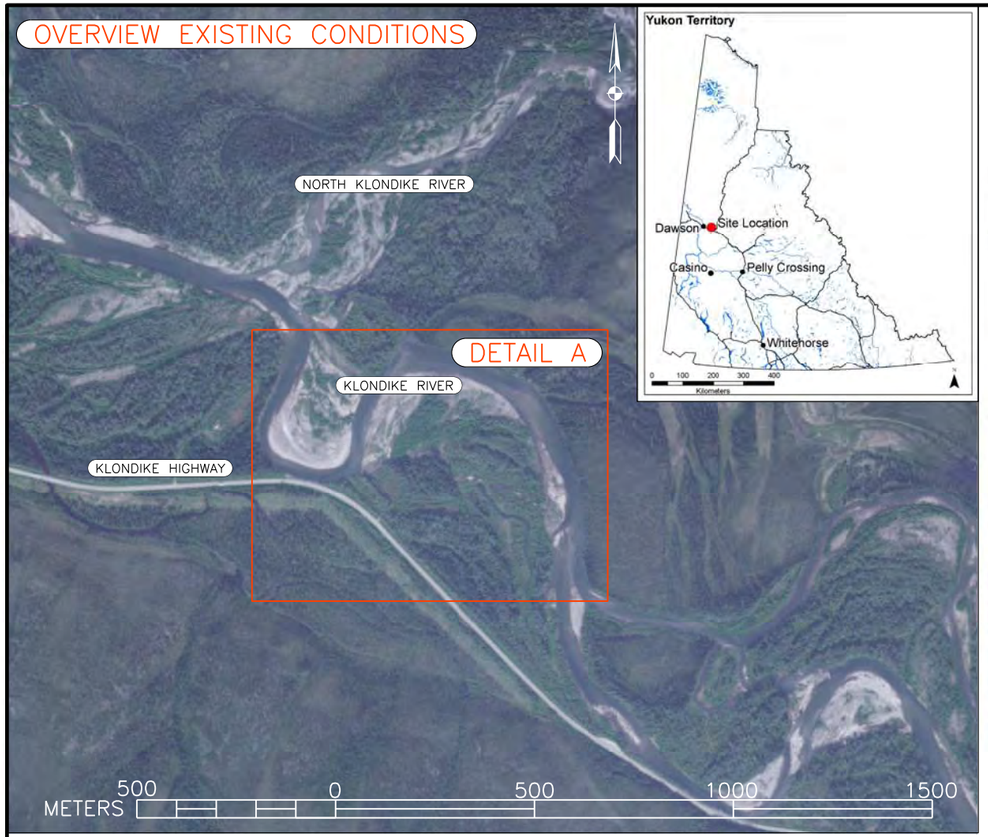
		SHEET NO.

OVERVIEW EXISTING CONDITIONS



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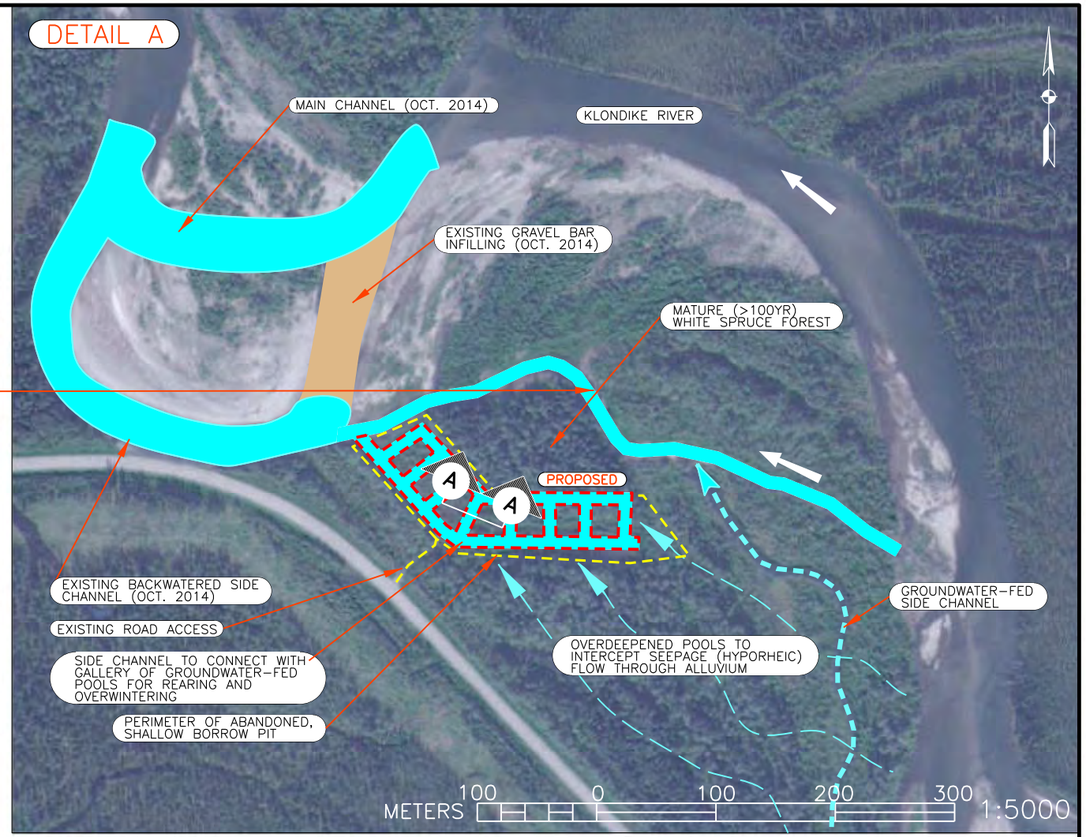
SIDE CHANNEL WITH DIRECT SURFACE CONNECTION AND POOL–RIFFLE MORPHOLOGY

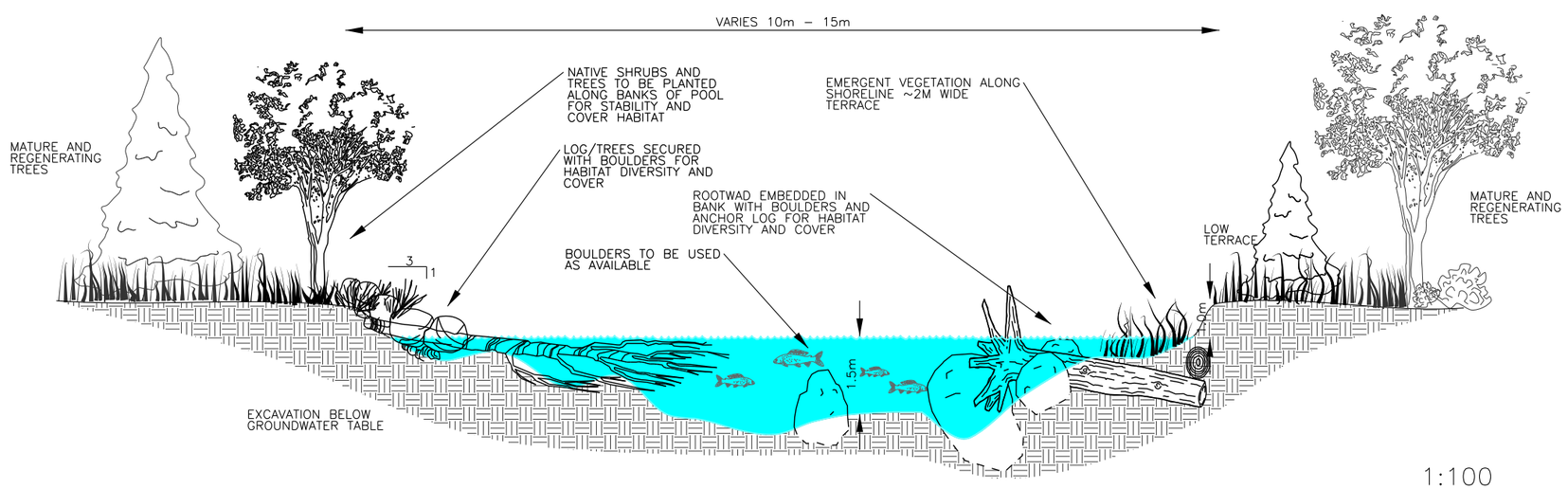

PROPOSED GALLERY AREA WITHIN PERIMETER OF ABANDONED, SHALLOW BORROW PIT

DETAIL A



BASE IMAGERY (2009) FROM YUKON GOVERNMENT

TYPICAL GALLERY POOL SECTION A-A



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KLONDIKE RIVER SIDE CHANNEL REARING GALLERY AT NORTH KLONDIKE RIVER

CASINO PROJECT

CONCEPT DESIGN

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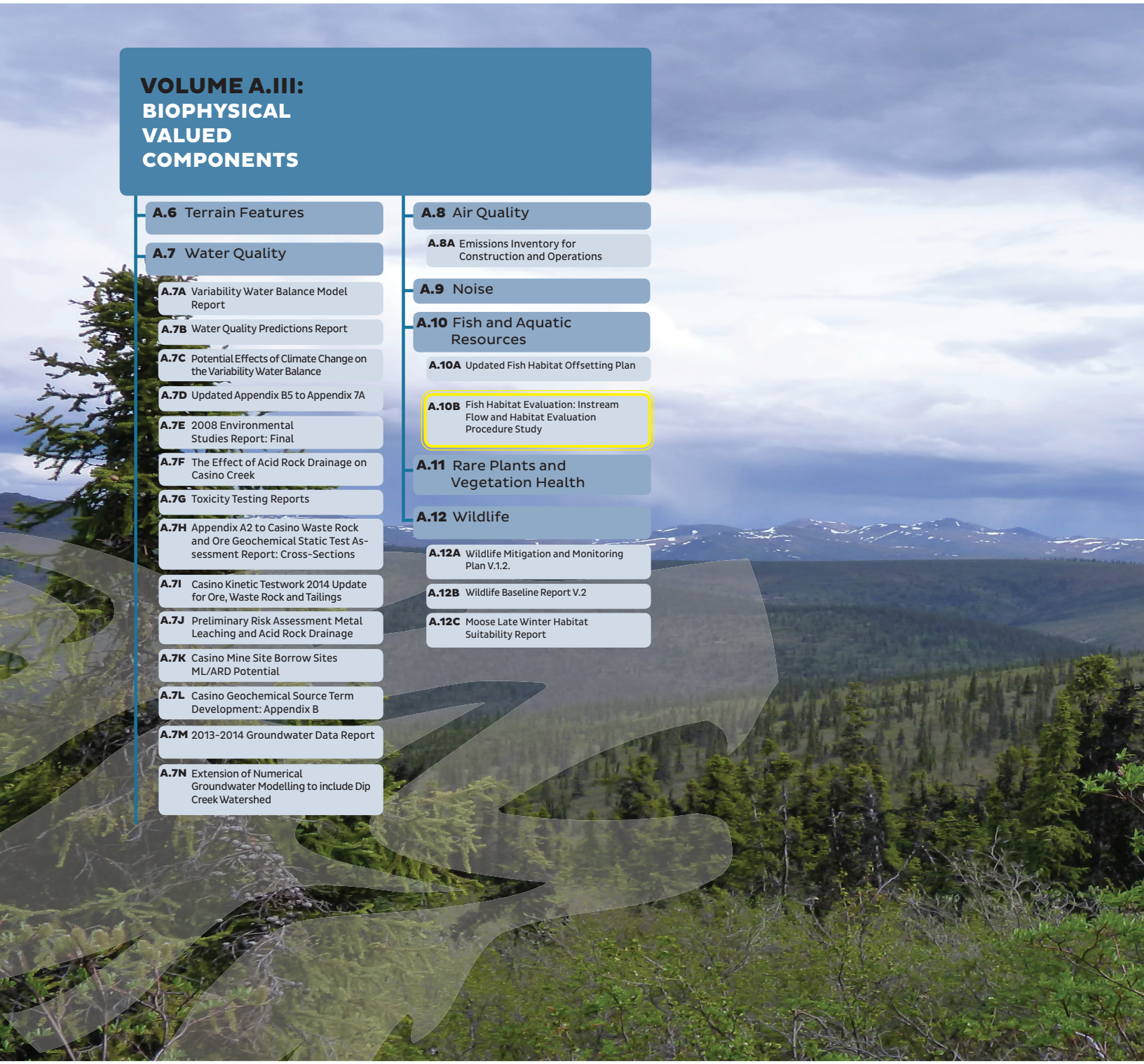
		SHEET NO.

APPENDIX A.10B: Fish Habitat Evaluation Instream Flow and Habitat Evaluation Procedure Study



NORMANDEAU ASSOCIATES
ENVIRONMENTAL CONSULTANTS

PALMER
ENVIRONMENTAL
CONSULTING
GROUP INC.

Casino Project

Fish Habitat Evaluation: Instream Flow and Habitat Evaluation Procedure Study

FINAL

Prepared for

Casino Mining Corporation

December 1, 2014

NORMANDEAU ASSOCIATES
ENVIRONMENTAL CONSULTANTS

PALMER
ENVIRONMENTAL
CONSULTING
GROUP INC.

December 1, 2014

Mary Mioska
Senior Environmental Manager
Casino Mining Corporation
1800 – 570 Granville Street
Vancouver, BC V6C 3P1

Dear Ms. Mioska,

Re: Casino Project – Fish Habitat Evaluation: Dip Creek and Casino Creek Instream Flow and HEP Study

Palmer Environmental Consulting Group Inc. and Normandeau Associates are pleased to submit this final report describing the results of our fish habitat evaluation study using Physical Habitat Simulation Modeling (PHABSIM) and Habitat Evaluation Procedure (HEP) methods to understand and quantify the loss or change in aquatic habitat as a result of the Casino Project.

If there are any questions or comments on this report, please contact Rick Palmer at (604) 629-9075.

Thank you for the opportunity to work on this project.

Yours truly,

Palmer Environmental Consulting Group Inc.

R. Palmer

Rick Palmer, M.Sc. R.P. Bio
President, Senior Fisheries Biologist

Revision Log

Revision #	Revised By	Date	Issue / Revision Description
1	Steve Eggers	Feb. 22, 2012	Draft
2	Steve Eggers	March 5, 2012	Draft/Comments
3	Steve Eggers	May 1, 2012	Draft
4	Eric Cleveland	November 19, 2013	Final Draft
5	Rick Palmer	November 29, 2013	Report Finalization
6	Nicola Lower/Eric Cleveland	November 27, 2014	Report updated results, memos consolidation
7	Rick Palmer	December 01, 2014	Report Review

Signatures

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Executive Summary

The Casino Project is a proposed porphyry copper-gold-molybdenum mine located in west-central Yukon, approximately 300 km northwest of the territorial capital of Whitehorse. Tailings generated from the mine, as well as process water, treated sewage effluent, leachate from the waste rock dumps and surface runoff from the mine site will be directed to a Tailings Impoundment Area (TIA) located north of a proposed tailings dam in the headwaters of Casino Creek.

The proposed Casino Mine TIA will create a physical loss of fish habitat in the upper portion of Casino Creek and will alter habitat downstream of the TIA, within lower Casino Creek and Dip Creek, due to reduced flow. This report presents the results of a Fish Habitat Evaluation Study conducted to evaluate and to quantify, the amount of aquatic habitat that will be lost or altered as a result of the proposed project. The study area consists of Casino Creek from the confluence of Dip Creek upstream to the upper extent of the proposed TIA, and Dip Creek, below the confluence of Casino Creek, downstream for a distance of 1.5 km, as well as Meloy and Taylor Creek. Lost habitat was also quantified in the Lower Britannia Creek as a result of a proposed stream diversion under the Fish Offsetting Plan, and in Canadian Creek, due to the diversion of upper Canadian Creek in to the open pit. As Arctic grayling compose the majority of the species composition within the Casino Creek/Dip Creek watershed, it was chosen as the target species for this study.

Two types of impacts on Arctic grayling habitat associated with the proposed Casino Project were evaluated as part of the Fish Habitat Evaluation Study:

- The physical loss of all aquatic habitat in upper Casino Creek due to the TIA; and
- The change in aquatic habitat area in Lower Casino Creek and Dip Creek due to a reduction of flow out of the TIA.

The first type of aquatic habitat impact, loss of all aquatic physical habitat, was assessed with a quantitative Habitat Evaluation Procedure (HEP) method, which gives a quality rating, based on biological parameters, to the total surface area of lost habitat. The second type of aquatic habitat impact, flow reduction, due to the TIA or partial diversion of a creek, was assessed using a Physical Habitat Simulation Model (PHABSIM) method that provides an index to habitat that varies with discharge. The net change in the PHABSIM habitat index under varied pre-project and modeled post-project flow regimes provides a relative quantitative measure that can be used to develop prospective compensation approaches.

The PHABSIM analysis showed that the reduction in flow in Casino Creek during construction and operation phases of the project results in a median increase in habitat for adult and juvenile grayling of between 16% and 22% for lower Casino Creek, and 10% to 15% for middle Casino Creek. This outcome is due to the tendency for these life stages to prefer lower velocities, and that at lower flows there is an increase in available low velocity refuge areas. Changes in habitat during the closure and post-closure phases are generally less than 10% based on the median habitat values.

Grayling fry habitat duration curves in both lower and middle Casino Creek exhibit similar results to adult and juvenile with increased habitat under project conditions. The median habitat values increase in the range of 95% for lower Casino Creek and around 125% for middle Casino Creek during construction and operation phases. Changes in habitat during the closure and post-closure phase are generally less than 7% to 15% based on the median habitat values.

Spawning is the only life stage which shows a decrease in habitat due to flow reduction during the projects construction and operation phases. The median habitat value percent change shows a decrease in lower Casino Creek (-72%) and middle Casino Creek (-83%) for the construction and operation phases of the project. This is an end result of lower availability of higher velocities generally used by grayling during spawning, the opposite condition of what is preferred during other life stages. Changes in habitat during the closure and post-closure phases are between 6% and 9% based on the median habitat values.

Habitat for adult and juvenile grayling in Dip Creek show a slight increase during construction and operation phases of the project. Fry and spawning life stages show virtually no difference in habitat during all project phases. The percentage change at the median habitat index value is between 7 and 8 per cent for juveniles and adults and a decrease of 2 to 3 per cent for fry and spawning life stages during construction and operation phases of the project. Habitat index values for closure phases differ little from baseline.

The Habitat Evaluation Procedure analysis was used to estimate the changes in habitat for Arctic grayling in Upper Casino Creek. The estimate of net habitat loss was based on the assumption that rearing habitat would limit fish population. The result is a net reduction of usable habitat of 2,451 m^2 in Reach 2a (the section of stream between Brynelson Creek and the proposed TIA), and 2,433 m^2 in Reach 2b (between the TIA and the identified barrier to fish migration). A loss of potentially usable habitat of 5,715m^2 is anticipated from the upper reaches of Casino Creek, upstream of a seasonal fish barrier. This is a conservative estimate as it is unlikely that this area provides year-round or critical habitat for Arctic grayling. The TIA will also impact upon the lower reaches of Meloy Creek, although this creek was found not to provide useable habitat for Arctic grayling,

The Habitat Evaluation Procedure analysis was used to evaluate the changes in habitat for both juvenile Chinook salmon and Arctic grayling in Lower Britannia Creek. There will be some loss of habitat if offsetting plans proceed in this area. The historic channel would be reinstated and the flow from the existing channel would be diverted. The estimate of the net loss in habitat in this reach was based on the most limiting factor, the percent pool habitat. The final net habitat loss was calculated as 2,384m^2, which would be offset by proposed restoration works in this area.

There was no detectable change in habitat for grayling adult and juvenile life stages under all project phases in Canadian Creek. A small increase in habitat for fry and a slight decrease in spawning habitat would occur during project closure phases. This equates to an increase in fry habitat by 28% and a decrease in spawning habitat of 11%.

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1 BACKGROUND

The Casino Project (the "Project") is a proposed porphyry copper-gold-molybdenum mine located in west-central Yukon, approximately 300 km northwest of the territorial capital of Whitehorse (**Figure 1**). In August 2008, a pre-feasibility study of the Project was completed by M3 Engineering (2008), which described a conventional truck-shovel, open pit mine. Tailings generated from the mine, as well as process water, treated sewage effluent, leachate from the waste rock dumps and surface runoff from the mine site would be directed to a Tailings Impoundment Area (TIA) located north of a proposed tailings dam in the headwaters of Casino Creek.

The proposed Casino Mine TIA will create a physical loss of fish habitat in the upper portion of Casino Creek and will alter habitat downstream of the TIA, within lower Casino Creek and Dip Creek, due to reduced flow. This report presents the results of a Fish Habitat Evaluation Study conducted to evaluate and to quantify, the amount of aquatic habitat that will be lost or altered as a result of the proposed project.

All habitat evaluations outlined in this report were conducted during 2011 to 2013 and based on the known mine footprint and potential impacts identified at this time. Additional habitat evaluations and field assessments were conducted in summer 2014, as additional potential impacts to fish habitat were identified. This work conducted in 2014 consisted of habitat mapping in three small tributaries to Casino Creek, and a tributary of Dip Creek, which has been identified as crossing the proposed airstrip in the Dip Creek valley. The results from these evaluations were included in the Fish Habitat Offsetting Plan (PECG, 2014) but detailed HEP and calculations and approach will be outlined in an addendum to this report in 2015.

1.1 Project Overview and Study Area

The study area consists of all water bodies within the project footprint or where impacts are predicted from a reduction in flow to downstream reaches, or from proposed offsetting fish habitat plans (**Figure 1**). The following habitats were evaluated as part of the Fish Habitat Evaluation Study:

- The physical loss of all aquatic habitat in upper Casino Creek due to the Tailings Impoundment Area (TIA);
- The change in aquatic habitat area in lower Casino Creek and Dip Creek (downstream for a distance of 1.5km) due to a reduction of flow out of the TIA;
- Meloy Creek – to quantify the amount of fish habitat lost as a result of the proposed TIA;
- Canadian Creek – the uppermost reach around the revised open pit area;
- Lower Britannia Creek – to quantify the amount of fish habitat lost as a result of diverting stream from the existing channel[1] back into a historical channel as part of the Fish Habitat Offsetting Plan (FHOP).

[1] At present, the existing lower reach of Britannia Creek artificially follows a former road alignment, and therefore, this reach has poor habitat quality relative to the historical channel. It is estimated that the channel "jumped" from its original path in the early 1970's and it is proposed as part of the FHCP to restore lower Britannia Creek to its original or historical channel.

The first type of aquatic habitat impact, loss of all aquatic habitat, was assessed with a quantitative Habitat Evaluation Procedure (HEP) method, which gives a quality rating, based on biological parameters, to the average surface area of the lost habitat. Potential compensation for loss of upper Casino Creek can be calculated and compared on an equivalent basis to candidate offsetting sites, such as stream segments above modified barriers or constructed spawning/rearing channels.

The second type of aquatic habitat impact, flow reduction below the TIA and diversion around the open pit area, was assessed using a Physical Habitat Simulation Model (PHABSIM) method that provides an index to habitat that varies with discharge. The PHABSIM is a suite of hydraulic and habitat models developed as part of the Instream Flow Incremental Methodology (IFIM) approach for evaluating flow alteration on aquatic habitat. The index is the sum of habitat suitability at each point multiplied by the area it represents. The index can be thought of as usable area. The net change in the PHABSIM habitat index under varied pre-project and probable post-project flow regimes provides a relative quantitative measure that can be used to develop prospective compensation approaches.

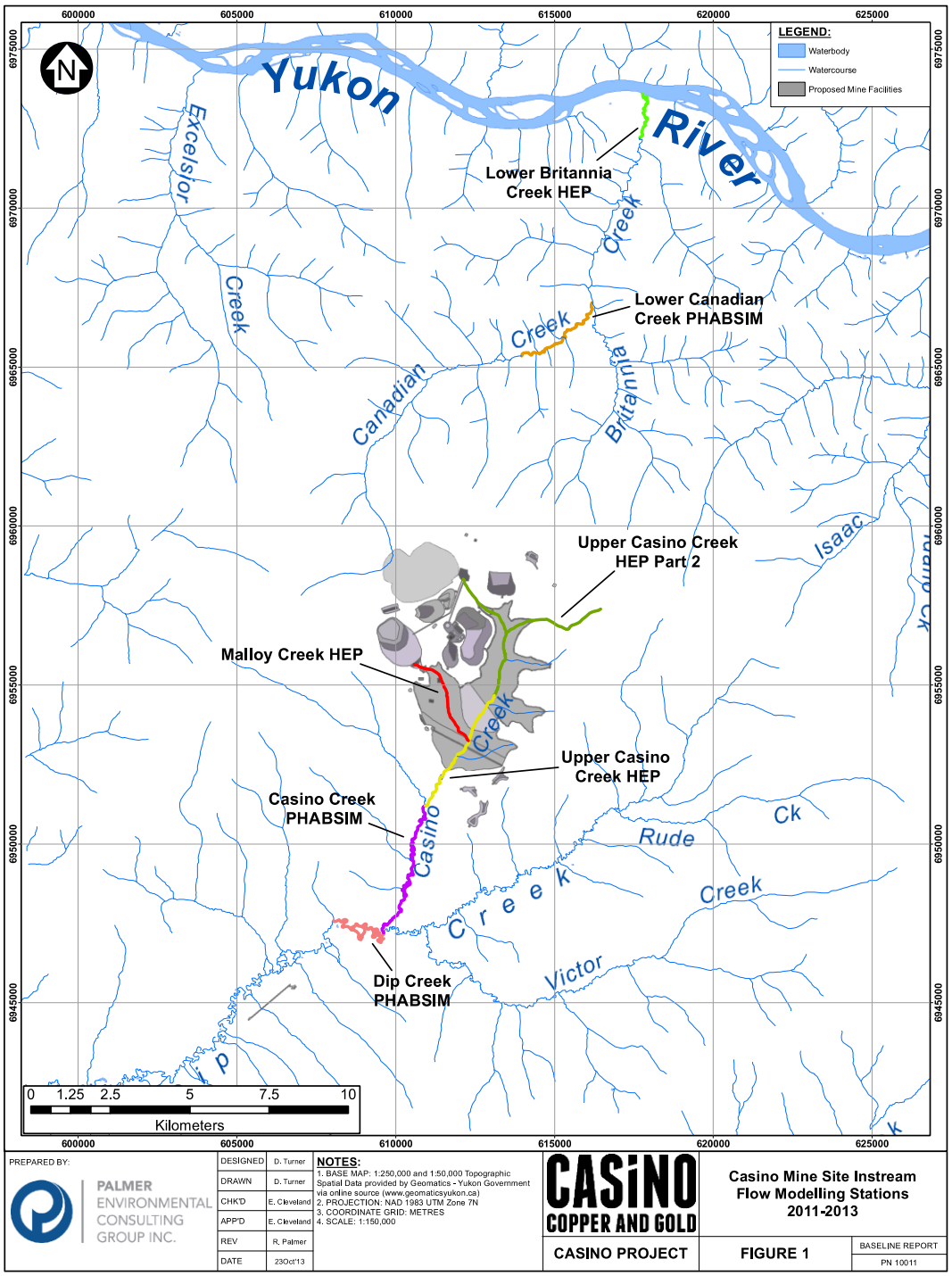


Figure 1. Locations of Fish Habitat and Instream Flow Evaluations.

Both HEP (USFWS 1980) and PHABSIM (Bovee 1982; Bovee et al. 1998) have been used recently for similar mining projects in Canada within accepted environmental assessment proceedings (e.g., Mount Milligan, Doris North, Kemess). These methods have also been applied extensively in many areas of the world since being developed in the late 1970s and have a proven track record for project evaluation and determination of impacts and acceptable compensation for fish habitat.

A summary of each study area reach and the specific method used to evaluate the aquatic habitat and function is provided below:

- Reach 1. Lower Casino Creek from the Dip Creek Confluence to Brynelson Creek was evaluated using PHABSIM.

- Reach 2. Upper Casino Creek was evaluated using HEP.
    - 2a - Casino Creek from Brynelson Creek upstream to the proposed TIA dam (an area that would be dewatered)
    - 2b - from the proposed TIA dam to an identified potential fish barrier (within the footprint of the TIA)

- Reach 3. Casino Creek from the fish barrier to the upper extent of the TIA (non-fish bearing) was evaluated using HEP. This also included the lower reach of Taylor Creek, a tributary of Casino Creek, up until a barrier to fish passage 400m upstream of the confluence with Casino Creek.

- Reach 4. Dip Creek, downstream of the confluence of Casino Creek was evaluated using PHABSIM.

- Meloy Creek. HEP was used to evaluate the lower 400m from the connection to Casino Creek, as the proposed TIA will overlay this section.

- Lower Britannia Creek, HEP was used to evaluate habitat from the Yukon River to approximately 1km upstream, where the habitat may be lost due to construction of fish offsetting plans.

Prior to initiating field investigations, the study team met with stakeholders to discuss study scope, design elements, and overall decision-making for the study. This is type of engagement is commonly instituted under the framework of the IFIM and PHABSIM as one of the first steps. As such, a study plan was developed and provided to participants outlining the proposed study design in June 2011 prior to the beginning of field data collection.

1.2 Existing Aquatic Ecosystem

Historical studies on the aquatic ecosystem of the Project property were conducted between 1993 and 1995 by Hallam Knight Piésold (1997). Recent studies of the aquatic ecosystem were initiated by AECOM in 2008 (AECOM 2009), and were continued by Palmer Environmental Consulting Group (PECG) from 2009 to 2012 (PECG 2011a; PECG 2011b; PECG 2012; PECG 2013).

Over the course of these investigations, detailed background data was collected on: water quality, sediment quality, periphyton, benthic invertebrates, fish species, fish habitat, and flow regime. It was

shown that the fish community in Casino Creek is dominated by two fish species, Arctic grayling (*Thymallus arcticus*) and Slimy sculpin (*Cottus cognatus*), with limited occurrences of burbot (*Lota lota*). As Arctic grayling compose the majority of the species composition within the Casino Creek/Dip Creek watershed, it was chosen as the target species for this study. This species was also used for habitat suitability indices for the Lower Britannia Creek as it shares habitat preferences with juvenile Chinook salmon, which also inhabits this section of the watershed.

2 STUDY OBJECTIVES

The fish communities and ecological characteristics of the watercourses outlined in this report have been determined, and are outlined in previous reports as outlined in section 1.2. The objective of this Fish Habitat Evaluation Study was to focus on available fish habitat for the existing fish community. As the fish community is limited in this area (a function of the northern environment, and the generally low productivity in these systems), one species was chosen as the focus of this assessment. The Arctic grayling is the dominant species in all watercourses outlined in this report, and provides a representation of habitat suitability for additional species, in particular, Chinook salmon.

The study objectives were to first establish baseline fish habitat conditions in Casino Creek, Dip Creek (downstream of the confluence with Casino Creek), Meloy Creek, Canadian Creek and Lower Britannia Creek,. This baseline aquatic habitat was then characterized as a function of flow. Project impacts to these watercourses are anticipated through a reduction or permanent loss, of flow. This objective was completed through a detailed fish habitat characterization and instream flow assessment study. Second, the results of the habitat characterization and instream flow study were evaluated using PHABSIM (for Reaches 1 and 4) and HEP analysis (for Reaches 2a, 2b, and 3, Meloy Creek, Lower Britannia Creek) to understand and quantify the loss or change in aquatic habitat as a result of the Project.

Specific study objectives include:

- Calculate the habitat versus flow relationship using PHABSIM for life stages of Arctic grayling in lower and upper Casino Creek and Dip Creek;
- Use the relationship between habitat and flow along with hydrological records to develop estimates of net habitat change (loss or gain) based on reduced streamflow from the upper Casino Creek watershed;
- Establish baseline habitat conditions for Arctic grayling in upper Casino Creek using a HEP analysis. Use the results along with known fish distribution and relative abundance estimates to quantify habitat loss in the proposed TIA; and
- Quantify the area (in m^2) of habitat lost or gained for each life stage of Arctic grayling to be compared on an equivalent basis to candidate compensation sites as potential compensation for loss of upper Casino Creek from the TIA, and from Lower Britannia Creek from a proposed offsetting option.

3 METHODS

3.1 PHABSIM Study

The Physical Habitat Simulation Modeling (PHABSIM) program been a standard approach to instream flow analysis since 1980 and allows comparison of changes in aquatic habitat with changes in flow (Bovee et al. 1998). The two primary products are the computation of a habitat index versus flow relationship for key aquatic species, and the development of a habitat time series to evaluate effects of current or proposed flow regimes.

Specific elements and steps of a PHABSIM study that will each be discussed in this section include:

- Habitat Mapping;
- Study Site and Transect Selection;
- Hydraulic Data Collection;
- Hydraulic Modeling;
- Identify Key Aquatic Species and Life Stages;
- Select Habitat Suitability Criteria;
- Habitat Modeling; and
- Time Series Analysis.

3.1.1 Habitat Mapping

A PHABSIM study begins with a representative sample of hydraulic and physical habitat conditions within the study area. The samples are obtained by establishing cross-sectional transects over a range of habitat types to produce 1-dimensional (1-D) models. The sample can be obtained in a variety of ways, including selecting:

- Representative Reaches – a short section of river is assumed to represent other unsampled portions; or

- Individual Mesohabitats – individual stream habitat features (e.g. pools, runs, and riffles) are selected within the study reach and sampled in proportion to their frequency by stream length to represent other unsampled portions.

Whichever method is chosen to select samples for modeling hydraulics and habitat, it is important to have an overall picture of habitat type distribution within the study reach. A habitat typing approach, termed habitat mapping, that was originally described by Morhardt et al. (1983) and summarized by Bovee et al. (1998), was chosen for this study. Habitat mapping not only assists in selecting study sites, but also with weighting and proportioning resulting habitat indexes from various study sites or reaches.

Habitat mapping consists of a ground level or aerial survey to identify and delineate major habitat types within the stream reach under study (Table 1). As part of the habitat mapping protocol, additional types or sub-types can be added according to the best judgment of the field personnel.

Table 1. Aquatic Habitat Types for Casino Creek Habitat Evaluation.

Habitat Type	Description
Pool	• Low velocity flow • Generally deep across the channel or scoured along one bank • Often contain eddy's along one or both banks • Retains standing water as discharge approaches zero
Glide	• Shallow, uniform channel with smooth or laminar flow • Normally little or no exposed substrate • Typically do not have defined thalweg • May also occur in tailouts of pools or interspersed with runs
Run	• Generally deep, higher velocity flow • Can contain intermittent exposed boulders, bedrock or coarse substrate • Well-defined thalweg, often along a single bank
Low Gradient Riffle	• Shallow and turbulent white-water flow, exposed substrate at low flows • Usually composed of gravel/cobble substrate • Lacks any definitive thalweg • Generally act as controls for lower gradient habitat types
High Gradient Riffle	• Fast, high gradient (usually greater than 4%) habitat type • Substrate generally cobble or boulder dominated • May have interspersed steps and small pools at low flow
Cascade	• Steep, high gradient habitat type • May have interspersed pools at low flow
Other	• Includes any uncommon habitat type (e.g., falls, bedrock chutes)

Habitat unit boundaries were delineated using a hand-held GPS unit with an accuracy of less than 3 meters (m) horizontal on average. This level of precision is considered adequate for defining habitat unit lengths and locations. In instances of islands or split channels, the primary channel was mapped and a cursory examination was performed on the secondary channel to determine habitat correspondence between the two channels. The survey crew also noted major stream features such as high flow channels, split channels, backwaters and woody debris accumulations.

3.1.2 Study Site and Transect Selection

Establishment of study sites and transects can be based on an array of techniques, from professional judgment to random selection, and often depends on the extent and quality of stream habitat data available. Because the entire study reach on lower Casino Creek could be mapped, a stratified random selection approach was chosen which incorporates the least-available habitat type (Payne 1992). This approach minimizes any selection bias, results in transect clusters thereby limiting travel time and cost, and assures representative transects in proportion to habitat availability.

The process involves the following:

- Only reasonably accessible areas within the project study area or study reach are designated for potential selection;

- Within the study area or reach, the habitat type with the lowest percentage abundance from habitat mapping is used a basis for random selection. Generally only habitats which represent greater than 5% of the total are used unless lower percentage habitats are deemed important;

- All least-available habitat units within the selected reach or sub-section are sequentially numbered and, depending on the number of units, three to five units are randomly selected;

- Using the first randomly selected unit, a cursory examination of habitat mapping data is conducted to determine habitat distribution and representation near the selected unit. If the availability of some habitat types is deemed too limited, the second randomly selected unit is used and so forth; and

- Depending on the anticipated number of study sites and/or number of transects per study site, the process is continued until an agreed upon sample is obtained.

Essentially, habitat units are being selected not transects. Actual transect placement is accomplished using professional judgment as to the location within the unit that best represents the overall habitat. The total number of transects required to adequately represent a stream reach is between 15 and 20, which precludes overrepresentation of any single transect or habitat type. In addition, at least two transects are used to represent the lowest percent habitat type to allow for variability.

3.1.3 Hydraulic Data Collection

Field data collection and data recording generally followed the guidelines established by the USGS and in the instream flow field techniques manuals (Trihey and Wegner 1981; Milhous et al. 1984; Bovee 1997). Data collection at each transect consists of water surface elevation (WSE), cross-section profile elevation (calculated from survey data or water depths), velocity measurements and stream discharge. Depth and velocity are measured at points (stations on a tape) across each transect at a minimum of one flow. The number of points established (referred to as cells in the PHABSIM model) depends on the width and complexity of a given transect.

3.1.3.1 Quality Control

Standard quality assurance/quality control (QA/QC) measures were followed during field data collection for the instream flow study. The following procedures and protocols were used:

- Staff gauges were established and monitored throughout the study at each selected site. Significant changes in gauge readings were recorded;

- An independent benchmark was established for each transect or set of transects. The benchmark was a spike placed at an immovable tree, boulder, or other naturally occurring object that would not be subject to tampering, vandalism, or movement. Pins marking the right and left

banks consisted of rebar or spikes, depending on bank topography and substrate composition. Allowable error tolerances on level loops or elevation measurements from separate field visits were set at 0.006 m. This tolerance is applicable to pin and benchmark measurements except where extenuating circumstances explain discrepancies such as elevation measurements made through foliage, leaning leveling rod or loose pins. All elevation surveying was made with an auto-level and telescoping fiberglass leveling rod;

- WSEs were measured on both banks of each transect. On more complex transects with stepped WSEs, additional measurements were taken across a given transect;

- For velocity measurements, an electromagnetic Marsh-McBirney Flow-mate Model 2000 flow meter was used. The flow meter was continually monitored during the daily course of data collection to ensure it was functioning properly; and

- Photographs were taken of all transects at all calibration flows. An attempt was made to shoot each photograph from the same location, though this was not always possible. The photographic record provides a valuable resource of streamflow conditions, water surface levels, and channel configurations.

3.1.3.2 Velocity Measurements

An electromagnetic Marsh-McBirney Flow-mate Model 2000 flow meter, attached to a top-set rod was used for all stream velocity measurements. Mean column velocity was determined by a single measurement at six-tenths of the water depth in depths less than 0.7 meters, and the mean of two-tenths and eight-tenths measurements for greater depths. In instances where the vertical velocity distribution was judged to be variable due to upstream obstructions, two-tenths and eight-tenths measurements were made regardless of depth. The number of points (stations on tape or cells) to sample was determined by transect width and proximity of high velocity areas. An attempt was made to establish a minimum of 20 points and allocate no more than 5-10% of the total flow passing through one cell.

Under PHABSIM, one set of velocities per transect measured at the highest calibration flow is the recommended method. However, if conditions are unsafe or collecting velocities at the highest flow level is not feasible, data is generally collected at the next highest calibration flow. By default, depth measurements are obtained at the same time as velocity.

3.1.3.3 Stage-Discharge Measurements

Discharge and WSE's are used to develop hydraulic rating curves for each transect. WSE is collected at each transect during each field data collection effort. At the highest flow level, or velocity acquisition flow, discharge is computed for each transect. If streamflow conditions are steady (i.e. no changes in WSE are noted through the course of data collection) the average of all transect discharges can be used to compute the best overall discharge. Under varying streamflow and fluctuating WSE conditions, the best discharge may be different for individual transects or groups of transects. Subsequent measurements at lower flow levels consist of a single discharge for each group of transects. Generally three sets of stage-discharge measurements are collected for each transect at different flow levels. However, under

unregulated flow situations coupled with the remote location of Casino and Dip Creek, the number and range of measurements was restricted by timing and access by field crews.

3.1.4 Hydraulic Modeling

PHABSIM was originally developed and maintained by the United States Fish and Wildlife Service Instream Flow Group (now USGS, Aquatic Systems and Technology Application Group, Fort Collins Science Center, Colorado). PHABSIM calculates a habitat index (referred to as Weighted Usable Area or WUA) based in part on simulation of river depths and velocities from 1-D hydraulic models that represent the river by cross-sections. For this study, the hydraulic and habitat index simulations were derived from the computer program RHABSIM (Riverine Habitat Simulation). RHABSIM is software developed by Thomas R. Payne & Associates (TRPA) that implements the equivalent algorithms of PHABSIM. RHABSIM is an enhancement of many of the original PHABSIM model's component programs and includes expanded input, output, graphic, error-checking, calibration, and interpretation capabilities.

Data collected in the field is entered into a spreadsheet module (FIELDAT) in RHABSIM for each individual transect. After error checking, each transect is brought into a hydraulic simulation module (HYDSIM), which includes several hydraulic modeling options. Hydraulic model calibration involves generating stage-discharge relationships, which are used to predict depth, and examining velocity calculations and distributions at the measured flows and over a range of simulated flows. Simulated velocities can be calculated by regression, by interpolation, or extrapolation based on measured velocities at multiple flows or by calculating velocity using Manning's equation and the velocity measured at a single flow.

3.1.4.1 Stage-Discharge Calibration

Stage-discharge relationships, or rating curves, for most 1-D transects are developed from measured discharge and WSE using either an empirical log/log formula or a channel conveyance method (MANSQ). Under these methods, each transect is treated independently. The log/log method generally needs three sets of stage-discharge measurements and an estimate of stage-at-zero-flow (SZF) for each transect. SZF is the point at which water no longer flows and is the lowest bed elevation of a transect or in the case of a pool the lowest bed elevation (control point) downstream. The quality of the rating curves is evaluated by examination of mean error and slope output from the model. Mean errors of less than 10% is considered acceptable and less than 5% is very good. In general the slope within groups of transects should be similar.

MANSQ only requires a single stage-discharge pair and utilizes Manning's equation and channel shape to determine a rating curve; however, it is generally validated by additional field stage-discharge measurements to determine how Manning's n changes with flow. This modeling method involves an iterative process where a beta coefficient is adjusted until a satisfactory result is obtained. In situations where irregular channel features occur on a cross section, for instance bars or terraces, MANSQ is often better at predicting higher stages than log/log. MANSQ is most often used on riffle or run transects and is generally not considered as effective in establishing a rating curves for transects that have backwater effects from downstream controls, such as pools. It can also be useful as a test and verification of log/log relationships.

Overall the degree of accuracy of rating curves for a group of transects is based on comparable logarithmic line slopes and intercepts, and similar changes in stage elevation between both measured and simulated flows. Water depths are calculated from transect rating curves that give the rise or fall in water surface.

3.1.4.2 Velocity Calibration

The single set of velocities measured at each transect was used to predict individual cell velocities over the range of flows to be modeled. Referred to as the 1-flow method, simulated velocities are based on measured data and a relationship between a fixed hydraulic roughness coefficient (Manning's n) and depth. In some cases, roughness is modified for individual cells if substantial velocity errors are noted at higher or lower simulation flows. Velocity adjustment factors (VAFs) are calculated by the hydraulic model for each simulated flow to account for increase or decrease in water levels and total discharge for each transect relative to the calibration flow. VAFs are examined to detect any significant deviations and determine if velocity distribution remains consistent with changes in stage and total discharge. VAFs also change because the point values of Manning's n change as the flow changes. VAFs in the range of 0.8 to 1.2 at the velocity acquisition flow (calibration flow) are considered acceptable.

3.1.4.3 Target Flows

Target flows are usually set based on the range of flows of interest, range of exceedance levels or project potential. Ideally, controlled flow release from a containment structure is best for acquiring target flows and stable flows. In instances where flow control is nonexistent, obtaining target flows is based on a combination of hydrological record and closely monitoring current flows and weather. For this study, an examination of limited hydrological records was used to establish a field schedule that would potentially allow for a range of flows to be measured. Because flows of interest were at the lower end of the hydrograph, measurements of very high flows were not necessary.

3.1.5 Target Aquatic Species and Life Stages

Fish species collected in the Casino Creek watershed during aquatic baseline surveys in 2009 consisted of Arctic grayling, slimy sculpin and a single burbot (PECG 2011). Arctic grayling and slimy sculpin are also both present in lower Canadian Creek. In addition to these species, round whitefish (*Prosopium cylindraceum*) and Chinook salmon juveniles (*Oncorhynchus tsawytscha*) are known to occur, or have been historically present, in Dip Creek. There are no known suitability criteria for slimy sculpin and this species was not evaluated for this study. As Arctic grayling compose the majority of the species composition within the Casino Creek/Dip Creek watershed, it was chosen as the target species for the study.

3.1.6 Habitat Suitability Criteria

The PHABSIM habitat index is computed by combining the hydraulic model with habitat suitability criteria (HSC). The most commonly used source for Arctic grayling riverine populations is Hubert et al. (1985). HSC for grayling includes depth, velocity for all life stages, substrate (fry and spawning only) and temperature (all life stages). Temperature was not incorporated into the PHABSIM model for this study

based on the assumption it is not a limiting factor during summer flows. Criteria from Hubert et al. (1985) have been used as a basis for habitat compensation planning as recently as 2006 on the Ruby Creek Project near Atlin B.C. (Adanac Moly Corporation, Ruby Creek Molybdenum Project EAC Application, Appendix 11 – Fish Habitat Compensation Plan, July 2006).

Based on suitability criteria categories, substrate was visually assessed and categorized into the following classes:

- Organics/Silt/Mud;
- Fines (<0.2 cm);
- Gravel (0.2 – 6.4 cm);
- Rubble (6.4 – 17.0 cm);
- Cobble (17.0 – 25.6 cm);
- Boulders (>25.6 cm); and
- Bedrock.

Rubble (basically small cobbles) was added as a substrate category based an examination of Arctic grayling life history and habitat use studies in the Northwest Territories (Stewart et al. 2007). They found some investigations that identified this size class as being important to spawning and adults.

There are no known Arctic grayling suitability criteria for cover. However, cover information was collected in the event of additional aquatic species analyses or new information. Cover was visually assessed using the following types:

- Large woody debris (LWD);
- Boulder;
- Bank overhang or ledge;
- Instream vegetation; and
- Overhanging vegetation.

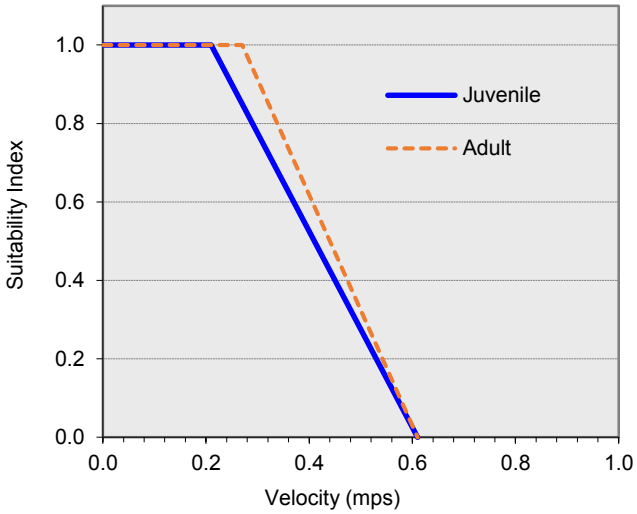
Velocity HSC for adult and juvenile Arctic grayling reported by Hubert et al. (1985) show a maximum suitability up to 0.25 m/s before declining to not suitable above 0.6 m/s (**Figure 2**). This is lower than that reported by Stewart et al. (2007) where typical mean velocity ranged from 0.5 to 1.1 m/s. However, another study reported adult grayling preferred water velocities between 0.2 and 0.45 m/s (Vehanen et al. 2003), similar to values used for this study. Adult and juvenile depths are broken into summer and winter (**Figure 2**). Winter depth suitability is zero below 1.2 m, a function of winter survival in pools that freeze over.

Grayling fry depth and velocity HSC are indicative of most young-of-year salmonids species with highest suitability for low velocities and shallow depths (**Figure 3**). Fry criteria also include a substrate component related to cover elements, with highest suitability for cobble and boulder (**Figure 3**).

Spawning suitability is 0.5 at a velocity of 0.4 m/s and 1.0 between velocities of 0.6 and 0.9 m/s (**Figure 4**). This matches well with an average range of 0.3 – 0.8 m/s reported by Stewart et al. (2007). Depth suitability for spawning is not limited except below 0.3 m (**Figure 4**).

Temperature criteria for spawning are shown for reference purposes on **Figure 5**. The relatively broad range, particularly for incubation, indicates that only under extreme conditions would this variable enter into a flow related habitat estimate.

Velocity (mps)	Juvenile SI	Adult SI
0.00	1.00	1.00
0.21	1.00	1.00
0.27	0.00	1.00
0.61	0.00	0.00
1.00	0.00	0.00
3.05	0.00	0.00



	Juvenile and Adult SI	
Depth (m)	Summer	Winter
0.00	0.00	0.00
0.18	0.00	0.00
0.21	1.00	0.00
1.22	1.00	0.00
1.37	1.00	1.00
2.00	1.00	1.00
9.14	1.00	1.00

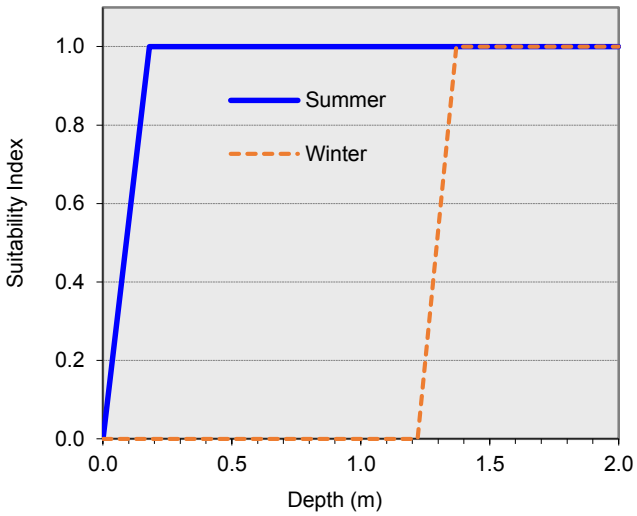
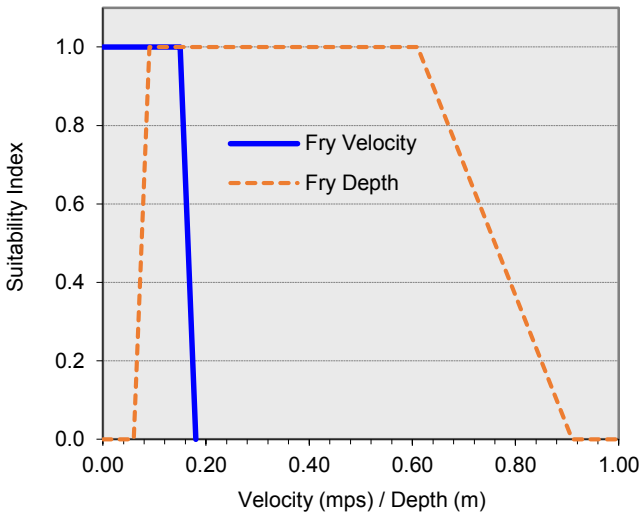


Figure 2. Adult and Juvenile Arctic Grayling HSC Curves – Velocity (Top), Summer and Winter Depth (Bottom).

Meters	Fry Velocity SI (mps)	Fry Depth SI (m)
0.00	1.00	0.00
0.06	1.00	0.00
0.09	1.00	1.00
0.15	1.00	1.00
0.18	0.00	1.00
0.61	0.00	1.00
0.91	0.00	0.00
1.00	0.00	0.00
10.00	0.00	0.00



Substrate	Size Class (cm)	Fry SI
Organics, Mud, Clay	< 0.2	0.50
Silt and Sand	< 0.2	0.50
Gravel	0.2-6.4	0.50
Cobble	6.4-25.6	1.00
Boulder	>25.6	1.00
Bedrock	>25.6	0.50

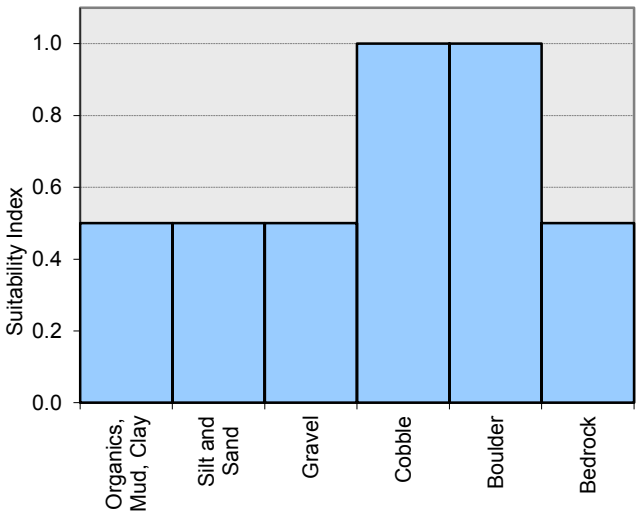
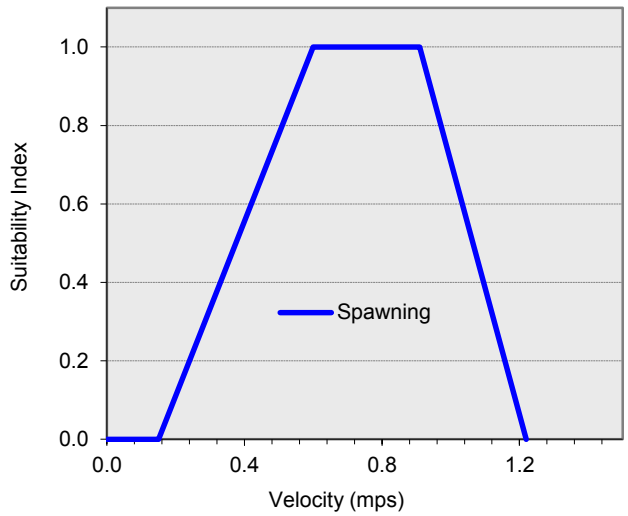


Figure 3. Arctic Grayling Fry HSC Curves – Depth and Velocity (Top), Substrate (Bottom).

Velocity (mps)	Spawning SI
0.00	0.00
0.15	0.00
0.60	1.00
0.91	1.00
1.22	0.00
3.05	0.00



Depth (m)	Spawning SI
0.00	0.00
0.12	0.00
0.30	1.00
2.00	1.00
9.14	1.00

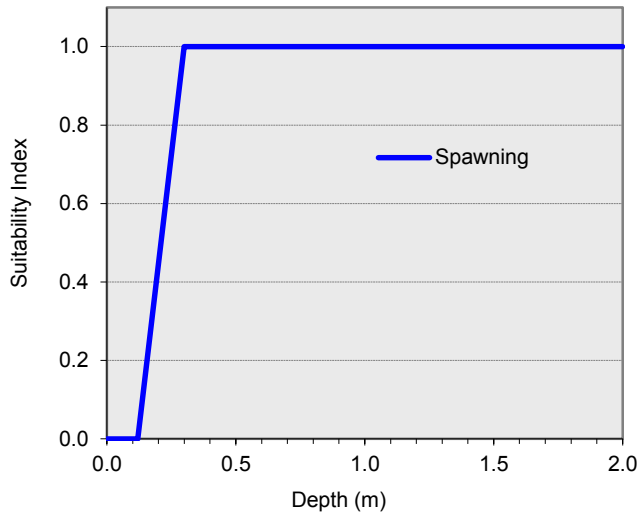
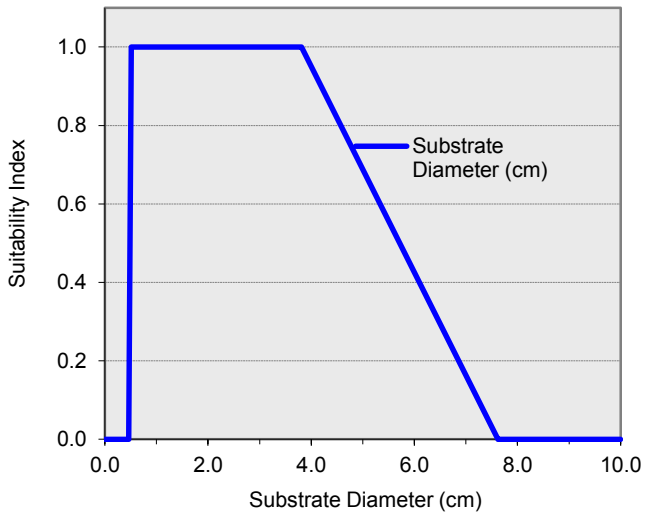


Figure 4. Arctic Grayling Spawning HSC Curves – Velocity (Top), Depth (Bottom).

Substrate Diameter (cm)	Spawning SI
0.00	0.00
0.46	0.00
0.51	1.00
3.81	1.00
7.62	0.00
10.00	0.00



Temperature °C	Spawning SI	Incubation SI
0.0	0.00	0.00
3.9	0.00	0.00
4.4	1.00	0.00
7.8	1.00	1.00
11.1	1.00	1.00
12.8	0.00	1.00
17.2	0.00	1.00
25.0	0.00	0.00

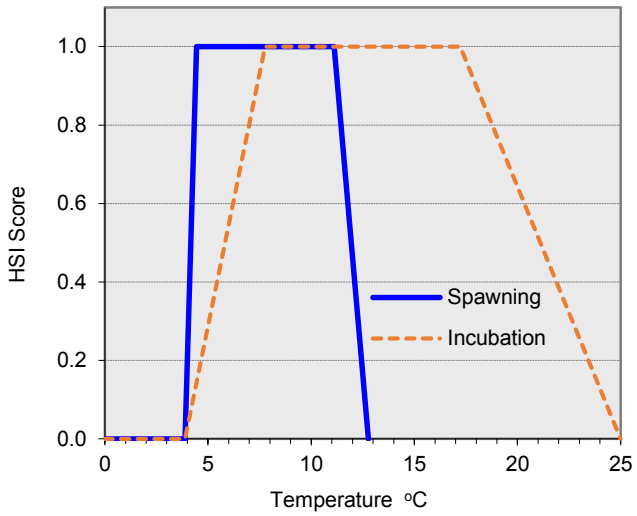


Figure 5. Arctic Grayling Spawning HSC Curves – Substrate (Top), Temperature (Bottom).

3.1.7 Habitat Modeling

The PHABSIM habitat index combines the hydraulic model attributes with HSC curves (**Figures 2** through **5**). Each cell in the calibrated hydraulic model has a predicted depth and water velocity associated with a type of substrate or cover for a particular flow. A fish habitat index is computed for each cell by multiplying the suitability of each variable from the HSC (velocity, depth, substrate, and/or cover) to produce a composite factor. The cell suitability composite index value was computed based on a multiplicative procedure:

$$Ci = Vi * Di * Si$$

Where:

Ci = Cell suitability composite index value
Vi = Velocity suitability value associated with cell
Di = Depth suitability value associated with cell
Si = Substrate or other channel suitability value associated with cell

The cell suitability composite index value is then multiplied by the number of square meters of area in that cell. For each transect, all the cells' areas are summed to produce a total number of square meters of usable habitat available at a specified flow. This result is then multiplied by the percentage (weight) the individual transect represents as a proportion of all transects being modeled (formula below). The final result is the Habitat Index value that represents the sum of all transects given in units of square meters of habitat per 1,000 m of stream length corresponding to each simulated flow.

$$Habitat\ Index\ (WUA) = \sum_{i=1}^{n} Ai * Ci$$

Where:

Ci = Cell suitability index value
Ai = Cell area weighted by transect representation based on 1,000 m stream length

3.1.8 Habitat Time Series Analysis

The amount of habitat available at any given time of year is a function of hydrology, incorporating a time-series analysis provides a more practical view of available habitat. Such an analysis is important when determining effects of different flow regimes that may result from project operations. Times series involves matching the habitat index for a given species or life stage to flow, as illustrated in **Figure 6**. Habitat duration indicates the amount of time habitat remains at certain levels over the range of flows to be evaluated, generally natural flow versus project related flow.

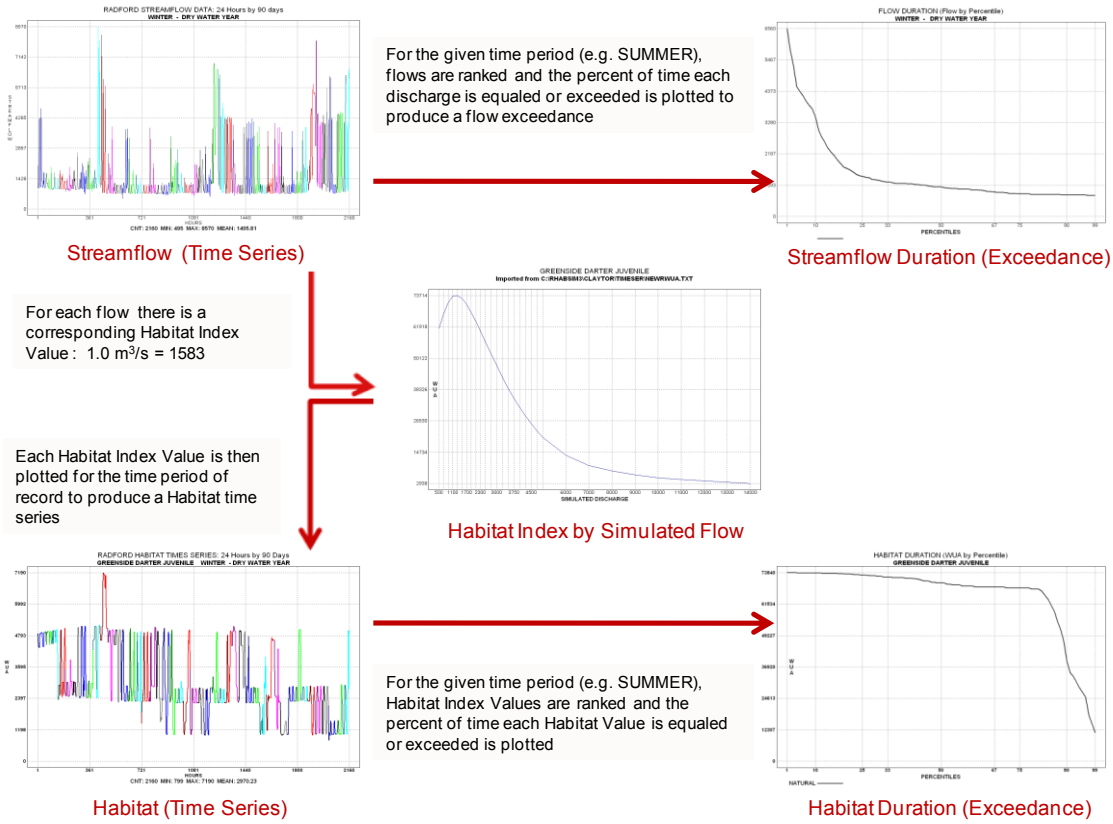


Figure 6. Habitat Time Series Evaluation Flow Chart.

Arctic grayling life stage periodicity, as it applies to the time series analysis, is presented in **Table 2**. The spawning period was limited to the end of June. Juvenile and adult life stages are assumed to occur throughout the ice-free period. Fry are generally considered age 0 until the end of their first year.

Table 2. Arctic grayling Life Stage Periodicity.

Life Stage	May	June	July	Aug	Sept	Oct.
Adult	X	X	X	X	X	X
Juvenile	X	X	X	X	X	X
Fry	X	X	X	X	X	X
Spawning	X	X				

3.2 HEP Study

A Habitat Evaluation Study (HEP) was conducted in Casino Creek upstream of Brynelson Creek in Dip Creek, Meloy Creek and Lower Britannia Creek, to quantify the habitat value of these reaches (**Figure 1**). Measurements were taken along the entire length of each reach and habitat type was recorded, along with the length of each section, average depth, average width, dominant and sub-dominant substrate, cover (type and percent), and maximum pool depth, if any. Additionally, if the habitat unit appeared to be suitable for Arctic grayling spawning, additional information including percent gravel and rubble, percent fines, area of suitable habitat, and estimated velocity were also taken. Similarly to the PHABSIM assessment, Arctic grayling were chosen as the target species for the HEP study.

The value of fish habitat for a HEP Study is evaluated using species specific Habitat Suitability Index (HSI) models. Hubert et al. (1985) provides a detailed description of the HSI model:

> "The HSI model consists of two components: (1) spawning and embryo development; and (2) migratory and wintering habitat for juvenile and adult life stages.
>
> The spawning, embryo and fry development component includes six habitat variables that are believed to govern spawning success and embryo survival of Arctic grayling. Variables V1 and V2 describe water temperature and dissolved oxygen concentrations required, while variables V3 and V4 describe substrate requirements. Variable V5 assesses current velocity and V6 assesses pool availability.
>
> The migratory and winter component uses four habitat variables that probably influence the quality of juvenile and adult habitat. Variables V7 and V8 describe water temperature and dissolved oxygen concentrations needed by these life stages. Variable V9 describes the need for migratory routes between wintering areas and spawning streams, while V10 assesses overwinter habitat quality."

To develop the HSI model, data for each of the variables are derived either from field data or regional information, and the resulting index is multiplied by the water surface area of the affected habitat. Some variables may not be employed depending on their availability or perceived importance to the stream under study. For example, water temperature may not be an issue at any time of the year and therefore would not be applied to the model.

Field survey data were compiled and totaled to provide an un-adjusted estimate of habitat within the potentially affected area. HSI curves were then applied to the data in order to quantify the suitability of the habitat to the target species (i.e., Artic grayling). The total amount of habitat was then recalculated, subtracting areas that the HSI calculations indicated were of no or low value.

The HEP method for Arctic grayling comes with the qualifier that "The model includes physical habitat variables believed important in maintaining viable populations of Arctic grayling. If the model is correctly structured, a high HSI for a habitat would indicate near optimal physical conditions for Arctic grayling and a low HSI would indicate poor habitat conditions. An HSI of zero does not necessarily mean that the species is not present; it does however indicate that the habitat is very poor and the species is likely to be scarce or absent (Hubert et al. 1985). The same qualification can be applied to WUA calculated using

PHABSIM. It is also worth noting that the habitat and population densities in these watersheds are generally low, and a further reduction in poor quality habitat is unlikely to have any effect on the species at the population level.

4 RESULTS

The results of the Fish Habitat Evaluation are presented based on the method used for evaluating the potential loss or change in fish habitat as a result of the Casino Project. Reaches 1 and 4 were evaluated using PHABSIM, and Reaches 2a, 2b and 3 were evaluated using HEP analysis (**Figure 1**). The results of each methodology are discussed separately.

4.1 PHABSIM Study

4.1.1 Habitat Mapping

4.1.1.1 Casino Creek – Reach 1

Habitat mapping of lower Casino Creek (Reach 1), located between Brynelson Creek and Dip Creek (**Figure 1**), was performed on June 8 and 9, 2011 under varying streamflow conditions estimated to range between 0.5 and 1.0 m^3/s. Habitat mapping field data were entered into a spreadsheet to compute habitat unit lengths from GPS coordinates and to summarize the data (**Appendix A**). Run habitat accounted for 36% of habitat mapped, and was the predominate type (**Table 3**); followed by pool (27.5%), low gradient riffle (23.4%), glide (12.4%) and high gradient riffle (0.8%). The total stream length mapped was about 6.5 km.

Table 3. Habitat Type Composition and Percent by Length on Lower Casino Creek (Reach 1).

Habitat Type	Number of Units	Habitat Length (m)	Average Habitat Length (m)	Percent by Length (%)
Pool	112	1783	16	27.5
Glide	30	802	27	12.4
Run	85	2336	27	36.0
Low Gradient Riffle	82	1514	18	23.4
High Gradient Riffle	4	49	12	0.8
Other	0	0	0	0.0

4.1.1.2 Dip Creek – Reach 4

Habitat mapping on Dip Creek, downstream of Casino Creek (Reach 4), was conducted on September 13 and 14, 2011. Mapping and transect selection was conducted by helicopter, in order to obtain general estimates of habitat percentages in the area. Habitat estimates can be found in **Table 4**, below. Once the helicopter survey was completed, specific study sites and transects were established at accessible locations near identified limited habitat units.

Table 4. Habitat Type Composition and Estimated Percent by Length on Dip Creek (Reach 4).

Habitat Type	Estimated Percent by Length (%)
Pool	30
Glide	50
Run	10
Low Gradient Riffle	10

4.1.1.3 Canadian Creek

Habitat mapping on lower Canadian Creek was conducted on May 25, 2013. Mapping and transect selection was conducted by helicopter, in order to obtain general estimates of habitat percentages in the area. Habitat estimates can be found in **Table 5**, below. Once the helicopter survey was completed, transects were established at accessible locations near identified limited habitat units.

Table 5. Habitat Type Composition and Estimated Percent by Length on Canadian Creek.

Habitat Type	Estimated Percent by Length (%)
Low Gradient Riffle	30
Run	30
Pool	20
Glide	20

4.1.2 Study Sites and Transects

4.1.2.1 Casino Creek – Reach 1

Habitat mapping of lower Casino Creek (Reach 1) identified no major differentiation in channel configuration or substrate composition along the mapped length. As a result, the reach was considered uniform and it was therefore, not necessary to segment it into sub-sections. Still, for the purposes of

further, detailed analysis, it was decided to split the mapped 6.5 km reach equally into 3.25 km upper and lower sections.

Using glide habitat as the least available habitat type, one glide unit each in the lower and upper portion of the reach was randomly selected. After a cursory examination of mapping data to ascertain availability of all habitat types near the selected unit, field crews visited the potential sites. Upon confirmation that the selected glide habitat unit was suitable for the PHABSIM model, a transect was established that best represented the habitat type. The crew then continued establishing transects upstream and downstream within the vicinity of the selected habitat unit with the goal to place 10 transects per study site in proportion to predetermined reach representation from habitat mapping results.

Two study sites were established: CAS 1 – in the upper portion of the study reach, 1.5 km downstream of Brynelson Creek, and CAS 2 – in the lower portion of the study reach, 1.9 km upstream of Dip Creek. A total of 20 transects were established, with 10 transects in the upper reach (CAS 1) and 10 transects in the lower reach (CAS 2) (**Table 6**).

Table 6. Lower Casino Creek Transects.

Study Site	Transect ID\WP	Percent Reach Representation (%)	UTM Coordinates	
			Easting	Northing
CAS 1	Run 190	6.1	610531	6950012
	Glide 189	3.1	610536	6950023
	Pool 188	5.5	610524	6950036
	Glide 187A	3.1	610503	6950062
	Pool 187	5.5	610504	6950066
	LGR 185	4.7	610488	6950106
	Run 183	6.1	610186	6950121
	LGR 182	4.7	610516	6950133
	Pool 181	5.5	610517	6950136
	Run 176	6.1	-------	-------
CAS 2	Run 119	6.1	610122	6948172
	Run 121	6.1	610149	6948192
	LGR 347	4.7	610137	6948199
	Pool 346	5.5	610133	6948208
	LGR 345	4.7	610130	6948222
	Glide 344	3.1	610132	6948230
	LGR 343	4.7	610137	6948277
	Pool 342	5.5	610138	6948286
	Glide 341	3.1	610146	6948292
	Run 340	6.1	-------	-------

LGR – Low Gradient Riffle

4.1.2.2 Dip Creek – Reach 4

Similarly to lower Casino Creek, Dip Creek (Reach 4) was also observed to be generally uniform along its length. Based on habitat composition estimates, Low Gradient Riffles (LGR) were determined to be the limiting habitat type. Two suitable transects within LGR Habitat were established, followed by 10 upstream and downstream transects from the selector.

The two study sites in Dip Creek are: Dip 1 – located approximately 1km downstream of the confluence with Casino Creek, and Dip 2 – located a further 1 km downstream. A total of 20 transects were established, with 10 transects in the upper reach (Dip 1) and 10 transects in the lower reach (Dip 2).

The results of the habitat mapping for both Dip 1 and Dip 2 are presented in **Table 7**.

Table 7. Dip Creek Transects.

Study Site	Transect ID\WP	% Reach Representation	UTM Coordinates	
			Easting	Northing
Dip 1	Dip1LGR1	2.5	608851	6946980
	Dip1Run2	2.5	608840	6946974
	Dip1Pool3	5.0	608808	6946998
	Dip1Pool4	5.0	608829	6947045
	Dip1Gld5	8.3	608824	6947052
	Dip1LGR6	2.5	608813	6947076
	Dip1Gld7	8.3	608811	6947158
	Dip1Pool8	5.0	608736	6947212
	Dip1Gld9	8.3	608727	6947217
	Dip1Run10	2.5	608626	6947285
Dip 2	Dip2Gld11	8.3	606528	6946595
	Dip2Pool12	5.0	606523	6946580
	Dip2Run13	2.5	606501	6946568
	Dip2Gld14	8.3	606447	6946610
	Dip2Pool15	5.0	606432	6946615
	Dip2LGR16	2.5	606368	6946512
	Dip2Run17	2.5	606403	6946494
	Dip2LGR18	2.5	606441	6946507
	Dip2Pool19	5.0	606472	6946470
	Dip2Gld20	8.3	606470	6946454

4.1.2.3 Canadian Creek

Twenty (20) transects were selected on Canadian Creek based on proportions of habitat type determined by an aerial flyover. Transects were selected beginning at the existing bridge over Canadian Creek, and

proceeded upstream (**Figure 1**). Transects were all within the lower reach of Canadian Creek, as this is the only section of stream identified as fish bearing (PECG, 2013c). Transect numbers were established in the following proportions based on habitat type (low gradient riffle, 6; run, 6; pool, 4; glide, 4). Each transect was established according to PHABSIM methodology with pins driven into each bank above the high water line to ensure consistent cross section measurements, and to provide secondary benchmarks. Each cross section was visited at three times during the course of the season in order to capture high flow, mid flow and low flow conditions.

The results of transect selection for Canadian Creek are presented in **Table 8**.

Table 8. Canadian Creek Transects.

Study Site	Transect ID\WP	% Reach Representation	UTM Coordinates	
			Easting	Northing
Canadian Ck	CCGLD1	2.0	615977	6966539
	CCRun2	7.0	615960	6966532
	CCPool3	2.0	615936	6966509
	CCLGR4	7.0	615907	6966491
	CCPool5	2.0	615900	6966496
	CCRun6	7.0	615889	6966500
	CCGLD7	2.0	615878	6966465
	CCGLD8	2.0	615883	6966393
	CCLGR9	7.0	615860	6966384
	CCLGR10	7.0	615798	6966363
	CCGLD11	2.0	615791	6966372
	CCRun12	7.0	615672	6966285
	CCPool13	2.0	615670	6966266
	CCLGR14	7.0	615605	6966218
	CCRun15	7.0	615600	6966209
	CCPool16	2.0	615575	6966204
	CCRun17	7.0	615413	6966190
	CCLGR18	7.0	615400	6966190
	CCRun19	7.0	615392	6966143
	CCLGR20	7.0	615384	6966129

4.1.3 Field Data Collection

4.1.3.1 Casino Creek – Reach 1

Field measurements took place in 2011 on June 10-12, September 13 and October 5 at both study sites on Casino Creek (CAS1 and CAS2). During the initial data collection rebar pins were positioned on both banks of each transect. Benchmarks consisting of nails or spikes were driven into stumps or conifers to

serve as fixed reference points for surveying groups of transects during subsequent site visits. A measuring tape attached to the rebar working pins was used to establish stations (points) across each transect for stream channel measurements. Due to unusually high precipitation during the June10-12, 2011 time period, it was anticipated this survey would constitute the highest of the three planned data collection efforts. Therefore, velocities and depths along with WSE and streambed elevation profiles were measured at each transect at this time. Data collection requirements for subsequent site visits on September 13 and October 5, 2011 consisted of WSE at each transect and a single discharge for each group of transects.

On June 10, 2011, at the CAS 1 study site total discharge increased from 0.64 m^3/s to 0.93 m^3/s during measurements of the 6 transects sampled that day (**Table 9**). On June 11, 2011, flow remained steady for the 4 remaining transects at this site, although measured flows were substantially higher than were recorded on the previous day. Overall, during the June high flow sampling event at CAS 1, the measured stream discharge ranged between 0.64-1.18 m^3/s (**Table 9**). During follow up visits to CAS 1 in September and October, 2011, measured discharges were 0.84 m^3/s and 0.44 m^3/s, respectively (**Table 10**).

At the CAS 2 study site, field measurements began on June 11, 2011. During the stream flow measurement at transect 10, a heavy rain caused a rise in stage and increased stream discharge from 1.64 m^3/s (transect 10) to 2.23 m^3/s (transect 7) (**Table 9**). As a result additional data collection was suspended until June 12. Starting the following day at transect 6, a slow decline in discharge was noted during stream discharge measurements that ranged from 1.90-2.14 m^3/s. Overall, during the June high flow sampling event at CAS 2, the measured stream discharge ranged between 1.64-2.23 m^3/s (**Table 9**). During the follow up visits made to CAS 2 in September and October, 2011, measured discharges were 0.91 m^3/s and 0.65 m^3/s, respectively (**Table 10)**.

Table 9. Discharge Measurements and Stage in Lower Casino Creek (Spring 2011).

Study Site	Transect #	Habitat Type Waypoint #	Measured Discharge (m^3/s)	Date (2011)	Stage Change (m)
CAS 1	1	Run 190	1.15	11-June	0
	2	Glide 189	1.13	11-June	0
	3	Pool 188	1.18	11-June	0
	4	Glide 187A	1.15	11-June	Start
	5	Pool 187	0.93	10-June	0
	6	LGR 185	0.83	10-June	0
	7	Run 183	0.84	10-June	0
	8	LGR 182	0.79	10-June	+0.01
	9	Pool 181	0.70	10-June	+0.01
	10	Run 176	0.64	10-June	Start
CAS 2	1	Run 119	1.90	12-June	NA
	2	Run 121	1.92	12-June	-0.03
	3	LGR 347	2.08	12-June	-0.03
	4	Pool 346	2.02	12-June	-0.02
	5	LGR 345	2.11	12-June	-0.01
	6	Glide 344	2.14	12-June	Start
	7	LGR 343	2.23	11-June	+0.04
	8	Pool 342	1.74	11-June	+0.03
	9	Glide 341	1.72	11-June	+0.02
	10	Run 340	1.64	11-June	Start

Table 10. Discharge Measurements and Stage in Lower Casino Creek (Fall 2011).

Study Site	Measurement Location	Measured Discharge (m^3/s)	Date (2011)	Stage Change (m)
CAS 1	Transect 8 - LGR 182	0.84	13-September	0
	Transect 8 -LGR 182	0.44	5-October	0
CAS 2	Transect 6 –Glide 344	0.91	13-September	0
	Transect 10 - Run 340	0.65	5-October	0

4.1.3.2 Dip Creek – Reach 4

The first of three stage-discharge data sets were collected from Dip Creek on September 13 and 14, 2011, at sites DIP 1 and DIP 2 (**Table 11**). During this visit, transects were established with rebar at 20 locations, and benchmarks were created for each transect or group of transects. One discharge

measurement was taken for each group of transects, and water surface elevations were taken at each transect. Water levels were low and no recent precipitation had occurred in the area. Discharges of 2.58 m^3/s and 2.35 m^3/s were recorded at the DIP 1 and DIP 2 sites, respectively.

Additional data were collected on May 25, 2012, and September 5 and 6, 2012 (**Table 12**). The May site visit consisted of WSE at all transects, in addition to two discharge measurements (7.35 m^3/s and 7.09 m^3/s at DIP 1 and DIP 2). The May site visit was timed as closely as possible with the estimated timing of the spring freshet in the area, in order to collect maximum high flow measurements at all sites.

The third site visit occurred during September, 2012. This visit included velocity/depth measurements at each transect as well as measurements of WSE. Recorded discharges were 2.39 m^3/s and 2.40 m^3/s at DIP 1 and DIP 2, respectively. Despite low flows in Dip Creek, pool depth continued to provide a challenge to accurate data collection. An inflatable float tube was used to assist in obtaining measurements in the deeper pools.

Table 11. Discharge Measurements and Stage in Dip Creek (Summer 2012).

Study Site	Transect #	Habitat Type Transect #	Measured Discharge (m^3/s)	Date (2011)	Stage Change (m)
DIP 1	1	Dip1LGR1	3.11	5-Sep	0
	2	Dip1Run2	3.13	5-Sep	0
	3	Dip1Pool3	2.87	5-Sep	0
	4	Dip1Pool4	2.36	6-Sep	0
	5	Dip1Gld5	2.39	6-Sep	0
	6	Dip1LGR6	3.27	6-Sep	0
	7	Dip1Gld7	2.65	6-Sep	0
	8	Dip1Pool8	2.46	6-Sep	0
	9	Dip1Gld9	2.57	6-Sep	0
	10	Dip1Run10	2.61	6-Sep	0
DIP 2	1	Dip2Gld11	2.41	7-Sep	0
	2	Dip2Pool12	2.52	7-Sep	0
	3	Dip2Run13	2.51	7-Sep	0
	4	Dip2Gld14	2.40	7-Sep	0
	5	Dip2Pool15	2.31	7-Sep	0
	6	Dip2LGR16	2.38	7-Sep	0
	7	Dip2Run17	2.36	7-Sep	0
	8	Dip2LGR18	2.31	7-Sep	0
	9	Dip2Pool19	2.51	7-Sep	0
	10	Dip2Gld20	2.26	7-Sep	0

Table 12. Discharge Measurements and Stage in Dip Creek (Fall 2011 & Spring 2012).

Study Site	Measurement Location	Measured Discharge (m^3/s)	Date	Stage Change (m)
DIP 1	Transect 5 – DIP1 Gld5	2.58	13-September, 2011	0
	Transect 5 – DIP1 Gld5	7.35	25-May, 2012	0
DIP 2	Transect 4 –DIP2 Gld14	2.35	14-September, 2011	0
	Transect 4 –DIP2 Gld14	7.09	25-May, 2012	0

4.1.3.3 Canadian Creek

High flow sampling occurred between May 25 and 27, 2013, after the cross sections were first established. During this event, water elevations were surveyed using a level and stadia rod and elevations were tied to a nearby established benchmark. Discharge measurements were taken at each of the 20 cross sections (**Table 13**).

Table 13. Lower Canadian Creek Discharge Measurements (High Flow Condition).

Study Site	Transect #	Habitat Type Waypoint #	Measured Discharge (m^3/s)	Date (2013)
Canadian Creek	1	CC Glide 1	3.12	May 25
	2	CC Run 2	3.27	May 25
	3	CC Pool 3	3.59	May 25
	4	CC LGR 4	3.55	May 26
	5	CC Pool 5	1.63	May 26
	6	CC Run 6	3.15	May 26
	7	CC Glide 7	2.57	May 26
	8	CC Glide 8	3.48	May 26
	9	CC LGR 9	1.21	May 26
	10	CC LGR 10	4.00	May 26
	11	CC Glide 11	4.17	May 26
	12	CC Run 12	3.94	May 26
	13	CC Pool 13	NA	May 26
	14	CC LGR 14	3.92	May 27
	15	CC Run 15	3.37	May 27
	16	CC Pool 16	4.16	May 27
	17	CC Run 17	3.45	May 27
	18	CC LGR 18	4.76	May 27
	19	CC Run 19	3.75	May 27
	20	CCLGR 20	3.73	May 27

Table 14. Lower Canadian Creek Discharge Measurements (Low and Mid Flow Conditions)

Study Site	Transect #	Habitat Type Waypoint #	Measured Discharge (m3/s)	Date (2013)
Canadian Creek	7	CC Glide 7	0.38	June 18 (Low Flow)
	7	CC Glide 7	0.66	July 4 (Mid Flow)

During each of the remaining two visits, conducted on June 18 and July 4, 2013 to capture mid and low flow conditions, a single discharge measurement was taken at a representative cross section, (**Table 14**) and water surface elevations were taken at each transect . Discharge measurements are taken at all locations during setup of the study, in order to obtain calibration data, and multiple point velocities at each cross section. During subsequent visits, it is only necessary to take one representative flow at the best cross section, in order to determine discharge for the study site.

Following sampling, velocities and habitat data was entered into the RHABSIM (Riverine Habitat Simulation) model for analysis. Time series analysis was conducted using the SEFA (System for Environmental Flow Analysis) model as it allowed for more efficient processing of the time series data.

4.1.4 Hydraulic Modeling

Hydraulic modeling for PHABSIM analysis involves constructing stage-discharge rating curves and calibration of velocity distributions for each transect. This is done in the HYDSIM component of RHABSIM. The measured stage-discharge pairs are referred to as calibration flows. For each simulated flow. WSE is calculated from the stage-discharge rating curve and water depths are calculated from the WSE and bed elevation. Velocities are simulated and an associated roughness coefficient (Manning's n) generated by the hydraulic model. Hydraulic model calibration details may be found in Appendix C.

4.1.4.1 Stage-Discharge

Developing stage-discharge rating curves is based on the assumption that no change in bottom profile occurs between calibration flow measurements. Casino Creek experienced several precipitation events during the summer of 2011, some of which produced bank full and over-the-bank flows. One effect of these high flows was bedload movement and consequently bottom profile changes on a number of transects. Bottom profile alteration can alter WSE controls (e.g. by scouring at pool tails, sediment deposition in riffles), and this can result in poor cross section rating curves, and consequently poor predictions of depth and velocity.

Water levels dropped as expected between the high and middle measured calibration flows for most transects at all three study sites (**Tables 15 to 19)**. Exceptions are found in the CAS 1 study site for transects 6-8, where high and middle measured calibration flows were virtually identical, but stages were not (**Table 15**). Of the 10 transects in the CAS 1 study site, 8 had higher stages at the lowest flow versus the middle flow. This indicates substantial bed aggradation occurred between site visits, raising the stream bed and as a result the water surface. Changes in stage were much more consistent at the CAS 2 study site with the exception of transects 8-10 (**Table 16**).

Dip Creek low and middle flow discharge and water surface levels were nearly identical at both study sites (**Tables 17** and **18**). Unlike Casino Creek there were no significant bed profile changes between site visits.

Stage dropped as expected between high, middle and low calibration flows at Canadian Creek. No issues with bedload movement were experienced (**Table 19**).

Table 15. Stage Discharge Calibration at CAS 1 on Lower Casino Creek

CAS 1 Study Site					Change in Stage Between Calibration Flows	
Transect #	**Habitat Type Waypoint #**	**Calibration Flow #**	**Calibration Flow (m^3/s)**	**Stage (m)**	**Flow #1 – Flow #2, #3**	**Flow #2 – Flow #3**
		1	1.15	98.565	------	------
1	Run 190	2	0.84	98.536	-0.029	------
		3	0.44	98.547	-0.018	0.011
		1	1.15	98.678	------	------
2	Glide 189	2	0.84	98.609	-0.069	------
		3	0.44	98.623	-0.055	0.014
		1	1.15	98.691	------	------
3	Pool 188	2	0.84	98.620	-0.071	------
		3	0.44	98.629	-0.062	0.009
		1	1.15	98.913	------	------
4	Glide 187A	2	0.84	98.872	-0.041	------
		3	0.44	98.874	-0.039	0.002
		1	0.90	98.890	------	------
5	Pool 187	2	0.84	98.874	-0.016	------
		3	0.44	98.873	-0.017	-0.001
		1	0.82	98.575	------	------
6	LGR 185	2	0.84	98.532	-0.043	------
		3	0.44	98.561	-0.014	0.029
		1	0.82	98.697	------	------
7	Run 183	2	0.84	98.768	0.071	------
		3	0.44	98.848	0.151	0.080
		1	0.82	98.738	------	------
8	LGR 182	2	0.84	98.788	0.050	------
		3	0.44	98.869	0.131	0.081
		1	0.70	98.870	------	------
9	Pool 181	2	0.84	98.889	0.019	------
		3	0.44	98.933	0.063	0.044
		1	0.64	98.590	------	------
10	Run 176	2	0.84	98.661	0.071	------
		3	0.44	98.644	0.054	-0.017

Table 16. Stage Discharge Calibration at CAS 2 on Lower Casino Creek

CAS 2 Study Site					Change in Stage Between Calibration Flows	
Transect #	**Habitat Type Waypoint #**	**Calibration Flow #**	**Calibration Flow (m^3/s)**	**Stage (m)**	**Flow #1 – Flow #2, #3**	**Flow #2 – Flow #3**
		1	1.91	98.742	------	------
1	Run 119	2	0.91	98.564	-0.178	------
		3	0.65	98.544	-0.198	-0.020
		1	1.91	98.929	------	------
2	Run 121	2	0.91	98.740	-0.189	------
		3	0.65	98.735	-0.194	-0.005
		1	2.07	98.989	------	------
3	LGR 347	2	0.91	98.831	-0.158	------
		3	0.65	98.814	-0.175	-0.017
		1	2.07	99.084	------	------
4	Pool 346	2	0.91	98.950	-0.134	------
		3	0.65	98.973	-0.111	0.023
		1	2.07	98.595	------	------
5	LGR 345	2	0.91	98.460	-0.135	------
		3	0.65	98.453	-0.142	-0.007
		1	2.14	98.684	------	------
6	Glide 344	2	0.91	98.549	-0.135	------
		3	0.65	98.514	-0.170	-0.035
		1	2.23	99.219	------	------
7	LGR 343	2	0.91	99.134	-0.085	------
		3	0.65	99.105	-0.114	-0.029
		1	1.73	99.250	------	------
8	Pool 342	2	0.91	99.202	-0.048	------
		3	0.65	99.244	-0.006	0.042
		1	1.73	99.253	------	------
9	Glide 341	2	0.91	99.220	-0.033	------
		3	0.65	99.244	-0.009	0.024
		1	1.64	99.247	------	------
10	Run 340	2	0.91	99.239	-0.008	------
		3	0.65	99.244	-0.003	0.005

Table 17. Stage Discharge Calibration at DIP 1 on Dip Creek

DIP1 Study Site					Change in Stage Between Calibration Flows	
Transect #	**Habitat Type Waypoint #**	**Calibration Flow #**	**Calibration Flow (m^3/s)**	**Stage (m)**	**Flow #1 – Flow #2, #3**	**Flow #2 – Flow #3**
		1	2.58	98.840	------	------
1	Dip1LGR1	2	2.49	98.839	-0.001	------
		3	7.35	99.089	0.249	0.250
		1	2.58	98.745	------	------
2	Dip1Run2	2	2.49	98.713	-0.032	------
		3	7.35	98.987	0.242	0.274
		1	2.58	98.700	------	------
3	Dip1Pool3	2	2.49	98.683	-0.027	------
		3	7.35	98.945	0.245	0.262
		1	2.58	98.488	------	------
4	Dip1Pool4	2	2.49	98.487	-0.001	------
		3	7.35	98.682	0.194	0.195
		1	2.58	98.481	------	------
5	Dip1Gld5	2	2.49	98.483	0.002	------
		3	7.35	98.679	0.198	0.196
		1	2.58	98.432	------	------
6	Dip1LGR6	2	2.49	98.425	-0.007	------
		3	7.35	98.589	0.157	0.164
		1	2.58	97.993	------	------
7	Dip1Gld7	2	2.49	97.994	0.001	------
		3	7.35	98.298	0.305	0.304
		1	2.58	97.853	------	------
8	Dip1Pool8	2	2.49	97.856	0.003	------
		3	7.35	98.195	0.342	0..339
		1	2.58	97.852	------	------
9	Dip1Gld9	2	2.49	97.854	0.002	------
		3	7.35	98.173	0.321	0.319
		1	2.58	97.801	------	------
10	Dip1Run10	2	2.49	97.786	0.015	------
		3	7.35	98.009	0.208	0.213

Table 18. Stage Discharge Calibration at DIP 2 on Dip Creek

DIP 2 Study Site					Change in Stage Between Calibration Flows	
Transect #	**Habitat Type Waypoint #**	**Calibration Flow #**	**Calibration Flow (m^3/s)**	**Stage (m)**	**Flow #1 – Flow #2, #3**	**Flow #2 – Flow #3**
		1	2.35	92.600	------	------
1	Dip2Gld11	2	2.33	92.626	0.026	------
		3	7.09	93.027	0.427	0.401
		1	2.35	92.550	------	------
2	Dip2Pool12	2	2.33	92.599	0.044	------
		3	7.09	92.989	0.439	0.390
		1	2.35	92.520	------	------
3	Dip2Run13	2	2.33	92.556	0.036	------
		3	7.09	92.918	0.398	0.362
		1	2.35	92.430	------	------
4	Dip2Gld14	2	2.33	92.427	-0.003	------
		3	7.09	92.718	0.288	0.291
		1	2.35	92.380	------	------
5	Dip2Pool15	2	2.33	92.393	0.013	------
		3	7.09	92.665	0.285	0.272
		1	2.35	92.260	------	------
6	Dip2LGR16	2	2.33	92.304	0.044	------
		3	7.09	92.492	0.232	0.188
		1	2.35	92.190	------	------
7	Dip2Run17	2	2.33	92.304	0.114	------
		3	7.09	92.424	0.234	0.120
		1	2.35	92.110	------	------
8	Dip2LGR18	2	2.33	92.115	0.005	------
		3	7.09	92.419	0.309	0.304
		1	2.35	92.080	------	------
9	Dip2Pool19	2	2.33	92.091	0.011	------
		3	7.09	92.384	0.304	0.293
		1	2.35	91.990	------	------
10	Dip2Gld20	2	2.33	91.993	0.003	------
		3	7.09	92.276	0.286	0.283

Table 19. Stage Discharge Calibration for Canadian Creek

Canadian Creek Study Site					Change in Stage Between Calibration Flows	
Transect #	**Habitat Type Waypoint #**	**Calibration Flow #**	**Calibration Flow (m^3/s)**	**Stage (m)**	**Flow #1 – Flow #2, #3**	**Flow #2 – Flow #3**
		1	3.29	98.879	------	------
1	CC Glide 1	2	0.38	98.604	0.275	------
		3	0.66	98.675	0.204	-0.071
		1	3.29	99.017	------	------
2	CC Run 2	2	0.38	98.743	0.274	------
		3	0.66	98.792	0.225	-0.049
		1	3.29	100.035	------	------
3	CC Pool 3	2	0..38	99.648	0.387	------
		3	0.66	99.704	0.331	-0.056
		1	3.29	101.460	------	------
4	CC LGR 4	2	0.38	101.292	0.168	------
		3	0.66	101.334	0.126	-0.042
		1	3.29	101.660	------	------
5	CC Pool 5	2	0.38	101.351	0.309	------
		3	0.66	101.407	0.253	-0.056
		1	3.29	101.890	------	------
6	CC Run 6	2	0.38	101.570	0.32	------
		3	0.66	101.654	0.236	-0.084
		1	3.29	102.094	------	------
7	CC Glide 7	2	0.38	101.942	0.152	------
		3	0.66	101.983	0.111	-0.041
		1	3.29	102.933	------	------
8	CC Glide 8	2	0.38	102.636	0.297	------
		3	0.66	102.694	0.239	-0.058
		1	3.29	103.106	------	------
9	CC LGR 9	2	0.38	102.888	0.218	------
		3	0.66	102.896	0.21	-0.008
		1	3.29	103.378	------	------
10	CC LGR 10	2	0.38	103.108	0.27	------
		3	0.66	103.160	0.218	-0.052
		1	3.29	103.579	------	------
11	CC Glide 11	2	0.38	103.251	0.328	------
		3	0.66	103.315	0.264	-0.064
		1	3.29	105.014	------	------
12	CC Run 12	2	0.38	104.663	0.351	------
		3	0.66	104.716	0.298	-0.053

		1	3.29	105.476	------	------
13	CC LGR 14	2	0.38	105.218	0.258	------
		3	0.66	105.261	0.215	-0.043
		1	3.29	105.886	------	------
14	CC Run 15	2	0.38	105.440	0.446	------
		3	0.66	105.502	0.384	-0.062
		1	3.29	106.201	------	------
15	CC Pool 16	2	0.38	105.967	0.234	------
		3	0.66	105.838	0.363	0.129
		1	3.29	106.637	------	------
16	CC Run 17	2	0.38	106.237	0.4	------
		3	0.66	106.278	0.359	-0.041
		1	3.29	106.801	------	------
17	CC LGR 18	2	0.38	106.518	0.283	------
		3	0.66	106.584	0.217	-0.066
		1	3.29	108.274	------	------
18	CC Run 19	2	0.38	107.892	0.382	------
		3	0.66	107.956	0.318	-0.064
		1	3.29	108.492	------	------
19	CC LGR 20	2	0.38	108.210	0.282	------
		3	0.66	108.253	0.239	-0.043

Each study site was examined and calibrated separately to establish individual transect stage-discharge relationships. Working with specific sites permitted examination of relationships between transects tied to common benchmark elevations, allowing general modeling errors to be detected. Grouped transects also assist in determination of SZF, by comparing thalweg elevations and plotting stages between transects.

Log/log rating curves could not be established for any transects in the CAS 1 study site and for only a few of transects in the CAS 2 study site. Except for transect #7 (LGR 343) in the CAS 1 study site, all stage-discharge rating curves were established using the MANSQ channel conveyance method.

MANSQ, rating curves were calculated based on the measured calibration and velocity acquisition flow, generally the highest flow for each transect, as a beginning point. Because only one stage-discharge pair was used in the model calibration, beta coefficients that show how Manning's n changes with flow are required. For the CAS 2 study site, log/log relationships for two transects, Glide 344 and LGR 343, were used initially. Because there were no transects in the CAS 1 study site that could be used for validation or comparison, an alternative was to evaluate rating curves using established stream gauge rating curves. As documented in "Western Copper Corporation Casino Copper-Gold Project. 2010 Hydrometric Data Collection Summary Report" (Knight Piesold 2011) site W4 in lower Casino Creek and site H18 in middle Casino Creek had established stage-discharge curves suitable for validation of MANSQ results. By plotting changes in stage versus calibration flows for the gauges and transects it was confirmed that the final rating curves for CAS 1 and CAS 2 were appropriate (**Figure 7**). Differences in slope of the curves is mostly attributed to channel width of individual transects. For example, the channel is narrower

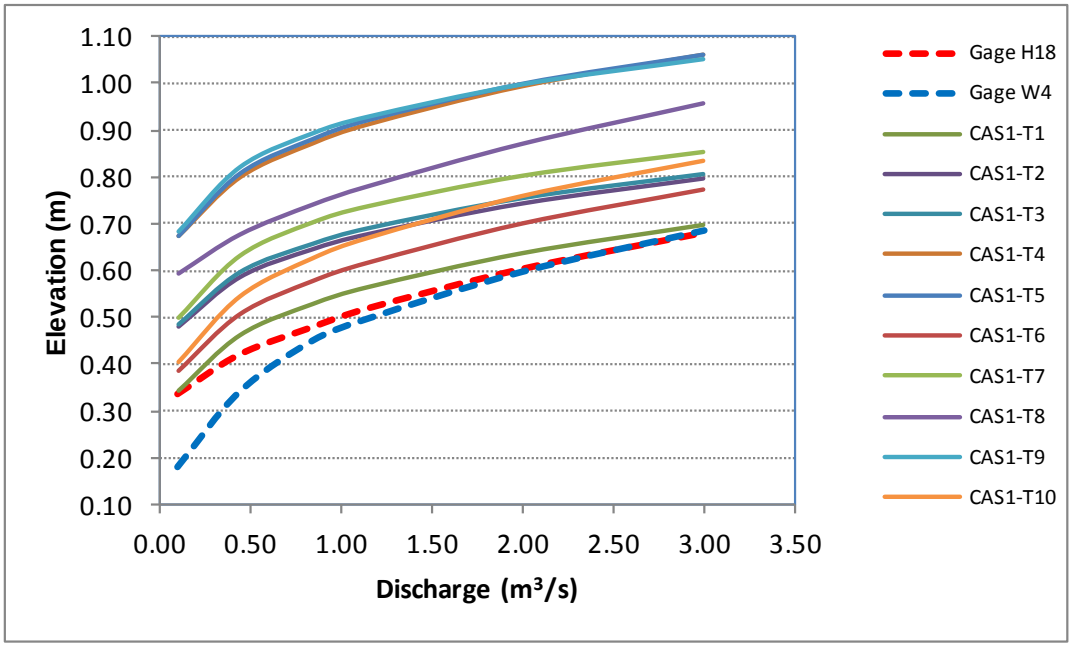
at the W4 gauge versus the H18 gauge, which results in a steeper rating curve for the W4 gauge due to water level increasing more rapidly in a narrow channel compared to a wide channel.

An additional validation check was to examine longitudinal WSE profile plots to detect obvious issues with simulated WSEs between groups of transects, such as water flow uphill and degree of separation between simulated flows.

For transects in Dip Creek (DIP 1 and DIP 2), log/log rating curves were used for all stage-discharge relationships (**Figure 8**). Since these ratings were based on essentially two data points, low/middle and high, it was important to verify the curves were accurate. This was accomplished by comparing each transects rating curve to those produced by the MANSQ channel conveyance method, and examining longitudinal simulated WSE plots. Resulting rating curve comparisons, which also includes the gage in Upper Casino Creek (W9), showed little difference and longitudinal WSE plots revealed a consistent variation between transects, indicating adequate hydraulic ratings.

4.1.4.2 Velocity Calibration

Velocity simulation was evaluated based on examination of (VAF's) and reasonableness of individual cell velocities over the range of flows being simulated. Point Manning n adjustments to individual cells were kept to a minimum and when applied were made primarily to edge cells. VAFs are considered excellent if they are near 1.0, and good if they fall between 0.8 and 1.2 at the velocity calibration flow. The range of VAF's is a function of the degree in which velocities are adjusted by the model so that the calculated discharge matches each simulation flow. VAFS also adjust for changes in manning n. As Manning n changes more in runs and riffles than in pools. Fast water transects such as riffles and runs generally require more velocity adjustment than deep slow transects such as pools. Final VAF's were within acceptable ranges and are presented for Casino Creek and Dip Creek on **Figures 9 and 10.**



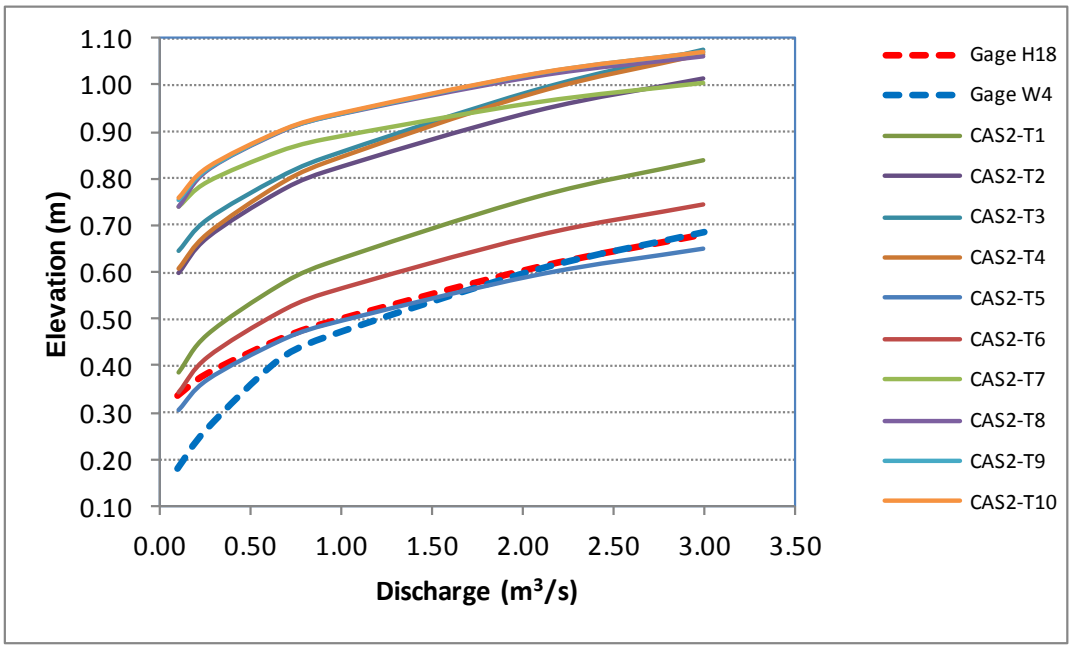
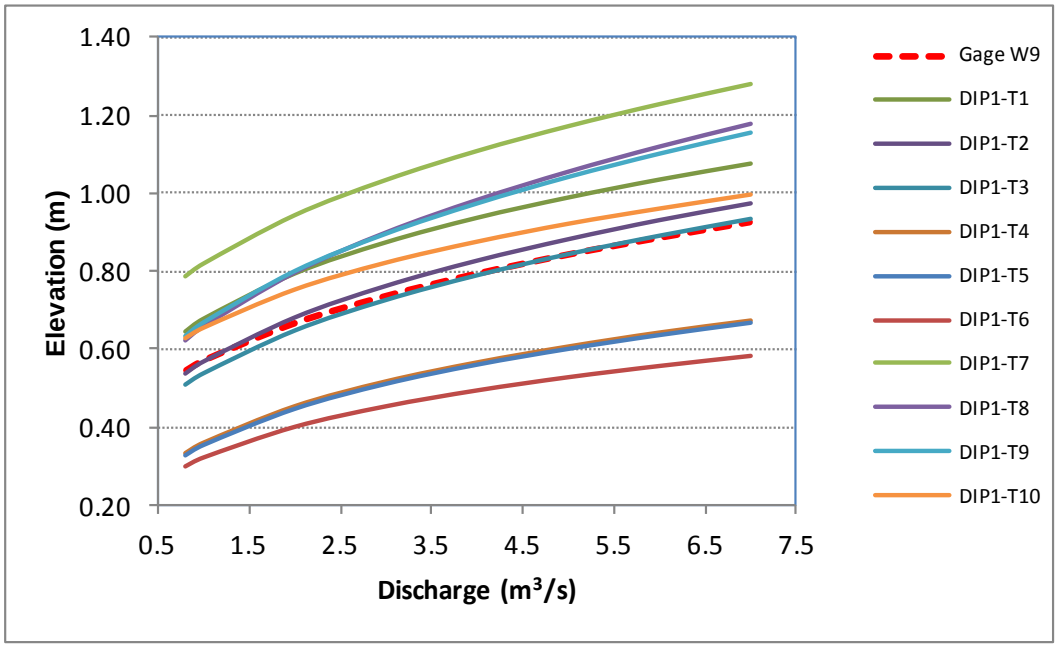


Figure 7. Rating Curves for Transects CAS 1 (Top) and CAS 2 (Bottom) in Lower Casino Creek



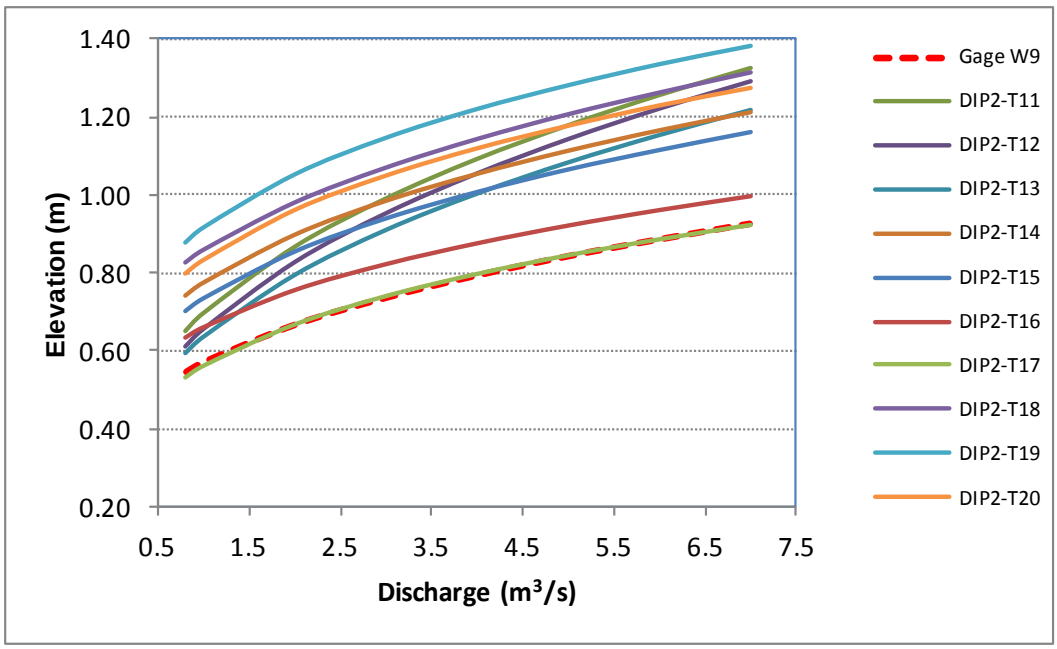


Figure 8. Rating Curves for Transects DIP 1 (Top) and DIP 2 (Bottom) in Dip Creek

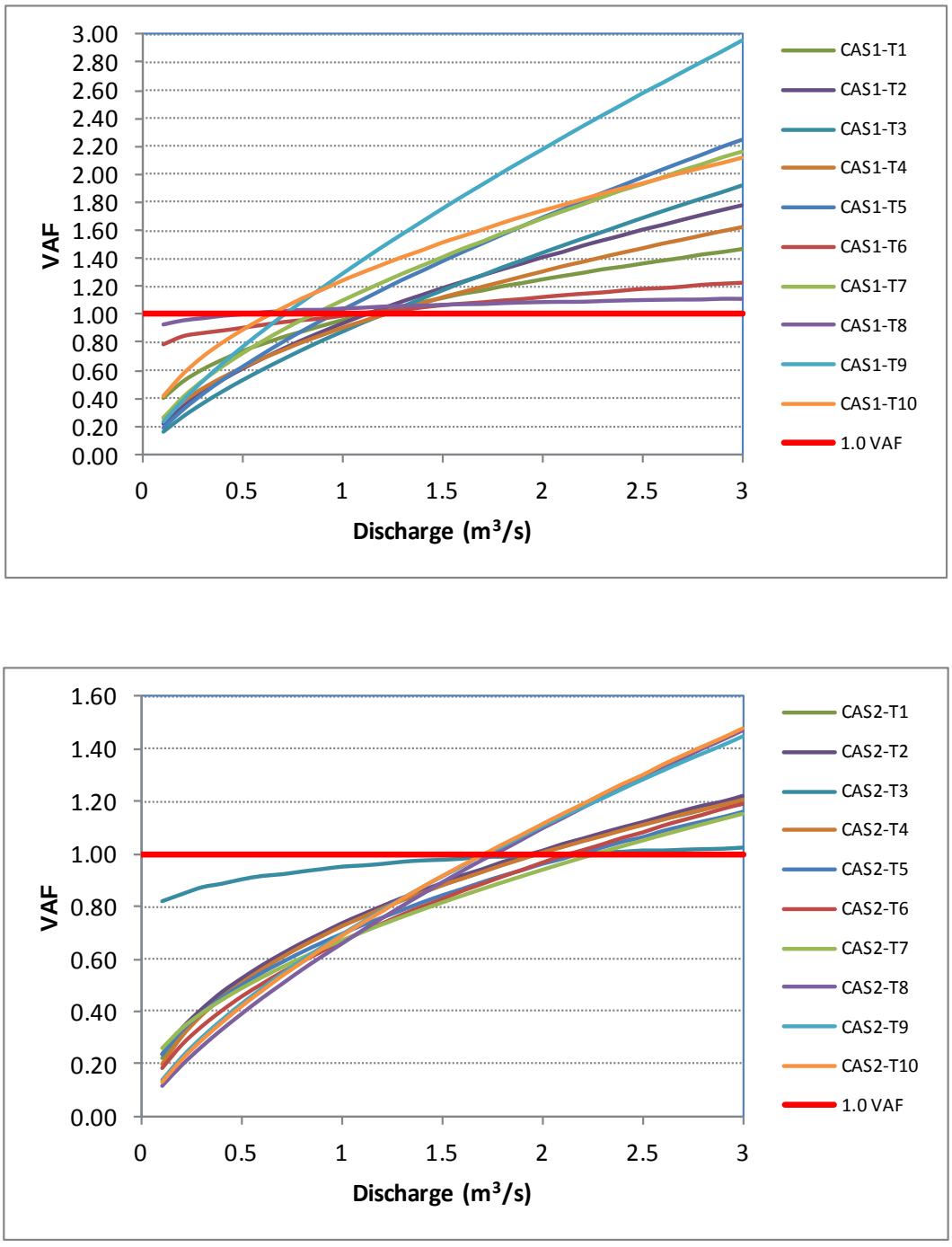
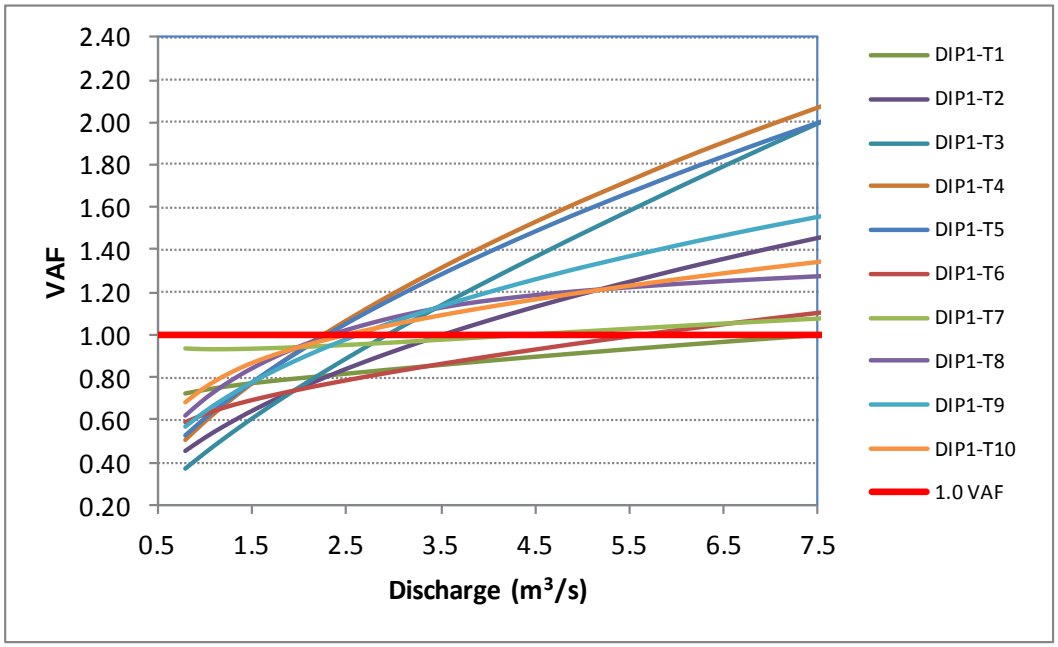


Figure 9. Velocity Adjustment Factors for CAS 1 (Top) and CAS 2 (Bottom) in Lower Casino Creek



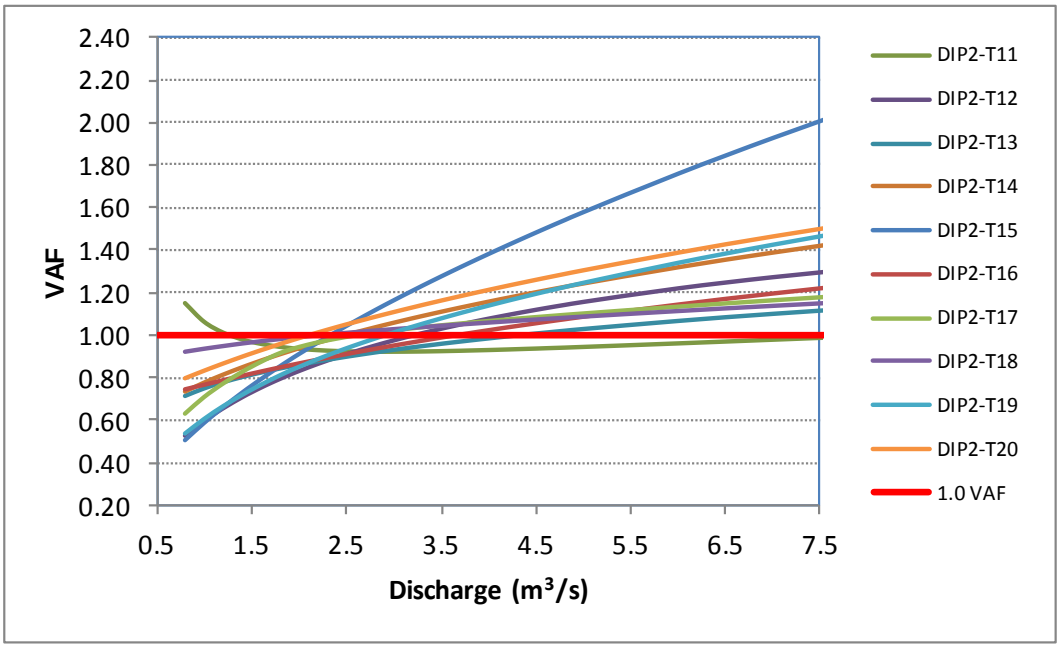


Figure 10. Velocity Adjustment Factors for DIP 1 (Top) and DIP 2 (Bottom) in Dip Creek

4.1.5 Habitat Modeling Results

Usable fish habitat is calculated by combining predicted depths and velocities from the hydraulic model with suitability criteria for individual fish species and life stages using the HABSIM module of RHABSIM. To produce a composite habitat index (presented as square meters of habitat per 1,000 m of stream), results from individual transects are combined based on amount of stream each transect represents. For this study transects were "weighted" based on the proportion of the corresponding habitat type within the study reach (refer to **Tables 3 to 5**).

Habitat index results for all life stages of Arctic grayling reflect characteristics of the HSC, particularly velocity. Lower velocities have the highest suitability for all life stages but spawning. The shape of the curves is a response to overall lower velocities at low flows. As flow increases, velocities in the middle of the channel become unsuitable and the amount of usable area is reduced to the margins, as long as depth is sufficient.

Within Casino Creek, adult and juvenile Arctic grayling show the most amount of habitat at flows below 1.0 m^3/s, and this is because of preference for low velocities that occur at low flows (**Figure 11** and **Table 20**). Adult and juvenile rearing curves climb slightly with increased discharge, before falling as flows continue to increase, due to increasing channel velocities. In addition, **Figure 11** shows that Arctic grayling spawning habitat has a large range of highly suitable flows between 0.6 and 2.0 m^3/s. Arctic grayling fry habitat index curve falls abruptly as flows increase before flattening out. The flat portion of the curve indicates the amount of habitat stays constant, mainly along the banks, with increased flow.

The habitat index was also simulated for winter flow values for adult and juvenile Arctic grayling (results shown in **Table 20** and not graphed). The results indicate there is very little winter habitat available in Casino Creek for adult and juvenile Arctic grayling due to lack of adequate pool depth.

Within Dip Creek, adult and juvenile Arctic grayling show the most amount of habitat at flows below 4.0 m^3/s (**Figure 12** and **Table 21**). Spawning habitat for Arctic grayling is primarily found at flows between 1.5 and 5.0 m^3/s. Fry habitat stays relatively constant over the range of flows and increases slightly under higher flow conditions due to increased available habitat.

Similarly to Casino Creek, the habitat index in Dip Creek was also simulated based on winter depths for adult and juvenile Arctic grayling. **Table 21** provides a summary of winter habitat index values for Arctic grayling in Dip Creek and shows that little winter habitat available in Dip Creek.

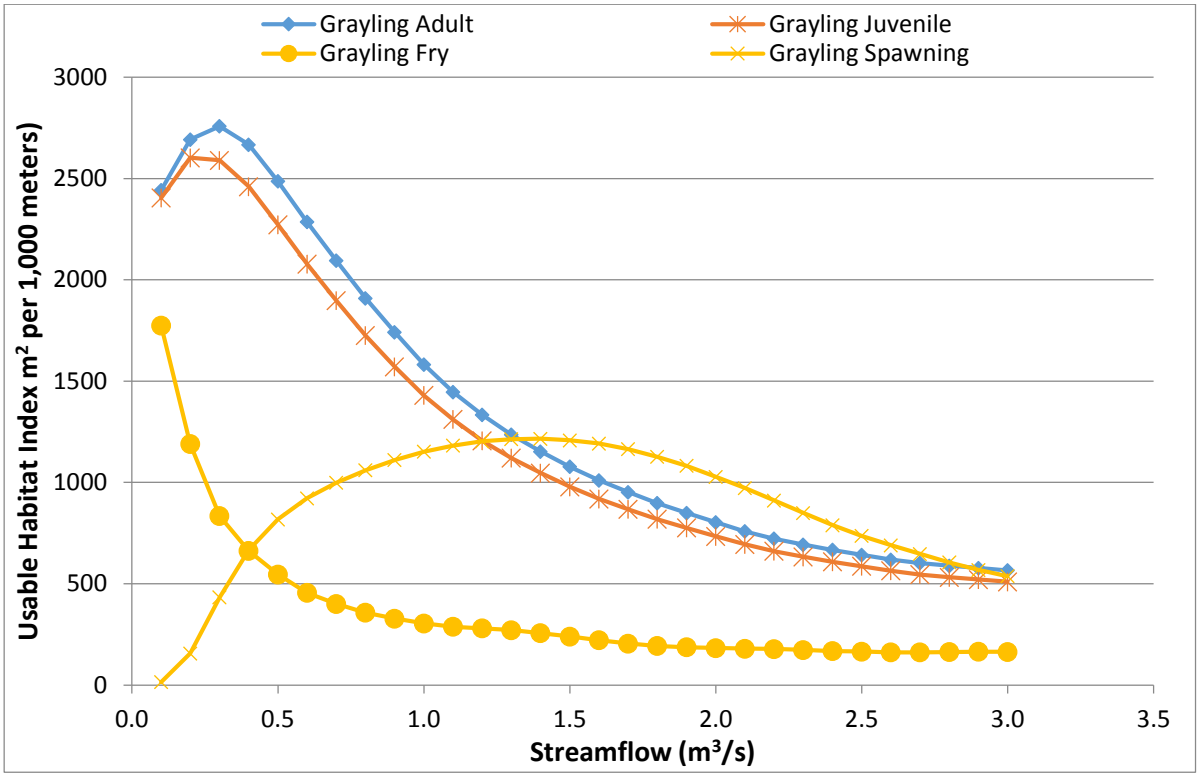


Figure 11. Usable Habitat Index vs. Streamflow for Arctic grayling in Casino Creek

Table 20. Usable Habitat Index Values vs. Streamflow for Arctic grayling in Lower Casino Creek

Flow (m^3/s)	Usable Habitat Index Values					
	Adult Summer	Juvenile Summer	Fry	Spawning	*Adult Winter*	*Juvenile Winter*
0.1	2443	2404	1775	15	0.0	0.0
0.2	2693	2603	1190	156	0.0	0.0
0.3	2758	2590	835	433	0.0	0.0
0.4	2668	2460	662	667	0.0	0.0
0.5	2487	2273	546	818	0.0	0.0
0.6	2286	2079	455	922	0.0	0.0
0.7	2096	1899	401	999	0.0	0.0
0.8	1910	1726	358	1060	0.0	0.0
0.9	1742	1571	329	1111	0.0	0.0
1.0	1583	1430	304	1152	0.0	0.0
1.1	1446	1311	288	1182	0.0	0.0
1.2	1333	1206	280	1203	0.0	0.0
1.3	1235	1121	271	1214	0.0	0.0
1.4	1153	1047	256	1216	0.0	0.0
1.5	1078	979	240	1208	0.0	0.0
1.6	1011	919	222	1192	0.2	0.2
1.7	952	868	205	1164	0.9	0.8
1.8	897	819	193	1127	1.5	1.2
1.9	850	776	187	1082	1.9	1.6
2.0	803	734	183	1028	2.3	2.0
2.1	758	695	180	973	2.7	2.3
2.2	723	661	178	911	2.9	2.5
2.3	693	633	173	850	3.0	2.6
2.4	667	609	168	789	3.0	2.6
2.5	642	587	166	737	2.9	2.5
2.6	619	564	162	690	2.9	2.4
2.7	603	546	162	647	2.7	2.3
2.8	589	532	163	605	2.5	2.2
2.9	578	521	165	568	2.3	2.0
3.0	566	510	164	538	2.0	1.7

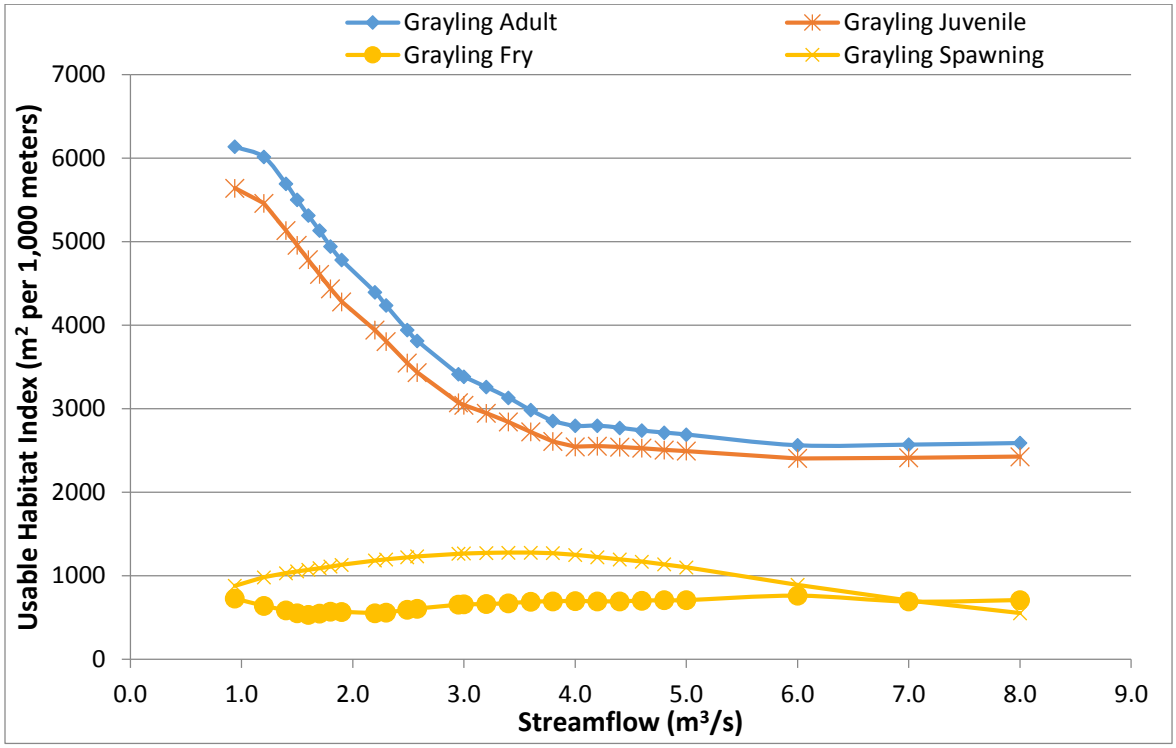


Figure 12. Usable Habitat Index vs. Streamflow for Arctic grayling in Dip Creek

Table 21. Usable Habitat Index Values vs. Streamflow for Arctic grayling in Dip Creek

Flow (m^3/s)	Usable Habitat Index Values					
	Adult Summer	Juvenile Summer	Fry	Spawning	*Adult Winter*	*Juvenile Winter*
0.94	6136	5641	728	880	3.85	3.71
1.20	6014	5459	641	983	26	23
1.40	5692	5132	585	1032	45	39
1.50	5500	4956	550	1053	53	46
1.60	5314	4783	533	1072	61	53
1.70	5133	4610	548	1091	68	59
1.80	4940	4436	569	1111	72	63
1.90	4780	4281	568	1130	78	68
2.20	4395	3942	552	1182	88	78
2.30	4236	3805	558	1197	89	79
2.49	3940	3546	593	1222	92	82
2.58	3813	3433	607	1233	94	83
2.95	3413	3074	653	1264	99	88
3.00	3382	3043	658	1266	100	88
3.20	3259	2947	662	1273	103	91
3.40	3131	2843	672	1276	110	97
3.60	2982	2722	689	1276	116	102
3.80	2855	2609	695	1271	121	105
4.00	2795	2545	699	1250	124	108
4.20	2796	2553	694	1224	127	109
4.40	2771	2541	695	1197	130	112
4.60	2738	2527	703	1170	132	113
4.80	2714	2506	707	1137	132	113
5.00	2691	2493	708	1101	131	112
6.00	2561	2405	763	892	123	104
7.00	2569	2413	692	704	119	102
8.00	2588	2426	710	552	131	114

4.1.6 Habitat Time Series

Long-term synthetic daily stream flow series hydrology for Casino Creek, Dip Creek and Lower Canadian Creek were developed by Knight Piesold (Knight Piesold, 2013). Estimated mean monthly percent flow change for each project phase were calculated (**Table 22**). Flow change percent values are averages for each project phase, and therefore do not represent the maximum change in each phase. The closure values are for the period after the Tailings Management Facility (TMF) begins to spill. The current assumption is that the TMF will be pumped back to the Open Pit and will not spill for the first 10 years of closure in order to establish a clean pond. The post-closure values are for the period after the Open Pit begins to spill.

Table 22. Mean monthly percent change in flow by station and project phase.

Project Phase	Station[1]	May	June	July	Aug.	Sep.
Construction	Casino Cr Middle- H18	-48%	-68%	-61%	-61%	-62%
	Casino Creek Lower - W4	-41%	-60%	-55%	-53%	-54%
	Dip Creek Upper – W9	0%	0%	0%	0%	0%
	Dip Creek (W4 + W9)	------	------	------	------	------
	Canadian Creek – W3	0%	0%	0%	0%	0%
Operation	Casino Cr Middle- H18	-47%	-68%	-61%	-61%	-62%
	Casino Creek Lower - W4	-41%	-60%	-55%	-53%	-54%
	Dip Creek Upper – W9	0%	0%	0%	0%	0%
	Dip Creek (W4 + W9)	------	------	------	------	------
	Canadian Creek – W3	-6%	-7%	-4%	-5%	-6%
Closure	Casino Cr Middle- H18	27%	-17%	-11%	-17%	-14%
	Casino Creek Lower - W4	23%	-15%	-10%	-14%	-12%
	Dip Creek Upper – W9	0%	0%	0%	0%	0%
	Dip Creek (W4 + W9)	------	------	------	------	------
	Canadian Creek – W3	-17%	-21%	-18%	-15%	-14%
Post-Closure	Casino Cr Middle- H18	27%	9%	8%	11%	22%
	Casino Creek Lower - W4	23%	8%	7%	9%	19%
	Dip Creek Upper – W9	0%	0%	0%	0%	0%
	Dip Creek (W4 + W9)	------	------	------	------	------
	Canadian Creek – W3	-17%	-21%	-18%	-15%	-14%

[1] Dip Creek station W9 is upstream of Casino Creek and not affected by the project. Adjusted flows for Casino Creek were added to flows from Upper Dip Creek to calculate flows for Lower Dip Creek.

Mean monthly percent flow change estimates were applied to the baseline daily flow data for the period 1990 to 2013 to construct flow time series hydrology by station and project phase. Graphic presentation of flow time series hydrology is based on average daily flow over the entire period. Streamflow duration (exceedance) is based on all daily flows over the entire period. Note that for Arctic Grayling spawning evaluation only those flows from May 15 to June 30 were used.

As would be expected, lower and middle Casino Creek have similar hydrology and flow duration for all project phases (**Figures 13 and 14**). In general flows are uniformly lower during construction and operation phases and similar to baseline for closure phases. Dip Creek shows little difference between all project phases (**Figure 15**). This is primarily attributed to the fact that flows from upper Dip Creek account for two to three times the flow in Casino Creek. Only the upper portion of Canadian Creek would be affected by the project. The result is little difference in flow for all project phases would be detected at the gage station (W3), located near the mouth of Canadian Creek (**Figure 16**). However, flows would be slightly lower after closure phases of the project.

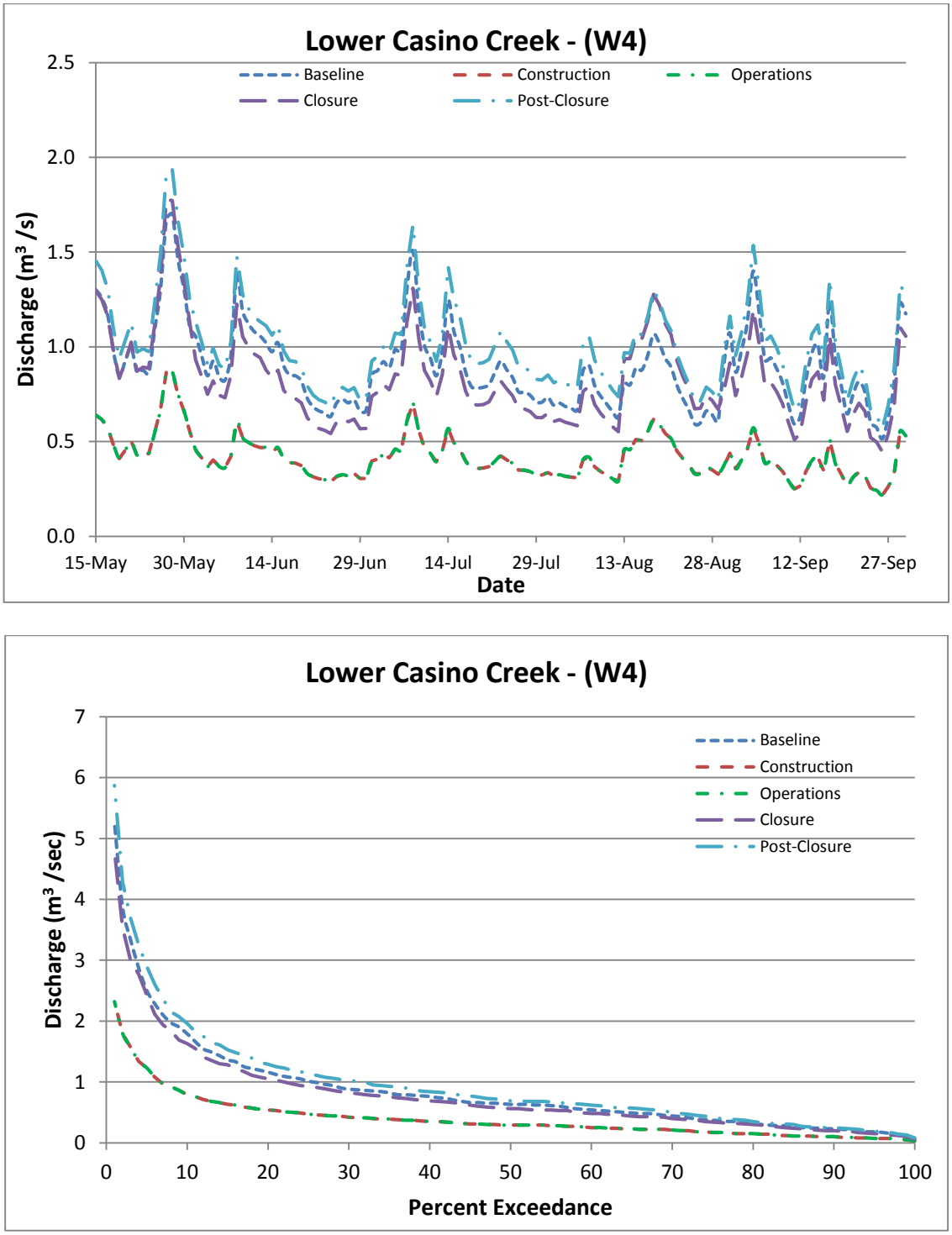
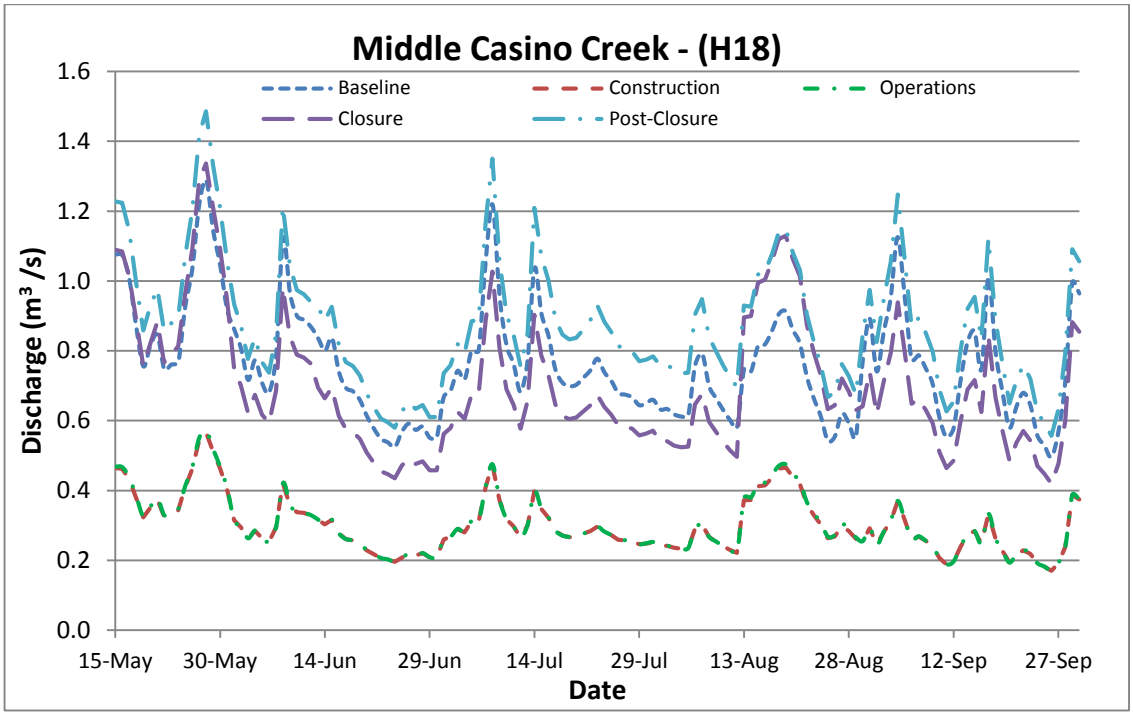


Figure 13. Flow times series of average daily flows from 1990 to 2013 (top) and flow duration for all daily flows from 1990 to 2013 (bottom) for Lower Casino Creek at W4 by project phase.



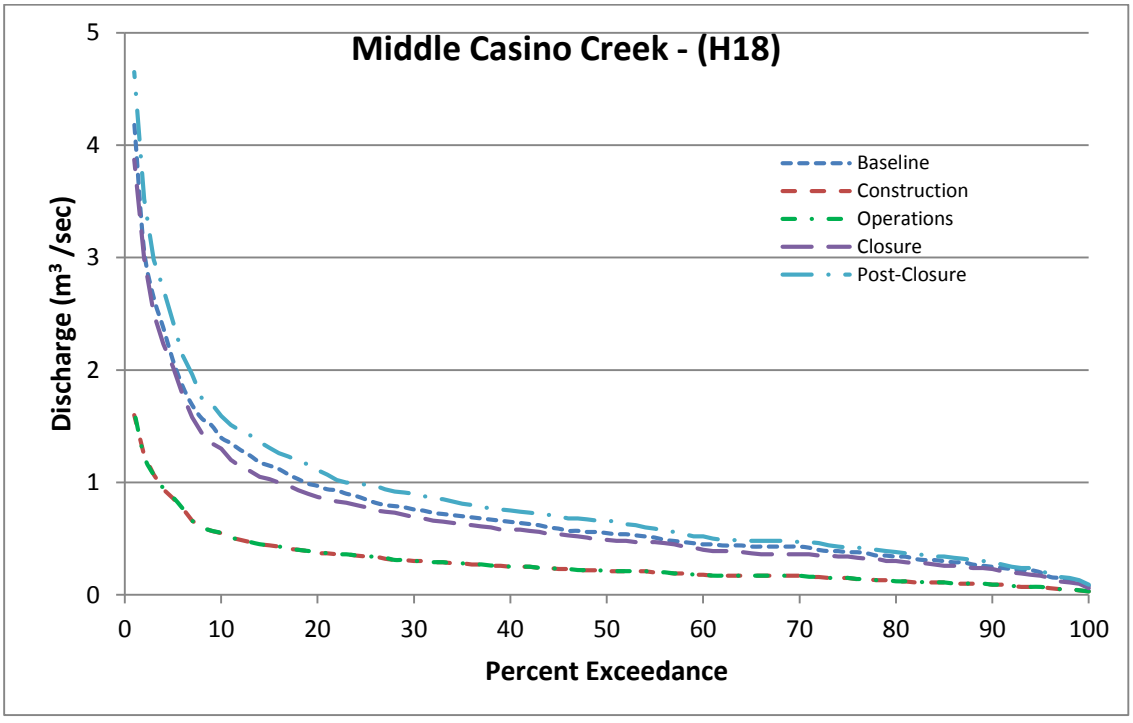
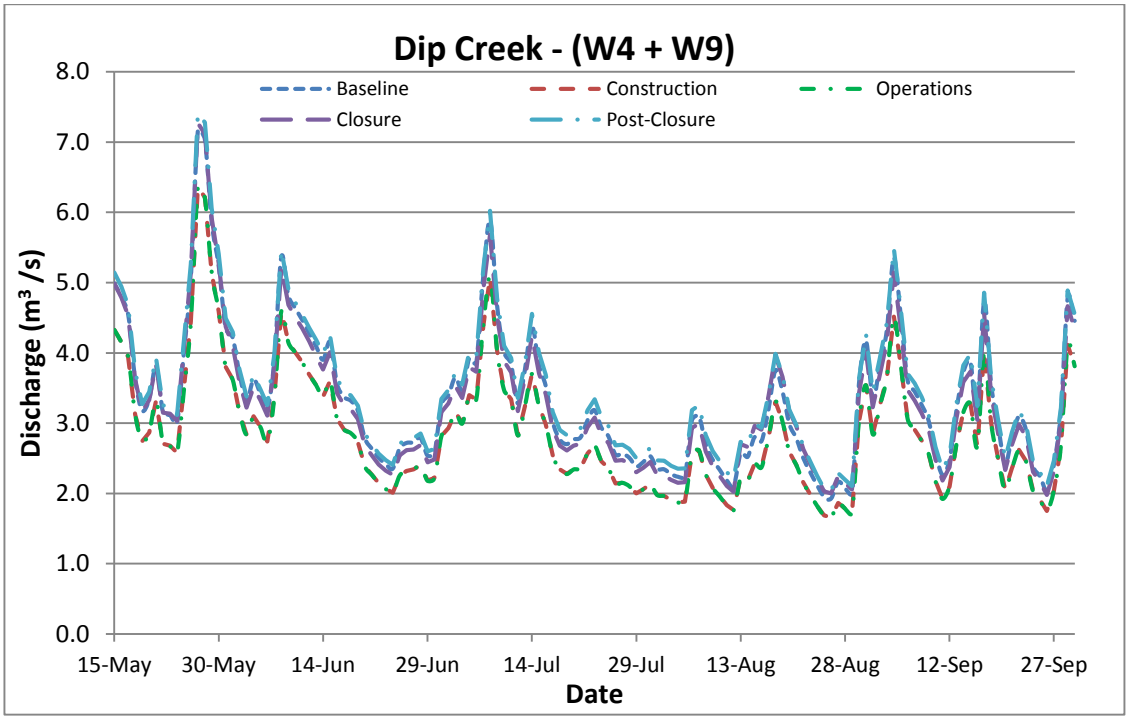


Figure 14. Flow times series of average daily flows from 1990 to 2013 (top) and flow duration for all daily flows from 1990 to 2013 (bottom) for Middle Casino Creek at H18 by project phase.



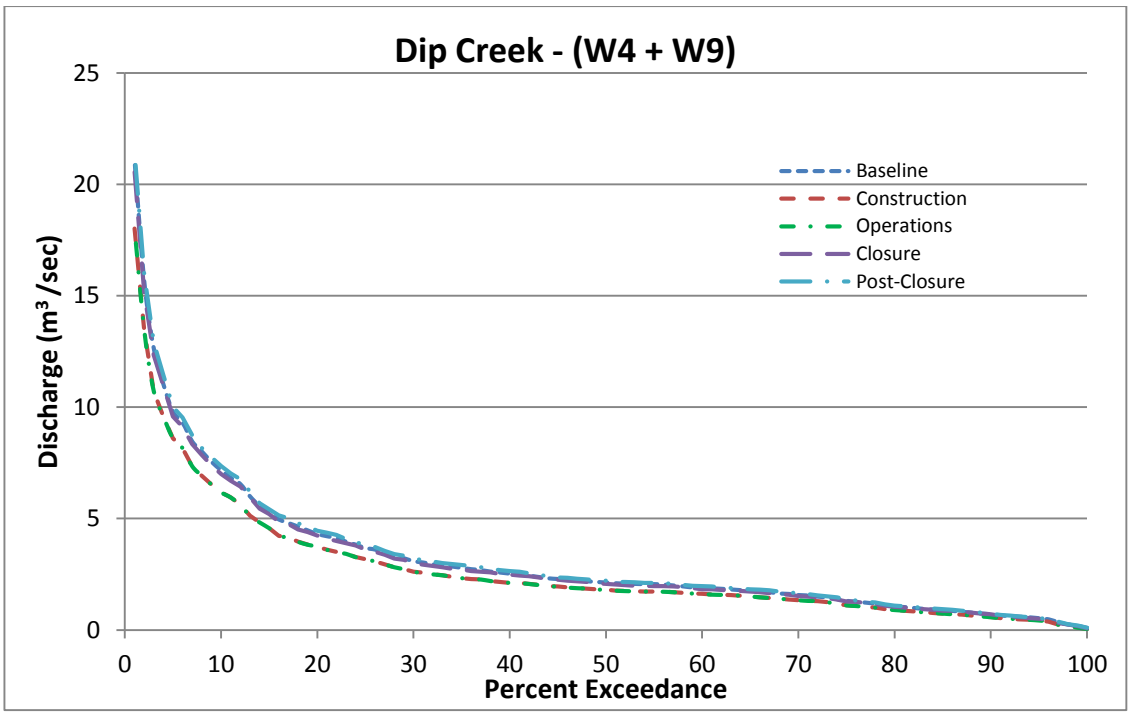


Figure 15. Flow times series of average daily flows from 1990 to 2013 (top) and flow duration for all daily flows from 1990 to 2013 (bottom) for Dip Creek below Casino Creek by project phase.

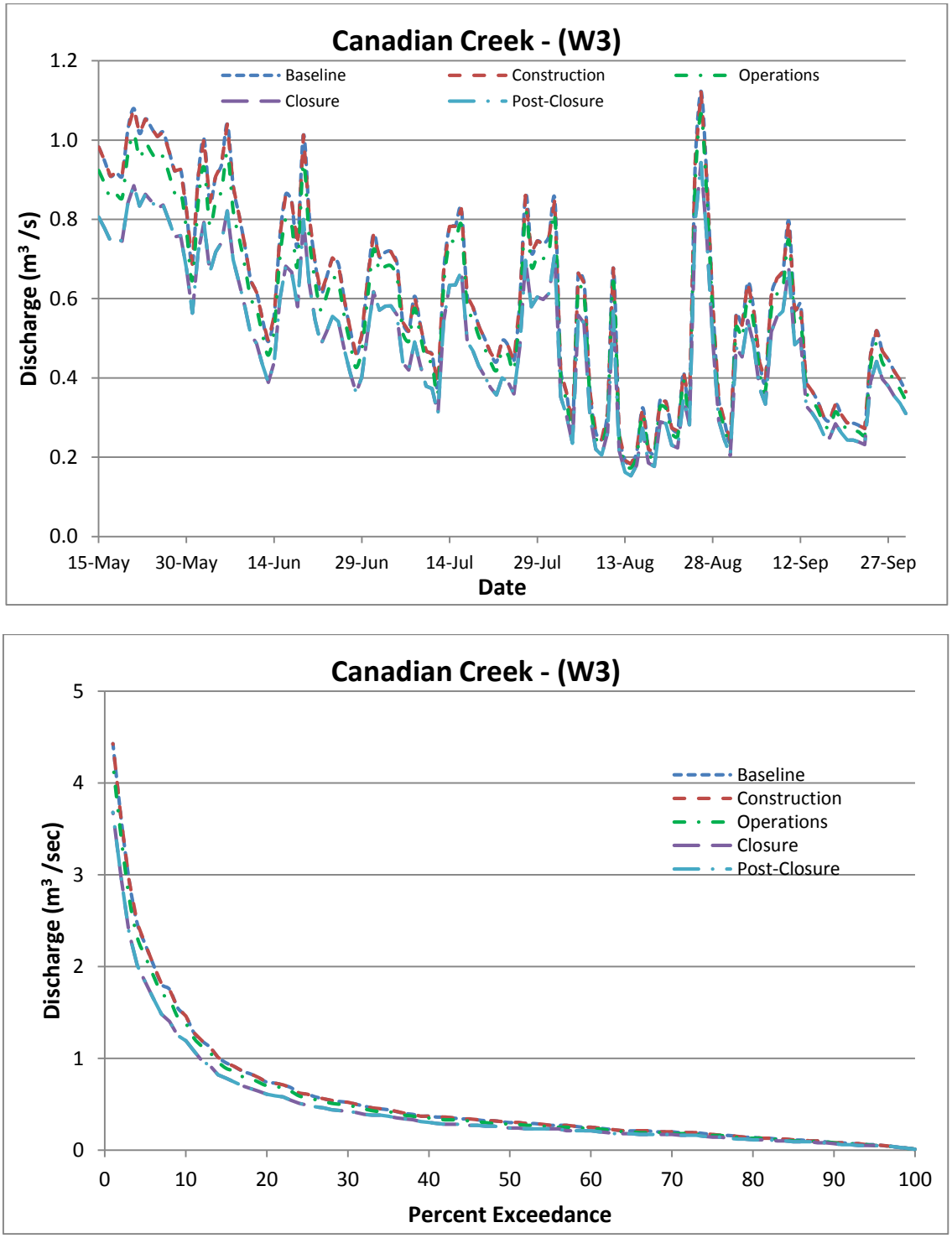
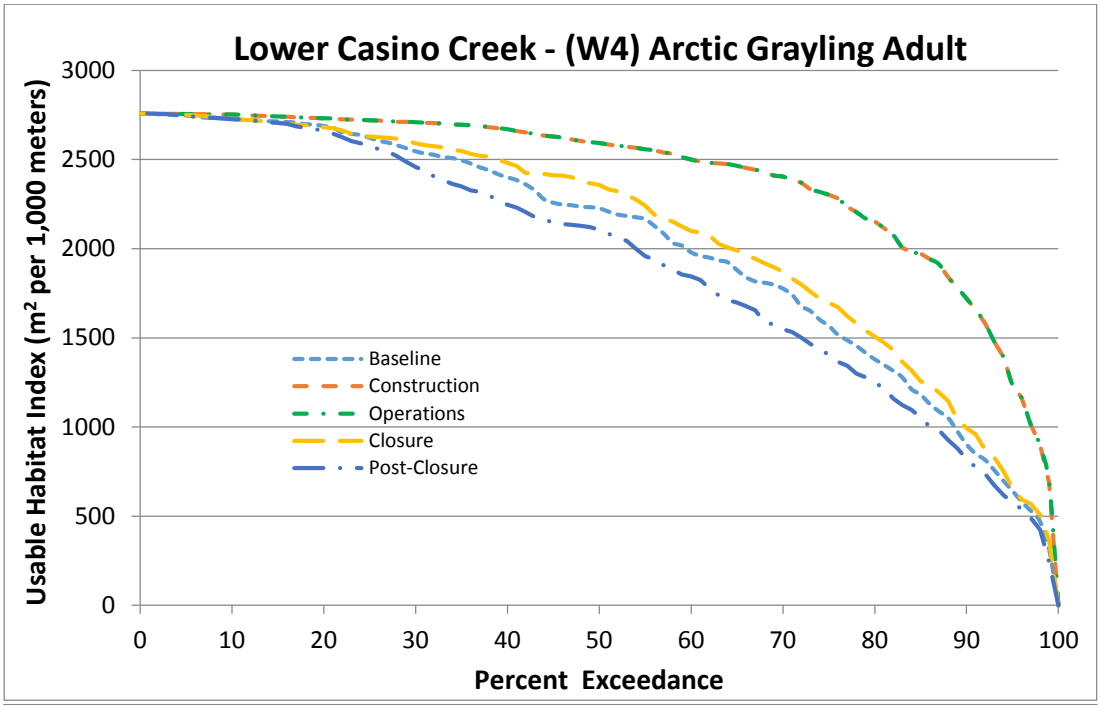


Figure 16. Flow times series of average daily flows from 1990 to 2013 (top) and flow duration for all daily flows from 1990 to 2013 (bottom) for Canadian Creek at W3 by project phase.



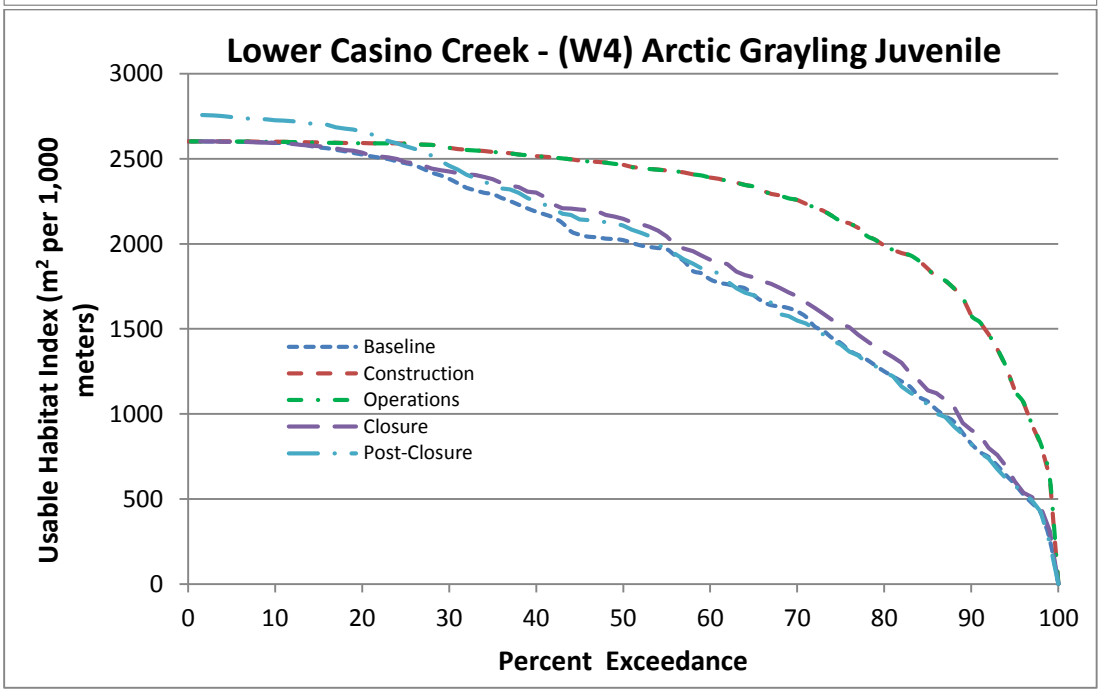


Figure 17. Habitat duration of Arctic grayling adult and juvenile on lower Casino Creek at W4 for all project phases.

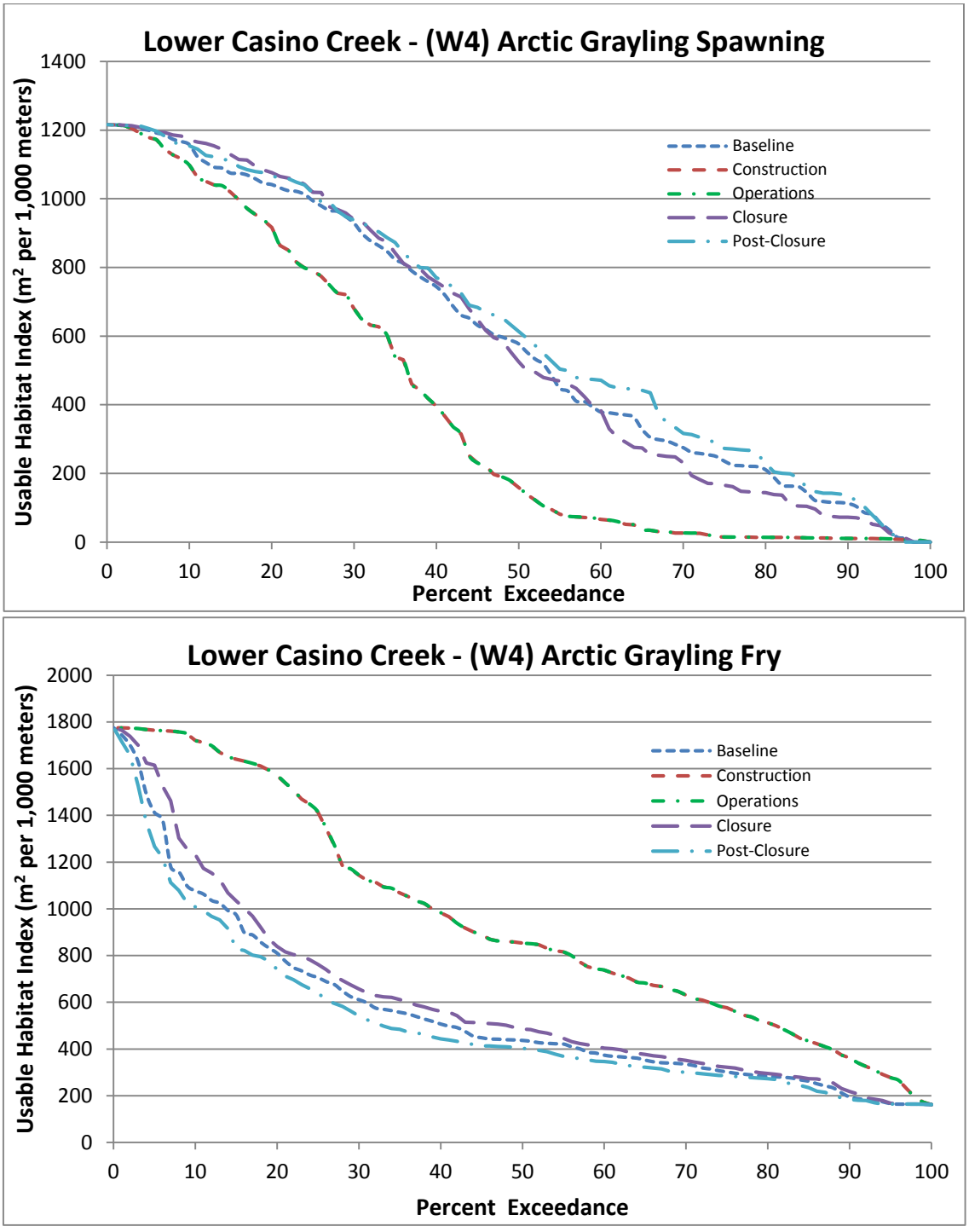
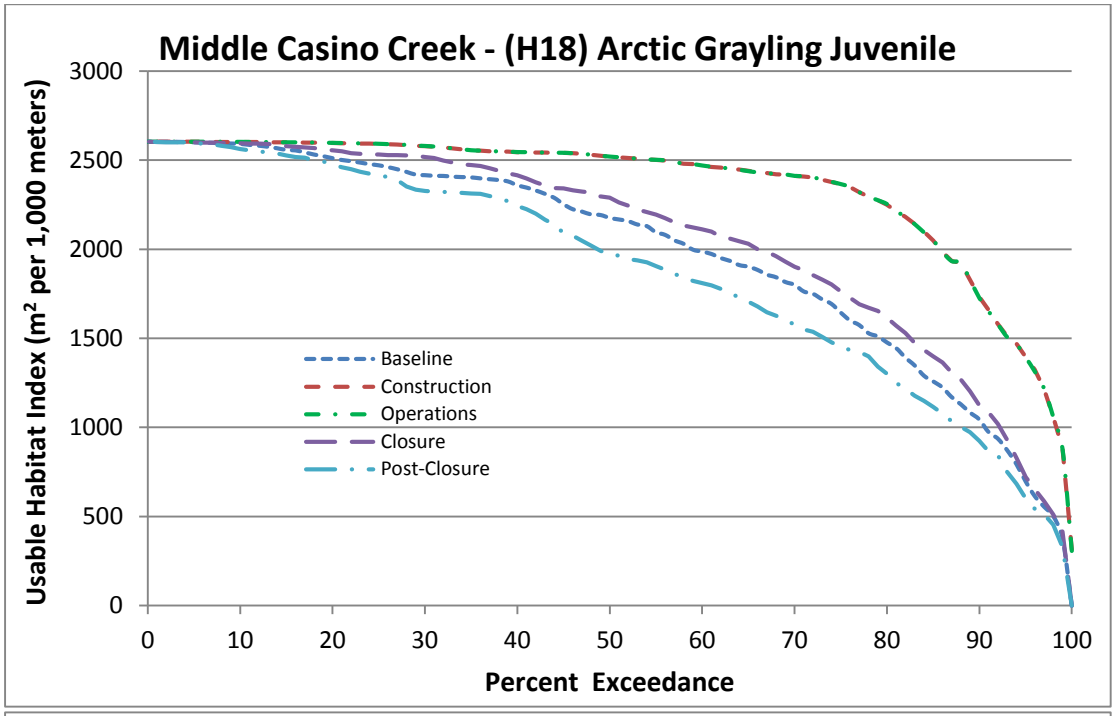


Figure 18. Habitat duration of Arctic grayling fry and spawning on lower Casino Creek at W4 for all project phases.



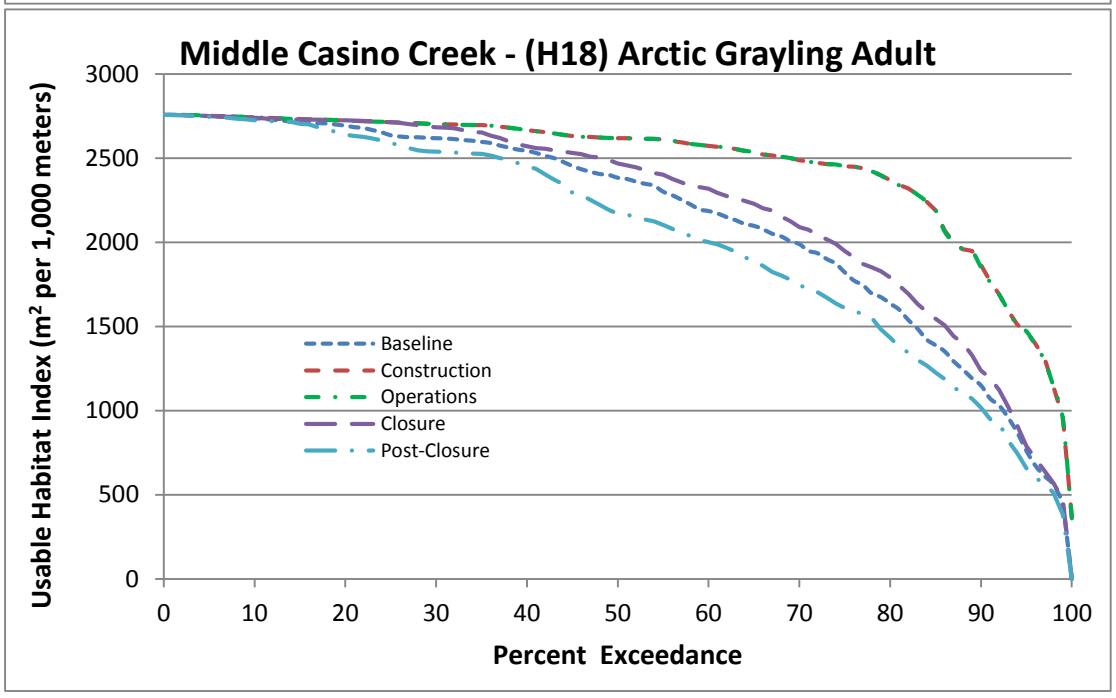


Figure 19. Habitat duration of Arctic grayling adult and juvenile on middle Casino Creek at H18 for all project phases.

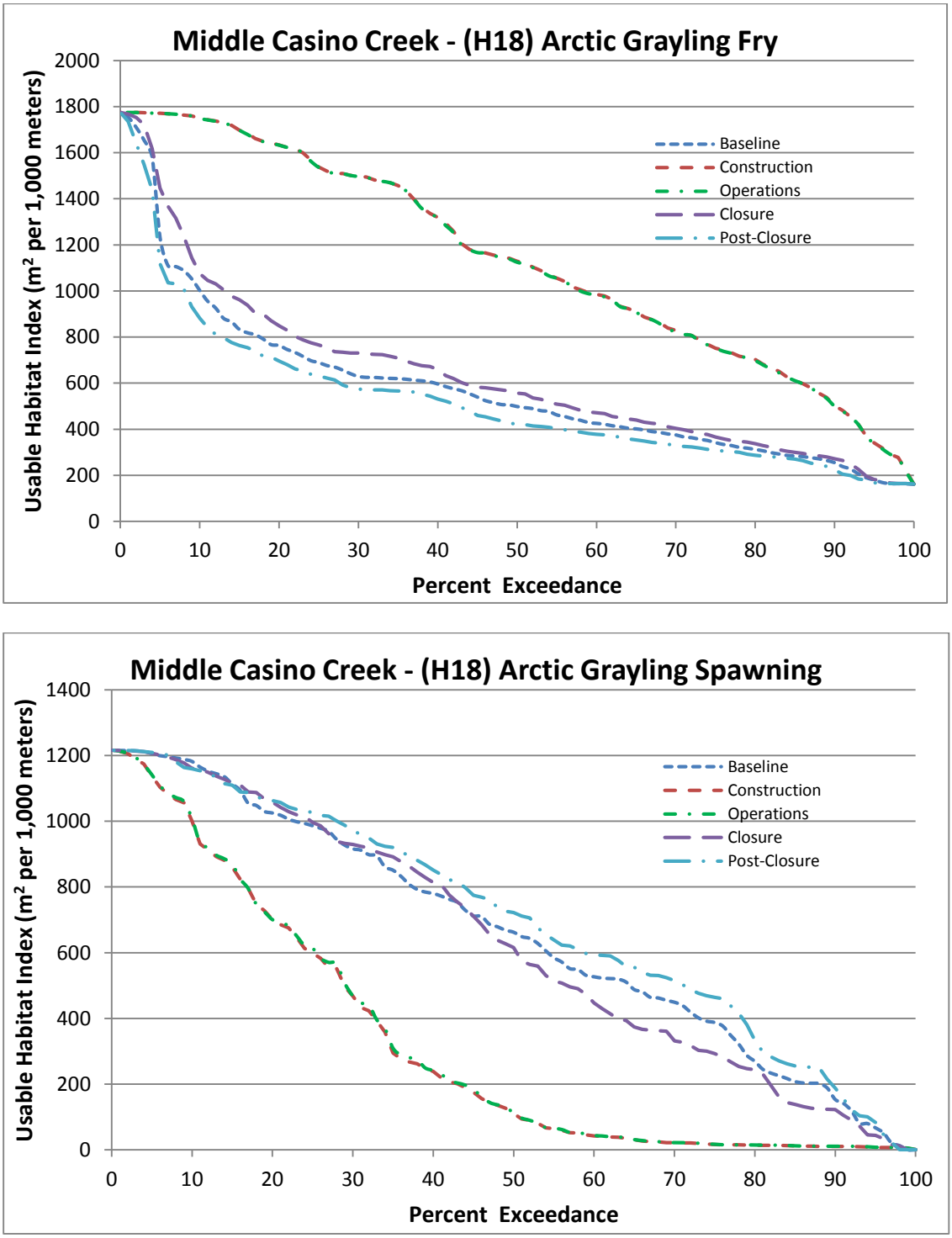
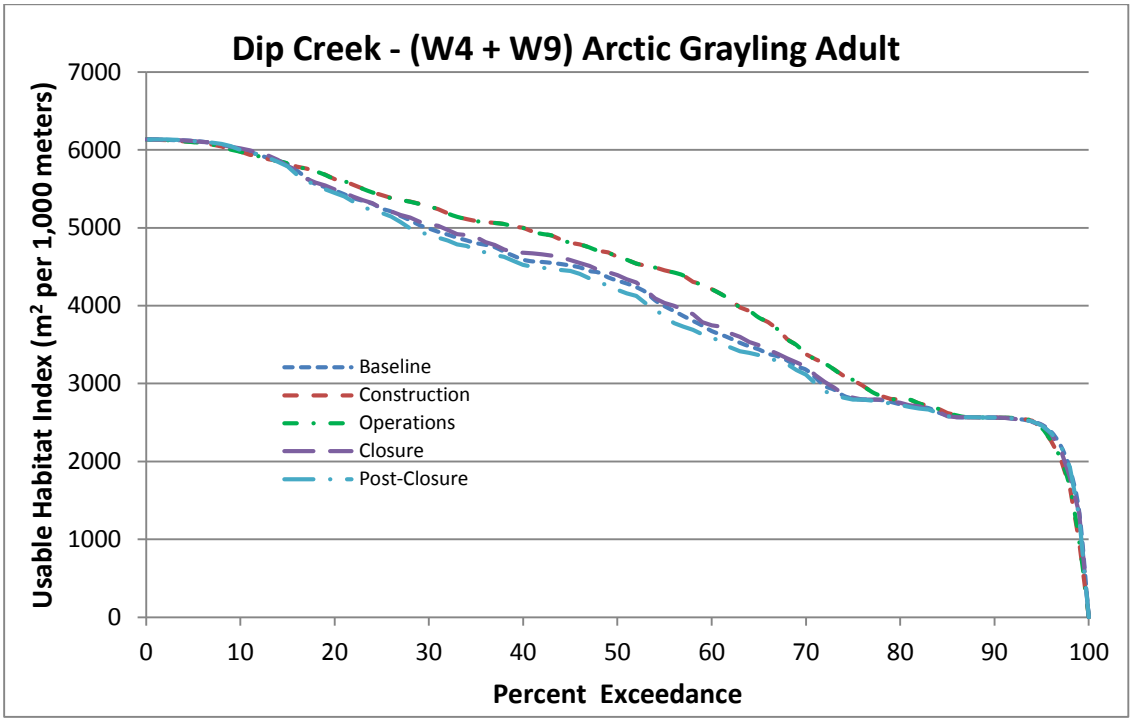


Figure 20. Habitat duration of Arctic grayling fry and spawning on middle Casino Creek at H18 for all project phases.



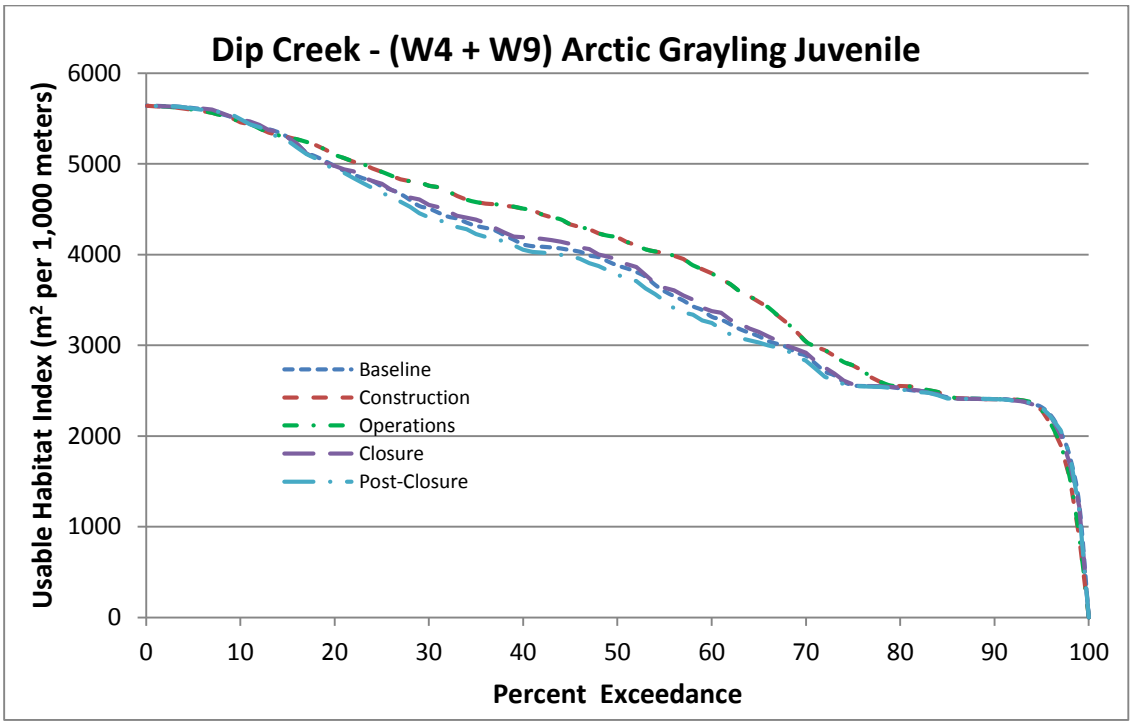
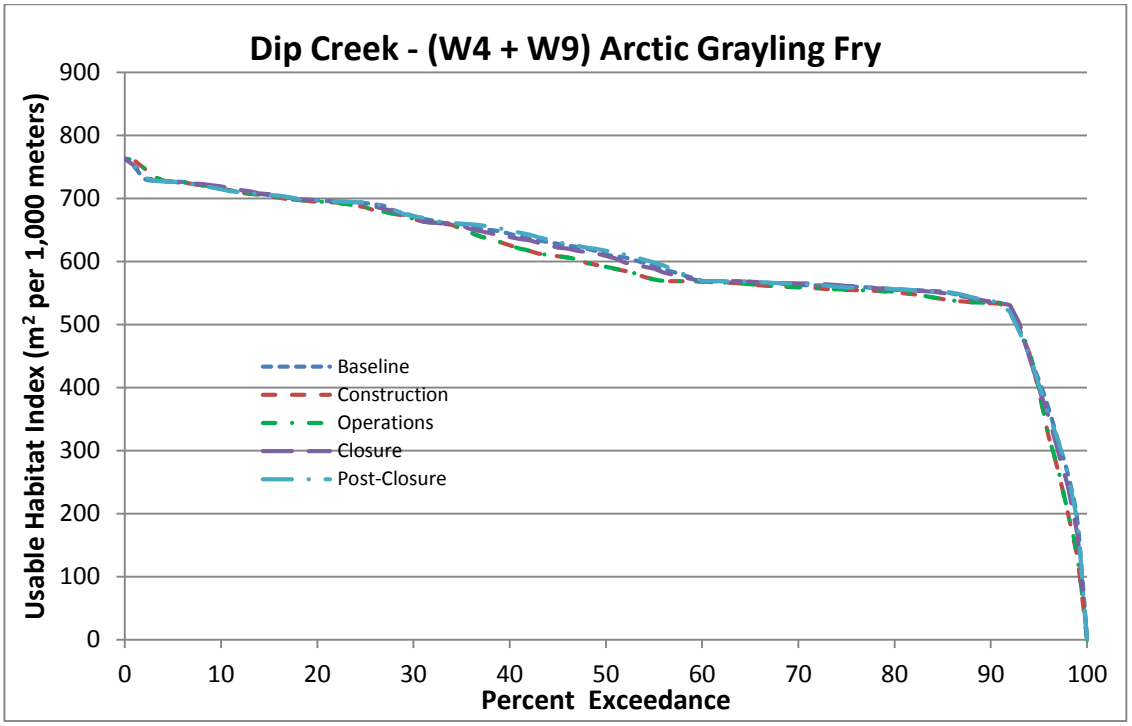


Figure 21. Habitat duration of Arctic grayling adult and juvenile on Dip Creek for all project phases.



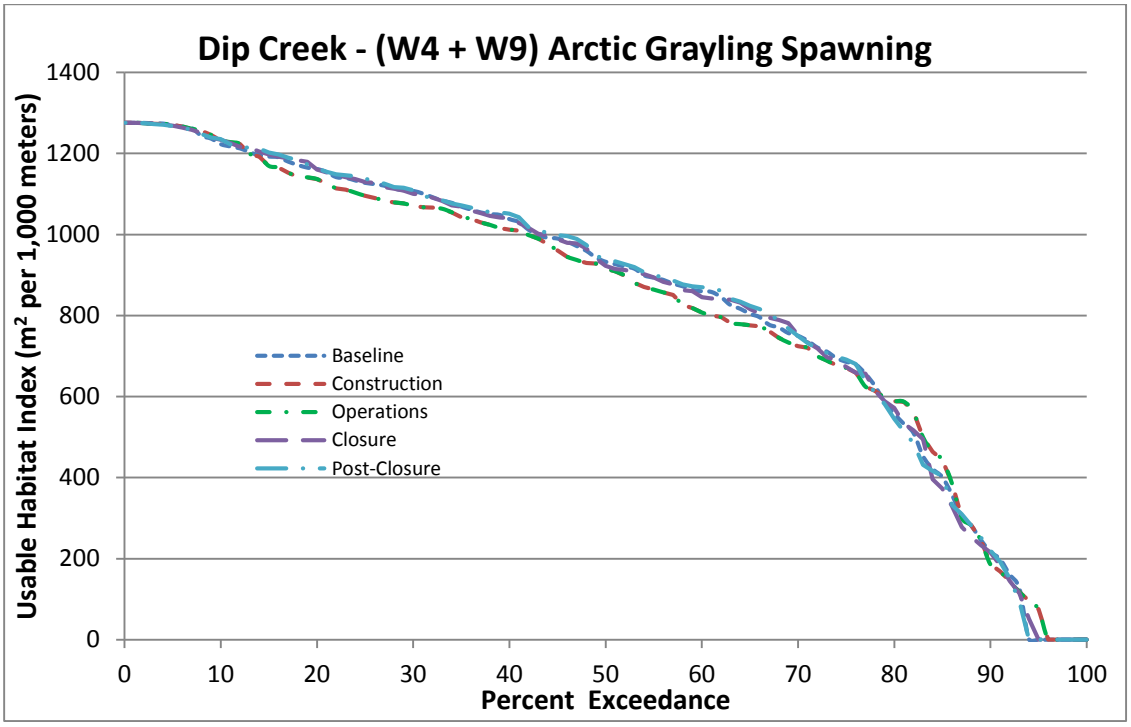
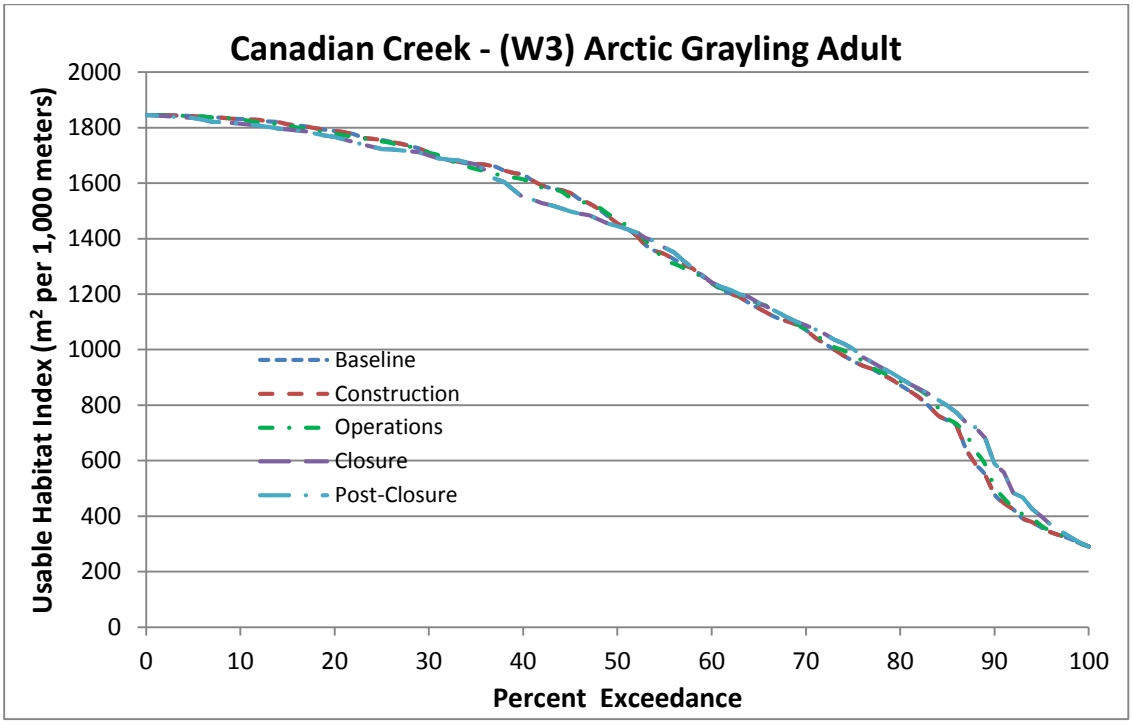


Figure 22. Habitat duration of Arctic grayling fry and spawning on Dip Creek for all project phases.



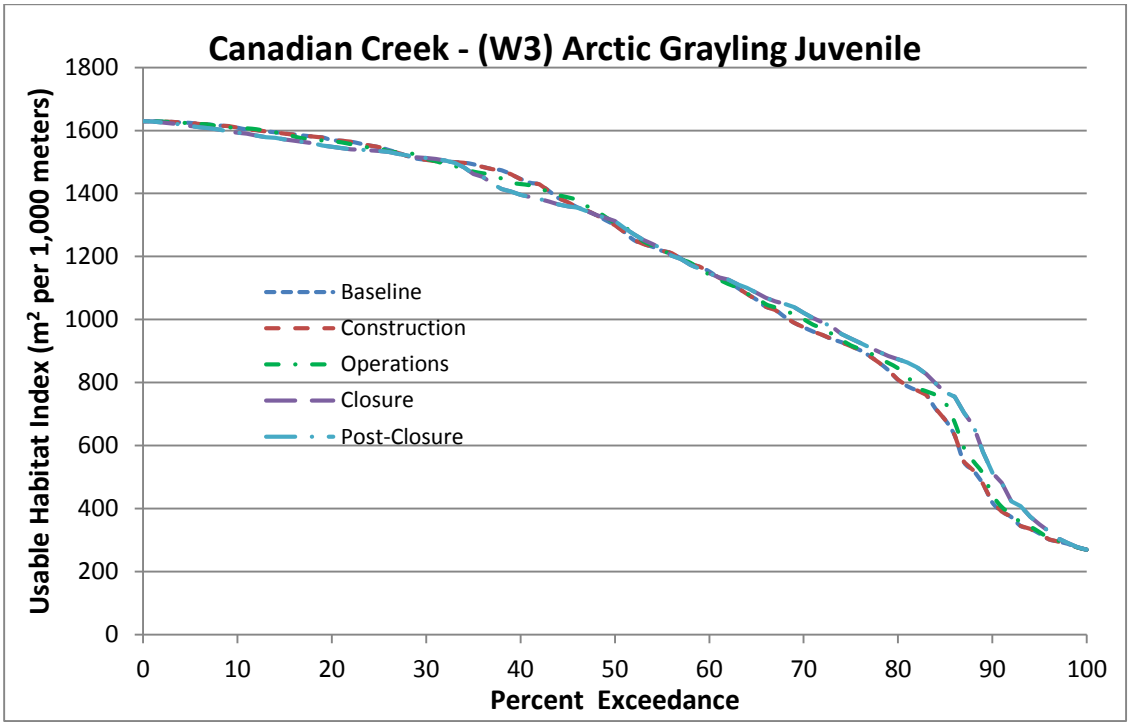


Figure 23. Habitat duration of Arctic grayling adult and juvenile on Canadian Creek for all project phases.

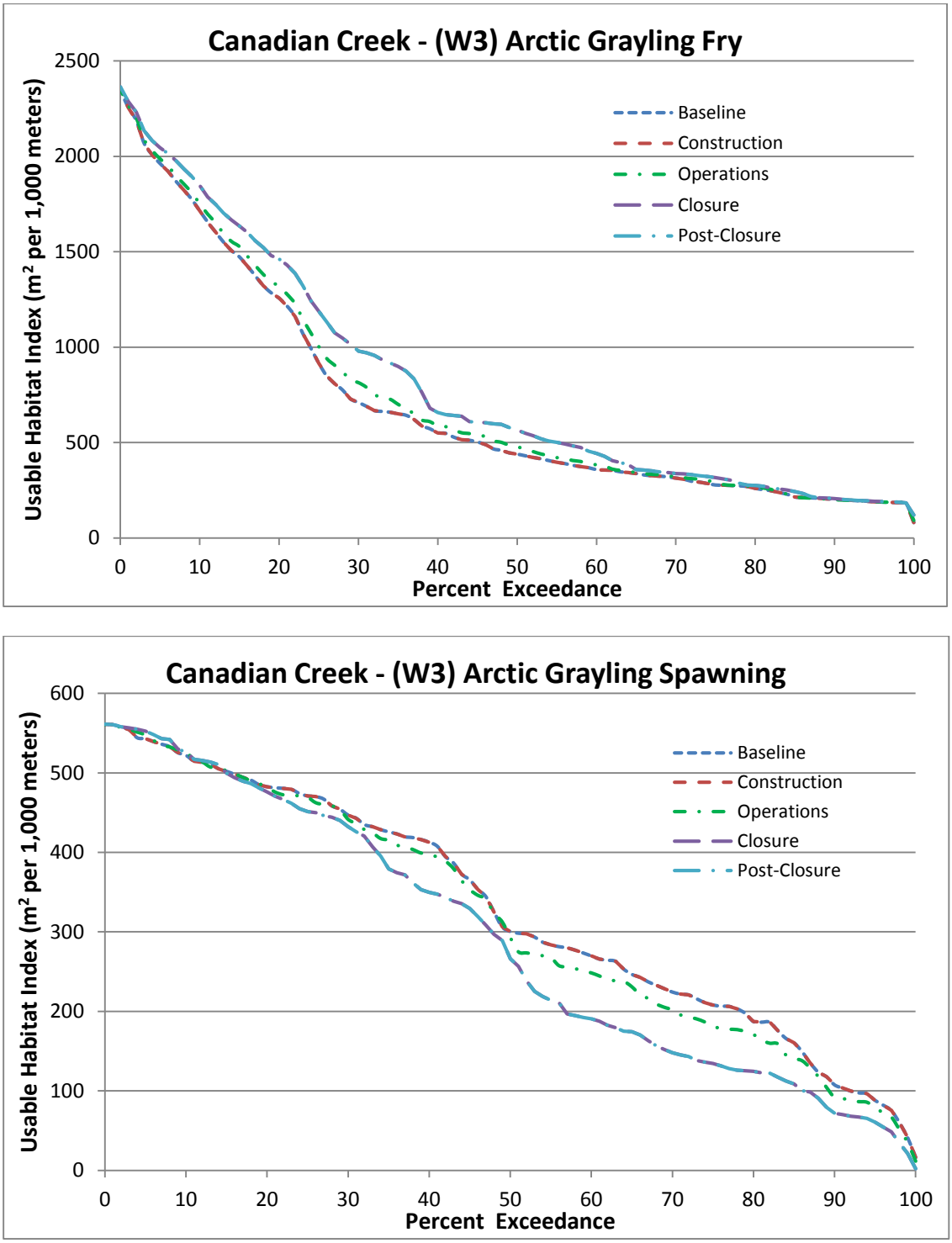


Figure 24. Habitat duration of Arctic grayling fry and spawning on Canadian Creek for all project phases.

4.1.7 Potential Change in Habitat – Casino Creek

The Habitat Index Duration from the time series analysis presented above demonstrates how the amount of fish habitat will vary with flow in different years (**Figures 17 to 20**). In this way, the results of the PHABSIM instream flow modeling are not static and will vary from year to year based on flow conditions and Arctic grayling life stage. Ideally, an average daily flow based on an extended gauge record for average, wet and dry years should be applied to this analysis

In order to assess change in amount of usable habitat based on flow we can examine habitat that occurs at various exceedance intervals. Using the 50% habitat exceedance, the median amount of habitat that occurs over the time period examined, should provide the best estimate of habitat gains or losses due to a change in stream flow.

Duration curves are similar for adult and juvenile grayling based on flows in lower (W4) and middle (H18) Casino Creek (**Figures 17 and 19**). The reduction in flow in Casino Creek during construction and operation phases of the project results in a median increase in habitat for adult and juvenile grayling of between 16% and 22% for lower Casino Creek, and 10% to 15% for middle Casino Creek (**Tables 23 and 24**). This outcome is due to the tendency for these life stages to prefer lower velocities, as indicated by the Habitat Suitability Curves (HSC) (Hubert et al., 1985), and that at lower flows there is an increase in available low velocity refuge areas. Changes in habitat during the closure and post-closure phases are generally less than 10% based on the median habitat values (**Tables 23 and 24**).

Grayling fry habitat duration curves in both lower and middle Casino Creek exhibit similar results to adult and juvenile with increased habitat under project conditions (**Figures 18 and 20**). The median habitat values increase in the range of 95% for lower Casino Creek and around 125% for middle Casino Creek during construction and operation phases (**Tables 23 and 24**). Again these results are a product of preference for low velocities by this life stage. Changes in habitat during the closure and post-closure phase are generally less than 7% to 15% based on the median habitat values (**Tables 23 and 24**).

Spawning is the only life stage which shows a decrease in habitat due to flow reduction during the projects construction and operation phases (**Figures 18 and 20**). The median habitat value percent change shows a decrease in lower Casino Creek (-72%) and middle Casino Creek (-83%) for the construction and operation phases of the project (**Tables 23 and 24**). This is an end result of lower availability of higher velocities generally used by grayling during spawning, the opposite condition of what is preferred during other life stages. Changes in habitat during the closure and post-closure phases are between 6% and 9% based on the median habitat values (**Tables 23 and 24**).

Table 23. Habitat Index values (m²/1000 meters) for Arctic grayling life stages at selected habitat duration percentages under baseline and project phases for lower Casino Creek.

Duration	Usable Habitat (m2/1000m)					Change in Usable Habitat from Baseline (m2/1000m)				Percent Change in Usable Habitat from Baseline (m2/1000m)			
Percent	**Baseline**	**Construction**	**Operation**	**Closure**	**Post-Closure**	**Construction**	**Operation**	**Closure**	**Post-Closure**	**Construction**	**Operation**	**Closure**	**Post-Closure**
	Arctic Grayling Adult					Arctic Grayling Adult				Arctic Grayling Adult			
10	2726	2752	2752	2728	2727	26	26	1	1	1.0%	1.0%	0.0%	0.0%
25	2622	2720	2720	2630	2573	98	98	8	-49	3.7%	3.7%	0.3%	-1.9%
50	**2226**	**2593**	**2593**	**2357**	**2107**	**366**	**366**	**131**	**-120**	**16.4%**	**16.4%**	**5.9%**	**-5.4%**
75	1568	2303	2303	1695	1407	735	735	128	-161	46.9%	46.9%	8.1%	-10.3%
90	903	1721	1721	994	821	818	818	91	-82	90.6%	90.6%	10.1%	-9.1%
	Arctic Grayling Juvenile					Arctic Grayling Juvenile				Arctic Grayling Juvenile			
10	2594	2601	2601	2592	2588	6	6	-2	-6	0.2%	0.2%	-0.1%	-0.2%
25	2475	2590	2590	2481	2412	115	115	6	-62	4.6%	4.6%	0.3%	-2.5%
50	**2022**	**2464**	**2464**	**2148**	**1909**	**442**	**442**	**125**	**-113**	**21.9%**	**21.9%**	**6.2%**	**-5.6%**
75	1417	2134	2134	1529	1275	717	717	112	-142	50.6%	50.6%	7.9%	-10.0%
90	824	1577	1577	904	750	753	753	80	-75	91.3%	91.3%	9.7%	-9.1%
	Arctic Grayling Fry					Arctic Grayling Fry				Arctic Grayling Fry			
10	1077	1721	1721	1233	1009	644	644	156	-68	59.8%	59.8%	14.5%	-6.3%
25	706	1414	1414	762	641	709	709	57	-65	100.4%	100.4%	8.0%	-9.2%
50	**437**	**853**	**853**	**486**	**404**	**416**	**416**	**49**	**-33**	**95.3%**	**95.3%**	**11.2%**	**-7.6%**
75	302	576	576	321	285	274	274	19	-17	90.7%	90.7%	6.4%	-5.6%
90	194	362	362	217	184	167	167	23	-10	86.2%	86.2%	11.9%	-5.1%
	Arctic Grayling Spawning					Arctic Grayling Spawning				Arctic Grayling Spawning			
10	1158	1098	1098	1172	1154	-60	-60	14	-4	-5.2%	-5.2%	1.2%	-0.3%
25	994	791	791	1019	1016	-204	-204	25	22	-20.5%	-20.5%	2.5%	2.2%
50	**578**	**159**	**159**	**526**	**613**	**-419**	**-419**	**-52**	**36**	**-72.5%**	**-72.5%**	**-9.0%**	**6.2%**
75	236	15	15	165	273	-221	-221	-71	37	-93.7%	-93.7%	-29.9%	15.7%
90	113	11	11	73	137	-103	-103	-40	24	-90.6%	-90.6%	-35.8%	21.3%

Table 24. Habitat Index values (m^2/1000 meters) for Arctic grayling life stages at selected habitat duration percentages under baseline and project phases for middle Casino Creek.

Duration	Usable Habitat (m2/1000m)					Change in Usable Habitat from Baseline (m2/1000m)				Percent Change in Usable Habitat from Baseline (m2/1000m)			
Percent	**Baseline**	**Construction**	**Operation**	**Closure**	**Post-Closure**	**Construction**	**Operation**	**Closure**	**Post-Closure**	**Construction**	**Operation**	**Closure**	**Post-Closure**
	Arctic Grayling Adult					Arctic Grayling Adult				Arctic Grayling Adult			
10	2737	2743	2743	2740	2726	6	6	3	-11	0.2%	0.2%	0.1%	-0.4%
25	2636	2714	2714	2714	2592	78	77	78	-44	2.9%	2.9%	3.0%	-1.7%
50	**2384**	**2620**	**2620**	**2470**	**2170**	**236**	**236**	**85**	**-214**	**9.9%**	**9.9%**	**3.6%**	**-9.0%**
75	1821	2452	2452	1948	1609	630	631	127	-213	34.6%	34.6%	7.0%	-11.7%
90	1150	1865	1852	1239	1017	716	702	89	-133	62.2%	61.1%	7.7%	-11.6%
	Arctic Grayling Juvenile					Arctic Grayling Juvenile				Arctic Grayling Juvenile			
10	2590	2602	2602	2595	2563	12	12	4	-28	0.4%	0.4%	0.2%	-1.1%
25	2471	2591	2591	2531	2417	121	121	61	-53	4.9%	4.9%	2.5%	-2.2%
50	**2175**	**2519**	**2519**	**2290**	**1969**	**344**	**344**	**115**	**-206**	**15.8%**	**15.8%**	**5.3%**	**-9.5%**
75	1644	2365	2365	1763	1453	721	721	119	-191	43.8%	43.9%	7.2%	-11.6%
90	1044	1733	1726	1124	924	689	681	80	-120	66.0%	65.3%	7.7%	-11.5%
	Arctic Grayling Fry					Arctic Grayling Fry				Arctic Grayling Fry			
10	1002	1749	1749	1075	882	747	747	73	-121	74.6%	74.5%	7.2%	-12.0%
25	689	1538	1536	765	631	849	847	76	-59	123.1%	122.8%	11.0%	-8.5%
50	**498**	**1129**	**1125**	**557**	**421**	**631**	**626**	**58**	**-78**	**126.5%**	**125.7%**	**11.7%**	**-15.6%**
75	342	752	752	367	308	410	410	25	-34	119.8%	119.8%	7.2%	-10.0%
90	255	502	500	271	224	247	245	16	-32	96.7%	96.0%	6.3%	-12.4%
	Arctic Grayling Spawning					Arctic Grayling Spawning				Arctic Grayling Spawning			
10	1182	1001	1009	1161	1159	-182	-174	-21	-23	-15.4%	-14.7%	-1.8%	-1.9%
25	986	598	613	996	1027	-388	-373	10	41	-39.4%	-37.8%	1.0%	4.1%
50	**662**	**110**	**109**	**616**	**722**	**-552**	**-553**	**-47**	**60**	**-83.4%**	**-83.5%**	**-7.0%**	**9.0%**
75	387	16	16	292	464	-371	-371	-95	76	-95.8%	-95.8%	-24.5%	19.7%
90	153	10	10	123	188	-143	-143	-30	35	-93.3%	-93.3%	-19.8%	22.9%

Table 25. Habitat Index values (m²/1000 meters) for Arctic grayling life stages at selected habitat duration percentages under baseline and project phases for Casino Creek (Average Values).

Duration	Usable Habitat (m2/1000m)					Change in Usable Habitat from Baseline (m2/1000m)				Percent Change in Usable Habitat from Baseline (m2/1000m)			
Percent	**Baseline**	**Construction**	**Operation**	**Closure**	**Post-Closure**	**Construction**	**Operation**	**Closure**	**Post-Closure**	**Construction**	**Operation**	**Closure**	**Post-Closure**
	Arctic Grayling Adult					Arctic Grayling Adult				Arctic Grayling Adult			
10	2732	2748	2748	2734	2726	16	16	2	-5	0.6%	0.6%	0.1%	-0.2%
25	2629	2717	2717	2672	2583	88	88	43	-46	3.3%	3.3%	1.6%	-1.8%
50	**2305**	**2606**	**2606**	**2413**	**2139**	**301**	**301**	**108**	**-167**	**13.1%**	**13.1%**	**4.7%**	**-7.2%**
75	1695	2377	2377	1822	1508	683	683	127	-187	40.3%	40.3%	7.5%	-11.0%
90	1026	1793	1786	1116	919	767	760	90	-108	74.7%	74.1%	8.8%	-10.5%
	Arctic Grayling Juvenile					Arctic Grayling Juvenile				Arctic Grayling Juvenile			
10	2592	2601	2601	2594	2575	9	9	1	-17	0.3%	0.3%	0.0%	-0.7%
25	2473	2590	2590	2506	2415	118	118	34	-58	4.8%	4.8%	1.4%	-2.3%
50	**2099**	**2492**	**2492**	**2219**	**1939**	**393**	**393**	**120**	**-160**	**18.7%**	**18.7%**	**5.7%**	**-7.6%**
75	1530	2249	2249	1646	1364	719	719	116	-167	47.0%	47.0%	7.6%	-10.9%
90	934	1655	1651	1014	837	721	717	80	-97	77.2%	76.8%	8.6%	-10.4%
	Arctic Grayling Fry					Arctic Grayling Fry				Arctic Grayling Fry			
10	1040	1735	1735	1154	945	696	695	114	-94	66.9%	66.9%	11.0%	-9.1%
25	698	1476	1475	764	636	779	778	66	-62	111.6%	111.5%	9.5%	-8.8%
50	**468**	**991**	**989**	**521**	**412**	**523**	**521**	**54**	**-55**	**111.9%**	**111.5%**	**11.5%**	**-11.9%**
75	322	664	664	344	296	342	342	22	-26	106.1%	106.1%	6.8%	-7.9%
90	225	432	431	244	204	207	206	20	-21	92.1%	91.8%	8.7%	-9.2%
	Arctic Grayling Spawning					Arctic Grayling Spawning				Arctic Grayling Spawning			
10	1170	1049	1053	1166	1157	-121	-117	-3	-13	-10.3%	-10.0%	-0.3%	-1.1%
25	990	694	702	1008	1022	-296	-288	17	31	-29.9%	-29.1%	1.8%	3.2%
50	**620**	**135**	**134**	**571**	**668**	**-485**	**-486**	**-49**	**48**	**-78.3%**	**-78.3%**	**-8.0%**	**7.7%**
75	312	15	16	229	368	-296	-296	-83	57	-95.0%	-95.0%	-26.6%	18.2%
90	133	10	10	98	163	-123	-123	-35	30	-92.1%	-92.1%	-26.6%	22.3%

4.1.8 Potential Change in Habitat – Dip Creek

Similarly to Casino Creek, in order to assess change in amount of usable habitat based on flow we can examine habitat that occurs at various exceedance intervals within Dip Creek (**Figures 21 to 22**). Using the 50% habitat exceedance, the median amount of habitat that occurs over the time period examined, should provide the best estimate of habitat gains or losses due to a change in streamflow.

For Dip Creek habitat for adult and juvenile grayling shows a slight increase during construction and operation phases of the project (**Figure 21**). Fry and spawning life stages show virtually no difference in habitat during all project phases (**Figure 22**). The percentage change at the median habitat index value is between 7% and 8% for juveniles and adults and a decrease of 2% to 3% for fry and spawning life stages during construction and operation phases of the project (**Table 26**). Habitat index values for closure phases differ little from baseline.

Table 26. Habitat Index values (m^2/1000 meters) for Arctic grayling life stages at selected habitat duration percentages under baseline and project phases for Dip Creek.

Duration	Usable Habitat (m2/1000m)					Change in Usable Habitat from Baseline (m2/1000m)				Percent Change in Usable Habitat from Baseline (m2/1000m)			
Percent	**Baseline**	**Construction**	**Operation**	**Closure**	**Post-Closure**	**Construction**	**Operation**	**Closure**	**Post-Closure**	**Construction**	**Operation**	**Closure**	**Post-Closure**
	Arctic Grayling Adult					Arctic Grayling Adult				Arctic Grayling Adult			
10	6000	5978	5978	6021	6000	-22	-22	20	0	-0.4%	-0.4%	0.3%	0.0%
25	5248	5419	5419	5246	5188	171	171	-1	-59	3.3%	3.3%	0.0%	-1.1%
50	**4323**	**4626**	**4626**	**4394**	**4205**	**303**	**303**	**71**	**-118**	**7.0%**	**7.0%**	**1.6%**	**-2.7%**
75	2806	3047	3047	2818	2796	240	240	11	-10	8.6%	8.6%	0.4%	-0.4%
90	2562	2562	2562	2562	2562	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Arctic Grayling Juvenile					Arctic Grayling Juvenile				Arctic Grayling Juvenile			
10	5475	5457	5457	5487	5494	-18	-18	12	18	-0.3%	-0.3%	0.2%	0.3%
25	4752	4912	4912	4782	4679	161	161	30	-73	3.4%	3.4%	0.6%	-1.5%
50	**3879**	**4191**	**4191**	**3946**	**3780**	**312**	**312**	**66**	**-100**	**8.0%**	**8.0%**	**1.7%**	**-2.6%**
75	2557	2778	2778	2570	2552	221	221	12	-5	8.6%	8.6%	0.5%	-0.2%
90	2406	2406	2406	2407	2406	0	0	0	-1	0.0%	0.0%	0.0%	0.0%
	Arctic Grayling Fry					Arctic Grayling Fry				Arctic Grayling Fry			
10	716	716	716	719	714	0	0	3	-1	0.0%	0.0%	0.5%	-0.2%
25	692	686	686	692	694	-6	-6	-1	1	-0.9%	-0.9%	-0.1%	0.2%
50	**611**	**591**	**591**	**609**	**617**	**-19**	**-19**	**-2**	**6**	**-3.2%**	**-3.2%**	**-0.2%**	**1.0%**
75	560	555	555	561	559	-5	-5	1	-1	-0.9%	-0.9%	0.2%	-0.3%
90	536	534	534	536	538	-2	-2	1	2	-0.4%	-0.4%	0.1%	0.4%
	Arctic Grayling Spawning					Arctic Grayling Spawning				Arctic Grayling Spawning			
10	1223	1232	1232	1234	1236	9	9	11	12	0.7%	0.7%	0.9%	1.0%
25	1128	1095	1095	1129	1138	-33	-33	2	10	-2.9%	-2.9%	0.1%	0.9%
50	**933**	**916**	**916**	**922**	**937**	**-17**	**-17**	**-11**	**4**	**-1.9%**	**-1.9%**	**-1.1%**	**0.5%**
75	686	671	671	673	691	-15	-15	-13	5	-2.2%	-2.2%	-1.9%	0.7%
90	133	10	10	98	163	-123	-123	-35	30	-92.1%	-92.1%	-26.6%	22.3%

4.1.9 Canadian Creek

No detectable change in habitat occurs for grayling adult and juvenile life stages under all project phases in Canadian Creek (**Figure 23**). A small increase in habitat for fry and a slight decrease in spawning habitat would occur during project closure phases (**Figure 24**). This equates to an increase in fry habitat by 28% and a decrease in spawning habitat of 11% (**Table 27**).

Table 27. Habitat Index values (m²/1000 meters) for Arctic grayling life stages at selected habitat duration percentages under baseline and project phases for Canadian Creek.

Duration	Usable Habitat (m2/1000m)					Change in Usable Habitat from Baseline (m2/1000m)				Percent Change in Usable Habitat from Baseline (m2/1000m)			
Percent	**Baseline**	**Construction**	**Operation**	**Closure**	**Post-Closure**	**Construction**	**Operation**	**Closure**	**Post-Closure**	**Construction**	**Operation**	**Closure**	**Post-Closure**
	Arctic Grayling Adult					Arctic Grayling Adult				Arctic Grayling Adult			
10	1831	1831	1830	1814	1814	0	-1	-17	-17	0.0%	0.0%	-0.9%	-0.9%
25	1756	1756	1751	1724	1724	0	-5	-32	-32	0.0%	-0.3%	-1.8%	-1.8%
50	**1454**	**1454**	**1468**	**1446**	**1446**	**0**	**13**	**-8**	**-8**	**0.0%**	**0.9%**	**-0.6%**	**-0.6%**
75	959	959	977	1004	1004	0	18	45	45	0.0%	1.8%	4.7%	4.7%
90	478	478	507	589	589	0	29	111	111	0.0%	6.0%	23.2%	23.2%
	Arctic Grayling Juvenile					Arctic Grayling Juvenile				Arctic Grayling Juvenile			
10	1609	1609	1608	1593	1593	0	0	-16	-16	0.0%	0.0%	-1.0%	-1.0%
25	1547	1547	1544	1535	1535	0	-4	-12	-12	0.0%	-0.2%	-0.8%	-0.8%
50	**1299**	**1299**	**1307**	**1313**	**1313**	**0**	**7**	**13**	**13**	**0.0%**	**0.6%**	**1.0%**	**1.0%**
75	916	916	918	940	940	0	2	24	24	0.0%	0.2%	2.6%	2.6%
90	420	420	444	513	513	0	24	93	93	0.0%	5.8%	22.2%	22.2%
	Arctic Grayling Fry					Arctic Grayling Fry				Arctic Grayling Fry			
10	1714	1714	1752	1847	1847	0	37	133	133	0.0%	2.2%	7.7%	7.7%
25	915	915	1004	1188	1188	0	88	273	273	0.0%	9.6%	29.8%	29.8%
50	**439**	**439**	**478**	**565**	**565**	**0**	**39**	**126**	**126**	**0.0%**	**8.8%**	**28.7%**	**28.7%**
75	277	277	289	317	317	0	12	39	39	0.0%	4.3%	14.2%	14.2%
90	203	203	201	207	207	0	-2	4	4	0.0%	-1.2%	1.8%	1.8%
	Arctic Grayling Spawning					Arctic Grayling Spawning				Arctic Grayling Spawning			
10	522	522	526	526	526	0	4	4	4	0.0%	0.7%	0.8%	0.8%
25	471	471	469	451	451	0	-2	-20	-20	0.0%	-0.3%	-4.1%	-4.1%
50	**300**	**300**	**293**	**266**	**266**	**0**	**-7**	**-34**	**-34**	**0.0%**	**-2.4%**	**-11.4%**	**-11.4%**
75	208	208	181	135	135	0	-27	-73	-73	0.0%	-12.9%	-35.3%	-35.3%
90	108	108	92	72	72	0	-16	-36	-36	0.0%	-14.7%	-33.3%	-33.3%

Habitat index values presented in **Tables 23 to 27** are expressed in m^2/1,000 meters of stream length. To determine the overall change in habitat in lower Casino Creek these values were converted to m^2 based on the total stream length affected, which is 6,500 m for Casino Creek, 8,500 meters for Dip Creek and 7,000 meters for Canadian Creek. **Table 28** presents the result of these calculations to show the overall change in habitat for the 50% habitat exceedance for each stream and project phase in addition to total available habitat.

Table 28. Usable habitat (m^2), total available habitat (m^2) and net change from baseline for Arctic grayling life stages for Casino Creek, Dip Creek and Canadian Creek under all project phases.

	Usable Habitat (m2)					Net Change in Usable Habitat from Baseline (m2)			
Stream	**Baseline**	**Construction**	**Operation**	**Closure**	**Post-Closure**	**Construction**	**Operation**	**Closure**	**Post-Closure**
	Arctic Grayling Adult					Arctic Grayling Adult			
Casino	14984	16940	16940	15687	13901	1956 (13.1%)	1956 (13.1%)	703 (4.7%)	-1083 (-7.2%)
Dip	36741	39321	39321	37346	35740	2579 (7.0%)	2579 (7.0%)	605 (1.6%)	-1001 (-2.7%)
Canadian	10179	10179	10273	10120	10120	0 (0.0%)	94 (0.9%)	-59 (-0.6%)	-59 (-0.6%)
	Arctic Grayling Juvenile					Arctic Grayling Juvenile			
Casino	13643	16197	16197	14423	12605	2555 (18.7%)	2555 (18.7%)	780 (5.7%)	-1038 (-7.6%)
Dip	32975	35623	35623	33537	32128	2648 (8.0%)	2648 (8.0%)	562 (1.7%)	-847 (-2.6%)
Canadian	9096	9096	9148	9189	9189	0 (0.0%)	52 (0.6%)	93 (1.0%)	93 (1.0%)
	Arctic Grayling Fry					Arctic Grayling Fry			
Casino	3040	6442	6428	3389	2679	3402 (111.9%)	3389 (111.5%)	349 (11.5%)	-360 (-11.8%)
Dip	5190	5027	5027	5178	5245	-164 (-3.2%)	-164 (-3.2%)	-13 (-0.3%)	54 (1.0%)
Canadian	3075	3075	3348	3957	3957	0 (0.0%)	272 (8.8%)	882 (28.7%)	882 (28.7%)
	Arctic Grayling Spawning					Arctic Grayling Spawning			
Casino	4029	874	872	3709	4340	-3155 (-78.3%)	-3157 (-78.4%)	-320 (-7.9%)	311 (7.7%)
Dip	7929	7783	7783	7839	7967	-147 (-1.9%)	-147 (-1.9%)	-90 (-1.1%)	38 (0.5%)
Canadian	2103	2103	2051	1863	1863	0 (0.0%)	-52 (-2.5%)	-240 (-11.4%)	-240 (-11.4%)
	Available Habitat (m^2)					**Net Change in Available Habitat from Baseline (m^2)**			
	Rearing (May 15 to Sept 30)					Rearing (May 15 to Sept 30)			
Casino	29959	28521	28523	29778	30203	-1438 (-4.8%)	-1437 (-4.8%)	-181 (-0.6%)	244 (0.8%)
Dip	90268	87926	87926	90022	90558	-2342 (-2.6%)	-2342 (-2.6%)	-245 (-0.3%)	291 (0.3%)
Canadian	35040	35040	34786	34239	34239	0 (0.0%)	-254 (-0.7%)	-801 (-2.3%)	-801 (-2.3%)
	Spawning (May 15 to June 30)					Spawning (May 15 to June 30)			
Casino	29426	27955	27985	29515	29662	-1472 (-5.0%)	-1441 (-4.9%)	89 (0.3%)	236 (0.8%)
Dip	87110	85139	85139	87283	87759	-1971 (-2.3%)	-1971 (-2.3%)	172 (0.2%)	648 (0.7%)
Canadian	36901	36901	36625	36123	36123	0 (0.0%)	-276 (-0.7%)	-778 (-2.1%)	-778 (-2.1%)

4.2 HEP Study

A Habitat Evaluation Procedure (HEP) study was carried out on the fish-bearing reaches of Upper Casino Creek, where the proposed TIA will completely remove available habitat in the creek. This includes reaches 2a and 2b, as well as Reach 3 and Meloy Creek, and Lower Britannia Creek (**Figure 1**).

Surveys in upper Casino Creek examined variables which may affect habitat quality and can be applied using HSI curves to determine net loss (**Appendix B**). All habitats were first surveyed, and each habitat feature was identified and measured. Measured habitat components were then tabulated, and usable habitat was calculated using HSI curves available for Arctic grayling. Major habitat features from the field surveys are shown in **Table 29**.

Table 29. Major Habitat Features in Upper Casino Creek

Habitat Feature	Total (%)	Reach 2a Brynelson to TIA (%)	Reach 2b TIA to Fish Barrier (%)
Pool [1]	7.9	12.0	6.1
Glide	6.6	5.9	6.9
Run	30.9	41.7	26.2
Low Gradient Riffle	28.2	34.0	25.6
High Gradient Riffle	26.4	6.4	35.2
Fines (Total Area)	4.0	5.5	3.4
Fines in Spawning Gravels	26.4	25.2	27.8

[1] *Includes Backwater (BW) Areas*

Total length and area for the three stream reaches examined in upper Casino Creek are given in **Table 30**, below. Estimates between Brynelson Creek and the identified seasonal barrier to fish migration are based on field measurements. Information between the identified seasonal barrier and the upper extent of the TIA is an estimate taken from a composite of mapping data in order to estimate total creek length affected, and an estimate of widths along this section of creek.

Table 30. Habitat Unit Areas for Upper Casino Creek

Stream Reach	Length (m)	Unadjusted Area (m^2)
Reach 2a - Brynelson Creek to TIA	1,601	5,979
Reach 2b - TIA to Fish Migration Seasonal Barrier	3,641	13,520
Reach 3 – Seasonal Barrier to Upper Extent of TIA	4,779	19,707
Meloy Creek	5,229	4,222
Total	**8,842**	**25,619**

After reviewing habitat data collected during the course of this study, as well as examining water quality data (maximum observed temperature and dissolved oxygen) collected during past sampling, it was determined that five variables would be used from the HSI model (**Table 31**). Scores based on suitability of measured values were calculated for each variable to determine habitat quality. The lowest score is applied to further calculations based on the assumption that the most limiting factor will have the most effect on fish habitat. Though overwinter habitat had the lowest score, a zero, applying this would result in no net habitat loss. This of course would not be appropriate because of known fish usage in summer in these reaches. The next lowest score in each reach was percentage of pools and backwaters, 12% in the reach between Brynelson Creek and the lower extent of the TIA, and 6% in the area from the TIA dam to the observed seasonal barrier to fish passage, and 8% in the area above the seasonal barrier.

Table 31. Summary of HSI variables for Upper Casino Creek

HSI Variable	Reach 2a - Brynelson to TIA		Reach 2b - TIA to Seasonal Fish Barrier		Reach 3 – Seasonal Barrier to Top of Watershed	
	Value %	Score	Value %	Score	Value %	Score
% Spawning Substrate	70	1.0	58	1.0	0	0
% Fines Spawning Areas	25	0.6	27	0.56	0	0
% Fines Total Area	5.5	1.0	3.4	1.0	7.7	1.0
% Pools and Backwaters	12	0.41	6	0.18	8	0.29
Overwinter Habitat[1]	0	0	0	0	0	0

[1] *Pools greater than 1.2 m in depth*

The HSI scores of 0.41, 0.18, and 0.29 were then applied to the unadjusted total area of each reach to determine net habitat loss (**Table 32**). The result is a net reduction of usable habitat of 2,451 m^2 in Reach 2a (the section of stream between Brynelson Creek and the proposed TIA), and 2,433 m^2 in Reach 2b

(between the TIA and the identified barrier to fish migration). Although a seasonal fish barrier was identified on Upper Casino Creek, a habitat evaluation was completed and net habitat loss calculated, based on percent pool rearing habitat as the limiting factor, based on the time of year that grayling can access this reach (summer and high flows).

A HEP study was conducted on Meloy Creek, a tributary of Casino Creek, as the proposed TIA will include the lower section of Meloy Creek. As the Meloy Creek valley consists of dense willow shrubs up to 2.5m in height, a sub-sampling technique was used to measure habitat for the HEP study. The lower 400m of the creek was measured, as this is the area most likely to be utilized by fish due to its proximity with Casino Creek. All habitats which could be accessed were measured for the HEP, with areas which were inaccessible due to dense vegetation inferred between measured sections of creek. During analysis, measured habitat was multiplied over the remaining length of creek which was not accessed during the time of the survey.

The bed of Meloy Creek consisted almost entirely of sand (*i.e*., fines) along its length (95.6% of total length) and contains almost no pool habitat. Therefore, a HSI score for adult Arctic grayling of 0.0 is appropriate for this creek. This HSI score was applied to the total area of Meloy Creek (calculated to be 4,222 m^2) to arrive at a calculated net habitat loss of 0 m (Table 32).

The Britannia Creek HEP study involved walking the reach of Britannia Creek from the Yukon River, to a location approximately 1 km upstream, where historic road activity had allowed the stream to “jump” from its historic channel and establish a new channel down the roadway. The habitat in this stretch is proposed to be lost as part of the construction of fish habitat compensation works at the mine site. Although some of the area within this reach (approximately 300 m length near the confluence with the Yukon River) is known to support juvenile Chinook salmon, the similarity in habitat usage between juvenile Chinook salmon and Arctic grayling allow the application of the HSI curves for Arctic grayling to be used in the HEP analysis.

The estimate of the net loss in habitat in this reach was based on the most limiting factor, in this case percent pool habitat. Using this limited habitat type, a HSI score of 0.25 was applied to the total area contained in the study reach (calculated to be 9535 m^2), in order to determine a final calculated net habitat loss of 2384 m^2.

Table 32. Net Habitat Loss in Upper Casino Creek Post-Project

Stream Reach	Unadjusted Area (m^2)	HSI Score Applied	Net Habitat Loss (m^2)
Reach 2a - Brynelson Creek to TIA	5,979	0.41	2,451
Reach 2b - TIA to Seasonal Fish Migration Barrier	13,520	0.18	2,433
Reach 3 - Seasonal Barrier to Upper Extent of TIA (Non-Fish Bearing)(incld Taylor Creek)	19,707	0.29	5715
Meloy Creek	4,222	0	0
Lower Britannia Creek	9,535	0.25	2384
Total	**48,741**	-	**12,983**

The estimate of net habitat loss was based on what was perceived as the most limiting factor, percent pool habitat for rearing, though other factors should also be considered. For example spawning habitat was found to be limited, though there is no evidence spawning takes place in these reaches. Additionally, had over-winter habitat (pools greater than 1.5 m in depth) been applied to this analysis the resulting habitat loss would have been zero. But it is unlikely that Arctic grayling use these stream reaches for over-wintering and basing the analysis on summer habitat is considered appropriate given our understanding of existing conditions and Arctic grayling life cycle.

5 DISCUSSION

The process of determining mitigation measures involves taking into account numerous factors. Instream flow studies using PHABSIM and HEP analysis are only one piece of the process and need to be discussed in the context of the long-range water and fishery management objectives desired by local regulatory agencies including Fisheries and Oceans Canada, Government of Yukon, the Yukon River panel and affected First Nations as well as fish habitat experts.

The study results must be put in context with other variables that may affect fish use and distribution such as water quality, temperature, and additional limiting factors that may be present. Initial results indicate that reduction in flows in Casino Creek downstream of the proposed project may have a minimal effect on Arctic grayling habitat.

Unlike the Habitat Evaluation Procedure (HEP) analysis which allows specific quantification of habitat loss due to the proposed project, the instream flow study conducted using PHABSIM modeling does not

provide a specific set of values based on habitat because it recognizes that flow related fish habitat requirements is not static. The time series analysis demonstrates how the amount of fish habitat will vary with flow under different flow scenarios and different life stages. Because the gain or loss of habitat varies by year and flow, there is no absolute estimate of net habitat change. In order to assess change in amount of habitat based on flow we can examine habitat that occurs at various exceedance intervals. The 50% habitat exceedance value (i.e., the median amount of habitat that occurs over the time period examined) was used to estimate habitat gains or losses due to changes in stream flow under the various phases of the project. Since lower and middle Casino Creek display virtually identical results, only those for lower Casino Creek are presented here.

Results from the instream flow studies using PHABSIM analysis indicate that there will be a small net gain in habitat for Arctic grayling adult and juvenile in lower Casino Creek downstream of the proposed project TIA, as well as in Dip Creek downstream of Casino Creek. However, the amount of spawning habitat in Casino Creek would be reduced. Whether this reduction in spawning habitat would have a significant effect on production is questionable given the low level of utilization and naturally low productivity of the existing habitat. At the same time, juvenile (fry) habitat would almost double in Casino Creek under predicted project flows, though again, if little spawning occurs in the reach this may not result in a significant increase in fisheries productivity. The net change in Arctic grayling habitat is based on a conservative estimate. Results based on alternate flows indicate an even greater increase in adult and juvenile habitat could take place, but with little difference in fry or spawning habitat. To determine the overall change in habitat in lower Casino Creek, values were converted to m^2 based on the total stream length affected, which is, 6,500 m for Casino Creek, 8,500 meters for Dip Creek and 7,000 meters for Canadian Creek.

The net change in habitat from the HEP analysis is based on the percent of pool and backwater habitat in the upper portions of Casino Creek. Pools and backwaters are considered critical to early life stages of Arctic grayling (and Chinook salmon in this area). Though other factors may be considered, it is assumed that the most limiting factor will control fish production and abundance. It should also be noted that spawning habitat is rare in the upper Casino Creek watershed and fish surveys have found no indication that spawning occurs there. The results presented here for habitat loss are therefore conservative, and habitat loss in these areas are unlikely to have significant impacts on the productivity of Arctic grayling, or the existing fish community as a whole.

6 CONCLUSIONS

Between June 2010 and July of 2013, in-stream flow studies using PHABSIM and HEP modeling analysis were conducted in order to examine potential impacts of the proposed Casino copper-gold project on fish habitat in Casino and Dip Creeks. These studies included: PHABSIM studies and modeling on lower Casino Creek and Dip Creek downstream of the confluence with Casino Creek in order to determine the impact of reduced flows due to the creation of a tailings management facility on Casino Creek, and a HEP study on upper Casino Creek in order to determine the loss of usable fish habitat due to the construction of the tailings management facility. Results of these studies were:

6.1 Lower Casino Creek

The reduction in flow in Casino Creek during construction and operation phases of the project results in a median increase in habitat for adult and juvenile grayling of between 16% and 22% for lower Casino Creek, and 10% to 15% for middle Casino Creek. This outcome is due to the tendency for these life stages to prefer lower velocities, as indicated by the Habitat Suitability Curves (HSC) (Hubert et al., 1985), and that at lower flows there is an increase in available low velocity refuge areas. Changes in habitat during the closure and post-closure phases are generally less than 10% based on the median habitat values.

Grayling fry habitat duration curves in both lower and middle Casino Creek exhibit similar results to adult and juvenile with increased habitat under project conditions. The median habitat values increase in the range of 95% for lower Casino Creek and around 125% for middle Casino Creek during construction and operation phases. Changes in habitat during the closure and post-closure phase are generally less than 7% to 15% based on the median habitat values.

Spawning is the only life stage which shows a decrease in habitat due to flow reduction during the projects construction and operation phases. The median habitat value percent change shows a decrease in lower Casino Creek (-72%) and middle Casino Creek (-83%) for the construction and operation phases of the project. This is an end result of lower availability of higher velocities generally used by grayling during spawning, the opposite condition of what is preferred during other life stages. Changes in habitat during the closure and post-closure phases are between 6% and 9% based on the median habitat values.

6.2 Dip Creek

Habitat for adult and juvenile grayling show a slight increase during construction and operation phases of the project. Fry and spawning life stages show virtually no difference in habitat during all project phases. The percentage change at the median habitat index value is between 7 and 8 per cent for juveniles and adults and a decrease of 2 to 3 per cent for fry and spawning life stages during construction and operation phases of the project. Habitat index values for closure phases differ little from baseline.

6.3 Upper Casino Creek

HEP analysis was used to estimate the changes in habitat for Arctic grayling in Upper Casino Creek. The estimate of net habitat loss was based the most limiting habitat factor of pool habitat for rearing. The result is a net reduction of usable habitat of 2,451 m^2 in Reach 2a (the section of stream between Brynelson Creek and the proposed TIA), and 2,433 m^2 in Reach 2b (between the TIA and the identified barrier to fish migration) (**Table 32**). A loss of potentially usable habitat of 5,715m^2 is anticipated from the upper reaches of Casino Creek, upstream of a seasonal fish barrier. This is a conservative estimate as it is unlikely that this area provides year-round or critical habitat for Arctic grayling. The TIA will also impact upon the lower reaches of Meloy Creek, although this creek was found not to provide useable habitat for Arctic grayling,

6.4 Lower Britannia Creek

HEP was used to evaluate the changes in habitat for both juvenile Chinook salmon and Arctic grayling. There will be some loss of habitat if offsetting plans proceed in this area. The historic channel would be reinstated and the flow from the existing channel would be diverted. The estimate of the net loss in habitat in this reach was based on the most limiting factor, the percent pool habitat. The final net habitat loss was calculated as 2,384m^2, which would be offset by proposed restoration works in this area.

6.5 Canadian Creek

There was no detectable change in habitat occurs for grayling adult and juvenile life stages under all project phases in Canadian Creek. A small increase in habitat for fry and a slight decrease in spawning habitat would occur during project closure phases. This equates to an increase in fry habitat by 28% and a decrease in spawning habitat of 11%.

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Appendix A

Lower Casino Creek Habitat Mapping Database

Appendix A. Lower Casino Creek Habitat Mapping Database

Unit #	Waypoint	Habitat Type [1]	Unit Length (m)	Total Distance (m)	Note:	UTM (7V) Easting	UTM (7V) Northing
0	122	Start			Brynelsen Creek	610892	6951173
1	123	Pool	39	39		610857	6951153
2	124	LGR	47	86		610820	6951125
3	125	Pool	23	109		610819	6951101
4	126	LGR	35	145	Split channel	610831	6951068
5	127	LGR	51	196		610836	6951017
6	128	Pool	15	211		610828	6951004
7	129	Run	25	235		610832	6950979
8	130	LGR	17	252		610844	6950970
9	131	Glide	18	270		610859	6950959
10	132	LGR	17	287		610874	6950948
11	133	Run	14	302		610887	6950944
12	134	Pool	13	315		610899	6950939
13	135	HGR	7	322		610906	6950935
14	136	Step-Run	29	351		610896	6950908
15	137	LGR	14	365		610890	6950896
16	138	Pool	11	376		610886	6950886
17	139	LGR	29	404		610868	6950863
18	140	Run	13	417		610859	6950853
19	141	LGR	47	464		610830	6950817
20	142	Pool	6	470		610832	6950811
21	143	Run	73	543		610808	6950743
22	144	LGR	30	572		610780	6950732
23	145	Pool	10	582		610773	6950725
24	146	LGR	13	595	Split unit	610777	6950712
25	147	Pool	8	603		610774	6950706
26	148	Pool	17	619	BW RB	610768	6950690
27	149	Run	21	641	Split	610779	6950672
28	150	LGR	40	681	Split	610786	6950631
29	151	Run	17	698		610784	6950614
30	152	LGR	16	714		610779	6950600
31	153	Glide	22	736		610774	6950579
32	154	LGR	19	755		610765	6950562
33	155	Run	21	776		610749	6950547
34	156	LGR	15	791		610736	6950539
35	157	Glide	24	815	BW LB	610716	6950525
36	158	LGR	17	832	Split channel begins	610701	6950519

Unit #	Waypoint	Habitat Type [1]	Unit Length (m)	Total Distance (m)	Note:	UTM (7V) Easting	UTM (7V) Northing
37	159	Run	63	895		610671	6950463
38	160	LGR	17	912		610664	6950447
39	161	Pool	14	927	Split channel ends	610665	6950432
40	162	LGR	22	949	Narrow; high flow chan LB	610656	6950412
41	163	Run	72	1021		610617	6950352
42	164	Glide	21	1042		610602	6950336
43	165	LGR	14	1056		610600	6950322
44	166	Pool	11	1067		610607	6950313
45	167	LGR	18	1085		610620	6950302
46	168	Run	21	1107		610619	6950280
47	169	Pool	14	1120		610608	6950272
48	170	Pool	9	1129	Corner	610600	6950274
49	171	Step-Run	43	1172	Corner	610588	6950233
50	172	Pool	21	1193		610601	6950216
51	173	LGR	28	1221		610604	6950187
52	174	Pool	17	1238		610591	6950176
53	175	LGR	14	1252		610582	6950166
54	176	Run	22	1273		610561	6950159
55	177	Pool	14	1287		610548	6950155
56	178	LGR	10	1297		610538	6950154
57	179	Pool	14	1311		610529	6950144
58	180	LGR	17	1327	BW LB	610517	6950132
59	181	Pool	16	1343		610501	6950132
60	182	LGR	7	1350		610494	6950130
61	183	Run	27	1376		610472	6950116
62	184	Pool	13	1389		610479	6950105
63	185	LGR	28	1417		610498	6950084
64	186	Pool	16	1433		610497	6950069
65	187	Pool	30	1463		610515	6950045
66	188	Pool	23	1486		610527	6950025
67	189	Glide	11	1497		610527	6950014
68	190	Run	22	1519	BW LB	610520	6949994
69	191	Pool	49	1568	Deep 1.5+ m	610491	6949954
70	192	LGR	12	1580	Split begins - follow RC	610478	6949952
71	193	Run	15	1595		610469	6949941
72	194	Pool	8	1603		610473	6949934
73	195	LGR	12	1615		610482	6949927
74	196	Pool	8	1623		610481	6949919

Unit #	Waypoint	Habitat Type [1]	Unit Length (m)	Total Distance (m)	Note:	UTM (7V) Easting	UTM (7V) Northing
75	197	LGR	12	1636		610472	6949911
76	198	Pool	8	1644		610473	6949903
77	199	LGR	8	1652		610480	6949900
78	200	Run	27	1679		610507	6949895
79	201	LGR	22	1701	Split Ends	610528	6949904
80	202	Pool	19	1719		610539	6949889
81	203	LGR	11	1731		610539	6949877
82	204	Run	19	1749		610545	6949860
83	205	Pool	10	1759		610549	6949851
84	206	Glide	21	1780		610556	6949831
85	207	Pool	34	1814		610549	6949797
86	208	Pool	12	1826		610538	6949794
87	209	LGR	9	1835	Split by cobble bar	610530	6949798
88	210	Run	20	1855		610518	6949814
89	211	LGR	9	1864		610510	6949818
90	212	Run	22	1886		610488	6949823
91	213	Run	25	1911		610465	6949816
92	214	Run	20	1931		610451	6949802
93	215	Run	30	1961		610446	6949772
94	216	LGR	16	1977	3-channels	610462	6949769
95	217	Run	37	2014		610480	6949736
96	218	Glide	64	2078		610530	6949697
97	219	Pool	15	2092		610533	6949682
98	220	Run	36	2128		610513	6949653
99	221	Pool	13	2141		610500	6949649
100	222	LGR	21	2162	BW LB	610482	6949638
101	223	Pool	7	2168		610476	6949636
102	224	LGR	8	2176		610471	6949629
103	225	Run	14	2190		610466	6949617
104	226	LGR	15	2204	BW RB	610464	6949603
105	227	Pool	22	2226		610470	6949581
106	228	LGR	27	2253		610463	6949556
107	229	Run	19	2272		610457	6949537
108	230	LGR	21	2293		610453	6949517
109	231	Run	21	2314		610455	6949496
110	232	Run	37	2351	Trib RB	610461	6949460
111	233	Glide	29	2380		610458	6949431
112	234	HGR	17	2397		610475	6949428

Unit #	Waypoint	Habitat Type [1]	Unit Length (m)	Total Distance (m)	Note:	UTM (7V) Easting	UTM (7V) Northing
113	235	Pool	8	2406		610484	6949427
114	236	Glide	60	2466		610538	6949400
115	237	Pool	8	2474		610537	6949393
116	238	HGR	10	2483	Split	610530	6949385
117	239	LGR	36	2519		610523	6949351
118	240	Run	28	2547		610518	6949323
119	241	Pool	10	2557	Corner	610518	6949313
120	242	LGR	10	2567		610518	6949302
121	243	Run	53	2620	Road xing	610494	6949256
122	244	LGR	17	2637		610479	6949245
123	245	Run	13	2650	BW RB	610469	6949238
124	246	LGR	11	2661		610463	6949230
125	247	Run	8	2669		610468	6949222
126	248	Pool	10	2679		610469	6949213
127	249	Glide	9	2688		610466	6949203
128	250	LGR	19	2707		610465	6949185
129	251	-	18	2725	Habitat type not noted	610463	6949167
130	252	Glide	23	2748		610473	6949146
131	253	LGR	15	2763		610483	6949134
132	254	Run	38	2801		610499	6949100
133	255	Pool	38	2839		610502	6949062
134	256	Run	21	2860		610503	6949041
135	257	Run	23	2883		610518	6949023
136	258	Pool	17	2900		610520	6949006
137	259	Pool	11	2911	LWD; corner	610512	6948998
138	260	Pool	18	2929	Corner	610494	6948998
139	261	LGR	11	2940		610484	6949002
140	262	Pool	9	2949	Eddy pool	610477	6949008
141	263	Run	22	2972		610455	6949001
142	264	Run	17	2989	Split; BW RB	610446	6948987
143	265	Run	17	3006		610433	6948975
144	266	Pool	10	3016		610424	6948980
145	267	LGR	12	3029		610421	6948991
146	268	Run	20	3048		610411	6949008
147	269	LGR	8	3056		610406	6949014
148	270	Run	19	3075		610387	6949017
149	271	Pool	19	3094		610368	6949013
150	272	Run	26	3120	Pocket -water-like; Bld	610358	6948990

Unit #	Waypoint	Habitat Type [1]	Unit Length (m)	Total Distance (m)	Note:	UTM (7V) Easting	UTM (7V) Northing
151	273	Run	97	3217		610355	6948893
152	274	Pool	42	3259		610384	6948862
153	275	LGR	12	3270		610390	6948853
154	276	Run	36	3307		610402	6948818
155	277	Glide	37	3344		610397	6948781
156	278	Pool	17	3361		610406	6948767
157	279	LGR	12	3372		610416	6948760
158	280	Run	20	3392		610422	6948742
159	281	Pool	9	3401		610422	6948733
160	282	Glide	26	3427		610419	6948707
161	283	Pool	13	3440		610408	6948699
162	284	Run	15	3455	Split by cobble bar	610393	6948705
163	285	Pool	2	3457	LWD	610391	6948704
164	286	Run	26	3483		610379	6948727
165	287	LGR	16	3499		610373	6948742
166	288	Pool	19	3518		610359	6948754
167	289	Glide	13	3531		610346	6948757
168	290	Pool	14	3545		610332	6948758
169	291	Pool	10	3555	Split; 1/3 riffle	610325	6948751
170	292	LGR	25	3580		610335	6948728
171	293	Run	21	3601		610345	6948709
172	294	LGR	21	3622		610355	6948691
173	295	Run	23	3645		610348	6948668
174	296	LGR	14	3659		610338	6948659
175	297	Pool	11	3670	S-corner	610327	6948662
176	298	Glide	39	3709		610291	6948678
177	299	Pool	12	3721		610279	6948679
178	300	Pool	24	3745		610257	6948669
179	301	HGR	14	3760		610243	6948674
180	302	Pool	14	3774		610234	6948664
181	303	LGR	14	3788		610235	6948648
182	304	Pool	14	3802	Corner	610246	6948641
183	305	Pool	20	3822		610266	6948639
184	306	Glide	26	3847		610275	6948616
185	307	LGR	22	3869		610281	6948594
186	308	Run	36	3905	1-step	610269	6948561
187	309	LGR	19	3924		610252	6948552
188	310	Pool	7	3931		610245	6948552

Unit #	Waypoint	Habitat Type [1]	Unit Length (m)	Total Distance (m)	Note:	UTM (7V) Easting	UTM (7V) Northing
189	311	Run	21	3953		610223	6948550
190	312	LGR	14	3966		610210	6948545
191	313	Glide	25	3991		610187	6948538
192	314	Pool	26	4017	Trib RB	610169	6948520
193	315	Pool	19	4035		610185	6948511
194	316	Run	29	4064	Split	610208	6948493
195	317	Pool	17	4082		610219	6948506
196	318	Run	29	4111		610247	6948502
197	319	LGR	16	4126		610254	6948488
198	320	Pool	11	4137		610259	6948478
199	321	Pool	21	4158		610242	6948465
200	322	LGR	8	4166		610235	6948463
201	323	Pool	12	4178		610236	6948451
202	324	LGR	20	4198		610235	6948431
203	325	Run	35	4234		610244	6948397
204	326	Pool	17	4251		610258	6948387
205	327	Pool	17	4268		610265	6948372
206	328	Pool	13	4281		610252	6948375
207	329	Pool	19	4300		610235	6948368
208	330	Run	16	4316		610227	6948354
209	331	Pool	24	4339	S-corner	610247	6948341
210	332	Run	25	4364		610251	6948317
211	333	Glide	15	4379		610247	6948302
212	334	Pool	11	4390		610242	6948292
213	335	LGR	11	4401		610232	6948288
214	336	Run	22	4423		610234	6948265
215	337	LGR	17	4440		610237	6948248
216	338	Run	42	4482	2-steps	610195	6948254
217	339	Pool	23	4505	S-corner	610184	6948273
218	340	Run	25	4530		610163	6948288
219	341	Glide	21	4551		610143	6948293
220	342	Pool	17	4568	Corner	610139	6948276
221	343	LGR	27	4596	Split + tree across	610135	6948249
222	344	Glide	27	4622		610133	6948223
223	345	LGR	15	4637		610137	6948209
224	346	Pool	10	4647		610143	6948201
225	347	LGR	12	4659		610152	6948192
226	121	Run	32	4691		610142	6948162

Unit #	Waypoint	Habitat Type [1]	Unit Length (m)	Total Distance (m)	Note:	UTM (7V) Easting	UTM (7V) Northing
227	120	Pool	14	4705		610129	6948167
228	119	Run	41	4746		610090	6948176
229	118	Pool	11	4757		610084	6948167
230	117	Glide	20	4777		610082	6948148
231	115	Run	20	4798	No WP 116	610086	6948127
232	114	Glide	34	4831		610078	6948095
233	113	LGR	36	4868		610049	6948073
234	112	Run	28	4896	Corner	610046	6948045
235	111	LGR	15	4911		610052	6948031
236	110	Pool	20	4931		610053	6948011
237	109	Run	28	4959		610047	6947983
238	108	LGR	15	4974		610052	6947969
239	107	Pool	7	4981	LWD	610059	6947971
240	106	LGR	12	4993		610071	6947969
241	105	Run	18	5011		610089	6947971
242	104	Pool	14	5025		610102	6947966
243	103	Pool	11	5037		610105	6947955
244	102	Glide	13	5050		610112	6947943
245	101	Run	17	5066		610124	6947931
246	100	Pool	11	5077		610132	6947923
247	99	Glide	14	5091		610137	6947910
248	98	Run	22	5113	1/3 riffle	610137	6947888
249	97	Pool	11	5125		610132	6947878
250	96	Run	15	5140		610118	6947870
251	95	Run	12	5152		610109	6947877
252	94	Run	25	5177		610085	6947884
253	93	Pool	22	5199	LWD, S-curve	610073	6947866
254	92	LGR	17	5216	1/3 run	610074	6947848
255	91	Pool	18	5234	S-curve	610088	6947837
256	90	Run	24	5258		610070	6947822
257	89	Glide	12	5270		610057	6947820
258	88	Run	64	5334		610004	6947785
259	87	Run	18	5352		609988	6947793
260	86	Pool	13	5365	Debris jam	609974	6947794
261	85	Step-Run	20	5385	2-steps	609961	6947780
262	84	Pool	18	5403		609977	6947771
263	83	Pool	20	5423	Log across channel	609987	6947754
264	82	LGR	11	5435		609982	6947744

Unit #	Waypoint	Habitat Type [1]	Unit Length (m)	Total Distance (m)	Note:	UTM (7V) Easting	UTM (7V) Northing
265	81	Pool	24	5459	S-corner	609962	6947731
266	80	LGR	21	5480	Split by bar	609943	6947739
267	79	Pool	17	5496		609934	6947724
268	78	LGR	17	5513		609929	6947709
269	77	Pool	12	5525	BW LB	609936	6947699
270	76	Pool	5	5530		609941	6947699
271	75	Pool	27	5557		609918	6947683
272	74	Glide	29	5586		609902	6947659
273	73	Pool	32	5618		609876	6947641
274	72	LGR	18	5636		609858	6947644
275	71	Pool	11	5646		609849	6947639
276	70	LGR	15	5661		609846	6947624
277	69	Run	11	5673		609844	6947613
278	68	Pool	9	5682		609853	6947616
279	67	LGR	19	5700		609866	6947630
280	66	Pool	14	5715		609880	6947625
281	65	Run	35	5750		609886	6947591
282	64	Pool	10	5760		609878	6947585
283	63	Run	35	5795		609842	6947585
284	62	Pool	12	5807		609833	6947579
285	61	LGR	16	5823		609837	6947563
286	60	Pool	16	5839	Debris jam	609824	6947552
287	59	Run	49	5888		609778	6947536
288	58	Pool	24	5912		609758	6947523
289	57	Run	1	5913	Same Run	609759	6947523
290	56	Run	18	5931	Split by bar	609760	6947505
291	55	Glide	33	5964		609748	6947475
292	54	Pool	13	5976		609737	6947468
293	53	Run	19	5996	Split unit	609722	6947480
294	52	Pool	18	6013		609708	6947469
295	51	LGR	27	6040		609686	6947454
296	50	Pool	15	6055		609671	6947454
297	49	Glide	30	6085		609641	6947448
298	48	Pool	20	6105		609626	6947462
299	47	LGR	24	6129		609635	6947485
300	46	Pool	22	6151		609614	6947482
301	45	Glide	15	6166		609600	6947486
302	44	Pool	21	6187		609595	6947466

Unit #	Waypoint	Habitat Type [1]	Unit Length (m)	Total Distance (m)	Note:	UTM (7V) Easting	UTM (7V) Northing
303	43	Pool	12	6198		609589	6947456
304	42	Run	52	6250		609583	6947404
305	41	Pool	9	6259		609589	6947397
306	40	Run	15	6274		609600	6947389
307	39	Pool	17	6291		609598	6947373
308	38	Run	21	6311		609577	6947370
309	37	Pool	18	6329		609561	6947360
310	36	LGR	14	6344		609548	6947356
311	35	Pool	17	6360		609540	6947341
312	34	Glide	72	6432		609562	6947273
313	33	LGR	21	6452		609568	6947253
314	32	Run	50	6502	Dip Creek Confluence	609597	6947213

1 LGR = Low Gradient Riffle; HGR = High Gradient Riffle;
Step-run is long sections of run separated by short riffle breaks

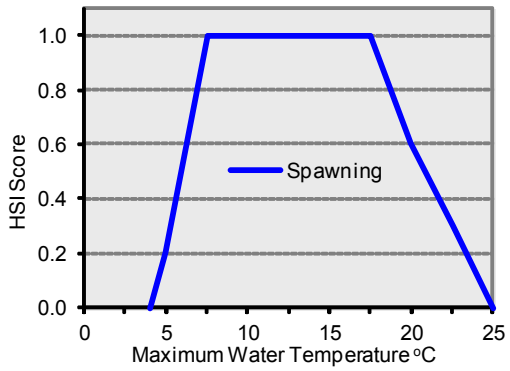
Appendix B

Habitat Evaluation Procedure (HEP) HSI Curves and Field Data from Upper Casino Creek

Arctic Grayling HSI Coordinates Hubert et al. 1985

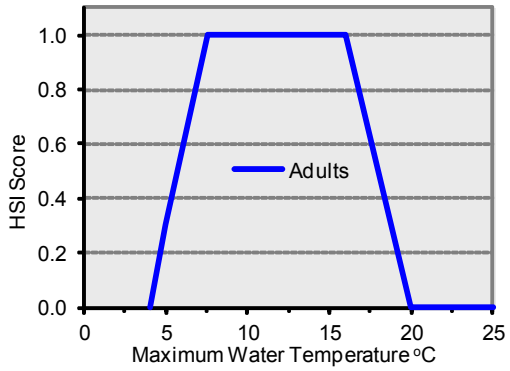
V1

Max Water Temp	Spawning
4.0	0.00
5.0	0.20
7.5	1.00
17.5	1.00
20.0	0.60
22.5	0.30
25.0	0.00



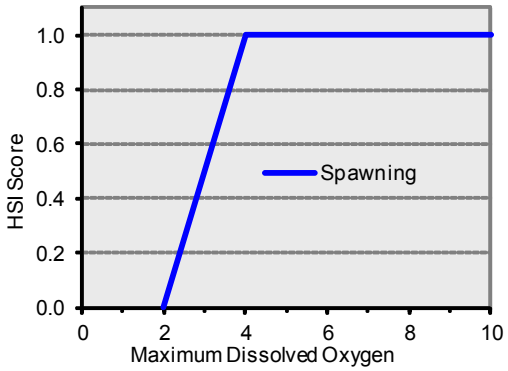
V7

Max Water Temp	Adults
4.0	0.00
5.0	0.30
7.5	1.00
16.0	1.00
20.0	0.00
25.0	0.00



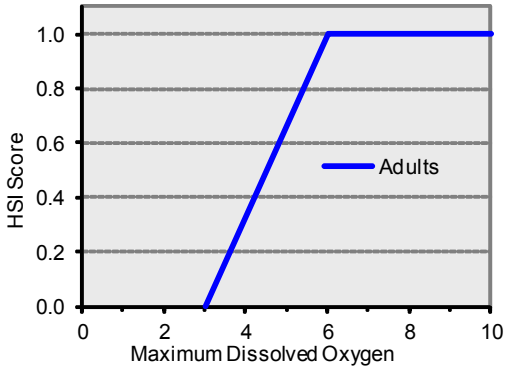
V2

Average DO	Spawning
2.0	0.00
4.0	1.00
10.0	1.00



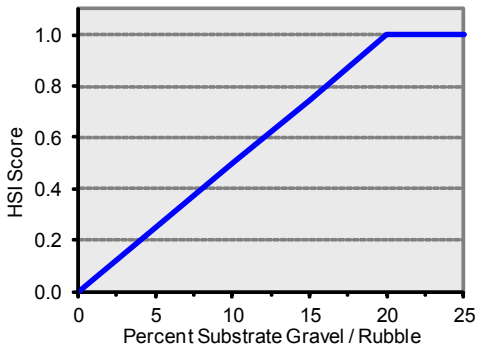
V8

Average DO	Adults
3.0	0.00
6.0	1.00
10.0	1.00



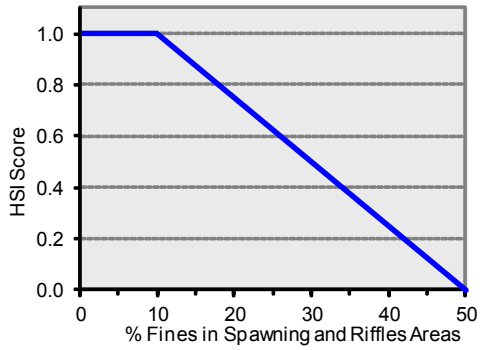
V3

Percent Spawning Gravel-Rubb	SI
0.0	0.00
5.0	0.25
10.0	0.50
15.0	0.75
20.0	1.00
25.0	1.00



V4

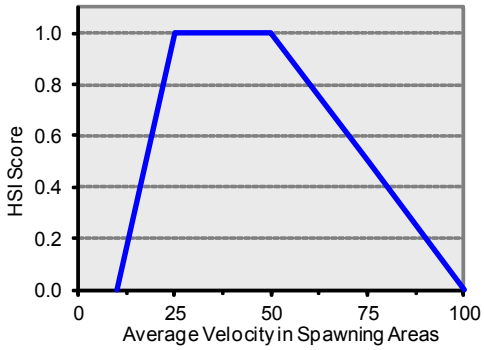
% Fines	SI
0.0	1.00
10.0	1.00
15.0	0.85
20.0	0.75
25.0	0.60
30.0	0.50
35.0	0.35
40.0	0.25
45.0	0.10
50.0	0.00



V5

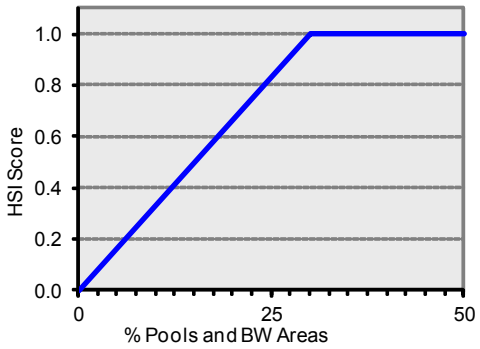
Avg. Velocity	SI
10.0	0.00
25.0	1.00
50.0	1.00
75.0	0.50
100.0	0.00

NOT USED



V6

% Pools	SI
0.0	0.00
5.0	0.15
10.0	0.35
15.0	0.50
20.0	0.65
25.0	0.85
30.0	1.00
50.0	1.00



V9 Tributary Access - NOT USED

V10 Occurrence of winter habitat - pools w/:

1) velocities less than 0.15 m/s
2) depths greater than 1.2 m

Appendix B – Field Data from Upper Casino Creek

	ALL HABITAT UNITS												POOLS	SPAWNING ONLY			NOTE:
						Substrate			Cover								
Unit #	Habitat Type	Total Length (m)	Unit Length (m)	Avg Unit Width (m)	Avg Unit Depth (m)	Dom	Sub	% Dom	Fry	%	Juv & Adult	%	Max Depth	% Gravel & Rubble	% Fines	Area (m^2)	
1	RUN	19.9	19.9	3.1	0.35	3	4	50			BANK	10					Start at
2	LGR	32.6	12.7	2.8	0.30	3	4	50			BANK	20					Brynelson
3	RUN	47.4	14.8	3.0	0.40	4	3	45			BANK	10					Creek
4	LGR	65.8	18.4	3.5	0.30	5	4	60			OVH	10					
5	POOL	77.4	11.6	3.1		3	2	55			OVH	10	1	75	15	2	
6	LGR	95.4	18.0	3.2	0.30	5	6	60									
6.1	BW		7.0	5.0	0.25						BANK	5					
7	RUN	117.3	21.9	3.0	0.40	4	4	45			BANK	5					
8	HGR	129.5	12.2	3.5	0.30	5	6	60			BANK	10					
9	RUN	155.0	25.5	3.2	0.50	5	4	65			BANK	10					
10	LGR	159.0	4.0	3.2	0.30	5	4	60									
11	RUN	172.8	13.8	2.8	0.40	4	3	40			OVH	10					
12	LGR	190.7	17.9	3.0	0.35	5	6	60									
13	HGR	199.8	9.1	4.2	0.30	6	5	40									
14	RUN	222.4	22.6	3.5	0.45	4	5	40			OVH	15					
15	LGR	230.4	8.0	3.4	0.35	5	6	50			OVH	10					
16	POOL	242.6	12.2	5.5	0.90	2	4	60	OVH	10	OVH	15	2				
17	HGR	255.4	12.8	4.0	0.40	6	5	50									
18	RUN	290.3	34.9	3.5	0.40	4	3	65			BANK	10					
19	LGR	303.7	13.4	10.7	0.30	5	6	40						80	10	2	
20	RUN	307.8	4.1	10.0	0.35	5	4	35	OVH	5	OVH	5		70	5	7	
21	S-RUN	335.4	27.6	2.5	0.40	5	6	55						70	5	7	
22	LGR	340.6	5.2	2.5	0.30	4	5	40									

	ALL HABITAT UNITS												POOLS	SPAWNING ONLY			NOTE:
				Avg	Avg	Substrate			Cover				Max	% Gravel			
Unit #	Habitat Type	Total Length (m)	Unit Length (m)	Unit Width (m)	Unit Depth (m)	Dom	Sub	% Dom	Fry	%	Juv & Adult	%	Depth	& Rubble	% Fines	Area (m^2)	
23	RUN	350.5	9.9	3.3	0.35	4	5	50	OVH	5	OVH	10					
24	LGR	354.9	4.4	5.5	0.25	5	4	35									
25	GLIDE	390.0	35.1	6.5	0.40	4	5	55	BANK	10	BANK	10		75	25	15	
26	POOL	398.2	8.2	5.2	0.60	3	2	40	BANK	10	BANK	10	0.8				
27	RUN	416.8	18.6	4.5	0.40	3	4	50	OVH	5	OVH	10					
28	LGR	438.4	21.6	4.0	0.30	5	10	60									
29	LGR	446	7.6	6.5	0.25	5	6	50									
29.1	BW	5	5	1	0.2	2	1	70									
30	RUN	470.1	24.1	4.5	0.5	4	3	50	BANK	10	BANK	10		60	35	9	
31	LGR	488.4	18.3	5	0.3	6	5	35									
32	RUN	497	8.6	4.2	0.4	4	2	50			OVH	10					
33	HGR	512.9	15.9	3.7	0.35	6	5	50									
34	RUN	522.2	9.3	0.4	0.4	4	6	30									
35	HGR	534.8	12.6	0.3	0.3	5	5	60									
36	LGR	547.4	12.6	0.3	0.3	4	4	40									
37	RUN	579.5	32.1	0.5	0.5	5	3	45	BANK	5	BANK	5		55	30	16	
38	LGR	587	7.5	0.4	0.4	3	4	55									
39	RUN	599	12	0.5	0.5	5	2	65									
40	HGR	624.3	25.3	0.35	0.35	5	6	45									
41	RUN	646.5	22.2	0.4	0.4	5	6	40	BANK	5	OVH	10					
42	LGR	658.5	12	0.3	0.3	5	6	60	BANK	10	OVH	15					
43	RUN	688	29.5	0.35	0.35	5	4	45			OVH	5					
44	POOL	702.9	14.9	0.4	0.4	5	4		BANK	5	BANK	10	0.6				
45	HGR	709.8	6.9	0.25	0.25	5	6	60									

	ALL HABITAT UNITS													POOLS	SPAWNING ONLY			NOTE:
						Substrate			Cover									
Unit #	Habitat Type	Total Length (m)	Unit Length (m)	Avg Unit Width (m)	Avg Unit Depth (m)	Dom	Sub	% Dom	Fry	%	Juv & Adult	%	Max Depth	% Gravel & Rubble	% Fines	Area (m^2)	
46	RUN	726.8	17	0.3	0.3	5	4	55									
46.1	Edge	5	5	0.2	0.2	2	3	35									
47	LGR	745.4	18.6	0.3	0.3	5	4	60									
48	HGR	759.9	14.5	0.3	0.3	6	5	50									
49	RUN	775.7	15.8	0.7	0.7	5	4	65									
49.1	Edge	4	4	0.4	0.4	2	3	60						80	30	4	
50	POOL	780	4.3	0.7	0.7	3	2	55									
50.1	Edge	8	8	0.2	0.2	2	3	50			WD	15					
51	S-RUN	847.9	67.9	0.4	0.4	5	4	65	OVH	5	BANK	10					
52	LGR	872.8	24.9	0.3	0.3	5	4	40									
53	LGR	889.2	16.4	9	0.2	5	6	55									
54	Pool	895.1	5.9	10	0.4	4	5	40	OVH	5	BANK	10	0.5				
55	LGR	898	2.9	10.5	0.2	4	5	35	BANK	10	BANK	15		70	35	10	
56	POOL	918.4	20.4	6.2	0.5	3	2	70									
57	LGR	932.7	14.3	4.4	0.35	5	4	50									
58	RUN	962.6	29.9	4.6	0.6	4	5	40									
59	LGR	980.6	18	4.8	0.3	5	6	65									
60	HGR	990.7	10.1	5.5	0.25	6	5	35									
60.1	BW	12.5	12.5	2.1	0.2	2	1	50									
61	POOL	1005.6	14.9	4	0.7	3	4	40	OVH	10	BANK	15	0.9				
62	S-RUN	1029.8	24.2	3.8	0.45	4	5	40			BANK	5					
63	LGR	1048.7	18.9	5.1	0.3	5	6	60									
64	GLIDE	1075.3	26.6	4.7	0.6	3	2	40	OVH	10	BANK	15		50	40	10.5	
65	POOL	1092.3	17	5	0.5	3	4	50			BANK	15					

	ALL HABITAT UNITS													POOLS	SPAWNING ONLY			NOTE:
						Substrate			Cover						%			
Unit #	Habitat Type	Total Length (m)	Unit Length (m)	Avg Unit Width (m)	Avg Unit Depth (m)	Dom	Sub	% Dom	Fry	%	Juv & Adult	%	Max Depth	Gravel & Rubble	% Fines	Area (m^2)	
66	LGR	1110.4	18.1	4.5	0.35	5	4	70									
67	POOL	1123.5	13.1	4.9	0.4	4	3	55	OVH	5	OVH	5	0.7				
68	HGR	1131.7	8.2	6.5	0.2	5	4	75									
69	S-RUN	1209.6	77.9	4.4	0.35	4	6	35	OVH	5	BANK	5					
70	LGR	1219.3	9.7	4.5	0.3	5	6	45									
71	RUN	1246.5	27.2	3.9	0.4	5	4	65			BANK	5					
72	LGR	1253.7	7.2	4	0.3	6	5	40									
73	RUN	1266.7	13	4.4	0.4	4	5	45									
74	LGR	1284.5	17.8	4.7	0.35	5	6	45									
75	RUN	1301.6	17.1	5.1	0.4	5	4	60									
75.1	BW	1008	8	1.5	0.2	4	5	50									
76	LGR	1311.3	9.7	4.2	0.3	5	6	60									
77	POOL	1314	2.7	3.5	0.5	5	4	40	BANK	10	BANK	10	0.9				
78	RUN	1330.1	16.1	4	0.6	5	4	50			OVH	10					
79	POOL	1333.2	3.1	3.8	0.7	4	3	60					0.8				
79.1	BW	1002	2	2	0.3	2	1	70									
80	LGR	1338.7	5.5	4.1	0.2	4	3	45									
81	RUN	1357.2	18.5	3.8	0.6	4	3	50	OVH	10	LWD	20					
82	LGR	1374.5	17.3	3.7	0.3	5	4	40									
83	RUN	1390.1	15.6	3.7	0.4	5	4	40									
84	LGR	1398.8	8.7	3.5	0.35	5	6	50									
85	S-RUN	1426.5	27.7	3.8	0.4	5	4	60									
86	LGR	1445.9	19.4	13.5	0.2	4	5	50									
87	LGR	1455.8	9.9	12.5	0.2	5	4	35									

	ALL HABITAT UNITS												POOLS	SPAWNING ONLY			NOTE:
				Avg	Avg	Substrate			Cover				Max	% Gravel			
Unit #	Habitat Type	Total Length (m)	Unit Length (m)	Unit Width (m)	Unit Depth (m)	Dom	Sub	% Dom	Fry	%	Juv & Adult	%	Depth	& Rubble	% Fines	Area (m^2)	
87.1	BW	1015	2	6.2	0.3	2	4	40									
88	POOL	1468.8	13	4.1	0.5	4	3	45	OVH	10	LWD	10	0.7				
89	LGR	1476.5	7.7	6	0.25	5	4	60									
90	RUN	1483.9	7.4	6.4	0.4	5	4	50									
91	LGR	1499.1	15.2	4.3	0.35	5	6	65									
92	RUN	1567.1	68	4	0.4	5	4	70			BANK	10					
93	HGR	1582.2	15.1	4.1	0.35	5	6	50									
94	RUN	1595.9	13.7	3.7	0.4	5	4	60	OVH	10	BANK	15					
95	LGR	1605	9.1	4	0.3	5	6	55									
96	RUN	1616.9	11.9	4.1	0.35	6	5	35			BANK	5					Approx TIA
97	LGR	1653.7	36.8	4	0.45	4	6	45									
97.1	Edge	1003	3	1.5	0.3	3	4	35									
98	LGR	1671.9	18.2	3.5	0.3	5	6	40									
99	HGR	1686.8	14.9	3.6	0.35	6	5	30									
100	RUN	1700	13.2	4.1	0.4	5	4	60	OVH	5	BANK	10					
101	LGR	1708.7	8.7	4	0.3												
102	RUN	1716.3	7.6	4.5	0.45	4	5	40									
103	HGR	1755.9	39.6	3.5	0.35	5	6	50									
103.1	BW	1000	9	3.1	0.4	1	3	40	OVH	10							
104	LGR	1764	8.1	5.5	0.25	4	6	35									
105	RUN	1774.6	10.6	5.2	0.6	4	3	30	OVH	10	BANK	10					
106	LGR	1812.9	38.3	6.2	0.3	5	6	60									
107	RUN	1836.5	23.6	3.5	0.5	5	4	45	OVH	5	LWD	10					
108	LGR	1855.5	19														

	ALL HABITAT UNITS													POOLS	SPAWNING ONLY			NOTE:
						Substrate			Cover						%			
Unit #	Habitat Type	Total Length (m)	Unit Length (m)	Avg Unit Width (m)	Avg Unit Depth (m)	Dom	Sub	% Dom	Fry	%	Juv & Adult	%	Max Depth	Gravel & Rubble	% Fines	Area (m^2)	
108.1	Edge	1003.5	3.5	0.7	0.2	2	3	75									
109	S-RUN	1870.3	14.8	4.1	0.5	5	4	65									
110	POOL	1880.7	10.4	4.2	0.6	4	2	40			OVH	10					
111	LGR	1887.2	6.5	3.8	0.4	5	6	50									
112	RUN	1896	8.8	4.5	0.4	5	6	40	OVH	10	BANK	15					
113	LGR	1908.7	12.7	5.5	0.3	5	4	65									
114	POOL	1930.9	22.2	4.7	0.65	3	2	30	OVH	10	OVH	10	1.05	80	20	20	
114.1	BW	1013.2	13.2	1	0.1	2	1	75									
115	RUN	1955	24.1	3.8	0.5	4	5	40			BANK	5					
116	POOL	1960.9	5.9	3.2	0.5	4	5	40			LWD	5	0.7				
117	LGR	1986.3	25.4	4.1	0.3	5	6	40									
118	RUN	2025.7	39.4	3.5	0.5	5	6	45									
119	LGR	2046.1	20.4	3.2	0.4	5	6	50									
120	HGR	2059.5	13.4	3.4	0.4	6	5	30									
121	RUN	2077.6	18.1	3.5	0.55	6	5	35			BANK	10					
122	LGR	2092.8	15.2	3.5	0.35	5	6	50									
123	RUN	2109.4	16.6	3.6	0.45	5	4	40			BANK	10					
124	HGR	2115.9	6.5	3.7	0.3	5	6	60									
125	LGR	2129	13.1	4	0.3	5	4	65									
126	RUN	2141.5	12.5	4.5	0.6	5	4	50	OVH	5	BANK	10					
127	HGR	2150.8	9.3	5.3	0.2	6	5	50									
128	GLIDE	2166.9	16.1	6	0.4	4	3	35	BANK	10	BANK	10		50	30	11	
129	POOL	2178	11.1	5.1	0.5	5	4	30	OVH	5	OVH	10	0.65				
130	LGR	2189.8	11.8	5.2	0.2	5	4	40									

	ALL HABITAT UNITS													POOLS	SPAWNING ONLY			NOTE:
						Substrate			Cover						%			
Unit #	Habitat Type	Total Length (m)	Unit Length (m)	Avg Unit Width (m)	Avg Unit Depth (m)	Dom	Sub	% Dom	Fry	%	Juv & Adult	%	Max Depth	Gravel & Rubble	% Fines	Area (m^2)	
131	RUN	2197.5	7.7	4.3	0.4	5	4	45									
132	LGR	2223.2	25.7	4.5	0.3	5	6	35									
133	RUN	2238.7	15.5	4.5	0.4	4	5	30									
134	LGR	2251.6	12.9	4.3	0.3	6	5	35									
135	POOL	2268.4	16.8	4.4	0.5	4	5	40	OVH	10	LWD	25	0.65				
136	LGR	2282	13.6	4.7	0.3	4	5	45	OVH	5	BANK	10					
137	HGR	2290.5	8.5	4.7	0.2	6	5	50									
138	RUN	2309.2	18.7	5	0.3	4	5	50	OVH	10	BANK	15					
139	HGR	2323.9	14.7	5.1	0.3	5	6	40									
140	POOL	2342.3	18.4	4.7	0.5	4	3	30	OVH	10	BANK	10	0.75				
141	LGR	2352.5	10.2	6.1	0.35	5	4	35									
142	RUN	2397.3	44.8	4.6	0.4	5	4	35			BANK	5					
143	LGR	2432.2	34.9	5	0.3	6	5	35									
144	S-RUN	2468	35.8	4.2	0.4	6	5	35									
145	LGR	2513	45														
146	HGR	2541.1	28.1	5.8	0.3	5	6	45									
147	RUN	2572	30.9	4.6	0.35	4	5	35	OVH	5	BANK	10					
148	LGR	2582	10	6.1	0.2	4	5	45									
149	RUN	2607.7	25.7	3.5	0.35	5	4	40	OVH	5	BANK	10					
150	HGR	2622.3	14.6	6	0.25	6	5	35									
150.1	BW	2637	11.3	1.3	0.2	1	4	50									
151	RUN	2691.1	68.8	5.4	0.4	4	3	35	OVH	10				70	25	36	
152	LGR	2738.2	47.1	4.3	0.35	5	6	40									
153	HGR	2772	33.8	5.3	0.3	6	5	40									

	ALL HABITAT UNITS												POOLS	SPAWNING ONLY			NOTE:
				Avg	Avg	Substrate			Cover					%			
Unit #	Habitat Type	Total Length (m)	Unit Length (m)	Unit Width (m)	Unit Depth (m)	Dom	Sub	% Dom	Fry	%	Juv & Adult	%	Max Depth	Gravel & Rubble	% Fines	Area (m^2)	
154	LGR	2801.8	29.8	5.1	0.25	6	5	30	OVH	5	BANK	5					
155	RUN	2830.5	28.7	4.5	0.4	5	4	55									
156	HGR	2860.9	30.4	3.8	0.35	5	6	40									
157	RUN	2887.8	26.9	3.5	0.3	5	6	45			BANK	5					
158	S-RUN	2917.3	29.5	3.3	0.4	5	6	35									
159	HGR	2931.5	14.2	3.2	0.3	6	5	50									
160	RUN	2942.4	10.9	3.5	0.35	6	5	50									
161	HGR	2972.5	30.1	3	0.35	6	5	40									
162	S-RUN	2992.1	19.6	3.6	0.4	4	6	30									
163	HGR	3024.9	32.8	3.4	0.3	6	5	40									
164	RUN	3084	59.1	3.4	0.4	6	5	40									
165	LGR	3107	23	3.2	0.3	5	6	35									
166	RUN	3122.9	15.9	3.1	0.25	5	4	60									
167	LGR	3186	63.1	4.5	0.25	4	3	50									
168	RUN	3218.8	32.8	3.2	0.3	4	3	40									
169	LGR	3257.4	38.6	3	0.35	5	6	35									
170	POOL	3267.1	9.7	2.8	0.4	5	4	45	OVH	5	BANK	10	0.55				
171	HGR	3276.2	9.1	3	0.35	6	5	40									
172	RUN	3283.4	7.2	2	0.4	4	3	45									
173	LGR	3307.8	24.4	4.2	0.25	5	6	35									
174	HGR	3329.7	21.9	3.3	0.25	5	6	50									
175	RUN	3345.9	16.2	3.7	0.4	4	5	40			BANK	5					
176	LGR	3399.7	53.8	3	0.25	5	6	45									
177	RUN	3413.8	14.1	3.1	0.45	5	4	40			BANK	10					

	ALL HABITAT UNITS													POOLS	SPAWNING ONLY			NOTE:
						Substrate			Cover						%			
Unit #	Habitat Type	Total Length (m)	Unit Length (m)	Avg Unit Width (m)	Avg Unit Depth (m)	Dom	Sub	% Dom	Fry	%	Juv & Adult	%	Max Depth	Gravel & Rubble	% Fines	Area (m^2)	
178	HGR	3463.8	50	3.5	0.35	6	5	35									
179	RUN	3473.7	9.9	3.7	0.4	5	4	50			BANK	5					
180	LGR	3488.8	15.1	3.1	0.3	5	6	40									
181	S-RUN	3504.2	15.4	2.9	0.4	6	5	30									
182	POOL	3508.8	4.6	2	0.6	5	4	35	OVH	5	BANK	10	0.9				
183	HGR	3522	13.2	4.5	0.35	5	6	40									
184	RUN	3535.7	13.7	3.2	0.4	5	4	30	OVH	5	BANK	10					
185	HGR	3561.2	25.5	4	0.25	5	4	55									
186	RUN	3580.4	19.2	2.5	0.5	5	6	45									
187	LGR	3580.4	19.2	1.7	0.2	5	6	45									
188	GLIDE	3602.5	22.1	3.1	0.35	4	3	35	OVH	5	BANK	10		55	30	36	
189	RUN	3621.4	18.9	2.8	0.35	6	5	30			BANK	5					
190	HGR	3643.1	21.7	3.2	0.35	6	5	35									
191	RUN	3649.9	6.8	3.2	0.3	5	6	40									
192	HGR	3688.7	38.8	4.2	0.35	6	5	35									
192.1	BW	3084.8	7.5	1.3	0.45	3	4	50									
193	RUN	3715.9	27.2	3.3	0.45	4	5	40	OVH	10	BANK	10					
194	HGR	3738.4	22.5	3	0.35	6	5	50									
195	RUN	3744.6	6.2	2.6	0.4	4	5	40									
196	HGR	3753.7	9.1	2.5	0.4	6	5	40									
197	RUN	3762.8	9.1	2.1	0.5	5	4	50	OVH	10	BANK	15					
198	HGR	3777.1	14.3	3.3	0.25	6	5	45									
199	POOL	3784	6.9	2.3	0.4	5	4	35					0.6				
200	HGR	3812	28	2.5	0.35	5	6	40									

	ALL HABITAT UNITS												POOLS	SPAWNING ONLY			NOTE:
						Substrate			Cover								
Unit #	Habitat Type	Total Length (m)	Unit Length (m)	Avg Unit Width (m)	Avg Unit Depth (m)	Dom	Sub	% Dom	Fry	%	Juv & Adult	%	Max Depth	% Gravel & Rubble	% Fines	Area (m^2)	
201	RUN	3820.8	8.8	3	0.45	5	4	50	OVH	5	BANK	5					
202	LGR	3841.9	21.1	3	0.25	5	6	40									
203	RUN	3857.7	15.8	3.2	0.4	5	4	45									
204	LGR	3871.5	13.8	2.6	0.35	5	6	45									
205	RUN	3877.6	6.1	2.5	0.35	6	5	35									
206	HGR	3900.8	23.2	6.4	0.25	5	6	40									
207	LGR	3930.7	29.9	3.7	0.35	5	4	50									
208	RUN	3945	14.3	2	0.4	5	4	35			BANK	5					
209	HGR	3945	0	5	0.25	5	4	45									
210	RUN	3976.7	31.7	2.5	0.5	4	5	40	OVH	5	BANK	10					
211	LGR	3986.1	9.4	2.7	0.3	6	5	30									
212	RUN	3993.4	7.3	2.5	0.4	5	6	40									
213	HGR	4009.6	16.2	2.8	0.3	6	5	30									
214	S-RUN	4030.1	20.5	2.5	0.35	5	4	35									
215	HGR	4037.9	7.8	2.4	0.35	6	5	30									
216	LGR	4057.5	19.6	2.2	0.3	5	6	40									
217	HGR	4072.6	15.1	2.4	0.35	6	5	30									
218	LGR	4136.6	64	2.5	33	6	5	80			OVH	5					
219	HGR	4145.6	9	2.7	25	6	5	80									
220	POOL	4149.2	3.6	3.7	32	5	4	60			SUB	5	46				
221	POOL	4154.7	5.5	2.9	34	5	4	60			OVH	10	44				
222	HGR	4202.3	47.6	3	35	4	6	70			OVH	15					
223	POOL	4214.6	12.3	3.4	50	5	2	80			OVH	10					
224	HGR	4239.1	24.5	3.4	27	5	4	60			LWD	5					

	ALL HABITAT UNITS													POOLS	SPAWNING ONLY			NOTE:
						Substrate			Cover									
Unit #	Habitat Type	Total Length (m)	Unit Length (m)	Avg Unit Width (m)	Avg Unit Depth (m)	Dom	Sub	% Dom	Fry	%	Juv & Adult	%	Max Depth	% Gravel & Rubble	% Fines	Area (m^2)	
225	LGR	4247.9	8.8	3.8	30	5	4	60			SUB	5					
226	POOL	4253.8	5.9	2.9	40	6	2	60			OVH	15	54				
227	POOL	4262.4	8.6	2.5	42	5	4	60			OVH	15	56				
228	HGR	4280.2	17.8	2.8	25	6	5	70									
229	GLIDE	4291.3	11.1	2.5	38	4	5	70			OVH	5					
230	HGR	4346.8	55.5	3.2	26	6	5	60									
231	POOL	4366.3	19.5	3.5	55	6	2	50			LWD	20	65				
232	HGR	4490.4	124.1	3.2	35	6	4	50			OVH	5					
233	GLIDE	4505.6	15.2	4.6	32	5	4	60			OVH	5					
234	LGR	4516.7	11.1	4.4	22	4	5	70									
235	HGR	4524.3	7.6	4.4	43	6	4	60									
236	POOL	4530	5.7	2.4	60	2	4	70			OVH	30	67				
237	HGR	4542.6	12.6	5.5	25	6	5	60									
238	POOL	4550.2	7.6	2.5	60	5	4	80			OVH	40	75				
239	LGR	4560.3	10.1	5	24	6	4	50									
240	GLIDE	4588.1	27.8	4	30	6	5	50			OVH	5					
241	HGR	4598.4	10.3	2.9	37	6	5	80			SUB	10					
242	GLIDE	4616.3	17.9	3.4	36	6	5	60			OVH	10					
243	HGR	4658.1	41.8	3.9	28	6	5	70									
244	GLIDE	4671.3	13.2	4.5	28	5	4	60			OVH	15					
245	HGR	4677.3	6	4.1	20	6	5	70									
246	POOL	4683.5	6.2	4.1	45	6	4	50			SUB	20	59				
247	GLIDE	4698	14.5	3.5	35	5	4	50			SUB	10					
248	HGR	4708.4	10.4	3.2	36	6	5	80			SUB	10					

	ALL HABITAT UNITS													POOLS	SPAWNING ONLY			NOTE:
						Substrate			Cover						%			
Unit #	Habitat Type	Total Length (m)	Unit Length (m)	Avg Unit Width (m)	Avg Unit Depth (m)	Dom	Sub	% Dom	Fry	%	Juv & Adult	%	Max Depth	Gravel & Rubble	% Fines	Area (m^2)	
249	GLIDE	4725.1	16.7	4.3	35	4	5	60									
250	HGR	4762.4	37.3	3.6	27	6	5	75			SUB	10					
251	LGR	4771	8.6	3.9	30	5	4	60			SUB	15					
252	HGR	4780.6	9.6	5.3	25	6	4	60									
253	GLIDE	4797.2	16.6	3.4	35	4	5	70									
254	HGR	4813.2	16	5	20	6	5	75									
255	HGR	4826.2	13	2.6	30	1	2	80			LWD	80					
256	GLIDE	4836.4	10.2	4.5	35	6	1	70									
257	HGR	4843.8	7.4	1.6	52	6	5	75									
258	LGR	4850.4	6.6	4	21	1	2	90									
259	POOL	4855.5	5.1	2.2	48	1	2	90					80				
260	LGR	4863.7	8.2	3.2	23	1	2	80									
261	GLIDE	4870.8	7.1	2.4	65	3	2	70			LWD	20					
262	POOL	4875.6	4.8	2.6	50	3	2	60			LWD	40	73				
263	RUN	4886.6	11	3.2	30	3	1	60			LWD	50					
264	LGR	4890.9	4.3	1.5	13	5	6	70									
265	HGR	4894.7	3.8	3.2	32	6	4	60			OVH	20					
266	RUN	4905	10.3	4.7	40	5	4	60			OVH	35					
267	LGR	4937.9	32.9	4.1	31	6	5	50									
268	HGR	4964.7	26.8	5	20	6	5	90									
269	GLIDE	4976.2	11.5	4.8	22	6	4	50			SUB	15					
270	HGR	4985.9	9.7	2.9	34	6	5	80			SUB	10					
271	RUN	4993.3	7.4	2.8	40	4	6	60			OVH	20					
272	HGR	4999.7	6.4	4.9	25	6	5	70			SUB	20					

	ALL HABITAT UNITS												POOLS	SPAWNING ONLY			NOTE:
				Avg	Avg	Substrate			Cover					%			
Unit #	Habitat Type	Total Length (m)	Unit Length (m)	Unit Width (m)	Unit Depth (m)	Dom	Sub	% Dom	Fry	%	Juv & Adult	%	Max Depth	Gravel & Rubble	% Fines	Area (m^2)	
273	GLIDE	5009.6	9.9	3.9	34	6	4	60			SUB	30					
274	HGR	5047.7	38.1	3.6	32	6	5	70			SUB	20					
275	POOL	5055.1	7.4	3.6	65	6	5	50			SUB	20					
276	HGR	5095.3	40.2	3.1	42	6	5	65			BNK	10					
277	GLIDE	5101.2	5.9	3.2	36	6	5	50			OVH	30					
278	HGR	5113.2	12	3.8	31	6	5	50			SUB	10					
279	GLIDE	5120.5	7.3	3.6	32	6	5	50			SUB	10					
280	HGR	5161.2	40.7	3.1	27	6	5	80			SUB	20					
281	POOL	5167.4	6.2	3.3	40	4	3	60			LWD	30	54				
282	HGR	5199.9	32.5	4.5	24	6	5	60			SUB	10					
283	GLIDE	5211.7	11.8	4.7	32	6	5	50									
284	HGR	5229.6	17.9	3.9	37	6	5	40									
285	POOL	5234.1	4.5	4.4	58	4	3	60			SUB	20	65				
286	HGR	5240.8	6.7	3.2	35	6	5	70			SUB	30					

Appendix C

Lower Casino Creek and Dip Creek PHABSIM Calibration Data

Casino Creek - Final Calibration Summary
CAS2 and CAS1 Study Sites Combined

CROSS-SECTION # 1 CAS2 RUN119
Points = 27
Slope = .0025
SZF = 98.2

Cross-section represents 6.050% of Total Reach.

>>> WSL Calibrations <<<
WSL Calculation Method: Channel Conveyance
Channel Conveyance Equation: Manning N
Use Weighted Area Hydraulic Radius: Yes
Reduce Hydraulic Radius to HR at S.Z.F.: Yes
BETA = .3692
>>> Velocity Calibrations <<<
Vel Calculation Method: 1-vel calibration
Vel Algorithm: Manning's N
Use Given N's: Yes
Vels calibrated to VelSet: 1

CROSS-SECTION # 2 CAS2 RUN121
Points = 26
Slope = .0025
SZF = 98.4

Cross-section represents 6.050% of Total Reach.

>>> WSL Calibrations <<<
WSL Calculation Method: Channel Conveyance
Channel Conveyance Equation: Manning N
Use Weighted Area Hydraulic Radius: Yes
Reduce Hydraulic Radius to HR at S.Z.F.: Yes
BETA = .415
>>> Velocity Calibrations <<<
Vel Calculation Method: 1-vel calibration
Vel Algorithm: Manning's N
Use Given N's: Yes
Vels calibrated to VelSet: 1

CROSS-SECTION # 3 CAS2 LGR347
Points = 34
Slope = .0025
SZF = 98.43

Cross-section represents 4.710% of Total Reach.

>>> WSL Calibrations <<<
WSL Calculation Method: Channel Conveyance
Channel Conveyance Equation: Manning N
Use Weighted Area Hydraulic Radius: Yes
Reduce Hydraulic Radius to HR at S.Z.F.: Yes
BETA = .09
>>> Velocity Calibrations <<<
Vel Calculation Method: 1-vel calibration
Vel Algorithm: Manning's N
Use Given N's: Yes
Vels calibrated to VelSet: 1

CROSS-SECTION # 4 CAS2 POOL346
Points = 26
Slope = .0025
SZF = 98.6

Cross-section represents 5.540% of Total Reach.

>>> WSL Calibrations <<<
WSL Calculation Method: Channel Conveyance
Channel Conveyance Equation: Manning N
Use Weighted Area Hydraulic Radius: Yes
Reduce Hydraulic Radius to HR at S.Z.F.: Yes
BETA = .34
>>> Velocity Calibrations <<<
Vel Calculation Method: 1-vel calibration
Vel Algorithm: Manning's N
Use Given N's: Yes
Vels calibrated to VelSet: 1

CROSS-SECTION # 5 CAS2 LGR345
Points = 29
Slope = .0025
SZF = 98.06

Cross-section represents 4.710% of Total Reach.

>>> WSL Calibrations <<<
WSL Calculation Method: Channel Conveyance
Channel Conveyance Equation: Manning N
Use Weighted Area Hydraulic Radius: Yes
Reduce Hydraulic Radius to HR at S.Z.F.: Yes
BETA = .4717668
>>> Velocity Calibrations <<<
Vel Calculation Method: 1-vel calibration
Vel Algorithm: Manning's N
Use Given N's: Yes
Vels calibrated to VelSet: 1

CROSS-SECTION # 6 CAS2 GLD344
Points = 30
Slope = .0025
SZF = 98.15

Cross-section represents 3.120% of Total Reach.

>>> WSL Calibrations <<<
WSL Calculation Method: Channel Conveyance
Channel Conveyance Equation: Manning N
Use Weighted Area Hydraulic Radius: Yes
Reduce Hydraulic Radius to HR at S.Z.F.: Yes
BETA = .4844
>>> Velocity Calibrations <<<
Vel Calculation Method: 1-vel calibration
Vel Algorithm: Manning's N
Use Given N's: Yes
Vels calibrated to VelSet: 1

CROSS-SECTION # 7 CAS2 LGR343
Points = 37
Slope = .0025
SZF = 98.68

Cross-section represents 4.710% of Total Reach.

>>> WSL Calibrations <<<
WSL Calculation Method: Log/Log Regression
Log/Log Regression A = .4623462
Log/Log Regression B = .192027
WSL = 0.4623 * Flow ^ 0.1920 + 98.68
>>> Velocity Calibrations <<<
Vel Calculation Method: 1-vel calibration

Vel Algorithm: Manning's N
Use Given N's: Yes
Vels calibrated to VelSet: 1

CROSS-SECTION # 8 CAS2 POOL342
Points = 32
Slope = .0025
SZF = 98.75

Cross-section represents 5.540% of Total Reach.

>>> WSL Calibrations <<<
WSL Calculation Method: Channel Conveyance
Channel Conveyance Equation: Manning N
Use Weighted Area Hydraulic Radius: Yes
Reduce Hydraulic Radius to HR at S.Z.F.: Yes
BETA = .63
>>> Velocity Calibrations <<<
Vel Calculation Method: 1-vel calibration
Vel Algorithm: Manning's N
Use Given N's: Yes
Vels calibrated to VelSet: 1

CROSS-SECTION # 9 CAS2 GLD341
Points = 28
Slope = .0025
SZF = 98.75

Cross-section represents 3.120% of Total Reach.

>>> WSL Calibrations <<<
WSL Calculation Method: Channel Conveyance
Channel Conveyance Equation: Manning N
Use Weighted Area Hydraulic Radius: Yes
Reduce Hydraulic Radius to HR at S.Z.F.: Yes
BETA = .626
>>> Velocity Calibrations <<<
Vel Calculation Method: 1-vel calibration
Vel Algorithm: Manning's N
Use Given N's: Yes
Vels calibrated to VelSet: 1

CROSS-SECTION # 10 CAS2 Run340
Points = 28

Slope = .0025
SZF = 98.8

Cross-section represents 6.050% of Total Reach.

>>> WSL Calibrations <<<
WSL Calculation Method: Channel Conveyance
Channel Conveyance Equation: Manning N
Use Weighted Area Hydraulic Radius: Yes
Reduce Hydraulic Radius to HR at S.Z.F.: Yes
BETA = .6475
>>> Velocity Calibrations <<<
Vel Calculation Method: 1-vel calibration
Vel Algorithm: Manning's N
Use Given N's: Yes
Vels calibrated to VelSet: 1

CROSS-SECTION # 11 CAS1 RUN190
Points = 39
Slope = .0025
SZF = 98.09

Cross-section represents 6.050% of Total Reach.

>>> WSL Calibrations <<<
WSL Calculation Method: Channel Conveyance
Channel Conveyance Equation: Manning N
Use Weighted Area Hydraulic Radius: Yes
Reduce Hydraulic Radius to HR at S.Z.F.: Yes
BETA = .35
>>> Velocity Calibrations <<<
Vel Calculation Method: 1-vel calibration
Vel Algorithm: Manning's N
Use Given N's: Yes
Vels calibrated to VelSet: 1

CROSS-SECTION # 12 CAS1 GLD189
Points = 27
Slope = .0025
SZF = 98.25

Cross-section represents 3.120% of Total Reach.

>>> WSL Calibrations <<<
WSL Calculation Method: Channel Conveyance

Channel Conveyance Equation: Manning N
Use Weighted Area Hydraulic Radius: Yes
Reduce Hydraulic Radius to HR at S.Z.F.: Yes
BETA = .5
>>> Velocity Calibrations <<<
Vel Calculation Method: 1-vel calibration
Vel Algorithm: Manning's N
Use Given N's: Yes
Vels calibrated to VelSet: 1

CROSS-SECTION # 13 CAS1 POOL188
Points = 29
Slope = .0025
SZF = 98.25

Cross-section represents 5.540% of Total Reach.

>>> WSL Calibrations <<<
WSL Calculation Method: Channel Conveyance
Channel Conveyance Equation: Manning N
Use Weighted Area Hydraulic Radius: Yes
Reduce Hydraulic Radius to HR at S.Z.F.: Yes
BETA = .64
>>> Velocity Calibrations <<<
Vel Calculation Method: 1-vel calibration
Vel Algorithm: Manning's N
Use Given N's: Yes
Vels calibrated to VelSet: 1

CROSS-SECTION # 14 CAS1 GLD187A
Points = 30
Slope = .0025
SZF = 98.4

Cross-section represents 3.120% of Total Reach.

>>> WSL Calibrations <<<
WSL Calculation Method: Channel Conveyance
Channel Conveyance Equation: Manning N
Use Weighted Area Hydraulic Radius: Yes
Reduce Hydraulic Radius to HR at S.Z.F.: Yes
BETA = .53
>>> Velocity Calibrations <<<
Vel Calculation Method: 1-vel calibration
Vel Algorithm: Manning's N

Use Given N's: Yes
Vels calibrated to VelSet: 1

CROSS-SECTION # 15 CAS1 POOL187
Points = 29
Slope = .0025
SZF = 98.4

Cross-section represents 5.540% of Total Reach.

>>> WSL Calibrations <<<
WSL Calculation Method: Channel Conveyance
Channel Conveyance Equation: Manning N
Use Weighted Area Hydraulic Radius: Yes
Reduce Hydraulic Radius to HR at S.Z.F.: Yes
BETA = .63
>>> Velocity Calibrations <<<
Vel Calculation Method: 1-vel calibration
Vel Algorithm: Manning's N
Use Given N's: Yes
Vels calibrated to VelSet: 1

CROSS-SECTION # 16 CAS1 LGR185
Points = 36
Slope = .0025
SZF = 98.12

Cross-section represents 4.710% of Total Reach.

>>> WSL Calibrations <<<
WSL Calculation Method: Channel Conveyance
Channel Conveyance Equation: Manning N
Use Weighted Area Hydraulic Radius: Yes
Reduce Hydraulic Radius to HR at S.Z.F.: Yes
BETA = .3
>>> Velocity Calibrations <<<
Vel Calculation Method: 1-vel calibration
Vel Algorithm: Manning's N
Use Given N's: Yes
Vels calibrated to VelSet: 1

CROSS-SECTION # 17 CAS1 RUN183
Points = 32
Slope = .0025

SZF = 98.3

Cross-section represents 6.050% of Total Reach.

>>> WSL Calibrations <<<
WSL Calculation Method: Channel Conveyance
Channel Conveyance Equation: Manning N
Use Weighted Area Hydraulic Radius: Yes
Reduce Hydraulic Radius to HR at S.Z.F.: Yes
BETA = .55
>>> Velocity Calibrations <<<
Vel Calculation Method: 1-vel calibration
Vel Algorithm: Manning's N
Use Given N's: Yes
Vels calibrated to VelSet: 1

CROSS-SECTION # 18 CAS1 LGR182
Points = 26
Slope = .0025
SZF = 98.48

Cross-section represents 4.710% of Total Reach.

>>> WSL Calibrations <<<
WSL Calculation Method: Channel Conveyance
Channel Conveyance Equation: Manning N
Use Weighted Area Hydraulic Radius: Yes
Reduce Hydraulic Radius to HR at S.Z.F.: Yes
BETA = .05
>>> Velocity Calibrations <<<
Vel Calculation Method: 1-vel calibration
Vel Algorithm: Manning's N
Use Given N's: Yes
Vels calibrated to VelSet: 1

CROSS-SECTION # 19 CAS1 POOL181
Points = 32
Slope = .0025
SZF = 98.35

Cross-section represents 5.540% of Total Reach.

>>> WSL Calibrations <<<
WSL Calculation Method: Channel Conveyance
Channel Conveyance Equation: Manning N

Use Weighted Area Hydraulic Radius: Yes
Reduce Hydraulic Radius to HR at S.Z.F.: Yes
BETA = .65
>>> Velocity Calibrations <<<
Vel Calculation Method: 1-vel calibration
Vel Algorithm: Manning's N
Use Given N's: Yes
Vels calibrated to VelSet: 1

CROSS-SECTION # 20 CAS1 RUN176
Points = 28
Slope = .0025
SZF = 98.1

Cross-section represents 6.050% of Total Reach.

>>> WSL Calibrations <<<
WSL Calculation Method: Channel Conveyance
Channel Conveyance Equation: Manning N
Use Weighted Area Hydraulic Radius: Yes
Reduce Hydraulic Radius to HR at S.Z.F.: Yes
BETA = .48
>>> Velocity Calibrations <<<
Vel Calculation Method: 1-vel calibration
Vel Algorithm: Manning's N
Use Given N's: Yes
Vels calibrated to VelSet: 1

Casino Creek - Final Calibration Details
CAS2 Study Site

CROSS-SECTION # 1 CAS2 RUN119
Points = 27 Slope = .0025 SZF = 98.2

CAL	Calib Stage	Given Flow	Wet Cnt	Wetted Perim	Wetted Area	Wetted Wdth	Hydrau Radius	Avg Depth
1	98.74	1.91	20	4.71	2.01	3.75	0.43	0.54
2	98.56	0.91	19	4.35	1.35	3.70	0.31	0.36
3	98.54	0.65	19	4.31	1.27	3.70	0.30	0.34

CROSS-SECTION # 2 CAS2 RUN121
Points = 26 Slope = .0025 SZF = 98.4

CAL	Calib Stage	Given Flow	Wet Cnt	Wetted Perim	Wetted Area	Wetted Wdth	Hydrau Radius	Avg Depth
1	98.93	1.91	19	4.46	1.91	3.84	0.43	0.50
2	98.74	0.91	18	4.03	1.21	3.63	0.30	0.33
3	98.74	0.65	18	4.01	1.18	3.62	0.29	0.33

CROSS-SECTION # 3 CAS2 LGR347
Points = 34 Slope = .0025 SZF = 98.43

CAL	Calib Stage	Given Flow	Wet Cnt	Wetted Perim	Wetted Area	Wetted Wdth	Hydrau Radius	Avg Depth
1	98.99	2.07	24	5.28	1.73	4.63	0.33	0.37
2	98.83	0.91	22	4.85	1.02	4.40	0.21	0.23
3	98.81	0.65	22	4.82	0.94	4.39	0.20	0.21

CROSS-SECTION # 4 CAS2 POOL346
Points = 26 Slope = .0025 SZF = 98.6

CAL	Calib Stage	Given Flow	Wet Cnt	Wetted Perim	Wetted Area	Wetted Wdth	Hydrau Radius	Avg Depth
1	99.08	2.07	20	5.46	2.67	4.96	0.49	0.54
2	98.95	0.91	18	4.80	2.04	4.40	0.43	0.46

CROSS-SECTION # 5 CAS2 LGR345
Points = 29 Slope = .0025 SZF = 98.06

CAL	Calib Stage	Given Flow	Wet Cnt	Wetted Perim	Wetted Area	Wetted Wdth	Hydrau Radius	Avg Depth
1	98.60	2.07	21	4.65	1.80	4.20	0.39	0.43
2	98.46	0.91	20	4.34	1.27	4.03	0.29	0.31
3	98.45	0.65	20	4.31	1.22	4.01	0.28	0.30

CROSS-SECTION # 6 CAS2 GLD344
Points = 30 Slope = .0025 SZF = 98.15

CAL	Calib Stage	Given Flow	Wet Cnt	Wetted Perim	Wetted Area	Wetted Wdth	Hydrau Radius	Avg Depth
1	98.68	2.14	22	5.08	2.48	4.33	0.49	0.57
2	98.55	0.91	21	4.79	1.90	4.24	0.40	0.45
3	98.51	0.65	21	4.72	1.75	4.22	0.37	0.42

CROSS-SECTION # 7 CAS2 LGR343
Points = 37 Slope = .0025 SZF = 98.68

CAL	Calib Stage	Given Flow	Wet Cnt	Wetted Perim	Wetted Area	Wetted Wdth	Hydrau Radius	Avg Depth
1	99.22	2.23	28	7.63	2.40	7.16	0.31	0.34
2	99.14	0.91	27	7.27	1.81	6.87	0.25	0.26
3	99.11	0.65	27	7.19	1.61	6.82	0.22	0.24

CROSS-SECTION # 8 CAS2 POOL342
Points = 32 Slope = .0025 SZF = 98.75

CAL	Calib Stage	Given Flow	Wet Cnt	Wetted Perim	Wetted Area	Wetted Wdth	Hydrau Radius	Avg Depth
1	99.25	1.73	21	6.61	3.41	5.61	0.52	0.61
2	99.20	0.91	21	6.47	3.14	5.52	0.49	0.57

CROSS-SECTION # 9 CAS2 GLD341
Points = 28 Slope = .0025 SZF = 98.75

CAL	Calib Stage	Given Flow	Wet Cnt	Wetted Perim	Wetted Area	Wetted Wdth	Hydrau Radius	Avg Depth
1	99.25	1.73	22	5.05	2.40	4.14	0.48	0.58
2	99.22	0.91	20	4.97	2.27	4.11	0.46	0.55

CROSS-SECTION # 10 CAS2 Run340
Points = 28 Slope = .0025 SZF = 98.8

CAL	Calib Stage	Given Flow	Wet Cnt	Wetted Perim	Wetted Area	Wetted Wdth	Hydrau Radius	Avg Depth
1	99.25	1.64	22	5.11	2.53	3.96	0.49	0.64
2	99.24	0.91	22	5.09	2.49	3.95	0.49	0.63

Casino Creek - Final Calibration Details
CAS1 Study Site

CROSS-SECTION # 1 CAS1 RUN190
Points = 39 Slope = .0025 SZF = 98.09

CAL	Calib Stage	Given Flow	Wet Cnt	Wetted Perim	Wetted Area	Wetted Wdth	Hydrau Radius	Avg Depth
1	98.57	1.15	25	5.24	1.29	5.05	0.25	0.26
2	98.54	0.84	24	5.04	1.15	4.87	0.23	0.24
3	98.55	0.44	24	5.12	1.20	4.94	0.24	0.24

CROSS-SECTION # 2 CAS1 GLD189
Points = 27 Slope = .0025 SZF = 98.25

CAL	Calib Stage	Given Flow	Wet Cnt	Wetted Perim	Wetted Area	Wetted Wdth	Hydrau Radius	Avg Depth
1	98.68	1.15	19	5.48	2.06	4.77	0.37	0.43
2	98.61	0.84	19	5.27	1.73	4.61	0.33	0.38
3	98.62	0.44	19	5.31	1.80	4.64	0.34	0.39

CROSS-SECTION # 3 CAS1 POOL188
Points = 29 Slope = .0025 SZF = 98.25

CAL	Calib Stage	Given Flow	Wet Cnt	Wetted Perim	Wetted Area	Wetted Wdth	Hydrau Radius	Avg Depth
1	98.69	1.15	20	5.63	2.81	4.95	0.50	0.57
2	98.62	0.84	19	5.46	2.46	4.87	0.45	0.50
3	98.63	0.44	19	5.48	2.50	4.88	0.46	0.51

CROSS-SECTION # 4 CAS1 GLD187A
Points = 30 Slope = .0025 SZF = 98.4

CAL	Calib Stage	Given Flow	Wet Cnt	Wetted Perim	Wetted Area	Wetted Wdth	Hydrau Radius	Avg Depth
1	98.91	1.15	22	4.99	1.99	4.25	0.40	0.47
2	98.87	0.84	21	4.90	1.82	4.22	0.37	0.43
3	98.87	0.44	21	4.91	1.82	4.22	0.37	0.43

CROSS-SECTION # 5 CAS1 POOL187
Points = 29 Slope = .0025 SZF = 98.4

CAL	Calib Stage	Given Flow	Wet Cnt	Wetted Perim	Wetted Area	Wetted Wdth	Hydrau Radius	Avg Depth
1	98.89	0.90	20	4.81	2.42	3.87	0.50	0.63
2	98.87	0.84	20	4.77	2.36	3.85	0.49	0.61
3	98.87	0.44	20	4.76	2.36	3.85	0.49	0.61

CROSS-SECTION # 6 CAS1 LGR185
Points = 36 Slope = .0025 SZF = 98.12

CAL	Calib Stage	Given Flow	Wet Cnt	Wetted Perim	Wetted Area	Wetted Wdth	Hydrau Radius	Avg Depth
1	98.58	0.82	29	7.22	1.73	6.92	0.24	0.25
2	98.53	0.84	27	7.02	1.43	6.76	0.20	0.21
3	98.56	0.44	27	7.16	1.63	6.87	0.23	0.24

CROSS-SECTION # 7 CAS1 RUN183
Points = 32 Slope = .0025 SZF = 98.3

CAL	Calib Stage	Given Flow	Wet Cnt	Wetted Perim	Wetted Area	Wetted Wdth	Hydrau Radius	Avg Depth
1	98.70	0.82	19	5.06	1.48	4.27	0.29	0.35
2	98.77	0.84	21	5.38	1.80	4.53	0.33	0.40
3	98.85	0.44	22	5.66	2.17	4.74	0.38	0.46

CROSS-SECTION # 8 CAS1 LGR182
Points = 26 Slope = .0025 SZF = 98.48

CAL	Calib Stage	Given Flow	Wet Cnt	Wetted Perim	Wetted Area	Wetted Wdth	Hydrau Radius	Avg Depth
1	98.74	0.82	20	5.33	0.95	5.22	0.18	0.18
2	98.79	0.84	22	5.48	1.21	5.32	0.22	0.23
3	98.87	0.44	22	5.70	1.65	5.46	0.29	0.30

CROSS-SECTION # 9 CAS1 POOL181
Points = 32 Slope = .0025 SZF = 98.35

CAL	Calib Stage	Given Flow	Wet Cnt	Wetted Perim	Wetted Area	Wetted Wdth	Hydrau Radius	Avg Depth
1	98.87	0.70	18	6.44	3.32	5.85	0.51	0.57
2	98.89	0.84	20	6.54	3.43	5.94	0.52	0.58
3	98.93	0.44	20	6.78	3.70	6.16	0.54	0.60

CROSS-SECTION # 10 CAS1 RUN176
Points = 28 Slope = .0025 SZF = 98.1

CAL	Calib Stage	Given Flow	Wet Cnt	Wetted Perim	Wetted Area	Wetted Wdth	Hydrau Radius	Avg Depth
1	98.59	0.64	19	5.25	1.84	4.76	0.35	0.39
2	98.66	0.84	20	5.41	2.18	4.82	0.40	0.45
3	98.64	0.44	20	5.37	2.10	4.80	0.39	0.44

Casino Creek – Cross Section Data
CAS2 and CAS1 Study Sites Combined

SUMMARY DATA: CROSS-SECTION # 1 CAS2 RUN119
Number of Points = 27

X	Y	VEL 1	SUBSTRATE
0.00	99.17		1.20
0.20	99.12		1.20
0.40	98.88		1.20
0.47	98.75		1.20
0.60	98.12	1.18	4.30
0.80	98.12	1.33	4.30
1.00	98.10	1.70	4.30
1.20	98.04	1.59	4.30
1.40	98.04	1.29	4.30
1.60	98.08	1.30	4.30
1.80	98.06	1.12	4.30
2.00	98.08	1.02	4.30
2.20	98.14	1.00	4.30
2.40	98.16	0.94	4.30
2.60	98.22	0.92	4.30
2.80	98.26	0.85	4.30
3.00	98.28	0.72	4.30
3.20	98.32	0.51	4.30
3.40	98.33	0.20	4.30
3.60	98.36	0.13	4.30
3.80	98.38	0.05	4.30
4.00	98.34	0.04	4.30
4.20	98.32	0.03	4.30
4.22	98.74		1.20
4.30	99.00		1.20
4.50	99.19		1.20
4.57	99.20		1.20

SUMMARY DATA: CROSS-SECTION # 2 CAS2 RUN121
Number of Points = 26

X	Y	VEL 1	SUBSTRATE
0.00	99.47		1.20
0.30	99.27		1.20
0.50	99.01		1.20
0.57	98.91		1.20

0.80	98.61	0.38	5.30
1.00	98.55	0.52	5.30
1.20	98.53	0.71	5.30
1.40	98.51	0.84	5.30
1.60	98.47	0.93	5.30
1.80	98.45	0.97	5.30
2.00	98.43	1.02	5.30
2.20	98.41	0.92	5.30
2.40	98.39	0.95	5.30
2.60	98.33	0.92	5.30
2.80	98.35	1.11	5.30
3.00	98.29	1.06	5.30
3.20	98.31	1.15	5.30
3.40	98.33	1.34	5.30
3.60	98.31	1.37	5.30
3.80	98.29	1.41	5.30
4.00	98.31	1.46	5.30
4.20	98.35	0.58	5.30
4.40	98.95		1.20
4.50	99.17		1.20
4.75	99.31		1.20
4.99	99.37		1.20

SUMMARY DATA: CROSS-SECTION # 3 CAS2 LGR347
Number of Points = 34

X	Y	VEL 1	SUBSTRATE
0.00	99.55		1.20
0.20	99.41		1.20
0.40	99.22		1.20
0.60	99.04		1.20
0.70	98.98		1.20
0.80	98.43	1.29	3.40
1.00	98.47	1.35	3.40
1.20	98.49	1.36	3.40
1.40	98.49	1.35	3.40
1.60	98.51	1.25	3.40
1.80	98.53	1.18	3.40
2.00	98.55	1.34	3.40
2.20	98.55	1.19	3.40
2.40	98.59	1.25	3.40
2.60	98.61	1.38	3.40
2.80	98.63	1.47	3.40
3.00	98.63	1.35	3.40
3.20	98.63	1.36	3.40
3.40	98.65	1.15	3.40
3.60	98.63	1.11	3.40

3.80	98.67	1.18	3.40
4.00	98.67	0.92	3.40
4.20	98.67	0.90	3.40
4.40	98.69	1.00	3.40
4.60	98.65	0.97	3.40
4.80	98.65	1.15	3.40
5.00	98.65	1.10	3.40
5.20	98.93	0.59	3.40
5.32	98.99		1.20
5.60	99.07		1.20
5.80	99.18		1.20
6.00	99.25		1.20
6.20	99.39		1.20
6.34	99.45		1.20

SUMMARY DATA: CROSS-SECTION # 4 CAS2 POOL346
Number of Points = 26

X	Y	VEL 1	SUBSTRATE
0.00	99.86		1.20
0.20	99.47		1.20
0.28	99.09		1.20
0.50	98.78	0.24	5.20
0.75	98.60	0.40	5.20
1.00	98.56	0.59	5.20
1.25	98.58	0.61	5.20
1.50	98.46	0.61	5.20
1.75	98.46	0.55	5.20
2.00	98.40	0.46	5.20
2.25	98.36	0.72	5.20
2.50	98.32	0.92	5.20
2.75	98.32	1.21	5.20
3.00	98.32	1.17	5.20
3.25	98.38	1.08	5.20
3.50	98.40	0.95	5.20
3.75	98.42	1.06	5.20
4.00	98.48	0.98	5.20
4.25	98.52	0.72	5.20
4.50	98.58	0.11	5.20
4.75	98.94	0.05	5.20
5.00	99.04		5.20
5.20	99.06		1.20
5.40	99.16		1.20
5.70	99.27		1.20
5.95	99.35		1.20

SUMMARY DATA: CROSS-SECTION # 5 CAS2 LGR345
Number of Points = 29

X	Y	VEL 1	SUBSTRATE
0.00	99.00		1.20
0.30	98.85		1.20
0.50	98.74		1.20
0.80	98.69		1.20
0.89	98.58		1.20
1.00	98.28	0.05	4.30
1.20	98.15	1.18	4.30
1.40	98.20	1.33	4.30
1.60	98.12	1.21	4.30
1.80	98.10	1.24	4.30
2.00	98.08	1.29	4.30
2.20	98.08	1.21	4.30
2.40	98.12	1.32	4.30
2.60	98.12	1.40	4.30
2.80	98.10	1.30	4.30
3.00	98.08	1.05	4.30
3.20	98.06	1.20	4.30
3.40	98.10	1.29	4.30
3.60	98.10	1.32	4.30
3.80	98.10	1.23	4.30
4.00	98.14	1.27	4.30
4.20	98.20	1.23	4.30
4.40	98.20	1.02	4.30
4.60	98.26	0.94	4.30
4.80	98.28	0.89	4.30
5.08	98.60		1.20
5.20	98.66		1.20
5.40	98.90		1.20
5.65	99.18		1.20

SUMMARY DATA: CROSS-SECTION # 6 CAS2 GLD344
Number of Points = 30

X	Y	VEL 1	SUBSTRATE
0.00	99.14		1.20
0.20	99.04		1.20
0.40	98.94		1.20
0.60	98.79		1.20
0.77	98.69		1.20
1.00	98.10	0.45	3.20

1.20	98.10	0.67	3.20
1.40	98.06	0.81	3.20
1.60	98.04	0.86	3.20
1.80	98.03	0.90	3.20
2.00	98.00	0.93	3.20
2.20	98.00	0.99	3.20
2.40	97.98	1.02	3.20
2.60	97.98	1.01	3.20
2.80	98.02	0.97	3.20
3.00	98.04	0.58	3.20
3.20	98.04	0.94	3.20
3.40	98.06	1.02	3.20
3.60	98.08	1.09	3.20
3.80	98.12	1.10	3.20
4.00	98.16	1.07	3.20
4.20	98.18	1.04	3.20
4.40	98.18	0.88	3.20
4.60	98.21	0.75	3.20
4.80	98.24	0.56	3.20
5.00	98.28	0.22	3.20
5.10	98.68		1.20
5.20	98.92		1.20
5.40	99.10		1.20
5.61	99.18		1.20

SUMMARY DATA: CROSS-SECTION # 7 CAS2 LGR343
Number of Points = 37

X	Y	VEL 1	SUBSTRATE
0.00	100.05		1.20
0.20	99.91		1.20
0.40	99.51		1.20
0.60	99.23		1.20
0.75	99.22		1.20
1.00	99.14	0.53	3.50
1.25	98.96	0.54	3.50
1.50	98.92	0.95	3.50
1.75	98.86	0.88	3.50
2.00	98.90	0.79	3.50
2.25	98.94	0.56	3.50
2.50	98.94	0.62	3.50
2.75	98.92	0.80	3.50
3.00	98.94	0.91	3.50
3.25	98.94	0.97	3.50
3.50	98.96	1.09	3.50
3.75	98.98	0.97	3.50
4.00	98.98	1.02	3.50

4.25	98.94	1.02	3.50
4.50	98.92	1.14	3.50
4.75	98.92	1.25	3.50
5.00	98.87	1.20	3.50
5.25	98.86	1.12	3.50
5.50	98.84	1.03	3.50
5.75	98.82	1.13	3.50
6.00	98.76	1.10	3.50
6.25	98.74	1.03	3.50
6.50	98.76	1.10	3.50
6.75	98.76	1.16	3.50
7.00	98.76	0.99	3.50
7.25	98.69	0.62	3.50
7.50	98.68	0.98	3.50
7.75	98.74	0.05	3.50
7.91	99.22		1.20
8.00	99.31		1.20
8.30	99.41		1.20
8.63	99.53		1.20

SUMMARY DATA: CROSS-SECTION # 8 CAS2 POOL342
Number of Points = 32

X	Y	VEL 1	SUBSTRATE
0.00	100.37		1.20
0.50	100.19		1.20
0.80	99.71		1.20
1.00	99.26		1.20
1.25	98.25	0.47	2.50
1.50	98.17	0.61	2.50
1.75	98.11	0.52	2.50
2.00	98.09	0.63	2.50
2.25	98.21	0.57	2.50
2.50	98.29	0.54	2.50
2.75	98.35	0.56	2.50
3.00	98.45	0.61	2.50
3.25	98.53	0.44	2.50
3.50	98.61	0.71	2.50
3.75	98.69	0.60	2.50
4.00	98.75	0.48	2.50
4.25	98.75	0.52	2.50
4.50	98.81	0.53	2.50
4.75	98.85	0.53	2.50
5.00	98.90	0.34	2.50
5.25	98.95	0.45	2.50
5.50	98.95	0.40	2.50
5.75	98.95	0.29	2.50

6.00	98.97	0.23	2.50
6.25	99.03	0.19	2.50
6.61	99.25		1.20
6.80	99.31		1.20
7.10	99.36		1.20
7.40	99.55		1.20
7.70	99.64		1.20
8.00	99.69		1.20
8.26	99.74		1.20

SUMMARY DATA: CROSS-SECTION # 9 CAS2 GLD341
Number of Points = 28

X	Y	VEL 1	SUBSTRATE
0.00	99.61		1.20
0.30	99.49		1.20
0.60	99.31		1.20
0.68	99.25		1.20
0.80	98.57	0.43	3.20
1.00	98.55	0.67	3.20
1.20	98.47	0.62	3.20
1.40	98.47	0.67	3.20
1.60	98.50	0.74	3.20
1.80	98.52	0.75	3.20
2.00	98.53	0.85	3.20
2.20	98.59	0.82	3.20
2.40	98.59	0.94	3.20
2.60	98.63	0.81	3.20
2.80	98.67	0.79	3.20
3.00	98.67	0.80	3.20
3.20	98.71	0.84	3.20
3.40	98.73	0.79	3.20
3.60	98.75	0.81	3.20
3.80	98.77	0.77	3.20
4.00	98.81	0.70	3.20
4.20	98.77	0.66	3.20
4.40	98.81	0.49	3.20
4.60	98.81	0.44	3.20
4.80	99.24		1.20
5.00	99.39		1.20
5.30	99.51		1.20
5.58	99.62		1.20

SUMMARY DATA: CROSS-SECTION # 10 CAS2 Run340

Number of Points = 28

X	Y	VEL 1	SUBSTRATE
0.00	99.74		1.20
0.30	99.53		1.20
0.50	99.34		1.20
0.55	99.23		1.20
0.60	98.61	0.02	3.20
0.80	98.59	0.03	3.20
1.00	98.67	0.11	3.20
1.20	98.55	0.21	3.20
1.40	98.55	0.43	3.20
1.60	98.55	0.58	3.20
1.80	98.57	0.72	3.20
2.00	98.57	0.81	3.20
2.20	98.57	0.78	3.20
2.40	98.58	0.75	3.20
2.60	98.63	0.88	3.20
2.80	98.63	0.93	3.20
3.00	98.61	0.96	3.20
3.20	98.59	1.01	3.20
3.40	98.59	1.06	3.20
3.60	98.57	1.04	3.20
3.80	98.59	0.91	3.20
4.00	98.61	0.72	3.20
4.20	98.63	0.47	3.20
4.40	98.65	0.17	3.20
4.48	99.18		1.20
4.50	99.25		1.20
4.80	99.41		1.20
5.10	99.77		1.20

SUMMARY DATA: CROSS-SECTION # 11 CAS1 RUN190
Number of Points = 39

X	Y	VEL 1	SUBSTRATE
-0.40	99.25		1.20
0.00	98.98		1.20
0.30	98.87		1.20
0.60	98.71		1.20
0.70	98.60		1.20
0.95	98.57		3.40
1.20	98.52	0.05	3.40
1.40	98.51	0.14	3.40
1.60	98.49	0.29	3.40
1.80	98.43	0.48	3.40

2.00	98.43	0.61	2.40
2.20	98.41	0.40	2.40
2.40	98.41	0.76	2.40
2.60	98.33	0.54	2.40
2.80	98.34	0.42	2.40
3.00	98.33	0.64	4.50
3.20	98.33	0.86	4.50
3.40	98.32	0.73	4.50
3.60	98.23	0.63	4.50
3.80	98.19	0.74	4.50
4.00	98.13	1.04	4.50
4.20	98.15	1.03	4.50
4.40	98.09	1.22	4.50
4.60	98.09	1.27	4.50
4.80	98.11	1.39	4.50
5.00	98.15	1.20	4.50
5.20	98.21	1.23	4.50
5.40	98.21	1.11	4.50
5.60	98.31	0.31	4.50
5.80	98.39	0.12	4.50
6.02	98.56		1.20
6.40	98.77		1.20
6.70	98.73		1.20
7.00	98.75		5.20
7.30	98.72		5.20
7.60	98.73		2.10
7.90	98.87		2.10
8.07	98.98		1.20
8.25	99.15		1.20

SUMMARY DATA: CROSS-SECTION # 12 CAS1 GLD189
Number of Points = 27

X	Y	VEL 1	SUBSTRATE
0.00	99.07		1.20
0.20	99.02		1.20
0.40	98.97		1.20
0.50	98.86		1.20
0.63	98.68		1.20
0.75	98.52	0.29	3.20
1.00	98.42	0.43	3.20
1.25	98.40	0.42	3.20
1.50	98.36	0.54	3.20
1.75	98.36	0.52	2.30
2.00	98.34	0.54	2.30
2.25	98.32	0.70	2.30
2.50	98.32	0.63	2.40

2.75	98.34	0.63	2.30
3.00	98.23	0.70	2.30
3.25	98.22	0.66	2.30
3.50	98.20	0.63	3.20
3.75	98.20	0.59	3.20
4.00	98.08	0.60	3.20
4.25	98.02	0.63	3.20
4.50	97.94	0.59	3.20
4.75	97.88	0.50	3.40
5.00	97.87	0.38	3.40
5.25	98.58	0.12	3.40
5.40	98.68		1.20
5.50	98.86		1.20
5.77	99.06		1.20

SUMMARY DATA: CROSS-SECTION # 13 CAS1 POOL188
Number of Points = 29

X	Y	VEL 1	SUBSTRATE
-0.30	99.49		1.20
0.00	99.09		1.20
0.40	98.93		1.20
0.70	98.83		1.20
0.90	98.76		1.20
0.95	98.69		1.20
1.25	98.31	-0.17	2.30
1.50	98.27	-0.04	2.30
1.75	98.21	-0.03	2.30
2.00	98.20	0.13	2.10
2.25	98.11	0.16	2.10
2.50	98.05	0.21	2.10
2.75	98.01	0.28	2.10
3.00	97.97	0.44	4.30
3.25	97.99	0.62	4.30
3.50	97.97	0.65	4.30
3.75	97.99	0.78	4.30
4.00	98.05	0.89	4.30
4.25	98.07	0.74	4.30
4.50	98.09	0.75	4.30
4.75	98.11	0.61	4.30
5.00	98.11	0.43	4.30
5.25	98.11	0.32	3.20
5.50	98.07	0.35	3.20
5.75	98.13	0.27	3.20
5.90	98.70		1.20
6.00	98.91		1.20
6.30	99.11		1.20

6.50	99.25		1.20

SUMMARY DATA: CROSS-SECTION # 14 CAS1 GLD187A
Number of Points = 30

X	Y	VEL 1	SUBSTRATE
0.00	99.76		1.20
0.30	99.55		1.20
0.40	99.09		1.20
0.50	98.91		1.20
0.60	98.47	0.02	2.10
0.80	98.47	0.03	2.10
1.00	98.46	0.54	2.30
1.20	98.46	0.64	2.30
1.40	98.46	0.65	2.30
1.60	98.43	0.74	2.30
1.80	98.42	0.72	2.30
2.00	98.40	0.73	2.30
2.20	98.39	0.79	2.30
2.40	98.40	0.80	2.30
2.60	98.38	0.80	2.30
2.80	98.37	0.81	3.40
3.00	98.47	0.73	3.40
3.20	98.45	0.75	3.40
3.40	98.47	0.67	3.40
3.60	98.47	0.60	3.40
3.80	98.39	0.58	3.40
4.00	98.41	0.39	3.40
4.20	98.41	0.47	4.30
4.40	98.42	0.35	4.30
4.60	98.45	0.25	4.30
4.75	98.93		1.20
4.90	99.30		1.20
5.30	99.54		1.20
5.50	99.73		1.20
5.70	99.94		1.20

SUMMARY DATA: CROSS-SECTION # 15 CAS1 POOL187
Number of Points = 29

X	Y	VEL 1	SUBSTRATE
0.00	99.62		1.20
0.20	99.34		1.20

0.30	99.05		1.20
0.50	98.97		1.20
0.60	98.87		2.10
0.80	98.39	-0.14	2.10
1.00	98.41	-0.10	2.10
1.20	98.39	0.04	2.10
1.40	98.33	0.11	2.10
1.60	98.25	0.21	2.10
1.80	98.17	0.37	2.10
2.00	98.11	0.55	4.30
2.20	98.13	0.61	4.30
2.40	98.11	0.72	4.50
2.60	98.11	0.74	4.50
2.80	98.17	0.76	3.20
3.00	98.19	0.74	3.20
3.20	98.21	0.58	3.20
3.40	98.23	0.43	2.10
3.60	98.27	0.27	2.10
3.80	98.27	0.20	3.20
4.00	98.25	0.18	3.20
4.20	98.30	0.20	3.20
4.40	98.31	0.04	3.20
4.45	98.89		1.20
4.60	98.97		1.20
4.80	99.17		1.20
4.95	99.24		1.20
5.20	99.43		1.20

SUMMARY DATA: CROSS-SECTION # 16 CAS1 LGR185
Number of Points = 36

X	Y	VEL 1	SUBSTRATE
0.00	99.19		1.20
0.30	99.18		1.20
0.50	98.73		1.20
0.65	98.57		2.10
0.75	98.33	0.08	2.10
1.00	98.18	0.16	2.10
1.25	98.12	0.36	2.10
1.50	98.13	0.35	2.30
1.75	98.16	0.47	2.30
2.00	98.13	0.46	2.30
2.25	98.16	0.46	2.30
2.50	98.18	0.41	2.30
2.75	98.24	0.41	3.40
3.00	98.30	0.51	3.40
3.25	98.31	0.47	3.40

3.50	98.36	0.41	3.40
3.75	98.40	0.69	4.30
4.00	98.45	0.73	4.30
4.25	98.36	0.67	3.40
4.50	98.38	0.65	4.30
4.75	98.36	0.62	4.30
5.00	98.34	0.52	4.30
5.25	98.40	0.61	4.30
5.50	98.36	0.75	4.30
5.75	98.36	0.95	4.30
6.00	98.36	0.59	4.50
6.25	98.38	0.05	4.50
6.50	98.40	0.95	4.50
6.75	98.43	0.89	4.30
7.00	98.50	0.55	4.30
7.25	98.48	0.27	3.50
7.55	98.57		2.10
8.00	98.77		2.10
8.50	98.84		2.10
9.00	98.98		1.20
9.55	99.10		1.20

SUMMARY DATA: CROSS-SECTION # 17 CAS1 RUN183
Number of Points = 32

X	Y	VEL 1	SUBSTRATE
0.00	99.30		1.20
0.50	99.13		1.20
0.80	98.95		1.20
0.90	98.70		5.40
1.00	98.04	0.45	5.40
1.20	98.00	0.75	5.40
1.40	98.02	0.73	5.40
1.60	98.04	0.66	4.30
1.80	98.08	0.62	4.30
2.00	97.94	0.69	4.30
2.20	98.00	0.70	3.20
2.40	98.22	0.63	3.20
2.60	98.24	0.58	3.20
2.80	98.30	0.41	4.30
3.00	98.40	0.45	4.30
3.20	98.46	0.41	2.30
3.40	98.48	0.38	2.30
3.60	98.54	0.29	4.20
3.80	98.56	0.15	4.20
4.00	98.56	0.30	3.20
4.20	98.58	0.21	3.20
4.40	98.62	0.18	3.20

4.60	98.64	0.13	3.40
5.20	98.70		4.30
5.50	98.80		4.30
5.75	98.94		4.30
6.00	99.01		4.30
6.50	99.02		4.20
7.00	99.06		2.10
7.45	99.13		1.20
8.00	99.25		1.20
8.50	99.43		1.20

SUMMARY DATA: CROSS-SECTION # 18 CAS1 LGR182
Number of Points = 26

X	Y	VEL 1	SUBSTRATE
0.00	99.27		1.20
0.30	98.97		1.20
0.50	98.74		1.20
0.75	98.62	0.27	4.30
1.00	98.54	1.39	4.30
1.25	98.53	1.06	4.30
1.50	98.53	0.70	4.30
1.75	98.56	0.62	4.30
2.00	98.57	0.61	4.30
2.25	98.53	0.72	4.30
2.50	98.58	0.60	4.30
2.75	98.59	0.75	5.40
3.00	98.48	0.85	4.50
3.25	98.52	1.07	4.50
3.50	98.51	1.07	4.50
3.75	98.48	1.05	4.50
4.00	98.52	0.85	4.50
4.25	98.54	1.19	4.50
4.50	98.54	0.69	4.50
4.75	98.52	0.77	3.40
5.00	98.57	0.91	3.40
5.25	98.58	0.70	3.40
5.50	98.64	0.32	3.40
5.75	98.75		1.10
6.00	99.04		1.10
6.35	99.34		1.10

SUMMARY DATA: CROSS-SECTION # 19 CAS1 POOL181
Number of Points = 32

X	Y	VEL 1	SUBSTRATE

X	Y	VEL 1	SUBSTRATE
-0.50	99.50		1.30
0.00	99.33		2.10
0.50	99.26		2.10
1.00	99.25		2.10
1.50	99.24		2.30
2.00	99.18		3.20
2.50	99.12		3.20
3.00	99.08		3.20
3.50	98.96		2.30
3.80	98.87		2.30
4.30	98.69	-0.08	2.30
4.60	98.59	-0.02	2.10
4.90	98.55	0.07	2.10
5.20	98.57	0.06	2.10
5.50	98.49	0.12	2.10
5.80	98.41	0.19	2.10
6.10	98.32	0.31	2.10
6.40	98.23	0.42	2.30
6.70	98.13	0.35	2.30
7.00	98.06	0.33	2.30
7.30	97.97	0.30	2.30
7.60	97.87	0.24	2.30
7.90	97.77	0.22	2.30
8.20	97.72	0.17	2.10
8.50	97.87	0.18	1.20
8.80	98.24	0.18	1.20
9.10	98.47	0.03	1.20
9.40	98.70	0.02	1.20
9.65	98.87		1.20
10.00	99.09		1.20
10.35	99.25		1.20
11.00	99.36		1.20

SUMMARY DATA: CROSS-SECTION # 20 CAS1 RUN176
Number of Points = 28

X	Y	VEL 1	SUBSTRATE
-1.00	99.28		1.20
-0.50	99.17		1.20
0.00	99.09		1.20
0.50	98.98		1.20
0.80	98.89		1.20
1.00	98.58		2.10
1.25	98.41	0.13	4.30
1.50	98.41	0.21	4.30
1.75	98.36	0.23	4.30
2.00	98.29	0.31	3.40

2.25	98.24	0.37	3.40
2.50	98.23	0.46	3.40
2.75	98.18	0.44	3.40
3.00	98.17	0.49	3.40
3.25	98.18	0.55	3.40
3.50	98.15	0.57	3.40
3.75	98.11	0.45	4.50
4.00	98.14	0.53	4.50
4.25	98.14	0.47	4.50
4.50	98.08	0.34	4.50
4.75	98.07	0.23	2.10
5.00	98.07	0.19	2.10
5.25	98.04	0.13	2.10
5.50	98.00	0.16	2.10
5.75	98.59		1.10
5.80	98.81		1.10
6.20	99.10		1.10
6.50	99.34		1.10

Dip Creek – Final Calibration Summary
Dip1 and Dip2 Study Sites Combined

CROSS-SECTION # 1 Dip1LGR1
Points = 39
Slope = .0025
SZF = 98.17

Weighting Factor = 1
Cross-section represents 2.500% of Total Reach.

>>> WSL Calibrations <<<
WSL Calculation Method: Log/Log Regression
Log/Log Regression A = .5076871
Log/Log Regression B = .2974874
WSL = 0.5077 * Flow ^ 0.2975 + 98.17

>>> Velocity Calibrations <<<
Vel Calculation Method: 1-vel calibration
Vel Algorithm: Manning's N
Use Given N's: Yes
Vels calibrated to VelSet: 1

CROSS-SECTION # 2 Dip1Run2
Points = 40
Slope = .0025
SZF = 98.17

Weighting Factor = 1
Cross-section represents 2.500% of Total Reach.

>>> WSL Calibrations <<<
WSL Calculation Method: Log/Log Regression
Log/Log Regression A = .3985453
Log/Log Regression B = .3615423
WSL = 0.3985 * Flow ^ 0.3615 + 98.17

>>> Velocity Calibrations <<<
Vel Calculation Method: 1-vel calibration
Vel Algorithm: Manning's N

Use Given N's: Yes
Vels calibrated to VelSet: 1

CROSS-SECTION # 3 Dip1Pool3
Points = 50
Slope = .0025
SZF = 98.17

Weighting Factor = 1
Cross-section represents 5.000% of Total Reach.

>>> WSL Calibrations <<<
WSL Calculation Method: Log/Log Regression
Log/Log Regression A = .3683222
Log/Log Regression B = .3733405
WSL = 0.3683 * Flow ^ 0.3733 + 98.17

>>> Velocity Calibrations <<<
Vel Calculation Method: 1-vel calibration
Vel Algorithm: Manning's N
Use Given N's: Yes
Vels calibrated to VelSet: 1

CROSS-SECTION # 4 Dip1Pool4
Points = 40
Slope = .0025
SZF = 97.89

Weighting Factor = 1
Cross-section represents 5.000% of Total Reach.

>>> WSL Calibrations <<<
WSL Calculation Method: Log/Log Regression
Log/Log Regression A = .4671371
Log/Log Regression B = .264659
WSL = 0.4671 * Flow ^ 0.2647 + 97.89

>>> Velocity Calibrations <<<
Vel Calculation Method: 1-vel calibration

Vel Algorithm: Manning's N
Use Given N's: Yes
Vels calibrated to VelSet: 1

CROSS-SECTION # 5 Dip1Gld5
Points = 37
Slope = .0025
SZF = 97.89

Weighting Factor = 1
Cross-section represents 8.300% of Total Reach.

>>> WSL Calibrations <<<
WSL Calculation Method: Log/Log Regression
Log/Log Regression A = .4605577
Log/Log Regression B = .2699184
WSL = 0.4606 * Flow ^ 0.2699 + 97.89

>>> Velocity Calibrations <<<
Vel Calculation Method: 1-vel calibration
Vel Algorithm: Manning's N
Use Given N's: Yes
Vels calibrated to VelSet: 1

CROSS-SECTION # 6 Dip1LGR6
Points = 34
Slope = .0025
SZF = 97.89

Weighting Factor = 1
Cross-section represents 2.500% of Total Reach.

>>> WSL Calibrations <<<
WSL Calculation Method: Log/Log Regression
Log/Log Regression A = .4286698
Log/Log Regression B = .2451833
WSL = 0.4287 * Flow ^ 0.2452 + 97.89

>>> Velocity Calibrations <<<

Vel Calculation Method: 1-vel calibration
Vel Algorithm: Manning's N
Use Given N's: Yes
Vels calibrated to VelSet: 1

CROSS-SECTION # 7 Dip1Gld7
Points = 36
Slope = .0025
SZF = 97.44

Weighting Factor = 1
Cross-section represents 8.300% of Total Reach.

>>> WSL Calibrations <<<
WSL Calculation Method: Log/Log Regression
Log/Log Regression A = .3773866
Log/Log Regression B = .4117717
WSL = 0.3774 * Flow ^ 0.4118 + 97.44

>>> Velocity Calibrations <<<
Vel Calculation Method: 1-vel calibration
Vel Algorithm: Manning's N
Use Given N's: Yes
Vels calibrated to VelSet: 1

CROSS-SECTION # 8 Dip1Pool8
Points = 44
Slope = .0025
SZF = 97.26

Weighting Factor = 1
Cross-section represents 5.000% of Total Reach.

>>> WSL Calibrations <<<
WSL Calculation Method: Log/Log Regression
Log/Log Regression A = .4001958
Log/Log Regression B = .4254784
WSL = 0.4002 * Flow ^ 0.4255 + 97.26

>>> Velocity Calibrations <<<
Vel Calculation Method: 1-vel calibration
Vel Algorithm: Manning's N
Use Given N's: Yes
Vels calibrated to VelSet: 1

CROSS-SECTION # 9 Dip1Gld9
Points = 48
Slope = .0025
SZF = 97.26

Weighting Factor = 1
Cross-section represents 8.300% of Total Reach.

>>> WSL Calibrations <<<
WSL Calculation Method: Log/Log Regression
Log/Log Regression A = .4067094
Log/Log Regression B = .4054285
WSL = 0.4067 * Flow ^ 0.4054 + 97.26

>>> Velocity Calibrations <<<
Vel Calculation Method: 1-vel calibration
Vel Algorithm: Manning's N
Use Given N's: Yes
Vels calibrated to VelSet: 1

CROSS-SECTION # 10 Dip1Run10
Points = 37
Slope = .0025
SZF = 97.26

Weighting Factor = 1
Cross-section represents 2.500% of Total Reach.

>>> WSL Calibrations <<<
WSL Calculation Method: Log/Log Regression
Log/Log Regression A = .3960827
Log/Log Regression B = .3197478
WSL = 0.3961 * Flow ^ 0.3197 + 97.26

>>> Velocity Calibrations <<<
Vel Calculation Method: 1-vel calibration
Vel Algorithm: Manning's N
Use Given N's: Yes
Vels calibrated to VelSet: 1

CROSS-SECTION # 11 Dip2Gld11
Points = 36
Slope = .0025
SZF = 91.87

Weighting Factor = 1
Cross-section represents 8.300% of Total Reach.

>>> WSL Calibrations <<<
WSL Calculation Method: Log/Log Regression
Log/Log Regression A = .5275591
Log/Log Regression B = .4017188
WSL = 0.5276 * Flow ^ 0.4017 + 91.87

>>> Velocity Calibrations <<<
Vel Calculation Method: 1-vel calibration
Vel Algorithm: Manning's N
Use Given N's: Yes
Vels calibrated to VelSet: 1

CROSS-SECTION # 12 Dip2Pool12
Points = 43
Slope = .0025
SZF = 91.83

Weighting Factor = 1
Cross-section represents 5.000% of Total Reach.

>>> WSL Calibrations <<<
WSL Calculation Method: Log/Log Regression
Log/Log Regression A = .5252265
Log/Log Regression B = .4067159

WSL = 0.5252 * Flow ^ 0.4067 + 91.83

>>> Velocity Calibrations <<<
Vel Calculation Method: 1-vel calibration
Vel Algorithm: Manning's N
Use Given N's: Yes
Vels calibrated to VelSet: 1

CROSS-SECTION # 13 Dip2Run13
Points = 49
Slope = .0025
SZF = 91.83

Weighting Factor = 1
Cross-section represents 2.500% of Total Reach.

>>> WSL Calibrations <<<
WSL Calculation Method: Log/Log Regression
Log/Log Regression A = .5062716
Log/Log Regression B = .3922157
WSL = 0.5063 * Flow ^ 0.3922 + 91.83

>>> Velocity Calibrations <<<
Vel Calculation Method: 1-vel calibration
Vel Algorithm: Manning's N
Use Given N's: Yes
Vels calibrated to VelSet: 1

CROSS-SECTION # 14 Dip2Gld14
Points = 35
Slope = .0025
SZF = 91.83

Weighting Factor = 1
Cross-section represents 8.300% of Total Reach.

>>> WSL Calibrations <<<
WSL Calculation Method: Log/Log Regression
Log/Log Regression A = .4422261

Log/Log Regression B = .3559343
WSL = 0.4422 * Flow ^ 0.3559 + 91.83

>>> Velocity Calibrations <<<
Vel Calculation Method: 1-vel calibration
Vel Algorithm: Manning's N
Use Given N's: Yes
Vels calibrated to VelSet: 1

CROSS-SECTION # 15 Dip2Pool15
Points = 33
Slope = .0025
SZF = 91.8

Weighting Factor = 1
Cross-section represents 5.000% of Total Reach.

>>> WSL Calibrations <<<
WSL Calculation Method: Log/Log Regression
Log/Log Regression A = .4347975
Log/Log Regression B = .3515442
WSL = 0.4348 * Flow ^ 0.3515 + 91.80

>>> Velocity Calibrations <<<
Vel Calculation Method: 1-vel calibration
Vel Algorithm: Manning's N
Use Given N's: Yes
Vels calibrated to VelSet: 1

CROSS-SECTION # 16 Dip2LGR16
Points = 37
Slope = .0025
SZF = 91.8

Weighting Factor = 1
Cross-section represents 2.500% of Total Reach.

>>> WSL Calibrations <<<
WSL Calculation Method: Log/Log Regression

Log/Log Regression A = .3575108
Log/Log Regression B = .3432324
WSL = 0.3575 * Flow ^ 0.3432 + 91.80

>>> Velocity Calibrations <<<
Vel Calculation Method: 1-vel calibration
Vel Algorithm: Manning's N
Use Given N's: Yes
Vels calibrated to VelSet: 1

CROSS-SECTION # 17 Dip2Run17
Points = 37
Slope = .0025
SZF = 91.59

Weighting Factor = 1
Cross-section represents 2.500% of Total Reach.

>>> WSL Calibrations <<<
WSL Calculation Method: Log/Log Regression
Log/Log Regression A = .4687696
Log/Log Regression B = .294189
WSL = 0.4688 * Flow ^ 0.2942 + 91.59

>>> Velocity Calibrations <<<
Vel Calculation Method: 1-vel calibration
Vel Algorithm: Manning's N
Use Given N's: Yes
Vels calibrated to VelSet: 1

CROSS-SECTION # 18 Dip2LGR18
Points = 33
Slope = .0025
SZF = 91.59

Weighting Factor = 1
Cross-section represents 2.500% of Total Reach.

>>> WSL Calibrations <<<

WSL Calculation Method: Log/Log Regression
Log/Log Regression A = .3666437
Log/Log Regression B = .4165899
WSL = 0.3666 * Flow ^ 0.4166 + 91.59

>>> Velocity Calibrations <<<
Vel Calculation Method: 1-vel calibration
Vel Algorithm: Manning's N
Use Given N's: Yes
Vels calibrated to VelSet: 1

CROSS-SECTION # 19 Dip2Pool19
Points = 35
Slope = .0025
SZF = 91.31

Weighting Factor = .3759398
Cross-section represents 5.000% of Total Reach.

>>> WSL Calibrations <<<
WSL Calculation Method: Log/Log Regression
Log/Log Regression A = .6037377
Log/Log Regression B = .2942657
WSL = 0.6037 * Flow ^ 0.2943 + 91.31

>>> Velocity Calibrations <<<
Vel Calculation Method: 1-vel calibration
Vel Algorithm: Manning's N
Use Given N's: Yes
Vels calibrated to VelSet: 1

CROSS-SECTION # 20 Dip2Gld20
Points = 33
Slope = .0025
SZF = 91.31

Weighting Factor = 0
Cross-section represents 8.300% of Total Reach.

>>> WSL Calibrations <<<
WSL Calculation Method: Log/Log Regression
Log/Log Regression A = .5214783
Log/Log Regression B = .3147746
WSL = 0.5215 * Flow ^ 0.3148 + 91.31

>>> Velocity Calibrations <<<
Vel Calculation Method: 1-vel calibration
Vel Algorithm: Manning's N
Use Given N's: Yes
Vels calibrated to VelSet: 1

Dip Creek – Final Calibration Details
Dip1 and Dip2 Study Sites Combined

CROSS-SECTION # 1 Dip1LGR1
Points = 39 Slope = .0025 SZF = 98.17

CAL	Calib Stage	Given Flow	Wet Cnt	Wetted Perim	Wetted Area	Wetted Wdth	Hydrau Radius	Avg Depth
1	98.84	2.58	24	14.57	4.49	13.94	0.31	0.32
2	98.84	2.49	24	14.56	4.48	13.94	0.31	0.32
3	99.09	7.35	29	16.05	8.18	15.23	0.51	0.54

CROSS-SECTION # 2 Dip1Run2
Points = 40 Slope = .0025 SZF = 98.17

CAL	Calib Stage	Given Flow	Wet Cnt	Wetted Perim	Wetted Area	Wetted Wdth	Hydrau Radius	Avg Depth
1	98.75	2.58	20	7.93	3.74	7.27	0.47	0.51
2	98.71	2.49	20	7.61	3.51	6.98	0.46	0.50
3	98.99	7.35	26	11.49	5.98	10.67	0.52	0.56

CROSS-SECTION # 3 Dip1Pool3
Points = 50 Slope = .0025 SZF = 98.17

CAL	Calib Stage	Given Flow	Wet Cnt	Wetted Perim	Wetted Area	Wetted Wdth	Hydrau Radius	Avg Depth
1	98.70	2.58	20	9.95	7.74	8.88	0.78	0.87
2	98.68	2.49	19	9.84	7.59	8.77	0.77	0.87
3	98.95	7.35	33	15.92	10.79	14.74	0.68	0.73

CROSS-SECTION # 4 Dip1Pool4
Points = 40 Slope = .0025 SZF = 97.89

CAL	Calib Stage	Given Flow	Wet Cnt	Wetted Perim	Wetted Area	Wetted Wdth	Hydrau Radius	Avg Depth
1	98.49	2.58	23	10.99	7.70	10.13	0.70	0.76

CAL	Calib Stage	Given Flow	Wet Cnt	Wetted Perim	Wetted Area	Wetted Wdth	Hydrau Radius	Avg Depth
2	98.49	2.49	23	10.98	7.69	10.13	0.70	0.76
3	98.68	7.35	31	15.07	9.88	14.13	0.66	0.70

CROSS-SECTION # 5 Dip1Gld5
Points = 37 Slope = .0025 SZF = 97.89

CAL	Calib Stage	Given Flow	Wet Cnt	Wetted Perim	Wetted Area	Wetted Wdth	Hydrau Radius	Avg Depth
1	98.48	2.58	24	11.97	7.11	10.97	0.59	0.65
2	98.48	2.49	24	11.98	7.13	10.97	0.60	0.65
3	98.68	7.35	27	13.16	9.34	12.02	0.71	0.78

CROSS-SECTION # 6 Dip1LGR6
Points = 34 Slope = .0025 SZF = 97.89

CAL	Calib Stage	Given Flow	Wet Cnt	Wetted Perim	Wetted Area	Wetted Wdth	Hydrau Radius	Avg Depth
1	98.43	2.58	25	15.89	3.93	15.53	0.25	0.25
2	98.43	2.49	24	15.88	3.82	15.52	0.24	0.25
3	98.59	7.35	25	16.33	6.39	15.81	0.39	0.40

CROSS-SECTION # 7 Dip1Gld7
Points = 36 Slope = .0025 SZF = 97.44

CAL	Calib Stage	Given Flow	Wet Cnt	Wetted Perim	Wetted Area	Wetted Wdth	Hydrau Radius	Avg Depth
1	97.99	2.58	23	11.77	4.10	11.46	0.35	0.36
2	97.99	2.49	23	11.77	4.11	11.46	0.35	0.36
3	98.30	7.35	25	12.47	7.63	11.75	0.61	0.65

CROSS-SECTION # 8 Dip1Pool8
Points = 44 Slope = .0025 SZF = 97.26

CAL	Calib Stage	Given Flow	Wet Cnt	Wetted Perim	Wetted Area	Wetted Wdth	Hydrau Radius	Avg Depth
1	97.85	2.58	25	10.11	5.93	9.08	0.59	0.65
2	97.86	2.49	25	10.14	5.96	9.11	0.59	0.65

CAL	Calib Stage	Given Flow	Wet Cnt	Wetted Perim	Wetted Area	Wetted Wdth	Hydrau Radius	Avg Depth
3	98.20	7.35	33	12.86	9.63	11.45	0.75	0.84

CROSS-SECTION # 9 Dip1Gld9
Points = 48 Slope = .0025 SZF = 97.26

CAL	Calib Stage	Given Flow	Wet Cnt	Wetted Perim	Wetted Area	Wetted Wdth	Hydrau Radius	Avg Depth
1	97.85	2.58	23	8.97	4.97	8.31	0.55	0.60
2	97.85	2.49	23	8.98	4.99	8.32	0.56	0.60
3	98.17	7.35	30	12.68	8.03	11.82	0.63	0.68

CROSS-SECTION # 10 Dip1Run10
Points = 37 Slope = .0025 SZF = 97.26

CAL	Calib Stage	Given Flow	Wet Cnt	Wetted Perim	Wetted Area	Wetted Wdth	Hydrau Radius	Avg Depth
1	97.80	2.58	25	14.59	5.24	13.87	0.36	0.38
2	97.79	2.49	24	14.55	5.04	13.85	0.35	0.36
3	98.01	7.35	27	15.08	8.15	14.10	0.54	0.58

CROSS-SECTION # 11 Dip2Gld11
Points = 36 Slope = .0025 SZF = 91.87

CAL	Calib Stage	Given Flow	Wet Cnt	Wetted Perim	Wetted Area	Wetted Wdth	Hydrau Radius	Avg Depth
1	92.60	2.35	24	13.29	5.74	12.72	0.43	0.45
2	92.63	2.33	24	13.34	6.07	12.72	0.45	0.48
3	93.03	7.09	27	14.18	11.21	12.92	0.79	0.87

CROSS-SECTION # 12 Dip2Pool12
Points = 43 Slope = .0025 SZF = 91.83

CAL	Calib Stage	Given Flow	Wet Cnt	Wetted Perim	Wetted Area	Wetted Wdth	Hydrau Radius	Avg Depth
1	92.55	2.35	19	8.76	5.68	7.75	0.65	0.73
2	92.60	2.33	21	9.18	6.07	8.13	0.66	0.75
3	92.99	7.09	30	12.87	9.80	11.37	0.76	0.86

CROSS-SECTION # 13 Dip2Run13
Points = 49 Slope = .0025 SZF = 91.83

CAL	Calib Stage	Given Flow	Wet Cnt	Wetted Perim	Wetted Area	Wetted Wdth	Hydrau Radius	Avg Depth
1	92.52	2.35	21	8.50	3.96	8.05	0.47	0.49
2	92.56	2.33	23	8.77	4.25	8.29	0.48	0.51
3	92.92	7.09	27	11.56	7.66	10.78	0.66	0.71

CROSS-SECTION # 14 Dip2Gld14
Points = 35 Slope = .0025 SZF = 91.83

CAL	Calib Stage	Given Flow	Wet Cnt	Wetted Perim	Wetted Area	Wetted Wdth	Hydrau Radius	Avg Depth
1	92.43	2.35	23	11.80	5.49	11.31	0.46	0.49
2	92.43	2.33	23	11.80	5.45	11.31	0.46	0.48
3	92.72	7.09	24	12.45	8.78	11.55	0.71	0.76

CROSS-SECTION # 15 Dip2Pool15
Points = 33 Slope = .0025 SZF = 91.8

CAL	Calib Stage	Given Flow	Wet Cnt	Wetted Perim	Wetted Area	Wetted Wdth	Hydrau Radius	Avg Depth
1	92.38	2.35	19	10.31	5.14	9.46	0.50	0.54
2	92.39	2.33	20	10.47	5.27	9.61	0.50	0.55
3	92.67	7.09	23	14.13	8.51	13.07	0.60	0.65

CROSS-SECTION # 16 Dip2LGR16
Points = 37 Slope = .0025 SZF = 91.8

CAL	Calib Stage	Given Flow	Wet Cnt	Wetted Perim	Wetted Area	Wetted Wdth	Hydrau Radius	Avg Depth
1	92.26	2.35	22	11.18	3.31	10.97	0.30	0.30
2	92.30	2.33	24	11.62	3.80	11.37	0.33	0.33
3	92.49	7.09	28	14.31	6.15	13.90	0.43	0.44

CROSS-SECTION # 17 Dip2Run17
Points = 37 Slope = .0025 SZF = 91.59

CAL	Calib Stage	Given Flow	Wet Cnt	Wetted Perim	Wetted Area	Wetted Wdth	Hydrau Radius	Avg Depth
1	92.19	2.35	21	12.68	3.61	12.07	0.28	0.30
2	92.19	2.33	21	12.70	3.66	12.09	0.29	0.30
3	92.42	7.09	24	13.51	6.51	12.62	0.48	0.52

CROSS-SECTION # 18 Dip2LGR18
Points = 33 Slope = .0025 SZF = 91.59

CAL	Calib Stage	Given Flow	Wet Cnt	Wetted Perim	Wetted Area	Wetted Wdth	Hydrau Radius	Avg Depth
1	92.11	2.35	20	15.53	4.88	15.31	0.31	0.32
2	92.12	2.33	21	15.84	4.96	15.62	0.31	0.32
3	92.42	7.09	27	17.55	10.06	16.99	0.57	0.59

CROSS-SECTION # 19 Dip2Pool19
Points = 35 Slope = .0025 SZF = 91.31

CAL	Calib Stage	Given Flow	Wet Cnt	Wetted Perim	Wetted Area	Wetted Wdth	Hydrau Radius	Avg Depth
1	92.08	2.35	27	12.43	6.18	11.68	0.50	0.53
2	92.09	2.33	28	12.47	6.31	11.71	0.51	0.54
3	92.38	7.09	28	13.11	9.77	11.91	0.74	0.82

CROSS-SECTION # 20 Dip2Gld20
Points = 33 Slope = .0025 SZF = 91.31

CAL	Calib Stage	Given Flow	Wet Cnt	Wetted Perim	Wetted Area	Wetted Wdth	Hydrau Radius	Avg Depth
1	91.99	2.35	21	11.59	5.40	10.78	0.47	0.50
2	91.99	2.33	22	11.60	5.43	10.79	0.47	0.50
3	92.28	7.09	24	12.34	8.55	11.23	0.69	0.76

Dip Creek – Cross Section Data
Dip1 and Dip2 Study Sites Combined

SUMMARY DATA: CROSS-SECTION # 1 Dip1LGR1
Number of Points = 39

X	Y	VEL 1	SUBSTRATE
0.00	99.39		0.20
0.50	99.45		0.20
1.00	99.41		0.20
1.30	99.36		0.20
1.50	99.23		0.20
1.60	99.09		0.20
1.70	98.95		0.20
2.10	98.92		0.20
2.50	98.87		0.20
3.10	98.77	0.13	0.20
3.90	98.74	0.24	0.20
4.80	98.72	0.29	0.20
5.60	98.69	0.41	0.20
6.40	98.66	0.36	12.00
7.20	98.61	0.48	12.00
8.00	98.60	0.59	12.00
8.80	98.51	0.74	12.00
9.60	98.60	0.63	12.00
10.10	98.56	0.54	12.00
10.60	98.51	0.61	12.00
11.10	98.49	0.81	12.00
11.60	98.46	0.75	12.00
12.10	98.45	0.80	12.00
12.60	98.44	0.90	12.00
13.10	98.40	0.85	12.00
13.60	98.30	0.99	12.00
14.10	98.27	0.90	12.00
14.60	98.22	0.99	12.00
15.10	98.22	0.93	12.00
15.60	98.17	0.87	12.00

16.10	98.32	0.35	0.20
16.60	98.26	-0.05	0.20
16.61	98.82		0.20
16.70	98.96		0.20
16.80	99.07		0.20
17.00	99.21		0.20
17.20	99.32		0.20
17.42	99.40		0.20
17.43	99.39		0.20

SUMMARY DATA: CROSS-SECTION # 2 Dip1Run2
Number of Points = 40

X	Y	VEL 1	SUBSTRATE
0.00	99.54		0.20
1.00	99.45		0.20
2.00	99.46		0.20
3.00	99.44		0.20
4.00	99.36		0.20
5.00	99.27		0.20
6.00	99.16		0.20
7.00	99.05		0.20
8.00	98.94		0.20
9.00	98.84		0.20
10.00	98.79		0.20
10.70	98.76		0.20
11.50	98.67	-0.02	0.20
11.90	98.58	-0.01	0.20
12.30	98.49	-0.05	0.20
12.70	98.41	-0.06	0.20
13.10	98.37	0.12	0.20
13.50	98.29	0.37	0.20
13.90	98.25	0.57	0.20
14.30	98.21	0.64	0.20
14.70	98.15	0.61	0.20
15.00	98.08	0.82	12.00

15.30	98.05	0.82	12.00
15.60	98.04	1.03	12.00
15.90	97.98	1.16	12.00
16.20	97.94	1.22	12.00
16.50	97.93	1.20	12.00
16.80	97.91	1.11	12.00
17.10	97.91	1.26	12.00
17.40	97.95	1.30	12.00
17.70	97.95	1.23	12.00
18.00	98.09	0.74	0.20
18.10	98.75		0.20
18.20	98.85		0.20
18.30	99.18		0.20
18.40	99.30		0.20
18.50	99.39		0.20
18.70	99.50		0.20
19.00	99.63		0.20
20.41	99.70		0.20

SUMMARY DATA: CROSS-SECTION # 3 Dip1Pool3
Number of Points = 50

X	Y	VEL 1	SUBSTRATE
0.00	99.52		0.20
2.00	99.58		0.20
4.00	99.60		0.20
6.00	99.55		0.20
8.00	99.54		0.20
10.00	99.48		0.20
12.00	99.45		0.20
12.50	99.40		0.20
12.90	99.26		0.20
13.20	99.18		0.20
13.50	99.13		0.20
14.00	99.04		0.20
14.50	99.01		0.20

15.00	98.93		0.20
15.50	98.89		0.20
16.00	98.82		0.20
16.50	98.81		0.20
17.00	98.74		0.20
17.50	98.71		0.20
18.00	98.77		0.20
18.50	98.79		0.20
19.00	98.78		0.20
19.50	98.79		0.20
20.00	98.78		0.20
20.40	98.69		0.20
20.80	98.63	-0.06	0.20
21.60	98.47	0.04	0.20
22.40	98.18	-0.11	0.20
23.20	97.94	-0.01	0.20
23.60	97.82	0.07	0.20
24.00	97.72	0.18	0.20
24.40	97.69	0.32	0.20
24.80	97.57	0.37	0.20
25.20	97.57	0.50	0.20
25.60	97.30	0.56	0.20
26.00	97.30	0.65	0.20
26.40	97.31	0.58	0.20
26.80	97.33	0.71	0.20
27.20	97.35	0.43	0.20
27.60	97.46	0.47	0.20
28.00	97.54	0.51	0.20
28.40	97.52	0.31	0.20
28.80	97.57	0.20	0.20
29.00	98.45	0.06	0.20
29.25	98.72		0.20
29.60	98.89		0.20
29.90	99.25		0.20
30.10	99.53		0.20
30.30	99.66		0.20
30.77	99.92		0.20

SUMMARY DATA: CROSS-SECTION # 4 Dip1Pool4
Number of Points = 40

X	Y	VEL 1	SUBSTRATE
0.00	99.22		0.20
0.50	99.03		0.20
1.00	98.93		0.20
1.50	98.79		0.20
1.80	98.71		0.20
2.00	98.62		0.20
2.35	98.48		0.20
2.57	97.64	0.10	0.20
3.00	97.65	0.09	0.20
3.50	97.58	0.07	0.20
4.00	97.48	0.13	0.20
4.50	97.35	0.19	0.20
5.00	97.23	0.22	0.20
5.50	97.25	0.23	0.20
5.75	97.27	0.27	0.20
6.00	97.31	0.29	0.20
6.25	97.35	0.33	0.20
6.75	97.52	0.34	0.20
7.25	97.63	0.38	0.20
7.75	97.71	0.36	0.20
8.25	97.83	0.44	0.20
9.25	97.81	0.55	0.20
9.75	97.83	0.62	0.20
10.25	97.93	0.60	3.00
10.75	98.05	0.50	3.00
11.25	98.15	0.49	3.00
11.75	98.36	0.37	0.20
12.25	98.42	0.09	0.20
12.45	98.48		0.20
12.60	98.57		0.20
12.80	98.61		0.20
13.20	98.65		0.20
13.80	98.65		0.20
14.60	98.64		0.20
15.40	98.64		0.20

15.90	98.63		0.20
16.10	98.74		0.20
16.40	98.84		0.20
16.80	98.86		0.20
17.20	99.08		0.20

SUMMARY DATA: CROSS-SECTION # 5 Dip1Gld5
Number of Points = 37

X	Y	VEL 1	SUBSTRATE
0.00	99.30		0.20
0.50	99.23		0.20
0.80	99.14		0.20
1.00	99.12		0.20
1.20	99.04		0.20
1.40	98.90		0.20
1.60	98.67		0.20
1.75	98.48		0.20
2.10	97.77	0.13	3.00
2.40	97.12	0.18	3.00
2.90	97.21	0.33	12.00
3.40	97.30	0.29	12.00
3.90	97.40	0.28	12.00
4.40	97.49	0.28	12.00
4.90	97.55	0.30	12.00
5.40	97.64	0.33	12.00
5.90	97.69	0.41	12.00
6.40	97.81	0.42	12.00
6.90	97.86	0.42	12.00
7.40	97.97	0.43	12.00
7.90	97.98	0.43	12.00
8.40	98.01	0.45	12.00
8.90	98.03	0.53	12.00
9.40	98.04	0.51	12.00
9.90	98.01	0.48	12.00
10.40	98.05	0.45	12.00

10.90	98.05	0.36	12.00
11.40	98.12	0.27	3.00
11.90	98.33	0.07	3.00
12.40	98.41	-0.03	3.00
12.70	98.47		0.20
12.80	98.53		0.20
13.00	98.63		0.20
14.00	98.71		0.20
14.50	98.76		0.20
15.00	98.86		0.20
15.35	98.99		0.20

SUMMARY DATA: CROSS-SECTION # 6 Dip1LGR6
Number of Points = 34

X	Y	VEL 1	SUBSTRATE
0.00	99.35		0.20
1.05	99.16		0.20
1.30	99.07		0.20
2.20	98.43		0.20
2.26	98.29	0.04	0.20
3.00	98.26	0.42	0.20
3.70	98.31	0.22	0.20
4.40	98.35		0.20
5.10	98.33	0.25	0.20
5.80	98.33	0.32	0.20
6.50	98.32	0.47	0.20
7.20	98.31	0.60	0.20
7.90	98.30	0.66	0.20
8.60	98.24	0.61	0.20
9.30	98.22	0.75	3.00
10.00	98.24	1.03	3.00
10.70	98.19	0.98	3.00
11.40	98.18	1.04	3.00
12.10	98.14	0.80	0.20
12.80	98.04	0.95	0.20

13.50	97.99	0.91	0.20
14.20	97.89	0.95	0.20
14.90	97.89	1.07	0.20
15.60	97.96	1.10	0.20
16.30	98.04	1.07	0.20
17.00	98.14	0.97	0.20
17.70	98.18	0.14	0.20
17.71	98.39		0.20
17.80	98.62		0.20
17.90	98.69		0.20
18.00	98.81		0.20
18.10	98.87		0.20
18.30	98.96		0.20
18.66	99.08		0.20

SUMMARY DATA: CROSS-SECTION # 7 Dip1Gld7
Number of Points = 36

X	Y	VEL 1	SUBSTRATE
0.00	99.00		0.20
0.20	98.82		0.20
0.30	98.59		0.20
0.40	98.55		0.20
0.50	98.50		0.20
0.60	98.39		0.20
0.70	97.99		0.20
0.90	97.58	0.45	0.20
1.45	97.56	0.47	0.20
2.00	97.56	0.58	0.20
2.55	97.62	0.60	12.00
3.10	97.61	0.71	12.00
3.65	97.48	0.73	12.00
4.20	97.45	0.74	12.00
4.75	97.44	0.82	12.00
5.30	97.45	0.73	12.00
5.85	97.49	0.82	12.00

6.40	97.54	0.81	12.00
6.95	97.61	0.75	12.00
7.50	97.63	0.76	12.00
8.05	97.63	0.59	0.20
8.60	97.71	0.59	0.20
9.15	97.72	0.50	0.20
9.70	97.75	0.49	0.20
10.25	97.79	0.38	0.20
10.80	97.83	0.26	0.20
11.35	97.88	0.29	0.20
11.90	97.92	-0.02	0.20
12.15	97.98		0.20
12.25	98.17		0.20
12.35	98.29		0.20
12.50	98.34		0.20
12.80	98.41		0.20
13.20	98.52		0.20
13.60	98.69		0.20
14.26	98.88		0.20

SUMMARY DATA: CROSS-SECTION # 8 Dip1Pool8
Number of Points = 44

X	Y	VEL 1	SUBSTRATE
0.00	98.69		0.20
0.30	98.55		0.20
0.50	98.43		0.20
0.70	98.31		0.20
0.80	98.25		0.20
0.90	98.16		0.20
1.00	97.88		0.20
1.50	97.96		0.20
2.05	97.93		0.20
2.50	97.90		0.20
2.95	97.85		0.20
3.50	97.78	0.30	0.20

4.00	97.71	0.35	0.20
4.50	97.64	0.56	3.00
5.00	97.60	0.63	3.00
5.50	97.51	0.66	3.00
6.00	97.42	0.67	3.00
6.35	97.29	0.56	3.00
6.70	97.23	0.59	3.00
7.05	97.14	0.59	3.00
7.40	97.06	0.64	3.00
7.75	96.98	0.61	3.00
8.10	96.90	0.59	3.00
8.45	96.86	0.57	3.00
8.80	96.83	0.54	3.00
9.15	96.79	0.43	0.20
9.50	96.78	0.34	0.20
9.85	96.77	0.28	0.20
10.20	96.82	0.23	0.20
10.55	96.92	0.25	0.20
10.90	96.98	0.23	0.20
11.25	96.97	0.19	0.20
11.60	96.88	0.08	0.20
11.90	96.87	0.01	0.20
12.00	97.85		0.20
12.10	98.02		0.20
12.20	98.13		0.20
12.30	98.19		0.20
12.40	98.24		0.20
12.50	98.30		0.20
12.70	98.47		0.20
12.90	98.55		0.20
13.10	98.68		0.20
13.48	98.83		0.20

SUMMARY DATA: CROSS-SECTION # 9 Dip1Gld9
Number of Points = 48

X	Y	VEL 1	SUBSTRATE

0.00	98.89		0.20
0.30	98.83		0.20
0.40	98.81		0.20
0.50	98.58		0.20
0.60	98.48		0.20
0.75	98.41		0.20
0.85	98.33		0.20
0.95	98.27		0.20
1.05	98.21		0.20
1.15	98.17		0.20
1.60	98.12		0.20
2.30	98.14		0.20
3.00	98.10		0.20
3.50	98.01		0.20
4.00	97.94		0.20
4.45	97.85		0.20
4.70	97.78	-0.02	0.20
5.10	97.70	0.04	0.20
5.50	97.59	0.04	0.20
5.90	97.52	0.16	0.20
6.30	97.45	0.35	0.20
6.70	97.37	0.38	0.20
7.10	97.39	0.42	0.20
7.50	97.36	0.48	0.20
7.90	97.25	0.53	12.00
8.30	97.15	0.64	12.00
8.70	97.07	0.68	12.00
9.10	97.00	0.67	12.00
9.50	96.95	0.68	12.00
9.90	96.94	0.63	12.00
10.30	96.96	0.63	12.00
10.70	97.01	0.68	12.00
11.10	97.04	0.50	0.20
11.50	97.09	0.46	0.20
11.90	97.13	0.43	0.20
12.30	97.18	0.39	0.20
12.70	97.27	0.31	0.20
12.75	97.85		0.20
12.90	98.12		0.20
13.00	98.20		0.20

13.10	98.34	0.20
13.20	98.47	0.20
13.30	98.51	0.20
13.50	98.59	0.20
13.60	98.77	0.20
13.70	98.85	0.20
13.80	98.96	0.20
14.12	99.12	0.20

SUMMARY DATA: CROSS-SECTION # 10 Dip1Run10
Number of Points = 37

X	Y	VEL 1	SUBSTRATE
0.00	98.69		0.20
0.40	98.51		0.20
0.60	98.33		0.20
0.70	98.16		0.20
0.80	97.93		0.20
0.90	97.77		0.20
1.50	96.91	-0.05	0.20
2.00	96.76	0.27	0.20
2.60	96.76	0.72	3.00
3.20	96.86	0.51	3.00
3.80	97.08	0.58	3.00
4.40	97.26	0.64	3.00
5.00	97.38	0.80	3.00
5.60	97.46	0.90	3.00
6.20	97.52	0.89	3.00
6.80	97.45	0.89	3.00
7.40	97.54	0.73	3.00
8.00	97.64	0.67	3.00
8.60	97.60	0.59	3.00
9.20	97.63	0.38	3.00
9.80	97.68	0.35	3.00
10.40	97.69	0.31	3.00
11.00	97.71	0.25	0.20

11.60	97.68	0.37	0.20
12.20	97.62	0.25	0.20
12.80	97.58	0.34	0.20
13.40	97.56	0.37	0.20
14.00	97.48	0.27	0.20
14.60	97.62	0.10	0.20
14.75	97.80		0.20
14.80	97.97		0.20
14.90	98.03		0.20
15.10	98.10		0.20
15.20	98.16		0.20
15.30	98.24		0.20
15.50	98.43		0.20
15.74	98.58		0.20

SUMMARY DATA: CROSS-SECTION # 11 Dip2Gld11
Number of Points = 36

X	Y	VEL 1	SUBSTRATE
0.00	93.33		0.20
0.20	93.21		0.20
0.30	93.08		0.20
0.40	92.95		0.20
0.49	92.63		0.20
0.50	92.58		0.20
0.70	92.40	-0.01	0.20
1.30	92.39	0.06	0.20
1.90	92.25	0.24	0.20
2.50	92.20	0.42	0.20
3.10	92.18	0.54	0.20
3.70	92.20	0.60	0.20
4.30	92.18	0.60	0.20
4.90	92.21	0.64	0.20
5.50	92.20	0.63	0.20
6.10	92.23	0.62	0.20
6.70	92.12	0.45	0.20

7.30	92.19	0.50	0.20
7.90	92.12	0.48	0.20
8.50	92.10	0.45	0.20
9.10	91.96	0.42	0.20
9.70	91.99	0.44	0.20
10.30	91.87	0.46	0.20
10.90	91.98	0.26	0.20
11.50	92.10	0.14	0.20
12.10	92.13	0.36	0.20
12.70	92.10	0.40	0.20
13.20	92.20	-0.04	0.20
13.21	92.59		0.20
13.25	92.89		0.20
13.30	93.33		0.20
13.40	93.33		0.20
13.60	93.42		0.20
13.80	93.59		0.20
14.10	93.75		0.20
14.30	93.86		0.20

SUMMARY DATA: CROSS-SECTION # 12 Dip2Pool12
Number of Points = 43

X	Y	VEL 1	SUBSTRATE
0.00	93.16		0.20
1.00	93.10		0.20
2.00	93.11		0.20
2.50	93.03		0.20
3.00	92.97		0.20
3.50	92.90		0.20
4.00	92.81		0.20
4.30	92.72		0.20
4.70	92.63		0.20
5.25	92.56		0.20
5.60	92.49	0.09	0.20
6.10	92.41	0.24	0.20

6.60	92.34	0.40	0.20
7.10	92.28	0.43	0.20
7.60	92.14	0.46	0.20
8.10	92.01	0.40	0.20
8.40	91.85	0.39	0.20
8.70	91.83	0.37	0.20
9.00	91.79	0.45	0.20
9.30	91.75	0.50	0.20
9.60	91.66	0.50	0.20
9.90	91.55	0.46	0.20
10.20	91.43	0.57	0.20
10.50	91.30	0.63	0.20
10.90	91.32	0.66	0.20
11.80	91.05	0.41	0.20
12.10	91.18	0.26	0.20
12.40	91.35	0.19	0.20
12.80	92.05	0.11	0.20
13.05	92.55		0.20
13.15	92.78		0.20
13.30	92.89		0.20
13.55	92.95		0.20
14.00	92.67		0.20
14.35	93.20		0.20
14.50	93.40		0.20
14.80	93.48		0.20
15.00	93.49		0.20
15.50	93.51		0.20
16.00	93.58		0.20
16.50	93.80		0.20
17.00	93.83		0.20
18.00	93.88		0.20

SUMMARY DATA: CROSS-SECTION # 13 Dip2Run13
Number of Points = 49

X	Y	VEL 1	SUBSTRATE

0.00	93.60		0.20
1.00	93.65		0.20
2.50	93.61		0.20
4.00	93.61		0.20
5.50	93.59		0.20
7.00	93.50		0.20
9.00	93.42		0.20
11.00	93.30		0.20
12.00	93.20		0.20
13.00	93.05		0.20
14.00	92.93		0.20
15.00	92.82		0.20
15.50	92.72		0.20
16.00	92.63		0.20
16.70	92.52		0.20
17.05	92.45	0.08	0.20
17.50	92.38	0.21	0.20
18.00	92.28	0.39	0.20
18.50	92.23	0.48	0.20
19.00	92.17	0.60	0.20
19.50	92.12	0.70	12.00
20.00	92.08	0.77	12.00
20.50	92.04	0.83	12.00
20.80	91.99	0.80	12.00
21.10	91.93	0.68	12.00
21.40	91.85	0.76	12.00
22.00	91.77	0.79	12.00
22.30	91.74	0.73	12.00
22.60	91.71	0.76	12.00
22.90	91.69	0.59	12.00
23.20	91.70	0.59	0.20
23.50	91.71	0.66	0.20
23.80	91.78	0.62	0.20
24.10	91.89	0.51	0.20
24.40	92.01	0.22	0.20
24.70	92.18	-0.06	0.20
24.75	92.52		0.20
24.80	92.79		0.20
24.95	93.01		0.20
25.15	93.16		0.20
25.30	93.15		0.20

25.45	92.95		0.20
25.60	92.98		0.20
25.80	93.16		0.20
26.00	93.34		0.20
26.20	93.40		0.20
26.70	93.60		0.20
27.30	93.72		0.20
27.80	93.62		0.20

SUMMARY DATA: CROSS-SECTION # 14 Dip2Gld14
Number of Points = 35

X	Y	VEL 1	SUBSTRATE
0.00	93.92		0.20
0.50	93.73		0.20
1.00	93.49		0.20
1.50	93.37		0.20
2.00	93.18		0.20
2.50	92.98		0.20
3.10	92.13	0.06	0.20
3.60	91.98	0.27	0.20
4.10	92.00	0.44	0.20
4.60	91.98	0.47	0.20
5.10	91.93	0.52	0.20
5.60	91.89	0.55	0.20
6.10	91.86	0.58	3.00
6.60	91.83	0.55	3.00
7.10	91.83	0.50	0.20
7.60	91.85	0.48	0.20
8.10	91.86	0.55	0.20
8.60	91.89	0.52	0.20
9.10	91.86	0.50	0.20
9.60	91.93	0.52	0.20
10.10	91.97	0.53	0.20
10.60	91.93	0.51	0.20
11.10	91.97	0.46	0.20

11.60	92.00	0.40	0.20
12.10	92.03	0.39	0.20
12.60	91.97	0.28	0.20
13.10	91.94	0.10	0.20
13.60	91.99	0.21	0.20
14.10	92.06	0.10	0.20
14.20	92.43		0.20
14.25	92.88		0.20
14.35	93.05		0.20
14.50	93.20		0.20
14.70	93.36		0.20
15.12	93.48		0.20

SUMMARY DATA: CROSS-SECTION # 15 Dip2Pool15
Number of Points = 33

X	Y	VEL 1	SUBSTRATE
0.00	92.95		0.20
0.40	92.82		0.20
0.60	92.82		0.20
0.75	92.74		0.20
0.95	92.36		0.20
1.40	91.94	0.29	0.20
1.65	91.18	0.37	0.20
2.00	91.14	0.41	0.20
2.40	91.27	0.43	0.20
2.80	91.33	0.56	3.00
3.20	91.35	0.64	3.00
3.60	91.36	0.62	3.00
4.00	91.44	0.59	0.20
4.80	91.57	0.51	0.20
5.20	91.70	0.52	0.20
5.60	91.78	0.52	0.20
6.00	91.84	0.45	0.20
6.40	91.92	0.34	0.20
7.00	92.06	0.01	0.20

7.60	92.17	-0.02	0.20
8.20	92.26	0.02	0.20
8.90	92.33	-0.03	0.20
10.10	92.35		0.20
10.50	92.39		0.20
11.50	92.46		0.20
12.50	92.48		0.20
13.50	92.52		0.20
14.00	92.72		0.20
14.50	92.92		0.20
15.00	93.09		0.20
15.50	93.14		0.20
16.00	93.20		0.20
16.52	93.29		0.20

SUMMARY DATA: CROSS-SECTION # 16 Dip2LGR16
Number of Points = 37

X	Y	VEL 1	SUBSTRATE
0.00	93.09		0.20
0.40	93.02		0.20
0.70	92.78		0.20
0.85	92.70		0.20
1.00	92.47		0.20
1.10	92.47		0.20
1.13	92.26		0.20
1.20	92.06	0.08	0.20
1.70	92.05	0.25	12.00
2.20	91.99	0.53	12.00
2.70	91.94	0.65	12.00
3.20	91.86	0.89	12.00
3.70	91.80	1.01	12.00
4.20	91.85	0.86	12.00
4.70	91.89	0.94	12.00
5.20	91.93	0.97	12.00
5.70	91.90	0.89	12.00

6.20	91.93	0.98	12.00
6.70	91.94	0.82	12.00
7.20	91.96	0.85	12.00
7.70	91.95	0.77	12.00
8.20	91.95	0.69	12.00
8.70	91.98	0.65	12.00
9.20	91.88	0.59	12.00
9.70	91.88	0.55	12.00
10.20	91.94	0.50	12.00
10.70	92.04	0.39	12.00
11.20	92.10	0.32	12.00
11.70	92.19	0.03	0.20
12.10	92.26		0.20
13.00	92.36		0.20
14.00	92.43		0.20
15.00	92.50		0.20
15.50	92.61		0.20
16.00	92.76		0.20
16.50	92.88		0.20
17.14	92.97		0.20

SUMMARY DATA: CROSS-SECTION # 17 Dip2Run17
Number of Points = 37

X	Y	VEL 1	SUBSTRATE
0.00	92.96		0.20
0.50	92.82		0.20
1.00	92.97		0.20
1.50	92.89		0.20
2.00	92.85		0.20
2.40	92.79		0.20
2.60	92.71		0.20
2.61	92.21		0.20
3.00	91.37	0.26	0.20
3.40	91.31	0.78	12.00
3.80	91.28	0.97	12.00

4.20	91.35	0.94	12.00
4.60	91.45	0.80	12.00
5.00	91.54	0.79	12.00
5.40	91.60	0.67	12.00
5.80	91.65	0.64	12.00
6.20	91.73	0.55	0.20
6.60	91.82	0.46	0.20
7.00	91.89	0.43	0.20
8.00	92.01	0.68	12.00
9.00	92.02	0.64	12.00
10.00	92.06	0.46	0.20
11.00	92.15	0.40	0.20
11.60	92.15	0.38	0.20
12.60	92.13	0.36	12.00
13.50	92.14	0.34	0.20
14.00	92.13	0.33	0.20
14.30	92.12	0.32	0.20
14.60	92.17		0.20
14.95	92.25		0.20
15.20	92.41		0.20
15.50	92.55		0.20
15.80	92.72		0.20
16.10	92.78		0.20
16.60	92.98		0.20
17.20	93.04		0.20
18.25	93.10		0.20

SUMMARY DATA: CROSS-SECTION # 18 Dip2LGR18
Number of Points = 33

X	Y	VEL 1	SUBSTRATE
0.00	92.64		0.20
0.50	92.58		0.20
0.70	92.57		0.20
0.80	92.49		0.20
0.90	92.22		0.20

1.10	92.14		0.20
1.70	92.12		0.20
2.30	92.11		0.20
2.87	92.09		0.20
4.40	92.06	0.02	0.20
5.10	92.01	0.25	0.20
5.80	91.96	0.04	3.00
6.50	91.93	0.48	3.00
7.20	91.86	0.44	3.00
7.90	91.77	0.49	3.00
8.60	91.68	0.54	3.00
9.30	91.60	0.74	3.00
10.00	91.60	0.71	3.00
10.70	91.63	0.71	3.00
11.40	91.67	0.62	3.00
12.10	91.67	0.59	3.00
12.80	91.68	0.58	3.00
13.80	91.77	0.55	3.00
14.50	91.68	0.44	3.00
15.20	91.69	0.34	0.20
15.90	91.59	0.27	0.20
16.60	91.64	0.17	0.20
17.30	91.75	-0.04	0.20
17.63	92.13		0.20
17.68	92.26		0.20
17.80	92.35		0.20
17.90	92.71		0.20
18.26	92.82		0.20

SUMMARY DATA: CROSS-SECTION # 19 Dip2Pool19
Number of Points = 35

X	Y	VEL 1	SUBSTRATE
0.00	92.86		0.20
0.30	92.76		0.20
0.50	92.54		0.20

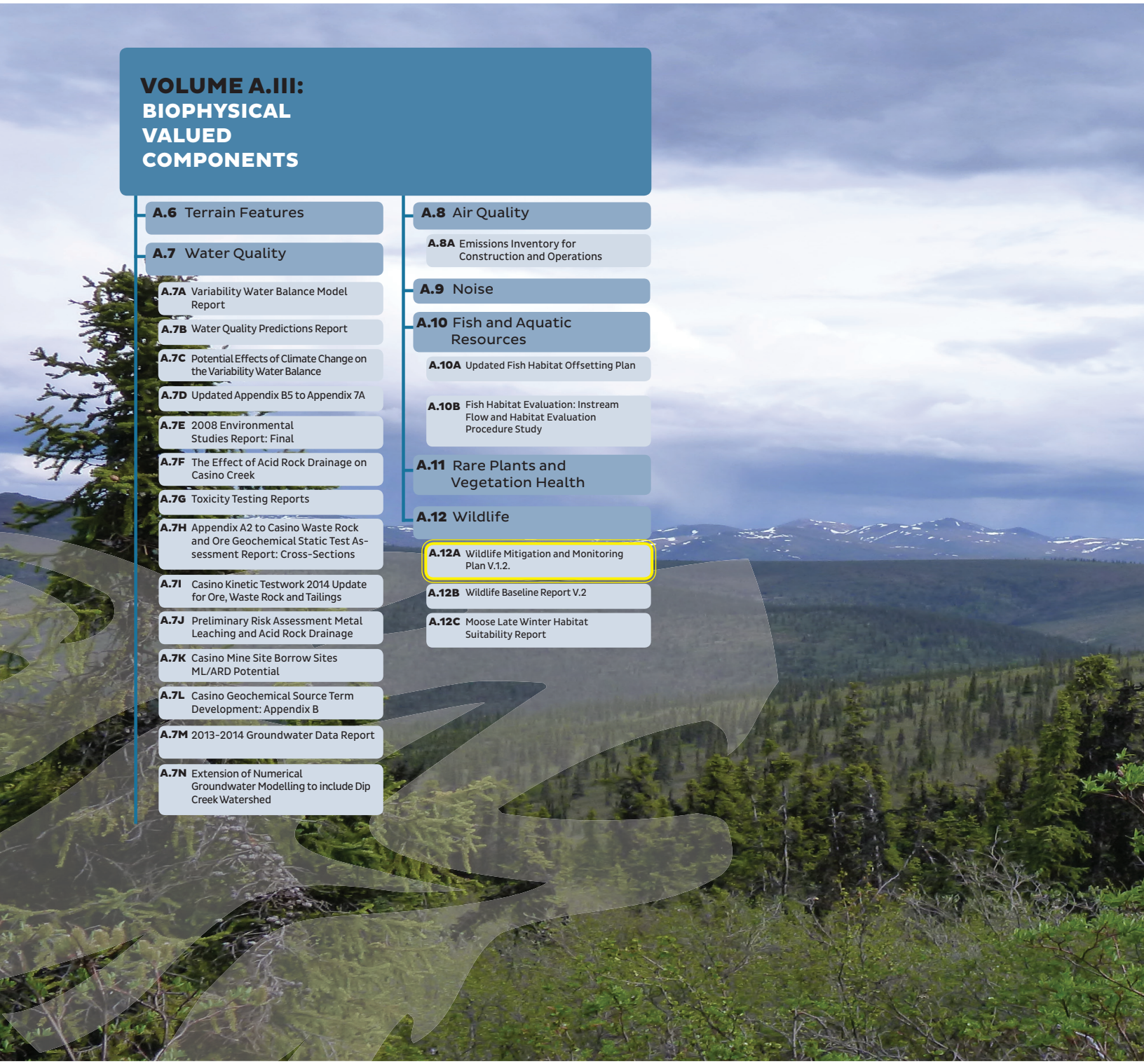
0.69	92.40		0.20
0.70	92.09		0.20
1.20	91.93	0.04	0.20
1.80	91.87	0.38	0.20
2.40	91.97	0.17	0.20
2.90	92.03		0.20
3.40	92.03		0.20
3.70	92.03		0.20
4.00	91.95	0.25	0.20
4.40	91.85	0.31	0.20
4.80	91.80	0.40	3.00
5.20	91.71	0.30	3.00
5.60	91.62	0.28	3.00
6.00	91.60	0.41	3.00
6.40	91.55	0.58	3.00
6.80	91.49	0.64	3.00
7.20	91.35	0.73	3.00
8.00	91.17	0.75	3.00
8.40	91.07	0.83	3.00
8.80	90.99	0.77	3.00
9.20	90.96	0.63	3.00
9.60	91.02	0.43	3.00
10.00	91.13	0.29	3.00
10.40	91.22	0.09	0.20
10.80	91.29		0.20
11.20	91.35	-0.09	0.20
11.60	91.41	-0.11	0.20
12.00	91.25	-0.06	0.20
12.40	92.07		0.20
12.60	92.39		0.20
12.90	92.71		0.20
13.25	92.87		0.20

SUMMARY DATA: CROSS-SECTION # 20 Dip2Gld20
Number of Points = 33

X	Y	VEL 1	SUBSTRATE

```
----------------------------------------
      0.00     92.74                0.20
      0.30     92.54                0.20
      0.40     92.50                0.20
      0.50     92.34                0.20
      0.60     92.15                0.20
      0.81     91.99                0.20
      0.82     91.36      0.04      0.20
      1.30     91.31      0.15      0.20
      1.80     91.36      0.18      0.20
      2.30     91.41      0.21      0.20
      2.80     91.45      0.36      0.20
      3.30     91.42      0.47      3.00
      3.80     91.40      0.42      3.00
      4.30     91.43      0.52      3.00
      4.80     91.43      0.53      3.00
      5.30     91.43      0.60      3.00
      5.80     91.45      0.67      3.00
      6.30     91.47      0.57      3.00
      6.80     91.51      0.60      3.00
      7.30     91.52      0.56      3.00
      7.80     91.54      0.53      3.00
      8.30     91.57      0.50      3.00
      8.80     91.57      0.53      3.00
      9.30     91.58      0.46      0.20
     10.30     91.59      0.37      0.20
     10.80     91.56      0.22      0.20
     11.30     91.63      0.22      0.20
     11.60     92.00                0.20
     11.80     92.33                0.20
     12.00     92.49                0.20
     12.20     92.75                0.20
     12.40     92.83                0.20
     12.72     93.03                0.20
```

APPENDIX A.12A: Wildlife Mitigation and Monitoring Plan V.1.2.



CASINO PROJECT

WILDLIFE MITIGATION AND MONITORING PLAN

Version 1.2

January 2015

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ABBREVIATIONS

Abbreviation	Definition
BACI	Before-After-Control-Impact
CMC	Casino Mining Corporation
COSEWIC	Committee on the Status of Endangered Species in Canada
COPC	Constituents of Potential Concern
GPS	Global Positioning System
EPP	Environmental Protection Plan
LSA	Local Study Area
LSCFN	Little Salmon/Carmacks First Nation
NMP	Northern Mountain Population of Woodland Caribou
Project	The Casino Project
PDA	Potential Disturbance Area
RRC	Renewable Resource Council
RSA	Regional Study Area
SARA	*Species at Risk Act*
SFN	Selkirk First Nation
TBD	To be decided
TMF	Tailings Management Facility
VC	Valued Component
WMMP	Wildlife Mitigation and Monitoring Plan
YESAB	Yukon Environmental and Socio-economic Assessment Board
YG	Yukon Government
ZOI	Zone of Influence

REVISION SUMMARY

Version no.	Date	Revision notes	Revision authors
1.0	28 November 2013	YESAB Project Proposal Submission version	EDI: M. Setterington, R.P.Bio.
1.1	24 June 2014	Details in Legislation and Management Section and Wildlife Working Group; some re-formatting of headers.	EDI: M. Setterington, Contract: B. Pelchat
1.2	January 2015	Incorporated reviewer input from the YESAB adequacy review of the Project Proposal.	EDI: M.Setterington

1 - INTRODUCTION

Casino Mining Corporation (CMC) is proposing to develop the Casino Project (the Project), a copper-molybdenum-gold mine at their Casino Mine property located at latitude 62°44' N and longitude 138°50' W, approximately 300 km northwest of Whitehorse, Yukon. The proposed Project will have a mine life of 34 years comprised of four phases: construction (4 years), operation (22 years), closure and decommissioning (3 years), and post closure (5 years). The Project includes the following primary components:

- Mine site — including open pit; stockpiles for low grade ore, gold ore, topsoil and overburden; a plant site; heap leach facility;
- Tailings management facility;
- Extension and upgrade of the Freegold Road (previously referred to as the Casino Trail). The Freegold Road will be upgraded and extended to connect the Casino mine site to Carmacks, Yukon area. The existing 70 km of the Freegold Road will require upgrading and route adjustments to meet design standards. The final road will be approximately 200 km long and maintained as an all-season gravel road suitable for ore and fuel transport;
- Construction and operation of a new airstrip; and
- Access road and water pipeline to the Yukon River.

Project components and activities will interact with and potentially affect wildlife by:

- Removing available habitat by land clearing and reducing adjacent habitat effectiveness because of sensory disturbances;
- Creating filters (semi-permeable barrier) or barriers to wildlife movement because of sensory disturbance or physical barriers created by mine infrastructure;
- Increasing mortality risk due to vehicle collisions, or increased harvest, or death as a result of defence of life or property; and
- Reducing quality of health of individual animals that may be attracted to the tailings management facility during operations or at closure.

The purpose of the Wildlife Mitigation and Monitoring Plan (WMMP) is to minimize effects to wildlife and wildlife habitat, monitor the results of mitigation to ensure effectiveness, and adaptively manage for any unanticipated effects given the final Project footprint and description as provided to the Yukon Environmental and Socio-economic Assessment Board (YESAB). The plan is intended to ensure that wildlife continue to use habitat in areas adjacent to the Project footprint and within the broader area, as well as reduce potential Project-related injury or mortality, while accounting for operational requirements and human health and safety requirements. The WMMP provides guidance to protect and limit disturbances to wildlife and wildlife habitat from Project activities.

Mitigation of Project effects on wildlife and avoidance of key habitat features were considered in the Project design and in preparation of the Project description and effects assessment. Wildlife management, monitoring, and/or protection plans from similar mining projects in the Yukon (e.g. Eagle Gold Project, Wolverine Mine, Minto Mine, Bellekeno Mine) were reviewed to provide details on mitigations and monitoring that has been implemented in the Yukon and to determine the effectiveness of those actions. This document does not provide detailed methods (i.e., study designs), cost estimates, or schedules. It is anticipated that further details will be developed in continued discussion with the management agencies, Renewable Resource Councils (RRCs), working groups established to monitor Project effects, and other interested parties.

1.1 REGULATORY AND MANAGEMENT CONTEXT

The following legislation and regulations may be relevant to the management and conservation of wildlife in the Project area, and in some circumstances may supersede the commitments made in this plan.

1.1.1 Federal Government

Yukon Act (2002)

The Yukon Act (2003) gives authority to the Yukon Legislature to make laws in relation to the conservation of wildlife and its habitat within Yukon Territory, other than in a federal conservation area. This Act prohibits the Yukon government from making laws that limit subsistence hunting by aboriginal people on lands where Final Agreements are not in effect. Where Final Agreements are in effect, such as the Project area, the Yukon government has the legislative authority to regulate all hunting, and must conform to the provisions of First Nation Final Agreements when addressing subsistence harvesting.

Yukon Environment and Socio-economic Assessment Act (YESAA)

YESAA gives authority and rules to the Yukon Environment and Socio-economic Assessment Board to administer the assessment process that applies to all lands within Yukon. It was called for in Chapter 12 of the Yukon First Nations Final Agreements and came into effect in 2003.

Migratory Birds Convention Act (1994) (MBCA)

MBCA and its regulations provide protection for migratory birds, their eggs, their nests, and their habitats, and regulate the hunting of migratory game birds. The MBCA and its regulations prohibit the incidental take of migratory birds, their eggs, or active nests. Hunting regulations can be updated annually. Proposed regulatory amendments in the Yukon are publicly reviewed by the Yukon Fish and Wildlife Management Board and recommended to the federal Minister of Environment.

Species at Risk Act (SARA)

SARA implements in part Canada's obligations under the United Nations *Convention of Biological Diversity*. It provides for the legal protection of wildlife species and the conservation of their biological diversity. The Act prevents wildlife species in Canada from disappearing, provides for the recovery of wildlife species that are extirpated (no longer exist in the wild in Canada), endangered or threatened as a result of human activity, and manages species of special concern to prevent them from becoming endangered or threatened. Within the Act, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), an independent body of experts, is responsible for identifying and assessing wildlife species considered at risk, which may then qualify for legal protection and recovery under SARA. Once listed under SARA, species plans are legal requirements to secure the necessary actions for species recovery and management. The only species at risk in the Project area with an existing management plan is the Northern Mountain Population of caribou (which includes the Klaza caribou herd).

Canadian Wildlife Act

The Canadian Wildlife Act allows for the creation, management and protection of wildlife areas to preserve habitats, and to permit wildlife research and interpretive activities. There are no such protected areas in the LSCFN and SFN traditional territories.

Convention on Wetlands (Ramsar, Iran, 1971)

RAMSAR commits the federal government to maintain the ecological character of wetlands of international significance and to plan for the sustainable use of all wetlands. The Federal Wetlands Policy was established in 1991 in response to RAMSAR. The policy provides goals, guiding principles and strategies for conserving wetlands on federal lands and those significant to Canadians. There are no wetlands of interest in the LSCFN and SFN traditional territories.

1.1.2 Yukon Government

Environment Act

The Yukon's Environment Act and regulations provide for the protection of land, water, and air. It applies on lands throughout the Yukon, including private property, Crown lands, lands within municipal boundaries, and First Nation settlement lands where the First Nation has not developed equivalent laws. This Act is primarily used for regulations related to air quality, waste, recycling, spills and contaminated sites, and not wildlife. However, the act provides for natural resource planning and management, including wildlife, and conservation easements for conserving and enhancing wildlife habitats. There are currently no regulations for the protection of wildlife and habitats under this act.

Yukon Wildlife Act (2002)

The Wildlife Act (2002) defines "wildlife" as any vertebrate animal of any species or type that is wild by nature, and includes wildlife in captivity, but does not include fish. This Act provides rules for hunting and trapping, outfitting and guiding, licensing, enforcement, and habitat protection. It also gives authority to make various regulations. Regulations include prescribing specially protected wildlife and measures to protect, prescribing areas to be wildlife sanctuaries and measures for management, methods of hunting and trapping wildlife, licensing and permitting conditions, zoning the Yukon to administer the Act, and the submission of harvest information. The Act is typically emended every 10–20 years while regulations can to updated annually. The four Habitat Protection Areas in the LSCFN and SFN traditional territories are administered under this Act.

1.1.3 Little Salmon/Carmacks First Nation (LSCFN) and Selkirk First Nation (SFN) Governments

LSCFN and SFN were established in 1997 through Settlement Legislation in Canada and the Yukon that gives effect to their final agreements. LSCFN and SFN are responsible for their settlement lands and resource management on these lands. Under their Self-Government Agreements, LSCFN and SFN have the legislative powers to manage, administer and control the rights or benefits of persons enrolled under their final agreements. SFN has established a Constitution for the purpose of protection of its settlement lands and resources, and governing the rights of its citizens on these lands. LSCFN has not established legislation for the management and administration of settlement lands and wildlife.

1.1.4 Carmacks (CRRC) and Selkirk (SRRC) Renewable Resources Councils

The Councils were established in 1997 pursuant to Section 16.6.0 of Little Salmon/Carmacks and Selkirk First Nations Final Agreements as instruments of public government for local renewable resource management in their respective traditional territories. The Councils can make recommendations to the affected Minister, the affected First Nation, the Yukon Fish and Wildlife Management Board, and the Salmon Sub-Committee on any matters related to the conservation of fish and wildlife, and on forest resource management on settlement and non-settlement lands. Governments (Yukon and First Nations) are required to make available to the Councils

information in their possession reasonably required by the Councils to carry out their functions. The Councils may establish bylaws under the Wildlife Act (2002) for the management of furbearers, although they have not yet done so. The Councils do not have powers in areas where traditional territories overlap until such time as the resolution of overlapping claims is resolved according to Schedule B of Chapter 2 of First Nation Final Agreements.

1.1.5 Management Plans

Community-Based Fish and Wildlife Work Plan for the Little Salmon/Carmacks First Nation Traditional Territory 2012–2017 (Little Salmon/Carmacks Fish and Wildlife Planning Team 2011)

This work plan addresses issues related to fish and wildlife populations, habitat, harvest and information gaps in the Little Salmon/Carmacks Traditional Territory. LSCFN, CRRC and the Yukon government developed this plan. Its purpose is to coordinate the efforts of the parties to address local concerns about fish and wildlife in the LSCFN traditional territory for the period 2012–2017. This plan provides management actions for a number of wildlife populations, including the Klaza caribou herd. Access and enforcement themes are integrated through each section of the plan.

Selkirk First Nation May Gatherings

Each year in May, the SFN and Yukon government meet to review their cooperative management actions for fish and wildlife, discuss new and pressing issues, and update their management actions for the coming year. This activity serves the purpose of a fish and wildlife work plan with annual updates.

Management Plan for the Northern Mountain Population of Woodland Caribou (Rangifer tarandus caribou) in Canada (Environment Canada 2012)

The Northern Mountain population (NMP) of woodland caribou was assessed by COSEWIC in 2002 and listed under SARA as a species of “special concern” in 2005. The purpose of this plan is to summarize the threats facing Northern Mountain caribou, set out management goals and objectives, and recommend a series of recovery measures for consideration by the responsible authorities for the management of the population’s 36 herds. The goal of the plan is to prevent the NMP from becoming threatened or endangered by engaging responsible agencies to carefully manage the NMP and their habitat. The plan is focused on achieving the following goals that are re-evaluated on a 5-year basis:

- NMP herds are maintained or recovered, and populations operate within the natural range of variability;
- The ecological integrity of key habitats and ecosystems required by the NMP are maintained; and
- First Nations, local communities, government agencies and other interested parties are meaningfully involved in the stewardship of the NMP and its habitats.

The objectives and recommended recovery measures are based on a set of principles developed by the Northern Mountain Caribou Steering Committee and Technical Working Group. Recommended management objectives for the NMP are:

- Objective 1: Determine herd status and trends over time.
- Objective 2: Manage harvest for sustainable use.
- Objective 5: Identify and assess the quality, quantity and distribution of important habitats for the population.
- Objective 6: Manage and conserve important habitats to support caribou herds.

Of particular relevance to the Casino Project’s effects assessment is management objective 7:

- Objective 7: Promote conservation of the NMP through environmental and cumulative effects assessments.

Yukon Fish and Wildlife Woodland Caribou Management Decision Guidelines (July 1996)

These interim guidelines (no update or final guidelines are known to exist) were developed by a caribou management team from the Yukon government. The guidelines were intended to provide a framework for consistent departmental input and responses to management plans and programs. Among many guidelines related to harvest, of particular relevance to the Casino Project is guideline no. 16 (habitat), stating:

- *Management experience in North America has shown that virtually any type of development activity that increases access for hunters results in a herd decline. Hunter access must be very carefully controlled, particularly where roads bisect caribou winter range*.

The WMMP should also be considered in association with the following Project-specific environmental management plans:

- **Road Use Plan** — includes details about road management, access controls, monitoring of use.
- **Waste and Hazardous Materials Management Plan** — may include details on handling kitchen waste that, if mishandled, could attract problem wildlife to the site.
- **Spill Contingency Management Plan** — provides background planning and operational procedures for spills response to minimize exposure of wildlife to deleterious substances.
- **Sediment and Erosion Control Management Plan** — provide details on what types of erosion and sedimentation control measures will be used and where and when they will be applied.
- **Invasive Species Management Plan** — summarizes the management and monitoring proposed to prevent the introduction and propagation of invasive plant species.
- **Air Quality Management Plan** — may include guidelines related to reducing noise, dust, and emission levels that would ultimately reduce the Project's zone of influence (ZOI) on adjacent habitat use by wildlife.
- **Air Quality and Fugitive Dust Deposition Monitoring Program** in the Environmental Monitoring, Surveillance and Reporting Plan provides a link to fugitive dust and potential effects on wildlife forage.
- **Progressive Reclamation Effectiveness Monitoring Program** in the Environmental Monitoring, Surveillance and Reporting Plan provides a link to Project footprint and wildlife habitat reclamation.
- **Water Quality Monitoring** in the Environmental Monitoring, Surveillance and Reporting Plan, summarizing water quality monitoring of potential contact waters for waterfowl.

2 - WMMP REPORTING

Once the Casino Project is permitted and all necessary licences are acquired, CMC will report annually on Project mitigation and monitoring activities, which will generally include the following key pieces of information:

- A summary of Project activities;
- Description of updates to relevant wildlife and bird baseline information — either collected by CMC or other inventories/research known to CMC;
- A review of annual monitoring results relative to levels of natural variability in the region (as described in the baseline report and new knowledge gained through successive annual reporting);
- A presentation of the analyses of wildlife distribution and abundance in relation to Project facilities;
- A description of stakeholder involvement (e.g., Governments, RRCs);
- Summary of key monitoring initiatives, as deemed necessary; and
- A discussion of proposed changes to mitigation and monitoring plans as necessary.

CMC will review the results of annual monitoring every three to five years and include in a detailed report the following information:

- An examination of trends in variability of wildlife distribution and abundance relative to natural trends;
- An analysis of measured wildlife responses to Project-related disturbances, including habitat use and measures of barriers/filters to wildlife movement;
- A description of how Project effects monitoring contributes to cumulative effects monitoring in the region;
- Detailed analyses of other variables as identified in individual monitoring programs as the Project evolves; and
- Description of changes to monitoring programs, statistical procedures, and proposed changes to mitigation activities to adaptively manage for unforeseen effects.

2.1 ADAPTIVE MANAGEMENT AND PLAN UPDATES

The WMMP will be updated periodically to include management reviews, incident investigations, regulatory changes, or other Project-related changes. The WMMP will also be updated as new methods or technologies become available. Mitigation and monitoring strategies for Species at Risk will be updated to maintain consistency with status reports, recovery strategies, action plans, or management plans that may become available during the life of the Project. The wildlife mitigation and monitoring measures will likely evolve during the life of the Project as a result of new resource discoveries, a better understanding of local wildlife behaviours, improved scientific techniques, stakeholder values, and to adapt to natural variability in wildlife distribution and abundance.

To address environmental and Project changes through time, an adaptive management approach is adopted for this mitigation and monitoring plan. It is anticipated that the plan will evolve and be adjusted to incorporate practical and workable solutions to minimize Project effects on wildlife and support regional wildlife research and management initiatives. The changes may be a result of inadequacies in the sampling methods or from increased awareness of environmental personnel, regulators, First Nations, or other public concerns. An adaptive approach means that increasing monitoring or changes to the monitoring program can occur if unanticipated adverse effects are detected, to further understand effects, or to change mitigation practices. Concomitantly, if no effects are detected over a reasonable time period, some mitigation and monitoring tasks may be removed from the program so that the resources may be applied elsewhere. To facilitate adaptive management and react to changing environmental and Project conditions, a process needs to be established to ensure regular review of the WMMP that includes regular and transparent reporting (Figure 2.1-1).

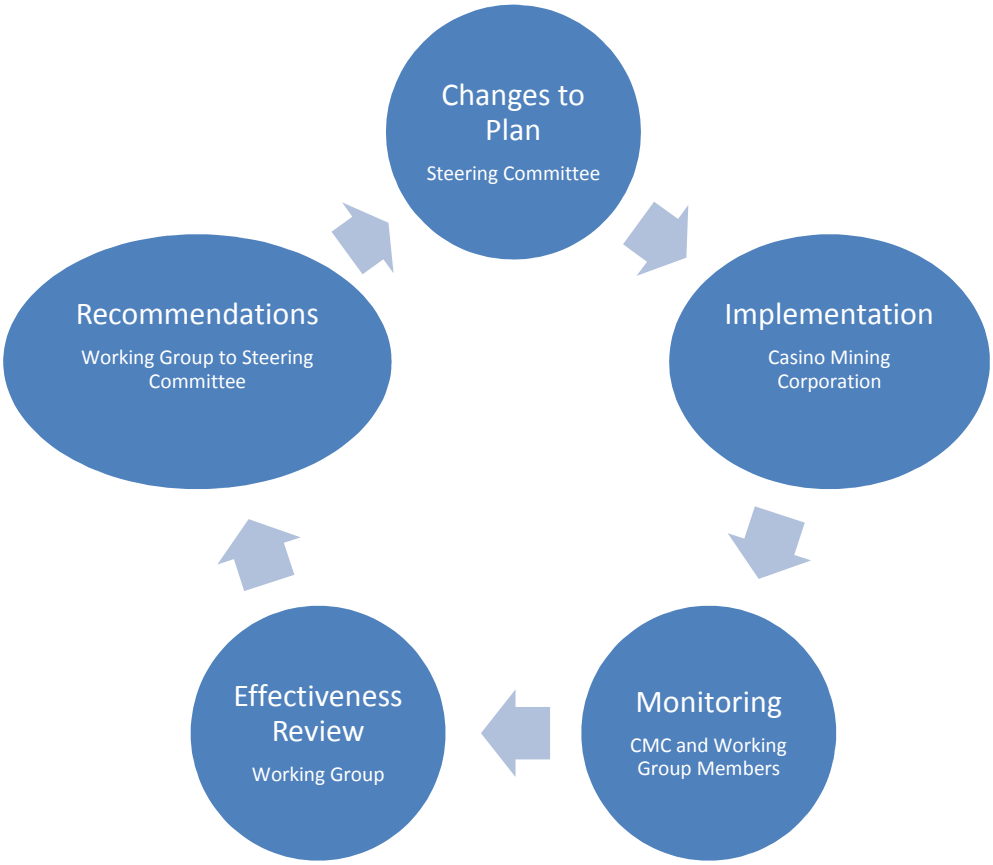

Figure 2.1-1 Schematic of the Adaptive Wildlife Mitigation and Monitoring Process

3 - CASINO MINING CORPORATION'S COMMITMENTS

CMC is committed to working with governments and stakeholders to ensure that wildlife populations remain healthy and can successfully coexist with the Project through construction, operation and closure phases of the mine. The WMMP is the primary management tool to achieve this. CMC will provide the necessary human, material, and financial resources to implement and maintain the WMMP. CMC has the capacity and authority to implement mitigation and monitoring actions and plans; however, CMC will not make decisions regarding wildlife management (e.g. harvest levels). Nonetheless, CMC is committed to actively supporting regional wildlife management initiatives.

3.1 WILDLIFE WORKING GROUP

CMC will establish a Wildlife Working Group (the working group) — the role of which is to act as an advisory body to support ongoing cooperation and communication, as well as to review and provide advice on all aspects of the WMMP, including:

- Develop and finalize the WMMP Program;
- Implement the WMMP Program;
- Monitor reports and results;
- Assess Project effects and effects predictions for wildlife;
- Assess effectiveness of mitigation measures; and
- Develop action plans for implementation of appropriate mitigation measures.

The working group may make recommendations to CMC and government agencies with wildlife management responsibilities on any aspects of the WMMP program or for the adoption of mitigation measures which are technically and economically feasible. It is expected that the working group would consist of a number of members including members from affected First Nations (particularly Selkirk First Nation and Little Salmon/Carmacks First Nation), CMC, Yukon Government, and Environment Canada. Other members can be considered as appropriate or necessary. The role of the working group is not intended to either duplicate or affect the regulating authorities or stakeholder responsibilities for wildlife management of participating members.

To keep the working group on task and focused on their roles and responsibilities, a draft Terms of Reference (TOR) can be developed that could address the following points:

- Purpose, objectives and duties
    - Partially identified in this WMMP
- Establishment
    - Working group time frame and meeting frequency
    - Working group membership and reporting structure
        - Assuming the key parties such as the LSCFN, SFN and Yukon governments, CRRC, SRRC, and possibly the federal government.
    - Working group chair and chair duties
- Communications, proceedings and recommendations
    - Identify obligations of the parties to provide information to the working group

- External communications protocol
- Working group recommendations — what is done with them (CMC will be obligated to respond to recommendations related directly to possible mine effects)

- Decision-making process
- Funding and expenses

3.2 WILDLIFE SPECIALISTS

The monitoring program established by CMC requires the input of specialists to carry out many of the wildlife surveys and studies required to monitor Project effects. Throughout the life of the Project, CMC will endeavor to hire qualified personnel to conduct these studies. As much as possible, CMC will insist on inclusion/participation of local experts/individuals in the execution of these surveys and studies.

3.3 INCORPORATION OF TRADITIONAL KNOWLEDGE

The monitoring program established by CMC requires the input and knowledge of First Nation hunters, trappers, and land users to design, conduct and review results of some of the surveys and studies required for monitoring. Throughout the life of the Project, CMC will endeavor to consult with knowledgeable individuals to conduct these studies. As much as possible, CMC will include participation of local experts/individuals in the conduct of the surveys and studies.

4 - MITIGATION FRAMEWORK

CMC recognizes that there will be disturbances and effects on wildlife and wildlife habitat as a result of the construction, operation, and closure of the Project. To reduce or eliminate potential Project effects on wildlife and wildlife habitat, CMC commits to a number of mitigation actions, some of which are general and apply to all Project phases, some that are specific to Project phases, some that are temporal and apply only at certain times of year or in certain years when wildlife are present, and some that are specific to identified sensitive habitat features. Sensitive habitat features are mineral licks, active den sites, wetlands, bat roosts, and re-used nest sites (e.g., cliff nests, stick nests or swallow colonies). CMC expects that some of the mitigation actions will be modified through the life of the Project as more information becomes available about the effectiveness of the mitigation and wildlife and habitat/vegetation response to Project-related disturbances. To inform CMC, Project regulators, and stakeholders about mitigation effectiveness and Project effects, the mitigation framework is supported by a Project effects monitoring framework described in Section 5.

Mitigation actions that are more general in nature and are applicable to the Project design phase or during all Project phases, throughout the year, are described in Section 4.1 (Project Design and General Mitigation). Mitigation actions that are most relevant to reducing the effects of construction activities (Section 4.2), operations (Section 4.3), and closure and post-closure (Section 4.4) are described in the appropriate sections. Species-specific mitigation is mentioned separately where warranted.

4.1 PROJECT DESIGN AND GENERAL MITIGATION

The construction footprint of the Project will have residual effects on wildlife and wildlife habitat because there will be long-term habitat removal, and sensory stimuli during the construction, operation, and closure and decommissioning phases will disturb wildlife. There are several elements that were considered in the Project design that will help to mitigate some of those effects, which are described below.

4.1.1 Minimize Project Footprint and Sensory Disturbance

To minimize loss of habitat, the Project footprint (~23.5 km²) is designed to be as small as possible. Examples of considerations made to minimize the Project footprint are further described in the Project description (YESAB Project Proposal, Section 4).

- To minimize disturbance to wildlife and wildlife habitat where Project design allows, Project infrastructure will be constructed outside of identified sensitive habitat features, and areas with sensitive habitat or vegetation (e.g., rare plant locations).
    - The number of gravel pits/borrow pits in Klaza caribou winter habitat will be minimized to the extent possible.
    - Visual and auditory construction disturbances near animals will be minimized to the extent possible.
    - Mineral licks will be avoided (two mineral licks were identified during baseline studies that are outside of the PDA).
    - Disturbance near active or re-used den sites will be minimized to the extent possible during the denning period (October to May).

- CMC recognizes that a section of the Freegold Road extension will be in late-winter habitat for the Klaza Caribou Herd. Further species-specific mitigation measures will be incorporated to accommodate the potential disturbances associated with the road footprint and sensory disturbances.

4.1.2 Minimize Barriers and/or Filters to Wildlife Movement

CMC will commit to the following measures to minimize barriers and/or filters to wildlife movement:

- Design and build roads with a low profile embankment that will reduce the potential for the road to filter, or act as a barrier, to wildlife movement.
- Construct the water pipeline so that it does not impede wildlife movement.
    - Design considerations for the pipeline could include the following components:
        - Raised sections of the pipeline will allow for wildlife movement under the pipeline. Using moose as a precedent, pipeline clearance (i.e., distance from ground to bottom of pipeline will be a minimum of 180 cm every 400 to 700 m (depending on terrain; Dunne and Quinn 2009) for minimum section lengths of 10 m (i.e., 10 m long section of the pipeline will be raised).
        - Pipeline crossing structures (made of vegetated fill or soil) may be constructed in high density crossing/movement areas or areas where the pipeline cannot be raised or buried completely.
    - Further baseline studies to determine high probability wildlife crossing areas (e.g., trail surveys, snow track surveys, camera surveys) along the proposed pipeline route prior to construction.
- Equipment laydown will not be placed in an area of known wildlife movement or areas of wildlife concentration (e.g., mineral licks).
    - No-clearing buffer zones will be established around riparian areas to minimize disturbance to movement corridors (see Sediment and Erosion Control Management Plan).
- Access roads will be designed to avoid blind spots and reduce potential for wildlife collisions.
    - Speed limits will be posted and enforced on all facility roads and on the CMC managed portion of the Freegold Road.
    - Signage will be posted in high collision risk areas (e.g., blind or obstructed turns or hills, water crossings).
    - Where embankments may pose a barrier or filter to wildlife movement, (e.g., > 2 m high and steep slope in areas of known wildlife movement), wildlife crossings will be constructed with the following characteristics:
        - 10 to 100 m in length
        - The embankment has a gradual grade (e.g., 5 horizontal to 1 vertical, compared to a standard 2:1 or 3:1)
        - Surfaces will be relatively smooth, compacted, and constructed of finer fill material (crushed rock minus 100 mm) to prevent leg entrapment
        - Crossing areas will be placed in areas of greater wildlife movement based on observational data and caribou collar data
        - Truck operators will be made aware of all high-use wildlife crossing areas and will be required to report any wildlife observations

4.1.3 Minimize Wildlife Incidents and Mortality Risk

CMC will conduct the following to minimize wildlife incidents and mortality risks:

- Design mine buildings to discourage use by animals:
    - Skirt all buildings and stair landings to the ground.
- Design mine buildings to prevent human-wildlife conflicts:
    - Avoid blind spots where possible around buildings.
    - Provide windows where practical on all exits.
- Design roads with clear lines of sight in areas of high wildlife interaction potential.
- Support YG Environment and affected First Nations wildlife harvest management initiatives in the Project area.

4.1.4 Wildlife Awareness and Sensitivity Training

Project personnel (employee and contractor) awareness programs will help to mitigate potential effects on wildlife by increasing personnel awareness of CMC's commitment to wildlife and habitat protection in the Project area. Personnel will receive an orientation on basic wildlife ecology relevant to the Project. Those personnel that are road users will receive training specifically focused on wildlife use of the road corridor, potential wildlife mortality risks, and road and traffic operation procedures that are established to mitigate effects on wildlife. Project personnel will be expected to comply with the direction provided by mine management and there will be enforcement of Project-specific wildlife provisions.

CMC commits to incorporating a wildlife awareness component to the on-site employee orientation program. The wildlife awareness component will include a presentation on the importance of wildlife protection around the Project and in the region. Training components will include:

- Introduction to regional wildlife and wildlife issues.
- Wildlife have the right-of-way policy.
- Bear awareness, garbage management and review of CMC's Waste and Hazardous Materials Management Plan.
- No feeding or harassing wildlife policy.
- Wildlife encounter directives.
- Incidental wildlife observation protocol.
- Awareness training regarding the importance of avoiding known and reporting new mineral licks, nest sites, and other sensitive habitat features.
- Road driving directives: speed limits, driving at winter, expected areas of wildlife occurrences.
- Wildlife reporting requirements.
- Notification of enforcement measures (e.g., tracking truck speeds through sensitive areas).

4.2 CONSTRUCTION MITIGATION

Construction is likely the most disruptive Project phase for wildlife and wildlife habitat. Wildlife habitat is actively removed (e.g. mine, temporary camps, road, and borrow site construction), more humans will be present in the area, and large, noisy equipment will be required to construct and haul Project infrastructure — a level of activity that will be unprecedented in the area. Construction mitigation actions aim to reduce or remove potential effects to wildlife and wildlife habitat during this time, and will include:

- Not putting construction camps inside identified Klaza caribou late-winter range.
- Whenever practical and not causing a human safety issue, implement a stop work policy when wildlife in the area may be endangered (i.e., risk of physical injury or death) by the work being carried out.
- Avoid construction in sensitive habitats and/or during sensitive times, which will include:
    - Avoidance of new clearing during the breeding bird nesting season (1 May to 31 July in Yukon), or conducting nest surveys immediately prior to clearing activities.
    - Late-winter (1 February to 30 April) is considered the most sensitive time for caribou and moose. For caribou, this generally means avoiding the initiation of new construction activities during this period between km 98 and km 130 on the Freegold Road extension.
    - Sensitive habitat features (e.g., mineral licks, raptor nests, dens, and bat roosts) identified during pre-clearing surveys will be addressed on a case-by-case basis.
    - Avoiding blasting within 500 m of sensitive habitat features (e.g., mineral licks, raptor nests, dens, and bat roosts) when wildlife are likely to be present, which will include:
        - Dens — active or re-used dens will be avoided from October through to May, where they are known to occur. This would include grizzly and black bears, wolverine, coyotes, and foxes.
        - Mineral licks — two mineral licks were identified during baseline studies that will be considered in construction monitoring (locations are not available for public distribution).
        - Raptor nests — any known raptor nests within the PDA will be avoided where possible, and nest management plans may be developed for specific nests.
- If clearing must occur during the bird nesting season, CMC commits to conducting active migratory bird nest surveys prior to clearing.
    - Survey methods will follow best practices implemented to date for other Yukon projects. Some aspects of those surveys included:
        - Survey teams are led by qualified individuals.
        - Surveys extend beyond the Project footprint the distance of the identified setbacks, where suitable habitat exists.
        - A no-disturbance buffer around active nests is established until chicks have fledged or the nest is determined to have been predated or abandoned. Recommended setback distances are listed in Table 4.2-1. Other set-back distance guidelines may be considered should they be made publicly available.
        - A 7-day window for clearing activities to be completed once the survey is conducted (if no nests are found).
        - Communication of survey results and overview of protected nests with clearing contractors or on-site construction supervisor.
        - Updates provided as part of the annual reporting to the working group.
    - Pre-clearing surveys will also include assessing for potential bat roosts.

- If bat roosts are detected, site-specific avoidance measures and a mitigation plan will be developed.

Table 4.2-1. Recommended Setback Distances for Construction Activity near Bird Nests

Species Group	Recommended Setback Distances (m)	Exceptions/Comments
Ground and tree-nesting birds	10	
Cliff-nesting and large stick-nesting raptors	500	Develop nest-specific management plans for potentially disturbed nests. Includes short-eared owl and common nighthawk.

Sensory disturbances that reduce habitat effectiveness within a Zone of Influence (ZOI) can only be partially mitigated. Caribou, moose, bears, and other wildlife will find some Project activities disturbing, and the degree to which animals will adapt or habituate to those disturbances is not known. Mitigation measures that will minimize the likelihood of reduced habitat effectiveness for wildlife include limiting sensory disturbances where possible throughout the year. This will be realized by developing a blasting program to minimize effects on wildlife including, but not limited to, the restriction of blasting when caribou or other sensitive wildlife (e.g. nesting raptors) may be present.

4.3 OPERATION MITIGATION

The operations phase is the longest Project phase, with regular mining activities occurring throughout the life of the Project. During this phase, the following mitigation measures will be implemented:

- To avoid unnecessary disturbances to wildlife, there will be no stopping or loitering in sensitive wildlife areas or during sensitive wildlife periods:
    - No stopping areas will have signs posted along Project roads (similar to “No Stopping, Avalanche Zone” road signs). These signs will be posted along road sections identified in the Project Proposal, or as deemed appropriate by the working group where sensitive wildlife areas have been identified.
    - Identification of and the reasons for no stopping zones as part of the employee education program (Section 4.1).
- To reduce the Project-related effects on mortality risk, wildlife near misses and collisions will be investigated to determine the root cause and identify corrective actions:
    - Near misses are when wildlife mortality could have occurred if immediate corrective actions were not taken.
    - Investigations will follow a standard procedure of employee interviews, scene investigation, recording time, date, incident details.
    - Corrective actions will be identified and are specific to the situation (e.g., reduce speed, improved lighting, roadside vegetation clearing).
- Minimize fugitive dust dispersal by using dust suppression methods, and thereby minimizing the Project’s zone of influence.
- CMC acknowledges the potential for an increase in the number of predators as a result of human activity in the area. To minimize the potential for increasing densities of bird nest predators (e.g., foxes, gulls), CMC will:

- Implement strict waste management procedures as outlined in the Waste Management Plan. Audits will be carried out periodically to assess the effectiveness of waste management practices.
- Conduct regular surveillance of Project facilities and waste disposal sites to ensure that predator control measures are effective.

- Incorporating Best Management Practices for food, waste and fuel management into the design on the Project. CMC has developed at Waste and Hazardous Materials Management Plan to ensure proper waste management practices are implemented. These practices may include:
  - Storing and incinerating garbage in an enclosed area surrounded by electric fencing. The gate will remain closed at all times.
  - Installing a stack scrubber in all kitchen vents to reduce food odour during cooking.
  - Storing all food and waste inside buildings or within an enclosed, bear proof area, unless field crews are working remotely. Field crew lunches will be sealed in airtight containers and all garbage will be pack out and properly disposed of.
  - Burning all food and kitchen waste in an incinerator.
  - Adding lime and dirt to latrines on a regular basis to reduce odour.
  - Storing all fuel in airtight containers in areas inaccessible to bears (i.e., fuel shed or fenced enclosure).
  - Training all workers in wildlife management protocols, including garbage management, bear encounter protocols (Section 4.1.4)

4.3.1 Road Operations and Access Management

CMC is aware that public access to the road may lead to unanticipated indirect effects on wildlife from collisions and harvest. To address that concern, CMC has developed a Road Use Plan, the key elements with respect to mitigating effects on wildlife include:

- No public access (access by permit only)
  - Chartered aircraft transportation to and from the Project site will be provided for Project staff.
- Controlled, gated, manned access (located at the new bridge over Big Creek — or as otherwise agreed).

Key elements of the Road Use Plan for wildlife include the following commitments – details of which are discussed elsewhere in this document:

- “No Hunting” in game management zones along access road (continuation of existing hunting ban in some areas, extended to include entire length of access corridor).
- Special management provisions for Klaza caribou that include long-term and increased active monitoring (currently underway), and other measures as agreed (Section 5).
- Identification of ‘wildlife crossing’ areas along route, that may include active monitoring (Section 4.1.2), snow clearing berm management in late-winter, travel speed reductions and restrictions as defined and agreed in the management plan.

To mitigate the Project’s direct effects on wildlife as a result of road operations by Project personnel, CMC commits to the following actions:

- Implement a “Wildlife have the Right-of-Way” policy to avoid potential collision or unnecessary disturbances to wildlife:

  - Vehicle operators will be vigilant and watch for wildlife near roads, and take all reasonable actions to avoid wildlife collisions.
  - Traffic will stop when wildlife are observed on the road.
  - To allow small groups (<10) or individual wildlife standing on the road to move off the road unalarmed, trucks will stop for 15 minutes, then proceed slowly (<20 km/hr) if wildlife have not moved within that 15 minute period.

- Implement compulsory speed limits through late winter caribou habitat to reduce the potential for wildlife collision and to reduce sensory disturbances along the road:
  - The speed limit will be established based on safe stopping distances and line of sight in areas of potential caribou encounters.
- Direct operators to include wildlife reports in their radio communications:
  - Truck-to-truck communication reporting wildlife presence by kilometer (e.g. "*two caribou north of road at kilometer 97*") will keep operators informed of potential hazard areas.
- Manage snow clearing so that caribou and other wildlife can easily cross the road without being deterred by steep and high snow banks:
  - Snow banks will be kept less than 1 metre high.
- If wildlife mortality were to occur as a direct result of Project-related collisions, increased traffic controls will be implemented. Timing and duration of increased controls is dependent on wildlife presence.
- CMC will have a wildlife monitor patrolling the road when there is a high likelihood of wildlife encounters and there is a risk of collision:
  - High likelihood of encounters can be based on increasing frequency of wildlife sightings.
  - During years of high interaction with the road, caribou numbers in the vicinity of the road will be re-evaluated on an every second day basis using light vehicles, aerial surveys, collar data, or other technologies available for the monitoring effort.
- Removal of carcasses from transportation corridors to discourage further collisions (e.g., scavengers on road).

An operational decision tree matrix for drivers dealing with wildlife sightings near roads is provided in Figure 2.1-1.

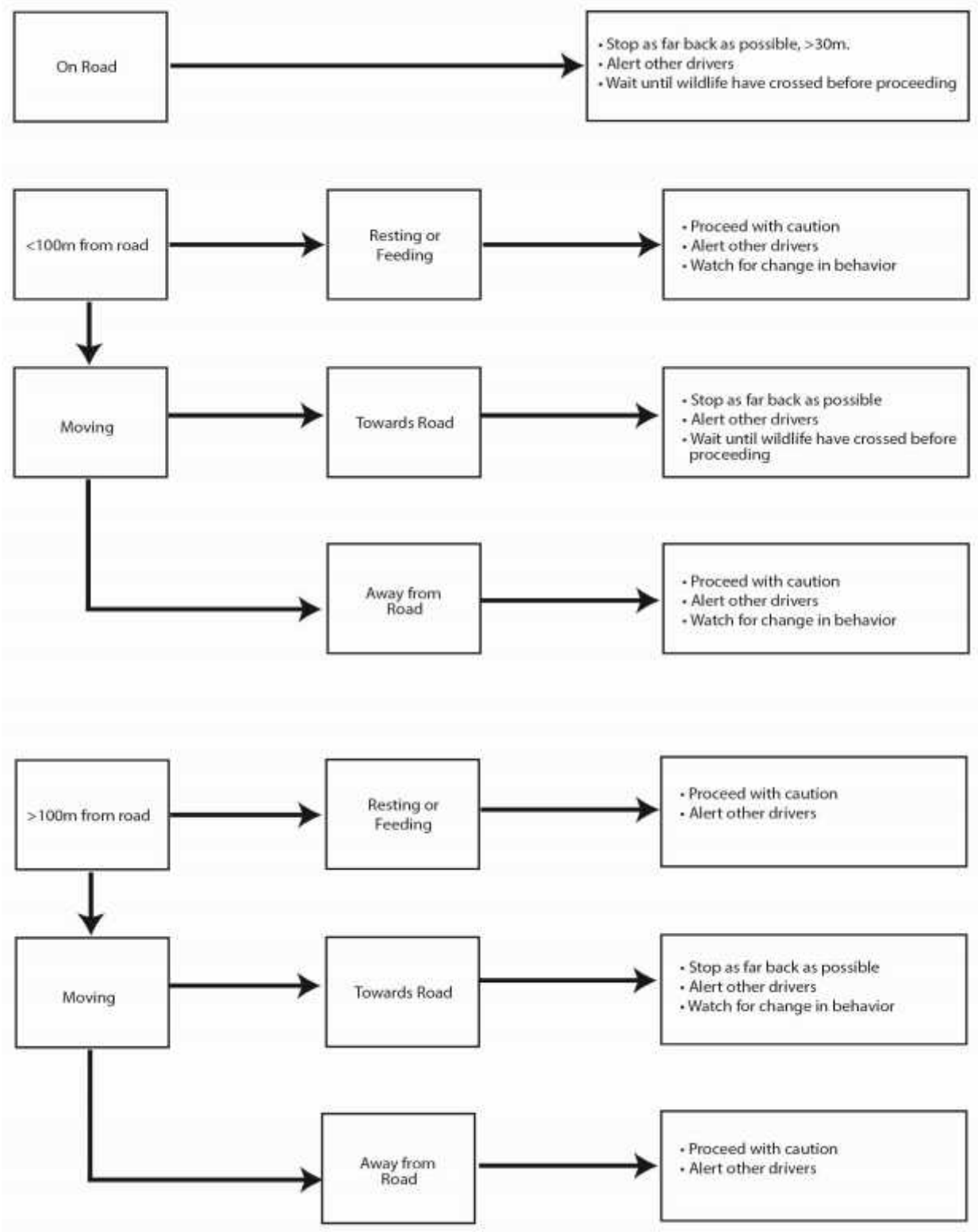

Figure 4.3-1 Wildlife and Road Operation Decision Matrix

4.3.2 Problem Wildlife Management

The goal of problem wildlife management is to reduce the potential for wildlife-human interactions at the Project. A problem wildlife protocol will help to ensure employee safety and minimize potential mortality due to threats to life or property. CMC will implement a problem wildlife protocol that includes:

- Employees will be required to report wildlife sightings near Project facilities.
- Warning signs will be posted in areas of frequent wildlife encounters on a seasonal basis or otherwise as required.
- Area closures will be used until proper control measures are in place or have been activated.
- If wildlife becomes a concern, Yukon Conservation Officer Services will be contacted for advice on appropriate actions.
- With prior approval of local Conservation Officer(s), adverse conditioning actions will be applied to problem wildlife to reverse habituation behaviours.
- CMC will identify appropriate personnel to monitor, manage and evaluate human-wildlife conflicts.

The decision matrix for managing CMC's response to problem wildlife is presented in Table 4.3-1.

Table 4.3-1. Problem Wildlife Encounter Management Matrix

Type of interaction	CMC Management Response					
	Monitor	**Post warning**	**Area closure**	**Contact Conservation Officer Services**	**Hazing actions***	**Relocate***
Animal sighting reported	•					
Animal showing normal feeding behaviour	•	•				
Animal reacting defensively	•	•	•			
Animal tolerates human disturbance and ignores people and facilities	•	•	•			
Animal shows repeated interest in people and facilities that will likely lead to habituation	•	•	•	•	•	
Animal is clearly habituated to humans and facility	•	•	•	•	•	•
Animal displays aggressive behaviour and is an immediate threat to human safety			•	•		•

* Hazing and relocation actions to be conducted only in accordance with advice from Conservation Officer Services.

4.3.3 TMF Wildlife Management

CMC expects that there will be some waterfowl and wildlife exposure to water in the Tailings Management Facility (TMF) during the Project's operation phase. It is not economically feasible, nor is it necessarily desirable to restrict all wildlife access to the TMF area when risks to animal health and mortality are relatively low — depending on constituents of potential concern (COPCs), ingestion rates, animal residency times, and individual health conditions. There is little evidence to predict what level of effect exposure to water in the TMF may have on wildlife, or the ultimate result of that exposure. Therefore, depending on animal responses to the TMF, the

following mitigation options may be considered to control wildlife presence at the TMF if deemed by CMC and/or regulators to be necessary:

- CMC will use wildlife deterrence measures in portions of the TMF that are identified as high risk areas to wildlife health.
- Deterrence measures can include wildlife fencing to keep wildlife out, scare crows, cannons, or any other proven methods at the time the risk is identified.

4.3.4 Cliff-nesting Raptor Mitigation

The Project area has cliff-nesting raptors that are known to breed in the PDA, and although the assessment concluded that the Project will have no population-level impacts, the potential to disturb and disrupt individuals is possible and proper mitigation procedures will be implemented to minimize unforeseen effects. General mitigation measures applied in all areas of the Project footprint will mitigate effects to cliff-nesting raptors. Additionally, nest-specific management plans will be developed for any cliff nests identified within 500 m of the PDA. Where possible, a site-specific no-disturbance or no stopping buffer (approximately 500 m) will be used for both Project personnel and equipment around the nests during the nesting period (1 April to 31 August for raptors).

4.4 CLOSURE AND POST CLOSURE

CMC expects that after Project operations are complete and mine facilities are decommissioned that mitigation for wildlife will be passive, and will include the following:

- As directed in the Road Use Plan, the Freegold Road extension will be decommissioned such that passage of vehicles will not be possible. Following decommissioning, no further mitigation activities for wildlife are expected to be implemented.
- As detailed in the closure plan, the TMF will include the construction of a wetland, creating a large littoral zone and wetland habitat where no wetlands currently exist. It is expected that wetland-associated wildlife will be attracted to and use the area after the mine has closed and the wetland has become established. There are no toxicological effects expected from use of the wetland and no further mitigation for wildlife is expected; however, if water quality monitoring results exceed acceptable standards, wildlife monitoring in the vicinity of TMF will be conducted.

5 - MONITORING FRAMEWORK

Monitoring effects on wildlife must be relevant to the Project and to the possible effects which the Project will have on the environment. The Casino Project's monitoring framework will inform adaptive management measures that can be effectively applied. The objectives of the monitoring framework are to:

- Develop a comprehensive and integrated environmental monitoring program.
- Incorporate an ecosystem-based approach for monitoring and management of Project related environmental effects.
- Integrate traditional knowledge, when possible and available, into the development and implementation of the environmental monitoring programs.
- Include the meaningful participation of stakeholders in all aspects of the environmental monitoring program in all phases of the development, including the decommissioning and reclamation.
- Report in an effective and timely manner on the environmental monitoring program and its results in ways that are meaningful to stakeholders.

Monitoring efforts will focus on a variety of spatial and temporal scales, depending on the focal species. Most local monitoring efforts will focus studies at the scale of the Project footprint (e.g. wildlife mortality monitoring), while others will focus on larger scales to adequately quantify and/or qualify effects (e.g. wildlife distribution).

5.1 MONITORING PRINCIPLES

The monitoring framework is based on the following principles:

- Monitor and verify potential effects related to the Project
- Ensure monitoring efforts are able to detect natural and Project-related changes to the environment.
- Monitor and evaluate the effectiveness of mitigation measures
- Identify unanticipated effects
- Monitor effects where predictions were based on weak data
- Provide an early warning of undesirable change in the environment
- Inform adaptive management measures

5.2 MONITORING FRAMEWORK OVERVIEW

The monitoring framework is based on three categories of study related to monitoring and follow-up of Project-related effects (adapted from Voisy's Bay EEM 2006):

1. **Baseline Research** — background studies intended to establish need for, or parameters of, an environmental effects management program. Research studies could address issues such as natural variability of a measurable parameter or monitoring target, or examine the nature, extent, or duration of a potential Project-focal species interaction.
2. **Surveillance** — programs to produce information about the pattern of occurrence of focal species.
3. **Monitoring** — programs to address and quantify effects mechanisms between Project activities and components of the receiving environment.

Table 5.2-1 defines the key considerations for each monitoring plan component. Monitoring is focused on measureable parameters of indicators. Monitoring will occur on and in areas adjacent to the Project footprint (Facilities Monitoring), and focal species monitoring will occur within the Regional Study Area (Focal Species

Monitoring). If stakeholders are interested or concerned about broader regional-level wildlife issues, a collaborative approach and participation by CMC can be considered for monitoring outside of the RSA.

Table 5.2-1. Monitoring Framework Overview

VC	Valued Component (e.g., Wildlife, Birds, Vegetation)
Indicator	The species or relevant feature selected to represent the VC (e.g., caribou)
Monitoring category	One of three categories – Research, Surveillance, Monitoring
Design	e.g., Before-After-Control-Impact (BACI), Opportunistic
Measurable parameter	A quantifiable feature used to assess potential effects on an indicator (e.g., movement)
Key project interactions	Identification of key project features that result in residual effects on the Indicator and Measurable Parameter (e.g., Freegold Road extension as a filter to caribou (Indicator) movement (Measureable Parameter))
Goal	Statement of the expected residual effect of the Project (e.g., the Project will have a not significant effect on caribou movements across Project infrastructure)
Objective	Evaluate a potential response specific to the mine and operations (e.g., evaluate movement patterns of caribou as they approach or cross the road)
Threshold	Early warning indicator (note: usually about an order of magnitude lower than the significance criteria used in the effects assessment)
Scope of monitoring work	Brief overview of key components of a monitoring program including note of temporal and spatial scale, frequency, and duration. It will also indicate if the monitoring is to occur in relation to direct project effects relative to day-to-day operations (facility-specific), or is intended to address broader-scale effects on a focal species: • **PDA/Facility-specific** monitoring will be a regularly occurring task for the on-site environmental staff focusing on wildlife interactions with Project infrastructure and facilities. • **Focal species** monitoring generally will occur at a broader scale with an emphasis on focal species abundance and distribution within the broader Project area, including monitoring of wildlife response to Project-related disturbances and predicted impacts and wildlife distribution in a broader Regional Study Area.
Agency/partner participation	Identification of agencies or key partners in the monitoring programs (e.g., YG Environment, RRCs)
Mitigation measures	A list of measures used to reduce or remove project related effects (e.g., project design elements, adjustments to operations)
Project Terms and Conditions	Indicates the Project Terms and Conditions (to be determined) that are being addressed by this monitoring plan component

5.3 PDA/FACILITY-SPECIFIC MONITORING

Project facilities, structures, and the Freegold Road extension (facilities within the PDA) pose potential risks to wildlife and obstacles to wildlife movement. The Project facilities will be monitored on a frequent basis to determine whether effects are occurring and if mitigation is adequate. Project components that will be monitored for wildlife effects include the following:

- The Freegold Road extension and other site roads for road traffic interaction and snow bank management.
- Traffic volume on all Project roads will be monitored to determine if volumes are exceeding expected levels.
- Access to the Freegold Road extension will be monitored to determine how many non-Project-related, but permitted people are accessing the road (e.g. First Nations, placer miners, trappers).
- The Yukon River water pipeline to determine if it is acting as a barrier to wildlife movement and effectiveness of mitigation actions.
- The Tailings Management Facility (TMF) to determine wildlife attraction, an assessment of the risks if wildlife are using it, and need for deterrence measures (if required).
- Project buildings as a potential haven for nest predators and problem wildlife.
- Waste management facilities as a potential attractant of problem wildlife.

PDA/Facility-specific monitoring will be conducted by CMC's on-site environmental management staff, wildlife monitors, and specialists as required. The on-site staff will be familiar with the Project's effects assessment and Project conditions related to wildlife, commitments made to mitigate effects on wildlife, and understand the adaptive management process used to manage responses to mitigation actions.

Results of PDA/Facility monitoring will be reported annually within the WMMP monitoring report. Successive reports will include a review of previous years' data to detect trends in wildlife occurrences and results of mitigation actions. Key features of the annual PDA/Facility monitoring report will include the following activities (Table 5.3-1):

- Project footprint monitoring — measures of the area(s) physically disturbed for construction and operations. Comparisons will be made between the planned footprint in the Project description and the actual footprint mapped using a GPS.
- Project activity — a summary of human presence (e.g., man days), general traffic statistics, construction activities, blasting activities, etc.
- Summary of a wildlife sightings log as an indication of wildlife presence in the immediate Project area. Data includes location, date, time, species, activity, etc.
- Summary of wildlife mitigation activities, including results of active migratory bird nest surveys (if required), deterrence actions, problem wildlife kills, etc.
- Summary of vehicle/wildlife collisions and results of investigations and corrective actions taken.
- Summary of non-Project related activities in the Project area (e.g., other land users, placer miners).
- Summary of regulator consultation for dealing with on-site wildlife issues.

There are no toxicological effects expected from use of the wetland and no further mitigation for wildlife is expected; however, if water quality monitoring results exceed acceptable standards, then wildlife monitoring in the vicinity of TMF will be triggered and additional mitigation measures will be implemented.

Table 5.3-1 Summary of PDA/Facility-Specific Monitoring Programs by Project Phase

PDA/Facility Monitoring	Construction	Operations	Closure/ Post-closure
Footprint assessment — measure the evolving Project footprint and compare the area prediction in the Project description	Annual	Annual	As needed to monitor reclamation
Building assessment — observe use of buildings for use by nest predators, nesting structures, or as a haven for potential problem wildlife.	Monthly	Monthly	n/a
Road monitoring — Reported observations of wildlife along the road, report on mitigations required. Report on follow-up investigations to wildlife-vehicle collisions and management actions. Report on traffic volumes and public access.	Ongoing	Ongoing	Ongoing to decommissioning of road
Nest monitoring			
Raptor nests adjacent to PDA	As required when adjacent nest sites are occupied	As required when adjacent nest sites are occupied	n/a
Active migratory bird nest surveys – survey areas that must be cleared 01 May to 31 July	As required prior to disturbance	n/a	n/a
Incidental human activity reporting — record of non-Project-related human activity in project area that may have interacted with wildlife. Data includes location, date, time, type of activity, number of people.	Ongoing	Ongoing	To coincide with TMF monitoring as required post-closure
Incidental wildlife reporting — Observation sheets placed throughout Project facilities encouraging personnel to record wildlife sightings. Data includes location, date, time, species, activity, etc.	Ongoing	Ongoing	To coincide with TMF monitoring as required post-closure
Waste area/TMF monitoring — Observations of wildlife use and mitigation actions taken to deter wildlife use.	Weekly	Weekly	To coincide with TMF monitoring as required post-closure
Exotic invasive plant species — Monitor methods used to reduce potential, and observations within PDA through life of Project.	Monitor washing of trucks and equipment prior to entering RSA	Annual botany surveys in PDA	As needed to monitor reclamation success

5.4 INDICATOR MONITORING PROGRAM

Monitoring will continue to be conducted to enhance baseline information, as a surveillance of occurrence in the Project area, and as ongoing monitoring efforts to validate Project effect predictions. General monitoring will enhance broader knowledge on multiple effects or species. The findings of the general monitoring may trigger additional focal species/effect monitoring if the results suggest an effect that exceeds the Project effect predictions or documents an unanticipated effect. Focal species/effect monitoring will refine the knowledge of the animals or issues in the local or regional study areas. The focal monitoring will assist with adaptive effects management, if needed, but will also increase knowledge base of human effects on wildlife in Yukon. The following will be included in focal species/effect monitoring (Sections 5.4.2 to 5.4.7):

- Plant invasive species — presence within and immediately adjacent to Project footprint
- Metals in plant tissue — an indicator of potential effects on animal health
- Cliff-nesting raptors — occupancy and productivity

- Klaza caribou herd — distribution and habitat use in the Project area (10 km radius of mine and road)
- Moose — distribution and habitat use in the Project area (10 km radius of mine and road)
- Grizzly bear, black bear, wolverine and wolf dens — activities relative to distance from the PDA
- Collared pika — continued presence in the Project area

Table summaries of suggested monitoring programs are provided below.

5.4.1 General Monitoring

To ensure that Project effects on all wildlife species are minimized, CMC will monitor and annually review the amount of direct habitat loss resulting from the Project footprint (Table 5.4-1). CMC will also track incidental observations of wildlife made by truck drivers and all Project personnel within and adjacent to the Project footprint, as well as all Project-related mortalities (Table 5.4-2 and Table 5.4-3). CMC will monitor wildlife use of known sensitive habitat features; and additional sensitive habitat features may be identified during the construction phase (Table 5.4-4).

Table 5.4-1 Wildlife Monitoring: Direct Habitat Loss

Indicator	All species
Monitoring category	Surveillance
Design type	Footprint survey
Measurable parameter	Project footprint
Key project interactions	Direct habitat loss within the footprint of the Project (either temporary or permanent)
Objective	Quantify direct habitat loss in the Project footprint
Threshold	Habitat loss limited to the amount identified in the Project description
Scope of monitoring work	Local monitoring: Measure area of Project disturbance on an annual basis using a GPS and GIS
Agency/partner participation	None required
Project terms and conditions	TBD

Table 5.4-2 Wildlife Monitoring: Incidental Observations

Indicator	All species
Monitoring category	Surveillance
Design type	Opportunistic
Measurable parameter	Wildlife presence in the Project area
Key project interactions	Wildlife using habitat adjacent to or within Project infrastructure
Objective	Track wildlife observations within and adjacent to the Project footprint
Threshold	None
Scope of monitoring work	Local monitoring: Log of wildlife observations within the RSA
Agency/partner participation	None required
Project terms and conditions	TBD

Table 5.4-3 Wildlife Monitoring: Project-Related Mortality

Indicator	All species
Monitoring category	Surveillance
Design type	Opportunistic
Measurable parameter	Wildlife mortality
Key project interactions	Wildlife mortality due to Project activities or infrastructure
Objective	Track Project-related mortality within and adjacent to the Project footprint
Threshold	Project-related caribou or moose mortalities will be reviewed to determine if further action is needed. Other species dealt with on a species-by-species basis.
Scope of monitoring work	Local monitoring: Record of near misses, collisions, and all other observed wildlife mortalities within the RSA
Agency/partner participation	None required
Project terms and conditions	TBD

Table 5.4-4 Wildlife Monitoring: Sensitive Habitat Features

Indicator	Habitat features: mineral licks, den sites, wetlands, bat roosts and reused bird nest sites
Monitoring category	Surveillance
Design type	Focussed surveys
Measurable parameter	Use of habitat features within the LSA
Key project interactions	The Project has the potential to affect animal use of habitat features within the LSA
Objective	Document use of habitat features within the LSA
Threshold	None
Scope of monitoring work	Local monitoring: Quantify the use of habitat features that could be affected by the Project within the LSA
Agency/partner participation	None required
Project terms and conditions	TBD

5.4.2 Vegetation

Vegetation will be monitored during Project construction, operation, and closure. Monitoring will occur every five years and will focus on invasive species and vegetation health in the vicinity of the Project and at control sites within the RSA for comparison.

Invasive species monitoring will occur within the Project footprint and adjacent habitats to ensure that no invasive species are introduced to the environment by the Project. Surveys for invasive plants will be conducted every five years, and additional surveys may be triggered by observations of plant invasive species. If any invasive species are found, these will be destroyed and, if the pathway of entry can be determined, changes will be made to reduce the possibility of further introduction of invasive species. See Table 5.4-5 and the Invasive Species Management Plan (Appendix A.22D) for more details on invasive species monitoring.

Vegetation health monitoring will be conducted through permanent monitoring plots in a variety of habitat types (minimum two plots per habitat type) near Project infrastructure and in control areas within the RSA. Plots in the vicinity of the Project infrastructure will be situated at varying distances from infrastructure to determine the extent of air quality impacts (the exact distance will be determined by the air quality monitoring program). Within each of the plots, species composition will be documented, and the percent cover of each species will be estimated.

Lichen and willow samples will be collected adjacent to the plots and sent to accredited laboratories for chemical analysis (Table 5.4-6).

Table 5.4-5 Vegetation Monitoring: Invasive Species

Indicator	Plant invasive species
Monitoring category	Surveillance
Design type	Footprint and adjacent habitat surveys
Measurable parameter	Occurrence of plant invasive species
Key project interactions	Introduction of plant invasive species (unnatural forage)
Goal	The Project will not introduce invasive plant species to the RSA
Objective	To quantify the occurrence of plant invasive species
Threshold	No introduction of plant invasive species as a result of Project activities
Scope of monitoring work	Local monitoring: Surveillance of Project footprint and adjacent habitat, at minimum, surveys to be conducted every 5 years or triggered by observations of plant invasive species
Agency/partner participation	None required
Project terms and conditions	TBD

Table 5.4-6 Vegetation Monitoring: Vegetation Health

Indicator	Vegetation Health
Monitoring category	Surveillance and Monitoring
Design type	Before-After-Control-Impact (BACI)
Measurable parameter	Vegetation class composition, biomass, and contaminant levels in lichen and willows
Key project interactions	Effluent, dust, and air emissions released into the environment have the potential to impact vegetation health. Dust and other contaminants may affect the survival of plant species (leading to changes in plant composition and biomass) and if contaminants are absorbed by plants then they may be ingested by wildlife or humans, which may have an effect on the health of individuals.
Goal	The Project will have a not significant effect on metal uptake in vegetation
Objective	Quantify through continued monitoring throughout the duration of the Project: - metals levels in lichen (caribou forage) - metals levels in willow (moose forage)
Threshold	Project activities resulting in >10% change in vegetation accumulation of contaminants in lichen and willow beyond acceptable threshold levels for wildlife and human health
Scope of monitoring work	Regional monitoring: Assess baseline vegetation class composition and contaminant levels in lichen and willow and re-assess every 5 years. Air quality monitoring program led by CMC.
Agency/partner participation	None required
Project terms and conditions	TBD

5.4.3 Birds

One monitoring program for birds will be implemented by CMC over the course of the construction, operation, closure, and post-closure phases to increase the available baseline data, to detect possible changes to cliff-

nesting raptors in the RSA, to assess the magnitude of these changes, and to determine whether these changes are naturally occurring variations or Project-related impacts.

Monitoring of cliff-nesting raptors (peregrine falcon, gyrfalcon, and golden eagle) will occur on an annual basis within the RSA to quantify occupancy and ensure that the Project is having a not significant effect on cliff-nesting raptors. This may involve up to four aerial surveys annually — one early in the nesting period, and one just before fledging for each species, and one for each of occupancy and productivity. Survey results for nests in close proximity to the PDA will be compared with results from other portions of the RSA and with baseline findings to determine whether the Project is affecting cliff-nesting species (Table 5.4-7).

Table 5.4-7 Cliff-nesting Raptors: Occupancy and Productivity

Indicator	Cliff-nesting raptors
Monitoring category	Baseline Research and Surveillance
Design type	Baseline research; Before-After-Control-Impact (BACI)
Measurable parameter	Occupancy and productivity
Key project interactions	Sensory disturbances generated from various Project activities
Goal	The Project will have a not significant effect on cliff-nesting raptor occupancy and productivity
Objective	To quantify cliff nesting raptor occupancy and productivity within the RSA
Threshold	Less than a 10% difference in near-site and far-site occupancy and productivity averaged over three consecutive years
Scope of monitoring work	Local monitoring: Annual territory surveys to determine occupancy and productivity of cliff-nesting raptors (total of four surveys – early and late season occupancy and early and late season productivity).
Agency/partner participation	Local monitoring: CMC, YG Environment
Project terms and conditions	TBD

5.4.4 Caribou

The Project interacts with the Klaza and Forty-mile caribou herds, and most importantly with late-winter habitat for the Klaza herd, and may present an increased risk of mortality (direct and indirect), and facilities may act as a barrier or filter to caribou movement. Project-related mortality on caribou will be tracked along with other wildlife species as part of the general wildlife monitoring (Table 5.4-3).

Monitoring of caribou habitat use will involve two monitoring objectives: the first assessing indirect habitat loss (resulting from sensory disturbances) and the second looking at caribou distribution within the RSA. Monitoring of both indirect habitat loss and habitat use during the late-winter season will occur at the local level by tracking incidental observations of caribou by Project employees, and at the regional level through aerial surveys. Long-term distribution patterns will also be identified by a YG-sponsored caribou satellite collaring program(s), but collared caribou do not represent the distribution of the entire Klaza caribou herd. Table 5.4-8 provides further details on the monitoring of indirect habitat loss and habitat use during the late-winter season. Monitoring will focus on aerial surveys during construction and initial years of operation to document occurrence, while local monitoring will continue throughout the life of the Project. Collar data from the YG-sponsored caribou satellite collaring program will inform regional late-winter distribution patterns. Additionally, periodic consultation will be conducted with local RRCs to provide information on the relative abundance of caribou in and around the RSA.

Table 5.4-8 Caribou Monitoring: Indirect Habitat Loss and Habitat Use During Late-Winter

Indicator	Caribou
Monitoring category	Baseline Research, Monitoring, and Surveillance
Design type	Observational (aerial surveys) and opportunistic
Measurable parameter	Distribution within RSA and late-winter habitat use
Key project interactions	Indirect habitat loss from Project activities that create sensory disturbances and/or temporarily reduce the effectiveness (usefulness) of habitats adjacent to the Project footprint, resulting in changed distribution.
Goal	The Project will have a not significant effect on distribution of caribou in the late winter (caribou use of late winter habitat was observed in baseline studies)
Objective	Evaluate trends in moose distribution in the ZOI and within late-winter habitat
Threshold	Caribou occurrence within the ZOI equivalent to the prediction made in the Project impact assessment
Scope of monitoring work	Local monitoring: Continuous log of caribou observations from CMC personnel to document occurrence near Project facilities. Regional monitoring: An annual aerial survey within a 10 km radius of Project infrastructure (as per 2013 late-winter survey; Figure 4.1, Appendix 12-A) will be implemented to document relative abundance and distribution of caribou relative to Project infrastructure. These surveys will be conducted during the first 3–5 years of road operation. Long-term distribution patterns as identified by a YG-sponsored caribou satellite collaring program. Collar data will inform regional late-winter habitat distribution.
Agency/partner participation	Local monitoring: CMC, RRCs; Regional monitoring: CMC, YG Environment
Project terms and conditions	TBD

Additionally, caribou monitoring will include a program looking at Project effects on caribou movement within the Zone of Influence (ZOI). Specifically, the program will monitor the effects of road infrastructure and operations on caribou movements through seasonal track surveys for the first 3–5 years of operation in key late-winter habitat, and remote motion-sensing cameras set up at select trails that cross or approach the road. If deemed necessary, additional monitoring of caribou movements could involve having wildlife monitors visit sections of the road that interact with caribou late-winter habitat on a regular basis (e.g., twice weekly) to document recent use (to determine if caribou are crossing the transportation infrastructure), and/or having wildlife monitors drive Project roads once a month to count the number of caribou in the area.

Table 5.4-9 Caribou Monitoring: Movement

Indicator	Caribou
Monitoring category	Baseline research and Surveillance
Design type	Observational
Measurable parameter	Movement in the ZOI
Key project interactions	Freegold Road structure and operations may be a filter of or barrier to movement of caribou through the RSA
Goal	The Project will have a not significant effect on caribou movements across Project infrastructure
Objective	Evaluate movement patterns of caribou as they approach or cross the road and other Project infrastructure
Threshold	Less than 10% deflection of approaches to road and infrastructure
Scope of monitoring work	Local monitoring: Seasonal caribou track surveys in key movement areas where existing trails were detected within the ZOI. These can be ground-based (snow machine) to observe movement during late winter. These surveys will be conducted during the first 3–5 years of road operation. Trail monitoring using remote motion-sensing cameras and documenting fresh tracks at select trails that cross or approach the road. Regional monitoring: Long-term movement patterns as identified by a YG-sponsored caribou satellite collaring program. This is a longer-term approach that requires analyses at a regional scale. These analyses are expected to be conducted by YG Environment.
Agency/partner participation	Local monitoring: CMC; Regional monitoring: YG Environment
Project terms and conditions	TBD

5.4.5 Moose

The Project interacts with moose, most importantly with late-winter habitat, and may result in an increased risk of mortality (direct and indirect), and facilities may act as a barrier or filter to moose movement. Project-related mortality on moose will be tracked along with other wildlife species as part of the general wildlife monitoring (Table 5.4-3).

Monitoring of moose habitat use will involve two monitoring objectives: the first assessing indirect habitat loss (resulting from sensory disturbances) and the second looking at moose distribution within the RSA. Monitoring of both indirect habitat loss and habitat use during the late-winter season will occur at the local level by tracking incidental observations of moose by Project employees, and at the regional level through aerial surveys. See Table 5.4-10 for further details on the monitoring of indirect habitat loss and habitat use during the late-winter season. Monitoring will focus on aerial surveys during construction and initial years of operation to document occurrence, while local monitoring will continue throughout the life of the Project. Additionally, periodic consultation will be conducted with local RRCs to provide information on the relative abundance of moose in and around the RSA.

Table 5.4-10 Moose Monitoring: Indirect Habitat Loss and Habitat Use During Late-Winter

Indicator	Moose
Monitoring category	Baseline Research, Monitoring, and Surveillance
Design type	Observational (aerial surveys) and opportunistic
Measurable parameter	Distribution within RSA and late-winter habitat use
Key project interactions	Indirect habitat loss from Project activities that create sensory disturbances and/or temporarily reduce the effectiveness (usefulness) of habitats adjacent to the Project footprint, resulting in changed distribution.
Goal	The Project will have a not significant effect on distribution of moose in the late winter Moose to use late winter habitat as was observed in baseline studies)
Objective	Evaluate trends in moose distribution in the ZOI and within late-winter habitat
Threshold	Moose occurrence within the ZOI equivalent to the prediction made in the Project impact assessment (50% fewer within 300 m of PDA)
Scope of monitoring work	Local monitoring: Continuous log of moose observations from CMC personnel to document occurrence near Project facilities. Regional monitoring: An annual aerial survey within a 10 km radius of Project infrastructure (as per 2013 late-winter survey, including near the mineral licks; Figure 4.1, Appendix 12-A) will be implemented to document relative abundance and distribution of moose relative to Project infrastructure. These surveys will be conducted during the first 3–5 years of road operation.
Agency/partner participation	Local monitoring: CMC personnel, RRCs Regional monitoring: CMC, YG Environment
Project terms and conditions	TBD

Table 5.4-11 Moose Monitoring: Movement

Indicator	Moose
Monitoring category	Baseline research and Surveillance
Design type	Observational
Measurable parameter	Movement in the ZOI
Key project interactions	Freegold Road structure and operations may be a filter of or barrier to moose movement through the Regional Study Area
Goal	The Project will have a not significant effect on moose movements across Project infrastructure
Objective	Evaluate movement patterns of moose as they approach or cross the road and other Project infrastructure
Threshold	Less than 10% deflection of approaches to road and infrastructure
Scope of monitoring work	Local monitoring: Seasonal moose track surveys in key movement areas where existing trails were detected within the ZOI. These can be ground-based (snow machine) to observe movement during late winter. These surveys will be conducted during the first 3–5 years of road operation. Trail monitoring using remote motion-sensing cameras and documenting fresh tracks at select trails that cross or approach the road.
Agency/partner participation	Local monitoring: CMC
Project terms and conditions	TBD

5.4.6 Den Sites

Dens are sensitive features that warrant monitoring. Although bears only re-use dens occasionally, they more often re-use denning areas. Wolves are known to re-use dens and denning areas for generations. Wolverine natal dens may get used during subsequent years, or may occur in similar areas. Consequently, monitoring efforts will aim to identify and maintain these areas throughout the life of the Project.

Table 5.4-12 Den Monitoring: Habitat and Use

Indicator	Grizzly bear, black bear, wolverine, and wolves
Monitoring category	Baseline research and Surveillance
Design type	Observational (aerial surveys) and opportunistic
Measurable parameter	Dens within 5 km of PDA
Key project interactions	Project footprint in known denning habitats
Goal	The Project will have a not significant effect on den sites
Objective	Allow carnivores to den undisturbed within the RSA
Threshold	Not a quantifiable threshold
Scope of monitoring work	Local monitoring: Aerial surveys within first 3-5 years of operation, of known den sites within a 5 km radius of the PDA, opportunistic documentation of other den sites. Regional monitoring: Maintain/add to long-term regional den site database in cooperation with YG Environment and support any regional programs targeting bears or wolves.
Agency/partner participation	Local monitoring: CMC, RRCs, YG Environment; Regional monitoring: YG Environment
Project terms and conditions	TBD

5.4.7 Collared Pika

Collared pika are present within the Project area — primarily located near the mine site in alpine felsenmeer habitats. The Project interacts with suitable pika habitat near the proposed mine site. Monitoring of pika will involve one monitoring objective: to assess pika presence within 1 km of the PDA. Monitoring will occur at the local level by conducting presence/ not detected surveys for the first 3–5 years of operation.

Table 5.4-13 Collared Pika Monitoring: Presence

Indicator	Collared pika
Monitoring category	Baseline Research and Surveillance
Design type	Observational (ground-based surveys) and opportunistic
Measurable parameter	Pika presence within 1 km of PDA
Key project interactions	Project footprint in suitable pika habitats
Goal	The Project will have a not significant effect on pika presence
Objective	Allow pika to use suitable habitat undisturbed
Threshold	Not a quantifiable threshold
Scope of monitoring work	Local monitoring: Ground-based surveys within first 3-5 years of operation, of suitable habitat within a 1 km radius of the PDA, opportunistic documentation of other sightings.
Agency/partner participation	Local monitoring: CMC
Project terms and conditions	TBD

6 - WILDLIFE RESEARCH SUPPORT

CMC recognizes that there are information and knowledge gaps about wildlife, vegetation, habitat, and industrial disturbance that are not addressed by the Project-specific mitigation actions and monitoring program identified in this document. There may be broader wildlife and terrestrial environmental science needs to help improve mining mitigation, First Nations knowledge, or general regional knowledge gaps. Although the information may not be specific to the Casino Project, CMC recognizes the need to develop partnerships to improve regional ecological knowledge that will help to improve understanding and future decision making.

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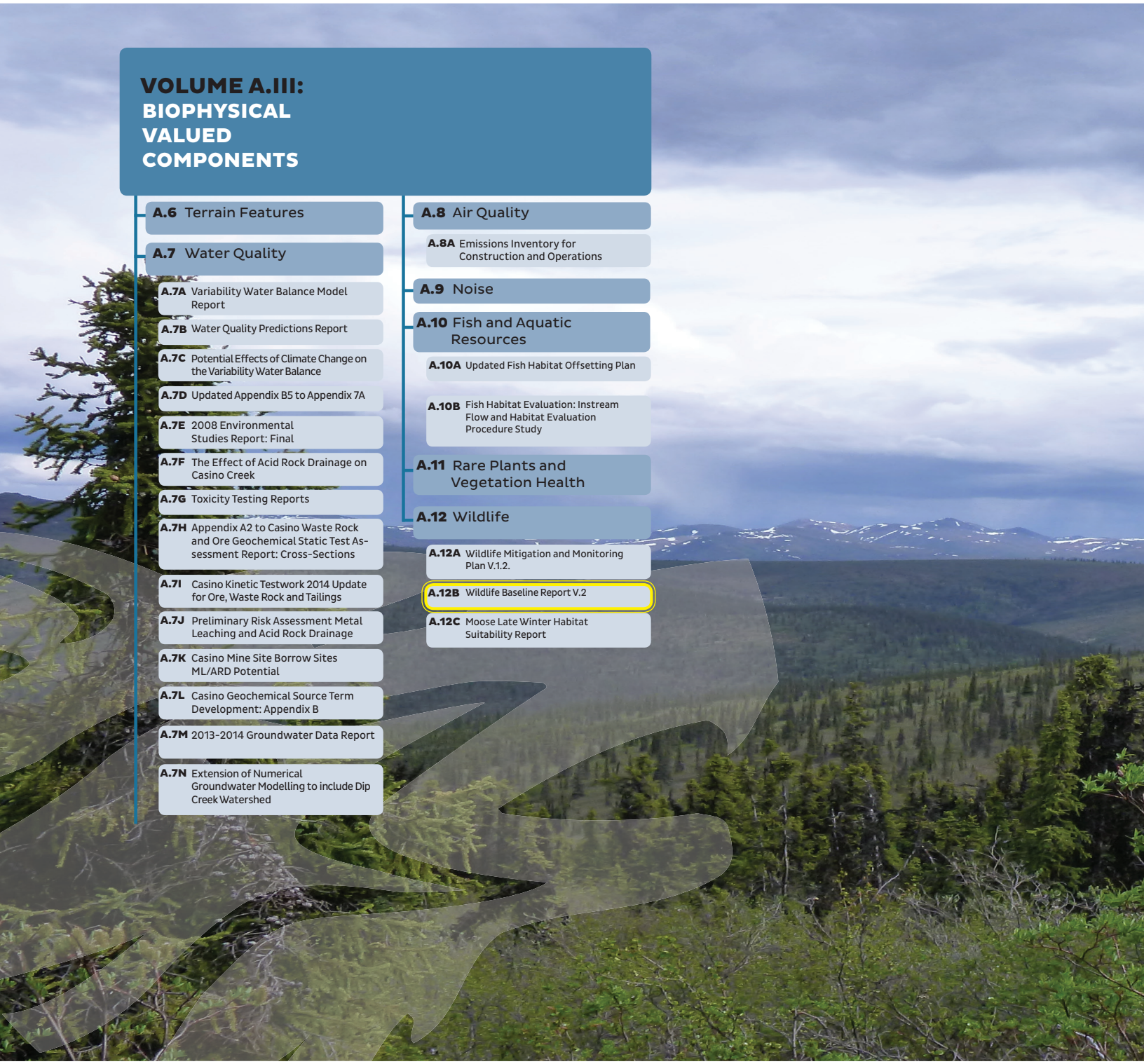
APPENDIX A.12B: Wildlife Baseline Report V.2.



Casino Project: Wildlife Baseline Report
Version 2



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FORWARD

This document summarizes terrestrial wildlife baseline information related to the proposed Casino Project area and was prepared in support of the environmental effects assessment. As part of the assessment process, the information submitted with the proposal was reviewed by regulators to determine the adequacy of the information needed for an environmental effects assessment. As part of the review process, this document has been updated with edits to specific sections based on new information and comments from reviewers. Those general edits are described below.

Baseline Section	Changes from November 2013 (Version 1) Document	Requester
3.1 Caribou Distribution	Update of caribou distribution model; addition of new late winter survey observations	YG
3.2 Caribou Winter Habitat Suitability Model	Removal of details, updated model provided in separate document	YG
4.1 Moose Distribution	Addition of new late winter survey observations	YG
4.2 Moose Winter Habitat Suitability Model	Removal of details, updated model provided in separate document	YG
5 Dall's Sheep	Map edits: removal sheep locations and inclusion of new distribution polygons	YG
12 Collared Pika	Addition of new information	SFN, YESAB's consultant, YG
13 Bats	Addition of new information	SFN, YESAB's consultant, YG
15 Mineral Licks	Addition of new information	None
16 Yukon River Water Pipeline Survey	Addition of new information	None

Suggested citation:

EDI Environmental Dynamics Inc. 2014. Casino Project: Wildlife Baseline Report, Ver. 2. Prepared for Casino Mining Corporation, Vancouver, BC by EDI, Whitehorse, YT. 1 December 2014

EXECUTIVE SUMMARY

The Casino Project (the Project) is a proposed copper-molybdenum-gold mine located in the Boreal Cordillera Ecozone of the Yukon Territory, approximately 300 km northwest of Whitehorse. In 2010, Casino Mining Corporation (CMC) requested that Environmental Dynamics Inc. (EDI) collect and summarize terrestrial wildlife data for the Project area.

Caribou (*Rangifer tarandus caribou*) and moose (*Alces alces*) dominate the landscape in this region and also play an integral role in the region's culture by providing sustenance and resource opportunities. Woodland caribou herds within the region include the Klaza, Aishihik, and Forty Mile herds; however, the Project interacts primarily with the Klaza herd. Woodland caribou from the Klaza herd are present within the Project's Regional Study Area (RSA) year-round, with parts of the herd's annual range overlapping with the proposed Freegold Road upgrade and extension. The Klaza herd has experienced a population increase since the early 1990s. The herd, once numbering approximately 440 animals is now estimated at 1,179 animals. Moose are the largest ungulate within the RSA and are considered the primary harvest species for resident hunters. Moose are distributed throughout the RSA, likely selecting available burned and treed riparian areas. Moose densities in the area are considered low for the Yukon.

Other ungulates present within the RSA include Dall's sheep (*Ovis dalli*), wood bison (*Bison bison athabascae*; Aishihik herd), and mule deer (*Odocoileus heminonus*). Dall's sheep are known to use traditional seasonal ranges in three main areas in the RSA. Wood bison are only sporadically present in the very southern section of the RSA, and mule deer are occasionally observed on south-facing slopes near the Yukon River (western RSA).

The dominant carnivores in the RSA include grizzly (*Ursus arctos horribilis*) and black bears (*Ursus americanus*), wolves (*Canis lupus*), and wolverine (*Gulo gulo*), which occur at relatively low densities; however, little is known about these species in the region. Lynx (*Lynx canadensis*), American marten (*Martes americana*), coyote (*Canis latrans)*, and red fox (*Vulpes vulpes*) are also present. Collared pika (*Ochotona collaris*) are known to inhabit alpine areas close to the proposed mine site.

This report summarizes and integrates the history of regional government surveys and studies, harvest data, habitat use, and Project-specific wildlife studies to provide a robust account of baseline conditions within the proposed Project area.

ACKNOWLEDGEMENTS

The information summarized in this report reflects a large amount of effort and resources from a number of people and organizations. This report would not be possible without them. CMC commissioned Project specific baseline studies since 2006. This work is included and referenced in this report and the results were helpful for planning further studies.

The Government of Yukon funded and staffed much of the data summarized in this report. Mark O'Donoghue (Biologist, Northern Tutchone Region) and Troy Hegel (Ungulate Biologist) designed, coordinated, and implemented the recent studies on the Klaza caribou herd, moose, and Dall's sheep. They provided data, advice, and comments. Joe Bellmore (Fish and Wildlife Technician) and Kyle Russell (Program Technician, Caribou/Sheep/Goat) participated in CMC funded surveys in 2012 and 2013, respectively. Their time and effort are greatly appreciated.

Local Carmacks residents who assisted with surveys include Willis Allen, Troy Fairclough, Terry Hanlon, Lauren Skookum, Gill Tulk, and Gary Wheeler. Their patience during weather delays, vigilance during long hours of work, and companionship were greatly appreciated and we look forward to working with them again in the near future. Rick Farnell (consulting wildlife biologist) provided perspective and knowledge that supplemented his original work on the Klaza caribou herd. His knowledge of caribou ecology was very helpful. Finally, we would like to thank Jesse Duke (Casino Mining Corporation) who considered and supported our suggestions. Without his confidence in EDI biologists, we could not have completed this work.

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ACRONYMS

BMU	Bear Management Unit
CEA	Cumulative Effects Assessment
CESCC	Canadian Endangered Species Conservation Council
CMC	Casino Mining Corporation
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
DC	Disturbance Coefficient
DEM	Digital elevation model
ELC	Ecological Land Classification
EOSD	Earth Observation for Sustainable Development
GIS	Geographic information system
GMS	Game Management Subzone
GPS	Global positioning system
HSI	Habitat Suitability Index
KCH	Klaza Caribou Herd
LSA	Local Study Area
LSCFN	Little Salmon Carmacks First Nation
masl	Metres above sea level
MMU	Moose Management Unit
NMP	Northern mountain population
PDA	Potential disturbance area
RSA	Regional Study Area
RSF	Resource Selection Function
RTC	Registered trapline concession
SARA	*Species at Risk Act*
SFN	Selkirk First Nation
UD	Utilization distribution
USDA	United States Department of Agriculture
VHF	Very high frequency
YESAA	*Yukon Environmental and Socio-economic Assessment Act*
YESAB	Yukon Environmental and Socio-economic Assessment Board
YEWG	Yukon Ecoregions Working Group

1 INTRODUCTION

1.1 PROJECT DETAILS

Casino Mining Corporation (CMC) is proposing to develop the Casino Project (the Project), a copper-molybdenum-gold mine at their Casino Mine property located at latitude 62° 44' N and longitude 138° 50' W, approximately 300 km northwest of Whitehorse, Yukon (Figure 1.1). The proposed Project will have a mine life of 34 years comprised of four phases: construction (4 years), operation (22 years), closure and decommissioning (3 years), and post closure (5 years).

The primary components of the Project, as shown in Figure 1.1, are:

- Mine site — includes open pit; stockpiles for low grade ore, gold ore, topsoil and topsoil/overburden; a plant site; heap leach facility;
- Tailings management facility;
- Extension and upgrade of the Freegold Road (previously referred to as the Casino Trail) — the Freegold Road will be upgraded and extended to connect the mine site to Carmacks, Yukon. The existing 70 km of the Freegold Road will require upgrading and route adjustments to meet design standards. The final road will be approximately 200 km long and maintained as an all-season gravel road suitable for ore and fuel transport;
- Construction and operation of a new airstrip; and
- Access road and water pipeline to the Yukon River.

All proceeding figures in this report display the Potential Disturbance Area (PDA) — an estimate of the amount of disturbance the Casino Project components and activities are likely to cause based on current available information. The PDA is a conservative estimate used to represent the maximum potential loss of habitat from the Project footprint and encompasses an 80.57 km^2 area.

The Project expects to process 120,000 tonnes of material per day; equivalent to 43.8 million tonnes per year. Anticipated volumes of metals produced over the life of the mine are:

- Gold: 5.72 million ounces
- Silver: 30.26 million ounces
- Copper: 3.58 billion pounds; and
- Molybdenum: 325 million pounds

Since the 1950s the Dawson Range has been a focal point for mineral resource exploration (Spencer Environmental Management Services Ltd. 1985; Pearse and Weinstein 1988; Jingfors 1989; Casino Trail Local Resource Group 1990). The proposed Freegold Road (previously called the Casino Trail) project was first introduced in the early 1960s — an idea that lay dormant until 1980 when mineral interest in the area redeveloped. In 1985 a formal proposal from the Yukon Chamber of Mines requested an all-weather road be built from Carmacks to the Casino mine property. The Government of Yukon began construction of the

Freegold Road in 1986, but ended construction in 1988 prior to completing the road. Several concerns were raised during construction, particularly by the Selkirk First Nations (SFN) and Little Salmon Carmacks First Nations (LSCFN) who were negotiating land claims at the time. Concerns were that the road would allow public access and increase hunting pressure on their traditional lands.

Terrestrial wildlife baseline work began on this Project in the late 1980s. Recent work funded by CMC started in 2006 and has continued through 2014. Preliminary wildlife surveys completed during the initial stages of environmental baseline studies were conducted by the Government of Yukon and a number of consultants, more recently AECOM at the mine site and Summit Environmental Consultants Inc. along the road. Information in this report relies heavily on publicly available information from the Government of Yukon.

EDI Environmental Dynamics Inc. (EDI) was retained by CMC in 2010 to complete the wildlife baseline studies and prepare a terrestrial wildlife baseline report in support of the eventual Project Proposal submission to the Yukon Environmental and Socio-Economic Assessment Board (YESAB). This report summarizes existing information on terrestrial wildlife in the Project area.

1.2 OBJECTIVES

To obtain the required regulatory approvals to proceed, the Project must be assessed under the *Yukon Environmental and Socio-economic Assessment Act* (YESAA). During this process, potential effects that the Project many have on environment and socio-economic valued components are identified, and where possible, mitigation measures are developed to reduce or eliminate those effects. To properly assess potential effects, a thorough understanding of baseline conditions is required.

YESAB's Proponents Guide of Information and Requirements for Executive Committee Project Proposal Submissions (YESAB 2005) recommends that for wildlife, Project Proposals should:

- Describe abundance and distribution characteristics of major wildlife species within the project area and vicinity. Include information on mammals, amphibians, birds, and reptiles (including rare and endangered species);
- Describe the habitat classifications used in the project area, and any implications concerning the distribution and abundance of habitat types that may influence the project; and
- Identify and describe transportation corridors and critical, sensitive and key habitats, including periods of habitat use in the project area and vicinity.

Specific objectives of the wildlife baseline report are to:

- Summarize available wildlife information in the study area, including abundance and distribution of key species; and identification of critical and sensitive habitats and transportation corridors; and
- Complete a baseline inventory of wildlife species in the study area to gain an understanding of regional wildlife ecology as a basis for assessing and mitigating potential Project effects on wildlife.

1.3 STUDY AREA

A wildlife Regional Study Area (RSA) was selected to include an area that is biologically relevant, consistent with wildlife management boundaries, and provides a regional context for Project-related effects at the population level. The Klaza caribou herd (KCH) has a relatively discrete and well defined range that intersects the Project and many species that occur within the RSA are managed as big game species within designated Game Management Subzones (GMSs; e.g., caribou, moose and grizzly bear); therefore, the RSA was delineated to include the 2012 KCH range and the GMSs that intersect the Project footprint (Figure 1.1). The total area of the RSA is 10,786 km². Species-specific study areas are discussed further in the species sections of this report. Generally, these species-specific study areas include the areas where the species is expected to interact with the Project infrastructure or associated activities. More detailed surveys and inventories were conducted for some species at smaller scales; for example, bear den surveys were conducted within 5 km of the proposed access road and snow track surveys for small animals were conducted along the proposed access road.

The LSA includes the length of the Freegold Road extension plus a roughly 1 km buffer on either side of the road alignment. The 1 km buffer was used to delineate terrestrial ecosystem mapping. All terrain polygons within the 1 km buffer were mapped and vegetation types assigned to the polygon's extent, often outside of the 1 km buffer. Surrounding the mine site, the LSA encompasses the watersheds of Britannia Creek and its tributary Canadian Creek, as well as upper Dip Creek and its tributary Casino Creek. The Yukon River defines the northern boundary of the LSA. The LSA encompasses an area that is approximately 886.4 km². Only collared pika (Section 12) is examined at the scale of the LSA.

1.3.1 Ecological Description

The Project is located in the Boreal Cordillera Ecozone within the Klondike Plateau and Yukon Plateau-Central Ecoregions (Figure 1.2). The following ecological description of the Boreal Cordillera Ecozone is largely adapted from Smith et al. (2004). Descriptions of the Klondike Plateau and Yukon Plateau-Central Ecoregions are adapted from the Yukon Ecoregions Working Group (YEWG 2004 in Smith et al. 2004) unless otherwise noted.

The Boreal Cordillera Ecozone is characterized by long, cold winters and short, warm summers. Mean temperatures range from below -27°C in winter to 15°C in summer. Mean annual precipitation ranges from 30 mm in the west to 1,000 mm in the east over the interior ranges and is greater at higher elevations.

Klondike Plateau Ecoregion

The Project is mostly located in the Klondike Plateau Ecoregion with the deposit situated at Patton Hill. The region has an estimated mean annual temperature of -2.7°C, with January being the coldest month at -18.1°C and July the warmest at 11.1°C. Mean annual precipitation is estimated to be 500 mm with most precipitation falling in July. Although the Dawson Range is mostly unglaciated there is evidence of minor glaciation in the subalpine. Permafrost is sporadic and discontinuous on north-facing slopes with less

consistency on south-facing slopes. Soil development ranges from coarse talus and immature soil horizons at higher elevations to mature soils with thick organic matter accumulating in valleys.

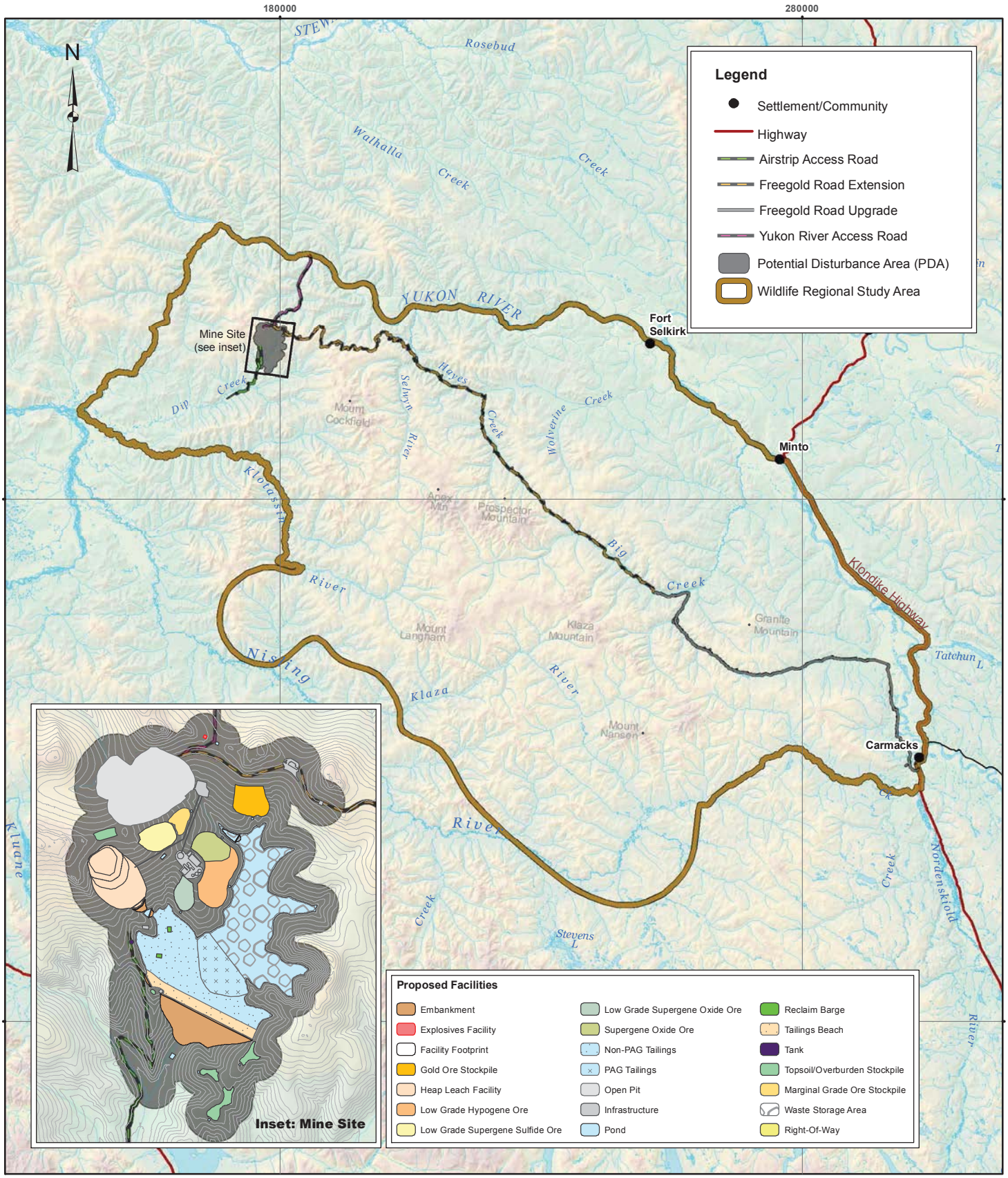
The topography of the ecoregion is typical of unglaciated terrain with rounded, rolling hills, V-shaped valleys, and sparsely vegetated alpine tundra hill tops. There is a high frequency of forest fires in the area and the dominant forest type is pure and mixed stands of white (*Picea glauca*) and black spruce (*Picea mariana*). Balsam poplar (*Populus balsamifera*) is typical of floodplains, while black spruce and paper birch (*Betula papyrifera*) are found in permafrost areas. Scrub birch (*Betula nana*) and willow (*Salix* spp.) stands extend from valley bottoms to subalpine. Understory communities vary across aspect and slope position with warmer south-facing slopes supporting ground shrubs, diverse forbs and feather mosses, while poorly drained depressions and upland sites include sphagnum mosses (*Sphagnum* spp.), tussock grass, sedges (*Carex* spp.), shrubs, and lichens (e.g. *Cladina* spp.).

Yukon Plateau-Central Ecoregion

The Yukon Plateau-Central Ecoregion has a strong continental climate with annual precipitation ranging from 250 to 300 mm. In the west, the ecoregion is dry as a result of being located in the rainshadow of the coastal ranges. The western boundary of this ecoregion coincides with the limit of Cordilleran Pleistocene glaciation. Glacial activity in the area has produced rounded and rolling hills, plateaus, and broad shaping valleys with high mountain ranges.

Permafrost is widespread and intermittently discontinuous in the ecoregion. Plateaus are too low for alpine permafrost, therefore ice-rich ground is typically found in valleys. Dominant soils in the ecoregion include Brunisolic (i.e., immature soils with a brownish B horizon) and Cryosolic soils (i.e., those affected by permafrost-related processes; Canadian Agricultural Services Coordinating Committee 1998). Unique to the ecoregion and formed in association with Pleistocene glacial drift are paleosol soils that are found nowhere else in Canada.

This ecoregion is dominated by the boreal forest zone. The boreal zone is modified within the cordillera by strong gradients of elevation, temperature, and precipitation. Dominant tree species are white spruce, black spruce, lodgepole pine (*Pinus contorta* var. *latifolia*), subalpine fir (*Abies lasiocarpa*), trembling aspen (*Populus tremuloides*), balsam poplar, and paper birch with climax communities typically of white and black spruce forests. Lower slopes are dominated by white spruce with a range of understory species including feather mosses, red bearberry (*Arctostaphylos rubra*), grasses, lichens, roses (*Rosa* spp.), horsetails (*Equisetum* spp.), willows and alders (*Alnus* spp.). Higher elevation areas are mostly subalpine fir and white spruce with an understory of scrub birch, willow, blueberry (*Vaccinium membranaceum*), crowberry (*Empetrum nigrum*), Labrador tea (*Ledum groenlandicum*), moss and lichen. Forest fires are common, resulting in a predominance of lodgepole pine and trembling aspen at lower elevations. On dry sites understory communities are commonly lichen, kinnikinnick (*Arctostaphylos uva-ursi*) and grass matrix, whereas moister sites contain alder, willow, lingonberry (*Vaccinium vitis-idaea*), soapberry (*Shepherdia canadensis*), and mosses. Floodplains are colonized by balsam poplar, horsetail, and willow. Extensive grassland communities are found on south and west-facing slopes.



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Potential Disturbance Area (PDA), roads, contours and mine site facilities provided by Knight Piesold Ltd. October, 2013.

Wildlife Regional Study Area produced by EDI Environmental Dynamics Inc. 2013.

Digital Elevation Models (30 m and 90 m) provided by Yukon Government - Geomatics Yukon; online Corporate Spatial Warehouse. www.geomaticsyukon.ca



The Casino Project overview and wildlife Regional Study Area

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MP/LG	MAS	12/12/2014	1.1

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kilometres

Map scale 1:1,000,000 (printed at 8.5x11)
North American Datum 1983 CSRS Yukon Albers

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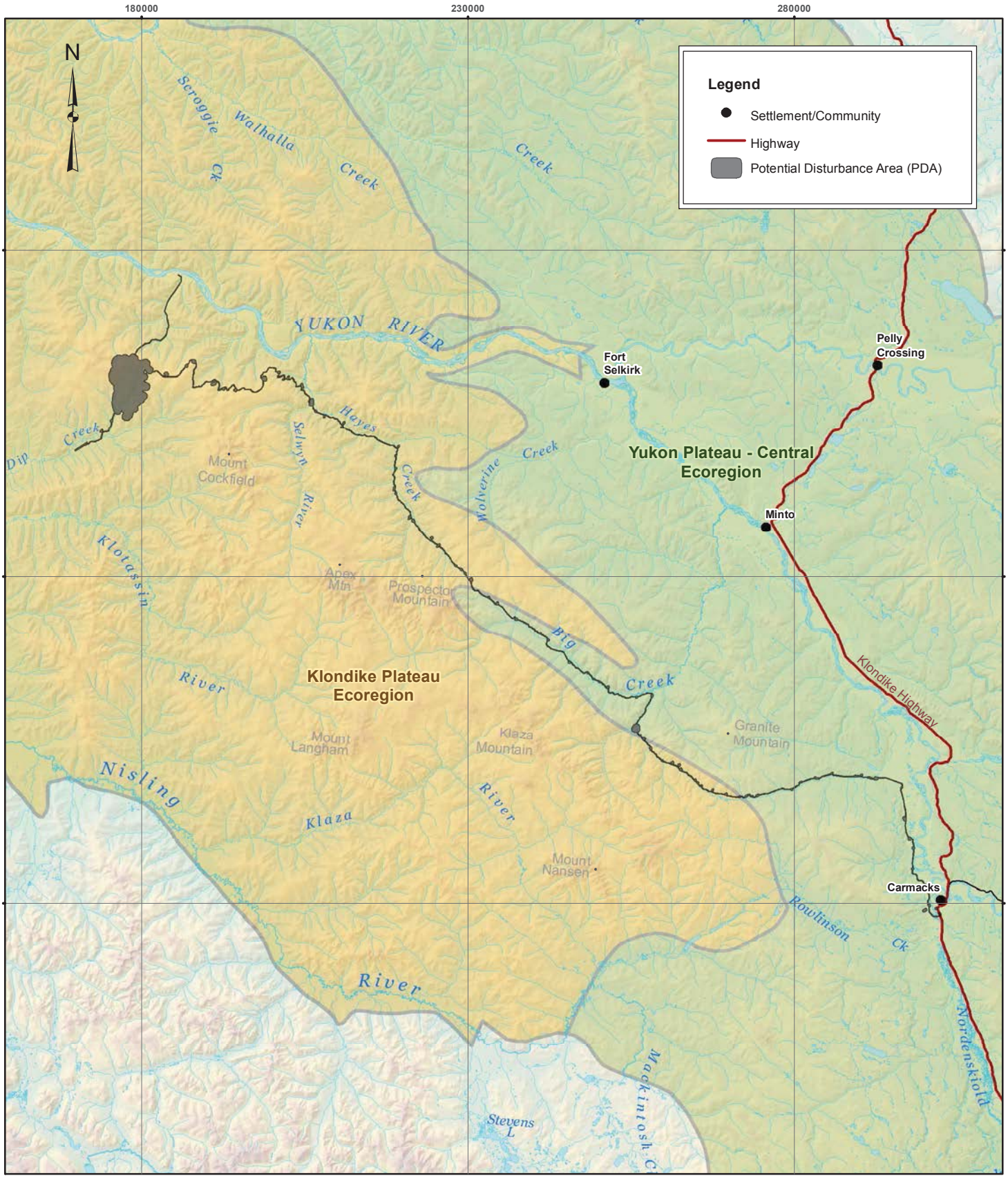

Notes:

Ecoregions, 1:250,000 Topographic Spatial Data, National Road Network; courtesy of Her Majesty the Queen in Right of Canada, Department of Natural Resources. All Rights Reserved.

Potential Disturbance Area (PDA) provided by Knight Piesold Ltd. September, 2013.

Digital Elevation Models (30 m and 90 m) provided by Yukon Government - Geomatics Yukon; online Corporate Spatial Warehouse. www.geomaticsyukon.ca

Ecoregions in the RSA

Drawn:	Checked:	Date:	Figure:
MP/LG	MAS	12/12/2014	1.2

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kilometres

Map scale 1:800,000 (printed at 8.5x11)
North American Datum 1983 CSRS Yukon Albers

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2 EXISTING INFORMATION

In response to local concerns and because there was very little documented information on wildlife in the Dawson Range, the Government of Yukon conducted the initial wildlife baseline studies in the region in the late 1980s. Government biologist completed the first inventory of the Klaza caribou herd, estimated the local moose density, identified sheep distribution and conducted raptor nest surveys. That information was supplemented by additional surveys during the following three decades up to and including the present work.

More recent baseline surveys conducted to generate data on wildlife presence, abundance, distribution, and habitat use within the RSA concentrated on focal wildlife — details of which are described in each species' section. Focal species for wildlife baseline studies are species that are known to occur in the RSA and are of local or cultural value, or of conservation concern.

Wildlife species that have cultural or economic value are species harvested by subsistence and trophy hunters, and local trappers. Subsistence hunters primarily target large ungulates, such as moose and caribou. Hunters that harvest for subsistence in the RSA are primarily from Carmacks and Pelly Crossing, and residents of Whitehorse. One outfitter is active in the area, Mervyn's Yukon Outfitting Ltd. Several traplines intersect the RSA; some are active.

Species of conservation concern in the Yukon, assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and/or listed on the *Species at Risk Act* (SARA), that are known to occur in the RSA include woodland caribou (Special Concern), wood bison (Threatened), grizzly bear (Special Concern), wolverine (Special Concern), and collared pika (Special Concern).

Characteristic wildlife species that are known or have the potential to occur in the RSA include woodland caribou, moose, thinhorn sheep (Dall's sheep), wood bison, mule deer, grizzly bear, black bear, grey wolf, coyote, red fox, wolverine, lynx, American marten, weasels (*Mustela* spp.), porcupine (*Erethizone dorsatum*), Arctic ground squirrel (*Spermophilus parryii*), red squirrel (*Tamiasciurus hudsonicus*), snowshoe hare (*Lepus americanus*), and collared pika. A number of other mammals are likely present in the RSA, including Canada beaver (*Castor canadensis*), muskrat (*Ondatra zibethicus*), hoary marmot (*Marmota caligata*), river otter (*Lontra canadensis*), and other small rodents. The area is also home to a number of bird species; however, birds are described in a separate baseline report.

3 CARIBOU

Caribou occur throughout Canada's forest and arctic ecosystems. The Canadian population of caribou is composed of five subspecies: Peary (*Rangifer tarandus pearyi)*, barren-ground (*R. t. groenlandicus)*, Dolphin and Union (*R. t. groenlandicus* x *pearyi*), Grant's caribou, (*R. t. granti*), and woodland caribou (*R. t. caribou*) (COSEWIC 2011a; Festa-Bianchet et al. 2011). Grant's and woodland caribou are the only subspecies that occur in the Yukon. There are five populations of woodland caribou that currently occupy regions of Canada: boreal, southern mountain, northern mountain, Newfoundland, and Atlantic-Gaspésie populations (Thomas and Gray 2002; COSEWIC 2011a). A sixth population known as the Queen Charlotte Islands population is now extinct. Woodland caribou are found in all jurisdictions in Canada except Nova Scotia, New Brunswick, Prince Edward Island and Nunavut. The total estimate of woodland caribou across Canada is roughly 184,000 (Thomas and Gray 2002). Throughout their range they occupy diverse habitats including mature and old-growth coniferous forests, alpine tundra, peatlands, marshes, and bogs (Environment Canada 2012; Thomas and Gray 2002).

The northern mountain population (NMP) of woodland caribou is distributed across the Yukon, western Northwest Territories, and northwestern British Columbia with an approximate area of occurrence of 308,000 km^2 (Thomas and Gray 2002; Environment Canada 2012). The NMP was assessed as a species of Special Concern by COSEWIC, and in 2005 was listed on Schedule 1 of the federal government's *Species at Risk Act* (SARA). The listing provides protection of the population under SARA and a management plan was developed to ensure that the population's conservation status is not elevated to Threatened. The conservation status determination was based on declines within specific herds of the population from habitat degradation, hunting pressure, disturbance by humans (e.g., fragmentation by roads), fire, and predation (e.g., wolves, bears, and coyotes; Environment Canada 2012). Also, there is some uncertainty in the population trends of some herds within the NMP; trends for 22 of the herds are unknown, seven are considered stable, four are increasing, and three are decreasing (Environment Canada 2012). The latest population estimate for the NMP in 2008 was of about 45,000 animals, which increased from 35,000 animals in 2002 (Environment Canada 2012).

The Project occurs within the historic range of the Forty Mile caribou herd and the current range of the Klaza caribou herd (KCH), formerly known as the Klotassin herd (Jingfors 1989). Archived written records and local knowledge indicate that the area was historically occupied by the Forty Mile caribou herd. Forty Mile caribou are currently absent from this area; the last documented occurrence of Forty Mile caribou in the study area was in 1941 (McDonald and Cooley 2004). The KCH is the main caribou herd that currently interacts with the Project (Figure 3.1). The KCH range is centered on and includes much of the Dawson Range mountains (Figure 3.2), and as of 2007 the size of the KCH range was estimated at 6,200 km^2 (Environment Yukon 2012). The northern extent of the Aishihik caribou herd's range slightly overlaps with the southern portion of the Klaza herd's range (Yukon Department of Environment 2012; Figure 3.2). Interaction between the Aishihik herd and the Project is expected to be limited to infrequent individual interactions.

The first formal study of the KCH was the 1987–1990 Klaza caribou inventory program that was initiated by the construction of the "Casino Trail" (Farnell et al. 1991). At the time, the road was being constructed by the Government of Yukon to provide access to the Casino mine site and other mineral resources in the area. Construction of the road ended in 1988 prior to being completed. The 1987–1990 studies included collaring of 17 cow caribou fitted with very high frequency collars (VHF; Table 3.1). By the end of the study, 12 collars remained active; two caribou cast the collars soon after capture, two caribou died, and one collar failed (Farnell et al. 1991). Relocation surveys were conducted 19 times during the study to document the seasonal distribution of caribou. After the completion of the inventory program, additional VHF collars were deployed and monitored until 2000 as part of an intensive study of the Aishihik caribou herd (Hayes et al. 2003). The KCH was monitored as part of the Aishihik study because a small portion of the two herds' ranges overlap in the southern portion of the KCH's range (Figure 3.2). The Government of Yukon initiated another collar study of the KCH in 2012 in response to renewed interest in the Casino Project and other exploration in the region. The study included collaring 30 female caribou (Hegel 2013a; Photo 1; Table 3.1) and is described further in the following sections.



Photo 1. A female caribou collared by the Government of Yukon in 2012 (second from back), along with four other Klaza caribou.

The first documented aerial survey of the KCH was completed during the summer of 1985 to document the distribution of the KCH. Inventories of the KCH started in 1987, with the collaring of 17 female caribou, described above, and continued through 1989. The inventory included composition surveys (i.e., rut counts) in 1987 and 1988, and a population census conducted during the late winter in 1989. Following the 1989 survey, the KCH was not surveyed again until 1993. The commencement of surveys in 1993 coincided with

the Aishihik wolf control program (Hayes et al. 2003). Regular composition surveys and irregular summer and late winter surveys, were conducted from 1993–2003.

With an increase in mineral exploration activity and renewed interest in the Casino Project, yearly late winter (March) surveys were conducted during early March 2011–2014. The objective of the surveys was to document regional distribution of ungulates (moose, caribou, and sheep) during the late winter. The survey area was defined by the KCH range and all GMSs that intersect the Casino mine site and access road footprints. At the time of the 2011 and 2012 surveys, the access road alignment had not been finalized and other road options were being explored; the large survey area was expected to include all access road options. The final road alignment was selected in early 2013, so the 2013 survey area was reduced to a 10 km buffer of the Casino project footprint (Figure 3.3) and was repeated in 2014.

The survey area was sampled using survey blocks to guide effort. Each block was sized at 5 minutes longitude by 2 minutes latitude (approximately 4 km x 4 km at the survey latitude), and four passes were flown through each block, which is roughly equivalent to 1 km transect spacing (Figure 3.3). Passes were flown within the blocks following terrain to maximize sightability of animals. In 2011 and 2012, two fixed-wing aircraft were required to survey the entire 11,371 km² survey area within a reasonable amount of time; however, in 2013 and 2014, only one plane was required to survey the reduced 4,247 km² survey area. All wildlife sightings and tracks were recorded as waypoints, with sex (cow, bull) and age class (adult, yearling, or calf) noted when possible. All surveys were flown around 100–300 m above ground level at approximately 150 km/h, depending on terrain and weather conditions. Composition and population surveys were conducted in the fall of 2012 (Hegel 2013a). Table 3.2 summarizes the 29 year period (1985–2013) of available caribou observations.

Ground-based surveys for snow tracks and range condition were conducted within the range of the KCH. These surveys were conducted twice in 2012 (15–19 February and 19–21 March) and once in 2013 (18–21 February). A second track survey was planned for March 2013, but snow cover was insufficient and the survey was cancelled. The primary objective of the work was to document the occurrence of species along the Freegold Road upgrade and extension that are not easily observed during aerial surveys. Each survey consisted of travelling the proposed Freegold Road upgrade and extension by snow machine as far as conditions permitted and recording the presence of animal tracks, summed within 1 km intervals (Figure 3.4).

The different survey methods sample different segments of the population, with the collars sampling only adult cow caribou, and the observational surveys and track counts sampling all age and sex cohorts within the population.

Table 3.1 Number of collar location data points for the Klaza caribou herd.

Year	Collar type	Late winter	Spring/Calving	Summer	Fall/Rut	Early winter
1987	VHF	12 (12)	12 (12)	13 (12)	-	10 (10)
1988	VHF	15 (15)	14 (14)	15 (15)	13 (13)	14 (14)
1989	VHF	38 (15)	31 (14)	14 (14)	12 (12)	11 (11)
1990	VHF	23 (12)	12 (12)	-	-	-
1991	VHF	9 (9)	-	-	-	-
1993	VHF	24 (12)	12 (12)	12 (12)	12 (12)	11 (11)
1994	VHF	17 (17)	14 (14)		15 (15)	12 (12)
1995	VHF	20 (16)	16 (16)	15 (15)	15 (15)	10 (10)
1996	VHF	36 (21)	20 (20)	20 (20)	39 (19)	-
1997	VHF	19 (19)	18 (18)	11 (11)	17 (17)	34 (20)
1998	VHF	16 (16)	-	-	-	-
1999	VHF	-	-	-	9 (9)	-
2000	VHF	-	-	-	2 (2)	-
2012	GPS	298 (3)	270 (2)	512 (2)	4,509 (28)	7,011 (28)
2013	GPS	6,702 (27)	2,995 (25)	5,770 (23)	3,193 (22)	6,895 (24)
2014	GPS	6,815 (24)	-	-	-	-

Notes:

Values in parentheses indicate the number of collared female caribou.

Seasons are defined in Section 3.1.

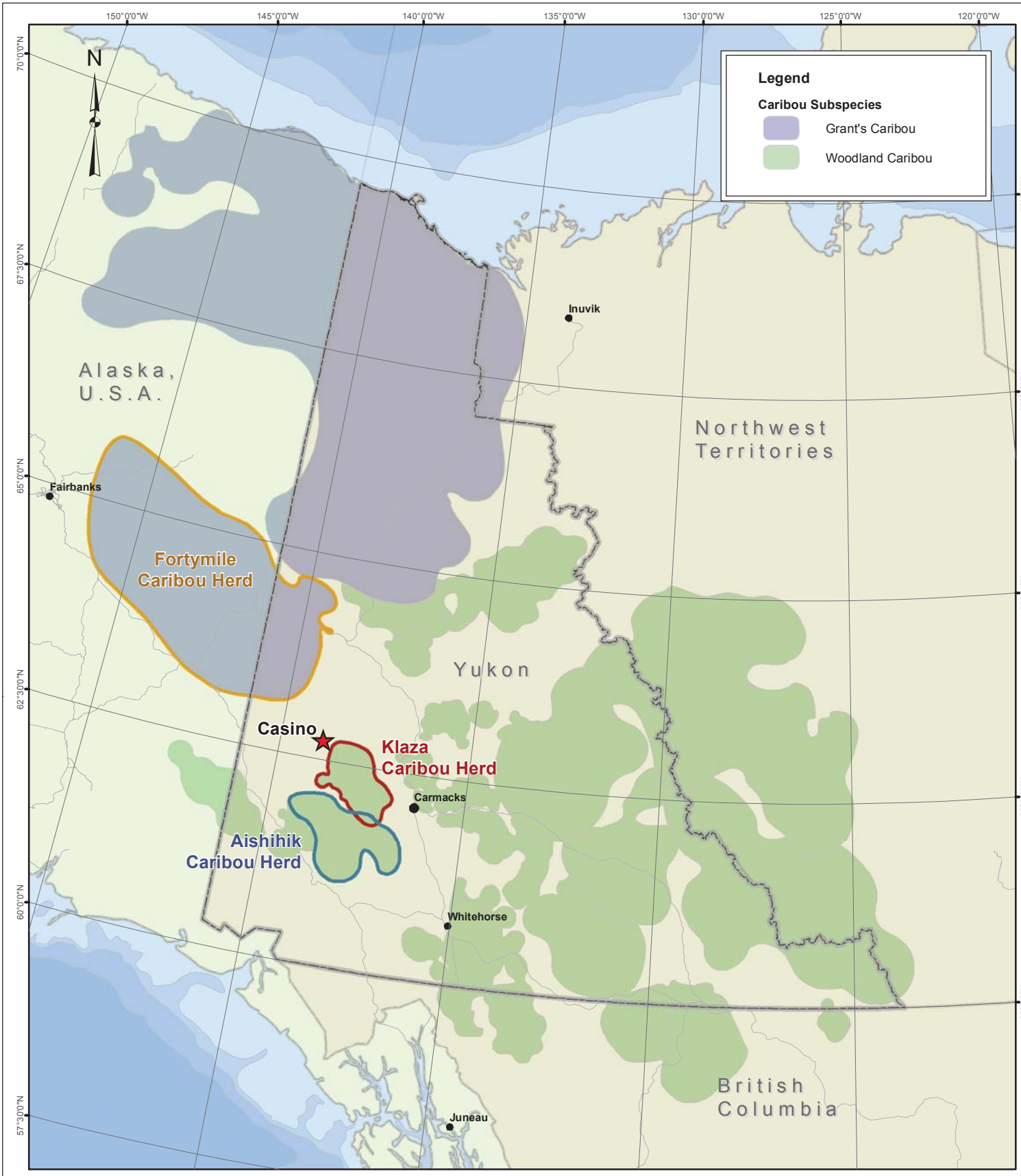
Data were provided by the Government of Yukon.

Table 3.2 Klaza caribou herd counts collected during seasonal surveys.

Year	Early winter	Late winter	Spring/calving	Summer	Fall/rut	Total
1985				181 (14)		181 (14)
1987					319 (17)	319 (17)
1988					174 (12)	174 (12)
1989		363 (42)				363 (42)
1993		151 (11)			251 (13)	402 (24)
1994					167 (8)	167 (8)
1995		190 (14)		133 (15)	268 (9)	591 (38)
1996		238 (28)		237 (14)	262 (18)	737 (60)
1997				265 (6)	197 (18)	462 (24)
1999					230 (8)	230 (8)
2000					651 (14)	651 (14)
2001					593 (20)	593 (20)
2002					348 (18)	348 (18)
2003					466 (31)	466 (31)
2011		125 (13)				125 (13)
2012		267 (16)			2245 (102)	2512 (118)
2013		27 (3)				27 (3)
2014		44 (7)				44 (7)
Total	0	1361 (127)	0	816 (49)	6171 (288)	8348 (464)

Notes:

Values in parentheses indicate the number of groups observed during the surveys. Data were collected by CMC (2011–2013) and Government of Yukon (1985–2012).



Notes:

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Caribou ranges provided by YG - Environment (received 2011).

Digital Elevation Models (30 m and 90 m) provided by Yukon Government - Geomatics Yukon; online Corporate Spatial Warehouse. www.geomaticsyukon.ca



Caribou herd ranges in Yukon

Drawn:	Checked:	Date:	Figure:
MP/LG	MAS	12/12/2014	3.1

0 50 100 200 300
kilometres

Map scale 1:7,000,000 (printed at 8.5x11)
North American Datum 1983 BC Environment Albers

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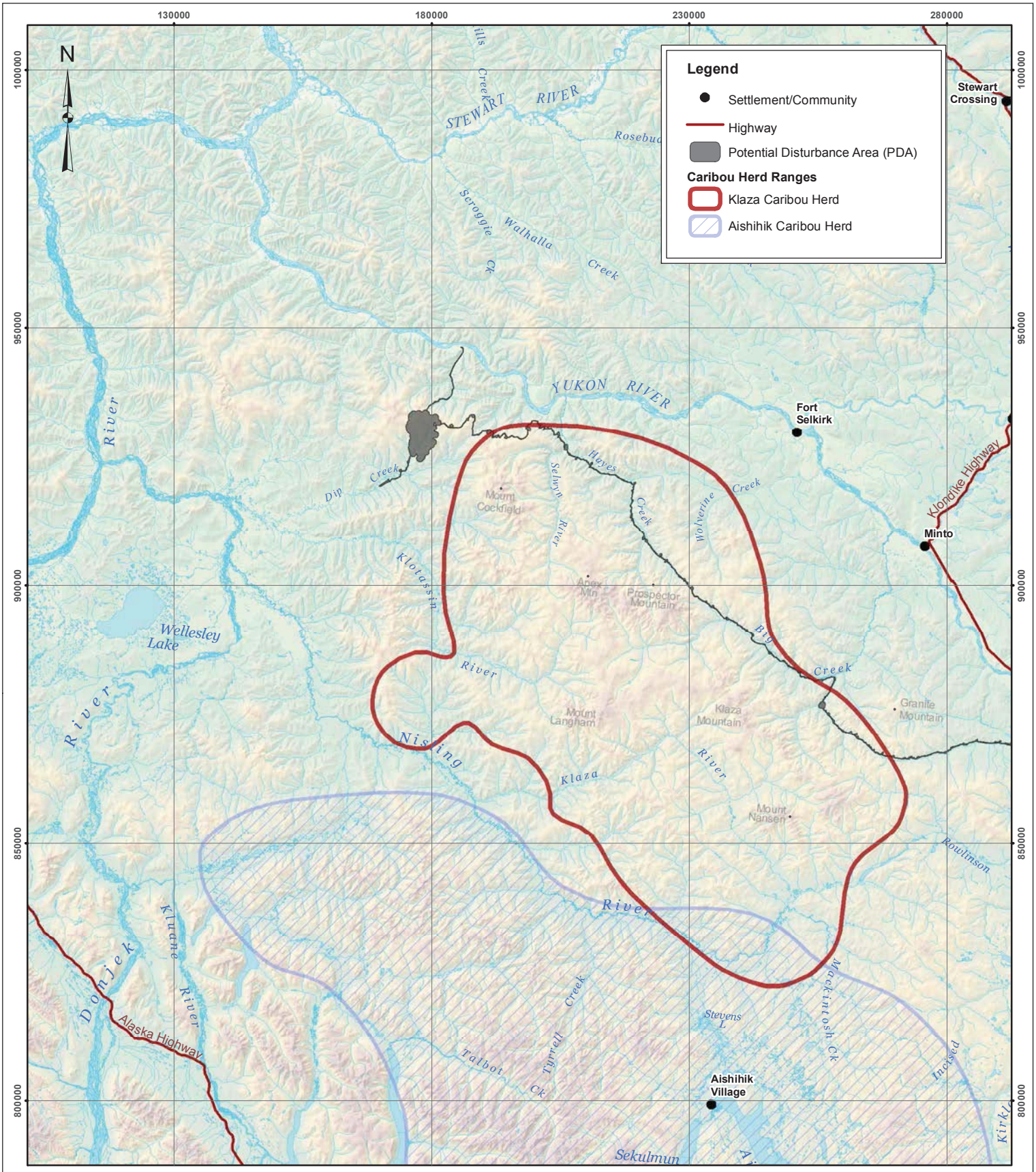

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Potential Disturbance Area (PDA) provided by Knight Piesold Ltd. September, 2013.

Aishihik aribou herd range provided by YG - Environment (received 2011). Klaza annual herd rage produced by EDI (2014).

Wildlife Key Areas, Digital Elevation Models (30 m and 90 m) provided by Yukon Government - Geomatics Yukon; online Corporate Spatial Warehouse. www.geomaticsyukon.ca



Ranges of the Klaza and Aishihik caribou herds as of 2012

Drawn:	Checked:	Date:	Figure:
MP/LG	MAS	12/12/2014	3.2

0 5 10 15 20 25
kilometres

Map scale 1:1,000,000 (printed at 8.5x11)
North American Datum 1983 CSRS Yukon Albers

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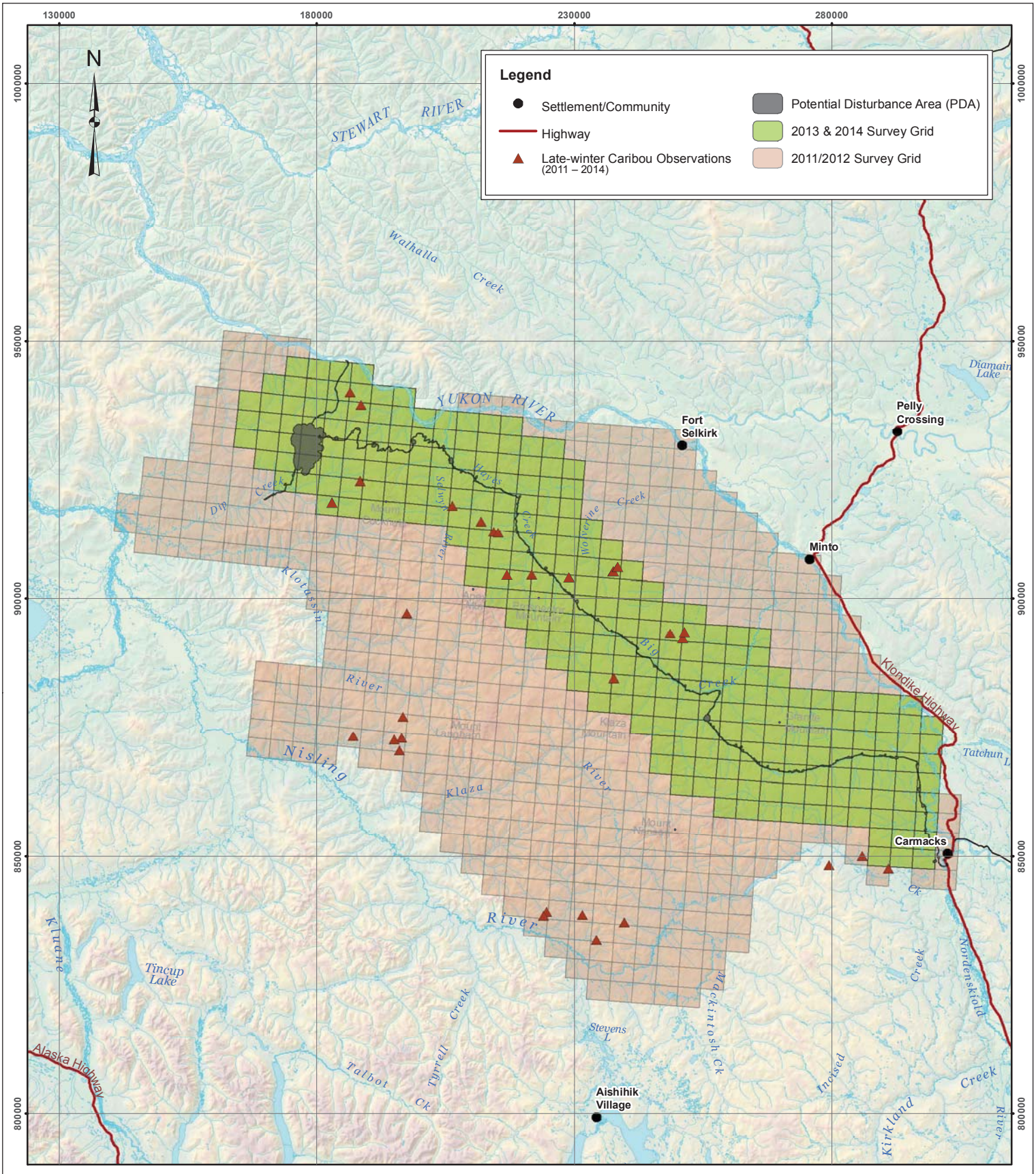

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Potential Disturbance Area (PDA) provided by Knight Piesold Ltd. September, 2013.

Digital Elevation Models (30 m and 90 m) provided by Yukon Government - Geomatics Yukon; online Corporate Spatial Warehouse. www.geomaticsyukon.ca



Late winter aerial survey areas (2013–2014)

Drawn:	Checked:	Date:	Figure:
MP/LG	MAS	12/12/2014	3.3

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kilometres

Map scale 1:1,000,000 (printed at 8.5x11)
North American Datum 1983 CSRS Yukon Albers

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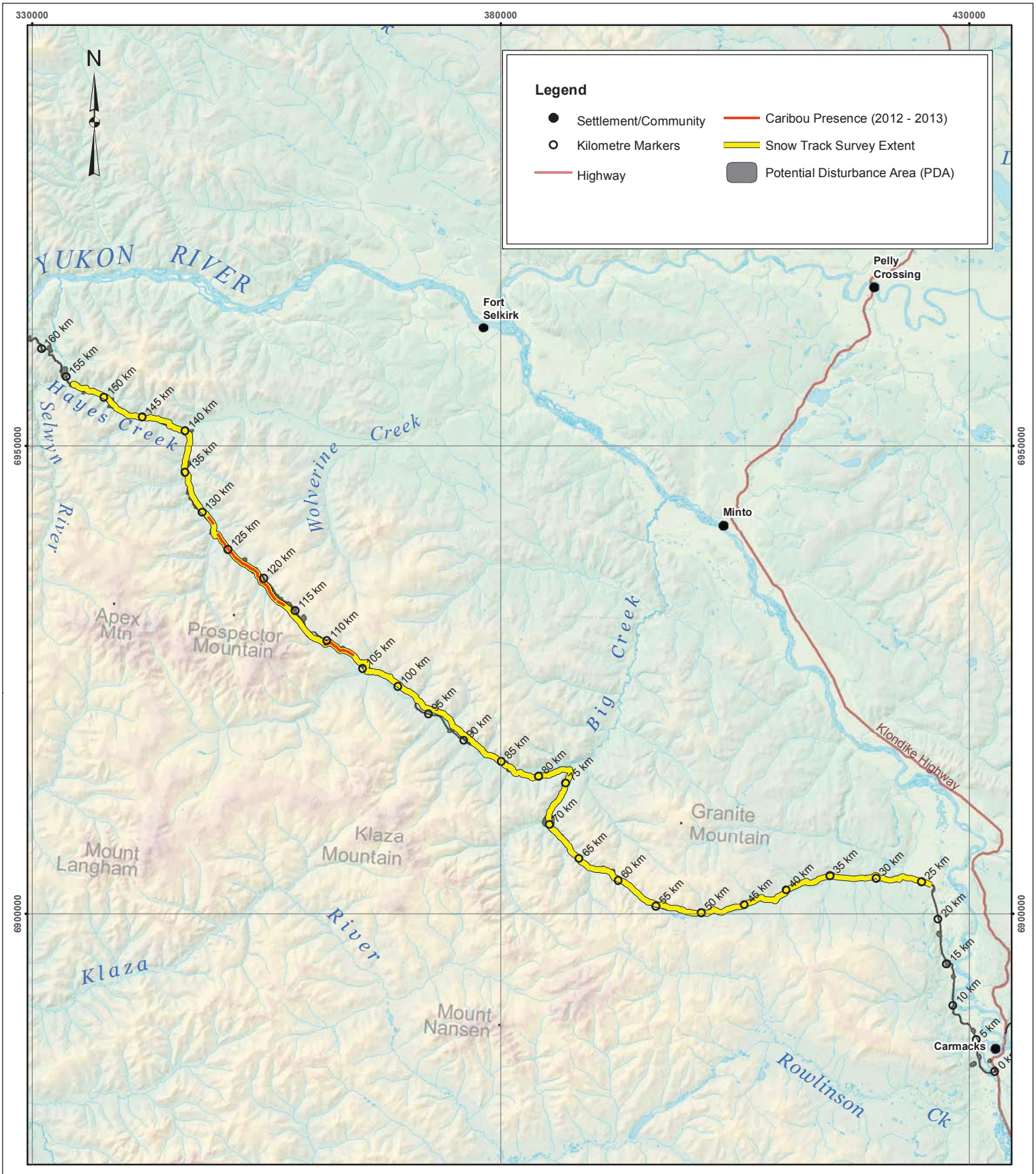

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Potential Disturbance Area (PDA) and kilometre markers provided by Knight Piesold Ltd., Sept., 2013.

2012 - 2013 snow tracking surveys designed and conducted by EDI.

Digital Elevation Models (30 m and 90 m) provided by Yukon Government - Geomatics Yukon; online Corporate Spatial Warehouse. www.geomaticsyukon.ca



Snow track survey area and caribou presence

Drawn:	Checked:	Date:	Figure:
MP/LG	MAS	12/12/2014	3.4

0 5 10 15 20
kilometres

Map scale 1:550,000 (printed at 8.5x11)
North American Datum 1983 UTM Zone 8N

CASINO

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3.1 DISTRIBUTION

Detailed descriptions of caribou distribution are provided below. The information is described for five biologically timeframes:

- Home range (annual data)
- Spring/calving and summer (1 May–31 July)
- Fall/rut (1 August–31 October)
- Early winter (1 November–31 January)
- Late winter (1 February–30 April)

The Government of Yukon's 2012 KCH range was developed using data collect during the original collaring program and aerial surveys; however, the newer GPS collar data provide more detailed information on KCH distribution so we delineated an updated annual herd range. Seasonal ranges were delineated to visualize patterns of use within the annual range. The annual ranges were estimated by considering a variety of data sources and analyses, while the seasonal ranges were estimated based entirely on modern collar relocation data collected during 2012–2014. VHF and GPS collar relocation data are not compatible, so the historical VHF collar relocations were excluded from the analysis.

Annual and seasonal ranges were estimated by creating utilization distributions (UD) for individual caribou developed using the 'tlocoh' package (Lyons et al 2013) in R version 3.01 (R Core Team 2013). T-LoCoH (Time Local Convex Hulls) is an improvement to a previous home range estimation tool (LoCoH, see Getz et al. 2007). Briefly, the method creates local convex hulls for each point based on a set of nearest neighbours, sorts hulls based on density, cumulatively merges the hulls together from smallest to largest, and estimates the UD based on the percent of points contained in the cumulative hulls. Individual caribou annual and seasonal home ranges were estimated by using the *a*-method (adaptive). Two user defined values are required to create the UD: *s* and *a*. The *s*-value determines the contribution of time to the estimate of distance between points, which allows the user to reduce the amount of influence observations (i.e., collar relocations) that occur at different times have on the estimate of use; for example, caribou collar relocations can be used to generate UD within a season allowing the exclusion of points that may overlap in space but not time, so should not necessarily be considered neighbours. The *a*-value is the cumulative distance to all points used to select the neighbourhood of points that define a local convex hull in distance units. Distance units are time-scaled if the s-value is greater than zero or map units if the s-value is equal to zero. When the s-value is equal to zero, then the method is equivalent to the LoCoH algorithm.

Values used to create the annual and seasonal UD were dependent on the availability of collar relocations, the fix rate of a collar, and the differences in individual caribou movements. The s-values were selected based on the particulars purpose of the output. Where applicable we selected s-values that balanced the influence of time and space on the selection of nearest neighbours. The annual range was estimated without considering the time (s=0) because the purpose of the output was to define the caribou's use of the landscape. The seasonal ranges were estimated by using *s*-values which allowed all relocations within year to be used to create local hulls but relocations among years would not be considered neighbours.

The annual range, or home range, was delineated using the following spatially referenced information: 95% UD for all caribou, waterbodies (the Yukon River), alpine and subalpine habitats defined by the bioclimate zones, survey observations, and VHF collar relocations. Layers were visually assessed to determine where continuity of the subalpine existed in relation to the UD and point data. Available survey observations and collar relocations not used to create the UD were inspected to ensure that they were contained within the polygon. Once complete, the final iteration was smoothed; this process smoothed out the angular corners of the polygon. The tool simplifies the edge and interpolates the perimeter using a Bezier algorithm. A maximum allowable offset of 100 m was used to ensure the smoothing effect did not offset the perimeter too far away from its original position, thus roughly adhering to the original delineation.

Data were screened prior to delineating the ranges to exclude problem data. Some caribou were excluded from the annual and/or seasonal analysis because they were not relocated enough within the timeframe to generate reasonable model outputs (e.g., mortality early within a season).

3.1.1 Home Range

The updated home range is a considerable increase in size compared to the 2012 KCH range (Figure 3.6). The size of the updated home range is 8,838 km², an increase in area of 2,638 km². Most of the increase is from the expansion of the northwest portion of the range. The KCH home range now includes most of the Dawson Range, and is characterized by abundant alpine and subalpine terrain. KCH caribou spend the majority of the year using alpine and subalpine habitats (Figure 3.5). Approximately 3,515 km² (40%) of the updated KCH home range is above 1,175 masl, the estimated treeline in the region.

Most of Yukon's woodland caribou exhibit seasonal elevational movements between winter and growing season ranges. Caribou tend to use habitat at lower elevation in winter because of easier access to terrestrial lichen, while during summers caribou move to higher elevation terrain to avoid predators and insects. KCH caribou show seasonal elevational movements consistent with the behaviour of other northern mountain population caribou herds (Figure 3.5). The herd tends to be above treeline during the growing season and use lower elevation habitat during the winter.

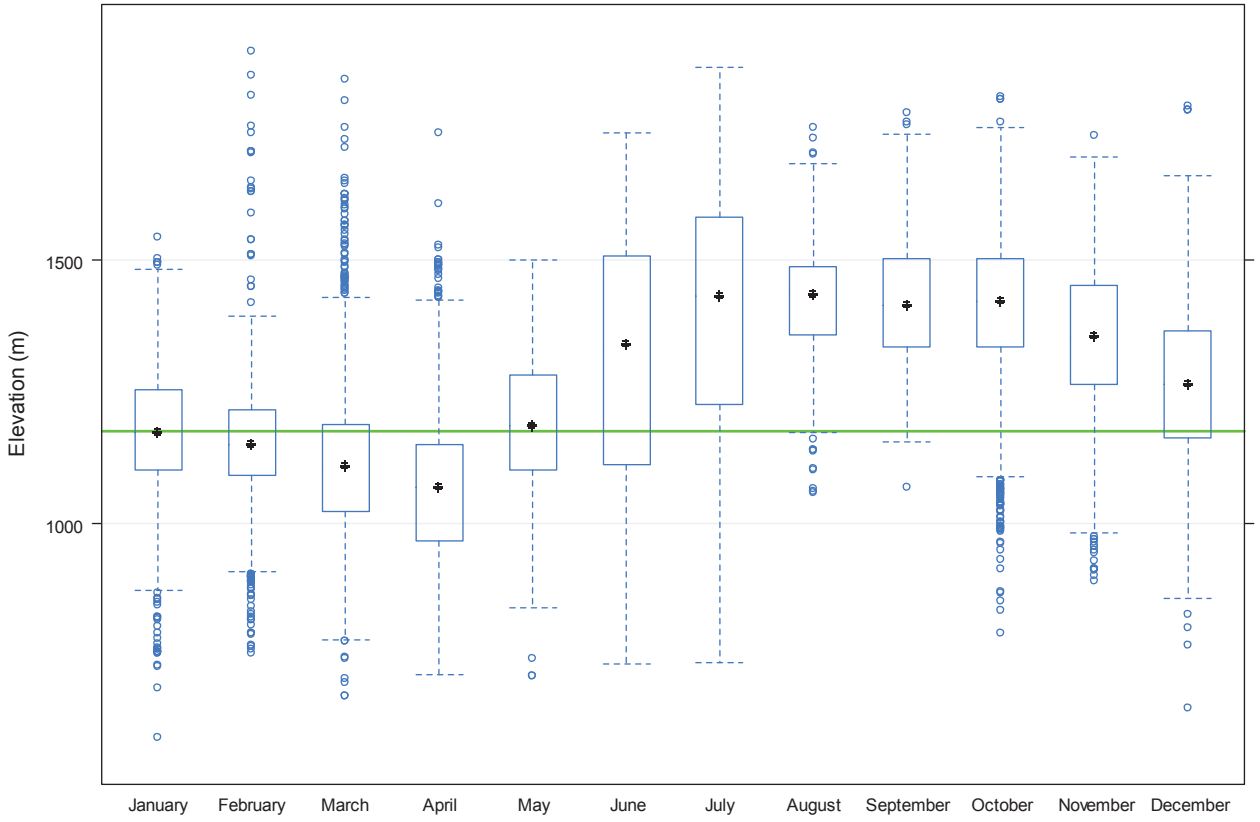


Figure 3.5 **Boxplot of caribou observations by elevation and month using all available location data (1987–2013; 464 caribou observations, 18,171 collar locations).**
The green line represents the average treeline estimate at 1,175 masl.

3.1.2 Spring/Calving and Summer

During the spring/calving and summer, woodland caribou cows disperse from their wintering habitats to higher elevation terrain as a predator avoidance tactic. Woodland caribou cows do not exhibit traditional use of calving areas commonly observed in migratory caribou herds. Parturient (i.e., about to give birth) female ungulates isolate themselves from larger groups, possibly to reduce encounter rates with predators and reducing offspring mortality risk (Farnell et al. 1996; Hebblewhite and Pletscher 2002). Higher elevation terrain reduces predation risk for caribou and their calves through spatial segregation from potential predators that tend to occur at lower elevations (Bergerud et al. 1984; Bergerud and Page 1987).

Distribution surveys have limited success during the calving season because parturient caribou are dispersed throughout higher elevation habitat and patchy snow makes spotting caribou difficult. The best available information on KCH spring and calving distribution is from collared cow caribou. Collar location data for parturient caribou collected during eight years between 1987 and 2012 indicate that the majority of caribou are using habitat above treeline (Figure 3.5); 64% of female caribou locations were above treeline (251 of 393 locations). The data also show that caribou are distributed broadly throughout their range during the

spring/calving season (Figure 3.6). Observations from the Casino wildlife log during the spring/calving season include 19 caribou from 2010–2013.

Summers are a time of the year when adult caribou recover from winter and replenish body fat. For lactating cow caribou the summer is important for milk production required to grow their young. Calves must grow quickly during the summer to survive their first winter. Consequently, summer range can be an important factor limiting population growth of large caribou herds that may be able to overgraze their summer range (e.g., George River caribou herd; Messier et al. 1988).

Yukon's northern mountain caribou herds, including the KCH, use higher elevation alpine and sub-alpine habitats during summers (Oosenbrug and Theberge 1980; Farnell et al. 1991; Quayle and Kershaw 1996). Higher elevation habitat provides relief from insects and high temperatures that are known to affect caribou behaviour (Toupin et al. 1996; Mörschel and Klein 1997; Wilson et al. 2012). Caribou use snow patches for cooling during hot days (Kuzyk et al. 1999b). KCH caribou are distributed throughout most of the high elevation terrain within their range (Farnell et al. 1991); 92% of caribou observations are above treeline (45 of 49) and the majority caribou collar relocations are above treeline (Figure 3.5). Small concentrations of caribou collar relocations occur throughout the herd's range (Figure 3.7) and those concentrations mostly reflect the individual collared caribou as opposed to multiple collared caribou (compare with winter distribution). Observations from the Casino wildlife log during the summer season include 260 caribou from 2008–2013.

3.1.3 Fall/Rut

Caribou aggregate in the alpine and subalpine during the fall, including during the rut (breeding season). The fall is the final opportunity for caribou to acquire the necessary fat reserves to survive the coming winter. The rut occurs in late-September to early October. Bulls move through their range in search of breeding opportunities with estrous cows.

Large groups of caribou were observed throughout the herd's range during 13 years of rut surveys conducted between 1987 and 2012 (mean group size=21, max group size=224). Caribou collar data and observations indicate that caribou occupy the alpine and subalpine habitat throughout their range during the fall and rut, focused primarily on the central and eastern portions of the range (Figure 3.8); 90% of caribou observations are above treeline (260 of 288).

3.1.4 Early and Late winter

Winter is the most limiting time of the year for woodland caribou. Forage is poorer quality and is less abundant because it is covered in snow. Animals spend more energy moving and cratering for forage during winters, and greater snow depth increases energy expenditure. Consequently, caribou select areas that have shallower snow. Habitat attributes such as presence of trees, wind exposure, slope, aspect and elevation are factors that contribute to local snow conditions. For example, forest canopies intercept snow and wind can scour snow from particular aspects. At coarser scales, large geologic formations may determine caribou

distribution in winter. The Dawson Range, which includes the KCH herd range, receives relatively less snow compared to many other parts of the Yukon because it is in a snow-shadow of the St. Elias Mountains (Table 3.3; Kuzyk et al. 1999a). Long-term weather stations managed by the Government of Yukon exist within the RSA (Figure 3.9 and Figure 3.10). Snow depths were also collected along the Freegold Road upgrade and extension during the 2013 snow track surveys; the data indicate an average snow depth of 53 cm (n=15, sd=5.5). A snow survey was also conducted in 1990 as part of the KCH inventory study. The survey found relatively shallow (mean=48 cm, n=85, sd=19.2) and uniform snow depths across the KCH's range (Farnell et al. 1991). Caribou tracks were observed intermittently between km 107 and 129, a 22 kilometre section of road, during 2012 snow track surveys. No caribou tracks were observed during the 2013 survey. Caribou distribution during early winter is throughout the central portion of the annual range (Figure 3.9). Higher intensity use occurs in the vicinity of the Nansen, Klaza, Prospector and Cockfield mountains, and parts of the Hayes Creek and Selwyn River watersheds. By late winter the central and eastern portions of the home range are largely devoid of caribou as animals move into habitat adjacent to Nisling, Klotassin and Selwyn rivers, and Hayes Creek (Figure 3.10). The KCH starts the winter at relatively high elevation, then occupy decreasing elevation as the winter progress; caribou occur at the lowest elevation during the late winter, particularly in April (Figure 3.5). Collared caribou locations from the original baseline studies show that caribou were generally observed within the current late winter range, though the most concentrated locations were in the Hayes Creek area (Figure 3.10). The changes observed in caribou locations from the 1980s to present are likely due to habitat changes and the methods for data collection. The current collaring technology provides a much more detailed understanding of the KCH seasonal and annual range use.

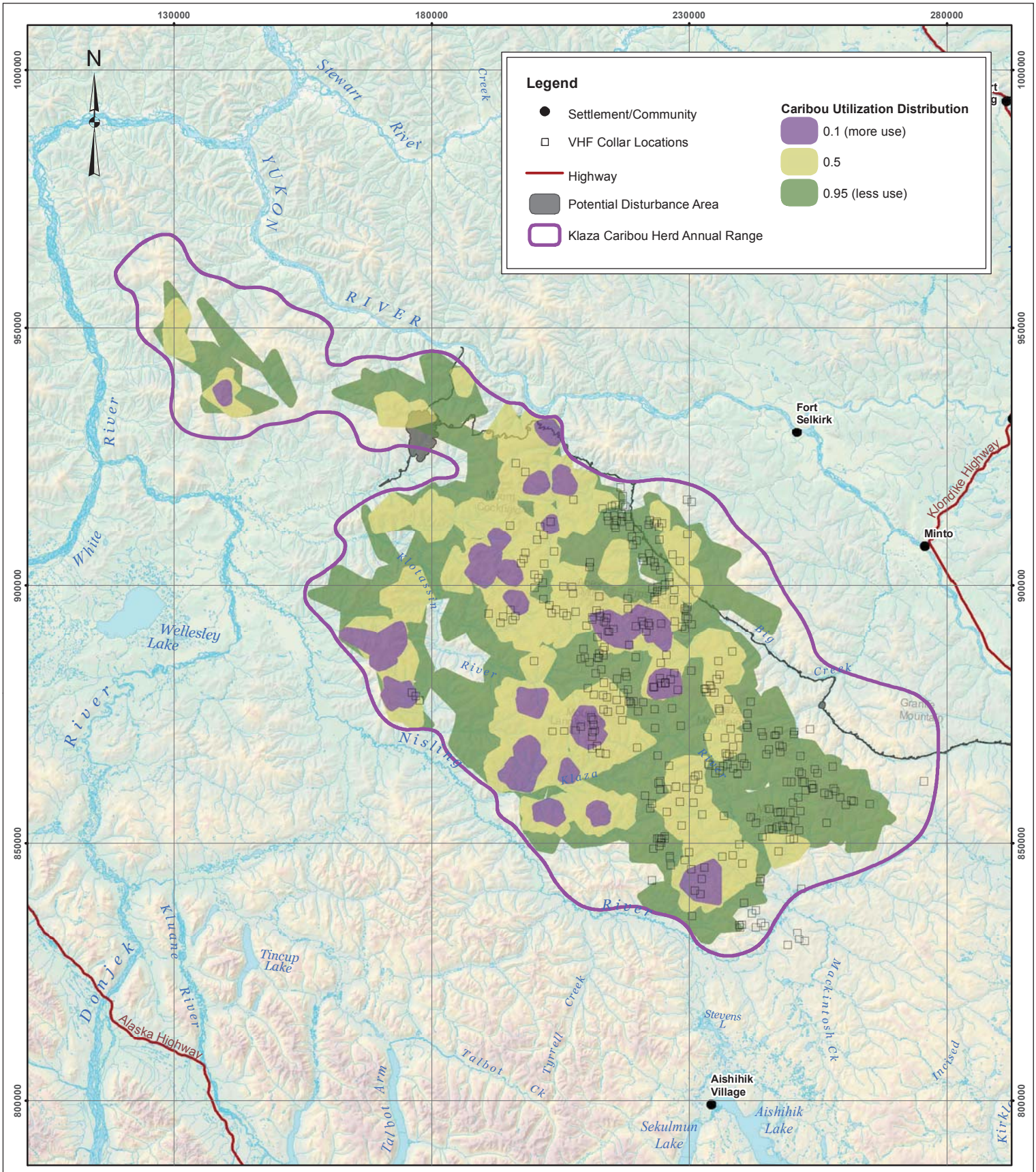
The KCH winter range conditions were determined to be relatively good in the late 1980s, as the caribou late winter diet was composed of 78% lichen and contained very little low quality forage, particularly moss (Farnell et al. 1991). Moss is not easily digestible so is ingested incidentally when caribou are feeding on other forage. If range conditions are poor and caribou are required to search for smaller patches of lichen, then moss content in their diet tends to increase (Farnell pers. comm. 2013). To begin assessing current range conditions, caribou fecal pellets were collected on 20 March 2013 from four sample locations to describe caribou late winter diet. The sample locations were based on the most recent collar location data provide by Environment Yukon and were chosen to cover the latitudinal extent of KCH range. Samples were collected from discrete pellet groups and kept frozen until they could be dried. The diet analysis was not available at the time of reporting because of a nine month sample backlog at the laboratory.

Table 3.3 Snow measurements in March at snow stations within or near the RSA.

Weather Station	Years of data	Measurement	Average (Range)	Coefficient of variation	2013
Casino	1977–2013	Snow depth	66.4 cm (43–99)	18.0%	60.9 cm
		Water equivalent	123.0 mm (68–225)	27.8%	109 mm
Nansen	1976–2013	Snow depth	45.6 cm (26–63)	20.5%	58.7 cm
		Water equivalent	79.5 mm (42–158)	30.4%	105 mm
Williams Creek	1995–2013	Snow depth	49.8 cm (27–70)	21.5%	59.0 cm
		Water equivalent	93.9 mm (43–146)	29.3%	110 mm

Note: Data provided by the Government of Yukon

Values in parentheses indicate the range of values recorded during all years of available data.



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Potential Disturbance Area (PDA) provided by Knight Piesold Ltd., Sept., 2013.

Klaza caribou herd collar data provided by YG - Environment (received 2014). The annual herd range was derived by EDI using YG collar data.

Digital Elevation Models (30 m and 90 m) provided by Yukon Government - Geomatics Yukon; online Corporate Spatial Warehouse. www.geomaticsyukon.ca



Klaza caribou herd annual range

Drawn:	Checked:	Date:	Figure:
MP/LG	MAS	12/12/2014	3.6

0 5 10 15 20 25 30
kilometres

Map scale 1:1,000,000 (printed at 8.5x11)
North American Datum 1983 CSRS Yukon Albers

CASINO
EDI

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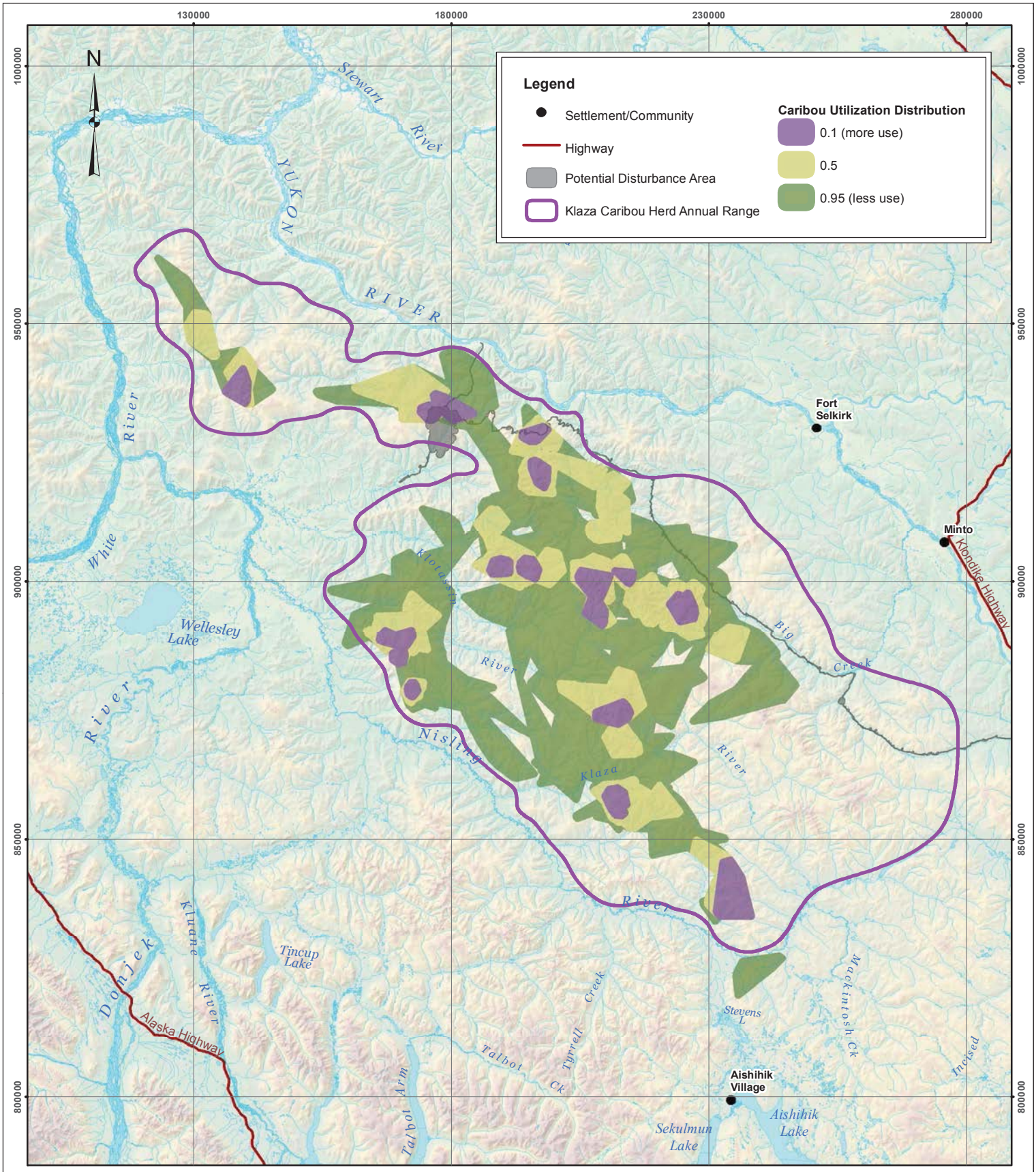

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Potential Disturbance Area (PDA) provided by Knight Piesold Ltd., Sept., 2013.

The annual and seasonal herd ranges were produced by EDI using Klaza caribou herd collar data from 2012 - 2014 (YG - Environment; received 2014).

Digital Elevation Models (30 m and 90 m) provided by Yukon Government - Geomatics Yukon; online Corporate Spatial Warehouse. www.geomaticsyukon.ca



Klaza caribou herd spring/calving and summer range

Drawn:	Checked:	Date:	Figure:
MP/LG	MAS	12/12/2014	3.7

0 5 10 15 20 25 30
kilometres

Map scale 1:1,000,000 (printed at 8.5x11)
North American Datum 1983 CSRS Yukon Albers

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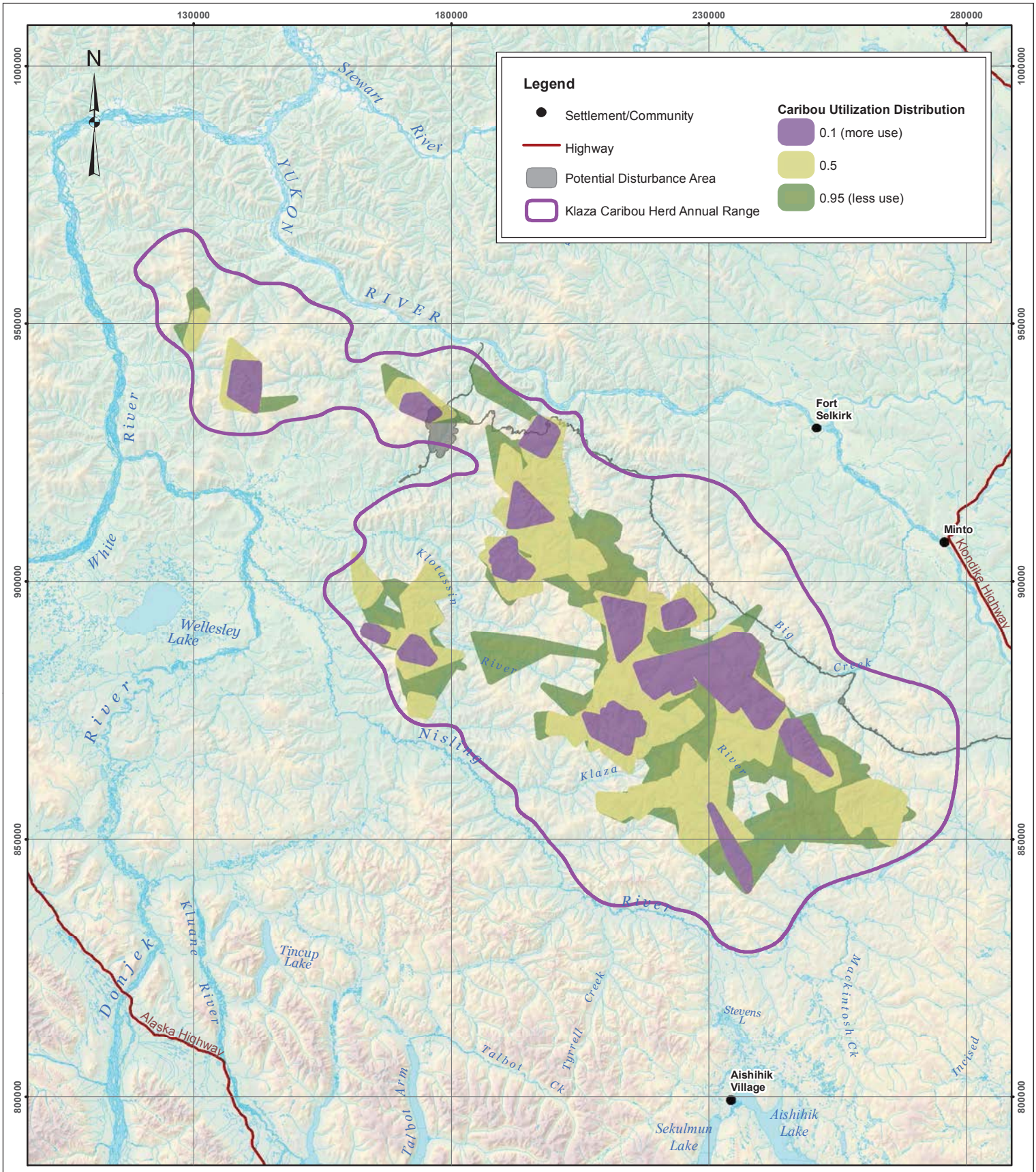

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Potential Disturbance Area (PDA) provided by Knight Piesold Ltd., Sept., 2013.

The annual and seasonal herd ranges were produced by EDI using Klaza caribou herd collar data from 2012 - 2014 (YG - Environment; received 2014).

Digital Elevation Models (30 m and 90 m) provided by Yukon Government - Geomatics Yukon; online Corporate Spatial Warehouse. www.geomaticsyukon.ca



Klaza caribou herd fall/rut range

Drawn:	Checked:	Date:	Figure:
MP/LG	MAS	12/12/2014	3.8

0 5 10 15 20 25 30
kilometres

Map scale 1:1,000,000 (printed at 8.5x11)
North American Datum 1983 CSRS Yukon Albers

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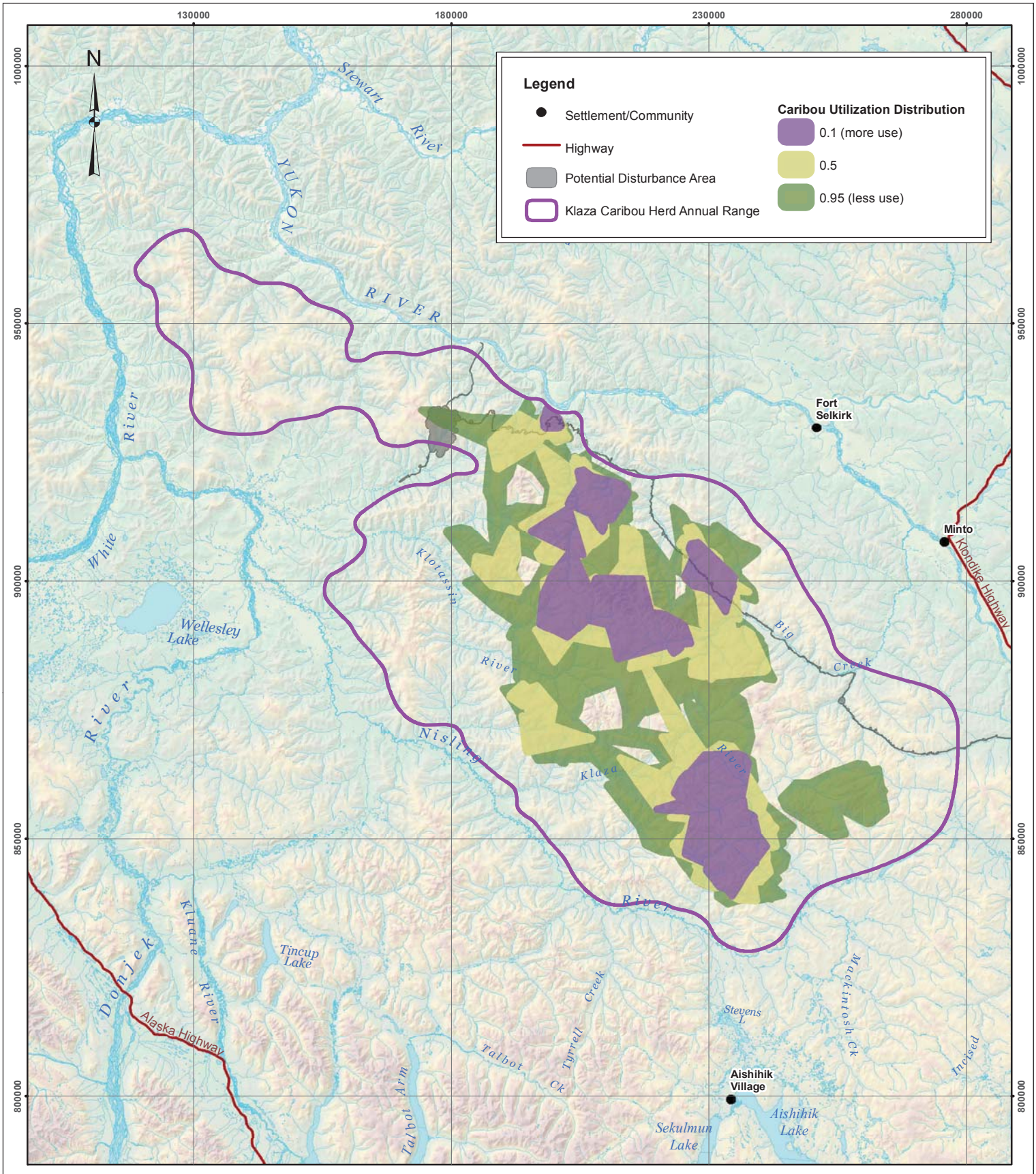

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Potential Disturbance Area (PDA) provided by Knight Piesold Ltd., Sept., 2013.

The annual and seasonal herd ranges were produced by EDI using Klaza caribou herd collar data from 2012 - 2014 (YG - Environment; received 2014).

Digital Elevation Models (30 m and 90 m) provided by Yukon Government - Geomatics Yukon; online Corporate Spatial Warehouse. www.geomaticsyukon.ca



Klaza caribou herd early winter range

Drawn:	Checked:	Date:	Figure:
MP/LG	MAS	12/12/2014	3.9

0 5 10 15 20 25 30
kilometres

Map scale 1:1,000,000 (printed at 8.5x11)
North American Datum 1983 CSRS Yukon Albers

CASiNO
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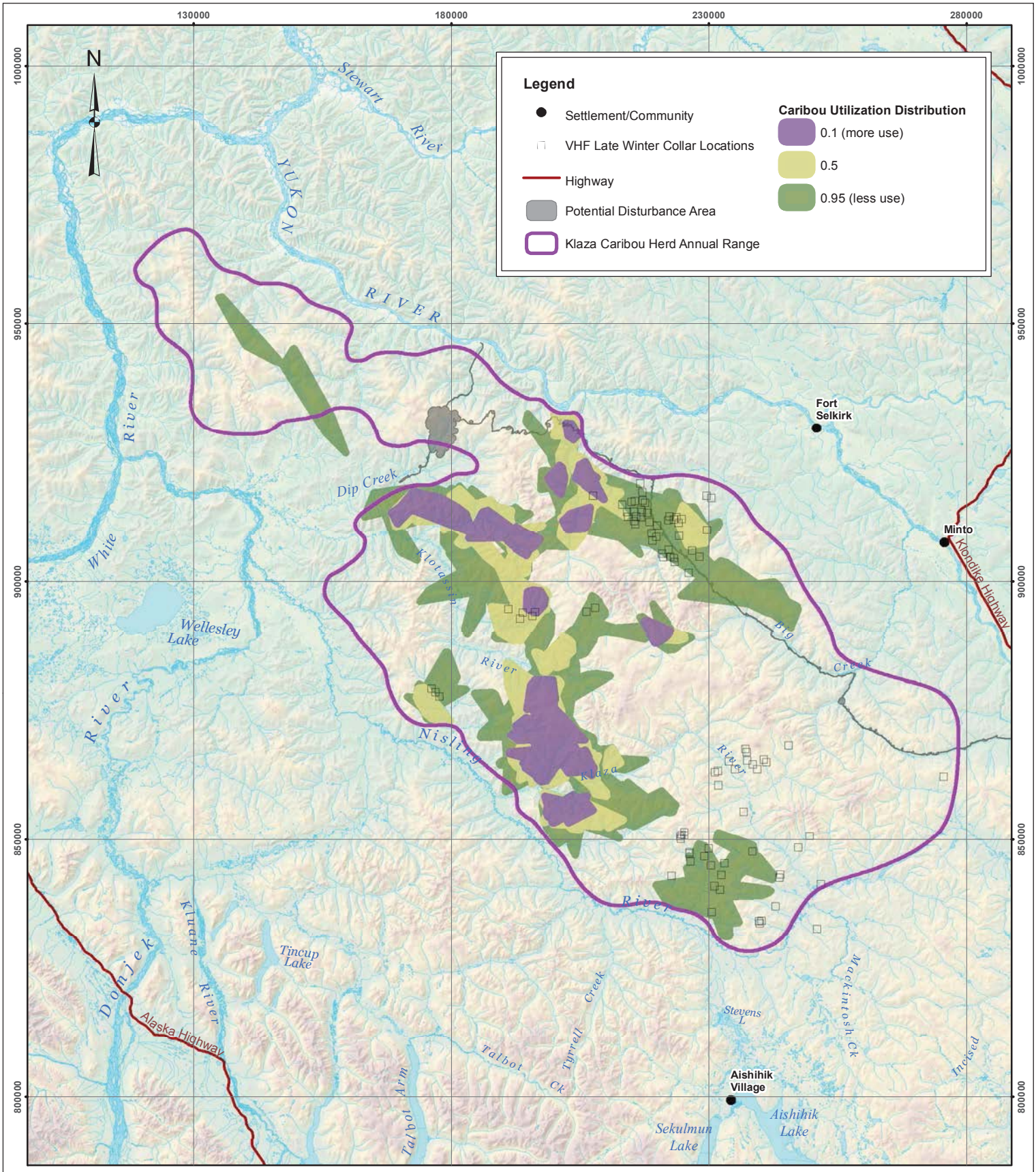

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Potential Disturbance Area (PDA) provided by Knight Piesold Ltd., Sept., 2013.

The annual and seasonal herd ranges were produced by EDI using Klaza caribou herd collar data from 2012 - 2014 (YG - Environment; received 2014).

Digital Elevation Models (30 m and 90 m) provided by Yukon Government - Geomatics Yukon; online Corporate Spatial Warehouse. www.geomaticsyukon.ca



Klaza caribou herd late winter range

Drawn:	Checked:	Date:	Figure:
MP/LG	MAS	27/02/2015	3.10

0 5 10 15 20 25 30
kilometres

Map scale 1:1,000,000 (printed at 8.5x11)
North American Datum 1983 CSRS Yukon Albers

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3.2 CARIBOU WINTER HABITAT SUITABILITY MODEL

Given the importance of the winter habitat to woodland caribou herds in Yukon (Farnell 1991, Kuzyk 1999a, Florkiewicz et al. 2007), habitat selection was modeled using GPS-collared female caribou relocations for the early and late winter seasons using the resource selection function method (RSF). RSFs are commonly used when GPS collar relocation data are available. The model was provided in the first version of the baseline report. Recently Environment Yukon developed a winter habitat model for the KCH using an additional year of collar data, new land cover variables and an improved method. The new model provides the most current baseline information describing KCH winter habitat use. The model output and documentation was not available prior to the submission of this version of the baseline report.

3.3 ABUNDANCE

The 2012 population estimate for the KCH was 1,179 caribou (95% CI = 952–1461; Hegel 2013a). The current population estimate represents a 70% increase compared to the 2000 minimum count (700 caribou; Hegel 2013a). Population estimates from 1989–2012 suggest that the herd has increased; however, the actual amount of change in the herd size cannot be determined because survey methods and boundaries differ among study years (Hegel 2013a). The southern portion of the herd's range was not included in the 1989 inventory (441 caribou; Farnell et al. 1991). The population estimate from 2000 is a minimum count and is likely an underestimate of the number of caribou in the herd at the time. The objective of the 2000 survey was to collect fall composition data; however, a large number of observations lead to a minimum population estimate (Hegel 2013a).

Data from the fall 2012 herd composition survey found low calf recruitment (14 calves/100 cows) and adult sex ratio (27 bulls/100 cows). These results suggest a declining population that is experiencing heavy hunting pressure, but are inconsistent with other data and the accuracy of the composition data is suspect (Hegel 2013a). The 2012 calf recruitment is the lowest calf to cow ratio ever reported for the KCH. Past recruitment surveys have averaged about 25 calves/100 cows (range 17–47; Hegel 2013a). Boreal caribou recruitment rates that indicate positive population growth are 26–29 calves/100 cows (Environment Canada 2008); however, a review of the demography of Yukon's NMP herds indicates that the threshold for positive population growth is 20–25 calves/100 cows (Hegel 2013a). The most recent data suggest that the herd has been increasing in size since 2000, and the harvest data indicates that the herd experiences little harvest pressure (Table 3.4). The timing of the 2012 composition survey was consistent with other composition surveys, but the fall of 2012 was abnormally warmer than usual (up to 20°C) and the caribou groups may not have adequately mixed prior to the survey (Hegel pers. comm.); consequently, these data should be interpreted with caution. Another fall composition survey is planned for fall 2013 to estimate the sex and calf ratios.

3.4 HARVEST

There are no data available describing current First Nation people's harvest practices within the RSA. Caribou are an important subsistence species for some First Nations in the Yukon. Subsistence hunting in

the Casino area was believed to be low during the original road construction (Spencer Environmental Management Services Ltd. 1985). The Freegold Road area was not being used regularly by local First Nations for subsistence hunting of caribou during the 1980s (Spencer Environmental Management Services Ltd. 1985, Pearse and Weinsten 1988), likely because access to the area was difficult. The local First Nations have not relied on caribou in the Dawson Range for subsistence hunting since the late 1940s when the Forty Mile caribou herd was extirpated from the region (Pearse and Weinsten 1988).

Caribou licensed harvest data are available 1979 to present in most Yukon GMSs. The 2013/2014 regulations restrict caribou harvest in all GMSs that intersect the Project footprint (Figure 3.12): GMSs 509 and 510 are closed to caribou hunting, and licensed hunters are required to enter a permit hunt lottery to harvest caribou in the GMSs 511 and 522 to 526 (Table 3.4). The majority of licensed harvest of the KCH in the last ten years (2002–2012) was concentrated in GMSs 523 and 526 (Table 3.4 and Figure 3.11). Resident harvest is mostly from GMS 526 likely because of access to caribou along the Mount Nansen Road. Non-resident harvest pressure is mostly within GMS 523, presumably from guided hunters accessing more remote areas with aircraft.

The Government of Yukon considers a sustainable harvest rate on woodland caribou to be between 2–3% of the population estimate. Based on the current population estimate, a sustainable harvest rate for the KCH is 24–35 caribou per year. Harvest from licensed hunters during the previous ten years has been 7–8 caribou per year, which is equivalent to 0.6–0.7% of the 2012 population estimate. Any First Nation harvest would be additive to these values.

Table 3.4 Summary of the latest ten years (2002–2012) of caribou harvest in GMSs that overlap with the Casino Project footprint.

GMS	Harvest regulation (2013/14)	Total harvest		Mean yearly harvest	
		Resident	Non-resident	Resident	Non-resident
509	Closed	0	0	0	0
510	Closed	0	0	0	0
511	Lottery Permit Hunt, 1 bull	0	0	0	0
522	Lottery Permit Hunt, 1 bull	2	0	1	0
523	Lottery Permit Hunt, 1 bull	5	35	0.5	3.5
524	Lottery Permit Hunt, 1 bull	1	0	0.1	0
526	Lottery Permit Hunt, 1 bull	37	0	3.7	0
TOTAL		**45**	**35**	**4.5**	**3.5**

Note: Government of Yukon, unpublished data

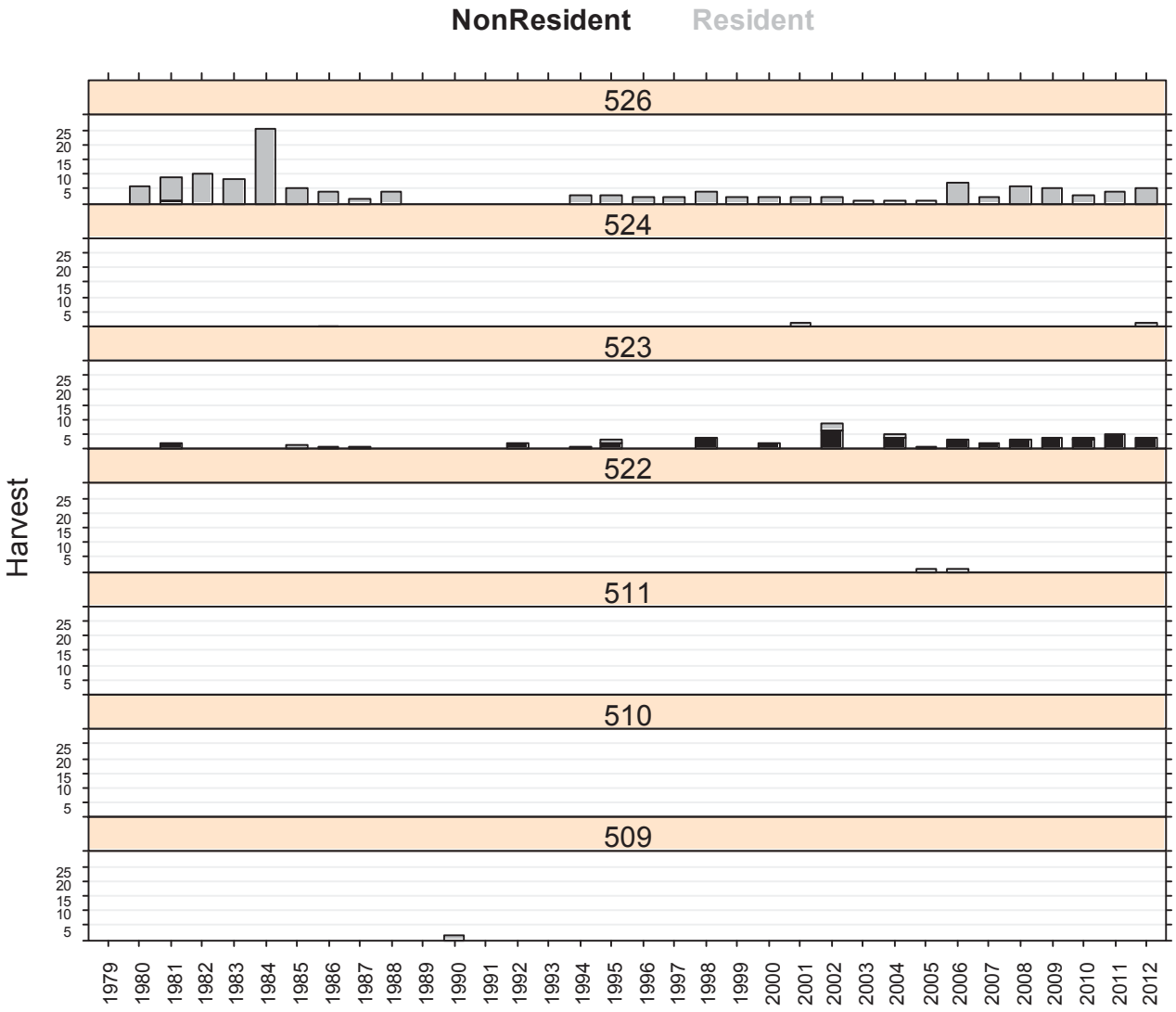

Figure 3.11 **Licensed caribou harvest within the GMSs that intersect the Project footprint, 1979–2012.**
The black bars indicate non-resident harvest and the gray bars indicate resident harvest.



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Game Management Subzones (GMS)

Drawn:	Checked:	Date:	Figure:
MP/LG	MAS	12/12/2014	3.12

0 5 10 15 20 25 30 35
kilometres

Map scale 1:900,000 (printed at 8.5x11)
North American Datum 1983 CSRS Yukon Albers

CASINO

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3.5 NATURAL MORTALITY

The natural mortality rate of the KCH was roughly 5% in the late 1980s (Farnell et al. 1991). Predation by wolves is likely the primary factor limiting population growth of the KCH (Hayes et al. 2003); however, wolverine can be an important predator of caribou calves during the first month after birth (Gustine et al. 2006). The amount of predation on the KCH is largely unknown. Previously, wolf numbers in the region were believed to be low due to the low density of prey in the region (Baer and Hayes 1987; Jingfors 1989). Wolves generally target alternative prey species that are more abundant and/or provide greater rewards. Caribou segregate themselves from wolves by using habitats where alternative prey (i.e., moose) are less abundant (James et al. 2004). The segregation of caribou from wolves may be an important tactic reducing predation rates.

Severe weather events (e.g., deep snow) have been suggested as a source of natural mortality for caribou. During the winter, forage availability is limited to ground-lichen and caribou must access the lichen under the snow, resulting in greater energy expenditure from digging craters (Bradshaw et al. 1998). Snow depths greater than 74 cm are considered adverse to caribou for digging craters to access forage (Farnell et al. 1991). Snow conditions can further limit the availability of forage based on snow depth, density, and hardness. Snow conditions do not seem to be a factor affecting population growth of the KCH, because snow depth in this herd's range rarely exceeds thresholds that are considered limiting to caribou (Farnell et al. 1991).

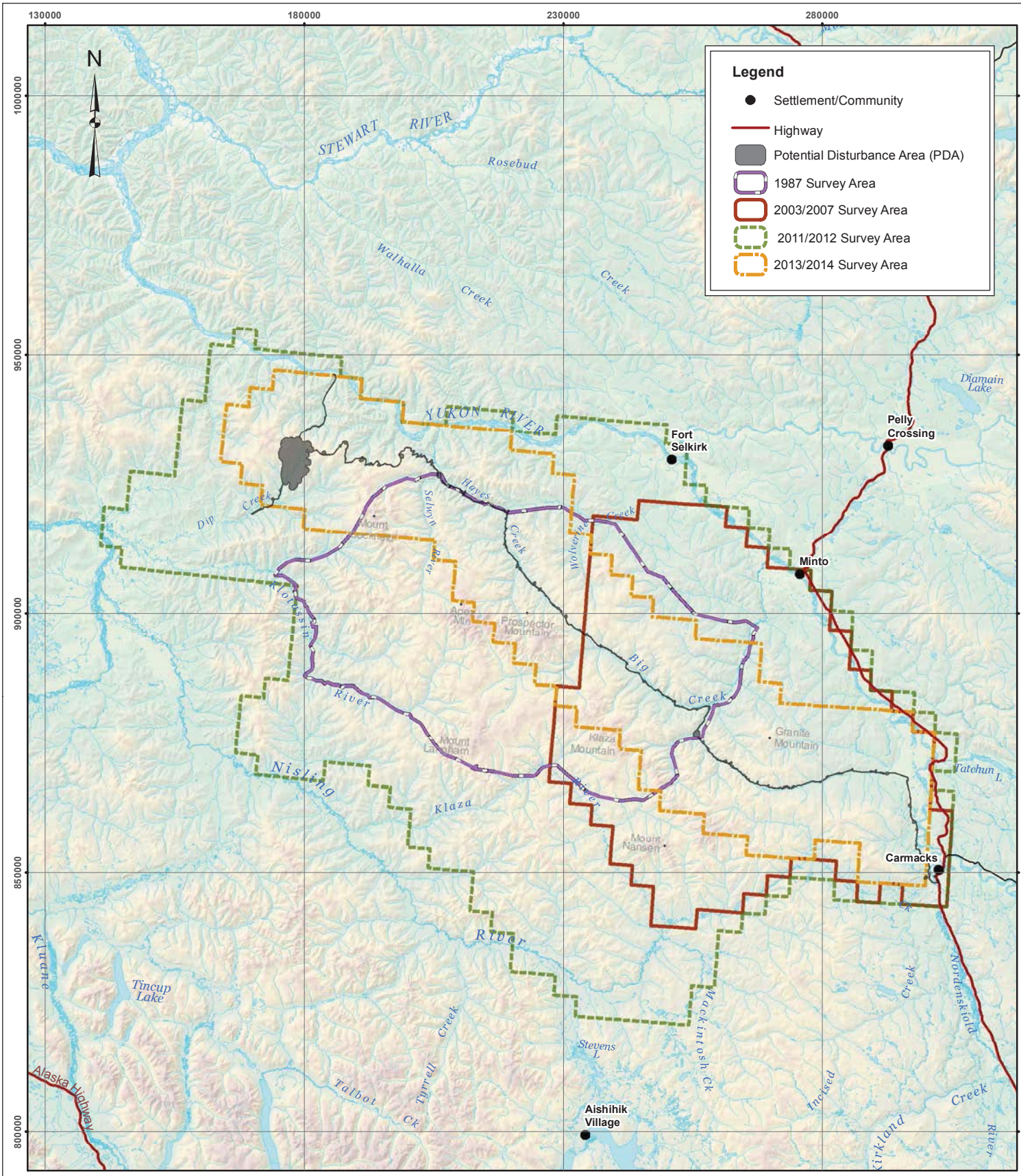
4 MOOSE

Moose is a highly valued harvest species in the Yukon and is considered the primary harvest species in the Project region. In the Yukon, moose management is defined by Moose Management Units (MMU), which were developed for consistent long-term monitoring and management of moose (O'Donoghue 2008a). The Carmacks West MMU overlaps primarily with the eastern half of the RSA (Figure 4.1). The Carmacks West MMU, along with GMSs intersecting Project components helped to guide the delineation of study areas for baseline moose surveys.

Baseline studies of moose in the Casino area began in the late 1980s and have included population censuses, composition, early winter and late winter distribution surveys, and incidental observations (Table 4.1; Markel and Larsen 1988; Jingfors 1989; O'Donoghue et al. 2008a, 2008b; O'Donoghue and Bellmore 2011). Results of these surveys provide information on the distribution and abundance of moose in the RSA. The study areas for moose are illustrated in Figure 4.1.

Table 4.1 History of moose surveys conducted in the Casino area from 1987–2013.

Date	Type of survey	Survey area	Survey Team
November 1987	Population census	Casino Trail area	YG Environment
November–December 2003	Population census	Carmacks West Moose Management Unit; KCH range; GMSs 524, 526, and parts of 522 and 523	YG Environment
November–December 2007	Population census	Same as 2003	YG Environment
March 2011	Late winter distribution	Extension of 2003 and 2007 survey area to include the mine site and all GMSs that spatially overlap with the Project	YG Environment and CMC
February–March 2012	Late winter distribution	Same as 2011	YG Environment and CMC
	Snow tracking	Freegold Road and extension	CMC
February–March 2013	Late winter distribution	Streamlined from 2011 and 2012 surveys to select survey blocks within 10 km of the mine site and the Freegold Road extension and upgrade	YG Environment and CMC
	Snow tracking	Freegold Road and extension	CMC
February–March 2014	Late winter distribution	Same as 2013	CMC



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Moose aerial survey areas

Drawn:	Checked:	Date:	Figure:
MP/LG	MAS	12/12/2014	4.1

0 5 10 15 20 25 30 35
kilometres

Map scale 1:900,000 (printed at 8.5x11)
North American Datum 1983 CSRS Yukon Albers

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4.1 DISTRIBUTION

Moose naturally occur in all Canadian provinces and territories, except Prince Edward Island and with introduced populations in Newfoundland (Geist et al. 2008). Moose are generally abundant across their range and populations are not at risk. In some areas, such as the southern boreal forest and the eastern Canadian provinces (e.g., Nova Scotia), moose range has decreased since the turn of the century; however, in other regions their range has expanded (e.g., coastal rainforests of BC; Geist et al. 2008). In the Yukon, moose are considered Secure (CESCC 2011) with a population of approximately 70,000 animals (Government of Yukon 2013a). Moose are distributed throughout the territory except Hershel Island, with unevenly high densities in southern Yukon, which represents only 15 percent of the land area (Government of Yukon 2010a).

Throughout their range moose prefer a mosaic of riparian and subalpine habitats, openings, and recent burn areas where they feed on tree leaves, woody and dwarf shrubs, herbs, and aquatic plants (Geist et al. 2008). Generally, moose select for habitats that provide abundant browse and foraging opportunities, thermal cover and protection from predators (Hamilton et al. 1980; Blood 2000). In an effort to better understand moose habitat use in the Dawson Land Use Planning Area, Morrison and Wong (2013) created late winter habitat selection models for adult moose and cows with young (one or more calves) to determine which areas moose selected and which were avoided. The models were based on moose late winter aerial survey data from surveys conducted in the Dawson Land use Planning Area in 2008–2010 and 2012. Adult moose selected areas close to forest, treed riparian areas, wide linear disturbances (>8 m wide), and 11–25 year old burned areas of intermediate elevation, on north-facing slopes, and with a high abundance of riparian forest (Morrison and Wong 2013). Cows with calves selected similar habitat, but did not select for wide linear disturbances or areas close to forest. Both adult moose and cows with calves avoided areas with a high proportion of wetlands, shrub cover, conifer forest, and mixed-wood forest, while only adult moose avoided areas close to recent burns (<10 years old; Morrison and Wong 2013). The avoidance of areas with high proportions of wetlands, shrub cover, conifer forest, and mixed-wood forest was unexpected, considering the requirements for shelter and forage (Morrison and Wong 2013). The avoidance of these habitats may have been a result of pooling all ages of vegetation types (i.e. young forest stands with little to no cover pooled with older, sheltering stands), misclassification error, or moose may have selected multiple vegetation types and avoided individual types (Morrison and Wong 2013).

In the RSA, previous examination of aerial photographs and helicopter reconnaissance led Spencer Environmental Management Services Ltd. (1985) to believe that higher elevation areas are not suitable habitat for moose during early spring and summer, whereas lower elevation areas (e.g., Big Creek) provide good habitat for feeding, thermoregulation, predator protection, and calving opportunities. Low elevation valleys and creeks provide abundant aquatic vegetation that moose highly prefer (MacCracken et al. 1993). Frequent moose sightings have been reported in both the Casino Creek and Britannia/Canadian Creek watersheds in late summer and early fall (Knight Piésold Limited 1997). These findings highlight the importance of low elevation forested valleys and waterways for moose, where they can be found browsing new buds and fresh growth such as willow and birch (Government of Yukon 2000; USDA Forest Service

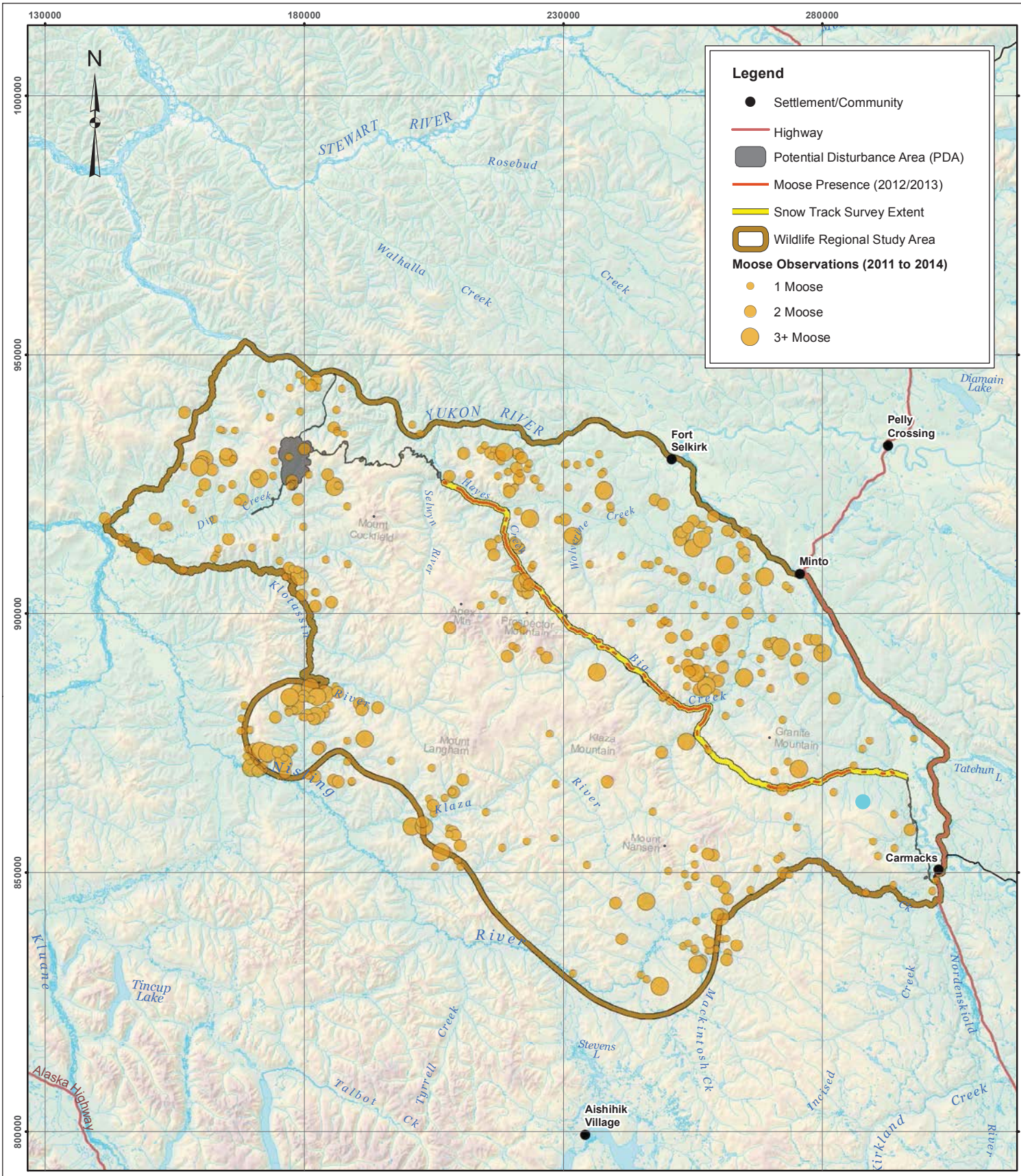
2010). In fall, during the rut, moose congregate in subalpine willow flats and creek draws where there is abundant willow. Observations of moose during fall and early winter surveys noted moose using subalpine areas, feeding on willow and shrub birch where snow depths remain shallow enough until mid-winter (Markel and Larsen 1988; Jingfors 1989; O'Donoghue and Bellmore 2011).

Winter can be a critical season for moose survival due to reduced forage availability and the energetic cost of moving through deep snow (Pierce and Peek 1984; Markel and Larsen 1988; Poole and Smith 2006; USDA Forest Service 2010). Key winter ranges for moose in mid to late winter are low elevation forested valleys where tree canopy cover intercepts snow, resulting in shallower snow conditions, lower energy costs, greater forage availability, and cover from predators (Government of Yukon 2010a). Willows generally make up the bulk of moose winter diet; therefore, areas with extensive shrubs and saplings provide good winter habitat, such as riparian areas, subalpine plateaus, shrub dominated draws, and early-successional forests (Government of Yukon 2010a). Lightning strikes causing wildfires are common in the Casino area (YEWG 2004), which benefit moose by providing high quality vegetative forage in recent burn areas. The most recent forest fire was in 2013, just west of the Freegold Road near Carmacks, and the most expansive fires occurred in 1994 and 1995 (O'Donoghue and Bellmore 2011).

During the 2011–2014 surveys, moose were widely distributed across the survey areas along creeks, open forest, and willow-rich habitats in previously burned or disturbed areas (e.g., near placer mine operations; Photo 2; Figure 4.2). In 2011, large concentrations of moose were observed in the northern and western portions of the survey area in open spruce forests and lower valleys along Klotassin River, Dip Creek, and Coffee Creek. In 2012, high concentrations of moose were observed in burned areas and river valleys; however, they were evenly distributed throughout the survey area. The study area in 2013 and 2014 was restricted to survey blocks 10 km or less from the existing Freegold Road and the proposed extension. Moose sightings in 2013 were distributed throughout the survey area, with minor concentrations noted north of the road alignment, between the Yukon River and Hayes Creek, and in the Big Creek area. In 2014, moose observations (tracks and sightings) were distributed throughout the survey area, with concentrations north of Big Creek, Hayes Creek, and the proposed mine site; the majority of moose sightings were in burned forests and on relatively high elevation slopes, which is somewhat atypical of moose during the late winter. Survey observations of moose distribution in late winter corresponded with known suitable winter habitats, especially areas that were likely to receive less snowfall and provided adequate winter browse. In general, observations from 2011–2014 were concentrated east of the proposed Freegold Road extension, in the Dip Creek area, and in the Nisling River valley (Figure 4.2). Observations from the Casino wildlife log include 76 moose from 2008 to 2013.



Photo 2. Three moose observed browsing on willow in disturbed habitat (cleared area near a placer mine) along the proposed Freegold Road extension during snow track surveys, 2013.



Notes:

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Potential Disturbance Area (PDA) provided by Knight Piesold Ltd. Sept., 2013.

2012 – 2013 snow tracking surveys (EDI), 2011 – 2014 aerial surveys (EDI/YG).

Digital Elevation Models (30 m and 90 m) provided by Yukon Government - Geomatics Yukon; online Corporate Spatial Warehouse. www.geomaticsyukon.ca

Late winter moose observations and snow track survey results

Drawn:	Checked:	Date:	Figure:
MP/LG	MAS	17/12/2014	4.2

0 5 10 15 20 25 30 35
kilometres

Map scale 1:900,000 (printed at 8.5x11)
North American Datum 1983 CSRS Yukon Albers

CASINO

EDI

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4.2 MOOSE WINTER HABITAT SUITABILITY MODEL

In consideration of the energetic costs to moose during winter, a late winter habitat suitability model was developed within the moose RSA. Habitat suitability indices (HSI) were created for habitat variables based on a review of literature, moose observations during baseline studies and professional experience. The detailed methods and results are presented in a separate technical report.

4.3 ABUNDANCE

The first moose survey conducted near the RSA was part of a larger study in 1975 covering Game Management Zone 5 and found relatively low densities of moose (Hoefs and Lortie 1975). The first survey targeting moose in the Casino area was conducted by the Government of Yukon in 1987 in response to the growing concern surrounding the potential impacts of the Freegold Road extension on moose and other wildlife populations (Markel and Larsen 1988). The Government of Yukon continued to conduct surveys in the Casino area in 2003, 2007, and 2011; however, the 2003 survey was only partially completed due to poor weather conditions (Table 4.2).

Moose densities in the RSA are relatively low, but may be increasing (Table 4.3); difference in survey timing and study area size confound rigorous trend analysis. Density estimates from 2003 are low and likely biased because of poor survey conditions, thus the apparent upward population trend from 2003 to 2007 may be somewhat unfounded (O'Donoghue et al. 2008b); however, there is a considerable increase in density from 1987 to 2007. Moose densities in the RSA are lower than the Yukon average, which generally ranges between 150 and 249 moose/1,000 km² (Yukon Fish and Wildlife Management Board 1996).

An estimate of moose composition could not be determined in 1987 and 2003 due to low sample size (O'Donoghue et al. 2008a). Estimates from 2007 and 2011 suggest that recruitment was relatively low in the RSA, below what is considered necessary for maintaining stable moose populations and lower in comparison to late winter distribution surveys done elsewhere in the Yukon (O'Donoghue et al. 2008b; O'Donoghue and Bellmore 2011). In general, moose populations in areas with typical mortality rates require about 25–30 calves per 100 adult cows to maintain stable moose populations (O'Donoghue et al. 2008b). Likewise, about 10–20 yearlings per 100 adults are necessary for maintaining stable moose populations. The number of mature bulls to adult cows (75 bulls per 100 cows) was slightly higher than the Yukon average (67 bulls per 100 cows) at the time of the survey and above the minimum target level of 30 bulls per 100 cows (Yukon Fish and Wildlife Board 1996).

In 2011, the observed number of calves in the population (4%) was low, suggesting low calf survival; however, this composition index is likely biased because the survey was aimed at determining moose distribution in the survey area (O'Donoghue and Bellmore 2011). Regardless, moose composition can be compared with results from similar late winter surveys done elsewhere in the Yukon, which suggests that calf survival in the study area was low in 2011.

Table 4.2 Results of moose surveys conducted in or near the Casino area, 1987–2013.

Year of survey	Type of survey	Abundance/# Moose Observed	Density[1]
1987	Early winter population census	137 ± 59% (90% CI)	40 moose/1,000 km²
2003[2]	Early winter population census	215 ± 48% (90% CI)	53 moose/1,000 km²
2007	Early winter population census	520 ± 21% (90% CI)	127 moose/1,000 km²
2011	Late winter distribution	278 individuals	n/a
2012	Late winter distribution	272 individuals	n/a
2013[3]	Late winter distribution	54 individuals	n/a
2014[3]	Late winter distribution	62 individuals	n/a

Notes:

[1]Density is based on moose observed in suitable habitat only (does not include entire study area).

[2]Results of this survey are biased low due to poor weather conditions.

[3]The number of moose observed in 2013 and 2014 reflects the reduced survey area size (Figure 4.1).

Table 4.3 Moose densities in GMSs that interact with the Project, based on early winter census survey results and discussion with regional biologists.

Game Management Subzone	# Moose/1,000 km²	Total Moose
509	200	205
510	200	142
511	100	47
522	125	252
523	145	319
524	100	117
526	125	166

Notes:

Rows in grey are not based on census data from that GMS. Within these GMSs, moose density is estimated from nearby censuses (Beaver Creek and or Casino Trail early winter surveys) and discussions with the Regional Biologist.

Data source: Government of Yukon 2012, unpublished data

4.4 HARVEST

Moose is a highly valued wildlife species in central and southern Yukon for recreational and trophy hunting and as subsistence food for First Nations (Spencer Environmental Management Services Ltd. 1985). Hunter questionnaire results from 1985 found that the demand for moose by resident hunters (licensed and unlicensed) was higher than all other big game species (Larsen et al. 1985). Although unlicensed (i.e., First Nation) harvest cannot be directly quantified, interviews with LSCFN and SFN members suggest that the Casino area is not highly used for subsistence hunting (Pearse and Weinstein 1988); however, this may have changed since that information was collected. Historical harvest data for moose are limited and harvest

estimates do not include unlicensed harvest. Harvest records from the LSCFN and SFN are voluntary; therefore, total harvest is unknown and can only be speculated based on personal communication or interviews with First Nation hunters.

Historically, moose numbers were found to be low in the Casino area and susceptible to overharvest (Spencer Environmental Management Services Ltd. 1985; Markel and Larsen 1988; Jingfors 1989; O'Donoghue et al. 2008a). Harvest data from 1979 to 2012 covers GMSs 510, 511, 522, and 523, with most harvest in the last ten years (2002–2012) from licensed resident users in GMS 509 (Table 4.4), corresponding with access from the Yukon River. Peak harvest was reported in 1984, and by 1987 GMSs 522–524 and 526 were closed to licensed hunting due to low moose numbers (Jingfors 1989; O'Donoghue et al. 2008a). In the RSA, these GMSs overlap with the Carmack West MMU, which has been closed to licensed hunting since 1987. However, First Nation harvest is unrestricted. At the time of writing this report, GMSs 522–524 and 526 are still closed, while 509–511 are open for the 2013–2014 hunting season, subject to a bag limit of one moose (Table 4.4).

Table 4.4 Summary of the latest ten years (2002–2012) of moose harvest data in GMSs that interact with the Project.

GMS	Harvest regulations (2013–2014 season)	Total harvest			Mean yearly harvest		
		Resident	Non-resident	Special Guided	Resident	Non-resident	Special Guided
509	Open; Bag limit 1	11	1	1	1.1	0.1	0.1
510	Open; Bag limit 1	1	3	0	0.1	0.3	0
511	Open; Bag limit 1	3	0	0	0.3	0	0
522	Closed	1	0	0	0.1	0	0
523	Closed	0	3	0	0	0.3	0
524	Closed	2	0	0	0.2	0	0
526	Closed	0	0	0	0	0	0
TOTAL		**18**	**7**	**1**	**1.8**	**0.7**	**0.1**

Note: Government of Yukon, unpublished data

4.5 NATURAL MORTALITY

The main source of natural mortality for moose in the RSA is likely predation by grizzly bears on newborn calves, followed by wolf predation on calves and adults (Larsen et al 1989). Predation levels are unknown in the Casino area, but studies from southern Yukon and east central Alaska strongly suggest that predation by grizzly bears limits moose population growth (Boertje et al. 1987; Markel and Larsen 1988; Jingfors 1989; Larsen et al. 1989).

Grizzly bear densities in the RSA are unknown, but likely range from 10–16 bears/1,000 km², based on studies southwest of Whitehorse and north of Tok, Alaska (Markel and Larsen 1988; Jingfors 1989; Larsen

and Markel 1989). In spring, grizzly bears are in the subalpine, which exposes moose and newborn calves to predation (Government of Yukon 2000). Grizzly bear mortality on moose tends to occur during the calving season before calves reach eight weeks of age, when they are weak and can be easily preyed upon (Larsen et al. 1989; Government of Yukon 2000). In late June, grizzly bears prey less on moose calves and wolves become the dominant predator during the remainder of the year and through winter (Larsen et al. 1989).

Another factor affecting natural mortality for moose in northern ecosystems is snow depth (Markel and Larsen 1988; Ballard et al. 1996). Snow depth is an important factor that influences forage availability and the energetic cost of moving across the landscape; however, moose may still select winter habitats primarily based on the overall availability of food (Serrouya and D'Eon 2002; Poole and Smith 2006). In the RSA, moose have been observed feeding on willow in areas of high snow depths (60–74 cm), suggesting that forage preference might be more important than snow depth in terms of habitat selection (O'Donoghue and Bellmore 2011). Although moose have evolved long legs to tolerate deep snow conditions, depths of 65–75 cm are known to restrict movements of cows and calves, and depths of 70–80 cm are considered critical to survival (Pierce and Peek 1984; Markel and Larsen 1988; Larsen et al. 1989). Generally, the average annual snowfall in the Yukon is not high enough to be a significant cause of natural mortality in moose (Government of Yukon 2010a).

5 DALL'S SHEEP

There are two subspecies of thinhorn sheep in Canada: Stone's sheep (*Ovis dalli stonei*) and Dall's sheep (*Ovis dalli dalli*). There is also a colour morph referred to as Fannin's sheep, which is a result of cross-breeding between Dall's and Stone's sheep (Worley et al. 2004; Government of Yukon 2010b). Dall's sheep occur throughout Canada's northwest including northern British Columbia, Yukon, Northwest Territories, and in Alaska (Loehr et al. 2006; Festa-Bianchet 2008) and are the only subspecies that exists within the RSA. They are distributed throughout the Yukon, extending as far north as the Arctic coast (Barichello et al. 1989a; Government of Yukon 2000b) with scattered pockets that extend across the territory in a broad band that follows the mountain ranges (Government of Yukon 1996, 2000b).

Few sheep-specific surveys have been conducted in or near RSA (Table 5.1); however, due to the traditional use of seasonal ranges by sheep, the existing historical information provides valuable data that are still relevant today.

Table 5.1 History of Dall's sheep surveys, including incidental sightings in or near the RSA from 1974–2013.

Year of survey	Type of survey	Location
1974	Population census	Dawson Range
1986	Population census	Dawson Range/Casino Trail area
2011	Moose late winter distribution	Carmacks West Moose Management Unit
2012	KCH re-sight survey	Klaza caribou herd range
2013	Late winter	Dawson Range

5.1 DISTRIBUTION

Sheep typically have a clustered distribution in traditionally used areas due to reliance on key habitats for seasonal life functions (e.g., winter range, lambing areas, and mineral licks; Heimer 1973; Festa-Bianchet 2008; Loehr et al. 2006). Dall's sheep are not migratory and their home ranges are usually not large (Spencer Environmental Management Services Ltd. 1985; Government of Yukon 1996; Geist 1999; Worley et al. 2004), and they can inhabit distinct seasonal ranges that are as little as a few kilometers apart (Government of Yukon 2000, 2010b). Adult male sheep may occupy as many as six seasonal ranges including pre-rutting, fall rutting, mid-winter, late winter, spring, salt lick, and summer ranges; whereas adult females typically have four seasonal ranges including winter, spring, lambing, and summer (Bowyer and Leslie 1992; Valdez and Krausman 1999). Lambing areas are re-used annually as an important source of suitable forage and protection from predators.

Dall's sheep inhabit dry mountainous regions where there is access to subalpine meadows, shrublands, and terrain with rocky slopes, ridges, and cliffs to help avoid predation and provide safe lambing grounds (Bowyer and Leslie 1992; Festa-Bianchet 2008). Nearby grasslands and meadows provide habitat for feeding

on grasses, sedges, and the leaves and buds of forbs and shrubs (Bowyer and Leslie 1992; Government of Yukon 2010b).

In summer (July/August), Dall's sheep can be found in alpine meadows where there is suitable forage and steep terrain for predator avoidance (Government of Yukon 2000). In fall (August/September), they move to winter ranges on wind-swept, south-facing alpine or subalpine slopes where snow is shallow and strong winds improve access to forage (Bowyer and Leslie 1992; Government of Yukon 2000, 2010b; Festa-Bianchet 2008). Winter ranges consist of scree slopes and broken cliffs located near prime lambing grounds, providing security from predators when the spring lambing season approaches (May/June; Valdez and Krausman 1999). A late winter habitat selection model for sheep in the Dawson region found that areas with high elevation, high convexity, high ruggedness, and a southerly aspect were selected by sheep, while areas distant from escape terrain with northerly aspects were avoided (Barker 2012).

Mineral licks are an important habitat feature for sheep because they provide a source of minerals. Dall's sheep diet mostly consists of graminoids (46.3%), forbs (36.8%), and browse (16.1%) (Bowyer and Leslie 1992).

The first survey to identify Dall's sheep wintering areas within the Dawson Range was in 1974, as part of a survey covering the greater area of GMZ 5 (Hoefs and Lortie 1975). In June and July 1986, the Government of Yukon conducted the first sheep surveys in the Casino area, focusing on the Freegold Road extension and in search of key habitat features (i.e., winter ranges; Jingfors 1989). Wintering areas in the Dawson Range were determined from direct observations and sporadic indirect sign (e.g., tracks, pellets, mineral licks). These surveys resulted in the definition of two separate "western" and "eastern" populations in the Dawson Range. The western population was located on a low mountain range between the Klotassin and Nisling Rivers (Jingfors 1989). The eastern population was found primarily on the mountains facing Klaza Creek, which are connected by alpine habitat to Apex, Prospector, and Klaza Mountains — areas that were believed to be used on a seasonal basis (Jingfors 1989). Winter range and suspected lambing areas for the eastern population were also located on the Klaza River — the same area that sheep were located in the 1974 survey (Hoefs and Lortie 1975; Jingfors 1989). In late winter 2013, a sheep survey conducted by the Government of Yukon in the Dawson Range found sheep winter range on Mount Langham, Apex Mountain, and near Klaza Mountain (O'Donoghue, pers. comm. 2013; Figure 5.1), suggesting that sheep distribution in the Casino area has likely experienced little change since the mid-1970s.

Sheep have been regularly observed during wildlife surveys that include suitable sheep habitat within the RSA. During aerial ungulate surveys in 2011 and the Klaza caribou herd re-sight surveys in 2012, Dall's sheep were observed on Mount Langham, Prospector Mountain, and Klaza Mountain). This is consistent with historical observations.

5.2 ABUNDANCE

In the Yukon, population estimates of all thinhorn sheep subspecies were made in 1974 and 1983, and totaled about 22,000 sheep in both years (Hoefs and Barichello 1985). Of this, 19,000 were Dall's sheep and 3,000 were Stone's sheep. This estimate is believed to have remained relatively stable through the 1970s and

1980s, based on repeated surveys of certain populations. The current population estimates for Dall's sheep in the Yukon is 20,000 (Government of Yukon 2013b).

Wolves, coyotes, golden eagles, wolverine, lynx, and grizzly bear are known predators of Dall's sheep (Hoefs and Cowan 1980; Stephenson et al. 1991; Arthur 2003); however, sheep are believed to be a minor part of most predators' diets. Wolves may limit populations when alternative prey is not available; however, in the Yukon, Dall's sheep populations are not known to be strongly influenced by wolf predation (Barichello et al. 1989b; Hayes et al. 2003).

Severe winter conditions (e.g., deep snow, icing events), high population density, low-quality forage, disease and over hunting have the potential to influence the productivity and/or carry capacity of sheep populations (Geist 1971; Bower and Leslie 1992; Government of Yukon 1996). Pregnant ewes typically experience a negative energy balance during the winter from high energy expenditures and/or low quality forage, potentially resulting in miscarriage if too much weight is lost (Geist 1971; Hoefs and Barichello 1985). Likewise, severe weather and poor forage quality during spring lambing can increase lamb mortality. The number of lambs entering the population is believed to be the driving force in sheep population dynamics, rather than the number of animals leaving the population through predation or hunting.

There are a number of diseases that are known to occur in sheep populations (Bower and Leslie 1992; Hoefs and Bunch 2001). High rates of a mandibular disease, known as lumpy jaw, have been found in Dall's sheep populations in the Yukon, with southern populations having a higher frequency and severity of infection than northern populations (Barichello et al. 1989c; Hoefs and Bunch 2001). Lumpy jaw disease may lower life expectancy of adult rams from the abnormal wearing of the teeth, loss of teeth, infection by oral bacteria, and subsequent impaired nutrient uptake; however, there is no evidence that it increases mortality (Barichello et al. 1989c).

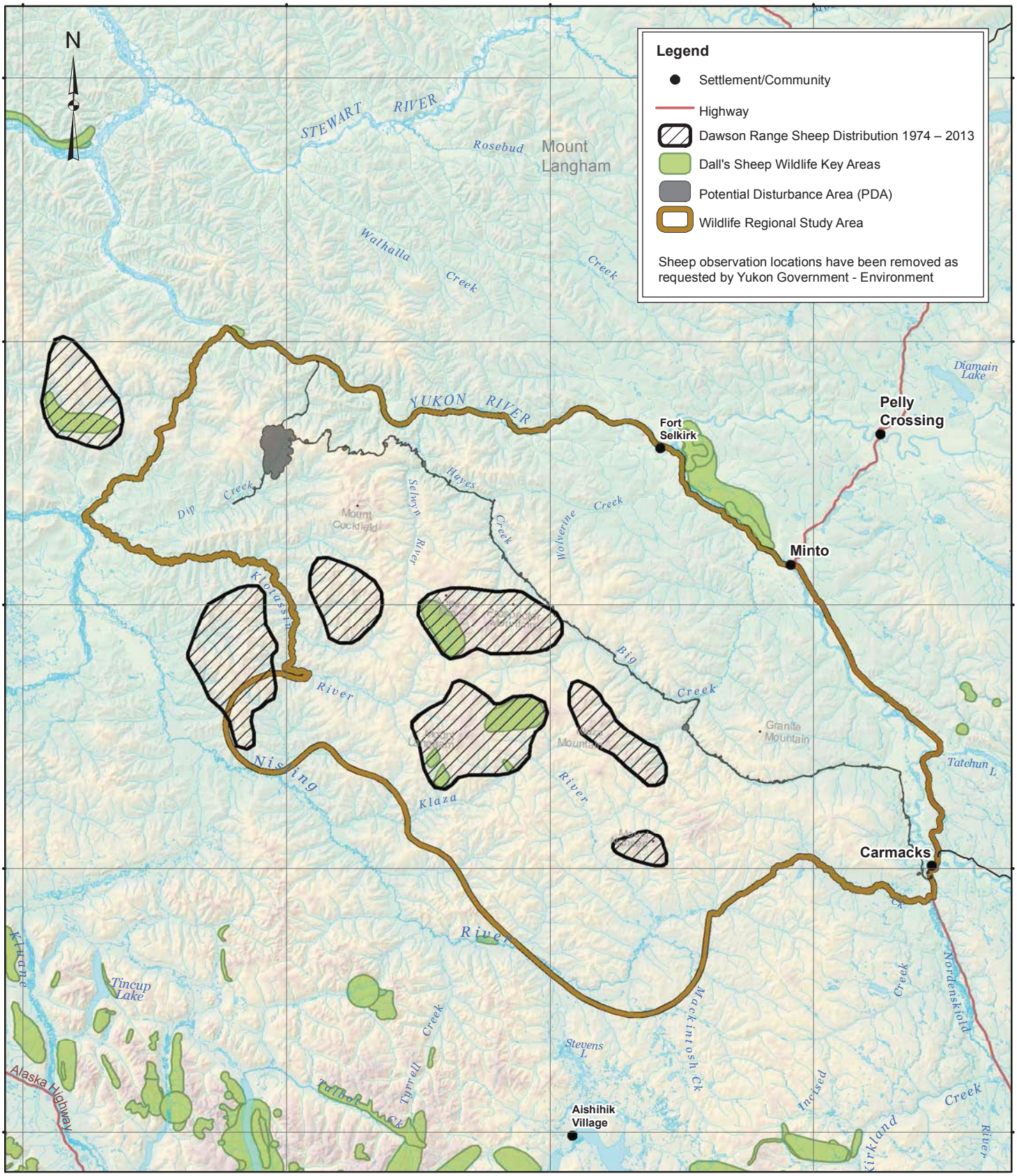
5.3 HARVEST

Dall's sheep are considered a valued sport-hunting resource in the Yukon. Hunters usually target old, large trophy rams. Historically, there were few harvest reports of Dall's sheep in the Dawson Range and harvest since 1979 has been limited to GMSs 523, 524, and 526, with the majority of reports coming from guided non-resident hunts (Table 5.2; Jingfors 1989; Government of Yukon, unpublished data). Sheep hunting remains open across the GMSs overlapping with the RSA; however, harvest in the last ten years has been limited to GMS 523 only (Table 5.2). Licensed hunters are restricted to one full curl ram per year. First Nation harvest statistics are unknown.

Table 5.2 Summary of the latest ten years (2002–2012) of sheep harvest data in GMSs associated with the Project.

GMS	Harvest regulations (2013–2014 season)	Total harvest		Mean yearly harvest	
		Resident	Non-resident	Resident	Non-resident
509	Open; Bag limit 1	0	0	0	0
510	Open; Bag limit 1	0	0	0	0
511	Open; Bag limit 1	0	0	0	0
522	Open; Bag limit 1	0	0	0	0
523	Open; Bag limit 1	1	6	0.1	0.6
524	Open; Bag limit 1	0	0	0	0
526	Open; Bag limit 1	0	0	0	0
TOTAL		**1**	**6**	**0.1**	**0.6**

Note: Government of Yukon, unpublished data



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Potential Disturbance Area (PDA) provided by Knight Piesold Ltd. Sept., 2013.

Wildlife key areas (updated 2012) and Dawson Range Sheep Distribution (2014) provided by YT - Environment.

Digital Elevation Models (30 m and 90 m) provided by Yukon Government - Geomatics Yukon; online Corporate Spatial Warehouse. www.geomaticsyukon.ca

Dall's sheep regional distribution

Drawn:	Checked:	Date:	Figure:
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0 5 10 15 20 25 30 35
kilometres

Map scale 1:900,000 (printed at 8.5x11)
North American Datum 1983 CSRS Yukon Albers

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6 WOOD BISON

Historically, the distribution of wood bison covered northeastern BC, northern Alberta, northwestern Saskatchewan, Yukon, southwestern Northwest Territories, and much of Alaska (Carbyn and Trottier 1988; Gates et al. 2001), with an estimated 168,000 animals in the early 1800s (Government of Yukon 2012). Due to heavy human exploitation, wood bison declined dramatically to a few hundred animals by the late 19th century, leading to extirpation in the Yukon in the early 20th century. In 1978 wood bison became a Species at Risk in Canada and were designated by COSEWIC as Endangered, leading to the creation of the National Wood Bison Recovery Program and a recovery goal of four free-ranging populations of at least 400 individuals (the number needed to support a minimal viable population; Gates et al. 2001). As part of this fulfillment, 170 bison were introduced to the Yukon between 1986 and 1992 (Gates et al. 2001; Government of Yukon 1998, 2012). These recovery efforts led COSEWIC to upgrade wood bison status to Threatened with legal protection under the federal *SARA*'s Schedule 1 (Government of Canada 2012).

Presently, wood bison inhabit BC, Alberta, Yukon, southwestern Northwest Territories, and Manitoba (Gates et al. 2001). In 2006 the Canadian population was estimated at 3,536 animals with 2,828 free-roaming (comprising six wild herds), 708 in captivity (comprising four captive herds), and with only two wild herds exceeding the minimum viable population threshold of 400 animals (Government of Canada 2012).

Yukon's wood bison were introduced to the Nisling River valley and have now extended their range south into the Aishihik, Sekulmun, and Hutshi Lakes watersheds (Government of Yukon 1998, 2012). Wood bison are not considered a migratory species; however, they do migrate locally between summer and winter ranges (Larter and Gates 1991; Gates et al. 2001; Government of Yukon 2012). The Aishihik herd's early and late winter range extends north of Aishihik Lake, along the North Klondike Highway, to approximately 30 km south of Carmacks (Figure 6.1; Government of Yukon 2012) with the herd's core range encompassing the area from the Nisling River valley eastward to the North Klondike Highway, lying largely south of the RSA.

Wood bison generally prefer open boreal and aspen forests, with a variety of habitat preferences which vary by herd and season (Reynolds et al. 1978; Larter and Gates 1991; Gates et al. 2001; Gardner and DeGange 2003). The diet of wood bison varies by herd, but generally consists of a variety of grasses, sedges, and willow with seasonal variation (Larter and Gates 1991; Reynolds et al. 1978; Gardner and DeGange 2003). In winter, sedges (*Carex* spp.) make up most of the diet, whereas a mix of grasses (e.g., *Calamagrostis* spp.), sedges, and willows (*Salix* spp.) comprises summer diet. For some herds, lichen (e.g., *Cladina mitis*) is the main forage component in the fall (Larter and Gates 1991).

A population census of the Yukon's Aishihik bison herd is typically conducted every two years, with the first survey in 1998 estimating close to 500 animals and the latest survey in 2011 estimating 1,230 animals. Two other transboundary herds occur seasonally in southeastern Yukon, known as the Nahanni and Nordquist herds (Government of Yukon 2012).

Following extirpation and subsequent reintroduction of wood bison into the Yukon, hunting was prohibited to promote population growth. In 1998, the requirement of a minimum viable population of 400 animals was fulfilled, allowing for their addition to the Yukon *Wildlife Act* as a harvestable species. The 2013–2014 hunting season is open to permit (non-lottery) hunting of wood bison across all GMSs, subject to a bag limit of one. Harvest data since 2002 for total and mean yearly bison harvest within the GMSs associated with the Project demonstrates that harvest is quite low and is concentrated primarily in GMS 526 (Table 6.1).

Table 6.1 Summary of the latest ten years (2002–2012) of wood bison harvest data in GMSs associated with the Project.

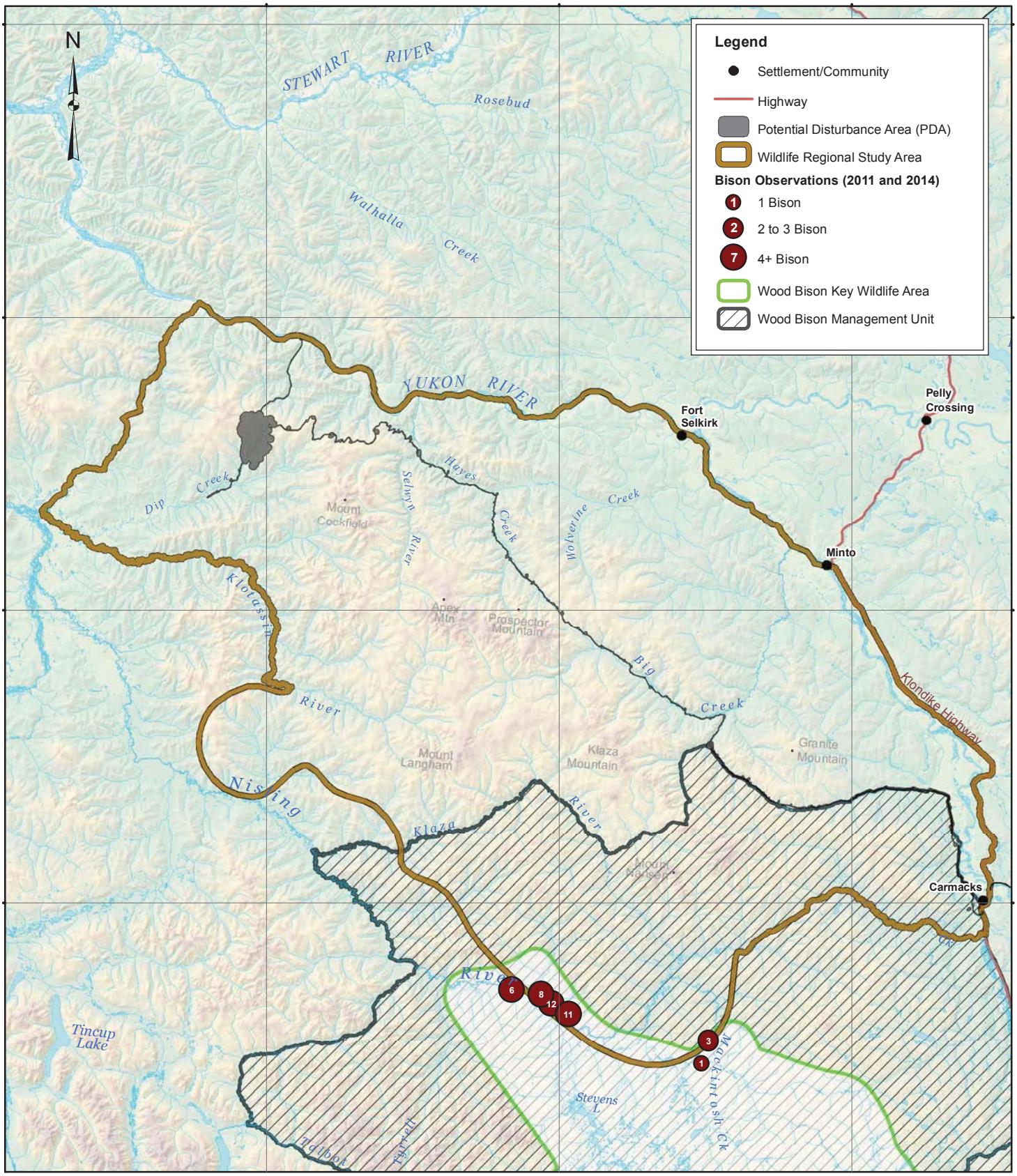
GMS	Harvest regulations (2013–2014 season)	Total harvest	Mean yearly harvest
		Resident	Resident
509	Permit required; Bag limit 1	0	0
510	Permit required; Bag limit 1	0	0
511	Permit required; Bag limit 1	0	0
522	Permit required; Bag limit 1	0	0
523	Permit required; Bag limit 1	1	0.1
524	Permit required; Bag limit 1	0	0
526	Permit required; Bag limit 1	4	0.4
TOTAL		**5**	**0.5**

Note: Government of Yukon, unpublished data

Grizzly bears and wolves are known to prey on wood bison; however, they are not considered the primary prey for either predator (Gardner and DeGange 2003) and in Yukon predation on bison is considered rare (Jung 2011). Wolf and wood bison have a history of predator-prey interactions and in some isolated herds wolves can limit bison populations (Carbyn and Trottier 1988; Gates et al. 2001; Gardner and DeGange 2003). The first record of a wolf-killed Aishihik bison occurred in 2007, with few other accounts after this (Government of Yukon 2011).

Other mortality factors include vehicle collisions (Hayes 1992) and disease. Three diseases are a problem for free-ranging wood bison populations in northern Canada, including tuberculosis (*Mycobacterium bovis*), brucellosis (*Brucella abortus*), and anthrax (caused by the bacterium *Bachillus anthracis*; Gates et al. 2001; Joly and Messier 2004; Government of Canada 2012). The Aishihik herd is considered disease-free and protecting the herd from disease is one of the main management objectives (Government of Yukon 2012).

Wood bison are expected to occur in the southern sections of the RSA only, due to limited suitable habitat. During the 2011 aerial ungulate survey, 18 bison, in two groups, were observed on the south edge of the RSA in their winter range on the edge of their core range. During the 2012 late winter survey, 23 bison in four groups were observed in the southern section of the study area, located in river valleys or on snow-free south-facing slopes (Figure 6.1).



Notes:

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Potential Disturbance Area (PDA) provided by Knight Piesold Ltd. Sept., 2013.

Wood bison observations collected by EDI and YG, 2011 and 2012.

Wildlife key areas provided by YT - Environment.

Digital Elevation Models (30 m and 90 m) provided by Yukon Government - Geomatics Yukon; online Corporate Spatial Warehouse. www.geomaticsyukon.ca



Wood bison regional distribution

Drawn:	Checked:	Date:	Figure:
MP/LG	MAS	12/12/2014	6.1

0 5 10 15 20 25 30 35
kilometres

Map scale 1:900,000 (printed at 8.5x11)
North American Datum 1983 CSRS Yukon Albers

CASiNO
EDI

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7 MULE DEER

Mule deer are distributed throughout most of western North America, naturally occurring in most provinces across Canada (Mule Deer Working Group 2004; Sanchez and Tessaro 2008). In the Yukon, mule deer are designated as Sensitive (CESCC 2011), mostly due to the suspected small population size.

Mule deer range has been expanding north into the territory for the past few decades, with reported sightings dating back to the 1930s (Hoefs 2001). It is believed the Yukon represents the northern extent of their range, with some sightings as far north as Dawson City and the Dempster Highway by the 1980s (Hoefs 2001). White-tailed deer have also been reported in the southern Yukon, but they are considered very rare. They were first observed at Tagish Lake near the British Columbia border in 1975, and as far north as Moose Creek on the North Klondike Highway in 1998 (Hoefs 2001). Mule deer occur in the RSA, likely concentrated in areas providing high quality habitat (e.g. open, south-facing slopes). During a moose survey in 2007, a mule deer and many mule deer tracks were observed on open ridges overlooking the Yukon River near Carmacks (O'Donoghue et al. 2008b) and two mule deer were observed on open ridges overlooking the Yukon River during baseline aerial ungulate surveys in 2011 and 2012.

Mule deer migrate locally within mountainous areas moving seasonally from high elevation summer ranges in alpine and subalpine habitats to low elevation forested winter ranges in valleys (Schoen and Kirchoff 1990; Hayden et al. 2008). They have been known to disperse distances of 100–200 km (Anderson and Wallmo 1984) and occupy areas as little as 30–40 hectares (Chapman and Feldhamer 1982).

Typical mule deer habitat in the Yukon consists of open, grassy areas and south-facing slopes bordered by aspen, where sunlight and high wind help expose forage and promote early green-up (Hoefs 2001; Government of Yukon 2013c). Mule deer can also be found along roadsides and highways feeding on grasses, forbs, foliage, and twigs (Government of Yukon 2013c). Their slender legs are not well suited for efficient travel in deep snow, making south-facing slopes and wind-swept areas prime habitat in the winter (Government of Yukon 2013c).

There is no population estimate of mule deer in the Yukon; however, their abundance is expected to be much lower than neighboring provinces and territories, but increasing. Due to their small population, mule deer harvest is by permit hunt only for all GMSs and is subject to a bag limit of one (Government of Yukon 2013d). There are no records of mule deer being harvested in the RSA. Natural predators of mule deer in the Yukon include bears, wolves, cougars, and coyotes (Government of Yukon 2013c). Other important factors influencing population dynamics includes habitat alterations, human-use patterns, forage availability and quality, weather, and disease. In northern climates, mule deer can be limited by cold and deep snow conditions (Mule Deer Working Group 2004; Sanchez and Tessaro 2008).

8 GRIZZLY BEAR

In the Yukon, there are an estimated 6,000 to 7,000 grizzly bears (COSEWIC 2012) that range across the territory from the BC border to the Beaufort Sea. Yukon's grizzly bear population represents about 25% of Canada's grizzly bear population (COSEWIC 2012). In Canada, grizzly bears are assessed as Special Concern because of threats from human-caused mortalities, including hunting, poaching, defense of life and/or property, and accidental mortality; incursions into grizzly bear habitat; and habitat loss (COSEWIC 2002).

Grizzly bears are opportunistic omnivores (Ross 2002), primarily feeding on vegetation but opportunistically preying on animals. Their diet and behaviour are dependent on local habitat and are highly variable. In Yukon, grizzly bears are the primary predator of moose calves each spring (Larsen et al. 1989). Other spring vegetation includes roots, the previous year's berries, and other old vegetation. Once new vegetation is available, grizzly bear forage switches primarily to grasses and then berries (Government of Yukon 2010c).

8.1 DISTRIBUTION AND ABUNDANCE

There is limited available information on grizzly bear distribution or abundance in the Project area. Grizzly bear densities for the project area are unknown; however, Markel and Larsen (1989) estimated densities between 10 to 16 bears/1,000 km^2, based on studies completed in nearby areas. The working estimate for the two ecoregions that overlap the study area is 15 grizzly bears/1,000 km^2 (Maraj pers. comm.). Grizzly bears are assumed to use the entire RSA as they have been harvested from all GMSs that intersect the Project footprint, with the exception of GMS 510. In the last ten years of available harvest data, a total of 11 bears were taken in GMSs 522–524 and 526 (Table 8.1).

To determine grizzly bear habitat use and distribution within the Project, a grizzly bear study area, herein referred to in Section 8 as the study area, was delineated (Figure 8.1). The study area encompasses all GMSs that overlap with the Project (GMSs 509, 510, 511, 522, 523, 524, and 526; Figure 8.2) and has a total size of 8,921 km^2. This study area was then used for the grizzly bear habitat modeling. A focal survey area around the proposed Project facilities was delineated for the bear den surveys (Figure 8.1).

During baseline studies conducted between 2010 and 2013, 15 grizzly bears have been observed in the RSA. These observations include one grizzly bear observed during the den surveys, photos of two grizzly bears taken by a game camera near Dip Creek and 12 bears observed as incidental observations during the baseline studies. In addition to the observations during the baseline studies, 25 grizzly bear observations were recorded by Project staff in the Casino wildlife log between August 2008 and August 2013.

Table 8.1 Summary of the latest ten years (2002–2012) of grizzly bear harvest data in GMSs associated with the Project.

GMS	Harvest regulations (2013–2014)	Total harvest		Mean yearly harvest	
		Resident	Non-resident	Resident	Non-resident
509	Open; Bag limit 1 every 3 years	0	0	0	0
510	Open; Bag limit 1 every 3 years	0	0	0	0
511	Open; Bag limit 1 every 3 years	0	0	0	0
522	Open; Bag limit 1 every 3 years	2	0	0.2	0
523	Open; Bag limit 1 every 3 years	1	5	0.1	0.5
524	Open; Bag limit 1 every 3 years	1	0	0.1	0
526	Open; Bag limit 1 every 3 years	2	0	0.2	0
TOTAL		**6**	**5**	**0.6**	**0.5**

Note: Government of Yukon, unpublished data

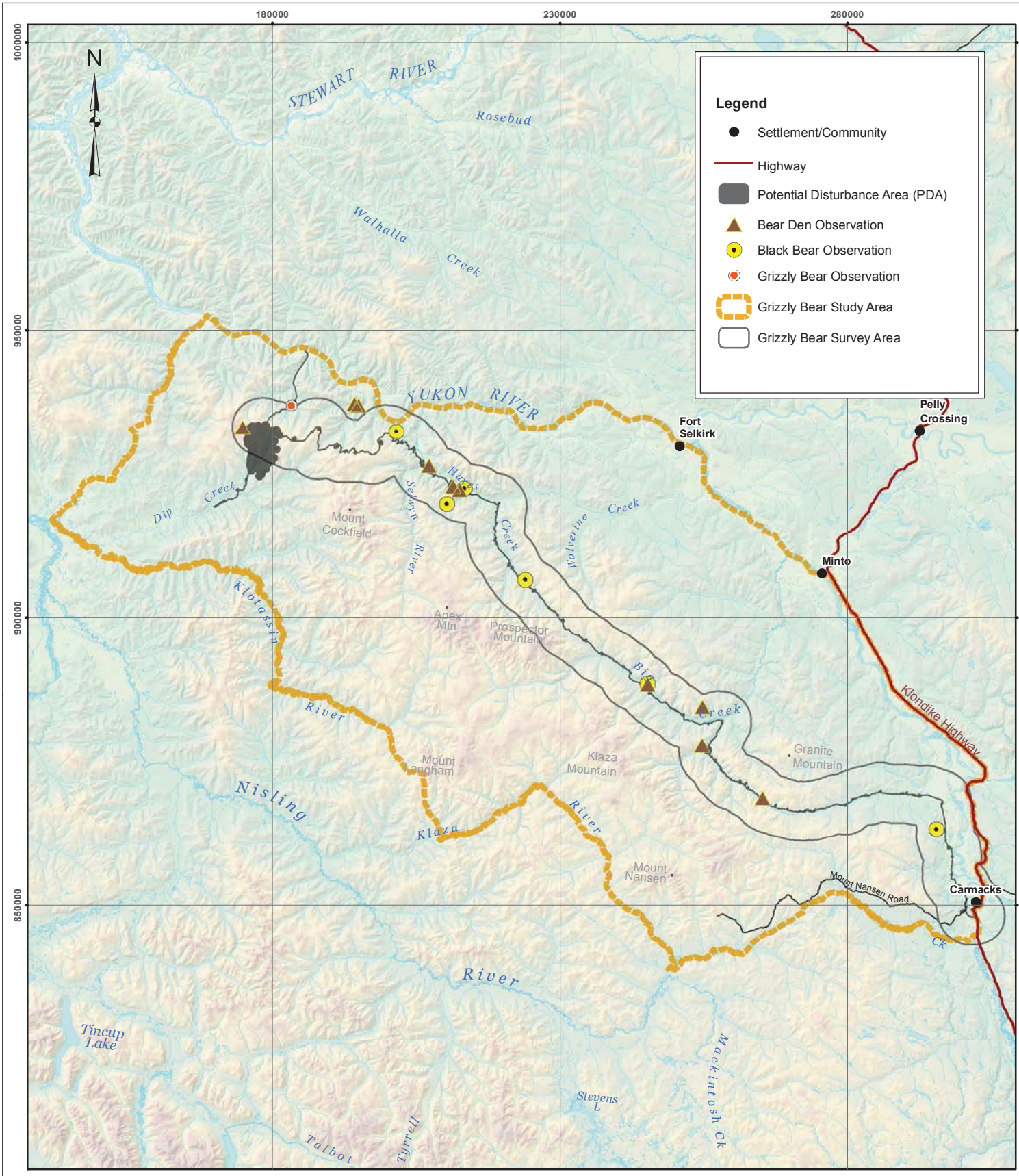
8.2 DEN SURVEYS

Grizzly bear den surveys were conducted during the spring of 2012 to document bear dens within close proximity to the Casino project. Using the denning spatial analysis (see Section 8.3.4), a survey area was defined as a 5 km buffer surrounding the footprint of the proposed Project, including the Freegold Road upgrade and extension (Figure 8.1). This survey area was then divided into 313 blocks, each 6.25 km² in size. Each block was then stratified into high, moderate or low probability den habitat by summing the number of 30 m pixels that contained suitable denning habitat (see Section 8.3.4) within each block. The high and low probability blocks were the upper and lower 25% of the blocks, respectively; while the moderate probability habitat was the middle 50% of the blocks.

All blocks classified as high probability denning habitat were surveyed during at least one of the surveys, while other classes were covered as much as flight time allowed. Surveys were conducted by fixed-wing aircraft (Alpine Aviation, Maule M-7), flying as low to the ground as possible. Four surveys were attempted between 20 April and 12 May 2012, but the 2 May survey was cancelled mid-survey due to extreme winds. Total survey time was 12.3 hours. The surveys were scheduled to coincide with the emergence of bears; however, the area receives relatively little snow and an early spring melt resulted in no snow at the time of the first survey. The presence of snow assists in locating active dens.

Nine dens were observed during the three 1-day surveys (Figure 8.1). Dens were primarily observed in higher probability habitat along Hayes Creek and Big Creek. All dens were excavated on relatively steep south facing slope, usually in the middle to upper parts of the slope. One den, observed west of the proposed Casino mine site was excavated under the embankment of an old mining road. Due to the lack of snow, it could not be determined if any of these dens were active during the winter of 2011/2012. No ground-truthing was done as part of this survey.

The survey area is dominated by forested slopes that make spotting dens difficult and the lack of spring snow in the area further reduces the probability of detecting dens. Consequently, observations of dens on open south facing slopes could be because bears use these habitat types, and because these are the only areas where survey crews get a good view of the ground.



1:250,000 Topographic Spatial Data, National Road Network; courtesy of Her Majesty the Queen in Right of Canada, Department of Natural Resources. All Rights Reserved.

Potential Disturbance Area (PDA) provided by Knight Piesold Ltd. Sept., 2013.

Bear habitat suitability created by EDI, 2013. Bear and bear den observations collected by EDI, 2012.

Digital Elevation Models (30 m and 90 m) provided by Yukon Government - Geomatics Yukon; online Corporate Spatial Warehouse. www.geomaticsyukon.ca



Bear den survey area and bear observations

Drawn:	Checked:	Date:	Figure:
MP/LG	LP/MAS	12/12/2014	8.1

0 5 10 15 20 25 30 35 40
kilometres

Map scale 1:900,000 (printed at 8.5x11)
North American Datum 1983 CSRS Yukon Albers

CASINO
EDI

Path: J:\Yukon\Projects\2014\14_Y_0285_Casino_EIS\Mapping\Baseline_Dec2014\Final_Mapping\450_Fig_8_1_BearDenSurvey_ObsRSA.mxd

8.3 GRIZZLY BEAR HABITAT MODELS

To determine the amount of effective seasonal grizzly bear habitat within the study area, the following models were developed and are summarized in this report:

- Habitat effectiveness model;
- Security areas model;
- Linkage zones model, and
- Denning habitat spatial analysis.

These models are often included as components of a grizzly bear cumulative effects assessment (CEA) and are used as tools to review the potential effects that a project may have on grizzly bears. Although this baseline report does not include an effects assessment, the habitat effectiveness, security areas and linkage zone models and the denning habitat spatial analysis have been used to assess the quality and quantity of grizzly bear habitat currently within the study area.

The CEA for grizzly bear was originally developed by the US Department of Agriculture (USDA 1990). The Geographic Information System (GIS) based methods used in this report are based on the work conducted by Purves and Doering (1998) and by Gibeau et al. (1996).

8.3.1 Habitat Effectiveness Model

The habitat effectiveness model examines habitat quality and human activities to estimate the overall effectiveness of grizzly bear habitat. This model is used to quantify the area's potential ability to support bears (Gibeau 1998). The inputs for the habitat effectiveness model are habitat type and disturbance. The habitat component (HC) is a qualitative assessment of the spatial and temporal distribution of potential habitat for grizzly bear foraging. The disturbance component (DC) is a quantitative assessment of human disturbance.

Habitat Component (HC) — Vegetation and land cover data for the study area were limited. EOSD data were available for portions of the study area but there were significant gaps in imagery due to cloud cover. Only broad-level vegetation data were available for the entire study area, so bioclimate zone data prepared by the Ecological and Landscape Classification Technical Working Group (ELC TWG 2012) was used for the habitat component. Bioclimate zones that occur in the study area include: alpine, subalpine, boreal highland and boreal lowland (Table 8.2). Definitions for the bioclimate zones that occur in the project area are (YECMWG 2003 and EBA 2003):

- **Alpine** — High elevations associated with mountainous conditions throughout Yukon. Dwarf shrubs, herb/cryptograms and low-growing and scattered krummholtz trees are the predominant vegetation condition. In very high elevation areas, bare rock, colluvium or ice/snow may be the dominant conditions.

- **Subalpine** — Sparsely forested areas at moderate to higher elevations on steep slopes above the boreal high. Subalpine areas form a transitional zone between forested boreal and the higher elevation non-forested, alpine bioclimate zones. Open canopy conifer forests (tree cover <20%) and tall shrub communities are characteristic vegetation conditions. Subalpine fir is the predominant tree species. Winters are long and cold, while summers are short, cool and moist.
- **Boreal High** — Middle to upper elevations of forested areas in all mountain valley and plateau ecoregions of southern and central Yukon. Found above the boreal low in large valleys. Characterized by steep slopes in southern mountainous ecoregions and gentle rolling plateaus in the central ecoregions. Summers are brief, cool and moist, with long cold winters. Forests are dominated by white spruce, lodgepole pine, and subalpine fir.
- **Boreal Low** — Continuously forested areas at low to middle elevations, below the boreal high of all mountain valley and plateau ecoregions of southern and central Yukon. Landscapes are generally wide valleys. Winters are long and cold, with short, cool and dry summers. Forests are generally mixedwood (lodgepole pine, white spruce and aspen) with moderately[1] developed understories. Wetlands are common.

The study area was divided into twelve bear management units (BMUs; Figure 8.2). Where possible, BMUs included entire drainage basins and their subordinate drainages, extending from the hydrological divide down to the valley bottom. The size of each BMU is based on the average home range size for a female grizzly bear. In the Kluane Region, Maraj (2007) noted that the weighted average multi-annual female home range size was 305 km². In the Mackenzie Mountains, the average home range size of six adult females was estimated to be 265 km² (Miller et al. 1982). The BMUs for this study range in size from 301 km² to 698 km².

Ecological Land Classification (ELC) mapping was completed during the vegetation baseline studies for the vegetation LSA. Bear foraging habitat within each bioclimate zone was inferred from the vegetation communities identified by the ELC mapping (Table 8.2). To reflect the spatial and temporal importance of food, a value between 0 and 1 was assigned for each bioclimate zone within each BMU, by season. A rating of 0 was used for bioclimate zones with no value to grizzly bears and a rating of 1 was used for the areas with the best possible habitat available.

Three seasons were used in this analysis: spring (late March through May), summer (June to mid-August) and fall (mid-August through October). The habitat ratings are summarized in Table 8.3. Habitat use during the winter/denning period (November to mid-March) was evaluated separately in the Denning Spatial Analysis (Section 8.3.4). The output from this analysis is the habitat rating component for the habitat effectiveness model (Purves and Doering 1998).

[1] Some publications consider the understory of boreal low to be "well" developed. This is a relative term that will become more explicit as Yukon vegetation classification is established.

Table 8.2 Bioclimatic zones and vegetation communities and their importance to grizzly bear

Bioclimate zone	Vegetation communities	Importance to grizzly bear
Alpine	Tors; Dryas-Sparse Herb; Felsenmeer	Provides suitable habitat for denning. Includes forage species such as mountain cranberry, crowberry, *Hedysarum*, sedges and grasses; Provides habitat for prey, including thinhorn sheep, woodland caribou, marmots and ground squirrels; Carcasses from winter kills
Subalpine	Mid to High Elevation Dry Shrub; Subalpine Moist Shrub; Tall Shrub; Mid to High Elevation Wet Shrub	Provides suitable habitat for denning. Includes forage species such as mountain cranberry, bog blueberry, common bearberry, *Hedysarum*, sedges and grasses. Provides habitat for prey, particularly calves of woodland caribou and moose; marmots; and ground squirrels. Carcasses from winter kills
Boreal High	Sloping Grassland; Dry Broadleaf Forest; Moist Broadleaf Forest; Coniferous Forest; Mixedwood Forest; Sparse Coniferous Forest; Riparian Shrub; Riparian Broadleaf; Riparian Coniferous; Coniferous Treed Bog; Shrubby Fen	Provides security habitat. Includes forage species such as rosehips, mountain cranberry, low bush cranberry, currants, grasses, sedges, horsetails. Provides habitat for prey species such as moose and caribou calves
Boreal Low	Riparian Shrub; Riparian Broadleaf; Riparian Coniferous; Coniferous Treed Bog; Shrubby Fen	Provides security habitat. Includes forage species such as rosehips, mountain cranberry, low bush cranberry, grasses, sedges, horsetails. Provides habitat for prey species such as moose and caribou calves

Table 8.3 Grizzly bear habitat ratings for each bioclimate zone by season

Season	Boreal High	Boreal Low	Sub-alpine	Alpine	Notes
Spring	1.0	1.0	0.5	0	Boreal high and boreal low spring/early summer, over-wintered berries, sedges, roots; riparian areas important. Little habitat available in alpine until snow melts (except winter kills).
Summer	1.0	1.0	1.0	1.0	Alpine and subalpine important; berries available in all bioclimate zones; spawning salmon in boreal high and low.
Fall	1.0	1.0	0.5	0.5	During the early fall, subalpine and alpine used; berries important.

Disturbance Component (DC) — The disturbance component of the habitat effectiveness model is based on human activity. Each activity is assigned a disturbance coefficient (DC) and zone of influence. DCs range from 0 to 1; a DC of 0 implies total displacement and a DC of 1 implies no displacement (Purves and Doering 1998).

Areas of disturbance were identified using various sources, including YESAB's online registry (2013) and Google Earth with imagery collected by Landsat (4/9/2013). Larger known projects in the area that are assumed to cause >100 disturbance events per month, including the existing Casino exploration work, were delineated using the Landsat imagery. A disturbance coefficient of 0.16 and 800 m zone of influence was assigned to each disturbance used in this analysis, including access roads, infrastructure, etc. (Purves and Doering 1998).

The cumulative DC for each BMU is the sum of each individual disturbance within that BMU. The potential habitat value is combined with the cumulative disturbance coefficient to calculate the realized habitat. The realized habitat measures the ability of grizzly bears to continue using the habitat when human disturbance is considered. A BMU with a realized habitat rating of 0 is interpreted as having no value to grizzly bears, while a realized habitat rating of 1 is interpreted as having high value to bears.

Habitat Effectiveness — Habitat effectiveness assesses an area's actual ability to support grizzly bears and it compares the potential habitat with the realized habitat, once disturbance has been accounted for (Gibeau 1998). The analysis of the habitat and disturbance components provides habitat effectiveness values for each BMU that represent the percentage of potential habitat available for that season. The habitat effectiveness value calculated for each BMU is the percentage of the habitat available once an account was made for human disturbance.

Assumptions — The modeling for all components was conducted using available data sets. Limitations of the data were identified and assumptions were required to complete the modeling, which include:

- Due to the lack of detailed site-specific habitat and vegetation data, TEM mapping data from the mine site collected in 2010 was used as a surrogate for vegetation communities within each bioclimate zone.
- Detailed disturbance mapping was not available for the study area; however, existing data was mapped using the Landsat imagery; assumptions were made about the type and amount of disturbance.
- Assumptions, such as frequency of use and zone of influence, were made on the effects of human use intensity and linear feature buffers on habitat use by grizzly bear.
- No ground truthing was completed as part of this modeling exercise.
- Habitat effectiveness, security areas and linkage zone models cannot predict the future. These models are based on the existing information available at the time of the analysis.
- These models quantify concerns about the viability of grizzly bear populations in the study area, but do not confirm them.
- As with most modeling efforts, it is challenging to simulate the effects of a highly complex environment in which cumulative effects of environmental, social, and individual variations on habitat use are not well understood. Very little grizzly bear information was available for the study area, so other projects in other parts of the Yukon, Alberta, and BC were used as reference for these models.



The habitat component provides a measure of inherent potential or productivity of the landscape for grizzly bears during the spring, summer and fall seasons. The disturbance component then addresses habitat productivity when human influences are considered. The habitat effectiveness value quantifies the extent of the landscape that is available to bears when human influences are considered (Gibeau 1998). Table 8.4 shows the habitat effectiveness values for each BMU.

Table 8.4 Grizzly bear habitat effectiveness for each BMU

BMU	Habitat effectiveness (HE)		
	Spring	Summer	Fall
1	89%	100%	90%
2	92%	100%	92%
3	91%	100%	91%
4	82%	100%	83%
5	53%	100%	58%
6	75%	100%	78%
7	100%	100%	100%
8	92%	100%	92%
9	73%	100%	75%
10	58%	100%	62%
11	60%	99%	65%
12	94%	100%	94%
13	97%	97%	97%
14	51%	100%	58%
15	55%	100%	59%
16	93%	100%	93%
17	75%	99%	76%
18	64%	99%	67%
19	72%	100%	73%
20	92%	100%	92%

8.3.2 Security Areas Model

Secure areas, away from human disturbance, allow bears to remain in areas for longer periods. This is an important factor for minimizing potential human-bear interactions and conflict. The habitat effectiveness model described above does not take habitat security into account. The security areas model identifies areas where a female grizzly bear can forage for 24 to 48 hours without human disturbance (Purves and Doering 1998). Security area models are run in conjunction with habitat effectiveness models because habitat effectiveness models (1) do not address habitat security; and (2) do not address the areas between zones of

human influence that are considered to be too small to provide secure habitat for bears (Gibeau et al., 2001). The security model developed for the Casino project uses the methods summarized in Purves and Doering (1998) and Gibeau (2001).

In this model, security areas are defined as:

1. Areas below 2,300 masl and vegetated;
2. Areas greater than 800 m from human activity where activity use is greater than 100 disturbance events per month, and
3. Contiguous areas greater than 9 km².

The following data sets were used in the security areas model:

- **Elevation** — Derived from the National Topographic Series 1:250,000 contour data;
- **Bear Management Units** — Described above;
- **Vegetation cover** — Bioclimate data from the Ecological and Landscape Classification Technical Working Group (2012), and
- **Human activity** — A variety of sources were used to determine anthropogenic activity in the study area. The majority of this activity is from mining exploration and placer mining (YESAB online registry 2013). One quartz mine is currently operating (the Minto Mine; Capstone Mining Corp 2013) and one quartz mine (Mt. Nansen) is currently undergoing remediation and closure work (Assessment and Abandoned Mines 2012). Other activity is likely ongoing in the project area, but specific locations of these sites were not available. It was assumed that other activity, not included in this analysis, occurs less than 100 times per month, and is therefore not considered. Areas with human activity were mapped as existing disturbed areas, such as existing camp locations, roads, and other activity using publically available Landsat imagery.

To calculate the amount of secure habitat within each BMU, and in the overall study area, areas that are not considered to be secure habitat for grizzly bear were removed:

- Areas >2,300 masl;
- Areas within the zone of influence (within 800 m of human activity), and
- Areas smaller than 9 km².

The remaining area is considered to provide secure habitat for grizzly bear. Typically non-vegetated areas, such as rock and ice, are also removed from this analysis; however, these data were not available for the study area. Table 8.5 provides the results of the security areas modeling based on the parameters listed above. Figure 8.3 depicts the four non-security areas in the study area. Within the entire study area, 8,566 km² (96%) is considered to be secure and 355 km² (4%) is considered to be not secure either from human activity or size (i.e., the patch is <9 km²).

Table 8.5 Grizzly bear security ratings for each BMU

BMU	Total area (km²)	Secure habitat	
		Area (km²)	% of BMU
1	511.35	477.73	93%
2	698.32	683.43	98%
3	369.43	369.43	100%
4	321.71	321.71	100%
5	395.06	395.06	100%
6	576.59	576.59	100%
7	331.94	326.98	99%
8	579.21	573.37	99%
9	346.42	346.42	100%
10	369.65	369.65	100%
11	709.04	694.60	98%
12	585.21	583.56	100%
13	348.93	296.11	85%
14	376.95	376.95	100%
15	302.87	302.87	100%
16	531.56	445.99	84%
17	523.62	476.11	91%
18	301.76	280.09	93%
19	384.97	311.00	81%
20	356.46	309.76	87%
Total	8921.07	8517.43	95%

8.3.3 Linkage Zone Prediction Model

Linkage zones are areas that provide foraging habitat, connectivity between home ranges and avenues of dispersal (Riddell 2005). Linkage zones are also important for maintaining genetic diversity (Ruediger 2000). Maintaining linkage zones is especially important in heavily fragmented landscapes (Riddell 2005). The Linkage Zone Prediction Model assesses a combination of landscape factors that affect wildlife movement through areas impacted by human activity (Purves and Doering 1998). It also identifies potential movement corridors in areas within intense human activity that still support high quality grizzly bear habitat. The output of this model is a scored map identifying four danger levels from human disturbance: minimal danger, low danger, moderate danger and high danger. Areas with a low danger rating represent potential linkage zones.

For the linkage zone prediction model, methods were based on Purves and Doering (1998). Their method used four inputs: access route density; intensity to developed sites; presence or lack of hiding cover; and proximity to riparian areas. The model developed by Purves and Doering (1998) assesses grizzly bear habitat in areas with intense human activity. With less than 4% of the area disturbed, the study area is considered to have minimal intense human activity. The latter two variables (presence or lack of hiding cover and proximity to riparian areas) were removed since grizzly bears can and will travel through areas that lack cover and are outside the riparian zone when they are not influenced by human disturbance. However, it is recognized that cover and riparian areas are extremely important for linkage zones in fragmented landscapes.

Access Route Density — Two sources of data were used to depict access features: National Road Layer v.9.0 and Google Earth imagery. Features not part of the National Road Layer, such as major access routes to mines (placer and quartz), were digitized using Google Earth. Features were merged into one file and converted to a raster file using ArcGIS Conversion tool; Polyline to Raster.

The Polyline to Raster conversion resulted in a raster file made up of 10 m x 10 m pixels following the access routes within the study area. Once the raster was created, spatial analysis was performed to obtain a density of access in units of km/km² using ArcGIS Spatial Analyst Tool: Focal Statistics. The neighborhood was set to *circular* with a radius of 564 which represents the radius (in metres) of 1 km². The lengths of the access within each cell were summed to get a total density. Finally, the final step to creating the access route density layer involved a reclassification of the densities into four classes:

- 0 km/km² Class 2
- 0–0.625 km/km² Class 3
- 0.625–1.250 km/km² Class 4
- >1.250 km/km² Class 5

Intensity of Developed Human Sites — Existing human disturbance (i.e., active mine sites, mining exploration, access roads) was represented by points and was obtained from various sources (YESAB 2012; YG Geomatics Yukon 2013). Points that were considered to have use-levels of <100 disturbance events per month or less were buffered by 120 m. For activities that are considered to have >100 disturbances per month, such as Fort Selkirk and the Minto, Carmacks Copper, and Mount Nansen mine sites, the areal extents were digitized and then a 240 m buffer was applied. These areas were considered high use-level sites. Digitizing the perimeter of these locations was completed in Google Earth.

All buffered features were merged into one file. The Euclidian distance tool was applied to the buffered feature dataset. The resulting raster file contained distances from each feature. The raster was then reclassified to represent a danger classification as follows:

- Within Influence Zone Class 6
- Within 100 m of Influence Zone Class 5
- Within 100–200 m of Influence Zone Class 4
- Beyond 200 m of Influence Zone Class 2

The sum of the two layers used in this analysis (access route density and intensity of developed human sites) provides a single combined danger score ranging from 4 to 11. High danger scores (i.e., danger score of 10 to 11) were given to areas with high human influence that are of greater danger to grizzly bears. Low danger scores (4–5) were given to areas with little to no human disturbance. The linkage zone model identified four danger score categories: minimal danger, low danger, moderate danger, and high danger. Table 8.6 provides the linkage zone results for each BMU. Linkage zones are shown in Figure 8.4.

Table 8.6 Grizzly bear habitat linkage zone model results by BMU

BMU#	BMU size (km²)	Danger categories							
		Minimal		Low		Moderate		High	
		Area (km²)	% of BMU	Area (km²)	% of BMU	Area (km²)	% of BMU	Area (km²)	% of BMU
1	511.35	491.45	96	18.69	4	0.99	0	0.22	0
2	698.32	688.98	99	4.12	1	2.30	0	2.92	0
3	369.43	369.43	100	0.00	0	0.00	0	0.00	0
4	321.71	321.70	100	0.00	0	0.00	0	0.00	0
5	395.06	395.06	100	0.00	0	0.00	0	0.00	0
6	576.59	576.59	100	0.00	0	0.00	0	0.00	0
7	331.94	328.99	99	1.11	0	1.84	1	0.00	0
8	579.21	576.25	99	1.53	0	1.44	0	0.00	0
9	346.42	346.43	100	0.00	0	0.00	0	0.00	0
10	369.65	369.65	100	0.00	0	0.00	0	0.00	0
11	709.04	702.40	99	5.99	1	0.56	0	0.09	0
12	585.21	584.76	100	0.35	0	0.10	0	0.00	0
13	348.93	312.75	90	20.18	6	12.54	4	3.46	1.0
14	376.95	376.95	100	0.00	0	0.00	0	0.00	0
15	302.87	302.87	100	0.00	0	0.00	0	0.00	0
16	531.56	482.04	91	46.10	9	2.55	0	0.86	0
17	523.62	497.40	95	25.54	5	0.53	0	0.15	0
18	301.76	289.07	96	6.43	2	2.43	1	3.84	1
19	384.97	342.79	89	42.18	11	0.00	0	0.00	0
20	356.46	329.78	93	26.68	7	0.00	0	0.00	0
Total	8921.07	8714.58	98	176.09	2	21.99	0	8.41	0

8.3.4 Denning Spatial Analysis

Bears require dens, and consequently suitable denning habitat, to survive winters. Grizzly bear denning habitat is generally located in alpine and sub-alpine habitats. Bears typically select denning locations with deeper soils and vegetation that keeps den roofs from caving in. Denning habitats tend to be 20-40° slopes, and are most likely to be found on south facing slopes (Pearson 1975). Permafrost and increased soil moisture reduces suitability of potential den sites.

The objective of the denning spatial analysis was twofold:

1. To increase efficiency of the denning survey and increase probability of locating dens; and

2. To determine the amount of suitable denning habitat available in the study area.

Denning habitat was identified using GIS and available spatial data for the entire grizzly bear study area. Landscape and vegetation characteristics were used to determine suitable denning habitat within the study area. Criteria used to determine suitable denning habitat were based on the experience and professional opinion of Government of Yukon biologists who conducted similar surveys in other areas of the Yukon (Maraj pers. comm.). These criteria included:

- 20–45 degree slopes;
- 600 to 1,200 m elevation, and
- Exclude wet habitat types.

Spatial data describing high and low probability denning habitat were generated by applying the criteria above to data generated from a 30 m resolution digital elevation model (DEM) downloaded from Environment Yukon. Potential denning habitat was assigned a score of 1 and the remaining areas were assigned a score of 0. The resulting raster layer identified suitable denning habitat within the study area (Figure 8.5).

The denning spatial analysis identified areas suitable for grizzly bears to den. A total of 1672 km², or 23% of the study area was identified as suitable denning habitat for grizzly bears. Table 8.7 summarizes the size of suitable denning habitat within each BMU.

Table 8.7 Grizzly bear denning habitat suitability within the study area

BMU	Suitable denning (km²)	Percent suitable for denning
1	223	44
2	154	22
3	162	44
4	111	34
5	68	17
6	188	33
7	32	10
8	74	13
9	114	33
10	46	12
11	122	17
12	61	10
13	32	9
14	54	14
15	7	2
16	28	5
17	143	27
18	11	4
19	16	4
20	27	7
Total	1672	19

8.3.5 Grizzly Bear Habitat Model Summary

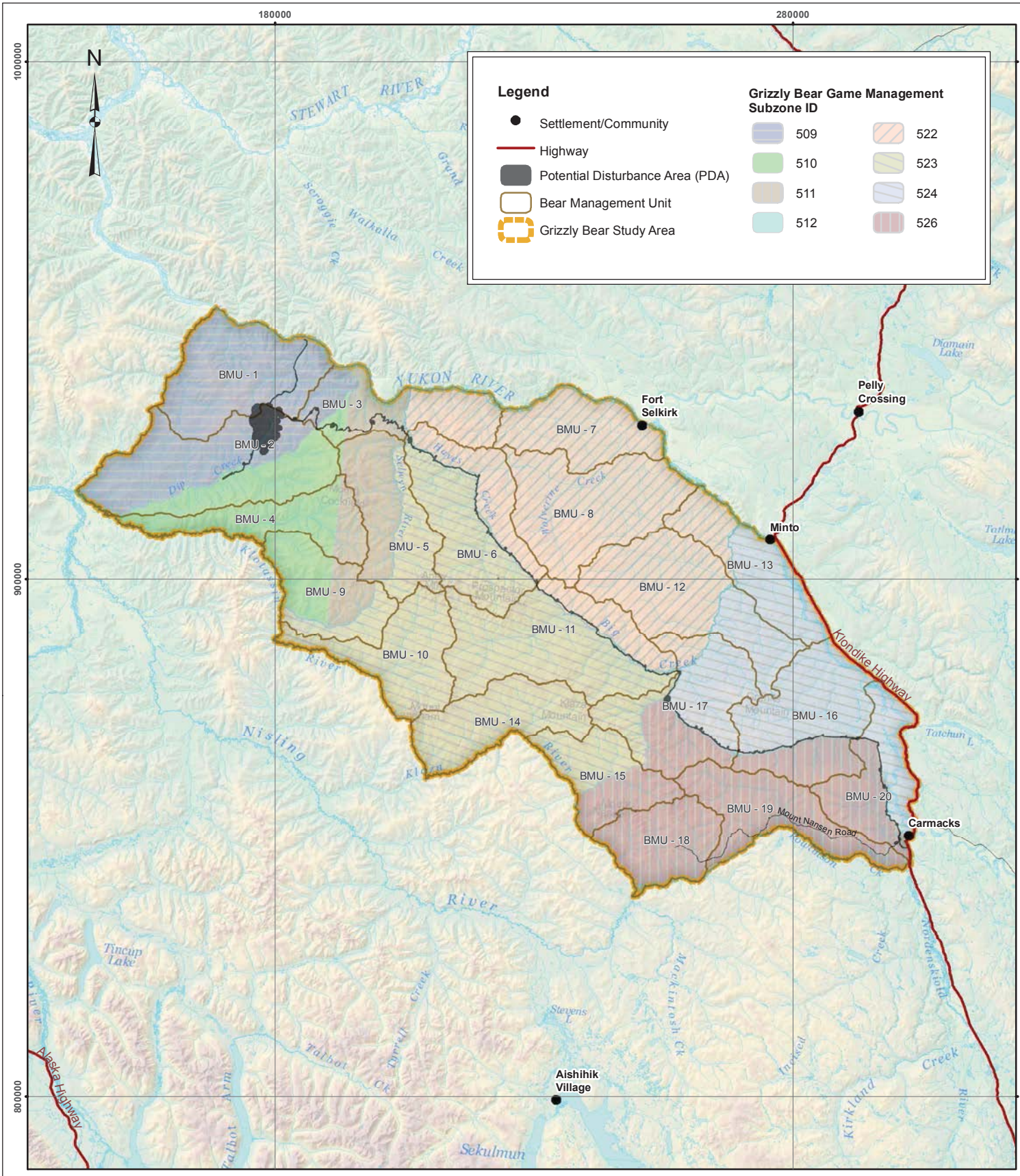
Results of the four models developed for the grizzly bear study area (habitat effectiveness, security areas, linkage zones and denning habitat) were developed to determine existing pressure on grizzly bears. Table 8.8 summarizes the results of the habitat effectiveness, security areas and linkage zone models.

During the summer period, all BMUs have a high percentage (i.e., >97%) of habitat available during the highest period of anticipated disturbance from activity within the study area. It is also important to note that the majority of the BMUs have a high percentage of secure areas and of linkage zones identified as having minimal danger. This indicates that there are currently extensive, safe travel corridors and secure feeding areas throughout the majority of the study area. Some disturbance currently exists, particularly in BMUs 1, 13, and 16 to 20. The majority of this disturbance is from existing access roads and mining, including exploration, operational and historic work.



Table 8.8 Grizzly bear BMU habitat effectiveness, secure areas and linkage zones summaries

BMUs		Habitat effectiveness (% of BMU)			Secure areas		Linkage zones (minimal danger)	
BMU #	Size (km²)	Spring	Summer	Fall	Area (km²)	% of BMU	Area (km²)	% of BMU
1	511	89%	100%	90%	478	93%	491	96%
2	698	92%	100%	92%	683	98%	688	99%
3	369	91%	100%	91%	369	100%	369	100%
4	322	82%	100%	83%	322	100%	322	100%
5	395	53%	100%	58%	395	100%	395	100%
6	577	75%	100%	78%	577	100%	577	100%
7	332	100%	100%	100%	327	99%	329	99%
8	579	92%	100%	92%	573	99%	576	99%
9	346	73%	100%	75%	346	100%	346	100%
10	370	58%	100%	62%	370	100%	370	100%
11	709	60%	99%	65%	695	98%	702	99%
12	585	94%	100%	94%	584	100%	585	100%
13	349	97%	97%	97%	296	85%	313	90%
14	377	51%	100%	58%	377	100%	377	100%
15	303	55%	100%	59%	303	100%	303	100%
16	532	93%	100%	93%	446	84%	482	91%
17	524	75%	99%	76%	476	91%	497	95%
18	302	64%	99%	67%	280	93%	289	96%
19	385	72%	100%	73%	311	81%	343	89%
20	356	92%	100%	92%	310	87%	330	93%
Total	8921.07				8517.43	95%	8714.58	98%



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Potential Disturbance Area (PDA) provided by Knight Piesold Ltd. Sept., 2013.

Digital Elevation Models (30 m and 90 m) provided by Yukon Government - Geomatics Yukon; online Corporate Spatial Warehouse. www.geomaticsyukon.ca



Grizzly bear management units

Drawn:	Checked:	Date:	Figure:
MP/LG	LP/MAS	12/12/2014	8.2

0 10 20 30 40 50
kilometres

Map scale 1:1,000,000 (printed at 8.5x11)
North American Datum 1983 CSRS Yukon Albers

CASINO
EDI

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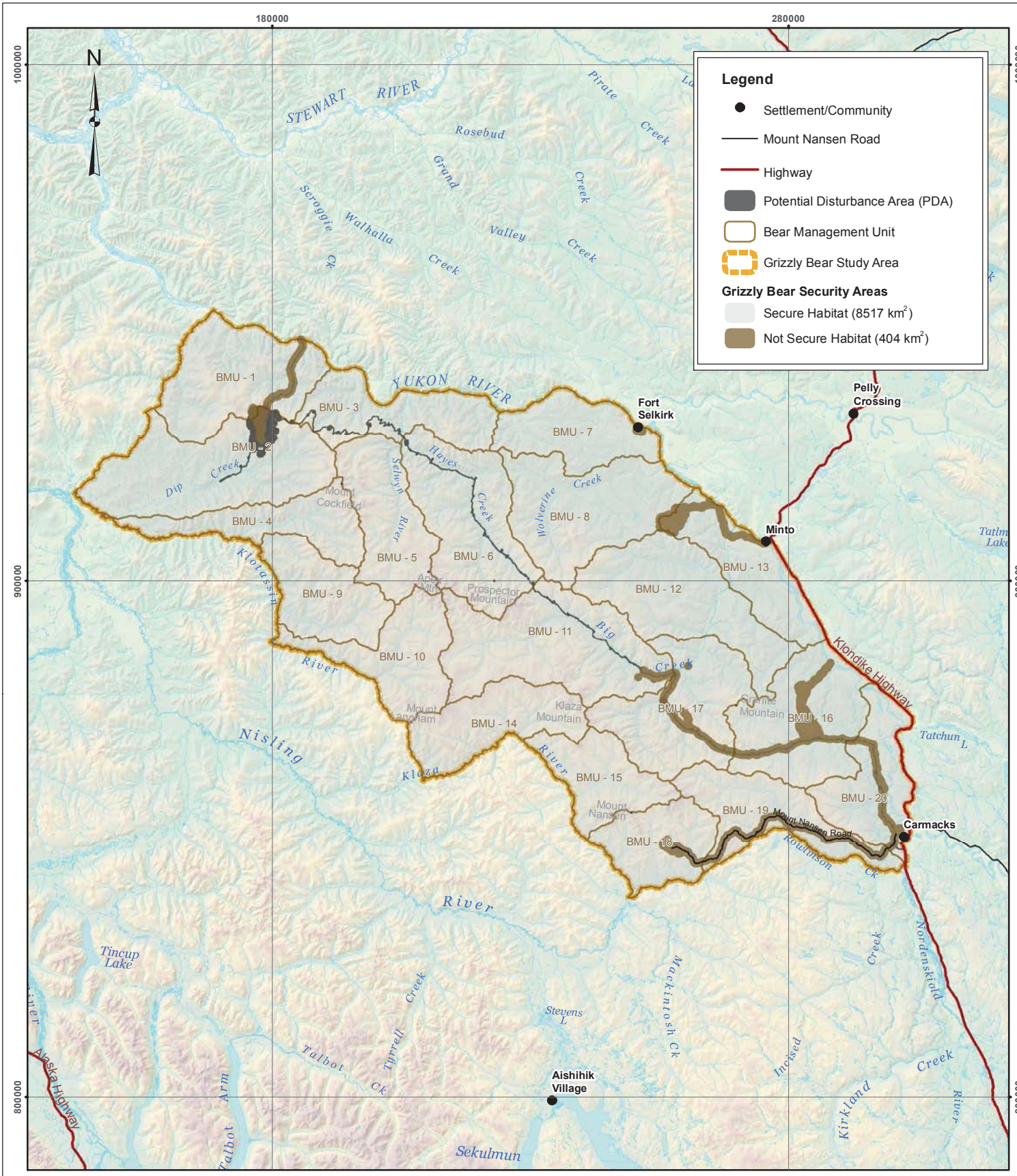

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Potential Disturbance Area (PDA) provided by Knight Piesold Ltd. Sept., 2013.

Grizzly Bear Security Areas created by EDI, 2013.

Digital Elevation Models (30 m and 90 m) provided by Yukon Government - Geomatics Yukon; online Corporate Spatial Warehouse. www.geomaticsyukon.ca



Grizzly bear security areas

Drawn:	Checked:	Date:	Figure:
MP/LG	LP/MAS	12/12/2014	8.3

0 10 20 30 40 50
kilometres

Map scale 1:1,000,000 (printed at 8.5x11)
North American Datum 1983 CSRS Yukon Albers

CASiNO
EDI

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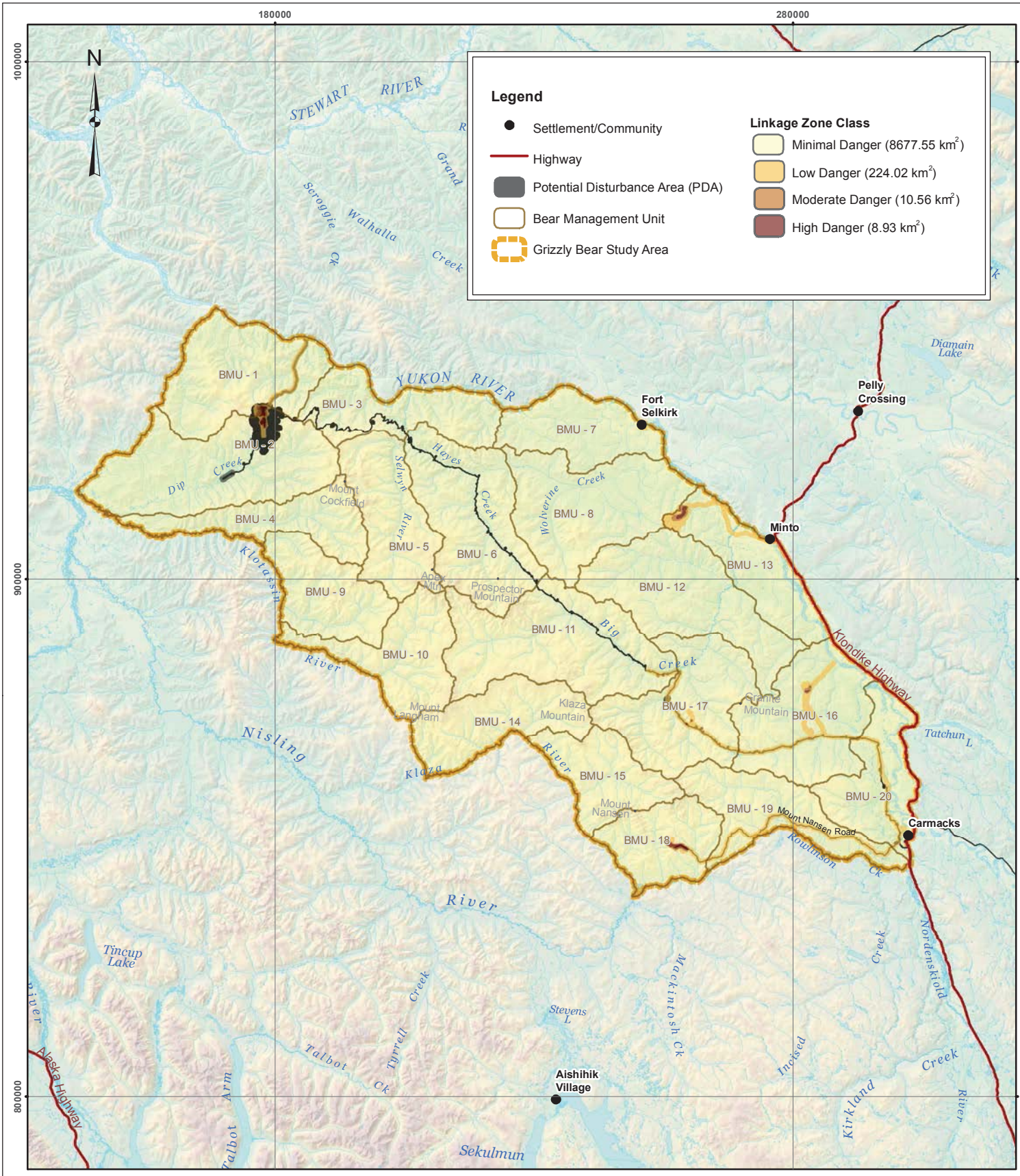

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Grizzly bear linkage zones created by EDI, 2013.

Potential Disturbance Area (PDA) provided by Knight Piesold Ltd. Sept., 2013.

Digital Elevation Models (30 m and 90 m) provided by Yukon Government - Geomatics Yukon; online Corporate Spatial Warehouse. www.geomaticsyukon.ca



Grizzly bear linkage zones

Drawn:	Checked:	Date:	Figure:
MP/LG	LP/MAS	12/12/2014	8.4

0 10 20 30 40 50
kilometres

Map scale 1:1,000,000 (printed at 8.5x11)
North American Datum 1983 CSRS Yukon Albers

CASINO
EDI

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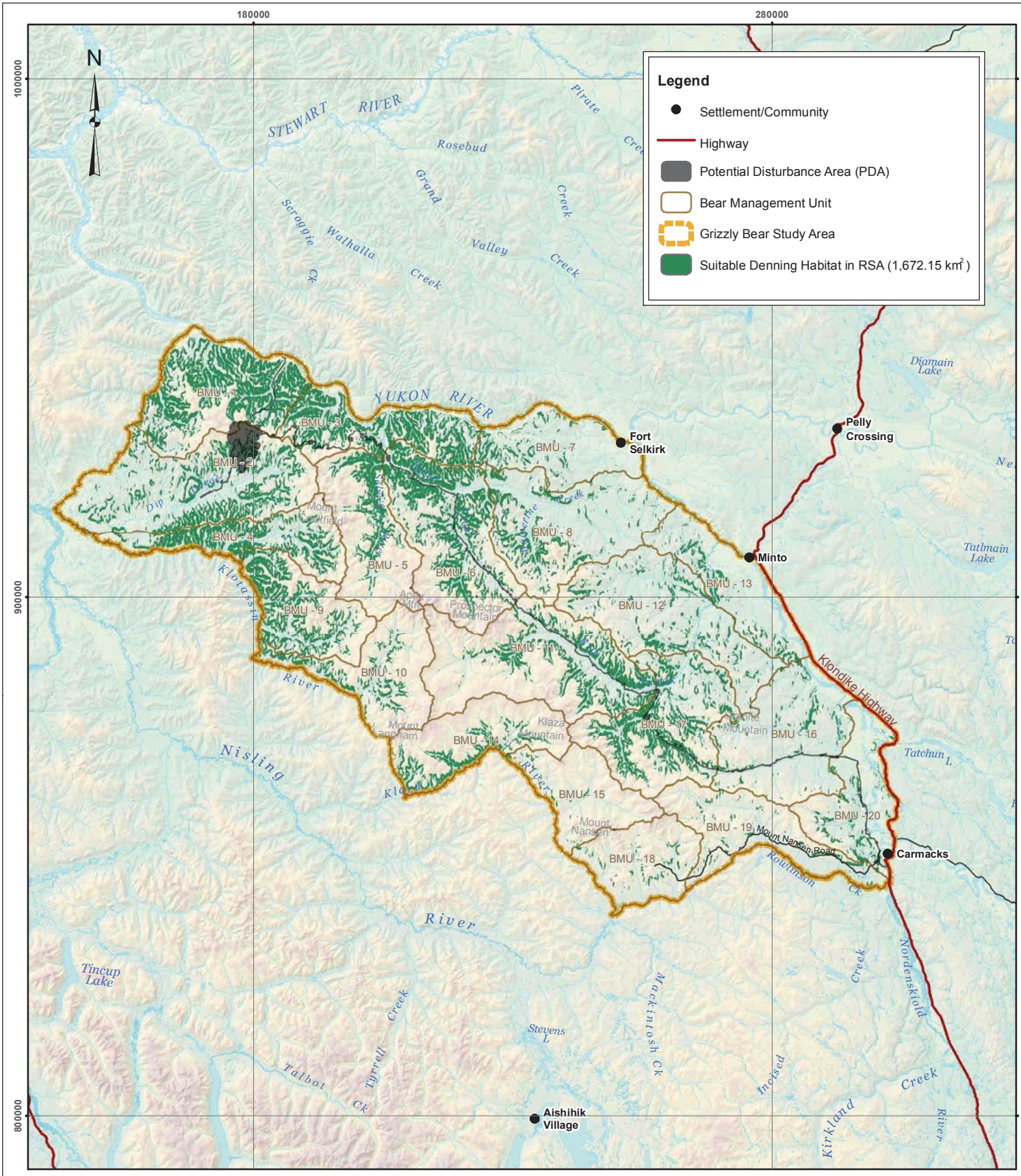

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PDA provided by Knight Piesold Ltd. 2013.

Bear den habitat suitability model produced by EDI, 2013.

Digital Elevation Models (30 m and 90 m) provided by Yukon Government - Geomatics Yukon; online Corporate Spatial Warehouse. www.geomaticsyukon.ca



Grizzly bear linkage zones

Drawn:	Checked:	Date:	Figure:
MP/LG	LP/MAS	12/12/2014	8.5

0 10 20 30 40 50
kilometres

Map scale 1:900,000 (printed at 8.5x11)
North American Datum 1983 CSRS Yukon Albers

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9 BLACK BEAR

Within the Yukon, the black bear is distributed from the southern border with B.C. to the Old Crow Flats; however, the highest densities are in the southern Yukon (Government of Yukon 2010d). Black bear was assessed by COSEWIC in 1998 and 1999 and was designated as Not at Risk (COSEWIC 2002). Within the Yukon, black bear is considered Secure (CESCC 2011), with an approximate population of 10,000 bears (Government of Yukon 2010d).

Black bears are omnivorous with plants (including berries) comprising up to 95% of their diet (MacHutchon 1989). Black bears typically den in mixed forest stands of aspen and spruce, or mature spruce stands, and excavate beneath the ground or under root masses (Tietje and Ruff 1980). Male bears generally emerge first from their dens, while females with cubs will emerge last and remain near the den for up to three weeks (Tietje and Ruff 1980).

Black bears are managed as a big game species in the Yukon, with all subzones open to spring and fall harvest and a bag limit of two bears per license year. Black bears are actively harvested in the subzones that interact with the Project, with subzones 509, 522, 524, and 526 reporting the greatest harvest (Table 9.1).

Between 2010 and 2013, a total of 13 black bears were observed in the RSA during the baseline programs. Of these, six black bears were observed during the den surveys, one was photographed by a remote wildlife camera and six were observed incidentally during other baseline surveys. A total of 66 black bear observations were recorded between August 2008 and August 2013 in the Casino Project wildlife log.

Table 9.1 Summary of the latest ten years (2002–2012) of black bear harvest data in GMSs associated with the Project.

GMS	Harvest regulations (2013–2014)	Total harvest		Mean yearly harvest	
		Resident	Non-resident	Resident	Non-resident
509	Open; Bag limit 2	2	0	0.2	0
510	Open; Bag limit 2	0	0	0	0
511	Open; Bag limit 2	1	0	0.1	0
522	Open; Bag limit 2	6	1	0.6	0.1
523	Open; Bag limit 2	0	0	0	0
524	Open; Bag limit 2	6	0	0.6	0
526	Open; Bag limit 2	3	0	0.3	0
TOTAL		**18**	**1**	**1.8**	**0.1**

Note: Government of Yukon, unpublished data

10 WOLF

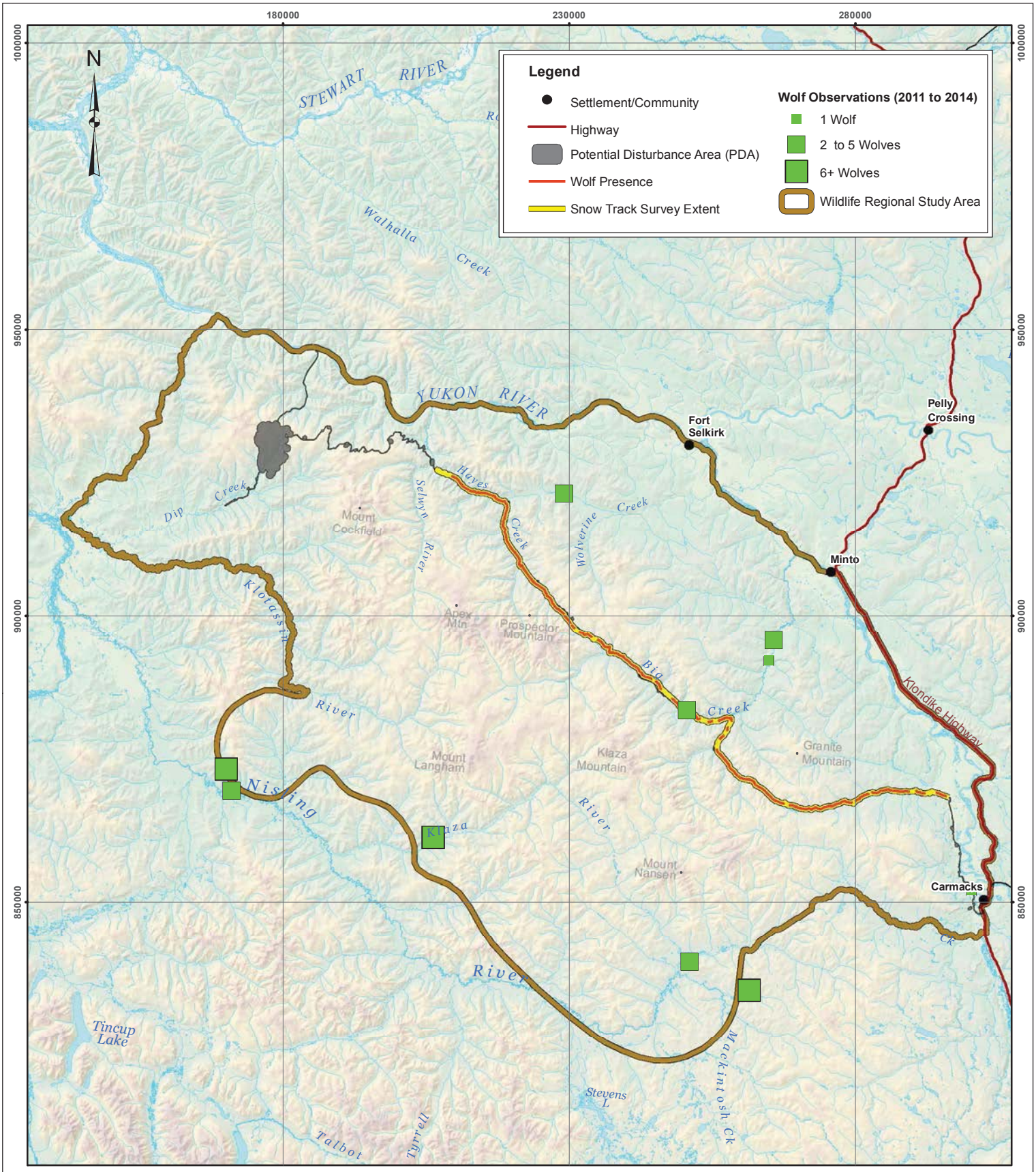
Wolf was once one of the most globally distributed species; however their range is has been considerably reduced (Mech and Boitani 2010). Currently, it is estimated that there are 4,500 to 5,000 grey wolves in Yukon, distributed throughout the territory (Yukon Wolf Conservation and Management Plan Review Committee 2011). Wolf numbers and distribution are largely dependent on the abundance of their primary prey species in the region — moose and caribou. In winter, wolves group together in packs to improve hunting success, and ultimately, winter survival. In summer, wolves are often solitary on the landscape.

A wolf population inventory was conducted in the Nisling River area (just south of the Casino study area) in 1986. The inventory study area included the upper reaches of the Klaza River and was bounded by Klaza Mountain and Rowlinson Creek to the north. Four wolf packs, with an estimated density of 3.2 wolves/1,000 km^2 were found. This was a comparatively low density of wolves, likely resulting from low ungulate densities or unreported harvest (Baer and Hayes 1987).

Currently, wolves are managed as both a big games species and a trapped furbearer in the Yukon, with an average of 60 wolves hunted and 155 wolves trapped each year in the territory (Yukon Wolf Conservation and Management Plan Review Committee 2011). According to trapline data from 1980–2010 (described in Section 11), a total of 38 wolves have been harvested on the ten registered trapline concessions (RTC) that interact with the Project (Government of Yukon data). Hunting for wolves in the Yukon (all subzones) is open, with a bag limit of seven for residents and two for non-residents. There are no records of wolves being hunted in the GMSs that interact with the Project.

During the 2011 late winter ungulate survey, 24 wolves were observed in six groups throughout the survey area. In 2012, 32 wolves were observed in three groups throughout the survey area, and no wolves were observed in the reduced 2013 survey area (Figure 10.1). One pack of 13 wolves was observed on a kill near the Klaza River, and another large pack of 16 was observed in the south end of the survey area traveling along a snowmobile track. Wolves were often observed near higher density moose areas and their tracks were noted in valleys or along creeks and rivers. The pack sizes observed are notably larger than mean pack sizes recorded in neighbouring regions (e.g., <4–5.6 wolves/pack in the Aishihik area and 6.1 wolves in the Mayo area; Hayes et al. 2003). This result could be a function of the higher visibility of larger packs; however, it is difficult to interpret these results as the surveys were not targeting wolves and sample sizes were small.

Snow tracking surveys (described in Section 11) detected wolves along the entire length of the surveyed section of the Freegold Road and Casino Road extension (Figure 10.1). It appeared wolves were using the road/trail to travel along, as most tracks followed the road/trail as opposed to crossing it. The Casino camp's wildlife log also recorded 22 wolves in the Project area from 2008 to 2013.



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Potential Disturbance Area (PDA) provided by Knight Piesold Ltd., Sept., 2013.

Wolf observations collected by EDI and YG, 2011 to 2013.

2012 – 2013 snow tracking surveys (EDI), 2011 – 2013 aerial surveys (EDI/YG).

Wildlife Key Areas, Digital Elevation Models (30 m and 90 m) provided by Yukon Government - Geomatics Yukon; online Corporate Spatial Warehouse. www.geomaticsyukon.ca



Incidental wolf observations

Drawn:	Checked:	Date:	Figure:
MP/LG	MAS	12/12/2014	10.1

0 5 10 15 20 25 30
kilometres

Map scale 1:900,000 (printed at 8.5x11)
North American Datum 1983 CSRS Yukon Albers

CASINO

EDI

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11 FURBEARERS

Furbearing species present in the RSA include wolf, wolverine, lynx, marten, coyote, and red fox. Other mammals considered furbearers and which are likely present in the RSA, but are not described further include red squirrel, mink, muskrat, otter, weasel, and beaver. It is unlikely that fisher or Arctic fox occur in the Project RSA.

The Government of Yukon maintains records of mammals harvested from registered traplines. Ten registered trapline concessions (RTCs) intersect with the Project RSA, including RTCs 116, 121, 122, 131, 145, 146, 148, 149, and 150 (Figure 11.1). Harvest statistics for individual RTCs are considered private, thus trapline data provided by the Government of Yukon represents a partial view of total furbearer harvest in the RSA (Table 11.1).

Furbearer data in the Project area are primarily limited to harvest and/or trapline data, with some incidental sightings recorded during baseline or other regional studies. This was identified as an information gap, and late winter snow tracking surveys were conducted to address it.

Snow tracking surveys were designed to examine the distribution of small mammals and/or furbearers; however, caribou and moose tracks were recorded whenever observed. The proposed Freegold Road upgrade and extension was used as the primary transect for the survey, which was conducted by snowmobile. Tracking surveys were conducted in February and March 2012 and in February 2013. These track surveys covered between km 101 and 133 along the proposed Freegold Road upgrade and extension (Figure 10.1). The road was surveyed in 1 km segments and a tally of the number and type of tracks (i.e., wolverine, marten, hare, etc.) entering or crossing the trail (including suspected re-crossings) was recorded (Thompson et al. 1989). Tracks for small mammals (snowshoe hare, marten, porcupine, and red fox), were counted only when the tracks were fresh (i.e., 1 day since last snowfall), whereas tracks of larger furbearers (wolverine and lynx) were recorded regardless of age. Presence/absence data was recorded for caribou, moose, and wolf.

The entire length of the proposed Casino Road extension was not surveyed each time as it became inaccessible due to open water conditions, overflow, and other terrain constraints. Track observations included those of moose, caribou, wolf, wolverine, lynx, porcupine, otter, marten, snowshoe hare, weasel, and red squirrel.

Table 11.1 Sum of furbearers harvested from 1980 to 2010 on registered trapline concessions 116, 121, 122, 131, and 145–150.

Animal	Total harvest	Mean annual harvest rate
Beaver	334	15.9
Coyote	30	1.4
Red fox	217	10.3
Arctic fox	1	<0.1
Lynx	801	38.1
Squirrel	15,981	761.0
Marten	1,538	73.2
Mink	99	4.7
Muskrat	67	3.2
Otter	5	0.2
Weasel	378	18.0
Wolf	38	1.8
Wolverine	133	6.3

11.1 WOLVERINE

Wolverines are solitary carnivores that have a circumpolar distribution from Russia and Scandinavia to Alaska, throughout Canada, and south to California (Abramov et al. 2009). Within Canada, wolverines generally follow the extent of the boreal forest, with lower relative densities in the eastern provinces (COSEWIC 2003). Wolverines occur throughout the Yukon, typically in large areas of intact wilderness including forests, alpine and subalpine areas, and the Arctic tundra.

Wolverine was designated as Special Concern in 1982, and was reassessed in 2014 and re-designated as Special Concern (COSEWIC 2014). The COSEWIC designation largely reflects concerns regarding a lack of information, a history of extirpation from regions of Canada, and a decline is abundance in the southern Canada, though populations seem to be growing or recovering in Northwest Territories, Nunavut, Manitoba and Ontario (COSEWIC 2014). Yukon's wolverine trends are unknown because of limited population inventories and monitoring. The primary threat to wolverine is harvest, but habitat disturbance from forestry, hydroelectric developments, oil and gas and mineral exploration and development, and transportation corridors contribute to permanent, temporary or functional habitat loss that may reduce long-term viability of populations.

Canada's population is estimated at more than 10,000 mature individuals (COSEWIC 2014), with an estimated 3,500–4,500 occurring within the Yukon (Slough 2007). The Yukon's wolverine population is monitored using fur harvest data, winter track counts, and an annual trapper questionnaire, resulting in

population estimates of 5.65/1,000 km² (in variable, unsaturated habitat) and 10.75/1,000 km² (in continuous, saturated habitat; Banci and Harestad 2006).

Primarily a scavenger, wolverine habitat use is less defined by geographic or vegetative features, than the presence and availability of ungulates and/or carrion, such as within undisturbed mountainous areas. Denning habitat is relatively specific, requiring security and thermal cover under boulders, felled trees, or snow tunnels (COSEWIC 2003).

Only one wolverine was observed during baseline studies; it was observed on a kill in the southern section of the study area during the 2012 aerial ungulate survey. Snow tracking surveys detected wolverines sporadically along the proposed Freegold Road extension and upgrade (Figure 11.2). Similar to wolves, wolverine tracks were most often observed following the road/trail as opposed to crossing it. One wolverine was also recorded by Casino staff in their wildlife log (July 2009). Although not one of the most commonly trapped species in the region (Table 11.1), wolverine pelts are the most highly valued of Yukon furbearer species (Government of Yukon, unpublished data).

11.2 LYNX

Lynx are present in forested regions across Canada, some parts of the northern United States, and Alaska (Hatler et al. 2008). In the Yukon, lynx are distributed throughout the territory, but, being primarily a forest species, they are not present on the Arctic coastal plain.

Numbers have declined in parts of its southern range, especially in New Brunswick and Nova Scotia; however, the overall Canadian population is considered Not at Risk by COSEWIC (Poole 2001). Lynx population density typically follows 8 to 11 year cycles; demonstrating a 1 to 2 year lag following the cyclical abundance of its primary prey — snowshoe hare. Dens are typically constructed under deadfall or blow-down debris, mature or shrub subalpine fir, or willow thickets (Slough 1999).

During snow tracking surveys in 2012 and 2013, lynx tracks were recorded along most of the surveyed area (Figure 11.1). Hare tracks from snow-tracking surveys show that lynx were almost exclusively present where snowshoe hare were present (Figure 11.3). Lynx are also one of the most commonly trapped furbearers in the region (Table 11.1).

11.3 AMERICAN MARTEN

American marten are distributed across Canada and some of the northern United States (Reid and Helgen 2008); however, the subspecies that inhabits Yukon, Northwest Territories, and Alaska is much larger than those found in more southern regions (Government of Yukon 2010e). Marten has not been assessed by COSEWIC or listed under SARA, with the exception of the Newfoundland subspecies *Martes americana atrata,* which was listed as Threatened in 2007 (COSEWIC 2007).

Marten are typically found in mature coniferous forests, which provide adequate cover, but they are also found moving through other, more open habitats such as alpine areas or burns (Slough 1989). Their diet

consists primarily of microtine species (e.g., voles), but hunt and forage opportunistically, often feeding on berries (e.g., crowberry), birds, and snowshoe hare (Slough et al. 1989; Poole and Graf 1996). Denning habitat is usually an enclosed feature such as a hollow downed tree, tree cavity, burrow, rock pile, or slash/brush pile (Hatler et al. 2008).

Marten are a highly valued furbearer in the Yukon and were the second most commonly trapped furbearer in the Project region (Table 11.1). Marten tracks were consistently observed in multiple habitat types along the Freegold Road and extension during snow tracking surveys in 2012 and 2013 (Figure 11.4).

11.4 COYOTE

Coyotes are continentally distributed across North America, occurring as far south as Central America (Hatler et al. 1998). Coyotes are present in many habitat types including urban settings, and are primarily limited in areas with deep snow and high densities of grey wolves (Hatler et al. 2008). Coyotes have not been assessed by COSEWIC or listed under SARA.

Coyotes are ubiquitous throughout the landscape, with a preference for open spaces (Hatler et al. 2008). Their diet consists of a variety of small mammals such as voles and hare, but they are also known to eat ungulate calves, birds, plant material, livestock, and garbage (Hatler et al. 2008). Dens are often dug into the sides of hills or banks, or under other covering structures such as caves, tree root hollows, or downed trees (Hatler et al. 2008).

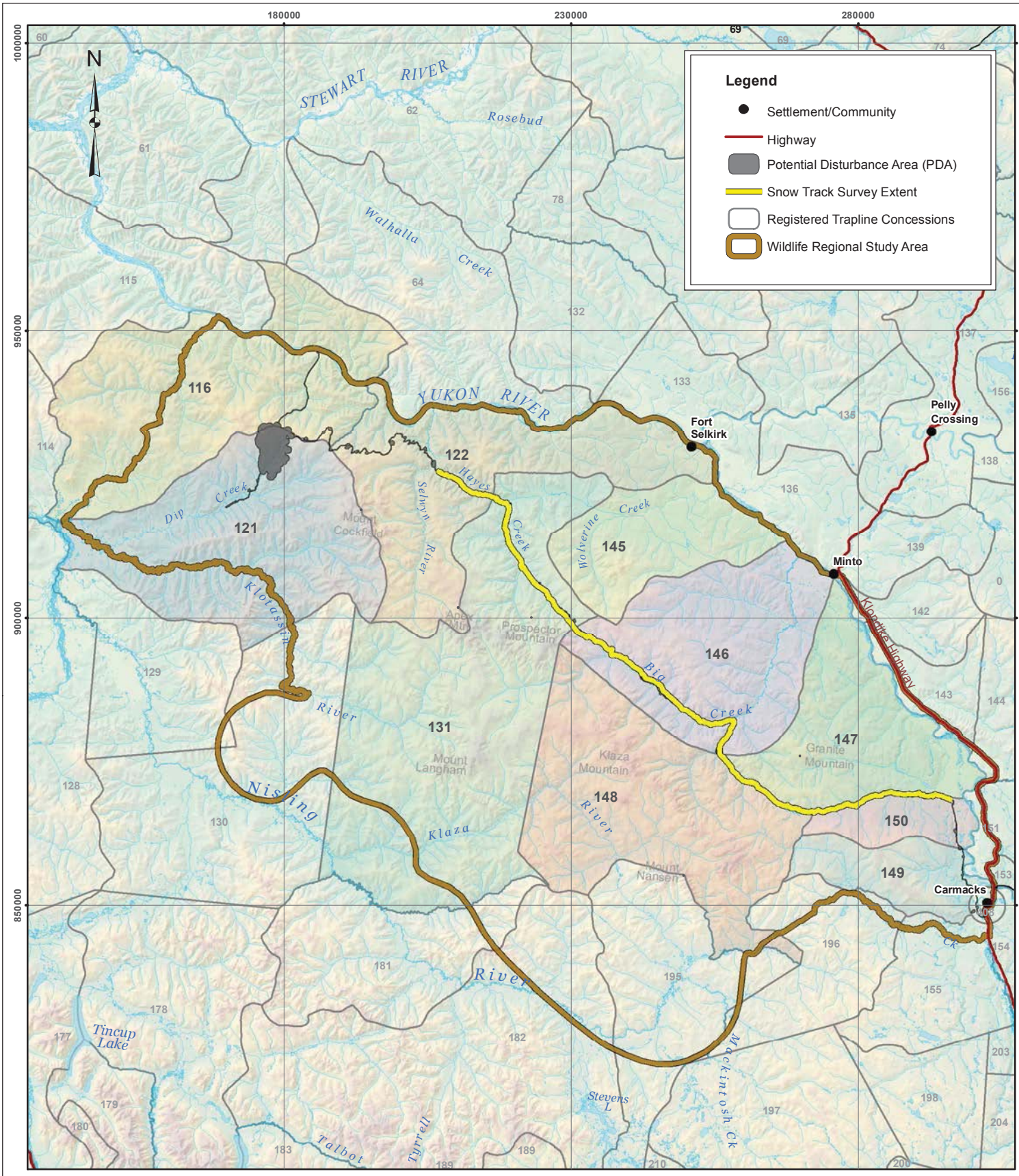
Coyote tracks were not observed along the Freegold Road extension during snow track surveys; however, based on their broad distribution and existing trapping records from RTCs in the area (Table 11.1) they are expected to occur at low densities in the area.

11.5 RED FOX

From Europe and Asia to North America, red fox is the most widely distributed global carnivore (Hatler et al. 2008). Red fox occurs throughout the Yukon, extending far north into the Arctic tundra. Red fox have not been assessed by COSEWIC.

Foxes feed upon many small mammals including voles, mice, ground squirrels, muskrats, and snowshoe hare. They also feed on birds, eggs, and some vegetation. Denning habitat is similar to that of coyotes; burrowing into the side of hills, under downed wood, caves, root hollows, or other animals' burrows (Hatler et al. 2008).

Red fox tracks were not observed along the Freegold Road extension during snow track surveys; however, based on their broad distribution and existing trapping records from RTCs in the area (Table 11.1) it is expected that they occur in the area.



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Potential Disturbance Area (PDA) provided by Knight Piesold Ltd., Sept., 2013.

2012 – 2013 snow tracking surveys (EDI), 2011 – 2013 aerial surveys (EDI/YG).

Wildlife Key Areas, Trapping Concessions, Digital Elevation Models (30 m and 90 m) provided by Yukon Government - Geomatics Yukon; online Corporate Spatial Warehouse. www.geomaticsyukon.ca



Registered trapline concessions and snow track survey extent

Drawn:	Checked:	Date:	Figure:
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0 5 10 15 20 25
kilometres

Map scale 1:900,000 (printed at 8.5x11)
North American Datum 1983 CSRS Yukon Albers

CASiNO
EDI

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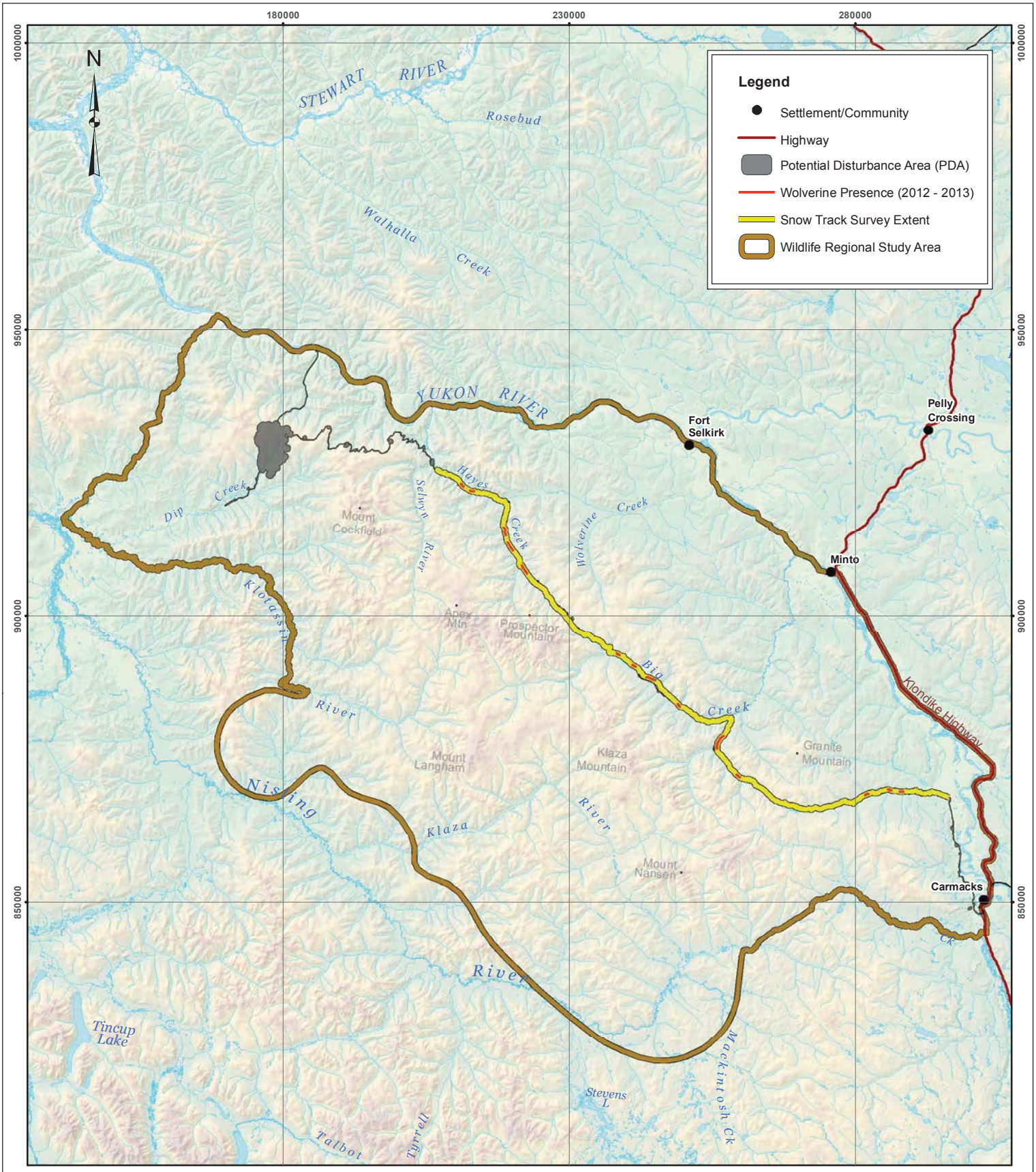

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Potential Disturbance Area (PDA) provided by Knight Piesold Ltd., Sept., 2013.

2012 – 2013 snow tracking surveys (EDI).

Wildlife Key Areas, Digital Elevation Models (30 m and 90 m) provided by Yukon Government - Geomatics Yukon; online Corporate Spatial Warehouse. www.geomaticsyukon.ca



Wolverine detections during the snow tracking surveys

Drawn:	Checked:	Date:	Figure:
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0 5 10 15 20 25
kilometres

Map scale 1:800,000 (printed at 8.5x11)
North American Datum 1983 CSRS Yukon Albers

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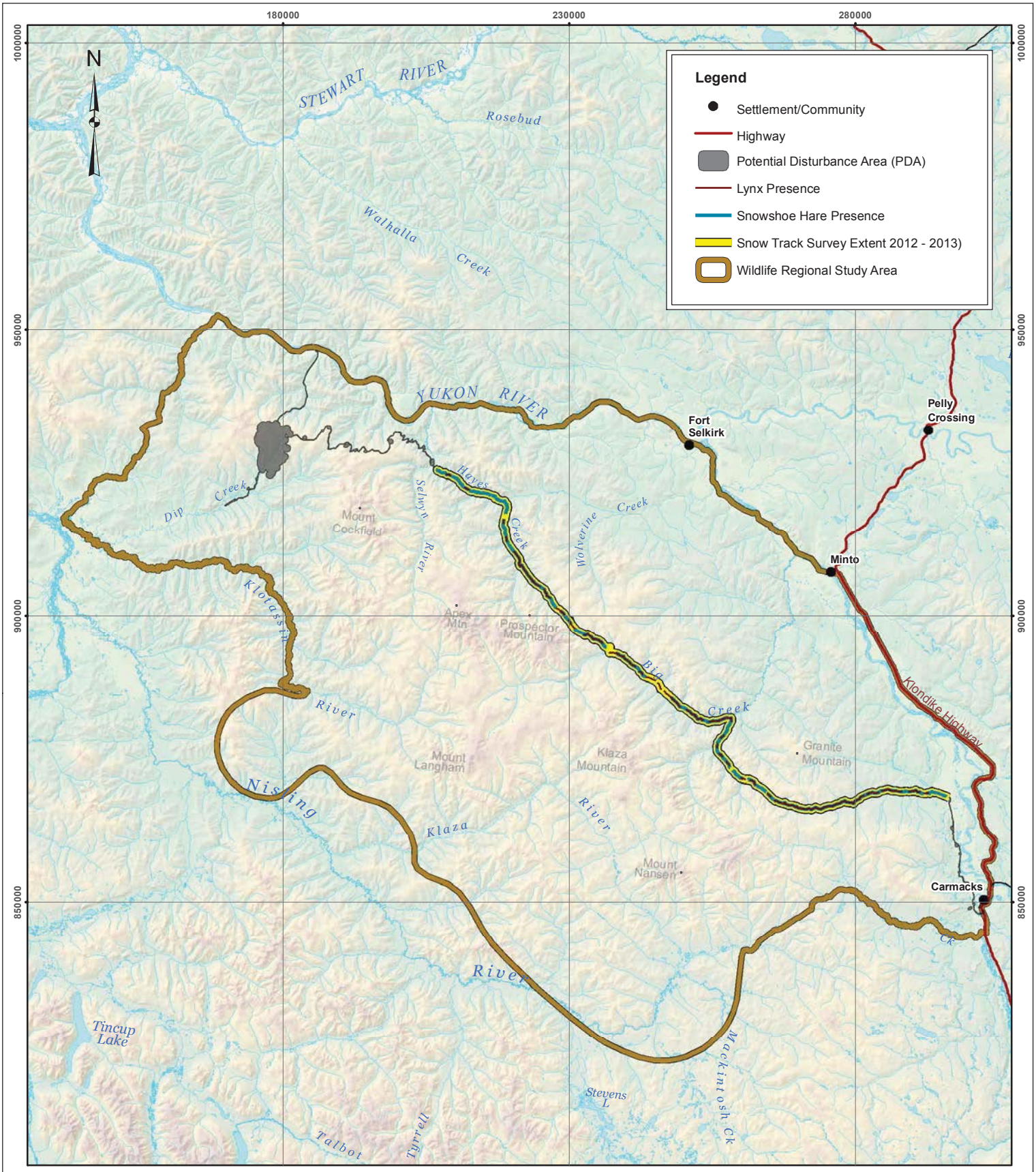

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Potential Disturbance Area (PDA) provided by Knight Piesold Ltd., Sept., 2013.

2012 – 2013 snow tracking surveys (EDI).

Wildlife Key Areas, Digital Elevation Models (30 m and 90 m) provided by Yukon Government - Geomatics Yukon; online Corporate Spatial Warehouse. www.geomaticsyukon.ca



Lynx and snowshoe hare detections during the snow tracking surveys

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MP/LG	MAS	12/12/2014	11.3

0 5 10 15 20 25 30
kilometres

Map scale 1:900,000 (printed at 8.5x11)
North American Datum 1983 CSRS Yukon Albers

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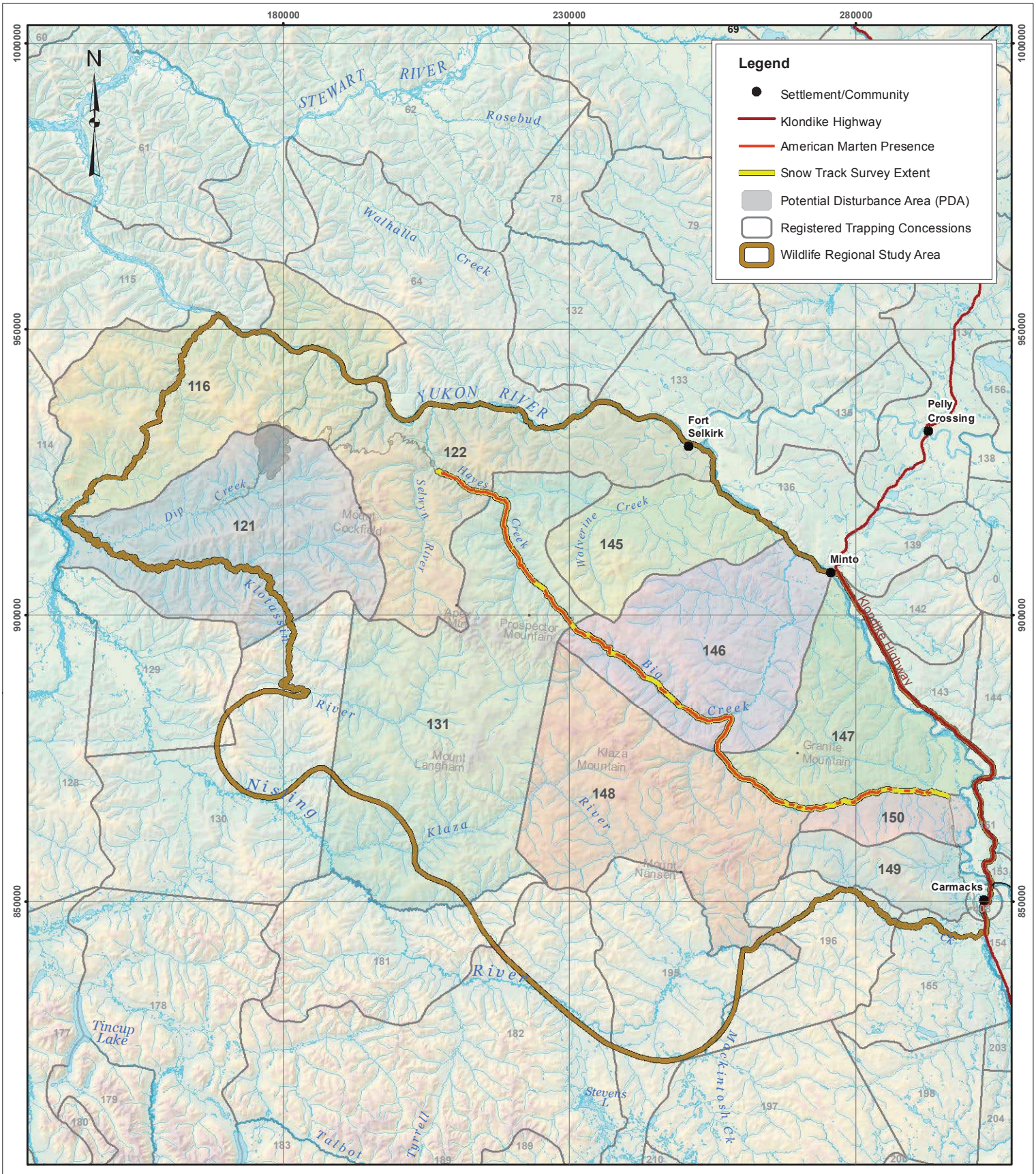

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Potential Disturbance Area (PDA) provided by Knight Piesold Ltd. 2013.

2012 – 2013 snow tracking surveys (EDI).

Wildlife Key Areas, Digital Elevation Models (30 m and 90 m) provided by Yukon Government - Geomatics Yukon; online Corporate Spatial Warehouse. www.geomaticsyukon.ca



American marten detections during the snow tracking surveys

Drawn:	Checked:	Date:	Figure:
MP/LG	MAS	10/12/2014	11.4

0 5 10 15 20 25 30
kilometres

Map scale 1:900,000 (printed at 8.5x11)
North American Datum 1983 CSRS Yukon Albers

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12 COLLARED PIKA

Within Canada, the collared pika is limited to alpine areas in BC, NT, and Yukon. In 2011, COSEWIC designated collared pika as a species of 'Special Concern' (COSEWIC 2011b). The main threat for the species is believed to be habitat alteration due to climate change (COSEWIC 2011b). Studies of pika in the Yukon have found recent population declines which have been attributed to climatic variability such as lower winter snow depths (less insulation), freeze-thaw events, freezing rain, and late winter snowfall (Morrison and Hik 2007, 2008).

The collared pika is primarily found on talus alpine slopes, interspersed with meadows or forest patches (Morrison and Hik 2008). Pikas spend the summer months collecting forbs and grasses to store them in a haypile cache for winter (Smith and Johnston 2008). Pikas typically live in small sub-populations in a single alpine or sub-alpine valley (Morrison and Hik 2007).

12.1 PIKA SURVEYS

A preliminary survey for pikas was conducted in the summer of 2013 at four locations near the proposed mine site to document the presence of pikas within the study area. Two biologists searched for pikas using binoculars and listening for calls during one hour at each location. No pika activity was detected during these surveys; however, 11 pikas were incidentally observed during bird and vegetation baseline work near the proposed mine site. Pikas were observed primarily in alpine habitats where they were located in small boulder fields (felsenmeer) on moderately steep slopes, adjacent to areas of herbaceous alpine vegetation (Photo 3; Figure 12.1).

A subsequent collared pika occupancy survey was conducted during the summer of 2014. The collared pika occupancy surveys were conducted during two day field trips in July and August 2014. Collared pikas are easily detected in late summer, particularly in August when they are actively hoarding their winter food in haypiles. The objective of this survey was to determine collared pika occupancy and distribution within the Casino Mine Site footprint. In order to be consistent with other programs in the Yukon, the methods used for the Casino pika occupancy surveys were based on the 2011 Tombstone Territorial Park Collared Pika Monitoring Protocol. Survey sites were pre-selected based on habitat suitability mapping and the resulting collared pika habitat polygons (see Section 12.2). Survey sites were accessed via ATV or helicopter, and then on foot. As per the monitoring protocol, all sites were surveyed at least twice. This was accomplished by two observers independently surveying patches during site visits.

The collared pika habitat polygons closest to the Casino Mine Site footprint were targeted. Once the pika habitat polygon was reached, the observers established a site and slowly walked the area to look and listen for pika. At each site, the observers also chose a vantage point to observe collared pika habitat for a minimum of 10 minutes. Each survey site was assessed for pika presence, including: haypiles, pika sightings, and pika calls. One to four sites were established in each polygon depending on the habitat patch size. The date, time, coordinates, photograph numbers, a unique site number, and surveyor names were also recorded.

Twelve polygons and 27 sites were surveyed during the two field visits. Nine sites were visited in July; some sightings and calls were observed, but there were no signs of haypiles. In August, 27 sites were visited, including revisits to the 9 sites surveyed in July. Sighting, calls and haypiles were all recorded.

Pika presence was detected in 20 of the surveyed sites (Figure 12.1). Of the 12 polygons surveyed, 6 contained collared pika. Of the 20 survey sites where collared pikas were recorded, three sites had only one of the two surveyors finding sign of collared pika. Individual collared pika numbers are difficult to determine since many of the observations were based on calls.

12.2 COLLARED PIKA HABITAT SUITABILITY MODEL

In consideration of the naturally fragmented and geographically limited area of pika habitat, a simplified habitat suitability model was developed for the LSA. Habitat suitability values were assigned to habitat variables based on a review of literature (Nagorsen 2005; Morrison and Hik 2007; COSEWIC 2011). Based on the accessed information, two variables were initially selected to qualify pika habitat: bioclimate zone (e.g., alpine) and proximity to boulder fields (i.e., felsenmeer); however, the bioclimate zone data had to be excluded as its resolution (90 m) was not suitable for the scale of the model. Consequently, only the proximity to felsenmeer land cover class (boulder fields) was used.

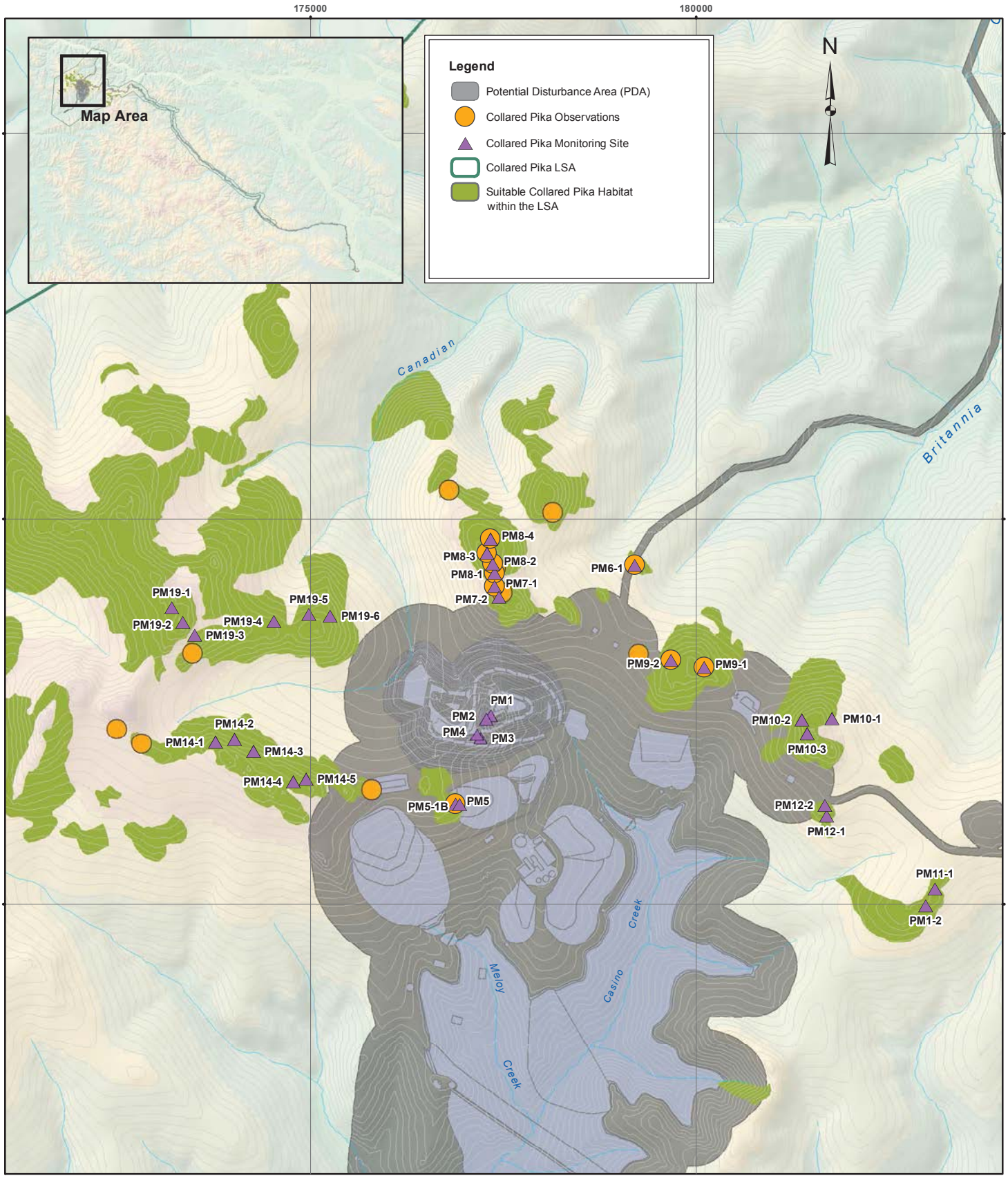
A Boolean approach was used to model suitable and unsuitable pika habitat. Suitable habitat were define as the felsenmeer land cover class buffered by 10 m, while unsuitable habitat was all areas beyond 10 m of the felsenmeer land cover class. The model indicates that the LSA may contain approximately 31 km² of suitable pika habitat, which is about 3.5% of the LSA (Table 12.1). All but one pika observations where within suitable habitats, though not all suitable habitat was occupied by pikas (Figure 12.1).

Table 12.1 Availability of suitable and unsuitable pika habitat within the LSA.

Habitat	Baseline area (km²)	% of total available
Suitable	31	3.5
Unsuitable	855	96.5



Photo 3. **Typical habitat where pika were located near the Casino Mine Site.**



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Potential Disturbance Area (PDA) provided by Knight Piesold Ltd. 2013.

Collared pika observations collected by EDI (2012-2013) and AECOM (2010). Habitat suitability model produced by EDI, 2013.

Digital Elevation Models (30 m and 90 m) provided by Yukon Government - Geomatics Yukon; online Corporate Spatial Warehouse. www.geomaticsyukon.ca



Collared pika observations and suitable habitat near the proposed Casino Mine Site

Drawn:	Checked:	Date:	Figure:
MP/LG	MAS	12/12/2014	12.1

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metres

Map scale 1:70,000 (printed at 8.5x11)
North American Datum 1983 CSRS Yukon Albers

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13 LITTLE BROWN BAT

Little brown bat (*Myotis lucifugus*), or little brown myotis, ranges through much of subarctic North America (Arroyo-Cabrales and Álvarez-Castañeda 2008). The Yukon population of little brown bat is thought to migrate to the coast, spending the winter in Alaska, and summers (April to September) in the Yukon (Government of Yukon 2014). The exact size of the Yukon population is still unknown (Government of Yukon 2014).

The little brown bat is a nocturnal insectivore, mostly foraging for flying insects over open water or along the edges of lakes and streams (Alaska Natural Heritage Program 2014). The short summer nights in the Yukon limit feeding time to only 1–2 hours each night (Government of Yukon 2014). Summer roost sites are usually dead tree hollows or buildings (Randall 2011).

The little brown bat and northern myotis (*Myotis septentrionalis*) have recently experienced drastic declines in its population (COSEWIC 2013). The little brown bat designation was changed to 'endangered' by COSEWIC in 2013 after an emergency assessment. The assessment and the species' designation are the result of a white-nose syndrome epizootic originating in eastern North America. The syndrome is a highly contagious fungal disease. Transmission occurs in hibernacula. It has spread quickly since being detected in North America and is expected to reach western North America in the next two decades. White-nose syndrome has devastating effects on exposed population of bats; more than 99% of some little brown bat populations in the northeastern United States have been lost solely because of the syndrome (COSEWIC 2013).

Surveys to assess the presence of the little brown bat at the proposed mine site were conducted during July 2014. Two EDI biologists surveyed potential roosting habitat at the proposed Casino mine site for signs of bat use. Since most of the area is above treeline, the only potential habitat identified was the camp buildings. Each building was visually assessed for bat presence. No signs of bats were found in the camp buildings.

A bat detector was also set up to monitor and record any ultrasonic echolocation calls of bats. The bat detector was an Anabat SD1 system, made by Titley Scientific, and is based on frequency division (Corben 2004). The detectors were attached to a cable microphone with the microphone set in a protective PVC tube sleeve. The microphones were angled down over a reflective plexi-glass plate, mounted at 45° to horizontal, resulting in the microphone sampling an area parallel to the ground. The Anabat detector was installed on the top of a silo approximately 10 m above the ground. This site was chosen since it is slightly lower in elevation then the camp, and closer to treeline and wetter habitat. It was also the only free standing infrastructure suitable for unobstructed bat monitoring. The anabat detector recorded ultrasonic acoustic detections for a total of six days. No bat calls where recorded in this time.

Two other species are known to occur in the Yukon but their current range does not overlap with the Project. Northern myotis, also known as northern bat, has been observed in the southeast Yukon (Government of Yukon 2014).

14 AMPHIBIANS

Only four species of amphibians are known to occur in the Yukon: wood frog (*Lithobates sylvaticus*), western toad (*Anaxyrus boreas*), Columbia spotted frog (*Rana luteiventris*), and boreal chorus frog (*Pseudacris maculate*). The only species expected to occur in the RSA is the wood frog. The range of the latter three species extends north only into the southeast corner of the Yukon (Government of Yukon 2013e).

The wood frog is the most widespread amphibian species that occurs in the Yukon, with its range extending from the BC border north to Old Crow Flats. The wood frog occupies a variety of habitats, including habitats located away from water. Breeding occurs in clear shallow ponds from late April through June (Government of Yukon 2013e). The wood frog is assumed to occur throughout the RSA in the appropriate habitats. Although wood frog habitat is limited in the Project area, suitable habitat does occur.

No amphibian surveys were conducted as part of the Casino baseline surveys. However, both tadpoles and adult frogs were observed along the Freegold Road near Big Creek, during the rare plants survey conducted in 2012.

15 MINERAL LICKS

Mineral licks used by moose are typically located in moist, muddy areas and are often identified by the presence of a worn trail or concentrated tracks in an area (Rea et al. 2004). Mineral licks not only provide mineral nutrients and water to moose, but also aid in digestion (by consuming soil) and are known as social gathering areas (Rea et al. 2004). During baseline studies, two mineral licks were identified — one near Dip Creek in the northern part of the RSA (west of the mine site) and one near Hayes Creek. Remote motion sensing cameras were placed at each site as a preliminary monitoring effort to quantify and qualify wildlife use of these licks. The cameras were placed at the licks 20 June 2013 and collected 25 August 2013.

The cameras documented the occurrence of moose, wolves, red fox, grizzly bears, black bear, and lynx. The majority of observations at both licks were of moose, including lone cows and bulls, as well as cow/calf groups. The camera at the Hayes Creek mineral lick was only active for eleven days because the camera was set to an aggressive setting and the digital camera memory card was filled entirely by one moose revisiting the site (Photo 4). The Dip Creek mineral lick recorded observations of moose, wolves (Photo 5), red fox, grizzly bears, one black bear, and one lynx. The camera was active for 66 days, and recorded 111 separate visits by wildlife. Thirteen individual moose (or moose groups) were recorded at this site including two bulls, eight cows, and three cow/calf groups (Photo 6). Grizzly bears were recorded on 11 July 2013 and 5 August 2013 (Photo 7).

Two cameras were installed on 3 March 2014 at each of the Dip Creek and the Hayes Creek mineral licks and removed on 22 July 2014. The cameras were active for 142 days. Moose, black bear, grizzly bear and wolf were recorded at both mineral licks. The majority of the observations at both licks continue to be moose (Table 15.1). Several individuals appear to revisit the mineral licks on a regular basis. Black bears and wolves occasionally visited the mineral licks. One grizzly bear was recorded at each of the mineral licks. No caribou were recorded.

Table 15.1 Summary of the number of days each species was photographed at the Dip Creek and Hayes Creek mineral licks, 3 March 2014 to 22 July 2014.

Mineral Lick	Camera #	Moose	Caribou	Black Bear	Grizzly Bear	Wolf
Dip Creek	1	23	0	1	0	5
	2	32	0	7	1	9
Hayes Creek	1	61	0	3	1	3
	2	63	0	3	0	3



Photo 4. Bull moose feeding at the Hayes Creek mineral lick.



Photo 5. Wolf walking through the Dip Creek mineral lick.



Photo 6. Cow moose with two calves at the Dip Creek mineral lick.



Photo 7. Grizzly bear walking through the Dip Creek mineral lick.

16 YUKON RIVER WATER PIPELINE SURVEY

To establish the potential of the project's interaction with wildlife along the proposed Yukon River water pipeline, two biologists traveled the entire length of the road looking for signs of wildlife use. The proposed water pipeline occurs within the range and habitat of most animals that occur in the region, so the purpose was to document the presence of wildlife features such as mineral licks, concentration of track, trails, or other features.

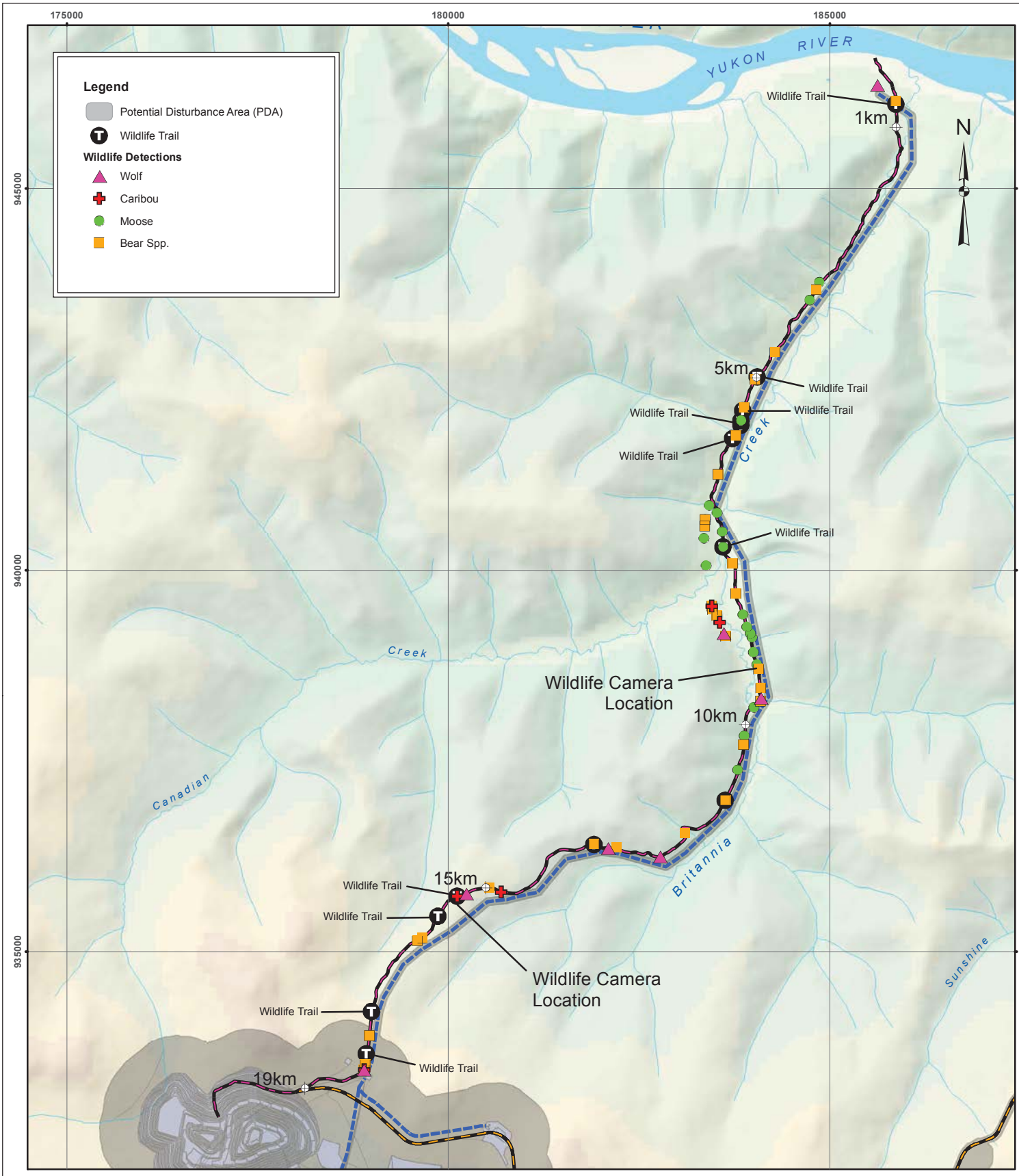
Two EDI biologists travelled the current access road 23 July 2014 on ATVs. The majority of the proposed pipeline alignment follows the road developed during Casino's exploration phase which accesses the proposed mine site from the Yukon River. One section of the proposed pipeline route follows the old road along Britannia Creek. The surveys drove along the route at approximately 10 km/h and watched for any sign of wildlife. The survey covered approximately 19 km between the deposit and Yukon River. Biologists travelled slowly along the route and recorded the location and description of all wildlife use observations. In addition, motion triggered cameras placed at two locations where wildlife trails were observed. The cameras collected images 23 July to 22 August 2014.

In total, 62 detections of wildlife sign were made (Table 16.1). Species observed included caribou, moose, bear (black and grizzly were grouped), and wolf. The most common wildlife sign observed was for bear species; a total of 23 observations of scat and tracks were made. Twenty signs of moose, 8 signs of wolf, and 5 signs of caribou scat and tracks were detected. In addition to the species specific observations, 14 wildlife trails were also observed, either crossing the proposed pipeline route, or running parallel to it.

In addition to the surveys, two wildlife cameras were set up at two sites along the proposed water pipeline route near observed wildlife trails (Figure 16.1). The cameras were set up on 23 July 2014 and were active for 30 days. The camera at km 15 of the road alignment did not record any animals, while the camera at km 9 along the road adjacent to Britannia Creek recorded a black bear sow with a cub on 25 July 2014.

Table 16.1 Summary of observations of wildlife sign by species along the proposed water pipeline route

Species	Tracks	Scat	Camera 1	Camera 2
Bear sp.	7	23	0	1 (+cub)
Caribou	2	3	0	0
Moose	14	6	0	0
Wolf	3	5	0	1



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Project infrastructure spatial data provided by Knight Piesold Ltd. 2014.

Wildlife observations collected by EDI (2014).

Digital Elevation Models (30 m and 90 m) provided by Yukon Government - Geomatics Yukon; online Corporate Spatial Warehouse. www.geomaticsyukon.ca



Yukon River water pipeline alignment widlife detections and trail locations

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Map scale 1:70,000 (printed at 8.5x11)
North American Datum 1983 CSRS Yukon Albers

CASINO

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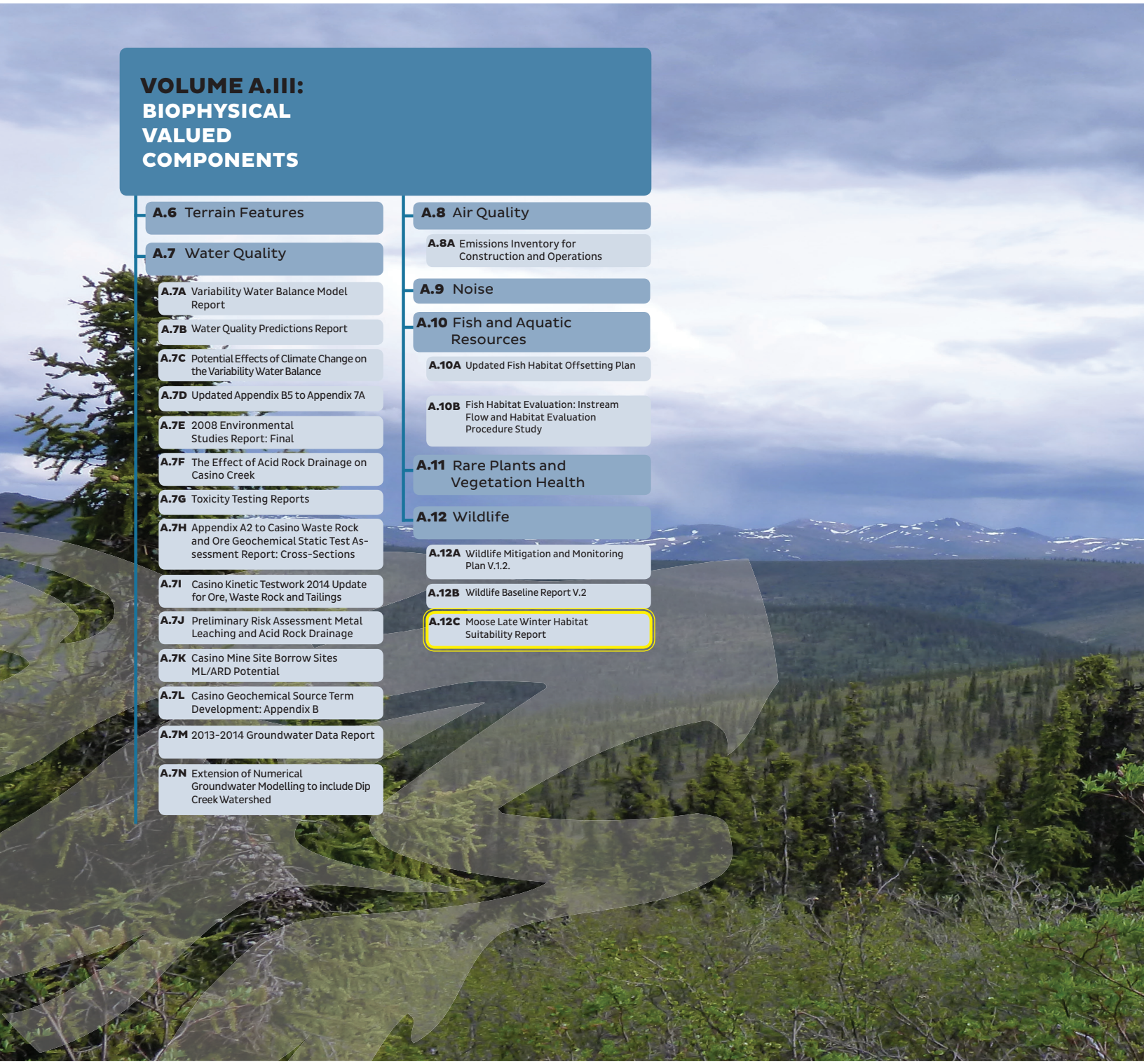
APPENDIX A.12C: Moose Late Winter Habitat Suitability Report



MOOSE LATE WINTER HABITAT SUITABILITY REPORT

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1 PART 1: HABITAT MODEL

1.1 Introduction

A moose habitat model was determined necessary in order to quantitatively assess the potential effect of the proposed Casino Mine Project on moose habitat availability. A model was developed and submitted with the Casino Mine Project proposal to YESAB in early 2014. Comments from the Yukon Government and newly available land cover information provided an opportunity to develop a new model of moose late winter habitat.

Habitat suitability index (HSI) models are simple models of habitat quality based on ranking species-habitat relationships. These models can be based on one suitability index or the combination of multiple suitability indices to quantify the quality of habitat for the focal species (Dijak and Rittenhouse 2009). Expert or local knowledge and results of detailed habitat selection studies are generally used as inputs to create suitability indices. The combination of all suitability inputs creates the HSI. The models are most accurate when animals have very specific habitat requirements and those habitat types are easily mapped. Animals that do not exhibit clear habitat selection, like moose, are more difficult to model accurately. Models of habitat use at the scale of large landscapes is particularly challenging because the availability of spatially explicit data is often missing or coarse.

In consideration of the increased energetic costs to moose during winter and that late winter is the most habitat–limited season for moose, a late winter habitat suitability index model was developed for the moose in the area around the proposed Casino Mine Project. The late winter moose HSI was developed using available spatially explicit terrain and land cover information. Suitability values were standardized for all variables input into the model, with a 0 value representing unsuitable habitat and a 1 representing suitable habitat.

1.2 Habitat selection background

Moose have been described selecting habitat based on three criteria: predator avoidance, food availability, and snow conditions (Dussault et al. 2005). Wolves, the primary predator of moose, are distributed throughout the region and Yukon. Wolves limit moose population growth and density (Hayes et al. 2003); consequently, moose are likely to avoid habitat types that increase the likelihood of detection by wolves (Dussault et al. 2005). Taller and denser vegetation land covers likely provide protection from wolf predation during winter. Habitat types that provide cover from predators may also contain taller trees that intercept snow reducing snow depth and, consequently, reducing the cost of movement. Willows are the primary winter food for moose. Rosenhoover (1989) found that willows accounted for more than 94% of the winter diet of moose in Denali National Park and Preserve. Moose were commonly observed foraging in areas that contain abundant willow during the Casino baseline surveys. As willow is an early succession species, the shrub is most abundant in disturbed areas such as stream riparian, human disturbed areas (e.g., placer mines and exploration camps) and burns. Moose have been reported selecting previously burned habitats that are 10-30 years old (Maier et al. 2005) and less than 40 years old (Wasser et al. 2011). Moose

have also been documented selecting areas within 100 m of streams and waterbodies (Wasser et al. 2011). Consequently, forest fires, fluvial processes, and placer mining, and other disturbances in the region provide higher quality moose habitat. Snow depth likely does not limit moose movement in the region because the area receives relatively little snow (Farnell et al. 1991); although snow depth and hardness at high elevations is likely to limit moose movement. Furthermore, land cover types, though related to snow conditions, can be a stronger predictor of winter habitat selection than snow conditions for moose (Kittle et al. 2008).

Terrain, particularly in mountainous areas, is a characteristic that restricts habitat availability for moose. The only information available describing moose winter habitat selection in similar terrain was a report on late winter habitat selection by moose in the Dawson land use planning region (Morrison and Wong 2013); however, the model results were determined to be inappropriate to inform this modelling exercise. Based on professional opinion, two terrain features are considered for the habitat suitability model: elevation and slope. Elevation is likely suitable as a proxy for vegetation availability and snow cover habitat limitations. The land cover dataset identified abundant shrub cover within the alpine and subalpine. Moose were rarely observed in the alpine and subalpine during baseline surveys, so the elevation dataset was used to exclude high elevation habitat as potentially suitable. Moose are typically observed occurring at all elevations below treeline, though information collected within the region indicates that moose may use the mid elevation slopes more frequently (EDI unpublished snow track data). Mid elevation may allow moose to avoid wolf packs that travel using the larger streams in the area and/or select elevations that have more comfortable temperatures, as temperature inversions are common in the area during winters. Slope likely restricts moose habitat availability as steep terrain is simply unavailable for moose. Moose were assumed to use flatter terrain more than steep terrain.

1.3 Methods

To model moose late winter habitat suitability, which is based on forage availability, predator avoidance and terrain restrictions, we developed a HSI by combining available datasets with suitable coverage to generate and validate the HSI (Table 1).

1.3.1 Study area

The moose late winter HSI was developed for the moose regional study area (RSA). The RSA is defined by all game management areas (GMAs) that intersect the proposed Casino Mine Project. Major landscape features in the RSA include Dawson Range and the Yukon River. The study area contains no notable lakes and wetlands. Climate in the area is characterized by long cold winters and short warm summers; and relatively little precipitation during any season (Smith et al. 2004). The region has an active wildland fire regime and has experienced a number of large burns since 1990.

The region has a long history of mineral exploration and development. The moose study area encompasses an operating hard rock mine, a number of active placer mines, one abandoned mine and a number of hard rock exploration properties. Access to the region is primarily from the Nansen Road, Minto Road, Freegold Road and Casino Trail. Other access infrastructure includes several maintained airstrips. The history of

human land use has resulted in a number of abandoned/inactive road and trails, mostly as spur roads from the existing roads.

Baseline studies conducted for the proposed Casino Project included several surveys for moose and caribou; parts of the study area have been surveyed for late winter ungulate distribution annually 2011–2014. Because moose and caribou were often surveyed simultaneously, an ungulate survey area was defined during baseline surveys to include the GMAs that intersect the Casino Mine Project and the entire range of the Klaza Caribou Herd (i.e. the survey area extends beyond the boundaries of the moose RSA in some areas). The entire area was surveyed during late winter in 2011 and 2012. In 2013, the Freegold Road extension was selected as the preferred access route for the Project and the 2013 and 2014 surveys were reduced in extent to a 10 km buffer of the preferred access route. Moose were the most common species observed during all surveys.

1.3.2 Data preparation

Available data used to create the late winter habitat suitability model was limited to datasets that covered the entire study area (Table 1). Land cover layers (Table 1) were merged because the 2014 land cover extent did not include the southeastern portion of the study area. The merged land cover dataset required resampling the EOSD data using the nearest method to increase cell size from 25 m to 30 m. The Yukon Fire history dataset was converted from vector to raster data with fire age as the cell values. A digital elevation model (DEM) was used to develop the steepness and elevation datasets.

We used fuzzy membership functions with a linear transformation between the suitable and unsuitable attributes to create suitability indices for the continuous variables. Boolean functions were used to create a suitability index for the categorical land cover variable.

All analyses were completed using the NAD83 geodetic reference system and the Yukon Albers projected coordinate system. All analyses and management of spatial data were completed using ArcGIS Desktop 10.2 with the Spatial Analyst extension (ESRI 2013).

Table 1. Spatial databases used in the development of the late winter moose HSI.

Dataset	Source	Description
Digital Elevation Model (DEM)	Geomatics Yukon, Yukon Government	Raster database 30 m cell size Developed 2002
Fire history	Geomatics Yukon, Yukon Government	Vector database Updated 2014
Land Cover	Environment Yukon, Yukon Government	Raster database 30 m cell size Imagery: 2008 and 2009 Developed 2014
Land Cover, EOSD	Canadian Forest Service, Pacific Forestry Centre	Raster database 25 m cell size Imagery: circa 2000 Developed 2006
Moose late winter locations	Project acquired data	Vector database Acquired 2011–2014

Elevation

Elevation within the study area is represented by the DEM. The elevation dataset was treated as a continuous variable in the habitat model. A fuzzy membership function was created to identify an elevation suitability index for late winter moose habitat using expert opinion. Elevation below treeline was considered suitable as moose late winter habitat, while elevation above treeline was considered unsuitable. Treeline was estimated at 1,175 m during baseline studies (EDI 2014). Treeline is not solid boundary between forested and alpine ecosystems and varies within landscapes; consequently, we created a 100 m altitudinal buffer for a linear transition from suitable to unsuitable habitat (Figure 1). The fuzzy membership model rates terrain up to 1,075 m as suitable habitat, followed by a linear transition to unsuitable habitat at 1,275 m (Figure 1, Equation 1).

Equation 1:
$$f(x) = \begin{cases} 0, & x \geq 1275 \\ \left(\frac{x-1275}{1075-1275}\right), & 1275 > x > 1075 \\ 1, & x \leq 1075 \end{cases} \qquad x \in X$$

Terrain steepness

The steepness of terrain within the study area was estimated by creating a slope dataset from the DEM. The slope database provides steepness in degrees and was treated as a continuous variable in the habitat model. A fuzzy membership function was created to identify a steepness suitability index for late winter moose habitat using the expert opinion. Terrain with less than or equal to a 20 degree slope was assumed to be suitable as moose winter habitat and slope greater than 70 degrees was assumed to be unsuitable (i.e., unavailable). Slopes in between the criteria were assumed to decrease in suitability with increasing slope (Figure 1, Equation 2).

Equation 2: $$f(x) = \begin{cases} 0, & x \geq 70 \\ \left(\frac{x-70}{20-70}\right), & 70 > x > 20 \\ 1, & x \leq 20 \end{cases} \qquad x \in X$$

Fire History

The burn age raster dataset was treated as a continuous variable in the habitat model. A fuzzy membership function was created to identify a suitability index for late winter moose habitat using published information. Fires less than or equal to 30 years old were considered suitable, followed by a linear transition to unsuitable habitat at 40 years old (Figure 1, Equation 3).

Equation 3: $$f(x) = \begin{cases} 0, & x \geq 40 \\ \left(\frac{x-40}{30-40}\right), & 40 > x > 30 \\ 1, & x \leq 30 \end{cases} \qquad x \in X$$

Land cover

The merged land cover dataset was grouped into broader habitat types based on dominant forest types. An accuracy assessment of the land cover dataset provided by YG revealed that the data poorly mapped most land covers types, but more accurately reflected broader land cover categories (ASL 2014). A Boolean membership function was used to identify a suitability index for moose late winter habitat. All land cover types were rated as suitable (1) or unsuitable (0) for moose foraging and predator avoidance value (Table 2). Conifer without a shrub component, unvegetated, and herb or lichen dominated land cover types were assumed to be unsuitable foraging late winter habitat for moose. All other land cover types were assumed to have the potential to contain forage species and were considered suitable foraging cover types. Unvegetated and herb or lichen dominated land cover types were assumed to be unsuitable predator avoidance cover types. All other land covers were assumed to have some potential value for predator avoidance. We combined values to create the land cover suitability index by taking the smallest forage or predation rating (i.e., product).

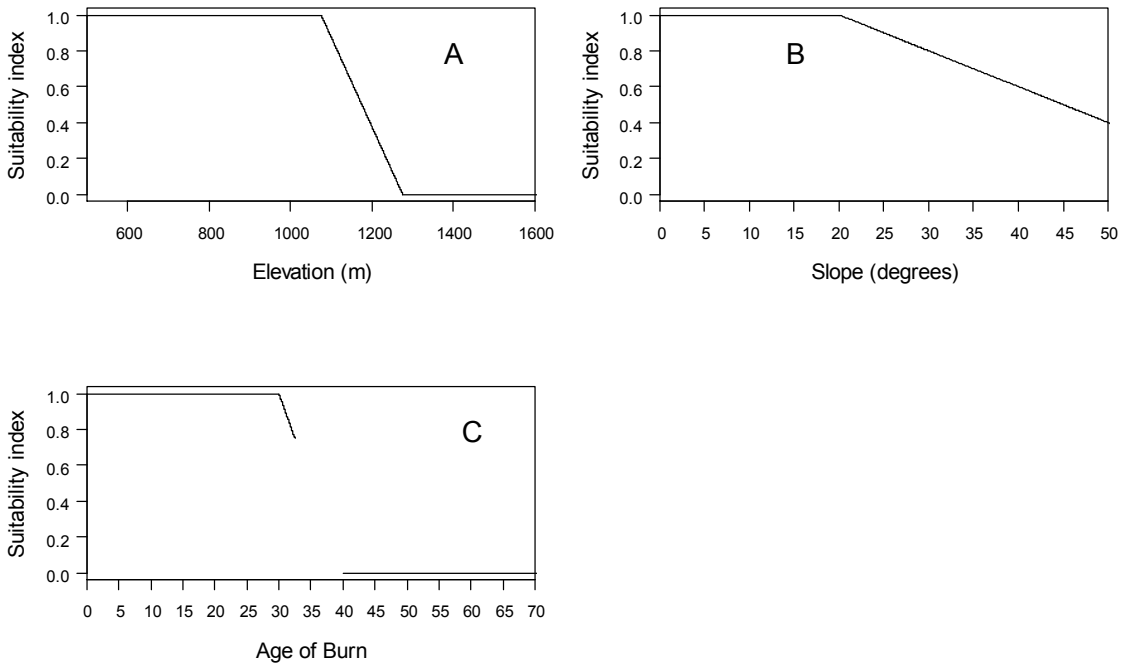


Figure 1. The suitability of moose late winter habitat as a function of elevation (A), slope/steepness (B) and age of burn (C). The x-axis approximately reflects the range of values that exist within the study area datasets.

Table 2. The suitability of moose late winter habitat as a function of land cover types.

Land Cover Code	Land Cover Type	Forage Rating	Predation Rating	Suitability Index
11, 12	Cloud or Shadow	NA	NA	NA
20, 31-33	Unvegetated	0	0	0
50	Shrub dominated	1	1	1
81-83	Wetlands	1	1	1
100, 101, 41-43	Herb or lichen dominated	0	0	0
211-215, 217-218, 240-241	Conifer without shrub	0	1	0
216, 219	Conifer with shrub	1	1	1
221-229	Broadleaf Dense	1	1	1
231-239	Mixed-wood Dense	1	1	1
232-239	Mixed-wood Open	1	1	1

1.3.3 Model Development

The HSI was developed by overlaying the terrain and land cover variables to create a model of moose late winter habitat quality. The steepness and elevation suitability indices were combined using an 'AND' overlay, which retains the minimum cell value of the combined datasets. The overlay is appropriate in this case because these steepness or elevation terrain attributes were assumed to be limiting for moose. For example, steep terrain at suitable elevation was still considered less suitable late winter habitat for moose. The land cover and burn age suitability indices were combined using an 'OR' overlay, which retains the maximum cell value of the combined datasets. The overlay is appropriate in this case because both datasets were assumed to contain some error so we identified the maximum area of potentially suitable land cover types. Furthermore, the land cover data are not as current as the fire history dataset.

The final moose habitat suitability model was created by combining the terrain and the land cover into one layer using a "PRODUCT" overlay. The overlay is appropriate in this case because it is a decreasive operation where a combination of values is considered less important than values from the inputs. The purpose in using this function was to ensure that values representing no or poor suitability from either input layer was maintained; for example, if an individual pixel in the terrain layer represented poor habitat, then that rating was maintained regardless of the value of the land cover. The resulting output layer represented the final moose habitat suitability model.

In consideration of the scale that moose select habitat, we used a focal statistics tool with a 1 km search radius (Oehlers et al. 2011). The focal statistics is also a method of smoothing raster datasets and is appropriate when there is uncertainty in the exact observation location. Moose observations were acquired during aerial surveys so the accuracy of the observation is likely ±100 m. Figure 2 is a graphical representation of the model development.

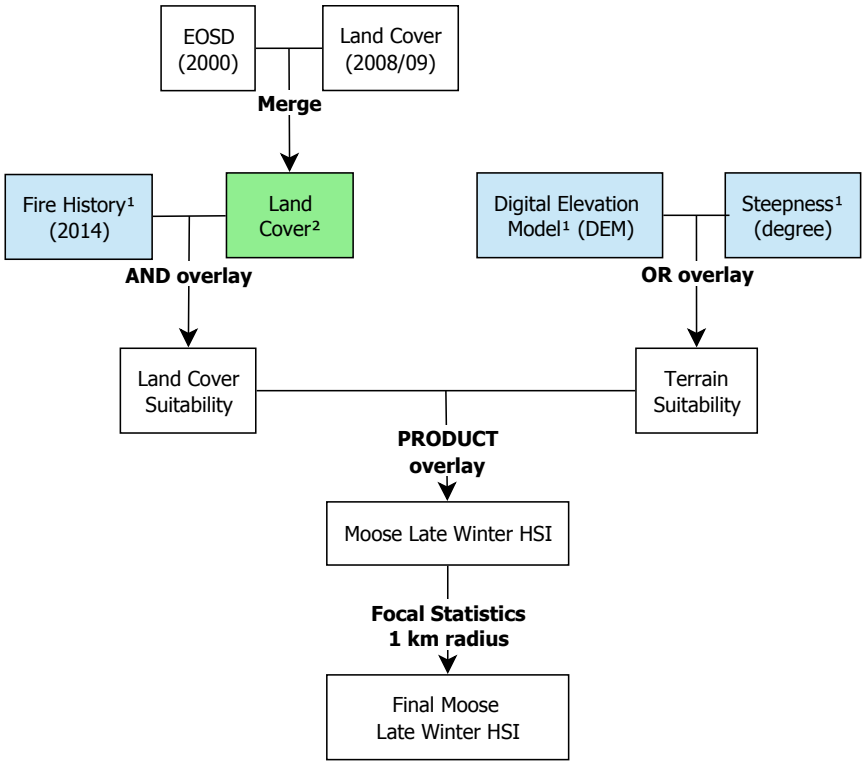


Figure 2. Moose late winter habitat suitability modelling workflow. The blue[1] and green[2] boxes identify the fuzzy and Boolean membership functions, respectively.

1.3.4 Statistical Validation

We grouped cells into suitable or unsuitable habitat. Habitat suitability values greater or equal to 0.5 are defined as suitable and values less than 0.5 are unsuitable. We used a simple one-sample proportions test with continuity correction to compare the observed proportion of moose observations within suitable habitat to the proportion of available suitable habitat within the study area. Used habitat was determined based on 248 moose observations within the habitat modelling area collected during the 2011 and 2012 late winter surveys. Observation collected during subsequent surveys in 2013 and 2014 were not used because the survey extent for those years was reduced, thus observations did not cover the entire habitat modelling area. Using the 2013 and 2014 moose locations could bias the validation results. The expected proportion of suitable habitat in the study area was determined by calculating the proportion of pixels identified as suitable habitat within the study area. Statistical tests were conducted using R version 3.1.2 (R Core Team 2014).

1.4 Results

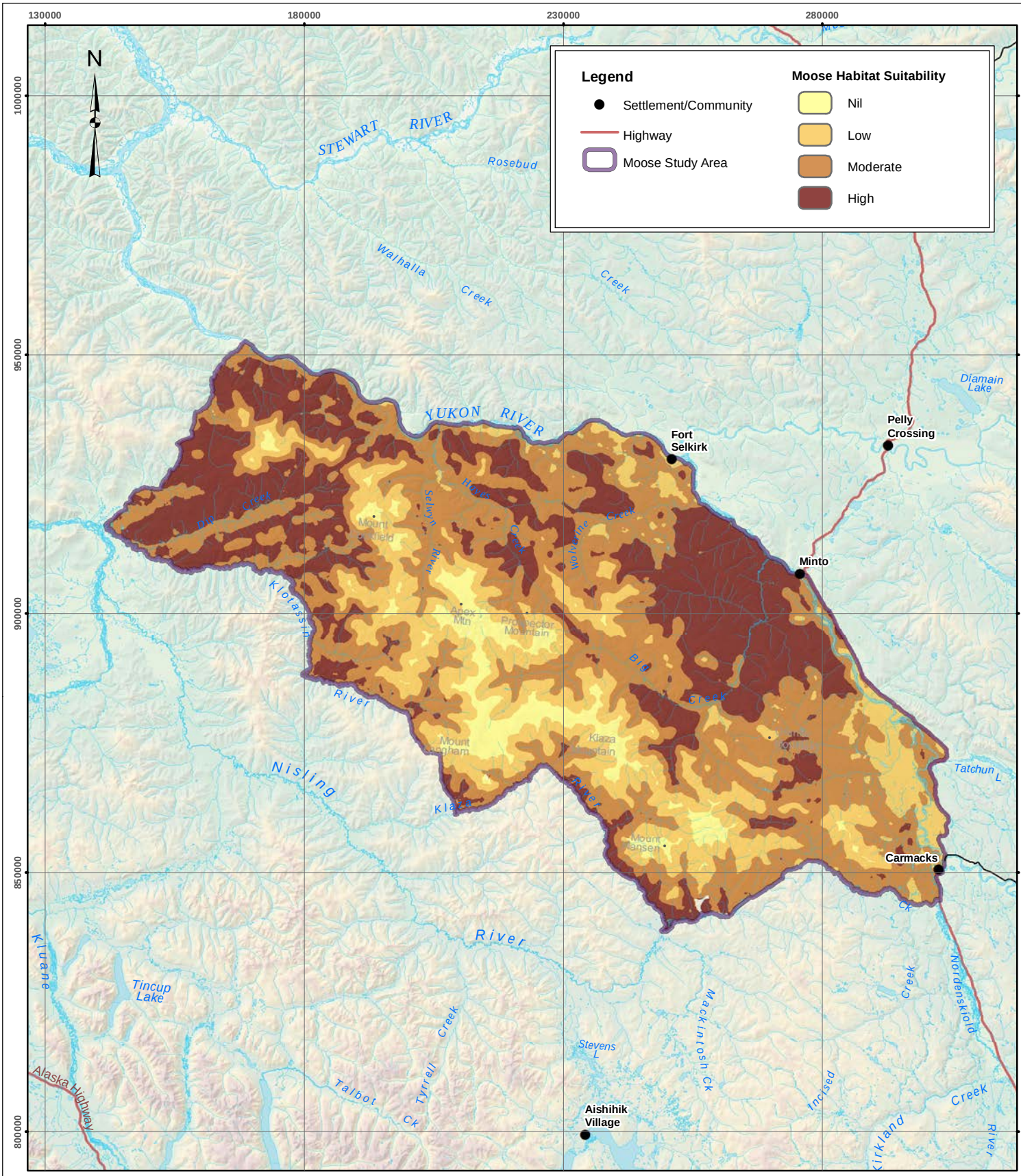
Moose were observed in areas identified as suitable habitat (HSI value ≥0.5) more often than unsuitable habitat. There is a statistically significant difference in the proportion of moose observations in suitable habitat (X-squared = 117.11, df = 1, $p<2.2e-16$). The results indicate that the model did a better job at predicting moose locations than random as 88% (95% confidence interval = 83–91) of moose observations

occurred within suitable habitat. If moose were randomly distributed across the RSA we would expect 53% of the observations to occur within suitable habitat.

The model indicates that the greatest concentrations of high quality late winter moose habitat in the RSA occur northeast of the Freegold Road extension near the Minto Mine and east near the Casino Mine Site infrastructure (Figure 3). The area east of the Freegold Road extension has experienced a number of wildland fires since 1990; consequently, the habitat in a large part of that area is presumed to be suitable habitat as it likely contains abundant willow. The area around the proposed Casino Mine site contains large gently sloping hills that contain abundant mixedwood forest types and broad valley bottoms that include wetlands and riparian habitats.

1.5 Limitations

The HSI is a knowledge–based model; consequently, biases in the knowledge and opinions of the author are reflected in the model. The HSI model validation is simplistic and based on presence only data and alternative models were not tested. Land cover variables included are correlated with one or both of the terrain inputs. However, the terrain variables were mostly used to restrict the more extreme terrain, so would not change substantially affect the suitability of habitats within the range of what is considered reasonable terrain for moose.



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Potential Disturbance Area (PDA) provided by Knight Piesold Ltd. Sept., 2013.

Habitat Suitability Index developed by EDI, 2015.

Digital Elevation Models (30 m and 90 m) provided by Yukon Government - Geomatics Yukon; online Corporate Spatial Warehouse. www.geomaticsyukon.ca

Moose late winter habitat suitability

Drawn:	Checked:	Date:	FIGURE:
MP/LG	MAS	05/03/2015	3

0 5 10 15 20 25 30 35
kilometres

Map scale 1:900,000 (printed at 8.5x11)
North American Datum 1983 CSRS Yukon Albers

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2 PART 2: EFFECTS ASSESSMENT

The following text updates the assessment of Project effects on moose habitat availability within Section 12.3.4 of the Project Proposal.

2.1 Potential Project Interactions with Moose

Habitat availability can be reduced as direct loss within the PDA, or as indirect loss from Project activities or infrastructure that create sensory disturbances and temporarily reduce the effectiveness (usefulness) of adjacent habitats, or by filtering movement (i.e., barrier or filter effect) between habitat patches. Moose are present in the RSA throughout the year in a variety of habitat types. Moose use habitat differently depending on season and life stage (i.e., adult versus cow/calf group), thus it is important to consider these factors when evaluating potential Project interactions with moose. Winter can be a critical time for moose, as snow depth creates greater energetic costs and forage quantity and availability are reduced. Cow/calf groups tend to use habitat differently than lone adults, as the risk of predation and energetic needs are greater.

During construction, loss of suitable habitat will occur as a result of clearing at the Mine Site, Airstrip Road, Yukon River Access Road, and along the Freegold Road upgrade and extension. For moose, the creation of roads could eventually be beneficial, as disturbed areas promote early successional vegetation growth and create refuges from predators (Beyer et al. 2013). Moose have been found to select disturbed areas (e.g., near towns or river margins) likely due to the availability of high-quality forage (e.g., willows; Maier et al. 2005). This is consistent with observations during baseline snow tracking surveys, where the highest densities of moose tracks and browse were found around existing placer mine operations along the Freegold Road. North of the RSA in the Dawson Land Use Planning Region, moose late winter habitat was examined using habitat suitability models (Morrison and Wong 2013). Disturbance features examined included distance to burns, areal disturbances and linear disturbances. Cow/calf groups selected habitat close to small roads, whereas adult moose tended to use wider linear features (>8 m), suggesting both groups did not avoid linear features and may in fact use them to reduce energetic costs in winter (Morrison and Wong 2013).

Moose may also experience reduced habitat effectiveness as a result of sensory disturbances from Project activities. Moose have been found to avoid active roads, humans, and other mechanical stimuli between 100 m and 3 km (Andersen et al. 1996; Burson III et al. 2000; Yost and Wright 2001; Jiang et al. 2009). All Project components are expected to result in temporary sensory disturbances to moose.

2.2 Effects Assessment Methods for Moose

2.2.1 Spatial and Temporal Boundaries

As described in Section 12.1.4 of the Project Proposal, the RSA was chosen to represent wildlife and habitat at an ecologically relevant scale. Since moose do not move in discrete units such as herds, but use a relatively large expanse of habitat annually, the most appropriate scale to assess the potential Project effects on moose is Game Management Subzones (GMSs). GMSs that overlap with proposed or existing Project

infrastructure were included in the assessment area (509–511, 522–524 and 526). Moose are present within the RSA year-round, thus Project activities during the construction, operations, closure and reclamation, and post-closure monitoring and inspection phases have the potential to affect moose.

2.2.2 Criteria for Significance

There are no prescribed thresholds for evaluating the Project effects on available moose habitat. For most bird and mammal species, evidence suggests that with less than 10–30% of remaining suitable habitat, habitat fragmentation compounds the effects of habitat loss on population size (Andrén 1994; Swift and Hannon 2010). Similar to the habitat thresholds for caribou, these values largely consider the population viability or persistence of a species, which is not considered to be a conservative approach to effects assessment. Persistence and viability suggests that population decline is acceptable as long as the defined population persists. These thresholds can provide a parameter for evaluating the magnitude of the Project's effects to habitat; however, they must be adjusted to reflect a more conservative approach. In consideration of this evidence and to reflect the inherent variability in these values (e.g., differences between species, landscapes, and population status) a reduction of greater than 15% from baseline to maximum disturbance (i.e. <85% residual habitat) is considered a high magnitude effect (Table 3). This threshold reflects a conservative approach to the assessment.

Table 3. Thresholds for Project Effects on Moose Late Winter Habitat

Magnitude of Effect	Total Range Disturbance Threshold
Low	0–10%
Moderate	10–15%
High	>15%

2.2.3 Habitat Effects Methods

To assess potential Project effects on moose habitat, direct habitat loss was quantified by calculating the area lost to the PDA, while reduced habitat effectiveness was quantified using a ZOI approach. It was assumed habitat within the PDA will become unavailable to moose. The ZOI defines the area beyond the PDA in which effects from Project infrastructure or activities could result in reduced habitat effectiveness. These effects, as described above, manifest as sensory disturbances (e.g., noise, lights, smells, human presence). Overall Project effects on habitat availability were assessed using a quantitative analysis of the change in the available area of low, moderate, or high value late winter habitat from baseline conditions. Effects to habitat availability will begin at the construction phase and continue throughout the life of the Project.

The size of the ZOI was based on multiple sources which provided information regarding the sensitivity of moose to certain Project components (Table 4). In Alaska, Yost and Wright (2001) found significantly fewer (55% less) groups of moose than expected within 300 m of a paved road through Denali National Park; however, they suspected these results were largely influenced by the spatial pattern of preferred forage and cover. Similarly, Burson III et al. (2000) found proportionally fewer moose within 100 m of the Denali Park road between 1972 and 1997; however, similar to Yost and Wright's (2001) findings, the mechanism for the

decline may have been related to poorer visibility of moose near the road due to vegetation growth. In Norway, Andersen et al. (1996) found moose were more responsive to human stimuli (e.g., people walking or skiing) than to mechanical stimuli (e.g., jet overflights), fleeing from human stimuli at distances of 200 to 400 m. Moose in northeastern China were found to avoid roads at a distance of up to 3 km; however, the authors state that the influences on moose decision-making in China is a result of many decades of disturbance from high density road networks and is likely quite different for moose in Canada (Jiang et al. 2009).

In consideration of these findings, precedence from similar mining projects in the Yukon and British Columbia (Table 4) and in an effort to maintain a conservative approach to Project effects, a 300 m ZOI was originally selected as an appropriate ZOI for assessing potential indirect effects on late winter moose habitat. However, the ZOI was increased to 500 m at the request of the Yukon Government. There is very limited existing information that quantifies the magnitude of moose avoidance of human disturbance. The indirect effect of the Project was quantified by reducing the HSI values within the ZOI. We assumed a linear relationship in the reduction of moose late winter habitat quality. The overall indirect effect within the ZOI is equivalent to a 50% reduction in habitat effectiveness, but the amount of reduction at any location within the ZOI was a function of distance to the PDA. The suitability of habitat outside the ZOI remained unchanged. The difference between the baseline HSI and predicted effect HSI values are used to assess project effects on moose late winter habitat (Table 5).

Table 4. Summary of disturbance zones of influence for moose reported in literature or used in other mining projects

ZOI	Context	References
None	ZOI used for sensory disturbance of Yukon and NWT mining projects	Ketza River Project; Prairie Creek Project, Mactung Mine Project
100 m	Reduced use near road	Burson III et al. (2000)
100 m and 250 m	ZOIs used for low and high use features of B.C. mining project	Prosperity Gold-Copper Project
200–400 m	Response to human and mechanical stimuli	Andersen et al. (1996)
200 m	ZOI used for sensory disturbance of Yukon mining project	Eagle Gold Project
300 m	Reduced use near roads in Alaska	Yost and Wright (2001)
300 m	ZOI used for sensory disturbance of B.C. mining project	Seabridge Gold Inc.
500 m	Avoidance of highways and roads in Quebec	Laurian et al. 2008
1000 m	Avoidance of roads and trails in Alaska	Shanley and Pyare 2011
3000 m	Avoidance of roads in China	Jiang et al. (2009)

Table 5. Change in moose late winter habitat quality due to project effects in the RSA

Habitat Quality	Baseline (km²)	Loss to PDA (km²)	Change in Effectiveness within ZOI (km²)	Maximum Disturbance (km²)[1]	Change (%)[2]
Nil	472	<-0.1	89	560	18.76%
Low	1,937	-15	101	2,023	4.46%
Moderate	3,906	-39	-49	3,818	-2.25%
High	2,639	-34	-53	2,552	-3.30%
Total	8,953	-89	89	8,953	NA
Sum HSI Values	**5,065,791**	**-58,016**	**-131,858**	**4,933,933**	**-2.60%**

Notes:
[1]Maximum disturbance represents the remaining habitat once habitat loss to PDA and reduced effectiveness in the ZOI is accounted.
[2]Percent change is the difference in habitat conditions at maximum disturbance from baseline conditions.

2.2.4 Habitat Residual Effects

The direct loss of 88.5 km² of late winter habitat within the PDA will result in a residual effect because the habitat will not be reclaimed within one generation of moose (Table 5). Additionally, the amount of high and moderate quality late winter habitat may be effectively reduced by 3.3% and 2.3%, respectively (Table 5); however, the effect of the ZOI is not permanent and will cease as soon as operations are complete and sensory disturbances are diminished. Considering the value of all habitat classes combined, there is a maximum overall reduction of 2.6% of the late winter habitat quality within the RSA (Sum HSI values; Table 5). An illustration of the Project effects on moose late winter habitat, considering habitat loss within the PDA, reduced effectiveness within the ZOI, and the winter range HSI is found in Figure 3. Project effects on habitat quality within the ZOI may be overestimated — in some cleared areas such as the Freegold Road Upgrade and extension, moose could be drawn to the roadside as the growth of willow is often promoted by disturbance (Maier et al. 2005).

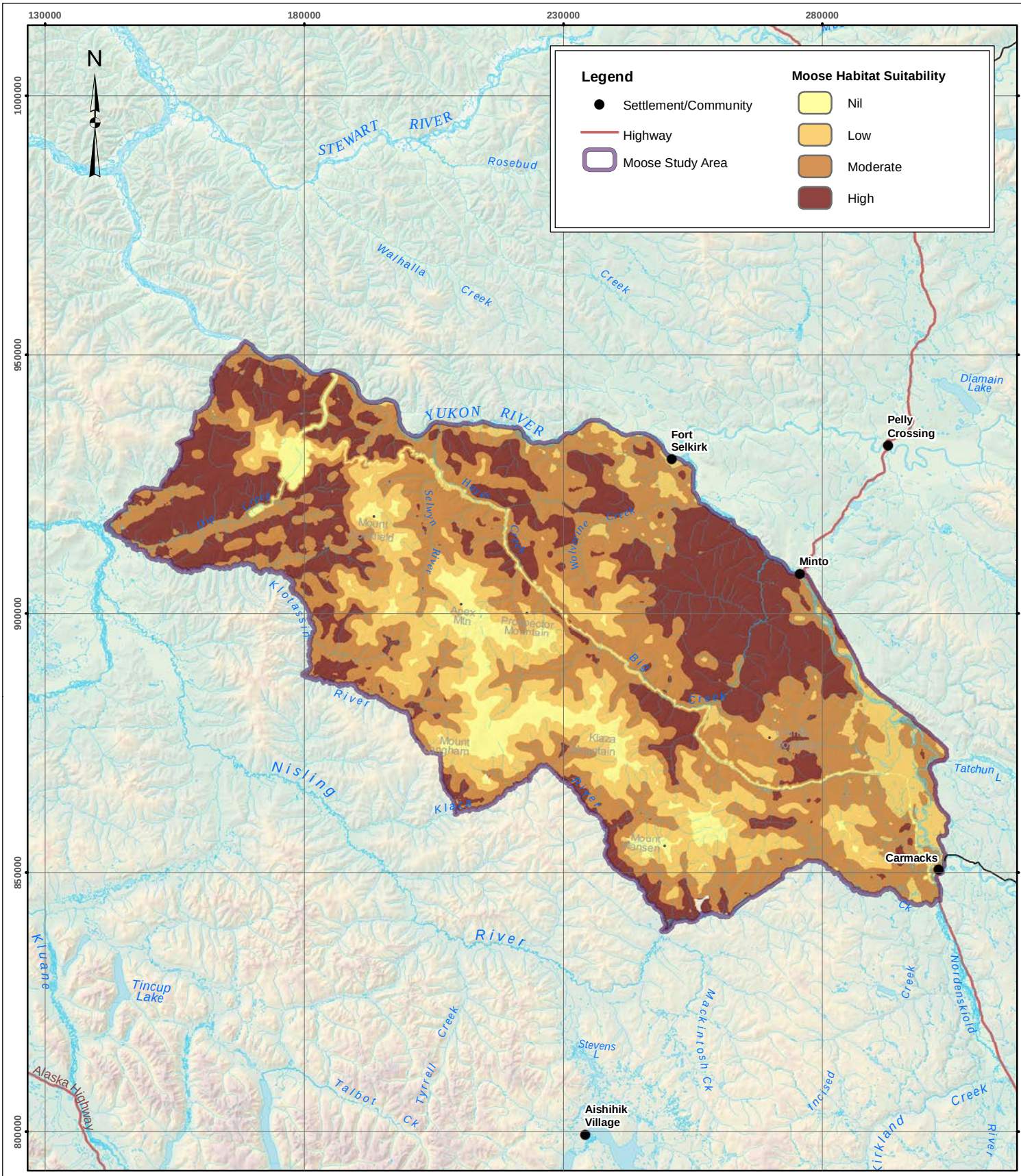
2.2.5 Significance of Effect on Habitat

Project-related effects to moose habitat availability will occur; however, due to the conservative approach taken throughout the assessment, the reduction of late winter habitat effectiveness is likely over-estimated. By minimizing the Project footprint, actively managing for sensory disturbances, and minimizing impacts to moose movement, effects to habitat availability can be minimized. Upon mine closure, the effectiveness of habitat within the ZOI will return to baseline levels.

Residual effects of the Project on moose habitat availability are quantified in Table 5. The area of late winter habitat within the moose RSA that will be directly lost totals 88.5 km². High quality late winter habitat lost because of direct overlap with the Project footprint is 34 km², while high quality late winter habitat lost due to indirect effects of human disturbance within the 500 m ZOI is 53 km². In total, the Project is anticipated to reduce the availability of high quality winter habitat by 87 km², which is equivalent to a 3.3% reduction in

available high quality winter habitat within the RSA. The overall loss of moose late winter habitat due to direct and indirect effects of the Project is 2.6%.

The effect of the Project on late winter moose habitat availability is not significant at the scale of the moose RSA, as the loss is within the range of the identified low threshold (Table 3). In consideration of uncertainty due to natural regimes (e.g., forest fires), the confidence in this prediction is moderate.



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Habitat Suitability Index developed by EDI, 2015.

Digital Elevation Models (30 m and 90 m) provided by Yukon Government - Geomatics Yukon; online Corporate Spatial Warehouse. www.geomaticsyukon.ca



Moose late winter habitat suitability at Project maximum disturbance

Drawn:	Checked:	Date:	FIGURE:
MP/LG	MAS	05/03/2015	4

0 5 10 15 20 25 30 35
kilometres

Map scale 1:900,000 (printed at 8.5x11)
North American Datum 1983 CSRS Yukon Albers

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APPENDIX A.13A: Economic Impacts of the Casino Mine Project









CASINO COPPER AND GOLD

MNP LLP

Casino Mine Corporation

Economic Impacts of the Casino Mine Project

March 2013

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1. EXECUTIVE SUMMARY

This report examines the economic impacts that may be realized by Yukon communities, residents and governments as a result of the development and operation of the Casino Mining Corporation's ("CMC") Casino project. CMC is a wholly-owned subsidiary of Western Copper and Gold Corporation ("WCGC").

MNP LLP's ("MNP") original economic impact study of the Casino project, based on the 2011 Pre-Feasibility Study, was issued in January 2012.[1] This updated economic impact assessment is based on the recently published Feasibility Study.[2]

Construction Impacts of the Casino Project

The construction of the Casino project is expected to occur over four years and to cost a total of $2.5 billion in capital expenditures.[3] The following table summarizes the economic impacts that are estimated to occur in Yukon and Canada through development of the mine. As indicated, we estimate GDP generated in Yukon by the construction of the Casino project at $363 million[4] (the equivalent of 13.6% of the Territory's 2011 nominal GDP of $2.7 billion).[5] Combining the impacts generated in Yukon and the rest of Canada, we estimate the construction of the Casino project to contribute $1,976 million to GDP throughout Canada. We also estimate the development of the mine to create total employment of 22,601 FTEs and to generate $1.1 billion in wages and salaries across Canada. Additionally, we estimate the mine's construction to generate $407 million in taxes to federal, provincial/territorial and municipal governments.

Total Projected Construction Impacts of the Casino Project

Total Construction Impacts (Direct, Indirect and Induced)	Output (millions)	GDP (million)	Employment (FTEs)	Wages and Salaries (millions)[6]	Federal Tax (millions)	Yukon Territorial and Provincial Tax (millions)	Other Tax (millions)
Total Yukon Impacts	$779	$363	5,091	$195	$33	$22	$7
Rest of Canada	$4,359	$1,613	17,509	$928	$201	$134	$10
All of Canada **Total**	**$5,138**	**$1,976**	**22,601**	**$1,123**	**$234**	**$156**	**$17**

Operation Impacts of the Casino Project

Operation of the Casino project is expected to generate economic benefits to Yukon and Canada through expenditures on goods and services, the creation of employment opportunities and the generation of tax revenues for local, territorial and federal governments. The following table summarizes the economic impacts that are estimated to occur in Yukon and Canada. We estimate the annual GDP generated in

[1] MNP. *Economic Impacts of the Casino Mine Project*. [Issued January 2012].
[2] M3 Engineering & Technology Corp. *Casino Project: Technical Report Feasibility Study.* [Published January 2013].
[3] M3 Engineering & Technology Corp. *Casino Project: Technical Report Feasibility Study.* [Published January 2013].
[4] Please note that economic impacts were derived using Statistics Canada's 2008 Input Output Model. In our previous report, we derived the economic impacts of the proposed Casino mine using Statistics Canada's 2007 Input Output Model.
[5] Statistics Canada, CANSIM, table 384-0038. *Gross Domestic Product, Expenditure-Based, Provincial And Territorial At Current Prices, 2011.* Available: http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/econ15-eng.htm [Last Modified 2012-11-19].
[6] Please note that throughout the report, estimated wage and salary impacts do not include employers' contributions or payments to benefit plans for the health and financial well-being of employees and their families.

Yukon by the operation of the Casino project at $274 million (equivalent to 10.3% of the Territory's 2011 nominal GDP of $2.7 billion).[7] Combining the impacts generated in Yukon and the rest of Canada, we estimate the annual operation of the mine to contribute $350 million to GDP in Canada. We also estimate the operation of the mine to create total employment of 1,308 FTEs and to generate $61 million in wages and salaries across Canada in each year of operation.

Total Projected Annual Operating Impacts of the Casino Project

Total Operating Impacts (Direct, Indirect and Induced)	Output (millions)	GDP (million)	Employment (FTEs)	Wages and Salaries (millions)	Federal Tax (millions)	Yukon Territorial Tax and Royalties and Provincial Tax (millions)	Other Tax (millions)
Total Yukon Impacts	$342	$274	855	$43	$20	$81	$1
Rest of Canada	$138	$76	453	$19	$12	$10	$0
All of Canada **Total**	**$480**	**$350**	**1,308**	**$61**	**$32**	**$92**	**$2**

Government Revenue

Our economic model estimates that $81 million in new annual tax revenues and royalties will accrue to the Yukon Government as a result of operation of CMC's proposed Casino mine. Of that amount, $25 million is attributable to direct income taxation sources (Personal Income Tax and Corporate Income Tax) and the other $56 million[8] is an estimate of annual resource royalty revenues.[9]

Total Impacts of the Casino Project

The Casino project will produce significant and extensive economic impacts for Yukon Territory and other provinces and territories across Canada. The following table summarizes the economic impacts that are estimated to occur in Yukon and Canada over the projected four years of construction and the 22 years of operation of the Casino mine. We estimate the Casino project to contribute a total of $6.4 billion to GDP in Yukon Territory. Combining the impacts generated in Yukon and the rest of Canada, we estimate the Casino project to contribute a total of $9.7 billion to GDP in Canada. Also, we estimate the Casino project to create overall employment of 51,373 FTEs and to generate a total of $2.5 billion in wages and salaries in Canada. In addition to these impacts, we estimate the Casino project to generate $3.1 billion in taxes to federal, provincial/territorial and municipal governments across the country during the life of the mine.

[7] Statistics Canada, CANSIM, table 384-0038. *Gross Domestic Product, Expenditure-Based, Provincial And Territorial At Current Prices, 2011.* Available: http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/econ15-eng.htm [Last Modified 2012-11-19].
[8] Yukon Mining Royalties are assumed to be over a 24 year period.
[9] Please note that estimates on new annual tax revenue and royalties generated to the Yukon Government as a result of the proposed Casino mine are before any federal financial agreement offsets.

Total Projected Impacts of the Casino project Construction and Operation

Total Projected Life Impacts- 4 years of construction and 22 years of operation (Direct, Indirect and Induced)	Output (millions)	GDP (million)	Employment (FTEs)	Wages and Salaries (millions)	Federal Tax (millions)	Yukon Territorial Tax and Royalties and Provincial Tax (millions)	Other Tax (millions)
Total Yukon Impacts	$8,308	$6,402	23,893	$1,131	$464	$1,810	$36
Rest of Canada	$7,388	$3,275	27,480	$1,338	$472	$359	$16
All of Canada **Total**	**$15,696**	**$9,678**	**51,373**	**$2,469**	**$936**	**$2,169**	**$52**

Other Economic Benefits

In contrast to economic impacts, economic benefits include long-term or downstream activity that would not normally be captured in economic impacts. Some of the economic benefits that are expected to be realized through the development of the Casino project include:

- Training opportunities
- Joint ventures
- Support for local developments or infrastructure

Social and Community Impacts

Social impacts are not easily quantified, but may have far reaching impacts on individuals, communities and the environment. Some of the social and community impacts that may occur through the development of the Casino project include impacts to:

- Population
- Local infrastructure, social services and community services
- Housing

Please see *Section 6* for more detail on the economic and social considerations related to the Casino project.

2. BACKGROUND AND STUDY PURPOSE

2.1 INTRODUCTION

Casino Mining Corporation's ("CMC") Casino project is a proposed open pit mine located in west central Yukon. The property is approximately 300 km northwest of the territorial capital of Whitehorse and is located on Crown land administered by Yukon Government. The property is located within the Selkirk First Nation traditional territory and neighbours on the Tr'ondek Hwechin First Nation traditional territory that lies to the north. The road access falls within Selkirk First Nation and Little Salmon/Carmacks First Nation traditional territories.

In 2013, a Feasibility study on the Casino project assessed that the project could be economically developed. Four metals are planned to be produced at the proposed open pit mine: copper, gold, silver and molybdenum. With a projected mine life of 22 years, the mine is expected to produce 3.6 billion pounds of copper, 325 million pounds of molybdenum, 30.3 million ounces of silver and 5.7 million ounces of gold.[10]

The Casino project is expected to be a major contributor to growth in the Yukon mining sector and is expected to provide economic benefits to both Yukon and the rest of Canada.

2.2 STUDY PURPOSE

In this report we examine the economic impacts that may be realized by Yukon communities, residents and governments as a result of the development and operation of the Casino mine.

2.3 DATA COLLECTION, AVAILABILITY AND RELIABILITY

Data for economic impact modelling were obtained from CMC, Statistics Canada and Yukon Government sources (e.g. Yukon Economic Development). Additional material was collected through the review of publicly available statistics, articles and reports. Estimates of economic impacts were derived from Statistics Canada's 2008 input/output model. When estimating future operational and capital spending, assumptions and approaches were selected in cooperation with CMC representatives. Additional material was collected through the review of publicly available statistics, articles and reports.

In addition, as part of MNP LLP's (MNP's) original economic impact study we also conducted face to face interviews with sixteen representatives from relevant organizations including Yukon Energy Corporation, Yukon Economic Development, the Yukon Chamber of Mines, Yukon Bureau of Statistics, the Whitehorse and Yukon Chamber of Commerce, the Tourism Industry Association of Yukon and Yukon Finance. Interview sessions focused on the Yukon economy and its ability to meet the demand of a mining project such as Casino.

2.4 ORGANIZATION OF THE REPORT

The remaining sections of the report are organized as follows:

- Section 3 provides an overview of the Casino project.
- Section 4 provides a description of the economic impact methodology and provides the aggregate results for the economic impact associated with construction and operation of the mine.
- Section 5 describes the implications for government revenue at the federal, territorial and local level.
- Section 6 describes other economic benefits that might be associated with the mine.
- Section 7 provides a description of the social impacts that might be associated with the mine.

[10] M3 Engineering & Technology Corp. *Casino Project: Technical Report Feasibility Study.* [Published January 2013].

2.5 REPORT LIMITATIONS

This report is not intended for general circulation, nor is it to be published in whole or in part without the prior written consent of MNP LLP. The report is provided for information purposes and is intended for general guidance only. It should not be regarded as comprehensive or a substitute for personalized, professional advice. We have relied upon the completeness, accuracy and fair presentation of all information and data obtained from CMC and public sources, believed to be reliable. The accuracy and reliability of the findings and opinions expressed in the report are conditional upon the completeness, accuracy and fair presentation of the information underlying them. As a result, we caution readers not to rely upon any findings or opinions expressed as accurate or complete and disclaim any liability to any party who relies upon them as such.



Additionally, the findings and opinions expressed in the report constitute judgments as of the date of the report, and are subject to change without notice. MNP is under no obligation to advise of any change brought to its attention which would alter those findings or opinions.

Finally, the reader must understand that our analysis is based upon projections, founded on past events giving an expectation of certain future events. Future events are not guaranteed to follow past patterns and results may vary, even significantly. Accordingly, we express no assurance as to whether the projections underlying the economic and financial analysis will be achieved.

3. OVERVIEW OF THE CASINO MINE PROJECT

3.1 YUKON ECONOMY AND MINING INDUSTRY

The Yukon economy, and in particular the mining sector, has experienced significant growth over the last couple of years. Yukon's real GDP has increased 7% from $2.2 billion in 2010 to $2.4 billion in 2011.[11] Statistics Canada real GDP by industry release also noted a gain of 6.5% in Yukon's real GDP.[12] According to Statistics Canada, the Mining, Quarrying and Oil and Gas Extraction sector was the primary contributor to total real GDP growth in 2011, accounting for over 80% of all estimated gains in 2011.[13] The economic growth in the Yukon mining sector can be attributed to a variety of factors, including the permitting and operation of three new mines (Minto Mine, Bellekeno Mine and Wolverine Mine), the continuation of high mineral exploration, development expenditures and utility construction.

Even though there is uncertainty on the level of construction activity, mining project development, and exploration expenditures that will take place in the Yukon in 2013. It is expected for the Yukon's real GDP in 2013 to grow for a tenth consecutive year, but likely below levels recorded in recent years.[14]

3.2 OVERVIEW OF THE CASINO MINE PROJECT

The Casino property has had a long exploration history dating from the first mineral claims dating in 1917. In 1936, discoveries of silver, lead and zinc were made, leading to focused exploration of the property for lead and silver through to 1967. From 1968 to 1995 the property was explored for its copper and molybdenum porphyry deposits (porphyry deposits are the world's most plentiful and important sources of copper and molybdenum).[15] In 2006, CMC acquired the Casino deposit and conducted several evaluations of the property. A Pre-Feasibility Study was conducted in 2008, and updated in 2011. The final Feasibility Study was released in January, 2013.[16]



The Casino property is located in south-western Yukon in the Dawson Range Mountains, where the terrain is characterized by rounded and rolling topography with moderate to deep valleys. The Yukon River flows to the west and is about 16 km north of the site. The property is situated about 300 km northwest of Whitehorse and 560 km from the year-round port in Skagway, Alaska. The area around the Casino project has been subject to increasing staking and exploration activities with over 100 mining companies now actively working in the general region.[17]

[11] Statistics Canada, CANSIM, table 384-0038. *Gross Domestic Product, Expenditure-Based, Provincial and Territorial, Chained 2007 Prices, 2011.* Available: http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/econ15-eng.htm [Last Modified 2012-11-19].
[12] Statistics Canada. *The Daily*, *Provincial and Territorial Account, 2011.* [Published November 2012].
Available: http://www.statcan.gc.ca/daily-quotidien/121119/dq121119a-eng.pdf [Released November 2012]
[13] Statistics Canada, CANSIM, table 379-0030. G*ross Domestic Product by NAICS Code, Provinces and Territories, Chained 2007 Prices, 2011.* Available: http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/econ15-eng.htm [Last Modified 2012-11-19].
[14] Department of Economic Development, Yukon Government. *Yukon Economic Outlook 2012.* [Published May 2012]. Available: http://economics.gov.yk.ca/economy2012/update.htm#GDP [February 2013 Update].
[15] Natural Resources Canada, *Geological Survey of Canada: Mineral Deposits of Canada.*
Available: http://gsc.nrcan.gc.ca/mindep/synth_dep/porph/index [October 2011].
[16] M3 Engineering & Technology Corp. *Casino Project: Technical Report Feasibility Study.* [Published January 2013].
[17] Western Copper and Gold Corporation. *Annual Information Forum*. [Published March 2012].
Available: http://www.westerncopperandgold.com/i/pdf/misc/2011-WRN-AIF-Final.pdf

An extensive amount of infrastructure, both on-site and off-site, will be required to support mine operations and the transport of people, supplies and extracted metals. On site infrastructure is planned to include a power generation plant fuelled by Liquefied Natural Gas (LNG). CMC has recently determined the best alternative is to construct a fit-for-purpose LNG liquefaction facility in the vicinity of Fort Nelson, BC and to truck LNG to the Yukon from this facility. The estimated cost of supplying LNG from BC is consistent with the costs used as the basis for the Feasibility Study released in 2013. Other on-site infrastructure will include construction of process buildings, a truck shop with service bays, accommodation and dining facilities, ancillary buildings such as an administrative building and warehouse, and sewage facilities.

The off-site infrastructure required for the transport of people, supplies and extracted metals is planned to include development of a new 1,600 metre airstrip for employee transport to and from the site and construction of a new 132 km all-weather access road to service the plant. The access road will link to the existing Freegold Road, which will also undergo improvements.

Significant amounts of construction labour will be required to build the Casino mine. At its peak, construction labour is estimated to total approximately 980 people. Initial capital costs associated with construction of the mine (including items such as an electricity generation plant, mine facilities and engineering activities) are estimated at $2.5 billion.[18]

The life of the Casino mine is expected to be 22 years, during which time significant amounts of operations labour will be required. Annual operations labour requirements are expected to total of approximately 600 to 700 permanent mining personnel and 100 to 200 contracting support staff, with annual operating costs expected to average $447 million.[19]

3.3 MINE VALUE CHAIN

A value chain can be defined as a chain of activities that combine to create products within specific sectors. Products pass through the chain gaining value at each activity. These activities can range from research and development, to production and manufacturing and marketing. When applied to the extraction of natural resources, the value chain describes the steps from the extraction of natural resources to their processing and sale.



For development, operation and reclamation of a mine the size of Casino, direct impacts arise through the major activities associated with each stage while the indirect and induced activities arise from the linkages that exist with suppliers and other sectors. Such linkages are illustrated in the diagram on the following page.

[18] M3 Engineering & Technology Corp. *Casino Project: Technical Report Feasibility Study.* [Published January 2013].
[19] M3 Engineering & Technology Corp. *Casino Project: Technical Report Feasibility Study.* [Published January 2013].


= Core Activities
= jobs created
Pre-Operation
Engineering Firms
Environmental Firms
Financial Advisors
Construction Companies
Drilling Companies
Equipment Suppliers
Transportation
LNG Suppliers
Explosive Suppliers
Surveying Companies
Drillers
Claim Staker
Geophysicists
Geologists
Equipment Operators
Mill Foreman
Camp Operators
Mine Foreman
Mill Maintenance
Safety Officer
Expediting
Staking Claims
Line Cutting
Operation
Engineering Firms
Environmental Firms
Warehousing
IT Services
Catering
Equipment Suppliers
Transportation
Fuel Companies
Financial Institutions
Accounting Firms
Commodity Marketing
Manufacturers
Hotels
Clothing/Equipment
Manufacturing
Laundry Services
Labourers
Janitors/Drymen
Blast Helpers
Drillers
Equipment Operators
Geophysicists
Mechanics
Electricians
Surveyors
Crusher Operators
Samplers
Grinding Operators
Flotation Operators
Reagent Operators
Dewatering Operators
Cook's Helpers
Warehouse Persons
Mine Clerks
Accounts Clerks
Welders
Administrative Assistants
Expediters
Plant Manager
Steel Erecters
Closure
Engineering Firms
Environmental Firms
Financial Advisors
Construction Companies
Equipment Suppliers
Catering
Hotels
Laboratories
Landscaping Companies
Transportation Companies
Hardware Supply Companies
Equipment Operators
Heavy Equipment Mechanics
Inspectors
First Aid Personnel
Security Personnel
Human Resources
Engineers
Labourers
Water Samplers
Environmental Monitors
Expediters
Environment Managers
Helicopter/Aircraft Pilots
Crane Operators
Fuel Truck Drivers
Grader Operators
Tree Planters
Millwrights
Pipefitters
Plumbers

4. ECONOMIC IMPACT ANALYSIS

4.1 METHODOLOGY

To estimate the economic impacts of the Casino project, we utilized an input-output methodology using economic multipliers published by Statistics Canada.[20] Input-output modeling is a widely-used and widely-accepted approach, making it recognizable by many different stakeholders and audiences. The structure of the approach also facilitates easy comparisons between reported results for different projects and facilities.

In general, economic impacts are viewed as being restricted to quantitative, well-established measures of economic activity. The most commonly used of these measures are output, GDP, government tax revenue and employment:

- **Output** is the total gross value of goods and services produced by a given company or industry measured by the price paid to the producer. This is the broadest measure of economic activity.
- **Gross Domestic Product (GDP)**, or value added refers to the additional value of a good or service over the cost of inputs used to produce it from the previous stage of production. Thus GDP is equal to net output, or the difference between revenues and expenses on intermediate inputs. It is the incremental value created through labour or mechanical processing. Total GDP is a more meaningful measure of economic impact, as it avoids double counting during each round of impacts.
- **Government Tax Revenues** arise from personal income taxes, indirect taxes less subsidies, corporate income taxes and natural resource royalties.
- **Employment** is the number of additional jobs created. Employment is measured in terms of full-time equivalents (FTE).

Economic impacts may be estimated at the direct, indirect, and induced levels.

- **Direct impacts** are changes that occur in "front-end" businesses that would initially receive expenditures and operating revenue as a direct consequence of the operations and activities of a facility.
- **Indirect impacts** arise from changes in activity for suppliers of the "front-end" businesses.
- **Induced impacts** arise from shifts in spending on goods and services as a consequence of changes to the payroll of the directly and indirectly affected businesses.

4.2 CONSTRUCTION AND DEVELOPMENT IMPACTS

Construction of the Casino project is expected to generate economic impacts throughout Yukon. Detailed cost estimates associated with the construction of the mine were provided to us by CMC. In addition, CMC was able to provide us with estimates related to the proportion of spending expected to occur within Yukon and the proportion of expenditures expected to occur elsewhere in Canada.

Using the projected construction costs and the related assumptions, we estimate GDP generated by the construction of the Casino project at $363 million (the equivalent of 13.6% of the Territory's $2.7 billion nominal GDP in 2011).[21] We also estimate the construction of the mine to create employment of 5,091 full-time equivalents (FTEs) and to generate $195 million in wages and salaries. In addition, the Casino project's construction is expected to generate $62 million in revenues to the federal, territorial and local governments.

[20] Please note that economic impacts were derived using Statistics Canada's 2008 Input Output Model. In our previous report, we derived the economic impacts of the proposed Casino mine using Statistics Canada's 2007 Input Output Model.
[21] Statistics Canada, CANSIM, table 384-0038. *Gross Domestic Product, Expenditure-Based, Provincial And Territorial At Current Prices, 2011.* Available: http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/econ15-eng.htm [Last Modified 2012-11-19].

Table 1: Projected Construction Impacts of the Casino project to Yukon Territory

Total Construction Impacts	Output (millions)	GDP (million)	Employment (FTEs)	Wages and Salaries (millions)[22]	Federal Tax (millions)	Yukon Territorial and Provincial Tax (millions)	Other Tax (millions)
Direct	$576	$261	3,275	$137	$24	$16	$5
Indirect & Induced	$204	$102	1,817	$58	$10	$6	$2
Total (Direct, Indirect and Induced)	**$779**	**$363**	**5,091**	**$195**	**$33**	**$22**	**$7**

In addition to the impacts generated in Yukon, economic impacts are created throughout the rest of Canada. As indicated in the table below, the construction of the Casino project is estimated to contribute an additional $1.6 billion to GDP outside of Yukon. We also estimate the construction of the mine to create employment of 17,509 FTEs and to generate $928 million in wages and salaries in Canadian regions outside of Yukon. Furthermore, we estimate the construction of the mine to generate $345 million in tax revenues to various levels of government outside of the Yukon.

Table 2: Projected Construction Impacts of the Casino project to the Rest of Canada

Total Construction Impacts	Output (millions)	GDP (million)	Employment (FTEs)	Wages and Salaries (millions)	Federal Tax (millions)	Yukon Territorial and Provincial Tax (millions)	Other Tax (millions)
Rest of Canada **Total (Direct, Indirect and Induced)**	$4,359	$1,613	17,509	$928	$201	$134	$10

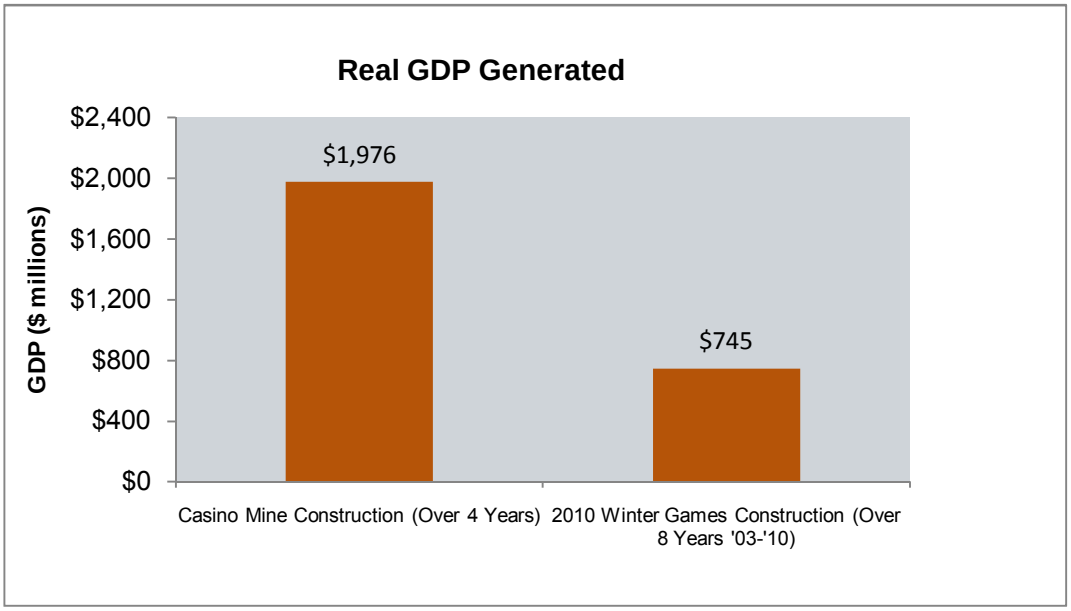
Combining the impacts generated in Yukon and the rest of Canada, we estimate the construction of the Casino project to contribute $2.0 billion to GDP in Canada. We also estimate the development of the mine to create employment of 22,601 FTEs and to generate $1.1 billion in wages and salaries in Canada. We estimate the mine's construction to generate $407 million in taxes to federal, provincial/territorial and municipal governments.

Table 3: Total Projected Construction Impacts of the Casino Project

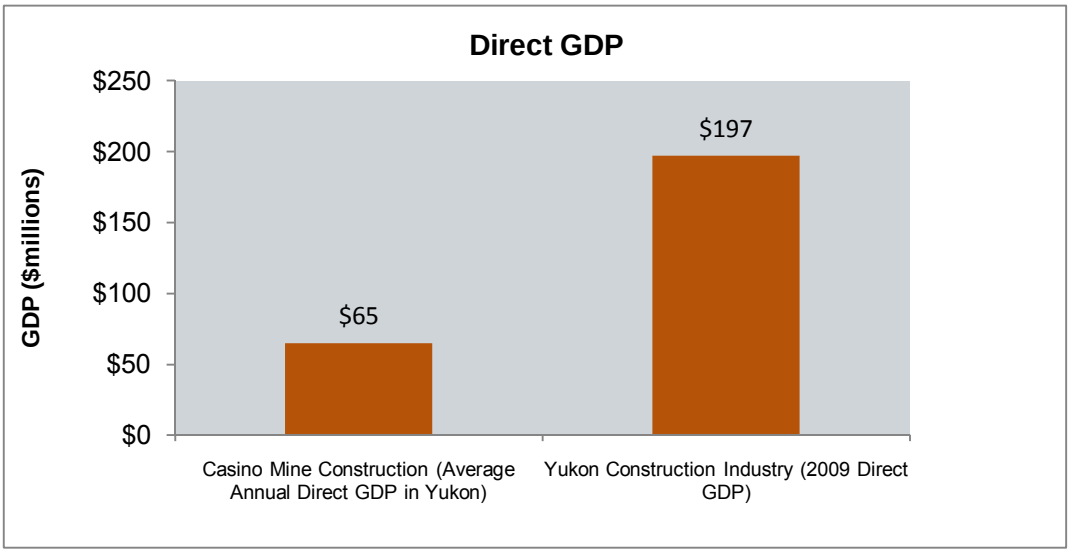
Total Construction Impacts	Output (millions)	GDP (million)	Employment (FTEs)	Wages and Salaries (millions)	Federal Tax (millions)	Yukon Territorial and Provincial Tax (millions)	Other Tax (millions)
All of Canada **Total (Direct, Indirect and Induced)**	$5,138	$1,976	22,601	$1,123	$234	$156	$17

[22] Please note throughout the report, estimated wage and salary impacts do not include employers' contributions or payments to benefit plans for the health and financial well-being of employees and their families.

To provide some perspective on the size of the Casino mine construction impacts it is illustrative to compare those impacts to ones produced by other projects and industries. As shown in the graph below, the total GDP (direct, indirect and induced) generated within Canada during the four years of mine construction are estimated to be close to three times as large as the total GDP generated by the eight years of construction activity related to the 2010 Winter Olympic and Paralympic Games in Vancouver.[23]

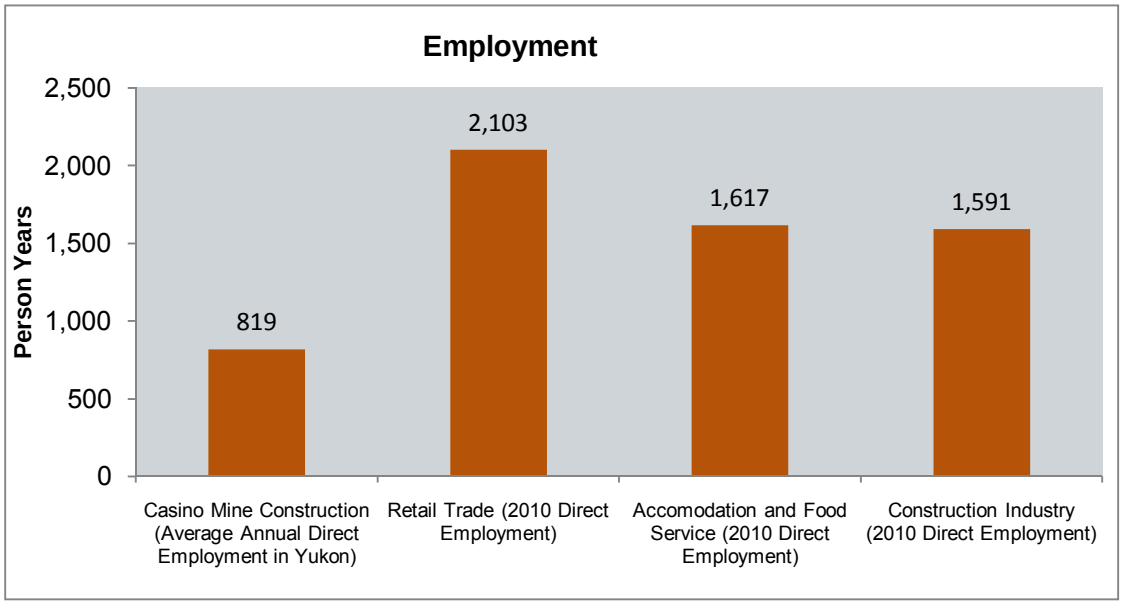


As shown in the graph below, the average annual direct GDP generated in Yukon by the construction of the Casino mine would be about 34% of the current annual GDP of the Yukon construction industry. [24]



[23] PWC. *The Games Effect Summary Report*. [Published October 2011]. Available: http://www.fin.gov.bc.ca/reports/PwC_The_Games_Effect_Summary_Report_7_2010_EN_FINAL.PDF
[24] Statistics Canada, CANSIM, table 379-0030. Gross Domestic Product (GDP) At Basic Prices, By North American Industry Classification System (NAICS), Provinces And Territories At Current Prices, 2009. Available: http://www5.statcan.gc.ca/cansim/a47.

The average annual direct employment produced in Yukon by the construction of the Casino mine would be between about 39% to 51% of the annual direct employment in major Yukon sectors, including the retail sector, the accommodation and food sector and the construction sector.[25]



[25] Yukon Bureau of Statistics. *Yukon Business Survey 2010.* Available: http://www.eco.gov.yk.ca/stats/pdf/2010_Business_Survey_Report.pdf.

4.3 ANNUAL OPERATIONS IMPACTS

The operations of the Casino project are expected to impact Yukon's economy through expenditures on goods and services, the creation of employment opportunities and the generation of tax revenues for local, territorial and federal governments. CMC believes that roughly 69% of operational spending will occur in Yukon. Using that percentage, together with projected annual operational spending data provided by CMC, we estimate the annual GDP generated in Yukon by the operation of the Casino project at $274 million. This is equivalent to 10.3% of the Territory's 2011 nominal GDP of $2.7 billion.[26] We also estimate the operation of the mine to create annual employment of 855 FTEs and to generate $43 million in annual wages and salaries.

Table 4: Projected Annual Operating Impacts of the Casino project to Yukon Territory

Operating Impacts	Output (millions)	GDP (million)	Employment (FTEs)	Wages and Salaries (millions)	Federal Tax (millions)	Yukon Territorial Tax and Royalties and Provincial Tax (millions)	Other Tax (millions)
Direct	$307	$232	542	$32	$16	$78	$1
Indirect and Induced	$36	$42	313	$11	$3	$3	$0.2
Total (Direct, Indirect and Induced)	**$342**	**$274**	**855**	**$43**	**$20**	**$81**	**$1**

In addition to the impacts generated in Yukon, Casino mine operations will generate economic impacts in other regions of Canada. Operations at the Casino project are estimated to contribute $76 million annually to GDP in other regions of Canada. We also estimate the projected operating expenditures of the mine to create annual employment of 453 FTEs and to generate $19 million in annual wages and salaries in regions outside of Yukon Territory. In addition, we estimate the operation of Casino project to generate $23 million in annual tax revenues to various levels of government.

Table 5: Projected Annual Operating Impacts of the Casino Project to the Rest of Canada

Operating Impacts	Output (millions)	GDP (million)	Employment (FTEs)	Wages and Salaries (millions)	Federal Tax (millions)	Yukon Territorial and Provincial Tax (millions)	Other Tax (millions)
Rest of Canada **Total (Direct, Indirect and Induced)**	$138	$76	453	$19	$12	$10	$0.3

[26] Statistics Canada, CANSIM, table 384-0038. *Gross Domestic Product, Expenditure-Based, Provincial And Territorial At Current Prices, 2011*. Available: http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/econ15-eng.htm [Last Modified 2012-11-19].

As shown in Table 6, we estimate the operations of the Casino project to contribute a total of $350 million annually to GDP in Canada (Yukon plus the remainder of Canada). Also, we estimate the operations of the mine to create total annual employment of 1,308 FTEs and to generate a total of $61 million in annual wages and salaries. In addition to these impacts, we estimate annual operations of the mine to generate $125 million in taxes to federal, provincial/territorial and municipal governments across the country.[27]

Table 6: Total Projected Annual Operating Impacts of the Casino project

Operating Impacts	Output (millions)	GDP (million)	Employment (FTEs)	Wages and Salaries (millions)	Federal Tax (millions)	Yukon Territorial Tax and Royalties and Provincial Tax (millions)	Other Tax (millions)
All of Canada **Total (Direct, Indirect and Induced)**	$480	$350	1,308	$61	$32	$92	$2

5. IMPLICATIONS FOR GOVERNMENT REVENUE

As described above, the construction of the Casino project is expected to generate tax revenues for federal, territorial and municipal governments. This section summarizes the impacts for these governments.

5.1 FEDERAL

Using the projected construction costs and related assumptions provided by CMC, we estimate the construction of the Casino project to generate (through direct, indirect and induced effects) $234 million in tax revenues to the federal government.

The operations of the Casino project are also expected to generate tax revenues to the Government of Canada. We estimate the operation of the mine to generate $32 million in annual tax revenues to the federal government.

[27] Figures may not add up due to rounding.

5.2 TERRITORIAL

The Casino project's construction is expected to generate tax impacts throughout Yukon. Using the projected construction costs and the related assumptions, we estimate the mine's construction to generate $22 million in revenues to Yukon Government.

Table 7: Projected Tax Impacts of the Casino Project Construction to Yukon Territory

Total Construction Impacts	Output (millions)	Yukon Territorial Tax (millions)
Direct	$576	$16
Indirect and Induced	$204	$6
Total	**$779**	**$22**

*Average Effective tax rates provided by Natural Resources Canada

The operations of the Casino project also impact Yukon's economy through the generation of tax revenues and royalties for the Yukon Government. Using estimated operational spending data provided by CMC (and assuming 69% of this spending occurs in Yukon), we estimate the operation of the mine to generate $81 million in annual tax revenues and royalties to Yukon Government.

Table 8: Projected Annual Tax Impacts of the Casino Project Operation to Yukon Territory

Operating Impacts	Output (millions)	Yukon Territorial Tax and Royalties (millions)
Direct	$307	$78
Indirect and Induced	$36	$3
Total	**$342**	**$81**

Please note that estimates from our economic impact model on the projected tax revenues and royalties that will accrue to the Yukon Government as a result of CMC's proposed Casino mine operations are before any federal financial agreement offsets (e.g. Territorial Formula Funding (TFF) and Resources Revenue Sharing (RRS) agreements). In the earlier MNP Economic Impact Assessment of the Casino mine, we estimated that, as a result of the provisions that were contained in the Yukon fiscal arrangement agreements with Canada, the Yukon Government would retain 78% of the annual tax and royalty amounts.[28]

[28] It is our understanding that this percentage may now be higher as a result of recent changes in the resource revenue arrangements between the government of Canada and Yukon. For more information on these changes please refer to http://www.gov.yk.ca/news/get-thefacts_dta.html.

6. OTHER ECONOMIC BENEFITS

In contrast to economic impacts, economic benefits include measures that are broader in scope, and may include both activity-based and outcome-based measures. These benefits may also describe long-term or downstream activity that would not normally be captured in economic impacts. While economic impacts utilize standard measures that can be estimated for nearly any type of project, economic benefits and their accompanying measures may vary greatly from project to project. The following section illustrates some of the economic benefits that are expected to be realized through the development of the Casino project.

6.1 TRAINING OPPORTUNITIES

It is our understanding that CMC is committed to providing training to local First Nations and other Yukon residents. While the specific training programs will not be created until the mine is in development, training opportunities are expected to include on the job training for mine employees and contractors, training on equipment and procedures and training for apprentices.

There may also be opportunities for literacy programs, completion of secondary school general equivalency degrees, pre-trades programs, community-based training, life-skills training, drug and alcohol awareness and rehabilitation and management development programs. It is our understanding that CMC is interested in opportunities to partner with local communities, government and others to provide community-based training.

6.2 SUPPORT FOR LOCAL DEVELOPMENTS OR INFRASTRUCTURE

The construction and operation of the Casino project will require significant infrastructure developments including a new all-weather access road (approximately 132 km), construction of a new airstrip, upgrades to the Freegold Road and construction of an electrical power generation plant. Legacy infrastructure related to road and energy development may provide surrounding communities with opportunities to utilize the infrastructure in the future. For example, the existence of an airstrip may create opportunities to fly in tourists to surrounding areas.

During interviews with the Yukon Chamber of Mines and other Yukon organizations, representatives noted that legacy infrastructure may provide economic benefits to area communities. Respondents suggested the infrastructure created through the development and operation of Casino mine could provide communities with future access to power generation opportunities, roads and other transportation routes.

There is a strong interest among exploration companies in the Freegold Road region generally. Therefore the legacy infrastructure may also be viewed as advantageous to other resource development in this region.

6.3 JOINT VENTURES

It is our understanding that CMC is committed to finding opportunities to partner with local First Nations and other local businesses. These joint ventures may provide an avenue for expanding local business capacity to prepare for and take advantage of business opportunities related to the Casino project's construction and operation.

Joint ventures offer an opportunity for two or more people to contribute goods, services or capital to a business enterprise. In the mining sector, joint ventures can be negotiated throughout the stages of a mine and offer opportunities for local communities to take advantage of the economic opportunities offered through construction and operation of a mine like Casino. Examples of joint ventures might include, catering, camp construction, equipment supply, sampling, fuel hauling or expediting. Typically business opportunities increase as a project moves through the stages of mine development.

7. SOCIAL AND COMMUNITY IMPACTS

Impacts generated from the development and operation of the Casino project also include impacts to communities. Social impacts are not easily quantified, but may have far reaching impacts on individuals, communities and the environment. The following section illustrates some of the social and community impacts that may occur through the development of the Casino project.

7.1 POPULATION AND INFRASTRUCTURE IMPACTS

Yukon's average annual population increased by 2% from 2011 to 36,101 in 2012.29 This marked the tenth consecutive year of population growth in the territory. Both direct and indirect employment associated with the Casino project will most likely result in significant, additional population growth in the Territory. The types of population changes that may occur with the Casino project can have implications for surrounding communities. Large increases to population may require additional local infrastructure, social services and community services.

Operation of Casino may impact labour supply in Yukon. Demand for labour at the mine and the associated high wages may increase competition for available labour. During interviews with various Yukon representatives, respondents noted they were concerned about the potential labour shortages that might occur with development and operation of Casino mine. The attractive salaries associated with a mine like Casino, may draw employees from other jobs thus creating shortages in other, lower paying industries.

The activity associated with the Casino project may have implications for health care and other related services in the Territory. Territorial health systems are currently facing shortages in the availability of family physicians, hospitals and specialists. This is of particular concern outside of Whitehorse. The size of Yukon coupled with a sparse population result in many patients being medically transported to health facilities in other parts of Canada. The 2008 Yukon Health Care Review noted that Yukon is facing strains within its health care system that raise concerns about the sustainability of the health care system.30

In interviews with Yukon Government representatives, respondents noted that development and operation of the Casino project may result in infrastructure impacts to roads, education, social services, and daycare. The additional demand on related infrastructure may represent costs to government.

7.2 HOUSING

Development and operation of the Casino project may have indirect impacts on the availability and cost of accommodations in the Territory. In some regions, mining activity has contributed to increased costs for rent or real estate. The influx of workers can result in housing shortages, inflated house prices or rents and low vacancy rates.

Housing or the lack thereof, appears to be an existing concern in the Territory, with homelessness and housing inadequacy having been identified by governments as an issue. Recent estimates place the rental vacancy rate in Whitehorse at 1.3%.31 In 2010, the Whitehorse Housing Adequacy Study found that 58% of respondents noted that it is difficult to find affordable rental accommodations and vacancies.32

During interviews with City of Whitehorse representatives, respondents suggested that the city was experiencing a housing crisis that may be exacerbated by development and operation of the Casino project. The project may place additional stress on the Yukon housing market leading to social and economic pressures on local residents who may not be directly benefiting from the resource development.

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[29] Statistics Canada, CANSIM, table 051-0001. *Estimates Of Population, By Age Group And Sex For July 1, Canada, Provinces And Territories.* Available: http://www5.statcan.gc.ca/cansim/a26;jsessionid=2694A2349B5252200DC57B024FEAEF6A.
[30] Health and Social Services-Yukon Government. *The Yukon Health Care Review (2008). Final Report.* [Published October 2011]. Available: http://www.hss.gov.yk.ca/pdf/yukon_health_care_review.pdf.
[31] Yukon Bureau of Statistics. *Yukon Rent Survey June 2012.* Available: http://www.eco.gov.yk.ca/pdf/rent_Jun12.pdf.
[32] Yukon Health and Social Services (2010). *2010 Whitehorse Housing Adequacy Study.* [Published October 2011]. Available: http://www.hss.gov.yk.ca/pdf/Whse_Housing_Adequacy-FINAL-DEC_03-10.pdf.

8. CONCLUSION

The Casino project will produce significant economic impacts for Yukon Territory. In addition, considerable and extensive economic impacts would be realized for provinces and territories across Canada.

The overall life of the Casino project is estimated to contribute significantly to the Yukon economy. As shown in Table 9, the construction and operation of the Casino project over its 22 year life is estimated to generate $6.4 billion (expressed in 2011 dollars) to GDP in Yukon. We also estimate the Casino project to create overall employment of 23,893 FTEs and to generate $1.1 billion in total wages and salaries in Yukon. In addition, we estimate the Casino project to generate $2.3 billion in tax revenues to various levels of governments over the project life.

Table 9: Total Projected Impacts of Casino project Construction and Operation to Yukon Territory

Total Project Life Impacts (combined construction and operations)	Output (millions)	GDP (million)	Employment (FTEs)	Wages and Salaries (millions)	Federal Tax (millions)	Yukon Territorial Tax and Royalties and Provincial Tax (millions)	Other Tax (millions)
Direct	$7,321	$5,373	15,199	$832	$386	$1,729	$30
Indirect and Induced	$988	$1,029	8,694	$299	$78	$80	$6
Total (Direct, Indirect and Induced)	**$8,308**	**$6,402**	**23,893**	**$1,131**	**$464**	**$1,810**	**$36**

In addition to the impacts generated in Yukon, the Casino project will generate considerable economic impacts in other regions of Canada. The Casino project is estimated to contribute a total of $3.3 billion (expressed in 2011 dollars) to GDP in other regions of Canada. We also estimate the Casino project to create overall employment of 27,480 FTEs and to generate $1.3 billion in total wages and salaries in regions outside of Yukon Territory. Furthermore, we estimate the Casino project to generate $848 million in overall tax revenues to various levels of government in regions outside of Yukon.

Table 10: Total Projected Impacts of Casino project Construction and Operation to the Rest of Canada

Total Project Life Impacts (combined construction and operations)	Output (millions)	GDP (million)	Employment (FTEs)	Wages and Salaries (millions)	Federal Tax (millions)	Yukon Territorial and Provincial Tax (millions)	Other Tax (millions)
Rest of Canada **Total (Direct, Indirect and Induced)**	$7,388	$3,275	27,480	$1,338	$472	$359	$16

As shown in Table 11, we estimate the Casino project to contribute a total of $9.7 billion to GDP in Canada (Yukon plus the remainder of Canada). Also, we estimate the Casino project to create overall employment of 51,373 FTEs and to generate close to $2.5 billion in wages and salaries in Canada. In addition to these impacts, we estimate the life of the Casino project to generate $3.1 billion in taxes to federal, provincial/territorial and municipal governments across the country.

Table 11: Total Projected Impacts of the Casino project Construction and Operation

Total Project Life Impacts (combined construction and operations)	Output (millions)	GDP (million)	Employment (FTEs)	Wages and Salaries (millions)	Federal Tax (millions)	Yukon Territorial Tax and Royalties and Provincial Tax (millions)	Other Tax (millions)
All of Canada **Total (Direct, Indirect & Induced)**	$15,696	$9,678	51,373	$2,469	$936	$2,169	$52

In addition to the economic impacts that would be realized for Yukon Territory and Canada as a whole, economic benefits and social and community impacts may result from the Casino project. Some of the additional economic benefits that may be realized through the development of the Casino project include training opportunities, joint ventures and support for local developments or infrastructure. In addition, social and community impacts to population, housing, local infrastructure, social services and community services may also result from the development of the Casino project.

APPENDIX A – ECONOMIC IMPACT MODELING ASSUMPTIONS

Economic Impact Calculations

Data for the economic impact modelling were obtained from CMC, Statistics Canada, and Yukon Government sources (e.g. Yukon Economic Development). Additional material was collected through the review of publicly available statistics, articles and reports. Estimates of economic impacts were derived from Statistics Canada's input/output model. When estimating future operational and capital spending, assumptions and approaches were selected in cooperation with CMC representatives. Additional material was collected through the review of publicly available statistics, articles and reports.

Analysis Approach

The economic impacts were estimated using Statistics Canada's interprovincial 2008 input-output model. The model was used to estimate the number of jobs, output, GDP and wages and salaries supported by proposed spending related to construction and operation of the Casino project. Tax impacts were also estimated based on model output.

Statistics Canada's interprovincial input-output model does not report induced multipliers. MNP estimated induced multipliers using the following procedure:

1. A portion of wages and salaries are directed towards consumption within the Yukon.
2. Wages and salaries are assumed to be spent in a pattern consistent with that reported in Statistics Canada's 2009 Yukon Survey of Household Spending (SHS).
3. Data from the SHS is matched with their respective industry (direct and indirect) Statistics Canada multipliers for output, GDP, employment and wages and salaries.
4. Using the above matching of industry multipliers to the SHS, estimate the first round of induced impacts. For example, if a worker is paid $1000 and has $700 remaining after taxes and savings, we distribute that $700 across consumer goods and services and apply relevant industry multipliers to estimate a first round of induced impacts. That first round of consumer spending will, in turn, generate further incremental wages, a portion of which will be consumed in the Yukon economy. That spending will create a further amount of incremental wages and this will continue until the successive rounds of impacts converges to zero. The sum total of all of these rounds of spending is then totalled.
5. Using the results from steps 1 to 4, together with the Statistics Canada direct and indirect multipliers we then construct a set induced multipliers for each NAICS code which can then be used to estimate induced impacts associated with a particular increase or decrease in a particular industry's output.

As a check, we have compared the induced multipliers for BC produced using this approach with the induced multipliers for BC reported by BC Stats. We found that the induced multipliers produced using this approach are very similar to those reported by BC Stats.

Main Assumptions

The analysis presented in this report is based on a number of assumptions. The main assumptions are:

- Dollar impacts are expressed in 2011 Canadian Dollars.
- Rest of Canada impacts were estimated using a blended multiplier constructed using Yukon import data:

Region	Percent of Impact
Ontario	29%
Alberta	25%
BC	30%
Rest of Canada	16%
Total	**100%**

- Based on information provided by CMC, the following assumptions regarding spending were used:

Percent of household spending in Yukon	70%
Percent of Mine Operations spending in Yukon	69%
Percent of Mine Construction spending in Yukon	26%
Percent of Workforce sourced from Yukon	70% (average over the life of mine)

- Economic impact analysis assumes that Yukon's economy can accommodate the resource allocation required to operate the mine including labour, capital and other materials.
- The tax assumptions used for the economic impact analysis are presented in the following table. Firms are assumed to pay statutory corporate income tax rates on estimated operating surplus. NRCan's recent tax modelling exercise has revealed that, for Yukon, average effective tax rates, which take into account the effect of delayed tax payments, were about only two-thirds of the statutory corporate rates. Hence, we used the effective tax rates corresponding to the statutory corporate rates for Yukon. It is our understanding that using effective tax rates of 6% for the federal corporate income tax and 10% for the Yukon corporate income tax better approximates the expected income tax generated from the project.

Tax Assumptions	
Average Personal Income Tax Rate	18.5%
Federal	12.7%
Provincial	5.8%
Corporate Income Tax Rate	
Federal	6.0%
Yukon	10.0%

- Based on data provided by CMC, the Average Annual Yukon Mining Royalty was assumed to be $56 million[33]. Yukon mining royalties are based on 12% of revenues less operating expenses, depreciation (no more than 15% of the initial capital cost balance at the beginning of the year) and taxes paid. The estimate is based on profitability and does not take into account changes that may affect profitability such as commodity prices. The baseline commodity price assumptions, including exchange rates, can be found in the Feasibility Study.[34]

[33] Yukon Mining Royalties are assumed to be over a 24 year period.
[34] M3 Engineering & Technology Corp. *Casino Project: Technical Report Feasibility Study.* [Published January 2013].

APPENDIX A.18A: Heritage Resources Summary Report



ECOFOR
natural and cultural resource consultants

Casino Heritage Resources Summary Report

Remaining Areas to Assessed and Heritage Resources to be Managed

TO BE INCLUDED IN YESAA MATERIALS
SITE SENSITIVE DATA HAS BEEN REMOVED

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Casino Heritage Resources Summary Report

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Ecofor Consulting Ltd. (Ecofor) prepared this report on behalf of Casino Mining Corporation.

James Mooney and Kevin Wilson (Owner) would like to thank Casino Mining Corporation for the opportunity to conduct this project and for providing us with assistance.

Ecofor is solely responsible for any errors evident in this report. The opinions and/or recommendations presented herein are ours and do not necessarily reflect those held by the Heritage Branch of the Yukon Government. Previous resource management recommendations made by other private consultants, and others by staff from the Yukon Heritage Resources Unit, are listed within this summary and identified by author. The authors would like to thank Ruth Gotthardt of the Heritage Branch for assistance in providing reports and clarification as needed.

MANAGEMENT SUMMARY

Cultural resources staff of Ecofor Consulting Ltd., (Ecofor) completed this desktop summary in 2014, at the request of Casino Mining Corporation in relation to their submittal to the Yukon Environmental and Socio-economic Assessment Board (YESAB). This report is intended to be a summary document for YESAB to clearly identify what heritage assessment and mitigation work, remains to be completed, and when it should be completed. There are three tasks remaining to be completed. These consist of: 1) remaining heritage impact assessment work; 2) management of impacts to heritage resources (such as avoiding sites, monitoring construction, and mitigating negative impacts where needed through detailed data recovery excavations); and 3) managing chance heritage finds during construction. The first two tasks must be completed after final engineering designs are prepared but prior to construction efforts.

The first steps are to identify all remaining areas where heritage resource impact assessments were not previously completed; and to summarize the management recommendations for archaeological sites and historic resources that may be impacted by the development of the proposed Casino Mine Site and ancillary facilities. These footprints include the upgrades to Freegold Road, the road upgrades from the mine area to the Yukon River, and construction of a road from the mine site to the proposed airstrip and the proposed airstrip itself. These combined footprints also include proposed borrow pits and access roads to the borrow pits, and the mine site and tailings facility. Previous heritage impact assessment work for the proposed extension of Freegold Road was completed and reported under permits 88-03ASR (Gotthardt 1988), 94-09ASR (Handly, Merchant, and Rousseau 1994), 94-22ASR (Handly and Rousseau 1995), 95-01ASR (Gotthardt 1995), 95-02ASR (Hammer 1995), 09-09ASR (Soucey et al 2010a), 10-04ASR (Soucey et al 2010b), 11-04ASR (Mooney 2011), 13-06ASR (de Guzman et al 2014), 13-07ASR (Mooney 2013a), and 13-18ASR (Mooney 2013b). Additional permitted work along the proposed Freegold Road includes 11-13ASR (Mooney 2012), and 12-03ASR (Mooney 2013c). This summary reviews each of these previous efforts and combines them for reference.

The results of this heritage resources summary are presented in the following sections:

1) Areas remaining to be assessed (17 proposed borrow pits and approximately 7.45 km of ROW);
2) Thirty-three (33) archaeological sites to be managed along the proposed upgrading of Freegold Road;
3) Thirty-one (31) historic structures and resources to be managed along the Freegold Road;
4) Seventeen (17) archaeological sites to be managed near the mine site, the proposed airstrip, the road to the airstrip, and the road to the Yukon River;
5) Sixteen (16) historic structures and resources to be managed near the mine site, the proposed airstrip, the road to the airstrip, and the road to the Yukon River;
6) Ten (10) previously noted First Nation use sites along the Freegold Road.

If this project moves forward it is possible that further revisions in the road and ancillary components will be made. It is recommended that any areas of potential ground disturbing impact not previously assessed are reviewed and assessed in the field prior to impacts. Impacts to recorded historic and prehistoric resources should be avoided were possible, or mitigation efforts should be completed prior to construction impacts. Site by site recommendations are presented below. Future ground disturbances associated with the proposed mine and ancillary components are also guided by the Casino Mine Interim Heritage Resources Management Plan (Mooney 2013b).

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1.0 INTRODUCTION

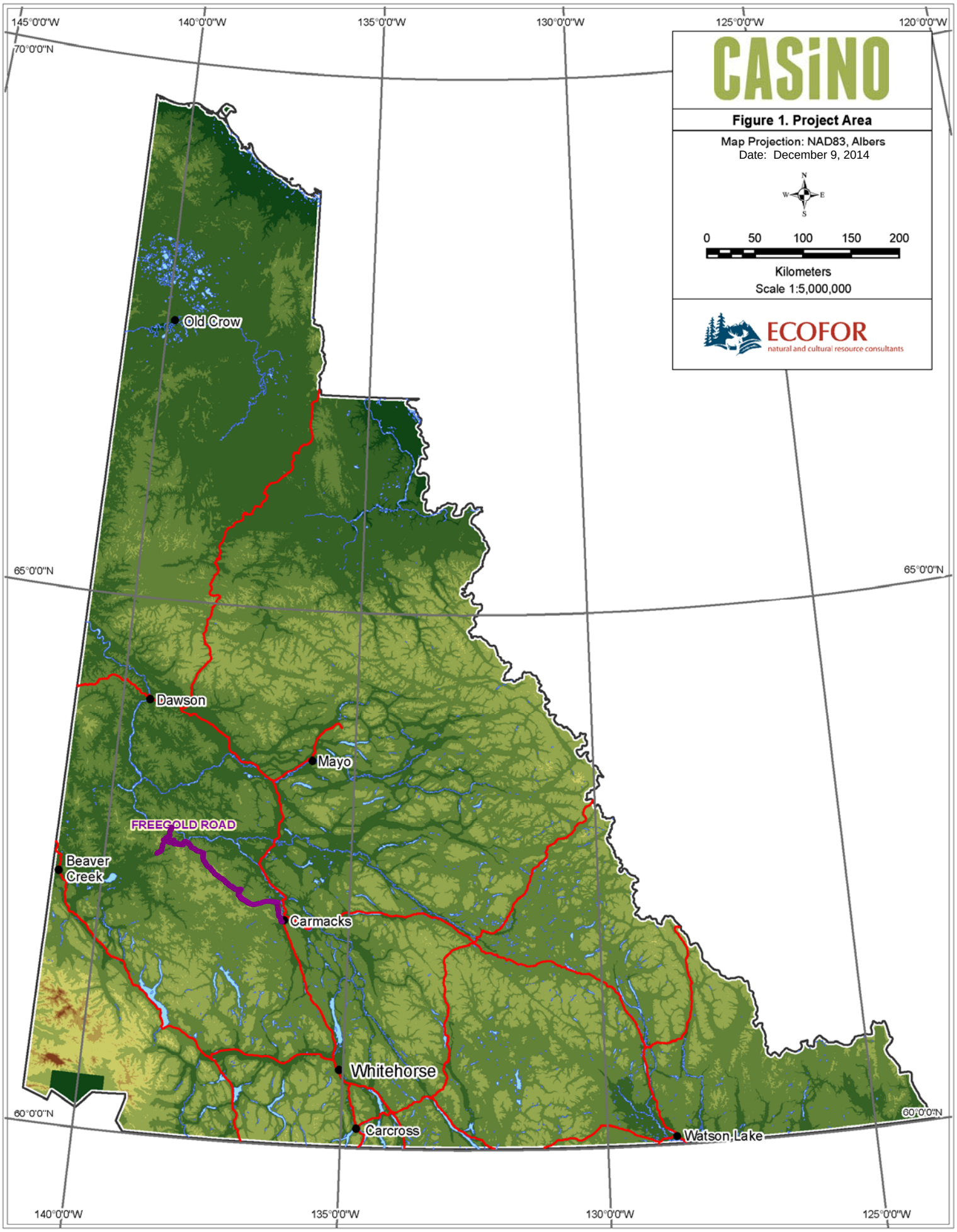
1.1 Scope of Project

The Casino Property is a proposed open-pit Gold, Copper, and Molybdenum mine. The property is located in south-western Yukon, near the Yukon River in the Klondike Plateau and Central Yukon Plateau. At present the property is only accessible by air or by boat via the Yukon River. Plans are being made by Casino Mining Corporation to build a road to connect Casino Property to Carmacks and the Yukon Highway systems. In addition, an airstrip and access road are also proposed southwest of the Casino Camp to accommodate larger aircraft. Previous heritage impact assessment work for the proposed extension of Freegold Road was completed and reported under permits 88-03ASR (Gotthardt 1988), 94-09ASR (Handly, Merchant, and Rousseau 1994), 94-22ASR (Handly and Rousseau 1995), 95-01ASR (Gotthardt 1995), 95-02ASR (Hammer 1995), 09-09ASR (Soucey et al 2010a), 10-04ASR (Soucey et al 2010b), 11-04ASR (Mooney 2011), 13-06ASR (de Guzman et al 2014), 13-07ASR (Mooney 2013a), and 13-18ASR (Mooney 2013b). Additional permitted work along the proposed Freegold Road includes 11-13ASR (Mooney 2012), and 12-03ASR (Mooney 2013c). This summary reviews each of these previous efforts and combines them for reference.

The Casino name may have first been used in this region in 1915, when prospectors Jack O'Hara and Frank Farnan, discovered gold in a tributary to Dip Creek and named it after their favourite card game (Coutts 2003). The Casino Trail has been referred to as a planned mining access road from the end of the Freegold Road to the near the upper Hayes Creek area in the Dawson Range, ever since the existing Freegold Road was built. The Freegold Road itself was built in 1949 by N.A. Timmons mining interests in order to explore and develop the LaForma Gold mine on Mount Freegold. The Casino Trail is said to run northwest of the end of the Freegold Road towards Casino Creek. Parts of the proposed Casino Trail follows previously used travel corridors which were linked to trails to important copper sources in the White River area, and a section of the old Chilkat trail from Fort Selkirk (the west branch of the Dalton Trail). This travel corridor provided connectivity in pre-contact times and since the early 1900s was known by the Casino name. Since then, this travel corridor provided access for multiple uses of trapping, hunting, fishing, mineral exploration, and other collection activities, as seen in the archaeological and historic resources left behind.

1.2 Report Format

Section 2 describes areas remaining to be assessed. Section 3 summarizes the archaeological sites to be managed along the proposed upgrading of Freegold Road. Section 4 historic structures and resources to be managed along the proposed upgrading of Freegold Road. Section 5 presents archaeological sites to be managed near the mine site, road to the Yukon River, the proposed airstrip, and a road to the airstrip. Section 6 summarizes the historic structures and resources to be managed near the mine site, the road to the Yukon River, and the proposed airstrip. Section 7 lists some previously noted First Nation use sites along the proposed upgrading of the Freegold Road. Two appendices are included at the end of this report. Appendix I contains the project mapping, Appendix II contains a detailed table of remaining areas to be assessed, the archaeology sites to be managed, the historic structures and resources to be managed, and some previously noted First Nation use sites along the proposed Freegold Road upgrade.


CASINO
Figure 1. Project Area
Map Projection: NAD83, Albers
Date: December 9, 2014
N
W
E
S
0 50 100 150 200
Kilometers
Scale 1:5,000,000
ECOFOR
natural and cultural resource consultants
145°0'0"W
140°0'0"W
135°0'0"W
130°0'0"W
125°0'0"W
120°0'0"W
70°0'0"N
65°0'0"N
60°0'0"N
Old Crow
Dawson
Mayo
FREEGOLD ROAD
Beaver Creek
Carmacks
Whitehorse
Carcross
Watson Lake

2.0 AREAS REMAINING TO BE ASSESSED

After detailed review, the remaining areas and footprints remaining to be assessed, fall into two groups; currently planned impact areas, and future revision areas. The currently planned impact areas have been reviewed and these are broken down further into linear right-of-way (ROW) segments along the proposed ROW upgrades, and planned borrow pits (including access to each borrow pit).

2.1 Proposed Upgrading of the Freegold Road Right-of-Way (ROW)

The areas of the currently proposed ROW that have not been fully assessed in the past are segments km 0+550 to approximately km 5+100 (all km markings are listed with 0+000 at the starting point from the Klondike Highway on the south side of Carmacks). This segment includes the east bank of the Nordenskiold River and continues to where it joins the existing Freegold Road on the west side of Carmacks.

The second segment requiring additional survey is km 14+100 to approximately km 17+000. A portion of this area was assessed by Handley and Rousseau in 1994 but not the entire segment. The currently proposed impacts in this area also includes proposed borrow pits which are listed below.

2.2 Proposed Borrow Pits and Access to the Borrow Pits

Between km 0+000 and km 32+000 there are seventeen (17) proposed borrow pits which have not been assessed. These require assessment and if they are used, the access roads to each pit also require assessment.

These proposed borrow pits and the proposed segments of the ROW remaining to be assessed are presented in Appendix I (mapping) and Appendix II (table summary by km and UTMs).

The remaining proposed borrow pits from km 32+000 all the way to the proposed mine site and road to the proposed airstrip have been assessed. However, in the cases where the proposed borrow pit does not lie adjacent to the proposed road ROW, an access road to the borrow pit needs to be proposed, and accessed for impacts to heritage resources. In some cases an estimated route to the borrow pit has been assessed in the field but these must be reviewed on a case by case basis as the planned borrow pits move forward in the selection process. Some of the currently planned borrow pits may be dropped from planning while others may be added. If any borrow pits are added to the project they must also be the subject of a heritage resource impact assessment.

3.0 ARCHAEOLOGICAL SITES ALONG UPGRADE OF FREEGOLD ROAD

Only the previously recorded sites near or within the impact area of the proposed upgrades to the Freegold ROW are discussed below. If a site is not listed, it is not in danger of being impacted by the project. Some sites are listed that are very close to planned footprints and could be impacted if plans change slightly. Other sites are close to proposed impacts and these should be monitored to ensure impacts are avoided. Many of the sites have had their boundary's flagged with 1" wide, yellow ribboning with "No Work Zone" printed in black. The sites near the proposed mine site, the road to the Yukon River, and the road to the proposed air strip, have also been signed with white plastic signs with black lettering "No Disturbance Zone". However not all of the sites along the proposed Freegold Road and extension have been flagged or signed, and some or all of the flagging or signage may be weathered or removed by natural forces. Each site is presented below (by the most relevant reports cited) with a brief summary and management recommendation. Management recommendations are listed by previous author. Where no previous recommendation was made, or current recommendations have been added, these are made by the current authors. Sites are listed in order of appearance travelling from Carmacks heading northwest to the proposed mine site. These summaries are also presented in Appendix I by mapping, and by Appendix II in table format.

3.1 KM 0 TO KM 33

KaVa-17/Mount Nansen Road Cemetery (No permit report just site form): The site is located on the southern end of a glacial moraine to the south of the First Nation cemetery on the Mount Nansen Road (Mount Nansen Road Cemetery). The site was found when a research team headed by Dawn Charlie of Carmacks was inspecting historic features around the grave yard and noted the presence of flakes.
Scope of Possible Impacts from Casino Project: This site and cemetery are not currently planned for impacts and are located upslope and to the east of the proposed ROW.
Management Recommendations: Avoidance of this site and the cemetery are recommended.

KaVa-3 (Handly and Rousseau 1995): A pre-contact site with surface and subsurface lithic scatter previously recorded by VanDyke in 1978. Situated near where the Freehold Road crosses the Nordenskiold River, northwest of Carmacks. Situated near the Freegold Project ROW (at time of 1995 report). Extensive disturbance from previous road construction, power lines, cemetery construction and gravel quarry. Remaining intact cultural deposits only apparent along terrace edge margins and road cutbanks. Debitage and bone recovered. Interpreted as a large campsite. A First Nations elder stated that Champagne-Aishihik peoples would camp in this area while trading with the Little Salmon Carmacks peoples. Presence of a contemporary community cemetery within portions of the site boundary may indicate the presence of precontact and/or historic First Nations and/or European burials along the terrace.
Scope of Possible Impacts from Casino Project: This site is not currently planned for impacts.
Management Recommendations:.Handly and Rousseau "strongly recommend that a detailed, systematic, archaeological data recovery program (i.e., mitigative excavations) be undertaken prior to the commencement of any further land-altering activities, including replacement of the bailey bridge. This would involve excavating 1m^2 excavation units dug in 5 cm-thick arbitrary levels" (1995:49). They estimated that 10 units would be required for a representative sample of remaining cultural materials and

could be accomplished by a crew of 4 experienced archaeologists assisted by 2 Band members in 3 working days.

KaVb-2 (Gotthardt 1995): Located on a high terrace of the Yukon River at the south end of the terrace. Location of the Dominion Land Surveys 1948 benchmark T397. Flakes and fire cracked rock recovered over 30 m area along terrace. Old foot trail that leads to Carmacks is visible on the edge of the terrace on the site.
Scope of Possible Impacts from Casino Project: This site is outside of the impact zone of the Freegold Road upgrade.
Management Recommendations: Site avoidance is recommended (Gotthardt 1995). If avoidance is not possible then data recovery mitigations are recommended. This site is not planned to be impacted by 2013 footprint.

KaVb-1 (Hammer 1995; Handly and Rousseau 1995): Handly and Rousseau first identified this site in 1994 as a medium sized, pre-contact subsurface lithic scatter site. Hammer (1995) reassessed the site through survey and conducted limited shovel tests, recovering a small number of lithics and fire cracked rock. The site sits on a ridge overlooking a small pond east of the Freegold Road and a portion of the eastern bank of the Yukon River to the east.
Scope of Possible Impacts from Casino Project: This site is located within a proposed borrow pit and the proposed ROW.
Management Recommendations: In developing the borrow pit, impacts to the south edge of the terrace should be avoided and it is recommended to maintain 30 m buffer along the terrace edge. Additionally, the borrow pit access road should be routed along north side of the terrace (Hammer 1995). If impacts cannot be avoided then data recovery excavations are recommended.

KbVb-2 (Hammer 1995; Handly and Rousseau 1995): Handly and Rousseau identified this site as a medium sized, precontact subsurface lithic scatter site. There was previous bulldozer disturbance to KbVb-2. Debitage from below White River Ash stratum (pre-1,250 BP). KbVb-2 recovered chert debitage and a unifacially flaked scraper. The site was interpreted as medium sized, short term campsite or possible game monitoring stations where tool production was occurring. Handly and Rousseau (1995) identified the preferred management option would be to avoid this site but if not a feasible option they recommended a detailed, systematic, archaeological data recovery program prior to any further land-altering activities. Hammer (1995) did a salvage excavation of the site over 6 days. They concluded that KBVb-2 was a small prehistoric campsite occupied during the Northern Archaic Tradition (4,500 – 1,250 BP). They recovered over 4,600 lithics, fire cracked rock, bone fragments, and recorded several features.
Scope of Possible Impacts from Casino Project: What remains of this site is within the 2013 planned ROW.
Management Recommendations: Hammer (1995) recommended that during construction for the upgrading of the Freegold Road, the surface soil (0-30 cm below surface) be removed in the vicinity of KbVb-2 and stockpiled so possible remaining cultural materials may be salvaged at a future date.

KbVb-4 (Gotthardt 1995): Small site on a low terrace on the north side of Crossing Creek. May have been a fishing camp as well as stop on the trail. Multiple occupations of the site are indicated which span from the mid-Holocene to within the last 1000 years. Site has been impacted by an old cat trail but intact portions remain.
Scope of Possible Impacts from Casino Project: This site is within the 2013 planned ROW.
Management Recommendations: Archaeological data recovery is recommended prior to upgrading the Freegold Road through the area.

3.2 KM 33 TO THE CASINO MINE SITE AREA

KbVb-3 (Gotthardt 1995): Site is interpreted as small and possibly a single occupation site. The old cat trail along the terrace edge has almost completely destroyed the site.
Scope of Possible Impacts from Casino Project: This site is within the 2013 planned ROW.
Management Recommendations: No further work.

KcVd-3 (Mooney 2013a): This site is located on the east end of a rounded ridge overlooking the confluence of Seymour and Big Creeks. This ridge point provides a significant view of both Seymour Creek and Big Creek Valleys. This landform likely contains a low to moderate density of lithic materials and likely represents a small sized temporary campsite, or lithic reduction workshop. No cultural diagnostic materials were identified, however all of these lithic materials were directly under a thick deposit of White River Tephra.
Scope of Possible Impacts from Casino Project: The site is located on the north edge of a proposed borrow pit and is also upslope from the proposed extension of Freegold Road. This site will be directly impacted by borrow pit use.
Management Recommendations: Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended. Data recovery should include additional shovel testing to better determine artifact distribution and density followed by 1 x 1 m block excavation. Approximately 14 - 18 square meters of excavation would be recommended based on existing data.

KcVe-4 (Mooney 2011): This prehistoric site is located on a terrace within the proposed Freegold Road Extension. The terrace overlooks the confluence of Burgis Creek and Big Creek. The cultural materials were all found below the White River ash along the southeast facing terrace edge. This lithic scatter likely represents a temporary campsite or lithic reduction workshop.
Scope of Possible Impacts from Casino Project: The site is located very close to the proposed extension of Freegold Road and may be directly impacted by the proposed road alignment.
Management Recommendations: Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended to include in-fill shovel testing to better determine artifact densities followed by a series of 1 x 1 m unit block excavations in relationship to the size and distribution of the site.

KcVf-2 (Mooney 2013a)**:** This site is located on a terrace and likely represents a temporary campsite or lithic reduction workshop; which included the use of microblades during the Little Arm Phase.

Scope of Possible Impacts from Casino Project: The site is located on the edge of a proposed borrow pit of the Freegold Road extension and would be directly impacted by the proposed developments.
Management Recommendations: Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended. Data recovery should include additional shovel testing to determine artifact distribution and density, followed by 1 x 1 m block excavation. Approximately 12 - 15 square meters of excavation would be recommended based on existing data.

KcVf-3 (Mooney 2013a): This site is located on an s-shaped terrace overlooking the head waters of Hayes Creek likely represents a temporary campsite(s) or lithic reduction workshop(s). No culturally diagnostic materials were identified and it is uncertain when these materials were deposited.
Scope of Possible Impacts from Casino Project: The site is located within a proposed borrow pit of the Freegold Road extension and would be directly impacted by the proposed developments.
Management Recommendations: Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended. Data recovery should include additional shovel testing to determine artifact distribution and density, followed by 1 x 1 m block excavation. Approximately 12 - 15 square meters of excavation would be recommended based on existing data.

KeVf-1 (Mooney 2011): This site is on a southwest facing bench located approximately 500 m NE and high above the headwaters to the tributaries to Hayes Creek. The lithic scatter likely represents a temporary campsite or lithic reduction workshop.
Scope of Possible Impacts from Casino Project: The site is located within a proposed borrow pit and will be directly impacted by 2013 designs.
Management Recommendations: If avoidance is not possible then data recovery work is recommended. Data recovery should include additional shovel testing to determine artifact distribution and density, followed by 1 x 1 m block excavation. Approximately 12 - 15 square meters of excavation would be recommended based on existing data.

KdVf-4 (Gotthardt 1988; Mooney 2011): The site is located on the south-eastern bench of a series of benches. This bench was found to contain lithics by Gotthardt in the 1980s. Gotthardt discussed the likelihood that this area was on, or near, an overland trail that was the traditional Chilkat return trail from Fort Selkirk to Dyea via Aishihik, was crossed by then proposed Casino Trail route in the upper Hayes Creek area. A section of (the 1988) proposed Casino Trail route in the drainages of Big Creek, North Big Creek, and Hayes Creek in fact parallels a traditional foot trail which leads ultimately to the important copper sources and trade rendezvous on the White River via the Klotassin River (Gotthardt 1988). The lithic scatter likely represents a temporary campsite or lithic reduction workshop overlooking the wide valley near the drainage divided between Big Creek to the southeast and Hayes to the northwest.
Scope of Possible Impacts from Casino Project: The site was located within a proposed borrow pit (now dropped from planning in 2013) and is located above the proposed extension of Freegold Road. This site would not be directly impacted.
Management Recommendations: Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended to include in-fill shovel testing to better determine artifact densities, followed by a series of 1x1m unit block excavations in relationship to the size and distribution of the site.

KdVf-13 (Mooney 2011): This prehistoric lithic site is located on the south-eastern corner of a terrace overlooking the confluence of a small tributary to Hayes Creek. The site has a lower section and a slightly higher section and both were found to contain prehistoric materials, over a significant area. The lithic scatter likely represents a moderate density, medium sized, temporary campsite or lithic reduction workshop overlooking the wide valley at the head of the Hayes Creek valley.
Scope of Possible Impacts from Casino Project: The site is located within a proposed borrow pit and is located above the proposed extension of Freegold Road. This site would be directly impacted by the proposed borrow pit.
Management Recommendations: Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended to include in-fill shovel testing to better determine artifact densities, followed by a series of 1 x 1 m unit block excavations in relationship to the size and distribution of the site.

KdVf-7 (Mooney 2011): This multi-component site was likely used during the Northwest Microblade Tradition and the Proto-historic (post A.D. 1667) period. Located on the Freegold Road Extension and approximately NE of the road alignment on a lower bench on the south-eastern corner of a terrace approximately NE of a tributary to Hayes Creek. This lithic scatter likely represents a moderate density small sized temporary campsite or lithic reduction workshop overlooking the wide valley at the head of the Hayes Creek valley. A Chinese coin was discovered during shovel testing. The Chinese coin was minted in China under the rule of Qing (Ch'ing) dynasty Emperor Sheng Zu (1662-1722 AD). One possible use of the coin may have been as a supplement to Tlingit warriors' armour. Another possibility is that this coin was curated and traded for many years as a token or amulet and deposited in the project area by Chinese placer miners.
Scope of Possible Impacts from Casino Project: The site is located within a proposed borrow pit and very close to the current proposed alignment of the road. This site may be directly impacted by the road construction.
Recommendations: Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended to include in-fill shovel testing to better determine artifact densities followed by a series of 1 x 1 m unit block excavations in relationship to the size and distribution of the site. Additional historical research in regards to possible Chinese placer mining in the project area is also recommended.

KdVf-6 (Mooney 2011): The site is located on the Freegold Road Extension and approximately NE of the road alignment along a banana shaped raised ridge in the Hayes Creek valley overlooking Hayes Creek. This prehistoric site contains lithics, including a project point fragment, and a possible cultural pit or cache feature. The lithic scatter likely represents a moderate density, medium sized, temporary campsite or lithic reduction workshop.
Scope of Possible Impacts from Casino Project: The site is located with the proposed extension of Freegold Road and potential borrow pits. This site will be directly impacted by the road construction.
Management Recommendations: Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended to include in-fill shovel testing to better determine artifact

densities followed by a series of 1 x 1 m unit block excavations in relationship to the size and distribution of the site.

KdVf-5 (Mooney 2011): This lithic site is located along a low bench above a tributary to Hayes Creek. Located approximately NE of the small tributary on the Freegold Road Extension. This small low landform provides a level camp site near water. A small area tested positive for a relatively dense scatter of prehistoric materials. The site is generally limited to the corner of the landform. The lithic scatter likely represents a moderate to high density, small sized, temporary campsite or lithic reduction workshop.
Scope of Possible Impacts from Casino Project: The site is located within the proposed extension of Freegold Road and a previously planned borrow pit. The borrow pit has been dropped but the site will be directly impacted by the road construction.
Management Recommendations: Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended to include in-fill shovel testing to better determine artifact densities followed by a series of 1 x 1 m unit block excavations in relationship to the size and distribution of the site.

KdVf-8 (Mooney 2011): This site is located near the road alignment on a level bench along a descending ridge line, overlooking Hayes Creek. This lithic site is represented by a single flake. The lithic isolate likely represents a low density, small sized temporary campsite, vista, or lithic reduction workshop.
Scope of Possible Impacts from Casino Project: The site was located upslope of a proposed borrow pit which in turn is upslope from the proposed extension of Freegold Road. This site will not be directly impacted by the road construction or borrow pit use.
Management Recommendations: No further work is recommended. However, if borrow pit construction impacts lead to upslope erosion then avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended.

KdVf-10 (Mooney 2011): This prehistoric lithic site located near the road proposed road alignment. This site is on a small knoll at the top of a descending ridge line approximately NE of a small tributary of Hayes Creek. This site is a small knoll and site limits are likely limited by the landform. The lithic scatter likely represents a low density small sized temporary campsite, vista, or lithic reduction workshop.
Scope of Possible Impacts from Casino Project: The site was located upslope of a proposed borrow pit which in turn is upslope from the proposed extension of Freegold Road. This site will not be directly impacted by the road construction or borrow pit use.
Management Recommendations: No further work is recommended. However, if borrow pit construction impacts lead to upslope erosion then avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended.

KdVf-11 (Mooney 2011): This prehistoric lithic site is near the proposed road alignment. It is on a small knoll near the bottom of a descending ridge line approximately NE of a small tributary of Hayes Creek. Artifacts recovered include 2 flakes.

Scope of Possible Impacts from Casino Project: The site was located upslope of a proposed borrow pit which in turn is upslope from the proposed extension of Freegold Road. This site will not be directly impacted by the road construction or borrow pit use.
Management Recommendations: No further work is recommended. However, if borrow pit construction impacts lead to upslope erosion then avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended.

KdVf-9 (Mooney 2011): This prehistoric lithic site is located near the Freegold Road Extension road alignment. It is located on the corner of a bench overlooking the valley approximately SW of a small tributary of Hayes Creek. This lithic scatter is likely limited by the landform but contains a moderate density of lithic materials. This lithic scatter likely represents a low to moderate density small sized temporary campsite, vista, or lithic reduction workshop with a potential ground cache.
Scope of Possible Impacts from Casino Project: The site was located within a proposed borrow pit which was dropped from planning but it is also within the proposed extension of Freegold Road. This site will be directly impacted by the road construction.
Management Recommendations: Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended to include in-fill shovel testing to better determine artifact densities followed by a series of 1 x 1 m unit block excavations in relationship to the size and distribution of the site.

KdVf-14/KdVf-1 (Mooney 2013a): This area was previously noted to include a possible spirit house and grave and was recorded as site KdVf-1 (Gotthardt 1988). Although this area is not currently planned to be impacted by the proposed project, the area was revisited in an attempt to confirm the presence of a spirit house or possible grave for further heritage management. No structural remains or human remains were identified in either area. This rocky knoll along the ridge was briefly tested and found to contain prehistoric lithic materials. The lithic scatter likely represents a temporary campsite or lithic reduction workshop overlooking the Hayes Creek valley.
Scope of Possible Impacts from Casino Project: This site is not located within any planned project impacts.
Management Recommendations: Avoidance of the site is recommended. If this area is planned for any future impacts then additional efforts are recommended to confirm possible grave or spirit house locations with First Nation representatives. A heritage management/data recovery plan should include additional traditional use/traditional knowledge efforts as well as additional shovel testing and possible block excavation.

KdVf-12 (Mooney 2011): This lithic site is located on a narrow point that overlooks the Hayes Creek valley, approximately SW of a small tributary of Hayes Creek. This sloping landform provides a view of the valley and close access to water. This lithic scatter is limited by the landform and contains a low density of lithic materials. It likely represents a low to moderate density small sized temporary campsite, vista, or lithic reduction workshop. Diagnostic materials include a possible microblade core and chalcedony shatter suggesting cultural affiliation with the Northwest Microblade Tradition.
Scope of Possible Impacts from Casino Project: The site appears to be located within the proposed extension of Freegold Road and will be directly impacted by the road construction.

Management Recommendations: Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended to include in-fill shovel testing to better determine artifact densities followed by a series of 1 x 1 m unit block excavations in relationship to the size and distribution of the site.

KeVf-3 (Mooney 2013a): This site is located on a narrow rocky ascending ridge line with a higher and slightly wider, east end. The lithic scatter was identified across the ridge with two pockets of higher concentrations in the middle and east end. The ridge line overlooks the confluence of Selkirk Creek and Hayes Creek and provides a significant vista across the combined valleys. The lithic scatter likely represents multiple moderate to high density small sized temporary campsite(s) or lithic reduction workshop(s). Culturally diagnostic materials consisted of a microblade and a microblade core.
Scope of Possible Impacts from Casino Project: The site is located within a proposed borrow pit for the construction of the proposed extension of Freegold Road and would be directly impacted by these developments.
Management Recommendations: Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended. Data recovery should include additional shovel testing to better determine artifact distribution and density followed by separate loci of 1 x 1 m block excavation. Approximately 20 – 28 square meters of excavation would be recommended based on existing data.

KeVg-5 (Mooney 2011): The lithic site is located on a bench near the proposed Freegold Road Extension. It is on a rounded bench at the bottom of a southeast facing descending ridge which overlooks a tributary to Hayes Creek. This point is also west of the historic steamers/upright boilers site (YHSI 115J/09/002) and was likely along a trail connecting the steamers placer mining site with previously recorded historic cabins at Site KeVg-1. This landform contains a low to moderate density of lithic materials and likely represents a small sized temporary campsite or lithic reduction workshop.
Scope of Possible Impacts from Casino Project: The site was located within a proposed borrow pit and the proposed extension of Freegold Road, however the borrow pit has since been dropped from planning. This site will be directly impacted by road construction.
Management Recommendations: Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended to include in-fill shovel testing to better determine artifact densities followed by a series of 1 x 1 m unit block excavations in relationship to the size and distribution of the site.

KeVg-4 (Mooney 2011): The site is located on a ridge near the proposed Freegold Road Extension. It is on a long southeast facing descending ridge which overlooks a tributary to Hayes Creek. This sloping landform provides good southern exposure and close access to water. This lithic scatter is limited by the landform and contains a moderate density of lithic materials and burned bone. This lithic scatter likely represents a moderate density, medium sized, temporary campsite, vista, or lithic reduction workshop.
Scope of Possible Impacts from Casino Project: The site was located within a proposed borrow pit and upslope of the proposed extension of Freegold Road, however the borrow pit has since been dropped from planning. This site will be upslope, and adjacent to the proposed road construction.
Management Recommendations: Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended to include in-fill shovel testing to better determine artifact

densities followed by a series of 1 x 1 m unit block excavations in relationship to the size and distribution of the site.

KeVg-9 (Mooney 2013a): The site is located on the east facing side of a north-south descending ridge overlooking the confluence of a tributary to Hayes Creek. This site has a lower section and a slightly higher section, both were found to contain prehistoric materials. What appears to be a historic cultural depression is located at the north end of the down slope ridge. A shovel test inside the center of the depression was negative. This depression may have been associated with placer mining activities. The lithic scatter likely represents a low density, medium sized, temporary campsite(s) or lithic reduction workshop(s). No culturally diagnostic materials were identified and it is uncertain when these materials were deposited.
Scope of Possible Impacts from Casino Project: The site is located within the proposed extension of Freegold Road. This site would be directly impacted by road construction.
Management Recommendations: Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended. Data recovery should include additional shovel testing to determine artifact distribution and density followed by 1 x 1 m block excavation. Approximately 8 - 10 square meters of excavation would be recommended based on existing data.

KeVg-7 (Mooney 2011): This lithic site is located on a rounded ridge, within a previously proposed borrow pit of the Freegold Road Extension. The southeast facing corner overlooks both the Selwyn River and Hayes Creek, about 750 m SW of the site. Location provides southern exposure, access to water, and an approximately 300 degree vista. This landform contains a low to moderate density of lithic materials and likely represents a small sized, temporary campsite, and/or vista, or lithic reduction workshop.
Scope of Possible Impacts from Casino Project: The site was located within a proposed borrow pit and upslope from the proposed extension of Freegold Road. The borrow pit has since been dropped from planning, however this site may be impacted by road construction.
Management Recommendations: Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended to include in-fill shovel testing to better determine artifact densities followed by a series of 1x1m unit block excavations in relationship to the size and distribution of the site.

KeVg-8 (Mooney 2013a): This contained a site single lithic flake fragment found along a narrow ascending ridge running southeast up to the northwest. Significant shovel testing along the ridge to the north and south failed to identify any other cultural materials. This ridge drops quickly to the southeast but provides a good southern exposure and a vista to the southeast over Selwyn Creek. This lithic isolate likely represents a low density, small sized, temporary campsite or lithic reduction workshop. No cultural diagnostic materials were identified however this lithic isolate was identified above the White River Tephra and likely represents an Aishihik Phase use of the landform.
Scope of Possible Impacts from Casino Project: This site is located within a proposed borrow pit which in turn is upslope from the proposed extension of Freegold Road. This site will be directly impacted by the borrow pit development.

Management Recommendations: Due to the amount of testing along this landform and in the area of the isolated lithic it is unlikely that additional efforts will add significantly to the understanding of the past use of this landform. No further heritage work for this site is recommended.

KeVg-3 (Mooney 2011): This site is now located within a proposed borrow pit of the Freegold Road Extension. It previously was not in planned 2011 impacts, however since then a proposed borrow covers this area. The site is on a high knoll approximately 1.5 km NW of the confluence between Hayes Creek and the Selwyn River, SW of the Selwyn River. This site is directly below KeVg-6 but unlike that site this landform provides a more protected bench with a rock wall at its back. This slightly raised area of bench contains a moderate to high density of lithic materials dispersed in pockets of level ground, and likely represents a small sized, temporary vista and lithic reduction workshop. The presence of microblade fragments suggests a Northwest Microblade Tradition cultural affiliation.
Scope of Possible Impacts from Casino Project: This site is within a proposed borrow pit and the proposed extension of Freegold Road. This site will be directly impacted by borrow pit use.
Management Recommendations: Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended to include in-fill shovel testing to better determine artifact densities followed by a series of 1 x 1 m unit block excavations in relationship to the size and distribution of the site.

KeVg-6 (Mooney 2011): This prehistoric lithic site is located within a proposed borrow pit north of the proposed Freegold Road Extension. It was previously not within planned impacts in 2011, but since then a proposed borrow covers this area. It is NW of the confluence between Hayes Creek and the Selwyn River. This prehistoric lithic site is located on a narrow ridge with an east-southeast facing aspect which overlooks the Selwyn River far below. This ridge provides southern exposure and a great vista. This landform contains a moderate to high density of lithic materials dispersed in pockets of level ground and likely represents a small sized temporary vista and lithic reduction workshop. Microblade fragments suggest a Northwest Microbade Tradition cultural affiliation.
Scope of Possible Impacts from Casino Project: The site is located within a proposed borrow pit and will be directly impacted by borrow pit use.
Management Recommendations: Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended to include in-fill shovel testing to better determine artifact densities followed by a series of 1x1m unit block excavations in relationship to the size and distribution of the site.

KeVh-3 (Mooney 2011): This site is located near the proposed road alignment of the Freegold Road Extension. It is on the southwest side of a rock outcrop high above the Yukon River between the headwaters of Mascot and Idaho Creeks. This rock outcrop would have provided a break from the wind and weather and a significant vista. This rock outcrop area contains a low density of lithic materials dispersed in pockets of level ground and likely represents a small sized, temporary vista and lithic reduction workshop.
Scope of Possible Impacts from Casino Project: The site appears to be just north of the proposed extension of Freegold Road. This site will not be directly impacted.

Management Recommendations: Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended to include in-fill shovel testing to better determine artifact densities followed by a series of 1x1m unit block excavations in relationship to the size and distribution of the site.

KeVh-4 (Mooney 2013a): This lithic isolate was found on a high elevation stepped rocky bench and outcrop that overlooks the Idaho Creek drainage. This lithic scatter likely represents a low density, small sized temporary campsite, or lithic reduction workshop. No cultural diagnostic materials were identified.
Scope of Possible Impacts from Casino Project: This site is located within a proposed borrow pit for the proposed extension of Freegold Road. This site will be directly impacted by the borrow pit development.
Management Recommendations: Due to the amount of testing along this landform and in the area of the isolated lithic it is unlikely that additional efforts will add significantly to the understanding of the past use of this landform. No further heritage work for this site is recommended.

4.0 HISTORIC STRUCTURES AND RESOURCES ALONG UPGRADE OF FREEGOLD ROAD

This resources were noted in a variety of reports and recorded in a variety of ways. Some were noted as historic roads and trails, while others were recorded as archaeological sites, or recorded as historic resources and recorded with the Yukon Historic Sites Inventory (YHSI). These historic structures and historic resources are presented in order by location along and near the proposed Freegold Road upgrade from Carmacks in the southeast to the proposed mine site in the northwest.

H1 Whitehorse-Dawson Winter Road (Handly and Rousseau 1995): Road was used after the turn of the century as an overland stage coach route for transporting goods and people from Dawson City to Whitehorse. The majority of the Freegold Road follows the old road but is outside of the proposed impact zone but a 2 km section appears to be within the ROW.
Scope of Possible Impacts from Casino Project: Sections of the Whitehorse-Dawson Winter Road are located within the proposed impact zone associated with the Freegold Project. These sections have already been significantly disturbed and/or destroyed during construction of the present Freegold Road. Remaining intact sections of the Winter Road are situated outside of the Freegold Project ROW impact zone. The use of heavy equipment in these areas, and subsequent land-altering activities, such as grading or the ground surface, and tree and ground-cover removal, could potentially impose a threat of adverse impact to these sections of the Whitehorse-Dawson Winter Road.
Management Recommendations: No further mitigation actions required.

H2 Log Structure (Handly and Rousseau 1995): A large almost completely intact log structure located on the alluvial terrace below precontact site KaVa-3. George and Hazel Mack Browns, owners of the Carmacks Roadhouse lived here from 1922-1942.
Scope of Possible Impacts from Casino Project: There are no impacts planned for this structure due to the road realignment around Carmacks.
Management Recommendations: Preferred management option would be to see the site avoided during land altering activities associated with the Freegold Road. If not feasible, Handly and Rousseau "strongly recommend that consultation between Community and Transportation Services and the Village of Carmacks be undertaken prior to the Freegold Project being developed, to determine the historical significance of Site H2 and define the appropriate mitigation procedures that should be implemented." (Handly and Rousseau 1995:52).

H3 Mink/Fox Fur Farm (Handly and Rousseau 1995): A completely destroyed mink/fox fur farm consisting mainly of metal cages and burned wood. Dated to early 20th Century. Completely destroyed from Freegold Road construction.
Scope of Possible Impacts from Casino Project: No impacts are planned for this area due to the road realignment around Carmacks.
Management Recommendations: No further mitigation actions required.

H4 Dalton Trail (Handly and Rousseau 1995): Originally a First Nations trail over the Chilkat Pass to the Yukon River, then became a toll road from 1896-1906. Used to transport cattle, horses, sheep and people from Skagway to Yukon Crossing and then by barge to Dawson City. A small section of the Dalton Trail was noted on a very steep slope on the east side of the Freegold Project impact zone north of Three Mile Lake.
Scope of Possible Impacts from Casino Project: There are no planned impacts to this section of the trail.
Management Recommendations: No further mitigation actions required.

H5 Place Mine Trench (Handly and Rousseau 1995): On the west side of the Freegold Road ROW, where it crosses Murray Creek, there was evidence of very recent placer mining activity. A small placer mine trench and sluice box where located outside the Freegold Project impact zone.
Scope of Possible Impacts from Casino Project: These remains were located outside the proposed impacts to Freegold Road.
Management Recommendations: No further mitigation actions required.

H6 Morrison Road House (Handly and Rousseau 1995): Two completely collapsed log structure along an access road leading from Freegold Road to Stanley Jonathan's fish camp on the Yukon River.
Scope of Possible Impacts from Casino Project: These remains are located outside the proposed impacts to Freegold Road.
Management Recommendations: No further mitigation actions required.

Tricker Cabin (Gotthardt 1995): Al and Ann Tricker's trapline cabin is located at about km 25 of the Freegold Road, about 20 - 30 m south of the Road. The cabin is situated on the north bank of Crossing Creek about 20 m of the creek and about 2 m above the water level. The cabin appears to have been constructed in the 1970's, based on the earliest entry in the journal/guest book left in the cabin: May 1974. The cabin is built from green balsam poplar, and measures about 10 x 12 feet.
Scope of Possible Impacts from Casino Project: The Tricker cabin is about 20 m south of the planned Freegold Road realignment and should escape road construction impacts.
Management Recommendations: Avoidance. No further mitigation actions required (Gotthardt 1995). It is uncertain what impacts the project will have on this cabin, avoidance is recommended.

Fallen Cache Cabin (YHSI 115I/03/002) (Mooney 2013a): These remains consist of a small one course high log cabin outline. These cabin remains are located between the Freegold Road and Seymour Creek. The cabin is approximately 110 m from the creek and can almost be seen from the current roadside. There are no roads or trails that lead directly to or from the cabin. It is unclear it is was unfinished or simply a base for a less permanent structure. There is a fallen high cache located nearby as well as two log lined pits and appears to have been used circa post 1940 AD.
Scope of Possible Impacts from Casino Project: Only the pit features and fallen cache feature of the Fallen Cache Cabin are within the proposed road realignment.
Management Recommendations: It is recommended that construction impacts to these historic structures are avoided, where possible. If these resources are not avoided then additional documentation is recommended prior to construction impacts. This additional documentation should include additional

on-site recording including site mapping and photo-documentation, as well as interviews with First Nation informants and other stakeholders to better document the history and use of the structures.

Dog House Cabin (YHSI 115I/06/012) (Mooney 2013a): The cabin is located between the Freegold Road and Seymour Creek. The cabin is approximately 80 m from the creek just east of a small unnamed tributary. There are no roads or trails that lead directly to or from the cabin. The structure, possible dog house or cache, and outhouse are all in fairly poor condition and appears to have been used circa post 1940 AD.
Scope of Possible Impacts from Casino Project: This cabin is within the planned road realignment and would be directly impacted.
Management Recommendations: It is recommended that construction impacts to these historic structures are avoided, where possible. If these resources are not avoided then additional documentation is recommended prior to construction impacts. This additional documentation should include additional on-site recording including site mapping and photo-documentation, as well as interviews with First Nation informants and other stakeholders to better document the history and use of the structures.

Gas Can Cabin (YHSI 115I/06/010) (Mooney 2013a): The cabin is located between the Freegold Road and Seymour Creek. The cabin is approximately 50 m from the creek and is located directly beside another smaller cabin (Melmac Cabin 115I/06/11). There are no roads or trails that lead directly to or from the cabin. A portion of the gas can roof is fallen in. The rest of the structure seems to be in fairly good condition and appears to have been used circa post 1940 AD.
Scope of Possible Impacts from Casino Project: Appears to be within the planned road realignment and would be directly impacted.
Management Recommendations: It is recommended that construction impacts to these historic structures are avoided, where possible. If these resources are not avoided then additional documentation is recommended prior to construction impacts. This additional documentation should include additional on-site recording including site mapping and photo-documentation, as well as interviews with First Nation informants and other stakeholders to better document the history and use of the structures.

Melmac Cabin (YHSI115I/06/011) (Mooney 2013a): The cabin is located between the Freegold Road and Seymour Creek. The cabin is approximately 50 m from the creek and is located directly beside another larger cabin (Gas Can Cabin 115/I/06/10). There are no roads or trails that deal directly to or from the cabin. The roof is almost completely collapsed and appears to have been used circa post 1940 AD.
Scope of Possible Impacts from Casino Project: Appears to be within the planned road realignment and would be directly impacted.
Management Recommendations: It is recommended that construction impacts to these historic structures are avoided, where possible. If these resources are not avoided then additional documentation is recommended prior to construction impacts. This additional documentation should include additional on-site recording including site mapping and photo-documentation, as well as interviews with First Nation informants and other stakeholders to better document the history and use of the structures.

Ketchup Cabin (YHSI 115I/06/009) (Mooney 2013a): The cabin is located between the current Freegold Road and Seymour Creek. The cabin has a small trail leading towards and away from it, however it is not connected to any currently used roadway. The cabin is approximately 100 m north of Seymour Creek and there are a number of large tree stumps in the surrounding area. The entire cabin is falling apart and only portions of the walls remain and appears to have been used circa post 1940 AD.
Scope of Possible Impacts from Casino Project: Appears to be within the planned road realignment and would be directly impacted.
Management Recommendations: It is recommended that construction impacts to these historic structures are avoided, where possible. If these resources are not avoided then additional documentation is recommended prior to construction impacts. This additional documentation should include additional on-site recording including site mapping and photo-documentation, as well as interviews with First Nation informants and other stakeholders to better document the history and use of the structures.

Three Room Cabin (YHSI 115J/06/013) (Mooney 2013a): The cabin is located between the Freegold Road and Seymour Creek. The cabin is approximately 100 m from the creek and there is a previous placer road that leads directly to the cabin, however it is no longer driveable. The cabin is fully standing and in fairly good condition. The floor is quite unstable but still fairly good and appears to have been used circa post 1940 AD.
Scope of Possible Impacts from Casino Project: Appears to be within the planned road realignment and would be directly impacted.
Management Recommendations: It is recommended that construction impacts to these historic structures are avoided, where possible. If these resources are not avoided then additional documentation is recommended prior to construction impacts. This additional documentation should include additional on-site recording including site mapping and photo-documentation, as well as interviews with First Nation informants and other stakeholders to better document the history and use of the structures.

The Frenchman Cabin (YHSI 115I/06/005) (Mooney 2011, 2012, 2013c): An historic sod roof log cabin. It is associated with a man known locally as "The Frenchman". The cabin has a packed dirt floor and a sod gable roof. The cabin is 13 courses of logs high on the front and back, all logs have been stripped of their bark. Constructed with saddle notched logs and moss chinking. The door is on the south wall and windows are located on the north and west walls. There is a hole in the south wall for a chimney and a cot made out of branches inside. There are names and dates written and inscribed inside the cabin from past use, from 1950 forward.
Scope of Possible Impacts from Casino Project: Near planned road construction but may not be directly impacted.
Management Recommendations: Avoidance, and if not possible, relocation of structure.

Bow Creek Cabins (Mooney 2011, 2012, 2013c): These three cabins were likely constructed in or after the 1970s and they were not recorded with YHSI forms.
Scope of Possible Impacts from Casino Project: Near planned road construction but should not be directly impacted.
Management Recommendations: Avoidance, and if not possible, relocation of structure.

KcVd-2 (possible Harry Baum trapline cabin) (Gotthardt1988): This old trapline cabin belonging to Harry Baum is located just west of confluence of Big Creek and Seymour Creek. The locality is bypassed by the road right-of-way, and was not visited in this survey (Gotthardt 1988).
Scope of Possible Impacts from Casino Project: Said to be located north of approximately km 77+000. Unknown exact location north of planned road construction but will not be directly impacted.
Management Recommendations: No further work required.

KcVd-1 (possible Tommy McGinty trapline cabin) (Gotthardt1988): Old trapline cabin belonging to Tommy McGinty is shown on map compiled by T. Pearse on the left bank of Big Creek, about 2 km above its confluence with Seymour Creek. The locality is outside the road right-of-way and was not visited in this survey (Gotthardt 1988).
Scope of Possible Impacts from Casino Project: Said to be located north of approximately km 78+000. Unknown exact location north of planned road construction but will not be directly impacted.
Management Recommendations: No further work required.

Five Course Cabin (YHSI 115I/06/001) (Mooney 2011, 2012, 2013c): Historic structure appears to be either an incomplete cabin or base structure for a wall tent. The remains of an outhouse are also present.
Scope of Possible Impacts from Casino Project: Near planned road construction but should not be directly impacted.
Management Recommendations: If these resources are not avoided then a limited amount of additional documentation is recommended prior to construction impacts.

Garage by Big Creek (Mooney 2011, 2012, 2013c): This log structure located on the north side of the existing Freegold Road may have been a garage and/or workshop for previous mining efforts and may have been constructed in or after the 1950s. They were not recorded with YHSI forms.
Scope of Possible Impacts from Casino Project: Near planned road construction but should not be directly impacted.
Management Recommendations: If these resources are not avoided then a limited amount of additional documentation is recommended prior to construction impacts.

High Cache Cabin (Mooney 2011, 2012, 2013c): This log cabin and high cache structure are located on the south side of the existing Freegold Road and were not recorded with YHSI forms.
Scope of Possible Impacts from Casino Project: Near planned road construction but should not be directly impacted.
Management Recommendations: If these resources are not avoided then a limited amount of additional documentation is recommended prior to construction impacts, or possible relocation of structure.

Burl Cabin (Mooney 2011, 2012, 2013c): This private cabin is located south of the proposed Freegold Road upgrade and was not recorded with YHSI forms.
Scope of Possible Impacts from Casino Project: Near planned road construction but should not be directly impacted.

Management Recommendations: If these resources are not avoided then a limited amount of additional documentation is recommended prior to construction impacts, or possible relocation of structure.

KcVe-3 (Gotthardt 1988): Reported to be an old grave site approximately in the area of the Casino Trail, just west of a small creek flowing into Big Creek from the north. A grave site was not found although there is an old brush camp adjacent to the proposed road. An old foot trail was also observed. Gotthardt suggests that the likely location for the grave site is on the small hill overlooking Big Creek, most of which has been removed by road construction. Local informant says the graves may belong to Mr. McGinty's grandfather (Chief Joseph McGinty) and another chief.
Scope of Possible Impacts from Casino Project: No impacts are currently planned for this site location and the current ROW is on the opposite (south) side of Big Creek.
Management Recommendations: Traditional and prehistoric sites in the road corridor should be avoided by adjustments to the road alignment if possible. Signs should be developed in consultation wth the Selkirk and Little Salmon/Carmacks First Nations and placed in appropriate locations on the Casino Trail to inform travellers of the history of the country and of its traditional importance to Selkirk people (Gotthardt 1988). Since the current alignment does not come near this location no further work is required.

KcVe-1 (Gotthardt 1988): This is an old grave site previously identified by the Selkirk Band (Land Claims Site S56). Although the site was not visited in the course of the present survey, it is likely located on top of the hill overlooking Big Creek on the north side (Gotthardt 1988).
Scope of Possible Impacts from Casino Project: No impacts are currently planned for this site location.
Management Recommendations: Avoidance of the area, likely location is west of proposed ROW.

KcVe-2 (Gotthardt 1988): This is an old trapline cabin belonging to Stanley Jonathan. This site was not visited during the present survey; judging from the location on the map (complied by T. Pearse and M. Weinstein in interviews with Mr. Jonathan, May 1988), the cabin is on Big Creek, just below the confluence of North Big Creek (Gotthardt 1988).
Scope of Possible Impacts from Casino Project: No impacts are currently planned for this site location.
Management Recommendations: Avoidance of the area, likely location is west of proposed ROW.

KdVf-3 (possible Jimmy Robert's trapline cabin) (Gotthardt 1988): This old trapline cabin is located on a lower bench of a side hill in the upper Hayes Creek area, near the proposed Casino Trail route. The cabin is constructed exclusively of axe cut logs, which suggest it was probably made in the early decades of the twentieth century. In overall dimensions, I would estimate the cabin is about 5 x 5 m, and was probably about 2 m high. Although the walls of the cabin are still intact, the roof has since collapsed into the cabin interior. Associated with the cabin was a mooseskin scraping pole. The pole, which is now charred, is a sharpened stake, about 1 m long, fixed in the ground. It is located about 10 m north of the cabin. About 5 m west of the cabin is a 'dog house' - essentially a small brush camp made for a dog. The trapper using this cabin did not have a dog team, and used his single dog for packing. No cache was observed associated with the cabin; Mr. Wilfred Charlie suggested that the cabin was used only on a temporary basis and otherwise served as a cache when the owners were travelling elsewhere. The old

foot trail to Wellesley Lake and White river was noted about 10 m on below the cabin on a lower bench of the side hill (Gotthardt 1988).
Scope of Possible Impacts from Casino Project: Said to be located east of approximately km 123+500. Unknown exact location east of planned road construction but, may be close to a proposed borrow pit or possible borrow pit access road.
Management Recommendations: The cabin is recommended to be relocated and flagged for avoidance. If avoidance of possible borrow pit or access road is not feasible then additional documentation is recommended.

KdVf-2 (possible log structure, cabin or spirit house) (Gotthardt1988): Attempts to relocated an old log structure reported by survey crew at near the proposed Casino Trail route (Percival 1988:34) were unsuccessful. The structure is located at the toe of a hill and across the stream (on the east side) from Site A. Percival has suggested that the structure may be a cabin or spirit house. The latter interpretation implies the structure is fairly small; I would propose as an alternative interpretation that the log structure is a ground cache, used for storing meat and furs by trappers exploiting the region in the historic period (Gotthardt 1988).
Scope of Possible Impacts from Casino Project: Said to be located east of approximately km 127+600. Unknown exact location east of planned road construction but will not be directly impacted.
Management Recommendations: No further work required.

Steamers/Upright Boilers Site (YHSI 115J/09/002) (Mooney 2011): Historic site consists of two Metal Steamers, two log ladders, eight+ placer pits and cribbed shafts. The boilers are situated in what appears to be an old placer mining site with shafts and open cuts nearby. Dates from 1906 to 1965. According to Mooney (2011), the Upright Boilers Site is very likely associated with the Hayes Creek Cabins (KeVg-1) and are likely connected by a trail system along the west side of the Hayes Creek Valley as mentioned in Soucey et al 2010a.
Scope of Possible Impacts from Casino Project: Now these resources appear to be within the planned ROW and previously they were within a planned borrow pit.
Management Recommendations: Avoidance is recommended. If these resources are not avoided then a limited amount of additional documentation is recommended prior to construction impacts. Relocation of some of these resources may be possible.

Hayes Creek Cabins (YHSI 115J/09/001) aka KeVg-1 (Mooney 2011, 2013a): Located approximately SW of Hayes Creek, SE from the confluence of Hayes and Selwyn Creeks previously recorded as KeVg-1. According to Mooney (2011), the Upright Boilers Site is very likely associated with the Hayes Creek Cabins (KeVg-1) and are likely connected by a trail system along the west side of the Hayes Creek Valley as mentioned in Soucey et al 2010a. Three structures were identified: two single story collapsed log cabins and a smaller log structure that could be a cache. There is a blazed trail that leads to the two cabins from a nearby stream. The cabins are in poor condition and date between 1906 and 1967.
Scope of Possible Impacts from Casino Project: The remains of Hayes Creek Cabins appear to be near, but just outside, the proposed alignment and borrow pit locations. As such these should not be directly impacted by road construction and no further work is recommended.

Management Recommendations: If avoidance is not possible then additional research and documentation is recommended.

AY09-19 Ethnohistoric trail (Mooney 2013; Soucey et al 2010a): A 2 m wide foot trail that traverses northwest-southeast across the northeast facing slope at the confluence of Hayes Creek and the Selwyn River. Extends for a minimum 600 m and is marked by a blazed tree. Historic site KeVg-1 is adjacent to this trail and it may join with AY-09-18.
Scope of Possible Impacts from Casino Project: Portion of trail to potentially be impacted was flagged by Ecofor (2013) with white CMT tape.
Management Recommendations: Impacts to the previously recorded ethno-historic trails are recommended to be avoided and/or minimized where possible. If impacts to these ethno-historic trails can't be avoided then additional background research, on-site recording, and informant interviews to document use of the trails is recommended.

AY-09-18 Ethnohistoric trail (Mooney 2013; Soucey et al 2010a): A 2 m wide foot trail aligned roughly north-south across the northeast facing slope at the confluence of Hayes Creek and the Selwyn River. May be part of the Tutchone Trail followed by Schwatka in 1891 (Soucey et al 2010a). Selkirk First Nation Elders suggested it may be a “Grandfather Trail”, a traditionally used inter-regional trail (Soucey et al 2010a).
Scope of Possible Impacts from Casino Project: Portion of trail to potentially be impacted was flagged by Ecofor (2013) with white CMT tape.
Management Recommendations: Impacts to the previously recorded ethno-historic trails are recommended to be avoided and/or minimized where possible. If impacts to these ethno-historic trails can't be avoided then additional background research, on-site recording, and informant interviews to document use of the trails is recommended.

KeVg-2 (Soucey et al 2010b; Mooney 2013a): A historic culturally modified tree (CMT) site consisting of a modified tree stump on the eastern bank of the Selwyn River. It is on level terrain less than 5 m from the river. The tree appears to have been cut by an adze rather than an axe.
Scope of Possible Impacts from Casino Project: The site is located outside of the project area.
Management Recommendations: No further work is recommended.

5.0 ARCHAEOLOGICAL SITES NEAR PROPOSED MINE SITE, ROAD TO YUKON RIVER, AND ROAD TO AIRSTRIP

Archaeological sites near the proposed mine site, the road to the Yukon River, and the road to the proposed airstrip are listed below.

KeVi-1 (Handly et al 1994; Mooney 2013a; Soucey et al 2010a): Originally recorded by Handly and Martin as a very small prehistoric lithic scatter site, KeVi-1 was revisited by Soucey et al in 2009 and was reported as having been destroyed by trail building activities. It is located on a colluvial ridge above the confluence of Meloy and Casino Creeks and below an access road. Both KeVi-1 and KeVi-2 are located on the same colluvial ridge.
Scope of Possible Impacts from Casino Project: This site was located with the proposed tailings management facility footprint (aka supernatant pond) and has been previously destroyed.
Management Recommendations: No further work is required.

KeVi-2 (Handly et al 1994; Mooney 2013a; Soucey et al 2010a): Originally recorded by Handly and Martin as a very small lithic scatter site, KeVi-1 was revisited by Soucey et al in 2009 and was reported as having been destroyed by trail building activities. It is located on a colluvial ridge approximately above the confluence of Meloy and Casino Creeks and below an access road. Both KeVi-1 and KeVi-2 are located on the same colluvial ridge.
Scope of Possible Impacts from Casino Project: This site was located with the proposed tailings management facility footprint and has been previously destroyed.
Management Recommendations: No further work is required.

KeVi-3 (Handly et al 1994; Mooney 2013a; Soucey et al 2010a): An archaeological site consisting of an isolated surface find (biface fragment) on an existing road. Shovel tests by Handly et al failed to find any other artifacts and a detailed inspection of the site by Soucey et al in 2009 found no other evidence of cultural activity.
Scope of Possible Impacts from Casino Project: This isolated find was located within the proposed mine site footprint.
Management Recommendations: No further work is required.

KeVi-6 (de Guzman et al 2014; Soucey et al 2010a): A prehistoric lithic site consisting of lithics and faunal material. The size of the assemblage and the diversity of material types suggest that KeVi-6 is a small, short-term campsite. The presence of a microblade core rejuvenation flake indicates that microblades were being manufactured at the site. Further testing at the site included two 1 x 1 units in 2013 leading to the recovery of a large number of lithics including microblades and one lancelate projectile point. The assemblage indicates that the site dates to the Little Arm Phase of Early Prehistoric Time Period dating it to between 8, 000 B.P. and 4, 500 B.P.
Scope of Possible Impacts from Casino Project: This site is located outside of planned project impacts.
Management Recommendations KeVi-6 is considered to be adequately sampled relative to the size of the landform and the site boundaries assessed in 2009. No further work is recommended.

KeVi-12 (Mooney 2013a): This prehistoric lithic site is located on a long, very narrow, south descending ridge near the proposed access road to the proposed airstrip. Ridge overlooks Casino Creek Valley at confluence with Brynelson Creek. This rocky ridge likely contains a low density of lithic materials dispersed in pockets of level ground and likely represents a small sized temporary vista and lithic reduction workshop.
Please Note: This Borden number was mistakenly assigned to two sites. This lithic site and an adze cut stump (Soucey et al 2010b). The stump is now part of Site KeVi-9 (Gotthardt personal communication 2014).
Scope of Possible Impacts from Casino Project: The site appears to be within approximately 50 m the proposed access road to the airstrip. This site will not be directly impacted.
Management Recommendations: No further work is recommended.

KeVi-13 (Mooney 2013a): This lithic isolate was found on a high elevation stepped rocky bench and outcrop that overlooks the Casino Creek drainage. This lithic scatter likely represents a low density small sized temporary campsite, lithic reduction workshop. No cultural diagnostic materials were identified.
Scope of Possible Impacts from Casino Project: This site is located within a proposed borrow pit for the proposed construction of the tailings management facility. This site will be directly impacted by the borrow pit development.
Management Recommendations: Due to the amount of testing along this landform and in the area of the isolated lithic it is unlikely that additional efforts will add significantly to the understanding of the past use of this landform. No further heritage work for this site is recommended.

KeVi-14 (Mooney 2013a): Site is located on a high elevation stepped rocky outcrop that overlooks the Casino Creek drainage. This lithic scatter likely represents a medium density small sized temporary campsite, lithic reduction workshop. The biface base shows evidence of basal thinning and edge grinding and appears to have been hafted. It is unlikely that the point base can be used to determine cultural affiliation. Therefore no culturally diagnostic materials were identified.
Scope of Possible Impacts from Casino Project: The site is located just on the north edge of a proposed borrow pit for the proposed construction of the tailings management facility. This site may be directly impacted by borrow pit use and/or access road construction.
Management Recommendations: Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended. Data recovery should include additional shovel testing to better determine artifact distribution and density followed by 1 x 1 m block excavation. Approximately 4 - 6 square meters of excavation would be recommended based on existing data.

KeVi-15 (Mooney 2013a): This site is located on the south-facing edge of a small bench which overlooks Casino Creek valley. The lithic scatter likely represents a moderate to low density small sized temporary campsite or lithic reduction workshop. No culturally diagnostic materials were identified and it is uncertain when these materials were deposited.
Scope of Possible Impacts from Casino Project: The site is located within a proposed borrow pit northeast of the proposed airstrip and would be directly impacted by these developments.

Management Recommendations: Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended. Data recovery should include additional shovel testing to better determine artifact distribution and density followed by 1 x 1 m block excavation. Approximately 4 - 6 square meters of excavation would be recommended based on existing data.

KdVi-1 (de Guzman et al 2014; Handly et al 1994; Mooney 2013a; Soucey et al 2010a): Located at the confluence of Casino Creek and one of its tributaries, this subsurface prehistoric lithic site is interpreted as a small to medium sized, temporary or short-term use, camp site measuring an area of about 50 m x 10 m. A radiocarbon date (3,390 +/- 60 B.P.) from a bone sample places occupation to the Taye Lake Phase of the Northern Archaic Time Period. Handly et al (1994) identified the site as being within or directly adjacent to the proposed impact zones relating to the tailings impoundment areas. In 2013, Altamira (de Guzman et al 2014) conducted excavations and shovel testing expanding the site boundaries and found a high ratio of tools relative to debitage. They identified KdVi-1 to be a highly significant historic resource.
Scope of Possible Impacts from Casino Project: Parts of this site are located within a proposed borrow pit west of the proposed road to the airstrip.
Management Recommendations: Soucey et al (2010a) recommend that the excavation needed to produce a reasonable recovery should be large. Given the high ratio of tools recovered from the southern activity area and the expansion of the northwest activity area, further excavation (up to 20 1-x-1 m units) at KdVi-1 is recommended (de Guzman et al 2014).

KdVi-2 (Mooney 2013a): This site is located along the north-south climbing ridge overlooking the confluence of Casino and Dip Creeks. This large site was found to contain a wide distribution of lithic materials but the lower section appears to hold the greatest concentration of materials, including microblades. The lithic scatter likely represents a large site use area but moderate density temporary campsite(s) or lithic reduction workshop(s) overlooking the valley at the confluence of the creeks. This landform may have been used repeatedly, however; thus far the only culturally diagnostic materials identified consist of microblades, which represent the Little Arm Phase.
Scope of Possible Impacts from Casino Project: The site is located within a proposed borrow pit northeast of the proposed airstrip and would be directly impacted by these developments.
Management Recommendations: Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended. Data recovery should include additional shovel testing to better determine artifact distribution and density followed by separate loci of 1 x 1 m block excavation. Approximately 20 - 28 square meters of excavation would be recommended based on existing data.

KdVi-3 (Mooney 2013a): This site is located at the southwest end of an ascending ridgeline overlooking the confluence of Casino and Dip Creeks. The cultural materials were found on a small level area that provides a significant vista over the valley below. The single positive shovel test contained a significant amount of lithic materials which likely represents a moderate density small sized temporary campsite or lithic reduction workshop. No culturally diagnostic materials were identified and it is uncertain when these materials were deposited.

Scope of Possible Impacts from Casino Project: This small site is located within a proposed borrow pit northeast of the airstrip and would be directly impacted by these developments.
Management Recommendations: Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended. Data recovery should include additional shovel testing to better determine artifact distribution and density followed by 1 x 1 m block excavation. Approximately 4 - 6 square meters of excavation would be recommended based on existing data.

KdVi-4 (Mooney 2013a): This site is situated on a rocky undulating ridge top overlooking the confluence of Dip and Casino Creeks. This landform provides small sections of level ground and a significant vista over the valley area. The lithic scatter likely represents a moderate to low density small sized temporary campsite(s) or lithic reduction workshop(s). No culturally diagnostic materials were identified and it is uncertain when these materials were deposited.
Scope of Possible Impacts from Casino Project: The site is located within a proposed borrow pit northeast of the airstrip and would be directly impacted by these developments.
Management Recommendations: Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended. Data recovery should include additional shovel testing to better determine artifact distribution and density followed by 1 x 1 m block excavation. Approximately 8 - 10 square meters of excavation would be recommended based on existing data.

KdVi-5 (Mooney 2013a): This site is located on a somewhat level ridge top overlooking the confluence of Dip and Casino Creeks. The lithic scatter likely represents a moderate to low density small sized temporary campsite(s) or lithic reduction workshop(s). No culturally diagnostic materials were identified and it is uncertain when these materials were deposited.
Scope of Possible Impacts from Casino Project: The site is located within a proposed borrow pit northeast of the airstrip and would be directly impacted by these developments.
Management Recommendations: Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended. Data recovery should include additional shovel testing to better determine artifact distribution and density followed by 1 x 1 m block excavation. Approximately 6 - 8 square meters of excavation would be recommended based on existing data.

KfVi-2 (de Guzman et al 2014, Soucey et al 2010a): KfVi-2 is an archaeological site located west of the eastern project boundary and south of the Yukon River. It is situated on a flat terrace, on the lowest terrace of the southern bank of the Yukon River, east of the confluence of Britannia Creek and the Yukon River. It consists of fire cracked rock (FCR) and faunal remains and hearth features. The landform has been modified by a 2 m wide road cut or trail that traverses north-south across the landform. The road cut lies 20 m to the west of KfVi-2. In 2014, Altamira completely excavated the hearth feature and noted the disturbance the area receives annually from frost heave and fluvial movements.
Scope of Possible Impacts from Casino Project: This site is located outside project impacts.
Management Recommendations: De Guzman et al (2014) recommend no further work because of the small number of artifacts recovered during the 2013 excavations at KfVi-2. They say that the site is considered to have been adequately sampled and mitigated through the excavations conducted in both 2010 and 2013 (De Guzman et al 2014).

KfVi-3 (de Guzman et al 2014; Soucey et al 2010a): A multi-component site consisting of archaeological and historic components. The historic component includes a poorly preserved wooden structure with an associated depression and scatter of Historic period artifacts. KfVi-3 is estimated to span an area of 1,375 square metres. According to de Guzman et al (2014) the recovered assemblage of the prehistoric component is typical of long-term and repeated occupation, spanning thousands of years: "Radiocarbon dating analysis places occupation to at least three different time periods, in addition to the Historic period occupation identified at the eastern extent of the site. Prehistoric occupation is dated to 1,170 to 1,260 cal BP, 4,650 to 4,830 calBP, and approximately 13,000 cal BP. Therefore, KfVi-3 likely represents continuous and/or repeated occupation that spans 13,000 years, extending throughout various phases and complexes in the Prehistoric period." (de Guzman et al 2014: 104). De Guzman et al consider the site rare, because of the size and extent and the variety of material recovered. They state that many questions remain unanswered because of the small amount of sampling done here.
Scope of Possible Impacts from Casino Project: There are no planned impacts for this site.
Management Recommendations: Continued avoidance of KfVi-3 is recommended. If avoidance is not feasible, Stage 1 excavations of at least a 15% sample are recommended at KfVi-3; this would entail hand excavation of an additional 190 1-x-1 m units. If artifact recovery is limited, excavation could be halted upon discussion with the Heritage Resources Unit.

KfVi-4 (de Guzman et al 2014; Soucey et al 2010a): This site is a small campsite located on a pre-Reid glacio-fluvial terrace on the eastern Britannia Creek valley wall. First identified through shovel testing in 2009, the small prehistoric site yielded a small number of lithic and faunal material. It was reassessed in 2013 through two 1 x 1 m units and additional tests yielded no additional material. It is interpreted as a short-term occupation site.
Scope of Possible Impacts from Casino Project: There are no planned impacts for this site.
Management Recommendations: De Guzman et al (2014) recommend no further work.

KfVi-5 (de Guzman et al 2014; Soucey et al 2010a; Mooney 2013b, 2014): A prehistoric lithic site. The diversity in raw materials suggests the possibility that the site was occupied on multiple occasions as a short-term workshop. Artifacts recovered in 2009 included a microblade fragment and lithic debitage. The microblade fragment suggests a site occupation age during the Little Arm Phase, which dates from 8, 000 B.P. to 4, 500 B.P. Further testing by Altamira in 2013 resulted in recovery of an adze (de Guzman et al 2014). Further archaeological mitigation efforts were conducted by Ecofor under permit 13-18ASR (Mooney 2013b).
Scope of Possible Impacts from Casino Project: There are no planned impacts for this site.
Management Recommendations: Mooney (2013b, 2014) recommends no further work and continued avoidance.

6.0 HISTORIC STRUCTURES AND RESOURCES NEAR PROPOSED MINE SITE, ROAD TO YUKON RIVER, AND ROAD TO AIRSTRIP

The following structures and resources are listed in and around the proposed mine site, the road to the Yukon River and the road to the proposed airstrip.

KeVi-4 (Hanley et al 1994, Soucey et al 2010a): An historic site that was described by Handly et al in 1994 as being demolished or partly obliterated log cabin associated with Euro-Canadian or Historic Native hunting and trapping and dating between 1910 and the early 1940's. Located on a knoll on the east bank of Casino Creek, 8.2 km along an access road leading from the main Casino Exploration Camp, through Dam Site 1 to Heap Leach Site 1. Survey during 2009 by Soucey et al failed to relocate the site.
Scope of Possible Impacts from Casino Project: These partially collapsed remains are located within the proposed tailings management facility footprint.
Management Recommendations: Handly et al recommend no further work if avoidance is not feasible. Soucey et al recommend additional survey and data collection to determine the age and ownership of the cabin.

KeVi-5 (Handly et al 1994; Soucey et al 2010a): An historic cabin located on a flat alluvial terrace above the west bank of Casino Creek and west of where the bulldozer crosses the creek. Cabin is partially collapsed. It dates to before 1936. It is located two kilometres southeast of the recorded location for KeVi-4 (Handly et al 1994). The site was revisited by Soucey et al in 2009 and was found to consist of the remains of a cabin structure.
Scope of Possible Impacts from Casino Project: These partially collapsed remains are located within the proposed tailings management facility footprint.
Management Recommendations: Handly et al (1994) recommend no further work if avoidance is not feasible. Soucey et al (2010a) recommend that in the event that it is determined that site disturbance is likely to occur, it is recommended that additional research and test excavation be carried out.

KeVi-7 (Soucey et al 2010a): A historic cabin that dates to urban development period of the historic era. Located south of the confluence of Canadian Creek and Brittania Creek and east of the western project boundary. The cabin is constructed with axe cut and hand sawn horizontal logs. The maximum height of the surviving walls is 15 logs in height. The cans and the tree cores date use of the cabin to the early 20th century. Given the presence close proximity of the cabin to two possible placer mine pits, it was likely occupied by a placer miner of European descent.
Scope of Possible Impacts from Casino Project: There are no planned impacts for this site.
Management Recommendations: Avoidance is recommended by the current authors. Additional testing at the site is recommended to augment the current knowledge of its placement and use within the historic time period.

KeVi-8 (Soucey et al 2010a): A partially collapsed, historic cabin situated on the south facing slope above Casino Creek. Site consists of one corner of a log cabin. The ownership, age and use of the cabin

are unknown but it likely dates to the late 19th to early 20th century. Located on the east side of Casino Creek, northeast of the confluence of Casino and Nelson Creeks.
Scope of Possible Impacts from Casino Project: This site is located near the tailings storage facility footprint and may be impacted by construction.
Management Recommendations: Avoidance is recommended by the current authors. In the event that it is determined that site disturbance is likely to occur, it is recommended that additional research and test excavation be carried out.

KeVi-9 (Soucey et al 2010a): Is a historic CMT site consisting of a black spruce tree that has been tied into a knot. It is located at the base of a large knoll. KeVi-6 is located on the top of the knoll. The site is thought to represent a marker on a trail that cuts a route between Britannia and Canadian Creeks. The site is dated to 1946 from a dendro-chronological sample. This site number now also includes what Altamira previously recorded as Site KeVi-12 (a possible adze cut stump). This possible adze cut stump was located fairly close to the above noted KeVi-9 CMT.
Please Note: The Borden site number KeVi-12 was also assigned to a small lithic site recorded by Ecofor. After consultation with Ruth Gotthardt the possible adze cut stump has been added to Site KeVi-9, and the lithic site will remain as site KeVi-12 (Gotthardt personal communication 2014).
Scope of Possible Impacts from Casino Project: There are no planned impacts for this site KeVi-9.
Management Recommendations: Avoidance is recommended by the current authors. In the event that it is determined that site disturbance is likely to occur, additional consideration and research is warranted to determine site value. Further consultation and research with local informants could provide additional information about the site and its association with an existing trail.

KeVi-10 (Soucey et al 2010a): A historic site consisting of a collapsed wooden framework found at the base of a spruce tree. It may have served as a platform or hunting blind. A small piece of plywood was near the framework. The site is on the west side of a quad trail paralleling Canadian Creek.
Scope of Possible Impacts from Casino Project: There are no planned impacts for this site.
Management Recommendations: Avoidance is recommended by the current authors. Site is located within the Canadian Creek valley, an area that may be impacted during project developments. In the event that it is determined that site disturbance is likely to occur, additional consideration and research is warranted to determine site value.

KeVi-11 (Soucey et al 2010a): An historic period site consisting of an ethno-historic hide working frame piece found on the north side of Nelson Creek.
Scope of Possible Impacts from Casino Project: There are no planned impacts for this site.
Management Recommendations: Avoidance is recommended by the current authors. Site is located within the Nelson Creek valley, an area that may be impacted during project developments. In the event that it is determined that site disturbance is likely to occur, additional consideration and research is warranted to determine site value.

KfVi-6 (Soucey et al 2010a): An historic cabin located on a bench overlooking the Yukon River to the north. It is located south of the Yukon River east of the current barge landing. It has been preliminarily associated with a known early inhabitant of the study area.
Scope of Possible Impacts from Casino Project: There are no planned impacts for this site.
Management Recommendations: Avoidance is recommended by the current authors. There is potential for additional materials to be recovered and additional research may confirm the cabin's owner(s). Additional investigation is warranted for this historic era site.

KfVi-7 (Soucey et al 2010a): An archaeological site that consists of an isolated modified ungulate metatarsal. The metatarsal shows evidence that it was used as an end scraper. The end scraper was found in a context next to the river; it is possible it may have been deposited during a flood event. It is possible that this site is associated with an ethno-historic site (KfVi-10) located nearby.
Scope of Possible Impacts from Casino Project: There are no planned impacts for this site.
Management Recommendations: Avoidance is recommended by the current authors. There is potential for additional information to be recovered from the site area. Thus, additional archaeological investigation of the two site area is warranted.

KfVi-8 (Soucey et al 2010a): An historic period site consisting of the remains of a tent campsite that may be associated with placer mining. The site is located directly east of Britannia Creek.
Scope of Possible Impacts from Casino Project: There are no planned impacts for this site.
Management Recommendations: Avoidance is recommended by the current authors. In the event that it is determined that site disturbance is likely to occur, additional consideration and research is warranted to determine site value and specific mitigation options. Further research and consultation with local informants could provide additional information about the site and its association with placer mining activities in the valley.

KfVi-9 (Soucey et al 2010a): An historic period site consisting of a partially buried wooden object. Located on the south bank of the Yukon River and east of the project boundary. The origin, date and use of the wooden object have are unknown. Preliminary interpretations suggest an association with human burial remains.
Scope of Possible Impacts from Casino Project: There are no planned impacts for this site.
Management Recommendations: Avoidance is recommended by the current authors. In the event that it is determined that site disturbance is likely to occur, additional consideration and research is warranted to determine site value and specific mitigation options. Further research and consultation with local informants is warranted to establish its origin, use and possible cultural relationship.

KfVi-10 (Soucey et al 2010a): An historic site consisting of a single item, a hide-working frame that was found on the south bank of the Yukon River and east of the western project boundary.
Scope of Possible Impacts from Casino Project: There are no planned impacts for this site.
Management Recommendations: Avoidance is recommended by the current authors. No management recommendations were given except that additional consideration and research could determine its value in terms of ownership and relationship to other sites or cultural activities in the area.

KfVi-11 (Soucey et al 2010a): A CMT site consisting of tree stump and pole that were used for hide-working. It has been identified as ethnohistoric. Site is located on a glacio-fluvial terrace above Britannia Creek. The site is west of the east project boundary east of archaeology site KfVi-4.
Scope of Possible Impacts from Casino Project: There are no planned impacts for this site.
Management Recommendations: Avoidance is recommended by the current authors. No management recommendations were given except that additional consideration and research is warranted to determine its value in terms of ownership and relationship to other sites or cultural activities in the area.

KfVi-12 (Soucey et al 2010b): The site consists of a birch tree that has had bark stripped for traditional use activities. The birch tree measures 1.5 m in height and 15 cm in diameter. The tree is dead and the top has broken off. The site is evidence for traditional use activities along the Yukon River near Britannia Creek. No date has been assigned to the tree.
Scope of Possible Impacts from Casino Project: There are no planned impacts for this site.
Management Recommendations: Avoidance is recommended by the current authors. Further research and consultation is recommended (Soucey et al 2010b).

KfVi-13 (Soucey et al 2010b): The site consists of a birch tree that has had bark stripped for traditional use activities. The birch tree is still living and only a small, 25 cm wide swatch of bark has been removed from the mid-lower portion of the tree. The site is evidence for traditional use activities along the Yukon River near Britannia Creek. No date has been assigned to the tree.
Scope of Possible Impacts from Casino Project: There are no planned impacts for this site.
Management Recommendations: Avoidance is recommended by the current authors. Further research and consultation is recommended (Soucey et al 2010b).

KfVi-14 (Soucey et al 2010b): The site consists of a spruce tree that has had a cambium strip removed. The strip is 50 cm high by 15 cm wide and the scar is 10 cm deep. Two shallow cut marks were noted at the top of the scar. A core sample was taken from the tree, however several large knots were cored through; therefore, it was not possible to determine when the cambium stripping took place. The site is evidence for traditional use activities along the Yukon River near Britannia Creek. No date has been assigned to the tree.
Scope of Possible Impacts from Casino Project: There are no planned impacts for this site.
Management Recommendations: Avoidance is recommended by the current authors. Further research and consultation is recommended (Soucey et al 2010b).

7.0 PREVIOUSLY NOTED FIRST NATION USE SITES ALONG FREEGOLD ROAD

Handly and Rousseau collected information regarding these First Nation use sites (abbreviated FN's) while conducting assessment along the previously identified planned upgrade to the Freegold Road (Handly and Rousseau 1995). This are listed below in order from Carmacks heading northwest towards the proposed mine site.

FN1: May Roberts indicated that a First Nation Traditional Brush Camp was located at the northern end of Three Mile Lake, approximately west of present Freegold Road.
Scope of Possible Impacts from Casino Project: There are no planned impacts for this site.
Management Recommendations: No further work required, but perhaps keep access to area open from Freegold Road.

FN2: At the head of a narrow valley past Three Mile Lake, LSCFN peoples used to stop at a spring for water on their way to, or from fishing and hunting camps.
Scope of Possible Impacts from Casino Project: This camp is located near the proposed ROW but there are no planned impacts for this site.
Management Recommendations: No further work required, but perhaps keep access to area open from Freegold Road.

FN3: May Roberts indicated that there was a traditional First Nations trail which began at km 5.0 on the present Freegold Road. It continued behind Mount Miller to several lakes, and from there to approximately km 24.0 on the Freegold Road. The trail was recently upgraded by several members of the LSCFN. An information plaque had been erected on the present Freegold Road, but at the time of our survey, the plaque had been knocked over. This 'bypass trail' joined the Agate Trail (FN 8 below), providing access to lithic raw material source areas, as well as access to fall hunting campsites at several lakes along the trail. The trail is situated 1 to 2 km west of the present Freegold Road.
Scope of Possible Impacts from Casino Project: There are no planned impacts for this site.
Management Recommendations: No further work required, but perhaps keep access to area open from Freegold Road.

FN4: May Roberts stated that a prominent knoll, situated near the proposed Freegold Road Project ROW, was used as a caribou monitoring station. The knoll overlooks a bend in the Yukon River where the Forty Mile Caribou Herd previously forded the Yukon River. When the caribou herds were sighted, hunters would descend to the river, get into their canoes, and kill caribou as they swam across the river. FN 4 is situated outside the proposed Freegold Project impact zone.
Scope of Possible Impacts from Casino Project: This knoll is likely within a proposed borrow pit.
Management Recommendations: If it is within the proposed borrow pit, it would be required to be assessed prior to impacts.

FN5: May Roberts Fish Camp is located at km 7.1 of the Freegold Road ROW. This large site (20 m N/S by 20 m E/W) consists of four walled tent-frame structures and two large, covered fish drying racks 5 to 10 m back from the banks of the Yukon River.
Scope of Possible Impacts from Casino Project: There no planned impacts for this site.
Management Recommendations: No further work required, but perhaps keep access to area open from Freegold Road.

FN6: Stanley Jonathan's Fish Camp is a medium sized (15 m N/S by 10 m , Chinook salmon fishing camp was identified by May Roberts at km 9.8 on the Freegold Road.
Scope of Possible Impacts from Casino Project: There no planned impacts for this site.
Management Recommendations: No further work required, but perhaps keep access to area open from Freegold Road.

FN7: The start of the Agate Trail (Mount Miller Gem and Mineral Trail) is located at km 13.7 on the present Freegold Road.
Scope of Possible Impacts from Casino Project: There no planned impacts for this site.
Management Recommendations: No further work required, but perhaps keep access to area open from Freegold Road.

FN8: A small (3 m N/S by 3 m W/E), First Nations traditional hunting and trapping camp was located at km 13.7, approximately 5 m to the east of the proposed Freegold Road Project ROW, where the Agate Trail and present Freegold Road intersect. May Roberts said this used to be Jessie Wolf's hunting and trapping camp.
Scope of Possible Impacts from Casino Project: There no planned impacts for this site.
Management Recommendations: We strongly recommend that the First Nation traditional cultural material remaining at this site be systematically collected by representatives of the LSCFN prior to construction of the proposed Freegold Road (Handly and Rousseau 1995 - may no longer exist).

FN9: The remains of a small (2 m N/S by 2 m N/S), First Nation traditional bush camp was observed around the base of a large, White Spruce tree that had been felled within the Proposed Project ROW at km 15.8. The camp was noted late in the afternoon on October 5, but by morning of the next day the White Spruce tree had been felled by workmen clearing the Freegold Road impact zone.
Scope of Possible Impacts from Casino Project: This camp area was adjacent to the proposed Freegold Road ROW.
Management Recommendations: No further work recommended.

FN10: A medium sized (10 m N/S by 6 m W/E) First Nations traditional fur trappers camp was noted at km 19.9), approximately 5 m outside the western edge of the proposed Freegold Project ROW. A brush lean-to, and a collapsed, rectangular tent-frame structure were noted, as well as four stoves and associated stovepipes, assorted hide stretchers, sawhorses, boots, saws, files, pots, pans, firewood and scattered

refuse. May Roberts indicated that this was originally Edward Charlie's trapping camp, but that now it was within Larry Tricker's (#150) trapline territory.
Scope of Possible Impacts from Casino Project: This camp area was adjacent to the proposed Freegold Road ROW.
Management Recommendations: We strongly recommend that the First Nation traditional cultural material remaining at this site be systematically collected by representatives of the LSCFN prior to construction of the proposed Freegold Road (Handly and Rousseau 1995 - may no longer exist).

Previous field efforts also recorded an additional modern cabin, and five trap trees near the existing Freegold Road (Mooney 2013a). These modern resources are noted here due to expected interests of current stakeholders. The modern cabin is located just above the existing Freegold Road and on the edge of a proposed borrow pit at what was previously known as "Mile 40" and currently at about 62 km on current project mapping. Due to the relatively modern age of this cabin it was not recorded with YHSI.

This cabin was constructed of milled lumber with a plywood exterior and a metal roof. This cabin is not anticipated to be impacted by borrow pit or road realignment but it is on the south edge of a proposed borrow pit and access to the cabin may be affected during construction.



Figure 2. Modern cabin looking southeast and a sample trap tree south of Freegold Road.

Five trap trees were noted along the south side of the existing Freegold Road between approximately 37 and 50 km of the current 2013 project mapping. Only a sample of them is shown above and not all will be impacted by the proposed realignments of Freegold Road.

No further heritage work is recommended for these moveable traps but consultation with the trapline holder(s) is recommended.

8.0 SUMMARY AND CONCLUSIONS

The proposed Casino Mine project and ancillary facilities consist of: proposed upgrades to the Freegold Road from the Klondike Highway to the mine site (including the proposed by-pass around Carmacks); road and infrastructure improvements from the mine site to the Yukon River; and road and airport construction to the southwest of the mine site. This summary presents what heritage resource impact assessment work remains to be completed, and which heritage resources are to be managed prior to and during construction. Overall there are fifty (50) known archaeological sites and forty-seven (47) known historic structures or historic resources that must be managed in relation to this project. These totals are further broken down by location along the proposed Freegold Road from the Klondike Highway to the proposed mine site, and from the mine site itself and access roads to the Yukon River and to the proposed airstrip. These are in addition to ten (10) previously recorded First Nation use sites. These are summarized below.

The heritage resource impact assessment remaining to be completed consists of seventeen (17) proposed borrow pits and approximately 7.45 km of ROW between the Klondike Highway and km 33+000, as well as, access roads to borrow pits, and any future additions of borrow pits or other ancillary components, or road re-alignments.

Some borrow pits are directly adjacent to the proposed ROW and do not require a separate access road to move borrow materials to the construction ROW. Other proposed borrow pits are not adjacent to the ROW, and will require access roads between the borrow pit and the ROW. No access roads for borrow pits have been specifically assessed (only in a few cases have approximate location of access roads been assessed). Each of the proposed borrow pits, that require an access road, will have to have their respective access road assessed.

There are thirty-three (33) known archaeological sites to be managed between the Klondike Highway and the mine site, along the proposed Freegold Road upgrade. These sites from Carmacks to mine site consist of: KaVb-17, KaVa-3, KaVb-1, KaVb-2, KbVb-2, KbVb-4, KbVb-3, KcVd-3, KcVe-4, KcVf-2, KcVf-3, KeVf-1, KdVf-4, KdVf-13, KdVf-7, KdVf-6, KdVf-5, KdVf-8, KdVf-10, KdVf-11, KdVf-9, KdVf-14 (a.k.a. KdVf-1), KdVf-12, KeVf-3, KeVg-5, KeVg-4, KeVg-9, KeVg-7, KeVg-8, KeVg-3, KeVg-6, KeVh-3, and KeVh-4. Each of these sites must be managed on a site by site basis. This management effort will ensure that the site boundaries are clearly marked. Management options range from avoiding impacts, minimizing impacts, to mitigating impacts with detailed data recovery excavations. Where engineering plans changes, these sites must be reviewed for possible impacts as per the Heritage Resource Management Plan (Mooney 2013b).

There are thirty-one (31) historic structures and/or historic resources to be managed along the proposed Freegold Road upgrade. From Carmacks to the mine site these include: H1 Whitehorse-Dawson Winter Road, H2 log structure, H3 mink fox farm, H4 Dalton Trail, H5 Place Mine, H6 Morrison Road House, Tricker Cabin, Fallen Cache Cabin, Dog House Cabin, Gas Can Cabin, Melmac Cabin, Ketchup Cabin, Three Room Cabin, Frenchman Cabin, Bow Creek Cabins, KcVd-2, KcVd-1, Five Course Cabin, Garage by Big Creek, High Cache Cabin, Burl Cabin, KcVe-3, KcVe-1, KcVe-2, KdVf-3, KdVf-2, Steamers/Upright Boilers, KeVg-1 (a.k.a. Hayes Creek Cabins), trail AY09-19, trail AY09-18, and KeVg-2. Specific recommendations vary on a resource by resource basis but where possible flagging and

avoidance is the first recommendation. Additional documentation and research is recommended for some resources, and if possible relocation of some resources is recommended. Where engineering plans changes, these sites must be reviewed for possible impacts as per the Heritage Resource Management Plan (Mooney 2013b).

There are seventeen (17) known archaeological sites to be managed near the mine site, road to the Yukon River, and road and airstrip to the southwest. These sites are KeVi-1, KeVi-2, KeVi-3, KeVi-6, KeVi-12 (lithic only CMT was reassigned to site KeVi-9), KeVi-13, KeVi-14, KeVi-15, KdVi-1, KdVi-2, KdVi-3, KdVi-4, KdVi-5, KfVi-2, KfVi-3, KfVi-4, and KfVi-5. Each of these sites must be managed on a site by site basis. This management effort will ensure that the site boundaries are clearly marked. Management options range from avoiding impacts, minimizing impacts, to mitigating impacts with detailed data recovery excavations. Where engineering plans changes, these sites must be reviewed for possible impacts as per the Heritage Resource Management Plan (Mooney 2013b).

There are sixteen (16) historic structures and/or historic resources to be managed near the mine site, road to the Yukon River, and road and airstrip to the southwest. These are: KeVi-4, KeVi-5, KeVi-7, KeVi-8, KeVi-9, KeVi-10, KeVi-11, KfVi-6, KfV-7, KfVi-8, KfVi-9, KfVi-10, KfVi-11, KfVi-12, KfVi-13, and KfVi-14. Specific recommendations vary on a resource by resource basis but where possible flagging and avoidance is the first recommendation. Additional documentation and research is recommended for some resources, and if possible relocation of some resources is recommended. Where engineering plans change, these sites must be reviewed for possible impacts as per the Heritage Resource Management Plan (Mooney 2013b).

There are ten (10) previously recorded First Nation use sites along the Freegold Road. These sites consist of FN 1 brush camp, FN 2 natural spring, FN 3 traditional trail, FN 4 look out site, FN 5 May Robert's fish camp, FN 6 Stanley Jonathan's fish camp, FN 7 Agate Trail, FN 8 small hunting and trapping camp, FN 9 small bush camp, and FN 10 trappers camp. Individual recommendations are provided on a site by site basis.

Along with these modern resources, there was also another cabin identified at approximately 62 km on current project mapping. Due to the relatively modern age of this cabin it was not recorded with YHSI. There were also five trap trees recorded along the existing Freegold Road. No further heritage work is recommended for these moveable traps but consultation with the trapline holder(s) is recommended.

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1995 *Archaeological Salvage of KbVb-2 and Archaeological Impact Assessment of the Area West of KaVb-1 on the Freegold Road, near Carmacks, Central Yukon.*. Permit No. 95-2ASR. Report prepared for the Government of Yukon, Community and Transportation Services, Transportation and Engineering Branch, Whitehorse, YT.

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1995 *An Archaeological Impact Assessment for Community and Transportation Services (Yukon Territorial Government) Proposed Freegold Road Upgrading and New Realignments (KM 0-20) Near Carmacks, Yukon.* Permit No. 99-22ASR. Report prepared for Heritage Branch-Yukon Tourism, Whitehorse.

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2012 *Historic Resource Impact Assessment of the Combined Northern Freegold Resources 2011 Exploration Program (Tinta Hill, Freegold, Nucleus, and Revenue Properties.* Permit No. 11-13ASR. Prepared for Northern Freegold Resources Ltd. On file with the Yukon Heritage Branch.

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2013b Interim Heritage Resources Management Plan for the Casino Mine Project. Report prepared for Casino Mining Corporation, Vancouver, BC.

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Soucey, Kristin, Bruce Ball, Alice Storey, and Sheila Greer

2010a 2009 *Historical Resource Assessment Western Copper Corporation Casino Project.* Permit No. 9-09ASR. Prepared on behalf of Western Copper Corporation by Altamira Consulting Ltd., Edmonton.

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2010b *Historical Resource Assessment Britannia Creek Road Re-Alignment – Casino Project Western Copper Corporation*. Permit No. 10-04ASR. Prepared on behalf of Western Copper Corporation by Altamira Consulting Ltd., Edmonton.

APPENDIX I: PROJECT MAPPING

CASiNO

PROPOSED EXTENSION OF FREEGOLD ROAD

ARCHAEOLOGICAL IMPACT ASSESSMENT MAP 1

Map Projection: NAD 83, UTM Zone 8
NTS Mapsheet: 115-I-1/2
Date: December 4, 2014

N

500 0 500 1000 1500

Meters

Scale: 1:50,000

LEGEND

- Waterbody
- Wetland
- Stream
- Contour
- Logging Road
- Proposed Road Alignment
- Propoed Borrow Pit
- Road Meter Marker
- Terrain Polygon

Archaeological Information

- Assessed Area
- Remaining Areas to be Assessed

Land Use Information

- First Nation Settlement Lands

First Nation Settlements

- Little Salmon/Carmacks First Nation

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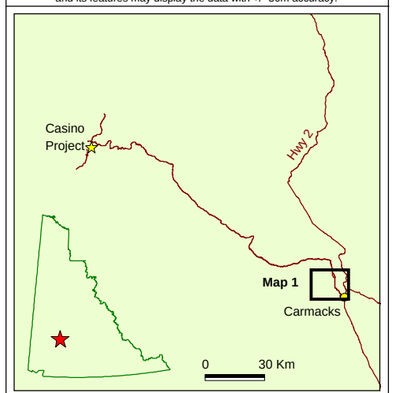

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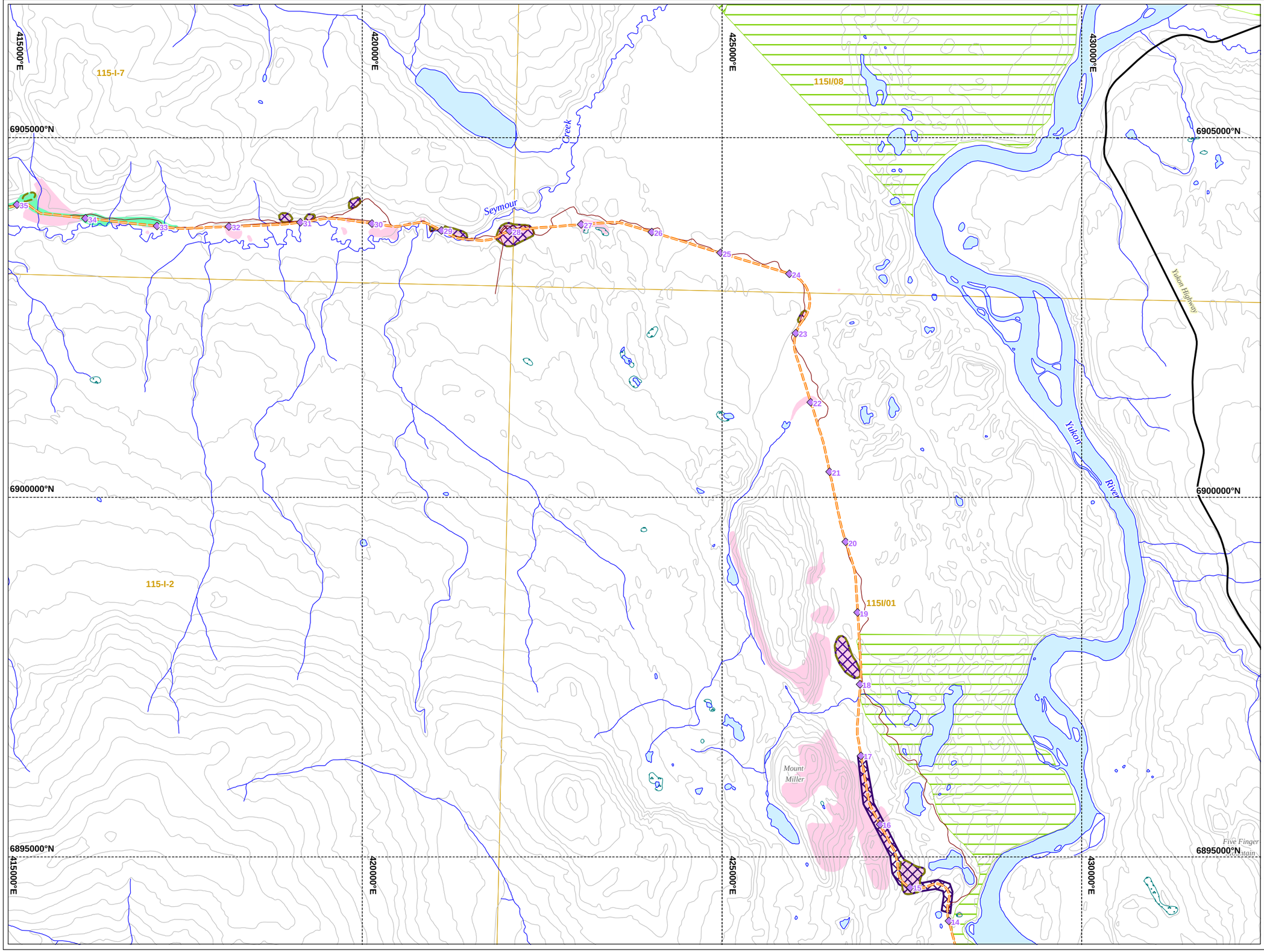
6895000°N
6890000°N
6885000°N
420000°E
425000°E
430000°E
435000°E
Five Finger Mountain
Yukon River
Murray Creek
Yukon Highway
115-I-2
115I/01
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0



CASiNO

PROPOSED EXTENSION OF FREEGOLD ROAD

ARCHAEOLOGICAL IMPACT ASSESSMENT MAP 2

Map Projection: NAD 83, UTM Zone 8
NTS Mapsheet: 115-I-1/2/7/8
Date: December 4, 2014

N

500 0 500 1000 1500
Meters
Scale: 1:50,000

LEGEND

- Waterbody
- Wetland
- Stream
- Contour
- Logging Road
- Proposed Road Alignment
- Proposed Borrow Pit
- Road Meter Marker
- Terrain Polygon

Archaeological Information

- Assessed Area
- Remaining Areas to be Assessed

Land Use Information

- First Nation Settlement Lands

First Nation Settlements

- Little Salmon/Carmacks First Nation

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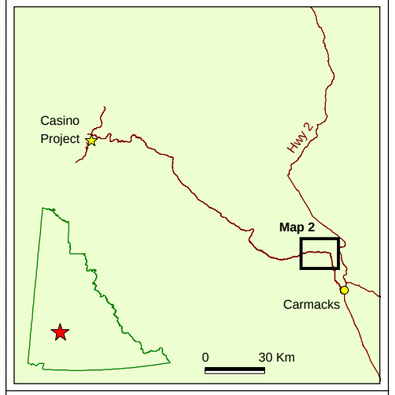

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405000°E
410000°E
415000°E
6905000°N
6900000°N
6896500°N
115-I-7
115-I-2
Creek
Seymour
35
34
33
32
31
36
37
38
39
40
41
42
43
44
45
46
47
48
49

CASiNO

PROPOSED EXTENSION OF FREEGOLD ROAD

ARCHAEOLOGICAL IMPACT ASSESSMENT MAP 3

Map Projection: NAD 83, UTM Zone 8
NTS Mapsheet: 115-I-2/7
Date: December 4, 2014

N

500 0 500 1000 1500
Meters
Scale: 1:50,000

LEGEND

- Waterbody
- Wetland
- Stream
- Contour
- Road
- Proposed Road Alignment
- Proposed Borrow Pit
- Road Meter Marker

Archaeological Information

- Assessed Area
- Remaining Areas to be Assessed

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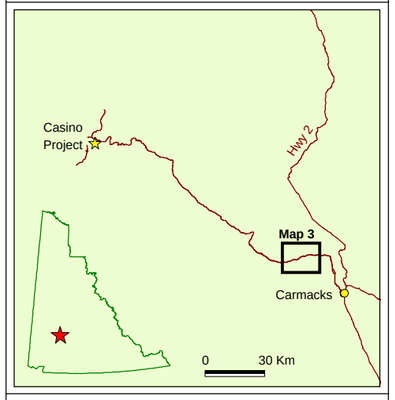

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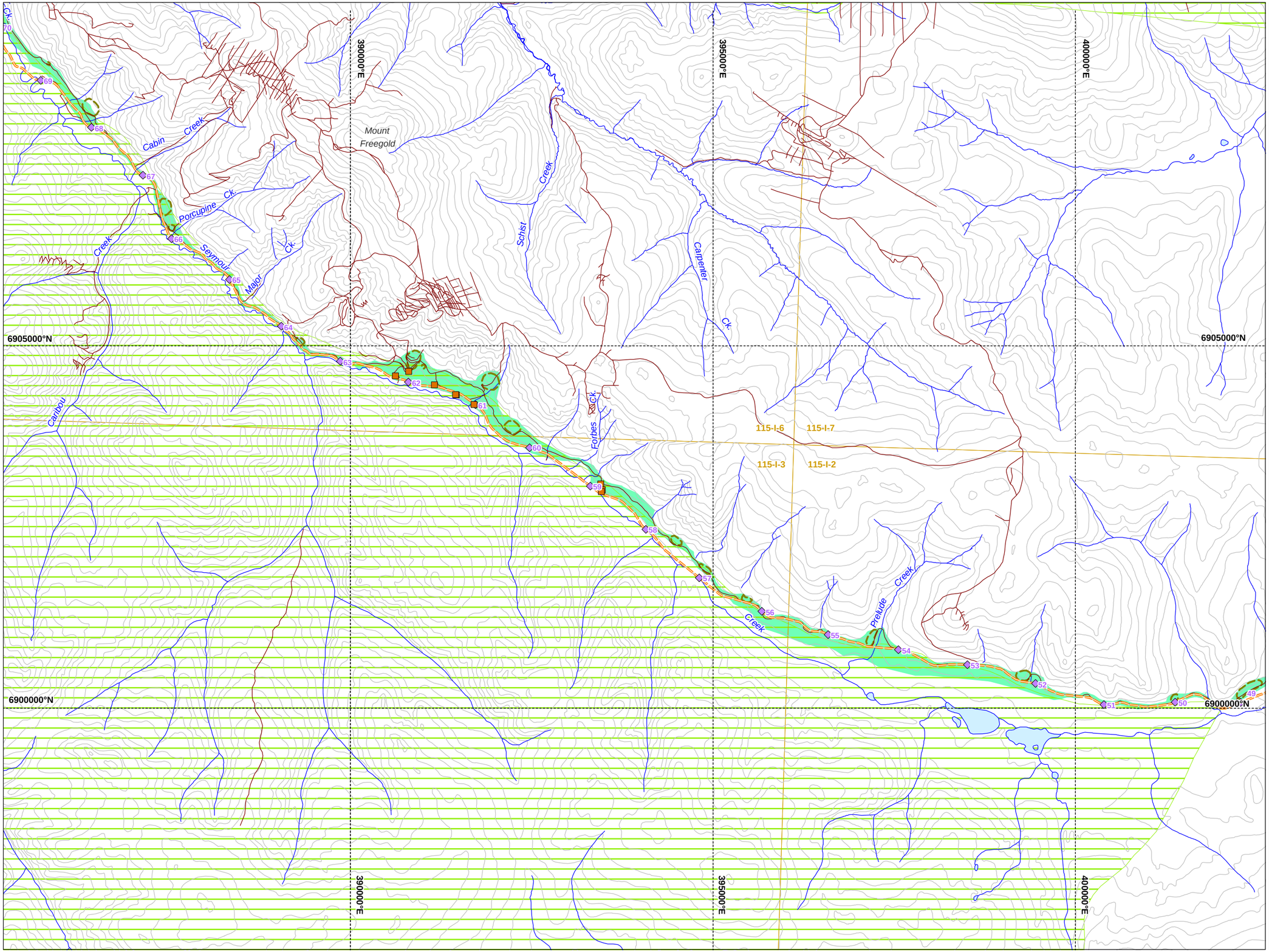

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PROPOSED EXTENSION OF FREEGOLD ROAD

ARCHAEOLOGICAL IMPACT ASSESSMENT MAP 4

Map Projection: NAD 83, UTM Zone 8
NTS Mapsheet: 115-I-2/3/6/7
Date: December 4, 2014

N

500 0 500 1000 1500
Meters
Scale: 1:50,000

LEGEND

- Waterbody
- Wetland
- Stream
- Contour
- Road
- Proposed Road Alignment
- Proposed Borrow Pit
- Road Meter Marker

Archaeological Information

- Assessed Area
- Historic Structure

Land Use Information

First Nation Settlements

- Little Salmon/Carmacks First Nation

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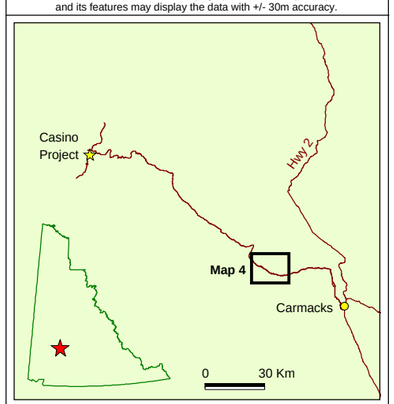

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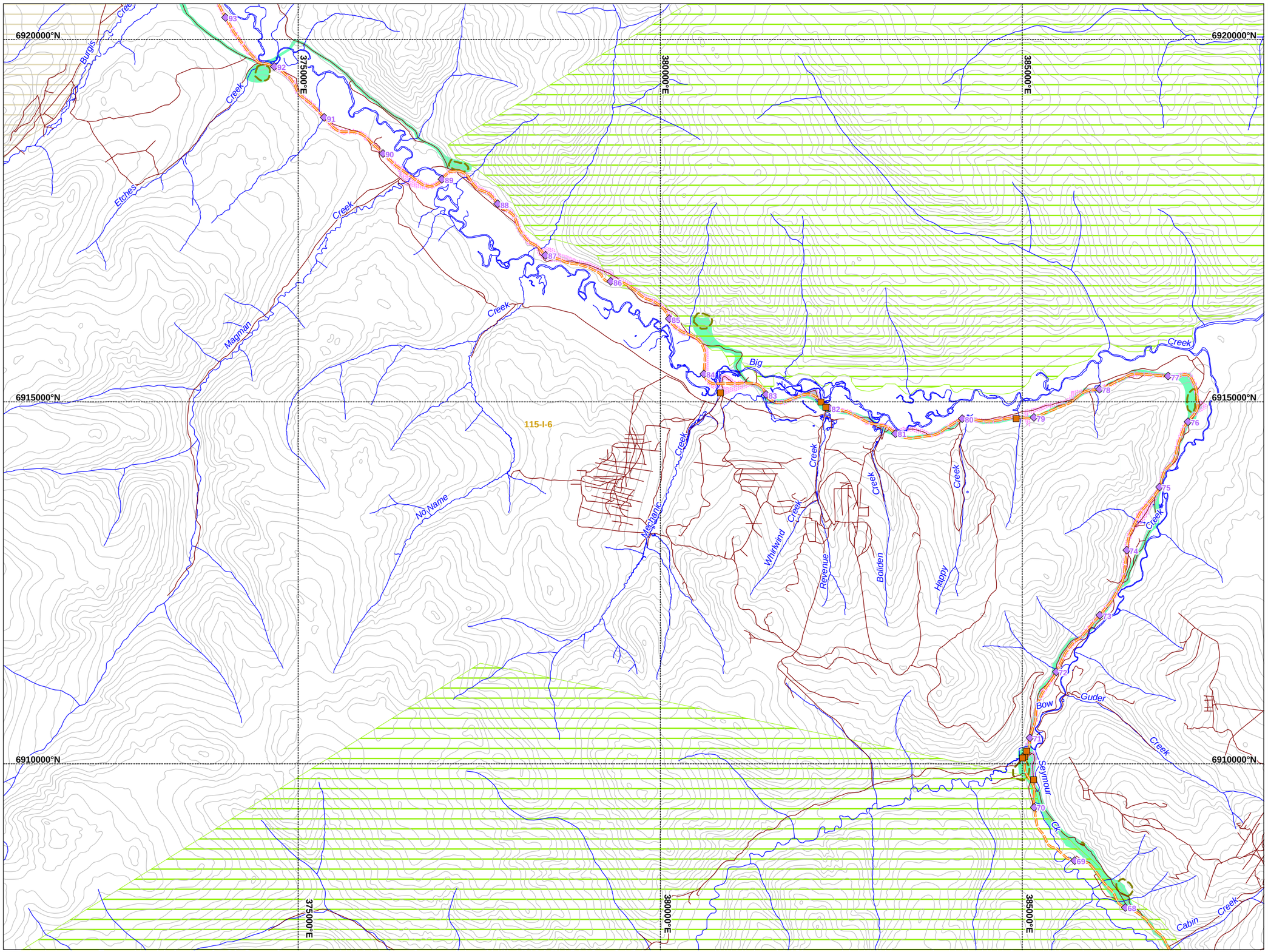

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PROPOSED EXTENSION OF FREEGOLD ROAD

ARCHAEOLOGICAL IMPACT ASSESSMENT MAP 5

Map Projection: NAD 83, UTM Zone 8
NTS Mapsheet: 115-I-6
Date: December 4, 2014

N

500 0 500 1000 1500
Meters
Scale: 1:50,000

LEGEND

- Waterbody
- Wetland
- Stream
- Contour
- Road
- Proposed Road Alignment
- Proposed Borrow Pit
- Road Meter Marker

Archaeological Information

- Assessed Area
- Previously Assessed Area
- Historic Structure

Land Use Information

First Nation Settlements

- Little Salmon/Carmacks First Nation
- Selkirk First Nation

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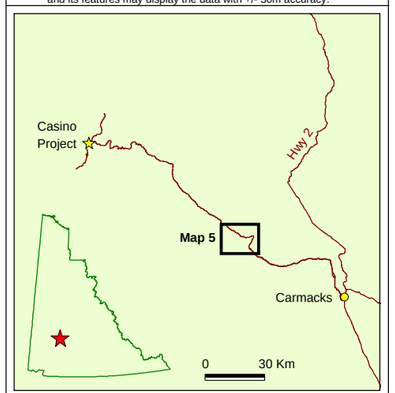

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PROPOSED EXTENSION OF FREEGOLD ROAD

ARCHAEOLOGICAL IMPACT ASSESSMENT MAP 6

Map Projection: NAD 83, UTM Zone 8
NTS Mapsheet: 115-I-5/6
Date: December 4, 2014

N

500 0 500 1000 1500
Meters
Scale: 1:50,000

LEGEND

- Waterbody
- Wetland
- Stream
- Contour
- Road
- Proposed Road Alignment
- Proposed Borrow Pit
- Road Meter Marker

Archaeological Information

- Assessed Area
- Previously Assessed Area

Land Use Information

First Nation Settlements

- Selkirk First Nation

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360000°E
365000°E
370000°E
375000°E
6930000°N
6925000°N
6920000°N
115-I-5
115-I-6
Big Creek
Burgs Creek
Creek

CASiNO

PROPOSED EXTENSION OF FREEGOLD ROAD

ARCHAEOLOGICAL IMPACT ASSESSMENT MAP 7

Map Projection: NAD 83, UTM Zone 8
NTS Mapsheet: 115-I-12
Date: December 4, 2014

N

500 0 500 1000 1500
Meters
Scale: 1:50,000

LEGEND

- Waterbody
- Wetland
- Stream
- Contour
- Road
- Proposed Road Alignment
- Proposed Borrow Pit
- Road Meter Marker

Archaeological Information

- Assessed Area
- Previously Assessed Area
- Historic Structure

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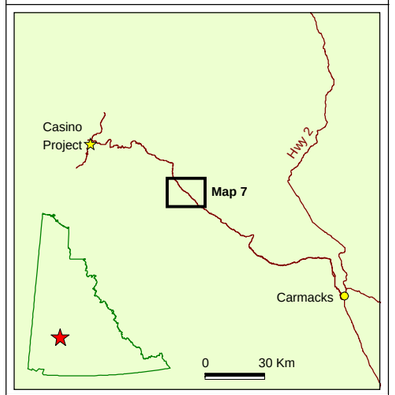

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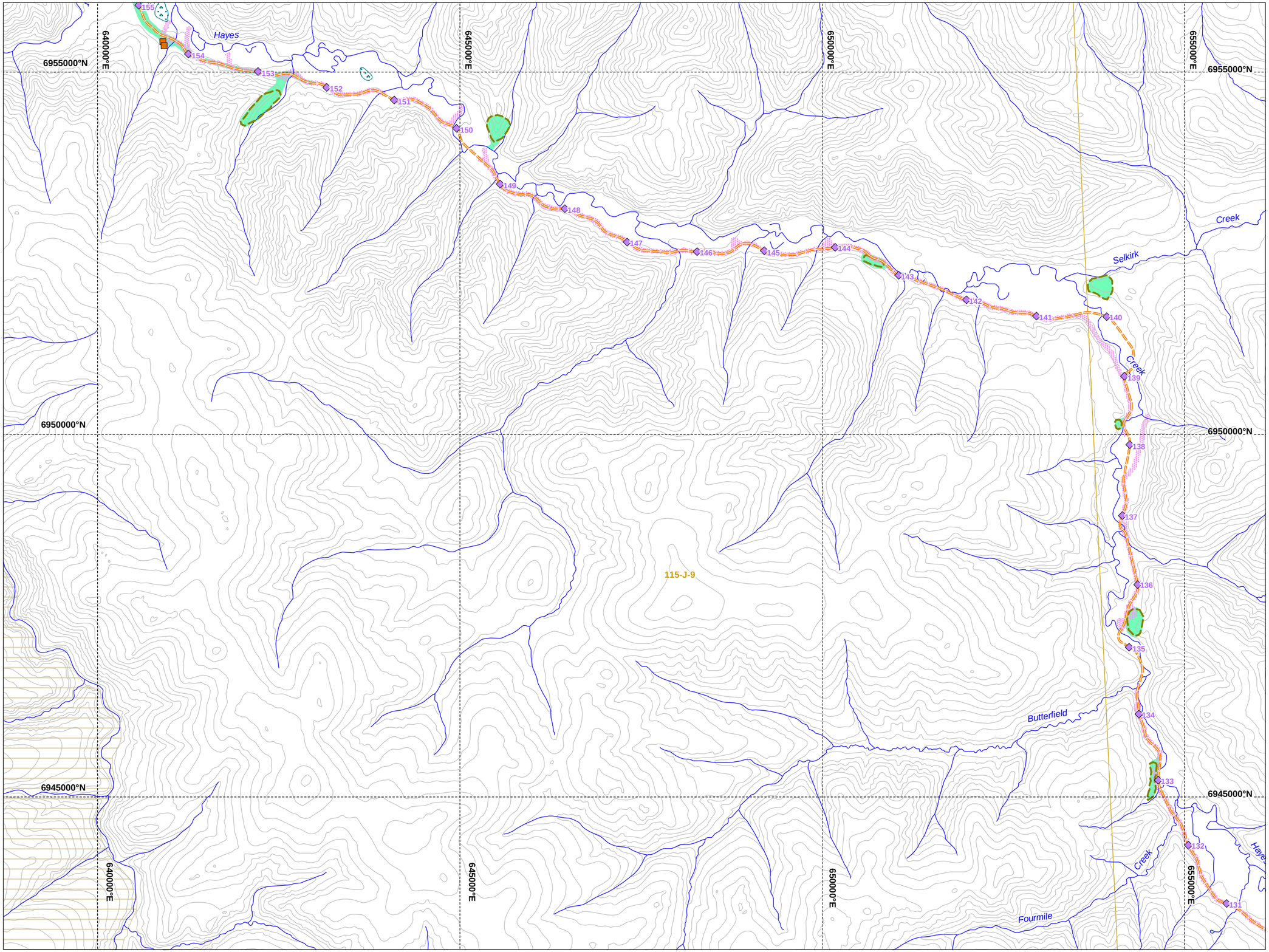
345000°E
350000°E
355000°E
360000°E
6940000°N
6935000°N
Fourmile Creek
Hayes Creek
115-I-12
132
131
130
129
128
127
126
125
124
123
122
121
120
119
118
117
116
115



CASINO

PROPOSED EXTENSION OF FREEGOLD ROAD

ARCHAEOLOGICAL IMPACT ASSESSMENT MAP 8

Map Projection: NAD 83, UTM Zone 7
NTS Mapsheet: 115-J-9
Date: December 4, 2014

N

500 0 500 1000 1500
Meters
Scale: 1:50,000

LEGEND

- Waterbody
- Wetland
- Stream
- Contour
- Road
- Proposed Road Alignment
- Proposed Borrow Pit
- Road Meter Marker

Archaeological Information

- Assessed Area
- Previously Assessed Area
- Historic Structure

Land Use Information

First Nation Settlements

- Selkirk First Nation

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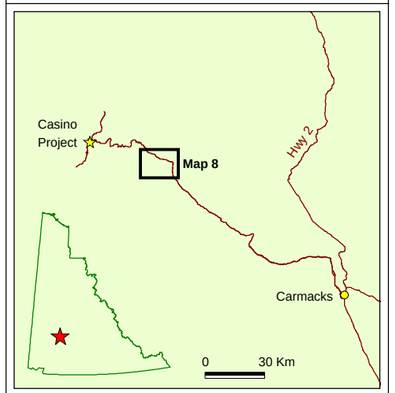

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PROPOSED EXTENSION OF FREEGOLD ROAD

ARCHAEOLOGICAL IMPACT ASSESSMENT MAP 9

Map Projection: NAD 83, UTM Zone 7
NTS Mapsheet: 115-J-9/10/15/16
Date: December 4, 2014

N

500 0 500 1000 1500
Meters
Scale: 1:50,000

LEGEND

- Waterbody
- Wetland
- Stream
- Contour
- Road
- 2013 Road Alignment
- 2013 Borrow Pit
- 2013 Road Meter Marker

Archaeological Information

- Assessed Area
- Previously Assessed Area
- Historic Structure

Land Use Information

First Nation Settlements

- Selkirk First Nation

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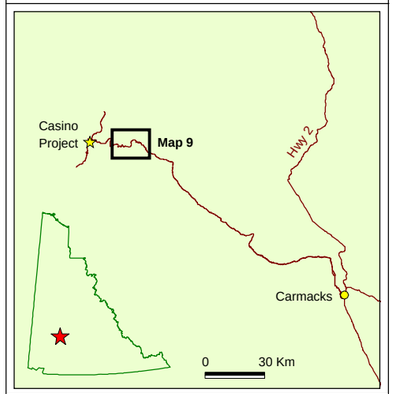

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6965000°N
6960000°N
6955000°N
625000°E
630000°E
635000°E
640000°E
115-J-15
115-J-16
115-J-10
115-J-9
Yukon River
Creek
Mascot
Creek
Idaho
Selwyn
Creek
River
Creek
Battle

PROPOSED EXTENSION OF FREEGOLD ROAD

ARCHAEOLOGICAL IMPACT ASSESSMENT MAP 10

Map Projection: NAD 83, UTM Zone 7
NTS Mapsheet: 115-J-10/15
Date: December 4, 2014

N

500 0 500 1000 1500
Meters
Scale: 1:50,000

LEGEND

- Waterbody
- Wetland
- Stream
- Contour
- Road
- Proposed Road Alignment
- Proposed Borrow Pit
- Road Meter Marker
- Drill Targets
- 2013 Additional Borrow Pits
- Mine Site, Tailings and Ancillary Footprints

Archaeological Information

- Assessed Area
- Previously Assessed Area
- Historic Structure

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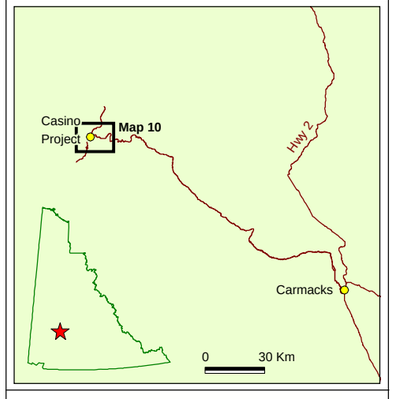

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6960000°N
6955000°N
610000°E
615000°E
620000°E
625000°E
115-J-15
115-J-10
Britannia Creek
Canadian Creek
Sunshine Creek
Isaac Creek
Melov Creek
Creek
203
203.280
202
201
200
199
198
197
196
195
194
193
192
191
190
189
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187
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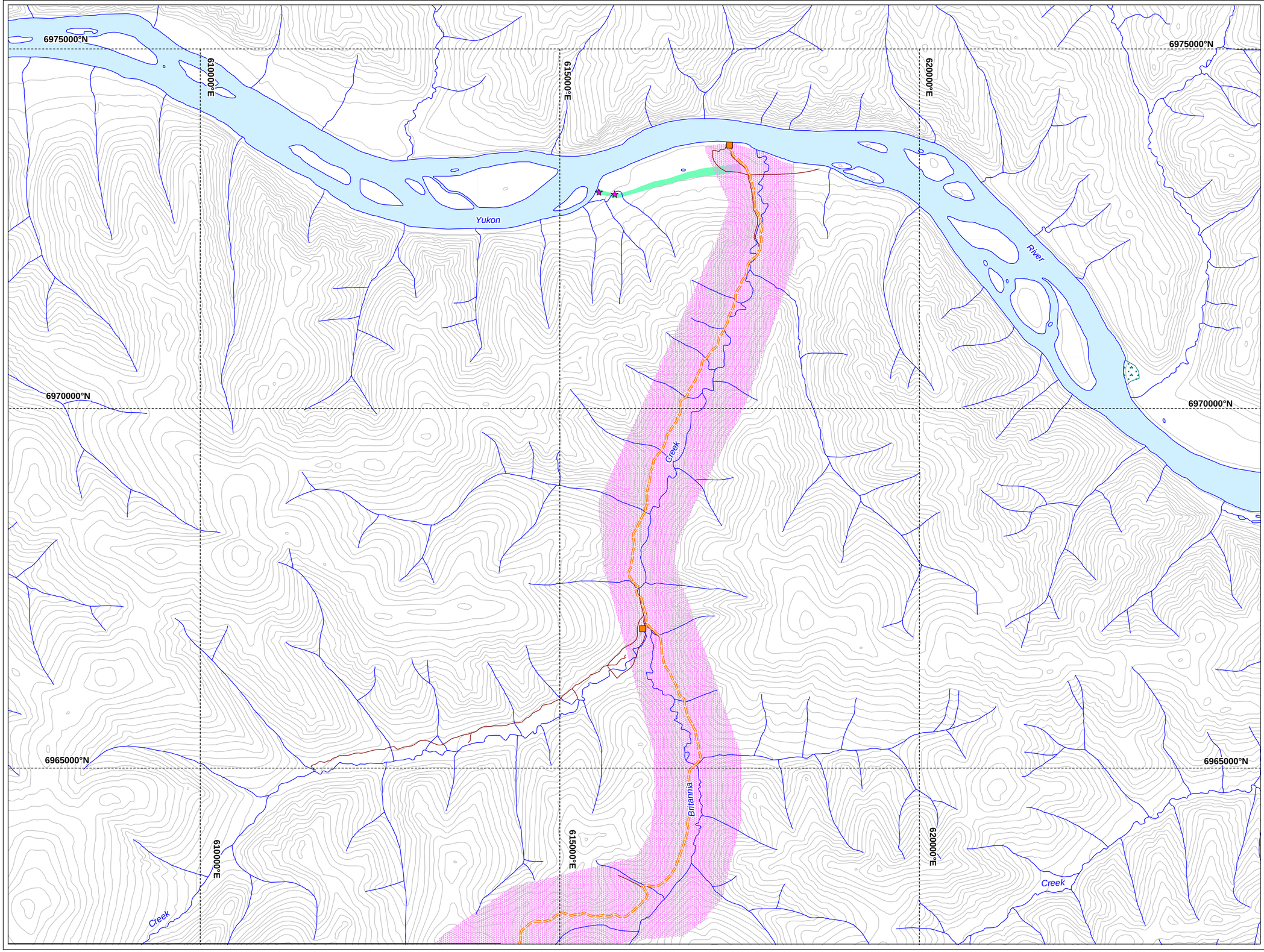
185
184
183



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PROPOSED EXTENSION OF FREEGOLD ROAD

ARCHAEOLOGICAL IMPACT ASSESSMENT MAP 11

Map Projection: NAD 83, UTM Zone 7
NTS Mapsheet: 115-J-10/15
Date: December 4, 2014

N

500 0 500 1000 1500
Meters
Scale: 1:50,000

LEGEND

- Waterbody
- Wetland
- Stream
- Contour
- Road
- Proposed Road Alignment
- Proposed Borrow Pit
- 2013 Road Meter Marker
- Drill Targets

Archaeological Information

- Assessed Area
- Previously Assessed Area
- Historic Structure

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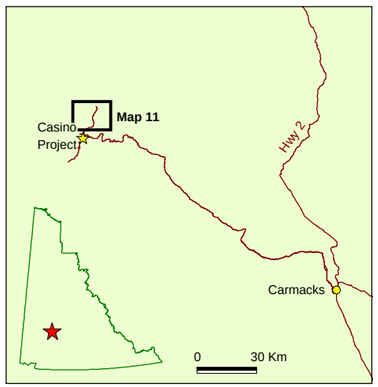

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CASINO

PROPOSED EXTENSION OF FREEGOLD ROAD

ARCHAEOLOGICAL IMPACT ASSESSMENT MAP 12

Map Projection: NAD 83, UTM Zone 7
NTS Mapsheet: 115-J-10/15
Date: December 4, 2014

N

500 0 500 1000 1500
Meters
Scale: 1:50,000

LEGEND

- Waterbody
- Wetland
- Stream
- Contour
- Road
- Proposed Road Alignment
- Proposed Borrow Pit
- Road Meter Marker
- Drill Targets
- 2013 Additional Borrow Pits
- Mine Site, Tailings and Ancillary Footprints

Archaeological Information

- Assessed Area
- Previously Assessed Area
- Historic Structure

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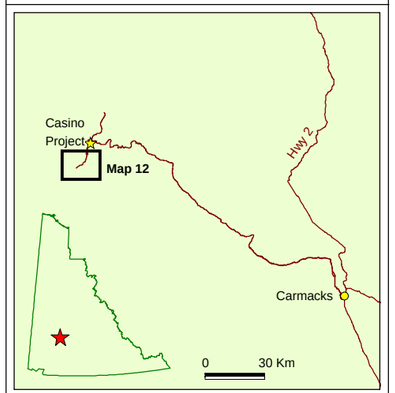

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6950000°N
6945000°N
605000°E
610000°E
615000°E
620000°E
115-J-10
Casino Creek
Dip
Victor Creek
Rude Ck

APPENDIX II: SUMMARY TABLE

Borden Number or Temp Site #	Class	Features	Current Status of Site	Scope of Possible Impacts from Casino Project	Site Boundary Clearly Flagged	Management Recommendations and Proposed Mitigation Strategy	Report/ Permit number and Authors	Bibliographic Reference
Remaining HRIA Survey Fieldwork To Be Completed								
na	na	na	na	Area is a proposed borrow pit east side of Klondike Highway.	na	HRIA Assessment Required	na	na
na	na	na	na	Area is a proposed borrow pit west side of Klondike Highway.	na	HRIA Assessment Required - Proposed Borrow Pit may be dropped as near possible graves	na	na
na	na	na	na	Within the proposed Freegold Project ROW.	na	HRIA Assessment Required	na	na
na	na	na	na	Area is a proposed borrow pit west side of Proposed ROW and near Nansen Road.	na	HRIA Assessment Required	na	na
na	na	na	na	Area is a proposed borrow pit east side of ROW.	na	HRIA Assessment Required	na	na
na	na	na	na	Area is a proposed borrow pit west side of ROW.	na	HRIA Assessment Required	na	na
na	na	na	na	Area is a proposed borrow pit west side of ROW.	na	HRIA Assessment Required	na	na
na	na	na	na	Area is a proposed borrow pit east side of ROW.	na	HRIA Assessment Required	na	na
na	na	na	na	Area is a proposed borrow pit west side of ROW.	na	HRIA Assessment Required	na	na
na	na	na	na	Within the proposed Freegold Project ROW.	na	HRIA Assessment Required	na	na
na	na	na	na	Area is a proposed borrow pit both sides of ROW.	na	HRIA Assessment Required	na	na
na	na	na	na	Area is a proposed borrow pit west side of ROW.	na	HRIA Assessment Required	na	na
na	na	na	na	Area is a proposed borrow pit west side of ROW.	na	HRIA Assessment Required	na	na
na	na	na	na	Area is a proposed borrow pit both sides of ROW.	na	HRIA Assessment Required	na	na
na	na	na	na	Area is a proposed borrow pit north side of ROW.	na	HRIA Assessment Required	na	na
na	na	na	na	Area is a proposed borrow pit south side of ROW.	na	HRIA Assessment Required	na	na

Borden Number or Temp Site #	Class	Features	Current Status of Site	Scope of Possible Impacts from Casino Project	Site Boundary Clearly Flagged	Management Recommendations and Proposed Mitigation Strategy	Report/ Permit number and Authors	Bibliographic Reference
na	na	na	na	Area is a proposed borrow pit north side of existing road.	na	HRIA Assessment Required	na	na
na	na	na	na	Area is a proposed borrow pit north side of existing road.	na	HRIA Assessment Required	na	na
na	na	na	na	Area is a proposed borrow pit north side of existing road.	na	HRIA Assessment Required	na	na

Borden Number or Temp Site #	Class	Features	Current Status of Site	Scope of Possible Impacts from Casino Project	Site Boundary Clearly Flagged	Management Recommendations and Proposed Mitigation Strategy	Report/ Permit number and Authors	Bibliographic Reference
Archaeological Sites to be Managed Along Proposed Freegold Road Upgrade								
KaVa-17	prehistoric site; and cemetery	surface scatter (lithic)	Slighlty disturbed by dirt track and vehicle traffic.	This site and cemetery are not currently planned for impacts and are located upslope and to the east of the proposed ROW.	No	Avoidance of this site and cemetery are recommended.	N/A no permit just site form	Just KaVb-17 Site form YG Heritage Branch 2012
KaVa-3	prehistoric	surface scatter (lithic) and subsurface scatter (lithic and faunal)	disturbed	None planned	No	Avoidance (preferred) or mitigative excavations. If the existing bridge over the Nordenskiold River was upgraded and or replaced as part of the Freegold Project reconstruction, adverse impacts could be placed on the remaining buried cultural materials.	94-22ASR (Antiquus)	Handly and Rousseau 1995
KaVb-2	prehistoric	surface scatter (lithic) and subsurface scatter (lithic)	intact (1995)	Outside of the zone of impact of Freegold Project ROW.	No	Site avoidance.	95-1ASR (Yukon Govt)	Gotthardt 1995
KaVb-1	prehistoric	subsurface scatter (lithic).	disturbed	Within the proposed Freegold Project ROW, and proposed borrow pit.	No	Avoidance (preferred) or Mitigative Excavations(Handly and Rousseau); avoid impacts to the south edge of the terrace and maintain 30 m buffer along terrace edge. Access road should be routed along north side of the terrace (Hammer 1995).	94-22ASR (Antiquus); 95-2ASR (Hammerstone)	Hammer 1995; Handly and Rousseau 1995
KbVb-2	prehistoric	subsurface scatter (lithic)	excavated in 1995	Within proposed Freegold Project ROW.	No	Recommended that during construction for the upgrading of the Freegold Road, the surface soil (0-30 cm below surface) be removed in the vicinity of KbVb-2 and stockpiled so possible remaining cultural materials may be salvaged at a future date.	94-22ASR (Antiquus), 95-2ASR (Hammerstone)	Hammer 1995; Handly and Rousseau 1995
KbVb-4	prehistoric	subsurface scatter (lithic and faunal bone)	some intact portions of site remain	Within Freegold Project ROW.	No	Mitigative Excavations	95-1ASR (Yukon Govt)	Gotthardt 1995
KbVb-3	prehistoric	scatter (lithic)	No Evidence of Site Remains	Within Freegold Project ROW.	No	None required.	95-1ASR (Yukon Govt)	Gotthardt 1995

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KcVd-3	prehistoric	subsurface scatter (lithic)	intact	Within Freegold Project proposed borrow pit.	Yes	If avoidance is not possible then data recovery work under is recommended. Data recovery should include additional shovel testing to better determine artifact distribution and density followed by 1 x 1 m block excavation. Approximately 14 - 18 square meters of excavation would be recommended.	13-07ASR (Ecofor)	Mooney 2013a
KcVe-4	prehistoric	subsurface scatter (lithic)	intact	Very close to the proposed extension of Freegold Road.	Yes	Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended to include in-fill shovel testing to better determine artifact densities followed by a series of 1 x 1 m unit block excavations in relation to the size and distribution of the site.	11-04ASR (Ecofor)	Mooney 2011
KcVf-2	prehistoric	subsurface scatter (lithic)	intact	On edge of Freegold Project proposed borrow pit.	Yes	If avoidance is not possible then data recovery work is recommended. Data recovery should include additional shovel testing to determine artifact distribution and density followed by 1 x 1 m block excavation. Approximately 12 - 15 square meters of excavation would be recommended.	13-07ASR (Ecofor)	Mooney 2013a
KcVf-3	prehistoric	subsurface scatter (lithic)	intact	Within Freegold Project proposed borrow pit.	Yes	If avoidance is not possible then data recovery work under is recommended. Data recovery should include additional shovel testing to determine artifact distribution and density followed by 1 x 1 m block excavation. Approximately 12 - 15 square meters of excavation would be recommended.	13-07ASR (Ecofor)	Mooney 2013a

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KeVf-1	prehistoric	subsurface scatter (lithic)	intact	Within Freegold Project proposed borrow pit as of 2013 (previously not in planned impacts 2011).	Yes	If avoidance is not possible then data recovery work under is recommended. Data recovery should include additional shovel testing to determine artifact distribution and density followed by 1 x 1 m block excavation. Approximately 12 - 15 square meters of excavation would be recommended.	11-04ASR (Ecofor)	Mooney 2011
KdVf-4	prehistoric	surface and subsurface scatter (lithic)	intact	Was planned to be impacted by the proposed borrow pit (2011) but now is not planned for impacts (2013).	Yes	Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended to include in-fill shovel testing to better determine artifact densities followed by a series of 1x1m unit block excavations in relationship to the relation to the size and distribution of the site.	88-3ASR (Gotthardt); 11-04ASR (Ecofor)	Gotthardt 1988; Mooney 2011
KdVf-13	prehistoric	subsurface scatter (lithic)	intact	Will be directly impacted by the proposed borrow pit.	Yes	Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended to include in-fill shovel testing to better determine artifact densities followed by a series of 1x1m unit block excavations in relationship to the size and distribution of the site.	11-04ASR (Ecofor)	Mooney 2011

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KdVf-7	Multi-component: Prehistoric and Proto-historic	subsurface scatter (lithic and Chinese coin)*	intact	The site is located within a proposed borrow pit and very close to the current proposed alignment of the road. This site may be directly impacted by the road construction.	Yes	Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended to include in-fill shovel testing to better determine artifact densities followed by a series of 1x1m unit block excavations in relationship to the size and distribution of the site. Additional historical research in regards to possible Chinese placer mining in the project area is recommended.	11-04ASR (Ecofor)	Mooney 2011
KdVf-6	prehistoric	subsurface scatter (lithic) and possible cache	intact	Within the proposed extension of Freegold Road and potential borrow pits.	Yes	Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended to include in-fill shovel testing to better determine artifact densities followed by a series of 1x1m unit block excavations in relationship to the size and distribution of the site.	11-04ASR (Ecofor)	Mooney 2011
KdVf-5	prehistoric	subsurface scatter (lithic)	intact	Was planned to be impacted by the proposed borrow pit (2011) but now borrow pit is dropped but site is within planned ROW impacts (2013).	Yes	Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended to include in-fill shovel testing to better determine artifact densities followed by a series of 1x1m unit block excavations in relationship to the size and distribution of the site.	11-04ASR (Ecofor)	Mooney 2011
KdVf-8	prehistoric	subsurface scatter (lithic)	intact	This site will not be directly impacted by the road construction or borrow pit use.	Yes	No further work is recommended. However, if borrow pit construction impacts lead to upslope erosion then avoidance of the site is recommended. If avoidance is not possible then data recovery work under is recommended.	11-04ASR (Ecofor)	Mooney 2011

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KdVf-10	prehistoric	subsurface scatter (lithic)	intact	This site will not be directly impacted by the road construction or borrow pit use.	Yes	No further work is recommended. However, if borrow pit construction impacts lead to upslope erosion then avoidance of the site is recommended. If avoidance is not possible then data recovery work under is recommended.	11-04ASR (Ecofor)	Mooney 2011
KdVf-11	prehistoric	subsurface scatter (lithic)	intact	This site will not be directly impacted by the road construction or borrow pit use.	Yes	No further work is recommended. However, if borrow pit construction impacts lead to upslope erosion then avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended.	11-04ASR (Ecofor)	Mooney 2011
KdVf-9	prehistoric	subsurface scatter (lthic) and possible cache	intact	This site will be directly impacted by the road construction.	Yes	Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended to include in-fill shovel testing to better determine artifact densities followed by a series of 1x1m unit block excavations in relationship to the size and distribution of each site.	11-04ASR (Ecofor)	Mooney 2011
KdVf-14 (aka KdVf-1)	prehistoric	subsurface scatter (lithic) and possible spirit house and grave site	intact	Outside of the zone of impact of Freegold Project ROW.	Yes	Avoidance of the site is recommended. If this area is planned for any future impacts then additional efforts are recommended to confirm possible grave or spirit house locations with First Nation representatives	88-3ASR (Gotthardt); 11-04ASR (Ecofor); 13-07ASR (Ecofor)	Gotthardt 1988; Mooney 2011, 2013a
KdVf-12	prehistoric	subsurface scatter (lithic)	intact	This site will be directly impacted by the Freegold road construction.	Yes	Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended to include in-fill shovel testing to better determine artifact densities followed by a series of 1x1m unit block excavations in relationship to the size and distribution of the site.	11-04ASR (Ecofor)	Mooney 2011

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KeVf-3	prehistoric	subsurface scatter (lithic)	intact	Inside the zone of impact of a proposed borrow pit.	Yes	If avoidance is not possible then data recovery work under is recommended. Data recovery should include additional shovel testing to better determine artifact distribution and density followed by separate loci of 1 x 1 m block excavation. Approximately 20 – 28 square meters of excavation would be recommended.	13-07ASR (Ecofor)	Mooney 2013a
KeVg-5	prehistoric	subsurface scatter (lithic)	intact	This site will be directly impacted by road construction.	Yes	Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended.	11-04ASR (Ecofor)	Mooney 2011
KeVg-4	prehistoric	subsurface scatter (lithic and bone)	intact	This site may be directly impacted by road construction.	Yes	Avoidance of the site is recommended. If avoidance is not possible then data recovery work under is recommended.	11-04ASR (Ecofor)	Mooney 2011
KeVg-9	prehistoric	subsurface scatter (lithic)	intact	Inside the zone of impact of the Freegold Road extension.	Yes	If avoidance is not possible then data recovery work under is recommended. Data recovery should include additional shovel testing to determine artifact distribution and density followed by 1 x 1 m block excavation. Approximately 8 - 10 square meters of excavation would be recommended.	13-07ASR (Ecofor)	Mooney 2013a
KeVg-7	prehistoric	subsurface scatter (lithic)	intact	Site may be impacted by road construction.	Yes	Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended to include in-fill shovel testing to better determine artifact densities followed by a series of 1x1m unit block excavations in relationship to the size and distribution of the site.	11-04ASR (Ecofor)	Mooney 2011
KeVg-8	prehistoric	subsurface scatter (lithic isolate)	intact	Within Freegold Project proposed borrow pit.	Yes	None Recommended	13-07ASR (Ecofor)	Mooney 2013a

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KeVg-3	prehistoric	subsurface scatter (lithic)	intact	Within Freegold Project proposed borrow pit as of 2013 (previously not in planned impacts 2011).	No	Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended to include in-fill shovel testing to better determine artifact densities followed by a series of 1x1m unit block excavations in relationship to the size and distribution of the site.	11-04ASR (Ecofor), 13-07ASR (Ecofor)	Mooney 2011, 2013
KeVg-6	prehistoric	subsurface scatter (lithic)	intact	Within Freegold Project proposed borrow pit as of 2013 (previously not in planned impacts 2011).	No	Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended to include in-fill shovel testing to better determine artifact densities followed by a series of 1x1m unit block excavations in relationship to the size and distribution of the site.	11-04ASR (Ecofor), 13-07ASR (Ecofor)	Mooney 2011, 2013a
KeVh-3	prehistoric	subsurface scatter (lithic)	intact	This site will not be directly impacted.	Yes	Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended to include in-fill shovel testing to better determine artifact densities followed by a series of 1x1m unit block excavations in relationship to the size and distribution of the site.	11-04ASR (Ecofor)	Mooney 2011
KeVh-4	prehistoric	subsurface scatter (lithic isolate)	intact	Within Freegold Project proposed borrow pit.	No	None Recommended	13-07ASR (Ecofor)	Mooney 2013a

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Archaeological Sites to be Managed Near Proposed Mine Site, Road to Yukon River, and Road to Proposed Airstrip								
KeVi-1	prehistoric	scatter (lithic) scatter (bone)	Destroyed (Soucey et al 2010a)	Supernatant pond area of Mine Site.	Yes	None Required (Handley et al 1994, Mooney 2013)	94-9ASR (Antiquus); 09-09ASR (Altamira); 13-07ASR (Ecofor)	Handly et al 1994 ; Mooney 2013a; Soucey et al 2010a
KeVi-2	prehistoric	scatter (lithic)	Destroyed (Soucey et al 2010a)	Supernatant pond area of Mine Site.	Yes	None Required (Handly et al 1994, Mooney 2013)	94-9ASR (Antiquus); 09-09ASR (Altamira); 13-07ASR (Ecofor)	Handly et al 1994; Mooney 2013; Soucey et al 2010a
KeVi-3	prehistoric	isolated lithic find	No Evidence of Site Remains	Mine Site Developments - within impact zone of Mine Site.	No - N/A	None Required (Mooney 2013)	94-9ASR (Antiquus); 09-09ASR (Altamira); 13-07ASR (Ecofor)	Handly et al 1994 ; Mooney 2013a; Soucey et al 2010a
KeVi-6	prehistoric	subsurface scatter (bone) subsurface scatter (lithic)	intact	Outside proposed project area.	Yes	No further work is recommended.	09-09ASR (Altamira); 13-06ASR (Altamira)	de Guzman et al 2014; Soucey et al 2010a
KeVi-12 Note: This Borden number was mistakenly assigned to two sites. This lithic site and an adze cut stump (Soucey et al 2010b). The stump is now part of Site KeVi-9 (Gotthardt personal communication 2014).	prehistoric	subsurface scatter (lithic) (Mooney 2011)	intact	Located within 50 m of the current proposed alignment of the road, not directly impacted.	Yes	Avoidance. The site appears to be within approximately 50 m the proposed access road to the airstrip. This site will not be directly impacted. No further work is recommended .	11-04ASR (Ecofor); 10-4ASR (Altamira)	Mooney 2011; Soucey et al 2010b
KeVi-13	prehistoric	subsurface scatter (lithic)	intact	Mine Site Developments	Yes	No further work is recommended.	13-07ASR (Ecofor)	Mooney 2013a

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KeVi-14	prehistoric	subsurface scatter (lithic)	intact	Mine Site Developments	Yes	Avoidance. If avoidance is not possible then data recovery work under is recommended. Data recovery should include additional shovel testing to better determine artifact distribution and density followed by 1 x 1 m block excavation. Approximately 4 - 6 square meters of excavation would be recommended.	13-07ASR (Ecofor)	Mooney 2013a
KeVi-15	prehistoric	subsurface scatter (lithic)	intact	Mine Site Developments	Yes	Avoidance. If avoidance is not possible then data recovery work under is recommended. Data recovery should include additional shovel testing to better determine artifact distribution and density followed by 1 x 1 m block excavation. Approximately 4 - 6 square meters of excavation would be recommended.	13-07ASR (Ecofor)	Mooney 2013
KdVi-1	prehistoric	surface and subsurface scatter (lithic)	intact - abundance and density of the remains appears low	Near Proposed Borrow Pit west of road to Proposed Airstrip.	Yes	Avoidance if possible. If not possible, then further excavation (up to 20 1-x-1 m units) at KdVi-1 is recommended (de Guzman et al 2014).	94-9ASR (Antiquus) 09-09ASR (Altamira); 13-06ASR (Altamira); 13-07ASR (Ecofor); 13-06ASR (Altamira)	de Guzman et al 2014; Handly et al 1994; Mooney 2013; Soucey et al 2010a; de Guzman 2014
KdVi-2	prehistoric	subsurface scatter (lithic)	intact	Within a proposed borrow pit.	Yes	Avoidance. If avoidance is not possible then data recovery work under is recommended. Data recovery should include additional shovel testing to better determine artifact distribution and density followed by separate loci of 1 x 1 m block excavation. Approximately 20 - 28 square meters of excavation would be recommended.	13-07ASR (Ecofor)	Mooney 2013a

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KdVi-3	prehistoric	subsurface scatter (lithic)	intact	Within a proposed borrow pit.	Yes	Avoidance. If avoidance is not possible then data recovery work under is recommended. Data recovery should include additional shovel testing to better determine artifact distribution and density followed by 1 x 1 m block excavation. Approximately 4 - 6 square meters of excavation would be recommended.	13-07ASR (Ecofor)	Mooney 2013a
KdVi-4	prehistoric	subsurface scatter (lithic)	intact	Within a proposed borrow pit.	Yes	Avoidance. If avoidance is not possible then data recovery work under is recommended. Data recovery should include additional shovel testing to better determine artifact distribution and density followed by 1 x 1 m block excavation. Approximately 8 - 10 square meters of excavation would be recommended.	13-07ASR (Ecofor)	Mooney 2013a
KdVi-5	prehistoric	subsurface scatter (lithic)	intact	Within a proposed borrow pit.	Yes	Avoidance. If avoidance is not possible then data recovery work under is recommended. Data recovery should include additional shovel testing to better determine artifact distribution and density followed by 1 x 1 m block excavation. Approximately 6 - 8 square meters of excavation would be recommended.	13-07ASR (Ecofor)	Mooney 2013a
KfVi-2	undetermined	subsurface hearth scatter (bone) scatter (fire cracked rock)	intact	Outside of the proposed project area.	Yes	No further work is recommended.	09-09ASR (Altamira); 13-06ASR (Altamira)	de Guzman et al 2014; Soucey et al 2010a

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KfVi-3	historic/prehistoric	house (building, outline) scatter (lithic)	intact	No planned impacts for this site.	Yes	Continued avoidance of KfVi-3 is recommended. If avoidance is not feasible, Stage 1 excavations of at least a 15% sample are recommended at KfVi-3; this would entail hand excavation of an additional 190 1-x-1 m units. If artifact recovery is limited, excavation could be halted upon discussion with the Heritage Resources Unit.	09-09ASR (Altamira); 13-06ASR (Altamira)	de Guzman et al 2014; Soucey et al 2010a
KfVi-4	prehistoric	subsurface scatter (bone) subsurface scatter (lithic)	intact	No planned impacts for this site.	Yes	No further work recommended.	09-09ASR (Altamira); 13-06ASR (Altamira)	de Guzman et al 2014; Soucey et al 2010a
KfVi-5	prehistoric	scatter (lithic)	Data Recovery Completed by Ecofor(13-18ASR)	No further planned Impacts.	Yes	Avoidance	09-09ASR (Altamira); 13-07ASR (Ecofor); 13-18ASR(Ecofor); 13-06ASR(Altamira)	de Guzman et al 2014; Mooney 2013a; Mooney 2014, Soucey et al 2010a

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Historic Structures and Resources to be Managed Along Proposed Freegold Road Upgrades								
H1: Whitehorse-Dawson Winter Road	historic	overland stage coach route	good	Outside of proposed ROW impact zone.	No - N/A	None Required	94-22ASR (Antiquus)	Handly and Rousseau 1995
H2: Log structure	historic	log structure	good	No impact due to road realignment around Carmacks.	No	Avoidance. Consultation between Community, Village of Carmacks, Community and Transportation Service prior to Project to determine historical significance and appropriate mitigation procedure.	94-22ASR (Antiquus)	Handly and Rousseau 1995
H3: Mink/Fox Fur Farm	historic	metal cages and burnt wood	highly disturbed	No impact due to road realignment around Carmacks.	No - N/A	None Required	94-22ASR (Antiquus)	Handly and Rousseau 1995
H4: Dalton Trail	historic	road/trail	disturbed	Outside of proposed ROW impact zone.	No - N/A	None Required	94-22ASR (Antiquus)	Handly and Rousseau 1995
H5: Place Mine Trench	historic	trench and sluice box	disturbed	Outside of proposed ROW impact zone.	No - N/A	None Required	94-22ASR (Antiquus)	Handly and Rousseau 1995
H6: Morrison Road House	historic	log structures	highly disturbed	Outside of proposed ROW impact zone.	No - N/A	None Required	94-22ASR (Antiquus)	Handly and Rousseau 1995
Tricker Cabin	historic cabin	log structure	unknown	Approximately 20 m south of proposed road realignment.	No	Avoidance. No further work is recommended.	95-1ASR (Yukon Govt)	Gotthardt 1995
Fallen Cache Cabin (YHSI 115I/03/002)	historic	cabin and two log pit features	poor	Within the proposed road realignment.	Yes	If these resources are not avoided then additional documentation is recommended prior to construction impacts. This should include additional on-site recording including site mapping and photodocumentationand interviews with First Nation informants and other stakeholders to better document the history and use of the structures.	13-07ASR (Ecofor)	Mooney 2013a

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Dog House Cabin (YHSI 115I/06/012)	historic	cabin	poor - mostly collapsed	Within the proposed road realignment.	Yes	If these resources are not avoided then additional documentation is recommended prior to construction impacts. This should include additional on-site recording including site mapping and photodocumentationand interviews with First Nation informants and other stakeholders to better document the history and use of the structures.	13-07ASR (Ecofor)	Mooney 2013a
Gas Can Cabin (YHSI 115I/06/010)	historic	cabin	Fair to Good	Within the proposed road realignment.	Yes	If these resources are not avoided then additional documentation is recommended prior to construction impacts. This should include additional on-site recording including site mapping and photodocumentationand interviews with First Nation informants and other stakeholders to better document the history and use of the structures.	13-07ASR (Ecofor)	Mooney 2013a
Melmac Cabin (YHSI 115I/06/011)	historic	cabin	poor - mostly collapsed	Within the proposed road realignment.	Yes	If these resources are not avoided then additional documentation is recommended prior to construction impacts. This should include additional on-site recording including site mapping and photodocumentationand interviews with First Nation informants and other stakeholders to better document the history and use of the structures.	13-07ASR (Ecofor)	Mooney 2013a

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Ketchup Cabin (YHSI 115I/06/009)	historic	cabin	poor - mostly collapsed	Within the proposed road realignment.	Yes	If these resources are not avoided then additional documentation is recommended prior to construction impacts. This should include additional on-site recording including site mapping and photodocumentationand interviews with First Nation informants and other stakeholders to better document the history and use of the structures.	13-07ASR (Ecofor)	Mooney 2013a
Three Room Cabin (YHSI 115J/06/013)	historic	cabin	good	Within the proposed road realignment.	Yes	If these resources are not avoided then additional documentation is recommended prior to construction impacts. This should include additional on-site recording including site mapping and photodocumentationand interviews with First Nation informants and other stakeholders to better document the history and use of the structures.	13-07ASR (Ecofor)	Mooney 2013a
Frenchman Cabin (YHSI 115I/06/005)	historic	cabin	intact	Near planned road construction but may not be impacted.	Yes	Avoidance and if not possible, relocation of structure.	11-04ASR (Ecofor)	Mooney 2011
Bow Creek Cabins	historic	three cabins	intact	Near planned road construction and borrow pit but may not be impacted.	Yes	Avoidance and if not possible, relocation of structures.	11-04ASR (Ecofor)	Mooney 2011
KcVd-2	historic cabin		unknown	None	No	None required.	88-3ASR (Gotthardt); 11-04ASR (Ecofor)	Gotthardt 1988; Mooney 2011, 2013a
KcVd-1	historic cabin		unknown	None	No	None required.	88-3ASR (Gotthardt); 11-04ASR (Ecofor)	Gotthardt 1988; Mooney 2011, 2013a
Five Course Cabin (YHSI 115I/06/001)	historic	cabin	intact	Near planned road construction but should not be impacted.	Yes	If these resources are not avoided then a limited amount of additional documentation is recommended prior to construction impacts.	11-04ASR (Ecofor)	Mooney 2011

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Garage by Big Creek	historic	cabin	intact	Near planned road construction but should not be impacted.	Yes	If these resources are not avoided then a limited amount of additional documentation is recommended prior to construction impacts.	11-04ASR (Ecofor)	Mooney 2011
High Cache Cabin	historic	cabin	intact	Near planned road construction but should not be impacted.	Yes	If these resources are not avoided then a limited amount of additional documentation is recommended prior to construction impacts, or possible relocation of structure.	11-04ASR (Ecofor)	Mooney 2011
Burl Cabin	historic	cabin	intact	Near planned road construction but should not be impacted.	Yes	If these resources are not avoided then a limited amount of additional documentation is recommended prior to construction impacts, or possible relocation of structure.	11-04ASR (Ecofor)	Mooney 2011
KcVe-3	historic/prehistoric	brush camp and possible grave site	unknown	None	No	No further work required.	88-3ASR (Gotthardt);	Gotthardt 1988
KcVe-1	possible grave		unknown	None	no	Avoidance of area	88-3ASR (Gotthardt);	Gotthardt 1988
KcVe-2	historic cabin		unknown	None	no	Avoidance of area.	88-3ASR (Gotthardt);	Gotthardt 1988
KdVf-3	historic	cabin	unknown	May be located near proposed borrow pit of borrow pit access road.	No	This cabin is recommended to be relocated and flagged for avoidance. If avoidance of possible borrow pit or access road is not feasible then additional documentation is recommended.	11-04ASR (Gotthardt); Mooney 2013 (Ecofor)	Gotthardt 1988; Mooney 2013
KdVf-2	historic	possible cache or cabin	unknown	Outside of the zone of impact of Freegold Project ROW.	No	No further work required.	88-3ASR (Gotthardt); 11-04ASR (Ecofor)	Gotthardt 1988; Mooney 2013a

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Steamers/Upright Boilers Site (YHSI 115J/09/002)	historic	boilers, pits, ladders	intact	Within the proposed alignment of Freegold Road (2013) previously listed within a proposed borrow pit (2011).	Yes	Avoidance and if not possible, relocation of resources where possible and additional documentation.	11-04ASR (Ecofor)	Mooney 2011
KeVg-1 (see YHSI 115J/09/001) AKA Hayes Creek Cabins	historic	two cabins & cache and trail AY09-19	poor	Outside of the zone of impact of Freegold Project ROW.	Yes	Avoidance. No further work is recommended. If planned impacts change then additional documentation.	09-09ASR (Altamira); 11-04ASR (Ecofor); 13-07ASR (Ecofor)	Mooney 2011; Soucey et al 2010a; Mooney 2013
AY09-19	ethnohistoric	trail	intact	Portions within Freegold Road ROW.	Yes - white CMT flagging	Impacts to the previously recorded ethno-historic trails are recommended to be avoided and/or minimized where possible. If impacts to these ethno-historic trails can't be avoided then additional background research, on-site recording, and informant interviews to document use of the trails is recommended.	09-09ASR (Altamira); 13-07ASR (Ecofor)	Mooney 2013a; Soucey et al 2010a
AY09-18	ethnohistoric	trail	intact	Portions within Freegold Road ROW.	Yes - white CMT flagging	Impacts to the previously recorded ethno-historic trails are recommended to be avoided and/or minimized where possible. If impacts to these ethno-historic trails can't be avoided then additional background research, on-site recording, and informant interviews to document use of the trails is recommended.	09-09ASR (Altamira); 13-07ASR (Ecofor)	Mooney 2013a; Soucey et al 2010a
KeVg-2	historic	adze-cut stump	intact	Outside of the zone of impact of Freegold Project ROW.	No	None Recommended	09-09ASR (Altamira); 13-07ASR (Ecofor)	Mooney 2013a; Soucey et al 2010b

Borden Number or Temp Site #	Class	Features	Current Status of Site	Scope of Possible Impacts from Casino Project	Site Boundary Clearly Flagged	Management Recommendations and Proposed Mitigation Strategy	Report/ Permit number and Authors	Bibliographic Reference
Historic Structures and Resources to be Managed Near the Proposed Mine Site, Road to the Yukon River, and Road to Proposed Airstrip								
KeVi-4	historic	cabin remains	partially collapsed	Within Tailings Management Facility. Mine Site Developments - within impact zone of Heap Leach Site #1.	Yes general area flagged	Additional survey and data collection is warranted to determine the age and ownership of the cabin (Soucey et al 2010a). Handly et al (1994) say avoidance if possible otherwise, no further work is recommended.	94-9ASR (Antiquus); 09-09ASR (Altamira); 13-07ASR (Ecofor)	Handly et al 1994; Mooney 2013a; Soucey et al 2010a
KeVi-5	historic	cabin remains	partially collapsed	Within Tailings Management Facility.	Yes	If site disturbance is likely to occur, it is recommended that additional research and test excavation be carried out (cabin is pre-1936) (Soucey et al 2010a). Handly et al (1994) recommend the site be avoided but if not feasible then no further work is recommended.	94-9ASR (Antiquus); 09-09ASR (Altamira)	Handly et al 1994; Soucey et al 2010a
KeVi-7	historic	cabin (log) depression	intact	No planned impacts for this site.	Yes	Avoidance. Additional testing at the site is recommended to augment the current knowledge of its placement and use within the Historic Time Period.	09-09ASR (Altamira)	Soucey et al 2010a
KeVi-8	historic	cabin (foundation)	partially collapsed	Mine Site Developments - possible impact.	Yes	Avoidance. If site disturbance is likely to occur, it is recommended that additional research and test excavation be carried out.	09-09ASR (Altamira)	Soucey et al 2010a
KeVi-9	indigenous historic	Culturally Modified Tree (knot); and possible adze cut stump formerly recorded by Altamira as KeVi-12 (Gotthardt personal communication 2014).	intact	No planned impacts for this site.	Yes	Avoidance. If site disturbance is likely to occur, additional consideration and research is warranted. Further consultation and research with local informants could provide additional information about the site and its association with an existing trail.	09-09ASR (Altamira); 11-04ASR (Ecofor); 10-4ASR (Altamira)	Soucey et al 2010a; Mooney 2011; Soucey et al 2010b

Borden Number or Temp Site #	Class	Features	Current Status of Site	Scope of Possible Impacts from Casino Project	Site Boundary Clearly Flagged	Management Recommendations and Proposed Mitigation Strategy	Report/ Permit number and Authors	Bibliographic Reference
KeVi-10	indigenous historic	platform or hunting blind	collapsed	No planned impacts for this site.	Yes	Avoidance. If site disturbance is likely to occur, additional consideration and research is warranted. Further consultation and research with local informants could provide additional information about the site and its association with an existing trail.	09-09ASR (Altamira)	Soucey et al 2010a
KeVi-11	indigenous historic	hide working rack	disturbed	Outside of zone of impact.	Yes	Avoidance. If site disturbance is likely to occur, additional consideration and research is warranted to determine site value.	09-09ASR (Altamira)	Soucey et al 2010a
KfVi-6	historic	cabin/depression/ dump/scatter (metal)	intact	No planned impacts for this site.	Yes	Avoidance. Additional investigation is warranted for this historic era site.	09-09ASR (Altamira); 10-4ASR (Altamira)	Soucey et al 2010a; Soucey et al 2010b
KfVi-7	indigenous historic	isolated find - bone tool	intact	No planned impacts for this site.	Yes	Avoidance. Additional investigation is warranted for this historic era site.	09-09ASR (Altamira); 10-4ASR (Altamira)	Soucey et al 2010a; Soucey et al 2010b
KfVi-8	historic	tent frame (log)	intact	No planned impacts for this site.	Yes	Avoidance. Additional consideration and research is warranted to determine site value and specific mitigation options.	09-09ASR (Altamira)	Soucey et al 2010a
KfVi-9	historic	partially buried wooden object	intact	No planned impacts for this site.	Yes	Avoidance. Additional consideration and research is warranted to determine site value and specific mitigation options.	09-09ASR (Altamira); 10-4ASR (Altamira)	Soucey et al 2010a; Soucey et al 2010b
KfVi-10	indigenous historic	hide working frame	intact	No planned impacts for this site.	Yes	Avoidance. Additional consideration and research could be undertaken to determine its value in terms of ownership and relationship to other sites or cultural activities in the area.	09-09ASR (Altamira); 10-4ASR (Altamira)	Soucey et al 2010a; Soucey et al 2010b

Borden Number or Temp Site #	Class	Features	Current Status of Site	Scope of Possible Impacts from Casino Project	Site Boundary Clearly Flagged	Management Recommendations and Proposed Mitigation Strategy	Report/ Permit number and Authors	Bibliographic Reference
KfVi-11	indigenous historic	Hide working stump and pole	intact	No planned impacts for this site.	Yes	Avoidance. Additional consideration and research is warranted to determine its value in terms of ownership and relationship to other sites or cultural activities in the area.	09-09ASR (Altamira)	Soucey et al 2010a
KfVi-12	indigenous historic	Culturally Modified Tree (bark stripping)	intact	No planned impacts for this site.	Yes	Avoidance. Further Consultation and Research.	10-4ASR (Altamira)	Soucey et al 2010b
KfVi-13	indigenous historic	Culturally Modified Tree (bark stripping)	intact	No planned impacts for this site.	Yes	Avoidance. Further Consultation and Research.	10-4ASR (Altamira)	Soucey et al 2010b
KfVi-14	indigenous historic	Culturally Modified Tree (bark stripping)	intact	No planned impacts for this site.	Yes	Avoidance. Further Consultation and Research.	10-4ASR (Altamira)	Soucey et al 2010b

Borden Number or Temp Site #	Class	Features	Current Status of Site	Scope of Possible Impacts from Casino Project	Site Boundary Clearly Flagged	Management Recommendations and Proposed Mitigation Strategy	Report/ Permit number and Authors	Bibliographic Reference
Previoulsy Noted First Nation Use Sites along the Proposed Upgrades to Freegold Road								
FN 1	indigenous historic	Brush Camp	unknown	No planned impacts for this site.	No	Keep access to area from old Freegold Road.	94-22ASR (Antiquus)	Handly and Rousseau 1995
FN 2	indigenous historic	natural spring	previously impacted	Adjacent to proposed ROW.	No	Keep access to area from old Freegold Road.	94-22ASR (Antiquus)	Handly and Rousseau 1995
FN 3	indigenous historic	trail	unknown	No planned impacts for this site.	No	Keep access to area from old Freegold Road.	94-22ASR (Antiquus)	Handly and Rousseau 1995
FN 4	indigenous historic	Caribou lookout	unknown	May be within a proposed borrow pit	No	Requires Heritage Assessment if in possible borrow pit	94-22ASR (Antiquus)	Handly and Rousseau 1995
FN 5	indigenous historic	fish camp	unknown	No planned impacts for this site.	No	Keep access to area.	94-22ASR (Antiquus)	Handly and Rousseau 1995
FN 6	indigenous historic	fish camp	unknown	None	No	Keep access to area.	94-22ASR (Antiquus)	Handly and Rousseau 1995
FN 7	indigenous historic	trail	unknown	Outside area of impact.	No	Keep access to area.	94-22ASR (Antiquus)	Handly and Rousseau 1995
FN 8	indigenous historic	hunting and trapping camp	unknown	Outside area of impact.	No	We strongly recommend that the First Nation traditional cultural material remaining at this site be systematically collected by representatives of the LSCFN prior to construction of the proposed Freegold Road.	94-22ASR (Antiquus)	Handly and Rousseau 1995
FN 9	indigenous historic	bush camp	previously impacted	Adjacent to proposed ROW.	No	No further work recommended.	94-22ASR (Antiquus)	Handly and Rousseau 1995
FN 10	indigenous historic	trappers camp	unknown	Adjacent to proposed ROW.	No	We strongly recommend that the First Nation traditional cultural material remaining at this site be systematically collected by representatives of the LSCFN prior to construction of the proposed Freegold Road (1995). Materials may no longer exist.	94-22ASR (Antiquus)	Handly and Rousseau 1995

APPENDIX A.18B: Heritage Sites Summary



Appendix A.18B
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Borden Number or Temp Site #	Class	Features	Current Status of Site	Scope of Possible Impacts from Casino Project	Site Boundary Clearly Flagged	Management Recommendations and Proposed Mitigation Strategy	Report/ Permit number and Authors	Bibliographic Reference
Archaeological Sites to be Managed Along Proposed Freegold Road								
KaVa-3	prehistoric	surface scatter (lithic) and subsurface scatter (lithic and faunal).	disturbed	None planned	No	Avoidance (preferred) or mitigative excavations. If the existing bridge over the Nordenskiold River was upgraded and or replaced as part of the Freegold Project reconstruction, adverse impacts could be placed on the remaining buried cultural materials.	94-22ASR (Antiquus)	Handly and Rousseau 1995
KaVb-2	prehistoric	surface scatter (lithic) and subsurface scatter (lithic)	intact (1995)	Outside of the zone of impact of Freegold Project ROW.	No	Site avoidance.	95-1ASR (Yukon Govt)	Gotthardt 1995
KaVb-1	prehistoric	subsurface scatter (lithic).	disturbed	Within the proposed Freegold Project ROW, and proposed borrow pit.	No	Avoidance (preferred) or Mitigative Excavations(Handly and Rousseau); avoid impacts to the south edge of the terrace and maintain 30 m buffer along terrace edge. Access road should be routed along north side of the terrace (Hammer 1995).	94-22ASR (Antiquus); 95-2ASR (Hammerstone)	Hammer 1995; Handly and Rousseau 1995
KbVb-2	prehistoric	subsurface scatter (lithic)	excavated in 1995	Within proposed Freegold Project ROW.	No	Recommended that during construction for the upgrading of the Freegold Road, the surface soil (0-30 cm below surface) be removed in the vicinity of KbVb-2 and stockpiled so possible remaining cultural materials may be salvaged at a future date.	94-22ASR (Antiquus), 95-2ASR (Hammerstone)	Hammer 1995; Handly and Rousseau 1995
KbVb-4	prehistoric	subsurface scatter (lithic and faunal bone)	some intact portions of site remain	Within Freegold Project ROW	No	Mitigative Excavations	95-1ASR (Yukon Govt)	Gotthardt 1995
KbVb-3	prehistoric	scatter (lithic)	No Evidence of Site Remains	Within Freegold Project ROW.	No	None required.	95-1ASR (Yukon Govt)	Gotthardt 1995
KcVd-3	prehistoric	subsurface scatter (lithic)	intact	Within Freegold Project proposed borrow pit	Yes	If avoidance is not possible then data recovery work under is recommended. Data recovery should include additional shovel testing to better determine artifact distribution and density followed by 1 x 1 m block excavation. Approximately 14 - 18 square meters of excavation would be recommended.	13-07ASR (Ecofor)	Mooney 2013a
KcVe-4	prehistoric	subsurface scatter (lithic)	intact	Very close to the proposed extension of Freegold Road.	Yes	Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended to include in-fill shovel testing to better determine artifact densities followed by a series of 1 x 1 m unit block excavations in relation to the size and distribution of the site.	11-04ASR (Ecofor)	Mooney 2011
KcVf-2	prehistoric	subsurface scatter (lithic)	intact	Within Freegold Project proposed borrow pit	Yes	If avoidance is not possible then data recovery work is recommended. Data recovery should include additional shovel testing to determine artifact distribution and density followed by 1 x 1 m block excavation. Approximately 12 - 15 square meters of excavation would be recommended.	13-07ASR (Ecofor)	Mooney 2013a

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Heritage Sites Summary

Borden Number or Temp Site #	Class	Features	Current Status of Site	Scope of Possible Impacts from Casino Project	Site Boundary Clearly Flagged	Management Recommendations and Proposed Mitigation Strategy	Report/ Permit number and Authors	Bibliographic Reference
KcVf-3	prehistoric	subsurface scatter (lithic)	intact	Within Freegold Project proposed borrow pit	Yes	If avoidance is not possible then data recovery work under is recommended. Data recovery should include additional shovel testing to determine artifact distribution and density followed by 1 x 1 m block excavation. Approximately 12 - 15 square meters of excavation would be recommended.	13-07ASR (Ecofor)	Mooney 2013a
KeVf-1	prehistoric	subsurface scatter (lithic)	intact	Within Freegold Project proposed borrow pit as of 2013 (previously not in planned impacts 2011).	Yes	If avoidance is not possible then data recovery work under is recommended. Data recovery should include additional shovel testing to determine artifact distribution and density followed by 1 x 1 m block excavation. Approximately 12 - 15 square meters of excavation would be recommended.	11-04ASR (Ecofor)	Mooney 2011
KdVf-4	prehistoric	surface and subsurface scatter (lithic)	intact	Was planned to be impacted by the proposed borrow pit (2011) but now is not planned for impacts (2013).	Yes	Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended to include in-fill shovel testing to better determine artifact densities followed by a series of 1x1m unit block excavations in relationship to the relation to the size and distribution of the site.	88-3ASR (Gotthardt); 11-04ASR (Ecofor)	Gotthardt 1988; Mooney 2011
KdVf-13	prehistoric	subsurface scatter (lithic)	intact	Will be directly impacted by the proposed borrow pit.	Yes	Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended to include in-fill shovel testing to better determine artifact densities followed by a series of 1x1m unit block excavations in relationship to the size and distribution of the site.	11-04ASR (Ecofor)	Mooney 2011
KdVf-7	Multi-component: Prehistoric and Proto-historic	subsurface scatter (lithic and Chinese coin)*	intact	The site is located within a proposed borrow pit and very close to the current proposed alignment of the road. This site may be directly impacted by the road construction.	Yes	Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended to include in-fill shovel testing to better determine artifact densities followed by a series of 1x1m unit block excavations in relationship to the size and distribution of the site. Additional historical research in regards to possible Chinese placer mining in the project area is recommended.	11-04ASR (Ecofor)	Mooney 2011
KdVf-6	prehistoric	subsurface scatter (lithic) and possible cache	intact	Within the proposed extension of Freegold Road and potential borrow pits.	Yes	Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended to include in-fill shovel testing to better determine artifact densities followed by a series of 1x1m unit block excavations in relationship to the size and distribution of the site.	11-04ASR (Ecofor)	Mooney 2011

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Borden Number or Temp Site #	Class	Features	Current Status of Site	Scope of Possible Impacts from Casino Project	Site Boundary Clearly Flagged	Management Recommendations and Proposed Mitigation Strategy	Report/ Permit number and Authors	Bibliographic Reference
KdVf-5	prehistoric	subsurface scatter (lithic)	intact	Was planned to be impacted by the proposed borrow pit (2011) but now borrow pit is dropped but site is within planned ROW impacts (2013).	Yes	Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended to include in-fill shovel testing to better determine artifact densities followed by a series of 1x1m unit block excavations in relationship to the size and distribution of the site.	11-04ASR (Ecofor)	Mooney 2011
KdVf-8	prehistoric	subsurface scatter (lithic)	intact	This site will not be directly impacted by the road construction or borrow pit use.	Yes	No further work is recommended. However, if borrow pit construction impacts lead to upslope erosion then avoidance of the site is recommended. If avoidance is not possible then data recovery work under is recommended.	11-04ASR (Ecofor)	Mooney 2011
KdVf-10	prehistoric	subsurface scatter (lithic)	intact	This site will not be directly impacted by the road construction or borrow pit use.	Yes	No further work is recommended. However, if borrow pit construction impacts lead to upslope erosion then avoidance of the site is recommended. If avoidance is not possible then data recovery work under is recommended.	11-04ASR (Ecofor)	Mooney 2011
KdVf-11	prehistoric	subsurface scatter (lithic)	intact	This site will not be directly impacted by the road construction or borrow pit use.	Yes	No further work is recommended. However, if borrow pit construction impacts lead to upslope erosion then avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended.	11-04ASR (Ecofor)	Mooney 2011
KdVf-9	prehistoric	subsurface scatter (lthic) and possible cache	intact	This site will be directly impacted by the road construction and borrow pit use.	Yes	Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended to include in-fill shovel testing to better determine artifact densities followed by a series of 1x1m unit block excavations in relationship to the size and distribution of each site.	11-04ASR (Ecofor)	Mooney 2011
KdVf-14 (aka KdVf-1)	prehistoric	subsurface scatter (lithic) and possible spirit house and grave site	intact	Outside of the zone of impact of Freegold Project ROW.	Yes	Avoidance of the site is recommended. If this area is planned for any future impacts then additional efforts are recommended to confirm possible grave or spirit house locations with First Nation representatives	88-3ASR (Gotthardt); 11-04ASR (Ecofor); 13-07ASR (Ecofor)	Gotthardt 1988; Mooney 2011, 2013a
KdVf-12	prehistoric	subsurface scatter (lithic)	intact	This site will be directly impacted by the Freegold road construction.	Yes	Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended to include in-fill shovel testing to better determine artifact densities followed by a series of 1x1m unit block excavations in relationship to the size and distribution of the site.	11-04ASR (Ecofor)	Mooney 2011
KeVf-3	prehistoric	subsurface scatter (lithic)	intact	Inside the zone of impact of a proposed borrow pit.	Yes	If avoidance is not possible then data recovery work under is recommended. Data recovery should include additional shovel testing to better determine artifact distribution and density followed by separate loci of 1 x 1 m block excavation. Approximately 20 – 28 square meters of excavation would be recommended.	13-07ASR (Ecofor)	Mooney 2013a

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Heritage Sites Summary

Borden Number or Temp Site #	Class	Features	Current Status of Site	Scope of Possible Impacts from Casino Project	Site Boundary Clearly Flagged	Management Recommendations and Proposed Mitigation Strategy	Report/ Permit number and Authors	Bibliographic Reference
KeVg-5	prehistoric	subsurface scatter (lithic)	intact	This site will be directly impacted by road construction.	Yes	Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended.	11-04ASR (Ecofor)	Mooney 2011
KeVg-4	prehistoric	subsurface scatter (lithic and bone)	intact	This site may be directly impacted by road construction.	Yes	Avoidance of the site is recommended. If avoidance is not possible then data recovery work under is recommended.	11-04ASR (Ecofor)	Mooney 2011
KeVg-9	prehistoric	subsurface scatter (lithic)	intact	Inside the zone of impact of the Freegold Road extension.	Yes	If avoidance is not possible then data recovery work under is recommended. Data recovery should include additional shovel testing to determine artifact distribution and density followed by 1 x 1 m block excavation. Approximately 8 - 10 square meters of excavation would be recommended.	13-07ASR (Ecofor)	Mooney 2013a
KeVg-7	prehistoric	subsurface scatter (lithic)	intact	Site may be impacted by road construction.	Yes	Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended to include in-fill shovel testing to better determine artifact densities followed by a series of 1x1m unit block excavations in relationship to the size and distribution of the site.	11-04ASR (Ecofor)	Mooney 2011
KeVg-8	prehistoric	subsurface scatter (lithic isolate)	intact	Within Freegold Project proposed borrow pit	Yes	None Recommended	13-07ASR (Ecofor)	Mooney 2013a
KeVg-3	prehistoric	subsurface scatter (lithic)	intact	Within Freegold Project proposed borrow pit as of 2013 (previously not in planned impacts 2011).	No	Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended to include in-fill shovel testing to better determine artifact densities followed by a series of 1x1m unit block excavations in relationship to the size and distribution of the site.	11-04ASR (Ecofor), 13-07ASR (Ecofor)	Mooney 2011, 2013
KeVg-6	prehistoric	subsurface scatter (lithic)	intact	Within Freegold Project proposed borrow pit as of 2013 (previously not in planned impacts 2011).	No	Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended to include in-fill shovel testing to better determine artifact densities followed by a series of 1x1m unit block excavations in relationship to the size and distribution of the site.	11-04ASR (Ecofor), 13-07ASR (Ecofor)	Mooney 2011, 2013a
KeVh-3	prehistoric	subsurface scatter (lithic)	intact	This site will not be directly impacted.	Yes	Avoidance of the site is recommended. If avoidance is not possible then data recovery work is recommended to include in-fill shovel testing to better determine artifact densities followed by a series of 1x1m unit block excavations in relationship to the size and distribution of the site.	11-04ASR (Ecofor)	Mooney 2011
KeVh-4	prehistoric	subsurface scatter (lithic isolate)	intact	Within Freegold Project proposed borrow pit	No	None Recommended	13-07ASR (Ecofor)	Mooney 2013a

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Borden Number or Temp Site #	Class	Features	Current Status of Site	Scope of Possible Impacts from Casino Project	Site Boundary Clearly Flagged	Management Recommendations and Proposed Mitigation Strategy	Report/ Permit number and Authors	Bibliographic Reference
Archaeological Sites to be Managed Near Proposed Mine Site, Road to Yukon River, and Road to Proposed Airstrip								
KeVi-1	prehistoric	scatter (lithic) scatter (bone)	Destroyed (Soucey et al 2010a)	Supernatant pond area of Mine Site.	Yes	None Required (Handley et al 1994, Mooney 2013)	94-9ASR (Antiquus); 09-09ASR (Altamira); 13-07ASR (Ecofor)	Handly et al 1994 ; Mooney 2013a; Soucey et al 2010a
KeVi-2	prehistoric	scatter (lithic)	Destroyed (Soucey et al 2010a)	Supernatant pond area of Mine Site.	Yes	None Required (Handly et al 1994, Mooney 2013)	94-9ASR (Antiquus); 09-09ASR (Altamira); 13-07ASR (Ecofor)	Handly et al 1994; Mooney 2013; Soucey et al 2010a
KeVi-3	prehistoric	isolated lithic find	No Evidence of Site Remains	Mine Site Developments - within impact zone of Mine Site.	No - N/A	None Required (Mooney 2013)	94-9ASR (Antiquus); 09-09ASR (Altamira); 13-07ASR (Ecofor)	Handly et al 1994 ; Mooney 2013a; Soucey et al 2010a
KeVi-6	prehistoric	subsurface scatter (bone) subsurface scatter (lithic)	intact	Outside proposed project area.	Yes	No further work is recommended.	09-09ASR (Altamira); 13-06ASR (Altamira)	de Guzman et al 2014; Soucey et al 2010a
KeVi-12 Note: This Borden number was mistakenly assigned to two sites. This lithic site and an adze cut stump (Soucey et al 2010b). The stump is now part of Site KeVi-9 (Gotthardt personal	prehistoric	subsurface scatter (lithic) (Mooney 2011)	intact	Located within 50 m of the current proposed alignment of the road, not directly impacted.	Yes	Avoidance. The site appears to be within approximately 50 m the proposed access road to the airstrip. This site will not be directly impacted. No further work is recommended .	11-04ASR (Ecofor); 10-4ASR (Altamira)	Mooney 2011; Soucey et al 2010b
KeVi-13	prehistoric	subsurface scatter (lithic)	intact	Mine Site Developments	Yes	No further work is recommended.	13-07ASR (Ecofor)	Mooney 2013a
KeVi-14	prehistoric	subsurface scatter (lithic)	intact	Mine Site Developments	Yes	If avoidance is not possible then data recovery work under is recommended. Data recovery should include additional shovel testing to better determine artifact distribution and density followed by 1 x 1 m block excavation. Approximately 4 - 6 square meters of excavation would be recommended.	13-07ASR (Ecofor)	Mooney 2013a
KeVi-15	prehistoric	subsurface scatter (lithic)	intact	Mine Site Developments	Yes	If avoidance is not possible then data recovery work under is recommended. Data recovery should include additional shovel testing to better determine artifact distribution and density followed by 1 x 1 m block excavation. Approximately 4 - 6 square meters of excavation would be recommended.	13-07ASR (Ecofor)	Mooney 2013

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Borden Number or Temp Site #	Class	Features	Current Status of Site	Scope of Possible Impacts from Casino Project	Site Boundary Clearly Flagged	Management Recommendations and Proposed Mitigation Strategy	Report/ Permit number and Authors	Bibliographic Reference
KdVi-1	prehistoric	surface and subsurface scatter (lithic)	intact - abundance and density of the remains appears low	Near Proposed Borrow Pit west of road to Proposed Airstrip.	Yes	Avoidance if possible. If not possible, then further excavation (up to 20 1-x-1 m units) at KdVi-1 is recommended (de Guzman et al 2014).	94-9ASR (Antiquus) 09-09ASR (Altamira); 13-06ASR (Altamira); 13-07ASR (Ecofor); 13-06ASR (Altamira)	de Guzman et al 2014; Handly et al 1994; Mooney 2013; Soucey et al 2010a; de Guzman 2014
KdVi-2	prehistoric	subsurface scatter (lithic)	intact	Mine Site Developments	Yes	If avoidance is not possible then data recovery work under is recommended. Data recovery should include additional shovel testing to better determine artifact distribution and density followed by separate loci of 1 x 1 m block excavation. Approximately 20 - 28 square meters of excavation would be recommended.	13-07ASR (Ecofor)	Mooney 2013a
KdVi-3	prehistoric	subsurface scatter (lithic)	intact	Mine Site Developments	Yes	If avoidance is not possible then data recovery work under is recommended. Data recovery should include additional shovel testing to better determine artifact distribution and density followed by 1 x 1 m block excavation. Approximately 4 - 6 square meters of excavation would be recommended.	13-07ASR (Ecofor)	Mooney 2013a
KdVi-4	prehistoric	subsurface scatter (lithic)	intact	Mine Site Developments	Yes	If avoidance is not possible then data recovery work under is recommended. Data recovery should include additional shovel testing to better determine artifact distribution and density followed by 1 x 1 m block excavation. Approximately 8 - 10 square meters of excavation would be recommended.	13-07ASR (Ecofor)	Mooney 2013a
KdVi-5	prehistoric	subsurface scatter (lithic)	intact	Mine Site Developments	Yes	If avoidance is not possible then data recovery work under is recommended. Data recovery should include additional shovel testing to better determine artifact distribution and density followed by 1 x 1 m block excavation. Approximately 6 - 8 square meters of excavation would be recommended.	13-07ASR (Ecofor)	Mooney 2013a
KfVi-2	undetermined	subsurface hearth scatter (bone) scatter (fire cracked rock)	intact	Outside of the proposed project area.	Yes	No further work is recommended.	09-09ASR (Altamira); 13-06ASR (Altamira)	de Guzman et al 2014; Soucey et al 2010a
KfVi-3	historic/prehistoric	house (building, outline) scatter (lithic)	intact	Mine Site Developments - possible impact.	Yes	Continued avoidance of KfVi-3 is recommended. If avoidance is not feasible, Stage 1 excavations of at least a 15% sample are recommended at KfVi-3; this would entail hand excavation of an additional 190 1-x-1 m units. If artifact recovery is limited, excavation could be halted upon discussion with the Heritage Resources Unit.	09-09ASR (Altamira); 13-06ASR (Altamira)	de Guzman et al 2014; Soucey et al 2010a

Appendix A.18B
Heritage Sites Summary

Borden Number or Temp Site #	Class	Features	Current Status of Site	Scope of Possible Impacts from Casino Project	Site Boundary Clearly Flagged	Management Recommendations and Proposed Mitigation Strategy	Report/ Permit number and Authors	Bibliographic Reference
KfVi-4	prehistoric	subsurface scatter (bone) subsurface scatter (lithic)	intact	Mine Site Developments - possible impact.	Yes	No further work recommended.	09-09ASR (Altamira); 13-06ASR (Altamira)	de Guzman et al 2014; Soucey et al 2010a
KfVi-5	prehistoric	scatter (lithic)	Data Recovery Completed by Ecofor(13-18ASR)	No further planned Impacts.	Yes	Avoidance	09-09ASR (Altamira); 13-07ASR (Ecofor); 13-18ASR(Ecofor); 13-06ASR(Altamira)	de Guzman et al 2014; Mooney 2013a; Mooney 2014, Soucey et al 2010a

Appendix A.18B
Heritage Sites Summary

Borden Number or Temp Site #	Class	Features	Current Status of Site	Scope of Possible Impacts from Casino Project	Site Boundary Clearly Flagged	Management Recommendations and Proposed Mitigation Strategy	Report/ Permit number and Authors	Bibliographic Reference
Historic Structures and Resources to be Managed Along Proposed Freegold Road Upgrades								
H1: Whitehorse-Dawson Winter Road	historic	overland stage coach route	good	Outside of proposed ROW impact zone.	No - N/A	None Required	94-22ASR (Antiquus)	Handly and Rousseau 1995
H2: Log structure	historic	log structure	good	Possibly no impact due to road realignment around Carmacks.	No	Avoidance. Consultation between Community, Village of Carmacks, Community and Transportation Service prior to Project to determine historical significance and appropriate mitigation procedure.	94-22ASR (Antiquus)	Handly and Rousseau 1995
H3: Mink/Fox Fur Farm	historic	metal cages and burnt wood	highly disturbed	Possibly no impact due to road realignment around Carmacks.	No - N/A	None Required	94-22ASR (Antiquus)	Handly and Rousseau 1995
H4: Dalton Trail	historic	road/trail	disturbed	Outside of proposed ROW impact zone.	No - N/A	None Required	94-22ASR (Antiquus)	Handly and Rousseau 1995
H6: Morrison Road House	historic	log structures	highly disturbed	Outside of proposed ROW impact zone.	No - N/A	None Required	94-22ASR (Antiquus)	Handly and Rousseau 1995
Tricker Cabin	historic cabin	log structure	unknown	To be determined	No	To be determined	95-1ASR (Yukon Govt)	Gotthardt 1995
Fallen Cache Cabin (YHSI 115I/03/002)	historic	cabin and two log pit features	poor	Within the proposed road realignment.	Yes	If these resources are not avoided then additional documentation is recommended prior to construction impacts. This should include additional on-site recording including site mapping and photodocumentationand interviews with First Nation informants and other stakeholders to better document the history and use of the structures.	13-07ASR (Ecofor)	Mooney 2013a
Dog House Cabin (YHSI 115I/06/012)	historic	cabin	poor - mostly collapsed	Within the proposed road realignment.	Yes	If these resources are not avoided then additional documentation is recommended prior to construction impacts. This should include additional on-site recording including site mapping and photodocumentationand interviews with First Nation informants and other stakeholders to better document the history and use of the structures.	13-07ASR (Ecofor)	Mooney 2013a
Gas Can Cabin (YHSI 115I/06/010)	historic	cabin	Fair to Good	Within the proposed road realignment.	Yes	If these resources are not avoided then additional documentation is recommended prior to construction impacts. This should include additional on-site recording including site mapping and photodocumentationand interviews with First Nation informants and other stakeholders to better document the history and use of the structures.	13-07ASR (Ecofor)	Mooney 2013a

Appendix A.18B
Heritage Sites Summary

Borden Number or Temp Site #	Class	Features	Current Status of Site	Scope of Possible Impacts from Casino Project	Site Boundary Clearly Flagged	Management Recommendations and Proposed Mitigation Strategy	Report/ Permit number and Authors	Bibliographic Reference
Melmac Cabin (YHSI 115I/06/011)	historic	cabin	poor - mostly collapsed	Within the proposed road realignment.	Yes	If these resources are not avoided then additional documentation is recommended prior to construction impacts. This should include additional on-site recording including site mapping and photodocumentationand interviews with First Nation informants and other stakeholders to better document the history and use of the structures.	13-07ASR (Ecofor)	Mooney 2013a
Ketchup Cabin (YHSI 115I/06/009)	historic	cabin	poor - mostly collapsed	Within the proposed road realignment.	Yes	If these resources are not avoided then additional documentation is recommended prior to construction impacts. This should include additional on-site recording including site mapping and photodocumentationand interviews with First Nation informants and other stakeholders to better document the history and use of the structures.	13-07ASR (Ecofor)	Mooney 2013a
Three Room Cabin (YHSI 115J/06/013)	historic	cabin	good	Within the proposed road realignment.	Yes	If these resources are not avoided then additional documentation is recommended prior to construction impacts. This should include additional on-site recording including site mapping and photodocumentationand interviews with First Nation informants and other stakeholders to better document the history and use of the structures.	13-07ASR (Ecofor)	Mooney 2013a
Frenchman Cabin (YHSI 115I/06/005)	historic	cabin	intact	Near planned road construction but may not be impacted.	Yes	Avoidance and if not possible, relocation of structure.	11-04ASR (Ecofor)	Mooney 2011
Bow Creek Cabins	historic	three cabins	intact	Near planned road construction and borrow pit but may not be impacted.	Yes	Avoidance and if not possible, relocation of structures.	11-04ASR (Ecofor)	Mooney 2011
KcVd-2	historic cabin		unknown	None	No	None required.	88-3ASR (Gotthardt); 11-04ASR (Ecofor)	Gotthardt 1988; Mooney 2011, 2013a
KcVd-1	historic cabin		unknown	None	No	None required.	88-3ASR (Gotthardt); 11-04ASR (Ecofor)	Gotthardt 1988; Mooney 2011, 2013a
Five Course Cabin (YHSI 115I/06/001)	historic	cabin	intact	Near planned road construction but should not be impacted.	Yes	Avoidance and if not possible, relocation of structure.	11-04ASR (Ecofor)	Mooney 2011
Garage by Big Creek	historic	cabin	intact	Near planned road construction	Yes	Avoidance and if not possible, relocation of structure.	11-04ASR (Ecofor)	Mooney 2011
High Cache Cabin	historic	cabin	intact	Near planned road construction but should not be impacted.	Yes	Avoidance and if not possible, relocation of structure.	11-04ASR (Ecofor)	Mooney 2011

Appendix A.18B
Heritage Sites Summary

Borden Number or Temp Site #	Class	Features	Current Status of Site	Scope of Possible Impacts from Casino Project	Site Boundary Clearly Flagged	Management Recommendations and Proposed Mitigation Strategy	Report/ Permit number and Authors	Bibliographic Reference
Burl Cabin	historic	cabin	intact	Near planned road construction but should not be impacted.	Yes	Avoidance and if not possible, relocation of structure.	11-04ASR (Ecofor)	Mooney 2011
KcVe-3	historic/prehistoric	brush camp and possible grave site	unknown	None	No	Traditional and prehistoric sites in the road corridor should be avoided by adjustments to the road alignment if possible. Signs should be developed in consultation wth the Selkirk and Little Salmon/Carmacks First Nations and placed in appropriate locations on the Casino Trail to inform travellers of the history of the country and of its traditional importance to Selkirk people. Where the Casino Trail crosses the old Chilkat Trail/Dalton Trail at km 44 should be signed.	88-3ASR (Gotthardt);	Gotthardt 1988
KcVe-1	possible grave		unknown	None	no	Avoidance of area	88-3ASR (Gotthardt);	Gotthardt 1988
KcVe-2	historic cabin		unknown	None	no	Avoidance of area.	88-3ASR (Gotthardt);	Gotthardt 1988
KdVf-3	historic	cabin	unknown	Above the proposed Casino Trail route.	No	Traditional and prehistoric sites in the road corridor should be avoided by adjustments to the road alignment if possible. Signs should be developed in consultation wth the Selkirk and Little Salmon/Carmacks First Nations and placed in appropriate locations on the Casino Trail to inform travellers of the history of the country and of its traditional importance to Selkirk people. Where the Casino Trail crosses the old Chilkat Trail/Dalton Trail at km 44 should be signed.	11-04ASR (Gotthardt); Mooney 2013 (Ecofor)	Gotthardt 1988; Mooney 2013
KdVf-2	historic	possible cache or cabin	unknown	not stated	No	Traditional and prehistoric sites in the road corridor should be avoided by adjustments to the road alignment if possible. Signs should be developed in consultation wth the Selkirk and Little Salmon/Carmacks First Nations and placed in appropriate locations on the Casino Trail to inform travellers of the history of the country and of its traditional importance to Selkirk people. Where the Casino Trail crosses the old Chilkat Trail/Dalton Trail at km 44 should be signed.	88-3ASR (Gotthardt); 11-04ASR (Ecofor)	Gotthardt 1988; Mooney 2013a
Steamers/Upright Boilers Site (YHSI 115J/09/002)	historic	boilers, pits, ladders	intact	Within the proposed alignment of Freegold Road (2013) previously listed within a proposed borrow pit (2011).	Yes	Avoidance and if not possible, relocation of resources where possible and additional documentation.	11-04ASR (Ecofor)	Mooney 2011
KeVg-1- (see YHSI 115J/09/001)	historic	two cabins & cache and trail AY09-19	poor	Outside of the zone of impact of Freegold Project ROW.	Yes	Avoidance. No further work is recommended. If planned impacts change then additional documentation.	09-09ASR (Altamira); 11-04ASR (Ecofor); 13-07ASR (Ecofor)	Mooney 2011; Soucey et al 2010a; Mooney 2013

Appendix A.18B
Heritage Sites Summary

Borden Number or Temp Site #	Class	Features	Current Status of Site	Scope of Possible Impacts from Casino Project	Site Boundary Clearly Flagged	Management Recommendations and Proposed Mitigation Strategy	Report/ Permit number and Authors	Bibliographic Reference
AY09-19	ethnohistoric	trail	intact	Portions within Freegold Road ROW.	Yes - white CMT flagging	Impacts to the previously recorded ethno-historic trails are recommended to be avoided and/or minimized where possible. If impacts to these ethno-historic trails can't be avoided then additional background research, on-site recording, and informant interviews to document use of the trails is recommended.	09-09ASR (Altamira); 13-07ASR (Ecofor)	Mooney 2013a; Soucey et al 2010a
AY09-18	ethnohistoric	trail	intact	Portions within Freegold Road ROW.	Yes - white CMT flagging	Impacts to the previously recorded ethno-historic trails are recommended to be avoided and/or minimized where possible. If impacts to these ethno-historic trails can't be avoided then additional background research, on-site recording, and informant interviews to document use of the trails is recommended.	09-09ASR (Altamira); 13-07ASR (Ecofor)	Mooney 2013a; Soucey et al 2010a
KeVg-2	historic	adze-cut stump	intact	Outside of the zone of impact of Freegold Project ROW.	No	None Recommended	09-09ASR (Altamira); 13-07ASR (Ecofor)	Mooney 2013a; Soucey et al 2010b

Appendix A.18B
Heritage Sites Summary

Borden Number or Temp Site #	Class	Features	Current Status of Site	Scope of Possible Impacts from Casino Project	Site Boundary Clearly Flagged	Management Recommendations and Proposed Mitigation Strategy	Report/ Permit number and Authors	Bibliographic Reference
Historic Structures and Resources to be Managed Near the Proposed Mine Site, Road to the Yukon River, and Road to Proposed Airstrip								
KeVi-4	historic	cabin remains	partially collapsed	Within Tailings Management Facility. Mine Site Developments - within impact zone of Heap Leach Site #1.	Yes general area flagged	Additional survey and data collection is warranted to determine the age and ownership of the cabin (Soucey et al 2010a). Handly et al (1994) say avoidance if possible otherwise, no further work is recommended.	94-9ASR (Antiquus); 09-09ASR (Altamira); 13-07ASR (Ecofor)	Handly et al 1994; Mooney 2013a; Soucey et al 2010a
KeVi-5	historic	cabin remains	partially collapsed	Within Tailings Management Facility	Yes	If site disturbance is likely to occur, it is recommended that additional research and test excavation be carried out (cabin is pre-1936) (Soucey et al 2010a). Handly et al (1994) recommend the site be avoided but if not feasible then no further work is recommended.	94-9ASR (Antiquus); 09-09ASR (Altamira)	Handly et al 1994; Soucey et al 2010a
KeVi-7	historic	cabin (log) depression	intact	Mine Site Developments - possible impact	Yes	Avoidance. Additional testing at the site is recommended to augment the current knowledge of its placement and use within the Historic Time Period.	09-09ASR (Altamira)	Soucey et al 2010a
KeVi-8	historic	cabin (foundation)	partially collapsed	Mine Site Developments - possible impact.	Yes	Avoidance. If site disturbance is likely to occur, it is recommended that additional research and test excavation be carried out.	09-09ASR (Altamira)	Soucey et al 2010a
KeVi-9	indigenous historic	Culturally Modified Tree (knot); and possible adze cut stump formerly recorded by Altamira as KeVi-12 (Gotthardt personal communication 2014).	intact	Not stated	Yes	In the event that it is determined that site disturbance is likely to occur, additional consideration and research is warranted. Further consultation and research with local informants could provide additional information about the site and its association with an existing trail.	09-09ASR (Altamira); 11-04ASR (Ecofor); 10-4ASR (Altamira)	Soucey et al 2010a; Mooney 2011; Soucey et al 2010b
KeVi-10	indigenous historic	platform or hunting blind	collapsed	May be impacted during project developments.	Yes	In the event that it is determined that site disturbance is likely to occur, additional consideration and research is warranted. Further consultation and research with local informants could provide additional information about the site and its association with an existing trail.	09-09ASR (Altamira)	Soucey et al 2010a
KeVi-11	indigenous historic	hide working rack	disturbed	Outside of zone of impact.	Yes	If site disturbance is likely to occur, additional consideration and research is warranted to determine site value	09-09ASR (Altamira)	Soucey et al 2010a
KfVi-6	historic	cabin/depression/ dump/scatter (metal)	intact	Mine Site Developments - possible impact.	Yes	Additional investigation is warranted for this historic era site.	09-09ASR (Altamira); 10-4ASR (Altamira)	Soucey et al 2010a; Soucey et al 2010b
KfVi-7	indigenous historic	isolated find - bone tool	intact	not stated	Yes	Additional site investigation is warranted	09-09ASR (Altamira); 10-4ASR (Altamira)	Soucey et al 2010a; Soucey et al 2010b

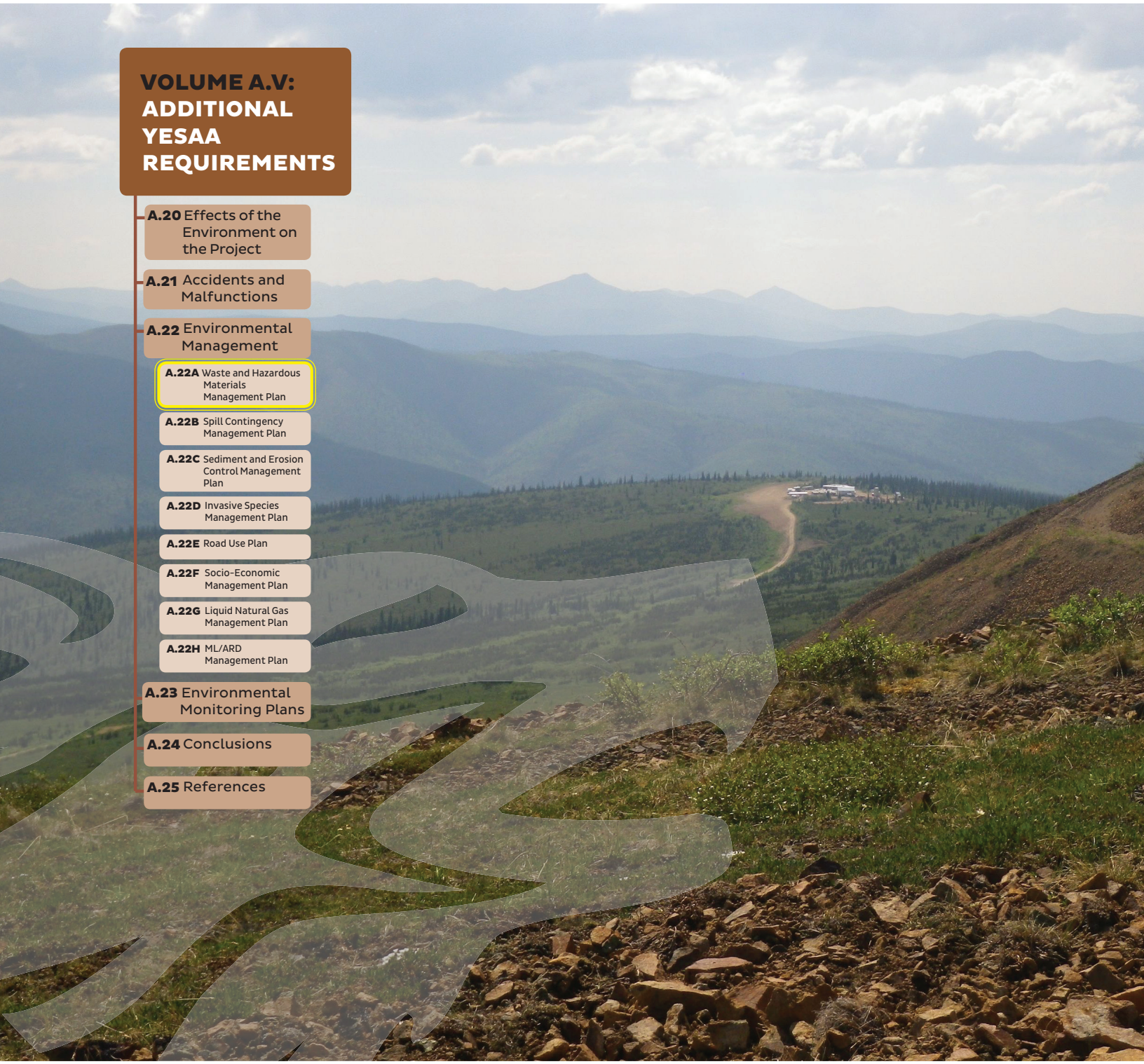
Appendix A.18B
Heritage Sites Summary

Borden Number or Temp Site #	Class	Features	Current Status of Site	Scope of Possible Impacts from Casino Project	Site Boundary Clearly Flagged	Management Recommendations and Proposed Mitigation Strategy	Report/ Permit number and Authors	Bibliographic Reference
KfVi-8	historic	tent frame (log)	intact	Mine Site Developments - possible impact.	Yes	Additional consideration and research is warranted to determine site value and specific mitigation options.	09-09ASR (Altamira)	Soucey et al 2010a
KfVi-9	historic	partially buried wooden object	intact	Mine Site Developments - possible impact.	Yes	Additional consideration and research is warranted to determine site value and specific mitigation options.	09-09ASR (Altamira); 10-4ASR (Altamira)	Soucey et al 2010a; Soucey et al 2010b
KfVi-10	indigenous historic	hide working frame	intact	Mine Site Developments - possible impact.	Yes	Additional consideration and research could be undertaken to determine its value in terms of ownership and relationship to other sites or cultural activities in the area.	09-09ASR (Altamira); 10-4ASR (Altamira)	Soucey et al 2010a; Soucey et al 2010b
KfVi-11	indigenous historic	Hide working stump and pole	intact	Mine Site Developments - possible impact.	Yes	Additional consideration and research is warranted to determine its value in terms of ownership and relationship to other sites or cultural activities in the area.	09-09ASR (Altamira)	Soucey et al 2010a
KfVi-12	indigenous historic	Culturally Modified Tree (bark stripping)	intact	Mine Site Developments - possible impact.	Yes	Further Consultation and Research. Avoidance.	10-4ASR (Altamira)	Soucey et al 2010b
KfVi-13	indigenous historic	Culturally Modified Tree (bark stripping)	intact	Mine Site Developments - possible impact.	Yes	Further Consultation and Research. Avoidance.	10-4ASR (Altamira)	Soucey et al 2010b
KfVi-14	indigenous historic	Culturally Modified Tree (bark stripping)	intact	Mine Site Developments - possible impact.	Yes	Further Consultation and Research. Avoidance.	10-4ASR (Altamira)	Soucey et al 2010b

Appendix A.18B
Heritage Sites Summary

Borden Number or Temp Site #	Class	Features	Current Status of Site	Scope of Possible Impacts from Casino Project	Site Boundary Clearly Flagged	Management Recommendations and Proposed Mitigation Strategy	Report/ Permit number and Authors	Bibliographic Reference
Previoulsy Noted First Nation Use Sites along the Proposed Freegold Road								
FN 1	indigenous historic	*Confidential*	*Confidential*	*Confidential*	*Confidential*	*Confidential*	94-22ASR (Antiquus)	Handly and Rousseau 1995
FN 2	indigenous historic	*Confidential*	*Confidential*	*Confidential*	*Confidential*	*Confidential*	94-22ASR (Antiquus)	Handly and Rousseau 1995
FN 3	indigenous historic	*Confidential*	*Confidential*	*Confidential*	*Confidential*	*Confidential*	94-22ASR (Antiquus)	Handly and Rousseau 1995
FN 4	indigenous historic	*Confidential*	*Confidential*	*Confidential*	*Confidential*	*Confidential*	94-22ASR (Antiquus)	Handly and Rousseau 1995
FN 5	indigenous historic	*Confidential*	*Confidential*	*Confidential*	*Confidential*	*Confidential*	94-22ASR (Antiquus)	Handly and Rousseau 1995
FN 6	indigenous historic	*Confidential*	*Confidential*	*Confidential*	*Confidential*	*Confidential*		
FN 7	indigenous historic	*Confidential*	*Confidential*	*Confidential*	*Confidential*	*Confidential*	94-22ASR (Antiquus)	Handly and Rousseau 1995
FN 8	indigenous historic	*Confidential*	*Confidential*	*Confidential*	*Confidential*	*Confidential*	94-22ASR (Antiquus)	Handly and Rousseau 1995
FN 9	indigenous historic	*Confidential*	*Confidential*	*Confidential*	*Confidential*	*Confidential*	94-22ASR (Antiquus)	Handly and Rousseau 1995
FN 10	indigenous historic	*Confidential*	*Confidential*	*Confidential*	*Confidential*	*Confidential*	94-22ASR (Antiquus)	Handly and Rousseau 1995

APPENDIX A.22A: Waste and hazardous Materials Management Plan



CASINO PROJECT

SOLID WASTE AND HAZARDOUS MATERIALS MANAGEMENT PLAN

PRELIMINARY DRAFT

Prepared by:
Casino Mining Corporation
March 2015

EXECUTIVE SUMMARY

The Casino Mine Project is an approximately 22 year mine project owned and operated by Casino Mining Corporation, that will produce copper and molybdenum concentrates, and gold dore bars via flotation milling and heap leach processing, respectively. The proposed project includes a four year construction period and a 90 year post-closure period. Key project components include the open pit, tailings management facility and waste rock storage area, heap leach facility, mill and associated infrastructure, ore stockpiles, liquefied natural gas power generating infrastructure, and office and accommodation buildings. The project also requires a 120 km access road from the town of Carmacks, YT, and concentrate will be trucked to the port at Skagway, Alaska.

The objective of the Solid Waste and Hazardous Materials Management Plan (the Plan) is to ensure that the handling, storage, transportation, and disposal of all wastes and hazardous materials (solids, liquids, special wastes) generated by the Project are conducted in such a manner as to reduce potential adverse environmental effects. This is a preliminary plan to describe the type of waste generated and related management strategies to responsibly handle, store, transport, and dispose of waste. The Plan will also describe the transportation, storage, use, and handling of hazardous materials to ensure protection of the environment and human health and safety, both of mine employees and members of the public. The Plan will be updated as the project is refined, and has been derived from Plan Requirement Guidance for Quartz Mining Projects. The final Plan will update the descriptions of methods used to manage all domestic and industrial solid, liquid, special wastes and hazardous materials for all phases of the Project. The final Plan will include a table of proponent commitments made during the environmental assessment process and permit and licence conditions relevant to waste management, and indicate how the plan addresses the commitments.

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APPENDICES

Appendix A Specifications for Potential Incineration and Waste Oil Burner Models
Appendix B Incinerator and Open Burning Log

ABBREVIATIONS

Aerofloat 208	Sodium diethyl dithiophosphate/sodium disecondary butyl dithiophosphate
Aerophine 2418A	Sodium-diisobutyl dithiophosphinate
BTEX	Benzene, toluene, ethylbenzene and xylene
CaO	Pebble lime
CMC	Casino Mining Corporation
EPHW10-19	Light extractable petroleum hydrocarbons
flomin d-910	Sodium dithiophosphate
H2SO4	Sulphuric acid
HCl	Hydrochloric acid
HEPH	Heavy extractable petroleum hydrocarbons
kPa	Kilopascals
LEPH	Light extractable petroleum hydrocarbons
LNG	Liquid natural gas
LTF	Land treatment facility
mg	Milligram
MIBC	Methyl isobutyl carbinol
NaCN	Sodium cyanide
NaCO3	Sodium carbonate
NaHS	Sodium hydrosulfide
NaHS	Sodium hydrosulphide
NaOH	Caustic soda (sodium hydroxide)
PAH	Polycyclic aromatic hydrocarbons
PAX	Potassium amyl xanthate
pg I-TEQ	Pictogram international toxicity equivalent
Rm3	One cubic metre of air at a temperature of 25°c and a pressure of 101.3 kpa
TDG	Transportation of Dangerous Goods
TEPH	Total extractable petroleum hydrocarbons
the Plan	Solid Waste and Hazardous Materials Management Plan
VHW6-10	Volatile petroleum hydrocarbons
WHMIS	Workplace Hazardous Materials Information System
µg	Microgram

1 – INTRODUCTION

The Casino Mine Project (the Project) is a proposed 22 year mine project owned and operated by Casino Mining Corporation (CMC), that will produce copper and molybdenum concentrates, and gold dore bars via flotation milling and heap leach processing, respectively. The proposed Project includes a four year construction period and an approximately 90 year post-closure period, during which time the open pit will fill with water. The location of the Casino Project is shown on Figure 1-1. Key project components include the open pit, tailings management facility and waste rock storage area, heap leach facility, mill and associated infrastructure, ore stockpiles, liquefied natural gas power generating infrastructure, and office and accommodation buildings. The project also requires a 120 km access road from the town of Carmacks, YT, and concentrate will be trucked to the port at Skagway, Alaska.

The objective of the Solid Waste and Hazardous Materials Management Plan (the Plan) is to ensure that the handling, storage, transportation, and disposal of all wastes (solids, liquids, special wastes) generated by the Project are conducted in such a manner as to reduce potential adverse environmental effects associated with waste materials. The Plan is preliminary and aims to describe the type of waste generated and related management strategies to responsibly handle, store, transport, and dispose of solid waste and hazardous materials, based on feasibility level design details. To achieve this, CMC will:

- Comply with all applicable territorial and federal waste management regulations;
- Minimize waste generation;
- Select products that are less harmful to the environment;
- Reuse and/or recycle materials;
- Transfer wastes in a safe and responsible manner; and
- Train staff and contractors on policies and operations.

The Plan will also describe the transportation, storage, use, and handling of hazardous materials to ensure protection of the environment and human health and safety, both of mine employees and members of the public. The major sources of waste from the Project will likely include:

- Hazardous waste: used reagent containers, batteries, paint;
- Non-hazardous solid waste: domestic camp waste (food, plastics, paper), and inert bulk wastes (rubber belts, drywall, etc.);
- Fuels and lubricants (petroleum products and oils); and
- Sewage (human sewage and gray water).

Details pertaining to the management of hazardous materials include:

- Hazardous material transport methods, routes, frequency, driver qualifications, spill kit requirements;
- Volumes and amounts of each material used, storage locations, containment measures (segregation, secondary containment, etc.), Material Safety Data Sheets;

- Employee training programs (e.g., Workplace Hazardous Materials Information System) related to proper handling techniques, use of personal protective equipment, and familiarity with the site layout and emergency stations;
- Site and substance-specific operating procedures describing unloading, mixing, plant operations, entry into confined spaces, and maintenance for reagents, including cyanide, to minimize risk to health and safety of mine personnel;
- Communication procedures between on-site and off-site personnel (suppliers, contractors, receivers);
- Inspection measures and frequency;
- Monitoring and reporting requirements;
- Location of copies of the *Spill Contingency Plan and Emergency Response Plan* and how the plans will be implemented as needed as they relate to hazardous materials; and
- Waste disposal methods.

The Plan will be updated as the project is refined, and has been derived from *Plan Requirement Guidance for Quartz Mining Projects* (Government of Yukon, 2013). The final Plan will describe the methods used to manage all domestic and industrial solid, liquid, special wastes and hazardous materials for all phases of the Project, and will include a table of proponent commitments made during the environmental assessment process relevant to waste management, and indicate how the plan addresses the commitments. Terms and conditions of any applicable licences, permits and approvals required for the Project operations will also be included, once acquired.

1.1 PERMIT REQUIREMENTS

The handling, storage, transportation, disposal, and treatment of hazardous and non-hazardous waste, excluding sewage, are regulated under the *Environment Act* and its associated regulations. The *Environment Act* also governs the incineration or burial of waste materials, and the identification and management of contaminated waste. The management of sewage and sewage disposal and treatment systems are regulated under the *Public Health and Safety Act*. The management of hazardous materials is governed by the *Dangerous Goods Transportation Act* as well as the Special Wastes Regulation and Storage Tank Regulations of the *Environment Act*. The use, storage, and handling of hazardous substances are also governed by the Occupational Health Regulations and the Workplace Hazardous Materials Information System Regulations of the *Occupational Health and Safety Act*.

As part of the regulating *Acts*, there are a variety of permits and licences required for the generation, storage, management and disposal of solid and hazardous wastes and materials at the Casino Project, as summarized in Table 1-1. The Air Emissions permit, Special Waste permit and Storage Tank permits are consolidated into a single Environment Act permit, issued jointly by the Government of Yukon, Department of Environment, Environmental Programs Branch and the Department of Community Services, Protective Services Branch, Fire Marshal's Office.

Table 1-1 Required Solid Waste and Hazardous Materials Management Permits

Legislation		Permit/Licence	Requirement	Government Agency
Quartz Mine Act		Quartz Mine Licence	Description of a plan that describes methods to manage solid and liquid wastes	Yukon Energy, Mines and Resources
***Environment Act* Consolidated Permit**	*Environment Act, Air Emissions Regulation*	Air Emissions Permit	Release of air pollutants	Yukon Environment, Environmental Programs
	Environment Act, Special Waste Regulation	Special Waste Permit	Handling, disposal, generation or storage of special (hazardous) wastes	
	Environment Act, Storage Tank Regulation	Storage Tanks Systems Permit	Storage and handling of petroleum products	Community Services, Protective Services, Fire Marshal's Office
		Application for Operation, Closure, Abandonment or Renovations to Storage Tanks	Use of storage tanks containing petroleum and allied petroleum products	
Environment Act, Contaminated Sites Regulation		Relocation permit	Relocation of contaminated material	Yukon Environment, Environmental Programs
		Land Treatment Facility Permit	Operation of land treatment facility for contaminated soils	
Environment Act, Solid Waste Regulation		Solid Waste or Waste Management Permit	Solid waste disposal facility or commercial dump	Yukon Environment, Environmental Programs
Explosives Act		Explosives Magazine Permit	Explosives storage	Yukon Workers' Compensation Health and Safety Board
Occupational Health and Safety Regulations		Underground and Surface authorization to conduct blasting in Yukon	Blasting – underground or surface	Yukon Workers' Compensation Health and Safety Board
Transportation of Dangerous Goods Act		Permit/certificate for Transport of Dangerous Goods	Transportation of hazardous materials including special wastes	Transport Canada
Public Health and Safety Act		Permit to Install a Sewage Disposal System	Installation and operation of construction phase septic tanks and sewage holding tanks	Yukon Health and Social Services
Nuclear Safety and Control Act		Nuclear Substances and Radiation Devices licence	Possess, use, store, transfer, import, export, service and abandon nuclear substances and radiation devices	Canadian Nuclear Safety Commission

1.2 DEFINITIONS

For consistency in interpretation with the contents herein, the following terms are defined:

Bear-proof container: a container sealed to prevent the escape of attractant odours and strong enough to exclude a bear from the contents.

Contaminated material: any soil, snow, sediment, or water that has one or more parameters in excess of applicable standards in the *Contaminated Sites Regulation*.

Modified transfer station: a waste disposal facility where most types of garbage are transferred to another facility for final disposal (usually by burial or incineration); the only exception is that construction and demolition wastes may be buried on-site.

MSDS: Material Safety Data Sheet.

Non-putrescible Waste: any waste that contains no more than trivial amounts of putrescible materials. Putrescible waste contains organic matter that is capable of being decomposed and may be capable of attracting or providing food for wildlife.

Open Burning: combustion of material without control of emitted products of combustion to the atmosphere.

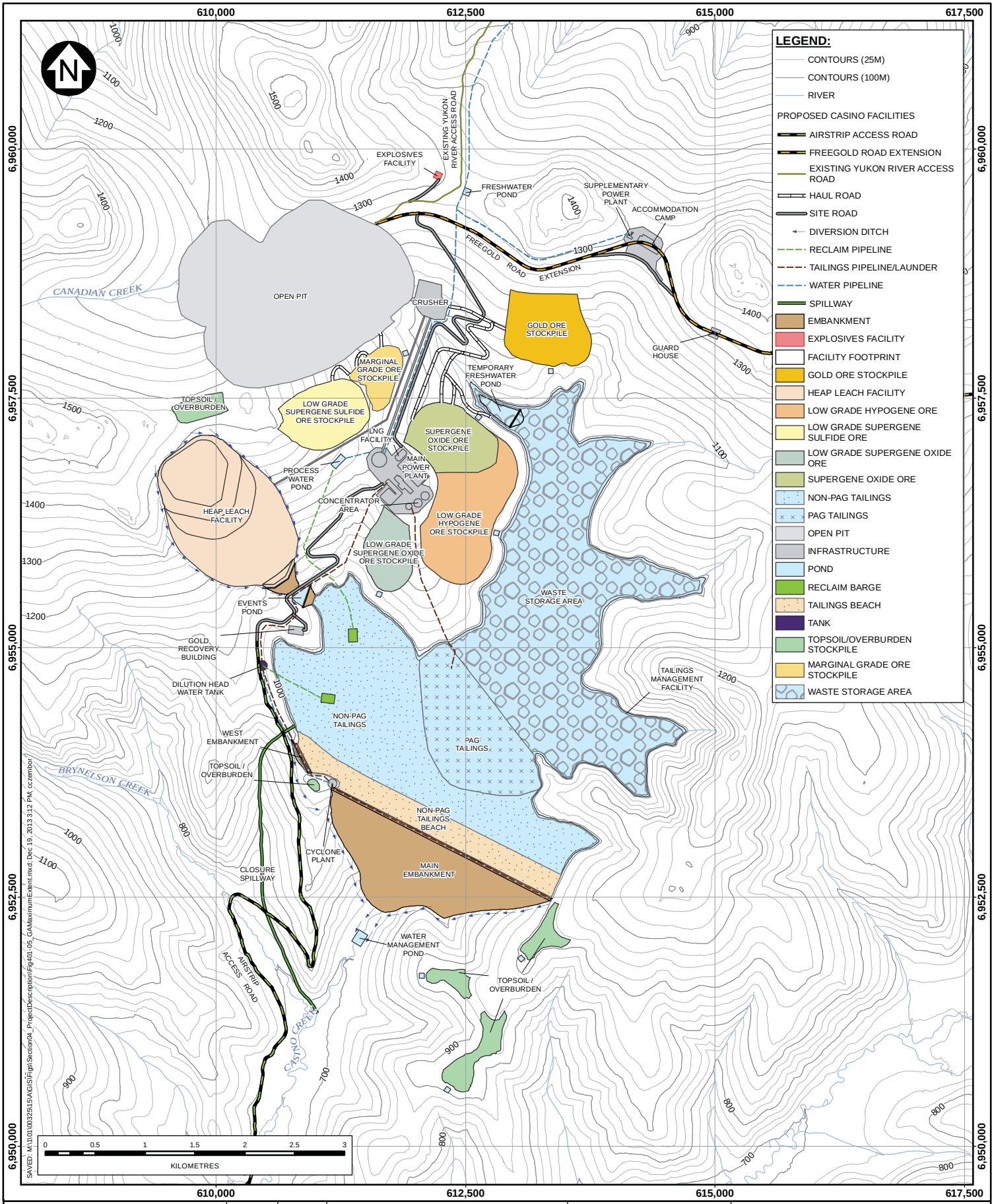
Putrescible Waste: waste that contains organic matter and is capable of decomposition. Putrescible waste may attract or provide food for wildlife (e.g., kitchen waste).

Solid Waste: waste that originates from residential, commercial, industrial or institutional sources, from the demolition or construction of buildings or other structures or is specified in a solid waste management plan to be solid waste.

Special or Hazardous Waste: any waste requiring special handling, storage, or destruction and prescribed as special waste by Yukon Special Waste Regulations, whether or not the waste has any commercial value or is capable of being used for a useful purpose (e.g., waste oil). For the purposes of this plan, special wastes and hazardous wastes are used interchangeably.

Waste: includes solid and special waste.

WHMIS: Workplace Hazardous Materials Information System.



PREPARED BY:

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DESIGNED	GLS/CAH
DRAWN	CC
CHK'D	CAH
APP'D	GLS
REV	0
DATE	16DEC'13

NOTES:

1. BASE MAP: EAGLE MAPPING
2. PROJECTION: NAD 1983 UTM ZONE 7N
3. COORDINATE GRID: METRES

CASINO COPPER AND GOLD

CASINO PROJECT

GENERAL ARRANGEMENT - MAXIMUM EXTENT

FIGURE 1-1

REF 1

P/A VA101-325/15

2 – WASTE INFRASTRUCTURE

A permanent waste management facility will be established at the Casino site during the construction phase. The waste management facility will serve as a central depot where wastes will be managed, processed, packaged, labelled, inventoried, secured and stored for either off-site transport or on site disposal. Non-hazardous solid waste will be separated into putrescible and non-putrescible wastes, and non-putrescible wastes will subsequently be separated into recyclables, burnables and non-burnable materials. The waste management facility will have an electric fence, which will be required to be operational from May 31 to October 31 to discourage wildlife interactions.

The permanent waste management facility will be constructed in accordance with the guidelines for modified transfer stations (Yukon Environment, 2014), which must meet one of the following three construction criteria as follows:

1. The facility must be constructed on a natural or constructed substrate that will support natural attenuation of landfill leachate. Modeling must be conducted to demonstrate that leachate will attenuate to the extent that all contaminants will be below the applicable standards in the Contaminated Sites Regulation at the points of contact with all relevant receptors. If a natural or constructed substrate to support natural attenuation of landfill leachate is not available, the facility must be constructed with a leachate collection system that must have a minimum permeability of 1 x 10-3 cm/s and must be of an appropriate thickness and design, with piping as needed to facilitate the movement of leachate to a collection point. Where the facility is constructed with a double liner, a leachate collection system must be installed above each liner; or
2. Establish a setback of 1.5 km from the nearest drinking water source and 1 km from the nearest surface water used by aquatic life; or
3. Implement a groundwater monitoring program to detect contaminant migration and, if exceedances of the applicable standards in the Contaminated Sites Regulation are detected, submit and implement an adaptive management plan to address those exceedances.

Following detailed engineering, the storage area locations, including type of storage area and foundation properties, will be provided. The waste management facility will have separate areas for recycle/reuse, hazardous waste storage, and a removal area that will contain waste that will be disposed of in an on-site facility. The waste in the waste management area will be segregated and stored using accepted management practices including the following:

- Fire prevention systems that are adequately designed for the materials being stored will be used;
- Spill kits, protective equipment, and other necessary equipment to clean and mitigate spills will be used;
- Only containers in good condition will be used to store items;
- Containers and liner materials will be compatible with the waste being disposed;
- Containers and drums will be labelled to identify the waste content and initial date of storage;
- Sufficient storage space will be left between containers to allow for safe access and handling of containers; and
- Incompatible waste will not be stored in the same containers and will be stored at a safe distance from each other.

3 – WASTE DISPOSAL

Disposal of waste generated at the Casino Project will be via landfill, incineration, open burning or burning for the purposes of heat generation (waste oil burner). The preliminary details for the proposed waste disposal infrastructure are summarized below.

3.1 LANDFILL

Non-putrescible, non-hazardous waste not incinerated, recycled or open burned will be disposed of in an on-site landfill. The landfill operational parameters and conditions for use will be detailed in the consolidated *Environment Act* permit (Table 1-1). The landfill location will be determined during detailed design, and information updated in this section will include the soil and hydrogeological characteristics (depth to groundwater, etc.); design permeability of the liner; access restrictions, and closure methods (e.g., over material stockpile locations). Construction requirements will include the following (from Yukon Environment, 2014):

- No facility is to be constructed on a site with greater than a 6% slope.
- All facilities must be constructed with berms and/or ditches as required to prevent surface water from flowing onto or off of the active portion of the facility, accommodating the larger of a 1 in 25 year storm event or snowmelt event.
- Organic overburden must be removed from each cell location, stockpiled, and retained for the life of the cell for use in restoration and re-vegetation during closure.
- A hydrogeological assessment must be conducted by a qualified professional in order to determine depth to groundwater, flow direction, gradients, and estimated travel times to potential receptors and to establish baseline groundwater quality.
- A groundwater monitoring system must be installed with a sufficient number of wells at locations and depths that yield samples representative of the shallowest aquifer both upgradient and downgradient of the facility, as determined by the hydrogeological assessment. Downgradient wells shall be positioned, where possible, between the facility and downgradient receptors.

The landfill at the Casino Project will be rated a “Class 2” facility, which is a public waste disposal site where waste is buried and/or incinerated and which serves a population of less than 13,000 people (Yukon Environment, 2014). Therefore, the landfill must be constructed to one of the two following specifications:

1. The facility must be constructed on a natural or constructed substrate that will support natural attenuation of landfill leachate. Modeling must be conducted to demonstrate that leachate will attenuate to the extent that all contaminants will be below the applicable standards in the Contaminated Sites Regulation at the points of contact with all relevant receptors.
2. If a natural or constructed substrate to support natural attenuation of landfill leachate is not available, the facility must be constructed with a leachate collection system that must have a minimum permeability of 1×10^{-3} cm/s and must be of an appropriate thickness and design, with piping as needed to facilitate the movement of leachate to a collection point.

3.2 GARBAGE INCINERATOR

Incineration is the preferred method of disposal for putrescible wastes (e.g., food and kitchen wastes, office waste), to ensure complete removal of animal attractants. Putrescible materials will be stored in bear-proof

containers outside of the kitchen and office areas, and waste will be collected twice daily. Putrescible materials will be incinerated daily, and will not be stored for longer than seven days prior to incineration. A dual chambered industrial incinerator will be installed at the waste management facility.

The maximum amount of waste permitted to be incinerated per day will be dictated by the incinerator model and by the *Environment Act* permit. The exact incinerator model will be determined during the purchasing and procurement phase of the Casino Project, however, example model specifications are provided in Appendix A. Ash resulting from the incineration activities will be stored adjacent to the incinerator and will be disposed of in the landfill (see Section 3.1). The incinerator will be inspected and maintained by trained employees familiar with the incinerator operating manual. The following standard operating procedures will be employed when using the incinerator:

- Complete the incinerator pre-operational inspection and checklist;
- Ensure that the integral components of the incinerator including the burners, gauges, valves, lines, walls, doors and exhaust components, are maintained in accordance with the manufacturer's specifications and in such a manner as to provide optimum control of contaminant emissions during all operating periods;
- Ensure all waste is completely reduced to ash during incineration before completion;
- Ensure that all hydrocarbon-contaminated absorbent pads are drip dried or wrung out to ensure that no excess hydrocarbons will leak during incinerator loading;
- Complete an Incinerator Log for all incineration activities; and
- Incinerator Log sheets will be provided to the Environmental department weekly.

3.3 OPEN BURN EQUIPMENT

Open burning is permissible under the *Solid Waste Regulations*, however, to burn waste generated by a commercial activity a Solid Waste Permit is required, and an Air Emissions Permit is required to burn more than 5 kg of solid waste per day. These permits are both incorporated into the Environment Act consolidated permit. The timing windows for open burning and maximum volumes of solid waste that can be open burned will be dictated by these permits. Open burning will be conducted for cardboard and scrap wood and the following precautions will be taken (from Yukon Environment, 2007):

- Burning of only weeds, untreated wood (except for waste plywood and particle board), brush and leaves. Burning of petroleum products, plastics, rubber, or anything else that causes excessive smoke or toxic fumes will not be undertaken;
- Avoid burning during winter thermal inversions because the smoke may settle and accumulate;
- Avoid burning on foggy or snowy days because the smoke will not disperse properly and may concentrate in one area;
- Burn only when wind conditions will disperse the smoke away;
- Do not burn during high winds or when the wind direction is frequently changing as fire can spread quickly;
- Keep fires an adequate distance from buildings;
- Ensure a quick, hot and complete burn by turning or aerating smouldering materials;

- Avoid burning rain-soaked garbage unless there is a risk of attracting wildlife;
- Make every reasonable effort to prevent runoff water from entering the burning area; and
- Burn in small manageable piles.

The Casino Project may also be permitted to open burn waste reagent bags as incinerating them poses some risk to incinerator operator safety. Ash generated from open burning will be disposed of in the landfill (Section 3.1).

3.4 WASTE OIL BURNER

Waste oil burners will be purchased from reliable suppliers to provide heat for smaller buildings located away from the power plant (e.g., airstrip facilities) through the incineration of waste oil produced from the maintenance of the vehicle fleet. Waste oil will be stored in storage tanks during the summer, when heat production is not required, and consumed in the winter to heat the buildings. The exact waste oil burner model will be determined during the purchasing and procurement phase of the Casino Project, however, example model specifications are provided in Appendix A.

3.5 USED TIRES

Tires present a significant environmental challenge in the Yukon. They do not break down in the natural environment and so can accumulate indefinitely. They take up valuable landfill space, provide a perfect breeding ground for mosquitoes, and are a serious fire hazard when stored in piles above ground (Yukon Environment, 2013). Used tires will be collected and stored at the waste management facility. Tires not used for the purpose of protection barriers or other on site uses will be hauled off site and disposed of in accordance with the Yukon Used Tire Management Program. Tires will be kept reasonably clean and not buried or burned, with the exception of tires with rim size greater than 24.5”, which are buried at the landfill.

To minimize the potential fire hazard created by tire stockpiles, the *National Fire Code* sets out the rules for both outdoor and indoor storage of rubber tires, as follows:

- The size and clearance limits for rubber tires storage areas are:
  - Maximum base area: 1,000 m^2
  - Maximum height of storage: 3 m
  - Minimum clear space around each storage area: 15m
  - The minimum clear space requirement above may be waived if an ISA has a base area not greater than 5 m^2.
- There must also be a clear space of not less than:
  - 30 m between stored products and brush or forested areas; and
  - 6 m between stored products and uncontrolled grass or weeds.
- An outdoor storage area shall be surrounded by a firmly anchored fence that is:
  - substantially constructed to discourage climbing and unauthorized entry;
  - not less than 1.8m high; and
  - provided with gates that shall be locked when the storage area is not staffed.

4 – WASTE TREATMENT

To minimize the amount of waste material shipped off-site, and prevent potential spills during transportation, wherever possible contaminated materials will be treated at the Casino Project and, once remediated, returned to the environment or used in industrial activities. Waste treatment infrastructure that may be implemented at the Casino Project includes a land treatment facility for the remediation of hydrocarbon and glycol contaminated soil, an oil/water separator for the treatment of hydrocarbon contaminated water and a sewage treatment system for the treatment of black and grey water produced by domestic activities. These proposed systems are detailed below.

4.1 LAND TREATMENT FACILITY

A land treatment facility (LTF) is usually required at a mine site to accept and treat contaminated soil generated from the day-to-day activities that may result in minor contamination of soil, water, snow or ice by hydrocarbons (e.g., diesel, waste oil, hydraulic oil), antifreeze, solvents or lubricants. An LTF is a specially constructed facility for bioremediating soil contaminated with petroleum hydrocarbons utilizing naturally occurring microbes to degrade hydrocarbon constituents (Yukon Environment, 2011). For microbes to function effectively, the contaminated material must have the correct moisture, oxygen, nutrient and pH conditions. Land treatment facilities are regulated under the *Contaminated Sites Regulations* and a permit for construction and operation is required from Yukon Government, Department of Environment, Environmental Programs Branch.

The location of a LTF will be determined during detailed design of the Casino Project. Construction of the LTF will be conducted in accordance with the guidelines in the *Contaminated Sites Regulations*, as follows (from Yukon Environment, 2011):

- The LTF will be located in an area large enough to accommodate the soil spread out into layers less than 0.5 metres in thickness, or placed in spaced rows of piles no higher than 4 metres.
- The native soil where the facility is to be built will be sufficiently fine-grained (silt or clay textured) to act as a semi-impermeable barrier to the movement of liquids. If the native soil is too porous, an artificial liner will need to be used.
- Natural liners will be a minimum of one metre thick throughout each LTF cell. The maximum permeability will be 10^{-5} cm/sec.
- Artificial liners must be resistant to petroleum hydrocarbons, and will be at minimum 30 mil (30 thousandths of an inch) thick. An artificial liner that is not UV-resistant will be covered at all times to prevent degradation. The liner will be installed as per the manufacturer's specifications, with a sufficient barrier layer to prevent punctures due to equipment traffic, etc. The liner will be installed by a qualified person according to the manufacturer's specifications and will be firmly anchored in the berms on each side of the cell.

The LTF will not be constructed on any land where:

- The slope is greater than 6 %;
- The seasonal high water table is less than 3 metres below the surface;
- The Facility would be within 100 metres of a surface water body; or
- The land is identified as being within a 25-year floodplain.

Each LTF cell will be surrounded by berms of sufficient size to contain the contaminated soil and prevent runoff from entering or escaping from the facility. These berms will be made of low-permeability soil or if an artificial liner is used, the liner will pass over or through the berms and will be securely anchored to prevent runoff from passing through.

Access ramps will be constructed over the berms to allow equipment to access the treatment cells.

Signs will be posted identifying the site as a land treatment facility and indicating that the facility contains contaminated material.

4.2 OIL/WATER SEPARATOR

Oil/water separators may be used to partition petroleum products from runoff generated during washing of equipment serviced at the mine site. Equipment services in the truck shop or maintenance building may have traces of oil, grease, hydraulic fluid or fuel that is rinsed off, and will collect in sumps or floor drains. Final locations of oil/water separators will be detailed during detailed engineering of the Casino Project.

An oil/water separator may be installed to remove contaminants prior to discharge of the water to the TMF. The oil/water separator will be installed, maintained and operated in accordance with the manufacturer's specifications. Generally, an oil/water separator is a tank used to collect runoff, sized to 1.85 m^2 of surface area per 1000 m^2 of drainage area to allow the petroleum to remain on the surface (BC EMPR, 2006). Settleable solids must be removed from the stormwater stream before it reaches the oil/water or the separator will become filled with sediment.

Weekly inspections will ensure the oil/water separators are functioning propersly, and allow for periodc removal of debris (if necessary). For outdoor facilities, inspections should be conducted after any rain totalling 13 mm or more in 24 hours. Oil products may be removed from the separator by absorbent pads, as the oil will float on the top of the water. The absorbent pads may then be incinerated in the on-site incinerator.

4.3 SEWAGE TREATMENT SYSTEMS

Sewage disposal systems in the Yukon are regulated under the *Public Health and Safety, Sewage Disposal Systems Regulation*. Sewage treatment for construction camps may consist of sewage holding tanks and septic fields, or portable sewage treatment plants (rotating biological contactors or similar units) which will discharge to a tile field more than 100 m from the high water mark. The selection of treatment system will depend on the location of the construction camp, and the availability of an acceptable septic field. Sewage holding tanks and septic fields will be constructed in accordance with the Yukon *Design Specifications for Sewage Disposal Systems* (Yukon Health and Social Services, 2014), and a permit acquired from Yukon Health and Social Services prior to operation of the system. Sewage holding tanks and septic fields will also be constructed to treat black and grey water generated at the each of the stand-alone facilities, such as the process plant, truck shop, and ADR/SART facility, located to distant from the accommodations camp to facilitate piping to the stand alone sewage treatment plant.

During operations, a sewage treatment plant will be installed to accept and treat all grey and black water generated from the kitchen, accommodations camp and dry facilities. The sewage treatment plant will be a stand-alone, pre-packaged system and treated effluent will be pumped to the TMF. Sludge will also be disposed of in the TMF. All the components of the system will be factory assembled, inspected, tested and delivered to the site in major assemblies for final installation and commissioning on site.

Typical sewage treatment systems incorporate flow equalization tanks and digestion in anoxic tanks. Anaerobic treatment is followed by aerobic treatment and subsequent filtration through a membrane reactor. The membrane reactor utilizes a fixed growth bacteria process whereby bacteria are grown on a media surface that is rotated into and out of the wastewater. The treated wastewater flows through separate zones each with a progressively higher standard of treatment. The media on which bacteria grow are engineered plastic disks made from grid extruded medium density polyethylene material with UV light inhibitors. The grid pattern promotes oxygen transfer into the wastewater. The system digests sludge efficiently as a result of the process design. The sludge remains in the primary settling tank during normal operation and will be pumped out every six to nine months depending on the influent total suspended solids level. Digested sludge from the facility will be disposed of in the tailings facility, or hauled offsite for disposal at an approved facility. The system is not prone to upsets and can be operated with varying flows.

5 – WASTE MANAGEMENT

Solid waste management at the Casino Project will include initial waste minimization, and if unavoidable, the disposal of solid waste primarily through off-site recycling, burning of putrescible wastes in a permitted incinerator, open burning of wood waste, and finally disposal of non-putrescible, non-burnable wastes in an on-site landfill. Generally solid waste generated at the Casino Project can be categorized as domestic waste, industrial waste, or contaminated material. The management of each of these types of materials is described below. Special waste disposal is detailed in Section 6.

5.1 WASTE MINIMIZATION

Waste minimization at the Casino Project will consist of, in preferential order, prevention, minimization, reuse, recycling and energy recovery. Waste prevention and minimization may be achieved through consolidation of shipments to the site, bulk purchases to minimize packaging and selection of suppliers that use a minimum amount of packaging. Additionally, efficient purchasing practices will ensure that orders of perishable consumables do not exceed usage rates and generate unnecessary waste, and accurate tracking of on-site equipment and materials will ensure that the proper stores are maintained and unnecessary shipments minimized.

Material reuse and recycling activities includes reuse of materials and products in their original form or recovering materials that can be processed into new products. At a mine site, generally materials reuse is in the form of using salvaged material (e.g., re-bar, coper wiring, wood products, metal drums, etc.) from primary construction activities for secondary construction or maintenance activities. Other materials may be “downcycled” for other uses (e.g., waste tires as traffic control/safety structures, re-use of metal or plastic drums to store waste). Stockpiles of salvageable materials will be kept at the waste management facility.

Incineration of waste products for energy will also be conducted to minimize disposal requirements for waste oil. Waste oil burners will be purchased from reliable suppliers to provide heat for smaller buildings (e.g., truck shops) through the incineration of waste oil produced from the maintenance of the vehicle fleet. Waste oil will be stored in storage tanks during the summer, when heat production is not required, and consumed in the winter to heat the buildings.

5.2 WASTE GENERATION

Both non-hazardous and hazardous (or special) waste will be generated by the Casino Project activities. A summary of the waste projected to be generated, treatment methods and disposal areas is provided in Table 5-1. Non-hazardous wastes include materials such as domestic garbage, food waste, paper materials, aluminum cans, glass, plastics, inert bulk waste, etc. Domestic waste will include putrescible food waste, recyclable containers (cans and bottles), packaging, inert non-combustible domestic waste, and paper products. Hazardous waste includes materials such as waste oil, laboratory chemicals and solvents, lead-acid batteries, oil filters, and used oily rags and absorbent pads. Hazardous waste requires special handling and training procedures. All employees, contractors, and sub-contractors who are handling hazardous waste will be provided with Workplace Hazardous Materials Information System training or will be required under contract to have that training, so they can identify hazardous waste and know how to handle it appropriately. Transportation of Dangerous Goods training will be provided, or required of employees, contractors, and sub-contractors who are receiving, off-loading, and storing potentially hazardous materials, or involved in the storage and shipment off-site of hazardous waste.

Table 5-1 Types, Treatment and Disposal Areas for Waste Generated at the Casino Project

Type of Waste	Treatment	Waste Disposal Area
Non-Hazardous Waste		
Inert Solid Waste		
Paper and corrugated cardboard	• Reuse • Incineration	Incinerator
Plastics	• Reuse • Recycle • Incinerator	• Waste management facility • Incinerator
Tires and conveyor belts	• Reuse • Disposal	• Waste management facility • Landfill
Vehicles	• Reuse • Disposal	• Waste management facility • Landfill
Scrap metal	• Reuse • Off-site recycling	Waste management facility
Waste lumber	• Recycling • Open burning	• Waste management facility • Open burn pit
Electrical equipment	Off-site recycling	Waste management facility
Solid Domestic Waste		
Food waste	Incineration	Incinerator
General camp waste	Incineration	Incinerator
Sewage		
Black and grey water	Treatment	• Sewage treatment plant • Sewage treatment systems
Sewage sludge	Disposal	TMF
Sewage effluent	Disposal	TMF
Special/Hazardous Waste		
Waste Oil and Diesel Fuel	Incineration	Waste oil burner
Waste Anti-Freeze	Store in labelled drums	Off-site disposal
Waste Solvents and Lubricants	Store in labelled drums	Off-site disposal
Used Lead-Acid Batteries	Store in covered pallets	Off-site disposal

Type of Waste	Treatment	Waste Disposal Area
Biomedical Wastes	Incineration	Incinerator
Used Aerosol Containers	Punctured with can puncturing machine	Off-site disposal
Waste Processing Reagents and Containers	Store in labelled drums	Off-site disposal
Laboratory Wastes	Incineration	Incinerator

5.3 RECYCLABLE MATERIAL

Beverage containers and tins produced in the kitchen facilities can be recycled at designated off-site recycling facilities. Recyclables will be washed prior to storage to minimize wildlife attractants, and will be stored at the waste management facility in designated bear-proof recycling bins until they are transported off-site. Refundable recyclable materials include:

- Aluminum and tin pop/juice cans;
- Plastic beverage containers;
- Glass beverage containers;
- Tetra packs; and
- Waxed cardboard juice containers.

Other mine sites in the Yukon have established programs with a local recycling company (Raven Recycling) and local charities to collect the recycling directly from the mine site and donate the revenue from the refund directly to the local charities. It is foreseen that the Casino Project will establish a similar program for recyclable materials. Materials that can be recycled are summarized in Table 5-2. Metal waste recycling may also be conducted following the construction phase, with the proceeds from the metal recycling going towards paying for the off-site disposal.

Table 5-2 Recyclable materials and proposed disposal strategies

Recyclable Material	Proposed Disposal Method
Dry cell alkaline batteries (e.g., AA, AAA, C, D, 6V, 9V, etc.)	Off-site shipment for recycling
Ink cartridges	Returned to supplier for recycling
Lithium batteries	Off-site shipment for recycling
Metal drums (used 205 L)	Returned to supplier for re-use/recycle
Non-ferrous metals	Aluminum, tin, etc. can be returned to Raven Recycling
Recyclable computers and electronics	Off-site shipment to Raven Recycling: LCD, flat screens, laptops and desktops = fee for disposal keyboards and mice, power cables, adaptors and powerbars, network cables and backup power unit = free disposal CRT monitors, scanners, laser printers and inkjet printers = not accepted
Refundable recyclables	Off-site shipment to Raven Recycling; proceeds donated to local charities.
Single use plastic reagent drums (used 205 L), cleaned and drained	Off-site shipment to Raven Recycling

5.4 OFF-SITE TRANSFER

Generally, is it desirable to dispose of solid waste on site to minimize risks to the environment during shipment. Often vehicles will come to the mine site with a full load of materials and may have an empty truck returning to the supplier. Empty return vehicles provide an opportunity for the removal of solid wastes and special wastes from the mine site. Pelly Crossing and Braeburn (south of Carmacks on the Alaska Highway towards Whitehorse) each have transfer stations that accept construction waste, appliances, and recycling, and the Pelly Crossing transfer station accepts special wastes. The landfill in Carmacks does not accept waste from industrial users, however, the Faro, Watson Lake and Whitehorse landfills will accept waste from industrial users. Therefore, depending on the route the vehicle is taking, solid waste can be transported to one of the landfills in the territory, or disposed of at the transfer station. The Watson Lake and Whitehorse landfills accept special waste, appliances, metals and recycling.

Hazardous waste will be transferred to an approved hazardous waste facility that will issue a certificate of destruction. Periodic audits of this facility to ensure proper handling and destruction of hazardous waste will be considered. All hazardous materials and dangerous goods will be stored in clearly labelled containers or vessels and handled in accordance with regulations appropriate to their hazard characteristics. Reputable certified transportation contractors will be used for the transport of goods and materials to and from the site. Project personnel will periodically inspect the transporters' performance and compliance with transport regulations, contract requirements, and overall performance. The transportation of special waste requires a permit for transportation issued by Yukon Government, Department of Environment and will involve a list of special wastes commonly carried and a spill response plan that addresses those special wastes (Yukon Environment, 2013).

Potential materials that will be transferred off site for recycling or disposal include:

- Recyclables for refund
- Scrap metals for refund
- Special wastes:
- Aerosol cans
- Appliances (with refrigeration)
- Contaminated flammable liquids (e.g., Jet B, gasoline)
- Fuel filters
- Lead acid batteries
- Oil filters
- Plastic oil pails and oil containers (20 L)
- Process facility chemicals
- Rubber tires (rim size < 24.5")
- Single use oil and glycol plastic drums
- Used florescent light ballasts/light tubes
- Waste antifreeze/glycol
- Contaminated waste oil (motor oil, diesel, hydraulic oil, etc.)

5.5 BURIAL

Materials that may be disposed of in the landfill include:

- Air filters;
- Conveyor belting rubber and miscellaneous rubber;
- Empty paints and coatings containers;
- Glass;
- Incinerator/open burning ash;
- Miscellaneous inert wastes (e.g., windshield glass, insulation, Portland cement, construction plastics, drywall, bentonite, sand, small, scrap non-recyclable materials, Styrofoam, etc.);
- Non-recyclable computers and electronics (CRT monitors, scanners, laser printers and inkjet printers);
- Reagent bags;
- Scrap piping (poly, ABS, PVC); and
- Tires (rim size >24.5").

Separate storage will be provided at the landfill for scrap metal, which may be removed from site for recycling (including structural steel, copper and brass).

5.6 OPEN BURNING

Open burning will only be conducted for cardboard, untreated wood and paper products.

5.7 INCINERATION

Incineration is the preferred method of disposal for putrescible wastes (e.g., food and kitchen wastes, office waste), to ensure complete removal of animal attractants. Incineration will be conducted for the following types of waste:

- Food waste and kitchen waste;

- Household/office waste;
- Light plastics;
- Oil absorbent materials and oil/grease rags; and
- Bio-hazardous materials (e.g., bandages, sharps, etc.).

5.8 INSPECTIONS AND RECORD KEEPING

A waste monitoring and auditing program will be established for the Casino Project, with the purpose of:

- Providing baseline data to enable continuous improvement of waste avoidance, reduction and management measures throughout the Project; and
- Assessing actual waste results and comparing with predicted results.

Off-site and on-site disposal will be documented by tracking waste type, volume, method of disposal, and location. Tracking of the waste streams by each department will show where changes can be made to further improve the waste management system over the life of the Project. Tracking will also alert management to areas or departments that may require new procedures or particular attention. A summary of the tracking will be reported annually by each department to the Environmental Department, along with an analysis of the effectiveness of the existing systems and any proposed improvements.

An audit program is required to alert management when enforcement is necessary to ensure compliance with the waste management plan and procedures. The Mine Manager will appoint a small audit team. Responsibilities of the audit team may include the following:

- Inspection of Project facilities for proper waste segregation, storage, and disposal. Waste streams and methods of disposal will be inspected and analyzed periodically to ensure compliance;
- Inspection of the waste management facility to ensure proper waste segregation, storage, and disposal;
- Perform periodic reviews of the waste management facility including procedures, training, equipment, records, and employee awareness; and
- Review the inspection findings with area supervisors, operation personnel, transporters, and contractors to correct deficiencies, improve procedures, maintain awareness and communication, and recognize positive or negative performance.

5.8.1 Incinerator Inspections and Record Keeping

Incinerator inspections include daily equipment checks, weekly blower checks and monthly inspections to check for changes in the equipment. Periodic emissions monitoring is also required as defined in the *Air Emissions Regulations*. Incinerator logs are maintained to track the amount of waste incinerated, the kind of waste incinerated and the frequency of incineration. An example Incinerator Log sheet is provided in Appendix B. Inspection forms will be created in accordance with the manufacturers requirements.

Equipment checks and logs are performed in accordance with the manufacturer's specifications. Daily checks include integral physical components such as thermocouples, contact switches, refractory in primary chamber, gaskets and seals, and general housekeeping. Weekly inspections consist of checking the incinerator blowers (primary, secondary and flame port blowers) to ensure they are working properly. Monthly inspections consist of

checking the external surfaces of the incinerators, more specifically checking for 'spotty' discolouration on surfaces.

The pre-operational inspections will be conducted to ensure the incinerator is ready and safe prior to use. The inspection must be performed by a qualified operator designated to use the equipment prior to operation. Operators are to inform the Site Manager if equipment deficiencies are discovered prior to use. The Site Manager will arrange for maintenance as required. The inspection checklist will include verification of the following items:

- The appropriate Personal Protective Equipment (PPE) is used;
- Ash bin is empty;
- Burner chamber is clean without presence of hot ambers or flames;
- The door to burner chamber is in working order and the seal around the door frame is without rips, tears or absent sections;
- The blower safety relay switch is not stuck and the retract spring is in good working order;
- The fire extinguisher is present and operational;
- The fuel shut off is free moving;
- All fuel lines are inspected for leaks or abrasions; and
- No flammable material is in the immediate area outside of the incinerator.

Periodic air emissions monitoring ensures that emissions from the incinerator do not contain contaminants in excess of the following concentrations derived from the Canada-Wide Standards for the noted contaminants:

- 20 µg mercury /Rm^3 air
- 50 mg hydrogen chloride /Rm^3 air;
- 57 mg carbon monoxide /Rm^3 air (4-hour average);
- 80 pg I-TEQ dioxins and furans /Rm^3 air;
- 50 mg particles /Rm^3 air (rated capacity less than 1 tonne per hour); and
- 20 mg particles /Rm^3 air (rated capacity equal to or greater than 1 tonne per hour).

To enable comparison with these standards, sample results must be corrected to 11% oxygen content and 0% moisture content and expressed in terms of reference cubic metres (Rm3, which is one cubic metre of air at a temperature of 25°C and a pressure of 101.3 kPa). In addition, bottom ash and fly ash from the incinerator must be individually sampled and analyzed for total metals and, using a TCLP test, for all inorganic substances for which a standard exists. Initial sampling involves the collection of one eight-hour composite sample per day for five consecutive operating days. After that, one eight-hour composite sample is collected twice per year. Eight-hour composite samples are created by taking a sample from the ash discharge once each hour for eight operating hours and combining the samples. The samples are crushed during sample preparation to pass a 3/8" (9.5 mm) screen prior to analysis.

5.8.2 Land Treatment Facility Inspections

Inspections of the LTF will be dictated by the relevant permit, but will likely include the following (from Yukon Environment, 2011):

- Inspections every two weeks during the operational season.
- If any irregularities are detected, they must be addressed immediately, and the Environmental Programs Branch must be notified.
- Implement a regular monitoring program for all soil being treated in order to monitor the progress of remediation. Samples must be representative of the soil being characterized by combining several grab samples from throughout the volume of soil to be represented, in accordance with *Protocol 11: Sampling Procedures for Land Treatment Facilities*.
- LTF operators must submit an annual report to the Environmental Programs Branch by March 31 of each year which provides information about the operation of the facility during the previous calendar year. Each facility's permit includes a detailed list of the specific information to be included in the annual report, but this list generally includes the following:
    - the origin of all contaminated material being treated, the volume of material accepted from each source, and the total volume being treated;
    - a figure showing the layout of the facility and the location of each stockpile of contaminated material;
    - laboratory analytical results for materials added or removed from the facility in that year (unless previously submitted in support of a permit or removal request), as well as results of any other sampling conducted;
    - data from groundwater monitoring, if applicable;
    - the volume of soil removed from the facility and the locations of the receiving sites;
    - operational details, such as how the contaminated material was tilled or turned and whether nutrients were added to help remediation; and
    - a sampling and analysis plan for the following year.

5.8.3 Landfill Monitoring and Inspections

Landfill monitoring and inspections will be dictated by the relevant permit, but may include the following (from Yukon Environment, 2014):

If installed, all groundwater monitoring wells must be checked for water levels and sampled twice each year, at the high and low water points, for the following parameters:

- Major ions (Calcium, Magnesium, Sodium, Potassium, Chloride, Sulphate, Nitrate Nitrogen, Nitrite Nitrogen, Phosphate)
- Dissolved metals
- Mercury
- pH and hardness
- Alkalinity
- Carbonate
- Bicarbonate
- Total dissolved solids
- Ammonia
- Dissolved organic carbon
- Volatile organic compounds
- Chemical oxygen demand
- Total Kjeldahl nitrogen
- EPH_{W10-19}
- VH_{W6-10}

Surface water samples must be collected from all downgradient surface water bodies within 1 km of the facility that are identified in the hydrogeological assessment as being potentially impacted by the facility. Where appropriate, a sample should also be taken from surface water upgradient of the facility for comparison. Surface water samples must be analyzed for the parameters listed above for groundwater, substituting total metals for dissolved metals, removing volatile organic compounds, and adding biochemical oxygen demand.

For facilities at which leachate collection is required, leachate samples are to be collected concurrently with each groundwater sampling event, and analyzed for the parameters listed above for groundwater. The monitoring report should include an analysis of groundwater quality in comparison to leachate quality to aid in determining if leachate may be impacting the groundwater. Landfill gas monitoring may also be required at large engineered facilities or cells, in which case landfill gas probes capable of monitoring the levels of all gases of concern would be installed in the most permeable strata between the waste disposal areas and each property boundary, as well as between the waste disposal areas and any structures where landfill gas could accumulate. Monitoring and alarm devices for methane and oxygen should also be installed within, beneath, and immediately adjacent to all on-site structures. Combustible gas concentrations may not exceed 25% of the lower explosive limit at any monitoring point.

6 – SPECIAL WASTE MANAGEMENT

Special wastes (or hazardous wastes) can include used oil, used fuel, used batteries, used antifreeze (glycol), used solvents and lab chemicals. Special wastes projected to be generated at the Casino Project are summarized in Table 6-1, as well as the proposed disposal method. A special waste permit is required under the *Special Waste Regulation* for any user that generates, stores, handles, mixes, transports, disposes or releases special wastes. The Yukon Government also offers an annual Special Waste Collection Program, up to a maximum of $2,500, which industrial users are able to participate in. Following detailed design of the Casino Project, this section will be updated with the design of the special waste collection and storage areas, including any secondary containment or monitoring systems. Handling and personal protective equipment or special precautions required for the various types of special waste are detailed in the material safety data sheets (MSDS) for each material, which will be provided by the manufacturer, and will be stored at the waste management facility, in the special waste management area.

Table 6-1 Special Wastes Generated at the Casino Project

Special Waste	Proposed Disposal Method
Aerosol cans	Punctured with can puncturing machine and shipped off-site for disposal.
Appliances (with refrigeration)	Off-site disposal
Contaminated flammable liquids (e.g., Jet B, gasoline)	Off-site disposal
Fuel filters	Store in drums or totes; off-site shipment to registered facility
Lead acid batteries	Off-site disposal at approved facility
Oil filters	Spent oil filters are drained of residual oil and crushed in a filter crusher. Shipped off-site for disposal.
Plastic oil pails and oil containers (20 L)	20 L pails: off-site disposal 1 L and 5 L containers: incinerated
Process facility chemicals	Off-site disposal
Rubber tires (rim size < 24.5”)	Off-site disposal
Single use oil and glycol plastic drums	Off-site disposal
Used florescent light ballasts/light tubes	Off-site disposal
Waste antifreeze/glycol	Stored in 205 L drums and shipped off-site for disposal at approved facility
Waste oil (motor oil, diesel, hydraulic oil, etc.)	Used crankcase, ATF, hydraulic, #2, #4 and #5 fuel oils can be burned in a waste oil burner. Waste oil contaminated with water or glycol must be stored and shipped off-site for disposal.

6.1 SPECIAL WASTE MANAGEMENT

CMC will handle and store special waste separately from solid waste to the extent practicable, and in the following manner to prevent endangering human and wildlife health and the environment:

- Waste oil from piston aircraft will not be mixed with other waste oil.
- Special waste will not be mixed with any other material unless authorized by the Yukon Environment Branch as an acceptable treatment/disposal option.
- All drums, and any other portable containers containing special wastes, will be covered to prevent container degradation from the sun or contamination by water from snow or rain. They will also be stored off the ground to prevent container degradation by ground moisture.
- Incompatible substances will be stored separately to prevent contamination, fires, explosions, gaseous emissions, leaching or other discharges, or other dangerous conditions. Refer to the MSDS for more information. Master copy MSDS binders for all hazardous substances are available at where products are used and stored. MSDS copies for area specific hazardous substances will be located in the process plant and assay lab.
- The contents of all storage containers will be clearly marked. Containers used for storage of special waste will be made of materials that will not adversely react with the special waste.
- The residue at the bottom of any container used for the storage of special wastes will not be drained to the environment. Such residue will be segregated and treated as a special waste until proven otherwise.
- During storage or transport of any special waste, the container will be closed at all times and will not be opened, handled or stored in a manner which may cause it to leak. Any special waste stored in leaking containers will be immediately removed or transferred to intact containers.
- Every closed container that:
    - has a capacity of more than 230 litres;
    - is designed to be installed in a fixed location; and
    - will contain special waste, will be certified by a testing agency recognized by the Standards Council of Canada prior to putting special waste in the container.

CMC will transport and transport special waste in the following manner:

- No special wastes will be transported by CMC other than within the Mine site;
- All special wastes transported off-site will be in accordance with applicable transport laws, to a facility permitted in the Yukon or other jurisdiction to receive them, by a carrier permitted in the Yukon or another jurisdiction to receive and transport special wastes. If the facility is in the Yukon, both the facility and the carrier must be permitted in the Yukon according to the *Transportation of Dangerous Goods Regulations*;
- A movement control document (manifest) will be completed to document each shipment of special waste (including volume), as per *TDG Regulations* noted above;
- All special wastes will be transported and transferred in such a manner as to prevent their release into the environment; and
- All vehicles carrying any special waste will be secured to prevent access to unauthorized personnel.

6.2 SPILL PREVENTION AND RESPONSE

The storage and disposal of special waste will be done in accordance with best management practices. Should a spill occur, refer to the *Casino Project Spill Contingency Management Plan* and the *Emergency Response Plan*. Spill cleanup requirements are provided within the MSDS for each material.

6.3 INSPECTIONS AND RECORD KEEPING

Storage facilities for special wastes will be inspected regularly for leaks or non-compliance with policies, plans, and procedures. Inspections will include tanks, pipelines, connections, valves, gauges and meters, sumps and separators, and inventory records. Inspections will be recorded and filed with the Mine Manager. Inspections of the special waste management area will be conducted monthly, and will include:

- Inventory of special wastes received, stored, used and disposed of;
- Details of disposal of all special wastes; and
- Records of collection from hazardous waste collection services.

7 – HAZARDOUS MATERIALS

Dangerous goods and hazardous materials will be required at the Casino Project throughout the Project, and typical dangerous goods and hazardous materials, their uses and storage locations are summarized in Table 7-1. Hazardous materials that will be used for the Casino Project include fuels (diesel and liquefied natural gas (LNG)), lubricants, solvents, antifreeze, explosives, and processing reagents, including cyanide. A separate *Cyanide Management Plan* will be developed and implemented in recognition of the higher level of public concern associated with this substance. Material Safety Data Sheets (MSDSs) will be required for each of these products prior to their delivery to the Mine Site. These products will be imported to the Project site and used throughout the Project facilities, including the sulphide and oxide ore processing plants (including the SART and ADR facilities), truck shops, accommodation camp, and the airstrip. Most of the products will be consumed on site, but some (e.g., hydraulic fluid and batteries) will require disposal after use as per Section 6. Below are summarized the requirements for transportation of these products to and from the Project site, and their proper and safe storage, use, and disposal on site.

Table 7-1 Typical Dangerous Goods and Hazardous Materials

Product	Use	Storage
Batteries	Vehicle maintenance	Truck shop
Diesel fuel	Throughout	Double-wall tanks or 205 L barrels
Domestic products	Camp and kitchen for cleaning	In accommodation camp
Ethylene glycol (anti-freeze)	Vehicle maintenance	Truck shop
Explosives	Blasting	Explosives magazine
Gasoline	Throughout	Double-wall tanks or 205 L barrels
H_2SO_4	Process plant reagent	Stored in framed 1 m^3 totes
Hydraulic fluid	Vehicle maintenance	Truck shop
Jet A and Jet B fuel	Helicopters and planes	Airstrip
Laboratory chemicals	Preservatives for environmental samples, reagents for laboratory analyses	Stored in 1 L and 5 L containers
Liquid natural gas (LNG)	Power generation	Power plant
Lubricants and greases	Vehicle maintenance	Truck shop
Lubricating oil	Vehicle maintenance	Truck shop
Oxygen	First aid for cyanide exposure	Camp medical facility

Product	Use	Storage
Process plant reagents	Used in sulphide ore processing facility and concentrate production	Dry reagents will be stored in bulk bags up to 1 tonne size. Liquids will be stored in tanks
Propane	Samp and other facilities for space heating	Portable and permanent tanks/cylinders
Smelting fluxes	Use during smelting (10% borax , 80% flouspar, 5% $NaCO_3$, 5% sodium nitrate)	ADR facility
Sodium cyanide (NaCN)	Gold extraction from ore	ADR facility leaching circuit reagent storage area
Sodium hydroxide (NaOH)	Used for the desorption of gold from the activated carbon	ADR facility leaching circuit reagent storage area, in supplier packaging
Solvents	Vehicle maintenance	Truck shop; 205 L barrels with secondary containment
Windshield washer fluid	Vehicle maintenance	Truck shop

7.1 HAZARDOUS MATERIAL MANAGEMENT PRACTICES

The management of hazardous materials is governed by the Dangerous Goods Transportation Act as well as the Special Wastes Regulation and Storage Tank Regulations of the Environment Act. In addition, the Occupational Health and Safety Act applies to hazardous waste material management, including the following sections:

- Employers must ensure that workers are aware of any hazard in the work and in the handling, storage, use, disposal, and transport of any article, device, or equipment, or of a biological, chemical, or physical agent (Section 3(2) (a));
- Employers must ensure that workers are informed of their rights, responsibilities, and duties under this Act (Section 3(2) (c));
- Duties of supervisors include proper instruction of workers and ensuring that work is performed without undue risk; ensuring that workers use applicable personal protective equipment; advising the worker of any known danger associated with the work; and providing written instructions on measures and procedures to be followed for the protection of the worker (Section 7);
- A worker has a right to refuse to do work that is believed to pose an undue hazard (Section 15); and
- Injuries and accidents include accidental release of a controlled product (Section 30(1) (i)).

Therefore, CMC will implement actions to avoid, control and mitigate the risks from dangerous goods handling, storage and disposal.

An inventory of dangerous goods and hazardous materials will be maintained and will list all chemicals on site, and will include MSDS and WHMIS information on the products to ensure that Project personnel have all the necessary information for their safe transportation, use, and disposal. Before any chemical is brought to the site,

the supplier or contractor will supply an MSDS for the product. Minimizing the risk of safety infractions and/or environmental damage from accidental releases of hazardous materials includes the following practices:

- Knowing which hazardous materials are on site through the maintenance of an inventory system;
- Allocating clear responsibility for managing hazardous materials;
- Understanding the actual or potential hazards and environmental impacts associated with the storage and handling of these materials;
- Minimizing the use and/or generation of hazardous materials;
- Constructing storage facilities that safely contain the materials in all foreseeable circumstances;
- Implementing physical controls and procedures to ensure that no materials escape during routine operation as well as in upset conditions;
- Having emergency response plans in place to ensure immediate action to minimize the environmental effects should accidental or unplanned releases occur;
- Monitoring all discharges and reporting unplanned discharges if they occur; and
- Keeping records to avoid reoccurring safety and environmental problems.

Materials will be stored in appropriate containers within suitably contained areas. All the process reagents will be prepared in a separate reagent preparation and storage facility in a containment area. The reagent storage tanks will be equipped with level indicators and instrumentation to ensure that spills do not occur during operation. Appropriate ventilation and fire and safety protection will be provided.

The following actions will be implemented to avoid, control, and mitigate risk:

- Manufacturers will provide safe packaging and labelling for packaged materials, as a condition of purchase agreements;
- Storage areas will be appropriately climate-controlled, dry, and well-ventilated;
- Containers holding the materials will remain sealed to prevent accidental leakage and/or spillage;
- Incompatible chemicals will be stored separately in order to prevent deleterious chemical reactions and cross contamination;
- Chemical storage areas will be designated as non-smoking areas and are located away from food storage areas;
- All personnel handling dangerous goods will be trained and provided with appropriate personal protective equipment; and
- All bulk chemical storage sites will be outfitted with concrete or lined floors and walls capable of containing 110% of the volume of the largest vessel in the area or as stipulated by appropriate legislation or permits.

Additional information on response plans in the event of any spills of hazardous materials is provided in the *Casino Project Spill Contingency Management Plan*.

7.1.1 Petroleum Products

The materials with the highest risk potential for a spill or accidental release are petroleum products, due to their frequency of use. Light natural gas (LNG) and diesel will be the most consumed materials, as well as smaller volumes of gasoline, Jet A and Jet B and vehicle maintenance fluids such as lubricating oil, ethelyne glycol (anti-freeze), hydraulic fluid, oil and grease. During operation, LNG will be shipped to site at an average of 11 trucks per day, whereupon the LNG will be pumped to the LNG storage tank. LNG is then pumped to the conversion plant, where it is converted to natural gas for use in the power plant and in the vehicle fleet.

Fuel handing, transportation, and storage facilities and activities will be consistent with British Columbia's *Health, Safety and Reclamation Code* (BC MEMPR, 2008) and the *Fuel Storage and Handling Guidebook* (Mineral Resources, 2002). All fuel storage vessels will include secondary containment, and all transfer stations will have concrete spill pads complete with oil/water separators during operation. Tanks and sumps will have high-level alarms. All transfers from tanker trucks to tanks will be done using enclosed lines, hoses, and pumps. All storage and transfer locations will also be equipped with appropriate spill kits. An inspection schedule will be developed for each fuel storage site, taking into account the volume of fuel stored at each site and the respective risks related to that storage. Inspections will include tanks, pipelines, connections, valves, gauges and meters, sumps and separators, and inventory records. Inspections will be recorded and filed.

Fuel transfer procedures will include management practices to ensure no overtopping of tanks or spillage. All spills or accidents will be reported immediately. Employees and contractors responsible for transporting or storing hydrocarbons or fueling vehicles will receive training in proper operating procedures and emergency response. Most mobile equipment, including mine haul trucks, will be fuelled from mobile fueling equipment. Mobile equipment, such as tracked dozers, will be serviced by a fleet of fuel/lube trucks. These vehicles will be equipped with spill kits. Hydrocarbon spills will be collected, and contaminated soils and overburden materials will be hauled to the land treatment facility.

Oils, lubricants degreasers, solvents, and other petroleum-based products will be delivered to the site in drums by truck (the drums will often be palletized). These will be unloaded using a fork lift and then stored in a secure area. The lubricants will be dispensed using hose reels and barrel pumps in the truck shop.

7.1.2 Reagents

Metal concentrates are produced at the Casino Project through both a sulphide ore flotation process and an oxide ore heap leaching process, both of which require substantial reagent inputs. Reagents used in the sulphide ore process include sodium-diisobutyl dithiophosphinate (Aerophine 2418A), sodium diethyl dithiophosphate/sodium disecondary butyl dithiophosphate (Aerofloat 208), methyl isobutyl carbinol (MIBC), pebble lime (CaO), sodium hydrosulfide (NaHS), flomin d-910 (sodium dithiophosphate), flocculant, potassium amyl xanthate (PAX). Reagents used in the oxide ore process include sodium cyanide (NaCN), caustic soda (sodium hydroxide, NaOH), pebble lime (CaO), hydrochloric acid (HCl), sodium hydrosulphide (NaHS), sulphuric acid (H2SO4), activated carbon, antiscalant, flocculant

All the reagents will be prepared in a separate reagent preparation and storage facility with containment. The reagent storage tanks will be equipped with level indicators and instrumentation to ensure that spills do not occur during operation. Reagents will be clearly labelled, and MSDSs will be readily available. An inventory will be maintained showing deliveries and consumption. All relevant staff will be trained regarding risks related to each reagent and the measures required for the safe handling, use, storage, and disposal of the reagents, including emergency and spill cleanup procedures. Appropriate ventilation and fire and safety protection, including personal protection equipment, will be provided at the facility.

The liquid reagents (including fuel oil, A208, 2418A, MIBC, HCl, H2SO4, and antiscalant) will be added in their undiluted form to various process circuits via individual metering pumps. Dry reagents will be packaged in large 1 tonne bulk bags. They will be trucked to the site in conventional transport trucks, and unloaded at the Process Plant into the reagent storage and makeup area. The bags will then be emptied into mix tanks for subsequent pumping and distribution to the appropriate area in the Process Plant. All the solid type reagents (including PAX, NaOH, and NaCN) will be mixed with freshwater to solution strength in the respective mixing tank and then stored in separate holding tanks before being added to various addition points by metering pumps. Cyanide transportation, storage, and use will be consistent with the International Cyanide Management Code, and is detailed in the *Casino Project Cyanide Management Plan*.

7.1.3 Nuclear Equipment Handling and Disposal Plan

Radioactive sources may exist at the Casino Project for use in such tasks as process monitoring (e.g., density gauges), exploration (e.g., down-hole logging), monitoring (e.g., neutron moisture gauges), geo-technical assessment (e.g., Troxler soil compaction meters), and research (e.g., for tracer studies).

All aspects of the purchase, handling, use, storage, and disposal of nuclear equipment are regulated in Canada under the *Nuclear Safety and Control Act* and its regulations. CMC and contractors will comply with all applicable regulations, including requirements for licensing. Radioactive materials at industrial facilities requires proper management of the potential human health hazard (both occupational and public), as radioactive contamination may not be detected in conventional occupational, environmental, or process stream monitoring. Periodic checks of radioactive sources will be undertaken to ensure that there has been no significant loss of integrity of the source container that could result in leakage or contamination. All radioactive materials will be appropriately labelled, and the labels will always be visible. Radioactive sources no longer being used will be stored in appropriate containers in secure storage buildings on site. Whenever possible, purchase agreements will be established with suppliers to take back the units being taken out of service, or other disposal agreements will be arranged. Specific requirements for storage, use and disposal will be detailed during the application for a Nuclear Substances and Radiation Devices licence.

7.1.4 Transport of Dangerous Goods and Materials

Transportation of dangerous goods and materials to the Casino Project will be contracted out to a certified transporter in compliance with the *Transportation of Dangerous Goods Act and Regulations*. Transportation of dangerous goods is regulated under the *Dangerous Goods Transportation Act*, which requires transporters to have a certified contract and a spill response plan for all goods to be transported. The transporter will be required to:

- MSDSs accompany all goods and materials.
- Non-compatible materials will be transported in a separate shipment.
- Fire extinguisher and fire prevention materials will be adequate and appropriate for the material being transported.
- Containers will be appropriate for the material being shipped.
- Containers will be properly secured.
- Containers and trucks will be properly marked, labelled, and placarded.
- Manifests will be maintained in accordance with federal and provincial regulations.

- Spill response materials will be adequate and appropriate for the materials being transported.
- Drivers will be adequately trained and equipped for spill first response, containment, and communication.

To the extent possible, the transportation of hazardous materials will only take place when road conditions are suitable. During winter months transport may be curtailed during periods when the roads are not safe for trucks due to ice or snow related hazards. When road conditions are uncertain for the transportation of hazardous materials, the vehicle or truck will be accompanied by an escort vehicle along the access road. The access road will be maintained to provide a safe and effective transportation route for all hazardous materials required on site.

7.2 MATERIAL SAFETY DATA SHEETS

Material safety data sheets (MSDSs) provides information primarily aimed at worker health and safety, with some secondary information related to environmental impacts and remedial action in the event of spillage typically provided; and commitment to train employees regarding transportation, storage, and use of dangerous goods and hazardous materials.

Current Material Safety Data Sheets (MSDS) provided by the manufacturer will be available to all personnel. The MSDS documentation will be available at every location where hazardous materials are stored; in addition all MSDS documentation will be retained in a central file at the on-site construction office during construction, and in the first aid building and administration building during operations. Hazardous materials storage areas will include signage using standard WHMIS symbols and descriptions of materials stored in each area. MSDS sheets will be replaced if necessary once final selection and procurement of hazardous materials has been completed.

8 – CONTAMINATED MATERIALS

Contaminated material may result from on-site spills of hydrocarbons (i.e., diesel, waste oil, and hydraulic oil), antifreeze, solvents and lubricants. These items each have specific disposal methods as follows:

- Hydrocarbon contaminated soil and snow will be excavated and transported to the land treatment facility (LTF);
- Hydrocarbon-contaminated absorbent pads will be incinerated;
- Antifreeze contaminated soil and snow will excavated and transported to the Land Treatment Facility;
- Antifreeze contaminated absorbent pads will be incinerated; and
- Solvents and lubricants have specific disposal requirements as per the MSDS sheets.

Below are the details of the assessment, treatment and confirmatory sampling for material disposed of the in LTF. Methods of assessment and treatment described below are as per the *Contaminated Sites Regulations* (Government of Yukon, 2002) and the protocols established under it.

8.1 ASSESSMENT

Soils and snow contaminated with hydrocarbons and glycol may be disposed of in a LTF. Material able to be treated in the LTF is immediately placed in the LTF to prevent further contamination and undergoes initial characterization. Initial material characterization requires in situ sampling during the excavation of contaminated materials, of both the materials excavated and the material left behind, to ensure that all contaminated materials are excavated. Sampling is done at a rate of one composite for every 50 m^3 of material, except where there is reason to believe that Petroleum Hydrocarbons (PHC) may be at Special Waste levels (30,000ppm or 3% and above), in which case a sample must be taken for every 10 m^3 of material. Note that 3% is the level at which pools of free product can be expected to form in many matrix types.

For soil sampling, a 250ml glass jar with a Teflon cap liner is filled with sample, and analyzed for BTEX group (Benzene, Toluene, Ethylbenzene and Xylene), TEPH, LEPH, HEPH (Total, Light and Heavy Extractable Petroleum Hydrocarbons), PAH (Polycyclic Aromatic Hydrocarbons), Styrene, chlorinated and non-chlorinated phenols and pH. Analytical results are compared to Contaminated Sites Regulations Schedules 1 and 2.

8.2 TREATMENT

Treatment of hydrocarbon contaminated soil is via microbes, that, under appropriate conditions break down long chain hydrocarbons into their less volatile counterparts. LTF operational requirements will be dictated by the terms of the Land Treatment Facility Permit, however, the following operation guidelines will be followed (from Yukon Environment, 2011):

If soil is placed in the facility to a depth of greater than 15 cm, the soil should be tilled or turned at least twice yearly. Tilling aerates the soil, which provides microbes with the oxygen they need to break down petroleum hydrocarbons. Tilling more frequently will allow the soil to remediate more quickly, and the Environmental Program Branch recommends that soil be tilled at least once per month.

In order to ensure that the microbes in the soil can process hydrocarbons efficiently, the pH of the soil should be maintained between 6.5 and 8.5.

The addition of fertilizer may be beneficial, or even necessary to ensure that the soil is remediated in a timely manner. Treatability studies can help to determine if fertilizer or other amendments would be helpful. Some commercial laboratories offer these tests.

Care should be taken to ensure that the soil in an LTF does not become saturated with water. Water saturation will slow or halt the remediation process by reducing the amount of oxygen available to microbes in the soil. Large land treatment facilities and those that do not undergo frequent tilling are particularly vulnerable to saturation. Depending on local climactic conditions, it may be beneficial to incorporate a sump into the design of the facility to collect runoff water in one location. This also allows collected water to be easily sprayed back onto the top of the soil piles, maintaining an even level of moisture that may encourage remediation.

Materials from different locations or containing different levels of contamination must be kept separate within the facility unless otherwise authorized by a permit.

8.3 CONFIRMATORY SAMPLING

Confirmatory sampling is conducted once interim samples indicate that the soil has been remediated to below *Contaminated Sites Regulations* (Government of Yukon, 2002) standards. Confirmatory sampling is conducted at a rate of one sample per 100 m^3 of soil using composite sampling techniques outlined in Protocol 11 of the *Regulations*. Each composite is to be composed of soil from the deeper horizons of the treatment cell where remediation rates are lowest. Once remediated material meets the *Contaminated Sites Regulations* standards, an application to the Yukon Government Environmental Programs Branch is sent to request permission to remove the soil from the treatment facility. If the treated material exceeds any of the standards in the Contaminated Sites Regulation, a Relocation Permit will be required to move the material from the LTF to an off-site receiving location. If all contaminant levels are below the most stringent standards, or if the material will not leave the property, no Relocation Permit will be required, but the Environmental Programs Branch must still authorize the removal of the material from the facility. Remediated materials are only used for the application under which they were approved by the Environmental Programs Branch (i.e., industrial use).

9 – EMPLOYEE TRAINING

All persons at the Project will be made aware of the waste management and hazardous materials program and of how to direct waste to the correct waste stream through an orientation and training program on domestic and industrial waste procedures. Permanent employees will receive regular retraining and updates when new procedures or changes are introduced. Employees charged with handling hazardous materials will also be provided with WHMIS and TDG training, as described below.

9.1 WORKPLACE HAZARDOUS MATERIALS INFORMATION SYSTEM (WHMIS)

Workplace Hazardous Materials Information System (WHMIS) training will be mandatory for CMC personnel that transport, use or dispose of hazardous materials. Personnel will undertake WHMIS training immediately upon commencing employment as part of an induction program. Personnel will be re-certified every 3 years. WHMIS will be implemented on site by the Health & Safety Manager by requiring:

- Communication between hazardous material suppliers prior to dispatching of materials;
- Adequate storage infrastructure in line with industry standards;
- The prominent display of valid MSDS and WHMIS signage on hazardous material storage areas;
- Regular inspection of containers and storage areas;
- Availability and use of appropriate personal protective equipment;
- Provision of emergency preparedness equipment such as fire extinguishers, eye flushing points, and first aid supplies;
- Availability of appropriate spill kits for all hazardous materials;
- Training of personnel handling hazardous materials;
- Ensuring that safe and secure storage of hazardous materials is implemented to avoid potentially dangerous chemical interactions; and
- The implementation of monitoring systems for hazardous material storage and handling areas, such as monitoring of HCN gas in cyanide storage areas.

9.2 TRANSPORTATION OF DANGEROUS GOODS

Personnel involved in the transportation of dangerous goods will be given certified training in WHMIS and Transportation of Dangerous Goods (TDG). Training will be per Transport Canada training requirements including:

- The nine classifications of hazardous materials;
- Documentation requirements for transportation of hazardous materials;
- Understanding safety marks, labels and placards required for transportation of hazardous materials;
- Safety requirements for Transportation of Dangerous Goods; and
- Spill response procedures for transportation of hazardous materials.

CMC will ensure that personnel required to oversee and be involved with the transportation of dangerous goods will hold valid certificates of competency during any time in which they transport dangerous goods.

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APPENDIX A

SPECIFICATIONS FOR POTENTIAL INCINERATION AND WASTE OIL BURNER MODELS

CLEAN BURN

The #1 Waste Oil Furnace In Customer Satisfaction™

HASSLE FREE CLEAN BURN 100% SATISFACTION 10 YEAR WARRANTY (or 15,000 Hours) HEAT EXCHANGER/COMBUSTION CHAMBER



VERSATILE WASTE OIL HEATING TECHNOLOGY

Furnace system includes:

- Oil supply pump
- In-line washable oil filter
- Vacuum gauge for filter
- Check valve
- Tank filter
- Oil line fittings package
- Wall thermostat
- Barometric damper



6 ft. figure shown for scale













	CB-140	CB-1750	CB-2500	CB-3250	CB-3500	CB-5000
***Maximum BTU/hour**	140,000 (41 kW)	175,000 (51.25 kW)	250,000 (73 kW)	325,000 (95.3 kW)	350,000 (102 kW)	500,000 (146 kW)
***Maximum oil consumption**	1.0 GPH (3.8 L/h)	1.2 GPH (4.54 L/h)	1.7 GPH (6.4 L/h)	2.1 GPH (7.91 L/h)	2.5 GPH (9.5 L/h)	3.6 GPH (13.6 L/h)
Fuels	← **Used oils:** Crankcase, ATF, hydraulic **Fuel oils:** #2, #4, and #5 fuel oil →					
Air flow output (CFM)	Unit heater 2000 Axial fan Furnace cannot be ducted	Unit heater 1700 Central furnace (ducted) 0.25 SPWC (in.) 1500 0.30 SPWC (in.) 1400	Unit heater 2700 Central furnace (ducted) 0.25 SPWC (in.) 2500 0.40 SPWC (in.) 2400	Unit heater 3300 Central furnace (ducted) 0.25 SPWC (in.) 3150 0.40 SPWC (in.) 2900	Unit heater 4200 Central furnace (ducted) 0.25 SPWC (in.) 4000 0.40 SPWC (in.) 3900	Unit heater 5500 Central furnace (ducted) 0.25 SPWC (in.) 5200 0.40 SPWC (in.) 5100
***Air compressor req'd**	2.0 CFM @ 20 PSI (3.4 m^3/h @ 1.4 bar)	2.0 CFM @ 20 PSI (3.4 m^3/h @ 1.4 bar)	2.0 CFM @ 20 PSI (3.4 m^3/h @ 1.4 bar)	2.0 CFM @ 20 PSI (3.4 m^3/h @ 1.4 bar)	2.0 CFM @ 25 PSI (3.4 m^3/h @ 1.7 bar)	2.5 CFM @ 25 PSI (4.25 m^3/h @ 1.7 bar)
Stack size	6 inch dia. (152.4mm dia.)	8 inch dia. (203mm dia.)	8 inch dia. (203mm dia.)	8 inch dia.(203mm dia.)	8 inch dia. (203mm dia.)	10 inch dia. (254mm dia.)
Furnace dimensions, assembled L x W x H (inches) (millimeters)	45" L x 28 W x 20 H (1143 x 711.2 x 508)	83 x 29.25 x 31.5 (2190 x 743 x 787)	103.25 x 29.25 x 31.5 (2623 x 743 x 787)	121" L x 31.25 W x 35 H (3073 x 794 x 889)	74 x 35 x 61 (1880 x 889 x 1549)	78 x 38 x 73 (1981 x 965 x 1845)
Approx. weight (Uncrated furnace system)	300 pounds (136.07 kg)	406 pounds (182.7 kg)	509 pounds (229.1 kg)	641 pounds (288.7 kg)	836 pounds (376.2 kg)	1036 pounds (466.2 kg)
Electrical requirements	115 VAC 60 Hz, single phase 20 A circuit breaker	115 VAC 60 Hz, single phase 20 A circuit breaker	115 VAC 60 Hz, single phase 30 A circuit breaker	115 VAC 60 Hz,single phase 30 A circuit breaker -or- 230 VAC 60 Hz,single phase 20 A circuit breaker	230 VAC 60 Hz, single phase 30 A circuit breaker	230 VAC 60 Hz, single phase 30 A circuit breaker

* Values indicated above are nominal. Actual values will vary depending on fuel and installation.

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DOUBLE CHAMBER CYCLONATOR INCINERATOR

SERIES CY2000



- **Built In Safety Features**
- **Readily Transportable**
- **Economical Operation**
- **Clean Burning**

CY-2050-FA "D"

Designed for Petroleum, Mining, and Lumber Industries

Capacity
1.4 m^3, 90 kg per hour.
Type No. 1, 2, & 3 waste.

Power Requirements
115 volts 60 cycle single phase.

Stack
Stainless Steel
- 14 gauge.
- 38cm diameter.
- 3m high.
- c/w stainless steel spark arrester.
- a hinged base plate for moving.

Casing
12 gauge steel.
Lining: high heat duty castable refractory over high temperature insulation.

Hearth
Refractory hearth over 6.35mm steel base.

Doors
6.35-cm steel plate c/w heavy-duty blade latch.
Charging:
- 61cm-x 71cm clear opening
- Refractory lined over steel plate.

Ash:
- 61cm x 40cm clear opening
- Refractory lined over steel plate

Air Supply
Forced air fan c/w duct to primary airs jets and to secondary over-fire air jets.

Timers
Cycle timer interconnected to air supply fan and gun type burner enclosed in burner housing.

Burners
650,000 BTU gun type primary burner.
Gun burner enclosed in protective plate steel housing.
450,000 BTU in secondary chamber.

Fuel Supply: Oil Fired Unit Only
1350-liter fuel storage tank c/w filter and flexible hose type connection.

Transporter
Incinerator and fuel storage mounted on skid type frame 4.27m long x 1.83m wide.
Height: 3.2m tall, with stack folded.
Constructed of W150 I-Beam c/w bumper posts.

Weight
5000 kg.

Options
* LPG Fired burner.
* Diesel fired burner.
* 2.3m Electric power cord.
* Stack winch.
* Cold climate assembly.

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APPENDIX B

INCINERATOR AND OPEN BURNING LOG

Incinerator/Open Burn Log

Date	Name of Operator	Start Time	End Time	Incinerator Use							Open Burning		
				Kitchen/Putrescible Waste	General Waste	Animal Solids	Contaminated Waste	Volume of Waste into incinerator (kg)	Volume of Ash Removed (kg)	Average Temp. in Secondary Chamber (°C)	Volume of Solid Waste Open Burned (kg))	Volume of Untreated Wood Open Burned (kg)	Description
21-Aug-14	*K. Smith*	*12:00*	*14:00*	*x*	*x*			*35*	*10*	*820*	*30*	*50*	*Inspection conducted on external components.*

APPENDIX A.22B: Spill Contingency Management Plan



CASINO PROJECT

SPILL CONTINGENCY MANAGEMENT PLAN

PRELIMINARY DRAFT

Prepared by:
Casino Mining Corporation
March 2015

Executive Summary

The Casino Mine Project is an approximately 22 year mine project that will produce copper and molybdenum concentrates, and gold dore bars via flotation milling and heap leach processing, respectively. The proposed project includes a four year construction period and a 26 year post-closure period. A key component of the Casino Project is the upgrade and extension to the existing Freegold road, jointly called the Casino Mine Access Road. The Freegold Road is an existing 80 km long gravel resource road owned and operated by the Yukon Government. Casino Mining Corporation (CMC) proposes to upgrade the existing Freegold Road, including the addition of a bypass road around the town of Carmacks, and extend the road a further 120 km to the Casino Mine Site. Both the upgrade and the extension would be two-lane, gravel resource roads designed for all weather use by haul trucks with highway legal loads. The roads will be designed to BC Ministry of Forest guidelines, with a 70 km/hr design speed, with some short 50 km/hr sections where road geometry is limited by the terrain. The road will be 8.2 m wide with maximum grades of 8%.

The Casino Project will require the transportation of various materials for operation and construction of the mine, including up to eleven tanker trucks per day for LNG transportation from Fort Nelson. Additionally, the milling processes will require shipment of reagents, including cyanide based reagents for the leaching of gold in the heap leach facility.

This Spill Contingency Management Plan (SCMP) is a preliminary plan to outline the precautions and spill response procedures for the proposed Casino Project. The SCMP will be updated as the project is refined, and has been derived from guidance in the Plan Requirements Guidance for Quartz Mining Projects (Government of Yukon, 2013), *Guidelines for Preparing Contingency Plans for Carriers of Hazardous Waste* (Ministry of Environment, 2011), and from the *Land Transportation Emergency Response Guideline for Petroleum Spills* (Canadian Petroleum Products Institute, 2008).

The SCMP contains information on the identification of the potential spills that may occur at the Casino Mine, and outlines spill response procedures for specific types of spills.

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1 - INTRODUCTION

The Casino Mine Project is an approximately 22 year mine project owned and operated by Casino Mining Corporation (CMC), that will produce copper and molybdenum concentrates, and gold dore bars via flotation milling and heap leach processing, respectively. The proposed project includes a four year construction period and a 26 year post-closure period. The location of the Casino Project is shown on Figure 1-1. Key project components include the open pit, tailings management facility and waste rock storage area, heap leach facility, mill and associated infrastructure, ore stockpiles, liquefied natural gas power generating infrastructure, and office and accommodation buildings. The project also requires a 120 km access road from the town of Carmacks, YT, and concentrate will be trucked to the port at Skagway, Alaska.

The objective of the Spill Contingency Management Plan (the SCMP) is to minimize the potential effects of any spills associated with the Casino Project. While CMC will take all reasonable measures to prevent spills while undertaking the construction, operation and closure of the Casino Project, it is unlikely that all physical operations can attain zero risk. Unforeseen events, accidents and malfunctions can occur from time to time that may result in a spill. To minimize the effect of a spill and to prevent such spills from leaving the site, design features, background planning and diligent operational procedures are required.

The SCMP has been derived from guidance in the *Plan Requirement Guideance for Quartz Mining Project* (Government of Yukon, 2013), the *Guidelines for Preparing Contingency Plans for Carriers of Hazardous Waste* (Ministry of Environment, 2011), and from the *Land Transportation Emergency Response Guideline for Petroleum Spills* (Canadian Petroleum Products Institute, 2008). The SCMP has been written to provide clarity on spill response activities at the Casino Project, specifically with regards to spill prevention measures, and spill response activities. This preliminary SCMP should not be taken as a final spill response plan, but as one that will provide the framework for future plans, once project details are confirmed. The SCMP will be amended or updated as required, to accommodate change in construction, operational procedures, regulations and guidelines. A plan for spill response is required for both a Quartz Mining License and a Water Use License.

A spill is defined under Section 132 of the *Yukon Environment Act* (Government of Yukon, 2002) as "*a release of a substance into the natural environment; from or out of a structure, vehicle or other container; and that is abnormal in quantity or quality in light of all the circumstances of the release; or in excess of an amount specified in the regulations*". Where a substance is defined as "*a hazardous substance, pesticide, contaminant or special waste*".

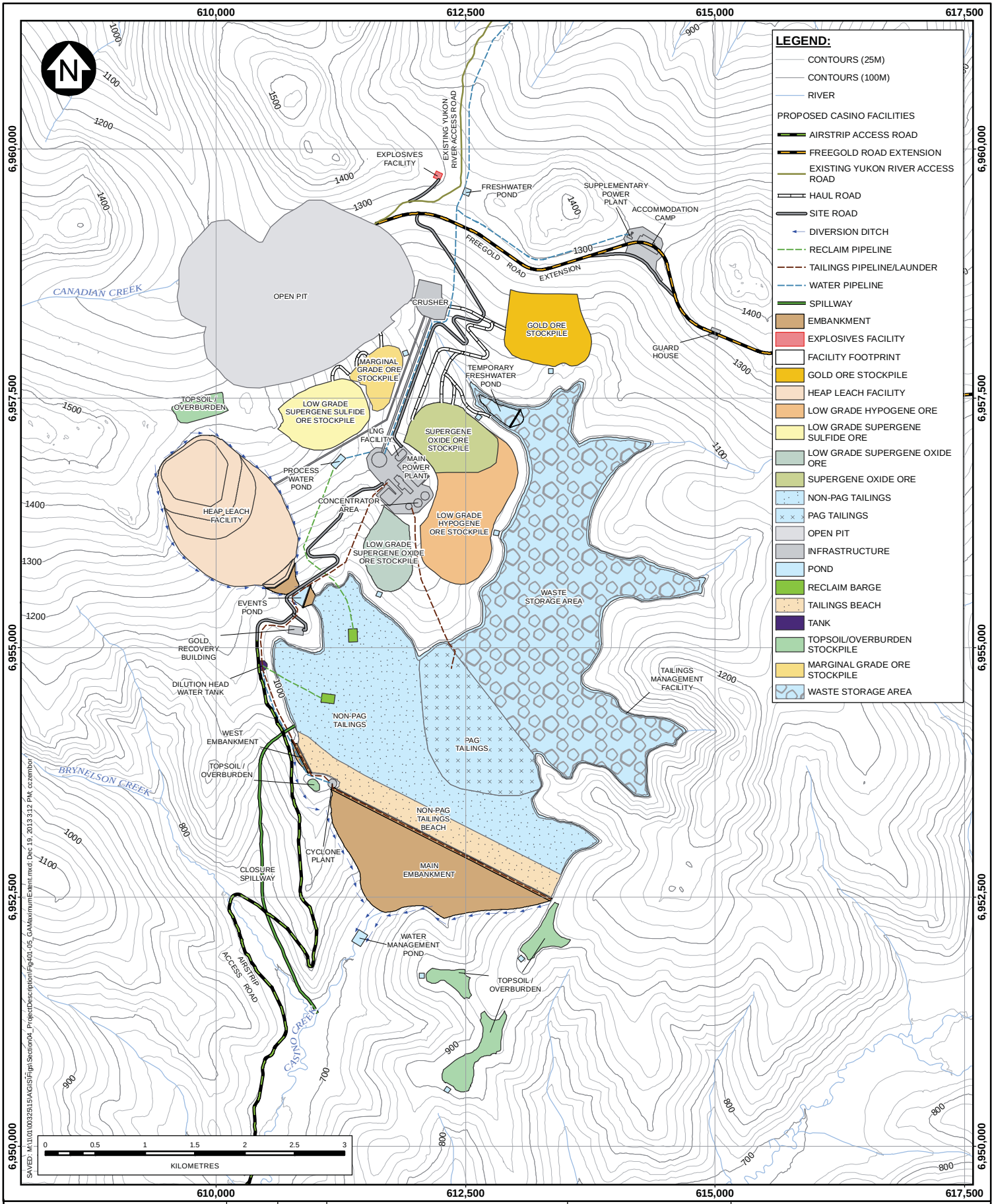
The purpose of the SCMP is to provide background planning and operational procedures for spills response to minimize:

- Danger to persons;
- Pollution of land and water;
- Size of the affected area;
- Degree of disturbance to plants, fish and animals; and

- Degree of disturbance during cleanup.

The SCMP identifies the types of spills that may occur at the Casino mine site, and provides procedures to respond to such emergencies. The purpose of the plan is to initiate an immediate response with trained personnel and equipment to clean any accidental spill and ensure minimal impact to the land or aquatic environment in the immediate and surrounding area. The SCMP includes procedures for cleanup, containment, disposal, and monitoring, including details regarding equipment and personnel allocations. The SCMP should be read in conjunction with the *Casino Project Emergency Response Plan*, and details of waste management and hazardous waste management are provided in the *Casino Project Waste Management Plan* and the *Casino Project Hazardous Materials Management Plan*, respectively.

The final SCMP will outline applicable commitments made during environmental assessment, the decision documents terms and conditions and conditions in the Quartz Mining and Water Use Licenses, and where these terms are addressed in the plan.



PREPARED BY:

Knight Piésold CONSULTING

DESIGNED	GLS/CAH
DRAWN	CC
CHK'D	CAH
APP'D	GLS
REV	0
DATE	16DEC'13

NOTES:

1. BASE MAP: EAGLE MAPPING
2. PROJECTION: NAD 1983 UTM ZONE 7N
3. COORDINATE GRID: METRES

CASINO COPPER AND GOLD

CASINO PROJECT

GENERAL ARRANGEMENT - MAXIMUM EXTENT

FIGURE 1-1

REF 1

P/A VA101-325/15

2 - HAZARDOUS MATERIAL IDENTIFICATION

The Casino Mine will use large volumes of diesel fuel, gasoline, oils, LNG, and hazardous chemical substances, that all have the potential to spill as they are transported to and around the mine site. Locations of fuels, chemicals and other materials at the mine site will be determined during detailed design prior to construction; however, general storage locations are likely to include the following, as described in Table 2-1 and shown on Figure 1-1:

Table 2-1 Hazardous Material Locations

Hazardous Material	Storage Area
Diesel fuels, gasoline, liquified natural gas	main power plant adjacent to LNG facility
Reagents, other process chemicals	Warehouse[1.], smaller volumes in mill building
Hazardous waste (e.g., used oils, contaminated materials)	Warehouse[1.]
Oils, glycol, fuels for machinery maintenance	Truck shop[2.]
Concentrate	Concentrate loadout building[2.]
Explosives	Explosives facility
Propane, natural gas	Adjacent to accommodation camp
Tailings facility effluent	Tailings management facility
Sediment laden water	Not stored on-site, but may result from construction activities

1. Location to be determined, but likely within mill complex near concentrator area
2. Location to be determined

Mitigation measures, as implemented though design and planning for the Project, will minimize the risk of a spill occurring and limit the extent of the environmental impact. However, these measures cannot completely prevent all risks from spills. The Access Road will be used for year-round hauling of materials into and out of the Casino mine site during operations. There will be 18 major bridge crossings located along the route, which include crossings of Bow Creek, Big Creek, Hayes Creek, and Selwyn River, and 71 major culvert crossings. Spills of any substance to water at any of the watercourse crossings along the transport route are of particular concern.

Accidental release of hazardous materials could result in contamination of soil, air or water; cause vegetation damage; and be toxic to wildlife or humans. Consequences of any spill depend on the magnitude and extent of the spill; the material, quantity, location, and duration of the spill; and environmental conditions at the time. The following components of the Casino Project have the potential to generate a spill:

- The transfer, storage, and shipment of fuels (primarily diesel and LNG), waste, and other hazardous liquids;
- The storage, mixing, and distribution of chemical reagents associated with the heap leach facility;

- Release of water from the TMF; and
- Offsite release of sediment laden water from a construction zone.

Hazardous materials associated with the Project can be grouped into three categories, and are described further below:

- Petroleum products and lubricants (e.g., LNG, diesel, oils and degreasers);
- Sulfide and oxide ore processing reagents (listed in Appendix A); and
- Contaminated effluent (e.g., tailings pond effluent or sediment laden water).

2.1 LNG

LNG spills completely evaporate, leaving no residue that could harm soil or groundwater (Drube, Haukoos, Thompson, & Williams, 2012). Liquefied natural gas evaporates at -162°C (it's normal boiling point) at atmospheric pressure and forms a visible cloud which is initially heavier than air until the methane vapour warms to -108°C; at this point the natural gas becomes lighter than air and therefore dissipates (Drube et al, 2012). If spilled to water, LNG is lighter than water and boils on top until it evaporates (Drube et al, 2012). Natural gas is also non-toxic; therefore, no impacts to water or sediment quality or fish and fish habitat are expected.

2.2 DIESEL

Diesel spills to water could result in direct mortality of fish and invertebrates, since diesel is considered to be one of the most acutely toxic oil types (National Oceanic and Atmospheric Administration, 2014). Because of its low viscosity it is readily dispersed in the water column; this oil could then adhere to fine-grained suspended sediments which would settle out and result in sediment contamination (National Oceanic and Atmospheric Administration, 2014). Lytle and Peckarsky (2001) assessed the effects of a diesel fuel spill on stream macroinvertebrates over a 15 month period and found that the spill significantly reduced invertebrate density and taxonomic richness in the area immediately below the spill. Schein et al (2009) concluded that diesel toxicity could impair the health of fish populations, depending on the extent of chemical or mechanical dispersion (naturally caused by fast-flowing, turbulent rivers) and life stage of the fish. Dispersion of diesel increases the bioavailability and apparent toxicity to fish embryos - dispersion was reported to cause acute lethality to juvenile trout between 40 mg/L and 200 mg/L (Schein et al 2009). Best practices will be followed when siting and using the mobile refuelers and two portable fueling stations (e.g., ensuring that they are more than 30 m from any watercourse).

2.3 REAGENTS

Potential process reagents are listed in Appendix A. The volume, form, transportation logistics and storage locations of the reagents listed will be determined during detail design engineering of the Casino Project. In the event that a transport truck carrying reagents or concentrate is involved in a collision or accident, the effects of a reagent or concentrate spill will depend on the volume released, which will be primarily determined by the containment methods used. Environmental effects could range from

negligible to moderate, depending on the location of the spill (to land or water) and the characteristics of the product. The following materials released to water could result in impacts to fish and fish habitat:

- Sodium-diisobutyl dithiophosphinate: at high concentrations acutely toxic to aquatic life
- Pebble Lime (CaO), because of the high pH, would be expected to be toxic to aquatic organisms and aquatic systems;
- Sodium Hydrosulfide (NaHS): strongly alkaline
- Potassium amyl xanthate: may persist for several days in water; highly toxic to aquatic life and may increase metal uptake in fish
- Sodium Cyanide (NaCN): highly toxic to fish, amphibians, aquatic insects and aquatic vegetation; cyanide is acutely toxic to most species of fish at concentrations greater than 200 µg/L (see Section 2.4).

2.4 CYANIDE

Oxide gold ore from the Casino Project will be processed by stacking crushed ore in lifts onto a heap leach pile and irrigating the pile with a sodium cyanide solution (barren process solution). The heap leach pad will consist of liners and a low-permeability soil overliner. Ore will be layered in eight lifts onto the pad and the barren process solution will be applied to ore lots with drip emitters to minimize evaporation losses. Pregnant solution from the ore heap will be collected in a network of pipes placed in the overliner material and directed to an in-heap collection area. The pregnant solution will then be pumped to the carbon-in-column (CIC) / Sulphidization, Acidification, Recycling and Thickening (SART) circuit for recovery of gold and copper. When the last process leach cycle is completed on the last ore lift, the ore heap will be rinsed with fresh water to recover the remaining gold and rinse the residue. Following operations, the heap leachate solution will be detoxified using a SO_2 / Air cyanide destruction process.

Prior to the start of operation, a comprehensive Cyanide Management Plan for the Casino Project will be developed to ensure worker safety and to prevent release of cyanide to the environment. The Cyanide Management Plan will be developed in consideration of the principles and standards of practice of the International Cyanide Management Code (Cyanide Code). Guidelines for transport, handling, storage and use of sodium cyanide at the Casino Project are summarized below.

To ensure the protection of communities and the environment during transport of cyanide to the Casino Project, the following Cyanide Code standards of practice will be followed:

- Responsibility for safety, security, release prevention, training, and emergency response will be established in written agreements with producers, distributors and transporters; and
- Emergency response plans and management measures will be implemented by cyanide transporters.

Casino Mining Corporation will require that contractors retained for delivery of cyanide to the Project will develop and implement a Cyanide Transportation Plan that is consistent with the Cyanide Code, as well as the Casino Cyanide Management Plan and component plans of the Environmental Management Plan.

The following industry best management practices will be described and implemented:

- Vehicles used for transportation of the cyanide and all containers and packaging comply with all applicable prescribed safety standards and display all applicable prescribed safety marks in accordance with the Dangerous Goods Transportation Act.
- Chain of custody documentation (including Material Safety Data Sheets) to track inventory and movement of cyanide.
- Methods to minimize the potential for contact of solid cyanide with water (e.g., covered trucks, sealed containers).
- Use of escort vehicles or convoys for cyanide shipments as necessary (e.g., inclement weather, change in road conditions).
- Regular maintenance of transportation equipment including containers, vehicles, loading and unloading machinery and storage systems.
- Training of all personnel operating cyanide handling and transport equipment.
- Emergency response plans for potential cyanide releases during transportation including:
    - Designate appropriate response personnel and commit necessary resources for emergency response.
    - Emergency response training of appropriate personnel.
    - Descriptions of the specific emergency response duties and personnel responsibilities.
    - A detailed list of all emergency response equipment available during transport or along the transportation route.
    - A detailed list of all emergency response and personal protective equipment during transport including self-contained breathing apparatus and oxygen gas.
    - Initial and periodic refresher training in emergency response procedures including implementation of the Emergency Response Plan and Spill Contingency Plan.
    - Develop procedures for internal and external emergency notification and reporting.
    - Periodically evaluate response procedures and capabilities and revise them as needed.

The final Cyanide Transportation Plan developed by the contractor responsible for transportation of cyanide the mine site will include a risk assessment of the transportation route that will consider water crossings, population centres, road characteristics, weather characteristics, and public infrastructure.

Measures implemented during cyanide handling, storage, and use at the Casino Project will be in accordance with the following principles of the Cyanide Code:

- Protect workers and the environment during cyanide handling and storage; and
- Manage cyanide process solutions and waste streams to protect human health and the environment.

The following Cyanide Code standards of practice will be implemented for cyanide handling, storage and use:

- Design and construct unloading, storage and mixing facilities consistent with sound, accepted engineering practices and quality control and quality assurance procedures, spill prevention and spill containment measures
- Operate unloading, storage and mixing facilities using inspections, preventive maintenance and contingency plans to prevent or contain releases and control and respond to worker exposures.
- Implement measures to protect birds and other wildlife from adverse effects of cyanide process solutions.
- Implement measures to protect fish and wildlife from direct and indirect discharges of cyanide process solutions to surface water.
- Implement measures designed to manage seepage from cyanide facilities to protect the beneficial uses of ground water.
- Provide spill prevention or containment measures for process tanks and pipelines.

Delivery and unloading of cyanide on site will take place in a covered, concrete-bounded area located away from general work areas and incompatible reagents. Portable pumps will be provided within the processing area for the pumping of spills within the bounded areas back to the storage tanks or emergency holding tanks. Ventilation will be provided to prevent build-up of hydrogen cyanide gas in storage and mixing areas.

The unloading and storage area will be designed to allow safe manoeuvring of forklifts, trucks, and trailers. Sodium cyanide containers will be offloaded to concrete pads with concrete curbing that provide a minimum of 110% containment of the largest sized container.

Unloading and storage area design drawings will be prepared for construction of the facilities as required by the Yukon Water Use License and Yukon Quartz Mining License applications. These designs will include:

- Details on use of level indicators and alarms.
- Foundation characteristics (e.g., seepage prevention).
- Details on methods to separate the cyanide from incompatible materials such as acids, strong oxidizers, etc.
- Employee safe-handling training and PPE.
- Fire suppression equipment.
- Waste disposal methods (empty cyanide containers).

2.5 CONTAMINATED EFFLUENT

Under the Yukon *Waters Act* and the *Waters Regulation* and the *Metal Mine Effluent Regulations* (MMER), mine operators are permitted to discharge effluent so long as the conditions outlined in the Water Use Licences are met, and the effluent concentrations are less than those outlined in the MMER Schedule 4 at prescribed locations. Should effluent be discharged outside of the normal course of events, or in exceedance of the prescribed limits, it is considered an “unauthorized discharge” and must be reported similar to a spill. Events that may results in an unauthorized discharge include earth moving activities during construction or operation of the Casino Project resulting in sedimentation of watercourses (exceedances of total suspended solids concentrations) or accidental release of mill tailings or tailings pond water.

Earth moving activities during construction or operations of the Casino Project that may result in erosion or sedimentation include:

- Land clearing and topsoil stripping;
- Stockpiling of topsoil and ice-rich materials;
- Pit excavation, site grading, and land filling;
- Construction of roads, bridges, and culverts; and
- Construction of the TMF, waste rock dumps, and heap leach facility.

Potential adverse effects from erosion and sedimentation can be minimized through project planning, following BMPs, and providing site specific controls that are commensurate with the potential risks to the natural environment. The *Casino Project Erosion and Sediment Control Management Plan* will provide a detailed description of the methods of sedimentation and erosion prevention and control that will be used, the specific situations that they will be used in, and the implementation procedures that will be followed to minimize spills of sediment laden water to the receiving environment.

Tailings pond effluent spills may result from problems with pipelines or valves, in particular, winter operations may result in ice formation which could impact reclaim barge stability and operation or result in

blockage of pipelines. Therefore, monitoring of civil and mechanical operational components of the tailings management facility will be a daily/shift requirement to ensure that systems are functioning correctly. Tailings pond effluent contains a number of contaminants, including metals, cyanide, and ammonia, due to the influence of mine waste and chemical reagents used in ore processing. Contaminant concentrations are generally close to drinking water standards, but exceed the guidelines for protection of aquatic life, therefore, it is desirable to contain the tailings effluent and pond water at all times.

3 - SPILL PREVENTION AND TRAINING

Comprehensive spill response training will be provided for all employees responsible for chemical handling, and all personnel visiting the site will be given basic spill prevention training. Specific details for the access road and mine site are provided in Sections 3.1 and 3.2, below.

3.1 ACCESS ROAD

Transportation of goods and materials will be in accordance with all applicable regulations and legislation, as well as the Explosives and Hazardous Materials Transport Permit required for the Project. All carriers and suppliers to the Casino Project will be certified under Transport Canada, and, as required, under the Transportation of Dangerous Goods Act. It is expected that external carriers and suppliers will have their own emergency response plans and training for their personnel, as they will be transporting supplies in their own vehicles with their own drivers.

Transportation of cyanide (as sodium cyanide) will be conducted in a manner to protect communities and the environment in accordance with the International Cyanide Management Code (International Cyanide Management Institute, 2012). Additionally, preventative maintenance along the access route will include regular maintenance and inspections for safe operation of vehicles, snow clearing, and the application of dust suppressants as required.

Shipping documents travel with hazardous materials, and are kept in the cab of the motor vehicle. Shipping documents provide vital information regarding the hazardous materials/dangerous goods to initiate protective actions, as per the Emergency Response Guidebook (Transport Canada, 2012). An example of information provided in the Emergency Response Guidebook is provided in Appendix B for sodium cyanide and LNG.

3.2 MINE SITE

Hazardous materials will be handled, stored and used in a manner that minimizes spills. Regular monitoring and inspections will ensure that small spills are avoided, and if they occur identified and cleaned up as soon as possible. CMC will ensure that its staff and contractors have basic emergency training as appropriate, such as standard first aid and Workplace Hazardous Material Information System (WHMIS), and are aware of CMC health and safety policies. Members of the Emergency Response Team require more vigorous and continual training. This training will focus on specific elements of the Casino mine site and will cover but not be limited to:

- Advanced First Aid and CPR;
- Surface Mine Rescue;
- Fire Response;
- Spill Response;
- Hazardous Materials Handling; and

- WHMIS.

Routine practice drills will occur to maintain Emergency Response Team member skills and test the ERP system and process.

4 - SPILL REPORTING

In addition to the definition in Section 1, spills are further defined by whether they are *reportable* (to an Environmental Protection Officer), or *non-reportable*. A reportable spill is one defined by the Yukon Spills Regulation (Government of Yukon, 1996) to be equal to, or to exceed the thresholds outlined in Table 4-1. Additionally, ANY spill onto a watercourse is considered a reportable spill under the Yukon Spills Regulation. Spills of any size will be reported to the environmental department, and a spill report will be completed and filed or submitted (Appendix C), as required.

Table 4-1 Reportable Spill Thresholds

Product	TDG[1] Code	Threshold Quantity
All petroleum products		> 200 liters
Explosives	1	Any amount
Flammable gases	2.1	> 100 liters
Non-flammable gases	2.2	> 100 liters
Non-poisonous gases	2.2	> 100 liters
Corrosive gases	2.4	Any amount
Non-corrosive gases	2.2	> 100 liters
Flammable liquids	3	> 200 liters
Flammable solids	4	> 25 kg
Spontaneously combustibles	4	> 25 kg
Dangerous when wet	4	> 25 kg
Oxidizers	5.1	> 50 kg or 50 liters
Organic peroxides	5.2	> 1 kg or 1 liter
Poisonous substances	6.1	> 5 kg or 5 liters
Corrosive materials	8	> 5 kg or 5 liters
Miscellaneous Dangerous Goods	9.1	> 50 kg
“Hazardous to Environment” material		> 1 kg
Dangerous wastes	9.3	> 5 kg or 5 liters

1. TDG = Transportation of Dangerous Good Regulations (Government of Canada, 1985)

Senior Project Managers are responsible for reporting spills. Under federal and territorial regulations, Managers are required to *immediately* notify the 24-hour Yukon Spill Report line should a reportable spill occur (see Table 4-2). Notification via email should also be sent to Yukon Government and Selkirk First Nations’ Lands Director at the emails provided in Table 4-2. The following information should be provided to the 24-Hour Spill Report line:

- Name
- Phone number
- Product spilled
- Quantity spilled
- Quality of product (thin, viscous etc.)
- Location of spill
- Distance to water
- Distance to drinking water wells
- What happened
- Responsible party
- Actions to contain the spill
- Obtain the Environment Yukon Spill Reporting Number and first/last name of the person whom the report has been made to (in the event of a reporting discrepancy it's always good to know this information).

Spill reports (provided in Appendix C) are to be filled out for all spills, regardless of quantity. Spill reports for reportable spills (i.e., in quantities in exceedance of Table 4-1) should be provided in the email notifications to the parties listed below. All spills entering a watercourse must be immediately reported to the Yukon Authorization Officer (Director, Environmental Protection Operations Division).

Table 4-2 Contact Information for Spill Reporting

Resource	Email	Contact Number
External Reporting Contacts		
Yukon 24- Hour Spill Line		(867) 667-7244
Yukon Authorization Officer (Director, Environmental Protection Operations Division): Steven Wright, Director		(604) 666-0064
Yukon Government Environment, Water Resources, Inspections Division: Carola Scheu, Manager		(867) 456-3980
YG Department of Environment, Water Resources Branch		(867) 667-3227
YG Environmental Protection Branch		(867) 667-3436
Selkirk First Nation, Lands Director		(867) 537-3331
YG EMR, Carmacks Natural Resource Officer		(867) 863-5271
YG EMR, Client Services and Inspections		(867) 667-3199
Contacts for Submission of Spill Reports		
YG EMR, Matthew Jenner, Natural Resources Officer - Mining	Matthew.Jenner@gov.yk.ca	(867) 863-5271
Yukon Government Environmental Health Services, Dianna Hayden, Environmental Health Officer	Dianna.Hayden@gov.yk.ca	(867) 667-8321
Selkirk First Nations, William Sydney, SFN Lands Director	sydneyw@selkirkfn.com	(867) 537-3331
Little Salmon Carmacks First Nation, Robert Moar, Lands Director	Robert.moar@lscfn.ca	(867) 863-5576 ext 256
Tr'ondëk Hwëch'in First Nation	Darren.taylor@trondek.ca	(867) 993-7145

5 - EMERGENCY RESPONSE COMMUNICATION

Preliminary emergency organization and reporting chain of command is presented in section 5.1 and the external reporting procedures are provided in sections 5.2.

5.1 EMERGENCY ORGANIZATION AND RESPONSIBILITIES

The Emergency Response Team will be made up of CMC personnel who will be responsible for managing emergency situations. CMC will ensure that sufficient trained emergency response personnel are on site at all times.

The Incident Commander or designate will assume responsibility for each incident in consultation with senior management, the Emergency Response Coordinator, and relevant Governmental Agencies. The Incident Commander is the primary decision-maker for assessing and responding to incidents at the Project site. The incident response organizational structure is depicted in Figure 5-1.

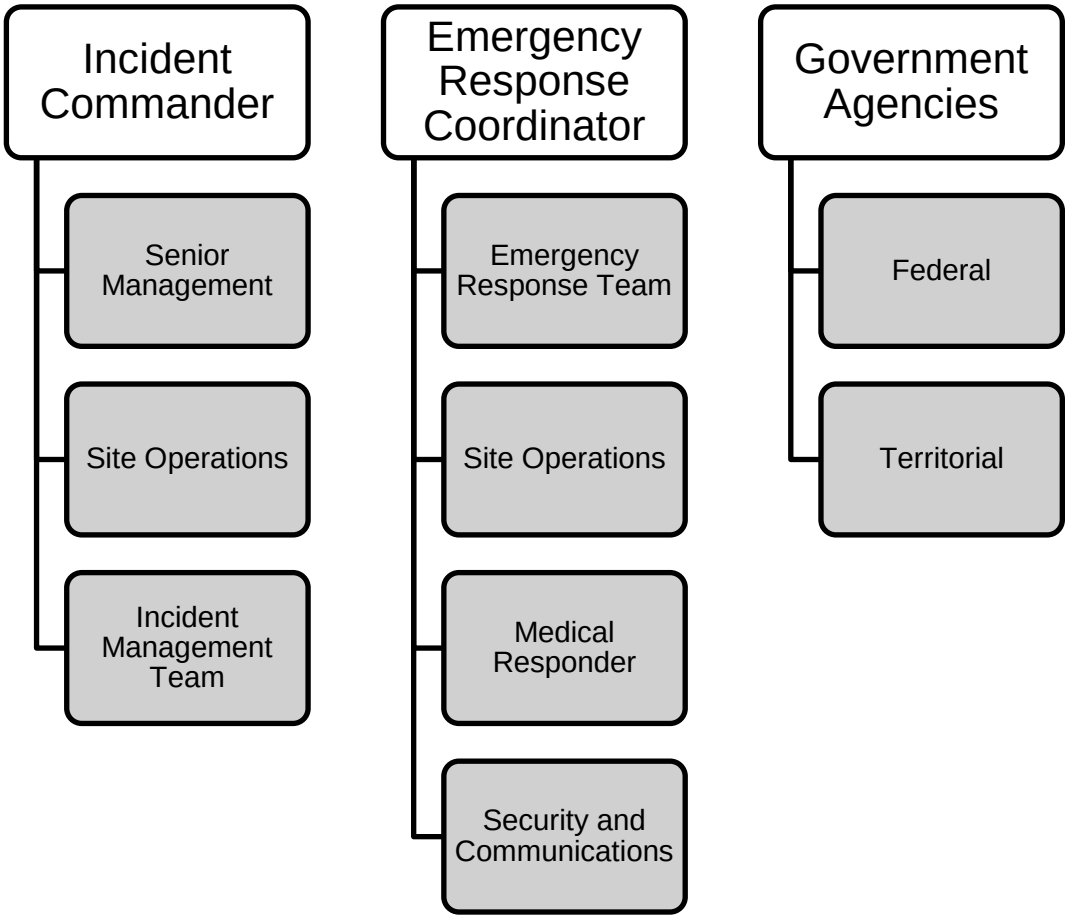


Figure 5-1 Emergency Response Organizational Chart

5.2 EXTERNAL NOTIFICATION

Key external emergency contacts are provided in Table 5-1. This list is not intended to be all inclusive at this stage and will be updated prior to beginning the construction phase of the Project. An emergency response responsibility matrix will also be created for definition and quick reference.

Table 5-1 External Emergency Contact List

Contact Name	Contact Number
Health Care Providers	
Whitehorse Regional Hospital	(867) 393–8700
Carmacks Health Centre	(867) 863-4444
Pelly Crossing Health Centre	(867) 537-4444
Emergency Responders	
Fire Department – Pelly (Emergency)	(867) 537-3000
Fire Department – Whitehorse	(867) 668-8699 or (867) 668-2462
Police – Pelly	(867) 537-5555
Police – Whitehorse	(867) 667-5555
Yukon EMS, Dispatch	(867) 667–3333
Poisonous Substance Ingestion	(867) 633–8477
Yukon Territory Government Contacts	
Yukon Dept. of Conservation	(867) 667–5317
Yukon Dept. of Fish & Game	(867) 393–6722
Yukon Spill Report Center	(867) 667–7244
Yukon Energy (afterhours)	(800) 676–2843
Yukon Workers' Compensation Health and Safety Board	(867) 667–5450
Yukon Occupational Health and Safety Mine Inspector	(800) 661–0443
Yukon Coroner's Office	(867) 667–5317
Helicopter Service Providers	
Capitol Helicopters	(867) 668-6200
Fixed Wing Service Providers	
Alkan Air	(867) 668-7725

6 - EMERGENCY RESPONSE TO SPILLS

The three levels of emergencies are identified as follows:

- LEVEL I: includes minor spills requiring an on-site worker to respond and take necessary corrective actions.
- LEVEL II: includes intermediate level spills requiring response by on-site or off-site trained staff but posing no danger to the public.
- LEVEL III: includes a major incident beyond the resources of a single facility, where there are subsidiary problems to complicate the situation such as fire, explosion, toxic compounds, and threat to life, property and the environment. Assistance will be required from local, regional, and/or territorial organizations.

Incident detection, information gathering and action decisions are the first steps in responding to an emergency incident. All these steps may occur over a short or extended time period depending on the circumstances and magnitude of the incident.

6.1 GENERAL EMERGENCY RESPONSE

Every emergency situation will be different depending upon the nature, location and cause of the incident. The following general course of action should be taken in all situations in combination with the incident-specific emergency response procedures described below:

1. Ensure your own safety as you approach the scene by making sure there is no hazard to you.
2. Where it is safe to do so, remove all personnel from the dangers posed by the emergency.
3. Contact the Emergency Response Coordinator. Describe the incident and take steps as instructed by the Emergency Response Coordinator to stop, slow or reduce the severity of the incident.
4. Report the details of the incident to the appropriate CMC staff and government agencies as per section 4.
5. Follow the response procedures in the Emergency Response Guidebook (Transport Canada, 2012):

RESIST RUSHING IN!

Approach cautiously from upwind, uphill or upstream:

- Stay clear of vapor, fumes, smoke and spills
- Keep vehicle at a safe distance from the scene

Secure the scene:

- Isolate the area and protect yourself and others

Identify the hazards using any of the following:

- Placards
- Container labels
- Shipping documents
- Rail car and road trailer identification chart
- Material safety data sheets (MSDS - Appendix A)
- Knowledge of persons on scene
- Consult applicable guide page (Transport Canada, 2012)

Assess the situation:

- Is there a fire, a spill or a leak?
- What are the weather conditions?
- What is the terrain like?
- Who/what is at risk: people, property or the environment?
- What actions should be taken – evacuation, shelter in-place or dike?
- What resources (human and equipment) are required?
- What can be done immediately?

Obtain help:

- Advise your headquarters to notify responsible agencies and call for assistance from qualified personnel

Respond:

- Enter only when wearing appropriate protective gear
- Rescue attempts and protecting property must be weighed against you becoming part of the problem

- Establish a command post and lines of communication
- Continually reassess the situation and modify response accordingly
- Consider safety of people in the immediate area first, including your own safety

Above all: do not assume that gases or vapors are harmless because of lack of a smell. Odorless gases or vapors may be harmful. Use caution when handling empty containers because they may still present hazards until they are cleaned and purged of all residues.

6.2 RESPONSE ACTION AND CONTAINMENT

In the event of a spill, the following priority sequence of spills response will be followed:

1. **Ensure Safety** – The implementation of spill containment measures and site cleanup and remediation will only be undertaken when it is safe to do so. If the nature of the spill hazard cannot be determined, it is to be assumed dangerous. Use appropriate Personal Protective Equipment (PPE). If the substance is flammable, remove all ignition sources.

2. **Administer First Aid** – If the spill has resulted in injured persons, and it is safe to do so, first aid should be administered through following the steps of the Medical Emergency ERP.

3. **Stop the Source** – Turn off valves, pumps or plug holes to stop to reduce flow from the source.

4. **Notify the Emergency Response Coordinator** – The Emergency Response Coordinator will be responsible for mobilizing the Emergency Response Team and notifying the appropriate CMC personnel and external agencies.

5. **Secure the Area** – Take steps to limit access to the spill area.

6. **Contain the Release** – Limit the extent of the spill through the use of spill response equipment (e.g., sorbent pads, socks or pillows) and by blocking drains and accesses to waterways through the use of dams, dykes, or drain covers.

7. **Clean-Up the Spill** – Clean-up and restore the affected area under direction of the Environmental Manager.

8. **Report the Spill** – The Emergency Response Coordinator will be responsible for reporting the details of the spill and the response actions to CMC and regulatory agencies.

9. **Conduct an Incident Investigation** – Understand the events that caused the spill and make modifications to site procedures, training, or emergency response planning to minimize the chance of a reoccurrence.

6.2.1 Spill Response Equipment

Spill response equipment will be stationed along the access road and around the mine site at appropriate intervals and in areas where hazardous materials are stored (e.g., warehouse, truck shop, processing buildings, accommodation buildings, power plant). Spill kits typically contain oil sorbents (pads, socks, and granular), shovels, and protective equipment including gloves, goggles and protective suits. Heavy equipment, such as front-end loaders and haul trucks will be available for larger spills, and pumps, suction hoses and portable storage tanks or drums will also be located at the mine site to assist with spill recovery and cleanup.

6.2.2 Containment and Cleanup

Many materials will be used at the Casino Mine, including petroleum products, liquefied natural gas (LNG), reagents used in the milling process, and copper and molybdenum concentrates. A spill will typically be in the form of a liquid or powder and can be contained. An exception is propane, which is a gas and therefore, containment should not be attempted. Also, LNG is a highly volatalizable liquid, and containment is unnecessary, as the liquid will evaporate with time whether the spill is to land or water. Sodium cyanide (a reagent used in the heap leaching process) has specific precautions that must be taken should a spill occur. Generally, spill responders should be familiar with the requirements in the *Emergency Response Guidebook* (Transport Canada, 2012).

Below are summarized specific actions for the different types of spills that can occur along the Casino Access Road, including:

- Spills to land;
- Spills to water;
- Spills to ice or snow;
- Chemical spills; and
- Gaseous releases.

6.2.3 Spills to Land

The following techniques should be followed to contain a spill to land, and a guide to selecting containment techniques for spills on land is provided in Table 6-1:

- Block entry into waterways by building a berm or trench (see Table 6-1).
- Do not flush into ditches or drainage systems that lead to water.
- Contain with earth dam or other barrier.
- Capture minor spills with appropriate sorbent pads.

- Recover large spills with pumps or vacuum equipment.

Table 6-1 Guide to Selecting Containment Techniques for Spills on Land

Technique	Primary Use	Controlling Variables	Resources Required
Earth Dike	Best suited for spills on relatively flat areas	• Sufficient earth may not be available, depending on location and season • Crew of four can create dike at 5 m/hr	• Earth moving machine or excavating equipment • Sandbags, liner material, sand or gravel • Work crew and foreman
Sorbent Dike	Can provide temporary containment and cleanup Applicable in all seasons	• Requires sufficient sorbent material • May become impractical for large spill volume	• Sorbent materials • Temporary storage or incinerator to burn used sorbents • Work crew
Snow/Ice Dike	Best suited on relatively flat areas in winter	• Requires sufficient snow or ice • Only applicable when ice is >1m thick • A crew of four with a bulldozer can create dike at 10 m/hr	• Earth moving machine • Ice chain saws • Equipment to spray water onto snow • Work crew and foreman
Land Trench	Best on relatively flat areas	• During the winter, frozen earth may be too difficult to excavate • In some areas, soil may be too thin to create trench • Can excavate 30 m/hr of trench per machine in summer, half that in winter	• Excavating equipment (backhoe or shovels) • Work crew and foreman • An oil recovery unit (pump)
Excavation by Bulldozer, Front-end Loader, or Backhoe	Heavy equipment has site access	• Disturbs surface of soil • Removes organics • Can lead to erosion or surface instability • Vegetation is slow to recover • Difficult in frozen soil	• Machine, fuel and operator • Work crew and foreman • Method to handle or dispose of excavated material
Manual Removal	Best suited for areas lightly contaminated or where equipment	• Some surface disturbance and removal of shallow organisms and vegetation	• Hand tools (rakes, shovels, wheelbarrows) • Work crew

Technique	Primary Use	Controlling Variables	Resources Required
	access is unavailable Labour intensive and time consuming	• More rapid repopulation of organisms than other excavation techniques	• Disposal facilities
Sorbent Application	Best suited for areas lightly contaminated or where equipment access is unavailable	• Require adequate supply of sorbents • Relatively little damage except surface disturbance of foot traffic	• Sorbents • Work crew • Disposal facility for used sorbents

6.2.4 Spills to Water

A spill on or into open water is very difficult to contain and every effort should be made to prevent the contaminant from entering the water. Some products (hydrocarbons such as gasoline and diesel) float, and therefore immediate deployment of surface booms can be used to effectively mitigate further spread of the spill. The following techniques should be followed to contain a spill to water, and a guide to selecting containment techniques for spills on water is provided in Table 6-2:

- Contain spill as close to release point as possible.
- Use spill containment boom to concentrate slicks for recovery.
- Protection (diversionary) booming using sorbent booms could be deployed to deflect slicks from nearby intakes or other sensitive areas.
- On small spills, recover using appropriate sorbent pads.
- Do not use sorbent booms/pads in fast currents and turbulent water.
- Intercept moving slicks in quiet areas using sorbent booms.

Table 6-2 Guide to Selecting Containment Techniques for Spills on Water

Technique	Primary Use	Resources Required
Containment Boom	Best at location where spill enters water	• Booms totalling 1.5 to 2 times the diameter of the slick • Labourer
Sorbent Boom	Best across small ditches	• Disposal containers or incinerator for used sorbents • Chicken wire and supports to make “fence” • Earth moving or excavation equipment • Labourer
Earth Berm	Best across shallow ditches	• Boom and an oil recovery unit (pump) • May also require sandbags, liner material, sheets of metal or wood • Labourer

6.2.5 Spills to Ice or Snow

Spills to snow and ice are generally easily contained and cleaned up, as snow is extremely absorbent and liquid spills are easily trapped within the snow, which can then be recovered for disposal. Snow can also be used to construct berms. For spills on ice, if the ice is safe to work on, then the methods of containment are similar to those on land. Where the spill has penetrated the ice, the methods of containment are similar to those on open water. The following techniques should be followed to contain a spill to land, and a guide to selecting containment techniques for spills on ice or snow:

- Block entry into waterways and contain with snow berm or other barrier.
- Trench or ditch to intercept or contain fuel on snow, where feasible.
- Compact the snow around the outside perimeter of the spill area.
- Construct a berm with snow, either manually or with shovels or heavy equipment such as graders and dozers where available.
- Contain or collect contaminated snow.
- Use synthetic liners to contain on site if feasible.
- Recover minor spills with appropriate sorbent pads or snow.

6.2.6 Chemical Spills

The Casino Project will use many chemicals required for mineral processing. Chemical spill response is dependent on the type of chemical, and the whether the spill is to land, water or ice and snow. Therefore, the *Emergency Response Guidebook* (Transport Canada, 2012) should be used to determine the appropriate response to each chemical based on the information provided in the shipping documents that will accompany each shipment along the Casino Project Access Road.

Cyanide (as sodium cyanide) is a primary reagent in the leaching process for extraction of metals in the heap leaching facility. A Cyanide Management Plan for the Casino Project will be developed prior to the start of operations and will be developed in consideration of the principles and standards of practice of the International Cyanide Management Code (International Cyanide Management Institute, 2012).

The response to a cyanide spill should follow the guidelines as provided in the Emergency Response Guidebook (Appendix B). Cyanide is a toxic and corrosive substance, and is non-combustible and water sensitive. Reaction with water or moist air may release toxic, corrosive or flammable gases. When spilled in water potassium cyanide and sodium cyanide produce hydrogen cyanide toxic-by-inhalation gas. The following techniques should be followed to contain a cyanide spill:

- Wear positive pressure self-contained breathing apparatus.
- Wear chemical protective clothing that is specifically recommended by the manufacturer.
- Eliminate ALL ignition sources.
- All equipment used when handling the produce must be grounded.
- Do not touch damaged containers or spilled material unless wearing appropriate protective clothing.
- Stop leak if you can do it without risk.
- A vapor suppressing foam may be used to reduce vapors.
- DO NOT GET WATER INSIDE CONTAINERS.
- Use water spray to reduce vapors or divert vapor cloud drift. Avoid allowing water runoff to contact spilled material.
- Prevent entry into waterways, sewers or confined areas.
- **Small spills to land:**
    - Cover with DRY earth, DRY sand or other non-combustible material followed with plastic sheet to minimize spreading or contact with rain.

- Use clean non-sparking tools to collect material and place it into loosely covered plastic containers for later disposal.

- **Small spills to water (from a small package or small leak from a large package):**
  - First ISOLAGE 30 m in all directions.
  - Then PROTECT persons downwind 1. During the day 0.1 km; 2. During night 0.2 km.

- **Large spills to water (from a large package or many small packages):**
  - First ISOLAGE 100 m in all directions.
  - Then PROTECT persons downwind 1. During the day 0.4 km; 2. During night 1.4 km.

6.2.7 Gaseous Releases

Gases that may be used at the Casino Mine site include propane, acetylene and oxygen, which are typically transported in cylinders. Should an incident occur that results in the spillage of these products, the following procedures should be followed:

- Wear insulated gloves, safety glasses, and, if in a confined space, a respirator.
- If safe to do so, shut off flow and remove ignition sources.
- Evacuate area.
- Gases will disperse with time.
- Consult supplier if container needs disposal.

Liquefied natural gas (LNG) will be shipped to the Casino Project for vaporization into natural gas for use at the on-site power plants. The LNG will be shipped via double wall vacuum tanker trucks at -162 °C and 1+ atmospheric pressure. LNG spills completely evaporate, leaving no residue that could harm soil or groundwater. If spilled to water, LNG is lighter than water and boils on top until it evaporates (Drube et al 2012). Natural gas is also non-toxic; therefore, no impacts to water or sediment quality or fish and fish habitat are expected. The Emergency Response Guidelines for LNG are provided in Appendix B.

6.3 DISPOSAL OF CONTAMINATED MATERIAL

Contaminated materials collected from the clean-up of petroleum hydrocarbon spills along the Access Road could be disposed of by the following methods:

- Incineration in the on-site incinerator;
- In an on-site Land Treatment Facility, if required, constructed as per the Yukon Contaminated Sites Regulation (2002); or

- Removal from site to a licensed disposal facility.

Chemical spills will be disposed of as per the Emergency Response Guidelines for each specific material.

6.4 SITE RESTORATION/REMEDIATION

Characterization of contaminated material will be done in accordance with the *Protocol No.3: Soil Sampling Procedures at Contaminated Sites*, under the Contaminated Sites Regulation (Yukon Environment, 2012). Sampling frequency for stockpiles created in emergency response situations include one sample for every 50 m^3 of contaminated material. Once excavation of contaminated material has been conducted a minimum of 5 samples should be taken from the faces of the excavation: one from each wall and one from the excavation floor. For shallow excavations not exceeding 0.2 m in depth, step out samples should be taken adjacent to each excavation boundary, at a frequency of one sample per 10 m running length to determine the extent of contamination. Should laboratory results indicate that contamination extends beyond the previously excavated material, more material should be excavated and the area re-sampled. Soil samples are required to comply with the generic numerical soil standards in Schedule 1 of the Contaminated Sites Regulation (Government of Yukon, 2002).

7 - PLAN UPDATES

This SCMP is controlled by Casino Mining Corporation. Casino Mining Corporation is responsible for training staff on methods and procedures, and implementing the SCMP in accordance with relevant legislation and permits, and will be responsible for regular review and updating of the SCMP to ensure that it is up-to-date with current practices and legislation.

A copy of the SCMP plan will be provided to all emergency responders, and the contents of the plan communicated to employees and visitors upon arrival at the site, during orientation. Copies of the SCMP will also be kept at the following mine locations:

- Project Office;
- Safety Office;
- Emergency Response Coordinator's Office;
- Environmental Manager's Office;
- First Aid room(s);
- Common areas and near telephones; and
- CMC corporate office.

8 - REFERENCES

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APPENDIX A

PROPOSED CHEMICALS FOR USE AT THE CASINO MINE PROJECT AND MSDS

Chemical	Description/Typical Material Safety Data Sheet Information
Sulphide Ore Process Reagents	
Sodium-diisobutyl dithiophosphinate (Aerophine 3418A Promoter)	Colorless to light yellow, odorless, mobile liquid; slightly alkaline; auto-ignition temperature 437°C; completely soluble in water; LC50: Bluegill, 96-hour: 375 mg/l Daphnia, 48-hour: 149 mg/L
Sodium diethyl dithiophosphate/sodium disecondary butyl dithiophosphate (Aerofloat 208 Promoter)	Slight fire hazard when exposed to heat or flame; acid may react with metals to produce hydrogen, a highly flammable and explosive gas; heating may cause expansion or decomposition leading to violent rupture of rigid containers; may emit acrid smoke and corrosive fumes.
Methyl Isobutyl Carbinol (MIBC, frother)	Clear liquid with a “sweet” odour; Flammable liquid and vapour. Vapours are heavier than air and may travel across the ground and reach remote ignition sources causing a flashback fire danger. Low toxicity: LD50 >2000 mg/kg for rat and rabbit.
Pebble Lime (CaO, pH modifier)	White or gray, odorless lumps, granules, or powder. Not combustible or flammable but reacts with water to form calcium hydroxide while generating heat, which could ignite combustible materials. Not explosive but reaction with water or other incompatible materials causes material to swell and may rupture containers. High pH therefore toxic to aquatic organisms and aquatic systems.
Fuel Oil (#2 Diesel fuel, moly collector)	Colourless to straw or red oily liquid with kerosene like odour. Combustion may produce CO, CO2 and reactive hydrocarbons.
Sodium Hydrosulfide (NaHS, copper mineral depressant)	High pH therefore toxic to aquatic organisms and aquatic systems (pH 11). Auto-ignition temperature 120°C; releases highly toxic and highly flammable hydrogen sulfide gas if mixed with an acid or if exposed to excessive heat. Toxic to terrestrial vertebrates.
Flomin D-910 (Sodium dithiophosphate)	Prepared by the reaction of phosphorus pentasulfide with sodium hydroxide; commonly called “Nokes reagent”
Flocculant	Typical flocculant like Anionic Polyacrylamide is a colourless of white granular powder with a pH of 6.0. Flammable, dust explosions may occur if material is dispersed in

Chemical	Description/Typical Material Safety Data Sheet Information
	air. Flammability may be enhanced by presence of strong oxidizers.
Potassium amyl xanthate (PAX – pyrite flotation)	May spontaneously ignite on exposure to moist air; flammable gas (carbon disulfide) when wet; highly toxic gases (carbon disulfide, hydrogen sulfide) if heated to decomposition. If discharged to waterways, xanthates may persist for several days; highly toxic to aquatic life - may form complexes with heavy metals.
Oxide Ore Process	
Sodium Cyanide (NaCN)	Solid white substance with a faint “bitter almond” odour; soluble in water. Decomposes on heating, emitting toxic fumes, including those of hydrogen cyanide, and ammonia; toxic to animals in comparatively low concentrations. Known to cause bird kills in tailings dams.
Caustic Soda (sodium hydroxide, NaOH)	Odourless white solid; highly reactive with metals; reactive with oxidizing agents, reducing agents, acids, alkalis, moisture.
Pebble Lime (CaO)	White or gray, odorless lumps, granules, or powder. Not combustible or flammable but reacts with water to form calcium hydroxide while generating heat, which could ignite combustible materials. Not explosive but reaction with water or other incompatible materials causes material to swell and may rupture containers. High pH - toxic to aquatic organisms and aquatic systems.
Hydrochloric Acid (HCl)	Liquid with a pungent odour; colourless to light yellow. Reacts violently with water, especially when water is added to the product; absorption of gaseous hydrogen chloride on mercuric sulfate becomes violent at 125°C; sodium reacts very violently with gaseous hydrogen chloride; reacts with oxidizers releasing chlorine gas. Incompatible with, alkali metals, carbides, borides, metal oxides, vinyl acetate, acetylides, sulphides, phosphides, cyanides, carbonates; reacts with most metals to produce flammable hydrogen gas.

Chemical	Description/Typical Material Safety Data Sheet Information
Sodium Hydrosulphide (NaHS)	High pH therefore toxic to aquatic organisms and aquatic systems (pH 11). Auto-ignition temperature 120°C; releases highly toxic and highly flammable hydrogen sulfide gas if mixed with an acid or if exposed to excessive heat. Toxic to terrestrial vertebrates.
Sulphuric acid (H_2SO_4)	Clear, colourless to dark brown, odourless; dense, oily liquid; hygroscopic. Will not burn but can decompose at high temperatures, forming toxic gases such as sulphur oxides. Contact with combustible materials may cause fire; highly reactive. Contact with many organic and inorganic chemicals may cause fire or explosion; contact with metals liberates flammable hydrogen gas; reacts violently with water; reacts with most metals, especially when diluted with water; this reaction produces highly flammable hydrogen gas that may explode if ignited.
Activated Carbon	Black, odourless, pelletized powder; insoluble in water;
Antiscalant	Typical antiscalants such as -1,1 Diphosphonic Acid 1-hydroxyethane may produce Cox, POx and phosphine on combustion.
Flocculant	Typical flocculant like Anionic Polyacrylamide is a colourless white granular powder with a pH of 6.0. Flammable, dust explosions may occur if material is dispersed in air. Flammability may be enhanced by presence of strong oxidizers.

CYTEC MATERIAL SAFETY DATA

Date: 10/14/97
MSDS No: 1787
Supersedes: 07/01/97
CAS No: 013360-78-6

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME: **AEROPHINE ® 3418A Promoter**
SYNONYMS: Sodium diisobutyldithiophosphinate, 50% aqueous solution
CHEMICAL FAMILY: Dithiophosphinate
MOLECULAR FORMULA: C8H18PS2.Na
MOLECULAR WGT: 232
CYTEC INDUSTRIES INC., FIVE GARRET MOUNTAIN PLAZA, WEST PATERSON, NEW JERSEY 07424, USA
For Product Information call 1-800/652-6013. Outside the USA and Canada call 973/357-3193.
EMERGENCY PHONE: For emergency involving spill, leak, fire, exposure or accident call CHEMTREC: 1-800/424-9300. Outside the USA and Canada call 703/527-3887.

2. COMPOSITION / INFORMATION ON INGREDIENTS

OSHA REGULATED COMPONENTS

COMPONENT	CAS. NO.	%	TWA/CEILING	REFERENCE
Sodium diisobutyldi-Thiophosphinate	013360-78-6	50-52	not established	

3. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW

APPEARANCE AND ODOR: Colorless to light yellow mobile liquid; odorless
STATEMENTS OF HAZARD:

WARNING! CAUSES EYE IRRITATION
MAY CAUSE SKIN IRRITATION

POTENTIAL HEALTH EFFECTS

EFFECTS OF OVEREXPOSURE:
The acute oral (rat) and acute dermal (rabbit) LD50 values for this material are 3.35 g/kg and greater than5.0 g/kg, respectively. Mild skin and moderate eye irritation were produced during primary irritation studies in rabbits. Skin irritation was increased after repeated exposures in rabbit studies.

4. FIRST AID MEASURES

In case of skin contact, immediately wash affected areas with soap and plenty of water. Remove contaminated clothing and shoes. Obtain medical attention. Destroy or thoroughly clean shoes before reuse. Do not reuse contaminated clothing without laundering.
In case of eye contact, immediately irrigate with plenty of water for 15 minutes. Obtain medical attention if irritation persists.
Material is not expected to be harmful if inhaled. If inhaled, remove to fresh air.

5. FIRE FIGHTING MEASURES

FLAMMABLE PROPERTIES

FLASH POINT: >200 F; 93 C
METHOD: Pensky-Martens Closed Cup

FLAMMABLE LIMITS (% BY VOL): Not applicable
AUTOIGNITION TEMP: 819 F; 437 C
DECOMPOSITION TEMP: >662 F; 350C

EXTINGUISHING MEDIA AND FIRE FIGHTING INSTRUCTIONS

Use water spray, carbon dioxide or dry chemical to extinguish fires. Use water to keep containers cool. Wear self-contained, positive pressure breathing apparatus and full fire-fighting protective clothing. See Section 8 (Exposure Controls/Personal Protection) for special protective clothing.

6. ACCIDENTAL RELEASE MEASURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED
Where exposure level is not known, wear NIOSH approved, positive pressure, self-contained respirator. Where exposure level is known, wear NIOSH approved respirator suitable for level of exposure. In addition to the protective clothing/equipment in Section 8 (Exposure Controls/Personal Protection), wear impervious boots.
Cover spills with some inert absorbent material; sweep up and place in a waste disposal container. Flush area with water.

7. HANDLING AND STORAGE

Avoid contact with eyes, skin, and clothing. Wash thoroughly after handling.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

ENGINEERING CONTROLS AND PERSONAL PROTECTIVE EQUIPMENT (PPE)
Where this material is not used in a closed system, good enclosure and local exhaust ventilation should be provided to control exposure. Food, beverages, and tobacco products should not be carried, stored, or consumed where this material is in use. Before eating, drinking, or smoking, wash face and hands with soap and water. Avoid skin contact. Protective clothing such as impervious gloves, apron, workpants, long sleeve work shirt, or disposable coveralls are recommended to prevent skin contact. For operations where eye or face contact can occur, wear eye protection such as chemical splash proof goggles or face shield. Eyewash equipment and safety shower should be provided in areas of potential exposure. For operations where inhalation exposure can occur, a NIOSH approved respirator recommended by an industrial hygienist may be necessary. A full facepiece respirator also provides eye and face protection.

9. PHYSICAL AND CHEMICAL PROPERTIES

APPEARANCE AND ODOR: Colorless to light yellow mobile liquid; odorless
BOILING POINT: 223 F; 106 C
MELTING POINT: 23-32 F; -5-0 C; (crystallization point)
VAPOR PRESSURE: 17.5 mm Hg @ 20 C; (value for water)
SPECIFIC GRAVITY: 1.14 @ 24 C
VAPOR DENSITY: Not applicable
% VOLATILE (BY WT): ~50; (water)
pH: Slightly alkaline
SATURATION IN AIR (% BY VOL): Not applicable
EVAPORATION RATE: Not applicable
SOLUBILITY IN WATER: Complete

10. STABILITY AND REACTIVITY

STABILITY: Stable
CONDITIONS TO AVOID: None known
POLYMERIZATION: Will Not Occur
CONDITIONS TO AVOID: None known
INCOMPATIBLE MATERIALS: Strong mineral acids and strong oxidizing agents.
HAZARDOUS DECOMPOSITION PRODUCTS: oxides of carbon; oxides of phosphorus; oxides of sulfur (includes sulfur di and tri oxides)

11. TOXICOLOGICAL INFORMATION

Toxicological information for the product is found under Section 3. HAZARDS IDENTIFICATION.
Toxicological information on the OSHA regulated components of this product is as follows:
Sodium diisobutyldithiophosphinate causes moderate eye and skin irritation.

12. ECOLOGICAL INFORMATION

Algae (Selenastrum capricornutum), 96 hr EbC50 = 35.1 mg/L; 96 hr ErC50 = 115 mg/L

LC50

BLUEGILL, 96 HOUR: 375 mg/L
DAPHNIA, 48 HOUR: 149 mg/L

BOD

28 Day: 78.8 %
OCTANOL/H_2O PARTITION COEF.: Not applicable

13. DISPOSAL CONSIDERATIONS

The information on RCRA waste classification and disposal methodology provided below applies only to the Cytec product, as supplied. If the material has been altered or contaminated, or it has exceeded its recommended shelf life, the guidance may be inapplicable. Hazardous waste classification under federal regulations (40 CFR Part 261 et seq) is dependent upon whether a material is a RCRA "listed hazardous waste" or has any of the four RCRA "hazardous waste characteristics." Refer to 40 CFR Part 261.33 to determine if a given material to be disposed of is a RCRA "listed hazardous waste"; information contained in Section 15 of this MSDS is not intended to indicated if the product is a "listed hazardous waste." RCRA Hazardous Waste Characteristic. There are four characteristics defined in 40 CFR Section 261.21-61.24: Ignitability, Corrosivity, Reactivity, and Toxicity. To determine Ignitability, see Section 5 of this MSDS (flash point). For Corrosivity, see Sections 9 and 14 (pH and DOT corrosivity). For Reactivity, see Section 10 (incompatible materials). For Toxicity, see Section 2 (composition). Federal regulations are subject to change. State and local requirements, which may differ from or be more stringent than the federal regulations, may also apply to the classification of the material if it is to be disposed. Cytec encourages the recycle, recovery and reuse of materials, where permitted, as an alternate to disposal as a waste. Cytec recommends that organic materials classified as RCRA hazardous wastes be disposed of by thermal treatment or incineration at EPA approved facilities. Cytec has provided the foregoing for information only; the person generating the waste is responsible for determining the waste classification and disposal method.

14. TRANSPORT INFORMATION

This section provides basic shipping classification information. Refer to appropriate transportation regulations for specific requirements.

	D.O.T. SHIPPING INFORMATION	IMO SHIPPING INFORMATION
SHIPPING NAME:	NOT APPLICABLE/NOT REGULATED	NOT APPLICABLE/NOT REGULATED
HAZARD CLASS/ PACKING GROUP:	Not Applicable	Not Applicable
UN NUMBER:	Not Applicable	Not Applicable
IMDG PAGE:	Not Applicable	Not Applicable
D.O.T. HAZARDOUS SUBSTANCES: (PRODUCT REPORTABLE QUANTITY)	Not Applicable	Not Applicable
TRANSPORT LABEL REQUIRED:	None Required	None Required

	ICAO / IATA	TRANSPORT CANADA
SHIPPING NAME:	NOT APPLICABLE/NOT REGULATED	NOT APPLICABLE/NOT REGULATED
HAZARD CLASS:	Not Applicable	Not Applicable
SUBSIDIARY CLASS:	Not Applicable	Not Applicable
UN / ID NUMBER:	Not Applicable	Not Applicable
PACKING GROUP:	Not Applicable	Not Applicable
TRANSPORT LABEL REQUIRED:	None Required	None Required
PACKING INSTR:		
PASSENGER	Not Applicable	Not Applicable
CARGO	Not Applicable	
MAX NET QTY:		
PASSENGER	Not Applicable	Not Applicable
CARGO	Not Applicable	

ADDITIONAL TRANSPORT INFORMATION

TECHNICAL NAME (N.O.S.):
Not Applicable

15. REGULATORY INFORMATION

INVENTORY INFORMATION

US TSCA: This product is manufactured in compliance with all provisions of the Toxic Substances Control Act, 15 U.S.C. 2601 et. seq.
CANADA DSL: Components of this product have been reported to Environment Canada in accordance with subsection 25 of the Canadian Environmental Protection Act and are included on the Domestic Substances List.

EEC EINECS: All components of this product are included in the European Inventory of Existing Chemical Substances (EINECS) in compliance with Council Directive 67/548/EEC and its amendments.

OTHER ENVIRONMENTAL INFORMATION

The following components of this product may be subject to reporting requirements pursuant to Section 313 of CERCLA (40 CFR 372), Section 12(b) of TSCA, or may be subject to release reporting requirements (40 CFR 307, 40 CFR 311, etc.) See Section 13 for information on waste classification and waste disposal of this product.

COMPONENT	CAS. NO.	%	TPQ(lbs)	RQ(lbs)	S313	TSCA 12B

This product does not contain any components regulated under these sections of the EPA

PRODUCT CLASSIFICATION UNDER SECTION 311 OF SARA
ACUTE (Y) CHRONIC (N) FIRE (N) REACTIVE (N) PRESSURE (N)

16. OTHER INFORMATION

NFPA HAZARD RATING (National Fire Protection Association)

Fire1
Health 2
Reactivity 0
Special —

FIRE: Materials that must be preheated before ignition can occur.
HEALTH: Materials which on intense or continued exposure could cause temporary incapacitation or possible residual injury unless prompt medical treatment is given
REACTIVITY: Materials which in themselves are normally stable, even under fire exposure conditions, and which are not reactive with water.

REASON FOR ISSUE:

Revised Sections 2, 3, 9 & 10

Randy Deskin, Ph.D., DABT

This information is given without any warranty or representation. We do not assume any legal responsibility for same, nor do we give permission, inducement, or recommendation to practice any patented invention without a license. It is offered solely for your consideration, investigation and verification. Before using any product, read its label.

CF Industries Sales, LLC
4 Parkway North, Suite 400
Deerfield, Illinois 6005-2590
847-405-2400

Material Safety Data Sheet

Ammonium Nitrate

MSDS Number 004 (Revised April 23, 2013) 9 Pages

1. CHEMICAL PRODUCT and EMERGENCY TELEPHONE CONTACT

Product Name:.....	Ammonium Nitrate
Trade Name.....	Amtrate
Chemical Family:	Inorganic Salt
Synonyms:.....	AN, Ammonium Saltpeter, Nitric Acid, Ammonium Salt
Formula:.....	NH_4NO_3
Product Uses:	Fertilizers

EMERGENCY TELEPHONE NUMBERS

CHEMTREC (U.S.):	800-424-9300
CANUTEC (Canada):.....	613-996-6666

2. COMPOSITION/INFORMATION ON INGREDIENTS

Component Name	Percentage by Weight	CAS Number
Ammonium Nitrate	98 - 100 %	6484-52-2
Conditioning Agent	0 – 0.2%	

Exposure Limits for Components

Component	TWA	STEL	PEL	IDLH
Ammonia	25 ppm	35 ppm	50 ppm	300 ppm

3. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW

Strong oxidizer. Contact with combustible material will increase fire hazard. May undergo detonation if heated under confinement causing pressure buildup or if subjected to strong shocks. Solid AN when sensitized or during decomposition may become unstable and/or explosive. When AN is heated to decomposition it may produce vapors which contain nitrogen oxides (NO_X). **AN is an oxidizer** and as such may increase the flammability and/or explosiveness of other substances. Use water to control fires involving AN, if water is compatible with burning material. AN itself is non-flammable. AN can cause irritation to eyes and skin and may be an inhalation discomfort in confined locations.

NFPA Hazard Classification

Health Hazard (Blue)…….. 1
Flammability (Red)…….. 0
Reactivity (Yellow)…….. 3
Other ……OX

POTENTIAL HEALTH EFFECTS

Primary Routes of Entry: Skin contact/absorption and eye contact.

General Acute Exposure: AN is a mild skin, eye, and respiratory irritant, possible allergen, and methemoglobin inducer. Because it can form methemoglobin, it may have irreversible effects which can be life threatening.

General Chronic Exposure: By analogy with nitrobenzene, AN is in Class A+ as a reproductive hazard. It is important to remember that this hazard is due to its association and there is no direct evidence for adverse reproductive effects. Nevertheless, it would be prudent for pregnant women not to be exposed to AN.

Carcinogenicity:
NTP:.....Not Listed
IARC:.....Not Listed
OSHA: .....Not Regulated

Medical Conditions Aggravated by Exposure: No test data available.

4. FIRST AID MEASURES

First Aid for Eyes: Immediately flush eyes with copious amounts of tepid water for at least 15 minutes. If irritation, pain, swelling, excessive tearing, or light sensitivity persists, the patient should be seen in a health care facility.

First Aid for Skin: Immediately flush exposed area with copious amounts of tepid water for at least 15 minutes followed by washing area thoroughly with soap and water. The patient should be seen in a health care facility if irritation or pain persists.

First Aid for Inhalation: Generally not considered an inhalation hazard. If irritation develops move patient to fresh air and monitor. If cough or difficulty in breathing develops, evaluate for respiratory tract irritation. If trained to do so, administer supplemental oxygen if needed. If irritation, coughing, or difficulty in breathing persists the patient should be seen in a health care facility.

First Aid for Ingestion: If conscious, give the patient large quantities of milk or water to drink immediately. Do not induce vomiting. Seek medical attention.

Symptoms of Overexposure

Acute: Cyanosis, nausea , vertigo, collapse, vomiting/abdominal pain, and tachycardia (rapid heartbeat), tachypnea (rapid breathing), coma, convulsions, and death can occur.

Chronic: Small repeated doses may lead to weakness, general depression, headache and mental impairment.

5. FIRE FIGHTING MEASURES

Firefighting Procedures
Flood burning ammonium nitrate fertilizer with large volumes of low pressure water. Do not use salt water, carbon dioxide, dry chemicals or foam extinguishers. Never attempt to smother fire, such as by sealing off, closing a compartment or building doors when fire occurs. Do not add steam. Ammonium nitrate fertilizer does not have the property of spontaneous combustion. Fire fighters should wear approved self-contained breathing apparatus to protect themselves from the toxic fumes of decomposing ammonium nitrate, and protective clothing to guard against molten nitrate splashes should also be worn.

Unusual Fire and Explosive Hazards
Nitrogen oxide gases emitted on decomposition are extremely toxic. Contamination of ammonium nitrate with oil, diesel fuel, charcoal, sulfur, metal fines or other combustible substances could possibly cause an explosion. If an explosion is expected, surrounding area should be evacuated.

Extinguishing Media: Use water only to extinguish a fire involving AN if water is compatible with the burning material. Do not use dry chemicals, CO_2, Halogens or foam.

Special Fire Fighting Procedures:

a. Flood fire area with water from a distance.
b. Move containers from the fire area if you can do it without risk. Do not move cargo or vehicle if cargo has been exposed to heat.
c. Fight fire from maximum distance or use unmanned hose holders or monitor nozzles.
d. Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks due to exploding potential when tanks are involved in a fire.
e. For massive fire, use unmanned hose holders or monitor nozzles; if this is impossible, withdraw from area and let fire burn.
f. Positive pressure self-contained breathing apparatus (SCBA) should be used when there is a potential for inhalation of vapors and/or fumes.
g. Structural firefighters' protective clothing will only provide limited protection.

Evacuation: If tank, rail car or truck is involved in a fire, isolate for 1/2 mile in all directions; also, consider initial evacuation for 1/2 mile in all directions.

Caution:

a. Runoff from fire control or dilution water may cause pollution.
b. AN solution pumps operated with blocked discharge have been known to detonate.
c. Avoid welding or burning on pipes, valves, or tanks, which have contained AN solution until they have been thoroughly washed out. Residual solidified AN may explode under conditions of confinement and high temperature.

6. ACCIDENTAL RELEASE MEASURES

Spill or Leak Measures: Keep combustibles (wood, paper, oil, etc.) away from spilled material. Do not touch damaged containers or spilled material unless wearing appropriate protective clothing. Stop leak if you can do so without risk. Do not get water inside containers.

Small Spill:

a. Stop leak if you can do so without risk.
b. With a clean shovel, place material into a clean , dry container and cover loosely; move containers from spill area.
c. Keep combustibles (wood, paper, oil, etc.) away from spilled material.
d. Wash contaminated areas with large volumes of water, if approved by local, state, and federal environmental agencies.
e. Runoff may cause pollution.

Large Spill:

a. Dike ahead of liquid spill for later recovery of usable product and proper disposal of any residue.
b. Stop leak if you can do so without risk.
c. Wash contaminated areas with large volumes of water, if approved by local, state, and federal environmental agencies.
d. Runoff may cause pollution.

Environmental Impact: Ammonium nitrate fertilizer is a plant nutrient, however, large spills can kill vegetation. If water courses are contaminated it may promote eutrophication and cause fish kills. If drinking water is contaminated beyond 10 mg of nitrate nitrogen per liter by ammonium nitrate fertilizer, it should be reported to the proper authorities.

Precautions if Spilled or Released: Spilled ammonium nitrate fertilizer can be reused if kept dry and uncontaminated. After cleanup, contaminated area should be washed down with water. Do not allow wash water to enter drinking water supplies. In the event of spill or wash water entering sewer or waterway, notify sewer authorities or other appropriate agencies.

Spills that have become contaminated with organic matter or other combustible material may present a fire and explosion hazard. Such material should be shoveled into drums and dissolved in water to obtain at least 50 percent water solution. Depending upon the amount of toxicity of the contaminated material, the solution can be reused as a fertilizer or disposed of.

7. HANDLING AND STORAGE

See NFPA 400 Hazardous Materials Code (2013 Edition)

Store in well-ventilated area away from acute fire hazards and easily oxidizable materials. Do not store near dynamite, blasting caps or other explosives. Avoid contamination. Floor drains and recesses should be plugged or eliminated to prevent entrapment of flowing, molten nitrate during fire.

Storage construction should be of non-combustible materials and preferably equipped with an automatic sprinkler system. Storage should be designed for safe release of pressure in emergency. Bagged ammonium nitrate fertilizer is subject to storage, stacking and quantity regulations. Follow federal, state and local regulations. See CFR 1910.109 regulations.

Handling Precautions: Keep away from open flames, hot surfaces and sources of ignition. Avoid contact with skin, eyes and clothing. Remove and wash contaminated clothing before re-use. Use only in area provided with appropriate exhaust ventilation. Avoid dust formation. Product is mildly corrosive to concrete and steel structures. Avoid materials made of copper and bronze in storage and handling equipment.

8. EXPOSURE CONTROLS, PERSONAL PROTECTION

Respiratory Protection Requirements:

a. AN itself does not pose an inhalation hazard.
b. Decomposition of AN may produce nitrogen oxides (NO_X vapors) and ammonia. Use fresh air supply systems to protect against NO_X vapors.
c. If user operations generate dust, fume, or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.
d. For conditions of use where exposure to dust or mist is apparent and engineering controls are not feasible, a particulate respirator (NIOSH type N95 or better filters) may be worn.

If necessary to enter a confined area which contains AN, monitor for ammonia vapors. If ammonia vapors are present protect as follows:

<25 ppm:	No protection required.
25 to 35 ppm:	Protection required if the daily TWA is exceeded.
35 to 50 ppm:	Protection required if exposed for more than 15 minutes.
50 to 250 ppm:	Minimum of an air-purifying respirator equipped with ammonia canister(s) or cartridge(s).
250 to 300 ppm:	Minimum of a full-face air-purifying respirator equipped with ammonia canister(s) or cartridge(s).
>300 ppm:	A fresh air supply system must be used (i.e. positive pressure self contained breathing apparatus).

Skin Protection Requirements:
Skin contact should be avoided. Wear gloves and clean body protective covering. Gloves and protective clothing made from rubber should be impervious under conditions of use. Other products such as viton or neoprene may be impervious to AN. All protective equipment should be tested for compatibility before use.

Eye Protection Requirements:
It is recommended that if there is a potential for AN to contact eyes that safety glasses/face shield and/or chemical goggles be used.

Other Protective Equipment:
Safety shower and eyewash fountain or at least 5 gallons of accessible clean water should be provided in an AN handling area

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical Form:	Solid prills or granules (deliquescent solid)
Color:	White
Odor:	Odorless
Boiling Point:	Decomposition temperature 410ºF
Melting point:	311º F - 337º F
pH:	(10% solution) 6-7
Solubility:	By Wt. 66.4% @ 70ºF. Highly Soluble.
Specific Gravity:	1.72 @ 70ºF
Vapor Density:	No test results
Vapor Pressure:	No test results
% Volatile by Volume:	No test results
Molecular Weight:	80.05
Critical Temperature:	No test results
Critical Pressure:	No test results

10. REACTIVITY

Stability: ..... This is a stable material.
Hazardous Polymerization: ..... Will not occur.
Decomposition: AN starts to dissociate and decompose at temperatures above 410º F. Upon decomposition it emits nitrogen oxide (NO_X) and water vapors and may explode if confined. Hazardous decomposition products can include ammonia, oxides of nitrogen and nitric acid. If the product has been contaminated with another substance the decomposition temperature and effects of the decomposition may be varied. See Incompatibilities.

Incompatibilities: AN is incompatible with the following substances: Acetic Acid, Acetic Anhydride, Alkali Metals, Aluminum + Calcium Nitrate, Aluminum, Ammonium Chloride, Ammonium Dichromate, Ammonium Phosphate + Potassium, Antimony, Barium Chloride, Bismuth, Brass, Cadmium, Charcoal + Metal Oxides, Chloride Salts, Chromium, Cobalt, Copper Iron II Sulfide, Copper, Cyanoguanidine, Hydrocarbon Oils, Iron, Lead, Magnesium, Manganese, Nickel, Organic Fuels, Potassium Chromate, Potassium Dichromate, Potassium Nitrate, Potassium Nitrite, Potassium Permanganate, Sawdust, Sodium Chloride, Sodium Perchlorate, Sugar, Sulfide Ores, Sulfur, Tin, Titanium, Trinitroanisole, and Zinc.

NOTE: The incompatibilities above is a partial list taken from books by SAX & Lewis: "Dangerous Properties of Industrial Materials", 7th. ed., 1989 and "Hawley's Condensed Chemical Dictionary", 11th. ed. 1987, both published by Van Nostrand Reinhold Company, New York and other sources. It is recommended that if additional information is needed, refer to these and other published information. Incompatibility varies with AN concentration and not all forms of the above listed substances are incompatible.

11. TOXICOLOGICAL INFORMATION

Toxicity

Acute Oral Toxicity
LD_{50} Rat ..... 2,800 mg/kg bw (OECD 401)
Acute Inhalation Toxicity
LC_{50} Rat ..... > 88.8 mg/L (4 hrs)
Acute Dermal Toxicity
LD_{50} Rat ..... > 5,000 mg/kg (OECD 402)
Acute Toxicity, Other Routes
Minimum lethal dose Rat……..0.065 mg NH_4NO_3-N
Corrosiveness / Irritation
Skin irritation Rabbit……Moderately irritating
Eye irritation Rabbit……No data available
Repeated Dose
NOAEL Inhalation Rat……185 mg/m^3 (2 weeks)
NOAEL Inhalation Rat……1 mg/m^3 (4 weeks)
Genetic Toxicity *in vitro*
Salmonella typhimurium…….Negative (Bacterial reverse mutation assay)
Development Toxicity / Teratogenicity
NOEL Rat……..> 57 mg/kg/day

Ecotoxicity

Acute Toxicity to Fish
LC_{50} *Cyprinus carpio L*……1.15 – 1.72 mg unionized NH_3/L (48 hrs)
LC_{50} Many species……420 – 1,360 mg NO_3/L (96 hrs)
Acute Toxicity to Aquatic Invertebrates
EC_{50} *Daphnia magna*……555 mg/L
Toxicity to Aquatic Plants (Algae)
EC_{50} *Scenedesmus quadricauda*……83 mg/L
Chronic Toxicity to Aquatic Invertebrates
NOEC *Bullia digitalis*……300 mg/L (Up to 7 days)

Source: TFI Product Testing Program April 2003.

12. ECOLOGICAL INFORMATION

Notify local health and wildlife officials and operators of any nearby water intakes of contamination or discharge into or leading to waterways. Fertilizers containing AN can cause poisoning in livestock and poultry. AN can be toxic to aquatic life and spills may cause algae blooms in static waters. Nitrate ions are assimilated by growing plants. AN will also be taken up by bacteria. In anaerobic soils, nitrate ions may be converted to nitrite, molecular nitrogen, nitrous oxide, or ammonium ions.

Note: See Ecotoxicity information in section 11.

13. DISPOSAL CONSIDERATIONS

Consult state/provincial and local environmental agencies for acceptable disposal methods. Recover product for use as a fertilizer if possible

.

14. TRANSPORTATION INFORMATION

U.S. DOT and Canadian TDG Act
Shipping Name:.....Ammonium nitrate
Hazard Class: .....Class 5.1
Product Identification Number (PIN):.....UN1942
DOT Placard: .....Oxidizer 5.1, color: yellow
RQ (Reportable Quantity):.....No RQ established
STCC Number:.....4918311

15. REGULATORY INFORMATION

OSHA: This product is considered a hazardous material under criteria of the Federal OSHA Hazard Communication Standard 29 CFR 1910.1200.

SARA TITLE III:

a. EHS (Extremely Hazardous Substances) List: Not Listed (EPA, 1992a)
b. EHS RQ (Reportable Quantity): No RQ established.
c. TPQ (Threshold Planning Quantity): None
d. As distributed by CF Industries Sales, LLC, this product contains no compounds subject to reporting under Section 313 of SARA III and 40 CFR 372; however, these federal regulations do contain reporting requirements regarding water solutions of ammonia and nitrates. Additionally, the following federal environmental statutes apply to this product: SARA Title III, Sections 311 & 312 (40 CFR 370).

CERCLA Hazardous Substances List: Not listed

TSCA Inventory:

a. Listed (RTECS, 1993)

Security:

This product is listed as a Chemical of Interest (COI) by the Department of Homeland Security (DHS) for theft. DHS 6 CFR part 27 Appendix A, Chemical Facility Anti-Terrorism Standards.

16. OTHER INFORMATION

Aug. 21, 2008	The MSDS was reformatted and additional sections populated to comply with ANSI Standard Z400.1-1993. Toxicity information from the TFI Product Testing Program April 2003 was added. Reviewed and updated as necessary.
Jan. 25, 2011	Reviewed and revised for logo change.
Dec. 11, 2012	Revised for company name change. Reviewed product specifications.
April 23, 2013	Revised to update NFPA reference.

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Material Safety Data Sheet

DIESEL FUEL

1 . Product and company identification

Product name : DIESEL FUEL

Synonym : Seasonal Diesel, #1 Diesel, #2 Heating Oil, #1 Heating Oil, D50, D60, P40, P50, Arctic Diesel, Farm Diesel, Marine Diesel, Low Sulphur Diesel, LSD, Ultra Low Sulphur Diesel, ULSD, Mining Diesel, Naval Distillate, Dyed Diesel, Marked Diesel, Coloured Diesel, Furnace special, Biodiesel blend, B1, B2, B5, Diesel Low Cloud (LC), Marine Gas Oil.

Code : W104, W293

Material uses : Diesel fuels are distillate fuels suitable for use in high and medium speed internal combustion engines of the compression ignition type. Mining diesels, marine diesels, MDO and naval distillates may have a higher flash point requirement.

Manufacturer : PETRO-CANADA
P.O. Box 2844
150 – 6th Avenue South-West
Calgary, Alberta
T2P 3E3

In case of emergency : Petro-Canada: 403-296-3000
Canutec Transportation: 613-996-6666
Poison Control Centre: Consult local telephone directory for emergency number(s).

2 . Hazards identification

Physical state : Bright oily liquid.

Odour : Mild petroleum oil like.

WHMIS (Canada) :



Class B-3: Combustible liquid with a flash point between 37.8°C (100°F) and 93.3°C (200°F).
Class D-2A: Material causing other toxic effects (Very toxic).
Class D-2B: Material causing other toxic effects (Toxic).

OSHA/HCS status : This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200).

Emergency overview : WARNING!

COMBUSTIBLE LIQUID AND VAPOUR. CAUSES EYE AND SKIN IRRITATION.

Combustible liquid. Severely irritating to the skin. Irritating to eyes. Keep away from heat, sparks and flame. Do not get in eyes. Avoid breathing vapour or mist. Avoid contact with skin and clothing. Use only with adequate ventilation. Wash thoroughly after handling.

Routes of entry : Dermal contact. Eye contact. Inhalation. Ingestion.

Potential acute health effects

Inhalation : Inhalation of this product may cause respiratory tract irritation and Central Nervous System (CNS) Depression, symptoms of which may include; weakness, dizziness, slurred speech, drowsiness, unconsciousness and in cases of severe overexposure; coma and death.

Ingestion : Ingestion of this product may cause gastro-intestinal irritation. Aspiration of this product may result in severe irritation or burns to the respiratory tract.

Skin : Severely irritating to the skin.

Eyes : Irritating to eyes.

Potential chronic health effects

Chronic effects : No known significant effects or critical hazards.

Carcinogenicity : Diesel engine exhaust particulate is probably carcinogenic to humans (IARC Group 2A).

Mutagenicity : No known significant effects or critical hazards.

Teratogenicity : No known significant effects or critical hazards.

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2 . Hazards identification

Developmental effects : No known significant effects or critical hazards.

Fertility effects : No known significant effects or critical hazards.

Medical conditions aggravated by over-exposure : Avoid prolonged or repeated skin contact to diesel fuels which can lead to dermal irritation and may be associated with an increased risk of skin cancer.

See toxicological information (Section 11)

3 . Composition/information on ingredients

Name	CAS number	%
Hydrotreated Renewable Diesel/ Fuels, diesel/ Fuel Oil No. 1/ Fuel Oil No. 2	64742-81-0/ 68334-30-5/ 8008-20-6/ 68476-30-2	95 - 100
Alkanes, C10 – 20 Branched and Linear (R100)	928771-01-1	10 - 20
Fatty acids methyl esters	61788-61-2 / 67784-80-9 / 73891-99-3	0 - 5

There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.

4 . First-aid measures

Eye contact : Check for and remove any contact lenses. Immediately flush eyes with plenty of water for at least 15 minutes, occasionally lifting the upper and lower eyelids. Get medical attention immediately.

Skin contact : In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash skin thoroughly with soap and water or use recognised skin cleanser. Wash clothing before reuse. Clean shoes thoroughly before reuse. Get medical attention immediately.

Inhalation : Move exposed person to fresh air. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention immediately.

Ingestion : Wash out mouth with water. Do not induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Get medical attention immediately.

Protection of first-aiders : No action shall be taken involving any personal risk or without suitable training. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation.

Notes to physician : No specific treatment. Treat symptomatically. Contact poison treatment specialist immediately if large quantities have been ingested or inhaled.

5 . Fire-fighting measures

Flammability of the product : Combustible liquid

Extinguishing media

Suitable : Use dry chemical, CO_2, water spray (fog) or foam.

Not suitable : Do not use water jet.

Special exposure hazards : Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training. Move containers from fire area if this can be done without risk. Use water spray to keep fire-exposed containers cool.

Products of combustion : Carbon oxides (CO, CO2), nitrogen oxides (NOx), sulphur oxides (SOx), sulphur compounds (H2S), smoke and irritating vapours as products of incomplete combustion.

Special protective equipment for fire-fighters : Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

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5 . Fire-fighting measures

Special remarks on fire hazards : Flammable in presence of open flames, sparks and heat. Vapours are heavier than air and may travel considerable distance to sources of ignition and flash back. This product can accumulate static charge and ignite.

Special remarks on explosion hazards : Do not pressurise, cut, weld, braze, solder, drill, grind or expose containers to heat or sources of ignition. Runoff to sewer may create fire or explosion hazard.

6 . Accidental release measures

Personal precautions : No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Do not touch or walk through spilt material. Shut off all ignition sources. No flares, smoking or flames in hazard area. Avoid breathing vapour or mist. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment (see Section 8).

Environmental precautions : Avoid dispersal of spilt material and runoff and contact with soil, waterways, drains and sewers. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air).

Methods for cleaning up

Small spill : Stop leak if without risk. Move containers from spill area. Dilute with water and mop up if water-soluble. Alternatively, or if water-insoluble, absorb with an inert dry material and place in an appropriate waste disposal container. Use spark-proof tools and explosion-proof equipment. Dispose of via a licensed waste disposal contractor.

Large spill : Stop leak if without risk. Move containers from spill area. Approach the release from upwind. Prevent entry into sewers, water courses, basements or confined areas. Wash spillages into an effluent treatment plant or proceed as follows. Contain and collect spillage with non-combustible, absorbent material e.g. sand, earth, vermiculite or diatomaceous earth and place in container for disposal according to local regulations (see section 13). Use spark-proof tools and explosion-proof equipment. Dispose of via a licensed waste disposal contractor. Contaminated absorbent material may pose the same hazard as the spilt product. Note: see section 1 for emergency contact information and section 13 for waste disposal.

7 . Handling and storage

Handling : Put on appropriate personal protective equipment (see Section 8). Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Remove contaminated clothing and protective equipment before entering eating areas. Do not ingest. Avoid contact with eyes, skin and clothing. Avoid breathing vapour or mist. Use only with adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Do not enter storage areas and confined spaces unless adequately ventilated. Keep in the original container or an approved alternative made from a compatible material, kept tightly closed when not in use. Store and use away from heat, sparks, open flame or any other ignition source. Use explosion-proof electrical (ventilating, lighting and material handling) equipment. Use non-sparking tools. Take precautionary measures against electrostatic discharges. To avoid fire or explosion, dissipate static electricity during transfer by earthing and bonding containers and equipment before transferring material. Empty containers retain product residue and can be hazardous. Do not reuse container.

Storage : Store in accordance with local regulations. Store in a segregated and approved area. Store in original container protected from direct sunlight in a dry, cool and well-ventilated area, away from incompatible materials (see section 10) and food and drink. Eliminate all ignition sources. Separate from oxidizing materials. Keep container tightly closed and sealed until ready for use. Containers that have been opened must be carefully resealed and kept upright to prevent leakage. Do not store in unlabelled containers. Use appropriate containment to avoid environmental contamination. Ensure the storage containers are grounded/bonded.

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8 . Exposure controls/personal protection

Ingredient	Exposure limits
Fuels, diesel	**ACGIH TLV (United States). Absorbed through skin.** TWA: 100 mg/m³, (Inhalable fraction and vapour) 8 hour(s).
Fuel oil No. 2	**ACGIH TLV (United States). Absorbed through skin.** TWA: 100 mg/m³, (Inhalable fraction and vapour) 8 hour(s).
Hydrotreated Renewable Diesel	**ACGIH TLV (United States). Absorbed through skin.** TWA: 200 mg/m³ 8 hour(s).
Fuel oil No. 1	**ACGIH TLV (United States). Absorbed through skin.** TWA: 200 mg/m³ 8 hour(s).

Consult local authorities for acceptable exposure limits.

Recommended monitoring procedures : If this product contains ingredients with exposure limits, personal, workplace atmosphere or biological monitoring may be required to determine the effectiveness of the ventilation or other control measures and/or the necessity to use respiratory protective equipment.

Engineering measures : Use only with adequate ventilation. Use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits. The engineering controls also need to keep gas, vapour or dust concentrations below any lower explosive limits. Use explosion-proof ventilation equipment.

Hygiene measures : Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing. Ensure that eyewash stations and safety showers are close to the workstation location.

Personal protection

Respiratory : Use a properly fitted, air-purifying or air-fed respirator complying with an approved standard if a risk assessment indicates this is necessary. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator. Recommended: organic vapour cartridge or canister may be permissible under certain circumstances where airborne concentrations are expected to exceed exposure limits. Protection provided by air-purifying respirators is limited. Use a positive-pressure, air-supplied respirator if there is any potential for uncontrolled release, exposure levels are unknown, or any other circumstances where air-purifying respirators may not provide adequate protection.

Hands : Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary.
Recommended: nitrile, neoprene, polyvinyl alcohol (PVA), Viton®. Consult your PPE provider for breakthrough times and the specific glove that is best for you based on your use patterns. It should be realized that eventually any material regardless of their imperviousness, will get permeated by chemicals. Therefore, protective gloves should be regularly checked for wear and tear. At the first signs of hardening and cracks, they should be changed.

Eyes : Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists or dusts.

Skin : Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Environmental exposure controls : Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

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9 . Physical and chemical properties

Physical state : Bright oily liquid.

Flash point : Diesel fuel and other distillate fuels: Closed cup: ≥40°C (≥104°F)
Marine Diesel/MDO/Naval Distillate: Closed Cup: ≥60°C (≥140°F)
Mining Diesel: Closed Cup: ≥52°C (≥126°F)

Auto-ignition temperature : 225°C (437°F)

Flammable limits : Lower: 0.7%
Upper: 6%

Colour : Clear to yellow (This product may be dyed red for taxation purposes).

Odour : Mild petroleum oil like.

Odour threshold : Not available.

pH : Not available.

Boiling/condensation point : 150 to 371°C (302 to 699.8°F)

Melting/freezing point : Not available.

Relative density : 0.80 to 0.88 kg/L @ 15°C (59°F)

Vapour pressure : 1 kPa (7.5 mm Hg) @ 20°C (68ºF).

Vapour density : 4.5 [Air = 1]

Volatility : Not available.

Evaporation rate : Not available.

Viscosity : Diesel fuel: 1.3 - 4.1 cSt @ 40°C (104°F)
Marine Diesel Fuel: 1.3 - 4.4 cSt @ 40°C (104°F)

Pour point : Not available.

Solubility : Insoluble in cold water, soluble in non-polar hydrocarbon solvents.

10 . Stability and reactivity

Chemical stability : The product is stable.

Hazardous polymerisation : Under normal conditions of storage and use, hazardous polymerisation will not occur.

Materials to avoid : Reactive with oxidising agents and acids.

Hazardous decomposition products : May release COx, NOx, SOx, H_2S, smoke and irritating vapours when heated to decomposition.

11 . Toxicological information

Acute toxicity

Product/ingredient name	Result	Species	Dose	Exposure
Fuels, diesel	LD50 Dermal	Mouse	24500 mg/kg	-
	LD50 Oral	Rat	7500 mg/kg	-
Fuel oil No. 2	LD50 Oral	Rat	12000 mg/kg	-
Fuel oil No. 1	LD50 Dermal	Rabbit	>2000 mg/kg	-
	LD50 Oral	Rat	>5000 mg/kg	-
	LC50 Inhalation Vapour	Rat	>5000 mg/m³	4 hours
Hydrotreated Renewable Diesel	LD50 Dermal	Rabbit	>2000 mg/kg	-
	LD50 Oral	Rat	>5000 mg/kg	-
	LC50 Inhalation Vapour	Rat	>5200 mg/m³	4 hours

Conclusion/Summary : Not available.

Chronic toxicity

Conclusion/Summary : Not available.

Irritation/Corrosion

Conclusion/Summary : Not available.

Sensitiser

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11 . Toxicological information

Conclusion/Summary : Not available.

Carcinogenicity

Conclusion/Summary : Diesel engine exhaust particulate is probably carcinogenic to humans (IARC Group 2A).

Classification

Product/ingredient name	ACGIH	IARC	EPA	NIOSH	NTP	OSHA
Fuels, diesel	A3	3	-	-	-	-
Fuel oil No. 1	A3	3	-	-	-	-
Fuel oil No. 2	A3	3	-	-	-	-
Hydrotreated Renewable Diesel	A3	3	-	-	-	-

Mutagenicity

Conclusion/Summary : Not available.

Teratogenicity

Conclusion/Summary : Not available.

Reproductive toxicity

Conclusion/Summary : Not available.

12 . Ecological information

Environmental effects : No known significant effects or critical hazards.

Aquatic ecotoxicity

Conclusion/Summary : Not available.

Biodegradability

Conclusion/Summary : Not available.

13 . Disposal considerations

Waste disposal : The generation of waste should be avoided or minimised wherever possible. Significant quantities of waste product residues should not be disposed of via the foul sewer but processed in a suitable effluent treatment plant. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Disposal of this product, solutions and any by-products should at all times comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Waste packaging should be recycled. Incineration or landfill should only be considered when recycling is not feasible. This material and its container must be disposed of in a safe way. Care should be taken when handling emptied containers that have not been cleaned or rinsed out. Empty containers or liners may retain some product residues. Vapor from product residues may create a highly flammable or explosive atmosphere inside the container. Do not cut, weld or grind used containers unless they have been cleaned thoroughly internally. Avoid dispersal of spilt material and runoff and contact with soil, waterways, drains and sewers.

Disposal should be in accordance with applicable regional, national and local laws and regulations.

Refer to Section 7: HANDLING AND STORAGE and Section 8: EXPOSURE CONTROLS/PERSONAL PROTECTION for additional handling information and protection of employees.

14 . Transport information

Regulatory information	UN number	Proper shipping name	Classes	PG*	Label	Additional information
TDG Classification	UN1202	DIESEL FUEL	3	III		-
DOT Classification	Not available.	Not available.	Not available.	-		-

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14 . Transport information

PG* : Packing group

15 . Regulatory information

United States

HCS Classification : Combustible liquid
Irritating material

Canada

WHMIS (Canada) : Class B-3: Combustible liquid with a flash point between 37.8°C (100°F) and 93.3°C (200°F).
Class D-2A: Material causing other toxic effects (Very toxic).
Class D-2B: Material causing other toxic effects (Toxic).

This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations and the MSDS contains all the information required by the Controlled Products Regulations.

International regulations

Canada inventory : All components are listed or exempted.

United States inventory (TSCA 8b) : All components are listed or exempted.

Europe inventory : All components are listed or exempted.

16 . Other information

Label requirements : COMBUSTIBLE LIQUID AND VAPOUR. CAUSES EYE AND SKIN IRRITATION.

Hazardous Material Information System (U.S.A.) :

Health	2
Flammability	2
Physical hazards	0
Personal protection	H

National Fire Protection Association (U.S.A.) :



References : Available upon request.
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Date of printing : **4/14/2014.**

Date of issue : 28 June 2013

Date of previous issue : No previous validation.

Responsible name : **Product Safety - DSR**

Indicates information that has changed from previously issued version.

For Copy of (M)SDS : Internet: www.petro-canada.ca/msds

Canada-wide: telephone: 1-800-668-0220; fax: 1-800-837-1228

For Product Safety Information: (905) 804-4752

Notice to reader

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16 . Other information

To the best of our knowledge, the information contained herein is accurate. However, neither the above-named supplier, nor any of its subsidiaries, assumes any liability whatsoever for the accuracy or completeness of the information contained herein.
Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

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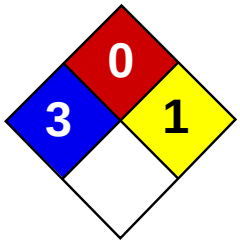



Material Safety Data Sheet
Hydrochloric acid MSDS

Section 1: Chemical Product and Company Identification

Product Name: Hydrochloric acid

Catalog Codes: SLH1462, SLH3154

CAS#: Mixture.

RTECS: MW4025000

TSCA: TSCA 8(b) inventory: Hydrochloric acid

CI#: Not applicable.

Synonym: Hydrochloric Acid; Muriatic Acid

Chemical Name: Not applicable.

Chemical Formula: Not applicable.

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call:
1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
Hydrogen chloride	7647-01-0	20-38
Water	7732-18-5	62-80

Toxicological Data on Ingredients: Hydrogen chloride: GAS (LC50): Acute: 4701 ppm 0.5 hours [Rat].

Section 3: Hazards Identification

Potential Acute Health Effects:
Very hazardous in case of skin contact (corrosive, irritant, permeator), of eye contact (irritant, corrosive), of ingestion, . Slightly hazardous in case of inhalation (lung sensitizer). Non-corrosive for lungs. Liquid or spray mist may produce tissue damage particularly on mucous membranes of eyes, mouth and respiratory tract. Skin contact may produce burns. Inhalation of the spray mist may produce severe irritation of respiratory tract, characterized by coughing, choking, or shortness of breath. Severe over-exposure can result in death. Inflammation of the eye is characterized by redness, watering, and itching. Skin inflammation is characterized by itching, scaling, reddening, or, occasionally, blistering.

Potential Chronic Health Effects:
Slightly hazardous in case of skin contact (sensitizer). CARCINOGENIC EFFECTS: Classified 3 (Not classifiable for human.) by IARC [Hydrochloric acid]. MUTAGENIC EFFECTS: Not available. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available. The substance may be toxic to kidneys, liver, mucous membranes, upper respiratory tract, skin, eyes, Circulatory System, teeth. Repeated or prolonged exposure to the substance can produce target

organs damage. Repeated or prolonged contact with spray mist may produce chronic eye irritation and severe skin irritation. Repeated or prolonged exposure to spray mist may produce respiratory tract irritation leading to frequent attacks of bronchial infection. Repeated exposure to a highly toxic material may produce general deterioration of health by an accumulation in one or many human organs.

Section 4: First Aid Measures

Eye Contact:
Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Cold water may be used. Get medical attention immediately.

Skin Contact:
In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Cover the irritated skin with an emollient. Cold water may be used.Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention immediately.

Serious Skin Contact:
Wash with a disinfectant soap and cover the contaminated skin with an anti-bacterial cream. Seek immediate medical attention.

Inhalation:
If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention immediately.

Serious Inhalation:
Evacuate the victim to a safe area as soon as possible. Loosen tight clothing such as a collar, tie, belt or waistband. If breathing is difficult, administer oxygen. If the victim is not breathing, perform mouth-to-mouth resuscitation. WARNING: It may be hazardous to the person providing aid to give mouth-to-mouth resuscitation when the inhaled material is toxic, infectious or corrosive. Seek immediate medical attention.

Ingestion:
If swallowed, do not induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention immediately.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: Non-flammable.

Auto-Ignition Temperature: Not applicable.

Flash Points: Not applicable.

Flammable Limits: Not applicable.

Products of Combustion: Not available.

Fire Hazards in Presence of Various Substances: of metals

Explosion Hazards in Presence of Various Substances: Non-explosive in presence of open flames and sparks, of shocks.

Fire Fighting Media and Instructions: Not applicable.

Special Remarks on Fire Hazards:
Non combustible. Calcium carbide reacts with hydrogen chloride gas with incandescence. Uranium phosphide reacts with hydrochloric acid to release spontaneously flammable phosphine. Rubidium acetylene carbides burns with slightly warm hydrochloric acid. Lithium silicide in contact with hydrogen chloride becomes incandescent. When dilute hydrochloric acid is used, gas spontaneously flammable in air is evolved. Magnesium boride treated with concentrated hydrochloric acid produces spontaneously flammble gas. Cesium acetylene carbide burns hydrogen chloride gas. Cesium carbide ignites in contact with hydrochloric acid unless acid is dilute. Reacts with most metals to produce flammable Hydrodgen gas.

Special Remarks on Explosion Hazards:

Hydrogen chloride in contact with the following can cause an explosion, ignition on contact, or other violent/vigorous reaction: Acetic anhydride AgClO + CCl4 Alcohols + hydrogen cyanide, Aluminum Aluminum-titanium alloys (with HCl vapor), 2-Amino ethanol, Ammonium hydroxide, Calcium carbide Ca3P2 Chlorine + dinitroanilines (evolves gas), Chlorosulfonic acid Cesium carbide Cesium acetylene carbide, 1,1-Difluoroethylene Ethylene diamine Ethylene imine, Fluorine, HClO4 Hexalithium disilicide H2SO4 Metal acetylides or carbides, Magnesium boride, Mercuric sulfate, Oleum, Potassium permanganate, beta-Propiolactone Propylene oxide Rubidium carbide, Rubidium, acetylene carbide Sodium (with aqueous HCl), Sodium hydroxide Sodium tetraselenium, Sulfonic acid, Tetraselenium tetranitride, U3P4 , Vinyl acetate. Silver perchlorate with carbon tetrachloride in the presence of hydrochloric acid produces trichloromethyl perchlorate which detonates at 40 deg. C.

Section 6: Accidental Release Measures

Small Spill:
Dilute with water and mop up, or absorb with an inert dry material and place in an appropriate waste disposal container. If necessary: Neutralize the residue with a dilute solution of sodium carbonate.

Large Spill:
Corrosive liquid. Poisonous liquid. Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material. Do not get water inside container. Do not touch spilled material. Use water spray curtain to divert vapor drift. Use water spray to reduce vapors. Prevent entry into sewers, basements or confined areas; dike if needed. Call for assistance on disposal. Neutralize the residue with a dilute solution of sodium carbonate. Be careful that the product is not present at a concentration level above TLV. Check TLV on the MSDS and with local authorities.

Section 7: Handling and Storage

Precautions:
Keep locked up.. Keep container dry. Do not ingest. Do not breathe gas/fumes/ vapor/spray. Never add water to this product. In case of insufficient ventilation, wear suitable respiratory equipment. If ingested, seek medical advice immediately and show the container or the label. Avoid contact with skin and eyes. Keep away from incompatibles such as oxidizing agents, organic materials, metals, alkalis, moisture. May corrode metallic surfaces. Store in a metallic or coated fiberboard drum using a strong polyethylene inner package.

Storage: Keep container tightly closed. Keep container in a cool, well-ventilated area.

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors below their respective threshold limit value. Ensure that eyewash stations and safety showers are proximal to the work-station location.

Personal Protection:
Face shield. Full suit. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Gloves. Boots.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Vapor respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits:
CEIL: 5 (ppm) from OSHA (PEL) [United States] CEIL: 7 (mg/m3) from OSHA (PEL) [United States] CEIL: 5 from NIOSH CEIL: 7 (mg/m3) from NIOSH TWA: 1 STEL: 5 (ppm) [United Kingdom (UK)] TWA: 2 STEL: 8 (mg/m3) [United Kingdom (UK)]Consult local authorities for acceptable exposure limits.

Section 9: Physical and Chemical Properties

Physical state and appearance: Liquid.

Odor: Pungent. Irritating (Strong.)

Taste: Not available.

Molecular Weight: Not applicable.

Color: Colorless to light yellow.

pH (1% soln/water): Acidic.

Boiling Point:
108.58 C @ 760 mm Hg (for 20.22% HCl in water) 83 C @ 760 mm Hg (for 31% HCl in water) 50.5 C (for 37% HCl in water)

Melting Point:
-62.25°C (-80°F) (20.69% HCl in water) -46.2 C (31.24% HCl in water) -25.4 C (39.17% HCl in water)

Critical Temperature: Not available.

Specific Gravity:
1.1- 1.19 (Water = 1) 1.10 (20%and 22% HCl solutions) 1.12 (24% HCl solution) 1.15 (29.57% HCl solution) 1.16 (32% HCl solution) 1.19 (37% and 38%HCl solutions)

Vapor Pressure: 16 kPa (@ 20°C) average

Vapor Density: 1.267 (Air = 1)

Volatility: Not available.

Odor Threshold: 0.25 to 10 ppm

Water/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties: See solubility in water, diethyl ether.

Solubility: Soluble in cold water, hot water, diethyl ether.

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Incompatible materials, water

Incompatibility with various substances:
Highly reactive with metals. Reactive with oxidizing agents, organic materials, alkalis, water.

Corrosivity:
Extremely corrosive in presence of aluminum, of copper, of stainless steel(304), of stainless steel(316). Non-corrosive in presence of glass.

Special Remarks on Reactivity:
Reacts with water especially when water is added to the product. Absorption of gaseous hydrogen chloride on mercuric sulfate becomes violent @ 125 deg. C. Sodium reacts very violently with gaseous hydrogen chloride. Calcium phosphide and hydrochloric acid undergo very energetic reaction. It reacts with oxidizers releasing chlorine gas. Incompatible with, alkali metals, carbides, borides, metal oxides, vinyl acetate, acetylides, sulphides, phosphides, cyanides, carbonates. Reacts with most metals to produce flammable Hydrogen gas. Reacts violently (moderate reaction with heat of evolution) with water especially when water is added to the product. Isolate hydrogen chloride from heat, direct sunlight, alkalies (reacts vigorously), organic materials, and oxidizers (especially nitric acid and chlorates), amines, metals, copper and alloys (e.g. brass), hydroxides, zinc (galvanized materials), lithium silicide (incandescence), sulfuric acid(increase in temperature and pressure) Hydrogen chloride gas is emitted when this product is in contact with sulfuric acid. Adsorption of Hydrochloric Acid onto silicon dioxide results in exothmeric reaction. Hydrogen chloride causes aldehydes and epoxides to violently polymerize. Hydrogen chloride or Hydrochloric Acid in contact with the folloiwng can cause explosion or ignition on contact or

Special Remarks on Corrosivity:

Highly corrosive. Incompatible with copper and copper alloys. It attacks nearly all metals (mercury, gold, platinium, tantalum, silver, and certain alloys are exceptions). It is one of the most corrosive of the nonoxidizing acids in contact with copper alloys. No corrosivity data on zinc, steel. Severe Corrosive effect on brass and bronze

Polymerization: Will not occur.

Section 11: Toxicological Information

Routes of Entry: Absorbed through skin. Dermal contact. Eye contact. Inhalation.

Toxicity to Animals:
Acute oral toxicity (LD50): 900 mg/kg [Rabbit]. Acute toxicity of the vapor (LC50): 1108 ppm, 1 hours [Mouse]. Acute toxicity of the vapor (LC50): 3124 ppm, 1 hours [Rat].

Chronic Effects on Humans:
CARCINOGENIC EFFECTS: Classified 3 (Not classifiable for human.) by IARC [Hydrochloric acid]. May cause damage to the following organs: kidneys, liver, mucous membranes, upper respiratory tract, skin, eyes, Circulatory System, teeth.

Other Toxic Effects on Humans:
Very hazardous in case of skin contact (corrosive, irritant, permeator), of ingestion, . Hazardous in case of eye contact (corrosive), of inhalation (lung corrosive).

Special Remarks on Toxicity to Animals:
Lowest Published Lethal Doses (LDL/LCL) LDL [Man] -Route: Oral; 2857 ug/kg LCL [Human] - Route: Inhalation; Dose: 1300 ppm/30M LCL [Rabbit] - Route: Inhalation; Dose: 4413 ppm/30M

Special Remarks on Chronic Effects on Humans:
May cause adverse reproductive effects (fetoxicity). May affect genetic material.

Special Remarks on other Toxic Effects on Humans:
Acute Potential Health Effects: Skin: Corrosive. Causes severe skin irritation and burns. Eyes: Corrosive. Causes severe eye irritation/conjuntivitis, burns, corneal necrosis. Inhalation: May be fatal if inhaled. Material is extremely destructive to tissue of the mucous membranes and upper respiratory tract. Inhalation of hydrochloric acid fumes produces nose, throat, and larryngeal burning, and irritation, pain and inflammation, coughing, sneezing, choking sensation, hoarseness, laryngeal spasms, upper respiratory tract edema, chest pains, as well has headache, and palpitations. Inhalation of high concentrations can result in corrosive burns, necrosis of bronchial epithelium, constriction of the larynx and bronchi, nasospetal perforation, glottal closure, occur, particularly if exposure is prolonged. May affect the liver. Ingestion: May be fatal if swallowed. Causes irritation and burning, ulceration, or perforation of the gastrointestinal tract and resultant peritonitis, gastric hemorrhage and infection. Can also cause nausea, vomitting (with "coffee ground" emesis), diarrhea, thirst, difficulty swallowing, salivation, chills, fever, uneasiness, shock, strictures and stenosis (esophogeal, gastric, pyloric). May affect behavior (excitement), the cardiovascular system (weak rapid pulse, tachycardia), respiration (shallow respiration), and urinary system (kidneys- renal failure, nephritis). Acute exposure via inhalation or ingestion can also cause erosion of tooth enamel. Chronic Potential Health Effects: dyspnea, bronchitis. Chemical pneumonitis and pulmonary edema can also

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The products of degradation are less toxic than the product itself.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:

Waste must be disposed of in accordance with federal, state and local environmental control regulations.

Section 14: Transport Information

DOT Classification: Class 8: Corrosive material

Identification: : Hydrochloric acid, solution UNNA: 1789 PG: II

Special Provisions for Transport: Not available.

Section 15: Other Regulatory Information

Federal and State Regulations:
Connecticut hazardous material survey.: Hydrochloric acid Illinois toxic substances disclosure to employee act: Hydrochloric acid Illinois chemical safety act: Hydrochloric acid New York release reporting list: Hydrochloric acid Rhode Island RTK hazardous substances: Hydrochloric acid Pennsylvania RTK: Hydrochloric acid Minnesota: Hydrochloric acid Massachusetts RTK: Hydrochloric acid Massachusetts spill list: Hydrochloric acid New Jersey: Hydrochloric acid New Jersey spill list: Hydrochloric acid Louisiana RTK reporting list: Hydrochloric acid Louisiana spill reporting: Hydrochloric acid California Director's List of Hazardous Substances: Hydrochloric acid TSCA 8(b) inventory: Hydrochloric acid TSCA 4(a) proposed test rules: Hydrochloric acid SARA 302/304/311/312 extremely hazardous substances: Hydrochloric acid SARA 313 toxic chemical notification and release reporting: Hydrochloric acid CERCLA: Hazardous substances.: Hydrochloric acid: 5000 lbs. (2268 kg)

Other Regulations:
OSHA: Hazardous by definition of Hazard Communication Standard (29 CFR 1910.1200). EINECS: This product is on the European Inventory of Existing Commercial Chemical Substances.

Other Classifications:

WHMIS (Canada):
CLASS D-2A: Material causing other toxic effects (VERY TOXIC). CLASS E: Corrosive liquid.

DSCL (EEC):
R34- Causes burns. R37- Irritating to respiratory system. S26- In case of contact with eyes, rinse immediately with plenty of water and seek medical advice. S45- In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).

HMIS (U.S.A.):

Health Hazard: 3

Fire Hazard: 0

Reactivity: 1

Personal Protection:

National Fire Protection Association (U.S.A.):

Health: 3

Flammability: 0

Reactivity: 1

Specific hazard:

Protective Equipment:
Gloves. Full suit. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Wear appropriate respirator when ventilation is inadequate. Face shield.

Section 16: Other Information

References:
-Hawley, G.G.. The Condensed Chemical Dictionary, 11e ed., New York N.Y., Van Nostrand Reinold, 1987. -SAX, N.I. Dangerous Properties of Indutrial Materials. Toronto, Van Nostrand Reinold, 6e ed. 1984. -The Sigma-Aldrich Library of Chemical Safety Data, Edition II. -Guide de la loi et du règlement sur le transport des marchandises dangeureuses au canada. Centre de conformité internatinal Ltée. 1986.

Other Special Considerations: Not available.

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Material Safety Data Sheet (Canada)
Liquefied Natural Gas

Section 1 – Material Identification and Use

Material Name: LIQUEFIED NATURAL GAS (CRYOGENIC LIQUID)
Use: Vehicle Fuel Gas
WHMIS Classification: Class A; Class B, Div. 1
TDG: **UN**: 1972 **Class:** 2.1 **Packing Group:** N.Av.
Shipping Name: LIQUEFIED NATURAL GAS (CRYOGENIC LIQUID)
Manufacturer/Supplier: ENCANA SERVICES COMPANY LTD.
500 Centre Street SE
CALGARY, ALBERTA, T2P 2S5
Emergency Telephone: CANUTEC: 1-613-996-6666
Chemical Family: Liquefied aliphatic paraffinic hydrocarbon

Section 2 – Hazardous Ingredients of Materials

Hazardous Ingredients	Approximate Concentrations %	C.A.S. Nos.	LD50/LC50 Specify Species & Route	Exposure Limits
Methane	>97%	74-82-8	N.Av.	1000 ppm (BC)
Ethane	2-3%	74-84-0	N.Av.	1000 ppm (AB & BC)

All exposure levels are 8-hour time-weighted exposure limits unless otherwise indicated.

Section 3 – Physical Data for Material

Physical State: Liquefied Gas
Specific Gravity: 0.422 to 0.546
Vapour Density (air=1): 0.55 to 1.1
Percent Volatiles, by volume: 100
pH: N.App.
Coefficient of Water/Oil Distribution: <0.1
(N.AV. = not available N.App. = not applicable)

Vapour Pressure (mmHg): N.App.
Odour Threshold (ppm): N.Av.
Evaporation Rate: N.Av.
Boiling Pt. (deg.C): -88.15
Freezing Pt. (deg.C): -172.15
Odour & Appearance: colourless, odourless or mercaptan odour

Section 4 – Fire and Explosion

Flammability: Yes **Conditions**: Material may ignite at normal temperatures.
Means of Extinction: Foam, CO_2, dry chemical. Explosive accumulations can build up in areas of poor ventilation.
Special Procedures: Use water spray to cool fire-exposed containers, and to disperse gas if leak has not ignited. Do not direct water at spill or source of leak. If safe to do so, cut off fuel and allow flame to burn out. If flames are accidentally extinguished, explosive re-ignition may occur.
Flash Point (deg.C): -187.78 to -135.15
Upper Explosive Limit (% by vol.): 15.0
Lower Explosive Limit (% by vol.): 3.0
Auto-Ignition Temp. (deg.C): 530

Sensitivity to Impact: No
Sensitivity to Static Discharge: Yes, may ignite
TDG Flammability Classification: 2.1

Hazardous Combustion Products: Carbon monoxide and carbon dioxide.

Section 5 – Reactivity Data

Chemical Stability: Yes **Conditions**: N.App.
Incompatibility: Yes **Substances**: Chlorine and other strong oxidizing agents.
Reactivity: Yes **Conditions**: Heat, strong sunlight
Hazardous Decomposition Products: Carbon dioxide and carbon monoxide

Section 6 – Toxicological Properties of Product

Routes of Entry:
Skin Absorption: Yes **Skin Contact**: Yes (liquid) **Eye Contact**: Yes
Inhalation: **Acute**: Yes **Chronic**: No **Ingestion**: No
Effects of Acute Exposure: Inhalation can cause headache, disorientation, dizziness, drowsiness and possibly unconsciousness at concentrations that cause oxygen deficiency and asphyxiation. Rapidly expanding gas or vaporized liquid may cause frostbite to skin and eyes.
Effects of Chronic Exposure: N.Av.
Sensitization to Product: No
Irritancy: N.Av.
Synergistic Materials: None reported
Carcinogenicity: N.Av. **Reproductive Effects**: N.Av. **Teratogenicity**: N.Av. **Mutagenicity**: N.Av.

Section 7 – Preventative Measures

Personal Protective Equipment: Use a NIOSH approved positive pressure self-contained breathing apparatus or supplied air breathing apparatus when concentrations may exceed exposure limits. Use approved gas detectors.
Gloves: Insulated gloves (e.g.: cryogenic)
Eye: Splash goggles and face shield or equivalent.
Footwear: Covered footwear such as steel-toed boots.
Clothing: Fire retardant garments that meet NFPA 2112. For situations or activities involving elevated risk of fluid contact, wear an insulated apron or smock.
Respiratory Protection: SCBA or SABA
Engineering Controls: Use only in well ventilated areas. Mechanical ventilation recommended in confined areas. Equipment must be explosion proof.
Leaks & Spills: If safe to do so, stop liquid flow. Remove all ignition sources. Provide explosion-proof clearing ventilation if possible. Prevent from entering confined spaces. Use personal protective equipment.
Waste Disposal: Controlled burning or venting in accordance with regulatory requirements.
Handling Procedures & Equipment: Avoid contact with liquid or liquid cooled equipment. Avoid inhalation. Bond and ground all transfers. Avoid sparking conditions.
Storage Requirements: Store in a cool, dry, well ventilated area away from heat, strong sunlight, and ignition sources.
Special Shipping Information: N.Av.

Section 8 – First aid Measures

Skin: If freeze burn occurs, gently bathe affected area in warm water (38 – 43 deg. C). Do not rub. Get medical attention. Seek immediate medical attention if blistering, tissue freezing or frost bite has occurred.
Eye: Immediately flush with large amounts of luke warm water for 15 minutes, lifting upper and lower lids at intervals. Seek medical attention if irritation persists.
Inhalation: Remove to fresh air. Give oxygen, artificial respiration, or CPR if needed. Seek medical attention.
Ingestion: Ingestion of liquid causes freeze burns to mouth, throat, esophagus and lungs. Get immediate medical attention.

Section 9 – Preparation Date of MSDS

Prepared By: Encana Environment, Health and Safety (EH&S)
Phone Number: (403) 645-2000 Preparation Date: July 1, 2014 Expiry Date: July1, 2017

Material Safety Data Sheet

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND COMPANY/UNDERTAKING

Material Name	:	**Methyl Isobutyl Carbinol**
Uses	:	Use as a solvent only in industrial manufacturing processes.
Product Code	:	S1216
Manufacturer/Supplier	:	**Shell Chemicals Europe B.V.** PO Box 8610 3009 AP Rotterdam Netherlands
Telephone	:	+31 (0)10 231 7000
Fax	:	+31 (0)10 231 7180
Emergency Telephone Number	:	+31 (0)10 431 3233

2. COMPOSITION/INFORMATION ON INGREDIENTS

Material Formal Name	:	4-methylpentan-2-ol
Synonyms	:	1,3-dimethyl 1-butanol MIBC Methyl Amyl Alcohol
CAS No.	:	108-11-2
INDEX No.	:	603-008-00-8
EINECS No.	:	203-551-7

3. HAZARDS IDENTIFICATION

Health Hazards	:	Irritating to respiratory system. Vapours may cause drowsiness and dizziness. May cause moderate irritation to skin. Repeated exposure may cause skin dryness or cracking. Moderately irritating to eyes.
Signs and Symptoms	:	Respiratory irritation signs and symptoms may include a temporary burning sensation of the nose and throat, coughing, and/or difficulty breathing. Skin irritation signs and symptoms may include a burning sensation, redness, swelling, and/or blisters. Eye irritation signs and symptoms may include a burning sensation, redness, swelling, and/or blurred vision. Other signs and symptoms of central nervous system (CNS) depression may include headache, nausea, and lack of coordination.
Aggravated Medical Condition	:	Pre-existing medical conditions of the following organ(s) or organ system(s) may be aggravated by exposure to this material: Respiratory system. Central nervous system (CNS). Skin. Eyes.
Safety Hazards	:	Flammable liquid and vapour. Vapours are heavier than air.

Vapours may travel across the ground and reach remote ignition sources causing a flashback fire danger.

4. FIRST AID MEASURES

Inhalation	:	Remove to fresh air. If rapid recovery does not occur, transport to nearest medical facility for additional treatment.
Skin Contact	:	Remove contaminated clothing. Flush exposed area with water and follow by washing with soap if available.
Eye Contact	:	Immediately flush eyes with large amounts of water for at least 15 minutes while holding eyelids open. Transport to the nearest medical facility for additional treatment.
Ingestion	:	If swallowed, do not induce vomiting: transport to nearest medical facility for additional treatment. If vomiting occurs spontaneously, keep head below hips to prevent aspiration.
Advice to Physician	:	Causes central nervous system depression. Call a doctor or poison control center for guidance.

5. FIRE FIGHTING MEASURES

Clear fire area of all non-emergency personnel.

Specific Hazards	:	Carbon monoxide may be evolved if incomplete combustion occurs. Will float and can be reignited on surface water. The vapour is heavier than air, spreads along the ground and distant ignition is possible.
Extinguishing Media	:	Foam, water spray or fog. Dry chemical powder, carbon dioxide, sand or earth may be used for small fires only. Do not discharge extinguishing waters into the aquatic environment.
Unsuitable Extinguishing Media	:	Do not use water in a jet.
Protective Equipment for Firefighters	:	Wear full protective clothing and self-contained breathing apparatus.
Additional Advice	:	Keep adjacent containers cool by spraying with water.

6. ACCIDENTAL RELEASE MEASURES

Observe all relevant local and international regulations.

Protective measures	:	Avoid contact with spilled or released material. Immediately remove all contaminated clothing. For guidance on selection of personal protective equipment see Chapter 8 of this Material Safety Data Sheet. For guidance on disposal of spilled material see Chapter 13 of this Material Safety Data Sheet. Shut off leaks, if possible without personal risks. Remove all possible sources of ignition in the surrounding area. Use appropriate containment (of product and fire fighting water) to avoid environmental contamination. Prevent from spreading or entering drains, ditches or rivers by using sand, earth, or other appropriate barriers. Attempt to disperse the vapour or to direct its flow to a safe location for example by using fog sprays. Take precautionary measures against static discharge. Ensure electrical continuity by bonding and grounding (earthing) all

		equipment. Monitor area with combustible gas indicator.
Clean Up Methods	:	For large liquid spills (> 1 drum), transfer by mechanical means such as vacuum truck to a salvage tank for recovery or safe disposal. Do not flush away residues with water. Retain as contaminated waste. Allow residues to evaporate or soak up with an appropriate absorbent material and dispose of safely. Remove contaminated soil and dispose of safely. For small liquid spills (< 1 drum), transfer by mechanical means to a labelled, sealable container for product recovery or safe disposal. Allow residues to evaporate or soak up with an appropriate absorbent material and dispose of safely. Remove contaminated soil and dispose of safely.
Additional Advice	:	See Chapter 13 for information on disposal. Notify authorities if any exposure to the general public or the environment occurs or is likely to occur. Vapour may form an explosive mixture with air.

7. HANDLING AND STORAGE

General Precautions	:	Avoid breathing vapours or contact with material. Only use in well ventilated areas. Wash thoroughly after handling. For guidance on selection of personal protective equipment see Chapter 8 of this Material Safety Data Sheet. Use the information in this data sheet as input to a risk assessment of local circumstances to help determine appropriate controls for safe handling, storage and disposal of this material.
Handling	:	Electrostatic charges may be generated during pumping. Electrostatic discharge may cause fire. Ensure electrical continuity by bonding and grounding (earthing) all equipment. Restrict line velocity during pumping in order to avoid generation of electrostatic discharge (<= 10 m/sec). Avoid splash filling. Do NOT use compressed air for filling, discharging, or handling operations. Extinguish any naked flames. Do not smoke. Remove ignition sources. Avoid sparks. Handling Temperature: Ambient.
Storage	:	Keep away from aerosols, flammables, oxidizing agents, corrosives and from products harmful or toxic to man or to the environment. Must be stored in a well-ventilated area, away from sunlight, ignition sources and other sources of heat. Storage Temperature: Ambient.
Product Transfer	:	Keep containers closed when not in use. Do not use compressed air for filling, discharging or handling.
Recommended Materials	:	For container paints, use epoxy paint, zinc silicate paint. For containers, or container linings use mild steel.
Unsuitable Materials	:	Aluminium if > 50 °C. Most plastics.
Container Advice	:	Containers, even those that have been emptied, can contain explosive vapours. Do not cut, drill, grind, weld or perform similar operations on or near containers.
Additional Information	:	Ensure that all local regulations regarding handling and storage facilities are followed.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Occupational Exposure Limits

Material	Source	Type	ppm	mg/m3	Notation
Methyl Isobutyl Carbinol	ACGIH	TWA	25 ppm		
	ACGIH	STEL	40 ppm		
	ACGIH	SKIN_DES			Can be absorbed through the skin.

Additional Information : Skin notation means that significant exposure can also occur by absorption of liquid through the skin and of vapour through the eyes or mucous membranes. Wash hands before eating, drinking, smoking and using the toilet.

Exposure Controls : The level of protection and types of controls necessary will vary depending upon potential exposure conditions. Select controls based on a risk assessment of local circumstances. Appropriate measures include: Adequate explosion-proof ventilation to control airborne concentrations below the exposure guidelines/limits. Eye washes and showers for emergency use.

Personal Protective Equipment : Personal protective equipment (PPE) should meet recommended national standards. Check with PPE suppliers.

Respiratory Protection : If engineering controls do not maintain airborne concentrations to a level which is adequate to protect worker health, select respiratory protection equipment suitable for the specific conditions of use and meeting relevant legislation. Check with respiratory protective equipment suppliers. Where air-filtering respirators are suitable, select an appropriate combination of mask and filter. Select a filter suitable for organic gases and vapours [boiling point >65 °C (149 °F)] meeting EN141. Where air-filtering respirators are unsuitable (e.g., airborne concentrations are high, risk of oxygen deficiency, confined space) use appropriate positive pressure breathing apparatus.

Hand Protection : Where hand contact with the product may occur the use of gloves approved to relevant standards (e.g. Europe: EN374, US: F739, AS/NZS:2161) made from the following materials may provide suitable chemical protection:
Longer term protection: Butyl rubber. Incidental contact/Splash protection: Neoprene rubber. Nitrile rubber. Viton. Suitability and durability of a glove is dependent on usage, e.g. frequency and duration of contact, chemical resistance of glove material, glove thickness, dexterity. Always seek advice from glove suppliers. Contaminated gloves should be replaced.
Personal hygiene is a key element of effective hand care. Gloves must only be worn on clean hands. After using gloves, hands should be washed and dried thoroughly. Application of a non-perfumed moisturizer is recommended.

Eye Protection : Chemical splash goggles (chemical monogoggles).

		Monogoggles (EN166)
Protective Clothing	:	Use protective clothing which is chemical resistant to this material. Safety shoes and boots should also be chemical resistant.
Monitoring Methods	:	Monitoring of the concentration of substances in the breathing zone of workers or in the general workplace may be required to confirm compliance with an OEL and adequacy of exposure controls. For some substances biological monitoring may also be appropriate. Examples of sources of recommended air monitoring methods are given below or contact supplier. Further national methods may be available. National Institute of Occupational Safety and Health (NIOSH), USA: Manual of Analytical Methods, http://www.cdc.gov/niosh/nmam/nmammenu.html. Occupational Safety and Health Administration (OSHA), USA: Sampling and Analytical Methods, http://www.osha-slc.gov/dts/sltc/methods/toc.html. Health and Safety Executive (HSE), UK: Methods for the Determination of Hazardous Substances, http://www.hsl.gov.uk/search.htm.
Environmental Exposure Controls	:	Local guidelines on emission limits for volatile substances must be observed for the discharge of exhaust air containing vapour.

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance	:	Clear. Liquid.
Odour	:	Sweet.
Boiling point	:	130 - 133 °C / 266 - 271 °F
Flash point	:	41 °C / 106 °F (IP 170)
Explosion / Flammability limits in air	:	1 - 5.5 %(V)
Auto-ignition temperature	:	305 °C / 581 °F (ASTM E-659)
Vapour pressure	:	420 Pa at 20 °C / 68 °F
Specific gravity	:	0.81 at 20 °C / 68 °F
Density	:	806 - 808 kg/m3 at 20 °C / 68 °F (ASTM D-4052)
Water solubility	:	16 g/l at 20 °C / 68 °F
Vapour density (air=1)	:	3.5
Volatile organic carbon content	:	70.6 % (EC/1999/13)
Evaporation rate (nBuAc=1)	:	0.3 (ASTM D 3539, nBuAc=1)

10. STABILITY AND REACTIVITY

Stability	:	Stable under normal conditions of use. Reacts with strong oxidising agents. Reacts with strong acids.
Conditions to Avoid	:	Avoid heat, sparks, open flames and other ignition sources.
Materials to Avoid	:	Strong oxidising agents. Strong acids.
Hazardous Decomposition Products	:	Thermal decomposition is highly dependent on conditions. A complex mixture of airborne solids, liquids and gases, including carbon monoxide, carbon dioxide and other organic compounds will be evolved when this material undergoes combustion or thermal or oxidative degradation.

11. TOXICOLOGICAL INFORMATION

Basis for Assessment	:	Information given is based on product testing.
Acute Oral Toxicity	:	Low toxicity: LD50 >2000 mg/kg , Rat
Acute Dermal Toxicity	:	Low toxicity: LD50 >2000 mg/kg , Rabbit
Acute Inhalation Toxicity	:	Low toxicity: LC50 greater than near-saturated vapour concentration. / 4 hours, Rat High concentrations may cause central nervous system depression resulting in headaches, dizziness and nausea; continued inhalation may result in unconsciousness and/or death.
Skin Irritation	:	May cause moderate skin irritation (but insufficient to classify). Prolonged/repeated contact may cause defatting of the skin which can lead to dermatitis.
Eye Irritation	:	Moderately irritating to eyes (but insufficient to classify).
Respiratory Irritation	:	Inhalation of vapours or mists may cause irritation to the respiratory system.
Sensitisation	:	Not expected to be a skin sensitiser.
Repeated Dose Toxicity	:	Kidney: caused kidney effects in male rats which are not considered relevant to humans
Mutagenicity	:	No evidence of mutagenic activity.
Carcinogenicity	:	Not expected to be carcinogenic.
Reproductive and Developmental Toxicity	:	Data not available.

12. ECOLOGICAL INFORMATION

Acute Toxicity		
Fish	:	Low toxicity: LC/EC/IC50 > 100 mg/l
Aquatic Invertebrates	:	Expected to have low toxicity: LC/EC/IC50 > 100 mg/l
Microorganisms	:	Expected to have low toxicity: LC/EC/IC50 > 100 mg/l
Mobility	:	Floats on water. If product enters soil, it will be highly mobile and may contaminate groundwater.
Persistence/degradability	:	Readily biodegradable meeting the 10 day window criterion. Oxidises rapidly by photo-chemical reactions in air.
Bioaccumulation	:	Not expected to bioaccumulate significantly.

13. DISPOSAL CONSIDERATIONS

Material Disposal	:	Recover or recycle if possible. It is the responsibility of the waste generator to determine the toxicity and physical properties of the material generated to determine the proper waste classification and disposal methods in compliance with applicable regulations. Do not dispose into the environment, in drains or in water courses. Waste product should not be allowed to contaminate soil or water.
Container Disposal	:	Drain container thoroughly. After draining, vent in a safe place away from sparks and fire. Residues may cause an explosion hazard. Do not puncture, cut or weld uncleaned drums. Send to drum recoverer or metal reclaimer.

Local Legislation	:	Disposal should be in accordance with applicable regional, national, and local laws and regulations. Local regulations may be more stringent than regional or national requirements and must be complied with.

14. TRANSPORT INFORMATION

ADR

Class	:	3
Packing group	:	III
Classification code	:	F1
Hazard indentification no.	:	30
UN No.	:	2053
Danger label (primary risk)	:	3
Proper shipping name	:	Methyl isobutyl carbinol

RID

Class	:	3
Packing group	:	III
Classification code	:	F1
Hazard indentification no.	:	30
UN No.	:	2053
Danger label (primary risk)	:	3
Proper shipping name	:	Methyl isobutyl carbinol

IMDG

Identification number	UN 2053
Proper shipping name	METHYL ISOBUTYL CARBINOL
Class / Division	3
Packing group	III
Marine pollutant:	No

IATA (Country variations may apply)

UN No.	:	2053
Proper shipping name	:	Methyl isobutyl carbinol
Class / Division	:	3
Packing group	:	III

15. REGULATORY INFORMATION

The regulatory information is not intended to be comprehensive. Other regulations may apply to this material.

EC Label Name	:	METHYL ISOBUTYL CARBINOL
EC label/EC Number	:	203-551-7
EC Classification	:	Irritant.
EC Annex I Number	:	603-008-00-8
EC Symbols	:	Xi Irritant.
EC Risk Phrases	:	R10 Flammable.

		R37 Irritating to respiratory system.	
EC Safety Phrases	:	S24/25 Avoid contact with skin and eyes.	
AICS	:	Listed.	
DSL	:	Listed.	
INV (CN)	:	Listed.	
ENCS (JP)	:	Listed.	(2)-217
TSCA	:	Listed.	
EINECS	:	Listed.	203-551-7
KECI (KR)	:	Listed.	KE-24720
PICCS (PH)	:	Listed.	
National Legislation			
OE_HPV	:	Listed.	

16. OTHER INFORMATION

R-phrase(s)

R10	Flammable.
R37	Irritating to respiratory system.

MSDS Version Number : 1.3

MSDS Effective Date : 22.04.2009

MSDS Revisions : A vertical bar (|) in the left margin indicates an amendment from the previous version.

Uses and Restrictions : Use as a solvent only in industrial manufacturing processes.

MSDS Distribution : The information in this document should be made available to all who may handle the product

Disclaimer : This information is based on our current knowledge and is intended to describe the product for the purposes of health, safety and environmental requirements only. It should not therefore be construed as guaranteeing any specific property of the product.

Revision Date: 11/07/2013

SODIUM HYDROSULFIDE - FLAKES 70-72 %

1. PRODUCT AND COMPANY IDENTIFICATION

1.1. Identification of the substance or mixture

Product name	:	SODIUM HYDROSULFIDE - FLAKES 70-72 %
Product grade(s)	:	SODIUM HYDROSULFIDE - (Solid 70-72 % - Crystallization water >= 25%)
Chemical Name	:	Sodium hydrosulfide
Molecular formula	:	NaHS xH2O; x >= 0,93
Molecular weight	:	72.81 g/mol

1.2. Use of the Substance/Mixture

Recommended use :
- Chemical industry
- Waste treatment
- Water treatment
- De-hairing agent
- Textile industry
- Pulp and paper

1.3. Company/Undertaking Identification

Address : SOLVAY FLUORIDES, LLC
3333 RICHMOND AVENUE
HOUSTON TX 77098-3099
United States

1.4. Emergency and contact telephone numbers

Emergency telephone number	:	**1 (800) 424-9300 CHEMTREC ® (USA & Canada)** **01-800-00-214-00 (MEX. REPUBLIC)**
Contact telephone number (product information):	:	**US: +1-800-765-8292 (Product information)** **US: +1-713-525-6500 (Product information)**

2. HAZARDS IDENTIFICATION

2.1. Emergency Overview:

NFPA	:	H= 2 F= 1 I= 2 S= None
HMIS	:	H= 2 F= 1 R= 2 PPE = Supplied by User; dependent on local conditions

General Information

Appearance	:	flakes
Colour	:	yellow

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Odour : odourless, slight, rotten-egg like

2.2. Potential Health Effects:

Inhalation
- No hazards to be specially mentioned.
- (in case of higher concentration): slight irritation.

Eye contact
- May cause irreversible eye damage.
- May cause blindness.
- Symptoms: Redness, Lachrymation, Swelling of tissue, Burn.

Skin contact
- Corrosive
- Symptoms: Redness, Swelling of tissue, Burn.

Ingestion
- If ingested, severe burns of the mouth and throat, as well as a danger of perforation of the oesophagus and the stomach.
- Symptoms: Nausea, Abdominal pain, Bloody vomiting, Diarrhoea, Suffocation, Cough, Severe shortness of breath.

Other toxicity effects
- See section 11: Toxicological Information

2.3. Environmental Effects:
- See section 12: Ecological Information

3. COMPOSITION/INFORMATION ON INGREDIENTS

Sodium hydrogensulfide (hydrate)
CAS-No. : 207683-19-0
Concentration : **>= 84.0 - <= 95.5 %**

Disodium sulfide (hydrate)
CAS-No. : 27610-45-3
Concentration : **<= 13.5 %**

Sodium carbonate
CAS-No. : 497-19-8
Concentration : **<= 1.0 %**

4. FIRST AID MEASURES

4.1. Inhalation
- Move to fresh air.
- Oxygen or artificial respiration if needed.
- Victim to lie down in the recovery position, cover and keep him warm.
- Call a physician immediately.

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4.2. Eye contact

- Call a physician or poison control centre immediately.
- Rinse immediately with plenty of water, also under the eyelids, for at least 15 minutes.
- In the case of difficulty of opening the lids, administer an analgesic eye wash (oxybuprocaine).
- Take victim immediately to hospital.

4.3. Skin contact

- Take off contaminated clothing and shoes immediately.
- Wash off immediately with plenty of water.
- Keep warm and in a quiet place.
- Call a physician or poison control centre immediately.
- Wash contaminated clothing before re-use.

4.4. Ingestion

- Call a physician or poison control centre immediately.
- Take victim immediately to hospital.
- If swallowed, rinse mouth with water (only if the person is conscious).
- Do NOT induce vomiting.
- Artificial respiration and/or oxygen may be necessary.

4.5. Notes to physician

Exposure to decomposition products :

- Take victim immediately to hospital.
- Immediate medical attention is required.

Exposure to decomposition products :

- Medical supervision for minimum 48 hours.

5. FIREFIGHTING MEASURES

5.1. Suitable extinguishing media

- Foam
- powder

5.2. Extinguishing media which shall not be used for safety reasons

- Water
- Carbon dioxide (CO2)

5.3. Special exposure hazards in a fire

- Not combustible.
- Hazardous decomposition products

5.4. Hazardous decomposition products

- Sulphur oxides

5.5. Special protective equipment for firefighters

- Exposure to decomposition products may be a hazard to health.
- In the event of fire, wear self-contained breathing apparatus.
- Use personal protective equipment.
- Wear chemical resistant oversuit

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6. ACCIDENTAL RELEASE MEASURES

6.1. Personal precautions, protective equipment and emergency procedures

6.1.1. Advice for non-emergency personnel

- Sweep up to prevent slipping hazard.
- Avoid dust formation.
- Prevent further leakage or spillage if safe to do so.

6.1.2. Advice for emergency responders

- Isolate the area.
- Wear self-contained breathing apparatus and protective suit.

6.2. Environmental precautions

- Discharge into the environment must be avoided.
- Do not flush into surface water or sanitary sewer system.
- In case of accidental release or spill, immediately notify the appropriate authorities if required by Federal, State/Provincial and local laws and regulations.

6.3. Methods and materials for containment and cleaning up

- Pick up and arrange disposal without creating dust.
- Keep in suitable, closed containers for disposal.

6.4. Reference to other sections

- Refer to protective measures listed in sections 7 and 8.

7. HANDLING AND STORAGE

7.1. Handling

- Use product only in closed system.
- Ensure adequate ventilation.
- Keep away from heat.
- Keep away from Incompatible products.

7.2. Storage

- Store in original container.
- Keep in a well-ventilated place.
- Keep in a dry place.
- Keep in properly labelled containers.
- Keep container closed.
- Keep away from heat.
- Avoid dust formation.
- Keep away from Incompatible products.

7.3. Packaging material

- Steel drum
- Polyethylene

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8. EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1. Exposure Limit Values

Sodium hydrogensulfide (hydrate)

- US. ACGIH Threshold Limit Values
  Remarks: none established

Disodium sulfide (hydrate)

- US. ACGIH Threshold Limit Values
  Remarks: none established

Sodium carbonate

- SAEL (Solvay Acceptable Exposure Limit) 2007
  TWA = 10 mg/m3

ACGIH® and TLV® are registered trademarks of the American Conference of Governmental Industrial Hygienists.
SAEL = Solvay Acceptable Exposure Limit, Time Weighted Average for 8 hour workdays. No Specific TLV STEL (Short Term Exposure Level) has been set. Excursions in exposure level may exceed 3 times the TLV TWA for no more than a total of 30 minutes during a workday and under no circumstances should they exceed 5 times the TLV TWA.

8.2. Engineering controls

- Provide appropriate exhaust ventilation at places where dust is formed.
- Apply technical measures to comply with the occupational exposure limits.

8.3. Personal protective equipment

8.3.1. Respiratory protection

- In case of insufficient ventilation, wear suitable respiratory equipment.
- When workers are facing concentrations above the exposure limit they must use appropriate certified respirators.
- In case of decomposition (see section 10), face mask with combined type B-P3 cartridge.
- Recommended Filter type:: P3

8.3.2. Hand protection

- chemical resistant gloves
- Suitable material: PVC, Neoprene, Natural Rubber

8.3.3. Eye protection

- Goggles

8.3.4. Skin and body protection

- Dust impervious protective suit
- Apron
- Boots
- PVC
- Neoprene

8.3.5. Hygiene measures

- Eye wash bottles or eye wash stations in compliance with applicable standards.
- When using, do not eat, drink or smoke.
- Handle in accordance with good industrial hygiene and safety practice.

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9. PHYSICAL AND CHEMICAL PROPERTIES

9.1. General Information

Appearance	:	flakes
Colour	:	yellow
Odour	:	odourless, slight, rotten-egg like

9.2. Important health safety and environmental information

pH	:	11.2 (1 % solution) : 12.1 (saturated aqueous solution)
Boiling point/boiling range	:	*Remarks*: not applicable
Flash point	:	( ) (inorganic) *Remarks*: not applicable
Flammability	:	*Remarks*: not applicable
Explosive properties	:	*Explosion danger*: *Remarks*: Not explosive
Oxidizing properties	:	*Remarks*: Non oxidizer
Vapour pressure	:	(inorganic) *Remarks*: not applicable
Relative density / Density	:	1.55
Solubility(ies)	:	548 g/l *Temperature*: 20 °C (68 °F)
Partition coefficient: n-octanol/water	:	*log Pow*: (inorganic) *Remarks*: not applicable
Viscosity	:	*Remarks*: not applicable
Vapour density	:	(inorganic) *Remarks*: not applicable
Evaporation rate	:	(inorganic) *Remarks*: not applicable

9.3. Other data

Melting point/range	:	44 - 48 °C (111 - 118 °F)
Auto-flammability	:	> 150 °C (302 °F)
Granulometry	:	7000 µm *Remarks*: d 50

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Decomposition temperature : *Remarks*: not applicable

10. STABILITY AND REACTIVITY

10.1. Stability
- Stable under recommended storage conditions.

10.2. Conditions to avoid
- Keep away from flames and hot surfaces.
- Exposure to moisture.

10.3. Materials to avoid
- Carbon dioxide (CO2), Acids, Oxidizing agents, Metals

10.4. Hazardous decomposition products
- Sulphur oxides: Hydrogen sulphide

11. TOXICOLOGICAL INFORMATION

Toxicological data

Acute oral toxicity
- LD50, rat, 72 - 105 mg/kg

Acute inhalation toxicity
- , Remarks: no data available

Acute dermal irritation/corrosion
- Remarks: study scientifically unjustified

Skin irritation
- Corrosive

Eye irritation
- Corrosive

Chronic toxicity
- Inhalation, 90-day, rat, (Hydrogen sulphide), Remarks: NOAEC

Carcinogenicity
- Remarks: no data available

Reproductive toxicity
- no data available

Remarks
- no data available
- In vitro tests did not show mutagenic effects
- In vivo tests did not show mutagenic effects

12. ECOLOGICAL INFORMATION

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12.1. Ecotoxicity effects

Acute toxicity

- Fishes, LC50, 96 h, 0.0027 mg/l (Hydrogen sulphide)
- Fishes, Lepomis macrochirus, NOEC, 826 Days, 0.0046 mg/l (Hydrogen sulphide)
- Crustaceans, EC50, 96 h, 0.02 mg/l (Fresh water) (Hydrogen sulphide)
- Crustaceans, EC50, 96 h, 0.032 mg/l (Marine water) (Hydrogen sulphide)

Chronic toxicity

- Amphipod (Eohaustorius estuarius), LOEC, 48 h, 1.92 mg/l (Hydrogen sulphide)
- Amphipod (Eohaustorius estuarius), LC50, 3.32 mg/l (Hydrogen sulphide)
- Algae, Nitszcheria linearis, EC50, 120 h, 1,900 mg/l (Sodium sulfate)
  Remarks: fresh water
- Algae, Skeletonema costatum, EC50, 4 h, 0.104 mg/l (Sodium sulfide)
  Remarks: salt water

12.2. Mobility

- Air
  Remarks: mobility as solid aerosols
- Water/soil
  Remarks: considerable solubility and mobility

12.3. Persistence and degradability

Abiotic degradation

- Air, indirect photo-oxidation, Chemical degradation 0.6 - 2 %, from 1 h (hydrogen sulphide)
  Conditions: sensitizer: OH/O3 radicals
  Degradation products: Sulphur dioxide / sulfates / Sulphides
- Water/soil
  Result: complexation/precipitation of inorganic and organic materials
- Water/soil
  Result: oxidation
  Degradation products: sulfates

Biodegradation

- aerobic, Tested according to: oxidation (Sulphides)
  Degradation products: sulfites / sulfates
- anaerobic, Tested according to: biodegradation by sulforeduction (sulfates)
  Degradation products: hydrogen sulphide
- anaerobic, Tested according to: methanogenesis (sulfates)
  Remarks: inhibitory action

12.4. Bioaccumulative potential

- Result: Does not bioaccumulate.

12.5. Other adverse effects

- no data available

12.6. Remarks

13. DISPOSAL CONSIDERATIONS

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13.1. Waste from residues / unused products

- In accordance with local and national regulations.
- Where possible recycling is preferred to disposal or incineration.
- Use an FeCl3 solution to precipitate FeS.
- Filtrate the product and send the cake to a landfill for industrial waste.

13.2. Packaging treatment

- The empty and clean containers are to be reused in conformity with regulations.
- Uncleaned empty packaging
- Dispose of as unused product.

13.3. RCRA Hazardous Waste

- Listed RCRA Hazardous Waste (40 CFR 302) - No
- Unlisted RCRA Hazardous Waste (40 CFR 302) - Yes
- D002 (corrosive waste)
- D003 (reactive waste)

14. TRANSPORT INFORMATION

IATA-DGR

UN number	UN 2949
Class	8
Packing group	II
ICAO-Labels	8 - Corrosive
Remarks	Environmentally hazardous

Proper shipping name: SODIUM HYDROSULPHIDE, HYDRATED

IMDG

UN number	UN 2949
Class	8
Packing group	II
IMDG-Labels	8 - Corrosive
EmS	F-A S-B
Remarks	Marine pollutant

Proper shipping name: SODIUM HYDROSULPHIDE, HYDRATED

U.S. Dept of Transportation

UN number	UN 2949
Class	8
Packing group	II
Label	8 - Corrosive
EmS	154

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Proper shipping name: SODIUM HYDROSULPHIDE, HYDRATED

Canada (TDG)

UN number	UN 2949
Class	8
Packing group	II
Label	8 - Corrosive
EmS	154

Proper shipping name: SODIUM HYDROSULPHIDE, HYDRATED

15. REGULATORY INFORMATION

15.1. Inventory Information

USA. Toxic Substances Control Act (TSCA)	: -	yes (Anhydrous form).
Australia. Inventory of Chemical Substances (AICS)	: -	yes (Anhydrous form).
Canada. Domestic Substances List (DSL)	: -	yes (Anhydrous form).
Korea. Existing Chemicals Inventory (KECI (KR))	: -	yes (Anhydrous form).
EU list of existing chemical substances (EINECS)	: -	yes (Anhydrous form).
Japan. Inventory of Existing & New Chemical Substances (ENCS)	: -	yes (Anhydrous form).
Inventory of Existing Chemical Substances (China) (IECS)	: -	yes (Anhydrous form).
Philippine. Inventory of Chemicals and Chemical Substances (PICCS)	: -	yes (Anhydrous form).
New Zealand. Inventory of Chemicals (NZIOC)	: -	yes (Anhydrous form).

15.2. Other regulations

US. EPA Emergency Planning and Community Right-To-Know Act (EPCRA) SARA Title III Section 302 Extremely Hazardous Substance (40 CFR 355, Appendix A)

- not regulated.

SARA Hazard Designation (SARA 311/312)

- Acute Health Hazard: Yes.
- Reactivity Hazard: Yes.

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US. EPA Emergency Planning and Community Right-To-Know Act (EPCRA) SARA Title III Section 313 Toxic Chemicals (40 CFR 372.65) - Supplier Notification Required

- not regulated.

US. EPA CERCLA Hazardous Substances (40 CFR 302)

- not regulated.

US. New Jersey Worker and Community Right-to-Know Act (New Jersey Statute Annotated Section 34:5A-5)

- yes.

US. Pennsylvania Worker and Community Right-to-Know Law (34 Pa. Code Chap. 301-323)

- yes.

US. California Safe Drinking Water & Toxic Enforcement Act (Proposition 65)

- not regulated.

16. OTHER INFORMATION

Ratings :

NFPA (National Fire Protection Association)

Health = 2 Flammability = 1 Instability = 2 Special =None

HMIS (Hazardous Material Information System)

Health = 2 Fire = 1 Reactivity = 2 PPE : Supplied by User; dependent on local conditions

Further information

- Update
  This data sheet contains changes from the previous version in section(s): 2.2.5,3.1.2,4.1.2,8.1.2,14
- Distribute new edition to clients

Material Safety Data Sheets contain country specific regulatory information; therefore, the MSDS's provided are for use only by customers of the company mentioned in section 1 in North America. If you are located in a country other than Canada, Mexico or the United States, please contact the Solvay Group company in your country for MSDS information applicable to your location.

The previous information is based upon our current knowledge and experience of our product and is not exhaustive. It applies to the product as defined by the specifications. In case of combinations or mixtures, one must confirm that no new hazards are likely to exist. In any case, the user is not exempt from observing all legal, administrative and regulatory procedures relating to the product, personal hygiene, and integrity of the work environment. (Unless noted to the contrary, the technical information applies only to pure product).

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Brenntag Canada Inc.

BRENNTAG

MATERIAL SAFETY DATA SHEET

POTASSIUM AMYL XANTHATE, SOLID

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Brenntag Canada Inc.
43 Jutland Rd.
Toronto, ON
M8Z 2G6
(416) 259-8231

Website: http:\\www.brenntag.ca

WHMIS#:	00060600
Index:	HCI0065/09B
Effective Date:	2009 June 17
Date of Revision:	2009 June 17

EMERGENCY TELEPHONE NUMBERS (FOR EMERGENCIES INVOLVING CHEMICAL SPILLS OR RELEASE)

Toronto, ON (416) 226-6117	Montreal, QC (514) 861-1211	Winnipeg, MB (204) 943-8827
Edmonton, AB (780) 424-1754	Calgary, AB (403) 263-8660	Vancouver, BC (604) 685-5036

PRODUCT IDENTIFICATION

Product Name:	Potassium Amyl Xanthate, Solid.
Chemical Name:	Dithiocarbonic Acid, Amyl Ester, Potassium Salt.
Synonyms:	Potassium Amyl Xanthate; KAX 51; Potassium Pentyl Xanthate; Potassium Pentyl Xanthogenate.
Chemical Family:	Salts of carbonic acid dithio esters.
Molecular Formula:	C6H11OS2. K.
Product Use:	Flotation agent.

WHMIS Classification / Symbol:

B-6: Reactive Flammable Material
D-1B: Toxic (acute effects)
D-2B: Toxic (skin and eye irritant)



READ THE ENTIRE MSDS FOR THE COMPLETE HAZARD EVALUATION OF THIS PRODUCT.

2. COMPOSITION, INFORMATION ON INGREDIENTS (Not Intended As Specifications)

Ingredient	*CAS#*	*ACGIH TLV*	*% Concentration*
Potassium Amyl Xanthate	2720-73-2	---	60 - 100
Potassium Hydroxide	1310-58-3	—	1 - 5
Isoamyl alcohol	123-51-3	100 ppm	1 - 5
Decomposition Product: Carbon disulfide	75-15-0	10 ppm (Skin)	

Skin Notation: Contact with skin, eyes and mucous membranes can contribute to the overall exposure and may invalidate the TLV. Consider measures to prevent absorption by these routes.

3. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW: May be fatal if swallowed. Harmful if inhaled. Causes skin and eye irritation. Dust is irritating to respiratory tract. See "Other Health Effects" Section. Heating of solid xanthate or aging or heating of solutions will cause formation of Carbon Bisulfide. Upon exposure of solid xanthates to moisture and/or heat, decomposition results and spontaneous combustion can occur. Contact of solid xanthate with moist air has resulted in ignition. (4) Emits a flammable gas upon contact with water or water vapour. Can decompose at high temperatures forming toxic gases. Powdered material may form explosive dust-air mixtures. Contents may develop pressure on prolonged exposure to heat.

POTENTIAL HEALTH EFFECTS

Inhalation:	Excessive contact with powder may cause drying of mucous membranes of nose and throat due to absorption of moisture and oils. Product may cause severe irritation of the nose, throat and respiratory tract. Repeated and/or prolonged exposures may cause productive cough, running nose, bronchopneumonia, pulmonary oedema (fluid build-up in lungs), and reduction of pulmonary function. Irritation of mucous membranes and respiratory tract is possible following exposure to the decomposition product. (3) See "Other Health Effects" Section.
Skin Contact:	Brief contact with the dust causes irritation. Greater exposure causes severe burns. In the presence of moisture (perspiration, humidity, tears), the dust dissolves to form a corrosive solution which may cause burns. (3) Potassium Amyl Xanthate may cause symptoms of skin irritation such as reddening, swelling, rash, scaling, or blistering. May cause defatting, drying and cracking of the skin.
Skin Absorption:	May be absorbed through intact skin. See Section 11, "Other Studies Relevant to Material".
Eye Contact:	This product may cause irritation, redness and possible damage due to abrasiveness. Brief contact with the dust causes irritation. Greater exposure causes severe burns. In the presence of moisture (perspiration, humidity, tears), the dust dissolves to form a corrosive solution which may cause burns. (3) Irritation of the eyes is possible following exposure to the decomposition product. (3)
Ingestion:	Ingestion is not a likely route of exposure. This product causes irritation, a burning sensation of the mouth and throat and abdominal pain.
Other Health Effects:	Effects (irritancy) on the skin and eyes may be delayed, and damage may occur without the sensation or onset of pain. Strict adherence to first aid measures following any exposure is essential. May cause cardiovascular effects, liver damage, peripheral nervous system (PNS) effects or central nervous system (CNS) depression. CNS depression is characterized by headache, dizziness, drowsiness, nausea, vomiting and incoordination. Severe overexposures may lead to coma and possible death due to respiratory failure. Peripheral Neuropathy is a progressive disorder of the nervous system characterized by sensory and motor abnormalities, muscle spasms, weakness and pain in the arms and legs, numbness and tingling of the fingers and toes and paralysis. Liver damage is characterized by the loss of appetite, jaundice (yellowish skin colour), and occasional pain in the upper left-hand side of the abdomen. Potassium Amyl Xanthate: Symptoms of potassium poisoning may occur. These include slow heartbeat, accelerated breathing, muscle weakness and, in severe cases, paralysis. Vapours of the decomposition products of Xanthates (Carbon Bisulphide) can cause severe disturbances of mood and behaviour, including excitation, anger and violent dreams. High concentrations of vapours can cause death. (4) Carbon Bisulphide: Contact with moisture in the body by inhalation may yield sodium hydroxide (corrosive) and 2-mercaptobenzothiazole, an irritant. (4) Contact with acids will liberate carbon disulphide. (3) Exposure to carbon disulphide (500 to 1000 ppm) may cause severe mood and personality disturbances, including excitability, confusion, irritability, uncontrollable anger, bizarre dreams, insomnia, psychosis and suicide. Exposure to carbon disulphide at 4800 ppm for thirty minutes results in coma and may be fatal. Carbon disulphide is readily absorbed through intact skin. Chronic exposure to carbon disulphide produces central and peripheral nervous system, cardiovascular, gastrointestinal, kidney, endocrine and eye disorders. (4) Potassium Hydroxide: Exposure to very low doses, even for a short period of time, has produced extensive damage to the esophagus, stomach and intestine extending into surrounding tissues, as well as hyperexcitability followed by apathy and weakness. In some cases, death has resulted from hemorrhage, adhesions or perforation. Following esophageal damage, strictures have frequently developed in surviving animals. (4)

4. FIRST AID MEASURES

FIRST AID PROCEDURES

Inhalation:	Move victim to fresh air. Give artificial respiration ONLY if breathing has stopped. Give cardiopulmonary resuscitation (CPR) if there is no breathing AND no pulse. Obtain medical advice IMMEDIATELY.
Skin Contact:	Prompt removal of the material from the skin is essential. Remove all contaminated clothing and immediately wash the exposed areas with copious amounts of soap and water for a minimum of 30 minutes or up to 60 minutes for critical body areas. Immerse the exposed part immediately in ice water to relieve pain and to prevent swelling and blistering. Place cold packs, ice or wet cloths on the burned area if immersion is not possible. Cover the exposed part with a clean, preferably sterile, lint-free dressing. Obtain medical attention IMMEDIATELY and monitor breathing and treat for shock for severe exposure.
Eye Contact:	Immediately flush eyes with running water for a minimum of 20 minutes. Hold eyelids open during flushing. If irritation persists, repeat flushing. Obtain medical attention IMMEDIATELY.

Ingestion:	Do not attempt to give anything by mouth to an unconscious person. If victim is alert and not convulsing, rinse mouth out and give 1/2 to 1 glass of water to dilute material. IMMEDIATELY contact local Poison Control Centre. Vomiting should only be induced under the direction of a physician or a poison control centre. If spontaneous vomiting occurs, have victim lean forward with head down to avoid breathing in of vomitus, rinse mouth and administer more water. IMMEDIATELY transport victim to an emergency facility.
Note to Physicians:	Treat symptomatically. Medical conditions that may be aggravated by exposure to this product include neurological and cardiovascular disorders, diseases of the skin, eyes or respiratory tract, preexisting liver and kidney disorders.

5. FIRE-FIGHTING MEASURES

Flashpoint (°C)	***AutoIgnition Temperature (°C)***	**Flammability Limits in Air (%):** ***LEL***	***UEL***
-30. (Carbon Disulphide)	90.1 (Carbon Disulphide)	1.25. (Carbon Disulphide)	50. (Carbon Disulphide)

Flammability Class (WHMIS):	B-6: Reactive Flammable Material
Hazardous Combustion Products:	Thermal decomposition products are toxic and may include Carbon Disulphide, Potassium sulphide, carbonyl sulphide, Amyl Alcohols, oxides of carbon, sulphur, potassium and irritating gases.
Unusual Fire or Explosion Hazards:	This product may be capable of forming flammable dust clouds in air. Avoid accumulation and dispersion of dust to reduce explosion potential. Spilled material may cause floors and contact surfaces to become slippery. Heating of solid xanthate or aging or heating of solutions will cause formation of Carbon Bisulfide. Upon exposure of solid xanthates to moisture and/or heat, decomposition results and spontaneous combustion can occur. Contact of solid xanthate with moist air has resulted in ignition. (4) Vapours from this product are heavier than air, and may "travel" to a source of ignition (eg. pilot lights, heaters, electric motors) some distance away, and then "flash back" to the point of product discharge causing an explosion and fire. Enforce NO SMOKING rules.
Sensitivity to Mechanical Impact:	Not expected to be sensitive to mechanical impact.
Rate of Burning:	Not available.
Explosive Power:	Not available.
Sensitivity to Static Discharge:	If product has come into contact with moisture and Carbon Bisulphide gas has evolved, then Carbon Bisulphide is expected to be sensitive to static discharge if vapours are present between the lower and upper explosive limits. (3) High voltage static electricity build-up is possible when significant quantities of dust are present.
EXTINGUISHING MEDIA	
Fire Extinguishing Media:	Use carbon dioxide or dry chemical media for small fires. If only water is available, use it in the form of a fog. Cool containers with flooding quantities of water until well after the fire is out. Exposure to heat and moisture may cause the decomposition of xanthates to release flammable, explosive and poisonous Carbon Bisulphide vapours. (3)
FIRE FIGHTING INSTRUCTIONS	
Instructions to the Fire Fighters:	Use water spray to cool fire-exposed containers or structures. Use water spray to disperse vapours; re-ignition is possible. Clean up immediately to eliminate slipping hazard. Do not allow to enter sewers or watercourses. Avoid accumulation and dispersion of dust to reduce explosion potential.
Fire Fighting Protective Equipment:	Use self-contained breathing apparatus and protective clothing.

6. ACCIDENTAL RELEASE MEASURES

Information in this section is for responding to spills, leaks or releases in order to prevent or minimize the adverse effects on persons, property and the environment. There may be specific reporting requirements associated with spills, leaks or releases, which change from region to region.

Containment and Clean-Up Procedures:	In all cases of leak or spill contact vendor at Emergency Number shown on the front page of this MSDS. Avoid accumulation and dispersion of dust to reduce explosion potential. Wear respirator, protective clothing and gloves. Spilled material may cause floors and contact surfaces to become slippery. Any recovered product can be used for the usual purpose, depending on the extent and kind of contamination. Where a package (drum or bag) is damaged and / or leaking, repair it, or place it into an over-pack drum immediately so as to avoid or minimize material loss and contamination of surrounding environment. Replace damaged containers immediately to avoid loss of material and contamination of surrounding atmosphere. Avoid dry sweeping. Do not use compressed air to clean surfaces. Vacuuming or wet sweeping is preferred. Return all material possible to container for proper disposal. Do not flush with water as aqueous solutions or powders that become wet render surfaces extremely slippery. Eliminate all sources of ignition. Collect product for recovery or disposal. For release to land, or storm water runoff, contain discharge by constructing dykes or applying inert absorbent; for release to water, utilize damming and/or water diversion to minimize the spread of contamination. Ventilate enclosed spaces. Notify applicable government authority if release is reportable or could adversely affect the environment.

7. HANDLING AND STORAGE

HANDLING

Handling Practices:	Avoid accumulation and dispersion of dust to reduce explosion potential. Ground and bond equipment and containers to prevent a static charge buildup. Use spark-resistant tools. Use normal "good" industrial hygiene and housekeeping practices. Clean up immediately to eliminate slipping hazard. Enforce NO SMOKING rules in area of use.
Ventilation Requirements:	See Section 8, "Engineering Controls".
Other Precautions:	Use only with adequate ventilation and avoid breathing dusts (aerosols, vapours or mists). Avoid contact with eyes, skin or clothing. Wash thoroughly with soap and water after handling. Wash contaminated clothing thoroughly before re-use. Do not use cutting or welding torches on empty drums that contained this material/product. Absorption via contact with skin, eyes and mucous membranes can contribute to the overall exposure. Consider measures to prevent absorption by these routes.

STORAGE

Storage Temperature (°C):	See below.
Ventilation Requirements:	Ventilation should be explosion proof.
Storage Requirements:	Store solid Xanthates under cool, dark, dry conditions. Liquid products must be kept cool and used as quickly as possible. (3) Store in a cool, well-ventilated area. Keep away from heat, sparks and flames. Keep containers closed. Do not expose sealed containers to temperatures above 40° C. Avoid moisture contamination. Prolonged storage may result in lumping or caking.
Special Materials to be Used for Packaging or Containers:	Materials of construction for storing the product include: carbon steel. Copper and its alloys should not be used in equipment for storage, handling or transportation. Attacks some types of rubber, plastics and coatings. Confirm suitability of any material before using.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Recommendations listed in this section indicate the type of equipment, which will provide protection against overexposure to this product. Conditions of use, adequacy of engineering or other control measures, and actual exposures will dictate the need for specific protective devices at your workplace.

ENGINEERING CONTROLS

Engineering Controls:	Local exhaust ventilation required. Ventilation should be explosion proof. Make up air should be supplied to balance air that is removed by local or general exhaust ventilation. Avoid accumulation and dispersion of dust to reduce explosion potential. Ventilate low lying areas such as sumps or pits where dense dust may collect. Enforce NO SMOKING rules.

PERSONAL PROTECTIVE EQUIPMENT (PPE)

Eye Protection:	Use chemical safety goggles when there is potential for eye contact. Use full face-shield and chemical safety goggles when there is potential for contact.
Skin Protection:	Gloves and protective clothing made from neoprene, PVC, polyethylene, rubber or plastic should be impervious under conditions of use. Attacks some types of rubber, plastics and coatings. Prior to use, user should confirm impermeability. Discard contaminated gloves.
Respiratory Protection:	No specific guidelines available. A NIOSH/MSHA-approved air-purifying respirator equipped with dust, mist, fume cartridges for concentrations up to 2 mg/m^3 Potassium Hydroxide. An air-supplied respirator if concentrations are higher or unknown.

Other Personal Protective Equipment:	Avoid accumulation and dispersion of dust to reduce explosion potential. Wear an impermeable apron and boots. Locate safety shower and eyewash station close to chemical handling area. Take all precautions to avoid personal contact. Clothing and footwear that is fire retardant and dissipates static electrical charges should be worn when handling flammable materials. Natural fibers (cotton, wool, leather and linen) should be selected in favour of synthetic materials (rayon, nylon and polyester). Skin Notation: Contact with skin, eyes and mucous membranes can contribute to the overall exposure and may invalidate the TLV. Consider measures to prevent absorption by these routes.

EXPOSURE GUIDELINES

SUBSTANCE	***ACGIH TLV***	***OSHA PEL***		***NIOSH REL***	
	(STEL)	***(TWA)***	***(STEL)***	***(TWA)***	***(STEL)***
Potassium Hydroxide	2 mg/m³ (Ceiling)	---	---	---	2 mg/m³ (Ceiling)
Isoamyl alcohol	125 ppm	100 ppm	---	100 ppm	125 ppm
Decomposition Product: Carbon disulfide	—	20 ppm (Skin)	30 ppm (Skin)	1 ppm (Skin)	3 ppm (Skin)

9. PHYSICAL AND CHEMICAL PROPERTIES (Not intended as Specifications)

Physical State:	Solid.
Appearance:	Yellow to yellow-green pellets.
Odour:	Strong, disagreeable sulphur odour.
Odour Threshold (ppm):	0.02 - 0.21(Carbon Disulphide)
Boiling Range (°C):	Not available.
Melting/Freezing Point (°C):	255 - 280 (decomposes). (3)
Vapour Pressure (mm Hg at 20° C):	Not applicable.
Vapour Density (Air = 1.0):	Not applicable.
Relative Density (g/cc):	0.7. (4)
Bulk Density:	Not applicable.
Viscosity:	Not applicable.
Evaporation Rate (Butyl Acetate = 1.0):	Not applicable.
Solubility:	Soluble in water. Hygroscopic (readily absorbs water).
% Volatile by Volume:	< 20. (3)
pH:	10.5 (10 % solution). (3)
Coefficient of Water/Oil Distribution:	Not available.
Volatile Organic Compounds (VOC):	Not applicable.
Flashpoint (°C):	-30. (Carbon Disulphide)

10. STABILITY AND REACTIVITY

CHEMICAL STABILITY

Under Normal Conditions:	Unstable. Solid Xanthates are stable when kept cool and dry. Exposure to heat causes decomposition. Acids and oxidizing agents accelerate aging. In solution, Xanthates will decompose slowly even at room temperature. (3)
Under Fire Conditions:	Flammable. This product may be capable of forming flammable dust clouds in air.
Hazardous Polymerization:	Will not occur.
Conditions to Avoid:	High temperatures, sparks, open flames and all other sources of ignition. Avoid accumulation and dispersion of dust to reduce explosion potential. Exposure to heat and moisture may cause the decomposition of xanthates to release flammable, explosive and poisonous Carbon Bisulphide vapours. (3)
Materials to Avoid:	Strong oxidizers. Lewis or mineral acids. Metal Salts. Copper and its alloys.. Contact with acids will liberate Carbon Bisulphide. Avoid moisture contamination. Contact with water or moisture will liberate Carbon Bisulphide. Mixtures or reactions of alcohols with the following materials may cause explosions: barium perchlorate, chlorine, hypochlorous acid, ethylene oxide, hexamethylene diisocyanate and other isocyanates, nitrogen tetroxide, permonosulfuric acid and tri-isobutyl aluminum. (4) Attacks some types of rubber, plastics and coatings.

Decomposition or Combustion Products:	Thermal decomposition products are toxic and may include Carbon Bisulphide, Potassium sulphide, carbonyl sulphide, Amyl Alcohols, oxides of carbon, sulphur, potassium and irritating gases.

11. TOXICOLOGICAL INFORMATION

TOXICOLOGICAL DATA:

SUBSTANCE	*LD50 (Oral, Rat)*	*LD50 (Dermal, Rabbit)*	*LC50 (Inhalation, Rat, 4h)*
Potassium Amyl Xanthate	1 000 mg/kg (3)	---	---
Potassium Hydroxide	214 - 365 mg/kg (1,3)	1 260 mg/kg (3)	---
Isoamyl alcohol	1 300 mg/kg (1)	3 216 mg/kg (1)	---
Decomposition Product: Carbon disulfide	1 200 mg/kg (1)	---	12 500 mg/m3 (1)

Carcinogenicity Data:	The ingredient(s) of this product is (are) not classed as carcinogenic by ACGIH, IARC, OSHA or NTP.
Reproductive Data:	This product: No adverse reproductive effects are anticipated.
Mutagenicity Data:	No adverse mutagenic effects are anticipated.
Teratogenicity Data:	No adverse teratogenic effects are anticipated.
Respiratory / Skin Sensitization Data:	None known.
Synergistic Materials:	Alcohols may interact synergistically with chlorinated solvents (example - carbon tetrachloride, chloroform, bromotrichloromethane), dithiocarbamates (example - disulfiram), dimethylnitrosamine and thioacetamide. (4) Carbon Bisulphide: The toxic effects of Carbon Bisulphide, particularly on the nervous system, can be intensified by consumption of alcohol, alcoholism, treatment with disulfiram (Antibuse), and exposure to Hydrogen Sulphide. (4) In animal studies the toxicity of Carbon Bisulphide was intensified by chemicals such as resperine and amphetamine which act on the nervous system. (4)
Other Studies Relevant to Material:	None known.

12. ECOLOGICAL INFORMATION

Ecotoxicity:	Not available. May be harmful to aquatic life.
Environmental Fate:	Not available. Product has an unaesthetic appearance and can be a nuisance. Can be dangerous if allowed to enter drinking water intakes. Do not contaminate domestic or irrigation water supplies, lakes, streams, ponds, or rivers.

13. DISPOSAL CONSIDERATIONS

Deactivating Chemicals:	Not available.
Waste Disposal Methods:	This information applies to the material as manufactured. Reevaluation of the product may be required by the user at the time of disposal since the product uses, transformations, mixtures and processes may influence waste classification. Dispose of waste material at an approved (hazardous) waste treatment/disposal facility in accordance with applicable local, provincial and federal regulations. Do not dispose of waste with normal garbage, or to sewer systems.
Safe Handling of Residues:	See "Waste Disposal Methods".
Disposal of Packaging:	Empty containers retain product residue and can be dangerous. Treat package in the same manner as the product.

14. TRANSPORTATION INFORMATION

CANADIAN TDG ACT SHIPPING DESCRIPTION:

XANTHATES, Class 4.2, UN3342, PG III.

Label(s): Substances Liable To Spontaneous Combustion. Placard: Substances Liable To Spontaneous Combustion.

ERAP Index: -----. Exemptions: None known.

US DOT CLASSIFICATION (49CFR 172.101, 172.102):

XANTHATES, Class 4.2, UN3342, PG III.

Label(s): Spontaneously Combustible. Placard: Spontaneously Combustible.

CERCLA-RQ: Not available. Exemptions: None known.

15. REGULATORY INFORMATION

CANADA

CEPA - NSNR: All constituents of this product are included on the DSL.

CEPA - NPRI: Not included.

Controlled Products Regulations Classification (WHMIS):

B-6: Reactive Flammable Material
D-1B: Toxic (acute effects)
D-2B: Toxic (skin and eye irritant)

USA

Environmental Protection Act: All constituents of this product are included on the TSCA inventory.

OSHA HCS (29CFR 1910.1200): Flammable Solid. Toxic. Skin and Eye Irritant.

NFPA: 3 Health, 4 Fire, 0 Reactivity (6)

HMIS: Health, Fire, Reactivity (Not available.)

INTERNATIONAL

Not available.

16. OTHER INFORMATION

REFERENCES

1. RTECS-Registry of Toxic Effects of Chemical Substances, Canadian Centre for Occupational Health and Safety RTECS database.
2. Clayton, G.D. and Clayton, F.E., Eds., Patty's Industrial Hygiene and Toxicology, 3rd ed., Vol. IIA,B,C, John Wiley and Sons, New York, 1981.
3. Supplier's Material Safety Data Sheet(s).
4. CHEMINFO, through "CCINFOdisc", Canadian Centre for Occupational Health and Safety, Hamilton, Ontario, Canada.
5. Guide to Occupational Exposure Values, 2007, American Conference of Governmental Industrial Hygienists, Cincinnati, 2007.
6. Regulatory Affairs Group, Brenntag Canada Inc.
7. The British Columbia Drug and Poison Information Centre, Poison Managements Manual, Canadian Pharmaceutical Association, Ottawa, 1981.

The information contained herein is offered only as a guide to the handling of this specific material and has been prepared in good faith by technically knowledgeable personnel. It is not intended to be all-inclusive and the manner and conditions of use and handling may involve other and additional considerations. No warranty of any kind is given or implied and Brenntag Canada Inc. will not be liable for any damages, losses, injuries or consequential damages which may result from the use of or reliance on any information contained herein. This Material Safety Data Sheet is valid for three years.

To obtain revised copies of this or other Material Safety Data Sheets, contact your nearest Brenntag Canada Regional office.

British Columbia: 20333-102B Avenue, Langley, BC, V1M 3H1
Phone: (604) 513-9009 Facsimile: (604) 513-9010

Alberta: 6628 - 45 th. Street, Leduc, AB, T9E 7C9
Phone: (780) 986-4544 Facsimile: (780) 986-1070

Manitoba: 681 Plinquet Street, Winnipeg, MB, R2J 2X2
Phone: (204) 233-3416 Facsimile: (204) 233-7005

Ontario: 43 Jutland Road, Toronto, ON, M8Z 2G6
Phone: (416) 259-8231 Facsimile: (416) 259-5333

Quebec: 2900 Jean Baptiste Des., Lachine, PQ, H8T 1C8
Phone: (514) 636-9230 Facsimile: (514) 636-0877

Atlantic: A-105 Akerley Boulevard, Dartmouth, NS, B3B 1R7
Phone: (902) 468-9690 Facsimile: (902) 468-3085

Prepared By: Regulatory Affairs Group, Brenntag Canada Inc., (416) 259-8231.

Material Safety Data Sheet
Calcium oxide

MSDS# 04030

Section 1 - Chemical Product and Company Identification

MSDS Name:	Calcium oxide
Catalog Numbers:	AC196910000, AC196910010, AC196910025, AC403895000, AC422830000, AC422830010 AC422830010, C114-3, C114-50, C117-500
Synonyms:	Lime; Quicklime; Burnt lime; Calx; Unslaked lime; Fluxing lime; Calcia; Pebble lime.

Company Identification:	Fisher Scientific One Reagent Lane Fair Lawn, NJ 07410
For information in the US, call:	201-796-7100
Emergency Number US:	201-796-7100
CHEMTREC Phone Number, US:	800-424-9300

Section 2 - Composition, Information on Ingredients

CAS#:	1305-78-8
Chemical Name:	Calcium oxide
%:	96+
EINECS#:	215-138-9

Hazard Symbols: C



Risk Phrases: 14 22 35

Section 3 - Hazards Identification

EMERGENCY OVERVIEW

Danger! Harmful if swallowed. Causes burns by all exposure routes. Reacts violently with water. Target Organs: Respiratory system, gastrointestinal system, eyes, skin.

Potential Health Effects

Eye: Causes eye burns.

Skin: Causes skin burns. May be harmful if absorbed through the skin.

Ingestion: Harmful if swallowed. Causes gastrointestinal tract burns.

Inhalation: Causes chemical burns to the respiratory tract. May be harmful if inhaled.

Chronic: Prolonged or repeated skin contact may cause dermatitis. Chronic inhalation may cause nasal septum ulceration and perforation.

Section 4 - First Aid Measures

Eyes: Immediately flush eyes with plenty of water for at least 15 minutes, occasionally lifting the upper and lower eyelids. Get medical aid immediately.

Skin: Get medical aid immediately. Immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes.

Ingestion: Do not induce vomiting. Get medical aid immediately. Call a poison control center.

Inhalation: Get medical aid immediately. Remove from exposure and move to fresh air immediately. If breathing is difficult, give oxygen. Do not use mouth-to-mouth resuscitation if victim ingested or inhaled the substance; induce artificial respiration with the aid of a pocket mask equipped with a one-way valve or other proper

respiratory medical device.

Notes to Physician: Treat symptomatically and supportively.

Section 5 - Fire Fighting Measures

General Information: As in any fire, wear a self-contained breathing apparatus in pressure-demand, MSHA/NIOSH (approved or equivalent), and full protective gear. Water reactive. Material will react with water and may release a flammable and/or toxic gas.

Extinguishing Media: Use foam, dry chemical, or carbon dioxide. DO NOT USE WATER!

Autoignition Temperature: Not available.

Flash Point: Not applicable.

Explosion Limits: Lower: Not available

Explosion Limits: Upper: Not available

NFPA Rating: ; Special Hazard: -W-

Section 6 - Accidental Release Measures

General Information: Use proper personal protective equipment as indicated in Section 8.

Spills/Leaks: Vacuum or sweep up material and place into a suitable disposal container. Wear a self contained breathing apparatus and appropriate personal protection. (See Exposure Controls, Personal Protection section). Avoid generating dusty conditions. Provide ventilation. Do not expose spill to water. Do not get water inside containers. Do not let this chemical enter the environment.

Section 7 - Handling and Storage

Handling: Do not allow water to get into the container because of violent reaction. Minimize dust generation and accumulation. Do not get in eyes, on skin, or on clothing. Do not ingest or inhale. Do not allow contact with water. Use only in a chemical fume hood.

Storage: Store in a cool, dry place. Store in a tightly closed container. Corrosives area. Store protected from moisture. Store under an inert atmosphere.

Section 8 - Exposure Controls, Personal Protection

Chemical Name	ACGIH	NIOSH	OSHA - Final PELs
Calcium oxide	2 mg/m3	2 mg/m3 TWA 25 mg/m3 IDLH	5 mg/m3 TWA

OSHA Vacated PELs: Calcium oxide: 5 mg/m3 TWA (not in effect as a result of reconsideration)

Engineering Controls:

Facilities storing or utilizing this material should be equipped with an eyewash facility and a safety shower. Use only under a chemical fume hood.

Exposure Limits

Personal Protective Equipment

Eyes: Wear appropriate protective eyeglasses or chemical safety goggles as described by OSHA's eye and face protection regulations in 29 CFR 1910.133 or European Standard EN166.

Skin: Wear appropriate protective gloves to prevent skin exposure.

Clothing: Wear appropriate protective clothing to prevent skin exposure.

Respirators: Follow the OSHA respirator regulations found in 29 CFR 1910.134 or European Standard EN 149. Use a NIOSH/MSHA or European Standard EN 149 approved respirator if exposure limits are exceeded or if irritation or other symptoms are experienced.

Section 9 - Physical and Chemical Properties

Physical State: Powder

Color:	white to light yellow - very slightly beige
Odor:	Odorless.
pH:	12.5 (1.65 g/L aq sol)
Vapor Pressure:	Negligible.
Vapor Density:	Not available
Evaporation Rate:	Negligible.
Viscosity:	Not available
Boiling Point:	2850 deg C @ 760 mmHg (5,162.00°F)
Freezing/Melting Point:	2570 deg C (4,658.00°F)
Decomposition Temperature:	Not available
Solubility in water:	Reacts
Specific Gravity/Density:	Not available.
Molecular Formula:	CaO
Molecular Weight:	56.08

Section 10 - Stability and Reactivity

Chemical Stability:	Air sensitive. Reacts violently with water. Moisture sensitive.
Conditions to Avoid:	Incompatible materials, dust generation, exposure to air, exposure to moist air or water.
Incompatibilities with Other Materials	Strong oxidizing agents, acids, carbon dioxide, chlorine trifluoride, fluorine, halogens, phosphorus pentoxide, calcium chloride, metal halides, hydrofluoric acid, hydrogen fluoride, ethanol, boron trifluoride.
Hazardous Decomposition Products	Calcium hydroxide.
Hazardous Polymerization	Has not been reported.

Section 11 - Toxicological Information

RTECS#:	CAS# 1305-78-8: EW3100000
LD50/LC50:	RTECS: Not available.
Carcinogenicity:	Calcium oxide - Not listed as a carcinogen by ACGIH, IARC, NTP, or CA Prop 65.
Other:	See actual entry in RTECS for complete information.

Section 12 - Ecological Information

Other: Do not empty into drains.

Section 13 - Disposal Considerations

Dispose of in a manner consistent with federal, state, and local regulations.

Section 14 - Transport Information

US DOT
Shipping Name: CALCIUM OXIDE
Hazard Class: 8
UN Number: UN1910
Packing Group: III
Canada TDG
Shipping Name: CALCIUM OXIDE
Hazard Class: 8
UN Number: UN1910
Packing Group: III

Section 15 - Regulatory Information

European/International Regulations

European Labeling in Accordance with EC Directives

Hazard Symbols: C

Risk Phrases:

R 14 Reacts violently with water.

R 22 Harmful if swallowed.

R 35 Causes severe burns.

Safety Phrases:

S 25 Avoid contact with eyes.

S 36/37/39 Wear suitable protective clothing, gloves and eye/face protection.

S 45 In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).

WGK (Water Danger/Protection)

CAS# 1305-78-8: 1

Canada

CAS# 1305-78-8 is listed on Canada's DSL List

Canadian WHMIS Classifications: E, F, D1B

This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations and the MSDS contains all of the information required by those regulations.

CAS# 1305-78-8 is listed on Canada's Ingredient Disclosure List

US Federal

TSCA

CAS# 1305-78-8 is listed on the TSCA Inventory.

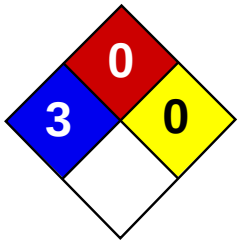
Section 16 - Other Information

MSDS Creation Date: 12/12/1997

Revision #13 Date 7/20/2009

The information above is believed to be accurate and represents the best information currently available to us. However, we make no warranty of merchantibility or any other warranty, express or implied, with respect to such information, and we assume no liability resulting from its use. Users should make their own investigations to determine the suitability of the information for their particular purposes. In no event shall the company be liable for any claims, losses, or damages of any third party or for lost profits or any special, indirect, incidental, consequential, or exemplary damages howsoever arising, even if the company has been advised of the possibility of such damages.







Material Safety Data Sheet
Sodium Cyanide MSDS

Section 1: Chemical Product and Company Identification

Product Name: Sodium Cyanide

Catalog Codes: SLS2314, SLS3736

CAS#: 143-33-9

RTECS: VZ7525000

TSCA: TSCA 8(b) inventory: Sodium Cyanide

CI#: Not available.

Synonym:

Chemical Name: Sodium Cyanide

Chemical Formula: NaCN

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call:
1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
Sodium Cyanide	143-33-9	100

Toxicological Data on Ingredients: Sodium Cyanide: ORAL (LD50): Acute: 6.44 mg/kg [Rat]. DERMAL (LD50): Acute: 10.4 mg/kg [Rabbit].

Section 3: Hazards Identification

Potential Acute Health Effects:
Very hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, of inhalation. Hazardous in case of skin contact (permeator). Corrosive to eyes and skin. The amount of tissue damage depends on length of contact. Eye contact can result in corneal damage or blindness. Skin contact can produce inflammation and blistering. Inhalation of dust will produce irritation to gastro-intestinal or respiratory tract, characterized by burning, sneezing and coughing. Severe over-exposure can produce lung damage, choking, unconsciousness or death. Inflammation of the eye is characterized by redness, watering, and itching. Skin inflammation is characterized by itching, scaling, reddening, or, occasionally, blistering.

Potential Chronic Health Effects:
CARCINOGENIC EFFECTS: Not available. MUTAGENIC EFFECTS: Not available. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available. The substance may be toxic to skin, eyes, central nervous system (CNS). Repeated or prolonged exposure to the substance can produce target organs damage. Repeated exposure of the eyes to a low level of dust can produce eye irritation. Repeated skin exposure can produce local skin destruction, or dermatitis. Repeated inhalation of dust can produce varying degree of respiratory irritation or lung damage. Repeated exposure to a highly toxic material may produce general deterioration of health by an accumulation in one or many human organs.

Section 4: First Aid Measures

Eye Contact:
Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Cold water may be used. Get medical attention immediately.

Skin Contact:
In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Cover the irritated skin with an emollient. Cold water may be used.Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention immediately.

Serious Skin Contact:
Wash with a disinfectant soap and cover the contaminated skin with an anti-bacterial cream. Seek immediate medical attention.

Inhalation:
If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.

Serious Inhalation:
Evacuate the victim to a safe area as soon as possible. Loosen tight clothing such as a collar, tie, belt or waistband. If breathing is difficult, administer oxygen. If the victim is not breathing, perform mouth-to-mouth resuscitation. WARNING: It may be hazardous to the person providing aid to give mouth-to-mouth resuscitation when the inhaled material is toxic, infectious or corrosive. Seek immediate medical attention.

Ingestion:
If swallowed, do not induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention immediately.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: May be combustible at high temperature.

Auto-Ignition Temperature: Not available.

Flash Points: Not available.

Flammable Limits: Not available.

Products of Combustion: Some metallic oxides.

Fire Hazards in Presence of Various Substances: Slightly flammable to flammable in presence of acids, of moisture.

Explosion Hazards in Presence of Various Substances:
Risks of explosion of the product in presence of mechanical impact: Not available. Risks of explosion of the product in presence of static discharge: Not available.

Fire Fighting Media and Instructions:
SMALL FIRE: Use DRY chemical powder. LARGE FIRE: Use water spray, fog or foam. Do not use water jet.

Special Remarks on Fire Hazards:
Dangerous on contact with acids, acid fumes, water or stream. It will produce toxic and flammable vapors of CN-H and sodium oxide. Contact with acids and acid salts causes immediate formation of toxic and flammable hydrogen cyanide gas. When heated to decomposition it emits toxic fumes hydgrogen cyanide and oxides of nitrogen

Special Remarks on Explosion Hazards: Fusion mixtures of metal cyanides with metal chlorates, perchlorated or nitrates causes a violent explosion

Section 6: Accidental Release Measures

Small Spill: Use appropriate tools to put the spilled solid in a convenient waste disposal container.

Large Spill:
Corrosive solid. Poisonous solid. Stop leak if without risk. Do not get water inside container. Do not touch spilled material. Use water spray to reduce vapors. Prevent entry into sewers, basements or confined areas; dike if needed. Eliminate all ignition sources. Call for assistance on disposal. Be careful that the product is not present at a concentration level above TLV. Check TLV on the MSDS and with local authorities.

Section 7: Handling and Storage

Precautions:
Keep locked up.. Keep container dry. Keep away from heat. Keep away from sources of ignition. Empty containers pose a fire risk, evaporate the residue under a fume hood. Ground all equipment containing material. Do not ingest. Do not breathe dust. Never add water to this product. In case of insufficient ventilation, wear suitable respiratory equipment. If ingested, seek medical advice immediately and show the container or the label. Avoid contact with skin and eyes. Keep away from incompatibles such as oxidizing agents, acids, moisture.

Storage: Keep container tightly closed. Keep container in a cool, well-ventilated area. Do not store above 24°C (75.2°F).

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.

Personal Protection:
Splash goggles. Synthetic apron. Vapor and dust respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Vapor and dust respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits:
STEL: 5 (mg/m3) from ACGIH (TLV) [United States] SKIN CEIL: 4.7 from NIOSH CEIL: 5 (mg/m3) from NIOSHConsult local authorities for acceptable exposure limits.

Section 9: Physical and Chemical Properties

Physical state and appearance: Solid. (Granular solid. Flakes solid.)

Odor:
Faint almond-like odor. Odorless when perfectly dry. Emits odor of hydrogen cyanide when damp.

Taste: Not available.

Molecular Weight: 49.01 g/mole

Color: White.

pH (1% soln/water): Not available.

Boiling Point: 1496°C (2724.8°F)

Melting Point: 563°C (1045.4°F)

Critical Temperature: Not available.

Specific Gravity: 1.595 (Water = 1)

Vapor Pressure: Not applicable.

Vapor Density: Vapor Density of Hydrogen Cyanide gas: 0.941

Volatility: Not available.

Odor Threshold: Not available.

Water/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties: See solubility in water.

Solubility:
Soluble in cold water. Slightly soluble in Ethanol

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Excess heat, moisture, incompatibles.

Incompatibility with various substances: Reactive with oxidizing agents, acids, moisture.

Corrosivity:
Corrosive in presence of aluminum. Non-corrosive in presence of glass.

Special Remarks on Reactivity:
Violent reaction with fluorine gas, magnesium, nitrates, nitric acid. Dangerous on contact with acids, acid fumes, water or stream. It wil produce toxic and flammable vapors of CN-H and sodium oxide. Cyanide may react with CO2 in ordinary air to form toxic hydrogen cyanide gas. Strong oxidizers such as acids, acid salts, chlorates, and nitrates. Contact with acids and acid salts causes immediate formation of toxic and flammable hydrogen cyanide gas.

Special Remarks on Corrosivity: Corrosive to aluminum

Polymerization: Will not occur.

Section 11: Toxicological Information

Routes of Entry: Absorbed through skin. Dermal contact. Eye contact. Inhalation. Ingestion.

Toxicity to Animals:
Acute oral toxicity (LD50): 6.44 mg/kg [Rat]. Acute dermal toxicity (LD50): 10.4 mg/kg [Rabbit].

Chronic Effects on Humans: May cause damage to the following organs: skin, eyes, central nervous system (CNS).

Other Toxic Effects on Humans:
Very hazardous in case of skin contact (irritant), of ingestion, of inhalation. Hazardous in case of skin contact (permeator).

Special Remarks on Toxicity to Animals: Not available.

Special Remarks on Chronic Effects on Humans: May cause adverse reproductive effects (maternal and paternal fertility) based on animal data.

Special Remarks on other Toxic Effects on Humans:
Acute Potential Health effects: Skin: May cause itching and irritation. May be fatal if absorbed through injured skin with symtpoms similar to those noted for inhalation and ingestion. Eyes: May cause eye irritation and eye damage. Inhalation: May cause respiratory tract irritation. May be fatal if inhaled. The substance inhibits cellular respiration causing metabolic asphyxiation. May cause headache, weakness, dizziness, labored breathing, nausea, vomiting. May be followed by cardiovascular effects, unconciousness, convulsions, coma, and death Ingestion: May be fatal if swallowed. May cause

gastrointestinal tract irritation with nausea, vomiting. May affect behavior and nervous systems(seizures, convulsions, change in motor activity, headache, dizziness, confusion, weakness stupor, aniexity, agitation, tremors), cardiovascular system, respiration (hyperventilation, pulmonary edema, breathing difficulty, respiratory failure), cardiovascular system (palpitations, rapid heart beat, hypertension, hypotension). Massive doses by produce sudden loss of conciousness and prompt death from respiratory arrest. Smaller but still lethal doses on the breath or vomitus. Chronic Potential Health Effects: Central Nervous system effects (headaches, vertigo, insomnia, memory loss, tremors, fatigue), fatigue, metabolic effects (poor appetite), cardiovascular effects (chest discomfort, palpitations), nerve damage to the eyes, or dermatitis, respiratory tract irritation, eye irritation, or death can occur. may prolong the illness for 1 or more hours. A bitter almond odor may be noted

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The products of degradation are less toxic than the product itself.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:
Waste must be disposed of in accordance with federal, state and local environmental control regulations.

Section 14: Transport Information

DOT Classification: CLASS 6.1: Poisonous material.

Identification: : Sodium cyanide UNNA: 1689 PG: I

Special Provisions for Transport: Marine Pollutant

Section 15: Other Regulatory Information

Federal and State Regulations:
Connecticut carcinogen reporting list.: Sodium Cyanide Illinois chemical safety act: Sodium Cyanide New York release reporting list: Sodium Cyanide Rhode Island RTK hazardous substances: Sodium Cyanide Pennsylvania RTK: Sodium Cyanide Minnesota: Sodium Cyanide Massachusetts RTK: Sodium Cyanide Massachusetts spill list: Sodium Cyanide New Jersey: Sodium Cyanide New Jersey spill list: Sodium Cyanide Louisiana RTK reporting list: Sodium Cyanide Louisiana spill reporting: Sodium Cyanide California Director's List of Hazardous Substances: Sodium Cyanide TSCA 8(b) inventory: Sodium Cyanide TSCA 4(a) final test rules: Sodium Cyanide TSCA 8(a) PAIR: Sodium Cyanide TSCA 8(d) H and S data reporting: Sodium Cyanide TSCA 12(b) one time export: Sodium Cyanide SARA 302/304/311/312 extremely hazardous substances: Sodium Cyanide CERCLA: Hazardous substances.: Sodium Cyanide: 10 lbs. (4.536 kg)

Other Regulations:
OSHA: Hazardous by definition of Hazard Communication Standard (29 CFR 1910.1200). EINECS: This product is on the European Inventory of Existing Commercial Chemical Substances.

Other Classifications:

WHMIS (Canada):
CLASS B-6: Reactive and very flammable material. CLASS D-1A: Material causing immediate and serious toxic effects (VERY TOXIC). CLASS E: Corrosive solid.

DSCL (EEC):
R27/28- Very toxic in contact with skin and if swallowed. R41- Risk of serious damage to eyes. S1/2- Keep locked up and out of the reach of children. S26- In case of contact with eyes, rinse immediately with plenty of water and seek medical advice. S28- After contact with skin, wash immediately with plenty of water S36/37- Wear suitable protective clothing and gloves. S39- Wear eye/face protection. S45- In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible). S46- If swallowed, seek medical advice immediately and show this container or label.

HMIS (U.S.A.):

Health Hazard: 3

Fire Hazard: 1

Reactivity: 0

Personal Protection: j

National Fire Protection Association (U.S.A.):

Health: 3

Flammability: 0

Reactivity: 0

Specific hazard:

Protective Equipment:
Gloves. Synthetic apron. Vapor and dust respirator. Be sure to use an approved/certified respirator or equivalent. Wear appropriate respirator when ventilation is inadequate. Splash goggles.

Section 16: Other Information

References: Not available.

Other Special Considerations: Not available.

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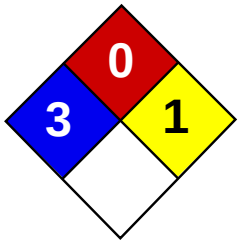



Material Safety Data Sheet
Sodium hydroxide MSDS

Section 1: Chemical Product and Company Identification

Product Name: Sodium hydroxide

Catalog Codes: SLS3298, SLS1081, SLS2503, SLS3925, SLS1705

CAS#: 1310-73-2

RTECS: WB4900000

TSCA: TSCA 8(b) inventory: Sodium hydroxide

CI#: Not available.

Synonym: Caustic Soda

Chemical Name: Sodium Hydroxide

Chemical Formula: NaOH

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call: 1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
Sodium hydroxide	1310-73-2	100

Toxicological Data on Ingredients: Sodium hydroxide LD50: Not available. LC50: Not available.

Section 3: Hazards Identification

Potential Acute Health Effects:
Very hazardous in case of skin contact (corrosive, irritant, permeator), of eye contact (irritant, corrosive), of ingestion, of inhalation. The amount of tissue damage depends on length of contact. Eye contact can result in corneal damage or blindness. Skin contact can produce inflammation and blistering. Inhalation of dust will produce irritation to gastro-intestinal or respiratory tract, characterized by burning, sneezing and coughing. Severe over-exposure can produce lung damage, choking, unconsciousness or death. Inflammation of the eye is characterized by redness, watering, and itching. Skin inflammation is characterized by itching, scaling, reddening, or, occasionally, blistering.

Potential Chronic Health Effects:
CARCINOGENIC EFFECTS: Not available. MUTAGENIC EFFECTS: Mutagenic for mammalian somatic cells. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available. The substance may be toxic to mucous membranes, upper respiratory tract, skin, eyes. Repeated or prolonged exposure to the substance can produce target organs damage. Repeated exposure of the eyes to a low level of dust can produce eye irritation. Repeated skin exposure can produce local skin destruction, or dermatitis. Repeated inhalation of dust can produce varying degree of respiratory irritation or lung damage.

Section 4: First Aid Measures

Eye Contact:
Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Cold water may be used. Get medical attention immediately.

Skin Contact:
In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Cover the irritated skin with an emollient. Cold water may be used.Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention immediately.

Serious Skin Contact:
Wash with a disinfectant soap and cover the contaminated skin with an anti-bacterial cream. Seek medical attention.

Inhalation:
If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention immediately.

Serious Inhalation:
Evacuate the victim to a safe area as soon as possible. Loosen tight clothing such as a collar, tie, belt or waistband. If breathing is difficult, administer oxygen. If the victim is not breathing, perform mouth-to-mouth resuscitation. WARNING: It may be hazardous to the person providing aid to give mouth-to-mouth resuscitation when the inhaled material is toxic, infectious or corrosive. Seek immediate medical attention.

Ingestion:
Do NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. If large quantities of this material are swallowed, call a physician immediately. Loosen tight clothing such as a collar, tie, belt or waistband.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: Non-flammable.

Auto-Ignition Temperature: Not applicable.

Flash Points: Not applicable.

Flammable Limits: Not applicable.

Products of Combustion: Not available.

Fire Hazards in Presence of Various Substances: metals

Explosion Hazards in Presence of Various Substances:
Risks of explosion of the product in presence of mechanical impact: Not available. Risks of explosion of the product in presence of static discharge: Not available. Slightly explosive in presence of heat.

Fire Fighting Media and Instructions: Not available

Special Remarks on Fire Hazards:
sodium hydroxide + zinc metal dust causes ignition of the latter. Under proper conditions of temperature, pressure and state of division, it can ignite or react violently with acetaldehyde, ally alcohol, allyl chloride, benzene-1,4-diol, chlorine trifluoride, 1,2 dichlorethylene, nitroethane, nitromethane, nitroparaffins, nitropropane, cinnamaldehyde, 2,2-dichloro-3,3-dimethylbutane. Sodium hydroxide in contact with water may generate enough heat to ignite adjacent combustible materials. Phosphorous boiled with NaOH yields mixed phosphines which may ignite spontanously in air. sodium hydroxide and cinnamaldehyde + heat may cause ignition. Reaction with certain metals releases flammable and explosive hydrogen gas.

Special Remarks on Explosion Hazards:
Sodium hydroxide reacts to form explosive products with ammonia + silver nitrate. Benzene extract of allyl benzenesulfonate prepared from allyl alcohol, and benzene sulfonyl chloride in presence of aquesous sodium hydroxide, under vacuum distillation, residue darkened and exploded. Sodium Hydroxde + impure tetrahydrofuran, which can contain peroxides, can

cause serious explosions. Dry mixtures of sodium hydroxide and sodium tetrahydroborate liberate hydrogen explosively at 230-270 deg. C. Sodium Hydroxide reacts with sodium salt of trichlorophenol + methyl alcohol + trichlorobenzene + heat to cause an explosion.

Section 6: Accidental Release Measures

Small Spill:
Use appropriate tools to put the spilled solid in a convenient waste disposal container. If necessary: Neutralize the residue with a dilute solution of acetic acid.

Large Spill:
Corrosive solid. Stop leak if without risk. Do not get water inside container. Do not touch spilled material. Use water spray to reduce vapors. Prevent entry into sewers, basements or confined areas; dike if needed. Call for assistance on disposal. Neutralize the residue with a dilute solution of acetic acid. Be careful that the product is not present at a concentration level above TLV. Check TLV on the MSDS and with local authorities.

Section 7: Handling and Storage

Precautions:
Keep container dry. Do not breathe dust. Never add water to this product. In case of insufficient ventilation, wear suitable respiratory equipment. If you feel unwell, seek medical attention and show the label when possible. Avoid contact with skin and eyes. Keep away from incompatibles such as oxidizing agents, reducing agents, metals, acids, alkalis, moisture.

Storage: Keep container tightly closed. Keep container in a cool, well-ventilated area. Hygroscopic. Deliquescent.

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.

Personal Protection:
Splash goggles. Synthetic apron. Vapor and dust respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Vapor and dust respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits:
STEL: 2 (mg/m3) from ACGIH (TLV) [United States] TWA: 2 CEIL: 2 (mg/m3) from OSHA (PEL) [United States] CEIL: 2 (mg/m3) from NIOSHConsult local authorities for acceptable exposure limits.

Section 9: Physical and Chemical Properties

Physical state and appearance: Solid. (Deliquescent solid.)

Odor: Odorless.

Taste: Not available.

Molecular Weight: 40 g/mole

Color: White.

pH (1% soln/water): 13.5 [Basic.]

Boiling Point: 1388°C (2530.4°F)

Melting Point: 323°C (613.4°F)

Critical Temperature: Not available.

Specific Gravity: 2.13 (Water = 1)

Vapor Pressure: Not applicable.

Vapor Density: Not available.

Volatility: Not available.

Odor Threshold: Not available.

Water/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties: See solubility in water.

Solubility: Easily soluble in cold water.

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Incompatible materials, moisture, moist air

Incompatibility with various substances:
Highly reactive with metals. Reactive with oxidizing agents, reducing agents, acids, alkalis, moisture.

Corrosivity: Not available.

Special Remarks on Reactivity:
Hygroscopic. Much heat is evolved when solid material is dissolved in water. Therefore cold water and caution must be used for this process. Sodium hydroxide solution and octanol + diborane during a work-up of a reaction mixture of oxime and diborane in tetrahyrofuran is very exothermic, a mild explosion being noted on one occassion. Reactive with water, acids (mineral, non-oxidizing, e.g. hydrochloric, hydrofluoric acid, muriatic acid, phosphoric), acids (mineral, oxidizing e.g. chromic acid, hypochlorous acid, nitric acid, sulfuric acid), acids (organic e.g. acetic acid, benzoic acid, formic acid, methanoic acid, oxalic acid), aldehydes (e.g. acetaldehyde, acrolein, chloral hydrate, foraldehyde), carbamates (e.g. carbanolate, carbofuran), esters (e.g. butyl acetate, ethyl acetate, propyl formate), halogenated organics (dibromoethane, hexachlorobenzene, methyl chloride, trichloroethylene), isocyanates (e.g. methyl isocyanate), ketones (acetone, acetophenone, MEK, MIBK), acid chlorides, strong bases, strong oxidizing agents, strong reducing agents, flammable liquids, powdered metals and metals (i.e aluminum, tin, zinc, hafnium, raney nickel), metals (alkali and alkaline e.g. cesium, potassium, sodium), metal compounds (toxic e.g. berylium, lead acetate, nickel carbonyl, tetraethyl lead), mitrides (e.g. potassium nitride, sodium nitride), nitriles (e.g. acetonitrile, methyl cyanide), nitro compounds (organic e.g. nitrobenzene, nitromethane), acetic anhydride, chlorohydrin, chlorosulfonic acid, ethylene cyanohydrin, glyoxal, hydrosulfuric acid, oleum, propiolactone, acylonitrile, phorosous pentoxide, chloroethanol, chloroform-methanol, tetrahydroborate, cyanogen azide, 1,2,4,5 tetrachlorobenzene, cinnamaldehyde. Reacts with formaldehyde hydroxide to yield formic acid, and hydrogen.

Special Remarks on Corrosivity: Very caustic to aluminum and other metals in presence of moisture.

Polymerization: Will not occur.

Section 11: Toxicological Information

Routes of Entry: Absorbed through skin. Dermal contact. Eye contact. Inhalation. Ingestion.

Toxicity to Animals:
LD50: Not available. LC50: Not available.

Chronic Effects on Humans:
MUTAGENIC EFFECTS: Mutagenic for mammalian somatic cells. May cause damage to the following organs: mucous membranes, upper respiratory tract, skin, eyes.

Other Toxic Effects on Humans:
Extremely hazardous in case of inhalation (lung corrosive). Very hazardous in case of skin contact (corrosive, irritant, permeator), of eye contact (corrosive), of ingestion, .

Special Remarks on Toxicity to Animals:
Lowest Published Lethal Dose: LDL [Rabbit] - Route: Oral; Dose: 500 mg/kg

Special Remarks on Chronic Effects on Humans: May affect genetic material. Investigation as a mutagen (cytogenetic analysis)

Special Remarks on other Toxic Effects on Humans:

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The product itself and its products of degradation are not toxic.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:
Waste must be disposed of in accordance with federal, state and local environmental control regulations.

Section 14: Transport Information

DOT Classification: Class 8: Corrosive material

Identification: : Sodium hydroxide, solid UNNA: 1823 PG: II

Special Provisions for Transport: Not available.

Section 15: Other Regulatory Information

Federal and State Regulations:
Illinois toxic substances disclosure to employee act: Sodium hydroxide Illinois chemical safety act: Sodium hydroxide New York release reporting list: Sodium hydroxide Rhode Island RTK hazardous substances: Sodium hydroxide Pennsylvania RTK: Sodium hydroxide Minnesota: Sodium hydroxide Massachusetts RTK: Sodium hydroxide New Jersey: Sodium hydroxide Louisiana spill reporting: Sodium hydroxide California Director's List of Hazardous Substances: Sodium hydroxide TSCA 8(b) inventory: Sodium hydroxide CERCLA: Hazardous substances.: Sodium hydroxide: 1000 lbs. (453.6 kg)

Other Regulations:
OSHA: Hazardous by definition of Hazard Communication Standard (29 CFR 1910.1200). EINECS: This product is on the European Inventory of Existing Commercial Chemical Substances.

Other Classifications:

WHMIS (Canada): CLASS E: Corrosive solid.

DSCL (EEC):
R35- Causes severe burns. S26- In case of contact with eyes, rinse immediately with plenty of water and seek medical advice. S37/39- Wear suitable gloves and eye/face protection. S45- In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).

HMIS (U.S.A.):

Health Hazard: 3

Fire Hazard: 0

Reactivity: 2

Personal Protection: j

National Fire Protection Association (U.S.A.):

Health: 3

Flammability: 0

Reactivity: 1

Specific hazard:

Protective Equipment:
Gloves. Synthetic apron. Vapor and dust respirator. Be sure to use an approved/certified respirator or equivalent. Wear appropriate respirator when ventilation is inadequate. Splash goggles.

Section 16: Other Information

References: Not available.

Other Special Considerations: Not available.

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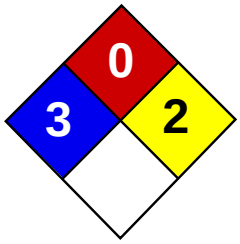



Material Safety Data Sheet
Sulfuric acid MSDS

Section 1: Chemical Product and Company Identification

Product Name: Sulfuric acid

Catalog Codes: SLS2539, SLS1741, SLS3166, SLS2371, SLS3793

CAS#: 7664-93-9

RTECS: WS5600000

TSCA: TSCA 8(b) inventory: Sulfuric acid

CI#: Not applicable.

Synonym: Oil of Vitriol; Sulfuric Acid

Chemical Name: Hydrogen sulfate

Chemical Formula: H2-SO4

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call: 1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
Sulfuric acid	7664-93-9	95 - 98

Toxicological Data on Ingredients: Sulfuric acid: ORAL (LD50): Acute: 2140 mg/kg [Rat.]. VAPOR (LC50): Acute: 510 mg/m 2 hours [Rat]. 320 mg/m 2 hours [Mouse].

Section 3: Hazards Identification

Potential Acute Health Effects:
Very hazardous in case of skin contact (corrosive, irritant, permeator), of eye contact (irritant, corrosive), of ingestion, of inhalation. Liquid or spray mist may produce tissue damage particularly on mucous membranes of eyes, mouth and respiratory tract. Skin contact may produce burns. Inhalation of the spray mist may produce severe irritation of respiratory tract, characterized by coughing, choking, or shortness of breath. Severe over-exposure can result in death. Inflammation of the eye is characterized by redness, watering, and itching. Skin inflammation is characterized by itching, scaling, reddening, or, occasionally, blistering.

Potential Chronic Health Effects:
CARCINOGENIC EFFECTS: Classified 1 (Proven for human.) by IARC, + (Proven.) by OSHA. Classified A2 (Suspected for human.) by ACGIH. MUTAGENIC EFFECTS: Not available. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available. The substance may be toxic to kidneys, lungs, heart, cardiovascular system, upper respiratory tract, eyes, teeth. Repeated or prolonged exposure to the substance can produce target organs damage. Repeated or prolonged

contact with spray mist may produce chronic eye irritation and severe skin irritation. Repeated or prolonged exposure to spray mist may produce respiratory tract irritation leading to frequent attacks of bronchial infection. Repeated exposure to a highly toxic material may produce general deterioration of health by an accumulation in one or many human organs.

Section 4: First Aid Measures

Eye Contact:
Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Cold water may be used. Get medical attention immediately.

Skin Contact:
In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Cover the irritated skin with an emollient. Cold water may be used.Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention immediately.

Serious Skin Contact:
Wash with a disinfectant soap and cover the contaminated skin with an anti-bacterial cream. Seek immediate medical attention.

Inhalation:
If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention immediately.

Serious Inhalation:
Evacuate the victim to a safe area as soon as possible. Loosen tight clothing such as a collar, tie, belt or waistband. If breathing is difficult, administer oxygen. If the victim is not breathing, perform mouth-to-mouth resuscitation. WARNING: It may be hazardous to the person providing aid to give mouth-to-mouth resuscitation when the inhaled material is toxic, infectious or corrosive. Seek immediate medical attention.

Ingestion:
Do NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention if symptoms appear.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: Non-flammable.

Auto-Ignition Temperature: Not applicable.

Flash Points: Not applicable.

Flammable Limits: Not applicable.

Products of Combustion:
Products of combustion are not available since material is non-flammable. However, products of decompostion include fumes of oxides of sulfur. Will react with water or steam to produce toxic and corrosive fumes. Reacts with carbonates to generate carbon dioxide gas. Reacts with cyanides and sulfides to form poisonous hydrogen cyanide and hydrogen sulfide respectively.

Fire Hazards in Presence of Various Substances: Combustible materials

Explosion Hazards in Presence of Various Substances:
Risks of explosion of the product in presence of mechanical impact: Not available. Risks of explosion of the product in presence of static discharge: Not available. Slightly explosive in presence of oxidizing materials.

Fire Fighting Media and Instructions: Not applicable.

Special Remarks on Fire Hazards:
Metal acetylides (Monocesium and Monorubidium), and carbides ignite with concentrated sulfuric acid. White Phosphorous + boiling Sulfuric acid or its vapor ignites on contact. May ignite other combustible materials. May cause fire when sulfuric acid is mixed with Cyclopentadiene, cyclopentanone oxime, nitroaryl amines, hexalithium disilicide, phorphorous (III) oxide, and oxidizing agents such as chlorates, halogens, permanganates.

Special Remarks on Explosion Hazards:
Mixturesofsulfuricacidandanyofthefollowingcanexplode:p-nitrotoluene,pentasilver trihydroxydiaminophosphate, perchlorates, alcohols with strong hydrogen peroxide, ammonium tetraperoxychromate, mercuric nitrite, potassium chlorate, potassium permanganate with potassium chloride, carbides, nitro compounds, nitrates, carbides, phosphorous, iodides, picratres, fulminats, dienes, alcohols (when heated) Nitramide decomposes explosively on contact with concentrated sulfuric acid. 1,3,5-Trinitrosohexahydro-1,3,5-triazine + sulfuric acid causes explosive decompositon.

Section 6: Accidental Release Measures

Small Spill:
Dilute with water and mop up, or absorb with an inert dry material and place in an appropriate waste disposal container. If necessary: Neutralize the residue with a dilute solution of sodium carbonate.

Large Spill:
Corrosive liquid. Poisonous liquid. Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material. Do not get water inside container. Do not touch spilled material. Use water spray curtain to divert vapor drift. Use water spray to reduce vapors. Prevent entry into sewers, basements or confined areas; dike if needed. Call for assistance on disposal. Neutralize the residue with a dilute solution of sodium carbonate. Be careful that the product is not present at a concentration level above TLV. Check TLV on the MSDS and with local authorities.

Section 7: Handling and Storage

Precautions:
Keep locked up.. Keep container dry. Do not ingest. Do not breathe gas/fumes/ vapor/spray. Never add water to this product. In case of insufficient ventilation, wear suitable respiratory equipment. If ingested, seek medical advice immediately and show the container or the label. Avoid contact with skin and eyes. Keep away from incompatibles such as oxidizing agents, reducing agents, combustible materials, organic materials, metals, acids, alkalis, moisture. May corrode metallic surfaces. Store in a metallic or coated fiberboard drum using a strong polyethylene inner package.

Storage:
Hygroscopic. Reacts. violently with water. Keep container tightly closed. Keep container in a cool, well-ventilated area. Do not store above 23°C (73.4°F).

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors below their respective threshold limit value. Ensure that eyewash stations and safety showers are proximal to the work-station location.

Personal Protection:
Face shield. Full suit. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Gloves. Boots.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Vapor respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits:
TWA: 1 STEL: 3 (mg/m3) [Australia] Inhalation TWA: 1 (mg/m3) from OSHA (PEL) [United States] Inhalation TWA: 1 STEL: 3 (mg/m3) from ACGIH (TLV) [United States] [1999] Inhalation TWA: 1 (mg/m3) from NIOSH [United States] Inhalation TWA: 1 (mg/m3) [United Kingdom (UK)]Consult local authorities for acceptable exposure limits.

Section 9: Physical and Chemical Properties

Physical state and appearance: Liquid. (Thick oily liquid.)

Odor: Odorless, but has a choking odor when hot.

Taste: Marked acid taste. (Strong.)

Molecular Weight: 98.08 g/mole

Color: Colorless.

pH (1% soln/water): Acidic.

Boiling Point:
270°C (518°F) - 340 deg. C Decomposes at 340 deg. C

Melting Point: -35°C (-31°F) to 10.36 deg. C (93% to 100% purity)

Critical Temperature: Not available.

Specific Gravity: 1.84 (Water = 1)

Vapor Pressure: Not available.

Vapor Density: 3.4 (Air = 1)

Volatility: Not available.

Odor Threshold: Not available.

Water/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties: See solubility in water.

Solubility:
Easily soluble in cold water. Sulfuric is soluble in water with liberation of much heat. Soluble in ethyl alcohol.

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability:
Conditions to Avoid: Incompatible materials, excess heat, combustible material materials, organic materials, exposure to moist air or water, oxidizers, amines, bases. Always add the acid to water, never the reverse.

Incompatibility with various substances:
Reactive with oxidizing agents, reducing agents, combustible materials, organic materials, metals, acids, alkalis, moisture.

Corrosivity:
Extremely corrosive in presence of aluminum, of copper, of stainless steel(316). Highly corrosive in presence of stainless steel(304). Non-corrosive in presence of glass.

Special Remarks on Reactivity:
Hygroscopic. Strong oxidizer. Reacts violently with water and alcohol especially when water is added to the product. Incompatible (can react explosively or dangerously) with the following: ACETIC ACID, ACRYLIC ACID, AMMONIUM HYDROXIDE, CRESOL, CUMENE, DICHLOROETHYL ETHER, ETHYLENE CYANOHYDRIN, ETHYLENEIMINE, NITRIC ACID, 2-NITROPROPANE, PROPYLENE OXIDE, SULFOLANE, VINYLIDENE CHLORIDE, DIETHYLENE GLYCOL MONOMETHYL ETHER, ETHYL ACETATE, ETHYLENE CYANOHYDRIN, ETHYLENE GLYCOL MONOETHYL ETHER ACETATE, GLYOXAL, METHYL ETHYL KETONE, dehydrating agents, organic materials, moisture (water), Acetic anhydride, Acetone, cyanohydrin, Acetone+nitric acid, Acetone + potassium dichromate, Acetonitrile, Acrolein, Acrylonitrile, Acrylonitrile +water, Alcohols + hydrogen peroxide, ally compounds such as Allyl alcohol, and Allyl Chloride, 2-Aminoethanol, Ammonium hydroxide, Ammonium triperchromate, Aniline, Bromate + metals, Bromine pentafluoride, n-Butyraldehyde, Carbides, Cesium acetylene carbide, Chlorates, Cyclopentanone oxime, chlorinates, Chlorates + metals, Chlorine trifluoride, Chlorosulfonic acid, 2-cyano-4-nitrobenzenediazonium hydrogen sulfate, Cuprous nitride, p-chloronitrobenzene, 1,5-Dinitronaphthlene +

sulfur, Diisobutylene, p-dimethylaminobenzaldehyde, 1,3-Diazidobenzene, Dimethylbenzylcarbinol + hydrogen peroxide, Epichlorohydrin, Ethyl alcohol + hydrogen peroxide, Ethylene diamine, Ethylene glycol and other glycols, , Ethylenimine, Fulminates, hydrogen peroxide, Hydrochloric acid, Hydrofluoric acid, Iodine heptafluoride, Indane + nitric acid, Iron, Isoprene, Lithium silicide, Mercuric nitride, Mesityl oxide, Mercury nitride, Metals (powdered), Nitromethane, Nitric acid + glycerides, p-Nitrotoluene, Pentasilver trihydroxydiaminophosphate, Perchlorates, Perchloric acid, Permanganates + benzene, 1-Phenyl-2-methylpropyl alcohol + hydrogen peroxide, Phosphorus, Phosphorus isocyanate, Picrates, Potassium tert-butoxide, Potassium chlorate, Potassium Permanganate and other permanganates, halogens, amines, Potassium Permanganate + Potassium chloride, Potassium Permanganate + water, Propiolactone (beta)-, Pyridine, Rubidium aceteylene carbide, Silver permanganate, Sodium, Sodium carbonate, sodium hydroxide, Steel, styrene monomer, toluene + nitric acid, Vinyl acetate, Thalium (I) azidodithiocarbonate, Zinc chlorate, Zinc Iodide, azides, carbonates, cyanides, sulfides, sulfites, alkali hydrides, carboxylic acid anhydrides, nitriles, olefinic organics, aqueous acids, cyclopentadiene, cyano-alcohols, metal acetylides, Hydrogen gas is generated by the action of the acid on most metals (i.e. lead, copper, tin, zinc, aluminum, etc.). Concentrated sulfuric acid oxidizes, dehydrates, or sulfonates most organic compounds.

Special Remarks on Corrosivity:
Non-corrosive to lead and mild steel, but dillute acid attacks most metals. Attacks many metals releasing hydrogen. Minor corrosive effect on bronze. No corrosion data on brass or zinc.

Polymerization: Will not occur.

Section 11: Toxicological Information

Routes of Entry: Absorbed through skin. Dermal contact. Eye contact. Inhalation. Ingestion.

Toxicity to Animals:
WARNING: THE LC50 VALUES HEREUNDER ARE ESTIMATED ON THE BASIS OF A 4-HOUR EXPOSURE. Acute oral toxicity (LD50): 2140 mg/kg [Rat.]. Acute toxicity of the vapor (LC50): 320 mg/m3 2 hours [Mouse].

Chronic Effects on Humans:
CARCINOGENIC EFFECTS: Classified 1 (Proven for human.) by IARC, + (Proven.) by OSHA. Classified A2 (Suspected for human.) by ACGIH. May cause damage to the following organs: kidneys, lungs, heart, cardiovascular system, upper respiratory tract, eyes, teeth.

Other Toxic Effects on Humans:
Extremely hazardous in case of inhalation (lung corrosive). Very hazardous in case of skin contact (corrosive, irritant, permeator), of eye contact (corrosive), of ingestion, .

Special Remarks on Toxicity to Animals: Not available.

Special Remarks on Chronic Effects on Humans:
Mutagenicity: Cytogenetic Analysis: Hamster, ovary = 4mmol/L Reproductive effects: May cause adverse reproductive effects based on animal data. Developmental abnormalities (musculoskeletal) in rabbits at a dose of 20 mg/m3 for 7 hrs.(RTECS) Teratogenecity: neither embryotoxic, fetoxic, nor teratogenetic in mice or rabbits at inhaled doses producing some maternal toxicity

Special Remarks on other Toxic Effects on Humans:
Acute Potential Health Effects: Skin: Causes severe skin irritation and burns. Continued contact can cause tissue necrosis. Eye: Causes severe eye irritation and burns. May cause irreversible eye injury. Ingestion: Harmful if swallowed. May cause permanent damage to the digestive tract. Causes gastrointestial tract burns. May cause perforation of the stomach, GI bleeding, edema of the glottis, necrosis and scarring, and sudden circulatory collapse(similar to acute inhalation). It may also cause systemic toxicity with acidosis. Inhalation: May cause severe irritation of the respiratory tract and mucous membranes with sore throat, coughing, shortness of breath, and delayed lung edema. Causes chemical burns to the repiratory tract. Inhalation may be fatal as a result of spasm, inflammation, edema of the larynx and bronchi, chemical pneumonitis, and pulmonary edema. Cause corrosive action on mucous membranes. May affect cardiovascular system (hypotension, depressed cardiac output, bradycardia). Circulatory collapse with clammy skin, weak and rapid pulse, shallow respiration, and scanty urine may follow. Circulatory shock is often the immediate cause of death. May also affect teeth(changes in teeth and supporting structures - erosion, discoloration). Chronic Potential Health Effects: Inhalation: Prolonged or repeated inhalation may affect behavior (muscle contraction or spasticity), urinary system (kidney damage), and cardiovascular system, heart (ischemic heart leisons), and respiratory system/lungs(pulmonary edema, lung damage), teeth (dental discoloration, erosion). Skin: Prolonged or repeated skin contact may cause dermatitis, an allergic skin reaction.

Section 12: Ecological Information

Ecotoxicity: Ecotoxicity in water (LC50): 49 mg/l 48 hours [bluegill/sunfish].

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The products of degradation are less toxic than the product itself.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:
Sulfuric acid may be placed in sealed container or absorbed in vermiculite, dry sand, earth, or a similar material. It may also be diluted and neutralized. Be sure to consult with local or regional authorities (waste regulators) prior to any disposal. Waste must be disposed of in accordance with federal, state and local environmental control regulations.

Section 14: Transport Information

DOT Classification: Class 8: Corrosive material

Identification: : Sulfuric acid UNNA: 1830 PG: II

Special Provisions for Transport: Not available.

Section 15: Other Regulatory Information

Federal and State Regulations:
Illinois toxic substances disclosure to employee act: Sulfuric acid New York release reporting list: Sulfuric acid Rhode Island RTK hazardous substances: Sulfuric acid Pennsylvania RTK: Sulfuric acid Minnesota: Sulfuric acid Massachusetts RTK: Sulfuric acid New Jersey: Sulfuric acid California Director's List of Hazardous Substances (8 CCR 339): Sulfuric acid Tennessee RTK: Sulfuric acid TSCA 8(b) inventory: Sulfuric acid SARA 302/304/311/312 extremely hazardous substances: Sulfuric acid SARA 313 toxic chemical notification and release reporting: Sulfuric acid CERCLA: Hazardous substances.: Sulfuric acid: 1000 lbs. (453.6 kg)

Other Regulations:
OSHA: Hazardous by definition of Hazard Communication Standard (29 CFR 1910.1200). EINECS: This product is on the European Inventory of Existing Commercial Chemical Substances.

Other Classifications:

WHMIS (Canada):
CLASS D-1A: Material causing immediate and serious toxic effects (VERY TOXIC). CLASS E: Corrosive liquid.

DSCL (EEC):
R35- Causes severe burns. S2- Keep out of the reach of children. S26- In case of contact with eyes, rinse immediately with plenty of water and seek medical advice. S30- Never add water to this product. S45- In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).

HMIS (U.S.A.):

Health Hazard: 3

Fire Hazard: 0

Reactivity: 2

Personal Protection:

National Fire Protection Association (U.S.A.):

Health: 3

Flammability: 0

Reactivity: 2

Specific hazard:

Protective Equipment:
Gloves. Full suit. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Wear appropriate respirator when ventilation is inadequate. Face shield.

Section 16: Other Information

References:
-Material safety data sheet emitted by: la Commission de la Santé et de la Sécurité du Travail du Québec. -The Sigma-Aldrich Library of Chemical Safety Data, Edition II. -Hawley, G.G.. The Condensed Chemical Dictionary, 11e ed., New York N.Y., Van Nostrand Reinold, 1987.

Other Special Considerations: Not available.

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APPENDIX B

SODIUM CYANIDE AND LNG EMERGENCY RESPONSE GUIDELINES (TRANSPORT CANADA, 2012)

POTENTIAL HAZARDS

FIRE OR EXPLOSION

- **EXTREMELY FLAMMABLE.**
- Will be easily ignited by heat, sparks or flames.
- Will form explosive mixtures with air.
- Vapors from liquefied gas are initially heavier than air and spread along ground.

CAUTION: Hydrogen (UN1049), Deuterium (UN1957), Hydrogen, refrigerated liquid (UN1966) and Methane (UN1971) are lighter than air and will rise. Hydrogen and Deuterium fires are difficult to detect since they burn with an invisible flame. Use an alternate method of detection (thermal camera, broom handle, etc.)

- Vapors may travel to source of ignition and flash back.
- Cylinders exposed to fire may vent and release flammable gas through pressure relief devices.
- Containers may explode when heated.
- Ruptured cylinders may rocket.

HEALTH

- Vapors may cause dizziness or asphyxiation without warning.
- Some may be irritating if inhaled at high concentrations.
- Contact with gas or liquefied gas may cause burns, severe injury and/or frostbite.
- Fire may produce irritating and/or toxic gases.

PUBLIC SAFETY

- **CALL EMERGENCY RESPONSE Telephone Number on Shipping Paper first. If Shipping Paper not available or no answer, refer to appropriate telephone number listed on the inside back cover.**
- As an immediate precautionary measure, isolate spill or leak area for at least 100 meters (330 feet) in all directions.
- Keep unauthorized personnel away.
- Stay upwind.
- Many gases are heavier than air and will spread along ground and collect in low or confined areas (sewers, basements, tanks).
- Keep out of low areas.

PROTECTIVE CLOTHING

- Wear positive pressure self-contained breathing apparatus (SCBA).
- Structural firefighters' protective clothing will only provide limited protection.
- Always wear thermal protective clothing when handling refrigerated/cryogenic liquids.

EVACUATION

Large Spill

- Consider initial downwind evacuation for at least 800 meters (1/2 mile).

Fire

- If tank, rail car or tank truck is involved in a fire, ISOLATE for 1600 meters (1 mile) in all directions; also, consider initial evacuation for 1600 meters (1 mile) in all directions.

EMERGENCY RESPONSE

FIRE

- **DO NOT EXTINGUISH A LEAKING GAS FIRE UNLESS LEAK CAN BE STOPPED.**

CAUTION: Hydrogen (UN1049), Deuterium (UN1957) and Hydrogen, refrigerated liquid (UN1966) burn with an invisible flame. Hydrogen and Methane mixture, compressed (UN2034) may burn with an invisible flame.

Small Fire

- Dry chemical or CO_2.

Large Fire

- Water spray or fog.
- Move containers from fire area if you can do it without risk.

Fire involving Tanks

- Fight fire from maximum distance or use unmanned hose holders or monitor nozzles.
- Cool containers with flooding quantities of water until well after fire is out.
- Do not direct water at source of leak or safety devices; icing may occur.
- Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank.
- ALWAYS stay away from tanks engulfed in fire.
- For massive fire, use unmanned hose holders or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

SPILL OR LEAK

- ELIMINATE all ignition sources (no smoking, flares, sparks or flames in immediate area).
- All equipment used when handling the product must be grounded.
- Do not touch or walk through spilled material.
- Stop leak if you can do it without risk.
- If possible, turn leaking containers so that gas escapes rather than liquid.
- Use water spray to reduce vapors or divert vapor cloud drift. Avoid allowing water runoff to contact spilled material.
- Do not direct water at spill or source of leak.
- Prevent spreading of vapors through sewers, ventilation systems and confined areas.
- Isolate area until gas has dispersed.

CAUTION: When in contact with refrigerated/cryogenic liquids, many materials become brittle and are likely to break without warning.

FIRST AID

- Move victim to fresh air.
- Call 911 or emergency medical service.
- Give artificial respiration if victim is not breathing.
- Administer oxygen if breathing is difficult.
- Remove and isolate contaminated clothing and shoes.
- Clothing frozen to the skin should be thawed before being removed.
- In case of contact with liquefied gas, thaw frosted parts with lukewarm water.
- In case of burns, immediately cool affected skin for as long as possible with cold water. Do not remove clothing if adhering to skin.
- Keep victim warm and quiet.
- Ensure that medical personnel are aware of the material(s) involved and take precautions to protect themselves.

POTENTIAL HAZARDS

HEALTH

- **TOXIC**; inhalation, ingestion or contact (skin, eyes) with vapors, dusts or substance may cause severe injury, burns or death.
- Reaction with water or moist air may release toxic, corrosive or flammable gases.
- Reaction with water may generate much heat that will increase the concentration of fumes in the air.
- Fire will produce irritating, corrosive and/or toxic gases.
- Runoff from fire control or dilution water may be corrosive and/or toxic and cause pollution.

FIRE OR EXPLOSION

- Non-combustible, substance itself does not burn but may decompose upon heating to produce corrosive and/or toxic fumes.
- For UN1796, UN1826, UN2031 at high concentrations and for UN2032, these may act as oxidizers, also consult GUIDE 140.
- Vapors may accumulate in confined areas (basement, tanks, hopper/tank cars etc.).
- Substance may react with water (some violently), releasing corrosive and/or toxic gases and runoff.
- Contact with metals may evolve flammable hydrogen gas.
- Containers may explode when heated or if contaminated with water.

PUBLIC SAFETY

- **CALL EMERGENCY RESPONSE Telephone Number on Shipping Paper first. If Shipping Paper not available or no answer, refer to appropriate telephone number listed on the inside back cover.**
- As an immediate precautionary measure, isolate spill or leak area in all directions for at least 50 meters (150 feet) for liquids and at least 25 meters (75 feet) for solids.
- Keep unauthorized personnel away.
- Stay upwind.
- Keep out of low areas.
- Ventilate enclosed areas.

PROTECTIVE CLOTHING

- Wear positive pressure self-contained breathing apparatus (SCBA).
- Wear chemical protective clothing that is specifically recommended by the manufacturer. It may provide little or no thermal protection.
- Structural firefighters' protective clothing provides limited protection in fire situations ONLY; it is not effective in spill situations where direct contact with the substance is possible.

EVACUATION

Spill

- See Table 1 - Initial Isolation and Protective Action Distances for highlighted materials. For non-highlighted materials, increase, in the downwind direction, as necessary, the isolation distance shown under “PUBLIC SAFETY”.

Fire

- If tank, rail car or tank truck is involved in a fire, ISOLATE for 800 meters (1/2 mile) in all directions; also, consider initial evacuation for 800 meters (1/2 mile) in all directions.

EMERGENCY RESPONSE

FIRE

- Note: Some foams will react with the material and release corrosive/toxic gases.

Small Fire

- CO_2 (except for Cyanides), dry chemical, dry sand, alcohol-resistant foam.

Large Fire

- Water spray, fog or alcohol-resistant foam.
- Move containers from fire area if you can do it without risk.
- Use water spray or fog; do not use straight streams.
- Dike fire-control water for later disposal; do not scatter the material.

Fire involving Tanks or Car/Trailer Loads

- Fight fire from maximum distance or use unmanned hose holders or monitor nozzles.
- Do not get water inside containers.
- Cool containers with flooding quantities of water until well after fire is out.
- Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank.
- ALWAYS stay away from tanks engulfed in fire.

SPILL OR LEAK

- ELIMINATE all ignition sources (no smoking, flares, sparks or flames in immediate area).
- All equipment used when handling the product must be grounded.
- Do not touch damaged containers or spilled material unless wearing appropriate protective clothing.
- Stop leak if you can do it without risk.
- A vapor suppressing foam may be used to reduce vapors.
- DO NOT GET WATER INSIDE CONTAINERS.
- Use water spray to reduce vapors or divert vapor cloud drift. Avoid allowing water runoff to contact spilled material.
- Prevent entry into waterways, sewers, basements or confined areas.

Small Spill

- Cover with DRY earth, DRY sand or other non-combustible material followed with plastic sheet to minimize spreading or contact with rain.
- Use clean non-sparking tools to collect material and place it into loosely covered plastic containers for later disposal.

FIRST AID

- Move victim to fresh air. • Call 911 or emergency medical service.
- Give artificial respiration if victim is not breathing.
- **Do not use mouth-to-mouth method if victim ingested or inhaled the substance; give artificial respiration with the aid of a pocket mask equipped with a one-way valve or other proper respiratory medical device.**
- Administer oxygen if breathing is difficult.
- Remove and isolate contaminated clothing and shoes.
- In case of contact with substance, immediately flush skin or eyes with running water for at least 20 minutes.
- **In case of contact with Hydrofluoric acid (UN1790)**, flush skin and eyes with water for 5 minutes; then, for skin exposures rub on a calcium/gel combination; for eyes flush with a water/calcium solution if available, otherwise continue with water for 15 minutes.
- For minor skin contact, avoid spreading material on unaffected skin.
- Keep victim warm and quiet.
- Effects of exposure (inhalation, ingestion or skin contact) to substance may be delayed.
- Ensure that medical personnel are aware of the material(s) involved and take precautions to protect themselves.

TABLE 1 - INITIAL ISOLATION AND PROTECTIVE ACTION DISTANCES

ID No.	Guide	NAME OF MATERIAL	SMALL SPILLS (From a small package or small leak from a large package) First ISOLATE in all Directions Meters	(Feet)	Then PROTECT persons Downwind during- DAY Kilometers	(Miles)	NIGHT Kilometers	(Miles)	LARGE SPILLS (From a large package or from many small packages) First ISOLATE in all Directions Meters	(Feet)	Then PROTECT persons Downwind during- DAY Kilometers	(Miles)	NIGHT Kilometers	(Miles)
1680	**157**	Potassium cyanide **(when spilled in water)**	30 m	(100 ft)	0.1 km	(0.1 mi)	0.2 km	(0.1 mi)	100 m	(300 ft)	0.3 km	(0.2 mi)	1.2 km	(0.8 mi)
1680	**157**	Potassium cyanide, solid **(when spilled in water)**												
1689	**157**	Sodium cyanide **(when spilled in water)**	30 m	(100 ft)	0.1 km	(0.1 mi)	0.2 km	(0.1 mi)	100 m	(300 ft)	0.4 km	(0.2 mi)	1.4 km	(0.9 mi)
1689	**157**	Sodium cyanide, solid **(when spilled in water)**												
1694	**159**	CA **(when used as a weapon)**	30 m	(100 ft)	0.1 km	(0.1 mi)	0.4 km	(0.3 mi)	100 m	(300 ft)	0.5 km	(0.4 mi)	2.6 km	(1.6 mi)
1695	**131**	Chloroacetone, stabilized	30 m	(100 ft)	0.1 km	(0.1 mi)	0.2 km	(0.1 mi)	60 m	(200 ft)	0.4 km	(0.3 mi)	0.8 km	(0.5 mi)
1697	**153**	CN **(when used as a weapon)**	30 m	(100 ft)	0.1 km	(0.1 mi)	0.2 km	(0.1 mi)	60 m	(200 ft)	0.3 km	(0.2 mi)	1.2 km	(0.8 mi)
1698	**154**	Adamsite **(when used as a weapon)**	30 m	(100 ft)	0.1 km	(0.1 mi)	0.3 km	(0.2 mi)	60 m	(200 ft)	0.3 km	(0.2 mi)	1.4 km	(0.9 mi)
1698	**154**	DM **(when used as a weapon)**												
1699	**151**	DA **(when used as a weapon)**	30 m	(100 ft)	0.2 km	(0.1 mi)	0.8 km	(0.5 mi)	300 m	(1000 ft)	1.9 km	(1.2 mi)	7.5 km	(4.7 mi)
1716	**156**	Acetyl bromide **(when spilled in water)**	30 m	(100 ft)	0.1 km	(0.1 mi)	0.2 km	(0.1 mi)	60 m	(200 ft)	0.5 km	(0.3 mi)	1.3 km	(0.8 mi)
1717	**155**	Acetyl chloride **(when spilled in water)**	30 m	(100 ft)	0.1 km	(0.1 mi)	0.3 km	(0.2 mi)	100 m	(300 ft)	1.0 km	(0.6 mi)	2.8 km	(1.7 mi)
1722	**155**	Allyl chlorocarbonate	100 m	(300 ft)	0.4 km	(0.2 mi)	0.9 km	(0.6 mi)	400 m	(1250 ft)	1.5 km	(1.0 mi)	3.0 km	(1.9 mi)
1722	**155**	Allyl chloroformate												

TABLE 2 - WATER-REACTIVE MATERIALS WHICH PRODUCE TOXIC GASES

Materials Which Produce Large Amounts of Toxic-by-Inhalation (TIH) Gas(es)
When Spilled in Water

ID No.	Guide No.	Name of Material	TIH Gas(es) Produced
1162	155	Dimethyldichlorosilane	HCl
1183	139	Ethyldichlorosilane	HCl
1196	155	Ethyltrichlorosilane	HCl
1242	139	Methyldichlorosilane	HCl
1250	155	Methyltrichlorosilane	HCl
1295	139	Trichlorosilane	HCl
1298	155	Trimethylchlorosilane	HCl
1305	155P	Vinyltrichlorosilane	HCl
1305	155P	Vinyltrichlorosilane, stabilized	HCl
1340	139	Phosphorus pentasulfide, free from yellow and white Phosphorus	H_2S
1340	139	Phosphorus pentasulphide, free from yellow and white Phosphorus	H_2S
1360	139	Calcium phosphide	PH_3
1384	135	Sodium dithionite	H_2S SO_2
1384	135	Sodium hydrosulfite	H_2S SO_2
1384	135	Sodium hydrosulphite	H_2S SO_2
1397	139	Aluminum phosphide	PH_3
1419	139	Magnesium aluminum phosphide	PH_3
1432	139	Sodium phosphide	PH_3
1541	155	Acetone cyanohydrin, stabilized	HCN
1680	157	Potassium cyanide	HCN
1680	157	Potassium cyanide, solid	HCN
1689	157	Sodium cyanide	HCN
1689	157	Sodium cyanide, solid	HCN

Chemical Symbols for TIH Gases:

Br_2	Bromine	HF	Hydrogen fluoride	NO_2	Nitrogen dioxide
Cl_2	Chlorine	HI	Hydrogen iodide	PH_3	Phosphine
HBr	Hydrogen bromide	H_2S	Hydrogen sulfide	SO_2	Sulfur dioxide
HCl	Hydrogen chloride	H_2S	Hydrogen sulphide	SO_2	Sulphur dioxide
HCN	Hydrogen cyanide	NH_3	Ammonia		

APPENDIX C

SPILL REPORT FORM

1	DATE OF SPILL: Click here to enter a date.	TIME OF SPILL:	
2	LOCATION OF SPILL:	SITE CONDITIONS (TEMPERATURE, WIND, GROUND PERMEABILITY, ETC.):	
3	SAFETY HAZARDS (FIRE, FUMES, EXPLOSIVE SUBSTANCES, ETC.):		
4	TYPE OF PRODUCT SPILLED: OIL ☐ GASOLINE ☐ DIESEL ☐ OTHER ☐ _____ QUANTITY RELEASED (IN LITERS):		
5	CAUSE OF THE SPILL (E.G., BROKEN HOSE, VEHICLE ACCIDENT):		
6	ACTIONS TAKEN TO DATE TO CONTAIN, RECOVER OR DISPOSE OF THE SPILLED PRODUCT AND CONTAMINATED MATERIALS:		
7	ENVIRONMENTAL RISK (DESCRIBE DISTANCE TO NEAREST WATER BODY, SENSITIVE HABITAT, ETC.): LOW ☐ MEDIUM ☐ HIGH ☐		
8	SAMPLES TAKEN:		
9	SUBSEQUENT ACTIONS REQUIRED TO CONTAIN, RECOVER OR DISPOSE OF THE SPILLED PRODUCT AND CONTAMINATED MATERIALS:		
10	RECOMMENDATIONS FOR IMPROVEMENTS/PREVENTATIVE MEASURES:		
11	COMPANY/CONTRACTOR INVOLVED:		FRONT LINE SUPERVISOR:
12	NAME OF ONSITE SUPERVISOR(S) AT THE TIME OF SPILL:	13	IS THE SPILL REPORTABLE AS PER REPORTABLE SPILL THRESHOLDS? YES ☐ NO☐ IF YES, FILL OUT BOX 16. IF NO, STOP AFTER BOX 14.

14	**INTERNAL REPORTING SEQUENCE:** FIRST OBSERVER: NAME _____ COMPANY _____ REPORTED TO: NAME _____ COMPANY _____ DATE/TIME _____ REPORTED TO ENVIRONMENTAL DEPARTMENT: NAME _____ BY WHOM _____ DATE/TIME _____ REPORTED TO MANAGEMENT (MINE MANAGER OR ALTERNATE): NAME _____ BY WHOM _____ DATE/TIME _____
15	**EXTERNAL REPORTING SEQUENCE:** REPORTED TO 24-HOUR YUKON SPILL HOTLINE (867) 667-7244: BY WHOM _____ TO WHO _____ DATE/TIME _____ REPORTED TO SELKIRK FIRST NATION (867) 537-3331: BY WHOM _____ TO WHO _____ DATE/TIME _____ REPORTED TO LITTLE SALMON CARMACKS FIRST NATION (867) 863-5576: BY WHOM _____ TO WHO _____ DATE/TIME _____ REPORTED TO TR'ONDËK HWËCH'IN FIRST NATION (867) 993-7145: BY WHOM _____ TO WHO _____ DATE/TIME _____ REPORTED TO YUKON GOVERNMENT – CLIENT SERVICES (867) 456-3852: BY WHOM _____ TO WHO _____ DATE/TIME _____ DETAILED WRITTEN REPORT TO YWB, EMR, ENVIRONMENT CANADA AND FIRST NATIONS (REQUIRED WITHIN 10 DAYS OF SPILL): DATE SUBMITTED _____ BY WHOM _____

PHOTOS

	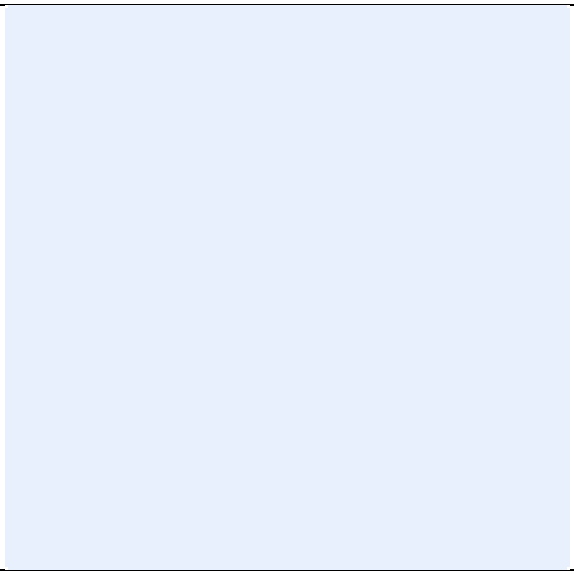
PHOTO 1: DESCRIPTION Click here to enter a date.	PHOTO 2: DESCRIPTION Click here to enter a date.
PHOTO 3: DESCRIPTION Click here to enter a date.	PHOTO 4: DESCRIPTION Click here to enter a date.

PHOTO 5: DESCRIPTION Click here to enter a date.	PHOTO 6: DESCRIPTION Click here to enter a date.
PHOTO 6: DESCRIPTION Click here to enter a date.	PHOTO 7: DESCRIPTION Click here to enter a date.

APPENDIX A.22C: Sediment and Erosion Control Management Plan



Supplementary Information Report A

to the Proposal for the Casino Project

submitted by Casino Mining Corporation

on January 3, 2014

Pursuant to the
Yukon Environmental and Socio-economic Assessment Act

March 2015

A.22C – SEDIMENT AND EROSION CONTROL MANAGEMENT PLAN

The Casino Mine Project is an approximately 22 year mine project owned and operated by Casino Mining Corporation (CMC), that will produce copper and molybdenum concentrates, and gold dore bars via flotation milling and heap leach processing, respectively. The proposed project includes a four year construction period and a 90 year post-closure period. Key project components include the open pit, tailings management facility and waste rock storage area, heap leach facility, mill and associated infrastructure, ore stockpiles, liquefied natural gas power generating infrastructure, and office and accommodation buildings. The project also requires a 120 km access road from the town of Carmacks, YT, and concentrate will be trucked to the port at Skagway, Alaska.

The objective of the Sediment and Erosion Control Management Plan (the Plan) is to control run-off, minimize erosion on exposed slopes and substrates, and prevent inputs of silt or sediment into watercourses during all phases of the Project. Erosion control measures are those designed to prevent exposed soil particles from becoming detached and transported by water or wind. Best management practices will be the primary tool used to mitigate erosion and sedimentation risks. The Plan will provide specific details on what types of erosion and sedimentation control measures will be used and where and when they will be applied. It will describe the requirements for inspection, cleaning, repair and ultimately removal of the erosion and sediment control measures.

The Plan contained herein is a preliminary draft, which will be updated as the project is refined, and has been derived from *Plan Requirement Guidance for Quartz Mining Projects*. The final Plan will provide an overview of the project, described the areas where erosion may be a concern, and provide specific monitoring and management strategies for addressing the areas of concern.

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ABBREVIATIONS

Abbreviation	Definition
BMP	Best management practices
CMC	Casino Mining Corporation
The Plan	Casino Project Sediment and Erosion Control Management Plan
TMF	Tailings management facility

REVISION SUMMARY

Version	Date	Revision notes	Revision authors
Conceptual draft	January 2014	YESAB Project Proposal Submission version	CMC
Preliminary draft	January 2015	Updated to provide more details, as requested by reviewers in the YESAB adequacy review	CMC

A.22C.1 INTRODUCTION

The Casino Mine Project is a proposed 22 year mine project owned and operated by Casino Mining Corporation (CMC), that will produce copper and molybdenum concentrates, and gold dore bars via flotation milling and heap leach processing, respectively. The proposed project includes a four year construction period and an approximately 7 year post-closure period. The location of the Project is shown on Figure A.22C.1-1. Key project components include the open pit, tailings management facility and waste rock storage area, heap leach facility, mill and associated infrastructure, ore stockpiles, liquefied natural gas power generating infrastructure, and office and accommodation buildings. The project also requires a 120 km access road from the town of Carmacks, YT, and concentrate will be trucked to the port at Skagway, Alaska.

The objective of the Sediment and Erosion Control Management Plan (the Plan) is to control run-off, minimize erosion on exposed slopes and substrates, and prevent inputs of silt or sediment into watercourses during all phases of the Project. Erosion control measures are those designed to prevent exposed soil particles from becoming detached and transported by water or wind. Sediment is comprised of soil particles resulting from erosion; sedimentation is the deposition of the transported sediment. Best management practices will be the primary tool used to mitigate erosion and sedimentation risks. The Plan will provide specific details on what types of erosion and sedimentation control measures will be used and where and when they will be applied. It will describe the requirements for inspection, cleaning, repair and ultimately removal of the erosion and sediment control measures.

The final Plan will describe the measures to be undertaken to manage erosion and sedimentation during all phases of the Project. To achieve these objectives, CMC will:

- Comply with applicable federal and territorial legislation, Project permits, licences and approvals;
- Understand the potential for erosion to occur by identifying all potential erosion and sediment sources prior to undertaking any activities that will disturb ground;
- Adopt a multi-barrier approach for erosion and sedimentation control measures; and
- Inspect and maintain sedimentation control equipment and infrastructure, and remove once work is complete.

The protection of the natural environment and management of environmental risk from erosion and sedimentation in the Yukon is governed by the *Quartz Mining Act*, *Waters Act*, *Lands Act and Territorial Lands Act,* and the *Environment Act*. Additionally, sediment and sediment laden water can be considered a deleterious substance under Section 34 of the federal *Fisheries Act*.

Guidance documents relevant to the topic include:

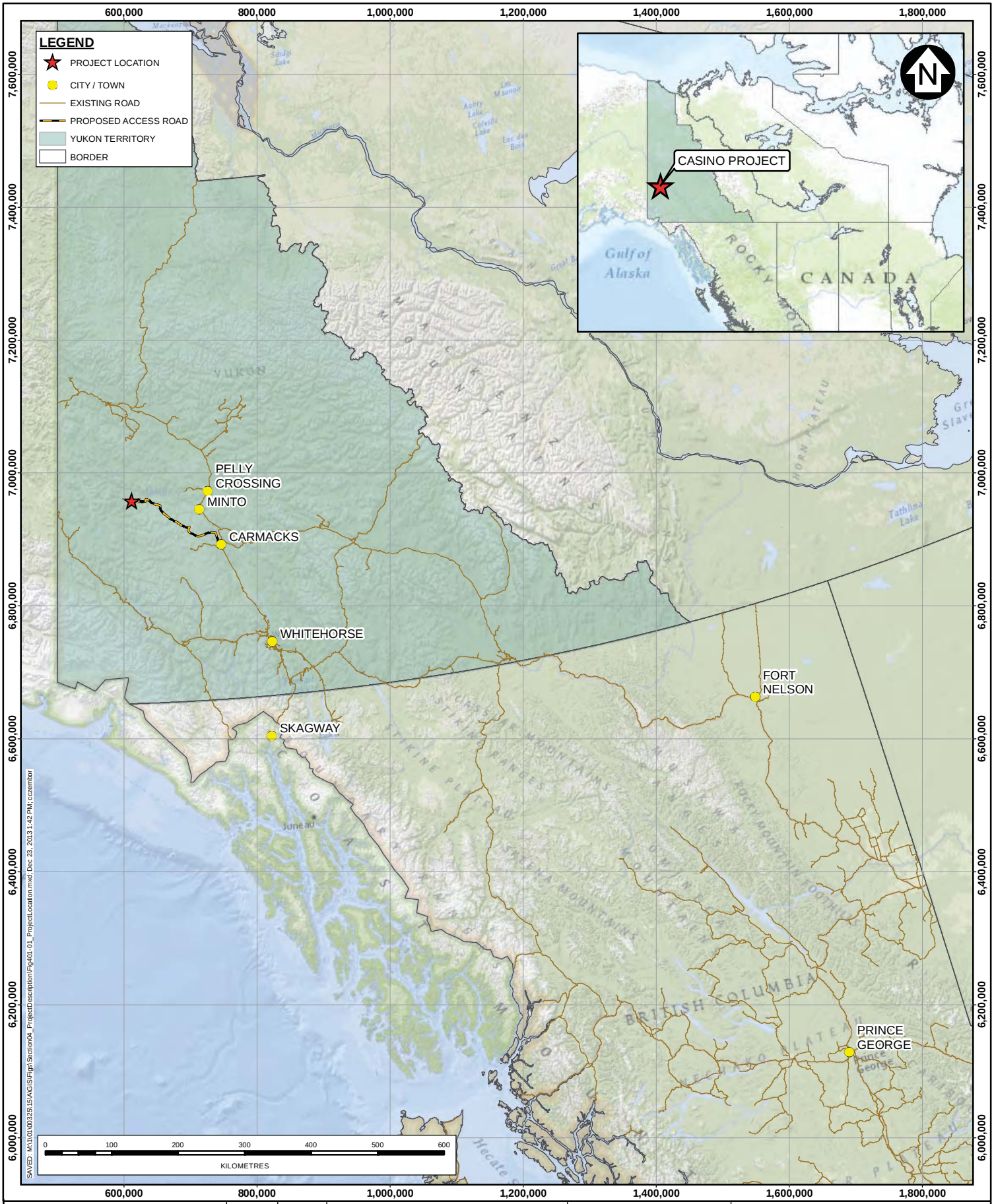
- Environmental Code of Practice for Metal Mines. Environment Canada. 2009;
- Canadian Environmental Quality Guidelines. Canadian Council of Ministers of the Environment (Guidelines for Canadian Drinking Water Quality, Recreational Water Quality, Protection of Aquatic Life, Agricultural Water Uses, as applicable); and
- Best Management Practices for Works Affecting Water in Yukon (Yukon Environment 2011).

Potential adverse effects from erosion and sedimentation can be minimized through project planning, following BMPs, and providing site specific controls that are commensurate with the potential risks to the natural environment. The Plan will provide a detailed description of the methods of sedimentation and

erosion prevention and control that will be used, the specific situations that they will be used in, and the implementation procedures that will be followed. The Plan will include details regarding:

- The appropriate location of control measures;
- The timing of installation, inspection and maintenance of control measures; and
- The responsible parties for implementation, operation, modification, inspection and maintenance control measures.

The Plan contained herein is a preliminary draft, which will be updated as the project is refined, and has been derived from *Plan Requirement Guidance for Quartz Mining Projects* (Government of Yukon, 2013). The final Plan will provide an overview of the project, described the areas where erosion may be a concern, and provide specific monitoring and management strategies for addressing the areas of concern. The final Plan will include a table of proponent commitments made during the environmental assessment process relevant to erosion and sedimentation management, and indicate how the Plan addresses the commitments. Terms and conditions of any applicable licences, permits and approvals required for the Project operations will also be included, once acquired.



PREPARED BY:

Knight Piésold CONSULTING

DESIGNED	GLS/CAH
DRAWN	CC
CHK'D	CAH
APP'D	GLS
REV	0
DATE	16DEC'13

NOTES:

1. BASE MAP: ARCGIS ONLINE NATIONAL GEOGRAPHIC MAPPING
2. PROJECTION: NAD 1983 UTM ZONE 7N
3. COORDINATE GRID: METRES

CASINO

CASINO PROJECT

PROJECT LOCATION

FIGURE A.22C.1-1

REF 1

P/A VA101-325/15

A.22C.2 MONITORING STRATEGIES

Monitoring of relevant water quality and sediment parameters in any receiving environment is included as a component of the *Casino Environmental Monitoring, Surveillance and Reporting Plan*. The frequency of erosion and sedimentation control monitoring and receiving environment monitoring will be established following Project permitting in consultation with regulatory agencies.

Monitoring will generally comprise of regular monitoring of key areas identified to be at high risk for erosion or sedimentation and follow up monitoring of installed mitigation measures. Periods of high flows (e.g., during spring melt/freshet periods, or high precipitation events) will also require monitoring of implemented best management practices (described in Section 4 -). Frequent and proper maintenance will allow for prolonged use instead of allowing the measures to be destroyed and in need of full replacement.

Silt fences, sediment traps/basins, ditches, culverts, exfiltration areas, and water management ponds will be visually inspected for the following:

- Excess sediment build-up;
- Structural/physical integrity; and
- Anticipated wear and tear.

Sediment removal and proper disposal shall be conducted as required.

A.22C.3 EROSION AND SEDIMENT SOURCES

While risks of erosion or sedimentation at the Project are greatest during the construction phase of the project, there are also operational considerations to be monitored to minimize the erosion and sedimentation potential of constructed infrastructure. Areas where erosion or sedimentation may be a concern during all phases of the Project are summarized in Table A.22C.3-1. Operational phases include construction (years -4 to -1), operations (years 1 to 22), post-closure (years 23 – 30) and closure (years 31+).

Generally, areas most at risk for erosion and sediment transport include steep slopes with high potential for wind and water induced erosion, exposed permafrost areas or areas where the vegetative mat has been removed resulting in thaw and fluidized movement of soils and overburden, and heavily trafficked areas.

Potential effects from the above activities in the absence of planned mitigation measures include:

- Increased surface erosion from disturbed and rehabilitated areas;
- Increased sediment load entering the natural water system; and
- Siltation or erosion of ditches and watercourses.

Table A.22C.3-1Potential Erosion and Sedimentation Sources

Erosion and Sedimentation Sources	Operational Period			
	Construction	Operations	Post-Closure	Closure
Land clearing and topsoil stripping	X	X		
Stockpiling of topsoil and ice-rick materials	X	X		
Ground disturbance to build access road	X			
Pit excavation, site grading and land filling	X	X		
Construction of roads, bridges, and culverts	X	X		
Construction of the TMF, waste rock dumps, and heap leach facility	X	X		
Ground disturbance during decommissioning of mine site infrastructure and access roads			X	
Particulate matter deposition caused by vehicle traffic within the mine site area and along the access roads	X	X	X	
Runoff from ore and topsoil stockpiles	X	X	X	

A.22C.4 EROSION AND SEDIMENT CONTROL MEASURES

Potential adverse effects from erosion and sedimentation can be minimized through project planning, following best management practices (BMPs), and providing site specific controls that are commensurate with the potential risks to the natural environment. The following BMPs will be followed:

- Ensure contractors and staff understand the objectives of the Sediment and Erosion Control Management Plan;
- Make the Sediment and Erosion Control Management Plan flexible and adaptable to different project areas, phases and risks;
- Adopt a multi-barrier approach to provide erosion and sediment control;
- Maintain a vegetated buffer between construction and any waterbodies where possible;
- Retain existing vegetation and stabilize exposed soils with vegetation where possible;
- Limit the duration of soil exposure and phase construction when possible;
- Limit the extent of disturbed areas by minimizing nonessential clearing and grading;
- Minimize slope length and gradient of disturbed areas;
- Stabilizing and re-vegetating disturbed areas following construction, as appropriate;
- Delineate areas that are susceptible to erosion (e.g., silty soils, long steep slopes);
- Stockpile topsoil away from watercourses, drainage features, and tops of steep slopes;
- Designing appropriate sediment settling ponds that conform to BC MELP (2001) guidelines;
- Designing appropriate diversion ditch systems to minimize contact water;
- Designing appropriate collection ditch systems to collect contact water;
- Assess all erosion and sedimentation control measures before and after all significant rainfall and snowmelt events to ensure they are functioning as designed;
- Monitoring of TSS and turbidity during construction to ensure compliance with regulatory guidelines (<25 mg/L increase if background levels are less than 250 mg/L, <10% increase if background levels are greater than 250 mg/L; (CCME, 2002)); and
- Using dust suppressants and enforcing traffic speed limits along all access roads.

The main methods for erosion and sedimentation control include prevention, through water management, and control, through various sediment control techniques, as discussed below.

A.22C.4.1 PREVENTION

The primary method of preventing erosion and preventing sediment laden water from entering watercourses is to limit the footprint near waterbodies and to maintain a vegetated buffer between construction activities and the watercourse. This method also protects riparian vegetation and aquatic habitat.

The water management objective during construction is to safely convey and/or detain the respective design storm event at each facility, while maintaining water quality at background levels or meeting water quality standards in the receiving environment. The primary means of achieving this objective will require the diversion of non-contact runoff, and erosion source control (i.e., minimizing total suspended sediment levels in runoff from construction areas). Water will be controlled in a manner that minimizes erosion in areas disturbed by construction activities and prevents the release of construction water which could adversely affect the quality of receiving waters.

Water will be controlled in a manner that minimizes erosion in areas disturbed by construction activities and prevents the release of sediment laden water to the receiving environment. Design criteria for the various sediment control elements will be based on industry standard guidance documents (BC MELP, 2001; BC Ministry of Energy and Mines, 1998). Sediment mobilization and erosion will be managed throughout the site by installing sediment controls (see Section 4.2) prior to construction activities, limiting the disturbance as much as possible and reducing water velocity across the ground, particularly on exposed surfaces and in areas where flow tends to concentrate. During operations, diversion ditches will be established and disturbed land surfaces will be stabilized to minimize erosion. This will be achieved by implementing progressive rehabilitation of disturbed land, construction drainage controls to improve stability, promoting infiltration, constructing appropriate sediment control devices and restricting access to rehabilitated areas.

Numerous design elements that have been included in the Project design include:

- **Maintaining vegetated buffers**: Wherever possible, vegetated buffers will be maintained between construction activities and waterbodies. Buffers may range from 10 m to 30 m, depending on the size and nature of the waterbody. The Project footprint near waterbodies will also be limited to the extent possible.
- **Coffer dams and pumping systems:** A coffer dam will be constructed with the TMF starter footprint to capture all runoff from the upstream areas and route it to the sediment pond downstream.
- **Sediment and erosion control elements and BMPs:** Typical BMPs that will be used at the project are maintaining vegetated buffers, runoff collection ditches, energy dissipaters, sediment traps, slope drains, surface roughening, filter bags, water bars, diversion structures, silt fences, sediment basins, temporary seeding, and mulching.
- **Sediment settling and water collection ponds:** Temporary sediment settling ponds will be constructed downstream of all construction activities to treat sediment laden water and discharge to existing channels via energy dissipating structures. Collection ponds will also be constructed at the toe of all stockpiles.
- **Water management pond:** This pond will collect surface runoff and seepage from the TMF embankments during operations and pump the water back to the TMF.
- **Winter seepage mitigation pond:** This pond will function as a mitigation measure at closure to store seepage from the TMF during the winter months (December to April) when there is no dilution from surface water runoff in Casino Creek.

A.22C.4.2 CONTROL

Erosion control BMPs reduce erosion potential by stabilizing exposed soil or reducing surface runoff flow velocities. There are generally two types of erosion control BMPs that are used:

- Source control BMPs for protection of exposed surfaces; and
- Conveyance BMPs for control of runoff.

Experience and adaptive management are integral to the successful selection of the appropriate BMPs and the design and implementation of an overall erosion and sediment control plan. Erosion control BMPs will be implemented prior to and during construction to minimize erosion and sediment discharge into surrounding areas. Typical BMPs that will be used at the project are:

• Runoff collection ditches	• Water bars
• Energy dissipaters	• Diversion structures
• Sediment traps	• Silt fences
• Slope drains	• Sediment basins
• Surface roughening	• Temporary seeding
• Filter bags	• Mulching

A.22C.4.2.1 Collection Ditches

A runoff collection ditch intercepts construction water runoff and diverts it to a stabilized area where it can be effectively managed. Collection ditches are used within construction areas to collect runoff and convey it to appropriate sediment control measures. General locations and conditions may include:

- Below disturbed slopes to divert sediment-laden water to control facilities;
- At or near the perimeter of the construction area to prevent sediment-laden runoff from leaving the site; and
- Below disturbed areas to prevent erosion before stabilization is achieved.

Collection ditches may be either temporary or permanent structures. Temporary collection ditches for construction will be sized to convey the runoff from a 10 year return period 24-hour storm event assuming that the entire footprint area has been disturbed and contributes sediment laden runoff to the sediment control and water management ponds. Collection ditches will be inspected and maintained regularly to remove any blockages to flow (accumulated sediment, debris, etc.) that may occur.

A.22C.4.2.2 Energy Dissipators

Energy dissipators are typically riprap lined plunge pools used to dissipate the energy of fast flowing water and prevent erosion of natural stream channels downstream. These structures are used in conjunction with diversion and collection ditches, and are typically located upstream of the receiving waterbody (e.g. stream, pond, lake, etc.). Energy dissipators will be inspected and maintained regularly to remove any blockages to flow (accumulated sediment, debris, etc.) that may occur.

A.22C.4.2.3 Sediment Traps

Sediment traps are typically constructed within collection ditches to detain sediment-laden runoff long enough to allow the majority of the sediment to settle out. The exact locations and final geometry of each trap will be field fitted to integrate with the terrain to minimize disturbance. Water from sediment traps will flow to holding ponds, sediment basins or other BMP structures. The sediment traps will be inspected regularly for sediment accumulation. Maintenance will include the removal of sediment if the sediment trap has accumulated sediment to one half of the wet storage. If the sediment trap is clogged by sediment and/or debris, the trap will be removed and cleaned, or replaced.

A.22C.4.2.4 Slope Drains

Slope drains consist of flexible tubing or conduit and are required to convey concentrated runoff into the appropriate BMP structure when ditches are deemed impractical. Slope drains shall be sized according to estimates of peak flows, which are dependent on contributing drainage area. Slope drains will be inspected and maintained regularly and any blocked or damaged parts will be cleaned, repaired, or removed and replaced.

A.22C.4.2.5 Surface Roughening

Cut and fill slopes will be roughened with tracked machinery where appropriate to reduce runoff velocity and erosion, increase infiltration, and aid in the establishment of vegetative cover with seeding. The roughening will be carried out by a tracked machine moving up and down the slope surfaces, creating undulations on the soil surface. This procedure is simple and inexpensive, and it provides immediate short-term erosion control for bare soil where vegetative cover is not yet established. A rough soil surface provides favorable moisture conditions that will aid in seed germination.

A.22C.4.2.6 Filter Bags

Filter bags are generally constructed from a sturdy non-woven geotextile capable of filtering particles larger than 150 microns. Filter bags are to be installed at the discharge end of pumped diversion pipelines, via fabric flange fittings, to remove fine grained materials such as silt before discharging water to the environment. Filter bags should be installed on flat, stable, non-erodible foundations, or in well vegetated areas. The pumping rate shall be no greater than specified by the manufacturer. Discharge from filter bags will be routed to minimize erosion. A smaller variety of filter bags, referred to as filter socks, can be installed on the discharge ends of gravity flow pipes, such as slope drains, to filter silt particles before discharging water to the environment.

A.22C.4.2.7 Waterbars

Waterbars serve to reduce sheet flow and surface erosion of areas of exposed soil and/or roads by diverting runoff towards a stable vegetated area or collection ditch. Spacing of waterbars will be field fitted based on the slope grade and general erodibility of the surface. Waterbars must not direct runoff into a ditch that will channel water toward the watercourse unless the ditch is adequately prepared with check dams and armouring, where appropriate. Waterbars may require regular maintenance when subjected to frequent traffic crossings.

A.22C.4.2.8 Diversion Structures

A temporary diversion structure consists of sandbags stacked in a pyramid formation with a polyethylene sheet placed diagonally in between the bags. Temporary diversion structures are useful for diverting concentrated overland flows to an appropriate sediment basin or other BMP structure where it can be effectively managed.

A.22C.4.2.9 Silt Fences

Silt fences are typically sheets of geotextile material installed downslope of erosion-susceptible terrain to prevent sediment-laden sheet flow from entering receiving waters. Drainage pools that form along the uphill side of the fence promote sediment settling. Drainage in contact with the fence is filtered through the geotextile. The small pores of the silt fence will filter coarse particles and restrict water exfiltration rates. Barrier locations are informally chosen based on site features and conditions (e.g. soil types, climate, terrain features, sensitive areas, etc.), design plans, existing and anticipated drainage courses, and other available erosion and sediment controls. Typical barrier sites are catch points beyond the toe of fill material, or on side slopes above waterways or drainage channels. Silt fences are not recommended for wide low-flow, low-velocity drainage ways, for concentrated flows, in continuous flow streams, for flow diversion, or as check dams. Silt fences should be inspected for damage, tears, clogging, or erosion of the surrounding areas. Damaged sections will be repaired or replaced to maintain functionality.

A.22C.4.2.10 Sediment Basins

A sediment basin is a temporary structure that is used to detain runoff from small drainage areas so that sediment can settle out. Sediment basins are generally located in areas where access can be maintained for sediment removal and proper disposal. Sediment basins are typically constructed at the end of collection ditches to detain sediment-laden runoff long enough to allow the majority of the sediment to settle out. A sediment basin can be created by excavating a basin, utilizing an existing depression, or constructing a dam on a slight slope downward from the work area. Sediment-laden runoff from the disturbed site is conveyed to the basin via ditches, slope drains, or diversion structures. The basin is a temporary measure, with a nominal design life of approximately six months, and is to be maintained until the site is permanently protected against erosion by vegetation and/or structures. The size of the temporary sediment basin is dependent on the size of the drainage area. The exact location and final geometry of each basin should be field fitted to integrate with the terrain to minimize disturbance.

A.22C.4.2.11 Temporary Seeding

Exposed slopes and other disturbed areas will be seeded to establish vegetative cover utilising native grass species. The purpose of temporary seeding is to stabilize the soil and reduce damage from wind and/or water until permanent stabilization is accomplished. Seeding is applicable to areas that are exposed and subject to erosion for more than 30 days, and is usually accompanied by surface preparation, fertilizer, and mulch; however, the timing of seeding is weather and season dependent and consequently this method is not applicable at all times. Temporary seeding may be accomplished by hand or mechanical methods, or by hydraulic application (hydroseeding), which incorporates seed, water, fertilizer, and mulch into a homogeneous mixture (slurry) that is sprayed onto the soil.

A.22C.4.2.12 Mulching

Mulching is the application of a uniform protective layer of straw, wood fiber, wood chips, or other acceptable material on or incorporated into the soil surface of a seeded area to allow for the immediate protection of the seed bed. The purpose of mulching is to protect the soil surface from the forces of raindrop impact and overland flow, foster the growth of vegetation, increase infiltration, reduce evaporation, insulate the soil, and suppress weed growth. Mulching helps to hold fertilizer, seed, and topsoil in place in the presence of wind, rain, and runoff, and reduces the need for watering. Mulching may be utilized in areas that have been seeded either for temporary or permanent cover.

There are two basic types of mulches: organic mulches and chemical mulches. Organic mulches likely to be used include straw, hay, wood fiber, wood chips, and bark chips. This type of mulch is usually spread by hand or by machine (mulch blower) after seed, water, and fertilizer have been applied. Chemical mulches, also known as soil binders or tackifiers, are composed of a variety of synthetic materials, including emulsions or dispersions of vinyl compounds, rubber, asphalt, or plastics mixed with water. Chemical mulches are usually mixed with organic mulches as a tacking agent to aid in the stabilization process, and are not used as mulch alone, except in cases where temporary dust and erosion control is required. The choice of materials for mulching should be based on soil conditions, season, type of vegetation, and the size of the area. One example is rolled erosion control blankets woven with degradable or poly netting with straw or coconut mulch, which can be used on steep slopes to provide a permanent or semi-permanent cover.

A.22C.4.3 IMPLEMENTATION SEQUENCE

Specific implementation sequences for water management and erosion and sedimentation control activities will be detailed during detailed engineering of the Project. At that time, this plan will be updated with the sequence of activities that will conducted to minimize erosion and sedimentation of the receiving environment during construction, operations and closure phases of the Project. For example, during construction of the tailings dam, a staged surface dual-ditch system has been designed to collect surface runoff from the embankment in an upslope ditch, and a downslope ditch diverts clean surface runoff. The ditches will be lined with scour protection to prevent erosion of the ditch channels. The exact sequence of ditch construction and lining will be outlined in the updated plan. The sequence of sedimentation basin, diversion ditches, energy dissipaters, sediment traps, etc., will also be detailed in the updated plan, once the exact construction requirements are known.

A.22C.5 REFERENCES

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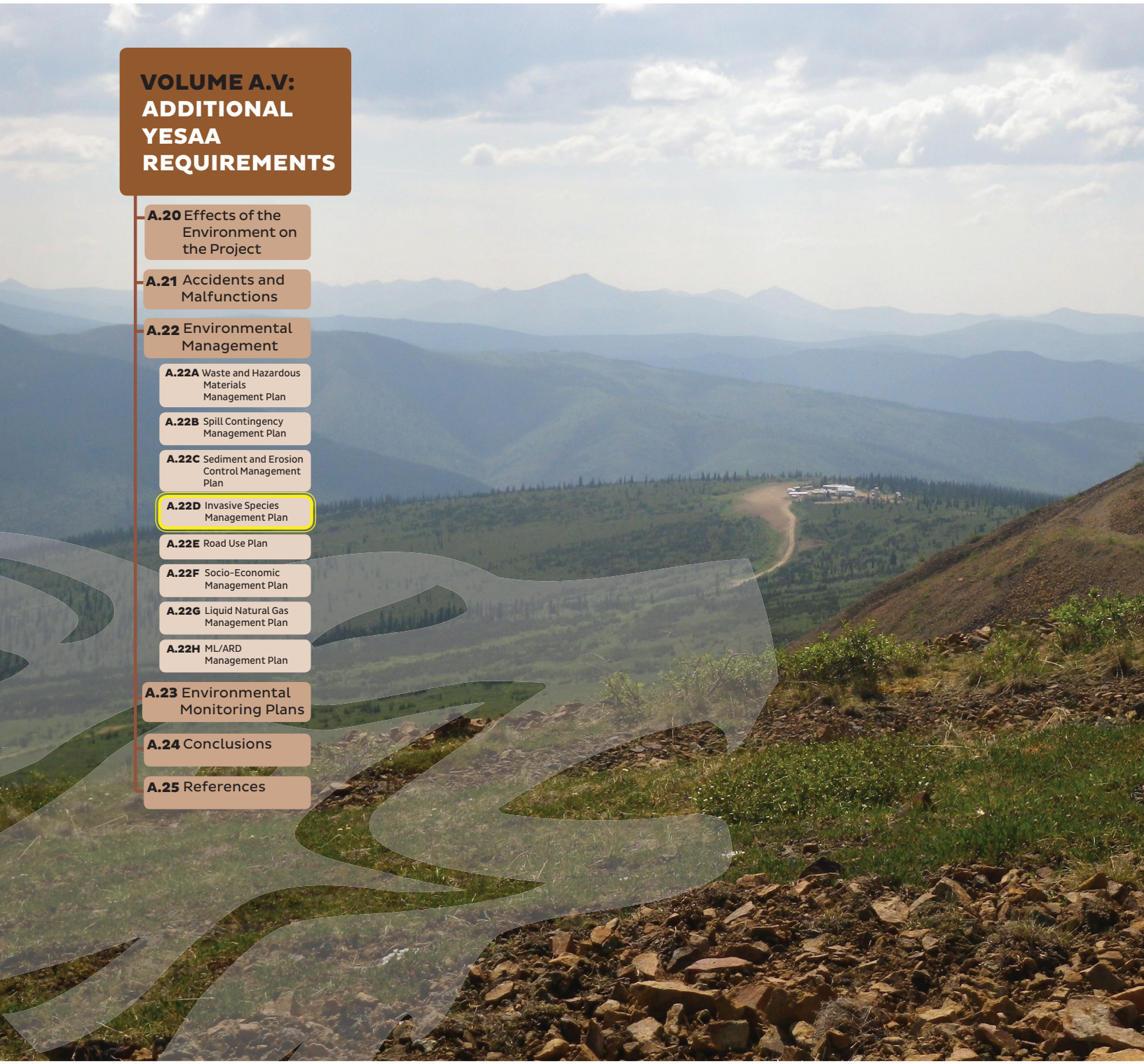
APPENDIX A.22D: Invasive Species Management Plan



CASINO

Supplementary Information Report A

to the Proposal for the Casino Project

submitted by Casino Mining Corporation

on January 3, 2014

Pursuant to the
Yukon Environmental and Socio-economic Assessment Act

March 2015

A.22D – INVASIVE SPECIES MANAGEMENT PLAN

The Casino Mine Project is a copper-gold open pit mine Project that will produce copper and molybdenum concentrates, and gold dore bars via flotation milling and heap leach processing, respectively. The proposed Project has a 22 year mine life, with an additional four year construction period and a 25 year closure period. Baseline monitoring at the site has been conducted since 1993, with comprehensive baseline studies conducted from 2008 through present. Environmental baseline studies and monitoring at the site include surface and ground water quality and hydrology; aquatic monitoring including sediment, benthic invertebrates, periphyton and fish studies; rare plant, ecosystem classification, and vegetation health; as well as extensive wildlife monitoring studies.

The preliminary Invasive Species Management Plan presented herein summarizes the management and monitoring proposed to prevent the introduction and propagation of invasive plant species at the Casino Project. Detailed closure monitoring will be provided in the *Casino Project Closure and Reclamation Plan*.

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Appendix A.22D B Yukon Invaders: Yukon Invasive Plant Species (Yukon Government, 2014)

REVISION SUMMARY

Version	Date	Revision notes	Revision authors
Preliminary Draft	January 2015	Produced for YESAB assessment process	CMC: M.Mioska

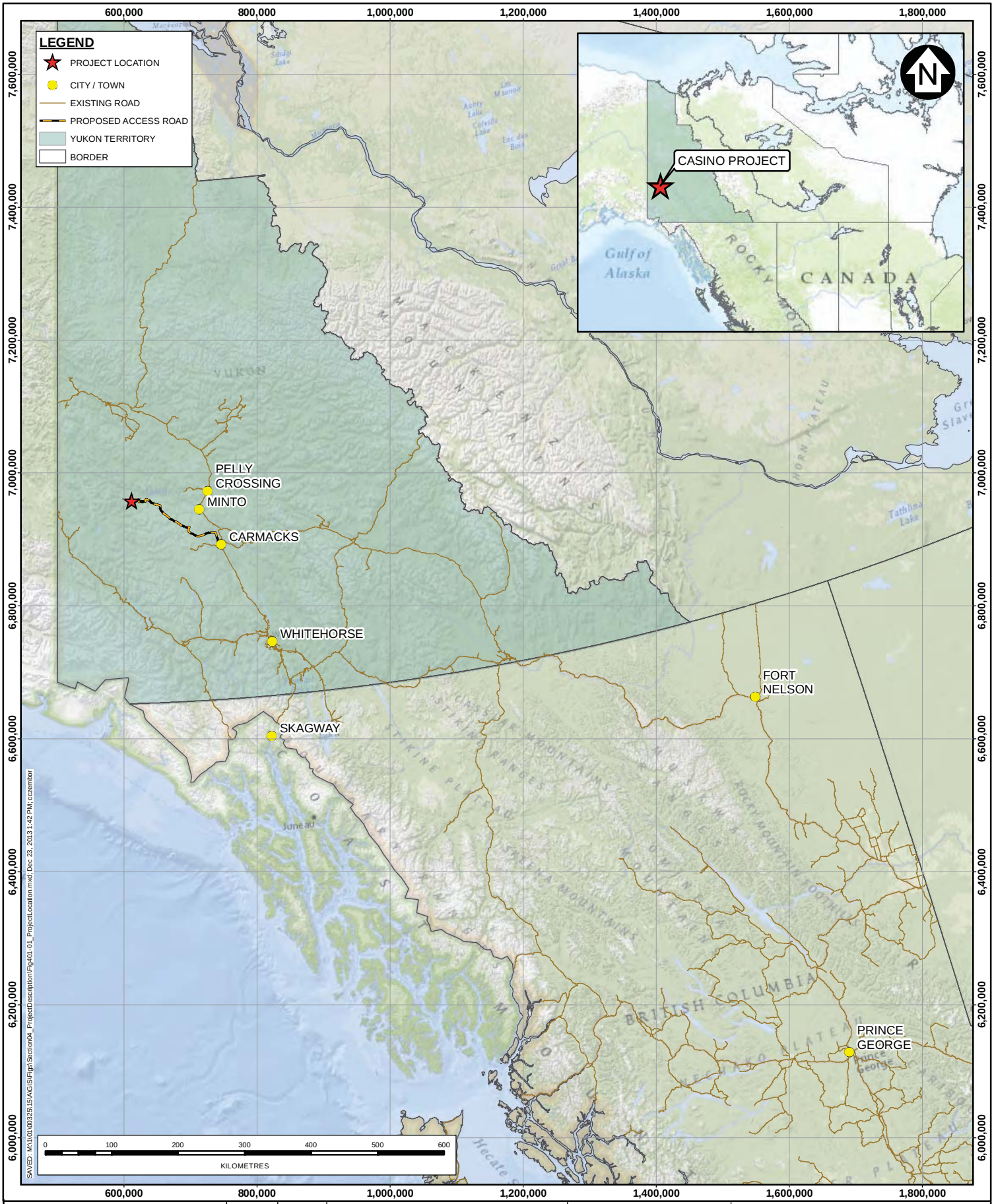
A.22D.1 INTRODUCTION

The Casino Project is a proposed copper-gold open pit mine located 150 km northwest of Carmacks and 300 km from Whitehorse (Figure A.22D.1-1). The Project is designed to process approximately 120,000 t/d of copper and gold ore over a 22 year mine life. Processing of the sulphide ore is via conventional flotation to produce copper and molybdenum mineral concentrates. Processing of oxide ore is via heap leaching and carbon adsorption technology that will produce gold and silver doré bars. Mining waste rock and flotation tailings will be stored sub-aqueously in a tailings management facility (TMF). The TMF will also function as a water storage pond to collect surface runoff and seepage from around the mine site, and provide process water to the ore processing facilities. Supplemental freshwater for processing and camp activities will be provided by a pipeline from the Yukon River. No effluent discharge is proposed for the construction and operations phase of the Casino Project; however, open pit overflow and TMF pond water will be treated with engineered wetlands during the closure phase of the Project. Access to the Project is via the 200 km Freegold Road from Carmacks, of which 80 km is a public use road maintained by the Yukon Government, and the remaining 120 km extension will be a private access road. Major Project infrastructure at the maximum extent of development is shown in Figure 1-2.

The *Casino Project Invasive Species Management Plan* (the Plan) has been developed to support the environmental assessment process, and the Quartz Mining Licence application. Details in this Plan are provided in support of the information provided by the Yukon Invasive Species Council (YISC). It is expected that this plan will evolve as Project permitting advances. The primary objectives of this Plan are to:

1. Develop a management plan to prevent the introduction and propagation of invasive plant species at the Casino Project;
2. Identify invasive plant species, if they establish, through consistent monitoring; and
3. Participate in the Yukon wide early detection and rapid response protocol set forth by the Yukon Invasive Species Council through reporting of identified invasive plants at the mine site.

This preliminary Plan is guided by the Project proposal currently under review with the Yukon Environmental and Socio-economic Assessment Board (YESAB), whereas the ultimate Plan will also be driven by requirements in the Quartz Mining Licence and Type A Water Use Licence required prior to the commencement of mining activities at the Casino Project.



PREPARED BY:

Knight Piésold CONSULTING

DESIGNED	GLS/CAH
DRAWN	CC
CHK'D	CAH
APP'D	GLS
REV	0
DATE	16DEC'13

NOTES:
1. BASE MAP: ARCGIS ONLINE NATIONAL GEOGRAPHIC MAPPING
2. PROJECTION: NAD 1983 UTM ZONE 7N
3. COORDINATE GRID: METRES

CASINO

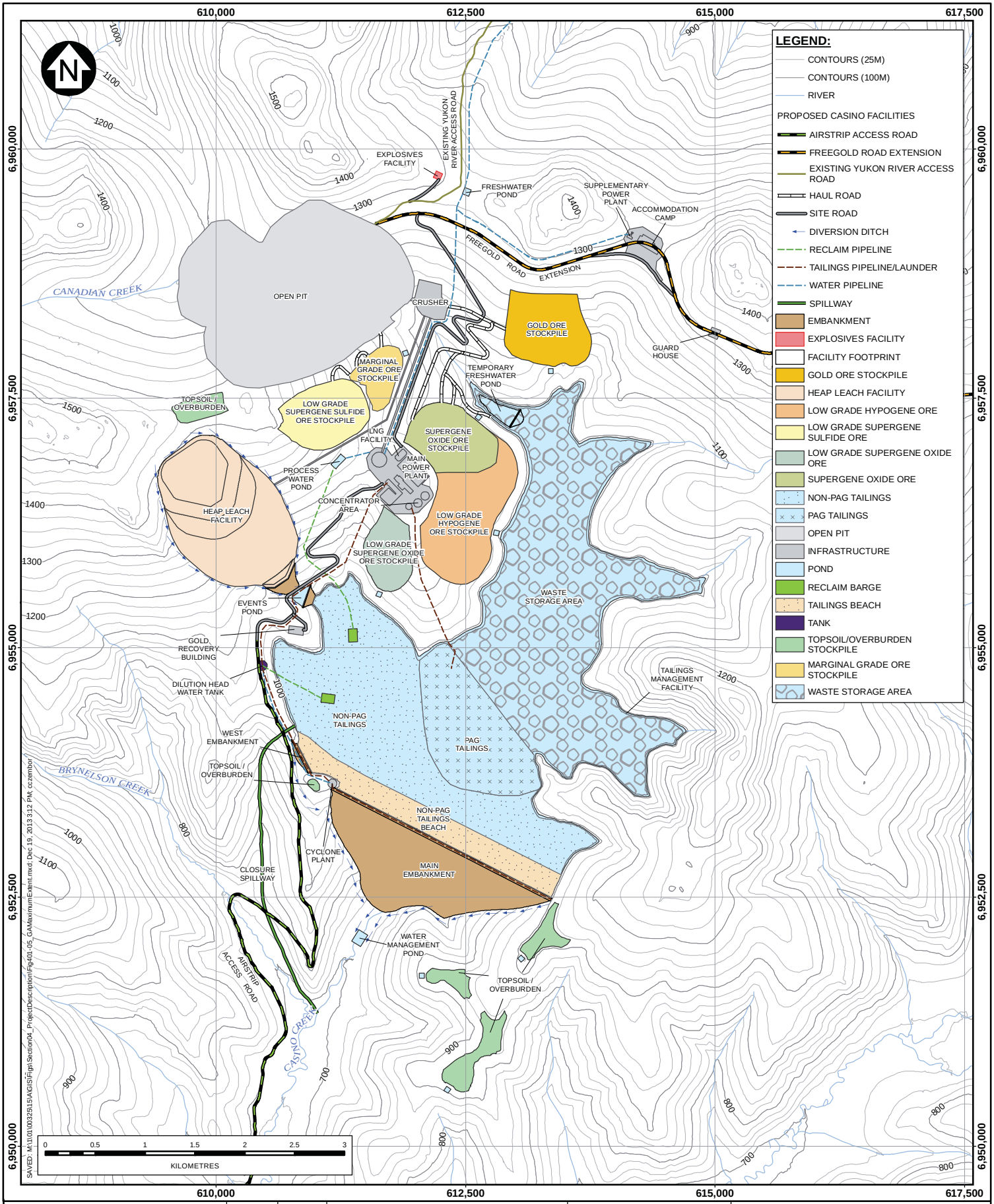
CASINO PROJECT

PROJECT LOCATION

FIGURE A.22D.1-1

REF 1

P/A VA101-325/15



PREPARED BY:

Knight Piésold CONSULTING

DESIGNED	GLS/CAH
DRAWN	CC
CHK'D	CAH
APP'D	GLS
REV	0
DATE	16DEC'13

NOTES:
1. BASE MAP: EAGLE MAPPING
2. PROJECTION: NAD 1983 UTM ZONE 7N
3. COORDINATE GRID: METRES

CASINO

GENERAL ARRANGEMENT - MAXIMUM EXTENT

CASINO PROJECT

FIGURE 1-2

REF 1

P/A VA101-325/15

A.22D.2 INVASIVE SPECIES

Invasive species generally refer to introduced species that have “negative effects on our economy, our environment, or our health” (YISC, 2014). While there are 154 introduced plant species in the Yukon, only 20 are considered invasive. Invasive plants can negatively impact the environment through competition with native plant species, increased erosion and sedimentation and the reduction of forage quality and quantity for animals (YISC, 2014). It is well known that disturbed areas, such as a mine site, can lead to the introduction of invasive plants through transportation mechanisms (i.e., vehicles traveling to the site from other areas) and through re-vegetation (if contaminated or non-native seed mixtures are used for reclamation activities). Consequently, this plan focuses on the management and mitigation of invasive plant species within the Casino Project area.

Within Yukon, there are relatively few invasive species compared to neighbouring jurisdictions, such as British Columbia (BC) and Alaska. Areas with the highest distribution of invasive species are along major highways and at rest stops, campgrounds, gravel pits and disturbed areas adjacent major roadways (Line *et al.,* 2008). A 2007 baseline evaluation of sweetclover (*Melilotus officinalis*) along major highways in Yukon found sweetclover along a number of highways and communities from ranging from Watson Lake north to Dawson City, including major river systems (Line *et al.,* 2008). As shown in Figure 2-1 and Figure 2-2, sweetclover and other non-native plants are found along major roadways that will be used to access the Casino Project (Klondike Highway and Alaska Highway).

The introduction, establishment and spread of invasive species can reduce biodiversity, change ecosystem processes and functions, alter wildlife habitat, accelerate soil erosion, stream sedimentation and reduce productivity and compete with and replace native vegetation, including rare and endangered species (YISC, 2014). Invasive species can be introduced in soil; as seed mixes or erosion control mixes; or from plant products (YISC, 2014). Seeds and viable plant parts can be distributed on equipment, trucks, all-terrain vehicles, boats and in bilge waters (YISC, 2014).

Invasive species have the potential to establish and spread quickly within the Project area and along the Freegold Road. The Project area will be exposed to anthropogenic activities associated with development and resource extraction which could introduce seeds from invasive species. Currently, there is no legislation to manage invasive species in Yukon. BC and Alaska are legislated under the *Weed Control Act* and *Plant Protection Act*, respectively, which places a duty on land occupiers to control designated noxious plants. CMC will exhibit due-diligence to prevent further spread of invasive species in Yukon and will mitigate and monitor areas within the Project area. Activities proposed to prevent, mitigate and monitor for invasive species for the Casino Project are summarized below.

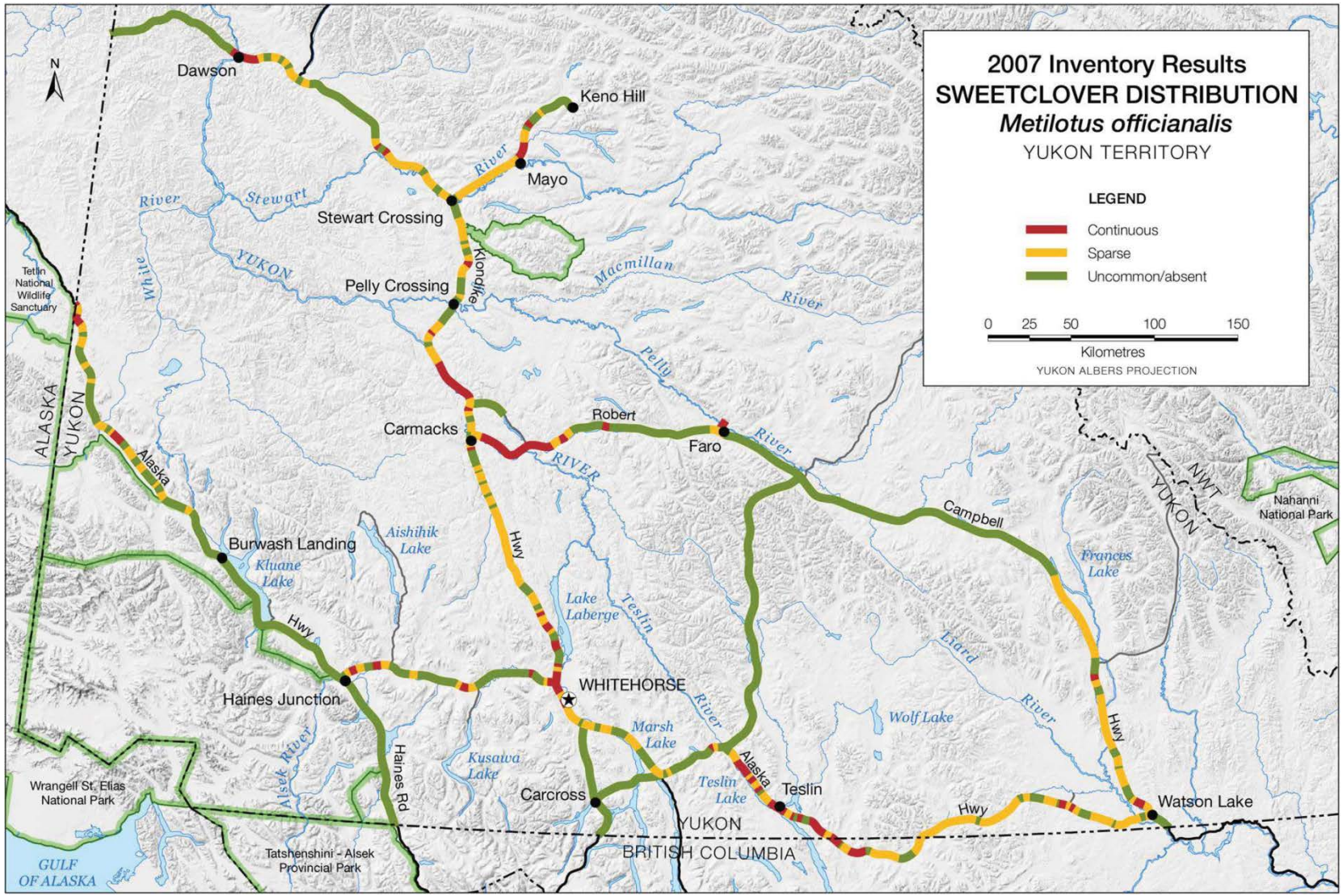


Figure A.22D.2-1 2007 Sweetclover distribution along major Yukon Highways (From Line, et. al., 2008)

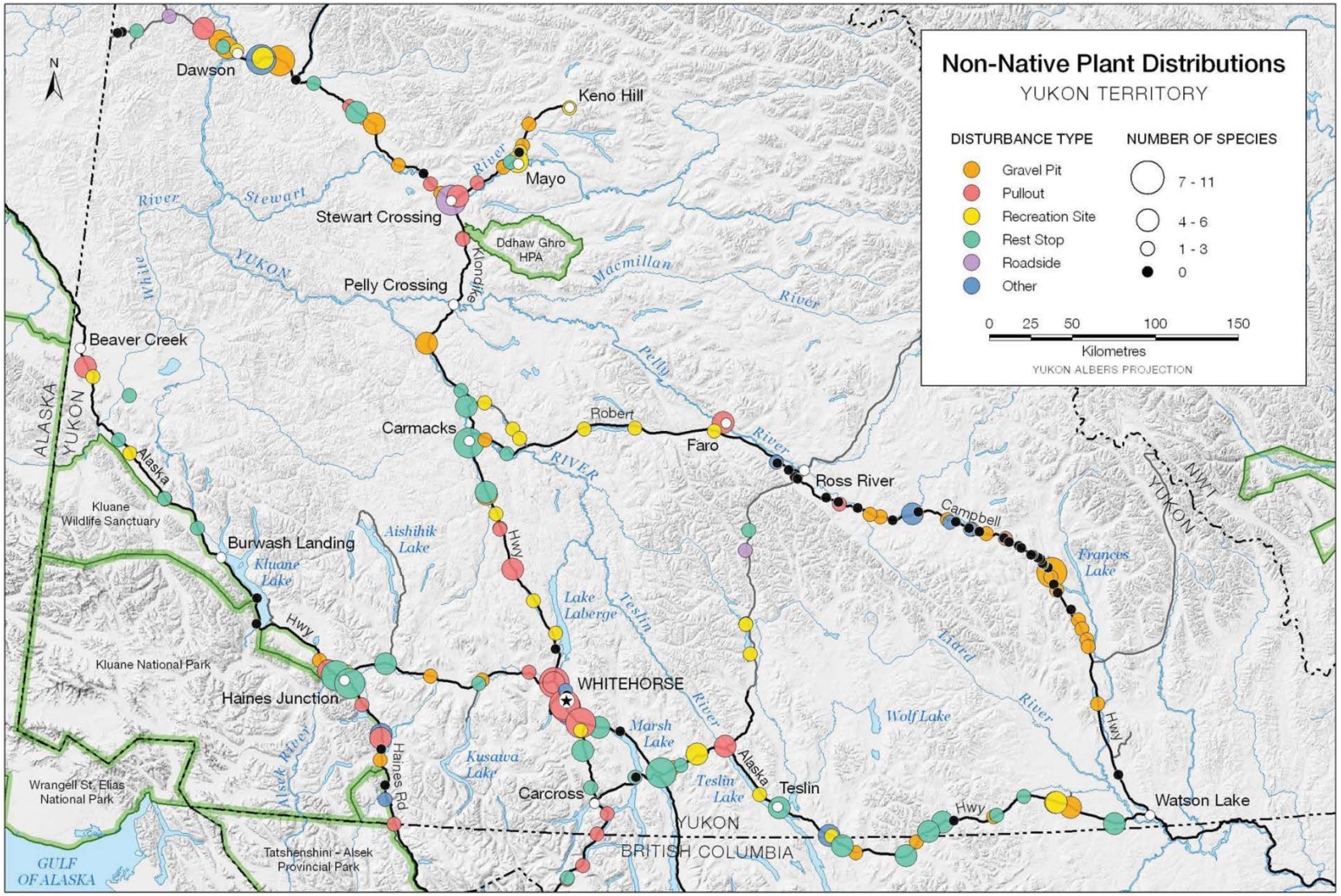


Figure A.22D.2-2 2007 non-native plant distribution along major Yukon Highways (From Line, *et al*., 2008)

A.22D.1.1 Prevention

Prevention is the most cost effective means of controlling invasive species (YISC, 2014). The Casino Project will implement the following measures:

- Minimize disturbance of the natural vegetation and exposure of soils.
- Avoid unnecessary compaction of soils by limiting the use of heavy equipment or vehicles directly after a rain event. Soil compaction issues are lowest when the soil is dry or frozen.
- Wherever possible, vehicle use (including ATVs) will be restricted to roads and existing pathways to limit additional disturbance to ecosystems and plants, and reduce the potential for introduction of invasive species.
- Wherever possible, vehicles entering site will be clean (e.g., no large obvious clods of mud) to limit the spread of invasive plant propagules. This will be monitored as part of the walk around inspection done prior to site access.
- Soil salvage to promote successful reclamation of the natural seed bank, including segregation of topsoil and woody overburden during soil striping. Salvaged soil will be used during reclamation.
- Disturbed and reclaimed areas will be allowed to re-vegetate naturally to reduce the risk of introducing invasive plant species to the region.
- Transplant woody species (e.g. cuttings or entire plant) on exposed surfaces to establish ground cover and reduce the likelihood of invasive plants colonization. Fertilizers may be considered to help the re-establishment of native species.
- Ensure that reclamation/re-vegetation equipment is clean and is not acting as a carrier for invasive plant seeds.
- If the transportation of aggregates is required, avoid sources where invasive species are growing (e.g., gravel from borrow pits with sweetclover colonization).

A.22D.1.2 Monitoring Program

Generally, the introduction of invasive species will be minimized by implementing the above prevention measures. In addition, monitoring efforts will encourage the early detection and rapid response (EDRR) of invasive species to track known populations and direct management efforts. Monitoring of invasive plant species will be done in conjunction with rare plant species monitoring, as detailed in the *Casino Project Environmental Monitoring, Surveillance and Reporting Plan*, although identification of invasive plants should be conducted at the same time as any other environmental monitoring program and during daily tasks around the mine site and access road.

Invasive species monitoring will occur within the Project footprint and adjacent areas to ensure that no invasive species are introduced to the region by the Project. Surveys for invasive plants will be conducted every five years by qualified personnel experienced in plant identification. Additional surveys may be triggered by observations of invasive plant species. Surveys will follow a standardized protocol that will be developed prior to construction. All monitoring efforts will be recorded. If any invasive species are found, management actions will be taken to reduce the distribution of the infestation, which may include

destroying the plant. Prior to construction, the YISC will be consulted for the appropriate actions in the event that invasive species are found, since management actions are species and population specific. The control methods listed for each species in YISC's Yukon Invasives Overview documents will also be consulted. If the pathway of entry can be determined, changes will be made to reduce the possibility of further introduction of invasive species.

The full list of invasive species in the Yukon is provided in Appendix A.22D A and the eight key invasive species are described in Appendix A.22D B (Yukon Government, 2007). If an invasive plant species is identified, then following information will be recorded:

- GPS location
- Species name
- Health and size of the plant
- Pictures (with reference point)
- Percent coverage of the area

A.22D.1.3 Reporting

If invasive plant species are found at the mine site, management actions will be taken, which may include removing and destroying plants using best practices recommended by YISC (867-393-3394). Additionally, reporting to the YISC will be essential to participating in the overall early detection and rapid response protocol required by YISC (YISC, 2014). Should invasive species be identified at the Casino Project, the following activities are to be completed:

1. Report invasive species to the Yukon Invasive Species Council (867-393-3394).
2. Ask for guidelines for collection and disposal of invasive plant material.
3. Record findings in an internal working database for the life of the mine.

A.22D.3 REFERENCES

Line, J., Brunner, G., Rosie, R., & Russell, K. (2008). *Results of the 2007 Invasive Plants Roadside Inventory in Yukon.* Whitehorse: NatureServe Yukon, Environment Yukon.

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APPENDIX A.22D A

YUKON INVASIVE PLANTS (FROM YISC, 2014)

Invasiveness Rank
1 - highly invasive - may displace or replace native ecosystems
2 - aggressive - widespread, persistent, but may not replace native species or change ecosystem function
3 - taxa present in the territory that area not known to be invasive here - but have been found to be invasive in other jurisdictions
4 - has been reported in the territory. Has not been shown to be problematic, may not persist
5 - species that likely don't persist
6 - false reports
7 - native and introduced populations exist

General Abundance
C common - widespread established
F falsely reported,
P possible but not yet documented
R rare known from only 1 or two localities,
U unknown
X possibly not persistent,
? possibly native,

Persistence
1=widespread
2=local
3=not persistent,
4=falsely reported

Alaska Invasiveness Rank
not ranked
<40 = Very Weakly Invasive
40-49 = Weakly Invasive
50-59 = Modestly Invasive
60-69 = Moderately Invasive
70-79 = Highly Invasive
>80 = Extremely Invasive
Ranking from: Matthew L. Carlson, Irina V. Lapina, Michael Shephard, Jeffery S. Conn, Roseann Densmore, Page Spencer, Jeff Heys, Julie Riley, and Jamie Nielsen. 2008.
Invasiveness Ranking System for non-native plants if Alaska. USDA Forest Service Alaska Region R10-TP-143 http://www.fs.fed.us/r10/spf/fhp/invasive/invasiveness%20ranking%20report.pdf
Introduced Plants of the Yukon - Source Cody, 1996 (cody et al 1998, 2000, 2001, 2002, 2003, 2004, 2005) Bennett, B. et al. (2008)
revised by B.A. Bennett December 2011 - this is a tentative list for review purpose only

Invasiveness Rank	Family	Genus	Species	Common Name	Abundance	Persistence	Alaska Rank	Source	Date of first collection
1	Grass family	Agropyron	cristatum	Crested Wheat Grass	C	1	nr	revegetation	1947
4	Grass family	Agropyron	fragile	Siberian Wheat Grass	U	2	nr	revegetation	1949
4	Grass family	Agrostis	capillaris	Colonial Bent Grass	R	2	nr	agriculture, revegetation	1993
3	Grass family	Agrostis	gigantea	Redtop	R	2	nr	revegetation	1916
P	Grass family	Agrostis	stolonifera	Creeping Bent Grass	P	P	nr	revegetation	
5	Grass family	Aira	caryophyllea	Silver Hair Grass	X	3	nr	transportation	1946
5	Grass family	Alopecurus	geniculatus	Water Foxtail	R	2	49	agriculture	1899
3	Grass family	Alopecurus	pratensis	Meadow Foxtail	C	1	52	agriculture	1947
3	Grass family	Avena	fatua	Wild Oasts	R	3	nr	agriculture	1943
5	Grass family	Avena	sativa	Cultivated Oats	X	3	nr	agriculture, transportation	1949
4	Grass family	Bromus	carinatus	California Brome	R	2		revegetation	1995
5	Grass family	Bromus	japonicus	Japanese Brome	X	3		revegetation	2003
5	Grass family	Bromus	racemosus	Bald Brome	X	3		agriculture	1902
1	Grass family	Bromus	inermis	Smooth Brome	C	1	62	agriculture, revegetation	1943
5	Grass family	Bromus	secalinus	Rye Brome	X	3	nr	agriculture	**1902**
5	Grass family	Bromus	tectorum	Downy Brome	X	3	78	agriculture	1916
2	Grass family	Dactylis	glomerata	Orchard Grass	R	3	53	revegetation	2000
5	Grass family	Deschampsia	danthonioides	Annual Hairgrass	X	3	nr	unknown	1902
5	Grass family	Deschampsia	elongata	Slender Hairgrass	X	3	35	transportation (railway)	1902

Invasiveness Rank	Family	Genus	Species	Common Name	Abundance	Persistence	Alaska Rank	Source	Date of first collection
2	Grass family	Elymus	repens	Creeping Wild Rye	U	2	59	revegetation	1949
2	Grass family	Elymus	sibiricus	Siberian Wild Rye	C	1	53	revegetation	1980
3	Grass family	Festuca	rubra ssp. rubra	Red Fescue	C	1		revegetation	
4	Grass family	Festuca	trachyphylla	Hard Fescue	R	2		agriculture	1949
5	Grass family	Hordeum	vulgare	Common Barley	R	3	39	agriculture	1983
1	Grass family	Leymus	angustus	Narrow-leaved (Altai) Lyme Grass	R	2	nr	revegetation	1998
4	Grass family	Lolium	multiflorum	Annual Rye Grass	R	1	41	revegetation	1902
2	Grass family	Lolium	perenne	Perennial Rye Grass	R	1	52	revegetation	1994
5	Grass family	Lolium	temulentum	Bearded Rye Grass	X	3	nr	unknown	1902
1	Grass family	Phalaris	arundinacea	Reed Canary Grass	?	1	83	agriculture, revegetation	1979
5	Grass family	Phalaris	canariensis	Common Canary Grass	X	3	nr	agriculture	1941
4	Grass family	Phleum	pratense	Common Timothy	C	1	54	agriculture	1902
3	Grass family	Poa	annua	Annual Blue Grass	C	1	46	transportation	1968
3	Grass family	Poa	compressa	Canada Blue Grass	U	1	39	revegetation	1980
7	Grass family	Poa	nemoralis	Forest Blue Grass	?	2		revegetation	
2	Grass family	Poa	pratensis ssp. pratensis	Kentucky Blue Grass	C	1	52	unknown	
3	Grass family	Poa	trivialis	Rough Blue Grass	U	1	52	revegetation	1902
5	Grass family	Polypogon	monospeliensis	Rabbit's-foot Grass	X	3		unknown	**1902**
3	Grass family	Psathyrostachys	juncea	Russian Wild-Rye	R	2	nr	agriculture	1960
7	Grass family	Puccinellia	distans	Spreading Alkali Grass	?C	1			
3	Grass family	Schedonorus	arundinaceus	Tall Fescue	R	2	66	revegetation	1980
5	Grass family	Secale	cereale	Common Rye	R	3	nr	agriculture, transportation	1949
5	Grass family	Setaria	viridis	Green Bristle Grass	X	3	nr	transportation	1998
4	Grass family	Thinopyrum	intermedium	Intermediate Wheat Grass	R	2		transportation	1999
2	Grass family	Thinopyrum	ponticum	Tall Wheat Grass	R	1	nr	agriculture	2000
5	Grass Family	Triticum	aestivum	Common Wheat	X	3	nr	agriculture, transportation	**1943**
5	Grass family	Vulpia	myuros	Rat-tail Six-weeks Grass	X	3	nr	unknown	**1902**
5	Nettle family	Urtica	urens	Burning Nettle	X	3	nr	unknown	1904
5	Goosefoot family	Atriplex	patula	Spear Saltbush	X	3	nr	unknown	
5	Knotweed family	Fagopyrum	esculentum	Buckwheat	X	3	nr	agriculture (birdseed)	1997
2	Knotweed family	Polygonum	achoreum	Leathery Knotweed	U	1		transportation	1997
7	Knotweed family	Polygonum	buxiforme	Prairie Knotweed	?C	1	45	transportation	
3	Knotweed family	Fallopia	convolvulus	Eurasian Black-bindweed	C	1	50	horticulture	1975
5	Knotweed family	Polygonum	fowleri	Fowler's Knotweed	X	3		unknown	**1943**
6	Knotweed family	Persicaria	maculosa	Spotted Lady's-Thumb	F	4	47		
3	Knotweed family	Rheum	rhaponticum	Rhubarb	C	1	nr	agriculture	1999
4	Knotweed family	Rumex	acetosella	Sheep Sorrel	R	2	51	unknown	**1994**
3	Knotweed family	Rumex	crispus	Curled Dock	R	2	48	unknown	**1980**
3	Knotweed family	Rumex	longifolius	Door-yard Dock	R	2	48	transportation	1980
3	Knotweed family	Rumex	pseudonatronatus	Field Dock	R	2	nr	transportation	2004

Invasiveness Rank	Family	Genus	Species	Common Name	Abundance	Persistence	Alaska Rank	Source	Date of first collection
3	Goosefoot family	Chenopodium	album	Lamb's-Quarter	C	1	37	unknown	1883
4	Pink family	Cerastium	fontanum	Common Mouse-ear Chickweed	U	1	36	unknown	1968
4	Goosefoot family	Spinacia	oleracea	Spinach	R	2		agriculture	1980
4	Pink family	Cerastium	glomeratum	Sticky Mouse-ear Chickweed	R	2	36	horticulture	2004
4	Pink family	Cerastium	nutans	Nodding Chickweed	R	2		horticulture	1996
5	Pink family	Dianthus	plumarius	Carnation	R	3		horticulture	**1994**
5	Pink family	Gypsophila	elegans	Showy Baby's-breath	R	3	nr	unknown	1980
3	Pink family	Silene	noctiflora	Night-flowering Catchfly	R	2	43	revegetation	1996
2	Pink family	Silene	vulgaris	Bladder Campion	R	2	42	agriculture, horticulture	1984
5	Pink family	Spergula	arvensis	Corn Spurry	X	3	32	unknown	**1902**
4	Pink family	Spergularia	rubra	Red Sandspurry	R	2	34	unknown	1977
2	Pink family	Stellaria	media	Common Chickweed	C	1	42	agriculture, horticulture	1943
5	Pink family	Vaccaria	hispanica	Cowcockle	R	3	nr	agriculture (birdseed)	1902
2	Buttercup family	Clematis	tangutica	Golden Clematis	R	1	nr	horticulture	1958
5	Buttercup family	Ranunculus	repens	Creeping Buttercup	X	3	54	transportation	1977
4	Buttercup family	Thalictrum	dasycarpum	Purple Meadow-rue	R	2		agriculture	1991
4	Buttercup family	Thalictrum	venulosum	Veiny Meadow-rue	?R	2		unknown	1949
4	Poppy family	Papaver	croceum	Saffron Poppy	U	2	39	horticulture	1949
4	Mustard family	Arabis	caucasica	Gray Rockcress	R	2		horticulture	2001
4	Mustard family	Arabis	glabra	Tower Mustard	?R	2	nr	transportation	1977
6	Mustard family	Armoracia	rusticana	Horse Radish	F	4			
3	Mustard family	Brassica	rapa	Bird's Rape	R	1	50	agriculture, revegetation	1980
4	Mustard family	Camelina	microcarpa	Little-pod False Flax	R	2	nr	unknown	1943
5	Mustard family	Camelina	sativa	Large-seeded False Flax	R	3	nr	agriculture	2007
3	Mustard family	Capsella	bursa-pastoris	Shepherd's Purse	C	1	40	agriculture	1916
4	Mustard family	Descurainia	sophia	Herb-Sophia	U	2	41	unknown	1943
5	Mustard family	Erysimum	cheiri	Wallflower	X	3		horticulture	2001
3	Mustard family	Hesperis	matronalis	Dames Rocket	R	2	41	horticulture	2010
3	Mustard family	Lepidium	ramosissimum	Branched Pepperwort	C	1	nr	unknown	1979
5	Mustard family	Lepidium	sativum	Garden Pepperwort	X	3	nr	horticulture	1902
5	Mustard family	Neslia	paniculata	Yellow Ball-mustard	X	3	nr	agriculture	1904
5	Mustard family	Rorippa	curvipes var. truncata	Blunt-leaved Yellowcress	R	3		unknown	1982
5	Mustard family	Sinapis	alba	White Mustard	X	3	nr	unknown	1902
5	Mustard family	Sinapis	arvensis	Corn Mustard	R	3	36	unknown	2002
5	Mustard family	Sisymbrium	altissimum	Tall Hedge Mustard	R	3	nr	unknown	1916
3	Mustard family	Thlaspi	arvense	Field Pennycress	C	1	42	agriculture	1949
5	Rose family	Potentilla	biennis	Biennial Cinquefoil	X	3	nr	unknown	1902
2	Rose family	Prunus	padus	Maytree or European Bird Cherry	C	2	74	horticulture	2003
2	Rose family	Sorbaria	sorbifolia	False Spiraea	R	2	nr	horticulture	1992
2	Pea family	Astragalus	cicer	Chick-pea Milk-vetch	R	2	nr	revegetation	1995

Invasiveness Rank	Family	Genus	Species	Common Name	Abundance	Persistence	Alaska Rank	Source	Date of first collection
2	Pea family	Caragana	arborescens	Siberian Peashrub	R	2	74	horticulture	1949
3	Pea family	Lotus	corniculatus	Garden Bird's-foot Trefoil	R	3	63	revegetation	2000
1	Pea family	Medicago	falcata	Lucerne	C	1	64	argiculture	1967
3	Pea family	Medicago	lupulina	Black Medick	R	2	48	transportation	2007
2	Pea family	Medicago	sativa	Alfalfa	C	1	59	agriculture, revegetation	1980
1	Pea family	Melilotus	alba	White Sweetclover	C	1	81	agriculture	1935
1	Pea family	Melilotus	officinalis	Yellow Sweetclover	C	1	69	argiculture	1980
3	Pea family	Onobrychis	viciifolia	Common Sainfoin	R	2	nr	revegetation	1980
5	Pea family	Trifolium	cyathiferum	Cup Clover	X	3		agriculture	1902
2	Pea family	Trifolium	hybridum	Alsike Clover	C	1	57	agriculture, revegetation	1902
2	Pea family	Trifolium	pratense	Red Clover	C	1	53	agriculture, revegetation	1902
2	Pea family	Trifolium	repens	White Clover	C	1	59	agriculture, revegetation	1916
7	Pea family	Vicia	americana	American Vetch	?R	1		unknown	
3	Pea family	Vicia	angustifolia	Garden Vetch	R	2		unknown	1992
1	Pea family	Vicia	cracca	Tufted Vetch	C	2	73	agriculture, transportation, horticulture	1943
5	Pea family	Vicia	villosa	Wolly Vetch	X	3	53	unknown	1916
3	Maple family	Acer	negundo	Manitoba or Ash-leaf Maple	R	2	nr	horticulture	1998
1	Euphorbia family	Euphorbia	esula	Leafy Spurge	R	2	84	argiculture	1992
4	Violet family	Viola	tricolor	Johnny-jump-up	C	1	34	horticulture	**1995**
4	Oleaster family	Hippophae	rhamnoides	Sea-Buckthorn	R	2		horticulture	2007
3	Carrot family	Heracleum	sibiricum	Siberian Cow-parsnip	R	2		unknown	1991
5	Carrot family	Pastinaca	sativa	Wild parsnip	R	3	nr	agriculture	1949
3	Mallow family	Malva	neglecta	Common Mallow	R	2	nr	agriculture	2008
5	Jacob's ladder family	Gilia	capitata	Blue-headed Gily Flower	X	3		unknown	**1902**
3	Forget-me-not family	Amsinckia	menziesii	Menzies' Fiddleneck	R	2	nr	unknown	1943
5	Forget-me-not family	Asperugo	procumbens	German Mad-wort	X	3	nr	horticulture	1949
7	Forget-me-not family	Hackelia	deflexa	Nodding Stickseed	?X	3		unknown	
3	Forget-me-not family	Lappula	squarrosa	European Stickseed	U	2	44	unknown	1973
5	Forget-me-not family	Myosotis	scorpioides	True Forget-me-not	R	3	54	horticulture	2000
7	Forget-me-not family	Plagiobothrys	scouleri	Scouler's Popcornflower	?R	3		unknown	
6	Verbena family	Verbena	hastata var. scabra	Simpler's-Joy	F	4			
5	Mint family	Dracocephalum	thymiflorum	Thyme-flowered Dragonhead	R	3	nr	agriculture	1949
3	Mint family	Galeopsis	tetrahit var. bifida	Bifid Hemp-nettle	R	1	50	revegetation, horticulture	1980
4	Mint family	Lamium	amplexicaule	Common Dead-nettle	R	3	nr	horticulture	2007
7	Mint family	Stachys	pilosa	Hedge-nettle	?R	2		unknown	
1	Figwort family	Linaria	dalmatica	Dalmatian Toadflax	X	3	58	unknown	2004
1	Figwort family	Linaria	vulgaris	Butter-and-Eggs	C	1	69	horticulture	1970
5	Figwort family	Veronica	arvensis	Corn Speedwell	R	3		unknown	**1970**
4	Figwort family	Veronica	longifolia	Long-leaf Speedwell	R	2	nr	agriculture, horticulture	1980
5	Figwort family	Veronica	serpyllifolia	Thyme-leaf Dragonhead	R	3	36	unknown	**1970**

Invasiveness Rank	Family	Genus	Species	Common Name	Abundance	Persistence	Alaska Rank	Source	Date of first collection
5	Plantain family	Plantago	aristata	Large-bract Plantain	X	3		unknown	**1902**
7	Plantain family	Plantago	major	Great Plantain	?C	1	44	unknown	
5	Bedstraw family	Galium	aparine	Sticky-willy	X	3		agriculture (birdseed)	2007
6	Bedstraw family	Galium	palustre	Common Marsh Bedstraw	F	4			
3	Valerian family	Valeriana	officinalis	Garden Valerian or Allheal	R	2	nr	horticulture	2007
4	Sunflower family	Achillea	ptarmica	Sneezeweed	R	2	46	horticulture	2011
5	Sunflower family	Anthemis	cotula	Stinking Chamomile	X	3	41	agriculture	**1902**
7	Sunflower family	Artemisia	biennis	Biennial Wormwood	R	4	nr	unknown	
5	Sunflower family	Centaurea	cyanus	Cornflower	X	3		horticulture	1998
1	Sunflower family	Centaurea	stoebe	Spotted Knapweed	X	3	86	unknown	1995
5	Sunflower family	Chrysanthemum	ircutianum	Early Daisy	X	3		unknown	1949
1	Sunflower family	Leucanthemum	vulgare	Oxeye daisy	R	1	61	horticulture, transportation	1980
1	Sunflower family	Cirsium	arvense	Creeping (Canada) Thistle	R	2	76	transportation	1995
5	Sunflower family	Crepis	capillaris	Smooth Hawksbeard	X	3	nr	transportation	1998
1	Sunflower family	Crepis	tectorum	Narrow-leaved Hawksbeard	C	1	56	transportation	1957
4	Sunflower family	Gaillardia	aristata	Great Blanket-flower	R	2	nr	agriculture	1973
7	Sunflower family	Gnaphalium	uliginosum	Marsh Cudweed	?R	2	nr	unknown	
5	Sunflower family	Helianthus	subrhomboideus	Stiff Sunflower	X	3		unknown	**1904**
1	Sunflower family	Hieracium	caespitosum	Field Hawkweed	R	2	79	transportation	2009
5	Sunflower family	Madia	glomerata	Mountain Tarplant	X	3	nr	unknown	1902
3	Sunflower family	Matricaria	discoidea	Pineapple Weed	C	1	32	unknown	1902
1	Sunflower family	Tripleurospermum	inodoratum	Scentless Chamomile	R	1	48	unknown	1980
5	Sunflower family	Senecio	eremophilus	Dryland Ragwort	R	3		transportation	1968
3	Sunflower family	Senecio	vulgaris	Common Ragwort	R	2	36	horticulture, agriculture	1902
1	Sunflower family	Sonchus	arvensis ssp. uliginosus	Field Sow-thistle	C	1	73	unknown	1980
2	Sunflower family	Sonchus	asper	Prickly Sow-thsitle	R	2	46	horticulture	1904
6	Sunflower family	Sonchus	oleraceus	Common Sow-thistle	F	4	46		
1	Sunflower family	Tanacetum	vulgare	Common Tansy	U	2	60	horticulture, transportation	1995
4	Sunflower family	Taraxacum	erythrospermum	Red-seeded Dandelion	X	2		unknown	1949
2	Sunflower family	Taraxacum	officinale	Common Dandelion	C	1	58	unknown	1943
2	Sunflower family	Tragopogon	dubius	Yellow Goat'sbeard	R	2	50	transportation	1995

APPENDIX A.22D B

YUKON INVADERS: YUKON INVASIVE PLANT SPECIES (YUKON GOVERNMENT, 2014)

YUKON INVADERS



Help Reduce the Spread of Invasive Plants in Yukon

Yukon Government

City of Whitehorse

Invasive Plants

Invasive plants and animals are the second greatest threat to biodiversity after habitat loss. The economics of controlling invasive species damage can be considerable. In 2004-05, the British Columbia government spent $8 million to protect valuable forest and range land from the effects of non-native plants and weeds.

There are 140 introduced plant species in Yukon. Forty-four are persistent and widespread; 59 are persistent but not widespread; and most of the remaining 37 are casual introductions that may not persist.

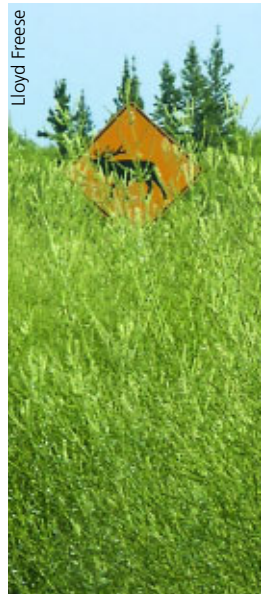
Many of these plants are responsible for habitat damage, loss of subsistence resources, and economic loss in other North American jurisdictions. Yukoners are in the enviable position of preventing plant infestations before they become so widespread that control is costly and eradication impossible.

Everyone can help reduce the spread of those already established. Keeping invasive species from becoming established in the territory should be everyone's responsibility.

This booklet highlights eight of the worst invaders.

White Sweetclover *(Melilotus alba)*

Sweetclover is a biennial, occasionally annual plant in the pea family that can attain a height of 2 m but is usually less than 1 m. It rapidly colonizes gravelly well-drained soils such as roadsides, waste areas and river banks and bars. A single plant can produce 300,000 seeds and the seeds remain viable in the soil for many years (80% survival after 30 years). This is likely Yukon's most invasive and problematic species.


Lloyd Freese

Range in Yukon: Widespread throughout the southern Yukon. It is known along much of the Alaska, Robert Campbell, Top-of-the-World highways and 20 km up the Dempster Highway. It has proved to be highly invasive along the LaBiche River. The only site so far reported on the Yukon River in Yukon is in Whitehorse; although it is a serious problem on Alaskan waterways including tributaries of the Yukon River.

Perennial Sow-thistle
(Sonchus arvensis)

Despite the name, sow-thistles more closely resemble giant dandelions than true thistles. Sow thistle is considered a noxious weed throughout most of its range. This is a highly invasive species able to spread long distances by wind-blown seed. It is perennial with rhizomes that grow up to 3 m deep are very difficult to remove by hand. It is particularly a problem for agricultural producers.



Irina Lapina

Range in Yukon: primarily in the Whitehorse area as far north as Carmacks but has been reported from Destruction Bay, Johnson's Crossing and the Kotaneelee gas plant; found commonly along highway corridors.

Canada Thistle *(Cirsium arvense)*

Though named Canada thistle, this species is native to Europe, Asia and Africa where it is called Creeping Thistle. It is one of the most invasive species in North America and is a noxious weed in most jurisdictions throughout Canada and the USA including Alaska.

The seeds of thistle and knapweed continue to mature after pulling. You may put plants into black garbage bags and then leave them in the sun to kill off the plants and roast the seeds. Herbicide control may be required.

Range in Yukon: known from just south of Haines Junction and observed in the LaBiche River Valley.

Irina Lapina



Spotted Knapweed
(Centaurea biebersteinii)

Knapweeds resemble thistles but differ in their lack of spiny leaves. They are biennial or short-lived perennials. This species reproduces entirely by seed. Large plants can produce over 20,000 seeds. It has not been known to be a problem in the north, but to date it has not had a chance to get established. Alaska has an active program of eradication.

Range in Yukon: It is presently not known in the Yukon but was removed from Haines Junction after several years of effort. It can be found in Atlin, BC.

Michael Rasy



Greater Butter-and-eggs
(Linaria vulgaris)

This very attractive plant resembles a yellow perennial snap-dragon. It is widely found in gardens and invading roadsides in Whitehorse. It is usually less than 50 cm tall. The plant is mildly toxic, persistent, and is known to alter local pollination ecology. It is a restricted noxious weed in Alaska.



Irina Lapina

Range in Yukon: Greater butter-and-eggs has been found throughout the Whitehorse area, South Canol Road in the Quiet Lake area, Watson Lake and Haines Junction. It is mainly spread through yard waste.

Foxtail Barley *(Hordeum jubatum)*

Foxtail barley is a perennial tufted plant that is native to North America including Yukon. It has feathery looking awns that many find attractive but are barbed and can work their way into the eyes, nose, gums and throats of animals, both domestic and wild. It is potentially invasive especially in the dry alkaline soil of the southern Yukon where it is problematic to agricultural producers.

Range in Yukon: known throughout the territory south of and including the Porcupine and Peel river drainages.

Brian Bell



Common Tansy *(Tanacetum vulgare)*

Common Tansy is a robust perennial plant that grows in clusters and forms flat-topped heads of bright yellow, button-like flowers. The plant emits a strong pungent smell when crushed. It is mildly toxic. It likes growing in full sun usually in disturbed sites such as roadsides, riverbanks and beaches. It is considered as a noxious weed in some areas of BC and Washington.

Range in Yukon: presently known from Whitehorse, Marsh Lake, Kathleen Lake and the Alaska and Robert Campbell highways. It is beginning to be used as a hardy garden plant.

Lloyd Freese



Altai Wild Rye
(Leymus angustus)

Altai wild rye is an Asian dune grass found throughout Mongolia, Siberia and China. In Canada it was previously only known to occur out of cultivation in Saskatchewan. This is a tall (1 m) coarse grass that reproduces mainly by seed and forms dense tussocks from short rhizomes. This is a dune stabilizing grass that could be a threat to the Carcross Dunes and the animals and plants that depend on the ecosystem. It may have already entered the Yukon River system.



Range in Yukon: known only from Carcross where it was first reported in 1998.

Yukon Government

Definitions

annual: completing its life history in one year
biennial: requiring two years to complete its life history
perennial: lasting many years (example: roses)
native: originating, growing, or produced in a certain place or region; indigenous
noxious: plant species that have been designated "noxious" by law. Harmful to living things; injurious to health
persistent: existing or remaining in the same state for an indefinitely long time; enduring
rhizome: a horizontal, usually underground stem that often sends out roots and shoots from its nodes. Also called rootstalk
taproot: the main, descending root of a plant that has a single, dominant main stem.
tussock: a clump or tuft, as of growing grass
weed: considered undesirable, unattractive, or troublesome, especially one growing where it is not wanted, as in a garden.

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http://www.environmentyukon.gov.yk.ca
http://www.cnipm.org/index.html
http://www.rbg.ca/cbcn/en/projects/invasives/invade1.html

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You can help by:

Careful gardening – many of the plants are attractive and are used to beautify homes and offices. Care must be taken when selecting which plants to grow and how to handle yard waste.

Keeping it clean – invasive species can be transported on vehicles, heavy equipment, footwear and clothing. All of these should be inspected and/or cleaned before entering or being used in the territory. Vehicle wheel-wells and CAT tracks are especially likely to hide invasive species and should be cleaned thoroughly.

Requesting and using only weed-free soil, hay, straw, mulch and certified seed.

Becoming aware – learn about invasive species that may be found in your area and report new findings. Learn about new ways to reclaim disturbed land. Seeding may not always be necessary.

Picking and carefully disposing of small infestations encountered, and reporting larger ones.

Spreading the word – Yukon is in a unique position to remain pristine, but the spread of invasive species and the costs and damages associated can only be prevented through vigilance and cooperation.

Cover photo: Irina Lapina

APPENDIX A.22E: Road Use Plan



CASINO PROJECT

Road Use Plan

26 June, 2014

REVISION SUMMARY

Version no.	Date	Revision notes	Revision authors
1.0	28 November 2013	YESAB Project Proposal Submission version	KP, AE, EDI.
1.1	26 June 2014	Updated with corrected cross-reference to Wildlife Mitigation and Monitoring Plan	EDI: M. Setterington

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1 INTRODUCTION

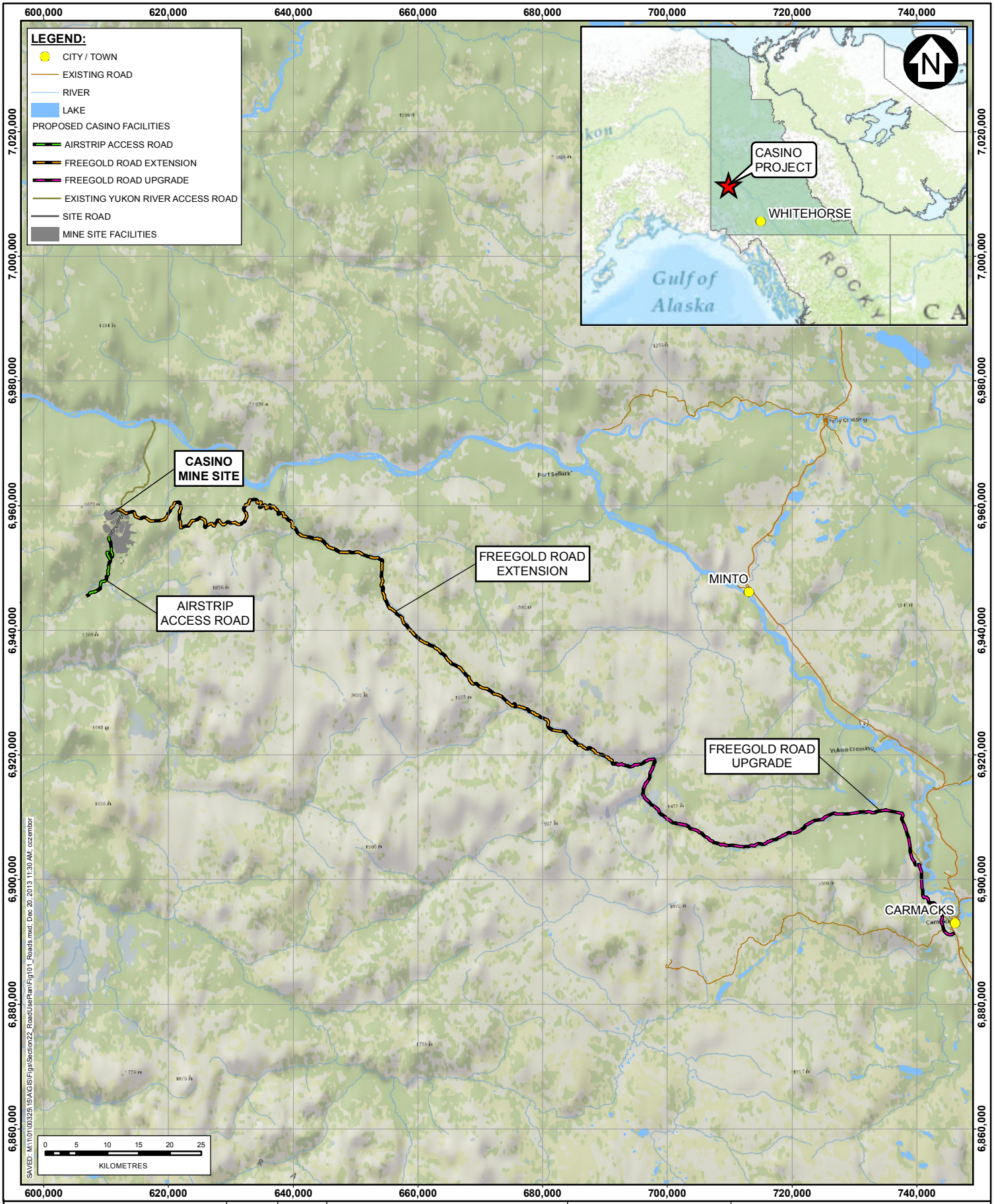
Casino Mining Corporation (CMC) proposes to construct, operate and decommission the Casino Project (the Project) located at latitude 62° 44'N and longitude 138° 50'W (NTS map sheet 115J/10), in west central Yukon, in the northwest trending Dawson Range mountains approximately 300 km northwest of Whitehorse. The Project will be a copper, gold, silver, and molybdenum open pit mine that is anticipated to process on average 120,000 t/d or 43.8 million t/y of material over 22 years of full production.

Road access to the Casino mine site during the life of the Project will be by the Freegold Road Extension and Freegold Road Upgrade, as shown on Figure 1.1.

A network of existing paved highways currently provides year-round access to the village of Carmacks from the Port of Skagway, northern British Columbia and Whitehorse. It will be necessary to construct an all-weather access road linking the Casino mine site to existing highway infrastructure in order to construct and operate the Project. Suitable paved roads currently exist up to the village of Carmacks where an existing limited access road, the Freegold Road, begins and extends approximately 83 km northwest towards the Casino mine site. The existing limited access Freegold Road is owned and operated by the Yukon Government and will require upgrades. CMC proposes to develop a continuous all season access road to the Casino mine site by constructing a new 120 km resource road, the Freegold Road Extension, which will generally follow the existing historic Casino Trail and will be owned and operated by CMC for the life of the Project. In addition, construction of a new by-pass around the village of Carmacks and a new bridge over the Nordenskiold River will be required to keep mine traffic away from the village.

The proposed roadways are primarily on lands administered by the Yukon Government. CMC will seek authorization from the Yukon Government to manage the new roads and to develop them as required in support of the Casino Project. A section of the proposed Freegold Road Upgrade will transit through the Little Salmon/Carmacks First Nation settlement land. Additionally, a section of the proposed Freegold Road Extension will transit through Selkirk First Nation settlement land, a portion of which has an existing right-of-way. Figure 1.2 presents the proposed road alignment in relation to the settlement lands of the Little Salmon/Carmacks First Nation and the Selkirk First Nation.

This is a conceptual Road Use Plan that outlines the proposed road operations and mine site access management measures that will be implemented during construction, operation, and closure and decommissioning. Based on the Yukon Environmental and Socio-economic Assessment Board (YESAB) Decision Document, the Road Use Plan will be updated periodically to include further details.



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PREPARED BY:

Knight Piésold CONSULTING

DESIGNED	GLS/CAH
DRAWN	CC
CHK'D	SJL
APP'D	GLS
REV	0
DATE	16DEC'13

NOTES:

1. BASE MAP: ESRI ARCGIS ONLINE NATIONAL GEOGRAPHIC MAPPING AND YUKON GOVERNMENT ELEVATION DATA
2. PROJECTION: NAD 1983 UTM ZONE 7N
3. COORDINATE GRID: METRES.

CASINO COPPER AND GOLD

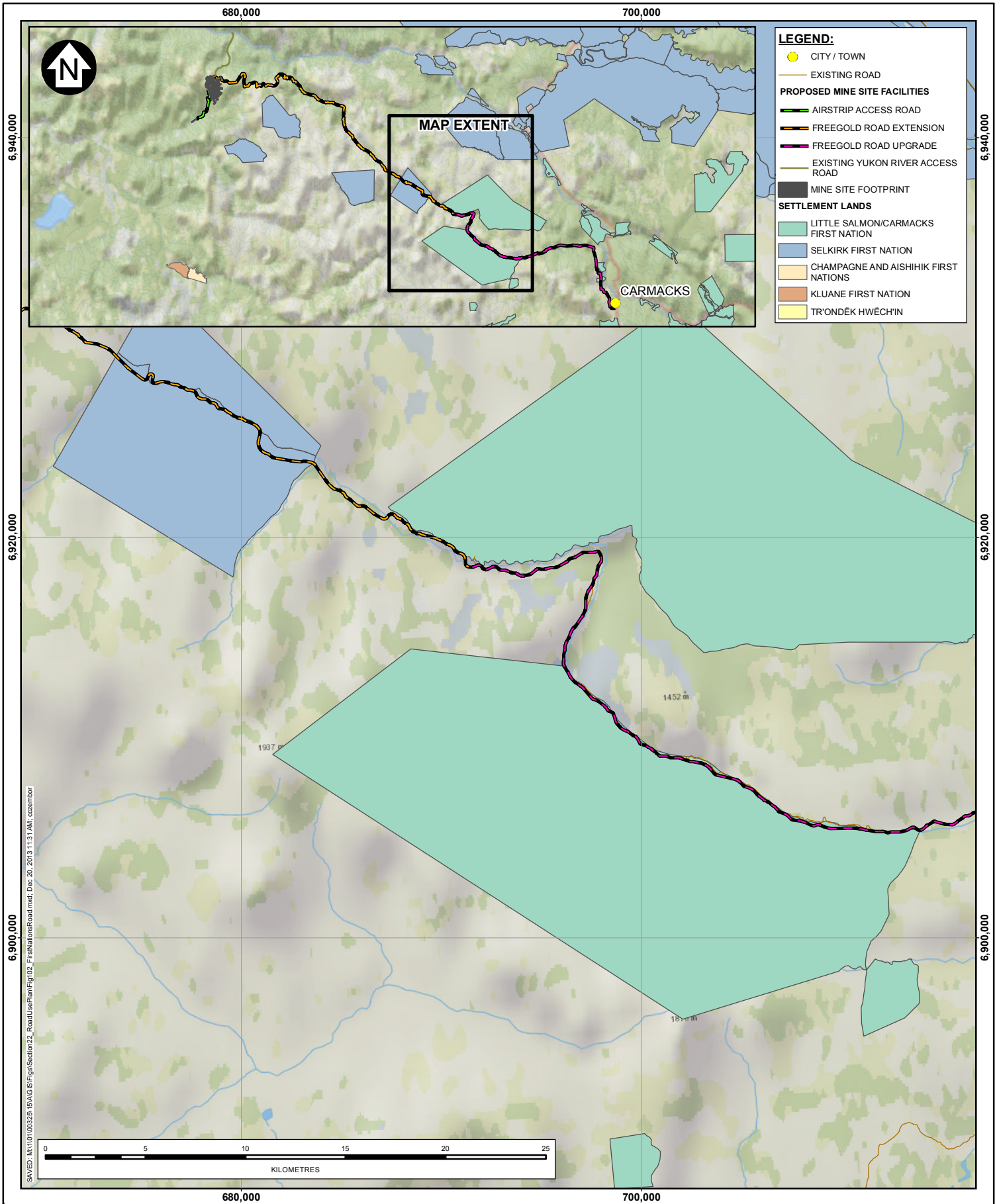
CASINO PROJECT

ROAD ACCESS TO THE CASINO MINE SITE

FIGURE 1.1

REF 1

P/A VA101-325/15



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DRAWN	CC
CHK'D	CAH
APP'D	KJB
REV	0
DATE	18DEC'13

NOTES:

1. BASE MAP: ESRI ARCGIS ONLINE NATIONAL GEOGRAPHIC MAPPING AND YUKON GOVERNMENT ELEVATION DATA
2. PROJECTION: NAD 1983 UTM ZONE 7N
3. COORDINATE GRID: METRES.

CASINO COPPER AND GOLD

CASINO PROJECT

ROAD ALIGNMENT IN RELATION TO SETTLEMENT LANDS

FIGURE 1.2

REF 1

P/A VA101-325/15

2 LEGAL FRAMEWORK

The proposed roadways are primarily on lands administered by the Yukon Government. CMC proposes to seek authorization from the Yukon Government to manage the Freegold Road Extension for the duration of the life of the Project, from construction into closure. A section of the proposed Freegold Road Upgrade will transit through the Little Salmon/Carmacks First Nation settlement land. Additionally, a section of the proposed Freegold Road Extension will transit through Selkirk First Nation settlement land, a portion of which has an existing right-of-way. CMC proposes to seek authorisation from First Nation governments for the proposed access across settlement land as part of the licensing process. CMC expects that the First Nation governments and the Yukon Government will proceed with developing an agreement for road management and use of these roadways. CMC will participate.

2.1 FIRST NATIONS GOVERNMENT ACCESS AGREEMENT

A section of the proposed Freegold Road Upgrade will transit through the Little Salmon/Carmacks First Nation settlement land. Additionally, a section of the proposed Freegold Road Extension will transit through Selkirk First Nation settlement land, a portion of which has an existing right-of-way. The Selkirk First Nation and Little Salmon/Carmacks First Nation have the statutory authority to enact laws and enter into agreements with respect to settlement lands through the authority provided in the Yukon First Nations Self-Government Act (Self-Government Act). Specifically in relation to settlement land, each of the First Nations have the authority under s. 11(1) and s. 1 of Part III of the Self-Government Act to enact laws in relation to, among other things, the “use, management, administration, control and protection of settlement land”. There are similar provisions in the Final Agreement for each of the First Nations. Within the agreements of the settlement lands, the First Nations governments also have the opportunity to impose conditions on the agreements, including requirements for a management plan.

2.2 TERRITORIAL LANDS (YUKON) ACT

CMC understands that the Yukon Government is developing a new regulation pursuant to the Territorial Lands (Yukon) Act to manage the construction, operation, maintenance, decommissioning and reclamation of access roads over the life of a project (McDowell, 2013). The new regulation is expected to update current regulations to address three key issues:

- Ability to tie the life of a permit to the life of the main project
- Remove the maximum financial security requirement so that it can be determined consistent with other policy direction (i.e., mine site reclamation policy); and
- Offer complete control of access.

It is also expected to include an ability to authorize multiple permit holders and facilitate agreements for multi-use as may be allowed under a management plan.

2.3 ROAD TENURE

CMC will pursue the appropriate tenure for the construction, operations and decommissioning of the Freegold Road Extension. The road tenure agreement will be developed between the Yukon Government and the First Nation Governments as appropriate.

2.3.1 Freegold Road Extension

CMC will obtain appropriate tenure for construction, operation and decommissioning of the Freegold Extension Road. In consultation with the Yukon Government, the following steps may be required:

- Current legislation provides a mechanism, by application, for Yukon Government to grant a long-term surface lease for all portions of the road route on Crown Land from the Big Creek crossing (approximately Km 83) to the proposed Casino mine site, including sufficient area to accommodate construction activities and related facilities; to allow for the construction, operation and maintenance of a private access road;
- CMC may apply for and receive a permit under a new regulation (under development) pursuant to the Territorial Lands (Yukon) Act under development by Yukon Government to construct, operate and decommission the road (McDowell, 2013); and
- Initiate a formal request to Little Salmon/Carmacks First Nation and Selkirk First Nations to allow certain sections along the existing right-of-way to be rerouted onto settlement land for safety, environmental, and cost reasons. A “land swap” under the land claims agreements may be pursued that would see the proposed right-of-way become crown land with the First Nation selecting another parcel of land as settlement land in exchange. Alternatively, the proponent may enter into an Access Agreement and/or Lease Agreement directly with the First Nation.

2.3.2 Freegold Road Upgrade

CMC will discuss details relating to the upgrading the existing Freegold Road, the construction of the Carmacks by-pass and the Nordenskold Bridge with the Yukon Government such that they will be developed on a schedule consistent with the overall construction schedule for the Casino Project. The ownership of these road sections lies with the Yukon Government, and will remain as such.

3 PROJECT ACCESS DESCRIPTION

3.1 FREEGOLD ROAD

3.1.1 Freegold Road Upgrade — Klondike Highway to Big Creek

A bypass of the village of Carmacks will be constructed from the Klondike Highway to the intersection of Mt. Nansen Road and the existing start of the Freegold Road. This approximately 5 km-long section of road will cross the Nordenskiold River. A preliminary design of this section of the road has been undertaken by CMC consistent with work already perform the Yukon Government. This section of road will become the first 5 km of the Freegold Road Upgrade.

The existing Freegold Road, which is part of the proposed Freegold Road Upgrade, begins at Mt. Nansen Road in the village of Carmacks and proceeds north and west to the confluence of Seymour and Bow Creeks. This section of road is used primarily to access mineral properties along its length, as well as by recreational users. The roadway is owned and managed by the Yukon Government.

In the mid-1990s, the Yukon Government completed substantial fieldwork and a design for the upgrade and realignment of the existing Freegold Road from its start to just beyond Km 32. The design was prepared to a rural collector, undivided road classification with a design speed of 80 km/hr (RCU80). Based on the engineering work completed to date, CMC has confirmed that the proposed road upgrades will meet the required design criteria for the Project. This section of roadway will form part of the proposed Freegold Road Upgrade.

The existing Freegold Road from approximately Km 32 to approximately Km 83 (at Big Creek crossing) will be upgraded to meet the 70 km/hr design speed with an 8.2 m wide gravel surface; the maximum grade in the design upgrade is 8%. The existing Freegold Road is generally located on the north side slopes of the Seymour Creek Valley. The proposed realignment for this section of the Freegold Road Upgrade is generally downslope of the existing road in order to achieve the design criteria and minimize earthworks quantities.

Settlement land belonging to the Little Salmon/Carmacks First Nation is located on the south side of the existing right-of-way (at approximately Km 48), close the confluence of Seymour and Bow Creeks. To address constraints pertaining to design criteria, CMC proposes that the road be realigned through the settlement lands from approximately Km 49 to approximately Km 63. Further realignment is proposed from approximately Km 68 to approximately Km 70 to meet the design criteria and the location of a proposed bridge. This section of roadway will also form part of the proposed Freegold Road Upgrade.

3.1.2 Freegold Road Extension — Big Creek to Mine Site

CMC has completed preliminary engineering design for the Freegold Road Extension from approximately Km 83 (at Big Creek crossing) to approximately Km 203 (at the Casino Mine Site). The Freegold Road Extension approximately follows the alignment of the Casino trail corridor. A manned gate is proposed at the Big Creek Bridge to control access to the Freegold Road Extension, as the Freegold Road Extension is expected to be listed as a private resource road under the new regulation pursuant to the Territorial Lands (Yukon) Act.

The Freegold Road Extension is designed to be a two-lane, gravel resource road suitable for all weather use by transport trucks with highway legal loads. The road design criteria complies with the BC Ministry of Forests and Range Forest Road Engineering Guidebook (2nd Edition, 2002) for a 70 km/h design speed, with some short 50 km/h sections where road geometry is limited by the terrain. The road will be approximately 8 m wide with maximum grades of 8%. Vertical profiles are designed to allow adequate stopping sight distance for drivers to identify wildlife or other hazards on the road.

The Casino Trail corridor runs through the parcel area of Selkirk First Nation R-9A, which are Category A Settlement Lands designated under the Selkirk Final Agreement. This is an encumbering right under the Selkirk First Nation Final Agreement and the right of way for the road is administered by the Government as though located on Crown Land. There are certain limited sections of the road that CMC proposes to build on settlement lands, since current access right-of-way through Selkirk First Nation R-9A managed by Yukon Government is not suitable to support the design criteria for the roadway.

The Freegold Road Extension will be used by CMC during the construction, operation and closure of the Project. After the active phase of closure is complete, the Freegold Road Extension will be decommissioned. The watercourse crossings will be removed and the road will be scarified to promote re-vegetation. Further decommissioning details will be developed with project planning.

4 TRAFFIC PROJECTIONS

The preliminary design for the Freegold Road Extension and Freegold Road Upgrade is complete and traffic projections for the life of the Project have been generated as part of the YESAB Proposal. Historical and existing traffic data does not exist for the Freegold Road Extension because the Freegold Road Extension has not yet been constructed. Limited traffic currently exists for a portion of the existing Freegold Road that will become the Freegold Road Upgrade, through this is assumed to be negligible.

4.1 CONSTRUCTION PHASE

Traffic on the Freegold Road Extension and Freegold Road Upgrade during the construction phase of the Project will include both heavy construction equipment and light vehicular traffic. The average daily traffic projections for the four years of construction are shown in **Error! Reference source not found.**.

Table 4.1 Construction Phase Traffic Projections

Construction Year	Avg./Day "Heavy" Traffic	Avg./Day "Light" Traffic	Avg./Day Total
Year -4	3	1	4
Year -3	10	8	18
Year -2	14	14	28
Year -1	10	16	26

Source: Excerpted from Access Overview for Submission to YESAB, November 2013, Appendix 04B
Note:

Light vehicles include autos and trucks up to 10 tonne capacity.
Heavy traffic includes vehicles greater than 10 tonne capacity.
Year -4 is the first year of construction related activities.
The figures represent averages and may be more or less on any given day,

4.2 OPERATION PHASE

Vehicle traffic on the Freegold Road Extension and the Freegold Road Upgrade are expected to increase when the Project is in the operations phase. The peak number of outbound trips from the Casino Mine Site during operations is projected to be on average 72, as indicated in Table 4.2. It is noted that the traffic on the roadway will vary seasonally and daily and is dependent on the mine operations requirements.

Table 4.2 Operation Phase Traffic Projections

Freight	**Avg./Day "Heavy" Traffic** (Freight)	**Avg./Day "Light" Traffic** (buses, vans)	**Avg./Day Total**
Inbound (Avg./Day)	36	20	56
Outbound (Avg./Day)	48	20	68
Peak Outbound (Avg./Day)	52	20	72

Source: Excerpted from Access Overview for Submission to YESAB, November 2013, Appendix 04B

Notes:

Daily and seasonal variations will occur.
Peak outbound results from years of higher than life of mine average copper concentrate production.

4.3 DECOMMISSIONING AND CLOSURE PHASE

The Freegold Road Extension will be used during Project decommissioning and closure, however, the anticipated traffic will diminish from the operation phase projections substantially. When the active closure phase is complete, the Freegold Road Extension will be decommissioned and traffic will cease.

5 ROAD OPERATIONS

5.1 ACCESS

CMC is committed to maintaining the Freegold Road Extension as a resource road with controlled access throughout the life of the Project. Specific permissions for individuals, outside of CMC, will be determined by the Freegold Road Extension access agreement. A manned gate is proposed at Big Creek (approximately Km 83), the beginning of the Freegold Road Extension. At the gate, CMC staff will confirm that all vehicles are travelling with an appropriate two-way radio, the appropriate frequency is set correctly and CMC will communicate with the driver to identify any specific roadway conditions (i.e. known icy patches, wildlife migration progress, etc.) both at the gate and during the transit time.

5.2 USE PRIORITIES

The Freegold Road Extension will to be utilized by a variety of traffic accessing the Casino Mine Site, ranging in size from transport trucks to pick-up vehicles. A standard protocol will be included in the final Road Use Plan to inform drivers who has the right-of-way when vehicles meet on the Freegold Road Extension. The preliminary road use priorities are:

1. Emergency vehicles, when lights are flashing;
2. Trucks transporting dangerous goods;
3. Transport trucks (from large to small);
4. Heavy equipment (from large to small); and
5. All other vehicles.

In general, other road use priorities are:

- Vehicles that are loaded will take priority on the roadway to vehicles travelling empty;
- If two vehicles with the same characterization meet, the blind-side vehicle will have the right-of-way; and
- If clear sight lines are available, speeds are regulated, and radio contact is confirmed between the vehicle operators, passing will be permitted.

5.3 RADIO USE

The Freegold Road Extension will be managed through radio control and radio frequencies will be implemented. CMC will enforce radio use with its employees and visitors to maintain safety and communication along the Freegold Road Extension. Drivers will be informed of the appropriate radio frequencies and call procedures at the manned gate (located at Big Creek) when entering the Freegold Road Extension All vehicles will be expected to adhere to the radio call procedures.

5.4 SIGNAGE

CMC will be responsible for monitoring and confirming that signs are legible and relevant to the season for the Freegold Road Extension. Signage, which is intended to be included on the roadway, will include, but not be limited to, the following:

Kilometer Markings

Kilometer marking signs will be placed at 1 kilometer intervals on the right side of the road for both travel directions. The signs will be critical for the vehicle call out protocols. Regular checks of the roadway will be completed by CMC to ensure the signs are visible, as they will have the opportunity to be obscured by snow or vegetation.

Radio Frequencies

Signs indicating the radio frequencies for road control will be posted at the entrance to the Freegold Road Extension and the Casino Mine Site. The appropriate frequencies will be pre-set on any radios that are distributed from the manned gate.

Speed Limits

Speed limit signs will be placed along the roadway for each traffic direction. Speed reductions will also be noted by signage along with cautionary signage indicating major corners, grades, etc.

Wildlife Crossings

Wildlife crossings along the Freegold Road Extension will be indicated with signage throughout the year. Intermittent wildlife hazards, such as presence of caribou, will be indicated through signage and travel speed reductions and restrictions as may be appropriate to reduce the risk of wildlife collisions will be implemented and communicated through appropriate signage. Updated details on mitigation specific to wildlife are provided in the Wildlife Mitigation and Monitoring Plan.

5.5 RADIO CALLING PROTOCOL

A major component of the CMC safety protocol for travel along the private Freegold Road Extension is the radio calling protocol for all vehicles. All vehicles travelling the Freegold Road Extension will be outfitted with a radio; the presence and operation of the radio will be confirmed at the Big Creek manned gate. The operational protocols will be defined in the final Road Use Plan; a preliminary radio calling protocol is proposed below:

Direction of Travel

The direction of travel will be called as “Up” or “Down,” consistent with the kilometer markings on the roadside; “Up” will be called by vehicles heading towards the Casino Mine Site and “Down” will be called by those departing the Casino Mine Site.

Identification

The general vehicle type will be required as identification (i.e. grader, pick-up, etc.).

Frequency

All vehicles will be required to call when travelling on the Freegold Road Extension. All vehicles travelling the Freegold Road Extension will be required to call at every 5 km marking.

The typical call over the radio for a vehicle will be, for example, “Pick-up 105 Down” for a light vehicle leaving the site or “Grader 165 Up” for a grader approaching the Casino Mine Site.

Must-Call

Must-call conditions will also be implemented for the following scenarios:

- Entering or leaving the Freegold Road Extension;
- Stopping and resuming travel along the roadway;
- Encountering a vehicle accident;
- Encountering large wildlife on or near the roadway (e.g. “two caribou north of road at kilometer 97”);
- Encountering a vehicle not calling; and
- Passing another vehicle.

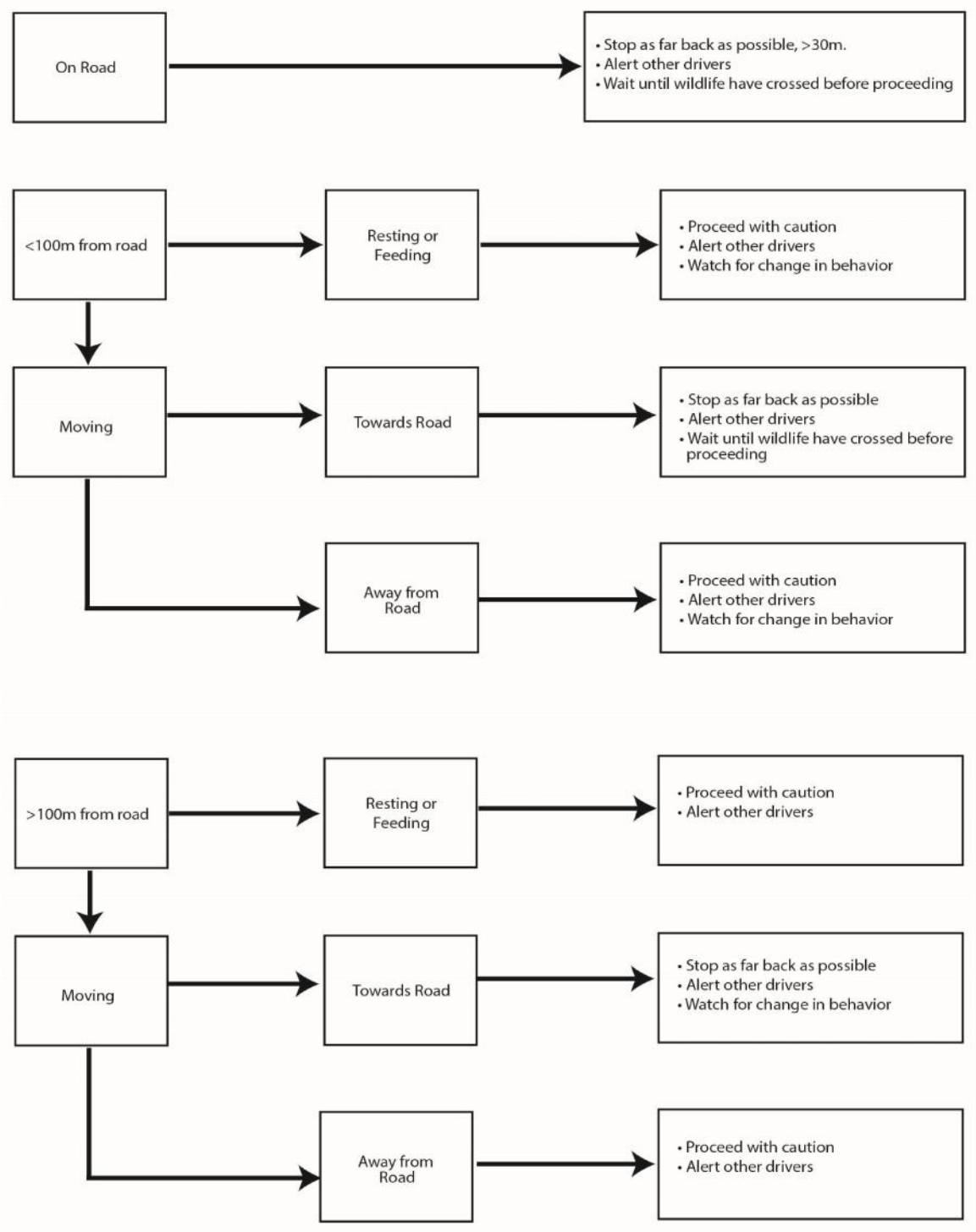
5.6 WILDLIFE ENCOUNTERS

Wildlife is a noted hazard on the Freegold Road Extension. CMC will implement a “Wildlife has the Right-of-Way” policy, if appropriate and if it does not compromise driver safety, to avoid potential collisions between wildlife and vehicles or unnecessary disturbances to wildlife. Vehicle operators will adhere to the following protocols:

- Be vigilant and watch for wildlife near roads, particularly in times of low light, and take all reasonable actions to avoid wildlife collisions;
- Stop when wildlife are observed on the road; and
- Allow small groups of animals (<10 individuals) standing on the road to move off the road unalarmed. Vehicles will stop for 15 minutes, then proceed slowly (<20 km/hr) if wildlife have not moved within that 15 minute period.

The safety procedures shown on Figure 5.1 will be followed by vehicle operators when wildlife is encountered, in accordance with the *Wildlife Mitigation and Monitoring Plan* (Appendix 23A of the Casino Proposal).

Figure 5.1 Wildlife and Road Operation Decision Matrix



Source: Wildlife Monitoring and Mitigation Plan, YESAB Proposal, Appendix 23A

5.7 MAINTENANCE

CMC is committed to maintaining the Freegold Road Extension for the life of the Project. The Freegold Road Extension will be maintained to ensure traffic can travel during all seasons and general maintenance will be completed seasonally, as required.

During winter months, snow clearing will be completed regularly, as required. Snow banks will be maintained to be less than 1 m high so that caribou and other wildlife can cross the Freegold Road Extension easily as per the *Wildlife Mitigation and Monitoring Plan* (Appendix 23A).

Debris on the road surface will be removed by CMC promptly. Vehicle operators encountering road debris will be required to report the location and material type on the roadway through the radio to CMC personnel. Any carcasses located on the road will be removed promptly to discourage further collisions.

Dust issues on the roadway will be abated using water sprays or suppressants, as necessary, to maintain safe driving conditions. It is expected that issues related to dust will be relayed to CMC personnel by vehicle operators travelling the roadway.

6 SAFETY

CMC recognizes the potential exists for vehicle collisions, malfunctions, spills, or wildlife encounters that could adversely affect the natural environment or cause an injury on the Freegold Road Extension. The operations protocols including speed limits, use priorities, radio use and signage, will be adhered to by all users of the road at all times to prevent incidents. Any incidents that occur will be managed by CMC in accordance with the *Emergency Response Plan (*Appendix 22B of the Casino Proposal).

The Freegold Road Extension will be monitored frequently to ensure that the road is safe and well kept. Radio communication will be available along all roads to allow for rapid communication with drivers and reporting of incidents. Personnel at the Big Creek manned gate will inform incoming traffic of any known safety concerns at the time of their travel.

Wildlife is a noted hazard along the Freegold Road Extension; a “Wildlife has the Right-of-Way” policy will be adopted to mitigate potential collisions between vehicles and wildlife or unnecessary disturbance to wildlife. Specific wildlife conditions will be communicated to incoming traffic when entering the site at the manned gate and radio communication will inform travellers of wildlife sightings.

Staff transporting goods to and from the Casino Mine Site will be trained according to Yukon Department of Transportation requirements and also have training in spills response, hazardous materials safety, and CMC’s environmental and transportation policies. CMC will ensure that its staff and contractors have basic emergency training as appropriate, such as standard first aid, and are aware of CMC health and safety policies. Routine practice drills will occur to maintain Emergency Response Team member skills and test the Emergency Response Plan system and processes.

In the event of an incident, available personnel are to contact the Casino Mine Site and relay all the pertinent details. The level of emergency will be determined in accordance with the Emergency Reponses Plan and appropriate Emergency Response Team members will be dispatched to the incident location. Road closures or delays will be relayed via radio to all travelling vehicles.

7 REPORTING

7.1 COMMUNICATION MANAGEMENT

CMC may be contacted to request access, submit general enquires or comments regarding the Freegold Road Extension. All comments relayed to CMC regarding the roadways and its users will be documented and noted for follow-up, as required. Complaints regarding particular vehicles on the roadway will be forwarded to the relevant CMC representative as well as documented within CMC's database. The following information will be recorded for each of the comments received:

- Date and time of the comment;
- Method of comment receipt;
- Details of the individual making the comments;
- Contents of the comment;
- Action taken for the comment (including further contact with the contact or no action, as relevant); and
- Reasons for action (or no action).

Comments received will be reported monthly to CMC Management and summarized in an annual report.

8 MANAGEMENT PLANNING

A final Road Use Plan will be developed when the road use agreement is in place with the Yukon Government and First Nation Governments; it will be the primary document that CMC will use to implement measures to manage controlled access on the Freegold Road Extension. The *Wildlife Mitigation and Monitoring Plan* is the primary document that will promote the protection of wildlife. It will include a monitoring and reporting requirement that allows adjustments to be made to the Road Use Plan to ensure an appropriate level of wildlife protection is achieved.

The final Road Use Plan for the Project will include a discussion of the potential impacts of mine site roads, haul roads and access roads (including the Freegold Road Extension) and implement mitigation measures to avoid or minimize adverse effects on watercourses, wildlife, and the public. The final Road Use Plan will overlap with other management plans and monitoring programs; where relevant the plans will be referenced (e.g., *Wildlife Mitigation and Monitoring Plan*, *Emergency Response Plan*, *Occupational Health and Safety Management Plan*).

The final Road Use Plan will capture the key mitigation measures for the protection of wildlife and for road use as suggested by CMC in the Project Proposal, and as reaffirmed and established in a YESAB Decision Document for the Project.

9 REFERENCES

McDowell, C. Director, Land Management Branch, Yukon Energy, Mines and Resources. Letter, 17 October, 2013.

BC Ministry of Forests. 2002. Forest Road Engineering Guidebook (2nd Edition, 2002). Province of British Columbia.

APPENDIX A.22F: Socio-Economic Management Plan



CASINO

Supplementary Information Report A

to the Proposal for the Casino Project

submitted by Casino Mining Corporation

on January 3, 2014

Pursuant to the
Yukon Environmental and Socio-economic Assessment Act

January 2015

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ABBREVIATIONS

SEMP ..... Socio-Economic Management Plan
the Project ..... Casino Mine Project
CMC ..... Casino Mine Corporation
YESAB ..... Yukon Environmental and Socio-economic Assessment Board
YMTA ..... Yukon Mine Training Association
HSS ..... Yukon Government Health and Social Services

REVISION SUMMARY

Version	Date	Revision notes	Revision authors
Preliminary Draft	January 2015	Produced for YESAB assessment process	CMC

A.22F – SOCIO-ECONOMIC MANAGEMENT PLAN

A.22F.1 INTRODUCTION

The purpose of the Socio-Economic Management Plan (SEMP) is to manage the socio-economic effects of the Casino Mine Project (the Project) on potentially affected First Nations and communities. The SEMP describes commitments and policies that Casino Mine Corporation (CMC) will undertake to encourage and promote positive socio-economic development to improve quality of life and well-being for those that live in neighbouring communities. The Plan is intended to maximize the Project opportunities for the benefit of First Nations and Yukoners that will be implemented during all stages of the Project consistent with Mining Association of Canada's Guiding Principles of "Towards Sustainable Mining" (2014), and will ensure that CMC:

- Protects the health and safety of employees, contractors, and communities;
- Practices continuous improvement through the application of new technology, innovation and best practices in all facets of operations; and
- Is responsive to community priorities, needs and interests through all stages of mining exploration, development, operations and closure.

CMC commits to the policies outlined in the SEMP that include a number of best practices to meet the following objectives:

- Provide long-term benefits to all employees and communities;
- Involve First Nation governments and stakeholders in staff hiring and business opportunities;
- Establish a relationship between the communities and stakeholders from the beginning of the Project based on mutual respect, understanding, and management of expectations;
- Engage and communicate with all groups to encourage and promote dialogue between communities and CMC on issues and concerns related to the management and procedures of the Project; and
- Establish a complaints/grievance mechanism which involves submission of local concerns and suggestions on Project operations; and
- Establish monitoring programs to track changes in socio-economic conditions of the communities and evaluate effectiveness of mitigation measures.

Mitigation of Project-specific socio-economic effects assessed by the Yukon Environmental and Socio-economic Assessment Board (YESAB) has been incorporated into, and will continue to feed into, the SEMP. CMC expects that the SEMP will be iterative and will evolve over the course of the environmental assessment, regulatory reviews, and development stages of the Project throughout the life of the Project. As the Project advances through the development stages and new ways to manage socio-economic effects are identified, the SEMP will be updated with the new mitigation measures. Suggestions and recommendations from the communities will be incorporated into the SEMP.

A.22F.2 EMPLOYMENT PLAN

The Casino Project is a major mining development project with potential to provide significant wealth in job creation and employment opportunities. This section outlines recruitment commitments, education and skills training commitments and employment commitments to be detailed in the final SEMP.

A.22F.2.1 Recruitment Commitments

CMC is committed to recruiting and hiring as many Yukoners as possible during the Construction and Operation Phases of the Project. Special emphasis will be placed on pre-employment training and employment of Aboriginal

persons who live in or originate from the communities of Pelly Crossing and Carmacks. Casino will also recruit for pre-employment training and employment in Whitehorse and other communities in the Yukon. Additionally, CMC will work with community leaders to address employment barriers for women and people with disabilities.

CMC will hire according to the following priorities, in order:

1. Hiring of First Nations;
2. Hiring of Yukoners who have been continuous resident in the Yukon Territory at least six months prior to being hired;
3. Hiring of Northerners residents in northern British Columbia and Northwest Territories; and
4. Hiring of Canadians across Canada.

Subject to the availability of Yukoners with the required skills, training and experience, CMC will work toward, and will take all reasonable steps, to meet the following goals:

- Meet a target employment of Yukoners in the Construction Phase of 63%;
- Meet a target employment of Yukoners in the Operations Phase of 78%;
- Encourage employment of First Nations by Contractors throughout the Project life; and
- Pursue recruitment and employment opportunities that meet the negotiated cooperation agreements between CMC and the First Nations governments.

CMC will maintain or consider various measures to meet these goals and assist employees who reside in the North. The company will, at its sole discretion, implement various measures related to qualifications for employment, terms of employment, wages, salaries, benefits, allowances, skills, training experience, work schedules, qualifications for training, terms of training, and promotion. CMC will work to:

- Establish a minimum of Grade school level as a standard for trainable positions;
- Develop work schedules compatible with the traditional pursuits of First Nations when possible;
- Fund and co-fund community research projects directed at gathering information and addressing barriers to successful employment;
- Actively promote and encourage careers in the mining industry to the youths in the Yukon;
- Promote and encourage partnerships with local schools for work experience and job placement programs as well as summer employment opportunities that allow students to gain experience while continuing to complete their education; and
- Provide opportunities for summer employment to Yukon post-secondary students during project operation.

A.22F.2.2 Education and Skills Training Commitments

CMC will collaborate with Yukon Government, Yukon College and Yukon Mine Training Association (YMTA) to provide education and skills training to increase the number of apprenticeships and positions to be filled for the Project. Apprentices, where reasonable, will be hired by CMC upon successful completion of apprenticeships.

Education and skills training programs will focus on:

- Providing pre-employment opportunities for training in accordance with the hiring priorities;
- Enabling Yukoners to gain access to jobs;
- Giving special emphasis on training opportunities in the communities of Pelly Crossing and Carmacks;
- Facilitating employment advancement for Yukoners;
- Enabling Yukoners to fill apprenticeships, technical, technological, supervisory, managerial, and professional occupations;
- Requiring all Contractors to adhere to the goal of maximizing the employment of Yukoners; and

- Collaboration with Yukon Government in the development of pre-employment preparation, skill development training, on-the-job training, and re-training programs to better enable Yukoners to take advantage of employment opportunities from the Project.

CMC agrees to:

- Collaborate with First Nations to encourage development and delivery of training programs based on cultural value systems which include a cultural component that would introduce new employees to rotation employment and the intricacies of scheduled work;
- Continue “on-the-job” training throughout the life of the Project;
- Initiate a pre-employment training program;
- Upgrade and train its Yukon employees so that they are able to accept positions of greater responsibility within CMC;
- Support programs that encourage careers in technology, science, and engineering, working in cooperation with the Yukon Government, YMTA, Yukon College and First Nations governments;
- Supplement existing training programs with “on the job” training as much as possible;
- Participate in regional career fairs;
- Organize and implement training programs so that employees completing the training will be able to use the skills acquired and time spent as credit towards certification or status;
- Support non-mining training and entrepreneurial initiatives in local communities;
- After Project production, CMC will assist employees to enhance their employability and find new employment in the mining industry; and
- Develop and implement training programs in accordance to the Yukon Government Apprentice Training Act.

A.22F.2.3 Employment Commitments

The company will provide employees with free work-related round-trip transportation to the mine site from the communities of Pelly Crossing, Carmacks, and Whitehorse. The company will also work with Yukon Government and Yukon College to enhance employment opportunities from other communities.

CMC will introduce and maintain measures to assist First Nation and non-First Nation employees to perform well in their jobs and to help their local communities with any potential effect of the Project, and will:

- Conduct cultural awareness training for all employees and contractors working at the mine site;
- Ensure that at least one Employee Relations Personnel will be able to communicate in Northern Tutchone language;
- Support efforts to revitalize Northern Tutchone language and incorporate Northern Tutchone language into mine signage;
- In cooperation with First Nation Governments, provide and maintain reading and video materials using the Northern Tutchone language on site;
- Address cultural sensitivity and cross-cultural awareness in all orientation training;
- Provide shifts to accommodate subsistence harvesting and participation in cultural activities / events;
- Fund cross-cultural training programs as may be agreed upon by CMC and First Nations Governments;
- Provide communication links to home communities;
- Permit periodic spousal tours of the work site;
- Develop an Assistance Program with personnel providing services and seminars in the field of counselling, addiction and rehabilitation, family adjustment, and savings plan for all employees;
- Provide space at the mine site for spiritual ceremonies for First Nations;

- Provide flexible work rotation schedules, where practical, that could accommodate the needs of local hires and industry practices;
- Enforce a sexual harassment policy at the mine site, and an alcohol-and drug-free workplace policy for the possession or use of any alcohol or illegal drugs at the Project; and
- Work with other mining companies to attract local workers set to be laid-off as other mines cease operations.

A.22F.3 LOCAL PROCUREMENT PLAN

CMC will establish local procurement policies to encourage and promote local businesses and contracting opportunities generated by Project operations. Whenever practicable, and consistent with procurement management, CMC will implement policies that are intended to maximize business opportunities and capacity building for local and Yukon businesses. CMC will purchase as many goods and services in the Yukon as possible.

CMC will take all reasonable steps to work toward the following objectives:

- Maximise the purchase of goods and services from local and Yukon businesses during the Construction Phase.
- Maximise the purchase of goods and services from local and Yukon businesses during the Operation Phase.
- Priority will be given to qualified businesses for procurement bids and opportunities in the following order:
  1. First Nation businesses;
  2. Yukon businesses; and
  3. Other businesses outside the territory.
- Special emphasis will be placed on developing business opportunities with the communities of Pelly Crossing, Carmacks and Whitehorse, and other communities where there is an expression of interest.

The criteria used for evaluating and awarding contracts for the Project shall include, but not limited to, the following:

- Quality;
- Ability to supply and deliver the goods and services;
- Timely delivery;
- Safety and environmental record; and
- Number of Yukon and First Nation staff and degree of participation by both groups.

The following measures will be taken to maximize Project related business opportunities for Yukon businesses:

- Work closely with Yukon Government to identify goods and services that will present the best opportunities for supply by Yukon businesses and to identify publicly available economic development programs in matching Project related business opportunities with new entrepreneurs and existing business capabilities;
- Work closely with First Nation and business groups to plan for and maximize participation of First Nation and Yukon businesses;
- Work closely with local communities to create long-term business and employment opportunities and increase business capacity;
- Develop clear guidelines and schedules regarding what resources the company will commit to Project-related business opportunity developments;
- Provide Yukon businesses with business opportunities forecast and other information relating to CMC's procurement needs; and
- Facilitate subcontracting opportunities for First Nation and Yukon businesses.

A.22F.4 SOCIAL AND CULTURAL WELL-BEING

The health and wellness of CMC's employees, their families, and local communities are the core foundation of a successful Project. CMC understands that while Project activities will have both positive and negative impacts, companies are increasingly expected to operate responsibly and to be committed to their employees and the communities in which the Project operates in. An important consideration is the expectation that businesses will foster and deliver sustainable benefits that enhances social and cultural well-being of all First Nations and community stakeholders. The success of the Project depends on the support of employees and communities.

To promote a healthy, stable and vibrant workforce and community support, CMC will work with employees to be successful in their jobs and careers and work collaboratively with communities to address and prevent negative impacts of the Project. CMC will work with agencies and parties to address the following social well-being issues for its employees and the communities:

- Support local and regional initiatives and programs to address alcohol and substance abuse problems;
- Establish partnerships to effectively address issues such as substance abuse, family violence, domestic abuse and provide programs for its employees, family members and the communities;
- Undertake prevention and awareness programs on-site and work with social service agencies such as Yukon Government Health and Social Services (HSS);
- Work with HSS and other social service agencies to assist with and deliver prevention and awareness programs on alcohol and substance abuse, family violence, and domestic abuse issues in the communities;
- Collaborate with HSS and other social service agencies to provide family counselling services in the communities for mine employees and their families that include family and relationship counselling, stress management, anger management, support services for women and single mothers, child care services, and parent training; and
- Encourage and promote use of support services in the communities by providing information on-site on the available programs and services in the communities.

CMC will also implement the following activities and initiatives:

- Hire a community liaison staff that is a First Nation member who will work with the local communities on community well-being matters;
- Help facilitate money management training in the communities to CMC's employees and their spouses as a mandatory requirement within the first six months of all newly hired employees;
- Work with First Nations and communities on ways to disseminate materials and information to employees and communities related to substance abuse awareness and prevention training;
- Establish a sexual harassment policy and an alcohol-free and drug-free workplace policy at the mine-site;
- Ensure that foods provided at the mine-site promote healthy living, and are appropriate for employees who are at risk for developing diabetes; and
- Provide recreation facilities and equipment on-site.

CMC will actively engage with and encourage Yukon Government to promote the well-being of its employees and the communities in the following ways:

- Facilitate the planning and delivery of community-based mental health and addictions programs and wellness programs;
- Collaborate with First Nations governments in the design of community mental health and addiction programs and wellness programs;
- Meet with Yukon Government to discuss program and service delivery plans and identify areas for collaboration.

Cultural preservation and protection of traditional activities is essential to the cultural well-being of First Nations. To promote and ensure that First Nations' cultural and traditional way-of-life are maintained and protected, CMC shall:

- Support the promotion of traditional cultural practices of the Aboriginal Authorities;
- Work with the community, governments and educational institutions to promote use of resources in local schools that are culturally appropriate to First Nations;
- Develop and implement a cultural exchange program to provide non-Aboriginal site employees with the opportunity to spend up to three days with a First Nation employee pursuing traditional activities;
- Provide cross-cultural training to all on-site staff;
- Provide mine site visits for employees' families; and
- Provide traditional foods on site when available.

A.22F.5 CASINO RESOURCE FUND

Mining provides tremendous social and economic opportunities to communities through employment, business opportunities, and the payment of taxes and royalties. In addition, benefits and opportunities can be realized through "social investment" where funds available from royalties and taxation are spent on cultural, economic, and social development projects. Investment funds can be established that are channelled back to communities and spent on projects that support community development goals. Specific criteria for expenditure of the monies can be established with proposals for the use of the fund will need to identify projects that provide social, economic and cultural benefits to the local communities.

Resouce Revenue Sharing arrangements between First Nations Governments, the Federal Government and the Yukon Government will provide a significant source of funds. Further discussions with First Nations Governments and other governments are required to determine an appropriate and effective approach to funding mechanisms to meet the needs of the communities.

A.22F.6 STAKEHOLDER ENGAGEMENT / COMMUNICATION PLAN

CMC is committed to ongoing engagement and communication with First Nations, local communities, regulatory agencies, and other stakeholders and land users. For communities to benefit from the Project, transparent and ongoing communication is needed so that governments, communities, and stakeholders are engaged and informed about the mine, mining activities and schedule, as well as opportunities such as jobs and employment, skills training, and business procurement for goods and services. Prior to mine development, CMC plans to hire a community liaison staff to work with the communities on Project opportunities (i.e. jobs and employment opportunities, contract/business opportunities) as well as socio-economic issues related to the mine. The community liaison will be responsible for engaging and consulting with First Nations, agencies and stakeholders outlined below.

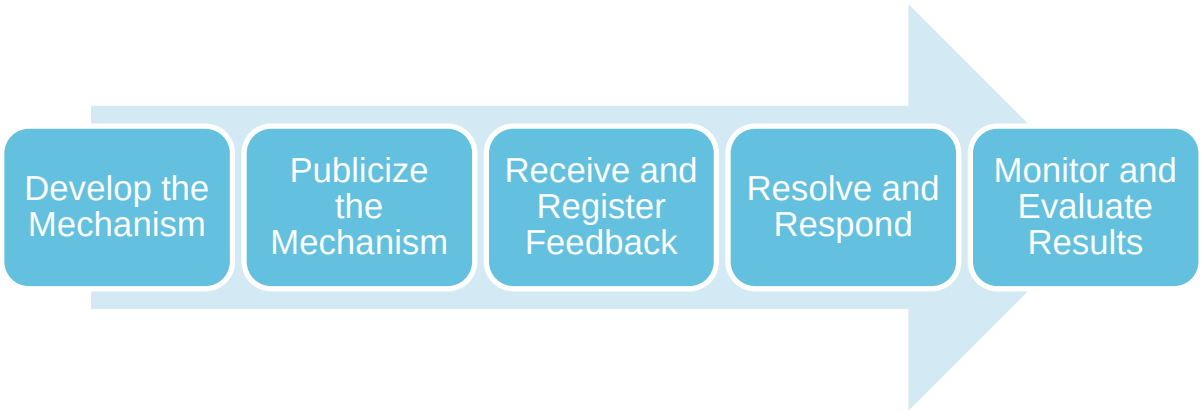
- First Nations Governments:
  - Selkirk First Nation
  - Little Salmon / Carmacks First Nation
  - Tr'ondëk Hwëch'in First Nation
- Municipal Governments:
  - Village of Carmacks
  - City of Whitehorse
- Yukon and Federal Government departments that interact with the communities.

To foster a collaborative and cooperative relationship with identified stakeholders, the objectives of the Stakeholder Engagement/Communication Plan are to:

- Promote engagement between the communities, the company and various levels of First Nations and Yukon Governments;
- Establish and maintain a relationship based on mutual respect and trust between CMC and the local communities;
- Encourage and promote dialogue from all stakeholders on issues and concerns related to the Project;
- Promote participation of communities, governments and other stakeholders in local initiatives and programs;
- Help to build trust and respect between CMC, First Nations, local communities, regulatory agencies, and other stakeholders and land users; and
- Establish a framework for engagement over the life of the Project.

Effective and open communication is also important in ensuring all parties' interests are considered. The company will establish a formal process of engagement and dialogue with First Nation governments and stakeholders to ensure dialogue and feedback are considered in the company's decision-making processes during all phases of the Project from construction to closure. Methods for engaging and communicating with affected parties will be developed collaboratively with the interest groups.

CMC will establish a Complaints/Grievance Management procedure for receiving complaints, grievances, suggestions, and recommendations from all parties. A formal grievance procedure provides the company and stakeholders an opportunity to improve overall management and operations of the Project. Submission of complaints and grievances can be filed in person, online through company website, letters, phone calls, and/or email, and an internal review process will subsequently be conducted. CMC will work toward establishing a procedure prior to the development of the mine, as summarized in the diagram below.



A.22F.7 MONITORING AND MITIGATION

CMC will work with affected First Nations and Yukon Government to monitor the activities of the Project to avoid or minimize adverse socio-economic effects on community health and well-being, and to enhance benefits where applicable.

CMC, in collaboration with government departments and affected First Nations, will work to establish a program to monitor the socio-economic effects of the Project during construction, operations, and closure phases in order to accomplish the following objectives:

- Collect and document data related to socio-economic conditions of affected communities;
- Work with local agencies to monitor Project socio-economic effects;

- Confirm and verify the predicted socio-economic effects of the Project;
- Identify unforeseen socio-economic effects of the Project;
- Monitor employment and skills training programs by CMC and other institutions such as Yukon College and YMTA;
- Evaluate the effectiveness of mitigation measures in managing socio-economic effects; and
- Revise, and where appropriate, develop new mitigation measures to manage unforeseen socio-economic effects.

This monitoring program will lay out the commitment and framework for monitoring the effects predicted through the environmental assessment under Yukon Environmental and Socio-economic Board (YESAB). Final selection of socio-economic valued components will occur following assessment of the Project through the YESAB process. Annual reports will be generated to summarize the monitoring program results and will include data on the socio-economic predicted effects in order to track the changes from pre-Project conditions through operations.

Monitoring and mitigation of socio-economic effects will also inform development of adaptive management plans in consultation with local and regional institutions and government agencies to determine effectiveness of adaptive and mitigation measures.

Where CMC deems applicable, CMC will not be required to report or disclose information considered to be of a proprietary or commercially sensitive nature, or that may infringe the personal privacy of its employees.

A.22F.8 REFERENCES

The Mining Association of Canada. (2014). Towards Sustainable Mining. Retrieved November 13, 2014, from The Mining Association of Canada: http://mining.ca/towards-sustainable-mining.

APPENDIX A.22G: Liquid Natural Gas Management Plan



CASINO PROJECT

LNG MANAGEMENT PLAN

PRELIMINARY DRAFT

Prepared by:
Casino Mining Corporation
November 2014

EXECUTIVE SUMMARY

The Casino Mine Project is an approximately 22 year mine project owned and operated by Casino Mining Corporation (CMC), that will produce copper and molybdenum concentrates, and gold dore bars via flotation milling and heap leach processing, respectively. The proposed project includes a four year construction period and a 90 year post-closure period. Key project components include the open pit, tailings management facility and waste rock storage area, heap leach facility, mill and associated infrastructure, ore stockpiles, liquefied natural gas power generating infrastructure, and office and accommodation buildings. The project also requires a 120 km access road from the town of Carmacks, YT, and concentrate will be trucked to the port at Skagway, Alaska.

The Casino Mine Project is a proposed 22 year mine project owned and operated by Casino Mining Corporation (CMC), that will produce copper and molybdenum concentrates, and gold dore bars via flotation milling and heap leach processing, respectively. The location of the Casino Project is shown on Figure 1 1. Key project components include the open pit, tailings management facility and waste rock storage area, heap leach facility, mill and associated infrastructure, ore stockpiles, liquefied natural gas power generating infrastructure, and office and accommodation buildings. The project also requires a 120 km access road from the town of Carmacks, YT, and concentrate will be trucked to the port at Skagway, Alaska.

LNG is proposed as the primary fuel supply for power generation and other ancillary uses at the Casino Project. All LNG deliveries to the mine will be by truck transport that will ramp up to an estimated 900 m3/day LNG when at full production. LNG storage is required at the mine to stockpile sufficient inventory to supply natural gas fuel needs during the period where road access is limited due to weather.

A management plan for toxic or hazardous substances is required by the Canadian Environmental Protection Act (CEPA) and through the Environmental Management Act (EMA) Hazardous Waste Regulation. Prior to the start of operation, a comprehensive LNG Management Plan for the Casino Project will be developed to ensure worker safety and to prevent uncontrolled releases to the environment. The LNG Management Plan will be developed in consideration of the principles and standards of practice of the Canadian Standards Association (CSA) standards CSA-Z276, CSA-Z731 and the National Fire Protection Association (NFPA) codes NFPA 59A, as well as other principles and standards of practice related to transportation, handling and storage/use and worker safety and emergency response.

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ABBREVIATIONS

API ..... American Petroleum Institute
ASME ..... American Society of Mechanical Engineers
BLEVE ..... Boiling Liquid Expanding Vapor Explosion
BOG ..... Boil-off gas
CEPA ..... Canadian Environmental Protection Act
CMC ..... Casino Mining Corporation
CSA ..... Canadian Standards Association
EMA ..... Environmental Management Act
ESD ..... Emergency shut down
LNG ..... liquefied natural gas
MDE ..... Maximum design earthquake
MSDS ..... Material Safety Data Sheets
NEC ..... National Electric Code
NFPA ..... National Fire Protection Association
PGA ..... Peak ground acceleration
psig ..... Pounds per square inch gauge
the Plan ..... LNG Management Plan
YESAB ..... Yukon Environmental and Socio-Economic Assessment Board

1 – INTRODUCTION

The Casino Mine Project is a proposed 22 year mine project owned and operated by Casino Mining Corporation (CMC), that will produce copper and molybdenum concentrates, and gold dore bars via flotation milling and heap leach processing, respectively. The location of the Casino Project is shown on Figure 1-1. Key project components include the open pit, tailings management facility and waste rock storage area, heap leach facility, mill and associated infrastructure, ore stockpiles, liquefied natural gas (LNG) power generating infrastructure, and office and accommodation buildings. The project also requires a 120 km access road from the town of Carmacks, YT, and concentrate will be trucked to the port at Skagway, Alaska.

LNG is proposed as the primary fuel supply for power generation and other ancillary uses at the Casino Project. All LNG deliveries to the mine will be by truck transport that will ramp up to an estimated 900 m^3/day LNG when at full production. LNG storage is required at the mine to stockpile sufficient inventory to supply natural gas fuel needs during the period where road access is limited due to weather.

A management plan for toxic or hazardous substances is required by the *Canadian Environmental Protection Act* (CEPA) and through the *Environmental Management Act* (EMA) Hazardous Waste Regulation. Prior to the start of operation, a comprehensive LNG Management Plan for the Casino Project will be developed to ensure worker safety and to prevent uncontrolled releases to the environment. However, a preliminary plan is provided herein to satisfy the requirements of the Yukon Environmental and Socio-Economic Assessment Board (YESAB).

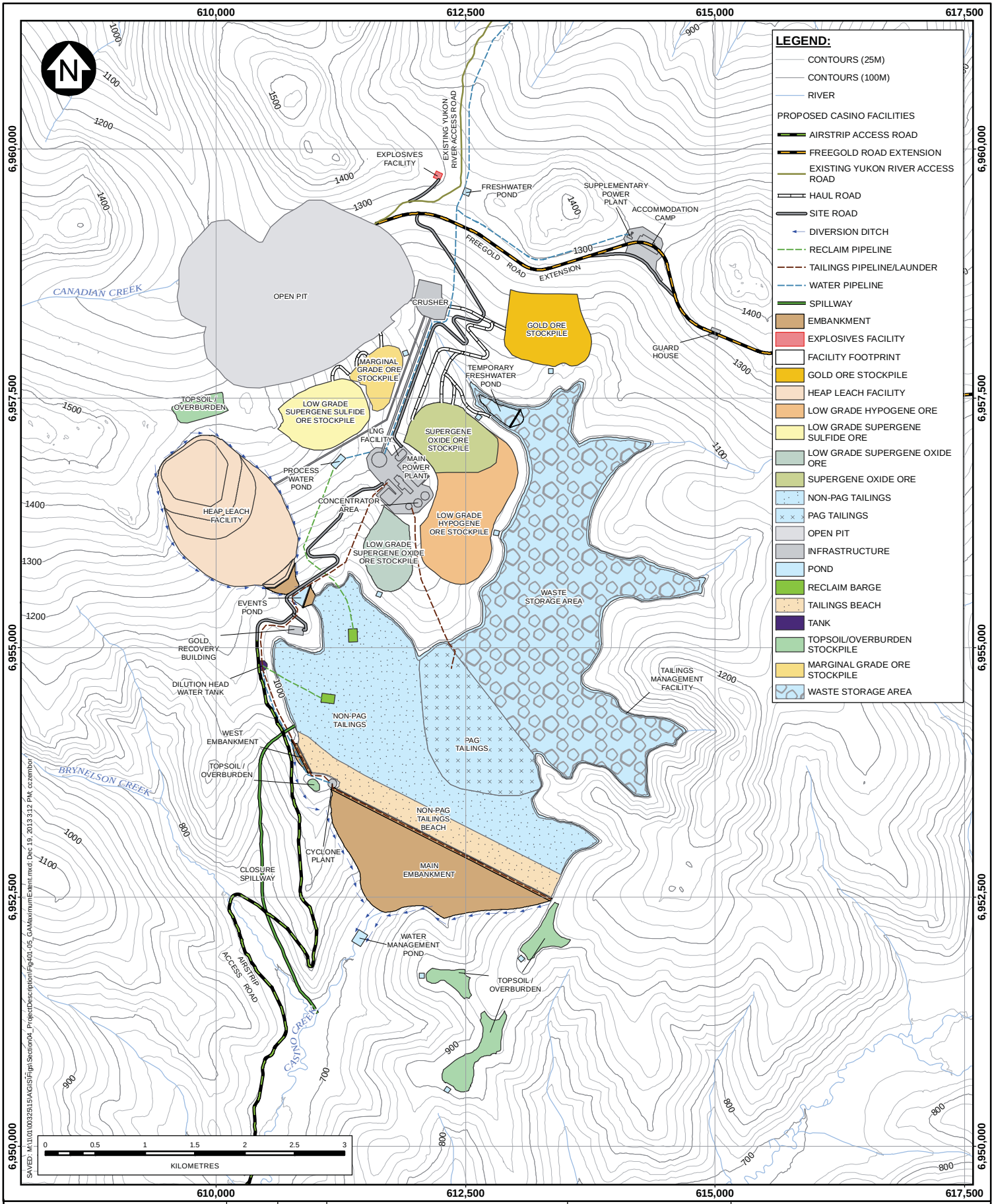
The following subsections provide a preliminary LNG Management Plan, outlining the information and the level of detail that will be provided in the final plan. The plan will include all applicable mitigation and management measures developed through the process and committed to by Casino Mining Corporation.

The LNG Management Plan will be developed in consideration of the principles and standards of practice of the Canadian Standards Association (CSA) standards CSA-Z276, CSA-Z731 and the National Fire Protection Association (NFPA) codes NFPA 59A, as well as other principles and standards of practice related to the following:

- Transportation;
- Handling and storage/use; and
- Worker safety and emergency response.

The LNG Management Plan will be integrated with other relevant Management Plans (e.g., Emergency Response Plan, Spill Contingency Plan) to ensure that worker/public health and safety as well as the environment are protected.

The Plan will be updated as the project is refined, and further details are acquired with regards to the management of LNG at the Casino Project. The final Plan will include a table of proponent commitments made during the environmental assessment process relevant to LNG management, and indicate how the plan addresses the commitments. Terms and conditions of any applicable licences, permits and approvals required for the Project operations will also be included, once acquired.



PREPARED BY:

Knight Piésold CONSULTING

DESIGNED	GLS/CAH
DRAWN	CC
CHK'D	CAH
APP'D	GLS
REV	0
DATE	16DEC'13

NOTES:
1. BASE MAP: EAGLE MAPPING
2. PROJECTION: NAD 1983 UTM ZONE 7N
3. COORDINATE GRID: METRES

CASINO

CASINO PROJECT

GENERAL ARRANGEMENT - MAXIMUM EXTENT

FIGURE 1-1

REF 1

P/A VA101-325/15

2 – TRANSPORTATION

The final LNG Management Plan will be based on best practices in transporting LNG on public roads, driver communications, vehicle location tracking, maintaining mobile equipment, maintenance record keeping, personnel records, regulatory & enforcement coordination, and to demonstrate compliance to national and local regulations on a long-term, and sustainable basis. The purpose of the plan is to establish standards that all transportation participants will be trained in and measured for conformity.

To ensure the protection of communities and the environment during transport of LNG to the Casino Project, the general guidelines below will be followed:

- Responsibility for safety, security, release prevention, training, and emergency response will be established in written agreements with producers, distributors and transporters.
- Emergency response plans and management measures will be implemented by LNG transporters.

The following practices from CSA-Z276 will be followed in the development of the more detailed transportation plan:

CSA-Z276

13.3.8 Transportation of LNG

13.3.8.1: The driver of each tank vehicle, or the shipper's representative accompanying the driver, shall have readily available written procedures regarding general operating precautions, manual venting, and emergency procedures, including names, addresses, and telephone numbers of individuals to be contacted in an emergency.

13.3.8.2: Stopovers of tank vehicles may occur at safe locations. Under no circumstances shall a tank vehicle be left unattended on a public highway.

13.3.8.3: It can be necessary to blowdown a tank at a remote and safe location. The driver or shipper's representative shall be trained to identify a suitable location and be trained in blowdown procedures.

13.3.8.4: The driver or the shipper's representative accompanying the driver shall be trained in the handling of LNG.

2.1 REQUIREMENTS AND GUIDELINES FOR TRANSPORTATION CONTRACTORS

Casino Mining Corporation will require contractors retained for LNG deliveries to the Project will develop and implement a LNG Transportation Plan that is consistent with the LNG standards mentioned above, and should be integrated with the overall LNG management plan as well as with related management plans (i.e. the Environmental Management Plan). Each contracting firm will be requested to prepare their approach and to submit their proposal based on the following:

- A staffing plan that will support the functional for the LNG trucking fleet. The staffing plan should include general management, drivers, mechanics, and other maintenance and shop personnel, dispatchers, road supervisors, quality assurance staff to handle issues that arise, training including operator and safety training, and office and administrative personnel. Their staffing plan will be used as one of the elements in

evaluating their capabilities and space requirements for the proposed LNG unloading and unloading facilities. Driver qualifications and training records are required.

- Trucks, trailers, and other components to be provided in the contract. Trucks and trailers to be a current model, new and unused, under standard production by the manufacturer, and of which parts are stocked at one or more locations in Western Canada. The requirement for parts to be stocked may be waived if the bidder provides an acceptable parts availability plan. All parts utilized on the unit should be new and unused.
- Queuing space allocations at the LNG unloading and unloading facilities for trucks be fueled (either LNG or diesel), LNG transfer to unload tankers, have consumable fluids checked and topped off as necessary, and the interiors cleaned without having to be moved. Bays are to be canopied, and designed to be pull-through able to be accessed at any time regardless of weather conditions.
- Transportation schedules and quantities.
- Carrier should furnish copies of Carrier's permits or authority to transport the products as issued by state or federal regulatory agencies.

The following practices will be described and implemented:

- Vehicles used for the transportation of LNG as well as the associated containers comply with the prescribed safety standards and display all applicable prescribed safety marks in accordance with CSA-Z276.
- Chain of custody documentation including MSDS (Material Safety Data Sheets) to track inventory and LNG movement.
- Use of escort vehicles or convoys for LNG shipments as necessary due to inclement weather and road conditions.
- Regular maintenance of transportation equipment including containers, trucks, loading and unloading machinery, and storage systems.
- Training of all personnel operating LNG handling and transport equipment.
- Emergency Response plans for a potential LNG release during transportation including:
    - Designate appropriate response personnel and commit necessary resources for emergency response;
    - Emergency response training of involved personnel;
    - Descriptions of the specific emergency response duties and personnel responsibilities;
    - A detailed list of all emergency response equipment available during transport or along the transportation route;
    - A detailed list of all emergency response and personal protective equipment during transportation;
    - Initial and periodic refresher training in emergency response procedures;
    - Develop procedures for internal and external emergency notification and reporting; and
    - Periodically evaluate response procedures and capabilities and revise if needed.

During operations, contractors as a minimum will need to provide evidence of compliance to the following:

- On a real time basis, identify limitations, risks and restrictions of conditions that might be encountered along the specific routes to be followed for driver awareness, and prescribed measures to be taken when they occur. Examples include:
  - Highway weight & dimensional limits;
  - Posted speed zones;
  - Bridge regulations;
  - Known traffic hazards;
  - Temporary road hazards;
  - Seasonal and climate related hazards; and
  - Highway impasse due to vehicle accidents, road obstructions, weather;
- Compliance to *LNG Transport Emergency Response Plan* for LNG highway transport operations:
  - Accidents involving LNG transport vehicles (no leaks or spills);
  - Accidents involving LNG transport vehicles (with leaks or spills);
  - LNG transport trailer rollover;
  - Leaks and spills;
  - Fire;
  - Weather related incidents; and
  - Coordination with local, provincial and federal authorities depending on the severity of the accident.
- Personnel policies and training (see Section 2.2).
- A system for real-time communications with drivers in transit.
- A system for tracking the location of vehicles in transit.
- A system to ensure all equipment used is appropriate for the products to be handled and transported. All equipment must comply with the requirements and standards. Equipment must be maintained in good condition and “fit for purpose”.
- A system to capture and report vehicle maintenance:
  - Preventative maintenance;
  - Maintenance problems and defective equipment;
  - Parts and procedures in performing maintenance and repairs;
  - Plan, schedule and record vehicle maintenance history;
  - Demonstrate the vehicle is maintained per the manufacturer recommendations; and
  - Specify tire types, use on specific axle as a minimum, and rules regarding repair and re-treading.

- A system for standard vehicle checklist prior to travel on a daily basis including:
  - A tire policy, tire inspection procedure, tire change and replacement frequency;
  - Regulations of tire pressures;
  - Fluids; and
  - Wiper blades, belts, hoses, etc.

2.2 PERSONNEL POLICIES AND TRAINING

Contractors who are evaluated for LNG transportation services will be requested to develop a training plan to ensure that training needs and effectiveness are reviewed on a regular basis. A training matrix should be prepared to determine what training will be delivered, by whom, and what frequency, etc. Training must take account of any statutory regulations, and should also reflect industry codes or standards relevant to the work. A designated person within the transportation services company is to coordinate and manage the provision of training and maintain appropriated training records. For employee qualification, training, and certification, detailed classroom study, testing, and safety training. Safety training that is expected to be included in the training syllabus matrix includes:

- Induction and Orientation
- Properties of LNG and Natural Gas
- LNG Transfer (unloading and loading) Operations
- LNG Fueling
- Fatigue & Tiredness
- Drug & Alcohol Abuse
- Vehicle Roll Over Awareness Training
- Personnel Protective Equipment
- Fire Prevention and Suppression
- Management Planning for the Specific Route
- Checklists, Logs, and Documentation
- Near Miss and Incident Reporting
- Tire inspections
- Journey Risks, Transportation Routes and Consideration of the Constraints and Risks Associated with the Routes
- Approved Rest Areas and Prominent Land Marks Along The Routes
- Emergency Response Plan

3 – HANDLING, STORAGE AND USE

The proposed LNG facility, storage and secondary containment infrastructure is shown in Figure 3-1. Delivery and unloading of LNG on site will take place at the LNG storage and receiving facility. The storage tank will include 110% secondary containment. The unloading and storage areas will be designed to allow safe maneuvering of plant vehicles. The LNG containment areas will be designed at 110% of the total volume held in the delivery container.

Measures implemented during LNG handling, storage, and use at the Casino project will be in accordance with the principles of CSA-Z276 – mainly to protect workers and the environment during LNG handling and storage. The relevant CSA-Z276 guidelines are summarized below.

CSA-Z276

13.3.9 LNG transfer

13.3.9.1: Where making bulk transfers into stationary storage containers,

(a) the LNG being transferred shall be compatible in composition and temperature or in density with the LNG already in the container; or

(b) means shall be employed to manage stratification and to prevent rollover and an excessive rate of vapor evolution where the compositions and temperatures or the densities are not compatible. If a mixing nozzle or agitation system is provided, it shall be designed to have sufficient energy to accomplish its purpose.

7.1.4 Basic design considerations

7.1.4.1: Those parts of LNG containers that normally are in contact with LNG and all materials used that are in contact with LNG or cold LNG vapor (vapor at a temperature below –29 °C [–20°F]) shall be physically and chemically compatible with LNG and intended for service at –168 °C (–270°F).

7.1.4.3: All LNG tank systems shall be designed to accommodate both top and bottom filling, unless other positive means are provided to prevent stratification.

7.1.4.4: Any portion of the outer surface area of an LNG container and any external members whose failure could result in loss of containment from accidental exposure to low temperatures resulting from leakage of LNG or cold vapor from flanges, valves, seals, or other non-welded connections shall be designed to withstand such temperatures or otherwise protected from the effects of such exposure.

7.1.4.5: Where two or more containers are situated in a common dike, the container foundations shall be capable of withstanding contact with LNG or shall be protected against contact with an accumulation of LNG that could endanger their structural integrity.

7.1.4.6 The density of the liquid shall be assumed to be the actual mass per unit volume at the minimum storage temperature; however, the assumed density shall not be less than 470 kg/m3 (29.3 lb/ft3).

Handling, storage and use of the LNG at the Casino Project will comply with the following best management practices:

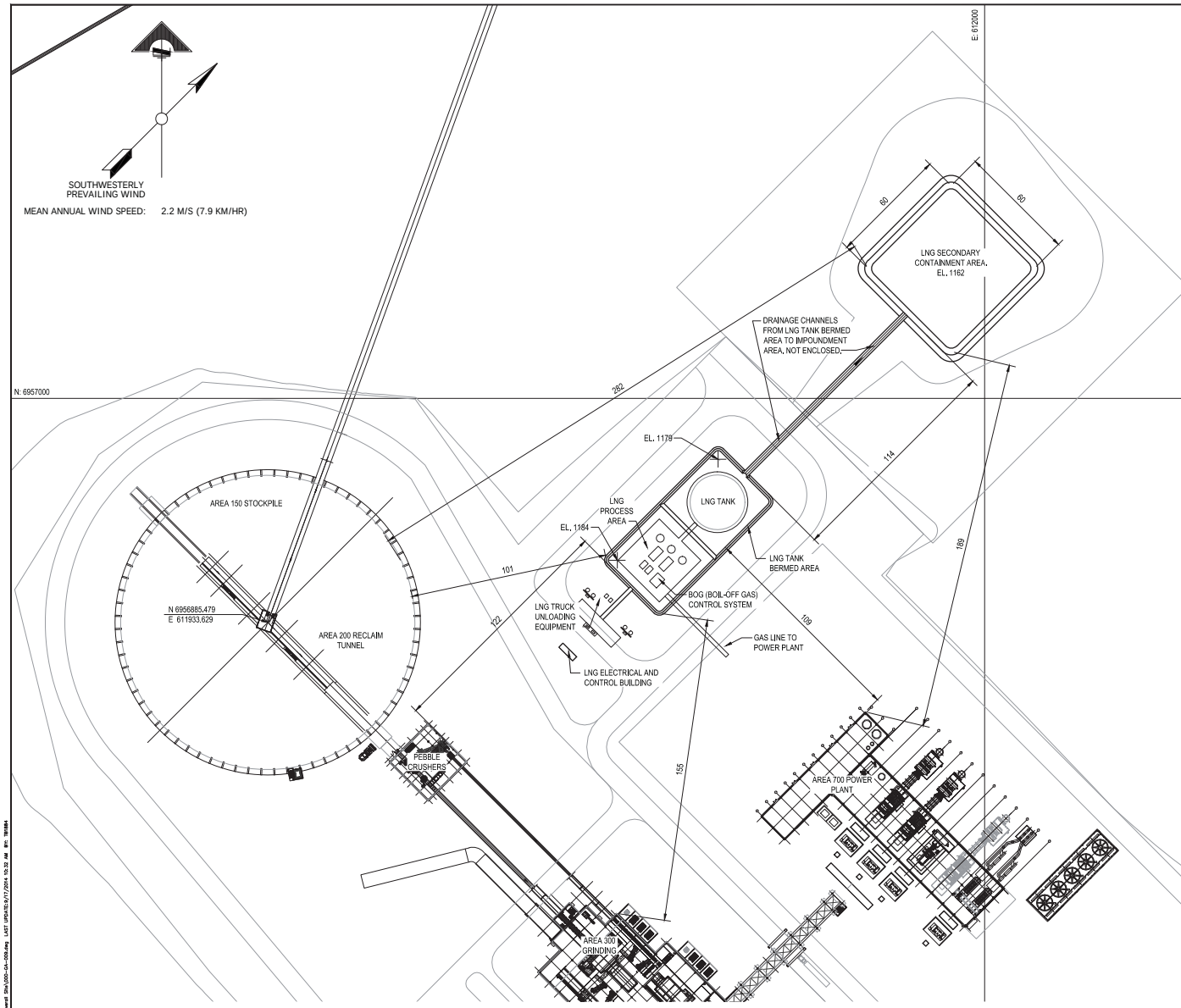
- Design and construct unloading and storage facilities consistent with sound, accepted engineering practices and quality control/assurance procedures, spill prevention and spill containment measures.
- Operate unloading and storage facilities using inspections, preventive maintenance and contingency plans to prevent or contain releases, and control and respond to worker exposures.
- Provide spill prevention or containment measures for associated tanks, pipelines, and associated process equipment.

3.1 LNG TRANSFER OPERATIONS

LNG transfer, storage and process equipment is a closed loop system such that during normal operations there should be no routine or significant releases to the atmosphere from plant equipment and processes. The exceptions are for extremely small releases during truck loading arm connection and disconnection operations. Operating procedures require that piping and transfer arms or hoses are to be purged with nitrogen prior to opening to the atmosphere to prevent an internal flammable mixture from occurring. The design, operating procedures, and are intended to eliminate the potential for:

- Unplanned or unsafe release of LNG or flammable vapors to the atmosphere;
- Flammable mixtures with air in piping, containers and other enclosed spaces;
- Hazards to personnel and equipment from improper valve isolations; or
- Hazards from improper cooldown and warm-up of LNG liquid and vapor lines.

Releases of flammable gas to the atmosphere may occur during certain planned maintenance activities, emergencies and abnormal operating conditions. “Hot Work” permits are required during truck loading/loading, arm/hose connection and disconnection operations where a potential for release of their contents to the atmosphere is possible. Transfer operations will comply with CSA Z276.



LNG FACILITY DATA :

LNG STORAGE TANK AND SECONDARY CONTAINMENT AREA, INCLUDING THE CHANNEL CROSSING THE ROAD AND TO THE IMPOUNDMENT AREA, DESIGNED TO THE SPECIFIC REQUIREMENTS OUTLINED IN THE FOLLOWING STANDARDS:

A. CSA Z276;
B. API 620 APPENDIX Q;
C. NFPA 59A.

LNG SECONDARY CONTAINMENT AREA

SIZE (INSIDE EDGE OF BERM):	60 M X 60 M
CONTAINMENT AREA:	3,600 SQUARE METERS (MAXIMUM AREA FOR POOL SIZE / RADIATION CALCULATION)
CONTAINMENT VOLUME:	11,000 CUBIC METERS (110% OF LNG TANK VOLUME)

LNG TANK

TANK SIZE:	28 M DIAMETER X 17.5 M HIGH (INTERIOR DIMENSIONS)
TANK VOLUME:	10,000 CUBIC METERS
LNG TANK BERM:	2 M WIDE, .75 M HIGH (AREA PROTECTION BERM. NOT THE CONTAINMENT BERM.)

LNG UNLADING PUMPS

NUMBER:	4
CAPACITY:	90 M^3/HR, EACH (LNG)

LNG TANK PUMPS

NUMBER:	2
CAPACITY:	45 M^3/HR, EACH (LNG)

LNG BOOSTER PUMPS (SUBMERGED)

NUMBER:	3
CAPACITY:	23 M^3/HR, EACH (LNG)

LNG GLYCOL/WATER CIRCULATION PUMPS

NUMBER:	2
CAPACITY:	185 M^3/HR, EACH (LNG)

LNG VAPORIZERS

NUMBER:	2
CAPACITY:	45 M^3/HR, EACH (LNG)

LNG BOG (BOIL-OFF GAS) COMPRESSORS

NUMBER:	2
CAPACITY:	1,171.6 M^3/HR, EACH (GAS)

LNG FACILITY LAYOUT

SCALE: 1:1000

25 12.5 0 25 50
SCALE IN METERS

DO NOT SCALE 11x17 DRAWINGS

PRELIMINARY
NOT FOR CONSTRUCTION

CASINO MINING CORPORATION

CASINO FEASIBILITY STUDY

REFERENCES		REFERENCES		REVISIONS						REVISIONS					
DWG. NO.	TITLE	DWG. NO.	TITLE	NO.	DESCRIPTION	BY	APP'D	DATE	CLIENT	NO.	DESCRIPTION	BY	APP'D	DATE	CLIENT

SCALE:	1:2000	DATE
DESIGNED BY	TFB	JUL 14
DRAWN BY	TFB	JUL 14
CHECKED BY		
PROJECT MGR		
CLIENT APPR.		

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CASINO PROJECT
OVERALL SITE
GENERAL ARRANGEMENT
LNG FACILITY LAYOUT

PROJECT NO. M3-PN 120001
DWG NO. **000-GA-009**
REV NO. P1
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3.1.1 LNG Truck Loading and Unloading

LNG supply to truck loading is from the LNG supplier's LNG tank transfer pumps. LNG unloading is from the highway trailer to the LNG storage tank using stationary LNG unloading transfer pumps. There is a common 'cold retention' liquid recirculation line for the two truck loading bays to retain LNG temperature in piping between LNG truck loadings. 'Cold retention' recirculation LNG is returned to the LNG tank zero send-out recirculation line.

For LNG code compliance for secondary containment, the loading and unloading bays are provided with a spill collection system to lead spills to an impoundment basin sized for 10 minute spill at max loading rate. A drain pot is provided to drain the LNG arms/hoses on completion of loading (for coupling disconnection, ease of handling and prevention of ice build-up during periods of no loading). Drained liquid is returned to the LNG recirculation line with nitrogen pressure.

Truck Loading and Unloading Bay Components:

- LNG unloading manifold
- LNG supply piping manifold
- Vapor return piping manifold
- Canopied Cover for loading bay and weighbridge (weather protection)
- Driver shelter
- Man-machine interface (MMI) for "load recognition and verification"
- Weighbridge
- Articulated liquid and vapor arms or hoses to connect Terminal piping to truck (arms or hoses will be determined during detailed engineering)
- Drain vessel for draining articulated arms/hoses
- Nitrogen supply for arms/hoses blow-down and drain-vessel blow-casing

Hazard detection, CCTV monitoring, and automatic and manual emergency shutdown is included in the truck loading design and includes the following truck loading and unloading area emergency shutdown initiators:

- ESD Hand Switch - Truck loading/unloading
- ESD Hand Switch - Truck loading/unloading perimeter (15m from bays)
- ESD Hand Switch– Main control room
- ESD (Automatic) truck loading fire, gas, spill hazard detection
- Instrument Air pressure: low-low, close truck loading ESDV's
- LNG tanker high liquid level (Alarm)
- LNG tanker high-high liquid level (ESD)

To contain potential LNG releases from loading/unloading areas and transfer piping, secondary containment curbs and transfer trenches will be installed in process areas and adjacent to LNG pipe racks to drain potential releases of LNG to impoundment basin.

Truck access to the Terminal Site is via an automatic gate. Only trucks and drivers with advance authorization and valid ID are admitted onto the Terminal Site. The truck loading operation is performed by trained truck drivers, who will remain in attendance throughout the loading procedure.

3.1.2 LNG Highway Tanker Loading Operational Steps

LNG highway tanker loading/unloading is accomplished by performing a sequence of operational steps:

1. Trucks access the facility via an automatic gate. Only approved trucks and drivers with valid ID are admitted.
2. The truck/tanker parks on the weighbridge
3. The driver secures the truck, chalk wheels, and steps away from the weighbridge
4. Driver identity, Truck/tanker identity, and weight are validated as accurate
5. The truck loading/unloading operation is performed by trained drivers who will remain in attendance throughout the loading procedure.
6. An umbilical cord is connected to LNG highway tanker to monitor truck/tanker safety systems and provide earthen grounding to the tanker.
7. Truck keys are removed and secured
8. LNG loading and vapor hoses are connected between the tanker and the loading manifold
9. Vapor pressure is equalized between the tanker and facility vapor system
10. The LNG loading valve is opened to provide cooldown of the LNG loading arm/hose
11. The LNG facility loading or unloading pump is started that provides the drive force for transfer of LNG from storage tanks to highway tankers (loading) or from highway tankers to the LNG storage tank (unloading).
12. LNG loading/unloading continues until the tanker is near 90% full of liquid, and 10% or more vapor space is retained (loading) or until the tanker is near empty of liquid (unloading). A suction drum is located before the LNG transfer pump that has a liquid level indicator that automatically stops the unloading pump when liquid level drops below the setpoint in the suction drum. By design, a small heel of LNG is retained in the highway tanker to keep the tank cold for the return trip.
13. Vapor and LNG valves on the loading manifold are closed.
14. Hoses are depressurized, and purged of LNG and flammable vapor to the LNG drain vessel.
15. Hoses/arms are disconnected
16. The umbilical cord is disconnected
17. The LNG tanker loaded/unloaded quantity validation is completed in the facility measurement system
18. The driver departs with the LNG tanker load and vapor space pressure of approximately 2 psig.

3.1.3 LNG Highway Tanker Loading Safety Features

The LNG highway tanker loading/unloading facility will incorporate a number of safety features to prevent unsafe conditions:

- Hazard detectors will be installed in the LNG highway tanker loading area where potential of LNG spills, gas leaks, flame, excess heat and cryogenic temperature indicate unsafe conditions. Logic in hazard detection control systems will automatically trigger an emergency shutdown (ESD) for specific events.
- Manual ESD activation hand-switches are provided at multiple locations in the tanker loading area.
- Emergency manual call points are provided, as well as sirens and beacons to alert personnel of emergency situations.
- A terminal-to-truck umbilical cable is connected to the LNG highway tanker that ensures that truck engine is off, LNG highway tanker is earthed, and truck & tanker braking systems are set before loading is permitted. Loading and vapor return hoses are vulnerable to “drive-off” with hoses connected. Cryogenic hoses are not provided with breakaway couplings to provide a “weak point” and to be avoided as a serious incident.
- Barriers protect pipe work from truck impact as practical.
- Fire suppression and firewater with remote activation and control in the event of fire is provided.

Note that operators will be trained to know when to apply fire water. Fire water is not an appropriate response for all fires.

3.1.4 LNG Highway Tanker Weighing During Loading/Unloading

A weighbridge is provided for each of the two LNG highway tanker loading and unloading bays. The truck and highway tanker is parked on the weighbridge the entire duration of loading and serves three primary purposes during loading:

1. Overfill protection is provided where the tanker has a maximum weight that when reached will stop loading. If exceeded, there will be an overfill alarm on high level. For high-high level, a safety interlock trip will stop loading. For high-high-high level, an ESD trip will stop loading.
2. For custody transfer measurement, loaded LNG quantities are automatically recorded in the LNG facility measurement system and based on the weight of LNG loaded. This is determined from the difference in starting weight to ending weight when loading is complete.
3. Prior to loading, a weight trip (pre-loaded set point for all truck/tanker) prevents the tanker from being loaded if not within expected weight range. The truck/tanker should weigh the same prior to the start of loading as the truck/tanker weighed after truck/tanker loading at Casino, less truck fuel consumed, or added en-route. A management override is required to document and explain any discrepancies.

And two primary purposes during unloading:

1. For custody transfer measurement, unloaded LNG quantities are automatically recorded in the LNG facility measurement system and based on the weight of LNG unloaded. This is determined from the difference in starting weight to ending weight when unloading is complete.
2. Prior to unloading, a weight trip (pre-unloaded set point for all truck/tanker) prevents the tanker from being unloaded if not within expected weight range. The truck/tanker should weigh the same prior to the start of unloading as the truck/tanker weighed after truck/tanker loading in Fort Nelson, less truck fuel consumed, or added en-route. A management override is required to document and explain any discrepancies.

4 – WORKER SAFETY AND EMERGENCY RESPONSE

The following principles for worker safety are of the utmost importance and must be followed at all times:

- Protect workers' health and safety from exposure to LNG/natural gas evaporating from the LNG.
- Protect communities and the environment through the development of emergency response strategies and capabilities.
- Train workers and emergency response personnel to manage LNG in a safe and environmentally protective manner.

This section of the LNG Management Plan will be implemented in conjunction with the Occupational Health and Safety Management Plan as well as with the Emergency Response Plan. The relevant CSA-Z276 safety and emergency response guidelines include:

CSA-Z276

4.5 Safety and loss management system

4.5.1: For each LNG facility, the operating company shall develop, implement, and maintain a documented safety and loss management system that provides for the protection of people, the environment, and property.

4.5.2: The safety and loss management system shall include the following elements:

(a) clearly articulated policy;

(b) leadership commitment;

(c) a suitable organizational structure with well-defined responsibilities and authorities;

(d)a process for the management of resources, including the establishment of competency requirements and an effective training program;

12.8 Personnel safety

12.8.1: Protective clothing that provides protection against the effects of exposure to LNG shall be available and readily accessible at the facility. Note: Protective clothing for normal liquid transfer operations should include cryogenic gloves, safety glasses, face shields, and coveralls or long-sleeve shirts.

12.8.2: Those employees who are involved in emergency activities, as determined in accordance with Clause 12.1.2, shall be equipped with the necessary protective clothing and equipment and shall be qualified in accordance with NFPA 600.

12.8.3: Written practices and procedures shall be developed to protect employees from the hazards of entry into confined or hazardous spaces. Note: Information concerning confined entry practices and procedures can be found in the U.S. Code of Federal Regulations, Title 29, Subtitle B, Chapter XVII, Part 1910.46, the Canada Labour Code, Part II, and any local, state, or provincial/territorial regulations and standards that apply.

12.8.4: At least three portable flammable-gas indicators shall be readily available. Note: Natural gas, LNG, and hydrocarbon refrigerants within the process equipment are usually not odorized, and the sense of smell cannot be relied upon to detect their presence. Two portable detectors should be available for monitoring when required, with a third detector for backup. This provides a spare detector in the event of failure of one of the primary detectors and also allows verification if the two primary detectors provide different readings.

13.3.3 Emergency procedures

13.3.3.1: The types of emergencies referred to in Clause 13.3.2(k) shall include, at a minimum, emergencies that arise from an operating malfunction, structural collapse of part of the LNG plant, personnel error, forces of nature, and activities carried out adjacent to the plant. Emergency procedures shall include:

(a) procedures for responding to controllable emergencies, including notifying personnel, the use of equipment that is appropriate for handling of the emergency, the shutdown or isolation of various portions of the plant, and other applicable steps to ensure that the escape of gas or liquid is promptly cut off or reduced as much as possible;

(b) procedures for recognizing an uncontrollable emergency and for taking action that will

(i) minimize harm to the personnel at the LNG plant and to the public; and

(ii) provide prompt notification of the emergency to the appropriate local officials, including notification of the possible need to evacuate persons from the vicinity of the LNG plant; and

(c) procedures for coordinating with the appropriate local officials an emergency evacuation plan that sets forth the steps necessary to protect the public in the event of an emergency.

13.3.3.2: The procedures and steps in Clause 13.3.3.1(c) shall include methods of advising the appropriate local officials of the

(a) quantity and location of fire equipment throughout the LNG plant;

(b) potential hazards at the LNG plant;

(c) communication and emergency control capabilities of the LNG plant; and

(d) status of each emergency.

13.3.3.3: Normally, gas fires (including LNG fires) should not be extinguished until the fuel source has been shut off, unless the fire would create more of a hazard than the gas dispersion.

The following principles will be implemented to meet the CSA-Z276 code requirements:

- Identify potential LNG spill scenarios and measures necessary to eliminate, mitigate and control, and minimize worker exposure. The scenarios will include vapor dispersion/thermal radiation from potential spills, and the layers of protection associated (i.e. a spill impoundment).

- Prepare detailed emergency response plans for potential LNG spills as they may cause fires if not contained. The plans will outline the potential scenarios and specific response actions including clearing the site, personnel, and the public as necessary.
- Develop and implement emergency response plans to respond to worker exposure to LNG/natural gas.
- Involve site personnel and stakeholders in the planning process.
- Periodically evaluate response procedures and capabilities and revise them as needed.
- Train appropriate personnel to operate the LNG receiving and unloading facility according to systems and procedures that protect human health, the community, and environment.
- Train workers to understand the hazards associated with LNG/natural gas.
- Train workers and personnel to respond to LNG/natural gas exposure and environmental releases, including use of first aid measures.
- Designate personnel and commit equipment and resources for emergency response as necessary.
- Develop internal and external procedures for emergency notification and reporting.

4.1 GENERAL HAZARDS

General hazards from the handling, storage and transportation of LNG include potential hazards during loading and unloading, during transit and during storage and from day-to-day operations. These hazards are discussed further below. Fire hazards from LNG and from the gasified natural gas are also outlined.

4.1.1 Hazards of LNG and Natural Gas

LNG liquid itself is not flammable – only the vapors emanating from the liquid can be lit. Natural gas and LNG vapor fires in the open atmosphere may flash and burn hot, but are not explosive because the flame propagation speed is much less than required to have an explosive pressure wave when the ignition is not within an enclosed space. In an unconfined space, the flame propagation speed of natural gas and LNG vapor increases with the temperature of the gas, but is significantly lower than other flammable hydrocarbons such as propane or gasoline vapors which can explode in an unconfined space.

Potential hazards from LNG, natural gas, explosion and from improper handling techniques are summarized below.

4.1.1.1 Hazards from LNG

The design, operations and maintenance procedures for handling, storage, and transfer of LNG are intended to eliminate the potential for LNG liquid from being released in the atmosphere or on the ground at all times. General hazards from LNG include:

- LNG vapor is flammable when in a 5 to 15% concentration in air. Please note that this is a fairly narrow concentration range in comparison to other hydrocarbons.
- Skin exposure by personnel to LNG (or bare metal surfaces chilled by LNG) will cause external dermal frost burns also called cryogenic “burns” or frostbite due to the -161 °C temperature of LNG. Cryogenic burns can cause serious skin injury in the form of skin discoloration, loss of skin layers and blistering dependent on the quantity and duration of exposure that requires immediate medical attention.

- If inhaled, LNG vapor is non-toxic to breathe the same as nitrogen or carbon dioxide but can act as an asphyxiate by displacing oxygen in the air.
- If inhaled, LNG vapor may be very cold and cause internal frost burns to the throat and lungs and may require immediate medical attention.
- When LNG liquid is confined in a pipe, container, or tank, the LNG will begin to absorb heat from the atmosphere that initiates vapor creation (boiling) of the LNG with a 1-to-615 of liquid (at atmospheric pressure) to vapor expansion ratio. Unless the pressure is released at an equal or greater rate, the container could be exposed to rapid and/or extremely high internal pressure buildup. The potential pressure buildup due to this effect could quickly exceed the containment pressure design rating that could cause a sudden failure of the container or other serious failures that may or may not include ignition.
- LNG vapor can be lighter or heavier than air based on the LNG vapor temperature with a specific gravity range of 1.7 when cold to 0.55 when warmed to ambient temperature. This characteristic results in the vapor having potential to collect in low places when cold, and high place when warm.
- LNG is an odorless, colorless, non-corrosive, and non-toxic clear liquid, where the presence of LNG or LNG vapor is not necessarily apparent to the human senses of smell and sight. When exposed to the atmosphere LNG produces a visible vapor cloud (fog) as moisture in the air condenses. Once the gas vapor temperature equalizes with the surrounding atmosphere, the vapor cloud fades away. Instruments for gas detection are to be relied upon for detecting the presence of natural gas and LNG vapor.
- LNG is very cold and therefore materials selected for storage and transfer of LNG need to be fully considered to be sure they are suitable for the application. Materials such as plastic and carbon steel become very brittle and will fail if exposed to the cryogenic temperatures of LNG liquid where stainless steel and aluminum materials retain their strength properties at cryogenic temperature.
- LNG is very cold that results in materials LNG comes into contact with to become smaller (contract) due to thermal contraction and expand upon warm-up. This effect needs to be considered to allow for movement where expansion and contraction occurs.

4.1.1.2 Hazards from Natural Gas

The design, operations and maintenance procedures for handling, storage, and transfer of natural gas are intended to eliminate the potential for natural gas from being released in the atmosphere at all times. General hazards from natural gas include:

- Natural gas is flammable when mixed with air and ignited.
- Natural gas is explosive when mixed with air and ignited in an enclosed space.
- Exposure of personnel to natural gas vented at high velocity can cause serious skin and eye injury that requires immediate medical attention.
- If inhaled, natural gas can act as an asphyxiate by displacing oxygen but is non-toxic to breathe the same as nitrogen or carbon dioxide.
- Natural gas is lighter than air and can collect in high place if confined.
- Natural gas is an odorless, colorless, non-corrosive, and non-toxic clear gas where the presence of natural gas is not necessarily apparent to the human senses of smell and sight. Instruments for gas detection are to be relied upon for detecting the presence of natural gas and LNG vapor.

4.1.1.3 Explosion Hazard Description of Natural Gas and LNG Vapors

Natural gas and LNG vapors are not explosive in an open space, and volatility of ignition decreases with colder ambient temperature. When natural gas and LNG vapor are ignited in a flammable mixture with air in an open space, the flame propagation speed is well below the speed of sound. When ignited, natural gas and LNG vapor will produce a flame and heat until the fuel is consumed, but no meaningful pressure wave will occur. Lower ambient temperature will further reduce the volatility of natural gas and LNG vapor where the intensity of the initial ignition is further reduced.

An explosion can occur with natural gas and LNG vapor, but only when combined with air in an enclosed space (pipe, containers, tanks, and buildings) and ignited. This is a far more serious hazard than fire in the open atmosphere. In addition to the effects of the fire, an explosion can be generated that has considerably more destructive power from the combined effects of fire and rapidly expanding vapor within an enclosed space structure. An explosion is caused when the initial ignition and fire causes a pressurization impulse wave that is initially contained by the enclosed space that further compresses the confined gases which also increases the gas temperature. The ignited gas burns behind a shockwave and releases energy that supports supersonic (faster than the speed of sound) shock propagation. This self-sustained detonation wave is different than an open fire as this can propagate at a supersonic speed and high temperature causing a significant and sudden pressure change and flashback (sonic boom). Because detonations generate rapid pressure changes and higher temperature they are generally much more destructive than subsonic fires. In all cases, an explosion will exceed the pressure containment rating of the enclosed space (pipe, containers, tanks, sumps and buildings) that results in complete loss of containment and failure of the enclosure and structure that further amplifies the destructive power of the blast. Other potential effects include flash fire, high temperature, supersonic pressure waves, domino failures, flying projectiles, burns, debilitating injury-death, hearing loss, asphyxiation, etc.

4.1.1.4 Hazards from Improper Purge, Isolation, and Ignition Sources

Hazards created by improper purge, improper isolations, the presence of ignition sources, and improper cooldown can be serious events. The following procedures will be included in the final LNG Management Plan to prevent such occurrences:

- Hazards from Improper Purge, Isolation, and Ignition Sources
- Purging
    - Purge-Into-Service
    - Leak Check and Pressurization Into Service
    - Purging-Out-of-Service
- Isolations for LNG and Natural Gas
- Cooldown-Into-Service
- Cooldown of LNG Piping
- Warm-up of LNG Piping and Containers

4.1.2 Potential Hazards at an LNG Loading / Unloading Facility

Hazards listed below are identified as potential safety hazards that will be addressed and managed in detail during facility design and development of safe operating procedures for LNG transfer operations of an LNG

highway tanker at an LNG loading/unloading facility. The transfer phase of operations includes arrival at the LNG transfer facility, arm/hose connection, preparing for the LNG transfer, LNG transfer operations, arm/hose disconnection, and departure from the LNG transfer facility. Hazards during LNG transfer operations of an LNG highway tanker include:

- Unconstrained flammable gases in the atmosphere;
- Accidental spills or releases involving LNG liquid or vapor;
- Arms or hoses beyond their safe operating limits due to LNG tanker movement during transfer operations. (arms or hoses will be determined during detailed engineering) This could be caused by improper wheel chalking or improper drive off;
- Overfill the tanker with LNG during loading;
- Overpressure the LNG tanker;
- Vacuum pressure the LNG tanker;
- Accidents caused by vehicle movement in the transfer area;
- Fire in the transfer area;
- Flammable mixtures in piping, containers and other enclosed spaces;
- Hazards to personnel and equipment from improper isolations;
- Hazards from fueling the transit vehicle;
- Potential ignition sources for accidental ignitions of unconfined flammable gases in the atmosphere;
- Potential hazards from improper cooldown and warm-up of LNG liquid and vapor lines;
- Slips and falls by drivers during LNG transfer and fueling in inclement winter weather; and
- Personnel exposure to lightning hazards during storms.

By design, during normal LNG transfer operations, there should be no flammable gas or LNG in the atmosphere from transfer equipment and processes except small releases during trailer arm/hose connection and disconnection processes when the arms/hoses are purged and inerted. Releases to the atmosphere may also occur during certain planned maintenance activities, emergencies and abnormal operating conditions. Maintenance should be avoided during transfer operations, however, if necessary, “Hot Work” permits are required for maintenance during transfer operations, and when the arms are purged and inerted and planned maintenance activities during which flammable gases may be present. The design of the transfer facility includes operability, potential ignition source management, maintainability requirements, and mitigations to all potential hazards listed above.

4.1.3 Potential Hazards of LNG during Transit

Hazards listed below are identified as potential safety hazards that will be addressed and managed in detail during LNG transit operating procedures development, LNG transportation contractor selection, LNG driver training, and routine operations for safe LNG transit operations of an LNG highway tanker. This phase of operations includes all the activities during the roundtrip transit after departing an LNG transfer facility to arrival at an LNG transfer facility. Hazards during LNG transit operations of an LNG highway tanker include:

- Driver fatigue or inattention;
- Vehicle accident during transit;
- Driver unsafe driving practices;
- Accidental spills or releases involving LNG liquid or vapor resulting in unconstrained flammable gases in the atmosphere;
- Overpressure the LNG tanker due to boil-off gas buildup;
- Vehicle fire during transit;
- Potential ignition sources from the transit vehicle, other vehicles, other activities en-route that present sources of accidental ignitions of unconstrained flammable gases in the atmosphere; and
- Slips and falls due to LNG transfer during inclement winter weather.

An LNG tanker trailer is a tight, double wall insulated tank, where all LNG tank interfaces are valved off and capped, except for pressure relief valves. During normal LNG transit operations there should be no ignitable flammable gas or LNG vapors in the atmosphere from the tanker or vehicle fuel system. Pressure in the LNG tank vapor space is normally maintained at low pressure, and significantly below the pressure relief valve setpoint. Releases to the atmosphere during transit are an exception, and considered an abnormal or emergency operating condition.

4.2 ACCIDENTS AND MALFUNCTIONS

All facilities, including LNG facilities, will be designed and constructed in accordance with applicable Federal and Territorial codes and regulations. Applicable permits will also be obtained prior to operation of the facility to fulfil compliance.

Incident scenarios involving uncontrolled release from vaporization, process pipework, and fuel gas systems may include an abnormal temperature or pressure. Potential releases will be prevented by following engineering best practices for LNG and requirements from CSA Z276. By design, during normal LNG facility operations, there should be no flammable gas or LNG in the atmosphere from process equipment, storage and transfer areas except small releases during trailer arm/hose connection and disconnection when the arms/hoses are purged and inerted. Releases that could cause flammable gas mixture build-up in a congested region of the plant are considered an abnormal and potentially emergency condition. Gas, fire, and LNG spill detection are provided as the first line of defense in detecting unsafe releases, and will provide audible alarms, and in some cases, an automatic process shutdown.

Mitigation measures have been incorporated into the design of the LNG and natural gas facility and distribution network. Mitigation measures implemented to avoid impacts from the environment on the project (e.g., seismic events, extreme weather, wildfire) are summarized in Table 4-1.

Table 4-1 Mitigation Measures to Avoid Disturbance from Environmental Events

Environmental Event	Mitigation Measure
Earthquake or seismic event	The LNG storage tank will be designed for MDE corresponding to 1 in 2,500 year earthquake with a mean PGA of 0.13g and a design earthquake magnitude of 8.0.
Terrain stability	The LNG tank is expected to be founded on bedrock with no possibility of permafrost being present. There is no prospect of terrain instability where these facilities are to be located.
Extreme weather (e.g., snow, wind, etc.)	The LNG tank and related facilities will be designed to withstand all site conditions including snow, wind, etc. as required by code and sound engineering practice.
Unstable areas	Detailed geotechnical studies and seismic analysis will be performed during detailed engineering to confirm the stability of the LNG tank soil conditions, and areas in proximity of the LNG facility that could potentially be unstable.
Wildfire	The LNG storage and related facilities are isolated from other site facilities and activities to preclude potential ignition sources for the LNG impoundment area.

Additionally, a hazard detection system for the facility will serve as the first line of defense for detection of gas, LNG releases and fire. The system is based on the following strategies:

- Continuous monitoring of areas that store, transfer, process flammable fluids by remote hazard detectors (flame, gas, and low temperature);
- Manual local emergency hand switches at strategic locations to manually activate the Hazard Detection System;
- Remote visual monitoring through closed circuit television (CCTV);
- Hazard detection system audible alarms and visual beacons to alert personnel of a potential hazard and abnormal operations in the immediate area of the detection and in the local & Main Control Room;
- Automatic trips of ESD system zones for certain events.

A fire suppression system may be employed which will detect, extinguish, and control the flame.

4.2.1 Seismic Events

The process equipment and piping will be designed to comply with the CSA-Z276 standards for site specific seismic conditions. The LNG storage tank will be designed for MDE corresponding to 1 in 2,500 year earthquake with a mean PGA of 0.13g and a design earthquake magnitude of 8.0. Table 4-2 describes the potential consequences if a foundation or structural failure occurs for various associated piping and equipment.

Table 4-2 Potential effects of seismic events on the LNG storage tank, other equipment, and pipelines carrying natural gas

Equipment	Seismic Event	Potential Effect
LNG Storage Tank	Foundation Failure/Structural Failure	Failure of the LNG storage tank foundation can affect the integrity of the LNG container, the impounding system and system components required to isolate the LNG container. An LNG spill can occur and if a source of ignition is present a pool fire can occur which can lead to a vapor cloud ignition.
Natural Gas Pipeline	Foundation Failure/Structural Failure	This can lead to a leak or rupture of the pipeline. If this occurs there is a potential for a flash fire if an ignition source is present. This can cause damage to other pieces of nearby equipment (i.e. BOG compressor) and personnel can suffer thermal injuries and fatalities. External incidents can occur from the flash fire as other pieces of nearby equipment may become compromised.
LNG Vaporizers	Foundation Failure/Structural Failure	This can lead to an accumulation of flammable products of combustion. If the accumulated gas is near an ignition source and there is between 5-15% of air in the mixture, an ignition will occur causing severe property damage and potential for personnel injury.
LNG Pumps	Foundation Failure/Structural Failure	This can lead to overstressed material which can fatigue or rupture the pump. The pump seal can fail and the LNG can vaporize through the seal and if it reaches an ignition source, can cause a flash fire or vapor cloud ignition.
Booster Pumps	Foundation Failure/Structural Failure	This can lead to overstressed material which can fatigue or rupture the pump. The pump seal can fail and the natural gas can leak through the seal and if it reaches an ignition source, can cause a flash fire or vapor cloud ignition
BOG Compressors	Foundation Failure/Structural Failure	This can lead to potential overpressure, vibration, and seal leakage. The gas leakage can lead to a flash fire or vapor cloud ignition
Heat Exchanger Gas/Glycol Water	Foundation Failure/Structural Failure	This can lead to potential overpressure and overheating of the gas. This hot gas can leak if the exchanger has been ruptured and reach an ignition source. As a result a vapor cloud ignition.

4.2.2 LNG Tank Rupture

A catastrophic failure of an LNG storage tank although unlikely, has the ability to create a long range flammable gas cloud, which will flash, but not explode as it reaches an ignition source. The consequences to personnel and the facility will be severe as there will be property damage and potential injuries and fatalities. LNG liquid itself is not flammable – only the vapors emanating from the liquid can be lit. Natural gas and LNG vapor fires in the open atmosphere may flash and burn hot, but are not explosive because the flame propagation speed is much less than required to have an explosive pressure wave when the ignition is not within an enclosed space.

If there is an uncontrolled release, a pool of LNG can form between the primary and secondary containment. If an ignition source is reached, the combustion of the material evaporating from the pool of liquid can occur. The larger the evaporative vapor cloud from the pool of LNG is, the more severe the potential damages could be to the facility and personnel. This is why it is important to use materials with low density, heat capacity, and thermal conductivity in order to minimize the vaporization rate, which determines the size of the vapor cloud.

Although both of these events are unlikely, the consequences of these events occurring are severe and must be treated with high importance. During detailed design a pool fire model will be created utilizing the programs approved by CSA-Z276 and NFPA 59A.

4.2.3 Uncontrolled Release

Uncontrolled releases may occur from process pipework, or from the LNG storage tank. These two scenarios are discussed below.

4.2.3.1 Uncontrolled Release from Process Pipework

Uncontrolled release from process pipework will be prevented as a primary design consideration to prevent unsafe conditions. LNG and vapor pipework will be designed and installed to meet or exceed LNG design standards. Hoop stress, thermal stress caused by expansion and contraction, corrosion potential, thermal shock cooling and heating, and location specific conditions will be considered during detailed design to apply and demonstrate best engineering practices. Non-destructive testing and pressure tests will be utilized to confirm and record the integrity of installed systems fit for purpose, and compliance to LNG regulations.

4.2.3.2 Uncontrolled release from LNG storage tank

The design standard that is the primary guideline is CSA-Z276. The particular sections that discuss the process instrumentation and controls for the prevention and monitoring of uncontrolled releases from the storage tank are shown below. This includes a variety of scenarios to prevent LNG overflow and uncontrolled release of LNG from the tank:

- LNG tank overfill;
- LNG tank overpressure;
- Leaks or releases from process piping associated with the LNG tank; and
- LNG tank integrity impacts from external forces, wind, snow, and seismic.

A combination of redundant high integrity liquid level devices, alarms if the set points are reached, and automatic shutdown for flow device, and operator monitoring will be employed in order to prevent and monitor tank LNG releases and other unsafe conditions.

LNG tank overpressure could cause uncontrolled release of LNG vapor from LNG tank pressure relief valves on the tank roof as an overpressure protection of last resort. Overpressure and relief valve discharge will be prevented by process controls, facility BOG recovery systems, and continuous monitoring to respond in advance to conditions that could create high tank pressure and avoid them before they occur. For overfill/flow scenarios for LNG tank the following alarms/trips are used:

- Liquid Level High Alarm;
- Liquid Level High-High Trip;

- Redundant Mechanical Liquid Level High-High Trip;
- LNG Tanker Unloading Trip;
- Unloading Pumps Trip; and
- Secondary Containment for LNG Tank Spills and Releases.

4.2.4 Downwind Ignition Sources

The design and layout of the LNG facility considers minimizing controllable ignition sources within proximity of the facility. During detailed engineering, an electrical hazardous area drawing will be prepared to designate hazardous areas, and electrical area classifications. Buffer zones will be created and designated by the LNG security fence. Isolating downwind ignition sources – other ignition sources which may be downwind of the facility include high temperature sources (flames), electrical sources, and physical sources such as compression energy. There are unlikely to be chemical sources as there are no chemical reactions that will occur at this facility. Recommendations to minimize ignition sources through isolation include:

- Electrical area classification (NEC 70);
- Reducing the combustible concentration by isolation; and
- Detecting and eliminating ignition sources.

Finally, trucks and other LNG transfer vehicles must remain at least 15 m away from equipment containing LNG and natural gas. In addition, these vehicles must not enter the impoundment area, unless authorized and under constant supervision.

4.3 EMERGENCY RESPONSE

A detailed emergency response plan will be developed during the detailed design phase of the project; however, a preliminary emergency response plan is provided herein. The Casino LNG receiving facility uses a closed loop process where the release of LNG to the environment is not expected, and considered an abnormal operating condition. Best practices are followed, and the use of flanged joints has been kept to an absolute minimum and all welded piping is used whenever possible to avoid potential leak sources.

General guidelines for cryogenic burns, vapor cloud ignition/explosions, jet fires, flash fires, pool fires and boiling liquid expansion are provided below for LNG and natural gas. The mitigation measures detailed below will be employed at all times during the transportation, handling and storage of LNG and natural gas.

4.3.1 Cryogenic Burns

Mitigation Measures: Proper Personal Protective Equipment (PPE) should be worn at all times when in close proximity to cryogenic equipment. This should consist of special cryogenic gloves, long sleeve shirts, long pants, leather steel toed boots, and a face shield to protect the face from any splashing liquid.

Emergency Response Procedures: Exposure to LNG or direct contact with metal at cryogenic temperatures can damage skin tissue more rapidly than when exposed to vapor. It is also possible for personnel to move away from the cold gas before injury. In addition, moist skin coming in contact with cryogenic parts will freeze instantly and may adhere to the part. If this occurs, treat the burned or frostbitten skin by flushing or immersing the affected area(s) in lukewarm water. Do not rub the area or remove clothing that may have adhered to the area from freezing. After sensation to the affected area has returned, keep the skin warm, dry, and clean. If blistering of the skin occurs, apply a sterile dressing. Seek medical attention as soon as possible.

4.3.2 Vapor-Cloud Ignition/Explosion

The Casino LNG receiving facility design includes strict guidelines to prevent potential ignition sources within the LNG facility boundaries, and safety setbacks from non-LNG operations in accordance with CSA Z276 section 13.3.4.

Mitigation Measures: In order to be ignited, LNG must first be vaporized and mixed with air between 5-15% concentration, and an ignition source must be present. Only the outer area of the LNG vapor cloud is ignitable. LNG, LNG vapor, and natural gas will not explode, provided the release is in an open environment. For an explosion to occur, LNG needs to vaporize, mix with 5-15% air, collect in a confined space, and be ignited. The design of the Casino LNG facility excludes confined space within the LNG facility area, except for buildings, which are monitored and protected to prevent migration of gas indoors at doors and fresh air intakes. Mitigation measures need to prevent the above conditions from occurring, and hence prevent the explosion itself. The suppression system will include:

- *Detection* – using flammable gas detectors, LNG spill detectors, or optical flame detectors that are configured to perform automatic shutdown of equipment.
- *Extinguishment* – high rate discharge containers with the suppressing agent for Type B and C fires (flammable gas, liquids, electrical fires). Extinguishing agents can be dry chemical formulations or foam. Firewater is not recommended for a polar climate, and for suppression of LNG and natural gas fires.
- *Control and supervision* – continue to monitor the appropriate detection monitors as the extinguishing agent is released until normal levels have been reached.
- *Isolation* – Emergency shutdown valves will isolate the plant sections to minimize quantities released.

Emergency Response Procedures:

1. *Assess the situation* – determine the wind direction and park vehicles in an upwind position. Eliminate sources of ignition such as cars and trucks (i.e. do not leave engines running or start stalled engines).
2. *Protect the area* – secure the area around the leak to limit non-essential personnel to a safe distance from the leak. Enter with caution, erect barricades, and evacuate people if needed. Establish a command site at the area to ensure proper communications between emergency response personnel. Try to prevent the spread of the fire itself. Avoid forced ventilation of structures and excavations as that can increase the likelihood of a flammable atmosphere.
3. *Contact Emergency Responders* – to secure the area.
4. *Work together* – ensure that the local, the operator, and emergency responders have proper communications and are working to resolving the emergency.

4.3.3 Jet Fire Following a Leak from Piping

Mitigation Measures: Piping will be designed using practices from ASME B31.3 for natural gas process facilities. The mitigation strategy should be incorporated to prevent a leak at a pipe joint and the rupture or loss of containment during a fire of surrounding piping systems. As a result, piping design will incorporate the following best practices:

- The pipe will exceed minimum code requirements and will meet the criteria of material compatibility, pressure, and temperature pertinent to that particular pipe. Relevant standards include API 607, FM-

7440, and BS-6755-2. Pipe will be welded as much as possible, and the use of flanged joints will be minimized.

- Fire safe rated valves meeting the requirements of API 607 will be designed, tested, and used to assure the prevention of fluid leakage internally along the valve flow path, and externally through the steam packing and seals.
- The basic design conditions will incorporate the following in order to remove natural gas from the pipeline: remote shut-off of the flow supply line; sealing of the flow path at the drain and vent valves; and ensuring the external path through the stem packing as well as the body seals remain intact during a fire.

Emergency Response Procedures: A jet fire is typically associated with the release of natural gas and is dependent upon the diameter of the pipe as well as the leak size. A jet fire occurs if a pipeline has a leak at a certain point in its path AND if an ignition source is present. An alarm should be activated, notifying personnel that there is a fire and the area should be evacuated. After the evacuation, emergency response teams should isolate the fuel source by closing the pipe as close to the leak as possible. The fire will be extinguished by removing the fuel source, and if needed, through the use of extinguishing agents such as dry chemical formulations.

4.3.4 Flash Fire Following a Release

Mitigation Measures: These measures are the same as for the vapor cloud ignitions (Section 4.3.2) in terms of equipment design, but additional mitigation measures should include the use of fire-retardant PPE to reduce and prevent thermal injury. Normal clothing will provide partial protection, but thermal injuries can still occur.

Emergency Response Procedures: A flash fire occurs due to a sudden intense fire caused by ignition of flammable materials. It is characterized by high temperature, short duration, a rapidly moving flame front, and considerable shock waves. This type of fire occurs due to a leak rather than a rupture. According to NFPA 2113, a flash fire may have a heat flux of up to 84 kW/m^2 for short periods of time (<3 seconds). If there is no confinement, a flash back will burn back towards the source relatively quickly. As flash fire flames spread at subsonic velocity, the overpressure damage is negligible and most of the damage is a result of thermal radiation and secondary fires. Therefore, the emergency response procedures are the same as for the vapor cloud fires (Section 4.3.2).

4.3.5 Pool Fire in the Secondary Containment Following a Release

Mitigation Measures: The main goal during a pool fire is to limit the distance of the ½ LFL vapor cloud and thermal radiation impacts if ignited. The liquid normally spills on concrete between the tank wall and secondary containment. Therefore, the concrete mixture selected should have a low density, low heat capacity, and low thermal conductivity, in order to shorten the cloud and potentially reduce the chance of the cloud reaching an ignition source.

Emergency Response Procedures: A pool fire in this case can occur if a flammable liquid (LNG) spills and forms a pool over a surface AND an ignition source is present. Specifically, if there is a leak and ignition occurs in the area between the tank wall and the secondary containment. The emergency response procedures are the same as for a vapor cloud (Section 4.3.2), as LNG will evaporate from the pool and if the vapor reaches an ignition source, there is potential for a vapor cloud ignition.

4.3.6 Boiling Liquid Expanding Vapor Explosion (BLEVE)

Mitigation Measures: The main goal to eliminate the possibility of a BLEVE:

- Eliminate conditions where a fire could occur in proximity to a storage vessel containing flammable fluids.
- Insulated LNG tanks provide inherent protection from a BLEVE by reducing heat transfer to the vessel contents.
- Install properly sized pressure relief valves (PRVs) in order to release pressure fast enough so that the pressure of the vessel is does not exceed its design pressure. If this is sized appropriately, the liquid inside the tank will boil off slowly, maintaining a constant pressure in the vessel until all the liquid has boiled off. This prevents the rapid phase transition of the liquid to vapor, and prevents the tank from pressurizing above its design limits such that a vapor BLEVE does not occur.
- To provide fire suppression to extinguish a fire if it occurs near a storage container.

Emergency Response Procedures: A BLEVE occurs when a vessel containing flammable liquid is exposed to an external fire, heat is transferred to the vessel contents, and temperature of the contents rises rapidly above its normal boiling point, and relief valves are unable to relieve the vapor pressure with enough capacity such that the vessel fails from high internal vapor pressure in a hot vessel causing a sudden catastrophic failure (rupture). As a result, a rapid, near instantaneous phase transition occurs where there is a massive energy release and a large fireball usually accompanies this if the material is flammable. The emergency response procedures are based on avoidance of conditions that support this from occurring in the first place.

5 – DECOMMISSIONING

Decommissioning of LNG equipment is guided by API standard 376. Disposal of materials generated from the decommissioning of the plant will be detailed in the *Casino Project Reclamation and Closure Plan*, and the *Casino Project Waste Management Plan*. Generally, it is expected that solid waste associated with LNG storage, secondary containment and distribution will be disposed of in conjunction with other material at the mine site.

Certain infrastructure will require specific decommissioning steps. The decommissioning procedures for the LNG facilities and associated infrastructure will be defined during detailed design of the facilities, however, decommissioning of the LNG storage tank is summarized below for example purposes.

5.1 LNG STORAGE TANK

The following steps must be followed to properly decommission the LNG storage tank. Once complete, the tank may be dismantled and is no longer considered contaminated.

1. **Pump-out:** Pump out all recoverable liquid LNG to a storage tank truck. Assisted pump-out may be required is the existing pump capacity is insufficient.
2. **Boil-off:** Once the pump-out is complete, there may be some residual liquid remaining in the tank. Residual liquid can be boiled off by leaking heat into the tank. Assisted boil-off (the addition of hot natural gas) may be used in increase the rate of boil off. The hot gas should be around ambient temperature to prevent temperature profiling within the tank. The boil-off gas can be flared or recovered.
3. **Warm-up:** After the gas has been boiled off, the tank should be warmed up at a maximum rate of 3 °C/hour to avoid thermal stresses. This process can be natural or assisted (via hot gas). The displaced gas from the warm up process would be routed to the flare system. The tank should continue warming at the rate until the temperature reaches -20 °C.
4. **Gas freeing:** Once the warm-up is complete, the gas remaining in the tank from the warm-up process must be removed from the tank via inert gas (nitrogen) introduction. The inert gas is introduced at the bottom of the tank (using the purge line) in order to vent the gas through a pipe on the roof of the tank. The gas can either be sent to the flare system or vented to the atmosphere a safe distance away from the tank roof. Through this process, the inner tank and dome space are gas free.
5. **Inert Gas Freezing:** The inert gas must be displaced by air to allow the space to be breathable. This is accomplished by venting the inert gas to the atmosphere. An oil-free compressor can be used to introduce air into the tank. A double block and bleed isolation is necessary to reduce the potential creation of an internal flammable environment. It is recommended that the tank is physically isolated as well, as this is essential for personnel to enter the tank.
6. **Preparation for Entry:** The tank should be physically isolated from all process and utility systems and air quality confirmed to be safe by oxygen detectors.

APPENDIX A.22H: ML/ARD Management Plan



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Casino ML/ARD Management and Monitoring Plan

Project No. J862-6

12 February 2015

DRAFT

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CASINO
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1. Introduction

CASINO
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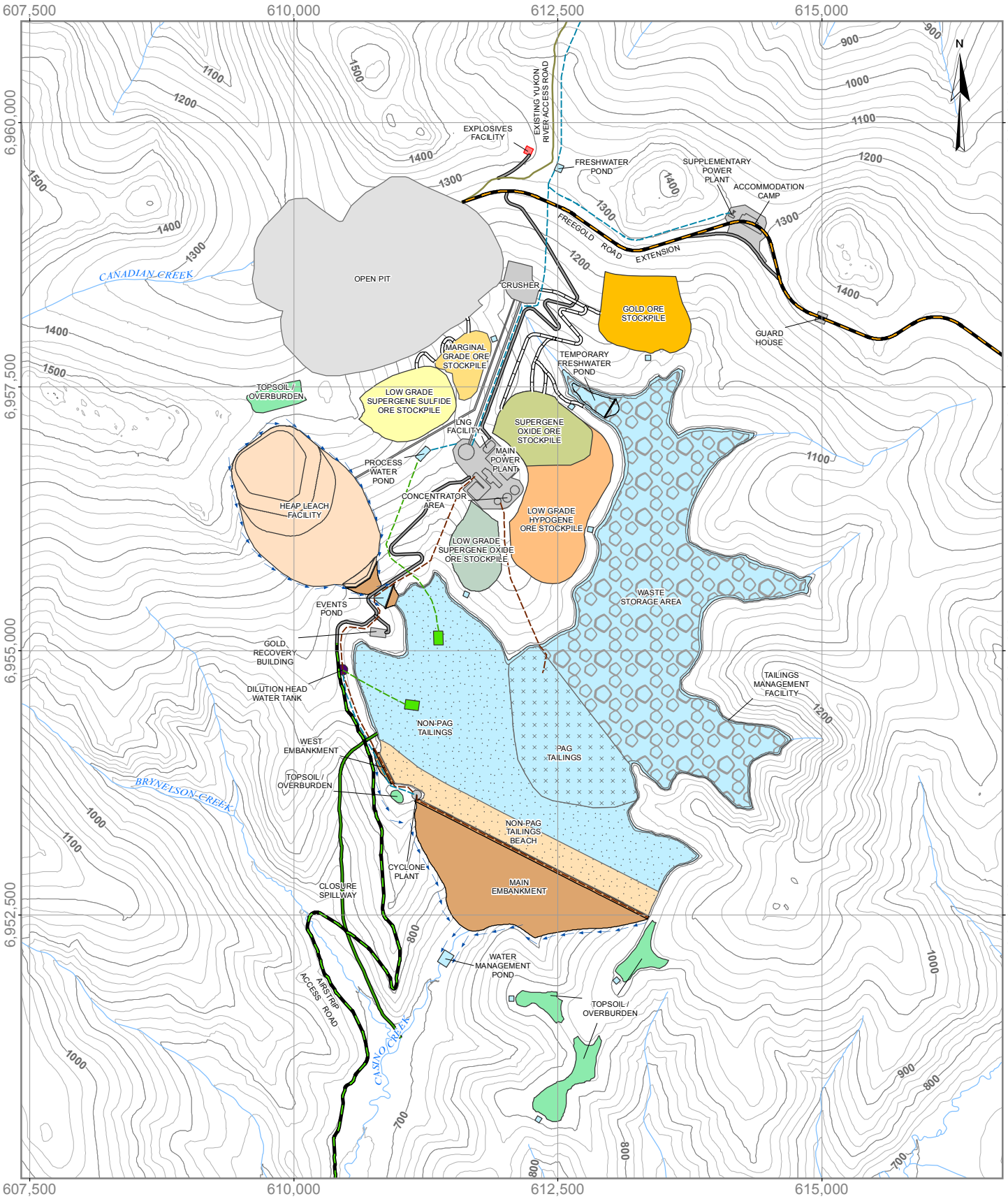
1. Introduction

The Casino Copper-Gold Project is located in the Dawson Range Mountains of the Klondike Plateau approximately 300 km north west of the City of Whitehorse. The deposit will be mined using open pit methods with a nominal daily mill throughput of approximately 120,000 tonnes of ore over a 22 year operating life. A total of 965 Mt of mill ore will be mined and 157.5 Mt of oxide ore will be leached on a heap leach facility (HLF). A tailings management facility (TMF) has been designed to store mine waste under saturated conditions including 956 Mt of tailings and embankment sands as well as 649 Mt of waste rock and overburden.

The waste rock, ore and tailings that will be produced by the Casino Project will require management to limit the effects of metal leaching and acid rock drainage (ML/ARD) on the receiving environment. The ML/ARD mine waste management plan describes the methods that will be used to manage these waste products and provides information regarding the storage, handling and placement of these wastes. A ML/ARD mine waste monitoring plan is also presented that describes how the materials will be assessed to identify potentially acid generating (PAG) material and non-PAG (NPAG) material and to track the performance and effects of the waste management plan's implementation.

The Casino Mining Corporation (CMC) commissioned Lorax Environmental Services Ltd. (Lorax) to compile the ML/ARD management and monitoring plan for the Casino Project (the Plan). ML/ARD management plans have been developed for handling ore and waste from the open pit and each of the major mine waste storage facilities including the heap leach facility (HLF), gold ore stockpile, mill ore stockpiles, waste rock and tailings in the flooded tailings management facility (TMF) (Figure 1-1). An ML/ARD monitoring plan has been developed for the open pit and includes confirmatory monitoring.

The contents of this plan are derived from the *Plan Requirement Guidance for Quartz Mining Projects* (Government of Yukon, 2013), and this plan will be updated as the Project is refined. The final Plan will describe the types of overburden and rock that will be encountered on site and how these materials will be characterized, segregated and stored to ensure long-term chemical and physical stability of the site. This draft plan has been produced for the purposes of meeting requirements of the Yukon Environmental and Socio-Economic Assessment Act (YESAA), and the final plan will include terms and conditions of any applicable licences, permits and approvals required for Project operations.



LEGEND

Proposed Casino Facilities

- Airstrip Access Road
- Freegold Road Extension
- Freegold Road Upgrade
- Existing Yukon River Access Road
- Haul Road
- Site Road
- Airstrip
- Diversion Ditch
- Freshwater Pond
- Reclaim Pipeline
- Tailings Pipeline/Launder
- Water Pipeline
- Spillway
- Embankment
- Explosives Facility
- Facility Footprint
- Gold Ore Stockpile
- Heap Leach Facility
- Low Grade Hypogene Ore
- Low Grade Supergene Sulfide Ore
- Low Grade Supergene Oxide Ore
- Supergene Oxide Ore
- Non-PAG Tailings
- PAG Tailings
- Open Pit
- Infrastructure
- Pond
- Reclaim Barge
- Tailings Beach
- Tank
- Topsoil/Overburden Stockpile
- Marginal Grade Ore Stockpile
- Waste Storage Area
- Right-Of-Way
- Contours (25m)
- Contours (100m)
- River

Note: Map Drawn by Knight Piesold. Figure 4.1-5, Proposal for Executive Committee Review, January 2014

Coordinate System: *NAD 1983 UTM Zone 7N*
Projection: *Transverse Mercator*
Datum: *North American 1983*
Units: *Meter*

1:50,000

0 0.5 1 Km

CLIENT: CASINO COPPER AND GOLD

LORAX ENVIRONMENTAL

PROJECT: **Casino Project**

TITLE: General Arrangement - Maximum Extent

PROJECT #: J862-6

FIGURE: 1-1

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2. ML/ARD Management Plan for Mine Site

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2. ML/ARD Management Plan for Mine Site

ML/ARD management during operations will be focused on segregation of ore, waste rock and soil and overburden. Ore will also be additionally segregated based on ore type and destination (*i.e.*, mill or heap leach facility). Preliminary ML/ARD management plans for gold ore, low grade ore, waste rock and soil and overburden are provided below. These plans will be refined as the Project geology and mine plan are further understood and engineered.

2.1 Gold Ore Stockpile and Heap Leach Facility Management

2.1.1 Gold Ore Stockpile Management

Gold ore will be mined and either temporarily placed on the gold ore stockpile or placed directly in the HLF where it will be permanently stored. The ore placement schedule is presented in Table 2-1 (from KP, 2012a and 2012b). A total of 157,454 kt of gold ore will be mined and placed on the HLF through Year 15 of mine operations. Not all mined ore can be immediately placed on the HLF, in Year -2 through Year 3 and Year 8 through Year 10 of the mine schedule, gold ore will be stockpiled temporarily before being placed on the HLF. However, by Year 15 all gold ore will have been moved from the stockpile and placed on the HLF (Table 2-1).

The gold ore is exclusively derived from the Oxide Cap (CAP) mineralization zone, hence, the ore typically has low neutralization potential and secondary sulphate and oxide minerals rather than sulphide minerals are the major source of acidity and metal leaching from CAP ore. The CAP ore overlies the Supergene Oxide zone (SOX) and the boundary between the SOX and the CAP is gradational. In contrast to the overlying CAP ore, SOX material contains sulphide minerals which will interfere with gold recovery and may lead to degradation of drainage quality after mine closure. Therefore differentiation of CAP ore from SOX rock needs to be determined operationally to allow for the two rock types to be segregated during mining and ensure that they are sent to the appropriate processing or storage facility.

Table 2-1:
Heap Leach Facility Gold Ore Schedule

	Leach Pad Stacking	Pit Production	Direct to Crusher	Gold Ore Stockpile	Stockpile Reclaim
Year	(kt)	(kt)	(kt)	(kt)	(kt)
-3	6,580	6,580	6,580		
-2	9,125	14,197	9,125	5,072	
-1	9,125	21,654	9,125	12,529	
1	9,125	18,667	9,125	9,542	
2	9,125	17,579	9,125	8,454	
3	9,125	12,879	9,125	3,754	
4	9,125	7,809	7,809		1,316
5	9,125	495	495		8,630
6	9,125	1,072	1,072		8,053
7	9,125	8,773	8,773		352
8	9,125	13,111	9,125	3,986	
9	9,125	13,352	9,125	4,227	
10	9,125	18,235	9,125	9,110	
11	9,125	1,263	1,263		7,862
12	9,125	625	625		8,500
13	9,125	925	925		8,200
14	9,125	238	238		8,887
15	4,874				4,874
TOTAL	157,454	157,454	100,780	56,674	56,674

The location of the CAP / SOX boundary within the open pit has been included in the block model. This boundary has been established from existing geologic logging and assay data. The assay data indicates that CAP is an Au enriched and Cu depleted oxide zone. The location of the boundary will refined during operations by continual tracking of operational ore grade sampling and in-pit mapping.

Gold Ore ML/ARD Management Objectives:

- Segregation of CAP ore from SOX ore by operational monitoring used to refine the boundary between these two mineralization zones in the block model.

Gold Ore ML/ARD Management Methodology:

- During Operations typical procedures examining blast hole cuttings will be used to differentiate between ore and waste.

- Differentiation criteria will be subject to revision due to changing mining costs and market conditions.
- Blast hole sample analysis will be conducted at the on-site assay lab (Section 4).
- Ore management details will be provided in the *Mill Development and Operations Plan*, required by the Quartz Mining Licence (Government of Yukon, 2013).

2.1.2 Heap Leach Facility Management

Mitigation of potential effects from the HLF will be maintained primarily through water management, liner systems, rinsing and active water treatment during the operation and closure phases. During the post-closure phase, potential effects will be mitigation through restriction of infiltration into the heap and passive treatment of drain-down in a bioreactor.

Preliminary reports indicate that ML/ARD management in the HLF will be achieved through the addition of lime to ore as it is conveyed and placed on the HLF. Lime addition to the ore facilitates the maintenance of alkaline conditions in the HLF during active leaching of the ore. The residual lime also assists in the maintenance of pH-neutral conditions during the drain-down phase and into the post closure period. Lime will be added to the ore on the conveyor belt system used to convey the ore to the final placement location in the HLF. The quantity of lime added to the ore is based on the residual acidity of the oxide CAP rock and the necessary excess to maintain alkaline conditions during active leaching of the pile.

Heap Leach Facility ML/ARD Management Objectives:

- Determine the required lime additions to maintain pH-neutral conditions during leaching and drain-down phases of HLF prior to the placement of the reclamation cover.

Heap Leach Facility ML/ARD Management Methodology:

- Lime consumption rates will be determined through metallurgical testwork prior to the commencement of operation of the HLF.
- Operational monitoring will follow general standards.
- HLF management details will be provided in the *Mill Development and Operations Plan*, required by the Quartz Mining Licence (Government of Yukon, 2013).

2.2 Low Grade Ore Stockpile and Tailings Management

2.2.1 Low Grade Ore Management

Ore that will be milled and processed in the flotation plant will be derived from Hypogene (HYP), SOX and Supergene Sulfide (SUS) zones. The ore production schedule from the

open pit listed in Table 2-2 (from M3, 2013) indicates that the majority of the mined ore will be derived from HYP zone. Although the HYP ore is predominantly PAG, the HYP ore typically contains neutralization potential (NP) ranging from 7 $kgCaCO_3/t$ to 65 $kgCaCO_3/t$. This quantity of NP is capable of maintaining pH-neutral conditions for several years to decades while stockpiled on surface (Lorax, 2013a). Conversely, ore from the SOX and SUS zones contains less NP than the HYP and approximately half of the Supergene ore is expected to have acidic paste pH when it is mined. However, portions of the Supergene ore will also contain neutralization potential in the form of carbonate minerals.

Table 2-2:
Ore Production Schedule (kt)

	Supergene Oxide (SOX)			Supergene Sulphide (SUS)			Hypogene (HYP)	
Year	**Direct Feed Mill Ore**	**SOX Stockpile**	**Low Grade Ore**	**Direct Feed Mill Ore**	**Marginal Grade**	**Low Grade Ore**	**Direct Feed Mill Ore**	**Low Grade Ore**
-3	0	20	0	0	0	0	0	0
-2	0	2,806	0	603	4	0	0	0
-1	0	9,950	31	3,878	18	153	448	0
1	0	19,634	387	26,675	421	452	2,896	0
2	1,228	0	2,034	28,786	1,319	3,967	15,914	1,186
3	888	0	742	9,179	1,642	1,643	35,747	1,010
4	4,350	0	3,739	18,498	5,432	5,733	19,207	1,300
5	2,816	0	3,320	19,113	0	6,681	19,724	6,511
6	6	0	1,209	1,894	0	1,883	39,705	19,141
7	0	0	0	0	0	25	41,576	11,948
8	628	0	107	132	0	144	41,385	6,524
9	1,180	0	276	3,069	0	1,757	38,243	6,267
10	1,182	0	280	29,872	0	3,974	10,121	1,321
11	138	0	105	30,269	0	3,196	10,688	1,642
12	394	0	397	16,054	0	3,296	25,803	5,768
13	717	0	767	7,591	0	1,332	37,941	6,930
14	30	0	606	10,775	0	1,721	34,993	4,343
15	0	0	43	8,954	0	2,835	36,233	5,742
16	0	0	0	1,171	0	559	43,893	6,584
17	0	0	0	0	0	0	44,772	4,216
18	0	0	0	0	0	0	44,934	0
19	0	0	0	0	0	0	14,676	0
TOTAL	13,557	32,410	14,043	216,513	8,837	39,351	558,899	90,433

The ML/ARD ore management plan incorporates the construction of stockpiles segregated by ore mineralization type (*i.e*. CAP, SOX, SUS and HYP). In-pit operations will segregate ore from the major mineralization zones and allow the distinct ore types to be placed into their respective stockpile. ML/ARD management includes the implementation water management strategies for seepage and runoff from the stockpiles that have the highest ML/ARD risk. The geochemical characterization studies have established that rock derived from both the SUS and SOX zones have a higher immediate ML/ARD risk than HYP due to limited NP content and reactive sulphide mineral assemblage comprised of both secondary and primary sulphide minerals. Stockpiles constructed of SUS have a high ML/ARD potential and water management considerations have been proposed to limit the impact on the downstream receiving environment.

Low grade ore will be segregated into stockpiles by mineralization type as illustrated on Figure 1-1. Contact runoff from the ore stockpiles will be collected in ponds and pumped to the TMF pond. In addition, an infiltration suppression system will be established beneath the Low Grade Supergene Sulfide Ore Stockpile to minimize infiltration to groundwater, as the drainage from the SUS Stockpile is predicted to have the greatest metal leaching potential. The Marginal Grade Stockpile contains SUS and is positioned near the perimeter of the open pit. Due to its location, seepage from this pile will discharge to the pit and be collected by the pit dewatering system that will be directed to the process plant. Segregation of the stockpiled ore will be based primarily on mineralization zone and grade rather than ML/ARD static test characterization due to the consistent key geochemical characteristics of the Casino ore within an individual zone and the temporary nature of the ore stockpiles.

In order to facilitate the segregation of ore into stockpiles based on the grade and mineralization during operations, in-pit identification of grade and mineralization type will be required. The boundaries between the SOX, SUS and HYP mineralization zones have been established by exploration drilling in the resource block model. Although the boundary between the SUS and HYP zones is visually distinct, the boundaries between the CAP, SOX and SUS zones are often gradational and not distinct. As a result, operational monitoring and management during mining of the material will be required in conjunction with the block model results to ensure that the ore is directed to the appropriate pile as per the general procedure outlined in Table 2-3. When mining SUS waste through Year 4 of the mine life, blast hole chip samples from the SUS Zone that does not have ore grade will also undergo a pH measurement to determine if the waste should report to the waste rock storage in the TMF or the Marginal Grade Stockpile.

Table 2-3:
Ore Stockpile Management

Ore Stockpile	Mineralization Zone	Segregation Method
Low Grade SOX	SOX	Alert based on block model CAP/SOX boundary Blast hole cutting samples (grade)
SOX Ore	SOX	Alert based on block model CAP/SOX boundary Blast hole cutting samples (grade)
Low Grade SUS	SUS	Blast hole cutting sampling (grade)
Marginal Grade Ore	SUS	Blast hole cutting sampling (grade, PpH)
Low Grade Hypogene	HYP	Alert based on block model SUS/HYP boundary Visual delineation in pit

Low Grade Ore ML/ARD Management Objectives:

- Segregate ore into stockpiles based on the grade and mineralization.

Low Grade Ore ML/ARD Management Methodology:

- Segregation of various types of ore.
- During Operations typical procedures examining blast hole cuttings will be used to differentiate between types of ore.
- Differentiation will likely be dependent on various parameters, such as Cu equivalent, Cu, Au concentrations, *etc*.
- Blast hole sample analysis will be conducted at the on-site assay lab (Section 4).
- Ore management details will be provided in the *Mill Development and Operations Plan*, required by the Quartz Mining Licence (Government of Yukon, 2013).
- Runoff management will be conducted to intercept runoff from the stockpiles and pump it to the TMF.
- Seepage interception from the Low Grade Supergene Sulfide Ore Stockpile, and re-directing to the TMF.

2.2.2 Tailings Management

Tailings and waste rock will be disposed of in the TMF, which has been designed to provide permanent, secure and total confinement of these solid waste materials. Construction of the TMF embankment will use cyclones to generate a clean tailings sand from the bulk NPAG tailings. The tailings ML/ARD management plan incorporates a pyrite floatation process to produce NPAG tailings that will be exposed in the TMF embankment and TMF beaches. However, the ore processing plant will produce both PAG and NPAG tailings. Non-ore sulphide minerals, predominately pyrite, will be concentrated into a PAG tailings stream that will be deposited and maintained under saturated conditions in the central

portion of the TMF. The residual low-sulphur tailings will be processed in single stage cyclones to produce a NPAG cyclone underflow sand that will be used to construct the TMF embankment. Embankment sand construction and NPAG slimes deposition will proceed for approximately 9 months of the year while climatic conditions permit. During the 3 month period when embankment sands are not being produced, NPAG bulk tailings will be discharged into the TMF on a tailings beach that separates the embankment from the upstream waste rock storage portion of the TMF.

Desulphurization criteria will vary relative to the NP of the ore feed from which the tailings will be derived. The ore processing schedule listed in Table 2-4 (from M3, 2013) indicates that the majority of the milled ore will be derived from the HYP zone. Based on the range of NP observed in the HYP ore and pyrite flotation metallurgical test results, a pyrite flotation circuit can reduce sulphur content sufficiently low in a NPAG bulk pyrite rougher tailings with a NP/AP > 2.0. A CaNP/AP > 2.0 criterion to define NPAG tailings is very conservative and a CaNP/AP = 1.5 is likely more appropriate for the low-sulphur desulphurized tailings as supported by the low sulphide oxidation rates in the tailings kinetic tests and liberation of carbonate minerals in the finely-ground well-mixed tailings.

Table 2-4:
Mill Processing Schedule (kt)

Year	Total	Supergene Oxide	Supergene Sulfide	Hypogene
1	34,500	0	31,156	3,344
2	45,928	1,228	28,786	15,914
3	45,814	888	9,179	35,747
4	45,655	7,950	18,498	19,207
5	45,253	6,416	19,113	19,724
6	45,205	3,606	1,894	39,705
7	45,176	3,600	0	41,576
8	45,745	4,228	132	41,385
9	46,092	4,780	3,069	38,243
10	44,775	4,782	29,872	10,121
11	44,695	3,738	30,269	10,688
12	45,861	4,004	16,054	25,803
13	46,249	717	7,591	37,941
14	45,798	30	10,775	34,993
15	45,187	0	8,954	36,233
16	45,064	0	1,171	43,893
17	44,772	0	0	44,772
18	44,934	0	0	44,934
19	45,591	1,011	5,744	38,836
20	45,055	1,570	13,081	30,404
21	44,983	4,429	8,377	32,177
22	22,874	7,033	12,149	3,692
TOTAL	965,206	60,010	255,864	649,332

Unlike the range of NP content in the HYP ore, NP content is more variable in Supergene ore and in many instances Supergene ore will be devoid of NP. The sulphur content required to achieve the CaNP/AP > 2.0 criterion for the range of NP present in the various milled ore types are listed in Table 2-5. Estimates of the target S content required to maintain a NPAG tailings a range from 1.4 %S to 0.15 %S for time periods when predominantly HYP is being processed, and from 0.58 %S to 0.01 %S when predominantly Supergene ore is being processed. The table indicates that NPAG tailings with S content within the range obtained from lock cycle testing and pilot tests can be routinely derived from HYP ore. However, only a portion of the Supergene ore could be used to derive NPAG tailings.

Table 2-5:
Sulphide Sulphur requirements to maintain CaNP/AP > 2.0 based on Ore Feed carbonate content

CaNP	SOX		SUS		HYP	
Percentile	**CaNP**	**%S**	**CaNP**	**%S**	**CaNP**	**%S**
90th	16	**0.26**	27	**0.43**	65	**1.04**
75th	6	**0.10**	12.5	**0.20**	51	**0.82**
Med	2	**0.03**	3	**0.05**	27	**0.43**
10th	0.4	**0.01**	0.5	**0.01**	7	**0.11**

Bench scale and pilot flotation testing on supergene ore indicated that sulphur content could be reduced to < 0.1 %S and < 0.25 %S, respectively. Although tests indicate a sulphur content < 0.1 %S can be achieved from the SOX and SUS ore, at this stage of ML/ARD management planning it is conservatively assumed that the sulphur content of the depyritized tailings would remain in the range of 0.2 %S. Based on the above assumption and the current inventory of Supergene Ore samples, it is estimated that 25% of the processed Supergene Ore would produce NPAG pyrite rougher tailings. In order for Supergene Ore to be used to produce NPAG tailings, an in-pit monitoring plan would be required to identify areas in the supergene ore where sufficient NP exists that could produce NPAG tailings.

Tailings ML/ARD Management Objectives:

- Determine amount of NP in Supergene ore to maintain NPAG tailings sands. Confirm that pyrite flotation circuit achieves low sulphur content to produce NPAG embankment sands and bulk tailings.

Low Grade Ore ML/ARD Management Methodology:

- Refinement of the block model to identify areas in the Supergene ore that meet the sulphide sulphur requirements to maintain CaNP/AP>2.0.
- Analyze sulphide sulphur and paste pH content of tailings routinely to confirm predictions.
- Deposition of all tailings with CaNP/AP<2.0 in the TMF.
- Tailings management details will be provided in the *Mill Development and Operations Plan*, required by the Quartz Mining Licence (Government of Yukon, 2013).

2.3 Waste Rock Management

Waste rock and overburden produced from the open pit will be deposited into the TMF, then flooded and stored sub-aqueously at closure to limit potential ML/ARD production from sulphide oxidation and mineral weathering reactions.

In general, the waste placement strategy is to locate the most reactive material in areas of the TMF where the lowest flow rates are expected, and the relatively non-reactive tailings where the highest seepage rates are expected. Waste rock is relatively reactive compared to the tailings in the TMF owing to the presence of partially weathered CAP, SOX and SUS. Therefore, waste rock is placed in the upstream section of the TMF, where hydrologic head gradients are generally expected to be lower than in the downstream portion of the facility where the tailings are deposited. In the final years of mine life, a layer of de-pyritized tailings will be placed over the waste rock.

During placement of waste rock, the crest elevation of the waste rock will be maintained several metres higher than the tailings and supernatant pond to provide a dry, stable surface for access and placement of waste rock by haul trucks. Waste rock placed in the TMF will remain unsaturated for an average of three years before saturation.

The quantity of SUP, HYP and CAP waste rock produced during the mine life is presented in Figure 2-1. For the first four years of operation, waste production will be dominated by CAP rock. Between Years 5 to 15 a mix of the mineralization types will be produced. After Year 15, HYP will be the dominant rock type being placed in the facility.

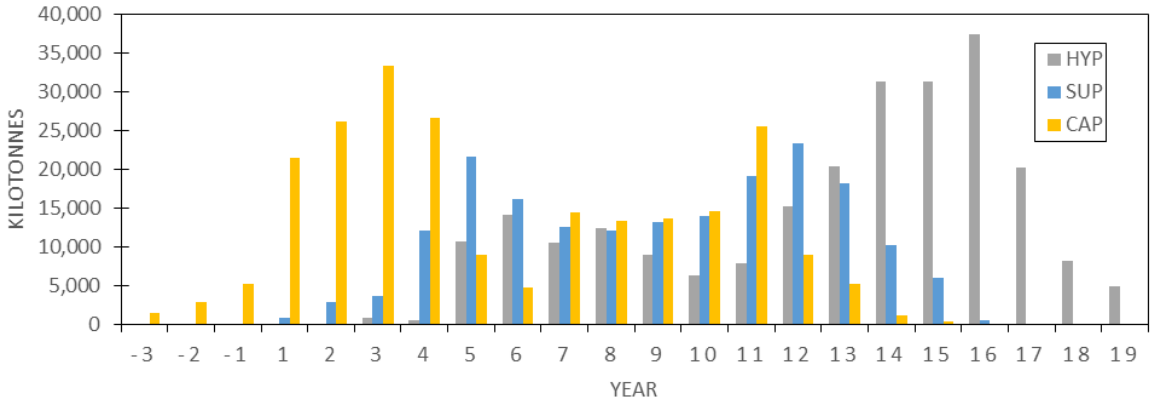
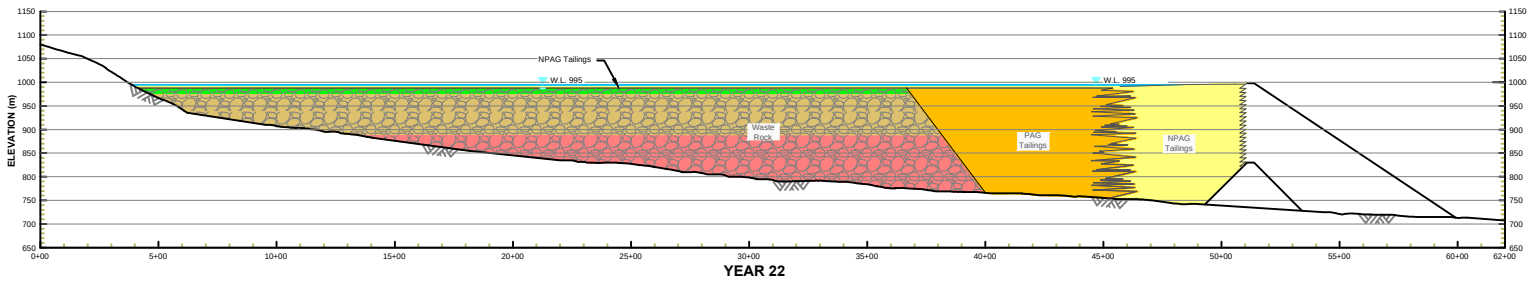
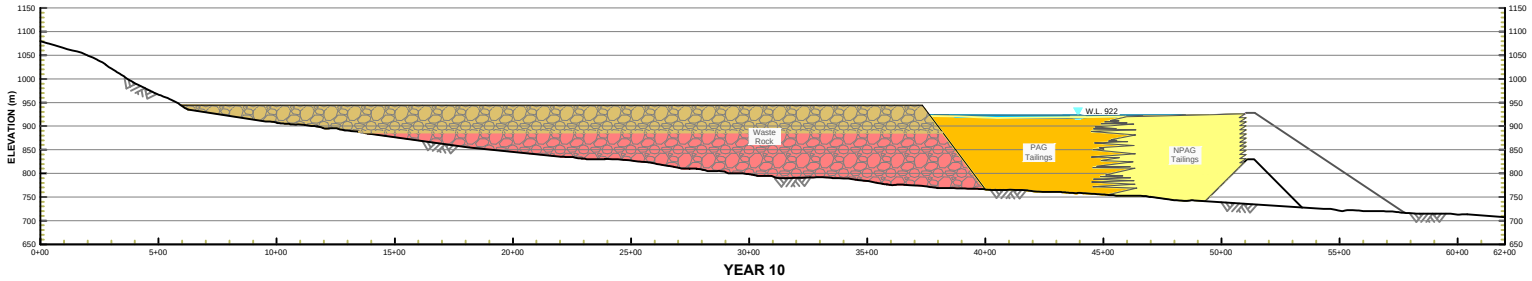


Figure 2-1: Annual waste rock mass and mineralization type placed in the TMF

The timing of waste rock production will result in vertical stratification of rock types in the waste rock storage area. The elevation of these three different areas of the downstream waste rock zone is illustrated in Figure 2-2. Geochemical characterization data indicates that SUP and HYP are PAG rock units, with only minor amounts of NPAG. In fact, a portion of the SUP waste rock placed in the waste rock storage zone will be NP deplete, and may become acidic prior to being flooded. Although the HYP is PAG it contains sufficient NP to remain pH-neutral for the relatively brief period it will be exposed in the TMF prior to flooding. The management plan calls for the NP-deplete SUP rock to be blended with the high-NP HYP rock in the mixed waste rock zone that will be constructed in Years 5 through 15. Layering these two rock types will limit the severity of potential acid generation during the relatively brief time period that the waste rock is exposed before subaqueous disposal. In addition, the layering configuration will allow alkalinity addition into porewaters along the flow path through the flooded wastes prior to discharge into the TMF pond or foundation.



YEAR 22



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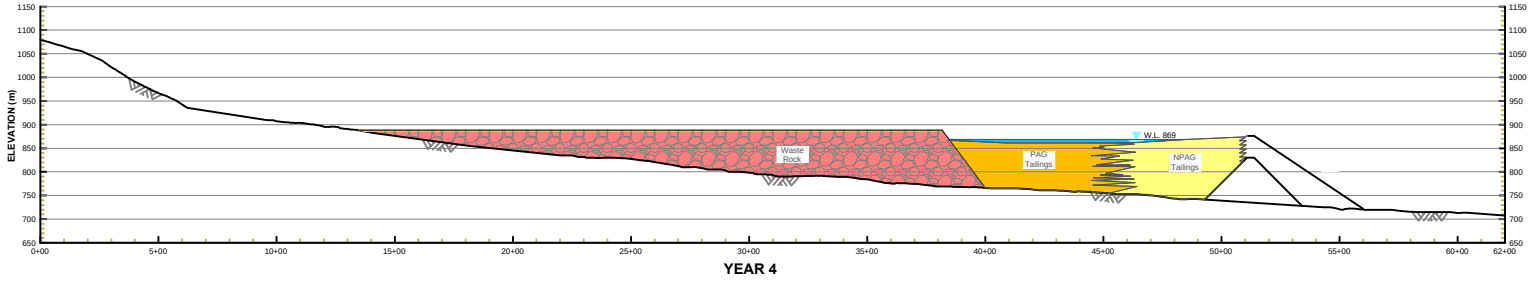
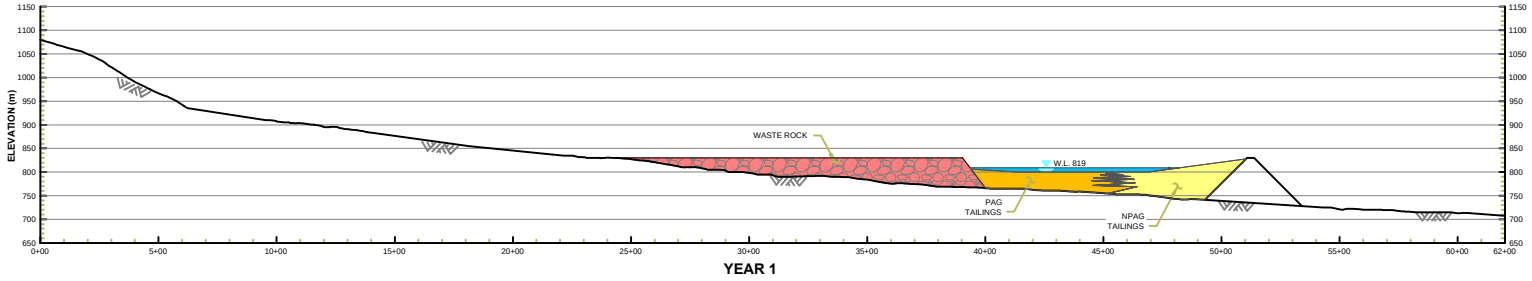


YEAR 4



YEAR 1

LEGEND

- NPAG Tailing
- PAG Tailing
- CAP Waste Rock
- CAP/SUP/HYP Waste Rock
- HYP Waste Rock

NOTES

Original Drawing obtained from Knight Piesold Figure 6
Drawing VA13-00949 Revised Waste Deposition Strategy
Typical Sections (Years 1, 4, 10)

DATE SAVED:	Feb 11, 2015
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REVIEWED:	BM
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PROJECT:

Casino ML/ARD Mangement and Monitoring Plan

TITLE:

Waste Rock Placement in TMF

PROJECT #:	FIGURE:
J862-6	2-2

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Implementation of the waste rock management plan will require special monitoring and handling requirements at different phases of the project:

- Pre-production - Identification of pH-neutral CAP rock to segregate sufficient material to be used for the construction of the starter embankment of the TMF. In-pit monitoring for grade, paste pH and total S.
- Operation Years 1 through 4 – Identification of acidic SUS waste rock for placement in the Marginal Grade Ore Stockpile. Identification of mineralization type and confirmation of waste grade will be required to segregate acidic SUS for placement in the Marginal Grade Ore Stockpile. In-pit monitoring for grade, paste pH and total S.
- Operation Years 5 through 15 – Identification of HYP waste and acidic SUS for placement of layered rock in the TMF to achieve mixing criteria for waste rock deposition. All HYP will be sent to TMF, no segregation is required for this unit. In-pit monitoring of HYP for grade. All SUP will be handled as PAG and flooded in the facility. However, a portion of the PAG SUP has an acidic in-situ pH and will need to be layered with the HYP rock to limit ARD. This unit will be segregated by in-situ pH. In-pit monitoring of SUS for grade, paste pH and total S.
- Operation Years 1 to 5 - CAP waste rock has little or no sulphide content, therefore it is not considered PAG, however, it has a mildly acidic in-situ pH and the unit has an intermediate metal leaching potential. All CAP waste rock will be sent to the TMF. No segregation is planned for this unit.

2.4 Soil and Overburden Management

Soil and overburden borrow materials will utilized during construction and reclamation. Borrow will be used for the construction of the TMF starter embankment, roads, aggregate for concrete, bedding sand and drainage rock. Reclamation borrow will be used to establish covers on the HLF, TMF Embankment, stockpiles and infrastructure footprints (Table 2-6 from BCL, 2013).

Table 2-6:
Soil Requirements for Closure Covers

Facility	Volume (Mm^3)
Ore Stockpiles	2.0
Ore Processing Complex	1.7
Heap Leach Facility	0.8
TMF Embankment	1.0
Total	5.5

Soils and terrain mapping has identified that the open pit, stockpiles and associated infrastructure will be located over colluvium and weathered bedrock. The preliminary ML/ARD evaluation of potential borrow in the area indicates that although overburden outside the Casino open pit has a low ML/ARD potential, portions of the soil and overburden inside the open pit footprint may have ML/ARD potential (Lorax, 2014). These finding are consistent with the colluvial materials retaining some of the ML/ARD characteristics of the underlying parent material from which it is derived. The mineralization in the open pit has resulted in portions of the colluvial overburden in this area having ML/ARD potential. Conversely, in areas near the TMF Embankment, HLF and ore stockpiles where the underlying bedrock has weak or no mineralization, the overlying colluvial material does not have ML/ARD potential.

ML/ARD management for soil and overburden will require the implementation of an operational monitoring plan to identify PAG material. The frequency of monitoring will be dependent of the risk posed at each borrow source. Soil and overburden that has an unacceptable ML/ARD potential that is removed from the foundation of the proposed mine components such as the stockpiles, TMF Embankment or open pit will be placed in the waste rock storage area of the TMF. The TMF waste rock storage area has been designed to store 17.5 Mt of overburden.

3. ML/ARD Monitoring for the Mine Site

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3. ML/ARD Monitoring for the Mine Site

The ML/ARD Monitoring Plan is designed to characterize mine waste during the implementation of the ML/ARD Management Plan. Although specific objectives and procedures of the monitoring plan vary slightly between the facilities, the primary objectives shared for all facilities are:

- provide sufficient characterization to effectively implement the operational management plan objectives; and
- provide sufficient characterization to document the geochemical characteristics of the rock in each storage facility as a result of the ML/ARD management activities.

The necessary in-pit monitoring and subsequent confirmatory monitoring is presented in the following sections.

3.1 In-Pit Monitoring

In-pit monitoring will be required for a number of purposes.

- Ore Identification and Management:
    - Identified by block model, confirmed visually by site geologist and assays on blast hole drill cuttings.
    - Confirm NP of Supergene mill ore to verify desulphurization criteria requirement.
    - Confirm that sulphidic material is not going to the CAP ore stockpile.
- Segregation of Low Grade Ore and marginal grade ore:
    - HYP and SUP segregated visually.
    - SUP segregated into SOX, SUS and MGO based on sulphur assays and paste pH.
- Waste Rock Identification:
    - Mineralization zones identified visually.
    - Paste pH and NP values will be measured in drill cuttings from blast hole drilling in Supergene waste.

When necessary, the monitoring program will be developed and implemented as described below. Procedures will vary depending on the specific requirements and capabilities of the Casino assay lab, however, the below are typical procedures and analysis usually performed at open pit mine sites.

In-Pit Sampling Procedures

1. Samples of cuttings from blast holes are collected for grade control purposes.
2. Cuttings samples are split into aliquots for grade control and for determination of the appropriate ABA parameter.
3. Samples sent to on-site laboratory for sample preparation and analysis (S_{TOT}, C_{TOT} and paste pH) are the ABA parameters that the laboratory can measure.
4. Test results are imported into the mine's grade control software for processing by the mine geologists.
5. ABA or necessary grade/mineralization types are plotted for each blast pattern, and mine geologists use the mine's grade control software to define polygons outlining contiguous zones of waste and ore types.
6. Ore grade polygons are drawn for material above the mine's operational cut-off grade, with the result being that all material in a blast is classified as:
   - Direct mill HYP ore;
   - CAP ore;
   - Low Grade SOX, SUS or HYP ore;
   - SOX and SUS ore NP < 13 $kgCaCO_3/t$ not suitable for embankment sand production;
   - CAP waste rock PpH > 7.1 and S_{TOT} < 0.1 % suitable for starter embankment;
   - HYP waste rock; or
   - SUS waste rock with PpH < 5.5 to be layered with HYP or placed in Marginal Grade Ore stockpile.
7. A map of the final ore and waste classifications is provided to the pit operations team to guide the dispatching of all rock released from the pit.

Segregation Procedures

1. The pit operations team will use blast classification maps to stake out the boundaries of each ore and waste class. Each class is represented by stakes in different colours. The maps are also used to communicate the shift's plans with equipment operators and supervisors at the beginning of each shift.
2. Haul trucks are loaded by a loader or excavator, the operator of which is responsible for knowing the material class being excavated and for communicating the class of each load to the haul truck operator.

3. The haul truck driver then delivers the load to the crusher or to the appropriate stockpile (if ore) or waste storage facility (if waste).

3.2 Confirmatory Monitoring

Confirmatory monitoring will be conducted for all waste that is placed in its final storage location, SUS to the Marginal Grade Stockpile and borrow material stockpiled for reclamation. The primary objective of this monitoring is to confirm that the ML/ARD Management Plan was implemented effectively. In order to achieve this, the proposed sampling frequency and ABA parameters are listed in Table 3-1. Duplicate samples that have been analysed at the onsite laboratory will be sent to an external lab for confirmatory testing.

Samples for waste rock, heap leach ore and reclamation overburden/soil will be collected from the storage facility during construction. The time and location that each sample was taken will be recorded. The results of the confirmatory sampling will be reviewed as they become available and the ML/ARD Management Plan updated should any concerns arise from the monitoring program.

Table 3-1:
Confirmatory Sample Analyses and Frequency

Facility	On-Site Analyses		External Analyses	
	Analyses	Frequency	Analyses	Frequency
CAP Waste Rock	PpH, S_{TOT}, S_{HCL}	100,000 t	S_{TOT}, S_{HCL}, Mod NP, C_{TOT}, Aqua-Regia metal	1,000,000 t
SOX & SUS Waste Rock	PpH, S_{TOT}, $S_{HCL,}$ C_{TOT}	100,000 t	S_{TOT}, S_{HCL}, Mod NP, C_{TOT}, Aqua-Regia metal	1,000,000 t
HYP Waste Rock	PpH, S_{TOT}, $S_{HCL,}$ C_{TOT}	100,000 t	S_{TOT}, S_{HCL}, Mod NP, C_{TOT}, Aqua-Regia metal	1,000,000 t
Embankment Sand	PpH, S_{TOT}, $S_{HCL,}$ C_{TOT}	Daily	S_{TOT}, S_{HCL}, Mod NP, C_{TOT}, Aqua-Regia metal	Monthly
Slimes or Rougher Tailing	PpH, S_{TOT}, $S_{HCL,}$ C_{TOT}	Weekly	S_{TOT}, S_{HCL}, Mod NP, C_{TOT}, Aqua-Regia metal	Monthly
PAG Tailings	PpH, S_{TOT}, $S_{HCL,}$ C_{TOT}	Weekly	S_{TOT}, S_{HCL}, Mod NP, C_{TOT}, Aqua-Regia metal	Semi-Annual
Heap Leach	PpH, S_{TOT}, $S_{HCL,}$ C_{TOT}	100,000	S_{TOT}, S_{HCL}, Mod NP, C_{TOT}, Aqua-Regia metal	500,000 t
Reclamation Stockpiles	PpH, S_{TOT}, $S_{HCL,}$ C_{TOT}	25,000 t	S_{TOT}, S_{HCL}, Mod NP, C_{TOT}, Aqua-Regia metal	100,000 t

4. Onsite Laboratory

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4. Onsite Laboratory

An onsite laboratory will be commissioned in order to facilitate the rapid analysis of samples collected to during the implementation of the ML/ARD Monitoring Plan. The laboratory will be located centrally on the site near the ore processing facility. The laboratory will have standard ore assay and sample preparation capabilities in addition to a selected set of ML/ARD specific tests.

ML/ARD test requirements include the following parameters:

- Total sulphur
- HCl soluble sulphur
- Total carbon
- Paste pH

5. Road Construction ML/ARD Management

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5. Road Construction ML/ARD Management

The access road to the Casino Project includes the Freegold Road Upgrade that extends 82 km from Carmacks and new construction of the Freegold Road Extension that extends an additional 120 km to the Casino Project Site. A risk based approach to evaluate ML/ARD potential associated with the Freegold Road Extension was reported in *Casino Road: Preliminary Risk Assessment Metal Leaching and Acid Rock Drainage* (Lorax, 2012) and the *Freegold Road Upgrade in the Site Access Road ML/ARD Risk Assessment – Update* (Lorax, 2013b). The reports identified areas of potential ML/ARD risk that will require additional sampling and evaluation in order to fully understand the ML/ARD risk posed by road construction. The additional characterization and risk assessment will be conducted in advance of detailed road design and the results of the analysis will be used to inform the design of the road and selection of quarry sites.

The primary purpose of the ML/ARD Risk Assessment for the road is to identify areas that would have an unacceptable risk to impact water quality and aquatic life. The preferred method to mitigate potential effects is via road design. Mitigation by design is accomplished by avoidance or minimizing disturbance of materials with a high ML/ARD potential. The management plan presented here identifies and lists preliminary management options that are available to minimize the potential environmental effects of ML/ARD along the Casino access road. This summary identifies the basic, conceptual options, and is intended to serve as the basis for further discussion and ongoing refinement, as the project progresses.

Various mitigation options for controlling and/or treating ML/ARD have been identified and evaluated over the past several decades. Research and practical experience is limited, but is adequate to provide a general indication of the options that are available, and the advantages and disadvantages of each. A total of five options have been identified that could be implemented should distinct sections of the road pose high risk of ML/ARD (Table 5-1).

Table 5-1:
Summary of ML/ARD Management Options

Decision Criteria	MANAGEMENT OPTIONS				
	Prevention and Control			Water Treatment	
	1 - Blending	2 - Dry Cover	3 - Water Cover	4 - Passive Treatment	5 - Active Treatment
Description	Potentially acid generating and acid consuming waste (limestone or other) can theoretically be blended or layered to produce a geochemically benign composite.	The purpose of a dry cover is to minimize water/oxygen ingress into underlying sulphide-rich rock. The cover forms a barrier to limit infiltration, or stores and releases stormwater, while maintaining saturated conditions under the cover.	Dispose sulphide-rich rock under water (subaqueous disposal) to inhibit oxidation. Laboratory and field studies indicate that flooding sulphide minerals is the most successful method presently known for preventing and controlling ARD.	Passive treatment systems use natural chemical, biological or physical processes to modify water that has been impacted by ML/ARD. Examples include anoxic limestone drains and constructed wetlands.	Active treatment systems may use chemical, physical (membrane) or biological processes to raise pH and extract metals from water affected by ML/ARD.
Limitations	Achieving adequate mixing to reduce sulphide oxidation rates is not considered feasible at field scale (requires adequate mixing to affect pore water chemistry).	Dry covers may limit the volume of drainage generated, however the reduced drainage volume may still contain high metal concentrations. Maintaining long-term performance of covers may be challenging.	Does not control oxidation that occurs prior to submergence, requires maintenance of water cover in perpetuity, does not immobilize all metals, any discharge may still require treatment.	Canadian climate and aquatic environments pose challenges, especially for biologically-driven systems. Passive treatment systems must be able to operate effectively in cold temperatures, drought, large storm events, and spring "freshet".	High capital and operating cost. It may not be practical to reduce pH and all metal concentrations to meet regulatory requirements or relevant guidelines. Sludge management, disposal and storage capacity may require careful consideration.
Residual Uncertainty	Moderate to High – Blending may delay the onset of acidic effluent, and reduce acid and/or metal loadings by providing attenuation for drainage, but is unlikely to eliminate metal leaching.	Moderate to High - The long-term durability of dry covers is uncertain. It has been suggested that cover systems should be designed to "fail" over geologic time such that the natural environment can withstand the incremental "failure".	Moderate – "…fundamental understanding of many phenomena influencing their performance is unknown, and the minimum depth of water required cannot be confidently determined"	Moderate – the long-term performance of passive treatment systems through climatic and weather extremes may be difficult to maintain.	Low to Moderate – Effluent quality can generally be maintained within a predictable range in the short to medium term. Long-term commitment to operate and maintain treatment system may be difficult to ensure.
Further Work Required to Reduce Uncertainty	Field tests to evaluate degree of blending that can be achieved and blending methodology, and to evaluate geochemical behaviour of blended material. Ongoing monitoring is required to characterize receiving environment and evaluate attenuation capacity.	Define cover performance criteria, evaluate options and select cover design. Predict long-term performance. Ongoing monitoring of both cover performance and environmental effects.	Identification of suitable site. Evaluation of chemical and physical design considerations. Ongoing monitoring of outfall, and to characterize receiving environment and attenuation capacity.	Define quality of influent and performance objectives. Research and design treatment system. Undertake sensitivity analysis and predict long-term performance. Define maintenance requirements. Water management system to collect and convey water.	Define quality of influent and performance objectives. Research and design treatment system. Determine method for sludge disposal. Water management system to collect and convey water to treatment system, and effluent to natural channel.
Capital Cost	Moderate – intensive re-handling required to excavate, mix and replace road base	Low to Moderate – depending on whether material can be covered in place or must be relocated.	Moderate – removal and replacement of road bed, preparation and deposition in impoundment	Low – limited to construction of passive system, including site grading, planting, *etc*.	High – cost to design and construct treatment plant may be considerable (average $7.5M, high $40M).
Operating Cost	Low – ongoing water quality monitoring	Low to Moderate – depending on cover monitoring requirement.	Low- ongoing water quality monitoring	Low – minor maintenance and monitoring.	High – average cost to operate treatment plant is $1.50 / m^3
Key Reference	MEND, 1998	MEND, 2004	MEND, 1998	MEND, 1996	MEND, 2013

6. Closure

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6. Closure

This report provides the preliminary ML/ARD Management and Monitoring Plan for the Casino Project for the YESAA review process. The report was prepared by the Lorax technical personnel listed below.

Sincerely,

LORAX ENVIRONMENTAL SERVICES LTD.

Bruce Mattson, M.Sc., P.Geo.
Principal Environmental Geoscientist

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